



**The PPPL Highlights for the week ending November 17, 2018, are as follows:**

**NSTX-U RECOVERY AND RESEARCH (J. MENARD)**

*Recovery:*

**Magnets** — Drawing modifications for the production inner PF1 coils are finished, and final checks, review, and signoff are forthcoming. PPPL staff is still on-site at ICAS Tratos supporting the PF1 conductor grit-blast and prime activity. Another sample run produced good results, and the vendor is working on the system for the hangers. ICAS processing of the first conductor was moved to Nov. 26, and six spools of conductor for production coils are projected to be available by Jan. 2. Limited corona testing of Sigma Phi and PPPL coil samples is complete. Fatigue testing for the coil sample began this week to verify insulation integrity.

*Research:*

**Conferences** — The 2nd AAPPS-DPP meeting was held in Kanazawa, Japan, Nov. 10-16. E-H. Kim presented a poster entitled, “2D Full-Wave Simulations of High Harmonic Fast Waves in the Scrape-Off Layer of NSTX/NSTX-U.” Her poster was selected as one of the winners of the poster prize for the Magnetic Fusion Plasma Program. Kim also presented an invited talk at the meeting entitled, “Full wave simulation of ULF waves at Earth's magnetosphere.” Y. Ren gave an invited talk entitled, “Experimental Observation of High-k Turbulence Evolution across L-H Transition in NSTX,” and A. Diallo gave an invited talk entitled, “Energy Exchange Dynamics across L-H transitions in NSTX.”

The following PPPL researchers and engineers presented papers, chaired and participated in plenary sessions, and exhibited visual media related to NSTX/NSTX-U research at the American Nuclear Society Winter Meeting and Expo/TOFE conference held Nov. 11-15 in Orlando, Florida:

- P. Dugan presented the paper, “Systems Engineering for NSTX-U,” as an invited speaker for the Fusion Systems Engineering technical session.
- S. Kaye gave a plenary talk entitled, “A Strategic Plan for U.S. Burning Plasma Research: Update on Panel Activities and Progress.”
- C. E. Kessel chaired TOFE Plenary Session II and participated in the panel discussion titled, “An Exploration of Liquid Metal Plasma-Facing Components for Fusion,” with researchers M. Jaworski, A. Khodak, E. Kolemen, R. Majeski, and G. Neilson at the Transformative Enabling Capabilities: Liquid Metal Plasma-Facing Components technical session. He also participated in the panel discussion, “Modeling the Edge-

Plasma Interface for Liquid-Metal Walls in FNSF,” with M. E. Rensink and T. D. Rognlien (LLNL).

- R. Maingi served as co-chair on the TOFE technical session, “Transformative Enabling Capabilities: Liquid Metal Plasma-Facing Components” and participated on the panel, “Summary of the FESAC Transformative Enabling Capabilities Panel Report,” with A. Lumsdain (ORNL) at the “Transformative Enabling Capabilities: Advanced Materials and Manufacturing TOFE” technical session. Maingi and I. Zatz contributed to “Latest Liquid Lithium/Metal Research Results from the Center for Plasma Material Interactions,” for the components technical session and the panel on “Technology and Science of Lithium Delivery Systems and Impact on Plasma Performance in EAST,” for the Plasma Material Interaction technical session.
- J. Petrella participated on the panel discussion, “Electrical Insulation Tape Winding and Inspection System,” in the TOFE magnets technical session with PPPL researchers M. D’Agostino, M. Cropper, and J. Guttenfelder. He was also part of the panel titled, “NSTX-U Global Thermal Analysis for Bake-Out and Normal Operation Scenarios,” with H. Zhang, P. Titus, A. Brooks, and S. Gerhardt that was part of the “Thermal Hydraulics for Fusion Components” technical session.
- Y. Zhai and the NSTX-U coil test team participated as invited panel guests for the discussion, “Prototype Coil Evaluation for NSTX-U Replacement Inner Poloidal Field Coils,” that was part of the TOFE magnets technical session.

PPPL researchers exhibited the following posters as collaborative work during the ANS Winter Meeting and Expo/TOFE conference. Exhibits are listed alphabetically by title:

“A Concept of Liquid Metal Flowing First Wall and Integrated Tub-like Divertor.” C. Kessel (PPPL), S. Smolentsev (UCLA), T. Rognlien (LLNL), M. Tillack (Consultant), L. Waganer (Consultant).

“An Analytical Study on the Impact of Halo Current-Induced Lorentz Load on Center Stack Case in the NSTX-U.” F. Cai, M. Smith, J. Fang, H. Zhang, N. Dean, P. Titus, A. Brooks (PPPL).

“Analytic Optimization of Free-Surface, Capillary Restrained, Liquid Metal, Plasma-Facing Components.” L.-D. Aparicio (PPPL), S. Ito, H. Hashizume (Tohoku Univ.).

“Design and Analysis of the Liquid Metal Free-Surface Divertor Cooling System.” C. Kessel (PPPL), M. Tillack (UCSD).

