PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending December 18 and 25, 2015 are as follows:

U.S. ITER FABRICATION (C. NEUMEYER):

Steady State Electric Network (SSEN):

PPPL was authorized to proceed with final three SSEN procurements (Uninterruptible Power Supply—UPS—system, DC Distribution, and Low Voltage—LV—Distribution and Sub-distribution Panels). Activities recently initiated will lead to a decision about the best strategy to pursue. Procurement of some of the items (battery banks associated with UPS and DC distribution, plus the LV Distribution and Sub-distribution Panels) will likely be transferred to the ITER Organization (IO) for future procurement action to avoid long storage times (battery banks) and to allow more time for the load consumers' designs to evolve (LV panels).

Diagnostics:

Electron Cyclotron Emission (ECE): G. Taylor, A. Khodak, and R. Feder visited the ECE system development team at the University of Texas at Austin. Progress in the testing and design of the ECE Hot Calibration Source was reviewed. The PPPL team also toured the testing facilities where the Hot Source is undergoing vacuum and thermal testing.

Diagnostic RGA (DRGA): The final components for the DRGA R&D gas mixing station have been received and assembled, and the unit will be moved to the testing area during the coming week and connected to the prototype analysis chamber instruments. At that point, all the hardware required to adequately conduct the interstage port tests with the Optical Penning Gauge will be ready for testing. In addition, all the hardware required for the magnetic field sensitivity testing of the Ion Trap Mass Spectrometer has been assembled, and coil calibration has been completed, so this system is also ready for testing. It is expected that both tests will start before the end of December and will continue into January.

Equatorial Port 9 Integration (EP09): The EP09 Integration team completed a draft of a new work plan and schedule in support of program Project Change Requests (PCRs) for January. The new plan is now under review with PPPL management and diagnostic teams and will provide updated milestones for all ITER EP09 systems.

Core Imaging X-ray Spectrometer (CIXS): N. Allen continued to work on refining the bracket design and making preparations for the magnetic field test expected to occur in early January. Also, progress was made toward completing the SOW to be issued for use of a test facility for nuclear testing of a purchased Dectris detector.

NSTX (M. ONO):

NSTX-U is in the FY16 plasma operation.

Matthew Lanctot from General Atomics (GA) visited PPPL from December 7-18 as part of a PPPL-GA collaboration on advanced operating scenarios and plasma control in NSTX-U. During the trip, the GA TokSys toolbox, a set of tokamak control software tools in Matlab/Simulink, was installed on PPPL clusters and the NSTX-U model was updated to include all new passive conductors, PF coils, PF power supplies, and magnetic diagnostics. The model was interfaced with the NSTX-U PCS allowing closed-loop simulations to test PCS algorithms. The accuracy of the new model is being assessed via comparison of simulations with vacuum field test shots. Meetings with NSTX-U staff and collaborators were also held to discuss a possible 3D magnetics upgrade that would complement the Non-axisymetric Control Coils (NCC) upgrade. Technical data, including detailed wall geometry, NSTX-U target equilibria, and 3D plasma response calculations, were obtained to allow an initial assessment of the existing 3D magnetic sensors, and new sensor configurations to be evaluated.

Plasma operations began on December 18 with XMP-101: Inductive Startup Scenarios for NSTX-U (Battaglia). A 120 kA discharge performed in August was successfully repeated, then progress was made in developing a startup scenario using lower loop voltage following plasma breakdown. A number of new tools were integrated into the startup scenario, including raising the on axis toroidal field to 0.65T, which exceeds the maximum field achieved on NSTX.

NSTX-U plasma operations continued with four experimental machine proposals (XMPs); these were successfully carried out. Net results of these efforts were dramatic improvements in the plasma performance. Inner wall limited L-mode discharges were achieved at B_T=0.65 T with an Ip flat-top of 700 kA for ~200 ms [discharge # 202440], and in a separate discharge, an Ip flat-top of 600 kA for ~320 ms [discharge # 202430]. These development activities will be continued following the vessel boronization presently planned for January 4.

