3rd Joint Meeting of the APS Division of Nuclear Physics and the Physical Society of Japan
Waikoloa, Hawaii
http://www.aps.org/meetings/meeting.cfm?name=HAW09
Tuesday, October 13, 2009 9:00AM - 12:30PM –
Session 1WA Workshop on Physics of Exotic Nuclei  Kohala 1

9:00AM 1WA.00001 Japan-US collaboration in Nuclear Physics AKITO ARIMA, Japan Science Foundation, President — I will mention some highlights from the history of Japan-US collaboration in Nuclear Physics. Although I have memories of my personal strong ties with many friends in US, I shall rather skip them, and focus on three major collaborative works which have made significant impacts on the developments of nuclear physics. The first one is the INS (Institute for Nuclear Study, University of Tokyo) - Berkeley collaboration. As well known, this led to the beginning of Rare Isotope (RI) beam experiments as a global trend and consequently the discovery of neutron halo by Tanihata et al. This Berkeley experiment was inspired by the Japanese Numatron project, which has remained only a plan. The second one would be RHIC. The RHIC is probably one of the most successful products of the INS- Berkeley project at least conceptually. Nagamiya has led US efforts over years, which has produced QGP finally, while he has moved back to Japan before this moment. The third point I would like to mention is the RIKEN Brookhaven Center. This has been supported by T.D. Lee strongly, and has contributed to the developments of spin physics, QGP experiments, Lattice QCD calculation. It also encouraged US young theoreticians by the supportive program with US universities. I now see many active physicists who were under this program. Now we have JUSTIPEN (Japan-US Theory Institute of Physics with Exotic Nuclei) program by DOE through the University of Tennessee. Since the summer of 2007, over fifty physicists including experimental groups have come to Japan for theoretical studies, and many workshops have been organized. Thanks also to its Japanese matching fund EFES(International Research Network on Exotic Femto Systems), a large number of Japanese physicists visited US, having many workshops and collaborations. At the era of RIBF completion and FRIB initialization, the Japan-US collaboration becomes of more significance, and I hope that this workshop and the joint meeting this week will accelerate the developments of this frontier field of physics.

9:30AM 1WA.00002 JUSTIPEN: Science in the international context1, DAVID DEAN, Oak Ridge National Laboratory — Physicists seek to understand nuclei through creating an experimental capability to investigate neutron rich nuclei and to utilize experimental data to validate a theoretical framework for describing all nuclei, including those produced in violent stellar deaths. Experimental efforts in Japan with the Radioactive Isotope Beam Factory (RIBF), and with the future Facility for Antiproton and Ion Research (FAIR) in Germany, and the future Facility for Rare Isotope Beams to be built at Michigan State University, along with existing facilities at Oak Ridge, Argonne, and other institutions, will be complemented by theoretical advances that focus on physics with exotic nuclei. The Japan Institute for Theoretical Physics with Exotic Nuclei (JUSTIPEN) was established between U.S. and Japanese scientists to facilitate theoretical investigations of exotic nuclei in the context of world-wide experimental efforts. Hosted by RIKEN and the University of Tokyo, JUSTIPEN is located at the RIBF facility at RIKEN with support coming from the Japan Society for the Promotion of Science and from the Department of Energy Office of Science, Office of Nuclear Physics. In this talk, I will describe the general physics thrusts of JUSTIPEN and its continuing program.

1Supported through JUSTIPEN under grant number DEFG02-06ER41407 (U. Tennessee). Oak Ridge National Laboratory is managed by UT-Battelle, LLC under Contract No. DE-FG05-87ER40361.

10:00AM 1WA.00003 Neutrinos in Nuclear Physics and Astrophysics and Japan-US Collaboration, TAKA KAJINO, National Astronomical Observatory, University of Tokyo — Neutrino is a tiny weakly interacting particle but plays several important and essential roles in nuclear physics, astrophysics and cosmology. Cosmological neutrinos take one of the keys to the formation of large scale structure and CMB anisotropies. Supernova neutrinos play critical roles in gravitational core-collapse and explosion of massive stars and also in explosive nucleosynthesis of light-to-heavy mass nuclei. In addition to these astrophysical interests, recent focus in neutrino physics is on the effects of flavor oscillation and self-interaction which indicate nature of fundamental symmetry or its breaking. Since these effects manifest themselves clearly through neutrino and matter interactions (i.e. neutrino-electron, -nucleon and -nucleus interactions), it is important to study the nuclear response to weak-electromagnetism. It is even more important to study the electroweak interaction as well as strong interaction in short-lived unstable nuclei because almost all catastrophic astrophysical phenomena occur on extreme conditions to be associated with frequent production and destruction of these exotic nuclei. Several Japan-US collaborations are underway on these topics in nuclear astrophysics. In this talk we will discuss several aspects of neutrinos in nuclear physics and astrophysics based on these collaborations.

10:30AM 1WA.00004 COFFEE BREAK –

11:00AM 1WA.00005 Extending the No-core Shell Model to heavier nuclei1, BRUCE R. BARRETT, Department of Physics, PO Box 210081, University of Arizona, Tucson, AZ 85721, USA — The No-core Shell Model (NCSM) has had considerable success in describing the binding energies, excitation spectra and other physical properties of light nuclei, A ≤ 16, e.g., [1]. The challenge facing future NCSM investigations is how to perform such calculations for heavier nuclei, for which the model spaces become unmanageable with existing computers. Our current studies involve the development of new many-body approaches for achieving this goal, such as the idea of successive unitary transformations, so as to include the effects of all nucleons, as proposed by Navrálí, et al.[2]. We construct effective one-body, two-body and three-body interactions for the p-shell by performing calculations for a few A = 5, 6 and 7 nuclei, respectively, with Nmax = 2, 4, ..., 12 and projecting the many-body Hamiltonians onto the lh21 space. We show how the averaged many-body correlations modify the p-shell two-body Hamiltonian and explore the dependence of the effective one-body and two-body matrix elements on Nmax. We will present the results of standard shell-model calculations using the derived effective Hamiltonian for p-shell nuclei with A > 6 and compare them to the exact NCSM results. The same procedure can be used for determining other effective operators within the p-shell, such as EM operators and transition operators.

1Supported through JUSTIPEN under grant number DEFG02-06ER41407 (U. Tennessee). Oak Ridge National Laboratory is managed by UT-Battelle, LLC under Contract No. DE-FG05-87ER40361.

1This work was partially supported by the NSF under grants PHY0244389 and PHY0555396.

11:30AM 1WA.00006 Nuclear structure studies in JUSTIPEN and EFES activities, NAOYUKI ITAGAKI, University of Tokyo — JUSTIPEN: Japan-US Theory Institute for Physics with Exotic Nuclei was launched in June 2006. JUSTIPEN has been established in order to facilitate collaborations between U.S. and Japanese scientists whose main research thrust is in the area of the physics of exotic nuclei. More than 40 nuclear scientists in U.S. have visited Japan in three years, and the many collaborations are established. I briefly summarize the JUSTIPEN activity from the Japanese side. There is a counterpart program for the Japanese scientists. International Research Network for Exotic Femto Systems (EFES) was selected as one of the Core-to-Core Programs of Japan Society for the Promotion of Science (JSPS). This is the program to send Japanese nuclear scientists to U.S., Germany, France, Italy, Norway, and Finland and to promote the international collaborations in the field of nuclear study. Many joint workshops were held with partner countries. To operate these international programs, University of Tokyo and RIKEN agreed to cooperate with each other and established TOhoku-RIKEN International Program for Nuclear Physics (TOKURIN) in June 2006. I summarize the activities in three years, and I also mention about the relation between these activities and my personal research — many-body correlations in light nuclei.
12:00PM 1WA.00007 The continuum-discretized coupled-channels method applied to exotic nuclei

9:00AM 1WB.00001 Coulomb excitation and transfer reactions to study neutron-rich nuclei

9:30AM 1WB.00002 Overview of RIBF and direct reactions with fast RI beams at RIBF

10:00AM 1WB.00003 Evolution of shell and nuclear structure in the neutron rich region

11:00AM 1WB.00005 Precision measurements of light neutron-rich nuclei

11:30AM 1WB.00006 Nuclear astrophysics with tracking arrays

12:00PM 1WB.00007 Spectroscopy of r-process nuclei using multi-nucleon transfer reaction

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Session 1WB Workshop on Physics Opportunities with GRETINA I Kona 4

The continuum-discretized coupled-channels method applied to exotic nuclei

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JPS:39543K
Tuesday, October 13, 2009 9:00AM - 12:30PM – Session 1WC Workshop on Frontiers in Nuclear Astrophysics | Kohala 4

9:00AM 1WC.00001 Enrichment of the heaviest elements Th and Pb in the Galaxy, WAKO AOKI, National Astronomical Observatory of Japan — The heaviest elements Th and Pb are key to understanding the neutron-capture reactions in the Universe. Abundance measurements of these elements for metal-deficient stars in the past decade have provided useful constraints on both the r- and s-processes, and early chemical enrichment in the Galaxy. Recent observational results on abundance ratios of Th to other stable elements in metal-deficient stars, Pb production of both r- and s-processes, and their enrichment history in the Galaxy are reviewed.

9:30AM 1WC.00002 First results from RIBF and the scope, SHUNJI NISHIMURA, RIKEN — Astrophysical rapid neutron-capture process (r-process) has been recognized to play an important role for the synthesis of approximately half of the heavy elements above iron. Recently, a new generation of accelerator facility (RIBF) has been completed and started providing opportunities of exploring very neutron-rich nuclei along the r-process path region. In this paper, the first results from RIBF will be presented. Furthermore, overall scope of experimental aspects will be discussed related to the astrophysical nucleosynthesis.

10:00AM 1WC.00003 Recent and future rp-process experiments at NSCL, FERNANDO MONTES, National Superconducting Cyclotron Laboratory — X-ray bursts are powered by a sequence of proton capture reactions and β+ decays (rp-process). Although much progress has been obtained, key nuclear physics uncertainties remain. Depending on the astrophysical conditions, the rp-process can extend up to the A≈100 mass region. Along the reaction path, even-even N=Z nuclei beyond 56Ni represent waiting points where abundances accumulate. The half-lives of these isotopes therefore determine the processing time-scale and the final composition once the burst is exhausted. Recent β-decay experiments of N=Z isotopes 84Mo, 90Cd, 98In and 100Sn will be discussed along with their astrophysical implications. In addition to the half-lives, proton capture reactions constitute important nuclear physics input for our understanding of the rp-processes. The new facility REA3 will provide opportunities for the study of many of the nuclei involved. Future possible experiments will be discussed.

10:30AM 1WC.00004 COFFEE BREAK —

11:00AM 1WC.00005 Study on astrophysical reactions using low-energy RI beams, HIDETOSHI YAMAGUCHI, CNS, the University of Tokyo — In recent years, low-energy RI beams can be produced in a good intensity and they have been used for studying many astrophysical reactions. One of the facilities producing low-energy RI beams is CRIB (CNS Radio-Isotope Beam separator) [1,2], an RI-beam separator of Center for Nuclear Study, University of Tokyo. Taking CRIB as an example, recent improvements on the RI-beam production and experimental results on astrophysical studies are presented. Several experimental approaches have been taken for the studies on astrophysical reactions. The feature of each method are discussed based on real measurements performed at CRIB. One is the direct method, applied for measurements of reactions such as (α,p) [3]. Another is the measurement of proton/alpha resonance scattering using the thick target method in inverse kinematics, by which we can obtain information on the resonances relevant in astrophysical reactions [4,5]. A recent fruitful result was from a measurement of proton resonance scattering using a 7Be beam [5]. The energy level structure of 10B, revealed by the experiment, is especially of interest as it is related with the 8Be(p,γ) 9B reaction, responsible for the production of 8B neutrinos in the sun. We successfully determined parameters of resonances in 7B below 6.7 MeV, which may affect the 8Be(p,γ) 9B reaction rate at the solar temperature. Indirect methods, such as ANC and the Trojan Horse Method, were also used in some of the measurements.

11:30AM 1WC.00006 Penning trap mass measurements along the astrophysical \( r^+ \) - and \( ν^+ \) - process paths\(^1\), JASON CLARK, Argonne National Laboratory — X-ray bursters and supernovae are examples of explosive stellar phenomena in which nuclides are quickly produced in great quantities. Observed as x-ray bursts, thermonuclear runaways on the surface of neutron stars accreting material from its binary star companion create elements by a nucleosynthetic process which involves a series of rapid proton-capture reactions, termed the rp process. The timescale, nuclides produced, and energy released during the rp process are very sensitive to delays encountered at waiting-point nuclides, nuclides in which their slow \( \beta^- \) decay is more probable than net proton capture. A possible mechanism to bypass the waiting-point nuclides is through the \( νp \) process, in which (\( n,p \)) and (\( n,γ \)) reactions on the waiting-point nuclides, in addition to the proton-capture reactions, are possible. Supernovae are possible sites for the \( νp \) process as the proton-rich ejecta can absorb antineutrons to produce the required free neutrons. It is this \( νp \) process which may resolve the long-standing discrepancy between the observed and predicted abundances of 92Mo and 94Mo. Proton-capture \( Q \) values of nuclides along the rp- and \( νp \)-process paths are required to accurately model the nucleosynthesis, especially at the waiting-point nuclides. In recent years, Penning traps have become the preferred tool to make precise mass measurements of stable and unstable nuclides. To make the best use of these devices in measuring the masses of radioactive nuclides, systems have been developed to quickly, cleanly, and efficiently transport the short-lived, weakly produced nuclides to the Penning traps. This talk will discuss the rp and \( νp \) nucleosynthetic processes and will highlight the precision Penning trap mass measurements of nuclides along these process paths.

\(^1\)This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.

12:00PM 1WC.00007 Photonuclear reactions studied with the time-dependent density-functional theory, TAKASHI NAKATSUKASA, RIKEN Nishina Center — Photonuclear reaction cross sections are known to be of fundamental importance in nuclear structure as well as a variety of applications, such as nucleosynthesis and nuclear power. Especially, it is highly desired to improve reliability of E1 strength distribution in unstable nuclei which are not experimentally reachable. We are performing systematic calculations of nuclear photoabsorption cross sections using the time-dependent density-functional theory. For this purpose, we have developed a new numerical approach to the linear response problems, "Finite Amplitude Method" (FAM). In this talk, we present recent results of our microscopic calculations with the FAM applied to the Skyrme functionals and discuss properties of nuclear E1 strength distribution in light- and medium-mass nuclei.

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The contrast between the alpha and beta phases strongly suggests the magnetic origin of the UCN production in solid oxygen. To summarize the experimental results, and then address the seemingly different physics of UCN production in the low-temperature magnetic phases of solid oxygen. (IUCF). The candidate material needs to have a large density of states which allows the incident cold neutrons to couple to leading to fast downscattering.

For the CUORE Collaboration

The rate of the process is sensitive to the effective neutrino mass. Cryogenic Underground Observatory for Rare Events (CUORE), a next-generation large-scale double-beta decay experiment, is currently under construction at the Gran Sasso National Laboratory (LNGS) in Italy. It will be sensitive to the neutrino mass differences between potential DBD nuclei, is far above energies of γ-rays from natural radioactivities (maximum 2.615 MeV from 208Ti decay), therefore we can naturally expect small backgrounds in the energy region we are interested in. We gave the best lower limit on the half-life of neutrino-less double beta decay of 48Ca by using CaF₂(Eu) detector system, ELEGANT VI though further development is highly desirable to reach the mass region of current interest. We have constructed the prototype detector, CANDLES III in our laboratory (Osaka U.) at sea level and studied the basic performance of the system, including the light collection, position reconstruction and background rejection. We are now moving the detector system to new experimental room (room D) at Kamioka underground laboratory (2700 m.w.e.) to avoid large background originated from cosmic rays. At the same time, we are increasing the total mass of the 48Ca compared to the one in the prototype detector. 96 (instead of 60 in prototype) CaF₂ modules which contains 350 g of 48Ca are immersed in a liquid scintillator (LS) which acts as an active veto (veto phase). The conversion phase contains wavelength shifter (Bis-MSB) which converts the emission light of CaF₂(pure) which has a peak in the UV region to the visible one where the quantum efficiency of the PMTs is high enough (maximum at ~ 400 nm) and materials at the optical path have good transparencies. Scintillation lights from both the CaF₂ modules and the liquid scintillator in veto phase are viewed by large PMTs (48 × 13” and 14 × 17” tubes). All the detector system described above are contained in a water tank which is 3 m in diameter and 4 m in height. The water tank and a purification system of the LS together with LS storage tanks were installed at room D. The purification system of the LS removes the radioactive impurities especially U and Th using the techniques of water-extraction and N₂ purge. Other components including the CaF₂ modules, the PMTs, the liquid scintillator vessel and DAQ system will be installed soon.

The observation of neutrinoless double beta decay, at any nonzero level, would imply that lepton number is not conserved, that neutrinos have Majorana masses, and that neutrinos are their own antiparticles. We mainly present the currect status of the development for upgrading the KamLAND detector toward the 0νββ decay experiment by adding 136Xe to the detector volume. Since the sensitivity of the 0νββ experiment is determined by the available source amount and the background rate, the KamLND detector is suitable for this purpose. We mainly present the current status of the development for upgrading the KamLAND detector toward the 0νββ decay experiment.

1For the CUORE Collaboration

9:00AM 1WD.00001 The Profound Implications of Neutrinoless Double Beta Decay . BORIS KAYSER, Fermilab — The observation of neutrinoless double beta decay, at any nonzero level, would imply that lepton number is not conserved, that neutrinos have Majorana masses, and that neutrinos are their own antiparticles. Majorana neutrino masses are physics far outside the Standard Model. Their existence would be evidence in favor of the see-saw model of the origin of neutrino mass, and evidence in favor of leptogenesis as the explanation of the baryon-antibaryon asymmetry of the universe. This talk will explain the physics of neutrinoless double beta decay, discuss what the observation of this process would teach us, and examine the nature of neutrinos that are their own antiparticles.

9:30AM 1WD.00002 CANDLES for the study of 48Ca double beta decay . IZUMI OGAWA, Graduate School of Science, Osaka University — CANDLES is the project to search for double beta decay (DBD) of 48Ca by using CaF₂ scintillators. The Q-value of 48Ca, which is the highest (4.27 MeV) among potential DBD nuclei, is far above energies of γ-rays from natural radioactivities (maximum 2.615 MeV from 208Ti decay), therefore we can naturally expect small backgrounds in the energy region we are interested in. We gave the best lower limit on the half-life of neutrino-less double beta decay of 48Ca by using CaF₂(Eu) detector system, ELEGANT VI though further development is highly desirable to reach the mass region of current interest. We have constructed the prototype detector, CANDLES III in our laboratory (Osaka U.) at sea level and studied the basic performance of the system, including the light collection, position reconstruction and background rejection. We are now moving the detector system to new experimental room (room D) at Kamioka underground laboratory (2700 m.w.e.) to avoid large background originated from cosmic rays. At the same time, we are increasing the total mass of the 48Ca compared to the one in the prototype detector. 96 (instead of 60 in prototype) CaF₂ modules which contains 350 g of 48Ca are immersed in a liquid scintillator (LS) which acts as an active veto (veto phase). The conversion phase contains wavelength shifter (Bis-MSB) which converts the emission light of CaF₂(pure) which has a peak in the UV region to the visible one where the quantum efficiency of the PMTs is high enough (maximum at ~ 400 nm) and materials at the optical path have good transparencies. Scintillation lights from both the CaF₂ modules and the liquid scintillator in veto phase are viewed by large PMTs (48 × 13” and 14 × 17” tubes). All the detector system described above are contained in a water tank which is 3 m in diameter and 4 m in height. The water tank and a purification system of the LS together with LS storage tanks were installed at room D. The purification system of the LS removes the radioactive impurities especially U and Th using the techniques of water-extraction and N₂ purge. Other components including the CaF₂ modules, the PMTs, the liquid scintillator vessel and DAQ system will be installed soon.

10:00AM 1WD.00003 EXO — An overview . GIORGIO GRATTA, Physics Dept. Stanford University — EXO is a program to develop and operate large neutrino-less double-beta decay experiments and measure Majorana neutrino masses with an ultimate sensitivity below 10 MeV. In this talk I will survey the different activities in progress, including the status of the EXO-200 detector that is approaching data taking and the R&D on Ba tagging and on large detectors in gaseous phase. The talk is given on behalf of the EXO collaboration including scientists from Canada, Russia, Switzerland and the US.

10:30AM 1WD.00004 COFFEE BREAK —

11:00AM 1WD.00005 Neutrinoless Double Beta Decay of 136Xe by KamLAND . SEI YOSHIDA, Tohoku University — There is, presently, strong evidence from recent neutrino experiments that neutrinos undergo flavor oscillations, and hence must have finite masses. The oscillation results can provide differences between squares of neutrino mass eigenvalues, but cannot determine the absolute mass scale nor its origin. So far only neutrinoless double beta(0νββ) decay measurement offers a realistic opportunity to establish the Majorana nature of neutrinos and give the absolute scale of the effective neutrino mass. Global analyses of the oscillation results imply the effective neutrino mass could have a minimum value as large as a few tens of meV for the inverted hierarchy of the neutrino mass spectrum. Next generation 0νββ decay experiments are currently proposed to achieve such mass sensitivity. The KamLAND detector is located in the Kamioka mine, and is filled with 1,000 tons of liquid scintillator. The detector is very sensitive to low energy neutrinos from nuclear reactors and the Earth. We are currently working on reducing backgrounds in the KamLAND to detect very low energy solar neutrinos produced by the 8B reaction in the Sun. We have proposed upgrading the KamLAND detector into a huge 0νββ decay experiment by adding 136Xe to the detector volume. Since the sensitivity of the 0νββ experiment is determined by the available source amount and the background rate, the KamLAND detector is suitable for this purpose. We mainly present the current status of the development for upgrading the KamLAND detector toward the 0νββ decay experiment.

11:30AM 1WD.00006 Status of the CUORE Neutrinoless Double-Beta Decay Experiment . YURY KOLOMENSKY1, LBNL/UC Berkeley — Observation of exotic neutrinoless double-beta decays would indicate that neutrinos are Majorana particles. The rate of the process is sensitive to the effective neutrino mass. Cryogenic Underground Observatory for Rare Events (CUORE), a next-generation large-scale double-beta decay experiment, is currently under construction at the Gran Sasso National Laboratory (LNGS) in Italy. It will be sensitive to the neutrino mass values suggested by recent atmospheric neutrino oscillation experiments in the so-called inverted mass hierarchy. We will review the status of the R&D and construction efforts and the prospects for the double-beta decay and other measurements with CUORE.

12:00PM 1WD.00007 Double Beta Decay in SNO+ . MARK CHEN, Queen’s University — SNO+ is the follow-up experiment to the Sudbury Neutrino Observatory with liquid scintillator replacing the heavy water. The experiment will detect lower energy solar neutrinos, including the pep and CNO solar neutrinos, and geo and reactor antineutrinos. In addition, SNO+ plans to deploy neodymium in the liquid scintillator to conduct a neutrinoless double beta decay search. Status and plans will be presented.

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9:00AM 1WE.00001 Investigation of New Approaches to Ultra-cold Neutron Production at IUCF . CHEN-YU LIU, Indiana University — Ultra-cold neutrons (UCN) can be produced beyond the thermal limits using superfluid He and solid deuterium. We have started systematic investigations into other systems that could potentially be an efficient UCN converter at the Indiana University Cyclotron Facility (IUCF). The candidate material needs to have a large density of states which allows the incident cold neutrons to couple to leading to fast downscattering, and more importantly, the source needs to have a small neutron absorption that allows the number density of UCN to accumulate. Our team has recently demonstrated experimentally that solid oxygen can be used to produce UCN through mechanisms different from the previous sources. In this talk, I will first summarize the experimental results, and then address the seemingly different physics of UCN production in the low-temperature magnetic phases of solid oxygen. The contrast between the alpha and beta phases strongly suggests the magnetic origin of the UCN production in solid oxygen.
9:30 AM 1WE.00002 He-II UCN source in Japan and Canada. KICHUJI HATANAKA, Research Center for Nuclear Physics, Osaka University — Ultracold neutrons (UCN) can be confined in a material/magnetic bottle. This unique property is very useful for various kinds of experiments, for example neutron EDM, β decay and gravity experiments. Confined neutrons distribute in a phase space with equal weight. A phase space density is one of the most important parameters for the experiments. In the traditional UCN source like the turbine UCN source at Grenoble, the phase space density is limited by Liouville’s theorem. We use phonon phase space of superfluid helium (He-II) for neutron cooling, where neutron phase space density is not limited by Liouville’s theorem. UCN density in He-II is represented as the product of a UCN production rate, which is the product of a production cross section and an incident neutron flux, and a UCN storage lifetime. The UCN storage lifetime is very long in He-II. We constructed a He-II spallation UCN source in a 392 MeV 1 μA proton beam line at RCNP. He-II was placed in a cold neutron source. UCN, which were produced in the He-II, were transported to an experimental volume through UCN guides. We obtained a UCN density of 15/cm³ additional very high intensity polychromatic beam for fundamental physics research will be presented. Physics experiments include a high intensity polychromatic beam, three monochromatic beams (0.496 nm, 0.89 nm, and .384 nm), and a neutron interferometer facility for studies that include condensed matter physics, materials science, nuclear chemistry, and biological science. The beam lines for fundamental neutron physics experiments include a high intensity polychromatic beam, three monochromatic beams (0.496 nm, 0.89 nm, and .384 nm), and a neutron interferometer and optics facility (0.2 nm – 0.49 nm). The presentation will discuss the broad program in fundamental neutron physics with a brief description of some of the experiments performed at the NCNR. In addition, the status of the new guide expansion project that includes a new neutron guide that will provide an additional very high intensity polychromatic beam for fundamental physics research will be presented.

10:00 AM 1WE.00003 Fundamental Neutron Physics at NIST. MUHAMMAD ARIF. NIST — The program in fundamental neutron physics at the National Institute of Standards and Technology (NIST) began nearly two decades ago. Currently, five neutron beam lines are dedicated to studies of fundamental neutron interactions. The neutrons are provided by the NIST Center for Neutron Research (NCNR), a national user facility for studies that include condensed matter physics, materials science, nuclear chemistry, and biological science. The beam lines for fundamental neutron physics experiments include a high intensity polychromatic beam, three monochromatic beams (0.496 nm, 0.89 nm, and .384 nm), and a neutron interferometer and optics facility (0.2 nm – 0.49 nm). The presentation will discuss the broad program in fundamental neutron physics with a brief description of some of the experiments performed at the NCNR. In addition, the status of the new guide expansion project that includes a new neutron guide that will provide an additional very high intensity polychromatic beam for fundamental physics research will be presented.

10:30 AM 1WE.00004 COFFEE BREAK

11:00 AM 1WE.00005 Cold neutron interferometry. MASAAKI KITAGUCHI, Research Reactor Institute, Kyoto University — Neutron interferometry is a powerful technique for studying fundamental physics. A large dimensional interferometer for long wavelength neutrons is extremely important in order to investigate problems of fundamental physics, including tests of quantum measurement theories and searches for non-Newtonian effects of gravitation, since the sensitivity of interferometer depends on the wavelength and the interaction length. Neutron multilayer mirrors enable us to develop the large scale interferometer for long wavelength neutrons. The multilayer mirror is one of the most useful devices in cold neutron optics. A multilayer of two materials with different potentials is understood as a one-dimensional crystal, which is suitable for Bragg reflection of long wavelength neutrons. Cold and very cold neutrons can be utilized for the interferometer by using the multilayer mirrors with the proper lattice constants. Jamin-type interferometer by using beam splitting etalons (BSEs) has shown the feasibility of the development of large scale interferometer, which enables us to align the four independent mirrors within required precision. The BSE contains two parallel multilayer mirrors. A couple of the BSEs in the Jamin-type interferometer separates and recombines the two paths spatially. Although the path separation was small at the first test, now we have already demonstrated the interferometer with perfectly separated paths. The BSE contains two parallel multilayer mirrors. A couple of the BSEs in the Jamin-type interferometer separates and recombines the two paths spatially. Although the path separation was small at the first test, now we have already demonstrated the interferometer with perfectly separated paths.

11:30 AM 1WE.00006 The Hadronic Weak Interaction and Parity Violation in Cold Neutron-Nucleus Capture. MICHAEL GERICKE, University of Manitoba — The study of the hadronic weak interaction has a long tradition, starting with the first observation of parity violation in the nucleon-nucleon (NN) interaction in cold neutron capture experiments, in the early 60’s (Y. Abov et al., 1964). Since then, there has been intense effort in gaining a better understanding of the weak NN interaction, both on the theoretical side, as well as on the experimental side. The existence of the NN weak interaction was first predicted in the generalization of Fermi’s theory of nuclear beta decay (Feynman, Gel-Mann, Sudarshan, and Marshall) to include a universal charged weak current. In other words, a consistent theory for nuclear beta decay required the existence of the NN weak interaction. This basic framework has survived within the Standard Model (SM), with the crucial addition of the neutral weak hadronic currents. To this day, the latter remains a very poorly tested (and poorly understood) sector of the SM. The basic weak currents, as they occur in the SM, are modified by the strong interactions at low energy. At the same time, the large mass of the weak bosons requires close proximity of the quarks engaged in the interaction. The precision measurement of parity violating observables in few body NN systems can therefore be used to provide important benchmarks for models that aim to describe low-energy, non-perturbative QCD, as well as effective models that seek to describe the NN weak interaction itself. Progress in measuring parity violating observables in cold neutron capture experiments has historically been hampered by a lack in high intensity neutron sources and other technological problems. Recently, significant technological advancements on all fronts and, especially, the completion of new, high intensity neutron sources have spurred renewed experimental activity in this area.

12:00 PM 1WE.00007 Precision measurement of quantum states of neutrons in the terrestrial gravity. YOSHIO KAMIYA, International Center for Elementary Particle Physics — Quantum states of matter in gravitational fields are expected as well as those in electromagnetic fields and nuclear fields. However, the gravitational force is extremely weak compared with the forces from the others fields. Therefore, the observation of the quantum effect of gravity is very challenging. UCNs are the best candidates as a probe for the gravitational force because of their neutral charge and long lifetime. They can be reflected on a normal material surface, so can be trapped and make quantum states on the bottom mirror in the terrestrial gravity. The scale of the quantum effect is around 10 microns in length. It is in measurable order. By observing the discriminative spatial distribution in vertical, the quantum effect can visibly be demonstrated. Currently, only a few experiments that demonstrate quantum effects are reported. Keys of the experiments are UCN’s flux, position resolution of a UCN detector, and fine neutron guides that select proper quantum states. I will present the experimental setup of the experiments at the Institute of New-Langevin in France. Then I will show our ongoing experiment using the position sensitive detector with fine spatial resolution of 3 microns. Details of the detector development will be presented. The quantum states are sensitive to non-Newtonian gravity and/or sensitive to the gravity-like force which reaches approximately 10 microns. The precision measurement has potential to search for such exotic forces.

Tuesday, October 13, 2009 9:00 AM - 12:30 PM

Session 1WF Workshop on the Structure of Hadrons and Hypernuclei Studied by Photonuclear and Hadronic Reactions at Jlab, LEPS, and J-PARC Kohala 3
9:00AM 1WF.00001 Strangeness in Hadronic and Nuclear Systems, ANTHONY THOMAS, Jefferson Lab — The strange quark presents many challenges and opportunities in modern nuclear physics. We first review some modern aspects of the spectroscopy of baryons involving a strange quark. In terms of baryon spectroscopy there are far less Σ and Ξ states established experimentally than are expected within quark models. Coupled with this, lattice QCD is currently better suited to studying the spectroscopy of excited hyperons than nucleons because of the heavier mass of the strange quark. This opens the possibility that lattice might actually be able to predict some states before they can be measured. We also review some remarkable recent progress in the understanding of the energies of hypernuclei starting at the quark level. One can very naturally understand the absence of Σ hypernuclei, the very small spin-orbit force in Λ hypernuclei and the binding energies of many Λ hypernuclei as well as predicting the binding energies of Ξ hypernuclei. The relevance of these phenomena to the properties of dense matter will also be discussed.

9:30AM 1WF.00002 Studies of the Nucleon Structure at Jefferson Lab, VOLKER BURKERT, Jefferson Lab — The JLab 6 GeV electron beam has been used to study the nucleon’s internal structure in the transition from the regime of strongly interacting quarks and gluons to the deep inelastic regime of quasi-free interactions. Elastic and inelastic electron scattering, including the measurement of polarization observables, has led to deeper insight into the complex spatial and spin structure of the nucleon. In this talk, I will discuss results on the electromagnetic nucleon elastic form factors and on nucleon resonance transition form factors of several excited states of the proton. I will also present recent measurements of the spin responses of protons and neutrons in inclusive and exclusive electro production processes. Finally, I will discuss the prospects of probing generalized parton distributions (GPDs) in measurement of processes such as deeply virtual Compton scattering, both with the current 6 GeV machine, as well as at the higher energies available after the JLab 12 GeV upgrade.

10:00AM 1WF.00003 Hadronic Physics at LEPS/SPring-8, TOMOAKI HOTTA¹, RCNP, Osaka University — At the Laser Electron Photon facility at SPring-8 (LEPS), highly polarized photon beams in the energy range from 1.5 to 3.0 GeV are used for studying hadronic physics. The beams are produced by Compton scattering of laser photons from 8-GeV electrons in the SPring-8 storage ring synchrotron radiation source. The main detector setup has been a charged-particle spectrometer with a dipole magnet in the forward direction. We recently extended our kinematical coverage by adding a time projection chamber (TPC) surrounding the target. We have been studying various meson/baryon photoproduction reactions, including searching for the exotics such as Θ⁺ pentaquark. For further upgrade of the beam and the detector, by constructing a new beamline at SPring-8, the LEPS2 project has been proposed. In this talk, recent results from the LEPS experiment are overviewed and future prospects are discussed.

¹for the LEPS collaboration

10:30AM 1WF.00004 COFFEE BREAK —

11:00AM 1WF.00005 Hypernuclear and Strange Quark Programs in Jefferson Lab Halls A and C, PETE MARKOWITZ, Florida International University — The first several generations of experiments on hypernuclei and strange quark production have been completed in Jefferson Lab’s Halls A and C. I will present a summary of the program showing the primary results. The wide range of results from the program has changed our understanding of both hypernuclei and strange quark electro- and photo-production. The results show that the elementary reaction is dominated by t-channel at forward angles for production of the Lambda, while s-channel dominates Sigma production. The Longitudinal response is large (approximately 50% of the Transverse), suggesting that these experiments can constrain models for the kaon form factor. On nuclear targets, good signal-to-noise ratios have been achieved with unprecedented resolutions. The reaction produces mirror nuclei to production with hadronic beams, and importantly determines the binding energies. Additionally, for the first time excited core states have been observed allowing tests of hypernuclear potentials and production models.

11:30AM 1WF.00006 Hypernuclear Study with Hadronic Reactions, from AGS/KEK-PS to J-PARC, TOMOKAZU FUKUDA, Osaka Electro-Communication University — I will overview the hypernuclear experiments with meson beams at BNL-AGS and KEK-PS, which have been carried out with strong collaboration between US and Japan. The talk will start with the S = -1 physics, Lambda-hypernuclear spectroscopy, Sigma hypernucleus search, weak decay of the Lambda hypernuclei, gamma-ray spectroscopy of the Lambda hypernuclei, production of the neutron-rich Lambda hypernucleus, and also cover the S = -2 physics; search for H-dibaryon, double-Lambda hypernuclear studies, and so on. Many of these experiments will continue at J-PARC with upgraded experimental equipments and conditions, which will be discussed in detail by Nagae at the plenary talk.

12:00PM 1WF.00007 Baryon resonance studies via meson photoproduction at CLAS, FRANZ KLEIN¹, Catholic University of America — The CLAS Collaboration has been investigating the formation of baryon resonances in photoproduction processes for several years using the CEBAF Large Acceptance Spectrometer in Hall B at Jefferson Lab. Differential cross section data for pseudoscalar and vector mesons have been obtained with unprecedented statistics. Recently, the focus has been shifted towards the extraction of polarization observables using circularly and linearly polarized beams and frozen-spin targets. Preliminary cross section and polarization data will be presented as well as results from partial wave analyses and model calculations discussed with regard to the extraction of s-channel contributions.

¹On behalf of the CLAS Collaboration.

Tuesday, October 13, 2009 9:00AM - 12:30PM —

Session 1WG Workshop on Investigations of Glue and the Physics and Prospects of the Electron Ion Collider — Kings 2

9:00AM 1WG.00001 What we have learned from the RHIC d+Au program, MICHAEL LEITCH, Los Alamos National Laboratory — Measurements in p+A, and at RHIC in d+Au collisions have long been a fundamental arena for the study of the modification of QCD processes in normal or cold nuclear matter (CNM). They provide insight into fundamental physics such as coherence effects or shadowing in nuclei, the saturation of gluons at small momentum, the energy loss of quarks or gluons in CNM, and soft multiple scattering effects that cause broadening of the transverse momentum. For heavy-ion physics it has been apparent for some time that CNM effects must be quantified before physics beyond these can be inferred from the heavy-ion results. Most notably at RHIC, the large densities of the hot-dense matter created in heavy-ion collisions indicated by the suppression of pions at high transverse momentum, could not be substantiated until it was verified that no such effects occurred in d+Au collisions. We will review the progress at RHIC in quantifying CNM effects in various sectors including high-pT particle suppression and correlations, direct photon production, particle production at forward rapidity and small x, and open and closed heavy-quark systems in the context of related measurements at Fermilab and CERN.
RHIC I
Kings 3
of view of exploration of the QCD phase diagram. The topics which arise from recent experimental results and still await a theoretical explanation. I will discuss the expected future of the LHC physics from the point that the strongly coupled quark-gluon plasma is created at RHIC. Now more detailed investigations from the theoretical side are carried out to know this hot
University — The success of theories, hydrodynamic models, recombination models, jet quenching and color glass condensate and so on brought us the fact
initial rough cost estimates for various designs, and the accelerator and detector research and development being launched to demonstrate technical feasibility
that would achieve lower collision energies at a fraction of the full cost. I will discuss the science reach of an EIC as a function of its energy and luminosity goals,
National Laboratory and Jefferson Lab have designs built upon their present facilities to achieve eventually an EIC with polarized electron beams up to 10-20
community as embodying the vision for reaching the next QCD frontier.” I will discuss the open questions of science, technology and strategy that are being
planned physics program will be discussed, including a precision study of valence quark distributions, a 3-d mapping of the transverse momentum dependent
and the generalized parton distributions, low-energy tests of the standard model, a search for exotic mesons and a study of few-body and nuclear medium effects.

10:00AM 1WG.00003 Physics Program with 12 GeV JLab1, JIAN-PING CHEN, Jefferson Lab — Jefferson Lab (JLab) is one of the premier facilities in nuclear and hadronic physics in the world. Recommended as the top priority in the most recent US nuclear physics long-range plan [1], JLab is undergoing an energy upgrade from 6 GeV to 12 GeV [2]. With high luminosity and high polarization CW electron beam, the 6 GeV physics program has produced exciting results in the last decade. The energy upgrade will greatly expand the JLab capability and open up new opportunities.

11:00AM 1WG.00005 The nucleon structure, what an Electron-Ion Collider will teach us. ELIKE-CAROLINE ASCHENAUER, Brookhaven National Laboratory — The question after the individual parton (quarks and gluons) contributions to the spin of the nucleon is even after 20 years of experimental efforts not yet solved. After several precise measurements in polarized deep inelastic scattering it is clear, that the spin of the nucleon cannot be explained by the contribution of the quarks alone. This is affirmed by the newest results from COMPASS, HERMES and JLAB on the inclusive spin structure function g1 and on the individual contributions from the different quark flavors from semi-inclusive deep inelastic scattering data. Recent measurements from the polarized proton proton collider RHIC show that also the contribution from the Gluons is smaller than originally expected.

11:30AM 1WG.00006 How universal gluodynamics underlying the structure of matter can be uncovered with precision by an Electron-Ion Collider (EIC). RAJU VENUGOPALAN, BNL — We discuss measurements in DIS off nuclei at an EIC that provide unique insight into the nature of strong color fields in QCD. We will focus in particular on what one can learn from diffractive DIS measurements that will be performed for the first time at an EIC.

12:00PM 1WG.00007 Planning and Realization of an Electron Ion Collider. STEVEN VIGDOR, Brookhaven National Laboratory — According to the 2007 Nuclear Physics Long Range Plan, “An EIC with polarized beams has been embraced by the U.S. nuclear science community as embodying the vision for reaching the next QCD frontier.” I will discuss the open questions of science, technology and strategy that are being addressed in order to convince the community to endorse a high priority for construction of such a facility in the next Long Range Plan. Both Brookhaven National Laboratory and Jefferson Lab have designs built upon their present facilities to achieve eventually an EIC with polarized electron beams up to 10-20 GeV colliding with polarized proton beams up to 250 GeV and with beams of heavy nuclei up to 100 GeV/nucleon. Both designs have introduced staging options that would achieve lower collision energies at a fraction of the full cost. I will discuss the science reach of an EIC as a function of its energy and luminosity goals, initial rough cost estimates for various designs, and the accelerator and detector research and development being launched to demonstrate technical feasibility of the ambitious design goals. I will also place these plans in the broader context of international discussions of possible electron-hadron colliders of both much lower and much higher energy.

Tuesday, October 13, 2009 9:00AM - 12:30PM — Session 1WH Workshop on the Expanding Future of High Energy Nuclear Physics at LHC and RHIC I Kings 3

9:00AM 1WH.00001 Relativistic Heavy Ion Theory: Present and Future. CHIHO NONAKA, Nagoya University — The success of theories, hydrodynamic models, recombination models, jet quenching and color glass condensate and so on brought us the fact that the strongly coupled quark-gluon plasma is created at RHIC. Now more detailed investigations from the theoretical side are carried out to know this hot and dense QCD matter at RHIC. I will give a brief overview on recent theoretical achievements for understanding of RHIC physics and also outline interesting topics which arise from recent experimental results and still await a theoretical explanation. I will discuss the expected future of the LHC physics from the point of view of exploration of the QCD phase diagram.
9:30AM 1WH.00002 The present status and future physics program of RHIC, HELEN CAINES, Yale University — RHIC is preparing to enter its second decade of operations. I will highlight several measurements from the first 10 years of running that have been pivotal in our belief that the hot and dense matter created in AA collisions at RHIC is strongly interacting, has partonic degrees of freedom, flows like a near-perfect fluid, and is highly opaque to high energy partons passing through it. I will then discuss the near-future heavy-ion program at RHIC. It is focussed on extended top energy Au-Au running and a systematic low energy beam scan. The goals of the 200 GeV collision runs are the detailed measurements of heavy-flavor (c and b) production and jet reconstruction. These results will greatly improve our understanding of the properties of the medium created. The purpose of the low energy beam scan is to search for the QCD critical point. Finally, there are also plans to study U+U collisions where interesting effects may be observed due to the highly oblate nature of the U nucleus.

10:00AM 1WH.00003 Jet shapes and jet cross sections in relativistic heavy-ion collisions, BEN-WEI ZHANG, Los Alamos National Laboratory — Energetic partons traversing a hot/dense nuclear medium are expected to lose a large fraction of their energy. In fact, the stopping power of strongly-interacting matter for color-charged particles has, by far, the largest experimentally established effect: the attenuation of the cross section for final-state observables of large mass/momentum/energy. This jet quenching mechanism has been used to successfully explain the strong suppression of the hadron spectra at large transverse momentum observed in nucleus-nucleus collisions at the Relativistic Heavy Ion Collider (RHIC). However, at present, most measurements of hard processes are limited to single particles and particle correlations, which are only the leading fragments of a jet. Experimental advances at RHIC and new opportunities provided by LHC will allow for innovative and much more definitive tests of the mechanisms of parton attenuation in matter. In this study we demonstrate that jet shape and jet cross section measurements are precisely the tools to probe the underlying QCD theory. We present a first step in understanding these shapes and cross sections in heavy ion reactions. Our approach allows for detailed simulations of the experimental acceptance/cuts that help isolate jets in such high-multiplicity environment. It is demonstrated for the first time that the pattern of stimulated gluon emission can be correlated with a variable quenching of the jet rates and provide an approximately model-independent approach to determining the characteristics of the medium-induced bremsstrahlung spectrum. Surprisingly, in realistic simulations of parton propagation through the QGP we find a minimal increase in the mean jet radius even for large jet attenuation. Jet broadening is manifest in the tails of the energy distribution away from the jet axis and its qualification may need high statistics measurements.

10:30AM 1WH.00004 COFFEE BREAK —

11:00AM 1WH.00005 Full jet-reconstruction in heavy-ion collisions at RHIC, JOERN PUTSCHKE, Yale University — Measurements of inclusive hadron suppression and di-hadron azimuthal correlations in ultra-relativistic nuclear collisions have provided important insights into jet quenching in hot QCD matter, but are limited in their sensitivity due to well-known biases. Complete jet reconstruction in heavy-ion collisions would provide a direct measurement of the energy of the scattered parton before energy loss, alleviating such biases and allowing a measurement of the energy loss probability distribution necessary to extract properties of the medium in a model-independent way from hard probes. In this talk measurements of the inclusive jet spectrum and the fragmentation function of fully reconstructed jets in 200 GeV heavy ion collisions will be presented. The fragmentation function as well as the jet spectra in heavy ion collisions will be presented and discussed with respect to p+p reference measurements.

11:30AM 1WH.00006 Direct Photon-Hadron Correlations in RHIC Collisions, JUSTIN FRANTZ, Ohio University — Direct photon-hadron correlations from photon-jet pairs are an important tool to study jet energy loss and jet modification in Heavy Ion collisions since the direct photon escapes the medium without strong interaction and can act as a control or energy calibrator to the opposing jet in the same event. Due to the large background of meson decay photons from di-jets, measurements are experimentally difficult, and further complications in interpretations arise from Bremstrahlung-like fragmentaiton photons also associated with di-jets. First measurements of direct photon-jet correlations have been performed by both PHENIX and STAR. Implications of these results and the status of future improvements will be discussed.

12:00PM 1WH.00007 Heavy Quarkonia Production in High Energy Heavy Ion Collisions at RHIC and Perspectives for the LHC, TAKU GUNJI, Center for Nuclear Study, University of Tokyo — High energy heavy ion collisions have been performed at RHIC to search for the new state of QCD matter and to study its properties. Quarkonia (J/ψ, ψ′, χc, Υ) have long been considered as one of the most promising probes for the deconfinement of the hot and dense QCD matter, since the attraction between heavy quark and anti-quark pairs is predicted to be reduced in the medium due to color screening. Quarkonia production is expected to be enhanced in p+p, d+Au, Cu+Cu and Au+Au collisions at RHIC to understand the production process, the cold nuclear matter effects that modify the quarkonia production in nuclear environment as well as, and the hot and dense medium effects such as color screening, thermal gluon dissociation, and regeneration of quarkonia from uncorrelated heavy q̅q pairs. Recent experimental and theoretical progress to understand the observed J/ψ suppression at RHIC will be presented, issues for the future quarkonia measurement at RHIC and perspectives for the upcoming LHC will be presented in this talk.

Tuesday, October 13, 2009 2:00PM - 5:30PM –
Session 2WA Workshop on Nuclear Physics with New-Generation Fast Rare Isotope Beams
Kohala 1

2:00PM 2WA.00001 Radium-225: The Path to a Next Generation EDM Measurement, PETER MUELLER, Argonne National Laboratory — Permanent electric dipole moments (EDMs) in atoms or molecules are signatures of time (T)- and parity (P)-violation. Experimental searches for these EDMs represent an excellent window to physics beyond the standard model. In the nuclear sector, the best limits for EDMs are currently set by measurements on the neutron and the diamagnetic atom 199Hg. A promising avenue for extending these searches is to take advantage of the large enhancement in the atomic EDM predicted for heavy octupole-deformed nuclei, as can be found in the radium and radon isotopic chains. One of these favorable case is 225Ra, which is calculated to be two to three orders of magnitude more sensitive to T-violating interactions than 199Hg. We are developing a next generation EDM search around laser-cooled and trapped 225Ra, which involves measuring the nuclear spin precession of polarized 225Ra atoms confined in an optical dipole trap. I will report on our recent experimental progress and on the impact of next generation isotope facilities on this line of research.

1This work is supported by DOE, Office of Nuclear Physics, under contract No. DE-AC02-06CH11357.
2:30PM 2WA.00002 Study of Exotic Nuclear Structures via Total Reaction Cross Sections¹

MAYA TAKECHI, RIKEN — Nuclear radius is one of the most basic physical quantities to study unknown exotic nuclei. A number of radii for unstable nuclei were studied through measurements of interaction cross sections (σI) at high energies, using the Glauber-type calculation (Optical-Limit approximation (OLA) of Glauber theory) to investigate halo and skin structures of exotic nuclei. On the other hand, it was indicated that reaction cross sections (σR) at intermediate energies (from several tens to hundreds of MeV/nucleon) were more sensitive to dilute nucleon density distribution owing to large nucleon-nucleon total cross sections (σNN) compared to high-energy region. Recently, we developed a new method to deduce nucleon density distributions from the energy dependences of σI, through the precise calculations for various nuclei and some modifications of Glauber-type calculation. Using this method, we studied nucleon density distributions of light nuclei by measuring σR, for those nuclei at HIMAC (Heavy ion Medical Accelerator in CHIBA), NIRS (National Institute of Radiological Sciences). And very recently, we deduced nuclear radii of neutron-rich Ne isotopes \(^{28-32}\text{Ne}\) which are in the island-of-inversion region by measuring σI using BigRIPS at RIBF (RI Beam Factory) to study nuclear structures of those isotopes using our method. In this workshop, results of nucleon density distributions obtained at HIMAC and results of the studies of Ne isotopes at RIBF will be introduced and discussed.

¹Research Projects with Heavy ions at NIRS-HIMAC, and RIKEN Nishina Center

3:00PM 2WA.00003 Extracting spectroscopic factors from direct reactions

KATE JONES, University of Tennessee — Direct reactions have been used to probe the structure of the nucleus for decades. After some decline in the 80’s and 90’s these methods have more recently had a surge in popularity, and new techniques have been added to the experimentalists’ toolbox. One goal of direct reaction experiments is to extract spectroscopic factors (SFs), related to the shell occupancy. SFs extracted from neutron knockout reactions show reductions, compared to the theoretical value, that are related to the neutron separation energy [1], whereas SFs from the well-established \((e,e'p)\) reaction on stable nuclei are consistently 50% - 60% lower than those expected from the independent-particle shell model [2] over a wide range of masses. \(\gamma\)ardAs the extraction of spectroscopic factors from direct reaction measurements requires the preparation of data with calculated differential cross sections, the results are by nature model dependent. The influence of different scattering (commonly optical), and bound state potentials, should not be over-looked. Recent attempts to reanalyze single-neutron transfer data using a consistent approach have shown agreement with large shell model calculations [3], clearly conflicting with both \((e,e'p)\) and the knockout data. It has been suggested that the Asymptotic Normalization Coefficient (ANC) is a more valid quantity to extract when the reaction is peripheral [4]. Spectroscopic factors are, how they are extracted and what they really mean will be discussed in this talk.


3:30PM 2WA.00004 COFFEE BREAK —

4:00PM 2WA.00005 Alpha inelastic scattering and cluster structures in light stable and unstable nuclei

TAKAHIRO KAWABATA, Department of Physics, Kyoto University — Alpha particle clustering where four nucleons strongly correlate to constitute an alpha cluster is an important concept in nuclear physics. The alpha cluster behaves as a subunit of the atomic nucleus and exhibits characteristic phenomena which cannot be described by single-particle models like the shell model. Since the theoretical description of the clustering phenomena under the shell-model framework requires a huge number of single-particle bases, it is generally difficult to treat the clustering phenomena in the truncated shell-model space. It is widely known that the ground-state wave function by the SU (3) shell model is mathematically equivalent to that by the alpha cluster model. This means the alpha particles inherently exist even in the compact ground-state wave function although its alpha cluster structure is not fully developed. Thus, the spatially developed alpha-cluster states are expected to be excited by stimulating the relative motion between the alpha particles in the ground state. We recently proposed that the inelastic alpha scattering is a very useful probe to examine the alpha cluster structure. Since the alpha inelastic scattering selectively excites isoscalar natural-parity transitions, it is very suitable to excite the inter-cluster relative motion. We measured the cross sections for the alpha inelastic scattering from \(^{11}\text{B}, \; ^{12}\text{C}, \; ^{13}\text{C}, \; ^{14}\text{Mg}\). The experiment was carried out by using a 400-MeV alpha beam at Research Center for Nuclear Physics, Osaka University. The experimental results were compared with the shell-model and cluster-model calculations, and the alpha-cluster structures in those nuclei were discussed. The present approach by means of the alpha inelastic scattering is very useful to examine the alpha-cluster structures in stable nuclei, and it should be naturally applied to unstable nuclei. In the present talk, the experimental details and results on the stable nuclei will be reported. Future prospects on the extended studies in unstable nuclei will be also discussed.

4:30PM 2WA.00006 Pursuing the most neutron-rich nuclei, status and prospective

DAVID MORRISSEY, Michigan State University — The production of the most neutron-rich nuclei by the fragmentation of \(^{40}\text{Ca}\) and \(^{72}\text{Ge}\) beams at Michigan State will be presented. The cross sections were measured for a large range of nuclei including fifteen new isotopes that are the most neutron-rich nuclides of magnesium, aluminum, silicon, and the elements from chlorine to manganese. The observation of \(^{42}\text{Al}\) was itself surprising. The cross sections of several new nuclides were found to be enhanced relative to a simple thermal evaporation framework, previously shown to describe similar production cross sections. This may be an indication that precursor excited nuclei in the region around \(^{68}\text{Ni}\) to \(^{76}\text{Ge}\) that decay to the observed nuclei are more stable than predicted by current mass models and may be evidence for a new island of inversion similar to that centered on \(^{34}\text{Na}\). The next generation radioactive beam facility, FRIB, for the United States will be constructed at Michigan State University. A brief overview of the proposed facility and the prospective for future studies of the most neutron-rich nuclei will be presented.

5:00PM 2WA.00007 In-beam \(\gamma\)-ray spectroscopy at the RIBF: recent results and future prospects

HEIKO SCHEIT, RIKEN Nishina Center — With the commissioning of the BigRIPS projectile fragment separator and the ZeroDegree spectrometer at the Radioactive Ion Beam Factory (RIBF) at the RIKEN Nishina Center a new window to study nuclei far from stability has been opened. Various experimental methods can now be applied to exploit the intense and high-energy primary and secondary beams at the RIBF. In a first set of experiments in-beam \(\gamma\)-ray spectroscopy has proved to be a very promising tool to study exotic nuclei far from stability. The so-called DayOne experimental campaign was carried out at the RIBF in November and December 2008, which comprises a set of experiments using the same primary beam \(^{40}\text{Ca}\) at 345 MeV/u and similar, or at least non-interfering, experimental setups. During this campaign the first spectroscopic study of the N=22 nucleus \(^{32}\text{Ne}\) was carried out. A single \(\gamma\)-ray transition with an energy of 722\(\pm\)9 keV was observed in both inelastic scattering of a 226 MeV/u \(^{32}\text{Ne}\) beam on a Carbon target and proton removal from \(^{26}\text{Na}\) at 245 MeV/u, which is assigned to the de-excitation of the first \(J^\pi = 2^+\) state in \(^{32}\text{Ne}\) to the \(0^+\) ground state. The low excitation energy and a comparison to state of the art shell model calculations demonstrate that the Island of Inversion extends to at least N=22 for the Ne isotopes. I will give a short overview of the existing facilities and then focus on the first experimental campaign carried out with BigRIPS and ZeroDegree. The experimental setup used for in-beam \(\gamma\)-ray spectroscopy will be introduced followed by a presentation of first results. An outlook will be given.
The development of RI beams has opened a wide region to study the nuclear structure far from the stability line. During the extensive studies of neutron-rich nuclei in the light mass region, new phenomena such as the disappearance of $N=8, 20$ magic numbers associated with the deformed ground states were revealed. Gamma-ray spectroscopy was employed for the study of the deformed structure. Based on the relatively low excitation energy of $2^+$ state and the large B(E2) value, large deformation of the ground state was identified. Observation of the excited states was thus far limited to the low-lying states, but the study of higher-spin states will be useful to understand the collectivity since a presence of a rotational band is one of the clear evidences of the deformed structure. In order to realize a high-resolution gamma-ray spectroscopy of exotic nuclei, we have developed a segmented Ge detector array, GRETINA, and plan to investigate unstable nuclei in the heavy mass region. To study collective structures of unstable nuclei, we plan to perform lifetime measurements of $2^+$ and higher excited states utilizing direct reactions with high-intensity fast RI beams. At present, RI beam factory (RIBF) at RIKEN has a potential to provide world’s highest intensity. In addition, experiments using low-energy reactions are planned to study high-spin states. Previously, we have successfully developed an energy-degraded $^{46}$Ar beam produced by the fragmentations of $^{64}$Am/$^4$He primary beam. It was used for a fusion-evaporation reaction with a $^5$Be target. Gamma rays emitted from high-spin states were clearly observed. Same technique to make low-energy RI beam could be applied to heavier RI beams at RIBF and the study of high-spin states will be widely expanded. In the talk, lifetime measurements and studies of high-spin states of unstable nuclei far from the stability using high-efficiency position-sensitive Ge detector array at RIBF will be discussed.

2:30PM 2WB.00002 Nuclear transition moment measurements of neutron rich nuclei. KRZYSZTOF STAROSTA, Simon Fraser University — The Recoil Distance Method (RDM) and related Doppler Shift Attenuation Method (DSAM) are well-established tools for lifetime measurements following nuclear reactions near the Coulomb barrier. Recently, the RDM was implemented at National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University using NSCL/Köln plunger device and a unique combination of the state-of-the-art instruments available there. Doppler-shift lifetime measurements following Coulomb excitation, knock-out, and fragmentation at intermediate energies of ~100 MeV/u hold the promise of providing lifetime information for excited states in a wide range of unstable nuclei. So far, the method was used to measure lifetimes of nuclei near $^{16,18,20}$C, $^{62,64,66}$Fe, $^{70,72}$Ni, $^{110,114}$Pd isotopes and also of the neutron-deficient $N=Z$ $^{48}$Ge. A significant fraction of these experiments was performed using NSCL’s Segmented Germanium Array instrumented with the Digital Data Acquisition System which enables gamma-ray tracking. The impact of GRETINA and gamma-ray tracking on RDM and DSAM studies of neutron-rich nuclei will be discussed.

3:00PM 2WB.00003 Nuclear moment measurements on neutron-rich nuclei. ANDREW STUCHBERY, The Australian National University — Two techniques have recently been proved workable to measure the magnetic moments (or g factors) of short-lived excited nuclear states in exotic nuclei produced as radioactive beams. These are the high-velocity transient-field technique (HVTF) [1,2], which has been demonstrated to be applicable to relatively low-Z isotopes produced by fast fragmentation, and the recoil-in-vacuum (RIV) technique, which has been applied to heavier nuclei near $^{135}$Sn [3,4]. This talk will report, firstly, on the analysis of recent moment measurements in neutron-rich nuclei, and, secondly, on the further development of the techniques for applications to new regions of the nuclear chart, with an emphasis on the opportunities opened up by the gamma-ray tracking array GRETINA. Progress on recently performed HVTF measurements, including the neutron-rich isotopes $^{42-46}$Ar at NSCL, will be discussed, along with experimental work to extend the technique towards higher-Z and the N=40 region. The feasibility of a HVTF g-factor measurement on the first-excited state in $^{30}$Mg, taking advantage of GRETINA, will also be evaluated. For slower beams with 2 – 5 MeV/nucleon, the RIV technique has advantages: these g-factor experiments are essentially identical to a B(E2) measurement, but with sufficient statistics to measure the particle-gamma angular correlations. Detailed studies of the free ion hyperfine fields, which must be characterized and understood for these moment measurements, have commenced using stable beams at the Australian National University. The results will be described with the view to future applications to moment measurements in the $N=34, N=40$ and A~100 regions, using re-accelerated radioactive beams and GRETINA.

4:00PM 2WB.00004 COFFEE BREAK

4:00PM 2WB.00005 Search of neutron-rich superdeformer, superheavy K-isomer, superfast rotor, and chiral wobblor with RIBF and GRETINA. MAKITO OI, Institute of Natural Sciences, Senshu University — Nuclear physics has entered a new phase of research with radioactive beams in the 21st century. The scope of the study is originally aimed at the dripline regions, but the study of neutron-rich and proton-rich systems, weakly-bound systems such as halo nuclei are currently the primary targets for the investigation. High-spin nuclear structure physics was developed thanks to the heavy ion collision and subsequent neutron-evaporation reactions. In the 1980s and 1990s, many new forms of exotic excited states were discovered such as superdeformation and magnetic rotation. However, it is still far from completion in understanding the structure of these high-spin states. For example, the decaying mechanism from super to normal deformed states is still unclear. Many of bandheads of superdeformed bands are unidentified. With a combination of GRETINA and RIBF, we can enjoy a new opportunity to go for the study of new physics: high-spin states with radioactive beams. In my talk, I would like to discuss what kind of new high-spin physics can be investigated with this new facilities, for example, neutron-rich superdeformation, superheavy K-isomers, ultra-fast high-spin states over 100h, and more exotics 3D rotating states such as wobbling and chiral rotation.

4:30PM 2WB.00006 Spectroscopy of the Heaviest Elements. RODERICK CLARK, Lawrence Berkeley National Laboratory — The specific "magic" proton and neutron numbers, representing major spherical shell gaps, beyond 208Pb are a matter of considerable debate. It is well established that nuclei near $Z=100, N=152$ (252Fm) have well-deformed prolate shapes. By performing prompt and delayed gamma-ray spectroscopy on $^{16,18,20}$C, $^{62,64,66}$Fe, $^{70,72}$Ni, $^{110,114}$Pd isotopes and also of the neutron-deficient $N=Z$ $^{48}$Ge. A significant fraction of these experiments was performed using NSCL’s Segmented Germanium Array instrumented with the Digital Data Acquisition System which enables gamma-ray tracking. The impact of GRETINA and gamma-ray tracking on RDM and DSAM studies of neutron-rich nuclei will be discussed.

1Supported in part by the Australian Research Council grant no. DP0773273.

3This work was supported in part by the U.S. DOE under contract no. DE-CA02-05CH11231 (LBNL).
5:00PM 2WB.00007 Isomer spectroscopy using RI beam, ATSUO ODAHARA, Dep. of Phys., Osaka Univ. — We have studied systematically high-spin oblate shape isomers in the \( \mathrm{N}=83 \) isotones, which have revealed the characteristics of nuclear structure, such as the preserving pairing interactions at high-spin states, decrease of \( Z=64 \) proton shell gap energy as the decrease of proton number from 64 to 60 and so on. Recently, it became possible to search for isomers by the secondary fusion reaction at high-spin states in nuclei, which could not be populated by the stable beam and stable target, using RCNP RI beam line at Osaka University. RI beams enable us to study high-spin states in nuclei in wide mass region. By using the RI beams delivered by RIBF and the high-efficiency \( \gamma \)-ray detection system GRETINA, it will be possible to investigate nuclei far from the stability line. Single-particle energies and nucleon-nucleon-interactions of these nuclei close to drip line are expected to be the test ground of nuclear models, such as shell structures. We have a plan to search for isomers with half lives of \( \sim \)sec to \( \sim \)msec and to explore the decay mechanism of isomers in the proton-rich nuclei along \( N=Z \) line with \( 80<\Delta<100 \). Moreover we try to search for nuclei beyond the proton drip line, which could be defined that isomeric states would be bound by the centrifugal potential although the ground states would be unbound against the proton emission. Isomers are expected to reveal the following characteristics of these nuclei. (1) Existence of isomers could prove the magicity of \( N=Z=50 \) and the large neutron-proton interaction, as one of the candidates of isomers is spin-gap isomer which is caused by the lowering of excitation energies resulting from the stretch coupling of spins of \( j\parallel \) of the \( ^{100}\mathrm{Sn} \) core. (2) Isomers could prove the nuclear deformation which is caused by the evolution of shell structure. One of spin-gap isomers in \( ^{94}\mathrm{Ag} \) was reported to have large prolate deformation. (3) This mass region is on the way of the rapid proton (rp) synthesis pass. Recently, neutrino reactions in the super novae were reported to play a role of the synthesis of the rp-process nuclei. In the case of no path or slow down of rp process, isomers could contribute to synthesis of rp-nuclei with larger \( Z \), although the production rates of isomers are small.

2:00PM 2WC.00001 On the Past, Present, & Future of 60Fe (and 26Al), FRANK TIMMES, Arizona State University — The radioactive isotopes \(^{60}\text{Fe}\) and \(^{26}\text{Al}\) have been detected in the galactic plane of the Milky Way through their diffuse by \( \gamma \)-ray emission, on the Earth in deep sea manganese crusts, on the Moon in returned lunar samples, and in meteoritic inclusions. I will discuss the colorful history, exciting present, and future of our attempts to calibrate the nuclear astrophysics of these two radionuclides.

2:30PM 2WC.00002 Review of (n, gamma) reactions in astrophysics and scope at J-PARC, YASUKI NAGAI, Japan Atomic Energy Agency — A neutron capture reaction cross section of a nucleus at stellar temperature is one of important key parameters in the construction of stellar models. A measurement of the mentioned cross section has been carried out worldwide using various neutron sources and various detectors to detect \( \gamma \)-rays promptly emitted from a neutron capture reaction of a nucleus at stellar energy. I will review recent works of the neutron capture reactions of stable and/or unstable nuclei from nuclear astrophysics interest, including our recent work of the neutron capture reaction cross section measurement of \(^{208}\text{Pb}\). I also discuss a new facility for a neutron capture reaction study at J-PARC. A new beam line (BL04) was constructed in the in the Materials and Life Science Facility (MLF). Two sample positions are located at 20 and 25 m away from the spallation neutron source, where anti-Compton Ge and NaI(Tl) spectrometers are placed, respectively. An experiment to measure the cross section of minor actinide isotopes has started since last November at a proton beam power of 20 kW.

3:00PM 2WC.00003 Explosive and Neutrino Nucleosynthesis in Supernovae, TAKASHI YOSHIDA, University of Tokyo — Supernova (SN) neutrinos play important roles for neutrino nucleosynthesis (the \( \nu \)-process). Light elements such as \(^{\text{Li}}\) and \(^{\text{B}}\) are mainly produced through the \( \nu \)-process. A part of Mn is also produced through this process in Si burning-region. The produced yields strongly depend on the luminosity and energy spectra of SN neutrinos. Neutrino oscillation also affects the yields of these elements. In this presentation, the \( \nu \)-process in SNe calculated using neutrino-nucleon reaction cross sections with new shell model Hamiltonians is shown. The influence of neutrino oscillation on the yields of the light elements and the dependence on mass hierarchy and the mixing angle \( \theta_{13} \) will be presented. Recently, the effects of neutrino self-interaction on neutrino flavor change in SNe have been discussed. Owing to the flavor change occurring in deep region of SN ejecta, the flavor change may affect \( r \)-process nucleosynthesis. The neutrino flavor change by neutrino self-interaction in SNe is explained and the influence to \( r \)-process nucleosynthesis will be discussed.

3:30PM 2WC.00004 COFFEE BREAK —

4:00PM 2WC.00005 Nuclear reactions in the deep ocean and crust of neutron stars: Implications of superbursts and cooling transients, EDWARD BROWN, Michigan State University — Accreting neutron stars provide a fascinating natural laboratory for processes in dense matter. Over the lifetime of a neutron star accreting from a solar-mass companion, the crust, where the mass density is less than that of saturated nuclear matter, is gradually replaced with material synthesized from the accreted hydrogen and helium. The resulting compositional and thermal structure of the crust is essential input for the neutron star’s magnetic field evolution, the detectability of the neutron star via gravitational wave emission from a “mountain,” and the strength of neutron emissivity from the core. In this talk, I will present our current understanding of the nuclear reactions in the deep ocean and crust of accreting neutron stars; that is, at depths where the hydrogen and helium have already fused to heavier elements. In addition to highlighting recent theoretical and experimental work on these reactions, I will emphasize what observations of superbursters—rare explosions some 1000 times more energetic than regular X-ray bursts—and of cooling from neutron star transients can tell us about the thermal structure of the neutron star crust. There is one source, KS 1731—260, that not only exhibited a superburst, but also cooled following the apparent cessation of active accretion. There is an interesting tension between the rapid cooling, which implies a high crust thermal conductivity and hence a cool crust, and the inferred (shallow) superburst ignition depth, which requires a hot crust. I will discuss solutions to this puzzle, including a strong resonance in the \( r \)-process.

3:00PM 2WC.00004 Session 2WC Workshop on Frontiers in Nuclear Astrophysics II Kohala 4

Tuesday, October 13, 2009 2:00PM - 5:30PM —

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1Supported by JINA

4:30PM 2WC.00006 Standard Solar Model Data Needs, GIANLUCA IMBRIANI, Naples University, Federico II, Italy — The progresses in the solar neutrino experiments and the more precise determination of neutrino mass parameters by means of reactor neutrino experiment allows for the opportunity to exploiting neutrinos to study the solar interior. Therefore, it will be possible to check the solar model and to better understand the evolution of low mass stars. To reach this ambitious result it is of fundamental importance to reduce the uncertainties in solar model physics inputs. In the centre of the sun hydrogen burning is taking place, the transformation of four protons in a helium nucleus is the basic mechanism by which the Sun replaces the energy lost from the surface (which amounts to \( 3.82 \times 10^{16} \text{ erg s}^{-1} \)). During this transformation two positrons and two neutrinos are emitted for each yielded helium nucleus. The sun is burning hydrogen mostly by means of p-p chain, the accurate knowledge of the rate of p-p chain and CNO cycle reactions at the relevant solar energy is a fundamental ingredient in the analysis of the solar neutrino experiments. In the talk I will report on the present experimental knowledge of the p-p chain and CNO cycle cross sections and how these uncertainties influence of the uncertainty the solar neutrino flux determinations.
5:00PM 2WC.00007 Neutron Sources in Stellar Carbon Burning, JOACHIM GOERRES, University of Notre Dame — The possibility of a high temperature s-process during the carbon burning phase in late stellar evolution depends critically on possible neutron sources. In this context the following alpha capture reactions are being discussed, $^{170}$O($\alpha$,n), $^{18}$O($\alpha$,n), $^{22}$Ne($\alpha$,n), $^{25}$Mg($\alpha$,n), and $^{26}$Mg($\alpha$,n). Their effective contribution to the neutron production depends on the abundance of the various seed nuclei, which in turn depend critically on the alpha or proton production in the $^{12}$C+$^{12}$C fusion process; it also depends on the reaction cross sections or rates of these processes at carbon burning temperatures. We have studied the reaction cross sections at low energies at the Notre Dame KN accelerator using a new $^4$He neutron detector array. The results will be shown and discussed in the context of late stellar evolution. In collaboration with Andreas Best, University of Notre Dame; Sascha Falahat, University of Mainz, Germany; Marco Pignatar, Keele University, UK; and Michael Wiescher, University of Notre Dame.

Tuesday, October 13, 2009 2:00PM - 5:30PM –

Session 2WD Workshop on Neutrinoless Double Beta Decay II – Kohala 2

2:00PM 2WD.00001 Neutrino Mass Spectrum, Majorana CP-Violation, $\beta\beta$-Decay and Beyond, SERGUEY PETCOV, SISSA/INFN, Trieste, Italy — The problem of determination of the nature - Dirac or Majorana, of massive neutrinos is discussed. The physics potential of experiments, searching for $\beta\beta$-decay, for providing information on the type of $\nu$-mass spectrum, absolute scale of $\nu$- masses and on the Majorana phases in the PMNS neutrino mixing matrix $U$, is reviewed. The possibility that the CP-violation necessary for the generation of the baryon asymmetry of the Universe is due exclusively to the Majorana CP-violating phase(s) in the PMNS neutrino mixing matrix $U$, is also briefly discussed.

2:30PM 2WD.00002 MAJORANA: An Ultra-Low Background Enriched-Germanium Detector Array for Fundamental Physics Measurements, JASON DETWILER, Lawrence Berkeley National Laboratory — The MAJORANA collaboration aims to perform a search for neutrinoless double-beta decay (0$\nu$beta) by fielding arrays of HPGe detectors mounted in ultra-clean electroformed-copper cryostats located deep underground. Recent advances in HPGe detector technology, in particular P-type Point-Contact (PPC) detectors, show great promise for identifying and reducing backgrounds to the 0$\nu$beta signal, which should result in improved sensitivity over previous generation experiments. The ultra-low energy threshold possible in PPC detectors also enables a broader physics program including sensitive searches for dark matter and axions. The MAJORANA Demonstrator R&D program will field three ~20 kg modules of PPC detectors at Sanford Underground Laboratory. Half of the detector mass will be enriched to 86% in $^{76}$Ge. I will present the motivation, design, recent progress and current status of this R&D effort, and discuss its physics reach.

3:00PM 2WD.00003 NEMO 3 double beta decay experiment and SuperNEMO project, HIKEKI OHSUMI — NEMO 3 is a double beta decay experiment operating in the Laboratoire de Souterraine de Modane (LSM). We will present the latest results of the neutrinoless double beta decays of 7kg of $^{100}$Mo and 1kg of $^{82}$Se, as well as two neutrino double beta decays of various isotopes in the NEMO 3 experiment with the highest precision measurements. The SuperNEMO project is being designed to the next step of the NEMO 3 double beta decay experiment. We will present the current status of the project.

3:30PM 2WD.00004 COFFEE BREAK —

4:00PM 2WD.00005 Status of the DCBA Experiment, NOBUHIRO ISHIHARA, KEK — Momentum analyzers called DCBA (Drift Chamber Beta-ray Analyzer) are being developed at KEK in order to study neutrinoless double-beta decay. DCBA consists of drift chambers interleaving thin decay-source plates and a solenoid magnet serving a uniform magnetic field. The momentum of individual beta-ray is measured from the helical track reconstructed in three dimension. Then its kinetic energy is calculable. As for backgrounds, pair creation events are easily rejected by electric charges in the magnetic field. Alpha particles have so large momenta that they don't make helical tracks. Since the vertex point of a double beta-decay event is clearly identified, a single electron track is easily eliminated, and double Compton scatterings are also identified. A prototype called DCBA-T2 had been operated, and the energy resolution of about 150 keV (FWHM) was obtained for 976 keV electrons, which were the internal conversion electrons from Bi-207. The DCBA-T2 has been in engineering run using natural Mo plates of 45 mg/cm$^2$ thickness to check comprehensive capabilities. New prototype DCBA-T3 is now under construction.

4:30PM 2WD.00006 The neutrinoless double beta decay experiment COBRA: Status and future plans, JERRAD MARTIN, Washington University in Saint Louis and the McDonnell Center for the Space Sciences — The COBRA experiment uses Cadmium Zinc Telluride (CZT) room-temperature solid-state detectors to search for neutrinoless double beta decays of the isotope $^{116}$Cd as well as for rare decays from several other Cd and Te isotopes. A prototype experiment is currently taking data in the Gran Sasso underground laboratory. In this contribution, recent results from the prototype will be presented. Furthermore, the on-going detector R&D will be described and two detector options for a large-scale experiment made of 420 kg of CZT detectors will be discussed. The first option uses “calorimetric coplanar grid detector units”. Alternatively, finely pixelated detectors may be used with pixel pitches of between 200 and 350 microns. The pixelated detectors would afford the possibility of tracking beta particles inside the detector and distinguishing them from background events.

1NEMO Collaboration

2Presented on behalf of the COBRA collaboration.
5:00PM 2WD.00007 Status and Progress of GERDA. KARL TASSO KNOEPELE1, MPI Kernphysik Heidelberg — The study of neutrinoless double beta decay (DBD) is the most powerful approach to the fundamental question if the neutrino is a Majorana particle, i.e. its own anti-particle. The observation of neutrinoless DBD would not only establish the Majorana nature of the neutrino but also represent a determination of its effective mass if the nuclear matrix element is given. So far, the most sensitive results have been obtained with Ge-76, and the group of Klapdor-Kleingrothaus has made a claim of discovery. Future experiments have to reduce radioactive backgrounds to increase the sensitivity. The GERmanium Detector Array “GERDA” [1] is a new double beta-decay experiment which is currently under construction in the INFN Gran Sasso National Laboratory, Italy. It is implementing a new shielding concept by operating bare Ge diodes—enriched in Ge-76—in high purity liquid argon supplemented by a water shield. The aim of “GERDA” is to verify or refute the recent claim of discovery, and, in a second phase, to achieve a two orders of magnitude lower background index than recent experiments. The paper will discuss design, physics reach, and status of construction of “GERDA,” and present results from various R&D efforts including long term stability of bare Ge diodes in cryogenic liquids, material screening, cryostat performance, design and production of enriched Ge diodes, cryogenic precision electronics, safety aspects, and Monte Carlo simulations.


3 On behalf of the GERDA collaboration

Tuesday, October 13, 2009 2:00PM - 5:30PM —
Session 2WE Workshop on Physics with Neutrons II Kona 5

2:00PM 2WE.00001 EDMs and beyond the standard model in particle physics. JUNJI HISANO, ICRR, University of Tokyo — New physics beyond the standard model of particle physics is expected to appear at TeV scale from a viewpoint of naturalness of the Higgs mass, and various experiments are searching for it in direct and indirect way. Electric dipole moments (EDMs) of electron, neutron and atoms are quite sensitive to CP violation in physics beyond the standard model of particle physics. In this talk I will review EDMs in the beyond the SM models, and discuss about related topics.

2:30PM 2WE.00002 Development of the neutron electric dipole moment experiment at the SNS. MARTIN D. COOPER, Los Alamos National Laboratory, for the nEDM Collaboration — The nEDM Collaboration is preparing an experiment to run at the Spallation Neutron Source (SNS) to search for the neutron electric dipole moment (EDM) experiment with a sensitivity of \(-1 \times 10^{-25} \text{ e} \cdot \text{cm}\) based on the scheme of Golub and Lamoreaux. The collaboration has been pursuing a R&D program to establish the technical feasibility of the design. Many results have been obtained from independent experiments that demonstrate the EDM experiment should work. The data from a number of these preparatory measurements will be presented and discussed in terms of their importance to the final design. The engineering of the project is now ready to produce shop drawings, so a comprehensive picture of the apparatus can be presented.

3:00PM 2WE.00003 UCN n-EDM experimental developments at RCNP. KENSAKU MATSUTA, Dpt. of Physics, Osaka Univ. and KEK-RCNP-Osaka-ICEPP UCN collaboration group — Our KEK-RCNP-Osaka-ICEPP collaboration group led by Y. Masuda of IPNS, KEK and K. Hatanaka of RCNP, Osaka Univ. is developing a new type high intensity UCN (ultracold neutron) source at RCNP, Osaka Univ., for the future experiments on fundamental physics including n-EDM (neutron electric dipole moment) precision measurements, which may disclose origin of the baryon asymmetry in the present universe by providing active evidence of the violation of the time reversal invariance. Our UCN source produces 15 UCN/cm³ at the exit, by the compact combination of the spallation neutron source and the super-fluid He-II moderator, which provides with the best power efficiency. In the present stage, we are trying to establish Ramsey resonance technique for the n-EDM measurements, by studying behavior of UCN and the polarization, using abundant UCNs produced in this source, in addition to the improvement of the source performance. The energy spectrum of UCN, i.e. the velocity distribution, is an important information in the estimation of the false EDM effect such as Bloch-Siegert shift and is found to be well reproduced by the uniform production in phase space. We tried to polarize UCN by the magnetic potential in pure ion foil. The production of polarization itself is found rather easy, namely, the polarization could reach as high as 100% in the beginning. Average polarization, however, is dominated by the relaxation of polarization during transportation and storage. For the n-EDM measurements in the next generation, our effort should be devoted to the understanding of the geometric phase such as Bloch-Siegert shift which dominates systematic error in the EDM measurements. Our next step will be demonstration of Ramsey resonance and the installation of the co-magnetometer and electric field, to detect geometric phase.

3:30PM 2WE.00004 COFFEE BREAK —

4:00PM 2WE.00005 High Precision Measurements of Neutron Beta-Decay at LANSCE. MARK MAKELA1, Los Alamos National Lab — High precision measurements of neutron beta-decay can be used to study the standard model of particle physics by testing the unitarity condition of the CKM matrix. Precise measurements of the neutrons’ lifetime and one of its angular correlations are needed to determine the necessary standard model parameters for a unitarity test from neutron decay alone. Several experiments are underway at the Los Alamos Neutron Science Center (LANSCE) to measure these parameters using Ultra-Cold Neutrons (UCN). During the last 10 year a program to study neutron physics with UCN has been under development at LANSCE by an international team of scientists. The first experiment of this program, UCNA, which measures the decay correlation between the polarized neutron and the resulting beta particle, is currently running. A neutron lifetime experiment that monitors the decay rate of UCN trapped in a magnetic bottle with a gravitational top is being built and scheduled to run later this year. A second decay correlation experiment, (UCNB), which will measure the decay correlation between the polarized neutron and the resulting anti-neutrino is currently in the research and development phase. This talk will give an overview of these experiments, as well as other highlights from the UCN program at LANSCE.

3 For the UCNA, UCNB and UCN Lifetime collaborations

4:30PM 2WE.00006 Neutron Science at J-PARC. HIROHIKO SHIMIZU, KEK — A pulsed cold neutron beamline for the study of neutron optics and fundamental physics (NOP beamline) is under development at the beam port BL05 of the spallation neutron source in the Materials and Life Science Facility (MLF) of the Japan Proton Accelerator Research Complex (J-PARC). The J-PARC spallation neutron source is a short pulse machine with the repetition rate of 25 Hz, which is expected to deliver pulsed cold neutrons with the highest instantaneous intensity when the machine power reaches the designed value. Physics measurements in the neutron decay, neutron scattering and neutron interferometry are scheduled at the NOP beamline by taking the advantage of the timing structure of the intense pulsed neutrons. Currently, optical components and detectors for precision measurements are under development. The physics program is being started with the in-flight neutron lifetime measurement. In this paper, we report the present status of the NOP beamline construction and planned measurement. Further extensions to utilize wider wavelength regions to very cold and ultracold regions are also discussed.
5:00PM 2WE.00007 Neutron beta decay measurements planned for the SNS. DINKO POCANIC, University of Virginia — A cold neutron beam line, dedicated to fundamental neutron physics (FnPB), is presently being completed at the Oak Ridge, TN, Spallation Neutron Source. Among other experiments, the beamline will host a comprehensive set of precise studies of the neutron beta decay. Neutron beta decay is characterised by the decay rate (or its inverse, the neutron lifetime), and a set of decay parameters describing the kinematical and spin correlations among the participating particles. Within the standard model (SM), the neutron lifetime and three decay parameters (a, A, and B) are fixed by two parameters: the V_{ud} element of the Cabibbo-Kobayashi-Maskawa mixing matrix, and λ = G_A/G_V, the ratio of axial vector and vector nucleon form factors. This overdetermined system provides a unique opportunity to explore possible departures from the simple SM, as well as the nature of such departures, e.g., left-right supersymmetric extensions, leptoquarks, non-(V−A) admixtures, etc., with broad implications in subatomic physics. The FnPB neutron beta decay program will include measurements of the neutron lifetime, continuing the present NIST experiment, a measurement of a, the electron-neutrino correlation, and B, the Fierz interference term, (the “Nab” experiment), along with measurements of A and B, the correlations between neutron spin and electron and neutrino momenta, respectively, (the “abBA” experiment). Current plans for these experiments will be discussed in detail.

1Work supported by a grant from the National Science Foundation

Tuesday, October 13, 2009 2:00PM - 5:30PM –
Session 2WF Workshop on the Structure of Hadrons and Hypernuclei Studied by Photonuclear and Hadronic Reactions at Jlab, LEPS, and J-PARC II Kohala 3

2:00PM 2WF.00001 Nucleon Transition Form Factors with CLAS12. RALF W. GOTHE, University of South Carolina — The measurements of exclusive single-meson and double-pion electroproduction cross sections off the proton to study nucleon resonances will be extended to higher momentum transfers with the CLAS12 detector and the energy upgraded CEBAF beam at JLab. Based on new theoretical developments to extract and interpret the electromagnetic transition form factors and on the experience gained from the most recent results, the newly formed collaboration of experimentalists and theorists shall enable us to provide unprecedented high-precision data, high-quality analyses, and state of the art model and QCD based calculations in a Q^2 domain up to 10 GeV^2. For the first time nucleon resonance structures will be studied at still unexplored distance scales, where the dressed quark contributions are the dominating degrees of freedom, and where their strong interaction is responsible for the ground and excited nucleon state formations. These studies will provide promising opportunities to understand the origin of more than 98% of the nucleon mass that is created by strong fields predominantly at the distance scales accessible with CLAS12.

2This work was supported in part by the National Science Foundation.

2:30PM 2WF.00002 Baryon resonances at LEPS. MIZUKI SUMIHAMA, Osaka University, RCNP — Backward-angle photoproductions of π^0, η, η', and ω mesons have been measured in the photon energy range from 1.5 GeV to 2.4 GeV at the SPring-8/LEPS facility. Differential cross sections and photon beam asymmetries have been obtained. The cross section data show the bump structures around 2.1 GeV. The photon beam asymmetries for π^0 photoproduction show a strong angular dependence. The data will be discussed connecting with baryon resonances. In addition, the future plan of experiments with photon energies up to 3 GeV will be introduced.

3:00PM 2WF.00003 Strangeness in the Proportion: strangeness in the nucleon probed via parity-violating electron scattering. DAVID S. ARMSTRONG, College of William and Mary — The contribution of strange quark/anti-quark pairs to the properties of the nucleon has been a topic of considerable interest for some time. While s̅τ pairs are clearly observed in deep-inelastic scattering processes, and have reasonably well-determined parton distribution functions, their influence on static nucleon properties, such as the scalar, axial and vector matrix elements, is more controversial. Their contribution to the vector matrix elements, where are encoded as the strange electric and strange magnetic form factors, can be isolated using parity-violating electron scattering as a probe. Over the past 15 years or so, a program of such measurements has been underway at Jefferson Lab (HAPPEx and G0 collaborations), the MAMI microtron at Mainz (PV-A4) and MIT/Bates (SAMPLE). These have lead to a remarkably consistent picture providing rather precise values for these strange form factors over a range of Q^2. The results from these experiments, and prospects for the near future, will be reviewed.

3:30PM 2WF.00004 COFFEE BREAK —

4:00PM 2WF.00005 Photoproductions for the study of baryon resonances. ATSUHI HOSAKA, RCNP, Osaka University — Photoproduction data from the recent photon-electron facilities have been providing interesting results in the region of strangeness production. Exclusive measurement is useful for the extraction of the structure of hyperons and their resonances, in particular of their expected exotic nature. It is then desired to have a standard framework to extract such information and establish some conditions suited to the search for the interesting features. In this talk, we will make discussions in the effective Lagrangian method. We formulate the model microscopically as much as available, and attempt to extract important reaction mechanism and resonance structure from the data in such a way that the results are compared with theoretical descriptions of QCD. We discuss examples of kaon photoproductions associated with Λ, and its resonances, and also φ photoproduction.

1Supported in part by the Grant for Scientific Research Contract No. 19540297 from the Ministry of Education.

4:30PM 2WF.00006 Light hypernuclei and hyperon-nucleon potentials based on lattice QCD. HIDEKATSU NEMURA, Tohoku University — We will provide an overview of recent theoretical studies on light hypernuclei and lattice QCD hyperon-nucleon potentials. Results of ab initio calculations of s-shell hypernuclei are outlined, revealing the importance of coupled-channel such as ΛN − ΣN. The challenge to obtain the lattice QCD potentials will also be presented.
Among the experimental facilities, such as the Materials and Life Science Experimental Facility and the Neutrino Experimental Facility, the Hadron Experimental Facility is for fixed target experiments which utilize the secondary beam produced by the proton beam slowly extracted from the 50-GeV synchrotron. At the Hadron Facility, the K1.8BR beam line, for secondary beams (pi, K, …) up to 1.1 GeV/c, is already available, and the K1.8 beam line, for secondary beams up to 1.8 GeV/c, will be ready by the end of October, 2009. The neutral kaon beam line, KL, is also under construction and will be tested in this fall. Other beam lines, such as K1.1BR (for secondary beam up to 0.8 GeV/c), K1.1 (up to 1.1 GeV/c), and high-momentum beam line (low intensity primary protons and high momentum unseparated secondary beams), are in preparation. Among many experiments proposed so far [http://j-parc.jp/NuclPart/Proposal_e.html], some nuclear/hadron physics experiments as well as particle physics experiments are being conducted at these beam lines. In this talk, hadron physics experiments at the Hadron Experimental Facility of J-PARC are introduced with a review of their predecessors. In addition, a summary will be presented on the discussions related to J-PARC during the previous two days of the US-Japan seminar titled “Meson Production Reactions at Jefferson Lab and J-PARC.”

Tuesday, October 13, 2009 2:00PM - 5:30PM
Session 2WG Workshop on Transverse Spin and the Transverse Structure of the Nucleon Kings

2:00PM 2WG.00001 Transversity at HERMES , STEPHEN GLISKE, University of Michigan — A brief introduction to the transversity distribution function, denoted $h_1$ or $h_t$, will be presented. Access to $h_1$ can be gained by measurement of Fourier moments of single-spin asymmetries in semi-inclusive production of mesons on a transversely polarized hydrogen target. Other transverse momentum dependent functions can also be accessed through various azimuthal moments. Preliminary results from HERMES will be presented. The experimental results from COMPASS will also be shown for comparison. An additional observable, the pion yield difference, will also be presented, as this observable has negligible contribution from vector meson decay.

2:30PM 2WG.00002 Spin Measurements at RHIC , MATTHIAS GROSSE PERDEKAMP, University of Illinois, Urbana Champaign — Large single transverse spin asymmetries, $A_N$, for inclusive hadron production were first observed by the E704 collaboration at Fermi National Laboratory in polarized proton-proton collisions at a center of mass energy of $\sqrt{s} = 20$ GeV. Different mechanisms have been suggested to explain the origin of large single transverse spin asymmetries in hard scattering processes: Collins has shown that correlations between transverse quark spin and transverse hadron momentum in the final state hadron fragmentation process can give rise to single transverse spin asymmetries. Alternatively, Sivers has identified correlations between the initial state transverse proton spin and the intrinsic transverse momentum of quarks as possible source for the observed single spin asymmetries. At RHIC large $A_N$ for inclusive hadrons have been observed to persist at center of mass energies of 62.4 GeV and 200 GeV. In addition to precise measurements of $A_N$ for inclusive hadrons new ideas have been explored to explicitly separate single spin asymmetries from the Collins and Sivers mechanisms through measurements at RHIC. Examples include Sivers asymmetries in back-to-back correlation of opposing jet hemispheres, Sivers asymmetries in Drell-Yan and jet-photon production and Collins-like asymmetries in di-hadron interference fragmentation. Present status and future plans based on increased luminosity and detector upgrades at RHIC will be presented.

3:00PM 2WG.00003 Theory of Transverse Spin and Transverse Structure of the Nucleon , YUJI KOIKE, Niigata University — Large single transverse spin asymmetries (SSA) observed in various collision processes opened a new window to disentangle QCD dynamics and quark-gluon substructure of the nucleon. Since SSA is a “naively T-odd” observable, it can only occur as an interference between the scattering amplitudes which have different complex phases in a time-reversal invariant theory like QCD. A conventional framework for hard inclusive processes, i.e. perturbative QCD in the twist-2 level, can only give rise to a negligible asymmetry and thus can not explain the observed data. Understanding the origin of the large SSAs requires the extension of the framework of the QCD hard processes, and by now QCD mechanisms leading to large SSAs have been clarified in greater detail. These mechanisms based on different perspectives introduce new concepts describing the nucleon structure not present in the conventional parton model, such as “parton’s intrinsic transverse momentum” and “multi-parton correlations.” Precise and unambiguous definition of these ideas requires much more careful theoretical analyses than the twist-2 case, in particular, in connection with the universality of the parton distribution/fragmentation functions, gauge invariance and factorization properties of the cross sections. In the literature, QCD mechanisms for SSAs are often classified into two categories. One is based on the (naively) “T-odd” distribution and fragmentation functions in the transverse momentum dependent (TMD) factorization approach. Collins and Sivers functions are typical examples for this one. The other one is based on the twist-3 quark-gluon (more generally, multi-parton such as triple-gluon) correlation functions in the collinear factorization approach. The former mechanism can describe SSAs in the small-$p_T$ region ($p_T \ll Q$) as a leading-twist effect, while the latter one describes SSAs in the large-$p_T$ region as a twist-3 effect. Both approaches have been applied to study SSAs in various processes, such as semi-inclusive deep-inelastic-scattering (SIDIS), Drell-Yan processes, $p^+ \rightarrow hX (h = \pi, K, \ldots)$ etc, for which experimental measurements are ongoing at DESY, CERN, JLab and BNL-RHIC etc. Although the starting points of the analysis and the applicable kinematic region for these two mechanisms are different, they are shown to give identical SSAs in the intermediate region of $p_T$ for the “Sivers” type SSA. Universality of the TMD functions and the factorization property with TMD functions have been studied in detail. Gauge invariance and the factorization property of the twist-3 cross section in the latter approach is also understood. In this talk, I will first review recent developments in the theoretical frameworks for SSAs described above, and then I will present our recent works on SSAs based on the twist-3 mechanisms. I will discuss the azimuthal structure of the twist-3 single-spin-dependent cross section for SIDIS and $A_N$ for $p^+ \rightarrow hX$ including all kinds of pole contributions.

3:30PM 2WG.00004 COFFEE BREAK –

4:00PM 2WG.00005 Jefferson Lab Neutron Transversity Experiments (E06-010) , XIAODONG JIANG, Los Alamos National Laboratory — Jefferson Lab A “Neutron Transversity” experiment (E06-010) collected data between Oct. 2008 and Feb. 2009. An electron beam of 5.9 GeV energy was used to scatter from a transversely polarized neutron (3He) target. The scattered electrons were detected in coincidence with charged hadrons (pion or Kaon) in deep inelastic kinematics of $x_{1}\lesssim 0.4$ and an average $Q^2$ of 2.2 GeV$^2$. The measured target single-spin asymmetries in semi-inclusive reactions allowed access to the quark transversity distributions as well as the T-odd Sivers distributions. The most recent status of physics analysis will be reported.

4:30PM 2WG.00006 Prospects in neutron transversity spin study with polarized 3He at 12 GeV Jefferson Laboratory , HAIYAN GAO, Duke University — Due to the unique ground state spin structure of the 3He nucleus, polarized 3He nuclear targets have been used widely in experiments ranging from measurements of the neutron electric and magnetic form factors to the study of the neutron spin structure. In this talk, I will discuss the recently completed neutron transversity experiment in Hall A at Jefferson Laboratory using a vertically polarized 3He target. This is the first time that a polarized 3He target has been used in probing the neutron transversity spin structure. I will focus in my talk the future prospects of neutron transversity spin study at 12-GeV Jefferson Laboratory after the energy upgrade. The work is supported by a U.S. Department of Energy grant DE-FG02-03ER41231.
The decay photons from lower pT relativistic heavy ion collisions. It has been found that the ratio of π/π small Moliere radius allow to separate two photons from done in order to understand the enhancement of di-electron yield in low mass and low pT di-electron yield over the known hadronic sources is observed in Au+Au collisions in the low both p+p and Au+Au collisions. While the p+p result is well-understood as a combination of electron pairs from know hadronic sources, an enhancement of transparent probes such as electrons and photons, and they are powerful probes to investigate properties of the matter created in heavy ion collisions. Especially, PHENIX experiment at RHIC medium.

Three photon-jet correlations. We show that a consistent treatment of photon emission must also include a theory of jet energy loss in the strongly interacting nuclear collisions at RHIC. This includes photon and lepton pair spectra from a variety of emitted sources, a discussion of the photon nuclear modification factor, and photon-jet correlations. We show that a consistent treatment of photon emission must also include a theory of jet energy loss in the strongly interacting medium.

Tuesday, October 13, 2009 2:00PM - 5:30PM —
Session 2WH Workshop on the Expanding Future of High Energy Nuclear Physics at LHC and RHIC II Kings 3

2:00PM 2WH.00001 Photon and Dilepton Emission from the QGP at RHIC, CHARLES GALE, Department of Physics, McGill University — We present a review of the theory and of the interpretation of photon and dilepton data measured in relativistic nuclear collisions at RHIC. This includes photon and lepton pair spectra from a variety of emitted sources, a discussion of the photon nuclear modification factor, and photon-jet correlations. We show that a consistent treatment of photon emission must also include a theory of jet energy loss in the strongly interacting medium.

2:30PM 2WH.00002 Measurements of low mass di-electrons and low pT direct photons in the PHENIX experiment at RHIC, YORITO YAMAGUCHI, University of Tokyo — The PHENIX experiment at RHIC is suitable for measuring transparent probes such as electrons and photons, and they are powerful probes to investigate properties of the matter created in heavy ion collisions. Especially, the di-electron measurements provide us deep insight into the created matter. Recently, the low mass di-electron yield has been successfully measured in both p+p and Au+Au collisions. While the p+p result is well-understood as a combination of electron pairs from know hadronic sources, an enhancement of di-electron yield over the known hadronic sources is observed in Au+Au collisions in the low pT region. The various efforts for developing models have been done in order to understand the enhancement of di-electron yield in low mass and low pT region. But these models do not explain this enhancement fully yet. Furthermore, the fraction of the contribution from virtual photon jet decay can be determined from dieletron yield by focusing on the region which satisfies pT^{ee} \gg m_{ee}. The real direct photon yield in p+p of 1-5 GeV/c has been obtained from the fraction of the virtual direct photon in p+p and Au+Au collisions. A significant excess over the binary scaled p+p result is seen in Au+Au collisions in this pT region, where the primary contributor is considered to be thermal photons from QGP. Theoretical models which can reproduce the Au+Au result indicate that the initial temperature of the created matter is higher than the critical temperature of QGP (200 MeV). In this talk, the latest results on the di-electron and virtual direct photon measurements in p+p, p+A and A+A collisions at PHENIX will be presented.

3:00PM 2WH.00003 Photon Physics Potential at ALICE, HISAYUKI TORII, Hiroshima University — The ALICE detector has been designed to study the strongly interacting matter created in nucleus-nucleus collisions at the Large Hadron Collider (LHC). In heavy-ion collisions, it is very critical to measure thermal photons, which are known to carry the temperature information of hot created matter. The thermal photon measurements at RHIC are choosing the systematic study with other photon detectors at LHC. Furthermore, the suppression of high pT hadrons has provided the first strong signature of hard and dense partonic matter created in heavy-ion collisions at RHIC. Therefore, the suppression behavior of various particle species, including photons, up to LHC energy, is a key observable for the study of the hot matter dynamics. The ALICE PHOTon Spectrometer (PHOS) consists of 17920 PWO crystals and Avalanche Photo Diode (APD) covering a rapidity range of ±1.4. The fine segment structure and small Moliere radius allow to separate two photons from π0 decay at pT=30GeV/c with about 100% efficiency and at even higher pT with smaller efficiency. The decay photons from lower pT π0 is the largest background in measuring the thermal photons and can be tagged in a very efficient way with a good energy resolution (3%/√(E(GeV))). The ALICE EMCal consists of shashlik lead-scintillator sampling units covering a rapidity range of ±0.7 and an azimuthal range of 110° and sits in the opposite coverage azimuthally to PHOS. The jet measurements by EMCal and other tracking detectors, especially when tagged by a direct photon in the opposite PHOS detector, represent a key probe for investigating jet quenching effects. In this presentation, physics potential with photon detectors at ALICE during the first physics run of LHC will be discussed. The construction and installation status of the photon detectors as well as their expected physics will be presented.

3:30PM 2WH.00004 COFFEE BREAK —

4:00PM 2WH.00005 Test of Ideal Hydrodynamical Limit at RHIC, HIROSHI MASUJ, Lawrence Berkeley National Laboratory — Elliptic flow (v2) is one of the most prominent observables to study collective properties of the hot and dense medium created in relativistic heavy ion collisions. It has been found that the ratio of v2 to the initial spatial anisotropy ε scales as transverse number density 1/SdN/dy for different collision energies and systems from AGS (√sNN = 5 GeV) to RHIC (√sNN = 200 GeV). Eventually, the linear dependence of v2/ε vs. 1/SdN/dy is expected to be saturated when the system reaches local thermal equilibrium. However, till now there is no sign of saturation of v2/ε at top RHIC energy. It is natural to ask the question to what extent the system has reached the ideal hydrodynamical limit. It is also important to understand how the v2/ε behaves at higher transverse number density. Compared to Au nucleus, uranium is a heavier and naturally deformed. The planned U + U collisions at RHIC (2012) could provide higher densities than that achieved in Au + Au collisions. In this talk, we present the results of a test on ideal hydrodynamical limit. The v2 data from Au + Au collisions at √sNN = 200 GeV are used. It has been found that even at most central Au + Au collisions the ideal hydrodynamical limit has not been reached. In addition, we present the prediction of v2 in U + U collisions at √sNN = 200 GeV by extrapolating the measured v2 in Au + Au collisions at RHIC.
4:30PM 2WH.00006 The Long Slow Death of the HBT Puzzle1. SCOTT PRATT, Michigan State University — Over the past 20 years two particle-correlations between identical pions have developed into a quantitative tool to test the space-time evolution of heavy-ion collisions. Surprisingly, correlations from RHIC failed to match expectations from hydrodynamic-based models, as the model-predicted source sizes were sometimes 50% higher than was inferred from experiment. This failure became known as the HBT puzzle (Hanbury-Brown and Twiss were pioneers in the original technique). Since the success of these very models in predicting spectra and elliptic flow was central to the discovery of the “perfect fluid,” the failure of their HBT predictions was disquieting. In this talk, I will show how the discrepancy can be explained by the conspiracy of three effects: pre-equilibrium flow, using a stiffer equation of state and adding a modest viscosity. I will review the progress in finding a single description that reproduces the totality of soft bulk observables at RHIC.

1Supported by DOE Office of Science, Grant #DE-FG02-03ER41259.

5:00PM 2WH.00007 The ALICE experiment — Nuclear collisions at the high-energy frontier at LHC1. KEN OYAMA, University of Heidelberg — A Large Ion Collider Experiment (ALICE) is the dedicated experiment for studying nuclear collisions at the LHC. It will address the physics of QCD matter under extreme conditions of temperature and energy density. ALICE is an international collaboration of more than 1000 physicists and engineers from presently 105 institutions. First p+p collisions provided by LHC are expected at the end of this year. The current status of the ALICE experiment, its instrumentation and performance capabilities are presented. The ALICE physics potential is highlighted by discussing some selected examples scheduled for first p+p collisions, and subsequent Pb+Pb collisions.

Wednesday, October 14, 2009 8:45AM - 11:00AM – Session AA Nuclear Physics: Highlights and Prospects I Monarchy Ballroom

8:45AM AA.00001 Welcome and Introductory Remarks, BRADLEY SHERRILL, Michigan State University, MAKOTO OKA, Tokyo Institute of Technology —

9:00AM AA.00002 Strangeness Nuclear Physics at the J-PARC era, TOMOFUMI NAGAE, Kyoto University — Strangeness degrees of freedom do not show up prominently in the standard nuclear physics at low energies. However, by explicitly implanting the strangeness in a nucleus, we can extend our scope of hadron many-body systems into the flavor SU(3) world and create new types of hadronic systems. In many cases, the extensions are not so trivial, and we need to reconsider our basic understandings of hadron physics which have been effective in the ordinary nuclear physics. After the shutdown of BNL-AGS and KEK-PS in US and Japan for strangeness nuclear physics, experimental researches have been conducted at Jefferson Laboratory in US, and LNF in Italy in the last several years, and are now about to start at GSI and Mainz in Germany. Recent topics are summarized in this talk. In Japan, construction of a high-intensity accelerator complex, Japan Proton Accelerator Research Complex (J-PARC), is completed. Beam commissioning of the slow-extraction beam from the J-PARC main proton synchrotron started from January, 2009. The beam was successfully extracted and transported to the Hadron Experimental Hall on January 27. The first secondary-beam production was confirmed on February 11 at the K1.8-branch beam line in the hall. Although we need a lot of work to be completed before the beam would be available for experimental users, we believe this is the start of the J-PARC era to open new research fields in strangeness nuclear physics. The K− beams with the highest intensity in the world enable us to carry out various interesting experimental subjects; the (K−,K+) missing-mass spectroscopy to discover Ξ hypernuclei, hypernuclear gamma-ray spectroscopy, search for kaonic nuclei, and so on. New detector systems such as the SKS+ spectrometer, Hyperball-J detector, and Cylindrical Detector System (CDS) are now in preparation. Present status of the experiments, our initial physics goals at J-PARC and the perspectives are discussed.

9:45AM AA.00003 Stranger than Fiction: Adventures in the QCD Wonderland, BERNDT MUELLER, Duke University — The Relativistic Heavy Ion Collider (RHIC) has initiated a new era in the scientific exploration of strongly interacting matter. Constructed to produce and investigate the quark-gluon plasma, the RHIC experiments have revealed a wealth of amazing phenomena: the ability of partonic matter to almost completely shear out the momentum of the struck target; the occurrence of collective flow; the observation of a non-trivial equation of state, and an isotropic viscosity. All of these discoveries open up new research fields in strangeness nuclear physics. The K− beams with the highest intensity in the world enable us to carry out various interesting experimental subjects; the (K−,K+) missing-mass spectroscopy to discover Ξ hypernuclei, hypernuclear gamma-ray spectroscopy, search for kaonic nuclei, and so on. New detector systems such as the SKS+ spectrometer, Hyperball-J detector, and Cylindrical Detector System (CDS) are now in preparation. Present status of the experiments, our initial physics goals at J-PARC and the perspectives are discussed.

10:30AM AA.00004 COFFEE BREAK –

Wednesday, October 14, 2009 11:00AM - 12:30PM – Session AB Nuclear Physics: Highlights and Prospects II Monarchy Ballroom

11:00AM AB.00001 New Aspects of Nuclear Structure, TAKAHARU OTSUKA, University of Tokyo — In recent years, more exotic nuclei have been studied, with unexpected features and their theoretical explanations. I shall sketch some of them. Over the past ten years, our understanding and treatment of the nuclear forces, two-, three- and n-body, have become deeper and more precise, in a closer way with QCD. At the same time, the effects of nuclear force on exotic nuclei have been clarified better. The conventional pictures of the nuclear shells, magic numbers, and correlations have been modified considerably. For instance, the shell structure of exotic nuclei are different from the one for stable nuclei due to some specific components of the nuclear force, e.g., the tensor force. The modern theory of the nuclear forces supports this picture, and experiments done in the past several years indeed suggest such changes from stable to exotic nuclei. The most striking recent finding is the effect of three-body force. The three-body force has been shown, by ab initio calculations, to increase binding energies. While this is correct, Fujita- Miyazawa three-body force coming from Delta excitation produces characteristic repulsive effects between excess neutrons, affecting binding and shell structure. A good example is exotic oxygen isotopes: the dripline is unusually closer to the stability line, and exotic magic numbers N=14 and 16 have been established experimentally. The underlying origin of these anomalies have remained a puzzle, but we can now solve it in terms of the three-body force. While the mechanism is understood very intuitively, the EFT plays a significant role in the evaluation of three-body force effects. These effects are a general and robust one. Thus, our view over exotic nuclei are being changed, and the interplay between nuclear structure physics and hadron physics should become more crucial in this frontier.

11:45AM AB.00002 The Decades of the Neutrino, STUART FREEDMAN, University of California, Berkeley and Lawrence Berkeley National Laboratory — The amount we have learned about neutrinos in the last ten years is truly remarkable. Neutrino mass and mixing is the first major revision in the Standard Model in decades and we are just beginning to understand all the implications. In the meantime the next decade promises even more discoveries. Nuclear physics, experiment and theory, is center stage in the developing neutrino story. I will review where we are and discuss the roadmap for the coming decade.

including jet spectra, jet–jet angular correlation, and the nuclear modification factor. We discuss the comparison and implication for models, and further outline

central

\[ \sqrt{s} = 200 \text{GeV} \] from STAR experiment at RHIC. This correlation is defined as a three-particle technique called “2+1”, by using a di-jet trigger of two back-to-back high-pT particles including both charged hadrons and high-energy photons. This analysis explores the relative distributions of soft hadrons with the two triggers. The trigger \( p_T \) ranges are varied to control the relative strength of jet modification. In contrast to those di-hadron correlations with a single high- \( p_T \) trigger, the associated hadron distributions in our “2+1” analysis reveal no modification in either \( \Delta \eta \) or \( \Delta \phi \) from d+Au to central Au+Au collisions. The present results indicate that di-jet triggered correlations select those jets that undergo no interactions or energy-loss with the medium created in collisions. The associated yields and trigger rates for such di-jets are studied as a function of \( N_{\text{part}} \) to provide additional insights into medium properties.
8:00PM BB.00004 Jet modifications in conditionally triggered di-hadron correlations at \( \sqrt{s_{NN}} = 200 \) GeV in Au+Au at RHIC-PHENIX

ERIC VAZQUEZ, Columbia University, PHENIX COLLABORATION

A hot dense medium exceeding the critical energy density for the formation of a partonic state of matter is created in Au+Au collisions at RHIC. This dense matter is extremely opaque to high energy partons and therefore leads to strong modifications of di-jets traversing the medium. These modifications are typically studied by comparing the di-hadron azimuthal correlation functions in Au+Au collisions to those in p+p collisions. However, di-hadron correlations measured in events triggered on a single hadron are subject to a surface bias due to the larger probability of a high-\( p_T \) parton emerging with little or no energy loss from production points near the surface of the medium. This effect can be reduced, and in fact controlled, by studying events in which the production of two high-\( p_T \) hadrons at large azimuthal separation is required. We present results of such an analysis performed in p+p and Au+Au collisions at \( \sqrt{s_{NN}} = 200 \) GeV.

8:15PM BB.00005 Infinite Matter Calculation of Jet Energy-Loss with the Parton Cascade Model

STEFFEN BASS, Duke University — Parton Cascade Models, which describe the full time-evolution of a system of quarks and gluons using pQCD interactions are ideally suited for the description of jet production, including the emission, evolution and energy-loss of the full parton shower in a hot and dense QCD medium. However, before applying the PCM to the off-equilibrium dynamics of the early stage of an ultra-relativistic heavy-ion collision, it is important to validate these calculations against analytically calculable test cases. In this talk, I shall present results of PCM calculations for parton energy loss in infinite matter and compare them to some analytically accessible test cases.

8:30PM BB.00006 High \( p_T \) hadron production and its quantitative constraint to model parameters

TAKAO SAKAGUCHI, Brookhaven National Laboratory, PHENIX COLLABORATION — Hot and dense matter created in relativistic heavy ion collisions is found to be opaque according to the degree of suppression of high \( p_T \) hadrons, which are considered to carry the major fraction of the momentum of hard scattered partons. The nuclear modification factors \( R_{AA} \) of \( p+p \) collisions from the latest PHENIX publication are found to be constant, meaning that the energy loss of partons is constant fractional. The phenomena have stimulated theoretical field, and deduced many models, but the quantitative discussion has not been realized until recently because of large uncertainty on both experimental and theoretical work. The PHENIX experiment has recently succeeded to constrain parameters of models by quantitatively comparing models and data. Such comparison became possible by properly taking systematic and statistical errors into account. In this presentation, an attempt to constrain model parameters using the latest high \( p_T \) hadron spectra with most statistics available from PHENIX Run7 data will be shown, and the characteristics of the matter produced obtained in the study will be discussed.

8:45PM BB.00007 Neutral pion production with respect to the reaction plane in \( \sqrt{s_{NN}} = 200 \) GeV Au+Au collisions at PHENIX

YOKI ARAMAKI, CNS, University of Tokyo, PHENIX COLLABORATION — It has been observed that the yield of neutral pion at high transverse momentum \( p_T > 6 \) GeV/c in Au+Au collisions at RHIC is strongly suppressed in central Au+Au collisions compared to \( p+p \) collisions. This suppression is interpreted as a consequence of an energy loss of hard partons in the medium (jet quenching), which results in a decrease of the yield at a given \( p_T \). Many calculations of parton energy loss predict the quantity of energy loss is proportional to square of the path length. Therefore measuring the quantity of the energy loss for each path length will be able to strongly constrain calculations. Furthermore, the reaction plane of di-jets produced in the PHENIX detector in RHIC 2007 run, and the reaction plane can be determined about 2 times better than before. Furthermore the integrated luminosity in RHIC 2007 run achieved 813 pb\(^{-1}\), and this is about 4 times larger than the previous run. With these improvements both the nuclear modification factor as a function of reaction plane will be measured and the respective average pathlength estimated with about a factor of 4 smaller errors than in the published RHIC 2004 data.\(^1\)


9:00PM BB.00008 Reaction plane dependence of inclusive photon-hadron \( \Delta \phi-\Delta \eta \) correlation in Au+Au \( \sqrt{s_{NN}}=200 \) GeV collisions at RHIC-PHENIX

TAKAHITO TODOROKI, University of Tsukuba, PHENIX COLLABORATION — Quark Gluon Plasma (QGP) is the phase composed of de-confined quarks and gluons of which interaction is described by QCD, and is formed from the high energy collisions of relativistic heavy ion collider (RHIC). Neutral pions produced in medium are used as good probe of the medium properties, because they are not strongly interacting and only absorb energy loss. In this talk, we will show the latest analysis results of the reaction plane dependence of inclusive photon-hadron \( \Delta \phi-\Delta \eta \) correlation in Au+Au collisions at \( \sqrt{s_{NN}}=200 \) GeV measured in the PHENIX experiment. This analysis is especially useful with centrality and reaction plane dependence. This study is performed using the latest analysis data measured in the PHENIX Run7.

9:15PM BB.00009 Are direct photons suppressed in PHENIX at high \( p_T \) in relativistic heavy ion collisions?\(^1\)

GABOR DAVID, BNL — Preliminary results from PHENIX on direct photon production in 200GeV Au+Au collisions indicate that while at moderate \( p_T \) (4-14GeV/c) the nuclear modification factor \( R_{AA} \) for photons is unity, at higher \( p_T \) it may be significantly smaller and possibly, similar to the well-established hadron suppression (jet quenching) level. Since \( R_{AA} \) has been derived using \( p+p \) data measured in the same experiment, such suppression may have several possible origins. One possibility is the large energy loss of \( p_T \) photons entering in jet hadrons, and another is the possible initial state energy loss in the medium. Furthermore, the observed suppression may be either due to medium effects or due to initial state energy loss and it is not clear if both effects are present. The initial parton distribution distributions themselves may be changed, which would be manifested already in d+Au collisions. Furthermore, the suppression of the high energy photons in Au+Au collisions may be enhanced by (collinear parton-photon “conversion”) or reduce the yield of high \( p_T \) photons. Based on the latest analysis of \( \sqrt{s}=200 \) GeV d+Au and Au+Au photon data from PHENIX we will investigate if direct photons are suppressed at high \( p_T \) and if so, what the physics implications may be.

1G. David, BNL for the PHENIX Collaboration.

9:30PM BB.00010 Fragmentation photons in p+p collisions at 200GeV with PHENIX

ALL HANKS, PHENIX COLLABORATION — Direct photons produced in relativistic heavy ion collisions are often viewed as insensitive to the final state effects leading to jet quenching, and are thus considered powerful penetrating probes. However, there is a contribution to direct photon production that is sensitive to jet quenching in the QGP. QCD predict that up to 30% of direct photons are produced through parton fragmentation. In A+\( A \) this contribution is expected to be modified due to stimulated photon emission as the parton propagates through the medium. Detection of these photons would provide a direct observation of the energy loss of jets in the medium. Measurements of fragmentation photon properties in p+p serve both as an important test for QCD descriptions and as a baseline for A+\( A \). A natural way of selecting fragmentation photons is with intra jet correlations of photons and high-pT hadrons. This method also allows for further study of the jet properties of fragmentation photons such as \( p_{out} \), the component of the photon \( p_T \) parallel to the trigger hadron, providing further constraint on the details of parton fragmentation. We present results from p+p data and discuss the potential for measurements in d+Au and Au+Au collisions.
energy loss and/or a possible difference between pseudo-scalar and vector mesons will be studied in details. Feasibility and prospects of high $p_T$ spectrometer, PHOS, of ALICE will allow identification of particles decaying into multiple photons up to very high $p_T$ energy loss of quarks. LHC will provide high production rates of particles up to much higher $p_T$ than RHIC does, and the high performance photon spectrometer, PHOS, of ALICE will allow identification of particles decaying into multiple photons up to very high $p_T$. Any dependence on quark flavors of energy loss and/or a possible difference between pseudo-scalar and vector mesons will be studied in details. Feasibility and prospects of high $p_T$ measurements with the PHOS detector, especially in the first $p_T$ and Pb-$p$ running in 2009-2010, will be discussed.

Wednesday, October 14, 2009 7:00PM - 10:00PM – Session BC Instrumentation I Kohala 1

7:00PM BC.00001 ZeroDegree spectrometer at RIKEN RI Beam Factory. TOSHIYUKI KUBO, TETSUYA OHNISHI, HIROYUKI TAKEDA, NAOKI FUKUDA, DAISUKE KAMEDA, KENSUKE KUSAKA, ATSUSHI YOSHIDA, KOICHI YOSHIDA, MASAO OHTAKE, NAHOITO INABE, YOSHIYUKI YANAGISAWA, KANENOBU TANAKA, RIKEN Nishina Center — At RI Beam Factory (RIBF) [1] at RIKEN Nishina Center, a variety of fast rare isotopes (RI) beams are produced using the BigRIPS in-flight separator [2] for studies of exotic nuclei. The beam line following BigRIPS is designed to work as a forward spectrometer named ZeroDegree, so that it can be used for reaction studies with RI beams. The ZeroDegree spectrometer consists of two dipoles and six superconducting quadrupole triplets, of which designs are essentially the same as those of BigRIPS. It analyzes and identifies projectile reaction residues, often in coincidence with gamma rays, and can be operated in different optics modes, depending on experimental requirements. The ZeroDegree spectrometer has recently been commissioned and used for a series of full-dress RI-beam experiments. Overview and status of the ZeroDegree spectrometer will be reported.


7:15PM BC.00002 Ion-optical studies of BigRIPS separator and ZeroDegree spectrometer at RIKEN RI Beam Factory. HIROYUKI TAKEDA, TOSHIYUKI KUBO, TETSUYA OHNISHI, NAOKI FUKUDA, DAISUKE KAMEDA, KENSUKE KUSAKA, ATSUSHI YOSHIDA, KOICHI YOSHIDA, MASAO OHTAKE, NAHOITO INABE, YOSHIYUKI YANAGISAWA, KANENOBU TANAKA, RIKEN Nishina Center, MASAFUMI MATSUSHITA, Rikkyo University. BigRIPS/ZeroDegree COMMISSIONING COLLABORATION — The BigRIPS in-flight separator[1] and the ZeroDegree spectrometer (ZDS) have been commissioned at RIKEN RI Beam Factory (RIBF) recently. Intense radioactive isotopes (RI) beams are produced, separated and analyzed by the BigRIPS and the ZDS. Both of them are operated in several optical modes according to experimental conditions. For particle identifications of RI beams, it is essentially important to achieve high resolutions in $A/Q$ ratio because RI beams are produced in several charge states in our energy region especially for heavy RI beams. Ion optical calculation with realistic magnetic field maps is indispensable for our purpose and we use COSY INFINITY[2] for that. Measured field maps are incorporated in the COSY calculations. In 2008, the ZDS was commissioned in the first time in three different modes. Experimental results and comparison with the COSY calculations will be presented in this report. [1] T. Kubo: Nucl. Instr. Meth. B 204, 97 (2003). [2] K. Makino, M. Berz: Nucl. Instr. Meth. A558, 346 (2006).

7:30PM BC.00003 Ion Optics Simulation for Fragment Separator. YOSUKE KAWADA, TAKASHI NAKAMURA, Tokyo Institute of Technology, TOSHIYUKI KUBO, HIROYUKI TAKEDA, RIKEN Nishina Center, TOSHIYUKI SUMIKAKA, Tokyo University of Science — We have developed a Monte-Carlo simulation code for unstable-nuclear beam experiments using a fragment-separator. This code primarily aims at calculating beam traces in the fragment separator BigRIPS and ZeroDegree Spectrometer (ZDS) at RIBF(RIKEN RI-Beam Factory). This code uses externally given transfer-matrices of ion optics such as an output of COSY Infinity[1]. We have applied this code to recent campaign of experiments using $^{48}$Ca at 345MeV/u as primary beam. In the experiments, two modes of ion optical settings, namely “Standard” and “High Brho” modes were used. The former is an ordinary used standard setting, which has a limit in the maximum rigidity ($B\rho < 0.2$Tm). On the other hand, the “High Brho” setting has been developed for a secondary beam with higher rigidity, such as for very neutron rich nuclei. $^{22}{C}$ A/Z=3.67. In this talk, we compare properties of these two optics settings and evaluate beam traces, emittances, and transmissions.


7:45PM BC.00004 Construction of high resolution beam line for SHARAQ spectrometer at RIKEN RI Beam Factory. YOSHIYUKI YANAGISAWA, TOSHIYUKI KUBO, KENSUKE KUSAKA, MASAO OHTAKE, KOICHI YOSHIDA, TETSUYA OHNISHI, RIKEN Nishina Center, YOSHIKO SASAMOTO, AKITO SAITO, TOMOHIRO UESAKA, SUSUMI SHIMOUIRA, CN, University of Tokyo, TAKAHIRO KAWABATA, Department of Physics, Kyoto University, SHUMPEI NOJI, HIDEYUKI SAKAI, Department of Physics, University of Tokyo — A high resolution beam line [1] has been constructed for the SHARAQ spectrometer [2] at RIKEN RI Beam Factory (RIBF), in order to achieve dispersion matching that allows high resolution measurement at the focal plane of the spectrometer. This beam line is formed by the existing BigRIPS separator [3] at RIBF and a newly constructed beam line that diverges from BigRIPS and leads to the target position of SHARAQ. The ion optics is so designed that it can be operated in the dispersion matching mode. The new part of the beam line consists of two 30-degree bend dipoles, three superconducting triplets and three superconducting quadrupole triplets. Recently the beam line has been successfully commissioned together with the SHARAQ spectrometer. Overview of the beam line will be reported. [1] T. Kawabata et al.: Nucl. Instr. and Meth. B 266 (2008) 4201. [2] T. Uesaka et al.: Nucl. Instr. and Meth. B 266 (2008) 4218. [3] T. Kubo: Nucl. Instr. and Meth. B 204 (2003) 97.