“Development of the Real-Time Thomson Scattering Software for NSTX-U.” R. Rozenblat, G. Tchilinguirian, F. Laggner, E. Kolemen, G. Zimmer, and P. Sichta (PPPL).

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“Heat Flux Testing of Prototype NSTX-U Plasma-Facing Components.” N. Allen, R. Ellis, M.A. Jaworski, A. Khodak, G. Smalley (PPPL), T.K. Gray, M.L. Reinke, D. L. Youchison (ORNL), D.E. Wolfe (Penn State).

“Inboard Divertor Heating and Cooling Design for the NSTX-Upgrade Fusion Device.” D. Cai, H. Zhang, A. Brooks, M. Smith, P. Titus, D. Loesser (PPPL).

“Low Heat Flux Plasma Facing Component Design for National Spherical Torus Experiment Upgrade (NSTX-U) Recovery.” A. Jariwala, B. Linn, N. Allen, N. Dean, A. Brooks, M. Messineo, D. Warner, L. Konkell, S. Jurczynski (PPPL).

“Rapid Radiative Disruption Mitigation Through Electromagnetically Driven Killer Pellet Injection.” A. Brooks, R. Ellis, and R. Lunsford (PPPL), W.S. Lay, R. Raman (Univ. Washington).

“Shaping the Aperture of the Absolute Collimator in DIII-D Neutral Beam Line Upgrade.” W. Wang, A. Khodak, I. Zatz, A. Nagy, P. Titus (PPPL).

“The Stress Analysis of PF1A Lower Terminals, Leads, and Bus Bars for NSTX-U.” J. Fang, P. Titus, D. Cai, H. Zhang (PPPL).

**Community Outreach** — W. Guttenfelder spoke on Nov. 10 at a STEM Symposium career speaker series organized by students of West Morris Central High School in Morris County, NJ, where he shared information about fusion and plasma research at PPPL.

## **U.S. ITER FABRICATION (H. NEILSON)**

The Laboratory’s ITER Diagnostics team participated in the bi-monthly management meeting with the Central Team’s Diagnostics Division. At the meeting, PPPL’s D. Johnson summarized joint discussions regarding the impact of planned configuration changes in the Diagnostic Building on the Toroidal Interferometer Polarimeter (TIP) diagnostic, a U.S. responsibility. The change, which calls for an open arrangement instead of “rooms” for each diagnostic demarcated by walls, is driven by fire safety requirements and HVAC-related issues. Johnson reported, on behalf of the TIP team, that the change would necessitate a change in the design strategy for controlling the TIP operating environment, which requires temperature control within plus or minus 1 degree Celsius; the team concluded that feasible alternatives exist. Additional measures would be required for laser safety and dust control. Although the discussion was focused on TIP, the issues are likely to apply, in varying degrees, to other U.S. ITER diagnostics with instrumentation in the diagnostic building.

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## **ITER & TOKAMAKS (R. NAZIKIAN)**

### **DIII-D Research (B. Grierson):**

This week, N. Logan chaired the 23rd Workshop on MHD Stability Control – A U.S.-Japan Workshop. The workshop, held on the UCLA campus, focused on common themes and challenges in studying MHD in stellarators and tokamaks. There was strong PPPL participation, including presentations by S. Lazerson, C. Zhu, A. Reimen, M. Okabayashi, E. Kolemen, and graduate student A. Glasser. Standout topics that generated extensive discussion included the physics of energetic particle MHD mode interactions, ergodic divertors and edge stochasticity, and the physics of electron cyclotron heating/current-drive suppression of islands.

At the 2018 APS-DPP meeting, K. Callahan, a UC Irvine undergraduate and SULI student being mentored by B. Grierson, won a poster prize for “Integrated Zeff Analysis on the DIII-D Tokamak Combining Multiple Diagnostics.” This award was given to the top six of 66 undergraduate posters presented at the APS-DPP meeting.

R. Nazikian and A. Diallo attended the AAPPS-DPP meeting in Kanazawa, Japan, Nov. 13-17. Nazikian presented an invited talk on the wide-pedestal grassy-ELM regime in DIII-D and its applicability to ITER scenarios. Diallo presented an invited talk on three-wave coupling of quasi-coherent modes at the top of the H-mode pedestal and its possible role in triggering ELMs.

### **International PMI (R. Maingi):**

R. Maingi presented an invited talk at the 2018 Technology of Fusion Energy meeting in Orlando, FL titled, “Summary of the FESAC Transformative Enabling Capabilities panel report.” The panel identified four very promising transformative enabling capabilities that could accelerate fusion energy development: 1) advanced algorithms, 2) high-temperature superconductors, 3) advanced materials and manufacturing, and 4) innovations in the tritium fuel cycle. The panel also identified one promising transformative enabling capability: fast-flowing, liquid-metal, plasma-facing components. The talk kicked off a number of sessions and talks at TOFE that focused on new prospects for the transformative enabling capabilities identified by the panel.

