Weekly HIGHLIGHTS

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

The PPPL Highlights for the week ending January 12, 2019, are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

Magnets — The production coil procurement package is under review by the DOE; the vendor oversight plan was signed off; and the G11 coil spacer requisition and vendor oversight plan is in procurement. The inner PF coil co-winding procedure is being updated, and the grit-blasted and primed conductor for the two PF1A and one PF1B coils has been crated for shipment. The fourth spool of grit-blasted and primed conductor is being cured, and work began on the conductor for the PF1C coils. Two magnet team members remain on site at ICAS Tratos, and once conductor production is complete, they will be replaced by a contracted QA inspector for the spare conductor as per the vendor oversight plan.

Metrology — A metrology contractor was on site last week to measure the NSTX-U vessel and PF4/5 coils and will be on site for an additional two weeks. The measurements will ultimately create a global coordinate system for the NSTX-U vacuum vessel and mark the placement of the PF-4 and PF-5 coils within that coordinate system. Precise alignment of the TF, PF-4, and PF-5 coils is important for plasma performance and supports a Key Performance Parameter in the Recovery Project Execution Plan (PEP).

Research:

Collaborations — R. Goldston, E. Kolemen, R. Maingi, R. Majeski, and M. Ono met with staff from UK private company Tokamak Energy to continue discussions on lithium-related collaborations on the ST-40 spherical tokamak. The ST-40 group presented several concepts for application of coatings and liquid lithium as well as work on liquid metal MHD, and the group had a vibrant exchange on these ideas. A more detailed discussion is tentatively scheduled for the end of January.

U.S. ITER FABRICATION (H. NEILSON)

The Low Field Side Reflectometer design team continues to develop its manufacturing strategy for the in-vessel waveguide assembly. Expert-led discussions on machining and welding details for selected test components, concurrent with design and analysis efforts, are advancing design maturity and refining the test manufacturing scope.

PPPL's ITER Diagnostics team participated in the bi-monthly management meeting ("GDAMM") with the Central Team's Diagnostics Division. The meeting featured a

follow-up discussion on the impact of diagnostic building design decisions that affect the toroidal interferometer-polarimeter (TIP) diagnostic, a U.S. responsibility. It was previously determined that changes in the layout of TIP equipment would be necessary to accommodate space constraints imposed by building services; at this meeting some options were presented by the Central Team staff. The discussion highlighted the need to ensure access to TIP lasers and control equipment for maintenance workers, so that work could be performed both safely and efficiently. It was agreed to make arrangements for TIP diagnostic experts to review and provide comments on the various options.

PPPL welcomes Graham Rossano, the newly appointed Technical Systems Division Director in the U.S. ITER Project Office. The Laboratory's work on ITER Diagnostics is under Rossano's direction.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson):

Research:

A paper by N.N. Gorelenkov, et al., titled, "Verification and application of resonance broadened quasi-linear (RBQ) model with multiple Alfvénic instabilities," was submitted to *Physics of Plasmas*. The paper follows the APS invited talk given in Portland by Gorelenkov that reported how DIII-D plasmas with strong fast-ion transport due to multiple Alfvén eigenmodes can be simulated using the quasi-linear RBQ model. The model captures the relevant physics of the fast ion redistribution and is quantitatively consistent with the experiment. The goal of this research is to integrate the RBQ model into scenario modeling with TRANSP in order to design optimized discharges for present day experiments and future burning plasmas.

The final design review for the DIII-D Lyman-alpha diagnostic was successfully held at General Atomics in California. An updated design was presented, which included new technical solutions for cooling and robustness of the diagnostic assembly. The diagnostic project, a collaboration with MIT-PSFC, transitions now into the construction phase. The diagnostic is expected to be installed on DIII-D to support the FY19 experimental run, providing measurements of main chamber neutral density and ionization source.

Operations:

A new dropper concept was presented this week to the national dropper team. The prototype uses an auger through a tube to pull powder out into the dropper tube. This new design will be vetted by a new capable high school senior intern. If successful, this

concept could replace the existing piezo feeder technology and the present flow meters would be replaced by the accurate stepper motor drive, eliminating the larger error bars on the flow rate with the present technology.

International PMI (R. Maingi):

The DIII-D impurity granule injector is being adapted to work on EAST, where it will provide new capabilities in the present run that extends until summer 2019. D. Mansfield, E. Gilson, and Z. Sun visited A. Nagy and A. Bortolon at DIII-D to begin this conversion. Carbon granules were tested in the modified system. This system will allot testing of different granule sizes and materials.

