Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending December 15, 2018 are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

Magnets — The inner poloidal field (PF) coil basis of estimate (BOE) for the magnet WAF has been updated for distribution and presentation. The source selection plan was passed back for more revisions and the vendor oversight plan was signed off. Magnet team members are still on site at ICAS Tratos. Compression testing of the glass tape is complete, and the test report and presentations for insulation compression testing and water fitting are in progress. The coil flag and mandrel are being worked on in the machine shop, and tooling modification design has begun.

On Dec. 11, the NSTX-U TF/OH bundle was tilted to a horizontal orientation in the test cell south high-bay area. A team of electrical engineers and technicians is preparing to electrically test the turn-to-turn insulation between each of the 36 TF bundle inner-leg conductors and perform cleaning of the exposed conductor ends, if required. This important recovery project scope will verify the integrity of the TF bundle that was built during the NSTX-U project and retire related project risks.

Personnel Safety System — The personnel safety system (PSS) conceptual design review (CDR) was held on Dec. 13. The scope of the CDR outlined a conceptual design of the NSTX-U personnel safety system and its interface with the centralized control system. The review also included accelerator safety order (ASO) requirements and community best practices, relevant industrial consensus standards, hazard analysis, and cost and schedule work packages. The CDR stems from concerns voiced at the recovery project director's review. The director's review safety panel determined that the existing system had to be redesigned to meet current industrial and ASO community safety standards. The CDR will provide important preliminary cost and schedule information for the project baseline in support of the project basis of estimate review and CDE-2/3A review. The CDR was deemed successful, pending resolution of chits.

Research:

Conferences — E.-H. Kim attended the 2018 American Geophysical Union fall meeting in Washington, D.C., Dec. 9-14, where she presented, "How Does EMIC Wave Polarization Depend on Magnetospheric Plasma Conditions?" and "Resonant Mode Conversion of Alfven Waves in the Low-Latitude Boundary Layer Structured by Kelvin-Helmholtz Instability."

Publications — The paper, "Resolving Interactions Between ICRF Heating and the SOL Plasma in EAST Using Divertor Probes," by R.J. Perkins, J. Hosea, G. Taylor, N. Bertelli, G. Kramer, Z. Luo, C. Qin, L. Wang, J. Xu, and X. Zhang has been accepted for publication in *Plasma Physics and Controlled Fusion*. The paper details the effect of ICRF heating on triple-probe signals in the EAST experiment. EAST is an advanced superconducting tokamak with two ion cyclotron range of frequency (ICRF) antennas and two megawatts of ICRF power that supports high-power and

long-pulse operation. Tokamak-heating using waves in the ICRF range is known to strongly interact with the scrape-off layer (SOL) plasma and could potentially limit ICRF performance. Dedicated to the memory of Joel C. Hosea, this paper will provide insight into the sputtering, impurity production, and antenna coupling as higher ICRF power levels are attempted on EAST.

Collaborations — S. Sabbagh, J.-H. Ahn, and Y. Jiang connected remotely to the KSTAR control room using the capabilities of PPPL Room B205 to conduct the start of an experiment on high-beta plasmas in KSTAR (at NFRI, South Korea). The group joined Y.-S. Park of Columbia who is presently at NFRI. The experiment focuses on understanding the destabilization of NTMs in KSTAR for disruption prediction and avoidance purposes by carefully bracketing regions of operation space that do / do not exhibit these instabilities. This initial portion of the experiment was successful in producing plasmas with / without the modes, thus bracketing the conditions for mode onset. Interestingly, mode onset occurred in the lower range of beta tested and did not occur in the conditions at higher beta. The q profile was varied as the start of a longer shot plan of plasma variations in this portion of operational space to determine the most important plasma conditions for mode onset / or stabilization. The experiment will continue next week.

U.S. ITER FABRICATION (H. NEILSON)

The Laboratory hosted a delegation of five team members from the U.S. ITER Project Office at Oak Ridge National Laboratory for a day of discussions regarding U.S. ITER procedures and expectations in the areas of system engineering, quality assurance, and documentation. With the PPPL-led Low Field SIde Reflectometer project making the transition from preliminary to final design, including planning for manufacturing prototypes, the meeting provided an opportunity to heighten awareness of the procedures that will apply in the coming year's work. Informative presentations on U.S. ITER procedures were made by visitors H. Bailey, G. Creasey, and A. Buckley, while PPPL Fabrication Group leader M. Safabakhsh described the Laboratory's fabrication capabilities and led a tour of on-site fabrication facilities. The group also toured the NSTX-U facilities and the NCSX stellarator subassembly. The meeting served to strengthen the ORNL-PPPL partnership in the U.S. ITER project and to raise awareness both of project expectations and of PPPL's capabilities for equipment fabrication.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D Research (B. Grierson):

Research:

