Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

**The PPPL Highlights for the week ending February 3, 2018, are as follows:**

**NSTX-U RECOVERY AND RESEARCH (J. MENARD)**

*Recovery:*

Final dry runs for the upcoming assessment by the DOE's Office of Science were performed during the week.

A preliminary design review for the NSTX-U ex-vessel heating system was held on Feb. 1. The second part of the TF/OH bundle and center-stack casing alignment peer review was also held on Feb. 1.

In the PPPL coil shop, a manufacturing readiness review was conducted on Jan. 31. Technicians completed formal training in the installation of ground insulation onto the winding form. Additional visual inspection using digital microscopy of the VPI test bundle confirmed good resin penetration into the insulation system.

*Research:*

S. Kaye gave a presentation entitled, "Containing a star on earth: the promise of fusion energy," to the Alumni Association of Franklin and Marshall College on Jan. 27. The event was held at PPPL. Over 50 people attended the presentation, which was followed by science demonstrations and tours of the Laboratory, including the NSTX-U test cell. The tour guides were W. Guttenfelder, A. Brereton and K. Lamb.

L. Delgado-Aparicio and M. Ono of PPPL visited the University of Tokyo on Jan. 22-23 under the US-Japan spherical tokamak collaboration. They toured the TST-2 and UTST spherical tokamak facilities and met with Profs. Y. Takase, A. Ejiri, and M. Inomoto, as well as a number of UT graduate students. Delgado-Aparicio gave a seminar entitled, "Current trends in X-ray spectroscopy for fusion plasmas: Possible applications for QUEST (Kyushu U.) and JT60SA (QST)." During the visit, he also worked with H. Yamazaki, a University of Tokyo graduate student, on multi-energy X-ray simulations for MST, DIII-D and JT60SA plasmas.

N. Bertelli, L. Delgado-Aparicio, and M. Ono of PPPL traveled to QUEST (Kyushu University), Fukuoka, Japan to attend a workshop on QUEST and related spherical tokamak radio-frequency startup and sustainment plasma research on Feb. 1-2. Bertelli gave a presentation entitled, "Initial Fokker-Planck simulations by using the CQL3D code for QUEST plasmas." Delgado-Aparicio gave a presentation entitled, "Multi-energy SXR imaging and its applications to QUEST plasmas." Ono gave a presentation entitled, "NSTX-U plasma start-up research program and collaboration strategy." During the visit,

they toured the QUEST Laboratory and discussed future collaborations on QUEST experiments, including a multi-energy soft X-ray camera and radio frequency modeling.

R. Maingi served on the Fusion Energy Sciences Advisory Committee (FESAC), and presented a talk titled, "Findings of the FESAC subcommittee on Transformative Enabling Capabilities." R. Maingi chaired the FESAC subcommittee and J. Menard served as a panelist. The panel identified five groups of transformative enabling capabilities: advanced algorithms, high-critical-temperature superconductors, advanced materials and manufacturing, novel techniques for control of the tritium fuel cycle, and fast-flowing liquid metals as plasma-facing components. The report was well received, and generated much enthusiastic discussion on the findings.

**U.S. ITER FABRICATION (H. NEILSON)**

The Laboratory has awarded a contract to Bertin Technologies to perform a reliability, availability, maintainability and inspectability assessment of the preliminary design of the ITER Low Field Side Reflectometer (LFSR). The analysis aims to address technical risks that have an impact on the availability of the system operation. Reports documenting the results of this analysis will be among the main deliverables for the upcoming preliminary design review of LFSR. The kick-off meeting for the 16-week task was held on Jan. 11.

**ITER & TOKAMAKS (R. Nazikian)**

R. Maingi served on the proto-Material-Plasma Exposure Experiment (MPEX) Advisory Committee at Oak Ridge National Laboratory (ORNL) on Jan. 30-31. The proto-MPEX team provided an update on the progress on resolving issues needed for MPEX design. The team demonstrated good progress on the helicon source, and the EBW & ECH & ICH heating schemes. The advisory committee provided advice on priorities and targets over the next 18 months, with an eye toward long-lead-time design issues for MPEX.

**DIII-D (B. Grierson)**

*Research:*

F. Poli traveled to DIII-D to participate in an experiment dedicated to the improvement of high qmin discharges led by B. Victor (LLNL) and K. Thome (ORAU). Predictive free-boundary simulation has been run with TRANSP to design a plasma discharge with improved sustainment of high qmin in the flattop phase. The applied strategy was to advance electron-cyclotron heating and in the current ramp-up phase to delay current diffusion, hence raise qmin and improve sustainment. The plasma achieved qmin around 2 with betaN~3.5, sustained for the several seconds in the current flattop. This

experiment significantly improved upon previous efforts that were not based on predictive modeling. The success of the experiment demonstrates the power of Predict First to optimize plasmas and the utilization of valuable resources including facility runtime. This work was made possible by the enhanced collaboration between NSTX-U and DIII-D in FY17-18.

