Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending March 16, 2019, are as follows:

NSTX-U RECOVERY (R. HAWRYLUK) AND RESEARCH (J. MENARD)

Recovery:

The recovery project team went through final preparations for the basis of estimate review (BOER) on March 18-20. The BOER will address an FY2019 FES notable that the project prepare a cost estimate that is deemed by external review to be well-documented, comprehensive, accurate, and credible as defined by the DOE and GAO by March 31.

Center Stack Casing — Center stack casing bid proposals arrived on March 15. The SPEB met on Saturday to review bids for the casing's fabrication.

Maintenance and Run Preparation — Maintenance was performed on all three of the pumps that supply deionized cooling water to the high harmonic fast wave (HHFW) systems. A small water leak was identified and repaired on HHFW System 4. To date, all of the cooling water pumps have been exercised, and all six systems have had water flow through them. The maintenance and repair of the cooling water system is being done to prepare for dummy load testing of HHFW systems 3 and 4.

Research:

Workshops — Several NSTX-U researchers gave presentations at the US-Japan and International Workshop on Power and Particle Control in DEMO Fusion Reactor by Liquid Metal Plasma-Facing Components held March 11-13 at PPPL. R. Maingi presented, "Similarities between flowing liquid lithium and lithium powder injection experiments on EAST, and lithium evaporation experiments on NSTX," and "The nearly continuous improvement of discharge characteristics and edge stability with increasing lithium coatings in NSTX." R. Goldston presented, "Advances towards a simplified lithium vapor box divertor." M. Ono presented, "Comments on liquid lithium loop system to solve challenging technology issues for fusion power plant." T. Brown presented, "Design status in the development of liquid metal divertor and first-wall concepts within a PPPL toroidal confinement facility study." And J. Menard presented, "Systems studies for a tokamak-based divertor test facility."

U.S. ITER FABRICATION (H. NEILSON)

The Low Field Side Reflectometer (LFSR) design team continued to make progress in remote handling design of the in-vessel antenna array. A meeting with ITER

Organization Central Team remote handling specialists clarified intentions and planning for a physical mockup project that will simulate LFSR component remote maintenance. This activity is ramping up and will play a valuable role in validating the LFSR maintenance design for the final design review. In addition, a discussion with the UK-based RACE nuclear robotics firm was productive in firming up a collaborative relationship (also with IO) and provided positive feedback towards the current LFSR design approach.

Preparations for a planned LFSR procurement action continued to progress. A draft of the ITER-required procurement description is nearly ready for submission. The statement of work and source selection plan is in final PPPL review. In a step toward final closeout of LFSR preliminary design, a revised draft of the ex-vessel structural integrity report was issued for internal review.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson):

Research:

A paper titled, “Quantitative modeling of neoclassical tearing mode driven fast ion transport in integrated TRANSP simulations,” by L. Bardoczi, M. Podestà, W. Heidbrink, and M. Van Zeeland has been accepted for publication in *Plasma Physics and Controlled Fusion*. The paper extends previous studies of fast ion transport by Alfvénic instabilities through the "kick model" implemented in TRANSP to fast ion transport by neoclassical tearing modes (NTMs). Several DIII-D discharges, including ITER-like scenarios, have been analyzed.

The charge-exchange recombination (CER) spectroscopy systems for main-ion and impurity measurements have been upgraded to include multiple new main-ion and impurity sightlines on the high-field side of the tokamak. These new sightlines provide (i) determination of the main-ion poloidal flow in the core through the in/out asymmetry in the toroidal velocity, (ii) in/out measurements of main-ion and impurity density, and (iii) beam neutral density from the low to high field side to reduce uncertainty in the beam stopping and attenuation, which is required for assessing the magnitude of in/out density asymmetries. The CER systems have been calibrated for the spatial location of the sightlines and absolute intensity response of the system. Absolute intensity calibration is required for determining the impurity and main-ion ion density as well as the beam neutral density from D-alpha beam emission to confirm atomic ionization calculations.

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Operations:

The neutral beam upgrade project, led by A. Nagy at DIII-D, is moving ahead rapidly. Testing this week successfully tilted the beam 18.55 degrees vertically and rotated the beam from the co to counter direction while in the fully tilted position. The vertical tilt time is 10 minutes and the toroidal direction rotation is 30 minutes, end to end. The movement functioned without incident. Several tests established that the tilt and rotation change could be performed routinely. This has been a very challenging and ultimately successful project. The next step is to get all facility systems restored in time for closing the DIII-D vacuum vessel on Apr. 15.

C. Jennings, a high school student intern from San Marcos, California, presented his research findings to a group of engineers at General Atomics this week. His presentation caps a three-month internship with A. Nagy in which he characterized several types of metering devices for dropping powders into the vacuum vessel. He tested four types of auger screws, carefully noting their strengths and weaknesses. From this experience, Jennings proceeded to invent a new helical metering device that he fabricated using a 3D printer. The new device worked extremely well and overcame the delivery variances he found with the earlier models. This new helical device is named Helio and a patent disclosure is in preparation. Jennings graduates from high school in June and is planning to enter college in the fall.