A new article titled, "Direct Observation of Nonlinear Coupling between Pedestal Modes Leading to the Onset of Edge-Localized Modes," by A. Diallo, J. Dominski, K. Barada, M. Knolker, G. Kramer, and G. McKee has been published in *Physical Review Letters*. This paper uses DIII-D data in type-I ELMy H-mode to show for the first time that coupling of modes leads up to the ELM onset. Three dominant pedestal modes, exhibiting both magnetic and density fluctuations, have been identified, and their amplitudes, frequencies, and radial profiles have been tracked during

the ELM cycle. The nonlinear coupling of these pedestal modes is associated with radial distortions pushing out of the pedestal prior to the ELM event. The paper is available here: https://doi.org/10.1103/PhysRevLett.121.235001

Operations:

The calorimeter for the 150-degree tiltable off-axis neutral beam delivered recently to General Atomics has passed quality assurance and will now be stored. This is the second set of calorimeter plates of this design delivered to replace leaking calorimeters at DIII-D. This calorimeter will not be installed during this long torus opening (LTO) but retained until the next opportunity for installation.

International PMI (R. Maingi):

ASDEX-Upgrade: F. Laggner and R. Lunsford provided remote support for Impurity Powder Dropper (IPD) operations on ASDEX-Upgrade (AUG) during the previous two weeks. Following a site visit to AUG to return the IPD to operational status after a 12-month hiatus, the AUG program committee awarded dedicated dropper checkout discharges to confirm readiness. Utilizing remote control room facilities at PPPL, Laggner and Lunsford recommended powder injection levels, analyzed results, and supported the local AUG dropper team to demonstrate full availability of the IPD in support of regular operations.

EAST: A paper titled, “Results from an improved flowing liquid lithium limiter with increased flow uniformity in high power plasmas in EAST,” by G. Zoo, J. Hu, R. Maingi, Z. Sun, Q. Yang, et al, was published in *Nuclear Fusion*. The paper describes the engineering upgrades and new experimental results for the second-generation flowing-liquid-lithium limiter in EAST, which resulted in improved lithium surface fractional flow coverage, removal of more than 50% of the discharge heat flux, and improved plasma discharges with up to 4.5 megawatts of auxiliary heating power. A gradual mitigation of edge-localized mode activity was observed. PPPL staff participated in the limiter design and the experiments to evaluate the performance.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

S. Lazerson was awarded 3 million hours at the National Energy Research Supercomputing Center (NERSC) to continue exploration into energetic particle physics in stellarators. The hours will be used to run the STELLOPT and BEAMS3D codes on the knights landing architecture of the Cori supercomputer. This award will support Lazerson's early career award work, allowing validation of the BEAMS3D code using data from recent neutral beam experiments on Wendelstein 7-X. Work is currently focusing on validation of the neutral beam deposition model in BEAMS3D and optimizations of code to more effectively use the knights landing architecture.

D. Gates traveled to Greifswald, Germany, for the week. He met with each of the members of the IPP directorate to discuss future and ongoing activities within the framework the IPP-PPPL collaboration on stellarators. He also met with A. Winter, the head of the CODAC group, to discuss ideas for future collaborations on plasma control and with A. Dinklage regarding the upcoming meeting of the Coordinated Working Group to be held in Berlin in March 2019. Numerous discussions were held with individual researchers as well regarding individual ongoing research tasks.

THEORY (S. HUDSON)

N. Ferraro and S. Jardin have been asked to participate in the Theory and Modeling group of a new ITER Disruption Mitigation Task Force led by M. Lehnen from ITER. In addition to this group, there are two other groups: Experiments and Technology. The goal of the Theory and Modeling group is to interpret mitigation experiments on today's experiments and to extrapolate results to ITER.

Computational Plasma Physics Group (S. Jardin and S. Kaye):

J. Chen gave a presentation titled, “Linear Solvers for Sparse Linear Systems.” Finding the solutions of large sparse linear systems is part of the daily work of researchers here at the lab. These linear systems are ubiquitous, appearing in a wide range of applications in computational science. The goal of this seminar was to impart a working knowledge of the sparse direct and iterative methods used to solve these systems. The presentation provided an overview of the algorithms, data schemes, and available software to both understand the methods and know how to best use them.

ENGINEERING (V. RICCARDO)

Engineering welcomes three new employees this week: diagnostic tech James Perich, metallurgist Mark Pauley, and programmer/machinist Nick Fahrney.

B. Bornstein from OLYMPUS Corporation presented a 2.5-hour training course at PPPL on the operation of the Epoch 650 ultrasonic detector. The detector will be used during the NDE evaluation of tanks in the GHT room and other areas as required.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted two press release to the PPPL website. One focused on the 2019 Science on Saturday \lecture series, and the other on C.S. Chang’s group winning hours on three leading supercomputers, including the world’s fastest. Both stories were also posted to the *Newswise* and *EurekAlert* press release distribution services.

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DIRECTOR'S OFFICE (S. COWLEY)

S. Cowley traveled to Washington, D.C., to attend the National Laboratory Director's Council (NLDC) meetings on Dec. 12 and 13.

R. Hawryluk attended a National Laboratory Chief Operations Officer (NLCOO) meeting in Chicago on Dec. 13 and 14.

This report is also available on the following web site:
http://www.pppl.gov/publication-type/weekly-highlights