Between-shot predictive TRANSP analysis on DIII-D has been installed by B. Grierson using the OMFIT framework to support the high qmin experiment and future experiments on DIII-D. For each DIII-D discharge, an automatic script prepares the TRANSP inputs, enables current profile simulations, and submits the TRANSP runs to the PPPL computing cluster from General Atomics. Twenty-nine discharges were simulated reliably on the run day, using four CPUs per simulation. The results of the simulations were available after a few DIII-D shots and enabled the tracking of success towards achieving high qmin and non-inductive fraction during the run day. A near-term goal will be to complete the TRANSP run before the start of the next shot countdown.

Along with Q. Hu and E. Kolemen, D. Boyer visited DIII-D for a control session, testing upgrades to a new feedback control algorithm that uses the variable beam voltage and perveance capabilities of the neutral beam injectors for power, torque, energy, and rotation control. The algorithm, which was initially tested last summer as part of the NSTX-U/DIII-D national campaign, determines the optimal combination of voltage, perveance, and duty cycle for each of the beams, constrained to the reliable operating range, to achieve requested total torque or power waveforms. Fast adjustments in the beam perveance and duty cycle are used to compensate for the slow response of the beam voltage to the requested changes. The new upgrades resulted in faster adjustments in perveance and therefore faster tracking of power and torque requests. The upgraded algorithm enables fast feedback control of plasma conditions without the need for perturbative pulse-width-modulation of the beams.

## ADVANCED PROJECTS (H. NEILSON)

### Stellarators (D. Gates)

The first 2018 group meeting for the LDRD study entitled, “Stellarator Configuration Investigations” was held recently. Scientists from the U.S., Germany, and China participated in the videoconference. Progress reports were given on the status of several aspects of the study including ongoing improvements to the STELLOPT stellarator optimization code. Of particular note is the first use of the SFINCS neoclassical code in conjunction with STELLOPT. In addition, there was progress made on an aspect ratio scan being performed by PPPL’s D. Mikkelsen. S. Lazerson reported on efforts to incorporate the various new developments into the public version of STELLOPT. A brief

report on a parallel development activity going on in Germany was also given by S. Henneberg from Max Planck Institute for Plasma Physics.

As part of his ongoing duties as the W7-X scenario and integration task force leader, PPPL's S. Lazerson currently leads the organization and development of approximately 40 experimental proposals that directly address key scientific goals for the upcoming OP1.2b experimental campaign. These topics include assessment of fueling methods (main gas valves, NBI, pellets, and He-Beam), characterization of configurations (error fields, confinement, operational limits), plasma performance (long pulse, high density, high stored energy), and diagnostic commissioning. Weekly task force meetings are currently being held to collect proposal titles and review plans for execution.

**System Studies (C. Kessel)**

C. Kessel participated in the International Atomic Energy Commission's Fusion Energy Conference paper selection meeting, representing the Virtual Laboratory for Technology (VLT) in the areas of 1) Fusion Engineering, Integration, and Power Plant Design, 2) Fusion Nuclear Physics and Technology, 3) Material Physics and Technology, and 4) Safety, Environment and Economic Aspects of Fusion. In coordination with P. Ferguson (ORNL), and other committee members, a series of U.S. contributions in these areas have been developed from the submissions.

**THEORY (A. BHATTACHARJEE)**

A Theory seminar titled, "Magnetic Reconnection in Three Dimensional Space" was presented by A. Boozer of Columbia University. The abstract is available here: http://theory.pppl.gov/news/seminars.php?scid=1&n=research-seminars

B. Sturdevant and S.-H. Ku visited Los Alamos National Laboratory (LANL) to collaborate with L. Chacon for development of numerical algorithm of kinetic electron simulation with electro-magnetic perturbation

**COMMUNICATIONS (L. BERNARD)**

The Communications Office posted a news story titled, "Two PPPL physicists, David Johnson and and Charles Skinner, named ITER Scientist Fellows," to the PPPL website and the *Newswise* distribution service. The Office also hosted two tours with a total number of 22 visitors.

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**DIRECTOR'S OFFICE (R. HAWRYLUK)**

On Feb. 1-2, M. Zarnstorff and R. Hawryluk attended the annual Fusion Energy Sciences Advisory Committee (FESAC), held in Gaithersburg, MD. The Director of the Office of Science charges the committee to provide advice and recommendations on various issues of concern to the Fusion Energy Sciences program.

**This report is also available on the following web site:**

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