XMP-106 [Magnetic Callibrations] was run on December 21 to obtain magnetics calibrations shots for the latest magnetic sensor configuration. All available NSTX-U coil systems were pulsed independently at full current over the course of four shots. A fifth shot was taken with combined ohmic and toroidal field coil currents in order to assess the interaction between the two coil systems.

This was followed by further execution of XMP-101 [Breakdown Scenario Development]. The shots focused on improving the null condition and the poloidal field ramp following breakdown. The XMP concluded with a start up scenario achieving a plasma current of 150 kA by 20 ms using less than 4 loop volts.

XMP-126 [I_p and R Control] was run at the end of December 21 and the morning of December 22. Plasma current feedback was successfully turned on, allowing the plasma current to be ramped and held constant at a fixed value. Major radius control was also implemented, and a first optimization of the associated control gains was made.

XMP-105 [Vertical Position Control Checkout] was started at the end of December 22. The plasma vertical position was successfully controlled using a reduced set of position sensors.

The Multipulse Thompson Scattering (MPTS) laser-beam delivery optics were successfully tested during plasma operations. Preparations are being made for the first vacuum vessel boronization using the new deuterated trimethylboron (dTMB) injection system on January 4.

A 0.51 run week and 51 plasma shots were completed by December 23. Total operation targets are to be decided.

ITER & TOKAMAKS (R. HAWRYLUK):

R. Maingi and R. Nazikian presented two lectures each at the 2015 ITER International School (IIS2015, http://www.iterschool2015.cn/iis/), which was held at the University of Science and Technology of China (USTC) in Hefei, China on December 14-18. Maingi's lectures were titled "The Effect of low-Z Impurities on H-mode Pedestal Structure, Performance, and ELMS" and Nazikian's lectures were titled "The effect of 3D fields on ELMs and pedestal transport." There were approximately 150 students that attended from countries all over the world.

R. Nazikian also visited Peking University to present talks on RMP ELM suppression and energetic particle driven modes in DIII-D steady-state plasmas.

DIII-D (R. Nazikian):

N. Logan was an active programmer for the neutral beams during the experiment testing the real time sensing of tearing modes on the DIII-D tokamak this week. The experiment included a half-day of operation on December 14 as well as a second half-day on December 17. Simultaneous control of power and torque was used to investigate tearing mode stability in the low torque ITER baseline. This was the first experiment as beam operator for Logan, who has been trained in the Plasma Control System (PCS) by W. Solomon over the last year of operations.

Offline tests and calibration of the Impurity Granule Injector (IGI) have been completed. The tests demonstrated the new capability of injecting granules of different materials, by manual adjustment of granule impact location. This new capability is critical for the upcoming DIII-D experiment on ELM pacing with non-fuel pellets. During the tests, sequential injections of Lithium, Boron and Carbon granules (diameter 0.3-0.7 mm), with granule velocities 60-110 m/s and variable injection rates <100Hz were performed, allowing individuals to determine the setup that maximizes the injection efficiency for each species. With these tests completed, the IGI is ready for installation on DIII-D.

ADVANCED PROJECTS (H. NEILSON):

Laboratory participation in the Wendelstein 7-X (W7-X) research program moved forward following the achievement of first plasma on December 10. N. Pablant reported that the first measurements from the U.S. x-ray imaging crystal spectrometer were made on December 15, the last day of W7-X operation before the holiday break. A short argon injection pulse was sufficient to enable the XICS to detect x-ray emission with excellent signal quality, and even to make preliminary central temperature estimates from the data. The results show that the XICS system is performing well, and it is expected that spatial profile measurements will be available soon

after W7-X resumes operation in January.

