Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending January 25, 2020, are as follows:

NSTX-U RECOVERY (J. GALAYDA) AND RESEARCH (S. KAYE)

Recovery (J. Galayda):

Coils — Winding of the poloidal field coils continued at Sigmaphi this week. The coil winding team has completed the third layer of conductor on PF1A and is currently winding the first of two layers for PF1B. C. Bovet continued to provide technical oversight in France.

Center Stack Casing — The weld prep and alignment for assembly of the center stack casing continues at the Turtle Creek facility. Dimensional checks were performed on the final machined inner diameter of the first wall, and the results were very good. During the next week, fit-ups of the components will begin, followed by alignment checks and welding.

VVHW Recovery Field Scope FDR Part II — The second half of this final design review (FDR) was held on Jan. 23. This FDR examined the detailed inspection results, design improvements, implementation procedures, relevant structural analysis, and detailed design of tooling to address remaining design verification and validation review (DVVR) chits related to ex-vacuum vessel components. Among other things, this second FDR assessed thermal expansion of the PF2/3/4/5 clamp VVIH1-14 and PF2358/S9, and assessed the contact point of radial restraints on outer PF Coils PF2355/S6. The first half of this FDR was held in Dec. 2019.

Shorted Turn Protection FDR — A final design review was also held on Jan. 23 for shorted turn protection. The review presented sufficient technical material for examination to prove shorted-turn protection can be implemented in a way that satisfies project requirements and that has an achievable cost and schedule. Shorted-turn protection would be used to detect arcing at the coil terminals. The review was favorably received.

Research (S. Kaye):

The paper titled, "Machine Learning Characterization of Alfvénic and Sub-Alfvénic Chirping and Correlation With Fast-Ion Loss at NSTX," by B. Woods, V. Duarte, *et al.* has been published in *IEEE Trans. Plasma Sci.* as part of a special issue on machine learning, data science, and artificial intelligence in plasma research. The paper reports the development of a framework to automate the classification of several types of Alfvénic instability characters (e.g., quiescent, fixed-frequency, chirping, avalanching) in NSTX(-U). Correlations were explored between the likelihood of each scenario and several

plasma profiles in different discharges. The paper can be accessed at https://doi.org/10.1109/TPS.2019.2960206

U.S. ITER FABRICATION (H. NEILSON)

The ITER Low Field Side Reflectometer (LFSR) antenna assembly is designed to launch microwave beams into the plasma and receive the reflected waves at the launch antenna. Alignment accuracy of the antennas relative to the local plasma surface is critical to meeting performance requirements. The PPPL team has developed a tolerancing strategy that accounts for the stack-up of tolerances including the vacuum vessel, port, port plug, diagnostic shield module (DSM), and antenna structure to ensure antenna aiming within the required ±0.25 degrees. The strategy includes a field machining operation, applying as-built assembly measurements in the final step, installation of the antenna assembly into the DSM. The required fabrication and field machining tolerances are achievable within reasonable limits for conventional machining technology. The plan also takes into account the requirement for compatibility with installation or removal of the antenna assembly by remote handling. A report on this strategy was submitted to the ITER Organization in response to a chit that was raised that the November 2018 preliminary design review. Resolution of this question is a required step in the project team's preparation of a final design review of the LFSR antenna assembly later this year.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

F. Nespoli traveled to the National Institute for Fusion Science (NIFS) in Toki, Japan, on Jan. 18 to perform experiments on the Large Helical Device (LHD) using the PPPL-designed and -built impurity powder dropper. Boron and boron nitride powder were successfully delivered in both NBI-heated plasmas and low-power ECH-only plasmas on Jan. 24 in preparation for the long-pulse experiments in the first week of February. Nespoli will stay at NIFS for the next two weeks.

K. Hammond, F. Laggner, and A. Xing (Princeton University) visited NIFS in Toki, Japan, Jan. 20-24 to set up and commission a real-time evaluation system for data from the Thomson scattering diagnostic on the LHD experiment. The system consists of fast digitizing cards (250 MSamples/sec) and a 20-core real-time server, and can in principle be scaled to calculate electron temperatures and densities in real time for an arbitrary number of spatial points. This was the first time the system was deployed *in situ* during plasma experiments. The system demonstrated its ability to record pulses of scattered

laser light at high time resolution at the 30 Hz firing rate of the LHD laser. In addition, the electron temperatures calculated by the real-time software appeared to be reasonable at first glance. Collaborators R. Yasuhara and H. Funaba served as the main points of contact at NIFS and supported the work. E. Kolemen of Princeton University originally proposed this system for NSTX-U.

D. Gates also traveled to NIFS in support of both the rt-Thomson activities and the powder dropper experiments. During his visit, he met with the LHD leadership and discussed future opportunities for collaborative activities.

A paper by N. Pablant has been accepted for publication by *Nuclear Fusion*. The paper, “Investigation of the neoclassical ambipolar electric field in ion-root plasmas on W7-X,” compares measurement of the radial electric field (Er) with calculation of the neoclassical ambipolar Er on W7-X. This comparison provides confidence in the validity of neoclassical theory for W7-X, the first large-scale optimized stellarator. These measurements use the XICS diagnostic which was developed for and operated on W7-X by PPPL in collaboration with the W7-X team. The publication is now available at: https://iopscience.iop.org/article/10.1088/1741-4326/ab6ea8.

THEORY (S. HUDSON)

M. Cole gave an invited talk on Jan. 21 titled, “High-fidelity gyrokinetics for stellarators with XGC," at the Max Planck Princeton Center Workshop in Goettingen, Germany.

N. Ferraro attended the CPP-Houston meeting in Houston, Texas, and made a presentation titled, “Overview of the Draft Community Plan for Fusion Energy and Discovery Plasma Science.” The CPP-Houston meeting was a community-wide workshop for the APS-DPP Community Planning Process, which seeks to provide input for a long-range strategic plan for the DOE Office of Fusion Energy Sciences.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Science Education (A. Zwicker):

Students participating in the mid-Atlantic region's American Physical Society Conference for Undergraduate Women in Physics joined PPPL Science Education staff members A. Dominguez and S. Swilley Greco for a workshop in plasma physics on Jan. 20. Many of these students come from small liberal arts colleges and have little opportunity to study plasma. In the workshop, students conducted laboratory experiments with the DC discharge experimental set-up to observe Paschen's Law. Laboratory Director S. Cowley joined the students for part of the workshop and participated in a lunch discussion with the students and physicist C. Smiet. Cowley, Smiet, and the students shared

their early interest in science and their current research interests. Workshop participants were encouraged to apply to the Science Undergraduate Laboratory Internship (SULI) program and Princeton University's graduate program in plasma physics.

Communications (L. Bernard):

The Office of Communications posted two press releases to the PPPL website. The first involved research by J. Ruiz Ruiz (Oxford University), Y. Ren, and W. Guttenfelder on modeling the key source of some turbulence in NSTX, showing that microscopic turbulent eddies can produce heat loss. The second reported that a former SULI summer intern at PPPL won an award at the 2019 APS-DPP conference for best student poster. The stories were also posted to the *EurekAlert* and *NewsWise* press release distribution services.

This report is also available on the following web site:

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