Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending July 7, 2018, are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

Magnets — External coil fabrication occurred last week at Tesla, and the coil was inserted into the mold for vacuum pressure impregnation (VPI). Testing for the Everson-Tesla coil is now complete, and the coil was sectioned and completed both low-power and full-power tests. VPI was also completed on the Sigma Phi external coil during the past week. The Sigma Phi coil will be removed from the mold next week, and is scheduled to ship from their shop in two weeks. PPPL internal coil fabrication acceptance tests were performed last week, and post-acceptance full-power tests are finished. The PPPL coil was sectioned and is preparing for turn-to-turn high-voltage tests.

Polar Region — Lower-polar-region (LPR) finite-element-model (FEM) troubleshooting was almost entirely finished last week, and mechanical finite element analyses (FEAs) will begin soon. The upper-polar-region Maxwell FEA and mechanical FEAs are complete, with only one outstanding LPR Maxwell simulation due on July 6. The team continued to prepare for its preliminary design review (PDR), which has been rescheduled to happen within the next two to three weeks. The team also continued working last week with project controls on work authorization forms and the Primavera update, and they met with vendors and other related contractors in connection with the central solenoid case work.

PFC Recovery — Stud weld tests were executed last week in order to see if it's necessary to re-shoot the mounting studs on the center stack casing. The studs tested were found to be acceptable and in accordance with project guidelines. Pin testing to qualify center stack, first wall (CSFW) tiles continued, with bolted-tile tests continuing from static testing through an initial set of fatigue tests. Plastic prototypes of the OBD R5 diagnostic gap tiles progressed through the fabrication process. These prototypes will ultimately be used to verify the installation procedure associated with the passive plates, which require additional hand and tool access at the gap between the divertor and passive plate plasma facing components.

Test Cell — A preliminary design review (PDR) date for test cell shielding work is scheduled for August 6. Calculation #NSTXU-CALC-81-01-00 was prepared last week and released for review in order to design the south high bay labyrinth shielding and the associated structural supports necessary to support the load.

TVPS Vacuum Pump Replacement — Chits for the PDR of the tokamak vacuum pumping system (TVPS) vacuum pump replacement and pump cooling system have been resolved and have been sent to the responsible line manager and the design review committee chair. A new vacuum pump for the TVPS has been ordered, but there is a lead time of 20 weeks for the pump. Team mechanical and electrical designers are working on the final drawing package for final design review (FDR).

Research:

E. Fredrickson and M. Podesta served as guest editors for a special issue of *Nuclear Fusion* with papers from the 15th IAEA Technical Meeting on Energetic Particles in Magnetically Confined Plasmas that was hosted by PPPL in September 2017. The special issue features several papers from NSTX-U researchers and collaborators, including the following:

-V. Duarte et al., "Study of the likelihood of Alfvénic mode bifurcation in NSTX and predictions for ITER baseline scenarios"
-E. Fredrickson et al., "Global Alfvén eigenmode scaling and suppression: experiment and theory"
-M. Podesta et al., "Destabilization of counter-propagating Alfvénic instabilities by tangential, co-current neutral beam injection"
-D. Liu et al., "Effect of sawtooth crashes on fast ion distribution in NSTX-U"
-D. Kim et al., "ORBIT modeling of fast particle redistribution induced by sawtooth instability"

The paper "Orbit modeling of fast particle redistribution induced by sawtooth instability" by D. Kim, et al. has been published in the journal *Nuclear Fusion*, Volume 58, 082029 (2018). In this paper, initial simulation results obtained from operation of the NSTX-U device in 2016 suggest that introducing energy selectivity for sawtooth-induced fast ion redistribution is required to improve the agreement between experimental and simulated quantities such as neutron rate and fast-ion D-Alpha profiles. This paper describes modeling using the ORBIT code to characterize the redistribution of fast particles induced by sawteeth. This work confirms the experimental observations that the sawtooth instability brings different effect on fast particles with different orbit types. The initial interpretative TRANSP simulation using the kick model based on the ORBIT modeling result shows an improvement of fast ion redistribution before and after a sawtooth crash. However, more simulations with different conditions are required as the simulated neutron rate still exhibits a discrepancy when compared to the experimental measurements.

Several researchers from PPPL held a collaboration discussion with the COMPASS team during the EPS conference: A. Diallo, F. Poli, N. Logan, S. Lazerson, J.-K. Park, and R.

Maingi, with R. Goldston online. COMPASS-U (2022) has as a central mission to perform liquid-metal divertor testing for the EU program. To get an early start, COMPASS plans to do a liquid-lithium divertor partial segment test in early 2019 and a second liquid-metal divertor partial segment test in late 2019, with as yet TBD material (e.g. tin or tin combined with lithium). The segments will be supplied by RedStar in Russia. PPPL colleagues expressed strong interest in collaboration, while the COMPASS team welcomed collaborations with a particular interest in our participating in liquid-metal divertor tests.