8:00PM BC.00005 Ion optical studies in the high resolution beam line and the SHARAQ spectrometer. YOSHIKU SASAMOTO, TOMOHIRO UESAKA, TAKAHIRO KAWABATA, G.P.A. BERG, KOHSUKE NAKAMISHI, SHUMPEI NOJI, HIROYUKI TAKEDA, SUSUMU SHIMOURA, HIDEYUKI SAKAI, TOSHIYUKI KUBO, SHARAQ COLLABORATION — The SHARAQ spectrometer is designed to achieve a resolving power of $p/\delta p \sim 15000$ and a high angular resolution $\delta \theta \sim 1$ mrad with RI beam at RIBF. To avoid loss of energy resolution due to the momentum spread of RI beams, the dispersion matching technique is applied. In the commissioning run in March and May 2009, we have investigated ion-optical properties of the SHARAQ spectrometer and the high resolution beam line. We measured the first order matrix elements of the beam line and the SHARAQ spectrometer using the primary beams. The resolving power $D/M$ of the SHARAQ spectrometer is 14.7 m, which corresponds to the design value of the resolving power when the beam spot size is assumed to be 1 mm. Based on the first order elements, the beam line was tuned to be dispersion-matched to the spectrometer. In the tuning, we used correlations of beam traces at different focal planes. As the results, we have partially achieved the dispersion matching for the lateral and angular direction simultaneously. At present, the resolving power of $\sim 8000$ is achieved. The tuning method and the obtained results in the commissioning will be presented.
8:15 PM BC.00006 Field mapping study of SHARAK dipole magnets\textsuperscript{1}, TOMOHIRO USEKAI, KOHSUKE NAKANISHI, HIROSHI KUREI, SHIN'SUKE OTA, SHIN'ICHIRO MICHIMASA, AKITO SAITO, YOSHIKO SÅSAMOTO, HIROYUKI MIYA, HIROSHI TOKIEA, SUSUMU SHIMOURA, CNS, University of Tokyo, KENJIRO MIKI, SHUMPEI NOJI, HIDEYUKI SAKAI, Department of Physics, University of Tokyo — High-resolution ion-optical analyses of radioactive isotope beams, accurate and precise knowledge of magnetic field distribution is of basic importance. We have measured magnetic field distributions in dipole magnets which make up the SHARAK spectrometer. Search-coil method was adopted in the measurement. Details of the method, devices, and results of magnetic field distribution will be reported.

\textsuperscript{1}This work is supported by the Grant-in-Aid of Specially Promoted Research (Grant No. 17002003) of MEXT, Japan.

8:30 PM BC.00007 The New DAQ System in RIKEN RIBF, HIDETADA BABA, TAKASHI ICHIHARA, TETSUYA OHNISHI, SATOSHI TAKEUCHI, KOICHI YOSHIDA, YASUSHI WATANABE, Nishina Center, RIKEN, SHINSUKE OTA, SUSUMU SHIMOURA, CNS, University of Tokyo — The new DAQ system for RIKEN RI-Beam factory (RIBF) have been introduced. Several thousands of RI beams are produced by the fragmentation and fission reactions. The in-flight RI-beam separator named BigRIPS discriminates RI beams by using many beam profiling detectors placed at seven focal planes along the beam line of 77-meter-long. RI beams identified by BigRIPS are impinged on the reaction target. The reaction products are transported to the separator and measured by BigRIPS. In the detector, the energy loss per unit length \( \frac{dE}{dx} \) is also tried. At present, we engage an operation test at present. Since many experiments with a different setup are started one after another in several weeks, the DAQ system is required the flexibility and the scalability. Therefore, we developed the new DAQ system with the functions of hierarchical event build in online and parallel data readout from CAMAC/VME modules. It is remarkable that these functions are achieved by only using commodity computer and network equipments and standard CAMAC/VME modules with the flexibility and the scalability. In this paper, we will introduce the configuration and the performance of this new DAQ system.

8:45 PM BC.00008 Performance test of detection system for $\beta - \gamma$ spectroscopy at RIBF, KENTARO YOSHINAGA, TOSHIYUKI SUMIKIKA, Tokyo University of Science, HIROSHI WATANABE, SHUJIN NISHIMURA, RIKEN, JUNSEI CHIBA, YUKI MIYASITA, Tokyo University of Science, Institute of Digital Sciences, RI-Beam Factory (RIBF), RIKEN, HIROYUKI SHIBAMOTO, KOICHI YOSHIDA, Nishina Center, RIKEN, SHINSUKE OTA, SUSUMU SHIMOURA, CNS, University of Tokyo — The energy loss per unit length \( \frac{dE}{dx} \) in the region of interest \( A > 32 \) is also tried. At present, we engage an operation test at present. Since many experiments with a different setup are started one after another in several weeks, the DAQ system is required the flexibility and the scalability. Therefore, we developed the new DAQ system with the functions of hierarchical event build in online and parallel data readout from CAMAC/VME modules. It is remarkable that these functions are achieved by only using commodity computer and network equipments and standard CAMAC/VME modules with the flexibility and the scalability. In this paper, we will introduce the configuration and the performance of this new DAQ system.

9:00 PM BC.00009 Mass of the lowest $T = 2$ level in $^{32}$Cl, C. WREDE, U. Washington, C.M. DEIBEL, Joint Inst. Nuclear Astrophysics and Argonne National Lab., J.A. CLARK, Argonne National Lab., S. CALDWELL, U. Chicago and Argonne National Lab., A. CHAUDHURI, J. FALLIS, U. Manitoba and Argonne National Laboratory, A. GARCIA, U. Washington, S. GULICK, McGill U., D. LASCAR, Northwestern U. and Argonne National Lab., G. LI, McGill U. and Argonne National Lab., G. SAVARD, Argonne National Lab. and U. Chicago, K.S. SHARMA, U. Manitoba, M. STERNBERG, U. Chicago and Argonne National Lab., T. SUN, Argonne National Lab., J. VAN SCHELT, U. Chicago and Argonne National Lab. — The mass of $^{31}$S has been measured to better than 0.5 keV/\( c^2 \) using the Canadian Penning Trap mass spectrometer at Argonne National Laboratory’s ATLAS facility. The result changes the mass of the lowest $T = 2$ level in $^{31}$Cl substantially and improves its precision by roughly a factor of three. The new $Q_{EC}$ value for the superallowed $\beta$ decay of $^{32}$Ar to this level affects constraints on scalar currents via the $\beta - \nu$ correlation and the isospin-symmetry-breaking correction ($\delta_f$) to the $f$ value for this decay. The quadratic isobaric multiplet mass equation (IMME) is found to fail for the lowest $T = 2$, $A = 32$ isobaric quintet with higher confidence than for any other isobaric multiplet; the cubic fit is excellent.

9:15 PM BC.00010 Performance of Focal-Plane Tracking Detector CRDC for SHARAK, HIROSHI TOKIEA, SHINICHIRO MICHIMASA, SHINSUKE OTA, SUSUMU SHIMOURA, TOMOHIRO USEKAI, CNS, University of Tokyo, SHUMPEI NOJI, HIDEYUKI SAKAI, Department of Physics, University of Tokyo, PATRICE ROUSSEL-CHOMAZ, JEAN-FRANCOIS LIBIN, PATRICE GANGNANT, CHARLES SPITAELS, GANIL — The high-resolution magnetic SHARAK spectrometer has been constructed at the RI Beam Factory (RIBF) at RIKEN. For tracking of charged particles at the dispersive focal plane of SHARAK, we have developed two 2-dimensional position-sensitive Cathode Read-out Drift Chambers (CRDCs). The CRDCs have large active areas of 550(H) $\times$ 300(V) mm$^2$ with i-C$_3$H$_6$ gas at low pressure of 15 - 30 Torr. The vertical and horizontal positions of charged particles are determined by measuring the drift times in the CRDCs and electron distributions from the production of induced charges on the cathode divided 512 pads, respectively. The cathode signals are read out by using GASSIPLEX chips, which is developed at CERN for multiplexed readouts. In March and May, 2000, we evaluated the performance of the CRDCs by using the primary beam of $^{11}$N at 250 MeV and its fragments. We found that the CRDCs have 100% efficiency not only for heavy ion beam but also for light ion beam such as $^3$H. The performance of the CRDCs evaluated from further analyses will be presented.

9:30 PM BC.00011 Performance evaluation of Low-Pressure Multi-Wire Drift chamber for RI beam, HIROYUKI MIYA, SUSUMU SHIMOURA, AKITO SAITO, Center for Nuclear Study, Graduate School of Science, University of Tokyo, KENJIRO MIKI, Department of Physics, University of Tokyo, TAKAHIRO KAWABATA, Department of Physics, Kyoto University, MASAKI SASANO, RIKEN Nishina Center, TOMOHIRO USEKAI, Center for Nuclear Study, Graduate School of Science, University of Tokyo, HIDEYUKI SAKAI, Department of Physics, University of Tokyo, SHARAK COLLABORATION — We are developing Low-Pressure Multi-Wire Drift Chambers (LP-MWDCs) as tracking detectors of light heavy ions with $Z = 1$–8 at 100–300 $\text{MeV}$ in RIKEN RI Beam Factory (RIBF). The thickness of the LP-MWDCs is designed to be about 20–30 $\mu\text{m}$, with respect to the $\alpha$-rays. The isobutane gas is used at a pressure of 10 kPa. In order to discriminate signals of the ions from the ones of electrons and heavy nuclei, we measure the energy loss and the stopping position of particles in the DSSDs. Then $\beta$ decay is detected by the DSSDs. Clover-type Ge detectors are arranged around DSSD to measure an energy of $\beta$-delayed gamma-ray. To veto the $\beta$-ray, thin plastic scintillator is placed on the front of each Clover. In addition, BGO, high-density scintillator, are arranged around each Clover to decrease background from Compton-scattering. We will report the performance test of these detectors and read out electronics with standard sources.

9:45 PM BC.00012 Development of ionization chamber for super-heavy elements, KAZUTAKA OZEKI, RIKEN Nishina Center for Accelerator-Based Science, TAKAYUKI SUMITA, Faculty of Science and Technology, Tokyo University of Science, KOJUJI MORIMOTO, AKIRA YONEDA, KOSUKE MORITA, RIKEN Nishina Center for Accelerator-Based Science — In the field of super-heavy elements, the direct measurements of atomic number $Z$ and mass number $A$ of produced nucleus is the most challenging tasks. One of the way to identify $Z$ and $A$ is to measure the energy loss per unit length $dE/dx$, and to measure total energy by stopping incident nucleus in a detector, respectively. $A$ is derived from the combination of total energy and velocity of the nucleus. In the region of our interest ($Z > 100$, $A > 250$), the density of electron-hole pairs or primary electrons is too high in semiconductor detector or even in normal gas detector, because of large $dE/dx$. Too high density of electron-hole pairs provokes the recombination of electrons and holes. As a result, the precise measurement of energy loss becomes almost impossible. In this work, we operate ionization chamber with low pressure to reduce the density of primary electrons. By this means, we try to measure the energy with a high degree of accuracy. Our first priority is to identify $A$ of super-heavy elements by measuring the total energy. In addition, Identifying $Z$ by measuring $dE/dx$ is also tried. At present, we engage a operation test using $\alpha$-source, and have a plan to examine operating characteristics for heavy ions. These results will be reported.
7:00PM BD.00001 φ(1020) Photo-production in Neutral Decay Channel \( \gamma p \rightarrow p' \phi \rightarrow p'K_SK_L \). HEGINH SERAYDARYAN, ODU, CLAS COLLABORATION — Using photo-production data on hydrogen target collected with CLAS detector at Thomas Jefferson National Accelerator Facility the \( \phi(1020) \) meson production cross-sections in the neutral decay channel \( \phi \rightarrow K_SK_L \) is obtained for the first time. The measured cross-section shows difference from the charged channel decay \( \phi \rightarrow K_L \). In this talk we present the cross-section and the \( t \) - slope for wide photon energy range \( E=1.6-3.6 \text{ GeV} \). The spin-density matrix elements were extracted in Helicity and Gottfried-Jackson frames.

7:15PM BD.00002 Photoproduction of the \( \phi \) meson on the neutron. ANNA MICHERDZINSKA, BARRY BERMAN, The George Washington University, CLAS COLLABORATION — The photoproduction of the \( \phi \) meson has attracted a lot of interest in the past decade. Due to the dominant \( s\pi \) component in the \( \phi \), quark-exchange mechanisms are expected to be strongly suppressed. This makes the photoproduction process an excellent tool to study gluon dynamics in its various manifestations. However, the mechanism of \( \phi \) photoproduction on the nucleon is not yet well understood. In order to differentiate between the various mechanisms proposed for \( \phi \) photoproduction, data for both differential cross sections and spin observables are needed. All existing experimental data come from \( \phi \) photoproduction on the proton, and there is only one published result currently available using a linearly polarized photon beam. There are no experimental results at all for \( \phi \) photoproduction on the neutron. Our \( g13 \) experiment, using the CLAS at Jefferson Lab, where both linearly and the circularly polarized photons were incident on a deuterium target, can provide such data. We are analyzing these large-kinematic-coverage data to extract both cross sections and angular distributions for the \( \gamma + n \rightarrow K^+ K^- + n \) reaction channel.

7:30PM BD.00003 ABSTRACT WITHDRAWN

7:45PM BD.00004 The extraction of \( \phi - N \) total cross section from \( d(\gamma, pK^+ K^- n) \) process. XIN QIAN, Duke University, CLAS COLLABORATION — In this talk, we will report on the first measurement of the differential cross section of \( \phi \)-meson photoproduction for the \( d(\gamma, pK^+ K^- n) \) exclusive reaction channel. The experiment was performed using a tagged-photon beam and the CEBAF Large Acceptance Spectrometer (CLAS) at Jefferson Lab. We carried out a combined analysis to extract the \( \phi - N \) total cross section, \( \sigma_{\phi N} \), using data from the \( d(\gamma, pK^+ K^- n) \) channel and those from a previous publication on coherent \( \phi \) production on the deuteron. The extracted \( \phi - N \) total cross section favors a value above 20 mb. This value is larger than the value extracted using vector-meson dominance models for \( \phi \) photoproduction on the proton.

8:00PM BD.00005 \( K^* \) photoproduction within Regge approach. SHO OZAKI, RCNP, Osaka University, HIDEKO NAGAHIRO, Nara Women’s University, ATUSHI HOSAKA, RCNP, Osaka University — Recently strangeness photoproduction has been of interest in hadron physics. Several photon facilities such as CLAS, LEPS, SAPHIR and CBELSA/TAPS have been providing rich and variety of data. The interesting phenomena are reported including the observation of the pentaquark. Also unexpected peak structures near the threshold are found in \( \phi \) photoproduction and in \( \Lambda \) resonance photoproduction. In order to understand those interesting phenomena, we have to understand a fundamental mechanism of the open strangeness photoproduction. In this contribution, we study \( K^* \) photoproduction within Regge approach in a gauge invariant manner. \( K^* \) is a vector meson like a \( \phi \) meson. In \( \phi \) photoproduction Pomeron contribution successfully reproduces various cross sections as well as spin observables. Therefore one can expect that Reggeons play an important role also in \( K^* \) photoproduction. We calculate the energy and \( t \) dependence of various cross sections and spin density matrices. We find that the energy dependence differs from that of the \( \phi \) photoproduction due to the different trajectories which are allowed in the reactions. In spin density matrices we find that there are obvious differences between our model with Regge phenomenology and the previous work based on the Feynman amplitude of the effective Lagrangian approach.

8:15PM BD.00006 Electroproduction of \( \pi^0 \) and \( \eta \) in the resonance region at high \( Q^2 \) with CLAS. MAURIZIO UNGARO, UCONN/JLAB, KYUNGSEON JOO, UCONN, CLAS COLLABORATION — We report the analysis of exclusive single \( \pi^0 \) and \( \eta \) electroproduction in the resonance region at Jefferson Lab in the \( Q^2 \) range 2 to 6 \text{ GeV}^2/c^2. A longitudinally polarized \( 5.75 \text{ GeV} \) electron beam was incident on a 5 cm long liquid Hydrogen target. The CLAS spectrometer at Jefferson Lab was used to detect the final state particles. The goal of this analysis is to extract \( \pi^0 \) and \( \eta \) c.m. differential cross sections over the entire 4\( \pi \) c.m. solid angle, up to \( W = 2 \text{ GeV} \), and their beam spin asymmetries.

8:30PM BD.00007 The Search for Exotic Mesons in \( \gamma p \rightarrow \pi^+ \pi^- \pi^- n \) System in Photoproduction with CLAS. CRAIG BOOKWALTER, Florida State University, CLAS COLLABORATION — In addition to ordinary \( q\bar{q} \) pairs, quantum chromodynamics (QCD) permits many other possibilities in meson spectra, such as gluonic hybrids, glueballs, and tetraquarks. Experimental discovery and study of these exotic states provides insight on the nonperturbative regime of QCD. Over the past twenty years, some searches for exotic mesons have met with controversial results, especially those obtained in the three-pion system. Prior theoretical work indicates that in photoproduction one should find gluonic hybrids at significantly enhanced levels compared to that found in pion production. To that end, the CLAS g12 run was recently completed at Jefferson Lab, using a liquid hydrogen target and tagged photons from a 5.71 GeV electron beam. The CLAS experimental apparatus was modified to maximize forward acceptance for peripheral production of mesons. The resulting data contains the world’s largest 3\( \pi \) photoproduction dataset, with \( \gamma p \rightarrow \pi^+ \pi^- \pi^- n \) events numbering in the millions. Early results describe the data quality, kinematics, and dynamics will be shown.

8:45PM BD.00008 The Neutron electromagnetic Form Factors at Large Momentum Transfer. BOGDAN WOJTESEKOWSKI, T.J.N.A.F, GORDON CATES, University of Virginia, RON GILMAN, Rutgers, The State University of New Jersey, BRIAN QUINN, Carnegie-Mellon University, SEAN R. RIORDAN, University of Virginia, SUPER BIGBITE COLLABORATION — Nucleon Form Factors provide powerful constraints on the Generalized Parton Distributions, which form a unified framework for a number of electromagnetic processes. Plans have been developed to measure the neutron electric and magnetic form factors at momentum transfers up to 10 and 18 \text{ GeV}^2, respectively. Experiments will be performed in JLab Hall A after the 12 GeV upgrade of the CEBAF accelerator, using the Super BigBite apparatus. In the talk we will present the proposed experimental setup and projected accuracy of the new measurements.
9:00PM BD.00009 Parity-Violating Asymmetry in the Nucleon to Delta Transition. CARISSA CAPUANO, College of William and Mary. G^0 COLLABORATION — The G^0 collaboration at Jefferson Lab has measured the parity-violating asymmetry of polarized electrons scattered inelastically from the proton. Data were obtained for inclusive pion electroproduction at a beam energy of 687 MeV, with the scattered electrons detected at backward angle ($\theta_e \sim 110^\circ$). These data will be used to extract the axial vector transition form factor $G_A^{\Delta}$ for $Q^2$ in the range $0.3 \text{ GeV}^2 < Q^2 < 0.4 \text{ GeV}^2$. $G_A^{\Delta}$ characterizes the intrinsic spin response of the nucleon during the transition to its first excited state, the $\Delta(1232)$. While previous measurements using charged current reactions have indirectly measured $G_A^{\Delta}$, the G^0 measurement represents the first direct determination of this quantity using a neutral current probe. Preliminary results will be presented.

Wednesday, October 14, 2009 7:00PM - 9:30PM – Session BE Mini-Symposium on Developments in Re-accelerated Rare Isotope Beam Physics

7:00PM BE.00001 Stopped and re-accelerated rare isotope beams at FRIB at MSU. GEORG BOLLEN, Michigan State University — FRIB, the US’s “Facility for Rare Isotope Beams” to be built at Michigan State University (MSU), will be based on a 400 kW, 200 MeV/u heavy ion driver linac. Once realized, FRIB will be a world-leading rare isotope beam facility. FRIB will provide a wide variety of high-quality beams of unstable isotopes at unprecedented intensities. Exciting research perspectives will be opened not only with fast, but also with stopped and reaccelerated beams. FRIB will be able to build on rare isotope beam capabilities that exist or under development at the NSCL. High-precision Penning trap mass measurements with stopped rare isotopes are successfully conducted since several years, laser spectroscopy is in preparation and ReA3, a modern reaccelerator, is presently being built.

7:30PM BE.00002 Reacceleration of rare isotopes at the NSCL - The ReA3 project. STEFAN SCHWARZ, GEORG BOLLEN, CHRIS COMPTON, MARC DOLEANS, WALTER HARTUNG, OLIVER KESTER, MIKHAIL KOSTIN, FELIX MARTI, PETER MILLER, XIAOYU WU, RICHARD YORK, QIANG ZHAO, NSCL/MSU — Rare-isotope beams in the energy range of a few 100 keV/u to up to several MeV/u allow for experiments such as low-energy Coulomb excitation and transfer reaction studies and for the precise study of astrophysical reactions. NSCL is currently constructing the so-called ReA3 expansion, a reaccelerator with design end energy of 3 MeV/u for $^{238}$U. The reaccelerator will be coupled to a gas stopper at the NSCL fragmentation facility to provide rare isotope beams of nuclides not available at ISOL facilities in this energy range. An Electron Beam Ion Source/Trap (EBIS/T) will be used to boost the acceleration process by providing highly charged ions at an energy of $\sim 12$keV/u. The charge breeder is followed by a room-temperature radiofrequency quadrupole (RFQ) and a series of superconducting linear accelerator structures housed in three cryo modules. The status of the re-accelerator project and the planned layout will be presented.

7:45PM BE.00003 RIPS upgrade and physics programs. HIDEKI UENO, AKIHIRO YOSHIMI, RIKEN Nishina Center, KOICHIRO ASAHI, Tokyo Tech — The upgrade of RIPS has been proposed in the phase-II program of RIKEN RI Beam Factory (RIBF) project. In this upgrade, the former fragment separator RIPS will be equipped with a new beam line that delivers beams of 115.4-MeV heavy ions extracted from the IRC cyclotron by skipping the final acceleration of SRC. This beam energy is high enough to produce radioactive isotope beams (RIBs) via the projectile-fragmentation reaction. Thus, compared with RIBs produced in the present AVF-RRC acceleration scheme, their production yield is drastically increased by this upgrade, especially in the mass region heavier than Kr. Remarkably, RIPS further enhances research opportunities on spin-related subjects such as nuclear structure studies through electromagnetic nuclear moments; it has been revealed that RIBs produced at this energy can be spin-oriented independently of their atomic and chemical properties. Also, the research subjects include not only nuclear moments but also material science by means, e.g., of the β-NMR, γ-PAD, γ-PAC, laser, and in-beam Mössbauer methods, because RIBs of this energy allow for a scheme to implant them into sample materials with limited thickness and thus stopped-RIB type experiments will be conveniently carried out.

8:00PM BE.00004 Precision laser and microwave spectroscopy of radioactive Be from a fragment separator RIPS. A. TAKAMINE, M. WADA, T. SONODA, T. NAKAMURA, Y. YAMAZAKI, N. KANAI, T.M. KOJIMA, T. KUBO, RIKEN, T. OKADA, Sophia University, P. SCHURY, University of Tsukuba, H. IIMURA, JAEA, I. KATAYAMA, KEK, S. OHTANI, University of Electro-Communications, H. WOLLNICK, University of Giessen, H.A. SCHUESSLER, Texas A&M University — Radioactive Be isotope beams from RIKEN RIPS at approximately 1 GeV were thermalized in an RF ion guide gas cell and extracted by a combination of DC and inhomogeneous RF electric fields. The extracted ions were transported via a carbon-OPIG to a linear RF trap located in UVH environment. They were further cooled down to $10^{-6}$ eV by laser cooling for precision atomic spectroscopy. The ground state hyperfine splitting of $^7$Be and $^{11}$Be were measured directly with accuracies of 10^{-7} by microwave-laser double resonance method. The optical transition frequencies for $2s_1/2-2p_3/2$ transition of $^7$Be, $^{11}$Be, $^{13}$Be, and $^{15}$Be ions were also measured with accuracies of $10^{-9}$ by laser-laser double resonance method. These experiments aim to independently measure the nuclear charge and magnetization radii by the isotope shift and the Bohr-Weisskopf effect, respectively, especially for one neutron halo nucleus $^{11}$Be. We discuss the RF-catcher ion guide technique and the results of spectroscopy experiments.

8:15PM BE.00005 OROCHI experiment - nuclear laser spectroscopy in superfluid helium for rare radioisotopes1. TAKESHI FURUKAWA, Tokyo Institute of Technology, OROCHI COLLABORATION — Spin and electromagnetic moments are one of the most important quantities for nuclear structure investigations. To determine those for rarely produced radioisotopes (RI), we now develop a new laser spectroscopic method on RI atoms stopped in superfluid helium (He II), named OROCHI (Optical Rb Atom Observation in Condensed Helium as Ion-catcher). The method enables us to measure the atomic Zeeman and hyperfine splittings in a rare isotope (yield: $< 1$ particle/sec) for the determination of the spin and moments, utilizing the absorption spectra characteristic of an atom immersed in He II To confirm the feasibility of the OROCHI method, we have demonstrated successful determinations of nuclear spins and moments for the stable Rb and Cs isotopes by measuring the Zeeman and hyperfine resonance in He II. Recently, we have also succeeded in producing high polarization in silver and gold atoms in He II using the characteristic spectra. In near future, we plan to measure the spins and moments of silver isotopes far from the stability line, including $^{94}$Ag, one of the heaviest N=Z nuclei. Details of the development and future prospect will be discussed.

1This work was supported by the G-COE Program “Nanoscience and Quantum Physics” of the Tokyo-Tech. and by Grant-in-Aid for JSPS.
8:30PM BE.00006 Fluorescence detection system for nuclear laser spectroscopy of Rb in superfluid helium, A. SASAKI, T. WAKUI, Tohoku Univ., T. FURUKAWA, Tokyo Inst. of Tech., M. KAZATO, Osaka Univ., M. WADA, T. SONODA, A. TAKAMINE, T. KOBAYASHI, M. NISHIMURA, H. UENO, A. YOSHIMI, N. AOI, S. NISHIMURA, Y. TOGANO, M. TAKECHI, RIKEN, Y. KONDO, Tokyo Inst. of Tech., A. HATAKEYAMA, Tokyo Univ. of Agr. Tech., Y. MATSUYA, Y. KATO, Meiji Univ., A. ODAHARA, T. SHIMODA, Osaka Univ., K. ASAIH, Tokyo Inst. of Tech., T. SHINOZUKA, Tohoku Univ., T. MOTOBAYASHI, Y. MATSUO, RIKEN — Laser spectroscopy in superfluid He (He II) is useful for determining the spins and moments of nuclei. We will apply this method, named ORICHI (Optical RI-atom Observation in Condensed Helium as Ion-catcher), to unstable nuclei. Because more photons of laser-induced fluorescence (LIF) from low-yield unstable nuclei should be observed, a highly efficient fluorescence detection system is indispensable to the project. We thus performed an optical simulation in order to maximize the detection efficiency while minimizing background count rates. The fluorescence detection system has been built based on the simulation results. As the first step of the project, we will perform an experiment to detect LIF from Rb atoms stopped in He II, using our fluorescence detection system. Details of the system and results of the off- and on-line experiments will be presented.

8:45PM BE.00007 Beam Cooling and Laser Spectroscopy (BECOLA) Project at NSCL1, K. MINAMISONO, B.R. BARQUEST, G. BOLLEN, P.F. MANTICA, D.J. MORRISSEY, R. RINGLE, S. SCHWARZ, NSCL/MSU — A new beam line for beam cooling and laser spectroscopy (BECOLA) has been designed and is being installed at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University. The BECOLA beam line will be capable of accepting ions of energy up to 60 keV. A linear Radio Frequency Quadrupole (RFQ) ion trap [1] will be used to cool and bunch the beam upstream of the BECOLA beam line. This beam line will have two dedicated experimental legs, one for collinear-laser spectroscopy with the bunched beam and another for polarization by optical pumping of low energy atoms/ions for β-NMR experiments. Initial studies at NSCL will include the measurement of μ, Q and (r^2) of light- and medium-mass refractory isotopes, using both the laser spectroscopy and the β-NMR technique. A frequency doubled light of Ti:Sapphire ring laser pumped by diode-pumped solid state laser will be used for spectroscopy and optical pumping for polarization. The present status of BECOLA beam line as well as the laser system will be presented.

1This work is supported by the National Science Foundation, Grant PHY06-06007.

9:00PM BE.00008 Electromagnetic Moments of ^28P, KENSUKU MATSUTA, M. MIHARA, D. NISHIMURA, M. FUKUDA, R. MATSUMA, Dep. of Physics, Osaka Univ., T. NAGATOMO, ICU, S. MOMOTA, K. OHI, Kochi Univ. of Tech., T. IZUMIKAWA, T. OHTSUBO, Y. NAMIKI, M. NAGASHIMA, Niigata Univ., D.M. ZHOU, Y.N. ZHENG, D.Q. YUAN, Y. ZUO, P. FAN, S.Y. ZHU, CIAE, A. KITAGAWA, M. KANAZAWA, M. TORIKOCHI, S. SATO, NIRS, T. SUMIKAMA, Tokyo Univ. of Tech. — In order to study nuclear structure of proton-rich nucleus ^28P (I^E=3^+, I_{1/2}=270.3 ms), electro magnetic moments of this nucleus have been measured. Obtained precise value of magnetic moment is |μ(28P)|=0.3115(34) μ_N. The experimental magnetic moment is much quenched from the Schenck value +0.88, but is well reproduced by the shell model value +0.306. To measure quadrupole moment, β-NMR has been observed on ^52P implanted in α-Al_2O_3. As a preliminary result, possible resonance was found around quadrupole frequency |ν_Q|=200 kHz, which corresponds to the quadrupole moment of about 120 mb, which is consistent with the shell model value.

9:15PM BE.00009 In-Beam Mössbauer Spectroscopy Using Heavy Ion Beams at HIMAC, M. MIHARA, Osaka Univ., K. KUBO, ICU, Y. KOBAYASHI, RIKEN, T. NAGATOMO, ICU, Y. YAMADA, Tokyo Univ. Science, W. SATO, Kanazawa Univ., J. MIYAZAKI, Nihon Univ., S. SATO, A. KITAGAWA, NIRS. — The in-beam Mössbauer spectroscopy, in which a short-lived probe nucleus is introduced into a material for on-line measurement, has been applied to materials science and chemistry, because it has unique advantages in investigating microscopic behavior of extremely dilute impurity atoms or exotic chemical states in solids. The short-lived nucleus ^57Mn (I_{1/2}=1.47 m) is useful for the Mössbauer spectroscopy of ^57Fe which is created following the β decay of ^57Mn. We have started to develop a ^57Mn secondary beam as the Mössbauer probe at Heavy Ion Accelerator in Chiba (HIMAC) in National Institute of Radiological Sciences (NIRS). The ^57Mn nuclei produced through the projectile fragmentation of ^59Co and ^58Fe beams at 500 MeV/nucleon were separated by a fragment separator and were implanted into samples. Clear Mössbauer spectra of ^57Fe in some materials were successfully observed under suppression of background events by anti-coincidence with beam-pulse and β-ray signals.

Wednesday, October 14, 2009 7:00PM - 10:00PM – Session BF Mini-Symposium on Electromagnetic Form Factors - from the Nucleon to Nuclei

Kohala 3

7:00PM BF.00001 Electromagnetic Form Factors - from Nucleon to Nuclei, KEES DE JAGER, Jefferson Lab — An overview will be given of recent results in both experiment and theory in the field of electromagnetic form factors. The development of polarized electron beams with high polarization at high current and of polarized targets and recoil polarimeters with large figures of merit has resulted in a wealth of new and accurate data for the charge form factor of the proton and for the charge and magnetic form factor of the neutron with a tremendous impact on our understanding of the structure of the nucleon, especially of the importance of the quark angular momentum. An significant side effect has been a renewed study of the influence of two-photon exchange on the form factors. New data on the form factors of nuclei have been scarce, but recent developments at electron storage rings have shown the feasibility of future measurements of the charge radii of short-lived isotopes.

7:30PM BF.00002 Generalized Parton Distributions from Nucleon Form Factors and Applications, PETER KROLL, University of Wuppertal — The extraction of the zero-skewness generalized parton distributions (GPDs) for valence quarks from data on the nucleon form factors will be reviewed. Results for the GPDs, their moments and quark orbital angular momenta as well as for the quark densities in the impact parameter plane will be presented. Applications of the zero-skewness GPDs to wide-angle Compton scattering and to polarization effects in exclusive meson electroproduction will also be discussed. Finally, implications of the recent JLab measurements of the electric and magnetic form factors of the neutron on the GPDs will be mentioned.

7:45PM BF.00003 Baryon resonance electromagnetic transition form factors in a light-cone model1, SIMON CAPSTICK, Florida State University, BRADLEY KESTER, National Science Foundation — Calculations using a constituent quark model of the electromagnetic form factors for transitions between nucleons and excited states of the nucleon with J=1/2 and 3/2, including the Roper resonance, are described. These form factors are calculated with a relativistic model based on light-cone dynamics, fit to the proton and neutron elastic form factors, and using wave functions determined from the solution of a realistic three-quark Hamiltonian.

1This work is supported in part by the US Department of Energy under contract DE-FG05-92ER40750.
8:00PM BF.00004 The Gep-III Experiment at Jefferson Lab Hall C, EDWARD BRASH, Christopher Newport University and Jefferson Lab, THE JEFFERSON LAB HALL C GEP-III COLLABORATION — Measurements of the elastic electric and magnetic form factors of the proton, $G_E$ and $G_M$, respectively, at large momentum transfer, $Q^2$, shed new light on its internal nonperturbative structure. The ratio, $R_p = G_E G_p/G_M$, where $G_p$ is the proton magnetic moment, has been measured extensively over the last decade at the Jefferson Laboratory, using the polarization transfer method, where one measures $R_p$ directly by measuring the ratio of transverse to longitudinal polarizations of the recoiling proton in elastic electron-scattering processes. These data have revealed that the ratio decreases approximately linearly with increasing $Q^2$ above a $Q^2 \approx 1$ GeV$^2$. At the same time, they are in disagreement with previous results obtained using the Rosenbluth method based on cross section measurements. The polarization transfer results are of unprecedented high precision and accuracy, due in large part to the small systematic uncertainties associated with the experimental technique. Most recently, the Gep-III Experiment was completed in June of 2008 in Hall C at Jefferson Laboratory. It extends the $Q^2$-range from 5.6 to 8.5 GeV$^2$. In this presentation, I will review the status of the proton elastic electromagnetic form factor data, including the latest results from the Gep-III experiment, and discuss a number of theoretical approaches to describing nucleon form factors.

8:15PM BF.00005 The GEp-2γ Experiment at Jefferson Lab Hall-C, MEHDI MEZIANE, The College of William & Mary, THE JEFFERSON LAB HALL-C GEP-2γ AND GEP-III COLLABORATION — Intensive theoretical and experimental efforts have been made over the past decade aiming at explaining the discrepancy between the data for the proton form factor ratio, $G_E/G_M$, obtained at Jefferson Lab using polarization transfer technique, and the world data obtained by the Rosenbluth method based on cross section measurements. One possible explanation for this difference is a two-photon exchange contribution, where both photons share the momentum transfer about equally. In the Born approximation for a fixed $Q^2$, the form factors do not depend upon the energy of the incident electron as they are relativistic invariants. We will report the results of the Jlab Hall-C GEp-2γ experiment which was designed to measure a possible kinematical variation of the ratio $G_E/G_M$ with statistical uncertainties of $\pm 0.01$ at $Q^2 = 2.5$ GeV$^2$, using the recoil polarization technique. Three kinematics were chosen, corresponding to values of the kinematic factor $\epsilon = 0.15, 0.63$ and 0.77. We will describe the new detectors built for both GEp-2γ and Gep-III experiments, the electromagnetic calorimeter BigCal which detected the scattered electron, and the focal plane polarimeter (FPP) which measured the polarization of the recoil proton.

8:30PM BF.00006 Transverse Beam Spin Asymmetries at Backward Angles in $G^0$, JULIETTE MAMMEL, Virginia Tech, G0 COLLABORATION — Transverse beam spin asymmetries in elastic electron-nucleon scattering arise due to the interference of the imaginary part of the two-photon exchange amplitude with that of a single photon. Two-photon exchange processes have received renewed interest because the inclusion of the real part of the two-photon exchange amplitude in the electron scattering cross section may account for the difference between polarization transfer measurements and unpolarized cross section measurements of the ratio of $G_E/G_M$. By measuring the beam-normal single-spin asymmetry, we are testing the theoretical framework used to calculate two-photon exchange effects as well as related $\gamma Z$ and $W^\pm W^\mp$ box diagrams that are important corrections to precision electroweak measurements. During the $G^0$ program, which ran in Hall C at Jefferson Lab, asymmetry data for (quasi-)jelastion electron scattering with a transversely polarized electron beam were collected for four target and beam energy combinations at backward ($\sim 108^\circ$) angles - hydrogen and deuterium at 362 and 687 MeV. Results for the asymmetries from hydrogen will be presented and compared with available theoretical models. Results from deuteron, which can be used to extract a transverse asymmetry for the neutron after appropriate corrections, will also be presented.

8:45PM BF.00007 Precision Measurements of the Proton Electromagnetic Form Factors at Low Transferred Momenta, SHALEV GILFOYLE, University of Richmond, JEFFREY LACHNIT, Carnegie Mellon University, WILLIAM BROOKS, Universidad Tecnica Federico Santa Maria, BRIAN QUINN, Carnegie Mellon University, MICHAEL VINEYARD, Union College, CLAS COLLABORATION — The neutron elastic magnetic form factor $G_M^n$ has been extracted from quasielastic scattering from deuterium in the CBELAF Large Acceptance Spectrometer at Jefferson Lab. The kinematic coverage of the measurement is continuous from 1 (GeV/c)$^2$ to nearly 5 (GeV/c)$^2$ in four-momentum transfer squared and eclipses the previous data in this region. High precision was achieved with a ratio technique, where many uncertainties cancel, and a simultaneous in-situ calibration of the neutron detection efficiency, the largest correction to the data. Neutrons were detected using the CLAS electromagnetic calorimeters and the time-of-flight scintillators. Data were taken at two different electron beam energies, allowing up to four semi-independent measurements of $G_M^n$ to be made at each value of $Q^2$. The dipole parameterization is found to provide a good description of the data for $Q^2 > 1$ (GeV/c)$^2$. The impact of these new data on the world data for $G_M^n$ will be presented.

This work is supported by the US Department of Energy (contract DE-FG02-96ER40980).

9:00PM BF.00008 Precise Measurement of the Neutron Magnetic Form Factor in the Few-GeV$^2$ Region, GERARD GILFOYLE, University of Richmond, JEFFREY LACHNIT, Carnegie Mellon University, WILLIAM BROOKS, Universidad Tecnica Federico Santa Maria, BRIAN QUINN, Carnegie Mellon University, MICHAEL VINEYARD, Union College, CLAS COLLABORATION — The neutron elastic magnetic form factor $G_M^n$ has been extracted from quasielastic scattering from deuterium in the CBELAF Large Acceptance Spectrometer at Jefferson Lab. The kinematic coverage of the measurement is continuous from 1 (GeV/c)$^2$ to nearly 5 (GeV/c)$^2$ in four-momentum transfer squared and eclipses the previous data in this region. High precision was achieved with a ratio technique, where many uncertainties cancel, and a simultaneous in-situ calibration of the neutron detection efficiency, the largest correction to the data. Neutrons were detected using the CLAS electromagnetic calorimeters and the time-of-flight scintillators. Data were taken at two different electron beam energies, allowing up to four semi-independent measurements of $G_M^n$ to be made at each value of $Q^2$. The dipole parameterization is found to provide a good description of the data for $Q^2 > 1$ (GeV/c)$^2$. The impact of these new data on the world data for $G_M^n$ will be presented.

9:15PM BF.00009 Measurements of the Electric Form Factor of the Neutron at High Momentum Transfer, SEAMUS RIORDAN, University of Virginia, E02-013 COLLABORATION — The electromagnetic form factors of the neutron provide experimental access to the underlying charge and magnetic momentum distributions of quarks. These form factors provide excellent testing grounds for QCD and QCD-inspired models and are of fundamental importance in our understanding of non-perturbative QCD. Of the four nucleon form factors, the electric form factor of the neutron, $G_E^n$, has been measured in the smallest range of momentum transfer. We have measured the electric form factor of the neutron at four $Q^2$ points between 1.2 and 3.5 GeV$^2$ in Hall A at Jefferson Lab. This more than doubles the momentum transfer region for which this quantity has previously been measured, providing new information on the structure of the neutron. Final results for $G_E^n$ at three $Q^2$ points, 1.7, 2.5 and 3.5 GeV$^2$, will be presented and compared with QCD-based models and phenomenological approaches.

9:30PM BF.00010 The $^3$He($e, e'\nu$) Channel in $A_y$ and $G_E^n$ Measurements, ELENA LONG, Kent State University, JEFFERSON LAB HALL A E05-102 COLLABORATION, JEFFERSON LAB HALL A E08-005 COLLABORATION — Experiments E05-102 and E08-005 involved measurements of electron scattering from polarized $^3$He reactions that have been conducted in Jefferson Lab’s Hall A this past year. E08-005 measured the Target Single-Spin Asymmetry $A_y$ in the quasi-elastic $^3$He($e, e'\nu$) reaction. Plane wave impulse approximation (PWIA) predicts that $A_y$ should be exactly zero. A previous experiment at $Q^2 = 0.2$ (GeV/c)$^2$, where Laget and Nagorny predict $A_y$ to be small, showed a large asymmetry as predicted by Faddeev calculations. The recent experiment measured this asymmetry at $Q^2 = 0.1$ (GeV/c)$^2$, 0.5 (GeV/c)$^2$ and 1.0 (GeV/c)$^2$. This is the first measurement of $A_y$ at large $Q^2$, which is another region where $A_y$ is expected to be small. Any non-zero result is an indication of effects beyond impulse approximation. During E05-102, a parasitic measurement of the electric form factor of the neutron ($G_E^n$) was taken using the $^3$He($e, e'\nu$) channel at $Q^2$ of 0.4 (GeV/c)$^2$, 0.5 (GeV/c)$^2$ and 1.0 (GeV/c)$^2$. An overview of these measurements will be presented.
9:45PM BF.00011 Recent results and future perspectives from the CB@MAMI programme\textsuperscript{1}. EVANGELINE JOY DOWNIE, Institut f"{u}r Kernphysik, Johannes Gutenberg-Universit"{a}t, Mainz, Germany, A2 COLLABORATION\textsuperscript{2} — The CB@MAMI four-pi spectrometer setup at the A2 Tagged Photon Facility in Mainz, Germany was installed in 2003. Since that time, a series of successful experiments have taken place studying a range of topics from the accurate determination of the eta slope parameter to photon asymmetries in neutral pion threshold photo production. The quality of these results is made possible by the large solid angle coverage of the CB and TAPS spectrometer arrangement in conjunction with the Edinburgh PID detector and two Multi-Wire Proportional Chambers for charged particle identification and tracking. An overview of the Crystal Ball experimental setup will be given and a selection of the physics results that are complete and in production will be shown. The future perspectives for the experiment after the successful MAMI and Glasgow Photon Tagger upgrade to 1.5 GeV and the imminent installation of the Mainz Frozen Spin target will be presented.

\textsuperscript{1}Funded by DFG through SFB443.

\textsuperscript{2}Institut f"{u}r Kernphysik, Johannes Gutenberg-Universit"{a}t, Mainz, Germany

Wednesday, October 14, 2009 7:00PM - 10:00PM – Session BG Mini-Symposium on Nuclear Physics in Stars I Kings 2

7:00PM BG.00001 Constraints on Nuclear Astrophysics from Presolar Stardust in Meteorites. LARRY NITTLER, Carnegie Institution of Washington — Meteorites contain presolar grains of stardust, solid condensates from previous generations of stars that survived destructive processes in interstellar space and the early solar system and can now be studied in detail in the laboratory. They are identified on the basis of extremely unusual isotopic compositions, which directly reflect nuclear processes in their parent stars as well as Galactic Chemical Evolution. They thus can provide important information for nuclear astrophysics, complementary to astronomical observations, but in many cases with much higher analytical precision. A large number of types of presolar grains, including elemental C and various carbides, oxides and silicates have now been identified. Based on comparisons with astronomical observations and theoretical models, a diversity of stellar sources has been identified for the grains including AGB stars, supernovae, and novae. The grain isotopic compositions have provided a wealth of new constraints on nuclear processes in these environments as well as on stellar and galactic evolution. This talk will review the current status of presolar grain studies as they apply to nuclear astrophysics.

7:30PM BG.00002 Study of the $^{14}$O + $\alpha$ reaction at low energy. T. HASHIMOTO, S. KUBONO, H. YAMAGUCHI, S. HAYAKAWA, N.B. DAM, D. KAHL; Center for Nuclear Study, The University of Tokyo, T. KAWABATA, Kyoto University, Y. WAKABAYASHI, JAEK, N.H. LEE, A. KIM, M.H. HAN, J.S. YOO, K.I. HAHN, Ewha Womans University, Y.K. KWON, C.S. LEE, Chung-Ang University, T. TERANISHI, Kyushu University, S. KATO, Yamagata University, T. KOMATSUBARA, University of Tsukuba, B.X. WANG, B. GUO, G. BING, Y.B. WANG, W.P. LIU, CIAE — The $^{14}$O($\alpha$, $p$)$^{17}$F stellar reaction is one of the key reactions for the breakout from the Hot–CNO cycle to the rp–process. Since the cross sections depend on the product of $\alpha$ and proton widths of the intermediate states in $^{18}$Ne, it is important to determine these widths. We performed an experiment of the $^{14}$O + $\alpha$ scattering with a thick target method at the CNS Radioactive Ion Beam (CRIB) facility. The experiment was carried out using a thick Helium gas target and position sensitive silicon telescopes. This measurement provides an excitation function of $^{14}$O + $\alpha$ scattering for an energy range of E(\text{cm}) = 1.7 – 5.9 MeV. We will concentrate on the elastic scattering channel in this presentation, since the $\alpha$–cluster structure in $^{18}$Ne above the $\alpha$ – threshold would play an important role for the stellar reaction. Several $\alpha$ – resonances were observed in the present experiment. The experimental result will be presented, and the $\alpha$ cluster structure in $^{18}$Ne and the significance to the stellar reaction will be discussed.

7:45PM BG.00003 Triple-$\alpha$ Process in Hot Astrophysical Scenarios. N.R. PATEL, U. GREIFE, CO School of Mines, K.E. REHM, C.M. DEIBEL, J. GREENE, D. HENDERSON, C.L. JIANG, B.P. KAY, H.Y. LEE, R. PARDO, K. TEH, Argonne National Laboratory, S.T. MARLEY, Western Michigan University, M. NOTANI, X.D. TANG, University of Notre Dame — The production of carbon in red giant stars relies significantly on the 1$^{st}$ 0$^{+}$ excited state of $^{12}$C at 7.65 MeV (the Hoyle state). The recent NACRE listing assumes a 2$^{+}$ resonance at 9.1 MeV which could be considered as the 2$^{nd}$ member of a deformed rotational band built on the Hoyle state. At temperatures of several billion Kelvin in explosive scenarios like supernovae where the 3$\alpha$ process is also relevant, this state would increase the astrophysical reaction rate by an order of magnitude. In order to determine the reaction rate of $^{12}$C + $^{12}$C, we performed a long run at the ATLAS in-flight facility at Argonne. The decay of $^{12}$C$^{*}$ into three alphas were detected in a twin ionization chamber, acting as a 4$\pi$ calorimeter. This minimized the effect of $\beta$-summing and allowed us to investigate the minimum between the 1$^{st}$ and the 2$^{nd}$ 0$^{+}$ state with much better accuracy than previously possible. An R-Matrix analysis was performed to determine an upper limit on the 2$^{nd}$ resonance in the 8-11 MeV region. Our data analysis thus far shows no evidence of a 2$^{nd}$ state in this region. This work is supported by U.S. DOE, and NSF grants.

8:00PM BG.00004 Present status of direct $^{4}$He($^{12}$C,$^{16}$O)$\gamma$ measurement near stellar energy at KUTL. KUNIHIRO FUJITA, JPS, KENSHI SAGARA, TAKASHI TERANISHI, TAKASHI GOTO, RIE IWABUCHI, SAYAKA MATSUDA, KEIJU NAKANO, NOZOMI OBA, MASAHIKO TANIGUCHI, HIROYUKI YAMAGUCHI — A $^{12}$C + $^{4}$He reaction plays a very important role in evolution of heavy stars. The cross section is, however, still unknown in spite of more than 40 years experiment in the world because of its quite low value. We are planning to measure the cross section with the direct detection of the produced $^{16}$O from E($\gamma$) = 2.4 down to 0.7 MeV by using a pulsed $^{12}$C beam and a windowless $^{3}$He gas target. Detection of $^{16}$O is the most possible method since detection efficiency of $^{12}$C recoils is very high. A new blow-in gas target was developed to achieve $^{3}$He pressure of 24 Torr, and the target thickness along the beam axis was measured by $\mu$+He scattering. Using many movable slits installed in a recoil mass separator, backgrounds generated by the $^{12}$C beam were eliminated effectively. Present experiment at E($\gamma$) = 1.5MeV is reported.

8:15PM BG.00005 Thick target measurement of the $^{40}$Ca($a$,$g$)$^{44}$Ti reaction rate. S.A. SHEETS, J.T. BURKE, D. BLUEUL, T.A. BROWN, P.G. GRANT, R.D. HOFFMAN, A.M. HURST, J.L. FISKER, Lawrence Livermore National Laboratory, E.B. NORMAN, University of California, Berkeley, L.W. PHAIR, Lawrence Berkeley National Laboratory. The thick-target yield for the $^{40}$Ca($a$,$\gamma$)$^{44}$Ti reaction has been measured for E\textsubscript{beam} = 4.13, 4.54, and 5.36 MeV using $\gamma$-ray spectroscopy. At the highest beam energy, an activation measurement was performed. The results of the two measurements agree. From the measured yield a reaction rate is deduced that is smaller than current statistical-model calculations. This implies a smaller $^{44}$Ti production in supernova compared to recently measured $^{40}$Ca($a$,$\gamma$)$^{44}$Ti reaction rates.
8:30PM BG.00006 Astrophysical measurements with radioactive 17F beams at HRIBF1, D. W. BARDAYAN, C. D. NESARAJA, S. D. PAIN, M. S. SMITH, ORNL, K. A. CHIPS, U. GREIFIE, Col. School Mines, J. C. BLACKMON, LSU, K. Y. CHAE, B. H. MOAZEN, S. T. PITTMAN, U. Tenn., R. HATARIK, W. A. PETERS, Rutgers, R. L. KOZUB, J. F. SHRINER, JR., Tenn. Tech., C. MATEI, ORAU — The astrophysical rates of the 14O(α,p)17F and 17F(p,γ)31Ne reactions affect the transition to the αp-process in x-ray bursts and 16F production in novae, respectively. Both reactions have been studied in the laboratory with the intense radioactive 17F beams delivered at HRIBF. Recently beam intensities greater than 107 17F ions/s have become available, making possible the first direct measurement of the 17F(p,γ)31Ne cross section [K. A. Chips et al., Phys. Rev. Lett. 102, 152502 (2009)]. These high beam intensities also provide an opportunity to make the first precise determination of the resonance strength of the 18O(α,p)17F resonance near Ec,m = 1 MeV. Recent results and upcoming plans for measurements with 17F beams at the HRIBF will be presented.

1ORNL is managed by UT-Battelle, LLC, for the U.S. DOE under contract DE-AC05-00OR22725.

8:45PM BG.00007 Probing Nucleosynthesis in Novae: 22Na(p,γ)23Mg, A. L. SALLASKA, D. W. STORM, T. A. BROWN, A. GARCIA, University of Washington, C. RUIZ, D. F. OTTEWELL, TRIUMF, C. WREDE, K. SNOVER, K. DERYCKX, University of Washington, D. A. HUTCHEON, L. BUCHMANN, C. VOCKENHUBER, TRIUMF, J. A. CAGGIANO, PNNL — Orbiting gamma ray telescopes have yet to observe the elusive 23Na isotope. More sensitive observatories are planned. Present uncertainties in the dominant destructive reaction, 22Na(p,γ), suggest new measurements in the proton energy range of 150 to 300 keV are needed to clarify the predictions of the amount of Na which have been detected by orbital satellite. This important reaction was directly studied at astrophysically relevant energies (E_{lab} ≳ 490 keV/μ) by the DRAGON collaboration during the summer and fall of 2008. However, due to limitations of the ISAC facility, the experiment was complicated by a 22Na contamination ranging from 2 to 5000 times more intense than the 23Mg component. To compensate, a new local time-of-flight system and a multi-segmented ion chamber were used for particle identification. This talk will present and discuss some details of the experiment and the results to date.

9:00PM BG.00008 First direct measurement of 23Mg(p,γ)24Al with DRAGON, L. ERIKSON, Colorado School of Mines, DRAGON COLLABORATION — During explosive nucleosynthesis, the 23Mg(p,γ)24Al capture reaction may function as a breakout from the NeNa to the MgAl cycles. Depending on the resonance strength and energy, such a breakout could substantially affect the production of 26Al and 22Na which have been detected by orbital satellite. This important reaction was directly studied at astrophysically relevant energies (E_{lab} ≳ 490 keV/μ) by the DRAGON collaboration during the summer and fall of 2008. However, due to limitations of the ISAC facility, the experiment was complicated by a 22Na contamination ranging from 2 to 5000 times more intense than the 23Mg component. To compensate, a new local time-of-flight system and a multi-segmented ion chamber were used for particle identification. This talk will present and discuss some details of the experiment and the results to date.

9:15PM BG.00009 Photoexcitation of Astrophysically Important States in 26Mg, RICHARD LONG-LAND, UNC-Chapel Hill, RICHARD DEBOER, University of Notre Dame, CHRISTIAN IILIADIS, UNC-Chapel Hill, GENCHO RUSEV, ANTON TONCHEV, Duke University, MICHAEL WIECHER, University of Notre Dame — The 22Ne(α,n)25Mg reaction is an important source of neutrons for the s-process in massive stars and Asymptotic Giant Branch (AGB) stars. Spin-parity ambiguities of levels in the 26Mg compound nucleus result in large uncertainties in the reaction rates at temperatures relevant to these environments. We report the results of a nuclear resonance fluorescence experiment at the High Intensity γ-ray Source (HI-γS) that used a linearly polarised photon beam to populate levels in 25Mg at astrophysically important excitation energies. High precision excitation energies, branching ratios, and unambiguous spin-parities were assigned to five levels between Eγ = 10.5 and 11.2 MeV. We will discuss the Eγ = 630 keV resonance, which, contrary to previous findings, has been found to have unnatural parity, and thus does not contribute to the 22Ne(α,n)23Na reaction. In addition, two natural parity states, located below the neutron threshold, are expected to reduce rate uncertainties for the competing 22Ne(α,n)23Na reaction significantly.

9:30PM BG.00010 Investigation of the 30S(p,γ)31Cl reaction via Coulomb dissociation, YASUHIRO TOGANO, RIKEN Nishina Center, RNC R403N COLLABORATION — The Stellar reaction 30S(p,γ)31Cl was studied via Coulomb dissociation. The nucleus 30S is a candidate for the waiting point, which the reaction flow temporary stops at this nuclei, in the rapid proton capture (rp) process. The 30S(p,γ)31Cl reaction decreases the amount of 30S, and thus speeds the reaction flow of the rp process up. Therefore the strength of this reaction affects the resultant abundance and energy production in the rp process. No direct measurement of the 30S(p,γ)31Cl reaction has been made so far. The aim of the present work is to determine the secondary beam capture reaction rate of 30S(p,γ)31Cl from the result of Coulomb dissociation of 30S. The experiment was performed at the RIKEN Nishina Center. The secondary beam of 31Cl at 58 MeV/nucleon was produced and separated using the RIKEN Projectile Fragment Separator (RIPS). The beam of 31Cl bombarded a 208Pb target. The momentum vectors of the breakup products, the isotopes 30C and protons, were determined using the detectors located downstream of the target. The relative energy spectrum of 30S+p system was extracted using invariant-mass method. In this presentation, we discuss the unbound state of 31Cl which is relevant to the resonant capture in the 30S(p,γ)31Cl reaction.

9:45PM BG.00011 Beta-decay of proton-rich 31Cl and its relevance for explosive H-burning1, L. TRACHE, A. BANU, J. C. HARDY, V. E. IACOB, M. MCCLESKEY, B. ROEDER, E. SIMMONS, G. TABACARU, R. E. TRIBBLE, Texas A&M University, T. DAVISON, G. LOTAY, J. P. WOODS, University of Edinburgh, UK, A. SAASTAMOINEN, A. JOKINEN, J. AYSTO, University of Jyvaskyla, Finland — We have produced and separated proton-rich 31Cl with the MARS recoil separator at TAMU. Then studied its beta-gamma and beta-delayed proton-decay using techniques designed for low-intensity, short-lived sources. The states populated in the daughter nucleus 31S above the proton threshold at S_p=6133 keV are resonances in the proton capture reaction 31S(p,γ)32Cl, crucially important for the explosive H-burning novae. The setup consisted of a telescope made of a thin double sided Si strip detector (p-detector) BB2-45 and a thick Si detector (β-detector). A HpGe detector outside the chamber detected γ-rays. The source nuclei produced at about 32 MeV/u were slowed down, and implanted in the middle of the thin Si strip detector. The technique allowed us to measure very low proton energies (down to 2-300 keV), has shown a remarkable selectivity to β-delayed charged particle emission, and would work even at radioactive beam rates of a few pps. Furthermore, the half-life of 31Cl was measured with under 1% accuracy, its Isobar Analog State was located and from IMME its mass excess better determined.

1Supported by US DOE.
7:00PM BH.00001 High spin structure of the neutron-rich nucleus $^{139}\text{Cs}$, JOSEPH HAMILTON, SHAOHUA LIU, AKUNURI RAMAYYA, Y.X. LUO, J.K. HWANG, Vanderbilt University, A. COVELLO, A. GARZANO, N. ITACO, Complutense University of Monte S. Angelo, Napoli, Italy, J.O. RASMUSSEN, Lawrence Berkeley National Laboratory, A.V. DANIEL, G.M. TER-AKOPIAN, JINR, Dubna, Russia, S.J. ZHU, Tsinghua University, China, W.C. MA,Mississippi State University — High spin excited states in the neutron-rich nucleus $^{139}\text{Cs}$ were investigated from a study of the prompt $\gamma$ rays emitted in the spontaneous fission of $^{252}\text{Cf}$ with the Gammasphere detector array. Ten new excited levels with eighteen new deexciting transitions were observed and the level scheme of $^{139}\text{Cs}$ was extended up to 4670 keV. Spins and parities of levels in $^{139}\text{Cs}$ were firmly assigned up to 25/2 $^+$ based on measurements of the angular correlations and an internal conversion coefficient. Shell model calculations were performed to interpret the experimental results. A good agreement between theory and experiment was found in the level energies and the mixing ratio of the 995.4 keV transition. This agreement shows the power of the shell model expanded to this nucleus with five protons and two neutrons beyond the double magic $^{132}\text{Sn}$ core. The present experiment has provided further evidence for the similarity of the spectroscopy of the $N=84$ isotones, which is clearly born out by our study.

7:15PM BH.00002 Application of the E-Gamma Over Spin (E-GOS) Method to Rare Earth Region Nuclei, D.A. MEYER, K.R. DUDZIAK, Rhodes College — The E-GOS (E-Gamma Over Spin) Method [1] provides a purely empirical way to determine the structure of a nucleus as a function of its angular momentum. Investigation of structure as a function of angular momentum complements existing comparisons of structural evolution as a function of nucleon number. No initial assumptions about a nucleide's structure are necessary in the E-GOS Method. Ratios of the experimental energies of gamma ray transitions between two levels divided by the spin of the originating levels can be calculated and plotted versus the spin of the originating levels. In this work, we plotted E-GOS curves using the data for the yrast bands of nuclei from $Z=52$ to $Z=78$. We then compare the E-GOS curves to the ideal limits of a perfect harmonic vibrator and an axially symmetric rotor. Known structural changes in this well-studied region are clearly observed in the E-GOS curves.


7:30PM BH.00003 Gamma spectroscopy of $^{150}\text{Sm}$, L. BIANCO, P. GARRETT, University of Guelph, J. SHARPEY, P.E. GARRETT, University of Guelph — The transitional nucleus $^{152}\text{Sm}$ has been described as a "soft" nucleus with low-lying $\beta$- and $\gamma$-vibrational states [1] and with candidate octupole phonons [2]. Studies of the gamma spectrum of $^{150}\text{Sm}$ were performed using multiple spectroscopic techniques reveal two extensive families of rotational bands that are remarkably similar. This result suggests that coexisting shapes which strongly mix. A prescription of two-state mixing calculations are presented which describe the experimental level energies of the ground-state and first excited (0$^+$) state) rotational bands, electric monopole transition rates, electric quadrupole matrix elements, and the isomer shift of the first excited 2$^+$ state.

1Supported in part by USDOE contract DE-FG02-96ER40985 (Ga. Tech).

8:00PM BH.00005 Transition Strength Ratios in the Tetrahedral Candidate $^{152}\text{Sm}$, D.J. HARTLEY, USNA, L.L. RIEDINGER, UT, D. CURIEN, J. DUDEK, B. GALL, Strasbourg, J.M. ALLMOND, C.W. BEAUSANG, Richmond, M.P. CARPENTER, C.J. CHIARA, R.V.F. JANSSENS, F.G. KONDEV, T. LAURITSEN, E.A. MCCUTCHAN, I. STEFANESCU, S. ZHU, ANL, P.E. GARRETT, Guelph, W.D. KULP, J.L. WOOD, Georgia Tech, K. MAZUREK, Polish Academy of Sciences, M.A. RILEY, X. XUN, WANG, FSU, N. SCHUNCK, C-H. YU, ORNL, J. SHARPEY-SCHAFER, iThemba Lab, J. SIMPSON, Daresbury — A new symmetry has been recently proposed where nuclei may stabilize in a tetrahedral (pyramid) shape. One of the consequences of this symmetry is that the transition strength, $S$ ($E2$), of the inband transitions should approach zero in the ideal case. Thus, one signal of this exotic shape would be a rotational band where the inband $E2$ transitions are extremely weak or nonexistent. Such bands exist in many of the lowest negative-parity bands in the $N \approx 90$ nuclei, which is also a predicted "magic" region for tetrahedral symmetry. A Gammasphere experiment was performed to measure the $B(E2)/B(11)$ ratios of such a negative-parity band in $^{152}\text{Sm}$. The results (which are consistent with the theory) will be presented, as well as a discussion of the proposed follow-up experiment to directly measure the $B(E2)$ rates.

1Supported by the NSF (PHY-0554762) and DOE (DE-AC02-06CH11357).

8:15PM BH.00006 Multitude of bands in $^{152}\text{Dy}$, L.L. RIEDINGER, Univ. Tenn., D.J. HARTLEY, USNA, D. CURIEN, J. DUDEK, B. GALL, Univ. Strasbourg, M. ALLMOND, C. BEAUSANG, Univ. Richmond, M.P. CARPENTER, C.J. CHIARA, R.V.F. JANSSENS, F.G. KONDEV, T. LAURITSEN, E.A. MCCUTCHAN, I. STEFANESCU, S. ZHU, ANL, P.E. GARRETT, Univ. Guelph, W.D. KULP, J.L. WOOD, Georgia Tech, M.A. RILEY, X.F. WANG, FSU, N. SCHUNCK, C. H. YU, ORNL, J. SHARPEY-SCHAFER, S. MAJOLA, iThemba Lab, J. SIMPSON, Daresbury — A Gammasphere measurement was performed on rotational bands in $^{152}\text{Dy}$ using the $^{148}\text{Nd}(^{12}\text{C},4n)$ reaction at 65 MeV with the Atlas accelerator at Argonne. The projectile was chosen to populate many bands at low to medium spins. We have added new transitions and new bands to the family of negative-parity structures in this $N \approx 90$ nucleus. The lowest lying bands in this region have generally been associated with octupole vibrational modes, converting to two-quasiparticle bands at moderate frequencies. There are deviations from this picture in $^{152}\text{Dy}$, due perhaps to the robustness of the octupole vibration through the first band crossing.

1Supported by DOE (DE-AC02-06CH11357 and DE-FG02-ER49083).

8:30PM BH.00007 E0 transitions in the deformed nucleus $^{158}\text{Dy}$, E. WILLIAMS, WNSL, Yale University, New Haven, CT 06520 USA, T. KIBEDI, Department of Nuclear Physics, The Australian National University (ANU), Canberra, ACT 0200, Australia, V. WERNER, WNSL, G. DRACOULIS, ANU, T. ANH, R.J. CARSPERSON, WNSL, A. DEVLIN, ANU, A. HEINZ, G. ILIE, WNSL, A. JIA XIN TEH, J.C. LANE, ANU, D. MCCARTHUR, J. QIAN, A. SCHMIDT, WNSL, A.E. STUCHBERY, ANU, J.R. TERRY, WNSL — The physics governing large $E0$ strengths between the first excited collective $0^+$ state and the ground state. To test this prediction, and further explore the as of yet ill-understood structure of the $0^+$ state in rare earth nuclei, the deformed $^{158}\text{Dy}$ nucleus was populated via electron capture decay from $^{158}\text{Er}$ and $^{158}\text{Ho}$. Gamma-rays and internal conversion electrons were measured; internal conversion coefficients and $B(E0)/B(E2)$ ratios were obtained. Preliminary results of this work will be presented. Work supported by DOE grant number DE-FG02-91ER40609 and The ANU.
8:45PM BH.00008 Lifetime measurements of the yrast band states of \(^{184}\)Pt and \(^{186}\)Pt, DAVID MCCARTHY, WNSL, Yale University, New Haven, CT 06511, USA, VOLKER WERNER, J. RUSSELL TERRY, WNSL, ZVI BERANT, Nuclear Research Center Negev, Beer-Sheva, 84190 Israel, ROBERT CASPERSON, ANDREAS HEINZ, WNSL, GREG HENNING, Department of Physics, ENS de Cachan, 94230 Cachan, France, JING QIAN, ELIZABETH WILLIAMS, RYAN WINKLER, WNSL — Recoil distance Doppler-shifted data was taken in a plunger experiment investigating \(^{184}\)Pt and \(^{186}\)Pt. Lifetime measurements were made of yrast states ranging in spin from 4\(^+\) to 12\(^+\) in those nuclei using the differential decay curve method. Reduced transition strengths were calculated. This data was examined in the context of the Interacting Boson Approximation (IBA) model which has been found to give good predictions for both energy levels and branching ratios for nuclei in this region. A strong agreement with IBA predictions was found in the B(E2)s for \(^{184}\)Pt though the results seen in \(^{186}\)Pt, where lifetimes had not previously been measured, could not be said to be in similar agreement and require further interpretation.

9:00PM BH.00009 Investigation of excited states in Pt isotopes: \(^{188}\)Pt, \(^{192}\)Pt, \(^{194}\)Pt, G. ILIE, WNSL, Yale University, New Haven, CT 06520, USA, NIPNE, 76090 Bucharest, Romania, T. AHN, WNSL, D. BUCURESCU, NIPNE, R.J. CASPERSON, R.F. CASTEN, WNSL, R. CHEVRIER, D. MCCARTHY, WNSL, Univ. of Surrey, Guildford, GU27XH, UK, A. HEINZ, WNSL, S. HEINZE, IKP, Univ. of Koeln, D-50937 Koeln, Germany, R. HERTENBERGER, TUM, D-85748 Garching, Germany, D.A. MEYER, WNSL, Rhodes College, Memphis, Tennessee 38112, USA, D. MUCHER, P. PEJOVIC, C. SCHOLL, IKP, J.R. TERRY, V. WERNER, R. WINKLER, WNSL, H.-F. WIRTH, TUM — The Pt isotope chain is located in a transitional region between well-deformed rare-earth and the spherical nuclei near the doubly-magic \(^{208}\)Pb. They are known to exhibit a range of interesting structural phenomena. Platinum isotopes, \(^{188}\)Pt, \(^{192}\)Pt and \(^{194}\)Pt, were investigated in different reactions. Excited states in \(^{188}\)Pt were populated in \(^{9}\)\(^-\) decay and studied through off-beam \(\gamma\)-ray spectroscopy. The \(\gamma\) energies and decay properties of the low-lying levels were measured. A \((p, t)\) experiment was performed to study \(^{192}\)Pt and \(^{194}\)Pt. The \((p, t)\) reactions are particularly sensitive to \(0^+\) excited states. The purpose of these studies is to obtain information which can help to discriminate between alternative structural interpretations. Results of this work will be presented. Research was supported by the U.S. DOE under Grant No. DE-FG02-91ER-40609, MLL, and DFG (C4-G894/2-3, Je391/2-3).

9:15PM BH.00010 Nuclear photon scattering experiments by quasi-monochromatic, linearly polarized light sources, T. SHIZUMA, T. HAYAKAWA, JAEA, H. OHGAKI, Kyoto Univ., H. TOYOKAWA, AIST, T. KOMATSUBARA, Univ. of Tsukuba, N. KIKUZAWA, JAEA, A. TAMIZ, Osaka Univ., H. NAKADA, Chiba Univ. — Magnetic dipole (M1) transitions in atomic nuclei have attracted increasing attention in nuclear physics and nuclear astrophysics. The knowledge of the M1 response allows one to elucidate the details of nuclear dynamics. It is also important for the estimate current neutron-nucleus cross sections for supernova explosion, because of the close relationship between the M1 excitation and neutron-nucleus processes. Low-lying electromagnetic transitions can be studied by the method of nuclear resonance fluorescence (NRF) or photon scattering. Recently, it has been shown that quasi-monochromatic, linearly polarized photon beams from inverse laser Compton scattering has considerably increased experimental sensitivity and to enable one to detect the fine structure of relatively weak M1 transitions. In this report, results of the NRF measurements on \(^{208}\)Pb using a linearly polarized photon beam will be presented. The M1 resonance below the neutron separation energy is resolved into several individual transitions. The experimental results are compared with an estimation of self-consistent random phase approximation using a semi-realistic interaction.

9:30PM BH.00011 Compton Scattering on \(^{209}\)Bi at HI\(\gamma\)S From \(E_{\gamma} = 11 - 30\) MeV, S.S. HENSHAW, M.W. AHMED, N. BROWN, B.A. PERDUE, S. STAVE, H.R. WELLER, Duke U, TUNL, P.P. MARTEI, A. TEMYURAZYAN, R. MISKIMEN, UMASS, R.M. PRIOR, M.C. SPRAKER, NGCSU, R. PYWELL, USAak, G. FELDMAN, GWU, A.M. NATHAN, UIUC, S. WHISNANT, JMU — New data collected at the High Intensity \(\gamma\)-ray Source (HI\(\gamma\)S) were taken to investigate the Iso-Vector Giant Dipole (IVGDR) and Giant Quadrupole (IVGQR) Resonance Regions in \(^{209}\)Bi, \(E_{\gamma} = 11 - 30\) MeV. Linearly polarized \(\gamma\)-rays were incident upon an isotopically pure (\(\gamma\approx 99.9\%\)) \(^{209}\)Bi target and the scattered \(\gamma\)-rays were detected using the HI\(\gamma\)S NaI Detector Array (HINDA). HINDA is an array of large (10"x10") core detectors surrounded by 3" thick NaI shields that are segmented optically into 8 individual segments. This assembly was run in an anti-coincidence mode to reduce background and improve the resolution as well as a coincidence mode to isolate the first escape peak. During the 150 hour run, the nearly mono-energetic \(\gamma\)-ray intensities were \(1 \times 10^{32} - 1 \times 10^{33}\)/sec on target and statistical accuracies of 1-3% were achieved. Preliminary analysis of angular distributions of cross sections and analyzing powers as well as absolute cross sections will be reported. Supported by US DOE Grant Nos. DE-FG02-97ER41033, DE-FG02-03ER41231 and NSF Grant No. PHY-0619183.

9:45PM BH.00012 Spectroscopy of the N=126 Nucleus \(^{215}\)Ac, ANDREAS HEINZ, WNSL, Yale University, R. WINKLER, J. QIAN, J.R. TERRY, WNSL, Z. BERANT, Nucl. Res. Cent. Negev. M. BUNCE. University of Surrey, R.J. CASPERSON, R.F. CASTEN, WNSL, G. HENNING, Dep. of Physics, Ecole Normale Superieure de Cachan, A. SCHMIDT, V. WERNER, E. WILLIAMS, WNSL — The investigation of heavy nuclei becomes increasingly difficult because of the fact that cross sections for the production of fusion-evaporation residues decreases while the probabilities for background channels like fission increase dramatically. This is the reason for the lack of data on prompt gamma radiation of many heavy nuclei. Here we report on an experiment which used the gas-filled recoil separator SASSYER and recoil-decay tagging to study the semi-magic nucleus \(^{215}\)Ac in order to improve our understanding of the evolution of single-particles energies along the N=126 neutron shell. Results linking prompt gamma transitions with isomeric ones are presented and discussed in the framework of the shell model.

Wednesday, October 14, 2009 7:00PM - 10:00PM — Session BJ Mini-Symposium on Progress in Strangeness Physics I

7:00PM BJ.00001 Spectroscopy of S = -1 hypernuclei at KEK, BNL and J-PARC, HIROKAZU TAMURA, Tohoku University — The hypernuclear physics program at J-PARC will start soon. Taking this occasion, I will summarize what we have achieved in the spectroscopy of \(\Lambda\) hypernuclei at KEK-PS and BNL-AGS using meson beams, where the SKS spectrometer and the Ge detector array, Hyperball, have played essential roles. The \((\pi^+, K^-)\) reaction spectroscopy data in a wide mass range clearly demonstrated single-particle orbits of a \(\Lambda\) even in a heavy nucleus and revealed properties of the \(\Lambda\) s nuclear potential. Then almost full set of p-shell \(\Lambda\) hypernuclear gamma-ray data provided the strengths of each of the \(\Lambda N\) spin-dependent forces (spin-spin,spin-orbit, and tensor interactions). In addition, the \((\pi^+, K^-)\) reaction was successfully introduced to observe neutron-rich hypernuclei as well as to study \(\Sigma\)-nucleus interaction. Future perspectives at the J-PARC 50 GeV proton synchrotron are also discussed. At J-PARC, the K1.8 beam line and the SKS spectrometer are almost ready to get the first beam. We plan gamma-ray spectroscopy experiments covering a wide mass range, from \(^4\)He to sd-shell hypernuclei such as \(^5\)F, and then even heavier ones, using a newly-constructed Ge detector array, Hyperball-J. The \((\pi^+, K^-)\) spectroscopy of neutron-rich hypernuclei will be also exploited. One of the physics motivations of these experiments is to investigate the three-body \(\Lambda NN\) force caused by \(\Sigma N\)-\(\Lambda\) coupling. We also try to extend the hypernuclear chart toward the neutron drip line and to investigate possible modifications of deformation induced by a \(\Lambda\). In future, more \(S = -1\) hypernuclear experiments are also planned at the K1.1 beam line and the high-resolution pion beam line with the dispersion matching technique.
7:30PM BJ.00002 γ-ray spectroscopy of $^{11}_ΛB$ and $^{12}_ΛC$: Results of the KEK E566 experiment . MA YUE, E566 COLLABORATION — Bond excited states of $^{11}_ΛB$ and $^{12}_ΛC$ were populated following the $(p^+, K^+)^{12}_ΛC$ $^{11}_ΛB$-p reaction. The 12-GeV/c primary proton beam was provided by KEK-PS and the secondary p+ beams of 1.05 GeV/c were produced and momentum analyzed by the K6 beam line bombarding a 16.8-g/cm$^2$ Carbon target. A momentum of the scattered K+ was subsequently tracked by the SKS spectrometer system. γ rays from hypernuclei produced were detected by the Ge detector array, Hyperba2, which consisted of 14 standard closed-end-type and 6 Clover-type detectors each surrounded by BGO background suppressing counters. Construction of missing mass spectrum identified the bound state as well as the proton emitting unbound excited states of $^{12}_ΛC$, the latter leading to $^{11}_ΛB$. γ rays in coincidence with these regions were associated with the respective hypernuclei. Six γ-ray transitions, three of each belonging to $^{11}_ΛB$ and $^{12}_ΛC$, were observed. Cascade decays of $^{11}_ΛB(3/2^+ → 1/2^+ → 5/2^+)$ and the ground state doublet spacing of $^{12}_ΛC$ were newly identified from the present analysis. In addition, a 157-keV γ-ray from a hyperfragment of $^{12}_ΛC$ was observed. From the energy level spacings we check the consistency of the strength of spin-spin ($\Delta$) and nuclear-spin orbit (S$\gamma$) in the effective AN interaction of the p-shell hypernuclei. Results of the analysis and the discussion will be presented.

7:45PM BJ.00003 Shell model study of typical sd-shell hypernuclei . ATSUSHI UMEEYA, RIKEN, TOSHIKO TOMOTO, TORU HARADA, Osaka Electro-Communication Univ. — Theoretical and experimental studies of $s$- and $p$-shell hypernuclei have been performed and, in the future, experiments of sd-shell hypernuclei will be carried out at J-PARC. The level structures of sd-shell nuclei are richer and more complex than those of p-shell nuclei. For example, the states of $^{15}_ΛP$ have the following structures: (i) the energy difference between the 1/2$^−$ ground state and the 1/2$^−$ first-excited state is only 0.110 MeV and (ii) a rotational band is seen in the energy spectrum. Thus we are interested in effects of the AN interaction on the parity doublet and the rotational part of the sd-shell hypernuclei. Also, an effects of a positive pairing correlation in the AN interaction may reveal in the structures of the sd-shell hypernuclei because of the 0d$^{1/2}$ orbit with the higher spin. In this presentation, we will discuss the structures of $^{19}_ΛF$ and $^{20}_ΛF$ obtained by shell-model calculations with 0hω and 1hω model spaces.

8:00PM BJ.00004 The Impurity Effects in sd-Shell Λ Hypernuclei . MASAHIRO ISAKA$^1$, MASAAKI KIMURA, Hokkaido University, AKINOBU DOTE, KEK, AKIRA OHNISHI, YITP — In this talk we will report the impurity effects in sd-shell Λ hypernuclei based on the theoretical model of Antisymmetrized Molecular Dynamics (AMD). One of the unique aspects of hypernuclei is the structure change caused by hyperon as an impurity. In particular, we can expect the drastic structure change in sd-shell Λ hypernuclei, since several sd-shell nuclei have the coexistence of various structures within very small excitation energy. To study such impurity effects in detail, we have extended AMD for hypernuclei. Since this extended AMD does not make any assumption on cluster structure, it makes possible to investigate the difference of the impurity effect for the shell and cluster structure. We have studied the structure change of sd-shell hypernuclei by this model using YNG interaction. For example, in the case of $^{20}_ΛNe$, we have found that the addition of Λ has opposite effect to the preceding study. Such calculation has been performed for C, F, Ne hypernuclei and we will discuss the structure change and its dependence on the core state and the Λ particle orbital.

8:15PM BJ.00005 High Resolution Hypernuclear Spectroscopy by the (e,e'K$^+$) Reaction (JLab E01-011). AKIHKO MATSUMURA, Tohoku Univ., E01-011 COLLABORATION — Λ hypernuclear spectroscopy by the (e,e$'_K^+$) reaction is a powerful tool to investigate AN interaction because this reaction excites various states up to deep inside of hypernucleus and sub-MeV resolution can be achieved thanks to the high quality primary electron beam from CEBAF at JLab. The second generation hypernuclear spectroscopy at JLab Hall C, E01-011, was successfully performed in the summer of 2005 introducing High resolution Kaon Spectrometer (HKS) and a new configuration for scattered electron spectrometer. These unique techniques significantly improved both energy resolution and hypernuclear tagging efficiency, and we succeeded to study various hypernuclei including $^7_ΛHe$ and $^{28}_ΛAl$ with high resolution and sufficient statistics for the first time by this reaction. The analysis is now in the final stage and systematic errors of binding energy and cross section were estimated with a help of the detailed Monte Carlo simulation. The overview and recent result of E01-011 experiment will be presented in this talk.

8:30PM BJ.00006 Strength Functions for Photoproduction of Medium-Mass Hypernuclei . TOSHIKO TOMOTA, Osaka Electro-Communciation University, PETR BYDZOVSKY, MILOSLAV SOTONA, Nuclear Physics Institute, Prague, KAZUNORI ITONAGA, Gifu University, KENGO OGAWA, RIKEN, OSAMU HASHIMOTO, Tohoku University — Strength functions have been calculated for the photo-production of Λ-hypernuclei by choosing typical medium-mass nuclear targets such as $^{28}_Si$, $^{40}_Ca$, and $^{52}_Cr$. The DWIA framework has been adopted together with the modern amplitudes for the elementary $\gamma p → ΛK^+$ process for the targets with surface proton $jj$-closed orbit (or the similar situation), the unnatural parity high-spin states such as $4^−$, $5^−$, $6^−$ and $7^−$ are selectively excited due to the spin-flip dominant character of the elementary amplitudes. On the other hand, for the proton LS-closed target ($^{10}_Ca$), natural parity high-spin states are excited as well. In both cases, it is important to obtain well-separated clear spectra. The nuclear level fragmentation caused by the proton annihilation is taken into account. The theoretical spectrum predicted for the first target ($^{28}_Si$) proved to be in very good agreement with the result of recent analysis for the $^{28}_Si(e,e'K^+)^{28}_Al$ experiment done at JLab. Thus predictions for the latter two targets seem to give the promising and reliable spectra to encourage further extension of the $(e,e'K^+)$ experiments. Novel aspects of medium-mass hypernuclear spectroscopy will be discussed.

8:45PM BJ.00007 Mesonic decay of neutron-rich Λ hypernuclei . YOJI NAKAGAWA, KOUCHI HAGINO, Tohoku University — Although the pionic decay of Λ particle is suppressed in finite nuclei due to the Pauli principle, it still competes with the more dominant non-mesonic decay mode in light hypernuclei. In this contribution, we discuss the pionic decay of light neutron-rich Λ hypernuclei. To this end, we describe the structure of hypernuclei with the Skyrmion-Hartree-Fock method, and compute the decay rate with the single-particle wave function so obtained. We apply this method to various isospin states of $^{13}_ΛC$ to $^{22}_ΛO$. Our calculation indicates that the decay rate for the $p^+$ mode, $Λ → n + p^+$, increases as a function of mass number, while that for the $n^0$ mode, $Λ → n + n^0$, is largely suppressed as expected. This is due to the fact that the proton single-particle potential is deepened for neutron-rich nuclei because of a strong proton-neutron interaction. We will also discuss the effect of the final state interaction between $n$ meson and nuclei.

9:00PM BJ.00008 Study of double-Λ Hypernuclei at J-PARC (E07) experiment . KAZUMA NAKAZAWA, Gifu University, E07 (J-PARC) COLLABORATION — To study double strangeness system such as double-Λ hypernuclei and H-dibaryon, Hybrid-emulsion experiments with counter (E176) and scintillating-fiber (E373) have been performed for these twenty years. In the experiments, we have obtained nearly ten thousand events of $\Xi^−$ hyperon capture at rest in nuclear emulsion, and observed 8 events of sequential decay of light double-Λ hypernuclei and 5 events of twin hypernuclei. Recently, we succeeded to measure two Λ binding energies of $ΛΛ^0He$, $ΛΛ^1Be$ and $ΛΛ^1B$. However, very little is known for double-strangeness system.

In this talk, we present a quite improved experiment (E07 at J-PARC) with ten times’ statistics of the previous experiments. A new-generation hybrid-emulsion method is applied to search for double-Λ hypernuclei. In the experiment, we handle Double-sided Silicon Strip tracking Detector (DSSD) for precise detection of $\Xi^−$ hyperon in the emulsion, and huge amount of emulsion gel (2.6 tons). We also develop speedy scanning system to complete scanning of 10$^6$ $\Xi^−$ hyperons within a few years. It is expected that one million $\Xi^−$ hyperons produce about 10$^3$ double-Λ hypernuclear events in the emulsion. We will make a nuclear chart with double strangeness.
9:15PM BJ.00009 Analysis method for double-$$\Lambda$$ hypernuclear events. ASUKA SAWA, KAZUMA NAKAZAWA, Gifu University, HITORISHI TAKAHASHI, KEK, E373 COLLABORATION — To study hyperon-hyperon interaction, the experiment E373 was carried out at KEK-PS. $$\Xi^-$$ hyperons are produced via the $$p(K^-, K^+)$$$$\Xi^-$$ reaction, and double-$$\Lambda$$ hypernucleus were produced at a $$\Xi^-$$ stopping point as a fragment in the nuclear emulsion. Double-$$\Lambda$$ hypernuclear sequential decays via non-mesonic or mesonic weak interaction. So that, double-$$\Lambda$$ hypernuclear event has three vertices. Until now, we successfully found 7 double-$$\Lambda$$ hypernuclear events. The recoiled hyperfragments had only few $$\mu$$m track lengths in the emulsion, then we need the precision measurement. In this paper, we report detailed method of analysis and those results for two double-$$\Lambda$$ hypernuclear events which were successfully reconstructed as those ones. To reconstruct events we took pictures all tracks related the event every 0.1 $$\mu$$m depth, and obtained the brightness and position information. Using central values of brightness along the tracks, straight-line fitting has been made. Thus, production and decay vertices have been measured as intersection of the lines. Accoring to the above analysis, one event was found to be as a $$\Lambda\Lambda\Lambda\Lambda$$ events, and another one was uniquely identified as a $$\Lambda\Lambda\Lambda\Lambda\Lambda$$.

9:30PM BJ.00010 Observation of cascade weak decays of double hypernuclei, HITOSHI TAKAHASHI, Institute of Particle and Nuclear Studies, KEK, KEK-PS E373 COLLABORATION — A hybrid-emulsion experiment E373 has been carried out at the KEK 12 GeV proton synchrotron using a 1.66 GeV/c $$K^-$$ meson beam. The purpose of this experiment is to study double-strangeness systems produced via $$\Xi^-$$ hyperon capture at rest with ten times as large statistics as past experiments. We have completed emulsion scanning and have successfully found several events which include a sequential weak decay of a double hypernucleus. Among them, the results of the reconstruction of two events, "Demachiyanagi" and "Nagara", were already reported. However, the recent change of the mass of a $$\Xi^-$$ hyperon in particle listings by Particle Data Group affects the reconstructed binding energies of these events. The event reconstruction of two new events have been made. One of them, named "Mikage", was uniquely identified as a cascade weak decay of a $$\Lambda\Lambda\Lambda\Lambda\Lambda$$ event. The other event, "Hida", was reconstructed most likely as a decay of a $$\Lambda\Lambda\Lambda\Lambda\Lambda$$ event. In this talk, we will give updated values of the binding energies of the first two events, and present the reconstructed results of two new events. The result of the reanalysis of the event found in the previous hybrid-emulsion experiment E176 will be also reported.

9:45PM BJ.00011 Five-body structure of double $$\Lambda$$ hypernuclei, EMIKO HIYAMA, MASAYASU KAMIMURA, RIKEN, YASUO YAMAMOTO, TOSHIO MOTOBA, Osaka E.C. University — Recently, in KEK-E373 experiment, new double $$\Lambda$$ hypernucleus, ‘hida’ event, was reported. This observation is important to get information on $$\Lambda\Lambda$$ interaction. For study of structure of this $$\Lambda$$ hypernucleus, we perform five-body calculation of $$\alpha + \alpha + n + \Lambda + \Lambda$$ model. In this symposium, the level structure of this hypernucleus will be discussed.

Wednesday, October 14, 2009 7:00PM - 10:00PM – Session BK Applications of Nuclear Physics I Queens 5

7:00PM BK.00001 Proton-induced population of the isomeric state in Zr-89 using short-pulse, high-energy laser systems. MATTHEW GARDNER, ANDREW SIMONS, PETER THOMPSON, AWE, CHRISTOPHER ALLWORK, MICHAEL RUBERY, AWE/University of Surrey, ROBERT CLARKE, Rutherford Appleton Laboratory — Short-pulse (ps), high-energy laser systems can be used to accelerate electrons, protons and ions to high energies via laser-plasma interactions. Such protons are then capable of causing nuclear reactions within target materials, the subsequent decay of which may be measured using scintillation detectors. During one such experimental campaign, AWE’s HELEN laser system was used in chirped-pulse amplification (CPA) mode to produce individual laser pulses of $$\sim 100$$ J energy at an irradiance of $$10^{19}$$ W/cm$$^2$$. Protons were accelerated by these pulses from a thin aluminium foil target via the target-normal sheath acceleration (TNSA) mechanism, and were incident upon a target of Y-89. The Y-89( p,n)Zr-89* reaction was observed via the direct measurement of decay gammas emitted at 587 keV during the isomeric transition between the excited and ground states of Zr-89. Half-life measurements add further confirmation of the source of these gamma rays against the background of gamma- and X-rays emitted during the laser-plasma interaction.

7:15PM BK.00002 Laser-Induced Nuclear Activation Studies. ANDREW SIMONS, MATTHEW GARDNER, PETER THOMPSON, AWE, CHRISTOPHER ALLWORK, MICHAEL RUBERY, AWE/University of Surrey, ROBERT CLARKE, Rutherford Appleton Laboratory — A series of experimental campaigns, each designed to activated carefully selected materials, have been conducted with high-power short-pulse laser systems. These relatively new CPA laser systems can produce large bursts of X-rays, electrons, protons and other ions. Characterising the nature of these mixed radiation fields is necessary for both physics experiments and facility safety. Three campaigns, two with the HELEN laser facility at AWE and one with the Vulcan Petawatt laser at the Rutherford Appleton laboratory, were designed to accelerate protons. These protons irradiated secondary activation targets of pure foils and various optical glasses, typically those used in target chamber environments such as those found at NIF, Omega and AWE’s Orion laser facility. This talk discusses these experiments and covers the production of laser-produced radiation fields, the selection of activation targets, the interpretation the radioactive decay signals, the current status of the analysis and the future applications of this research.

7:30PM BK.00003 Alternative Neutron Detection Technology for Homeland Security, RICHARD KOUZES, EDWARD SICILIANO, Pacific Northwest National Laboratory — Neutron detection is an essential aspect of interdiction of radiological threats for homeland security purposes since plutonium is a significant source of fission neutrons. Radiation portal monitoring (RPM) systems, of which there are thousands deployed for homeland security and non-proliferation purposes, currently use $$^{3}$$H gas-filled proportional counters for detecting neutrons. Due to the large increase in use of $$^{3}$$He for homeland security, the supply has dwindled, and can no longer meet the demand. Consequently, a replacement technology for neutron detection is required in the very near future. In addition to alarming on the presence of actual neutron sources, homeland security applications also have a strict requirement for limiting neutron false alarms produced by a detector. This constrains any possible replacement neutron detection technology not to generate false neutron counts in the presence of a large gamma-ray-only source. Of the currently available neutron detection technologies, BF$_3$-filled proportional detectors, boron-lined proportional detectors, Li-loaded scintillating glass fiber, or non-scintillating coated plastic fiber detectors are the possible replacements for $$^{3}$$He detector technology—if they are proven to have appropriate capabilities.

7:45PM BK.00004 Physics Applications for Nuclear Incident Response, JENNIFER CHURCH, Lawrence Livermore National Laboratory — Radiation detection plays a significant role in global security and nuclear incident response. Gamma-ray and neutron measurements are key elements in this capability, greatly improving interpretations of real-world situations. An overview of nuclear incident response efforts and applications will be presented. This work is performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.
8:00PM BK.00005 Nuclear Resonance Fluorescence Measurements on $^{237}$Np for Security and Safeguards Applications\textsuperscript{1}, C.T. ANGELL, T. JOSHI, RYAN YEE, E.B. NORMAN, UC Berkeley, W.D. KULP, GeorgiaTech, G.A. WARREN, PNL, S. KORSLY, A. KLIMENKO, C. WILSON, Passport Systems, R. COPPING, D.K. SHUH, LBNL — The smuggling of nuclear material and the diversion of fissile material for covert weapon programs both present grave risks to world security. Methods are needed to detect nuclear material smuggled in cargo, and for proper material accountability in civilian fuel re-processing facilities. Nuclear resonance fluorescence (NRF) is a technique that can address both needs. It is a non-destructive active interrogation method that provides isotope-specific information. It works by using a γ-ray beam to resonantly excite levels in a nucleus and observing the γ-rays emitted whose energy and intensity are characteristic of that isotope. $^{237}$Np presents significant safeguard challenges; it is fissile yet currently has fewer safeguard restrictions. NRF measurements on $^{237}$Np will expand the nuclear database and will permit designing interrogation and assay systems. Measurements were made using the bremsstrahlung beam at the HVRL at MIT on a 7 g target of $^{237}$Np with two incident electron energies of 2.8 and 3.1 MeV. Results will be presented with discussion of the relevant nuclear structure necessary to predict levels in other actinides.

\textsuperscript{1}This work was supported in part by the U.S. DHS and DOE.

8:15PM BK.00006 Nuclear Resonance Fluorescence from Uranium above 2 MeV\textsuperscript{1}, E. KWAN, C.R. HOWELL, R. RAUT, G. RUSEV, A.P. TONCHEV, W. TORNOW, Duke, A. ADEKOLA, S.L. HAMMOND, H.J. KARWOWSKI, J.R. TOMPKINS, UNC-Chapel Hill, C. HUBBREGTSE, J.H. KELLEY, NCsu, B. JOHNSON, NCA&T — The detection of special nuclear materials is critical to the nation’s efforts to counter serious threat from nuclear terrorist attacks. A research program has been initiated at TUNL to address the need for new nuclear data on the actinides using the High-Intensity Gamma-Ray Source (HiS). The high-intensity nearly monoenergetic and 100% polarized γ-ray beams from HiS were utilized to search for dipole states in $^{235}$U and $^{238}$U above 2 MeV. This information is necessary for developing technologies using Nuclear-Resonance Fluorescence (NRF) to nonintrusively scan cargo for specific nuclei. The existence of strong nuclear dipole transitions in the actinides above 2 MeV is important for nuclear forensics, because interrogation photons using NRF are the most penetrating at these energies. Results from our experiments at $E_{\gamma} > 2.0$ MeV on uranium will be presented.

\textsuperscript{1}Supported by the DOE under grants DE-FG02-97ER41033, DE-FG02-97ER41042, DE-FG02-97ER41041, DE-FG52-06NA26155 and 2008-DN-077-AR1014.

8:30PM BK.00007 Development of a neutron source for NRF diagnostics\textsuperscript{1}, R. HATARIK, J. CERNY, UC Berkeley, L. PHAIR, Lawrence Berkeley National Laboratory, L.A. BERNSTEIN, D.L. BLEUEL, S. LIDDICK, D. SCHNEIDER, Lawrence Livermore National Laboratory — Neutron time-of-flight is a key diagnostic to determine the neutron spectrum from inertial confinement fusion at the National Ignition Facility (NIF). The down scattered fraction of the neutron spectrum with neutron energies between 10 and 13 MeV is proportional to the time-weighted areal density of the fuel, which is an important quantity for obtaining ignition. To detect down scattered neutrons after the initial 14 MeV neutrons from DT fusion, a fast neutron scintillator is required. To test different scintillator material for decay time and efficiency, a deuterium breakup neutron source is being developed at the 88-Inch cyclotron of Lawrence Livermore National Laboratory (LBNL). The commissioning of this facility will be discussed including neutron energy and flux measurements, dosimetry and results from testing the neutron scintillators.

\textsuperscript{1}Work supported by the US DOE.

8:45PM BK.00008 Neutron Activation Diagnostic at the National Ignition Facility\textsuperscript{1}, DARREN BLEUEL, Lawrence Livermore National Laboratory — A new cost-effective implementation of a Neutron Activation Diagnostic at the National Ignition Facility (NIF) will complement the Magnetic Recoil Spectrometer (MRS) and neutron Time-of-Flight (nToF) diagnostics by measuring the spatial distribution of downscattered neutrons (2-13 MeV) in the NIF target chamber. This diagnostic will have single-to-analyte mapping-features in the nToF diagnostics and single-projection insensitivity to capsule implosion asymmetries. It will also provide a high-accuracy (<2% uncertainty) absolute measurement of the primary DT neutron yield. Activation samples will be mounted on three roughly-orthogonal DIMs (Diagnostic Instrument Manipulators), including one near the MRS for normalization. Only reactions with long half-lives (several hours to days) will be used and the samples will be removed manually. The ratio of the neutron-induced activities of fissile material for covert weapon programs both present grave risks to world security. Methods are needed to detect nuclear material smuggled in cargo, and for proper material accountability in civilian fuel re-processing facilities. Nuclear resonance fluorescence (NRF) is a technique that can address both needs. It is a non-destructive active interrogation method that provides isotope-specific information. It works by using a γ-ray beam to resonantly excite levels in a nucleus and observing the γ-rays emitted whose energy and intensity are characteristic of that isotope. $^{237}$Np presents significant safeguard challenges; it is fissile yet currently has fewer safeguard restrictions. NRF measurements on $^{237}$Np will expand the nuclear database and will permit designing interrogation and assay systems. Measurements were made using the bremsstrahlung beam at the HVRL at MIT on a 7 g target of $^{237}$Np with two incident electron energies of 2.8 and 3.1 MeV. Results will be presented with discussion of the relevant nuclear structure necessary to predict levels in other actinides.

\textsuperscript{1}Work supported by the US DOE.

9:00PM BK.00009 Diagnosing Implosion Velocity and Ablator Dynamics at NIF, GARY GRIM, ANNA HAYES, JERRY JUNGMAN, Los Alamos National Laboratory, DOUG WILSON, JERRY WILHELMY, PAUL BRADLEY, BOB RUNDBERG, CHARLIE CERJAN, Lawrence Livermore National Laboratory — An enhanced understanding of the environment in a burning NIF capsule is of interest to both astrophysics and thermonuclear ignition. In this talk we introduce a new diagnostic idea, designed to measure dynamic aspects of the capsule implosion that are not currently accessible. During the burn, the NIF capsule ablator is moving relative to the 14.1 MeV dt neutrons that are traversing the capsule. The resulting neutron-ablator Doppler shift causes a few unique nuclear reactions to become sensitive detectors of the ablator velocity at peak burn time. The “point-design” capsule at the NIF will be based on a $^{6}$Be ablator, and the $^{6}$Be(n,p)$^{7}$Li reaction has an energy threshold of 14.2 MeV, making it the ideal probe. As discussed in detail below, differences in the ablator velocity lead to significant differences in the rate of $^{7}$Li production. We present techniques for measuring this $^{7}$Li implosion velocity diagnostic at the NIF. The same experimental techniques, measuring neutron reactions on the ablator material, will allow us to determine other important dynamical quantities, such as the areal density and approximate thickness of the ablator at peak burn.

9:15PM BK.00010 Reaction-in-Flight Neutrons as a Probe of Hydrodynamical Mixing at NIF, ANNA HAYES, Los Alamos National Laboratory, GARY GRIM, JERRY JUNGMAN, Los Alamos — At the National Ignition Facility (NIF) reaction-in-flight (RIF) neutrons above the main 14 MeV peak make up about 0.5% of the neutrons production. In this talk we present calculations that show the sensitivity of the RIF neutron production to hydrodynamical mixing of the outer shell of the NIF capsule into the main dt fuel. This mixing generally quenches the dt burn and could be a serious mode of ignition failure. These calculations suggest that a time-of-flight measurement or radiochemical measurement of the RIF neutrons could be used as a robust indicator of the degree of mix taking place in an imploded NIF capsule.
9:30PM BK.00011 Gamma-ray Spectroscopic Performance of a ∼10 kg Array of High Purity Germanium Crystals1, JOHN ORRELL, CRAIG AALSETH, CHRIS BONEBRAKE, JAC CAGGIANO, TONY DAY, JIM FAST, ERIN FULLER, BRIAN HYRONIMUS, DENNIS MULLEN, BOB RUNKLE, JES SMART, GLEN WARREN, Pacific Northwest National Laboratory — The gamma-ray spectroscopic performance of a single-cryostat, close-pack array of high purity germanium crystals is presented. The unit design is intended to provide high detection efficiency (∼100% relative efficiency) for standoff gamma-ray detection in field measurement applications. However, the array design shares much in common with design concepts proposed by the Majorana Collaboration to search for neutrinoless double beta decay of Ge-76. The presentation will focus on those topics of relevance to both the field application and basic scientific research. Specifically this will include array operation, data collection, and data reduction that elucidate the unique features of a ∼10 kg compact array of high purity germanium gamma-ray spectrometers.

1This work was funded by the Office of Defense Nuclear Nonproliferation, Office of Nonproliferation Research and Development (NA-22).

9:45PM BK.00012 Observation of stress effect on iron diffusion in Si by Mössbauer spectroscopy1, KUNIFUMI SUZUKI, Tokyo Institute of Technology, TOMOHIRO KAMIMURA, MASAIRO ICHINO, YUTAKA YOSHIDA, Shizuka Institute of Science and Technology, KOICHIRO ASAI, Tokyo Institute of Technology — A silicon wafer may contain metallic impurities and crystal defects such as vacancies and dislocations. Such a defect must cause stress fields, which are considered to affect the atomic diffusion and segregation properties. Although such the stress-induced diffusion must play an important role in the metallic impurities diffusion as well, the diffusion of metallic impurities in Si has never been studied under external stress until now. In the present study, in order to investigate the influence of a stress on the iron diffusion in Si matrix, Mössbauer spectra for 57Fe doped Si sample were measured at room temperature as a function of the external stress up to 44 MPa using an Instron-type tensile testing machine. The Mössbauer spectra were analyzed in terms of two Lorentzian components each corresponding to substitutional and interstitial Fe. The interstitial line gets broader when the external stress is applied presumably due to a high Fe jump rate of about 10^6 s^-1. More details of the experiments will be presented.

1This work was supported by the Global Center of Excellence Program by MEXT, Japan through the “Nanoscience and Quantum Physics” Project of the Tokyo Institute of Technology.

Wednesday, October 14, 2009 7:00PM - 10:00PM — Session BL Nuclear Reactions: Heavy-Ions/Rare Isotope Beams I

7:00PM BL.00001 Measurement of shell energies for 40,48Ca by using (p, 2p) reaction, YOSHIHIDE MATSUDA, TETSUO NORO, TOMOTSUGU WAKASA, YUKIKO YAMADA, MASANORI DOZONO, MIDORI OKAMOTO, TAKURO SHISHIDO, Kyushu Univ., KICHIJI HATANAKA, HIROYUKI OKAMURA, ATUSHI TAMII, HIROAKI MATSUBARA, DAIKI ISHIKAWA, RCNP, Osaka Univ. — The binding energies and the spectroscopic factors of the proton orbits in 40Ca and 48Ca nuclei were measured by using (p,2p) reaction at 200MeV. The aim of this experiment is to investigate the neutron-number dependence of the shell energies, which is motivated by a recent theoretical work [1] on the monopole effect of the tensor force. Since the (p,2p) reaction shows clear j-dependence at this energy, unambiguous j-assignment is expected. The experiment was performed at RCNP using a two-arm spectrometer system. The energy resolution achieved was better than 200eV FWHM. In the presentation, comparison of the present result with a previous (d,3He) result [2] will be also given.


7:15PM BL.00002 Study of spin dipole strength in 12N via complete polarization transfer measurements, MASANORI DOZONO, TOMOTSUGU WAKASA, TETSUO NORO, KENSHI SAGARA, YUKIKO YAMADA, SHO KUROITA, TAKUMI IMAMURA, HIROKI SHIMODA, TAKEHIRO SUET, YOSHIHIDE MATSUDA, YUICHIRO EGUCHI, KEISUKE YASHIMA, Kyushu University, KICHIJI HATANAKA, HIROYUKI OKAMURA, ATUSHI TAMII, HIROAKI MATSUBARA, DAIKI ISHIKAWA, RCNP, YASUHIRO SAKEMI, TETSUYA NAGANO, TOSHIYA TAKAHASHI, CYRIC — Spin-isospin excitations in nuclei have been studied exhaustively, the understanding of spin dipole (SD) (\Delta S=1, \Delta T=1, \Delta L=0) excitations have been investigated extensively in the past decades. While Gamow-Teller (\Delta S=1, \Delta T=1) excitations have been measured exhaustively, the understanding of spin dipole (SD) (\Delta S=1, \Delta T=1, \Delta L=0) excitations is still rather limited with respect to the three different spin-parity states of J^π=0^+, 1^+, 2^+. The strength distribution of each SD state gives us fundamental information on the tensor correlations. In order to deduce the SD strength distributions in 12N, we have measured complete cross sections and complete sets of polarization transfer observables for 12C(p,pn) reaction. The measured polarization transfer observables are used to separate cross section into spin-longitudinal I_Dp and spin-transverse I_Dp polarized cross sections. These polarized cross sections enable us to separate the SD components in each J^π.

7:30PM BL.00003 Spectroscopic Factors from the Single Neutron Pickup Reaction 64Zn(\bar{d},t) , KYLE LEACH, University of Guelph — P.E.Garrett^1, G.C.Ball^2, J.C.Bangay^1, L.Bianco^1, G.A.Demand^1, T.Faestermann^3, P.Finlay^1, K.L.Green^1, R.Hertenberger^1, R.Krücken^1, A.A.Phillips^1, E.T.Rand^1, C.S.Sumithrarachchi^1, C.E.Svensson^1, S.Triambak^1, H.-F.Wirth^4, J.Wong^1, Guelph, TRIUMF, TU München, LMU München — A great deal of attention has recently been paid towards high-precision superallowed β-decay F\Delta values. With the availability of extremely high-precision (< 0.1%) experimental data, precision on the individual F\Delta values are now dominated by the ~1% theoretical corrections^3. This limitation is most evident in heavier superallowed nuclei (e.g. 62Ga) where the isospin-symmetry-breaking (ISB) correction calculations become more difficult due to the truncated model space. Experimental spectroscopic factors for these nuclei are important for the identification of the relevant orbitals that should be included in the model space of the calculations. Motivated by this need, the single-nucleon transfer reaction 64Zn(\bar{d},t)63Zn was conducted at the Maier-Leibnitz-Laboratory (MLL) of TUM/LMU in Munich, Germany, using a 22 MeV polarized deuterons beam from the tandem Van de Graaff accelerator and the TUM/LMU Q3D magnetic spectrograph, with angular distributions from 10° to 60°. Results from this experiment will be presented and implications for calculations of ISB corrections in the superallowed β^- decay of 62Ga will be discussed.

7:45PM BL.00004 Determining (n,γ) cross sections using surrogate reactions, NICHOLAS SCIELZO, JUTTA ESCHER, LLNL. STARS/LIBERACE COLLABORATION — Direct measurements of neutron-reaction cross sections on unstable nuclei are currently challenging due to the difficulties associated with radioactive targets and neutron beams. Indirect methods, such as the surrogate reaction method, are currently the only feasible way to determine many of the cross sections for radioactive nuclei that are of interest to nuclear astrophysics, nuclear energy, and other applications. We have used the surrogate reaction method to determine (n,γ) cross sections for 153,155,157Gd nuclei at energies up to 3 MeV through inelastic proton scattering on stable targets. The STARS/LiBerACE silicon and germanium detector arrays were used to detect γ rays in coincidence with the scattered protons to determine γ-ray exit-channel probabilities. Techniques are being explored to extract reliable cross sections at energies for which the Weisskopf-Ewing limit of the Hauser-Feshbach theory is not applicable. This measurement will provide the first determination of the (n,γ) cross section for 153Gd, an s-process branch-point nucleus with a half-life of 240 days. This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

8:00PM BL.00005 Inelastic and Transfer Couplings in Nucleon Induced Reactions, GUSTAVO NOBRE, IAN THOMPSON, JUTTA ESCHER, FRANK DIETRICH, Lawrence Livermore National Laboratory, MARC DUPUIS, CEA-DAM France — A microscopic calculation of the optical potential for nucleon-nucleus scattering has been performed by explicitly coupling the elastic channel to all the particle-hole (p-h) excitation states in the target. These p-h states may be regarded as doorway states through which the flux flows to more complicated configurations, and to long-lived compound nucleus resonances. The random-phase approximation (RPA) and the quasi-particle RPA (QRPA) provide linear combinations of p-h states that include the residual interactions within the target, and we show results for reaction cross sections using the QRPA description of target excitations of different nuclei and coupling to all open channels. We also included couplings to relevant pick-up channels, which were found to represent a very important contribution to a more accurate and realistic description of the reaction process. With this procedure we observed coupling and structure effects of the studied nuclei by comparing the different coupled-channel (CC) calculations results with predictions of a well-established optical potential and with experimental data. The effect of including couplings between excited states in CC calculations was also analyzed within the RPA context and its relevance was assessed. Prepared by LLNL under Contract DE-AC52-07NA27344. LLNL-ABS-414348

8:15PM BL.00006 Unique double folding optical parameters for 240 MeV6Li beam, KRISHICHAYAN, Texas A&M University, X. CHEN, Washington University at St. Louis, Y.-W. LUI, Y. TOKIMOTO, J. BUTTON, D.H. YOUNGBLOOD, Texas A&M University — Theoretical calculations with different interactions and relativistic models have shown that the location of the GMR is sensitive to the symmetry energy. To better determine the contribution from symmetry energy ISGMR measurements should be extended to unstable nuclei using inverse reactions. Most ISGMR information has come from inelastic α scattering but unfortunately helium does not make a good target. Chen et al.[1] have demonstrated that 6Li inelastic scattering at 40 MeV/A is a viable reaction for ISGMR studies and 6Li foil targets are well suited to these studies. Here we report results for elastic scattering of 240 MeV 6Li ions on 24Mg, 28Si, 40Ca, 48Ca, 58Ni, 90Zr, and 116Sn and inelastic scattering to low-lying states of these targets to develop a systematic optical potential that can be tested in α induced ISGMR studies of unstable nuclei. Density-dependent double folding calculations using the M3Y effective NN interaction were used to obtain the real part of the optical potential and the transition potential. A Woods-Saxon potential was used for the imaginary part. B(E) values obtained for low lying 2+ and 3+ states are mostly in agreement with the adopted values. The progress on developing a systematic potential will be presented. [1] X.Chen et al., Phys.Rev. C79,024320(2009).

9:00PM BL.00009 Shift and width of momentum distribution of projectile-like fragments produced at 290 MeV/u, SADAOKI MOMOTA, Kochi University of Technology, MITSUTAKA KANAZAWA, ATSUISHI KITAGAWA, SHINJI SATO, NIRS — The shift and width of momentum distribution of projectile-like fragments (PLFs) produced at an intermediate energy were investigated experimentally. The longitudinal momentum distributions of PLFs produced from the Ar- and Kr-beams were observed at an energy of 290 MeV/u. The measurements were performed by using HIMAC facility at NIRS. Observed distributions show an asymmetric features, which is minor than that was observed at 100 MeV/u or lower. In order to extract the reaction mechanism, observed distributions were fitted with an asymmetric Gaussian function. Based on the fitting process, the precise determination of the shift and width of momentum distribution was performed for PLFs with AF = 10 ~ 40 and 20 ~ 84 for Ar-beam and Kr-beam, respectively In principle, the shift and width are independent on the target (C, Al, Nb, Tb, Au). Some light PLFs produced from Kr-beam show the anomalously large momentum shift and width.
9:15PM BL.00020 Measurements in the Quasi-Continuum

9:30PM BL.00011 A Quadrupole Momentum Thermometer for Heavy-Ion Reactions

9:45PM BL.00012 Classical studies of nuclear isoscaling

Wednesday, October 14, 2009 7:00PM - 10:15PM
Session BM Nuclear Theory I Kings 1

7:00PM BM.00001 Microscopic Calculation of Excitation Energies for Heavy Systems

7:15PM BM.00002 Coupling effects in the extraction of spectroscopic factors

7:30PM BM.00003 Ensemble measurements of thermal pairing in nuclei

7:45PM BM.00004 Effective interactions between neutrons and protons in the intruder orbitals


3Supported by DOE grant DE-FG02-96ER40963.
8:15PM BM.00005 Tensor force in effective shell model interaction. NAOFUMI TSUNODA, TAKAHARU OTSUKA, KOSHIRO TSUKIYAMA, The University of Tokyo — Tensor force interaction in effective shell model interaction is investigated. It has been known in recent years that tensor force causes important effect on the structure of exotic nuclei, for example, neutron rich nuclei. Monopole part of the tensor force varies the effective single particle energy in the shell model calculation. In early studies on this subject, the tensor force in the shell model interaction has been taken, as a modeling, to be the bare NN potential generated by \( p + p \) meson exchange potential. We propose a justification of this modeling by presenting the behavior of the tensor force in the effective interaction obtained from microscopic theory. We obtain effective interactions for shell model calculation in two steps. We first integrate out the high momentum part and obtain potential called \( V_{\text{p-wave}} \) defined in low momentum. With this potential, we then perform folded-diagram expansion which includes the effect caused by the truncation to a small model space, for example, the effect of the core-polarization. After obtaining an effective shell model interaction by such a microscopic theory, we decompose it to central, spin-orbit and tensor parts and analyze the basic robust properties of the tensor part. This study will suggest which tensor force should be appropriate for the calculations of nuclear structure.

8:30PM BM.00007 Model space truncation in shell-model fits. CALVIN JOHNSON, Dept. of Physics, San Diego State University, GEORGE BERTSCH, Institute for Nuclear Theory and Dept. of Physics, University of Washington — The interacting shell model with fitted interactions has been a powerful predictive tool of nuclear structure theory, but there has been little study of the errors associated with truncation of the model shell spaces. We present a model study of spectra in the \( sd \)-shell nuclei to address this question. Carrying out a truncation with a model Hamiltonian we find that the binding energies are strongly affected and the excitations less so, by an order of magnitude. We then refit the matrix elements of the two-particle interaction to compensate for the space truncation, and find that it is easy to capture 90\% of the binding energy shifts by refitting a few parameters. Numerically, the rms initial error associated with our Hamiltonian is 3.4 MeV and the remaining residual error is 0.16 MeV, to be compared with the 0.11 MeV residual error in the application to experimental data.

8:45PM BM.00008 The effective three-body monopole interaction and ground-state energies in the \( (0p) \)-shell. A.F. LISETSKIY, S.G. DE CLARK, B.R. BARRETT, M.K.G. KRUSE, University of Arizona — Following Refs. [1,2], we have earlier developed a valence cluster expansion to construct effective 2- and 3-body Hamiltonians for the \( 0p \)-shell by performing No Core Shell Model (NCSM) calculations for \( A = 6 \) and 7 nuclei and explicitly projecting the many-body Hamiltonians onto the \( 0\Omega\Omega \) space. These effective Hamiltonians can be separated into 0-, 1- and 2-body contributions( also 3-body for \( A = 7 \)), which can be used in standard shell model (SSM) calculations. In new studies we have derived the effective 3-body monopole Hamiltonian for the \( 0p \)-shell by performing \( 0\Omega\Omega \) NCSM calculations for \( A = 7 \rightarrow 16 \) nuclei and used it to investigate how the ground-state energies of these nuclei are affected, when it is included in the SSM calculations.

1This work was supported by the UNEDF SciDAC Collaboration under DOE grants DE-FC02-07ER41457, DE-FG02-04ER41132, and DE-FC02-09ER14587.

9:00PM BM.00009 Predominance of Prolate Nuclear Deformations Emerging from Many-Body Interactions. MIHAI HOROI, Department of Physics, Central Michigan University, Mount Pleasant, MI 48859, USA, VLADIMIR ZELEVIN-SKY, National Superconducting Cyclotron Laboratory, and Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824 — A new approach to the old problem of the predominance of prolate deformations among well deformed nuclei is proposed within the shell model framework. The parameter space is explored using the ensemble of random rotationally-invariant interactions. Subsets with rotational energy ratio \( E(4^+)/E(2^+) \) and the rigid-rotor relation between the quadrupole moment \( Q(2^+) \) and the transition probability \( B(E2; 2^+ \rightarrow 0^+) \) are found exhibiting prolate predominance. We identify matrix elements of the effective forces responsible for the predominance of prolate deformation.

1Support from the NSF grant PHY-0758099 is acknowledged.

9:15PM BM.00010 Mean-field derivation of the Interacting Boson Model for deformed nuclei. KOSUKE NOMURA, LU GUO, NORITAKA SHIMIZU, Department of Physics, University of Tokyo, TAKAHARU OTSUKA, Department of Physics, University of Tokyo / Center for Nuclear Study, University of Tokyo / RIKEN Nishina Center / MSU — We propose a new scheme to determine a Hamiltonian of the Interacting Boson Model (IBM) microscopically, starting from the mean-field model with Skyrme-type interactions [PRL101, 142501 (2008)]. The multi-fermion dynamics of surface deformation and the effects of nuclear forces are simulated by bosonic degrees of freedom. By comparing the potential energy surface of the mean-field model with that of the IBM, the parameters of the IBM Hamiltonian can be obtained as functions of \( N \) and \( Z \). One of the merits is being able to compute levels and wave functions of excited states precisely. By this method, existing cases of dynamical symmetries of the IBM and the critical-points of the quantum shape-phase transitions can be reproduced. Moreover, intriguing spectroscopic properties, e.g., unexpectedly large region of the E(5) symmetry, are predicted for experimentally unknown heavy exotic nuclei such as osmium and tungsten isotopes with \( N \geq 126 \). Finally, we would like to discuss more precise analysis on excited spectra of well-deformed samarium nuclei by making a minor correction for the present mapping procedure. The strategy and the preliminary results will be presented.

9:30PM BM.00011 Systematics in the structure of low-lying, non-yrast band-head configurations of strongly deformed nuclei. GABRIELA POPA, Ohio University — Strongly deformed nuclei show interesting patterns in the energy spectrum above around 1 MeV. An empirical investigation of the trends in the properties of the non-yrast \( K^\pi = 2^+ \) and \( K^\pi = 0^+ \) bandhead configurations in nuclei that are related to one another through the addition or removal of alpha-particle-like structures, reveals their complex and changing behavior in contrast to the smooth behavior of the yrast states. A systematic application of the pseudo-SU(3) model for such a sequence of deformed nuclei from the rare earth region leads to an accurate and unified description of not only yrast, but non-yrast collective bands. The onset of deformation as manifested through the position of the excited bandheads in the spectra is understood and interpreted by using a realistic model Hamiltonian in conjunction with a microscopic distribution of the eigenstates across allowed proton and neutron strong- coupled SU(3) configurations.
9:45PM BM.00012 Comment on top-on-top mechanism in triaxial strongly deformed even mass nuclei, KOSAI TANABE, RIKEN, Nishina Center, Saitama, 351-0198, Japan, KAZUKO SUGAWARA-TANABE, Otsuma Women’s University, Tama, Tokyo, 206-8540, Japan — We have derived the algebraic solution to the particle-rotor model with high j nucleon coupled to a triaxially deformed core, 

\[ H = H_{rot} + H_{sp} \]. The rotating core top with \( \vec{R} = \vec{l} - \vec{j} \) and the single-particle top with \( \vec{j} \), are strongly correlating each other. We call this mechanism as top-on-top mechanism, where the Coriolis term, \( \vec{l} \cdot \vec{j} \), is explicitly taken into account, giving a big difference from the wobbling model. The algebraic solution to the top-on-top mechanism clarifies not only the energy level scheme, but also gives the approximate selection rules in the strength of transitions among bands. If the single-particle angular momentum \( j \) is assumed to be the sum of two angular momenta as \( j = j_1 + j_2 \) and the value of integer \( j \) keeps constant over some range of \( l \), then the algebraic solution is easily extended to the even-even nucleus with alignment of integer \( j \). Although several candidates of TSD bands are observed in Hf isotopes, no linking transitions between \((0,0)\) and \((1,0)\) are found. The rough estimation of the transition rates give a factor of \( (\frac{l+1}{l})^4 \) both in \( B(E2) \) and \( B(M1) \) values for the transitions with \( \Delta I = 1 \) among the favored \((0,0)\) and the unfavored \((1,0)\) bands. The value of \( l - j \) is smaller for even-A case than odd-A case, which makes the observation of the other partner band difficult.

10:00PM BM.00013 BCS-BEC transition in finite systems, NGUYEN DINH DANC, NGUYEN QUANG HUNG, Heavy-Ion Nuclear Physics Laboratory, RIKEN Nishina Center for Accelerator-Based Science, PETER SCHUCK, Groupe de Physique Theorique, IPN Orsay, France — The BCS-BEC (Bose-Einstein condensation) transition is studied in finite systems by using an exactly solvable multilevel pairing model as well as a realistic single-particle spectrum for \( ^{20}\text{O} \) nucleus. The predictions obtained within the selfconsistent quasiparticle RPA that includes the effects due to quantal and thermal fluctuations are discussed along with those given by the BCS theory and exact solutions. They show a smooth BCS-BEC transition in the qualitative behavior of the chemical potential as a function of the pairing interaction parameter \( G \). The BEC is achieved at \( G = G_c(BEC) \), where the chemical potential reaches the bottom of the single-particle spectrum, and continues to decrease as \( G \) becomes larger than \( G_c(BEC) \). The critical temperature \( T_c(BEC) \) of the BCS-BEC transition in the strong coupling regime is deduced, at which the entropy of the system reaches the limit of the free boson gas. The effect due to the angular momentum on the BCS-BEC transition is also discussed.