The Laboratory is leading the fabrication of two TDU Scraper Elements for W7-X, in collaboration with Oak Ridge National Laboratory and Germany's Max Planck Institute for Plasma Physics (IPP). Each scraper consists of two sub-assemblies that will be supplied by commercial fabricators using material furnished by the project, with final assembly to be performed by PPPL. A request for quotation (RFQ) for one of the sub-assemblies was issued in December.

C. Kessel participated in the Fusion Power Associates annual meeting, presenting the work on the Fusion Nuclear Science Facility (FNSF) study being pursued by the Fusion Energy Systems Studies group, motivating its need in the US fusion development program. A wide array of efforts were represented at the meeting, ranging from privately funded fusion development, ITER, NIF and inertial confinement, GA and DIII-D, EU DEMO, JA fusion strategy, DOE OFES, PPPL and NSTX-U, to name a few. Many views and approaches to fusion energy development were expressed.

As part of its collaboration with the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP), the Laboratory welcomed Dr. Jinxing Zheng for a week of joint work on the China Fusion Engineering Test Reactor (CFETR) concept study. The Laboratory's CFETR engineering team worked together with Dr. Zheng to define a reference design point for CFETR, addressing issues of machine configuration and magnet structural limits. In addition, a meeting with MIT superconducting magnet experts was held to discuss the risks and benefits of various superconductor materials options for the magnets. The intensive period of work and discussions led to substantial progress and good preparation for a joint CFETR workshop to be held at ASIPP in January.

A manuscript by N. Pablant, et al., "Investigation of ion and electron heat transport of high-Te ECH heated discharges in the Large Helical Device," was accepted for publication in the journal Plasma Physics and Controlled Fusion. The paper reports on work performed in collaboration with Japan's National Institute for Fusion Science (NIFS) using the U.S. x-ray imaging crystal spectrometer diagnostic that operated on LHD from 2012 to 2014.

A production allocation of 1,000,000 hours at NERSC has been awarded to S. Lazerson as the PI on a project entitled "Optimizing stellarators for energetic particle confinement." This project utilizes the newly developed BEAMS3D stellarator energetic particle code and the STELLOPT code to explore possible improvements to energetic particle losses through 3D shaping.

THEORY (A. BHATTACHARJEE):

A CSEP/GSEP SciDAC workshop was held from December 14-16 at PPPL. This was a joint project meeting of the two energetic particle SciDAC teams: CSEP (Center for nonlinear Simulation of Energetic Particles in burning plasmas) and GSEP (Gyrokinetic Simulation of Energetic Particle Turbulence and Transport). The purpose of the workshop was to review recent progress and discuss future plans in the next five years. The workshop presentations included 14 oral presentations on recent results and future research needs as well as two discussion sessions on the most important research problems for the next five years. G. Fu (CSEP PI) of PPPL and

Zhihong Lin (GSEP PI) of UCI organized the workshop. The workshop attendees included: E. Belova, V. Duarte, N. Gorelenkov, M. Podesta, F. Wang and R. White from PPPL; Yang Chen from University of Colorado; Herbert Berk, Boris Breizman, and Ge Wang from IFS; Guangzhou Hao, Bill Heidbrink and Deyong Liu from UCI; Don Spong from ORNL; Ron Waltz from GA; and Eric Bass from UCSD.

DIRECTOR'S OFFICE (C. AUSTIN):

S. Prager, M. Zarnstorff, R. Hawryluk, and G. Neilson participated in the University Fusion Association Forum on December 14-15, held at University of Maryland, College Park. The two-day forum was held to discuss the status and future of fusion energy and plasma science research.

On December 16, S. Prager attended the National Lab Director's Council meeting, held in Washington, DC.

On December 16, Dr. Frans Pretorius, Princeton University, presented a colloquium entitled, "Binary Black Hole and Neutron Star Collisions".

December 16-17, S. Prager, M. Zarnstorff, and R. Hawryluk attended the annual Fusion Power Associates Symposium in Washington. The topic of the symposium was "Strategies to Fusion Power".

This report is also available on the following web site:
http://www.pppl.gov/publication-type/weekly-highlights