Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending July 25, 2020, are as follows:

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

Recovery (J. Galayda):

Management — A. Indelicato and J. Galayda presented a summary of NSTX-U status to C. Fall, Director of the DOE Office of Science, on July 23. The briefing went well. Fall was particularly interested in the impact of COVID-19 and the curtailment on the project. He stressed that since the workforce at PPPL and other labs have been away from work for an extended time, we should be wary of a measure of "rustiness" in the workforce, and managers should focus on a safe and appropriately paced return to full activity.

In a follow-up to an incident in which a number of incorrectly sized holes were drilled in the NSTX-U vessel, the Project has halted any vessel work that produces an irreversible change; e.g., drilling. M. Bonkalski led a committee charged with investigating the incident and its root causes, using a "human performance improvement" (HPI) methodology. The Project will act promptly to implement the recommended corrective actions.

Coils — Low-power electrical testing of the first coil fabricated by Sigmaphi (PF1B Lower) was successfully completed at PPPL. In addition, PF1A Lower was received at PPPL and was prepped for low-power electrical testing. In France, coil fabrication continued as final paperwork was reviewed for PF1C#1. PF1C#1 will be shipped, along with PF1A#2, to PPPL early next week. PF1B#2 winding was completed and was prepared for vacuum pressure impregnation (VPI), which will be conducted on Aug. 25. PF1C#2 VPI continued as the coil cured. In addition, the order for spare coils was processed, and the Red Book is with the DOE for approval prior to placement of the order.

Center Stack Casing (CSC) — Machining continued in Camden on the center stack casing. The machining of the CSC is being done in two shifts and on weekends at the Holtec facility in Camden, New Jersey. The spiral groove for the heat transfer tube has been started on both ends, and the ID of each end is in the final machining stages. This phase of machining will continue through July 29, when the CSC will be shipped to Turtle Creek to attach the collar pieces on each end. The CSC will be returned back to Camden in early August for more machining.

Machine Core Structure (MCS) — Many fabrication activities continue at the three facilities currently making sling parts. Precision Boring in Michigan shipped all Lower PF1B sling component parts to PPPL; they were received this week. In addition,

fabrication continued of the PF1A and PF1B capture and common flanges and the PF1C capping flanges for the sling supports. In South Carolina, Carolina Fabricators first articles and production of PF1A sling parts continued, and partial shipment is expected early next week. G. J. Oliver finished radiograph inspection and resumed final machining of the welded parts of the PF1C supports. The preload parts at Magnaplate were coated and will ship early next week to PPPL. Additional procurement activities to award contracts for the remaining MCS components neared completion.

Interspace Vacuum Pumping System (IVPS) — On-site activities to install power to the vacuum pump and perform mechanical installations of the vacuum system components will resume next week.

Research (S. Kaye):

S. Munaretto (General Atomics) gave a presentation at the July 20 Magnetic Fusion meeting titled, "Magnetic Measurements of the 3D Plasma Response in DIII-D." Munaretto used the singular value decomposition method to determine the poloidal structure of two simultaneously observed n=2 modes within the plasma response to applied 3D magnetic perturbations. This experimentally inferred poloidal structure compared favorably to results obtained in modeling the plasma response using the MARS-F code.

Y.-S. Na of Seoul National University concluded his part-year stay at PPPL in July 2020. While he was at PPPL, he collaborated with a number of researchers on various topics, including reconstruction of kinetic EFIT database and JOREK-PETNRC code coupling for KSTAR (with J.-K. Park, N. Logan, and S.M. Yang); 3D field in KSTAR hybrid scenarios (with R. Nazikian, S.M. Yang, and J.-K. Park); statistical approach on electron heat transport in NSTX tokamak (with S. Kaye and W. Guttenfelder); and turbulence-driven current simulation with GTS for KSTAR hybrid scenario.

U.S. ITER FABRICATION (H. NEILSON)

Electron Cyclotron Emission — ECE (G. Paraiso)

The ECE in-vessel system includes a pair of shutter-mirrors that will enable operators to switch between measurement and calibration modes of operation. In measurement mode, these components act as shutters protecting the calibration sources; in calibration mode they act as mirrors directing the calibration source emission down the transmission lines to the ECE instruments. This week, PPPL engineer K. Yu presented the status of a scoping study, including an assessment of candidate configuration and material solutions to meet these requirements within the constraints of the shield

module structure that houses the in-vessel parts of the system. Yu identified the material choices for the hinge about which the shutter-mirror pivots and the interface with an actuator mechanism as key issues for the design development.

Equatorial Port 9 Integration — EP09 (A. Basile)

The EP09 integration activity resumed this week with the first in a new series of bi-weekly project meetings with Central Team (CT) counterparts. Project leader A. Basile reported on the tasks now under way on the U.S. side including a review of configuration changes made by the CT to conform to a new in-vessel shield module design. PPPL engineer M. Messineo reported the current assessment of those changes, identifying issues needing work on the U.S. side. Central Team colleagues offered that work performed on their side in developing EP12 to near final design maturity could be used by the U.S. team to rapidly advance the design of EP09 since the basic structure is the same and the tenants in these two ports have similar requirements.