Thursday, October 15, 2009 9:00AM - 12:00PM — Session CA Correlations in Structure Up To and Beyond Bound Limits Kona 5

9:00AM CA.00001 Ab initio calculations of \( ^{12}\text{C} \) and neutron drops, STEVEN C. PIEPER, Argonne National Laboratory — Ab initio calculations of nuclei, which treat a nucleus as a system of \( A \) nucleons interacting by realistic two- and three-nucleon forces, have made tremendous progress in the last 15 years. This is a result of better Hamiltonians, rapidly increasing computer power, and new or improved many-body methods. Three methods are principally being used: Green’s function Monte Carlo (GFMC), no-core shell model, and coupled cluster. In the limit of large computer resources, all three methods produce exact eigenvalues of a given nuclear Hamiltonian. With DOE SciDAC and INCITE support, all three methods are using the largest computers available today. Under the UNEDF SciDAC grant, the Argonne GFMC program was modified to efficiently use more than 2000 processors. E. Lusk (Argonne), R.M. Butler (Middle Tennessee State U.) and I have developed an Asynchronous Dynamic Load-Balancing (ADLB) library. In addition all largest computers available today. Under the UNEDF SciDAC grant, the Argonne GFMC program was modified to efficiently use more than 2000 processors. E. Lusk (Argonne), R.M. Butler (Middle Tennessee State U.) and I have developed an Asynchronous Dynamic Load-Balancing (ADLB) library. In addition all

9:45AM CA.00002 Nuclear Halo and Shell Evolution along the Neutron Drip Line, TAKASHI NAKAMURA, Tokyo Institute of Technology — Nuclear halo is a weakly-bound exotic state of nuclear matter where one or two valence neutrons extend far beyond the nuclear potential well. We present recent experimental results on halo nuclei, with Coulomb and nuclear breakup. In the first part, we show experimental results on Coulomb breakup of \( ^{11}\text{Li} \), where observed three-body energy spectrum allows us to discuss the di-neutron correlation of this nucleus. In the second part, we show the results of nuclear breakup of \( ^{14}\text{Be} \) where its Borromean constituent \( ^{13}\text{Be} \) structure is revealed. We discuss the shell melting of this unbound nucleus. In the third part, we show the most recent results on the inclusive breakup reactions of \( ^{12}\text{C} \) and \( ^{11}\text{Be} \) at 230MeV/nucleon using the newly commissioned RI-beam facility RIBF (RIKEN RI-Beam Factory) at RIKEN. These nuclei are candidates of halo nuclei, located heavier than the known halo nuclei. We have observed enhancement of the Coulomb and nuclear breakup cross sections of these two nuclei, suggesting that these nuclei have halo structures. The detailed comparison of the observed cross sections and calculation shows that \( ^{31}\text{Ne} \) has a halo property as well as shell vanishing in nature.

10:30AM CA.00003 In-beam \( \gamma \)-ray spectroscopy towards the nucleon driplines, ALEXANDRA GADE, Michigan State University — The often surprising properties of neutron-rich nuclei have prompted extensive experimental and theoretical studies aimed at identifying the driving forces behind the dramatic changes encountered in the exotic regime. In-beam nuclear spectroscopy with fast beams and thick reaction targets - where \( \gamma \)-ray spectroscopy is used to tag the final state - provides information on the single-particle structure as well as on collective degrees of freedom in nuclei that are accessible for experiments at beam rates of only a few ions/s. Recent results from nuclear spectroscopy experiments that utilize the interplay of nuclear-structure effects and reaction mechanisms performed at the National Superconducting Cyclotron Laboratory at Michigan State University will be presented.
In this report, we show the unified study of the exotic structures of $^{12}\sigma$ (important to interpret the results of heavy flavor in Au+Au collisions. In this presentation we will show the latest PHENIX results for the production of charm the generalized two-center cluster model in which the covalent MO and the atomic orbital (AO) configurations with $x\pi$ heavy quark in the hot medium. Transverse momentum indicates that the drag force is much stronger than the leading order perturbative QCD prediction and is rather close to the AdS/CFT $R$ parametrized according to the formula calculated by AdS/CFT correspondence. In this setup, we calculate the nuclear modification factor, YUKINAO AKAMATSU, TETSUO HATSUDA, TETSUFUMI HIRANO, University of Tokyo — Relativistic Langevin dynamics for RHIC and LHC di-hadron as well as dijet and jet-hadron correlations will be presented.

Thursday, October 15, 2009 9:00AM - 12:00PM —
Session CB Mini-Symposium on Heavy Flavor and Hard Probes in the Quark Gluon Plasma II
Kona 4

9:00AM CB.00001 Latest Results from Heavy Flavor Measurements . XIN DONG, Lawrence Berkeley National Lab — Heavy flavors are ideal probes to quantify the QCD medium properties in relativistic heavy ion collisions. In this talk, I will review the most recent measurements and results on open heavy flavor and heavy quarkonium production from heavy ion experiments. I will discuss our current understandings of heavy flavor hadron production mechanisms, heavy quark in-medium interactions, QCD medium properties we’ve learned so far, as well as the limitations of these measurements. In the end, I will outlook a bright future in heavy flavor measurements with machine and detector upgrades in the RHIC II era.

9:30AM CB.00002 Measurement of charm and bottom production at RHIC-PHENIX . YUHEI MORINO, RCNP, PHENIX COLLABORATION — Measurements of heavy flavor production (charm and bottom) in $p+\bar{p}$ collisions provides stringent tests for perturbative QCD (pQCD) calculations. In addition, heavy quarks are good probes of the hot and dense medium created in relativistic heavy ion collisions, since they are mainly generated at the beginning of collisions and interact with the media in all collision stages. Production of heavy quarks has been studied by the PHENIX experiment at RHIC via measurements of single leptons from heavy quark decay in $p+p$ and Au+Au collisions at $\sqrt{s_{NN}}=200$ GeV. The ratio of $(b\to e)/(c\to e+b\to e)$ is important to interpret the results of heavy flavor in Au+Au collisions. In this presentation we will show the latest PHENIX results for the production of charm and bottom. In addition, large energy loss and flow of the heavy quarks will be discussed based on the measured $(b\to e)/(c\to e+b\to e)$.

9:45AM CB.00003 High Order Opacity Analysis of Jet Quenching1. MIKLOS GYULASSY, ALESSANDRO BUZZATTI, ANDREJ FICNAR, SIMON WICKS, Columbia University — Recent progress in implementing the DGLV multiple collision opacity series using Monte Carlo techniques is presented to compute triple differential jet energy loss and transverse acoplanarity for both light and heavy quark jets. Predictions for RHIC and LHC di-hadron as well as dijet and jet-hadron correlations will be presented.

1 DOE Nuclear Science Grant DE-FG02-93ER40764.

10:00AM CB.00004 Langevin + Hydrodynamics Approach to Heavy Quark Diffusion in the Quark Gluon Fluid . YUKINAO AKAMATSU, TETSUO HATSUDA, TETSUFUMI HIRANO, University of Tokyo — Relativistic Langevin dynamics is developed under the background of hydrodynamic expansion of strongly interacting quark-gluon fluid. The drag force acting on charm and bottom quarks is parametrized according to the formula calculated by AdS/CFT correspondence. In this setup, we calculate the nuclear modification factor $R_{AA}$ for the single electrons from the charm and bottom quarks to extract the magnitude of the drag force from the PHENIX and STAR data. The $R_{AA}$ for electrons with high transverse momentum indicates that the drag force is much stronger than the leading order perturbative QCD prediction and is rather close to the AdS/CFT prediction. Effects of the drag force to the elliptic flow $v_2$ of single electrons will be also discussed. This approach is further applied to the study of heavy quark correlation. We will report our recent prediction of the electron-muon and electron-hadron correlations, which are closely related to the dynamical properties of heavy quark in the hot medium.

10:15AM CB.00005 ABSTRACT WITHDRAWN —
From the discovery of direct-single-$e^\pm$ from charm in 1974 to a fundamental test of the Higgs Yukawa coupling in Heavy Ion Collisions, MICHAEL TANENBAUM, Brookhaven National Laboratory. Searches for the intermediate boson, $W^\pm$, the heavy quantum of the Weak Interaction, via its semi-leptonic decay, $W \rightarrow e^\pm + \nu$, in the 1970's instead discovered unexpectedly large hadron production at high $p_T$, notably $K^0_S$, which provided a huge background of $e^\pm$ from internal and external conversions. Methods developed at the CERN ISR led to the discovery of direct-single-$e^\pm$ in 1974, later determined to be from the semi-leptonic decay of charm which had not yet been discovered. The same methods—i) $\geq 10^5$ charged hadron rejection; ii) minimum of material in the aperture to avoid external conversions; iii) zero magnetic field on the axis to avoid de-correlating conversion pairs; iv) precision background determination in the direct-single-$e^\pm$ signal channel by adding external converter—were used at RHIC to make precision measurements of heavy quark production in p-p and Au+Au collisions, leading to the puzzle of apparent equal suppression of light and heavy quarks in the QGP. If the Higgs mechanism gives mass to gauge bosons but not to fermions, then a proposal that all 6 quarks are nearly massless in a QGP, which would resolve the puzzle, can not be excluded. This proposal can be tested with future measurements.

Supported by U.S. Department of Energy, DE-AC02-98CH10886.

Electron-Muon Correlations in p+p and d+Au at RHIC-PHENIX at $\sqrt{s}=200\text{ GeV}$, TATIA ENGELOMORE, Columbia University, PHENIX COLLABORATION. Heavy quarks are useful in understanding the hot, dense medium created in a heavy ion collision, and are an important test of proposed mechanisms of energy loss. In order to study heavy quark production, electron-muon pairs are a valuable measurement because these are produced with a clean signal. PHENIX detects electrons in the central arms and muons in the forward and backward regions, so it is sensitive to heavy quark pairs produced in an intermediate rapidity range. To understand the behavior of $e^-\mu^+$ pairs in the medium, we first need to establish a baseline measurement in p-p, as well as determine the cold-matter effects in d+Au collisions. In d+Au, a comparison of the yield of pairs with muons at forward rapidity (small x) to pairs with muons at backward rapidity (large x) could help to better understand saturation and shadowing effects on heavy quarks versus enhancement from antishadowing. Results of $e^-\mu^+$ azimuthal correlations in p-p will be presented and related to heavy quark jet properties. Also, recent work on $e^-\mu^-$ in d+Au collisions will be discussed.

Characterizing cold nuclear matter effects through dielectrons in d+Au collisions at PHENIX, JASON KAMIN, Stony Brook University, PHENIX COLLABORATION. Electron-positron pairs are effective probes for the properties of the dense medium created in RHIC collisions because they are color neutral and, once created, do not interact strongly with the medium. As a result, they retain characteristics of the full time evolution and dynamics of the system. Among the many features, the low mass region ($m<1\text{ GeV}/c^2$) consists primarily of pairs from Dalitz decays of light hadrons and direct decays of vector mesons that can be modified by the medium, while the intermediate ($1<m<3\text{ GeV}/c^2$) and high ($4<m<12\text{ GeV}/c^2$) mass regions are dominated by charm and bottom. The PHENIX experiment has presented the dielectron continuum in p-p, Cu+Cu and Au+Au collisions at $\sqrt{s_{NN}}=200\text{ GeV}$. Recently PHENIX measured d+Au collisions which are crucial as they provide a complimentary reference for comparison with heavy ion collisions while illuminating cold nuclear matter effects. The statistics provided by the 2008 RHIC d+Au data set allow the dielectron spectrum to extend to mass ranges where bottom dominates. These data are currently being analyzed and the dielectron status will be presented.

Hadroproduction of Charmonium Excited States and Bottomonium at $\sqrt{s_{NN}}=200\text{ GeV}$ Measured by PHENIX Detector, CESAR L. SILVA, Iowa State University, PHENIX COLLABORATION. During the last few years RHIC has demonstrated sizable medium effects on the inclusive $J/\psi$ yields in heavy ion collisions. Feed-down contributions, mainly from excited charmonium states $\chi_{cJ}$ and $\psi'$, should be considered when comparing the measured production and medium modification factors with theoretical models. Relative production between different charmonium states can also provide insights about the production mechanisms, different hadronic absorption or breakup cross sections and sequential charmonium dissociation in sQGP. Bottomonium measurements can probe the same physics involved in charmonium, but with more reliable theoretical production calculations, no important coalescence at RHIC energies and a presumed higher dissociation temperature. In this presentation we will show recent measurements of $\chi_{cJ}$, $\psi'$ in p+p collisions, $\Upsilon(15,25,3S)$ in p+p and Au+Au collisions, the progress towards these similar measurements in d+Au collisions as well as expected advances using upcoming detector upgrades in PHENIX.

$\Upsilon$ production in p+p, d+Au, Au+Au collisions at $\sqrt{s_{NN}}=200\text{ GeV}$ in STAR, ROSI REED, MANUEL CALDERON, DEBASISH DAS, PIBERO KISA, HAIHONG LIU, STAR COLLABORATION. The properties of the dense matter produced in heavy-ion collisions can be investigated by studying its effect on quarkonia production. In particular, the T states are of interest because both the effect due to co-movers and feed down is smaller than for $J/\psi$. Suppression of quarkonia is theorized to be a QGP signature due to the Debye color screening of the potential between the heavy quarks. Lattice studies show that a sequential suppression of quarkonia states in heavy ion collisions when compared to production in p-p collisions can provide us with a thermometer for the matter produced in relativistic heavy-ion collisions. This requires a detailed understanding of $\Upsilon$ production in p+p collisions, as well as d+Au calculations so that R$_{AA}$ can determined. We will present our preliminary results for mid-rapidity $\Upsilon$ production in p+p, d+Au, and Au+Au at $\sqrt{s_{NN}}=200\text{ GeV}$ in the STAR experiment. We will compare these results with theoretical QCD calculations.

Future measurement of Charm and Beauty Using the Silicon Vertex Detector at PHENIX, XIAORONG WANG, New Mexico State University, PHENIX COLLABORATION. The study of heavy quarks (c and b) is essential to adequately understand in-medium energy loss and to test the basics properties of QCD. The current PHENIX heavy flavor physics program will be significantly enhanced by addition of the Silicon Vertex Detector (VTX) and Forward Silicon Vertex upgrade detector (FVTX) in a much broader acceptance range. These silicon trackers are planned to be put into operation in FY2011. They will provide precision tracking, reconstruction of the primary vertex and the recognition of secondary decay vertices in the collisions. This capability will enhance the heavy-quark signal and greatly reduce backgrounds. The description of tracking performance and some of the physics goals and capabilities from the simulations will be presented.

Thursday, October 15, 2009 9:00AM - 12:00PM –
Session CC Mini-Symposium on Thermal and Collective Properties of the Quark Gluon Plasma

Kohala 1
9:00AM CC.00001 What We Have Learned from the Measurement of Azimuthal Anisotropy of Identified Particles in Relativistic Heavy Ion Collisions, MAYA SHIMOMURA, University of Tsukuba — Measuring the azimuthal anisotropy of particles produced in relativistic heavy ion collisions is a powerful probe for investigating the characteristics of the quark-gluon plasma (QGP), which is the phase in QCD matter of de-confined quarks and gluons. The strength of the elliptic anisotropy ($v_2$) in the momentum phase space is transferred from the geometrical anisotropy of the initial collisional region because of the pressure gradient. Thus, the measured $v_2$ reflects the equation of state of the dense matter, possibly the QGP, produced in the collisions. One of the most remarkable findings at RHIC is that the $v_2$ can be well described by hydro dynamical models assuming very short thermalization times (<0.5 fm/c) in the low transverse momentum region ($p_t < \sim 1$ GeV/c). In the intermediate transverse momentum region ($p_t = 1$-4 GeV/c), $v_2$ is scaled with the number of quarks, and consistent with the quark-recombination model. A comprehensive understanding of $v_2$ has been reached ideal hydrodynamic limits even for central collisions. Constrains on the product of the cross section and the speed of sound are provided, eta/s is estimated. The Knudsen fit is also applied to $v_2$ from viscous hydro calculations and the result is compared to data.

9:30AM CC.00002 Directed and Elliptic flow measured by STAR Experiment for AuAu collisions at $\sqrt{s_{NN}}=200$ GeV, AIHONG TANG, Brookhaven National Lab, STAR COLLABORATION — With large statistics obtained in RHIC run VII, directed flow measurements for charged particles are extended to $p_t$ as large as 8 GeV/c, for AuAu collisions at $\sqrt{s_{NN}}=200$ GeV. The directed flow of pion, proton, kshort and lambda will be reported. The wiggle structure as a signature of the first order phase transition is not observed within the statistical significance of the present measurements. Comparison to previous measurements will be made. Elliptic flow scaled by initial eccentricity ($v_2/e$) as a function of particle density in the transverse plane (1/s$^N$/d$\Omega$) is fitted with transport model motivated formula. Measurements of event anisotropy at $\sqrt{s_{NN}}=200$ GeV are compared to transport calculations. It is found that the $1/s^N/d\Omega$ dependence of $v_2/e$ can be described well by transport models with finite Knudsen numbers. The result indicates that the system has not yet reached ideal hydrodynamic limits even for central collisions. Constrains on the product of the cross section and the speed of sound are provided, eta/s is estimated. The Knudsen fit is also applied to $v_2$ from viscous hydro calculations and the result is compared to data.

9:45AM CC.00003 Azimuthal Anisotropy of Unidentified Hadrons at Forward Rapidity in PHENIX at RHIC, ERIC RICHARDSON, University of Maryland, PHENIX COLLABORATION — At the Relativistic Heavy Ion Collider (RHIC), where Au nuclei are collided at 200 GeV per nucleon pair, key insights into the bulk properties of the newly formed matter have been made by studying the azimuthal anisotropy ($v_2$) of the produced particles. Studies of $v_2$ have shown that the hot dense matter undergoes rapid thermalization and behaves hydrodynamically at low $p_t$. Furthermore, the quark scaling of the $v_2$ signal for different particle species suggests that thermalization occurs at the quark level and that $v_2$ is the same for all quark flavors. This analysis will attempt to expand upon these principles by examining the $v_2$ of unidentified hadrons in the less studied pseudorapidity region of $|1.2| < \eta < |2.0|$ using PHENIX’s forward arm detectors. The analysis procedure and results will be explored.

10:00AM CC.00004 Partonic collectivity at RHIC, HIROSHI MASUI, Lawrence Berkeley National Laboratory — The discovery of partonic collectivity and the brand-new process for hadronization - quark coalescence were obtained through a systematic study of $v_2$ for 200 GeV Au+Au collisions at RHIC [1]. However, early dynamic information might be masked by later hadronic rescatterings. Multistrange hadrons ($\phi$, $\Xi$ and $\Omega$) with their large mass and presumably small hadronic cross sections should be less sensitive to hadronic rescattering in the later stage of the collisions and therefore a good probe of the early stage of the collision. We will present the measurement of $v_2$ of $\pi$, p, $K^*$, $\Lambda$, $\Xi$, $\phi$ and $\Omega$ in heavy ion collisions. In minimum-bias Au+Au collisions at $\sqrt{s_{NN}}=200$ GeV, a significant amount of elliptic flow, almost identical to other mesons and baryons, is observed for $\phi$ and $\Omega$. Experimental observations of $p_T$ dependence of $v_2$ of identified particles at RHIC support partonic collectivity. [1] B. I. Abelev et al., (STAR Collaboration), Phys. Rev. C 77, 054901 (2008).

10:15AM CC.00005 Bridging the soft and the hard at RHIC, JIANGYONG JIA — Measurements from RHIC at intermediate $p_T$ of 2-6 GeV/c revealed many features in various single particle and two particle correlation observables. These measurements not only suggest the leading roles of collective flow and jets in this $p_T$ region, but also show how strong and sophisticated the coupling between the two is. Experimental results are discussed in the hope to elucidate the connections between the soft and the hard processes.

10:30AM CC.00006 Predictions in $^{238}$U + $^{238}$U collisions at RHIC, HIROSHI MASUI, Lawrence Berkeley National Laboratory — Planned $^{238}$U + $^{238}$U collisions at RHIC (2012) would provide opportunities to answer several open questions at RHIC. For example, the ratio of elliptic flow $v_2$ to the initial spatial anisotropy $e$ as a function of transverse number density would indicate to the extent which the system approaches the ideal hydrodynamical limit. The saturation of $v_2/e$ could indicate that the system reaches local thermal equilibrium. Until now, there were no hint of saturation even at most central $^{197}$Au + $^{197}$Au collisions at top RHIC energy. Due to the larger size and the deformation of Uranium, the $^{238}$U + $^{238}$U collisions could reach higher densities than that achieved in $^{197}$Au + $^{197}$Au collisions at the same energy. In this talk, we present the predictions of various observables in $^{238}$U + $^{238}$U collisions at $\sqrt{s_{NN}} = 200$ GeV at RHIC. We discuss our Glauber Monte Carlo model to extrapolate the observables from $^{197}$Au + $^{197}$Au to $^{238}$U + $^{238}$U collisions at top RHIC energy and show the results as a function of centrality.

10:45AM CC.00007 Bulk Viscous Effects on Relativistic Hydrodynamic Models of the Quark-Gluon Plasma, AKIHIKO MONNAI, TETSUFUMI HIRANO, The University of Tokyo — The quark-gluon plasma (QGP) created at Relativistic Heavy Ion Collider (RHIC) is well described within the framework of ideal hydrodynamic models. Our next step is to develop the treatment for viscosity in relativistic hydrodynamics. We mainly discuss the effects of bulk viscosity because recent studies suggest that it becomes large near the pseudo-phase transition temperature. Viscous corrections are brought into QGP physics through (i) modification of the distribution $d\beta$ and (ii) variation of the flow $b\nu$ and the hyperbolic surface $|\delta T|$. In principle, viscosity could increase multi-plane hydrodynamic models beyond the single-plane hydrodynamics. Effects of bulk viscosity on the QGP phenomena is discussed, along with the prospect for the consistent development of viscous hydrodynamic models to estimate $d\beta$ and $d\delta T$. We see that bulk viscous effects can be large, and they should be treated with care in constraining the transport coefficients and/or the equation of state with precision from experimental data.

11:00AM CC.00008 Systematic Approach to Knudsen Number and Viscosity Extraction, JAMIE NAGLE, University of Colorado, Boulder, PETER STEINBERG, Brookhaven National Laboratory, BILL ZAJC, Columbia University — We explore the determination of the Knudsen Number ($K$) and shear viscosity to entropy density ratio ($\eta/s$) from experimental data at the Relativistic Heavy Ion Collider. We detail the various inputs, assumptions, and uncertainties involved in the methods of Drescher et al. We extend these results to incorporate other functional Knudsen Number dependencies and a quantum limit on $\eta/s$. 
11:15AM CC.00009 Novel diagrammatic method for computing transport coefficients — beyond the Boltzmann approximation —, YOSHIMASA HIDAKA, TEIJI KUNIHIRO, Department of Physics, Kyoto University — We propose a novel diagrammatic method for computing transport coefficients in relativistic quantum field theory. Our method is based on a reformulation and extension of the diagrammatic method by Eliashberg given in the imaginary-time formalism to the relativistic quantum field theory in the real-time formalism, in which the cumbersome analytical continuation problem can be avoided. The transport coefficients are obtained from a two-point function via Kubo formula. It is known that naive perturbation theory breaks down owing to a so called pinch singularity, and hence a resummation is required for getting a finite and sensible result. As a novel resummation method, we first decompose the two point function into the singular part and the regular part, and then reconstruct the diagrams. We find that a self-consistent equation for the two-point function has the same structure as the linearized Boltzmann equation. It is known that the two-point function at the leading order is equivalent to the linearized Boltzmann equation. We find the higher order corrections are nicely summarized as a renormalization of the vertex function, spectral function, and collision term. We also discuss the critical behavior of the transport coefficients near a phase transition, applying our method.

11:30AM CC.00010 Time-Dependent Variational Approach to the pure Gauge Theory for Evaluating the Shear Viscosity\textsuperscript{1}, YASUHIKO TSUE, TONG-GYU LEE, HIROSHI ISHII, Kochi University — The time-dependent variational approach to the pure Yang-Mills gauge theory, especially a color $su(3)$ gauge theory, is formulated in the functional Schrödinger picture with a Gaussian wave functional approximation. The equations of motion for the quantum gauge fields are formulated in the Liouville-von Neumann form. This variational approach is applied in order to derive the shear viscosity, which is one of the transport coefficients for the pure gluonic matter, by using the linear response theory. As a result, the contribution to the shear viscosity from the quantum gluons is zero up to the lowest order of the coupling $g$ in the quantum gluonic matter.

\textsuperscript{1}Supported by the Grants-in-Aid of the Scientific Research No. 18540278 from the Ministry of Education, Culture, Sports, Science and Technology in Japan.

11:45AM CC.00011 Non-collective component in v2 and how to detect it\textsuperscript{1}, JINFENG LIAO, LBNL — Current RHIC data on elliptic flow v2 as a function of pT display distinctive patterns at low and high pT due to different sources of particle yield: the hydrodynamic collective flow dominating the low pT and the non-collective hard processes dominating the high pT. The intermediate region where v2 shows nontrivial structure is yet not well understood. We emphasize the non-collective source which can also contribute to the observed v2 at low to intermediate pT. We further show that the backward-forward elliptic anisotropy correlation provides an experimentally accessible observable which distinguishes between collective and non-collective contributions to the observed v2. The measurement of this observable will reveal valuable information on the interpolation pattern at intermediate pT between the low-pT collective flow regime and the high-pT (semi)-hard processes regime. We also argue that the shift of dominance between the collective and non-collective sources is an alternative explanation to the dropping v2 at intermediate pT which may have important impact on quantifying the shear viscosity from v2 data. Reference: Jinfeng Liao & Volker Koch, arXiv: 0902.2377.

\textsuperscript{1}Supported by DoE under Contract No. DE-AC02-05CH11231.

Thursday, October 15, 2009 9:00AM - 12:00PM —
Session CD Mini-Symposium on Meson-Nucleus Systems and the Partial Restoration of Chiral Symmetry I | Kohala 4

9:00AM CD.00001 Recent topics of hadrons in nuclei, DAISUKE JIDO, Yokawa Institute for Theoretical Physics, Kyoto University — The investigation of the properties of hadrons in nuclei is one of the important subjects of contemporary nuclear physics. Especially, production and confirmation of meson-nucleus bound states are challenging both in experimental and theoretical points of view. With the structure of the (quasi)bound states, one can learn the in-medium properties of individual hadrons, and also universal consequences among the in-medium effects on the hadrons, such as the in-medium quark condensate. In this talk, I briefly review the recent topics of hadrons in nuclei. First, I will show that the in-medium properties of pion do relate to the quark condensate in finite density based on an exact sum rule derived recently by exploiting operator relations in QCD. We will discuss the consequences obtained in the deeply bound piconic atoms based on the sum rule. For the mesonic nuclei, I emphasize that, to understand physics of mesons in nuclei, detailed knowledge of baryon resonances is also important, since the meson inside the nucleus excites one of the nucleons and creates a baryon resonance. The interesting examples are N (1535) in the eta mesonic nuclei and A (1405) in the kaon and nucleus systems. For the mesonic nuclei, I discuss a possibility of the level crossing between the eta and N (1535)-hole modes caused by the reduction of the mass gap between N and N (1535) in the context of partial restoration of chiral symmetry. For the kaonic nuclei, reviewing the present status of A (1405), I discuss the important role of A (1405) and possible hadronic molecular states with multiple kaons.

9:30AM CD.00002 η meson production in nucleus and observation of in-medium behavior of N\textsuperscript{*}(1535), HIDEKO NAGAIRO, Nara Womens University, DAISUKE JIDO, YITP, Kyoto University, SATORU HIRENZAKI, Nara Womens University — The study of the in-medium hadron properties is one of the important subjects in nuclear physics. It would provide us useful information on chiral symmetry in finite density. In this contribution, we investigate the properties of the η-nucleus interaction in chiral models and discuss the possible observation of the in-medium behavior of the N\textsuperscript{*}(1535) resonance in experiments. The strong coupling of the ηN system to N\textsuperscript{*} enables us to investigate the in-medium properties of N\textsuperscript{*} through the η meson production in nuclei. For in-medium properties of N\textsuperscript{*}, there are some theoretical models paying respects to chiral symmetry. In the chiral doublet model, in which N\textsuperscript{*} is regarded as a chiral partner of nucleon, the effect of the partial restoration of chiral symmetry reduces the mass difference of N and N\textsuperscript{*} in the nuclear medium. On the other hand, the chiral unitary model, in which N\textsuperscript{*} is introduced as a resonance dynamically generated by meson-baryon scattering, predicts almost no mass shift of N\textsuperscript{*} in nuclear matter. To investigate the in-medium properties of N\textsuperscript{*}, we would like to discuss the formation probability of the η mesic nuclei by using the missing mass spectroscopy and also investigate the production reaction of the η meson off nuclei that has a different kinematics from the former reaction.
9:45AM CD.00003 Recent results on in-medium properties of the omega meson\(^1\). VOLKER METAG, II. Physikalisches Institut, Univ. Giessen, CBELSA/TAPS COLLABORATION — Data on the photo production of \(\omega\) mesons on nuclei have been re-analyzed. For incident photon energies of 900 – 2200 MeV, \(\omega\) mesons have been identified via the \(\pi^0\gamma\) channel using the CBELSA/TAPS detector. A new procedure has been developed which allows a model-independent background determination in shape and absolute magnitude directly from the data. Applying this method, an earlier claim of an in-medium lowering of the \(\omega\) mass [1] can not be confirmed. Because of the strong in-medium broadening of the \(\omega\) meson, deduced from a transparency ratio measurement [2], the fraction of in-medium \(\omega \rightarrow \pi^0\gamma\) decays is correspondingly reduced and the experiment becomes less sensitive to in-medium mass shifts. A higher sensitivity is expected for incident energies close to the production threshold [3]. A measurement at incident photon energies of 800-1400 MeV has been performed. Results of this experiment, including an analysis of the \(\omega\) excitation function, will be presented.


\(^1\)Supported by BMBF and SFB/TR16.

10:00AM CD.00004 Coherent \(\pi^+\) Photoproduction on \(^3\)He. RAKHSHA NASSERIPOUR, BARRY BERRYMAN, The George Washington University, CLAS COLLABORATION — Comparing an elementary meson-production process on a free nucleon with the same process inside a nucleus has been an interesting problem in nuclear physics. Studying these processes are useful in developing our understanding of nuclear structure and the long-range part of the nucleon-nucleon interaction described by the one-pion-exchange model. In the present analysis, we have measured the differential cross section for the \(\gamma^3\)He \(\rightarrow \pi^+\) reaction channel. Studying this channel is ideal for understanding the interaction of pions with nuclei and for searching for possible effects mediated by nucleon resonances in nuclear matter. The \(^3\)He target contains the lightest nucleus on which one can observe coherent (elastice) \(\pi^+\) photoproduction with charge exchange that also leads to a well defined final state that can be easily identified. This reaction was studied using the CEBAF Large Acceptance Spectrometer (CLAS) at Jefferson Lab. Real photons produced with the Hall-B bremsstrahlung tagging system in the energy range from 0.35 to 1.55 GeV were incident on a cryogenic liquid \(^3\)He target. The differential cross sections for the \(\gamma^3\)He \(\rightarrow \pi^+\) reaction were measured as a function of photon-beam energy and pion-scattering angle in the center-of-mass frame. Our results will be presented and discussed.

10:15AM CD.00005 Precision Spectroscopy of Pionic Atom in (d,\(^3\)He) Reaction at RIKEN-RIBF. SATOSHI ITOH, University of Tokyo, PIAF COLLABORATION — Spectroscopy of pionic atoms has been contributing to understanding of the origin of hadron masses. The hadron masses dynamically grow as the chiral symmetry is partially broken. The order of the symmetry breaking is parameterized by the magnitude of the quark condensate. The objective of our experiment is to evaluate the magnitude of the quark condensate through precise experimental determination of the in-medium isovector interaction strength between the pion and the nucleus. Previous results of the pionic atom spectroscopy yielded the first quantitative estimation of its reduction at the normal nuclear density to be about 33% compared to that in the vacuum. However, the value of 33% definitely needs more careful and precise evaluation. The next experiment will be performed at RIKEN-RIBF. In this experiment, we use the dispersion matching to minimize the effect of the incident beam momentum spread. After fulfilling the necessary technical issues, we will achieve about twice better resolution of 150 – 200 keV compared to the previous. In this contribution, we introduce the next experiment and report the present status.

10:30AM CD.00006 Deeply Bound Pionic 1s and 2s States in Sn at RIBF. NATSUMI IKENO, Nara Women's University, JUNKO YAMAGATA-SERIKHARA, YITP, Kyoto, HIDEKO NAGAIRO, Nara Women's University, DAISUKE JIDO, YITP, Kyoto, SATORU HIRENZAKI, Nara Women's University — Deeply bound pionic states are interesting exotic systems since we can observe the properties of NG boson in nucleus and deduce clear information on the partial restoration of chiral symmetry around normal nuclear density. Recently it has been reported that the (d,\(^3\)He) reaction at recoilless kinematics efficiently populates these states. New experiments will be performed at a new facility, RIKEN RIBF, in near future with significantly better energy resolution than those in the previous experiments. There, one expects to observe the 2s atomic state, which has not been observed so far, in addition to the deepest 1s state. In this contribution, we discuss physical implications of the new data obtained in simultaneous observation of the 1s and 2s states with high energy resolution. It is known that only information of pionic atom yrast levels hardly provides the pion properties at different nuclear densities. We expect that the pion in the 2s state can probe different nuclear densities from the yrast levels. Thus, we perform a systematic evaluation of the effective nuclear densities which can be probed by pions in various atomic states. We explore the possibilities to deduce the pion properties at different nuclear densities by observing the different atomic states, and discuss the importance of the 2s pionic states in Sn isotopes.

10:45AM CD.00007 Precision spectroscopy of kaonic atom x rays at DAΦNE with silicon drift detectors in SIDDHARTA (III). HEXITI SHI, University of Tokyo, SIDDHARTA COLLABORATION — The SIDDHARTA (Silicon Drift Detector for Hadronic Atom Research by Timing Application) project is currently in progress at the DAΦNE e-e\(^-\) collider in LNF (Laboratori Nazionali di Frascati), Italy. In this experiment, the \(K^-\) series x rays of kaonic hydrogen atom will be measured to a precision below 10 eV to determine the strong interaction shift and width of the kaonic hydrogen atom 1s state with the best accuracy ever, which is important for the understanding of the kaon nucleon interaction. A gaseous target is used to stop the kaons produced resonantly through \(\phi \rightarrow K^+K^-\) at DAΦNE interaction point. And the specifically designed SDDs with a time resolution at micro-second order in addition to an energy resolution of about 150 eV FWHM at 6 keV, were introduced to achieve both a good timing selection to reduce background and a high energy resolution. The array of 144 such SDDs each with 1 cm\(^2\) effective surface will cover a large sensitive area, leading to a better acceptance of kaonic x rays. Preliminary results of the measurement carried out in 2009 will be discussed.

11:00AM CD.00008 \(K^-pp\) studied with Coupled-Channel Complex Scaling Method. AKINOBU DOTE, IPNS/KEK, TAKASHI INOUE, Univ. of Tsukuba — \(K^-\) nuclei (nuclear system with anti-kaon) might have lots of interesting properties due to the strong \(K^-\) \(N\) attraction in \(s\)-wave isoscalar channel. Recently, people are focusing on the most essential \(K^-\) \(N\) "\(K^-pp\)". A variational calculation with an effective \(K^-\) potential, derived from the chiral SU(3) theory, performed by one of authors (A. D.), concluded the shallow binding of \(K^-pp\) (only 20 MeV). However, a Faddeev (AGS) calculation, also constrained by chiral SU(3) theory, reported 80 MeV binding energy. Such a large discrepancy is considered to be caused by the \(\pi\SigmaN\) three-body dynamics. Since the \(\pi\SigmaN\) degree is not explicitly dealt with in the variational calculation and is incorporated in the effective \(K^-\) \(N\) potential, the \(\pi\SigmaN\) three-body dynamics might be lack in the previous study. We will perform a coupled channel calculation treating the \(\pi\SigmaN\) channel explicitly. Since the obtained \(K^-pp\) \(\pi\SigmaN\) coupled state is expected to appear above the \(\pi\SigmaN\) threshold as a resonant state, we employ "Complex Scaling Method" (CSM) which has succeeded in the treatment of resonances in nuclear physics. Studying \(K^-pp\) with “Coupled-Channel Complex Scaling Method” using a reliable \(NN\) potential (Av18 potential) and theoretical/phenomenological \(K^-\) \(N\) potentials, we will report its binding energy and decay width. Then, analyzing the CSM function, detailed property of \(K^-pp\) will be investigated.
11:15AM CD.00009 Search for kaonic nuclear state using p+p reaction, KEN SUZUKI, Stefan-Meyer-Institut, Austrian Academy of Sciences, FOPI COLLABORATION — Since so-called “kaonic hydrogen puzzle” has been solved about 10 years ago with a modern X-ray measurement of kaonic hydrogen, and K N interaction has been reasonably well constrained from the experimental data, a possible existence of exotic nuclear systems involving K as a constituent has been a hot topic for theory and experiment. Such systems are said to have peculiar features compared to conventional nuclear systems, namely high binding energy (> 50 MeV), bound states like K^-pp, K^-ppp due to strong I = 0 K N interaction, density that does not saturate at normal nuclear density. We plan an experimental program to aim at the first high statistics, low background measurement in order to examine unambiguously the existence of the prototype kaonic nuclear state, K^-pp using p+p → K^- + K^- + p reaction at Tp = 3 GeV. The experiment employs the FOPI apparatus at GSI (Germany) and beamtime is scheduled in August 2009. In the talk, an impression of quick analysis will be reported as well.

11:30AM CD.00010 Λ(1405)-induced non-mesonic decay in kaonic nuclei, TAKAYASU SEKIHARA, Department of Physics, Kyoto University, JUNOKI YAMAGATA-SEKIHARA, DAISUKE JIDO, YOSHIKO KANADA-EN’YO, Yukawa Institute for Theoretical Physics, Kyoto University — The non-mesonic decay of kaonic nuclei is studied under the Λ(1405)-doorway picture, in which the K absorption to the nuclei takes place through the Λ(1405) resonance, owing to the presence of the Λ(1405) just below the KN threshold. For the study of the Λ(1405)- doorway non-mesonic decay of kaonic nuclei, we calculate the Λ(1405)→YN transition in uniform nuclear matter using one-meson exchange model. In the present calculation we find that the non-mesonic decay ratio ΓΛN/ΓΣN depends strongly on the ratio of the couplings Λ(1405)-KN and Λ(1405)-πΣ. Especially a larger Λ(1405)-KN coupling leads to enhancement of the decay to N. Using the chiral unitary approach for description of the KN amplitudes, we obtain ΓΛN/ΓΣN ≈ 1.2 almost independently of the nuclear density, and find the total two-nucleon absorption of the K in uniform nuclear matter to be 22 MeV at the normal density. We also show the two-nucleon absorption spectrum of the (K^-, N) reaction in our approach.

11:45AM CD.00011 Λ*-hyper-nuclei with chiral dynamics, TOSHIHATA UCHINO, TETSUO HYODO, MAKOTO OKA, Tokyo Institute of Technology — Bound states of Λ = Λ(1405) in nuclei, the Λ*–hyper-nuclei, are studied from the viewpoint of chiral dynamics. As the Λ* is formed by a strong attraction between the Λ and the nucleon, the Λ*-hyper-nuclei can be a main component of the K nucleon bound states. We use an extension of the Nijmegen one-boson-exchange potential for the interaction between the Λ* and the nucleon. The coupling constants concerning the Λ* are determined by a microscopic theory based on chiral dynamics of meson-baryon systems. We discuss the level structure of the Λ*-hyper-nuclei in the case when the Λ* is described as a superposition of two states.

Thursday, October 15, 2009 9:00AM - 11:30AM – Session CE Mini-Symposium on Developments in Re-accelerated Rare Isotope Beam Physics

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9:00AM CE.00001 A new approach for Next-TRIAC1, HIROARI MIYATAKE, IPNS, KEK — TRIAC (Tokai Radioactive Ion Accelerator Complex) is a unique RIB facility in Japan based on the ISOL and post-acceleration scheme. It has been operated as a User Facility since the November of 2005. Fission fragment beams via the proton-induced uranium fissions of 10^13 fss/sec are available in the acceleration energy range 0 to 1.1 MeV/u. At this moment, before considering an immediate extension (or upgrade) of the present TRIAC in terms of facility, we have proposed a new research program, which is supposed to be one of important physics programs at the next generation of TRIAC-like facility (Next-TRIAC). That is an experimental approach to study unknown nuclei in the vicinity of waiting region for A=195 r-process abundance peak through the multi-nucleon transfer reactions of neutron-rich beams. In the talk, after the brief summary of TRIAC activities, I will introduce an outline of our short term experimental proposal and underlined physics motivation relevant to the future’s Next-TRIAC. Also I will mention some important R&D subjects to be solved in the short term project.

1 for TRIAC collaboration

9:30AM CE.00002 Spectroscopy around N = 126 nuclei produced by multi-nucleon transfer reaction, Y. HIRAYAMA, IPNS, KEK, N. IMAI, H. ISHIYAMA, S.C. JEONG, H. MIYATAKE, K. NIKI, M. OKADA, M. OYAIZU, Y.X. WATANABE, 202Os will be extracted as singly-charged ions by laser resonance ionization and transported to a detection station after being mass-separated for the spectroscopy.

9:45AM CE.00003 Radioactive beams from Californium fission at the CARIBU facility1, GUY SAVERD, RICHARD PARDO, SAM BAKER, CARY DAVIDS, DON PETERSON, DON PHILLIPS, RICK VONDRASEK, BRUCE ZABRANSKY, GARY ZINKAN, Argonne National Laboratory — The Californium Rare Ion Breeder Upgrade (CARIBU) of the ATLAS superconducting linac facility aims at providing low energy and reaccelerated neutron-rich radioactive beams to address key nuclear physics and astrophysics questions. These beams are obtained from fission fragments of a 1 Ci 252Cf source, thermalized and collected into a low-energy particle beam by a helium gas catcher, mass analyzed by an isobar separator, and charge bred to higher charge states for acceleration in ATLAS. The method described is fast and universal and short-lived isotope yield scale essentially with Californium fission yields. Expected intensities of reaccelerated beams are up to ~5x10^17 (10^17 at low energy) far-from-stability ions per second on target. Initial commissioning is being performed with weaker 2.5 and 80 mCi sources. Commissioning results, together with the nuclear physics and astrophysics program that will be pursued with the neutron-rich beams made available, will be presented. Plans for installation of the 1 Ci source will be discussed.

1 This work was supported by the U.S. department of Energy, Office of Nuclear Physics, under contract No. DE-AC02-06CH11357.

10:00AM CE.00004 Recent activities with slow and stopped RI at Tohoku-Cyclotron, TAKASHI WAKUI, Tohoku University, YURI MIYASHITA, RIKEN, KENZI SHIMADA, Tohoku University, NOZOMI SATO, JAEA, SAYO HOSHINO, HIROYUKI OUCHI, AYAKO SASAKI, SAYAKA IZUMI, TSUTOMU SHINOZUKA, Tohoku University — An overview will be presented of our recent activities with slow and stopped radioactive isotopes (SSRIs) at Cyclotron and Radioisotope Center (CYRIC), Tohoku University. Slow RI beams are mainly provided by the RF ion guide isotope separator on-line (RF-IGISOL) in which neutron rich nuclei in medium mass region are produced by proton induced fission reactions with a Uranium target. Using the RF-IGISOL, some experimental programs have been carried out, such as measurements of γ-factors and half-lives of excited states. A brief description of some ongoing projects utilizing the SSRIs will also be given. This description includes the production of spin polarization and installation of a new ECR ion source. Furthermore, the future prospects with SSRIs will be mentioned with emphasis on further development of the RF-IGISOL.
10:15AM CE.00005 Half-Life and Magnetic Moment of the First Excited State in $^{132}$I. S. IZUMI, Tohoku Univ., M. TANIGAKI, Kyoto Univ., H. OUCHI, A. SASAKI, S. HOSHIKO, Tohoku Univ., Y. MIYASHITA, RIKEN, N. SATO, JAEK, K. SHIMADA, T. WAKUI, T. SHINOZUKA, Tohoku Univ., Y. OHKUBO, Kyoto Univ. — The half-life and the magnetic moment of the first excited state in $^{132}$I are reported. There have been a long time confusion on the half-life measurements of the first excited state in $^{132}$I. Several groups performed the lifetime measurements, but the reported values range from 1 ns to 7 ns. The only reported value of the magnetic moment for this state was measured by Singh, but their result should be treated as unreliable because the time-integral perturbed angular correlation technique (TIPAC), which requires the life time data of this state, was used in their measurement. From this point of view, the half-life and the magnetic moment of this state were measured. $^{132}$I was obtained as the radioactive beam of $^{132}$Te and $^{132}$Sb from the newly developed RF-IGISOL (Radio frequency IGISOL system) at Tohoku University. The half-life of this state was determined to be $1.12 \pm 0.015$ ns by a conventional coincidence technique with a pair of BaF$_2$ detectors. The TDPAC measurement for the $^{132}$I implanted kinematically into nickel was performed with the help of a strong hyperfine field at iodine site in nickel, and the magnetic moment of this state was determined to be $\mu = + (2.06 \pm 0.18) \mu_N$. The configuration of this state based on the present results will be discussed.

10:30AM CE.00006 High precision Penning trap mass spectrometry of rare isotopes produced by projectile fragmentation. ANNA KWATKOWSKI, C. BACHELET, B.R. BARQUEST, G. BOLLEN, C.M. CAMPBELL, R. FERRER, C. GUENAUT, D. LINCOLN, D.J. MORRISSEY, G.K. PANG, A.M. PRINKE, R. RINGLE, J. SAVORY, S. SCHWARZ, Natl. Superconducting Cyclotron Lab./Michigan State Univ., M. BLOCK, GSI, P. SCHURY, RIKEN, C.M. FOLDEN III, D. MELCONIAN, Cyclotron Inst./Texas A&M Univ., S.K.J. SJUE, TRIUMF — The Low Energy Beam and Ion Trap (LEBIT) facility combines high precision Penning trap mass spectrometry with fast beam projectile fragmentation and high pressure gas stopping techniques. Advanced ion manipulation, such as high efficiency continuous mass selection in an ion-guide and radio-frequency ion accumulation and bunching, are used to purify, cool, and pulse the beam. Recent mass measurements include $^{51-56}$Fe, $^{60}$As, and $^{132}$Si. The neutron-rich iron isotopes access the N = 40 subshell closure. The new significantly lower mass uncertainty makes $^{60}$As a candidate to test the CVC hypothesis. $^{132}$Si, member of the A = 32, T = 2 quintet, provides the most precise test of the isobaric multiplet mass equation. An overview of the various aspects of ion manipulation and some of the resulting measurements will be presented.

10:45AM CE.00007 Status of Multi-Reflection Time-of-Flight Spectrometer for Radio-Isotopes at RIKEN. PETER SCHURY, Tsukuba University, MICHIHARU WADA, TETSU SONODA, AIKO TAKAMINE, YASUNORI YAMAZAKI, RIKEN, HERMANN WOLLNIK, Universität Geissen — The new Radioactive Ion Beam Factory at RIKEN will provide unprecedented access to exotic neutron-rich isotopes such as important for r-process nucleosynthesis. To utilize these exotic Rl beams, we continue to develop a Multi-Reflection Time-of-Flight (MRTOF) spectrograph. Our system will make use on an advanced gas cell to thermalize relativistic ions of exotic radioactive ions and transfer them to high-vacuum quickly and efficiently. An RF ion trap of novel geometry will cool and bunch ions extracted from the gas cell. A pair of electrostatic mirrors creates an extended flight path of 1 km or more for the ions. By combining high-quality ion pulses with the long flight path, simulations have indicated that the device should be capable to achieve mass resolving powers of $R = \frac{m}{\Delta m} > 500,000$. The high-resolving power will allow the MRTOF spectrometer to be competitive with Penning trap mass spectrometers. We will present the current state of development of our MRTOF along with an overview of our anticipated impact on the nuclear landscape.

11:00AM CE.00008 ORISS: A compact isomer and isobar separator for study of exotic decays. A. PIECHACZEK, V. SHCHEPUNOV, H.K. CARTER, J.C. BĂȚCHELDER, UNIRIB, ORAU, Oak Ridge, TN 37830, E.F. ZGANJAR, Louisiana State University, Baton Rouge, LA 70803 — A compact isobar and isomer separator and separator ORISS (Oak Ridge Isomer Separator and Spectrometer), based on the multi-pass-time-of-flight principle, is being constructed. A mass resolving power of 110,000 (fwhm) and a transmission of 50% have been achieved as a spectrometer with an off-line ion source with large emittance. As a separator, molecules of N$_2$ and CO with a mass difference of 1/2500 or 10.433 MeV were separated with ToF peaks corresponding to a mass resolution of 40,000. For injection of radioactive ions into ORISS and to further improve its mass resolution, we have constructed cooler/buncher RF quadrupoles and demonstrated a bunch width of 9 ns (fwhm) and a transmission of 75 – 80%. With this bunch width, ORISS can achieve a mass resolution of ~ 400,000 and will be able to separate nuclei or isotopes with a mass difference of 1/200,000, corresponding to 470 keV at mass A ~ 100. At present, the quadrupoles are being integrated into the ORISS system. ORISS will be used for decay spectroscopy to provide isotopically pure samples of exotic species around $^{106}$Sn and of neutron rich nuclei. In addition, ORISS will allow a fast and efficient search for isomers within an entire isobaric chain.

11:15AM CE.00009 Parasitic production of slow RI-beam from a projectile fragment separator by ion guide Laser Ion Source (PALIS). TETSU SONODA, RIKEN, SLOWRI COLLABORATION — The projectile fragment separator BigRIPS of RIBF at RIKEN provides a wide variety of short-lived radioactive isotope (RI) ions without restrictions on their lifetime or chemical properties. A universal slow RI-beam facility (SLOWRI) to decelerate the beams from BigRIPS using an RF-carpet ion guide has been proposed as a principal facility of RIBF. However, beam time at such a modern accelerator facility is always limited and operational costs are high. We therefore propose an additional scheme as a complementary option to SLOWRI to drastically enhance the usability of such an expensive facility. In BigRIPS, a single primary beam produces thousands of isotopes but only one isotope is used for an experiment while the other >99.99% of isotopes are simply dumped in the slits or elsewhere in the fragment separator. We plan to locate a compact gas cell with 1 bar Ar at the slits. The thermalized ions in the cell will be quickly neutralized and transported to the exit by gas flow and resonantly re-ionized by lasers. Such low energy RI-beams will always be provided without any restriction to the main experiment. It will allow us to run parasitic experiments for precision atomic or decay spectroscopy, mass measurements. Furthermore, the resonance ionization in the cell itself can be used for high-sensitive laser spectroscopy, which will expand our knowledge of the ground state property of unstable nuclei.
9:00AM CF.00001 Photon-pion transition form factor and pion distribution amplitude. ANATOLY RADYUSHKIN, ODU and Jefferson Lab — The pion distribution amplitude (DA) $\varphi_\pi(x)$ [1,2] is an important function accumulating information about momentum sharing between the quarks of the pion when the latter is in its valence $q\bar{q}$ configuration. It is an inherent element of perturbative QCD calculations of hard exclusive reactions involving the pion. A scenario is investigated in which the leading-twist pion DA $\varphi_\pi(x)$ is approximated by the pion decay constant $f_\pi$ for all essential values of the light-cone fraction $x$. A model for the light-front wave function $\Psi(x, k_L)$ is proposed that produces such a DA and has a rapidly decreasing (exponential for definiteness) dependence on the light-front energy combination $k_L^2/x(1-x)$. It is shown that this model easily reproduces the fit of recent large-$Q^2$ BABAR data [3] on the photon-pion transition form factor. Some aspects of scenario with flat pion distribution amplitude are discussed.


9:15AM CF.00002 ABSTRACT WITHDRAWN —

9:30AM CF.00003 Nucleon strangeness form factors from $N_f = 2 + 1$ clover fermion lattice QCD, TAKUMI DOI, University of Tsukuba, MRIDUPAWAN DEKA, SHAO-JING DONG, TERRENCE DRAPER, KEH-FEI LIU, DEVDATTA MANKAME, University of Kentucky, NILMANI MATHUR, Tata Institute of Fundamental Research, THOMAS STREUER, University of Regensburg, $\chi$QCD COLLABORATION — Recent experiments of parity-violating electron scattering (PVES) make it possible to pin down the strangeness electromagnetic form factors in the nucleon. In my talk, I will present a theoretical calculation of strangeness electric and magnetic form factors from a full QCD lattice simulation using $N_f = 2 + 1$ clover fermion configurations generated by CP-PACS/JLQCD collaborations. I will discuss the methodology which significantly improves the signal for the disconnected insertion calculation. Our lattice results are consistent with experimental values, and our errors are at an order of magnitude smaller. I also present preliminary results for the strangeness parton moments in the nucleon.


9:45AM CF.00004 Strange quark contribution to the electromagnetic properties of the nucleon, Results of the Gzero experiment, FATIHA BENMOKHTAR, Carnegie Mellon University, GZERO COLLABORATION — The G0 experiment at Jefferson Laboratory measured the parity violating asymmetry in the cross section for polarized electrons scattered at backward angles off liquid hydrogen and deuterium. Measurements were made at two momentum transfers: 0.23 and 0.62 (GeV/c)^2. Combined with forward angle measurements on a hydrogen target the contribution of strange quarks to the proton’s charge and magnetization distributions can be determined. These measurements also allow the extraction of the isovector axial form factor as seen in electron scattering. Final results of the complete separation of the strange electric, strange magnetic and the isovector axial form factors are presented. A variety of recent theoretical predictions of these form factors are discussed.

10:00AM CF.00005 Measurement of the gp-$\eta$P reaction with Crystal Ball detector at the Mainz Microtron (MAMI-C) [1]. IGOR STRAKOVSKY, GWU, SERGEY PRAKHOV, University of California LA, YAKOV AZIMOV, Petersburg Nucl. Phys. Inst., WILLIAM BRISCOE, GWU, BERND KRUSCHE, Basel Univ., MICHAEL OSTRICK, Mainz Univ., FOR THE A2 CBTAPS COLLABORATION — The gp-$\eta$P reaction has been measured with the Crystal Ball multiphoton spectrometer and TAPS calorimeter in the energy range from the production threshold of 707 to 1400 MeV. Bremsstrahlung photons produced by the 1.5 GeV electron beam of the Mainz Microtron MAMI-C and tagged by the Glasgow photon spectrometer were used for the eta-meson production. The available statistics of $3.8 \times 10^9$ gp-$\eta$P reactions were sufficient to study in detail the reaction dynamics at our energies. The gp-$\eta$P differential cross sections were determined for the full range of the production angles by dividing the data in 120 energy intervals. The systematic uncertainties in the differential cross sections are at the order of 4%. The data have been used to evaluate the etaP multipoles in the vicinity of several low-lying $1 = 1/2$ baryon resonances. These data and the extracted multipole can be compared to previous determinations.

1 Supported by US DOE, NSF OISE/RES, and German DFG, SFB 443.

10:15AM CF.00006 ABSTRACT WITHDRAWN —

10:30AM CF.00007 Electron scattering for exotic nuclei, TOSHIMI SUDA, RIKEN Nishina Center — One of burning issues of nuclear physics today is to understand the structures of short-lived nuclei, some of which, especially at near the drip lines, were discovered to have peculiar structures, such as skin or halo. Electron scattering which is the best probe for the study of atomic nuclei, has never been applied due to difficulties for target preparation; their short lifetime and low production rate. In order to overcome the difficulties, we have proposed a novel internal-target scheme, SCRIT (Self-Confining RI Target). This technique is based on the “ion-trapping” phenomenon known at electron storage rings, which is seriously harmful for the ring performances. SCRIT uses the phenomena positively to form the targets of exotic nuclei on the electron beam. The feasibility study of this scheme has been done using a prototype. The results of the study using stable $^{133}$Cs ions, which completely mimicked the usage of short-lived nuclei, show that the SCRIT scheme works, and a luminosity of higher than $10^{26}/\text{cm}^2/\text{s}$ is achievable using only $10^7$ ions, which is high enough for elastic scattering. A door to completely untouched fields in nuclear physics is now ready to open. An electron scattering facility in RIKEN RI Beam Factory is under construction.

10:45AM CF.00008 Development of a Recoil Ion Detector for Self-Confining RI Target (SCRIT) [1], KAZUO SHINDO KURITA, Rikkyo University, TAKASHI EMOTO, RIKEN, KENICHI ISHIH, Rikkyo University, SACHIKO ITO, RIKEN, AT-SUHIRO KUWAJIMA, Tohoku University, AKIRA NODA, TOSHIYUKI SHIRAI, Kyoto University, TOSHIHIRO SUWA, RIKEN, TADAHIKO TAMA, Tohoku University, HIROMU TONG, MASANORI WAKASUGI, SHUO WANG, YASUSHI HANANO, RIKEN, SCRIT TEAM — SCRIT is a radioactive isotope target (SCRIT) which produces such a DA and has a rapidly decreasing (exponential for definiteness) dependence on the light-front energy combination $k_T^2/x(1-x)$. It is shown that this model easily reproduces the fit of recent large-$Q^2$ BABAR data [3] on the photon-pion transition form factor. Some aspects of scenario with flat pion distribution amplitude are discussed.

[1] Supported by US DOE, NSF OISE/RES, and German DFG, SFB 443.
11:00AM CF.00009 Electric quadrupole moment of the $^{33}$Al ground state. K. ASAHI, T.I. Tech, H. UENO, RIKEN, D.L. BALABANSKI, INRNE, J.M. DAUGÄS, CEA, M. DEPUYDT, M. DE RYDT, IKS/K.U. Leuven, L. GAUDEFROY, CEA, S. GREVY, GANIL, Y. HASAMA, T.I. Tech, Y. ICHIKAWA, D. KAMEDA, RIKEN, P. MOREL, CEA, T. NAGATOMO, RIKEN, L. PERROT, IPN/Orsay, K. SHIMADA, Tohoku U., CH. STOEDEL, J.C. THOMAS, GANIL, Y. UTSUNO, JAEA, W. VANDERHEUDEN, N. VERMEULEN, P. VINGERHOETS, IKS/K.U. Leuven, E. YAGI, K. YOSHIDA, A. YOSHIMI, RIKEN, G. NEYENS, IKS/K.U. Leuven — The ground-state $\beta$-moment of $^{33}$Al has been measured by applying the $\beta$-ray-detected nuclear magnetic resonance technique to spin-polarized $^{33}$Al fragments produced in the projectile fragmentation reaction. The obtained $\beta$-moment, $|Q_{\text{exp}}(^{33}\text{Al})| = 132(16) \text{mb}$, shows a significant deviation from the theoretical value predicted in the shell model calculation with the USD interaction. The deviation will be discussed in context of possible erosion of the $N\rightarrow 20$ shell gap, by comparing the experimental $\beta$ and theoretical predictions from the large scale shell model calculation and the particle-vibration coupling calculation.

11:15AM CF.00010 Deeply Virtual Compton Scattering on $^4$He with CLAS. HOVANES EGIYAN, University of New Hampshire. CLAS COLLABORATION — The introduction of the Generalized Parton Distribution (GPD) formalism transformed the landscape for probing the deep inelastic structure of hadrons. Deeply Virtual Compton Scattering (DVCS) provides us with the cleanest way of accessing these GPDs. Recent DVCS experiments have mainly focused on proton targets, demonstrating the applicability of the GPD formalism above momentum transfers of $Q^2 > 2 \text{GeV}^2$, while relatively less effort has been devoted to the understanding of nuclei in terms of GPDs. Studies of the DVCS process on nuclei can provide us with information on the quark-gluon structure of nuclei, as well as significantly improve our understanding of the modifications of nucleons in the nuclear medium. In this talk we will review the existing data on nuclear DVCS, and will describe the new experiment at Jefferson Lab to measure the Compton form-factor of the helium nucleus.

11:30AM CF.00011 A Precision Measurement of the Neutron Radius in $^{208}$Pb. DUSTIN McNULTY, University of Massachusetts. PREX COLLABORATION — The upcoming $^{208}$Pb Radius Experiment (PREx) at Jefferson Lab’s Hall A will determine the neutron radius $R_n$ of Lead with $\pm 1\%$ projected precision. The experiment will measure the parity-violating electron asymmetry in the elastic scattering of polarized electrons from $^{208}$Pb at an energy of 1.05 GeV and scattering angle of 5°. In this way, the neutrons are isolated by the weak charge probe and thus allow for a model independent measurement of $R_n$ analogous to the classic measurements of the proton radius $R_p$. The theoretical corrections to the measured asymmetry are either small or well understood providing a clean extraction of the neutron form factor and charge density. In addition to being a fundamental test of nuclear theory, a precise measurement of $R_n$ pins down the density dependence of the symmetry energy of neutron rich nuclear matter which has impacts on neutron star structure, heavy ion collisions, and atomic parity violation experiments.

11:45AM CF.00012 Nuclear Charge Radius of $^4$He$^1$. P. MUELLEI, I.A. SULAI, K. BAILEY, R.J. HOLT, R.V.F. JANSSENS, Z.-T. LU, T.P. O’CONNOR, Argonne National Lab, A.C.C. VILLARI, J.A. ALCANTARA-NUNEZ, M. DUBOIS, C. ELEON, G. GAUBERT, N. LECESNE, M.G. SAINT-LAURENT, J.C. THOMAS, R. ALVES-CONDE, GANIL, G.W.F. DRAKE, University of Windsor, L.-B. WANG, Los-Alamos National Lab — $^4$He is the most neutron-rich matter to have been synthesized on Earth: it consists of two protons and six neutrons, and remains stable for an average of 0.2 seconds. It is often viewed as a $^4$He core with four additional neutrons forming a neutron halo. Because of its intriguing properties, $^4$He has the potential to reveal new aspects of the fundamental forces among the constituent nucleons. We have recently succeeded in laser trapping and cooling this exotic helium isotope, and have performed precision laser spectroscopy on individual trapped atoms. Based on the frequency shifts of atomic transitions measured along the isotope chain $^4$He – $^7$He, the nuclear charge radius of $^4$He has been determined for the first time. Comparing this result with the values predicted by a number of nuclear structure calculations, we test theoretical understanding of the nuclear forces in the extremely neutron-rich environment.

This work is supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.

12:00PM CF.00013 Experimental Probes of Two-Photon Exchange. MICHAEL KOHL, Hampton University — The observed discrepancy in measurements of the proton electric to magnetic form factor ratio between the Rosenbluth and recoil polarization method has been interpreted as due to previously neglected effects of two-photon exchange (TPE). Calculations involving TPE in turn lead to changes in the angular dependence of elastic cross sections and double polarization observables. Evidence for TPE can be directly and most stringently tested by comparison of positron-proton and electron-proton elastic cross sections. Further, the imaginary part of the TPE amplitude gives rise to transverse single-spin asymmetries for polarized beam or target. The experimental efforts to address TPE will be reviewed.

Thursday, October 15, 2009 9:00AM - 12:00PM – Session CG Mini-Symposium on Nuclear Physics in Stars II Kings 2

9:00AM CG.00001 Neutrino Oscillation in Supernovae and Its Influence on Nucleosynthesis. TAKASHI YOSHIDA, University of Tokyo — During a supernova (SN) explosion, a huge amount of neutrinos are emitted from a proton-neutron star. These neutrinos change their flavors by neutrino oscillation. In the O/C and He/C layers, the flavor change occurs by the MSW effect and, therefore, the average energies of $\nu_e$ and $\nu_\mu$ increase. The increase in the average neutrino energies enhance the effect of charged-current neutrino-nucleus reactions so that the yields of light elements produced through the $\nu$-process increase. Recently, the flavor change by neutrino self-interaction has been discussed. Since the flavor change occurs in the innermost region of SN ejecta, it could affect neutrino-nuclear reactions in such a deep region. I would like to talk about neutrino oscillations in SNe, including the MSW effect and neutrino self-interaction, and the change of neutrino energy spectra in SNe. I also would like to discuss the influence of the neutrino oscillation on the nucleosynthesis of light elements produced through the $\nu$-process and heavy elements produced in the innermost region of the SN ejecta.

9:30AM CG.00002 Quantum Coherence of Relic Neutrinos. CHAD KISHIMOTO, UCLA, GEORGE FULLER, UCSD — The cosmic neutrino background (i.e., the relic neutrinos) last scattered in the early universe when the photon-baryon plasma was very hot, around the epoch of big bang nucleosynthesis. At this last scattering surface the neutrinos are largely in flavor eigenstates. We discuss the implications of this fact on cosmology and cosmological limits on neutrino parameters.

9:45AM CG.00003 ABSTRACT WITHDRAWN –
10:00AM CG.00004 Neutrino-Induced Reactions on Ni and Fe Isotopes and Nucleosynthesis in Stars. TOSHIRO SUZUKI, Nihon University; MICHIKO HOMMA, University of Aizu; KOJI HIGASHIYAMA, Chiba Institute of Technology; TAKASHI YOSHIWA, TAKAHARU OTSUKA, HIDEYUKI UMEUDA, KENICHI NOMOTO, University of Tokyo — Neutrino-induced reactions on Ni and Fe isotopes are investigated based on the neutron model Hamiltonians for fp-shell, GXPF1. Spin and magnetic properties of nuclei have been considerably improved by the Hamiltonians, where important roles of tensor interaction on shell evolutions are properly taken into account. Charge-exchange reactions on $^{56}$Fe induced by DAR neutrinos is investigated by using Gamow-Teller strength obtained by the new Hamiltonian, GXPF1J. The observed cross section is shown to be consistent with the observation. The Gamow-Teller strength in $^{56}$Ni is found to be more spread compared to previous calculations and result in a considerable large branching ratio for the proton knock-out channel. This leads to the enhancement of the production yields of heavy elements such as $^{54}$Mn and $^{59}$Co in population III stars for the new Hamiltonian [1]. The electron capture reactions on $^{56}$Ni, neutrino-induced reactions on $^{52}$Fe and the production of elements such as $^{51}$V in supernovae will be also discussed.


10:15AM CG.00005 Breakup of proton-rich nuclei $^{24}$Si and $^{23}$Al at intermediate energies for reaction rates in explosive H-burning in novae and X-ray bursts. A. BANU, L. TRACHE, R.E. TRIBBLE, B. ROEDER, E. SIMMONS, Cyclotron Institute, Texas A&M University; N. ORR ET AL., LPC, Caen, France; M. CHARTIER ET AL., University of Liverpool, UK; R. LEMMON ET AL., CCLRC Daresbury Laboratory, UK; W. CATFORD ET AL., University of Surrey, UK; M. FREER, University of Birmingham, UK; F. CARSTOU ET AL., IFIN-HH, Bucharest, Romania; M. HOROI, Central Michigan University; A. BONACCORSO, University of Pisa, Italy — We present the use of one-proton-removal reactions of loosely bound nuclei at intermediate energies as an indirect method in nuclear astrophysics, with particular reference to the results of a GANIL experiment with a cocktail beam around $^{23}$Al at 50 MeV/nucleon. Momentum distributions of the core fragments, inclusive and in coincidence with gamma rays, from which we determine configuration mixing in the structure of the ground states of the projectile nuclei, were measured. The method has the advantage that it can be used for beams of low quality, such as cocktail beams, and intensities as low as a few pps. These breakup reactions provide information on H-burning reaction rates for $^{23}$Al(p,$\gamma$)$^{24}$Si and $^{23}$Al(p,$\gamma$)$^{24}$Si, important in novae and X-ray bursts.

10:30AM CG.00006 A Study of the $^{30}$S($\alpha$,p)$^{33}$Cl Reaction Rate1, C.M. DEIBEL, Argonne National Laboratory (ANL), Joint Institute for Nuclear Astrophysics, C.L. JIANG, B.P. KAY, H.Y. LEE, R.C. PARDO, K.E. REHM, C. UGALDE, A. WOODARD, ANL, J.M. FIGUEIRE, U.A. FISICA, S.T. MARLEY, ANL, Western Michigan University (WMU), N.R. PATEL, ANL, Colorado School of Mines, M. PAUL, Hebrew University, A. WUOSMAA, WMU — The $^{30}$S($\alpha$,p)$^{33}$Cl reaction rate has major implications for x-ray bursts (XRBs). No experimental information exists for this reaction rate, though XRB models have shown that it affects final isotopic abundances and the total energy output. This rate may also influence XRB observables such as the structure of double-peaked luminosity curves and the composition of the neutron star crust. We have studied the time-inverse reaction $^{33}$Cl($^{30}$S,$\alpha$)$^{36}$Cl at ATLAS using a radioactive $^{33}$Cl beam. The residual $^{30}$S nuclei were detected at the focal plane of the split-pole spectrograph, which was used in gas-filled mode, in coincidence with the $^{\alpha}$ particles, which were detected in a double-sided Si detector. The experimental results and conclusions about the impact on XRB nucleosynthesis will be discussed.

1Supported in part by the DOE.

11:00AM CG.00008 Galactic Chemical Evolution and Origin of r-Process Elements. YUHRI ISHIMARU, International Christian University, SHINYA WANAJI, Technische Universität Muenchen — Metal-poor stars record enrichment history of the Galaxy at the early epoch. Observations of these stars show large star-to-star scatter in their abundances of neutron-capture elements. This indicates that these stars were enriched by only one or a few supernovae (SNe), since the inter-stellar medium had not been fully mixed when they were formed. Thus, the huge dispersions suggest that r-process events are highly linked on the SN progenitor mass, although the astrophysical site of r-process remains still uncertain. We attempt to determine the origin of r-process elements from the point of view of chemical evolution of the Galaxy. We construct an inhomogeneous chemical evolution model on the assumption of SN induced star formation. Various stellar mass ranges are assumed for the site of r-process, and the predicted distributions of stellar chemical components are compared with observational data including those collected at the SUBARU Telescope.

11:15AM CG.00009 Elucidating the Properties of Dense Matter from Starquakes in Neutron Star Crusts1, ANDREW STEINER, Michigan State University — The recent observation of quasi-periodic oscillations in giant flares produced in highly magnetized neutron stars offers a unique opportunity to constrain the properties of the neutron star crust. The frequencies, some of which are thought to be normal modes of oscillation of the neutron star crust, can be measured to few percent accuracy. I will show that the normal mode frequencies are quite sensitive to the nuclear physics aspects of the crust, in particular, to the nuclear symmetry energy. This promises to be an important constraint on the nuclear symmetry energy which is complementary to constraint obtained by the determination of the neutron skin thickness of lead at Jefferson Lab.

1Supported by NASA ATP grant NNX08AG76G and NSF grant 04-56903.

11:30AM CG.00010 Nuclear limits on gravitational waves from neutron stars. PLAMEN KRASTEV, San Diego State University, TAMU-Commerce; AARON WORLEY, University of Denver, TAMU-Commerce, BAO-AN LI, Texas A&M University-Commerce — Neutron stars are among the possible sources emitting gravitational waves (GWs) with a strain-amplitude dependent upon star’s quadrupole moment, rotational frequency, and distance from detector. We show that the gravitational wave strain amplitude depends strongly on the equation of state of neutron-rich stellar matter. Applying an equation of state with symmetry energy constrained by recent nuclear laboratory data, we set an upper limit on the strain amplitude of GWs produced by neutron stars. Implications will be discussed.
11:45AM CG.00011 Nuclear Equation of State in the Presence of a Strong Magnetic Field
GRANT MATHEWS, IN-SAENG SUH, University of Notre Dame — Strong magnetic fields (~ 10^{12} G) can exist in the interiors of some neutron stars (magnetars). Such fields can modify the nuclear equation of state through effects of the magnetic pressure and the population of Landau levels by the electrons and nucleons. In this work magnetic properties such as the magnetization and the susceptibility of magnetar nuclear matter are calculated in the framework of relativistic Hartree mean field theory in which the baryons (neutrons, n, and protons, p) interact via the exchange of scalar σ and vector ω, ρ mesons. We find that the magnetization undergoes large de Haas van Alphen oscillations. The magnetic susceptibility then becomes unstable to the formation of magnetic domains. This magnetic domain formation can affect the surface properties of magnetars. In particular, the energy released by the domain formation is comparable to the observed episodic energy outbursts of soft gamma repeaters (SGRs) and Anomalous X-ray Pulsars (AXPs) thought to result from magnetars.

1Supported in part by the US Department of Energy.

Thursday, October 15, 2009 9:00AM - 11:30AM —
Session CH Mini-Symposium on the Three-nucleon Force in Few-Body Scattering and Reactions

9:00AM CH.00001 Few Nucleon Scattering and Three Nucleon Force
KIMIKO SEKIGUCHI, RIKEN Nishina Center — One recent topic of the few-nucleon system studies to explore the properties of three nucleons forces (3NFs) that appear in the system more than two nucleons. The 3NFs arise naturally in the standard meson exchange picture as well as in the more recent concept of chiral effective field theory. These forces are considered to be one key element to understand the nuclear phenomena in a consistent way. However there had been little knowledge with which to constrain the 3NFs. That is due to the fact that 3NFs are relatively weak compared to the nucleon–nucleon (NN) forces and then their effects are easily masked. Few nucleon scattering is one of the most promising tools for the 3NF study, because this system provides a rich set of energy dependent spin observables and differential cross sections. In the end of 1990’s two theory groups reported the rigorous numerical Faddeev calculations incorporating 2π scattering is one of the most promising tool for the 3NF study, because this system provides a rich set of energy dependent spin observables and differential cross sections. In the end of 1990’s two theory groups reported the rigorous numerical Faddeev calculations incorporating 2π exchange 3NFs in elastic nucleon-deuteron elastic and inelastic scattering and breakup reactions have been performed by groups at RIKEN, RCNP, KVI, IUCF and Upsalla. Theoretically addition of 3NFs other than 2π exchange types, and/or relativistic treatment, and completely new approach based on chiral effective field theory are now in progress. The importance of 3NFs has also been noted in other instances; e.g. descriptions of the binding energies of light mass nuclei and the empirical saturation point of symmetric nuclear matter. It is clear that the testing of 3NF models has just begun. In the presentation, recent progress in the 3NF study with few nucleon scattering at intermediate energies will be given.

9:30AM CH.00002 Three-nucleon forces in neutron-deuteron elastic and inelastic scattering
J.L. MATTHEWS, M. CHTANGEEV, W.A. FRANKLIN, MIT, T. AKDOGAN, E. ERTAN, Bogazici University, M.A. KOVASH, U. Kentucky, M. YULY, Houghton College — The sensitivity to three-nucleon forces (3NF) of nucleon-deuteron elastic scattering at large center-of-mass angles is by now well known. Previous p-d experiments (differential cross sections and spin observables) have tended to agree better with calculations that include 3NF, although at energies 200 MeV and above both p-p and n-d cross sections exceed theoretical predictions. We have undertaken a measurement of the dependence on incident neutron energy of the differential cross section for n-d elastic scattering and p-d breakup reactions have been performed by groups at RIKEN, RCNP, KVI, IUCF and Upsalla. Theoretically addition of 3NFs other than 2π exchange types, and/or relativistic treatment, and completely new approach based on chiral effective field theory are now in progress. The importance of 3NFs has also been noted in other instances; e.g. descriptions of the binding energies of light mass nuclei and the empirical saturation point of symmetric nuclear matter. It is clear that the testing of 3NF models has just begun. In the presentation, recent progress in the 3NF study with few nucleon scattering at intermediate energies will be given.

9:45AM CH.00003 Cross section enhancement in pd breakup at \( E_p = 250 \text{ MeV} \)
SHO KUROITA, KENSHI SAGARA, YUICHIRO EGUCHI, KEISUKE YASHIMA, TAKURO SHISHIDO, TATSUYA YABE, MASANORI DOZONO, YUKIKO YAMADA, TOMOTSUGU WAKASA, TETSUO NORO, Kyushu University, HIROAKI MATSUBARA, JUZO ZENIHIRO, ATSUSHI TAMII, HIROYUKI OKAMURA, KICHIJI HATANAKA, RCNP, Osaka University, TÖRÖ SÁNTI, YUKIE MAEDA, University of Miyazaki, HIROYUKI KAMADA, Kyushu Institute of Technology, YUJI TAMESHIGE, NIRS — Up to a few times enhancement of \( pd \) breakup cross section was found in our inclusive experiment of \( ^3\text{He}(p,p_1)n \) at \( E_p = 250 \text{ MeV} \). The enhancement around \( E_{p_1} = 150 \text{ MeV} \) has been investigated in our exclusive experiment \( ^3\text{He}(p,p_1p_2)n \) at the same incident energy in the range of \( \theta_2 = 35^\circ - 80^\circ \). We found that the exclusive cross section enhancement depend on \( \theta_2 \). Enhancement of \( pd \) elastic scattering cross section has been found also at the incident energy.

10:00AM CH.00004 Systematic measurement of quasi-free scattering in pd breakup
YUICHIRO EGUCHI, KENSHI SAGARA, SHO KUROITA, KEISUKE YASHIMA, TAKURO SHISHIDO, TATSUYA YABE, Kyushu University, SOUCHI ISHIKAWA, Hosei University — Space-star anomaly in \( N\bar{d} \) breakup cross section is well known. There were reports on anomaly in quasi-free scattering (QFS) cross section in \( nd \) breakup reaction. We measured QFS cross section in \(pd \) breakup reaction, and compared the data with recent \( pd \) calculations. It was found that experimental QFS cross sections in \(nd\) \( pd \) breakup reaction are higher/lower than calculations, respectively.

10:15AM CH.00005 Quantum Monte Carlo Calculations of Nucleon-Nucleus Scattering
R.B. WIRINGA, KENNETH M. NOLLETT, STEVEN C. PIEPER, I. BRIDA, Argonne National Laboratory — We report recent quantum Monte Carlo (variational and Green’s function) calculations of elastic nucleon-nucleus scattering. We are adding the cases of proton-\(^{4}\text{He} \), neutron-\(^{1}\text{H} \) and proton-\(^{3}\text{He} \) scattering to a previous GFMC study of neutron-\(^{4}\text{He} \) scattering [1]. To do this requires generalizing our methods to include long-range Coulomb forces and to treat coupled channels. The two four-body cases can be compared to other accurate four-body calculational methods such as the AGS equations and hyperspherical harmonic expansions. We will present results for the Argonne \( v_{18} \) interaction alone and with Urbana and Illinois three-nucleon potentials.

1Supported in part by the US Department of Energy.

1Research supported by the DOE Office of Nuclear Physics under contract DE-AC02-06CH11357 and under SciDAC grant DE-FC02-07ER41457.
10:30AM CH.00006 Calculation of the \( nd \) Scattering Lengths by a Realistic Nonlocal Gaussian Potential  
KENJI FUKUKAWA, YOSHIKAZU FUJIWARA, Kyoto University — The calculation of the quartet and doublet \( nd \) scattering length, \( a_{nd} \) and \( a_{nd}^2 \), is difficult because of the deuteron distortion effect, especially for \( a_{nd} \). Even for \( a_{nd}^2 \), it is not easy to keep the numerical accuracy since the many channels couple. The well-known correlation between the triton binding energy and \( a_{nd}^2 \) is not completely understood in the calculations including three-body forces. Motivated by the successful application of the our quark-model baryon-baryon interaction fss2 to the triton binding energy without the three-body forces, we reexamine \( a_{nd} \) and \( a_{nd}^2 \) to study the effect of the nonlocality. We use a nonlocal Gaussian potential based on fss2, which is constructed to make few-baryon calculations much easier than the original interaction. We calculate the eigen-phase shift \( \delta \) and plot \( k \cot \delta \) versus \( k^2 \). The charge independence breaking is ignored. The energy region examined is from \( E_{cm} = 50 \) keV to 1 MeV. For the quartet scattering length, \( k \cot \delta \) is almost linear with respect to \( k^2 \) above \( E_{cm} = 100 \) keV. Below 100 keV, the numerical accuracy seems not to be maintained. We have obtained \( a_{nd} = 6.3 \) fm, which is close to the experimental value \( a_{nd} = 6.3 \pm 0.03 \) fm. For the doublet scattering length, \( a_{nd}^2 \) is expected to be about 0.8 fm (vs. \( a_{nd}^2 = 0.65 \pm 0.03 \) fm), but we need much wider model space than \( J_{max} = 2 \) and fine mesh points to keep the numerical accuracy of the eigen-phase shifts.

10:45AM CH.00007 Neutron-Neutron Scattering Length Determinations Using \( nd \) Breakup in Different Nuclear Detection Geometries  
C.R. HOWELL, A.S. CROWELL, J. DENG, J.H. ESTERLINE, M.R. KISER, R.A. MACRI, S. TAJIMA, W. TORNOW, Duke Univ. and TUNL, B.J. CROWE III, NC Central Univ., R.S. PEDRONI, NC A&T State Univ., W. VON WITSCHE, Univ. of Bonn, H. WITALA, Jagiellonian Univ. — Significant differences in the value for the \( 1S_0 \) neutron-neutron (\( nn \)) scattering length(\( a_{nn} \)) have been obtained with neutron-deuteron (\( nd \)) breakup measurements made using different detection geometries [1,2]. We report the results of a new determination of \( a_{nn} \) made using the \( nd \) breakup reaction in recoil proton geometry. The measurements were made at the Triangle Universities Nuclear Laboratory (TUNL) with a neutron beam energy of 19.0 MeV. The momenta of the recoil proton and one of the outgoing neutrons were measured at mean angles of \( \theta_p = 45.0^\circ \) and \( \theta_n = 52.1^\circ \), respectively. Details of the experiment and analysis will be presented, and results will be discussed.

Thursday, October 15, 2009 9:00AM - 11:30AM – 
Session CJ Mini-Symposium on Progress in Strangeness Physics II  
Queens 4

9:00AM CJ.00001 Baryon Resonances from Measurements of Strange Baryon Production  
KENNETH HICKS, Ohio University — The spectrum of excited states of the nucleon has been a topic of interest for both experimental and theoretical investigations for many years. The goal is to measure the masses of resonances of the nucleons (\( N^* \)), of the hyperons (\( \Lambda^* \)) and of other baryons such as the \( \Delta \). Once these masses are known, then theoretical calculations (either models or lattice gauge theory) can be used to interpret the resonance spectrum, and in search for missing resonances. Among kaon photoproduction processes, the \( \gamma n \rightarrow K^+\Lambda \) reaction is a unique process and is vital to understanding kaon photoproduction. In order to study this reaction, we have constructed the new spectrometer (NKS2) optimized to cover the forward region, thus making it possible to measure much larger kinematical region of \( K^+ \). We have performed the experiment of \( K^+ \) photoproduction near the threshold region (\( E_K = 0.8-1.1 \) GeV) with a liquid deuterium target at the Laboratory of Nuclear Science, Tohoku University (LNS-Tohoku). The data analysis is in progress. The preliminary results of the cross section will be presented in this talk.

9:30AM CJ.00002 Measurement of \( \gamma d \rightarrow K^+\Lambda p \) reaction with NKS2 at SENDAI  
KENTA Futatsumi, Tohoku Univ., NKS2 COLLABORATION — Kaon photoproduction plays an important role in the investigation of meson-baryon interactions, the structures of hadrons, and in search for missing resonances. Among kaon photoproduction processes, the \( \gamma n \rightarrow K^+\Lambda \) reaction is a unique process and is vital to understanding kaon photoproduction. In order to study this reaction, we have constructed the new spectrometer (NKS2) optimized to cover the forward region, thus making it possible to measure much larger kinematical region of \( K^+ \). We have performed the experiment of \( K^+ \) photoproduction near the threshold region (\( E_K = 0.8-1.1 \) GeV) with a liquid deuterium target at the Laboratory of Nuclear Science, Tohoku University (LNS-Tohoku). The data analysis is in progress. The preliminary results of the cross section will be presented in this talk.
9:45AM CJ.00003 The investigation of strangeness photoproduction in the threshold region at LNS-Tohoku, MASASHI KANETA, Department of Physics, Tohoku University, NKS2 COLLABORATION — Strangeness photoproduction near the threshold is important to study the production mechanism. The process had been intensively studied based on the high-quality data of the charged kaon channel, \( \gamma + p \rightarrow K^+ + \Lambda(\Sigma^0) \). However, there was no reliable data for the neutral kaon channel \( \gamma + n \rightarrow K^0 + \Lambda \) and the theoretical investigations suffered seriously from the lack of the data. In order to obtain reliable data for the neutral kaon photoproduction process, we have been making an effort to measure the \( \gamma + n \rightarrow K^0 + \Lambda \) reaction in the \( \pi^+ - \pi^- \) decay channel of \( K_\Sigma^0 \), using a liquid deuterium target and a tagged photon beam in the energy region from 0.8 to 1.1 GeV at Laboratory of Nuclear Science (LNS), Tohoku University. We have taken exploratory data quite successfully with use of Neutral Kaon Spectrometer (NKS). Now we are at the second stage of the experimental study using a new spectrometer for extending the previous experiment in the statistics and the momentum/angular acceptance for \( K^0 \)'s and \( \Lambda \). The data was taken in 2005-2007. In this talk, we will present recent results from the NKS2 experiment and future plan of the experiment.

10:00AM CJ.00004 Pseudoscalar-meson-octet-baryon coupling constants in two-flavor lattice QCD, M. OKA, Tokyo Tech, G. ERLKOL, Ozyegin Univ., T.T. TAKAHASHI, YITP, Kyoto Univ. — We evaluate the \( \pi NN, \pi \Sigma \Sigma, \pi \Lambda \Sigma, K \Lambda N \) and \( K \Sigma N \) coupling constants and the corresponding monopole masses in lattice QCD with two flavors of dynamical quarks. The parameters representing the SU(3)-flavor symmetry are computed at the point where the three quark flavors are degenerate at the physical \( s \) state sits below \( \bar{\Lambda}K_0 \). We discuss the method’s benefits, and show the effect on the missing mass distributions.

10:15AM CJ.00005 Prospects of realistic Quark-model baryon-baryon interactions\(^1\), CHOKI NAKAMOTO, National University of Singapore, Department of Physics, Kyoto University, YASUYUKI SUZUKI, ZHANG, Y. ZHANG, Department of Physics, and Graduate School of Science and Technology, Niigata University — The QCD-inspired spin-flavor SU(6) quark model for the baryon-baryon interaction, proposed by the Kyoto-Niigata group, is a unified model for the full octet-baryons \( \{\Lambda = N, \Lambda, \Sigma \} \), which has achieved very accurate descriptions of the nucleon-nucleon \( NN \) and hyperon-nucleon \( YN \) interactions. The present model, fss2, is not only more sophisticated than the previous model, FSS, for the description of the realistic \( NN \) and \( YN \) interaction, but also valid for reproducing of the existing experimental data in the strangeness \( S = \pm 2 \) sector. We attempt to construct the more realistic quark-model baryon-baryon interactions possessing both the desirable feature of the quark model and the accuracy equivalent with fss2 for the experimental data.

\(^1\)This work was supported by Grants-in-Aids for Scientific Research on Priority Areas (Grant No. 20028003).

10:30AM CJ.00006 A novel spectral broadening from vector-axial-vector mixing in dense matter\(^1\), MASASU HARADA, Nagoya University, CHIHIRO Sasaki, Technische Universitaet Muenchen — The presence of baryonic matter leads to the mixing between transverse \( \rho \) and \( a_1 \) mesons through a set of \( \omega \Gamma_{a_1} \)-type interactions, which results in the modification to the dispersion relation. We show that a clear enhancement of the vector spectral function appears below \( \sqrt{s} = m_{\rho} \) for small three-momenta of the \( \rho \) meson, and thus the vector spectrum exhibits broadening. We also discuss its relevance to dilepton measurements.

\(^1\)Supported in part by the JSPS Grant-in-Aid for Scientific Research (c) 20540262.

10:45AM CJ.00007 Perturbation of Chiral Soliton, ANJAN BISWAS, Delaware State University — This talk is on perturbation of soliton due to the chiral Nonlinear Schrodinger’s equation by the aid of soliton perturbation theory. The perturbation term that is studied is the quantum potential perturbation of the chiral soliton that is known as Bohm potential. The stable fixed point of the chiral soliton parameters is obtained.

11:00AM CJ.00008 Experimental Study of \( \Lambda(1405) \) by a Virtual Meson-Baryon Scattering\(^1\), HIROYUKI NOUMI, RCNP, Osaka University — It is a long standing problem if \( \Lambda(1405) \) is a 3-quark state or a kaon nucleon bound state. Recent theoretical studies based on chiral unitary model claimed that \( \Lambda(1405) \) may consist of two components in a coupled-channel \( K N \) system. Namely, poles coupled to \( K N \) and \( \pi \Sigma \) are suggested at different positions. If it is true, decomposition of the two components are desired in the \( \Lambda(1405) \) spectrum. Since the \( \Lambda(1405) \) state sits below \( K N \) threshold, it is of essentially importance to investigate a \( K N \) scattering process in a virtual state. The \( (K^- n) \) reaction on deuteron is promising to enhance a virtual \( K N \) reaction to produce \( \Lambda(1405) \). The experimental study of \( \Lambda(1405) \) via the reaction has been proposed at J-PARC.

\(^1\)A collaboration of this experimental work is being formed based on the E15 collaboration

11:15AM CJ.00009 Application of Likelihood PID Method in Hypernuclear Experiment E01-011\(^1\), PAUL Baturin, JOERG Reinhold, Florida International University, JEFFERSON LAB E01-011 (HKS) COLLABORATION — JLab experiment E01-011, employed the \( (e,e'K^+) \) reaction for a new generation of hypernuclear spectroscopy studies. A new high resolution kaon spectrometer (HKS) together with the newly introduced tilt method for the electron spectrometer (ENGE) allowed to simultaneously achieve excellent energy resolution and significantly reduce background events due to bremsstrahlung and Moller electrons. The energy spectra of exotic neutron rich \( \Lambda \) hypernuclei \( \{^7,^9,^9\text{He},^9\text{Li},^12\text{B},^20\text{Al}\} \) were measured with high statistics. Efficient kaon particle identification (PID) is key to obtaining good signal to background ratios. We introduced a method based on probability density functions for independent detector distributions that are combined into likelihood values for each possible particle. The goal is to improve statistical significance, especially for low statistic core excited states that are observed in the excitation spectra. The presentation will illustrate the novel likelihood approach, compare it to standard PID cuts, discuss the method’s benefits, and show the effect on the missing mass distributions.

\(^1\)Supported in part by DoE ER41047 & ER41065 and MEXT, Japan.
9:00AM CK.00001 Low-energy probes of physics beyond the Standard Model. VINCENZO CIRIGLIANO, Los Alamos National Laboratory — I will discuss theoretical aspects of symmetry tests with low-energy probes. I will focus mostly on (i) beta decays and gauge universality tests; (ii) lepton flavor violation in the charged lepton sector; (iii) searches for CP violating sources beyond the Standard Model and their cosmological implications. In all cases, I will emphasize the complementarity between collider searches and low-energy probes in understanding fundamental interactions at the weak scale and beyond.

9:30AM CK.00002 Neutron lifetime experiment with pulsed neutron beam at J-PARC 01. KENJI MISHIMA, KEK, NOP COLLABORATION — A new beam line using novel techniques of neutron optics for fundamental physics experiments, “NOP.” has been constructed on December 2008. In this talk, we introduce the beamline and a plan of neutron lifetime experiment. An accurate determination of neutron lifetime is important for tests of the Standard Model of Fundamental Particles, as well for the production of light mass nuclei in big bang nucleosynthesis. For the measurement of the neutron lifetime, there are two principally different approaches: one is “In-beam” methods, and the other is the ultracold neutron storage methods. The latest measurement of the latter methods (878.5 ± 0.7 stat. ± 0.3 syst. sec) differs from the previous former method (886.3 ± 1.2 stat. ± 3.2 syst.) by 7.8 sec. Thus we are planning the measurement of the lifetime with a intense pulsed neutron source at J-PARC by “in beam” method, and our target accuracy is 0.1%, which is comparable to the ultracold neutron storage method. Our method is a relative measurement of decay electrons and He(n,p)H reactions by a time projection chamber. The neutron beam is bunched by a spin flip chopper for background reduction and definition of the fiducial volume. In this talk, we would like to introduce our method and discuss how to improve the measurement up to 0.1%.

9:45AM CK.00003 Neutron lifetime experiment with pulsed neutron beam at J-PARC 02. HIDETOSHI OTONO, The University of Tokyo, NOP COLLABORATION — For the measurement of the neutron lifetime, there are two principally different approaches: one is “In-beam” methods, and the other is the ultracold neutron storage methods. Nowadays the latest measurement of the latter methods (878.5 ± 0.7 stat. ± 0.3 syst. sec) differs from the previous former method (886.3 ± 1.2 stat. ± 3.2 syst. sec) by 7.8 sec. Against this problem, we are planning another “In-beam” experiment by detecting decay electrons from neutron beam. The apparatus of our experiment consists of a time projection chamber for the track of decay electron and plastic scintillators with MPPCs for the trigger detector. The difficulty of our experiment is expected as the discrimination between decay electron and ambient background. For this purpose, we use neutron bunched by a spin flip chopper. The bunched neutron beam makes us possible to distinguish signal in chamber and background from outside. In addition, the fiducial position of neutron decay is determined as the function of time. In this talk, we present the performance of our experimental apparatus and the results of a test experiment.

10:00AM CK.00004 Progress Toward a Redetermination of the Neutron Lifetime Through the Absolute Determination of Neutron Flux. A. YUE, The University of Tennessee - Knoxville, G. GREENE, The University of Tennessee - Knoxville / Oak Ridge National Laboratory, M. DEWEY, D. GILLIAM, J. NICO, National Institute of Standards and Technology, A. LAPTEV, Los Alamos National Laboratory — The measurements of the neutron lifetime using “bottled” ultra- cold neutrons that claim the smallest experimental uncertainties are seriously discrepant with respect to each other. Given that the statistical contribution to their uncertainty is much smaller than the discrepancy, it is likely that one or more of these measurements suffers from an unidentified systematic effect. In the most precise cold neutron beam measurement of the lifetime which gives \( \tau_n = (886.3 ± 3.4) \) s, the largest uncertainty was attributed to the absolute determination of the capture flux of the neutron beam. A new direct measurement of the neutron lifetime flux monitor efficiency using an absolute “black” neutron detector could reduce this contribution to the uncertainty. A “black” detector that achieves 0.1% statistical precision in several days of running has been put into operation at the NIST Center for Neutron Research. A 0.1% calibration of the flux monitor efficiency will reduce the neutron lifetime uncertainty to approximately 0.25% (2.2 s). The technique, the uncertainty budget, and the current status of the experiment will be discussed.

10:15AM CK.00005 A Gravito-Magnetic Trap for Measuring the Neutron Lifetime using Ul- tracold Neutrons. KEVIN HICKERSON, California Institute of Technology. UCN LIFETIME COLLABORATION — There continues to be a significant discrepancy amongst the most precise measurements of the neutron lifetime. To help resolve this, the lifetime experiment at the Los Alamos Neutron Science Center (LANL) will use polarized ultracold neutrons (UCN) trapped by gravity in an asymmetric compound toroidal trap made of permanent magnets arranged in a high field gradient configuration called a Halbach array. Progress has been made on constructing the LANL experiment which removes marginally trapped UCN, a problematic systematic effect in previous measurements, with a compound toroid and a rippled multipole field that can quickly reduce the fraction of phase space of the trap that is quasi-bound, decreasing the probability that UCN escape or have material interactions during the lifetime measuring period.

10:30AM CK.00006 Overview of the UCNA Experiment. JIANGLAI LIU, California Institute of Technology, UCNA COLLABORATION — In neutron beta decay, the beta asymmetry \( \Delta \) is the angular correlation parameter between the neutron spin and the outgoing electron momentum. A measurement of \( \Delta \) allows a direct determination the ratio of the nucleon axial to vector coupling constants \( g_A/g_V \). While this ratio plays a significant role in solar fusion as well as in understanding other phenomena (in many instances in which the weak interaction in nuclear decays is involved), the axial coupling constant can not presently be calculated from first principles following the Standard Model. However, in combination with the neutron half life, it can provide stringent constraints to the Standard Model. The UCNA experiment is designed to measure the neutron decay \( \Delta \) parameter to very high precision (<0.5%), using the ultracold neutron (UCN) source at the Los Alamos Neutron Science Center. UCN are transported in a guide system, fully polarized, then loaded into a decay trap within a solenoidal beta spectrometer. A proof-of-principle measurement in 2007 has been published, and we are on track to produce a 1% measurement of \( \Delta \) based on data collected in 2008. In this talk, I will present an overview of the experiment, give a status report of the data analysis and ongoing data taking, as well as provide a projection for the near future.

1 Representing the UCNA Collaboration

10:45AM CK.00007 Systematics of the UCNA Experiment. ROBERT PATTIE, N.C. State University, UCNA COLLABORATION — The UCNA experiment measures the \( \beta \)-asymmetry parameter in free neutron \( \beta \)-decay using polarized ultracold neutrons (UCN). UCN created in the spallation source at LANSCE are polarized by a 7 T magnetic field in transit to a \( 2 \times 2 \) m spectrometer where the emitted electrons are measured. During the 2008 run cycle the major systematics were investigated, including neutron depolarization, electron scattering and energy loss, and neutron generated backgrounds. The asymmetry was measured in three geometries designed to maximize or minimize the effect of scattering and energy loss, \textit{in situ} and \textit{ex situ}. Measurements of the neutron depolarization were performed, and by blocking the \( \beta \)'s from neutron decay, limits were placed on the gamma flux from neutron capture in the spectrometer. Results of these tests will be presented in the context of a < 1% measurement of the \( \beta \)-asymmetry.
11:00AM CK.00008 Measuring the Parity-Violating Neutron Spin Rotation in Helium: The Neutron Spin Rotation Experiment. C.D. BASS, T.D. BASS, B.E. CRAWFORD, J.M. DAWKINS, K. GAN, B.R. HECKEL, J.C. HORTON, C.R. HUFFER, D. LIOU, D.M. MARKOFF, A.M. MICHERDZINSKA, H.P. MUMM, J.S. NICO, A.K. OPPER, M.G. SARSOUR, E. SHARAPOV, W.M. SNOW, H.E. SWANSON, S.C. WALBRIDGE, V. ZHUMABEKOVA — We have performed a precision measurement of the parity-violating neutron spin rotation in helium due to the nucleon-nucleon weak interaction at the NIST Center for Neutron Research. The measurement employed a beam of low energy neutrons passing through a liquid helium target system located between a neutron polarizer-analyzer pair. The parity-violating spin rotation magnitude was determined from measured count asymmetries in the analyzer. The expected parity-violating spin rotation of order $10^{-11}$ rad placed severe constraints on the apparatus design. In particular, isolation of the parity-odd component of the spin rotation from the much larger Larmor precession required use of a nonmagnetic target system that allowed movement of the target helium upstream or downstream of a vertical precession coil, which enabled us to take asymmetry differences to subtract background rotations. We describe the design and performance of the apparatus used for this experiment.

11:15AM CK.00009 A Measurement of the Parity-Violating Neutron Spin Rotation in 4He$^1$. W. SNOW, Indiana University/IUCF, C. BASS, T. BASS, National Institute of Standards and Technology, B. CRAWFORD, Gettysburg College, M. DAWKINS, Indiana University/IUCF, K. GAN, George Washington University, B. HECKEL, University of Washington, J. HORTON, Indiana University, C. HUFFER, North Carolina State University/TUNL, D. LIOU, Indiana University, D. MARKOFF, North Carolina Central University, A. MICHERDZINSKA, George Washington University, P. MUMM, J. NICO. National Institute of Standards and Technology, M. SARSOUR, Georgia State University, E. SHARAPOV, Joint Institute for Nuclear Research, E. SWANSON, University of Washington, S. WALBRIDGE, Indiana University, V. ZHUMABEKOVA, Al-Farabi Kazakh National University, P. HUFFMAN, North Carolina State University — A weak interaction between nucleons is induced by the quark-quark weak interaction in the Standard Model. At present the NN weak interaction is poorly constrained by experiment. We conducted an experiment to search for parity violation in the rotation of the plane of polarization of slow neutrons in liquid 4He at the Center for Neutron Research at the National Institute of Standards and Technology. In this talk we will report a preliminary result for a measurement of parity-violating neutron spin rotation in 4He. We will also discuss the prospects for follow-on experiments with reduced statistical and systematic errors.

1 Work is supported in part by NSF PHY-0457219 and NSF PHY-0758018.

11:30AM CK.00010 Testing Supersymmetry with Neutron Decay, W.S. WILBURN, V. CIRIGLIANO, A. KLEIN, P.L. MCGAUGHEY, M.F. MAKELA, C.L. MOLLIS, J. RAMSEY, A. SALAS-BACCI, A. SANDERS, Los Alamos National Laboratory, L.J. BROUSSARD, Duke University, A.R. YOUNG, North Carolina State University — It has been recently realized that the neutrino correlation parameter $B$ in neutron decay is sensitive to Minimal Supersymmetric Models for the case of maximal mixing. $B$ is currently known to a precision of $3 \times 10^{-3}$, but a precision better than $1 \times 10^{-3}$ is required to test these models. Improvements in experimental techniques developed for the ongoing UCNIA experiment and the planned abBA experiment may allow an improved measurement of $B$ with a precision approaching $1 \times 10^{-4}$. An emerging concept for combining these techniques into an experiment to measure $B$ using ultracold neutrons and large-area silicon detectors will be discussed.

11:45AM CK.00011 R-parity violating supersymmetric contribution to the nuclear beta decay, NODOKA YAMANAKA, TORU SATO, TAKAHIRO KUBOTA, Osaka University — The R-parity violating supersymmetric extension of the Standard Model is known to contribute to the neutron beta decay by the scalar coupling of the hadron and lepton currents. Among its decay distribution, the Fierz interference term and the coefficient of the triple product of the initial neutron's polarization, the momentum and polarization of the emitted electron, are observables sensitive to the scalar coupling. We investigate them within R-parity violating MSSM by constructing the hadronic matrix elements and find that new bounds on the R-violating couplings can be deduced from recent new measurement of the transverse polarization of the final electron. We also find contributions to additional angular correlation coefficients.

Thursday, October 15, 2009 9:00AM - 12:00PM
Session CL Instrumentation II Queens 6

9:00AM CL.00001 Performance study of a Vertex Drift Chamber (VDC) for the measurement of strangeness photoproduction in the $d(\gamma, K^0)\Lambda p$ reaction. BRIAN BECKFORD, Tohoku University, NKS2 COLLABORATION — Kaon photoproduction has been used extensively to study the strangeness production mechanism. However, relatively little is known about the strangeness production of neutral hyperons ($\Lambda$ or $\Sigma^0$). An experiment has been designed at the Laboratory of Nuclear Science of Tohoku University (LNS-Tohoku) which employs the recently upgraded Neutral Kaon Spectrometer 2 (NKS2), to study the $d(\gamma, K^0)\Lambda p$ reaction. Recent beam time at the LNS was used to commission the latest version of the NKS2 detector system. The VDC is included in order to measure the invariant mass of the $K^0_s$ and $\Lambda$, if coincident. Thus, avoiding the Fermi motion effect in the cross-section calculation; a determination of both invariant masses requires the four-track reconstruction of the reaction vertex. It is composed of 8 layers with wires placed only at stereo angles, resulting in an approximately 4 mm half-cell size. Preliminary tests have yielded a layer efficiency of 99% in the HV operating range of 2100-2150 V, and for a threshold range of 2.0-6.0 V for all layers. The motivation for the upgrade, experimental technique and preliminary results will be presented.

9:15AM CL.00002 Development of the Cylindrical Detector System for an experimental search for kaon nuclei at J-PARC. FUMINORI SAKAMOTO, RIKEN, J-PARC E15 COLLABORATION — The experiment J-PARC E15 searches for the simplest kaonic nuclear bound state, $K^+p$, by in-flight $^4He(K^+, n)$ reaction. To reconstruct invariant mass spectroscopy via the expected decay $K^-p \rightarrow \Lambda p \rightarrow np n$, the Cylindrical Detector System (CDS) has been constructed at the K1.8BR beam-line in the J-PARC 50GeV PS. The CDS consists of a solenoid magnet, Cylindrical Drift Chamber (CDC) and Cylindrical Detector Hodoscope (CDH) with the invariant-mass resolution via the $K^-p$ decay of 19 MeV/$c^2$ ($\sigma$). In addition, we are developing a thick-GEM (TGEM) TPC as an inner tracker for the upgrade of the experiment. In this talk, an overview of the detectors and the preparation status will be presented.

9:30AM CL.00003 ABSTRACT WITHDRAWN —

9:45AM CL.00004 Performance of PHENIX Prototype Resistive Plate Chambers$^1$, BRETT FADEM, Muhlenberg College, PHENIX COLLABORATION — The PHENIX detector is located on the ring of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. Prototype resistive plate chambers (RPC) modules were deployed during the latest RHIC run. The production versions of such modules will form an integral component of an upgrade to the PHENIX muon trigger. As a result of this upgrade, the determination of flavor separated quark and anti-quark distribution functions will be possible using single spin asymmetries of muons created in the parity-violating decay of W bosons. A report on the relative efficiency and timing resolution of the prototype under the $\sqrt{s} = 500$ GeV beam will be given.

$^1$ with support from the National Science Foundation.
10:00AM CL.00005 Assembly and Testing of the Resistive Plate Chamber Upgrade for the PHENIX Muon Arms. WILLIAM POWELL, Morgan State University, PHENIX TEAM — Important questions remain to be answered about the origin of the proton spin. A new fast resistive plate chamber (RPC) based trigger system is being developed for the PHENIX muon spectrometer arms that will allow for the first time the measurement of the flavor structure of the quark polarization in the proton through the observations of W-bosons in polarized proton-proton collisions at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. The new PHENIX Muon Trigger will improve the efficiency by which the data acquisition system can identify potential W events by approximately two orders of magnitude. W-bosons can be detected through the appearance of a high-energy muon in one of two existing muon spectrometers. The upgrade consists of four detector stations based on RPC technology, and new front-end electronics for the existing muon tracking detectors. Detector modules for one RPC station are currently being assembled and tested. Testing of the module components, completed modules and half octants will be described. Tests results and progress will be reported.

1PHENIX Team at Brookhaven National Lab

10:15AM CL.00006 Development of Fast-Data-Formatting Circuit for High Energy Muon Trigger in PHENIX Experiment, KATSURO NAKAMURA, Kyoto Univ./JSPS/RIKEN, PHENIX COLLABORATION — One of the main goals of the PHENIX experiment at RHIC is the understanding of the sea-quark polarization in a proton. Measuring the asymmetry of W boson production in polarized proton-proton collision is a powerful method to study the sea-quark polarization. The W boson is identified by the detection of a high energy muon from the decay. To acquire the data of high energy muons efficiently, an upgraded-trigger system which discriminates the high energy muons from large amount of low energy muons from hadron decays is required. One of the challenging points in this trigger system is that hit data from up to 9,500 strips of cathode-strip chambers are to be transmitted to a level-1 trigger circuit. Therefore, development of a digital circuit (MuTRG-MRG) which merges these hit data into a few data lines is necessary. In addition to the MuTRG-MRG, another digital circuit (MuTRG-DCMIF) which transmits the data to recording system is also needed for the study of the trigger performance. These two boards have been developed in KEK, installed in the PHENIX DAQ. Installed boards have been confirmed their communications with the level-1 trigger circuit and data recording module. In this presentation, the development and performance of the MuTRG-MRG board and the MuTRG-DCMIF board will be reported.

10:30AM CL.00007 Development and Performance Evaluation of Front-end Electronics for Forward W Trigger at RHIC-PHENIX experiment, YOSHINORI FUKAOKO, RIKEN, PHENIX COLLABORATION — RHIC performed the first polarized proton-proton physics run with √s = 500 GeV in 2009. One of the challenging goals in 500 GeV run is to probe flavor-sorted sea quark contribution to the proton spin through the measurements of spin asymmetry in W boson production. High momentum muons from W’s are detected by forward muon arms in PHENIX. Two major upgrades for the muon arm are in progress, Resistive Plate Counters (RPC) and Muon-Tracking-Chamber Forward-Electronics Upgrade (MuTRG-FEE), to provide a trigger for the W detection. RPC features good timing and spacial resolution. MuTRG-FEE extracts fast signal of Muon Tracking Chamber. Combination of these detectors realizes the high-momentum muon trigger for W by rough online tracking. We installed MuTRG-FEE into a half of muon arm as well as the prototype of RPC in 2008. Commissioning of the new trigger was carried out with beam collisions in 2009 run. The analysis is underway to evaluate the performance of the trigger such as the efficiency and the rejection power. In this talk, I focus on the result of the MuTRG-FEE analysis and will discuss the observed performance from the data in 2009.

10:45AM CL.00008 The GlueX Central Drift Chamber, YVES VAN HAARLEM, Carnegie Mellon University, GLUEX COLLABORATION COLLABORATION — The GlueX Central Drift Chamber (CDC) is a cylindrical detector located close to a liquid hydrogen cell as a part of the GlueX spectrometer in Hall-D at Jefferson Lab. It is designed to track charged particles originating from a 12 GeV polarized photon beam impinging on a liquid hydrogen target. One of the main goals of the GlueX experiment is to map out the hybrid meson spectra. The CDC has to be able to track charged particles with relative large polar angles (6-16°) in a solenoid magnetic field of 2.24 T. Also, this detector has to perform particle identification: to separate pions from protons in a momentum range up to 450 MeV/c. To fulfill these tasks the GlueX collaboration opted for a straw tube chamber because this option minimizes the material in the tracking region. The straw tubes will be 1.5 m long and the chamber will consist of 28 layers (12 axial + 16 stereo) or 3500 straws. The current status of this detector and test results obtained with prototypes will be presented.

11:00AM CL.00009 The GEM Tracking Subsystem for Qweak, TAMUNA DIDBERIDZE, TONY FOREST, Idaho State University, QWEAK COLLABORATION — A tracking subsystem for the Qweak experiment at Jefferson Lab has been constructed using gas electron multipliers (GEMs) to enable the detection of elastically scattered electrons at high rates. Unlike other similar tracking devices, the GEM based tracking system uses a polar coordinate system and custom designed digitization cards for readout. The coordinate system was chosen to simplify a measurement of the elastically scattered electron's squared momentum transfer. The readout electronics, designed at CERN, may be used by either silicon or GEM based detectors. The compact readout system has a high radiation tolerance and contains 128 readout channels per card. Each channel is sampled up to 40 MHz and is buffered to facilitate readout latencies up to 128 clock cycles. A description of the tracking system and the performance of the readout system will be presented.

1Work supported by the National Science Foundation.

11:15AM CL.00010 Simulation study of performance of active target GEM-TPC, RYOJI AKIMOTO, Center for Nuclear Study — For studying nuclear properties using scatterings and charge-exchange reactions with light nuclei as incident beams, it is crucial to measure their communications with the level-1 trigger circuit and data recording module. In this presentation, the development and performance evaluation of the MuTRG-MRG and the MuTRG-DCMIF board will be reported.

11:30AM CL.00011 A tight-alignment method of emission position using beam tracks to study double hypernuclei, YOSHIKI NAKANISHI, Gifu University, ED7-J-PARC COLLABORATION — In the KEK E373 experiment, there occurred misalignment of emulsion plates. This ratio was about 3% for tracking of 10^3 Ξ^- hyperon candidate. Since number of double hypernuclear event is at most 10^2 for 10^5 Ξ^- hyperon tracks in the E07 experiment at J-PARC, it is quite important to develop a tight-alignment method. The method needs local calibration of emission positions. Therefore, we check pattern of the large amount of beam tracks which penetrate vertically emulsion plate. To do so, beam tracks should be detected at the same level, for example moving focal plane under the microscope. First step of processing is binarizing the emulsion images by applying a threshold value. Second step is summing up the all binary images and binarizing the summed image by another threshold. Thus, there are two threshold variables. We change the values of the two and check the success ratio of beam detection. Then we got the optimum values and found about 5 tracks in one position(view size:3000μm^-2). These beam tracks are detected in another plate, it is expected that position alignment between two emulsion plates shall be carried out with 1 μm accuracy.
that meson mass is useful for fitting the model parameters at imaginary chemical potential. Therefore, an adopted model must have the RW periodicity. We fit the model parameter by LQCD data at imaginary chemical potential. At the imaginary chemical potential, there are some problems in moderate real chemical potential region. Therefore, we propose the new approach, imaginary chemical potential matching approach, to quantitatively determine the QCD phase diagram by using a phenomenological model that reproduce LQCD data at imaginary chemical potential. In this approach, we fit the model parameter by LQCD data at imaginary chemical potential. At the imaginary chemical potential, the QCD partition function has the special periodicity called Roberge-Weiss (RW) periodicity. Therefore, an adopted model must have the RW periodicity. We will report on the calculations of the QCD transition temperature at vanishing chemical potential, on attempts to establish the universal structure of the chiral transition in the limit of vanishing quark mass and on the QCD equation of state with physical light and strange quark masses. At Brookhaven National Laboratory — We will discuss the status of studies of the QCD phase diagram through lattice QCD calculations at non-zero temperature and density. We will report on the calculations of the QCD transition temperature at vanishing chemical potential, on attempts to establish the universal structure of the chiral transition in the limit of vanishing quark mass and on the QCD equation of state with physical light and strange quark masses. At the early universe, and therefore precise data of the photonuclear reactions as well as their inverse radiative capture reactions are indispensable for quantitative studies of astrophysical nucleosynthesis. Photonuclear reactions are also useful to probe the analogous neutrino-induced nuclear reactions by weak neutral current, which are supposed to play critical roles in the dynamics of Type-II supernova explosions and in accompanying neutrino-induced nucleosynthesis. Recently developed γ-ray sources based on the Compton backscattering of laser photons with relativistic electrons are expected to provide a powerful tool for high-precision experiments on photonuclear reactions at astrophysically important energies, because they have nice features such as quasi-monochromatic and tunable energy, high polarization, small angular spread, and so on. In this contribution the current status of the backscattered γ-ray facilities in the intermediate energy regions will be introduced, and some topics on nuclear astrophysics studies at those facilities will be presented.

8:30PM DA.00003 Direct Measurements of Radiative Capture and Charged Particle Reactions of Astrophysical Importance Using Radioactive Beams1, CHRIS RUIZ, TRIUMF — This decade has seen the growth of facilities such as TRIUMF-ISAC, and methods enabling the direct measurement of nuclear reactions considered to have astrophysical importance using radioactive ion beams. Many challenges exist in developing the intense radioactive ISOL beams needed, and the sensitive and precise detectors required, to make these measurements, which are crucial inputs to astrophysical models of explosive scenarios such as novae and x-ray bursts enabling direct comparison with astronomical data such as those from orbiting gamma ray observatories. With emphasis on the radiative capture reaction measurements made at the DRAGON facility using radioactive beams in the last decade for classical novae, I will discuss these direct measurements and their role in certain stellar environments, as well as the technical challenges involved in these difficult experimental measurements. Where relevant I will also refer to connected auxiliary indirect measurements at TRIUMF-ISAC and other laboratories, or similar stable beam measurements. I will present the results of the first direct measurement of the $^{23}$Mg($p,\gamma)^{24}$Al reaction at DRAGON, and discuss it in its context of explosive hydrogen burning in classical novae.

9:15PM DA.00004 TBD, BOB RUTLEDGE, McGill University —

Thursday, October 15, 2009 7:00PM - 10:00PM — Session DB Mini-Symposium on Mapping the QCD Phase Diagrams I Kona 4

7:00PM DB.00001 The QCD Phase Diagram from Lattice Regularized QCD, FRITHJOF KARSch, Brookhaven National Laboratory — We will discuss the status of studies of the QCD phase diagram through lattice QCD calculations at non-zero temperature and density. We will report on the calculations of the QCD transition temperature at vanishing chemical potential, on attempts to establish the universal structure of the chiral transition in the limit of vanishing quark mass and on the QCD equation of state with physical light and strange quark masses. At non-zero baryon chemical potential we will report on attempts to establish the existence of a critical point and comment on studies of higher moments of charge fluctuations that may serve as signatures for the QCD critical points.

7:30PM DB.00002 Importance of imaginary chemical potential for determination of QCD phase diagram, KOUIJI KASHIWA, Department of Physics, Kyushu University, Japan, HIROAKI KOUNO, Department of Physics, Saga University, Japan, YUJI SAKAI, MASANOBU YAHiro, Department of Physics, Kyushu University, Japan — Lattice QCD (LQCD) calculations have the well-known sign problem at finite real chemical potential. One approach to circumvent the problem is the analytic continuation of LQCD data to real chemical potential from imaginary one. This approach, however, has some problems in moderate real chemical potential region. Therefore, we propose the new approach, Imaginary chemical potential matching approach, to quantitatively determine the QCD phase diagram by using a phenomenological model that reproduce LQCD data at imaginary chemical potential. In this approach, we fit the model parameter by LQCD data at imaginary chemical potential. At the imaginary chemical potential, the QCD partition function has the special periodicity called Roberge-Weiss (RW) periodicity. Therefore, an adopted model must have the RW periodicity. We reveal the Polyakov-loop extended Nambu-Jona-Lasinio (PNJL) model has the RW periodicity. Moreover, we investigate the meson mass behavior and show that meson mass is useful for fitting the model parameters at imaginary chemical potential.
7:45PM DB.00003 Determination of QCD phase diagram from the imaginary chemical potential. SAKAI YUJI, KASHIWAA KOUJI, Kyushu University, KOUNO HIROAKI, Saga University, YAHIRO MASANOBU, Kyushu University — Lattice QCD has the well-known sign problem at real chemical potential. An approach to circumvent the problem is the analytic continuation to complex potential from imaginary one. We propose a new analytic continuation by using the Polyakov-loop extended Nambu–Jona-Lasinio (PNJL) model. This work is published in our papers of Phys. Rev. D77, 051901 (2008), Phys. Rev. D78, 036001 (2008), Phys. Rev. D78 076007 (2008), Phys. Rev. D 79, 076008 (2009), Phys. Rev. D 79, 096001 (2009). This talk presents the latest result of these studies. The partition function of QCD has the Roberge-Weiss (RW) periodicity in the imaginary chemical potential region. We revealed that the PNJL model has the RW periodicity. Strength parameters of the vector-type four-quark and scalar-type eight-quark interactions are determined so as to reproduce lattice data on pseudocritical temperatures of the deconfinement and chiral phase transitions in the imaginary chemical potential region. The QCD phase diagram in the real chemical potential region is predicted by the PNJL model. The critical endpoint survives, even if the vector-type four-quark interaction is taken into account.

8:00PM DB.00004 Quark number density in the phase with unbroken center Z2 symmetry in two-flavor QCD. SHINPEI TAKEMOTO, MASAYASU HARADA, Nagoya University, CHIHIBO SASAKI, Technische Universitat Munchen — We study the phase structure of two-flavor QCD including the 2-quark and 4-quark states. Using the Ginzburg-Landau type approach, we show a possible existence of the phase in which the chiral SU(2)L × SU(2)R symmetry is spontaneously broken to SU(2)V × Z2 symmetry, i.e., the center Z2 symmetry is left unbroken. In this Z2 symmetric phase, the chiral symmetry is broken by the 4-quark condensate although the 2-quark condensate vanishes. We find that it appears a new tricritical point between the Z2 symmetric phase and the Z2 broken phase. It is shown that the quark number susceptibility is strongly enhanced at the restoration point of the center Z2 symmetry rather than that of the chiral symmetry.

8:15PM DB.00005 Next-to-Next-to-Leading Order Evaluation of Effective Potential in the Strong Coupling Lattice QCD. TAKASHI NAKANO, Kyoto University, AKIRA OHNISHI, KOHTAROH MIURA, Yukawa Institute for Theoretical Physics, Kyoto University — Strong Coupling Lattice QCD (SC-LQCD) is a method directly based on QCD, and has been applied to investigate the properties of QCD in the strong coupling regime. To evaluate the finite temperature phase diagram of QCD, we need to go beyond the leading order (LO) and next-to-leading order (NLO) approximations. We discuss the effects of NLO in the effective potential are renormalized in modification of the quark mass and chemical potential in the strong coupling limit (SCL), and two order parameters (the chiral condensate and the density) are found to appear. These studies indicate the possibility of the partially chiral restored phase as well. In this study, we evaluate the effective potential in the next-to-next-to-leading order of SC-LQCD. We also discuss the properties of QCD phase diagram from the effective potential, including the position of the critical point which will be searched for in the low energy RHIC program.

8:30PM DB.00006 Deconfined phase transition in dense and hot QCD at large Nc. ARIEL ZHITNITSKY, University of British Columbia — We conjecture that the confinement- deconfinement phase transition in QCD at large number of colors Nc and Nf < Nc at T ≠ 0 and μ ≠ 0 is triggered by the drastic change in θ behavior. The conjecture is motivated by the holographic model of QCD. The conjecture is also supported by a number of numerical lattice results. Based on papers. Phys.Rev.D78:125002,2008, Nucl.Phys.A813:279-292,2008.

8:45PM DB.00007 2+1 flavor QCD phase structure at finite temperature and density in chiral random matrix models. TAKASHI SANO, HIROTSUGU FUJI, Univ. of Tokyo — The conventional chiral random matrix models are known to predict a second-order phase transition at finite temperature irrespective of the number of flavors. Here we propose a random matrix model which properly contains the UA(1) breaking term and as a result predicts a first-order transition for the three- flavor case. This is the first chiral random matrix model which allows us to investigate the effects of the strange quark degree on the QCD phase diagram, especially on the QCD critical point, at finite temperature and density. We will discuss the shape of the critical surface by varying the strength of the UA(1) anomaly.

9:00PM DB.00008 Analysis of the phase structure of graphene using lattice gauge theory. YASUFUMI ARAKI, TETSUO HATSUDA, The University of Tokyo — The electrons in graphene can be described as the (2+1)-dimensional Weyl fermions with massless Dirac-type dispersion moving in the (3+1)-dimensional Abelian gauge field. It is suggested that the emergence of the emergent gap of graphene has intimate relation to the dynamical chiral symmetry breaking in gauge theories. We have studied the phase structure of monolayer graphene by employing the techniques of lattice gauge theory. We report our recent studies on the exciton condensate in graphene for variable temperature and coupling constant.

9:15PM DB.00009 Non-Gaussian fluctuations and the search for the QCD critical point. MIKHAIL STEPHANOV, University of Illinois at Chicago — We study the effect of the QCD critical point on non-Gaussianity of fluctuations of experimental observables in heavy-ion collisions. We find that non-Gaussian moments are very sensitive to the proximity of the critical point, as measured by the magnitude of the correlation length ξ. For example, the cubic central moment of multiplicity grows as ξ−5/2, and the quartic cumulant as ξ−7. We estimate the magnitude of the critical point effects and conclude that non-monotonic variation of non-Gaussian moments with the collision energy can serve as a very sensitive signature of the QCD critical point.

