Weekly HIGHLIGHTS

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

The PPPL Highlights for the week ending September 22, 2018, are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

Magnets — A successful final design review (FDR) was held on Sept. 20 for the PF1B coil bipolar power circuit. The FDR covered design and installation plans for all the equipment required to connect the field coil power conversion building (FCPC) and the NSTX-U test cell. This connection will allow operation of a dedicated PF1B power supply system. The FDR is complete pending resolution of outstanding chits.

Test Cell — Monte Carlo N-Particle (MCNP) analysis has been performed on various neutron-shielding designs for the NSTX-U test cell. The analysis shows the standard concrete labyrinth in front of the southeast door of the test cell provides 99.9% neutron attenuation. This reduces radiation levels in the gallery to less than half the dose limit requiring that radiation badges be worn when accessing the area.

Research:

Collaborations — F. Poli traveled to Chicago to attend the 2nd Summit on Diversity and Inclusion for Scientific Leaders in DOE Laboratories. The meeting was organized by the CoaCH Organization, funded by the Department of Energy, and based at the University of Oregon. The meeting was organized to conduct surveys and interview research on factors contributing to the low number of women and minorities in career positions and leadership roles in science and engineering across the DOE labs. The group reviewed the steps undertaken by the 17 national laboratories following the recommendations after the first summit in 2015 and identified and discussed challenges. Based on all inputs, a new set of recommendations has been prepared for DOE and for the laboratory directors.

U.S. ITER FABRICATION (H. NEILSON)

Following a successful U.S. ITER readiness review on Sept. 11, the Low Field Side Reflectometer (LFSR) team continues its preparations for an ITER Organization preliminary design review (PDR), now scheduled for Nov. 7-8. Work this week has focused on developing the project's design compliance matrix (DCM), which will document how all of the more than 250 LFSR system requirements are being addressed in the design work, with references to the relevant design reports where the details are documented. An update of this work in progress was issued to U.S. ITER and Central Team representatives, in preparation for a status review meeting the week of Sept. 23.

The ITER Central Team reported that the main substation for the Steady State Electrical Network (SSEN) was officially connected to the French 400 kV electrical grid and energized. The substation consists of four 75 MVA transformers that were procured by PPPL and supplied to ITER as part of the U.S. ITER project. The transformers were procured from Hyundai Heavy Industries in S. Korea and delivered to the ITER site in four separate shipments over the course of a year, with the last transformer arriving at ITER in May 2015. The SSEN provides power to all conventional loads at the ITER site, including cooling water pumps, cryogenic compressors, and facility lighting and power. One of the four units has been operating since early 2017, but now the entire substation is operating and supporting site operations. The Laboratory completed its SSEN responsibilities in 2017.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson):

Research:

B. Grierson, S. Haskey, and A. Ashourvan traveled to the ITPA Transport and Confinement meeting in Cadarache, France. Ashourvan presented a talk on gyrokinetic simulations of pedestal transport in wide-pedestal discharges at high beta poloidal (>1.5) in DIII-D. Pedestal pulsations are sometimes observed in these plasmas where the width of the pedestal increases and decreases periodically with a period of ≈ 50 ms. In the narrow pedestal width phase, C-GYRO calculates that the pedestal pressure gradient is within 10% of the kinetic ballooning mode (KBM) threshold. However, during the wide pedestal phase, C-GYRO indicates that low-wavenumber electrostatic modes exist, consistent with the flattening of the pressure profile near the bottom of the Er well.

Haskey presented new edge main-ion temperature measurements on DIII-D, which revealed that the ion temperature can be much lower than the commonly measured impurity carbon temperature near the separatrix. The implications of these measurements are that the electron-ion energy exchange in the edge are lower than assumed using carbon temperatures, resulting in a larger ion energy flux in power balance calculations near the plasma edge. This has implications for ion thermal transport in the pedestal where low or negative ion heat diffusivities have been computed.

Operations:

A. Nagy traveled to the 30th Symposium on Fusion Technology (SOFT) meeting in Giardini Naxos (Messina, Sicily), Italy. Nagy presented a poster entitled, “A Probe-Mounted Particle Injector for W7-X.” The unit is currently being installed on W7-X in

Greifswald, Germany, by R. Lunsford. Nagy also held discussions with engineers from W7-X at the SOFT conference.

International PMI (R. Maingi):

U.S. (PPPL: R. Maingi, Z. Sun; JHU: K. Tritz, UIUC: D. Andruczyk) and Chinese (G.Z. Zuo, X.C. Meng) scientists involved in the US-PRC PMI collaboration held a video conference to discuss results and analysis of the flowing liquid lithium limiter experiment conducted on EAST in August. The discussions included the content for the 2018 IAEA paper on this line of research, along with planning for the next set of experiments on EAST, as well as near-term testing of limiter designs in HIDRA at UIUC.

