9:00AM 1WA.00001 Scattering and reactions in ab initio nuclear theory1 KENNETH NOLLETT, Argonne National Laboratory — Over the past decade, much progress has been made toward understanding nuclei as collections of neutrons and protons, taking into account all of the complications of their interactions. Precise characterizations of the those interactions together with vast increases in computer power now allow ab initio calculations of many nuclear energy levels. Several ab initio computational methods are being pursued by different groups, and each has a distinct set of advantages and disadvantages. I will discuss the Argonne v18 interaction, the Illinois three-body interactions, and the quantum Monte Carlo computational methods. I will describe their past successes and the efforts currently under way to apply them to nuclear scattering and reactions. These methods have significant advantages in describing unbound states, because they involve no spatial basis functions and therefore do not require recourse to specialized bases or generator coordinate methods. Our results so far include radiative capture calculations in A = 6 and A = 7 systems, and a set of scattering calculations for A = 5. Our initial calculation of low-energy 4He-neutron scattering has been particularly successful. General single-channel scattering and electrocapture reaction cross sections for A ≤ 12 are within grasp, and prospects for computing nucleon-transfer cross sections are good. A truly predictive ab initio description of reactions, if we can achieve it, will be a great boon to astrophysics as a supplement to cross section data from difficult laboratory experiments and as a source of reliable information about processes not observable in the laboratory. It will also greatly expand the range of laboratory tests for the nuclear potentials.

1Work supported by US Department of Energy, Office of Nuclear Physics, under contract W-31-109-ENG-38.

9:30AM 1WA.00002 Measurement of the 17F + p ANC to Inform the 17F(p,γ)18Ne Cross Section STEVEN PAIN, Oak Ridge National Laboratory — The decay of 17F, which is produced in novae by proton capture on 17O, is possibly the dominant Galactic source of 17O. However, 17F is destroyed by the 17F(p,γ)18Ne reaction. This reaction rate is unknown in novae environments, and is important for understanding the production of 18O and 18F. At typical nova temperatures, the 17F(p,γ)18Ne rate is dominated by direct capture (DC) to bound states in 18Ne, which is currently unmeasured due to the significant experimental challenges in performing the direct measurement. However, DC cross sections can be reliably calculated from Asymptotic Normalization Coefficients (ANCs) determined by, for example, a peripheral transfer reaction. We have measured the 14N(17F,18Ne)13C reaction, in order to determine 17F + p ANC, utilizing a 170 MeV beam of 17F incident on a melamine (C3N6H6) target at the Holifield Radioactive Ion Beam Facility at ORNL. Charged particles were detected in a pair of resistive strip silicon detector telescopes. Due to insufficient resolution to separate states in 18Ne by charged particle detection alone, coincident de-excitation γ rays were measured in coincidence using the CLARION array. Details of the motivation, experiment, analysis and preliminary results will be presented.

10:00AM 1WA.00003 Reaction Studies With Light, Unstable Nuclei K. ERNST REHM, Argonne National Laboratory — The availability of beams of exotic nuclei allows us for the first time to study in a terrestrial laboratory reactions, which occur in stellar explosions, such as Novae, Supernovae or X-ray bursts. In this talk I will present results from recent experiments performed with beams of light, unstable nuclei, which are produced via the in-flight technique at the ATLAS accelerator at Argonne. This work was supported by the US Department of Energy, Nuclear Physics Division, under contract No. W-31-109-ENG-38 and by the NSF Grant No. PHY-02-16783 (Joint Institute for Nuclear Astrophysics).

10:30AM 1WA.00004 Break —

11:00AM 1WA.00005 Determination of the 11Li charge radius MATTHEW PEARSON1, TRIUMF — Despite being discovered over 20 years ago the structure of halo nuclei is still not fully understood. One particularly important question concerns the interaction between the halo particles and the nuclear core. This has been investigated in 11Li via the measurement of the change in the nuclear charge radius between 11Li and 11Be which can be observed in a model independent way via high precision isotope shift measurements on atomic transitions. The short lifetime and necessity to isolate the small, charge radius dependent field shift from the much larger mass dependent shift requires both experimental techniques and facilities as well as atomic theory at the forefront of todays capabilities. The result of these measurements will be presented along with a discussion of fits implications on nuclear structure.

1For the TOPLIS collaboration

11:30AM 1WA.00006 Nuclear structure studies with fast exotic beams ALEXANDRA GADE, National Superconducting Cyclotron Laboratory, Michigan State University — Observations in exotic nuclei have demonstrated that the sequence and energy spacing of single-particle orbits is not as immutable as once thought: some of the familiar magic numbers disappear and new shell gaps develop. This talk will summarize some of the recent results on the changes of shell structure in the vicinity of neutron number N = 28 as probed with nucleon-removal reactions and inelastic scattering experiments at the NSCL. This work was supported in part by the National Science Foundation grant PHY-0110253.

12:00PM 1WA.00007 Trigger of the rp- and αp-process MICHAEL WIESCHER, University of Notre Dame — X-ray bursts are driven by thermonuclear runaways in the atmosphere of accreting neutron stars. The runaway is driven by the αp and the rp-process. These processes are triggered by the 15O(α,γ)19Ne and the 18Ne(α,p)21Na break-out reactions from the hot CNO cycles. New experimental data for the determination of these rates will be presented and the impact on the x-ray burst ignition conditions will be discussed.

Wednesday, October 25, 2006 9:00AM - 12:40PM – Session 1WB DNP: Pre-Meeting Workshop: Properties and Signatures of sQGP I Gaylord Opryland Bayou B

9:00AM 1WB.00001 New Developments in the Theory of Strongly Coupled Quark-Gluon Plasma EDWARD SHURYAK, Stony Brook — The talk will review new developments and also connections to other strongly coupled systems in physics. One is to strongly coupled electromagnetic plasmas, which are usually studied numerically via molecular dynamics simulations. New studies of a plasma containing both electrically and magnetically charged particles will be shown. Another is to strongly coupled gauge theories studied via AdS/CFT correspondence to string theory. New results are numerous, they include heavy quark diffusion constant, jet drag force and even development of the conical flow. Finally, there is a connection to strongly coupled fermionic domains; new results here include usage of universal relations between those and sQGP in a color superconductor domain.
and make the approach suitable for use with cocktail beams. The results to be discussed examined the systematic behavior of low-energy states in nuclides fragment. The time and position correlations between fragment implantations and emitted beta particles, on an event-by-event basis, greatly reduce background.

Laboratory at Michigan State University. The use of fast fragmentation allows for unambiguous mass and proton number assignments to each implanted measurements of beta-delayed and isomeric gamma rays from neutron-rich nuclides produced by fast fragmentation at the National Superconducting Cyclotron Laboratory.
4:00PM 2WA.00005 Reactions Induced by Neutron-Rich Nuclei — WALTER LOVELAND, Oregon State University — Nuclear reactions involving the fusion of neutron-rich nuclei allow us to study the properties of halo or other loosely bound projectile nuclei, such as $^{9}$He and $^{11}$Li and to form and study the properties of the heaviest nuclei. In the latter case, the n-rich projectile allows us to reach nuclei with large neutron numbers, with resulting longer half-lives (qualitatively changing the study of the atomic physics and chemistry of these elements) along with allowing increased production cross sections due to lowered fusion barriers and higher survival probabilities. In four typical reactions $^{32,38}$S + $^{181}$Ta, $^{27,29,31}$Al + $^{197}$Au, $^{124,132}$Sn + $^{64}$Ni and $^{32,38}$S + $^{208}$Pb, one observed enhanced fusion cross sections and most interestingly, large and unanticipated shifts of the fusion barrier heights for the most n-rich projectiles. The systematics of these shifts are presented and compared to ideas of neutron flow in these reactions. In a related measurement for the $^{124,132}$Sn + $^{96}$Zr reaction, no evidence for increasing fusion hindrance with increasing isospin of the system was found. The implications of these results for the synthesis of heavy nuclei using radioactive beams are discussed. The interaction of $^{9}$He with $^{208}$Bi and $^{238}$U has been extensively studied. The fusion cross section is enhanced at sub-barrier energies and reduced above the barrier. Detailed calculations of the fusion excitation functions that consider breakup processes do reproduce the observed cross sections. The recent attempt to measure the fusion excitation functions for the $^{9,11}$Li + $^{70}$Zn reaction will be discussed.

1Work supported in part by the USDOE under Grant DE-FG06-97ER41026

4:30PM 2WA.00006 The Heaviest Exotic Nuclei in the Laboratory — Superheavy Nuclei — MARK STOYER, LLNL — How many more new elements can be synthesized? What are the nuclear and chemical properties of these exotic nuclei? Does the Island of Stability exist and can we ever explore the isotopes inhabiting that nuclear region? Some of the most fascinating questions about the limits of nuclear stability are confronted in the heaviest nuclei. This talk will focus on the current experimental research on the synthesis and characterization of superheavy nuclei with $Z\geq112$ from the Dubna/Livermore collaboration. Reactions using 48Ca projectiles from the U400 cyclotron and actinide targets (233,238U, 237Np, 242,244Pu, 243Am, 245,248Cm, 249Cf) have been investigated using the Dubna Gas Filled Recoil Separator in Dubna over the last 8 years. In addition, several experiments have been performed to investigate the chemical properties of some of the observed longer-lived isotopes produced in these reactions. A summary of the current status of the upper end of the chart of nuclides will be presented.

Wednesday, October 25, 2006 2:00PM - 3:00PM —
Session 2WB DNP: Pre-Meeting Workshop: Properties and Signatures of sQGP II Gaylord Opryland Bayou B

2:00PM 2WB.00001 Charmonium Properties in the Deconfinement Phase from Lattice QCD — TAKUMI DOI, RIKEN BNL Research Center/Brookhaven National Laboratory — Charmonium properties have been known as suitable probes to understand the nature of QGP generated by RHIC. Lattice QCD is a powerful first-principle framework to study them, and actually has been revealed quite nontrivial features for the charmonium spectrum above the critical temperature. In this talk, I review the recent progress on the lattice QCD development on charmonium spectrum, in particular, from the viewpoint of distinction between a compact bound state and quark-antiquark scattering state in the spectrum.

2:30PM 2WB.00002 $J/\psi$ production and interactions with the medium — ALEXANDRE LEBEDEV, Iowa State University — $J/\psi$ production provides a sensitive probe of the properties of the hot and dense medium created in high energy heavy ion collisions at RHIC. $J/\psi$ suppression due to Debye screening was long considered to be a leading signature of Quark Gluon Plasma formation. Recent theoretical studies suggest that such suppression can be compensated by recombination, or explain suppression by decreased feed-down from “melted” higher mass charmonia, while $J/\psi$’s themselves remain unscreened. Measurement of $J/\psi$ production in nucleus-nucleus collisions at RHIC can clarify these questions. Baseline measurements in pp and dAu collisions can be used to distinguish cold nuclear matter effects. In this talk I will review recent results in this field from the PHENIX Experiment.

Wednesday, October 25, 2006 3:30PM - 6:45PM —
Session 2WC DNP: Pre-Meeting Workshop: Spin Structure of the Nucleon Gaylord Opryland Bayou B

3:30PM 2WC.00001 Theoretical Overview of Spin Physics — FENG YUAN, RIKEN/BNL Research Center, BNL — In this talk, I will review recent theoretical developments on spin structure of nucleon, focus on the gluon helicity contribution to the proton spin, the three-dimensional imagine of proton (Generalized Parton Distributions), and transverse spin physics.

4:00PM 2WC.00002 Nucleon Spin Studies in the Valence Quark Region — ZEIN-EDDINE MEZIANI, Temple University — With a minimal contamination from the sea quarks and gluons the valence quark region provides a clean region to study the spin structure of the nucleon. Precision deep inelastic scattering measurements of $g_1$ and $g_2$spin-dependent structure functions and their higher moments (integrals over $x$) offer an opportunity for testing our grasp of this structure. The valence quark distributions offer a good testing ground for constituent quark models of the nucleon. The higher moments of the quark distributions dominated by their valence contribution provide some of the cleanest tests of QCD. However, these tests require precision measurement in the large $x$ region were cross sections fall rapidly. Last but not least, these distributions are a crucial input for calculating cross sections for hard processes in high-energy hadron-hadron colliders such as the LHC or the Fermilab Tevatron, in searches for the Higgs boson or for physics beyond the Standard Model. I shall discuss some of the recent precision results of the nucleon spin-dependent structure functions obtained in this region and their impact on our overall understanding of the nucleon spin structure. I’ll finish with remarks on prospects of extending these studies in the future using the 12 GeV upgrade of CEBAF at Jefferson Lab.

4:30PM 2WC.00003 Spin Results from Hermes — EDWARD KINNEY, University of Colorado — This abstract has not been submitted electronically yet.

5:00PM 2WC.00004 Break —
5:15PM 2WC.00005 Transverse Quark Spin Effects in SIDIS and Drell Yan Scattering. LEONARD GAMBORG, Penn State University-Berks — The connection between quark orbital angular momentum and final state interactions for transversely polarized quarks in unpolarized hadrons suggests significant azimuthal asymmetries in pion production in semi-inclusive deep inelastic scattering (SIDIS) \((p \rightarrow \pi^- \ell^+ X)\) as well as in di-lepton production in Drell Yan \((p \rightarrow \ell^+ \ell^- X)\) scattering. When transverse momentum of the reaction, \(P_T\), is on the order of or less than \(\Delta_{\text{cut}}\), that is \(P_T \sim k_T\) where \(k_T\) is intrinsic transverse quark momentum, these effects are characterized in term of naive time reversal odd (so called \(T\)-odd) transverse momentum dependent (TMD) parton distribution and fragmentation functions. At these moderate transverse momentum scales we estimate the size of the \(c(x,\Delta)\) azimuthal asymmetry in SIDIS and Drell Yan scattering in the parton spectator framework. In the former case we consider this so called “Boer-Mulders” effect for a proposed experiment at the upgraded CLAS-12 GeV detector at Jefferson Lab. In the latter case we consider this asymmetry for proton anti-proton collider, as well as \(\pi\) nucleon fixed target experiments. We also consider competing contributions to these asymmetries from perturbative QCD (pQCD) contributions which emerge when \(P_T > \Delta_{\text{cut}}\). Evidence of a strong dependence on transverse momentum would indicate the presence of \(T\)-odd structures in unpolarized SIDIS and Drell Yan scattering, implying that transversity properties of the nucleon can be accessed without invoking beam or target polarization.

5:45PM 2WC.00006 Recent Spin Physics Results from PHENIX. CHRISTINE AIDALA, University of Massachusetts, Amherst — The performance of RHIC as a polarized proton collider has increased dramatically with every year of running. The polarized data taken by PHENIX in the 2005 and 2006 runs have made a variety of new analyses possible, with significant data sets available for both longitudinal and transverse spin physics. Measurements of the double-helicity asymmetry in the production of various particle species provide further constraints on the gluon polarization, and the data from transversely polarized collisions offer the opportunity for several exploratory measurements probing the transverse spin structure of the proton, still poorly understood. Latest results and the status of ongoing analyses will be discussed.

6:15PM 2WC.00007 Spin Results from STAR. BERND SURROW, Massachusetts Institute of Technology — This abstract has not been submitted electronically yet.

12:30PM - 12:30PM — Session 3A CEU Poster Session
Gaylord Opryland Cheekwood ABC, 12:30pm - 2:00pm

3A.00001 An Automated Relative Time Calibration for the MoNA. DANIEL ALBERTSON, Concordia College, MONA COLLABORATION — The Modular Neutron Array (MoNA) is a highly efficient time-of-flight neutron detector consisting of 144 individual plastic scintillation bars. It is used in conjunction with a sweeper magnet and charged particle detectors at the National Superconducting Cyclotron Laboratory to determine using the Beam Beam Counters. However, the RxnP will increase the resolution by nearly a factor of two over the currently achievable levels. This detector, we present here data from in-beam gamma-ray spectroscopy.

3A.00002 In-beam gamma-ray spectroscopy of 172Os. K. ALEKSANDROVA, P. MANCHEV, M.S. FETEA, Department of Physics, University of Richmond, A. HEINZ, WNSL, Yale University, G. GURDAL, WNSL, Yale University and Clark University, R. CASPERSON, R.F. CASTEN, WNSL, Yale University, M. CHAMBERLAIN, University of Surrey, UK and WNSL, Yuk University, E.A. MCCUTCHAN, J. QIAN, WNSL, Yale University, N.J. THOMPSON, University of Surrey, UK and WNSL, Yale University, Y. WERNER, R. WINKLER, WNSL, Yale University — A 30Si beam was used for a test experiment at the WNSL facility. The production of the compound nucleus 174Os was achieved through complete fusion in a 100 \(\mu\)g/cm2 144Sm target at beam energy of 134MeV. Gamma-rays from residual nuclei were detected with the YRAST ball array consisting of 7 Compton-suppressed clover detectors. A number of Os isotopes, in particular 172Os were also detected. While the main goal of the experiment was the commissioning of a gas-filled detector, we present here data from in-beam gamma-ray spectroscopy.

This work was supported by NSF grants PHY 0204811 and 0555665, Jeffress Fund grant J-809, U.S. DOE Grant Nos. DE-FG02-91ER40409, DE-FG02-88ER40417, DE-FG02-05ER40417.

3A.00003 Testing and Evaluation of PHENIX Reaction Plane Detector Photomultiplier Tubes. NICHOLAS ANDERSON, ERIC RICHARDSON, ALICE MIGNEREY, University of Maryland, PHENIX COLLABORATION — The PHENIX Reaction Plane Detector (RxnP) at the Relativistic Heavy Ion Collider is designed to determine the reaction plane in heavy ion collisions. Currently the reaction plane is determined using the Beam Beam Counters. However, the RxnP will increase the resolution by nearly a factor of two over the currently achievable levels. This detector’s location in the central region of PHENIX will expose it to a magnetic field of approximately 1 Tesla. The curvature of the field lines makes it necessary to understand the relationship between the angle of the photomultiplier tubes (PMTs) in the magnetic field and the PMTs’ output. Results of bench-top tests of the PMTs in similar magnetic fields and their impact on the final design will be presented.

3A.00004 Precision \(n,\gamma\) cross-section measurement of Cu at 8 and 12 MeV for shielding designs for the next generation of \(0\nu\beta\beta\) decay experiments. M. ANTONACCI, St. Vincent, A. CHYZH, N.C. State Univ., J.H. ESTERLINE, Duke Univ., S. ELLIOTT, LANL, B. FALLIN, Duke Univ., A. HIME, LANL, C.R. HOWELL, A. HUTCHESON, Duke Univ., H.J. KAWRYSKI, Univ. of N.C., J.H. KELLY, N.C. State Univ., M.F. KIDD, Duke Univ., D. MEI, LANL, B. SPAUN, Whitworth, A.P. TONCHEV, W. TORNOW, Duke Univ., MAJORANA COLLABORATION — Renewed interest in observing \(0\nu\beta\beta\) decay reactions has sparked efforts to experimentally verify the existence of such decays, and produce new physics beyond the Standard Model. These reactions, with half-lives around \(10^{27}\) years, require an extensive understanding of background sources. The potential for neutron induced excitation of the shielding and detector materials is important for understanding and designing future \(0\nu\beta\beta\) decay experiments. Gamma transitions through 2041, 2615, and 3062 keV directly obscure \(0\nu\beta\beta\) decay detection of \(^{76}\mathrm{Ge}\) at 2040 keV. Due to lack of experimental information in the nuclear database, high-resolution \(\gamma\)-ray spectra from the interaction of mono-energetic and pulsed neutrons were measured at TUNL. The emitted gamma rays were detected with 3 HPGe segmented clover detectors at 62°, 90°, and 135°. From these data, partial cross-sections for prominent \(\gamma\) transitions in \(^{63,65}\mathrm{Cu}\) were derived at \(E_n = 8\) and 12 MeV. This experimental information will also help to understand the existing \(0\nu\beta\beta\) data and serve as a benchmark for statistical model calculations. Supported in part by DOE grant DE-FG02-97ER41033 and NSF grant NSF-PHY-05-52723.
3A.00005 New precise $\alpha_K$ measurement as part of a test of electronic conversion theory - 166 keV transition in $^{139}$La

CHRISTINE BALONEK, NINEL NICA, JOHN HARDY, Texas A&M University, Cyclotron Institute — Precise internal conversion coefficients (ICCs) are crucial to the study of nuclear decay schemes, including spin and parity designations, transition rates, and branching ratios. However, various calculations of ICCs disagree with one another and with experiment by several percent. The situation is further confused by the fact that very few ICC measurements have uncertainties under 1%. Until recently, it was even unclear if the calculations should incorporate the hole left by the departing electron. To remedy this situation, we have set out to measure the K-shell ICC values of three different isotopes to that precision. The ICCs for 127.55 keV E3 transition of $^{134}$Cs and 661.657 keV M4 transition of $^{138}$Ba have already been completed. We report here on the third and final case: the 165.858 keV M1 transition in $^{130}$La.

3A.00006 Modeling nuclear stopping with in-medium modifications of nucleon-nucleon cross sections.1

BRENT BARKER, PAWEL DANIELEWICZ, NSCL and Department of Physics and Astronomy, Michigan State University — Stopping in heavy ion collisions is investigated with the aim of understanding microscopic dynamics of collisions and transport properties of nuclear matter. Boltzmann-equation simulations are compared to available data on stopping in the energy range between 0.02 A and 1.5 A GeV. Stopping observables used include momentum anisotropy, linear momentum transfer, and isospin tracing. The data clearly shows that modeling the transport with free elementary cross-sections is inaccurate and reduced cross-sections are required. Reduction of the cross-sections produce an increase in transport coefficients of nuclear matter, compared to calculations based on free cross-sections.

3A.00007 RPC Detector Research and Development for PHENIX

AUSTIN BASYE, Abilene Christian University, PHENIX COLLABORATION — PHENIX, an experiment located on the RHIC ring at Brookhaven National Laboratory, is currently studying heavy ion collisions and polarized proton-proton collisions. To increase the effectiveness of the existing detector systems, Resistive Plate Chambers (RPCs) have been proposed for a level 1 trigger upgrade for the Muon Spectrometer Arms. These RPCs will improve W boson reconstructions from single high Pt muons by rejecting a large low Pt muon event background. This background will become larger as RHIC begins 500 GeV proton-proton collisions at higher luminosities. RPCs are currently being installed at all the major experiments at LHC, and it is from CMS, principally, that we have patterned the bulk of our design proposals. Based upon simulations, significant progress has been made to model signal pad layout, the mechanical structure and acceptance, and overcome design obstacles related to read-out and gas gap design.

3A.00008 Primordial Nucleosynthesis of Lithium Isotopes

JANILEE BENITEZ, GEORGE FULLER, CHAD KISHIMOTO, CHRISTEL SMITH, University of California, San Diego — A key issue in modern cosmology involves the synthesis of Lithium in the early universe. We investigate the production of $^6$Li and $^7$Li in primordial nucleosynthesis. We discuss key nuclear reaction rates and the effects of lepton degeneracy.

3A.00009 Integrating Wireless Networking for Radiation Detection

JEREMY BOARD, ALEXANDER BARZILOV, PHILLIP WOMBLE, JON PASCHAL, Western Kentucky University — As wireless networking becomes more available, new applications are being developed for this technology. Our group has been studying the advantages of wireless networks of radiation detectors. With the prevalence of the IEEE 802.11 standard (“WiFi”), we have developed a wireless detector unit which is comprised of a 5 cm x 5 cm NaI(Tl) detector, amplifier and data acquisition electronics, and a WiFi transceiver. A server may communicate with the detector unit using a TCP/IP network connected to a WiFi access point. Special software on the server will perform radioactive isotope determination and estimate dose-rates. We are developing an enhanced version of the software which utilizes the receiver signal strength index (RSSI) to estimate source strengths and to create maps of radiation intensity.

3A.00010 Behavior of a Radial Time Projection Chamber

PETER BRADSHAW1, Old Dominion University, BOUND NUCLEON STRUCTURE COLLABORATION — Using Gas Electron Multiplying (GEM) foils for amplification, the detector allows for three-dimensional representations of particle tracks through two half cylinders filled with gas. Developed for the Bound Nucleon Structure (BONUS) experiment at Jefferson Lab, the RTPC allows experimenter to study the quark composition of the neutron by scattering electrons from deuterium nuclei. The defining feature of the detector is that it allows for a complete view of the interaction of the electron and target gas, including the protons left over after a reaction on the neutron. This experiment seeks to understand the efficiency of the detector and its amplification (signal strength for a given ionization, as a function of detector gas and high voltage), by making a measurement of the amount of energy deposited in the chamber per unit length from cosmic radiation. In order to test each half of the Radial Time Projection Chamber we use an 85% Helium and 15% Dimethyl Ether (85/15 HeDME) and an 80/20 HeDME at optimal voltages to detect cosmic particles. The detector takes an electronic snapshot of the incident particle by examining the charge deposited as a function of time. The importance of this technology should not be underestimated. Radial Time Projection Chambers could, in some applications, replace current Time Projection Chambers and Wire Chambers.

3A.00011 Implementation of PC’s in Control Systems for Large Physics Experiments

JENNIE BURNS, Creighton University — Traditionally large physics experiments have used dedicated specialized processors for their control systems. Increased processor speed has permitted the use of personal computers for the control and monitoring of these experiments. The control system for the STAR (Solendoidal Tracker At RHIC) experiment was implemented using VME-based front end processors for detector control and graphical work stations as the user interfaces. The system is being revised to accommodate new detector subsystems and to replace ten year old hardware with PC’s which are less expensive and more easily maintained. The hardware control system for ALICE (A Large Ion Collider Experiment) is being developed in a PC-based environment. Personal computers are used for both front end functions and the user interface. The original STAR control system is compared with the upgraded system. The architecture and the implementation of the control system for the ALICE experiment are also presented. Comparisons between the STAR and ALICE systems are outlined.

BARZILOV, PHILLIP WOMBLE, JON PASCHAL, Western Kentucky University — As wireless networking becomes more available, new applications are being developed for this technology. Our group has been studying the advantages of wireless networks of radiation detectors. With the prevalence of the IEEE 802.11 standard (“WiFi”), we have developed a wireless detector unit which is comprised of a 5 cm x 5 cm NaI(Tl) detector, amplifier and data acquisition electronics, and a WiFi transceiver. A server may communicate with the detector unit using a TCP/IP network connected to a WiFi access point. Special software on the server will perform radioactive isotope determination and estimate dose-rates. We are developing an enhanced version of the software which utilizes the receiver signal strength index (RSSI) to estimate source strengths and to create maps of radiation intensity.

1Research Made Possible By: Western Kentucky University Applied Physics Institute

1Undergraduate

This work is supported by the Office of Science, US Department of Energy.
3A.00012 CLAS Simulations for $D(e,e'p)n^2$. ROBERT BURRELL, KURI GILL, GERARD GILFOYLE, University of Richmond, CLAS COLLABORATION — We are simulating the electrodisintegration of the deuteron in the $D(e,e'p)n$ reaction in the CEBAF Large Acceptance Spectrometer (CLAS) at the Thomas Jefferson National Accelerator Facility. CLAS is a large, complex particle detector that measures the debris from collisions of electron and photon beams with nuclear targets with nearly $4\pi$ solid-angle coverage. To better understand the response of CLAS, to calculate its acceptance, and to test our analysis codes, we simulate the detector’s performance. Working on the University of Richmond’s supercomputing cluster, we have written a Perl script to perform the simulation by executing a sequence of commands running different programs, managing files, etc. We use a model of quasi-elastic scattering called QUEEG (Quasi-Elastic Electron Generator) to generate the initial four-vectors for each event. These events pass through a GEANT simulation of CLAS, are reconstructed with standard CLAS software, and final-stage analysis of the reconstructed four-vectors is performed with ROOT. We will report results of the application of this technique to the measurement of asymmetries in CLAS for the 2.56-GeV, reversed-polarity data set of the E5 running period.

1This work is supported by the US Department of Energy (contract DE-FG02-90ER40980).

3A.00013 Characterization of Silicon Tetra-lateral PSDs. ZHON BUTCHER, University of Colorado — This research project characterized the tetra-lateral position sensitive detectors (PSDs) in terms of energy and position resolution as well as non-linearity in position reconstruction. Measurements were made of impinging positions of alpha particles on three different PSDs. One 200 um and one 400 um thick detector with a resistive strip and one 200 um thick detector without the strip were tested. The resistive strip was framed around the detector active area and was approximately 1/10th the resistance of the active area. The detector with no resistive strip produced a very pronounced “pin-cushion” effect when the position data was analyzed. The 200 um thick detector with the resistive strip produced much greater energy and position resolution. This resolution of both energy and position was found to be enhanced by the 400 um thick detector. Optimal energy and position resolution were obtained with the 400 um detector using Indiana University preamplifiers in conjunction with a CAEN amplifier using a 3us shaping time. Energy and position resolution were found to be dependent on the type of preamplifier used as well as the shaping time of the amplifier. Further investigations of these dependencies are ongoing.

3A.00014 A study on the reflectivity of Tyvek. ALVARO CHAVARRIA, Duke University — Tyvek is a permeable, strong, white material made by Dupont. Due to its high reflectivity, many physics experiments use Tyvek to increase the collection of light. The Super-Kamiokande neutrino experiment at Kamioka, Japan, uses Tyvek extensively in its detector and Monte Carlo simulation. Currently, the reflective properties of Tyvek that are in the Super-K Simulation are not precisely known. Thus, a good way to improve the outer detector (OD) simulation might be to implement a more realistic model for the reflection of photons on the Tyvek surface. An experiment was developed to measure the reflectivity (percentage of light reflected at a particular angle for a particular angle of incidence of the incoming photons) of Tyvek under water, for all angles of incidence and all angles of reflection. Preliminary results have been obtained and will be presented at the conference. Once all results are in, it will be attempted to fit the reflectivity function to Lambert’s cosine law or some variation of it. After a successful experimental fit is found, the model will be implemented into Super-K’s Monte Carlo simulation.

3A.00015 Measuring scintillation light using Visible Light Photon Counters (VLPC). ALVARO CHAVARRIA, Duke University — A new search for the neutron electric dipole moment (EDM) using ultra cold neutrons proposes an improvement on the neutron EDM by two orders of magnitude over the current limit ($10^{-28}$ e cm). Detection of scintillation light in superfluid $^4$He is at the heart of this experiment. One possible scheme to detect this light is to use wavelength-shifting fibers in the superfluid $^4$He to collect the scintillation light and transport it out of the measuring cell. The fiber terminates in a visible light photon counter (VLPC). VLPCs are doped, silicon based, solid state photomultipliers with high quantum efficiency (up to 80%) and high gain ($> 40000$ electrons per converted photon). Moreover, they are insensitive to magnetic fields and operate at temperatures of $0.65$K. A test setup has been assembled at Duke University using acrylic cells wrapped in wavelength-shifting fibers that terminate on VLPCs. This setup is being used to evaluate the feasibility of this light detection scheme. The results obtained in multiple experiments done over the past summer (2006) and the current status of the project will be presented at the conference.

Reference

3A.00016 B(E2) in heavy Pd nuclei through the time-of-flight method. AARON CHESER, Michigan State University/NSCL, NSCL 03029 COLLABORATION. — The onset of deformation in even nuclei is manifested by a decreasing energy of the $2^+$ excited state, $E(2^+)$, correlated with an increase in the reduced transition probability $B(E2)$. It is surprising to observe for $A \geq 110$ Pd nuclei that as $E(2^+)$ decreases so does $B(E2)$ as reported by the National Nuclear Data Center. This trend was investigated with the time-of-flight method using a plunger device designed in collaboration with the University of Cologne, Germany. The plunger consists of a moveable target and a stationary passive degrader. A fast beam of $^{114}$Pd was Coulomb-excited to the $2^+$ state on the plunger target. The degrader, downstream of the target, was used to slow the nuclei. Gamma-rays emitted before and after the degrader were measured at different Doppler shifts due to the change in velocity. A modified Segmented Germanium Array setup used for gamma-ray detection provided an optimal balance of sensitivity to changes in velocity and energy resolution. The ratio of the peak intensities yields information about the lifetime of the state of interest. A new $B(E2)$ value was found for $^{114}$Pd that is twice as large as the previous measurement, but follows the expected trend.

1The 03029 Collaboration included a group from University of Cologne, Germany headed by Alfred Dwald.

3A.00017 Graphic User Interface for the NIMROD Silicon Detectors. CHRISTOPHER CRANE — Graduate student Sara Wenschel and I created the “Bias Box Control v3.2” Graphic User Interface program. It was designed with the intent of monitoring voltage and current while biasing to NIMROD's detector material extensively in its detector and Monte Carlo simulation. NIMROD and ISIS are both nuclear particle detectors located in the Texas A&M Cyclotron Institute. The program takes user input values and sends Biasing voltages to NIMROD’s various rings. The GUI also monitors the actual charge held in the detectors of a specified ring, and the leakage current on a specific silicon of the detector. This work is supported by DOE Grant DE-FG02-97ER41020.

3A.00018 Analyzing Sources of Uncertainty in a Precision Measurement of $^3$He($\alpha,\gamma$)$^7$Be. A.M. CRISP, T.A.D. BROWN, C.A. HORDEANU, K.A. SNOVER, D.W. STORM, Center for Experimental Nuclear Physics and Astrophysics, University of Washington, Seattle, WA 98195 — The $^3$He($\alpha,\gamma$)$^7$Be reaction plays an important role in the solar p-p chain. The uncertainty in this reaction rate is currently the largest nuclear physics uncertainty in solar model calculations of the neutrino flux from the decay of both $^7$Be and $^8$B in the Sun. At CENPA we are measuring the low energy cross section for this reaction at center-of-mass energies of 1.2 MeV and lower, using a $^3$He gas cell with a thin nickel entrance window. The goal of this experiment is to determine the astrophysical S-factor to ±5% or better, from measurements of both the prompt $\gamma$s and the $^7$Be activity produced in the same irradiation. In order to reach this goal one must measure and minimize the important systematic errors. We will discuss beam heating of the target gas, sources of background radiation, and detector efficiency, as well as other important aspects of the experimental technique.

1Supported by DOE Grant DE-FG02-96ER40980.
3A.0019 Upstream Photon Veto Studies for the GlueX Project, JAMES CUSTER, Florida State University, GLUEX COLLABORATION — The Upstream Photon Veto (UPV), being developed at Florida State University, is a sampling electromagnetic calorimeter that will become part of the GlueX project. The detector will be placed upstream of the photon beam. The main goal of this detector is to veto photons in the backwards direction of the target. This study looks to optimize the detector configuration for resolution and efficiency. To do this, we’ve modeled the detector in the Geant4 simulation toolkit. Past studies have shown that the optimal configuration is 12 layers of lead-scintillator followed by 6 layers of double the thickness of lead, and scintillator. In this study, we test how the resolution and efficiency respond to changing the number of layers with a fixed total volume, by changing the sizes of the layers overall, and the addition of a pre-radiator. The results have shown that we can most effectively increase our resolution and efficiency by doubling the thickness of the scintillator, or by doubling the number of layers, but keeping the same overall volume.

3A.0020 Environmental Radiation Measurements of Sea Sponges (Microciona prolifera and Halichondria bowerbanki), BERTA DARAKCHIEVA, MILOSLOVA EVTIMOVA, CORNELIUS BEAUSANG, SHELLY LESHER, MALCOLM HILL, University of Richmond — The applications of radiometrics in the ecological sciences are numerous and of increasing importance. It is a powerful technique that can be used both for tracing various biological processes and for assessing levels of radioactive pollution in the environment. The aim of this project is to gather information on the levels of radioactivity in the Chesapeake Bay area by evaluating the radiation dose concentrations in sea sponges. Microciona prolifera and Halichondria bowerbanki, which are abundant in the Bay, serve as experimental organisms. A radiometric test is performed with two HPGe detectors located at the University of Richmond to identify any radionuclides present in the sponges. In order to increase the efficiency of the measurements, the collected sponges are frozen and ground in liquid nitrogen, thus forming a sample of condensed biomass which can be close packed around the germanium detector. The analysis includes measurement of the relative intensities of the detected gamma rays and identification of the elements. The spectral data will be used to calculate DCCs (dose conversion coefficients for the species), which will be compared with the values typical for natural radioactivity and for anthropogenic contamination. This work is partly supported by the U.S. DOE under grant numbers DE-FG52-06NA26206 and DE-FG02-05ER41379 and by the University of Richmond HHMI fellowship.

3A.0021 Modeling a Graphite Diagnostic System using MCNPX, J. DEAVEN, S.L. STEPHENSON, Gettysburg College, S.J. PADALINO, SUNY Geneseo, V. YU. GLEBOV, T.C. SANGSTER, Laboratory for Laser Energetics — Inertial Confinement Fusion (ICF) implosions can be characterized by the target areal density (ρ). The ρF of ICF targets in the National Ignition Facility (NIF) target chamber can be determined by tertiary-induced neutron activation of elements with appropriately high thresholds. In such materials as 12C, neutron activation results in beta decay and the emission of 511-keV coincidences which are detected by a pair of NaI(Tl) detectors. Optimal diagnostic thickness, contamination effects, and detector response have been modeled using MCNPX. Results will be presented.

3A.0022 Analysis of Kinematics and Decay Energy in the Breakup of 7He, DEBORAH DENBY, PAUL DEYOUNG, GRAHAM PEASLEE, Hope College, MONA COLLABORATION — The energy resolution of the Modular Neutron Array and Sweeper magnet was studied by measuring the breakup of 7He. A 40 MeV/A 7Li beam was produced with the coupled cyclotrons at the National Superconducting Cyclotron Laboratory and following proton stripping in a Be target unstable 7He were produced. After breakup of the 7He into 6He and a neutron, the resultant charged fragments were detected by the Sweeper magnet and detected, and the corresponding neutrons were detected in MoNA. The decay energy of 2He was calculated based on reconstructed fragment and neutron energies. Further analysis is in progress to verify results and determine uncertainty. Analysis procedures and the setup and operation of the experiment will be presented. Decay energy results and implications will also be discussed.

3A.0023 Lifetime of the first excited state in 64Ge by the time-of-flight method, ATHENA DUNOMES, Michigan State University, National Superconducting Cyclotron Laboratory — Picosecond lifetime measurements using the relativistic time-of-flight plunger method were performed at the NSCL from fragmentation and knockout reactions. The experiment was aimed at the predicted 5.4 as lifetime of the 64Ge first excited state and tested the limits of the method. The 65Ge beam was delivered from the A1900 separator and impinged on the target of the plunger. The ensuing single neutron knockout reaction produced 64Ge nuclei. These excited nuclei emerged from the target and decayed in flight after a distance corresponding to the lifetime. A moveable reset position located downstream from the plunger target was used to reduce the velocity of the investigated nuclei. As a consequence, the gamma rays, which decayed from the excited states before and after the degrader foil, were detected at different Doppler shifts by a modified Segmented Germanium Array setup with forward and backward rings at 30˚ and 140˚ with respect to the beam axis. The obtained decay curve provides information about the lifetime since the distance between the target and degrader foils and beam velocity are known. The result of the lifetime measurement will be presented.

3A.0024 Off-Axis Calibration of KamLAND and Modeling of the “FourPi” Calibration System, GILLY ELOR, Lawrence Berkeley National Laboratory, UC Berkeley Physics Department — KamLAND is a 1000-ton liquid scintillator detector which uses the prompt and delayed signals from inverse beta decay to detect electron anti-neutrinos produced in nuclear reactors. KamLAND has made the first observation of the disappearance of reactor electron anti-neutrinos. The largest contribution to the systematic uncertainty in KamLAND is the fiducial volume uncertainty (4.7% out of a total 6.5%). Until now the detector has been calibrated using gamma-ray sources of known energy deployed along the detector’s vertical axis. A new 4π calibration system allows for off-axis source deployment throughout the entire fiducial volume. The 4π system is expected to reduce the fiducial volume uncertainty from 4.7% to ~1-2%, and improve KamLAND’s sensitivity in the determination of the mass-difference parameter ∆m2. The 4π system is currently in the initial stages of off-axis deployment. An off-line calculation is used to predict the location of the gamma-ray sources within the detector. The calculation takes into account the systems geometry, buoyancy effects in the liquid scintillator, and gravitational deflection of the 4π pole from its neutral axis (deflection correction incorporates both a theoretical model, and survey data). Comparison of the predicted source location with the vertex reconstructed using the KamLAND analysis software, allows for an investigation of the biases in the reconstruction procedure.

3A.0025 Investigating the Structure of High-Spin Francium, M. EVTIMOVA, C. BEAUSANG, B. DARAKCHIEVA, B. CRIDER, R.B. CAKIRLI, V. WERNER, D. MEYER, E. NOVITSKI, G. GURDAL, J. QIAN, L. AMON, R. CASPERSON, C. FITZPATRICK, Univ. of Richmond — The purpose of this research is to investigate the structure of high-spin nuclei with odd atomic number, in particular Francium 209 and Francium 210 nuclei. This work was done in the Wright Nuclear Structure Laboratory at Yale University in the summer of 2005. I have been involved in the analysis of these results since September 2005. In the experiment a gold target is bombarded by a beam of accelerated oxygen ions. The beam was supplied by the ESTU accelerator at WNSL. Au-197 and O-16 nuclei produce to Fr-213, which then “evaporate” neutrons, resulting in Fr-209 (4n) and Fr-210 (3n). These Fr nuclei emit gamma rays in order to lower their energy and achieve their ground states. These gamma rays were detected using the gamma detector array YRAST Ball, and the spectra they produce reveal information about the energy difference between levels in the level scheme. However, the gamma ray spectra do not directly show the order in which the transitions occur. Therefore, I am using various spectral analysis techniques, including gamma-gamma coincidences and gamma correlations, in order to determine what energies and what transformations are allowed for these nuclei. I have already found new information about both nuclei. However, there are still some discrepancies in the data for Fr-210. I am going to continue working on them, and I hope to resolve the problems soon.
3A.00026 An Analysis of Simulated Identified Particle Spectra in ALICE at Intermediate and High Transverse Momentum\(^1\), XIEYUE FAN, Yale University, ALICE COLLABORATION — High transverse momentum \(p_T\) particles have provided a wealth of information on the hot and dense matter created in heavy-ion collisions at the Relativistic-Heavy Ion Collider (RHIC) at BNL. Charged, high-\(p_T\) particles were observed to be suppressed relative to binary scaling. Also, a difference between baryon and meson spectra at intermediate \(p_T\) was found. With the startup of the Large Hadron Collider (LHC) at CERN coming in 2007, it will be interesting to see how these effects evolve with increasing beam energy. To explore the capabilities of the ALICE experiment, we present an analysis of simulated events from Pythia \((p+p)\) and HIJING \((\text{Pb}+\text{Pb})\) at 5.5 TeV/Nucleon. Particles from these simulated events are propagated through the ALICE GEANT model and reconstructed using the full software chain. Characterizations of identified particle spectra and yields are presented, with focus on the high \(p_T\) region.

\(^1\)This work has been supported by the Mellon Mays and Bouchet Fellowship.

3A.00027 Nuclear and Nucleon Compton Scattering at the High Intensity Gamma Ray Source (HI\(\gamma\)S) and Commissioning of the HI\(\gamma\)S NaI Detector Array (HINDA)\(^1\), W. FREDERICK, Northwest Missouri State University, M.W. AHMED, H.R. WELLER, Duke University, Triangle Universities Nuclear Laboratory, TUNL CAPTURE GROUP TEAM — The availability of a high intensity, nearly monochromatic, linearly or circularly polarized gamma ray beam at the Duke Free Electron Laboratory has set the stage for unprecedented precision measurements of the electric, magnetic, and spin polarizabilities of the neutron. These measurements will be performed by Compton scattering polarized gamma rays from polarized proton, deuteron, and \(^3\)He targets. In order to perform these measurements, a geometrically flexible, highly efficient NaI detector array with a large photon acceptance, dubbed HINDA, is being constructed. The HINDA detectors will be contained in 2\(''\) thick segmented NaI anti-coincidence shields, in order to produce high resolution background free spectra. This research lays the foundation for HINDA's assembly. The purpose of this research was to maximize the energy resolution of the HINDA detectors utilizing an AmBe source and to establish an identification and record system to facilitate its assembly.

\(^1\)Supported by the National Science Foundation (NSF-PHY-05-52723) and the DOE, Office of Nuclear Physics (DE-FG02-97ER41033).

3A.00028 Spin Polarization Diagnostics for Magneto-optical Trapped \(\beta^+\)-Decaying Atoms, A. GAUDIN, C. HÖHR, D.G. ROBERGE, J.R.A. PITA-CAIRN, M.R. PEARSON, J.A. BEHR, TRIUMF. Vancouver, British Columbia, Canada — To test the degree of parity violation in \(\beta\) decay, the spin polarization of the decaying atoms must be known. In the TRIUMF Neutral Atom Trap project, the polarization of decaying atoms is achieved through optical pumping, which is a random walk through atomic spin states, biased to higher angular momenta with circularly polarized light. This poster presents work on spin polarization diagnostics for trapped \(^{41}\)K. \(^{41}\)K serves as a stable test base for \(\beta^+\)-decaying \(^{37}\)K and \(^{80}\)Rb, due to its similar hyperfine structure. Experimental techniques for measuring the fluorescence produced during the optical pumping are detailed. As the atom population is pumped to higher polarization states the atoms are excited less frequently and produce less fluorescence. Experimental tests precisely comparing measurements of the fluorescence and the excited state population, as determined by photoionization, will be shown; only the latter can be measured due to the small number of atoms. The circular polarization of the fluorescence also varies with atomic polarization. In addition, two computational models of the pumping process, used to fit the data to obtain polarization values, will be presented. Determination of the atomic polarization to 5\% would be helpful for \(\beta^+\)-decay experiments.

3A.00029 A Pyroelectric Crystal Particle Accelerator, AMANDA GEHRING\(^1\), RAND WATSON, Cyclotron Institute - Texas A&M University — Recent experiments have shown that the electric field produced by heating or cooling a pyroelectric crystal can be utilized to accelerate deuterons to sufficient energies to initiate the \(d+d\) fusion reaction, which suggests the possibility of developing a pyroelectric crystal neutron generator. The objective of this project was to investigate parameters that determine the energy and intensity of the particle beam with the final goal of maximizing the neutron output. A lithium tantalate pyroelectric crystal and two 25 W resistors were mounted on a copper block. An external power supply was connected to the resistors. Upon heating, the front face of the crystal becomes positively charged, creating positive ions from field ionization of nearby gas molecules. The positive ions are accelerated toward the target, and electrons from the target are accelerated toward the crystal where they collide, producing x rays and bremsstrahlung. Resulting spectra are measured with a Si(Li) detector, and the endpoint of the bremsstrahlung is used to determine the accelerating potential. Upon cooling, the polarity reverses. Heating cycles at different heating currents were observed, and the highest potential (88 kV) and intensity were achieved at 2.0 A. Next, a deuteron polyethylene target, deuterium gas, and a liquid scintillator neutron detector were added to the system. Runs were carried out at gas pressures ranging from \(5\times10^{-3}\) to \(1\times10^{-4}\) Torr, but the observed neutron counting rates were never above the background rate.

\(^1\)Home Institution: Rose-Hulman Institute of Technology

3A.00030 Hadron Fiducial Cuts for the CLAS E5 Data\(^1\), KRISTEN GREENHOLT, GERARD GILFOYLE, University of Richmond, CLAS COLLABORATION — We have developed selection cuts for positively-charged hadrons from the \(D(e,e'p)n\) reaction in the CEBAF Large Acceptance Spectrometer (CLAS) at the Thomas Jefferson National Accelerator Facility. CLAS measures the scattering of electron and photon beams on nuclear targets and is a large, complex, particle detector. For accurate measurements we select data from regions of CLAS where its response is well understood and not changing quickly. We use fiducial cuts to define the regions of CLAS where the azimuthal dependence of positive hadrons is constant. First, a trapezoidal function is fitted to this azimuthal dependence in a particular scattering angle and momentum bin of a proton or positive pion. Next, the limits of the trapezoid's plateau are fitted as a function of the hadron scattering angle for each momentum bin. Last, the parameters of this second generation fit are, in turn, fitted as functions of hadron momentum to give us well-behaved functions defining the active region of CLAS. We will discuss the details of this method and apply it to the electrodisintegration of the deuteron in the \(D(e,e'p)n\) reaction. The data were collected at two beam energies, 2.6 GeV and 4.2 GeV. Different magnetic field polarities were used for the 2.6-GeV data to cover a broader Q^2 range.

\(^1\)This work is supported by the US Department of Energy (contract DE-FG02-96ER40980).

3A.00031 Straggling Effects in the S800 Ion Chamber, JOSEPH GROCHOWSKI, Michigan Technological University, BRAD SHERRILL, DANIEL BAZIN, NSCL. Michigan State University — A detailed investigation of the atomic number resolution of the S800 ion chamber has been performed. Accurate identification of the atomic number of ions resulting from nuclear reactions is essential to separate various reaction products. The main source of uncertainty in the identification of atomic number is energy loss straggling. Experimentally, energy straggling is an observed width of the energy loss distribution as ions traverse matter. To improve the resolution of ion identification, detector straggling must be minimized. First, the sources of straggling must be identified and quantified. An effort has been made to identify and minimize all source of error in the energy loss measurement. The most common source is energy loss straggling. This is the statistical variability in collisions, thus energy losses, as a large number of identical ions pass through matter. Charge exchange straggling is another potential source. This is described as the tendency of an incoming ion to capture a number of electrons, influencing its range through matter. Contributions from the finite momentum acceptance of the S800 and electronic noise were also evaluated. Details of the analysis and techniques to improve the atomic number resolution will be presented.
3A.00032 Parton Momentum Distribution of the \( \Lambda \)\(^1 \). STEPHANIE HARP, TOM SHELLY, Seattle University — In the proton there exist valence quarks, two up and one down quark, as well as light flavor sea quarks: up, anti-up, down, anti-down; and gluons. Zhang et al. assumed a Fock state expansion for the proton and used the principal of detailed balance to find the probability of each state. They assumed that there are three types of transitions; a quark can split into a quark and a gluon, a gluon can split into a quark anti-quark pair and lastly a gluon can split into two gluons. In this model, the numbers of light flavor sea quarks were found to be asymmetrical (\( d\)-bar-\( u\) \( \neq 0 \)), in agreement with experiment. We extend this model to the Lambda particle, the lightest strange baryon. The Lambda particle has three valence quarks: an up quark, a down quark and a strange quark. We calculate parton distributions for the Lambda, and find a symmetric light sea. Using the assumption of detailed balance of Zhang et al. and a Monte-Carlo calculation, we find the momentum distribution of the partons in the Lambda.

3A.00033 Calibration of the Thick and Thin Scintillators for the NSCL/FSU Sweeper Magnet System , ANNE HAYES, University of Minnesota Morris, MONA COLLABORATION — The MoNA (Modular Neutron Array) Sweeper-magnet setup at the NSCL is designed to measure neutron unbound states by full kinematic reconstruction of the neutrons and the decay fragments. One crucial aspect of these coincidence experiments is the particle identification of the charged fragments in the focal plane detectors following the sweeper magnet. The particle ID is achieved by the measurement of the energy-loss and total kinetic energy in large thin and thick plastic scintillation detectors, respectively. The pulse-height of the signals from these detectors is strongly position dependent. In order to achieve accurate Delta-E/E-identification for the fragments it is thus necessary to correct for these position dependencies. A procedure was developed to implement this correction quickly and efficiently for the on-line analysis. The procedure is based on Tcl-scripts sourced in the analysis program SpecTcl in combination with fitting routines in Excel. The performance of this procedure will be presented with data from experiment 05124, which studied neutron unbound states close to the neutron dripline.

3A.00034 Pion efficiency analysis for ALICE Transition Radiation Detector prototypes using an LQ-X method\(^1 \). DAVID HERNANDEZ, Institut f"ur Kernphysik, Universit"at M"unster, Germany — One goal of ALICE, the only dedicated heavy-ion experiment at CERN’s Large Hadron Collider (LHC), is to study the elusive Quark-Gluon Plasma (QGP), using theoretically predicted changes in the production of particles. Original particles can be reconstructed via their decay electrons. The Transition Radiation Detector (TRD) detects transition radiation from ultrarelativistic electrons, facilitating electron/pion discrimination in momenta ranges above 1 GeV/c. In addition to an increased energy deposit, electrons differ from pions in time signatures, because the transition radiation photons are absorbed in the first instance. The pion identification is analyzed for 2004 electron/pion beams of momenta 4 to 10 GeV/c, with 6 layers of the TRD, by calculating and combining the two signatures in what is called a bidimensional LQ-X method. Rejection factors increase by more than 10% with respect to a standard energy deposit analysis. The effects on pion rejection of tail cancellations in the signals and amplification regions in the TRD are explored.

3A.00035 Beam Transport Efficiencies of the LEBIT Cooler/Buncher , MATTHEW HODEK, Bowling Green State University, GEORGE BOLLEN, STEFAN SHWARZ, AMANDA PRINKE, JOSH SAVORY, National Superconducting Cyclotron Laboratory — The Low Energy Beam and Ion Trap (LEBIT) facility at the NSCL is used to make high precision mass measurements of rare isotopes. A continuous beam of fragments from the NSCL’s Coupled Cyclotrons Facility is stopped in a gas cell and extracted as a continuous ion beam. These ions are then accelerated and cooled using a linear radio frequency quadrupole (RFQ) ion trap filled with a low pressure buffer gas. On command the ions are ejected as a low emittance bunch. This pulsed beam is then injected into a 9.4T Penning trap for mass measurement. The cooling and bunching of the isotopes is essential for an efficient capture in the Penning trap and for obtaining high mass precision. Presented here is a study of the transport efficiencies of the RFQ cooler and buncher of LEBIT. The role of unwanted ‘parasitic’ traps inside this cooler and buncher was investigated. For this purpose detailed SIMION simulations were performed. These simulation results are compared to the results of dedicated experimental tests.

3A.00036 Coulomb Excitation of \(^{49}\text{Cr}\)\(^1 \). KELLY HOSIER, DARREN MCLINCHY, LEWIS RILEY, Ursinus College — We measured gamma rays in coincidence with \(^{49}\text{Cr}\) particles scattered from a \(^{209}\text{Bi}\) target with a mid-target beam energy of 58 MeV/u at the National Superconducting Cyclotron Laboratory. We used GEANT simulations to extract the probability of populating the 272 keV \(7/2^-\) state of \(^{49}\text{Cr}\) via Coulomb excitation. This result is compared with existing measurements and shell model calculations.

3A.00037 Elemental Analysis using Pulsed Neutrons\(^1 \). ERIC HOUCHINS, PHILLIP WOMBRE, ALEXANDER BARZILOV, JON PASCHAL, IAN RICE, JEREMY BOARD, JOSEPH HOWARD, Western Kentucky University — Elemental analysis using pulsed fast neutrons is a method in which elemental compounds can be analyzed during neutron bombardment using a pulsed d-T neutron generator. The 14 MeV neutrons impinging upon a material create a plethora of nuclear reactions, including \((n,n')\), \((n,p)\), \((n,\gamma)\), etc. Each isotope has a specific gamma ray pattern which leads to isotope identification and the intensity of each gamma ray can determine the relative amount of that isotope. From the elemental densities, the threat potential can be discerned. We will discuss the methodology as well as a recent examination of 53 naval ordnance items found in Yorktown VA.


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\(^3 \)This work was supported by the National Science Foundation under Grant No. PHY-0355129.

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\(^3 \)Work supported in part by the U.S. Department of Energy and National Science Foundation.
3A.00039 Fiducial Cuts for the CLAS G3 Data Set¹, ELLIOT IMLER, RICHARD BONVENTRE, CHRISTIAN SHULTZ, MICHAEL VINEYARD, Union College, CLAS COLLABORATION — Fiducial cuts have been determined for protons and charged pions produced by photons with energies between 0.3 and 1.5 GeV incident on Helium targets in the CEBAF Large Acceptance Spectrometer (CLAS) at the Thomas Jefferson National Accelerator Facility. This work is part of a systematic study of neutral meson photoproduction from the proton and light nuclear targets to investigate nuclear medium modifications of nucleon resonances and the meson-nucleon interaction. The fiducial cuts are performed to eliminate data from regions of the detector with non-uniform acceptance. The cuts are determined by fitting a trapezoidal function to the γ spectra binned in scattering angle and momentum for each particle type. The φ position of the corners of the trapezoids were then fitted as a function of scattering angle, and the parameters of these fits were fitted as a function of momentum to obtain the functions that are applied to the data to produce the cuts. The procedure will be described and the results will be presented.

1 Supported by the U.S. Department of Energy under contract number DE-FG02-03ER41252.

3A.00040 Integration constraints on a future high Pt muon trigger for PHENIX at RHIC, DANIEL JUMPER, Abilene Christian University, PHENIX COLLABORATION — The PHENIX experiment is a large-scale, complex detector system stationed at the RHIC accelerator ring. One of PHENIX’s goals is to understand the long obscured contributing factors of the protons’ spin structure. This is accomplished by studying the muon decay of W bosons produced by quark-anti quark interaction in polarized proton-proton collisions. A trigger upgrade of Resistive Plate Chambers (RPCs), currently funded for PHENIX, will significantly enhance the ability to trigger on muons at high Pt, where they are more prevalent than other signal sources. By triggering in this manner, the rejection factor of undesired sources is greatly increased, bringing the previously unmanageable rate of data acquisition within practical ranges. The RPCs, however, fall under serious design limitations due to integration constraints of experiment complexity leaving extremely limited space for the chambers, their support systems, and installation. Although these restrictions are far from trivial, careful designs and integration plans have been implemented that overcome them and will bring this spin study to a practical reality.

3A.00041 Test of the Optical Readout of the UConn TPC Detector¹, TRISTAN KADING, MOSHE GAI, UConn, KAI TITTLEMEIER, VOLKER DANGENDORF, PTB — The UConn Time Projection Chamber (TPC) detector is being constructed as a UConn-Yale-Weizmann-PTB-TUNL-LLN collaboration to measure at the Hi-5 at TUNL the 10^6(γ,α)C reaction of importance for stellar evolution theory. We are currently constructing the readout of this TPC using the optical chain of the CERN-CHORUS neutrino experiment. The Contrast Transfer Function (CTF) across the entire chain was measured at the Lab at PTB, Braunschweig, Germany, using a CCD camera and it was found to be sufficient (sub-millimeter resolution) for resolving the expected tracks of particles in the TPC. Results of this measurement will be presented.

1 Supported by USDOE Grant # DE-FG02-94ER40870.

3A.00042 Design, Construction, and Operation of a Small-Scale Radioactivity Assay Chamber, WESLEY KETCHUM, Center for Experimental Nuclear Physics and Astrophysics, Univ. of Washington, and Homer L. Dodge Dept. of Physics and Astronomy, Univ. of Oklahoma, J.A. DETWILER, P.J. DOE, R.A. JOHNSON, M.G. MARINO, A.S. REDDY, A.G. SCHUBERT, B.A. VANDEVENDER, J.F. WILKERSON, Center for Experimental Nuclear Physics and Astrophysics, University of Washington — The ability to limit background signals from naturally occurring and cosmic ray induced radioactive materials is often necessary for many nuclear physics experiments. Projects investigating the nature of neutrinos, such as the tritium single-beta decay experiment KATRIN and the neutrinoless double-beta decay experiment Majorana, require very low levels of backgrounds noise in order to succeed. To test the radioactivity of materials that may be used in these experiments, we have designed, constructed, and operated a small-scale low-background radiometric assay chamber at the University of Washington, CENPA. This chamber consists of two high-purity germanium detectors enclosed in both active and passive shields. We present early results showing energy calibrations, efficiency calculations for known sources, and the effectiveness of a lead shield and cosmic veto at reducing background radiation from the environment and the resulting increase in sensitivity to radioactive impurities. With the aid of computer simulations, we hope to be able to maximize this sensitivity by optimizing the detector geometry, shield, and cosmic veto design.

3A.00043 Search for Triaxial Superdeformed Bands in 174W¹, ANDREW KNOX, University of Massachusetts Lowell — Nuclei at high angular momentum occasionally stabilize in elongated ellipsoidal shapes, and, more rarely, in triaxial superdeformed shapes. Rotation of superdeformed nuclei leads to long sequences of regularly spaced gamma-ray transitions between successive states. Transitions from the sparsely populated superdeformed bands to normal deformed states are extremely weak due to the large difference in their wavefunctions. The approximately regular nature of a superdeformed nucleus leads to long sequences of regularly spaced gamma-ray transitions between successive states. Transitions from the sparsely populated superdeformed bands to normal deformed states are extremely weak due to the large difference in their wavefunctions. The approximately regular nature of a superdeformed nuclei leads to long sequences of regularly spaced gamma-ray transitions between successive states. Transitions from the sparsely populated superdeformed bands to normal deformed states are extremely weak due to the large difference in their wavefunctions. The approximately regular nature of a superdeformed nuclei leads to long sequences of regularly spaced gamma-ray transitions between successive states. Transitions from the sparsely populated superdeformed bands to normal deformed states are extremely weak due to the large difference in their wavefunctions. The approximately regular nature of a superdeformed nuclei leads to long sequences of regularly spaced gamma-ray transitions between successive states. Transitions from the sparsely populated superdeformed bands to normal deformed states are extremely weak due to the large difference in their wavefunctions. The approximately regular nature of a superdeformed nuclei leads to long sequences of regularly spaced gamma-ray transitions between successive states. 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Transitions from the sparsely populated superdeformed bands to normal deformed states are extremely weak due to the large difference in their wavefunctions. The approximately regular nature of a superdeformed nuclei leads to long sequences of regularly spaced gamma-ray transitions between successive states. Transitions from the sparsely populated superdeformed bands to normal deformed states are extremely weak due to the large difference in their wavefunctions. The approximately regular nature of a superdeformed nuclei leads to long sequences of regularly spaced gamma-ray transitions between successive states. Transitions from the sparsely populated superdeformed bands to normal deformed states are extremely weak due to the large difference in their wavefunctions. The approximately regular nature of a superdeformed nuclei leads to long sequences of regularly spaced gamma-ray transitions between successive states. 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3A.00044 g-Factors in 94Zr¹, D.A. KOVACHEVA, C.A. COPOS, University of Richmond — V.Werner2, P. Boutachkov3, E. Stefanova3, N. Benczer-Koller3, C. Koberle3, C. Pietralla4, M. Perry5, M. Fetaoa, H. A12, R.B. Carkin2, 6, R.P. Castaneda, M. Chamberlain2, 7, C.R. Fitzpatrick7, 7, A.B. Gamsky7, T. GfG12, 8, A. Hoenig8, M. Liss13, 9, P. D. Lokhov10, E.A. McCutchen72, D.A. Meyer12, J. Qian12, K.-H. Spindell11, A.E. Stuchbery12, N.J. Thompson2, 7, E. Williams2, R. Winkler2, K. Aleksandrov2, G. Anderson1, B. Darakchieva1, M. Evtimova1, M. Manchev1, J.P. Greene2, C. Lambie-Hanson2, 1, U. of Richmond, 2 WNSL, Yale, 3 Rutgers University, 4 Universitat zu Koln, DE, 5 Florida State University, 6 Istanbul University, 7 U. of Surrey, UK, 8 Clark University, 9 U. of Paisley, UK, 10 Technische Universitat Munchen, DE, 11 Universitat Bonn, DE, 12 Australian National University — An experiment was performed to investigate the p-n configurations in symmetric and mixed-symmetric low-lying states, in 94Zr. A precision nuclear measurement was used to deduce g-factors. The 94Zr was accelerated at WNSL to 275 MeV with intensities of 1pNA. The 94Zr isotope was Coulomb excited in the C layer and exposed to a strong transverse magnetic field in the Gd layer of the multilayer target. Gamma rays were detected in coincidence with the forward-scattered C in either of four clever Ge detectors. Preliminary results on anisotropy ratios of intensities at two angles will be presented.

¹ Work supported by grants: NSF PHY 0204811 and 0555665, Jeffress J-809, US DOE DE-FG02-91ER-40609 and DE-FG02-88ER-40417.

3A.00045 Coulomb excitation of 46V and Testing Isospin Symmetry in the A = 46, T = 1 Multiplet¹, J.W. KREMENAK, D.C. McGINCHIEY, L.A. RILEY, Ursinus College — A beam of the rare isotope 46V was studied via intermediate energy Coulomb excitation at 60 MeV/nucleon at the National Superconducting Cyclotron Laboratory (NSCL). The B(E2; 0^+ → 2^+) value of 46V was used to calculate the M0 value for the nucleus. The extracted M0 value in 46V was compared with the isoscalar multipole matrix element extracted from the previously determined B(E2; 0^+ → 2^+) values of 46Cr and 46Ti. Preliminary results will be compared with this.

1 Supported by NSF Grant PHY-0355129.
3A.00046 A New Measurement of the Muon Lifetime with the MuLan Experiment. JOSH KUNKLE, University of Illinois at Urbana-Champaign, MULAN COLLABORATION — Following recent theoretical calculations, the uncertainty on the Fermi coupling constant is now limited by the precision with which the muon lifetime is measured. The current world average uncertainty on the lifetime is 17 ppm. The MuLan experiment is designed to measure the muon lifetime to 1 ppm. To supply muons, a periodic, pulsed muon beam is created. During a 5 μs “fill period”, muons are directed to a thin stopping target. A 22 μs “measurement period” follows with the beam “off” while the stopped muons decay. A spherical detector surrounding the target detects the decay positrons. A wire chamber with a 10 × 10 cm window is used during beam tuning and for regular measurements during data production. An FPGA is used to enable fast readout of the wire chamber. The firmware that controls the FPGA allows for prescaling during the fill period to reduce the data rate. A number of scalar signals are produced that reflect the flux of muons in specific areas of the chamber. This firmware is currently being used in the 2006 data production run. I have been responsible for the FPGA firmware, as well as various analysis studies.

3A.00047 Investigation of 0+ States in the Transitional Nucleus 108Pd. CHRISTOPHER LAMBIE-HANSON, R. WINKLER, A. HEINZ, R.F. CASTEN, J. QIAN, Yale University, R. KRUECKEN, T. FAESTERMANN, H.F. WIRTH, R. GERAETZ, Technical University Munich, S. CHRISTEN, University of Cologne — A (p,t) reaction on a 110Pd target at the MLL (Maier-Leibnitz Laboratory at LMU and TU Munich) MP tandem accelerator laboratory was used to populate excited 0+ states of 108Pd, which lies in the transitional region between spherical and deformed nuclei. A QSD spectrometer separated the components of the reaction products according to their energies. The angular distributions of the population cross sections of excited states along with their relative energies were used to assign spin, parity, and excitation energy. The unique shape of the angular distributions of 0+ states allowed the identification of both previously known and previously unknown 0+ states in 108Pd at and below the excitation energy of 3.5 MeV. The study of these excited states will lead to a greater understanding of collective behavior and nuclear deformation. This experiment extends previous research into the nature of 0+ excitations in deformed and transitional nuclei in the rare earth region to a transitional nucleus of lower mass. Experimental results and details of data analysis will be presented. This work was supported by DOE Grant DE-FG02-91ER-40609.

3A.00048 Measurements of 11B( p, p)11B. THOMAS LEWIS, RALPH FRANCE III, Georgia College and State University, AJ RICHARDS, The College of New Jersey, MOHAMMAD AHMED, MATTHEW BLACKSTON, SETH HENSHAW, PAUL KINGSBURY, BRENT PERDUE, HENRY WELLER, TUNL/Duke University, RICHARD PRIOR, MARK SPRAKER, North Georgia College and State University — The vector analyzing powers, A0(θ, E), of the 11B( p, p)11B reaction were measured as a function of angle and energy as part of a program to study the reaction 11B( p, α)2α. The experiment was performed at the Triangle Universities Nuclear Laboratory at Duke University, where polarized proton beams between 100 nA and 600 nA with energies (Ep) of 1.388, 2.65, 3.9, 4.0, 4.93, 5.11, and 5.5 MeV were produced using the ABPIS source and the FN tandem. These energies were selected to be on (and off) several of the known resonances in this region. The target was composed of 35 μg/cm2 isotopically pure (99.9% enriched) 11B deposited on a 9 μg/cm2 carbon backing. Scattered protons were detected by an array of six surface barrier detectors placed symmetrically to the left and right of the target. The analyzing powers will be used to further our understanding of the reaction dynamics of the elastic proton channel in this energy region.

3A.00049 Describing Nuclei on the Alhassid-Whelen Arc of Regularity in a SU(3) Basis1, P. MANCHE, M.S. FETEA, Department of Physics, University of Richmond, R.F. CASTEN, S. ECKEL, WNSL, Yale University — Until fairly recently, it was thought that most nuclei lie on or near the perimeter of the Casten triangle. It is now known this is not the case; in fact, most nuclei inhabit the interior of the Casten triangle. More than a decade ago Alhassid and Whelen discovered a striking benchmark. They identified an interior path connecting the U(5) and SU(3) vertices of the Casten triangle which unlike most of the rest of the interior does not exhibit chaos but rather preserves regularity. Jolie et al. [1] found 12 nuclei whose parameters lie along this regularity. They also identified an almost one-to-one correspondence between the near degeneracy of the γ band head and the K=0+ band head for those nuclei. Most of the calculations involving the IBA are done in a U(5) basis. Wave functions of the nuclei on the arc of regularity are complicated when expressed in a U(5) basis but may be easier to work with in a SU(3) basis. Our goal is to determine features of nuclei on or close to the Arc based on the SU(3) description of their wave functions. Preliminary results will be presented. References: [1] J. Jolie et al., Phys. Rev. Lett. 93, 132501 (2004).

3A.00050 Systematics of Giant Electric Dipole Resonances in Hot, Rotating Nuclei1. KATHERINE MCALPINE, Department of Physics & Astronomy, Michigan State University, ANDREAS SCHILLER, National Superconducting Cyclotron Laboratory, Michigan State University, MICHAEL THOENNESSEN, Department of Physics & Astronomy, Michigan State University — The dependence of hot Giant Dipole Resonance (GDR) widths on spin, temperature, and mass is an exciting field of study. In 2001, Kusnezov et al. [1] developed a scaling law to predict the width as a function of these parameters. The law is a reliable description of their data set. Recently, Schiller and Thoennessen [2] prepared a compilation of GDR parameters built on excited states. The scaling law is tested over this larger data set, about five times the number of entries utilized by Kusnezov. Beyond a more detailed study of the dependence of the width on temperature and spin, the compiled data can be broken into subsets with common characteristics. By analyzing subsets of the data, we hope to gain a clearer understanding of the influence of shell effects, deformation, and gating conditions on the GDR width.


3A.00051 Monte Carlo Simulation of New UCN Source at LENS. PATRICK MCCCHESNEY, Indiana University Cyclotron Facility, LENS UCN-SO2 COLLABORATION — My research has focused on a Monte Carlo study of a new ultracold neutron (UCN) source under development at the Low Energy Neutron Source (LENS) at the Indiana University Cyclotron Facility. UCNs are neutrons with energies below 3 × 10−7 eV. They can be used to make extremely accurate measurements of the electric dipole moment of the neutron to test time reversal symmetry. LENS has successfully produced cold neutrons and we are designing an extension to study UCN production. I have modeled a UCN module which will test a novel technique involving magnon interactions in solid oxygen to produce UCNs. Our module slows down the fast neutrons produced by a (p,n) reaction in Be target with a polyethylene cold neutron moderator and directs the resulting cold neutrons into a half liter piece of solid oxygen with water and polyethylene as reflectors. Cold neutrons enter into solid oxygen and are down-scattered to the UCN energy range. These UCNs are then directed upwards toward a storage bottle at a higher elevation, further being slowed down by gravity. I have tested various design configurations trying to maximize the cold neutron flux through the solid oxygen component while minimizing the heat load in the cryogenic system. The simulations predict a cold neutron flux of 2 × 1010 n/cm2/s with a heat load around 1 W from 2.5 mA of 13 MeV protons. My findings are being used as a guideline to design our module.
3A.00052 Geant4 Simulations of Gamma Ray Detectors\textsuperscript{1} . D.C. MCLGLNCHY, Ursinus College — The Geant4 toolkit is used to develop simulations of the Segemented Germanium Array (SeGA) at the National Superconducting Cyclotron Laboratory (NSCL). A simple NaI detector is used as a starting example in order to test the Geant4 toolkit. Simulated spectra were compared with measured spectra from $^{137}$Cs, $^{133}$Ba, $^{22}$Na, and $^{60}$Co. It has been found that the lineshape of the simulated spectrum matches well with the lineshape of the collected spectrum within the tested energy range of 0-1400 keV. A similar comparison of source data from a single SeGA detector has been made and results will be presented.\textsuperscript{1} Supported by NSF Grant PHY-0351529.

3A.00053 The Utilization of Free-Running Digital Signal Processors as a Method of Multi-channel Analysis\textsuperscript{1} . CHRI MCGRAT, MATTHEW NICHOLS, PHILLIP WOMBLE, ALEX BARZILOV, IVAN NOVIKOV, JEREMY BOARD, JOHN PASCHAL, Western Kentucky University — A new generation of neutron-based explosives detection systems is beginning to be built. However, these systems are handicapped by low through-put data acquisition systems. We are developing a faster data acquisition system using a continuously digitizing (“free running”) analog to digital converter. In our method, the incoming electrical signals are processed directly from the anode output of the voltage divider chain on the photo-multiplier tube. The shape and duration of the waveform to be analyzed is strongly dependent on the time constants of the RC components in the last stages of the voltage divider chain. The rise times of these signals are typically less than one hundred ns and their fall times are much longer (>5 $\mu$s). Signal filters and signal amplitudes are calculated from the digital data stream without any front-end analog electronics. In addition, signals which normally would be rejected during high-counting rates because of “pile-up” conditions can be recovered under certain circumstances. This will allow the faster investigation times and reduce risk to personnel and the public. A potential spin-off application is the utilization of these electronics in medical imaging such as PET scanning.\textsuperscript{1} This work is supported in part by the Applied Research and Technology Program of Western Kentucky University.

