

PRINCETON PLASMA PHYSICS LABORATORY

**WEEKLY** highlights



**The PPPL Highlights for the week ending June 6, 2014, are as follows:**

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

WBS Manager D. Johnson attended the High Temperature Plasma Diagnostics in Atlanta, Georgia presenting the banquet talk entitled "ITER Diagnostic Development".

For the Toroidal Interferometer/Polarimeter (TIP) diagnostic, one of the five retro-reflectors is located in U.S. port plug E3. In this location, there are several configurations that have been considered, including: 1) retro located behind vacuum window in interspace with plane mirrors in port plug relaying beams to/from retro; 2) retro located in port plug actively water-cooled; and 3) retro located in port plug passively cooled by contact (with graffoil gasket) to cooled shield module. Option 3 has the potential advantage robotic change-out using an in-vessel manipulator and custom insertion/removal tool. Option 3 is now considered preferred if scoping analysis confirms that thermal distortion is tolerable.

**NSTX (M. ONO):**

NSTX-U researchers attended the International Conference on Plasma Surface Interactions in Controlled Fusion Devices from May 26-30 held in Kanazawa, Japan. This meeting highlights research around the world on physical processes at the plasma-material interface, material erosion and migration, plasma fueling and particle control, wall conditioning, impurity sources and transport, edge and divertor plasma physics as well as plasma-material interaction issues related to future fusion reactors. NSTX-U research in these areas was presented by PPPL personnel M. Ono, R. Maingi, M. Jaworski, D. Stotler, R. Goldston, A. Capece, and T. Abrams; ORNL personnel T.K. Gray and J.-W. Ahn; and LLNL personnel F. Scotti and E. Meier. Initial results from the Material Analysis and Particle Probe (MAPP) diagnostic on the Lithium Tokamak Experiment (LTX) (being readied for NSTX-U by professor J.-P. Allain's U-Illinois group) were also presented by PPPL graduate student M. Lucia. In addition, NSTX-U researchers E. Kolemen (PPPL) and V. Soukhanovskii (LLNL) gave presentations on DIII-D collaboration experiments on the plasma control and snow-flake divertor experiments, respectively. A. Hubbard (MIT) also gave a PSI talk on the 2013 Joint Research Target including contributions from three major facilities (C-Mod, DIII-D, and NSTX-U) which was led by a NSTX-U researcher S. Gerhardt (PPPL). NSTX-U presentations and manuscripts submitted to the Journal of Nuclear Materials will be available on the NSTX-U "Drag'n'Drop" website.

Several presentations were made by PPPL participants at the IEEE International Conference on Plasma Science in Washington, D.C. this past week. R. Kaita gave an invited talk that included a

summary of past tokamak research with lithium plasma-facing components (PFCs), and an overview of PFC plans for NSTX-U. C. Skinner described observations of stainless steel wetting by solid lithium using scanning auger microscopy. A poster by T. Abrams covered the observation of significant lithium redeposition under high flux bombardment of lithium on a planned NSTX-U PFC material (TZM). A poster by J. Nichols reported on the development of modeling tools and new diagnostics in support of material migration studies on NSTX-U.

Princeton University graduating senior Alex Creely '14 was awarded the Jeffrey O. Kephart '80 Prize in Engineering Physics for outstanding independent thesis research. His thesis, entitled "Characterization of Thermal Desorption from Hydrogen-Carbon Co-Deposition Layers for Fusion Applications via Crystal Microbalance Measurements with Gallium Orthophosphate Crystals", tested the ability to thermally desorb hydrogen from carbon codeposit layers while simultaneously measuring mass loss. This research was conducted in the NSTX-U Lithium Technology Development Laboratory under the direction of PPPL researcher Michael Jaworski. This work lays the groundwork for performing thermogravimetric analysis within the NSTX-U vacuum vessel as a means of characterizing fuel and PFC material mass fluxes at various locations within the device and will continue to be developed in the Materials and PFCs topical science group.

M. Ono (PPPL) visited National Institute for Fusion Science, Gifu, Japan to discuss various US-Japan NSTX-U/LHD collaboration topics including the LHD long-pulse ICRF/ECH experiments with Professors Mutoh and Seki and the LHD RF team members. He also discussed the superconducting ST "JUST" design with Prof. Nagayama and the liquid metal R&D activities at NIFS with Prof. Hirooka. M. Ono gave a seminar entitled "National Spherical Torus Experiment -Upgrade Status and Plans". He then visited the QUEST group at Kyushu University where he discussed with Professor Hanada and his associates on the CHI experimental preparation on QUEST as the design is being finalized for the upcoming CHI QUEST modification this summer. He also discussed the 28 GHz ECH/EBH start-up and sustainment experiment on QUEST.