U.S. ITER FABRICATION (H. NEILSON)

PPPL engineers A. Basile, W. Wang, and M. Duco, representing the Low Field Side Reflectometer (LFSR) design team, met by video conference with members of the Russian Federation's Equatorial Port 11 (EP11) integration team. The group reviewed the design of the so-called "antenna block," a massive steel structure that supports the LFSR microwave launchers and bears the brunt of the heat loads, mainly nuclear heating, from the plasma. The group discussed the water flow rate required for cooling of the LFSR structures, and which must be allocated to LFSR by the EP11 infrastructure. Thermal analysis by the LFSR team shows that the currently allocated flow rate of 0.6 kg/s is marginal and an increase to 0.7 kg/s is requested. Further investigations are planned to determine if the additional flow can be made available within the overall EP11 water flow allocation.

ITER & TOKAMAKS (R. Nazikian)

DIII-D (B. Grierson):

Research:

Two PPPL scientists from the DIII-D collaboration attended the 45th EPS Conference on Plasma Physics in Prague, Czech Republic. F. Poli presented a poster entitled. "How Predict first will change how we approach experimental planning." The poster describes the predictive simulations that led to the successful experiments sustaining high qmin for long durations in DIII-D. N. Logan presented a poster entitled, "Optimizing 3D spectra for rotation control." The work represents the first experimental test of the Generalized Perturbed Equilibrium Code (GPEC) predictive modification of the Neoclassical Toroidal Viscosity (NTV) torque profile. N. Logan also participated in the US DOE delegation visit to the Institute of Plasma Physics, Czech Academy of Sciences on July 4.

The visit was led by DOE representative M. Lanctot from FES. The Czech IPP is actively looking for collaboration opportunities on the topics of 3D fields, error field correction, and coil design on Compass Upgrade.

Operations:

The last two low-frequency radio frequency (RF) ABB sources have been removed from DIII-D. In the past, there were three RF sources connected to three individual RF antennas on DIII-D managed by A. Nagy. The FMIT source was removed two years ago to make room for the Helicon Klystron, and now the two adjacent ABBs have been removed to make more room for other hardware installations.

International PMI (R. Maingi):

R. Maingi presented a paper at the 2018 EPS conference in Prague, Czech Republic, July 2-6 titled, "Amelioration of Plasma-Material Interactions and ELMs, and Improvement to Plasma Performance with Lithium Injection and Conditioning in EAST." There was substantial interest on the new experiments using lithium-delivery technologies in EAST.

E. Gilson and D. Mansfield visited KSTAR to supervise installation of the Impurity Powder Dropper on KSTAR. The dropper was positioned on top of the device, placed under vacuum, and the electronics has been installed and tested. The powders will be installed in the coming weeks, and initial experiments are planned for September.

International Long Pulse (F. Poli):

J.-K. Park gave an invited talk at the 45th EPS Conference on Plasma Physics in Prague, Czech Republic entitled, "Phase space visualization and validation of 3D field operating windows for ELM suppression in KSTAR." The presentation introduced the methods and models used to identify the complete n=1 RMP operating windows for ELM suppression with disruption avoidance in KSTAR. The visualized windows were successfully used to find new RMP operating windows for ELM suppression in KSTAR.

ADVANCED PROJECTS (H. NEILSON)

Stellarators (D. Gates):

N. Pablant reported that the inverted emissivity profile of helium-like iron has been measured during an impurity transport experiment from the first Wendelstein 7-X divertor campaign. The measurements were enabled by recent upgrades to the U.S. X-ray imaging crystal spectrometer (XICS). Auburn University's P. Traverso has developed an

optimization code that allows matching of impurity transport simulations to the measured time-resolved emissivity profiles. Transport simulations within the optimizer are performed using the STRAHL 1D impurity transport code. This process, in which a chi-squared minimization is performed while varying the impurity diffusion and convective velocity profiles, provides an initial estimate of the radially resolved impurity transport parameters in W7-X. This work was presented at the 45th European Physical Society Conference on Plasma Physics (EPS 2018) in a poster entitled, "STRAHL modeling of impurity transport on Wendelstein 7-X during the first divertor campaign." P. Traverso is a graduate student who is working with Pablant on impurity transport research at the W7-X Stellarator.

S. Lazerson attended the EPS 2018 conference and presented a poster titled, "Analysis of W7-X divertor load symmetrization." The poster reviewed work using the W7-X trim coil system to balance heat loads among the ten W7-X divertors, allowing for plasma pulse lengths up to 30 seconds. In addition, Lazerson attended a meeting organized by the DOE to explore collaboration on the COMPASS-U tokamak at the Institute of Plasma Physics of the Czech Academy of Sciences.

COMMUNICATIONS (L. BERNARD)

The Office of Communications posted one press release to the PPPL website: A 10-question Q&A with new PPPL director S. Cowley, on such subjects as why fusion is important, why it is taking a long time to perfect the technology, and what he does in his spare time. The story was posted on the Newswise press release distribution site as well.

DIRECTOR'S OFFICE (S. COWLEY)

On July 3, an all-hands meeting was held. D. McComas, Princeton Vice President for PPPL, introduced our New Lab Director, S. Cowley. The meeting was followed by a coffee-and-cake reception in the LSB Lobby.

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