3A.00054 Investigating $\phi(1020)$ mesons from photo- and electro-production on nuclear targets with the CLAS detector\textsuperscript{1} . WILL MORRISON, MAURIK HOLTROP, University of New Hampshire, CLAS COLLABORATION — The data sets from two large experiments with the CLAS detector at Jefferson Laboratory were used to look for the $\phi(1020)$ meson in photo-production on deuterium and in electro-production on $^1$H, $^12$C and $^{56}$Fe. The $\phi$ mesons were identified by their decay to a $K^+$ $K^-$ pair. We investigate the possibility of extracting nuclear transparency ratios from this data and discuss implications for future experiments with an upgraded CLAS detector. The experimental setup, the data analysis technique and some preliminary results will be presented.\textsuperscript{1} This work is supported in part by DOE grant #DE-FG02-88ER40441 and UNH SURF program.

3A.00055 Cosmic Muon Flux Variations Using the Modular Neutron Array\textsuperscript{1} . EVAN MOSBY, SHEA MOSBY, JAMIE GILLETTE, MALINDA REESE, WARREN F. ROGERS, Westmont College, MONA COLLABORATION — We’ve developed an acquisition and analysis package for the Modular Neutron Array (MoNA), located at the National Superconducting Cyclotron Laboratory (NSCL), for offline monitoring of angular and temporal variations of cosmic muon flux in the sky. The Cosmic Muon Detector Array (CMDA), a device developed by undergraduate students at Westmont College, was modeled after MoNA for use in cosmic muon flux measurements. Much of the analysis routines for the CMDA were adapted for use in MoNA. Because of MoNA’s larger and more numerous detectors, it is capable of gathering much better statistics in shorter time compared with the CMDA. The top and bottom layers of MoNA are used to optically image the muon distribution in the sky with the help Tcl scripts, which also apply optical corrections for angular efficiency of the array. Long term variations in cosmic flux anisotropies, as well as data binned into the 24 solar and sidereal hours are monitored, and compared with results from the CMDA. Results will be presented.\textsuperscript{1} Work supported by National Science Foundation grant PHY0502010.

3A.00056 Neutron Multiplicity Discrimination in MoNA\textsuperscript{1} . SHEA MOSBY, EVAN MOSBY, WARREN F. ROGERS, Westmont College, MONA COLLABORATION — The Modular Neutron Array (MoNA) is a high efficiency neutron detector located at the National Superconducting Cyclotron Laboratory at Michigan State University and used in conjunction with the NSCL/FSU sweeper magnet to conduct coincidence experiments on unstable nuclei near the neutron drip-line. Experiments using this detector combination involve the loss of one or more neutrons from particle-unbound nuclei; it is therefore important to distinguish neutron multiplicity in MoNA in order to effectively analyze data from these experiments. We’ve developed an algorithm to distinguish neutron multiplicity based on the kinematic propagation properties of neutrons through MoNA. Scatter plots of neutron velocity, energy deposition, and scattering angle are constructed from which gates can be drawn for neutron multiplicity discrimination. Data from a few one- and two-neutron experiments have been analyzed, and results will be presented.\textsuperscript{1} Work supported by National Science Foundation grant PHY0502010.

3A.00057 A Gamma Ray Spectrometer Based on Mobile Phone Technology\textsuperscript{1} . KYLE MOSS, ALEXANDER BARZILOV, PHILLIP C. WOMBLE, JON PASCHAL, Western Kentucky University — We have developed a miniature spectrometer for gamma-ray detection and automatic isotope identification (RadPhone) which uses mobile phone technology to analyze the data and to distribute the results to security personnel. The RadPhone system consists of two modules, a detector module and wireless phone module. The detector module houses a detector, a small data acquisition system, Bluetooth transceiver, and power supply (battery). Using a Bluetooth channel, this module communicates to the Motorola\textsuperscript{2} MPx220 wireless phone with data acquisition and analysis software which serves as a data acquisition computer. RadPhone offers a small, portable means of gamma-ray detection and identification.\textsuperscript{1} This work is supported in part by the Applied Research and Technology Program at Western Kentucky University.

3A.00058 Studies of nuclei around proton drip-line at the HRIBF Recoil Mass Spectrometer using a rotating target\textsuperscript{1} . CLARKE NELSON, Vanderbilt University — The investigations of nuclei around proton drip line allow us to verify nuclear structure models initially developed based on data obtained for the isotopes near a beta stability line. However, these exotic nuclei are very difficult to study, mainly because of very low production cross section. The fusion-evaporation reactions between heavy-ions and fragmentation of relativistic heavy-ions are preferred production methods for very proton rich nuclei. In both cases, the high intensity of primary beam helps to increase the amount of produced nuclei. This contribution analyses the yields of alpha and proton radioactivities produced in fusion-evaporation reactions and studied at the Recoil Mass Spectrometer at the Holifield Radioactive Ion Beam Facility (HRIBF). The recently commissioned rotating target device \cite{1} allowing us a substantial increase in the primary beam current will be presented. In particular, the probability to reach doubly-magic nucleus $^{190}$Sn in so far unobserved superallowed alpha decay chain $^{108}$Xe$\rightarrow^{104}$Te$\rightarrow^{100}$Sn \cite{2} will be discussed.\textsuperscript{1}[1] J.Johnson et al., HRIBF, Oak Ridge, 2006 \textsuperscript{2} S.Liddick et al., Phys. Rev. Letters, in press.
3A.00059 Single Particle Energies in Skyrme Hartree-Fock and Woods-Saxon Potentials. BRIAN NEWMAN, Carnegie Mellon University — Atomic nuclei exhibit the interesting phenomenon of single-particle motion that can be described within the mean field approximation for the many-body system. We have obtained Hartree-Fock calculations for a wide range of nuclei, using the Skyrme-type interactions. We have examined the resulting mean field potentials $U_{HF}$ by fitting $r^2 U_{HF}$ to $r^2 U_{WS}$, where $U_{WS}$ is the commonly used Woods-Saxon potential. We consider, in particular, the asymmetry ($\kappa=(N-Z)/A$) dependence in $U_{WS}$ and the spin-orbit splitting in the spectra of $^{13}$F and the recently measured spectra of $^{20}$F. Using $U_{WS}$, we obtained good agreement with experimental data.

3A.00060 The Effect of Nuclear Cross-Section Data on the Measurement of Elemental Densities in Explosives Threat Analysis. M. E. NICHOLS, P.C. WOMBLE, A. BARZILOV, E. HOUCHINS, J.R. MOORE, J. BOARD, J. PASchal, H. HOPPER, Western Kentucky University Applied Physics Institute — With the impending threat of terrorist attacks in the modern age, it is important to neutralize these threats as quickly and efficiently as possible. Our research principally deals with the detection and quantification of the elements hydrogen, oxygen, nitrogen and carbon to differentiate between explosives and non-explosives and presents an effective means of detection via quantification of these elemental densities. Materials can be separated into innocuous and threat categories based on their elemental densities. For nuclear-based measurements, however, the nuclear cross-sections erode this segregation. We have been developing threat algorithms in which the nuclear cross-section has been coupled with the elemental density.

This work is supported in part by the Applied Research and Technology Program of Western Kentucky University.

3A.00061 Understanding the N*(1710) Resonance by Scanning the $\pi^+ p$ System in the (1610-1770) MeV Region. TEMITOPE OMIAWADE, Abilene Christian University — Abilene Christian University in collaboration with Petersburg Nuclear Physics Institute (PNPI) and Institute for Theoretical and Experimental Physics (ITEP) have been working to improve the pion-nucleon resonance by scanning of the $\pi^+ p$ system invariant mass in the (1610-1770) MeV region with the detection of $\pi^+ p$ and $KN$ decays. Previous experiments indicate inconsistencies in the $\Pi^0(1710)$ resonance in the reaction $\pi^+ p \rightarrow \pi^+ p$, however, using the reaction $\pi^+ p \rightarrow KN$, the nucleon resonance can be understood better. Using a GEANT4 simulation, we were able to model the interaction of the target and retrieve information on these particles from the hodoscope. Using ROOT, a detailed analysis was retrieved from the data to differentiate between the protons and pions at the hodoscope. The goal of my work is to provide criteria for discrimination of proton from pion tracks in the final state using the TOF system.

3A.00062 A Data Acquisition System for $\nu$-SNS Development. S.V. PAULUSKAS, R.L. KOZUB, Tennessee Tech. Univ., J.C. BLACKMON, D.W. BARDAYAN, Q. ZENG, Oak Ridge National Lab., Y.V. EFREMENKO, Univ. of Tennessee-Knoxville, K. SCHOLBERG, A. CROWELL, Duke Univ. — The $\nu$-SNS project at the Spallation Neutron Source aims to study neutrino-nucleus interactions important for understanding nuclear structure and astrophysics. Understanding the neutron background produced by the 1 GeV proton beam of the SNS is crucial to designing the shielding and detectors for $\nu$-SNS. To this end a facility is being constructed to study the neutron backgrounds at the SNS. In order to process data from scintillation detectors a LabVIEW program was written. This program communicates with CAMAC based ADC modules via a GPIB crate controller and a USB interface. Three of the ADCs receive gates to store information from different time intervals for neutron-gamma discrimination. The fourth ADC stores TAC signals with neutron TOF information. The LabVIEW program creates spectra that can be used to identify neutrons and gamma rays. Measurements with neutron and gamma sources were performed to study the effectiveness of different techniques of neutron-gamma discrimination.

3A.00063 p-n configurations of symmetric and mixed-symmetric states. M. PERRY, WNSL Yale Univ., F. SCHNEE, T. SHUTT, Case Western Reserve University, S. GOLWALA, Z. AHMED, California Institute of Technology, CRYOGENIC DARK MATTER SEARCH COLLABORATION — The beta cage is a proposed multi-wire proportional chamber that will be the most sensitive device available to screen low-energy (200 keV) betas emitted at rates as low as $10^{-5}$ counts keV$^{-1}$ cm$^{-2}$ day$^{-1}$ (of order $10^{-4}$ Bq/m$^2$). The expected sensitivity and details of the construction and commissioning of its prototype chamber are presented. The prototype beta cage is a 50x50x25 cm frame gridded by stacked wire planes contained in a chamber of gas. To reduce background, the chamber contains only enough mass to stop betas of interest. Samples are placed beneath the grid; the wires multiply the betas and collect their electron avalanche. Readouts allow discrimination of its events from background and determination of the beta (or alpha) source. The beta cage has potential use in carbon or tritium dating, with $^{3}$H/$^{1}$H sensitivity of $10^{-20}$ and $^{14}$C/$^{12}$C sensitivity of $10^{-18}$. Its design was motivated by CDMS, whose sensitivity to the dark matter candidate WIMPs is currently limited by low-energy beta contamination.

3A.00064 The Beta Cage: Screening Low Radioactive Backgrounds. K. POINAR, D. AKERIB, D. GRANT, R. SCHNEE, T. SHUTT. Case Western Reserve University, S. GOLWALA, Z. AHMED, California Institute of Technology, CRYOGENIC DARK MATTER SEARCH COLLABORATION — The beta cage is a proposed multi-wire proportional chamber that will be the most sensitive device available to screen low-energy (200 keV) betas emitted at rates as low as $10^{-5}$ counts keV$^{-1}$ cm$^{-2}$ day$^{-1}$ (of order $10^{-4}$ Bq/m$^2$). The expected sensitivity and details of the construction and commissioning of its prototype chamber are presented. The prototype beta cage is a 50x50x25 cm frame gridded by stacked wire planes contained in a chamber of gas. To reduce background, the chamber contains only enough mass to stop betas of interest. Samples are placed beneath the grid; the wires multiply the betas and collect their electron avalanche. Readouts allow discrimination of its events from background and determination of the beta (or alpha) source. The beta cage has potential use in carbon or tritium dating, with $^{3}$H/$^{1}$H sensitivity of $10^{-20}$ and $^{14}$C/$^{12}$C sensitivity of $10^{-18}$. Its design was motivated by CDMS, whose sensitivity to the dark matter candidate WIMPs is currently limited by low-energy beta contamination.

3A.00065 Hold-up Time Measurements for Various Actinide Targets. EMILY PRETTYMAN, DePaul University/Oak Ridge Associated Universities, H.K. CARTER, ANDREAS KRONENBERG, EUGENE SPEJEWSKI, Oak Ridge Associated Universities, DANIEL STRACENER, Oak Ridge National Laboratory — At Oak Ridge National Laboratory the Holifield Radioactive Ion Beam Facility produces radioactive ion beams (RIBs) by proton-induced fission on an actinide target. The RIB yields depend on the chemical and physical properties of the target used. The rates at which chemical elements are released from the target ion source, called hold-up times, can give information about the movement of chemical elements within the target material. This information may be useful in designing optimal targets to maximize production of specific isotopes. Hold-up times are measured using the UNISOR isotope separator, connected to the tandem accelerator. The proton beam is turned on until the element of interest reaches equilibrium between production and release. It is then turned off and the decrease of the release is observed. The current analysis was done by fitting the data with two exponential decay functions and the trend is hold-up times decrease as target temperature increases. Another attempt to fit the data would be to use equations that take into account diffusion and effusion with the goal of determining the ratios of the processes to see which dominates. The results will be presented.
3A.00066 Detector resolution in the “EPECUR” project. ALOD RAELIARJAOANA, Abilene Christian University — In order to study the N*(1710) in the “EPECUR” project, the hodoscopes were put at some reasonable distance. This resolved the triggering problem since within a 10 cm strip-horizontally as well as vertically- there are 4 times less of double hit from one event than a single hit, there are also negligible multiple (3 or 4) hit providing from the collision p the decays K\(^+\) to + and A\(^−\) to p.

3A.00067 Determining the Feasibility and Precision of an On-Site Radioactivity Test Chamber, A.S. REDDY, Center for Experimental Nuclear Physics and Astrophysics, University of Washington, North Dakota State University Department of Physics, J.A. DETWILER, P.J. DOE, R.A. JOHNSON, WESLEY KETCHUM, M.G. MARINó, A.G. SCHUBERT, B.A. VANDEVENDER, J.F. WILKERSON, CENPA, University of Washington — Backgrounds are a limiting factor to the sensitivity of many high precision nuclear physics experiments. Lowering these backgrounds is essential to experiments like Majorana and KATRIN, which look at neutrinoless double beta-decay and tritium beta-decay respectively. These backgrounds could be significantly reduced by using materials with low radioactivity. In order to aid these experiments in lowering backgrounds, we performed simulations to assess the feasibility and sensitivity with which an in-house radioactivity test chamber could be operated. Simulations were done in parallel with initial tests of the system. The system consists of two Ortec high purity germanium detectors housed in a lead chamber, which is shielded by scintillators used to determine cosmic coincidence. The programming utilized the Geant4 monte carlo toolkit, and analysis was done using ROOT. Simulations of calibration sources were compared with data in terms of spectral shape and overall normalization. The efficiency of the system was explored as a function of energy, detector orientation, and sample geometry. Simulations of the lead shielding and cosmic veto coverage were also done.

3A.00068 Measurements of \(^{11}B(p,\alpha)^8Be\), A.J. RICHARDS, The College of New Jersey, HENRY WELLER, Triangle Universities Nuclear Laboratory, MOHAMMED AHMED, MATTHEW BLACKSTON, SETH HENSHAW, P. KINGSBURY, BRENT PERDUE, TUNL, RALPH FRANCE, Georgia College and State University, TOM LEWS, GICRU, RICHARD PRIOR, North Georgia College and State University, M. SPRAKER, NGCSU, TUNL CAPTURE GROUP TEAM — The vector analyzing powers of the \(^{11}B(p,\alpha)^8Be\), reaction were measured as a function of energy and angle as part of a program to study the \(^{11}B(p,\alpha)2\alpha\) reaction at low energies. Polarized proton beams were produced by the ABPIS source and accelerated through the FN tandem at the Triangle Universities Nuclear Laboratory. The target was composed of 35 \(\mu g/cm^2\) of isotopically enriched \(^{11}B\) deposited on a 9 \(\mu g/cm^2\) carbon backing. Emitted \(\alpha\)-particles were detected in an array of six surface-barrier detectors placed symmetrically to the left and right of the target. Measured asymmetries in scattering from the carbon backing were used to calibrate the beam polarization. Beams of 100 nA to 600 nA were used at energies of \(E_p\) = 1.388 MeV, 2.65 MeV, 3.9 MeV, 4.0 MeV, 4.93 MeV, 5.11 MeV and 5.5 MeV. An aluminum degrader foil was used to produce 575 keV through 775 keV beams (3 to 6 nA) to study the 675 keV resonance. These data will be used to develop a detailed understanding of the off- and on-resonance nature of this reaction.

1\(^{11}S\)Sf grant NSF-05-52723.

3A.00069 Analysis of the 11B(d,n)12C Reaction, NATHAN RIDLING, RICHARD PRIOR, MARK SPEAKER, HENRY WELLER, BRENT PERDUE, Triangle Universities Nuclear Laboratory — Studies have been performed on the \(^{11}B(d,n)^{12}C\) reaction to measure the absolute astrophysical S factor and its energy dependence, the reaction cross section, and tensor and vector analyzing powers \(T_{g.s.},T_{11}\), and \(t_{11}\). The motivation behind this research project is not only its relevance to nuclear astrophysics, but also in the reaction dynamics of \((d,n)\) reactions at very low energies. PSD (Pulse shape discrimination) was used along with PAW (Physics Analysis Workstation) in order to extract the neutrons from the gamma-rays. Using a neutron function response fitting routine in Root, we have determined the number of neutron counts leading to the ground and first excited states of \(^{12}C\). These yields were used to construct the angular distributions of the cross section and analyzing powers. Ultimately, we will extract the reaction specific transition matrix elements.

3A.00070 Application of THGEM to XENON Dark Matter Search, DANIEL RUBIN, Yale University, XENON COLLABORATION — Thick GEM-like (THGEM) multipliers made from copper-clad Cirlex (rather than the typical g10) were studied, with the goal of finding a low-background GEM that could be used in the XENON detectors. The Cirlex THGEMs were made with particularly large (1.0 mm) holes, in the hope that gain reduction due to xenon condensation in the holes could be avoided. Such THGEMs were found to have very high resistances (in the 10 TeraOhm range) and sample geometry. Simulations of the lead shielding and cosmic veto coverage were also done. These THGEMs were found to have very high resistances (in the 10 TeraOhm range) and gain curves similar to those of g10 THGEMs of the same thickness in a mixture of carbon dioxide and nitrogen at 75 torr. However, the THGEMs were used to construct the angular distributions of the cross section and analyzing powers. Ultimately, we will extract the reaction specific transition matrix elements.

3A.00071 Using the Neutron-Deuteron Breakup Reaction as a Probe for the Three-Nucleon Force\(^1\), KIRBY RUNYON, STEVEN WALLACE\(^2\), ALEXANDER LIPNICKI, MARK YULY\(^3\). Houghton College, ND BREAKUP COLLABORATION — An experiment is being performed at the Los Alamos Neutron Science Center to probe for a three-nucleon component (3NF) of the strong force. Historically, the strong force has been modeled as a two-nucleon interaction, but experimental evidence suggests interactions between nucleon triplets may contribute to the strong force. Neutrons with energies up to 800 MeV will strike a liquid deuterium target. Deuteron usage allows detection of the 3NF using the smallest possible nuclei since interactions will involve three nucleons. A magnetic spectrometer will measure scattered proton momenta and large plastic scintillators will detect neutrons. Neutron-proton elastic scattering will also be detected at conjugate angles for calibration purposes. Data collection is anticipated in October 2006.

\(^1\)Thanks to LANSE-NS for supporting student work.

\(^2\)2006 Graduate

\(^3\)Faculty Advisor

3A.00072 Lifetime Measurements and Deformation in \(^{79}\)Sr, Y.K. RYU, R.A. KAYE, S.R. ARORA, Ohio Wesleyan Univ., S.L. TABOR, T. BALDWIN, D.B. CAMPBELL, C. CHANDLER, M.W. COOPER, C.R. HOFFMAN, J. PAVAN, M. WIEDEKING, Florida St. Univ., J. DÖRING, GSI, Germany, Y. SUN, Univ. of Notre Dame, S.M. GEBRICK, O. GRUBOR-UROSEVIC, Purdue Univ. Calumet, L.A. RILEY, Ursinus College — High-spin states in \(^{79}\)Sr were produced following the \(^{12}\)Fe(\(^{7}\)Li, \(^{2}\)p) reaction using a beam energy of 90 MeV at the Florida State University (FSU) Tandem-Linac facility, and the resulting de-exciting \(\gamma\) rays were detected with the FSU Ge array of 10 Compton-suppressed detectors. The \(^{12}\)Fe target was thick enough so that all of the synthesized nuclei could stop completely in the target, resulting in Doppler-shifted \(\gamma\) ray lines that could be analyzed using the Doppler-shift attenuation method. In all, 23 lifetimes were measured in three separate band structures using this method, and then used to infer transition quadrupole moments \(Q_2\) and quadrupole deformations \(\beta_2\) using the rotational model. The results show good qualitative agreement with the predictions of both cranked Woods-Saxon (CWS) and projected shell model (PSM) calculations. The band based on \(d_{3/2}\) single-particle orbit, verified in this study through \(\gamma - \gamma\) coincidences, intensity measurements, and directional correlation of oriented nuclei (DCO) ratios, was found to have the largest average deformation \(\beta_2,ave = 0.41\) among the three bands, in agreement with the CWS and PSM predictions. Supported in part by the NSF and the ONU SSRP.
3A.00073 Astrophysical S(E)-factor of the $^{15}$N(p,$\alpha$)${}^{12}$C reaction at sub-Coulomb energies via the Trojan-horse method\(^1\), DANIEL SCHMIDT, Liberty University, M. LA COGNATA, S. ROMANO, C. SPITALERI, S. CHERUBINI, V. CRUCILLA, L. LAMIA, R. PIZZONE, A. TUMINO, Dipartimento di Metodologie Fisiche e Chimiche per l’Ingegneria-Università di Catania, Catania Italy  Lafayette National Laboratory, New Mexico, U.S.A., D. SIMPSON, C. MAZZOCCHI, R. GRZYWACZ, C.R. BINGHAM, A. KORGUL, University of Tennessee, C.J. GROSS, K.P. RYKACZEWSKI, Oak Ridge National Laboratory, J.C. BATCHELDER, S.N. LIDDICK, Oak Ridge Associated Universities, J.H. HAMILTON, J.K. HWANG, K. LI, Vanderbilt University, S. ILYUSHKIN, J.A. WINGER, Mississippi State University, W. KROLAS, Institute of Nuclear Physics, R.D. PAGE, University of Liverpool — Charged particle spectroscopy can provide insight into the nuclear structure of exotic nuclei. The moments of charged particles detected in CLAS are corrected for energy losses in the cryogenic targets and start counter by integrating a FORTRAN code written for this purpose into our C++ analysis code. The analysis will be described and the effects of the corrections on momentum and missing mass distributions will be presented.

\(^1\)Supported by the U.S. Department of Energy under contract number DE-FG02-03ER41252.

3A.00078 First observation of $^{109}$I alpha decay, D. SIMPSON, C. MAZZOCCHI, R. GRZYWACZ, C.R. BINGHAM, A. KORGUL, University of Tennessee, C.J. GROSS, K.P. RYKACZEWSKI, Oak Ridge National Laboratory, J.C. BATCHELDER, S.N. LIDDICK, Oak Ridge Associated Universities, J.H. HAMILTON, J.K. HWANG, K. LI, Vanderbilt University, S. ILYUSHKIN, J.A. WINGER, Mississippi State University, W. KROLAS, Institute of Nuclear Physics, R.D. PAGE, University of Liverpool — Charged particle spectroscopy can provide insight into the nuclear structure of exotic nuclei. Far away from the valley of stability nuclei become difficult to produce and observe. Short lifetimes and low count rates make experiments very challenging. One way to do these experiments is by implanting a nucleus into a silicon detector and observing its alpha or proton decay. At short lifetimes, the implantation induced signal distorts the energy measurement of the decay pulse. An algorithm was designed to correct this effect, making possible the observation of $^{109}$I alpha decay. The method and preliminary results will be presented.
3A.00070 Statistical Analysis of Nucleon Resonances: Updating the Nuclear Data Ensemble  
D.J. SISSOM, J.F. SHRINER, JR., Tenn. Tech. Univ., G.E. MITCHELL, N. Car. St. Univ. and TUNL — Statistical properties of both neutron and proton resonance data are thought to be described by the Gaussian Orthogonal Ensemble of Random Matrix Theory. The most convincing evidence is from the analysis by Haq et al. of the Nuclear Data Ensemble (NDE) collection of resonance levels from 32 different nuclides. Since the data that comprise the NDE are over 20 years old, it seems reasonable to examine current resonance data with the goal of providing an updated NDE. We have examined current resonance data not only for the nuclides in the original NDE but also for other even-even targets as well. Tests of data quality have included N(E) staircase plots and comparison of reduced width distributions with the Porter-Thomas distribution. New data exist for 16 of the 32 original nuclides, and data from five other nuclides also seem suitable for inclusion. A description of the new data set and results for several of the standard statistical measures, including the nearest-neighbor spacing distribution and the Dyson-Mehta $\Delta_{2}$ statistic, will be provided.

3A.00080 One-Zone x-Ray Burst Model Adjustment  
KARL SMITH, MATT AMTHOR, National Superconducting Cyclotron Laboratory, Michigan State University, ALEXANDER HEGER, Los Alamos National Laboratory, EMILY JOHNSON, Michigan State University, HENDRIK SCHATZ, National Superconducting Cyclotron Laboratory, Michigan State University — Multi-zone x-ray burst models simulate thermonuclear explosions on the surface of accreting neutron stars. The underlying nuclear reaction sequence in the x-ray burst is the rp-process. We explored the validity of one-zone approximations as tools to investigate nuclear physics by comparing to a full 1D multi-zone model. A one-zone model uses less computation time to run an x-ray burst than for a multi-zone model. The multi-zone model requires more time because it considers convection within the star. Our goal was to produce a one-zone model to quickly study changes in nuclear reaction rates, if interesting results were found to rerun the conditions with the multi-zone model. By changing the initial composition, temperature, and pressure in the one-zone model, we succeeded to match the x-ray light curve and final produced ashes of the multi-zone model.

3A.00081 Determination of Acceptance for the $\pi^-p \rightarrow K Lambda$ Reaction  
DOLASO SOBOYEDE, MICHAEL SADLER, Abilene Christian University — ACU fairly recently became involved in an experiment proposed by the Institute for Theoretical and Experimental Physics (ITEP) and the Petersburg Nuclear Physics Institute (PNPI). In this experiment, our aim is to gain a better understanding of the second and third resonance regions in pion-nucleon scattering. In $\pi^-p \rightarrow \pi^-p$ scattering, the $P_{11}$ (1710) resonance is poorly seen, but in the $\pi^-p \rightarrow K\Lambda$ reaction the resonance is more clearly defined. In addition, previous experiments have been insensitive to narrow pion-nucleon resonances, but this experiment will be sensitive to such excited states of bound quarks. This research focuses on a GEANT4 simulation of the experiment and an analysis of the data using ROOT in order to determine the acceptance for the $\pi^-p \rightarrow K\Lambda$ reaction. Our experimental setup is designed to detect only charged particles, thus this simulation concentrates on charged decay modes.

3A.00082 The Results of a Resistive Plate Chamber Study for the PHENIX Forward Muon Trigger Upgrade  
NATHAN SPARKS, Abilene Christian University, PHENIX COLLABORATION — The aim of the PHENIX Forward Muon Trigger Upgrade is to allow the use of W boson physics, specifically the non-invariance of W decay under parity reversal, to elucidate a better understanding of the spin structure of the proton. A fast muon trigger system will be assembled by adding three Resistive Plate Chamber (RPC) stations to the existing PHENIX infrastructure at RHIC. There are a number of RPC prototypes being carefully studied to ensure that the upgrade succeeds. One such study is being conducted at the University of Illinois at Urbana-Champaign and involves the tracking of cosmic rays passing through an RPC test stand. The main objective of the study is to determine the cluster size, position resolution, efficiency, and rate capability of the RPCs. The analysis of the data collected during the study will be presented.

3A.00083 Partial neutron induced gamma-ray cross section measurements of Pb at 8 and 12 MeV for background subtraction of $0\nu\beta\beta$ decay experiments  
B.N. SPAUN, Whitworth College, M.A. ATONACCI, Saint Vincent College, A.P. TONCHEV, W. TORNOW, Duke University and TUNL, MAJORANA COLLABORATION — The Majorana collaboration is currently seeking to detect neutrinoless double beta decay $(0\nu\beta\beta)$ using $^{76}\text{Ge}$ as both the source and detector. If $0\nu\beta\beta$ decay were detected, it would indicate that neutrinos are their own antiparticles (Majorana particles), and it would provide an absolute mass scale for the three neutrino mass states. However, the predicted half life of such a decay is on the order of $10^{27}$ years, making its detection above background extremely difficult. Although the $^{76}\text{Ge}$ source and detectors are placed underground and shielded with lead, cosmic-ray muons still produce neutrons which interact with the lead shielding to produce gamma rays in the energy region of interest, 2040 eV. In an effort to determine the rate of neutrons induced gamma production, we at TUNL, in collaboration with Los Alamos, have recently measured the partial cross section of several key lead transitions using both an 8 MeV and a 12 MeV neutron beam. We are especially interested in the partial cross sections of 2041 keV, 2614 keV, and 3062 keV lead transitions, which will directly interfere with the detection of $0\nu\beta\beta$ decay events. We will present the results of these partial cross section measurements. Supported in part by DOE grant no. DE-FR02-97ER41030 and by NSF no. NSF-05-52723.

3A.00084 Understanding Na22 Cosmic Abundances  
S. STATTEL, Columbia University, J.A. CAGGIANO, L. BUCHMANN, TRIUMF, J.M. D'AURIA, Simon Fraser Univ., D.A. HUTCHEON, M. TRINCEK, C. VOCKENHUBER, J. PEARSON, C. RUIZ, TRIUMF, K. SNOVER, U. Washington, J.J. RESSLER, Simon Fraser Univ., J. JOSE, Barcelona, A. SALLASKA, D. STORM, A. GARCIA, U. Washington, DRAGON TEAM — $^{22}$Na is an elusive cosmic gamma ray emitter that should be abundant as a product of novae, but this isotope is as yet unobserved except in the central galactic bulge. The detection of $^{22}$Na would be resolved through a recent measurement of $^{23}$Mg structure, which discovered a level that may have significant implications on the rate for $^{22}$Na destruction via the $^{22}$Na(p,$\gamma$)$^{23}$Mg reaction. One of the main goals of this project is to perform a direct $(p,\gamma)$ measurement of the new resonance using a beam of protons that will be accelerated to impinge on a $^{22}$Na radioactive target. The target will be produced at TRIUMF-ISAC in Canada. We are currently in the beginning stages of setting up this experiment at CENPA. I will explain the motivations for the experiment, describe the set up, and present calculations that allow optimization of our beam-line design.

3A.00085 Study of di-jets and the Sivers effect at STAR  
JUSTIN STEVENS, STEVE VIGDOR, JAN BALEWSKI, Indiana University, STAR COLLABORATION — It has been known for a number of years that the preferential alignment of quark spins inside the proton can account for only a small fraction of the proton's total spin. The rest of the spin must arise from some combination of gluon spin alignment and parton orbital angular momentum. One possible manifestation of orbital angular momentum of the partons is the Sivers effect: transverse spin asymmetries that arise from a directional preference in the intrinsic transverse momentum of partons, correlated with the transverse spin direction of a polarized proton. One method of quantifying this effect is measuring high energy polarized proton collisions at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory using the STAR detector. The key to the analysis was di-jet events, where the Sivers effect would be manifested by a spin-dependent change in the azimuthal opening angle, zeta, between the two jets. Monte Carlo simulations were run in order to better understand the shape of the zeta distribution for these events. Also data from the 2006 run at STAR were analyzed using electromagnetic calorimeter information only, before charged-particle tracking information allowing full jet reconstruction was available. I will report an analysis looking in different subsets of the data where theory predicts non-zero Sivers effects should be, based on earlier experimental results for transverse spin asymmetries measured in semi-inclusive deep inelastic scattering from protons.

3A.00086 The Results of a Resistive Plate Chamber Study for the PHENIX Forward Muon Trigger Upgrade  
B.N. SPAUN, Whitworth College, M.A. ATONACCI, Saint Vincent College, A.P. TONCHEV, W. TORNOW, Duke University and TUNL, MAJORANA COLLABORATION — The Majorana collaboration is currently seeking to detect neutrinoless double beta decay $(0\nu\beta\beta)$ using $^{76}\text{Ge}$ as both the source and detector. If $0\nu\beta\beta$ decay were detected, it would indicate that neutrinos are their own antiparticles (Majorana particles), and it would provide an absolute mass scale for the three neutrino mass states. However, the predicted half life of such a decay is on the order of $10^{27}$ years, making its detection above background extremely difficult. Although the $^{76}\text{Ge}$ source and detectors are placed underground and shielded with lead, cosmic-ray muons still produce neutrons which interact with the lead shielding to produce gamma rays in the energy region of interest, 2040 eV. In an effort to determine the rate of neutrons induced gamma production, we at TUNL, in collaboration with Los Alamos, have recently measured the partial cross section of several key lead transitions using both an 8 MeV and a 12 MeV neutron beam. We are especially interested in the partial cross sections of 2041 keV, 2614 keV, and 3062 keV lead transitions, which will directly interfere with the detection of $0\nu\beta\beta$ decay events. We will present the results of these partial cross section measurements. Supported in part by DOE grant no. DE-FR02-97ER41030 and by NSF no. NSF-05-52723.
3A.00086 Finite Size Effects on Dilepton Properties in Relativistic Heavy Ion Collisions. TRENT STRONG, HENDRIK VAN HEES, RALF RAPP. Texas A&M University — In order to understand better the basic properties of matter at the subnuclear level, relativistic heavy-ion collision experiments are utilized to explore the interactions of strongly interacting particles in hot and dense matter. A particularly valuable probe is dilepton radiation, since leptons do not strongly interact and therefore transmit direct information from the medium in which they were produced, in particular on the in-medium properties of vector mesons. Thus, electromagnetic probes could greatly enhance our understanding of the QGP and the relevant processes within, including strangeness suppression and the study of the NAG experiment and account for the observed dilepton spectrum by means of a twofold component model, which treats the spectra as being produced from separate thermal and non-thermal hadronic sources and aims to provide a consistent description of both invariant-mass and momentum spectra.

3A.00087 Spectroscopic Factors of Mirror Nuclei. SHI CHUN SU, Chinese University of Hong Kong — Neutron spectroscopic factors have been extracted from all measured excited states of $^{36}\text{Cl}$, $^{27}\text{Mg}$, $^{35}\text{S}$ and $^{31}\text{Si}$. These nuclei were chosen because of the availability of the $(d,p)$ transfer reaction data and the astrophysical interest in the corresponding mirror nuclei ($^{36}\text{Ca}$, $^{27}\text{P}$, $^{31}\text{K}$ and $^{31}\text{Cl}$). These latter four nuclei are important in the evolution theory of neutron stars. Since no Sf's for these four nuclei are available experimentally, shell model is used to calculate them. To assess the uncertainties of the calculated Sf's, we compare the experimental SF values to the calculated values from Oxbash. Three different interactions (USDA and USDB) for sd shell nuclei are used. USDA and USDB are new interactions developed recently. The results show that all the three interactions agree to within 20% when the experimental Sf's are larger than 0.02. However, for Sf's, as small as 0.003, good agreements can only be achieved with the new USDB interaction. The present work lowers substantially the validity limit of the shell model SFs calculations for the sd nuclei. It also quantifies the uncertainties of the calculated Sf's. These theoretical uncertainties will be important to assess the outputs of the network calculations for evolution theory of neutron star.

3A.00088 EPICS Slow Controls System in the Search for a Neutron Electric Dipole Moment. COURTNEY TAYLOR, North Carolina State University — The measurement of a nonzero electric dipole moment (EDM) of the neutron would significantly impact our understanding of the nature of the weak and strong interactions. The goal of the current experiment is to improve the measurement sensitivity of the EDM by two orders of magnitude. The experiment is based on the magnetic-resonance technique of rotating a magnetic dipole moment in a magnetic field. The measurement of the neutron EDM comes from a measurement of the difference in the precession frequencies of neutrons when a strong electric field parallel to the magnetic field is reversed. This construction project is divided into a number of subsystems, five of which require automated control. The Experimental Physics and Industrial Control System (EPICS) is a slow-controls data acquisition (DAQ) system and is the system of choice for this experiment. It was selected for both its ease of use and ability to act as a total control system for large systems. As part of the initial research and development for the EDM project, we are setting up a prototype system that will eventually be copied and sent to the subsystem managers. This prototype consists of a VME crate housing a single board computer and DAQ modules. EPICS, running on a PC with CentOS Linux-x86, interfaces with the VME single board computer and provides a graphical user interface for the control system. The details on building this prototype DAQ system will be presented. Supported in part by the U.S. DoE.

3A.00089 Limitations and Improvements of the Gamow Window Approximation for Thermonuclear Reaction Rates. J. TOKIWA, R.L. KOZUB, Tenn. Tech. U., M.S. SMITH, ORNL, J.P. SCOTT, E.J. LINFELDT, K. CHAE, ORNL/UT-Knoxville — The knowledge of thermonuclear reaction rates is vital to simulate numerous types of astrophysical events. Standard codes to calculate rates, such as the tools at nucastrodata.org, utilize a Gaussian approximation to estimate the relative energy range (Gamow window) over which the calculation is performed. This approximation is less accurate at low temperatures, such as the $d(d,n)^{4}\text{He}$ and $d(d,p)^{4}\text{He}$ reactions, which are important for Big Bang Nucleosynthesis. A new code has been written to numerically determine the energy range for the calculation needed to obtain an accuracy of less than 1% in the reaction rate, based on rate contributions from various energies in the Gamow window at a given temperature. This extends the rate calculation capabilities at nucastrodata.org to include Big Bang Nucleosynthesis. This research is supported by the U.S. Department of Energy under grants DE-AC05-00OR22725 (ORNL) and DE-FG02-96ER40955 (TTU).

3A.00090 $n$-$d$ Analyzing Power at $E_{n}=21.0$ and 22.7 MeV. JEROMY TOMPKINS, Gordon College, M.W. AHMED, A.S. CROWELL, J.H. ESTERLINE, C.R. HOWELL, W. TORNOW, Duke University and TUNL, B.J. CROWE III, NCCU, R.S. PEDRONI, N.C. A&T University, G.J. WEISEL, PSU Altoona, I. SLAUS, Rudjer Boskovic, H. WITALA, Jagiellonian University — The $n-d$ analyzing power $A_{y}(\theta)$ was measured for $E_{n}=21.0$ MeV and $E_{n}=22.5$ MeV. Polarized deuterons were accelerated using the TUNL FN-Tandem into a $^{4}\text{He}$ gas cell to produce the incident polarized neutrons using the $^{4}\text{He}(d,\alpha)^{2}\text{H}$ source reaction. We used a deuterated scintillator as the center detector in our $A_{y}(\theta)$ measurements and a $^{3}\text{He}$ gas cell to determine the beam polarization. $A_{y}(\theta)$ values were taken at lab angles $39^\circ$, $60^\circ$, $81^\circ$, $94^\circ$, $107^\circ$, and $128^\circ$. This data addresses the long standing discrepancy between rigorous three-nucleon calculations and experimental data (3NAPP) in the unexplored neutron energy range from 19.0 to 30.0 MeV. Our results confirm the 3NAPP. They also show a sensible trend in the maxima and minima between $E_{n}=19.0$ and 30.0 MeV. This suggests that the theoretical treatment of the three-nucleus systems needs revision.

Funded by the NSF (NSF-PHY-05-52723) and the DOE, Office of Nuclear Physics (DE-FG02-97ER41033).

3A.00091 Two-Body Scattering Observables in a Truncated Harmonic Oscillator Basis. J. TORKKOLA, B. BARRETT, I. STETCU, U. VAN KOLCK, University of Arizona — The no-core shell model (NCSM) is a powerful many-body method which provides the solution to the Schrödinger equation for $J$ interacting nucleons in a restricted space [1]. The conventional approach uses high precision nucleon-nucleon (NN) potentials (and three-body forces) and involves a unitary transformation that takes into account the truncation of the (infinite) Hilbert space to a model space which allows for an exact large-scale diagonalization. However, in the process, one has to make a cluster approximation, which is under control for some observables (short-range observables), but less so for others (long-range observables) [2]. Based on a effective field theory (EFT) that integrates out the pions as degrees of freedom (pionless theory), we present a new approach to the derivation of effective interactions suitable for many-body calculations to be used within a NCSM framework. In this contribution, we concentrate on the description of two-body scattering observables in a restricted harmonic oscillator (HO) basis, and the inherent Gibbs oscillation problem that arises from the truncation of the Hilbert space using HO wave functions. In particular, we investigate the connection between the results obtained in leading order in the restricted HO basis and the corresponding continuum results [1].


3A.00092 Measurement of the Neutral Pion $A_{LL}$ with the PHENIX Muon. AARON VEITCH, PHENIX - UIUC — The PHENIX experiment at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory commissioned a new forward calorimeter during the 2006 polarized proton run. The Muon Piston Calorimeter, MPC, is a PbWO$_4$ based electromagnetic calorimeter that will cover $3.1 < \eta < 3.65$ in pseudo rapidity and $2\pi$ in azimuthal angle. The MPC will be able to reconstruct neutral pions with momenta up to $p \sim 100$ GeV, allowing a measurement of the double helicity asymmetry $A_{LL}$ in a kinematic region previously inaccessible in the PHENIX experiment. In this poster I will present the commissioning, operation, and calibration of the MPC, as well as the latest status from the analysis of the neutral pion $A_{LL}$ from the $\phi \rightarrow 0.2G$ run at RHIC.
3A.00093 Muon Piston Calorimeters for the PHENIX Forward Upgrade at RHIC. COLE WATTS, Abilene Christian University — New forward electromagnetic calorimeters for the PHENIX experiment at Brookhaven National Laboratory have been integrated into the PHENIX muon spectrometer magnet yokes. The two Muon Piston Calorimeters (MPCs) each consist of an array of PbWO$_4$ crystals, closely installed around the beam pipe. The South MPC was installed during the RHIC shutdown in 2005, while the North MPC, still in construction, is scheduled to be installed during the RHIC shutdown in 2006. The detectors have an angular acceptance of $3.1 < \eta < 3.65$ and $0 < \phi < 2\pi$ in azimuth. The two MPCs make it possible to measure cross sections and spin asymmetries for neutral pions in d-Au and polarized proton-proton collisions, respectively. We discuss the detector design, as well as the assembly and integration of the MPC in PHENIX, including the techniques used to prepare the PbWO$_4$ crystals.

3A.00094 Search for Cosmic Neutrinos Using UHE Upward-Going Muons in SK-II. KATIE WEST, Duke University — Astrophysical models predict a diffuse flux of cosmic neutrinos which should be an observable excess to the diffuse flux of atmospheric neutrinos at higher energies. Such high energy neutrinos are postulated to come from cosmic accelerators such as Active Galactic Nuclei (AGN’s), and Gamma Ray Bursts (GRB’s). This study searches for HE neutrinos (in the 1 TeV range) among Super-Kamiokande II’s highest energy sample by looking for ultra-high energy upward-going muons induced by HE neutrinos interacting in the rock beneath the detector. A total of three UHE-upmu candidates were found in 860.37 days of live-time. We are now in the process of determining the efficiencies of the cuts that were made. The search will be used to place a 90% confidence level limit on an assumed E$^{-2}$ spectrum for cosmic neutrino flux.

3A.00095 Setting limits on a new parameter outside of Standard Model muon decay. KRISTEN WILLIAMS, Cyclotron Institute - Texas A&M University — This work is a response to predictions concerning a new tensor interaction which is outside of the Michel local interactions of Standard Model muon decay. This interaction is assumed to be parameterized by the addition of a new variable, $\kappa$, to the differential decay probability spectrum. The TWIST experiment is measuring the Michel parameters $P$, $P_\xi$, and $\delta$ in muon decay to search for deviations from the Standard Model. Our analysis was of the approximate contribution that $\kappa$ would make to the TWIST measurements and the sensitivity of this contribution to the fitted momentum range. Efforts were made to set a limit on $\kappa$ in accordance with both past TWIST fit ranges and assumed future ones.

3A.00096 Proton Recoil Detectors and Fission Ionization Chambers for Neutron Dosimetry. BRENT WILSON, PEGGY MCMANAHAN, BRAD BARQUEST, MIKE JOHNSON, Lawrence Berkeley National Laboratory — This research involved the creation and development of detectors for the measurement of neutron flux. These detectors will be utilized to obtain dose information for fast neutron irradiations of electronic components, materials, and biological samples in the new neutron beamline at the 88-Inch Cyclotron at Lawrence Berkeley National Laboratory. As a first step, we have developed two well-established neutron detectors - the proton recoil detector and the fission ionization chamber - for the energy range of the neutrons at our facility, 5 to 30 MeV. Using activation foil measurements (to obtain absolute neutron flux) and time-of-flight measurements with a Stibene detector (to obtain the neutron energy spectra), we can calculate the efficiency of our detectors for both monoenergetic and white spectrum neutrons in this energy range.

3A.00097 Data Acquisition in Research and Development of Resistive Plate Chambers for the Trigger Upgrade for the PHENIX experiment at RHIC. JOHN WOOD, Abilene Christian University — To study the contributions of different flavors of quarks to the total spin of the proton, the PHENIX experiment at RHIC is installing a first-level trigger system employing Resistive Plate Chambers (RPC’s). The trigger will allow data to be taken from the decay of bosons produced in the parity-violating interactions of quarks during polarized p-p collisions with far less background by triggering on detection of high-$p_T$ muons produced during the decay. Prototypes of RPC’s are being built with different materials and tested at the University of Illinois to determine characteristics such as position resolution, timing resolution, and rate capability. The data acquisition system and visualization software for the test stand is presented in this poster. The system uses a number of CAMAC modules including a Jorway 73A crate controller.

3A.00098 Resistive Plate Chamber Test Stand and Read Out System for the PHENIX RPC Forward Upgrade. RYAN WRIGHT, Abilene Christian University, PHENIX COLLABORATION — The PHENIX experiment, using the Relativistic Heavy Ion Collider at BNL, uses polarized proton-proton collisions to study the origin of the proton spin. In order to facilitate this, the forward muon arms are being upgraded in order to provide a first level trigger for high $p_T$ muons resulting from W-boson interactions. The new trigger will be based on fast Resistive Plate Chambers to provide a fast trigger to reject low momentum muons. A test stand at the University of Illinois Urbana-Champaign has been set up to study the behavior of a small RPC. The setup used for the research contains drift chambers, scintillators, and a multitude of electronics for data acquisition. This allows for the tracking of cosmic rays through the RPC to study details of the behavior of the RPC. The test setup and goals of the research will be presented, with special attention given to the read out system and the pre-amps for the data acquisition.

3A.00099 Optics Simulations for the optimization of the CLAIRE Ion Beam Extraction and Transport System. NIAN XU, DAMON TODD, DANIELA LEITNER, Lawrence Berkeley National Lab — CLAIRE, Center for Low Energy Astrophysics and Interdisciplinary Research, is a proposed national astrophysics facility under design at the Lawrence Berkeley National Laboratory. The facility will measure cross sections relevant to stellar burning, namely $^3$He($^3$He,$\gamma$)$^7$Be, a reaction which is one of the leading sources of uncertainty when correlating solar neutrino data with theoretical solar models. A beam line concept has been developed to extract and transport a tightly focused (<5mm), high current (100mA), low energy (50keV–300keV) $^3$He$^+$ beam to a high density gas jet target. The beam is first extracted from a plasma ion source, and is then focused by two solenoid lenses mounted on a 3000V high voltage (HV) platform. The envelope of the accelerated beam leaving the HV platform is kept as small as possible by another lens before going through a 60° analyzing magnet. The last focusing solenoid lens produces the desired beam size on the target. An extensive simulation program was employed to optimize the extraction and the transport of the beam over the desired energy range. The detailed analysis of this simulation will be shown and discussed.

Thursday, October 26, 2006 8:30AM - 1:00PM — Session AA DNP: Future Directions in Nuclear Physics Gaylord Opryland Tennessee C
8:40AM AA.00002 Fundamental Investigations in QCD. W.A. ZAJC, Columbia University — Quantum Chromodynamics is both an integral part of the Standard Model and the archetype for nature’s non-Abelian gauge theories. The running coupling constant of QCD allows (requires) the theory to be studied in both the perturbative and the non-perturbative regime. Strongly interacting matter is predicted to have a rich phase structure, which is of particular interest in that QCD is the only fundamental theory with a phase transition that is currently accessible to direct experimental investigation. The intrinsically non-Abelian nature of QCD also leads to intriguing predictions of essentially classical fields in heavy nuclei at low momentum fraction. In addition, seemingly straightforward theoretical questions such as the origin of the proton’s spin remain only partially addressed because of complications arising from the strength of the interaction. Answers to those questions will depend on additional experimental measurements to quantify the contributions of the gluons and the sea to the nucleon’s spin. The opportunities to explore the rich structure of QCD at existing and future facilities will be presented, the current understanding of recent data will be reviewed, and the emerging connections of QCD to other fields of physics will be discussed.

9:15AM AA.00003 The JLab Physics Program Today and with the 12 GeV Upgrade. GORDON CATES, University of Virginia — JLab is bringing about a new and deeper understanding of nuclear matter, and with the 12 GeV upgrade, qualitatively new possibilities will open. JLab has accomplished many of its original goals, including exploring the transition between the nucleon/meson and quark/gluon regimes and a substantially improved understanding of the strong force. There have also been important discoveries. Precision studies of elastic scattering have shown an unanticipated $Q^2$ dependence of the ratio $G_E^p/G_M^p$, a result that has underscored the importance of quark orbital angular momentum (OAM). The role of OAM appears to be critical for understanding other results as well, including data from both inclusive and semi-exclusive deep inelastic scattering (DIS). An important theoretical achievement has been the development of generalized parton distributions (GPDs), which among other things, make it possible to understand both elastic and inelastic processes under a single theoretical framework. GPD’s are already being probed at JLab, and after the upgrade, it will become possible to do what is essentially tomography of the nucleon. Another important probe in electron scattering is the study of parity violating spin asymmetries. Experiments have already used parity violation (PV) to probe the role of strange quarks in the nucleon, and both precision electroweak tests as well as studies of the properties of neutron matter are planned. At 12 GeV, the study of PV in DIS will provide new information on both hadronic and electroweak physics. Finally, of great importance at 12 GeV will be the GlueX experiment that will search for new exotic hybrid mesons. Predicted to exist because of excitations of gluonic flux tubes, the discovery of these mesons might well provide the most definitive probe to date of the glue that makes up a large fraction of the nucleons mass.

9:50AM AA.00004 Towards a Deeper Understanding of the Nucleus with Exotic Nuclei. ERICH ORMAND, Lawrence Livermore National Laboratory — Despite more than fifty years of study, many questions about now nuclei are put together remain. While nuclei near the valley of stability have provided a wealth of information, they are not sufficient to provide us with a comprehensive and unified description of the nucleus. Especially lacking is an accurate picture of those exotic species that are the basis of cosmic alchemy. The missing pieces in the puzzle can be filled in with a determined experimental and theoretical effort focusing on nuclei lying far from the valley of stability. Here, I will outline the intellectual challenges that can be addressed by proposed exotic-beam facilities, and how new experimental data will quide and refine theoretical descriptions of the nucleus.

1This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory, under contract No. W-7405-Eng-48.

10:25AM AA.00005 Coffee Break —

11:00AM AA.00006 How nuclear physics is helping us get beyond the Standard Model. STUART FREEDMAN — Nuclear physics experiments were instrumental in establishing the elements of the weak interaction that are incorporated into the Standard Model. After decades of scrutiny there are now substantial indications that require important Standard Model revisions. Nuclear physics continues to play a key role. I will discuss some new results and some of the key discoveries that may be just around the corner.

11:35AM AA.00007 Long Range Plan Introduction, S. SEESTROM, Los Alamos National Laboratory —

11:45AM AA.00008 Long Range Plan Overview, R. TRIBBLE, Cyclotron Institute, Texas A&M University —

12:05PM AA.00009 Long Range Plan Discussion —

12:55PM AA.00010 Closing Remarks, S. SEESTROM, Los Alamos National Laboratory —

Thursday, October 26, 2006 2:00PM - 4:24PM —

Session BA DNP: Societal Impact of Nuclear Physics Gaylord Opryland Tennessee C

2:00PM BA.00001 A Medical Application of Nuclear Physics: Particle Radiotherapy with Protons, JONATHAN B. FARR, Midwest Proton Radiotherapy Institute; Indiana University, Department of Physics — Since the discovery of radiation, applications have been made to medicine. The advent of higher energy particle accelerators in the second half of the twentieth century enabled modern teletherapy using relatively high energy x-rays and particles. Today mega-voltage (MV) x-rays are the most common modality of delivering high doses of potentially life saving radiation to a wide variety of disease, mostly malignant cancers. However, the maximum radiation dose that can be delivered is always limited by the effects to critical surrounding biologic structures. In many cases, due to their physical properties, “heavy” particle radiotherapy with protons and light ions may provide an advantage in this respect over MV x-rays allowing either a higher dose of radiation to be delivered to the volume or, for the same dose, reducing the concomitant damage to critical structures. This motivation, together with recent advances in particle therapy systems that are making the technology more readily available, is serving to grow the field of particle therapy. In particular, treatment with fast protons is becoming more widespread with over 20 facilities operating worldwide and more under construction. This presentation will provide an introduction to heavy particle therapy and additional details specifically on proton therapy.

2:36PM BA.00002 The future of energy security in the 21st Century, RAJAN GUPTA, Los Alamos National Laboratory, Group T-8 — Energy is essential for modern life and is a critical resource that we take for granted. Economies and security of nations depend on reliable and cost-effective access. As the world transitions from conventional oil and natural gas to nuclear, renewables, and unconventional sources we are increasingly confronted by many unsettling questions. Will there be enough cheap oil and gas for preserve the standard of living in the developed world and allow the industrializing world to develop? Will renewable sources provide a significant fraction of our energy needs in the near future? Is global warming already happening as a result of our consumption of fossil fuels? If there is a resource crunch before new sources come on line, will there be conflict or global cooperation? This talk will attempt to answer these questions by examining the global oil and gas resources, geopolitics, and key science and technology issues that need to be addressed by the global community with cooperation and a sense of urgency.
3:12PM BA.00003 Global Nuclear Energy Partnership: Origin and Path Forward , VICTOR H. REIS, Global Nuclear Partnership (GNEP) — The Global Nuclear Energy Partnership (GNEP) will be discussed, starting with its origins. The discussion will include the challenges to realizing the GNEP vision; these challenges are technical, economic, and political. The role of number of on-going activities will be discussed. The national science community, and nuclear science in particular, has the potential to contribute to advancement of GNEP on both technical and political fronts. This presentation will be used to engage the nuclear science community in a a dialog about how they might effectively contribute.

3:48PM BA.00004 Non-destructive Elemental Analysis on Paintings and Metal Artifacts1 , ANDREAA DENKER, Ionenstrahllabor, Hahn-Meitner-Institut, Glienicker Str., 100, D 14109 Berlin — In most cases sampling on art objects is prohibited for several reasons: The uniqueness of the objects, their - intellectual - value, and their fragility. In the cases where sampling is authorized, it is only possible on hidden places, not, e.g. in the facial region of a portrait. Therefore, non-destructive methods have to be applied in order to obtain information about the composition and structure of the objects. One non-destructive method of choice is the proton induced X-ray Emission (PIXE). High energy protons with an energy of around 60 MeV have a large range in the investigated material and, therefore, can provide information from deep inside the object. Measurements on ancient paintings, providing complementary information to the Neutron Autoradiography, as well as the analysis of Bronze Age and Medieval metal objects, will be presented.

Thursday, October 26, 2006 2:00PM - 4:00PM — Session BB DNP: Neutrino Physics | Gaylord Opryland Tennessee A

2:00PM BB.00001 Charged-current cross section measurements in MiniBooNE , TEPPEI KATORI, Indiana University, MINIBOONE COLLABORATION — The MiniBooNE experiment is a short baseline electron neutrino appearance experiment at FNAL. In addition to oscillation physics, the Booster neutrino beam offers excellent neutrino cross section measurements. The charged-current (CC) interaction is the most fundamental process for neutrino physics, and so requires careful investigation. The high statistics data set of MiniBooNE will shed light on this process. We will discuss recent developments in the analysis of the CC interaction, including charged-current quasi-elastic (CCQE) and charged-current pion production (CC1π).

2:12PM BB.00002 A Search for $\nu_\mu \to \nu_e$ with the MiniBooNE Experiment , REX TAYLOE, Indiana University, MINIBOONE COLLABORATION — The MiniBooNE experiment, located at Fermilab, is designed to test, with high sensitivity, the LSND result which indicates $\nu_\mu \to \nu_e$ oscillations with a probability of $0.264 \pm 0.067 \pm 0.045\%$. MiniBooNE searches for $\nu_\mu \to \nu_e$ oscillations in a high-purity, narrow-band $\nu_\mu$ beam of average energy 800 MeV. The detector is located 550 m from the neutrino source, consists of 800 tons of mineral oil, and records Cerenkov light produced in the signal reaction, $\nu_e n \to e^- p$. The experiment and analysis methods will be discussed and results from the neutrino oscillation search will be presented.

2:24PM BB.00003 A measurement of neutrino nucleon elastic scattering in MiniBooNE , D. CHRISTOPHER COX, Indiana University, MINIBOONE COLLABORATION — Neutrino nucleon elastic scattering $\nu N \to \nu N$ is a fundamental process of the weak interaction, and provides insight into the structure of the nucleon. In MiniBooNE, a neutrino oscillation experiment at Fermilab, this process comprises about 15% of all neutrino interactions, making it MiniBooNE’s third largest scattering process with over two hundred thousand events expected in the current data sample. A measurement of this process in MiniBooNE will be presented.

2:36PM BB.00004 Future Prospects for the Booster Neutrino Beamline at FNAL , CHRIS POLLY, Indiana University, MINIBOONE COLLABORATION — The Booster neutrino beamline at FNAL was constructed to provide a high-intensity source of neutrinos in the 1 GeV range for the MiniBooNE experiment. Short-term plans for the beamline include the continued operation of the MiniBooNE detector with the beam in antineutrino mode, and the addition of the former K2K SciBar detector in a near location for the SciBooNE experiment. Longer-range possibilities include BooNE, an improved oscillation measurement via the addition of a second large-volume Cerenkov detector, and FINeSSE, a fine-grained detector for measuring cross sections with an emphasis on neutral current interactions.

2:48PM BB.00005 Free Proton Charged Current Cross Section using MiniBooNE Anti-Neutrino Data , HEATHER RAY1, Los Alamos National Laboratory, MINIBOONE COLLABORATION — The MiniBooNE experiment completed neutrino running in the fall of 2005 and switched to anti-neutrino running in early January in 2006. The anti-neutrino data sample provides a set of charged current quasi-elastic events which may be used to extract a measurement of the free proton cross section. This talk will focus on the status of the $\nu_\tau$ CCQE free proton cross section measurement.

3:00PM BB.00006 Event Reconstruction and Particle Identification for MiniBooNE Experiment1 , HAIJUN YANG, University of Michigan — The MiniBooNE experiment at Fermilab is designed to confirm or refute the evidence for $\nu_\mu \to \nu_e$ oscillations at $\Delta m^2 \sim 1 eV^2/c^4$ found by the LSND experiment. It is a crucial experiment which may imply new physics beyond the standard model if the LSND signal is confirmed. This talk will focus on the event reconstruction, event identification (or Particle Identification) based on boosted decision trees and expected $\nu_\mu \to \nu_e$ oscillation sensitivity.

1This work is supported by DOE/LANL grant.
3:12PM BB.00007 Results for the Cross Section of the Reaction $^{12}$C(n,n'γ)$^{12}$C* (4.44 MeV) at $E_n$ = 6.20 and 6.34 MeV using Gamma Ray Detection1, M.F. KIDD, J.H. ESTERLINE, B. FALLIN, A. HUTCHESON, A.P. TONCHEV, W. TORNOW, Duke University and TUNL, J.H. KELLEY, North Carolina State University and TUNL. The $\nu$ energy spectrum measured by KamLAND is contaminated with background events which are a result of the neutrinos from the $^{13}$C(α,n)16O reaction. Because the energy range of these neutrinos reaches $E_{\nu} = 7.3$ MeV, the inelastic scattering off $^{12}$C to the 2$^+$ first excited state at 4.44 MeV can occur in the liquid scintillator for $E_{\nu}$ exceeding 4.85 MeV. The neutron from the inelastic scattering is indistinguishable from the neutron of interest in the anti-neutrino detection process $\bar{\nu} + p \rightarrow e^+ + n$, and the subsequent $\gamma$ from the deexcitation mimics the positron. Using the Shielded Neutron Source at TUNL with a gamma ray detection setup, we have measured the differential gamma-ray production cross section for this reaction. Clover detectors were placed 62°, 90°, and 135° from the incident pulsed neutron beam direction at distances of 9.75 cm, 5.7 cm, and 9.2 cm respectively from a 0.75" diameter by 1.0" high graphite cylinder. The differential cross section was measured at neutron energies of 6.20 and 6.34 MeV with an energy spread of 0.14 MeV.

1Work supported by U.S. DOE under contract numbers DE-FG02-97ER41033, DE-FG02-03ER41231, and DE-FG02-97ER41042.

3:24PM BB.00008 Differential cross sections for $^{13}$C(α,n)$^{16}$O reaction1, CYNTHIA WOOD, UNC and TUNL, BRUNO BRAIZINHA, HUGON KARWOWSKI, MARY KIDD, Duke and TUNL, WERNER TORNOW. The reaction $^{13}$C(α,n)$^{16}$O is the major source of correlated background in the prompt energy spectrum obtained at KamLAND. The source of α-particles is the decay of $^{210}$Po. In the α-particle energy range from 2.5 and 5.4 MeV there are more than 20 resonances present in the (α,n) excitation function. To reduce the uncertainties, a high precision measurement of the differential cross section data for $^{13}$C(α,n) was made. The α-particle beam was produced at the TUNL Tandem accelerator and directed onto self-supporting 100 to 200 μg/cm2 thick $^{13}$C targets. Outgoing neutrons were detected in eight LS detectors placed at lab angles between 23° and 150° and identified by pulse shape discrimination. The differential cross section data will be presented and normalization techniques will be discussed.

1Work supported in part by the US DOE under grant #’s DE-FG02-97ER41041 and DE-FG02-97ER41231.

3:36PM BB.00009 Multianode Photomultiplier Tube Alignment for the MINERvA Experiment at Fermilab, JORGE BRUNO. James Madison University, MINERVA COLLABORATION. The MINERvA experiment (Main Injector Experiment vA) at FNAL will study the neutrino-nucleon and neutrino-nucleus interaction. The light collection from the detector will be done via optic fibers using Hamamatsu H8804 64-channel photomultiplier tubes (PMT). Each PMT channel needs to be precisely aligned with the corresponding optic fiber. The MINERvA PMT optical boxes contain precision machined optic “cookies” which capture the 8x8 array of optic fibers. Each PMT-cookie pair needs to be aligned as precisely as possible. This contribution will describe the alignment setup and procedure implemented at James Madison University.

3:48PM BB.00010 A Global three-parameter model for neutrino oscillations using Lorentz violation, TEPPEI KATORI, ALAN KOSTELECKY, REX TAYLOE, Indiana University. The neutrino oscillation experiment is a natural interferometer. It is sensitive to small spacetime properties without using the photon (QED) but the sensitivity is comparable with precision optical measurements ($< 10^{-19}$GeV). So neutrino oscillations may be seeing small spacetime effects, such as Lorentz violation. Lorentz and CPT violation are predicted phenomena from Planck scale physics and are actively studied, mainly under the Standard-Model Extension (SME) formalism, the Standard Model with Particle Lorentz Violation. We have developed a model of neutrino oscillations that has only three degrees of freedom and is consistent with existing data under the renormalizable sector of SME, and it offers an alternative to the standard 3-neutrino massive model. All classes of neutrino data are described, including solar, reactor, atmospheric, and LSND oscillations. The disappearance of solar neutrinos is obtained without matter-enhanced oscillations (MSW effect). Quantitative predictions are offered for the ongoing MiniBooNE experiment and for the future experiments OscSNS, NOνA, and T2K.

Thursday, October 26, 2006 2:00PM - 4:48PM
Session BC DNP: Nuclear Structure I Gaylord Opryland Tennessee B

2:00PM BC.00001 A Direct Measurement of the Neutron-Neutron Scattering Length: Progress and Status1, S.L. STEPHENSON, B.E. CRAWFORD, Gettysburg College, C.R. HOWELL, W. TORNOW, Duke University and TUNL, G.E. MITCHELL, NC State University and TUNL, W.I. FURMAN, A.R. KRYLOV, E.Y. LYCHAGIN, A. YU. MUZICHKA, G.V. NEKHAEV, E.I. SHARAPOV, V.N. SHVETSOV, A.V. STRELKOV, JINR, Dubna, Russia, YU. I. CHERNUKHIN, YA. Z. KANDIEV, B.G. LEVAKOV, A.E. LYZHIN, G.V. NEKHAEV, E.I. SHARAPOV, JINR, Dubna, Russia — A direct measurement of the neutron-neutron scattering length ($\langle a_{nn} \rangle$) provides a unique contribution to understanding charge symmetry breaking in the nuclear force. A brief status report on such an experiment at the YAGUAR reactor facility will be given.

1This work was supported in part by ISTC project 2286, RFBR grant 05-02-17636, NSF grants 0555662 and 0107293 and DOE grants DE-FG02-97ER41042 and DE-FG02-97ER41033.

2:12PM BC.00002 Variational microscopic treatment of halo nuclei1, IVAN BRIDA, FILOMENA NUNES, NSCL and Department of Physics and Astronomy, Michigan State University, East Lansing MI 48824, KALMAN VARGA, Vanderbilt University, Nashville, TN 37235 — We present first results of a variational microscopic model for two neutron halo nuclei. The wavefunction of the system consists of two parts: a core and the valence neutrons. The core is given in terms of correlated Gaussians. The three-body asymptotics and dynamics between the core and valence neutrons are taken into account by means of hyperspherical functions employed to describe the motion of the valence particles. To avoid the spurious motion of the center of mass, Jacobi coordinates are used for the entire system. The wavefunction is properly antisymmetrized. Both - core’s and valence – pieces of wavefunction contain nonlinear parameters involved in energy minimization procedure. Results for $^6$He are presented and compared with the three-body model.

1This work is supported by the NSF through grant PHY-0456656.
2:42PM BC.00003 Ab Initio Calculations of Electroweak Matrix Elements.1 MUSLEMA PERVIN, ROBERT WIRINGA, STEVEN PIEPER, KENNETH NOLLETT, Argonne National Laboratory — The variational Monte Carlo (VMC) and Green’s function Monte Carlo (GFMC) techniques are powerful tools for calculating properties of light nuclei. These methods in combination with the Argonne v18 (AV18) two-nucleon and Illinois-2 (IL2) three-nucleon potentials, reproduce the energies of many bound and narrow states in nuclei up to A = 12. They have also been applied to calculate properties beyond the structures of nuclei, for example, radiative capture cross sections and electroweak matrix elements. We are now exploring some nuclear transitions particularly electromagnetic transition strengths and nuclear beta decay rates, with the GFMC technique using the AV18 + IL2 potential for nuclei with A = 6 to 8. A few of the transitions have previously been calculated using the more approximate VMC technique but with an older potential. However, GFMC wave functions are better approximations to the true wave functions, hence GFMC results for these transitions should be more reliable.

1This work was supported by: Department of Energy, Office of Nuclear Physics, contract no. W-31-109-ENG-38.

2:36PM BC.00004 Towards a Laser Spectroscopic Determination of the 8He Nuclear Charge Radius1 P. MULLER, K. BAILEY, R.J. HOLT, R.V.F. JANSSENS, Z.-T. LU, T.P. O’CONNOR, J.P. SCHIFFER, I. SULAI, Argonne National Laboratory, M.-G. SAINT LAURENT, J.-CH. THOMAS, A.C.C. VILLARI, GANIL, O. NAVILIAT-CUNCIC, X. FLECHARD, Laboratoire de Physique Corpusculaire, Caen, S.-M. HU, University of Science and Technology of China, G.W.F. DRAKE, University of Windsor, M. PAUL, Hebrew University — 8He (t1/2 = 119 ms) has the highest neutron to proton ratio of all bound nuclei. Precision measurements of its nuclear structure shed light on nuclear forces in neutron rich matter that, for example, play a critical role in neutron stars. Our experiment to measure the 8He rms nuclear charge radius to be 2.054(14) fm. We are currently well on the way to improve the overall trapping efficiency and signal-to-noise ratio of our system to compensate for the shorter lifetime and lower production rates of 8He as compared to 6He. The 8He measurement is planned to be carried out at the GANIL cyclotron facility in Caen, France in late 2006.

1This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. W-31-109-ENG-38

2:48PM BC.00005 Large Study of Short-Range Correlations in 12C(e,e'pn), RAMESH SUBEDI, Kent State University, JEFFERSON LAB E01-015 COLLABORATION, JEFFERSON LAB HALL A COLLABORATION — Experiment E01-015 at JLab Hall A has been investigating electron induced two nucleon emission from carbon with the goal of being sensitive to and studying short-range correlations. The experiment took data from January through April 2005 at a kinematic coverage of Q2 = 2 (GeV/c)2, xp = 1.2 and the missing momentum from 12C(e,e'p) reaction ranging 250 to 650 MeV/c. Two high resolution spectrometers were used for e' and p detection in the reaction 12C(e,e'pn). The recoiling neutrons were detected by a neutron detector which covered an 81 msr solid angle and consisted of 4 layers of neutron counters, each layer being 10 cm thick. We used a time-of-flight method to reconstruct the neutron momentum. Short-range correlations can be emulated by various two-body effects, so we chose an anti-parallel kinematics with high Q2 at xp > 1 to minimize meson exchange currents, isobar currents and final-state interactions. Preliminary analysis results from 12C(e,e'p) reaction will be presented.

3:00PM BC.00006 Microscopic Coupled Cluster approach to Neutron Rich Nuclei, GAUTE HAGEN, DAVID DEAN, Oak Ridge National Laboratory, MORTEN HJORTH-JENSEN, UiO, THOMAS PAPENBROCK, ORNL — Building nuclei from the ground up starting with the bare nucleon-nucleon interaction is a major challenge in nuclear structure today. We present results starting with the fully microscopic Coupled Cluster approach. Critical role in theory today, is correlation on a given reference state through an exponential correlation operator acting on the reference state. We have implemented Coupled Cluster with two- and three-body forces and present ab-initio calculations of O16 starting with a two- and three-body low-momentum interaction. Further, we have extended the Coupled Cluster technique to the complex energy plane using a complex single-particle basis where bound, resonant and continuum states are treated on equal footing. This allows for an ab-initio description of nuclei far from the valley of stability, and results of the various ground-states of the Helium isotopes, starting with a realistic nucleon-nucleon interaction are presented. Within this formalism we are able to reproduce basic properties of these nuclei, such as He5 unbound and He6 bound in its ground state.

3:12PM BC.00007 Study of 18Ne Structure by 14O+Alpha Elastic Resonance Reaction, CHANGBO FU, V.Z. GOLDBERG, G.V. ROGACHEV, G.C. CHUBARIAN, G. TABARACU, M. MCCLESKEY, Y. ZHAI, T. AL-ABDULLAH, L. TRACHE, A. BANU, R.E. TRIBBLE, Cyclotron Institute, Texas A&M University, TEXAS A&M UNIVERSITY TEAM — Data on the α cluster structure in NpZ nuclei are very scarce, however a recent work [1] showed unusual features of α cluster states in these nuclei. It was also shown in [1] that a comparison study of mirror α cluster states in T=1 nuclei can result in understanding of some details of nuclear structure resulting in α cluster configuration. Besides this, the astrophysical impact of the knowledge of the 14O+α interaction is well known. We report the use of an 14O beam at the Texas A&M University [2], produced by MARS facilities [3], to study resonances in the 14O+α interaction. The α-14O resonance interaction was studied using the Thick Target Inverse Kinematics (TTIK) method. The time of flight method, providing for the possibility of the identification of low energy particles, was used to identify reaction products. New states with large α cluster reduced widths were found in 18Ne in the excitation energy region 8-16 MeV. The alpha structure in 18Ne and in 16O is discussed using results obtained in on 14C+α interaction. References [1] V. Z. Goldberg et al., Phys. Rev. C 69, 024602 (2004). [2] V. Z. Goldberg et al., Phys. Rev. C 69, 031302 (2004) [3] R. E. Tribble et al., Nucl. Phys. A701, 278c (2002)

3:12PM BC.00008 Production of light neutron-rich nuclei in fusion-evaporation reactions1, M. WIEDEMANN, P. FALLON, A.O. MACCHIAVELLI, L.W. PAIR, D.L. BLEUEL, R.M. CLARK, M. CROMAZ. M.A. DEPLELANQUE, J.D. GEBIEN, I-Y. LEE, L.G. MORETTO, E. RODRIGUEZ-VIEITEZ, D. WARD, LBNL, Berkeley, CA 94720, L.A. BERNSTEIN, J.T. BURKE, B.F. LYLES, LNL, Livermore, CA 94550 — I will discuss our work to extend the experimental data on light neutron-rich nuclei and present new results on 18N (Z=7), which is sufficiently far from stability to exhibit modified shell structure, yet still within the reach of stable beam facilities. 18N was produced using the 9Be(14,2p)18N fusion reaction at LBNL’s 88-Inch Cyclotron and studied using STARS-LIBERACE, a large area segmented silicon ∆E-E detector telescope and six HPGe “Compton Suppressed” Clover detectors. Previous information on the excited states of 18N came from 15C beta-decay and charge-exchange reactions only. A key aspect of the current measurement was to use the 2-proton evaporation reaction channel. The large Q-value and the chosen beam energy (50 MeV) suppressed the evaporation of additional neutrons, with the result that a 2p “gate” uniquely selected the 18N products.