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

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

D. Battaglia led an experiment with B. Grierson and the DIII-D team to assess the physics of edge ion flow and its relation to bulk angular momentum generation. The experiment explored the dependence of edge flow on collisionality, parallel connection length and ion temperature, all at nominally zero injected NBI torque. The newly installed edge main-ion CER prototype diagnostic was used to characterize the edge flow. Initial measurements indicate that edge main-ion CER system is successful in resolving the narrow channel of co- $I_p$  flow observed previously on Mach probes.

The Lithium Granular Injector (LGI) ferrofluidic feed through was shipped to GA from PPPL and has been successfully tested down  $1e-7$  Torr. This feed through is used to rotate the lithium granule impeller up to 15k RPM in order to inject granules at up to  $\sim 100$ m/s into the plasma. The feedthrough is now qualified for installation on DIII-D.

B. Tobias attended the High Temperature Diagnostics Conference in Atlanta and presented a paper titled "Phase-locking of magnetic islands diagnosed by ECE-Imaging".

#### **C-Mod (S. Scott):**

The MSE group participated in the second half of MP739, which is looking at the effect of magnetic shear on intrinsic rotation. R. Mumgaard presented his invited talk at the HTPD, "Toward Reactor Relevant MSE: Polarized Background Subtraction and In-situ Calibration on Alcator C-Mod", based on the last several years of work on MSE at C-Mod.

#### **International (R. Maingi):**

R. Maingi visited ASIPP during June 2-6. He presented a seminar on the initial DIII-D lithium aerosol injection experiments, and discussed collaborative experiments using the lithium dropper and the granule injector for ELM control, as well as details of a joint PPPL-ASIPP IAEA paper on ELM control with lithium conditioning.

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

In its collaboration with the Wendelstein 7-X stellarator project at Germany's Max Planck Institute of Plasma Physics (IPP), on-site commissioning of all five U.S. trim coil power supplies was completed this week. The commission was led by a representative of the manufacturer, Applied Power Systems, Inc., working under contract to PPPL, and was supported by IPP engineering and technical staff. Completion of the commissioning is a milestone, marking the end of the trim coil power supply fabrication project.

N. Pablant presented a contributed paper entitled "Tomographic inversion techniques incorporating physical constraints for line integrated spectroscopy" at the Topical Conference on High-Temperature Plasma Diagnostics in Atlanta, Georgia. This work is the culmination of several years of developing the inversion analysis package for the LHD x-ray imaging crystal spectrometer (XICS) diagnostic. The inversion technique is important not only on LHD, but also for future XICS systems on Wendelstein 7-X and ITER. The poster presentation was well received and provided an excellent focal point for many discussion of inversion techniques in general and for XICS systems in particular.

C. Kessel and H. Neilson attended a public meeting of the FESAC Strategic Planning sub-panel, held June 3-5 in Gaithersburg, Maryland. Kessel made a presentation describing a ten-year initiative on Critical Fusion Nuclear Science Activities Required Over the Next Decade to Establish the Scientific Basis for a Fusion Nuclear Science Facility. Neilson participated in discussions on a proposed stellarator initiative.

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

W. Fox attended the Meeting of the American Astronomical Society, and presented a talk titled "Astrophysical Weibel Instability in Counter-Streaming Laser-Produced Plasmas".

On May 30, L.E. Zakharov gave a Research & Review Seminar to the Theory Department, titled "Li-Wall Fusion - no alternative, no other option". He explained an innovative "particle diffusion based" confinement regime and introduced the LiWF theory. The implementation of this best possible confinement regime requires the plasma pumping from its edge, which is made realistic by the recent invention of a system with a continuous flow of thin lithium film (called 7/24 FLiLi) along the plasma facing surface of limiters or divertor plates. A lithium limiter based on this concept was manufactured, and delivered from PPPL to EAST tokamak in Hefei, China, where it was installed and prepared for the plasma experiments in July. An initial cylindrical version of a new vertical disruption code (CylVDE) was written by the Theory Department visitor Xujing Li. First results of CylVDE clarified the important details of plasma-wall interactions and MHD processes during disruptions. The simulations confirmed the generation of Hiro and Evans currents previously predicted by Zakharov and measured on EAST in 2012. These simulations stimulate the development of new diagnostics, which will measure the radial profile and localization of the Evans currents during disruptions. The corresponding proposal was submitted to NSTX-U management for future implementation.