Upper Wide Angle Viewing — UWAV (M. Smith)

The UWAVS team is working with Central Team counterparts to bring the UWAV System Requirements Document (SRD) up to date. The SRD is a key basis document for project planning and estimating the cost and schedule for completing the design of the system.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates)

The paper titled, “Characterization of impurity injections on Wendelstein 7-X from a novel in-vacuo periodic particle source” has been submitted by R. Lunsford to *Nuclear Fusion* for publication. The paper describes periodic bursts of boron carbide impurity granules from the PPPL probe-mounted particle injector (PMPI) directly introduced into the W7-X plasma edge to determine impurity transport characteristics and examine the stability of the plasma to injected material. The discharge was found to be stable to injection quantities of up to 30 mg/pulse with the unexpected discovery of a coincident transient increase in core ion temperature and stored energy as a result of impurity injection.

On July 23, a paper titled, “Geometric concepts for stellarator permanent magnets,” by K. Hammond, C. Zhu, T. Brown, K. Corrigan, D. Gates, and M. Sibilia was accepted for publication in *Nuclear Fusion*. This paper describes a new code that has been developed to assist in the design of stellarators that employ permanent magnets. The code, called MAGPIE (MAGnets, PIEcewise), designs arrangements of magnets to be placed around the plasma vessel. The arrangements can then be evaluated by the FAMUS code,

recently developed by C. Zhu, to determine whether they are capable of adequately confining a plasma and how much magnet volume is necessary. Initial studies also described in the paper have evaluated the trade-offs of different geometric concepts as well as the minimum required magnet layer thickness. The code will be a useful design tool for the upcoming permanent magnet project that was recently approved jointly by FES and ARPA-E. The manuscript has been made available at https://doi.org/10.1088/1741-4326/aba8dc.

OFFICE OF ACADEMIC AFFAIRS (N. FISCH)

V. Munirov, a graduate student in the Program in Plasma Physics, successfully defended his thesis, "Radiative Processes in Astrophysical and Laboratory Plasmas," and passed his FPOE on July 20. His thesis advisor was N. Fisch. He will be starting a postdoctoral appointment at the University of California, Berkeley, in August.

Y. Shi, a 2018 doctoral graduate of the Program in Plasma Physics, has won the 2020 Marshall N. Rosenbluth Outstanding Doctoral Thesis Award conferred by the American Physical Society for his thesis, "Plasma Physics in Strong Field Regimes." His advisors were N. Fisch and H. Qin. Shi is now a Lawrence Postdoctoral Fellow at Lawrence Livermore National Laboratory.

THEORY (S. HUDSON)

A talk by A. Reiman for the IAEA Technical Meeting on Disruptions titled, "Magnetic Island Suppression and Disruption Avoidance via RF Current Condensation," can be found at https://drive.google.com/file/d/1kISfPF51IZE1iCGcOOy6a5vH-xviIN7p/view?usp=sharing, and the slides can be found at https://drive.google.com/file/d/1TAlSNXaSgiui3F9zbV3kXcoAcn3BuGhZ/view?usp=sharing. The main points of the talk are that electron-cyclotron current drive (ECCD) stabilization of large islands produced by off-normal events could play an important role in reducing the disruption frequency in ITER, and the nonlinear RF current condensation effect could facilitate this. The collaborators on this work have been N. Bertelli, N. Fisch, S. Jin, R. Nies, and E. Rodriguez at PPPL, and P. Bonoli and S. Frank at MIT.

A talk titled, "A paradigm shift on stabilizing NTMs or how I learned to stop worrying and love the locked mode," was presented by R. Nies at the IAEA Technical Meeting on Plasma Disruptions and their Mitigation. In ITER, active stabilization with electron-cyclotron current drive of rotating islands will be challenging, most notably due to the fast locking of these modes. It is argued that locked mode stabilization is to be preferred instead, as it is more robust and requires lower power. The collaborators on this work are A. Reiman and N. Fisch. The talk can be found at

https://drive.google.com/file/d/1eDa_W1MbQHkliMhYE6PgBKUBs6jAujte/view?usp=sharing and the slides at https://drive.google.com/file/d/1PXhz2bEdS9NIBkab9GqxNody33YOPVaA/view?usp=sharing.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted two press releases to the PPPL website this week. The first reported research by R. White, V. Duarte, and others involving computer simulations of a type of plasma movement that can bump highly energetic particles from the core to the edge, a phenomenon that could occur in ITER, the multinational tokamak being built in France to demonstrate the feasibility of fusion as an energy source. The second noted that physicist Y. Shi, who received his doctorate from the Princeton Program in Plasma Physics in 2018, has won the prestigious 2020 Marshall N. Rosenbluth Outstanding Doctoral Thesis Award presented by the American Physical Society (APS). Both stories were posted to the *Newswise* and *EurekAlert* press release distribution services.

L. Bernard participated in the National Laboratory Chief Communications Officers (NLCCO) virtual meeting on July 23.

DIRECTOR'S OFFICE (S. COWLEY):

Laboratory leadership has been communicating ongoing updates to staff regarding the COVID-19 virus and PPPL.

S. Cowley participated in the July 15 National Laboratory Directors Council (NLDC) virtual meeting regarding systemic racism and the path forward.

Laboratory leadership presented the PPPL 2020 Annual Laboratory Plan and Campus Strategy plans to the U.S. Department of Energy, Office of Science on July 20.

S. Cowley participated in the National Laboratory Directors Council (NLDC) COVID-19 virtual meeting on July 24.

J. Menard participated in the National Virtual Biology Laboratory (NVBL) working group call on July 24.

This report is also available on the following web site:

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