International 3D (J-K Park):

Z. Wang visited Dalian University of Technology (DUT) in China Sept. 3-14 and presented a seminar titled, “Multiple mode plasma response model and experimental validation.” He also presented the research progress of kinetic plasma response including self-consistent neoclassical toroidal viscosity simulations.

KSTAR Stability (S. Scott):

Processing of the beam-into-gas calibration data for the KSTAR Motional Stark Effect (MSE) background polychromator is nearly complete. The polarized signal strength and polarization fraction are maximized when the optical filters are shifted +0.1 to +0.25 nanometers to the red of the MSE p3 line. The polarization angle calibration shows offsets of a few degrees relative to the in-vessel calibration, in line with previous calibrations of the KSTAR MSE diagnostic. The measured polarization angle changes by approximately one degree as the torus pressure varies a factor of two; this effect on the calibration accuracy is under investigation.

ADVANCED PROJECTS (H. NEILSON)

Stellarators (D. Gates):

N. Pablant led an experimental session on W7-X to investigate the role of neutral beam heating and particle fueling with the newly commissioned neutral beam injection (NBI) system. Pure NBI heating of W7-X plasma was demonstrated for the first time in this experiment. It was shown that plasmas with densities in the range of 0.6 to 1.2×10^{20} m^{-3} could be sustained with 3 megawatts of NBI heating; these plasmas showed excellent performance with $T_i \approx 2$ keV, $T_e \approx 1.5$ keV and a stored energy above 500 kJ. Importantly, these plasmas featured highly peaked density profiles, which have not been previously achieved on W7-X. This achievement was part of an extensive detailed experimental

investigation of NBI heating and fueling and of profile shaping with NBI and off-axis electron cyclotron resonance heating (ECRH). During these experiments, it was observed that with 3 megawatts of NBI heating, even adding small amounts of central ECRH heating (500 kW) dramatically changed the behavior of the density evolution by preventing density accumulation and flattening the density profiles. Finally, during experiments with mostly NBI heating, long impurity confinement times and impurity accumulation trends were observed for the first time on W7-X. These observations will significantly advance the understanding of impurity transport on W7-X and have important implications related to impurity accumulation in future stellarator reactors. The development, execution, and analysis of these important experiments with the close collaboration of the entire W7-X team.

The PPPL-designed-and-constructed Probe Mounted Particle Injector (PMPI) was successfully delivered to the W7-X project in Greifswald, Germany. The mission of the PMPI is to study impurity transport in the stellarator configuration and to determine if particulate injection can be used to augment the present boronization schemes to allow extended operational periods and enhanced long pulse discharges. R. Lunsford arrived on site this week and has completed successful testing of the PMPI. Lunsford will participate in the installation of the actuator on the Multi-Purpose Manipulator (MPM) and in experiments planned to be carried out in the coming days. The PMPI utilizes a piezoelectrically driven rotary motor coupled to a vibrational feed tray to mechanically drive 100-micron boron carbide particulates into the edge of the W7X discharge. By mounting the injector on the MPM probe, the PMPI can be moved directly adjacent to the plasma edge, allowing strong coupling of the injected powder into the edge of the discharge.

SITE PROTECTION (M. COHEN)

Ambulance 166 responded to three mutual aid assignments in Plainsboro Township and Engine 66 responded to two mutual aid assignments in Princeton Township.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. BERNARD)

The Office of Communications posted one press release to the PPPL website. It focused on a new flowmeter designed and built by Princeton University associate professional specialist M. Hvasta, PPPL scientist E. Kolemen, and graduate students D. Dudt and A. Fisher. The novel invention, reported in *Measurement Science and Technology*, won first place in Princeton University's 13th Annual Innovation Forum in March. The key innovation is a new type of low-friction bearing that connects the flowmeter to a

stationary frame. The near-frictionless operating conditions mean that the flowmeter does not have to be calibrated before installation, a process that consumes time and money. The story was also posted to the *Newswise* press release distribution service.

DIRECTOR'S OFFICE (S. COWLEY)

From Sept. 17-21, R. Hawryluk visited USTC and ASIPP in China and gave presentations at both facilities. He also discussed possible collaborations with ASIPP.

Sept. 18-19, M. Zarnstorff attended the DOE InnovationXLab — Energy Storage Summit at SLAC National Accelerator Laboratory.

On Sept. 19, O. Hurricane, from the Lawrence Livermore National Laboratory, presented a colloquium entitled, "Beyond alpha-heating: driving inertially confined implosions toward a burning-plasma state on the National Ignition Facility."

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