### **KSTAR MSE (Steve Scott):**

A kick-off conference call was held this week involving S. Scott (PPPL) and S. Sabbagh and J. Riquezes (Columbia University) to discuss plans for using the background channels of the MSE background polychromator now installed at KSTAR to measure the Zeff profile. The high-level components of the project are: (1) measure the VB brightness

along 25 MSE sightlines using the MSE background channels; (2) invert to get local VB emissivity as a function of minor radius; (3) obtain  $n_e$  and  $T_e$  data from existing KSTAR diagnostics and map to same radial grid as the VB emissivity; and (4) compute the local  $Z_{eff}$  given the emissivity,  $T_e$ , and  $n_e$ . The KSTAR beam '1a' which is typically used for MSE is currently under repair. For the next few weeks, MSE will instead view beam '1b' which is slightly more tangential; this affects the Doppler shift of the MSE spectrum. However, the existing MSE filter set is adequate to cover the range 1.5-2.9 Tesla at  $E_{beam} = 95 - 100$  keV.

### **ADVANCED PROJECTS (D. GATES)**

#### **Stellarators (D. Gates):**

S. Lazerson presented a talk entitled, "Overview of the stability and control of Wendelstein 7-X," at the 23rd Workshop on MHD Stability and Control held Nov. 12-14 at the University of California-Los Angeles. The talk covered recent progress on divertor strike line control and MHD modes seen in W7-X. C. Zhu also presented a talk entitled, "Novel RMP coil designs using stellarator optimization tools," at the MHD workshop. The talks were well received and generated many good discussions.

Research performed at W7-X by N. Pablant was recently highlighted in APS press release entitled, "Peak Performance: New Stellarator Experiments Show Promising Results." The press release describes the recent performance records achieved at W7-X and highlights the contribution of the PPPL-supplied XICS diagnostic in measuring the core plasma performance. This press release has been picked up by several media outlets including AAAS EurekAlert!, Science Daily and Phys.org. The results highlighted in this release were presented at the APP-DPP meeting in Portland, OR, by R. Wolf (IPP-Greifswald) in a plenary talk.

### **THEORY (S. HUDSON)**

F. Ebrahimi attended the Sherwood Executive Committee meeting during the APS-DPP meeting in Portland, OR, as the local chair and the PPPL host of 2019 Sherwood conference, which will be held April 15-17 in the Westin Princeton at Forrestal Village. Ebrahimi presented the logistics for hosting this meeting; more details will be announced in December. In addition, as one of the invited subcommittee chairs of the 2019 APS-DPP program, she attended the DPP 2019 program committee meeting.

During the APS-DPP meeting in Portland, N. Ferraro attended the CTTS SciDAC meeting, the Sherwood executive committee meeting, and the APS-DPP Women in Plasma Physics committee meeting.



B. Sturdevant visited Los Alamos National Laboratory Oct. 29-Nov. 2 to collaborate with L. Chacon on the development of a fully implicit kinetic electromagnetic algorithm for XGC. In particular, improvements made to a preconditioner helped reduce the number of iterations, and hence computational cost, needed per time step in the algorithm.

### **COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)**

#### **Science Education (A. Zwicker):**

The Science Education department was very busy at the APS-DPP meeting in Portland, Oregon. A. Dominguez participated in the APS-DPP fall executive committee meeting on Nov. 4 and as chair of the education and outreach committee presented on the APS-DPP E&O activities of the week.

On Nov. 5, Dominguez and Lawrence Livermore National Laboratory's T. Ma gave a *Science on Tap* talk in Portland to a general public audience on magnetic and inertial confined fusion. Approximately 200 people were in the audience.

Dominguez, D. Ortiz, and the rest of the E&O organizing committee organized the Teacher's Day workshop aimed at Portland high school and middle school teachers. 36 local teachers participated. Ortiz, Dominguez, A. Zwicker, and S. Greco presented on the ongoing work led by the Science Ed. department at the DPP meeting.

Dominguez, Ortiz, and the rest of the E&O organizing committee organized the plasma expo at the Portland meeting. There were more than 1,300 local students in attendance. The Science Ed. team led the PPPL booth at the plasma expo at DPP on Nov. 8 and 9. The booth was run by volunteers from PPPL's research and graduate student staff

#### **Communications (L. Bernard):**

The Office of Communications posted one press release to the PPPL website. It focused on PPPL's participation in the 60th annual meeting of the American Physical Society's Division of Plasma Physics in Portland, Oregon, mentioning that more than 135 researchers and students from PPPL gave presentations. This story was also posted to the *EurekAlert!* and *Newswise* press release distribution services.

#### **DIRECTOR'S OFFICE (S. COWLEY)**

A bi-annual meeting of the PPPL Advisory Board was held on Nov. 14-15. The purpose of the board is to provide an outside independent review of PPPL science and operations; the committee then provides Princeton University with feedback and recommendations.

**This report is also available on the following web site:**

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