9:30PM DB.00010 Exploring QCD phase diagram with third moments of conserved charges. MASAKIYO KITAZAWA, MASAYUKI AŠAKAWA, SHINJI EJIRI — We point out that the third moments of conserved charges, the baryon and electric charge numbers, and energy, as well as their mixed moments, change their signs around the QCD phase boundary in the temperature and baryonic chemical potential plane. These signs can be measured in relativistic heavy ion collisions, and will give clear information on the phase structure of QCD and the state of the system in the early stage of relativistic heavy ion collisions. The behaviors of these moments on the temperature axis and at small quark chemical potential can be analyzed in lattice QCD simulations. We emphasize that the third moments obtained on the lattice, together with the experimental results, will provide a deep understanding about the QCD phase diagram and the location of the state created in heavy ion collisions.

9:45PM DB.00011 Chiral phase transition with the functional renormalization group equation. KAZUHIKO KAMIKADO, KENJI FUKUSHIMA, Yukawa Institute for Theoretical Physics, Kyoto University — It has been conjectured by the perturbative renormalization group technique (epsilon-expansion) that, if interaction induced by the axial anomaly is suppressed at high temperature, the chiral phase transition of two-flavor quark matter is of fluctuation-induced first order transition. We discuss the shape of the effective potential using the linear sigma model and the functional renormalization group method and confirm that the shape change leads to the first-order phase transition. That is, the effective potential has a double-well structure in a certain parameter region. We also clarify the relation between the perturbative renormalization group (epsilon-expansion) and the functional renormalization group equations.

Thursday, October 15, 2009 7:00PM - 10:00PM — Session DC Mini-Symposium on Thermal and Collective Properties of the Quark Gluon Plasma
7:00PM DC.00001 Understanding Thermal and Collective Properties of the Quark Gluon Plasma, YASUSHI NARA. — This abstract not available.

7:30PM DC.00002 Recent results on identified particle spectra from d + Au collisions at RHIC

CHITRASEN JENA, 1Lawrence Berkeley National Laboratory, Berkeley, USA and 2Institute of Physics, Bhubaneswar, India, STAR COLLABORATION — The Cronin effect [1], the enhancement of hadron spectra at intermediate \( p_T \) in \( p + A \) collisions as compared to those in \( p + p \) collisions, has received renewed interest at RHIC [2]. It is thought that this effect may reflect on the early parton scatterings in high-energy nuclear collisions. In order to further investigate the Cronin effect, and shed light on the initial conditions at RHIC, we have analyzed the rapidity dependence of \( \phi \) meson production in \( d + Au \) collisions at RHIC.

In this talk, we report on STAR preliminary results of \( \phi \) meson transverse momentum distributions (using the hadronic decay mode \( \phi \rightarrow K^+ K^- \)) and charged hadrons spectra from 200 GeV \( d + Au \) collisions. The dataset used for this analysis is from STAR’s year 8 \( d + Au \) collisions with significantly reduced material (~1/10) and high statistics (~3) compared with previous runs. The particle species and the mass dependence of the nuclear modification factor as a function of rapidity will be presented.

7:45PM DC.00003 Detailed source structures of hadron emissions measured by RHIC-PHENIX

AKITOMO ENOKIZONO, Oak Ridge National Laboratory, PHENIX COLLABORATION — During the first decade of 21th century, experiments at the Relativistic Heavy Ion Collider at BNL have revealed detailed insights into the hot and dense matter created in \( Au+Au \) collisions at 200 GeV per nucleon, which is reasonably described as an almost perfect liquid state by hydrodynamics models. Despite our increased understanding of this partonic matter, there still remain some open questions with respect to its space-time evolution. Studies of the space-time evolution of the collisions are needed to elucidate the properties of the hot, dense, and strongly interacting matter, probe the time scale and degree of thermalization, and investigate the order of the deconfinement phase transition. Two-particle interferometry, aka HBT, is a powerful tool for measuring the space-time extent of particle-emitting sources. In addition to the traditional HBT analysis, recent developments of HBT-imaging analyses allow us to measure more detailed model-independent source functions of particle emissions. In this talk, we will show the result of the traditional 3D and 1D imaging analyses for charged kaons in \( Au+Au \) at 200 GeV, compared with the previous results for charged pions. Also the latest status of PHENIX-HBT analyses for the other particles/collision systems will be reported.

8:00PM DC.00004 Femtoscopy in \( \sqrt{s} = 200 \) GeV \( p+p \) collisions at RHIC-PHENIX¹

ANDREW GLENN, Lawrence Livermore National Laboratory, PHENIX COLLABORATION — Femtoscopy measurements from two particle interferometry exploit the Hanbury Brown and Twiss effect to provide information about the bulk medium created in heavy-ion collisions. Experiments at the Relativistic Heavy Ion Collider use HBT measurements to study source sizes and emission duration of the strongly interacting Quark Gluon Plasma created in \( \sqrt{s} = 200 \) GeV \( Au+Au \) collisions. These HBT measurements show azimuthal sensitivity relative to the reaction plane of non-central collisions. Future HBT measurements may similarly use a jet axis to define the event-by-event geometry to gain insight into the modification of jets by the QGP, and conversely, the feedback of the jet into the medium. Understanding HBT in systems with significant correlations due to local energy and momentum conservation, such as \( p+p \) collisions, will be required to properly perform and interpret such measurements. Comparisons of correlations from minimum bias data to those from a jet region are of particular importance. PHENIX preliminary measurements from the HBT analysis for charged pions from \( \sqrt{s} = 200 \) GeV \( p+p \) collisions will be presented. The status of 1-D imaging and the analysis of jet selected events will be discussed.

¹For the PHENIX collaboration

8:15PM DC.00005 Mach Cones in Heavy Ion Collisions¹

JORGE NORONHA, Columbia University — We study the fate of the energy deposited by a jet in a heavy ion collision assuming that the medium created is opaque (jets quickly lose energy) and its viscosity is so low that the energy lost by the jet is quickly thermalized. The expectation is that under these conditions the energy deposited gives rise to a Mach cone. We argue that, in general, the behavior of the system is different from the naive expectation and it depends strongly on the assumptions made about the energy and momentum deposited by the jet into the medium. We compare our phenomenological hydrodynamical calculations performed for a variety of energy-momentum sources (including a pQCD-based calculation) with the exact strong coupling limit obtained within the AdS/CFT correspondence. We also discuss the observability of hydrodynamical features triggered by jets in experimentally measured di-hadron correlations at RHIC.

¹Jorge Noronha acknowledges support from US-DOE Nuclear Grant No. DE-FG02-93ER40764.

8:30PM DC.00006 Attenuation of Dynamical Density Fluctuation around QCD Critical Point and its Phenomenological Implications

YUKI MINAMI, TEIJI KUNIHIRO, Department of Physics, Kyoto University — We explore the dynamical density fluctuations around the QCD critical point (CP) using dissipative relativistic fluid dynamics in which the coupling of the density fluctuations to those of other conserved quantities is taken into account. We show that the sound mode which is directly coupled to the mechanical fluctuations is attenuated and in turn the thermal mode which comes from the entropy fluctuation becomes the genuine soft mode at the QCD CP, which is actually known for the liquid-gas transition point. A speculation is given on the possible fate of Mach cone in the vicinity of the QCD CP as a signal of the existence of the CP on the basis of the above finding. We also apply and extend the mode-mode coupling theory to the relativistic system to study the properties of the dynamical density fluctuation in the close vicinity of the QCD CP.

8:45PM DC.00007 Spectral function of a fermion coupled with a massive vector particle at finite temperature — analysis on gauge dependence in the Stueckelberg formalism

DAISUKE SATOH, YOSHIMASA HIDAKA, TEIJI KUNIHIRO, Kyoto University — Effective chiral models of QCD suggest that hadronic collective excitations may exist even in the quark gluon plasma (QGP) phase. In turn, the coupling with such a collective mode can lead to a drastic change in the quark quasi-particle picture. We analyze the spectral function of a fermion coupled with a massive vector collective mode at finite temperature in the one-loop order in the Stueckelberg formalism, which has a gauge invariance and is renormalizable so that the correct high temperature limit can be obtained. It is known that the pole position of the fermion propagator is generally independent of the gauge fixing condition, although the residue of the pole has a gauge dependence. In perturbation theory, however, even the pole can also artificially depend on the gauge fixing condition owing to the truncation of the higher order terms. In fact, the pole as well as the residue of the fermion propagator show a dependence on the gauge in our numerical calculation. In this presentation, we are going to propose a prescription to obtain the pole in a gauge-independent way, and discuss the possible quasi-particle picture of a fermion coupled with a massive vector mode.
9:00PM DC.00008 Heavy-quark free energy at finite temperature in full-QCD lattice simulations, YU MAEZAWA, En’yo Radiation Laboratory, Nishina Accelerator Research Center, RIKEN, SHINYA AOKI, University of Tsukuba, SHINJI EJIRI, Brookhaven National Laboratory, TETSUO HATSUDA, NORIYOSHI ISHII, University of Tokyo, KAZUYUKI KANAYA, HIROSHI OHNO, University of Tsukuba, TAKASHI UMEDA, Hiroshima University, WHOT-QCD COLLABORATION — We present recent results of free energies between a heavy quark and antiquark at finite temperature in 2+1 flavors lattice simulations. We perform simulations on 32^4 times 16-4 lattices in fixed scale approach with 2+1 flavors of improved Wilson quark action, and extract static quark free energies from Polyakov-line correlations projected to a color-singlet channel in the fixed Coulomb gauge. As interesting results, at short separation, magnitude of the heavy-quark free energies for any temperatures converges to that of a heavy-quark potential calculated from the Wilson-loop at zero temperature. This suggests that the renormalization is common for all temperature in the fixed scale approach. We also show properties of the Debye screening mass at long separation and discuss dynamical quark effect from comparison with previous studies in two-flavors and quenched QCD simulations.

9:15PM DC.00009 Pair Creation of Quarks in Electric Flux Tube, AIICHI IWAZAKI, Nishogakusha-U — We discuss the pair production of massless fermions under the flux tube of electric field \(\mathcal{E}\) and homogeneous magnetic field \(\mathcal{B}\), using the formula of chiral anomaly. The tube of the electric field is finite in transverse directions but infinitely long in longitudinal direction. In the limit of \(\mathcal{B} \gg \mathcal{E}\), we can analytically obtain the spatial and temporal behaviors of the electric field and transverse magnetic field generated by currents of the produced particles. We find that the life time \(t_\ell\) of the electric field is shorter as the width of the tube is narrower. Applying the result to the glasma in high-energy heavy-ion collisions, we find that \(t_\ell \approx 7Q_s^{-1}\) with saturation momentum \(Q_s\).

9:30PM DC.00010 Direct photon measurement via internal conversions in Cu+Cu collisions at \(\sqrt{s_{NN}} = 200\,\text{GeV}\) in PHENIX, DAISUKE WATANABE, Hiroshima University, PHENIX COLLABORATION — The measurement of direct photons on hot and dense matter created in heavy ion collisions can provide thermodynamic information, but their measurement in the low \(p_T\) region is very challenging due to large hadronic background. However, internal conversion method allows access to low and intermediate \(p_T\) direct photons. In an earlier measurement in Au+Au collisions, direct photon invariant yield was obtained in the pair mass region \(M_{\gamma\gamma} < 300\,\text{MeV}/c^2\) for transverse momentum \(1 < p_T < 5\,\text{GeV}/c\). In the case of Au+Au central collisions, direct photon \(p_T\) spectra have been fitted to an exponential with inverse slope parameter \(T = 221 \pm 23(\text{stat}) \pm 18(\text{syst})\,\text{MeV}\), which is higher than critical temperature \(T_c = 170\,\text{MeV}\) predicted by Lattice QCD [1]. Therefore, it is interesting to also measure direct photons and the temperature of hot and dense matter created in Cu+Cu collisions, a smaller system that might be expected to reach a lower temperature. The latest status of the measurement is reported.


9:45PM DC.00011 Photon Physics at LHC-ALICE, TAKUMA HORAGUCHI, University of Tsukuba and JSPS, ALICE COLLABORATION — The “A Large Ion Collider Experiment” (ALICE) is to study physics of strongly interacting matter and the quark-gluon plasma (QGP) in heavy ion collisions at Large Hadron Collider (LHC). Production of deconfined partonic phase has been basically proven at the BNL-RHIC, via high pT jet suppression and a constituent quark number scaling in collective motions of hadrons. However, there are topics which should be further investigated, e.g. quantitative understanding thermal properties of the deconfined partonic phase. A unified picture is awaited at the LHC, especially via studies of thermal radiations. At BNL-RHIC, the excess of direct photon yield above binary scaled NLO pQCD in Au+Au collisions is observed with virtual photon measurement via internal conversion. Thermal properties at LHC is expected to be emphasized with the highest energy heavy ion collisions in the world. In this talk, photon physics at LHC-ALICE will be discussed, with an emphasis on thermal radiations with ALICE detector via comparison with various methods of photonic measurement in pp and heavy ion collisions.

Thursday, October 15, 2009 7:00PM - 9:15PM
Session DD Mini-Symposium on Meson-Nucleus Systems and the Partial Restoration of Chiral Symmetry II Kohala 4

7:00PM DD.00001 Meson Properties at Finite Density, CHADEN DJALALI, University of South Carolina — Quantum Chromodynamics (QCD), the theory of the strong interaction, has been remarkably successful in describing high-energy and short-distance-scale experiments involving quarks and gluons. However, applying QCD to low energy and large-distance-scale experiments has been a major challenge. The symmetries of QCD (such as Chiral Symmetry) provide guiding principles to deal with strong interaction phenomena in the non-perturbative domain. Various QCD-inspired models predict a modification of the properties of hadrons in nuclear matter from their free-space values. A review of experiments searching for the in-medium modifications of light mesons will be given trying to assess if they confirm or refute these theoretical predictions. The majority of experiments both with relativistic heavy-ion reactions as well as with elementary reactions observe a substantial broadening of the width of light vector mesons inside the nuclear medium, with no evidence of a mass shift. Several complementary high statistics experiments are planned at JLab, GSI, JPARC and RHIC to further study the properties of mesons in the medium.

7:30PM DD.00002 Formation of Slow Heavy Mesons in Nuclei, SATORU HIRENZAKI, Nara Womens University — Meson - nucleus systems such as mesic atoms and mesic nuclei have been studied systematically for a long time. The binding energies and widths of these bound states provide us unique and valuable information on the meson-nucleus interactions. In addition, the measurements of light vector meson spectra in nucleus as the invariant mass of lepton pairs have also provided interesting information. So far, the properties of relatively light mesons have been studied well both theoretically and experimentally. In this contribution, to extend our studies to a domain of heavier mesons, we will like to report recent research activities on the formation of heavy mesons in nuclei with small momenta. We think it is very interesting to consider the in-medium properties of heavier mesons including heavy quark contents. As a first step to heavier mesons, we will report our studies on formation of slow \(\phi\) meson in nuclei. In-medium properties of \(\phi\) meson have been studied theoretically, which have close relation to \(K\) and \(K\)-bar meson properties in medium because of the strong coupling of \(\phi\) to \(K\) and \(K\)-bar. The study of QCD sum rule and the data taken at KEK suggested 3 percent mass reduction of \(\phi\) at the normal nuclear density, while the \(\phi\) meson selfenergy calculated in some effective models indicated a significantly smaller attractive potential for \(\phi\). We will show the calculated spectra for some reactions.
7:45PM DD.00003 Studying the Medium Effects of the $\omega$ and $\phi$ Mesons at JLab. MICHAEL WOOD, Canisius College, RAKHSHA NASSERIPOUR, George Washington University, CHADEN DJALALI, University of South Carolina, DENNIS WEGYAND, Thomas Jefferson National Accelerator Facility, CLAS COLLABORATION — The E01-112 experiment at Jefferson Lab (JLab) in Newport News, VA, USA is an investigation of the properties of the $\rho$, $\omega$, and $\phi$ mesons in dense nuclear matter. The vector mesons are produced by a high-intensity photon beam, with energies up to 4 GeV, incident on targets ranging from $^4$He to Pb. Using the CEBAF Large Acceptance Spectrometer (CLAS) in Hall B at TJNAF, the mesons are reconstructed by means of their rare leptonic decay to $e^+e^-$, eliminating any hadronic final state interactions. These data make possible an analysis of the in-medium widths of the $\omega$ and $\phi$ mesons. The in-medium widths can be accessed by measuring the amount of absorption inside the nucleus. An increase in the in-medium $\omega N$ and $\phi N$ cross sections leads to an increase in the number of absorbed mesons. The signature of absorption is a decrease of the nuclear transparency as a function of the number of target nucleons. The results indicate a substantial widening of the $\omega$ and $\phi$ mesons in the medium. The CBELSA/TAPS Collaboration has published transparency ratios for the channel $\omega \rightarrow \pi^+\gamma$, that also shows an increase in the in-medium width. The JLab results show a greater absorption than what was measured by CBELSA/TAPS.

8:00PM DD.00004 $\phi$ Meson Photoproduction on Nuclear Targets at Jefferson Lab. DENNIS WEGYAND, Jefferson Laboratory — Theoretical calculations predict a shift of vector meson masses within the nuclear medium due to partial restoration of chiral symmetry. Experimental data from KEK on the $\phi$ meson suggests such a shift. Experiment E01-112 at Jefferson Lab produced $\phi$ mesons using a tagged bremsstrahlung photon beam up to 4 GeV incident on a range of nuclear targets. The $\phi$ mesons were observed via the rare leptonic $e^+e^-$ decay, which is devoid of final state interactions, as well as the dominant hadronic mode $K^+K^-$. As the $\phi$ decay is near the $K^+K^-$ production threshold energy, a small change in the meson mass will result in a sharp change in the ratio of the two branching ratios. Preliminary results will be shown.

8:15PM DD.00005 Development of GEM detectors for a large acceptance phi meson spectrometer. YOSUKE WATANABE, Univ. of Tokyo, KAZUYA AKOI, HIDETO ENYO, Riken, TAKU GUNJI, HIDEKI HAMAGAKI, YASUTO HORI, CNS, YUSUKE KOMATSU, SHINICHI MASUMOTO, KYOICHIRO OZAWA, TAMOTSU SATO, Univ. of Tokyo, MICHIKO SEKIMOTO, KEK, TOMOYA TSUJI, CNS, KAZUKI UTSUNOMIYA, YOSUKE WATANABE, Univ. of Tokyo, SATOSHI YOKKAICHI, Riken — New experiment is being proposed at J-PARC to study chiral properties and meson mass modification in nucleus. Mass modification of $\phi$ meson in nucleus can be considered as a signal of partial chiral symmetry restoration. Experimentally, the first observation of $\phi$ mass modification is reported by K2K-ES25. However, several possibilities for the origin of the mass modification exist. Thus, the next generation experiments are highly required to distinguish several physics processes. For such purpose, large acceptance spectrometer and high intensity beam line are needed. We are developing a new spectrometer using GEM detectors to cover a large acceptance and cope with high counting rates. A prototype is reconstructed and tested using electron beam. Test experiments are performed at FUJI test beam line at KEK and at LNS GeV-Gamma beam line at Tohoku University. Detailed evaluation of position resolutions at several conditions is performed. Currently, a position resolution of 100 $\mu$m is achieved. We will report details of the prototype and results of beam tests.

8:30PM DD.00006 A development of a Hadron Blind Detector for J-PARC E16 experiment. KAZUYA AKOI, HIDETO ENYO, RIKEN, TAKU GUNJI, HIDEKI HAMAGAKI, CNS, YASUTO HORI, YUSUKE KOMATSU, SHINICHI MASUMOTO, KYOICHIRO OZAWA, TAMOTSU SATO, Univ. of Tokyo, MICHIKO SEKIMOTO, KEK, TOMOYA TSUJI, CNS, KAZUKI UTSUNOMIYA, YOSUKE WATANABE, Univ. of Tokyo, SATOSHI YOKKAICHI, Riken — Spontaneous breaking of the chiral symmetry is considered to be the origin of hadron mass, however, the experimental confirmation is not given yet. J-PARC E16 experiment was proposed to investigate the origin of the mass through the mass modification of the $\phi$ meson in a finite nuclear medium through the electron-positron ion decay. A cherenkov detector with a high rate capability and fine segmentation is required for the electron identification. Hadron Blind Detector (HBD) is ideal for the purpose, which is a windowless cherenkov detector with a stack of GEMs on top of which CsI is evaporated. CF$_4$ works as amplification gas and cherenkov radiator in the HBD. We developed a prototype of HBD for J-PARC E16 experiment. It is constructed with a stack of an CsI-evaporated LCP-GEM with a thickness of 100 $\mu$m and double kapton-GEMs with a thickness of 50 $\mu$m. Very stable operation without severe damage from sparks is possible due to the lower voltage operation compared to triple 50 $\mu$m kapton-GEMs. A beam test was performed with an electron beam at Tohoku Univ. The performance of the prototype will be reported and discussed.

8:45PM DD.00007 Relativistic chiral mean field model and chiral property of finite nuclei and nuclear matter. HIROSHI TOKI, YOKO OGAWA, JINNIU HU, RCNP, Osaka University — We study the role of pion in finite nuclei and nuclear matter with the relativistic chiral mean field (RCMF) model. In the RCMF model, we use a sigma model Lagrangian, which contains the nucleon field and sigma and pion fields in chiral symmetric way. We introduce further the omega meson coupling in order to include necessary repulsion to form nucleus. We take the first mean field approximation and obtain meson fluctuation terms to be treated in the 2p-2h space so that the pion exchange interaction is fully taken into account. The pion exchange interaction provides major contribution to the nuclear binding. We calculate $^4$He, $^{12}$C and $^{16}$O and nuclear matter. For finite nuclei, we obtain more than a half of the attraction from the pion exchange interaction. We get an extra binding for $^{12}$C than $^{16}$O due to the pion exchange interaction coming from the Pauli-blocking effect. We find the nuclear mass is reduced about 20% from the free space value in the interior of finite nuclei. We calculate also chiral condensate in nuclear matter, which has a similar behavior to the model independent expression as a function of density. This behavior agrees with the behavior of isovector s-wave parameter extracted from deeply bound picnic atoms.

9:00PM DD.00008 Softening of the dynamical $\sigma$ meson. TETSUO HYODO, Tokyo Institute of Technology, DAISUKE JIDO, Yokawa Institute for Theoretical Physics, TELKI KUNIHIRO, Kyoto University — We study the structure of the lowest lying scalar meson with $J = 0$, the sigma meson, through the softening phenomena associated with partial restoration of chiral symmetry. We formulate two-flavor dynamical chiral models with a finite nuclear matter. We take the mean field approximation to describe the chiral partner of pion, or a dynamically generated resonance by $\pi\pi$ attraction. We show that, when the chiral symmetry is partially restored, the dynamically generated sigma meson shows qualitatively different softening pattern from the behavior of the chiral partner, reflecting the nature of an s-wave resonance. Investigating the properties with large symmetry restoration, we find that the mass of the dynamical sigma meson approaches the pion mass and that the coupling to $\pi\pi$ scattering state is proportional to the pion mass. Although the dynamical sigma meson consists of mesonic molecule, the behavior near the restoration limit is similar to that of the chiral partner. This suggests an interesting possibility of the dynamical sigma meson as the chiral partner of the pion.

Thursday, October 15, 2009 7:00PM - 9:45PM Session DE Mini-Symposium on Precision Lifetime Gauge Theory I Kohala 2

7:00PM DE.00001 Lattices and non-perturbative field theory. MICHAEL CREUTZ, Brookhaven National Laboratory — To introduce this session I discuss some of the historical circumstances that drove us to use the lattice as a non-perturbative regulator. This approach has had immense success, convincingly demonstrating quark confinement and obtaining crucial properties of the strong interactions from first principles.

1Supported under contract number DE-AC02-98CH10886 with the U.S. Department of Energy.
7:30PM DE.00002 Physical results from (2+1) flavor Domain Wall Fermion simulations. CHUL-WOO JUNG. Brookhaven National Laboratory, RBC COLLABORATION, UKQCD COLLABORATION — We present results from (2+1) flavor dynamical lattice QCD simulations, using Domain Wall Fermion and Iwasaki gauge action, in 2 different lattice spacings. We focus on continuum extrapolations of pseudoscalar meson masses and decay constants and Kaon bag parameter ($B_K$).

7:45PM DE.00003 Nucleon properties from chirally symmetric lattice QCD. YASUMICHI AOKI, RIKEN BNL Research Center, RBC-UKQCD COLLABORATION — We report on the calculations for properties of nucleon using domain-wall fermions on the lattice. The calculation takes into account the effect of $u$, $d$ and $s$ sea quarks. The use of domain-wall fermion makes it possible to have chiral symmetry of the lattice action under control. Hence the influence of the spontaneous chiral symmetry breaking onto low energy quantity is correctly incorporated even at a finite lattice spacing. The form factors of the isovector vector and axial vector current, as well as some lowest momentum structure functions are calculated. Finite volume effect on these quantities are examined. Direct calculation of the matrix elements of baryon number violating nucleon decay is performed, which provides a reliable estimate of the proton lifetime.

8:00PM DE.00004 Lattice calculations of the nucleon form factors in full QCD. MEIFENG LIN, Massachusetts Institute of Technology, LATTICE HADRON PHYSICS COLLABORATION — We present recent results for the nucleon form factors from lattice simulations by the LHP Collaboration using the chirally symmetric domain wall fermions at pion masses as light as 300 MeV. The improved numerical techniques and the access to the increasing national computing resources have allowed us to achieve unprecedented precisions in these full QCD calculations. We investigate phenomenological fits to the momentum transfer dependence of the form factors, and study chiral extrapolations using baryon chiral effective field theories. Results are compared with the experiment and challenges in these calculations are also discussed.

8:15PM DE.00005 Progress in Excited Hadron States in Lattice QCD. COLIN MORNINGSTAR, Carnegie Mellon University, HADRON SPECTRUM COLLABORATION — Progress in extracting the spectrum of excited hadron resonances in lattice QCD Monte Carlo calculations is reviewed and the key issues and challenges in such computations are outlined. The importance of multi-hadron states as simulations with lighter pion masses are done is discussed, and the need for all-to-all quark propagators is emphasized.

8:30PM DE.00006 Excited-Nucleon Spectroscopy with 2+1 Fermion Flavors. HUEY-WEN LIN, University of Washington, HADRON SPECTRUM COLLABORATION — We present progress made by the Hadron Spectrum Collaboration (HSC) in determining the tower of excited nucleon states using 2+1-flavor anisotropic clover lattices[1]. HSC has been investigating interpolating operators projected into irreducible representations of the cubic group[2] in order to better calculate two-point correlators for nucleon spectroscopy; results are published for quenched[3] and 2-flavor anisotropic Wilson lattices[4]. In this work, we present the latest results using a new technique, distillation[5], which allows us to reach higher statistics than before. Future directions will be outlined at the end of the presentation.

[5] M. Peardon et al., 0905.3352[hep-lat].

8:45PM DE.00007 Nuclear Forces from Lattice QCD. TETSUO HATSUDA, Physics Department, University of Tokyo, HAL QCD COLLABORATION — Recent results of the HAL QCD collaboration on the nucleon-nucleon interactions in quenched and full QCD lattice simulations will be reported. Special emphasis are placed on the non-locality of the NN potential, derivation of the tensor and spin-orbit forces and the quark mass dependence of the two-nucleon observables.

9:00PM DE.00008 Noise in Baryon Correlation Functions. MARTIN SAVAGE, University of Washington, NPLQCD COLLABORATION — One of the main objectives of lattice QCD is to calculate the properties and interactions of multi-nucleon systems. I will present recent results by the NPLQCD collaboration on one-, two- and three-baryon systems, with particular focus on the behavior of the noise in the correlation functions. Understanding and taming the noise in these correlation functions is important for future progress.

9:15PM DE.00009 Extracting Nuclear Forces from Lattice QCD. THOMAS LUU, Lawrence Livermore National Laboratory — I discuss the theoretical aspects of extracting nuclear force parameters from LQCD calculations. I give the current status of these calculations and describe the issues that must be addressed as we move towards the exascale era.

9:30PM DE.00010 Charmonium-Nucleon Interaction from Quenched Lattice QCD with Relativistic Heavy Quark Action. TAICHI KAWANAI, SHOICHI Sasaki, TETSUO HATSUDA, The University of Tokyo — Low energy charmonium-nucleon interaction is of particular interest in this talk. A heavy quarkonium state like the charmonium does not share the same quark flavor with the nucleon so that the $\bar{c}\bar{c}$-nucleon interaction might be described by the gluonic van der Waals interaction, which is weak but attractive. Therefore, the information of the strength of $\bar{c}\bar{c}$-nucleon interaction is vital for considering the possibility of the formation of charmonium bound to nuclei. We will present the preliminary results for the scattering length and the interaction range of charmonium-nucleon $s$-wave scattering from quenched lattice QCD. These low-energy quantities can provide useful constraints on the phenomenological $\bar{c}\bar{c}$-nucleon potential, which is required for precise prediction of the binding energy of nuclear-bound charmonium in exact few body calculations. Our simulations are performed at a lattice cutoff of $1/a=2.0$ GeV with the nonperturbatively O(a) improved Wilson action for the light quark and a relativistic heavy quark action for the charm quark. A new attempt of calculating the $\bar{c}\bar{c}$-nucleon potential through the Bethe-Salpeter wave function will be also discussed.

Thursday, October 15, 2009 7:00PM - 10:15PM — Session DF Mini-Symposium on Hadron Structure and QCD in High Energy Processes I Kohala
7:00PM DF.00001 Probing hadron structure by high energy scattering processes. JIANWEI QIU, Iowa State University — Protons and neutrons are known to be the building blocks of matter, and also known to be the bound states of quarks and gluons - the partons, whose dynamics is best described by Quantum Chromodynamics (QCD). QCD has been very successful in interpreting and predicting high-energy scattering processes and in extracting the information on short-distance QCD dynamics. In this talk, I will review the progress in probing hadron structure by using high energy scattering processes. In addition to probing parton momentum and helicity distribution functions, I will discuss possibilities and progresses to probe parton’s transverse motion and multiparton quantum correlations inside a hadron by using various QCD high energy scattering processes.

7:30PM DF.00002 Parton distributions in nuclear systems. WOLFGANG BENTZ, TAKUYA ITO, Dept. of Physics, Tokai University, Japan, IAN CLOET, Dept. of Physics, University of Washington, USA, ANTHONY THOMAS, Jefferson Lab, USA — Quark distribution functions in the nuclear medium are calculated by using an effective quark theory of QCD. We mainly concentrate on the flavor dependence of the in-medium quark distributions, and discuss the following interesting applications: (1) The EMC effect for parity-violating deep inelastic scattering of charged leptons on nuclear targets: Here we make predictions for the spin asymmetries, which are relevant to future experiments. (2) An explanation of the NuTeV anomaly in deep inelastic scattering of neutrinos on nuclear targets: Here we point out that the medium modifications of parton distribution functions can explain a large part of the so called NuTeV anomaly, which was observed in 2002 by using an iron target.

7:45PM DF.00003 A Study of Quark Energy Loss in p-A Collisions in the Fermilab E906 Experiment1, MING LIU, Los Alamos National Lab, FERMILAB E906 COLLABORATION — It is believed that the jet suppression observed at RHIC is mainly due to parton energy loss. However, our knowledge of the high energy parton energy loss in nuclear matter is very limited and constitutes one of the largest gaps in our understanding of the fundamental nuclear interactions at relativistic heavy ion collisions. As a consequence, it also hampers the quantitative determination of the properties of the new state of matter created in the relativistic heavy ion collisions at RHIC. A unique opportunity exists today to perform a benchmark measurement at the Fermilab E906 experiment via an active p-A program. The E906 Dimuon Experiment will use Drell-Yan scattering to measure the anti-quark structure of both the nucleon and nucleus, to measure absolute DY cross sections and to examine quark energy loss. The experiment will use the 120GeV proton beam extracted from the Fermilab Main Injector and is scheduled to take data in 2010. In this talk I will briefly discuss our experimental approach how to determine quark energy loss in p-A collisions in the E906 experiment.

1This work is supported by LANL LDRD grant

8:00PM DF.00004 Forward particle production at STAR. ANDREW GORDON, Brookhaven National Laboratory, STAR COLLABORATION — STAR has enhanced its forward acceptance with a new calorimeter (Forward Meson Spectrometer (FMS), 2.5 < η < 4.0, 0 < φ < 2π), first brought online during the 2008 transverse p+p and d+Au RHIC run. This has extended the kinematic reach of asymmetry measurements and enhanced the ability to analyze multi-cluster correlations within an event. Multi-cluster events in the FMS hold the promise of separating Collins and Sivers effects by summing over fragmentation products. As a step towards understanding such data, we have begun to analyze three-cluster events, with a focus on the spin 1 ω through its decay to a neutral pion and photon. I will discuss the data obtained in 2008 and progress made in the analysis.

8:15PM DF.00005 First Observation of W Boson Production at the PHENIX Detector. KEN’ICHI KARATSU, Kyoto University / RIKEN, PHENIX COLLABORATION — The collisions of polarized protons at the Relativistic Heavy-Ion Collider (RHIC) provide us very good opportunities to study proton spin structure. One of the main goals of the RHIC spin program is to measure the polarization of sea quarks using W boson production. The uncertainty of sea quark polarization still remains large, though the polarizations of valence quarks have been determined well by DIS and Semi-Inclusive DIS. Asymmetry of W boson production is a clean way to measure the sea quark polarization due to the V-A coupling of W bosons to quarks, which means the chirality of interacting quarks are almost fixed. The flavor identification of sea quarks is also possible by separate measurement of W+/W- production. PHENIX is a detector located at one of the collision points of RHIC, and observes W bosons through the decay to leptons at mid-rapidity (|η| < 0.35) and forward rapidity (1.2 < |η| < 2.4). The first run(s) = 500GeV run at RHIC was held in early 2009 (RHIC Run0), and the first attempt to measure W bosons was performed at PHENIX. In this talk, the current status of the measurement of W bosons at PHENIX mid-rapidity region will be presented.

8:30PM DF.00006 The STAR W Physics Program at RHIC. JOSEPH SEELE, MIT — The production of W→(±) bosons in polarized proton-proton collisions provides an ideal tool to study the spin-flavor structure of the proton, namely the polarized and unpolarized light quark sea asymmetries. W→(±) bosons are produced in d(d+u) collisions and can be detected through their leptonic decays, \(e^-+\bar{\nu}_e\) (e^+ + \nu_e), where only the respective charged lepton is measured. The discrimination of d(d+u) quark combinations requires distinguishing between high p_T e^-/(+) through their opposite charge sign, which in turn requires precise tracking information. In spring 2009, STAR recorded its first data set at \(\sqrt{s} = 500 GeV\) which allows for a first measurement of the cross section and single helicity asymmetry for W→(±) production at mid- rapidity in polarized proton-proton collisions. The status of the W→(±) production analysis will be presented.

8:45PM DF.00007 High-x measurement of the anti-quark distributions in the nucleon: An extension of E866/NuSea measurements1. LARRY DONALD ISHENOW, Abilene Christian University, E906 COLLABORATION — The quark-level structure of the nucleon has been studied by various methods. Fixed-target Drell-Yan scattering can kinematically select events which specifically probe the target’s antiquark distributions and is ideally suited to study these effects. The Fermilab E906 detector is under construction at the H1 area at Fermilab. It is planned for the experiment to begin taking data in June 2010. E866/NuSea yielded a number of important physics results, including the first measurement of the cross section ratio of proton-proton to proton-deuteron collisions over a large kinematic range, allowing the extraction of the ratio of anti-down to anti-up quarks in the proton. The increase in the Drell-Yan cross section at 120 GeV/c will allow the extension of the range of the light anti-quark ratios to larger Bjorken-x. The apparatus to be used will be discussed, along with the expected impacts these measurements should have on our understanding of the nucleon.

1This work is supported in part by the U.S. Department of Energy, Office of Nuclear Physics, under Grant No. DE-FG03-94ER40860.
9:00PM DF.00008 Measurement of nuclear effects in antiquark distributions\(^1\), PAUL REIMER, Physics Division, Argonne National Laboratory, FERMILAB E-906/DRELL-YAN COLLABORATION — Parton distribution within a free nucleon differ from those of a bound nucleon, an effect first discovered by the EMC collaboration. Most of the data on nuclear dependence is from charged lepton scattering and is sensitive only to the charge-weighted sum of all quarks and antiquarks. Nuclear effects in the quark sea were observed to be different from those in the valence sector by Fermilab E-772, although, with limited statistics. In the context of nuclear convolution models, virtual pion contributions to nuclear structure functions were expected to lead to sizable increases in sea distributions of the nuclei compared with deuteron, an expectation that was convincingly shattered by the E-772 data, calling into question widely believed traditional meson-exchange models of the nucleus. A new experiment, Fermilab E-906/Drell-Yan, will be able to precisely measure nuclear effects in antiquark distributions with higher precision and to larger x than previous experiments. This talk will discuss the nuclear parton distribution measurements proposed by E-906/Drell-Yan. The experiment is being installed at Fermilab and anticipates data collection to begin in summer 2010.

\(^1\)This work is supported in part by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.

9:15PM DF.00009 Design and Kinematical Coverage of FNAL-E906 Spectrometer for Drell-Yan Measurement with 120-GeV Proton Beam, KENICHI NAKANO, RIKEN, FNAL-E906 COLLABORATION — One of the major goals of the experiment at FNAL is a precise measurement of the angular distributions of $u$ and $d$ in the nucleon. With the 120 GeV proton beam and the liquid hydrogen and deuterium targets, muon pairs from the Drell-Yan process ($q + ar{q} \rightarrow \gamma^* \rightarrow \mu^+\mu^-$) are measured. Particularly E906 focuses on the higher Bjorken-$x$ range ($> 0.3$) of anti-quark distributions, at which a non-zero and unpredicted negative asymmetry has been observed by the FNAL-E866 experiment although it has rather a large experimental uncertainty. The E906 spectrometer has been designed to effectively collect high-$x$ events. This presentation will show the spectrometer design and its kinematical coverage of expected physics results.

9:30PM DF.00010 Probing Quark-Gluon Correlations in the Neutron: Precision Measurements of $d_{20}^n$ and $g_2^n$, BRAD SAWATZKY, Temple University, E06-014 COLLABORATION, E12-06-121 COLLABORATION, JLAB HALL A COLLABORATION — The spin structure function $g_2$ and the higher twist reduced matrix element $d_2$ are fundamentally coupled to the quark-gluon interactions and transverse momentum of the quarks in the nucleus. Unlike most higher-twist processes which can not be separated from associated leading twist terms, $g_2$ contributes to leading order in the longitudinal-polarized lepton scattering on a transversely polarized nucleon. This makes $g_2$ one of the cleanest higher twist observables. Within the OPE, the second moment of a linear combination of $g_1$ and $g_2$ may be connected to the higher twist reduced matrix element $d_2$. This quantity has been well studied in Lattice QCD and other theoretical models. While calculations on the proton are in good agreement with data, calculations on the neutron not only have the opposite sign, but are $\pm 3$ sigma away from the world average. This talk presents two Jefferson Lab measurements focused on $g_2$ and $d_2$ for the neutron. The first, E06-014, completed its run in March 2009 and will reduce the uncertainty on the neutron $d_2$ by a projected factor of four. The second experiment to be described, E12-06-121, is targeted to run shortly after the JLab 12 GeV upgrade is completed (est. 2014–5) and will focus on precision measurements of $g_2^n$ over the region $0.2 < x < 0.95$ and $2.5 < Q^2 < 6$ GeV$^2/c^2$.

9:45PM DF.00011 Measurement of $F_2$ and $R = \sigma_L/\sigma_T$ on Nuclear Targets in the Nucleon Resonance Region, VAHE MAMANY, University of Virginia — Jefferson Lab Experiment E04-001 used the Rosenbluth technique to measure $R = \sigma_L/\sigma_T$ and $F_2$ on nuclear targets. This experiment was part of a multiflat effort\(^1\) to investigate quark-hadron duality and the electromagnetic and weak structure of the nuclei in the resonance region. In addition to the studies of quark-hadron duality in electron scattering on nuclear targets, these data will be used as input form factors in future analysis of neutrino data which investigate quark-hadron duality of the nucleon and nuclear axial structure functions. An important goal of this experiment is to provide precise data which to allow a reduction in uncertainties in neutrino oscillation parameters for neutrino oscillation experiments (K2K, MINOS). This inclusive experiment was completed in July 2007 at Jefferson Lab where the Hall C High Momentum Spectrometer detected the scattered electron. Measurements were done in the nuclear resonance region ($1 < W^2 < 4$ GeV$^2$) spanning the four-momentum transfer range $0.5 < Q^2 < 4.0$ (GeV$^2$). Data was collected from four nuclear targets: C, Al, Fe and Cu. After a brief presentation of the physics motivation of the experiment and its experimental and analysis details, the results will be presented. The results of global fit performed on existing world data in this kinematics region will also be presented.

\(^1\) Fermilab Minerva Experiment [http://minerva.fnal.gov/]

10:00PM DF.00012 A Confinement Theory for Quarks, CARL CASE, Case Consulting — Wilson et al (Phys Rev D, Vol 49, pp 6720; 1994) states that 4 barriers have prohibited a quark confinement theory. These are: (1) diverging confinement potentials, (2) spontaneous chiral symmetry breaking, (3) unlimited growth of running coupling constant in confinement region, and (4) non-perturbative structure of QCD vacuum. This paper identifies a fiber bundle (a constant force acting upon each flavor) and winding numbers matching one to one with angular momentum quantum numbers. The single constant force spawns a degenerate series of ground states for the quark flavors. Chiral symmetry is broken. Quarks are trapped by color magnetic forces. Gluons, in the form of quantized color magnetic flux bundles, are trapped by encircling quarks. The flavors behave as a composite particle. Quantized color magnetic flux allows calculation of the running coupling constant. Using Hartree-Fock methods and chiral symmetry breaking leads to Dirac equations for each flavor and anti-flavor (a set of 12 Dirac equations). Mass calculations are presented for observed baryons and mesons. A scaling law for flavor speeds predicts the $b'$ flavor is in the mass range of 110-120 GEV.

Thursday, October 15, 2009 7:00PM - 10:00PM — Session DG Nuclear Structure II Kings 2

7:00PM DG.00010 Identification of new neutron-rich isotopes produced by in-flight fission of $^{238}$U at 345 MeV/u, TETSUYA OHNISHI, TOSHIYUKI KUBO, HIROYUKI TAKEDA, NAOKI FUKUDA, DAISUKE KAMEDA, KENSUKE KUSAKA, ATSUSHI YOSHIDA, KOICHI YOSHIDA, MASAO OHTAKE, NAOHITO INABE, YOSHIYUKI YANAGISAWA, KANENOBU TANAKA, RIKEN Nishina Center, BIGRIPS/ZERODEGREE NEW ISOTOPE COLLABORATION — At RI Beam Factory (RIBF) at RIKEN Nishina Center, an in-flight radioactive isotope beam separator BigRIPS\(^1\) was commissioned in 2007. Then we made a search for new isotopes using in-flight fission of a $^{238}$U beam at 345 MeV/u, and observed two new palladium isotopes $^{125}$Pd and $^{126}$Pd\(^2\). In November 2008, we revisited this experiment with improved experimental conditions and better tuning of BigRIPS. The intensity of the $^{238}$U beam was $1.6 \times 10^{10}$ particles sec on average, which was about 40 times higher than in 2007. The search was performed for three $B_\pi$ settings that targeted different isotope regions. The achieved resolution of particle identification was good enough to well identify fission fragments even if some of them were not fully stripped. We observed more than 20 new isotopes with $Z = 26$ to 53, including $^{129}$Pd, which demonstrated the RI-beam production power of BigRIPS at RIBF. The details of the experiment will be reported. [1] T. Kubo, Nucl. Instr. and Meth. B204, 97(2003). [2] T. Ohnishi et al, J. Phys. Soc. Jpn. 77, 083201(2008).

\(^1\)This work is supported in part by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.
7:15PM DG.00002 Single-particle states in $^{112}$Cd probed with the $^{111}$Cd($d, p$) reaction\textsuperscript{1}. P.E. GARRETT, D. JAMIESON, G.A. DEMAND, P. FINLAY, K.L. GREEN, K.G. LEACH, A.A. PHILLIPS, C.S. SUMITHRARACHCHI, C.E. SVENSSON, S. TREADWELL, J. WONG, University of Guelph, C.G. BALL, TRIUMF, H.-F. WIRTH, Eidg.-Forschungsanlagen-Universitat Muenschen, R. KRUCKEN, T. FAESTERMANN, Technische Universitat Muenchen — As a part of a program of detailed spectroscopy of the Cd isotopes, the single-particle neutron states in $^{112}$Cd have been probed with the $^{111}$Cd($d, p$) reaction. Beams of polarized 22 MeV deuterons, obtained from the LBNL/TUM Tandem Accelerator, bombarded a target of $^{111}$Cd. The protons from the reaction, corresponding to excitation energies up to 3 MeV in $^{112}$Cd, were momentum analyzed using the QD spectrograph. Cross sections and analyzing powers were fit to results of DWBA calculations, and spectroscopic factors were determined. The results from the experiment, and implications for the structure of $^{112}$Cd, will be presented.

\textsuperscript{1}Work supported in part by the Natural Sciences and Engineering Research Council, Canada.

7:30PM DG.00003 Properties of quadrupole-octupole coupled states in $^{116}$Cd from the (n, n$\gamma$) reaction. C.S. SUMITHRARACHCHI, P.E. GARRETT, K.L. GREEN, Department of Physics, University of Guelph, M. KADA, Department of Chemistry and Physics & Astronomy, University of Kentucky, J. JOLIE, N. WARR, Institute of Nuclear Physics, University of Cologne, S.W. YATES, Department of Chemistry and Physics & Astronomy, University of Kentucky — Negative-parity levels in the 2.4 MeV region, arising from the coupling of the $2^+_1$ quadrupole and $3^+_2$ octupole states, have been investigated with the (n, n$\gamma$) reaction. The measured $\gamma$-ray excitation functions, $\gamma$-$\gamma$ coincidences and angular distributions were utilized to characterize the decays of these states. The level lifetimes have been measured with the Doppler-shift attenuation method, and B(E1) and B(E2) values for the associated transitions have been determined. The enhanced B(E2) values for decay to the $3^+_2$ octupole state from many of the candidate negative-parity states were observed to be consistent with the expected signature of quadrupole-octupole coupled states. These results will be compared with the systematics of quadrupole-octupole coupled states in Cd isotopes and IBM calculations.

7:45PM DG.00004 Collective and Non-Collective States in $^{116}$Cd. J.C. BATCHELDER, H.K. CARTER, E.H. SPEJEWISKI, UNIRIB/ORAU, J.L. WOOD, D. KULP, GATech, P.E. GARRETT, U. Guelph, K.P. RYKACZEWSKI, J.C. BILHEUX, D.W. STRACENER, ORNL, C.P. BINGHAM, R. GRZYWACZ, M.N. TANTAWY, Y. LAROCHELLE, U. Tennessee, D. FONG, J.H. HAMILTON, J.K. HWANG, A.V. RAMAYYA, Vanderbilt, U., D.J. HARTLEY, U.S. Naval Academy, W. KROLS, U. Krakow, A. PIECHACZEK, E.F. ZGANJAR, Louisiana St. U., J.A. WINGER, Miss. St. U. — We have re-investigated the beta decay of the three isotopes of $^{116}$Ag to levels in $^{116}$Cd at the HRIBF. Using the CARDS array at UNISOR, we have measured gamma-rays and conversion electrons and their decay times. Through the use of this information, we have been able to construct individual decay schemes for each isomer. Significant deviations are observed from expected U(5) symmetry in the $0^+_1$ and $2^+_1$ members of the previously assigned three-phonon quintuplet. We have identified candidates in $^{116}$Cd for the complete quadrupole-octupole quintuplet. The states are $5^-\to 2249.2$ keV, $4^-\to 2340.1$ keV, $3^-\to 2392.1$ keV, $1^-\to 2478.2$ keV and $2^-\to 2519.2$ keV. All show E2 transitions to the previously known $3^+_2$ octupole state at 1921.7 keV. High-energy negative-parity states have been identified via their conversion electron data. These states are identified as possible broken pair states. This work is supported by the U. S. DOE contract DE-AC05-76OR00033 and others.

8:00PM DG.00005 Shell model calculation on Sn isotopes and evolution of shell structure. NORITAKA SHIMIZU, Department of Physics, University of Tokyo, TAKAHARU OTSUKA, Department of Physics and CNS University of Tokyo, RIKEN, NSCL MSU — We perform shell model calculations of low-lying excited states of $^{100-118}$Sn even-even isotopes, and discuss the properties of the E2 transition probabilities of low-lying states. Recent improvements of the modified typer beam technique provide us with the experimental information of proton-rich tin isotopes towards $^{110}$Sn, especially $B(E2; 2^+_1 \to 0^+_1) = 2^+_1$ values of $^{100-114}$Sn. These E2 probabilities show unexpectedly large and inconsistent with the prediction of the large scale shell model calculation based on G-matrix prescription. In this work, we adopt rather schematic interaction such as pairing-plus-quadrupole interaction and monopole interaction, which is considered to play an important role in shell evolution of proton-rich nuclei around $^{100}$Sn and Z = N = 50 shell gaps, with utilizing angular-momentum and number projection techniques and the Monte-Carlo shell model instead of traditional n-particle n-hole truncation. We demonstrate how the shell gap and n0h1/2 intruder orbit evolve with decreasing neutron numbers of Sn isotopes, and appeal the origin of the anomalous behaviour of E2 transition probabilities.

8:15PM DG.00006 Evolution of the one-phonon mixed-symmetry state in the N=48 isotonic chain\textsuperscript{1}. LINUS BETTERMANN, Yale University, NORBERT BRAUN, CHRISTOPH FRANSEN, STEFAN HEINZE, JAN JOLIE, ANDREAS LINNEMANN, DENNIS MUECHER, RAFAL SCHULZE, Universitaet zu Koeln, DESIREE RADECK, Yale University, ULRICH NEUBER, HEINZ-H. PITZ, MARCUS SCHHECK, Universitaet Stuttgart — In collective nuclei one can find excitations that are not fully symmetric with respect to the proton-neutron degree of freedom. Those states are called mixed-symmetry states and in vibrator-like nuclei their fundamental one-phonon excitation is the $2^+_1$=52 isoscalar state. Near the $N=50$ shell closure these 2$^+_1$=52 states are well known in the light stable nuclei and in the $N=52$ isotonic chain, while the data base in the $N=48$ chain is sparse. A nuclear resonance fluorescence experiment on $^{94}$Kr was performed at the University of Stuttgart and $\gamma\gamma$ coincidence measurements after fusion evaporation reactions on $^{90}$Mo and $^{88}$Zr at the Cologne Tandem accelerator to investigate a low spin structure and collectivity of these nuclei. We will present results concerning the identification of candidates for the 2$^+_1$=48 state in all three nuclei and discuss these results in the framework of the Interacting Boson Model. Finally we will compare the $N=48$ with the $N=52$ isotonic chain.

\textsuperscript{1}Work supported by German DFG under Grant No. Jo391/3-2 and US DOE under Grant No. DE-FG02-91ER40609.

8:30PM DG.00007 Low-spin excitations in $^{100}$Pd. — D. RADECK, L. BETTERMANN, WINSL, Yale University, USA+IKP, Universitaet Koeln, Germany, A. BLAHEV, U. BERNARDS, A. DEWALD, C. FRANSEN, S. HEINZE, J. JOLIE, D. MUECHER, T. PISSULLA, K.O. ZELL, IKP, Universitaet Koeln, Germany, O. MOELLER, IKP, TU Darmstadt, Germany — In the context of investigating collectivity in the A=100 mass region the nucleus $^{100}$Pd was measured at the Cologne Tandem facility using the HORUS and the plunger setups. Detailed data exists for the N=52 isotones and the evolution of collectivity - especially of the symmetric and mixed-symmetric phonon states - was discussed. To extend the knowledge of the evolution in this region it is important to measure the $N=54$ isotones. Up to now the low-energy part of the excitation spectrum of $^{100}$Pd was known sparsely and only the lifetime of an $1^+_2$ isomer was known. Using the HORUS data the level scheme was extended and the multipole mixing ratios were determined for the first time. The plunger experiment yielded lifetimes of the yrast states up to 1$^+_2$. Both, the experimental excitation spectrum and electric transition strengths, were compared to predictions of theoretical models, i.e. the anharmonic vibrator model, the Interacting Boson Model and the shell model. A candidate for the one-phonon-mixed-symmetry excitation 2$^+_1$=52 was identified due to its dominating M1 transition to the symmetric 2$^+_1$=48 state. The results will be presented and discussed. Supported by DFG, grant Jo 391/3-2 and US DOE DE-FG02-91ER40609.
8:45PM DG.00008 Evidence for Breakdown of Vibrational Motion in $^{110}\text{Cd}$  
JACK BANGAY, PAUL GARRETT, LAURA BIANCO, KYLE LEACH, PAUL FINLAY, KATIE GREEN, ANDREW PHILLIPS, EVAN RAND, CARL SVENSSON, CHANDANA SUMITHRARACHCHI, JAMES WONG, University of Kentucky — $^{110}\text{Cd}$ has long been considered an excellent example of a vibrational nucleus. However, recent work with other even-even Cadmium isotopes show a breakdown of vibrational motion at the 2 and 3-phonon level, suggesting the need for more precise measurements on $^{110}\text{Cd}$. The structure of $^{110}\text{Cd}$ is studied with the ($n,n'\gamma$) reaction performed at the University of Kentucky, as well as with the high statistics $\beta$-decay of $^{110}\text{In}$ performed at the TRIUMF-ISAC facility using the $8\text{ sr}$ spectrometer. Excitation functions and angular distributions from the ($n,n'\gamma$) reaction provide us with spectroscopic information on the level scheme, including level lifetimes and spins. This data is complemented by the $\gamma\gamma$ coincidences measured in the $^{110}\text{In}$$\beta$-decay that allows that the observation of the full octupole-quadrupole coupled quintuplet, will be presented.

9:00PM DG.00009 Description of strong M1 transitions between $4^+$ states at $N=52$ within the sdg-IBM-2$^1$. R.J. CASPERSON, V. WERNER, WNSL, Yale University, S. HEINZE, IKP, Univ. of Kiel, Germany — The interplay between collective and single-particle degrees of freedom for nuclei near the $N=50$ shell closure has recently been under investigation. In Molybdenum and Ruthenium nuclei, collective symmetric and mixed-symmetric structures have been identified, while in Zirconium, underlying shell-structure plays an enhanced role. The one-phonon $2^+\rightarrow2^+$ symmetry state was identified from its strong M1 transition to the $2^+$ state. Similar transitions were observed between $4^+$ states in $^{94}\text{Mo}$ and $^{92}\text{Zr}$, and shell model calculations indicate that hexadecapole excitations play a role. These phenomena will be investigated within the sdg-Interacting Boson Model-2 in order to gain a better understanding about the structure of the states involved, and to which extent the hexadecapole degree of freedom is important at relatively low energies. First calculations within this model, using an F-spin conserving Hamiltonian to disentangle symmetric and mixed-symmetric structures, will be presented and compared to data.

$^1$Work supported by US DOE under grant number DE-FG02-91ER-40609.

9:15PM DG.00010 Level density and radiative strength of $^{116,117}\text{Sn}$  
ANDREAS SCHILLER, Ohio University, UNDRAA AGVAANLUYSAN, Stanford University, ANN CECILIE LARSEN, Oslo University, ROSITZA CHANKOVA, North Carolina State University, MAGNE GUTTORMSEN, Oslo University, GARY E. MITCHELL, North Carolina State University, SUNNIVA SIEM, Oslo University, ALEXANDER VOINOV, Ohio University — We have determined the level density and radiative strength function for energies less than the neutron separation energy for the isotopes $^{116,117}\text{Sn}$ using the Oslo method. The excited nuclei were produced by the ($^3\text{He},\alpha$) and ($^4\text{He},\alpha\gamma$) reactions, respectively, from a 38-MeV-$^3\text{He}$ beam bombarding a highly enriched $^{117}\text{Sn}$ target. The level densities show the characteristic near-exponential increase with energy and a factor 5 difference in magnitude due to the odd-even effect. Step structures which indicate successive pair breaking are superimposed the general trend. The radiative strength function of $^{117}\text{Sn}$ shows a dramatic increase in slope above 4.5 MeV $\gamma$ energy. Connecting our data, from below the neutron separation energy to literature data above this value (obtained from the ($\gamma,\gamma'$) reactions) suggests the presence of a pygmy resonance with a centroid just above the neutron separation energy of 7 MeV and about 5–10 times the strength of the M1 spin-flip resonance or 1–2% of the TRK sum rule.

9:30PM DG.00011 DANCE (Detector for Advanced Neutron Capture Experiments) is a 4π array of BaF$_2$ crystals installed at LANSCE, Lujan Center. Neutron capture measurements on $^{157}\text{Gd}$ and $^{89}\text{Y}$ nuclei were conducted using this facility. A. CHYZH, NCSU, LANL, G. MITCHELL, NCSU, TUNL, D. VIEIRA, T. BREDEWEG, J. ULLMANN, M. JANDEL, A. COUTURE, A. KEKSIS, R. RUNDBERG, J. WILHELMY, J. O’DONNELL, B. BARAMSAI, R. ITHRARACHCHI, JAMES WONG, University of Guelph — We have determined the level density and radiative strength function for energies less than the neutron separation energy for the isotopes $^{110}\text{Cd}$ and $^{92}\text{Zr}$, and shell model calculations indicate that hexadecapole excitations play a role. These phenomena will be investigated within the sdg-Interacting Boson Model-2 in order to gain a better understanding about the structure of the states involved, and to which extent the hexadecapole degree of freedom is important at relatively low energies. First calculations within this model, using an F-spin conserving Hamiltonian to disentangle symmetric and mixed-symmetric structures, will be presented and compared to data.

9:45PM DG.00012 Multi-quasiparticle isomers involving proton-particle and neutron-hole configurations in $^{131}\text{I}$ and $^{133}\text{I}$  
H. WATANABE, RIKEN, G.J. LANE, G.D. DRACOU LIS, A.P. BYRNE, P. NIEMIEN, ANU, F.G. KONDEV, ANL, K. OGAWA, RIKEN, M.P. CARPENTER, R.V.F. JANSSSENS, T. LAURITSEN, D. SEWENYNIKAI, S. ZHU, ANL, P. CHOWDHURY, UMASS — The iodine isotopes with $Z = 53$ have attracted considerable interest because they exhibit a transition from more collective nature in the middle of the neutron shell to spherical-shell-model structure as the number of neutrons increases toward the $N = 82$ closed shell. We have populated excited states in $^{131}\text{I}$ and $^{133}\text{I}$ using multi-nucleon transfer from $^{130}\text{Xe}$, with the aim of understanding the effect of neutron holes on nuclear structure. By means of time-correlated $\gamma$-ray coincidence spectroscopy and the measurement of $\gamma$-ray angular correlations, a $J^P = 19/2^+$ isomer at 1918 keV, with a half-life of 24(1) $\mu$s, has been identified in $^{131}\text{I}$, as well as nanosecond isomers with $23/2^+$ in both isotopes. A $T_{1/2} = 25(3)$ ns isomer at 4308 keV in $^{131}\text{I}$ is suggested to have $J^P = (31/2^-, 33/2^-)$ and is primarily attributed to the coupling of an odd proton in the $d_3/2$ or $g_7/2$ orbit with the $(n^3)^{10} (\nu h_11^2 d_3^2)^{15}$ configuration in $^{130}\text{Te}$ responsible for the $15^-$ isomer in that nucleus. In this presentation, the observed level properties will be compared with predictions of a shell-model calculation based on a jj coupling scheme.

Thursday, October 15, 2009 7:00PM - 9:15PM
Session DH Mini-Symposium on the Three-nucleon Force in Few-Body Scattering and Reactions
Kings 3
7:00PM DH.00001 Three-nucleon force effects in 3N hadronic reactions\textsuperscript{1}. HIROYUKI KAMADA\textsuperscript{2}, Kyushu Institute of Technology — Results on three-nucleon scattering below the pion production threshold will be presented with emphasis on the need of a three-nucleon force (3NF). The large discrepancies between a theory based on numerical solutions of 3N Faddeev equations with modern NN interactions and data clearly point to the action of 3NF's. Successes and failures in the description of high precision 3N data using in addition to the pairwise interactions present day 3N forces will be discussed. The large theoretically predicted 3NF effects for different 3N polarization observables nourish the hope to pin down the proper spin structure of 3NF's. Especially interesting in this respect are higher energy data which, however, require to study magnitude of relativistic effects. Importance of relativistic in 3N continuum, in particular of boost and Wigner spin rotation, on observables in elastic scattering and breakup will be discussed. The boost effects turn out to be significant for the elastic scattering cross section mostly at higher energies. They diminish the transition matrix elements at higher energies and lead, in spite of the increased relativistic phase-space factor as compared to the nonrelativistic one, to rather small effects in the cross section, mostly restricted to the backward angles. At energies below ~20 MeV boost and Wigner spin rotation lower the maximum of vector analyzing power increasing the discrepancy between theory and data. This calls for even larger 3NF effects to explain low energy analyzing power puzzle. Higher energy elastic scattering spin observables are only slightly modified by relativity. The selectivity of the breakup singles out this reaction as a tool to look for localized effects which when averaged are difficult to see in elastic scattering. At higher energies this selectivity of breakup allows to find the configurations with large relativistic and/or 3NF effects.

\textsuperscript{1}This work was supported by the Polish 2008-2011 science funds as a research project No. N N202 077435. It was also partially supported by the Helmholtz Association through funds provided to the virtual institute “Spin and strong QCD” (VI-211).

\textsuperscript{2}In collaboration with Henryk Witala, Jagiellonian University.

7:30PM DH.00002 Three-nucleon force effects in three-nucleon continuum states. SOUICHI ISHIKAWA, Hosei University — The introduction of the two-pion exchange three-nucleon force (2π-E3NF) into nuclear Hamiltonian is known to be unsuccessful in explaining the existing discrepancies between calculations with two-nucleon forces and experimental data for some polarization observables, such as $A_y(\theta)$ and $T_{21}(\theta)$ in nucleon-deuteron scattering. A phenomenological 3NF is suggested to reproduce such observables at a low energy is examined for those at higher energies. For proton-deuteron scattering, effects of the long-range proton-proton Coulomb potential are properly included by solving a Coulomb-modified Faddeev integral equation in coordinate space. Also studies of searching for realistic mechanisms to produce the same effects as the phenomenological 3NF will be reported.

7:45PM DH.00003 Universal Correlations in “Pion-less” Effective Field Theory: 3, 4 and 6 Nucleons\textsuperscript{1}. HARALD W. GRIESSHAMMER, JOHANNES KIRSCHER, DEEPSHIKHA SHUKLA, Center for Nuclear Studies, George Washington University, HARTMUT M. HOFMANN, University Erlangen-Nuernberg — In a feasibility study for chiral EFT and heavier systems, we analyse bound and scattering properties of 3-, 4- and 6-nucleon systems in the Effective Field Theory ‘without pions’ at next-to-leading order using the Refined Renormalisation Group Method with full Coulomb treatment, with 3N-interactions, phase-equivalent potentials and a range of cut-offs for convergence checks. For correlations between the triton binding energy $B_{3\H}$, its charge radius and the binding energy of $^4\text{He}$, convergence is consistent with an expansion parameter $\alpha \approx \frac{1}{2}$. No 4N-interaction is needed for renormalisation. Between the binding energy $B_{3\H}$ and $^3\text{He}$ binding energy iso-spin symmetric at NLO, the model-independent difference at the physical $B_{3\H}$, $[0.10 \pm 0.03]\text{MeV}$, is the same both in magnitude and uncertainty as estimates from charge-symmetry breaking. In the first scattering calculation for $A \geq 4$, we found a correlation between $B_{3\H}$ and the real part of the singlet scattering length of $^3\text{He}$-n scattering similar to the Tjon line. Finally, we address convergence of “pion-less” EFT in the halo nucleus $^6\text{He}$.

\textsuperscript{1}Supported in part by NSF CAREER-grant PHY-0645498 and DOE grant DE-FG02-95ER40907.

8:00PM DH.00004 Measurement of tensor analyzing powers of $pd$ capture at RCNP. KENSHI SAGARA, Kyushu University, YUUJI TAMESHIGE, KICHIJI HATANAKA, ATSUSHI TAMAI, RCNP, SHO KUROTA, Kyushu University, HIROAKI MATSUBARA, HIROYUKI OKAMURA, RCNP, KIMIKO SEIKIGUCHI, RIKEN, YASUYUKI SAKEMI, Tohoku Univ., KUNIHITO FUJITA, TOMOTSUGU WAKASA, Kyushu Univ., TAKAHIRO KAWABATA, Kyoto Univ., YOHEI SHIMIZU, CNS, YUKIE MAEDA, Miyazaki Univ. — Tensor analyzing powers $A_{1x}$, $A_{1y}$ and $A_{1z}$ of $pd$ radiative capture at $E_d = 136$ MeV were measured again at RCNP. Results are basically consistent with our previous data, i.e., $A_{1x}$ and $A_{1z}$ are about twice larger in their absolute values than theoretical predictions. Similar discrepancy has been found also at $E_d = 137$ MeV.

8:15PM DH.00005 Precision\textsuperscript{1} Measurement of the n-$^3\text{He}$ Incoherent Scattering Length Using Neutron Interferometry. FRED WIETFELDT, MICHAEL HUBER, Tulane University, TIMOTHY BLACK, University of North Carolina, Wilmington, MUHAMMAD ARIF, WANGCHUN CHEN, TOM GENTILE, DAN HUSSEY, DIMITRY PUSHIN, LIANG YANG, NIST — The low energy neutron-deuteron scattering, effects of the long-range proton-proton Coulomb potential are properly included by solving a Coulomb-modified Faddeev integral equation in coordinate space. Also studies of searching for realistic mechanisms to produce the same effects as the phenomenological 3NF will be reported.

\textsuperscript{1}Supported in part by NSF CAREER-grant PHY-0645498 and DOE grant DE-FG02-95ER40907.

8:30PM DH.00006 Three-Nucleon Scattering with a Possible Long-Range Force. SHINSHO ORYU, YASUSHI HIRATSUKA, Tokyo University of Science, SHUICHI GOJUKI, SGI-Japan, TETSUO SAWADA, Nihon University, TAKASHI WATANABE, Tokyo University of Science — Three-nucleon scattering problems have been intensely investigated during almost a half century in an effort to constrain models of the nuclear force. However, we still see discrepancies between theoretical predictions based on certain nuclear forces and the experimental data. Two decades ago, one of the authors (T.S.), in search of a possible long range force between hadrons, analysed S-wave phase shift data for proton-proton scattering. He found that it is consistent with a potential corresponding to a strong Van der Waals force. Here, we try to reproduce modern nuclear phase shifts by replacing the $\sigma$-meson term of the Paris potential with a Van der Waals potential $C(r+a)^3$ having two parameters, the range $a$ and the depth $C$. We obtained a reasonable fit to the phase shifts $S_0$, $S_1$, $P_1$, $D_1$, $G_2$, $F_2$, $D_3$, $G_3$ and $D_4 = -G_4$ by using the GSE method. Preliminary calculations for three-body $pd$ elastic scattering were performed to obtain sample physical observables using the new potentials plus other states from the original Paris (PEST) potentials. We found differences in the three-body observables compared with the original nuclear force results.

3Work supported by NSF and NIST.
8:45PM DH.00007 Long Range Component of the Nuclear Potential , TETSUO SAWADA, Institute of Quantum Science, Nihon University, Tokyo, Japan — Possible long range force of the strong Van der Waals type is searched in the nuclear potential. For the case of the short range potential, the amplitude $A(s,t)$ is regular at $t = 0$, on the other hand, when the potential is long range, namely $V(r) \sim -C/r^6$, the extra branch point $A(s,t) = C^6(t^{-3})^\gamma \cdots$ with $\gamma = (\alpha - 3)/2$ appears at $t = 0$. Therefore if we try the polynomial fit to the amplitude, it must deviate rather abruptly from the fit in the small neighborhood of the charged pion. In terms of the partial wave, the extra branch point of the once subtracted S-wave amplitude $(a_0(\nu) - a_0(0))/\nu$ becomes a cusp $C^2/\sqrt{\nu}$ when the long range potential is the Van der Waals of the London type, namely $\alpha = 6$, where $\nu$ is the center of mass momentum squared. In order to see the cusp as clearly as possible, we must subtract the near-by unitarity cut ($\nu \geq 0$) and the one-pion exchange cut ($\nu \leq -\mu^2/4$). By fitting to the cusp, the parameters of the long range potential are determined: $\alpha = 6.09$ and $C = 0.170$, in which the Compton wave length of the charged pion is used as the unit of the length.


1Prepared by LLNL under Contract DE-AC52-07NA27344. Support from the U.S. DOE/SC/NS (Work Proposal No. SCW0498), LLNL LDRD Grant No. PL09-ERD-020, and from the U. S. Department of Energy Grant DE-FC02-07ER41457 is acknowledged.

Thursday, October 15, 2009 7:00PM - 9:15PM — Session DJ Neutrinos I — Queens 4

7:00PM DJ.00001 First Production Detectors for the MAJORANA Experiment , VICTOR GEHMAN, Los Alamos National Laboratory, MAJORANA COLLABORATION — The MAJORANA experiment is a next-generation search for 0νββ in $^{76}$Ge. The MAJORANA collaboration is focused on fielding 60 kg of HPGe detectors as research and development (particularly the demonstration background levels) for a 1000-kilogram search. To this end, the MAJORANA collaboration has purchased the first eighteen detectors for its DEMONSTRATOR phase from Canberra. The detectors are based on “Broad Energy Germanium” (BEGe) detectors, made from natGe and are roughly 600 grams each. BEGes have low electronic noise, which leads to excellent energy resolution and sub-keV energy threshold. BEGes also require that electron-hole pairs drift over much longer distances than in semi-coaxial HPGe detectors. Long drift times lead to reliable separation of single-site signals from multi-site backgrounds with pulse shape analysis. The performance of BEGe detectors make them a powerful technology in the search for 0νββ. We plan to populate half of the DEMONSTRATOR array with natural germanium detectors, and the other half with germanium enriched to 86% in $^{76}$Ge. Here, we will present acceptance and characterization tests performed on these first eighteen detectors. In particular, we will focus on: energy resolution/leakage current, capacitance, charge collection and pulse shapes from single and multi-site events.

7:15PM DJ.00002 Status of the EXO-200 Experiment , LIANG YANG, SLAC National Accelerator Laboratory, EXO COLLABORATION — The Enriched Xenon Observatory (EXO) collaboration aims to perform the most sensitive search of the neutrinoless double beta decay process using Xe-136. The first phase of the experiment, EXO-200, uses 200 kg of liquid xenon with 80% enrichment in Xe-136. The double beta decay of xenon is detected in an ultra-low background time projection chamber (TPC) by collecting both the scintillation light and the ionization charge. EXO-200 is currently undergoing final assembly and commissioning at the Waste Isolation Pilot Plant (WIPP) in New Mexico and Stanford in California, and we will begin data taking at the end of 2009. With two years of running, EXO-200 is expected to be sensitive to half-lives of less than 6.4 x 10^24 years for neutrinoless double beta decay.

7:30PM DJ.00003 Large Area APDs in the EXO-200 neutrinoless double beta decay experiment , RUSSELL NEILSON, Stanford University, EXO COLLABORATION — EXO (Enriched Xenon Observatory) is a program aimed at building a ton-class neutrinoless double beta decay detector using xenon enriched to 80% in the isotope 136 as the source and detection medium. The first EXO experiment, known as EXO-200, is currently being commissioned in its underground location at the WIPP facility in Carlsbad, New Mexico. The centerpiece of EXO-200 is a liquid xenon TPC containing 200 kg of enriched xenon with simultaneous readout of ionization and scintillation. Scintillation photons are detected by 468 large area avalanche photodiodes (LAAPDs). This talk will briefly summarize the current status of EXO-200 and describe our study and characterization of more than 800 LAAPDs for selective installation in the EXO-200 detector.

7:45PM DJ.00004 The Barium tagging system used at the EXO Enriched Xenon Observatory for Double Beta Decay research , AXEL REIMER MUELLER, Stanford University, EXO COLLABORATION — One of the most interesting questions in Neutrino Physics is that of the absolute scale of the neutrino mass. Neutrinoless Double Beta Decay provides an avenue for probing Majorana Neutrino masses below 10meV. The EXO experiment aims to detect Neutrinoless Double Beta Decay in Xeon-136, and to use ion trapping and laser spectroscopy techniques to tag the barium daughter of the double beta decay for the purpose of background elimination. This talk will be focused on ion extraction probe research, and the construction and use of a 70cm linear RF ion trap for the purpose of single ion fluorescence detection in a buffer gas environment.

8:00PM DJ.00005 The gas phase of EXO, status and perspectives , BASSAM AHARMIM, Laurentian University, EXO COLLABORATION — In my talk, I will be describing the R&D programs conducted at different EXO institutions to develop detector technology and analysis tools that will lead to a sensitive search for the neutrinoless double beta decay of 136Xe in the gas phase. The prototypes being developed consist of pressure vessels able to operate at pressures up to 10 bar. Different readout systems (a cathode-anode drift filed system, CsI pads, Micromegas...) are considered to detect the scintillation and ionization signals. Monte Carlo studies based on Geant 4 are used to help in optimizing the performance of the detectors. The prototypes will be used to evaluate and optimize the energy resolution and tracks reconstruction for background rejection. The longer-term goal is to scale up the technology to a multi-tonne detector.
8:15PM DJ.00006 Double-Beta Decay of $^{150}$Nd to Excited Final States, MARY KIDD, JAMES ESTERLINE, WERNER TORNOW, TUNL/Duke University — Determining the half life of two neutrino double-beta decay (2$\nu$$\beta$$\beta$) is important not only because it will be a background consideration for large-scale neutrinoless double-beta (0$\nu$$\beta$$\beta$) decay experiments, but also it is a valuable check for theoretical models. Models such as QRPA and the nuclear shell model can be used to calculate the nuclear matrix elements for 0$\nu$$\beta$$\beta$ decay, which would be necessary to obtain the effective electron neutrino mass from 0$\nu$$\beta$$\beta$ decay data. In QRPA models, the calculated matrix elements for transitions to the ground state and excited states depend in a different way on the so-called $\delta_{\nu\mu}$ parameter. Therefore, 2$\nu$$\beta$$\beta$ decay data to excited states are of special interest. Because SNO+ plans to use $^{150}$Nd as a nuclide in searches for 0$\nu$$\beta$$\beta$ decay, our goal is to measure the 2$\nu$$\beta$$\beta$ decay of $^{150}$Nd to the first excited 0$^+$ state in 150Sm. We search for this particular decay by detecting the 334 keV and 406.5 keV deexcitation gamma rays in coincidence. After 155 days of counting using a 90 g enriched $^{150}$NdO$_2$ (43 g $^{150}$Nd) sample placed between two high-purity germanium detectors, we obtained a half-life of $T_{1/2} = 0.83^{+0.77}_{-0.27}$ (stat)$\pm0.04$ (syst)$\times10^{20}$ years. Here we update that result after collecting data for 12 months. Our apparatus is located at the Kimballton Underground Research Facility (KURF). This work was supported by the U.S. Department of Energy, Office of Nuclear Physics under grant number DE-FG02-97ER41033.

3This work has been supported by grants from NSERC, Canada, and by the U.S. DOE, Nuclear Physics Division, under Contract No. DE-AC0206CH11357.

8:30PM DJ.00007 Double-beta decay Q values of $^{130}$Te, $^{120}$Te, and $^{120}$Te$^\prime$, S.A. CALDWELL, N.D. SCIELZO, G. SAVARD, J.A. CLARK, J. VAN SCHELT, C.M. DEIBEL, J. FALLIS, S. GULICK, D. LASCAR, A.F. LEVAND, G. LI, J. MINTZ, E.B. NORMAN, K.S. SHARMA, M. STERNBERG, T. SUN — Using the Canadian Penning Trap mass spectrometer we have measured Q values for the double-beta decay processes with parent nuclei $^{120}$Te, $^{120}$Te, $^{130}$Te. These measurements are relevant to the search for neutrinoless double-beta decay (0$\nu$$\beta$$\beta$) at the COURE/CUORICINO experiment. If observed, 0$\nu$$\beta$$\beta$ decay would imply that the electron neutrino is a massive Majorana particle and that lepton number is not universally conserved in nature. We provide our results and a discussion of their implications.

8:45PM DJ.00008 Study of the $^{150}$Sm(t,$^3$He) and $^{150}$Nd($^3$He,t) reactions with applications for the 0$\nu$$\beta$$\beta$ decay of $^{150}$Nd, CAROL GUESS, NSCL/MSU, NSCL, MSU/RCNP, OSAKA UNIV./UNIV. OF MUENSTER CHARGE-EXCHANGE AND DOUBLE BETA DECAY COLLABORATION — The NSCL charge-exchange group has ongoing programs to measure the spin-isospin response of nuclei. This talk will focus on measurements of the $^{150}$Sm(t,$^3$He)$^{150}$Pm* and $^{150}$Nd($^3$He,t)$^{150}$Pm* reactions, which are essential for studies of the neutrinoless double beta (0$\nu$$\beta$$\beta$) decay of $^{150}$Nd. $^{150}$Nd is one of the main candidates for 0$\nu$$\beta$$\beta$ decay detection experiments. To design detectors for 0$\nu$$\beta$$\beta$ decay and to extract information about the neutrino mass scale and hierarchy from resulting experimental data, accurate nuclear matrix elements are needed. Nuclear charge-exchange reactions can constrain theories used to predict these matrix elements by providing Gamow-Teller and higher order multipole transition strengths in the virtual intermediate nucleus. In addition to its applications for 0$\nu$$\beta$$\beta$ decay, investigation of the spin-isospin response of heavy, deformed nuclei is important for future work on rare isotopes.

9:00PM DJ.00009 Shell model calculations of double-beta decay lifetimes of $^{48}$Ca, SABIN STOICA, ANDREI NEACSU, Horia Hulubei National Institute for Physics and Nuclear Engineering, P.O. Box MG-6, 077125 Magurele-Bucharest, Romania, MIHAI HOROI, Department of Physics, Central Michigan University, Mount Pleasant, Michigan 48859 — Recent results from neutrino oscillation experiments have convincingly demonstrated that neutrinos have mass and they can mix. The neutrinoless double beta (0$\nu$$\beta$$\beta$) decay is the most sensitive process to determine the absolute scale of the neutrino masses, and the only one that can distinguish whether neutrino is a Dirac or a Majorana particle. A key ingredient for extracting the absolute neutrino masses from 0$\nu$$\beta$$\beta$ decay experiments is a precise knowledge of the nuclear matrix elements (NME) for this process. We developed a new strategy for computing the NME for the two-neutrino (2$\nu$$\beta$$\beta$) decay mode of Ca48, using GXPF1 and GXPF1A interactions. We reproduce the experimental value of the half-life for the g.s. to g.s. transitions, and we predict the lifetime for the g.s. to the first 2$^+$ excited state. We also developed a new shell model approach for computing the NME for the 0$\nu$$\beta$$\beta$ mode and used it in the case of $^{48}$Ca. The dependence of the results on short range correlations, the neutrino energy, and on the effective interaction will be discussed.

3This work was supported by the US NSF (PHY-0606007 and PHY-0822648).

Thursday, October 15, 2009 7:00PM - 9:30PM — Session DK Mini-Symposium on Probing Fundamental Symmetries with Nuclei, Neutrons, Muons, and Atoms II — Queens 5

7:00PM DK.00001 $ft$ value of the mirror nucleus $^{19}$Ne, SMARAJIT TRIAMBAK, TRIUMF, THE S8I COLLABORATION — The mirror nucleus $^{19}$Ne provides excellent opportunity to probe for physics beyond the Standard Model. The decay of polarized $^{19}$Ne has been studied previously to set limits on right-handed and second-class currents, beyond the minimal Standard Model. In addition, the best experimental limit on T-violating interactions from weak decays also comes from the decay of $^{19}$Ne. In this talk we will present preliminary results from a recent experiment performed at TRIUMF to measure the $ft$ value of the decay of $^{19}$Ne with improved precision. This result will allow for more stringent constraints on exotic interactions that are not predicted by the Standard Model.

7:15PM DK.00002 The NPDGamma experiment - A measurement of parity violation in polarized cold neutron capture, NADIA FOMIN, University of Tennessee, NPDGamma COLLABORATION — The NPDGamma experiment aims to measure the correlation between the neutron spin and the direction of the emitted photon in neutron-proton capture. An up-down parity violating asymmetry from this process can be directly related to the strength of the hadronic weak interaction between nucleons. The first phase of the experiment was completed in 2006 at LANSCE. The methodology will be discussed and preliminary results will be presented. The next run will start in late 2009 at the SNS at ORNL with several improvements, which will be discussed. The upcoming run will yield a measurement with a projected statistical error $1 \times 10^{-8}$. This will finally allow the result can be compared with theoretical predictions.
7:30PM DK.00003 The n-3He experiment at the SNS, CHRISTOPHER CRAWFORD, University of Kentucky. N-3He COLLABORATION—The n-3He experiment will measure the parity violating proton asymmetry with longitudinally polarized neutrons in the reaction n + 3He → 4He + p. As part of an ongoing program to experimentally characterize the hadronic weak interaction (HWI), this experiment is approved to run at the Fundamental Neutron Physics Beamline (FnPB) at the SNS following the NPDGamma experiment in 2011. Components being constructed for this experiment include an innovative resonant spin rotator for longitudinally polarized neutrons; and a 3He gas target which also functions as an ion chamber to detect the proton asymmetry. Preliminary calculations indicate that this experiment will provide one of the most sensitive measurements of a hadronic parity violating observable in a few-body system.

7:45PM DK.00004 ABSTRACT WITHDRAWN –

8:00PM DK.00005 A new Muon-to-Electron Conversion Experiment at J-PARC, ED HUNGERFORD, University of Houston. COMET COLLABORATION—A new experimental search for coherent, neutrinoless, muon-to-electron conversion from a muonic atom has been proposed for the Japanese Proton Accelerator, J-PARC, now under commissioning. The experiment is completing a conceptual design which proposes a single event sensitivity in the branching ratio of lepton number violating to lepton conserving decays of approximately 2.6 × 10^-11. This talk briefly describes the experiment and its objectives.

8:15PM DK.00006 π^0 to two-photon decay in lattice QCD, EIGIO SHINTANI, Osaka University. JQCD COLLABORATION—nπ^0 → γγ decay, which is induced by the axial anomaly. Using the overlap fermion we explicitly calculate the amplitude for the nπ^0 → γγ process. Our result nicely reproduces the prediction from the axial anomaly in the on-shell limit thanks to the exact chiral symmetry on the lattice, and also give a useful information for the lattice calculation of hadronic light-by-light scattering diagram for muon g-2.

8:30PM DK.00007 Overview of Jefferson Lab’s Q_weak Experiment, DAVID MACK, TJNAF, QWEAK COLLABORATION—Precision measurements of Standard Model-suppressed, weak-scale observables provide a window on potential new physics. An attractive observable which has never been directly measured is the proton neutral weak charge, Q_p^W, which measures the coupling of the Z boson to the proton. Because Q_p^W is proportional to the small quantity 1 − 4 sin^2θ_W at tree level, new parity-violating electron-quark interactions at the TeV scale could be revealed by an experiment with our modest 4% projected uncertainty. By measuring the parity-violating asymmetry in elastic e + p scattering at low momentum transfer, and utilizing bounds from the world’s strangest quark form factor program, the proton weak charge can be determined with relatively small hadronic interpretational ambiguities. After overviewing the physics case and the status of our construction efforts, commissioning activities and the time-scale for production data taking will be discussed.

8:45PM DK.00008 The Parity Violating Asymmetries of Backgrounds in the Q_weak Experiment, KATHERINE MYERS, The George Washington University. QWEAK COLLABORATION—The Q_weak Collaboration at Jefferson Lab will perform the first direct measurement of the proton’s weak charge, Q_p^W, to a precision of 4%. At tree level, the weak mixing angle is related to the weak charge of the proton by Q_p^W = 1 − 4 sin^2θ_W, leading to a 0.3% measurement of sin^2θ_W at low energy - making this the best low energy measurement to date. The parity-violating asymmetry in elastic electron-proton scattering will be measured and is expected to be small, ∼ 250 ppb. To reach the experimental goals, systematic uncertainties must be measured precisely. One particular systematic uncertainty is background contributions to the experimental asymmetry. Q_weak will take data in integrating mode, which requires that the asymmetry-weighted backgrounds be well understood. The largest source of asymmetry-weighted background is expected to come from the target windows. Elastic e-Aluminum and e-Beryllium yields and parity-violating asymmetries must therefore be measured to subtract target window background contributions to the measured asymmetry. The simulation of these window asymmetries and other backgrounds will be discussed.

9:00PM DK.00009 Test of Newtonian gravity at short range using pico-precision displacement sensor, TAKASHI AKIYAMA, MAKI HATA, KAZUHIKO NINOMIYA, HIRONORI NISHIO, NARUYA OGAWA, YUTA SEKIGUCHI, KENTARO WATANABE, JIRO MURATA—Recent theoretical models of physics beyond the standard model, including attempts to resolve the hierarchy problem, predict deviations from the Newtonian gravity at short distances below millimeters. Present NEWTON project aims an experimental test of the inverse-square law at the millimeter scale around micrometers, we have developed a new apparatus NEWTON-III, which can determine the local gravitational acceleration by measuring the motion of the torsion pendulum. In this presentation, the development status and the results of the NEWTON-experiment will be reported.

9:15PM DK.00010 The New Muon (g-2) Experiment at Fermilab, DINKO POCANIC, University of Virginia. NEW (G-2) COLLABORATION—We discuss a new proposal to measure α_mu, the muon anomalous magnetic moment, to 0.14 ppm at Fermilab, a fourfold improvement over the 0.54 ppm precision obtained in the BNL experiment E821. The muon anomaly is a fundamental quantity whose precise determination will have lasting value. We plan to use the unique FNAL complex of accelerators and rings to produce high-intensity bunches of muons, to be directed into the located BNL muon ring. The physics goal of the experiment, δαmu = 16 × 10^-11, will require 21 times the statistics of the BNL measurement, and a 3x reduction of the systematic error. Our goal is well matched to the anticipated advances in the effort to determine the standard model (SM) value of the anomaly. The present comparison, δαmu(Expt. − SM) = 295(81) × 10^-11, is already suggestive of possible new contributions to the muon anomaly. Assuming a 40% reduction of the current theory error, the combined uncertainty with our projected final result would be ≈ 31 × 10^-11, a sensitive and complementary benchmark for proposed SM extensions. The experimental data will also be used to improve the muon EDM limit by up to a factor of 100, and to make a higher-precision test of Lorentz and CPT violation.

Thursday, October 15, 2009 7:00PM - 10:00PM –
Session DL Nuclear Reactions: Heavy-Ions/Rare Isotope Beams II Queens 6
7:00PM DL.00001 Statistical model of heavy-ion fusion-fission reactions, JOHN LESTONE, Los Alamos National Laboratory, SCOTT MCCALLA, Brown University — Methods commonly used to estimate the Bohr-Wheeler fission decay width are incorrect for several reasons. After making corrections to standard computational techniques, we find the cross-section and neutron-emission data from heavy-ion fusion-fission reactions are consistent with the fission of fully equilibrated systems with fission lifetime estimates obtained via a Kramers-modified statistical model. The strong increase in the nuclear viscosity above a temperature of ~1.3 MeV deduced by others is an artifact generated by an inadequate model.

7:15PM DL.00002 Fusion of $^{128}$Sn with $^{40,48}$Ca$^+$, A. VILLANO, H. AMRO, F.D. BECCCHETTI, Univ. of Michigan, J.J. KOLATA, A. ROBERTS, Univ. of Notre Dame, D. SHAPIRA, J.F. LIANG, C.J. GROSS, R.L. VARNER, Oak Ridge National Laboratory, E. CHAVEZ, IFUNAM, Mexico, W. LOVELAND, Chemistry Dept., Oregon State Univ. — Fusion of $^{124}$Sn with $^{40,48}$Ca$^+$ near and below the barrier has been measured at ORNL. The ultimate goal is to compare with fusion of $^{128}$Sn on the same targets to study the effects of neutron excess and neutron-transfer Q-values on fusion. The Ca isotopes are ideal for this purpose since an identical $^{176}$Yb composite system is produced using two essentially spherical targets, thus reducing deformation effects on the fusion. The $^{124}$Sn, $^{40}$Ca system displays weak sub-barrier fusion enhancement which is completely accounted for by coupling to the first 2$^+$ and 3$^+$ states in the target and projectile, but $^{128}$Sn-$^{40}$Ca fusion is strongly enhanced below the barrier. This effect appears to be related to the large positive Q-values for $^{124}$Sn+$^{40}$Ca neutron transfer reactions. The implications for $^{132}$Sn+$^{40}$Ca fusion will be discussed.

1This work was supported by the US NSF under Grant No. PHY0652591, and by the US Dept. of Energy, Office of Nuclear Physics.

7:30PM DL.00003 Fast neutron-induced fission of Pu-240, Am-243 and W-nat, A. LAPTEV, R. HAIGHT, LANL, O. SCHERBAKOV, A. VOROBYEV, PNPI, A. CARLSON, NIST — The fast neutron-induced fission cross sections of Pu-240, Am-243, W-nat and Bi-209 have been obtained relative to the fission cross section of U-235 for incident neutrons from 1 MeV to 200 MeV in “shape” experiments. The measurements were done at the GNEIS facility simultaneously for each investigated isotopic target using two multiplate ionization chambers and the time-of-flight (TOF) technique on a 48-m flight path. The pulsed “white spectrum” neutron source GNEIS had an average intensity of 3 x 10$^{11}$ n/s, burst duration 10 ns and repetition rate 50 Hz. The statistical uncertainty of the measured cross section ratios for the actinide nuclei Pu-240 and Am-243 is about 2% at neutron energies above fission threshold and is less than 10% for the natW at energies above 150 MeV. The systematic error budget is discussed. In addition, the fission cross section of Bi-209 has been obtained to compare with results of previous experiments. The new fission cross section of U-235(n,f) from the international standards evaluation was used to convert the ratio data to fission cross-sections. Finally the shape fission cross section measurements were normalized using the new evaluations from the ENDF/B-VII.0 library for the actinides, while for the sub-actinides the normalization was done using the target thicknesses of (U-235) nuclei. The fission cross section of Am-243 above ~40 MeV was measured for the first time and that of W-nat was measured for the first time with a “white spectrum” neutron source.

7:45PM DL.00004 Production of the Heaviest Elements Using RIBs, WALTER LOVELAND, Oregon State University — Previously we have evaluated quantitatively the prospects for the synthesis of transactinide nuclei using radioactive beams (PRC 76, 014612 (2007)). We have revised these calculations to include current approaches to properly deal with the excitation energy dependence of shell and pairing corrections along with recent experimental advances in our understanding of the fusion probability, $P_{RN}$ and the capture cross sections for very neutron-rich systems. Using our simple formalism for calculating the complete fusion cross sections that reproduces the known heavy element production cross sections over six orders of magnitude, we calculate the production rates for transactinide nuclei with Z ≤ 120 using modern proposed radioactive beam facilities. All possible projectile and target combinations are evaluated. New possibilities for studies of the atomic physics, chemistry and nuclear spectroscopy of the heaviest elements exist at modern radioactive beam facilities. Examples of possible experiments at pre-FRIB facilities will be discussed. The synthesis of new heavy elements is best undertaken at stable beam accelerators.

3Supported by U.S. Dept. of Energy, Grant No. DE-FG06-97ER41026.

8:00PM DL.00005 Estimating Super Heavy Element Event Random Probabilities Using Monte Carlo Methods, MARK STOYER, ROGER HENDERSON, JACQUELINE KENNEALLY, KENTON MOODY, LLNL, SARAH NELSON, DAWN SHAUGHNESSY, PHILIP WILK, LLNL — Because superheavy element (SHE) experiments involve very low event rates and low statistics, estimating the probability that a given event sequence is due to random events is extremely important in judging the validity of the data. A Monte Carlo method developed at LLNL [1] is used on recent SHE experimental data to calculate random event probabilities. Current SHE experimental activities in collaboration with scientists at Dubna, Russia will be discussed.


2This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

8:15PM DL.00006 Gamow-Teller transition strengths in the intermediate nucleus of the $^{116}$Cd double-$\beta$ decay by the $^{116}$Cd($p$, $p$) and $^{116}$Sn($p$, $p$) reactions at 300 MeV, MASAKI SASANO, HIDEYUKI SAKAI, KENTARO YAKO, KENJIRO MIKI, SHUMpei NOJI, TOMOTsUCI WAKASA, MASANORI DOZONO, KUNIHIRO FIJITA, MARK GREENFIELD, KICHIHI HATANAKA, TAKAHIRO KAWABATA, HIROYUKI KOBUKI, YUKIE MAEDA, HIROYUKI OKAMURA, YASUHIRO SAKEMI, KIMIKO SEKIGUCHI, YOHEI SHIMIZU, YUJI TAMESHIGE, ATSUSHI TAMAI, TOMOHiro UESAKA, YOSHIKO SASAMOTO, KEI SUKE ITOH, KAZUO MUTO, RIKEN, Nishina Center — Gamow-Teller (GT) transition strengths in the intermediate nucleus of the $^{116}$Cd double-$\beta$ ($3\beta$) decay, namely $^{116}$In have been studied by measuring the double differential cross sections for the $^{116}$Cd($p$, $n$) and $^{116}$Sn($n$, $p$) reactions at 300 MeV over a wide excitation-energy region including GT giant resonance (GTGR). A large amount of the strengths in the $3\beta$ direction has been newly found in the GTGR region ($E_N = 5$ to 20 MeV), which may indicate that a large part of the nuclear matrix element of the two-neutrino $3\beta$ decay comes from this region as well as the cancellation due to phase.


1Supported by U.S. Dept. of Energy, Grant No. DE-FG06-97ER41026.
8:45PM DL.00008 Important role of three-body forces effect on nucleus-nucleus elastic scattering. TAKENORI FURUMOTO, YUKINORI SAKURAGI, Department of Physics, Osaka City University, YASUO YAMAMOTO, Physics Section, Tsuru University — An analysis of nucleus-nucleus ($AA$) elastic scattering is made by the double-folding model (DFM) with a new complex G-matrix interactions called CEG07. The CEG07 interactions are derived from the free-space nucleon-nucleon interaction the Extended Soft Core model, including the three-body forces (TBF) contributions composed of the two parts of three-body repulsive and attractive forces. We have tested the present microscopic DFM optical potential with CEG07 in the $^{16}O + ^{16}O$ system at $E/A = 70$ MeV. The TBF effect is clearly seen in the cross section and the folding model potential (FMP) calculated with TBF well reproduces the experimental data up to the backward angles. The role of each part of TBR and TBA are also demonstrated in the same system. The effect of TBF is very important not only for nuclear saturation properties but also proper understanding of $AA$ elastic scattering. Furthermore, the FMP with CEG07 was compared with one with CDM3Y6 that is one of the realizable and successful effective density-dependent $NN$ interaction to be used in the DFM.

9:00PM DL.00009 ABSTRACT WITHDRAWN

9:15PM DL.00010 Astrophysical S-factors from reactions with exotic nuclei. CARLOS BERTULANI, Texas A&M University-Commerce, KAZUYUKI OGATA, Kyushu University — Accurate nuclear reaction rates are needed for primordial nucleosynthesis and hydrostatic burning in stars. The relevant reactions are extremely difficult to measure directly in the laboratory at the small astrophysical energies. In recent years direct reactions have been developed and applied to extract low-energy astrophysical S-Factors. These methods require a combination of new experimental techniques and theoretical efforts, which are the subject of this presentation. In this talk I will discuss the role of continuum states and their mutual coupling in extracting the nuclear astrophysical information from experimental data carried out at radioactive beam facilities.

9:30PM DL.00011 A Thick Target Method for Nuclear Astrophysics. ROY J. PETERSON, University of Colorado — Many years ago, a wide array of nuclear reaction rates relevant to stellar nucleosynthesis was developed, applied, and compiled for proton- [1] and alpha-induced reactions [2]. A recent thin-target study of the $^{12}\text{C}(p,p')^{13}\text{N}$ reaction [3] has confirmed the accuracy of one of the important examples of these thick-target thermonuclear reaction rates. The thick-target method, stopping the beam in the sample and analyzing the subsequent radioactivity or prompt gamma radiation, has many advantages, especially since it is independent of the assumed reaction mechanisms and uses all of the beam. The method and its strengths will be reviewed, and a new extension to reactions induced by radioactive ion beams in reverse kinematics in a hydrogen-rich thick sample will be presented. This method may offer advantages for the use of sparse beams.

1. N. A. Roughton et al., At. Data and Nuclear Data Tables 23, 177 (1980)
2. N. A. Roughton et al., At. Data and Nuclear Data Tables 28, 341 (1983)

9:45PM DL.00012 Application of Random Matrix Theory to low-energy heavy-ion reactions. SHUSAKU YUSA, KOICHI HAGINO, Department of Physics, Tohoku University — Coupled-Channels calculations taking into account collective excitations have been applied to the analysis of heavy-ion sub-barrier fusion as well as quasi-elastic scattering and have provided good descriptions of the experimental data. Recently, however, there arise some experimental data which cannot be accounted for by such a conventional coupled-channels approach. That is, the experimental quasi-elastic barrier distribution for e.g., $^{20}\text{Ne} + ^{56}\text{Zr}$, is much more smeared than a theoretical barrier distribution. One of the possibilities to cure this problem is to take into account single-particle excitations in the coupled-channels calculation. In order to incorporate that kind of excitations, we employ random matrix theory. In this talk, we will present model calculations for penetrability for a one dimensional potential barrier. We will compare the results in the presence of only the collective excitation to those with both collective and single-particle excitations. Effects of single-particle excitations on barrier distributions and Q-value distributions will be also discussed.

Thursday, October 15, 2009 7:00PM - 10:00PM — Session DM Nuclear Theory II Kings 1

7:00PM DM.00001 Effective theory for two fermions in a trap. IONEL STETCU, University of Washington, JIMMY ROTUREAU, BRUCE BARRETT, BIRA VAN KOLCK, University of Arizona — Systems with large scattering length $a_2$ are of particular interest since they exhibit universal properties when particle momenta are small compared to $1/r_0$ with $r_0$ being the range of the interaction. This situation occurs for instance, in nuclear physics where the two-nucleon system has two $S$-wave channels where $a_2 > r_0$. We have applied the general principles of Effective Field Theory for the description of two fermions in a harmonic oscillator trap. Our formalism is based on a controlled expansion of the interaction between the two fermions as a series of contact interactions with an increasing number of derivatives. Corrections to the interaction beyond leading order are treated in perturbation theory. Results for the energies of the two-fermion system for different values of $a_2/b$ ($b$ being the trap length) and $r_0/b$ will presented.

This research was supported by the U.S. Department of Energy and the National Science Foundation.

7:15PM DM.00002 Effective theory for trapped few-fermion systems. JIMMY ROTUREAU, University of Arizona, IONEL STETCU, University of Washington, BRUCE BARRETT, University of Arizona, MIKE BIRSE, University of Manchester (UK), BIRA VAN KOLCK, University of Arizona — The properties of strongly interacting Fermi gases have been the object of great interest in recent years. When the scattering length $a_2$ is much larger than the effective range of the interaction $r_0$, few-atom systems serve as a testing ground for techniques developed for the ab-initio solution of few-nucleon systems. We have applied the principles of Effective Field Theory to describe few-fermions systems in a harmonic trap. The interaction is written as a controllable expansion of contact interactions with derivatives. The no-core shell model is used to solve the many-body Schrödinger equation at leading order and corrections beyond LO are treated in perturbation theory. We have also addressed the relationship between the two-body and many-body cutoffs needed for a consistent model space. Results for the energies of the 3-fermions system at unitarity will be presented and shown to agree with known results. Results for systems with 3, 4 fermions for different values of $a_2/b$ ($b$ being the trap length) and $r_0/b$ will also be presented.

This research was supported by the U.S. Department of Energy and the National Science Foundation.

7:30PM DM.00003 Ab initio no core results for light nuclei with realistic basis functions. JAMES VARY, ALINA NEGOTI, PIETER MARIS, Iowa State University, ANDREY SHIROKOV, Skobeltsyn Institute of Nuclear Physics, Moscow State University, Russia — We perform no-core (NCFC) calculations for a set of light nuclei with realistic NN interactions. We perform our calculations both in a harmonic oscillator and Woods-Saxon basis and compare convergence rates for the ground state energies, energies of selected excited states, r.m.s radii and other observables. The results for r.m.s radii of light and weakly bound nuclei present useful tests of more realistic basis spaces such as the Woods-Saxon basis. We will discuss factorization of the center-of-mass motion and show how insuring factorization affects the results in the Woods-Saxon basis spaces.

3Supported in part by DOE Grants and DE-AC02-09ER41582.
Ab initio no-core full configuration calculation of light nuclei by Monte Carlo shell model with JISP16 $NN$ interaction, T. Abe, University of Tokyo, P. Maris, Iowa State University, T. Otsuka, N. Shimizu, University of Tokyo, Y. Utsuno, Japan Atomic Energy Agency, J. P. Vary, Iowa State University — Benchmark test calculation of ground-state properties of light nuclei in no-core full configuration approach is presented. Monte Carlo shell model calculation by a stochastic diagonalization technique is compared with that in a exact diagonalization using the J-matrix inverse scattering potential (JISP16).

8:00PM DM.00005 Toward the first ab initio description of the deuterium-tritium fusion. Sofia Quaglioni, Petr Navratil, Lawrence Livermore National Laboratory — We are building a new capability to describe light-ion fusion reactions from first principles, known as ab initio NCSM/RGM approach [1,2]. Using a recently developed formalism based on nucleon-nucleus basis states, we have completed a promising preliminary study of nucleon-nucleus scattering, particularly $n$-4He scattering below the $d$+$t$ threshold, [1,2]. Now we are developing the deuterium-nucleus formalism that coupled with the nucleon-nucleus basis will allow us the first ab initio calculation of the $^3$H$(d,n)^4$He fusion. We present recent results and work in progress.


8:15PM DM.00006 Density Functional Theory for non-relativistic Fermions in the Unitarity Limit, Gautam Rupak, Mississippi State University, Thomas Schaefer, North Carolina State University — We derive an energy density functional for non-relativistic spin one-half fermions in the limit of a divergent two-body scattering length. Using an epsilon expansion around $d = 1 + \epsilon$ spatial dimensions we compute the coefficient of the leading correction beyond the local density approximation (LDA). In the case of $N$ fermionic atoms trapped in a harmonic potential this correction has the form $E = E_{LDA}[1 + c_4(N^2/3)^{-7/3}]$, where $E_{LDA}$ is the total energy in LDA approximation. At next-to-leading order in the $\epsilon$-expansion we find $c_4 = 1.68$, which is significantly larger than the result for non-interacting fermions, $c_4 = 0.5$.

8:30PM DM.00007 3D Time-Dependent Density Functional Theory for Superfluid Nuclear Systems, Aurel Bulgac, University of Washington, Piotr Magierski, Warsaw University, Kenneth Rocher, Oak Ridge National Laboratory, Ionel Stetcu, University of Washington — We have recently formulated a full 3D Time-Dependent version of the Density Functional Theory for superfluid nuclear systems and implemented it as a highly efficient parallelized code on leadership class supercomputers and, we refer to it as the Time-Dependent Superfluid Local Density Approximation (TD-SLDA). TD-SLDA can be used in particular to calculate the linear response to an arbitrary external probe of any nucleus, without any symmetry restrictions and in a fully self-consistent manner and with a correct treatment of all spurious modes. As one of the first applications of TD-SLDA we study the response of a nucleus to a Coulomb field generated by a relativistic projectile.

1We acknowledge partial support from DOE grants DE-FG02-97ER41014 and DE-FG02-07ER41457.

8:45PM DM.00008 Non-empirical pairing functional from low-momentum two- and three-body interactions, Thomas Lesinski, University of Tennessee; Oak Ridge National Laboratory; Universite Claude Bernard Lyon 1; CNRS-IN2P3; IPNL; Thomas Duguet, CEA Saclay, IFU, SPHIN; Michigan State University; NSCL, Kai Hedeber, Achim Schwenk, TRIUMF — We present systematic calculations of pairing gaps in semi-magic nuclei across the nuclear chart using the Energy Density Functional method. A non-empirical pairing functional is derived at lowest order in the low-momentum, vacuum two-nucleon interaction, including the Coulomb force, and chiral three-nucleon interaction. The particle-hole part of the functional is built to reproduce the Hartree-Fock level density obtained with the same interaction. Energies of odd nuclei are calculated self-consistently in the equal-filling approximation, which allows a direct comparison to odd-even mass difference data. We assess the relative contributions of two-body and three-body direct terms, blocking, and missing higher-order terms of the perturbative expansion to pairing in finite nuclei.

9:00PM DM.00009 ABSTRACT WITHDRAWN —

9:15PM DM.00010 Helium Halo Nuclei from Low-Momentum Interactions, Sonia Bacca, TRIUMF — The physics of the strong force gives rise to fascinating halo structures in light nuclei. A prominent example are the helium halo nuclei, He6 and He8, with a two- and a four-neutrons halo, respectively. In literature, several ab initio calculations of these nuclei are found, which are based on traditional potentials and include short-range phenomenology. Our goal is to describe properties of halo nuclei starting from forces derived within the modern approach of effective field theory, where two- and three-body forces among nucleons arise naturally and consistently with each other. Along the road to accomplish that, we present our theoretical approach to the study of He6 and He8 with low momentum interactions. Binding energies and radii will be discussed and compared to experimental data.

9:30PM DM.00011 Large-Scale Calculations of Single-Particle Properties, Carlo Barbieri, Riken — We review recent large-scale calculations of single-particle energies and spectroscopic factors around closed shell nuclei in the sd and pf regions. Emphasis will be put on the following results:

- The self-consistent Green’s functions method employed in the calculations reproduces the benchmark results for the binding energy of $^4$He with good accuracy. Ab-initio calculations have now been performed up to $^{56}$Ni.
- Preliminary studies of spectroscopic factors, based on the chiral N3LO force, exhibit an asymmetry dependence similar to that observed in heavy-ion knockout experiments but weaker in magnitude.

9:45PM DM.00012 The Importance of Concavity for Nuclear BEs and Thermodynamical Functions, Bruce Barrett, University of Arizona, Bertrand Giraud, CEA Saclay, Byron Jennings, TRIUMF, Nicholas Tobberg, CMS, Cambridge — The role of concavity of nuclear energy chains or surfaces in determining the BEs of unknown nuclides by extra- and/or interpolation will be presented. Studies of the concavity of nuclear thermodynamical functions allows the determination of the average value of $H$ and the free energy as functions of the average value of $A$ for finite temperature. These two quantities allow error bars to be set on the BE predictions previously. The consequences of the concavity of $H$ on the nuclear density functional will also be discussed.

1Partially supported by NSF grant PHY-0555396 and the National Research Council of Canada.
Session EA Strangeness in Nuclear Physics  
Friday, October 16, 2009 9:00AM - 12:00PM

9:00AM EA.00001 Study of spectroscopy of $\Lambda$-hypernuclei using the (e,e$'$$K^+$) reaction at JLAB  
LIGUANG TANG, Hampton University/JLAB — Electroproduction using high precision continuous-wave electron beam, such as available at Continuous Electron Beam Accelerator Facility (CEBAF) at the Jefferson National Laboratory (JLAB), has proved to be an effective mechanism to study the spectroscopy of $\Lambda$-hypernuclei. One way to study production using secondary meson beams, the present use of precision electron beam improves the energy resolution by more than a factor of two, reaching sub-MeV level while approximately preserving the yield. In addition, the (e,e$'$$K^+$) reaction acts on protons, dominantly producing high spin stretched, spin-flip states of neutron rich hypernuclei which are in complementary to that produced by the $(K^-,\pi^-)$ and $(\pi^+,K^+)$ reactions. The precision and power of the beam enables a detailed spectroscopic study of $\Lambda$-hypernuclei for a wide range of target masses and selected isotopes. The program will provide new information on the $\Lambda N$ interaction, SU(3)-flavor symmetry in the nuclei, and the single particle nature of a $\Lambda$ in the nuclear mean-field. This presentation will give an overview of the spectroscopy programs carried out in both Hall A and C with their presently achieved results.

9:45AM EA.00002 Hyperon Interactions from Lattice QCD  
TETSUO HATSUDA, Physics Department, University of Tokyo — Current status of the the full QCD simulations of the hyperon(Y)-nucleon(N) and hyperon(Y)-hyperon(Y) interactions on the lattice is reviewed.

10:30AM EA.00003 Study of the $K^-pp$ bound state in the FINUDA experiment  
HIROYUKI FUJIOKA, Department of Physics, Kyoto University — The possible existence of antikaon-nucleon bound states has been suggested by many theoretical studies in this decade, after the first quantitative calculations on few-body systems by Akaishi and Yamakazi [Phys. Rev. C 65, 044005 (2002)]. Experimental searches, including reanalyses of old experiments, on such a bound state has been carried out in several institutes up to now. The FINUDA experiment also investigated the existence of light kaonic nuclei, produced by stopped $K^-$ absorption. It was carried at a $\phi$-factory, DAFNE at INFN-LNF (Italy), which supplies very slow kaons (\sim 16 MeV) as decay particles of $\phi$ mesons produced by the electron-positron collision. In 2005, we reported the first result on the invariant mass spectrum of back-to-back $\Lambda$-$p$ pairs, emitted from light nuclear targets [Phys. Rev. Lett. 94, 212303 (2005)]. Their invariant mass distributes far below the $K^- + p + p$ threshold around 2.37 GeV/c$^2$, and we proposed a possibility that a $K^-pp$ bound state with its binding energy \sim 115 MeV and width \sim 67 MeV was produced by kaon absorption, and decayed into a $\Lambda$ and a proton. However, there are alternative interpretations on the $\Lambda$-$p$ invariant-mass spectrum, such as the effect of final state interaction, pointed out by Magas et al. [Phys. Rev. C 74, 025206 (2006)]. In order to distinguish them experimentally, we analyzed three kinds of back-to-back hyperon-nucleon pairs ($\Lambda-p$, $\Lambda-n$, $\Sigma-p$) with about one order of magnitude more statistics taken in 2006–2007. We observed a large difference, especially between the $\Lambda-p$ and $\Lambda-n$ pairs, with regard to the distribution near the threshold. It may originate from a strong isospin dependence of $K\Lambda$ interaction, and reinforce the assumption of the $K^-pp$ production in kaon absorption. In this talk, the current status of the analysis on hyperon-nucleon pairs will be presented.

\footnote{on behalf of the FINUDA collaboration}

11:15AM EA.00004 Exclusive Hyperon Production at CLAS  
DANIEL CARMAN, Jefferson Laboratory — This talk will provide an overview of the exclusive hyperon production experiments being carried out by the CLAS Collaboration at Jefferson Laboratory. The program is designed to measure cross sections and a complete set of beam, target, and recoil hyperon polarization observables for both $K\Lambda$ and $K\Sigma$ final states with beam energies up to 6 GeV. These data will span a broad kinematic range in momentum transfer $Q^2$ and invariant energy $W$, and nearly the full center-of-mass angular range of the kaon. Analyses of data on both proton and neutron targets are underway or planned for the near future involving polarized beams (longitudinally polarized electrons, circularly and linearly polarized photons) and polarized targets (longitudinally and transversely polarized). The main goal of this series of measurements is to provide precision data needed to disentangle the resonant and non-resonant amplitudes in the intermediate state to uncover baryon resonances that couple to the strangeness channels ($N^* \rightarrow K\Lambda, K\Sigma, \Delta^* \rightarrow K\Sigma$). This will improve our understanding of the nucleon excitation spectrum, and hence, probe the effective degrees of freedom of the nucleon. These data will also serve to improve our understanding of the dynamics underlying strangeness production in general. Over the next several years it is expected that a full coupled-channels analysis, including hadroproduction data, as well as data with both real and virtual photons, will be completed by several groups, including the Excited Baryon Analysis Center (EBAC) at Jefferson Laboratory. The precision data from CLAS will be a crucial input for these analyses. Within the next five years, the CLAS facility will be significantly upgraded for use with the higher-energy electron beams available with the 12-GeV Jefferson Laboratory energy upgrade. The future of the strangeness physics program with the new CLAS12 facility will be highlighted.

Friday, October 16, 2009 9:00AM - 11:45AM

9:00AM EB.00001 Critical Properties of Quark Matter at Finite Temperature and Density  
TEIJI KUNIHIRO, Department of Physics, Kyoto University — We examine the nature the soft modes of the QCD phase transitions and their phenomenological consequences. In this talk, we mainly focus on the soft mode of the QCD critical point (CP) at finite $T$ and baryon chemical potential $\mu$. The QCD CP belongs to the same universality class $Z_3$ as that of the liquid-gas phase transition, and, hence, a large density fluctuation is expected around the CP. We apply the relativistic fluid dynamics to analyse the dynamical properties of the density fluctuations, and show that its coupling with the thermal fluctuation is significant, which eventually overwhelms the density fluctuations. We show that the density mode is attenuated around the CP because of the divergence of the correlation length $\xi$. We speculate that if a suppression or disappearance of Mach cone is observed as the incident energy is lowered, say to 40 GeV/A at RHIC, it could be a signal of the existence of the QCD CP. We also mention the critical phenomena of the chiral transition and the color superconductivity at finite $T$.

9:30AM EB.00002 Equation of State and Phase Instabilities near the Chiral Critical Point\footnote{This work was supported by the Department of Energy under grant DE-FG02-87ER40328.}  
JOSEPH KAPUSTA, University of Minnesota, LASZLO CSERNAI — The thermodynamics and critical exponents of high temperature and dense matter near the chiral critical point is studied. The parameterized equation of state matches on to that calculated with lattice QCD at zero chemical potential and to the known properties of nuclear matter at zero temperature. The extent to which finite size effects wash out the phase separation near the critical point is determined. The degree to which the critical point acts as an attractor in high energy heavy ion collisions is also investigated.
9:45AM EB.00003 Lattice study of ratios between Israel-Stewart parameters. YASUHIRO KOHNO, MASAYUKI ASAKAWA, MASAKIYO KITAZAWA, Osaka University, CHIHO NONAKA, Nagoya University, SCOTT PRATT, Michigan State University — Navier-Stokes equations are known as hydrodynamic equations which take account of effects of dissipations, i.e. the viscosities and heat conductivity. There are, however, problems in the relativistic Navier-Stokes equations, i.e. the equations violate causality. Israel-Stewart equations, which evade the problems of Navier-Stokes equations by introducing new parameters, such as relaxation times, have recently been used in describing the space-time evolution of the quark-gluon plasma produced in high energy heavy ion collisions. The viscosities and relaxation times are related to each other by imposing entropy constraints on the system. According to Boltzmann-Einstein principle, the probability distribution of the fluctuation in energy-momentum tensor is related to the entropy of the system. Applying this principle to the entropy in Israel-Stewart theory, one can obtain the ratios of the viscosities to the relaxation times. We evaluate the ratios of the viscosities to the relaxation times in SU(3) lattice gauge theory. This analysis reduces the number of phenomenological parameters that appear in Israel-Stewart equations.

10:00AM EB.00004 Measurement of Low-mass Vector Mesons in the PHENIX experiment at RHIC. YUJI TSUCHIMOTO, CNRS, Univ. of Paris, PHENIX COLLABORATION — Extensive study of heavy-ion collisions at RHIC has established the creation of a strongly coupled Quark Gluon Plasma (sQGP). Study of the Chiral Symmetry restoration and degree of freedom of quarks is important for understanding of the sQGP properties. The spectral shape of the Low-mass Vector Mesons (LVM's), p, ω and φ can be modified in the medium by the partial restoration of Chiral symmetry. Due to the short life times of the LVM's, this modification can be directly studied by measuring low-momentum LVM via their decays into electron pairs, which do not participate in strong interaction and keep their properties unchanged throughout the evolution of the system. Since the width of the meson may be affected in the medium, the branching ratio of various decay modes may also be modified from vacuum values. In particular, the branching ratio of $\phi \rightarrow e^+e^-$ and $\phi \rightarrow K^+K^-$ may be sensitive to the modification due to the small Q-value of $\phi \rightarrow K^+K^-$. Suppression of $\phi$ at high-$p_T$ in Au+Au collisions is interesting to discuss flavor dependence of quark energy loss in the QGP. The $R_{AA}$ of $\phi$ suggests the suppression is guided by the number and flavor of valence quarks rather than by hadron mass. The PHENIX experiment has measured $\omega$ and $\phi$ production using di-electron and different hadronic decay channels at mid-rapidity at $s_{NN}=200$ GeV/c^2 and Au+Au and Au+Au collisions.

10:15AM EB.00005 Dielectron mass spectra from $\sqrt{s_{NN}} = 200$ GeV heavy ion collisions at PHENIX. SARAH CAMPBELL, SUNY Stony Brook, PHENIX COLLABORATION — The dielectron mass spectrum consists of light vector meson decays, in addition to decays from other hadronic and photonic sources. In heavy ion collisions, light vector mesons may also be modified by the medium via chiral symmetry restoration and process different hadronic states at low masses above known hadronic sources. The PHENIX $\sqrt{s_{NN}} = 200$ GeV Au+Au analysis has measured a centrality dependent excess in the low mass region ($0.15 \text{ GeV}/c^2 < m_{ee} < 0.75 \text{ GeV}/c^2$) over the cocktail of known hadronic sources. The status of the PHENIX $\sqrt{s_{NN}} = 200$ GeV Cu+Cu analysis, in minimum bias and separated into centrality classes, will be shown, providing additional sensitivity in the study of this centrality dependent trend.

10:30AM EB.00006 Masses of vector bosons in two-color dense QCD based on the hidden local symmetry. TETSURO YAMAKA, MASAYASU HARADA, CHIHO NONAKA, Nagoya University — In two-color QCD the chiral SU(2N_c) symmetry is spontaneously broken to the Sp(2N_c) symmetry. The Nambu-Goldstone bosons (NG bosons) carrying the baryon charge also appear together with the mesonic NG bosons in the low energy effective theory. It is known that the condensation of baryonic NG bosons cause the spontaneous breaking of U(1)_B symmetry at a certain finite baryon density. Based on the hidden local symmetry (HLS), we construct the chiral effective Lagrangian for two-color QCD with two-flavor quarks and one-NG bosons in the low energy effective theory. It is known that the condensation of baryonic NG bosons cause the spontaneous breaking of U(1)_B symmetry to Sp(2N_c). In the framework of quark coalescence for particle production, baryon to meson ratios may be sensitive to local parton densities. The measurement of $p/K$ ratios also involves both baryon and strangeness quantum numbers in nuclear collisions. Fluctuations in the parton density and ratios will be used to search for the phase of QCD and the evolutions of these experimental observables.

10:45AM EB.00007 Identified Charged Hadron Spectra at RHIC and Phase of QCD from PHENIX. TATSUYA CHUJO, University of Tsukuba, PHENIX COLLABORATION — It is widely accepted that the new state of QCD matter, Quark Gluon Plasma (QGP), has been produced in central Au+Au collisions at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. Among many experimental data, a baryon production provides an unique tool to investigate the phase of QCD, and to characterize the properties of QGP. It is interesting to know how the experimental observables, such as a high $p_T$ hadron yield suppression and baryon enhancement, change as a function of system sizes and beam energies, and how they are affected by the existence of the QCD critical end point, which may be accessible by the lower beam energy scan proposed in the future RHIC program. In this talk, we will review the existing data of single particle spectra measured at RHIC in p+p (62.4, 200 GeV), Cu+Cu (22.5, 62.4, 200 GeV), Au+Au (62.4, 200 GeV). The most recent data of identified charged hadron spectra in p+p collisions at $s=62.4$ and 200 GeV from PHENIX will be shown. Using these data, we investigate the evolutions of $(1) x_F$ scaling for baryons and mesons, $(2)$ baryon enhancement determined by the nuclear modification factor ($R_{AA}$) and $p_T$ ratio, and $(3)$ freeze-out properties. We will also discuss a potential connection between the phase of QCD and the evolutions of these experimental observables.

11:00AM EB.00008 $K^\pi$ and $p/\pi$ Fluctuations in Au+Au Collisions in STAR. GARY WESTFALL, Michigan State University, STAR COLLABORATION — The freeze-out of an extended, strongly-interacting system created in relativistic heavy ion collision at RHIC produces a medium with many of the properties of a QGP. The study of fluctuations, such as $v_2$, provides a sensitive probe of the phase of QCD, and can help determine the critical temperature and density of the QGP. We present results for $K^\pi$ and $p/\pi$ fluctuations from central Au+Au collisions at $s_{NN}=20, 62.4, 130, 200$ GeV in terms of the variable $\delta_{v_2}$. We compare these results with recent data from NA49 [1] for central Pb-Pb collisions. The energy dependence of the present data for central collisions extends smoothly from the NA49 measurements. We present the centrality dependence of $K^\pi$ and $p/\pi$ fluctuations from Au+Au collisions at $s_{NN}=62.4$ and 200 GeV in terms of the variable $\delta_{v_2}$. To minimize contributions from background protons, we restrict our measurements for $p$ and $\pi$ to the transverse momentum range $0.4 < p_T < 1.0 \text{ GeV}/c$. We present results for $K^\pi$ and $p/\pi$ fluctuations separated by sign as a function of centrality. In addition, we present results for net charge fluctuations. We discuss how $v_2$ changes in $K^\pi$ and $K^+/K^-$, and net baryon fluctuations ($p/\pi$). We compare our results with the predictions of the Statistical Hadronization, HIJING, UrQMD, and HSD models.

