



The PPPL Highlights for the week ending November 14, 2020, are as follows:

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

### **Recovery (J. Galayda):**

**Bus Supports** — Water testing of the PF1B power cables continued. The materials required for the PF extension and OH coax bus connection were inspected and prepared for fabrication of the supports in conjunction with the work packages.

**Coils** — Preparations for machining the six production coils continued at PPPL. Coil PF1C-S (spare) arrived at PPPL from Sigmaphi. PF1B-S (spare) paperwork was assembled and was packaged for shipping to PPPL with arrival on Nov. 20. Coil PF1A-S (spare) was cured and demolded and low-power electrical testing was completed.

**Center Stack Casing (CSC)** — The finish machining of the CSC in Camden, New Jersey, continues with good progress. PPPL has resumed QA oversight in Camden twice a week and engineering oversight at Turtle Creek. At Turtle Creek, the bellows mockup welding continued, along with stud installation prototyping and organ pipe welding. Bellows testing continued.

**IVPS** — Installation of the pump and electrical and controls packages were prepared for near-term installation.

**Machine Core Structure (MCS)** — Precision Boring in Michigan resumed fabrications on Nov. 9 after a two-week shutdown from Covid. They are operating at approximately 75% as their staff returns. The capture and common flanges neared completion. In South Carolina, Carolina Fabricators' production of PF1A sling base parts continued, with 27 parts completed. G. J. Oliver delivered lower PF1C support and dimensional inspection and preps for welding and leak testing are progressing. The upper PF1C support is at the vendor for coating. The ceramic break flange was machined, and the outer skirt forging was due the week of Nov. 9 so fabrication could proceed. At PPPL, mockup activities were completed, and lessons learned continued to be reviewed and incorporated into assembly procedures. PF1B lower slings welding was completed, and post-weld inspection and heat treating are slated to begin.

**Personnel Safety System Conduit and Cable Installation** — Subcontractor Electri Tech, Inc., mobilized on Nov. 9 to begin setup of their office trailer and materials and tool storage containers. Installation of the conduit system will begin on Nov. 16.

**PF-1b Bipolar Circuit Installation** — Work resumed this week with the FCPC crew installation of the new cables and cable trays in the FCPC.

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**Personnel Safety System (PSS) Breaker Refurbishment** — The PPPL AC power crew continued packaging the remaining 18 medium-voltage circuit breakers for shipment to ABB, Inc. for refurbishment.

## **ITER PROJECTS (H. NEILSON)**

### **Low Field Side Reflectometer — LFSR (A. Zolfaghari, S. Shirey):**

This week LFSR welding trials continued with a focus on thermal imaging of the process to better characterize any parameters that can lead to weld cracking. The goal is to continue to refine the parameters to create a robust process on all of the different geometry weld plugs. Progress was also made in initial assembly trials for installing a CuCrZr bushing into a groove in the front of the antenna block. The bushing will provide critical aiming support of the antenna while allowing movement between the antenna and the antenna block throughout thermal cycling.

### **Upper Wide Angle Viewing — UWAV (M. Smith):**

The UWAVS team reviewed a draft list of deliverables proposed by the central team counterparts and submitted a revised version for their consideration. The team also met with the Upper Port 2 and 8 port integrator to discuss integration concerns regarding electrical components and remote handling access to the in-vacuum components. The remote handling interfaces for the in-vacuum UWAVS components are optimized for the generic diagnostic shield module (DSM) design used by UP 2, 8, 11, and 14. It was found to be incompatible with the fifth UWAV location, UP17, which uses a different DSM design. It appears likely that two different UWAV in-vessel optical designs will be necessary to integrate with the two different DSM styles.

### **Motional Stark Effect — MSE (A. Cohen):**

The MSE team presented a plan for defining its interface with Equatorial Port 1, one of two ports which hosts the MSE system. As explained by PPPL engineer A. Cohen, the plan has multiple components, as follows: 1) Optical design and mirror placement compatible with the DSM of EP01 including local constraints; 2) Design of the front mirror unit, consisting of the first two mirrors in the optical path, a shutter, and mirror cleaning and cooling connections; and 3) shutter actuation mechanism. While a mature design will take considerable time to develop, the near-term goal is only to define the interfaces with EP01 to support the design schedule for that system.

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## **Diagnostic Residual Gas Analyzer — DRGA (C. Klepper, ORNL):**

The DRGA team is investigating alternative sampling configurations in the Equatorial Port 11 ex-vessel regions. The instrumentation is installed in port cell structure and connects to the vacuum extensions of nearby diagnostics through a sampling tube. An option to connect to the vacuum ultraviolet (VUV) spectrometer, also a tenant in EP11, is being investigated. That system's pumping configuration was found to be favorable for DRGA, since it provides a high-vacuum condition at the DRGA connection point. It can also provide a sufficiently fast response time for DRGA sampling of the plasma exhaust gases in the midplane region.