1Supported by the U.S. DoE, LBNL Contract No. DE-AC02-05CH11231 and LNL Contract No. W-7405-Eng-48.
3:36PM BC.00009 First excited state of doubly-magic $^{24}$O 1. N. FRANK, Michigan State Univ./Nat. Superconducting Cyclotron Laboratory, A. SCHILLER, BAUMANN, NSCL, J. BROWN, Wabash College, P. DEYOUNG, Hope College, J. HINNEFELD, Indiana Univ. at South Bend, R. HOWES, Marquette Univ., J.-L. LECOUYE, Laboratoire de Physique Corpusculaire, B. LUTHER, Concordia College, W.A. PETERS, M. THONESENNES, Michigan State Univ./NSCL — Neutron separation energy systematics indicate the formation of a new magic number $N=16$ close to the drip-line. The energy of the first $2^+$ state may indicate or invalidate the existence of a shell closure. The search for excited states in $^{23,24}$O using in beam $\gamma$ ray spectroscopy has yielded no results, which could indicate that the $2^+$ state is neutron unbound. In order to unambiguously identify $^{24}$O as a doubly magic nucleus, we therefore have resorted to neutron decay spectroscopy. Experimentally, the two-proton-knockout reaction of a 86 MeV/u $^{20}$Ne beam on a Be target at the fragment–fragmentation radiobeam facility of the National Superconducting Cyclotron Laboratory was investigated and ~ 5000 neutron–$^{20}$O coincidences were recorded using the Sweeper/MoCA setup. From these events, a decay energy spectrum was reconstructed which combined with the neutron separation energy of $^{24}$O yields an excitation energy of the first excited state of $^{24}$O in the order of 3.6 MeV, in agreement with new shell-model calculations.

This work was supported by the National Science Foundation Grant No. PHY-01-10253.

3:48PM BC.00010 Compressional-mode Giant Resonances in $^{24}$Mg 1. P.V. MADHUSSUDHANA RAO, T. LI, B.K. NAYAK, U. GARG, Physics Department, University of Notre Dame, Notre Dame, IN 46556, USA, M. ITOH, M. YOSOI, M. UCHIDA, H. TAKEDA, Y. YASUDA, H. SAKAGUCHI, Dept. of Physics, Kyoto University, Kyoto 606-8502, Japan, H. FUJIMURA, K. HARA, M. FUJIWARA, RCNP, Osaka University, Osaka 567-0047, Japan, T. KAWABATA, CNS, University of Tokyo, Tokyo 113-0033, Japan, H. AKIMUNE, Dept. of Physics, Konan University, Hyogo 658-8501, Japan, M.N. HARAKEH, KVI, 9747 AA Groningen, The Netherlands — A precise measurement of the incompressibility of nuclear matter ($K_{nm}$) will be discussed.

This work is supported in part by the U.S. National Science Foundation, JSPS and the University of Notre Dame.

4:00PM BC.00011 Studying the Transition to the Island of Inversion E. RODRIGUEZ-VIEITEZ, P. FALLO, R.M. CLARK, M. CROMAZ, M.A. DELEPLANQUE, I.Y. LEE, A.O. MACCHIABELLI, F.S. STEPHENS, M. WIEDEKING, LBNL, Berkeley, CA 94720, S.G. PRUSSIN, UC Berkeley, CA 94720, D. BAZIN, C.M. CAMPBELL, J.M. COOK, D.-C. DINCA, A. GADE, T. GLASMACHER, W.F. MUELLER, K. YONEDA, NSCL, Michigan State University, East Lansing, MI 48824 — The existence of deformed (2p2h) intruder gsr states in A~39 N~20 nuclei ("island of inversion") signals a modification of conventional shell structure in neutron-rich nuclei. While intruder ground states have been identified in e.g. $^{30}$Ne and $^{31}$Na, questions remain as to where the normal-to-deformed transition occurs and the nature of their collectivity: data on excited states will help answer these questions. An experiment was conducted at MSU to study N~20 Ne and Na nuclei. A 140 MeV/A $^{40}$Ca primary beam produced secondary-beam "cocktails" ($^{29}$Na/$^{30}$Mg/$^{31}$Al, $^{32}$Mg/$^{33}$Al/$^{35}$Si) which underwent secondary reactions to produce Ne and Na; $\gamma$-ray decays were detected by the segmented Ge array, SeGA, and $\gamma-\gamma$ coincidences were critical to establish a correct level scheme in e.g. $^{26}$Ne. The data provide information on the transition to the island of inversion and a test of recent shell-model calculations.

4:12PM BC.00012 $^{32}$S(\(p,\gamma\)) and its relevance to calibrating a $^{33}$Ar beta-delayed proton spectrum S. MARAJITI TRIAMBAK, ALEJANDRO GARCIA, DAN MELCONIAN, University of Washington, MEGHAN MELLA, University of Northern Colorado, OWEN BIESEL, University of Washington — Bounds on scalar contributions to the weak-interaction have been obtained from a measurement of the $^{32}$Ar e$^{-} + \nu$ correlation which is determined from the shape of the beta-delayed proton spectrum. The proton-energy calibration plays an important role and is obtained using delayed proton groups from $^{33}$Ar, corresponding to resonances in $^{32}$S(\(p,\gamma\)). In order to check for potential systematic effects and to improve the precision of the above experiment we have performed a high precision measurement of excitation energies of the relevant states corresponding to $^{32}$S(\(p,\gamma\)) resonances. We also measured the relative gamma branches and width of the second $J^{\pi} = 3/2^{+}$ excited state in $^{34}$Cl. The relative gamma branches are in significant disagreement with a previous measurement. Using our value for the width we are able to resolve an apparent discrepancy. \cite{1}


4:24PM BC.00013 Large Scale Shell Model Studies of M1 Strength in Argon and Calcium Isotopes A.F. LISETSKYI, GSI, Darmstadt, Germany, E. CAURIER, IRS, Strasbourg, France, K. LANGANKE, G. MARTINEZ-PINEDO, GSI, Germany, P. VON NEUMANN-COSEL, TU Darmstadt, Germany, F. NOWACKI, IRS, Strasbourg, France, A. RICHTER, TU-Darmstadt, Germany — We have calculated the M1 strength distributions in the 36–40Ar and 40Ca isotopes within large-scale shell model studies which consider valence nucleons in the sd and pf shells. While the M1 strength in $^{36}$Ar is well reproduced within the sd shell, the experimentally observed fragmentation of the M1 strength in $^{38}$Ar and $^{40}$Ca requires n-particle n-hole excitations with $N \geq 4$ from the sd to the pf shell. The mechanism of M1 strength fragmentation and the role of different n-particle n-hole cross-shell excitations are discussed.

4:36PM BC.00014 Binding-Energy Systematics of 0$^+$, 2$^+$, 3$^-$, and 4$^-$ T=0 States of Even-Even Self-Conjugate Nuclides from $^{16}$O to $^{40}$Ca A. FRIEDRICH EVERLING, NCSU, Raleigh, NC, and TUNL, Durham, NC, USA (Early affiliation; present address: Ringheide 24 f, 21149 Hamburg, Germany; everling@ncaud.com) — Binding energies of self-conjugate even-even nuclides are plotted as $B^+ (9.5$ MeV) A versus mass number $A$, where $B^+$ is the binding energy of ground states and levels. A diagram from $A=0$ to 76 mainly for ground states shows a subshell systematics. In a diagram from $A=16$ to 40, established and hypothetical $0^+$ levels are shown; 24 states of supposed 1d$_{3/2}$, 2s$_{1/2}$, and 1d$_{5/2}$ subshell occupations are connected by almost linear trends. Surprisingly, early insufficient measurements at $E_\gamma = 0.65$ MeV in $^{20}$Ne and 0.5 (and 0.43) MeV in $^{32}$S fit the trends. A diagram for the 0$^+$, 2$^+$, 4$^-$, and 6$^+$ from $^{16}$O to $^{28}$Si suggests the 0$^+$ head in $^{28}$Ne to be at 0.65 MeV. A systematics of 2$^+$ states supports both levels. A plot of 3$^-$ and 4$^-$ states contains two pairs of nearly parallel and linear 3-point trends. Two odd 2s$_{1/2}$ and 1f$_{5/2}$ nucleons couple to 3$^-$ and (not completely established) to 4$^-$ in trends $\approx 1.6$ and $\approx 1.7$ MeV above. Below each of the two pairs of trends, the 0$^+$ trends are expected to be also nearly linear, which they are with these complementary $^{20}$Ne and $^{32}$S levels. A table suggests a total of 18 important experimental investigations.
BC.00015 Binding-Energy Systematics of $0^+$, $T=1$ and $1^+$, $2^+$ and $3^+$, $T=0$ States of Odd-Odd Self-Conjugate Nuclides from $^{11}$N to $^{38}$K, FRIEDRICH EVERLING, NCSU, Raleigh, NC, and TUNL, Durham, NC, USA (Early affiliation; present address: Ringheide 24 f, 21149 Hamburg, Germany; everling@aol.com) — Binding energies of self-conjugate odd-odd nuclides are plotted as $-B^+_Z+(9.5\text{ MeV})$. A versus mass number $A$. Four diagrams show all $0^+$, $T=1$ and $1^+$, $2^+$, and $3^+$, $T=0$ states and those without $J^*$. The connection of states by almost linear trends leads to approximate parallelisms or to single trends if supplemented by complementary levels and reference points. Including 8 unarranged states according to the phenomenon of 6 MeV steps, 99 states are involved with supposedly relatively clean subshell configurations. Of these, 65 have the corresponding spin, while for 15 known levels the spin has not yet been determined. Four states are complementary and 15 are just reference points, most of them probably forbidden. Two additional complementary levels are isobaric analogs at $A=14$. Trends with different spins are combined in pairs to show parallelisms associated with a spin-flip. The energy gain upon addition of four $1d_{5/2}$ nucleons is almost constant, independent of the occupation of the $1d_{5/2}$ and $1d_{3/2}$ subshells, but not of the $2s_{1/2}$ subshell. A table lists 40 levels for which experimental clarification is needed. The nuclide $^{22}$Na has 9 reference points, probably mainly forbidden states caused by the abnormal ground state of the $^{20}$Ne core.

Thursday, October 26, 2006 2:00PM - 3:48PM
Session BD DNP: Mini-symposium on Applications of GEM Technology

2:00PM BD.00001 Development and Applications of the Gas Electron Multiplier, FABIO SAULI, INFN Trieste and CERN — Detectors based on the Gas Electron Multiplier (GEM), introduced a few years ago, have excellent high rate capabilities and are used for fast tracking in several HEP experiments. After a brief general introduction on gaseous micro-pattern devices, I will describe the major operating characteristics of GEM-based detectors, and provide examples of implementation and performances in running and proposed experiments. Novel developments include the use of GEMs as end-cap detectors in Time Projection Chambers for the Linear Collider and for a Hadreron-Blind detector at BNL. Coating the first GEM in a cascade with a photosensitive layer permits to detect and localize single photons; recent developments in view of applications in Cherenkov Ring Counters will be described. The excellent micro-pattern imaging characteristics are exploited for neutron detection and for measurement of X-ray attenuation in astrophysics. Operation in cryogenic conditions has also been demonstrated, opening the way to new possibilities in detection of WIMPs and dark matter.

2:36PM BD.00002 Advances in Thick GEM-like (THGEM) multipliers, AMOS BRESKIN1, RACHEL CHECHIK, MARCO CORTESE, Weizmann Institute of Science, VOLKER DANGENDORF, PTB Braunschweig, WEIZMANN TEAM, PTB TEAM — The concept and properties of the novel and robust Thick GEM-like (THGEM) hole-multiplier, economically produced by standard printed-circuit techniques, is presented. It has a GEM-like structure and operation mode, with dimensions expended to the sub-mm to mm scales, and mechanically-drilled holes etched at their rim. Very high electron multiplication, $10^3$ and $10^7$ in single- and double-THGEM elements were reached; very efficient electron transport into and out of the holes permits efficient multi-element cascading. The fast avalanche buildup leads to ns timing properties and rates exceeding MHz/mm². The THGEM can efficiently detect single gas-ionization electrons or radiation-induced electrons from a solid converter — e.g., a photocathode deposited on its top surface. The former is important for particle tracking, x-ray imaging etc., and the latter has important applications in photon and neutron imaging. The results of recent studies will be presented, including sub-mm imaging properties of a 100x100 mm² detector prototype. Potential applications will be discussed: UV-photon imaging in RICH, moderate-resolution tracking, TPC read out, sampling elements in calorimetry, x-ray and neutron imaging, charge and light detection in 2-phase noble-liquid detectors etc.

3:00PM BD.00004 A novel idea for an ultra-light cylindrical GEM based vertex detector, DANILIO DOMENICI, GIOVANNI BENCIVENNI, ENZO IACUESSA, STEFANO LAUCIANI, FABRIZIO MURTAS, LNF - INFN — An ultra-light cylindrical triple-GEM detector for vertex purposes is being developed. The cathode, the three GEMs and the anode are five concentric cylinders, obtained winding parallel-grooved foils, with a resulting helicoidal junction overlap (~3 mm wide). The result is a wholly cylindrical GEM, almost free of dead-zones and with support frames inside the active area, fruitfully usable as a vertex detector. The detector is also extremely light: considering that the material used is mainly kapton, and the possibility to reduce the copper layer thickness to 2μm, a single tracking layer can have a material budget as low as 0.2% of $X_0$. The readout of the detector is performed with large stereo angle U-V strip layers: one directly realized on the anode electrode, and the other onto the bottom side of the third GEM foil. Considering a large stereo angle of about 40 degrees and a strip pitch of 400μm, the spatial resolutions achievable are $\sigma_R \approx \sigma_z \approx 200μm$. In order to avoid ambiguity in the position reconstruction the right strips crossing angle, corresponding to the winding angle, must be $\theta = L/\pi R$ (where $L$ is the length of the vertex detector and $R$ its radius). The mechanical assembly of one single layer is described and preliminary results obtained with an Ar/CO₂ = 70/30 gas mixture are discussed.

3:12PM BD.00005 Development of tracking detectors for STAR with industrially produced GEM foils, FRANK SIMON, BERND SURROW, Massachusetts Institute of Technology — The planned tracking upgrade of the STAR experiment at RHIC includes a large-area central tracker used to determine the charge sign of electrons and positrons produced from W⁺(→) decays. For such a large-scale project commercial availability of GEM foils is necessary. We report first results obtained with a triple GEM detector using GEM foils produced by TechEtch Inc of Plymouth, MA, USA. Measurements of gain uniformity, long-term stability as well as measurements of the energy resolution for X-Rays are compared to results obtained with an identical detector using GEM foils produced at CERN. A quality assurance procedure based on optical tests using an automated high-resolution scanner has been established. Comparative measurements for CERN and TechEtch produced GEM foils will be presented.
measurements.

High demands on the acceptance of the recoil spectrometer are important, but difficult to achieve. In this talk I will report on our experience with these devices.

12C(p, γ) 13N is an important reaction for the study of the weak interaction. It consists of a 50cm long radiator and triple-GEM detector modules with pad readout. The detector is operated in pure-CF4 in a windowless configuration. A CsI photo-cathode is evaporated onto the top GEM of each stack, which converts Cherenkov photons into photoelectrons. The whole detector system covers 3/4 of full azimuth and rapidity of |y|<0.45. In the RHIC year-2006 run, a prototype HBD with limited acceptance was successfully installed, and tested using particles emitted from p+p collisions at √s =200GeV. The basic characteristics of GEMs in the detector and the overall performance of the detector will be presented and discussed.

3:36PM BD.00007 Cargo Container Imaging with Gaseous Detectors

The gas electron multiplier (GEM), developed at CERN by Fabio Sauli, represents the latest innovation in micropattern gaseous detectors and has been utilized as a preamplification stage in applications ranging from fundamental physics experiments to medical imaging. Although cargo container inspection systems are currently in place using gamma-rays or X-rays, they are predominantly designed with a resolution to detect contraband. Current imaging systems also suffer from false alarms due to naturally radioactive cargo when radiation portal monitors are used for passive detection of nuclear materials. Detection of small shielded radioactive elements is even more problematic. Idaho State University has been developing a system to image cargo containers in order to detect small shielded radioactive cargo. The possible application of an imaging system with gas electron multiplication will be shown along with preliminary images using gaseous detectors instead of the scintillators currently in use.

1Idaho Accelerator Center

Thursday, October 26, 2006 2:00PM - 5:00PM – Session BE DNP: Mini-symposium on Experimental Techniques in Low Energy Nuclear Astrophysics Studies

Gaylord Oryoland Hermitage B

2:00PM BE.00001 Experimental nuclear astrophysics underground

The thermal dileptons emitted from a hot and dense nuclear matter are an important probe to understand the quark deconfinement transition because they reflect the initial temperature and the degree of freedom of the matter. The measurement of dileptons is, however, very challenging due to a huge combinatorial background. With the present set-up of the PHENIX detector, a signal to background ratio is expected to be ∼1/500, and therefore an efficient rejection of the background is necessary. The background mainly arises from random combinations of electrons and positrons originating from daisy decays of neutral pions and conversion photons. A Hadron Blind Detector (HBD) is planned to be installed close to the beam pipe inside the PHENIX detector to identify and reject such electrons by looking at Cherenkov light emitted by them. The detector consists of a 50cm long radiator and triple-GEM detector modules with pad readout. The detector is operated in pure-CF4 in a windowless configuration. A CsI photo-cathode is evaporated onto the top GEM of each stack, which converts Cherenkov photons into photoelectrons. The whole detector system covers 3/4 of full azimuth and rapidity of |y|<0.45. In the RHIC year-2006 run, a prototype HBD with limited acceptance was successfully installed, and tested using particles emitted from p+p collisions at √s =200GeV. The basic characteristics of GEMs in the detector and the overall performance of the detector will be presented and discussed.

2:36PM BE.00002 Cross sections for reactions in explosive H burning from indirect methods

LIVIUS TRACHE, T. AL-ABDULLAH, A. BANU, C. FU, C.A. GAGLIARDI, J.C. HARDY, V.E. IACOB, M. MCCLESKEY, A.M. MUKHAMEDZHANOV, G. TABACARU, R.E. TRIBBLE, Y. ZHAI, Texas A&M University — We present results for the cross sections of radiative proton capture reactions relevant for explosive H burning in stars, extracted from a number of indirect techniques using stable or radioactive nuclear beams. We use or combine transfer reactions above the Coulomb barrier, breakup of loosely bound proton rich nuclei at intermediate energies, and beta-decay studies to extract nuclear information needed to determine capture cross sections at very low energies. The extraction of ANC from proton transfer reactions around 10 MeV/u will be briefly discussed with examples from the latest measurements at the K500 superconducting cyclotron. Studies of the breakup of 9C and 23Al will be used to exemplify the method and its spectroscopic power, and to assess the astrophysical S-factors for the 8B(p, γ) 9C and 22Mg(p, γ) 23Al reactions, respectively. Finally, we will show how the results of a β-decay study of pure samples of 21Al separated with MARS can be used to constrain the direct contribution to the reaction rate for 22Mg(p, γ) 23Al and to determine resonant contributions for the 22Na(p, γ) 23Mg. These reactions are considered candidates to explain why space-based gamma-ray telescopes do not observe γ-rays from the decay of long-lived 20Na formed in ONe novae explosions: flux is diverted from the A=22 into the A=23 mass chain.

1Work supported by DOE.

2:48PM BE.00003 Measurement of capture reactions with the recoil mass spectrometer DRAGON

CHRISTOF VOCKENHUBER, TRIUMF, DRAGON COLLABORATION — DRAGON is a state-of-the-art recoil mass spectrometer located at the radioactive beam facility ISAC at TRIUMF in Vancouver/Canada. It is designed to measure proton and alpha-capture reactions of light nuclei in inverse kinematics. In the last few years several astrophysically important reactions have been successfully measured, among them 21Na(p, γ) 22Mg and 26Al(α, γ) 27Si using the high intensity radioactive beams available at ISAC. In addition, reactions with stable beams have been also investigated. Besides the astrophysical context, the wider range of available beams and the higher intensities allow to explore the limits of the current setup. With the recently measured 40Ca(α, γ) 44Ti reaction we could demonstrate the capabilities of DRAGON in the mass 40 range. Another important reaction is 12C(α, γ) 16O which makes high demands on the acceptance of the recoil spectrometer. In this talk I will report on our experience with these for astrophysics important, but difficult measurements.

3:00PM BE.00004 Experimental techniques to investigate astrophysical key reactions at the extremes

WOLFGANG HAMMER, University of Notre Dame — In order to explore stellar evolution and nucleosynthesis the reaction rates of the relevant nuclear reactions must be determined at burning temperatures. This means investigating the reactions down to a picobarn or subpicobarn level. To achieve this, all important experimental parameters have to be optimized, which are: high primary beam intensity, targets of high chemical and isotopic purity and high stability, high detection efficiency and resolution for the reaction products, appropriate means to reduce disturbing background of any kind, sufficient long measuring time. The key reaction 12C(α, γ) 16O was investigated using enriched solid targets, which could withstand beam powers of up to 10 kW/cm2 and beam currents of up to 800 μA. The angular distributions of the γ-rays were measured using a close 4π Ge-detector array or the GANDI array of high efficient Ge-detectors on a turntable. The background was suppressed by active shielding. Thus the E1 and E2 S-factors could be determined in the energy range Eγ, m. = 890 – 2800 keV, enabling the extrapolation of the reaction rate with 25% accuracy.

The astrophysical key neutron source 22Ne(α, n) 25Mg was investigated using the windowless recirculating gas target RHINOCEROS with gas purification in the main stream. The neutrons were detected by a 4π detector with an absolute efficiency of 50%. The excitation function was determined down to the threshold with a sensitivity at the 10−11 level. The uncertainty of the reaction rate was reduced considerably.
3:12PM BE.00005 Measuring the Radiative Width of the Hoyle State in $^{12}$C$^{*}$  J.T. BURKE, R.D. HOFFMAN, E.B. NORMAN, L.A. BERNSTEIN, R. MACRI, LLNL, L.W. PHAIR, J. GIBELIN, M. WIEDEKING, R.M. CLARK, E. VIEITEZ-RODRIGUEZ, P. McMahan, I.Y. LEE, LLNL, A.O. MACCHIAVELLI, LLNL, C. BEAUSANG, S. LESHER, B. DARAKCHIEVA, M. EVTIMOVA, Univ. of Richmond, B. LYLES, M. DOLINSKI, U.C. Berkeley, S. SHEETS, N.C. State Univ., H. AI, Yale University — Helium burning is possibly the most important burning phase for stellar nucleosynthesis. The two main products are carbon, produced via the $3\alpha$ reaction, and oxygen by $^{12}$C($\alpha$, $\gamma$)$^{16}$O. The $3\alpha$ reaction represents the start of heavy element production in stars. The fortuitous resonance formed by $^8$Be and an alpha particle allows the creation of $^{12}$C$^{*}$ (the Hoyle state at 7.65 MeV). Overwhelmingly, $^{12}$C$^{*}$ decays by emitting an alpha particle, followed by the break up of $^8$Be into two alpha particles. Fortunately, there is a small radiative decay branch (approximately $4 \times 10^{-4}$) which allows the excited $^{12}$C$^{*}$ nucleus to decay to its ground state. A new measurement of the ratio of the radiative width to the total width has been performed by the Lawrence Livermore National Laboratory and Lawrence Berkeley National Laboratory STARS/LIBERACE Collaboration. Our current results and experimental method will be presented. This work was sponsored by UC-LLNL under Contract No. W-7405-Eng-48 and Grant Nos. DE-FG-05NA29592, DE-FG02-06NA26206, and DE-FG02-05ER41379.

3:24PM BE.00006 Nuclear Astrophysics at the LENA facility: The $\gamma$-ray detection system.  RICHARD LONGLAND, CHRISTIAN ILIADIS, ARTHUR CHAMPAGNE, CHRIS FOX, JOE NEWTON, University of North Carolina — Details of the detection system used at The Laboratory for Experimental Nuclear Astrophysics is described, including methods for measuring weak capture-$\gamma$-ray resonances. $\gamma\gamma$-coincidence techniques with a large solid angle NaI(Tl) annulus are described, as well as their effects on background count rates in the energy regions of interest at LENA. In order to reduce the background further, cosmic muon induced counts can be decreased with the aid of an anti-coincidence plastic scintillator shield. In order to create a compact detection system, a novel, wavelength shifting fibre method of light readout has been used. These techniques are shown to reduce background count rates significantly for cascade decays in our regions of interest, and are shown to have a significant improvement over our previous results.

3:36PM BE.00007 Q-Value Gating Techniques for Gamma-ray Background Reduction  AARON COUTURE, Los Alamos National Laboratory, JOACHIM GOERRES, ELIZABETH STRANDBERG, MICHAEL WIESCHER, University of Notre Dame — For certain classes of experiments, the limiting background comes from beam induced reactions on the nucleus of interest rather than external sources. Techniques using a combination of high-efficiency and high-resolution detectors were developed for separating the $^{19}$F(p,$\gamma$) and $^{19}$F(p,$\alpha$) reactions—which both are important for quiescent and explosive CNO burning. The measurement will be compared to previous attempts with particular emphasis on the advantages Q-value gating offers in an inherently high-background scenario.

3:48PM BE.00008 Sub-Coulomb alpha transfer reactions in Nuclear Astrophysics  GRIGORY ROGACHEV, Florida State University — Prohibitively small cross section of nuclear reactions at energies, relevant for nuclear astrophysics, require application of indirect techniques to deduce the reaction rates from experimental data. One such technique is sub-coulomb $\alpha$ transfer reaction ($^{6}$Li,$d$), which can be used to measure the $\alpha$ particle Asymptotic Normalization Coefficients (ANCs) of sub and near threshold resonances. ANC, obtained in $\alpha$ transfer reaction, performed at energy below the Coulomb barrier in both exit and entrance channels are model independent. This leads to a reliable evaluation of resonant component contribution into the total rate of nuclear reaction, which involves $\alpha$ particle capture. For example, the rate of $^{13}$C($\alpha$,$n$) reaction, which is considered to be the main source of neutrons for s-process in AGB stars, is uncertain by $\sim$1 at 10$^7$ K. The $^{13}$C($\alpha$,$n$) resonance at 6.356 MeV in $^{13}$C has been measured, using a recoil separator to reject the beam ions which did not react. The measurement will be compared to previous attempts with particular emphasis on the advantages sub-coulomb $\alpha$ transfer reaction for evaluation of rates of other astrophysically important nuclear reactions will be discussed.

3This work was supported by NSF under grant PHY-04-56463.

4:00PM BE.00009 The Notre Dame recoil separator  MANOEL COUNDER, GEORG P. BERG, JOACHIM GOERRES, LARRY O. LAMM, P.J. LEBLANC, EDWARD STECH, MICHAEL WIESCHER, Department of Physics, University of Notre Dame, Notre Dame, In 46556 — Studies of ($p$,$\gamma$) and ($\alpha$,$\gamma$) reactions at low energies provide crucial information to improve our interpretation of the observed isotopic abundances, to predict the energy production and the time scale of nucleosynthesis processes during the stellar evolution and explosive events. While many radiative captures measurements have been made using various setup in direct kinematics, the very small cross section at astrophysically interesting energy of these reactions and the beam induced background limit the possible range of measurements. Reversing the kinematics and using a recoil separator to reject the beam ions which did not react in the target and to guide the reaction products to a detector is a good solution. Such a device aimed at low energy ($\alpha$, $\gamma$) measurements with stable beams is under development at the University of Notre Dame. In this talk I will present the concept of this new facility that is based on proven principles in existing devices. I will discuss the challenges encountered in low energy measurements and the solutions that we are pursuing.

4This project is funded by the NSF through grant PHY0216783.

4:12PM BE.00010 Alpha-induced reactions in stellar burning  JOACHIM GOERRES, University of Notre Dame — Alpha-induced reactions play an important role in a variety of astrophysical environments. They provide the neutron sources for the main s-process which takes place in highly convective AGB stars and for the weak process during core Helium burning in massive stars. In addition, alpha induced reactions on $^{15}$O and $^{18}$Ne provide a break-out from the CNO cycle which is important for the dynamics of explosive Hydrogen burning. To illuminate experimental difficulties in determining reaction rates results of recent and ongoing experiments will be presented and future developments at the Nuclear Structure Laboratory at Notre Dame will be discussed.

3Supported by the National Science Foundation.

4:24PM BE.00011 Prospects for Improved Measurements of the S-Process Neutron Source Reactions  CARL R. BRUNE, Ohio University — The $^{13}$C($\alpha$,$n$)$^{16}$O reaction is thought to be the main s-process neutron source, taking place in AGB stars at temperatures around 10$^8$ K. The $^{22}$Ne($\alpha$,$n$)$^{25}$Mg reaction is also thought to be an important neutron source and takes place in more massive stars at somewhat higher temperatures of $(2 - 3) \times 10^8$ K. Both reaction rates are uncertain at astrophysical temperatures due to the difficulty of measuring the low cross sections. In the case of $^{13}$C($\alpha$,$n$)$^{16}$O, measurements exist down to $E_{cm} = 300$ keV but the extrapolation to the needed range of 150-200 keV is complicated by subthreshold resonances. The $^{22}$Ne($\alpha$,$n$)$^{25}$Mg reaction rate is dominated by narrow resonances – the possibility of as-yet-unobserved backgrounds near threshold leads to significant uncertainty in this reaction rate. The prospects for improved data using high-intensity beams, inverse kinematics, and background reduction techniques will be discussed.

1Work supported in part by the U.S. Department of Energy.
4:36PM BE.00012 CLAIRE - A Novel Nuclear Astrophysics Accelerator Facility at the Lawrence Berkeley National Laboratory. DANIELA LEITNER, DAMON TODD, PAUL VETTER, MATTHAEUS LEITNER, REINA MARUYAMA, KEVIN NAN XU, Lawrence Berkeley National Laboratory — CLAIRE (Center for Low Energy Astrophysics and Interdisciplinary Research) is a proposed nuclear astrophysics accelerator facility to be built at the 88-Inch Cyclotron at LBNL. Its primary goal will be to measure cross sections relevant to stellar burning. In particular, our focus is to build a facility powerful enough to measure the $^3$He($e^-, \gamma$) $^7$Be cross section near the Gamow peak. In its first phase, this facility will consist of a high-power high-voltage platform (100mA $^3$He beam at 50 keV to 300 keV), four solenoid lenses, and one 60° bend magnet for mass separation. The high current (>100mA) $^3$He beam will be delivered at sub-centimeter diameter onto the cooled high density gas jet $^4$He target. Germanium detectors will be used to detect the $\sim 1$ MeV $\gamma$ line resulting from this reaction. As a possible second phase, a short linear post accelerator section could be added to widen the applicability of the facility to cover a higher range of energies of interest for stable ion beam astrophysics cross sections in the CNO and NaNe cycle. The preliminary layout of this new experimental facility will be shown and discussed.

4:48PM BE.00013 Proposed facility for a precise measurement of $S_{134}$. PAUL VETTER, DANIELA LEITNER, REINA MARUYAMA, MATTHAEUS LEITNER, DAMON TODD, Lawrence Berkeley National Laboratory — We propose a new measurement of the cross section for the direct capture reaction $^3$He($e^-, \gamma$)$^7$Be at a total uncertainty of 1%. Current and planned solar neutrino experiments seek to measure the total $^7$Be neutrino flux at this level. A direct comparison at 1% of measured to calculated neutrino flux can constrain models of non-standard neutrino oscillation or “invisible” energy production, and will also constrain the Standard Solar Model, acting as a gauge of the temperature and metallicity of the sun and other main sequence stars. A new accelerator, designed for low energy < 300 keV, with high current ($\approx 100$ mA) and beam purity is necessary to improve the statistical power of measurements at low energy (at or near the solar Gamow window) to control potential systematic errors. To control target error sources, a favorable design would have a tight final focus, intersecting a dense gas jet target. High resolution germanium detectors can provide good signal to background recovery in direct capture reactions. We are currently designing such an accelerator facility. The proposed facility could be used to measure several direct capture reactions in the H, He, and CNO burning cycles. We will review the limiting uncertainties (experimental and theoretical) which constrain our design, and the current status of the project. Supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Thursday, October 26, 2006 2:00PM - 5:24PM — Session BG DNP: Hadronic Physics Gaylord Opryland Hermitage D

2:00PM BG.00001 First Observation of the $f_1(1285)$ / $\eta(1295)$ Meson in Photoproduction. RYAN DICKSON, Carnegie Mellon University, JEFFERSON LAB - CLAS COLLABORATION — A meson of mass $m_{f_1} = 1281$ MeV and a FWHM of $\Gamma_f = 18$ MeV is seen in photoproduction off the proton using real photons in the energy range between 1.8 GeV and 4.0 GeV. The decay modes seen in the Jefferson Lab CLAS spectrometer are $x \rightarrow \eta \pi^+ \pi^-$ and $x \rightarrow K^+ K^0 \pi^-$, with a large fraction going through $a_0(980)\pi$. The state is not seen in the $x \rightarrow \rho^0 \gamma$ decay channel, with an upper limit on the branching fraction (B.R.) < 0.62% (95% c.l.). This non-observation is inconsistent with the known nearby state $f_1(1285)$, which has a PDG-given B.R. of $5 \pm 1.3\%$ to $\rho^0 \gamma$. This could mark the first direct observance of the $\eta(1295)\rho^0$, albeit with a width that is much narrower than obtained through partial wave analysis of earlier hadronic production experiments. This presentation will emphasize the experimental production of this meson and the search for its $\rho^0 \gamma$ decay mode.

2:12PM BG.00002 $K^+$ vector meson photoproduction on a proton target at Jefferson Lab. LEI GUO, Jefferson Lab, CLAS COLLABORATION — It has been pointed out that the $K^+Y$ channels could provide some unique opportunities in searching for those missing resonances which couple to the $KY$ and $N\pi$ channels weakly. Compared with the $KY$ channels, the photoproduction of $K^+$ vector meson has not been studied in as much details mainly due to the lack of data. The CLAS Collaboration at Jefferson Lab conducted a photoproduction experiment on a proton target using a tagged photon beam with an energy range of 1.6-3.8 GeV during May-July 2004. With an integrated luminosity of about 75 pb$^{-1}$, this experiment provides the largest data set for photon-proton reactions ever collected. The two reactions $\gamma p \rightarrow K^+ Y - K^+ p\pi^- (\pi^0)$ and $\gamma p \rightarrow K^0 Y^* \rightarrow K^+ \pi^-(\pi^0)$ have been investigated. The comparison of the two channels could provide insight into the contributions of the controversial $\Lambda$ meson. The preliminary results of the cross section measurement and angular distributions for the photon energy range of 2.0-3.8 GeV will be presented and compared with theoretical calculations.

2:24PM BG.00003 $\Sigma(1385)$ photoproduction on a proton target at Jefferson Lab. LEI GUO, Jefferson Lab, CLAS COLLABORATION — Previous investigation of the $J^P = \frac{3}{2}^-$ $\Lambda(1520)$ decay in the Gottfried-Jackson (GJ) frame has suggested the dominance of $K$ exchange in the eletroproduction data ($e^{+} e^{-} \rightarrow e^{+} K^{+} \Lambda(1520)$) as opposed to the strong contribution of $K^*$ exchange in the photoproduction data ($\gamma p \rightarrow K^* \Lambda(1520)$). In the case of the $\Sigma(1385)(J^P = \frac{5}{2}^+)$, there has been no such study in the literature, probably due to the lack of available data. The recent large statistics ($L = 75 pb^{-1}$) photon-proton production data collected by the CLAS Collaboration at Jefferson Lab has made possible the detailed study of the $\Sigma(1385)$ photoproduction through the reaction $\gamma p \rightarrow K^+ \Sigma(1385) \rightarrow K^+ \Lambda(\pi^0)$. Preliminary cross section results for the photon energy range of 1.5-3.8 GeV, as well as the angular distribution of the $\Sigma(1385)$ decay in the GJ frame will be presented. The results could provide new constraints on the hadro-dynamic models for hyperon production, and help determine the production mechanisms of the $\Sigma(1385)$ in photoproduction.

2:36PM BG.00004 Photoproduction of the $\phi(1020)$ Meson Near Threshold1. DAVID TEDESCHI, University of South Carolina, CLAS COLLABORATION — The differential cross section for the photoproduction of the $\phi(1020)$ near threshold ($E_\gamma = 1.57$ GeV) is sensitive to production mechanisms other than diffraction. Moreover, at large momentum transfer, the production of $\phi$-mesons becomes a test of quark and gluon degrees of freedom. We have performed a measurement of $\phi$-meson photoproduction on the proton at The Thomas Jefferson National Accelerator Facility using a liquid hydrogen target and the CEBAF Large Acceptance Spectrometer (CLAS). The energy of the tagged, bremsstrahlung photons ranged from $\phi$-threshold to 3.6 GeV, and the $\phi(1020)$ was identified in the channels $\phi \rightarrow K^{+} K^{-}$ and $\phi \rightarrow K_{S} K_{L}$. Preliminary differential cross sections (d$\sigma$/d$t$) will be presented. An analysis of the energy dependence of the cross section at low and high momentum transfer will also be discussed.

1Supported by NSF Grant No. 0555604
2:48PM BG.00005 The Search for Missing Baryon Resonances in the Reaction $\gamma p \rightarrow p\pi^0\eta^+$.

VOLKER CREDE, CB-TAPS COLLABORATION — The problem of so-called missing baryon resonances will be discussed on the basis of recent experimental results of the Crystal-Barrel experiment (CB-TAPS Collaboration) and discussion will be given on planned double-polarization experiments at the $e^-$ accelerator ELSA in Bonn. The Crystal-Barrel detector is the ideal instrument to study various multi-photon final states over the full dynamical range due to its almost $4\pi$ coverage of the solid angle and its excellent energy resolution. Resonance production and even decay cascades of the type $\gamma p \rightarrow \Delta^* \rightarrow \Delta \pi \rightarrow p\pi\eta$ have been observed. Indications for at least one $\Delta$ resonance around 1900 MeV/c$^2$ have been seen. The latter is particularly interesting if it had negative parity because a confirmation of this state would be in contradiction with current constituent quark models. Constraints provided by polarization observables are important because analyses of unpolarized data often result in ambiguous solutions. For the upcoming data-taking, circularly- and linearly-polarized photons will be used incident on the Bonn frozen-spin butanol target providing longitudinal polarization. Studies of the sensitivity of polarization observables to baryon resonances will be discussed.

3:00PM BG.00006 Measurement of $\pi^+\pi^-$ Photoproduction In Double-Polarization Experiments using CLAS.

CHARLES HANRETTY, Florida State University, CLAS COLLABORATION — Discussion will be given on an upcoming double-polarization experiment using a tagged-photon beam and the CLAS spectrometer at Jefferson Lab in Newport News, VA. Constituent quark models (CQMs) predict numerous baryon resonances that have not been experimentally verified and are thus “missing.” CQMs also predict a strong coupling of these states to $\gamma p$ as well as to $\pi \Delta$ or $\Delta \pi$ making photoproduction experiments a promising method to find these missing resonances. Previous analyses show that constraints provided by polarization observables are important because analyses of unpolarized data often result in ambiguous solutions. A linearly- and circularly-polarized photon beam will be incident on a polarized butanol target in Hall B’s CLAS detector. This detector allows for the use of a longitudinally- or transversely-polarized frozen spin target (FROST) giving rise to nine double-polarization observables in $\pi^+\pi^-$ production. Studies of the sensitivity of these observables to baryon resonances will be discussed.

3:12PM BG.00007 Search for New Forms of Hadronic Matter in Photoproduction.

LUKASZ BLASZCZYK, Florida State University, JEFFERSON CLAS COLLABORATION — Discussion will be given of an upcoming experiment at Jefferson Lab, in Hall B, scheduled for mid 2007. Recent experimental results for gluonic hybrid candidates as well as theoretical predictions suggest photoproduction is ideal in the search for gluonic matter. The CEBAF Large Acceptance Spectrometer (CLAS) detector at Jefferson Lab in Newport News, VA offers an excellent opportunity to study meson spectroscopy at photon beam energies up to 5.7 GeV. The g12 HyCLAS experiment will collect the largest set of photoproduction data in meson spectroscopy to date, over an order of magnitude more than previous photoproduction experiments at CLAS. This will lead to substantial yields for the purpose of Partial Wave Analysis.

3:24PM BG.00008 The search for the $\Phi(1860)^{--}$ pentaquark with CLAS.

MAURIK HOLTROP, HOVANES EGIYAN, University of New Hampshire, JÖRN LANGHEINRICH, University of South Carolina, CLAS COLLABORATION — A search for a narrow exotic resonance, the $\Phi(1860)^{--}$, is being conducted in the EG3 experiment with the CLAS detector at Jefferson Lab. The $\Phi(1860)^{--}$ is predicted to be the $S = -2$ exotic state in the pentaquark anti-decuplet. Evidence for this state has been cited by the NA49 experiment, but has not been confirmed so far. The search is conducted by looking for the decay $\Phi(1860)^{--} \rightarrow \Xi^{-}\pi^{+}$, which can use the detached vertices of the $\Xi^{-}\Lambda\pi^{-}$ and $\Lambda \rightarrow p\pi^{-}$ decay chain, a new technique for CLAS. We will report on the ongoing analysis.

3:36PM BG.00009 $\Theta^+$ Search in CLAS with $\gamma d \rightarrow pK^0 K^- (p)$.

NATHAN BALTZELL, DAVID TEDESCHI, University of South Carolina, CLAS COLLABORATION — A search for photo-production of the $\Theta^+(1540)$ pentaquark in the $pK^0$ decay mode was performed with the CLAS detector at Jefferson Lab. About 20,000 $\gamma d \rightarrow pK^0 K^- (p)$ events with photon beam energies 1.6 - 3.6 GeV were fully reconstructed and kinematically fitted. To investigate the resonant backgrounds, a phenomenological model including hyperon and meson production has been developed and fitted to the data with a maximum-likelihood method. The model results serve as a background to evaluate the existence of a pentaquark signal in the invariant mass of the $pK^0$ system. The cross-section upper limit on $\Theta^+$ photo-production in this channel will be reported.

This work is supported in part by DOE grant #DE-FG02-88ER40410.

3:48PM BG.00010 The Light-Front Quark Model and Exotic Matter.

MARTIN DEWITT, CHUENG JI, North Carolina State University — According to the Standard Model of particle physics, much of the matter we see is made up of quarks bound together by the strong force. Although a theory of the strong force, Quantum Chromodynamics (QCD), has existed for many years, it has not been possible to solve it exactly. As such, models based on the essential characteristics of strong force, which have been gleaned from approximate solutions of QCD, have been very useful in understanding the properties of bound states of quarks. The light-front quark model (LFQM) has generally been successful in predicting the properties of two-body (quark-antiquark) bound states called mesons. While experimental data on mesons with certain quantum numbers have matched well with the model predictions, the $^3P_0$ (scalar) mesons have not. In fact, more scalar states have been observed experimentally than should exist if they were all two-body bound states. It is suspected that other “exotic” forms of matter, which have been predicted by QCD but have never been directly confirmed in experiments, are complicating the scalar meson spectrum. These exotic states have the same quantum numbers as the scalar mesons, and are thus allowed to mix with them. The result is that the states observed experimentally are actually quantum-mechanical superpositions of the scalar mesons and these other exotic forms of matter, thus making them difficult to clearly identify. We discuss how the LFQM is used to predict the properties of mesons in general, as well as how it can be used to shed light on the more complicated structure of the scalar states.

4:00PM BG.00011 A Unitary and Relativistic Model for $\pi\eta N$ and $\pi\pi N$ Photoproduction.

ALVIN KISWANDHI, SIMON CAPSTICK, Florida State University, T.-S. HARRY LEE, Argonne National Laboratory — We investigate $\pi\eta N$ photoproduction by using a unitary and relativistic model based on the effective Lagrangian approach. Unitarity is ensured by using the Lippmann-Schwinger equation to iterate the vertices and dress the propagators to all orders, and by including all possible two-body and quasi-two-body intermediate channels. The approach we present here has also been used to investigate $\pi\pi N$ photoproduction. A comparison of our calculation to an existing $\pi\pi N$ photoproduction study is made, and shown to produce consistent results. This agreement convinces us that our ongoing study of $\pi\eta N$ photoproduction will produce similar interesting results.

This work is supported by NSF grant 0456463.

This work is supported in part by DOE grant #DE-FG02-88ER40410.

This work is supported by grant 0244982 of the National Science Foundation.
4:12PM BG.00012 Hybrid and Conventional Baryons as Four-Body Systems in the Flux-Tube Model. SIMON CAPSTICK, ANTON SOUSLOV, Florida State University — In the strong-coupling limit baryons can be viewed as constituent quarks connected by gluon flux tubes in a Y-shaped configuration. A previous study of the spectrum of hybrid and conventional baryons separated the motion of the gluonic degrees of freedom and that of the quarks using an adiabatic approximation, and showed that the motion of the gluon flux can be approximated by the motion of the junction of the three flux tubes. The calculation described here goes beyond the adiabatic approximation to solve directly for the states of a four-body system comprised of three quarks and a massive junction connected to the quarks by linear strings. Results for the spectrum and properties of hybrid baryons are shown, along with the effects of the motion of the flux on conventional baryons.

4:24PM BG.00013 Extrapolations of Lattice Meson Form Factors1, T. BRIAN BUNTON, FU-JUN JIANG, BRIAN C. TIBURZI, Duke University — We use chiral perturbation theory to study the extrapolations necessary to make physical predictions from lattice QCD data for properties of pseudoscalar mesons. We focus on the quark mass, momentum, lattice spacing, and volume dependence and apply our results to simulations employing mixed actions of Ginsparg-Wilson valence quarks and staggered sea quarks. As an example, to determine charge radii at quark masses on the lattices currently used, we find that the chiral and continuum extrapolations dominate the systematic error.

4:36PM BG.00014 A PWA of ρω in photoproduction using CLAS, MIKE WILLIAMS, Carnegie Mellon University, CLAS COLLABORATION — We will present results of a partial wave analysis, (PWA), on the reaction γp → ρω with the ω decaying to π^+π^−π^0. The decay of the ω into its three pseudoscalar final state provides information on the polarization of the ω which in turn provides an additional handle in the PWA analysis. These data are analyzed using a covariant tensor formalism which provides a natural mechanism for including both t-channel contributions as well as background terms in the PWA. The results of such an analysis are a decomposition of the s-wave contributions to the final state. The mass dependence of the intensity and phase of these partial waves can be used to deduce information about the baryon resonances that couple to ρω final states.

4:48PM BG.00015 A Coupled Partial Wave Analysis of πη and πη′ in photoproduction using CLAS1, ZEBULUN KRAHN, Carnegie Mellon University, CLAS COLLABORATION — In late 2004, a very large photoproduction data set was collected using the CLAS detector at Jefferson Lab. This data set contains several hundred thousand events of the type γp → πη and γp → πη′. Results of a coupled partial wave analysis, (pwa), of this data set will be presented. The pwa analysis uses a covariant tensor formalism with the aim of disentangling resonance structure in the πη and ηπη systems. Such a formalism also allows a method to handle t-channel contributions to the cross sections. In addition, the use of a coupled channel approach takes advantage of the fact that given sufficient phase space, all intermediate states that couple to η must also couple to η′. Given both the different acceptances and systematic errors for the two data sets, this provides for a more constrained method of pulling out partial waves from the two data sets.

1 Supported in part by Grant DE-FG02-05ER41368-0.

5:00PM BG.00016 A PWA of pπ^+π^- in photoproduction using CLAS, MATTHEW BELLIS, Carnegie Mellon University, CLAS COLLABORATION — While the Constituent Quark Model does an excellent job at categorizing much of the observed baryon spectrum, there are multiplets which are conspicuously absent from the experimental data. With much of this data coming from Nπ → Nπ scattering and a small predicted coupling to Nπ, it is perhaps not surprising they have not yet been seen. The CLAS detector allows us to make a comprehensive search for these missing resonances in states that do not have Nπ in either the initial or final state. We are engaged in a PWA of multiple final states using a covariant tensor formalism in a mass-independent approach. This allows us to extract the amplitudes for intermediate s-channel processes as well as measure the t-channel contribution. Resonances will be observed by motion in both intensity and phase. This talk will discuss the current status of the analysis of one of these channels: γp → pπ^+π^- . We use isobars to model the intermediate Δ^+Δ^- and p^0 states. Differential and total cross sections will also be shown.

5:12PM BG.00017 Implementation of Vertex Reconstruction in the Search for Resonances in the 1610-1770 MeV Invariant Mass Region, EZEKIEL WALKER, Abilene Christian University — In recent years, there has been considerable activity in the realm of baryon spectroscopy. A collaboration between Petersburg Nuclear Physics Institute (PNPI), Institute for Theoretical and Experimental Physics (ITEP), and Abilene Christian University (ACU), is aimed at increasing the understanding of the 1610-1770 MeV invariant mass region. This collaboration is particularly interested in the N*(1710) resonance, a poorly defined excited state of the nucleon. Utilizing GEANT4 and ROOT, two powerful simulation and analysis programs, ACU is simulating the CLAS detector at Jefferson Lab. This data set contains several hundred thousand events of the type γp → pπ^+π^- . We use isobars to model the intermediate Δ^+Δ^- and p^0 states. Differential and total cross sections will also be shown. The p^+p^− channel processes as well as measure the t-channel contribution. Resonances will be observed by motion in both intensity and phase. This talk will discuss the current status of the analysis of one of these channels: γp → pπ^+π^- . We use isobars to model the intermediate Δ^+Δ^- and p^0 states. Differential and total cross sections will also be shown.

Thursday, October 26, 2006 2:00PM - 4:00PM – Session BH DNP: Applications in Nuclear Physics

2:00PM BH.00001 Plant Physiology Studies Using Positron-Emitting Isotopes, M. R. KISER, C. R. HOWELL, A. S. CROWELL, Duke University Physics Department and TUNL, C. D. REID, R. P. PHILLIPS, Duke University Biology Department — Over the past century the atmospheric carbon dioxide CO2 concentration has increased by more than 25%, and climate experts predict that CO2 levels will double by the end of this century. Understanding the mechanisms of resource management in plants is important for predicting how plants will respond to the increase in atmospheric CO2 concentration. We use short-lived radioisotope labeling techniques to measure carbon and nitrogen translocation in plants under different global change conditions to gain insight on how plants respond to elevated CO2 levels. Carbon-11 dioxide is produced at TUNL using the 14N(p,α)11C reaction. The plants are labeled under environmentally controlled conditions in a specially equipped growing chamber at the Duke University Phytotron facility. The close proximity of TUNL and the Duke University Phytotron creates a unique opportunity for these global change studies. These experiments use single detectors collimated to restrict the field of each detector to one of three regions of the plant (uptake leaf, shoot, and root). Recent results will be presented.
2:12PM BH.00002 Background Reduction by Gamma-ray Tracking Detectors, MARIO CROMAZ, Lawrence Berkeley National Laboratory — Low-energy cross-section measurements of capture reactions for astrophysics applications are often limited by gamma-ray background. This background may be reduced with the recent advent of high resolution HPGe tracking detectors which are capable of rejecting background gamma-rays which do not originate from the target position. This is accomplished by segmenting the outer contact of the HPGe crystal and analyzing the transient currents generated at the segments to locate the individual scattering points of the gamma ray and the energy deposited within the crystal. Using the Compton-scattering relation, one can define a cone which specifies the direction of the incident gamma-ray. Furthermore, one can discern from the positions and energies of the scattering points if the gamma-ray scattered out of the crystal. Simulations will be presented that outline detector performance as well as achievable background reduction factors based on the performance characteristics of the prototype detectors for the GRETRAN spectrometer.

1Supported by the U.S. DoE, LBAN Contract No. DE-AC02-05CH11231

2:24PM BH.00003 Tests of a Cryogenic Gas Cell for Radioactive Ion Beam Experiments, K. CHIPPS, Colorado School of Mines, D. BARDAYAN, J. BLACKMON, Oak Ridge National Laboratory, K. CHAE, University of Tennessee, J. EASTBURG, U. GREIFIE, Colorado School of Mines, K.L. JONES, University of Tennessee, K. KOZUB, Tennessee Technological University, R. LIVESAY, Colorado School of Mines, B. MOAZEN, University of Tennessee, C.D. NESARAJA, Oak Ridge National Laboratory, S. PAIN, Rutgers University, M. PORTER-PEDEN, F. SARAZIN, Colorado School of Mines, M.S. SMITH, Oak Ridge National Laboratory — The properties of resonances that dominate thermoelectric reaction rates on proton-rich, unstable nuclei can be probed using transfer reactions like $(^{1}H,e,p)$. In inverse kinematics, this is achieved with a radioactive ion beam and a $^{3}$He gas target. A cryogenic gas cell target for such experiments has been constructed at the Colorado School of Mines and tested at Oak Ridge National Laboratory with a stable $^{17}$O beam. The gas cell design has been modified several times, and a number of techniques are being explored to reduce the significant yield from background reactions with the window material. Alternatively, a gas jet target with recycling capability could be a better solution to the long-term problem of using rare gases as targets. Results from our beam tests and future plans will be presented.

2:36PM BH.00004 Determination of precipitation “age” via gamma rays from accreted radon progeny, M.B. GREENFIELD, N. ITO, A. IWATA, K. KUBO, M. ISHIGAKI, Int’l Christian Univ., K. KOMURA, LLRL Kanazawa Univ. — Measurements of gamma ray activities from $^{214}$Pb and $^{214}$Bi condensed from precipitation can determine the average time activity has been removed from secular equilibrium. Atmospheric gamma ray activities arising from absorption/absorbed radon progeny on/in the surface/volume of droplets are proportional to the 0.4 to 0.6 power of rain rates, respectively, assuming that on average most progeny are accreted early in the formation of droplets rather than scavenged. Thus, the average elapsed time between accretions of radon progeny onto droplets until the droplets reach ground may be estimated. After removal from secular equilibrium the initial ratio of $^{214}$Bi to $^{214}$Pb activity evolves towards a limiting ratio which is independent of absolute activity. Measurement of relative activities may thus determine the “age” of precipitation, limited only by the statistical uncertainty. Activity in condensates from 5-30 L of rain viewed with 25 solid angle by a 50% efficient, high-resolution Ge detector is typically 10s up to 100s of cts/sec (during thunderstorms). The half-lives of gamma activities from $^{214}$Bi and $^{214}$Pb, 19.7 and 26.9 minutes, respectively, are on the same scale as rain “ages” and close enough to each other to enable estimates of rain “ages” to within a few minutes.

Greenfield et al., J. of Appl. Phys. 93, 5733 (2003); 2preceding abst.

2:48PM BH.00005 Intense gamma radiation from radon progeny accreted in/on rain during and following thunderstorms, M.B. GREENFIELD, A. IWATA, N. ITO, M. ISHIGAKI, K. KUBO, Int’l Christian Univ., K. KOMURA, LLRL Kanazawa Univ. — Delayed atmospheric gamma’s decaying with a half-life of 10s of minutes has been observed in Japan and in Florida associated with natural and triggered lightning, respectively. This activity may be from 1) excess precipitation of positively charged radon progeny or 2) decay of ejectiles from nuclear reactions initiated by protons or photons. Activity condensed from 5-20 liters of rain, via ion exchange resins, was measured with 25 solid angle, by a 50%, high resolution Ge detector. Activities from $^{214}$Bi and $^{214}$Pb, initially exceeding up to 100’s of cts/sec, decayed with their characteristic half-lives of 19.7 and 26.9 minutes, respectively. Atmospheric radiation was also observed in close proximity to triggered lightning at the Lightning Research Lab in Florida. In both cases excess delayed activity with thunderstorms observed at ground level is almost entirely due to increased precipitation of radon progeny. An enhancement of the 511 keV annihilation peak may be from positron decay of $^{13}$C, $^{18}$F. Following lightning induced nuclear reactions. Identification of corresponding 20, 10 and 100 minute half lives, respectively, requiring closer lightning, greater volumes of collected rain water, and/or reduction in sample preparation times is in progress.

Greenfield et al., J. of Appl. Phys. 93, 1839 (2003); 2see next abst.

3:00PM BH.00006 Experimental Study of LaBr3(Ce) Gamma-Ray Detector Performance in Mixed Radiation Field, ALEXANDER BARZILOV, PHILLIP WOMBLE, JON PASCHAL, LINDSAY HOPPER, RYAN MOORE, ERIC HOUCHINS, JEREMY BOARD, Western Kentucky University — High energy gamma-ray spectrometry has a number of practical applications. Neutron-based explosives detection systems are the important part of active interrogation technology. Pulse neutron technique is excellent choice to rapidly determine bulk elemental content of the cargo in non-destructive and non-intrusive manner. Pulse mode of operation provides simultaneous detection of gamma-rays from neutron inelastic scattering and thermal capture reactions. The physical parameters of selected detectors govern parameters of system. A gamma-ray detector must be suitable for operation in mixed radiation fields consisting of neutrons and photons. It must have high Z-value to detect photons with energies in 4.4 MeV -10.8 MeV range emitted from neutron scattering reactions on carbon and nitrogen nuclei. In this paper, we discuss results of experimental study of LaBr3(Ce) detector operation with the t-T neutron generator. This lanthanum halide scintillator is activated by neutrons in mixed field under 14.1-MeV neutron irradiation showing the beta spectrum with endpoint energy ∼2 MeV.

3:12PM BH.00007 Future Directions of Space Radiation Protection, RAM TRIPATHI, NASA Langley Research Center — For the success of NASA’s vision for space exploration to Moon, Mars and beyond, exposures from the hazards of severe space radiation in deep space long duration missions is a show stopper problem. The payload penalty demands a very stringent requirement on the design of the spacecrafts for human deep space missions. Langley has developed state-of-the-art radiation protection and shielding technology for space missions. The exploration beyond low Earth orbit (LEO) to enable routine access to more interesting regions of space will require protection from the hazards of the accumulated exposures of space radiation; trapped radiation, galactic cosmic rays (GCR) and solar particle events (SPE), and minimizing the production of secondary radiation is a great advantage. It is desirable to divert them from the spacecraft without paying the payload penalty while taking advantage of the state-of-the-art material shielding. The goal is to repel enough positive charge ions so that they miss the spacecraft without attracting thermal electrons at the same time taking advantage of revolutionary next generation of shielding materials for Mars missions. Aspects of future directions of space radiation protection technology involving a combination of active-electrostatic and passive-material shielding will be presented.
3:24PM BH.00008 Baryon Confinement Theory, CARL CASE, Case Consulting — The Dirac Equation is solved for massless quarks and color gauge fields in the baryon confinement region. The dynamical situation of quarks and gluons that have identical velocities is investigated. This condition leads to spontaneous chiral symmetry breaking (SCSB) resulting in quarks experiencing a color magnetic force field only. SCSB leads to several consequences including: (1) quarks being confined within a color magnetic bottle; (2) gluons, in quantized bundles of color magnetic flux, being trapped by circulating quarks; (3) quarks and gluons behaving as a single composite particle gaining mass and acquiring velocities below the speed of light; and (4) the quantized flux conditions providing a mechanism for calculating the running strong coupling constant. Second quantization formalism describes quarks and gluons as field quanta and is convenient for studying systems of particles that can be transformed into other particles. Application of the Hartree self-consistent-field methodology and the Born approximation provide solutions for well-defined quantum states corresponding to the baryon mass spectra. The topological winding numbers from quantized flux are shown to correspond to gluon angular momentum states that give rise to the quark flavors. Resulting mass spectra calculations are presented along with insights to the nucleon spin and orbital angular momentum structure.

3:36PM BH.00009 Big Numbers Hypothesis, SHANTILAL GORADIA, Gravity Research Institute, Inc. — The dark matter predicted by the quantum field theory has a value of force $10^{-12}$ greater than indicated by observations. The product of $10^{90}$ nucleons and the surface area $10^{40}$ of each nucleon is $10^{210}$. The surface area of the universe taken as a single particle is $10^{210}$. The coupling constant between inter universes calculable, as square of $D$ (Hubble time) as done in [1] is $10^{210}$. The ratio of Hubble time to nucleon diameter is the same as the ratio of nucleon surface area to Planck length, both equal to $10^{10}$, raising a question: Are they both inflating at the same time or is it the Planck length that is shrinking since the big bang, and impacting evolution? The universe looks inflationary looking inside out. We are taking Doppler effect as scale invariant, while the fundamental constants of nature are changing. The 2002 publication of the English translation of Einstein’s 1919 paper by Hawking reveals clearly that he retracted the 1917 introduction of the cosmological constant. He might have informally uttered to Gamow about his blunder made in 1917 without clarifying his correction in 1919. His 1919 paper and his 1935 paper, both connect particles to normal spacetime implying he held the same view the rest of his life. I connect them too in physics/0210040 and will present more details. [1] S. G. Goradia gr-qc/0507130 (Indian Journal of Theoretical Physics 52 143 2004)

3:48PM BH.00010 A Postulation of a Concept in Fundamental Physics, SHANTILAL GORADIA, Gravity Research Institute, Inc. — I am postulating that all fermions have a quantum mouth (Planck size) that radiates a flux density of gravitons as a function of the mass of the particle. Nucleons are not hard balls like light bulbs radiating photons challenging Newtonian concepts of centers and surfaces. The hardball analogy is implicit in coupling constants that compare strong force relative to gravity. The radiating mouth is not localized at the center like a hypothetical point size filament of a light bulb with a hard surface. A point invokes mass of zero volume. It is too precise, inconsistent and illogical. Nothing can be localized with more accuracy that Planck length. Substituting the hard glass bulb surface with flexible plastic surface would clearly make the interacting mouths of particles approach each other as close as possible, but no less than the quantum limit of Planck length. Therefore, surface distance in Newtonian gravity would be a close approximation at particle scale and fits Feynman’s road map [1]. My postulation reflected by Fig. 2 of gr-qc/0507130 explains observations of increasing values of coupling constants resulting from decreasing values of Planck length (See physics/0210040 v1). Since Planck length is the fundamental unit of length of nature, its variation can impact our observation of the universe and the evolutionary process.
9:36AM CB.00002 Theoretical Description of the Fission Process1, WITOLD NAZAREWICZ, University of Tennessee/ORNL — Spontaneous fission is one of the oldest decay modes known, but is still not fully understood. On the one hand, various nuclear structure models have been applied to fission barriers, lifetimes, and mass/charge distributions, and they provide a good overall description of the phenomenon and, in many cases, detailed predictions. On the other hand, the full-fledged, non-adiabatic description of fission, based on effective nucleon-nucleon interactions, still does not exist. The aim of our project on “Theoretical Description of the Fission Process,” supported by NNSA (www.phys.utk.edu/witke/fission/fission.html), is to attack the problem of spontaneous fission using modern theoretical methods and state-of-the-art computational tools. During the first stage of the project, we have studied static fission barriers of the even-even actinide and transactinide nuclei within the self-consistent Density Functional Theory. The computations are carried out applying a code that makes it possible to break all self-consistent symmetries of the nuclear mean field, including axial symmetry and reflection symmetry. Particular attention has been paid to symmetry-breaking effects along the fission path.

1Supported by the U.S. DOE under Contract Nos. DE-FG02-96ER40963 (University of Tennessee), DE-AC05-00OR22725 with UT-Battelle, LLC (Oak Ridge National Laboratory), and by the NNSA through DOE Research Grant DE-FG03-03NA00083


3Work performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory, under contract No. W-7405-Eng-48.

10:00AM CB.00004 Testing the Absolute Surrogate Technique for Astrophysics1, D.L. BLEUEL, R.M. CLARK, P. FALLOn, J.D. GIBELIN, I-Y. LEE, A.O. MACCHIAVELLI, M.A. MCMAHAN, L. PHAIR, E. RODRIGUEZ-VIEITEZ, M. WIEDEKING, Lawrence Berkeley National Laboratory, L.A. BERNSTEIN, J.T. BURKE, R.D. HOFFMAN, B.F. LYLES, E.B. NORMAN, Lawrence Livermore National Laboratory — Neutron-induced reaction cross-sections on unstable nuclei are difficult to impossible to measure. However many of these reactions are of central importance to the understanding of stellar nucleosynthesis and the interpretation of radiochemical data from nuclear tests. In this talk we will present results from an experiment designed to “benchmark” the use of the absolute probability surrogate method to determine (n,xn) cross sections. Furthermore, 157Gd(He,αn) probabilities will be compared to 155Gd(n,γn) cross sections calculated using the STAPRE reaction model. The 157Gd(He,α) reaction was performed at the 88-Inch Cyclotron at Lawrence Berkeley National Laboratory, as a surrogate for 155Gd(n,γ) reactions. In conjunction with a future-planned 155Gd(He,α) experiment, the 155Gd(n,γ) cross section, an important s-process branch point reaction, will be determined through use of the ratio method.

1This work was sponsored by UC-LLNL under Contract No. W-7405-Eng-48 and Grant Nos. DE-FG-05NA25929, DE-FG52-06NA26206, and DE-FG02-05ER41379.

10:12AM CB.00005 Benchmarking the Surrogate Ratio Method Using 234U(α,α′f)/236U(α,α′f) , S.R. LESHER, C.W. BEAUSANG, Univ. of Richmond, J.T. BURKE, L.A. BERNSTEIN, J.A. CHURCH, F.S. DIETRICH, J. ESCHER, B.F. LYLES, K.J. MOODY, E.B. NORMAN, LLNL, H. AI, Yale University, R.M. CLARK, M.A. DELEPLANQUE, P. FALLOn, I.Y. LEE, A.O. MACCHIAVELLI, M.A. MCMAHAN, L. PHAIR, E. RODRIGUEZ-VIEITEZ, LBNL — The Surrogate Ratio Method [1] is expected to demonstrate less sensitivity to differences in spin between the neutron-induced and surrogate reactions than the absolute surrogate method. The first ratio method experiment shown that the 237U/235U fission probability ratio was independent of whether the nuclei were formed using neutron-capture or the (d,p) reaction over a wide range of equivalent neutron energy [1]. However, this result had significant (~20%) uncertainty. In order to benchmark the ratio method with greater precision a new experiment was performed at the 88-Inch Cyclotron at LBNL using the Silicon Telescope Array for Reaction Studies (STARS) where the ratio of the 234U(α,α′) and 236U(α,α′) probabilities were compared to the known 235U(n,f)/235U(n,f) cross section ratio. This talk will discuss the surrogate ratio method and the preliminary results of our measurement. This work was sponsored by UC-LLNL under Contract No. W-7405-Eng-48 and Grant Nos. DE-FG-05NA25929, DE-FG52-06NA26206, and DE-FG02-05ER41379.


10:24AM CB.00006 The Effect of the J-pi Population Mismatch on the Surrogate Method , BETHANY LYLES, University of California, Berkeley, LEE BERNSTEIN, JASON BURKE, Lawrence Livermore National Laboratory, LARRY PHAIR, JULIEN GIBELIN, DARREN BLEUEL, MATHIS WIEDEKING, RODERICK CLARK, AUGUSTO MACCHIAVELLI, PEGGY MCMAHAN, Lawrence Livermore National Laboratory, CORNELIUS BEAUSANG, SHELLY LESHER, University of Richmond, CYBELE JEWETT, Lawrence Berkeley National Laboratory, ERIC NORMAN, Lawrence Livermore National Laboratory — The surrogate method is an indirect means for determining neutron-induced reaction cross sections on unstable nuclei. This is accomplished by measuring the relevant decay probabilities of the composite nucleus of interest produced via a light-ion induced surrogate reaction using a stable target and beam. To properly characterize the surrogate method, the effect of differences in angular momentum populations between the surrogate light-ion and desired neutron-induced reactions must be determined. To this end, the following experiment was performed at the 88 Cyclotron at Lawrence Berkeley National Laboratory: 235U(3He,af) and 238U(3He,af) as surrogates for 233U(n,f) and 236U(n,f), respectively. The extracted cross sections were compared to known values and the implication on the J-pi population mismatch will be discussed.

10:36AM CB.00007 Applying the Surrogate Technique to Stockpile Stewardship , J.T. BURKE, L.A. BERNSTEIN, J. ESCHER, L. AHLE, J.A. CHURCH, F.S. DIETRICH, K.J. MOODY, E.B. NORMAN, LLNL, L. PHAIR, P. FALLOn, R.M. CLARK, M.A. DELEPLANQUE, D.L. BLEUEL, I.Y. LEE, A.O. MACCHIAVELLI, M.A. MCMAHAN, M. WIEDEKING, E. RODRIGUEZ-VIEITEZ, F.S. STEPHENS, LBNL, C. PLETTLNER, H. AI, Yale University, C. BEAUSANG, B. CRIDDER, University of Richmond — Recent work has focused on developing the absolute probability and external ratio surrogate techniques for use in determining neutron-induced cross sections on unstable nuclei. In this talk we will present a new “internal” ratio method where a ratio of different exit channel probabilities for the same compound nucleus can be used to determine the cross section for an unknown exit channel when a cross for a different exit channel (e.g. determining (n,γ) when (n,f) is known). This technique can be used in combination with an “external” ratio method measurement to “bootstrap” several surrogate (n,x) cross sections from a single surrogate measurement. We will present results from two experiments using STARS-LIBERACE at the 88-Inch cyclotron at LBNL to determine the 237U(n,γ) and 237U(n,2n) cross sections using this “internal” ratio method. This work was sponsored by UC-LLNL under Contract No. W-7405-Eng-48 and Grant Nos. DE-FG-05NA25929, DE-FG52-06NA26206, and DE-FG02-05ER41379.
10:48AM CB.00008 Pre-equilibrium nucleon emission and its effect on the surrogate measurement of $^{237}$U(n, f) . HAI, AI, Yale, WNSL, C.W. BEAUSANG, University of Richmond, L. AHLE, L.A. BERNSTEIN, J.T. BURKE, J.A. CHURCH, K.J. MOODY, E.B. NORMAN, W. YOUNES, LLNL, D.L. BLEUEL, R.M. CLARK, P. FALLOON, I.Y. LEE, A.O. MACCHIAVELLI, M.A. MCMANUS, L.W. PHAIR, E. RODRIGUEZ-VIEITEZ, S. SINAHA, M. WIEDEKING, LBL — The surrogate ratio technique of using surrogate measurements to estimate the cross section ratio of two different but similar reactions was found to be reliable by recent works. To further confirm the validity of the surrogate method, we performed an experiment at LBL to extract the $^{237}$U(n, f) reaction cross section from the surrogate $^{238}$U(α, f) reaction directly, without the use of ratios. Interestingly, the directly estimated $^{237}$U(n, f) reaction cross section was lower than that obtained by the ratio method for equivalent neutron energy above one neutron separation energy. A possible explanation is that a direct reaction has occurred where a single nucleon in the composite system is excited with enough energy to escape, leaving a nucleus with much less excitation energy deduced from energy of the scattered α beam. To check this we searched for scattered α’s in coincidence with other charged particles, and evidence of such events will be presented. This work was supported in part by U.S. DOE Grant No. DE-FG02-91ER40609, DE-FG02-05ER41379, DE-FG52-06NA26206, and Contract No. W-7405-Eng-48, DE-AC03-76SF0098.

11:00AM CB.00009 Surrogate Reaction Measurements of Fission γ-ray Spectra with LIBERACE and STARS. C.C. JEWETT, University of California at Berkeley, S.R. LESHER, University of Richmond, J.T. BURKE, LLNL, C.W. BEAUSANG, University of Richmond, L.A. BERNSTEIN, LLNL, HAI, A.W. Wright Nuclear Structure Laboratory, J.A. CHURCH, LLNL, R.M. CLARK, M.A. DELEPLANCHÉ, LLNL, F.S. DIETRICH, J. ESCHER, LLNL, P. FALLOON, I.Y. LEE, LLNL, B.F. LYLES, LLNL, A.O. MACCHIAVELLI, M.A. MCMANUS, LLNL, K.J. MOODY, E.B. NORMAN, LLNL, L. PHAIR, E. RODRIGUEZ-VIEITEZ, LLNL — Very few high-resolution measurements have been made of the prompt γ-ray spectra following non-spontaneous fission. However, this information is useful for stockpile stewardship and can also provide a wealth of information about the fission process. Recent experiments using STARS+LIBERACE at the 88-Inch cyclotron designed to determine surrogate neutron-induced cross sections in the Uranium isotopic chain have also produced a wide range of triple-coinicident particle-fission-γ data which can be used to determine fission γ-ray spectra for $^{234-238}$U and $^{235,236}$Np compound nuclei. In this talk we will present the spectra from these different systems and compare γ-ray spectra from different “chance” fission channels over a wide range of isotopes and energies. This work was sponsored by UC-LLNL under Contract No. W-7405-Eng-48 and Grant Nos. DE-FG-05-09NA25929, DE-FG02-06NA26206, and DE-FG02-05ER41379.

