Weekly HIGHLIGHTS

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

The PPPL Highlights for the week ending August 10, 2019, are as follows:

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

Recovery (J. Galayda):

TF Bundle — An intensive and successful two-day review was held for the TF bundle on Aug. 7 and 8. A committee of external subject matter experts at the Stage 2 review was asked to answer two questions: did the TF bundle task force properly address chits and recommendations from the Stage 1 review, and did testing and analysis results provide confident determination that the GRD shot spectrum could be achieved as determined by the task force? The committee stated "yes" on both questions and supplied a short list of recommendations at the end of the review as follow-up. This satisfactory outcome is a critical step as the recovery project moves towards baseline.

Machine Core Structures — A successful final design review (FDR) was held on Aug. 5 and 6. Formerly known as the polar region, the machine core structures (MCS) required extensive redesign efforts as a result of an extent of condition (EoC) and design verification and validation (DVVR) review. The redesign includes, but is not limited to, the PF1A/B/C coil supports, lateral support shims, ceramic break, all MCS vacuum sealing interfaces, the outer skirt, and the MCS pedestal. The FDR was held to review the design progress of the MCS components since the conceptual and preliminary design reviews, and the FDR was deemed successful pending resolution of chits.

PF 4/5 Realignment — An FDR was held on Aug. 9 to review the development of the permanent clamps that will be installed on the PF 4/5 coils. This clamping system is required to maintain the existing relative position between the pancake pairs, and will prevent misalignment during shift and tilt adjustments to the PF 4/5 coil. The review was deemed successful, pending resolution of chits.

Research (S. Kaye):

A paper entitled, "Experimental Observation of Electron-scale Turbulence Evolution across the L-H Transition in National Spherical Torus Experiment," has been published in *Nuclear Fusion*. The paper presents the first detailed local measurements of electron-scale turbulence evolution across the L-H transition in NSTX using a high-k scattering system.

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U.S. ITER FABRICATION (H. NEILSON)

The Laboratory's ITER Diagnostics team continues its intense collaboration with the Russian Federation's (RF) port integration team, aimed at finalizing the mechanical interfaces between the Low Field Side Reflectometer (LFSR) and equatorial port 11 structures. The LFSR antenna assembly will be enclosed in a so-called diagnostic shield module (DSM), which supports the LFSR equipment and provides services such as shielding and cooling water. The basic DSM design includes a standardized shield consisting of an array of small rectilinear bricks, but additional shielding, known as "backfill," must be provided around the odd-shaped diagnostic components in order to maximize the attenuation of neutron radiation from the plasma and minimize the activation of ex-vessel components. Recent discussions with the RF team have reached agreement on the division of responsibility for design of local backfill shielding around the LFSR equipment. The teams are also nearing agreement on details of the LFSR support arrangement within the DSM, shape of the first wall aperture, arrangement of closure plate penetrations, and integration of the two systems' water cooling networks.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson):

Research:

M. Clement, a new postdoc collaborating on DIII-D, traveled to PPPL to work with D. Boyer to develop closed-loop TRANSP simulations. Building upon the recently developed capability of communicating between TRANSP and Matlab/Simulink, Clement worked with Boyer to develop a Python/C interface for communicating with TRANSP runs. Plasma control system (PCS) software written in C can be used in the Python/C server interface to test PCS algorithms. Plans for control-oriented modeling and control algorithm design/implementation were also established during the visit.

Operations:

T. Raines presented a PDR on the TF reversing switch that PPPL Engineering is providing for DIII-D. This switch is the realization of A. Nagy's strategy for making a four-man-hour task one that can be accomplished in less than a minute. Nagy and Raines have partnered with Staubli Inc. to use their patented electrical contact technology in a compact switch design. The switches are rated for 180 kA, with operational needs at 124kA. Diagnostics include thermal, voltage drop, resistance, cycle counter, and water flow. Once commissioned, the experimental paradigm will become more flexible, not requiring additional experimental days to run the same experiment in the TF coil reverse

direction, which tends to be in different wall conditions. The switches will be installed in FY21.