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

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

#### *Research:*

A review article titled, "Turbulence dynamics during the pedestal evolution between edge localized modes in magnetic fusion devices" by A. Diallo and F. Laggner has been published in *Plasma Physics and Controlled Fusion*: <https://doi.org/10.1088/1361-6587/abbf85>. The paper reviews the experimentally observed signatures of instabilities during the pedestal parameter evolution made in between edge-localized modes in multiple tokamaks. A key emphasis made in the review is that potential future research avenues will require multiscale-nonlinear gyrokinetic analyses to study the nonlinear interaction between these instabilities, and which pedestal conditions facilitate such nonlinear interactions, as well as the relationship with the formation of the pedestal through transport.

Q. Hu gave an invited presentation in the 62nd APS-DPP virtual meeting with the title, "Predicting operational windows of ELMs suppression by resonant magnetic perturbations in the DIII-D and KSTAR tokamaks." In this talk, understanding of the access conditions of q95 windows, density and rotation for ELM suppression by RMPs in both DIII-D and KSTAR tokamaks were presented.

S. Haskey gave an invited presentation in the 62nd APS-DPP virtual meeting with the title, "Main-ion thermal transport in high performance DIII-D edge transport barriers." In this talk, both neoclassical and turbulent contributions to ion thermal transport in the H-mode pedestal were shown necessary to account for the ion energy flux inferred using new main-ion measurements.

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At the APS-DPP meeting, E.-H. Kim presented an oral talk on physics of simultaneous excitation of electrostatic slow mode and fast helicon waves. F. Effenberg presented an oral talk on divertor power exhaust with impurity powders in DIII-D. G. Kramer presented an oral talk on full-orbit simulations of fast-ion charge-exchange losses induced by neutral particles outside the plasma. Princeton graduate student O. Nelson presented an oral talk outlining the identification of microtearing modes in a DIII-D pedestal through the use of edge-current-perturbing fast vertical oscillations. Princeton graduate student J. Abbate presented an oral talk on a machine learning profile predictor used for a novel model-predictive control algorithm at DIII-D. Five posters from Princeton University and three posters from PPPL were also presented.

Two SULI students co-mentored by F. Laggner and A. Bortolon presented their summer projects at the virtual APS-DPP 2020 meeting. J. Spendlove (Brigham Young University) developed a parametric model that allows accurate prediction of the common-mode component of the noise in the LLAMA diagnostic measurements. E. Zeger (University of California-Los Angeles) successfully developed a neural network regression model that predicts the structure of H-mode pedestal parameters. This work received an APS-DPP Outstanding Undergraduate Poster Award, which was among approximately 100 undergraduate research contributions.

## **International PMI and Liquid Metal PFC Concept Development (R. Maingi & A. Diallo):**

Z. Sun presented an invited talk at the annual APS DPP meeting titled, “On-demand destabilization of edge turbulence and robust ELM elimination with boron powder injection in EAST.” The talk presented results demonstrating suppression of edge-localized modes (ELMs) by boron powder injection during discharges in the EAST device, over a wide operational window. The powder either destabilizes or strengthens an edge mode with multiple harmonics, which provides particle and impurity exhaust to prevent ELMS and impurity accumulation.

R. Maingi presented a contributed oral at the annual APS DPP meeting titled, “Status and Progress of the Domestic Liquid Metal Plasma-Facing Component Design Program.” The talk highlighted heat transfer calculations of flowing liquid lithium plasma-facing components, showing designs that could exhaust peak heat flux of 10 MW/m<sup>2</sup> while maintaining a surface temperature below 450 degrees Celsius. Material compatibility experiments in test stands and flow characterization experiments in the Liquid Metal eXperiment were also discussed. R. Maingi also chaired a tutorial session presented by D. Ruzic titled, “Lithium: A Path to Make Fusion Energy Affordable.”

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E. Gilson presented a contributed oral at the annual APS DPP meeting titled, “Wall Conditioning Effects of Boron Nitride Powder Injection in KSTAR.” Boron nitride powder injection was shown to reduce recycling and stabilize ELMs for 5-second-long durations. Details of deployment of an impurity powder dropper were also discussed.

## ADVANCED PROJECTS (D. GATES)

### Stellarators (D. Gates):

A. Chambliss won the Student Poster Contest for her poster entitled, “Position Tolerance of Permanent Magnets in the Stellarator MUSE” at APS-DPP on Nov. 10. This poster presented her work calculating the shape gradients of normal field error for dipole position as well as her preliminary results from implementing the Hessian matrix method for MUSE. This new Hessian matrix data represented the dipoles whose positions have the most impact on normal field error. She and four other student poster award recipients received recognition from APS-DPP chair E. Zweibel along with a \$50 prize for winning the contest.

