

PRINCETON PLASMA PHYSICS LABORATORY

**WEEKLY** highlights



**The PPPL Highlights for the week ending June 5, 2015, are as follows:**

### **U.S. ITER FABRICATION (D. JOHNSON):**

The following presentations were given on U.S. ITER Diagnostics, Port Plug Engineering, and State Electric Network SOFE this week: G. D. Loesser, SO2-1: Development of ITER Generic Diagnostic First Wall for a Wide Range of Diagnostic Configurations, R. Feder, SO2-1: Engineering Challenges for ITER Diagnostics, Y. Zhai, SO2-6: Electromagnetic Analysis of ITER Diagnostic Port Plugs and Diagnostic Systems During Plasma Events, T. N. Carlstrom, SO11-4: Status of TIP, LFSR, WAVS Diagnostic Designs for ITER, W. L. Rowan, SO11-5: Development of a Hot Source for in-Situ Calibration of the ITER Electron Cyclotron Emission Diagnostic, W. Wang, SP2-20: Thermal Protection of ITER Diagnostic Equipment in the Port Plug Interspace. C. Neumeyer and J. Dellas, Lessons Learned During The Procurement of the ITER Steady State Electrical Network Components by the U.S. Domestic Agency

A. Khodak and Y. Zhai spent two days with the ECE diagnostic team at University of Texas-Austin providing structural analysis and ITER design code training. UT-Austin is providing ECE physics modeling and system performance optimization as well as hardware components for ECE. The main component is the In-Situ Hot Calibration source, which provides broadband microwave calibration by heating a silicon carbide disc to over 700° Celsius. The specially machined disk radiates as a black body and allows for real time monitoring of ECE optical degradation and changes in system throughput. The ECE hot sources need to operate at high temperature in the hostile port plug high vacuum environment. Several iterations of computer analysis and prototype testing will be conducted by UT-Austin and it is critical that this design work follows ITER required specifications.

The U.S. is supplying five Upper Port Wide Angle View Visible-IR camera systems to ITER. The UPP WAVs serve a critical machine protection role for ITER with combined 360-degree visible and infrared views of the divertor and lower inner blanket modules. To achieve this distribution the five camera system need to be integrated in to five different port plugs owned by three different domestic agencies. A. Jariwala and M. Smith are actively managing this complex integration puzzle holding a series of web-meetings with the port integration teams in Russia and Europe and here at PPPL.

Members of the PPPL MSE diagnostic team reviewed new results from the MSE-LS data study being conducted at DIII-D by Lang Lao and company. The DIII-D team has added an MSE-LS module to the DIII-D EFIT reconstruction code. Synthetic plasma spectroscopic data based on various DIII-D discharge scenarios was then used for equilibrium reconstruction.

The Reactive Power Compensators RFP package was revised to reflect DOE comments and is now in final DOE review. Request for proposal issue date anticipated is June 10.

### **NSTX (M. ONO):**

NSTX-U is in the Upgrade Project outage in FY15.

The exit flight tube of the Multi-Pulse Thompson Scattering (MPTS) has started to be baked. Testing of the MPTS safety interlocks has been completed, and the Laser Room shutter has been locked and tagged closed to accommodate isolated testing of the MPTS Lasers.

The Material Analysis Particle Probe (MAPP) probe and chamber were installed, pumped and leak checked. All vacuum components of the MAPP have been determined to be leak tight from the analysis chamber attached to NSTX-U through the probe drive below it. Preparation of the electronics rack for installation in the NSTX-U Test Cell has been completed with the connection of all components to a single point ground.

Recovery from an external arc fault at the Ohmic Heating (OH) coil terminals continued this past week. Cleanup of the upper ceramic break assembly was completed, and daily inner/ outer vacuum vessel electrical insulation tests (Hi-Pots) have resumed. A trial of the OH Coil coaxial connection assembly potting process was performed, and results are being analyzed. New G-10 spacers for the TF connector restraints are being fabricated, and tests of a structural filler (adhesive) to minimize stresses in that area have been completed. Field Coil Power Conversion (FCPC) rectifier dummy load testing of additional TF parallel circuits continued this week.

### **ITER & TOKAMAKS (R. HAWRYLUK):**

J. R. Wilson and P. T. Bonoli published a review article in a special edition of Physics of Plasmas entitled “Progress on ion cyclotron range of frequencies heating physics and technology in support of the International Tokamak Experimental Reactor” [Phys. Plasmas 22, 021801 (2015); <http://dx.doi.org/10.1063/1.4901090>]. The abstract states “Ion cyclotron range of frequency (ICRF) heating is foreseen as an integral component of the initial ITER operation. The status of ICRF preparations for ITER and supporting research were updated in the 2007 [Gomezano et al., Nucl. Fusion 47, S285 (2007)] report on the ITER physics basis. In this report, we summarize progress made toward the successful application of ICRF power on ITER since that time. Significant advances have been made in support of the technical design by development of new techniques for arc protection, new algorithms for tuning and matching, carrying out experimental tests of more ITER like antennas and demonstration on mockups that the design assumptions are correct. In addition, new applications of the ICRF system, beyond just bulk heating, have been proposed and explored.”