KSTAR:

As part of the development of a real-time coil monitoring system for KSTAR, D. Boyer generated an offline calculator for the field and forces on each PF coil due to the plasma current and currents in other PF coils. The model is derived from the TOKSYS conductor model developed for KSTAR by GA and NFRI to design shape-control algorithms. Based on discussions held with engineer H.-J. Ahn during a visit to NFRI in Dec., the calculator was extended to include the effect of combined radial and vertical coil forces on the central solenoid structural components. The preload on the central solenoid coils is one of the most critical forces to monitor during KSTAR operation. The results of the offline calculator were validated against example calculations for a KSTAR discharge provided by Ahn and were found to agree. A specification for a real-time PCS implementation of the calculations was also developed. K. Erickson implemented the PCS algorithm based on this specification and made preparations for stand-alone software testing.

K. Erickson working with S. Sabbagh received a real-time computer for disruption prediction and avoidance on KSTAR. The computer was purchased by Columbia University and is being configured and tested at PPPL before being shipped for permanent installation at KSTAR. The computer includes a field-programmable gate array card (FPGA) that will acquire 16 independent magnetic probe data streams at 300 kHz, compute fast Fourier transforms (FFT) in real-time, and eventually use this information for real-time disruption prediction and control. The computer was received more than two months earlier than originally anticipated.

J.-K. Park, N. Logan, Z. Wang, R. Nazikian participated in the 2018 KSTAR campaign summary meeting. The summary of PPPL-led experiments included the preliminary results of the observed q95 and density dependencies of n=1 RMP ELM mitigation and suppression in H-mode plasmas close to the L-H power threshold. Also, new results were obtained on the plasma response to the RMP during ELM suppression. The

improved Thomson scattering and MSE diagnostics this year in KSTAR will be used to improve the accuracy of kinetic equilibria for more detailed physics studies.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

N. Allen, C. Welch, and S. Lazerson met with the CEO and engineers of the Reynard Corporation on a conference call to discuss the development of prototype fast ion loss detectors for W7-X. Engineering, manufacturing, and quality control issues were discussed. Positional accuracy issues were unexpected and Reynard agreed to look into the cause for the large discrepancies and follow up with Allen. Modification of the sandwich style of the device to be more pyramidal was discussed along with a new electrical contact solution that would greatly improve the robustness of the detector. Additionally, a path toward thinner layers was identified allowing layer thicknesses of 500 Å. This would allow for finer fidelity in the energies measured by the diagnostic.

A paper by N. Pablant, et. al. titled, "Core radial electric field and transport in Wendelstein 7-X plasmas," (https://doi.org/10.1063/1.4999842) has been highlighted by *Physics of Plasmas* as one of the four most cited papers in 2018. This highlight was sent as an AIP alert and also mentioned in the interim report of the editor-in-chief of PoP. The paper describes radial electric field measurements that were made using the US-built XICS diagnostic during the OP1.1 campaign.

A. Nagy's refereed SOFT 2018 paper titled, "A Horizontal Powder Injector for W7-X," was accepted for publication in *Fusion Engineering and Design*. The paper covers the design and construction of the probe-mounted powder injector that was used to inject boron carbide dust in the edge of the W7-X plasma during the OP1.2b campaign.

System Studies (C. Kessel):

THEORY (S. HUDSON)

D. Ruiz (Sandia), M. Glinsky (Sandia), and I. Dodin (PPPL) published a paper titled, "Wave kinetic equation for inhomogeneous drift-wave turbulence beyond the quasilinear approximation," in the *Journal of Plasma Physics*: https://doi.org/10.1017/S0022377818001307. The idea of this study is as follows. The formation of zonal flows from inhomogeneous drift-wave (DW) turbulence is often described using statistical theories derived within the quasilinear approximation. However, this approximation neglects wave-wave collisions; hence, some important effects are not captured within this approach. In their paper, Ruiz et al derive a wave kinetic equation that includes a DW collision operator in the presence of zonal flows.

The derivation makes use of the Weyl calculus, the quasinormal statistical closure, and the geometrical-optics approximation. The obtained model conserves both the total enstrophy and energy of the system. The derived DW collision operator breaks down at the Rayleigh-Kuo threshold. This threshold is missed by homogeneous-turbulence theory but expected from a full-wave quasilinear analysis.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted four press releases to the PPPL website. One was a round-up of 10 not-to-be-missed stories of 2018, covering topics ranging from magnetic reconnection in outer space to sawtooth swings in plasmas to a profile of new PPPL director Steven Cowley. Another focused on new research by A. Reiman and N. Fisch involving radio-frequency waves, magnetic islands, and temperature. A third reported research by K. Caspary and others into the magnetorotational instability. The fourth detailed how PPPL staff photographer E. Starkman recently won Honorable Mention for the Council for Advancement and Support for Education photo contest for District 2. The stories were also posted to the *Newswise* and *EurekAlert!* distribution services.

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