11:15AM EB.00009 $p/K$ Fluctuations from Au+Au Collisions at RHIC. JIAN TIAN — Event-by-Event fluctuations may be employed to probe the dynamics of dense matter hadronization and possibly be sensitive to critical behavior in the evolution of QCD matter. In the framework of quark coalescence for particle production, baryon to meson ratios may be sensitive to local parton densities. The measurement of $p/K$ ratios also involves both baryon and strangeness quantum numbers in nuclear collisions. Fluctuations in the parton density and ratios will be used to search for possible critical point in nucleus-nucleus collisions. We will present measurements of fluctuations on $p/K$ multiplicity ratios from Au+Au collisions using the STAR detector. Fluctuations from Au+Au collisions at $s_{NN}=200$ GeV and 62.4 GeV with various collision centralities will be compared. Different analysis techniques and comparisons with the AMPT model calculation will be used to illustrate the effects of resonance decays and pair production on the particle ratios.

[1] for the STAR Collaboration
Friday, October 16, 2009 9:00AM - 11:30AM – Session EC Ultrarelativistic Heavy-Ions I Kohala 1

9:00AM EC.00001 From RHIC to EIC: structure functions . JAMAL JALILIAN-MARIAN, Baruch College — We consider nuclear structure functions at small x using the Color Glass Condensate formalism. Using the successful parameterization of the dipole cross section from QA data at RHIC, we make predictions for the shadowing of nuclear structure functions \( F_2 \) and gluon distribution function.

9:15AM EC.00002 Pair creation of quarks and gluons under color electric fields\(^1\) . NAOTO TANJI, University of Tokyo, Komaba — Non-perturbative pair creation of quarks and gluons from a uniform electric field and its back reaction are investigated to explore the mechanism of matter formation in heavy-ion collisions. Time-evolution of a system where a classical color electric field and quantum fields of quark and gluon interact with each other is studied up to leading order of quantum fields. We reveal how an initial electric field decays into particles and compare momentum distributions of quark and gluon.

\(^1\)This work is supported by JSPS research fellowships for Young Scientists.

9:30AM EC.00003 Kadanoff-Baym approach to nonequilibrium field theories with kinetic entropy . AKIHIRO NISHIYAMA, Institute of Physics, University of Tokyo — Recent phenomenological analysis of hadron production in ultrarelativistic nucleus-nucleus collisions at RHIC in terms of hydrodynamic model suggests that local thermalization is achieved very rapidly in dense matter created by the collision, much earlier than the time scale which has been expected from naive parton cascade picture. This poses a difficulty of applying the Boltzmann equation with usual binary collision term to describe the early thermalization process. We apply the relativistic Kadanoff-Baym (KB) theory to describe the time evolution of the gluonic matter produced by ultrarelativistic nucleus-nucleus collision. The merit of this approach is that it can incorporate the off-shell quantum evolution of partons as well as the memory effect in the collision process, both of these effects are usually ignored in the Boltzmann equation approach. As a preparatory step of our research, we study the non-equilibrium quantum evolution of the model systems described by scalar field theories. We present the analytical proof of the H-theorem with the relativistic KB equation and derive an equation to describe the entropy production. Numerical solutions of these equations are discussed.

9:45AM EC.00004 Instabilities of Initial Gauge Field Configurations in Heavy Ion Collisions . H. FUJII, University of Tokyo, K. ITAKURA, KEK, A. IWAZAKI, Nishogakusha University — The color-glass-condensate effective theory predicts that strong longitudinal chromo-electric and magnetic fields are generated in the initial state of high-energy nuclear collisions. We investigate analytically time-evolution of such unique gauge field configurations, and point out that unstable fluctuations are inherent to the longitudinal chromomagnetic background because of the non-abelian field nature, which was first recognized by Nielsen and Olesen (N-O) in a different context some time ago. We argue that characteristic features of the instabilities observed in the preceding simulations can be explained by identifying them as the N-O instability, and discuss possible implications to thermalization mechanism of the colliding system.

10:00AM EC.00005 Freeze-out dynamics of expanding quantum meson clouds\(^1\) . YOSHIKI ONISHI, TETSUO MATSUI, Institute of Physics, University of Tokyo, Komaba — We construct kinetic equations for self-interacting meson fields in a manifestly covariant form in order to describe the boost invariant expansion in the freeze out stage of the relativistic nucleus-nucleus collision. We employ the two-time Wigner functions in order to ensure manifest covariance. The equations of motion for two times are obtained in terms of the Wigner functions. We eliminate the off-diagonal elements of the Wigner functions from these equations in the long wave approximation and derive a closed form of kinetic equations for the diagonal component of the Wigner functions. The result is a manifestly covariant form of the kinetic equations. We show that this construction is equivalent to perform a local Bogoliubov transformation to the particle creation/annihilation operators taking into account the local change of the mass parameter due to the space-time dependent self-energy. These equations together with the non-linear Klein-Golden equation for meson condensates form a closed set of equations. We show that these equations lead to essentially the same results to the collective excitation of the system near equilibrium as obtained using one-time Wigner functions. We construct a boost invariant solutions of these kinetic equations in order to describe the expansion of meson cloud.

\(^1\)Supported by the Grant-in-Aid of MEXT, Japan, No. 19540269.

10:15AM EC.00006 Investigating nuclear collision geometry at the parton level with a modified Monte-Carlo Glauber model . RYAN WARD, J.L. KLAY, California Polytechnic State University — The Glauber model of nuclear collisions describes the geometrical distribution of interacting nucleons. Monte Carlo versions of the Glauber model have been very usefully applied to data from the Relativistic Heavy Ion Collider. This talk will review how it is used to model the collisions of nuclei at RHIC and LHC, and describe the addition of a new parton-level interaction algorithm to model the geometric distribution of hard-scattered quarks in high energy nuclear collisions. The simulation, written in Java with full visualization and outputs to ROOT, will be demonstrated and results for collisions at RHIC and LHC will be discussed.

10:30AM EC.00007 Distortion of the HBT images by meson clouds\(^1\) . KOICHI HATTORI, TETSUO MATSUI, Institute of Physics, University of Tokyo — We study the effects of mesonic final state interactions on the Hanbury Brown and Twiss intensity interferometry in ultra-relativistic heavy ion collisions. Modification of the one-body amplitude of emitted mesons while traversing a cloud of other mesons is estimated adopting the semiclassical approximation. The difference of the phase shifts causes a distortion of the images reflecting the two particle interference. Many body interaction due to the strong interaction among a particle and the rest of the system except for baryons is modeled with a optical potential which incorporates both coherent forward scattering and the absorption due to the incoherent scattering in the clouds. We found distortion of the images in the direction of both outward and sideward due to the real part of optical potential. Repulsive potential elongate the images in the outward direction, and attractive potential stretches in the sideward direction. However, the surface-dominated emission in the existence of the imaginary part of optical potential weakens the effect of the real part. The distortion is effective below around 100 MeV and weakens at high momentum regime. K. Hattori, T. Matsui, nucl-th/0905.3210

\(^1\)This work is supported in part by the Grants-in-Aid of MEXT, Japan, Nos. 19540269, and GCOE for Phys. Sci. Frontier, MEXT, Japan
10:45AM EC.00008 Calculation of the thermal properties of the QGP with 2D viscous hydrodynamics with LQCD equation of state, pre-equilibrium flow, and cascade freeze-out. RON SOLTZ, MICHAEL CHENG, JASON NEWBY, ANDREW GLENN, LLNL, SCOTT PRATT, MSU — Several recent developments nuclear theory have made it possible to calculate the thermal properties (spectra, flow, and HBT) of the QGP created at the Relativistic Heavy Ion Collider with a reasonable chance of success. We have incorporated these developments into a multi-stage model that incorporates pre-equilibrium flow into the UVH2+1 viscous hydrodynamic model that includes the recent HotQCD equation of state and uses UrQMD cascade for the final state particle distributions. With this model we will investigate the sensitivity to initial conditions and the equation of state. Results from the model will be compared to recent measurements of spectra, flow, and HBT from the Relativistic Heavy Ion Collider.

11:00AM EC.00009 FOCAL: a FOraWR CALorimeter for PHENIX. CARLA VALE, BNL, PHENIX COLLABORATION — As RHIC enters its second decade of running, upgrades to the PHENIX experiment are in the planning and construction stages. Among them, the conceptual design of FpCal and its performance study by a GEANT simulation and a beamtest of PHENIX Forward Calorimeter. A prototype of this design was tested at CERN in June. Results from this test, and an overview of the FOCAL physics capabilities, will be presented.

11:15AM ED.00010 A simulation study for a Forward Calorimeter upgrade plan in ALICE at LHC. YASUTO HORI, TAKU GUNJI, HIDEKI HAMAGAKI, University of Tokyo, CNS, JAN LAK, RICHARD SETO, EDWRD KISTENEV, MICKEY CHIU, CARLE VALE, ANDREY SUKHANOV — We plan to install a Forward Calorimeter (FOCAL) in the forward region of the ALICE experiment at LHC. A main subject is the study for signatures of small-x parton saturation effects, which are recently discussed from the point of Color Glass Condensate (CGC). It also enables to study long range hadron correlations like "Ridge" found in the AuAu collision at RHIC. The basic measurements are n° and direct γ spectrums in p+p, p+A, and A+A collisions. Since two γ from a high momentum π° decays are merged into a same cluster, π°/γ separation at high momentum is a challenging task. The measurement of single electron from heavy quarks and W boson is also possible in p+p, p+A collisions. A SiW Tracking Calorimeter can be the solution to these requirements. It is a sampling calorimeter which measures a precise lateral and longitudinal shower shape by a set of silicon sensors. A tungsten is a good choice for absorber material because of its short radiation length and excellent ratio of radiation and absorption lengths. A simulation study for possible physics will be presented. And then the conceptual design of FpCal and its performance study by a GEANT simulation and a beamtest of PHENIX Forward Calorimeter prototype will be also presented.

Friday, October 16, 2009 9:00AM - 12:15PM
Session ED Instrumentation III Kohala 4

9:00AM ED.00001 BrillLaNcE detector energy resolution characterization at HI2S1. N. BROWN, M.W. AHMED, S. STAVE, S.S. HENSHAW, B.A. PERDUE, P.-N. SEO, H.R. WELLER, Duke U/TUNL, P.P. MARTEL, A. TEYMUZASYAN, UMass, F. QUARATI, ESA/ESTEC — The High Intensity γ-ray source (HI2S) produced a variable γ-ray beam in the energy range of 2.5 to 15.5 MeV with an energy resolution of 50-100 keV. The γ-ray spectra from several BrillLaNcE detectors (manufactured by Saint-Gobain Ceramics and Plastics, Inc.) were collected over this range of energy. The beam energy resolution was monitored throughout the experiment using a High Purity Germanium (HPGe) detector, running in parallel. The energy resolution of the γ-ray beam was obtained using a Gaussian fit to deconvoluted HPGe data. Gaussian fits to the BrillLaNcE detector spectra were then corrected for the beam energy spread to obtain the detector resolution. A 4′′ (diameter)× 6′′ (long) LaCl3 Ce detector, a 3′′ × 3′′ LaBr3:Ce detector and a 2′′ × 2′′ LaBr3:Ce detector are characterized in the present study. The energy resolution of each detector will be reported as a function of incident γ-ray energy from 2.5 to 15.5 MeV, and the response functions will be compared to spectra obtained with HPGe and NaI detectors.

9:15AM ED.00002 Development of a Ge detector array for γ-ray spectroscopy of hypernuclei at J-PARC. TAKESHI YAMAMOTO, Dept. of Physics and Astronomy, Tohoku University, Sendai, Japan, HYPERBALL-J COLLABORATION — At the J-PARC facility, several light hypernuclei will be studied via γ-ray spectroscopy at the K1.8 beam line as a Day-1 experiment (E13). γ-rays from the hypernuclei are detected by a new germanium (Ge) detector array, Hyperball-J (HBJ), for an ultra high energy deposit rate. The array consists of 32 coaxial Ge detectors surrounded by newly developed PWO counters for fast background suppression. The simulated absolute photo-peak efficiency of HBJ is 5.8% for 1-MeV γ-rays. A Gaussian fit to deconvoluted HPGe data. Gaussian fits to the BrillLaNcE detector spectra were then corrected for the beam energy spread to obtain the detector resolution. A 4′′ (diameter)× 6′′ (long) LaCl3 Ce detector, a 3′′ × 3′′ LaBr3:Ce detector and a 2′′ × 2′′ LaBr3:Ce detector are characterized in the present study. The energy resolution of each detector will be reported as a function of incident γ-ray energy from 2.5 to 15.5 MeV, and the response functions will be compared to spectra obtained with HPGe and NaI detectors.

9:30AM ED.00003 Pulse shape analysis for Ge semiconductor Compton camera. TOMONORI FUKUCHI, SHINJI MOTOMURA, YOUSUKE KANAYAMA, SHIN’ICHIRO TAKEDA, HIROMITSU HABA, YASUYOSHI WATANABE, SHUICHI ENOMOTO, RIKEN — The Compton camera has found applications in many fields such as medical imaging, astrophysics, environmental monitoring and nuclear non-proliferation. We are developing a γ-ray Compton camera for medical use of multiple molecular imaging, which we call GREI (Gamma-Ray Emission Imaging). The GREI system consists of two double-sided orthogonal-strip high-purity germanium semiconductor detectors. Each detector can detect the interaction position and deposited energy of γ-ray, and γ-ray source distributions can be visualized based on Compton scattering kinematics. In order to improve the imaging resolution of the GREI, a pulse shape analysis techniques is under development. In general for the segmented semiconductor detector, its output pulses have variety of the shapes depending on the γ-ray interaction positions. Therefore, by analyzing the pulse shape, interaction position of γ-ray interaction can be extracted. Especially, analyzing not only pulse shape appearing in γ-ray hit segment but also transient signals in neighboring segments, 3D interaction position within the electrode can be extracted. We implemented a pulse shape analysis system for GREI and succeeded to extract 3D interaction position in sub-millimeter order. Consequently, imaging resolution is vastly improved.
New method of digital waveform analysis of signals from segmented Ge detectors

SHINTARO GO, SUSUMU SHIMOURA, EIJI IDEGUCHI, SHINSUKE OTA, HIROYUKI MIYA, Center for Nuclear Study(CNS), The University of Tokyo — We study digitized waveforms \( f(t_i) \) from a segmented Ge detector in CNS GRAPE [1], by means of \( n \)-th "moments":

\[
\sum_{i=1}^{n} t_i \cdot f(t_i)/\sum_{i=1}^{n} f(t_i)
\]

Nine sets of digitized data of the signal from 3 x 3 cathodes were recorded by using ADC with 105 MHz sampling [2]. The purpose is to determine the interaction position of \( \gamma \)-ray. The moments from \( n = 0 \) to 3 are examined. The characteristics of the moments will be discussed as a function of the hit position. In the preliminary analysis, it shows that the root-mean-square \((n=2)\) and the skewness \((n=3)\) vary in wide ranges with changing the hit position.


Pulse shape discrimination with new single crystal organic scintillators

JASON NEWBY, NATALIA ZAITSEVA, STEPHEN PAYNE, NERINE CHEREPY, LESLIE CARMAN, Lawrence Livermore National Laboratory, GIULIA HULL — Pulse shape discrimination in organic single crystal and liquid scintillators provides a means of identifying fission energy neutrons with high specificity. We present the results of a broad survey of over one hundred single crystal organic scintillators produced from low-temperature solution growth technique. Each crystal was evaluated for light yield and pulse shape discrimination performance. The pulse shape dependence on excitations via a Compton electron from a gamma and a recoil proton from a fast neutron was measured using full waveform digitization. Several groups of compounds were compared in relation to molecular and crystallographic structures, crystal perfection, and the effect of impurities. New prospective materials offering neutron/gamma discrimination comparable or superior to stilbene will be presented. We also report on the growth of large single crystal lithium salicylate and other promising Li compounds which have sensitivity to lower energy neutrons via neutron capture on \( ^7Li \) and are separable from other excitations via pulse shape discrimination.

Neutron Detection Efficiency of The Crystal Ball and TAPS

BERHAN DEMISSIE, George Washington University, A2 AT MAMI COLLABORATION — Photodisintegration of the deuteron - \( d(\gamma,p)n \) and \( \pi^0 \) production off the deuteron - \( d(\gamma,p,\pi^0)2n \) channels are investigated to measure the neutron detection efficiency of the combined Crystal Ball and Two Arm Photon Spectroscopy, TAPS, detector system currently employed by the A2 collaboration in the Tagged Photon hall at MAMI accelerator in Mainz, Germany. For this purpose, liquid Deutrium target data with 885 and 1557 MeV beam energy will be compared. Preliminary neutron efficiency results are produced. The resulting efficiencies will be compared to results obtained from a Geant 4 simulation of the complete detector setup in order to validate the neutron response provided therein. The ultimate conclusion of this project will be vital for cross section measurement of channels such as double \( \gamma,p,\pi \) production.

Radiation damage study of a Geiger-mode avalanche photo-diode (MPPC) using a pion beam at TRIUMF

MICHAEL HASINOFF, University of British Columbia, DAVID GILL, TRIUMF, YOUCHEI IGARASHI, JUN IMAZATO, KEK, Japan, ROB PYWELL, Univ of Saskatchewan, TORU MATSUMURA, Nat. Defense Academy of Japan — Silicon solid state Geiger-mode avalanche photo-diodes (MPPC) are now available from several manufactures. They offer several advantages compared to a conventional PMT — small size, weight, and even cost. However such solid state devices are also much more susceptible to radiation damage. Previous studies of a Hamamatsu S10362 400 pixel detector have shown significant radiation damage after exposure to 100M protons (<50 MeV). We have studied the signal deterioration and dark current during irradiation by a 130 MeV/c pion beam at TRIUMF. The results for a total exposure of 5000M pions will be presented.

Solid-State Photomultiplier with Integrated Front End Electronics

JAMES CHRISTIAN, CHRISTOPHER STAPELS, ERIK JOHNSON, SHARMISTHA MUKHOPADHYAY, XIAO JIE CHEN, Radiation Monitoring Devices, RORY MISKIMEN, University of Massachusetts — Physics experiments that are conducted at low temperatures and within high magnetic fields require improved optical detectors that operate under these conditions to provide the critical data for new discoveries. One experiment that will push the limits of existing photodetectors is the HIFROST target at the H:3 facility at TUNL, where a photodetector is required to readout scintillation material with embedded polarized protons. The readout of the scintillation material with a photodetector is used to reject coherent Compton scattering from \( ^{12}C \) in comparison to scattering of free polarized protons. To ensure proper readout of the scintillation material, a photodetector will be operated at 4 K, and to maintain the polarization of the target, the region will be under a 5T magnet field. We have verified an avalanche photodiode structure that can provide a quantum efficiency of ~20% at 5 K for 532-nm optical photons, even with an onset of carrier freeze out. The solid-state device is fabricated using a commercially available CMOS process, providing a low-cost means for fabrication. The electrical and optical properties of the photodetector are presented.

Solid-State Avalanche Photodetector for Operation at 4 K

ERIK JOHNSON, JAMES CHRISTIAN, CHRISTOPHER STAPELS, SHARMISTHA MUKHOPADHYAY, XIAO JIE CHEN, Radiation Monitoring Devices, RORY MISKIMEN, University of Massachusetts — Physics experiments that are conducted at low temperatures and within high magnetic fields require improved optical detectors that operate under these conditions to provide the critical data for new discoveries. One experiment that will push the limits of existing photodetectors is the HIFROST target at the H:3 facility at TUNL, where a photodetector is required to readout scintillation material with embedded polarized protons. The readout of the scintillation material with a photodetector is used to reject coherent Compton scattering from \( ^{12}C \) in comparison to scattering of free polarized protons. To ensure proper readout of the scintillation material, a photodetector will be operated at 4 K, and to maintain the polarization of the target, the region will be under a 5T magnet field. We have verified an avalanche photodiode structure that can provide a quantum efficiency of ~20% at 5 K for 532-nm optical photons, even with an onset of carrier freeze out. The solid-state device is fabricated using a commercially available CMOS process, providing a low-cost means for fabrication. The electrical and optical properties of the photodetector are presented.

J-PARC E17 experiment

YUYA FUJIWARA, The University of Tokyo, J-PARC E17 COLLABORATION — Precision x-ray spectroscopy of the 3d-2p X-ray of kaonic helium 3 atoms (J-PARC E17) will be performed as one of the Day-1 experiments at the J-PARC, a new proton synchrotron facility in Japan. By using eight Silicon Drift Detectors (SDDs) which has a high energy resolution of 150 eV (FWHM) and a large sensitive area of 100 mm², the 2p level shift will be measured with precision of a few eV. Experimental apparatus consist of three parts, x-ray detectors, the cryostat and liquid \(^{3}He \) target, and drift chambers. In this talk, an overview of the detectors and the preparation status will be presented.
11:30AM ED.00011 Observing coherent neutrino/nucleus scatters with a dual-phase argon detector\(^1\), KAREEM KAZKAZ, ADAM BERNEST, LLNL, MICHAEL FOXE, Purdue University, CHRISTIAN HAGMANN, LLNL, TENZING JOSHI, UC Berkeley, IGOR JOVANOVIC, Purdue University, BRANDON MORRISON, University of Chicago, PETER SORENSEN, WOLFGANG STEFFL, LLNL. Coherent neutrino/nucleus scatters are a prediction of the Standard Model of particle physics, though they have not yet been observed in the laboratory. We are planning an argon-based dual-phase detector to observe these scatters, and our research program involves three detectors: a single-phase detector to study the systematics of the signal volume, a small dual-phase detector to measure the nuclear quenching factor at 8 keVee, and a large dual-phase detector to search for the neutrino interactions themselves. We will present recent results of the systematic effects of the single-phase detector, including a measurement of gas content via electron drift speed. We will also present a progress update on construction of the small dual-phase detector, as well as a possible design for the large dual-phase detector.

\(^1\)This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory in part under Contract W-7405-Eng-48 and in part under Contract DE-AC52-07NA27344. Funded by Lab-wide LDRD.

Friday, October 16, 2009 9:00AM - 11:30AM –
Session EE Mini-Symposium on Precision Lattice Gauge Theory II Kohala 2

9:00AM EE.00001 Equation of State and the finite temperature transition in hot QCD, RAJAN GUPTA, Los Alamos National Laboratory. This talk will summarize the results obtained by the HotQCD collaboration on the equation of state and the crossover transition in 2+1 flavor QCD. We will present results on bulk thermodynamic quantities - energy density, pressure, entropy density, and the speed of sound over the temperature range 140 < T < 540 MeV. These results have been obtained on lattices of temporal size N_t = 6 and 8 and with two improved staggered fermion actions, asqtad and p4. Our most extensive results are with masses of the two degenerate light quarks set at m_{ud} = 0.1m_s, corresponding to the lightest pion mass m_{\pi} between 220 – 260 MeV. In these simulations, the strange quark mass is tuned to its physical value and defines lines of constant physical p4. We will also summarize the current state of results on observables sensitive to the chiral and deconfining physics - the light and strange quark number susceptibilities, the chiral condensate and its susceptibility, and the renormalized Polyakov loop. Our results indicate that the deconfinement and chiral symmetry restoration occur in the same narrow temperature interval.

9:30AM EE.00002 pi-pi, K-pi and K-K interactions from lattice QCD, ANDRE WALKER-LOUD, College of William and Mary, NPLQCD COLLABORATION. I will discuss recent lattice calculations of the l=2 pi-pi, l=3/2 K-pi and l=1 K-K scattering processes from the NPLQCD Collaboration. Combined with chiral perturbation theory, these hadron interaction processes can be used to make precise determinations of the corresponding scattering lengths and the Gasser-Leutwyler coefficients which contribute to these interactions.

9:45AM EE.00003 S-wave \(\pi - K\) scattering length from lattice QCD, KIYOSHI SASAKI, Tokyo Institute of Technology, NARUHITO ISHIZUKA, TAKESHI YAMAZAKI, Tsukuba University, MAKOTO OKA, Tokyo Institute of Technology. We present the S-wave \(\pi - K\) scattering lengths for both the isospin 1/2 and 3/2 channels evaluated by using the finite size formula. We utilize the \(N_f = 2 + 1\) gauge configurations generated on l=32\(^3\) x 64 lattices using the Iwasaki gauge action and the \(O(4)\)-improved Wilson action at \(\beta = 3.17\) GeV. The quark masses correspond to \(m_{\pi} = 0.30\) - 0.70 GeV. For \(I = 1/2\), to separate the effects from excited states, we construct a 2 x 2 matrix of the time correlation function and diagonalize it. Here, we adopt the two kinds of operators, \(s\pi\) and \(\pi - K\). Our preliminary results show signs of the scattering lengths in agreement with experiment, namely attraction in \(I = 1/2\) and repulsion in \(I = 3/2\). We investigate the quark-mass dependence of the scattering length and also discuss the limitation of chiral perturbation theory.

10:00AM EE.00004 Extracting the energies of multi-hadron states in lattice QCD, JUSTIN FOLEY, Carnegie Mellon University, THE HADRON SPECTRUM COLLABORATION. The ability to reliably measure the energy of an excited hadron in lattice QCD simulations hinges on the accurate determination of all lower-lying energies in the same symmetry channel. These include not only single-particle energies, but the energies of multi-hadron states. The same multi-hadron energies measured at a number of lattice volumes may also be used to determine hadron scattering lengths. In this talk, we discuss the determination of multi-hadron energies in lattice QCD. The group-theoretical derivation of lattice interpolating operators which couple optimally to multi-hadron states is described. We briefly outline recent algorithmic developments which allow for the efficient implementation of these operators in software, and present numerical results from the Hadron Spectrum Collaboration.
10:15AM EE.00005 Charmed-Meson Scattering in lattice QCD, TAKUYA YAGI, Univ. of Tokyo and KEK, MUNEHISA OHTANI, Kyorin Univ. and KEK, OSAMU MORIMATSU, KEK, Univ. of Tokyo and SOKENDAI, SHOJI HASHIMOTO, KEK and SOKENDAI — The interaction of $D_s$ and $D_s^*$ mesons is studied in lattice QCD aiming at obtaining some hint on the nature of the $Z(4430)$. Our calculation is done using the Wilson fermion on a quenched $24^3 \times 48$ lattice. We calculate the correlation functions of $D_s$ and $D_s^*$ mesons and obtain the energy in a finite box, from which we extract the scattering length of $D_s$ and $D_s^*$ mesons by means of Lüscher's formula.

10:30AM EE.00006 The effective gluon mass and the gluon propagator form in the Landau gauge in SU(3) lattice QCD, TAKUMI IRITANI, HIDEO SUGANUMA, Dept. of Phys., Kyoto Univ., HIDEAKI IDA, RIKEN — We study the gluon propagator in the Landau gauge in SU(3) lattice QCD with $\beta = 5.7, 5.8$ and 6.0 at the quenched level in the region of $r = 0.1 \sim 1.0$ fm, which is relevant to quark-hadron physics. First, we evaluate the effective gluon mass in lattice QCD, since gluons have been conjectured to acquire large effective mass due to non-perturbative effects of QCD. The effective gluon mass is estimated to be about $400 \sim 600$ MeV in the Landau gauge in an infrared region of $r = 0.5 \sim 0.8$ fm. Next, we investigate the functional form of the gluon propagator in the Landau gauge. As a remarkable fact, the gluon propagator is found to be well reproduced by the simple Yukawa-type function $e^{-mr}/r$ in the whole region of $r = 0.1 \sim 1.0$ fm in the four-dimensional Euclidean space-time. Note that this Yukawa-type propagator in four-dimensional space-time corresponds to a new-type propagator of $(p^2 + m^2)^{-3/2}$ in the momentum space. Based on the Yukawa-type gluon propagator obtained from lattice QCD, we also discuss a possible construction of the infrared effective theory such as a Nambu-Jona-Lasinio-type theory from QCD.

10:45AM EE.00007 Relevant energy scale of color confinement from lattice QCD, ARATA YAMAMOTO, HIDEO SUGANUMA, Kyoto University — We propose a new lattice framework to extract the relevant gluonic energy scale of QCD phenomena which is based on a “cut” on link variables in momentum space. This framework is expected to be broadly applicable to all lattice QCD calculations. Using this framework, we quantitatively determine the relevant energy scale of color confinement, through an analysis of the quark-antiquark potential. The relevant energy scale of color confinement is found to be below 1.5 GeV in the Landau gauge. In addition, we analyze meson masses and the flux-tube distribution by this framework.

11:00AM EE.00008 ABSTRACT WITHDRAWN —

11:15AM EE.00009 Proper Heavy-Quark Potential in a Spectral Decomposition from the Thermal Wilson Loop, ALEXANDER ROTHKOPF, TETSUO HATSUDA, SHOICHI SASAKI, The University of Tokyo — Experimental findings of QCD suppression urge for a better understanding of the underlying in-medium effects. To this end we propose a non-perturbative definition of the proper Heavy-Quark potential $\bar{\omega}(R)$ from the spectral decomposition of the thermal Wilson loop $\omega(t, R)$ via $\sum_{\omega \rightarrow \bar{\omega}(R)} \int e^{-\omega t} \rho(\bar{\omega}, R) d\bar{\omega}$. Re$[V(R)]$ can be extracted using peak positions in $\rho(\bar{\omega}, R)$ at different $R$, and the imaginary part from the width of the envelope. The use of spectral functions allows to connect imaginary- and real-time quantities such as the forward propagator $D^>(t, R)$, $\int d\omega e^{-\omega t} \rho(\bar{\omega}, R) d\bar{\omega} = D^>(t, R)$, and invariant mass of the residual system $m_{\omega,R}^2 = \int d\omega e^{-\omega t} V(R)$. This bridges the gap between rigorous results at $T=0$ and perturbative studies well above the critical temperature. The peak structure of the spectral function also determines when a Schrödinger-equation description of the system is possible, in which this proper potential can be used. First results for the real part in SU(3) gauge theory, using a 3-peak model for the spectral function, reveal that well above the critical temperature the string tension of the heavy QQ system still contributes significantly. Thus, Debye screening is not as pronounced as in the case of the Polyakov loop correlator free energies. These hints toward an increased stability of heavy quarkonia up to $2T_c$, as compared to melting within a free energy potential framework are consistent with both experimental data and lattice studies on the QQ spectrum and its wavefunction.

Friday, October 16, 2009 9:00AM - 12:00PM —
Session EF Mini-Symposium on Hadron Structure and QCD in High Energy Processes II Kohala

9:00AM EF.00001 Studies of spin-averaged SIDIS at Jefferson Lab, PETER BOSTED, Jefferson Lab, HALL C MESON DUALITY COLLABORATION — Cross sections for semi-inclusive deep-inelastic electroproduction of positive and negative charged pions have been measured at Jefferson Lab from both proton and deuterion targets. The kinematic range spans $0.2 < x < 0.5$, $2 < Q^2 < 4$ GeV$^2$, $0.3 < \phi < 1$, transverse momentum $P_T < 0.2$ GeV$^2$, and invariant mass of the residual system $1.1 < M_x < 2$ GeV. The data are in good agreement with models fit to higher invariant mass data which can be considered as a manifestation of quark-hadron duality. We find the azimuthal dependence to be small. Small but statistically significant differences in the $P_T$-averaged $F_2$ dependence for the four cases were found. In the context of a simple model, we fit the data for the initial transverse momentum width of $u$ and $d$ valence quarks and also the transverse momentum widths of favored and unfavored fragmentation functions. We find all four widths to be qualitatively similar and of order 0.05 to 0.15 GeV$^2$. There is good potential to improve on this technique with future data using 11 GeV electrons.

9:15AM EF.00002 Quark helicity distributions from DIS and SIDIS at COMPASS, TATSURO MATSUDA, University of Miyazaki, TAKAHIRO IWATA, Yamagata University, NAOAKI HORIKAWA, Chubu University, TAKAO HASEGAWA, University of Miyazaki, SHIGERU ISHIMOTO, KEK, NORIHITO DOSHITA, KIYOSHI HIRAIWA, TAKUMA MICHIGAMI, Yamagata University, COMPASS COLLABORATION — The COMPASS collaboration at CERN is measuring the spin structures of nucleon. At this meeting we will present the inclusive asymmetry $A_1$ and the semi-inclusive asymmetries $A_1^{u,d}$, $A_2^{u,d}$ measured in the polarized deep inelastic muon-deuteron scattering. The data cover the range $Q^2 > 1$ GeV$^2$ and $0.004 < x < 0.3$. These results were obtained from the data collected in years 2002-2004 and 2006. We will also present the valence, non-strange sea and strange quark helicity distributions extracted from the LO analysis using these results. The strange quark distribution is compatible with zero in the whole measured range.

9:30AM EF.00003 Access quark information through SIDIS measurements at JLab-12 GeV$^1$, XIAODONG JIANG, Los Alamos National Laboratory — At JLab-12 GeV, one hopes to access quark information such as helicity and transverse spin distributions, Sivers functions and momentum distributions through semi-inclusive deep-inelastic scattering experiments (SIDIS). But, how can we know that the hard probe really hit a quark? How can we know that the quark information is still preserved through the fragmentation process? What will be the experimental evidences? A plan of measurements of SIDIS cross section ratios will be outlined, the goal of these measurements is to firmly establish the kinematic region over which SIDIS reactions can be reliably interpreted to the next-to-leading-order QCD in terms of parton distributions and fragmentation functions.

1Work supported by DOE, Office of Science.
9:45AM EF.00004 Measurement of Single Target-Spin Asymmetry in Semi-Inclusive DIS using Transversely Polarized \(^3\)He Target , KALYAN ALLADA, University of Kentucky, JEFFERSON LAB E06-010 COLLABORATION, JEFFERSON LAB HALL A COLLABORATION — We recently measured the neutron target single spin asymmetry in the semi-inclusive deep inelastic \(e^+(e, e'\pi^+)X\) reactions with a transversely polarized \(^3\)He target. The experiment was performed at Jefferson Lab Hall A from October 2008 to February 2009. The pions were detected in the high-resolution spectrometer in coincidence with the scattered electrons detected by the BigBite spectrometer. The kinematic coverage focuses on the valence quark region, \(x = 0.13\) to 0.41, at \(Q^2 = 1.31 - 3.10\) (GeV/c\(^2\)). Good particle identification was achieved using a RICH detector, an aerogel Cherenkov counter and Time-of-Flight detectors, which allowed for clean \(\pi^+\) and \(K^+\) detection. The data from this experiment, when combined with the world data, will provide constraints on the transversity and Sivers distributions on both u-quark and d-quark in the valence region. An update on the on-going analysis will be presented in this talk.

10:00AM EF.00005 Measurement of Double Spin Asymmetry \(A_{LT}\) in Semi-Inclusive Pion Electroproduction on a Transversely Polarized \(^3\)He Target , JIN HUANG, Massachusetts Institute of Technology, JEFFERSON LAB A COLLABORATION — We recently measured the neutron double spin asymmetry \(A_{LT}\) in the semi-inclusive deep inelastic \(e^+(e, e'\pi^+)X\) reactions with polarized electron beam and a transversely polarized \(^3\)He target. The measurement was performed in Jefferson Lab Hall A, using a 6 GeV polarized electron beam scattered from a 40 cm polarized \(^3\)He target. The produced pions were detected by the left high-resolution spectrometer in coincidence with the scattered electrons detected by the BigBite spectrometer. The kinematic coverage focused on the valence quark region, \(x \sim 0.13\) to 0.41, at \(Q^2 \sim 1.31 - 3.10\) (GeV/c\(^2\)). When combined with the world data, the new data will provide constraints on the \(g_1^{LT}\) distribution functions. These distribution functions describe the longitudinal polarization of up and down quarks in the valence region for a transversely polarized nucleon. Current data analysis progress will be presented in this talk.

10:15AM EF.00006 Target Single-Spin Asymmetry Measurements in Quasi-Elatic \(^3\)He\!(e, e')\_\_\_, BO ZHAO, College of William and Mary, JEFFERSON LAB HALL A COLLABORATION — The target single-spin asymmetry for the neutron, \(A_N\), was measured using the inclusive quasi-elastic \(e^+(e, e'\pi^+)X\) reaction in Hall A at Jefferson Lab with a vertically polarized \(^3\)He target for \(Q^2 = 0.13, 0.46\) and 0.97 GeV\(^2\). Since the target single-spin asymmetry is expected to be zero in the one-photon exchange approximation, the non-zero results from this experiment clearly demonstrate the effects due to two-photon exchange. They establish the two-photon exchange process as a powerful tool to probe hadron structure, such as information on Generalized Parton Distributions. The ongoing analysis of this experiment will be presented.

10:30AM EF.00007 Recent DVCS Results from HERMES, RALF KAISER, University of Glasgow, HERMES COLLABORATION — This talk presents recently released HERMES results on DVCS beam spin, beam charge and target spin asymmetries for polarised and unpolarised hydrogen and deuterium targets. A new analysis technique has been used to extract the relevant asymmetries simultaneously: beam charge and beam spin asymmetry for unpolarised target data and the longitudinal target spin asymmetry and beam spin asymmetry for longitudinally polarised target data. The extracted asymmetries and their dependences on the \(t\) and \(Q^2\) are presented over the entire kinematic acceptance of HERMES. The results are compared with asymmetries calculated based on a phenomenological GPD model based on double distributions from Vanderhaeghen, Guidal and Guichon.

10:45AM EF.00008 Timelike Compton Scattering with CLAS, STEPAN STEPANYAN, Jefferson Lab, CLAS COLLABORATION — Deeply Virtual Compton Scattering (DVCS), \(\langle E_p \rangle\), has been under intense theoretical and experimental studies in recent years as a new tool to access Generalized Parton Distributions (GPDs) of the nucleon. The simplest observables in DVCS for studying GPDs are spin dependent cross section differences. These asymmetries measure the imaginary part of Compton Form-Factors (CFFs), where GPDs enter at specific kinematical point, \(\xi = x\). Here \(\xi\) is the generalized Bjorken variable and \(x\) is the light-cone momentum fraction of the struck quark. The real part of CFF is proportional to the integral of GPDs over \(x\) and can only be accessed in the measurements of the DVCS cross section or the beam charge asymmetry. Studying the real part is important for modeling GPDs. It is sensitive to the so-called D-term, introduced in the modeling of GPDs to ensure the polynomiality of their Mellin moments. Photoproduction of lepton pairs, or so-called Time-like Compton Scattering (TCS), is an inverse process to DVCS and offers additional constraints on GPDs. In particular, TCS can be used as an effective tool to study the real part of the Compton amplitude using the azimuthal angular asymmetry arising from exchange of \(t^+\) and \(t^-\) momenta. In this report, first analysis of the Time-like Compton Scattering using the CLAS electroproduction data will be presented. Details of the extraction of quasi-real photoproduction of lepton pairs will be discussed.

11:00AM EF.00009 Deeply Virtual Exclusive Reactions with CLAS, VALERY KUBAROVSKY, Jefferson Lab, CLAS COLLABORATION — Deeply virtual exclusive reactions offer a unique opportunity to study the structure of the nucleon at the parton level as one varies both the size of the probe, i.e. the photon virtuality \(Q^2\), and the momentum transfer to the nucleon \(t\). Such processes can reveal much more information about the structure of the nucleon than either inclusive electroproduction (\(Q^2\) only) or elastic form factors (\(t = -Q^2\)). A dedicated experiment to study Deeply Virtual Compton Scattering (DVCS) and Deeply Virtual Meson Production (DVMP) has been carried out in Hall B at Jefferson Lab. DVCS helicity-dependent and helicity-independent cross sections, as well as beam spin asymmetry, and cross sections and asymmetries for the \(n^o\) and \(\eta\) exclusive electroproduction in a wide kinematic range of \(Q^2, x_B, t\) have been measured with CLAS. Preliminary data will be presented for the kinematic range in \(Q^2 = 1.45\) GeV\(^2\), \(x_B = 0.1-0.5\) and \(t = 2\) GeV\(^2\). We view the work presented in this report as leading into the program of the Jefferson Lab 12 GeV upgrade. The increased energy and luminosity will allow us to make the analysis at much higher \(Q^2\) and \(x_B\) and perform Rosenbluth L/T separations of the cross sections.

11:15AM EF.00010 First results of the helicity asymmetry measurements for \(p^0\) photoproduction with FROST at Jlab, HIDEKO IWAMOTO, the George Washington University — One of the longstanding unsolved problems in the nuclear physics is that of the nucleon resonances \(N^\ast\) and \(\Delta^\ast\). The lifetime of these intermediate states is very short since they decay strongly. Their parameters, mass, width, and coupling constants to various decay modes are not well known. To solve this problem, double polarization experiments are considered to be a very effective tool. I will present the result of a single pion photoproduction from the first double polarization experiment at Jefferson Lab and compare this result with the prediction of theoretical models.

11:30AM EF.00011 Exclusive \(\pi^0\) electroproduction in the resonance region at low \(Q^2\), NIHOLAY MARKOV, KYUNGSEON JOO, MAURIZIO UNGARO, University of Connecticut, COLE SMITH, University of Virginia, CLAS COLLABORATION — We report the analysis of single \(n^0\) electroproduction in the resonance region to study the electromagnetic excitation of the nucleon resonances. The study is aimed at understanding of the internal structure and dynamics of the nucleon. The experiment was performed using an unpolarized cryogenic hydrogen target and 2.0 GeV polarized electron beam during the e1e run period with CLAS at Jefferson Lab. The new measurements will produce a data base with high statistics and large kinematic coverage for the hadronic invariant mass \(W\) up to 1.8 GeV in the momentum transfer \(Q^2\) range of 0.3 - 1.0 (GeV/c\(^2\)). Preliminary results will be presented and compared with the various model calculations.
11:45 AM EF.00012 \( \pi^0 \) electroproduction in semi-inclusive deep inelastic scattering off D, C, Fe, Pb. TAISYA MINEEVA, University of Connecticut, Storrs, CT, WILL BROOKS, Universidad Tecnica Federico Santa Maria, Valparaíso, Chile. KYUNGSEON JOO, MAURIZIO UNGARO. University of Connecticut, Storrs, CT. CLAS COLLABORATION — Measurement of neutral pion electroproduction is being performed in semi-inclusive deep inelastic scattering off deuterium, carbon, iron, and lead targets. The data were taken with the CLAS detector in Jefferson Lab using a 5.014 GeV electron beam. The two targets, liquid deuterium plus a solid foil, were positioned in the beam simultaneously. Hadronic multiplicity ratios \( R_{\pi^0} \) and transverse momentum broadening distributions \( \Delta p_T \) were measured as a function of \( (E_\gamma, Q^2, p_T) \) kinematic bins. These results provide new insights into the phenomena of hadron production through the access to the average lifetime of the quasi-free quark and time required to form full hadronic wave function. The status of data analysis as well as preliminary results of multiplicity ratios will be presented.

Friday, October 16, 2009 9:00AM - 12:00PM — Session EG Nuclear Astrophysics I Kings 2

9:00AM EG.00001 Suppression of the stellar enhancement factor and reaction rates far from stability. THOMAS RAUSCHER, Department of Physics, University of Basel, Switzerland — Nuclei in astrophysical plasmas occur in excited states because they are in thermal equilibrium with the stellar plasma. This modifies the reaction cross sections and has important consequences for the determination of stellar reaction rates. The application of detailed balance implies that stellar effects are less pronounced in the direction of positive Q-value and that measurements should preferably be performed in this reaction direction. However, we show that the general Q-value rule does not apply for a number of cases due to the suppression of low-energy transitions in the exit channel by an additional barrier (Coulomb or centrifugal). Additionally, it has to be realized that the validity of detailed balance cannot be taken for granted in all cases. This is well known for nuclei at stability having isomeric states but may also become problematic in nuclei with low level densities. Another complication with low level densities is that the Hauser-Feshbach model cannot be applied anymore to predict reaction cross sections. Resonant and direct reactions also become important. Preliminary results of a new large-scale prediction of astrophysical reaction rates across the nuclear chart including both the compound and the direct mechanism will be shown.

9:15AM EG.00002 Hoyle Reloaded: A fix for the Cosmological Lithium Problem?1, RICHARD CY-BURT, JINA/NSCL/MSU, MAXIM POSPELOV. University of Victoria/Perimeter Institute — There is a significant discrepancy between the current theoretical prediction of the cosmological lithium abundance, mostly produced as \(^7\)Be during the Big Bang, and its observationally inferred value. We investigate whether the resonant enhancement of \(^7\)Be burning may alleviate this discrepancy. We identify one narrow nuclear level in \(^7\)B, \(E_{1/2}\) \(\approx\) 16.7 MeV that is not sufficiently studied experimentally, and being just \(\sim\) 200 keV above the \(^7\)Be-\(^7\)B threshold, may lead to the resonant enhancement of \(^7\)Be\((d,\gamma)\)\(^7\)B and \(^7\)Be\((d, p)\)\(^7\)B reactions. We determine the relationship between the domain of resonant energies \(E_r\) and the deuteron separation width \(\Gamma_d\) that results in the significant depletion of the cosmological lithium abundance and find that \((E_r, \Gamma_d) \approx (170 - 220, 10 - 40)\) keV can eliminate current discrepancy. Our results also imply that before dedicated nuclear experimental and theoretical work is done to clarify the role played by this resonance, the current conservative BBN prediction of lithium abundance should carry significantly larger error bars, \([^{7}\text{Li}/^{7}\text{H}]_{\text{BBN}} = (2.5 - 6) \times 10^{-10}\).

1The work of RC was supported by the U.S. National Science Foundation Grant No PHY-02-016783.

9:30AM EG.00003 The Impact of Reaction Rate Uncertainties (and other nuclear physics inputs) on Nucleosynthesis in the Neutrino-p Process. CARLA FROHLICH, EFI & Dept of Astronomy, Univ of Chicago, X. TANG, Dept of Physics, Univ of Notre Dame, J.W. TRURAN, Univ of Chicago & Argonne NL — The neutrino-p (\(\nu p\)) process has been shown to be an important nucleosynthesis process, occurring in core collapse supernovae, that contributes to the abundance of nuclei in the mass region \(64 < A < 120\). Such a nucleosynthesis process (in addition to the r- and s-processes) is needed to explain the observed abundance patterns in this mass region - particularly in very low metallicity stars. The \(\nu p\)-process consists of a sequence of \((p,\gamma)\) and \((n, p)\) or \(\beta^+\) reactions, where the slowest reactions set the timescale. Nucleosynthesis studies of such events as the \(\nu p\)-process typically involve the use of reaction networks that include several thousand nuclei and associated reaction cross sections and lifetimes, most of which are only known theoretically. A majority of the nuclei involved are unstable and hence pose a challenge for experimental nuclear physicists. With improvements in existing facilities such as NSCL at MSU and ATLAS at ANL and with a future FRIB facility, experimental investigations of reaction rates and other nuclear quantities involving unstable nuclei will become feasible. In this talk, we will demonstrate how uncertainties in the reaction rates influence the resulting nucleosynthesis. In addition, we will identify important reactions and nuclei to be studied experimentally with upcoming techniques at the new facilities.

9:45AM EG.00004 Looking for Dark Matter with the CDMS Detectors. MARK KOS, Syracuse University, CDMS COLLABORATION — The Cryogenic Dark Matter Search (CDMS) has the world’s best sensitivity to Weakly Interacting Massive Particle (WIMP) interactions. By independently measuring phonon and ionization energy, CDMS distinguishes electromagnetic backgrounds from possible WIMP nuclear recoil events. CDMS consists of five towers of Ge and Si detectors. Recently a SuperTower has been installed with larger Ge detectors and improved phonon readout. I will present the experiment’s most recent results and discuss operation of the new detectors.

10:00AM EG.00005 LUX dark matter search: expected sensitivity. PETER SORENSEN, Lawrence Livermore National Laboratory — The LUX 300 kg two-phase Xe detector aims to detect or exclude dark matter in the form of Weakly Interacting Massive Particles (WIMPs) with scalar cross section (per nucleon) as low as \(7 \times 10^{-46} \text{ cm}^2\). This is equivalent to \(\sim 0.5\) events/100 kg/month in a 100 kg fiducial volume. The LUX design is set to ensure \(< 1\) background event / 10 months live, which could potentially be characterized as a WIMP interaction. Based on above-ground calibrations and data from the XENON10 experiment, LUX expects to reject up to 99.9% of the dominant electron-recoil background at detector threshold (\(\sim 5\) keV), with 50% acceptance for nuclear recoils. This talk will discuss the projected sensitivity of the LUX experiment for elastic and inelastic dark matter scenarios.

10:15AM EG.00006 LUXSim: A GEANT4-based Simulation Framework for the Large Underground Xenon Detector. MELINDA SWANEY, UC Davis, LUX COLLABORATION — The Large Underground Xenon (LUX) detector is a 100 kg target mass WIMP detector capable of achieving a cross section sensitivity of \(7 \times 10^{-46} \text{ cm}^2\) for a 100 GeV WIMP. LUX will commence operations in early 2010 at the Sanford Underground Lab in Lead, South Dakota. The most important consideration in building LUX is the minimization and characterization of neutron backgrounds that could emulate a WIMP signal. In order to accurately determine the level of background, we require a precise simulation of radioactive sources embedded within the detector components. Traditionally in GEANT4 simulations, particle beams have been distinct from the detectors, as is typical in high energy or medical applications. We are developing a GEANT4 simulation framework, LUXSim, capable of generating primary particles within detector components from independently specified activities of radionuclides. Geometry classes are also recast so that tracking information within individual components, such as energy deposits, is easily stored without specifying each as a sensitive detector. In addition, LUXSim includes built-in commands for changing detector type, activities within components, and the level of information storage for each detector component, so that reconfiguration is not necessary. The basic class structure of LUXSim will be described, including examples of usage, and preliminary results will be presented.
10:30AM EG.00007 The LUX Dark Matter Search Program. KENNETH CLARK, Case Western Reserve University. LUX COLLABORATION — LUX (Large Underground Xenon) is a two-phase Time Projection Chamber that will instrument 350 kg of Xenon, 100 kg of which will form a fiducially active target for WIMP interactions. It will be deployed at the Sanford Underground Lab at the Homestake Mine in Lead, South Dakota, where the Early Implementation Program is providing space at the 4850 feet level for LUX. The first detector with 120 photomultiplier tubes is being constructed and is projected to start collecting data in early 2010. Prior to this installation, a prototype detector with a reduced fiducial volume has been in operation in an above ground environment. Results from this detector, along with discussion of the full LUX sensitivity will be presented.

10:45AM EG.00008 Measuring the ultra-high energy cosmic ray flux with the Telescope Array Middle Drum detector, THOMAS SONLEY, University of Utah, TELESCOPE ARRAY COLLABORATION — The Telescope Array (TA) Experiment, located 200 kilometers southwest of Salt Lake City, Utah, is the largest Ultra-High Energy cosmic ray detector in the northern hemisphere. TA is a follow up to the High Resolution Fly’s Eye (HiRes) and AGASA experiments, and seeks to gain insight into cosmic ray acceleration by measuring the flux of cosmic rays with energies over $10^{18}$ eV. The detector consists of 507 scintillator counters distributed in a square grid with 1.2 km spacing. Three fluorescence detector stations sit on the corners of a 30 km equilateral triangle overlooking the array of surface detectors, and provide full hybrid coverage with the scintillator array above 10 TeV. Telescope Array underwent commissioning in 2007 and began routine data collection operations at the beginning of 2008. One of the three fluorescence stations, the Middle Drum (MD) site, is instrumented with detectors previously used at the HiRes-I site. The inclusion of the MD site makes possible a direct comparison between the fluorescence energy scales and spectra between TA and HiRes. We will present a progress report on the analysis of the TA data collected by the MD site.

11:00AM EG.00009 Search for WIMPs dark matter by means of thin NaI(Tl) scintillator. KEN-ICHI FUSHIMI, The Univ. of Tokushima, PICO-LON TEAM — The segmented detector system made of inorganic crystal is applied to search for WIMPs dark matter. The NaI(Tl) crystal has great advantages to search for WIMPs dark matter.

1. 100% of natural abundance of odd A nuclei ($^{23}$Na and $^{127}$I).

2. $^{127}$I has a low energy excited state at 57.6keV which is excited by spin-dependent interaction.

The prototype detector of thin NaI(Tl) was tested. The energy resolution and the low energy threshold will be reported. The future prospect of WIMPs dark matter search by various detector will be discussed.

1 JPS:27847D

11:15AM EG.00010 Neutron production by cosmic ray muons at the Sudbury Neutrino Observatory. JAMES LOACH, Lawrence Berkeley National Laboratory, SUDBURY NEUTRINO OBSERVATORY COLLABORATION — Neutrons produced by cosmic ray muon interactions can be a significant background in sensitive underground experiments. The Sudbury Neutrino Observatory (SNO) is an efficient and well-calibrated neutron detector capable of measuring the rate and characteristics of thermal neutrons produced by muon interactions in its heavy water target, light water shielding and surrounding rock. The location of the detector, beneath a rock overburden 5900 meters water equivalent, implies that the muon flux is particularly low in rate and high in energy. SNO’s measurements, with their unique target materials and high energy muons, are important for benchmarking Monte Carlo codes that will be used to predict muon-induced neutron fluxes in future low background experiments.

11:30AM EG.00011 Equation of State for Asymmetric Nuclear Matter at Finite Temperatures with the Variational Method. HAJIME TOGASHI, HIROAKI KANZAWA, MASATOSHI TAKANO, Waseda University, KAZUHIRO OYAMATSU, Aichi Shukutoku University, KOHSUKE SUMIYOSHI, Numazu College of Technology — The free energies of uniform nuclear matter at various densities, temperatures and proton fractions are calculated with the variational method, toward a new nuclear equation of state (EOS) for supernova simulations. Following the method by Schmidt and Pandharipande, the expectation value of the two-body Hamiltonian with the AV18 potential is calculated in the two-body cluster approximation. The averaged occupation probabilities of the single particle states in the Jastrow trial wave function at finite temperature are parameterized by the proton and neutron effective masses. The energy caused by the UIX three-body potential is treated somewhat phenomenologically so as to obtain the realistic nuclear EOS at zero temperature. The entropy is also expressed with the averaged occupation probabilities, and then the free energy is minimized with respect to the effective masses. The proton fraction dependence of the obtained thermodynamic quantities is discussed.

11:45AM EG.00012 Equation of State for Non-uniform Nuclear Matter by the Variational Method with Thomas-Fermi Calculations. HIROAKI KANZAWA, MASATOSHI TAKANO, Waseda University, KAZUHIRO OYAMATSU, Aichi Shukutoku University, KOHSUKE SUMIYOSHI, Numazu College of Technology — Toward a new equation of state (EOS) for supernova (SN) simulations based on the realistic nuclear forces, the EOS for non-uniform nuclear matter is constructed in the Thomas-Fermi (TF) approximation. The energy of uniform nuclear matter used in the TF calculation is obtained by a simplified variational method with the AV18 and UIX potentials. The parameters associated with the nuclear three-body force are fixed so that the TF calculation for atomic nuclei reproduces the gross behavior of their experimental masses and radii. With use of this TF method, the EOS of non-uniform nuclear matter, which is assumed to be composed of a Coulomb lattice of single species of nucleons immersed in a uniform electron gas (with neutrons dripped out of the nuclei), are calculated for various baryon densities and proton fractions at zero temperature. The obtained thermodynamic quantities of non-uniform matter are compared with those of Shen-EOS.

Friday, October 16, 2009 9:00AM - 12:00PM – Session EH Nuclear Structure III Kings 3
9:00AM EH.00001 \( ^{213,214}\)Th using SASSYER\(^1\) - TAN AHN, ANDREAS HEINZ, JING QIAN, RYAN WINKLER, ROBERT CASPERSON, GABRIELLA ILIE, DAVID MCCARTHY, AXEL SCHMIDT, J. RUSSELL TERRY, ELIZABETH WILLIAMS, WNSL, Yale University — Data for excited states have been scarce in the proton-rich region above \(^{208}\)Pb near the \(N=126\) shell closure due to the low fusion cross section and high fission background present when producing these nuclei, but measurements of new excited states have helped elucidate the local single particle structure and can be a good test for various nuclear models. A recent measurement by Khuyagbaatar et al. (Eur. Jour. Phys. A 34 335 (2007)) of the first excited states of \(^{213,214}\)Th, including the discovery of an \((8^+\) isomer, helped shed light on the single particle structure in the region. These excited states have been identified through the observation of \(\gamma\) rays coming from the decay of the \((8^+)\) isomeric state. An experiment to extend the known levels and transitions in these nuclei by measuring prompt \(\gamma\) rays from \(^{213,214}\)Th has been performed at the WNSL at Yale University. The gas-filled separator SASSYER was used to identify \(\gamma\) rays from the nuclei of interest by gating on evaporation residue recoils and their subsequent known alpha decays, a technique known as recoil-decay tagging. Current results from this experiment will be presented.

\(^1\)Supported by DOE grant number DE-FG02-91ER40609.

9:15AM EH.00002 Investigation of the \(N=127\) nucleus \(^{217}\)Th\(^1\) - R. CHEVRIER, WNSL, University of Caen 14000 France, A. HEINZ, J. QIAN, A. AHN, R. CASPERSON, G. ILIE, J.R. TERRY, R. WINKLER, E. WILLIAMS, WNSL, D. MCCARTHY, WNSL, University of Surrey, Guildford, GU2 7XH, U.K., L. KUCUK, G. SUSOY, Istanbul University, Turkey — The evolution of the \(N=126\) neutron shell is interesting, since it can be compared to large-scale shell model calculations and the structure of heavy-proton-rich nuclei exhibit a number of interesting structural phenomena. The recoil decay tagging technique, which provides an extremely clean method for channel selection, is the key to the investigation of heavy nuclei near \(N=126\). Here we report on results of an experiment performed with the gas-filled recoil separator SASSYER which attempted, for the first time, in-beam gamma-ray spectroscopy of the nucleus \(^{217}\)Th with one neutron above the 126-neutron shell.

\(^1\)This work is supported by the U.S. Department under Grant No. DE-FG02-91ER40609.

9:30AM EH.00003 Determination of the \(^{229}\)Th isomer half-life - JASON BURKE, BREIT BECK, JOHN BECKER, MICHAEL HAYDELL, RICK NORMAN, NICHOLAS SCIELZO, STEVEN SHEETS, ERIK SWANBERG, Lawrence Livermore National Laboratory — Recently there has been renewed interest in studying the nuclear properties of the \(^{229}\)Th isomer. \(^{229}\)Th has the lowest known isomer at 7.6 eV [1]. Direct laser manipulation of the ground and first excited states could lead to the realization of the world’s first nuclear clock. To understand the linewidth of the isomeric state we are conducting experiments to directly observe the half-life of the isomer decay. We use a novel “hot-atmosphere” technique in which we catch the recoiling \(^{229}\)Th nuclei following the alpha decay of \(^{233}\)U \(\rightarrow\) \(^{229}\)Th + \(\alpha\). On average 2% of the \(^{229}\)Th populate the isomeric 3/2\(^+\) state compared to the 5/2\(^+\) ground state. Recoils are collected on various catcher plate materials, rotated in vacuum in front of an einzel lense and multi-channel plate detector. The internal conversion electrons are counted as a function of time to determine the half-life. Varying the catcher plate material we can investigate the effect that the materials have on the half-life. Determination of the half-life will provide valuable guidance to \(^{233}\)Th trapping research [2]. 1) Beck et al., PRL 98, 142501 (2007) 2) Campbell et al., PRL 102, 232004 (2009) This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

9:45AM EH.00004 Multiple Octupole-Band Structures in \(^{238}\)U\(^1\) - SHAOFEI ZHU, Argonne National Laboratory, R.V.F. JANSEN, M.P. CARPENTER, T.L. KHOO, F.G. KNODEV, T. LAURITSEN, C.J. LISTER, D. SEWERYNIAK, Argonne National Laboratory — An experiment with a \(^{207}\)Pb beam (1400 MeV) has been carried out on a thick \(^{238}\)U target at Gammasphere. The level scheme of the \(^{238}\)U has been extended significantly. The signature partner bands of the known \(K=1\) and \(K=2\) octupole bands were uncovered for the first time, in addition to another newly observed positive-parity band. This band decays to all the \(K=0, 1, 2\) octuple bands with an intensity much stronger than that observed for the deexcitation to the groundstate band. Its most important features can be related to a double octupole phonon excitation. The comparison between this band and a similar one in \(^{240}\)Pu [1] sheds more light on the recently proposed concept of octupole phonon condensation [2].

2) S. Frauendorf, Phys. Rev. C 77, 021304(R)(2008)

10:00AM EH.00005 Observation of new neutron-rich micro-second isomers among fission products of \(^{238}\)U at 345 MeV/u - DAISUKU KAMEDA, TARO NAKAO, TOSHIYUKI KUBO, TETSUYA OHNISHI, HIROYUKI TAKEDA, NAOKI FUKUDA, KENSUKE KUSAKA, ATSUSHI YOSHIDA, KOICHI YOSHIDA, MASAO OHTAKE, NAOHITO INABE, YOSHIYUKI YANAGISAWA, KANENOBU TANAKA, YASUYUKI GONO, RIKEN Nishina Center, BIGRIPS/ZERODEGREE NEW ISOTOPES COLLABORATION — In the production of the radioactive isotope (RI) beam using projectile fragment separators, \(\gamma\) rays emitted from metastable states, isomers, of the reaction products can be used as a fingerprint of the isotope that is analyzed in the separator. In the operation of the superconducting in-flight RI beam separator BigRIPS [1] at RIKEN RI Beam Factory, the detection of such \(\gamma\) rays plays important roles not only in the identification of the RI beam [2] but also in searching for new isomers, providing valuable spectroscopic information on the isotopes. In the recent new-isotope production experiment with BigRIPS using in-flight fission of \(^{235}\)MeV/nucleon \(^{238}\)U at the beam intensity around 0.3 pNA, we have observed a number of short-lived isomeric decays which include unknown decays from more than 10 isotopes, using three clover-type Ge detectors with a beam stopper of aluminum. The final result of the observations will be reported. [1] T. Kubo: Nucl. Instr. and Meth. B 204 (2003) 97. [2] T. Ohnishi et al.: J. Phys. Soc. Jap. 77 (2008) 083201.

10:15AM EH.00006 \(^{238}\)U shape isomer population with a neutron beam\(^1\) - J.A. CAGGIANO, J.J. RESSLER, P. PEPLOWSKI, Battelle/PNNL, H. WELLER, TUNL — Actinide nuclei are expected to have isomeric nuclear states that are significantly. These isomers are called shape isomers, or “fission” isomers, because of the preference of the higher-Z isomers to decay via fission. Shape isomers can decay by gamma-ray emission or fission and have been identified in some of the thorium, uranium and the trans-uranic nuclei. Semi-empirical studies of these shape isomers indicate that the lower-Z actinides such as uranium and neptunium may preferentially decay via gamma-ray emission. \(^{238}\)U and \(^{235}\)U are known examples. The \(^{238}\)U shape isomer population via neutron bombardment has been measured in the energy range of approximately 2-6 MeV and at 14.5 MeV (using a d-t neutron generator), but no measurements have been reported between 6 and 14.5 MeV. In previous measurements, fission fragments were used to characterize the population instead of the (dominant) gamma ray branch. Thus, we performed an experiment to investigate shape isomer population using a neutron beam in the energy range of 5-15 MeV to look for the characteristic shape isomer gamma-rays using the neutron irradiation facility at TUNL. Results of our measurements will be presented.

\(^1\)This work was sponsored by the U.S. Department of Energy under contract number DE-AC05-76RLO-1830.
10:30AM EH.00007 Recent Experimental Searches for Fission Isomers in U and Np Isotopes1

Fission fragments were tagged using a thin Si detector near the GAMMASPHERE/CHICO states in 07NA27344 (LLNL), and DE-AC02-05CH11231 (LBNL).  

A ∼ is a well-known mechanism to populate excited states in neutron-rich isotopes. Fission is also an effective tool for studying isomeric decays, as they are often high-purity germanium detector array surrounding the actinide target within varying time windows which were chosen based on theoretical predictions for the lifetimes of fission isomers of interest. Results from these experiments will be presented.

1This work was performed under the auspices of the U.S. Department of Energy under contract numbers DE-AC05-76RLO-1830 (PNNL), DE-AC52-07NA27344 (LLNL), and DE-AC02-05CH11231 (LBNL).

10:45AM EH.00008 Spectroscopy of Short-Lived Fission Fragment Isomers1

J.A. CAGGIANO, D.V. JORDAN, P. PEPLOWSKI, G.A. WARREN, Pacific Northwest National Laboratory, STARS+LIBERACE COLLABORATION — Fission is a well-known mechanism to populate excited states in neutron-rich isotopes. Fission is also an effective tool for studying isomeric decays, as they are often well-populated and relatively easy to detect. Isomeric states with half-lives in the ∼5 – 100 μs range were examined using 4Li-induced fission on 232Th. A 45-MeV 4Li beam from the 88-Inch Cyclotron of LBNL was alternately blocked to provide beam on/off periods to populate and observe the isomeric decays. Fission fragments were tagged using a thin Si detector near the 232Th target, and coincident gamma rays were detected using six clover and one LEPs HPGe detectors of the LiBerACE array. Several isomers were identified in the A∼95 and A∼140 mass regions, as expected. Numerous isomers were also observed near A∼120, due to the significant contribution from symmetric fission. Characteristics of the induced fission, with observed isomer populations and decays, will be discussed.

1This work was performed under the auspices of the U.S. Department of Energy under contract numbers DE-AC05-76RLO-1830 (PNNL), DE-AC52-07NA27344 (LLNL), and DE-AC02-05CH11231 (LBNL).

11:00AM EH.00009 Rotational alignments in 235Np1

AARON HURST, Lawrence Livermore National Laboratory, GAMMASPHERE COLLABORATION, CHICO COLLABORATION — The neutron/orbital alignment has been studied by exploring γ-ray transitions of yrast states in 235Np, populated utilizing the nucleon-transfer reaction 235Np(116Sn,118Sn). The experiment was carried out at Argonne National Laboratory using the GAMMASPHERE/CHICO setup. The ground-state band for this nucleus has been delineated to high spin for the first time, with the α = +1/2 and α = –1/2 signature partners reaching spin–state population levels of 49/2+ and 47/2+, respectively. Assignable assignments for these intraband transitions were established through γ-ray cross correlations between 235Np and 118Sn and events where at least three γ rays corresponding to Np-like particles were detected. These transitions reveal clear upper bounds in the aligned-angular momentum and kinematic moment of inertia plots; this observation is indicative of a strong interaction between an aligned α-band and the g-band in 235Np. The role of the νj15/2, πh9/2, and π11/2 alignment mechanisms in the deformed U–Pu region will be discussed in light of the current spectroscopic data and in the framework of the CSM.

1Supported by the DOE, LLNL Contract DE-AC52-07NA27344, ANL Contract DE-AC02-06CH11357, the AFOSR, the NSF, and the STFC of the UK.

11:15AM EH.00010 Search for a new element Z=117 among the 249Bk + 48Ca reaction products1

K. RYKACZEWSKI, ORNL; YU OGANESSIAN; S. DMITRIEV; V. UTYONKOV ET AL, JINR Dubna, J. HAMILTON, A. RAMAYYA, Vanderbit, R. HENDERSON, K. MOODY, D. SHAUGHNESSY, M. STOYER ET AL, LLNL; J. ROBERTO ET AL, ORNL; M. RYABININ ET AL, IAR Dmitrovgrad — Following irradiation of Am and Cm seed isotopes at the ORNL High Flux Isotope Reactor, the 249Bk activity (T1/2=320 d) has been separated at the ORNL Radiochemical Engineering Development Center [1] to be used as target material for a search for element Z=117 using an intense 48Ca beam from the U-400 cyclotron at JINR Dubna. The targets will be made from Bk nitrate at the IAR Dmitrovgrad. The search for the A=294 and A=293 isotopes of the new element Z=117 and their decay products, see [2], is scheduled to begin at the Dubna Gas Filled Recoil Separator at JINR Flerov Laboratory of Nuclear Reactions in August 2009. Details of the 249Bk separation and experiment will be reported. [1] C.Alexander, P.Bailey, J.Ezold, M.Ferren, C.Porter, F.Riley et al., HFIR/REDC campaign 74, 2009. [2] Yu. Oganessian, J.Phys.G 34, R164, 2007.

1Supported by the U.S. DOE through the Oak Ridge transplutonium facilities and by the LDRD projects D09-40 (ORNL) and 08-ERD-030 (LNL).

11:30AM EH.00011 Alpha-gamma coincidence spectroscopy of 259Rf using a mixed Cf target

MASATO ASAI, KAZUKI TSUKADA, YOSHIHATA KASAMATSU, TETSUYA K. SATO, ATSUSHI TOYOSHIMA, YASUO ISHI, RYUTA TAKAHASHI, YUICHIRO NAGAME, TETSURO ISHII, ICHIRO NISHINAKA, Japan Atomic Energy Agency, DAIYA KAJI, KOUJI MORIMOTO, RIKEN, YASUKI KOJIMA, Hiroshima University — Gamma rays following the α decay of 259Rf have been observed for the first time by means of α-γ coincidence spectroscopy. 259Rf was produced via the 251Cf(12C,4n)255Rf reaction at the JAEA tandem accelerator. The target consists of 63% 249Bk, 12% 250Cf, and 25% 251Cf with a thickness of 420 μg/cm². Reaction products were transported with a He/KCl aerosol jet into a rotating wheel detection system equipped with two sets of two Si detectors and two Ge detectors. Two γ lines were observed at 97.3 and 146.7 keV in coincidence with the 8770 keV α transition of 259Rf. In addition, a few γ events appeared at ∼125 keV. The energy differences and intensities of these γ transitions, which are very similar to those in the α decay of 259No, allow us to assign the 3/2+ [622] configuration to the 146.7 keV level in 255No as well as to the ground state of 259Rf. This result indicates that the order of neutron orbitals should be inverted between 255Fm and 257No in 15 isospin isotones.

11:45AM EH.00012 Decay Properties of 266Bh and 262Db Produced in the 248Cm + 23Na Reaction1

KOSUKE MORITA, KOUJI MORIMOTO, DAIYA KAJI, HIROMITSU HABA, KAZUKI TSUKADA, Japan Atomic Energy Agency, YASUYUKI FUJIMORI, FUYUKI TOKANAI, Yamagata University, HIROYUKI KOURA, KAZUKAKI TSUKADA, Japan Atomic Energy Agency, YASUYUKI FUJIMORI, FUYUKI TOKANAI, Yamagata University, HIROYUKI KOURA, KAZUKAKI TSUKADA, Japan Atomic Energy Agency, YASUYUKI FUJIMORI, FUYUKI TOKANAI, Yamagata University, YUKIKO KOMORI, KAZUKI TSUKADA, Osaka University, AKIRA OZAWA, University of Tsukuba, TAKAYUKI YAMAGUCHI, Saitama University — Decay properties of an isotope 266Bh and its daughter nucleus 262Db produced by the 248Cm(21Na, 5 n) reaction were studied by using a gas-filled recoil separator coupled with a position-sensitive semiconductor detector. 266Bh was clearly identified from the correlation of the known nuclide, 262Db. The obtained decay properties of 266Bh and 262Db are consistent with those observed in the 278Ni, 152Cu which provided further confirmation of the discovery of 278Ni.

1This research was partly supported by Grant-in-Aid for Specially Promoted Research, 19002005, from the Ministry of Education, Culture, Sports, Science and Technology, Japan.
A preliminary analysis and study of detector performance will be presented. The neutrino-nucleus interaction. The experiment uses a fully active scintillation detector to allow full event reconstruction, using 4He, C, Fe, and Pb targets to measure sin$^2$2$\theta_{13}$, explore systematics, and uncertainties in the reactor antineutrino flux. The Daya Bay experiment is a next-generation reactor experiment under construction at Daya Bay, China. Using $\nu_\mu$ appearance analysis results, we will measure the neutrino mixing angle $\theta_{13}$ with a sensitivity of 0.01 at 90% C.L. The discovery of non-zero $\sin^2 2\theta_{13}$ belongs to the Chooz experiment conducted over 10 years ago in French Ardennes. Described in this talk, is another experiment, Double Chooz, that is being prepared at the same site. The Double Chooz experiment offers several fundamental improvements and is aiming to surpass the current limit by an order of magnitude ($\sim 10^{9}$) in the near future.
A phenomenological study of photon production in low energy neutrino nucleon scattering. JAMES JENKINS, Los Alamos National Laboratory. — Low energy photon production is an important background to many current and future precision neutrino experiments. I present a phenomenological study of t-channel radiative corrections to neutral current neutrino nucleus scattering. After introducing the relevant processes and phenomenological coupling constants, I will explore the derived energy and angular distributions as well as total cross section predictions along with their estimated uncertainties. This is supplemented throughout with comments on possible experimental signatures and implications. I conclude with a general discussion of the analysis in the context of complimentary methodologies.

11:15AM EJ.00010 Short Baseline Neutrino Oscillations. GEOFFREY MILLS, Los Alamos National Laboratory, MINIBOONE COLLABORATION. — The status and future of short baseline neutrino oscillation experiments will be discussed. LSND and MiniBooNE both have significant deviations from expected events rates in anti-electron and electron neutrinos respectively. Because both were single detector experiments they were unable to distinguish between a neutrino oscillation and an oscillation signal. This paper explores possible future experiments which could determine whether or not the observed event excesses are due to an oscillation phenomenon.

Friday, October 16, 2009 9:00AM - 12:00PM
Session EK Mini-Symposium on Probing Fundamental Symmetries with Nuclei, Neutrons, Muons, and Atoms III. Queens 5

9:00AM EK.00001 Testing the CPT symmetry using slow antiprotons. RYUGO HAYANO, The University of Tokyo. — In this “antimatter” overview talk, I will cover the following topics: (1) Why antimatter experiments are important? (2) CERN’s antiproton decelerator (AD), and the goals of the major experiments in the AD hall. (3) Antiprotonic helium laser spectroscopy pursued by the ASACUSA collaboration. In a series of measurements, the antiproton- to-electron mass ratio was determined to the level of $2 \times 10^{-9}$. In addition to being one of the most stringent CPT-symmetry tests, the antiproton-helium results now contribute to the CODATA recommended values of the fundamental physical constants. (4) Production and detection of antihydrogen by ATHENA, ATRAP and ALPHA collaborations. For example, in ATRAP (in 2002), some 100 antihydrogen atoms per second were produced by mixing $10^9$ positrons with $10^8$ antiprotons in a “nested” Penning trap. The next step is to confine them in a magnetic trap, but despite more than 5 years of hard work, antihydrogen trapping has not yet been successful. I will discuss why this is difficult, based on a recent re-analysis of the ATHENA data. (5) Production of ultra low energy antiprotons in ASACUSA, and future possibilities with the ELENA (extremely low energy antiproton ring).

11:00AM EJ.00009 A phenomenological study of photon production in low energy neutrino nucleon scattering. JAMES JENKINS, Los Alamos National Laboratory. — Low energy photon production is an important background to many current and future precision neutrino experiments. I present a phenomenological study of t-channel radiative corrections to neutral current neutrino nucleus scattering. After introducing the relevant processes and phenomenological coupling constants, I will explore the derived energy and angular distributions as well as total cross section predictions along with their estimated uncertainties. This is supplemented throughout with comments on possible experimental signatures and implications. I conclude with a general discussion of the analysis in the context of complimentary methodologies.

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10:30AM EK.00006 Measurement of Systematic Error Effects for a Sensitive Storage Ring EDM Polarimeter

ASTRID IMIG, BNL, EDWARD STEPHENSON, Indiana University, STORAGE RING EDM COLLABORATION — The Storage Ring EDM Collaboration was using the Cooler Synchrotron (COSY) and the EDDA detector at the Forschungszentrum Jülich to explore systematic errors in very sensitive storage-ring polarization measurements. Polarized deuterons of 235 MeV were used. The analyzer target was a block of 17 mm thick carbon placed close to the beam so that white noise applied to upstream electrostatic plates increases the vertical phase space of the beam, allowing deuterons to strike the front face of the block. For a detector acceptance that covers laboratory angles larger than 9°, the efficiency for particles to scatter into the polarimeter detectors was about 0.1%. Various measurements were made of the sensitivity of the polarization measurement to beam position and angle. Both vector and tensor asymmetries were measured using beams with both vector and tensor polarization. Effects were seen that depend upon both the beam geometry and the data rate in the detectors.

1Supported by the DOE.

10:45AM EK.00007 Modeling Systematic Error Effects for a Sensitive Storage Ring EDM Polarimeter

EDWARD STEPHENSON, Indiana University, ASTRID IMIG, BNL, STORAGE RING EDM COLLABORATION — The Storage Ring EDM Collaboration has obtained a set of measurements detailing the sensitivity of a storage ring polarimeter for deuterons to small geometrical and rate changes. Various schemes, such as the calculation of the cross ratio [1], can cancel effects due to detector acceptance differences and luminosity differences for states of opposite polarization. Such schemes fail at second-order in the errors, becoming sensitive to geometrical changes, polarization magnitude differences between opposite polarization states, and changes to the detector response with changing data rates. An expansion of the polarimeter response in a Taylor series based on small errors about the polarimeter operating point can parametrize such effects, primarily in terms of the logarithmic derivatives of the cross section and analyzing power. A comparison will be made to measurements obtained with the EDDA detector at COSY-Jülich.


1Supported by NSF PHY-0758018.

11:00AM EK.00008 Development of Rb atomic magnetometer for EDM experiment with 129Xe spin maser

AKIHIRO YOSHIMI, RIKEN Nishina Center, KOICHIRO ASAHI, TAKESHI INOUE, MAKOTO TSUCHIYA, MAKOTO UCHIDA, TAKESHI FURUKAWA, Tokyo Institute of Technology — We have been investigating the frequency stability of the low-frequency nuclear spin maser with 129Xe aiming at EDM (permanent Electric Dipole Moment) experiment. One of the main sources for this frequency instability comes from the field fluctuation of the applied static magnetic field in a relatively long time scale. The present stability 30 mG of the applied field B0 = 30 mG in a time scale of 108 s should be suppressed in order to perform EDM experiment. We have been preparing for introduction of magnetometer to stabilize the magnet current to produce the B0 field. This magnetometer utilizes NMOE (Nonlinear Magneto Optical Effect) in Rb atom. The expected sensitivity of this type of magnetometer achieves the order of pG. We will report on systematic measurement of NMOE in Rb atom with different type of Rb cells using a tunable external-cavity diode laser, and on present status for the development of this type of magnetometer.

11:15AM EK.00009 A 129Xe active spin maser with digitalized feedback

TAKESHI INOUE, Tokyo Institute of Technology, AKIHIRO YOSHIMI, RIKEN, MAKOTO UCHIDA, TAKESHI FURUKAWA, NAOTO HATAKEYAMA, MASATO TSUCHIYA, HIRONORI HAYASHI, KOICHIRO ASAHI, Tokyo Institute of Technology — Observation of non-zero value for an electric dipole moment (EDM) will imply the existence of new physics. This is where our active spin maser comes in. An active spin maser we are developing is a scheme in which the spin precession is maintained by applying the feedback field externally generated according to an optically detected spin precession signal. By using this scheme, the frequency precision of 9.3 nHz has been obtained for a measurement time of 30,000 s duration. We report on recent construction of a renewed Maser setup which employs a computer-based digitalized feedback system.

1This work was supported by the Grant-in-Aid for Scientific Research (No. 21244029) by MEXT, Japan. One of the authors (T.I.) acknowledges the support from the JSPS.

11:30AM EK.00010 Search for Dark Matter Axion with Rydberg Atoms

KENICHI IMAI, T. ARAI, A. FUKUDA, Kyoto Univ., H. FUNAHASHI, Osaka Electric Communication Univ., S. IKEDA, Kyoto Univ., Y. KIDO, Ritsumeikan Univ., A. MATSUBARA, Kyoto Univ., S. MATSUKI, Ritsumeikan Univ., T. MIZUSAKI, R. NAKANISHI, M. SAEED, A. SAWADA, K. YAMAMOTO, Kyoto Univ. — Axion is a strong candidate of the dark matter in the universe. From various astrophysical arguments, the mass of the dark matter axion is expected to be in the region from 5 micro-eV to 0.1 meV. At Kyoto, a novel single microwave photon detector (CARRACK) had been developed for the search of the dark matter axion. The axion is converted to a microwave photon in the strong magnetic field (77T) by Primakoff process in a cavity which is cooled to 10mK to avoid black-body radiation. The photon is then detected by a Rydberg atom, which is excited by absorbing the photon and then selectively ionized. After the extensive pioneering studies of the CARRACK detector, it was recently moved to a new laboratory and New-CARRACK collaboration was formed. In the previous work by using Rb Rydberg atoms, a stray electric field of an order of mV/cm limited the overall sensitivity of the detector because of its large Stark effect. The New CARRACK utilizes Potassium as Rydberg atom which is estimated to be much less sensitive to a stray electric field. We describe the New CARRACK detector and its sensitivity for the dark matter axion based on our spectroscopic measurements of Potassium Rydberg atoms.

11:45AM EK.00011 Depleted Argon for Large Scale Dark Matter Detectors

JASON SPAANS, DONG-MING MEI, YONGCHEN SUN, CHRISTINA KELLER, University of South Dakota — Our project aims to provide argon depleted of 39Ar by utilizing established thermal diffusion methods for isotopic separation. The depleted argon can then be used as a target material for next generation large scale dark matter detectors. Thermal diffusion exploits an established temperature gradient to produce a concentration gradient along the length of a vertical column. In this concentration gradient, the heavier isotopes accumulate at the bottom end of the column and the lighter isotopes at the top. We have built a thermal diffusion system that consists of a copper column containing a tungsten wire which is heated to 1200 K. The copper column is surrounded by a water bath which is maintained at a temperature of 300 K, thus establishing a temperature gradient between the copper column and the tungsten wire. We expect to deplete the 39Ar isotope by a factor of 10 with the current design, with the ultimate goal of a depletion factor of 100. The preliminary results of this effort will be reported utilizing the more abundant isotope 36Ar.

2We would like to thank the South Dakota Board of Regents, the USD Office of Research, and NASA for their contributions.

Friday, October 16, 2009 9:00AM - 12:00PM
Session EL Nuclear Structure IV Queens 6
9:00AM EL.00001 ABSTRACT WITHDRAWN

9:15AM EL.00002 Excitations of 4He induced by electro-weak interactions, WATARU HORIUCHI, YA-SUYUKI SUZUKI, Niigata University, TORU SATO, Osaka University — 4He is the lightest closed shell nucleus which has several excited states above the excitation energy of 20 MeV. We have recently reported that all the observed levels below 26 MeV are well reproduced in a full four-body calculation using realistic interactions (Phys. Rev. C 78, 034305 (2008)). It is very interesting to extend this approach in order to study some excitations in 4He. In the energy region around 26 MeV, photoabsorption reaction occurs mainly through the electric dipole transition. The current experimental situation is controversial. Some experiments show different cross sections. Because there are only few theoretical studies on the dipole strength starting from a realistic interaction, further theoretical study may help clarify the situation. A study of neutrino-nucleus reaction is important to the scenario of a supernova explosion. In the final stage of a core collapse supernova, 4He is exposed to intense flux of neutrino. The ν→4He reaction is expected to play a significant role, and the reaction rate is proportional to the weak responses, for example, due to Gamow-Teller, spin-dipole, etc. operators. In this contribution, we will discuss electro-weak responses from the ground state of 4He to its continuum states by performing a full four-body calculation using realistic interactions. The photo-absorption and ν→4He reaction cross sections are discussed.

9:30AM EL.00003 Resonances of He isotopes using complex scaling method, TAKAYUKI MYO, Osaka Institute of Technology, RYOSUKE ANDO, KIYOSHI KATO, Hokkaido University — We investigate the properties of resonances of He isotopes, in particular, 6He, 7He and 8He. We describe the He isotopes with the cluster model of 4He+n+n+n+n. The many-body resonances (for example, five-body resonances of 8He) and non-resonant states are described within the correct boundary condition using the complex scaling method. We discuss and predict the energy spectra and decay widths of resonances of He isotopes. We also investigate the characteristics of the structures of each resonances, such as the spectroscopic factors, configuration mixing. In 6He, we derive the spectroscopic factors of 4He+n component of the obtained resonances, and also evaluate the corresponding strength functions of one-neutron removal reaction into 6He. It is found that the 6He(2+) resonance gives the dominant contribution in the strength. Non-resonant contributions of 4He+n and 4He+n+n are very small.

9:45AM EL.00004 Structure of the neutron-rich isotope 13B with N = 8 studied via lifetime measurements with low-energy fusion reactions, HIRONORI IWASAKI, ALFRED DEWALD, CHRISTOPH FRANSEN, ADRIAN GELBERG, MATTHIAS HACKSTEIN, JAN JOLIE, THOMAS PISSULLA, WOLFRAM ROTHER, KARL-OSKAR ZELL, IKP, University of Cologne, Germany, PAVEL PETKOV, Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences, 1784 Sofia, Bulgaria — We report recent experimental studies on the structure of the neutron-rich isotope 13B with N = 8 performed at the FN Tandem facility of the University of Cologne [1]. The lifetime measurements of the excited states in 13B were performed by the Doppler-shift attenuation method with the T(Li3Li)p13B reaction at a beam energy of 5.4 MeV. To select the reaction channel unambigiously, and hence reduce the background considerably, the particle-γ coincidence was employed. An anomalously long mean lifetime of 1.3(3) ps was found for the excited state at 3.53 MeV in 13B. The hindered transition strengths between the ground and 3.53-MeV states clearly indicate significant intruder configurations for the excited state. The data are well explained by recent shell model calculations which suggest J° = 3/2− for the 3.53-MeV state with the dominant intruder (π2s2π) configuration, pointing to the fading effects of the N = 8 shell closure. The occurrence of the intruder configurations in the N = 8 isotones will be discussed.

9:45AM EL.00005 Proportionality between (t,3He) reaction differential cross sections and Gamow-Teller strengths,1 C. Excited states in 4He induced by electro-weak interactions, 2009. 

10:00AM EL.00005 Proportionality between (t,3He) reaction differential cross sections and Gamow-Teller strengths,1 GEORGE PERDIKAKIS, Michigan State University, (T,3He) COLLABORATION AT NSCL, MICHIGAN STATE UNIVERSITY COLLABORATION — The so-called unit cross section describing the proportionality between differential cross sections and Gamow-Teller transition strengths is studied for the case of the (t,4He) charge-exchange reaction. Experimental data for H, and 12,13C targets taken at 115 AMeV are complimented by existing data for 4He, 6Li, and 26Mg. The (t,4He) results are compared with results for the (4He,t) reaction at 140 AMeV and for targets with 12A/120. Fairly consistent results for the unit cross section are found in the overlapping mass region. The (t,3He) and (4He,t) data sets are combined and used for a systematic study of the parameters that describe the unit cross section in the eikonol approximation.

10:15AM EL.00006 Recoil Distance Method Lifetime Measurement of the First 2+ State in 18C1, PHILIP J. VOSS, T. BAUGHER, D. BAZIN, H. CRAWFORD, S. MC DANIEL, D. MILLER, A. RATKIEWICZ, K. WALSH, D. WEISSHAAR, MSU/NSCL, K. STAROSTA, Simon Fraser University, A. DEWALD, W. ROTHER, IKP Cologne — Electromagnetic transition rates can be directly obtained from lifetime measurements and shed light on the evolution of nuclear structure as one proceeds further from the valley of stability. Recoil Distance Method lifetime measurements have been successfully carried out at NSCL through the coupling of the Segmented Germanium Array and the NSCL/Köln plunger [1]. During a recent NSCL campaign, the collectivity and shape evolution of neutron-rich carbon isotopes were studied by lifetime measurements of the 2+ → 0+ transition in 16,18,20C. Excited states in 16C were populated by a one-proton knockout at the target position of the 5800 spectograph. Particle-gated gamma-ray spectra were collected at five plunger target-degrader separation distances. The results of the lifetime measurement for 16C will be presented.

1This work was supported by the US NSF (PHY-0216783 (JINA) & PHY-0606007).

10:30AM EL.00007 Short-Range Correlations from 12C(e,e'n)/2H(e,e'n), RAMESH SUBEDI, University of Virginia, E01015 AND HALL A COLLABORATION — The data analysis of the semi-inclusive channel of one of the kinematics of the Short-Range Correlations experiment E01-015 in Hall A at Jefferson Laboratory is in progress. The kinematics involved has a beam energy of 4.6 GeV, an energy transfer of 0.9 GeV, a Q^2 of 2 GeV^2/c^2, and a wide x_b coverage around 1.2. In this analysis we are looking at backward going neutrons for each detected electron. The reactions being analyzed are 12C(e,e'n) and 2H(e,e'n) in order to calculate the cross-section ratio 12C(e,e'n)/2H(e,e'n). We compare this ratio with the result of inclusive reaction’s ratio 12C(e,e')/2H(e,e'). We see a clear dip at x_b =1 and a flat region at x_b >1.4 for the inclusive data. Due to the scarcity of semi-inclusive data in the region of x_b >1.3, we cannot see the flat region, but the shape of available data in the two cases appear to be matching. The flat region is believed to be due to the two nucleon short-range correlations. The method of analysis and the recent results will be presented.

1This work is supported in part by US NSF Grant No. PHY06-06007.
10:45AM EL.00008 Algebraic N-α model (applications for 12C), TOORU YOSHIDA, CNS, University of Tokyo, KIYOSHI KATO, Hokkaido University — Algebraic nuclear models have successively applied for various mass regions. Its semi-microscopic treatment has been applied for light nuclei like 12C where the Pauli principle between each cluster is completely taken into account. However, the method does not have been used directly for decay information. Therefore, we extend this algebraic method and investigate the structure of 12C. We use the model space expanded by Pauli allowed states (PAS) [H. Horiuchi, PTP58 204 (1977)] with orthogonality condition model (OCM). One advantage of this method is that we can generate infinite number of PAS by operating $\hat{S}^{2m}\hat{R}$ generators [K. Kato et al., PTP76 75 (1985)] from its band head state. Therefore, the group theoretical relation for each state becomes clear. We can see that the large electromagnetic transition strength appears in the same band states. This affects total expectation values, which we calculated by using truncated model space of SUS. In order to investigate their decay information, we use complex scaling method (CSM). Firstly, we check consistency of PAS method and CSM for alpha-alpha cluster system. As a next step, we combine this PAS method with CSM for 12C.

11:00AM EL.00009 Three α linear-chain structure in 13C, NAOYA FURUTACHI, MASAKI KIMURA, Hokkaido University — The realization of linear-chain configurations of α clusters has been a long-standing subject of nuclear structure study. Recently, the linear-chain structure has been discussed in $N > Z$ C isotopes, and candidates for that structure have been suggested in 12C based on the systematic search of multi-particle transfer reactions. In the past, the linear-chain structure was suggested for 0$^+_1$ state of 12C, which is now recognized as an α-condensed state. It is interesting to investigate how the additional one neutron change this structure and other cluster states in 12C, and whether the linear-chain structure is stabilized or not. We have investigated the structure of 13C focusing on the linear-chain structure of 3α cluster by using a microscopic 3α+n model. We describe the 3α wave function by using the generator coordinate method (GCM), and the neutron wave function is optimized for each basis of GCM. In this talk, structures of several rotational bands obtained in this calculation are analyzed, and the realization of the linear-chain structure is discussed.

11:15AM EL.00010 10Be+ α correlation in 14C, TADAHIRO SUHARA, Department of Physics, Kyoto University, YOSHIKO KANADA-ENYO, Yukawa Institute for Theoretical Physics, Kyoto University — We will report structure of excited states in 14C while paying attention to 10Be+α correlation. In the stable carbon nucleus, 12C, it is already known that various 3α cluster structures appear in the excited states. It is natural to expect that rich phenomena may appear also in 12C which is an unstable neutron-rich nucleus. Many experiments indicate that there are various clustering structures in excited states of 12C. In these structures, a 10Be+α structure attracts much interest in association with a linear-chain structure of 3α that has been studied for many years. For the systematic study of 14C, we adopted AMD(Antisymmetrized Molecular Dynamics) which has proved to be a powerful approach to describe various structures. The configurations were superposed in the GCM framework using $(\beta, \gamma)$ as the generator coordinates. As the results, we obtained various states which have characteristic structures such as a triaxial structure, an equilateral-triangular structure and a linear-chain structure. We examined the possibility of the existence of 10Be+α correlation in these states. In linear-chain states, it was suggested that strong 10Be+α correlation exists, and this correlation plays an important role to stabilize the linear-chain structure.

11:30AM EL.00011 Lifetime measurements in 16C and 20C, MARINA PETRI, Lawrence Berkeley National Laboratory — The search for new phenomena and structure effects due to the influence of large isospin, weak nucleon binding, and coupling to the continuum is of great interest in nuclear structure physics. We present data from a direct lifetime measurement of the 2$^+$ states in 16C and 20C, which have been cited as examples of “neutron decoupling.” The deduced B(E2:2$^+ \rightarrow 0^+$) values are compared to shell model calculations. Neutron-rich carbon nuclei are one of the few isotopes experimentally accessible up to the neutron drip-line and provide an opportunity to follow changes in structure from stability to the drip-line. The experiments were carried out at the NSCL using the recoil distance method. This work is a collaboration between LBNL, MSU/NSCL, and Cologne.

11:45AM EL.00012 Search for Alpha particle Condensation in 16O, TOSHIYUKI TAKAHASHI, CYRIC, Tohoku University, MASATOSHI ITOH, HIDEOMI YOSHIDA, YASUHIRO SAKEMI, CYRIC, NAOYA SUGIMOTO, TOTUYA NAGANO, AKIHITO OIKAWA, TOMOHISA HAYAMIZU, CYRIC, Tohoku University — Recently, Tohsaki et al proposed the α particles condensed state existed in the vicinity of the threshold energy that decay into 3- and 4-α particles in the 12C and 16O nuclei. The energy state of the 4-α particles condensation has not been specified yet in 16O though it is considered that the second 0$^+$ state (7.65MeV) in 12C is the 3-α particles condensed one theoretically. To verify the existence of the α condensation in 16O, we performed the experiment on the 12C(16O,$^{12}$C+$^{12}$C) reaction. The probability of the 4-α particles condensed state of 16O decays to 3-α condensed one of 12C and an α particle is large. Therefore, we investigate the excited state in 16O by obtaining the branching ratio of each decay channel of 16O$^*$→12C(0$^+_2$)+2α, 16O$^*$→12C(2$^+_1$)+2α, 16O$^*$→12C(3$^+_1$)+α. In this talk, we will report on result of the experiment and the Monte Carlo simulation of 16O for excited state of 15.1MeV which was one of candidates for the 4-α condensation.

Friday, October 16, 2009 9:00AM - 12:15PM — Session EM Nuclear Theory III — Kings 1

9:00AM EM.00001 Renormalization of the leading-order chiral nucleon-nucleon interaction and bulk properties of nuclear matter, RUPRECHT MACHELDEIT, PEI LIU, University of Idaho — It is well known [1] that the nucleon-nucleon (NN) interaction at leading order (LO) of chiral perturbation theory can be renormalized (i.e., cutoff independence can be achieved) when certain counter terms of next-to-leading (NLO) and next-to-next-to-leading order (NNLO) are promoted to LO. It is then of interest to investigate if also the predictions for few- and many-nucleons observables turn out to be cutoff independent when calculated from the renormalized LO NN interaction. As a first test, we have calculated the binding energy per nucleon in nuclear matter as a function of density and find saturation and cutoff independence of the results.


9:15AM EM.00002 Our recent progress in microscopic calculations of the equation of state1, FRANCESCA SAMMARRUCA, PEI LIU, University of Idaho — We are involved with a broad spectrum of studies aimed at improving our knowledge of nuclear matter, including its states far from equilibrium. Our “ab initio” approach is microscopic and relativistic, with the calculated nuclear matter properties being derived self-consistently from realistic nuclear forces. The isovector features of the equation of state, in particular, are still poorly understood. They have relevance for the physics of rare, short-lived nuclei and, on a dramatically different scale, the physics of neutron stars. In both cases, the crucial role is played by the symmetry energy, which determines the formation of the neutron skin in neutron-rich nuclei and the radius of a neutron star, a system 18 orders of magnitudes larger and 55 orders of magnitude heavier. We will report on our progress, which includes predictions of the energy per particle in hyperon matter and, most recently, the effect of temperature on the single-particle properties.

1Support from the U.S. Department of Energy is acknowledged.
9:30AM EM.00003 Neutron star and β-stable EOS with Brown-Rho scaled low-momentum NN interactions, HUAN DONG, THOMAS KUO, Stony Brook University, RUPRECHT MACHLEIDT, University of Idaho — Neutron star properties, such as its mass, radius, and moment of inertia, are calculated by solving the Tolman-Oppenheimer-Volkov equations using the ring-diagram equation of state (EOS) obtained from realistic low-momentum NN interactions $V_{\text{low-\kappa}}$. Several NN potential models (CDBon, Argonne, Nijmegen) have been employed to calculate the ring-diagram EOS where pp/hh ring diagrams are summed to all orders. The proton fraction for a β-stable neutron star is determined from the chemical potential condition $\rho_p - \rho_e = \rho_e$. The neutron star masses and radii given by the above potentials alone both tend to be about 30% too small compared with accepted values. Our results are largely improved with the inclusion of medium corrections based on Brown-Rho scaling where the in-medium meson masses, particularly those of $\omega$, $\rho$, and $\sigma$, are slightly decreased compared with their in-vacuum values. Initial results using such medium corrected $V_{\text{low-\kappa}}$ are neutron star mass $M \sim 1.6M_{\odot}$ and radius $R \sim 8$ km. Effects from superconducting neutron EOS are discussed.

9:45AM EM.00004 Similarity renormalization group to the many-body problems, KOSHIROH TSUKIYAMA, Department of Physics, The University of Tokyo, SCOTT BOGNER, NSCL, MSU, ACHIM SCHWENK, TRIUMF — One of the major goals of nuclear structure theory is to explain many-body phenomena from nucleonic interactions. Since realistic nucleon-nucleon interactions have strong repulsion and tensor component at short distance, nuclear system is non-perturbative and even few-body problems are difficult to solve. Several methods based on renormalization group (RG) or unitary transformation can be used to treat the short-range correlation, the consequence of which nuclear many-body calculations converge rapidly. These methods, however, generate many-body forces which significantly affects the observable unless the induced forces are treated properly. To overcome this problem, one way is to keep the induced many-body forces explicitly. We propose an alternative way, In-medium similarity renormalization group (SRG), by extending the free-space SRG. We derive the flow equations for normal-ordered Hamiltonian assuming a core so that the dominant part of many-body correlations are incorporated into density dependent lower-body forces, driving the Hamiltonian more formal form for the many-body calculations. In-medium SRG provides a new systematic and non-perturbative path from nucleonic interactions to the many-body calculations. We will show the newest results of the methods.

10:00AM EM.00005 Evolution of Nuclear Many-Body Forces with the Similarity Renormalization Group¹, ERIC JURGENSON, Ohio State Univ., PETR NAVRATIL, Lawrence Livermore Natl Lab, RICHARD FURNSTAL, Ohio State Univ. — The first practical method to evolve many-body nuclear forces to softened form using the Similarity Renormalization Group (SRG) in a harmonic oscillator basis is demonstrated. When applied to 4He calculations, the two- and three-body oscillator matrix elements yield rapid convergence of the ground-state energy with a small net contribution of the induced four-body force.

¹Supported by NSF Grant No. PHY-0653312, UNEDF SciDAC Collaboration under DOE Grant DE-FC02-07ER41457, and LLNL under Contract DE-AC52-07NA27344.

10:15AM EM.00006 Schrodinger’s Wave Structure of Matter (WSM), MILO WOLFF, MIT retired, GEOFF HASELhurst, SpaceAndMotion.com — The puzzling electron is due to the belief that it is a discrete particle. Einstein deduced this structure was impossible since Nature does not allow the discrete particle. Clifford (1876) rejected discrete matter and suggested structures in ‘space’. Schrödinger, (1937) also eliminated discrete particles writing: What we observe as material bodies and forces are nothing but shapes and variations in the structure of space. Particles are just schaumkommnen (appearances). He rejected wave-particle duality. Schrödinger’s concept was developed by Milo Wolff and Geoff Haselhurst (SpaceAndMotion.com) using the Scalar Wave Equation to find spherical wave solutions in a 3D quantum space. This WSM, the origin of all the Natural Laws, contains all the electron’s properties including the Schrödinger Equation. The origin of Newton’s Law $F=ma$ is no longer a puzzle; It originates from Mach’s principle (1883) that depends on the space medium and the WSM. Carver Mead (1999) at CalTech used the WSM to design Intel micro-chips correcting errors of Maxwell’s magnetic Equations. Applications of the WSM also describe matter at molecular dimensions: alloys, catalysts, biology and medicine, molecular computers and memories. See “Schrödinger’s Universe” - at Amazon.com

10:30AM EM.00007 Neutron-deuteron scattering in configuration space II¹, VLADIMIR SUSLOV, MIKHAIL BRAUN, North Carolina Central University, IVO SHLAUS, Duke University, IGOR FILIHKIN, BRANISLAV VLAVHOVIC, North Carolina Central University — A new computational method to solve the configuration-space Faddeev equations for the breakup scattering problem [1] has been applied to study the elastic $nd$ scattering above the deuteron threshold. To perform numerical calculations for arbitrary nuclear potentials and with arbitrary numbers of partial waves retained, we use the approach proposed in [2]. Calculations of the elastic differential cross section, neutron and deuteron analyzing powers for lab energy 14.1 MeV were performed with the charge independent AV14 potential. To compute the observables, the maximum value for the total momentum $j$ of a nucleon pair was chosen equal to 3 and all values of the conserved total three-nucleon angular momentum up to 13/2 with both signs of parity were taken into account. The results are compared with those of the Bochum group.


¹This work is supported by NSF CREST award, HDR-0833184.

10:45AM EM.00008 Three-nucleon forces and neutron-rich nuclei¹, ACHIM SCHWENK, TRIUMF — I will discuss the role of three-nucleon forces on neutron-rich nuclei, in particular for the evolution to and the location of the neutron dripline, as well as their impact on neutron-rich matter and the symmetry energy.

¹This work is supported in part by NSERC and TRIUMF receives funding via a contribution through NRC Canada.

11:00AM EM.00009 The general relativistic harmonic oscillator¹, JOSEPH GINOCCHIO, Los Alamos National Laboratory — The relativistic harmonic oscillator has been solved analytically in two limits. One is the spin limit for which the scalar potential, $V_S$, is equal to the vector potential, $V_V$, plus a constant, and the other is the pseudospin limit in which the scalar potential is equal in magnitude but opposite in sign to the vector potential plus a constant [1,2]. Like the non-relativistic harmonic oscillator, each of these limits has a higher symmetry. For example, for the spherically symmetric oscillator, these limits have a SU(3) and pseudo-SU(3) symmetry respectively [3]. Atomic nuclei are close to the pseudospin limit. However, the analytic solutions in this limit are those of the Dirac “negative” energy states. In the exact pseudospin limit there are no bound Dirac valence states. For this reason we have started to investigate the general spherically symmetric relativistic harmonic oscillator for which $V_S = \frac{2}{5} \omega^2 r^2$ and $V_V = \frac{2}{5} \omega^2 r^2$. We report on the progress made in solving analytically the Dirac Hamiltonian with these potentials.


¹This work was supported by the US Department of Energy under Contract No. W-7405-ENG-36.
We introduce the finite amplitude method (FAM) for the QRPA. This method allows to build fully self consistent QRPA codes; since the FAM method is not limited to spherically symmetric systems it is also useful in the solution of the deformed QRPA problem where the construction of the matrices is a difficult task in itself. All that is needed to write a QRPA code with the FAM method is a HFB code: the residual fields \(\delta h\) limited to spherically symmetric systems is helpful in the solution of the deformed QRPA problem where the construction of the matrices is a difficult task in itself. From the oscillator Hamiltonian without spin-orbit interaction, and suppose that three oscillator frequencies have an integral rational ratio \(a : b : c\). In order to construct a SU(3)-invariant expression, we express the harmonic oscillator boson operator \(c_k\) (\(k = x, y, z\)) in terms of a \(m\)-fold product of new bosons \(s_m\) \((m = a, b, c)\), by requiring \(c_k^\dagger = \prod_{m=1}^3 s_m^{1/2}\). Applying the analogy of Elliott’s group operators, we obtain a similar set of group operators from new bosons. Together with Casimir operator and two operators which make-up a resultant force function, when more than one force vector component simultaneously do work on an object or particle, along the same axis, using the transform function, and new additional theorem.

11:45AM EM.00012 A method to compute the QRPA
PAOLO AVOGADRO, TAKASHI NAKATSUKASA, RIKEN — We introduce the finite amplitude method (FAM) for the QRPA. This method allows to build fully self consistent QRPA codes; since the FAM method is not limited to spherically symmetric systems it is helpful in the solution of the deformed QRPA problem where the construction of the matrices is a difficult task in itself. All that is needed to write a QRPA code with the FAM method is a HFB code: the residual fields \(\delta h\) limited to spherically symmetric systems is helpful in the solution of the deformed QRPA problem where the construction of the matrices is a difficult task in itself. From the oscillator Hamiltonian without spin-orbit interaction, and suppose that three oscillator frequencies have an integral rational ratio \(a : b : c\). In order to construct a SU(3)-invariant expression, we express the harmonic oscillator boson operator \(c_k\) (\(k = x, y, z\)) in terms of a \(m\)-fold product of new bosons \(s_m\) \((m = a, b, c)\), by requiring \(c_k^\dagger = \prod_{m=1}^3 s_m^{1/2}\). Applying the analogy of Elliott’s group operators, we obtain a similar set of group operators from new bosons. Together with Casimir operator and two operators which make-up a resultant force function, when more than one force vector component simultaneously do work on an object or particle, along the same axis, using the transform function, and new additional theorem.

12:00PM EM.00013 The covering SU(3) group over anisotropic harmonic oscillators
KAZUKO SUGAWARA-TANABE, Otsuma Women’s University, Tama, Tokyo 206-8540, KOSAI TANABE, RIKEN, Nishina Center, Saitama 351-0198, AKITO ARIMA, Science Museum, Japan Science Foundation, Tokyo 102-0091, BRUNO GRUBER, Southern Illinois University, Carbondale, IL 62901 — We propose new non-linear boson transformation by which all the anisotropic oscillator states can be embedded in the SU(3) bases. We start from the oscillator Hamiltonian without spin-orbit interaction, and suppose that three oscillator frequencies have an integral rational ratio \(a : b : c\). In order to construct a SU(3)-invariant expression, we express the harmonic oscillator boson operator \(c_k\) (\(k = x, y, z\)) in terms of a \(m\)-fold product of new bosons \(s_m\) \((m = a, b, c)\), by requiring \(c_k^\dagger = \prod_{m=1}^3 s_m^{1/2}\). Applying the analogy of Elliott’s group operators, we obtain a similar set of group operators from new bosons \(s_k\), \(s_0\) and \(s_1\), i.e., \(Q_k = q_0 = \pm 1\) and \(\pm 2\), and \(\ell_k\) for \(k = a, b, c\). Then, the commutation relations among these 8 operators are closed, and they commute with \(H\). Together with Casimir operator and two operators which have diagonal form in number operators, i.e., \(Q_0\) and \(Q_2 + Q_2\), we can classify the single-particle states in \(N_{ab}\), and find the new magic numbers for the triaxially deformed field.

1:00PM - 1:00PM —
Session GB Conference Experience for Undergraduates Poster Session (1:00-3:00 PM)
Grand Promenade

GB.00001 Rate Capability of Doped Linseed Oil coated Bakelite RPCs
ZARAH AHMAD, Southeast Missouri State University, PHENIX COLLABORATION, UNIVERSITY OF ILLINOIS AT URBANA CHAMPAIGN TEAM — Bakelite Resistive Plate Chambers (RPCs) are used as muon trigger detectors for the PHENIX experiment at RHIC and the CMS and ATLAS experiments at LHC. These muon trigger RPCs are gas detectors in which high voltage is applied across two Bakelite plates spaced 2 mm apart. The detector gas is 95% R134a, 4.5% isobutene and 0.5% SF6. The rate capability of Bakelite RPCs is limited by the time it takes to re-store the initial charge distribution on the dielectric plates after the ionization charge from an avalanche has been collected on the plates. The rate capability depends on the bulk and surface resistivity of the Bakelite plates and its coating. We have doped the linseed oil coating used in the PHENIX RPCs to lower the surface resistivity of the coated Bakelite plate. The rate capability of the modified RPCs was studied using measurements of the RPC detection efficiencies for cosmic rays in presence of high rate backgrounds from two Fe55 radioactive sources. We will present methods for the production of doped linseed oil coats and discuss status and results from rate capability measurements.

GB.00002 The production and Testing of High Voltage Cables for Resistive Plate Chambers in the PHENIX Detector
ETHAN ALLEN — The Pioneering High Energy Nuclear Interaction eXperiment (PHENIX) is located on the Relativistic Heavy Ion Collider (RHIC) ring at Brookhaven National Laboratory. One of the primary goals of PHENIX is to study the spin structure of the proton. The creation of a fast muon trigger will allow scientists to measure high momentum muons at forward rapidity to sample the rare leptons from W decay in nuclear matter. We add the intermediate attractive and repulsive forces by introducing the \(\sigma\) which is not the chiral partner of the \(\pi\) meson, and the \(\omega\) mesons. We determine the model parameters by requiring the condition at normal density. As a consequence, we find that the effect of gluon and pion exchanges provides the hyperfine splitting in the hadron spectra, and the hyperfine interaction due to the gluon exchange plays an important role in the in-medium baryon spectra. In contrast, the pion-cloud effect is relatively small. At the quark mean-field level, the \(\Lambda\) feels more attractive force than the \(\Sigma\) or \(\Xi\) in matter.

11:30AM EM.00011 Advances in Energy and Integral Area Calculations
BRETTE DELAHOUSSAYE, Los Angeles Unified School District, Calgate Software — A transform function, and new additional theorem, allows work and energy, to be calculated for any constant, or time-varying force function, in integral form, as a function of time. In addition, the work \(W = \int f(x) dx\) and the corresponding change in kinetic energy \(E\), of an object or particle, with a time-varying mass \(m(t)\), can be determined using the transform function. The individual work, and change in kinetic energy, can be calculated for the vector component(s), which make-up a resultant force function, when more than one force vector component simultaneously do work on an object or particle, along the same axis, using the transform function, and new additional theorem.

11:15AM EM.00010 Effect of Gluon and Pion Exchanges on Hyperons
TSUYOSHI MIYATSU, KOICHI SAITO, Department of Physics, Faculty of Science and Technology, Tokyo University of Science, Japan — A new version of the quark-meson coupling model, which involves not only the quark-gluon interaction but also the pion-quark coupling based on chiral symmetry, is applied to hyperons in a nuclear medium. Our aim is to study the effects of one-gluon exchange (OGE) and pion-cloud on the mass of hyperon \((\Lambda, \Sigma, \Xi)\) in a nuclear matter. To describe a nuclear matter, we add the intermediate attractive and repulsive forces by introducing the \(\sigma\) which is not the chiral partner of the \(\pi\) meson, and the \(\omega\) mesons. We determine the model parameters by requiring the condition at normal density. As a consequence, we find that the effect of gluon and pion exchanges provides the hyperfine splitting in the hadron spectra, and the hyperfine interaction due to the gluon exchange plays an important role in the in-medium baryon spectra. In contrast, the pion-cloud effect is relatively small. At the quark mean-field level, the \(\Lambda\) feels more attractive force than the \(\Sigma\) or \(\Xi\) in matter.
GB.00004 Discovery of Cadmium, Indium, and Tin Isotopes. STEPHANIE AMOS, North Georgia College and State University and NSCL/MSU, MICHAEL THOENNESSEN, NSCL/MSU — As of today, no comprehensive study has been made covering the initial observations and identifications of isotopes. A project has been undertaken at MSU to document the discovery of all the known isotopes. The criteria defining discovery of a given isotope is the publication of clear mass and element assignment in a refereed journal. Prior to the current work the documentation of the discovery of eleven elements had been completed. These elements are cerium, arsenic, gold, tungsten, krypton, silver, vanadium, einsteinium, iron, barium, and cobalt. We will present the new documentation for the cadmium, indium, and tin isotopes. Thirty-seven cadmium isotopes, thirty-eight indium isotopes, and thirty-eight tin isotopes have been discovered so far. The description for each discovered isotope includes the year of discovery, the article published on the discovery, the article’s author, the method of production, the method of identification, and any previous information concerning the isotope discovery. A summary and overview of all ~500 isotopes documented so far as a function of discovery year, method and place will also be presented.


GB.00005 Search for the single-β decay of $^{48}$Ca. HIROKI ANDO, KAZUYA TAKUBO, Department of Physics, Osaka University — Large efforts have been made to search for the single-β decay of $^{48}$Ca, for the purpose of determining its lifetime. At present we have the experimental lower limit of its lifetime; it is $T_{\beta/2} > 6.0 \times 10^{13}$ yr as the most stringent value, but is still much shorter than the theoretical estimate of $T_{\beta/2} = 7.6 \times 10^{15}$yr. We aim to satisfy the followings (1)~(3) in final phase of our experiment. (1) Enrichment of $^{48}$Sc which is a daughter nucleus of $^{48}$Ca. (2) To achieve the highest coincidence efficiency, we will use large detectors with optimum layout. (3) Background reduction by using appropriate shields and underground laboratory. We are preparing the first phase of our experiment where we will find the optimal layout of detectors and shields. We will then go to the enrichment. Presently we are searching for the optimum layout with GEANT4 simulation, considering rough experimental setup. We will use 6 Na(TI) detectors which is size of 5x5x21cm$^3$. We put these detectors close to each other to achieve 4r-detector by which 1160cm$^3$ of Ca sample can be fully covered. Then about 1000g CaCO$_3$ powder (density is roughly 1g/cm$^3$) can be put in this space. We will report the preliminary result of the first phase of our experiment and future plan.

GB.00006 Archiving Quality Control Tests in the PHENIX Resistive Plate Chamber Assembly Facility, KELLER ANDREWS, Abilene Christian University. PHENIX COLLABORATION — The PHENIX collaboration at RHIC studies polarized proton-proton collisions to better understand the spin structure of the proton. PHENIX is in the process of upgrading the muon trigger to improve our capabilities of selecting the muons from the decay of W-bosons which are produced more readily at a high transverse momentum than other muon sources. By triggering on single, high transverse momentum muons, new observations on the spin asymmetries of a proton can be obtained. The trigger upgrade will consist of four stations of Resistive Plate Chambers (RPCs), with stations on each side of the interaction region. Each RPC consists of two Bakelite gas gaps, a copper signal plane, an aluminum base, and a layer of mylar and copper. With all of these parts comes the need to archive the manufacturing and quality assurance information along with test results performed on them. This information is kept in a PostgresQL Database in the RPC factory and is maintained, modified, and read out through several PHP web pages. A new output page has been produced that will make all of this information much more accessible. This poster will focus on what data is archived, how it is stored, and how it can be easily retrieved and put to use.

GB.00007 Sarcophagus of the CMS Zero Degree Calorimeters, KYLE AXTON, MICHAEL MURRAY, University of Kansas — The Zero Degree Calorimeters of the CMS experiment at the Large Hadron Collider will become significantly radioactive after the first few proton-proton runs. The detectors sit within large copper blocks, called TANS, that also include the two beam pipes. The calorimeters must be removed during bake out of the beam pipes. To minimize the radiation received by the personal a remotely controlled crane will place the calorimeters into a sarcophagus that will shield workers from the induced radioactivity. Both the mass and size of the sarcophagus are limited by constraints of the LHC tunnel. We will describe the design, construction and use of the sarcophagus.

1University of Kansas Honors Program and the National Science Foundation Award Number: 0449913.

GB.00008 Nuclear Structure of $^{101}$Pd, N.S. BADGER, D.A. MEYER, Rhodes College. A. HEINZ, R.J. CAPERSON, B. HUBER, WNSL, Yale University. J.D. LEBLANC, Rhodes College, R. LUTTKE, WNSL, Yale University, TU Darmstadt. E.A. MCCUTCHAN, Argonne National Lab, J. QIAN, WNSL, Yale University, B. SHORAKA, WNSL, Yale University, University of Surrey, J.K. SMITH, Rhodes College, J.R. TERRY, H. AI, WNSL, Yale University, J.J. HUGON, Rhodes College, E. WILLIAMS, WNSL, Yale University — $^{101}$Pd lies in a region of nuclei where $A\approx110$ and structural changes from vibrational to rotational are significant. In order to examine the nuclear structure of $^{101}$Pd, an experiment was performed at the Wright Nuclear Structure Laboratory at Yale University using the ESTU-1 Tandem Van de Graaff Accelerator. A beam of 70 MeV $^{12}$C collided with $^{92}$Zr target nuclei to produce $^{101}$Pd via the $^{12}$C + $^{92}$Zr → $^{101}$Pd + 3n reaction. Emitted γ-rays were detected by the SPEEDY array consisting of eight Compton-suppressed HPGe clover detectors. Then, γ-γ coincidence measurements were made using RadWare to analyze the data. We were able to confirm many energy levels and observe several new ones. Also, new inter-bank connections have been discovered. The structure of $^{101}$Pd was then interpreted using the strictly empirical E-GOS (E-Gamma Over Spin) method. The E-GOS plot, created by graphing energies of γ-rays over spin versus spin, revealed a clear transition from vibrational structure to rotational structure.

GB.00009 Deconvolution of Bremmsstrahlung Spectra from Measurements, T.A. BALINT, G.P. TREES, B.A. DETWILER, J.J. CARROLL, Youngstown State University — The X-ray Effects Laboratory (XEL) at Youngstown State University primarily uses an industrial X-ray bremmstrahlung source for in-house experimentation. This source has a high photon flux, with energies emitted in a non-uniform but smooth continuous spectrum over a range that can reach a maximum of 450 keV. To quantitatively analyze the results of any irradiation producing nuclear photovoltaization, it is necessary to first accurately determine this bremmsstrahlung spectrum. This poster explores measurements of the response function for a shielded HPGe detector and how that function is used to determine the actual bremmsstrahlung spectrum incident on the detector by a numerical deconvolution.

1Supported by DTRA.

GB.00010 Partitional Clustering Algorithms for Prompt-Photon Identification in the STAR Endcap Electromagnetic Calorimeter, BENJAMIN BARBER, JASON WEBB, Valparaiso University. STAR COLLABORATION — Photon candidates are frequently identified in electromagnetic calorimeters utilizing hierarchical algorithms, whereby detector elements are clustered based upon a fixed set of clustering criteria, which a candidate cluster must satisfy to be considered. Imperfections in detector response and event-to-event fluctuations result in the rejection of true candidates. When searching for rare signals, such as prompt-photon production in pp collisions, such inefficiencies are undesirable. Partitional clustering is an alternative approach. Partitional clustering divides detector elements between a preset number of clusters based upon their distance to the cluster centers, and iterates until the position of the cluster centers converges. This approach is advantageous when $N_{clusters}$ is known. This research applies partitional clustering to the problem of $e^+e^−/\gamma$ discrimination in the STAR Endcap Electromagnetic Calorimeter (EEMC). The EEMC is a lead-scintillator sampling calorimeter, with a highly-segmented scintillator strip shower maximum detector (SMD). Partitional clustering algorithms, with $N_{clusters} = 2$, are applied to the SMD strips corresponding to large energy deposits in the EEMC. The clusters are used to calculate two-body decay kinematics. In simulation, invariant mass distributions show a good separation between prompt photons and $π^0$ background.
GB.00011 Neutron Capture Rates and the r-Process Abundance Pattern in Shocked Neutrino-Driven Winds. DANIEL BARRINGER, REBECCA SURMAN, Union College — The r-process is an important process in nucleosynthesis in which nuclei will undergo rapid neutron captures. Models of the r-process require neutron data such as neutron capture rates for thousands of individual nuclei, many of which lie far from stability. Among the potential sites for the r-process, and the one that we investigate, is the shocked neutrino-driven wind in core-collapse supernovae. Here we examine the importance of the neutron capture rates of specific, individual nuclei in the second r-process abundance peak occurring at A ∼ 130 for a range of parameterized neutrino-driven wind trajectories. Of specific interest are the nuclei whose capture rates affect the abundances of nuclei outside of the A ∼ 130 peak. We found that increasing the neutron capture rate for a number of nuclei including 131In, 132Sn, 137Sb, 137Sb, and 136Te can produce changes in the resulting abundance pattern of up to 13%.

GB.00012 Calibrating the PHENIX Muon Piston Calorimeter for the Analysis of Au+Au Collisions. JONATHAN BEN-BENJAMIN, PHENIX Collaboration — The Pioneering High Energy Nuclear Interaction eXperiment (PHENIX), located at the Relativistic Heavy Ion Collider (RHIC) ring at Brookhaven National Laboratory, is designed to examine direct probes from proton-proton and heavy ion collisions. The PHENIX Muon Piston Calorimeter (MPC) is being calibrated for a measurement of transverse energy in the forward region, 3.1 < |p| < 3.8, using RHIC Au+Au collisions at s_{NN} = 200 GeV. The MPC consists of 196 towers in the north station and 220 towers in the south. The gain of each tower will be calibrated using an iterative process based on the π^0 peak formed from the photon pairs into which they decay. This poster will focus on the methods we use for the reconstruction of π^0, such as data cuts, background generation and data isolation.

GB.00013 Unifying Inflation and Dark Energy Using an Interacting Holographic Model. ABBY BESEMER, MICHAEL BERGER, Indiana University — The universe has gone through at least two very different periods of accelerated expansion. The earliest stage was a rapid exponential expansion known as inflation while the acceleration we are experiencing at the current epoch is driven by dark energy. Because the energy scale of dark energy is approximately 27 orders of magnitude smaller than that of inflation, the relationship between these two periods of acceleration is unknown. The construction of an interaction between dark energy and matter and the holographic principle offers a possible way to unify these two eras of expansion using a model based on a simple physical principle. Here we present a possible expansion history for the universe using a model of interacting holographic dark energy.

GB.00014 Investigation of Structure of Gd and Tb Nuclei using STARS and LiBerACE. CAIN BONNIWELL, BEN PAUERSTEIN, J.M. ALLMOND, C.W. BEAUSANG — This experiment, performed at Livermore Berkeley National Lab as a collaboration of Livermore, Berkeley, and the University of Richmond, was designed to investigate the structure of gadolinium and terbium nuclei using the P + 156Gd reaction at E = 27 MeV. The experimental design included use of the STARS system for detecting charged particles as well as the LiBerACE clover array for detecting gamma rays. The master gate was set to record particle-gamma as well as gamma-gamma coincidences. The data is currently being analyzed using the RADWARE esclbr software package which has allowed the creation of extensive level schemes for several Gd and Tb nuclei. So far the data suggests new gamma ray transitions as well as new energy states in 154Gd and 155Tb. The project is ongoing, and the results will be presented. This work was supported by the US Department of Energy under grant numbers DE-FG52NA26206 and DE-FG02-05ER41379.

