

PRINCETON PLASMA PHYSICS LABORATORY

**WEEKLY** highlights



**The PPPL Highlights for the week ending May 15, 2015, are as follows:**

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

The final three of four HV Substation Transformers are en route, via special convoy, from the port Fos du Mer to the ITER site.

Bruce Lenzer, a Value Engineering and program management expert from Jefferson Laboratory, conducted a two-day Introduction to Value Engineering workshop at PPPL this week. IN addition to all the diagnostic and port plug system CAMs, attendees included ORNL/USITER and General Atomics staff.

IO-CT reflectometry experts accepted the US proposal for an All-Monostatic Low Field Side Reflectometry (LFSR) diagnostic configuration using seven fixed microwave antennas. This configuration is optimal for satisfying the primary LFSR measurement requirements laid out in the LFSR procurement arrangement.

Parts for the prototype TIP retroreflector were accepted for delivery following fabrication at Imperial Machine and inspection at PPPL. Other components needed to test this prototype were procured and assembled. Over the next weeks, the plan is to assemble the three-part retroreflector and test that the design to fine-tune the optical performance is viable.

The DRGA team submitted the revised Lower Port 12 DRGA Load Spec to iDOCS for U.S. review. It has been 9-1/2 months since the DRGA FDR#1 at which the load spec was determined to be incomplete. It has been a difficult process to update the load spec because many of the supporting documents from the IO were incomplete. A key event was gaining acceptance for the U.S. team to use the ASME piping code instead of the European RCC-MR code.

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

S. Sabbagh (Columbia University) made the presentation “Global MHD Mode Stabilization for Disruption Avoidance in Tokamaks” at Columbia University on May 8. The presentation showed several elements of disruption control research bridging from NSTX to NSTX-U including kinetic RWM stabilization physics and experiments, use of neoclassical toroidal viscosity (NTV) in plasma rotation feedback control, dual field component and model-based, state-space RWM active control, high normalized beta and NTV experiments on the KSTAR superconducting tokamak, and the analysis of the NCC 3D coil set upgrade for NSTX-U for RWM control. These

research elements were shown in the context of ITPA joint experiments in 2014, and the present efforts of the NSTX-U Disruption Prediction, Avoidance, and Mitigation Working Group.

The following NSTX-U scientists attended the US/EU TTF Workshop held in Salem, Massachusetts from April 28-May 1, and gave the following presentations: Oral talks were “Non-perturbative critical gradient model for Alfvénic fast ion relaxation using HINST code” by N. Gorelenkov (PPPL), “Validation of a new fast ion transport model for TRANSP” by M. Podesta (PPPL), “Physical mechanisms setting the divertor heat-load width seen from the XGC1 gyro kinetic simulations” by S.-H. Ku (PPPL), “Experimental studies of electron-scale turbulence on NSTX and NSTX-U: present status and future plans” by Y. Ren (PPPL), and “Nailing down the bootstrap current physics in steep pedestal plasma from advanced numerical simulation” by R. Hager (PPPL). Poster presentations were “Reduced model prediction of electron temperature profiles in microtearing-dominated NSTX plasmas” by S. Kaye (PPPL), “Distinct turbulence sources and confinement feature in spherical tokamak plasma regime” by W. Wang (PPPL), “Identifying distinct evolution patterns among ELMs on NSTX with unsupervised machine learning” by D. Smith (University of Wisconsin), “Variations in Edge and SOL Turbulence in NSTX” by S. Zweben (PPPL), “Theory-based interpretive analysis of the NSTX GPI database” by J. Myra (Lodestar), and “Electron density gradient stabilization of electron scale turbulence at NSTX” by J. Ruiz Ruiz (MIT).

J. Menard (PPPL) attended the KSTAR PAC meeting held April 27-29 at the National Fusion Research Institute (NFRI) in Daejeon, South Korea. Following the PAC meeting, he gave a seminar presentation to NFRI/KSTAR scientists entitled “NSTX-U Research Highlights and Program Status and Plans”.

The NSTX-U Team Meeting was held on May 1 at PPPL. The NSTX-U team was updated on the recent electrical fault event in the upper OH cooling water outlet area and the associated repair plan. An updated schedule toward research operation and the research program plan were also discussed. The meeting material is available on the web at [http://nstx.pppl.gov/DragNDrop/NSTX\\_Meetings/Team\\_Meetings/2015/2015-05/](http://nstx.pppl.gov/DragNDrop/NSTX_Meetings/Team_Meetings/2015/2015-05/).

The Multi-pulse Thomson Scattering (MPTS) Guillotine shutter has been successfully recommissioned allowing for isolated Laser tests, and initial alignments have been checked from the MPTS optics box through the exit flight tube. Installation of the MPTS laser beam exit flight tube is complete and it is under vacuum with all three beam turning mirror crosses and its internal components installed. The Material Analysis and Particle Probe (MAPP) sample analysis chamber was successfully installed under the NSTX-U vacuum vessel.

