The PPPL Highlights for the week ending November 28, 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. Two cables failed at the fittings and PPPL worked with the vendor to correct the problem. 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 PF1B-S (spare) was shipped from Sigmaphi to PPPL on Nov. 20. Coil PF1A-S (spare) document review was in progress prior to packaging and shipping next week.

**Center Stack Casing (CSC)** — The finish machining of the CSC continued in Camden, New Jersey. PPPL stopped twice-weekly QA oversight in Camden due to Covid-19 considerations. Engineering oversight at Turtle Creek continued. At Turtle Creek, the bellows mockup welding found an issue with distortion that was reviewed in Engineering and by Holtec machining. Stud installation prototyping and organ pipe welding continued, with leak testing being performed in concert to the completion of organ pipe welding.

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

**Machine Core Structure (MCS)** — Precision Boring in Michigan continued with fabrications; they operated at approximately 90% as their staff returned from their Covid-19 issues. The capture and common flanges neared completion and fixture plates also began fabrication. In South Carolina, Carolina Fabricators' production of PF1A sling base parts continued, with 27 completed. G. J. Oliver completed the upper PF1C support. The ceramic break flange was machined and fabrication began on the outer skirt forging. Mockup activities were completed at PPPL 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 began. The PF1C support was dimensionally checked and moved into welding, cleaning, and testing.

**NSTX-U Oxygen Deficiency Hazards Balance Of Plant Final Design Review** — A final design review (FDR) was held Nov. 24 to review the final design and installation plans for upgrading the existing balance of plant oxygen deficiency hazard (ODH) monitors and ventilation systems in areas of high risk of ODH conditions. The final design outlined the
requirements, ODH risk assessment, ODH detector time response, final hardware design, system safety concern, and system configuration.

Research (S. Kaye):

An ST40 collaboration meeting was held between Tokamak Energy and U.S. researchers collaborating on the ST40 device on Nov. 20. T. Gray (ORNL) gave an update on the IR camera system to be installed on ST40 for divertor power exhaust studies, M. Romanelli (Tokamak Energy, UK) gave an update on scenario modeling for the future ST-F1 device (Q≥2), and S. McNamara (Tokamak Energy, UK) gave an update on the ST40 program status. ST40 will commence its P2.2 physics program in late January/early February 2021.

ITER PROJECTS (H. Neilson)

Members of the Diagnostics team participated in a three-day workshop on the linked issues of in-situ mirror cleaning and shutter actuation, hosted by the ITER Organization. Many diagnostic systems, including two under PPPL’s responsibility, include in-vessel mirrors to relay light from the plasma through three-meter-long port plugs to vacuum windows. The plasma-facing mirrors are subject to surface contamination due to wall material migration and must be cleaned periodically. At the workshop, the team learned about progress in the development of several in-situ techniques for creating a local discharge to sputter contaminants away from the mirror surface. Movable shutters are used to close input apertures to limit mirrors’ exposure to contamination and to open during measurement operations. PPPL’s M. Smith made a presentation on the potential of so-called “smart materials,” including piezo ceramics, electrostrictive ceramics, and shape memory alloys, to offer compact, robust solutions to the challenges of in-vessel shutter actuation.

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

The LFSR design team continues to make progress toward closure of chits from the final design review (FDR) of the in-vessel antenna assembly. Chit responses are being documented in memos prepared by PPPL and General Atomics (GA) team members. S. Shirey has documented the plans for helium leak testing of the components at elevated temperatures during manufacture. G. Paraiso has provided an illustrated list of the remote handling equipment and tooling that will be required to perform LFSR maintenance tasks in ITER’s hot cell facilities. GA’s C. Muscatello has documented test and analysis results showing that the effects on microwave transmission of in-tolerance misalignments between the in-vessel waveguide and the vacuum window are small. In addition, the team is working to finalize interfaces with the close-fitting shielding
material inside the port plug. PPPL engineer A. Buahin is working with suppliers in
industry to develop a feasible thermal conductor design, compatible with the available
space, that is required to transfer heat from the waveguides to cooled structures.