J. Cordell and C. Xu, two of Nagy's summer students, presented their research projects and a poster to the General Atomics engineering group. Cordell's project involved 3D-printing a housing and wheel loaded with 800-micron carbon granules, with a variable dropping speed that can drop single and multiple granules rotating. Xu's project involved advanced powder metering devices using paddle wheel technology. He built four prototypes by printing various versions and tested them using boron and boron nitride powder. Both students expanded the powder dropping team's repertoire of tested technology approached. A third student, A. Misleh, will present his project on a vacuum scale with a one-mg resolution next week.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates)

The TF coil set originally built for the NCSX project has been analyzed for use on a proposed project called SAS (Simons Advanced Stellarator). Engineering modelling and electrical transient simulations with PSCAD software have been performed to evaluate the coil temperature elevation and current ripple. The TF cycle requirement has been established based on the magnetic field requirement of 0.5 T and the flat top duration of 175 ms. This initial configuration assumes the D-site power supplies will be used. A good compromise has been found to reach the physics requirements and minimize project complexity and reduce the cost of powering the TF system. Two Transrex sections connected in series allow a current up to 21 kA at 2 kV DC, in excess of the field requirements of 16.4kA. The ripple current is low due to high inductance of the coil. From an electrical point of view, the TF coil set originally designed for NCSX can be used for the SAS project. Minimal work on the FCPC site is required with this solution. The NSTX-U and SAS experiments can be run in parallel without “hot spare” power supply availability.

An article entitled "Identification of important error fields in stellarators using the Hessian matrix method,” by C. Zhu et al. has been accepted for publication in *Nuclear Fusion*. This paper improves the recently proposed Hessian matrix method to rapidly identify important coil deviations. By relaxing unnecessary coil tolerance, this method will hopefully lead to a substantial reduction in time and cost.

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THEORY (S. HUDSON)

On July 31, I. Dodin gave an invited talk at the 12th Plasma Kinetics Working Meeting in Vienna, Austria: http://www-thphys.physics.ox.ac.uk/research/plasma/wpi/workshop2019.html. The talk, titled, "Cross-scale interactions and the Dimits shift in reduced models of drift-wave turbulence," describes the recent updates on the basic studies of drift-wave turbulence by Dodin's research team, including H. Zhu (Princeton University) and Y. Zhou (PPPL). In particular, the nature of cross-scale interactions is explained within the Hasegawa-Mima model, and a semi-analytic theory of the tertiary instability and the Dimits shift is derived within the Terry-Horton model. A similar talk was scheduled as a PPPL Theory Seminar on Aug. 8.

Three papers were published by members of the Theory Department (I. Dodin, Y. Zhou) and their collaborators from NIFS (K. Yanagihara, S. Kubo) and Sandia National Laboratories (D. Ruiz) on quasioptical modeling of short-wavelength electromagnetic beams in fusion plasmas: https://doi.org/10.1063/1.5095076, https://doi.org/10.1063/1.5095173, and https://doi.org/10.1063/1.5095174]. Unlike other existing quasioptical schemes, the theoretical model and the new code presented in these papers can capture mode conversion, such as the X-O conversion at the plasma periphery caused by the magnetic-field shear.

T. Stoltzfus-Dueck has been given an Early Career Research Program award for a research project titled, "Development and Testing of Reduced Models of the Edge Radial Electric Field." In this five-year project, he will develop simplified analytical models for edge toroidal rotation, including NTV torque and momentum transport by neutrals, as well as self-consistent models for the effects of ion-orbit modulation of turbulent and collisional transport in the edge. The theoretical results will be used to develop and exploit numerical diagnostics to evaluate the physical drivers for edge electric field in XGC1 simulations. Theoretical and numerical results will be compared to edge rotation and neutral measurements from both NSTX/U and DIII-D.

ENGINEERING (V. RICCARDO)

C. Neumeyer's last day at PPPL was Aug. 9 and he delivered the NSTX-U TF bundle stage 2 review successfully. R. Ellis is the interim chief engineer.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted one news story to the PPPL website. It featured research led by N. Ferraro into detecting error fields in tokamaks. The story was also posted to the *Newswise* and *EurekAlert* press release distribution services.

July was a busy month for tours. The Office of Communications hosted 15 tours with a total of 435 visitors from organizations including Princeton University, the U.S. Department of Energy's (DOE) Office of Technology Transitions, the DOE's Financial Risk Policy & Controls Division of the Chief Financial Officer, Rutgers University, Bryn Mawr College, Princeton Educational Services, Tree of Living Water, a STEAM camp, several high schools from South Korea, and the general public. Tour guides included M. Cole, S. DePasquale, O. Nelson, J-H Ahn, S. Greco, M-G Yoo, M. Ono, B. Kraus, D. Cai, A. Brereton, S. Sheckman, D. Battaglia, E. Gilson, and Y-S Park.

DIRECTOR'S OFFICE (S. COWLEY)

S. Cowley attended the Plasma Kinetics Working Meeting at the Wolfgang Pauli Institute, held in Vienna, Austria, August 3-7.

J. Menard and R. Davies participated in an LDRD meeting held at Pacific Northwest National Laboratory, Richland, Washington, August 6-8.

C. Ferguson hosted a visit by Jim Colgary, Chief of Staff to Deputy Secretary of Energy Dan Brouillette, on August 7.

This report is also available on the following web site:

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