### **DIII-D (R. Nazikian):**

Upgrades to ECE-Imaging and MIR for the coming experimental campaign are proceeding with in situ testing and calibration on DIII-D. New microwave sources and other components has been successfully bench tested and installed for the beginning of plasma operations on June 8.

Improved source stability and increased power will extend the fluctuation bandwidth of MIR to near DC frequency with dramatic improvements in signal to noise for both MIR and ECEI. In upcoming calibration tasks, the goal is to demonstrate limited frequency stepping capability, which would allow MIR and ECEI to acquire radially swept fluctuation profile measurements to better characterize fluctuations near the plasma edge.

#### **International (S. Scott):**

S. Scott and J. Strachan visited Henri Weisen at JET for analysis of neutron emission in JET plasmas that approximate conditions in the proposed 'ITER baseline' plasma scenario that is the leading candidate for ITER to fulfill its mission of a fusion power amplification of ten. There is concern that the measured neutron emission in these JET plasmas falls below predictions of a simple Fokker-Planck beam-ion thermalization code developed at JET (CHEAP) by up to a factor of two in some regions of parameter space. Plasma simulations by the TRANSP code, which has a more sophisticated and well-benchmarked physics model for beam ion physics confirm the existence and approximate magnitude of this 'neutron deficit' although parametric dependencies differ from that inferred by the CHEAP code. Approximately 200 plasmas were simulated by Steve and JET plasma-scenario modeling staff in this effort, in addition to approximately 40 simulations to evaluate sensitivity to diagnostic and modeling uncertainties. This work will be reported by Henri Weisen at the upcoming EPS meeting.

#### **ADVANCED PROJECTS (H. NEILSON):**

The IEEE Symposium on Fusion Engineering (SOFE) was held May 31-June 4 in Austin, Texas, and featured a special session on "Design and Analysis Tools for Stellarator DEMO Devices." The session, which was co-organized by H. Neilson and H.-S. Bosch (Max Planck Institute for Plasma Physics, Germany), highlighted advances in stellarator understanding and new capabilities to design stellarators for fusion. Presentations by F. Warmer (Germany) and T. Goto (Japan) showed advances in stellarator system codes that now provide capabilities for design optimization, sensitivity, and trade-off studies for stellarators comparable to those available for tokamaks. O. Schmitz (University of Wisconsin) explained the current status and plans for developing divertor optimization tools, emphasizing the critical role of Wendelstein 7-X in this area. T. Brown highlighted advances made by PPPL in the development of design tools for stellarator coils with improved engineering characteristics, and D. Andruczyk (University of Illinois) described new opportunities to use a stellarator to study plasma-facing material issues relevant to all confinement concepts.

During the SOFE conference, PPPL's C. Kessel received the Fusion Technology Award in recognition of his contributions to fusion science and technology, especially his leadership in U.S. fusion system studies, over many years. Kessel's presentation in a special Fusion Technology Award session discussed the mission requirements and technical metrics for a fusion nuclear science facility (FNSF), reporting on recent work by the national system studies team under his leadership. In addition, it was announced that several PPPL staff will have key roles in the organization of the next SOFE, which will be held in Shanghai, China in 2017: K. Lukazik (registration chair), C. Neumeyer (finance chair), and H. Neilson (general chair).

## **THEORY (A. BHATTACHARJEE):**

A paper by E. V. Belova, N. N. Gorelenkov, E. D. Fredrickson, and K. Tritz, N. A. Crocker, entitled "Coupling of Neutral-beam-driven Compressional Alfvén Eigenmodes to Kinetic Alfvén Waves in NSTX and Energy Channeling" has been accepted to Physical Review Letters. The abstract reads "An energy channeling mechanism is proposed to explain flattening of the electron temperature profiles at high beam power in beam-heated National Spherical Torus Experiment (NSTX). Results of self-consistent simulations of neutral-beam-driven compressional Alfvén eigenmodes (CAEs) in NSTX are presented that demonstrate strong coupling of CAE to kinetic Alfvén wave at the Alfvén resonance location. It is suggested that CAE can channel energy from the beam ions to the location of the resonant mode conversion at the edge of the beam density profile, modifying the energy deposition profile."