International PMI (R. Maingi):

M. Ono and R. Maingi co-hosted the inaugural US-Japan and International Workshop on Power and Particle Control in DEMO Fusion Reactor by Liquid Metal Plasma-Facing Components, held at PPPL March 11-13. Five Japanese scientists, along with an Italian researcher and a Chinese researcher, joined about 15 people from PPPL and several from Princeton University and the Univeristy of Illinois. There was an excellent exchange of ideas and a plan to hold a follow-on workshop in Japan next year. A complete list of talks and speakers is given at https://sites.google.com/pppl.gov/lmad/program?authuser=0.

The PPPL powder dropper on ASDEX-Upgrade was used to support experiments both last week and this week. This week, boron nitride was injected to understand nitrogen physics and wall conditioning. Afterward, two discharges with full ELM suppression were obtained using 3D fields, indicating improved wall conditioning, due partly to the injection.

A. Bortolon and F. Laggner visited PPPL to discuss impurity powder dropper physics and development, and the powder dropper work on DIII-D.

International Long Pulse (F. Poli):

ITER-JET (F. Poli):

F. Poli visited JET March 4-13 to participate in the winter modeling campaign. She discussed with the JET team details of the PPPL collaboration on scenario modeling using TRANSP to guide the upcoming experiments dedicated to the development of a safe plasma termination phase for DT experiments. The JET program has hired a new responsible officer for TRANSP (Z. Stancar) in order to enhance TRANSP support in preparation for JET-DT. Poli has discussed with JET management how to transfer best practices in the use of TRANSP to users at JET for data preparation as well as procedures for checking the consistency between TRANSP outputs and diagnostic data.

KSTAR Stability (S. Scott):

The beam-into-gas calibration of the MSE background polychromator performed last fall revealed a significant contribution from secondary beam emission. However, it was recognized that the effect is minimized for horizontal field lines. A new calibration has been obtained for the MSE system by extrapolating the data taken at three different values of torus pressure to zero pressure. The accuracy of this procedure is being evaluated by comparing MSE measurements with other diagnostics.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates)

On March 12, D. Gates, S. Lazerson, and N. Pablant attended the Coordinated Working Group Meeting in Berlin, Germany. The focus of the meeting was to develop comparative experimental and theoretical science activities among the worldwide stellarator community. In this way, its function is very similar to that of the ITPA, but with a specific stellarator focus. Reports from this meeting are presented to the International Energy Agency.

Lazerson served as the coordinator for a session on fast ions and presented a talk entitled, “Equilibrium reconstruction in support of energetic particle modeling in stellarators,” which highlighted his recent work fitting profiles and performing equilibrium reconstructions on Wendelstein 7-X. A synergistic activity with J. Schmitt was identified in which the STELLOPT and V3FIT codes could be compared on Wendelstein 7-X and the Large Helical Device.

Pablant chaired the session on impurity transport. As part of this task, Pablant presented an update on the international activity and progress on the impurity

transport joint tasks in 2018 and 2019. He also led the extended discussion to formulate detailed plans for collaborative work within these tasks for the upcoming year.

Gates serves on the international program committee for the CWGM and made two presentations. The first was entitled, “The physics of the density limit in tokamaks and stellarators,” in which he proposed a series of comparative experiments on the interesting differences in density limit behaviors between stellarators and tokamaks. The second talk was a summary of the US experimental stellarator program.

THEORY (S. HUDSON)

C. Dong has been selected as one of the eight US-based participants in the 9th and 10th Forums for New Leaders in Space Science by the Space Studies Board of U.S. National Academies of Sciences, Engineering, and Medicine. Note that D. Spergel (at Princeton/CCA) was invited to participate in the 1st and 2nd Forums for New Leaders in Space Science.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

COMMUNICATIONS (L. Bernard)

The Office of Communications posted three press releases to the PPPL website. One announced that the U.S. Department of Energy and Princeton University signed an agreement to extend its contract for three years. Another focused on research by physicist C. Smiet into topological properties of magnetic field lines within tokamaks that impose limits on how plasma can evolve over time. And another press release announced that physicist S. Cohen has received funding from an ARPA-E award to his collaborator to upgrade and operate his Princeton Field Reversed Configuration device. The articles were also posted to the *Newswise* and *EurekAlert* press release distribution services.

DIRECTOR’S OFFICE (S. COWLEY)

On March 12-13, S. Cowley and M. Zarnstorff attended the U.S. Department of Energy's Fusion Energy Sciences Advisory Committee (FESAC) meeting in North Bethesda, Maryland.

This report is also available on the following web site:

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