This week the members of the Advanced Projects department participated in the APS-DPP conference (held virtually). There was one invited talk by R. Lunsford entitled, “Confinement Improvement through Impurity Induced Profile Modification on W7-X.” There were three oral contributions: “Geometric concepts for stellarator permanent magnet arrays” by K. Hammond, “First results from boron and boron nitride powder injection in LHD” by F. Nespoli, and a special Student Day talk entitled, “Fast particle optimization of a quasi-axisymmetric stellarator equilibrium” by A. LeViness. There were 12 posters covering a diverse set of topics in plasma physics ranging from theoretical stellarator design to experimental results at major facilities to novel diagnostic development. This tally includes contributions from several students that were mentored by Advanced Projects scientists. There were an additional 15 presentations/posters in which members of Advanced Projects were co-authors.

PPPL is a partner with Oak Ridge National Laboratory in a project to deliver a Continuous Pellet Fueling System (CPFS) for Wendelstein 7-X. At a recent project meeting, engineers J. Philip and B. Smith reported progress toward final design reviews (FDR) of PPPL scope. Philip presented a mature model of the injector support stand, describing recent progress in resolving space conflicts and showing details of structural connections and floor supports. A seismic analysis is under way. Smith reported on the maturing status of the safety-related design aspects of instrumentation and controls (I&C) integration. PPPL has led the entire partnership in that area and Smith reported the main accomplishments through the most recent meetings. It is currently forecast that



mechanical integration and I&C integration, respectively, will be reviewed in separate FDRs early in 2021.

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

V. Duarte presented an invited talk at the APS-DPP meeting titled, “Integrated two-dimensional quasilinear modeling of fast ion relaxation in tokamaks” on Nov. 13.

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

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

The Office of Communications posted three press releases to the PPPL website. The first reports on research by H. Qin, Y. Fu, and L. Zhang resulting in the development of a new algorithm that helps track fast charged particles in plasma. The second, to coincide with Veterans Day recognition, focuses on G. LaForest, a new staff member who has served in three branches of the military. The third reports that PPPL welcomed more than 160 people to a virtual Industry Day when business owners learned about opportunities to partner with the national laboratory on major upcoming projects over the next decade. These stories were also posted to the *Newswise* and *EurekAlert* press release distribution services.

L. Bernard participated remotely in the Council for Fusion Communications monthly meeting.

### **DIRECTOR’S OFFICE (S. COWLEY)**

S. Cowley, J. Menard, and M. Zarnstorff participated virtually in the annual American Physical Society Division of Plasma Physics meeting (APS-DPP) Nov. 9-13.

J. Menard gave an APS-DPP contributed oral presentation entitled “Configuration Studies for a Sustained-High-Power-Density Next-Step Tokamak” on Nov. 13.

C. Ferguson hosted the monthly supervisor's meeting on Nov. 10.

C. Ferguson participated virtually in the Department of Energy’s Deputy Director Field Officers (DDFO) meeting on Nov. 10.

Laboratory leadership hosted a lab-wide virtual Veteran's Day celebration on Nov. 11. The celebration honored more than 30 veterans. S. Cowley and C. Ferguson provided a welcome and a roll call with veteran's names. G. LaForest provided an overview of the numerous military organizations PPPL staff can support.



C. Ferguson participated in the PPPL Project Management Assurance Board Meeting on Nov. 11.

C. Fall, Director of the DOE Office of Science, and Troy Hall, DOE staff member, visited PPPL for the day on Nov. 12. Fall and Hall met with the Princeton site office and PPPL and Princeton University leadership. The visitors were provided with an updated overview of the Laboratory's science and operational missions and given tours of various scientific facilities at PPPL and Princeton University.

S. Cowley participated in the bi-weekly virtual National Laboratory Directors Council (NLDC) Coordination meeting on Nov. 13.

On Nov. 14, S. Cowley participated as a panelist in the Princeton University Energy Association (PUEA) Fall Conference 2020: "Where Will We Go From Here? Energy Implications and Futures Beyond COVID-19."

PPPL staffed a virtual exhibitor booth Nov. 5-7 at the National Society of Black Physicists 2020 Conference, which was co-hosted by Brookhaven National Laboratory, to promote employment opportunities at the lab.

PPPL participated in the APS-DPP job fair, which took place in conjunction with the APS-DPP conference Nov. 10-12 to promote employment opportunities at the lab.

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

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