11:12AM CB.00010 ABSTRACT WITHDRAWN —

11:24AM CB.00011 Simultaneous measurement of (n,γ) and (n,fission) cross sections with the DANCE array. T.A. BREDEWEG, M. JANDEL, M.M. FOWLER, E.M. BOND, J.M. O’DONNELL, R. REIFARTH, R.S. RUNDBERG, J.L. ULLMANN, D.J. VIEIRA, J.B. WILHELMY, J.M. WOUTERS, LANL, R.A. MACRI, C.Y. WU, J.A. BECKER, LLNL — We have recently begun a program of high precision measurements of the key production and destruction reactions of important radiochemical diagnostic isotopes, including several isotopes of uranium, plutonium and americium. The Detector for Advanced Neutron Capture Experiments (DANCE), a 4π array located at the Los Alamos Neutron Science Center, will be used to measure the neutron capture cross sections for most of the isotopes of interest. Since neutron capture measurements on many of the actinides are complicated by the presence of γ-rays arising from low-energy neutron-induced fission, we are currently using a dual parallel-plate avalanche counter with the target material electro-deposited directly on the center cathode foil. This design provides a high efficiency for detecting fission fragments and allows loading of pre-assembled target/detector assemblies into the neutron beam line at DANCE. An outline of the current experimental program will be presented as well as results from measurements on $^{235}$U and $^{232}$Cf that utilized the fission-tag detector.

1Work performed under the auspices of the U.S. Department of Energy by the University of California and Los Alamos National Security, LLC.

11:36AM CB.00012 Neutron-Induced Partial Gamma-Ray Cross-Section Measurements on Uranium Using a Pulsed and Monoenergetic Beam at TUNL. A. HUTCHESON, A.S. CROWELL, J.H. ESTERLINE, C. FALLEN, C.R. HOWELL, M. KISER, A.P. TONCHEV, W. TORNOW, Duke University and TUNL, J.H. KELLEY, North Carolina State University and TUNL, C.T. ANGELL, M. BOSWELL, H.J. KARWOWSKI, University of North Carolina and TUNL, R.S. PEDRONI, North Carolina A&T and TUNL, G.J. WEISE, Penn State Altoona, J.A. BECKER, D. DASHDORJ, R.A. MACRI, Lawrence Livermore National Laboratory, R.O. NELSON, Los Alamos National Laboratory — Precision measurements have been performed on $^{235,238}$U targets at Triangles Universities Nuclear Laboratory using a pulsed and monoenergetic neutron beam. The excitation function of (n,2n) reaction has been studied with incident neutron energies between 5 and 15 MeV and beam flux of 10$^{8}$ n cm$^{-2}$ s$^{-1}$.

1Supported by the NNSA under the Stewardship Science Alliances Program through DOE Research grant #DE-FG03-02NA00073.

11:48AM CB.00013 Measurement of the $^{235m}$U Production Cross Section Using a Critical Assembly*. R. ROBERT MACRI, Lawrence Livermore National Laboratory, NICOLAS AuthIER, CEA, JOHN BECKER, Lawrence Livermore National Laboratory, GILBERT BELIER, CEA, EVELYN BOND, TODD BREDEWEG, S. GLOVER, Los Alamos National Laboratory, VINCENT MEOT, CEA, ROBERT RUNDBERG, DAVID VIEIRA, JERRY WILHELMY, Los Alamos National Laboratory — Measurements of the creation and destruction cross sections for actinide nuclei constitute an important experimental effort in support of Stockpile Stewardship. In this talk I will give a progress report on the effort to measure the production cross section of the $^{235m}$U isomer integrated over a fission neutron spectrum. This ongoing experiment is fielded at CEA in Valduc, France, taking advantage of the CALIBAN critical assembly. This effort is performed in collaboration with LANL, LLNL, Bruyeres le Chatel, and Valduc staff. This experiment utilizes a technique to measure internal conversion electrons from the $^{235m}$U isomer with the French BIII detector (Bruyeres le Chatel), and involves a substantial chemistry effort (LANL) to prepare targets for irradiation and counting, as well as to remove fission fragments after irradiation. Experimental techniques will be discussed and preliminary data presented. *Work performed under the auspices of the U.S. Department of Energy by Los Alamos National Laboratory (W-7405-ENG-36) and Lawrence Livermore National Laboratory (W-7405-ENG-48), and CEA-DAM under CEA-DAM NNSA-DOE agreement.
12:00PM CB.00014 Measurement of the $^{241}$Am(n,2n) Reaction Cross Section with the Activation Technique$^3$. A. TONECHEV, A. CROWELL, B. FALLIN, C. HOWELL, A. HUTCHESON, W. TORNOW, Duke and TUNL, J. KELLEY, NCSU and TUNL, C. ANGELL, H. KARWOWSKI, UNC and TUNL, R. PEDRONI, NC A&T and TUNL, J. BECKER, D. DASHDORJ, R. MACRI, J. WILHELMY, LLNL, E. BOND, J. FITZPATRICK, A. SLEMMONS, D. VIEIRA, LANL — High precision measurements of the $^{241}$Am(n,2n)$^{240}$Am reaction have been performed with neutron energies from 8.8 to 14.0 MeV. The monoenergetic neutron beams were produced via the $^2$H(d,n)$^3$He reaction using the 10 MV Tandem accelerator at TUNL. The radioactive targets consisted of 1mg highly-enriched $^{241}$Am sandwiched between four different thin monitor foils. They were irradiated with a neutron flux of 3x10$^{12}$ n cm$^{-2}$ s$^{-1}$. After each irradiation the induced activity in the targets and monitors was measured off-line with 60% HPGe detectors. Our preliminary neutron induced cross sections will be compared with recent literature results and statistical model calculations using the GNASH and EMPIRE codes.

3Supported by the NNSA under the Stewardship Science Academic Alliances Program through DOE Research grant #DE-FG03-02NA00073.E and the auspices of the U.S. Department of Energy by LANL (W-7405-ENG-36) and LLNL (W-7405-ENG-48).

Friday, October 27, 2006 9:00AM - 12:00PM
Session CC DNP: Nuclear Structure II Gaylord Opryland Tennessee B

9:00AM CC.00001 The $K$ quantum number in the Shell Model—$^{50}$Cr, SHADOW ROBINSON, U. Southern Indiana, ALBERTO ESCUDEROS, LARRY ZAMICK, Rutgers U. — It was suggested [1,2] that the $10^+_1$ state in $^{50}$Cr at 6.340 MeV does not belong to the $K=0^+$ g.s. band. In [1] it is noted that the static quadrupole moments of the $J=2^+_1$ and $5^+_1$ states are all negative, but that of $10^+_1$ is positive. While Ref. [1] suggested that the $10^+_1$ state belongs to a high $K$ prolate band, in Ref. [2] they assign it as $K=10^+$. There is a nearby second $10^+$ state. However, the $B(E2)^{10+_1-10+_0}$ was not quoted by either group. In this work, we performed full $f_p$ shell model calculations using four different interactions: FPd6, KB3, GXPF1, and GXPF1A. The results for $B(E2)^{10+_1-10+_0}$ are robust around 135 e$^2$fm$^4$ and suggest strong $K$ mixing. It is not clear what the $K$ value for the $10^+_1$ state is. With FPd6, $Q(10^+_1)$ is negative, suggesting it is a member of the $K=0^+$ band. But it is hard to understand how to get strong mixing of $K=0^+$ and $K=10^+$. With the other interactions, $Q(10^+_1)$ is positive and thus inconsistent with a $K=0^+$ (prolate) band. If we assume that the $10^+_1$ state has $K=10^+$ and the $8^+_1$ state has $K=0^+$, then the $B(E2)^{10+_1-8+_1}$ would vanish. However, for the last three interactions, the corresponding $B(E2)$ is about 75 e$^2$fm$^4$, which implies substantial $K$ mixing. Thus, while a $K=10^+$ assignment for the $10^+_1$ states makes the most sense in terms of energy systematics, in detail the situation is more complicated. [1] L. Zamick et al., Phys. Rev. C 53, 188 (1996); Phys. Rev. C 54, 956 (1996). [2] F. Brandolini et al., Phys. Rev. C 66, 021302(R) (2002).

9:12AM CC.00002 Update on the structure of n-rich 52-56Ti$^4$. S. ZHU, Argonne National Laboratory, R.V.F. JANSSSENS, M.P. CARPENTER, S. FREEMAN, University of Manchester, B. FORNAL, Niewodniczanski Institute of Nuclear Physics, A. DEACON, University of Manchester, B. KAY, J. KOZEMCZAK, Greenville College, A. LARABEE, T. LAURITSEN, Argonne National Laboratory, A. ROBINSON, D. SEWERYNIAK, J. SMITH, University of Manchester, D. STEPPENBECK, X. WANG$^2$, Argonne National Laboratory — Neutron-rich nuclei above $^{48}$Ca are presently the subject of much theoretical and experimental focus because of the presence of a N=32 sub-shell gap [1]. The spectroscopy of these hard-to-reach nuclei has been carried out with a number of reactions including deep inelastic processes and fusion-evaporation utilizing extremely weak channels. An example of the latter is the use of the $^9$Be($^{48}$Ca,2p) reaction with a ~1 nb cross section to investigate $^{53}$Ti. In this case, advantage is taken of the resolving power of the combination of the Argonne Fragment Mass Analyzer and the Gammasphere array. Recent experimental progress in the structure of the odd and even Ti isotopes will be presented and compared with shell model calculations carried out with recently developed effective interactions.


9:24AM CC.00003 A g-factor puzzle for the N=38 nuclei:First measurement of the $^{70}$Ge $4^+$ magnetic moment. M. PLAMEN BOUTACHKOV, G. KUMBARTZKI, N. BENZER-KOLLER, Rutgers University, S. ROBINSON, University of Southern Indiana, A. ESCUDEROS, E. STEFANOVA, Y. SHARON, L. ZAMICK, Rutgers University, E. MCCUTCHEAN, V. WERNER, H. AI, G. GURDAL, A. HEINZ, J. QIAN, E. WILLIAMS, R. WINKLER, Yale University, A. GARNSWORTHY, N. THOMPSON, University of Surrey, P. MAIER-KOMOR, Technische Universität Munchen — The transient field technique in inverse kinematics allows the g-factor studies of short-lived states. This method gives information on both the sign and the magnitude of the g factor. In a recent experiment, the g factor of the $4^+$ state of $^{90}$Zn$_{38}$ was measured to be -0.37(17) suggesting a significant neutron $g_{9/2}$ contribution to the wave function[1]. However, shell model calculations in the $0f_{7/2},1p_{1/2},1p_{3/2},0g_{9/2}$ space [1] predict a positive, nearly zero g factor. To obtain more information on this region we measured the magnetic moment of the $4^+$ in $^{76}$Ge$^{38}$. The measurement was performed at WNSL, Yale, using a 275 MeV $^{70}$Ge beam and a multilayered $C+Gd+Cu$ target. A positive $g$ factor was obtained. The measured magnetic moment was compared to full $fp$ shell model calculations which we performed with the code ANTOINE using several effective interactions. The results were in good agreement with the experiment. The experiment and the implications of the new results will be discussed.


9:36AM CC.00004 High Spin Structure in Neutron Rich Zn Isotopes A.A. HECHT, N. HOTELING, Maryland, Argonne Natl Lab, W.B. WALTERS, Maryland, M.P. CARPENTER, R.V.F. JANSSSENS, T. LAURITSEN, D. SEWERYNIAK, X. WANG, S. ZHU, Argonne Natl Lab, B. FORNAL, R. BRODA, W. KROLAS, J. WRZESINSKI, Niewodniczanski Inst of Nucl Phys, Poland, A. WOEHR, Notre Dame, N.J. STONE, Tennessee, J. STONE, Maryland — The neutron rich region near doubly-magic $^{78}$Ni is significant for both nuclear structure and nuclear astrophysics: as input for models on shell structure near the neutron drip-line and as the seed region for the beginning of the rapid neutron capture process of nucleosynthesis. This region is not easily accessible and most of the data towards the drip line are on low spin states. To expand this knowledge to high spin states, a deep inelastic scattering (DIS) experiment was performed at Argonne National Laboratory. Pulsed beams of $^{82}$Se and $^{64}$Ni impinged on a target of $^{238}$U and the gamma rays emitted from the DIS products were observed using the Gammasphere detector array. $\gamma - \gamma$ coincidence matrices were made with both prompt and delayed data and excited states of $^{58-78}$Zn were observed. Angular correlations and new high spin states were measured for $^{74}$Zn and several other Zn isotopes. This work was supported in part by the US DOE under Contract Nos. W-31-109-ENG-38, DE-FG02-94ER40834 and Polish Sci. Committee Grant No. 1P03B-059-29.
9:48AM CC.00005 Transition strengths and degree of deformation in $^{79}$Sr$^{\,1}$, R.A. Kaye, Y.K. Ryu, Ohio Wesleyan University, S.L. Tabor, T. Baldwin, D.B. Campbell, C. Chandler, M.W. Cooper, C.R. Hoffman, J. Pavan, M. Wiedeking, Florida State University, J. Döring, GSI, Germany, Y. Sun, University of Notre Dame, S.M. Gerbick, O. Grubor-Urosevic, Purdue University Calumet, L.A. Riley, Ursinus College — High-spin states in $^{79}$Sr were studied using the $^{54}$Fe($^{28}$Si, 2n)$^{52}$Fe target used to stop all recoils. Prompt $\gamma$-$\gamma$ coincidences were detected using the FSU Compton-suppressed Ge array, and allowed for a verification of the $^{79}$Sr level scheme in three separate band structures. Lifetimes of 34 excited states were measured using the Doppler-shift attenuation method, with the experimental line shapes obtained at two separate observation angles and by gating from above the transition of interest whenever possible. Transition quadrupole moments $Q_{\gamma}$ inferred from the lifetimes indicate a high degree of collectivity and deformation over a rather wide range of spins in all three observed bands. These results will be interpreted within the framework of the projected shell and cranked Woods-Saxon models.

1 Supported in part by the National Science Foundation through Grant Nos. PHY-99-70991 and PHY-0140324, and the OUW Summer Science Research Program.

10:00AM CC.00006 M1 transitions between low-lying states in the sdg-IBM-2, Robert Casperson, Volker Werner, WNSL, Yale University, CT 06520 — The interplay between collective and single-particle degrees of freedom for nuclei in the A=90 region have 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. Collective symmetric structures appear when protons and neutrons are in phase, whereas mixed-symmetric structures occur when they are not. The one-phonon 2$^{+}$ mixed-symmetric state was identified from strong M1 transitions to the 2$^{+}$ state. Similar transitions were observed between higher-spin states, and are predicted by the shell model. These phenomena will be investigated within the sdg Interacting Boson Model 2 in order to obtain a better understanding about the structure of the states involved, and results from first model calculations will be presented. Work supported by US DOE under Grant number DE-FG02-91ER-40609.

10:12AM CC.00007 Low spin structure of $^{94}$Zr from (n,n$'$γ) measurements$^{1}$, E. Elhami, J.N. Orce, S. Mukhopadhyay, S.N. Choudry, M. Scheck, M.T. McCellistrem, S.W. Yates, University of Kentucky — Recent measurements of negative g-factors for the 2$^{+}$ and 4$^{+}$ states in $^{92}$Zr and $^{94}$Zr have established the dominant role of 2d$^{-1/2}$ neutron configurations between the N=50 closed shell and the N=56 subshell closure. Moreover, further studies of mixed-symmetry (MS) states in $^{92}$Zr supported a weaker p-n interaction for the 2$^{+}_{2}$ MS state, as compared with the 2$^{+}_{1}$ MS state in $^{94}$Zr, which results in a partial decoupling of proton and neutron excitations. The strong M1 transition with B(M1)=0.37(4) $\mu_{N}^{2}$ connecting the 2 lowest 2$^{+}$ states indicates, however, that both proton and neutron configurations are still important parts of their wavefunctions. Following the previous discussion, we have analysed the low-lying structure of $^{94}$Zr at the University of Kentucky. The nuclide was studied through the (n,n$'$γ) reaction at energies of 2.3, 2.8 and 3.5 MeV. A 98% enriched $^{94}$Zr sample was used and angular distribution information yields to the measurement of branching and mixing ratios of 2γ transitions, and determination of level lifetimes and transition strengths. For the purpose of this work, only the results for the 2.3 MeV data will be presented.

1 This material is based upon work supported by the U.S. National Science Foundation under Grant No. PHY-0354656.

10:24AM CC.00008 First Experimental Value of a mixed-symmetry G Factor: $^{94}$Zr, M. Perry, WNSL Yale Univ., FSU, V. Werner, WNSL, P. Bouchakov, E. Stefanova, N. Benzer-Koller, G. Kumbartzki, Rutgers Univ., N. Pietralla, IKP, Univ. at Köln, Germany, H. Al, R.F. Casten, A. Heinz, E.A. McCutchian, D.A. Meyers, J. Qian, E. Williams, R. Winkler, WNSL, M. Chamberlain, C.R. Fitzpatrick, A.B. Garnsworthy, N.J. Thompson, WNSL, Univ. of Surrey, UK, R.B. Cakirli, WNSL, Istanbul Univ, Turkey, X. Liang, WNSL, Univ of Paisley, UK, P. Maier-Komor, TU, Munich, Germany, G. Gürdal, WNSL, Clark Univ, A.E. Stuchbery, ANU, Australia, K.-H. Speidel, ISKP, Bonn Univ, Germany — Zr isotopes have the characteristic of a neutron(n)-dominated and a proton(p)-dominated 2$^{+}$ state, resembling the building blocks of collective quadrupole excited states, i.e. one-phonon pn symmetric and mixed-symmetric 2$^{+}$ states. The pn configuration mixing in these states can be tested by measuring their g factors. The g factors predicted by different models vary due to the characterization of the symmetry breaking. The g factors of a mixed symmetric state have been measured for the first time in $^{94}$Zr using the transient magnetic field technique at WNSL. The result, proving dominant p character in the 2$^{+}$ state, will be presented and compared with theory. Work supported by USDOE under contracts DE-FG02-91ER-40609, DE-FG52-05NA25929, and DE-FG02-88ER40417 and th US NSF.

10:36AM CC.00009 Identification of high spin states and nearly degenerate $\Delta I=1$ bands in $^{100}$Zr, J.K. Huang, A.V. Ramayya, J.H. Hamilton, Vanderbilt Univ., J.O. Rasmussen, Y.X. Luo, LBNL, D. Fong, K. Li, C. Goodin, Vanderbilt Univ., S.J. Zhu, Tsinghua Univ., S.C. Wu, LBNL, M.A. Stoyer, LLNL, R. Donangelo, Univ. Fed. do Rio de Janeiro, X.-R Zhu, Xiamen Univ., H. Sagawa, Univ. Aizu — Eight new high spin states and twenty-three new $\gamma$ transitions have been identified in $^{100}$Zr from studies of 252Cf spontaneous fission with Gammasphere. A near-spherical excited band in $^{100}$Zr based on the 331.1 keV 0$^{+}$ state is extended from 4$^{+}$ up to 12$^{+}$. A $\Delta I=1$ band with band-head energy of 2316.1 keV is extended. This band now forms $\Delta I=1$ doublet bands with the previously known $\Delta I=1$ band beginning at 2259.8 keV. The energy difference between the bands with the same spins in the two bands are nearly degenerate, $\Delta E=25.2(8^{+})$, 8.6(9$^{+}$), 4.8(10$^{+}$) and 12.1(11$^{+}$) keV. Our theoretical calculations indicate the coexistence of prolate and oblate shapes for the two 0$^{+}$ bands in $^{100}$Zr. We propose the possible coexistence of prolate, oblate and triaxial shapes for the highly excited 2 quasiparticle bands.

10:48AM CC.00010 Identification of band structures and proposed one- and two-phonon $\gamma$-vibrational bands in $^{105}$Mo, H.B. Ding, S.J. Zhu, Tsinghua Univ., J.H. Hamilton, A.V. Ramayya, J.K. Huang, K. Li, Vanderbilt Univ., Y.X. Luo, Vanderbilt Univ./LBNL, J.O. Rasmussen, I.Y. Lee, LBNL, C.T. Goodin, Vanderbilt Univ., X.L. Che, Y.J. Chen, M.L. Li, Tsinghua Univ. — High spin band structures in neutron-rich $^{105}$Mo were studied by measuring prompt $\gamma$-rays emitted by the spontaneous fission fragments of 252Cf with the Gammasphere detector array. The target has been bombarded and five new collective bands are observed. The three bands based on the 240.3, 332.0 and 310.0 keV levels are proposed as the single-neutron excitation bands built on the 3/2$^{+}$ [411], 1/2$^{+}$ [411] and 5/2$^{+}$ [413] Nilsson orbitals, respectively. The other two bands with band head levels at 870.5 and 1534.6 keV are candidates for one-phonon K=9/2 and two-phonon K=13/2 $\gamma$-vibrational bands, respectively. Systematic comparison of these bands with bands in $^{104,106}$Mo are discussed.
11:00AM CC.00011 Identification of ¹⁰⁹Xe and ¹⁰⁵Te — S. LIDDICK, J.C. BATCHELDER, UNIRIB, R. GRZYWACZ, C. MAZZOCCHI, C.R. BINGHAM, G. DRAFTA, A. KORGUL, M.N. TANTWAY, R.D. PAGE, I.G. DARBY, D.T. JOSS, J. THOMSON, University of Liverpool, K.P. RYKACZEWSKI, C. GROSS, ORNL, C. GOODIN, J.H. HAMILTON, J.K. HWANG, K. LI, Vanderbilt, S. ILYUSHKIN, J.A. WINGER, Miss State University, K. LAGERGREN, W. KROLAS, JIHIR, A.A. HECHT, Maryland University — The existence of a region of alpha emitting nuclei above ¹⁰⁰Sn is due to the presence of the Z=50 shell closures. The region is a fertile area to investigate possible enhanced correlations between neutrons and protons filling the same single-particle orbits and could lead to the observation of superallowed alpha decay as an approach is made towards Sn. The new isotope ¹⁰⁹Xe was produced at the HRIBF at Oak Ridge National Laboratory. The tightest mass α-radioactivity identified to date, ¹⁰⁵Te was detected through the ¹⁰⁹Xe—¹⁰⁵Te—¹⁰ⁱSn alpha decay chain. This marks the closest approach to the N = Z line above the HRIBF at Oak Ridge National Laboratory. The lightest mass single-particle orbits and could lead to the observation of superallowed alpha decay as an approach is made towards presence of the Z=50 shell closures. The region is a fertile area to investigate possible enhanced correlations between neutrons and protons filling the same state to states of the low-lying dipole strength distributions in the odd-mass nuclei ¹³⁷Ba, ¹³⁵Ba, ¹³⁹La, and ¹⁴¹Pr were studied in nuclear resonance fluorescence (NRF) experiments performed at the Stuttgart Dynamitron facility. experiments used bremsstrahlung beams with endpoint energies of 4.1 MeV. The spin selective NRF reaction allowed the excitation of states through dipole transitions, up to 4 MeV. A special focus is the fragmented E1-strength of transitions connecting the ground state to states of the ²¹³Sn of 2.7 indicates a superallowed character of the α-emission from ¹⁰⁵Te. Fine structure in the millisecond alpha decay of ¹⁰⁹Xe to ¹⁰⁵Te was identified and the energy difference between the vgs/2 ground state and the vgs/2 first excited state was determined to be around 150 keV in ¹⁰⁵Te. Prospects for reaching the superallowed alpha decay chain ¹⁰⁹Xe—¹⁰⁴Te —¹⁰⁰Sn will also be discussed.

11:12AM CC.00012 Identification of ⁰⁺ States in Transitional Nuclei — R. WINKLER, A. HEINZ, R.F. CASTEN, C. LAMBE-HANSON, J. QIAN, Yale University, R. KRUKEN, T. FAESTERMANN, H.-F. WIRTH, R. GRAEGER, Technical University Munich, J. JOLIE, P. VON BRENTANO, C. SCHOLL, S. CHRISTEN, University of Cologne — The (p,t) pickup reaction was used to populate excited ⁰⁺ states of nuclei near the N=82 isotones, MARCUS SCHECK, University of Kentucky, INST. FUER STRAHLENPHYSIK, STUTTGART UNIVERSITY TEAM — The quasi-rotational bands with different deformations. Details of these studies and data from recent experiments focused on stability of Qα corrected for the recoil effect, yield the difference between the ground-state masses of parent and daughter nuclides (Qα). Far from stability the determination of Qα, often represents the only way to determine the masses of ground and isomeric states. The evolution of Qα values along an alpha-decay chain are also a probe for shell effects. In the region above ¹⁰⁰Sn an alpha-decay island occurs, its presence is related to the strong Z=50. N=50 double shell-closure. In an experiment performed at the Recoil Mass Separator of the HRIBF at Oak Ridge National Laboratory, the first evidence for the alpha-decay branch of the proton-emitter ¹⁰⁹I was obtained. The results and the consequences for nuclear masses in this region will be discussed.

11:36AM CC.00014 Dipole strength distributions in stable odd-mass nuclei in the vicinity of the N=82 isotones — MARCUS SCHECK, University of Kentucky, INST. FUER STRAHLENPHYSIK, STUTTGART UNIVERSITY TEAM — The low-lying dipole strength distributions in the odd-mass nuclei Ba, Ba, La and Pr were studied in nuclear resonance fluorescence (NRF) experiments performed at the Stuttgart Dynamitron facility. experiments used bremsstrahlung beams with endpoint energies of 4.1 MeV. The spin selective NRF reaction allowed the excitation of states through dipole transitions, up to 4 MeV. A special focus is the fragmented E1-strength of transitions connecting the ground state to states of the ²¹³Sn of 2.7 indicates a superallowed character of the α-emission from ¹⁰⁵Te. Fine structure in the millisecond alpha decay of ¹⁰⁹Xe to ¹⁰⁵Te was identified and the energy difference between the vgs/2 ground state and the vgs/2 first excited state was determined to be around 150 keV in ¹⁰⁵Te. Prospects for reaching the superallowed alpha decay chain ¹⁰⁹Xe—¹⁰⁴Te —¹⁰⁰Sn will also be discussed.

11:48AM CC.00015 Systematic Features Indicative of Shape Coexistence in the Doubly-Even N=90 isotopes — W.D. KULP, J.L. WOOD, Georgia Institute of Technology, P.E. GARRETT, University of Guelph — The N = 90 nuclei near stability (¹⁵⁰Nd, ¹⁵²Sm, ¹⁵⁴Gd, and ¹⁵⁶Dy) are at the onset of stable nuclear deformation and have often been labeled as “soft” nuclei. Results from recent experimental and theoretical studies of these nuclei challenge this interpretation, however, and indicate instead strong mixing of near-degenerate coexisting quasi-rotational bands with different deformations. Details of these studies and data from recent experiments focused on Dy, Er, and Yb using the ⁸π Spectrometer at TRIUMF/ISAC will be presented.

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Work supported in part by USDOE contract DE-FG02-96ER40958 (Ga. Tech).

Friday, October 27, 2006 9:00AM - 11:24AM — Session CE DNP: Nuclear Astrophysics — Gaylord Opryland Hermitage B

9:00AM CE.00001 Measurement of ⁷Be+p elastic and inelastic scattering¹ — R.J. LIVESAY, CO School of Mines, D.W. BARDAYAN, J.C. BLACKMON, ORNL, K.Y. CHAE, Univ. Tennessee Knoxville, A.E. CHAMPAEGNE, UNC Chapel Hill, C. DEIBEL, WNSL, Yale Univ., R.P. FITZGERALD, UNC Chapel Hill, U. GREIFIE, CO School of Mines, K.L. JONES, Rutgers Univ., R.L. KOZUB, TN Tech. Univ., Z. MA, Univ. Tennessee Knoxville, C.D. NESARAJA, ORNL, S.D. PAIN, Rutgers Univ., F. SARAZIN, CO School of Mines, J.F. SHRINER JR., TN Tech. Univ., D.W. STRACENER, M.S. SMITH, ORNL, J.S. SMITH, Rutgers Univ., D.W. VISSER, ORNL, C. WREDE, M.S. JOHNSON, Rutgers Univ. — We have measured ⁷Be+p elastic and inelastic scattering cross sections at the Holifield Radioactive Ion Beam Facility (HRIBF) at ORNL. Beams of isotopically pure ⁷Be bombarded thin (100 μg/cm²) polypropylene targets; scattered protons were detected in an array of silicon strip detectors. Cross sections were measured at 17 bombarding energies ranging from E=0.5 to 3.4 MeV. The data at each energy were normalized using ⁷Be+Au elastic scattering from a combined target of polypropylene and gold.

¹funded by Department of Energy: Office of Nuclear Physics
9:12AM CE.00002 Study of the $\beta$-decay of $^{11}$Li at ISAC/TRIUMF, C. MATTISON, F. SARAZIN, Colorado School of Mines, A. ANDREIV, P.E. GARRETT, G.F. GRINYER, C.E. SVENSSON, University of Guelph, A. ANDREYEV, G.C. BALL, R.S. CHAKRABARTHY, G. HACKMAN, A.C. MORTON, C. PEARSON, M.B. SMITH, Triumf, R.A.E. AUSTIN, Saint Mary's University, D. CROSS, D. MELCONIAN, J. RESSLER, Simon Fraser University, E.S. CUNNINGHAM, J. DAOUD, University of Surrey, J. SCHWARZENBERG, University of Vienna — The $\beta$-decay of $^{11}$Li was investigated at ISAC/TRIUMF with the 8r spectrometer, an array of 20 Compton-suppressed HPGe detectors. Doppler-broadened line shapes appear in the $\beta$-decay spectrum, arising from the decay of excited states of $^{11}$Be populated by $\beta$- delayed one-neutron emission. A Monte Carlo simulation for these line shapes was developed, permitting the analysis of excited states in $^{11}$Be and neutron emitting states in $^{11}$Be. This experiment improves on a previous work [F. Sarazin et al., Phys. Rev. C 70 (2004) 033102R] through greater $^{11}$Li yield and the addition of Sceptar, a plastic scintillating array in the inner volume of the 8r. Analysis of the higher quality line shapes from the new experiment should help resolve discrepancies observed between the previous work and [Y. Hirayama et al., Phys.Lett. B 611 (2005) 239] (an experiment using polarized $^{11}$Li and time-of-flight neutron detectors) and possibly lead to new insights in the $\beta$-decay of $^{11}$Li. This work is partially supported by the US Department of Energy through Grant/Contract No. DE-FG03-93ER40789.

9:24AM CE.00003 Improving the Rate of the Triple Alpha Reaction, C. TUR, NSCL, MSU, A. WUOSSMAA, WMU, S.M. AUSTIN, NSCL, MSU, J. LIGHTHALL, S. MARLEY, N. GOODMAN, J.J. BOS, WMU, A. HEGER, LANL, S.E. WOOSLEY, UBC, R. HOFFMAN, LLNL, and JINA — The rate of the triple alpha process is known with an accuracy of about 12%. Variations within those errors can significantly change the size of the iron core in core-collapse supernovae and double the surface abundance of $^{12}$C in light AGB stars. Studies being done using the code KEPLER show that changing the triple alpha rate or the rate of the $^{13}\alpha(C,\gamma)^{16}$O reactions can significantly affect the production of the medium weight elements in core-collapse supernova progenitors. Hence, the experiment aims at reducing the uncertainty of this ratio to about 6% through an accurate measurement of the pair branch for the Hoyle state excited through inelastic scattering of 10.6 MeV protons from the Tandem accelerator at WMU. The pair branch is given by the ratio of the number of $^e+e^-$ pairs in the plastic scintillators in coincidence with protons scattered at 135 degrees in the lab to the total number of such protons. The gamma ray background is considerably reduced by a coincidence requirement between a thin scintillator tube and the large block of scintillator surrounding it. The experimental status will be presented.

9:36AM CE.00004 A New Measurement of the E1 Component of the $^{12}$C($\alpha,\gamma)^{16}$O Reaction, X.D. TANG, M. NOTANI, K.E. REHM, I. AHMAD, J. GREENE, A.A. HECHT, D. HENDERSON, R.Y.F. JANSENS, C.L. JIANG, E.F. MOORE, N. PATEL, R.C. PARDO, G. SAVARD, J.P. SCHIFFER, S. SINHA, Argonne National Laboratory, M. PAUL, Hebrew University, L. JISONNA, R.E. SEGEL, Northwestern University, C. BRUNE, Ohio University, A. CHAMPAGNE, University of North Carolina, A. WUOSSMAA, University of Michigan — During the past few years we have been involved in a measurement of the E1 component of the $^{12}$C($\alpha,\gamma)^{16}$O reaction. Using a new approach with a set of high acceptance ionization chambers, we have measured the beta-delayed alpha decay in $^{16}$N. The subthreshold 1+ state, which dominates the S-factor of (E1) at astrophysical energies, produces a small interference peak in the alpha spectrum, whose strength is sensitive to $S(E1)$. The data have been analyzed using extrapolations obtained from R-matrix theory. The results from two independent runs will be presented and compared to previous experiments. The contributions from systematic uncertainties as well as the sensitivity of S(E1) to various R-matrix parameters will be discussed. This work was supported by the US Department of Energy, Nuclear Physics Division, under contract No. W-31-109-ENG-38 and by the NSF Grant No. PHY-02-16783 (Joint Institute for Nuclear Astrophysics).

9:48AM CE.00005 A Study of the $^{13}$C($\alpha,n)^{16}$O Reaction Rate Through the ANC Technique, ERIC JOHNSON, GRIGORY ROGACHEV, LAGY BABY, WARREN CLIFF, AMY CRISP, ERIC DIFFENBENDER, BERT GREEN, TRISHA HINNERS, CALEM HOFFMAN, KIRBY KEMPER, OLEANDER MYOMUKT, PATRICK PEPLOWSKI, AKIS PIPIDIS, ROB REYNOLDS, BRIAN ROEDER, Florida State University, A. KIRKHAM, A. MUKHAMEDZHANOV, V. GOLDBERG, Texas A&M University, SIMON BROWN, The University of Surrey — The $^{13}$C($\alpha,n)^{16}$O reaction is the main source of neutrons for the s-process. Currently the adopted rate has an uncertainty of ~300% [Angulo et al., Nucl. Phys. A656, 3 (1999)] at the relevant stellar temperatures (~10$^8$ K). This leads to a large uncertainty in the modeling of AGB stars, which is where the s-process occurs. Recently, we measured the ANC of the 1/2+ state, 6.356 MeV, near threshold state in $^{17}$O. This was done via the transfer reaction $^{16}$O($^{12}$Li,17O)(1/2+,6.356) at sub-Coulomb energies. Using this information we were able to calculate the contribution of the 1/2+ state to the astrophysical S-factor. From our S-factor curve we calculated that the $^{13}$C($\alpha,n)$ reaction rate is reduced by a factor of 3, also the associated uncertainty is improved to ~15%[E.D. Johnson et al., currently under review with PRL].

10:00AM CE.00006 Single and Double Protons from the $^{14}$O+$\alpha$ Interaction, C. FU, V.Z. GOLDBERG, G.V. ROGACHEV, G.G. CHUBARIAN, M. MCCLESKEY, Y. ZHAI, T. AL-ABDULLAH, L. TRACHE, A. BANU, R.E. TRIBBLE, CYCLOTRON INSTITUTE, TEXAS A&M UNIVERSITY TEAM — The proton production in the $^{14}$O+$\alpha$ interaction is important because it determines the onset of the high-temperature rp-process. The 2p decay is of current interest in relation with a possibility of a correlated 2p-pair decay from the excited states in $^{20}$Ne. There are evident experimental difficulties to obtain reliable information on each of the processes in question. To solve these problems we produced a $^{14}$O beam at the K500 Cyclotron at Texas A&M University using MARS. A system of double photomultipliers looking at thin plastic scintillators provided information on the intensity of the $^{14}$O beam, beam contaminations, and a “start” signal for the proton identification by the time of flight method. The $^3$He($^{14}$O,p) and $^3$He($^{14}$O,2p) reactions were studied using the Thick Target Inverse Kinematics method. TOF between Si detectors and the PM system provided for the overall time resolution (~1ns), which was enough for reliable identification of single protons from $\alpha$ particles as well as for the identification for proton decay from the highly excited states in $^{17}$F. The double proton events were detected as coincidence events in a system of 16 Si detectors. Over 4000 double proton events were accumulated which showed strong correlation between energies of the protons.

10:12AM CE.00007 Trojan Horse as indirect technique in nuclear astrophysics, A. MUKHAMEDZHANOV, Cyclotron Institute, Texas A&M University, C. SPITALERI, Universita di Catania, Catania, Italy, R.E. TRIBBLE, Cyclotron Institute, Texas A&M University, L. LAMIA, R.G. PIZZONE, R.G. PIZZONE, S. ROMANO, Universita di Catania, Catania, Italy, G. TABACARU, Cyclotron Institute, Texas A&M University, L. TRACHE, A. TUMINO, Universita di Catania, Catania, Italy — The Trojan Horse method (THM) is a powerful indirect technique which allows one to determine the astrophysical factor for rearrangement reactions with bare nuclei (i.e. without electron screening) down to zero energy. We will present the latest results for the astrophysical factor for the resonant reaction $^{14}$Ni(p,α)$^{20}$C determined using the Trojan Horse reaction $^{2}$He($^{14}$Ni,α$^{20}$C) at $E_{\text{beam}} = 60$ MeV. The measurements have been done at Texas A&M University in collaboration Catania National Lab—Texas A&M University. The astrophysical S factor is compared with the direct data in the same energy region. A fair agreement is found down to 80 keV, while the low-energy behaviour of the S factor suggests a smaller rate than reported in literature.

This work was supported by the U.S. DOE under Grant No. DE-FG03-93ER40773
10:24AM CE.00008 The $^{17}\text{O}(p,\alpha)^{14}\text{N}$ reaction measured using a novel technique$^1$, B.H. MOAZEN, Univ. of Tenn., J.C. BLACKMON, ORNL, D.W. BARDAYAN, ORNL, K.Y. CHAE, Univ. of Tenn., K. CHIPPS, CO School of Mines, C.P. DOMIZIOLI, Tenn. Tech Univ., R. FITZGERALD, UNC, U. GREIFE, CO School of Mines, K.L. JONES, Rutgers, R.L. KOZUB, Tenn. Tech Univ., R.J. LIVESAY, CO School of Mines, C.D. NESARAJA, Univ. of Tenn., ORNL, S.D. PAIN, Rutgers, J.F. SHRINER JR., Tenn. Tech Univ., M.S. SMITH, ORNL, J.S. THOMAS, Rutgers — The $^{17}\text{O}(p,\alpha)^{14}\text{N}$ reaction is important for understanding nucleosynthesis in giant stars and in novae. We developed a new approach for measuring $(p,\alpha)$ reactions and applied it to measure the energy and strength of the 183 keV resonance that was recently reported to increase the $^{17}\text{O}(p,\alpha)^{14}\text{N}$ reaction rate by a factor of as much as 100. A beam of $^{17}$O from the Holifield Radioactive Ion Beam Facility tandem accelerator bombarded hydrogen gas, which filled a scattering chamber at pressures up to 4 Torr. The chamber was connected to the beamline via 4 differential pumping stages. Reaction products were detected in coincidence by a large array of silicon strip detectors, and the vertex of the reaction was determined from the relative kinematics of the two products. Results will be presented as well as plans for measurements with radioactive beams.

$^1$ORNL is managed by UT-Battelle for the US DOE.

10:36AM CE.00009 Determination of the Reaction Rate for $^{17}\text{F}(p,\gamma)^{18}\text{Ne}$ using the Neutron Transfer Reaction $^{13}\text{C}(^{17}\text{O},^{18}\text{O})^{15}\text{C}$, T. AL-ABDULLAH, X. CHEN, C.A. GAGLIARDI, Y.-W. LUI, G. TABACARU, Y. TOKIMOTO, L. TRACHE, R.E. TRIBBLE, Y. ZHAI, Texas A&M University, F. CARSTOIU, IFIN-HH, Bucharest, Romania — The electron-positron annihilation during the expansion of nova envelope leads to the emission of a $\gamma$-ray line at 511 keV and a continuum below it. To estimate the production rate of these $\gamma$-rays, its is proposed to study the nuclear reactions that create and destroy the long-lived isotope $^{18}$F ($\tau=158$ min). Its abundance may be influenced by the reaction rate for $^{17}\text{F}(p,\gamma)^{18}\text{Ne}$. Since direct measurements have not been performed, the ANC method is applied to determine this rate at astrophysical energies. The ANCs for the $2^+$ excited states at 1.98 MeV and 3.92 MeV in $^{18}$O are sought through measuring the peripheral reaction $^{13}\text{C}(^{17}\text{O},^{18}\text{O})^{15}\text{C}$, and then transposed to the mirror states in $^{18}$Ne. The elastic scatterings were measured separately with $^{17}$O and $^{18}$O beams at 12 MeV/A to obtain the optical model parameters of the incoming and outgoing channels, which are used in the DWBA calculation to predict the angular distribution for the transfer reaction. Results will be presented and discussed.

10:48AM CE.00010 Gamma rays from neutron scattering in $^{18}$O, SADIA CHOUDRY, NICO ORCE, VIJJ VARADARAJAN, SHELLY LESHER, DIPA BANDYOPADHYAY, SHARMISTA MUKHOPADHYAY, STEVE YATES, MARCUS MCCULLISTREM, University of Kentucky — A neutron scattering experiment in $^{18}$O has been concluded using both neutron and $\gamma$-ray detection measurements. The $\gamma$-ray measurements provide the relative decay intensities of many excited levels. These, branching ratios of level-decays, and known lifetimes enable us to provide or affirm previously obtained E2 and M1 decay intensities. Simple sd-space shell model tests, repeated here, provide the dominant configurations for the excited levels of $^{18}$O. Incident energies where direct coupling alters inelastic scattering cross sections, deviations from the predictions, can change the S-factor by a factor of 20 at nova energies.

10:00AM CE.00011 First experimental constraints on the interference of $\frac{3}{2}^+$ resonances in the $^{18}\text{F}(p,\alpha)^{15}\text{O}$ reaction$^1$, K.Y. CHAE, Univ. of TN, D.W. BARDAYAN, J.C. BLACKMON, M.S. SMITH, ORNL, M.W. GUIDRY, C.D. NESARAJA, Univ. of TN, ORNL, D. GREGORY, R.L. KOZUB, S. PAULIAUSKAS, J.F. SHRINER JR., N. SMITH, TN Tech Univ., M.S. JOHNSON, ORAU, R.J. LIVESAY, M. PORTER-PEDEN, CO School of Mines, Z. MA, Univ. of TN, S.D. PAIN, J.S. THOMAS, Rutgers Univ. — The $^{18}\text{F}(p,\alpha)^{15}\text{O}$ reaction has been measured in the energy range of $98\text{ MeV}$ and $38\text{ MeV}$ in $^{18}$O from the Holifield Radioactive Ion Beam Facility tandem accelerator bombarded hydrogen gas, which filled a scattering chamber at pressures up to 4 Torr. The chamber was connected to the beamline via 4 differential pumping stages. Reaction products were detected in coincidence by a large array of silicon strip detectors, and the vertex of the reaction was determined from the relative kinematics of the two products. Results will be presented as well as plans for measurements with radioactive beams.

$^1$ORNL is managed by UT-Battelle for the US DOE.

11:00AM CE.00012 $^{18}\text{F}(a,p)^{21}\text{Ne}$ reaction study for astrophysical implications, HYE YOUNG LEE, M. COUDER, University of Notre Dame, A. COUTURE, Los Alamos National Laboratory, J. GOERRES, E. STECH, E. STRANDBERG, W. TAN, M. WIESCHER, University of Notre Dame, H.-W. BECKER, Ruhr-Universitat Bochum, Germany, C. ANGULO, E. CASAREJOS, P. LELEUX, Universite Catholique de Louvain, Belgium, D. GROOMBRIDGE, B. FULTON, A. LAIRD, University of York, UK, M. ALIOTTA, University of Edinburgh, UK — As an alternative neutron source for the weak $r$-process, one of models suggested the $r$-process nucleosynthesis in the supernova shock passing through the He-rich shell of the pre-supernova star. In this helium rich environment, a possible neutron source for the second $r$-process would be the reaction sequence $^{15}\text{N}(\alpha,\gamma)^{18}\text{F}(a,p)^{21}\text{Ne}(\alpha,n)^{24}\text{Mg}$ with rapid depletion of $^{15}$N. The $(\alpha,\gamma)$ reaction on $^{18}$F will be faster than $\beta^+$ decay at the high densities and temperature in the shock. The $^{18}\text{F}(a,p)^{21}\text{Ne}$ reaction and the inverse reaction $^{21}\text{Ne}(p,\alpha)^{18}\text{F}$ have been measured in the energy range of the Gamow window. Experimental results will be presented and compared with Hauser-Feshbach calculations and the interests in nuclear physics. The astrophysical implications of the new reaction rates will be discussed.

Friday, October 27, 2006 9:00AM - 11:36AM — Session CF DNP: Electroweak Interactions I Gaylord Opryland Hermitage C
9:00AM CF.00001 An Experiment for a Precision Measurement of the Radiative Decay Spectrum of the Neutron, R.L. COOPER, T.E. CHUPP, U. Michigan, K.J. COAKLEY, M.S. DEWEY, T.R. GENTILE, H.P. MUMM, J.S. NICO, A.K. THOMPSON, NIST, B.M. FISHER, I. KREMSKY, F.E. WIETTLEDT, Tulane U., E.J. BEISE, K.G. KIRILUK, U. Maryland, J. BYRNE, U. Sussex — We have recently observed the radiative decay mode of the free neutron, in which a photon accompanies the usual beta decay products. Monte Carlo methods were used in the analysis of this observation, and these are being applied to optimize the apparatus for a precision measurement of the photon spectrum. The goal is to substantially increase the number of detected radiative decay events while better understanding the systematic effects. Increased statistical sensitivity is expected with the inclusion of scintillation detectors that are currently being constructed and modeled. These 12 independent channels for photon detection will allow a more thorough examination of our sources of background. Monte Carlo methods address subtle design issues regarding the charged particle detector and neutron transport. Direct photon detection with an avalanche photodiode as a potential photon detector will also be discussed.

9:12AM CF.00002 Ft value for the superallowed decay of $^{32}$Ar$^1$, A. GARCIA, M. BHATTACHARYA, D. MELCONNIA, E.G. ADELBERGER, H.E. SWANSON, S. TRIAMBAK, University of Washington, A. KOMIVES, DePauw University, T. GLASMACHER, P.F. MANTICA, A. ROS, J.L. PRISCINDARO, M. STEINER, B.A. BROWN, Michigan State University, M.W. COOPER, S.L. TABOR, M. WIEDEKING, Florida State University, V. GUIMARAES, University of Notre Dame — $^{32}$Ar produced by fragmentation at the NSCL at MSU was implanted into a Si detector. Beta-delayed protons and gammas were measured with the help of additional Si detectors and Ge detectors. We were able to determine the superallowed branch with a precision of $\sim 0.2\%$. With this information plus the half-life and endpoint from previous work we extract the $ft$ value which allows for a comparison of predicted versus measured isospin-breaking correction. Results will be presented.

9:24AM CF.00003 Measurement of the γ branches in the $\beta^+$ decay of $^{32}$Cl, DAN MELCONNIA, C. BORDEANU, A. GARCIA, University of Washington, J.C. HARDY, V.E. IACOB, N. NICA, H.I. PARK, G. TABACARU, L. TRACHE, Texas A & M University, S. TRIAMBAK, University of Washington, R.E. TRIBBLE, Y. Zhai, Texas A & M University — As discussed in the previous talk (A. Garcia, et al.), one of the dominant systematic uncertainties in the measurement of the $ft$ value of $^{32}$Ar arises from the uncertainty in the HPGe $\gamma$ efficiency. The $\gamma$s emitted in the decay of $^{32}$Cl cover the same range of energies and, since $\approx 10\%$ of the time it is a daughter product of $^{32}$Ar, a precise knowledge of these branches will provide us with an in situ calibration of our HPGe detectors. This talk will describe the experiment and results of the measurement performed at the Texas A & M Cyclotron Institute. We have identified a number of new branches and determined the $\gamma$ yields to $< 0.3\%$, generally an order of magnitude improvement from previous results. Implications for the $^{32}$Ar experiment will be discussed.

9:36AM CF.00004 Precise Half Life Measurement of $^{10}$C, V.E. IACOB, V. GOLOVKO, J. GOODWIN, J.C. HARDY, N. NICA, H.I. PARK, L. TRACHE, R.E. TRIBBLE, Cyclotron Institute, Texas A&M University — We have measured the half-life of $^{10}$C as part of our program to test the unitarity of the Cabibbo-Kobayashi-Maskawa (CKM) matrix via $0^+ \rightarrow 0^+$ superallowed $\beta$ transitions. The $^{10}$C half-life has been measured twice before, with precisions of 0.10% and 0.08%. With our current techniques, we expect to be able to improve that precision by a factor of two. To obtain $^{10}$C, we used a $^{11}$B primary beam at 23.1 MeV to bombard a cryogenic hydrogen target. From the reaction products, a high purity $^{12}$C beam of 18.51 MeV was produced by the MARS spectrometer. The beam was then extracted in air, passed through a 0.3-mm-thick BC-404 plastic scintillator and a set of Al degraders, which had been adjusted so that the $^{10}$C nuclei stopped in the center of the 76-$\mu$m-thick aluminized-mylar tape of our fast tape-transport system. We collected $^{10}$C nuclei for 10, 15 or 20 s; then the beam was switched off and the activity was moved in less than 0.2 s to the center of a $\theta \approx 45\%$ proportional counter, located in a well shielded region. The observed decays were then multi-scaled over a 400 s time span. To ensure an unbiased result, we split the experiment into several runs, each differing from the others in its discriminator threshold, detector bias or dominant dead-time setting. The analysis of these separate runs showed no systematic bias with these parameters. Our preliminary result is $t_{1/2}(^{10}\text{C}) = 19.313(10)\ s$, a result with 0.05% precision.

9:48AM CF.00005 New measurement of the parity-violating asymmetry $A_\gamma$ in neutron-proton capture, ROB MAHURIN, University of Tennessee, Knoxville, NPDGamma COLLABORATION — The NPDGamma experiment aims to measure the parity-violating correlation $A_\gamma$ between the spin of the (polarized) neutron and photon direction in the capture of polarized cold neutrons on hydrogen, to a precision $5 \times 10^{-5}$, 10% of the expected value. This asymmetry measures the neutral weak hadronic coupling without the complicating effects of nuclear structure. In summer 2006 the collaboration will have commissioned its liquid parahydrogen target at the Los Alamos Neutron Science Center. I will present a preliminary analysis of the hydrogen data.

10:00AM CF.00006 Parity Violating Gamma-Ray Asymmetries in Compound Nuclei from Polarized Cold Neutron Capture in the NPDGamma Experiment, MICHAEL GERICKE, Jefferson National Laboratory and the University of Manitoba, NPDGamma COLLABORATION — In an effort to measure the strength of the neutral weak hadronic N-N coupling the NPDGamma collaboration has completed constructing and commissioning an apparatus to measure the parity-violating up-down asymmetry in the angular distribution of gamma rays with respect to the neutron spin direction in the reaction $n + p \rightarrow d + \gamma$. The asymmetry has a predicted size of $\delta E$ and we measure it to 10%. The small size of the asymmetry requires the precise determination of effects from neutron capture on all other materials found in the experiment. We introduce a statistical approach to estimate the expected root mean square (RMS) of the asymmetry in the integrated gamma spectrum from the capture of cold polarized neutrons on various medium A targets. Parity-odd asymmetries in the electromagnetic decays of compound nuclei can sometimes be amplified above values expected from simple dimensional estimates by the complexity of compound nuclear states and it is important to verify that this effect will not produce a large background asymmetry in the hydrogen signal.

1This Experiment is Supported by: DOE, NSF, NSERC.

10:12AM CF.00007 Performance of Current-Mode Ion Chambers as Beam Monitors in a Pulsed Cold Neutron Beam for the NPDGamma experiment, R. CHAD GILLIS, Indiana University, NPDGamma COLLABORATION — The NPDGamma collaboration has built and commissioned an apparatus to measure the parity-violating gamma asymmetry $A_\gamma$ in the low energy np capture process $n + p \rightarrow d + \gamma$. The asymmetry in question is a $10^{-8}$ correlation between the spin of the incident (polarized) neutron and the outgoing 2.2 MeV gamma ray. A set of purpose-built, 3He-filled ionization chambers read out in current mode is used to monitor the incident neutron flux, the beam polarization, and the transmission of the liquid para-hydrogen target during the NPDGamma measurements. As will be described in the talk, these beam monitors are simple, reliable, low-noise detectors that have performed excellently for NPDGamma. We have verified that the beam monitor signals can be interpreted to reproduce the known time-of-flight dependence of beam flux from the LANSE pulsed cold neutron source, and that the neutron beam polarization can be measured at the 2% level from direct measurements of the transmission of the beam through the beam polarizer.
The NPDGamma experiment aims to measure the directional asymmetry of the gamma ray direction and the neutron spin when polarized neutrons capture on protons. The asymmetry results from the weak parity-violating hadronic interaction. The asymmetry is expected to be small ~10^{-7}, however the measured asymmetry can be expressed in terms of the coupling strengths of the meson-exchange model of the hadronic weak interaction. The measured asymmetry is strongly dominated by pion exchange and the measurement will determine the pion coupling, \( f \). The first phase of the experiment is being tested at Flight Path 12 at the Los Alamos Neutron Scattering Center. The goal of this phase of the experiment is to measure the asymmetry with an accuracy of 10^{-7}. After the first phase is complete, the experiment will be moved to the Fundamental neutron Physics Beam at the Spallation Neutron Source and measure the asymmetry with a combined statistical and systematic uncertainty. All components of the experiment, beam, beam monitors, \( ^{3}\text{He} \) spin-filter neutron polarizer, guide field, radio-frequency spin rotator, liquid para-hydrogen target, and cesium iodide gamma detector have been tested and installed. I will give an overview describing the functions of these components, their design goals, and their expected and measured performance.

10:36 AM CF.00009 \( ^{3}\text{He} \) polarizer performance in the NPDGamma experiment, MONISHA SHARMA, University of Michigan Ann Arbor, FOR THE NPDGAMMA COLLABORATION — The ability to polarize neutrons in a broad energy range and measure the neutron polarization with absolute accuracy using a \( ^{3}\text{He} \) polarizer has opened up opportunities in Nuclear and other branches of Physics. \( ^{3}\text{He} \) polarizers are based on the transmission of neutrons through the polarized \( ^{3}\text{He} \) gas which has a strong spin dependent absorption of neutrons. \( ^{3}\text{He} \) polarizer is currently in use in the NPDGamma experiment on FP12 at LANSCe. In a \( ^{3}\text{He} \) polarizer, \( ^{3}\text{He} \) polarization is produced by the Rb spin exchange method. With the previous cell, BooBoo, used in the experiment maximum \( ^{3}\text{He} \) polarization of 57\% was obtained and the neutron polarization of 80\% was obtained at 5 A. For the final run of the experiment a new cell, Pebbels, which is considered to be a better cell as compared to BooBoo will be used. The set up for the polarizer has been improved to obtain a better polarization. Improvements include greater laser power, achieved by combining two fiber-coupled laser diodes into a single fiber and a new oven for heating the cell, which will allow more stable and higher temperatures. In this work, we will present the behavior of the polarizer and the neutron polarization in the NPDGamma experiment.

1 This work is supported by U.S. National Science Foundation, the Department of Energy and NIST.

10:48 AM CF.00010 Determination of the ortho/para ratio in the LH\(_2\) target for the NPDGamma experiment, LIBERTAD BARRÓN-PALOS, Arizona State University, FOR THE NPDGAMMA COLLABORATION — In the NPDGamma experiment to measure the parity violating asymmetry, \( A_p \), in the distribution of the gamma rays emitted in the capture of polarized neutrons by protons (\( \bar{n} \rightarrow p - d + \gamma \)), an important issue is to ensure that the neutrons retain their polarization as they travel into the hydrogen target. For that purpose, a 16-liter LH\(_2\) vessel, held at 17-18 K and 15 psi pressure, is used as the target. Under these conditions, the concentration of para-hydrogen is 99.97\%, so that the effect of polarization loss by the incoherent scattering of neutrons in ortho-hydrogen is reduced. Due to the large difference in the scattering cross-section for low energy neutrons in both hydrogen species, changes in the ortho/para ratio can be monitored through the study of the transmitted neutron flux. In this work, we present a model for the transmission of neutrons through the apparatus and hydrogen target, as well as the effect of different ortho/para ratios in the data of the 2006 NPDGamma commissioning run.

1 This work is supported by U.S. National Science Foundation, the Department of Energy and NIST.

11:00 AM CF.00011 Evaluation of Systematic Effects for the NPDGamma Experiment, WILLIAM M. SNOW, Indiana University/IUCF, NPDGAMMA COLLABORATION — The NPDGamma experiment proposes to search for the parity-odd correlation between the neutron polarization and the direction of gamma emission in polarized neutron-proton capture with a sensitivity at the level of 10^{-8} for the amplitude of the asymmetry. An extensive set of systematic effects could contaminate the asymmetry if not properly suppressed. In the course of several measurements conducted on FP12 at LANSCe, the NPDGamma collaboration has placed upper bounds on some systematic effects, has demonstrated methods of discovering other systematic effects in a time short compared to the running time required to achieve the statistical accuracy goal, and has verified that yet other classes of possible systematic effects are adequately suppressed by the design and properties of the apparatus. In this talk we will present an extensive list of possible systematic effects and show our current upper bounds on their size.

1 Supported by NSF PHY-0457219.

11:12 AM CF.00012 The Liquid H\(_2\) target for NPDGamma, JIAWEI MEI, Indiana University, NPDGAMMA COLLABORATION — The NPDGamma experiment requires a liquid hydrogen target. The target must possess a large volume (17 liters) to produce n-p capture events, be bubble-free to reduce noise in the current-mode gamma array, exist as para-hydrogen at 17K to suppress neutron depolarization, be fabricated from low Z nonmagnetic materials to pass 2.2 MeV gammas and maintain magnetic field uniformity, and produce negligible parity violation from capture gammas other than hydrogen. It also must incorporate safety features such as triple-confinement of the hydrogen, a relief path which can respond to all credible accident scenarios, and various warning and alarm systems. We will describe the design and performance of the NPDGamma hydrogen target system.

11:24 AM CF.00013 The NPDGamma Motion System for Detector Array Alignment, CHRISTOPHER CRAWFORD, University of Tennessee, NPDGAMMA COLLABORATION — One of the major systematic uncertainties of the NPDGamma experiment is the Mott-Schweringer effect (the electromagnetic spin-orbit interaction between the neutron magnetic moment and the nuclear charge). It is a parity conserving asymmetry of the same order of magnitude as the parity violating asymmetry being measured. The two asymmetries can be separated since they are 90 degrees out of phase in the azimuthal angle with respect to the neutron beam. A method of measuring the effective detector alignment to the required precision for this separation will discussed along with preliminary results.

Friday, October 27, 2006 9:00 AM - 12:00PM
Session CG DNP: Mini-symposium on Identifying Dark Matter: Direct Detection of WIMP Dark Matter
- Gaylord Opryland Hermitage D

9:00 AM CG.00001 Direct Detection of WIMP Dark Matter, RICHARD SCHNEE, Case Western Reserve University — Astrophysical observations indicate that about 80\% of the mass of the universe is in the form of non-baryonic particles beyond the standard model of particle physics. One exciting and well motivated candidate is weakly interacting massive particles (WIMPs) left over from the Big Bang. Direct detection of these particles requires sophisticated detectors to defeat much higher-rate backgrounds due to radioactivity and other sources. Promising techniques identify individual interactions in shielded fiducial volumes and distinguish nuclear recoil signal candidates from electron-recoil backgrounds, based on the timing, energy density, and/or the division of the energy into signals of ionization, scintillation, or phonons. I will review the techniques of the dozens of experiments searching for WIMPs and summarize the most interesting results of experiments not being discussed in greater detail at this symposium.
9:36AM CG.00002 The Cryogenic Dark Matter Search II: Current Run Status. ANGELA REISetter. University of Minnesota. CRYOGENIC DARK MATTER SEARCH COLLABORATION — The CDMSII experiment has proven the merits of using germanium crystals and tungsten transition-edge sensors in searching for dark matter WIMPs, obtaining the world’s most sensitive upper limits on the WIMP-nucleon cross-section of $1.6 \times 10^{-43} \text{cm}^2$ from its exposure of twelve detectors (1.5 kg Ge) in 2004. These ZIP (Z/depth)-sensitive Ionization and Phonon detectors use phonon and ionization measurements to discriminate between electron-recoil backgrounds and nuclear-recoil signal. Currently in the Soudan Underground Laboratory, twenty-nine detectors (4.5 kg Ge) have been commissioned and are taking data. This talk will focus on the current run, including operational improvements, calibrations, and overall data quality and detector performance.

9:48AM CG.00003 SuperCDMS: Taking Cryogenic Dark Matter Search Techniques to 25kg and Beyond. MICHAEL DRAGOWSKY. Case Western Reserve University. SUPERCDMS COLLABORATION — The CDMS II experiment has demonstrated the merits of using athermal phonon signatures in single-crystal semiconductor detectors to search for dark matter in the form of weakly-interacting massive particles (WIMPs), obtaining the world’s most sensitive upper limits on the WIMP-nucleon cross-section of $1.6 \times 10^{-43} \text{cm}^2$ (60 GeV/$c^2$ WIMP) from its exposure of twelve detectors (1.5 kg Ge and 0.6 kg Si) in 2004. The SuperCDMS Collaboration will extend our strategy to perform zero-background experiments featuring progressively larger target mass for WIMP direct detection. The next stage experiment will employ enhanced CDMS II-style detectors, and improved analysis techniques to achieve $10^{-44} \text{cm}^2$ sensitivity using 25 kg of Ge-based detectors. Such sensitivity in a direct detection dark matter experiment is of great interest for particle physics, astrophysics and cosmology. The design changes and performance obtained from the enhanced detectors, and the current understanding of background levels and rejection techniques applicable to SuperCDMS 25-kg will be reported. Prospects to further improve background rejection through advances in detector design and consideration of the needs to industrialize our fabrication methods will be outlined.

10:00AM CG.00004 Zeplin II Status Update. WEICHUNG OOI, HANGUO WANG, DAVID CLINE. ULA. PETER SMITH, ULA/RAL. ZEPLIN II COLLABORATION — We discuss the design, underground performance and current status of 32 kg Zeplin II two phase detector. Zeplin II is designed to observe low energy nuclear recoil events from hypothetical weakly interacting massive particles (WIMPs) with liquid xenon (LXe) as the active target. The detector records two signals from each event - the direct scintillation signal S1 in Xe liquid, followed by ionization signal S2 produced by ionization electron in gas phase via electroluminescence. The ratio of S1 and S2 discriminates nuclear recoils events from gamma recoil events.

10:12AM CG.00005 The XENON Dark Matter Experiment: Status of the XENON10 Phase. MARI A ELENA MONZANI. Columbia University. XENON COLLABORATION — The XENON experiment searches for Weakly Interacting Massive Particles (WIMPs) with liquid xenon (LXe) as the active target. The detector is a 3-D position sensitive Time Projection Chamber optimized to simultaneously measure the ionization and scintillation produced by a recoil event down to energies of 16 keV. The distinct ratio of the two signals for nuclear recoils arising from WIMPs and neutrons and for electron recoils from the dominant gamma-ray background determines its event-by-event discrimination. With 1 ton of LXe distributed in ten identical modules, the proposed XENON1T will achieve a sensitivity more than a factor of thousand beyond current limits. A phased program will test the 10 kg target (XENON10) followed by a 100 kg (XENON100) module. The XENON10 detector was assembled and preliminarily tested at Columbia in January 2006. It was shipped to the Gran Sasso National Laboratory in March and then installed in the underground lab. Testing and calibration runs have been performed in January through June 2006. The detector shows the expected behavior, with the energy resolution for the nuclear recoils, and has accumulated a total exposure of 10 keV cm$^2$ day was accumulated.

10:24AM CG.00006 The WARP program for Direct WIMP Dark Matter Search. CRISTIANO GALBITRI. Princeton University. WARP COLLABORATION — The WARP detector is characterized by a unique technology for the identification of nuclear recoils, eventually induced by WIMPs’ interactions with argon. The detection technique takes advantage of a double discrimination between argon recoils and gamma or beta induced background, providing a discrimination power against betas potentially in excess of one event over $10^{-8}$. The 100 liter (140 kg) detector, presently under construction and to be commissioned during the second half of 2006, will be also equipped with an active shield for identification and rejection of neutron induced recoils. A 2.3 liter volume prototype (3 kg active mass, 1.8 kg fiducial mass) is installed in Gran Sasso since May 2004 and was run underground in several operating conditions: with and without gamma shielding, with and without neutron shielding. Our measurements confirm the discrimination power indicated above. I will present results on the characterization of the background. I will also present results of a run for direct search of WIMP Dark Matter, with the complete neutron and gamma shielding, in which a total exposure of about 100 kg-day was accumulated.

10:36AM CG.00007 Dark matter Experiment with Argon and Pulse shape discrimination (DEAP). KEITH RIELAGE. Los Alamos National Laboratory. DEAP COLLABORATION — The Dark matter Experiment with Argon and Pulse shape discrimination (DEAP) exploits pulse-shape discrimination of scintillation light in liquid argon to provide background reduction required for a sensitive dark matter search. Currently, a 7-kg detector has been built (DEAP-1) and is being commissioned this fall at SNOLAB. A summary of the design of the detector and current status will be presented with emphasis on backgrounds to the dark matter search. Prospects of scaling this technology up in size to a future one ton detector will be discussed.

10:48AM CG.00008 Dark matter and mini-CLEAN. JAMES NIKKEL. HUGH LIPPINCOTT. DANIEL McKINSEY. Yale University. ANDREW HIME, DONG-MING MEI. Los Alamos National Laboratory. CLEAN COLLABORATION — The mini-CLEAN detector under development to search for WIMP dark matter using 100 kg of liquid argon or liquid neon as the target material. We show that neutron backgrounds can be sufficiently suppressed in a conceptually simple detector using the coincidence between the prompt nuclear recoil signal and the delayed neutron capture gamma ray. The shielding of $(\alpha, n)$ neutrons that are produced in rock as a function of thickness of polyethylene is modeled.

11:00AM CG.00009 Depth & Shielding Requirements for mini-CLEAN$^1$. DONG-MING MEI. Los Alamos National Laboratory/University of South Dakota. ANDREW HIME. Los Alamos National Laboratory. CLEAN COLLABORATION, DEAP COLLABORATION — Neutron-induced nuclear recoil represents an irreducible background in detectors aimed at the direct detection of WIMP dark matter. Muon-induced neutrons can be adequately suppressed by staging experiments sufficiently deep underground, however, it is also critical to suppress neutron production via $(\alpha, n)$ interactions due to naturally occurring radioactivity in detector construction materials. We present the results of simulations for the mini-CLEAN detector under development to search for WIMP dark matter using 100 kg of liquid argon or liquid neon as the target material. We show that neutron backgrounds can be sufficiently suppressed in a conceptually simple detector using the coincidence between the prompt nuclear recoil signal and the delayed neutron capture gamma ray. The shielding of $(\alpha, n)$ neutrons that are produced in rock as a function of thickness of polyethylene is modeled.

$^1$U.S. Department of Energy and Los Alamos Directed Research and Development Program.
11:12AM CG.00010 A Bubble Chamber for Dark Matter Detection: The COUPP Project
BRIAN ODOM. University of Chicago, COUPP COLLABORATION — Heavy-liquid bubble chambers can be made stable-enough to be used in WIMP searches. Advantages of this approach are an optimal choice of target (CF3I, maximally sensitive to both spin-dependent and -independent WIMP interactions), low cost, good scalability, room temperature operation, extraordinary intrinsic rejection of minimum-ionizing backgrounds (rejection $> 10^5$, as opposed to $\sim 10^4$ in cryogenic devices), and a number of features permitting rejection of irreducible neutron backgrounds. Scalability to a ton-level mass also appears quite promising. A 2 kg prototype chamber has been constructed and is currently operating at a depth of 300 m.w.e. (meters water equivalent) in the NuMi gallery of Fermilab. The currently observed event rate, believed to be from alpha backgrounds, is expected to yield the best limits on WIMP-proton spin-dependent coupling. A 20 kg modular chamber, expected to have substantially reduced alpha backgrounds, is currently under construction and is expected to yield extremely competitive spin-independent coupling results.

11:24AM CG.00011 Two-Component Dark Matter in UED Models
KEN HSIEH, RABINDRA MOHAPATRA, SALAH NASRI, University of Maryland — We show that in a class of universal extra dimension models (UED), which solves both the neutrino mass and proton decay problem, an admixture of KK photon and KK right handed neutrinos can provide the required amount of cold dark matter (CDM). This model has two parameters $R^{-1}$ and $M_{Z'}$ ($R$ is the radius of the extra space dimensions and $Z'$ the extra neutral gauge boson of the model). Using the value of the relic CDM density, combined with the results from the cryogenic searches for CDM, we obtain upper limits on $R^{-1}$ of about $400 - 650$ GeV and $M_{Z'} \leq 1.5$ TeV, both being accessible to LHC and a lower bound on the dark matter- nucleon scattering cross section of $10^{-44}$ cm$^2$, which can be probed by the next round of dark matter search experiments.

11:36AM CG.00012 Status of the DRIFT-II Directional Dark Matter Detector
BRIAN ODOM, University of Chicago, COUPP COLLABORATION — DRIFT is a directional dark matter detection programme that utilises the fact that as the Earth rotates and revolves around the Sun, an annual and diurnal signal modulation could be detected as a result of relative motion between the Earth and the non-rotating WIMP halo. This would provide very strong evidence of WIMPs since such a signal could not be mimicked by background sources. DRIFT II is an array of gas filled time projection chambers (TPCs) with Multi Wire Proportional Counter (MWPC) readout. Signals from different types of events differ greatly, between nuclear and electron recoils for example, due to the amount of ionisation initially produced and recombinination times. This provides phenomenal discrimination capabilities. The first module of the DRIFT-II detector was successfully installed underground at Boulby Mine, N. Yorkshire early last year and has proven very stable, collecting high quality calibration and WIMP data. Since then a second module has been installed and is also currently operational. This presentation will describe the status of the detector and will focus on the determination of neutron efficiency and gamma rejection factors.

11:48AM CG.00013 Future Techniques for WIMP Astronomy
C.J. MARTOFF, MICHAEL HOSACK, JAN MASOUH, Temple University, DEPT. OF PHYSICS, TEMPLE UNIVERSITY TEAM — This miniconference title appropriately focusses attention on the crucial problem of identification of dark matter; how to associate signals in direct detection experiments with galactic halo WIMPs. Spergel, Freese and others long ago pointed out the strong directional anisotropy of WIMP recoils which provides an unambiguous identification signature. Such anisotropy (present in almost any halo model) will rotate in the lab at the sidereal rate, distinguishing it from all terrestrial backgrounds. The author's Negative Ion TPC (NITPC) method allows low-pressure, high field TPC's to be built with 100's of kg of active gas target, and with the high spatial resolution to measure WIMP recoil tracks directionally. DRIFT I, in which the author was a principal investigator, was the first example. Further developments toward practical construction of 100 kg and larger NITPC will be presented here. Topics will include: proven, low channel-count readouts allowing 3-D tracking in these low-occupancy experiments; reconstruction algorithms and simulations of response to several halo models; and work in progress on alternative negative ion formation agents and on new veto detection media. Finally, a fieldable design for an NITPC array made of modules each having $\sim 10$ kg active mass will be discussed.

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Friday, October 27, 2006 9:00AM - 11:00AM
Session CH DNP: Mini-symposium on From Crust to Core: QCD in Neutron Stars
Gaylord Opryland Cheekwood F

9:00AM CH.00001 Neutron Star Structure From Observations
JAMES LATTIMER, Stony Brook University — Neutron stars are laboratories for dense matter physics. Observations of neutron stars, in the form of radio pulsars, X-ray binaries, X-ray bursters, and thermally-emitting isolated stars, are rapidly accumulating. Especially interesting are the radio pulsars PSR J0751+1807, Terzan 5 I and Terzan 5 J (with surprisingly large measured masses of $2.1 \pm 0.2, 1.69 \pm 0.1$ and $1.85 \pm 0.05$ solar masses, respectively), the pulsar PSR J1748-2446ad with the most rapid spin rate of 716 Hz, and the radio pulsar binary PSR J0737-3039 for which a moment of inertia of one of the neutron stars might be measured within a few years. Extremely massive neutron stars are important because they set limits to the maximum mass and upper limits to the maximum density found in cold, static, objects, and might limit the appearance of exotic matter such as hyperons, Bose condensates or deconfined quarks in a star’s interior. The spin rate sets an upper limit to the radius of a star of a given mass, and the moment of inertia, being roughly proportional to $MR^2$, is a sensitive measure of neutron star radius. While the maximum mass speaks to the relative stiffness of the high-density equation of state at several times nuclear matter density, the radius is a measure of the relative stiffness of the low-density equation of state in the vicinity of the nuclear saturation density. For the nearly pure neutron matter found in neutron stars, it is a direct measure of the density dependence of the nuclear symmetry energy. Other promising observational constraints might be obtained from neutron star seismology (which limits the relative crustal thickness) and Eddington limited fluxes observed from bursting sources, and from thermal emissions from cooling neutron stars. The latter have the potential of constraining $R_{S} = R/\sqrt{1 - 2GM/Rc^2}$ if the source’s distance can be accurately assessed. The distances of two nearby isolated sources, RX J1856-3754 and Geminga, have been determined by parallax. However, there are major difficulties in accounting for atmospheres of unknown composition and uncertain magnetic field strengths for these stars. The distances to several distant X-ray emitting neutron stars have also been estimated with some precision because they are members of globular clusters. These sources have advantages because, having undergone recent accretion, they should have relatively weak surface magnetic fields and hydrogen-dominated atmospheres. Preliminary results from the interpretation of thermal emissions indicate consistency with a radius in the range of 10-15 km, but only a restricted subset of possible equations of state can account for the $(M, R)$ constraints of all the sources.