GB.00015 Optimizing the Fermilab E-906 Spectrometer Design Using GEANT Simulations. BRANDON BOWEN, Abilene Christian University, E-906 COLLABORATION — Experiment 906 at Fermi National Accelerator Laboratory (FNAL) is a fixed target experiment measuring Drell-Yan scattering. The purpose of E-906 is to determine the ratio of anti-down to anti-up quarks in the nucleon sea by measuring the total cross section of the Drell-Yan muon pairs from liquid hydrogen and liquid deuterium targets. E-906 will extend the FNAL E-866/NuSea measurements to higher Bjorken x, which will help reveal the structure of the proton. These results focus on using GEANT4 Monte Carlo simulations to investigate spectrometer acceptance and background rates at the downstream end of the spectrometer using various amounts and types of absorbers. Muons in the simulations were generated over a momentum range of 15 to 35 GeV for each proposed configuration, since at this location the background will be dominated by electrons knocked out of the shielding blocks by muons. These simulations will determine the downstream shielding that will be used in the experiment.

GB.00016 Monte Carlo Fast Dose Calculator for Proton Radiotherapy. TRAVIS BRANNAN, JESSIE HUANG, PABLO YEPES, Rice University, RICE - M.D. ANDERSON COLLABORATION — Monte Carlo methods used in proton radiotherapy are more accurate than commonly used analytical dose calculations, at the cost of being computationally intensive. We intend to show the feasibility of the Fast Dose Calculator (FDC), a Monte Carlo track-repeating algorithm based on GEANT4, to perform dose calculations for a clinical proton beam. FDC was developed to retain the accuracy of the Monte Carlo approach while substantially decreasing the calculation time required. FDC uses a database of proton trajectories in water and extrapolates this data in order to calculate the dose in heterogeneous media by scaling the proton range and scattering angles. FDC has been extended to include all of the patient-dependent elements of a passive proton scattering treatment unit: aperture, range compensator, and voxelized patient geometry. Improved database packing provides additional computational efficiency in FDC, which speeds calculation by more than two orders of magnitude. In addition FDC shows no acceptance and background rates at the downstream end of the spectrometer using various amounts and types of absorbers. Muons in the simulations were generated over a momentum range of 15 to 35 GeV for each proposed configuration, since at this location the background will be dominated by electrons knocked out of the shielding blocks by muons. These simulations will determine the downstream shielding that will be used in the experiment.

GB.00017 Sensitivity to masses in the r-process. SAM BRETT, Joint Institute for Nuclear Astrophysics, Surrey, ANI APRAHAMIAN, Joint Institute for Nuclear Astrophysics — The rapid neutron capture process is thought to produce over 50% of the elements beyond iron and still remains, in many ways, a mystery. Questions about the single proton capture process and its role in the r-process are outstanding open questions. The process is affected by the astrophysics of the scenario and the nuclear physics of the nuclei involved in the process. Simulations of the r-process require large sets of data such as cross sections, separation energies and decay rates. Clearly, it would be desirable if all of these data sets to be observed and experimentally proven, but since we are looking toward extremely neutron rich nuclei, perilously close to the drip line, we must use many theoretical values. Using an r-process simulation written by Bradley Meyer in 1993, we have been able to see the effects of changing the mass models (and therefore the separation energies) on the final abundances. The input includes the weak range Drouet model, the EFSI, Dufo-Zucker, and F0 models. By comparing these theoretical models against each other and against known masses, we hope to be able to suggest key regions for further mass measurements.

GB.00018 Determination of Neutron Branching in 12C+ 12C Fusion. JUSTIN BROWNE, University of Notre Dame — The neutron branch in the 12C+ 12C is important for the carbon shell burning and carbon explosive burning. The 23Mg created by the 12C(12C,γ)23Mg reaction may undergo β^− decay, changing the neutron excess in the combusting material, and the neutrons emitted from this reaction may contribute to s- and r-processes. Both the β^− decay and the neutron emission greatly affect the subsequent nucleosynthesis in the star. A detection system, consisting of an array of four plastic scintillators and two Germanium detectors, has been developed to detect the decay of the 23Mg. The system has been tested at E_{c.m.} = 4.2 MeV. Using β^− → γ coincidence technique, the 23Mg reaction products has been unambiguously identified.

1Supported in part by the National Science Foundation under Grant Numbers NSF-PHY05-52843 and PHY07-58100.
GB.00019 The Muon Tracker Front End Electronics for the PHENIX Muon Trigger Upgrade 1, DAVID BROXMeyer, Muhlenberg College. PHENIX COLLABORATION — The RHIC spin program at Brookhaven National Laboratory is designed to determine the spin of the constituents of the nucleon by using the collision of polarized protons. An elegant technique for determining the angular momentum of different flavors of quarks and anti-quarks is to use the parity violating decay of W bosons into high transverse momentum muons. PHENIX is engaged in an upgrade to its muon trigger to help select events that contain these high transverse momentum muons. This upgrade consists of four new stations of Resistive Plate Chambers (RPCs) and an upgrade to the front end electronics of the existing muon tracking system. A portion of the signal from the muon tracker will now be split off for use in the new trigger. The current electronics allow excellent position resolution in the offline analysis, but not very good timing resolution for the trigger. The front end electronics that are fed by the split signal will allow a rough determination of position and excellent timing information. The status of the RPC installation and new front end electronics will be described. 1Thanks to the National Science Foundation.

GB.00020 Nuclear Structure in Even-Even Nuclei, 24 ≤ Z ≤ 72 2, SARAH BUCHHORN, HSHSP-MSU — Analysis of the spectra of excited nuclei has been used for decades to reveal trends and build models. Power regressions of the form E(J) = a(\sqrt{J(J+1)})^b fitted to the yrast line of isotopes reveal an average b of \sim 0.45. It should be noted that this is the value predicted for large angular momenta by the Variable Moment of Inertia model [1,2]. A second plot of R_{11} (R_{11} = E_{J=1} - E_{J=0}) vs. J reveals curves described by power regressions where 0.66 ≤ b ≤ 1.81. Graphs of b vs. neutron number (N) reveal V-shaped patterns for many nuclei, with the lowest exponent corresponding to a magic N. In addition, sharp jumps in exponents are seen at the (N = 88) → (N = 90) transition point in several nuclei. A third chart — an abbreviated energy level diagram including O^{16}, O^{17}, O^{18}, S^{32}, and S^{34} states reveals the energy increases at magic numbers, along with the near-degenerate two-phonon triplet of S^{32}, S^{34}, and S^{36} — most clearly observed in isotopes of Z = 28,34,36,44,46, and 48. Lastly, a fourth chart of \gamma (neutron number) vs. J © (J) shows positive correlation that is well described by equation E(3_2^+) = A - \frac{\beta_{2}^2}{E(2_1^+)} - not only for Z =54 [3] but also for Z =36,42-52, and 68. Data obtained through ENDF database. [1] M.A.J.Mariscotti,G.Sharff-Goldhaber and B.Buck, Phys.Rev.178,1864(1969). [2] M.I. Stockmann and V.G.Zelelevsky, Phys.Lett.41B,19(1972). [3] W.F. Mueller et al., Phys.Rev.C 73, 014316(2006).

GB.00021 Analysis of Resistive Plate Counter Detector used at Hadron Colliders, ALEX BURNAP, PHENIX COLLABORATION — Resistive Plate Counters (RPC) used for muon detection in the ATLAS and CMS experiments at the Large Hadron Collider are essentially based on the same design as those currently being installed for the level one muon trigger upgrade of the PHENIX experiment at the Relativistic Heavy Ion Collider. A full size RPC prototype double gas gap RPC was constructed for detector performance studies in the PHENIX RPC assembly laboratory at BNL. The RPC was then taken to UIUC where a setup of scintillators and drift chambers makes it possible to reconstruct cosmic ray tracks with a position resolution of about 1 mm. This tracking makes it possible to characterize RPC efficiencies and position resolution as a function of position in the detector and to study the efficiency near the detector edges and in regions where mechanical spacers in the gas gaps are located.

GB.00022 Elastic Compton Scattering from Carbon, JOHN CAPONE, GERALD FELDMAN, George Washington University, COMPTON@MAX-LAB COLLABORATION — A Compton scattering experiment was conducted at MAX-Lab in Lund, Sweden, in which tagged photons of energy E_\gamma = 81.5 Assumption of a low energy cut-off on the angle resolution makes the effective angle of the Compton scattering peak well defined by setting a time window on \textit{true} photons of energy \textit{E}_\text{\gamma} against \textit{E}_\text{\gamma1}. For all the \textit{E}_\gamma, the energy resolution of the NaI detector is used to estimate the energy of the scattered photons. The scattered photons are then detected by a magnetic field setup of three large-volume (50 cm × 50 cm) NaI scintillator detectors located at 60°, 120° and 150° from the electron beam axis. The elastic Compton scattering peak was identified by setting a time window on “true” coincidences between the NaI detectors and the tagger focal plane array. The data required a background subtraction to remove unwanted contributions to the energy spectra from “random” events such as cosmic rays and untagged photons. After this subtraction, the residual background was fit in order to determine the integral of the elastic scattering peak. With this experimental yield, normalization factors such as the target thickness, photon flux and NaI detector solid angle were applied to determine the absolute cross section. The results for the differential cross section will be presented as a function of angle and energy and the integral of the elastic scattering peak. With this experimental yield, normalization factors such as the target thickness, photon flux and NaI detector solid angle were applied to determine the absolute cross section. The results for the differential cross section will be presented as a function of angle and energy and the integral of the elastic scattering peak.

GB.00023 Electropolishing Copper Substrates for Niobium Thin-Film Coatings in SRF Technologies, ANDREA CARLINI, Virginia Tech, ANNE-MARIE VALENTET-FELICIANO, Jefferson Laboratory — Electropolishing (EP), the electro-chemical removal of contaminants and microscopic smoothing of metallic surfaces, has been used for surface preparation of superconducting radio frequency (SRF) cavities. Cu substrate EP is particularly useful for Nb thin-film coatings as surface roughness and impurities can negatively influence the efficiency of these superconductors. During the EP process, Cu atoms on the highest peaks of the surface ionize and travel away from the substrate, resulting in a smoothing of the surface. The focus of this project was to improve Cu EP by optimization of various parameters. Here it is shown that a high and low current density (J) was identified for optimum polishing. Values such as bath age, previous mechanical polishing, time, electrode distance, and J combinations were tested to analyze the effect on Cu samples. The results indicate that considerable leveling of the copper surface is achievable through optimization of the considered parameters. Significant improvements in the efficiency and maximum accelerating field of Cu/Nb cavities may be achievable through this improved process.

GB.00024 Development of a Conversion Electron Source for Timing Measurements and the Determination of Angle Dependent Detector Response in the UCNA Experiment, A.J. CETNAR, Grove City College, L. BROUSSARD, Duke University, R.W. PATTIE, A.R. YOUNG, NCSU. UCNA COLLABORATION — The beta-asymmetry from polarized neutron beta-decay is proportional to (v/c)Cos\theta, where \theta is the emission angle of the beta particles, A is the beta-asymmetry parameter with a small energy dependence, and v is the speed of the beta-particle. In the UCNA experiment, ideally, the average value of cos\theta=1/2 and the detected energy of the electrons determines the v/c factor. Scattering and energy loss in non-active materials in the trajectory of the emitted electrons introduces an angular dependence to the efficiency and response of the detectors. This deviation is corrected in the UCNA experiment based on results from Monte Carlo simulations. In order to directly establish the angle dependent corrections, we have developed a timing source that can be placed in the 1T magnetic field in the beta spectrometer. An avalanche photodiode detects Auger electrons emitted in coincidence with conversion electrons from ^{118}Sn providing the time of flight for the conversion electrons. Because the conversion electrons are essentially monoenergetic, the time of flight is determined by the pitch angle of the trajectories in the magnetic field of the spectrometer. We present an evaluation of the performance of the timing source and expected response in the UCNA experiment.

1Supported by the National Science Foundation, Department of Energy, Old Dominion University REU Program, and Jefferson Laboratory.
GB.00025 Structure of even-A nuclei in the neutron-rich region of the nuclear chart predicted by the r-process. RAUL CHAVARRIA, Florida International University, ANI APRAHAMIAN, Notre Dame University — The main goal in nuclear physics is the study of the properties of the nucleus as a function of protons and neutrons that make it up. Three particular areas of interest in nuclear physics are the study of masses, structures and half-lives of nuclei. Much is known about nuclei close to stability but lack of sophisticated equipment has limited research on exotic nuclei in the neutron-rich region of the nuclear chart predicted by the r-process. By studying the energies of the 4+ and 2+ excited states of nuclei to the ground state of even-A nuclei, it is possible to roughly determine the structure of nuclei. Looking at how this ratio changes as a function of the P factor, it is possible to see how the structure changes for nuclei as the neutron and proton count move away from close shell magic numbers. This provides an important tool to study the structure of exotic nuclei whose quadrupole moment is very difficult to see experimentally. I will discuss specific predictions on the structure of even nuclei at A∼110.

1 NSF-PHY05-52843, McNair Scholars Program

GB.00026 Simulation on the Charged Particle Response of the STAR Heavy Flavor Tracker Pixel Detector, ALEX CIMAROLI, XIN LI, Purdue University — The main task of the STAR experiment, located at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory, is to study the quark-gluon plasma (QGP), which is believed to have been created a few microseconds after the “Big Bang.” Heavy quarks are ideal tools for studying the properties of QGP. The Heavy Flavor Tracker (HFT) is the central part of the STAR future heavy flavor physics program and will enable STAR to directly measure heavy flavor mesons. The core of HFT is a pixel detector (PIXEL) using CMOS Active PIXEL Sensor. This poster will describe the development of a detailed simulation of the pixel detector response to charged particles and the corresponding fast simulation that dramatically enhances the simulation speed with little sacrifice in accuracy. The full simulation randomly generates ionized electrons along an incoming track and diffuses the electrons inside the pixel array until they are collected by the electronics or recombined inside a pixel. With the same result, the fast simulation, which quickens processing time from one hour to 5 seconds, generates a grid inside a single pixel and create a map of probability distribution functions for a single ionized electron generated from a grid point. We will also discuss the study of pixel detector position resolution using a simple clustering algorithm.

GB.00027 Signal Efficiency of the Resistive Plate Chambers in the PHENIX Forward Trigger Upgrade, MARK COLEY, Abilene Christian University, PHENIX COLLABORATION — PHENIX is an experiment at the Relativistic Heavy Ion Collider (RHIC) that studies polarized proton-proton and heavy ion collisions. PHENIX is in the process of upgrading the forward muon trigger to improve its capabilities of studying W-bosons. By triggering on single, high transverse momentum muons, new observations on the spin structure of a proton will be obtained. The trigger upgrade will consist of four stations of Resistive Plate Chambers (RPCs) with two stations on each side of the interaction region. Inside an RPC, there are several copper strips which form a signal plane. When a charged particle travels through the adjacent gas gaps a signal is induced on these strips. This signal propagates from the copper strip to the readout electronics. In the readout electronics, the signal is amplified and sent to a discriminator. Care must be taken when setting the chamber high voltage and the readout electronics threshold to balance the detector efficiency and noise. Lowering the threshold increases the efficiency of detecting muons but also increases the background interference. These RPCs are tested on a cosmic ray test stand to determine the optimal operating conditions. This poster will describe the RPCs, how the signal propagates out of the chamber and how the high voltage and threshold affect performance.

GB.00028 Testing Analysis Algorithms for the $^2\text{H}(e,e'p)n$ Reaction, CALINA A. COPOS, GERARD P. GILFOYLE, University of Richmond, CLAS COLLABORATION — We have measured the asymmetry $A_{L/T}$ of the $^2\text{H}(e,e'p)n$ reaction in quasielastic kinematics at a beam energy of 2.56 GeV over a 4-momentum transfer range $Q^2 = 0.2 - 2.0(\text{GeV}/c)^2$ with the CLAS detector at Jefferson Lab. We have performed a Monte Carlo simulation of the reaction in order to test the analysis code used to extract $A_{L/T}$ associated with the fifth structure function. The Hulthen distribution was used to select the magnitude of the internal Fermi momentum of the target nucleus and the direction was chosen isotropically. The direction and Fermi momentum of the target nucleus were weighted by integrating the elastic cross section in the frame of reference of the moving nucleus over the CLAS acceptance. A fit to the measured $A_{L/T}$ was incorporated into the Monte Carlo simulation to model the fifth structure function. The GEANT3-based code GSI3 was used to simulate the CLAS detector. Monte Carlo events were analysed with the same code used to extract $A_{L/T}$ from the experimental data. We simulated quasielastic scattering at a beam energy of 2.56 GeV using two polarizations of the CLAS toroidal magnet. The asymmetry extracted from Monte Carlo events is consistent with the input function for the asymmetry within the uncertainties of the calculation.

GB.00029 Generation of Unprecedented high Electric Fields with Pyroelectric Crystals, SARAH CRIMI, Florida Atlantic University, WERNER TORNOW, Duke University and TUNL, ZACH CORSE, Duke University — Since a few years pyroelectric crystals in a deuterium gas environment have been used to produce neutrons via the $^3\text{H}(d,n)^{4}\text{He}$ reaction. The figure-of-merit for neutron production in the energy region of interest is about IE$^2$/I, where I is the deuterium ion current and E is the associated ion energy. Therefore, it is important to maximize E. Using single and double crystal arrangements with electric field enhancing nano-tips, the highest positive potentials reported in the literature were 115 keV [1] and 250 keV [2], respectively. Using longer LiTaO$_3$ crystals than commonly employed (2.5 cm versus 1.0 cm) and without attaching a nano-tip, we have produced positive deuterium ion beams of energies up to 325 keV with a single crystal during the cooling phase from 130 °C to 0 °C. In a double crystal arrangement we have obtained positive ion energies of up to 390 keV. Details of our experimental approach will be presented.


GB.00030 Constructing the Fermilab E-906 Spectrometer to Investigate Proton Anti-Quark Asymmetry, MANDI CROWDER, Abilene Christian University, E-906 COLLABORATION — Fermilab E-906 is a fixed target experiment that has a primary goal of extracting the sea anti-quark structure of the proton. For E-906, Abilene Christian University (ACU) is responsible for the design and construction of the downstream hodoscopes that will form a part of the experiment trigger. The detector design is based on the E-866/NuSea experiment, which determined the proton’s excess of anti-down quarks relative to anti-up quarks over an extended kinematic range. The improvements over E-866/NuSea include replacing the scintillators and light guides to ensure better efficiency. E-906 will also add double-ended read-out on the three farthest downstream hodoscopes to provide better timing and trigger efficiency. The required 224 photomultiplier tubes (PMTs) will be tested to find their approximate operating voltages and maximum counting rates. The method to find the operating voltage used the Compton edge of Cesium-137 found with a Multi-Channel Analyzer (MCA) to cover all of the PMTs. All other testing procedures, results, and design plans will be presented.

1 This work is supported in part by the U.S. Department of Energy, Office of Nuclear Physics, under Grant No. DE-FG03-94ER40860.
GB.00031 Improved detectors for the new muon g-2 measurement. GREGORY DAMHORST, University of Illinois Urbana–Champaign — A precision measurement of the muon anomalous magnetic moment (g-2) is one of the most promising efforts for the detection of new physics beyond the standard model. A new proposal to perform the measurement at Fermi National Accelerator Laboratory promises to reduce uncertainty in the measurement from 0.54 ppm to 0.14 ppm, improving the measurement’s power in discriminating various extensions to the standard model. To accomplish this greater precision, the new g-2 measurement will require improved detectors and data acquisition techniques. Calorimeters made of tungsten and scintillating fiber (SciFi) will be used for the detection of weak decay electrons. This design is preferred over the grooved lead/SciFi calorimeters used in past g-2 measurements for its simple assembly and smaller radiation length. Photons produced in the scintillation process will be directed to photomultipliers for electronic readout through foil-lined acrylic light guides which must concentrate photons with minimal loss within a limited available space. The challenge of developing an optimal detector design is being addressed by the University of Illinois Nuclear Physics Group through Monte Carlo simulations and tests of prototype calorimeters and light guides. Significant aspects of this project include determining optimal calorimeter module size, light guide geometry, and photomultiplier style. Supported by DTRA.

GB.00032 Identifying the induced depletion of $^{166m}$Ho. B.A. DETWILER, N. CALDWELL, G.P. TREES, J.J. CARROLL, Youngstown State University, N. PEREIRA, Ecopulse, Inc., M. LITZ, G. MERKEL, Army Research Lab, J. SCHUMER, Naval Research Lab — Current nuclear data indicates that incoming photons below 300 keV may allow for an induced depletion of the $^{166m}$Ho isomer. Such photons will excite the nucleus of a sample of $^{166m}$Ho up to a higher state. From there, the nucleus could decay back to this first metastable state or take a separate decay path down to the ground state. While the first metastable state has a half-life of 1200 years, such an induced depletion would allow the nucleus to decay to its ground state in just fractions of a second. From there, further beta decay occurs on the order of about 24 hours. During the induced depletion cascade, a 136 keV gamma ray will be emitted from a level that has a 185 µs half-life and is above the initial isomer. A detection system has been designed to detect this unique photon as well as evidence of the 185 µs half-life; both are signals that the induced depletion has occurred. A cerium-doped lanthanum chloride (LaCl$_3$:Ce) scintillator coupled to a gated photomultiplier tube is used to observe gamma rays from the isomeric sample of $^{166m}$Ho. Timing data of the unique photon will be recorded in between bremsstrahlung pulses from an electron linac. First results of this experiment will be discussed. Supported by DTRA.

GB.00033 Data analysis for spectroscopy of $^{108}$Ag via single-neutron transfer. T. DETWILER, B. DETWILER, G.P. TREES, I.N. MILLS, T. HARLE, N. CALDWELL, Youngstown State University, S.A. KARAMIAN, Joint Institute for Nuclear Research, T. SHIZUMA, JAEA Kansai Photon Science Institute, T. ISHII, H. MAKII, JAEA Advanced Science Research Center, E. IDEGUCHI, University of Tokyo, P.M. WALKER, University of Surrey, R.S. CKAURAVA WARTHE, J.J. CARROLL, Youngstown State University — $^{108}$Ag contains an isometric state with excitation energy of 110 keV and a half-life of 418 years. A level above this state with excitation energy of 364 keV provides decay paths to both the isomeric and ground states; therefore, this level might serve to enable an induced depletion of the isomer. To obtain improved level data, an experiment was conducted at the tandem accelerator facility, JAERI, Tokai where a beam of $^{185}$O ions were incident on a $^{107}$Ag target. Arrays of Si $\Delta$E-E detectors and HPGe detectors were arranged to detect projectile-like ions and gamma rays, respectively. Among numerous reactions, single-neutron transfer produced excited states in $^{108}$Ag with scattered projectile-like $^{17}$O ions. This poster will discuss data sorting to extract these events and preliminary analysis of the corresponding gamma-gamma coincidence matrix. Supported by DTRA.

GB.00034 Determination of environmental dependence of the $\beta^-$ decay half-life of $^{198}$Au. A. DIBIDAD, REU student from Florida A&M University, J. GOODWIN, J. HARDY, Cyclotron Institute, Texas A&M University — A series of articles by the C. Rolfs group [1] claimed changes in the half-lives of isotopes undergoing $\alpha$, $\beta^-$, $\beta^+$, and electron-capture decays as the temperature reduced to 12 K from room temperature. These isotopes were contained in metallic, conductive environments, such as Au, Cu, and Pd, but it was also suggested that the half-life is different in an insulator. One publication [1] reported the half-life of $^{198}$Au in a gold metal environment to change by 3.6 ±1.0% between room temperature and 12 K. Until then, radioactive half-lives were considered independent of environmental factors. We repeated the measurements of the $^{198}$Au half-life in a gold metal environment under similar conditions as ref. [1] and demonstrated [2] that the half-life is the same at both temperatures within 0.04%, two orders of magnitude below the original claims. In the experiment reported here, we measured the half-life of $^{198}$Au in an insulated environment – gold (III) oxide – at room temperature. Preliminary results indicate there is no difference in the measured half-life in an insulator as compared in a conductor. [1] T. Spillane et al, Eur. Phys. J. A 31, 203 (2007) [2] J.R. Goodwin et al, Eur. Phys. J. A 34, 271 (2007) Funded by DOE and NSF-REU Program.

GB.00035 Assembling Resistive Plate Chambers for the PHENIX Detector. KIRK DRUMMOND, Morgan State University, PHENIX COLLABORATION — A fast muon trigger for the Pioneering High Energy Nuclear Interaction eXperiment (PHENIX) will enable the study of flavor separated quark and anti-quark spin polarizations in the proton through the analysis of single spin asymmetries for $W^-$-boson production in proton-proton collisions. The Phenix experiment is capable of measuring high momentum muons at forward rapidity, but the current online trigger does not have sufficient rejection to sample rare leptons from W-decay at the highest luminosities at the Relativistic Heavy Ion Collider. This upgrade will enhance our ability to collect and analyze muons that decay from W-bosons produced in polarized proton-proton collisions. This upgrade is comprised of half-octants which encompass three different Resistive Plate Chamber (RPCs) modules that encase a sandwich of copper, mylar, gas gaps, and a signal plane. The summer of 2009 marked the start of this full production, with teams from many institutions contributing to the production in the assembly tent at Brookhaven National Lab. The North Arm Station 3 part of the upgrade is scheduled to be installed in the fall of 2009, and the remaining stations will be installed by the fall of 2011.

GB.00036 Development of a large acceptance, tracking gas ionization chamber. CHRISTOPHER DUPUIS, J.C. BLACKMON, L.E. LINHARDT, M. MATOS, Louisiana State University, D.W. BARDAYAN, Oak Ridge National Lab, G. ROGACHEV, I. WIEDENHÖEVER, Florida State University — The detection of heavy ions at forward laboratory angles provides an efficient and selective technique for identification of reaction channels in measurements with radioactive ion beams in inverse kinematics. This can be very important in some experiments as the intensity and purity of radioactive ion beams is often low. We are developing a large-acceptance (more than 60 mrad), gas ionization chamber that is designed for such cases. The counter provides atomic number selectivity through relative energy loss measurements from 3 anodes. The trajectory of ions is also measured using resistive-wire readout from proportional counting wires. We have modeled the performance of the counter and are testing its performance using alpha radioactive sources. Supported by the U. S. Dept. of Energy and the National Science Foundation.
GB.00037 Reconstruction of Radiation Source Locations Using Goodness-of-Fit Tests on Spectra Obtained from an HPGe Detector, LEN EVANS, University of North Carolina — High purity germanium (HPGe) detectors are ubiquitous in nuclear physics experiments and are also used in numerous low radioactive background detectors, including the proposed MAJAHANA experiment. Spatial reconstruction of the location of radiation sources from spectral distortions could be used to locate unwanted backgrounds or "hot-spots" inside the detector shield. The effect of the position of $^{60}$Co and $^{137}$Cs point sources on the shape of spectra were studied with both Monte Carlo and HPGe detector measurements. We briefly confirm previous work on the position dependence of relative heights of peaks. Spectra taken with the radiation sources placed at locations around the detector were then compared using the Kolmogorov-Smirnov (K-S) goodness-of-fit test. We discuss the position reconstruction accuracy of this statistical method, which is promising.

GB.00038 Understanding the Isotopic Fragmentation of a Nuclear Collision1, T.C. FAGAN, REU student from Florida A&M Univ., L.W. MAY, S. WUENSCHER, Z. KOHLEY, A.S. BOTVINA, S.J. YENELLO, Cyclotron Institute, Texas A&M Univ., S.J.YERGUARD TEAM — The Statistical Multi-fragmentation Model (SMM) coupled with the Deep Inelastic Transfer Model (DIT) was used to simulate the production and fragmentation of quasi-projectiles produced in the reactions of $^{78.86}$Kr+$^{58.64}$Ni at 35 MeV/u. In order to compare the theoretical results to experimental data taken on the NIMROD-ISIS charged particle array, the simulated data was filtered to account for the acceptance of the detector and experimental source cuts. An isoscaling analysis was performed on the resulting fragments by comparing fragment yields from neutron-rich and neutron-poor reconstructed quasiprojectiles. The results from the simulation showed qualitative agreement with the experimental data. The isoscaling parameter $\alpha$, which is related to the symmetry energy, decreases with increasing excitation energy. This result is seen in both the filtered and un-filtered simulation demonstrating that the experimental observation of the decreasing $\alpha / \Delta \alpha$ value is not due to the detector bias or source cuts. Furthermore, the isoscaling was investigated as a function of the source N/Z bin widths and a trend in $\alpha$ as a function of changing bin width is observed.

1 Funded by DOE and NSF-REU program.

GB.00039 Transport Properties of a Perturbative Quark-Gluon-Plasma, JOHN FUINI, University of Texas at San Antonio, NASSER DEMIR, STEFFEN BASS, Duke University — Ultrarelativistic heavy-ion collisions may create a deconfined state of QCD matter, called the Quark Gluon Plasma, which was the state of the early Universe shortly after the Big Bang. The very low shear-viscosity over entropy density ratio ($\eta/s$) of the QGP discovered at RHIC has attracted a lot of interest, due to the use of the AdS/CFT conjecture in string theory to calculate a possible lower bound of 1/4pi for $\eta/s$ in a QCD-like theory. In this work, we use the Parton Cascade Model to calculate $\eta/s$ of a weakly interacting QGP. The PCM has been successfully applied to the study of the non-equilibrium time evolution of the QGP created in heavy ion collisions at high temperatures. Here we perform a study of QGP matter in equilibrium and, using the Kubo formalism, calculate $\eta/s$ as a function of temperature and system composition. We find values of $\eta/s$ which are too high to explain the near ideal fluid behavior observed at RHIC. By increasing the coupling constant beyond the applicability of perturbative QCD, we find $\eta/s$ values compatible with the RHIC data. Our results confirm the strongly interacting nature of the QGP at RHIC and provide a baseline for $\eta/s$ values to be expected at the LHC, where higher temperatures are thought to dominate the evolution of the system.

GB.00040 Timing Resolution of the Prototype Resistive Plate Chambers for the PHENIX Trigger Upgrade, KYLE GAINEY, Abilene Christian University — The PHENIX collaboration at the Relativistic Heavy Ion Collider (RHIC) studies polarized proton-proton collisions to understand the spin structure of the proton. The muon trigger in PHENIX is being upgraded to improve its ability to select high pT single muons such as those produced in the decay of W-bosons. Two prototype Resistive Plate Chambers (RPCs) have been in the interaction region of RHIC during the run that ended earlier this year. The addition of the RPCs to PHENIX will provide precision timing information to the muon reconstruction. Among other benefits, this will allow for the differentiation between particles originating from collisions at the interaction point and background particles originating elsewhere. The additional capability to reject background will be important at the higher energies needed to study W-bosons. The 2009 run was the first time RHIC collided polarized protons at 500 GeV and thus the background levels were initially imprecisely known. This poster will focus on how the prototype chambers performed during this high energy run and include details about their timing resolution.

GB.00041 Calibrations of Beta and Gamma Detector Efficiencies1, CAMILLE GARCIA, University of Puerto Rico at Humacao and University of Notre Dame, XIAODONG TANG, CHI MA, University of Notre Dame — The $^{12}$C+$^{13}$C reaction has been studied at sub-barrier energies from Ecm = 2.55 MeV to 4.7 MeV by detecting the decay of $^{24}$Na resulting from the proton decay branch of the compound nucleus $^{25}$Mg. To determine the absolute cross section, two different methods, coincidence method and sum peak method, have been applied to determine the detector efficiency and the total amount of the produced $^{24}$Na. A calibrated $^{24}$Na standard source has been used to validate the sum-peak method. The angular correlation effect of the two coincident gamma rays from the $^{24}$Na decay was corrected by means of the Monte Carlo simulations. Applying the sum-peak method to the $^{24}$Na experimental data, the reference value for the activity and the activity obtained experimentally agreed within a range of 1%.

1 Supported by grants NSF-PHY05-52843 and NSF-PHY07-58100.

GB.00042 Study of Charmonia States in Vacuum and High Density Medium, JUAN GARCIA, The University of Texas at El Paso — Quantum Chromodynamics (QCD) predicts a hot state of quark matter with a critical temperature of about $T_c = 2 \times 10^{12}$ K. Heavy quarks (charm and bottom) provide a probe for the QGP because of their large masses which are much greater than $T_c$. We study bound states these quarks form, in particular Charmonium, a charm-anticharm bound state. For our study we take a non-relativistic approach using different potential models to study the system in both vacuum and medium by solving Schrödinger’s Equation for different eigen states and eigen energies.

GB.00043 Particle Induced X-Ray Emission Analysis of Atmospheric Aerosols Collected in Upstate New York, COLIN GLEASON, CHARLES HARRINGTON, KATIE SCHUFF, SCOTT LABRAKE, MICHAEL VINEYARD, Union College — Elemental analysis of atmospheric aerosols collected in the historic Stockade District of Schenectady, New York, was performed using particle induced X-ray emission (PIXE) spectroscopy. This is part of a systematic study in the Mohawk River Valley of upstate New York to identify the sources and understand the transport, transformation, and effects of airborne pollutants and the connection between aerosols, the deposition of pollution, and the uptake of pollutants by wildlife and vegetation. The atmospheric aerosols were collected with a nine-stage cascade impactor that allows for the analysis of the particulate matter as a function of particle size. The samples were bombarded with 2-MeV proton beams from the Union College Pelletron Accelerator and the energy spectra of the X-rays were measured with a silicon drift detector. The X-ray spectra were analyzed using GUPIX software to extract the elemental concentrations of the particulate matter. The sample collection and analysis will be described, and preliminary results will be presented.
GB.00044 Eliminating the effect of SRC beam-energy spread on the BigRIPS focal plane{1, YUSUKE GOTO, TAKAHIRO NISHI, The University of Tokyo, PIAF COLLABORATION — At RIKEN RIBF, precise and systematic studies on the 1s binding energies and widths of pionic-Sn atom using the Sn(d,3He) pion-transfer reaction are planned, but a relatively large energy spread of the RIKEN Superconducting Ring Cyclotron (SRC) poses a difficulty in achieving the required resolution. “Dispersion matching” is a way of adjusting the optical settings of the beam line to overcome this problem. It makes positions of particles on a focal plane independent of the beam-momentum spread, while ensuring the particles with different Q values focused at the different positions on the focal plane. We recently made an experiment for testing the dispersion matching at RIKEN. In this experiment, a 14N beam of 250 MeV/nucleon was used; the value of energy per nucleon being the same as that of the deuteron which will be used in the experiment on pionic-Sn atom. We tried some ion-optical settings and verified that particles with a finite momentum spread could be focused to one point. In the Hawaii meeting, we will present the detailed analysis of this test experiment.

1A test experiment for the pionic-atom precision spectroscopy at RIKEN RIBF.

GB.00045 Monte Carlo Simulation of Neutron Background Sources in the Measurement of the $^{12}$C($\alpha,\gamma$)$^{16}$O Reaction Rate{1, KEVIN GULLIKSON, Illinois Institute of Technology, CLAUDIO UGALDE, Argonne National Laboratory — The $^{12}$C($\alpha,\gamma$)$^{16}$O reaction rate strongly affects the relative abundances of chemical elements, as well as when core collapse supernovae occur. In a proposed experiment, a water-filled bubble chamber will be used to measure the reverse reaction rate. A potential background source is photonneutrons from the $\gamma$-ray beam collimator entering the bubble chamber and generating a false signal. To minimize this effect, a Monte Carlo simulation has been performed to compare the number of photoneutrons created in lead, copper, and aluminum collimators. The simulation also compared the effectiveness of concrete, polyethylene, and water neutron shields. It was found that 30 cm of copper would be an effective collimator, and 30-40 cm of polyethylene a satisfactory neutron shield.

1This research was done at Argonne National Laboratory, as part of the Science Undergraduate Laboratory Internships program run by the Department of Energy.

GB.00046 Using Geometry Description Markup Language to store the geometry of FNAL E-906, TYLER HAGUE, Abilene Christian University — The primary goal of FNAL E-906 is to investigate the ratio of d(bar)/u(bar) in the nucleon sea. To do this, the Drell-Yan cross section ratio will be measured in proton-proton and proton-deuteron collisions. FNAL E-906 is utilizing Geometry Description Markup Language (GDML) to describe the geometry of the spectrometer. GDML is capable of describing the spectrometer in great detail and is fully functional with GEANT4 and ROOT. By using this we will have a common geometry input for all of our software codes including two Monte Carlo simulations, primary data analysis code, and a ROOT-based event display. The use of such a language creates the need for an easy way to read it and extract data, as well as to update the geometry when changes are made. A tool has been developed to convert a GDML file into an experiment-specific, easy to read ASCII file. Another tool is in development to create a simple interface to update a GDML file without knowledge of the language. These tools use ROOT’s geometry tree to traverse the volumes described in GDML. This poster will describe the advantages of using GDML and its implementation.

GB.00047 Detailed Gamma Ray Spectroscopy of 31Si using GAMMASPHERE and MICROBALL{1, LEANNE HAMILTON, Florida State University (University of Surrey), PAUL FALCON, STEFANOS PASCHALIS, MARINA PETRI, AUGUSTO MOICCHIACELLI, ROD CLARK, LBNL, PETER BENDER, CALLUM HOFFMAN, SAMUEL TABOR, VANDANA TRIPATHI, FSU, DEMETRIOS SARANTITES, WALTER REVIOL, XINFENG CHEN, Washington University, C. CHIANA, UoMD/ANL, ROBERT JANSENS, SHAOFEI ZHU, TORBEN LAURITSEN, L. MCCUTCHAN, ANL, YOSHUKE ZOH, JAEA — I participated in an experiment carried out at Argonne National Laboratory to investigate the relation between normal and intruder states in the s-d shell of neutron-rich nuclei. The experiment used a 25 MeV 18O beam incident on an 18O target with a thick Ta backing. Gamma rays were detected by the 101 Compton-suppressed HPGe detectors that comprise the GAMMASPHERE array and channel selectivity was provided by MICROBALL’s 95 CSI(Tl) scintillators. This work focuses on the nuclear structure of 31Si through measuring nuclear state decays. $\alpha-\gamma$ and $\alpha-\gamma-\gamma$ coincidence data are being analyzed by the in-house software package GNUSCOPE. Preliminary spectroscopic results have currently verified 13 previously known transitions and 22 new gamma ray dec-exitations have been identified. Both the positive and negative parity states have so far compared well with shell model calculations using the WBP-a interaction.

1Supported in part by the NSF and DOE.

GB.00048 Study of dark matter and neutrino by means of thin NaI(Tl){1, KATSUYA HARADA, The University of Tokushima, PICO-LON COLLABORATION, MOON COLLABORATION — The MOON/PICO-LON consists of two thin NaI(Tl) crystal is applied to search for 0νββ decay and WIMPs dark matter; $^{12}$C($\alpha,\gamma$)$^{16}$O Reaction Rate

1Supported in part by the NSF and DOE.

1CEU09 grant from Japan

GB.00049 Chamber Performance of Prototype Resistive Plate Chambers for the PHENIX Forward Trigger Upgrade, CAITLIN HARPER, Muhlenberg College, FOR THE PHENIX COLLABORATION — The Pioneering High Energy Nuclear Interaction Experiment (PHENIX) is located on the Relativistic Heavy Ion Collider (RHIC) ring at Brookhaven National Laboratory. One of the ultimate goals at RHIC is to obtain a more accurate understanding of a proton’s intrinsic spin structure through polarized proton-proton collisions. The parity violating decay of W-bosons created in some of these collisions allow for the determination of flavor separated quark distribution functions. Recently, PHENIX has been focusing on the construction and installation of Resistive Plate Chambers (RPC’s) as part of upgrade to the PHENIX muon trigger. These RPC’s are useful in the selection of high transverse momentum muon events from a background of low transverse momentum muon events. The second RPC station for the North side of the detector is still in the prototype stage. In order to make sure that this RPC is as efficient as possible, it is vital to reduce the amount of noise in the chamber. Efforts to measure and decrease the noise rates for the prototype will be further discussed.
GB.00050 Elemental Concentrations as a Function of Particle Size for Aerosol Samples Collected in Upstate New York from PIXE, CHARLES HARRINGTON, COLIN GLEASON, KATIE SCHIFF, SCOTT LABRAKE, MICHAEL VINEYARD, Union College — Using proton induced X-ray emission (PIXE) spectrometry, aerosol samples were studied to measure concentrations of airborne pollutants around Schenectady, New York. The health and climate effects of atmospheric aerosols depend on the size distribution of the particulate matter, which also is important for identifying the sources and for understanding the transport, transformation, and removal processes. For this reason, the aerosol samples were collected using a cascade impactor that separates the particulate matter into ten diameter ranges that allows for the analysis as a function of particle size. Beams of 2-MeV protons, provided by the Union College Pellettron Accelerator, were incident on the thin Kapton impaction foils, producing X-rays. The energy and intensity of the X-rays were measured using a silicon drift detector. The X-ray spectra were fit using the GUPIX software package to determine the elemental concentrations of the aerosols as a function of particle size. The analysis will be discussed and the elemental concentrations as a function of the size of the particulate matter will be presented.

GB.00051 One-proton knockout from $^{82}$Ge$^+$, B.A. HARTL, J.L. PALARDY, L.A. RILEY, Ursinus College, T.R. BAUGH, D. BAZIN, A. GADE, T. GLASMACHER, G.F. GRINYER, S. MCDANIEL, R.T. MEHARCHAND, A. RATKIEWICZ, K.A. WALSH, D. WEISSHAAR, National Superconducting Cyclotron Laboratory, Michigan State University — We report the results of an experiment performed at the National Superconducting Cyclotron Laboratory at Michigan State University in which the one-proton knockout reaction $^8$Be$(^8$Ge, Ga$)X$ was observed. The $\approx 90$ MeV/nucleon exotic cocktail beam had primary components $^{82}$Ge and $^{76}$As. The incoming beam was purified with the A1900 fragment separator, gamma rays emitted by the reaction products were detected with the Segmented Germanium Array (SeGA), and the reaction products were identified in the S800 magnetic spectrograph. We measured gamma rays in coincidence with incoming $^{82}$Ge and outgoing $^{81}$Ga, as well as the one-proton knockout cross section. Preliminary Results are discussed.

GB.00052 Development of Thermal Ionizer for the Search of the Electron Electric Dipole Moment, TOMOHIRO HAYAMIZU, AKIHITO OIKAWA, TOSHIYA TAKAHASHI, HIDETOMO YOSHIDA, MASATOSHI ITOH, YASUHIRO SAKEMI, CYRIC, Tohoku University — A non-zero Electric Dipole Moment (EDM) of an elementary particle means the violation of the time-reversal symmetry and the CP violation assuming the CPT invariance. The super symmetry model (SUSY) predicts the EDM large enough to be observed with the modern experimental technique. In alkali atoms, an electron EDM results in an atomic EDM enhanced by the factor $\sim 2^{3/2}$, especially francium (Fr) has the largest enhancement factor $\sim 1150$. However, Fr is a radioactive atom with a finite life time, we need to establish the technique to produce over $10^{15}$ atoms/sec, cool and collect them quickly in a non-destructive apparatus as a cold dense cloud of atomic atoms to measure the EDM accurately. Thermal ionizer produce the high intensity Fr ion using a fusion reaction of $^{19}$O$+^{197}$Au$\rightarrow^{210}$Fr$+\alpha n$ with a primary beam energy $E_B^{19}$MeV/nucleon. This ionizer consists of the Au target surrounded by the high temperature oven to stop the ion spreading out. Thanks to the small extraction electrode hole, we can realize the small emittance Fr beam, and the high transmission efficiency. We have achieved to produce over $10^4$ atoms/sec, and transport them along 3 meter without losing the Fr ions.

GB.00053 PIXE Analysis of Ceramic Artifacts, ELIZABETH HIGH, LARRY LAMM, MARK SCHURR, EDWARD STECH, MICHAEL WIESCHER, University of Notre Dame — Particle Induced X-ray Emissions, or PIXE, is a nuclear physics technique used as a non-destructive material analysis method which gives a detailed and comprehensive profile of the elemental composition of a target. Using the University of Notre Dame KN and FN accelerators in the ISNAP laboratory a beam of particles, here protons, is accelerated and used to knock out electrons from lower orbitals within the target sample but also their relative abundances in parts per million. In a previous run done in collaboration with the Anthropology Department at the University of Notre Dame pottery shards from the Collier Lodge, located in northwest Indiana, were analyzed and only relative abundances were able to be compared between samples. We are now implementing a new setup into the beam-line which will incorporate the ability to take Rutherford Back Scattering, or RBS, measurements of the beam during the PIXE runs, which will allow for a standard normalization for the runs and give the facility the ability to acquire a more absolute and quantitative analysis of the data. Initial results using the same pottery shards as a comparative data set will be presented.

GB.00054 Lifetime Measurements in $^{71}$Se$^+$, A.R. HOWE, R.A. KAYE, N.R. BAKER, S.R. AOROSA, Ohio Wesleyan University, J.K. BRUCKMAN, Monmouth College, S.L. TABOR, T.A. HINNERS, C.R. HOFFMAN, S. LEE, Florida State University, J. DÖRING, BIS (Germany) — In the light selenium isotopes, $^{71}$Se appears to be a transitional nucleus, showing signs of competing single particle and collective structures, but its level structure is not well known. The present work measured lifetimes in $^{71}$Se in order to quantify the degree of collectivity as a function of spin as the configuration of the unpaired neutron changes. $^{71}$Se nuclei were produced at high spin by a $^4$Fe($^9$Na, p) fusion reaction at 80 MeV conducted at Florida State University. Fifteen lifetimes were measured from the resulting gamma-ray coincidence data using the Doppler-shift attenuation method. Experimental transition quadrupole moments $Q_{22}$ were inferred from the lifetimes and found to be in rough agreement with the predictions of cranked Woods-Saxon calculations. Comparisons with neighboring odd-mass nuclei confirmed that $^{71}$Se exhibits moderate collective behavior. Based on coincidence relations and systematic arguments, the level scheme was enhanced and extended to higher spin. A band that was previously assigned positive parity was reassigned as the “missing” signature partner of an existing negative-parity band.

GB.00055 Radiation Hardness of PHENIX Muon Trigger Resistive Plate Chambers, JUSTINE IDE, Muhlenberg College, PHENIX COLLABORATION, UNIVERSITY OF ILLINOIS AT URBANA CHAMPAIGN TEAM — The measurement of quark and anti-quark helicity distributions through parity violating single spin asymmetries in W-production with the PHENIX experiment at RHIC requires new fast muon trigger detectors. PHENIX utilizes Bakelite RPC technology that has been developed for the CMS experiment at LHC. These new detectors will collect data for many years, and it is important to understand the impact the constant radiation exposure in PHENIX will have on the performance of the detectors. Prototype RPCs were exposed to two 0.6 mCi Fe-55 sources that were embedded in the detector gas. The RPC efficiency for cosmic ray detection was measured as a function of the total radiation dose exposure using a cosmic ray tracking detector at UIUC. This poster will discuss the radiation hardness of PHENIX Bakelite RPC prototypes, and how the results compare to the requirements at RHIC.

GB.00056 Production and use of thermal and cold neutron with tandem accelerator in Kyoto University, TASHIRO JIN — As a graduate research in the Faculty of Science, Kyoto University, we are developing a miniature neutron source and conducting experiments with neutrons produced. Compared with X-rays, neutrons haven’t been widely used for material science until now. It is because there are few facilities for experiments, for an experiment with neutrons requires large-scale ones, such as a nuclear reactor or a high-energy accelerator for spallation reaction. However, neutrons can be also produced by nuclear reactions with much lower energy. Using this method, facilities can be smaller and lower in price than traditional methods. We are building a small neutron source using the tandem accelerator of Kyoto University. To produce neutrons, we used 7Li(p, n) reaction with 3MeV protons. In order to obtain thermal and cold neutrons, we used polyethylene and the mesitylene moderator, which was cooled down to 10K with a refrigerator, respectively. The production of the thermal neutrons was already confirmed, by measuring the time-of-flight of moderated neutrons. However, we could not confirm the production of cold neutrons. Finally, we are planning to utilize thermal neutrons for experiments, such as neutron capture.
GB.00057 High-Multiplicity Clustering in the Barrel Electromagnetic Calorimeter at STAR 1

DARRICK JONES, Cyclotron Institute, Texas A&M University (REU Student from The College of New Jersey), STAR COLLABORATION — The STAR detector at RHIC is used to investigate the formation and properties of the Quark Gluon Plasma (QGP), which is believed to be created in heavy-ion collisions. High-$p_T$ hadron suppression was discovered and attributed to energy loss of initially scattered partons in the medium. Because direct photons are produced early and do not interact with the evolving medium, a $\gamma$-jet coincidence serves as an effective probe of the medium. For such an analysis, $\pi^0$-decay photons must be distinguished from direct photons. The sub-detector that measures photons is the Barrel Electromagnetic Calorimeter (BEMC), which contains the Barrel Shower Maximum Detector (BSMD). Using the high (position) resolution of the BSMD, an algorithm was previously developed for high-multiplicity events. This algorithm is being modularized for implementation into libraries to be made available to all members of the STAR collaboration. We describe how the algorithm takes advantage of the structure of the BSMD and detail the methods used to distinguish direct photons from $\pi^0$ decay photons.

1 Funded by DOE and NSF-REU Program.

GB.00058 Altering Beamline Components to Reduce the Cost of Prostate Cancer Treatment

T. JONES, A. GEIBLER, R. ZHANG, W.D. NEWHAUSER, The University of Texas M. D. Anderson Cancer Center — Proton beam therapy is an advanced technique used for the control of localized cancers. Currently it is one of the most cutting edge treatment options for prostate cancer but is still scarce and expensive. The expense is due, in part, to the unique beam collimators and range compensators that are manufactured for each treatment beam. The purpose of this study is to determine whether the custom collimator could be replaced by a reusable multileaf collimator and by eliminating the range compensator. Treatment plans were retrospectively selected for 10 patients who were treated for prostate cancer with 69 Gy delivered by two proton treatment fields. The originals were altered to include the multileaf collimator and to eliminate the range compensators. The dose distributions for each plan were calculated using a treatment planning system, which uses an analytical dose algorithm. They were then verified with Monte Carlo simulations, which are able to take into account individual particle trajectories and calculate dose resulting from stray neutron exposure. The calculated dose distributions for the altered treatments were dosimetrically equal or superior to the original plans. Our findings suggest that the proton-beam treatment technique for prostate cancer could be substantially simplified, thus yielding substantial cost savings.

GB.00059 Systematic Uncertainties of Out-of-Plane Measurements of the Fifth Structure Function of the Deuteron

MATTHEW JORDAN, GERARD GILFOYLE, The University of Richmond, CLAS Collaboration — We have measured the $H(e,e'p)$ reaction and the asymmetry $A_{L}$ associated with the fifth structure function in quasi-elastic electron scattering from deuterium at a beam energy of 2.56 GeV and over the range $Q^2 = 0.2 - 2.0$ GeV$^2$ with the CLAS detector at Jefferson Lab. The data were collected using both magnet polarities to explore different $Q^2$ regions. We extracted $A_{L}$ as a function of missing momentum $(p_{TM})$ using spectra weighted by $\sin \phi_{\gamma}$ where $\phi_{\gamma}$ is the angle between the electron scattering plane and the plane defined by the ejected proton and 3-momentum transfer. To understand the systematic uncertainties on $A_{L}$ we varied the positions of the cuts placed on the data used to define the position of the deuteron target, the active region of the electromagnetic calorimeters (EC), the sampling fraction of the EC, and the production of photoelectrons in the Cherenkov counters. These results show a systematic uncertainty of less than 1% in regions of high statistics and much lower than the statistical uncertainty across the full $p_{TM}$ range. We combined these results with our previous study of systematic uncertainties on our identification of the proton and neutron. Work supported by US Department of Energy contract DE-FG02-96ER40980.

GB.00060 Optimized Bunching and Other Improvements to the HIS Ion Source 1

FREDERICK JUNG, ANI APRAHAMIAN, WANPENG TAN, University of Notre Dame — Ion sources for nuclear accelerators produce a constant stream of particles, but for some nuclear reactions, it is useful to have discrete packets of accelerated particles hit the target. Bunchers create these groups of particles that hit a target at a specific point in time. This project found optimum buncher settings for $^4$He and proton beams at Notre Dame’s FN Tandem Accelerator. A tantalum target was bombarded with the $^4$He and the proton beams. The resultant gamma rays were detected by a BaF$_2$ detector placed outside the target chamber. In this way, the resolution of each setting could be determined, and ultimately, the optimal resolution could be found. The optimal resolution was found to be 1.82 ns for $^4$He, when the buncher was set at 95 mV, the sweep was set at 2 V, and the High Voltage Platform was set at 30 V. The optimal resolution for the proton beam was not able to be found, as a clean resolution could not be achieved. This means that a more extensive study of the SNICS ion source needs to be made.

1 NSF-PHY05-52843

GB.00061 Ambient Neutron Flux Measurements at Kimballton Underground Research Facility (KURF)

DAVID KALEKO, REYCO HENNING, University of North Carolina at Chapel Hill, WERNER TORNOW, Duke University — It is important to accurately measure the ambient neutron flux at the Kimballton Underground Research Facility (KURF) in Virginia for the low background experiments housed there, some of which are associated with the MAJORANA project. This paper presents initial results for measurements of the neutron flux at KURF, which will be compared to those from other sites around the world.

GB.00062 Developments of thick solid neon as an active target

NAGAAKI KAMIGUCHI, TETSURO MORIGUCHI, AKIRA OZAWA, Institute of Physics, University of Tsukuba, SIGERU ISIMOTO, KEK — One of research subjects in our group is to measure reaction cross sections ($\sigma_R$) of RI beams. By measuring $\sigma_R$, we can deduce root mean square radii of unstable nuclei. In the measurements of $\sigma_R$, we usually used a carbon as the reaction targets (a few cm thickness). If we use the reaction target as a detector (active target), there are some advantages in the measurements (1) The events only colliding with the reaction target can be selected. (2)If position information is available, we may define the colliding point inside the target. (3)If energy information is available, we may measure the energy loss of the beams inside the target. As the active target in the $\sigma_R$ measurements, we noticed the solid neon. Since the neon is a noble gas, it is predicted to emit scintillations and work as an ionization chamber for charged particles. Indeed, scintillations from liquid and solid neon have been already observed. We will present production of the thick solid neon (~30mm thickness), and observations of scintillations and ionization signals from the solid neon. We will also discuss possibility to use the solid neon as the active target in the $\sigma_R$ measurements.

GB.00063 Commissioning the STAR Zero Degree Calorimeter as a Local Polarimeter at $\sqrt{s} = 500$ GeV

NATHAN KELLAMS, JASON WEBB, Valparaiso University, DAVID GROSNICK, JOSHUA KELLAMS, Ball State University, STAR COLLABORATION — Experiments over the past thirty years have shown that only approximately 30% of the spin of the proton is due to its valence quarks. The balance must be accounted for by the spin and orbital motions of the quarks, antiquarks and gluons. The STAR experiment at the Relativistic Heavy Ion Collider (RHIC) measures spin asymmetries in both longitudinally and transversely polarized proton-proton collisions to investigate the origin of the proton’s spin. Residual transverse components of longitudinally polarized collisions are determined by measuring the polarization vector locally through a transverse single-spin asymmetry in forward hadron production. The Zero Degree Calorimeters (ZDCs) measure both the energy and the position of neutral hadrons produced at forward angles. The analyzing power, $A_{LT}$, can be measured in transversely polarized proton-proton collisions and then used with the spin asymmetries observed in longitudinally polarized collisions to extract the polarization vector of the nominally longitudinal beam. In this presentation we will present measurements of $A_{LT}$ and its commissioning as a local polarimeter at STAR.
GB.00064 Investigation on Periodic Oscillation in Orbital Electron Capture Decay in $^{140}$Pr . K. KISAMORI, Y. KUNIWARA, M. FUKUDA, Osaka University, D. NISHIMURA, Y. FUJITA, K. MAKISAKA, R. MATSUMIYA, K. MATSUTA, M. MIHARA, T. SUZUKI, A. TAKAGI, T. YAMAGUCHI, R. YOKOYAMA, Osaka University — According to recent experimental data at GSI , periodic oscillation have been observed in orbital electron capture (EC) of Hydrogen-like ion $^{140}$Pr$^{8+}$ . They reported that this phenomenon can be explained by the neutrino mass difference . In order to test the existence of such a periodic oscillation in the decay of $^{140}$Pr under the normal condition, we carried out an experiment to observe the EC decay of $^{140}$Pr at the Van de Graaff accelerator facility in Osaka University. A 4.7-MeV proton beam was used to produce $^{140}$Pr through the $^{140}$Ce(p,n)$^{140}$Pr reaction. Observing K-X rays of Ce emitted just after the EC decay by using a Ge detector, a decay curve of $^{140}$Pr was obtained. We could accumulate the time spectrum of the K-X rays with a good statistics under the low background condition. As a result, a finite-size component of the periodic oscillation could not be observed. We will discuss the experimental details and the result comparing with the GSI result.

GB.00065 A follow-your-nose tracker for the NIFFTE TPC . R. KUDO, J.L. KLAY, California Polytechnic State University, NIFFTE COLLABORATION — The Neutron Induced Fission Fragment Tracking Experiment (NIFFTE) will employ a compact, pressurized Time Projection Chamber (TPC) to study neutron-induced fission of the major actinides. The software to reconstruct the fragment tracks in the TPC must be capable of sifting through the large volume of sampled data to identify them and determine their (A,Z). This poster presents the status of a “follow-your-nose” tracking algorithm developed for NIFFTE that proceeds in several stages. It first performs 2-dimensional clustering of raw TPC voxels, followed by mountain-finding and hit-fitting to form hits. It then searches for contiguous hits, starting from the outer edge of the TPC near the pad plane where the population is lower, and working inward toward the target. At each step, the most likely location for the next hit is predicted by a straight-line extrapolation of the current list of hits associated to the track. Track-fitting and error correction are completed once no more hits are found to belong to a given track. The status of the track finder and its performance on simulated events will be presented.

GB.00066 Empirical Determination of Effective Germanium Detector Efficiency for Use in Sample Assays . BENJAMIN H. LAROCQUE, L. LAROCQUE, UNC Chapel Hill, S.R. ELLIOTT, V.E. GIUSEPPE, L. LAROCQUE, R.A. JOHNSON, Univ. of Wash., MAJORANA COLLABORATION — The MAJORANA project is an experiment which uses gamma ray detectors made of enriched Ge-76 to detect neutrinoless double-beta decay, a process which would indicate that the neutrino is its own antiparticle. Studies of such a rare decay process require very low background levels, making contamination by neutrons at the Earth’s surface potentially significant. To quantify this contamination, a piece of enriched germanium was exposed to a slow neutron beam before being assayed using a low background gamma ray spectrometer. The analysis of the assay data is dependent on knowing the detector’s efficiency at the sample gamma energies. Those values can be interpolated from an empirically determined efficiency curve but producing such a curve is nontrivial because efficiency values are also needed to correct for the coincidence summing effects from gamma cascades and positron annihilations. The process of generating a partially efficiency curve will be presented along with the analysis used to account for coincidence summing and the results of the sample assay.

GB.00067 Characterization of the MARS Velocity Filter for Low Velocity Ions1 . K.R. LAWRENCE, Florida A&M Univ., M.C. ALFONSO, A. AL-HARBI, E. BERDUGO, P.J. CAMMARATA, C.M. FOLDEN III, Cyclotron Institute, Texas A&M Univ. — A program to study the heaviest elements using the MARS separator at the Cyclotron Institute at Texas A&M University has begun. MARS is typically used for light energetic ions, which travel at high velocities (>).MARS has been modified for use with low velocity ions (<<). The separator was tuned with the velocity filter off and no degrader in place. The velocity filter was turned on and the electric field was set. The magnetic field was working inward toward the target. At each step, the most likely location for the next hit is predicted by a straight-line extrapolation of the current list of hits associated to the track. Track-fitting and error correction are completed once no more hits are found to belong to a given track. The status of the track finder and its performance on simulated events will be presented.

GB.00068 Designing and Testing a Database for the Qweak Experiment . REBECCA LEONARD, DAMON SPAYDE, Hendrix College — The Qweak experiment at Jefferson Laboratory in Newport News, Virginia aims to make the first precision measurement of the proton’s weak charge by measuring the parity-violating asymmetry in electron-proton scattering. The weak charge of the proton is directly related to the value of the Weinberg angle, which varies depending on the momentum of the exchanged Z boson. The Qweak experiment will provide a 3% measurement of the Weinberg angle which could indicate new physics if any significant deviation from the prediction is uncovered. A database will be used to store results necessary to make a precise determination of the proton’s weak charge such as detector and beam monitor yield, asymmetry, and error as well as control parameters such as the temperature of the liquid hydrogen target. This talk will discuss the design and testing of this database.

GB.00069 The $B(E2; 4^+ \rightarrow 2^+)/B(E2; 2^+ \rightarrow 0^+)$ Ratio in Even-Even Nuclei . C. LOELIUS, Y.Y. SHARON, L. ZAMICK, G. GURDAL, Rutgers University — We considered 207 even-even nuclei throughout the chart of nuclides for which the NNDC Tables had data on the energies and lifetimes of the $2^+$ and $4^+$ states. Using these data we calculated for each nucleus the electric quadrupole transition strengths $B(E2; 4^+ \rightarrow 2^+)$ and $B(E2; 2^+ \rightarrow 0^+)$, as well as their ratio. The internal conversion coefficients were obtained by using the NNDC HSICC calculator. For each nucleus we plotted the $B(E2)$ ratio against A, N, and Z. We found that for close to 90% of the nuclei considered the ratio had values between 0.5 and 2.5. Most of the outliers had magic numbers of protons or neutrons. Our ratio results were compared with the theoretical predictions for this ratio by different models—10/7 in the rotational model and 2 in the simplest vibrational model. In the rotational regions (for A < 180 and A > 220) the ratios were indeed close to 10/7. For the few nuclei thought to be vibrational the ratios were usually less than 2. Otherwise, we got a wide scatter of ratio values. Hence other models, including the NpNp scheme, must be considered in interpreting these results.

GB.00070 Spectroscopy of $^{12}$Li1 . ERIC LUNDERBERG, CHRISTOPHER HALL, PAUL DEYOUR, Hope College, ARTEMIS SPYROU, MICHAEL THONESEN, NSCL-MSU, THE MONA COLLABORATION — The spectroscopy of neutron-unbound levels in $^{12}$Li is presented. The $^{12}$Li were formed by a two-proton knockout reaction from a 53.4 MeV/u $^{14}$B beam at the National Superconducting Cyclotron Laboratory. The decay energy spectrum measured with the Modular Neutron Array (MoNA) and Sweeper superconducting dipole magnet experimental setup. The measured decay energy spectrum exhibits one $s$-wave resonance and two $d$-wave resonances. The $d$-wave resonances are modeled by energy-dependent Breit-Wigner line shapes, and the $s$-wave resonance line shape was calculated with a scattering length of -13.7 fm. The specific energies for the two Breit-Wigner resonances are 250±20 keV and 555±20 keV. The observed widths were dominated by the experimental resolution.

1This work was supported by the National Science Foundation; PHY-0651627
GB.00071 Development of a multi-anode ionization chamber. HIROKI MAKINO, Department of Physics, Faculty of Science, Kyushu University, TSUYEYASU MORIKAWA, TETSUO NORO, TOYOKAZU MAEDA, Department of Physics, Faculty of Science, Kyushu University — A multi-anode ionization chamber with a Frisch grid has been developed. An immediate purpose is the use in accelerator mass spectrometry (AMS), but the system will also be applied to measurements in heavy-ion nuclear physics. In order to identify the incident heavy ions, the anode is divided into 16 sections so that the ionization distribution along the ion trajectory (Bragg curve) can be analyzed. Layout of the electrodes, for field shaping, has been determined based on calculations by using a computer code, Poisson-Superfish. A good discrimination of $^{36}$Cl ions from background $^{56}$Fe ions has been shown by the Monte Carlo simulation. For the signal readout, an originally designed charge-sensitive preamplifier was newly made by using conventional operational amplifiers so as to integrate the ionization charge and interface the shaped signal to the electronic modules of existing data acquisition system. These developments are still in progress. In the meeting, the overall performance of the ionization-chamber system investigated by using accelerated heavy ion beams will be presented.

GB.00072 Effects of Finite Size of Nuclei on their Thermodynamic Properties. E.M. MANION-FISCHER, REU student from Kent State University, D.C. FULS, S. SHLOMO, Cyclotron Institute, Texas A&M University — We investigate the effects of finite size on the thermodynamic properties of nuclei. For this purpose we first calculate the single particle level density, $g(\epsilon)$, which was derived using the Thomas-Fermi approximation and a finite single particle potential of a trapezoidal form. We carried out these calculations for nuclei with $Z=N$. We then calculate the level density parameter and the temperature dependence of the excitation energy $E^*$ and the entropy $S$. We demonstrate the important effects the finite size of nuclei has on these values by comparing our results with the values obtained using the commonly adopted Fermi Gas model.

GB.00073 Neutron Detection Efficiency in the Crystal Ball and TAPS at MAMI. ZOE MARINIDES, The George Washington University, A2 AT MAMI COLLABORATION — The aim of the research project is to determine the neutron detection efficiency of the Crystal Ball and Two Armed Photon Spectrometer (TAPS) detector system used in the A2 collaboration at MAMI, at the University of Johannes Gutenberg in Mainz, Germany. A photon beam of energies up to 1.5 GeV is used to investigate photodisintegration and photo-production processes from a deuterium target. By looking at both the breakup of the deuterium into the proton and neutron, as well as coherent $^3$He production, the efficiency of neutron detection can be determined at a range of energies. The results of the efficiency measurements are essential in determining cross sections for future experiments as well as in testing the accuracy of simulations for channels such as double $^3$He production on the neutron.

GB.00074 Low-Background Counting at Homestake. ISELEY MARSHALL, University of South Dakota — Background characterization at Homestake is an ongoing project crucial to the experiments located there. From neutrino physics to WIMP detection, low-background materials and their screening require highly sensitive detectors. Naturally, shielding is needed to lower “noise” in these detectors. Because of its vast depth, Homestake will be effective in shielding against cosmic-ray radiation. This means little, however, if radiation from materials used still interferes. Specifically, our group is working on designing the first low-background counting facility at the Homestake mine. Using a high-purity germanium crystal detector from ORTEC, measurements will be taken within a shield that is made to specifically account for radiation underground and fits the detector. Currently, in the design, there is a layer of copper surrounded by an impenetrable stainless steel casing, which will be manufactured air tight to accommodate for nitrogen purging. Lead will surround the stainless steel shell to further absorb gamma rays. A mobile lift system has been designed for easy access to the detector. In the future, this project will include multiple testing stations located in the famous Davis Cavern where future experiments will have the ability to use the site as an efficient and accurate counting facility for their needs (such as measuring radioactive isotopes in materials). Overall, this detector (and its shield system) is the beginning of a central testing facility that will serve Homestake’s scientific community.

GB.00075 Development of an Automated Target Oscillator For Use in Reaction Studies. WILLIAM MARTIN, Univ. of Tenn., D.W. BARDAYAN, ORNL, K.L. JONES, Univ. of Tenn., J.A. CIZEWSKI, Rutgers — When a high current (greater than 10$^6$ particles per second) of heavy ion beam bombard a plastic target, the energy deposition and heat build up can cause target degradation. In the case of calibration/pilot beams used on thin (100-250ug/cm$^2$) deuterated polyethylene targets, even a short exposure has been found to result in damages such as cracking, burn through, and target carbonization/oxygenation. One way to reduce the deleterious effects of this accumulated energy is to oscillate the target, thereby spreading the deposited energy over a larger area and allowing for an increased rate of heat dissipation. At the HRIBF in Oak Ridge, an automated target oscillation system has been developed using an electronic stepper motor and a control unit equipped with a custom Field Programmable Gated Array (FPGA) circuit board. Taking into consideration varying target sizes and beam densities, the algorithm loaded onto the FPGA allows the user to adjust both the frequency and amplitude of oscillation. Conclusive testing shows that incorporation of the target oscillator apparatus introduces no detectable electromagnetic noise to the detector array. Live beam testing is planned in the near future, and it is anticipated that the target oscillator will greatly assist HRIBF’s efforts to maintain target integrity during calibration and experiments.

GB.00076 Combining the Statistical and Meson Cloud models of the Proton. TYLER MATOSSIAN, Seattle University — The meson cloud model of [1] of the proton is extended to include the statistical model of [2] to study the $\overline{\chi}$, $\pi$ asymmetry in the population of sea quarks in the proton. The meson cloud model represents the proton in terms of non-perturbative fluctuations into meson-baryon pairs. The statistical model has the proton built up of states which include valence quarks, gluons, and sea quarks, connected in detailed balance through perturbative quark-gluon processes. Although both models provide good agreement with the E866 measurements of $\overline{\alpha}(x)$—$\alpha(x)$, they fail to agree with the $\overline{\alpha}(x)/\alpha(x)$ distribution. In our hybrid model, parton distributions calculated in the statistical model are used for the meson and baryon terms in the meson cloud model. Results will be compared to the E866 experiment.


This research has been supported in part by the Research in Undergraduate Institutions program of the National Science Foundation, Grant No. 0555706.

GB.00077 A windowless He-gas target for astrophysics experiments. SAYAKA MATSUDA, KENSHI SAGARA, TAKASHI TERANISHI, KUNIHIRO FUJITA, RIE IWABUCHI, MASASHIKO TANIGUCHI, TAKASHI GOTOH, KEIZYU NAKANO, NOZOMI OBA, HIROYUKI YAMAGUCHI, Department of Physics, Kyushu University — In He-burning in stars $^4$He($^{12}$C,$^{16}$O)$\gamma$ reaction plays an important role, however, the reaction cross section at stellar energy has not been measured yet. This experiment is very difficult. To measure the $^4$He($^{12}$C,$^{16}$O)$\gamma$ cross section, a thick (24Torr x 3cm) windowless $^4$He gas target has been developed at Kyushu University. Structure of the windowless gas target and measurement of the target thickness using a proton beam will be reported.
will determine the anti-down to anti-up quark asymmetry to a much larger Bjorken-x than was attained by its predecessor, E-866/NuSea. At its highest

E-906 COLLABORATION — Fermilab E-906 will use the Drell-Yan process to improve our knowledge of the structure of the nucleon. This experiment

and drift chambers will be used to reconstruct particle trajectories to separate events originating in the target from those originating from the internal beam

spectrometer consisting of four detector stations, similar to the E866/NuSea spectrometer. A fast level one trigger will come from eight hodoscope planes. Wire

Injector to collide protons with targets of liquid hydrogen, liquid deuterium and solid nuclear targets. The detector under construction is a two-magnet, focusing

E-906 will use nuclear targets to measure partonic energy loss in cold nuclear matter and study anti-shadowing. E-906 will use the Fermilab 120 GeV/c Main

influence of nuclear masses and beta decay rates on the

capture, nucleosynthesis require nuclear data such as masses, beta decay rates, and neutron capture rates for thousands of nuclei far from stability. While the

, ANA PAOLA MIKLER, REBECCA SURMAN, Union College — Simulations of

by using NMR techniques (adiabatic fast passage). We will show the consistency of these two measurements and the resulting precision of neutron polarimetry

We focus on nuclei in the

of the existing studies on the influence of neutron capture rates on the

process has been well studied, neutron capture rates have received less attention. Furthermore most

process or a main

process or a main

0.5. In addition,

He cell. An

He cell. An

proceed from negative squared matrix elements of the weak potential. The most positive squared matrix elements involve the interaction of the weak potential

work done by the Fermilab E-906 Drell-Yan Experiment1,1, BENJAMIN MILLER, Abilene Christian University, FERMILAB E-906 COLLABORATION — E-906 will use the Drell-Yan process to improve our knowledge of the structure of the nucleon. This experiment

will determine the anti-down to anti-up quark asymmetry to a much larger Bjorken-x than was attained by its predecessor, E- 866/NuSea. At its highest

measurements, E-866/NuSea hints at very interesting behavior for this ratio. E-906 will extend the light anti-quark asymmetry to x ~ 0.5. In addition, E-906 will use nuclear targets to measure partonic energy loss in cold nuclear matter and study anti-shadowing. E-906 will use the Fermilab 120 GeV/c Main

injector to collide protons with targets of liquid hydrogen, liquid deuterium and solid nuclear targets. The detector under construction is a two-magnet, focusing

spectrometer consisting of four detector stations, similar to the E866/NuSea spectrometer. A fast level one trigger will come from eight hodoscope planes. Wire

and drift chambers will be used to reconstruct particle trajectories to separate events originating in the target from those originating from the internal beam
dump.
GB.00085 Design and Automation of an Induced Depletion Experiment on $^{108m}$Ag$^{1}$. I. N. MILLS, G.P. TRESSES, C.J. SWEENEY, T.A. BALINT, Youngstown State University, S.A. KARAMIAN, JINR, Dubna, J.J. CARROLL, Youngstown State University — Nuclear isomers may be able to store and provide energy for certain applications. To determine if a particular nuclear isomer is a good candidate for such an application, an experiment must demonstrate an induced depletion. This depletion would bypass the slow decay transitions of the metastable state by exciting the nucleus into a shorter-lived, higher-energy intermediate states with a decay branch that leads to the ground state. An experiment is being conducted at Youngstown State University’s X-Ray Effects Laboratory as part of the Isomer Physics Project which has been custom designed to test induced depletion of $^{108m}$Ag by bremsstrahlung. The poster will cover the design of the experiment, the use and development of an automated control and DAQ system, and initial results.

$^{1}$Supported by DTRA.

GB.00086 Simulating the Neutron Detection of the CLAS12 Detector$^{1}$. MARK MOOG, GERARD GILFOYLE, MATT KING, CLAS COLLABORATION — We have studied the expected performance of the CLAS12 detector that will be built at Jefferson Lab as part of the 12-GeV Upgrade. The Upgrade hopes to further our understanding of the internal structure of nucleons by studying nucleon properties such as form factors and generalized parton distributions. The CLAS12 detector will consist of drift chambers, scintillators, Cherenkov counters, calorimeters, and a vertex finder. The initial round of experiments for the 12-GeV upgrade include ones that require neutron detection and are underway in preparation for such experiments. To study CLAS12’s performance we generated the four-momenta of an electron and neutron after a relativistic, elastic collision and passed these data into the GEANT4-based program gemc. The code uses the four-momenta of these particles and simulates their interaction with the components of the detector. Reconstruction of the events was done with the program Socrat. By comparing the number of reconstructed neutron events to the number of thrown neutron events we extracted the efficiency of the outer time-of-flight scintillators. A precise knowledge of the neutron detection efficiency is required to keep systematic uncertainty low in future experiments.

$^{1}$University of Richmond

GB.00087 Fluorescence Efficiency of Tetra-Phenyl-Butadiene, D.A MOORE, J. MAASSEN, Los Alamos National Laboratory, Dakota State University, V.M. GEHMAN, S. SEIBERT, A. HIME, K. RIELSE, Los Alamos National Laboratory, D. MEI, Y. SUN, University of South Dakota, DEAP/CLEAN COLLABORATION — Tetra-Phenyl-Butadiene (TPB), a known organic wavelength shifter, converts UV scintillation light into visible light detectable by Photomultiplier Tubes (PMTs). Experiments based in liquid argon, such as CLEAN and DEAP require TPB to correct for the sensitivity of the PMTs. The primary objective of these experiments is detecting WIMPs (Weakly Interacting Massive Particles) that may compose the dark matter in the Universe. We systematically investigated the effects of different wavelengths on TPB-coated acrylic disks using a deuterium lamp as a source of UV light, a monochromator, and a calibrated photodiode detector. We tested a variety of thicknesses of TPB on acrylic disks and blank disks to analyze the spectra and shed new light on several properties and attributes of TPB. We examined the emission spectrum of TPB and evaluated the conversion efficiency (photons out / photons in) in order to broaden the knowledge of how to optimize the visible light collection on the PMTs, while aiding in several modeling processes. We will present our findings on the efficiency and spectral emission of TPB, along with images of the actual setup, as well as possible future research.

GB.00088 Simulations to Understand the Calibration of the PHENIX Muon Piston Calorimeter, STEVEN NITSCHWILLER, PHENIX COLLABORATION — In 2007, the Relativistic Heavy Ion Collider (RHIC) generated $\sqrt{s}$ = 200 GeV Au + Au collisions. The PHENIX Muon Piston Calorimeter will allow a measurement of transverse energy in the forward/backward region ($3.1 < |\eta| < 3.8$) but first the detector must be calibrated in this high occupancy environment. In order to understand the steps that must be taken with the real data, a simulated set of $\pi^0$s were generated and allowed to decay. Same event photon pairs and mixed event photon pairs were used to generate histograms with signals plus combinatoric background, and histograms with only combinatoric background. Normalization of the background histogram and subtraction from the histogram with the signal recovered the original sample of pions. Having accomplished this, identical steps were performed on the real data.

GB.00089 The design and commissioning of a polarized helium-3 test stand, TIMOTHY NICHOLS, DAMON T. SPAYDE, Hendrix College — Many experiments, such as the neutron electric dipole moment (nEDM) experiment, are interested in achieving high degrees of polarization and long relaxation times in helium-3 in order to complete their measurements. It is possible to add another degree of sensitivity to the aforementioned experiment by using a technique known as spin dressing. In this technique the polarized helium-3 sample is placed into a large uniform magnetic field, known as the holding field. A radio frequency (RF) field is then applied transverse to the holding field altering the effective gyromagnetic ratio and propagation are unique probes to the dense matter created at RHIC. The HFT (Heavy Flavor Tracker) is a proposed detector upgrade of STAR, capable of measuring $D_s^{*}$, $K_s^{*}$, $K^-$ at displaced vertices as a function of transverse momentum. We present preliminary results on the statistical significance of the reconstructed $D_s$ signal as well as on the $D_s$ detection efficiency using HFT. The physics impact of the $D_s$ measurement will also be discussed.

GB.00090 $D_s$ Meson Reconstruction from STAR Heavy Flavor Tracker$^1$, OUMAROU NJOYA, Michigan State University, STAR COLLABORATION — Nuclear-Nucleus Collisions at RHIC (the Relativistic Heavy Ion Collider) have produced a strongly interacting dense partonic matter whose degrees of freedom are governed by the Quantum ChromoDynamics (QCD). The Solenoid Tracker At RHIC (STAR) is an ongoing major experiment which aims to study the properties of the QCD matter under extreme energy density, pressure, and temperature. Heavy quark production and propagation are unique probes to the dense matter created at RHIC. The HFT (Heavy Flavor Tracker) is a proposed detector upgrade of STAR, capable of reconstructing open charm hadrons from hadronic decay channels. We carry out a study of $D_s$ meson reconstruction using GEANT simulations. We reconstruct $D_s$ mesons through a 3-body decay of $K^+ K^- \pi$ at displaced vertices as a function of transverse momentum. We present preliminary results on the statistical significance of the reconstructed $D_s$ meson, signal as well as on the $D_s$ detection efficiency using HFT. The physics impact of the $D_s$ measurement will also be discussed.

$^1$NSF, UCLA

$^2$HFT, UCLA

GB.00091 Observation of neutron-unbound resonant states in 23O and 28Ne. JOHN NOVAK, Western Michigan University, NSCL/MSU, STEVE QUINN, MICHAEL STRONGMAN, SHEA MOSBY, ARTEMIS SPYROU, THOMAS BAUMANN, MATT KING, CLAS COLLABORATION — The decay energy spectra of neutron-rich 23O and 28Ne were measured. The isotopes were produced in stripping reactions from a 85MeV/u 29Na beam on a beryllium target. Neutrons were measured in coincidence with light neutron-rich fragments produced in stripping reactions from an 85MeV/u 29Na beam on a beryllium target. The neutrons were detected with the Modular Neutron Array (MoNA) and the fragments were analyzed with the MSU/FSU Sweeper magnet system. Low-energy resonances close to the neutron-separation energies were observed in both system. The results for 23O agrees with a previous measurement$^1$ and the resonance in 28Ne was observed for the first time.

GB.00092 Structure of $^{206}$Radium\textsuperscript{1}. PAUL ORLAND, A. SCHMIDT, A. HEINZ, R. WINKLER, J. QIAN, T. AHN, R. CASPERSON, G. ILIE, D. MCCARTHY, J.R. TERRY, V. WERNER, E. WILLIAMS, Yale University — Various radium isotopes have been investigated in the past in order to study the onset of collectivity below $N=126$. Here we present results of an investigation of $^{206}$Ra which has six protons above the $Z=82$ shell closure and eight neutron holes in the $N=126$ neutron shell closure. Though experiments on $^{206}$Ra have previously been performed, this is the first time prompt gamma ray transitions have been measured. Using the technique of recoil decay tagging at the gas-filled Small Angle Separator System at Yale for Evaporation Residues (SASSYER), $^{206}$Ra and other isotopes were identified at the focal plane and correlated to their prompt gamma rays detected at the target position. A comparison of $^{206}$Ra with neighboring isotopes, especially with respect to trends in collectivity, is presented.\textsuperscript{2}This work was supported by U.S. DOE Grant No. DE-FG02-91ER-40609.

GB.00093 One Proton Knockout from $^{83}$As\textsuperscript{1}. J.L. PALARDY, B.A. HARTL, L.A. RILEY, Ursinus College, T.R. BAUGHER, D. BAZIN, A. GADE, T. GLASMACHER, G.F. GRINERY, S. MCDANIEL, R.T. MEHARCHAND, A. RATKIEWICZ, K.A. WALSH, D. WEISSHAAR, National Superconducting Cyclotron Laboratory, Michigan State University — We present a one-proton knockout measurement from the $N=50$ nucleus $^{83}$As, conducted at the National Superconducting Cyclotron Laboratory at Michigan State University (NSCL). A cocktail beam composed primarily of $^{52}$Ge (56%) and $^{48}$As (35%) was produced through fragmentation of a $^{86}$Kr beam incident on a $^{9}$Be primary target. Incoming beam particles are identified by time of flight, and reaction products are identified with the S800 Magnetic Spectrograph. Gamma rays from the beam-like reaction products were captured by the Segmented Germanium Array (SegA). Preliminary results will be discussed.\textsuperscript{2}This work was supported by the National Science Foundation under Grant Nos. PHY-0653323 and PHY-0606007.

GB.00094 Performance of a 2m prototype neutron detector for VANDLE\textsuperscript{1}. CASEY PANGAN, J.C. BLACKMON, L.E. LINHARDT, M.M. WHITE, Louisiana State University, J.A. CIZEWSKI, P. O’MALLEY, W.A. PETERS, Rutgers University, D.W. BARDAYAN, Oak Ridge National Lab, R. GRZYWACZ, M. MADURGA, S. PAULAUŠKAS, University of Tennessee, C. MATEI, B.C. RASCO, Oak Ridge Associated Universities, F. RAIOLA, F. SARAZIN, Colorado School of Mines — VANDLE (Versatile Array for Neutron Detection at Low Energies) is an array of plastic scintillator detectors that is being developed for measurements with radioactive ion beams. The array will consist of over 200 scintillator elements in two different shapes that can be configured in a variety of geometries to achieve efficient neutron detection with good time-of-flight for different types of measurements. We have constructed a 2 meter long prototype detector element for VANDLE and characterized its performance through a variety of measurements using cosmic rays, neutron and gamma sources. The position resolution, time resolution, light output, efficiency, and neutron-gamma discrimination by time-of-flight have all been studied. Results from these tests will be presented. Plans for a test measurement of the (d,n) reaction using a number of these detector elements will also be discussed.\textsuperscript{2}This work supported by the U.S. Dept. of Energy.

GB.00095 Instillation of Resistive Plate Chambers for the PHENIX Detector. LANGSTON PARKS, Morgan State University, PHENIX COLLABORATION — The muon trigger upgrade for Pioneering High Energy Nuclear Interaction eXperiment (PHENIX) will allow for faster and more accurate studying of flavor separated quark and anti-quark spin polarizations in the proton. One way to measure these polarizations is through the analysis of single spin asymmetries for $W$-boson production in proton-proton collisions. PHENIX is capable of measuring high momentum muons at forward rapidity, however the current trigger is not capable of separating leptons from $W$-decay. The goal of the upgrade is to improve the ability of the Relativistic Heavy Ion Collider (RHIC) to collect and analyze muons that decay from $W$-bosons produced in polarized proton-proton collisions. To achieve this goal Resistive Plate Chambers (RPCs) will be installed at the PHENIX detector located at RHIC along with new front-end electronics. This poster will discuss the installation of the RPCs.

GB.00096 Gamma Ray Spectroscopy and SASSYER. BENJAMIN PAUPERSTEIN, CAIN BONNIWELL, J.M. ALLMOND, C.W. BEAUSANG, University of Richmond, UNIVERSITY OF RICHMOND COLLABORATION, LAWRENCE BERKELEY NATIONAL LAB COLLABORATION, LAWRENCE LIVERMORE NATIONAL LAB COLLABORATION — An experiment was performed to study the Gd and Tb nuclei resulting from a 27 MeV proton beam on a 159Gd target. This work was conducted at Lawrence Berkeley National Laboratory using the STARS/LIBERACE array. The main focus of the experiment was on charged particle channels (p,d) into 155Gd and (p,t) into 154Gd. However, the trigger was either gamma-gamma or particle-gamma so new data was also obtained on 155Tb nuclei following fusion evaporation reactions. Preliminary analysis was conducted at Wright Nuclear Structure Lab where RADIWARE programs were used to analyze the data and search for unknown gamma rays. A second, separate, experiment was conducted using the SASSYER (a gas-filled separator at Yale). In this experiment, fission fragments from a 252Cf source were focused to a DSSD and a Ge detector was used to search for either gamma-decay from long lived isotomers in the fission fragments or to find gammas from recoil-beta-decay tagging on the fission fragments. The data collection seems to have gone smoothly, and the data is currently being sorted for analysis. This work was supported by the US Department of Energy under grant numbers DE-FG02-52NA26206 and DE-FG02-05ER41379.

GB.00097 The R-process, nucleosynthesis, and new nuclear masses, NANCY PAUL, University of Notre Dame — Precise, accurate measurements of nuclear masses are crucial for astrophysical modeling, reproducing the observed solar abundances of the elements, and for disentangling the nuclear physics imprinted on those abundances. More generally, masses are necessary for understanding nucleosynthesis via the r-process, thought to be responsible for over 50% of the elements heavier than Iron. The advent of ion traps and storage rings has generated a profusion of very precise measurements since the 2001 Atomic Mass Evaluation. I compiled an up-to-date list of new measurements from labs worldwide and incorporated them into Bradley Meyer’s (Clemson University) classical model of the r-process to examine the impact of the new measurements. Sensitivity studies of various theoretical mass models and the new measurements in the r-process code, showed the largest deviations in the $A = 70 – 85$ mass region. These studies will be used to plan new measurements of nuclei along the r-process path, near $^{77}$Ni.

GB.00098 NIFFTE TPC Experiment: Slow Controls, NATHAN PICKLE, Abilene Christian University — The Time Projection Chamber (TPC) experiment conducted by the Neutron-Induced Fission Fragment Tracking Experiment (NIFFTE) collaboration will allow for unprecedented precision in observing neutron-induced fission events. Previous fission detectors only registered quantity and magnitude of events; the TPC will be capable of reconstructing a track for each fragment that is detected. Developing a better understanding of fission events will allow for the design of nuclear reactors that are more efficient and produce minimal waste. The slow controls portion of the data acquisition (DAQ) system for this experiment will set and monitor high and low voltages, as well as make measurements of temperature, barometric pressure, humidity, and other factors that might affect experimental results. The Maximum Integration Data Acquisition System (MIDAS) framework software will be used as the basis of the slow controls DAQ system. IOTech DaqScan/2001 hardware will be used with DBK50 and DBK51 modules to monitor voltages, and DBK90 modules to record temperature. Support for other hardware modules may be added in the future. The presented work includes device driver development and DAQ system construction.
GB.00099 Using Support Vector Machines for $D^0$ Reconstruction in STAR Simulations, BIJAN POURHAMZEH, University of California, Berkeley, STAR COLLABORATION — The STAR Collaboration proposes to construct a microvertex detector, called the Heavy Flavor Tracker (HFT), using components made up of active pixel sensors and silicon strips to study the quark-gluon plasma (QGP). The HFT is designed to measure heavy mesons containing $c$ and $b$ quarks, such as the $D^0$ meson. These heavy quarks are an ideal probe to study the QGP. Support Vector Machines (SVMs), which are a set of kernel-based learning methods used for classification and regression, provide one candidate method for $D^0$ reconstruction in the HFT. Given two sets of training data, viewed as vectors in an $n$-dimensional space, the SVM will construct an $(n - 1)$-dimensional hyperplane which maximizes the separation between the data, while minimizing misclassification error. Using the hadronic decay channel, $D^0 \rightarrow K^- + π^+$, our preliminary results show that with a Radial Basis Function (RBF) kernel, $K(x, z) = \exp(\|x - z\|^2)$, SVMs can correctly classify pion-kaon pairs with a very high success rate. We compare the performance of SVM reconstruction with the currently implemented reconstruction method, and determine which yields a greater signal significance, $S/\sqrt{S + B}$, per $p_T$ bin.

GB.00100 Non-Resonant Neutron Emission of Excited Neutron-Rich Nuclei, STEPHEN QUINN, Notre Dame, NSCL/MSU, JOHN NOVAK, MICHAEL STRONGMAN, SHEA MOSBY, ARTEMIS SPYROU, THOMAS BAUMANN, MICHAEL THOENNESSEN, NSCL/MSU, MONA COLLABORATION — Neutron-decay spectroscopy of neutron-unbound states at and beyond the dripline rely on the correct description of non-resonant events underlying the resonance states. In order to understand the origin of these events, decay energy spectra of isotopes with no apparent resonances were analyzed. Neutrons were measured in coincidence with light neutron-rich fragments produced in stripping reactions from an 85MeV/u 29Na beam on a beryllium target. The neutrons were detected with the Modular Neutron Array (MoNA) and the fragments were analyzed with the MSU/FSU Sweeper magnet system. The decay energy spectra of the isotopes 18N, 19N, 20N, 21O, 22O, 23F, 24F, 26Ne, and 27Ne were analyzed. No evidence for an isotope dependence was observed, but the spectral shape exhibited differences as a function of element. The description of the data using a thermal emission model will be presented.

GB.00101 Effects of Fluctuations and Inhomogeneities on Jet quenching in High Energy Nuclear Collisions$^1$, ENRIQUE RAMIREZ-HOMS, University of Texas at El Paso, R.J. FRIES, R. RODRIGUEZ, Texas A&M Cyclotron Institute — In a quark-gluon plasma with color degrees of freedom, jets of energetic partons interact and lose energy. They can thus be used to probe its properties. Here we study fluctuations in the nuclear density within the plasma affect this process. The goal is to determine the size of the fluctuations required to have an observable effect on the nuclear modification factor and elliptic flow of pions.

$^1$Funded by NSF-REU Program.

GB.00102 Hydrogen Outgassing in Stainless Steel Gun Chambers, MELISSA RICKETTS — Vacuum quality is an important aspect in electron guns. The hydrogen outgassing rate is a deterministic of the vacuum quality in stainless steel gun chambers. A low outgassing rate allows for a better vacuum and therefore a longer photocathode lifetime. Low outgassing rates depend on thermal treatments of the chamber. The purpose of this project is to put together a gun chamber, and assess the hydrogen outgassing rate after an administered thermal treatment. To determine the hydrogen outgassing rate, pressure measurements of the vacuum chamber must be taken. Once these measurements have been obtained, they can be used along with the known volume and surface area of the chamber to calculate the outgassing rate. A thermal treatment of 400 °C for nine days achieved an outgassing rate of $1.12 \times 10^{-13}$ Torr L/s cm$^2$. The value obtained for the hydrogen outgassing rate is one order of magnitude better than previous outgassing rates. This is because in the past, this specific thermal treatment has never been used. This improvement illustrates the success of the project.

GB.00103 Accurate Position Calibrations for Charged Fragments, AUTUMN RUSSELL, JOSEPH E. FINCK, Central Michigan University, ARTEMIS SPYROU, MICHAEL THOENNESSEN, NSCL/Michigan State University — The Modular Neutron Array (MoNA), located at the National Superconducting Laboratory at Michigan State University, is used in conjunction with the MSU/FSU Sweeper Magnet to study the breakup of neutron-rich nuclei. Fragmentation reactions create particle-unstable nuclei near the neutron drip line which spontaneously break up by the decay of one or two neutrons with energies that reflect the nuclear structure of unbound excited and ground states. The neutrons continue forward into MoNA where their position and time of flight are recorded, and the charged fragments' position and energy are measured by an array of detectors following the Sweeper Magnet. In such experiments the identification of the fragment of interest is done through energy loss and time-of-flight measurements using plastic scintillators. The emitted angles of the fragments are determined with the use of CRDCs. The purpose of the present work was the calibration of the CRDCs in the X and Y axis (where Z is the beam axis) using specially designed masks. This calibration was also used for the correction of the signal of the plastic scintillators, which is position dependent. The results of this work are used for the determination of the ground state of the neutron-unbound $^{24}$Na.

GB.00104 Geant Simulation of Cosmic Ray Veto System, MATTHEW RUSSELL, University of Notre Dame — The double-beta decay processes can provide essential details on the interactions of neutrinos, and many experiments are underway that may be able to detect the highly sought neutrinoless double-beta decay channel. This decay can provide a measurement of the absolute mass scale of neutrinos, but only if the Nuclear Matrix Elements (NME) of the candidate nuclei are known to high precision. Predictions for the NMEs of one of the most heavily studied candidates, $^{76}$Ge, vary by at least 50% and need to be further investigated. The University of Notre Dame Nuclear Structure Lab is in a unique position to probe the pairing structure of nucleons in $^{76}$Ge via a two-proton transfer reaction. A time of flight measurement identifies neutrons from the $^{76}$Ge($^{12}$C,2p) reaction using a large acceptance neutron detector. The cosmic ray background in our detector is large compared to the neutron signal, making it necessary to construct a plastic scintillator veto system. The rejection of background is necessary to cut the fractional error in half. A Geant simulation of the veto plastic is necessary in understanding the expected vetoed background signal in our detector and optimizing the rejection system. This project will report on the energy spectrum our Geant simulation predicts from the scintillator, as well as the accuracy of our model compared to the actual energy spectrum taken from our scintillator. The data's relevance to the veto system and error analysis will be discussed.

GB.00105 Systematic Error Studies for a Measurement of the Beta Asymmetry Parameter Using Ultracold Neutrons, REBECCA RUSSELL, California Institute of Technology, UCN COLLABORATION — The angular correlation between a neutron’s spin and the initial direction of its emitted electron when undergoing beta decay is known as the beta asymmetry parameter. This parameter can be used to help search for physics beyond the Standard Model by determining the value of the up and down quark weak mixing angle and testing the unitarity of the Cabibbo-Kobayashi-Maskawa matrix. The UCNA experiment at the Los Alamos Neutron Science Center seeks to obtain a precise measurement of the neutron beta asymmetry by studying the beta decay of a dense population of identically-polarized ultracold neutrons (UCN.) The UCN are produced in a solid deuterium source and are polarized by a static magnetic field. Electrons emitted from the beta decay of UCN travel outwards along solenoidal field lines and enter a multi-wire proportional chamber backed by a plastic scintillator detector. Accurate determination of the events in these detection units is essential to a high-quality measurement of the expected directional asymmetry. The results of systematic error studies of recent UCNA data are presented.
GB.00106 Optimal Seeding of Multiprong Reconstruction of the NovA Prototype Detector1.
DONOVAN RUTH, Kutztown University of Pennsylvania, MARK MESSIER, Indiana University (Bloomington) — NOvA is a research project based at Fermilab that will search for neutrino oscillations in the NuMI muon neutrino beam. The near (at Fermilab) and far (Ash River, MN) detectors are arrays of tubes filled with liquid scintillator oriented alternatively horizontally, and vertically. When a neutrino interacts with a nucleus in the detector, the outgoing charged particles cause the liquid scintillator to ionize and emit visible light which is collected by optical fibers for detection. We can determine the magnitude of charge and position of these particles based on the intensity and pattern of the light given off from the liquid scintillator. A computer program reads the data from every tube, and attempts to reconstruct a vertex where the interaction occurred, and “prongs” or paths in which these particles have travelled by taking data of an event from the detector and seeding a vertex and one prong. Then using a fitter, finds the best fit path for some vertex and the prong, determines if this fit is “good enough” using certain scoring methods and loops through this process using one more prong each time to make a final placement of the vertex and prongs as the best fit to the event. Using simulated events, we have tested several seeding methods for the vertex of this program and determined the most accurate among them. We are currently testing a method to directionally seed these prongs, and have made several other observations of the fitter.

1Work supported by the DOE, Indiana University, and the NSF-REU program in Physics.

GB.00107 Decay Detector For The Study of Isoscalar Giant Monopole Resonances1, CALEIGH SAMUELS, Cyclotron Institute Texas A&M University, Radford University, DAVE YOUNGBLOOD, YIU-WING LUI, JONATHAN BUTTON, Cyclotron Institute Texas A&M University — The nuclear matter incompressibility is extracted from measurement of the energy of giant monopole resonances. This incompressibility term is incorporated in the nuclear matter equation of state, which can be used to physically describe supernovae and neutron stars. Progress has been made in the design, construction, and calibration of a decay particle detector mainly composed of plastic scintillator arrays, which we will use to study the isoscalar Giant Monopole Resonance (ISGMR) in unstable nuclei. Nuclei excited to the ISGMR region are particle unstable and will p, alpha, or n decay shortly after excitation in light nuclei. We explore two methods for predicting the light output by the scintillators of the detector due to energy loss by light ions.

1Funded by DOE and NSF-REU program.

GB.00108 Polarization Correlations of Entangled Photon Pairs from Positronium Decay as a Test of Bell’s Inequality, MINORU SANDA, MOTONOBU TAKAKI, Department of Physics, Kyushu University — It is well known that Einstein, Podolsky, and Rosen (EPR) claimed that quantum mechanics might be incomplete in terms of local realism. Bell showed that experimental verification of local hidden variable theories is possible by comparing with the Bell’s inequality. We measured polarization correlations $\langle AB \rangle$ of two photons produced by positronium decay. Here $A$ and $B$ are the polarizations of photons. The value $\langle AB \rangle$ can be expressed as $-\cos(2\phi)$ where $\phi$ is the angle between the axes of two photon polarizations. The Bell’s inequality gives $\kappa \leq \frac{\sqrt{2}}{2}$ in local realism, whereas non-local quantum mechanics gives $\kappa = 1$ which disagrees with local hidden variable predictions. We have constructed two sets of Compton polarimeters, each of which consists of a liquid scintillator and four NaI scintillators. The photon polarization can be deduced from the azimuthal distribution of Compton scattering. The experimental data was combined in order to reduce experimental false polarizations, and thus we have succeeded to deduce $\langle AB \rangle$ with high accuracy. Our preliminary result is $\kappa = 1.0$. This result is consistent with the prediction based on non-local quantum mechanics, and violates the Bell’s inequality. In the meeting, we will report final results for $\langle AB \rangle$. Furthermore, we will compare our results with theoretical predictions.

GB.00109 Developments of Hadron Blind Detector for $\phi \rightarrow e^+e^-$ measurements at J-PARC, TAMOTSU SATO, Ozawa.lab University of Tokyo — We are proposing a new experiment at J-PARK to measure mass modifications of $\phi$ of two photon polarizations. The Bell’s inequality gives for the PHENIX experiment at BNL and modified for the experiment. Current design has a 50cm Cerenkov radiator operated with pure CF$_2$ to a 3layers-GEM detector with CsI photocathode and a pad-readout is used. CsI is directly evaporated on the top of GEM foil and used as a photocathode. A $\gamma$ experiment using electron-beam at LNS GeV-first photocathode-GEM foil. Thus, we carry out a stable operation. We measured the quantum efficiency of CsI photocathode GEM in pure CF$_2$. The photon polarization can be deduced from the azimuthal distribution of Compton scattering. The experimental data was combined in order to reduce experimental false polarizations, and thus we have succeeded to deduce $\langle AB \rangle$ with high accuracy. Our preliminary result is $\kappa = 1.0$. This result is consistent with the prediction based on non-local quantum mechanics, and violates the Bell’s inequality. In the meeting, we will report final results for $\langle AB \rangle$. Furthermore, we will compare our results with theoretical predictions.

GB.00110 A Signature of New Physics: Determining Missing Energy in the ATLAS Detector, THOMAS SCHMIT, VIVEK JAIN1, DARIA ZIEMINSKA2, Indiana University — Missing energy is a major discriminant for new physics in high energy proton-proton collisions generated by the Large Hadron Collider at CERN. The ATLAS detector, which collects data at the LHC, has a very sophisticated calorimeter that measures the energy and position of particles and jets created in these collisions. A vector sum of the energy of these objects is performed over the entire detector; a non-zero value implies missing energy. When missing energy is large it indicates that a non-interacting particle may have passed through the detector. Accurate reconstruction of missing energy is necessary to identify new particles, such as candidates for dark matter, e.g., the Lightest Super-symmetric Particle. The focus of this survey was on the accuracy of missing energy reconstruction, specifically, on the role of muons that are created in the collisions.

1Advisor
2Advisor

GB.00111 Elemental Composition and Concentration of Upstate New York Rainwater Samples Using the Union College Pelletron Particle Accelerator and Proton Induced X-ray Emission (PIXE) Spectroscopy, KATIE SCHUFF, SCOTT LABRAKE, MICHAEL VINEYARD, CHARLES HARRINGTON, COLIN GLEASON, Union College — A 1-megavolt tandem electrostatic Pelletron particle accelerator housed at Union College was used to measure the elemental composition and concentration of rain water collected in Schenectady, NY in June 2009. A beam of 2.0-MeV protons was directed at an approximately 12-micrometer thick Mylar film substrate onto which 1.0-ML of concentrated rainwater was dried. The interaction of the incident protons with the target material causes inner shell electrons to be ejected and these vacancies are filled by electronic transitions of higher orbital electrons with the production of x-ray photons characteristic of the elemental composition of the target. This is the PIXE Method. Data on the intensity and energy of x-rays were collected using an Amptek silicon drift detector. Spectra of the number of x-rays collected as a function of energy were analyzed and the elemental composition was found to contain Ca, K, S, Cl, Ti, Cr, Fe, Cu, Zn, & Se (added as an internal standard) with concentrations determined using the analysis package GUPIX.
GB.00112 Sensitivity enhancement for the newly commissioned high efficiency CAESAR array via shielding. CHRISTOPHER SEGAL, Department of Physics, Florida State University, Tallahassee, FL 32306, ALEXANDRA GADE, ANDREW RATKIEWICZ, TRAVIS BAUGHNER, Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824, USA, GEOFFERY GRINER, DIRK WEISSHAAR, National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA, MIGUEL BENCOMO, Physics Department, The University of Texas at El Paso, El Paso, Texas 79968-8015 — The CAESIum iodide ARray (CAESAR) has been constructed at the National Superconducting Cyclotron Laboratory (NSCL) to further probe the structure of nuclei and determine their level of deformation by in-beam gamma-ray spectroscopy. Completed in May 2009 the commissioning experiment of Coulomb excitation (Coullex) in $^{56}$Ni was performed with great success. The commissioning run was quickly followed by a second Coullex experiment in the region of $^{170}$Hf with improved shielding against background radiation. The difference in live time, detector efficiency, and detector sensitivity between the two experiments improved noticeably. Quantitative comparisons between the two experiments will provide great insight into the optimization of CAESAR’s performance as well as determining if additional shielding will further improve detection efficiency of the array for future experiments.

GB.00113 Track Reconstruction Techniques for the NIFFTE Time Projection Chamber. SARVAGYA SHARMA, Abilene Christian University — The Time Projection Chamber (TPC), being constructed by the NIFFTE (Neutron Induced Fission Fragment Tracking Experiment) collaboration will be used for high-precision fission cross-section measurements. These measurements will aid in the design of future generation nuclear power plants. The track reconstruction effort has employed various machine-based image processing algorithms, some of which are borrowed from existing high-energy physics experiments. One of the methods investigated, the Hough Transform is a brute force attempt at finding tracks that isolates features in the TPC space by populating histograms. The dimensions of these histograms represent the unknown track parameters. The second, Binary Space Partitioning (BSP), recursively divides the TPC volume until all tracks are segregated. To determine track fit parameters, an iterative Kalman Filter has been implemented that accounts for multiple scattering and kinks in the track. The final tracks obtained from the reconstruction routines are traced back to the origin for vertex reconstruction. Comparing simulated and reconstructed tracks have shown the validity of these track reconstruction methods. This poster shall illustrate these techniques intended for intelligent track finding and track fitting.

GB.00114 PMT Linearity Studies for HAPPEX III. AIMEE SHORE, Smith College, LUIS MERCUADO, University of Massachusetts, HAPPEX III COLLABORATION — HAPPEX is an experiment that will run in Hall A at Jefferson Lab in August – October 2009. The experiment will measure the parity violating electron scattering asymmetry with 3.5 GeV electrons from a liquid proton target at Q2 = 0.62 GeV. The experiment intends to measure the expected asymmetry of 24 ppm to 1% uncertainty. This precision measurement of a small quantity requires minimizing and measuring the non-linearities produced by the detectors.

GB.00115 Lifetime Measurements of $^{170}$Hf and a test of the Confined Beta Soft Rotor Model. M.K. SMITH, Central Connecticut State University, V. WERNER, A. HEINZ, J.R. TERRY, J. QIAN, R. WINKLER, R. CASPERSON, E. WILLIAMS, Yale University, Z. BERANT, Yale, NRC Neveg, R. LÜTTKE, Yale, Darmstadt, B. SHORAKA, Yale, Surrey, G. HENNING, Yale, ENS-Cachen — Significant deviations from rigid rotor model energy level predictions have been known to occur in rare earth nuclei. Recently, it was shown these deviations may be caused by centrifugal stretching effects within the nucleus [1]. New geometrical models have been proposed that account for centrifugal stretching, such as the confined beta soft model (CBS). We present the results from a high precision lifetime experiment performed with the New Yale Plunger Device at WNSL, Yale University. The ground state band of $^{170}$Hf was measured through the J=12$^+$ level using the Recoil Distance Doppler Shift method. Excited states were populated in the $(^{124}$Sn($^{58}$Ti,$n$))$^{170}$Hf fusion evaporation reaction. Using the lifetimes, the E(2) values and the quadrupole deformation parameter are determined. Centrifugal stretching is observed as an increased deviation in energy at higher spins in $^{170}$Hf. These results are compared to theoretical predictions from the CBS rotor model. Supported by grant DE-FG02-91ER40069.


GB.00116 Laser energy absorption and ion production in thick and thin targets. THALASSA SODRE, Muhlenberg College — A fully relativistic model has been developed for the interaction of an intense laser with an overdense plasma. The model is based on conservation laws in one dimension for momentum flux and energy flux across the vacuum-plasma boundary [M. G. Haines et al. Phys. Rev. Lett. 102, 045008 (2009)]. The main results are (a) that the maximum hot electron temperature scales as $(1 + 2^{1/2} n_0)^{1/2} - 1$ in units of the electron rest mass energy and (b) the light absorption can be 80%-90% for intensity $> 10^{19}$ W/cm$^2$. This theory has been extended to the case of a thin target, at the rear boundary of which fast electrons can reflux. Momentum and energy flux conservation leads to surface ion acceleration (typically protons in experiments), while refluxing electrons re-entering the front boundary region lead to greatly reduced laser-light absorption. This is relevant to proton driven fast ignition.

GB.00117 Time and Position Resolution Studies for the VANDLE Prototype Detectors. IRENA SPASSOVA, JOLIE CIZEWSKI, WILLIAM PETERS, Rutgers University, CATALIN MATEI, ORAU — The Versatile Array of Neutron Detectors at Low Energies (VANDLE) was developed to study the properties of unstable nuclei via (d,n) reactions and beta delayed neutron emission. This array is comprised of individual scintillator bars of two set lengths: 2 m and 60 cm, coupled to photomultiplier tubes (PMTs). The attenuation length of the scintillator bar plays a direct role in the detector efficiency while the position and timing calibrations help pinpoint where an event occurred in the bar. By using different configurations and sources, it was possible to measure the attenuation length and the position and timing resolutions. Experiments have also been performed pertaining to the construction of the detectors and the materials used in coupling the scintillator to the PMT. Such tests will help optimize the performance of the detectors. The experimental results for the prototype detectors will be presented.

This work was supported by U.S. DOE and NSF grants.

GB.00118 Measurement of the Target Single-Spin Asymmetry in Quasi-Elastic 3He?(e,e’). JEREMY ST. JOHN, Longwood University, HALL A JEFFERSON LAB COLLABORATION — Experiment E05-015 measured the target single spin asymmetry, Ay for the neutron using the inclusive quasi-elastic 3He?(e,e’) in Hall A at Jefferson Lab with a vertically polarized 3He target at Q2 = 1.0 and 2.3 GeV. Ay is the asymmetry of target spin up versus target spin down, and is sensitive to the two-photon exchange amplitude. For my presentation I will discuss the goals of the experiment, my contributions and, my involvement in creating a new 3He Target lab at Longwood University.

GB.00119 Improving the Accuracy of Neutron Multiplicity Counting. SCOTT STEWART, Abilene Christian University — Neutron Multiplicity Counting is an assay method used in non-destructive analysis of plutonium for safeguards applications. It is widely used in nuclear material accountancy by international (IAEA) and national inspectors. The method uses the measurement of the correlations in a pulse train to extract information on the spontaneous fission rate in the presence of neutrons from (n,n) reactions and induced fission. There is currently interest in improving the accuracy of the technique in order to reduce the number of samples that need to be analyzed chemically. Therefore the achievable accuracy of the technique is being studied in detail. The accuracy of a neutron multiplicity measurement can be affected by a number of variables. Monte Carlo neutron transport simulations with MCNP have been done to understand how the density, isotopic composition, chemical composition and moisture in the material affect the count rate. These calculated count rates have been analyzed with the “point model” in order to determine the effect on the deduced plutonium mass. In practice, dead time in the electronics affects the count rate. Uncorrelated neutron sources have been measured in order to determine optimum settings for dead time compensation.
GB.00120 Alternative RPC Coatings. JASON STRACK, University of Illinois Urbana Champaign, PHENIX COLLABORATION, UNIVERSITY OF ILLINOIS AT URBANA CHAMPAIGN TEAM — The nuclear physics group at the University of Illinois is currently developing techniques to further improve the performance of Bakelite Resistive Plate Chambers (RPCs) for use as muon trigger detectors in experiments at hadron colliders. Muon trigger RPCs at LHC and RHIC typically use Bakelite plates coated with linseed oil. Both Bakelite and linseed oil, however, have high bulk and surface resistivity thus limiting the detection efficiency of the RPC at high rates. Experiments which dope the linseed oil with either carbon or copper are carried out with the goal to select targeted lower surface resistivity values for the coating applied to the Bakelite plates. Two doping procedures have been studied. In the first method a thin layer of graphite is deposited between the Bakelite and the linseed oil. For the second method the graphite or copper powder are deposited on top of the drying linseed oil coating. In this presentation the coating methods will be discussed and the effects of the coating on the RPC position resolution, cluster size and efficiencies will be discussed.

GB.00121 Production and Separation of Radioactive Beams $^{20}$Na and $^{20}$Mg with MARS1. GOPAL SUBEDI, REU student from Colby College, B.T. ROEDER, A.A. ALHARBI, M. MCCLESKEY, E. SIMMONS, A. SPIRIDON, L. TRACHE, R.E. TRIBBLE, Cyclotron Institute, Texas A&M University — We studied the production and separation of $^{20}$Na and $^{20}$Mg using the MARS spectrometer at the Cyclotron Institute, TAMU. Using a $^{20}$Ne beam at 25 MeV/u on a H$_2$ gas target at 2 atm and 77 K, a large production of $^{20}$Na was observed. Further, we were able to study its $\beta^-$-, $\beta^+$-, and $\beta^+$-delayed $\alpha$-decay. For the $\beta^+$-delayed $\alpha$-decay, we observed alpha particles with energies 2.1, 3.8, 4.4, 4.8 MeV. Following this run, we ran a test experiment to obtain the maximum production of the rarer isotope $^{20}$Mg with the same $^{20}$Ne beam on a $^3$He gas target. The gas cell was filled with $^3$He at 1.5 atm and 77 K. Overall, the fusion-evaporation of $^{20}$Ne($^3$He,3n) was found to be a better reaction for $^{20}$Mg production than the fragmentation of $^{20}$Ne at 45 MeV/u previously tested with MARS. These findings will be used for planning an upcoming study of the $\beta^+$-delayed proton decay of $^{20}$Mg to better understand the resonance states in the $^{19}$Ne($p,\gamma$)$^{20}$Na reaction of crucial astrophysical interest in studies of the hot CNO cycle in stars.

1 Funded by DOE and NSF-REU program.

GB.00122 Development of the Low-cost Analog-to-Digital Converter (for nuclear physics experiments) with PC sound card. KENKOH SUGIHARA, Tohoku University — A low-cost ADC (Analogue-to-Digital Converter) with shaping embedded for undergraduate physics laboratory is developed using a home made circuit and a PC sound card. Even though an ADC is needed as an essential part of an experimental set up, commercially available ones are very expensive and are scarce for undergraduate laboratory experiments. The system that is developed from the present work is designed for a gamma-ray spectroscopy laboratory with NaI(Tl) counters, but not limited. For this purpose, the system performance is set to sampling rate of 1-kHz with 10-bit resolution using a typical PC sound card with 41-kHz or higher sampling rate and 16-bit resolution ADCs. Details of the system and the status of development will be presented. Ping circuit and PC soundcard as a system performance is set to sampling rate of 1-kHz with 10-bit resolution using a typical PC sound card with 41-kHz or higher sampling rate and 16-bit resolution ADCs. In the conference details of the system and the status of development will be presented.

GB.00123 Trace-Element Analysis by Use of PIXE Technique on Agricultural Products. A. TAKAGI, R. YOKOYAMA, K. MAKISAKA, K. KISAMORI, Y. KUWADA, D. NISHIMURA, R. MATSUMIYA, Y. FUJITA, M. MIHARA, K. MATSUMA, M. FUKUDA — In order to examine whether a trace-element analysis by PIXE (Particle Induced X-ray Emission) gives a clue to identify production area of agricultural products, we carried out a study on soy beans as an example. In the present study, a proton beam at the energy of 2.3MeV was provided by Van de Graaff accelerator at Osaka University. We used a Ge detector with Be window to measure X-ray spectra. We prepared sample soy beans from China, Thailand, Taiwan, and 7 different areas in Japan. As a result of PIXE analysis, 5 elements, potassium, iron, zinc, arsenic and rubidium, have been identified. There are clear differences in relative amount of trace-elements between samples from different international regions. Chinese beans contain much more Rb than the others, while there are significant differences in Fe and Zn between beans of Thailand and Taiwan. There are relatively smaller differences among Japanese beans. This result shows that trace-elements bring us some practical information of the region where the product grown.

GB.00124 Design of a high-precision $\beta$-telescope1. R.H. TERBEE, REU student from Hillsdale College, Hillsdale, MI, USA, S. BEHLING, D. MELÇONIAN, Cyclotron Institute, Texas A&M University, College Station, TX, USA — The question is raised of whether or not parity is maximally violated in the weak interaction, focusing on $\beta$ decay. Efforts to measure the neutrino asymmetry parameter, $B_\beta$, and how it will provide limits on the existence of a new right-handed $W$ boson are described. In this experiment, a magneto-optical trap is used to laser-cool and confine $^{71}$K atoms, which are then polarized using optical pumping techniques. A $\beta$-telescope will be used to detect the energy and direction of the $e^+$s emitted from the decay. This detector will be used in coincidence with a microchannel plate which observes the momentum of the recoiling $^{37}$Ar nucleus. The kinematics of the decay allow us to deduce the neutrino’s momentum event-by-event, and so by correlating the neutrino’s momentum with the initial nuclear spin, we will be able to make a precise measurement of $B_\beta$. The physics of positron detection and constraints on $\beta$-telescope design are covered in detail, as well as research into computer simulation methods for the analysis of response functions and the optimization of certain parameters of a $\beta$-telescope.

1 Funded by DOE and NSF-REU program.

GB.00125 Possible sub-barrier hindrance in the fusion of light nuclei. SPENCER ANGUS THOMAS, XIAODONG TANG, MASAIRO NOTANI, BRIAN BUCHER, CHI MA, XIAO FANG, LARRY LAMM, University of Notre Dame, CHENG-LIE JIANG, Argonne National Laboratory, Argonne, Illinois 60439 — Fusion reactions between light nuclei have been studied because of the significance of their reactions for a wide variety of stellar burning processes. Since the experimental data are limited to energies higher than those of astrophysical interest, S-factors must be extrapolated using theoretical model calculations. Recently, an unexpected hindrance of heavy-ion fusion cross sections has been observed at sub-barrier energies, which could affect the astrophysically important fusion reactions. To investigate the hindrance effect, we have measured the cross sections for the $^{12}$C($^3$He,$^6$He) reaction through measurement of $\beta$-decay of $^{24}$Na by the $\beta^-$-coincidence method. We developed a cosmic-ray veto system required for the low background coincidence measurements. The background suppression achieved with the veto system allowed us to measure the fusion cross sections at extreme sub-barrier energies, below the lowest energies previously studied.

GB.00126 Creation of a Program to Calculate Thermonuclear Reaction Rates for Stellar Explosion Research. KYLE THOMSEN, Tennessee Technological Univ., MICHAEL SMITH1, ORNL, RAY KOZUB, Tennessee Technological Univ., ERIC LINGERFELT, ORNL — Current models suggest that sequences of hundreds to thousands of thermonuclear reactions form heavier elements in the variety of stellar burning processes. To provide input for these studies, a program has been written that accommodates many combinations of experimental and theoretical nuclear data to calculate the nonresonant, narrow resonant, and broad resonant contributions to the rates of these reactions. This program will help researchers quickly and easily calculate thermonuclear reaction rates. It will be incorporated into the Computational Infrastructure for Nuclear Astrophysics (CINA) [1], an online system that is used by researchers in 70 institutions in 20 countries for astrophysics research. We have used this new program to calculate a new rate of proton capture on $^{17}$F, which influences the amount of $^{18}$F synthesized in novae. This new rate is based on the first direct measurement of the strength of the dominant resonance [2]. [1] M.S. Smith et al., Proc. Nuclear in the Cosmos IX, 2006. [2] K.A. Chippis et al., Phys. Rev. Lett. 102 (2009) 152502.

1 ORNL managed by UT-Battelle, LLC, for the US DOE under contract DE-AC05-00OR22725
GB.00127 Simulation of NIFFTE TPC , REMINGTON THORNTON, Abilene Christian University. NIFFTE COLLABORATION — The Neutron Induced Fission Fragment Tracking Experiment (NIFFTE) collaboration’s Time Projection Chamber (TPC) is designed to make high precision fission cross-section measurements. These measurements have long-term applications for future generations of nuclear power plant designs. An important component of this project is accurate simulation of the active volume including the physical features of the tracks and the electronics. Tracks are generated using the Geometry And Tracking (Geant4) simulation code, while the detector response simulation is custom written. After reading in tracks, from the Geant4 simulations, the detector response simulation transforms the data using a series of modules with behavior characterized by the TPC design. Asynchronous trigger, 3-D charge diffusion, capacitive charge sharing, digitization, random trigger cells, and noise from the electronics have been modeled. The detector response simulation was designed and written so that it can be reused in future TPC projects. This poster will focus on how these detector response modules are produced and used.

GB.00128 Spectroscopic Factor and ANC Sensitivity to Single Particle Parameters and Global Optical Potentials1 , LUKE TITUS, University of Wisconsin-River Falls, FILOMENA NUNES COLLABORATION— For over 40 years direct transfer reactions, such as (d,p), (d,n) and (4He,α), have been the key tool to extract structure information, usually in the form of a spectroscopic factor (SF), as well as information of interest for astrophysics. Transfer reactions are gaining popularity for the study of exotic nuclei. A systematic study was performed to investigate the sources of uncertainties in spectroscopic factors resulting from the choice of global optical potentials (GOPs). A 15% uncertainty in the cross section at the first peak of the theoretical distribution was observed. Also, the sensitivity of the asymptotic normalization coefficient (ANC) on single particle parameters was analyzed. The ANC was found to be insensitive to single particle parameters for peripheral reactions. However, uncertainties resulting from GOPs prevent an accurate theoretical determination of the highest energy at which a reaction becomes peripheral.

1Special thanks to the REU program at Michigan State University for making this project possible.

GB.00129 Precision Measurement of the Neutron d2: Towards the Electric ?E and Magnetic ?B Color Polarizabilities , WOLFGANG TROTH, Longwood University, HALL A JEFFERSON LAB COLLABORATION — Jefferson Lab Experiment 06-014 was performed to measure the spin-dependent structure function, g2, by measuring the parallel and perpendicular asymmetries of longitudinally polarized electrons scattering off of both longitudinally and transversely polarized 3He. Energies were solely in the deep inelastic valence quark region. By determining the higher twist piece of the structure function, we will be able to evaluate the quantity d2n. The experiment details and the 3He target will be discussed.

GB.00130 Production of high pT J/ψ in p+p collisions at √sNN = 200 GeV in STAR , BARBARA TRZECIAK, Warsaw University of Technology/LBNL, STAR COLLABORATION — Suppression of the J/ψ production by color screening in ultra-relativistic heavy-ion collisions was suggested as the signature of the Quark-Gluon Plasma formation. Measurement of J/ψ production in p+p collisions is a baseline measurement which allows to verify the J/ψ suppression in A+A collisions and could provide information about the J/ψ production mechanism. Run 2008 p+p STAR data was taken with reduced detector material, therefore it has significantly reduced background compare to the earlier runs. In this presentation, the preliminary analysis of mid-rapidity J/ψ production at high transverse momentum through dielectron decay channel in p+p collisions at √sNN = 200 GeV from year 2008 will be shown.