Recovery from an external arc fault at the Ohmic Heating (OH) coil terminals continued this past week. Disassembly/analysis of components in the upper umbrella and cleanup of components in the upper umbrella have been completed, and electrical insulation tests (Meggers) of the OH coil as well as hydrostatic testing of the OH coil cooling paths have been successfully performed. Procedures have been prepared and approved, and work has started to remove the lower TF flex buses for inspections and to replace the OH cooling tube brackets. Vessel magnetic sensors and Rogowski coils have been successfully tested. A PPPL committee has been appointed to review the OH coil fault and met on May 8 to develop a report on this event. Conditioning of all three ion sources on neutral beam #2 is in progress. Work also continues on post CD-4 capabilities needed for NSTX-U experimental operations. Work packages are being prepared for the

installation of the Zeus, LoWeus, and MonaLisa spectrometers and for MAPP. Conditioning of all three ion sources on neutral beam #2 is in progress. Work also continues on post CD-4 capabilities needed for NSTX-U experimental operations. The Glow Discharge Cleaning (GDC) system has been returned to service, and ~ 6 hours of-in vessel GDC were performed this week. Power testing of Field Coil Power Conversion (FCPC) rectifiers into a “dummy” load was completed on power supplies for coils PF1cU, PF2U/L, PF4, and several more TF parallels. The replacement of the MG cyclo-converter transformer with a spare unit has been completed, and operational testing of the MG Set is planned for the week of May 19.

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

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

A paper titled "Enhanced H-mode pedestals with lithium injection in DIII-D" by T.H. Osborne, G.L. Jackson, Z. Yan, R. Maingi, D.K. Mansfield, B.A. Grierson, et. al. was published in Nucl. Fusion 55 (2015) 063018. This paper documents the use of injected microscopic lithium granules to transiently improve the edge pedestal and confinement in DIII-D H-mode discharges, in the presence of an existing edge instability. The experiments used a Lithium dropper deployed on DIII-D by G. Jackson and C. Chrobak (GA) that was designed by D. Mansfield and L. Roquemore (PPPL).

The assembly of the neutral beam controller (NBLCS8) has been completed this week and checkout was completed. A few wiring issues were identified during checkout that needs correction. The PLC software is now being updated for this system and is next in line for testing. The NBLCS5 controller is next in line for assembly, with 65 percent of its parts in-house and the cabinet delivery scheduled for June 28.

### **C-Mod (J. Kung):**

J. Kung visited C-Mod from May 4-8 to work on the O-mode reflectometer. The new consolidated power supply designed by PPPL was delivered and successfully powered up the 50, 60, and 75 GHz O-mode reflectometer system. Because one of the Gunn oscillators in the 88-GHz system failed and was sent back for evaluation, the 88-GHz system performance with this new power supply was not verified. Also, we have identified that the modulator in the 88-GHz system failed. MIT PSFC will look into the replacement part while waiting for the repaired 88-GHz Gunn oscillator. In terms of the 112, variable, and 140-GHz reflectometer system, the repaired 125-GHz Gunn oscillator was installed in the system and the overall system performance was verified on the bench. The whole reflectometer system other than 88-GHz channel was moved into the test cell on the evening of May 14 and the performance with plasma will be verified during the week of May 18.

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

Laboratory engineering and design efforts in collaboration with South Korea's National Fusion Research Institute have been published in the Nuclear Fusion article, "Design concept of K-DEMO for near-term implementation," Nucl. Fusion 55 (2015) 053027. The paper describes

progress in the development of the K-DEMO design in the last two years, as reported in four papers at the IAEA Fusion Energy Conference in October. The Laboratory's main contributions are reflected in the machine configuration description, physics assessment, and magnet structure analysis sections of the paper.

T. Brown and H. Neilson attended the IAEA DEMO Programme Workshop, May 11-14 in Hefei, China. The workshop featured an international discussion of scientific and technical issues encountered in moving beyond ITER to facilities designed to demonstrate fusion electricity production. Highlights of this year's workshop included presentations on the current and future contributions of ITER to DEMO physics and technology, including the advances expected via the ITER test blanket module (TBM) program. PPPL contributions to the meeting included a presentation by Brown, "Design strategies for high availability: Accommodating in-vessel piping services and auxiliary systems," and a poster by Neilson, "Application of TRLs to compare the readiness of stellarators and tokamaks for DEMO." In addition, Neilson participated as a member of the workshop committee in the planning for the fourth workshop, including expected topics, venue, and program chair.

The vacuum chambers for the W7-X XICS diagnostic were received at PPPL on May 14. This is the largest single procurement for the W7-X XICS system. Following successful onsite inspections of the chambers the parts will be shipped to IPP-Greifswald for installation. All remaining procurements are expected to arrive in the next several weeks. Installation of the remainder of the diagnostic is currently planned to begin on June 10.