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1On behalf of the DRIFT Collaboration

2Supported by the National Science Foundation and by Temple University.

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Session CH.00001: Neutron Star Structure From Observations
Support: DOE grant DE-FG02-87ER-40317
9:36AM CH.00002 QCD in Neutron Stars and Strange Stars. FRIDOLIN WEBER, Department of Physics, San Diego State University — Neutron stars contain matter in one of the densest forms found in the Universe. This feature, together with the unprecedented progress in observational astrophysics, makes such stars superb astrophysical laboratories for a broad range of exciting physical studies, several of which are intimately connected to QCD. This talk summarizes the role of QCD for neutron stars and strange stars. Particular emphasis will be put on the role of strangeness. Strangeness is carried by hyperons, mesons, H-dibaryons, and color superconducting strange quark matter, and may leave its mark in the masses, radii, cooling behavior, surface composition and the spin evolution of neutron stars. I also discuss the effects of a net electric charge distribution on the bulk properties of strange quark stars. Depending on the amount of electric charge distributed over the surface of such objects, the mass-radius relationship of strange quark stars may deviate substantially from the standard mass-radius relationship of electrically uncharged stars. This finding is of key importance for the properties of hypothetical strange quark stars made of color superconducting quark matter, since these objects could possess electric surface fields strong enough to alter the mass-radius relationship significantly.

1This work is supported by the National Science Foundation under Grant PHY-0457329, and by the Research Corporation.

9:48AM CH.00003 Evidence for White Dwarfs with Strange-Matter Cores. GRANT MATTHEWS, INSAENG SUH, NGUYEN LAN, WILLIAM ZECH, University of Notre Dame, KAORI OTSUJI, FRIDOLIN WEBER, San Diego State University — We summarize masses and radii for a number of white dwarfs as deduced from a combination of proper motion studies, Hipparcos parallax distances, effective temperatures, and binary or spectroscopic masses. A puzzling feature of these data, however, is that some stars appear to have radii which are significantly smaller than that expected for a standard electron-degenerate white-dwarf equations of state. We construct a projection of white-dwarf radii for fixed effective mass and conclude that there is at least marginal evidence for bimodality in the radius distribution for white dwarfs. We argue that if such compact white dwarfs exist it is unlikely that they contain an iron core. We propose an alternative of strange-quark matter within the white-dwarf core. We also discuss the impact of the so-called color-flavor locked (CFL) state in strange-matter core associated with color superconductivity. We show that the data exhibit several features consistent with the expected mass-radius relation of strange dwarfs. We identify eight nearby white dwarfs which are possible candidates for strange matter cores and suggest observational tests of this hypothesis.

3Work supported by the US Department of Energy under Nuclear Theory grant DE-FG02-95ER40934.

10:00AM CH.00004 Nuclear Equation of State at Supernuclear Densities. JIRINA STONE, Physics Division, ORNL — The density and temperature dependence of the energy per particle of a system (the Equation of State (EoS)) is a fundamental ingredient of all models of nuclear matter and stars. As nucleons and leptons form the main components of all stars, the best possible description of the strong and weak interactions amongst these particles is essential for a correct understanding of birth, life and death of stars. At supernuclear densities, the presence of strange baryons and/or partially deconfined quarks is energetically favorable. We review recent development in EoS models in the high density region, based on selected relativistic mean field and quark models. These EoS shed new light on the density dependence of the phase transition between pure nuclear uniform matter and matter containing strange baryons and deconfined quarks. Application of these EoS to neutron star models (assuming general beta-equilibrium) and to core-collapse supernova models (non-equilibrium matter) will be discussed.

2Funded by ScIDAC grants from the DOE Office of Science High-Energy, Nuclear, and Advanced Scientific Computing Research Programs and partly supported by US DOE grant DE-FG02-94ER40834.

10:12AM CH.00005 What is the crust composition of accreting neutron stars? JACOB FISKER, MARY BEARD, Joint Institute for Nuclear Astrophysics, University of Notre Dame, EDWARD BROWN, Joint Institute for Nuclear Astrophysics, Michigan State University — The nuclear reaction flow of an X-ray burst (XRB) on an accreting neutron star (NS) determines the composition of the burst ashes. These ashes subsequently descend down into the crust and influence many crustal properties of the NS such as the electric conductivity, the amount of heat, $Q_c$, deposited in the crust, and the competing neutrino loss rate. These factors determine the equilibrium core temperature relevant for probing the equation of state of the interior neutron star. Reciprocally, the crustal properties determine the heat flux through the atmosphere and thus influence the reaction flow of the XRBs. The crustal heat flux, $Q_c$, has previously been calculated by assuming a composition of ashes given by pure $^{56}$Fe and the ashes of the one-zone model of respectively. However, as the thermonuclear burning of the XRB may depend on $Q_c$, we expand on these studies by using a self-consistently symmetric XRB model to calculate the composition of the resulting XRB ashes for different values of the crustal heating rates. We report the results of this study for different accretion rates.

2This work is supported by the Joint Institute for Nuclear Astrophysics, NSF-PFC grant PHY02-16783.

10:24AM CH.00006 Heating from Electron Captures in the Crusts of Accreting Neutron Stars. SANJIB GUPTA, EDWARD BROWN, HENDRIK SCHATZ, Dept. Physics and Astronomy, National Superconducting Cyclotron Laboratory, and Joint Institute for Nuclear Astrophysics, Michigan State University, PETER MÖLLER, Theoretical Division, Los Alamos National Laboratory, KARL-LUDWIG KRATZ, Institut für Kernchemie, Universität Mainz — We present new calculations of nuclear reactions in the outer crust (densities less than neutron drip) of an accreting neutron star. Our crust model improves on previous work by starting with a realistic distribution of nuclei and by allowing for electron captures into excited states, rather than just transitions into the ground state. We find that the heat deposited in the outer crust is substantially larger (factor of 4) than previous estimates and that the amount of heat deposited depends strongly on the composition of matter synthesized during rp-process burning of accreted hydrogen and helium. This increased heating raises the temperature in the crust and makes the unstable ignition of carbon—which is thought to power superbursts observed for some accreting neutron stars—occur at lower density. This alleviates some of the discrepancy between the ignition depth inferred from observations and theoretical superburst models.

2This work is supported by the Joint Institute for Nuclear Astrophysics, NSF-PFC grant PHY02-16783.

10:36AM CH.00007 Constraints on dense matter physics from deep heating of accreting neutron stars. EDWARD BROWN, Joint Institute for Nuclear Astrophysics, Michigan State University — Accretion of matter from a stellar companion compresses the crust of a neutron star and induces reactions that heat the interior. The temperature in the crust is set by balancing this heating with thermal radiation from the surface and neutrino emission from the crust and core. Many neutron stars accrete intermittently; when the accretion halts, the crust cools. Recent observations have now observed evidence of crustal cooling. In this talk, I present theoretical models of heating and cooling in the neutron star crust, and compare them with observations. I assess how these observations constrain the neutrino emissivity of the neutron star core. These new crust models improve on previous ones by incorporating electron captures into excited states, which increases the heat deposited into the crust. In addition, our models allow us to compute the heating in the outer crust for a wide range of possible crust compositions.

1Work supported in part by the Joint Institute for Nuclear Astrophysics, NSF-PFC grant PHY 02-16783

2National Superconducting Cyclotron Laboratory
10:48AM CH.00008 Probing the interiors of accreting neutron stars

ANDREW CUMMING, McGill University

— Neutron stars in low mass X-ray binaries accrete hydrogen and helium from a low mass companion. The neutron star can be observed directly in X-rays during periods of quiescence, when accretion switches off, or during thermonuclear X-ray bursts which result from unstable thermonuclear burning of the accreted matter. Recent long term monitoring observations of these systems have revealed new types of long duration X-ray bursts resulting from unstable burning of thick helium or carbon layers. The properties of these long bursts are sensitive to the heat flux emerging from deep in the star, and therefore give a new way to probe neutron star cooling. I discuss the current constraints on the neutrino emissivity of the stellar core, and the dense matter interior, including the possibility that these stars are in fact strange stars.

Friday, October 27, 2006 2:00PM - 4:24PM —
Session DA DNP: Precision Weak Interaction Studies at Low Energy
Gaylord Opryland Tennessee C

2:00PM DA.00001 Observation of the Radiative Decay Mode of the Free Neutron
T.R. GENTILE
National Institute of Standards and Technology — Despite decades of detailed study, the radiative decay mode of the neutron has never been definitively observed. We report observation of this process, in which a photon is emitted along with the proton, electron and antineutrino. Photons with energies between 15 keV and 340 keV were detected by a scintillating crystal coupled to an avalanche photodiode and were distinguished from uncorrelated background photons by coincidence with both the decay electron and proton. Correlated background from external bremsstrahlung generated in the electron detector has been estimated to be minor, due to the physical separation and limited line-of-sight between the particle and photon detectors. Measurement of the dependence of the radiative decay rate on the available phase space of the decay is consistent with the expected behavior for radiative decay. The energy spectrum of the radiated photons, which differs from the uncorrelated background spectrum, is also consistent with the calculated spectrum. The measured branching ratio is consistent with theoretical predictions. We discuss the results of this first experiment, and the design of an improved apparatus to perform a precision measurement of the branching ratio and spectrum.

In collaboration with M.S. Dewey, H.P. Mumm, J.S. Nico, A.K. Thompson, NIST-Gaithersburg; B.M. Fisher, I. Krenskey, F.E. Wietfeldt, Tulane University; T.E. Chupp, R.L. Cooper, University of Michigan; E.J. Beise, K.G. Kiriluk, University of Maryland; J. Byrne, University of Sussex; and K.J. Coakley, NIST-Boulder.

2:36PM DA.00002 New results in rare pion and muon decays
DINKO POCANIC, University of Virginia — The PIBETA experiment, a program of precise measurements of rare pion and muon decays at PSI, completed in 2004 an experimental study of the pion and muon radiative decays, \( \pi^+ \rightarrow e^+\gamma \) and \( \mu^+ \rightarrow e^+\nu\bar{\nu} \gamma \), respectively. The pion radiative decay data have enabled us to evaluate the branching ratio with better than 2\% accuracy, with broad phase space coverage. Consequently, we have evaluated \( F_\pi \), the axial form factor of the pion, with \( \sim 2.5\% \) accuracy, a more than five-fold improvement over previous data, as well as improved six-fold the accuracy of \( F_\gamma \), the pion vector form factor, previously poorly determined. The latter result provides one of the most direct confirmation of the validity of the CVC hypothesis in the pion sector. We’ve also measured, for the first time ever, the momentum dependence of the pion form factors. All our results are in excellent agreement with chiral perturbation theory. Equally important is a new stringent upper limit on the long-debated tensor form factor for the pion. Our study of the muon radiative decay has resulted in a fourteen-fold improvement over previous data in the accuracy of this decay’s branching ratio for a large phase space region \( (E_\gamma > 10 \text{ MeV}, \theta_{\gamma\nu\bar{\nu}} > 30^\circ) \). Our 2\% result is in excellent agreement with theoretical predictions. Focusing on a narrower range of phase space, we were able to improve significantly the upper limit on the Michel parameter \( \eta \), reducing the world average upper limit by a factor of 2.5. \( \eta \) is sensitive to non-(V-A) admixtures in the weak lagrangian. The new results, their implications, and prospects for future improvements are discussed in detail.

1Work supported by a grant from the National Science Foundation

3:12PM DA.00003 Significance of the TRIUMF Weak Interaction Symmetry Test
ANDREI GAPONENKO1, LBNL — The TRIUMF Weak Interaction Symmetry Test (TWIST) experiment uses unique features of muons to do a model independent search for new physics, and to provide constraints on properties of the weak interaction that are complementary to those coming from collider experiments, nuclear decay measurements, and astrophysics inputs. TWIST has provided the world’s best measurements of 3 out of 4 parameters describing the distribution of positrons in polarized muon decay, and even more precise results are expected. This talk will discuss the physics output of TWIST, and give a brief update on the status of the experiment.

1for the TWIST Collaboration

3:48PM DA.00004 Weak Interactions with Neutral Atom Traps: new observables using beta-decay daughter momenta
J.A. BEHR, TRIUMF — We use modern atomic physics techniques to trap localized samples of atoms with polarization known to high accuracy. The low-energy daughter nuclei escape the trap, and their detection permits a variety of new observables. We have placed the best general limits on first generation scalar interactions by measuring the \( \beta \nu \) correlation in \( ^{37}\text{K} \) decay [Gorelov, PRL 94 (2005) 142501], and we have also made a 3\% measurement of the \( \nu \) spin asymmetry in \( ^{37}\text{K} \) decay [Melconian DNP 2005]. We plan upgrades of both. Here we concentrate on measurements of the daughter nucleus momentum by time-of-flight with respect to the atomic shakeoff electrons, a technique demonstrated by LBL researchers [Scielsz, Nucl.Phys.A 746 (2004) 677c]. The spin asymmetry of daughter nuclei in singles in a pure Gamow-Teller decay vanishes in the standard model [Teiman, Phys. Rev. 110 (1958) 448], so it is a very sensitive probe for new interactions. We have measured the daughter spin asymmetry in \( ^{86}\text{Rb} \) decay, achieving statistical accuracy that would complement the best existing limits on tensor interactions in beta decay. The same observable in \( ^{37}\text{K} \) decay would be sensitive to right-handed currents with statistics competitive with \( \mu \) decay experiments. We also plan a search for the admixture of keV-mass \( \nu \)‘s with the electron \( \nu \) in the electron capture decay of \( ^{131}\text{Cs} \). Our goal is sensitivity to \( <10^{-5} \) admixtures at mass \( <30 \text{ keV} \). Such a \( \nu \) would be a warm dark matter candidate and would have other astrophysics implications.


Friday, October 27, 2006 2:00PM - 4:48PM —
Session DB DNP: Mini-symposium on Stewardship Science II
Gaylord Opryland Tennessee A
2:00PM DB.00001 Activities of the Center of Excellence for Radioactive Ion Beam Studies for Stewardship Science, J.A. CIZEWSKI, Rutgers University — The Center of Excellence for Radioactive Ion Beam Studies for Stewardship Science is a consortium of universities, Oak Ridge Associated Universities, and Oak Ridge National Laboratory, led by Rutgers University. The purpose of this project, funded by the NNSA/DP Academic Alliance for Stewardship Science program, is to use radioactive ion beams to study low-energy nuclear reactions of importance to stewardship science, as well as to prepare future researchers in applied nuclear science. These studies are enabled by the plethora of unstable accelerated beams available at the Holifield Radioactive Ion Beam Facility at Oak Ridge. The initial measurements use neutron-rich beams of uranium fission fragments to study neutron transfer reactions. We also develop new radioactive ion beams of interest to nuclear structure, nuclear astrophysics, and stewardship science. This talk will present an overview of the activities of the Center and the available facilities, describe initial results of a (d,p) reaction with a fission fragment beam, and outline activities proposed for the near term. In collaboration with H.K. Carter, ORAU.

2:36PM DB.00002 Reaction Mechanisms for (d,p) on Exotic Nuclei, NEIL SUMMERS, Rutgers University, FILOMENA NUNES, NSCL/MSU, IAN THOMPSON, Surrey University / LLNL — Transfer reactions are typically analyzed using DWBA reaction theory. The structure of the exotic nuclei of affects the (d,p) cross section through overlaps of the relevant many body wave functions. In standard DWBA theory this overlap is approximated by a single particle wave function, and the core is considered inert. Then the cross section is scaled by the spectroscopic factor. Transfer to excited states and even continuum states for weakly bound nuclei can also be considered. This “standard” reaction theory neglects many things. On top of multi-step effects which can be investigated using a coupled channels approach, the single particle nature of the final states and the assumption that the core is inert are two approximations that can now be examined using an extension of the coupled channels approach called XCDCC (eXtended Continuum Discretized Coupled Channels). We use XCDCC to study Be10(d,p)Be11 and Be11(p,d)Be10 reactions and the effects of couplings. We examine the continuum states of Be11 where we can now model resonances built on excited core components. We compare our results with various sets of data and draw general conclusion important for (p,d) and (d,p) reactions.

2:48PM DB.00003 Radioactive Ion Beams for Stewardship Science, ANDREAS KRONENBERG, H.K. CARTER, E.H. SPEJEWSKI, Oak Ridge Associated Universities, OAK RIDGE ASSOCIATED UNIVERSITIES TEAM — Measurements of particular reaction sequences that influence the cumulative fission yield of specific fission products of interest for stewardship science as well as for nuclear reactions on radioactive detectors used in testing nuclear devices are often not accessible with radioactive targets because of short half-lives, high specific activities or availability of sufficient target material. Therefore, a possible surrogate reaction for (n,γ) is the neutron transfer in (d,p) or (p,γ) reactions, which can be measured with ion beams of short-lived radioactive species in inverse kinematics. The Center of Excellence for Radioactive Ion Beam Studies for Stewardship Science is developing experimental techniques for measuring (d,p) reactions. Therefore, a strong component of our center is the development of accelerated radioactive ion beams such as 48V, 73,74As, 92,94,95Sr, 82Ge, 132,134Sn, Zr, Mo, Tc, and others. Some of these beams had not been available before, because the elements are refractory, or some beams require high acceleration and that is expensive. Beam development techniques include different actinide targets, e.g. ThO2, molecular sideband formation, e.g. for Sr and possibly charge-exchange processes. This talk will consider specific beams of interest for our center. This research was sponsored by the NNSA under Stewardship Science Academic Alliance program through DOE Cooperative Agreement # DE-FC03-3NA00143.

3:00PM DB.00004 Development of the Oak Ridge Rutgers University Barrel Array, S.D. PAIN, J.A. CIZEWSKI, R. HATARIK, K.L. JONES, M. SIKORA, J.S. THOMAS, Rutgers University, D.W. BARDAYAN, J.C. BLACKMON, C.J. NESARAJA, M.S. SMITH, ORNL, J. HOWARD, R.L. KOZUB, Tennessee Tech., J. JAMES, R.J. LIVESAY, Colorado School of Mines, A. GADDIS, Furman University, M.S. JOHNSON, ORAU, B.H. MOAZEN, University of Tennessee — The development of high quality RIBs, such as those at the HRIBF at ORNL, has made possible the performance of transfer reactions on unstable nuclei. Measurements of (d,p) reactions on n-rich fission fragment reactions yield data on nuclear structure away from stability, are of importance to stewardship science and are of astrophysical interest due to the proximity to suggested r-process paths. Experimentally, (d,p) reactions on heavy (Z>50) fission fragments are complicated by the strongly inverse kinematics and low beam intensities. Ejectile detection with high resolution in position and energy, a high dynamic range and a high solid angular coverage is required. The Oak Ridge Rutgers University Barrel Array (ORRUBA) is currently under development for such measurements, providing a high solid angular coverage for angles forward and backward of 90 degrees. Resistive strip silicon detectors are used to obtain high-precision position and energy measurement, and ΔE-E particle identification is employed at angles forward of θlab = 90°. The array’s scientific motivation and technical aspects will be presented, along with a report of the first measurements performed with an early implementation of ORRUBA.

3:12PM DB.00005 Results from (d,p) measurements in inverse kinematics at the HRIBF, K.L. JONES, Rutgers University (currently at the Univ. of Tennessee), R.L. KOZUB, Tennessee Technological University, ORRUBA COLLABORATION — The Center of Excellence for Radioactive Ion Beam Studies has begun a program of (d,p) transfer experiments on fission fragment beams. These types of measurements probe the structure of nuclei away from stability, providing critical information for neutron-capture network models. The doubly-magic nuclei are used as bench marks for structure models. However, few exotic doubly-magic nuclei are available for in depth study, such as can be made using transfer reactions. Understanding the evolution of single-particle structure of nuclei close to the magic numbers, but away from the valley of stability, is crucial for improving models of the nucleus. This, in turn, provides critical information for neutron-capture network models. Fission fragment beams in the 132Sn region are available at Coulomb barrier energies at the Holifield Radioactive Ion Beam Facility (HRIBF). A major focus of our studies is on nuclei around the doubly-magic 132Sn nucleus. We have made a proof of principle study of (d,p) reactions in inverse kinematics in the A=136-132 region using a stable beam of 124Sn [1]. Results from the test measurement and the status of two experiments using radioactive 130Sn and 132Sn beams will be presented. [1] K.L. Jones et al., Phys. Rev. C 70, 067602 (2004).

3:24PM DB.00006 Benchmarking (d, pγ) as surrogate reaction for (n, γ), R. HATARIK, J.A. CIZEWSKI, K. JONES, S.D. PAIN, T. SWAN, Rutgers University, D.W. BARDAYAN, J.C. BLACKMON, Oak Ridge National Laboratory, L.A. BERNSTEIN, J.T. BURKE, F.S. DIETRICH, J.E. ESCHER, M.S. JOHNSON, Lawrence Livermore Natl Laboratory, R. KOZUB, Tennessee Tech University, A. KRONENBERG, Oak Ridge Associated Universities — Neutron capture cross sections on unstable nuclei are important for many applications in nuclear structure and astrophysics. Measuring these cross sections directly is a major challenge and often impossible. In the surrogate reaction technique a desired cross section can be extracted by measuring a different (surrogate) reaction that produces the same compound nucleus. In contrast to neutron capture, a neutron transfer cross section can be measured in inverse kinematics, which allows to measurements of cross sections on short lived-species. To test the feasibility of using a (d, pγ) reaction as a surrogate for (n, γ), 144Nd and 146Nd have been chosen. The goal of this benchmark experiment is to reproduce the known neutron capture cross sections ratio of these isotopes.

3:Work supported in part by the Department of Energy and the National Science Foundation.

3:Work supported in part by the Department of Energy, the National Science Foundation, and the LDRD program of ORNL.
3:36PM DB.00007 Cross section measurements of $^9$Be($\alpha$, n)$^{12}$C, Z. HEINEN, A. ADEKOLA-A, C.R. BRUNE, S.M. GRIMES, H. HADIZADEH, M.J. HORNISH, T.N. MASSEY, C. MATEI, A. VOINOV, Ohio University — The $^9$Be($\alpha$, n)$^{12}$C reaction has a large cross section and hence is useful in applications as a neutron source. This reaction is also a key step in the formation of $^{12}$C in neutron-rich environments, such as the ejecta of type-II supernovae. Using the 4.5-MV tandem accelerator at Ohio University, the differential cross section of $^9$Be($\alpha$, n)$^{12}$C has been measured for an incident energy of $E_{\alpha} = 4.5$ MeV. The time-of-flight method was used with a flight path of 30 m. A 15-\(\mu\)m-thick target of $^9$Be was used. This thickness yielded broad peaks in the neutron energy spectra which allowed the energy dependence of the cross section to be inferred for $2 \leq E_{\alpha} \leq 4.5$ MeV. Using a beam swinger apparatus, neutrons were detected at laboratory angles of $0^\circ$, $15^\circ$, $35^\circ$, $40^\circ$, $60^\circ$, $88^\circ$, $110^\circ$, $120^\circ$, $130^\circ$, and $145^\circ$. Neutrons associated with the ground state and the first two excited states of $^{12}$C were measured. I will present the cross section data and discuss its implications.

3:48PM DB.00008 Radiative strength functions and spin measurements for $^{95,96}$Mo from radiative neutron capture, STEVEN SHEETS, North Carolina State University, U. AGGAANULVSAN, Lawrence Livermore National Laboratory, M. KRTICKA, Charles University, G.E. MITCHELL, North Carolina State University, J.A. BECKER, Lawrence Livermore National Laboratory, J.L. ULLMANN, T.A. BREDEWEG, J.M. O’DONNELL, R. REIFARTH, R.S. RUNDBERG, DAVID VIEIRA, J.M. WOUTERS, Los Alamos National Laboratory — Statistical properties in $^{95,96}$Mo have been measured using the multiplicity of \(\gamma\)-rays following neutron capture. Below the neutron separation energy an unusual enhancement in the radiative strength function (RSF) of Fe and Mo isotopes has been reported. We provide a new measurement of the RSF and compare our results with those obtained from two-step cascade measurements. An improved spin assignment for resonances in $^{96}$Mo is given.

4:00PM DB.00009 ABSTRACT WITHDRAWN

4:12PM DB.00010 Neutron induced reactions of $^{152}$Sm and influence of spin distribution in the pre-equilibrium process, D. DASHDORJ, G.E. MITCHELL, NCSU/TUNL, U. AGGAANULVSAN, J.A. BECKER, J.R. COOPER, P.E. GARRETT, C.Y. WU, W. YOUNES, LLNL, T. KAWANO, M. CHADWICK, M. DEVLIN, N. FOTIADES, R.O. NELSON, LANL — Cross-section measurements were made of prompt \(\gamma\)-ray production as a function of incident neutron energy ($E_{\text{n}} = 1$ to 35 MeV) on an enriched ($95.6\%$) $^{152}$Sm sample. Energetic neutrons were delivered by the Los Alamos National Laboratory spallation neutron source located at the Los Alamos Neutron Science Center facility. The prompt-reaction \(\gamma\) rays were detected with the large-scale Compton-suppressed Germanium Array for Neutron Induced Excitations (GEANIE). Neutron energies were determined by the time-of-flight technique. The pre-equilibrium reaction process is important at high energies. The spin distribution transferred in pre-equilibrium neutron-induced reactions was calculated using the quantum mechanical theory of Feshbach, Kerman, and Koonin (FKK). These pre-equilibrium spin distributions were incorporated into a new version of the Hauser-Feshbach statistical reaction code GNASH and the \(\gamma\)-ray production cross sections were calculated and compared with experimental data. The difference in the partial \(\gamma\)-ray cross sections using spin distributions with and without pre-equilibrium effects will be discussed.

4:24PM DB.00011 Production of Neutron-Rich Isotopes from ThO$_2$ Targets, E.H. SPEJEWSKI, A. KRONENBERG, H.K. CARTER, Oak Ridge Associated Universities, D.W. STRACENER, Oak Ridge National Laboratory — The Holifield Radioactive Ion Beam Facility at Oak Ridge National Laboratory provides radioactive-ion beams for research in nuclear and astrophysics. An essential function is to produce a variety of radioactive species to meet the intensity, energy, and purity requirements of specific experiments. The primary production method has been proton-induced fission of uranium. However, production rates in the mass 80-95 region are expected to be higher from proton-induced fission of thorium. [1] In particular, $^{24}$Ge is expected to increase by an order or magnitude [2], and $^{195}$Sr yields should increase. Our first series of online experiments using a dense ThO$_2$ powder target, nevertheless, produced yields roughly a factor of 10 less than for UC$_2$ targets. Porous targets of ThO$_2$ have been produced and extensive yield measurements performed. Results from the different ThO$_2$ targets are compared to each other and to yields from some UC$_2$ targets. In order to obtain some understanding of these results, holdup-time measurements have been made on some chemical elements. [1] T. Ohtsuki, et al., Phys Rev C40 (1989) 2144. [2] V. Rubchenny, private communication.

4:36PM DB.00012 Fission Fragment Spectroscopy Using a Frisch-Gridded Chamber in RPI’s Lead Slowing-Down Spectrometer, CATHERINE ROMANO, Rensselaer Polytechnic Institute — A double sided Frisch-gridded fission chamber for use in RPI’s Lead Slowing-Down Spectrometer (LSDS) is being developed at Rensselaer Polytechnic Institute. Placing this fission chamber in the high neutron flux of the LSDS allows measurements of neutron induced fission cross sections, as well as the mass and kinetic energy of the fission fragments of various isotopes. The fission chamber consists of two anodes shielded by Frisch grids on either side of a single cathode. The sample is deposited on a thin polyimide film located in the center of the cathode. Samples are made by dissolving small amounts of actinides in solution, placing the solution on the films and allowing the solution to evaporate. The anode signal and the sum of the anode and grid signals are collected by the data acquisition system. These values are used to calculate the angle of emission of the fission fragments which is then used to determine their energies and masses. RPI’s LSDS is a 75 ton, 1.8m cube of lead. The RPI 60MeV Linac creates neutrons through a ($\alpha$, n) reaction when the electrons interact with a tantalum target inside the lead spectrometer. The resulting neutron flux is about 4 orders of magnitude larger than an equivalent resolution time-of-flight experiment. The high neutron flux allows for the measurement of isotopes that are not available in large quantities (sub-micrograms) or with small fission cross sections (microbarns). In collaboration with Ezekiel Blain, Zack Goldstein, Yaron Danon and Robert Block at Rensselaer Polytechnic Institute. Funded by Stewardship Science Academic Alliance, National Nuclear Security Agency.

Friday, October 27, 2006 2:00PM - 5:00PM — Session DC DNP: Nuclear Structure III Gaylord Opryland Tennessee B

2:00PM DC.00001 The Parity Dependence of Nuclear Level Densities, HANGHUI CHEN, YORAM ALHASSID, ANGEL MANZUR, Yale University — We use a simple model to calculate the odd-to-even parity ratio of nuclear level densities as a function of excitation energy. The model is based on a deformed single-particle Hamiltonian with pairing interaction. It differs from the model introduced in Ref. [1] by including fluctuations in the pairing gap and using number-parity projection to account for odd-even effects in particle number. We compare the results of the simple model with microscopic shell model calculations in the full $^{15+}$ nuclei shell for nuclei in the iron region.


This work was supported in part by the U.S. DOE grant No. DE-FG-0291-ER-40608.
2:12PM DC.00002 Time - Odd Mean Fields in Covariant Density Functional Theory. ANATOLI AFANASJEV, Mississippi State University — The role of the time-odd mean fields, their evidence in experiment, and an accurate description of these fields are subjects of current interest. In the covariant density functional theory they are related to nuclear magnetism: time-odd mean fields arise from the space-like parts of the vector mesons and Lorentz invariance requires that their coupling strength is identical to that of the time-like parts. The role of time-odd fields and their impact on physical observables will be presented. It will be shown that these fields modify the moments of inertia, effective alignments, alignment gains at the band crossings and other physical observables in rotating nuclei. In particular, the question whether the time-odd mean fields are related to the isoscalar proton-neutron pairing will be discussed. The time-odd mean fields also reveal themselves in non-rotating odd and odd-odd nuclei (nuclei with broken time-reversal symmetry). Their impact on the binding energies, odd - even mass differences, the structure of such nuclei along the neutron and proton-drip lines will be discussed. Magnetic properties of deformed nuclei and the impact of time-odd mean fields on such properties, the study of which is in progress, will be covered. Whenever it is possible, the results will be compared with the ones obtained in the nonrelativistic Skyrme density functionals.

2:24PM DC.00003 Coupling of chiral and shape vibrations in the A=130 region, DANIEL ALMEHED, STEFAN FRAUENDORF, University of Notre Dame — Several near degenerate Dl = 1 bands with the same parity have been found in the A = 130 and A = 105 regions. Some of these bands have been interpreted as chiral rotational bands within the Tilted Axis Cranking (TAC) model [V. I. Dimitrov et al., PRL 84, 5720 (2000)]. Chiral rotation can appear in triaxial nuclei when proton and neutrons align along different principal axes and the collective rotation occurs along the third. Candidates for chiral partner bands generally show a slowly decreasing or nearly constant energy splitting of a couple of 100 keV. This observation has been interpreted as appearance of a chiral vibration, which is a vibration of the orientation of the principal axes of the nucleus with respect to the angular momentum vector [K. Starosta et al., PRL 86, 971 (2001)]. The TAC calculations of chiral bands give potential energy surfaces that are soft in both the deformation degree of freedom. This suggests that these collective vibrations are in fact made up of a pure chiral vibration coupled with γ-vibration. To investigate the structure of these vibrations we performed RPA calculations, using for the planar TAC mean field solutions. This allows us studying the coupling of shape and orientation degrees of freedom. We will discuss how the different degrees of freedom contribute to the collective vibration and present energy systematics and transition rates.

2:36PM DC.00004 Lifetime spectroscopy of 112Cd via the (n, n′γ) reaction. P.E. GARRETT, K.L. GREEN, University of Guelph, J. LEHMANN, University of Fribourg, J. JOLIE, University of Koeln, C.A. MCGRATH, MINSFANG YEH, S.W. YATES, University of Kentucky — Lifetimes of many levels up to 4 MeV in 112Cd have been measured using the Doppler shift attenuation technique following neutron inelastic scattering with monoenergetic neutrons. Using these lifetimes, reduced transition matrix elements are determined. The electromagnetic properties of 112Cd are outlined, and together with results from previous studies, levels are interpreted in terms of single-particle configurations and collective excitations. The separate roles of proton and neutron excitations in a subset of excited states are determined by combining the ground state electromagnetic transition rates with the hadronic transition rates. The collective states and their γ-ray decays are compared with IBM-2 model calculations that allow for the mixing between the nonphonon states and intruder configurations.

2:48PM DC.00005 Probing the Pygmy Dipole Resonance in 112Sn and 124Sn. MELISSA BOSWELL, C. ANGELL, H.H. KARWOWSKI, J. ENGEL, UNC and TUNL, J.H. KELLEY, NC State and TUNL, A.P. TONCHEV, W. TORNOW, Duke U. and TUNL — A high-resolution nuclear fluorescence experiment of enriched 112,124Sn has been performed using the 100% polarized photon beam at the High-Intensity Gamma-Ray Source (HIγS). Four HPGe detectors were used to observe 60 dipole transitions with excitation energies between 6.4 MeV and 8.4 MeV. The parity of each of the 21 previously identified transitions in 124Sn was found to be J′=1−. In addition, 10 new levels in 124Sn were identified, as well as 5 new levels in 112Sn all of which are E1 excitations with the exception of a 6.917 MeV state in 124Sn excited by an M1 transition. Both nuclei exhibited considerable decay strength to the first excited state. We shall discuss the possible causes of these decays as well as their implications to r-process nucleosynthesis. The measurements will be compared with calculations using quasiparticle random-phase approximations.

3:00PM DC.00006 Beta decay strengths from the decay of 116m1, m2, 3Ag. J.C. BATCHELDER, H.K. CARTER, E.H. SPEJEWSKI, UNIRIB/ORAU, J.C. BILHEUX, K.P. RYKCZEWSKI, D.W. STRACÉNÉ, C.R. BINGHAM, R. GRZYWacz, M.N. TANTawy, Y. LAROCHELLE, U. Tennessee, J.H. HAMILTON, W. KROLAS, D. FONG, A. RAMAYYA, J.K. HWANG, Vanderbilt University, P.E. GARRETT, U. Guelph, D.J. HARTLEY, U.S. Naval Academy, D. KULP, J.L. WOOD, Ga. Tech, A. PIECHACZEK, E.F. ZGANJAR, Louisiana State U, J.A. WINGER, Mississippi State University — An inconsistency with the published data on the decay of a 5− in 116mAg has been the non-zero beta feeding strength for the decay of 116Ag to low-lying levels with spins of 2 and 3 [1]. Recently [2], we have shown that 116Ag has a third isomer. Through the use of conversion electron and gamma spectroscopy, we were able to show that the ground state must be 0− rather than the previously assigned 2− [3]. This results in the three beta-decaying levels in 116Ag having Jπ of 0−, 3−, and 6−. Our results indicate that the feeding of the levels in 116Cd with spins of 2 and 3 arise from the 3+ isomer in 116Ag, which is perfectly consistent with allowed beta transitions from the 3+ 116m1Ag isomer. In this talk, a discussion of the beta strengths of the three isomers as well as the levels in Cd will be presented. [1] Y. Wang et al., Phys. Rev. C 64, 054315 (2001). [2] J. C. Batchelder, et. al., Rev. C. 72, 044306 (2005). [3] T. Bjørnstad and J. Alstad, J. Inorg. Nucl. Chem., 36, 2159 (1974).

3:12PM DC.00007 Multiphonon and Mixed-Symmetry States in 127I, SHARMISTHA MUKHOPADHYAY, University of Kentucky — The complex low-lying structure observed in odd-mass nuclei arises from the interplay of phonon, intruder, mixed-symmetry and single particle degrees of freedom. Multiphonon excitations in odd-mass nuclei may occur as a result of weak coupling of an unpaired particle with the core nucleus. Little is known, however, about these collective vibrations in odd-mass nuclei. We have studied 127I using the (n, n′γ) and (n, n′, γγ) reactions at incident neutron energies ranging from 1.2 to 3.0 MeV. From excitation functions and angular distribution, branching and mixing ratios were measured and level lifetimes and transition probabilities determined. To construct and extend 127I decay scheme both excitation functions and coincidence data were used. New information on multiphonon and mixed-symmetry states built on the 5/2−ground state and the 7/2+[404] and 3/2+[422] Nilsson orbitals will be presented.

3:24PM DC.00008 Candidates for Quadrupole-Octupole Multi-phonon Excitations Observed in the Te Isotopes. S.F. HICKS, University of Dallas, J.R. VANOY, United States Naval Academy — Excited levels in the even-even isotopes 120−130Te have been investigated to 3.3 MeV using γ-ray spectroscopy following inelastic neutron scattering. Level characteristics including spins, multipole-mixing and branching ratios, and lifetimes in the fs to ps regime have been deduced from γ-ray angular distributions, excitation functions, and Doppler-shift measurements, as well as γ−γ coincidence measurements. This consistent set of measurements has enabled us to examine multi-phonon excitations across the isotopic chain. In particular, the quintet of negative-parity states (1−, 5−) arising from the coupling of the lowest quadrupole- and octupole-phonon excitations have been examined and candidates have been identified. Results from these investigations across the Te isotopic chain will be presented.

1This work was supported in part by the National Science Foundation.
3:36PM DC.00009 Evolution of shape phase transitions as functions of energy, spin, and boson number in the Interacting Boson Model E. WILLIAMS, R. J. CASPERSON, V. WERNER, Wright Nuclear Structure Laboratory, Yale University, New Haven, CT 06520 — Shape phase transitions from spherical to deformed nuclei have been a subject of recent interest because explorations of such behavior have led to a greater understanding of the evolution of collectivity throughout the nuclear landscape. Two critical points in particular, X(5), a first order shape transition, and E (5), a second order shape transition, were identified in the geometrical model. Recent work within the context of the Interacting Boson Model (IBM) has explored these regions in the finite N limit corresponding to realistic nuclei. IBM calculations extending to large boson numbers provide powerful tools for relating transitional behavior observed in nuclei to phase transitions in macroscopic systems. A study of first and second order phase transitions in the large boson limit as functions of N, spin, and energy has been undertaken with the use of a variety of observables, including both electromagnetic transitions, and energies. The results of this investigation will be presented. Work supported by US DOE grant number DE-FG02- 91ER-40609.

3:48PM DC.00010 Deformation shrinking of the β-band at the first order shape phase transition V. WERNER, E. WILLIAMS, WNSL, Yale University, C. SCHOLL, P. VON BRENTANO, IKP, Universität zu Köln, Germany — One main effect of the nuclear shape phase transition between spherical and deformed nuclei is the vast rise of the geometrical deformation parameter β for the ground state towards deformed nuclei. This rise is reflected in the rise of the model independent quadrupole shape invariant q2, from which an effective ground state β-deformation can be extracted. While one would naively expect similar behavior for the q2 value of the first excited 0+ state, which corresponds to the head of the β-vibrational band, the IBM-1 predicts indeed a shrinking of its β-deformation when crossing the first order phase transition between vibrators and well-deformed nuclei. Absolute B(E2) values known for the ground-band and the β-band of 152,154Gd support this effect. This work is supported by USDOE under contract numbers DE-FG02-91ER-40609, and DFG under Br 799/12-1.

4:00PM DC.00011 135Ba - A First Test of the E(5/4) Bose-Fermi Symmetry1, M.S. FETEAA, Department of Physics, University of Richmond, Richmond, VA 23173 and Wright Nuclear Structure Laboratory, Yale University, New Haven, CT 06520 (WNSL), R.B. CACKIRLI, WNSL and Department of Physics, University of Istanbul, Istanbul, Turkey, R.F. CASTEN, WNSL, D.D. WARNER, WNSL and Daresbury Laboratory, Warrington WA44AD, UK, E. MCCUTCHAN, D.A. MEYER, A. HEINZ, H. AI, G. GURDAL, J. QIAN, R. WINKLER, WNSL — Very recently, the first case of a critical point Bose-Fermi symmetry for odd-mass nuclei, E(5/4) was developed. It describes analytically a gamma-soft critical point E(5/4) core coupled to a j = 3/2 particle, where E(5/4) represents a second order phase transition from a vibrator U(5) to a gamma-soft rotor O(6). Since 134Ba has been found to be an empirical manifestation of E(5), 135Ba - in which the last neutron can occupy the 2d3/2 orbit, is the natural initial test of E(5/4). To complement this test and provide a perspective, we performed shell model and interacting boson-fermion approximation calculations. We will present the work and discuss the results. We will show that E(5/4) can account for some of the observables in 135Ba but that it does not provide a fully satisfactory description. Specifically, many of the collective and forbidden B(E2) values of E(5/4) agree well with the data.

1This work was supported by the NSF Grant PHY 0204811, the Research Corporation Grant CC5494, USDOE Grants DE-FG02-91ER-40609 and DE-FG02-88ER-40417, and the Flint Fund.

4:12PM DC.00012 Identification of high spin states in 137,138Cs nuclei K. LI, Y.X. LUO, J.K. HWANG, A.V. RAMAYYA, J.H. HAMILTON, H.L. CROWELL, C. GOODIN, Vanderbilt Univ., J.O. RASMUSSEN, E.Y. LEE, S.C. WU, LBNL, G.M. TER-AKOPIAN, A.V. DANIEL, JINR(Dubna), J.D. COLE, INL, A. COVELLO, A. GARGANO, Univ. di Napoli Fed. II, R. DONANGELO, Univ. Fed. do Rio de Janeiro, W.C. MA, Mississippi State Univ., M.A. STOYER, LLNL, S.J. ZHU, Tsinghua Univ. — High spin states of 137,138Cs have been studied by measuring the γ-γ-γ coincidences from the spontaneous fission of 252Cf with the Gammasphere detector array. The level scheme of the N=83 neutron-rich Cs (Z=55) isotopes, 138Cs, has been established for the first time up to a 4626keV level assigned (16+) and that of 137Cs has been expanded up to a 5495keV level assigned (31/2+). Spins, parities and configurations are assigned based on shell model calculations and level systematics. Pronounced differences in low-lying yrast cascade patterns are seen between N=83 isotones 138Cs (Z=55), 135Sb (Z=51) and 130I (Z=53), and between Cs isotopes 138Cs and 137Cs. Significant similarity is observed in the N=82 isotones 137Cs and 135I up to 17/2+ but not above the spin nor with 135Sb, which indicates the important role played by interactions between the excitation of the 9/2+ valence protons outside the Z=50 major shell, and the 17/2 valence neutron outside the N=82 major shell.

4:24PM DC.00013 Partial Cross-Sections of 140Ce(n,2n)139Ce Reaction1, C.T. ANGELL, B. FALLIN, A. HUTCHESON, H.J. KARWOWSKY, J.H. KELLEY, A.P. TONCHEV, W. TOWNOW, UNC Chapel Hill, NC State U., Duke U. and Triangle Universities Nuclear Laboratory — The excitation function for the 140Ce(n,2n)139Ce reaction has been studied in the TUNL Shielded Neutron Source area. A pulsed and quasi-monoenergetic neutron beam was produced via the D(d,n) reaction (2D(E)/E=3-5%) with energies of 12, 13.3, 14.5, and 16 MeV with a beam flux of ~10^4 n/s( steradian) . The target consisted of a mixture of natural Ce and Fe. Two clover and two planar HPGe detectors were used to make in-beam measurements of the γ-ray cascade deexciting 139Ce. The partial cross sections were normalized to the 847 keV transition in 56Fe. Statistical model calculations using code EMPIRE will be compared with the present data as well as with the previously obtained [1] transition amplitudes for the 140Ce(γ,n)139Ce reaction.


1This research was supported by DOE grants DE-FG02-97ER41041 and DE-FG02-97ER41033.

4:36PM DC.00014 Fine structure in proton emission from 141gsHo and 141mHo K. RYKACZEWSKI, ORNL, M.K. KARNY, Warsaw U., R. GRZYWACZ, U. Tennessee, J. BATCHELDER, UNIRIB, C. BINGHAM, U. Tennessee, C. GOODIN, Vanderbilt U., C. GROSS, ORNL, J. HAMILTON, J. HWANG, Vanderbilt U., A. KORGUL, Warsaw U., W. KROLSA, INP Krakow, S. LIDDIKC, UNIRIB, K. LI, K. MAIER, JIHIR, C. MAZZOCCHI, U. Tennessee, A. PIECHACZEK, LSU, A. RAMAYYA, Vanderbilt U., D. SHAPIRA, ORNL, D. SIMPSON, M. TANTAWY, U. Tennessee, J. WINGER, Mississippi State U., C. YU, ORNL, E. ZGANJAR, LSU — Fine structure in proton emission from the 7/2-[523] ground state and from 1/2+[411] isomeric state in the deformed nucleus 141Ho was discovered at the HRIBF, Oak Ridge. Proton transitions to the 0+ ground state and to the 202 keV 2+ state in 140Dy were observed. The branching ratios of I2−2+/I2−1+ = 0.9(1)% and I2+2+/I2+1+ = 1.7(4)% were measured by means of fusion-evaporation reactions. Recoil Mass Separator and digital processing of the Double-sided Silicon Strip Detector recoil implantation and decay signals. The structure of the deformed wave functions of the 7/2-[523] and 1/2+[411] states will be discussed. The decay properties of 141mHo can be explained by postulating a small triaxial deformation, while the same model fails to explain observed decay properties of 141Ho. The measured isomeric halflife and I2−m value suggest that the contribution of the rπ1/2 0+ component in the 1/2+[411] wave function is reduced to about 3% only.
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VIEIRA, J.M. WOUTERS, LANL — We have determined spins of resonances in the 147

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systems, such as the spherical systems 16

and O

+ 16

and are carried out on a large 3-D Cartesian lattice using the Basis-Spline collocation method. One of the appealing features of TDHF is that one can follow γ multiplicities of distributions for resonances in the energy range 350 < Eγ < 700 eV. The new spin assignments also allowed us to reanalyze 147Sm(n,nγ) data and obtain more reliable α widths. Although our new α widths are somewhat different from previous work, recently reported non-statistical effects revealed by these widths remain. Taken together, the neutron-width, α-width, and level-spacing data indicate the onset of some non-statistical effect near EN = 350eV. We will discuss possible explanations for these effects and their possible relation to similar effects previously observed in 232Th + n resonances.

1Supported in part by U.S. DOE under Contract No. DE-AC0600OR22725 with UT-Battelle, LLC.

Friday, October 27, 2006 2:00PM - 4:36PM
Session DD DNP: Heavy Ion / Rare Isotope Reactions Gaylord Opryland Hermitage A

2:00PM DD.00001 Simulations of the ancillary silicon array for TIGRESS M. PORTER-PEDEN, F. SARAZIN, L. ERIKSON, Dept. of Physics, Colorado School of Mines — A highly segmented and compact silicon array is currently being designed to complement the TIGRESS gamma-ray array (TRIUMF-ISAC Gamma-ray Escape-Suppressed Spectrometer) at ISAC2. The silicon array fits in the inner volume of TIGRESS and is expected to be used in both Coulomb excitation and transfer reaction experiments. Simulations using GEANT4 are underway to optimize its configuration. At present, the layout of the array consists in two boxes made of four ΔE-E telescopes in the forward angles and four E detectors in the backward angles. A CD detector covers the extreme backward angle. Simulations of a few case-experiments will be presented. This work is supported by the US department of Energy through Grant/Contract No. DE-FG03-93ER40789.

2:12PM DD.00002 Symmetry Energy of Hot Heavy Fragments Produced in the Multifragmentation of Neutron-Rich Systems at Fermi Energies G.A. SOULIOTIS, A.S. BOTVINA, D.V. SHETTLY, A.L. KEKIS, M. VESELSKY, S.J. YENNELLO, Cyclotron Institute, Texas A&M University — Mass spectrometric data of the isotopic distributions of heavy projectile-like fragments (heavy IMFs: A = 20-40 and heavy residues: A = 40-60) from peripheral collisions of heavy neutron-rich beams on a variety of targets are systematically compared with model calculations appropriate for this energy regime (part of the data are presented in [1]). The model approach consists of a deep-inelastic transfer code (DIT) for the dynamical stage of the collision and the Statistical Multifragmentation model (SMM05) for the de-excitation stage. The comparisons indicate a gradual evolution of the symmetry energy coefficient of the binding energy of the hot primary fragments from 25 MeV around E∗/A = 2 MeV and below (compound nucleus regime) towards 15 MeV at about E∗/A = 4 MeV and above (bulk multifragmentation). The robustness of the above result to the input parameters of the calculation is explored in detail. Comparison of our calculations with literature data on heavy fragments at higher energies will also be presented. Consequences of the observed gradual decrease of the symmetry energy to the distribution of hot exotic nuclei in the multifragmentation of neutron-rich systems and in core-collapse supernova environments will be discussed. [1] G.A. Soulis et al, nucl-ex/0603006.

2:24PM DD.00003 Symmetry energy, temperature, density and isoscaling parameter as a function of excitation energy in A ~ 100 mass region D.V. SHETTLY, S.J. YENNELLO, G.A. SOULIOTIS, A.L. KEKIS, S.N. SOISSON, B.C. STEIN, S. WIENSCHEL, Cyclotron Institute, Texas A&M University, College Station, TX 77843 — Understanding the correlation between the temperature, density and symmetry energy of a nuclear system as it evolves with excitation energy is important for constructing the nuclear matter equation of state. Experimentally, the multifragmentation reaction provides the best possible means of studying nuclear matter at temperatures, densities and isospin (neutron-to-proton asymmetry) away from those of normal nuclear matter. Results from recent studies aimed at understanding this correlation will be presented; their relevance to the density dependence of the symmetry energy will be emphasized.

1This work was supported in part by the Robert A. Welch Foundation through grant No. A-1266, and the Department of Energy through grant No. DE-FG03-93ER40773.

2:36PM DD.00004 3-D unrestricted TDHF fusion studies of spherical and deformed nuclei SAIT UMAR, VOLKER OBERacker, Vanderbilt University — We utilize the Time-Dependent Hartree-Fock (TDHF) method to calculate heavy-ion fusion cross sections for stable and neutron-rich nuclei. The calculations involve modern Skyrme forces, including all time-odd terms in the energy density functional, and are carried out on a large 3-D Cartesian lattice using the Basis-Spline collocation method. One of the appealing features of TDHF is that one can follow the time-evolution of the nuclear density distributions, resulting in either fusion or deep-inelastic reactions. We have studied both stable and neutron rich systems, such as the spherical systems 16O + 16O and 18O + 18O [Ref.1], and the spherical plus deformed system 15O + 24Ne [Ref.2]. Within the framework of density-constrained TDHF [Ref.3], we have found a method to deduce the corresponding heavy-ion interaction potentials for these systems. Most recently, the TDHF code has been implemented on a massively parallel supercomputer; first results for the neutron-rich system 12C + 26Mg will be presented. 1. A.S. Umar and V.E. Oberacker, Phys. Rev. C73, 054607 (2006). 2. A.S. Umar and V.E Oberacker, nucl-th/0604010. 3. A.S. Umar and V.E. Oberacker, nucl-th/0605084

1Supported by U.S. DOE grant DE-FG02-96ER40963, and by National Energy Research Scientific Computing Center

2:48PM DD.00005 Neutron transfer and flow in reactions between heavy neutron-rich nuclei DAN SHAPIRA, FELIX J. LIANG, J. GROSS, ROBERT L. VARNER, JAMES R. BEENE, Physics Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA. — Two Step WKB calculations of nucleus nucleus capture were carried out. In our calculations we investigate the possibility of enhanced capture cross sections for neutron rich heavy nuclei. The model calculation uses a systematic potential [1] that incorporates the effect of barrier distributions due to excitation and deformation in the entrance channel. Neutron transfer is treated in a semiclassical approximation [2][3]. The transfer form factor used in neutron transfer saturates at an internuclear distance where neutron can flow freely between the two nuclear centers [4].


3This work was supported by the U. S. Department of Energy under contracts DE-AC05-00OR22725 with UT-Battelle, LLC.
3:00PM DD.00006 Total cross sections for nucleon elastic scattering from stable and unstable nuclei at energies between 10 MeV and 1 GeV, H.F. ARELLANO, Physics Department - CFCM, University of Chile, H.V. VON GERMAB, University of Hamburg, M. GIROD, CEA/DIF/DPTA Service de Physique Nucléaire, Bruyères-le-Châtel, France — Parameter-free optical model potential results for total cross sections of nucleon elastic scattering are presented and discussed. The applications span over a wide energy range (10-1000 MeV) considering both stable and unstable nuclei. The study is based on in-medium g-matrix full-folding optical model approach with the appropriate relativistic kinematic corrections needed for the higher energy applications. The effective interactions are based on realistic NN bare potentials supplemented with a separable non-Hermitian term to allow optimum agreement with current NN phase-shift analyses, particularly to account for inelasticities above pion threshold. The ground-state radial strengths of the targets are obtained from Hartree-Fock-Bogoliubov calculations based on the finite range, density dependent Gogny force. Total cross sections and reaction cross sections are evaluated for neutron and proton scattering from $^{12}_{\Lambda}O$, $^{34}_{\Lambda}S$, $^{50}_{\Lambda}Ca$, $^{56}_{\Lambda}Fe$, $^{116}_{\Lambda}Sn$ and $^{176-224}_{\Lambda}Pb$. The results for the stable nuclei as function of the energy are in reasonable agreement with the data. The systematics of the calculated cross sections as function of the target nucleus number is also discussed. Supported in part by FONDECYT grant 1040938. 1) H. F. Arellano and H. V. von Geramb, Phys. Rev C 66, 024602 (2002).

3:12PM DD.00007 Population of Neutron-Unbound States from Direct Fragmentation, GREGORY CHRISTIAN, DANIEL BAZIN, NATHAN FRANK, ALEXANDRA GADE, BRAGE GOLDING, WILLIAM PETERS, ANDREW RATKIEWICZ, ANDREW STUMP, ANDREAS STOLTZ, MICHAEL THOENNESSEN, Michigan State University, MATTHEW KLEBER, JASON MILLER, Concordia College, JIM BROWN, TED WILLIAMS, Wabash College, JOSEPH FINK, Central Michigan University, PAUL DEYOUNG, JERRY HINNEFELD, Indiana University South Bend, MONA COLLABORATION — Fragmentation of a Calcium 48 beam was used to directly populate neutron-unbound states of nuclei located near the dripline. Neutron-rich fragments were detected with position sensitive detectors following a focusing quadruple triplet and a dipole magnet. The setup allowed for good isotopic separation and identification. Neutrons were detected in coincidence with the Modular Neutron Array (MoNa) located at zero degrees. Fragments from $Z = 6$ to $Z = 12$ with $A/Z$ ranging from 2.0 to 2.7 were detected. From the relative velocity spectra of the neutrons and fragments information of the population of excited states in the different isotopes was extracted and will be presented.

3:24PM DD.00008 Proximity decay and the Tidal effect, A.B. MCINTOSH, R.T. DE SOUZA, S. HUDAN, C.J. METELKO, R. ALFARO, B.P. DAVIN, Y. LAROCHELLE, H. XU, L. BEAULIEU, T. LEFORT, R. YANEZ, Department of Chemistry and IUCF, Indiana University, R. CHARITY, L.G. SOBOTOKA, Washington University in St. Louis, T-X. LIU, X-D. LIU, W.G. LYNCH, R. SHOMIN, W.P. TAN, M.B. TSANG, A. VANDER MOLEN, A. WAGNER, H.F. XI, NSCL, Michigan State University — An excited nucleus can decay by emission of clusters. These clusters may be excited and subseqently themselves undergo particle decay. Peaks in the relative energy spectrum of the secondary decay products indicate resonance reflecting the discrete internal structure of the primary emitted cluster. Resonance spectroscopy can be used, for example, to determine the temperature of the initial source within a statistical approach. To date however, the effect of the field of the emitting nucleus on the decay of the cluster has been largely neglected. Tidal effects result in the correlation of the relative energy with emission angle as a function of the decay time. We explore the influence of the external Coulomb field on the decay of the first excited state of $^{114}_{\Lambda}Cd$ in the reaction $^{114}_{\Lambda}Cd + ^{92}_{\Lambda}Mo$ at $E/A=50$ MeV. Comparison of the experimental data with the predictions of a simple Coulomb trajectory model indicate that the interaction with the nuclear surface (proximity interaction) on the emitted cluster is not negligible.

1PHY01-10253

3:36PM DD.00009 Neutron to proton ratios of quasiprojectile and midrapidity emission in the $^{64}_{\Lambda}Zn + ^{114}_{\Lambda}Zn$ reaction at 45 MeV/nucleon, D. THERIAULT, J. GAUTHIER, F. GRENIER, F. MOISAN, C. ST-PIERRE, R. ROY, Laboratoire de Physique Nucl. eaire, Departement de Physique, Universite Laval, Canada, B.P. DAVIN, S. HUDAN, T. PADUSZYNISKI, R.T. DE SOUZA, Dept. of Chemistry and IUCF, Indiana University, E. BELL, J. GAREY, J. IGLO, A.L. KEKSIS, S. PARKETON, C. RICHERS, D.V. SHETTY, S.N. SOISSON, G.A. SOULIOTIS, B.C. STEIN, S.J. YENELLO — Simultaneous measurement of both neutrons and charged particles emitted in the reaction $^{64}_{\Lambda}Zn + ^{114}_{\Lambda}Zn$ at 45 MeV/nucleon allows comparison of the neutron to proton ratio at midrapidity with that at projectile rapidity. The evolution of N/Z in both rapidity regimes with increasing centrality is examined. For the completely re-constructed midrapidity material one finds that the neutron-to-proton ratio is above that of the overall $^{64}_{\Lambda}Zn + ^{114}_{\Lambda}Zn$ system. In contrast, the re-constructed ratio for the quasiprojectile is below that of the overall system. This difference provides the most complete evidence to date of neutron enrichment of midrapidity nuclear matter at the expense of the quasiprojectile.

1Work supported in part by U.S. DOE under Grant No. DE-FG-92ER40714

2Cyclotron Institute, Texas A&M University

3:48PM DD.00010 Fusion induced by radioactive $^{123}_{\Lambda}Sn$ on $^{64}_{\Lambda}Ni$, J.F. LIANG, D. SHAPIRA, C.J. GROSS, R.L. VARNER, J.R. BEENE, A. GALINDO-URIABARRI, J. GOMEZ DEL CAMPO, P.A. HAUSLADEN, P.E. MUELLER, D.C. RADFORD, D.W. STRANER, Oak Ridge National Laboratory, H. AMRO, J.J. KOLATA, University of Notre Dame, J.D. BIERNER, Gonzaga University, A.L. CARALEY, State University of New York at Oswego, K.L. JONES, Rutgers University, Y. LAROCHELLE, University of Tennessee, W. LOVELAND, D. PETERSON, Oregon State University — The fusion excitation function for $^{115}_{\Lambda}Sn$ on $^{64}_{\Lambda}Ni$ was measured. The evaporation residues (ERS) were identified by their energy loss in an ionization chamber located at zero degrees and by time-of-flight. The fission fragments were detected by an annular double-sided silicon strip detector. The fragment-fission coincidence and angular distributions were used to distinguish fission events from other reaction channels such as deep inelastic scattering. The fusion cross sections for $^{123}_{\Lambda}Sn$ and $^{64}_{\Lambda}Ni$ below the barrier are enhanced as compared to other stable Sn isotopes on $^{64}_{\Lambda}Ni$. Detailed data analysis and model comparisons will be presented.

1Oak Ridge National Laboratory is supported by the U.S. Department of Energy under contract No. DE-AC05-00OR22725 with UT-Battelle, LLC.

4:00PM DD.00011 The fusion of $^{9,11}_{\Lambda}Li$ with $^{70}_{\Lambda}Zn$, WALTER LOVELAND, RADHIKA NAIR, JAMES NEEWAY, PETER SPRUNGER, A.M. VINOIKDARMA, Oregon State University, MICHAEL TRINCLEK, MARÍK DOMBSKY, PETER MÁCHULÉ, D. OTTEWELL, TRIUMF, DAVID CROX, K. GAGNON, W. MILLIS, Simon F section at UNIB — The fusion of $^{9}_{\Lambda}Li$ with $^{70}_{\Lambda}Zn$ was studied at TRIUMF. Beam intensities were $5 \times 10^6$ particle/s while the $^{11}_{\Lambda}Li$ intensities were $800$ particles/s. As and Ge evaporation residues were assayed using gamma and beta spectroscopy following post-evaporation chemical separation from the irradiated targets. A seven point excitation function for the $^{9}_{\Lambda}Li$ and $^{70}_{\Lambda}Zn$ reaction was measured and compared to coupled channels calculations. Due to the low $^{11}_{\Lambda}Li$ beam intensity, only upper limits for fusion of $\approx 2$ pb could be established for $^{11}_{\Lambda}Li$.

1This work was supported in part by the USDOE under Grant DE-FG06-97ER41027.
will be shown. The preliminary result of the first test in run 6 p+p collisions will be discussed. A significant enhancement of high 

µµfreezeout. More importantly, 

to the electromagnetic nature of interaction, 

is crucial for many interesting physics in heavy ion collision experiment, like the dimuon continuum, the quarkonia production, and the Drell-Yan process. Due 

xaway-side distribution has the nice property that it both exhibits 

the fragmentation function. The lack of sensitivity to the fragmentation function will be explained, and an analytic formula for the 

x of charged particles triggered by a 

πRHIC will be presented, leading to some interesting conclusions.

achieved in this test run. Finally the plans for future upgrade will be presented. 

is the fragmentation variable. It was generally assumed, following Feynman, Field and Fox, as shown by data from the CERN-ISR experiments, that the 

fragmentation function as observed in 
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edge distribution of away side hadrons from a single particle trigger [with 

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reveals that each CDCC calculation is only appropriate to describe specific regions of phase space. 

1Work performed under the auspices of the US DOE by University of California, LLNL under contract W-7405-Eng-48 and LANL under contract W-7405-ENG-36, and benefited from the use of the LANSE accelerator supported under contract W-7405-ENG-36

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DD.00014 Comparison of CDCC and Faddeev calculations for 11Be-p scattering, A.C. FONSECA, A. DELTUVA, Centro de Física Nuclear da Univ. de Lisboa, Portugal, A.M. MORO, Departamento de FAMN, Univ. de Sevilla, Spain, F.M. NUNES, NSCL and Dept. of Physics and Astronomy, Michigan State Univ., USA — The strong coupling between elastic and breakup channels in direct nuclear reactions involving halo type nuclei has lead to the development of CDCC calculations where an effective three-body problem is solved via the expansion of the full wave function in a selected set of continuum wave functions of a given pair subsystem Hamiltonian. Recent results [1] obtained with basis sets pertaining to two different pair subsystems lead to substantially different breakup cross sections. Given that the exact numerical solution of the Faddeev equations with two charged particles has recently become possible above three-body breakup threshold, we test CDCC by benchmarking calculations of the p(11Be,10 Be)pn breakup reaction with the corresponding exact solution of the Faddeev equations. The exact semi-inclusive cross section for the detection of 11Be at different energies or angles reveals that each CDCC calculation is only appropriate to describe specific regions of phase space. 


Friday, October 27, 2006 2:00PM - 4:36PM – 
Session DE DNP: Ultrarelativistic Heavy Ions I Gaylord Opryland Hermitage B

2:00PM DE.00001 Centrality Dependent Studies of Charged Particle Spectra at RHIC1, SELEMON BEKELE, The University of Kansas, BRAHMS COLLABORATION — A major goal of the RHIC program is to create a deconfined state of nuclear matter at high temperatures and densities and to study the properties of this matter. A transition from a deconfined phase of quarks and gluons to hadronic matter requires significant rescattering of particles in the initial phase. The amount of rescattering is expected to increase with the size of the reaction region. It is therefore of interest to study reactions over a wide range of collision geometries as measured by centrality. Recent results from AuAu collisions at \( \sqrt{s_{NN}} = 200 \) GeV at RHIC show clear evidence of suppression of the hadron yields at mid-rapidity. Surprisingly, comparable suppression at forward rapidity has also been observed. While the suppression at mid-rapidity is believed to be due to final state effects, the cause of the suppression at forward rapidity is not very well understood. Comparing data from different collision systems may help us understand the underlying mechanism for the suppression at forward rapidity. We present preliminary results from the BRAHMS experiment on charged hadron spectra at pseudo-rapidity \( \phi \) as a function of centrality in CuCu collisions at \( \sqrt{s_{NN}} = 200 \) GeV.

1This work was supported by the Office of Nuclear Physics of the U.S. Department of Energy.

2:12PM DE.00002 Centrality dependence of the N(\( \Omega \))/N(\( \phi \)) ratios and \( \phi \) anisotropic flow, SARAH BLYTH, Lawrence Berkeley National Laboratory / University of Cape Town, STAR COLLABORATION — Due to its long lifetime and relatively small hadronic interaction cross-section, the \( \phi \)-meson is a clean probe for studying the properties of the hot and dense medium created in high-energy nuclear collisions. We present the first results of the centrality dependence of the N(\( \Omega \))/N(\( \phi \)) ratios and \( \phi \) anisotropic flow \( \langle v_2 \rangle \) from \( \sqrt{s_{NN}} = 200 \) GeV Au+Au collisions measured by STAR at RHIC. In more central collisions, the eccentricity-scaled anisotropic flow \( \langle v_2 \rangle /\langle \sin \theta \rangle \) is large, indicating a stronger collective expansion at the early partonic stage. For \( \rho > 2 \) GeV/c, \( \langle v_2 \rangle \) values are consistent with the \( v_2 \) values of other mesons, and expectations from parton recombination models. In addition, the N(\( \Omega \))/N(\( \phi \)) ratio is found to increase linearly as a function of \( \rho \), a characteristic of coalescence of thermal quarks for both \( \phi \) and \( \Omega \). In the most central collisions, the linear increase reaches up to \( \rho \sim 4 \) GeV/c implying that most of the multistrange hadrons are formed directly from thermalized s-quarks in Au+Au collisions at RHIC.

2:24PM DE.00003 Why the \( x_E \) distribution triggered by a pizero does not measure the fragmentation function, MICHAEL TANNENBAUM, Brookhaven National Laboratory — Hard-scattering in pp collisions was discovered at the CERN-ISR in 1972 by measurements utilizing single or pairs of hadrons. Due to the steeply falling power-law spectrum of the scattered partons, the inclusive single particle (e.g. pizero) spectrum from jet fragmentation is dominated by trigger fragments with large \( z_1 \sim 0.7 - 0.8 \), where \( z_1 = p_T/p_T^{jet} \) is the fragmentation variable. It was generally assumed, following Feynman, Field and Fox, as shown by data from the CERN-ISR experiments, that the \( p_T \) distribution of away side hadrons from a single particle trigger \( [p_T] \), corrected for \( z_1 \), would be the same as that from a jet-trigger and follow the same fragmentation function as observed in \( e^+e^- \) or DIS. PHENIX attempted to measure the fragmentation function from the away side \( x_E \) \( \sim p_T/p_T^{jet} \) distribution of charged particles triggered by a \( x^0 \) in p\-p collisions and showed by explicit numerical calculation that the \( x_E \) distribution was actually quite insensitive to the fragmentation function. The lack of sensitivity to the fragmentation function will be explained, and an analytic formula for the \( x_E \) distribution given. The away~side distribution has the nice property that it both exhibits \( x_E \) scaling and is directly sensitive to the ratio of the away jet \( p_T^{jet} \), to that of the trigger jet, \( p_T \), and thus to the relative energy loss of the two jets escaping from the medium in RHIC collisions. Applications to measurements from Au+Au collisions at RHIC will be presented, leading to some interesting conclusions.

2:36PM DE.00004 A New Large-area Muon Telescope Detector at Mid-rapidity at RHIC, GUOJI LIN, Yale University, ZHANGBU XU, Brookhaven National Laboratory, STAR COLLABORATION — \( \mu \) particle identification at middle and high \( p_T \) range is crucial for many interesting physics in heavy ion collision experiment, like the dimuon continuum, the quarkonia production, and the Drell-Yan process. Due to the electromagnetic nature of interaction, \( \mu \) carries information with direct sensitivity to the early stage of the high-energy nuclear collision before chemical freezeout. More importantly, \( \mu \) is a background free probe compared to electron with no photon conversion background and much less Dalitz decay. A large-area Muon Telescope Detector (MTD) at mid-rapidity at RHIC is proposed and under investigation. In this talk the simulation of \( \mu \) detection and hadron rejection will be shown. The preliminary result of the first test in run 6 p\-p collisions will be discussed. A significant enhancement of high \( p_T \) charged particles is achieved in this test run. Finally the plans for future upgrade will be presented.
2:48PM DE.00005 Microscopic Transport Approaches to Analyzing Hadronic Matter, Nasser Demir, Steffen Bass, Department of Physics, Duke University — Ultra-relativistic heavy-ion collisions at RHIC are thought to have created a strongly interacting Quark-Gluon-Plasma (sQGP) with a very low shear viscosity in the deconfined phase. However, as the sQGP hadronizes it will evolve through a hadronic phase with rapidly increasing viscosity. In order to fully characterize the sQGP state, one has to separately determine the viscosity of the hadronic phase. Here, we present a calculation of the shear viscosity coefficient of hadronic matter in equilibrium for a range of initial conditions and energy and baryon number densities. The dynamics of the particles comprising this medium are simulated using the Ultra-relativistic Quantum Molecular Dynamics (UrQMD) model in a box with periodic boundary conditions. Green-Kubo theory enables us to compute linear transport coefficients of a medium by examining fluctuations of the system's stress-energy tensor near equilibrium. We outline how to apply this approach to compute other transport coefficients, such as the baryon diffusion constant of hadronic matter. We also sketch an algorithm that combines the Green-Kubo formalism and our microscopic transport model to analyze the time evolution of the shear viscosity of a system gradually drifting out of equilibrium.

3:00PM DE.00006 ABSTRACT WITHDRAWN —

3:12PM DE.00007 Effect of the “minimal” viscosity on observables at RHIC\(^1\), Denes Molnar, Purdue University / RIKEN-BNL Research Center, Pasii Huovinen, University of Virginia — The goal of heavy ion experiments at the Relativistic Heavy Ion Collider (RHIC) is to create and study a novel hot and dense phase of quark-gluon matter, the so-called quark-gluon plasma (QGP). Several features of the RHIC data can be reproduced using ideal hydrodynamics, which lead to the suggestion that the plasma could be a “perfect fluid.” However, ideal hydrodynamics assumes zero viscosity (and therefore no dissipation), contrary to general expectations based on quantum mechanics that imply finite rates and, therefore, a nonzero “minimal viscosity.” These expectations have been verified for strongly-coupled \(\mathcal{N} = 4\) supersymmetric Yang-Mills theories, for which the lower bound on the shear viscosity to entropy density ratio is \(\eta/s = 1/(4\pi)\). Parton kinetic theory calculations based on microscopic 2 \to 2 rates do indicate that short, but non-zero, effective mean free paths generate sizable dissipative effects for conditions expected at RHIC. We show that these results imply that even a small \(\eta/s\) ratio \(\sim 0.1\) affects observables at RHIC and leads to significant deviations from ideal hydrodynamic behavior.\(^3\)

3:24PM DE.00008 Anomalous Viscosity of an Expanding Quark-Gluon Plasma\(^1\), Steffen Bass, Duke University, Masayuki Asakawa, Osaka University, Berndt Mueller, Duke University — We argue that an expanding quark-gluon plasma has an anomalous viscosity, which arises from interactions with dynamically generated color fields. We derive an expression for the anomalous viscosity in the turbulent plasma domain and apply it to the hydrodynamic expansion phase, when the quark-gluon plasma is near equilibrium. The anomalous viscosity dominates over the collisional viscosity for weak coupling and not too late times. This effect may provide an explanation for the apparent “nearly perfect” liquidity of the matter produced in nuclear collisions at the Relativistic Heavy Ion Collider without the assumption that it is a strongly coupled state.\(^3\)

3:36PM DE.00009 Anti-particle to Particle Ratios in Cu+Cu Collisions, Vasundhara Chetluru, University of Illinois at Chicago, PHOBOS Collaboration — Anti-particle to particle ratio measurements in heavy-ion collisions are an interesting probe in the context of understanding the chemical freeze out parameters. In PHOBOS, particle identification is achieved by energy loss measurements in the two arm magnetic spectrometer. This detector, located at mid-rapidity, consists of 16 planes of highly segmented silicon pads, some of which are in a 2T magnetic field. This talk will present the analysis techniques and results of anti-particle to particle ratios for identified protons, kaons and pions from 200 and 62.4 GeV Cu+Cu collisions. We will discuss the centrality and transverse momentum dependence of the ratios and compare them to Au+Au, d+Au and p+p data.

3:48PM DE.00010 Production of Phi Mesons in AA Collisions at \(\sqrt{s_{NN}} = 62.4\text{GeV}\) measured by the PHENIX experiment, Shengli Huang, PHENIX Collaboration — The phi meson mass centroid and width may provide information about partial chiral symmetry restoration in the hot and dense medium. The similar mass of the phi meson and the proton also makes the phi meson a good probe to study the baryon/meson anomaly in hadron production at intermediate transverse momentum (2 GeV/c < p_t < 5 GeV/c). The PHENIX experiment has studied the production of phi mesons in Au+Au and Cu+Cu collisions at \(\sqrt{s_{NN}} = 62.4\text{GeV}\) using the \(\phi \rightarrow K^+ K^-\) decay channel. We will present the latest results on transverse momentum spectra, invariant yields, nuclear modification factor\((R_{NN})\) and line-shape analysis (mass centroid and width) measured as a function of centrality.