GB.00131 Detecting Protons in the aCORN Neutron Beta Decay Experiment1 , ANNA E. WALKER, Covenant College, EDWARD J. STEPHENSON, Indiana University — The aCORN experiment will measure the angular correlation coefficient "little a" between the electron and the anti-neutrino in neutron beta decay. The goal is to reduce the error on a = −0.014 ± 0.004 (PDG value) to less than 0.001 to check the completeness of the V11 . A model of the weak interaction and the value of Vud in the CKM matrix. The aCORN apparatus selects electrons and protons that, after a +2 kV acceleration, have oppositely directed momenta by restricting the acceptance using a series of tungsten collimators and a co-axial 360° magnetic field. The lack of transverse anti-neutrino momentum for the selected decays creates two event groups with the anti-neutrino momentum either parallel or anti-parallel to the electron momentum and whose rate asymmetry measures a. These groups are distinguished using proton time of flight to a silicon detector. Proton detector electronics was tested for installation in a confined tube where it will be cooled with liquid nitrogen and mounted on a ~30-kV acceleration platform to separate the proton signal from noise. An optical link transfers the signal to the data acquisition system. Spectra of 60-keV gamma rays from 241Am were used as a test signal.

1Supported in part by NSF REU.

GB.00132 Modeling radon daughter deposition rates for low background detectors , S. WESTERDALE, Los Alamos National Laboratory, Massachusetts Institute of Technology, V.E. GUISEPPE, K. RIELAGE, S.R. ELLIOT, A. HIME, Los Alamos National Laboratory, WEAK INTERACTIONS TEAM — Detectors such as those looking for dark matter and those working to detect neutrinoless double-beta decay require record low levels of background radiation. One major source of background radiation is from radon daughters that decay from airborne radon. In particular, 222Rn decay products may be deposited on any detector materials that are exposed to environmental radon. Long-lasting daughters, especially 214Po, can pose a long-term background radiation source that can interfere with the detectors’ measurements by emitting alpha particles into sensitive parts of the detectors. A better understanding of this radon daughter deposition will allow for preventative actions to be taken to minimize the amount of noise from this source. A test stand has therefore been set up to study the impact of various environmental factors on the rate of radon daughter deposition so that a model can be constructed. Results from the test stand and a model of radon daughter deposition will be presented.

GB.00133 Implanted Helium Targets for Use in Inverse Kinematics Reactions , J.L. WHEELER, R.L. KOZUB, D.J. SISSOM, Tenn. Tech.Univ., D.W. STRACENER, D.W. BARDAYAN, ORNL, C. JOST, Mainz/ORAU — Proton transfer reactions, such as (4He,d), are extremely important for gathering information about single particle states and resonances. For example, near-threshold resonances, which may be important in the rp process of explosive nucleosynthesis, cannot be measured via resonance scattering directly. However, measurements involving proton transfer reactions with radioactive ion beams (RIBs) in inverse kinematics also involve a number of experimental challenges. For the (4He,d) reaction, for example, it is necessary to use localized 4He targets, and gas jet targets are expensive and difficult to construct. This problem can be alleviated by implanting 4He into aluminum foils. We have begun the process of implanting 4He and 3He into aluminum foils of two different thicknesses (0.65 and 0.8 μm) at the On-Line Test Facility at ORNL. Target profiles will be analyzed using Rutherford backscattering to determine the concentration and distribution of the implanted He on the foils. These results and a detailed description of the technique will be presented. This research is supported by the U.S. Department of Energy.
GB.00134 Electronics and Data Acquisition for miniLENS1, M.M. WHITE, J.C. BLACKMON, L.E. LINHARDT, C. PANGAN, Louisiana State University, THE LENS COLLABORATION — The Low-Energy Neutrino Spectroscopy (LENS) Collaboration aims to precisely measure the entire energy spectrum of solar neutrinos through charged-current neutrino interactions using indium-loaded scintillator in a novel, optically-segmented detector architecture. The collaboration is currently constructing prototype detectors, aiming towards a 1 m$^3$ prototype, miniLENS, that will demonstrate the performance and selectivity of the full-scale LENS instrument. Here we present the electronics and data acquisition system that we are developing for miniLENS. The responses of smaller (up to 15 liter) prototype detectors have been studied to characterize the combined response of the scintillator and detector architecture. We have studied various approaches for triggering and for combining signals from multiple photomultipliers to help design an acquisition system best suited to fully characterize the performance of the miniLENS prototype in a cost-effective manner. Analysis of our current prototype measurements and the design of the data acquisition system for miniLENS will be presented.

1Supported by Louisiana State University and the Louisiana Board of Regents.

GB.00135 Designing Electronics and PMT Housing for a Liquid Scintillator Detector to be Used for Measuring Muon-Induced Processes at Homestake , BRIAN WOLTMAN, PATRICK DAVIS, DONGMING MEI, CHAO ZHANG, CUBED TEAM — Understanding the backgrounds produced by muon-induced processes is important to the success of experiments searching for rare event physics such as neutrinoless double-beta decay, dark matter, or neutrino oscillations, which require extremely low backgrounds. Measuring these muon-induced processes is vital for the low background experiments planned for the Sanford Lab. We have designed a detector to measure the muon-induced backgrounds produced underground. Our detector consists of a 10.8 liter scintillator joined with two PMT’s. We will present our design for housing the PMT’s, including their attachment to the scintillator and necessary magnetic shielding. We will also present our design for a voltage divider that was constructed and tested for use on each of the PMT’s.

GB.00136 Quality Control of the PHENIX Resistive Plate Chambers being produced for the Forward Trigger Upgrade , RYAN WRIGHT, Abilene Christian University, PHENIX COLLABORATION — The PHENIX experiment at the Relativistic Heavy Ion Collider at Brookhaven National Lab uses polarized proton-proton collisions to study the spin structure of the proton by reconstructing muon tracks produced from these collisions. As RHIC moves to higher energies, a new $W$-boson physics program is accessible, requiring the existing muon trigger system to be upgraded allowing for triggering on high $p_T$ muons produced from $W$ decays. One of the upgrades is the addition of fast Resistive Plate Chambers (RPC) made from Bakelite to give position and timing information for muons produced from $W$-boson decays. Before these chambers are installed in PHENIX, they must be tested for quality assurance to ensure proper performance with minimal failures in the future. These tests are conducted in a dedicated cosmic ray test stand in the RPC factory. Tests performed on each RPC include measuring the dark current, cluster sizes, and gap efficiencies. These test identify bad gas gaps and modules while in the construction phase where repairs and modifications can be made. I will present the module quality assurance process and data recorded from these tests.

GB.00137 String theory: a model beyond popular physics1, EDWARD WUNDER, Mississippi State University and Texas A&M Cyclotron — String theory was originally proposed as a theory of hadrons in the 1950’s. Though its nuclear roots were eventually supplanted by quantum chromodynamics, string theory continues to hold significant potential. The physical and mathematical ideas of such a theory are easily extended to all branches of theoretical physics. For the layperson interested in string theory, there is a vast amount of accessible literature. However, when one chooses to seek a level of understanding beyond popular physics, the prerequisite knowledge renders the subject inaccessible. It is my intention to provide a more involved understanding of the basic ideas of bosonic string theory at a level that requires only the solution of the differential equations found in every undergraduate physics class. Beginning with the classical action for a point particle, we will follow a series of logical steps to illustrate how strings can manifest as a variety of bosons. While this model of string theory lacks fermions, its purpose as a pedagogical tool cannot be underestimated.

1Funded by DOE and NSF-REU Program.

GB.00138 Search for the alpha-cluster $2^+$ state in $^{12}$C1, NAOKI YOKOTA, Faculty of Science, Kyoto University — Alpha particle clustering is an important concept in nuclear physics. Many works were devoted to examine the alpha-cluster structure in atomic nuclei. The $^{12}$C nucleus is one of the well-investigated nuclei, and its energy level is successfully explained by the alpha-cluster-model (ACM) calculations except for the $2^+$ state. The ACM calculation strongly suggests the $2^+$ state should be observed at $E_x \sim 10$ MeV. Recently, Itoh et al suggested both the $0^+$ and $2^+$ states exist in a broad bump at $E_x \sim 10$ MeV in $^{12}$C, but Fynbo et al claimed they observed no $2^+$ states in the bump. Thus the existence of the $2^+$ state is still controversial. We propose to measure the cross sections for the $^{16}$O(d,$^6$Li) reaction at $E_d = 45$ MeV to search for the $2^+$ state in $^{12}$C. We will perform the multipole-decomposition analysis on the basis of the DWBA calculation and pin down the $2^+$ strengths in the broad bump at $E_x \sim 10$ MeV. We will use a $\Delta E$-E Si counter to detect reaction products. This counter consists of two Si strip detectors with the thicknesses of $65 \mu$m and $500 \mu$m. We performed a test experiment and confirmed the performance of the $\Delta E$-E Si counter is good enough to carry out the proposed measurement.

1This research is supported by the special study course P3 under Kyoto University.

GB.00139 Asymptotic Normalization Coefficients from $^{3}$He + $^{4}$He and Astrophysical Factor for $^{3}$He + $^{4}$He -> $^{7}$Be + gamma1, SUSAN ZHANG, Undergraduate Student at Princeton University — The $^{3}$He + $^{4}$He $\rightarrow$ $^{7}$Be + gamma reaction is an especially important pp-chain reaction at a level that requires only the solution of the differential equations found in every undergraduate physics class. Beginning with the classical action for a point particle, we will follow a series of logical steps to illustrate how strings can manifest as a variety of bosons. While this model of string theory lacks fermions, its purpose as a pedagogical tool cannot be underestimated.

1Funded by the DOE and the NSF REU Program.

Saturday, October 17, 2009 9:00AM - 12:00PM – Session KA The Next Decade of Probing Hot and Dense Nuclear Matter Kona 5
The most recent progress in the neutron TPC hardware and software development will be discussed. Preliminary results will be presented, including a calibration range and automatically reject gamma ray events since the ionization profile from Compton scattering is vastly different from the scattering of heavier particles. From a single scattering and a higher efficiency compared to other point methods, such as the scatter camera. Also, neutron TPCs are sensitive to the entire 4π unique capabilities for the detection of fast neutrons, particularly from special nuclear materials. This includes the ability to determine directional information and the stopping power of the hot QCD matter. In this talk, I first overview the dynamical modeling to describe space-time evolution of the hot matter in qualitative understanding and aims at more quantitative studies to constrain properties of the QGP such as the equation of state, the transport coefficients, modeling of various stages in relativistic heavy ion collisions. It is now being in transition from the discovery stage to the stage of precision studies. Moreover, role in interpretation of observables related with the QGP expansion and experimental data leads to a new paradigm “the strongly interacting QGP” at RHIC. Here relativistic hydrodynamics plays an important role in interpretation of observables related with the QGP expansion. Hot QCD matter created in relativistic heavy ion collisions is highly dynamic and complex QGP expansion and experimental data leads to a new paradigm “the strongly interacting QGP” at RHIC. Here relativistic hydrodynamics plays an important role in interpretation of observables related with the QGP expansion. Hot QCD matter created in relativistic heavy ion collisions is highly dynamic and complex by its nature. Thus, the relation between theoretical calculations of equilibrium properties of the QCD matter and experimental observables demands dynamical modeling of various stages in relativistic heavy ion collisions. It is now in being in transition from the discovery stage to the stage of precision studies. Moreover, establishment of a realistic, standard, and dynamical model could lead us to new discoveries yet to be known. The society now tries to go beyond the current qualitative understanding and aims at more quantitative studies to constrain properties of the QGP such as the equation of state, the transport coefficients, and the stopping power of the hot QCD matter. In this talk, I first overview the dynamical modeling to describe space-time evolution of the hot matter in relativistic heavy ion collisions. I next introduce several attempts towards more quantitative understanding of the hot QCD matter. Finally, I discuss the role of the dynamical modeling and theoretical issues in the upcoming LHC era.

Tetsufumi Hirano, the University of Tokyo — Our knowledge of the hot QCD matter, the quark gluon plasma (QGP), has increased drastically since Relativistic Heavy Ion Collider (RHIC) started to operate at the beginning of this century. There are several major discoveries at RHIC such as large anisotropic flow coefficients and suppression of high $p_T$ hadrons. Among them, the reasonable agreement between elliptic flow coefficients from ideal hydrodynamics of the QGP expansion and experimental data leads to a new paradigm “the strongly interacting QGP” at RHIC. Here relativistic hydrodynamics plays an important role in interpretation of observables related with the QGP expansion. Hot QCD matter created in relativistic heavy ion collisions is highly dynamic and complex by its nature. Thus, the relation between theoretical calculations of equilibrium properties of the QCD matter and experimental observables demands dynamical modeling of various stages in relativistic heavy ion collisions. It is now in being in transition from the discovery stage to the stage of precision studies. Moreover, establishment of a realistic, standard, and dynamical model could lead us to new discoveries yet to be known. The society now tries to go beyond the current qualitative understanding and aims at more quantitative studies to constrain properties of the QGP such as the equation of state, the transport coefficients, and the stopping power of the hot QCD matter. In this talk, I first overview the dynamical modeling to describe space-time evolution of the hot matter in relativistic heavy ion collisions. I next introduce several attempts towards more quantitative understanding of the hot QCD matter. Finally, I discuss the role of the dynamical modeling and theoretical issues in the upcoming LHC era.

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Experimental studies on the modification of hadron mass in dense matter have been performed for the last two decades. The recent results of the experiments searching for the hadron mass modification in nuclear medium are reviewed. I will discuss in detail the KKE-PS E325 experiment reporting the modification of the invariant mass spectra of $p,\pi,\phi \to e^+e^-$ measured in p-A reactions. This presentation will also provide an outlook for the capability of the proposed experiments at J-PARC to investigate hadron properties in nuclear matter. The dilepton measurement will be performed to study the nuclear size and velocity dependence of the mass modification systematically. There are also programs to measure the vector mesons in nuclei in exclusive reactions. These different experimental methods will provide an opportunity to study meson properties in nuclear matter in many aspects.

Saturday, October 17, 2009 9:00AM - 12:15PM – Session KB Instrumentation IV Kona 4

9:00AM KA.00001 Development of a neutron time projection chamber1, PATRICK OMALLEY, Rutgers University, MIKE HEFFNER, NATHANIEL BOWDEN, GIANGPAOLO CAROSI, Lawrence Livermore National Lab — Time projection chambers (TPCs) have unique capabilities for the detection of fast neutrons, particularly from special nuclear materials. This includes the ability to determine directional information from a single scattering and a higher efficiency compared to other point methods, such as the scatter camera. Also, neutron TPCs are sensitive to the entire 4π range and automatically reject gamma ray events since the ionization profile from Compton scattering is vastly different from the scattering of heavier particles. The most recent progress in the neutron TPC hardware and software development will be discussed. Preliminary results will be presented, including a calibration analysis, the directional sensitivity, and the efficiency of the detector.

1Worked supported by the DOE NNSA SSGF and DOE NNSA.

9:15AM KB.00002 Simulation of a Neutron Time Projection Chamber Detector JESSICA MINTZ, MICHAEL FOXE, Purdue University, NATHANIEL BOWDEN, MIKE HEFFNER, ADAM BERNSTEIN, LLNL, IGOR JOVANOVIC, Purdue University — A neutron time projection chamber (nTPC) prototype constructed at Lawrence Livermore National Laboratory is a promising detector for directional detection of shielded special nuclear material, exhibiting powerful background rejection and neutron/gamma discrimination. The location of the fast neutron source is determined by detection of preferentially forward-pointed proton recoils in our hydrogen/methane-filled nTPC. A simulation of the nTPC in a real environment is conducted, characterizing the angular spread of detected proton recoils by taking into account the detector design, detector environment, and various analysis cuts. Accuracy of nTPC pointing to the neutron source is determined by simulation. Comparison of the simulation results with the experimental data undergoing the identical data analysis indicates the accuracy of the detector model and detector limitations. Among the limitations, particular attention is given to several classes of events which may reduce the pointing accuracy, including multiple scatters within the chamber and neutron scatters off of the surrounding material.
9:30AM KB.00003 Neutron Multiplicity Discrimination in MoNA Using Hit Pattern Analysis

W.F. ROGERS, M. GARDNER, M. BENNETT, Westmont College, MONA COLLABORATION — The Modular Neutron Array (MoNA) at NSCL, Michigan State University, consists of 144 2-m long scintillator bars with PMT’s attached at each end, designed to measure the kinematic trajectory of neutrons resulting from breakup reactions. The ability to filter data based on neutron multiplicity is critical to the study of multiple-neutron breakup reactions. The approach presented here is based on the analysis of “hit patterns” in MoNA, consisting of singlet (s) and doublet (d) event combinations ranging from multiplicity 2 (ss, dd events) to 4 (ss, dd, sds, dd events, etc.). A singlet event is defined as a hit spatially separated from all other hits by more than a “separation” radius and a doublet event as two hits occurring within a “doublet” radius. A doublet event can result from neutron scattering that produces a sufficiently energetic proton (through charge exchange scattering, for example) to scintillate in two adjacent bars. Since a neutron loses significant energy in doublet scattering, multiple neutron decays are predicted to produce fractionally more doublet combination events (ss, dd, sds, dd etc.) than single-neutron decays. Neutron decay energy spectra are then gated on specific hit patterns to optimize the relative number of multiple neutron events in the dataset. Hit pattern analysis has been applied to three separate experimental data sets involving multiple neutron decay, and results will be presented.

1Supported by NSF grant PHY-0502010.

9:45AM KB.00004 Simulations for DESCANT - a neutron array for TRIUMF-ISAC

JAMES WONG, P.E. GARRETT, J. BANGAY, K.G. LEACH, C. SUMITHRAXACHHI, C.E. SVENSSON, University of Guelph — A novel neutron tagging array is being developed for the study of high-spin states of neutron-rich systems. This ground-breaking design will be based upon an array of liquid deuterated scintillators for neutron detectors and is called the DEuterated SCintillator Array for Neutron Tagging or DESCANT. DESCANT will serve as an auxiliary detector for the TIGRESS spectrometer located at TRIUMF’s ISAC radioactive beam facility. DESCANT is comprised of 70 fully close-packed neutron detectors which subtends an angle of θ = 65.5° and covers 92.6% of this solid angle or 1.08π sr. The multiple scattering of neutrons between detectors is commonly dealt with by vetoing signals collected in adjacent detectors. This results in a much-reduced detection efficiency for higher neutron multiplicity events. The measured pulse height spectrum is forward-peaked and this information can be correlated with the time-of-flight to overdetermine the neutron energy, thus rejecting multiple scattering without the need to veto nearest neighbours. Results from early feasibility tests will be presented, along with the status of our GEANT4 simulations of the array performance.

1This work is being supported by Canadian Fund for Innovation, Ontario Research Fund and TRIUMF.

10:00AM KB.00005 Geant4 simulations for the Verseatile Array of Neutron Detectors at Low Energies (VANDLE)

F. RAIOLA, F. SARAZIN, Colorado School of Mines, D.W. BARDAYAN, Oak Ridge National Laboratory, J.C. BLACKMON, Louisiana State University, J.A. CIZEWSKI, Rutgers University, R.K. GRZYWACZ, M. MADURGA, University of Tennessee, P. O’MALLEY, Rutgers University, C. MATEI, Oak Ridge Associated Universities, S. PALAUASKAS, University of Tennessee, W.A. PETERS, Rutgers University, B.C. RASCO, Oak Ridge Associated Universities — The Verstatile Array of Neutron Detectors at Low Energies (VANDLE) (En ~ 100keV - 10 MeV) has been proposed to study the structure of exotic nuclei with low-energy radioactive ion beams from the Holifield Radioactive Ion Beam Facility (HRIBF) at the Oak Ridge National Laboratory (ORNL). The VANDLE array is highly modular based on bars of scintillator allowing the configuration of the individual elements to be optimized for particular experimental requirements. Proposed experiments include (d,n) reactions and beta-delayed neutron emission studies relevant to nuclear astrophysics. Simulations performed using the GEANT4 toolkit are in progress in order to achieve the best configuration: to cover a large solid angle, to have an optimal position resolution and high efficiency. The GEANT4 simulations are currently being compared with neutron data obtained at the Edwards Accelerator Laboratory at Ohio University, as well as with cosmic-ray data acquired at Louisiana State University. This work is supported in part by the U.S. Department of Energy.

10:15AM KB.00006 Development of digital electronics for VANDLE

MIGUEL MADURGA, S. PALAUASKAS, R. GRZYWACZ, S. PADGETT, UTK, D.W. BARDAYAN, ORNL, J.C. BLACKMON, LSU, J.A. CIZEWSKI, P. O’MALLEY, Rutgers U., S.N. LIDDIICK, LNL, C. MATEI, W.A. PETERS, C. RASCA, ORAU, F. RAIOLA, F. SARAZIN, Mines — The proposed Verstatile Array of Neutron Detectors at Low Energies (VANDLE) will be used in reactions and decay studies with exotic nuclei. VANDLE will consist of plastic scintillator modules for neutron energy measurement in the range between 100 keV and 10 MeV using time of flight (TOF) technique. TOF measurements require a sub-nanosecond electronic timing resolution in order to achieve good energy resolution. It is proposed to use a digital data acquisition system to instrument VANDLE. Series of tests have been performed with elements of the prototype detector and a digital data acquisition system. The data indicate that even with the fast scintillator signal sampled with relatively low (100 MHz) frequency one can achieve a low neutron detection threshold and desired timing resolution.

1This work is fundend by NNSA through DOE Cooperative Agreement DE-FG52-08NA28552.

10:30AM KB.00007 Geant Simulation of a Fission Fragment Spectrometer

WILLIAM MOORE, UWE GREIFRE, Colorado School of Mines — A dual arm, time of flight, fission fragment mass spectrometer has been simulated using Geant to determine if any improvements in mass resolution will be achieved by using a segmented silicon energy detector. The simulation was also used to determine the optimum fission fragment source size, as well as the spectrometer arm length.

10:45AM KB.00008 Improvements in Measuring Fission-Neutron Spectra at a White Neutron Source

ROBERT HAIGHT, Los Alamos National Laboratory, CHI-NU COLLABORATION — The spectrum of neutrons emitted in fission induced by MeV neutrons is important for a wide range of applications and for testing models of fission physics. At the Los Alamos Neutron Science Center, we are developing a program to improve the experimental data base for neutron-emission spectra from fission induced by incident neutrons from 0.5 MeV to 200 MeV. These experiments are based on double time-of-flight techniques to determine the energies of the incident and emitted neutrons. Parallel-plate avalanche detectors with excellent timing characteristics are being developed to identify fission in actinide samples. A large neutron-detector array is being assembled to detect the fission neutrons. Design considerations for the array include neutron-gamma discrimination, neutron energy resolution, angular coverage, segmentation, detector efficiency calibration and data acquisition. The status of these developmental activities and preliminary tests of the components will be presented.

1This work was performed under the auspices of the U.S. DOE under contracts Nos. DE-AC52-07NA27344 and DE-AC52-06NA25396.

11:00AM KB.00009 The Fission Time Projection Chamber Project

TONY HILL, Idaho National Laboratory — New high-precision fission experiments have become a priority within the low-energy nuclear community. Modern sensitivity calculations have revealed unacceptable liabilities in some of the underlying fundamental nuclear data and have provided target accuracies for new measurements that are well beyond what can be delivered using current experimental technologies. A potential breakthrough in the precision barrier for these measurements is the deployment of a Time Projection Chamber (TPC). TPC detector systems were originally developed within the particle physics community and have played a central role in that field for nearly 25 years. A group of 6 universities and 3 national laboratories have undertaken the task of building the first TPC designed specifically for the purpose of measuring fission cross sections. In this talk, I will present the motivation for the fission TPC concept, a few details of the device and why we think an improvement on 50 years of fission experiments can be accomplished.
11:15AM KB.00010 The Fission Time Projection Chamber, MIKE HEFFNER, Lawrence Livermore National Laboratory, NIFFTE COLLABORATION — New high-precision fission experiments have become a priority within the nuclear energy community due to a growing, worldwide interest in nuclear reactors. In particular, the designs of next generation reactors require reductions in the uncertainties on a number of energy dependent, neutron induced fission cross sections. The fission Time Projection Chamber (fission TPC) is the instrument that has been selected to carry out these challenging cross section measurements. This 6000 pad TPC with 2mm hex pads has a volume of only 2 liters and is filled with a hydrogen working gas. A unique set of electronics have been designed for the TPC that use all off the shelf components to reduce development costs. In this talk, I will show how the TPC will improve previous measurements, the design specifics of the fission TPC and the progress to date.

11:30AM KB.00011 NIFFTE software and simulations: results from the first mock data challenge, JENNIFER KLAY, California Polytechnic State University San Luis Obispo, NIFFTE COLLABORATION — The Neutron Induced Fission Fragment Tracking Experiment will employ a novel, high granularity, pressurized time projection chamber to measure fission cross-sections of the major actinides to sub-1% precision. The first suite of GEANT4 simulation and reconstruction software has been developed and run in a “mock data challenge” to validate the detector design and demonstrate the capabilities of the experiment. This talk will present the current status of results from this exercise, details for future simulation runs and plans for analysis of the first experimental data.

11:45AM KB.00012 Design of a Gas Delivery System for use with a Fission Time Projection Chamber, LUCAS SNYDER, UWE GREIFE, Colorado School of Mines — Developing advanced nuclear reactors and waste recycling techniques requires an improvement in many basic nuclear physics measurements. To address part of this need a Time Projection Chamber is being constructed to measure fission cross sections to a higher precision than traditional fission chambers. This talk will discuss how a Time Projection Chamber works and the details of a gas delivery system being constructed for use with it.

12:00PM KB.00013 The Data Acquisition System for the NIFFTE Fission TPC Project, RUSTY TOWELL, Abilene Christian University, NIFFTE COLLABORATION — The NIFFTE Time Projection Chamber (TPC) is a powerful tool that has been selected to take precision measurements of neutron-induced fission of transuranic elements. The improved data will in turn help with the development of the next generation of nuclear reactors. An innovative design has been developed to read the data from the TPC including both commercially available and custom components. For basic run control we have adopted the MIDAS system. For slow controls and monitoring we are using commercial hardware with custom written software. An overview of the system, its current status, and initial tests will be presented.

Saturday, October 17, 2009 9:00AM - 11:45AM — Session KC Nuclear Reactions: Hadrons/Light Ions Kohala 1

9:00AM KC.00001 Study of charged pion photoproduction on deuteron and proton, YUNCHENG HAN, Lanzhou University & Tohoku University, NKS2 COLLABORATION — Pion photoproduction on nucleon and nuclei is an important tool to explore hadron structure and meson-baryon interaction. Charged pion production γd→π−pp and γd→π+n p with En from 0.67 to 0.92 GeV were measured with the second generation of Neutral Kaon Spectrometer, and tagged photon facility at the Laboratory of Nuclear Science, Tohoku University.

9:15AM KC.00002 Feeding of the 1− isomer in 176Lu in neutron induced reactions, N. FOTIADES, M. DEVLIN, R.O. NELSON, LANL — The (n, n′γ) reaction was used to measure γ-ray excitation functions in 175,176Lu with a 900mg target. The data were taken using the GEANTE spectrometer comprised of 26 Ge detectors. The pulsed neutron source of the LANSCE/WRN facility provided neutrons with incident energies from 1 to 300 MeV, determined using the time-of-flight technique. The excitation functions for 111γ-rays from several reaction channels were determined, among them two transitions feeding directly the 1−, 3.664h isomer, and one transition feeding directly the 7−, 3.76×1010y ground state in 176Lu. Both states β-decay to 170Hf. The Lu-Hf radioactive decay system, with a half-life of ~37 billion years from the ground state, is a chronometer for dynamic processes on a stellar time scale. Recent anomalies have questioned the accuracy of this chronometer, one possible explanation being that astrophysical (n, n′γ) reactions populate the 1− isomer and reduce the effective half-life of 170Lu. The excitation functions for the three 176Lu transitions from the present experiment can be compared to nuclear reaction model calculations that predict the 176Lu(n, n′γ)176Lu cross section, thus providing an important check for such models. Attempts to improve the experimental results to obtain absolute partial γ-ray cross sections for more γ-rays feeding the isomer and ground state of 176Lu in future GEANTE experiments will be discussed. This work was supported by U.S. DOE DE-AC52-06NA25396.

9:30AM KC.00003 Proton pairing correlation studies1, A. ROBERTS, J.J. KOLATA, Univ. of Notre Dame, A. VILLANO, F.D. BECCHETTI, Univ. of Michigan, J.P. SCHIFFER, J.A. CLARK, B.P. KAY, K.E. REHM, Argonne National Laboratory, S.J. FREEMAN, A.M. HOWARD, Univ. of Manchester — A program to study proton pairing correlations in nuclei relevant for neutrinoless double β decay has been initiated at Notre Dame. The results will complement neutron-pairing studies [S.J. Freeman, et al., Phys. Rev. C75, 05301R (2007)], helping to constrain theoretical calculations of this decay mode. High-precision measurements of the (4He,n) reaction using a pulsed beam and a large neutron detector are in progress. The necessary 250 keV resolution at a neutron energy of 25 MeV is well within reach. Recent results obtained with a 29Mg target will be presented. This well-studied system serves as a calibration for measurements on 72Ge and other targets. Ground-state cross sections will be obtained with relative precision of <5% and absolute accuracy of <10%. Proton pairing vibrations (if any) will be identified and measured.

1This work was supported by the US NSF under Grant No. PHY0652591, by the US Dept. of Energy, Office of Nuclear Physics, and the UK Engineering and Physical Sciences Research Council.
9:45AM KC.00004 Fission cross section measurements at LANSCE, FREDRIK TOVESSON, Los Alamos National Laboratory, TONY HILL, Idaho National Laboratory — Neutron induced fission cross sections of actinides are measured at the Los Alamos Neutron Science Center (LANSCE) in support of the Advanced Fuel Cycle Initiative (AFCI) and the National Nuclear Security Administration (NNSA). Nuclear technologies are increasingly dependent on advanced simulations for design and licensing requirements, and nuclear cross section data are important input parameters for the simulation tools. Fast nuclear reactor and stockpile stewardship applications often share nuclear data needs and requirements, and the LANSCE neutron source is ideal for measuring many of these data. The fission cross section measurements are guided by sensitivity studies performed in support of the AFCI program, as well as requests from NNSA. Recent results for the Pu-239 and Pu-241 fission cross sections from 0.01 eV to 200 MeV will be presented, and the discrepancy with current evaluations of the Pu-241 fission cross section discussed. Ongoing activities to extend the fission program will be presented, such as the development of a Time Projection Chamber (TPC) to significantly improve the experimental accuracies in fission cross section measurements.

10:00AM KC.00005 Study of medium effect in NN interaction by using (p, pn) reactions, YUKIKO YAMADA, TETSUO NORO, TAKUMI IMAMURA, TOMOTSUGU WAKASA, MASANORI DOZONO, YOSHIHIDE MATSUDA, MIDORI OKAMOTO, SHO KUROTA, YUICHIRO EGUCHI, KEISUKE YASHIMA, TATSUYA YABE, Kyushu University, HARUTAKA SAKAGUCHI, KICHIJI HATANAKA, HIROIKI OKAMURA, ATSUSHI TAMII, YUSUKE YASUDA, JUZO ZENIHIRO, HIROAKI MATSUBARA, DAIKI ISHIKAWA, RCNP Osaka University, YUKIE MAEDA, ATSUSI NONAKA, NORIYUKI FUJITA, TORU SAITO, Miyazaki University, YASUHIRO SAKEMI, HIDETOMO P. YOSHIDA, CYRIC Tohoku University — Exclusive measurement of nucleon quasi-free scattering is a direct tool to investigate how nucleon-nucleon (NN) interaction changes in the nuclear medium. We measured analyzing powers ($A_y$) for $1s_{1/2}$-knockout (p, pn) reactions on light nuclei aiming at studying such modification. The experiment was performed at RCNP with a 392 MeV proton beam. It is found that the $^{12}$C(p,pn) exclusive $A_y$ data are mostly consistent with impulse calculations based on the p-n interaction in free space, in contrast to the (p,2p) case, where a strong suppression of $A_y$ is observed. This large imbalance between the (p, pn) and (p,2p) results is difficult to explain in conventional models.

10:15AM KC.00006 Hadronic description for the $\phi$-photoproduction near the threshold, HUIYONG RYU, ATSUSHI HOSAKA, Research Center for Nuclear Physics (RCNP), Ibaraki, Osaka 567-0047, Japan, HYUN-CHUL KIM, Department of Physics, Inha University, Incheon 402-751, Korea — The Pomeron-exchange plays an important role in the $\phi$-photoproduction from the nucleon. It describes well the increasing behavior of the production rate at high energies, a consequence of the Regge theory with the Pomeron trajectory $\alpha(t)$. Recently LEPS has reported a bump-like structure in $d\sigma/dt$ near the threshold energy. Within the Regge theory, the second Pomeron is examined, but it is difficult to reproduce such a narrow bump structure. Besides the Pomeron-exchange, we could expect hadronic processes relevant in the threshold region. In this work, we attempt a hadronic description for the $\phi$-photoproduction. Since the $O(1)$ mechanism suppresses Born diagrams at the tree level, we consider loop contributions. We pay special attention to the gauge invariant set of diagrams and momentum ($s,t$ and $u$) dependence of the amplitude. We discuss that some features of momentum dependence may help to understand the underlying reaction mechanism. We also discuss that some correlated steps may express effectively a meson exchange diagram, for instance, in the $t$-channel.

10:30AM KC.00007 Capabilities of the Recent Absolute Total np and pp Cross Section Determinations to Predict Experimental Observables, A.B. LAPTEV, R.C. HAIGHT, LANL, R.A. ARNDT, W.J. BRISCOE, M.W. PARIS, I.I. STRAKOVSKY, R.L. WORKMAN, The George Washington University — The absolute total cross sections for np and pp scattering below 1000 MeV are determined based on detailed parametrical analyses (PWAs) of nucleon-nucleon scattering data. These cross sections are compared with most recent ENDF/B and JENDL data files, and the Nijmegen PWA. Systematic deviations from the ENDF/B and JENDL evaluations are found to exist in the low-energy region. Comparison of the np evaluation with the result of most recent np total cross section measurement made at LANL in the energy range from 9 to 500 MeV will be discussed. This measurement was not used in the evaluation database. A comparison was done to check a quality of evaluation and its prediction capabilities. Excellent agreement was found between the new experimental data and our PWA prediction.

10:45AM KC.00008 Systematic measurement of “star anomaly” in pd breakup around 10 MeV, K. YASHIMA, K. SAGARA, Kyushu University, Y. MAEDA, Miyazaki University, S. KUROTA, H. SHIMODA, T. SUETA, Y. EGUCHI, T. SHISHIDO, T. YABE, Kyushu University, KUTL FEW-BODY TEAM — In 3-nucleon breakup around 10 MeV, there is cross section anomaly when three outgoing nucleons form an equilateral triangle (star configuration) perpendicular to the beam axis. We have measured pd breakup cross section at various star configurations which are inclined to the beam axis, and compared the data with recent pd breakup calculations. Angular dependence and energy dependence of star anomaly will be discussed.

11:00AM KC.00009 Neutron density distributions of $^{204,206,208}$Pb observed via polarized proton elastic scattering, JUZO ZENIHIRO, HARUTAKA SAKAGUCHI, MASARU YOSOI, YUSUKE YASUDA, Research Center for Nuclear Physics, Osaka University, SATORU TERASHIMA, GSI, TETSUYA MURAKAMI, SATOSHI KISHI, Department of Physics, Kyoto University, MASATOSHI ITOH, HIDETOMO YOSHIDA, Cyclotron and Radioisotope Center, Tohoku University, MAKOTO UCHIDA, Tokyo Institute of Technology, HIROYUKI TAKEDA, YOHEI NAKATSUGAWA, RIKEN — Cross sections and analyzing powers of polarized proton elastic scattering from $^{204,206,208}$Pb at $E_p = 295$ MeV have been measured with the high-resolution magnetic spectrometer “Grand Raiden” at RCNP. For the data analysis, special cares for trigger efficiencies, charge collections of Faraday Cups, and so on, have been paid to deduce absolute values of the cross sections in the measurement and data reduction. We have used relativistic impulse approximation (RIA) with medium-modified nucleon-nucleon interaction and realistic point proton density distributions unfolded from charge distributions obtained by electron scattering data. We will show preliminary results of the deduced neutron density distributions of $^{204,206,208}$Pb and their error envelopes.

11:15AM KC.00010 Measurement of deep hole states in $^{39}$K by $^{40}$Ca($p$,2p) reaction at 392 MeV, YUSUKE YASUDA, HARUTAKA SAKAGUCHI, KICHIJI HATANAKA, MASARU YOSOI, JUZO ZENIHIRO, RCNP, Osaka University, TETSUO NORO, TOMOTSUGU WAKASA, KUNIHIRO FUJITA, Kyushu University, TAKAIRO KAWABATA, Kyoto University, YASUHIRO SAKEMI, MASATOSHI ITOH, HIDETOMO YOSHIDA, TAKASHI ISHIYA, Tohoku University, HIROYUKI TAKEDA, RIKEN, MAKOTO UCHIDA, Tokyo Inst. of Tech., SATORU TERASHIMA, GSI, YOHEI SHIMIZU, CNS, University of Tokyo, YUIJI TAMAEHIGE, NIRS — The spectroscopic factor and the width of $1s_{1/2}$ state in $^{40}$Ca have been deduced from $^{40}$Ca(p,2p) reaction experiment. In the experiment the cross sections and analyzing powers of the $^{40}$Ca($p$,2p) reaction at 392 MeV have been measured. The strength distributions of the single-hole states in $^{39}$K were successfully obtained by multipole decomposition analysis on the basis of the angular momentum $L$. The central value and the width (FWHM) of the obtained strength distribution of $1s_{1/2}$ are 52 MeV and 22 MeV. The obtained spectroscopic factor of $1s_{1/2}$ is about 60% of the $2J + 1$. This value will be compared with the theoretical calculations that include short-range correlations and tensor correlations.
Especially, the structure of $\Lambda(1405)$ remains mysterious. Whereas $\Lambda(1405)$ is interpreted as a flavor-singlet three-quark state in quark models, $\Lambda(1405)$ could be interpreted as a Kaon-nucleon molecule. $\Lambda(1405)$ is then considered to be a bound-state of $K$ and $N$ with binding energy of 30 MeV, and this large binding energy implies strong attraction between $K$ and $N$. Such strong attractive interactions predict a new type of hadronic matter. The property of $\Lambda(1405)$ can be therefore an important clue to new paradigm in hadron physics. Lattice QCD calculations are powerful, and expected to cast light on the nature of $\Lambda(1405)$. However, few detailed lattice QCD study on $\Lambda(1405)$ have been done so far. We study properties of $\Lambda(1405)$ with lattice QCD. We make use of the full-QCD gauge configurations generated by CP-PACS/PACS-CS collaboration. We construct correlation matrices from several independent “octet” and “singlet” operators, and diagonalize them so that we can investigate mass spectra in $(J, I, S)=(1/2, 0, -1)$ channel as well as possible mixing between octet and singlet states, which has not been discussed yet in the context of lattice QCD studies. As a result, we found that the lowest (2nd-lowest) state in this channel is dominated by a flavor-singlet (flavor-octet) state. We also extract the $KN$ and $\pi\Sigma$ components in each observed state.
10:30AM KD.00007 Dynamical coupled-channels study of photo- and electro-production reactions1, H. KAMANO, EBAC@JLab, B. JULIA-DIAZ, EBAC@JLab, University of Barcelona, T.-S.H. LEE, EBAC@JLab, ANL, A. MATSUYAMA, EBAC@JLab, Shizuoka University, T. SATO, N. SUZUKI, EBAC@JLab, Osaka University — A comprehensive study of the meson production reactions with initial $\pi N$, $\gamma N$, and $N(e,e')$ based on a dynamical coupled-channels approach is being made to explore the structure of the $N^*$ states in the Excited Baryon Analysis Center (EBAC) at Jefferson Lab. In this talk we present a current status of our study of the photo- and electro-production reactions, particularly focusing on the single and double pion production reactions. We will also discuss what impact the so-called “complete-measurement” of single pseudoscalar meson photoproduction reactions has on the construction of reaction models, which is a key to the precise determination of the $N^*$ properties.

1Supported by U.S. Department of Energy, Office of Nuclear Physics, under contract No. DE-AC02-06CH11357 and No. DE-AC05-06OR23177.

10:45AM KD.00008 Electromagnetic form factor of nucleon resonances from meson production, N. SUZUKI, Osaka University, B. JULIA-DIAZ, Universitat de Barcelona, H. KAMANO, Jefferson Laboratory, T.-S. H. LEE, Argonne National Laboratory, A. MATSUYAMA, Shizuoka University, T. SATO, Osaka University — The nuclear resonances appear as poles of the scattering amplitudes on the complex energy plane. The masses of $N^*$ and the electromagnetic $NN^*$ transition form factors are obtained from the pole positions and the residues of the scattering amplitudes. We have developed a method of analytic continuation to extract resonance parameters from the amplitudes of the dynamical reaction model, which includes unstable particle channels such as $\pi\Delta, \sigma N$ and $\rho N$. We apply the method for the $\pi N$ and $\gamma^* N$ amplitudes from our coupled channel model of meson production reactions. The extracted $N^*$ form factors for a few $N^*$ resonances will be presented.

11:00AM KD.00009 Nucleon resonances in $K$ and $T$ matrix calculations and fits1, MARK PARIS, R. ARNDT, W. BRISCOE, J. STRAKOVSKY, R. WORKMAN, George Washington University, CENTER FOR NUCLEAR STUDIES - DATA ANALYSIS CENTER TEAM — The characterization of resonances of the nucleon is considered in extractions from multichannel hadronic $K$ and $T$ matrix models. We obtain the poles of the $K$ matrix and their relation to the poles of the $T$ matrix as determined from the SAID multichannel, unitary fit to observed cross sections and asymmetries. We study the dependence of $K$ and $T$ matrix structures on the fit parameterization. We also make comparisons to a dynamical model calculation of the inelastic hadronic amplitudes.

1This work was supported in part by the US Department of Energy Grant DE-FG02-99ER41110 and funding provided by Jefferson Lab.

11:15AM KD.00010 Thirty Unsolved Problems in the Physics of Elementary Particles v. CHRISTIANTO, People’s Friendship University of Russia, FLORENTIN SMARANDACHE, University of New Mexico, Gallup Campus — Unlike what some physicists and graduate students used to think, that physics science has come to the point that the only improvement needed is merely like adding more numbers in decimal place for the masses of elementary particles or gravitational constant, there is a number of unsolved problems in this field that may require that the whole theory shall be reassessed. In the present article we discuss thirty of those unsolved problems and their likely implications. In the first section we will discuss some well-known problems in cosmology and particle physics, and then other unsolved problems will be discussed in next section.

Saturday, October 17, 2009 9:00AM - 12:00PM – Session KE Instrumentation V Kohala 2

9:00AM KE.00001 Large-area silicon photomultipliers as readout candidates for the GlueX experiment1, ZISI PAPANDREOU, KATHRYN JANZEN, GEORGE LOLOS, ANDREI SEMENOV, University of Regina, CARL ZORN, Jefferson Laboratory, GLUEX COLLABORATION — The core mission of the GlueX experiment involves a search for exotic hybrid mesons as evidence of gluonic excitations in an effort to understand confinement in QCD. A key subsystem of the GlueX detector is the electromagnetic barrel calorimeter (BCAL) located inside a 2.5 Tesla superconducting solenoid. Due to this arrangement, light sensors are required that can operate in the high magnetic field environment. Among these, Silicon photomultipliers (SiPMs) are very promising candidates as front-end detectors. To date, routine use of SiPMs has been limited to those with an active area of a few mm². GlueX will require 2300 large-area SiPMs, each composed of sixteen $3 \times 3$ mm² cells arranged in a $4 \times 4$ array for a total area of $\sim 144$ mm² per array. This has placed the GlueX collaboration in the unique position of driving the technology for such large-area sensors. In this talk, I will present tests carried out at Regina and Jefferson Lab regarding performance parameters of prototype SiPM arrays and their micro subcomponents.

1This work is being supported by NSERC and Jefferson Lab/DOE.

9:15AM KE.00002 New detector design for combined measurements of omega meson, KAZUKI UTSUNOMIYA, KYOICHIRO OZAWA, YOSUKE WATANABE, SHINICHI MASUMOTO, YUSUKE KOMATSU, TAMOTSU SATO, The University of Tokyo, SATOSHI YOKKAICHI, KAZUYA AOKI, Riken, TOMOYA TSUJI, CNS, the University of Tokyo — We proposed an experiment at J-PARC for measurements of a direct omega meson mass modification in nucleus. The experiment also aims measurements of a nuclear bound state. In the experiment, mass of meson in nucleus is measured with omega to pi0 gamma decays and initial conditions in produced omega meson are also measured in $\rho(\pi^+\pi^-)$ reaction. Produced pi0 meson is detected with two gamma decays. Therefore, two detector are needed such as Gamma detector and neutron counter. We have developed a TOF type neutron counter. The counter consists of an iron plate and scintillators. This has 4 layers, and 6 scintillators in each lay. To achieve enough mass resolution, time resolution needed to be less than 80 ps. At K1.8 beam line in J-PARC Hadron Hall, the maximum flight path is 7m and the mass resolution of 22 MeV/c2 can be achieved. A Gamma-ray detector is also needed for detecting total three gammas. We perform beam tests and simulations for these two detectors. The result and the present status of detector development and design will be presented.

9:30AM KE.00003 A Report on the BETA Detector Package from SANE, JONATHAN MULHOLLAND, University of Virginia, SANE COLLABORATION1 — The Spin Asymmetries of the Nucleon Experiment measured the parallel and near-perpendicular inclusive double spin asymmetries in an electron scattering experiment using Thomas Jefferson National Laboratory’s polarized electron beam and the University of Virginia’s polarized frozen ammonia target in Hall C. The experiment ran from January to March of this year, collecting data in a $Q^2$ region from 2.5 to 6.5 $GeV^2$ with high Bjorken $x$. Particle detection was accomplished using the Big Electron Telescope Array (BETA), consisting of a forward hodoscope, a gas Cerenkov detector, a Lucite hodoscope, and a lead glass calorimeter. This talk will be a progress report on the data analysis, discussing the calibration of the SANE detector package and the techniques used for tracking particles with this non-magnetic spectrometer.

1SANE: Spin Asymmetries of the Nucleon Experiment
10:00AM KE.00005 Development of Green Laser Cavity for Precision Compton Polarimetry in Jefferson Lab Hall A, ABDURAHIM RAKHMAN, Syracuse University, Syracuse, NY 13244, SIRISH NANDA, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, PAUL SOUDER, Syracuse University, Syracuse, NY 13244, HAPPEX/PREX COLLABORATION — Many experiments at Jefferson Lab have good knowledge of the polarization of the electron beam. The Pb Radius Experiment (PREx) demands polarization measurement of a lower energy (1.0 GeV) electron beam at 1.0% accuracy, which can not be achieved by the infra-red (1064 nm) laser Compton polarimeter presently operating in Hall A. Therefore a green laser (CW, 532 nm) based Fabry-Perot cavity for upgraded high precision Compton Polarimetry has been proposed and under development. The system used as a high energy polarized photon target for measuring the polarization of a low- to high-energy (1.0 GeV to 11.0 GeV) electron beam in a nondestructive manner. Our goal is to amplify a low power laser beam to achieve 1.5 kW of intra cavity power to improve signal to noise ratio of the polarimeter. We locked our test cavity to a frequency doubled Nd:YAG tunable narrow linewidth laser using the Pound-Drever-Hall (PDH) technique. The recent progress and future plan of this project will be presented.

10:15AM KE.00006 Performance of a thick windowless He gas target at KUTL, R. IWABUCHI, K. SAGARA, K. FUJITA, T. TERANISHI, M. TANIGUCHI, T. GOTOH, K. NAKANO, N. OBA, S. MATSUDA, H. YAMAGUCHI, Kyoto University, KUTL ASTRO TEAM — A blow-in type windowless He gas target has been developed at Kyushu University tandem laboratory (KUTL). To increase He target thickness, various trials and efforts have been made for many years. Recently we have achieved 24 Torr of He gas pressure in the central region of the target. This capacity is sufficient for our H^4(12C, 16O) experiment near the stellar energies, from E_{kin} = 2.4 MeV down to 0.7 MeV. The He target thickness integrated along the beam axis was measured using p+ 4He scattering. Due to the sufficient thickness, a post stripper is not necessarily put downstream the target to make the charge distribution of 16O equilibrium. Performance of this windowless 4He target is presented.

10:30AM KE.00007 Pulse structure dependence of proton spin polarization rate, TOMOMI KAWAHARA, Department of Physics, Toho University, TOMIHISO UESAKA, YOHEI SHIMIZU, Center for Nuclear Study, Graduate School of Science, University of Tokyo, SATOSHI SAKAGUCHI, RIKEN, TAKASHI WAKUI, Cyclotron and Radioisotope Center, Tohoku University — A polarized proton solid target for RI beam experiments has been developed at the University of Tokyo [1]. The proton is polarized by transferring population difference in photo-excited triplet states of aromatic molecule. Through this method proton polarization of about 20% have been obtained at 0.1 T and in 100 K. Although this target has been successfully applied to RI beam experiments [2,3], further improvement in the polarization is desirable for future applications. To pursue possible improvement in photo-excitation power, we have examined pulse-structure dependence of proton polarization rate. The excitation light is provided by a cw Ar-ion laser and pulses by an optical chopper. We have found that proton polarization depends strongly on the pulse structure and the optimum condition is found to be duty factor 50% and a repetition frequency of 10 kHz. At this condition, the polarization rate can be increased by a factor 2.5 or more compared with the old settings, where a duty factor and a repetition frequency were 5% and 2.5 kHz, respectively. [1] T. Wakui et al., Nucl. Instrum. Methods A 550 (2005) 521. [2] M. Hatano et al., Eur. Phys. J. A 25 (2005) 255. [3] S. Sakaguchi et al., CNS Annual Report 2006 (2007).

10:45AM KE.00008 Measurement of the uniformity of a 1/2 scale prototype magnet for the SNS neutron electric dipole moment experiment, ADRIAN PEREZ GALVAN, BRAD FILIPPONE, JUSTIN CHEN, California Institute of Technology, BRAD PLASTER, University of Kentucky, NEDM COLLABORATION — An observation of a neutron electric dipole moment (nEDM) would constrain proposed extensions of the Standard Model and possibly explain the baryon asymmetry of the Universe. A new effort to measure the nEDM using ultra-cold neutrons (UCN) at the Spallation Neutron Source at Oak Ridge National Laboratory is currently underway. The experiment will require a uniform magnetic field as well as stringent control of the magnetic field environment to suppress systematic effects. The uniform magnetic field will be generated by a Cos(θ) coil inside a series of magnetic shields. We present measurements of the uniformity of the main magnetic field as well as the techniques used to achieve the required specifications of the coil.

We acknowledge support from DOE and NSF.
Now at MIT-Lincoln Laboratory

11:00AM KE.00009 AC loss measurement of high temperature superconducting magnets, KICHIHI HATANAKA, MITSUHIRO FUKUDA, TETSUHIKO YORITA, TAKANE SAITO, JINTA NAKAGAWA, Research Center for Nuclear Physics (RCNP), Osaka University, YASUHIRO SAKEMI, Cyclotron and Radioisotope Center (CYRIC), Tohoku University, KOJI NODA, National Institute of Radiological Sciences (NIRS), TAKEO KAWAGUCHI, KT Science Ltd. — Twenty years have passed since the discovery of high temperature superconductivity. A new effort to measure the nEDM using ultra-cold neutrons (UCN) at the Spallation Neutron Source at Oak Ridge National Laboratory is currently underway. The experiment will require a uniform magnetic field as well as stringent control of the magnetic field environment to suppress systematic effects. The uniform magnetic field will be generated by a Cos(θ) coil inside a series of magnetic shields. We present measurements of the uniformity of the main magnetic field as well as the techniques used to achieve the required specifications of the coil.

In order to investigate the applicability of HTS wires at higher frequencies, two sets of air core magnets were fabricated using a Bi2223 wire and AC loss was measured at 10-21 Hz. Each magnet consists of two coils. Each coil consists of 3 double pancakes and the number of turns is 420 in total. The critical currents were measured at 77 K to be 56 - 62 A for double pancakes and 40 - 43 A after assembling to form coils. The maximum current is assumed to be 200 A at 20 K. Magnets were installed in a cryostat and cooled to 20 K. The critical currents were measured to be 257 A and 282 A for Bx-coil and By-coil, respectively, at 20K. The AC loss was measured at 10, 15 and 21 Hz. AC and 40 - 43 A after assembling to form coils. The maximum current is assumed to be 200 A at 20 K. Magnets were installed in a cryostat and cooled to 20 K.
11:30AM KE.00011 The Neutron Emission Ratio Observer NERO at the National Superconducting Cyclotron Laboratory. JORGE PEREIRA, PAUL HOSMER, GIUSEPPE LORUSSO, PETER SANTI, MARCELO DEL SANTO, National Superconducting Cyclotron Laboratory, Michigan State Univ. MI, US, CLEMENS HERLITZIUS, Max Planck Institut fuer Chemie, Universitat Mainz, Germany, KARL-LUDWIG KRATZ, FERNANDO MONTES, HENDRIK SCHATZ, National Superconducting Cyclotron Laboratory, Michigan State Univ. MI, US, FLORIAN SCHERTZ, Max Planck Institut fuer Chemie, Universitat Mainz, Germany, LINDA SCHNORRENBERGER, Institut fuer Kernphysik, Technische Universitat Darmstadt, Darmstadt, Germany, KARL SMITH, National Superconducting Cyclotron Laboratory, Michigan State Univ. MI, US, MICHAEL WIESCHER, Institute of Structure and Nuclear Astrophysics, Univ. Notre Dame, IN, US. The new neutron counter NERO (Neutron Emission Ratio Observer) was built at the National Superconducting Cyclotron Laboratory (NSCL) for measuring $P_n$, values of neutron-rich nuclei produced as fast fragmentation beams. The design was motivated by the requirement of being coupled to the NSCL beta counting system, so that $\beta$-decay particles and neutrons emitted from implanted nuclei can be measured simultaneously, while keeping a high efficiency. The detector’s performance and main features will be discussed, as well as recent measurements done at NSCL for astrophysical studies of the r-process.

11:45AM KE.00012 Background reduction by position reconstruction for CANDLES III. KENNSUKE YASUDA, Graduate School of Science, Osaka University, TADAUMI KISHIMITO, IZUMI OGAWA, SAORI UMEHARA, GO ITO, HIDEKAZU KAKUBATA, MASAKI MIYASHITA, KENJI MATUO, RYUTA HAZAMA, Graduate School of Science, Hiroshima University, CANDLES COLLABORATION — CANDLES is the project to search for double beta decay of $^{48}$Ca. We use CaF$_2$ crystals as $^{48}$Ca sources and scintillation detectors. They are immersed in liquid scintillator. Signals that fire liquid scintillator are backgrounds. Their rejection is achieved by employing pulse shape difference of signals from the CaF$_2$ scintillator and liquid scintillator. In addition to that position resolution helps further to reduce backgrounds. We employed the least squares method to give position of each crystal. We will report the background reduction with a help of position information.

Saturday, October 17, 2009 9:00AM - 12:15PM
Session KF Mini-Symposium on Hadron Structure and QCD in High Energy Processes III

9:00AM KF.00001 Experimental quest for the proton spin structure – past, present and future. HIDETO EN’YO, RIKEN Nishina Center — For the last 20 years there have been many great discoveries are made experimentally and theoretically, concerning on the spin structure of the nucleon, the fundamental bound states of the strong interaction. Motivated largely from the “Spin Puzzle,” many experimental plans emerged in early 90s to measure the gluon contribution to the proton spin, by hoping to solve the puzzle with gluons. After more than 10 years, the recent experimental outcomes from RHIC and other polarized deep-inelastic interactions set a stringent limit on the gluon polarization. Although further studies must be continues on the spins, the simplest solution to the spin puzzle seems to be fail, i.e., the spin structure of the proton is much richer than we thought. The scientific focus is now moving to the new direction. Keys are in our own findings on the way, namely, discoveries of finite Collins and Sivers effects and progress on deeply virtual Compton scattering both in theoretical and experimental sides. Based on these new discoveries, we now need to rebuild the long range plan toward the complete understanding of the proton spin structure. Discussions are planned to give the general overview of the past, and to hint future experiments utilizing the existing facilities and the electron ion collider.

9:30AM KF.00002 The Proton Spin Puzzle: Recent Results and Prospects from STAR at RHIC. WILLIAM CHRISTIE1, Brookhaven National Lab, STAR COLLABORATION — Polarized deep-inelastic lepton-nucleon scattering measurements have shown that a surprisingly small fraction of the proton spin is carried by quark and anti-quark spins. This observation has renewed the interest in proton spin structure, which is currently being pursued by experiments worldwide. One of the main objectives of the STAR experiment at Relativistic Heavy Ion Collider is to determine the polarization of gluons, Delta G, in the polarized proton. Our measurements use proton-proton collisions at high center-of-mass energies. STAR measurements of inclusive jet and pion probes, using data collected in the years 2003-2006 at 200 GeV center-of-mass energy, have placed constraints on Delta G for gluon momentum fractions, x, over the range of about 0.03 < x < 0.3. STAR has just completed a data taking period with substantially better statistics and has recorded also a first data sample at a higher beam collision energy of 500 GeV. The new 200 GeV data is expected to better constrain Delta G and, using correlated probes such as di-jets and photon-jets, to give insight also in its x-dependence. The 500 GeV data form the start of a program to delineate quark polarization by using leptonic decays of W-bosons as probes. I will present a summary of recent results and will discuss expectations from the 2009 data taking period as well as prospects for the further future.

1On behalf of the STAR Collaboration

9:45AM KF.00003 Measurements of the Gluon Polarization in the Nucleon at COMPASS. TAKAHIRO IWATA, Yamagata University, SHIGERU ISHIMOTO, KAORI KONDO, NORIHIRO DOSHITA, Yamagata University, TAKEO HASEGAWA, Miyazaki University, NAOAKI HORIKAWA, Chubu University, TATSURO MATSUDA, Miyazaki University, TAKUMA MICHIGAMI, Yamagata University, COMPASS COLLABORATION — The gluon polarization in the nucleon has been investigated in COMPASS at CERN with a polarized muon beam and a longitudinally polarized deuteron target. The gluon polarization was determined by longitudinal double spin asymmetries for the photon-gluon-fusion (PGF) process. Identifying the PGF by detecting either a charm hadron(“open charm”), namely $D^0$ meson decaying into charged K π, or two light hadrons with high Pt(“high Pt hadron”), the gluon polarization values were extracted with a help of LO-QCD. In this talk, the final result from open charm events taken from 2002 to 2006 (all the deuteron data) and the recent results from high Pt hadrons taken from 2002 to 2004 will be presented. The former case, which is expected to be ideal process with less physical background, shows negative polarization with relatively large error due to limited statistics. While, the results from the high Pt hadron events gives smaller errors show small gluon polarization values around 0.1 for the gluon’s Bjorken-x.

10:00AM KF.00004 Polarized gluon distribution from DIS and collider data. MASANORI HIRAI, Tokyo University of Science, SHUNZO KUMANO, High Energy Accelerator Research Organization — We investigate the determination of the polarized gluon distribution by a global analysis using the DIS and the collider data. The polarized gluon distribution gives an important information about gluon contribution to the nucleon spin, however it has still large uncertainty. In the DIS experiments, the J-Lab provides the precise data in the large- $x$ and low- $Q^2$ region. The data is useful to determining the gluon distribution because the higher order contribution of the gluon is rather large at low $Q^2$. In addition, the collider experiment at the RHIC has measured the $n^1h$ production process. Since the process is sensitive to the gluon distribution, the data has the strong constraint power on the determination. Therefore, we include these data in the global analysis. The DIS data suggest the positive value in the medium and large-$x$ region, however the RHIC data require the negative value in the small-$x$ region. So, the gluon distribution changes the sign around $x \sim 0.1$ at $Q^2 = 1$ GeV$^2$ We will discuss the behavior of the gluon distribution from the DIS and Collider data in the analysis.
10:15AM KF.00005 Dijet Cross Section and Longitudinal Double Spin Asymmetry Measurements in Polarized Proton-Proton Collisions at 200 GeV at STAR. MATTHEW WALKER, MIT, STAR COLLABORATION — The polarized gluon distribution function of the proton, $\Delta g(x)$, has been constrained by inclusive measurements from polarized proton-proton collisions at RHIC. Correlation measurements, such as the dijet measurement, provide access to the leading order parton kinematics, which provides sensitivity to the shape of $\Delta g(x)$. STAR's large acceptance electromagnetic calorimeter and tracking make it well suited for this measurement. The status of the dijet cross-section analysis from the 2005 and 2006 RHIC data sets and of the longitudinal double spin asymmetry analysis from the 2006 data set, all at mid-rapidity, will be presented.

10:30AM KF.00006 Probing the Spin Structure of the Proton via Heavy Flavor Production at PHENIX. HAN LIU, Los Alamos National Lab, PHENIX COLLABORATION — At RHIC energy, heavy flavor production is dominated by gluon gluon fusion. So measurements of spin asymmetries in heavy flavor production are expected to provide valuable new information about the spin structure of the nucleon. In particular, the longitudinal double spin asymmetries ($A_L$) will allow us to directly probe the polarized gluon distribution $\Delta g(x)$ and the dynamics of spin dependent QCD hard-scattering beyond light hadrons and jet productions. The transverse single spin asymmetries ($A_T$) are sensitive to the gluon Sivers function which is related to the orbital angular momentum of gluons inside the proton. Furthermore, $A_N$ in $J/\psi$ production can give us more insight on the production mechanism of quarkonia. The latest PHENIX results on $A_1L$ and $A_N$ of $J/\psi$ and open heavy flavor will be presented in this talk.

10:45AM KF.00007 Study of $J/\psi$ spin alignment in proton-proton collisions at $\sqrt{s} = 200$ GeV in the PHENIX experiment at RHIC1. KOHEI SHOJI, Kyoto University, RIKEN, PHENIX COLLABORATION — Non-relativistic QCD calculations using Color Octet Models (COMs) succeed in describing the production cross section of heavy quarkonia measured by CDF and other experiments. However, these models can not reproduce the experimental data for $J/\psi$ spin alignment (polarization). The understanding of the heavy quarkonium production mechanism cannot proceed without additional experimental measurements. The $J/\psi$ spin alignment is experimentally determined by measuring the decay angular distribution of leptons in the $J/\psi$ center of mass system. The anisotropy in the helicity frame was measured at CDF; however, the necessity of analyzing data with respect to another frame like Collins-Soper was recently discussed because the proper polarization axis which is sensitive to the interesting physics phenomenon is not known well. Moreover, measurements of not only the polar angular distribution but also the azimuthal one are important. Proton-proton collision experiments are in progress at the Relativistic Heavy-Ion Collider (RHIC) at Brookhaven National Laboratory. The PHENIX experiment at RHIC has muon spectrometers which can detect decay muons from $J/\psi$ at forward and backward rapidity, $1.2 < |y| < 2.2$. We present the status of our $J/\psi$ spin alignment study in proton-proton collisions at $\sqrt{s} = 200$ GeV.

11:00AM KF.00008 Transverse Spin Structure of the Proton Studied by HERMES. TOSHI-AKI SHIBATA, Tokyo Institute of Technology, HERMES COLLABORATION — HERMES is a deep inelastic scattering experiment at DESY-HERA. It uses the polarized electron/positron beam of 27.5 GeV and polarized gas targets such as hydrogen and deuterium, along with unpolarized high density gas targets. One of the major aims of HERMES is to explore the spin structure of the nucleon. The "Proton spin problem" was initiated by the discovery of EMC that quark spin contribution to the proton spin is small. The spin of the nucleon, which is 1/2, may consist of contributions of quark spin and gluon spin, and also of orbital angular momenta of quarks and gluons. One way to look into the spin structure of the nucleon is helicity distributions of the partons in the nucleon. The other way, which is developing rapidly, is to study transverse spin structure of the nucleon using a transversely polarized nucleon target. Sivers and Collins asymmetries from azimuthal angular dependence are typical examples. In this talk, the update of transverse spin structure of the nucleon at HERMES is presented.

11:15AM KF.00009 Transverse Spin Asymmetries in Back-to-Back Di-Hadron Correlations in the PHENIX Experiment at RHIC. JOHN LAJOIE, Iowa State University, PHENIX COLLABORATION — The measurement of transverse single spin asymmetries gives us an opportunity to probe the parton structure of transversely polarized nucleons. We present an analysis of single nucleon transverse spin asymmetries using di-hadron correlations in transversely polarized $p+p$ collisions as measured by the PHENIX experiment. The Sivers effect predicts that a non-zero $k_t$ in transversely polarized nucleons can lead a very small azimuthal asymmetry in back-to-back di-jets events. Because the PHENIX detectors do not have full phase space coverage it is problematic to fully reconstruct jets. Instead, we use di-hadron correlations in our analysis and measure the sum of two leading back-to-back hadrons' transverse momentum as $q_t$, which contains contributions both from partonic $k_t$ and fragmentation. Because of this, such measurements may also include contributions from spin-dependent fragmentation. We present yields and asymmetries of the projection of $q_t$ on the direction perpendicular to the spin orientation, which is the most sensitive to the small asymmetry due to Sivers effect. These correlations are performed for both midrapidity di-hadron pairs, as well as correlations between midrapidity hadrons and hadrons detected at forward rapidity in the PHENIX muon arms. These measurements offer the potential to elucidate the origin of large transverse single-spin asymmetries observed at RHIC.

11:30AM KF.00010 Transverse single spin asymmetries of single electrons from open heavy flavor decay in transversely polarized $p+p$ collisions. SEISHI DAIKAKU, Kyoto University, THE PHENIX COLLABORATION — The measurements of transverse single spin asymmetries ($A_T$) give us a good opportunity to advance our understanding of hadron structure. A number of mechanisms based on QCD for explaining $A_N$ have been proposed, and measurements in different processes have played complementary and important roles in attempts to understand $A_N$. Using the PHENIX Detector at the Relativistic Heavy Ion Collider (RHIC), we study open heavy flavour production with single electrons in transversely polarized $p+p$ collisions. At RHIC energy, heavy flavor production is dominated by gluon fusion process, so there is no chance to observe any large transverse single spin asymmetry of single electrons from open heavy flavor decay which may be explained in terms of the Collins effect because the gluon's transversity is zero. Therefore, the measurement of transverse single spin asymmetries of single electrons from heavy flavor decay at RHIC serve as a clean probe of the gluon Sivers effect. In 2006, the PHENIX experiment has collected 2.7 pb$^{-1}$ integrated luminosity in transversely polarized $p+p$ collisions at $\sqrt{s}=200$GeV. Present status of the analysis of $A_N$ of single electrons from heavy flavor decay at mid-rapidity will be presented.

11:45AM KF.00011 Beam Asymmetry for the $\vec{\gamma} n \rightarrow K^+\Sigma^-\overline{\Sigma}$ Reaction. EDWIN MUNEVAR, BARRY BERMAN, The George Washington University, CLAS COLLABORATION — Strangeness channels have been shown to be important for the experimental search for missing resonances. They are uniquely suited because they allow the possibility of determining several spin observables. A recent experiment performed at Jefferson Lab (g13 run period) [1], using a liquid deuterium target with linearly and circularly polarized tagged photon beams covering energies from threshold to 2.3 GeV, and using the CLAS detector, provides high-quality data (about 50 billion triggers) with good kinematic coverage and many experimental observables available for each reaction channel. We have analyzed these data to measure strangeness production on the neutron. In particular, we are interested in the exclusive analysis of the $\vec{\gamma} n \rightarrow K^-\overline{\Sigma}$ reaction. A preliminary first exclusive measurement of the photon beam asymmetry for this reaction will be presented.

12:00PM KF.00012 Transversity results and polarized Drell-Yan measurement at COMPASS, NORIHIRO DOSHITA, Yamagata University, COMPASS COLLABORATION — The recent results of the transversity measurement at COMPASS will be presented. And the Drell-Yan measurement with a transversal polarized target as a COMPASS future program will be shown.

Saturday, October 17, 2009 9:00AM - 11:45AM — Session KG Nuclear Astrophysics II Kings 2

9:00AM KG.00001 Determination of Gamow-Teller Strength Distributions and Electron Capture Rates for pf-shell Nuclei in Pre-supernova Stars1, ARTHUR L. COLE, Physics Department, Kalamazoo College, REMCO G.T. ZEGERS, B. ALEX BROWN, G. WESLEY HITT, LEAHAWNA UHER, National Superconducting Cyclotron Laboratory, Joint Institute of Nuclear Astrophysics, Department of Physics and Astronomy, Michigan State University — Modeling the evolution of pre-supernova stars and their collapse requires determining the electron capture rates for pf-shell nuclei. We intend to systematically calculate Gamow-Teller strength B(GT) distributions for all pf-shell nuclei and present preliminary result for the initial calculations. Calculations will be performed with a shell-model code using at least two different Hamiltonians to describe the interaction between the nucleons in the nuclei undergoing electron capture. The resulting B(GT) distributions were used to calculate the corresponding electron capture rates at stellar temperatures and densities relevant to pre-supernova core collapse stars. Calculated B(GT) distributions are compared to experimental measurements if they exist.

1This work is supported in part by NSF grant PHY-0758099.

9:15AM KG.00002 Very low energy protons from β-delayed p-decay of proton-rich nuclei for nuclear astrophysics1, E. SIMMONS, L. TRACHE, A. BANU, J.C. HARDY, V.E. IACOB, M. MCCLESKEY, B. ROEDER, A. SPIRIDON, R.E. TRIBBLE, Texas A&M University, T. DAVINSON, G. LOTAY, P.J. WOODS, University of Edinburgh, UK, A. SAASTAMOINEN, J. AYSTO, University of Jyvaskyla, Finland — We developed a technique to measure very low energy protons from the beta-delayed proton-decay of proton-rich nuclei produced and separated with the MARCOS recoil separator at TAMU. A simple setup consisting of a telescope made of a thin double sided Si strip detector (p-detector) backed or sandwiched between two thick Si detectors (β-detectors) was designed. The source nuclei are slowed down from 30-40 MeV/u and implanted in the middle of the thin p-detector. The excited states populated in daughter nucleus above the proton threshold are resonances in the radiative proton capture leading to that nucleus; therefore, beta-decay can be a useful mechanism to study these resonances. In particular, we have studied 23Al and 31Cl and got information on the resonances of 22Na(γ, p)21Mg and 30P(γ, p)31S reactions, both important in novae. We studied different W1 and BB2 p-detectors, 45-140 µm thick, made by MSL, and found that thinner detectors with a small cell size are best to measure proton energies as low as 2-300 keV.

1Supported by US DOE.

9:30AM KG.00003 Beta-decay measurement of 46Cr, Y. WAKABAYASHI, JAAE, H. YAMAGUCHI, T. HASHIMOTO, S. HAYAKAWA, Y. KURIHARA, D.N. BINH, D. KAHL, S. KUBONO, CNS, University of Tokyo, S. NISHIMURA, Y. GONO, RIKEN, M. SUGA, Y. FUJITA, Osaka University — For the rapid proton capture process (rp-process) in X-ray bursts and the core-collapse stage of supernovae, proton-rich pf-shell nuclei far from the line of stability play important roles. Studies of the feeding ratios and half-lives of the β and electron capture decay of these proton-rich pf-shell nuclei are of great astrophysical interest not only for nucleosynthesis but also for Fermi and Gamow-Teller transition study. The experiment to measure the half life of β decay of 46Cr was performed using the low-energy RI beam separator (CRIB) of the Center for Nuclear Study (CNS), University of Tokyo. The 46Cr particles were produced by the 36Ar + 12C fusion reaction. A natural C foil of 0.56 mg/cm² was installed as the primary target. The 36Ar primary beam was accelerated up to 3.6 MeV/nucleon by the RIKEN AVF cyclotron. A double sided Si strip detector (DSSD) of 500-µm thickness was used as a β-ray detector. A Si detector of 1.5-mm thickness was placed just behind the DSSD for a β-ray detector. To measure β-delayed γ rays, 3 clover and 1 coaxial Ge detectors were set around the target chamber. Beam was pulled to measure the half life of the β decay of 46Cr. The β-delayed γ ray of 46Cr was observed in this experiment. The experimental result will be discussed.

9:45AM KG.00004 Re-measuring the half-life of 60Fe, PHILIPPE COLLON, University of Notre Dame, ANDREAS STOLZ, SAM AUSTIN, Michigan State University, MANOËL COUDER, University of Notre Dame, IRSHAD AHMAD, JOHN GREENE, Argonne National Laboratory, DANIEL ROBERTSON, CHRIS SCHMITT, MATT BOWERS, WENTING LU, KIRK POST, MICHAEL CARILLI, University of Notre Dame — A recent experiment both at PSI and at Munich on the 60Fe lifetime points to a T1/2 for 60Fe that is possibly 70% higher (i.e. ~2.6x10⁶ years) than the presently accepted value (1.5x10⁶ years). 60Fe is mainly produced in core collapse supernovae explosions and these new results open up a number of questions as many factors scale with this number; from the 60Fe abundance determination with gamma ray telescope measurements to recent 60Fe(n, γ) cross section studies. We are presently working on a double-pronged attempt at re-measuring this half-life using the “old” AMS technique used by the Kutschera group in 1984 as well as a low-background activity measurement on the growth of 60Co from the decay of 60Fe. Both rely however on a clean production of a 60Fe sample as measurements rely on measuring the 60Co decay γ-line from 60Co produced by the decay of 60Fe. Beam time was made available at the NSCL to produce a well characterized 60Fe sample at the focal plane of the A1900. The 60Fe ions were implanted in a high purity Al target. We will report the results from this run as well as from the chemical separation of the 60Fe and first measurements of the sample.

10:00AM KG.00005 Spallation process by weakly interacting charged massive particle in nuclearastrophysics1, KENICHI SUGAI, JOE SATO, Saitama University, KAZUNORI KOHRI, Lancaster University, KOICHI YAZAKI, RIKEN, MASAFUMI KOIKE, Saitama University, MASATO YAMANAKA, Institute for Cosmic Ray Research, University of Tokyo, TOSHIFUMI JITTO, Saitama University — Recent result from WMAP suggests the possible deficit of the abundance of the lithium in the universe. We note that this deficit can be accounted for by Supersymmetric extentions of the Standard Model of the elementary particles. The abundance of lithium 6 has been considered in these models, but without taking account of any nuclear spallation process caused by a Supersymmetric particle. In this work we calculate a rate of the spallation to evaluate the abundance.
While more accurate and realistic measurements are obtained, the precision measurements of nuclear masses near the astrophysical r-process path are vital to reducing the uncertainties in the relevant neutron separation energies given by mass models, and the consequent abundance predictions. As part of an ongoing program, the Canadian Penning Trap mass spectrometer at Argonne National Laboratory has measured the masses of fission products from a 252Cf source in a large-volume gas catcher. This has produced 38 new mass measurements of neutron-rich nuclei ranging from Z = 51 to 64, many closer to the r-process path than had previously been measured for these elements. Systematic deviations from the AME 2003 are seen over a wide range of elements. The program of mass measurements will continue at the CARIBU upgrade to the ATLAS accelerator at ANL this fall.

[This work has been supported by grants from NSERC, Canada and by the U.S. DOE, Nuclear Physics Division, under Contract No. DE-AC02-06CH11357.]

10:30AM KG.00007 New experimental studies of the production of 44TiI, DANIEL ROBERTSON, PHILIPPE COLLON, JOACHIM GOERRES, MICHAEL WIESCHER, University of Notre Dame, HANS WERNER BECKER, RuhrUniversität Bochum, Germany, JOINT INSTITUT FOR NUCLEAR ASTROPHYSICS TEAM, DTL TANDEM LABORATORY TEAM — The main production reaction of 44Ti observed in core collapse supernova models is the (p,γ)44Ti reaction. A number of different experimental studies have been performed in the last years to determine the stellar reaction rate. These measurements were based on in-beam gamma spectroscopy techniques, accelerator mass spectrometer (AMS) techniques, and inverse reaction techniques with a recoil separator for separating and detecting the reaction products. The experimental results showed drastic differences. New experiments have been performed at the DTL Bochum and at the NSL Notre Dame using gamma spectroscopy and AMS techniques, respectively to investigate the reaction and the present discrepancies in the predictions. The results of the experiments will be presented and the impact on the reaction rate will be discussed.

10:45AM KG.00008 Pycnonuclear fusion in the curst of accreting neutron stars, MARY BEARD, University of Notre Dame, EDWARD BROWN, Michigan State University, LEANDRO GASQUES, University of Lisbon, Portugal, RITA LAU, HENDRIK SCHATZ, Michigan State University, MICHAEL WIESCHER, University of Notre Dame, DIMITRIY YAKOVLEV, University of St. Petersburg, Russia, JOINT INSTITUT FOR NUCLEAR ASTROPHYSICS TEAM, DTL TANDEM LABORATORY TEAM — Pycnonuclear fusion processes take place at extreme density conditions of \(\rho > 10^{11} \text{ g}/\text{cm}^3\), anticipated for the core of white dwarfs or the crust of neutron stars. A formalism was developed for predicting pycnonuclear reaction rates for neutron rich nuclei in the carbon to magnesium range. The reaction rates have been used to simulate pycnonuclear burning in the deeper crust of an accreting neutron star. The pycnonuclear reaction rates will be presented and the results of the nucleosynthesis simulations will be discussed.

11:00AM KG.00009 Effect of long-lived strongly interacting relic particles on big bang nucleosynthesis1, MOTOHIKO KUSAKABE, University of Tokyo, TOSHITAKA KAJINO, National Astronomical Observatory of Japan, TAKASHI YOSHIDA, University of Tokyo, GRANT MATHEWS, University of Notre Dame — Some particle theories beyond the standard model predict that relic long-lived strongly interacting massive particles (SIMPs or X particles) could exist in the early universe. We study effects of such long-lived SIMPs on big bang nucleosynthesis (BBN). The interaction strength between an X particle and a nucleon is assumed to be similar to that of other nucleons. We then calculate BBN in the presence of the unstable neutral charged X0 particles taking account of the capture of the X0 particles by nuclei to form X-nuclei. We find that SIMPs form bound states with normal nuclei during a relatively early epoch of BBN. This leads to the production of heavy elements. Constraints on the abundance of X0 particles are derived from observational limits on the primordial light element abundances. Particle models including long-lived colored particles with lifetimes longer than 200 s are rejected based upon these constraints.

1 This work is supported by the Mitsubishi Foundation, MEXT KAKENHI (20105004 and 20240305), the JSPS Core-to-Core Program, International Research Network for EFES, the JSPS Grant-in-Aid (18.11384) and the U.S. DOE (Nuclear Theory Grant DE-FG02-95-ER40934).

11:15AM KG.00010 Mass, Energy, Space And Time Systemic Theory MEST— repulsion and gravity, DAYONG CAO, Beijing National Providence Science & Technology Development Co., Ltd — Things have their physical system of the mass, energy, space and time of themselves-MEST. Sun can give the planets the repulsion and the gravity. It decided the relationship between the mass-energy and space-time of themselves-MEST. Sun can give the planets the repulsion and the gravity. It decided the relationship between the mass-energy and gravity.

11:30AM KG.00011 Entropy growth in the early universe and confirmation of initial big bang conditions (Why the quark-gluon model is not the best analogy), ANDREW BECKWITH, Amerian Institute of Beam Energy Propulsion — This paper shows how increased entropy values from an initially low big bang level can be measured experimentally by counting relic gravitons. Furthermore the physical mechanism of this entropy increase is explained via analogies with early-universe phase transitions. The role of Jack Ng’s revised infinite quantum statistics in the physics of gravitational wave detection is acknowledged. Ng’s infinite quantum statistics can be used to show that \(\Delta S \approx N_{\text{gravitons}}\) is a starting point to the increasing net universe cosmological entropy. Furthermore, we compare the increase in relic gravitons with “chilled neutrinos” generated as of at the start of the pre CBMR era, before CBMR “turned on” roughly 400 thousand years after the big bang.

Saturday, October 17, 2009 9:00AM - 12:00PM

Session KH Mini-symposium on Direct Reactions Involving Unstable Nuclei I

9:00AM KH.00001 Overview of reaction theories to probe exotic nuclear structure, IAN THOMPSON, Lawrence Livermore National Laboratory — Reactions are the key connection between nuclear structure and experiments. Determining the detailed structure of short-lived exotic nuclei is best done by an accurate application of reaction theory. Only with a good reaction theory can we probe the spectroscopic properties of those nuclei. Collective and single-particle reactions have traditionally been first analyzed by one-step DWBA methods. Such simple methods allow spectroscopic information to be extracted as the ratio between experimental cross sections and unit theoretical predictions. However, especially when studying states close to threshold, it is vital to calculate couplings to the continuum, as well as other higher-order contributions. I therefore discuss modern methods that include a discretized continuum, as well as dynamic core excitations. There is now no longer a simple ratio between spectroscopic nuclear properties and observed cross sections, but more accurate and realistic measurements are thereby obtained. Prepared by LLNL under Contract DE-AC52-07NA27344.
9:30AM KH.00002 Structure of $^{12}\text{Be}$ studied via the $^{11}\text{Be}(d,p)$ reaction, J. A. Cizewski, P. D. O'Malley, W. A. Peters, Rutgers, N. Hatarik, UC Berkeley, J. Escher, LLNL — Neutron capture reactions on unstable nuclei have important implications for nuclear astrophysics and applications of nuclear science, e.g., nuclear energy and national security. Given the limited capabilities to measure such reactions directly (because of intense background from targets with half-lives shorter than 100 days), it is important to determine if a surrogate reaction is effective and, if so, develop the techniques for these reactions with beams of rare isotopes. The neutron-transfer reaction, $^{12}\text{B}(d,p)^{13}\text{B}$, has been studied as a reference standard. The angular distribution for the $3.48\text{ MeV}$ state is consistent with an $l=0$ transition as expected from shell-model calculations which suggest a $1/2^+$ state that is primarily an $s_{1/2}$ neutron coupled to the $1^+$ ground state of $^{12}\text{B}$. The $3.68\text{ MeV}$ angular distribution is dominantly $l=2$ (with a slight $l=0$ admixture), consistent with the shell-model expectation of a $3/2^+$ state, although the spectroscopic factor relative to that for the $3.48\text{ MeV}$ state is much smaller than the shell-model prediction.

9:45AM KH.00003 Study of the $^{12}\text{B}(d,p)^{13}\text{B}$ reaction with the HELIOS spectrometer, H. Y. Lee, J. P. Schiffer, Argonne National Laboratory, A. H. Wuosmaa, Western Michigan University, HELIOS COLLABORATION — The $^{12}\text{B}(d,p)^{13}\text{B}$ reaction has been studied in inverse kinematics at ATLAS at an energy of 6.25 MeV/u with the HELIOS spectrometer to study the positive-parity orbitals for the neutron-rich $^{13}\text{B}$ nucleus. Two states previously suggested to have positive-parity at 3.48 and 3.68 MeV were resolved and their proton angular distributions measured. The $^{12}\text{B}(d,p)^{13}\text{B}$ reaction was also studied as a reference standard. The angular distribution for the $3.48\text{ MeV}$ state is consistent with an $l=0$ transition as expected from shell-model calculations which suggest a $1/2^+$ state that is primarily an $s_{1/2}$ neutron coupled to the $1^+$ ground state of $^{12}\text{B}$.

10:00AM KH.00004 Missing mass spectroscopy on the proton-unbound $^{12}\text{O}$ nucleus and the breakdown of the $Z=8$ shell closure, D. Suzuki, H. Iwasaki, Department of Physics, University of Tokyo, D. Beaumel, IPN Orsay, E537-SPEG COLLABORATION — We will report on the first observation of an excited state in the proton-unbound $^{12}\text{O}$ with $Z=8$. Recent studies have shown that the shell closure at $N=8$ disappears far from stability. A further interest then arises in mirror nuclei, addressing an open question about a persistency or a disappearance of the proton magicity at $Z=8$. Level properties of the low-lying states of $^{12}\text{O}$ should provide invaluable information on studies on the low-lying intruder states in the mirror partner $^{12}\text{Be}$. Suzuki and Iwasaki have highlighted the breakdown of the neutron shell closure. However, no definite observation has been made for excited states of $^{12}\text{O}$, which lies beyond the proton-drip line. In this study, we applied the missing mass method to the $^{14}\text{O}(p,1)^{13}\text{O}$ reaction at 50 MeV/u. The experiment was performed at the GANIL-SPEG facility. The secondary $^{14}\text{O}$ beam was produced in the SISSI device, and impinged on a 1-mm-thick solid hydrogen target. Recoiling particles were detected by an array of the MUST2 telescopes, each of which was composed of a double-sided silicon strip detector and a CsI calorimeter. A large active area of 100×100 mm² with a high granularity achieved efficient measurements as well as a good momentum resolution. Based on the experimental result, we will discuss the breakdown of the $Z=8$ shell closure in $^{12}\text{O}$.

10:15AM KH.00005 Determination of the radiative neutron capture rate on $^{14}\text{C}$ via indirect methods, M. T. McLeskey, A. M. Mukhamedzhanov, R. E. Tribble, E. Simmons, A. Spidron, A. Banu, B. Roeder, V. Goldberg, L. Trachte, X. F. Chen, Y.-W. Liu, Cyclotron Institute, Texas A&M University — $^{14}\text{C}(n,\gamma)^{15}\text{C}$ is being used as a test case in the development of an indirect method to determine neutron capture cross sections on neutron-rich unstable nuclei at astrophysical energies. Our approach combines information about the peripheral component of the reaction (ANC) with information from the interior contribution (spectroscopic factor). The ANC for $^{13}\text{C}$ has been determined using HI neutron transfer with a 12 MeV/nucleon $^{14}\text{C}$ beam on a thin foil target. The spectroscopic factor will be determined using $^{13}\text{C}(d,p)$ in forward kinematics with an incident deuteron energy of about 60 MeV. Both experiments were done with the high-resolution MDM spectrometer of Texas A&M University.

10:30AM KH.00006 Developing a surrogate for neutron capture reactions with rare isotope beams, J. A. Cizewski, P. D. O'Malley, W. A. Peters, Rutgers, N. Hatarik, UC Berkeley, J. Escher, LLNL — Neutron capture reactions on unstable nuclei have important implications for nuclear astrophysics and applications of nuclear science, e.g., nuclear energy and national security. Given the limited capabilities to measure such reactions directly (because of intense background from targets with half-lives shorter than 100 days), it is important to determine if a surrogate reaction is effective and, if so, develop the techniques for these reactions with beams of rare isotopes. The neutron-transfer reaction, $(d,p)$, in which the final nucleus is populated at excitations above the neutron separation energy and the gamma-ray de-excitation is measured, is a promising method to obtain cross sections for neutron capture on unstable nuclei. The Surrogate reaction method is an indirect approach for determining compound-nuclear reaction cross sections via a combination of theory and a transfer-reaction or inelastic-scattering experiment. Past applications of the method have demonstrated that it can provide useful cross section estimates for neutron-fusion of actinides. Most analyses of fission data carried out so far have made approximations that are expected to break down for situations relevant to extracting $(n,\gamma)$ cross sections from Surrogate measurements. This presentation focuses on the prospects for employing the Surrogate method to obtain cross sections for neutron capture on unstable nuclei. A brief outline of the approach will be given and recent progress made in moving beyond currently-employed approximations, such as the Weiskopf-Ewing and Ratio approximations, will be discussed. An application of the newly-developed tools to data taken recently by STARS/LiBerACE collaboration for the gadolinium region will be presented.

10:45AM KH.00007 Determining Cross Sections for Low-Energy Neutron Capture Reactions via the Surrogate method - Recent Progress, J. Tuesta, E. Escher, F. S. Dietrich, N. D. Scioli, Lawrence Livermore National Laboratory — Many reactions of interest to nuclear energy and astrophysical applications cannot be measured directly since they involve short-lived or highly radioactive target nuclei. The Surrogate reaction method is an indirect approach for determining compound-nuclear reaction cross sections via a combination of theory and a transfer-reaction or inelastic-scattering experiment. Past applications of the method have demonstrated that it can provide useful cross section estimates for neutron-fusion of actinides. Most analyses of fission data carried out so far have made approximations that are expected to break down for situations relevant to extracting $(n,\gamma)$ cross sections from Surrogate measurements. This presentation focuses on the prospects for employing the Surrogate method to obtain cross sections for neutron capture on unstable nuclei. A brief outline of the approach will be given and recent progress made in moving beyond currently-employed approximations, such as the Weiskopf-Ewing and Ratio approximations, will be discussed. An application of the newly-developed tools to data taken recently by STARS/LiBerACE collaboration for the gadolinium region will be presented.

1Work supported in part by U.S. D.O.E.

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory, DE-AC52-07NA27344.)
11:00AM KH.00008 Complex-Scaled CDCC method for nuclear breakup reactions, MASAaki Takashina, RCNP, Osaka Univ., Takayuki Myo, Osaka Inst. Tech., Yuma Kikuchi, Yoshihru HIRABAYASHI, KiyoShi Kato, Hokkaido Univ. — Nuclear breakup process is very important for light unstable nuclei (typically halo nuclei) induced reactions because of their weak-binding nature. The continuum-discretized coupled-channel (CDCC) method is known to be one of the powerful method to describe the nuclear breakup reaction. Indeed, CDCC has been applied to a number of analyses for the breakup reactions of both the stable and unstable nuclei, and the successful results have been obtained. In the present study, we propose complex-scaled CDCC (CS-CDCC) method, in which only the internal coordinate and momentum of the projectile are complex-scaled. The expected advantages of CS-CDCC are (1) in spite of the discretization, we can obtain the continuous S matrix elements without the smoothing function, because the continuum level density is correctly obtained, (2) in the framework of the complex scaling method, three-body scattering state can be solved properly, (3) the resonance state is strictly separated from the continuum states, and this fact is more advantageous for investigation of reaction mechanism than the ordinary CDCC method. We apply CS-CDCC to the d → p + n breakup reaction on a ^{58}Ni target at E_d=80 MeV to confirm the availability of CS-CDCC. We also plan to apply it to breakup reactions of light unstable nuclei.

11:15AM KH.00009 Core Excitation in Few-Body Reaction Theory, Neil Summiers, LLNL, Filomena Nunes, NSCL/MSU, Ian Thompson, LLNL, Steven Pain, ORNL — Direct reactions theories involving one-neutron halo nuclei such as ^{11}Be, typically treat the nucleus as a two-body projectile where the valence neutron and core degrees are freedom are explicitly included in the reaction. This allows inclusion of the two-body breakup continuum in the reaction calculation. One such model is the Continuum Discretized Coupled Channels (CDCC) method, where the breakup continuum is expanded into partial waves and discretized in energy. Recent advances in this method, called XCDCC (X for eXtended), allow for the treatment of excited states for the ^{10}Be core. This goes beyond the single particle model that reaction theories typically employ, and allows for coupled-channel descriptions of the projectile. By including excited states of the core the properties of the projectile can be more accurately described in the reaction, such as the B(E1) strength crucial for Coulomb excitation and breakup. We will present the results of extracting the B(E1) strength of ^{11}Be from the Coulomb excitation experiments performed at GANIL, MSU and RIKEN.

11:30AM KH.00010 Proposed experiment for the observation of the isovector spin monopole resonance via the exothermic charge-exchange reaction using the SHARAQ spectrometer, Shumpei Noji, Hideyuki Sakai, Department of Physics, University of Tokyo, SHARAQ COLLABORATION — We are developing the exothermic charge-exchange reaction induced by the β-unstable beam, (^{12}N, ^{12}C), as a new probe for the study of spin-isospin modes in nuclei. Good features of this reaction include the large mass difference of ^{12}N and ^{12}C, the spin-isospin selection of ΔS = ΔT = 1, and the surface-sensitivity due to the strong absorption. They are suited for the study of spin-isospin modes such as the isovector spin monopole resonance (IVSMR). We have proposed, at the RI Beam Factory (RIBF) at RIKEN, a measurement of the ^{90}Zr(^{12}N, ^{12}C) reaction at 200 A MeV at 0 degrees to observe the IVSMR in ^{90}Ni. The ^{12}N beam is produced via the projectile fragmentation of the ^{14}N primary beam at 250 A MeV and separated in the BigRIPS, and transported through the dispersion-matched beam line to the reaction target of ^{90}Zr. The reaction product of ^{12}C is momentum analyzed by the newly constructed SHARAQ spectrometer. We performed commissioning experiments in March and May, 2009, to study the production of the ^{12}N secondary beam and the ion optical properties of the beam line and the SHARAQ spectrometer. We report the results from the commissioning experiments together with the present situation of this project.

11:45AM KH.00011 Constructing formula for total reaction cross sections without adjustable energy-dependent parameters, Akihisa Kohama, Riken Nishina Center, Kei Iida, Kochi University, Kazuhiro Oyamatsu, Aichi Shukutoku University — We review our formula for a proton-nucleus total reaction cross section, σ_R, constructed in the black-sphere approximation, in which a nucleus is viewed as a “black” sphere of radius 'a'. In this formula, the cross section, πa^2, is expressed as a function of the mass and neutron excess of the target nucleus and the kinetic energy of incident proton, T_p, in a way free from any adjustable T_p-dependent parameter. We deduce the dependence of σ_R on T_p from a simple argument involving the proton “optical” depth within the framework of the black-sphere approximation of nuclei. We find that, for stable nuclei, this formula remarkably well reproduces the empirical T_p dependence of σ_R at T_p = 100–1000 MeV without introducing any adjustable energy-dependent parameter. We show that, in this formula, the energy dependence of a is determined by that of nucleon-nucleon total cross sections, while the target-mass-number dependence of a is sensitive to the surface thickness of the target. In the future experiments of neutron-rich unstable nuclei, we could expect that the neutron-excess dependence of a would play an important role in deducing the density dependence of nuclear symmetry energy.

Saturday, October 17, 2009 9:00AM - 12:15PM — Session KJ Electroweak Interactions — Queens 4

9:00AM KJ.00001 The TRIUMF TWIST experiment, Jean-Michel Poutissou, TRIUMF — The TWIST experiment at TRIUMF has been conducted by a Canadian-USA-Russia collaboration which has measured the parameters describing the decay at rest of polarized muons, with the goal of placing constraints on physics beyond the Standard Model. The original objective of an order of magnitude improvement on the precision with which the parameters rho, delta and xi,-which describe the positron momentum and emission angle spectra,-are determined is within reach and final analysis of the systematic uncertainties on the new measurements are almost complete. I will present an update on this important high precision experiment and place it in the context of several recent other muon decay measurements.

9:15AM KJ.00002 Status of the MiniCLEAN dark matter experiment, Keith Rielage, Los Alamos National Laboratory, DEAP/CLEAN COLLABORATION — MiniCLEAN utilizes over 400 kg of liquid cryogen to detect nuclear recoils from WIMP dark matter with a projected sensitivity of 2×10^{-45} cm^2 for a mass of 100 GeV. The liquid cryogen is interchangeable between argon and neon to study the A dependence of the potential signal and examine backgrounds. MiniCLEAN utilizes a unique modular design with spherical geometry to maximize the light yield using cold photomultiplier tubes in a single-phase detector. Pulse shape discrimination techniques are used to separate nuclear recoil signals from electron recoil backgrounds. Particular attention is being paid to mitigating the backgrounds from contamination of surfaces by radon daughters during assembly. The design and assembly status of the experiment will be discussed. The projected timeline and future plans for staging the experiment at SNOLAB in Sudbury, Canada will be presented.
9:30AM KJ.00003 Optical Tests in support of the MiniCLEAN Dark Matter Search

This work was supported by the LANL LDRD program.

9:45AM KJ.00004 ABSTRACT WITHDRAWN

10:00AM KJ.00005 Measurement of Q-Weak Detector Sensitivities

10:15AM KJ.00006 The Qweak Čerenkov Detector

10:30AM KJ.00007 Track Reconstruction and Extrapolation In Qweak Experiment

10:45AM KJ.00008 Systematic Studies with the Qweak Tracking System

11:00AM KJ.00009 Target Density Fluctuation Studies for the Qweak Experiment

The Qweak Čerenkov Detector

The Qweak experiment at Jefferson Laboratory will make a determination of the proton’s weak charge \( Q^p \) by measuring the parity violating e-p scattering asymmetry \( A_{PV} \). The proposed experimental precision and statistical uncertainty demand a high performance Čerenkov detector system working in integration mode. These Čerenkov detectors are made of fused silica, allowing us to handle the high rate of 800 MHz per detector for a running time of 2500 hours without significant radiation damage. In this talk, I shall introduce the Monte Carlo simulation, the design, the construction of this detector system, as well as detector performance tests.

Track Reconstruction and Extrapolation In Qweak Experiment

The Qweak experiment at Jefferson Laboratory is designed to precisely determine the proton’s weak charge \( Q^p \) and thus the weak mixing angle \( \theta_W \) by measuring the parity violating elastic electron-proton scattering at low momentum transfer \( Q^2 \). The Qweak experimental result will enable a precise test of the Standard Model prediction of \( Q^p \), and hence will probe new physics. The tracking detectors however, are only operable in low-current (counting) mode for \( Q^2 \) determination. To reach the proposed experimental precision, the average \( Q^2 \) needs to be determined to \( 0.7\% \) requiring individual tracks to be reconstructed with high efficiency. A set of high resolution tracking detectors were designed for this purpose. The hit information for each detector will then be fed into the tracking software for reconstructing the trajectories and extracting the \( Q^2 \). The tracking detectors however, are only operable in low-current mode. Therefore a tracking Čerenkov detector, the “focal-plane scanner,” was designed for further extrapolating the \( Q^2 \) from low current to high current. A brief introduction on the tracking mechanism will be presented, along with some detailed track reconstruction strategies and the \( Q^2 \) extrapolation method.
11:15AM KJ.00010 Ultra-High Precision Half-Life Measurement for the Superañcluded $\beta^+$ Emitter $^{26}$Al$^{19}$, P. Finlay, G. Demand, P.E. Garrett, K.G. Leach, A.A. Phillips, C.S. Sumithrarachchi, C.E. Svensson, S. Tri-Amank, University of Guelph, G.F. Grinyer, NSCL/MSU, J.R. Leslie, Queens University, C. Andreoiu, D. Cross, Simula, Fraser University, R.A.E. Austin, St. Mary's University, G.C. Ball, D. Bandypadhyay, M. Djongolov, S. Ettenauer, G. Hackbar, C.J. Pearson, S.J. Williams, TRIUMF — The calculated nuclear structure dependent correction for $^{26}$Al$^m$ ($\delta_C - \delta_S = 0.305(27)\%$ [1]) is smaller by nearly a factor of two than the other twelve precision superallowed cases, making it an ideal case to pursue a reduction in the experimental errors contributing to the $T_f$ value. An ultra-high precision half-life measurement for the superallowed $\beta^+$ emitter $^{26}$Al$^{19}$ has been made at the Isotope Separator and Accelerator (ISAC) facility at TRIUMF in Vancouver, Canada. A beam of $\sim 10^5$ $^{26}$Al$^m$/s was delivered in October 2007 and its decay was observed using a $4\pi$ continuous gas flow proportional counter as part of an ongoing experimental program in superallowed Fermi $\beta$ decay studies. With a statistical precision of $\sim 0.008\%$, the present work represents the single most precise measurement of any superallowed half-life to date.


11:30AM KJ.00111 High Precision Measurement of the $^{19}$Ne Lifetime, Leah Broussard, H.O. Back, M.S. Boswell, A.S. Crowell, C.R. Howell, M.F. Kidd, R.W. Pattie, Jr., A.R. Young, TUNL, P.G. Dendooven, G.S. Giri, D.J. Van der Hoek, K. Jungmann, W.L. Kruthoff, C.J.G. Underwater, B. Santra, P.D. Shidling, M. Sohani, O.O. Versolota, L. Willmann, H.W. Wilschut, KVI — Recently, a rigorous review of the $T_\pm = \frac{1}{2}$ mirror transitions has identified several systems which can contribute to high precision tests exploring deviations from the Standard Model’s description of the electroweak interaction. Arguably, one of the best candidates is the $\beta^+$ decay of $^{19}$Ne to $^{19}$F. In this system, the main contribution to the uncertainty of extracted Standard Model parameters is due to the measured value of the lifetime of the decay. In March 2009, a high precision measurement of the lifetime of $^{19}$Ne was made by a collaboration between the Triangle Universities Nuclear Laboratory (TUNL) and the Kernfysisch Versneller Instituut (KVI) at the Trapped Radioactive Isotopes: Microcalorimeters for Fundamental Physics (TRIqip) facility. An overview of the experiment and preliminary results will be presented.

11:45AM KJ.00012 Confirmation of the Precise Half Life of $^{26}$Si, V. Iacob, V. Golovko, J. Goodwin, J.C. Hardy, N. Nica, H.I. Park, L. Trachte, R.E. Tribble, Cyclotron Institute at Texas A&M University — Precise $T_f$-values (with uncertainties below 0.1%) for superallowed $0^+ \rightarrow 0^+$ $\beta$ transitions provide a demanding test of the Standard Model via the unitarity of the Cabibbo-Kobayashi-Maskawa matrix. Our preliminary report of such a measurement for the half-life of $^{26}$Si [1], was consistent with the previously accepted value but turned out to be higher than a subsequent result published in 2002 [2]. This prompted us to repeat the measurement described in [1] with increased statistics and with a strong focus on all experimental details that could have generated a biased result. We collected more than 200 million $^{26}$Si nuclei in 60 separate runs, which differs from one another in their discriminator threshold, detector bias or dominant dead-time setting. We repeatedly verified and confirmed the stability of the source purity and detector response function. The analysis of these separate runs shows no systematic bias with these parameters and confirms our initial result [1]. The discrepancy between our result and that of reference [2] can be accounted for by the latter's neglect [3] of the difference in beta-detection efficiencies between the parent and daughter decays. Our preliminary result is 2245(3) ms, with the final analysis expected to yield an uncertainty of 0.05% or better. [1] V. Iacob et al., Bulletin APS 53, (12) DNP-Meeting 2008 [2] I. Matea et al., EPJ A37, 151 (2008) [3] B. Blank, private communication

12:00PM KJ.00013 Upgrade of a Right-Handed Current Search Using Highly-Polarized, Laser-Cooled $^{37}$K, S. Behling, D. Melconian, Texas A&M University, A. Gorelov, J.A. Behr, K.P. Jackson, T. Kong, M.R. Pearson, O. Theriault, Triumf, D. Ashery, Tel Aviv University — The Triumf Neutral Atom Trap facility is able to provide $^{37}$K that is laser-cooled and highly polarized. This will be used to search for new physics via studies of the angular distributions of its decay products. The first planned experiment will measure the $\beta$ asymmetry parameter, $A_\beta$, using back-to-back detectors placed along the polarization axis. One key aspect of the upgraded system is the addition of a shake-off electron detector which, used in coincidence with the $\beta$ detectors, will minimize the background from untrapped depolarized atoms. The other major improvement is the conversion of our traditional magneto-optical trap (MOT) to an AC-MOT [1] to allow us to switch between trapping and polarizing much more quickly. Our goal is to measure $A_\beta$ to $\lesssim 1.0\%$ of its value and to estimate systematics as we work towards a $\approx 0.1\%$ experiment. An overview of the experiment and our expected sensitivity to physics beyond the Standard Model based on GEANT4 simulations will be presented.


Saturday, October 17, 2009 9:00AM - 12:15PM — Session KK Mini-Symposium on Probing Fundamental Symmetries with Nuclei, Neutrons, Muons, and Atoms IV — Queens 5

9:00AM KK.00001 ABSTRACT WITHDRAWN —

9:15AM KK.00002 Ultracold Neutrons in Canada and Japan1, Jeffery Martin, The University of Winnipeg — When neutrons are taken out of atomic nuclei and cooled down, they have weird properties: they bounce off walls, they can be stored in magnetic bottles, and they form quantized energy levels in Earth’s gravitational field. Once they’ve been trapped using such methods, their properties can be studied very carefully to search for deviations from expectations based on the standard model of particle physics. If a deviation is found, it would signify new physics beyond the standard model. We are building a new source of ultracold neutrons in Canada (at TRIUMF, Vancouver, BC) with the help of collaborators from Japan (Masuda, et al). The source is projected to provide the highest density of ultracold neutrons ever produced in the world, and we’ll use the neutrons to push some very interesting physics experiments to unprecedented levels of precision, as I’ll describe.

1Research supported by NSERC, CFI, and JSPS.

9:30AM KK.00003 Progress on the Construction of the PULSTAR Solid Deuteron Ultracold Neutron Source, Grant Palquist, Chris Cottrell, Robert Golub, Paul Huffman, Albert Young, North Carolina State University Department of Physics, Ayman Hawari, Ekaterina Korobkina, Bernard Wehring, North Carolina State University Department of Nuclear Engineering — An ultracold neutron (UCN) source utilizing solid deuterium is being constructed at the 1MW PULSTAR nuclear reactor on the campus of North Carolina State University. The final stages of assembly and commissioning are underway. The overall design, status of construction, and benchmarking measurements will be discussed. The UCN source design is based on detailed simulations including MCNP, UCN transport Monte Carlo, and CFD of the cryogenic systems. The source will be available for developing general UCN experiment technology, such as guides and detectors in support of current neutron EDM and UCNa projects. Other plans include fundamental physics measurements such as neutron beta decay and gravity measurements, as well as development of new techniques to use UCN in material and surface physics studies. The expected experimental density of UCN will be competitive with currently available sources, including those at significantly more powerful reactors. This work is supported in part by NSF grant #0314114 and funds from the DOE INIe program.
A New Ultra-Cold Neutron Source Available at Los Alamos

ALEXANDER SAUNDERS, Los Alamos National Lab, UCNA COLLABORATION — A new source of ultra-cold neutrons (UCNs) has been constructed at Los Alamos National Lab and is now in operation. Although the primary purpose of the source is to supply UCNs to the UCNA experiment, a second test beam port is also available and can be used to supply UCNs to another experiment simultaneously. During source operation, the neutron density at the test port has been estimated to be approximately 5 UCN/cc. During UCNA data acquisition, the UCN beam is available at the test port with a duty factor of about 1/6; that is, 10 minutes out of each hour, with the balance being delivered to UCNA. Experiments that have used and/or intend to use the test port beam include nEDM engineering tests, guide tests for UCN transport and depolarization, and a new measurement of the neutron lifetime using magnetically trapped UCNs. Measurements of the density, flux, and velocity distribution of the neutrons at the test port will be presented.

Detailed Characterization of Copper Guide Polishing Methods for use in UCN Transport

RUSSELL MAMMEI, Virginia Tech, UCNA COLLABORATION — The UCNA experiment at Los Alamos National Lab (LANL) employs polarized ultracold neutrons (UCN) to measure the beta-asymmetry in free neutron decay. The 2009 beamline makes use of electro-polished stainless steel and copper guides. In the depolarization region of the experiment, hydrogen-free Diamond-like-Carbon (DLC) coated copper guides are utilized. A target-biased, pulsed laser deposition technique was used to produce an adhered coating on these copper guides with an expected Fermi potential of 240eV. A series of guide tests performed last December indicate that these DLC coated copper guides have very low depolarization per bounce and a higher Fermi potential than bare copper. However, transmission results, for both the coated and uncoated copper guides, suggest that the underlying polish was not optimum. An investigation of the mechanical and electro-polishing processes has been conducted utilizing profilometry and atomic force microscopy. These data have been used to simulate the effects of these polishes on UCN transport and indicate that the final mechanical polish direction can have a big impact. Results of this study will be presented along with its impact on making higher Fermi potential DLC coated copper guides.

Precision UCN Polarimetry and the UCNA Experiment

A.T. HOLLEY, FOR THE UCNA COLLABORATION — The goal of the UCN experiment is to determine the angular correlation between the electron momentum and the neutron spin (the beta-asymmetry) in free neutron decay. The 2009 beamline makes use of electro-polished stainless steel and copper guides. In the depolarization region of the experiment, hydrogen-free Diamond-like-Carbon (DLC) coated copper guides are utilized. A target-biased, pulsed laser deposition technique was used to produce an adhered coating on these copper guides with an expected Fermi potential of 240eV. A series of guide tests performed last December indicate that these DLC coated copper guides have very low depolarization per bounce and a higher Fermi potential than bare copper. However, transmission results, for both the coated and uncoated copper guides, suggest that the underlying polish was not optimum. An investigation of the mechanical and electro-polishing processes has been conducted utilizing profilometry and atomic force microscopy. These data have been used to simulate the effects of these polishes on UCN transport and indicate that the final mechanical polish direction can have a big impact. Results of this study will be presented along with its impact on making higher Fermi potential DLC coated copper guides.

Current mode wire chambers for cold neutron detection at the SNS FNBP

MARK MCCREA, Univ. of Manitoba, NPDGAMMA COLLABORATION, N3HE COLLABORATION — A 3He chamber is a multi-wire proportional counter for detecting neutrons. A 3He nucleus that captures a neutron will break up by the reaction $n + ^3\text{He} \rightarrow p + ^4\text{He} + 765$ keV which is detected by gas ionization inside the chamber, caused by the reaction products. The 765 keV is released as kinetic energy of the proton and triton, allowing a consistent signal from each capture. The chamber gas is a mixture of gases with a fraction of a 3He, the amount of which is used to adjust the neutron thickness; the fraction of beam that is captured in the monitor. I will report on the design, construction, and testing of a new set of beam monitors for the Spallation Neutron Source Fundamental Neutron Physics Beam line (FNBP), which use this technology. The 3He chambers will be used to monitor the neutron flux at various positions along the beam, as it passes through cold neutron experiments planned at the SNS. In addition, I will report on the design of a 3He wire chamber that will be used in the nHe experiment at the SNS. This chamber uses the same neutron detection process as described above, but will be black to neutrons (high $^3\text{He}$ content) with a small amount of ionization gas, in order to allow the protons to range out over as long a distance as possible. This chamber will be used to measure the parity violating longitudinal asymmetry in the number of protons emitted in the capture reaction.

Proton source for Silicon detector tests

DAVID HARRISON, University of Manitoba, MARK ABOTOSAWAY, JOSH BOULDING, University of Winnipeg, MICHAEL GERRICKE, University of Manitoba, JEFF MARTIN, University of Winnipeg, PETER MCCOWN, KUMAR SHARMA, University of Manitoba — In neutron beta decay a neutron decays through the weak force into an electron, proton and antineutrino. The detection of the decay protons is an important aspect of certain neutron beta decay experiments. One particular experiment of this type is the Nab experiment. In the Nab experiment decay protons are electrostatically accelerated to 30keV in a flat magnetic field region of the magnetic spectrometer before striking silicon detectors. To calibrate the silicon detectors for such experiments a low intensity proton accelerator is being designed and built at the University of Manitoba. Progress in proton source and accelerator development will be discussed. The results of the silicon detector tests would be important for experiments detecting post-accelerated recoil protons using silicon detector technology.

Calibration of the UCNA Beta Spectrometer

MICHAEL MENDENHALL, Caltech, UCNA COLLABORATION — The UCNA experiment measures the angular correlation between the polarization direction of a neutron and the momentum of the electron emitted in beta decay. Polarized ultracold neutrons decay in a 1T magnetic field, which conducts the emitted betas to detectors on either side of the decay region. Measuring the energy spectrum of the electrons is necessary due to energy dependence of the observed asymmetry and electron backscattering corrections. The beta detectors consist of a wire-chamber for position tracking and a plastic scintillator calorimeter. This talk describes how conversion electron sources and the beta spectrum endpoint are used to calibrate the position-dependent energy response of the scintillators, and how the calibration of the detectors is monitored and stabilized throughout the 2008 run.
et al., W.E. Collins, J.H. Hamilton, et al., of the selenium isotopes. We have developed a He-II spallation UCN source at RCNP, Osaka Univ. In this source, fast neutrons obtained by spallation reactions are moderated by RT D₂O and 10K solid D₂O, then scattered by phonons in superfluid helium (He-II) to be UCN. The obtained UCN density was 15 UCN/cm³. We measured the energy spectrum of UCN at the exit of this source by storing them in a cylindrical bottle in order to understand the performance of this source. A polyethylene disk installed at the height h in this bottle absorbs UCN with energy larger than mgh. The UCN energy spectrum was deduced by differentiating the UCN counts detected as a function of the disk height. The obtained spectrum is well reproduced by the Monte Carlo simulation.

12:00PM KK.00013 Search for Violation of Time Reversal Invariance at J-PARC, MICHAEL KOHL, Hampton University, TREK COLLABORATION — The Time Reversal Experiment with Kaons (TREK) at J-PARC aims to find New Physics beyond the Standard Model by measuring the T-violating transverse polarization P_T of muons in the K^+π^- decay of stopped kaons. TREK will use a high-intensity kaon beam and the upgraded apparatus of the E-246 experiment from KEK-PS. The sensitivity for P_T of 10^-4 at J-PARC is improved by a factor of 20 compared to the current E-246 limit, well in the allowed range of various models involving New Physics from exotic scalar interactions. An overview of the planned experiment and the status of the detector upgrade will be presented.

Saturday, October 17, 2009 9:00AM - 11:45AM –
Session KL Nuclear Structure V

9:00AM KL.00001 Collective behavior in ^71As, R.A. KAYE, C.J. DROVER, S.R. ARORA, N.R. BAKER, Ohio Wesleyan University, S.L. TABOR, T.A. HINNERS, C.R. HOFFMAN, S. LEE, Florida State University, J. DORING, BIS (Germany), J.K. BRUCKMAN, Monmouth College — High-spin states in ^71As were studied using the ^54Fe(^23Na, 2νp) reaction at 80 MeV provided by the John D. Fox superconducting accelerator at Florida State University. Prompt γ-γ coincidences were measured using an array of 10 Compton-suppressed Ge detectors. The yrast band based on the π/2g2 intrinsic configuration was extended up to a (5/2-) state and now shows evidence of a band crossing near ω = 0.7 MeV. Lifetimes of 17 excited states were measured using the Doppler-shift attenuation method applied to the experimental line shapes of decays in three known rotational bands. Transition quadrupole moments Q2 inferred from the lifetimes indicate that moderate to high collective behavior persists to the highest observed spins in the lowest positive- and negative-parity bands. The band suggested to be based on the πf7/2 orbital shows similar collectivity and large intraband B(M1) strengths, but the associated Q2 values are somewhat smaller than expected from cranked Woods-Saxon calculations. These results will also be compared with the predictions of the projected shell model.

9:15AM KL.00002 Shape Coexistence in ^72Se, C.J. LISTER, S.M. FISCHER, E.A. MCCUTCCHAN, Argonne National Laboratory IL 60439, T. AHN, R.J. CASPERSON, WNSL Yale CT 06511, A. HEINZ, G. IILIE, J. QIAN, E. WILLIAMS, R. WINKLER, WNSL Yale CT 06511 — One of the original candidates for shape co-existence in nuclei was ^72Se [1,2]. We have collected extensive new data, both "in-beam" following the ^40Ca(^36Ar,4p)^72Se reaction using Gammaphase at Argonne's ATLAS accelerator, and from the decay of ^72Br populated in the ^58Ni(^16O,pn) reaction studied at WNSL Yale. A new J^π=0^+ state was found at 1876 keV, the published [2] decay scheme was corrected, and twenty-six new levels were established. This detailed spectroscopy of low-lying states helps to delineate the two shape minima. The mixing of prolate-deformed and near-spherical states can be now quantified, and the gamma decay path from high-spin can be followed. The inferred groundstate shape is consistent with trends in experiment and calculation of the selenium isotopes [3,4].

9:30AM KL.00003 Photon scattering on the (0νββ)-decay daughter nucleus candidate ^76Se, N.M. COOPER, V. WERNER, L. BETTERMANN, Yale University, F. REICHELT, N. PIETRALLA, D. SAVRAN, K. SONNABEND, M. FRITZSCHIE, TU-Darmstadt, Germany, S.W. YATES, University of Kentucky — The Pygmy dipole resonance (PDR) was extensively studied in spherical nuclei, especially along the N=82 shell line. The PDR is thought to be a dipole vibration of an inert proton-neutron core against a neutron skin. The dependence of the PDR on deformation has so far not been tested in nuclei with small N/Z ratios. The dipole strength distribution up to 9 MeV may serve as a test for QRPA calculations relevant to (0νββ)-decay. Photon scattering experiments on ^76Se have been performed using incident photons from the S-DALINAC facility at the TU-Darmstadt. The isotopically enriched sample was irradiated at different photon endpoint energies. Preliminary results will be presented.

3Supported by US DOE grant DE-FG02-91ER40609, German DFG grants SFB 634 and Pi393/2-1, and LOEWE/HIC4FAIR.

9:45AM KL.00004 Generator coordinate method analysis of low-lying and high-spin states in medium- and heavy-mass nuclei, KOJI HIGASHIYAMA, Chiba Institute of Technology, NAOYIKA YOSHINAGA, Saitama University — The generator coordinate method (GCM) is applied to the neutron-rich Se, and Ge isotopes, where the monopole and quadrupole pairing plus quadrupole-quadrupole interaction is employed as an effective interaction. As for single-particle levels, all the relevant orbitals, 0g9/2, 1p1/2, 1p3/2, 0f5/2, in the major shell between the magic numbers 28 and 50 are taken into account for both neutrons and protons. The energy spectra and electromagnetic transitions obtained by the GCM are compared to the shell model results and the experimental data. The model reproduces well the energy levels of high-spin states as well as the low-lying states. The structure of the high-spin states and low-lying collective states is analyzed through the GCM wave functions. It is shown that the triaxial components play essential roles in describing the quasi-γ bands.

1Supported by the DOE Office of Nuclear Physics under contract DE-AC02-06CH11357 and DE-FG02-91ER40609.

This research is supported by the U.S. National Science Foundation and Ohio Wesleyan University.

3Supported by the DOE Office of Nuclear Physics under contract DE-AC02-06CH11357 and DE-FG02-91ER40609.

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9:45AM KL.00004 Generator coordinate method analysis of low-lying and high-spin states in medium- and heavy-mass nuclei, KOJI HIGASHIYAMA, Chiba Institute of Technology, NAOYIKA YOSHINAGA, Saitama University — The generator coordinate method (GCM) is applied to the neutron-rich Se, and Ge isotopes, where the monopole and quadrupole pairing plus quadrupole-quadrupole interaction is employed as an effective interaction. As for single-particle levels, all the relevant orbitals, 0g9/2, 1p1/2, 1p3/2, 0f5/2, in the major shell between the magic numbers 28 and 50 are taken into account for both neutrons and protons. The energy spectra and electromagnetic transitions obtained by the GCM are compared to the shell model results and the experimental data. The model reproduces well the energy levels of high-spin states as well as the low-lying states. The structure of the high-spin states and low-lying collective states is analyzed through the GCM wave functions. It is shown that the triaxial components play essential roles in describing the quasi-γ bands.
10:00AM KL.00005 High-spin states of $^{70}$Ge and a role of $g_{9/2}$ orbit, MASAKI TAKEDA, T. IZUMI, T. TANAKA, T. OHBA, H. SAITO, S. KONDO, A. SHINODA, K. TAKAYAMA, K. SHIONOZUKA, T. SATOH, S. HAYASHI, T. KOBAYASHI, TOHOKU UNIVERSITY, Sendai, Japan.

10:15AM KL.00006 Structure of $^{74-76}$Cu and $^{71-73}$Ni from $\beta$-decay studies, MUSTAFA RAJABALI, R. GRZYWACZ, S.N. LIDDICK, C. MAZZOCCHI, C. BINGHAM, I. DARBY, University of Tennessee, J. BATCHELDER, K. RYKACZEWSKI, ORNL, L. MANTICA, T. BAUMANN, T. GINTER, NSCL, M. PFUTZNER, K. MIERNIK, W. KROLAS, University of Warsaw and Polish Academy of Science, S.V. ILYUSHKIN, J. WINGER, Mississippi State University — The low-energy excited states in $^{74-76}$Cu and $^{71-73}$Ni were populated through the beta decay of $^{74-76}$Ni and $^{71-73}$Co isotopes respectively. The experiment was performed at the NSCL at MSU. The parent isotopes were obtained from the fragmentation of $^{80}$Kr beam, at 140 AMeV, on a Be target. The experimental setup consisted primarily of a thick Double-sided Silicon Strip Detector for the correlation of implanted ions with their subsequent beta decays and the NSCL Segmented Germanium Array (Sega) to monitor the emitted gamma rays. All detectors were read out with a new digital data acquisition system. Results from this experiment are interpreted using shell model with residual interactions which takes into account the monopole migration of single proton levels near $^{78}$Ni. Expected strong hindrance of M1 transitions was observed in $^{71-72}$Ni. The observed decay of $^{76}$Ni gives a first insight into the possible decay pattern of $^{78}$Ni.

10:30AM KL.00007 Beta decay studies of isobareically separated $^{81}$Zn, STEPHEN PADGETT, UTK, J.C. BATCHELDER, ORAU, L. CARTEGGI, UTK, I.G. DARBY, IKS Leuven, C.J. GROSS, ORNL, R. GRZYWACZ, UTK, S. ILYUSHKIN, Mis.St. U., S.N. LIDDICK, LLNL, M. MADURGA, UTK, T. MENDEZ, ORNL, C. MAZZOCCHI, IFGA, Milan, M. RAJABALI, UTK, K.P. RYKACZEWSKI, D. SHAPIRA, ORNL, J.A. WINGER, Mis.St. U., E.F. ZGANJAR, LSU — A new Low-energy Radioactive Ion Beam Spectroscopy Station (LeRIBSS) dedicated to the beta decay studies in $^{81}$Zn produced at the rate of 30 pps. The beta decay of $^{81}$Zn populated states in the N=50 isotope. $^{81}$Ga, just three protons above $^{78}$Ni. This nucleus is an important case to test the competition between allowed and forbidden beta decay transitions, which is essential to reliably predict beta decay lifetimes.