### **PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):**

Klaus Widmann from the Lawrence Livermore National Laboratory (LLNL) is visiting PPPL. He is taking data with a new high-resolution grating spectrometer (HIGS) that was developed at LLNL and recently installed on LTX. Lines have been identified that correspond to the impurity charge states measured with the LLNL Long Wavelength Extreme Ultraviolet Spectrometer (LoWEUS) already on LTX. The focusing and slit size are being adjusted to optimize the resolving power for determining lithium line widths.

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

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

Construction: The new RF straps have been installed in-vessel and the installation of the faraday cages has been started. CHERS calibrations will preclude other in-vessel activities for the next two weeks. In two weeks, the vessel floor will be removed as part of the preparations for the new centerstack.

The new RWM coil at JK has passed its megger test. The new RWM coil at LA will be megger tested in a few days. Potting of the lower TF outer leg aluminum blocks continues. Installation of vacuum/RGA cables and fiberoptics continues with cable pulls and terminations. The SSNPA cable installation has been completed. The bay J port cover has been installed.

CS Upgrade: The mold is being prepared to receive the OH coil for the VPI process. A successful trial fit up of the OH/TF Mold was made on the coil this week. Some minor modifications were made to accommodate the as-built condition of the coil. The VPI procedure is in the approval cycle. Hollis has begun welding type B & C Finger supports. The delivery schedule is holding for the end of June. Major Tool cut the slots for the jumper weld connection and formed the first jumper. First plate shipment is now scheduled for June 20. A slightly oversized gasket (+0.020") was identified as a remedy for the CS ceramic break leak.

NBI Upgrade: The High Voltage Transmission Line support and ground wire installation is complete, with transmission lines in their final positions. The BL2 High Voltage Enclosures have been bolted to the floor. The vacuum system roughing line and SF6 fabrication and installation were on hold due to conflicting priorities. The airlines for BL2 SIVs were fabricated and installed. NB Armor thermocouple scanning system software development is complete. Mod/Reg controls work, chassis preparations, fiber optics, and D.C power supply preparation continues. LCC low voltage power supply installation and reactivation is in progress including startup troubleshooting. NB Controls fabrication and installation cabling work on rack connections, cable runs, and BL wiring continued in NTC and gallery. Telemetry fiber optics termination, polishing, and testing are in progress in NTC. OMA hardware installations continued on BL2 source platform. Additional NB installation procedures are in development and review. Management performed the monthly EVMS status review of all active jobs.

Digital Coil Protection System: The Hardware Interface FDR is taking place this week. Work continued on the DCPS GUI. LabView was updated on the Autotester computer and DCPS testing in FCC continued. Progress continues on the AT panel and RCIM interface. Other changes in DCPS for overcurrent protection were discussed for implementation. Hardware and I/O layout and design nears completion for the FDR. Work on hardware drawings also nears completion. The HW user interface panel and chassis design updates are in progress. PCB design is in progress, several more PCBs were ordered, and additional parts ordering continues. Water PLC and HSC testing development continues. The Lemo connector cable orders are in progress. The DCPS PTP and OP procedure development continues. The review of development of reliability, failure modes, and administrative control continued. The review of open chits is in progress. The DCPS Team prepared and presented status at the monthly project meeting.

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

On June 2, the Directorate and J. DeLooper hosted a visit by Dr. Marc Kastner, and Dr. Franklin Orr. Topics discussed were fusion, PPPL, and a tour was provided.

June 3-5, a FESAC Strategy Panel meeting was held in Gaithersburg, Maryland. PPPL participants included: S. Prager, M. Zarnstorff, C. Kessel, W. Fox, H. Ji, Y. Raitses, P. Efthimion.

### **PUBLICATIONS:**

The following PPPL Reports were posted to the web:

Progress In Understanding The Enhanced Petestal H-mode In NSTX PPPL-5031  
Authors: Stefan Gerhardt, et. al.  
Submitted to: Nuclear Fusion (January 2014)

Magnetic Diagnostics For Equilibrium Reconstruction And Realtime Plasma Control In NSTX-Upgrade PPPL-5032  
Authors: Stefan Gerhardt, et. al.

Submitted to: Review of Scientific Instruments (June 2014)

Development and Operation of High-throughput Accurate-wavelength Lens-based Spectrometer  
PPPL-5033

Authors: Ronald E. Bell

Submitted to: Review of Scientific Instruments (June, 2014)

Presented at: High Temperature Plasma Diagnostics Conference, Atlanta, GA (June 1-5, 2014)

This report is also available on the following web site:

<http://www.pppl.gov/publication-type/weekly-highlights>