4:00PM DE.00011 Searching for the \(D_s\) in STAR's d-Au Collisions, Stephen Baumgart, Yale University, STAR Collaboration — By studying the production of charm quarks at Relativistic Heavy Ion Collider we should be able to better understand the hard QCD processes which occur in high energy collisions. The STAR detector at RHIC has the potential to measure several different species of charmed hadrons. STAR has successfully measured \(D^0\) spectra in d-Au and Au-Au collisions. Weak signals from the \(D_s^+\) and \(D_s^-\) were also observed. A measurement of the \(D_s\) meson together with the measurements of the other observed charmed mesons would enable a more precise calculation of the total charm production cross-section. Simulations have shown that it may be possible to reconstruct the \(D_s\) via its hadronic decay channels in the STAR data. We report on those simulations and the progress of this search in d-Au collisions at \(\sqrt{s_{NN}} = 200\text{GeV}\).

4:12PM DE.00012 J/\psi Measurements in \(\sqrt{s_{NN}}=200\text{GeV}\) Au+Au Collisions, Andrew Glenn, University of Colorado, PHENIX Collaboration — Heavy quarkonia production is considered to be one of the most important probes of the hot and dense state created in relativistic heavy ion collisions. At RHIC energy, J/\psi yields, especially the large feed-down contributions from \(\chi_c\) and \(\psi'\) states, are expected to be suppressed in a quark gluon plasma due to color screening. The PHENIX experiment at RHIC has measured J/\psi production in \(\sqrt{s_{NN}}=200\text{GeV}\) Au+Au collisions at both forward (1.2 < |y| < 2.2) and mid (|y| < 0.35) rapidities. The most recent results for the centrality, rapidity and transverse momentum dependence of J/\psi production will be discussed and compared with PHENIX baseline measurements and various theoretical calculations.\(^3\)
Friday, October 27, 2006 2:00PM - 5:12PM –

Session DF DNP: Electromagnetic Interactions Gaylord Opryland Hermitage C

2:00PM DF.00001 Search for the onset of Color Transparency in $\rho^0$ electroproduction.1, LORENZO ZANA, MAURIK HOLTROP, University of New Hampshire, CLAS COLLABORATION — The nuclear transparency for the coherent production of $\rho^0$ mesons was measured on $^1\text{H}$, $^{12}\text{C}$ and $^{56}\text{Fe}$ in the $Q^2$ range of 1.-2.5 GeV$^2$/c$^2$ with the CLAS detector at Jefferson Laboratory. The nuclear transparency is extracted for a number of bins in $Q^2$ as the ratio of $\rho^0$ production on a nuclear target over the production on deuterium. Systematic errors were reduced by measuring on these two targets simultaneously. A rise in the nuclear transparency for increasing $Q^2$ would indicate the onset of Color Transparency. We will discuss the experimental setup, the data analysis, preliminary results, and outlook for this experiment.

2:12PM DF.00002 Search for medium effects on light vector mesons, RAKHSHA NASSERIPOUR, CHADEN DJALALI, University of South Carolina, DENNIS WEYGAND, Jefferson Laboratory, MICHAEL WOOD, University of Massachusetts, Amherst, CLAS COLLABORATION — Theoretical calculations predict the modification of properties of vector mesons, such as a shift in their masses and/or broadening of their widths in dense nuclear matter. These effects can be related to partial restoration of chiral symmetry at high density or temperature. To explore these, we performed an experiment at Jefferson Lab using the CEBAF Large Acceptance Spectrometer (CLAS). The data were taken with a beam of tagged photons with energies up to 4 GeV on various nuclear targets. The properties of the $\rho$ vector mesons were investigated via their rare leptonic decay to $e^+e^-$. This decay channel is preferred over hadronic modes in order to eliminate final state interactions in the nuclear matter. The combinatorial background in the mass spectrum was removed by a self-normalizing mixed-event technique. The $\rho$ mass distributions were extracted for each of the targets. We obtained statistically significant results regarding medium modification of the $\rho$ in the nuclear medium that rule out large medium effects (mass shift parameter $\alpha > 0.1$) within the 99% coincidence level.

2:24PM DF.00003 Rosenbluth Separation of the pion electroproduction cross section from Hydrogen, Deuterium, Carbon and Copper targets1, XIN QIAN, Duke University/ TUNL, BEN CLASIE, Massachusetts Institute of Technology, DIPANGKAR DUTTA, Duke University/ TUNL, HAIYAN GAO, Duke University/ TUNL, JLAB E01107 COLLABORATION — Pion electroproduction data was collected from six targets, including hydrogen, deuterium, carbon and copper, in Jefferson Lab experiment E01-107. The primary motivation of this experiment is to search for signatures of a phenomenon predicted by perturbative quantum chromodynamics (pQCD) known as Color Transparency (CT). In this experiment the nuclear transparency of pions is extracted by using the ratio of semi-exclusive pion electroproduction from nuclear targets to the same from a hydrogen target. This method relies on the assumption that the reaction mechanism of electroproduction from hydrogen is similar to the quasi-free lepton production from nuclear targets. This assumption can be tested by performing a Longitudinal-Transverse (L-T) separation of the pion electroproduction cross section and comparing the separated cross sections from hydrogen to that from heavier targets. In order to perform an L-T separation, data were collected at forward and backward electron angles at fixed momentum transfer squared ($Q^2$), for $Q^2=2.15$ and 4.0 GeV$^2$/c$^2$, which were chosen to fall within the $Q^2$ range over which the nuclear transparency is extracted. The extracted longitudinal and transverse cross sections at the two $Q^2$ settings from hydrogen, deuterium, carbon and copper targets will be presented.

2:36PM DF.00004 Status of the Jefferson Lab BONUS Experiment, an Effective Free Neutron Target, VLADAS TVASKIS, Hampton University / Jefferson Lab, BONUS COLLABORATION — To understand the structure of the nucleon is one of the fundamental goals of nuclear and high-energy physics. Deep-inelastic lepton scattering off proton and nuclear targets has produced a large amount of accurate data on the proton structure function. However, due to the unavailability of free neutrons, the neutron structure function must be extracted from measurements on nuclear targets. The precision of such extractions is limited because of the theoretical uncertainties introduced by the nuclear models needed to deduce information from the bound nucleons in the nuclei. To alleviate this problem the Barely Of-shell Nucleon Structure (BONUS) Collaboration has constructed a novel radial time projection chamber (RTPC) that uses a gas electron multiplier readout to detect slow, backward-going spectator protons resulting from electron-deuteron interactions. Spectator protons in the RTPC are detected in coincidence with electrons in the CEBAF Large Acceptance Spectrometer (CLAS) in Hall B at Jefferson Lab, thereby ensuring an inclusive electron - neutron scattering event. Two months of data (roughly 900 million triggers) were collected in late 2005 at beam energies from 1.1 to 5.3 GeV. Preliminary results will be discussed, focusing on the performance of the RTPC in CLAS.

2:48PM DF.00005 Measurement of the Compton scattering cross section during PrimEx Experiment at Jefferson Lab, PAWEL AMBROZEWICZ, North Carolina A&T State University, PRIMEX COLLABORATION — A precision experiment to extract the neutral $\pi^0$ lifetime was performed in Hall B of Jefferson Lab in the Fall of 2004. The experiment used Primakoff effect, small angle coherent photoproduction of $\pi^0$’s in the Coulomb field of various nuclei, to determine the radiative decay width of the $\pi^0$. This measurement constitutes one of the most precise tools in investigating fundamental symmetry predictions of low energy QCD. The projected experimental accuracy of this lifetime determination is 1.5%, it therefore requires thorough understanding of the underlying systematic uncertainties. To facilitate that Compton scattering data were taken along with the photoproduction data. This allowed to measure the Compton scattering cross section with high precision in a few GeV region. The results of this analysis will be presented.
3:00PM DF.00006 A Precision Measurement of the Pair Production Cross Section in the Jefferson Lab PrimEx Experiment, ARAM TeymurazyAN, University of Kentucky, PRIMEX COLLABORATION — The Jefferson Lab Hall B PrimEx Collaboration, is performing a 1.4% level measurement of the absolute cross section for the photo-production of neutral pions in the Coulomb field of a nucleus. Two key elements of the PrimEx experimental setup are the Jefferson Lab Hall B photon tagger, and the new 1728 channel hybrid calorimeter (HyCal) for detecting the two decay photons from the neutral pions. In the view of the stringent requirements on the required precision of the photon flux for this experiment, periodic measurements of the pair production cross section were performed throughout the run. In these measurements, both the photon energy and flux were determined by the tagger, and the electron-positron pairs were swept by a magnetic field and detected in the calorimeter. The experimental setup and the analysis of these measurements will be described. In addition, the pair production cross sections so obtained will be compared to those expected by theory.

3:12PM DF.00007 π⁰ meson radiative width results on ¹²C from the PrimEx collaboration at Jefferson Lab, ERIC CLINTON, PRIMEX COLLABORATION — The π⁰ lifetime is arguably the most precise theoretical calculation possible in low energy QCD, but current world’s data is not commensurate with current theory. The next-leading order Chiral Perturbation Theory calculation [hep-ph/0206007] calls for a π⁰ radiative width of 8.1 eV ± 1%. The PDG average stands at 7.84 eV ± 7%. The Primakoff Experiment (PrimEx) collaboration has utilized the Primakoff effect, photo-meson production in the Coulomb field of nuclei, to measure the π⁰ radiative width. The final sensitivity of this π⁰ lifetime measurement is expected to approach 1.5%. The PrimEx collaboration recorded data in the Fall of 2004 in Hall B of the Thomas Jefferson National Accelerator Facility. Preliminary results for this run will be presented. This is expected to be a stringent test of the U(1) axial anomaly and thus fill an important gap in our knowledge of low energy QCD.

3:24PM DF.00008 Pion-Nucleon Single Charge Exchange at Tₚ⁺ = 10.6, 20.6, and 39.4 MeV, DONALD ISENHOWER, Abilene Christian University — Measurements will be presented for the differential cross sections for π⁻p → π⁻n near 0°, 90°, and 180° at Tₚ⁺ = 10.6, 20.6, and 39.4 MeV (Pₑ⁻ = 55.4, 78.6, and 112.0 MeV/c) from LAMPF Experiment 882. These data include the lowest energies ever measured for this interaction and are the only low-energy data to cover the entire angular region from 0° to 180°. The results are compared with the partial wave analyses and potential models. The goal of determination of the differential cross sections to better than 10% has been obtained by these measurements.

This work supported by the U.S. Department of Energy

3:36PM DF.00009 Theoretical Investigation of A₁LT in Electron Scattering from the Deuteron, SABINE JESCHONNEK, The Ohio State University at Lima — Currently, several data sets on D(e,e′p)n reactions, taken at Jefferson Lab, are analyzed. A solid theoretical description is necessary in order to understand these data and extract all possible information, both on the reaction mechanism and the nuclear ground state. In order to gain a full understanding of this important reaction, we need to consider several observables: cross section, response functions, and asymmetries. Final state interactions and relativistic treatment of the current operator are very important at the relevant high energies. The asymmetry A₁LT, which is non-zero only for out-of-plane kinematics, has been measured in Jefferson Lab’s Hall B. This observable is very interesting because it is highly sensitive not just to central final state interactions, but also to spin-orbit final state interactions. We will briefly discuss the employed theoretical model, and focus on the sensitivity of the results to the various final state interactions and wave functions.

This work was supported in part by NSF grant NSF PHY-0354916.

3:48PM DF.00010 Out-of-Plane Measurements of the Fifth Structure Function of the Deuteron, GERARD GILFOYLE, University of Richmond, CLAS COLLABORATION — We have measured the asymmetry A₁LT associated with the fifth structure function in quasi-elastic kinematics at beam energies of 2.56 GeV and 4.23 GeV over a Q² range 0.1 – 2.0 (GeV/c)² with the CLAS detector at Jefferson Lab. The differential cross section of the D(e,e′p)n reaction with a polarized beam and unpolarized target has a component that is the imaginary part of the interference term between the longitudinal and transverse parts of the nuclear current. This fifth structure function is non-zero only for protons ejected out of the scattering plane defined by the incoming and outgoing electron and is sensitive to final-state interactions. Only limited measurements have been made of this quantity before now. We extract A₁LT using quasi-elastic, missing momentum (pₑm) spectra weighted by sin(ϕₑm) where ϕₑm is the angle between the scattering plane and the plane defined by the ejected proton and neutron. We will present event selection criteria, calibrations, and consistency checks of the analysis. We will show results for measurements of A₁LT that explore different Q² regions and different W ranges near the quasi-elastic peak. The data agree with theoretical calculations at low pₑm, but diverge at higher missing momenta.

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

4:00PM DF.00011 Nucleon Polarisabilities from Deuteron Compton Scattering, and Its Lessons for Chiral Power Counting, HARALD W. GRIESSHAMMER, The George Washington University — Chiral Effective Field Theory with explicit Δ(1232) degree of freedom is for photon energies up to 300 MeV the tool to accurately determine the polarisabilities of the proton and neutron from Compton scattering experiments in a model-independent and systematic way. It proves in particular indispensable to understand deuteron Compton scattering at 95 MeV as measured at SAL. Simple consistency arguments derived from nuclear phenomenology lead for the deuteron case to the correct Thomson limit, demonstrating gauge-invariance and shedding new light on Weinbergs proposed power-counting of nuclear forces. In our global analysis of all elastic proton and deuteron Compton scattering up to 150 MeV, we find for the static scalar dipole polarisabilities αₛ = (11.0 ± 1.4(stat) ± 0.4(sys)) × 10⁻⁴ fm³ for the proton and αₛ = (11.6 ± 1.5(stat) ± 0.6(sys)) × 10⁻⁴ fm³ for the neutron. Therefore, proton and neutron polarisabilities are identical within the accuracy of available data. New experiments e.g. at MAXlab (Lund) will improve the statistical error bar.


4:12PM DF.00012 A(Q) at Low Q in ed Elastic Scattering, DOUGLAS HIGINBOTHAM, Jefferson Lab. FOR THE HALL A COLLABORATION — Using the Jefferson Lab Hall A high resolution spectrometers, data have been taken to resolve a discrepancy between low Q elastic deuteron cross section measurements. This new data will provide a test of models of deuteron structure including chiral perturbation theory, conventional non-relativistic models, and relativistic models. An overview of the new data will be presented along with the expected uncertainties.
4:24PM DF.00013 Measuring the Neutron and $^3$He Spin Structure at Low $Q^2$, VINCENT SULKOSKY.
The College of William and Mary, E97-110 COLLABORATION, HALL A COLLABORATION — Originally derived for real photon absorption, the Gerasimov-Drell-Hearn (GDH) sum rule was first extended to non-zero $Q^2$ in 1989. The extension of the sum rule provides a unique relation, valid at any $Q^2$, that can be used to study the nucleon spin structure. The goal of Jefferson Lab experiment E97-110 is to perform a precise measurement of the $Q^2$ dependence of the generalized GDH integral and of the moments of the neutron and $^3$He spin structure functions between 0.02 and 0.3 GeV$^2$. This $Q^2$ range will allow us to test predictions of Chiral Perturbation Theory, and verify the GDH sum rule by extrapolating the integral to the real photon point. This measurement also provides a better understanding of the nucleon resonances. The data have been taken in Hall A using the Jefferson Lab high polarization continuous electron beam and a polarized $^3$He target. The status and perspectives of the data analysis will be discussed, and preliminary results will be shown.

4:36PM DF.00014 A Measurement of $G_E^n$ at High Momentum Transfer in Hall A, ROBERT J. FEUERBACH, BOGDAN WOJTSEKHOWSKI, Thomas Jefferson National Accelerator Facility, E02-013 COLLABORATION, HALL A COLLABORATION — A precision measurement of the electric form-factor of the neutron, $G_E^n$, at $Q^2$ up to 3.5 GeV$^2$ was recently completed in Hall A at the Thomas Jefferson National Accelerator Facility (Jefferson Lab). The ratio $G_E^n/G_M^n$ was measured through the beam-target asymmetry $A_L$ of electrons quasi-elastically scattered off neutrons in the reaction $^3$He$(e,e'n)$. The experiment took advantage of recent developments of the electron beam and target, as well as two detectors new to Jefferson Lab. The measurement used the accelerator’s 100% duty-cycle high-polarization (typically 84%) electron beam and a new, hybrid optically-pumped polarized $^3$He target, which achieved polarizations above 50%. A medium acceptance (80 msr) open-geometry magnetic spectrometer (BigBite) detected the scattered electron, while a new neutron detector was constructed to observe the released neutron. An overview of the experiment and the experimental motivation will be discussed, in particular the large range of predictions from modern calculations for $G_E^n$, at this relatively high $Q^2$. Finally, the analysis progress and preliminary results will be presented.

4:48PM DF.00015 N-∆ transition form factors, MANDAR BHAGWAT, Argonne National Laboratory — Nucleon and ∆ amplitudes have been obtained by solving a Poincaré-covariant Faddeev equation, which describes baryons as composites of confined-quarks and confined-nonpointlike-diquarks. The amplitudes were used to calculate the nucleon form factors. The calculation predicts a ratio $\mu_p G_E^n/G_M^n$ that agrees with extracted JLab data and also predicts that this ratio will pass through zero at $Q^2 = 6.5$ GeV$^2$. This prediction will be tested in forthcoming JLab experiments. We have extended the framework to study the electromagnetic N-∆ transition form factors. Results for the ratios $G_E^n(p^2)/G_M^n(p^2)$ and $G_C^n(p^2)/G_M^n(p^2)$ are compared with observations. Effects of pion loops, which in dynamical coupled-channel models contribute substantially to $G_C^n(p^2)/G_M^n(p^2)$ at low $Q^2$, are also considered.

5:00PM DF.00016 Data consistency checks for Jefferson Lab Experiment E00-002, JOHN TELFEYAN, GABRIEL NICULESCU, IOANA NICULESCU, James Madison University, EXPERIMENT E00-002 COLLABORATION — Jefferson Lab experiment E00-002 aims to measure inclusive electron-proton and electron-deuteron scattering cross section at low $Q$ squared and moderately low Bjorken $x$. Data in this kinematic region will further our understanding of the transition between the perturbative and non-perturbative regimes of Quantum Chromodynamics (QCD). As part of the data analysis effort underway at James Madison University (JMU) a comprehensive set of checks and tests was implemented. These tests ensure the quality and consistency of the experimental data, as well as providing, where appropriate, correction factors between the experimental apparatus as used and its idealized computer-simulated representation. This contribution will outline this testing procedure as implemented in the JMU analysis, highlighting the most important features/results.

Friday, October 27, 2006 2:00PM - 5:00PM —
Session DG DNP: Mini-symposium on Identifying Dark Matter II: Axion and Sterile Neutrino
Dark Matter
Gaylord Opryland Hermitage D

2:00PM DG.00001 Axion Astrophysics and Cosmology, DARIN KINION, Lawrence Livermore National Laboratory — Experimental evidence suggests that the strong interactions conserve the discrete CP symmetry. Standard Model QCD, however, predicts that CP should be violated unless the angular parameter $\Theta$ is exceedingly small ($< 10^{-10}$). The most elegant and compelling solution to this so-called Strong-CP problem was proposed by Peccei and Quinn and involves the spontaneous breaking of a new $U(1)_{PQ}$ global symmetry. The axion arises as the pseudo-Goldstone Boson associated with this SSB. Astrophysics has played an important role in constraining the allowed axion mass. I will review the arguments from stellar evolution and supernovae that lead to an upper bound of 1-10 meV for the mass. Axions with $\mu eV$ mass have not been ruled out and would have sufficient relic density to be a very plausible candidate for cold dark matter. I will describe different scenarios for axion production in the early universe and comment on their compatibility with current measurements of cosmological parameters. Finally, I will summarize the current experimental and theoretical bounds of the axion-to-photon coupling constant.

2:36PM DG.00002 Microwave Cavity Searches for Axions, D.B. TANNER, L.D. DUFFY, P. SIKIVIE, University of Florida, S.J. ASZTALOS, G. CAROSI, D. CARTER, C. HAGMANN, D. KINION, L.J. ROSENBERG, K. VAN BIBBER, LLNL, D.B. YU, MIT, R.F. BRADLEY, NRAO — The axion is a hypothetical elementary particle proposed as a solution to the "strong CP" problem. The mass of the axion is constrained by experimental and astrophysical considerations to a range where the axion is a very plausible cold dark matter candidate. This weakly interacting dark matter makes up the halo of our galaxy. In the ADMX experiment, halo axions flow through a microwave resonant cavity permeated by a static magnetic field where some convert into microwave photons. These photons are detected by an ultra-low-noise receiver. The ADMX Collaboration has set limits on the axion-to-photon coupling and/or local axion halo mass density for axion mass between 1.9 and 3.3 $\mu$eV.

1Supported by the U.S. DOE contract W-7405-ENG-48.

1Supported by the U.S. DOE contracts W-7405-ENG-48 at LLNL and DE-FG02-97ER41029 at UF.
2:48PM DG.00003 The High Resolution Search for Axions in Galactic Halo Substructure.
LEANN DUFFY 1 University of Florida, AXION DARK MATTER experiment (ADMX) collaboration — The Axion Dark Matter Experiment uses a SIKivie microwave cavity detector to search for dark matter axions. The new, high resolution channel is designed to search for discrete flows of axions passing through the detector. Such flows are expected to be present in our galactic halo from tidal stripping of dwarf galaxies and from late infall of dark matter on our galactic halo. A discrete flow of axions with small velocity dispersion will appear as a narrow peak in the output of a microwave cavity detector. Such a peak can be searched for with high signal-to-noise ratio using the high resolution channel. This new channel increases the sensitivity of ADMX by a factor of 3, compared to using ADMX’s medium resolution channel only.

1Present address: Los Alamos National Laboratory.

3:00PM DG.00004 Technology for Next Generation Dark-Matter Axion Searches.
DARIN KINION, S.J. ASZTALOS, G. CAROSI, C. HAGMANN, L.J. ROSENBERG, K. VAN BIBBER, Lawrence Livermore National Laboratory, L.D. DUFFY, P. SIKIVIE, D.B. TANNER, University of Florida, R. BRADLEY, NRAO, ADMX collaboration — The ADMX Collaboration has set limits on the axion-to-photon coupling for axion mass between 1.9 and 3.3 μeV, assuming both that axions dominate the local halo density and are “hadronic” or KSVZ axions. A definitive search should relax both constraints, i.e. be sensitive to DFSZ model axions comprising a fraction of the local halo density. We will show that such a search could be realized using near-quantum-limited microwave amplifiers based on dc SQUIDs. The first phase of this upgrade is currently underway.

3:12PM DG.00005 A Search for KK Axions with DRIFT detectors using.
JOHANNA TURK 2 University of New Mexico, DRIFT collaboration — Theoretical models with Kaluza-Klein (KK) axions predict that they will be produced in the solar core, with some fraction becoming trapped in gravitational orbits around the Sun. The mass range of gravitationally trapped KK axions is typically between 2 and 12 keV and they are unstable with long lifetimes, in principle allowing them to be directly detected by decay to 2 photons. We explore the potential for observation of KK axions by gaseous detectors using data collected with the Directional Recoil Identification From Tracks (DRIFT) negative ion RPC operating in the Boulby Mine.

3:24PM DG.00006 Searching for the dark matter U boson with a positron beam.
BOGDAN WOJTKOWSKI, Thomas Jefferson National Accelerator Facility — A fixed-target experiment with a 300 MeV positron beam at high luminosity is proposed that would provide a unique sensitivity search for the dark matter boson U in the reaction e+e- → U gamma in the relevant mass range. A detailed plan of the experiment will be presented.

3:36PM DG.00007 Coherent Sterile Neutrino Production in the Early Universe.
CHAD KISHIMOTO, GEORGE FULLER, CHRISTEL SMITH, UC San Diego — We calculate the resonant production of sterile neutrinos from active neutrinos in the early universe when there is a significant net lepton number residing in active neutrino seas. We study feedback on this process from the expansion rate of the universe, and we find interesting implications for primordial nucleosynthesis and models of sterile neutrino dark matter.

3:48PM DG.00008 Sterile Neutrinos and Supernova Nucleosynthesis.
JOSHUA BEUN, GAIL MCLAUGHLIN, North Carolina State University, REBECCA SURMAN, Union College, RAPH HIX, Oak Ridge National Laboratory — Neutrinos play an important role in the core-collapse supernova environment, from facilitating the explosion mechanism to influencing the outflow’s elemental composition. Traditional heavy element nucleosynthesis, the r-process, are stifled by electron neutrinos during the alpha particle formation epoch. Introduction of a sterile neutrino species can temper this alpha effect as well as generate an environment sufficiently neutron-rich for fission cycling to occur. Fission cycling in the r-process produces abundance patterns similar to the halo star data. Here we examine reductions in the neutrino flux necessary to achieve fission cycling; sterile neutrinos or other new physics may realize these reductions.

4:00PM DG.00009 Sterile Neutrinos and Big Bang Nucleosynthesis.
CHRISTEL SMITH, GEORGE FULLER, CHAD KISHIMOTO, University of California, San Diego — We calculate primordial element abundances in the presence of neutrino spectral distortion resulting from active-sterile transformation. We find that the effects of adding a significant lepton number to the big bang nucleosynthesis calculation are reversed when we include nonthermal distorted spectra. Our results show that this can be true for a variety of ν0 and νe spectral distortions arising from various active-sterile transformation processes.

4:12PM DG.00010 Primordial Element Synthesis Calculations with the bigbangonline.org Software Suite.
M.S. SMITH, E.J. LINGERFELT, J.P. SCOTT, W.R. HIX, C.D. NESARAJA, ORNL Physics Division*, G.M. FULLER, D. TYTLER, Univ. California San Diego, L.F. ROBERTS, Colorado College — Predictions of the abundances of 2H, 3He, and 7Li synthesized three minutes after the Big Bang can be compared with abundances inferred from observations to constrain the total amount of baryonic matter in the Universe, the number of ν species, and other cosmological parameters. These constraints can be compared to those derived from measurements of the cosmic microwave background. A new online suite of computer codes has been developed at bigbangonline.org to facilitate custom big bang nucleosynthesis (BBN) calculations. Users of this freely available system can specify the latest set of input thermonuclear reaction rates and cosmological parameters to set up their simulation, and the latest primordial abundance observations to determine their constraints. Monte Carlo BBN simulations [1] are also enabled, where uncertainties of the input reaction rates are propagated into uncertainties of the cosmology constraints. The suite features excellent visualization tools and enables sharing of simulation results between Users. Features of the suite and its utilization in a new set of BBN calculations will be presented.

4:24PM DG.00011 Searching for an X-Ray Emission Line from Sterile Neutrino Dark Matter.
JOHN TOMSICK, UCSD/CASS — If keV-mass sterile neutrinos exist and if they are the Dark Matter, Abazajian & Fuller have argued that decays of these particles could lead to an X-ray emission line that could be detected by current satellites such as XMM-Newton and the Chandra X-ray Observatory. In this presentation, I discuss the work that has been done to search for this line in the X-ray background, from clusters of galaxies, and from nearby galaxies. I also discuss prospects for further searches that could lead to discovering the signature emission line or ruling out sterile neutrinos as a significant contributor to the Dark Matter.
4:36PM DG.0012 Measuring Active-Sterile Neutrino Oscillations with a Stopped Pion Neutrino Source, RICHARD VAN DE WATER, GERRY GARVEY, ANDREW GREEN, WILLIAM LOUIS, GEOFF MILLS, HEATHER RAY, RICHARD SCHIRATO, HYWELL WHITE, Los Alamos National Laboratory — The possible existence of light sterile neutrinos is of great interest in many areas of particle physics, astrophysics, and cosmology. Furthermore, should the MiniBooNE experiment at Fermilab confirm the LSND oscillation signal, then new measurements are required to identify the mechanism responsible for these oscillations. Possibilities include sterile neutrinos, CP or CPT violation, variable mass neutrinos, Lorentz violation, and extra dimensions. In this paper, we consider an experiment at a stopped pion neutrino source to determine if active-sterile neutrino oscillations with $\Delta m^2$ greater than 0.1 eV can account for the signal. By exploiting stopped $\pi^-$ decay to produce a monoenergetic $\nu_\pi$ source, and measuring the rate of the neutral current reaction $\nu_\mathrm{e}^{\mathrm{e}} + C^{12} \rightarrow \nu_\mathrm{e}^{\mathrm{e}} C^{12} + \gamma$ ($15.11$) as a function of distance from the source, we show that a convincing test for active-sterile neutrino oscillations can be performed.

4:48PM DG.00013 Sterile Neutrinos in a 6x6 Matrix, T. GOLDMAN, Los Alamos National Laboratory, B.H.J. MCKELLAR, University of Melbourne, G.J. STEPHENSON, JR., University of New Mexico — An early study of neutrino mixing within the see-saw framework considered random mass matrices in what is now known as the sterile sector[1]. The mixing angles in the lepton sector were found to be closely distributed about the CKM angles that were assumed. In that work, rank 3 was assumed for the weak isospin zero Majorana mass matrix in the sterile neutrino sector. We report here on the character of new results using a reduced rank (“singular”) sterile matrix. We find that an additional flavor misalignment in the sterile sector can produce several interesting effects; including: 1) mass eigenstates that lead to very large flavor mixing among active neutrinos, and 2) small values for the 1-3 mixing angle parameter[2]. We also discuss the limits that current observations place on the mass scale of light sterile neutrinos in this model. [1]T. Goldman and G. J. Stephenson, Jr., “How Large Are the Neutrino Mixing Angles?” Phys. Rev. D 24, 236 (1981). [2] J. Stephenson, Jr., T. Goldman, B. H. J. McKellar and M. Garbutt, “Large Mixing from Small: Pseudo-Dirac Neutrinos and the Singular Seesaw,” Int. J. Mod. Phys. A20 (2005) 6373; [hep-ph/0404015].

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Friday, October 27, 2006 2:00PM - 4:36PM
Session DH DNP: Instrumentation I Gaylord Opryland Cheekwood F

2:00PM DH.00001 Absolute Polarization Measurements At RHIC In The Coulomb Nuclear Interference Region, OLEG EYSER, IGOR ALEKSEEV, ALESSANDRO BRAVAR, GERRY BUNCE, SATISH DHAWAN, RONALD GILL, WILLY HAE BERLI, HAIXIN HUANG, YOUSEF MAKSIDI, ITARU NAKAGAWA, ALEXANDER NASS, HIROMI OKADA, EDWARD STEPHENSON, DIMA SVIRIDA, THOMAS WISE, JEFF WOOD, ANATOLI ZELENSKI — The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) is the world’s first polarized proton collider which currently delivers center of mass energies of 200 GeV. For polarimetry, proton-Carbon and proton-proton scattering is used in the Coulomb Nuclear Interference (CNI) region at low momentum transfer $t$. While two proton-Carbon polarimeters provide fast polarization measurements with small statistical errors at several times during an accelerator store, a polarized Hydrogen Jet device is needed for absolute normalization over multiple stores. The jet polarization is constantly monitored in a Breit-Rabi unit. In 2005 the Jet polarimeter has been used with both RHIC beams and can, therefore, be combined with both Carbon polarimeters. Systematic errors have been studied in detail and results were compared to the previous run in 2004 when the Jet polarimeter had an extended acceptance for only one beam. Results of the analyzing power at 100 GeV have been published and other energies up to the RHIC goal of 250 GeV are under investigation.

2:12PM DH.00002 Development of a beam profile diagnostics device for the VENUS ECR ion source beam line, CARY PINT, DANIELA LEITNER, DAMON TODD, Lawrence Berkeley National Laboratory — This work describes the design and development of the instrumentation for a beam profile diagnostics unit for the low energy beam transport line of the superconducting Electron Cyclotron Resonance (ECR) ion source VENUS (Versatile ECR ion source for Nuclear Science). VENUS is currently being commissioned at LBNL and serves as the prototype ECR injector source for next generation heavy ion accelerators. In order to enhance simulations of beam transport from extraction in VENUS, a measurement device (called a harp) consisting of a grid of thin conducting wires is placed into the beam line, directly downstream from extraction, to measure the beam profile. Utilizing the diagnostics unit developed and described in this work, the first measurements of the beam profile for a simple helium beam are presented. By changing the Glaser current to focus the ion beam onto the harp, the helium beam profiles illustrate that the extracted beam has the same symmetry as the plasma surface from which they are extracted, and not the uniform circular symmetry that is assumed in most simulation models. These results give quantitative insight into the enhancement of initial conditions needed for using simulations to give a physically accurate description of beam transport from extraction of an ECR source.

2:24PM DH.00003 Ion signals with R134a and R134 in a parallel plate proportional counter, EDWIN NORBECK, J.E. OLSON, Y. ONEI, University of Iowa — The electrical signals from a PPAC (parallel plate avalanche counter) are identical for R134a (1,1,1,2-tetrafluoroethane) and R134 (1,1,2,2-tetrafluoroethane) except for the ion part, which, for R134a, is slower and smaller, but with the same area. The two compounds are identical except for the location of one fluorine atom. With three fluorine atoms on one end, the more common R134a has a large electric dipole moment, about the same as water, while R134 is symmetric, with no dipole moment. The attraction of the polar R134a molecules interferes with the motion of the ions, which results in a longer ion collection time. The counter is two circular plates of 1.0 cm$^2$ area separated by 0.5 mm operating at 700 torr and 2120 V. The ion signal is constant for a time $t_0$ and then goes linearly to zero at time $t_1$. The values of $t_0$ and $t_1$ are 1.3 $\mu$s and 1.8 $\mu$s for R134a, but only 0.8 $\mu$s and 1.3 $\mu$s for R134. These are not precise times because the signals are very small and the values depend on the location of the primary ion formation (from a $^{137}$Cs $\gamma$ source). During the constant part of the signal the ions are moving between the plates. The signal goes toward zero as the ions are collected at the cathode. For both gasses the large signal from electrons is fast with a full width at half maximum of only 1.0 ns.

2:36PM DH.00004 Validation of the GEANT4 code for simulations of a plastic $\beta$-detector and its application to efficiency calibration, V.V. GOLOVKO, V.E. IACOB, J.C. HARDY, Cyclotron Institute, Texas A&M University, College Station, TX 77843-3366 — Precise $\beta$-branching-ratio measurements are required to determine ft-values as a part of our program to test the Standard Model via unitarity of the Cabibbo-Kobayashi-Maskawa matrix. For the measurements to be useful in this test, their precision must be close to 0.1% [1]. In a branching-ratio measurement, we collect a radioactive source in mylar tape, and then move the tape to a counting station, where the sample is positioned between a scintillator used to detect $\beta$-particles, and a HPGe detector for $\gamma$-rays. The signals from both detectors are recorded for all events in which there is a $\beta$,$\gamma$ coincidence. Utilizing the branching ratio from the absolute intensity of the coincidence $\gamma$-rays, the relative efficiency of the $\beta$-detector as a function of $\beta$ energy is crucial to our achieving a precise result since different $\gamma$-ray peaks correspond to $\beta$-transitions with different end-point energies. We have studied our $\beta$-detector response function using Monte Carlo calculations performed by GEANT4 code. Since there are always questions about the validity of any particular simulation code, the simulated results were compared to measured $\beta$-spectra from various standard $\beta$-sources, as well as with Monte Carlo simulated $\beta$-response functions obtained with the EGS-code [2]. [1] J. C. Hardy and I. S. Tower. PRC, 71(5):055501, 2005. [2] V. E. Iacob, J. C. Hardy, and N. Nica. BAPS 49, no 6, p 11, 2004.
3:00PM DH.00006 The Radio Frequency Fragment Separator for Rare Isotope Beams at the NSCL
JOSHUA STOKER, VLADIMIR ANDREEV, DANIEL BAZIN, ANA BECERRIL, MARC DOLEANS, DIMITRY GORELOV, PATRICK GLENNON, TERRY GRIMM, DON LAYTON, PAUL MANTICA, FELIX MARTI, JACK OTTARSON, HENDRICK SCHATZ, JOHN VINCENT, JIM WAGNER, XIAOYU WU, AL ZELLER, National Superconducting Cyclotron Laboratory, Michigan State University — Secondary beams at the National Superconducting Cyclotron Laboratory (NSCL) are separated through a combined application of magnetic rigidity and energy loss filtering. Design and construction of a Radio Frequency Fragment Separator (RFFS) for further beam purification is underway. The RFPS will apply a time-varying electromagnetic field to induce transverse beam separation. This method relies on velocity differences of the beam species to selectively apply separation to unwanted fragments. The technical design of the RFPS and the expected purification of exotic beams are shown in detail.

3:12PM DH.00007 ABSTRACT WITHDRAWN

3:24PM DH.00008 Polarization sensitivity measurements in SeGA detectors
DAVID MILLER, KRZYSZTOF STAROSTA, PRZEMEK ADRICH, AARON CHESTER, CONSTANTIN VAMAN, DIRK WEISSHAAR, National Superconducting Cyclotron Laboratory/Michigan State University — For isotopes far from stability, the nuclear shell structure is modified influencing the location of intruder states within major shells. Parity is a key observable in nuclear spectroscopy to identify the intruder states for example in the “island of inversion” around $^{32}$Mg where the $f_{7/2}$ neutron orbital is expected to play a key role. Linear polarization measurements of $\gamma$-rays are a probe to access the parities of energy levels. Utilizing the segmentation of detectors in the Segmented Germanium Array (SeGA) at the NSCL and analyzing the hitpatterns thereof allows the detectors to be used as Compton polarimeters. The linear polarization sensitivity of SeGA has been measured using $\alpha-\gamma$ correlations from a $^{249}$Cf source. Existing analog electronics for data acquisition worked in parallel to the first phase of a new digital data acquisition system being implemented at the NSCL. The results and future improvements that could have substantial impact to the detector sensitivity are discussed.

3:36PM DH.00009 Alpha-Gamma Coincidence Spectroscopy using a Si PSAPD and Ge DSSD combination
C.M. WILSON, P. CHOWDHURY, R. GRAMER, S.K. TANDEL, U. Massachusetts Lowell, N.I. HAMMOND, C.J. LISTER, S.M. FISCHER, E.F. MOORE, K.M. TEH, Argonne Nat. Lab., M. MCCLISH, K.S. SHAH, R. FARRELL, R. RFFS and the expected purification of exotic beams are shown in detail. This work is supported by the U.S. National Science Foundation.

3:48PM DH.00010 Multiplexed Analog Shaped Electronics (MASE): A new approach to the readout of segmented silicon arrays
ROMUALDO DE SOUZA, CARL METELKO, SYLVIE HUWAN, Department of Chemistry and IUCF, Indiana University, ANDREW ALEXANDER, JOHN POEHLMAN, Department of Chemistry, Indiana University — A new approach in the signal processing and readout of highly segmented silicon detector arrays is described. The realization of this approach is Multiplexed Shaped Analog Electronics (MASE), an electronic system that allows the effective readout of highly segmented detector arrays when the occupancy in a single event is low. MASE combines the features of good energy resolution with time resolution adequate for random rejection. It employs the tight integration of analog signal conditioning together with digital signal manipulation in discrete component surface mount technology. External digitization of a sparsified analog stream makes MASE cost effective and scalable. It can be used as easily to read out 4096 channels as it can to read out a single silicon detector. Both the design and the performance characteristics of MASE are presented.

4:00PM DH.00011 Energy Spectrums from Unshaped Signals
ELIZA OSENBAUGH-STEWART, Triangle Universities Nuclear Labs - University of North Carolina — Digital signal processing was used to produce an energy spectrum from the raw output of a preamplifier. It is our hope to use the signals generated from the preamplifier for pulse shape discrimination. Therefore we needed to generate a energy spectrum without relaying on the shaping done by an amplifier. The voltage pulse produced by a germanium detector was recorded with a flash ADC. The data was then filtered twice, first using a low-pass recursive filter to get rid of high frequency noise and again to remove lower frequency problems. The resulting pulse was integrated to determine the energy. This was tested with various spectrums and produces expected results with a small decrease in energy resolution as compared to shaped data. At this time optimal filtering is being studied as a possible way to increase energy resolution.
4:12PM DH.00012 Shielding Design for the CARIBU Project1, EUGENE MOORE, SCD, Argonne National Laboratory, SAMUEL BAKER, EQO/RSO, Argonne National Laboratory, RICHARD PARDO, GUY SAVARD, PHY, Argonne National Laboratory, CARIBU COLLABORATION — The Californium Radioactive Ion Breeder Upgrade (CARIBU) [1] will serve as a source of radioactive ions to be accelerated by the ATLAS accelerator [2]. CARIBU will consist of an open, 1 Ci Cf-252 source electroplated on a Ta backing. Fission fragments emitted from the source will be captured in a He gas cell with DC and RF fields that will direct the radioactive ions toward the exit nozzle. The ions will be mass analyzed and transported to a charge breeding ECR source and injected into ATLAS. The radiation fields produced by an unshielded 1 Ci Cf-252 source exceed 4 rem/hr (neutron), and 250 mR/hr (gamma) at 1 meter. In order to allow unlimited access to the CARIBU source area, we are designing a shielding system to reduce the radiation fields to ~1 rem/hr at 30 cm from accessible surfaces. The MCNPX code [3] is being used to model the neutron and gamma radiation shielding. The results of the simulations and some comparisons with measurements will be presented. REFERENCES [1] www.phy.anl.gov/atlas/caribu.html [2] www.phy.anl.gov/atlas/index.html [3] mcnpx.lanl.gov/.

1This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. W-31-109-ENG-38.

4:24PM DH.00013 CASSPERR - an Improved Resonant Nuclear Reaction Analysis Detector1, ARTHUR PALLONE, Murray State University, J. DEREK DEMAREE, U.S. Army Research Laboratory — Although it is a powerful tool, nuclear reaction analysis is not yet widely practiced at ion beam facilities because data is acquired sequentially, i.e. collecting data at incremental energies (depths). Data collection can be improved by increasing the efficiency of detection or reducing the noise. The most commonly used method to reduce the noise is to passively shield the detector from the background (typically cosmic rays or naturally-occurring radioactive elements). The volume of shielding required to decrease the noise from these interfering backgrounds occupies too much space for implementation at most ion beam facilities. Active shielding via coincidence rejection requires that a cosmic ray interact with both the detector and the coincidence shield. The low probability for both interactions to occur limits the effectiveness of this coincidence rejection technique. Sum coincidence spectrometry is a common technique used in nuclear decay studies and in neutron activation analysis. Singh suggested that this technique be applied to (p, γ, γ) reactions. The development, testing, and some potential materials research applications of the CAScade SPEctrometer for Resonant Reactions (CASSPERR) based on this technique are presented.

1Work partially completed during a Kentucky EPSCoR National Laboratories Initiative grant.

Saturday, October 28, 2006 9:00AM - 11:24AM Session GA DNP: Topics In Nuclear Physics Gaylord Opryland Tennessee C

9:00AM GA.00001 The Diffuse Supernova Neutrino Background1, JOHN BEACOM, Ohio State University — The cosmic stellar birth rate can be measured by standard astronomical techniques. It can also be probed via the cosmic stellar death rate, though until recently, this was much less precise. However, new results based on measured supernova rates, and importantly, also on the attendant diffuse fluxes of neutrinos and gamma rays, have become competitive, and a concordant history of stellar birth and death is emerging. The neutrino flux from all past core-collapse supernovae, while faint, is realistically within reach of detection in Super-Kamiokande, and a useful limit has already been set. I will discuss predictions for this flux, the prospects for neutrino detection, the implications for understanding core-collapse supernovae, and a new limit on the contribution of type-la supernovae to the diffuse gamma-ray background.

1Research supported by NSF CAREER grant No. PHY-0547102.

9:36AM GA.00002 First Physics Results from the MuCap Experiment at PSI1, PETER KAMMEL, University of Illinois at Urbana-Champaign — The MuCap experiment will measure the rate of the muon capture reaction \( p + p \rightarrow n + \nu \) on the free proton to 1% precision. This directly determines the pseudoscalar form factor \( g_P \) at \( q^2 = -0.88 \text{ m}^2 \) to 7%. The pseudoscalar is the least well-known of the basic nucleon form factors characterizing the structure of its charged electro weak current. Modern effective theories based on the chiral symmetry of QCD and its breaking can calculate \( g_P \) to 3%. In spite of efforts spanning the last 30 years, experimental results are still controversial and subject to large uncertainties in their interpretation. While the first radiative muon capture experiment on hydrogen recently observed a four standard deviation discrepancy from the precise chiral prediction, new results on muonic atomic physics processes in hydrogen underscore the model dependence of the present \( g_P \) determinations. The resulting uncertainty in \( g_P \) is as large as 50 percent. The MuCap experiment is designed to overcome the problems that plagued earlier efforts. The method requires a combination of novel and challenging detector techniques. The capture rate will be determined from the difference of the \( \mu^- \) and \( \mu^+ \) lifetimes measured after muons are stopped in a time projection chamber operating with 10 bar hydrogen gas. Electrons from muon decay are reconstructed with an electron tracking system. A sophisticated gas system maintains and monitors the ultra-high purity of the deuterium-depleted H2 gas used as an active target. In 2004 the hardware for the complex detector was commissioned and 20% of our final statistics was recorded. After additional performance upgrades in 2005, the experiment successfully reached the proposed goal of 103+ events in 2006. The 2004 data analysis is at an advanced stage. The data surpass all previous experiments both in statistics and in reduction of systematic uncertainties. First results on the \( \mu^+ \) capture rate will be presented at this conference. As a possible second stage, we are exploring a precision measurement of the related muon capture reaction on deuterium. A measurement at the 1% level could be compared with recent high-precision calculations, provide direct information on the two-nucleon axial current and calibrate fundamental neutrino reactions.

1Supported by NSF, DOE, CRDF, PSI and Russian Academy of Sciences.

program and travel to interesting locales. for these applications. This talk will focus on the opportunities and experiences afforded physicists in the support of national security, beyond the weapons research and development of instrumentation and systems used to monitor nuclear materials and nuclear facilities. With a projected increase in the use of these materials had been stolen (Second Line of Defense - SLD). In the 2000s, new programs have been put in place in the United States for radiation detection, and research is being funded for more advanced systems. This talk will briefly touch on the history of nuclear security and then focus on some recent research efforts in radiation detection. Specifically, a new breed of radiation monitors will be examined along with the concept of sensor networks.

Making measurements in support of international agreements can pose many challenges both from a policy and science point of view. Policy issues may arise because physics measurements made in the area of arms control or disarmament may be deemed too intrusive since they could possibly reveal sensitive information about the material that is being interrogated. Therefore, agreements must include a framework for safeguarding against the potential release of this information. Most of the scientific issues center around the fact that it is desirable to make high quality measurements without any operator interaction. This leads to the development of instrumentation and software that are very stable and robust. Due to different concerns, policy and science priorities may be at odds with one another. Therefore, it is the scientists challenge - in this field - to keep policy makers informed by conveying what is technically possible and what is not in a manner that is easily understood and also negotiable. In this paper we will discuss some of the technology that has been developed to address some of these challenges in various international and model agreements. We will discuss the principle of informational barrier used in these measurement technologies to safeguard the release of sensitive information. We will also discuss some of the pitfalls that may arise when policy is ill informed about the physical constraints in the making of measurements of nuclear materials.

Being a nuclear physicist and working at a national laboratory provides many opportunities to ply one’s skills in support of national security and the benefit of all mankind. Over the last 40 years, Los Alamos National Laboratory has been pioneering the field of Domestic and International Safeguards through the efforts in radiation detection. Specifically, a new breed of radiation monitors will be examined along with the concept of sensor networks.

- Making measurements in support of international agreements can pose many challenges both from a policy and science point of view. Policy issues may arise because physics measurements made in the area of arms control or disarmament may be deemed too intrusive since they could possibly reveal sensitive information about the material that is being interrogated. Therefore, agreements must include a framework for safeguarding against the potential release of this information. Most of the scientific issues center around the fact that it is desirable to make high quality measurements without any operator interaction. This leads to the development of instrumentation and software that are very stable and robust. Due to different concerns, policy and science priorities may be at odds with one another. Therefore, it is the scientists challenge - in this field - to keep policy makers informed by conveying what is technically possible and what is not in a manner that is easily understood and also negotiable. In this paper we will discuss some of the technology that has been developed to address some of these challenges in various international and model agreements. We will discuss the principle of informational barrier used in these measurement technologies to safeguard the release of sensitive information. We will also discuss some of the pitfalls that may arise when policy is ill informed about the physical constraints in the making of measurements of nuclear materials.

10:00AM GB.00004 Mapping Isotopic Distributions in Cargo to Detect SNM and its Configuration1, DENNIS P. MCNABB, Lawrence Livermore National Laboratory — Plans to demonstrate isotope-specific imaging using nuclear resonance fluorescence (NRF) via tunable quasi-monochromatic (Thomson) photon sources, while at the same time providing a conventional radiograph of the bulk matter distribution, will be discussed. The implementation of NRF-based imaging depends strongly on the nature of the X-ray illumination source [1]. Monte Carlo simulations used to study source properties to study the sensitivity of the technique in thick cargos for different photon source characteristics will be presented. Thomson or inverse-Compton scattering of laser photons from beams of relativistic electrons produce beams that are quasi-monochromatic, highly collimated and have been shown to scale in spectral brightness as the square of the X-ray energy [2]. A source with a larger fraction of the photons in the region of the resonance energy will result in higher signal-to-noise ratios with considerably less dose than conventional Bremsstrahlung-based machines. The ability to make an isotope-specific image has the potential to transform the special nuclear material detection problem from simply identifying high optical depth cargo or high-Z material, to unambiguous detection and verification of the specific contraband material. The high spectral brightness of this technology significantly reduces the radiological dose required for detection and largely eliminates artifacts due to small-angle Compton scattering. In collaboration with C.P.J Barty, F.V. Hartemann, J. Pruet, S.G. Anderson, P.D. Barnes, D.J. Gibson, C.A. Hagmann, J.E. Hernandez, M.S. Johnson, I. Jovanovic, M.J. Messerly, E.B. Norman, M.Y. Silverin, C.W. Siders, and A.M. Tremaine, Lawrence Livermore National Laboratory. [1] J. Pruet, D.P. McNabb, C.A. Hagmann, F.V. Hartemann, and C.P.J. Barty J. Appl. Phys., in press (2006). [2] F.V. Hartemann et al., PRLSTAB 8, 100702 (2005).

1Research support from U.S. Dept of Energy

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9:00AM GB.00001 Nuclear Security in the 21st Century, DANIEL E. ARCHER, Oak Ridge National Laboratory — Nuclear security has been a priority for the United States, starting in the 1940s with the secret cities of the Manhattan Project. In the 1970s, the United States placed radiation monitoring equipment at nuclear facilities to detect nuclear material diversion. Following the breakup of the Soviet Union, cooperative Russian/U.S. programs were launched in Russia to secure the estimated 600+ metric tons of fissionable materials against diversion (Materials Protection, Control, and Accountability – MP&C&A). Furthermore, separate programs were initiated to detect nuclear materials at the country’s borders in the event that these materials had been stolen (Second Line of Defense - SLD). In the 2000s, new programs have been put in place in the United States for radiation detection, and research is being funded for more advanced systems. This talk will briefly touch on the history of nuclear security and then focus on some recent research efforts in radiation detection. Specifically, a new breed of radiation monitors will be examined along with the concept of sensor networks.

9:36AM GB.00002 Measurement Challenges in International Agreements, JOHN LUKE, NNSA/LLNL — Making measurements in support of international agreements can pose many challenges both from a policy and science point of view. Policy issues may arise because physics measurements made in the area of arms control or disarmament may be deemed too intrusive since they could possibly reveal sensitive information about the material that is being interrogated. Therefore, agreements must include a framework for safeguarding against the potential release of this information. Most of the scientific issues center around the fact that it is desirable to make high quality measurements without any operator interaction. This leads to the development of instrumentation and software that are very stable and robust. Due to different concerns, policy and science priorities may be at odds with one another. Therefore, it is the scientists challenge - in this field - to keep policy makers informed by conveying what is technically possible and what is not in a manner that is easily understood and also negotiable. In this paper we will discuss some of the technology that has been developed to address some of these challenges in various international and model agreements. We will discuss the principle of informational barrier used in these measurement technologies to safeguard the release of sensitive information. We will also discuss some of the pitfalls that may arise when policy is ill informed about the physical constraints in the making of measurements of nuclear materials.

9:48AM GB.00003 Nuclear Physics for National Security, DOUGLASS MAYO, Los Alamos National Laboratory — Being a nuclear physicist and working at a national laboratory provides many opportunities to ply one’s skills in support of national security and the benefit of all mankind. Over the last 40 years, Los Alamos National Laboratory has been pioneering the field of Domestic and International Safeguards through the research and development of instrumentation and systems used to monitor nuclear materials and nuclear facilities. With a projected increase in the use of nuclear energy, effective systems must be designed to reduce the possibility that nuclear materials may be diverted for used in weapons. The recent focus has been the many applications of radiation detection used for safeguarding nuclear material and to support Homeland Security. There is a critical need for trained nuclear scientists who can understand and overcome measurement complexities, combinations of multiple sensor inputs, data reduction, and automated analysis for these applications. This talk will focus on the opportunities and experiences afforded physicists in the support of national security, beyond the weapons program and travel to interesting locales.
10:12 AM GB.00005 Detection of fissionable material in cargo containers using active neutron interrogation. JENNIFER CHURCH, Lawrence Livermore National Laboratory — Roughly 6 million cargo containers will be shipped to U.S. seaports in a single year, each container carrying up to 30 tons of freight in varied configurations. Highly enriched uranium and other fissionable material concealed inside these containers is a challenge for existing portal monitors, due in part to the attenuation of signals in the cargo. A system is currently being developed to overcome these challenges without slowing the flow of commerce through the port, keeping the likelihood of false-negative and false-positive detections to a minimum. The technique utilizes a neutron beam to induce fission, and a wall of plastic scintillators to detect subsequent delayed high-energy \( \gamma \)-rays after \( \beta \)-decay of the fission product. Decay curves utilizing these delayed \( \gamma \)-rays with energies above 3 MeV are an efficient diagnostic. New experimental work using a 3-7 MeV broad spectrum neutron source will be presented and compared to simulations and past experimental results. This work is performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory contract No. W-7405-Eng-4, UCRL-ABS-219231.


10:24 AM GB.00006 Inherent Challenges of Mobile Radiation Detection. DAVID CAMPBELL, Lawrence Livermore National Laboratory — The need for effective mobile detection systems is paramount when searching for rogue sources of radiation. However, once a detector begins to move, it encounters a dynamic environment where ambient radiation levels vary dramatically. Some of the challenges inherent to mobile radiation detection will be detailed along with some methods for addressing them.

1 This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

10:36 AM GB.00007 Physical Limitations of Neutron-Based Explosives Detection Systems. PHILLIP WOMBLE, ALEXANDER BARZILOV, JON PASCHAL, LINDSAY HOPPER, RYAN MOORE, JEREMY BOARD, ERIC HOUCHINS, IAN RICE, JOSEPH HOWARD, Western Kentucky University — Recent events in Madrid and London have once again focused attention on the problem of threat detection using elemental analysis. Neutron-based systems are utilized to perform bulk chemical analysis due to their high chemical specificity and their fairly rapid response time. While there are many acronyms for these systems, their working principle is typically to interrogate the sample with a beam of neutrons and to identify and quantify secondary particle emissions (e.g. photons) and relate these emissions back to number of atoms present of a given element. These systems perform optimally when their designers and operators are aware of the physical limitations inherent in these devices. For example, minimum detection limits are strongly constrained by the signal-to-noise ratio in a given system. The purpose of this paper is not to denigrate any of these systems but to discuss the strengths and limitations of various approaches.

10:48 AM GB.00008 Savannah River National Laboratory Underground Counting Facility. TIM BROWN, SRNL — The SRNL UCF is capable of detecting extremely small amounts of radioactivity in samples, providing applications in forensics, environmental analyses, and nonproliferation. Past customers of the UCF have included NASA, (Long Duration Exposure Facility) the IAEA, (Iraq), and nonproliferation concerns. The SRNL UCF was designed to conduct ultra-low level gamma-ray analyses for radioisotopes at trace levels. Detection sensitivity is enhanced by background reduction, high detector efficiency, and long counting times. Backgrounds from cosmic-rays, construction materials, and radon are reduced by counting underground, active and passive shielding, (pre-WWII steel) and situation behind a Class 10,000 clean facility. High-detection efficiency is provided by a well detector for small samples and three large HPGe detectors. Sample concentration methods such as ashing or chemical separation are also used. Count times are measured in days. Recently, two SCUREF programs were completed with the University of South Carolina to further enhance UCF detection sensitivity. The first developed an ultra-low background HPGe detector and the second developed an anti-cosmic shield that further reduces the detector background. In this session, we will provide an overview status of the recent improvements made in the UCF and future directions for increasing sensitivity.

1 Work described here was supported by the South Carolina Universities Research and Education Foundation

11:00 AM GB.00009 Accelerate the transition of radioisotopes or unwanted weapons-grade \(^{239}\)Pu into stable nuclei with a system of high frequency modulation for a net energy gain. EUGENE PAMFILOFF, Dept. of Physics and Astronomy, University of Georgia, UGA, Optigon Research and Development, Division of Vivitar, VPDM, CA, retired — A process of high frequency stimulation of nucleons can be utilized for the accelerated fission, decay or controlled transition of unstable isotopes. For example \(^{235}\)U could be persuaded to transition promptly into \(^{206}\)Pb, where portions of the total mass difference of 29873.002 MeV per nucleus becomes available energy. The proposals of this paper describe an effective system for nuclei stimulation configured to accelerate such a series of 14 transitions over several milliseons, instead of 4.47 x \(10^{9}\) years. Positive ions or ionized capsules of fuel suspended by magnetic fields and subjected to the system of correlated frequency modulation of multiple beam lines, tailored to the specific target, will emit sufficient energy to stimulate subsequent targets. The system can be applied to all radioisotopes, including \(^{232}\)Th, nuclear waste product isotopes such as \(^{240}\)Pu, and a variety of other suitable unstable or stable nuclei. Through the proposed confinement system and application of high frequency stimulation in the 10\(^{22}\) to 10\(^{24}\) Hz regime, the change in rest mass can be applied to both the fragmentation of subsequent, periodically injected targets, and the production of heat, making a continuous supply of energy possible. The system allows the particle fragmentation process to be brought into the laboratory and provides potential solutions to the safe disposal of fissile material.

11:12 AM GB.00010 New Nuclear Decay Library for ENDF/B-VII. ALEJANDRO SONZOGNI — As a part of the ENDF/B-VII (Evaluated Nuclear Data File) release, a new library containing nuclear decay data was produced. Its main sources are the Evaluated Nuclear Structure Data File, which is continuously updated and the 2006 edition of the Nuclear Wallet Cards. An important component of it is the use of the Total Absorption Gamma-ray Spectrometer (TAGS) data measured by Idaho National Laboratory. The library is well suited to complex decay network calculations. It is expected to have an impact in many nuclear science and technology applications such as reactor operations and radionuclide management. Decay heat calculations and comparison with other libraries will be presented.

Saturday, October 28, 2006 9:00 AM - 11:48 AM — Session GC DNP: Nuclear Structure IV Gaylord Opryland Tennessee B

9:12AM GC.00002 Internal Conversion Coefficient Measurements of Transitions in $^{167}$Lu G. GÜRDAL, Clark University; W.NL, Yale University, C.W. BEAUSANG, University of Richmond, D.S. BRENNER, Clark University, H. AI, R.F. CASTEN, A. HEINZ, E. WILLIAMS, WNSL, Yale University, C. CRIDER, R. RAABE, University of Richmond, D.J. HARTLEY, United States Naval Academy, M. CARPENTER, R.V.F. JANSENS, T. LAURITSEN, C.J. LISTER, D. SEWERYNIAK, S. ZHU, Argonne National Laboratory, A.A. HECHT, Argonne National Laboratory; University of Maryland, J.X. SALADIN, University of Pittsburgh — Experimental internal conversion coefficients can be used to determine the polaritivities of electromagnetic transitions and thus are valuable for assigning or confirming spins and parities of excited states. The normal and highly deformed bands of $^{167}$Lu were populated by the $^{166}$Ho($^{88}$Sr,$\pi$) reaction. Gammasphere and ICEBALL spectrometers were used to detect the coincidences between $\gamma$-rays and electrons. $\gamma\gamma$ and $\gamma\mu$ matrices as well as $\gamma \gamma \gamma$ and $\gamma \mu \mu$ cubes were produced to analyze the coincidence data. Internal conversion coefficients were measured for the transitions from the normal deformed band and the triaxially deformed bands, which have the importance of testing the wobbling mode in $^{167}$Lu. The preliminary results of the analysis will be presented. This work was supported by the US D.O.E grants DE-FG02-88ER40417, DE-FG02-91ER-40609, DE-FG52-06NA26206, DE-FG02-05ER41379, Contract No. W-31-109-ENG-38 and by the NSF grant number PHY-0300673.

9:36AM GC.00004 Search for highly deformed rotational structures in tungsten isotopes S.K. TANDEL, A.J. KNOX, U.S. TANDEL, C. PARNELL-LAMPEN, P. CHOWDHURY, University of Massachusetts Lowell, D.J. HARTLEY, United States Naval Academy, JING-YE ZHANG, University of Tennessee, Knoxville, M.P. CARPENTER, R.V.F. JANSENS, T.L. KHOO, T. LAURITSEN, C.J. LISTER, D. SEWERYNIAK, X. WANG, S. ZHU, Argonne National Laboratory — Highly excited states in tungsten isotopes ($^{174}$Lu, $^{176}$Lu) in the vicinity of $N=100$ were populated using a 225 MeV (on target) $^{50}$Ti beam from the ATLAS accelerator at Argonne National Laboratory, incident on a 235$^{128}$Te target. The $\gamma$-rays emitted by the evaporated residues were detected using the Gammasphere array. New rotational structures have been identified and existing bands have been extended, in some cases, beyond the second nucleonshell. Theoretical calculations predict that triaxial structures with large deformation states originating from couplings of the $\tau/2$ and $\nu/2$ orbits. The path via the $\tau=0^+$ band cannot be explained through conventional Coriolis mixings and the accidental mixing scenario between the isomer and a nearby collective level was invoked. Details of these measurements will be presented, together with a comparison with predictions from multi-quasiparticle calculations.

1 Supported by USDOE Grant DE-FG02-94ER40848 and W-31-109-ENG-38

10:00AM GC.00006 Studies of Triaxial Rotor and Band Mixing in $^{186, 188, 190, 192}$Os J.M. ALLMOND, Georgia Institute of Technology, J.L. WOOD, A-M. OROS-PUEQUENS, R. ZABALLA, W.D. KULP — The $E2$ matrix elements of the Os isomtropes are studied in the framework of collective models. [1] The rotational model with $\Delta K = 2$ mixing fits the data fairly well; but deviations at high spin suggest that the spin-dependence of $\Delta K = 2$ mixing in the rotor model is too strong. This supports a finding in $^{166}$Er [2].


1 DOE Grant No. DE-FG02-96ER40958
10:12AM GC.00007 ABSTRACT WITHDRAWN

10:24AM GC.00008 Search for isomers in $^{199-203}\text{Tl}$, N. FOTIADES, R.O. NELSON, M. DEVLIN, LANL, J.A. BECKER, W. YOUNES, LLNL. — The $^{203}\text{Tl}(n,\gamma n)$ reactions were used to study excited states in $^{199-203}\text{Tl}$ isotopes. The data were taken using the GEANIE spectrometer comprised of 26 high-purity Ge detectors. The pulsed neutron source of the Los Alamos Neutron Science Center's WNR facility provided neutrons in the energy range from 0.6 to 100 keV. The time-of-flight of the fission fragments was used to determine the incident neutron energies. Partial $\gamma$-ray cross sections were measured from the beam-on data while half-lives of isomers were determined from the beam-off data. A candidate for the unknown $0^+/2^-$ isomer in $^{203}\text{Tl}$ has been identified. The half-life of this state is less than the shortest half-life that could be determined in the present experiment (typically, the half-lives that can be currently measured with GEANIE vary between a few $\mu$s to a few ms). The candidate state is located at 1484-keV excitation energy, in excellent agreement with the theoretical prediction for the excitation of the $0^+/2^-$ state in Ref. [1]. In $^{202}\text{Tl}$, for the previously known $7^+$ isomer at 950-keV excitation energy a $592(4)\mu$s half-life was obtained in the present work, which differs by $\sim 4\%$ from the value adopted in the literature [572(7) $\mu$s]. In the lighter Ti isotopes, the life-time measurements yielded very consistent agreement with the theoretically predicted values reported in the literature. This work was supported by the U.S. Department of Energy under Contracts No. DE-AC52-06NA25396 (LANL) and W-7405-ENG-48 (LLNL).


10:36AM GC.00009 Octupole Strength in the $^{238,240,242}\text{Pu}$ isotopes1, X. WANG, Argonne National Laboratory, Argonne, IL 60439/University of Notre Dame, Notre Dame, IN 46556, S. ZHU, R.V.F. JANSENS, M.P. CARPENTER, I. AHMAD, J.P. GREENE, T.L. KOHO, F.G. KONDEV, T. LAURITSEN, C.J. LISTER, D. SEWERYNIAK, Argonne National Laboratory, Argonne, IL 60439, S.J. FREEMAN, University of Manchester M3 PL, Uk/Argonne National Laboratory, Argonne, IL 60439, U. GARG, University of Notre Dame, Notre Dame, IN 46556, I. WIEDENHOEVER, A. BERNSTEIN, P. WILSON, E. DIFFENDERFER, C. TEAL, Florida State University, Tallahassee, FL 32306, A. LARABEE, B. MEREDITH, Greenville College, Greenville, IL 62246 — A series of so-called "unsafe" Coulomb excitation experiments as well as 1-neutron transfer measurements was carried out with Gammasphere at the ATLAS accelerator in order to investigate the collective properties of $^{238,240,242}\text{Pu}$. New experimental evidence has emerged that in $^{242}\text{Pu}$ a transition from an octupole vibration to stable octupole deformation occurs at high spin. A similar situation may be present in $^{238}\text{Pu}$, but is clearly absent in the heavier $^{242}\text{Pu}$. The data will be presented and discussed together with available information on neighboring nuclei in the region.1

1 This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under contract No. W-31-109-ENG-38, and the National Science Foundation.

10:48AM GC.00010 Preliminary results on $^{241,243}\text{Am}$ and $^{235}\text{U}(n,\gamma)$ cross sections measured at DANCE, M. JANDEL, T.A. BREDEWEG, M.M. FOWLER, E.M. BOND, J.M. O’DONNELL, R. REIFARTH, R.S. RUNDBERG, J.L. ULLMANN, D.J. VIERA, J.B. WILHELMY, J.M. WOUTERS, Los Alamos National Laboratory, R.A. MACRI, C.-Y. WU, J.A. BECKER, Lawrence Livermore National Laboratory — The Detector for Advanced Neutron Capture Experiments (DANCE) at Los Alamos National Laboratory (LANL) was used for neutron capture cross sections measurements. Its high granularity of 160 BaF$_2$ detectors allows for highly efficient detection of prompt gamma-rays following a neutron capture. DANCE is located on the 20.26 m neutron flight path 14 at the Manuel Lujan Jr. Neutron Scattering Center at the Los Alamos Neutron Science Center (LANSCE). The moderated production target provides neutrons in the 0.02 eV - 500 keV energy range. An analysis of neutron capture measurements on $^{241,243}\text{Am}$ and $^{235}\text{U}$ targets was presented. The experiments were carried out using a customized Parallel-Plate Avalanche Counter (PPAC) detector installed in the center of the DANCE array. The PPAC was used as a fission-tagging detector to separate (n,$\gamma$) from (n,fission) events. Preliminary results of (n,$\gamma$) cross sections will be presented and compared with the available data for neutrons energies from 0.02 eV to 1 keV. Additional neutron capture measurements with DANCE will be briefly discussed.

11:00AM GC.00011 $\gamma - \gamma$ Angular Correlations and g-factor Measurements from Spontaneous Fission of $^{252}\text{Cf}$ with Gammasphere, K. LI, C. GOODIN, A.V. RAMAYYA, J.H. HAMILTON, J.K. HWANG, Vanderbilt Univ., A.V. DANIEL, G.M. TER-AKOPIAN, JINR(Dubna), N.J. STONE, Univ. Oxford/Univ. Tenn., J.O. RAMMUSSEN, Y.X. LUO, LBNL, S.J. ZHU, Tsinghua Univ. — Measurements of g-factors of excited states have been determined by measuring attenuated $\gamma$-ray angular correlations from spontaneous fission of $^{252}\text{Cf}$ with the Gammasphere detector array. A $^{252}\text{Cf}$ fission source was sandwiched between two iron foils (10 mg/cm$^2$) and placed at the center of Gammasphere. For successive transitions in a cascade with the lifetime of the intermediate state much greater than the stopping time of the fission fragments, it is assumed that the fission fragment are implanted into the iron foils before emitting $\gamma$-rays. By measuring the time-integral attenuation coefficients, the mean Larmor precession angle of the intermediate state is obtained, which is proportional to the lifetime and g-factor of the state and the hyperfine field acting on the nucleus. Lifetimes of several states have been measured by using the triple $\gamma$ coincidence technique. We will present details of this technique and compare our results with previous measurements.

11:12AM GC.00012 Alpha decay of $^{257}\text{Rf}*$, J. QIAN, A. HEINZ, R. WINKLER, J. VINSON, Yale University, A.B. GAMSWORTH-THY, University of Surrey, R.V.F. JANSENS, D. PETERSON, D. SEWERYNIAK, B. BACK, M.P. CARPENTER, G. SAVARD, A.A. HECHT, C.L. JIANG, T.L. KOHO, F.G. KONDEV, T. LAURITSEN, C.J. LISTER, A. ROBINSON, X. WANG, S. ZHU, Argonne National Laboratory, M. ASAI, Japan Atomic Energy Agency — In this work, we studied $^{257}\text{Rf}$ by using the Fragment Mass Analyzer (FMA) at Argonne National Laboratory. In addition to $\alpha-\alpha$ correlations, the FMA measures the Mass/charge (A/Q) ratio of residues which helps to identify the origin of weak alpha lines. A 233 MeV $^{10}$Ti beam with an average intensity of 115 nA/beam on a rotating $^{208}$Pb target wheel. The recoil positions at the FMA focal plane - which allow the measurement of the A/Q ratio - were determined with a Parallel Grid Avalanche Counter (PGAC) and subsequently implanted in a Double-sided Silicon Strip Detector (DSSD). Recoils are identified by their energy deposition inside the DSSD as well as their time-of-flight between the PGAC and the DSSD. Position and time of implant events and subsequent alpha decays were measured and correlated. The details of the data will be presented. These data can test model predictions concerning the next proton shell closure and the structure of heavy nuclei in the absence of a liquid-drop fission barrier. This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under contract No. W-31-109-ENG-38 and DE- FG02-91ER40609, and Nexia Solutions Ltd.

11:24AM GC.00013 Microscopic study of Nuclear Spin Cut-off Parameter1, AZIZ BEHKAMI, Mahabad, Azad University, Iran, MEHMET KILDIR, MEHRDAD GHALAMI, Middle East Technical University, Turkey — Spin cut-off parameter and effective moment of inertia have been investigated within the microscopic approach based on BCS- Hamiltonian. The spin cut-off parameter has been calculated at neutron binding energies over a large range of nuclear mass A, using the BCS theory. The results are compared with their corresponding macroscopic values. It is found that the values of $\alpha^2(E)$ do not increase smoothly with A as expected based on macroscopic theory. Instead, the values of $\alpha^2(E)$ shows structure reflecting the angular momentum of the shell model orbitals near the Fermi energy. The spin cut-off parameter $\sigma^2(E)$ has also been computed from the knowledge of nuclear level density, at neutron binding energy, $B_n$, and the average 5-wave neutron spacing, $\langle\delta n\rangle = 1/2\mu(B_n)<D_{1/2}>$. These are also compared with their corresponding values from the model calculations. The results will be presented and discussed.

1 Work is supported by Mahabad I. A. University research council
measure is suggested.

The mass and energy regions are reviewed. The transition strength distribution for one channel follows a chi-squared distribution of one degree of freedom (the predictions of the relevant version of RMT – the Gaussian Orthogonal Ensemble (GOE). Subsequent tests of spectra (level statistics) in different regions of validity of Fermi-liquid theory. The incoherent parts of residual interaction play the role of a heat bath. Are such descriptions complementary, mutually exclusive or equivalent? We give arguments in favor of equivalence of these approaches under an appropriate choice of nucleon-nucleon interaction and an accurate description of the individual nucleonic motion. Such approach becomes quickly intractable with increasing particle number. On the other hand, certain simple features begin to emerge, which reflect collective properties of many nucleons. Some of them become familiar macroscopic properties as compressibility, surface tension, viscosity, heat capacity, entropy when the particle number becomes very large. Phase transitions or hydrodynamic behavior may develop in this limit. Other features, as shell structure or rotational bands, remain mesoscopic, i.e. they are only important up to not too large a number of particles. Since these emergent phenomena are not sensitive to the details of the interactions between the constituent particles, they may appear in non-nuclear mesoscopic systems quite analogous to nuclei. Fluctuations of the average quantities become very important in the mesoscopic regime, which may lead to qualitatively new behavior. The nuclei that can be studied experimentally are essentially mesoscopic in nature. Strong fluctuations combined with a pronounced shell structure restrict the accuracy with which the macroscopic properties of neutron matter can be determined from finite nuclei. However macroscopic characteristics as compressibility, binding energy, and symmetry energy of neutron matter determine the properties of neutron stars.