ITER & TOKAMAKS (R. NAZIKIAN)

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

R. Maingi and A. Khodak gave presentations on the domestic liquid metal plasma-facing
component design program at the NSTX-U/magnetic fusion science meeting. Maingi
presented “Status and progress in the domestic liquid metal plasma-facing component
design program” while Khodak presented, “MHD pumping of liquid lithium in plasma-
facing components.”

ADVANCED PROJECTS (D. GATES)

F. Nespoli, R. Lunsford, and E. Gilson participated remotely in experiments on LHD on
Nov. 25. The PPPL impurity powder dropper (IPD) was operated locally by collaborator S.
Masuzaki (NIFS) and was used to inject tens of milligrams of boron powder into ICH-
sustained deuterium LHD discharges, following an experimental proposal by F. Nespoli
titled, “Towards real-time boronization in steady state operation.” The objective was to
investigate the effect of IPD-delivered boron on wall conditioning in real time, using
discharges longer than 20 seconds, extending the parameter space from similar previous
experiments last year.

The article, “First impurity powder injection in LHD” by F. Nespoli et al. has been
published in the journal “Nuclear Materials and Energy” on Nov. 18 and is available
online with open access at https://doi.org/10.1016/j.nme.2020.100842. The article
reports on the first series of experiments on LHD employing the Impurity Powder
Dropper, designed and built by PPPL. The plasma response to the injection of controlled
amounts of boron and boron nitride powder has been characterized. As a result, low-
density plasmas appear to be more favorable for boronization applications, since the
powder penetrates deeper into the ergodic layer, and the created impurities are pushed
outwards by the radial electric field. The experimental observations are supported by
simulations with the SFINCS code.

THEORY (S. HUDSON)

V. Duarte gave a plenary talk titled, “Instabilities due to supra-thermal particles in fusion
plasmas” at the annual meeting of the Brazilian Physical Society on Nov. 23, where he
received the Society’s thesis award.
A paper titled, “Machine learning and serving of discrete field theory” by H. Qin was published in *Scientific Report*: [https://doi.org/10.1038/s41598-020-76301-0](https://doi.org/10.1038/s41598-020-76301-0). The algorithm trains a discrete field theory from a set of observational data and then directly serves the learned discrete field theory to predict new observations. As an application, the algorithm solves the Kepler problem without learning or knowing Newton’s laws of motion and universal gravitation. It learns a discrete field theory from a set of data of planetary orbits similar to what Kepler inherited from Tycho Brahe in 1601 and then correctly predicts other planetary orbits, including parabolic and hyperbolic escaping orbits, of the solar system. The proposed algorithms are expected to be applicable when the effects of special relativity and general relativity are important.

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

Communications (L. Bernard):

The Office of Communications posted two press releases to the PPPL website. The first noted that a computer platform developed by physicist A. Dominguez and others that allows users all over the world to operate a real plasma experiment from their living rooms was among 10 winners chosen by an international science committee as a cutting-edge digital education technology. The second noted that PPPL has been awarded the lead role in a grant worth $3 million in DOE Advanced Research Projects Agency-Energy (ARPA-E) funding for the design and construction of powerful permanent magnets for a new generation of stellarators. Complementing the ARPA-E award for the three-year project is $1 million from the Fusion Energy Sciences office of the DOE Office of Science. The stories were also posted to the *Newswise* and *EurekAlert* press release distribution services.

**DIRECTOR’S OFFICE (S. COWLEY)**

S. Cowley and C. Ferguson participated in an Advisory Committee for Employees (ACE) meeting on Nov. 19.

C. Ferguson participated virtually in the bi-weekly meeting of the National Laboratory Chief Operating Officers (NLCOO) on Nov. 24.

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

[http://www.pppl.gov/publication-type/weekly-highlights](http://www.pppl.gov/publication-type/weekly-highlights)