Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending January 16, 2021, are as follows:

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

Recovery (J. Galayda):

Management — Project personnel have assembled a revised baseline for the project in preparation for its director's review Feb. 2-4. This review will assess the project's revised schedule and its estimate of cost-to-go.

Bus Supports — The water-cooled power cables were repaired at the vendor with an improved closure design. 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. The new rotary table was installed and commissioned.

Center Stack Casing (CSC) — The finish machining of the CSC continued in Camden, New Jersey. At Turtle Creek, the bellows mockup welding found an issue with distortion of the diverter flange. PPPL engineering was engaged with Holtec in developing fixtures and methods to minimize this distortion. A new mockup at Holtec was in progress, and PPPL supported the design and development of the process to resolve the distortion.

Machine Core Structure (MCS) — Precision Boring in Michigan continued with fabrications. The capture flanges were completed and the common flanges were in final inspection. PPPL requested enlargement of several flange holes to improve clearances, which will be done in the next two weeks. Fixture plates fabrication were also in inspection and spare PF1B coil components were fabricated. In South Carolina, Carolina Fabricators' production of PF1A sling base parts continued and all Phase 2 machining is complete. Drilling of the base plates will be completed via contract modification in the near term. G. J. Oliver continued with the machining of the outer skirt support; the ceramic break flange will ship next week. At PPPL, assembly procedures were in review for PF1A and PF1b coil assemblies. PF1B lower slings welding was completed and post-weld inspection and heat treating began. Upper PF-1B sling welding began, as did preparations to weld the PF1A slings. The PF1CL support was dimensionally checked and moved into welding, cleaning, and testing.

Personnel Safety System (PSS) — Installation of the test cell surveillance camera system started Jan. 11. Installation and testing is expected to be completed by month's end. The first 12 of 30 of the refurbished medium voltage circuit breakers and one new circuit breaker were received from ABB, Inc.

Center Stack Casing Assembly Bellow Weld Modification Peer Review — A peer review was held Jan. 13 to evaluate the casing bellow weld configuration modification, which includes additional bolts to provide the weld distortion control needed for welding the bellows, and the bellow welding analysis that justifies the modification for the casing assembly. During

fabrication of the casing assembly, it was found that the weld distortion of casing bellows flange induced a prying and lifting off on the backside of the weld. Configuration of the weld on the outside may cause the diverter flange where the HTP will mount an 0.25" extra amount out of the tolerance gap.

Passive Plate In-Vessel Weld Modification Peer Review — A peer review was held Jan. 15 to review the consistency of the existing vessel bracket weld dimension (Weld #5 in the inspection report) between the as-built condition and the global analysis model for the passive plate assembly. During in-vessel inspections for the vertical welds of existing brackets to the vessel, a deficiency was found that invalidated the weld length assumption used in the passive plate global model developed for the FDR calculations.

Research (S. Kaye):

J. Chen (UCLA) gave a presentation at the NSTX-U / Magnetic Fusion Science weekly seminar on Jan. 11 summarizing results of the polarimetry-interferometry diagnostic measurements of internal magnetic field fluctuations measurements on DIII-D. The measurements have helped clarify and constrain what type of turbulence mechanisms are present in the pedestal region. A similar system will be installed on NSTX-U.

A paper titled, "Synergy of coupled kink and tearing modes in fast ion transport" by J. Yang, et al. was accepted for publication in *Plasma Physics and Controlled Fusion*: https://iopscience.iop.org/article/10.1088/1361-6587/abd9e4/pdf. The paper discusses the effect of coupled kink and tearing modes on fast ion transport in NSTX discharges. Soft X-ray data are used to identify the spectrum and amplitude, which are then used in TRANSP + kick model simulations to compute the expected fast ion transport. Numerical scans of the mode parameters show that the relative phase of the kink and tearing mode and the overlapping of kink and tearing mode resonances in phase space have a synergistic effect on fast ion transport.

ITER PROJECTS (H. NEILSON)

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

Manufacturing partner General Atomics in San Diego continued its development study of the CuCrZr Antenna Block bushing insertion this week. A new round of alternate test samples is underway to better understand the expansion process and how the geometry affects the success of the mechanical bond. Positive feedback from the welding study indicates that adjustments to weld input heat and use of chill blocks have reduced cracking while maintaining adequate weld penetration.

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Electron Cyclotron Emission — ECE (G. Paraiso):

The updated Statement of Work for design partner University of Texas at Austin has been completed and submitted to the Project Office for review. The team is nearing completion of their initial review of the interface sheets prepared by the IO. The team is also nearing completion of an initial update of the List of Deliverables (LoD), which comprises the design documentation package and will be submitted as design reviews. After an informal review by the IO responsible officer, the LoD will be submitted for approval.

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

The UWAVS team completed a revised Statement of Work for design partner General Atomics as well as detailed work plans for developing two in-vessel configurations of the UWAVS diagnostic to be integrated into the two different types of upper ports that host the UWAV system.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson):

Research:

The paper, “3D modeling of boron transport in DIII-D L-mode wall conditioning experiments" by F. Effenberg, et al. was published in *Nuclear Materials and Energy:* https://doi.org/10.1016/j.nme.2021.100900. The paper reports the first-time full-torus modeling of boron transport with EMC3-EIRENE. The results show that local boron injection causes a non-axisymmetric boron distribution in the scrape-off layer (SOL) and the divertor. Impurity transport analysis reveals that the frictional flows are mostly responsible for coating the divertor plasma-facing components in the far SOL region. The discussion covers how the plasma density, radiative dissipation, and erosion affect the boron flux distribution.