This approach has proven remarkably successful, but the development was both lengthy and sporadic. Data of sufficiently high quality (both pure and complete) is basically gone. The study of very exotic nuclei at the limits of isospin and mass will provide the missing links in our present understanding.

To describe the fluctuation properties of neutron resonance spacings, Wigner made the first application of Random Matrix Theory (RMT) to nuclear physics. — Shell structure is a fundamental property of leptodermous finite Fermi systems. It results from a one-body motion of weakly interacting quasi-particles in an average mean-field potential. The concept of single-particle motion in nuclei, developed in the late forties, is a cornerstone of nuclear structure. But how robust is this concept? A significant new theme concerns shell structure near the particle drip lines crucially depends on many-body correlations that are impacted by the presence of the low-lying continuum of unbound nuclear states that can decay by particle emission. In the superheavy nuclei, an effective interaction derived from the realistic Argonne V18 interaction using the Unitary Correlation Operator Method is used for all nuclei. Results for nuclei in the $p$-shell will be presented. Halo features are present in the Helium isotopes, cluster structures are studied in Beryllium and Carbon isotopes. The interplay between shell structure and cluster structures in the ground and the Hoyle state in $^{12}$C will be discussed.

In the Fermionic Molecular Dynamics (FMD) model the nuclear many-body system is described using Slater determinants with Gaussian wavepackets as single-particle states. The flexibility of the FMD wave functions allows for a consistent description of shell model like structures, deformed states, cluster structures as well as halos. An effective interaction derived from the realistic Argonne V18 interaction using the Unitary Correlation Operator Method is used for all nuclei. Results for nuclei in the $p$-shell will be presented. Halo features are present in the Helium isotopes, cluster structures are studied in Beryllium and Carbon isotopes. The interplay between shell structure and cluster structures in the ground and the Hoyle state in $^{12}$C will be discussed.

Quantum Chaos and Thermodynamics of Self-Bound Mesoscopic Systems. VLADIMIR ZELEVINSKY, Michigan State University — There are different languages for description of excited states in small self-bound systems, like complex nuclei: in terms of thermodynamical concepts (temperature and entropy) or in terms of properties of individual quantum levels at given excitation energy. Are such descriptions complementary, mutually exclusive or equivalent? We give arguments in favor of equivalence of these approaches under an appropriate choice of a “thermometer.” Many-body quantum chaos serves as a stirring instrument that mixes close eigenfunctions and produces a smoothly evolving degree of complexity as a necessary feature of thermal equilibrium. With a consistent choice of the mean field, a quasiparticle thermometer can do the job extending the region of validity of Fermi-liquid theory. The incoherent parts of residual interaction play the role of a heat bath.

Chaos in quantum many-body systems. GARY MITCHELL, North Carolina State University — To describe the fluctuation properties of neutron resonance spacings, Wigner made the first application of Random Matrix Theory (RMT) to nuclear physics. This approach has proven remarkably successful, but the development was both lengthy and sporadic. Data of sufficiently high quality (both pure and complete) were limited in sample size. Bohigas and colleagues combined the best available neutron and proton resonance data to provide conclusive evidence for agreement with the predictions of the relevant version of RMT – the Gaussian Orthogonal Ensemble (GOE). Subsequent tests of spectra (level statistics) in different mass and energy regions are reviewed. The transition strength distribution for one channel follows a chi-squared distribution of one degree of freedom (the Porter-Thomas distribution), which results from a Gaussian distribution for the transition amplitudes. The (relatively recent) precise experimental confirmation of the Gaussian distribution is described. In spite of the extremely successful application of RMT in many fields, development in nuclear physics has been relatively limited. The primary reason is that the standard measures used to analyze the experimental data are too sensitive to mistakes. An alternative measure is suggested.
10:24AM GD.00006 Thermodynamics of Pairing in the Mesoscopic Nuclear System1, TONY SUMARYADA, ALEXANDER VOLYA, Florida State University — We present a systematic study of the thermodynamic properties of pairing correlation in mesoscopic nuclear system. The realistic and model Hamiltonians are used in this study. Various thermodynamic quantities are calculated and analyzed using the exact solution of pairing. We conduct an in-depth comparison of microcanonical, canonical and grand canonical approaches. The nature of the pairing phase transition in small system is of a particular interest. We discuss the onset of discontinuity in thermodynamic variables, fluctuations, and evolution of zeros of the partition function in the complex temperature plane associated with the transition to a superconducting phase.

1This work is supported by the U.S. Department of Energy, grant DE-FG02-92ER40750.

10:36AM GD.00007 Thermal signatures of pairing correlations in nuclei and nanoparticles1, T. FANG, S. SCHMIDT, Y. ALHASSID, Yale University — Pairing correlations in nuclei at zero temperature are well documented but much less is known about their thermal signatures. Nuclei are in the crossover regime between the bulk BCS limit and the fluctuation-dominated regime. We have used the shell model Monte Carlo approach to study pairing correlations at finite temperature beyond the BCS limit. We identify signatures of pairing correlations in both the heat capacity and moment of inertia [1]. These signatures depend on the particle-number parity of protons and neutrons. Ultra-small metallic grains (nanoparticles) whose linear size is below a few nanometers are also close to the fluctuation-dominated regime. We use auxiliary-field Monte Carlo methods to study pairing correlations in such nanoparticles and find odd-even effects in their heat capacity and spin susceptibility, in analogy to the signatures found in nuclei. This work was supported in part by the U.S. DOE grant No. DE-FG-0291-ER-40608. [1] Y. Alhassid, G.F. Bertsch, L. Fang, and S. Liu, Phys. Rev. C 72, 064326 (2005).

10:48AM GD.00008 Collectivity and random interactions1, CALVIN JOHNSON, San Diego State University — Diverse quantum systems, from nuclei to buckyballs to superconducting metals, often show similar collective behaviors, such as pairing or collective bands. These universalities show up when one uses random two-body interactions. In this talk I will discuss some new signatures of collectivity found in fermion systems with random interactions.

1Supported by a grant from the U.S. Dept of Energy

11:00AM GD.00009 Exploring super-radiance phenomena in mesoscopic systems1, ALEXANDER VOLYA, Florida State University, VLADIMIR ZELEVINSKY, Michigan State University — Mesoscopic physics is a term used to address many-body world between macro and micro. Quantum wires and dots, prototypes of quantum computers, molecular structures, atomic nuclei and even multi-quark hadrons all fall under this definition. From formation to decay, the life of a mesoscopic system is inseparable from outside perturbations; the coupling to the continuum of external states is a common element. The super-radiance to be discussed in this talk is a robust collective phenomenon appearing when this coupling becomes strong. Using schematic and realistic examples from different branches of science and from nuclear physics in particular we address the formation of a collective super-radiant mode in nuclei and condensed matter systems under conditions of regular and chaotic dynamics. Phase transition into super-radiant regime, competition of collective decay mode and other collective many-body features are to be discussed. Super-radiance saturates the entire continuum coupling in a few states making the remaining quantum many-body states quasi-stable. This counterintuitive enhancement of stability that appears in response to a strong continuum coupling is investigated.

1This work is supported by the U.S. Department of Energy (DE-FG02-92ER40750) and by the National Science Foundation (PHY-0070911 and PHY-0244453).

11:12AM GD.00010 Density-functional theory for resonant Fermi gases, THOMAS PAPENBROCK, University of Tennessee — Resonant Fermi gases interact via short-ranged forces that exhibit a two-body bound state at zero energy. Within the local density approximation, the form of the density functional is strongly constrained and contains only a small number of parameters. The parameters can be determined by exploiting the universality of the density functional, and by comparing results from Kohn-Sham density-functional theory with analytical solutions for the harmonically trapped two-body system. The results for the leading term and the correction due to a large scattering length agree rather well with Monte Carlo studies. The correction due to a small effective range is a prediction.

Saturday, October 28, 2006 9:00AM - 11:48AM
Session GE DNP: Nuclear Scattering and Reactions Gaylord Opryland Hermitage B

9:00AM GE.00001 Coincidence Geometry Measurements of the 1S0 Scattering Lengths in Neutron-Deuteron Breakup at 19 MeV1, A.S. CROWELL, J. DENG, J.H. ESTERLINE, C.R. HOWELL, M.R. KISER, R.A. MACRI, S. TAJIMA, W. TORNOW, Duke University and TUNL, B.J. CROWE III, North Carolina Central University, R.S. PEDRONI, North Carolina A&T State University, W. VON WITSCH, University of Bonn, H. WITALA, Jagellonian University — Measurements of the 1S0 neutron-neutron (nn) and neutron-proton (np) scattering lengths, a_{nn} and a_{np}, respectively, using neutron-induced deuteron breakup were made at Triangle Universities Nuclear Laboratory (TUNL) at an incident neutron energy of 19.0 MeV. Six liquid scintillator detectors were configured in a coincidence geometry to measure the momenta of the two neutrons in two nn and np final-state-interaction (FSI) pairs while the energy of the proton was determined using a C_0 D_2 A active target. The scattering lengths were extracted from the experimental cross sections by comparison to rigorous three-nucleon calculations using the CD Bonn nucleon-nucleon potential for various values of a_{nn} and a_{np}. In this talk results from the two nn and np FSI measurements and the analysis to obtain a_{nn} will be presented.

1This work was supported in part by USDOE Grant No. DE-FG02-97-ER41033.

9:12AM GE.00002 Three-body scattering with two charged particles: Application to direct nuclear reactions1, A.C. FONSECA, A. DELTUVA, Centro de Física Nuclear da Universidade de Lisboa, Portugal — The conventional treatment of direct nuclear reactions involves the use of optical potentials for elastic channels together with Coupled Channel theory or DWBA to describe inelastic or one particle transfer reactions such as (d, p) or (d, n) on a heavier nucleus. The application of exact Faddeev three-body theory to the understanding of these reactions has been always shadowed by the difficulty in dealing with the long range Coulomb interaction between the proton and the heavier target of atomic number Z. Given the progress achieved recently for p−d elastic scattering and breakup [1] we show the results of calculations for the reactions p(^{11}Be,^{11}Be)p and p(^{11}Be,^{11}Be)d at 38.4 MeV per nucleon, taken as a three-body system made up of p, n, and ^{10}Be as an inert core. The same is done for other (p, d) reactions at similar energies. The results show that three-body calculations can provide a competing explanation of the data. Further studies are forthcoming.

9:24AM GE.00003 Neutron-Helium-3 Analyzing Power at 2.26, 3.14, 4.05, and 5.54 MeV\(^1\). J.H. ESTERLINE, A.S. CROWELL, C.R. HOWELL, A. HUTCHESON, M.R. KISER, R.A. MACRI, S. TAJIMA, W. TORNOW, Duke University & TUNL, B.J. CROWE, N.C. Central University & TUNL, R.S. PEDRONI, N.C. A&T State University & TUNL, G.J. WEISEL, Penn State Altoona & TUNL — In continuation of an ongoing study of analyzing powers in the four-nucleon system, chosen for its sensitivity both to nucleon-nucleon phase shifts and possibly to new three-nucleon forces relevant to solving the three-nucleon analyzing power puzzle, we have measured analyzing powers for neutron-helium-3 scattering at Triangle Universities Neutron Laboratory (TUNL) at neutron energies of 2.26, 3.14, 4.05, and 5.54 MeV, over a wide angular distribution for each energy. Neutrons were obtained using the source reactions \( T(p,n)^{12}\)He and \( D(d,n)^{14}\)He. For the lower energies (2.26 and 3.14 MeV) and higher energies (4.05 and 5.54 MeV), respectively, resulting neutron polarizations were between 0.3 and 0.5. Statistical uncertainties in the analyzing power were found in preliminary analysis to be less than 0.03 at the cross section minima, corresponding to values of analyzing powers in excess of 0.6. The data are compared to rigorous calculations based on the Yakubovskiy equations, with which they are in marked disagreement, and existing proton-triton data corrected for the Coulomb barrier.

\(^1\)Work supported by USDOE grant no. DE-FG02-97ER41033.

9:36AM GE.00004 The \( ^6\)He and \( ^6\)Li interaction with \( ^{12}\)C at energies of 20–50 MeV/nucleon\(^1\). OLEAXENDR MOMOTYUK\(^2\), KIRBY KEMPER, The Florida State University, NICHOLAS KEELEY, CEA-Saclay, CEA-Saclay, DSM/DAPNIA/SPHN, GyÅ-sur-Yvette, France, KRZYSZTOF RUSEK, The Andrzej Soltan Institute for Nuclear Studies, Warsaw, Poland — The elastic scattering data for \( ^{4}\)He\(^{+^{12}}\)C \(^1\) when plotted on top of similar \( ^{6}\)Li\(^{+^{12}}\)C data \(^2\) shows that the absorption of \( ^{4}\)He is weaker than \( ^{6}\)Li, a surprising result since \( ^{4}\)He has a much lower binding energy (0.98 MeV) than does \( ^{6}\)Li (1.47 MeV). In order to understand the origin of this surprising result the elastic scattering cross sections for \( ^{4}\)He and \( ^{6}\)Li by \( ^{12}\)C in the energy range 20–50 MeV/nucleon were analyzed using coupled reaction channels (CRC) calculations that employed optical potentials of Woods-Saxon type, double-folded (DF) and cluster-folded (CF) potentials. The results of these calculations and possible reasons for the weaker absorption of \( ^{4}\)He relative to \( ^{6}\)Li will be presented.

\(^1\)Work supported in part by the U.S. National Science Foundation, State of Florida and NATO.

\(^2\)Permanent address: Institute for Nuclear Research, Kyiv, Ukraine.

9:48AM GE.00005 ABSTRACT WITHDRAWN —

10:00AM GE.00006 Final state interactions in two-proton interferometry and decay\(^1\). CARLOS BERTULANI, University of Arizona — There is an intriguing possibility, that a diproton (2\(^\mathrm{p}\)) correlation may play an important role in the mechanism of 2\(^\mathrm{p}\) emission from nuclear states. Correlations of 150 proton pairs produced in (d,2He) reactions have also been used to test the Bell and Wigner inequalities against the predictions of quantum mechanics. Finally, two-particle correlations are widely used in relativistic heavy-ion physics as a tool for extracting information about the spatial and temporal extent of the system at freeze-out. We have performed calculations for the effect of final state interactions of the correlated pair depending on initial conditions and on the properties of the interaction.

\(^1\)US Department of Energy Grant No. DE-FG02-04ER41338.

10:12AM GE.00007 Investigation of surrogate reactions near \( A=100\): \(^{102,104}\)Ru\((\alpha,\alpha')\) for \( ^{101,103}\)Ru\((n,\gamma)\). J.A. CHURCH, L.A. BERNSTEIN, J.T. BURKE, F. DIETRICH, J. ESCHER, C. FORSSEN, E.B. NORMAN, LLNL, H.-C. Al, Yale, L. PHAIR, R. CLARK, P.A. FALLOON, D. LEE, I.Y. LEE, A.O. MACCHIAVELLI, P. MCMANAHAN, S. SINHA, M. STEPHENS, E. R.-VIETEZ, M. WIEDEKING, LBNL — For two-step, neutron-induced reactions proceeding through an equilibrated intermediate state, an alternate, “surrogate reaction” technique is applicable. Measured decay probabilities for the intermediate nucleus formed via a light-ion reaction are combined with optical-model calculations for the formation of the same intermediate nucleus via the \( n \)-induced reaction, and result in the overall \((n,\gamma/n/2n)\) cross sections. \(^{102,104}\)Ru\((\alpha,\alpha')\) were studied separately as surrogate reactions for \(^{101,103}\)Ru\((n,\gamma)\). The test, \(^{101}\)Ru\((n,\gamma)\), has been previously measured directly (EXFOR). The unknown, \(^{103}\)Ru\((n,\gamma)\), is a branch in the s-process. Energy of scattered \( ^{12}\)C particles were detected in double-sided silicon detectors (STARS) over scattering angles of 42-60 degrees. Ge clover detectors (LiBerACE) were used to count \( \gamma \)-rays in coincidence with \( \alpha \) particles scattered at energies corresponding to 0-3 MeV equivalent neutron energy in the desired \((n,\gamma)\) reaction. Work performed under the auspices of the U.S. DOE by the Univ. of CA, LLNL contract No. W-7405-Eng-4, and DOE grants DE-FG02-91ER40609 and DE-FG03-03NA00081, LDRD-04-ERD-057.


10:24AM GE.00008 Towards improved optical potentials for composite particle scattering\(^1\). HELMUT LEEB, WOLFGANG DUNGE, ROMAN KOGLER, Atominstitution of the Austrian Universities, Vienna University of Technology — Quantitative evaluations of almost all nuclear reaction cross sections depend strongly on the quality of the optical potentials. This is particularly true for nuclear reactions involving composite projectiles or ejectiles, e.g. deuterons, alpha-particles etc. Despite their importance for various applications (embrittlement of materials, nuclear astrophysics) the current status of microscopic approaches is not fully satisfactory with regard to their predictive power. In this contribution we present a study of a microscopic approach to the alpha-nucleus optical potential, which is based on a consistent treatment of the composite nature of the collision partners. In addition, we also consider contributions due to the breakup in the case of loosely bound projectiles.

\(^1\)This work, supported by the EC under the Contract of Association between EURATOM and the Austrian Academy of Sciences, was carried out within the framework of EFDA. The views and opinions expressed herein do not necessarily reflect those of the EC.

10:36AM GE.00009 Covariance analysis for the fission program at LANSCE. F. TOVESSON, T.S. HILL, K.M. HANSON, P. TALOU, T. KAWANO, R.C. HIGHT, L. BÔNNEAU, Los Alamos National Laboratory — An experimental program at Los Alamos Neutron Scattering Center (LANSCE) has been developed to precisely measure differential fission cross sections over half decades in incident neutron energy for a range of actinides relevant to advanced nuclear reactor designs and transmutation concepts. As the need for uncertainty quantification (UQ) and covariance matrix evaluations significantly increased in the past few years, the detailed assessment and reporting of experimental uncertainties has become crucial. We will report on the analysis of the sensitivity vectors and covariance matrices for some of the fission data taken at LANSCE and provide examples of the impact experimental covariance data has in the evaluation process.


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\[^5\] Work supported in part by the U.S. National Science Foundation, State of Florida and NATO.

\[^6\] Permanent address: Institute for Nuclear Research, Kyiv, Ukraine.

\[^7\] Work supported by USDOE grant no. DE-FG02-04ER41338.

\[^8\] US Department of Energy Grant No. DE-FG02-04ER41338.

\[^9\] Work supported by the EC under the Contract of Association between EURATOM and the Austrian Academy of Sciences, was carried out within the framework of EFDA. The views and opinions expressed herein do not necessarily reflect those of the EC.

\[^10\] This work, supported by the EC under the Contract of Association between EURATOM and the Austrian Academy of Sciences, was carried out within the framework of EFDA. The views and opinions expressed herein do not necessarily reflect those of the EC.
10:48AM GE.00010 Using the 152Sm(p,3n)150Eu* Reaction as a Means to a Clean 150Gd target, B. BARQUEST, J. CERNY III, C. JEWETT, LBNL & UC Berkeley, D. BLEUEL, M.A. MCMANAHAN, LBNL, L. AHLE, L. BERNESTEIN, J. BURKE, LNL. As part of an ongoing program to measure direct neutron cross sections on radioactive targets, we have been investigating the feasibility of making a clean 150Gd target - a long-lived alpha-emitter of interest for stockpile stewardship - by making isomeric 150Eu, which decays to 150Gd with an 89% branching ratio. In the first part of this study, the 152Sm(p,3n) reaction was studied at several energies ranging from 19-27 MeV, using an array of five clover Ge detectors to look at the relative population of the ground state (τ1/2 = 36.9 years) and the isomer (τ1/2 = 12 hour) of 150Eu. In the second experiment, we bombarded a thicker 152Sm target at 25 MeV and measured the delayed gamma rays from the ground state and isomer to get an absolute production yield. Preliminary results from these studies will be presented including a tentative excitation function.

3This work was performed under the auspices of the US Department of Energy by Lawrence Berkeley National Laboratory under contract D-AC02-05CH11231 and NNSA Grant NA0078, and by Lawrence Livermore National Laboratory under contract W-7405-ENG-48.

11:00AM GE.00011 Time-variability of alpha from realistic models of Oklo reactors, C. GOULD, North Carolina State University and TUNL, EDUARD SHARAPOV, JINR, Dubna, STEVE LAMOREAUX, Los Alamos National Laboratory. We reanalyze Oklo 149Sm data using realistic models of the natural nuclear reactors. Disagreements among recent Oklo determinations of the time evolution of α, the electromagnetic fine structure constant, are shown to be due to different reactor models, which led to different neutron spectra used in the calculations. We use known Oklo reactor epithermal spectral indices as criteria for selecting realistic reactor models. Two Oklo reactors, RZ2 and RZ10, were modeled with MCNP. The resulting neutron spectra were used to calculate the change in the 149Sm effective neutron capture cross section as a function of a possible shift in the energy of the 97.3-meV resonance. We independently deduce 149Sm effective cross sections, and use these values to set limits on the time-variation of α. Our study resolves a contradictory situation with previous Oklo α-results. Our suggested 2σ bound on a possible time variation of α over two billion years is stringent: −0.11 < Δα/α < 0.24, in units of 10−7, but model dependent in that it assumes only α has varied over time.

3Work supported in part by the US Department of Energy, Office of Nuclear Physics.

11:12AM GE.00012 Scattering Kernel for Phase II Solid Methane, YUNCHANG SHIN, CHRISTOPHER LAVILLE, WILLIAM MICHAEL SNOW, CHEN-YU LIU, DAVID BAXTER, University of Indiana — Methane is one of the few substances that possess free rotor groups even in the solid phase at low temperature. These rotational degrees of freedom allow for efficient energy loss for cold neutrons and CH₄ is therefore a good choice for a low energy neutron moderator. In addition to its use as a cold neutron moderator at LENS, solid methane is planned to be used as a pre moderator for an ultracold neutron (UCN) source at the NC State PULSAR reacto and can also be used as a premoderator for solid O₂ UCN source at LENS. We have developed a simple model for the double differential cross section for solid methane for incident neutron energies from 0.1 meV to 1000 meV and temperatures from 4 K to 20.4 K. In this temperature range the solid methane exists in a phase (called phase II) with partial orientation of the free rotors. We adapted this analytical model due to Ozaki. et al., which describes free and hindered rotor excitations in phase II valid for neutron energies below 6.5 meV, and convoluted it with a phonon model good for energies between 6.5 and 1000 meV. The parameters of the model are consistent with neutron and Raman measurements of the excitations of phase II CH₄. We present the total cross section and MCNP simulation from the scattering kernel and compare to the measurement of LENS at IUCF.

11:24AM GE.00013 Solid Oxygen Ultra-cold Neutron Source for Fundamental Physics Experiments, YUNCHANG SHIN, CHEN-YU LIU, Department of Physics, Indiana University/ IUCF — Ultra-cold neutrons (UCN) are neutrons with energy of a few hundred neV. This energy is so low that UCN experience total external reflection from material surfaces. High precise measurements of fundamental physics such as neutron lifetime measurement or neutron EDM are possible with UCN. However a deficiency of intensity restricts us from achieving meaningful measurements. A UCN source with higher intensity is necessary to perform these precise measurements. Solid oxygen may be an attractive choice as a UCN source with this demand. Theoretical calculations predicted the possible advantages of solid oxygen. However, it has been experimentally shown that the UCN production rate from solid oxygen highly depends on the crystal condition, especially at low temperatures. We are testing crystal growths of solid oxygen over a wide range of temperature. Preliminary results will be presented.

11:36AM GE.00014 Level density and γ-strength function for A=56-60 nuclei, A.V. VOINOV, C.R. BRUNE, S.M. GRIMES, M.J. HORNISH, T.N. MASSEY, Ohio University, Athens, Ohio 45701 — The knowledge of the compound nuclear cross sections is important in various fields of nuclear science and applications. The level density and γ-strength function are the main quantities needed for such calculations and corresponding experimental data are in high demand. Traditionally, the nuclear level density below the particle separation energy is determined from neutron resonance spacing and low-lying discrete levels by means of interpolation function based on Fermi-gas model. But the question of how reliable these level densities are for reaction rate calculations remains open. Differential cross sections with ⁴He and deuteron beams on A=56-60 nuclei have been measured at Edwards Laboratory of Ohio University. Level density parameters are obtained and compared to available systematics. The results on the γ-strength function for ⁵⁶,⁵⁷Fe nuclei obtained from (⁴He,γ) and (⁴He,⁵Heγ) reactions measured at Oslo Cyclotron Laboratory will be presented. The data show a large enhancement relative to existing models in the low-energy region (<3 MeV).

This work is supported in part by U.S. DOE, grant No. DE-FG52-06NA26187.

Saturday, October 28, 2006 9:00AM - 12:00PM –
Session GF DNP: Spin Structure of the Nucleon at High Energy

9:00AM GF.00001 Double Longitudinal Spin Asymmetry for Inclusive Jet Production in Polarized p+p Collisions at 200 GeV, MURAD SARSOUR, Texas A&M University, STAR COLLABORATION — The STAR experiment at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory is measuring polarized pp collisions at a center of mass energy of √s = 200 GeV to determine the polarization gluon distribution in the proton, ∆G, in the kinematic range 0.03 < x < 0.3, via spin asymmetry measurements. Data were collected during 2005, at sampled luminosity of ~ 3 pb⁻¹, with 40-50% beam polarization. We present run 2005 preliminary results for the double longitudinal spin asymmetry for inclusive jet production at mid-rapidity, along with results from 2003/04. Comparisons to theoretical calculations using deep-inelastic scattering parameterizations for gluon polarization in the nucleon are also presented.
9:12AM GF.00002 Constraining the Gluon Contribution to the Proton's Spin by Measuring the Double Longitudinal Spin Asymmetry in Neutral Pion Production in Polarized p+p Collisions — KIERAN BOYLE, Stony Brook University, PHENIX COLLABORATION — The quark contribution to the proton’s spin measured with polarized DIS fixed target experiments was found to be only 20-30%. This has raised interest in measuring the gluon contribution, $\Delta g$, directly. Using the PHENIX Detector at the Relativistic Heavy Ion Collider (RHIC), we study longitudinally polarized proton collisions. The double longitudinal spin asymmetry in $\pi^0$ production, $A_{LL}^{\pi^0}$, is related to $\Delta g$. RHIC has recently completed its second long polarized proton run. In 2005, 46% average polarization and 2.7 pb$^{-1}$ integrated luminosity was achieved while in 2006, 60% average polarization and 7.5 pb$^{-1}$ was achieved. Our current status of our analysis of $A_{LL}^{\pi^0}$ will be presented.

9:24AM GF.00003 Longitudinal Spin Asymmetry and Cross Section of Inclusive Pi0 Production in Polarized p+p Collisions at 200 GeV — FRANK SIMON, Massachusetts Institute of Technology, STAR COLLABORATION — One goal of the polarized p+p program at RHIC, the first high-energy polarized p+p collider, is the study of the gluon polarization in the proton via spin asymmetry measurements in a variety of photon production. Due to its large acceptance tracking and electromagnetic calorimeter the STAR detector is an ideal tool for these studies. We present the first measurement of the cross section and the double longitudinal spin asymmetry of inclusive Pi0 production in polarized p+p collisions at mid-rapidity with the STAR detector, using the barrel electromagnetic calorimeter. The measured cross section is compared to NLO pQCD calculations, and can provide constraints on fragmentation functions. The comparison of the measured unpolarized cross section to theory is crucial in order to validate model calculations used to extract the gluon polarization from the observed asymmetry. The double longitudinal spin asymmetry is compared to NLO pQCD calculations based on different assumptions for the gluon polarization in the nucleon to provide constraints on $\Delta g/\langle g \rangle$. Although present the asymmetry result is still limited by statistics, it provides a proof of principle for future analysis with higher integrated luminosity and increased acceptance.

9:36AM GF.00004 Longitudinal Double Spin Asymmetry and Cross Section for $\eta$ production at mid-rapidity in polarized p+p collisions at $\sqrt{s_{NN}} = 200$ GeV — JOSEPH SEELE, University of Colorado at Boulder, PHENIX COLLABORATION — Longitudinal double spin asymmetries, $A_{LL}$, measured for inclusive hadron production in polarized proton-proton collisions at high energies have been shown to be sensitive to the gluon helicity distribution, $\Delta g$. A recent measurement of the longitudinal double spin asymmetry for neutral pion production at RHIC by the PHENIX experiment (Phys. Rev. Lett. 93, 202002 (2004)) has provided a significant constraint on the gluon helicity distribution of the nucleon. The extraction of $\Delta g$ from these data depends on the experimental knowledge of the relevant fragmentation functions. However, the measurement of $A_{LL}$ for different hadrons with independent experimental uncertainties and different fragmentation functions will further constrain the uncertainties present in global analyses of $\Delta g$. The measurement of the longitudinal double spin asymmetry for $\eta$ production will provide such a constraint. The PHENIX spectrometer has been used to measure the production of $\eta$ particles at mid-rapidity ($|y| < 0.35$). The results for the $A_{LL}$ and cross section for $\eta$ production in polarized p+p collision at $\sqrt{s_{NN}} = 200$ GeV at RHIC will be presented.

9:48AM GF.00005 Accessing the Gluon Polarization through the Double-Helicity Asymmetry in PHENIX — CHRISTINE AIDALA, University of Massachusetts-Amherst, PHENIX COLLABORATION — The RHIC spin program with its use of strongly interacting probes provides a unique opportunity that allows the direct study of gluon polarization within the nucleon. Among a variety of experimental channels the double-helicity asymmetry ($A_{LL}$) of charged pions seems to be an especially interesting probe. Charged pion asymmetry measurements will be an important component in obtaining global analysis, which will allow determination of the gluon polarization over a wide range in $x$. Comparison of differential cross section measurements to next-to-leading order (NLO) pQCD calculations has been essential to confirm our understanding of hard scattering at RHIC energies and the applicability of NLO pQCD in interpreting polarized processes. Quark-gluon scattering dominates mid-rapidity pion production at RHIC at transverse momenta above 5 GeV/$c$ in this kinematic region and the favored and unfavored fragmentation functions for each pion species provide relevant information. Relative differences among $A_{LL}$ of positive, neutral, and negative pions at high transverse momentum are sensitive to the sign of $\Delta g$. The current status of the charged pion $A_{LL}$ and cross section analyses using PHENIX data from the 2005 polarized proton run at RHIC will be presented.

10:00AM GF.00006 Double Longitudinal Spin Asymmetries of Inclusive Charged Pion Production in Polarized p+p Collisions at 200 GeV — ADAM KOCOLOSKI, Massachusetts Institute of Technology, STAR COLLABORATION — A primary goal of the STAR Spin program at RHIC is the measurement of the polarized gluon distribution function $\Delta g$, which can be obtained from a global analysis incorporating measurements of the double spin asymmetry $A_{LL}$ in various final state channels of polarized p+p collisions. Final states with large production cross sections such as inclusive jet and hadron production are analyzed as the program moves towards the measurement of $A_{LL}$ in the theoretically clean channel of pion production. The channels with the largest $A_{LL}$ are unique in that the ordering of the measurements of $A_{LL}$ in these two channels is sensitive to the sign of $\Delta g$. Moreover, STAR has already established the procedure for the identification of charged pions and the calculation of their production cross-sections over a broad kinematic range. This contribution will present first measurements of double longitudinal spin asymmetries for inclusive charged pion production extracted from 3 pb$^{-1}$ of data at $\sqrt{s}=200$ GeV and 50% beam polarizations. The asymmetries are calculated over the transverse momentum region 2<p$<12$ GeV/$c$ and compared with theoretical predictions incorporating several gluon polarization scenarios. A systematic bias introduced by the selection of charged pions from events satisfying electromagnetic energy triggers will be discussed and estimated using Monte Carlo.

10:12AM GF.00007 Longitudinal Double Spin Asymmetry and Cross Section for Direct Photon Production at Mid-rapidity in Polarized pp Collisions at $\sqrt{s} = 200$ GeV — ROBERT BENNETT, State University of New York at Stony Brook, PHENIX COLLABORATION — Inclusive direct photon production to $\sqrt{s} = 200$GeV pp collisions at RHIC, is one of the important channels PHENIX will employ to determine the polarized gluon distribution. We measure the cross section and the longitudinal double spin asymmetry $A_{LL}$ of direct photons using PHENIX data recorded in 2003 (Run-3) and 2005 (Run-5), with the perturbative QCD calculations at next-to-leading order. The extraction of the cross section relies on two techniques: First purifying our sample by considering only isolated photons as direct photon candidates and second by a statistical subtraction of weighted spectra of known sources of indirect photons from the total photon event sample. We then proceed to evaluate the double helicity spin asymmetries from these data sets, and extract the polarized gluon distribution, $\Delta g$, using the known polarized quark distribution functions obtained from deep inelastic scattering. Final results from Run-3, based on luminosity of 240 nb$^{-1}$ and polarization of 27%, and the status of Run-5 analysis, 2.7 pb$^{-1}$ and polarization 45%, will be presented in this talk.

10:24AM GF.00008 Di-final state measurements to constrain event kinematics in longitudinally polarized p+p collisions at STAR — TAI SAKUMA, MIT, STAR COLLABORATION — A primary motivation of the RHIC spin program is the extraction of the gluon helicity distribution ($\Delta g$) from polarized p+p collisions. Initial studies have focused on measurements of inclusive final states, such as pions and jets. Steady improvements in RHIC integrated luminosity and polarization open more exclusive final states such as di-jets and di-hadrons, allowing tighter constraints on initial state parton kinematics. With it’s large acceptance electromagnetic calorimetry and tracking, STAR is particularly well suited for this measurement. We report progress towards measurement of di-jet and di-hadron final state $A_{LL}$ extracted from $~6$ pb-1 of polarized p+p collisions at 200 GeV. In particular, we focus on data vs MC comparisons that provide insight into the level of constraint of the event kinematics.
10:36AM GF.00009 Transverse Quark Spin Effects in Azimuthal Asymmetries in SIDIS and Drell Yan. LEONARD GAMBING, Penn State Berks — The connection between quark orbital angular momentum and final state interaction for transversely polarized quarks in unpolarized hadrons suggests significant cos2\(\phi\) azimuthal asymmetries in pion production in semi-inclusive deep inelastic scattering (SIDIS) (\(e p \rightarrow e' X\)) and in di-lepton production in Drell Yan (\(p p \rightarrow e^+e^- X\)). When transverse momentum of the reaction, \(P_T\), is on the order of or less than \(\Lambda_{QCD}\), that is where \(P_T \sim k_T\), where \(k_T\) is intrinsic transverse quark momentum, these effects are characterized in term of naive time reversal odd (so-called T-odd) transverse momentum dependent (TMD) parton distribution and fragmentation functions. At these moderate transverse momentum scales we estimate the size of the cos2\(\phi\) azimuthal asymmetry in SIDIS and Drell Yan scattering in the parton spectator framework. In the former case we consider this so called “Boer-Mulders” effect for a proposed experiment at the upgraded CLAS-12 GeV detector at Jefferson Lab. In the latter case we consider this asymmetry for proton anti-proton experiments.

10:48AM GF.00010 Determination of the Collins Function from Di-Hadron Fragmentation in \(e^+e^-\) Annihilation. MATTHIAS GROSSE PERDEKAMP, DAVID MERTENS, RALF SEIDL, University of Illinois — The Collins function connects transverse quark spin with an observable azimuthal asymmetry of final state hadrons around the initial quark momentum direction. The Belle experiment has carried out a first measurement of Collins asymmetries for pion pairs produced in \(e^+e^-\) annihilation. We will present an extraction and parametrization of the favored and disfavored Collins fragmentation functions from the Belle fragmentation data as functions of the fractional hadron energy. We will discuss the sensitivity of the Belle data in discriminating between different possible functional forms for the Collins fragmentation function.

11:00AM GF.00011 Transverse Single Spin Asymmetries for identified charged hadrons in \(p+p\) collisions at \(\sqrt{s}=200\) and 62 GeV. J.H. LEE, F. VIDEBAEK, Brookhaven National Laboratory, BRAHMS COLLABORATION — The transverse single-spin asymmetries of identified charged hadrons, \(\sigma_1\), of K, p and pbar, have been measured at mid and forward rapidities in polarized proton-proton collisions at \(\sqrt{s}=200\) GeV and for \(p_T\) = 0 to 62 GeV. The data were obtained with the two magnetic spectrometers in the BRAHMS experiment at RHIC. The data cover a Feynman-x (x_F) range 0.003 to 0.30 at 200 GeV and 0.06 to 0.62 at 62 GeV in 0.05 < \(p_T\) < 1.5 GeV/c. The dependence on \(p_T\) and x_F are discussed in the context of theoretical models based on pQCD. In addition, inclusive cross sections at forward rapidities are compared to NLO pQCD calculations. This work is supported by the Division of Nuclear Physics of the Office of Science of the US DOE.

11:12AM GF.00012 Measurement of Sivers Transverse Spin Asymmetries for Di-Jet Production in 200 GeV Polarized Proton Collisions at STAR. STEVEN VIGDOR, Indiana University, STAR COLLABORATION — Hard-scattering collisions of transversely polarized protons may be preferentially initiated by partons with transverse momentum (k_T) directed toward one side of the plane formed by the proton’s momentum and spin vectors [1]. Parton orbital angular momentum within the proton is a prerequisite for this so-called Sivers effect. We report the first measurement of this effect in collisions of transversely polarized pp beams, using di-jet production data acquired with the STAR detector during the 2006 RHIC run. A non-zero Sivers function would be manifested directly by a spin-dependent change in the distribution of the azimuthal opening angle between the two reconstructed jets [2]. We present a preliminary analysis reconstructing the jet thrust axes only from the electromagnetic calorimeter component of the jet energies, recorded online at trigger level for a sample of \(\sim\) 3 million di-jet events. By selecting subsets of events within particular phase space regions, we can emphasize quark- or gluon-dominated Sivers functions. In addition to experimental results, we present model simulations that demonstrate the correlations among various measures of the Sivers asymmetries, and their sensitivity to the shape of the underlying k_T distribution. [1] D. Sivers, Phys. Rev. D41, 83 (1990) and Phys. Rev. D43, 261 (1991). [2] D. Boer and V. Vogelsang, Phys. Rev. D69, 094025 (2004).

11:24AM GF.00013 Measurement of dipion azimuthal angular correlations in transversely polarized pp collisions at \(\sqrt{S} = 62.4\) GeV in Center of Mass using PHENIX detector at RHIC. NATHAN MEANS, SUNY Stony Brook, PHENIX COLLABORATION — It has been recently suggested that observation of azimuthal asymmetry in back-to-back jets produced in single transversely polarized pp collisions at RHIC would be a direct evidence for non-zero transverse momentum in the nucleon [Boer and Vogelsang]. The connection of this transverse momentum and the orbital angular momentum of the partons in the nucleons has also been discussed in the literature. PHENIX is a multipurpose detector at RHIC with electromagnetic calorimeter (\(d\phi \times dp_T = 0.01 \times 0.01\)) in the diagonally opposite \(d\phi = 90^\circ\) regions around the horizontal plane, and a pseudorapidity range of \(|y| = 0.35\). This enables PHENIX excellent measurement of \(e^+e^-\) which may be the remnants of produced the jet in pp collisions. In the recently finished run (RHIC Run-6) we added the Muon Pion Calorimeter (MPC), a new PbWO_4 crystal calorimeter, which covers the pseudorapidity range 3.1 to 3.6 and \(\phi = \pi\). With these two EM calorimeters we plan to make the back-to-back angular correlation measurements in double pion production from the transverse proton-proton collisions. About 20 nb^{-1} of data with an average beam polarization of 57% were collected in Run-6. I will present the status of this analysis from Run-6 data.

11:36AM GF.00014 Perspective of \(\Lambda\) hyperon production in semi-inclusive DIS with an 11 GeV electron beam at Jefferson Lab. XIAODONG JIANG, Rutgers, the State University of New Jersey, HAI-JIANG LU, University of Science and Technology of China, Hefei, China — With the planned energy upgrade and the large acceptance CLAS12 detector operated at the high luminosity of 10^{34} cm^{-2}s^{-1}, Jefferson Lab provides unique opportunities to study \(\Lambda\) hyperon productions in semi-inclusive DIS reactions in the current fragmentation regime (x_F > 0.1, z > 0.5). Based on the LUND model and the recent HERMES data, we carried out numerical estimations of the following physics observables: 1. lepton to \(\Lambda\) longitudinal spin transfer, 2. beam-target double-spin asymmetries, 3. nucleon to \(\Lambda\) spin transfer, 4. Induced \(\Lambda\) polarization on an unpolarized target, 5. transverse \(\Lambda\) polarization on a transversely polarized target. The projected statistical accuracies will be compared with existing theory models and recent data from the COMPASS and the HERMES collaborations.

11:48AM GF.00015 Realistic Simulation of W Boson Production in the PHENIX Muon Spectrometers. KRISTIN KIRILUK, University of Colorado, PHENIX COLLABORATION — The separate contributions of \(u\) and \(d\) quarks to the proton spin are at present known only from lepton DIS double spin asymmetries, in which they are extracted using the “hadron tagging” technique. Single spin asymmetries of leptons from W bosons produced in longitudinally polarized pp collisions are directly sensitive to the sea quark polarizations; a detailed understanding of the final hadron state is not required[1]. The PHENIX collaboration at RHIC plans to determine the W^+ and W^- boson production cross sections and single spin asymmetries at \(\sqrt{s} = 500\) GeV by detecting decay muons at forward and backward rapidities. In order to understand resolution, backgrounds, and efficiency effects, the PHENIX spectrometer simulation PISA was used to study the planned measurements and determine realistic expectations of the yields and the sensitivity to the light quark polarizations.

9:00AM GG.00001 Interference in vector meson production in Au + Au Collisions at $\sqrt{s} = 200$ GeV from STAR. BROOKE HAAG, UC Davis, STAR COLLABORATION — Photoproduction in Ultra Peripheral Collisions (UPCs) at the RHIC generates $\rho$ mesons. This occurs when a photon from one nucleus fluctuates into a quark-antiquark pair and scatters off the second nucleus producing a vector meson. The $t = p_T^2$ spectrum of the produced $\rho$ mesons, where $t$ is the 4 momentum transfer squared, is sensitive to interference between the two possible production channels: the first nucleus emits a photon which scatters from the second nucleus, or vice versa. This interference is observed in the STAR data as a suppression in the $dN/dt$ spectrum at small $t$. In this talk, a measurement of the degree of interference will be presented as well as a discussion of systematic and statistical errors.

9:12AM GG.00002 Systematic uncertainties in heavy ion collision centrality measures1. LANNY RAY, MICHAEL DAUGHERITY, The University of Texas at Austin — The collision centrality for relativistic heavy-ion scattering events is often reported in terms of geometrical quantities using a model to relate the latter to multiplicity [1]. Using a Monte Carlo Glauber model the accuracy of several geometrical measures is reported for collision systems relevant to the RHIC program. The measures include impact parameter, number of interacting nucleons ($N_{NN}$), number of binary interactions ($N_{2NN}$), and the average number of binary collisions per incident participant nucleon $\nu = N_{2NN}/N_{part}$ for Au-Au collisions at $\sqrt{s}_{NN}$ = 20, 62, 130 and 200 GeV and Cu-Cu at 62 and 200 GeV. Systematic uncertainties in the centrality measures due to errors in the matter densities, nucleon-nucleon cross section, multiplicity production model, and measured multiplicity frequency distribution are estimated. We find that the impact parameter is most accurately determined, followed closely by $\nu$. Centrality measures $N_{NN}$ and $N_{2NN}$ can be significantly affected by experimental uncertainties in the multiplicity frequency distribution [1], particularly that caused by trigger and primary vertex finding inefficiencies for low multiplicity events. Combined systematic errors for each collision system are given.

1Supported in part by the U. S. Dept. of Energy.

9:24AM GG.00003 Centrality dependence of thermal excitation-energy deposition in 14.6 GeV/c p+Au reactions and 8.0 GeV/c pbar/π−+Au reactions. RON SOLTZ, Lawrence Livermore National Laboratory, E900 COLLABORATION — Experiments E900 and E900a recorded data from proton, $\pi^-$, and antiproton induced reactions on Au using the at the BNL AGS using the ISIS 4π spectrometer. The energy and angular distributions for light-charged particles with $E/A > 8$ MeV and intermediate mass fragments with $3 < Z < 16$ were used to extract the excitation energy deposition for each event. We analyzed data for the highest energy runs of 8 and 14.6 GeV using protons with $30 < E < 350$ MeV (grey protons) to extract the mean number of hadron-nucleon inelastic scatterings ($n$) and the mean impact parameter (b) as a function of the grey track multiplicity. The analysis follows that of Experiment E910 and previous emulsion experiments of hadron-nucleus collisions in that an assumed distribution for the grey track multiplicity was convoluted with a glauber distribution and fit to the data. Systematic errors were estimated by varying the shape of the assumed distributions, the grey track cuts, and the hadron-nucleon cross-section of the glauber model. The thermal excitation-energy deposition will be presented as a function of the mean number of hadron-nucleon scatterings and the mean impact parameter.

9:36AM GG.00004 Charged Particle Multiplicities from Cu+Cu, Au+Au and d+Au Collisions at RHIC. ANETA IORDANOVA, University of Illinois at Chicago, PHOBOS COLLABORATION — The charged particle multiplicity produced at RHIC will be presented as a function of collision energy, system size and geometry. The results will include d+Au, Au+Au and the recent Cu+Cu data. The data presented will utilize the unique, and nearly complete, solid angle coverage of the PHOBOS detector. With the data available, we will examine volume effects on the charged particle multiplicity to address global features of the particle production at RHIC energies. The data will be discussed in terms of collision geometry scaling of mid-rapidity yields and extended longitudinal scaling of the pseudo-rapidity density distributions.

9:48AM GG.00005 Energy Dependence of Short and Long-Range Multiplicity Correlations in Au+Au Collisions at RHIC. TERENCE TARNOWSKY, Purdue University, STAR COLLABORATION — Production of particles in the central rapidity region is dominated at all energies by short range correlations (SRC). Correlations that extend over a longer range are observed in high energy hadron-hadron interactions. Results from STAR for short and long-range multiplicity correlations (LRC) are presented for Au+Au collisions at $\sqrt{s}_{NN} = 200$ and 62.4 GeV. These correlations are measured with an increasing gap in pseudorapidity ($|\eta|$), from no gap to a separation of 1.6 units. A suppression in the SRC strength near midrapidity is observed in central Au+Au data at 200 GeV. An increase in LRC are seen with larger $|\eta|$. For $p_T > 1$ GeV, the suppression in SRC is diminished. This suppression of the SRC at midrapidity is not seen in Au+Au data at 62.4 GeV. Comparisons to HIJING and the Parton String Model (PSM) do not fully reproduce the central Au+Au data. String fusion as implemented in the PSM is one possibility that has been explored to understand the behavior seen in the data. This result may indicate a reduction of particle sources and possible formation of high density matter in central 200 GeV Au+Au collisions.

10:00AM GG.00006 ABSTRACT WITHDRAWN

10:12AM GG.00007 Scaling properties of Elliptic Flow at RHIC energies1. ARKADJU TARANENKO, Department of Chemistry, SUNY Stony Brook, PHENIX COLLABORATION — Elliptic flow $v_2$ is one of the most sensitive probes to study the dynamical evolution and properties of the hot and dense medium created in ultra-relativistic heavy ion collisions at RHIC. One of the most important observations is the very good description of these measurements, up to $p_T < 1.5$ GeV/c, by perfect fluid hydrodynamics, which predicts several scaling relations between elliptic flow and eccentricity, colliding system size, and transverse kinetic energy for different particle species. Testing these scaling predictions give the possibility to understand better the properties of the matter produced in heavy-ion collisions at RHIC. Detailed analysis of the scaling properties of the fine structure of elliptic flow at RHIC (i.e dependence on transverse momentum, particle type, centrality, system size, colliding energy...) will be presented and discussed.

1for the PHENIX collaboration

10:24AM GG.00008 Elliptic Flow of Unidentified Hadrons at Forward Rapidity in 200GeV Au+Au collisions at RHIC. MATTHEW WYSOCKI, University of Colorado at Boulder, PHENIX COLLABORATION — Elliptic flow ($v_2$) for different particles and in different regions of momentum space is a useful constraint on hydrodynamic models of heavy ion collisions at RHIC. Previous measurements of $v_2$ at forward rapidity in Au+Au collisions have been integrated over all $p_T$. Unidentified hadrons can be measured using the PHENIX Muon Spectrometers out to $|y| < 2.0$, and their $v_2$ as a function of transverse momentum characterized. A description of the method for selecting hadrons is given, along with the most recent results.
10:36AM GG.00009 Centrality, \( p_T \) and particle-type dependence of azimuthal anisotropy in Au+Au collisions at RHIC. YAN LU\(^1\), LBNL/IOPP — Anisotropy parameters \( v_1, v_2, v_3, \ldots \) carry information about interactions at early times in high-energy nuclear collisions. The systematic studies of azimuthal anisotropy may shed light on the relevant initial conditions, the degree of thermalization of the system, the equation of state, and the relevant degrees-of-freedom at the time that the momentum space anisotropy is established. In this talk, I present STAR measurements of identified particle \( v_2 \) and \( v_4 \) from low \( p_T \) to high \( p_T \) and as a function of collision centrality. These measurements will provide the most complete investigation of hadron-mass ordering, quark-number scaling and particle-type dependencies at very high momentum. Two important consequences indicated from the observation: (i) ‘collective flows’ has developed prior to hadronization – partonic collectivity at RHIC; (ii) partons are flowing in a volume that is much bigger than that of nucleons prior to hadronization.

\(^1\)Yan Lu for STAR collaboration

10:48AM GG.00010 ABSTRACT WITHDRAWN

11:00AM GG.00011 Forward-rapidity Elliptic Flow at RHIC\(^1\), S.J. SANDERS, E.B. JOHNSON, U. Kansas, BRAHMS COLLABORATION — At RHIC energies large azimuthal anisotropies are observed in particle production with respect to the reaction plane for non-central heavy-ion collisions (i.e., azimuthal flow). Elliptic flow is measured by the 2\(nd \) harmonic \((v_2)\) of the Fourier expansion of the azimuthal distribution. The observed anisotropies and the measured \( v_2(p_T) \) values suggest an almost perfect fluid state is created, consistent with the production of a quark-gluon plasma. Most measurements of identified-particle \( v_2(p_T) \) behavior at RHIC have been done near mid-rapidity, although a strong pseudorapidity dependence is seen for the charged-hadron, \( p_T \)-integrated \( v_2 \) values\(^1\). The interpretation of the integral \( v_2 \) data is complicated, however, by the rapidity dependent change in \( \langle p_T \rangle \) for each particle type. This talk will present new results of the BRAHMS experiment on \( \pi^+ \), \( K^0 \) and \( \pi^- \) \( v_2(p_T) \) behavior at \( y \approx 0, 1, \) and \( 3 \). The associated spectra will also be presented to help disentangle the kinematic factors affecting the integral \( v_2 \) values. These results can be used to better define the longitudinal expansion of the medium created through heavy-ion reactions at RHIC energies.\(^1\) B.B. Back et al., PRL 94, 122303(2005).

\(^1\)This work was supported by the Office of Nuclear Physics of the U.S. Department of Energy.

11:12AM GG.00012 Elliptic Flow of Thermal Photons from Hydrodynamics, E. FRODERMANN, U. HEINZ, The Ohio State University, R. CHATTERJEE, D. SRIVASTAVA, VECC Kolkata — Anisotropic flow in non-central heavy ion collisions yields valuable constraints on dynamical models used to describe the evolution of the hot dense fireball. The elliptic flow of hadrons has been measured precisely, but hadrons only decouple from the thermal medium late in the evolution. Extracting information from hadrons about the QGP thus involves dynamical models. Photons, on the other hand, decouple from the medium upon creation, carrying information from the full fireball duration, particularly from the hottest early QGP stage. The flow pattern of direct photons should thus help to constrain dynamical models and the QGP equation of state especially during the early expansion stages. We calculate the elliptical flow of thermal photons in Au+Au collisions from a boost-invariant ideal hydrodynamical model. The photon elliptic flow decreases at high \( p_T \) in contrast to the hadronic elliptic flow, reflecting the weak collectivity during the early QGP phase. We also point out an interesting structure at low \( p_T \) which illuminates the dominating photon production channels in the late hadronic stage.

11:24AM GG.00013 \( T \)-Matrix Approach to Quarkonium Correlation Functions in the QGP, DANIEL CABRERA, RALF RAPP, Cyclotron Institute and Physics Department, Texas A&M University — We study the evolution of heavy quarkonium states with temperature in a Quark Gluon Plasma (QGP) by evaluating the in-medium \( \eta Q \) \( T \)-matrix within a reduced Bethe-Salpeter equation in both \( S \)- and \( P \)-wave channels. The underlying interaction kernel is extracted from recent finite-temperature QCD lattice calculations of the singlet free energy of a \( Q\bar{Q} \) pair. The bound states are found to gradually move above the \( Q\bar{Q} \) threshold after which they rapidly dissolve in the hot system. The \( T \)-matrix approach is particularly suited to investigate these mechanisms as it provides a unified treatment of bound and scattering states including threshold effects and the transition to the (perturbative) continuum. The \( T \)-matrix is then applied to calculate \( Q\bar{Q} \) spectral functions as well as pertinent Euclidean-time correlation functions which are then compared to results from lattice QCD. The sensitivity to the interplay of bound and scattering states is found to be large. We furthermore investigate the impact of finite-width effects on the single-quark propagators in the QGP as estimated from recent applications of heavy-quark rescattering to RHIC data.

11:36AM GG.00014 Numerical Studies of Time-Dependent Relativistic Quantum-Mechanical Systems, ATHANASIOS PETRIDIS, KHINLAY WIN, Drake University — Using the numerical staggered leap-frog method the time-dependent Dirac equation is solved for a variety of systems. Specifically the relativistic decay of spinors initially set in potential wells constant in time is studied and found to exhibit strong non-exponential features as well as non-monotonic dependence on the potential strength. The relativistic decay of mesons is examined as they propagate through a medium in view of the recent Relativistic Heavy Ion data. The employed method is very stable and fast and is implemented on standard desk-top computers without loss of accuracy for both one- and three-dimensional systems.

Saturday, October 28, 2006 9:00AM - 11:48AM –
Session GH DNP: Instrumentation II Gaylord Opryland Cheekwood F

9:00AM GH.00001 Position Resolution for PHENIX Muon Resistive Plate Counter, RUIZHE YANG, University of Illinois, Urbana-Champaign, PHENIX COLLABORATION — A new 1\(^{\text{st}} \) level muon trigger is being developed for the PHENIX experiment at Brookhaven National Laboratory. The trigger will be based on two fast momentum sensitive spectrometers using Resistive Plate Counters (RPC) for charged particle detection. The spectrometers will utilize RPC technology developed for the CMS experiment at CERN. Position resolution measurements of RPC prototypes have been carried out with cosmic rays. In this talk, we will discuss the position resolution which can be achieved with the PHENIX muon trigger RPCs.

9:12AM GH.00002 Multi-Gap Resistive Plate Chamber (MRPC) for the PHENIX TOF upgrade, HUGO VALLE, Vanderbilt University, PHENIX COLLABORATION — The PHENIX experiment has observed enhanced proton/pion ratios in central Au+Au collisions as compared to the expectation from parton fragmentation. The measurements have been done using the scintillator based Time-of-Flight (TOF) detector in the PHENIX east arm, which allowed \( p_t/K \) and \( K/p \) separation up to \( p_t = 2.5 \) and 4 GeV/c respectively. Particle identification (PID) to higher \( p_t \) (\( > 8 \) GeV/c) is needed to better characterize the hadron production mechanism at intermediate and high-\( p_t \) and differentiate between competing theoretical descriptions. The PHENIX detector is being upgraded with a high-\( p_t \) PID system. A cost-effective TOF system based on Multi-gap Resistive Plate chambers (MRPC) has been implemented as part of this upgrade. The MRPC-TOF will provide high-resolution timing measurement in the PHENIX West arm. It will supplant the PID provided by the Argon- and Fluorine-filled time projection chambers in the range of \( 0.2 < \ p_t < 9 \) GeV/c. Three different prototypes were installed and operated in heavy ion beam conditions during RUN5. The design goal of \( \sin(\alpha) \approx 100 \) ps has been achieved. The final TOF-MRPC detector will be installed and ready for operation for RUN7. The details on the MRPC design and the electronics chain will be presented.
9:24AM GH.00003 RPC Prototypes for the PHENIX Forward Muon Trigger Upgrade at RHIC, JUN YING, Georgia State University, PHENIX COLLABORATION — The PHENIX collaboration at RHIC plans to build a fast muon trigger system for the PHENIX detector based on Resistive Plate Chamber (RPC) technology to determine $W^+$ boson production cross sections and single spin asymmetries at $\sqrt{s} = 500$ GeV by detecting decay muons at forward and backward rapidities. Several prototypes have been built and tested using cosmic ray in order to understand the RPC performances like time resolution, trigger efficiency, power consumption etc. The results are reported here.


9:36AM GH.00004 Detection Efficiency of the Modular Neutron Array, T. BAUMANN, W.A. PETERS, ORNL, Michigan State University, East Lansing, MI 48824-1321, MONA COLLABORATION — The Modular Neutron Array (MoNA) has been designed as a high-efficiency large-area detector array for neutrons stemming from reactions of fast rare isotope beams. In its current setup, it is optimized for neutron energies between 30 and 100 MeV. MoNA consists of 144 detector modules of plastic scintillator. Two methods to gather experimental data on the detection efficiency were used, one by employing the breakup reaction of $^{11}$Be into $^{10}$Be plus a neutron, and one by comparing the response of MoNA to an additional liquid scintillator neutron detector. These experimental data will be presented together with simulated detection efficiencies.

The MoNA project is supported by the National Science Foundation.

9:48AM GH.00005 A prototype, high-efficiency, position sensitive neutron detector for the proposed neutron spin rotation experiment at the SNS, D.M. MARKOFF, NC Central University, V. CIANCIOLO, C.L. BRITTON, R.G. COOPER, R.J. WARMACK, ORNL — We are developing a position sensitive (~ 1 cm resolution) neutron detector with nearly 100% efficiency for use at the high flux (> 5 × 10^11 neutrons/sec) pulsed beam at the Oak Ridge Spallation Neutron Source (SNS). The prototype detector is important for transmission experiments such as the proposed parity-violating neutron spin rotation in hydrogen measurement. The detector concept integrates the segmented $^3$He ionization chamber designed for the preliminary spin-rotation in helium experiment and the position sensitive, charged particle collection technology currently being developed at ORNL for low-efficiency beam-translation monitors for the SNS. Neutron absorption on $^3$He produces $^1$H and $^4$H that pass through a wire grid producing an $e^-$ shower detected in current mode by wire strips mounted on a substrate. For 100% efficiency, regions are created with a series of high-voltage plates, grids, and wire strips each strategically located along the beam axis. Analysis over several regions with alternating wire strip orientation provides a two-dimensional beam profile. We will present our prototype model and test results.


10:00AM GH.00006 Cosmic Muon Detection using the NSCL Modular Neutron Array, W.F. ROGERS, S. MOSBY, E. MOSBY, J. GILLETTE, M. REESE, Westmont College, MONA COLLABORATION — The NSCL Modular Neutron Array (MoNA), constructed by a multi-institution collaboration (including several undergraduate colleges), was designed and constructed for the study of nuclei near the neutron dripline. During offline periods we’ve developed a program for use of MoNA for monitoring the long-term behavior of the cosmic muon angular flux distribution. The top and bottom layers of the array (each consisting of nine 2-m long position-sensitive scintillator detectors) are used to optically image the 2-dimensional muon flux distribution over a wide angular range of the sky. Continuous data acquisition is divided into hourly runs, locked to the sidereal clock. Of particular interest are time-dependent north-south and east-west asymmetries in the flux distribution, both long term trends as well as values binned into 24 solar and sidereal hours, and long time variation in the total integrated flux. The accumulated cosmic muon data is also used to track individual muons through the array in order to accurately position-calibrate all of the array detectors for use in accelerator experiments. Undergraduate students developed the coding for optical imaging and associated efficiency corrections for the device, and conducted analysis on stored data. Results will be presented.

The MoNA collaboration is supported by the National Science Foundation.

10:12AM GH.00007 The new PHENIX Reaction Plane Detector at RHIC, ERIC RICHARDSON, University of Maryland, PHENIX COLLABORATION — Determining event anisotropy is a key method used in the investigation of the hot dense partonic matter created at RHIC. The $v_2$ measurements of rare observables such as electrons, photons, $J/\psi$, and high $p_T$ particles provide rich information about the properties of this matter. Previous $v_2$ studies have been limited by statistics and reaction plane resolution. The installation of the new reaction plane detector at PHENIX will improve the reaction plane resolution in heavy ion collisions by a factor of 2 to $< \cos 2\Delta \Psi >$ 0.7. This talk will give an overview of the new PHENIX reaction plane detectors components, and discuss the detector’s design and expected results.

10:24AM GH.00008 The PHENIX Muon Piston Calorimeter, JOHN KOSTER, University of Illinois - Urbana Champaign, PHENIX COLLABORATION — The Muon Piston Calorimeter (MPC) is a new electromagnetic calorimeter which has been integrated into the muon forward spectrometers of the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory. The calorimeter acceptance is $2\pi$ in azimuth and $3.1 < \eta < 3.65$ in pseudorapidity. The MPC uses PbWO$_4$ scintillator crystals with APD readout developed for PHOS as part of the ALICE experiment at CERN. We present an overview of the detector, results from beam tests at the Meson Test Beam Facility at Fermi National Laboratory and first results from the operation of the MPC during the 2006 RHIC run.

For the PHENIX Collaboration

10:36AM GH.00009 Understanding Release from Actinide Targets – Recent Results from RIB Development, ANDREAS KRONENBERG, H.K. CARTER, E.H. SPEJEWski, Oak Ridge Associated Universities, D.W. STRACENER, Oak Ridge National Laboratory, OAK RIDGE ASSOCIATED UNIVERSITIES TEAM — Development of ion beams of short-lived isotopes is crucial for modern nuclear structure and nuclear astrophysics. The Holifield Radioactive Ion Beam Facility at Oak Ridge National Laboratory uses the ISOL (Isotope Separation Online) technique to provide radioactive ion beams. So far, uranium carbide has been used as a target to produce neutron-rich fission fragments. Thermodynamic calculations indicate the possibility of in-situ chemical side band formations of volatile species of refractory metals, such as V and Re. These elements release out of oxide targets after production in a nuclear reaction, and can occur only through in-situ formation of their volatile oxide. These have been confirmed experimentally. The results from recent, more detailed investigations of ThO2, UB4 and other actinide targets as well as conclusions from systematic studies will be presented. This research was sponsored by the NNSA under Stewardship Science Academic Alliance program through DOE Cooperative Agreement # DE-FC03-0NA0143.
10:48AM GH.00010 On Line Yield Measurements of UC Targets, H.K. CARTER, E.H. SPEJEWSKI, A. KRONENBERG, Oak Ridge Associated Universities, D.W. STRACENER, Oak Ridge National Laboratory, W. TALBERT, H.-H. HSU, TechSource, Inc, J. NOLEN, J. GREENE, T. BURTSEVA, Argonne National Laboratory — Actinide targets, especially UC, are being used in current radioactive beam facilities to provide neutron rich beams. For future facilities, especially high power, two-step, neutron-generator configurations, requirements such as thermal conductivity and release of a wide variety of beams must be satisfied simultaneously. A set of three different UC targets varying in particle size have been prepared by ANL and the release properties measured at the HRLS at ORNL. Using the UNISOR on line test facility which utilizes low intensity protons we have measured, for over 20 elements and 4 to 8 isotopes per element, the yields (atoms / sec) for each of these targets. We find that the yields for the different target materials are within a factor of 10 of each other however this difference is important both in the selection of target material and understanding the reasons for the different yields. The results of yield measurements will be presented with a discussion of our understanding of the processes.

11:00AM GH.00011 The Polarized \(^{3}\text{He}\) Target for the Measurement of \(G^{n}_{E}\) at high \(Q^{2}\) in Hall A, AMEYA KOLARKAR, University of Kentucky, E02-013 COLLABORATION, HALL A COLLABORATION — In early 2006, the Jefferson Lab experiment E02-013 successfully collected data to measure the neutron electric form factor \(G^{n}_{E}\), at four-momentum transfer values in the range of 1.2 to 3.5 (GeV/c)^2. It used a polarized \(^{3}\text{He}\) target and a polarized electron beam at energies up to 3.2 GeV to study the semi-exclusive \(^{3}\text{He}(e,e'\text{n})\) scattering reaction in quasi-elastic kinematics. The electrons were detected in the BigBite spectrometer and the recoiling neutrons in an array of scintillators. The data will be used to extract \(G^{n}_{E}\) from the transverse asymmetry \(A_{T}\). The expected statistical accuracy for \(\Delta G^{n}_{E}/G^{E}_{Dipole}\) is 0.04 for these values of \(Q^{2}\). To reduce the systematic uncertainties in \(A_{T}\), the magnetic field direction was measured to better than 2 rad with a newly developed air-floated compass. For the first time at JLab, the \(^{3}\text{He}\) target was polarized using spin-exchange with rubidium and potassium. A uniform magnetic field was generated in the target region by a newly developed iron enclosure. Nuclear Magnetic Resonance (NMR) and Electron Paramagnetic Resonance (EPR) techniques were used to measure target polarization. Polarizations in excess of 50% were achieved during running conditions. This talk will focus on various aspects of the target.

11:12AM GH.00012 The Neutron Detector for the Measurement of \(G^{n}_{E}\) at high \(Q^{2}\) in Hall A, JONATHAN MILLER, University of Maryland, HALL A COLLABORATION, E02-013 COLLABORATION — Data collection for an asymmetry measurement of the electric form-factor of the neutron, \(G^{n}_{E}\), was completed during the spring of 2006 in Hall A at the Thomas Jefferson National Accelerator Facility. To detect the neutron from the quasi-elastic \(^{3}\text{He}(e,e'\text{n})\) reaction, a large neutron detector was constructed with an active frontal area of 11.25 m^2. The techniques of the construction and the operation of the 1432 channel and 83 ton detector will be discussed. The achieved timing resolution and neutron detection efficiency, both critical for identifying the quasi-elastic neutrons, will be shown.

11:24AM GH.00013 The BigBite Spectrometer: Tracking and Optics for the Measurement of \(G^{n}_{E}\) at High \(Q^{2}\) in Hall A, SEAMUS RIORDAN, Carnegie Mellon University, E02-013 COLLABORATION, HALL A COLLABORATION — The \(G^{n}_{E}\) experiment, a measurement of the electric form factor of the neutron between the \(Q^{2}\) range 1.2 to 3.5 GeV^2 through \(^{3}\text{He}(e,e'\text{n})\) has been carried out at Jefferson Lab's Hall A. This experiment was made possible by the arrival of the BigBite spectrometer, a non-focusing large momentum and angular acceptance spectrometer. With a recently constructed detector package in BigBite, efforts are now being made to understand and optimize the reconstruction of charged particle tracks and momenta. The data taken during \(G^{n}_{E}\) provide a good opportunity for understanding the behavior and performance of the spectrometer. However, identifying tracks from charged particles accurately and efficiently is especially challenging given the high background rates up to 20 MHz at the detectors. Results showing the performance of the track reconstruction and the momentum resolution of the spectrometer will be presented.

11:36AM GH.00014 The BigBite Drift Chambers for the Measurement of \(G^{n}_{E}\) at High \(Q^{2}\) in Hall A, BRANDON CRAVER, University of Virginia, E02-013 COLLABORATION, HALL A COLLABORATION — A precision measurement of the electric form factor of the neutron, \(G^{n}_{E}\), has been carried out in Jefferson Lab's Hall A for \(Q^{2}\) values of 1.2 to 3.5 GeV^2 using a highly polarized \(^{3}\text{He}\) target and the quasi-elastic semi-exclusive \(^{3}\text{He}(e,e'\text{n})\) reaction. The experiment detected the ejected neutron with an array of scintillators and the scattered electron with the newly commissioned BigBite spectrometer. This new spectrometer has a large angular acceptance (80 msr), complementing the existing 6 msr high-resolution spectrometers, and will enable a new generation of low-rate experiments with lower resolution requirements. A package of three multi-wire drift chambers was constructed in order to allow the spectrometer to operate under high rate conditions and achieve a spatial resolution of \(\Delta r \sim 200 \mu m\). Novel construction techniques used for the drift chambers will be discussed. Online results showing chamber performance at raw hit rates up to 20 MHz per plane will be presented.

Saturday, October 28, 2006 2:00PM - 4:24PM — Session HA DNP: New Symmetries in Nuclei Gaylord Opryland Tennessee C

2:00PM HA.00001 Mixed Proton-Neutron Symmetry in the Valence Shell of Heavy Nuclei, E.A. MCCUTCHAN, Yale University — The understanding of collective nuclear structure often relies upon a set of benchmarks or symmetries which describe idealized limits. The three standard benchmarks of nuclear structure, the vibrator, rotor, and \(\gamma\)-soft structure have been known for decades. Few nuclei actually manifest these symmetries, however, and the range of structures between them is extensive. Until recently, transitional nuclei were traditionally described by numerical diagonalization of a multi-parameter Hamiltonian. However, newly proposed critical point symmetries, \(X(5)\) and \(E(5)\), can now describe nuclei at the point of a phase transition from spherical to deformed shapes. The success of these analytic models has generated considerable interest in developing other simple models to describe a wider class of transitional nuclei. These models in fact, now provide analytic solutions to describe the entire range of nuclei between spherical and deformed shapes. The predictions of these models, along with traditional descriptions, will be presented. They show both excellent agreement and striking discrepancies with the data on most transitional nuclei. This work was supported by the U.S. DOE Grant No. DE-F602-91-ER-40609.

2:36PM HA.00002 The Transition Between Symmetry Phases in Nuclei, E.A. MCCUTCHAN, Yale University — The understanding of collective nuclear structure often relies upon a set of benchmarks or symmetries which describe idealized limits. The three standard benchmarks of nuclear structure, the vibrator, rotor, and \(\gamma\)-soft structure have been known for decades. Few nuclei actually manifest these symmetries, however, and the range of structures between them is extensive. Until recently, transitional nuclei were traditionally described by numerical diagonalization of a multi-parameter Hamiltonian. However, newly proposed critical point symmetries, \(X(5)\) and \(E(5)\), can now describe nuclei at the point of a phase transition from spherical to deformed shapes. The success of these analytic models has generated considerable interest in developing other simple models to describe a wider class of transitional nuclei. These models in fact, now provide analytic solutions to describe the entire range of nuclei between spherical and deformed shapes. The predictions of these models, along with traditional descriptions, will be presented. They show both excellent agreement and striking discrepancies with the data on most transitional nuclei. This work was supported by the U.S. DOE Grant No. DE-F602-91-ER-40609.

3This research was supported under USDOE contract numbers DE-AC05-06OR23100 and W-31-109-ENG-38.
3:12PM HA.00003 Magnetic Moment of $^{57}$Cu and shell breaking of the $^{56}$Ni core, KEI MINAMISONO, NSCL, Michigan State University — The nuclear magnetic moment of the ground state of $^{57}$Cu was deduced for the first time. Together with a known magnetic moment of the mirror partner, $^{57}$Ni, the spin expectation value, which is a contribution of nucleon spins to the magnetic moment, was extracted from the isoscalar part of magnetic moments. In the $sd$ shell, a systematic trend of the spin expectation value of isospin $T = 1/2$ mirror nuclei has been observed. On the other hand, in the $fp$ shell, only a few mirror magnetic moments are known and therefore it is essential to measure more magnetic moments to explore the evolution of shell structure. Because $^{57}$Cu consists of the closed-shell $^{58}$Ni core plus one proton, the single-particle contribution is expected to be strong and any deviation from the shell model is a direct proof of shell breaking at $^{56}$Ni, which has been suggested [1] based on a systematic deviation between magnetic moments of odd-mass $Cu$ isotopes and theoretical shell-model predictions. From the resonance frequency, the magnetic moment was derived as $\mu_{s}^{(57)Cu} = (2.00 \pm 0.05)\mu_{N}$ [2]. The $A = 57$, $T = 1/2$ spin expectation value was extracted as $\langle \Sigma_{z} \rangle = -0.78 \pm 0.13$. The small $\mu_{s}^{(57)Cu}$ results in a large deviation and opposite sign from the shell-model calculations [3,4]. Considering the systematic behavior of the spin expectation value of $T = 1/2$ nuclei in the $sd$ shell, the present result indicates a significant shell breaking at $^{56}$Ni with the neutron number $N = 28$.


3:48PM HA.00004 Aspects of nuclear pairing, ALEXANDER VOLYA, Florida State University — Pairing correlations between nucleons are known to be one of the major driving forces behind the nuclear many-body dynamics. The collective effects resulting from pairing play a crucial role in many nuclear properties. Despite a long history the methods of treating pairing along with corresponding questions and problems have constantly evolved. The role of pairing in exotic nuclei where superconducting phase competes with particle instability will be addressed in this presentation. Apart from this, the mesoscopic nature of the problem also accentuates other problems such as interplay of pairing and collective effects including rotations and deformations. The extended pairing phase transition, instability to large fluctuations and related thermodynamical properties are inseparable components of nuclear superconductivity. In this presentation I will explore these questions highlighting simultaneously the novel methods and techniques. The method of Exact Pairing (EP) is based on the algebraic treatment of pairing that relies on quasispin algebra. Recently the EP has evolved into a powerful technique that provides an exact numerical solution to the many-body problem. The EP serves as a foundation for understanding of manifestations of pairing in mesoscopic systems, and provides some answers to the above questions. The method allows for far-reaching extensions such as inclusion of collective dynamics within Random Phase Approximation, treatment of interactions beyond pairing and exploration of continuum of reaction states. Considering pairing within a rotating deformed proton emitter I will address its effect on particle emission. The kinematical suppression of the recoil, known as Coriolis attenuation, due to the superfluid nature of the rotating core is of special interest.

