The PPPL Highlights for the week ending May 30, 2020, are as follows:

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

**Recovery (J. Galayda):**

**Independent Project Review (IPR)** — The DOE Office of Fusion Energy Sciences conducted an independent project review (IPR) of NSTX-U May 26-29 to assess the project’s readiness for approval of CDE-3b, the gating authorization to complete the project. The review was chaired by H. Lee (DOE SLAC Site Office). The online review spanned 3 ½ days and covered cost, schedule, technical, and safety aspects of the project. The project presented the status of work to date, including an assessment of the lab closure on cost and schedule. The project team also provided a forecast of cost and schedule based on an assessment of enhanced work planning and control necessary to safely complete the work-to-go. In its report, the committee found the project’s cost forecast to be reasonable. The committee complimented the NSTX-U project on the quality of the work presented and the excellent logistics of the online review and recommended that the DOE proceed to approval of CDE-3b. The committee also acknowledged the need to revise the total project cost to provide enhanced resources to manage the COVID-19 risk.

**Coils** — Coil winding continued at Sigmaphi, with PPPL contract oversight in place. PF1B lower coil electrical testing concluded, and final testing and fabrication documents were prepared for submission prior to shipment of the coil to PPPL. The PF1A lower coil underwent vacuum pressure impregnation (VPI). PF1C lower coil winding is complete and preparations for VPI have started. The fourth and final layer of conductor for the PF1A upper coil was laid in this week, and PF1C upper winding began.

**Center Stack Casing (CSC)** — Machining of the center stack casing continued at the Holtec facility in Camden, New Jersey, and the facility’s focus on maintaining high quality continued during the difficult machining process. A second shift will start next week on this machining. Mockup work was also performed in Pittsburgh to understand weld deformation of the bellows flange and, separately, to understand best methods for installation of the microtherm.

**Machine Core Structure (MCS)** — Fabrication of machine core parts continued at multiple facilities across the United States. In Michigan, Precision Boring approached completion of the pre-load parts for the slings. In addition, they fabricated PF1C capping flanges, PF1B sling component parts, and PF1A and PF1B sling capture flanges, in addition to the PF1A/B common flanges. In South Carolina, Carolina Fabricators fabricated PF1A sling parts. In New Jersey, G.J. Oliver welded together the forgings that
will eventually become the PF1C coil supports. Other minor fabrication and procurements of other parts and hardware continued in parallel to these large fabrications.

Research (S. Kaye):

The NSTX-U Five Year Research Plan for 2021-2025 was completed and submitted to FES in anticipation of the formal review of the plan, scheduled for June 9-11.

U.S. ITER FABRICATION (H. Neilson)

The ITER Upper Wide Angle Viewing (UWAV) diagnostic is a system of visible and infrared cameras that will monitor the high heat flux divertor surfaces from several of the upper ports. The U.S. UWAV team, led by engineer M. Smith, is currently working with Central Team counterparts to define interfaces with the plant CODAC network. In addition, meetings with U.S. ITER instrumentation experts were productive in terms of clarifying requirements and implementation costs associated with radiation-hardened electronics.

The ITER Electron Cyclotron Emission (ECE) diagnostic is a broadband microwave receiver system that is being designed to measure the plasma electron temperature profile. Progress in design development was reported by lead engineer G. Paraiso at a meeting with Central Team counterparts. The PPPL team now has design ownership and has completed initial review of CAD models in the ITER CAD database, Enovia. Work on laying out and verifying component positions in the in-vessel diagnostic shield module (DSM) assembly is in progress.

ITER & TOKAMAKS (R. Nazikian)

DIII-D (B. Grierson):

Research:

This week, Nuclear Fusion published the paper entitled, “The role of edge resonant magnetic perturbations in edge-localized-mode suppression and density pump-out in low-collisionality DIII-D plasmas:” https://doi.org/10.1088/1741-4326/ab8545. The authors were Q. Hu, R. Nazikian, B. Grierson, N. Logan, C. Paz-Soldan (GA), and Q. Yu (IPP). The paper presented a comprehensive understanding of ELM suppression and density pump-out caused by 3D fields observed in the DIII-D tokamak based on nonlinear two-fluid MHD simulations using the TM1 code. The TM1 simulations quantitatively explain the required plasma density, rotation and RMP amplitude for the ELMs suppression by n=2 RMPs due to the formation of magnetic islands at the top of

the pedestal. The observed density pump-out is reproduced from the MHD simulations for the penetration of resonant fields in the resistive foot of the pedestal.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates)

On May 28, a manuscript entitled, “Geometric concepts for stellarator permanent magnets,” by K. Hammond, C. Zhu, T. Brown, K. Corrigan, D. Gates, and M. Sibilia, was submitted to the journal *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 very useful design tool for the upcoming permanent magnet project that was recently approved jointly by FES and ARPA-E.

THEORY (S. HUDSON)

On May 26, H. Qin presented a research review seminar titled, “Machine learning and serving of discrete field theories — when artificial intelligence meets the discrete universe.” A theory and an algorithm for machine learning and serving of discrete field theories were developed. As an example of application, the algorithm solves the Kepler problem without learning or knowing Newton’s laws of motion and universal gravitation. The learning algorithm learns a discrete field theory from a set of data of planetary orbits similar to what Kepler inherited from Tycho Brahe, and the serving algorithm correctly predicts other planetary orbits, including parabolic and hyperbolic escaping orbits, of the solar system. Applications to magnetic fusion research are also discussed.

C. Zhao’s paper “Simulation of MHD instabilities with fluid runaway electron model in M3D-C1” was accepted by *Nuclear Fusion*.

The paper titled, “Phase-space dynamics of Alfvén mode chirping” by R. White, V. Duarte, *et al.* has been published in *Physics of Plasmas*: [https://doi.org/10.1063/5.0004610](https://doi.org/10.1063/5.0004610) The paper reports the detailed dynamics of phase-space holes and clumps in the distribution function of fast ions in a tokamak and the consequent excitation of chirping oscillations of Alfvénic waves. It is found that the
onset of chirping correlates with a marked drop of the wave amplitude in conjunction with a phase flip by pi.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted two news stories to the PPPL website. The first reports on research by S. Zweben and others that shows a connection between blob-like turbulence at the edge of fusion plasmas and the magnetic fields confining those plasmas. The second reports that V. Graber, a doctoral student in mechanical engineering at Lehigh University, has won a highly competitive award from the DOE that he will use to conduct research at PPPL. The award, one of 62 recently announced by DOE under the Office of Science Graduate Student Research (SCGSR) Program, enables standout graduate students in science and engineering to pursue part of their doctoral theses in collaboration with a researcher at a DOE national laboratory. Both stories were also posted to the Newswise and EurekAlert press release distribution services.

DIRECTOR’S OFFICE (S. COWLEY)

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

On May 26, C. Ferguson participated virtually in the monthly NLCOO meeting.

A virtual colloquium was presented on May 27 by NYU professor T. Marzetta titled, “Principles of Wireless Power Transfer.”

On May 29, S. Cowley participated virtually in the National Laboratory Directors Council (NLDC) COVID-19 Coordination conference call.

On May 29, J. Menard participated in the weekly National Virtual Biotechnology Laboratory (NVBL) working group conference call.

This report is also available on the following web site:

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