10:45AM KL.00008 Inverse kinematics RDDS lifetime measurements: $^{82}$Se, E.T. HOLLAND, V. WERNER, J.R. TERRY, R. WINKLER, R.J. CAPERSHON, A. HEINZ, J. QIAN, E. WILLIAMS, WNSL, Yale University, P.H. REGAN, Univ. Surrey, U.K. E.MCCUTCHEN, WNSL/Argonne, B. SHORAKA, WNSL/Surrey, R. LÜTTEKE, WNSL/TU Darmstadt, Germany, C.W. BEAUSANG, J.M. ALLMOND, Univ. Richmond, D.A. MEYER, J. LEBLANC, Rhodes College, A new method for inverse kinematics lifetime measurements was introduced at WNSL. A heavy beam is Coulomb excited on a light target and subsequently stopped in a second foil, chosen so the forward scattered light nuclei can trespass the stopper and be detected by a Si detector. A particle-gamma coincidence requirement minimizes background, and fixes the quantization axis. Lifetimes are determined independent from the Coulomb excitation mechanism, and the measurement of attenuated angular distributions shall be used in future $g$ factor measurements. $^{82}$Se is situated two neutrons below the N=50 shell closure. This allows to study the interplay between collective and single-particle degrees of freedom. We used a $^{82}$Se beam incident on a C target for lifetime measurements of high-lying excited states at a beam energy ~25% above the Coulomb barrier. The new RDDS method will be introduced, and first results on $^{82}$Se will be presented.

11:00AM KL.00009 Measurements of the $g$ factors of the low-lying excited states in stable even-even Ge nuclei, G. GURDAL, G. KUMBARTZKI, N. BENCZER-KOLLER, Rutgers University, S.J.Q. ROBINSON, Millsaps College, Y.Y. SHARON, L. ZAMICK, Rutgers University, Z. BERANT, Yale University, Nuclear Research Center, Negev, Israel, T. AHNI, R. CAPERSHON, R. CHEVRIER, A. HEINZ, G. HENNING, G. IIE, D. MCCARTHEY, J. QIAN, A. SCHMIDT, J.R. TERRY, W. VERNER, E. WILLIAMS, R. WINKLER, Yale University — The g factors of the low-lying excited states of $^{72-74,76}$Ge were measured using the Transient Field (TF) technique, and the results will be presented. The states of interest were populated by projectile Coulomb excitation in inverse kinematics. The $g$ nuclei were accelerated at the Yale ESTU Tandem Van de Graaff accelerator and impinged on C or Mg/gadolium/copper targets. The measured $g$ factor results will be compared to the predictions of large-scale shell model calculations in the $p_3/2f_5/2p_1/2g_{9/2}$ space for both protons and neutrons. A summary of the $g$ factors of $2^+_1$, $4^+_1$ and $2^+_2$ states in the mass A ~ 70 region will also be presented.

11:15AM KL.00010 Nuclear g-factor measurement for the low-lying state of $^{100}$Rh using On-line TDPAC technique and RF-IGISOL technique, YUJI MIYASHITA, HIROYUKI OUCHI, SAYAKA IZUMI, AYAKO SAKASU, NOZOMI SATO, MIKI TATEOKA, SAYO HOSHINO, TETSUYA NAGANO, WATARU YAMASHITA, Department of Physics, Tohoku University, Sendai, Japan, AKIYOSHI YAMAOKA, KENJI SHINODA, TAKASHI ISHIDA, TAKASHI WAKUI, TSUTOMU SHINOZUKA, Cyclotron and Radioisotope Center, Tohoku University, Sendai, Japan, MINORU TANIGAKI, Research Reactor Institute, Kyoto University, Osaka, Japan — To extend the studies on neutron-rich nuclei, we have developed an RF-IGISOL technique, which is combination of the gas catcher technique and the electrical field guiding technique with a large volume gas cell. As the first step to such approach, we are planning and trying the systematic measurement of g-factor in the neutron rich nuclei extracted as an radioactive beam from our RF-IGISOL at Tohoku University. The g-factor measurement for the low-lying state of $^{100}$Rh ($E_x=225.98$ keV, $T_{1/2}=1.66$ µs) is the first on-line experiment with our RF-IGISOL system. The g-factor for this state has been determined to be $g = 0.78 \pm 0.03$ $\mu N$ by the on-line TDPAC method. In this contribution, the details of experimental results will be reported.
11:30AM KL.00011 Measurements of the magnetic moments of the excited $2^+_1$, $4^+_1$ and $2^+_2$ states in $^{106}$Pd$^\dagger$ — G. KUMBARTZKI, Rutgers University, G. GURDAL, N. BENCZER-KOLLER, Rutgers University, S.I.Q. ROBINSON, Millsaps College, Y.Y. SHARON, L. ZAMICK, Rutgers University, Z. BERÁNT, Yale University, Nuclear Research Center Negev, Israel, T. AHN, R. CASPERSON, A. HEINZ, G. ILIE, D. MCCARTHEY, J. QIAN, A. SCHMIDT, J.R. TERRY, E. WILLIAMS, R. WINKLER, Yale University — The magnetic moments of the low-lying excited states of $^{106}$Pd were measured using the Transient Field (TF) technique, in order to compare the results with predictions from either collective model or shell model calculations. The states of interest were populated by projectile Coulomb excitation in inverse kinematics. The $^{106}$Pd beam was accelerated at the Yale ESTU Tandem Van de Graaff accelerator and impinged on a multilayer C/gadolinium/copper target. The measured magnetic moment of the excited $2^+_1$ state in $^{106}$Pd was compared to the results of previous measurements in the literature and of magnetic moment measurements in the neighboring Ru and Mo nuclei as a test of the Rutgers parametrization of the transient field in this region.

$^\dagger$Work supported by the U.S. National Science Foundation and U.S.D.O.E under grant DE-FG02-91ER-40609.

Saturday, October 17, 2009 2:00PM - 5:00PM — Session LA Spin Structure of the Nucleon  Kona 5

2:00PM LA.00001 Update on the spin structure of the nucleon — XIANGDONG JI, University of Maryland — In this talk, I review some of recent progress in understanding the spin structure of the nucleon. I will comment on some of the theoretical activities and experimental data as well.

2:45PM LA.00002 Nucleon structure from 2+1 flavor lattice QCD — SHOICHI SASAKI, University of Tokyo — This talk gives a review of the recent lattice results obtained on the coarse RIKEN-BNL-Columbia (RBC) and UKQCD joint dynamical (2+1)-flavor domain-wall fermions (DWF) ensembles, where the simulated strange quark mass is close to its physical value, and the up and down quark masses are down to about 1/7 the strange quark mass ($M_{\pi} = 330$ MeV). Topics to be covered include isovector nucleon form factors and low moments of isovector structure functions of the nucleon, which are relevant for theoretical understanding of nucleon structure. Unresolved issues and future directions in lattice QCD will be discussed.

3:30PM LA.00003 RHIC-Spin: Results and Outlook — YUJI GOTO, RIKEN / RIKEN BNL Research Center — Contribution of the gluon spin ($\Delta G$) to the proton spin 1/2 has been investigated as the first goal of spin physics at RHIC. Polarized proton collision experiments at a collision energy 200 GeV started in 2001. The PHENIX and STAR experiments have investigated the $\Delta G$ by measuring a longitudinal-spin asymmetries of neutral pion and jet produced in longitudinally polarized proton collisions. Experimental results from data taken in 2006 showed that these asymmetries are very small and they strongly restrict $\Delta G$ in the theoretical calculations based on perturbative QCD. From 2009, polarized proton collisions at a collision energy 500 GeV started and we investigate flavor-sorted contribution of the quark spin to the proton spin with weak-boson production. The final remaining piece of information to understand the proton spin is orbital-angular momenta of quarks and gluons inside the proton. Correlation between momentum-distribution of quarks and gluons inside the proton and their spin direction in transversely-polarized proton collisions will be investigated to understand the spin structure of the proton including the orbital-angular momentum.

4:15PM LA.00004 The Nucleon Spin Program at Jefferson Lab — XIAOCHAO ZHENG, University of Virginia — Spin structure of the nucleon has been one of the key research topics in nuclear science during the past three decades. Recent precision spin structure data from Jefferson Lab have significantly advanced our knowledge of nucleon structure in the valence quark (high-$x$) region and improved our understanding of higher-twist effects, spin sum rules, and quark-hadron duality. First, results of spin sum rules and polarizabilities in the low to intermediate $Q^2$ region will be presented and compared with theoretical calculations such as those based on Chiral Perturbation Theory (ChPT). Next, precision measurements of the spin asymmetry, $A_1$, in the high-$x$ region will be presented. They provide crucial input for global fits of polarized parton distribution functions. Finally, plans for the nucleon spin program at the upgraded 12 GeV JLab will be presented.

Saturday, October 17, 2009 2:00PM - 4:45PM — Session LB Ultrarelativistic Heavy-Ions II  Kona 4

2:00PM LB.00001 Two-dimensional charged particle correlations from 62 and 200 GeV Au+Au and Cu+Cu collisions from STAR — LANNY RAY, The University of Texas at Austin, STAR COLLABORATION — 2D angular correlations on relative pseudorapidity $\eta_\Delta = \eta_1 - \eta_2$ and azimuth $\phi_\Delta = \phi_1 - \phi_2$ are presented for charged particles with $p_t > 0.15$ GeV/c, $|\eta_\Delta| \leq 1$ and $2\Delta \phi$ in azimuth. A number of features are evident in the data including a 2D peak for small angle pairs and a ridge along $\eta$ at large azimuth. It is conjectured that both structures result from fragmenting, back-to-back semi-hard scattered partons, which follow binary scaling to mid-central collisions for each set of data. At a specific centrality, which varies with collision energy and ion, a transition to a qualitatively different trend is observed. This trend is characterized by rapidly increasing amplitudes, broadening in $\eta_\Delta$ and a reduced azimuth width for the small angle peak. Candidate scaling variables for the transition onset will be presented. These and other correlation data from STAR imply that correlated, low $p_t$ particles from fragmenting semi-hard scattered partons persist at RHIC energies, even in central collisions. The yields, including back-to-back processes, indicate relatively unsuppressed transport throughout the entire collision system, in strong contradiction with the expected attenuation of such processes in an opaque, thermalized medium.

$^3$Supported in part by the U. S. Dept. of Energy.

2:15PM LB.00002 Two particle angular correlations in heavy ion collisions — SIARHEI VAURYNOVICH, Massachusetts Institute of Technology, PHOBOS COLLABORATION — The nearly 4\pi angular acceptance of the PHOBOS silicon detector allows to perform measurements of 2-particle correlations over uniquely long distances in pseudorapidity with broad azimuthal angular coverage. Projections of the inclusive 2-particle angular correlation on the $\Delta \eta$ axis are studied in the context of a cluster model, allowing the extraction of the cluster size and decay width of the correlated particle production. This procedure reveals that particles are produced in very large clusters (up to an average size of around 6 charged particles) in the heavy ion collisions that were studied. Comparisons of the cluster size centrality dependence in Au+Au and Cu+Cu collisions demonstrate a scaling with the fractional cross section suggesting that the geometry of heavy ion collisions plays a significant role in the hadronization process. The high $p_t$-triggered correlations ($p_T > 2.5$ GeV/c) are studied by comparing heavy ion collision data to $p$-$p$ collisions simulated using PYTHIA, revealing in central Au+Au collisions an enhanced away-side yield much broader in $\Delta \eta$ and the presence of a near-side “ridge” extending continuously up to $\Delta \eta = 4$. Comparison of the near-side correlated yield to PYTHIA suggests a decomposition into separate jet and ridge constituents, with the ridge yield having a significant centrality dependence.
The ALICE Electromagnetic Calorimeter (EMCAL) will provide the ALICE detector with enhanced jet triggering and reconstruction capabilities. This will allow detailed studies of the interaction and energy loss of high energy partons in the dense matter created in heavy ion collisions. The EMCAL consists of 12288 individual Pb-scintillator/shashlik towers grouped into 10 2/3 SuperModules. The detector thickness is approx. 20 X0 and the energy resolution has been measured to be better than 12% (√E) + 2%. The EMCAL's coverage will be 1.4 units in η and 107 degrees in φ and it is positioned to provide partial back-to-back coverage with the PHOS calorimeter. The EMCAL will be installed in ALICE during the years 2009 - 2011, with four SuperModules ready for the first LHC 2009-2010 physics run. The detector status with a focus on readiness and plans for first physics measurements will be presented.

Study of jet modification at LHC-ALICE. MASATO SANNO, University of Tsukuba and Research Fellow of the Japan Society for the Promotion of Science, ALICE COLLABORATION — The A Large Ion Collider Experiment (ALICE) is to study physics of strongly interacting matter and the quark-gluon plasma (QGP) in heavy ion collisions at Large Hadron Collider (LHC). Production of deconfined partonic phase has been basically proven at the BNL-RHIC, via high pt jet suppression. LHC will provide a high denseness, high temperature and longer life time matter comparing with BNL-RHIC, therefore strong suppression and modification in jet production will be expected. A unified picture of jet quenching scenario is awaited at LHC-ALICE in wide energy range and various heavy ion collisions. However, jet finding in heavy ion collisions will be difficult at LHC due to the high multiplicity comparing with BNL-RHIC. Jet finding algorithm study for high multiplicity heavy ion collisions at LHC is so important. In this talk, we will present the results of comparison with some jet finding algorithms and study of the optimization of the algorithm for heavy ion collisions at LHC-ALICE.

Optimization of Jet Finding Algorithm in High energy heavy ion collisions with ALICE at LHC. DOUSATSU SAKATA, University of Tsukuba and Junior Research Associate of RIKEN Nishina Center, TAKUMA HORIZUCHI, University of Tsukuba and Research Fellow of the Japan Society for the Promotion of Science, ALICE COLLABORATION — The A Large Ion Collider Experiment (ALICE) is to study physics of strongly interacting matter and the quark-gluon plasma (QGP) in heavy ion collisions at Large Hadron Collider (LHC). Production of deconfined partonic phase has been basically proven at the BNL-RHIC, via high pt jet suppression. LHC will provide a high denseness, high temperature and longer life time matter comparing with BNL-RHIC, therefore strong suppression and modification in jet production will be expected. A unified picture of jet quenching scenario is awaited at LHC-ALICE in wide energy range and various heavy ion collisions. However, jet finding in heavy ion collisions will be difficult at LHC due to the high multiplicity comparing with BNL-RHIC. Jet finding algorithm study for high multiplicity heavy ion collisions at LHC is so important. In this talk, we will present the results of comparison with some jet finding algorithms and study of the optimization of the algorithm for heavy ion collisions at LHC-ALICE.
4:30PM LB.00011 Muons with High Transverse Momentum in IceCube, LISA GERHARDT, Lawrence Berkeley National Laboratory, ICECUBE COLLABORATION — Muons with a large transverse momentum \( p_T \) are produced in cosmic ray air showers via semileptonic decays of heavy quarks and the decay of high \( p_T \) kaons and pions. These high \( p_T \) muons will have a large lateral separation from the shower core. IceCube, a neutrino telescope consisting of a three-dimensional array of photodetectors buried in the ice of the South Pole and a surface air shower array, is well suited for the detection of high \( p_T \) muons. The surface shower array can determine the energy, location and direction of the cosmic ray air shower while the ice array can do the same for the high \( p_T \) muon. This makes it possible to measure the decoherence function (lateral separation spectrum) at distances greater than \(-150\) meters. The high \( p_T \) muon can be determined from the muon energy (measured by \( dE/dx \)) and the lateral separation. The high \( p_T \) muon spectrum may be calculated in a perturbative QCD framework; this spectrum is sensitive to the cosmic-ray composition.

Saturday, October 17, 2009 2:00PM - 4:30PM – Session LC Applications of Nuclear Physics II Kohala 1

2:00PM LC.00001 A New Method for Identifying Nuclear Isotopes Based Upon Polarized \((\gamma, n)\) Asymmetries1, S. STAVE, M.W. AHMED, N. BROWN, S.S. HENSHAW, B.A. PERDUE, P.-N. SEO, H.R. WELLER, Duke U/TUNL, P.P. MARTEL, A. TEYMURAYAN, UMass, G. WAREN, PNNL — Linearly polarized gamma rays between neutron threshold and 20 MeV can be a powerful tool for the interrogation of materials. In addition to their ability to penetrate shielding, they also induce the emission of several MeV neutrons. The ratio of neutron yields parallel and perpendicular to the plane of polarization as a function of outgoing neutron energy can provide a unique signature of isotopes. The photon-neutron yield asymmetries on \( ^{235}U \) using polarized photons have been measured at gamma-ray energies of 10 and 15 MeV using the High Intensity Gamma-ray Source (HI\( ^{235}U \)). Additional targets included \( Pb, Bi \) and \( Fe \). The results from these different targets will be compared to one another and to a calculated energy averaged result based upon previous unpolarized measurements and the assumption of pure E1 absorption.

1Supported by US DOE Grant Nos. DE-FG02-97ER41033 and DE-FG02-97ER41046 and by the DOE Office of Nonproliferation Research and Development.

2:15PM LC.00002 Experimental study of cross-sections for some medical radioisotopes production via proton induced nuclear reactions on nat\( ^{235}Mo \) up to 40 MeV, A.A. ALHARBI1, M. MCCLESKEY, G. TABACARU, B. ROEDER, A. BANU, A. SPIRIDON, E. SIMMONS, L. TRACHE, R. REIFARTH, R.S. RUNDBERG, J.L. ULLMANN, D.J. VIEIRA, J.B. WILHELMY, LANL — A research program has been initiated at TUNL to perform precision \((\gamma, n)\) and \((\gamma, p)\) cross-section measurements on actinide nuclei using the novel source of radiation at the High Intensity Gamma-ray Source (HI\( ^{235}U \)). A stack was made from several groups of targets: nat\( ^{235}Mo, ^{237}Al \) and nat\( ^{64}Cu \), with the Al and Cu as monitor foils to measure the excitation functions of the well known cross-sections monitor reactions \(^{27}Al(p,xn)^{26}Na \) and \(^{64}Cu(p,xn)^{62}Zn \) simultaneously with the reactions induced on the targets. The determined excitation functions were compared with the available previous published research and with the ALICE-IPPE pre-compact hybrid model simulated calculations. The integral yield \((MBq,µA^{-1},h^{-1})\) of the nat\( ^{235}Mo(p,xn) \) nuclear reactions deduced using the excitation functions and the stopping power of nat\( ^{235}Mo \).

2Fulbright Fellow 2009, Faculty of Sciences, Physics Department, Princess Nora Bint Abdul Rahman University, Riyadh, Saudi Arabia

2:30PM LC.00003 Precision photo-induced cross-section measurements using the monenergetic and polarized photon beams at HI\( ^{235}S \), A. P. TONCHEV, C. R. HOWELL, E. KWAN, G. RUSEV, W. TORNOW, Duke, J. H. KELLEY, C. HUIBREGTSE, NCSU, S. L. HAMMOND, UNC, D. VIEIRA, J. B. WILHELMY, LANL — A research program has been initiated at TUNL to perform precision \((\gamma, \gamma')\) and \((\gamma, xn)\) cross-section measurements on actinide nuclei using the novel source of radiation at the High Intensity Gamma-ray Source (Hi\( ^{235}S \)) facility. This facility provides nearly mono-energetic (\( \Delta E/E \geq 2\% \)) and intense \((10^6\ s^{-1})\) photon beams after the recent upgrade. A precision knowledge of photon-induced processes is of practical importance for new reactor technologies, nuclear transmutation, and nuclear forensics. Our recent photodisintegration cross section measurements on radioactive \(^{241}Am\) targets in the energy range from \(9 < E_\gamma < 16\) MeV will be presented. The experimental data for the \(^{241}Am(\gamma,n)\) reaction in the giant dipole resonance energy region will be compared with statistical nuclear-model calculations.

1This work was supported by the DOE under grants DE-FG02-97ER41033, DE-FG02-97ER41042, DE-FG02-97ER41041, and DE-FG52-06NA26155.

2:45PM LC.00004 New measurements of \((n,\gamma)\) and \((n,fission)\) cross sections and capture-to-fission ratios for \(^{233,235}U\) and \(^{239}Pu\) using the DANCE \(4\pi\) BaF\(_2\) array1, T.A. BREDEWEG, M. JANDEL, M.M. FOWLER, E.M. BOND, R.C. HAIGHT, A.L. KEKSIS, J.M. O’DONNELL, R. BARTSH, R.S. RUNDWERG, J.L. ULLMANN, D.J. VIEIRA, J.B. WILHELMY, LANL — Accurate neutron nuclear data are important to many issues in stockpile stewardship, nuclear reactor design and re-certification, nuclear non-proliferation and nuclear forensics. Of particular interest are the production and destruction reactions for all of the major and most of the minor actinides. The competition between capture and fission in many of the actinides presents both an obstacle and an opportunity for large \( \gamma \) detector arrays such as DANCE. Additional instrumentation is required to deconvolve the two contributions to the total observed \( \gamma \)-ray spectrum. However, conducting a simultaneous measurement can simplify background treatment and other sources of systematic uncertainty. An outline of the current experimental program will be presented along with results from neutron capture measurements on \(^{233,235}U\) and \(^{239}Pu\).

1Work was performed under the auspices of the U.S. DOE under contracts W-7405-ENG-36 [UC LANL], DE-AC52-06NA25396 [LANS], W-7405-ENG-48 [UC LLNL], and DE-AC52-07NA27344 [LLNS].

3:00PM LC.00005 Neutron capture cross section of \(^{243}Am\), M. JANDEL, Los Alamos National Laboratory, Los Alamos, NM, 87545, USA, DANCE COLLABORATION — The Detector for Advanced Neutron Capture Experiments (DANCE) at Los Alamos National Laboratory (LANL) was used for neutron capture cross section measurement on \(^{243}Am\). The high granularity of DANCE (160 BaF\(_2\) detectors in a 4\( \pi \) geometry) enables the efficient detection of prompt gamma-rays following neutron capture. DANCE is located on the 20.26 m neutron flight path 14 (FP14) at the Manuel Lujan Jr. Neutron Scattering Center at the Los Alamos Neutron Science Center (LANSCE). The methods and techniques established in [1] were used for the determination of the \(^{243}Am\) neutron capture cross section. The cross sections were obtained in the range of neutron energies from 0.02 eV to 400 keV. The resonance region was analyzed using SAMMY7 and resonance parameters were extracted. The results will be compared to existing evaluations and calculations. Work was performed under the auspices of the U.S. Department of Energy at Los Alamos National Laboratory by the Los Alamos National Security, LLC under Contract No. DE-AC52-06NA25396 and at Lawrence Livermore National Laboratory by the Lawrence Livermore National Security, LLC under Contract No. DE-AC52-07NA27344.

2:00PM LD.00001 Studies on exotic hadrons at Belle

— In this talk, we will present updated results on exotic hadrons from the Belle experiment at KEK. First, we will present results from reanalysis of the Z(4430) into πKK resonances using the Dalitz plot technique. We have observed the signal peak with more than 6 sigma significance, consistent with our previous measurement. We will also present some more new results obtained by Summer 2009. Then, we will present on the plan for the upgrade of the KEKB accelerator and the Belle detector to the Super-KEKB and Belle II, and discuss future prospects of research in this area.

1This work is supported by grant-in-aid from MEXT, Japan, for Scientific Research in Innovative Area, “Quest on New Hadrons with Various Flavors.”
2:15PM LD.00002 X(3872) as a coupled two-meson molecular state with a tetraquark configuration. SACHIKO TAKEUCHI, Japan College of Social Work, MAKOTO TAKIZAWA, Showa Pharmaceutical Univ., KIYOTAKA SHIMIZU, Dept. of Physics, Sophia Univ. — X(3872) may be a superposition of the two-meson molecular states and the compact tetraquark state because the X(3872) mass is very close to or almost on the threshold and because the quark interaction can be attractive for the tetraquark state. In order to understand its structure, we employ a quark model where the orbital correlations of the four quarks are fully taken into account. The parameters in the model are taken so that the relevant ηN meson mass spectrum as well as the S-wave baryon mass spectrum are reproduced. We also consider the c¯c core state for the isospin I=0 system. The results show that there can be such a bound state, namely a two-meson molecule with a compact tetraquark configuration in the short range region, for each of the I=0 and 1 systems. Their masses can be very close to each other. When the isospin symmetry breaking terms, namely the electromagnetic interaction between quarks as well as the ud-quark mass difference, are introduced to the system, the effect of the mixing between the I=0 and 1 states can be large. This may be the mechanism of the observed large isospin symmetry breaking of X(3872).

This work was supported in part by KAKENHI (No. 20540281).

2:30PM LD.00003 Exotic Charm Mesons X(3872) and Z(4430) with Multi-Hadronic Components, MAKOTO TAKIZAWA, Showa Pharmaceutical University, SACHIKO TAKEUCHI, Japan College of Social Work — In order to understand the structure of the X(3872), we have studied the effects of the c¯c core state coupling to the multi-hadronic states such as D(0)π, D′(1238) etc. We have calculated the transition strength S(E) using the Green’s function approach with the simple solvable interactions. We have also studied the S(E) in the case of the c¯c state as the core state, namely, the D0(TP) molecule. Since the calculated shapes of the transition strengths are different from each other, we shall be able to determine the degree of the mixing of the c¯c state in the X(3872) from the shape of the energy spectrum. We shall also study the structure of the Z(4430) in the similar approach, namely, the tetraquark core state coupling to the D′(1238)π, etc. in the Green’s function approach.

2:45PM LD.00004 Exotic nuclei with open heavy flavor mesons, SHIGEHIRO YASUI, KEK, KAZUTAKA SUDOH, Nishogakusha University — We discuss stable exotic nucleon bound with D and B mesons with respecting heavy quark symmetry. We indicate that an approximate degeneracy of D(B) and D′(B′) mesons plays an important role, and discuss the stability of DN and BN bound states. We find the binding energies 1.4 MeV and 9.4 MeV for each state in the Jπ = 1/2− with I = 0 channel, and no bound states with the other channels. These states are stable in the strong decay, and can be observed in the weak decay processes DN → K±π±π− + p, and BN → D−π+ + p. We discuss also possible existence of exotic nuclei DNN and BNN. The existence of DN and BN bound states would provide an opportunity to probe new exotic states near the thresholds, and, as well as strangeness nuclei, open a new way to investigate for exotic nuclei with variety of multi-flavor explored at future hadron facilities such as J-PARC (Japan Proton Accelerator Research Complex) and GSI (Gesellschaft für Schwerionenforschung).

3:00PM LD.00005 Charmed and Bottom baryon spectrum from Lattice QCD, KOSINSTANTINOS ORGINOS, College of William and Mary, JLab — We compute the masses of the singly and doubly charmed baryons in full QCD using the relativistic Fermilab action for the charm quark. For the light quarks we use domain-wall fermions in the valence sector and improved Kogut-Susskind sea quarks. We use the low-lying charmed meson spectrum to tune our heavy-quark action and as a guide to understanding the discretization errors associated with the heavy quark. Our results are in good agreement with experiment within our systematics. In addition we predict the mass of the (isospin averaged) spin-1/2 Ωc to be 3680(31)(36)(11) MeV. In addition we calculate bottom-hadron mass splittings with respect to B0 and Λb in the static limit for the heavy quark. Our results are in agreement with experimental observations and other lattice calculations within our statistical and systematic errors. In particular, we find the mass of the Λb to be consistent with the recent CDF measurement. We also predict the mass for the as yet unobserved Σb0 to be 5955(27) MeV.

3:15PM LD.00006 ABSTRACT WITHDRAWN —

3:30PM LD.00007 S=+1 pentaquarks in QCD sum rules, PHILIPP GUBLER, Department of Physics, Tokyo Institute of Technology, DAISUKE JIDO, Yukawa Institute of Theoretical Physics, Kyoto University, TORU KOJO, RRBC, Brookhaven National Laboratory, TETSUO NISHIKAWA, Faculty of Health Science, Ryotokuji University, MAKOTO OKA, Department of Physics, Tokyo Institute of Technology — The QCD sum rule technique is employed to investigate pentaquark states with strangeness S = +1 and Jπ = 1/2−, 3/2−, 3/2+, 5/2−, 5/2+. Throughout the calculation, we emphasize the importance of the establishment of a valid Borel window, which corresponds to a region of the Borel mass, where the operator product expansion (OPE) converges and the predicted ground state pole dominates the sum rule. Such a Borel window is achieved by constructing the sum rules from the difference of two carefully chosen independent correlators and by calculating the OPE up to dimension 14. As a result, we conclude that the state with quantum numbers 0−+ state appears to be the most probable candidate for the experimentally observed Θ+(1540), while we also obtain states with 0−+, 1−−, 1−+, 1++ at somewhat higher mass regions. We furthermore discuss the contribution of the KN scattering states to the sum rules, and the possible influence of these states on our results.

3:45PM LD.00008 Spin transfer in pp → ΛΛ: MARY ALBERG, Seattle University, University of Washington — A complete determination of spin observables for pp → ΛΛ, at an antiproton lab momentum of 1.637 GeV/c, has been made by the PS185 Collaboration. The results of this experiment disagree strongly with the predictions of calculations which used either meson-exchange or quark models for the reaction mechanism. The experiment will be repeated at FAIR by the PANDA Collaboration, and extended to higher energies. A model-independent description of the spin structure of this reaction is provided by the transition matrix M, which can be written in the center of mass frame as a function of 6 complex parameters. These parameters are also determined by any model calculation for pp → ΛΛ, so they are related to the reaction mechanism and initial and final state interactions. We have computed these parameters for several reaction mechanisms, and have explored their dependence on initial and final state interactions.

4:00PM LD.00009 Evaluation of the Underlying Event in Pp Collisions at vs = 200 GEV at Star, GRANT WEBB, University of Kentucky, STAR COLLABORATION — The interpretation of STAR’s published inclusive jet cross-section and longitudinal asymmetry data relies on a robust connection between the experimentally measured and theoretically calculated jet energy scale (JES). Evaluation of the underlying event (UE), the isotropic distribution of particles resulting from partonic interactions not associated with the partonic collision producing the jet, is a necessary step in the quantification of the JES in hadronic collisions. This presentation will discuss progress toward the extraction of the UE in √s = 200 GeV proton collisions produced at the Relativistic Heavy Ion Collider (RHIC) and detected in the Solenoidal Tracker at RHIC (STAR). Techniques, developed by the CDF collaboration at Fermilab, are used to isolate and characterize the UE in dijet events. Comparisons between CDF and STAR results will be evaluated and progress towards quantifying the UE contribution to the JES for jets reconstructed at STAR will be reported. These results facilitate the prediction of underlying event observables at LHC collision energies by providing vital constraints on the center of mass scaling of the UE in pp collisions.
4:15PM LD.00010 Topological charge and susceptibility at finite temperature in a random matrix model. MUNEHISA OHTANI, Kyorin University — Random matrix model is known to describe the chiral phase transition of QCD qualitatively, but at finite temperature it suppresses the topological susceptibility in the thermodynamic limit by the inverse of the volume $V$. We propose a modified model in which the topological susceptibility at finite temperature behaves reasonably. In the microscopic domain of QCD, where the Compton wavelength of the pion is much larger than the size of the box, the quark mass $m$ dependence of the QCD partition function in a fixed topological charge becomes insensitive to the topological charge for $m V^2 \gg 1$ with the chiral condensate $\Sigma$ in the chiral limit. Applying this property to a random matrix model at finite temperature, we show that an additional normalization factor is required for the partition function at the fixed topology. We report that the random matrix model with the additional factor to satisfy the universal behavior of the partition function agrees with the modified model to make the topological susceptibility well-defined.

4:30PM LD.00011 AdS/QCD Applied to Baryon Structure and Strangeness Changing Currents. CARL CARLSON, College of William and Mary — We calculate observables such as the electromagnetic form factors of nucleons and their gravitational or energy-momentum form factors (which can be obtained experimentally as moments of the generalized parton distributions) by using an AdS/QCD model, where one considers a Dirac field coupled to a vector field in the 5-dimensional AdS space. We will also comment on how to extend AdS/QCD considerations to include quarks of differing masses, giving results for the $K_{\pi}$ form factor as a dynamical example.

4:45PM LD.00012 The NJL-jet model for quark fragmentation functions. TAKUYA ITO, WOLFGANG BENTZ, Department of Physics, Tokai Univ., Hiratsuka, Japan, IAN CLOET, Department of Physics, University of Washington, Seattle, USA, KOICHI YAZAKI, Riken, Wako-shi, Japan — Quark distribution and fragmentation functions are the basic nonperturbative ingredients for a QCD-based analysis of hard scattering processes. We present some results of our recent calculations of quark fragmentation functions to pions in the NJL model. The important point is that our fragmentation functions naturally satisfy the momentum and isospin sum rules without any new parameters into the theory. Our calculation is based on a product ansatz to describe cascade-like fragmentation processes, similar to the product ansatz used in the quark-jet model of Field and Feynman. We arrive at the following expression for the total fragmentation function:

$$D^p_q(z) = \frac{1}{N} \sum_{k=1}^N P(k) \left( \int_0^1 d\tau_1 \cdots \int_0^1 d\tau_N \right) \times \sum_{Q_k} \left( \eta_1 F_{Q_1} \cdots \eta_N F_{Q_N} \right) b(z; z_0) d(\tau_1 \cdots \tau_{N-1} - \tau_N)/2.$$  

We present numerical results and compare with the empirical results. We argue that this NJL-jet model provides a very useful framework to calculate the fragmentation functions in an effective chiral quark theory.

Saturday, October 17, 2009 2:00PM - 4:30PM – Session LE Mini-Symposium on Strangeness in Stellar Systems Kohala 2

2:00PM LE.00001 Strangeness in compact stars. SANJAY REDDY, Los Alamos National Laboratory — Neutron stars have long been suspected to contain some form of strangeness in their interiors. Matter containing hyperons, or kaons or deconfined quark matter can have lower energy than neutron-rich matter at supranuclear density. I will briefly review models of dense matter where a phase transition to matter strangeness is favored. If strangeness were to occur inside neutron stars it can dramatically change both the structure and transport properties of the compact object. These changes influence observable aspects of neutron stars. I will review observable phenomena that have the potential to directly probe the composition of the interior. While these observations can provide insights about the existence of new forms of matter inside neutron stars, we need to improve theoretical models of dense matter ad neutron star evolution to properly interpret the current suite of neutron star observations. I will outline a few areas where we can anticipate progress in the near future.

2:30PM LE.00002 Kaon condensation from lattice QCD. WILLIAM DETMOLD, KOSTAS ORGINOS, College of William and Mary/JLab, MARTIN SAVAGE, University of Washington, ANDRE WALKER-LOUD, College of William and Mary, NPLQCD COLLABORATION — Kaon condensation may play an important role in the structure of hadronic matter at densities greater than that of nuclear matter, as exist in the interior of neutron stars. We present the results of the first lattice QCD investigation of kaon condensation obtained by studying systems containing up to twelve negatively charged kaons. Surprisingly, the properties of the condensate that we calculate are remarkably well reproduced by leading order chiral perturbation theory. In neutron stars. We present the results of the first lattice QCD investigation of kaon condensation obtained by studying systems containing up to twelve negatively charged kaons. Surprisingly, the properties of the condensate that we calculate are remarkably well reproduced by leading order chiral perturbation theory.

3:00PM LE.00004 Impact of strange quark matter nuggets on pycnonuclear reaction rates in the crusts of neutron stars. FRIDOLIN WEBER, BARBARA GOLF, JOE HELLMERS, San Diego State University — This paper presents an investigation into the pycnonuclear reaction rates in dense crustal matter of neutron stars contaminated with strange quark matter nuggets. The presence of such nuggets in the crustal matter of neutron stars would be a natural consequence if Witten’s strange quark matter hypothesis is correct. The methodology presented in this paper is a recreation of a recent representation of nuclear force interactions embedded within pycnonuclear reaction processes. The study then extends the methodology to incorporate dynamic theoretical characteristics of strange quark matter nuggets, like their low charge-per-baryon ratio, and then assesses their effects on the pycnonuclear reaction rates. Particular emphasis is put on the impact of color superconductivity on the reaction rates. Depending on whether or not quark nuggets are in this novel state of matter, their electric charge properties vary drastically which turns out to have a dramatic effect on the pycnonuclear reaction rates. Future nuclear fusion network calculations may thus have the potential to shed light on the existence of strange quark matter nuggets and on whether or not they are in a color superconducting state, as suggested by QCD.

1 Supported NSF under Grant PHY-0457329.
3:15PM LE.00005 Hot hadron-quark mixed phase including hyperons, NOBUTOSHI YASUTAKE, National Astronomical Observatory of Japan, TOSHIKI MARUYAMA, Japan Atomic Energy Agency, TOSHIHATA TATSUKI, Kyoto University — We study the hadron-quark phase transition with the finite size effects at finite temperature. For the hadron phase, we adopt the nuclear equation of state in the framework of the Bruekner-Hartree-Fock theory including hyperons. The properties of the mixed phase are clarified by considering the finite size effects under the Gibbs conditions. We find that the equation of state similar that given by the Maxwell construction. Moreover, the number of hyperons is suppressed by the presence of quarks. These are characteristic features of the hadron-quark mixed phase, and should be important for many astrophysical phenomena such as collisions of neutron star-neutron star binaries.

3:30PM LE.00006 Hadronic Star Matter in an RMF Model with a SCL Chiral Potential, KOHSUKE TSUBAKIHARA, Department of Cosmophysics, Hokkaido University, AKIRA OHNISHI, YITP, Kyoto University — In constructing the dense matter equation of state (EOS), it is desired to respect both chiral symmetry and hypernuclear physics. In dense matter, strangeness is expected to play a decisive role and the partial restoration of chiral symmetry would modify the hadrons' properties. From the point of view of chiral symmetry, we have developed a chiral SU(2) symmetric RMF model with a logarithmic sigma potential, which is derived in the strong coupling limit (SCL) of the lattice QCD in zero temperature. In order to investigate hypernuclear systems, we have introduced an extended chiral SU(3) RMF model which includes both chiral symmetry and hypernuclear physics information. We determine hyperon-meson coupling constants in this chiral SU(3) RMF model by fitting existing data. The EOS of symmetric matter is found around $\rho_0$ by the scalar meson with hidden strangeness, $\zeta = ss$ and to be consistent with the EOS in a variational calculation at around $\rho_0$. At higher $\rho_0$, however, EOS is so soft that the calculated neutron star mass underestimates the observed value. In order to cure this problem, we have examined arcsinh type chiral potential which is derived in the finite temperature treatment of SCL. In this presentation, we discuss how to construct this chiral SU(3) RMF model and show an effect to nuclear star maximum mass by introducing this potential.

3:45PM LE.00007 EOS table with hyperons and emergence of hyperons in core-collapse processes, AKIRA OHNISHI, Yukawa Institute for Theoretical Physics, Kyoto University, C. ISHIZUKA, Keele University, K. TSUBAKIHARA, Hokkaido University, K. SUMIYOSHI, Numazawa CT, S. YAMADA, Waseda U., H. SUZUKI, Tokyo U. of Science — We discuss the roles of hyperons in dense matter formed during core-collapse supernovae. We have recently presented several nuclear matter EOS tables including hyperons using an SU(3)$_c$ extended RMF model [1]. $\Sigma$ and $\Xi$ potential in nuclear matter are chosen to be $U_{\Sigma}(\rho_0) \approx +30$ MeV and $U_{\Xi}(\rho_0) = -15$ MeV, based on recent hypernuclear physics information. Hyperons do not play important roles in the collapse and bounce stages, but they are found to be populated at 0.5-0.7 s after the core bounce and to trigger the re-collapse to a black hole in failed supernovae [2]. Hyperons start to show up off center owing to high temperatures caused by the shock-accretion interaction, and later prevail at center when the central density becomes high enough. The neutrino emission stops much earlier with the hyperonic EOS, while the average energies and luminosities are not affected much. In the presentation, we discuss the EOS due to hyperons with high temperatures, and its dependence on hyperon potentials.

4:00PM LE.00008 YN interaction with Lattice QCD, ASSUMPTA PARRENO, University of Barcelona, NPLQCD COLLABORATION — Lattice QCD simulation of hadronic interactions in the non perturbative regime has been pointed out as a powerful and useful technique to obtain information of relevance in Nuclear Physics, in special in those sectors where experiments are elusive or difficult to perform. This would be the case of the hyperon-nucleon interaction, crucial for the correct understanding of hypernuclear processes, as well as for a better knowledge of astrophysical phenomena related to the evolution of compact stellar systems. I will discuss recent efforts driven by the Nuclear Physics Lattice QCD (NPLQCD) Collaboration to formulate and simulate the interaction between two baryons in the strange sector with Lattice QCD. After outlining the techniques that are used to extract the relevant physics parameters in the low energy regime, I will present the latest results we have produced.

4:15PM LE.00009 ABSTRACT WITHDRAWN —

Saturday, October 17, 2009 2:00PM - 4:45PM — Session LF Mini-Symposium on Hadron Structure and QCD in High Energy Processes IV Kohala

2:00PM LF.00001 Quark Structure of the Nucleon and Angular Asymmetry of Proton-Neutron Hard Elastic Scattering, MISAK SARGSIAN, CARLOS GRANADOS, Florida International University — We investigate the asymmetry in angular distribution of hard elastic proton-neutron scattering with respect to 90° center of mass scattering angle. This asymmetry on quark level is generated due to the mixture of quark scatterings with and without flavor interchange in the isoscalar pn state. We demonstrate that the magnitude of the angular asymmetry is related to the helicity-isospin symmetry of the quark wave function. Our estimate of the asymmetry within the quark-interchange model of hard scattering demonstrates that the quark wave function of a nucleon based on the exact SU(6) symmetry predicts an angular asymmetry opposite to that of experimental observations. On the other hand the quark wave function within diquark picture of the nucleon produces an asymmetry consistent with the data. Comparison with the data allowed us to extract the relative sign and the magnitude of the vector and scalar diquark components of the quark wave function of nucleon. Overall, our conclusion is that the angular asymmetry of hard elastic scattering of baryons provides a new venue in probing quark-gluon structure of baryons and should be considered as an important observable in constraining the theoretical models.

3:00PM LF.00002 Basis function approach to Hamiltonian light front gauge theory, HELI HONKANEN, JUN LI, PIETER MARIS, JAMES VARY, Iowa State University, STAN BRODSKY, SLAC National Accelerator Laboratory, Stanford University, AVAROTH HARINDRANATH, Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Kolkata, India, GUY DE TERAMOND, Universidad de Costa Rica, San JosÉ, Costa Rica — Hamiltonian light-front quantum field theory constitutes a framework for the non-perturbative solution of invariant masses and correlated parton amplitudes of self-bound systems. By choosing the light-front gauge and adopting a basis function representation, we obtain a large, sparse, Hamiltonian matrix for mass eigenstates of gauge theories that is solvable by adapting the

1Supported in part by a DOE Grant DE-FG02-87ER40371 and by DOE Contract DE-AC02-76SF00515.
2:30PM LF.00003 Polarized structure functions from AdS/CFT1. BOWEN XIAO, Lawrence Berkeley National Lab, JIAN-HUA GAO, University of Science and Technology of China — We investigate deep inelastic and elastic scattering on a polarized spin \( \frac{1}{2} \) hadron using gauge/string duality. AdS/CFT correspondence provides us new insights into gauge theories in strong coupling regime. This spin \( \frac{1}{2} \) hadron corresponds to a supergravity mode of the dilatino. The polarized deep inelastic structure functions are computed in supergravity approximation at large \( t \) 't Hooft coupling \( \lambda \) and finite \( x \) with \( \lambda^{-1/2} \ll x < 1 \). Furthermore, we discuss the moments of all structure functions, and propose an interesting sum rule \( \int_{0}^{1} dx g_2 (x, q^2) = 0 \) for \( g_2 \) structure function which is known as the Burkhardt-Cottingham sum rule in QCD. In addition, we discuss the possible small-\( x \) contributions for \( g_1 \) due to the consideration of the angular momentum sum rule. In the end, the elastic scattering is studied and elastic form factors of the spin \( \frac{1}{2} \) hadron are calculated within the same framework.

1This work is partially supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Divisions of Nuclear Physics, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

2:45PM LF.00004 The STAR Forward GEM Tracker. BERND SURNOW, MIT, STAR COLLABORATION — The STAR collaboration is preparing a tracking detector upgrade, the Forward GEM Tracker (FTG), which will focus on novel spin physics measurements in high-energy polarized proton-proton collisions at a center-of-mass energy of 500 GeV, determining the flavor dependence (\( \Delta u \) versus \( \Delta d \)) of the polarized sea. STAR plans to probe these polarized distribution functions using parity violating W production in the electron/positron decay mode. This upgrade will consist of six triple-GEM detectors with two dimensional readout arranged along the beam axis. The FTG project has completed an extensive R&D program of industrially produced GEM foils at Tech-Etch Inc. in comparison to GEM foils produced at CERN based on optical measurements, testbeam and \( 1^2 \)Be source measurements of a triple-GEM prototype detector using \( 10 \times 10 \text{cm}^2 \) GEM foils. The FTG project requires large GEM foils (~ 40 \times 40 \text{cm}^2) which are currently being tested. The FTG design, the status of large GEM foil tests, the performance of triple-GEM prototype detectors based on industrially produced GEM foils along with the status of the FTG construction and the installation schedule will be presented.

3:00PM LF.00005 Trigger Upgrade of PHENIX Muon Arms for Polarized Sea Quark Measurement and Background Study at \( \sqrt{s} = 500 \) GeV. ITARU NAKAGAWA, RIKEN, PHENIX COLLABORATION — Parity-violating production of the W boson with longitudinally polarized protons at RHIC provides a direct measure of the individual polarizations of the quarks and anti-quarks in the colliding protons. The high energy scale set by the W-mass makes it possible to extract quark and anti-quark polarizations from inclusive lepton asymmetries in W-production with minimal theoretical uncertainties. This program thus will break new ground in our detailed understanding of the proton’s structure. The program was initiated by the first operation of RHIC polarized beams at its highest operational energy \( \sqrt{s} = 500 \) GeV. A new trigger on forward muons in PHENIX identifies and triggers on high momentum muons from \( W \) decay suppressing a large number of background low momentum muons coming from hadronic decays. In this talk, we will update the installation and commissioning status of the new trigger electronics and discuss about the observed background conditions at 500 GeV from Run09 data.

3:15PM LF.00006 Silicon Pixel Detector for Vertex Tracker in RHIC-PHENIX experiment. ATSUSHI TAKETANI, RIKEN Nishina Center, PHENIX COLLABORATION — The PHENIX experiment at the RHIC will be upgraded with a Silicon Vertex Tracker (VTX) in 2010 to enhance the physics capability in both of spin and heavy ion program. The VTX will be placed near the collision point with large geometrical acceptance (\( \phi \sim 2 \pi, |\eta| > 1.2 \)). It is able to identify the heavy quark productions by measuring the displaced vertex and identify the jet production by measuring momentum of charged tracks. The VTX is required fine spatial resolutions with low material budget and high speed readout up to 20 KHz trigger rate. The VTX is consisted from 2 inner pixel layers and 2 outer stripixel layers. The pixel detectors are 30 of ladder modules and their readout electronics. The ladder module is made from 4 pixel sensors modules (pixel size 50\times425 \mu m^2), carbon fiber support structure including cooling pipe, and pin pitch low radiation length readout bus. We archived 1.26% X/\X0 in total to minimize the multiple scattering. The spatial resolution of the prototype ladders was measured as 14 \mu m in \phi direction and 150\mu m in Z by using 120GeV proton beam. The production of pixel ladders and readout electronics has been started in spring of 2009. We will report their performance and status of the production.

3:30PM LF.00007 Nuclear modification factor \( R_{CP} \) for \( \phi \) meson production in \( d+Au \) collisions at \( \sqrt{S_{NN}} = 200 \) GeV measured by the PHENIX experiment at RHIC. LEI GUO, Los Alamos National Laboratory, PHENIX COLLABORATION — In \( d+Au \) collisions, vector mesons produced in hard scattering are sensitive to various nuclear effects such as parton shadowing/saturation in the small \( x \) region (forward rapidity) leading to suppression, and antishadowing (large \( x \), backward rapidity) or the Cronin effect which both can produce enhancement. Since approaches such as the Color Glass Condensate (CGC) and pQCD-based Glauber-Eikonal models do not agree on the nature of these nuclear effects from multiple scattering, etc. Fully reconstructed jets offer a new experimental handle on probing this physics. It has the advantage over single particle and di-hadron measurements since the underlying kinematics of the hard scattering process is better known. In spite of the seemingly small acceptance of the PHENIX detector at RHIC, measurements of fully reconstructed jets using the Anti-\( k_T \) algorithm are possible. In this contribution we will present the current status of measurements using fully reconstructed jets in \( d+Au \) collisions at \( \sqrt{S_{NN}} = 200 \) GeV using the PHENIX detector at RHIC. We discuss the current and future physics that are provided with such measurements focusing on the centrality dependence of nuclear \( k_T \) and jet \( p_T \) cross-sections related to the nuclear parton distribution functions.

3:45PM LF.00008 Jet Reconstruction in \( d+Au \) collisions at RHIC-PHENIX. NATHAN GRAU, Columbia University, PHENIX COLLABORATION — Collisions between protons (deuterons) and nuclei provide a testing ground to understanding nuclear effects, e.g. shadowing and the EMC effect in nuclear parton distribution functions, nuclear \( k_T \) effects from multiple scattering, etc. Fully reconstructed jets offer a new experimental handle on probing this physics. It has the advantage over single particle and di-hadron measurements since the underlying kinematics of the hard scattering process is better known. In spite of the seemingly small acceptance of the PHENIX detector at RHIC, measurements of fully reconstructed jets using the Anti-\( k_T \) algorithm are possible. In this contribution we will present the current status of measurements using fully reconstructed jets in \( d+Au \) collisions at \( \sqrt{S_{NN}} = 200 \) GeV using the PHENIX detector at RHIC. We discuss the current and future physics that are provided with such measurements focusing on the centrality dependence of nuclear \( k_T \) and jet \( p_T \) cross-sections related to the nuclear parton distribution functions.

4:00PM LF.00009 ABSTRACT WITHDRAWN —

4:15PM LF.00010 Reduced helicity amplitudes for deuteron photodisintegration1. JOHN HILLER, SOPHIA CHABYSHEVA, University of Minnesota-Duluth — We apply the reduced nuclear amplitude analysis to the helicity amplitudes of deuteron photodisintegration. This combines covariant, point-like amplitudes for the nucleons with the electric and magnetic form factors of the nucleons. The point-like amplitudes are modeled on the QCD one-gluon exchange amplitudes for \( nM \rightarrow q\bar{q} \), where \( M \) is a \( q\bar{q} \) meson. The form factors take into account the internal structure of the nucleons. We compare the resulting cross section and polarization observables to recent data.

1Work supported in part by the US Department of Energy.
2:00PM LG.00001 Unbound states of $^{32}$Cl studied via the $^{32}$S($^{3}$He,t)$^{32}$Cl charge-exchange reaction. M. MATOŠ, LSU, D.W. BARDAJAN, ORNL, J.C. BLACKMON, LSU, J.A. CLARK, ANL, C.M. DEIBEL, ANL, JINA, L. LINHARDT, LSU, C.D. NESARAJA, ORNL, P.D. O’MALLEY, Rutgers, P.D. PARKER, Yale, K.T. SCHMITT, UT-K, Breakout from the SIF cycle [1], which is closed by the $^{31}$S(p,$^{20}$P) reaction, can occur via the $^{31}$S(p,$^{18}$O) reaction. The duration of the cycle influences the timescale of explosive hydrogen burning. At average temperatures 0.1-0.4 GK, the $^{18}$O($^{14}$Ne,$^{14}$O) reaction rate is dominated by $^{31}$S+p resonances. Discrepancies in the $^{32}$Cl resonance energies have been reported in previous measurements [1,2]. We have used the $^{32}$S($^{3}$He,t)$^{32}$Cl charge-exchange reaction to produce unbound states in $^{32}$Cl and determined their excitation energies by detecting the tritons at the focal plane of the Enge Spectrograph at the Yale University’s Wright Nuclear Structure Laboratory. To determine the proton branching ratios the decay protons coming from the residual $^{31}$Cl nuclei have been detected using a silicon-strip detector array around the target position. Results from the experiment will be presented. [1] S. Vouzoukas et al., PRC 50 (1994) 1185. [2] C. Jeanperrin et al., NPA 503 (1989) 77.

2:15PM LG.00002 The $^{28}$Si(p,t)$^{26}$Si Reaction and Implications for $^{25}$Al(p,$^{18}$O)$^{26}$Si. K.A. CHIPPS, Rutgers University, D.W. BARDAJAN, Oak Ridge National Laboratory, K.Y. CHAE, University of Tennessee Knoxville, R. KOZUB, Tennessee Tech. University, C. MATEI, Oak Ridge Associated Universities, B.H. MOAZEN, University of Tennessee Knoxville, C.D. NESARAJA, Oak Ridge National Laboratory, P.D. O’MALLEY, Rutgers University, S.D. PAIN, Oak Ridge National Laboratory, W.A. PETERS, Rutgers University, S.T. PITTMAN, K. SCHMITT, University of Tennessee Knoxville, M.S. SMITH, Oak Ridge National Laboratory. We have studied several resonances in $^{25}$Al(p,$^{18}$O)$^{26}$Si via the $^{28}$Si(p,t)$^{26}$Si reaction at HRIBF. In addition to measuring angular distributions of the tritons, an additional silicon detector array was used to measure the coincident protons emitted from the decay of states in $^{26}$Si above the proton threshold. We confirm experimentally that the $3^{-}$ 5914 keV resonance, the first $\ell = 0$ state above the proton threshold, does in fact decay essentially 100% of the time via proton emission, resulting in a proton branching ratio consistent with one. [3] This work is funded by the US DOE. [4] current address: University of York

2:30PM LG.00003 Analysis of $^{26}$Al + p elastic and inelastic scattering reactions in inverse kinematics at the HRIBF. S.T. PITTMAN, K.Y. CHAE, K.L. JONES, B.H. MOAZEN, Univ. of TN, D.W. BARDAJAN, C.D. NESARAJA, S.D. PAIN, M.S. SMITH, ORNL, K.A. CHIPPS, CO School of Mines, R.L. KOZUB, J.F. SHRINER, JR., TN Tech., C. MATEI, ORAU, M. MATOS, LSU, P.D. O’MALLEY, W.A. PETERS, Rutgers Univ., P.D. PARKER, Yale Univ. It is known to what degree the neutron capture contributes to the abundance of $^{26}$Al in the Galaxy. Destruction through the $^{25}$Al(p,$^{18}$O)$^{27}$Si reaction may reduce the nova contribution, but uncertainties in the properties of $^{27}$Si levels above the proton threshold limit reaction rate estimates. Inelastic proton scattering in these environments may also reduce the net production of $^{26}$Al. To constrain estimates of the degree of $^{26}$Al destruction in novae, the $^{26}$Al+p and inelastic reactions were investigated in inverse kinematics ($E_{cm}$ = 0.5-1.5 MeV) at the HRIBF. The experiment and results of the analysis will be discussed.

2:45PM LG.00004 Direct Measurement of $^{21}$Na(α,p)$^{21}$Na Stellar Reaction. NGUYEN BINH DAM, H. YAMAGUCHI, Y. WAKABAYASHI, S. HAYAKAWA, T. HASHIMOTO, D. KAHIL, S. KUBONO, Center for Nuclear Study, University of Tokyo, H.K. LE, T.T. NGUYEN, Institute of Physics, Vietnamese Academy for Science and Technology, N. IWASA, N. KUME, Department of Physics, Tohoku University, S. KATO, Department of Physics, Yamagata University, T. TERANISHI, Department of Physics, Koyasu University. Nucleosynthesis of $^{22}$Na is an interesting subject because of possible $\gamma$-ray observation and isotopic anomalies in pre-solar grains. $^{22}$Na would have been mainly produced in the NeNa cycle. At high temperature conditions, $^{21}$Na(p,$^{19}$F)$^{21}$Mg reaction could play a significant role to make flow from the NeNa cycle to the next MgAl cycle and beyond. Clearly, the $^{21}$Na(p,$^{19}$F)$^{21}$Mg stellar reaction would bypass $^{22}$Na, resulting in reduction of $^{22}$Na production, therefore, it is strongly coupled to the Ne-E problem. It could also be important to understand the early stage of the rp-process. Experiment was performed using a 39 MeV $^{21}$Na radioactive beam obtained by the CNS Radio Isotope Beam separator CRIB of the University of Tokyo. Both protons and alphas were measured from $^{19}$F+$^{21}$Na scattering with a thick $^{4}$He gas target.

3:00PM LG.00005 Direct and Indirect Techniques for Determining Reaction Rates. ERIC JOHNSON, Florida State University, ANASEN COLLABORATION. Astrophysically important reactions have been studied through indirect techniques for many years due to their prohibitive small cross sections at Gamow window energies. Indirect techniques, such as $\alpha$-transfer reactions, constrain the reaction cross section of interest in the astrophysically relevant energy range. Recently, we determined the contribution of the $3^{-}$ state at 6.4 MeV in $^{16}$O to the $^{14}$C($^{3}$He,$^{3}$He)t at the John D. Fox Superconducting Accelerator Laboratory at FSU. Using the same experimental data we were able to determine the asymptotic normalization coefficient (ANC) of the $1^{-}$ state at 6.2 MeV in $^{18}$Ne. This state is a mirror of the $1^{-}$ state at 6.2 MeV in $^{18}$Ne, which dominates the $^{14}$O($^{3}$He,$^{3}$He) reaction rate at temperatures of Novae and X-ray bursters. An experimental apparatus which will allow for direct measurements of the astrophysically important ($p$,$p$) reaction rates in the Gamow window, the LSU-FSU Array for Nuclear Astrophysics Studies with Exotic Nuclei (ANASEN), is now under construction. I will discuss our recent results on the $^{14}$C($^{3}$He,$^{3}$He) and $^{14}$O($^{3}$He,$^{3}$He) reaction rates and the current status of the ANASEN project.
3:15PM LG.00006 Direct Measurement of the $^{11}\text{C}(\alpha,p)^{14}\text{N}$ Reaction, S. HAYAKAWA, S. KUBONO, H. YAMAGUCHI, T. HASHIMOTO, D.N. BINH, D. KAHL, Center for Nuclear Study, the University of Tokyo, Y. WAKABAYASHI, Japan Atomic Energy Agency, N. IWASA, N. KUME, Y. MIURA, Tohoku University, T. TERANISHI, Kyushu University, J.J. HE, Institute of Modern Physics, Y.K. KWON, Chung Ang University, T. KOMATSU, University of Tsukuba, S. KATO, Yamagata University, S. WANAJO, IPMU, the University of Tokyo — A recent simulation of the rp-process in neutrino-driven winds in type II supernovae (rp-process) suggests that the $^{11}\text{C}(\alpha,p)^{14}\text{N}$ reaction could be an important breakour pass from the pp-chain region to the CNO region. However, there are only very limited experimental information of the reaction cross section available from the time-reverse reaction studies. In order to determine the reaction rate of $^{11}\text{C}(\alpha,p)^{14}\text{N}$, a direct measurement by means of the thick-target inverse-kinematics method has recently been performed using low-energy $^{12}\text{C}$ beams from the RNS Radioactive Ion Beam (CRIB) separator, a $^{4}\text{He}$ gas target and a E-E position-sensitive silicon telescopes at three downstream angles. The experiment covered $E_{CM} = 0.5-5$ MeV corresponding to the stellar temperature of 1.5-7GK. The obtained reaction cross section including some resonances and transitions of the excited states of $^{14}\text{N}$ will be reported.

3:30PM LG.00007 The resonant structure of $^{18}\text{Ne}$ and its relevance in the breakout of the Hot CNO cycle, S. ALMARAZ-CALDERON, W. TAN, A. APRAHAMIAN, B. BUCHER, J. GORRES, A. ROBERTS, A. VILLANO, M. WIESCHER, ISNAP, University of Notre Dame, USA, C. BRUNE, Z. HEINEN, T. MASSEY, Department of physics and astronomy, Ohio University, USA, H. MACH, ISV, Uppsala University, Sweden, N. GURAY, R.T. GURAY, Department of Physics, Kocaeli University, Turkey — In explosive hydrogen burning environments such as Novae and X-ray bursts, temperatures and densities achieved are sufficiently high to bypass the beta decay of the waiting points of the hot CNO cycle by alpha captures, leading to a thermonuclear runaway via the rp-process. One of the two paths to a breakout from the hot CNO cycle is the route starting from $^{14}\text{O}(\alpha,p)^{17}\text{F}$ followed by $^{17}\text{F}(\gamma)^{18}\text{Ne}$ and $^{18}\text{Ne}(\alpha,p)$. The $^{14}\text{O}(\alpha,p)$ reaction proceeds through resonant states in $^{18}\text{Ne}$ making the reaction rate depend on the excitation energies and as well as both partial and total widths of these resonances. We used the $^{16}\text{O}(^{4}\text{He},n)$ reaction and charged particle-neutron coincidences to measure the structure details of levels in $^{18}\text{Ne}$. In particular, the $\alpha$ and proton decay branching ratios via ground state and excited states in $^{17}\text{F}$ were measured. The analysis of the data will allow us to provide crucial information to be included in the reaction network calculations that could have great impact on the nuclear energy generation and nucleosynthesis that occur in these explosive environments.

3:45PM LG.00008 The $^{11}\text{B}(p,\alpha\alpha)^{8}\text{Be}$ Reaction at Low Energies, R.M. PRIOR, M.C. SPRAKER, North GA College and State U, R.H. FRANCE III, GA College and State U, S. STAVE, P.-N. SEO, N. BROWN, S.S. HENSCHAW, M.W. AHMED, B.A. PERDUE, H.R. WELLER, Duke U/TUNL, A. TEMURZAYAN, P.P. MARTEL, UMass — The $^{11}\text{B}(p,\alpha\alpha)^{8}\text{Be}$ reaction has been proposed for use in an astrophysical fusion target. Detailed knowledge of the angular and energy distribution of the outgoing $\alpha\alpha$ particles is needed to model this reaction. The reaction has been previously modeled as a two-body process proceeding through the first excited state of $^{8}\text{Be}$. The $2^+$ resonance at 0.675 MeV is critical in the reactor models. We have previously studied the reaction at proton beam energies of 0.40 MeV and above and have developed a three-body reaction model that describes the spectra of the emitted alphas in that energy range. To further the study of the reaction, we have taken data at 5 angles between 50˚ and 150˚ for several energies between 0.40 MeV and 0.15 MeV which includes the region of the $2^+$ resonance at 0.162 MeV. The measured $\alpha\alpha$ particle energy distributions are consistent with the higher energy data and our model except at energies in the vicinity of the 0.162 MeV resonance. We will discuss our results and the deviation from the model.

4:00PM LG.00009 Measurement of E1 and E2 cross sections of the $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ reaction at $E_{eff}=1.4$ MeV, YASUKI NAGAI, HIROYUKI MAKII, TATSUSHI SHIMA, MARIKO SEGAWA, KENJI MISHIMA, HITOSHI UEDA, Osaka University, MASAYUKI IGASIRA, TOSHIRO OHSAKI, Tokyo Institute of Technology — The gamma-ray angular distribution from $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ to the ground state of $^{16}\text{O}$ was measured using a pulsed alpha beam at $E_{eff}=1.6$ and 1.4 MeV. True gamma-ray events of $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ were obtained by discriminating backgrounds due to neutrons from $^{12}\text{C}(\alpha,n)^{16}\text{O}$ with a time-of-flight method. A Rutherford backscattering spectrum of alpha particles from enriched $^{12}\text{C}$ targets was measured during beam irradiation. The astrophysical S factors for E1 and E2 derived from the present cross sections are discussed in comparison with the values derived by the recent R-matrix calculation.

4:15PM LG.00010 Performance of the UConn-TUNL O-TPC with the Upgraded Optical Readout System, W.R. ZIMMERMAN, M. GAI, UConn, M.W. AHMED, S.S. HENSCHAW, C.R. HOWELL, P.-N. SEO, S.C. STAVE, H.R. WELLER, TUNL, P.P. MARTEL, UMass — An Optical-Readout Time Projection Chamber (O-TPC) is being used at the High-Intensity gamma Source (HI-$$S$$) at TUNL to study oxygen formation during stellar helium burning by measuring the time-reversed $^{16}\text{O}(\gamma,\alpha)^{12}\text{C}$ reaction. The photodissociation of $^{16}\text{O}$ generates ionization tracks in the $30cm$ x $30cm$ x $20.5cm$ drift chamber. The electrons drift toward the multiplication region composed of three grids separated by 5 mm. The avalanche electrons induce scintillation light (primarily $\lambda = 338$ nm) in $\text{N}_2$ gas, and a CCD camera records an image of the two-dimensional projection of the tracks; hence the in-plane angle ($\alpha$). Photomultiplier tubes measure the time-projection; hence the out-of-plane angle ($\beta$). The azimuthal ($\phi$) and scattering ($\theta$) angles are reconstructed from $\alpha$ and $\beta$. The total energy deposited in the detector is measured by the charge signal from the last grid, as well as from the photomultiplier tubes. Recent upgrades of the optical-readout system have improved the event identification. The larger design lens (142mm diameter) was installed leading to a factor of 15 increase in the light collection. The operation of the upgraded O-TPC system and measured in-beam events will be discussed. *Work supported by the US DOE grant No. DE-FG02-94ER40870 and DE-FG02-97ER41033.

Saturday, October 17, 2009 2:00PM - 4:45PM — Session LH Mini-Symposium on Direct Reactions Involving Unstable Nuclei II, Kings 3

2:00PM LH.00001 Direct Reactions studies at RIBF new facility, TOHRU MOTOBAYASHI, RIKEN Nishina Center — The RIKEN RI Beam Factory (RIBF) is the first realization of new-generation facilities with beams of unstable nuclei. It is based on heavy-ion primary beams accelerated to 345 MeV/nucleon for all elements up to uranium. When the goal intensity, 1 pA, is reached, RIBF allows production of about 150 new isotopes with the yield higher than 1 particle per day. Since the RI beam energy after production in-flight fission and/or projectile fragmentation is be around 200-300 MeV/nucleon, the direct reaction is one of the useful processes for spectroscopy of uncle very far from the stability. Several experiments were proposed and a few of them have been performed with intense ( currently) $^{48}\text{Ca}$ primary beams. The ZeroDegree Spectrometer, which is already operational, can be used to identify the product of a direct reaction in inverse kinematics coupled with, for example, measurement of $\gamma$-rays from excited states in the product. Construction of SAMURAI, a large-acceptance spectrometer, has been started. Decays of unbound states or breakup products from various types of direct reaction will be measured in coincidence. Experimental and theoretical considerations for the specific conditions in this new opportunity will be discussed together with brief overview of near-term research.
2:30PM LH.00002 Low-lying states in \(^{32}\)Mg studied by proton inelastic scattering . SATOSHI TAKEUCHI, RIKEN Nishina Center, R37N COLLABORATION — Low-lying excited states in the neutron-rich nucleus \(^{32}\)Mg were studied by proton inelastic scattering in inverse kinematics via an in-beam \(\gamma\)-ray spectroscopy technique. Populated states were identified by measuring de-excitation \(\gamma\) rays, in which five new states were found by \(\gamma - \gamma\) coincidence analyses. The differential cross sections were analyzed by using coupled-channel calculations to determine the transferred angular momentum and the amplitudes of individual transitions. The spin and parity of the 2321-keV \(\gamma\) state was assigned as \(4^+\). The ratio between the energies of the 2\(^+\) and 4\(^+\) states indicates that \(^{32}\)Mg is a transitional nucleus rather than an axially deformed rigid rotor. A candidate for the 3\(^+\) state was found at an excitation energy of 3115 keV, which is lower than the 3\(^+\) energies in other \(N = 20\) isotones. A small B(E3) value of 0.6 W.u. suggests a single-particle nature. The collectivities in the nucleus \(^{32}\)Mg with \(N = 20\) are discussed based on the results obtained in the present experiment.

2:45PM LH.00003 Mechanisms in knock-out reactions . D. BAZIN, R.J. CHARITY, R.T. DE SOUZA, M.A. FAMIANO, A. CADE, V. HENZL, D. HENZLOVA, S. HUDEK, J. LEE, S. LUKYANOV, W.G. LYNCH, S. MCDANIEL, M. MCKO, A. OBERTELLI, A.M. ROGERS, L.G. SOBOTKA, H. TERRY, J.A. TOSTevin, M.B. TSANG, M.S. WALLACE — We report on the first detailed study of the mechanisms involved in knock-out reactions, via a coincidence measurement of the residue and fast proton in one-proton knock-out reactions, using the S800 spectograph in combination with the HiRA detector array at the RIBF. Results on the reactions \(^{9}\)Be(\(^{12}\)C,\(p\)+\(p\))\(^{12}\)C and \(^{9}\)Be(\(^{12}\)C,\(p\)+\(X\))\(^{12}\)C are presented. They are compared with theoretical predictions for both the diffraction (elastic breakup) and stripping (inelastic breakup) reaction mechanisms, as calculated in the eikonal model. The data shows a clear distinction between the two reaction mechanisms, and the observed respective proportions are very well reproduced by the reaction theory. This agreement supports the results of knock-out reaction analyses and their applications to the spectroscopy of rare isotopes. In particular, this adds considerable support to the use of the eikonal model as a quantitative tool, able, for example, to determine single-particle spectroscopic strengths in rare isotopes.

3:00PM LH.00004 Studying the neutron-unbound \(^{18}\)B . A. SPRYOU, T. BAUMANN, D. BAZIN, G. CHRISTIAN, S. MOSEY, M. STROGMAN, M. THOENENNES, NSCL/MSU, J. BROWN, Wabash College, P.A. DEYOUng, Hope College, A. DELINE, J.E. FINCK, A. RUSSEL, Central Michigan University, N. FRANK, Augustana College, E. BREITBACH, R. HOWES, Marquette University, W.A. PETERS, Rutgers, A. SCHILLER, Ohio University, MONA COLLABORATION — The decay of the neutron-unbound ground state of \(^{18}\)B was studied for the first time through a single-proton knockout reaction from a 62 MeV/u \(^{19}\)C beam. The decay energy spectrum was reconstructed from coincidence measurements between the emitted neutron and \(^{17}\)B fragment using the MoNA/Sweeper setup. An \(s\)-wave line shape was used to describe the experimental spectrum resulting in an upper limit for the scattering length of \(\neut\) fm which corresponds to a decay energy < 10 keV. Observing an \(s\)-wave decay of \(^{18}\)B provides an experimental verification that the ground state of \(^{18}\)C includes a large \(s\) component. In addition, our results show that the \(s\) + \(d\) mixing proposed for \(^{19}\)C is also present in \(^{18}\)B, therefore no clear signs of an inversion between the \(s_1/2\) and \(d_5/2\) orbitals can be suggested.

3:15PM LH.00005 Two-particle correlations in continuum dipole transitions in Borromean nuclei , K. HAGINO, Tohoku University, H. SAGAWA, University of Aizu, T. NAKAMURA, Tokyo Institute of Technology, S. SHIMOURA, Center for Nuclear Study (CNS) — We discuss the energy and angular distributions of two emitted neutrons from the dipole excitation of typical weakly-bound Borromean nuclei, \(^{11}\)Li and \(^{14}\)He. To this end, we use a three-body model with a density dependent contact interaction between the valence neutrons. Our calculation indicates that the energy distributions for the valence neutrons are considerably different between the two nuclei, although they show similar strong dineutron correlations in the ground state to each other. This different behaviour of the energy distribution primarily reflects the interaction between the neutron and the core nucleus, rather than the interaction between the valence neutrons. That is, the difference can be attributed to the presence of \(s\)-wave virtual state in the neutron-core system in \(^{11}\)Li, which is absent in \(^{14}\)He. It is pointed out that the angular distribution for \(^{11}\)Li in the low energy region shows a clear manifestation of the strong dineutron correlation, whereas the angular distribution for \(^{14}\)He exhibits a strong anticoherence effect.

3:30PM LH.00006 Subsystem correlations in soft E1 excitation of \(^{11}\)Li , YUMA KIKUCHI, Hokkaido University, TAKAYUKI MYO, Osaka Institute of Technology, MASAAMI TAKASHINA, Research Center for Nuclear Physics (RCNP), KIYOSHI KATÔ, Hokkaido University, KIYOMI IKEDA, The Institute of Physical and Chemical Research (RIKEN) — The \(^{11}\)Li nucleus has characteristic features of neutron-rich nuclei such as two-neutron halo structure and large \(s\)-wave mixing in the ground state, and has been studied with keen interest from both theoretical and experimental sides. Experimentally, the Coulomb breakup reactions have been performed to investigate the exotic features of \(^{11}\)Li, and significant E1 strength was measured at low excitation energy. However, the nature of this soft E1 excitation for \(^{11}\)Li is not clearly understood. To understand the nature of the soft E1 excitation, it is necessary to understand the complicated structure of \(^{11}\)Li, which contains both \(^{9}\)Li-\(n\) and \(n-\)\(n\) subsystems. In the present study, we investigate soft E1 excitation for \(^{11}\)Li based on the core-\(n\)-\(n\) three-body model. We analyze the E1 strength as a function of relative energies in binary subsystems in \(^{11}\)Li, and discuss the correlations of \(^{9}\)Li-\(n\) and \(n-\)\(n\) subsystems through the soft E1 excitation.

3:45PM LH.00007 Inclusive Coulomb breakup of \(^{22}\)C and \(^{31}\)Ne, NOBUYUKI KOBAYASHI, TAKASHI NAKAMURA, YOSUKE KONDO, Department of Physics, Department of Technology, YOSHITERO SATO, Department of Physics and Astronomy, Seoul National University, RIBF-55 TEAM — One-neutron removal cross section of \(^{31}\)Ne and two neutron-removal cross section of \(^{22}\)C on Pb and C targets were measured at about 230 MeV/u at RIBF(RI-Beam Factory) at RIKEN. This experiment aims at extracting the inclusive Coulomb breakup cross sections of these nuclei to see if these nuclei can involve halo structures. The enhancement of low-energy E1 strength, called "soft E1 excitation" is a unique property of halo nuclei. Hence, the enhancement of Coulomb breakup cross section can be used as a direct signal for halo structures. This measurement was made as one of experiments of 'Day-One campaign' using \(^{48}\)Ca primary beam at 345MeV/u. The typical secondary-beam intensities of 5-10 cps were obtained oth for \(^{22}\)C and \(^{31}\)Ne. The result indeed showed the significant enhancement of \(I(2n)\) removal cross sections for \(^{31}\)Ne(\(^{22}\)C). This result thus shows the occurrence of soft E1 excitations, which suggests the 2n and 2n halo structures for \(^{31}\)Ne and \(^{22}\)C, respectively. We discuss also the possible shell melting in \(^{31}\)Ne using both nuclear and Coulomb breakup data.

4:00PM LH.00008 Inelastic Proton Scattering on 21Na in Inverse Kinematics . ROBY AUSTIN, Saint Mary’s University — R.A.E. Austin, R. Kanungo, S. Reeve, Saint Mary’s University; D.G. Jenkins, C.Aa.Diget, A. Robinson, A.G. Tuff, O. Roberts, University of York, UK; P.J. Woods, T. Davidson, G. J. Lotay, University of Edinburgh; C.-Y. Wu, Lawrence Livermore National Laboratory; H. Al Falou, G.C. Ball, M. Djogolov, A. Garnsworthy, G. Hackman, J.N. Orce, C.J. Pearson, S. Triambak, S.J. Williams, TRIUMF; C. Andreou, D.S. Cross, N. Galinski, R. Kshetri, Simon Fraser University; C. Sumithrarachchi, M.A. Schumaker, University of Guelph; M.P. Jones, S.V. Rigby, University of Liverpool; D. Cline, C. Hayes, University of Rochester; T.E. Drake, University of Toronto; We describe an experiment and associated technique [1] to measure resonances of interest in astrophysical reactions. At the TRIUMF ISAC-II radioactive beam accelerator facility in Canada, particles inelastically scattered in inverse kinematics are detected with Bambino, a \(\Delta E\)-E silicon telescope spanning 15-40 degrees in the lab. We use the TIGRESS to detect gamma rays in coincidence with the charged particles to cleanly select inelastic scattering events. We measured resonances above the alpha threshold in 22Na of relevance to the rate of break-out from the hot-\(\mathcal{CNO}\) cycle via the reaction \(^{22}\)Ne(\(p\),\(\gamma\))\(^{23}\)Na. [1] PJ Woods et al. Rex-ISOLDE proposal 424 Cern (2003).

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1This work was supported by NSERC, STFC, and DOE.
4:15PM LH.00009 Elastic scattering of polarized protons from neutron-rich helium isotopes at 71 MeV/A1. SATOSHI SAKAGUCHI, RIKEN, R388N COLLABORATION2. R399N COLLABORATION3 — In recent studies of unstable nuclei, increasing interest has been attracted by the manifestations of spin-dependent interactions in nuclei. Spin-dependent interactions such as tensor, spin-orbit, and three-nucleon forces have been investigated via direct reactions of polarized light ions. Application of this method to the physics of unstable nuclei should provide us with new information on the effects of spin-dependent interactions on the structure and reaction mechanisms involving unstable nuclei. For this purpose, we have successfully developed a solid polarized proton target which can be operated under a low magnetic field of 0.1 T and at high temperature of 100 K. Making use of this target, we measured vector analyzing powers for the elastic scattering of polarized protons from neutron-rich helium isotopes, 4He and 5He, at 71 MeV/A. Features of spin-orbit potential between protons and neutron-rich helium isotopes have been extracted by the phenomenological optical model analysis.

1This work was partly supported by a Grant-in-Aid for Japan Society for the Promotion of Science (JSPS) Fellows (No. 18-11398).
2Collaboration for the R388n experiment at RIKEN.
3Collaboration for the R399n experiment at RIKEN.

4:30PM LH.00010 Relativistic impulse approximation analysis of unstable nickel isotopes: 48-82Ni, KAORI KAKI, Department of Physics, Shizuoka University — Recent relativistic mean-field calculations have provided nuclear distributions of Ni isotopes whose mass numbers are 48 through 82. We calculate observables of proton elastic scattering from these unstable isotopes and discuss relations between observables and nuclear distributions of such unstable nuclei. The calculations are based on relativistic impulse approximation (RIA) at incident proton energies: 300 and 400 MeV where predictions of RIA have been shown to provide good agreement with experimental data.

Saturday, October 17, 2009 2:00PM - 4:00PM — Session LJ Electromagnetic Interactions Queens 4

2:00PM LJ.00001 Studies of the \((e,e'p)\) reaction on \(\ ^{208}\text{Pb}\), \(\ ^{209}\text{Bi}\) and \(\ ^{12}\text{C}\) at quasielastic kinematics at large values of \(Q^2\), GUIDO URCIUOLI, Instituto Nazionale di Fisica Nucleare - Sezione di Roma, Piazzale Aldo Moro 2, 00185 Rome, Italy, JEFFERSON LAB HALL A COLLABORATION — Experiment E06-007 took place in Hall A at JLab (Virginia, USA) in 2007 and 2008. It measured the \(\ ^{208}\text{Pb}(e,e'p)^{207}\text{TI}, \ ^{209}\text{Bi}(e,e'p)^{208}\text{Pb}\) and \(\ ^{12}(e,e'p)^{11}\text{B}\) reaction cross sections at true quasielastic kinematics with \((q,\omega)\) constant \((eB = 1, \omega = 1 \text{ GeV}/c, \omega = 0.53 \text{ GeV}/c)\) and both sides of \(Q^2\) from 0.8 to 1.3 \(\text{GeV}/c^2\) over a wide range of missing momenta \((0 < p_m < 1.97 \text{ GeV}/c^2\)). The experiment addressed several issues concerning our understanding of nuclear structure like the role of reality and of long-range correlations in the description of nuclei and a possible dependence on \(Q^2\) of spectroscopic factors. The existence of long range correlations is checked looking for excess of strength with respect to the predictions of the mean field approximation at high missing momentum. The presence of relativistic effects in nuclei is checked measuring the asymmetry \(A_{\text{RL}}\), that is the ratio between the difference of the cross sections of both sides of \(q\) divided by the sum. The possible dependence on \(Q^2\) of spectroscopic factors is investigated with the measurements of the cross sections at low missing momentum and at \(Q^2\) from 0.81 to 1.97 \(\text{GeV}/c^2\).

2:15PM LJ.00002 A precise extraction of the proton recoil polarization in \(\ ^{4}\text{He}(e,e'p)^{3}\text{H}\), SIMONA MALACE, MICHAEL PAOLONE, STEFFEN STRAUCH, University of South Carolina, JEFFERSON LAB HALL A COLLABORATION — I will present final results from the experiment E03-104 at Jefferson Lab where the proton recoil polarization in the \(\ ^{4}\text{He}(e,e'p)^{3}\text{H}\) reaction was measured with unprecedented precision at \(Q^2\) values of 0.8 (\(\text{GeV}/c\))^2 and 1.3 (\(\text{GeV}/c\))^2. We extracted both the polarization-transfer coefficients and the induced polarization. The precise extraction of the latter was only possible after extensive work to minimize false asymmetries, and provides a measure of final-state interactions. The measured ratio of polarization-transfer coefficients differs from a fully relativistic calculation by Udias et al. The inclusion of a medium modification of the proton form factors predicted by a quark-meson coupling model or a chiral quark-soliton model brings the calculation in agreement with the data. Our data are equally well described by the prediction of Schiavilla et al. which instead uses free proton form factors but incorporates meson-exchange current effects and strong charge-exchange final states interactions. Neither theoretical calculation offers a satisfactory description of our induced polarization results.

2:30PM LJ.00003 Light Vector Meson Photoproduction off of \(\ ^{1}\text{H}\) at Jefferson Lab, MICHAEL PAOLONE, CHADEN DJALALI, University of South Carolina, RAKHSHA NASSERIPOUR, George Washington University, DENNIS WEYGAND, Thomas Jefferson National Accelerator Facility, MIKE WOOD, Canisius College, CLAS COLLABORATION — Modification of light vector mesons in the nuclear medium continues to be a topic of high interest to the nuclear physics community. Results from recent photoproduction and heavy ion collision experiments have shown a clear broadening of the width in medium, but there remains no consensus on whether the meson undergoes a definite mass shift. An experimental study of the elementary free-space processes is necessary for a precise interpretation of prior in-medium analysis, and is valuable input for theoretical models and calculations. In experiment E04-005, high statistics photoproduction data has been taken in Jefferson Lab's CLAS detector with tagged photon energies up to 5 GeV incident on a LH2 target. Preliminary results of the \(\epsilon\gamma\to e^-\gamma\) decay channel, with emphasis on the \(\rho\omega\) interference region, will be shown and compared to similar experimental data of photoproduction off of heavier nuclear targets (\(\ ^{2}\text{H} \to \ ^{3}\text{H}\)) from Jefferson Lab experiment E01-112.

2:45PM LJ.00004 Scalar and Spin-Polarisabilities of the Nucleon from Deuteron Compton Scattering1. H.W. GRIESSHAMMER, D. SHUKLA, George Washington University, J.A. MCGOVERN, University of Manchester, UK, D.R. PHILLIPS, Ohio University — We present progress in elastic deuteron Compton scattering in Chiral Effective Field Theory. Including the \(\Delta(1232)\) as explicit degrees of freedom is particularly important for deuteron Compton scattering at \(\geq 90 \text{ MeV}\) as measured at SAL and MAXlab. Consistency arguments dictate including the \(np\)-rescattering states and automatically render the correct Thomson limit, shedding new light on Weinberg's power-counting of nuclear forces. We show that the static electric and magnetic scalar polarisabilities of the proton and neutron are identical within the accuracy of available data. In view of proposals at HI-S and ongoing effort at MAXlab, we address in detail single- and doubly-polarised observables with linearly or circularly polarised photons on both un- and vector-polarised deuterons. Several observables can be used to extract not only spin-independent nucleon polarisabilities, but also the so-far practically un-determined spin-dependent polarisabilities which parameterise the stiffness of the nucleon spin in external electro-magnetic fields. Amongst the questions addressed are: convergence of the expansion when including the \(\Delta\), the rôle of \(np\)-rescattering, and sensitivity to the deuteron wave function.

1Supported in part by NSF CAREER, DOE and STFC.

3:00PM LJ.00005 ABSTRACT WITHDRAWN —
3:15PM LJ.00006 Spin Asymmetry on the Nucleon Experiment, HOVHANNES BAGHDASARYAN, University of Virginia, SANE COLLABORATION — The Spin Asymmetry on the Nucleon Experiment (SANE) is a measurement of the spin structure function $g_1$ and $A_1^n$ over a broad range of Bjorken scaling variable $x$ from 0.3 to 0.8, for four-momentum transfers from 2.5 GeV$^2$ to 6.5 GeV$^2$. The experiment measured inclusive double spin asymmetries using TJNAF polarized electron beams of about 4.7 and 5.9 GeV energies, scattered off UVA solid polarized NH$_3$ target. The experiment took place from January to March of 2009. We will discuss the physics motivation for SANE and current status of the analysis, energy resolution and kinematic coverage.

3:30PM LJ.00007 Vibrational and Rotational as well as Linear Kinetic Energies Should be Included in Compton Effect Energy Formula, STEWART BREKKE, Northeastern Illinois University (former grad student) — In Compton scattering the incident photon will affect the vibration and rotation of the impacted particle as well as its linear motion. Therefore, the energy equation for the Compton Effect must be modified to include the change in vibrational and rotational kinetic energy of the particle before and after photon impact. The Compton Effect equation equation should then be as follows. $hc/\lambda_1 + m_0c^2 + 1/2mv_1^2 + 1/2I\omega_1^2 + 1/2k_1x_0_1^2 = hc/\lambda_2 + m_0c^2 + 1/2mv_2^2 + 1/2I\omega_2^2 + 1/2k_2x_0_2^2$.

3:45PM LJ.00008 Lattice QCD in Background Fields, BRIAN TIBURZI, University of Maryland, WILLIAM DETMOLD$^1$, ANDRE WALKER-LOUD, College of William and Mary — The response of hadrons to electromagnetic probes is highly constrained by chiral dynamics; but, in some cases, predictions have not compared well with experimental data. Electromagnetic properties of hadrons can be computed by lattice simulations of QCD in background fields. Focusing on calculations in background electric fields, we demonstrate new techniques to determine electric polarizabilities. We argue that the lattice can be used to test the chiral electromagnetism of hadrons, and ultimately confront experiment.

1 also at Thomas Jefferson National Laboratory

Saturday, October 17, 2009 2:00PM - 4:15PM – Session LK Neutrinos III Queens 5

2:00PM LK.00001 ABSTRACT WITHDRAWN –

2:15PM LK.00002 Study of background origin by data analysis and simulation for CANDLES III, GO ITO, JPS, TADAOFUMI KISHIMOTO, IZUMI OGAWA, SAORI UMEHARA, KENSUKE YASUDA, MASAKI MIYASITA, SYUICHI KAKUBATA, KENJI MATSUOKA, RYUTA HAZAMA, YOICHI TAMAGAWA, CANDLES COLLABORATION — Neutrinoless double beta decay is sensitive to not only effective neutrino mass but also to confirm Majorana nature of neutrinos. We constructed the CANDLES III detector at sea level and have been studying basic performances of the detector. Its central detector is 200kg CaF$_2$ crystals. The performances we studied were energy resolution, background rate, detection efficiency, and so on. In order to study background events we analyzed experimental data and compared with GEANT4 simulation. We are now constructing CANDLES III detector at the Kamioka underground laboratory. I’ll report the result of background study at sea level and the current status of construction at underground laboratory.

2:30PM LK.00003 Study of copper and TeO$_2$ contaminations due to radon exposure$^1$, M. PEDRETTI, N.D. SCIELZIO, LLNL, E.B. NORMAN, LLNL, UC Berleke, C. ANGELL, UC Berkeley — The main goal of CUORE experiment is to search for neutrinoless double beta decay of $^{130}$Te, that could give information on the effective Majorana neutrino mass and the nature of the neutrino. The sensitivity of the experiment strongly depends on the radioactive background level that can be reached. CUORE R&D has shown that surface contaminations of detector materials are major contributors to the CUORE background. In this context $^{220}$Rn and $^{222}$Rn, and their daughters, are dangerous isotopes that can cause potential surface contamination of detector elements, like the copper frames and TeO$_2$ crystals. We used silicon surface-barrier detectors to study the contamination produced by exposing copper to high radon concentrations and we investigated the diffusion of radon inside the copper. Results of these measurements will be presented.

$^1$This work was supported in part by the U.S. Dept. of Energy.

2:45PM LK.00004 Measurements of proton-induced radionuclide production cross sections to evaluate cosmic-ray activation of tellurium$^1$, E.B. NORMAN, B.J. QUITER, UC Berkeley, A.R. SMITH, LLNL, S.A. WENDER, R.C. HAIGHT, LANL, A.F. BARGHOUTY, NASA, C. BROFFIERIO, S. CAPELLI, M. CLEVENZIA, O. CREMONESI, E. FIORINI, E. PREVITALI, M. SISTI, Univ. of Milan-Bicocca, S. CEBRIAN, Univ. of Zaragoza — Minimization of radioactive backgrounds is critical for experiments attempting to measure neutrinoless double beta decay. To estimate cosmic ray-induced radionuclide production in the CUORE experiment, we irradiated targets containing natural isotopic composition Te with protons at LANL (0.8 GeV) and at CERN (1.4 and 24 GeV). Targets were counted with high purity germanium detectors after irradiation to determine cross sections for radionuclide production. A large number of radioactive products were observed at each bombarding energy. Results from these measurements will be presented and compared with predictions from the semi-empirical Silberberg and Tsao code. The implications of these results for CUORE will be discussed.

$^1$This work was supported in part by the U.S. Dept. of Energy and by the INFN in Italy.

3:00PM LK.00005 Development of A Web Toolkit for Calculating $(\alpha, n)$ Induced Neutron Yield and Energy Spectrum$^1$, CHAO ZHANG, DONGMING MEI, the University of South Dakota — Neutrons from $(\alpha, n)$ reactions induced by natural radioactivity are important sources of background for low-background experiments such as direct detection of dark matter and neutrinos. A web toolkit has been built for calculating $(\alpha, n)$ neutron yield and neutron energy spectrum induced by $^{238}$U, $^{232}$Th and $^{232}$Sm decays in all possible elements or compound. We describe the web toolkit that offers neutron yield and energy spectrum in terms of customized input.

$^1$This work is supported in part by the NSF grant 0758120, the Office of Research at the University of South Dakota, and by Laboratory Directed Research and Development at Los Alamos National Laboratory.
3:15PM LK.00006 External Background Characterization of Homestake Mine for DUSEL1, KEENAN THOMAS, DONGMING MEI, The University of South Dakota, FREDERICK GRAY, Regis University, CHAO ZHANG, The University of South Dakota, HOMESTAKE BACKGROUND CHARACTERIZATION TEAM — The Homestake Mine in Lead, South Dakota has been selected as the site for the Deep Underground Science and Engineering Laboratory (DUSEL). The former gold mine will provide ample underground facilities for low background experiments such as the detection of neutrinos and dark matter. Although the earth overburden provides shielding of cosmic rays, there are still sources of external background underground that are of concern to early experiments while the mine is in the initial stages of renovation. The goal of this project is to measure sources of external background underground including muons, neutrons, gamma-rays, and radon concentrations in the air. The information produced by these measurements is of use for future experiments in the design of shielding and infrastructure such as ventilation systems for radon removal. This paper will report the results regarding muon flux, neutron flux, gamma-ray flux, as well as radon at the different levels.

1Special thanks to Sanford Laboratory. Project supported by NSF-PHYS-0758120.

3:30PM LK.00007 Measuring Muon-Induced Processes at Homestake1, PATRICK DAVIS, DONGMING MEI, BRIAN WOLTMAN, CHAO ZHANG, The University of South Dakota, HOMESTAKE BACKGROUND CHARACTERIZATION TEAM — Muon-induced processes are important background to the low background experiments in searching for rare event physics such as neutrinoless double-beta decay, dark matter, and neutrino oscillation. Measuring muon-induced processes including muon- induced fast neutrons and negative muon capture on different nucleus are critical to the next generation ultra-low background experiments. A R&D program has been carried out in studying the design of the detector array to measure the muon- induced fast neutron yield, energy spectrum, multiplicity, and angular distribution with different targets. This detector array is also optimized to measure the stopping muon flux underground. We report preliminary results from the R&D study.

1NSF Grant Number PHY-0758120, South Dakota EPSCoR Office.

3:45PM LK.00008 Center for Ultra-Low Background Experiments at DUSEL (CUBED), DONG-MING MEI, CHRISTINA KELLER, The University of South Dakota, CUBED COLLABORATION — With the selection of Homestake as the site for DUSEL, the state of South Dakota has sought ways to engage its faculty and students in activities planned for DUSEL. One such effort is the creation of a 2010 Research Center focused on ultra-low background experiments or a Center for Ultra-low Background Experiments at DUSEL (CUBED), which provides support for South Dakota scientists to continue participation in large experiments searching for rare and difficult to detect phenomena such as neutrinoless double-beta decay and dark matter. The CUBED focus is on material purification and crystal growth underground for ultra-low background experiments, to minimize the amount of cosmogenic isotopes such as $^7$T, $^{40}$Ge, and $^{60}$Co, which one finds in surface-produced enriched $^{76}$Ge or natural germanium crystals, and which limit the sensitivity of next generation double-beta decay/dark matter experiments. Purification and crystal growth performed underground avoids cosmogenic contamination that can occur if the crystals reside on the surface for as little as a week. We will provide an update on the progress made in developing underground capabilities for material purification and crystal growth.

4:00PM LK.00009 CdWO$_4$/CsI and APDs for Low Background Experiments1, DOUGLAS DAILEY, AYSSA DAY, KEENAN THOMAS, DONGMING MEI, YONGCHEN SUN, University of South Dakota — Large Area Avalanche Photodiodes (LAAPDs) serve many functions in modern science. CdWO$_4$ crystals enable us to detect both neutrinoless double beta decay and geo-neutrinos. CsI crystals can be used to directly detect dark matter. In our study, we will use two APDs coupled to CsI and CdWO$_4$ crystals to study neutrons and gamma ray responses. We will report some preliminary results on the discrimination of neutrons and gamma rays. Efforts on stabilizing the temperature and gain will also be described.

1Funding provided by the South Dakota Board of Regents under a 2010 Grant and the Office of Research at the University of South Dakota.

Saturday, October 17, 2009 2:00PM - 5:00PM — Session LL Nuclear Structure VI Queens 6

2:00PM LL.00001 Beta decay of $^{24}$Si and mirror asymmetry of Gamow-Teller transition strength, YUICHI ICHIKAWA, TOSHIYUKI KUBO, NARI AOI, NAOKI FUKUDA, TOHRU MOTOBAYASHI, KAZUNARI YAMADA, HIROYOSHI SAKURAI, Nishina Center, RIKEN, TAKEO ONISHI, DAISUKE SUZUKI, HIROHARA IWASAKI, TAKAHIRO NAKAO, HIROSHI SUZUKI, MASARU SUZUKI, University of Tokyo, VAISHALI NAIR, ALOK CHAKRABARTI, Variale Energy Cyclotron Centre, B. ALEX BROWN, Michigan State University, SHIGERU KUBONO, HIDETOSHI YAMAGUCHI, CNS, University of Tokyo, TAKUMI NAKABAYASHI, TAKASHI NAKAMURA, TOSHIFUMI OKUMURA, Tokyo Institute of Technology, H. JIN ONG, RCNP, Osaka University, TAKASHI TERANISHI, Kyushu University — We performed the $\beta$ decay spectroscopy on $^{24}$Si in order to study the behavior of a weakly-bound $s$-wave proton. The behavior of a weakly-bound proton in a proton-rich nucleus is one of the interesting topics to explore exotic nuclear structures such as proton halo. Thomas-Ehrman shift of the proton $\frac{1}{2}^+$ orbital induces a configuration change in the wave function. The change can be investigated in terms of the mirror asymmetry for Gamow-Teller transition strengths $B(\text{GT})$ for a proton-rich nucleus of $^{24}$Si. The experiment was carried out at the RIPS facility. In this presentation, we will report the experimental results. Discussion on the comparison with theoretical calculations which takes into account the Coulomb force and the Thomas-Ehrman shift is also given.

2:15PM LL.00002 Approaching the Island of Inversion: $^{34}$P, PETER C. BENDER, CALEM HOFFMAN, MATHIS WIEDEKING, J.M. ALLMOND, L.A. BERNSTEIN, J.T. BURKE, D.L. BLEUEL, R.M. CLARK, P. FALLON, B.L. GOLDBLUM, T.A. HINNERS, H.B. JEPPESEN, S.L. LEE, I.-Y. LEE, S.R. LESHNER, A.O. MACCHIARELLI, M.A. MCMAHAN, D. MORGAN, M. PERRY, L. PHAIR, N.D. SCIELZO, S.L. TABOR, V. TRIPATHI, A. VOLYA, Florida State University — $\beta$-ray states in $^{34}$P were investigated using the $^{18}$O($^{16}$O,pn) reaction at energies of 20, 24, 25, 30, and 44 MeV at Florida State University and at Lawrence Berkeley National Laboratory. The level scheme was expanded, $\gamma$-ray angular distributions were measured, and lifetimes were inferred with the Doppler-shift attenuation method by detecting decay protons in coincidence with one or more $\gamma$ rays. The results provide a clearer picture of the evolution of structure approaching the "Island of Inversion", particularly how the 1 and 2 particle-hole (ph) states fall in energy with increasing neutron number approaching inversion. Shell model calculations made using a small modification of the WBP interaction reproduce the negative-parity, 1-ph states rather well.

2:15PM LL.00002 Approaching the Island of Inversion: $^{34}$P, PETER C. BENDER, CALEM HOFFMAN, MATHIS WIEDEKING, J.M. ALLMOND, L.A. BERNSTEIN, J.T. BURKE, D.L. BLEUEL, R.M. CLARK, P. FALLON, B.L. GOLDBLUM, T.A. HINNERS, H.B. JEPPESEN, S.L. LEE, I.-Y. LEE, S.R. LESHNER, A.O. MACCHIARELLI, M.A. MCMAHAN, D. MORGAN, M. PERRY, L. PHAIR, N.D. SCIELZO, S.L. TABOR, V. TRIPATHI, A. VOLYA, Florida State University — Yrast states in $^{34}$P were investigated using the $^{18}$O($^{16}$O,pn) reaction at energies of 20, 24, 25, 30, and 44 MeV at Florida State University and at Lawrence Berkeley National Laboratory. The level scheme was expanded, $\gamma$-ray angular distributions were measured, and lifetimes were inferred with the Doppler-shift attenuation method by detecting decay protons in coincidence with one or more $\gamma$ rays. The results provide a clearer picture of the evolution of structure approaching the "Island of Inversion", particularly how the 1 and 2 particle-hole (ph) states fall in energy with increasing neutron number approaching inversion. Shell model calculations made using a small modification of the WBP interaction reproduce the negative-parity, 1-ph states rather well.

2Supported in part by the NSF and DOE.
2:30PM LL.00003 Disappearance of the N=14 Shell. M.J. STRONGMAN, T. BAUMANN, D. BAZIN, N. FRANK, S. MOSBY, W.A. PETERS, A. SCHILLER, A. SPYROI, M. THOENENESSEN, NSCL/MSU, C.R. HOFFMAN, S.L. TABOR, Florida State University, J. BROWN, Wabash College, P.A. DEYOUNG, Hope College, J.E. FINK, Central Michigan University, W.F. ROGERS, Westminster College, MONA COLLABORATION — The decay-energy spectrum of $^{28}$Na was measured in a neutron-fragment coincidence experiment at the National Superconducting Cyclotron Laboratory at MSU. An excited state of $^{22}$N, unbound with respect to neutron emission measured by the Modular Neutron Array (MoNA), was observed in a stripping reaction from a secondary 85 MeV/u $^{20}$F beam. The observed decay energy of 650(50) keV places the state, which is interpreted to be the first $3^-$ level, at an excitation energy of 1.93(22) MeV. Together with the previously measured bound states of $^{22}$N, the reduction of the N = 14 shell gap at the neutron dripline is observed. The magnitude of the reduction of the shell gap indicates the disappearance of the gap and even a possible reoccurrence of the inversion of the $\nu 1s_{1/2}$ and the $\nu 0d_{5/2}$ levels in the neutron-unbound nucleus $^{21}$C.

2:45PM LL.00004 The Structure of Neutron- rich $^{28,29}$Mg Studied through $\beta$-decay of Spin-polarized $^{28,29}$Na Beams at TRIUMF. K. TAJIRI, K. KURA, M. KAZATO, M. SUGA, A. TAKASHIMA, T. HORI, T. MASUE, T. SUZUKI, T. FUKUCHI, A. ODAHARA, T. SHIMODA, Osaka University, Y. HIRAYAMA, N. IMAI, H. MIYATAKE, KEK, M. PEARSON, C.D.P. LEVY, K.P. JACKSON, TRIUMF — The structure of neutron-rich Mg isotopes in the region of Island of Inversion has been attracting much attention because of vanishing of N=20 magic number and their large deformation in the ground states. However, most of the spins and parities of the excited states in Mg isotopes with A$\geq$29 are left unknown. We have started systematic $\beta$-decay studies at TRIUMF, Canada, where highly spin-polarized radioactive Na beams are available. The experiment to determine the spins and parities of the states in $^{28,29}$Mg by using spin-polarized $^{28,29}$Na beams were performed at Osaka beam line in TRIUMF. The results are as follows: Many $\gamma$-transitions and energy levels were newly found in $^{28,29}$Mg. In $^{28}$Mg, spins and parities of the 4 levels reported previously were reconfirmed and those of the newly found 7.461 MeV level was assigned to be $2^+$. In $^{29}$Mg, spins and parities of 3 energy levels were assigned for the first time. Shell model calculations were performed with NuShell code by using USD, USD and USDB interactions to compare with the experimental results. In $^{28}$Mg, we also compared with MCMC calculation. The level structure in $^{28}$Mg was well explained by only sd-shell configurations.

3:00PM LL.00005 Medium to high spin spectroscopy of A = 30 - 60 neutron-rich nuclei at JAEA. TSUNEYASU MORIKAWA, Kyushu University, EJII IEGUCHI, SHINSUKE OTA, CNS, University of Tokyo, MASUMI OSHIMA, MITSUO KOIZUMI, YOSUKE TÔH, ATSUSHI KIMURA, HIDEO HARADA, KAZUYOSHI FURUTAKA, SHOJI NAKAMURA, FUMITO KITATANI, YUICHI HATAKAWA, TOSHIYUKI SHIZUMA, Japan Atomic Energy Agency, MASASHI SUGAWARA, Chiba Institute of Technology, HIROARI MIYATAKE, YUTAKA WATANABE, YOSHIKAZU HIRAYAMA, KEK, HIDESHIGE KUSAKARI, Chiba University — Motivated by the recent progress in the RI-beam physics and the discovery of the island of inversion, a systematic investigation of the medium to high spin excited states in neutron-rich A = 30 ~ 40 region has been underway as a cooperative study at the JAEA tandem accelerator facility. Since the evolution of shell structure is a function of nuclear deformation and rotation as well as the isospin, systematic understanding of the levels in this neutron-rich region is of great interest. Especially, the systematic identification of the high-spin levels involving the sd to fp cross-shell excitation could be a key to clarify the evolution of N = 20 neutron shell gap. We will present recent results on some neutron rich nuclei in this mass region and discuss their shell structure.

3:15PM LL.00006 Triaxial deformation and shape coexistence in Ni and Cr isotopes studied by Antisymmetrized Molecular Dynamics + Bogoliubov method. MASAAKI KIMURA, Hokkaido University — In this talk, I will introduce an extended version of Antisymmetrized Molecular Dynamics (AMD) and discuss the triaxial deformation and shape coexistence in Ni and Cr isotopes based on this extended framework. Recently, we have extended AMD to study the various phenomena in neutron-rich nuclei. By using localized Gaussian wave packets as the basis of quasi particle wave function, AMD is extended to include the pairing correlation (AMD+Bogoliubov). The use of Gaussian wave packets makes it easy to perform the parity and angular momentum projection and Generator Coordinate Calculation (GCM). Characteristic behavior of the $2^+$ energies and B(E2) values in Ni and Cr isotopes have been experimentally observed. Theoretically, based on the shell model and beyond mean-field calculations, their behavior has been discussed in relation to new magic number in neutron-rich nuclei, and possible triaxial deformation in several isotopes has been pointed out. We have applied AMD+Bogoliubov to Ni and Cr isotopes and the behavior of $2^+$ energies and B(E2) are reproduced well. It is found that most of isotopes have the shape coexistence and some manifest triaxial deformation. By comparing with the axial calculation, the importance of the triaxial deformation to understand the zigzag behavior of $2^+$ energies and B(E2) will be discussed.

3:30PM LL.00007 Band structures in neutron-rich A $\sim$ 60−80 nuclei via deep-inelastic reactions with Gammasphere. C.J. CHIARA, I. STEFANESCU, J.R. STONE, W.B. WALTERS, University of Maryland, M.P. CARPENTER, R.V.F. JANSSSENS, B.P. KAY, F.G. KONDEV, T. LAURITSEN, C.J. LISTER, E.A. MCCUTCHAN, D. SEWERYNIAK, S. ZHU, Argonne National Laboratory, R. BRODA, B. FORNAL, W. KROLAS, T. PAWLAT, J. WRZESINSKI, Niewodniczanski Institute, N.J. STONE, U. of Oxford/U. of Tennessee — Several experiments have been performed at Argonne National Laboratory in the past few years using deep-inelastic reactions on thick $^{238}$U targets to produce neutron-rich nuclei in the A $\sim$ 60 to 80 mass region. Beams of 430-MeV $^{64}$Ni, 530-MeV $^{76}$Ge, and 630-MeV $^{82}$Se have been provided by the ATLAS facility at ANL. Gamma rays were detected with the Gammasphere Ge-detector array. Band structures have been newly observed in a number of neutron-rich nuclei [e.g., I. Stefanescu et al., Phys. Rev. C 79, 064302 (2009)]. In some cases, spin and parity assignments are strengthened by angular-correlation measurements. These observations can provide insights into the single-particle and collective properties of these nuclei. Highlights of this study will be presented.

This research is supported by the DOE Office of Nuclear Physics under Contracts DE-FG02-94ER40834 and DE-AC02-06CH11357.

3:45PM LL.00008 Shell-model description of $N = Z, A \sim 70$ nuclei. MICHIO HONMA, University of Aizu, TAKAHARU OTSUKA, University of Tokyo, TAKAHIRO MIZUSAKI, Senshu University, MORTEN HJORTH-JENSEN, University of Oslo — We present the results of shell-model calculations in the model space consisting of four single-particle orbits $1p_{1/2}, 0f_{5/2}, 1p_{3/2}$ and $0g_{9/2}$ using a new semi-microscopic effective interaction. The structure of $N = Z$ nuclei around $^{68}$Se is discussed focusing especially on the role of the $0g_{9/2}$ orbit. The development of the band structure is interpreted in terms of successive excitations of neutrons into the $0g_{9/2}$ orbit. The triaxial/$\gamma$-soft structure in $^{64}$Ge and the prolate/oblate shape-coexistence in $^{68}$Se are predicted, showing a good correspondence with the experimental data. The isomeric states in $^{66}$As and $^{71}$Br are obtained with the structure of an aligned proton-neutron pair in the $0g_{9/2}$ orbit. In spite of the modest model space, the new interaction turns out to describe rather well properties related to the $0g_{9/2}$ orbit in various cases including moderately deformed nuclei.

This work was supported by the DOE Office of Nuclear Physics under Contract DE-AC02-06CH11357.
4:00PM LL.00009 UMOA calculations for $^{16}$O, $^{40}$Ca, and $^{56}$Ni. Ryoji Okamoto, Kyushu Institute of Technology, Shinnichiro Fujii, Kyushu University, Kenji Suzuki, Kyushu Institute of Technology — One of the most fundamental problems in nuclear theory is to describe nuclear structure from the underlying nuclear interactions. The unitary-model-operator approach (UMOA) is an $ab\ initio$ method which can describe the structure of nuclei beyond the $p$ shell using realistic nuclear forces. In the UMOA, the original Hamiltonian is unitarily transformed, and thus three-or-more-body cluster terms are generated even if we employ only the two-body force as the original interaction. In this work, the UMOA is applied to nuclei around $^{16}$O, $^{40}$Ca, and $^{56}$Ni. The ground-state and single-particle energies for hole states of these nuclei including three-body-cluster effects are calculated with realistic nucleon-nucleon interactions. We show that the calculated results are fairly close to the experimental values. The dependence of the results on the two-body interactions and effects of the genuine three-body force are also discussed.

4:15PM LL.00010 Nuclear Structure and Decay Data Evaluation: Status and Perspectives1

F.G. Kondev, ANL; E. Browne, C. Quelette, B. Pritychenko, C. Reich, A. Sonzogni, S. Taneda, J.K. Tuli, BNL; J. Cameran, A. Chen, B. Singh, McMasters U.; J. Kelley, E. Kwan, TUNL; C. Baglin, M.S. Basunia, R.B. Firestone, LBNL; N. Nica, Texas A&M U.; C.D. Nesaraaja, M.S. Smith, ORNL — Reliable nuclear structure data represent the fundamental building blocks of nuclear structure physics and astrophysics research, and are of vital importance in a large number of applications. Members of the Nuclear Structure and Decay Data Working Group of the U.S. Nuclear Data Program, in collaboration with scientists from Japan and other countries within the International Nuclear Structure and Decay Data Network (under the auspices of IAEA), are involved in compilation, evaluation, and dissemination of nuclear structure and decay data for all known nuclei. The network’s principal effort is devoted to the timely revision of information in the Evaluated Nuclear Structure Data File (ENSDF) library, which is the only comprehensive nuclear structure and decay data database that is updated continuously. This presentation will briefly review recent achievements of the network, present on-going activities, and reflect on ideas for future projects and challenges in the field of nuclear structure and decay data evaluation.

4:30PM LL.00011 Search for High-Spin Isomer in $^{142}$Pr by RI Beam Induced Fusion Reaction at RCNP, A. Takashima, M. Suga, K. Kura, T. Tajiri, M. Kazato, Y. Kenmoku, Y. Ito, K. Yamaguchi, K. Kurata, T. Oda, Hata, T. Shimoda, Dept. of Phys. Osaka Univ., S. Go, E. Ideguchi, CNS, Univ. of Tokyo, Y. Gono, S. Nishimura, H. Watanabe, Riken, C. Pertache, IPN Orsay and Univ. Paris Sud, T. Suzuki, RCNP, Osaka Univ., Y. Wakahayashi, JAEA — Systematic studies of high-spin shape isomers in $^{17}$N=83 isotones provided important information on the properties of pairing interactions. The high-spin isomer in $^{142}$Pr, which is not effectively populated by any combinations of stable beams and targets, was searched for in the fusion reaction induced by RI beam, $^{130}$Te($^{17}$N, 5n)$^{142}$Pr, at RCNP, Osaka Univ. The $^{17}$N beam was produced in the $^7$Be ($^{18}$O, $^{17}$N) $^{16}$O reaction at 9.1 MeV/u. Gamma-rays at the secondary target were detected by a RCNP Ge array consisting of 14 HPGe detectors. Contaminant $\gamma$-rays due to $\beta$-decay of $^{17}$N and the natural activities could be eliminated with the coincidence requirement that the $^{17}$N particles were detected in the PPAC. The $^{17}$N beam of $\sim$10$^5$ pps has been obtained with energy of $\sim$4.2 MeV/u. In the preliminary analyses, clearly seen were the $\gamma$-rays deexciting the states with spins up to 21/2 in $^{141}$Pr and the reported $\gamma$-rays after the decay of (9+) isomer with $T_{1/2}=61$ ns in $^{144}$Pr. The results of $\gamma\gamma$ coincidence analyses searching for the isomers will be presented.

4:45PM LL.00012 Study of Density and Structure of Oxygen Isotopes with the Cluster-Orbital Shell Model Approach, Hiroshi Masui, Kitami Institute of Technology, Kitami, 090-8507, Japan, Kiyoshi Kato, Department of Physics, Faculty of Science, Hokkaido University, Sapporo, 060-0810, Japan, Kiyomi Ikeda, The Institute of Physical and Chemical Research (RIKEN), Wako, 351-0198, Japan — We study structure of oxygen isotopes through the analysis of the density and the $s$-wave contribution. From experiments, the r.m.s.radius of oxygen isotopes has an abrupt increase at $^{23}$O from the empirical $A^{1/3}$-low. However, as we have shown with the calculation by using our m-scheme cluster-orbital shell model (COSM) approach, such the abrupt increase can hardly be reproduced only by considering the valence nucleon degree of freedom. In our COSM approach, we construct the core-N Hamiltonian using a semi-microscopic approach by taking into account the Pauli principle for the nucleons in the core. As the nucleon-nucleon potential, we use Volkov No.2 potential. The parameters of the potential are adjusted so as to reproduce the $^{16}$O+$2n$ threshold. Using the potential model described above, however, we obtain the over bound nature as the number of valence nucleon increase. Hence, we perform calculations using slightly weaker potential strength for the valence neutrons so as to reproduce the drip-line at $^{24}$O. Using the potential model described above, however, we obtain the over bound nature as the number of valence nucleon increase. Hence, we perform calculations using slightly weaker potential strength for the valence neutrons so as to reproduce the drip-line at $^{24}$O. In this study, we discuss the density distributions of the isotopes and the contributions of partial waves especially the $s$-wave.

Saturday, October 17, 2009 2:00PM - 4:45PM — Session LM Nuclear Theory IV Kings 1

2:00PM LM.00001 Spin- and Parity-Dependent Shell Model Nuclear Level Densities for Medium-Mass Nuclei, Mike Scott, Miha Horoi, Department of Physics, Central Michigan University, Mount Pleasant, MI 48859 — The spin- and parity-dependent nuclear level density (SPNLD), $\rho(E_x, J, \pi)$, is an important element in the description of highly excited nuclei, and it is used to predict the nuclear reactions rates necessary for understanding the nucleosynthesis. Using the methods of statistical spectroscopy, we have developed a method for obtaining the SPNLD using the first two spin-projected moments of the Hamiltonian for each configuration of nucleons. We compare the results of this method with the results of the shell model, whose direct diagonalization approach quickly loses its feasibility, for nuclei in the pf model space and in the f5/2p9/2 model space. Potential implications for reactions cross sections of nuclei in the rp-path will be discussed.

2:15PM LM.00002 Parallel on-the-fly configuration-interaction shell-model code, William Ormand, Lawrence Livermore National Laboratory, Calvin Johnson, Plamen Krastev, San Diego State University — Configuration-interaction shell-model codes generally rely on computing and storing the full many-body Hamiltonian matrix, which while sparse, nonetheless push computational memory demands, especially when the number of basis states approach 10$^6$ and up. On-the-fly algorithms mitigate the memory burden by factorizing both the basis and the Hamiltonian. We describe BigStick, an efficient on-the-fly code designed for large-scale parallel operation with both two- and three-body interactions. We present algorithm developments utilizing MPI, OPENMP, and hybrid schemes. Prepared by LLNL under Contract DE-AC52-07NA27344. Support from U.S. DOE/SC/FP (Work Proposal No. SCW0498) and U.S. DOE Grants DE-FG02-03ER41272 and DE-FC02-09ER41587 is acknowledged.

2:30PM LM.00003 ABSTRACT WITHDRAWN —
2:45PM LM.00004 Microscopic analysis of large amplitude collective dynamics in triaxial nuclear shapes. TAKASHI NAKATSUKASA, NIJIOBU HIKONARA, RIKEN Nishina Center, KOICHI SATO, Kyoto University, MASAYUKI MATSUO, Niigata University, KENICHI MATSUYANAGI, RIKEN Nishina Center — We have developed a microscopic theory of large amplitude collective motion that provides us with a collective Hamiltonian. The method is based on the adiabatic expansion of equations of the self-consistent collective coordinate method (Prog. Theor. Phys. 103, 959 (2000)). In this approach, the canonical collective variables are self-consistently determined, and all the quantities in the collective Hamiltonian (mass parameters and potential) are also microscopically calculated. Quantizing the collective Hamiltonian, we can treat nuclear dynamics beyond the harmonic limit. We apply the method to the pairing-plus-quadrupole Hamiltonian to discuss properties of nuclear anharmonicity and shape mixing. Especially we stress importance of triaxial degrees of freedom in the shape coexistence phenomena.

3:00PM LM.00005 RPA calculations with Gaussian expansion method. HITOSHI NAKADA, Chiba University, KAZUHIRO MIZUYAMA, University of Jyvaskyla, MASAYUKI YAMAGAMI, University of Aizu, MASAYUKI MATSUO, Niigata University — The Gaussian expansion method (GEM) is applied to the calculations in the random-phase approximation (RPA). We adopt the mass-independent basis-set that has been tested in the mean-field calculations. The RPA results by the GEM are compared with those obtained by several other available methods in Ca isotopes, using a density-dependent contact interaction and the Woods-Saxon single-particle states. It is confirmed that energies, transition strengths and widths of their distribution are described by the GEM to good precision, for the 1−, 2+ and 3− collective states. The GEM is then applied to the self-consistent RPA calculations with the finite-range Gogny D1S interaction. The spurious center-of-mass motion is well separated from the physical states in the E1 response, and the energy-weighted sum rules for the isoscalar transitions are fulfilled reasonably well.

3:15PM LM.00006 Nuclear Rotations and the Born–Oppenheimer Method1. NOUREDINE ZETTILI, Jacksonville State University — We want to discuss the study of nuclear rotations and collective motion within the context of the nuclear Born–Oppenheimer (NBO) method—a truly quantum mechanical method. As an illustration, we apply the NBO method to study permanently deformed (non-spherical) nuclei; in particular, we study nuclei that are axially-symmetric and even, but with non-closed shells. In the presentation, we focus on the derivation of formal expressions for the energy and for the moment of inertia. Using trial functions in which the intrinsic structure is described in a mean-field approximation, we then show that the NBO formalism yields the Thouless-Valatin formula for the moment of inertia and that this moment of inertia increases with angular momentum, in agreement with experimental data. We show that the NBO formalism is well equipped to describe low-lying as well as high lying rotational states. Additionally, we establish a connection between the NBO method and the self-consistent Cranking (SCC) model, which is known to be successful in reproducing vast amounts of experimental data ranging from low-lying rotational states to high angular momentum states.

3:30PM LM.00007 On Ratios of B(E2)’s1. CHARLES LOELIUS, LARRY ZAMICK, YITZHAK SHARON, Rutgers University — We have conducted a wide survey of the ratio B(E2; 4÷to2÷) / B(E2; 2÷ to zero÷) throughout the periodic table. In the rotational model this ratio is 10/7 and in the vibrational model it is 2/1(stimulated emission). There are considerable deviations from this for magic or semi-magic nuclei e.g. for 86Kr (N=50) the ratio is close to zero. But what is more surprising is that there are large deviations for other nuclei as well, which will be systematically shown. Theoretical discussions for some of these deviations will be given.

3:45PM LM.00008 Operator Evolution Using SRG Flow Equations for Few-Body Systems1. E.R. ANDERSON, Ohio State Univ., S.K. BOGNER, Michigan State Univ., R.J. FURNSTAL, E.D. JÜRGENSEN, R.J. PERRY, Ohio State Univ. — The Similarity Renormalization Group (SRG) flow equations are a series of unitary transformations which can be used to achieve different patterns of decoupling in a Hamiltonian. An SRG transformation applied to inter nuclei interactions leads to greatly improved convergence properties while preserving observables. Not only does it provide a way to consistently evolve many-body potentials, but also other operators[1]. Here, a method to implement SRG evolved few-body operators is applied to both model and realistic calculations. Properties of the corresponding observables are explored for both long- and short- range operators. Methods to improve their convergence in a truncated model space are also considered.

4:00PM LM.00009 Fission of heavy Λ hypernuclei with the Skyrme-Hartree-Fock approach. FUTOSHI MINATO, Japan Atomic Energy Agency, KOUCHI HAGINO, Tohoku University, SATOSHI CHIBA, Japan Atomic Energy Agency — It has been shown that the shape of a few deformed nuclei change toward spherical when a Λ particle is added to them. This is caused because the interaction between a Λ particle and a nucleon is attractive. This fact has motivated us to investigate the influence of a Λ particle on the fission of heavy nuclei. In this talk, we will discuss the fission-related phenomena of heavy Λ hypernuclei with the constraint Skyrme-Hartree-Fock+BCS (SHF+BCS) method. We employ a Skyrme-type interaction for the ΛN interaction and assume adiabaticity, that is, the Λ particle is assumed to be in the lowest state at all deformations. We will show that the fission barrier heights increase by about 200 keV by adding a Λ particle. Our result confirms that the Λ particle is stuck to the heavier fission fragment, which is consistent with the experimental result of CERN. We will also discuss the deformation of heavy Λ hypernuclei and the Λ particle motion inside the core nuclei.

4:15PM LM.00010 Microscopic description of fission-fragment properties1. WALID YOUNES, Lawrence Livermore Natl Lab — The development of a microscopic theory of fission remains one of the greatest challenges in nuclear physics. At the same time, recent advances in theoretical tools and computational power are bringing the goal of a predictive microscopic theory of fission within reach. In this talk, I will discuss the quantitative definition of scission, and the identification of scission configurations within the framework of Hartree-Fock-Bogoliubov (HFB) formalism with the Gogny effective interaction. I will present fission-fragment properties (shapes, kinetic and excitation energies) for low-energy fission of 238Pu, obtained using static HFB calculations and discuss the prospects for future work within a time-dependent treatment of fission.

4:30PM LM.00011 The role of pions on finite nuclei with relativistic chiral mean field model. YOKO OGAWA, HIROSHI TOKI, Research Center for Nuclear Physics, Osaka University — We present a relativistic chiral mean field (RCMF) model, which is a method for proper treatment of pion-exchange interaction in the nuclear-many body problem. There the term of the pionic correlation is expressed in 2-particle 2-hole (2p-2h) states with particle-hole having pionic quantum number . We further the effect of the short-range repulsion in terms of the unitary correlation operator method (UCOM) for the central part of the pion-exchange interaction. We apply this model to 4He, 12C, and 40Ca nuclei. Pion plays an important role on the formation of the j-magic shell structure by the Pauli-blocking mechanism of the pion-exchange interaction. The lowest pionic quantum number, , is the dominant component for construction of the surface structure. We also discuss chiral symmetry in finite nuclei in the linear sigma model.