Saturday, October 28, 2006 2:00PM - 4:00PM — Session HB DNP: Neutrino Physics II Gaylord Opryland Tennessee A

2:00PM HB.00001 CUORE: The Cryogenic Underground Observatory for Rare Events, E.B. NORMAN, M.J. DOLINSKI, Lawrence Livermore National Lab. — CUORE is a next-generation double beta decay experiment designed primarily to search for the neutrinoless double beta decay of $^{130}$Te. CUORE will use a bolometric technique to measure the temperature changes produced in large crystals of TeO$_2$ when radiation is absorbed. $^{130}$Te was selected for initial study because of its high Q-value energy of 2529 keV and its large natural isotopic abundance of 34%. These characteristics of $^{130}$Te place the expected position of the neutrinoless double beta decay peak above most background from terrestrial radioactive decays, and provide the desired experimental sensitivity without the need for expensive and time consuming isotopic enrichment. The construction of CUORE has recently begun at the LNGS in Italy. CUORICINO is a working prototype for CUORE and is currently the largest operating double beta decay experiment in the world. In this talk, the present status of CUORE and the latest experimental results from CUORICINO will be presented.

3:12PM HB.00002 Recent progress on the Majorana experiment, ROB JOHNSON, University of Washington, MAJORANA COLLABORATION — The Majorana collaboration proposes to search for the process of neutrinoless double-beta decay by employing high-purity, segmented, enriched (86% $^{76}$Ge) germanium as both source and detector. Recent improvements in signal processing, detector design, and advances in controlling intrinsic and external backgrounds will augment this well-established technique. The Majorana reference design advances a scalable approach in which detectors are deployed in modules consisting of 57 1.1-kg germanium crystals in a cryostat made of electro-formed copper. The experiment’s initial phase with one or more modules aims to quickly and definitively test a recent claimed observation of this decay in $^{76}$Ge by members of the Heidelberg-Moscow collaboration. In addition, the collaboration seeks to achieve backgrounds near 1 count/tonne/year in a 4 keV region-of-interest around the $^{76}$Ge double-beta decay endpoint (2039 keV) in order to demonstrate the required backgrounds for a next-generation experiment with $\geq$ 1 tonne detector mass. With such low backgrounds and after 3 years of running with 60 kg of $^{76}$Ge, Majorana will achieve a sensitivity of $T_\beta = 2 \times 10^{26}$ years (90% CL), corresponding to a Majorana neutrino mass sensitivity of 200 meV (using the latest RQRPA nuclear matrix element calculation$^\dagger$).

$^\dagger$This work is supported by the DOE Office of Nuclear Physics.

V.A. Rodin, et al., nucl-th/0503063
2:24PM HB.00003 Neutron excitation of lead and copper in search for specific excited state decays1, DONG-MING MEI, Los Alamos National Laboratory/University of South Dakota, STEVE ELLIOTT, ANDREW HIME, Los Alamos National Laboratory, ANTON TONCHEV, WERNER TORNOW, MICHAEL ANTANACI, ANDRII CHYZH, JAMES ESTERLINE, BRENT FALVIN, CALVIN HOWELL, ANTHONY HUTCHESON, HUGO KARWOWSKI, JOHN KELLEY, MARY KIDD, BEN SPAUN, Triangle Universities Nuclear Laboratory, MAJORANA COLLABORATION — Monoenergetic neutron beams of 8 and 12 MeV were produced at the TUNL Shielded Neutron Source. The beam-on data obtained with three CLOVER detectors were used to measure the excitation function in lead and copper for some specific excited state decays. These decays are an important background for the next generation of double-beta decay experiments which are designed to reach the sensitivity set by the atmospheric neutrino mass scale. Measuring and understanding high energy neutron excitation of the shielding and detector materials for neutrinoless double beta decay experiments are crucial for interpreting the result and establishing the shielding requirements. Moreover, locating some specific excited state transitions, such as the $5/2^+$ to $2/2^-$ decay in $^{207}$Pb, the $1^+$ to $1^+$ decay in $^{206}$Pb etc., will make important contributions to nuclear structure.


2:36PM HB.00004 Prospects for Measuring Neutrino-Nucleus Coherent Scattering at a Stopped-Pion Neutrino Source, KATE SCHOLBERG, Duke University — Coherent neutral current neutrino-nucleus elastic scattering has never been observed. Although the cross-section is very high, nuclear recoil energies are very small. However, detection of the process may be within the reach of the new generation of low-threshold detectors. A promising prospect for the first detection of this process is an experiment at a high flux stopped-pion neutrino source such as the SNS. Results of some preliminary rate calculations will be presented, and sensitivity of such a measurement to new physics will be explored.

2:48PM HB.00005 Developing the Cosmic Ray Veto for $\nu$-SNS1, L. ERIKSON, J. EASTBURG, U. GREIFE, Colorado School of Mines. $\nu$-SNS COLLABORATION — The newly operational Spallation Neutron Source (SNS) will produce large quantities of neutrinos ($\sim 2 \times 10^{17}/\text{cm}^2\text{s} / \text{at} 20\text{m}$) at energies relevant to nuclear astrophysics. To exploit this opportunity, the proposed Neutrinos at the SNS (\nu-SNS) facility will host 2 detectors (target mass of $\sim 20$ tons each) to measure neutrino-nucleus cross sections for a number of materials (e.g. C, O, Fe, Pb). Shielding the detectors from background is crucial so the facility will employ an iron bunker and a cosmic ray veto. As part of the \nu-SNS collaboration, the Colorado School of Mines nuclear group is responsible for the design and construction of this veto. Presented in this talk is the current progress for the research and development of the highly efficient, low cost, large veto panels based on extruded plastic scintillator.

3:00PM HB.00006 Three flavor neutrino oscillation analysis of atmospheric neutrinos in Super-Kamiokande, ROGER WENDELL, Duke University, SUPER-KAMIOKANDE COLLABORATION — The nature of the neutrino mass hierarchy and the possibility of a nonzero $\theta_{13}$ are open problems in neutrino physics that can be probed by extending the standard two-flavor neutrino oscillation scenario to include all active flavors. In a three-flavor oscillation scheme there is known resonant enhancement (suppression) of the $\nu_\mu \rightarrow \nu_e$ transition probability in matter for several GeV neutrinos at long baselines for a normal (inverted) hierarchy when $\theta_{13} > 0$. This effect is not present for the corresponding anti-neutrino transition. The Super-Kamiokande I atmospheric data has been analyzed using a three-flavor model testing both the normal and inverted mass hierarchies and has found no significant change in flux in its enriched multi-GeV $\nu_\mu$ or $\nu_e$ samples. Accordingly, confidence intervals for the atmospheric oscillation parameters have been obtained, the best fits being consistent with previous atmospheric results and zero $\theta_{13}$ for both hierarchies.

3:12PM HB.00007 NEXTEX- The next generation of electron anti-neutrino mass experiment, JACEK BORYSOW, Michigan Tech University, MANFRED FINK, The University of Texas at Austin, HERMANN WELLENSTEIN, Brandeis University, TIMOTHY GAY, University of Nebraska at Lincoln, RICHARD MAHWORTER, Pomona College — The design and progress towards meeting the objectives of the Neutrino Mass Experiment in Texas (NEXTEX) is presented. The mass of the electron antineutrino will be inferred from the beta endpoint energy spectrum from gaseous tritium molecules with precision of at least 0.5 eV. Two differential electrostatic spectrometers will be used to analyze the beta electrons near the endpoint energy with 1 eV resolution. The mass of the neutrino will be deduced following the deconvolution of the well established Fermi function and the measured spectrometer function. The correlations between electrodes' potentials and the energy of the transmitted electrons will be determined with high endpoint energy with 1 eV resolution. The mass of the neutrino will be deduced following the deconvolution of the well established Fermi function and the measured spectrometer function. The correlations between electrodes’ potentials and the energy of the transmitted electrons will be determined with high energy electron diffraction on the T$_2$ gas. The differential cross section exhibits an oscillatory pattern due to the coherent scattering from the two atoms forming T$_2$. This procedure will provide a series of calibration markers for the spectrum with uncertainties of about 100 meV. The background of less than one count a day, at the detector have been demonstrated. The isotopic purity of tritium is monitored by a novel, laser diode based Raman Spectrometer.

3:24PM HB.00008 Measuring the Neutrino Mixing Angle $\theta_{13}$ with Reactor Antineutrinos at Daya Bay, KARSTEN HEEGER, LBNL and University of Wisconsin, Madison. DAYA BAY COLLABORATION — The observation of neutrino flavor change and mixing in recent experiments has provided compelling evidence for neutrino mass and oscillation. Two of the three neutrino mixing angles have been measured but the coupling of the electron neutrino flavor to the third mass eigenstate is not yet known. Its corresponding mixing angle $\theta_{13}$ is a fundamental parameter of the new Standard Model and critical for future CP violation searches in the lepton sector. This talk will describe the proposed precision measurement of $\theta_{13}$ with the Daya Bay reactor antineutrino experiment and report on its recent progress and status. Using multiple liquid scintillator detectors at distances between 0.3 and 2 km from the Daya Bay-Ling Ao nuclear power plant the experiment plans to measure the subdominant $\nu_e$ oscillation with a sensitivity of $\sin^2 2\theta_{13} \lesssim 0.01$.

3:36PM HB.00009 The Detector Calibration System for the Daya Bay Reactor Neutrino Experiment, JIANGLAI LIU, California Institute of Technology, DAYA BAY REACTOR NEUTRINO COLLABORATION — The detector calibration system will be critical for the analysis of the Daya Bay Reactor Experiment. The experiment will use multiple detector modules at various baselines from the reactor cores to measure the neutrino mixing angle $\theta_{13}$ with a sensitivity to $\sin^2 2(\theta_{13}) < 0.01$. The modules must be "identical," therefore the detector properties need to be understood and calibrated accurately. In this talk, I will present some R&D work towards an automated full-volume calibration system, including the simulation studies with various radioactive sources, as well as a preliminary hardware design.
3:48PM HB.00010 Development of Gadolinium-Loaded Liquid Scintillators for 1%-Precision Measurement at the Daya Bay Nuclear Reactors of the Neutrino Mixing Angle, $\theta_{13}$. R.L. HAHN, M. YEH, A. GARNOV, Chemistry Department, Brookhaven National Laboratory, Upton NY 11973, DAYA BAY COLLABORATION — The Daya Bay collaboration intends to use multiple organic-liquid-scintillator (LS) detectors placed at various distances between 0.3 and 2 km from the Daya Bay LNG Ao nuclear power reactors to detect antineutrino oscillations and to determine the unknown neutrino-mixing angle, $\theta_{13}$. The nuclear reaction in the LS is inverse $\beta$-decay on protons, with the coincidence tag between the emitted prompt positron and the delayed neutron-capture providing a clear signature of the antineutrino capture. The neutron-capture signal is enhanced by loading $\sim$0.1% gadolinium into the liquid scintillator (Gd-LS), because of the 49000-barn ($n,\gamma$) cross section of natural abundance Gd and the $\sim$8 MeV of emitted $\gamma$ rays. The Daya Bay plan is to use eight identical antineutrino detectors, each containing 20 tons of Gd-LS. The BNL Nuclear Chemistry Group has developed chemical procedures to synthesize high-purity Gd-LS with long attenuation length (>15 m), high light output ($\sim$95% of pseudocumene), and long-term stability (>1.5 years to date). Groups at IHEP in Beijing, China and JINR in Dubna, Russia are also doing Gd-LS R&D. This paper discusses the properties of Gd-LS.


Saturday, October 28, 2006 2:00PM - 4:48PM — Session HC DNP: Electroweak Interactions II Gaylord Opryland Tennessee B

2:00PM HC.00001 Overview of the Parity Violating Neutron Spin Rotation Measurement in Liquid $^{4}\text{He}$, T.D. FINDLEY, C.D. BASS, J.M. DAWKINS, J.C. HORTON, C.R. HUFFER, D. LUO, A.M. MICHERDZINSKA, M.G. SARSOUR, W.M. SNOW, Indiana University / IUCF, B.E. CRAWFORD, Gettysburg College, K. GAN, A.K. OPPER, The George Washington Univ, B.R. HECKEL, H.E. SWANSON, Univ of Washington, P.R. HUFFMAN, D.M. MARKOFF, North Carolina Central Univ, H.P. MUMM, J.S. NICO, NIST, E.I. SHARAPOV, Joint Institute for Nuclear Research, Dubna, V. ZHUMABEKOVA, Al-Farabi Khazakh National Univ — We present an overview of the physics and experimental design of an experiment to measure the parity violating (PV) neutron spin rotation of polarized neutrons propagating through liquid $^{4}\text{He}$. This spin rotation is a PV observable that can be used to study the hadronic weak interaction, which is poorly understood. A previous measurement gave a result of $(8.0\pm1.4\,\text{(stat)}\pm2.2\,\text{(syst)})\times10^{-7}$ rad/m [1]. The new measurement has sensitivity goal of $3\times10^{-7}$ rad/m. [1] PhD thesis: Measurement of the Parity Nonconserving Spin-Rotation of Transmitted Cold Neutrons Through a Liquid Helium Target; D.M Markoff

2:12PM HC.00002 ABSTRACT WITHDRAWN —

2:24PM HC.00003 Calibration of Apparatus for Parity-Violating Neutron Spin Rotation in $^{4}\text{He}$ Using Heavy Nuclei and Small Angle Scattering Standards, J.M. DAWKINS, Indiana Univ./IUCF, V. ZHUMABEKOVA, Al-Farabi Khazakh National Univ., K. GAN, A.K. OPPER, The George Washington Univ., B.E. CRAWFORD, Gettysburg College, C.D. BASS, J.M. DAWKINS, T.D. FINDLEY, J.C. HORTON, C.R. HUFFER, D. LUO, A.M. MICHERDZINSKA, M. SARSOUR, W.M. SNOW, Indiana University / IUCF, E.I. SHARAPOV, Joint Institute for Nuclear Research, Dubna, H.P. MUMM, J.S. NICO, NIST, D.M. MARKOFF, North Carolina Central Univ., P.R. HUFFMAN, North Carolina State Univ. / TUNL, B.R. HECKEL, H.E. SWANSON, Univ. of Washington — A measurement of parity-violating (PV) neutron spin rotation in light $^{4}\text{He}$ is being prepared at the NIST Center for Neutron Research (NCNR). To test the apparatus and amplify certain possible systematic effects we plan to conduct spin rotation measurements in the nuclei $^{139}\text{La}$, $^{81}\text{Br}$, and $^{35}\text{Cl}$. Large PV spin rotation effects have been seen in the past in $^{139}\text{La}$ and $^{81}\text{Br}$, and $^{35}\text{Cl}$ possesses a large P-odd gamma asymmetry. We also plan to use $^{2}$H$_{2}$O, whose small angle neutron scattering is well-known, to verify our estimates of systematic effects from small angle scattering and longitudinal magnetic fields. I will talk about our choices of targets and the design of target system. Work supported in part by NSF PHY-0457219.

2:36PM HC.00004 Measurements of Polarized Neutron Beam Properties at NG-6 NIST and Performance of Polarized Neutron Optical Devices for a Precision Measurement of Parity-Violating Neutron Spin Rotation in $^{4}\text{He}$, A.M. MICHERDZINSKA, Indiana Univ./IUCF, V. ZHUMABEKOVA, Al-Farabi Khazakh National Univ., K. GAN, A.K. OPPER, The George Washington Univ., B.E. CRAWFORD, Gettysburg College, C.D. BASS, J.M. DAWKINS, T.D. FINDLEY, J.C. HORTON, C.R. HUFFER, D. LUO, M.G. SARSOUR, W.M. SNOW, Indiana Univ./IUCF, E.I. SHARAPOV, Joint Institute for Nuclear Research, Dubna, H.P. MUMM, J.S. NICO, NIST, D.M. MARKOFF, North Carolina Central Univ., P.R. HUFFMAN, North Carolina State Univ./TUNL, B.R. HECKEL, H.E. SWANSON, Univ. of Washington — A measurement of parity-violating (PV) neutron spin rotation in $^{4}\text{He}$ to learn about NN weak interactions is now in preparation at the NIST Center for Neutron Research (NCNR). Because the expected magnitude of the PV signal is $\sim 10^{-7}$ rad/m, and our sensitivity goal is $3\times10^{-7}$ rad/m, knowledge of certain beam properties is essential to interpret the data properly and set limits on possible sources of systematic errors. I will present measurements of the beam intensity profile, wavelength distribution, flux, and the product of the polarizing power of the polarizer and the analyzing power of the polarization analyzer as a function of wavelength, position, and angle. Work supported in part by NSF PHY-0457219.

2:48PM HC.00005 Magnetic field compensation for $n-^{4}\text{He}$ parity-violating spin-rotation experiment at NIST, K. GAN, The George Washington Univ., V. ZHUMABEKOVA, Al-Farabi Khazakh National Univ., A.K. OPPER, The George Washington Univ., B.E. CRAWFORD, Gettysburg College, C.D. BASS, J.M. DAWKINS, T.D. FINDLEY, J.C. HORTON, C.R. HUFFER, D. LUO, A.M. MICHERDZINSKA, M.G. SARSOUR, W.M. SNOW, Indiana Univ./IUCF, E.I. SHARAPOV, Joint Institute for Nuclear Research,Dubna,Russia, H.P. MUMM, J.S. NICO, NIST, D.M. MARKOFF, North Carolina Central Univ., P.R. HUFFMAN, North Carolina State Univ./TUNL, B.R. HECKEL, H.E. SWANSON, Univ. of Washington — A high precision measurement of the parity-violating spin rotation $\phi_{PV}(n,\alpha)$ for transversely polarized neutrons passing through $^{4}\text{He}$ is currently underway at the NIST Center for Neutron Research (NCNR). Reducing parity conserving rotations due to ambient magnetic fields is the primary experimental challenge and is being met through the use of magnetic shielding, movable targets, four separate target locations, and neutron energy detection. External coils are used to stabilize the ambient field in the longitudinal direction at a predefined value. The system is based on measuring the magnetic field outside the shielding and using a proportional-integral-derivative (PID) feedback loop to control the current through the external coil system, suppressing any change of the ambient field by a factor of 10-20. The presentation will also include an internal coil system designed within magnetic shielding.
3:00PM HC.00006 The Liquid Helium Target for the Neutron Spin-Rotation Experiment\textsuperscript{1}, C.D. BASS, J.M. DAWKINS, T.D. FINDLEY, J.C. HORTON, C.R. HUFFER, D. LIOU, A.M. MICHERDZINSKA, M.G. SARSOUR, W.M. SNOW, Indiana Univ / IUCF, V. ZHUMABEKOVA, Al-Farabi Kazakh National Univ, K. GAN, A.K. OPPER, The George Washington Univ, B.E. CRAWDID, GETTYSBURG COLLEGE, E.I. SHARAPOV, Joint Institute for Nuclear Research, Dubna, H.P. MUMM, J.S. NICO, NIST, D.M. MARKOFF, North Carolina Central Univ, P.R. HUFFMAN, North Carolina State Univ / TUNL, B.R. HECKEL, H.E. SWANSON, Univ of Washington — We are performing a new precision measurement of the parity-violating neutron spin-rotation of polarized neutrons that propagate through liquid helium with a sensitivity goal of \(3 \times 10^{-7} \text{ rad/m} \) at the NCNR. We describe the design, operation, and evaluation of systematic effects of a new liquid helium target that consists of a pair of target chambers located upstream and downstream of a vertically-aligned spin-precession coil. A system for changing target states by moving liquid helium between the front and back chambers allows one to isolate the parity-violating spin-rotation signal from much larger parity-conserving rotations that are primarily due to background magnetic fields. The targets are further split into left and right chambers, where the transfer of liquid helium between the front and back targets occurs in the opposite sense for left and right sides, thus allowing simultaneous measurements of opposite target states.\textsuperscript{1}

3:12PM HC.00007 A segmented \(^3\)He ion chamber for n-spin rotation experiment\textsuperscript{1}, D. LIOU, Indiana Univ / IUCF, V. ZHUMABEKOVA, Al-Farabi Kazakh National Univ, K. GAN, A.K. OPPER, The George Washington Univ, B.E. CRAWDID, GETTYSBURG COLLEGE, C.D. BASS, J.M. DAWKINS, T.D. FINDLEY, J.C. HORTON, C.R. HUFFER, A.M. MICHERDZINSKA, M.G. SARSOUR, W.M. SNOW, Indiana Univ / IUCF, E.I. SHARAPOV, Joint Institute for Nuclear Research, Dubna, H.P. MUMM, J.S. NICO, NIST, D.M. MARKOFF, North Carolina Central Univ, P.R. HUFFMAN, North Carolina State Univ / TUNL, B.R. HECKEL, H.E. SWANSON, Univ of Washington — Searches for parity violation effects in few nucleon systems often require current-mode detectors. We describe a high efficiency \(^3\)He/Ar ion chamber designed to operate in current mode at a CW cold n source. It uses \(^3\)He to absorb the neutrons and Ar to limit the range of the ions from the \(n^+\)He reaction. It is longitudinally partitioned to gain information on the neutron velocity spectrum and transversely segmented to monitor the spatial distribution of the n beam. We adjust the \(^3\)He and Ar density to obtain an approximately even absorption of the beam in the 4 longitudinal partitions. A similar detector is described by Penn et al\textsuperscript{[1]} and was tested at the LANSCHE for possible use in the NPD\textsuperscript{[2]} experiment.\textsuperscript{1} We will present details on the design and performance as measured on the NGB beam at NIST.\textsuperscript{[1]} S.D. Penn et al, Nucl. Instr. and Meth. A 457 (2001) 332-337.\textsuperscript{[2]} C. Blessinger, PhD thesis, Indiana Univ 2000 \textsuperscript{1}

3:24PM HC.00008 Measurement of Cold Neutron Depolarization in Liquid and Solid Deuterium, ALEXANDER KOMIVES, ANDREW BEVER, SARAH CARLSON, DePauw University, MIKE SNOW, YUN SHIN, CHEN-YU LIU, Indiana University, JOHN DAWSON, University of New Hampshire. KLAUS KIRCH, MALGORZATA KASPRZAK, MARCIN KUZNIAK, BEN VAN DEN BRANDT, PATRICK HAUTLE, TON KONTER, AXEL PICHMAIER, Paul Scherrer Institut, KAZIMIERZ BODEK, STANISLAW KISTRYN, MARCIN KUZNIAK, JACEK JEZMA, Institute of Physics; Jagiellonian University — A proposed experiment to measure the spin rotation originating from the parity violating weak interaction, of polarized cold neutrons as they traverse through a deuterium target will yield further information on the weak meson coupling constants. However, neutron depolarization from a relatively large scattering cross section of a few barns could severely dilute the already small spin rotation signal. Likewise another proposed experiment, also designed to shed light on the weak meson couplings by measuring the parity violating gamma asymmetry from neutron capture on deuterium, could be compromised by the same neutron depolarizing scattering process. To explore the feasibility of these proposed measurements, an experiment was recently performed at the FUNSPIN beamline at the Paul Scherrer Institut to measure the depolarization of neutrons transmitted through liquid and solid ortho-deuterium as a function of neutron energy. Preliminary results will be presented.

3:36PM HC.00009 Development of an Ultracold Neutron Source at the NC State PULSTAR Reactor, GRANT R. PALMQUIST, ROBERT GOLUB, AYMAN I. HAWARI, ADAM T. HOLLEY, PAUL R. HUFFMAN, EKATERINA KOROBKINA, BERNARD W. WEHRING, YANPING XU, ALBERT R. YOUNG, North Carolina State University — Development of an ultracold neutron (UCN) source is underway at the North Carolina State University 1 MW PULSTAR reactor facility. Fast neutrons from the reactor core are moderated first by heavy water at room temperature and then by solid methane at a temperature of approximately 25 K. The cold neutrons emerging from the methane are then down-scattered to lower energies (< 300 neV) by phonons in the 5 K solid ortho-deuterium converter. The UCN emerging from the deuterium source are guided to the experimental area through diamond-like carbon-coated quartz. The anticipated UCN densities in an experimental volume connected to the end of the guide should exceed densities presently obtained at the UCN source at the Institute Laue–Langevin. The current status of the design and construction will be discussed, with an emphasis on the thermal modeling of the cryostat cooling system. This work is supported in part by NSF grant #0314114 and funds from the DOE INI program.

3:48PM HC.00010 Measuring the Neutron Lifetime using Magnetically Trapped Ultracold, LIANG YANG, J.M. DOYLE, Harvard University, F.H. DUBOSE, E. KOROBKINA, R. GOLUB, C.M. O’SHAUGHNESSY, G.L. PALMQUIST, P.-N. SEO, P.R. HUFFMAN, North Carolina State University, K.J. COAKLEY, H.P. MUMM, A.K. THOMPSON, G. YANG, National Institute of Standards and Technology, S.K. LAMOREAUX, Los Alamos National Laboratory. The neutron lifetime plays an important role in the test of standard model and big bang nucleosynthesis. Our collaboration has successfully demonstrated the feasibility of a neutron lifetime measurement using magnetically trapped ultracold neutrons, which has the potential to improve the current experimental limit. In this experiment, ultracold neutrons are loaded into a loffe-type superconducting magnetic trap through inelastic scattering of 0.89 nm neutrons with phonons in superfluid helium-4. Trapped neutrons are detected via the scintillation light of decay electrons in liquid helium. The primary advantages of this technique are continuous detection of decay events and the elimination of wall losses. We are currently upgrading the experiment to incorporate a larger and deeper magnetic trap, which can reduce the statistical uncertainty in the measurement to 1-3 s. The apparatus upgrade and studies of systematic uncertainties such as above-threshold neutrons and Helium-3 impurities will be discussed.

4:00PM HC.00011 Laser trapping of Ra-225 and Ra-226 and progress towards an electric dipole moment measurement\textsuperscript{1}, J.R. GUEST, N.D. SCIHELZO, I. AHMAD, K. BAILEY, J.P. GREENE, R.J. HOLT, Z.-T. LU, T.P. O’CONNOR, D.H. POTTERVELD, Physics Division, Argonne National Laboratory — Permanent electric dipole moments (EDMs) in atoms or molecules are signatures of Time (T)-and Parity (P)-violation and represent an important window onto physics beyond the Standard Model. We are developing a next generation EDM search around laser-cooled and trapped Ra-225 (\(t_1/2 = 15\) d). Due to octupole deformation of the nucleus, Ra-225 is predicted to be two to three orders of magnitude more sensitive to T-violating interactions than Hg-199, which currently sets the most stringent limits in the nuclear sector. We will discuss our progress, including the successful laser cooling and trapping of Ra-225 and Ra-226 atoms. We have demonstrated transverse cooling, Zeeman slowing, and capture of Ra-225 and Ra-226 atoms in a magneto-optical trap (MOT). By driving a second atomic transition, we have extended the lifetime of the trap from milliseconds to seconds and performed necessary spectroscopic measurements.\textsuperscript{1}

\textsuperscript{1}This work was supported by the U.S. Department of Energy, Office of Nuclear Physics, under contract no. W-31-109-ENG-38.
4:12PM HC.00012 Current-current correlators as a probe of the chirality-flip scale in QCD\textsuperscript{1} 

TRANG NGUYEN, PETER TANDY, Kent State University — In the chiral limit, vector and axial vector current-current correlators are identical, and quark chirality is preserved, to any finite order of perturbation theory in QCD. The difference of such correlators, as distance increases from \( x = 0 \), probes the scale for the onset of the leading non-perturbative phenomena in QCD. We examine the influence of dynamical chiral symmetry breaking upon such a correlator difference and deduce the characteristic distance scale for the onset of this non-perturbative phenomena. The analysis is fully covariant and uses ladder-rainbow dynamics constrained by the quark condensate. Comparison is made with the non-perturbative distance scale deduced some years ago in a similar analysis based on the Instanton Liquid model.

\textsuperscript{1}Work supported in part by NSF grant no. PHY-0301190

4:24PM HC.00013 Transverse Beam Spin Asymmetries in the G0 Forward-Angle Measurement\textsuperscript{1} 

SARAH K. PHILLIPS, The College of William and Mary, Williamsburg, Virginia, USA, PAUL M. KING, University of Illinois at Urbana-Champaign, Urbana, Illinois, USA, G0 COLLABORATION — Although neglected historically, two-photon exchange contributions have become increasingly important as electron-scattering experiments push to higher precision measurements of nucleon structure. The transverse beam spin asymmetry measured in the elastic scattering of transversely polarized electrons from unpolarized nucleons provides a direct probe of the imaginary component of the two-photon exchange amplitude. Transverse beam spin asymmetries for 3 GeV electrons were measured during the forward-angle run of the G0 experiment in Jefferson Lab’s Hall C, with center of mass scattering angles ranging from 19 to 37 degrees. A description of the analysis of the data and the results of the measurements will be presented.

\textsuperscript{1}This work is supported in part by CNRS (France), DOE (U.S.), NSERC (Canada), and NSF (U.S.).

4:36PM HC.00014 The Qweak Experiment: Design of Quartz Čerenkov Detectors for a Measurement of the Proton Weak Charge\textsuperscript{1} 

MICHAEL GERICKE, Jefferson National Laboratory and University of Manitoba, QWEAK COLLABORATION — The Qweak experiment at Jefferson Lab aims to make a 4\% measurement of the parity-violating asymmetry in elastic scattering at very low \( Q^2 \) of a longitudinally polarized electron beam on a proton target. The experiment will measure the weak charge of the proton, and thus the weak mixing angle at low energy scale, providing a precision test of the Standard Model. The experiment is currently being constructed and is scheduled for a 2200 hour measurement starting in 2009, employing: an 80\% polarized, 180 \( \mu \)A, 1.2 GeV electron beam; a 35 cm liquid hydrogen target; and a toroidal magnet to focus electrons scattered at 9\(^{\circ}\) forward angle, corresponding to \( Q^2 = 0.03 \) (GeV/c\(^2\)). The experiment will run at an event rate of over 6 GHz. This requires current mode detection of the scattered electrons, using synthetic quartz Čerenkov detectors. In this talk we will present a brief introduction to the experiment, with a focus on the design and status of the main Čerenkov detectors.

\textsuperscript{1}Supported by: DOE, NSF, NSERC.

Saturday, October 28, 2006 2:00PM - 4:00PM –
Session HD DNP: Mini-symposium on Nuclei as Mesoscopic Systems II Gaylord Opryland Hermitage A

2:00PM HD.00001 Neutron Stars\textsuperscript{1} 
FRIDOLIN WEBER, Department of Physics, San Diego State University — The determination of the properties of matter inside of neutron stars constitutes a tremendous challenge for nuclear and many-body physics. Here I shall selectively review some of the recent developments in these fields, which concern nuclear processes in the crusts of neutron stars and new states and properties matter (hyperons, boson condensates, quark matter, superconductivity) at supernuclear densities encountered in the cores of neutron stars. Particular emphasis will be put on the physics inside of massive neutron stars.

\textsuperscript{1}This work is supported by the National Science Foundation under Grant PHY-0457329, and by the Research Corporation.

2:36PM HD.00002 Nuclear Clusters in Astrophysics 
ALAN H. WUOSMAA, Western Michigan University — Alpha-cluster nuclei are prototypical mesoscopic systems that play significant roles in the most important nucleo-synthesis reactions forming the elements crucial to life on Earth, \( ^{12}\text{C} \) and \( ^{16}\text{O} \). The production rates of these nuclei depend critically on the stellar environment, as well as detailed nuclear structure properties. The famous “triple-alpha” reaction that produces \( ^{12}\text{C} \), for example, proceeds through the well known excited \( ^{0+} \) state in \( ^{12}\text{C} \) which possesses a well developed alpha-cluster character. In massive stars, the properties of and reactions involving cluster nuclei continue to strongly influence stellar evolution through processes such as \( ^{12}\text{C} + ^{12}\text{C} \) fusion. Current modeling of stellar evolution has evolved to a stage where new and better data are required to reduce the uncertainties in these theoretical predictions. I will review some of the important aspects of cluster nuclei in astrophysical environments, and discuss some ongoing experimental efforts to refine our knowledge of the rates of \( ^{12}\text{C} \) production through the triple-alpha reaction, and \( ^{16}\text{O} \) production via the \( ^{12}\text{C}(\alpha,\gamma)^{16}\text{O} \) reaction. Finally, I will discuss some of the challenges that are faced in understanding burning of heavier cluster nuclei in massive stars. Work supported by the U. S. Department of Energy, Office of Nuclear Physics under contracts DE-FG02-04ER41320 and W-31-109-ENG38, and the National Science Foundation grants PHY01-10253 and PHY02-16783.

2:48PM HD.00003 Nuclear quantum phase transitions 
M.A. CAPRIO, Yale University — Quantum phase transitions in nuclei are discussed in relation to the properties of nuclei as mesoscopic systems. Recent results obtained within the framework of algebraic models, including investigations of quantum phase transitions at finite particle number, are summarized. Supported by the US DOE under grant DE-FG02-91ER40608.
Coupling between bosonic and fermionic degrees of freedom in $^{93}$Nb$^{11}$. J.N. ORCE, University of Kentucky, J.D. HOLT, Stony Brook, A. LINNEMANN, Universität zu Köln, C.J. MCKAY, University of Kentucky, et al. — Excited states in $^{93}$Nb can be regarded as resulting from the weak coupling of a $\pi 1d_{5/2}$ proton to a $^{92}\mathrm{Zr}$ core, and a $\nu 2p_{3/2}$ proton-hole to a $^{94}\mathrm{Mo}$ core. These couplings result in two independent and unmixed one-phonon structures of opposite parity. The lack of mixing provides a good opportunity for a comprehensive analysis of the low-spin structure in this odd-mass nuclide. $^{93}$Nb has been studied using the $^{93}$Nb($n,\gamma$) reaction with neutron energies from 1.5 to 3 MeV, the $^{93}$Nb($\gamma,\gamma'$) reaction with a bremsstrahlung end-point energy of 2.75 MeV, and $^{94}$Zr($p,2n\gamma$)$^{93}$Nb reaction at bombarding energies ranging from 11.5 to 19 MeV. Excitation functions, lifetimes, and branching ratios were measured, and multipolarities and spin assignments were determined. The results from these experiments will be presented in this DNP meeting, including the proposed mixed-symmetry states at 1779.7 and 1840.6 keV, respectively, associated with the $\nu 2p_{1/2} \otimes (21,\mathrm{MS})^{11}$.}

3:12PM HD.00005 Band Termination in Heavy-Nuclei$^1$, MARK RILEY, Florida State University — The generation of angular momentum (spin) is perhaps one of the most beautiful illustrations of finite particle number effects in nuclei. A deformed proton core can increase its spin by collective rotation about an axis perpendicular to its symmetry axis leading to I(I+1) quantum-rotor behavior and the observation of regular rotational bands. However, since the nucleus is a finite mesoscopic quantal system, such collective behavior must have an underlying microscopic basis which limits the spin that a particular nuclear configuration, or band, can generate. A combination of Coriolis and centrifugal forces, induced by rapid rotation, can break the valence pairs and align the individual nucleonic angular momentum along the collective rotation axis. These aligned nucleons move in equatorial orbits polarizing the nucleus, from its original prolate shape, towards an oblate one. Eventually the available spin is exhausted when all the valence nucleons outside a spherical core, at least the number to achieve the desired band termination, are all aligned. This phenomenon has been observed in giant dipole emission spectra by the Brookhaven and characteristic end to a rotational band. High-spin terminating bands in heavy nuclei were first identified around Er-158, see Ref. [1] and references therein. Recent experimental data on this classic and nuclei and their characteristics have greatly enhanced the band termination story and will be presented. [1] A.V. Afanasjev, D.B. Fossan, G.J. Lane, and I. Ragnarsson, Phys. Rep. 322, 1 (1999).

3:24PM HD.00006 Giant resonances in $^{112}$-$^{124}$Sn isotopes and the symmetry term in nuclear . T. LI, U. GARG, P. V. MADHUSUDANA RAO, R. MARKS, Department of Physics, University of Notre Dame, M. FUJIWARA, S. OKUMURA, M. YOSOI, Y. NAKANISHI, H. HASHIMOTO, K. KAWASE, S. TERASHIMA, Research Center for Nuclear Physics, Osaka University, M. UCHIDA, Department of Physics, Tokyo Institute of Technology, T. KAWABATA, CNS, University of Tokyo, M. ITOH, T. TERAZONO, R. MATSUO, M. ICHIKAWA, Cyclotron and Radioisotope Center, Tohoku University, H. SAKAGUCHI, T. MURAKAMI, Y. YASUDA, Y. TERAHIMA, J. ZENNIRO, Y. IWAQ, Department of Physics, Kyoto University, H. AKIMUNE, Department of Physics, Konan University — Based on the same data on the giant monopole resonances, calculations within the non-relativistic and relativistic models predict for nuclear incompressibility $K_\infty$ values which are significantly different from one another, viz. $K_\infty \approx 220$-235 and $\approx 250$-270 MeV respectively. It appears that the solution of this puzzle requires a better determination of the symmetry energy at saturation point. We have investigated the isoscalar giant monopole resonance (ISGMR) and the isoscalar giant dipole resonance (ISGDR) in Sn isotopes, using inelastic $\alpha$-particle of 400 MeV at extremely forward angles, including $0^\circ$. The ISGMR and ISGDR strength distributions have been extracted from the background-free inelastic scattering spectra by using multipole-decomposition analysis. The implications of these results on the symmetry energy term will be discussed.

3:36PM HD.00007 Two-quasiparticle states in $^{252,254}$No and the stability of superheavy nuclei$^1$. T.L. KHOO, Argonne National Laboratory, S.K. TANDEL, Univ. Massachusetts Lowell, A. ROBINSON, D. SEWERYNIAK, F.G. KONDEV, Argonne National Laboratory — Two-quasiparticle (qp) states in shell-stabilized probe nuclei probe the levels that govern the stability of superheavy nuclei, test $2q$-energies from theory and, thereby, check their predictions of magic gaps. We have identified in $^{254}$No 2- and 4-particle states, with quantum numbers $K^* = 8^+$ and (14$^+$), and a low-energy $2qK^* = 3^+$ state, as well as a $K^* = 8^-$ isomer in $^{252}$No. The use of Woods-Saxon single-particle energies reproduces the experimental proton $2q$-energies in $^{254}$No. Some shortcomings in the 2-q energies from self-consistent mean-field theories suggest that their predictions of magic gaps at $Z=120$ and 126 should be viewed with reservations. The resilient survival of superheavy nuclei with high Z, up to 118, well past the onset of spontaneous fission at $Z\approx 92$, is an interesting phenomenon in heavy and mesoscopic physics. This research was conducted by a collaboration from Argonne National Laboratory and the Massachusetts Lowell, Jyväskylä, Köln, Liverpool, Maryland, Notre Dame and Yale.

3:48PM HD.00008 The Symmetry Energy, Nuclei, and Neutron Stars, ANDREW STEINER, LANL and JINA/NSCL at MSU — The isospin symmetry energy, also known as the nuclear symmetry energy, is one of the key bridges between the description of heavy nuclei and neutron stars. Correlations among several observables that are connected to the symmetry energy will be discussed including the neutron skin thickness in heavy nuclei, the pressure of neutron-rich matter, the degree of isospin diffusion in intermediate-energy heavy-ion collisions, the radii of 1.4 solar masses neutron stars, and the threshold density for the direct Urca process. Particular attention will be paid to the critical density for the direct Urca process and how it can be modified by the isospin dependence of the symmetry energy. Connections to present neutron star observations and cooling data will be discussed.

Saturday, October 28, 2006 2:00PM - 4:12PM — Session HE DNP: Nuclear Astrophysics II Gaylord Opryland Hermitage B

2:00PM HE.00001 TOF-B$^\beta$ Mass Measurements at the NSCL, MSU, M. MATOS, A. ESTRADA, A. AMTHOR, D. BAZIN, A. BECERRIL, T. ELLIOT, D. GALAVIZ, A. GADE, G. LORUSSO, J. PEREIRA, M. PORTILLO, A. ROGERS, Michigan State University, D. SHAPIRA, ORNL, H. SCHATZ, MSU, E. SMITH, OSU, A. STOLZ, MSU, M. WALLACE, LANL — The radioactive beam facilities such as the NSCL offer ideal opportunities for time-of-flight mass measurements of very exotic ions. We have recently implemented a TOF-B$^\beta$ technique at the NSCL and performed a mass measurement of neutron-rich nuclides in the Fe region. Masses of neutron rich nuclei are important for r-process calculations, and for calculations of processes occurring in the crust of accreting neutron stars. At the NSCL, we have introduced a beam $^{68}$Kr was accelerated in the K500 and K1200 coupled superconducting cyclotrons to the energy of 100MeV/u. A fast radioactive beam was then produced by fragmentation reactions in the 47 mg/cm$^{2}$ and 94 mg/cm$^{2}$ Be targets and separated in the A1900 fragment separator. For this experiment a 58 m long time-of-flight path was used starting at the extended focal plane of the A1900 and ending at the focal plane of the S800 spectrograph. Fast scintillation detectors provided a timing resolution of about $\sigma=30$ ps, the relative magnetic rigidity B$^\beta$ was measured at the momentum dispersive plane of the S800 by position sensitive micro-channel plate (MCP) detectors. Details of the experimental technique will be discussed and preliminary results will be presented.
2:12PM HE.00002 On the Gamow Peak in Thermonuclear Reactions, JOSEPH NEWTON, CHRISTIAN ILIADIS, ARTHUR CHAMPAGNE, University of North Carolina at Chapel Hill and Triangle Universities Nuclear Laboratory, ALAIN COC, CNRNS/IN2P3/UPS, Bat. 104, 91405 Orsay Campus, France, YANNIS PARPOTTAS, Department of Physics, University of Cyprus, CLAUDIO UGALDE, University of North Carolina at Chapel Hill and Triangle Universities Nuclear Laboratory — The Gamow peak is an essential tool when considering non-resonant thermonuclear reactions. It is the mechanism for describing the effective burning window of charged particle reactions, at a given temperature. It is an especially useful tool when determining thermonuclear reaction rates. The Gamow peak concept is also widely used in connection with narrow resonances [1]. If the nuclear reaction of interest is in the narrow resonance realm, then the Gamow peak concept will break down under specific conditions. Stellar rates are often dominated by the narrow resonance contributions to the reaction rates, and therefore may be significantly affected by the misuse of the Gamow peak. We investigated ten different \((p, \gamma)\) reactions, ranging from \(A=21\) to \(A=35\) and determined a true effective energy burning window using each reaction, at a given energy, which is often significantly different form the Gamow peak window. [1] W.A. Fowler and F. Hoyle, Astrophys. J. Suppl. 9, 201 (1964) ap. C.

2:24PM HE.00003 A new \(^{30}\text{P}(p,\gamma)^{31}\text{S}\) reaction rate and its astrophysical implications\(^3\), Z. MA, M. GUIDRY, U. of Tenn, D.W. BARDAYAN, J.C. BLACKMON, W.R. HIX, M.S. SMITH, Oak Ridge National Lab, R.P. FITZGERALD, D.W. VISSER, UNC - Chapel Hill, K.L. JONES, J.S. THOMAS, Rutgers, R.L. KOZUB, Tenn Tech U., R.L. LIVESAY, Colorado School of Mines — The \(^{30}\text{P}(p,\gamma)^{31}\text{S}\) reaction rate plays a crucial role in the synthesis of heavier elements in ONe nova outbursts. However, this rate is very uncertain due to the lack of spectroscopic information on the \(^{31}\text{S}\) levels. We have measured differential cross sections for the \(^{12}\text{C}(p,d)^{13}\text{S}\) reaction and determined excitation energies for 26 states in \(^{31}\text{S}\). Spins and parities were determined or constrained for strongly populated levels through a DWBA analysis. A total of 42 levels in \(^{31}\text{S}\) were examined. A new \(^{30}\text{P}(p,\gamma)^{31}\text{S}\) rate was calculated using this new resonance information. Our results indicate that the \(^{30}\text{P}(p,\gamma)^{31}\text{S}\) rate is reduced by up to a factor of 10 at nova temperatures compared to an estimate made with a statistical reaction model. We have performed network calculations using the new rate. Production of elements in the Si-Ca region are found to be altered by as much as 30%. Important isotopic ratios such as \(^{12}\text{C}/^{13}\text{C},^{14}\text{N}/^{15}\text{N},^{26}\text{Al}/^{27}\text{Al}\) and \(^{29}\text{Si}/^{30}\text{Si}\) are found to agree well with observations on presolar grains of nova origin.

\(^3\)Managed by UT-Batelle, LLC for the U.S. DOE under contract DE-AC05-00OR22725

2:36PM HE.00004 \(^{24}\text{Mg}(\alpha,\gamma)^{28}\text{Si}\) Resonance Parameters at Low Alpha Energies, ELIZABETH STRANDBERG, HEIDE COSTANTINI, JOAChIM GOERRES, HYE YOUNG LEE, EDWARD STECH, MICHAEL WIESCHER, University of Notre Dame, AARON COUTURE, Los Alamos National Laboratory, KENT SCHELLER, University of Southern Indiana — \(^{28}\text{Si}\) is formed by successive alpha captures during later stages of stellar burning; for carbon burning, the relevant alpha energy range is 1.0 to 1.5 MeV. Previous measurements of the \(^{24}\text{Mg}(\alpha,\gamma)^{28}\text{Si}\) reaction observed only one resonance in this energy range, although there are several \(^{28}\text{Si}\) states that appear favorable for this reaction. Using a high efficiency coincidence detection system, several new resonances were observed between 1.1 and 1.5 MeV, and an upper limit for any lower energy resonances was obtained. Newly calculated resonance parameters and reaction rates will be discussed.

2:48PM HE.00005 Elastic scattering on \(p\)-nuclei for the improvement of the optical model potential, A. PALUMBO, W. TAN, J. GOERRES, M. WIESCHER, Nuclear Structure Laboratory, University of Notre Dame, D. GALAVIZ, National Superconducting Cyclotron Laboratory, Michigan State University, G. GYURKY, ZS. FULOP, E. SOMORJAI, Institute of Nuclear Research (Atomki), N. OZKAN, R.T. GURAY, Kocaeli University, UNIVERSITY OF NOTRE DAME TEAM, MICHIGAN STATE UNIVERSITY TEAM, ATOMKI TEAM, KOCASEL UNIVERSITY TEAM — \(p\)-nuclei are thought to form through photodisintegration reactions on seed \(r\)- or \(s\)-nuclei, mainly \(^{16}\text{O}\). This work was carried out under the auspices of the National Nuclear Security Administration of the U.S. Department of Energy at Los Alamos National Laboratory under Contract No. DE-AC52-06NA25396.

2:50PM HE.00006 Neutron Capture Measurements on Tl-isotopes at DANCE\(^1\), A. COUTURE, T.A. BREDEWEG, E.-I. ESCH, M. JANDEL, R.C. HIGHT, J.M. O’DONNELL, R. REIFARTH, R.S. RUNDBERG, J.L. ULLMANN, D.J. VIEIRA, J.M. WOUTERS, Los Alamos National Laboratory — The thallium isotopes play an important role in the \(s\)-process nucleosynthesis at the \(s\)-process endpoint. Furthermore, \(^{205}\text{Tl}\) is one of few branch point isotopes in the endpoint region. The understanding of branch point isotopes provides modeling constraints on the temperatures during which the process takes place. The production of \(s\)-only \(^{204}\text{Pb}\) is controlled entirely by \(^{205}\text{Tl}\). Measurements of the capture cross-sections of the stable Tl isotopes have recently been made using the DANCE 4-\(\pi\) array at LANSE. This provides needed resonance information in the region as well as preparing the way for measurements of as yet unmeasured capture cross-section of the unstable \(^{204}\text{Tl}\). The neutron capture data for the stable isotopes as well as the plan for future measurements will be discussed.

\(^1\)Funded by the US Department of Energy

3:00PM HE.00007 The \(r\)-process peak at \(A = 130\) and \(N = 82\), KARL-LUDWIG KRATZ, Institut für Kernchemie, Universität Mainz D-55099 Mainz, Germany, PETER MÖLLER, Theoretical Division, Los Alamos National Laboratory, Los Alamos NM 87545 — It is well-known that \(r\)-process abundances can be modeled to some reasonable accuracy based on calculated beta-decay properties such as beta-decay half-lives, beta-delayed neutron-emission probabilities, neutron separation energies, and stellar environment conditions such as temperature, neutron densities and neutron-flux duration. However, characteristic deviations between observed and calculated abundances occur near the magic number peaks. Recently in measurements at Isole full-spectroscopy data were obtained on \(^{130}\text{Cd}\). This permitted an optimization of Nilsson-model parameters to this region of nuclei far from stability. Beta-decay half-lives calculated with this new set of Nilsson parameters are longer than our previously published 1997 tables. We present these and other features of the new \(r\)-process calculations near the \(A = 130\) peak.

\(^1\)This work was carried out under the auspices of the National Nuclear Security Administration of the U.S. Department of Energy at Los Alamos National Laboratory under Contract No. DE-AC52-06NA25396.
3:24PM HE.00008 Nuclear Fission for Nuclei in the Region 190 ≤ A ≤ 3301. PETER MOLLER, Theoretical Division, Los Alamos National Laboratory, KARL-LUDWIG KRATZ, Institut für Kernchemie, Universität Mainz — At the DNP meeting in Maui one year ago we reported on initial results on fission calculations of nuclei at the end of the r-process. We now have much more complete results for nuclei in this region. Compared to our preliminary results, in which the potential energy was calculated for about 1 000 000 different shapes we now consider more than 5 000 000 different shapes. More elongated and more mass-asymmetric shapes are included in the current more comprehensive results. We compare our calculated barrier heights to available actinide experimental data. We also present calculated barrier heights for all nuclei in this region of the nuclear chart, more than 3000. We furthermore calculate beta-decay strength functions which allows us to study beta-delayed fission at the end of the r-process. First results on the termination of the r-process by fission, which is to a large extent determined by the relations between barrier heights and neutron-separation energies will also be presented.

3:36PM HE.00009 Theory of Magnetic Fields of Astronomical Bodies, KRISHNA KUMAR, Tennessee Technological University — As part of a Unified Field Theory of the four Fundamental forces, which has recently been developed by the author and applied to Atomic Nuclei, Neutron Stars and Black Holes, a new theory of the magnetic fields of astronomical bodies has been developed. The basic ideas are very simple. (1) Each object contains four types of charges: Electric, Gravitational (related to Mass), Weak (related to isotopic spin), and Strong. (2) Each of these charges produces an electric field due to its location, and a magnetic field due to its motion including spin. Just as in the electromagnetic field theory, interaction between an electric charge and an electric field produces electric (Coulomb) interaction energy, in the Unified Field theory, the other three types of charges also produce interaction energies and contribute to the binding energies, and determine other saturation properties like radii, compressibility, and symmetry energy. These have been tested for some Atomic Nuclei, Neutron Stars, and Black Holes. Now comes the surprising part! Other charges like mass can also produce magnetic fields. The calculated magnetic fields of electrically neutral bodies come out to be too large by one to two orders of magnitude. Total calculated magnetic field varies from 16 G for the Earth to 1.8 x 10^14 G for the Neutron Star associated with the Crab Pulsar, as compared to the experimental variation from ~1 G to ~10^12 G.

3:48PM HE.00010 Electron screening in \((d,p)t\) for deuterated metals: temperature dependence1, FRANCESCO RAIOLA, Ruhr Universität Bochum, LUNA COLLABORATION — The electron screening effect in the \((d,p)t\) reaction has been studied at the Ruhr-Universität Bochum for most of the metals and some insulators/semiconductors by using deuterated targets [1]. The deuterated targets were produced via implantation of low-energy deuterons. As compared to measurements performed with a gaseous \(D_2\) target, a large effect has been observed for all metals. In particular work has been done to investigate the high solubility for the metals of groups 3 and 4 and the lanthanides, at a sample temperature \(T = 200^\circ\) C. The hydrogen solubility in the samples dropped to a level of few percent (compared to \(T = 20^\circ\) C) and a large screening became thus observable. An explanation of the large effect in metals is provided by the plasma model of Debye applied to the quasi-free metallic electrons. A first evidence of the validity of Debye’s model is that the deduced number of free electrons per metallic atom agrees with the calculated number from the Hall coefficient [2], for all metals investigated. A critical test of the classical Debye model is the temperature dependence \(U_e \sim T^{-1/2}\).

1Supported by BMBF(05C11P1/1), DFG(Ro429/31-1), and Dynamitron-Tandem-Laboratorium.

Saturday, October 28, 2006 2:00PM - 4:48PM — Session HF DNP: Topics In Nuclear Theory Gaylord Opryland Hermitage C

2:00PM HE.00001 Neutron-Proton Bremsstrahlung Compared to Experiment at 225 MeV, VIRGINIA BROWN, MIT and University of MD/College Park, JERROLD FRANKLIN, Temple University, PERRY ANTHONY, SLAC/Stanford — Neutron-proton bremsstrahlung \((np)\) with out-of-plane contributions, relativistic spin effects, charge form-factor contributions, and meson-exchange effects included to order K in the photon momentum [1] are calculated with various modern nucleon-nucleon potentials to compare to experimental results at 225 MeV obtained by J. Matthews et al.[2] at LANCE. The data include various coplanar neutron exit angles. These are the first experimental \((np)\) data to explicitly measure the photon angular distribution. Finite-size detector effects are determined with the out-of-plane calculations.


2J. Matthews and T. Akdogan, private communication.

2:12PM HF.00002 How to Classify Three-Body Forces – and Why, HARALD W. GRIESSHAMMER, The George Washington University — To add 3-body forces when theory and data disagree is untenable when predictions are required. For the “pion-less” Effective Field Theory at momenta below the pion-mass, I provide a recipe to systematically estimate the typical size of 3-body forces in all partial waves and orders, including external currents [1]. It is based on the superficial degree of divergence of the 3-body diagrams which contain only two-body forces and the renormalisation-group argument that low-energy observables must be insensitive to details of short-distance dynamics. Naive dimensional analysis must be amended as the asymptotic solution to the leading-order problem depends for large off-shell momenta crucially on the partial wave and spin-combination considered. The typical strength of most 3-body forces turns out weaker than expected, demoting many to high orders. As application, the cross section of to the leading-order problem depends for large off-shell momenta crucially on the partial wave and spin-combination considered. The typical strength of most 3-body forces turns out weaker than expected, demoting many to high orders. As application, the cross section of

2:24PM HF.00003 Realistic three-nucleon effective interaction from the folded-diagram theory
, MAXIM KARTAMYSHEV, MORTEN HJORTH-JENSEN, TORGERE ENGELAND, EIVIND OSNES, Department of Physics, University of Oslo, Norway —
Starting from the folded-diagram theory of Kuo and collaborators, we construct an effective three-nucleon interaction originating from the two-nucleon force. Influence of the three-nucleon terms on nuclear properties is investigated in shell-model studies of selected nuclei in $^{16}$O, $^{40}$Ca and $^{100}$Sn mass regions.

2:36PM HF.00004 No-core shell model in an EFT framework , IONEL STETCU, JUHANI L. TORKKOLA, BRUCE R. BARRETT, UBIRAJARA VAN KOLCK, University of Arizona — Based on an effective field theory (EFT) that integrates out the pions as degrees of freedom (pionless theory), we present a new approach to the derivation of effective interactions suitable for many-body calculations by means of the no-core shell model. The main investigation is directed toward the description of two-body scattering observables in a restricted harmonic oscillator (HO) basis, and the inherent Gibbs oscillation problem which arises from the truncation of the Hilbert space using HO wave functions. Application of the effective interactions to the description of $^2$He will be discussed, I.S. J.L.T. and B.R.B. acknowledge partial support by NSF grant numbers PHY0070858 and PHY0244389. U.v.K. acknowledges partial support from DOE grant number DE-FG02-04ER41338 and from the Sloan Foundation.

2:48PM HF.00005 Relativistic Effects in First Order Three-Body Calculations
, T. LIN, CH. ELSTER, Ohio University, W. POLYZOU, U. Iowa, W. GLOECKLE, Ruhr-Univ. Bochum — The Faddeev equation for three-body scattering including relativistic features is directly formulated in momentum space without employing the partial wave decomposition. Based on a Malfliet-Tjon-type potential, the observables of three-body scattering are calculated in first order. The relativistic features considered are kinematics and boost effects, and are examined within the framework of Poincaré invariant quantum mechanics. Differential cross sections for elastic and break-up scattering are calculated at selected energies up the GeV scale and compared to the corresponding nonrelativistic cross sections.

1Supported by the U.S. Department of Energy.

3:00PM HF.00006 A closed form inverse scattering scheme for the Dirac equation at fixed energy , HELMUT LEEB, HARALD LEHNINGER, CHRISTIAN SCHILDER, Atominstitut of the Austrian Universities, Vienna University of Technology, Vienna, Austria — A new hierarchy of Dirac equations with spherically symmetric scalar and fourth component vector potentials is presented, for which closed form expressions for the solutions, the potentials and the S-matrix can be given in terms of solutions of an original Dirac equation. The hierarchy is generated via a generalized translation operator for the Dirac equation. Using these transformations an inverse scattering scheme has been constructed for the Dirac equation which is the analog to the rational scheme in the non-relativistic case. The method provides for the first time an inversion scheme with closed form expressions for the S-matrix for non-relativistic scattering problems with central and spin-orbit potentials. The inversion scheme was numerically implemented and its features are studied in several examples.

3:12PM HF.00007 Low Energy Nuclear Reactions Explained by Nuclear Oscillation—The End of Tunnelling, STEWART BREKKE, Northeastern Illinois University — Low energy nuclear reactions can be explained through a nuclear oscillation factor using classical mechanics eliminating the need for a tunnelling explanation. Consider an incoming positive charge approaching vibrating nucleus. If the KE needed to mount the barrier height is KE = kQ(n)q(i)/(4(AcosX))² + (AcosY)² + (AcosZ)² then KE needed for the barrier height is KE = kQ(n)q(i)/(4(AcosX)² + (AcosY)² + (AcosZ)²)². If the maximum for all cos values is +1 and for all minimum values is -1, r = (6)¹/²/A. For a static nucleus r = 0. The barrier height minimum is KE = kQ(n)q(i)/(4(AcosX)² + (AcosY)² + (AcosZ)²)². Therefore the Coulomb barrier is different at different times accounting classically for all nuclear reactions.

3:24PM HF.00008 Understanding in-medium hadronic interactions through the nuclear equation of state, PLAMEN KRASTEV, FRANCESCA SAMMARRUCA, University of Idaho — The relation between energy/particle and density, known as the nuclear equation of state (EOS), plays a major role in a variety of nuclear and astrophysical systems. Spin- and isospin- asymmetries can have a dramatic impact on the equation of state and potentially alter its stability conditions. An example is the possible manifestation of ferromagnetic instabilities, which would signal the existence, at some density, of a spin-polarized state with lower energy than the unpolarized one. This issue is being discussed extensively in the literature and the conclusions are presently very model dependent. We will present and discuss recent progress in our study of highly asymmetric neutron/nuclear matter, in particular spin-polarized matter. The approach we take is microscopic in that the EOS properties are derived from realistic free-space nucleon-nucleon interactions. This makes it possible to understand the nature of the predicted EOS in terms of specific features of the nuclear force and the applied medium effects.

1Support from the U.S. Department of Energy is gratefully acknowledged.

3:36PM HF.00009 ABSTRACT WITHDRAWN —

3:48PM HF.00010 Loop Corrections in Quantum Hadrodynamics
, JEFF MCINTIRE, Indiana University — Although one-loop calculations provide a realistic description of bulk and single-particle nuclear properties, it is necessary to examine loop corrections to develop a systematic finite-density power-counting scheme for the nuclear many-body problem when loops are included. Moreover, it is still imperative to study exchange and correlation corrections systematically, in order to make reliable predictions for other nuclear observables. One must also verify that the natural sizes of the one-loop parameters are not destroyed by explicit inclusion of many-body corrections. The loop expansion is applied to our chiral QHD lagrangian; with the techniques of Infrared Regularization, we found that it is possible to separate out the short-range contributions and to write them as products of fields that are already present in our lagrangian. (The appropriate field variables must be re-defined at each order in loops.) The corresponding parameters implicitly include short-range effects to all orders in the interaction, so these effects need not be calculated explicitly. The remaining (long-range) contributions that must be calculated resemble those in conventional nuclear-structure calculations (e.g. ladders, rings, etc.).
4:24PM HF.00013 Density Functional Theory Approach to Shell Model Hamiltonians1. MIHAI HOROI, Department of Physics, Central Michigan University, Mount Pleasant, MI 48859 — Density Functional Theory (DFT) is a well established method of obtaining ground state (g.s.) energies and one-body densities for systems of interacting fermions, such as electron and nucleons. DFT is mostly used in nuclear physics via short-range, Skyrme-type, interactions in coordinate space. We investigate a different density functional approach in finite model spaces, specific to shell model calculations. We attempt to extract the density functional form and the associated parameters in a fixed model space, by comparing the DFT results with the exact shell model calculations for small number of particles/holes. We than use the density functional to calculate cases with more particles that are more challenging for the shell model. Examples in the sd and fp model spaces will be presented.

1Support from the NSF grant PHY-0555366 is acknowledged.

4:36PM HF.00014 Nuclear shadowing at small Bjorken-x from diffractive scattering1. ADEOLA ADELUYI, GEORGE FAL, Kent State University — We calculate the nuclear shadowing ratio at small Bjorken-x for nuclei in the mass range $1 \leq A \leq 210$. We work in the kinematic regime relevant to small-x shadowing data of both the NMC and E665 experiments. The diffractive dissociation cross section, which is an input to our calculation, is parameterized separating the low-mass resonances and the high-mass continuum, following the H1 collaboration [1], using data from FNAL [2]. Our calculated results are in reasonable agreement with the NMC/E665 data at $x \approx 10^{-4}$, indicating the applicability of generalized Gribov theory.

Saturday, October 28, 2006 2:00PM - 4:36PM –
Session HG DNP: Ultrarelativistic Heavy Ions III Gaylord Opryland Hermitage D

2:00PM HG.00001 In-medium Modifications of Hadrons and the NA60 dimuon measurements, HENDRIK VAN HEES, RALF RAPP, Texas A&M University — The theoretical understanding of dimuon spectra as measured in 158 GeV In-In collisions by the NA60 collaboration at the CERN SPS is summarized. The low-mass region, $M \leq 0.9$ GeV, is well described by in-medium modifications of the $\pi$-meson spectral function within a hadronic many-body approach. To account for the yield in the intermediate-mass region, 0.9 GeV $\leq M \leq 1.5$ GeV, four-pion contributions in the electromagnetic emission function have to be taken into account. The data are consistent with the assumption of chiral mixing of isovector-vector and -axialvector currents, which could be indicative for the onset of chiral-symmetry restoration in heavy-ion collisions. Our calculation also includes the contribution from the quark-gluon plasma phase which turns out to be small compared to that of the hadronic source. Predictions for the modifications of $\omega$- and $\phi$-meson spectral shape may be experimentally checked in future experiments.

2:12PM HG.00002 ABSTRACT WITHDRAWN –

2:24PM HG.00003 Probing Jet Topology with Multi-particle Correlations, NUGGEHALLI AJITANAND, SUNY Stony Brook, PHENIX COLLABORATION — Recent theoretical studies have indicated that jets can form a Mach cone like topology while traversing the low viscosity medium formed in the high energy Au+Au collisions at RHIC. Two particle azimuthal correlations are indicative of such a shape but can also be ascribed to away side jet deflection due to interactions with the strong flow field. Three particle correlations can distinguish between these scenarios. Use of a high pT particle frame can enhance this capability. In this presentation results from the application of this method to simulations and RHIC 200 GeV Au+Au collisions will be shown.

2:36PM HG.00004 Two particle azimuthal correlations in Cu+Cu collisions at $\sqrt{s_{NN}} = 200$ GeV at RHIC. CHRISTINE NATTRAESS, Yale University, STAR COLLABORATION — Two particle correlations should yield information about jet quenching and production mechanisms at RHIC energies. They have already been studied extensively at RHIC in Au+Au, d+Au, and p+p collisions at $\sqrt{s_{NN}} = 200$ GeV. Two particle azimuthal correlations in Cu+Cu collisions in the STAR detector at $p_{T} = 0$ using $\Delta$ and $K^{0}$ trigger particles are presented. Dependence of the near side peak on centrality and transverse momentum is investigated. Comparisons between baryons and mesons and between particles and antiparticles are made.

2:48PM HG.00005 Low- and intermediate-$p_{T}$ azimuthal di-hadron correlations from $\sqrt{s_{NN}} = 200$ GeV central AuAu collisions measured in STAR, MARK HORNER, Lawrence Berkeley National Laboratory,University of Cape Town, STAR COLLABORATION — Low- and intermediate-$p_{T}$ di-hadron correlations have already uncovered novel and exciting results at RHIC, tying together had processes with bulk properties. We present systematic studies of di-hadron correlations for various trigger and associated $p_{T}$ selections, starting in the coalesence dominated region and extending up into the domain of fragmentation dominated triggers. We study the effects of varying the $\Delta_{T}$ and $\Delta_{\phi}$-integration windows within the STAR acceptance. The results are discussed in light of the interplay between radiative, hydrodynamic and recombination scenarios.

3:00PM HG.00006 ABSTRACT WITHDRAWN –

3:12PM HG.00007 Momentum dissipation and evolution of the bulk-medium produced in Au-Au collisions at RHIC1, MICHAEL DAUGHERITY, The University of Texas at Austin, STAR COLLABORATION — A summary of two-particle number and transverse momentum ($p_{T}$) correlation results is presented which provides evidence for and properties of the highly dissipative medium formed in RHIC collisions. Large momentum scale two-particle correlation measurements in Au-Au collisions at $\sqrt{s_{NN}} = 130$ GeV [1] have now been extended to 62 and 200 GeV, and to finer centrality bins. Number correlations on transverse momentum coordinates reveal strong momentum dissipation of low-$Q^{2}$ partons to the soft, bulk medium causing increased fluctuations. Similar correlation studies on pseudorapidity ($\eta$) and azimuth ($\phi$) indicate dramatic evolution of the same-side, low-$Q^{2}$ parton correlation peak with centrality. Net-charge correlations reveal a qualitative change of hadronization geometry from one-dimensional longitudinal fragmentation in p-p to two-dimensional bulk fragmentation in central Au-Au. Other features of the net-charge correlation data imply the development of an opaque medium. Transverse momentum correlations on $\eta$, $\phi$ suggest that the bulk medium recoils collectively in response to parton stopping. Current results will be shown and the data compared to Hijing and other model predictions. [1] J. Adams et al., Phys. Lett. B634, 347 (2006); nucl-ex/0411003; nucl-ex/0408012.

1Supported in part by The U. S. Dept. of Energy.
3:24PM HG.00008 Systematic Study of Di-Jet Shape Modification in hot QCD matter with the PHENIX detector. PAUL CONSTANTIN, Los Alamos National Lab, PHENIX COLLABORATION — Experimental data collected at the Relativistic Heavy Ion Collider suggests the formation of a new state of dense deconfined QCD matter. One of the best tools to probe its properties is the study of its interaction with hard scattered partons that propagate through it. By using the method of di-hadron angular correlations, we study the shape modifications of hadronic di-jets produced from the fragmentation of such partons. We present a systematic study of the away-side ($\Delta \phi \sim \pi$) di-jet induced angular correlations in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}} = 200$ and 62 GeV in the intermediate (1-5 GeV/c) transverse momentum region.

3:36PM HG.00009 Temperature uniformity of the bulk medium produced in relativistic heavy-ion collisions. LANNY RAY, The University of Texas at Austin — The success of hydrodynamic models of elliptic flow in relativistic heavy ion collisions is often touted as evidence for rapid thermal equilibration. However, large momentum scale two-particle correlations indicate that a significant fraction of the final-state hadrons retain jet-like correlation structure associated with early stage, non-equilibrated low-Q^2 partons [1]. In addition, correlations on transverse momentum $(p_{T1} \times p_{T2})$ suggest that low-Q^2 parton momentum is partially dissipated causing fluctuations in the effective temperature (thermal and/or collective motion) of the bulk medium[2]. We first show that both global and local temperature fluctuation models describe the available $(p_{T1} \times p_{T2})$ correlation data equally well. Results of an analytical model are then presented which tests the sensitivity of $(p_{T1} \times p_{T2})$ correlations to the first few lower-order cumulants of the two-point temperature distribution for the event ensemble. Unique signatures in the predicted $(p_{T1} \times p_{T2})$ correlations are observed for each cumulant term studied. The prospects for direct measurement of the absolute temperature distribution in the bulk medium produced in relativistic heavy-ion collisions using $(p_{T1} \times p_{T2})$ and other correlation measures are discussed. [1] J. Adams et al., Phys. Rev. C 73, 064907 (2006); J. Phys.G. 32, L37 (2006). [2] J. Adams et al., nucl-ex/0408012.

3:48PM HG.00010 Study of dihadron fragmentation functions in Au – Au at $\sqrt{s_{NN}} = 200$ GeV collisions at RHIC as a probe of the medium. OANA CATU, STAR COLLABORATION — Previous studies have shown jet modification in heavy ion collisions due to parton energy loss. One way to investigate this phenomenon is to study the dihadron fragmentation functions. In this work we use azimuthal correlations of high transverse momentum ($p_T$) hadrons to extract dihadron fragmentation functions. We study the correlations as a function of $p_T$ of the trigger and associated particles in Au – Au collisions at $\sqrt{s_{NN}} = 200$ GeV as measured in STAR. Earlier results showed that the ratio of opposite-sign pairs to same-sign pairs from Pythia simulations describe charge ordering in p-p collisions for lower $p_T$. We investigate charge ordering in heavy ion collisions and compare it to results from Pythia simulations. These new results will help gain insight into jet modification in the hot medium of high energy collisions, and hence put constraints on the nature and the magnitude of energy loss in this medium.

4:00PM HG.00011 Azimuthal $\gamma - h^\pm$ and $\pi^0 - h^\pm$ jet correlations in 200 GeV CuCu collisions at RHIC. ANDREW ADARE, University of Colorado, PHENIX COLLABORATION — Azimuthal 2-particle jet correlations involving direct photons provide an important opportunity to study energy loss and jet fragmentation in the dense nuclear medium produced in heavy-ion collisions. A promising analysis technique is the statistical subtraction method, which involves obtaining direct $\gamma - h^\pm$ jet pairs by removing the decay component from inclusive $\gamma - h^\pm$ jet pairs. A description of this process is presented in addition to an update on recent results from the PHENIX experiment.

4:12PM HG.00012 The Impact Parameter Dependence of Heavy Ion Lepton Pair Production to All Orders in Zx. ANTHONY J. BALTZ, Brookhaven National Laboratory — The impact parameter dependence of the ultrarelativistic exact Dirac equation solution of heavy ion electron and muon pair production has been investigated. The exact formulation obtained differs from perturbation theory in such a way that the usual Feynman integral techniques cannot be used for the intermediate photon integral in the impact parameter dependent amplitude. Therefore a piecewise analytic numerical technique has been exploited. The total probability for electromagnetic pair production is found to be smaller than the perturbation theory result for both $e^+ e^-$ and $\mu^+ \mu^-$ pairs throughout the entire impact parameter range. This result may find application in heavy ion experimental conditions, where accepted events are triggered by zero degree calorimeter detection of neutrons from Coulomb dissociation. Detected pair production is thus more heavily weighted at small impact parameters. Predicted cross sections are then appropriately constructed from the integral of the product of the pair production probability times the dissociation probability.

4:24PM HG.00013 Fast Forward Calorimetry for CMS. JESSICA SNYDER, University of Kansas, CMS COLLABORATION — The CMS experiment at the LHC will study heavy ion and p-p collisions at 5 and 14 TeV respectively. The CMS heavy ion group has designed and built a Zero Degree Calorimeter (ZDC), to measure the topology of these collisions. This is part of a general effort in CMS to study low X physics and dense gluonic systems such as the Color Glass Condensate. The calorimeters are comprised of electromagnetic (EM) and hadronic sections with the Berkley shower maximum detector in between. The EM section is segmented transverse to the beam while the hadronic portion is segmented along the beam axis. For p-p collisions, we will study pomerion and odderon production since these are sensitive to the gluonic component of the proton wave function. For heavy ion collisions, we will measure the centrality of the events and provide a fast trigger for ultra-peripheral collisions. I will report on results from our recent beam test at CERN and extrapolate the ZDC’s performance to LHC energies.
3:00PM HH.00004 Beam Spin Asymmetry Measurements from Deeply Virtual Meson Production, KYUNGSEON JOO, MAURIZIO UNGARO, BO ZHAO, University of Connecticut, CLAS COLLABORATION — Study of deeply virtual exclusive meson production (DVMP), is being conducted in the E1-DVCS experiment with the CLAS detector at Jefferson Lab. The main motivation of the experiment is to characterize the partonic properties of the nucleon in the framework of generalized parton distributions (GPDs). Especially, the pseudo-scalar channels are sensitive to the polarized GPDs. The data were taken in the spring of 2005 using a 5.7 GeV longitudinally polarized electron beam and an un-polarized hydrogen target. We will report on the ongoing beam spin asymmetry (BSA) analysis for pseudo-scalar channels. We also discuss a proposed experiment that requires the use of 11 GeV electron beams, in anticipation of an energy upgrade to the existing Jefferson Lab accelerator.