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

A paper, "Heat flux viscosity in collisional magnetized plasmas," has been published in the May 2015 issue of *Physics of Plasmas*, with authors C. Liu, W. Fox, and A. Bhattacharjee. This paper concerns the dynamics of magnetic fields in regimes where the magnetic field is advected by a strong heat flux (via the so-called Nernst effect). Such situations often arise in laser-produced plasmas due to the strong localized laser heating. This paper demonstrates a new effect, a viscosity associated with the heat flux that should be kept in fluid theories in these regimes. We believe that this term may provide the dissipation mechanism allowing reconnection in Nernst-driven (heat-flux-driven) reconnection and a follow up paper will examine this effect. We also envision that these results could be important in magnetized shocks and magnetic field compression experiments, such as Z or OMEGA.

The abstract reads "Momentum transport in collisional magnetized plasmas due to gradients in the heat flux, a "heat flux viscosity," is demonstrated. Even though no net particle flux is associated with a heat flux, in a plasma there can still be momentum transport owing to the velocity dependence of the Coulomb collision frequency, analogous to the thermal force. This heat-flux viscosity may play an important role in numerous plasma environments, in particular, in strongly driven high-energy-density plasma, where strong heat flux can dominate over ordinary plasma flows. The heat flux viscosity can influence the dynamics of the magnetic field in plasmas through the generalized Ohm's law and may therefore play an important role as a dissipation mechanism allowing magnetic field line reconnection. The heat flux viscosity is calculated directly using the finite-difference method of Epperlein and Haines [*Phys. Fluids* 29, 1029 (1986)], which is shown to be more accurate than Braginskii's method [S. I. Braginskii,

Rev. Plasma Phys. 1, 205 (1965)], and confirmed with one-dimensional collisional particle-in-cell simulations. The resulting transport coefficients are tabulated for ease of application.”

W. Fox attended the first Conference on Laser Energetics, held at the Optics and Photonics International Congress, in Yokohama, Japan, from April 21-27, where he presented an invited talk, "Colliding magnetized and unmagnetized high-energy-density plasmas for laboratory astrophysics." PPPL co-authors on the study were A. Bhattacharjee and W. Deng.

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

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

Following the NSTX-U Internal Review, a formal Root Cause Analysis and Extent of Condition are in progress. The date for an NSTX-U External Review is to be determined.

CS: Work continued inside the lower umbrella this week. More flex connectors have been removed with signs of tarnish as was seen in the upper connections. Measurements of the flex surfaces indicate they are flat to better than 0.001 inches and well within tolerances. Electrostatic analysis of the water tube insulator has been completed and indications are it can pass the hipot within significant margin. Three prototype assemblies of the water tube insulators have been fabricated to the drawings. Testing of the water tube insulator at 26kv is expected this week. Adhesive potting test is underway in the CS winding area for the outer TF joint. The parts will be assembled May 15, and disassembled for inspection on May 18. Engineers are working with members of the RCA Committee, Internal Review Committee, and the Extent of Condition Committee by providing the materials and information that are requested.

NBI: The KPP of demonstrating the injection of a 40 keV neutral beam into the vacuum vessel armor for at least 50 milliseconds was successfully completed on May 12.

## **BUSINESS OPERATIONS (K. FISCHER):**

A subcontract was awarded for the architectural and engineering work related to the IOI Project (PPPL facilities upgrade), which includes design and construction support. The kick-off meeting is scheduled for May 19.

PPPL submitted its FY17 Integrated Facilities and Infrastructure (IFI) Crosscut budget information to DOE. Crosscuts are used by DOE to consolidate the budget for a functional area funded by multiple sources. The IFI Crosscut demonstrates the funds budgeted for facility and infrastructure construction, maintenance, and disposition.

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

PPPL physicist L. Delgado-Aparico was interviewed by a variety of Peruvian media, including television, radio, and print. He was also featured in a YouTube video interview by the Pontifical Catholic University of Peru.

## **INVITED TALKS:**

Fox, W., "Colliding Magnetized And Unmagnetized High-Energy-Density Plasmas For Laboratory Astrophysics," Conference on Laser Energetics, Optics and Photonics International Congress, Yokohama, Japan

## **PUBLICATIONS:**

Osborne\*, T.H.; Jackson, G.L.; Yan, Z.; Maingi, R.; Mansfield, D.K.; Grierson, B.A.; et. al., "Enhanced H-mode Pedestals With Lithium Injection in DIII-D," Nuclear Fusion 55 (2015) 063018

Kim\*, K.; Im, K.; Kim, H.C.; Oh, S.; Park, J.S.; Kwon, S.; Lee, Y.S.; Yeom, J.H.; Lee, C.; Lee, G -S.; Neilson, G.; Kessel, C.; Brown, T.; Titus, P.; Mikkelsen D.; and Zhai, Y., "Design Concept of K-DEMO for Near-Term Implementation," Nuclear Fusion 55 (2015) 053027

Liu\*, C.; Fox, W.; and Bhattacharjee A., "Heat Flux Viscosity In Collisional Magnetized Plasmas," Physics of Plasmas, 22, 053302 (2015); <http://dx.doi.org/10.1063/1.4918941>

## **LEADERSHIP POSITIONS:**

Menard, J., member, KSTAR PAC

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