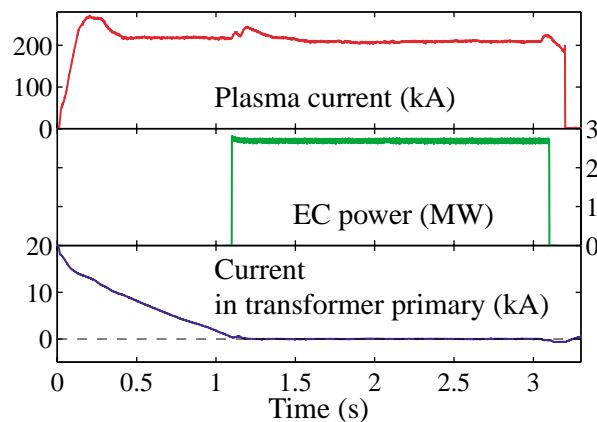


## Full Current Sustainment and Profile Control with Electron Cyclotron Current Drive

The TCV tokamak at CRPP in Lausanne, Switzerland, has produced the first demonstration that a steady-state tokamak discharge can be sustained using only microwaves - “electron cyclotron” waves (ECCD). In a tokamak, the plasma current circulating through the doughnut-shaped vessel generates an essential component of the stabilizing magnetic field. This current is normally maintained by induction using a coil in the center of the torus as the primary and the plasma as the secondary of a transformer. However, continuous current cannot be driven by a transformer, so this method limits tokamaks to pulsed operation. This wastes time between the pulses and also places repeated thermal and mechanical stresses on all the systems involved. Steady-state operation requires the transformer current drive to be replaced with some continuous current drive, like microwaves.

In ECCD, the microwave beam is tuned close to the cyclotron frequency at which electrons orbit about magnetic field lines, and the waves drive plasma current for as long as the power is applied as shown in Fig. 1. This technique allows positioning the current at specific locations within the plasma, which can reduce the severity of plasma instabilities. TCV has shown that accurate steering of the launchers is required to control the pressure and current profiles to sustain stable plasmas. (Paper: MI1.004, olivier.sauter@epfl.ch). More detailed comparisons with theoretical predictions, including the effects of electron trapping and collisionality, have been made possible by new experiments with localized ECCD in the DIII-D tokamak. In DIII-D, the motional Stark effect diagnostic has made possible detailed measurement of the profile of driven current for comparison to theory. (Paper MI1.003, linliu@fusion.gat.com). These results together provide the first comprehensive validation of the theory of ECCD.



Temporal evolution of total plasma current microwave (EC) power, and primary transformer current in TCV, showing no transformer driven current after EC is applied.