## **ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):**

### **NSTX Upgrade (R. Strykowski, E. Perry, L. Dudek, T. Stevenson):**

Several NSTX-U engineers and researchers participated in the IEEE Symposium on Fusion Engineering (SOFE) held May 31-June 4, in Austin, Texas. Oral presentations included: "The NSTX-U Program for Closing Gaps to Fusion Energy", by J. E. Menard, "Developing Snowflake Divertor Physics Basis in the DIII-D, NSTX, and NSTX-U Tokamaks Aimed at the Divertor Power Exhaust Solution" by V. A. Soukhanovskii, "Prospects for Power and Particle Exhaust with High-Temperature Liquid Lithium Divertors" by M. A. Jaworski, "NSTX-U Digital Coil Protection System Integration with Existing Plasma Control System" by K. G. Erickson, "NSTX Upgrade Power Supply System" by W. Que, and "Tensile Strain Mitigation During the NSTX-U OH Coil Cooldown" by P. H. Titus. Posters presented included: "The NSTX-U Digital Coil Protection System AutoTester" by G. N. Zimmer, "Design and Operation of a Fast Gas Valve for Disruption Mitigation Studies on NSTX-U" by R. Raman, "MDSplus for the NSTX-U Digital Coil Protection System" by G. J. Tchilinguirian, "The Materials Analysis Particle Probe Upgrade (MAPP): Summary of Status and Upcoming Experiments in the National Spherical Torus Experiment Upgrade (NSTX-U)" by F. Bedoya, "Lithium as a Plasma Facing Component to Optimize the Edge Plasma Performance" by R. Maingi, "NSTX Toroidal Field Coil Turn to Turn Short Detection" by S. Ramakrishnan, "New DSP-Based Firing Generator for the PPPL AC/DC Converters" by W. Que, and "NSTX-U Coils Bus Bars Design and Construction" by N. D. Atnafu. R. Maingi was also was an invited instructor for a mini-course on Plasma-Material Interactions just preceding the SOFE conference and delivered a lecture entitled "PMI in fusion devices."

### **Facilities and Site Services (M. Viola):**

Loan Agreement 11-05 with the National Fusion Research Institute (KSTAR) was approved by DOE.

## **OFFICE OF COMMUNICATIONS (C. CANE):**

Cosas, a Peruvian media outlet, wrote a story about PPPL physicist L. Delgado-Aparicio's winning an Early Career Research Program grant.

WHYY published a piece by reporter Carolyn Beeler that includes quotes from PPPL Director S. Prager, and focuses on NSTX-U.

## **DIRECTOR'S OFFICE (C. AUSTIN):**

On May 23-29, A. Cohen visited ITER in Cadarache, France to participate in a Management Advisory Committee Meeting (MAC).

On June 2-4, A. Cohen traveled to Fermi National Laboratory in Warrenville, Illinois to participate in a CD-1 Director's Review of the Long-Baseline Neutrino Facility (LBNF) and the Deep Underground Neutrino Experiment (DUNE) meeting.

M. Zarnstorff, A. Bhattacharjee, F. Poli, W. Tang, S. Kaye, G.Y. Fu, S. Jardin, C.S. Chang, G. Hammett, and B. Grierson, participated in the DOE Workshop on Integrated Simulations for Magnetic Fusion Energy Sciences, which was held June 2-4 in Rockville, Maryland. The workshop reviewed recent progress to identify gaps and challenges in fusion theory and computation directly relevant to the topic of disruption prevention, avoidance, and mitigation and that of plasma boundary physics, with whole device modeling as the long-term goal.

A colloquium was presented on June 3 by Dr. Joe Kilkenney, Lawrence Livermore National Laboratory/ General Atomics and Dr. Greg Rochau, Sandia National Laboratory entitled "Progress towards fusion on NIF and Z requires new plasma measurement capabilities".

## **AWARDS:**

Kessel, C., SOFE, Fusion Technology Award in recognition of his contributions to fusion science and technology, especially his leadership in U.S. fusion system studies, over many years.

## **PUBLICATIONS:**

Wilson, J.R.; and Bonoli, P.T., "Progress On Ion Cyclotron Range Of Frequencies Heating Physics And Technology In Support Of The International Tokamak Experimental Reactor," Physics of Plasmas 22, 021801 (2015); <http://dx.doi.org/10.1063/1.4901090>

## **LEADERSHIP POSITIONS:**

H. Neilson, H., General Chair, SOFE, Shanghai, China 2017  
Lukazik, C., Registration Chair, SOFE, Shanghai, China 2017  
Neumeyer, C., Finance Chair, SOFE, Shanghai, China 2017

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