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

The IPD and its cabling was successfully installed on WEST at the beginning of January. Boron powder was loaded into two of the four feeders. The initial commissioning experiment took place on Jan. 12, where powder was successfully dropped into three discharges. The dropping was confirmed by fast and slow visible cameras as well as visible spectroscopy. Further analysis of these plasmas will be done later this week. The plan for next week is to drop larger amounts of powder into discharges with auxiliary heating and current drive with a focus on the divertor power exhaust. This work is being guided remotely by PPPL staff G. Bodner, R. Lunsford, and A. Nagy.

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ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

On Dec. 23, a manuscript titled, "Initial operation of a real-time Thomson scattering system in the Large Helical Device," by K. Hammond, F. Laggner, A. Diallo, S. Doskoczynski, C. Freeman, H. Funaba, D. Gates, R. Rozenblat, G. Tchilinguirian, Z. Xing, I. Yamada, R. Yasuhara, and E. Kolemen was submitted to *Review of Scientific Instruments*. The paper presents initial data collected by a system that processes signals from the Thomson scattering diagnostic to output profiles of electron temperature and density in real time. The system, initially implemented for NSTX-U, was replicated and operated for the first time during plasma discharges on the Large Helical Device at the National Institute for Fusion Science in Toki, Japan, in January 2020. The paper also describes subsequent improvements to the analysis code that the system uses to interpret the input signals. A preprint of the manuscript is available at https://arxiv.org/abs/2101.03444.

N. Pablant submitted an article for publication in *Review of Scientific Instruments* in the HTPD special issue. The paper, entitled, "Correction and verification of XICS analysis on W7-X through X-ray ray tracing" notes research about using X-ray raytracing with the PPPL developed code XICSRT to develop ion temperature corrections for the XICS ion temperature measurements. Raytracing is then further used to perform verification of the entire analysis chain, providing confidence in the basic analysis technique, the approximations therein, and the applicability to stellarator geometry. This work pushes the envelope for analysis and accuracy in XICS diagnostics.

On Jan. 14, F. Nespoli, E. Gilson, and R. Lunsford participated remotely in experiments on LHD. The PPPL impurity powder dropper (IPD) was operated locally by collaborators S. Masuzaki and N. Ashikawa (NIFS) and was used to inject boron powder into LHD discharges, following an experimental proposal by NIFS collaborator M. Shoji. The objective of the experiment was to deposit a boron layer on two material samples located in the LHD divertor by injecting boron powder in high-density plasma. The second part of the experiments, featuring low density plasmas, will be performed on Jan. 19. The experimental results will be compared with ERO2.0 simulations.

THEORY (S. HUDSON)

The paper entitled, "Machine learning for the complex, multi-scale datasets in fusion energy" by M. Churchill was published in the Smoky Mountain Conference edition of *Communications in Computer and Information Science*: https://doi.org/10.1007/978-3-030-63393-6_18

C. Smiet gave a talk on Jan. 8 at the Phil Morrison's Friday Seminar titled, "Topological bifurcations of the magnetic axis and the alternating-hyperbolic sawtooth."

A paper titled, "Collisionless adiabatic afterglow," by A. Khrabrov, I. Kaganovich, et al., was published in *Physics of Plasmas*: https://doi.org/10.1063/5.0021833.

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COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted two press releases to the PPPL website. The first summarizes 12 significant stories from 2020 touching on Laboratory breakthroughs ranging from improved control of efforts to bring the fusion energy that powers the sun and stars to Earth to advanced modeling of the formation of heavenly bodies.

The second reports that PPPL is honoring R. Hawryluk and his contributions by renaming the Laboratory's main conference room the Richard J. Hawryluk Conference Room. Room B318 in the Lyman Spitzer Building will permanently carry the Richard J. Hawryluk name. These stories were also posted to the *EurekAlert* and *Newswise* press release distribution services.

C. Cane participated remotely in the U.S. Department of Energy Office of Public Affairs Social Media meeting on Jan. 15.

DIRECTOR'S OFFICE (S. COWLEY)

S. Cowley participated virtually in the joint National Laboratory Director's Council/EIRO forum on Jan. 13 titled, "Driving Innovation: Supporting Europe's Enterprises." The EIRO is Europe's eight largest intergovernmental scientific, research, organizations that are responsible for infrastructures and laboratories.

A virtual colloquium was presented on Jan. 13 by I. Chapman, CEO of the UK Atomic Energy Authority (UKAEA), titled, "The UK Fusion Programme."

D. Graves participated in an ARPA-E webinar.

S. Cowley participated in the virtual FLARE Simulation Workshop on Jan. 15.

J. Menard participated in the virtual monthly NLCRO (National Laboratory Chief Research Officers) teleconference on Jan. 15.

This report is also available on the following web site:

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