Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending July 21, 2018, are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

Center Stack Casing — The center stack casing trial fit was initiated and lowering of the casing over the TF/OH bundle was successfully completed. The support stand was installed without any drag indicated by the load cells, which indicates that there is clearance between the casing and the TF/OH bundle. The alignment fixture performed as expected; the next step is to achieve and document that the TF/OH bundle can be aligned to the casing within the specified tolerance.

Magnets — Sigma-Phi has completed all coil testing and measurements and has an approved packaging method for the coil and is completing the final documentation package for a shipping release. Surplus PF1A and PF1B conductor was shipped to ICAS in Italy for the grit-blast and prime trial runs. The article, "Forensic Analysis of Faulted NSTX-U Inner Poloidal Field Coil," by J. Petrella, et al., was published in the June 2018 volume of the journal *IEEE Transactions on Plasma Science*. In the article, Petrella, *et al.* provide an in-depth post mortem on the PF1AU coil and what led to its failure.

Real-Time Protection and Control (RTP&C) —The Real-Time Protection and Control Group completed design of the Stand-Alone Digitizer 2 (SAD-2) component, and is preparing for the final design review.

Research:

M. Ono visited the QUEST Group at Kyushu University, Japan, under the NSTX-U/QUEST collaboration. He met with K. Hanada, H. Idei and research scientists and students at QUEST, and discussed ongoing collaboration research program including the ECH and CHI startup experiments. He also attended the QUEST 10th anniversary research meeting and gave a presentation entitled, "Roles and Opportunities of the QUEST Program for the Spherical Tokamak Reactor Development." Earlier in the week, he visited the National Institute for Fusion Science, Gifu, Japan, under the US-Japan Collaboration Exchange. He met with Y. Hirooka, N. Tamura, R. Yasuhara, S. Kubo, and the LHD RF group.

M. Podestà and F. Poli visited CCFE (Culham, UK) the week of July 16 to discuss ongoing collaborative activities with MAST-U researchers. Discussions included the use of TRANSP to analyze MAST discharges with neutral beam (NB) ion transport enhanced by low-frequency instabilities. Analysis of MAST scenarios complements work by the NSTX-U Energetic Particles group on Milestone R18-4, "Optimize energetic particle

distribution function for improved plasma performance." F. Poli met with S. Henderson to discuss TRANSP simulations for MAST-U, including possible improvements to streamline access and processing of diagnostics and magnetic equilibrium data to prepare TRANSP inputs.

S. Sabbagh, J. Berkery, Y. Jiang, J.-H. Ahn, and J. Riquezes made presentations on disruption event characterization and forecasting (DECAF) and supporting physics analysis at the sixth annual Theory and Simulation of Disruptions Workshop held at PPPL July 16-18. Results shown included large database analyses from multiple devices (data from four tokamaks shown), disruption event chain analysis in conjunction with the database analysis, and equilibrium, ideal, resistive, and kinetic MHD stability stability, and TRANSP interpretive/predictive analyses of KSTAR plasmas. The results included predict-first analysis of scheduled high-beta experiments planned for the 2018 KSTAR run campaign.

U.S. ITER FABRICATION (H. NEILSON)

The Laboratory's Low-Field-Side Reflectometer (LFSR) design team has produced a detailed load specification report for the system's ex-vessel components. The LFSR ex-vessel systems extend from the port plug vacuum closure plate, penetrate a series of barriers demarcating the safety zones in the ITER tokamak building, and terminate in the diagnostic building, a span of over 20 meters. The load specification documents the types of loads, including thermal (in both bakeout and operating conditions), electromagnetic, gravity, seismic, fire, and radiation loads, that will be experienced by these components. It defines the load combinations, a total of 16 cases in all, that apply to the LFSR system and that are being addressed by the design team. The report, which was prepared under the leadership of PPPL engineer W. Wang, provides the basis for the official ex-vessel load specification that will be issued by the ITER Central Team (CT) once approved. The report was transmitted to the CT diagnostics unit this week; it was subsequently posted and distributed for review.

International PMI (R. Maingi):

R. Maingi (PPPL), Z. Sun (PPPL), J. Canik (ORNL), and K. Tritz (JHU) participated in ELM mitigation and suppression experiments in EAST, using several particle injection techniques, in collaboration with the wall conditioning group led by J.S. Hu (ASIPP). Lithium granules were gravitationally accelerated by the new impurity powder dropper into EAST H-modes and provided short periods of ELM mitigation. Boron powder at trace levels was injected for the first time in EAST H-modes. The lithium and deuterium pellet injectors were also used for ELM control, as was an impurity supersonic molecular

beam injection system. The PPPL-built flowing liquid lithium limiter was received at ASIPP, and is being prepared for plasma exposure in EAST.

ADVANCED PROJECTS (H. NEILSON)

Stellarators (D. Gates):

For the first time on the Wendelstein 7-X stellarator (W7-X), measurements of the radial electric field (Er) have confirmed that ion-root conditions (negative radial electric field over the entire plasma core) have been achieved at high density (ne > 6x10^19m^-3). These measurements, enabled by the U.S. X-ray imaging crystal spectrometer (XICS) diagnostic, confirm basic neoclassical expectations about the Er profile dependence on the density and temperature profiles. The W7-X design included an optimization for reduced neoclassical transport in the the high density ion-root regime; experimental validation that ion-root has been achieved is an important achievement in the understanding of transport on W7-X. These initial measurements represent the beginning of a more detailed study into the validation of neoclassical transport predictions. These results were presented by N. Pablant in a poster and contributed paper titled, “Dependence of the Core Radial Electric Field on Ion and Electron Temperature in W7-X," at the 45th European Physical Society Conference on Plasma Physics, held July 2-6 in Prague.

D. Gates visited the Max Planck Institute for Plasma Physics (IPP) in Greifswald, Germany, to discuss future plans for collaboration and meet with on-site PPPL staff who are collaborating on the W7-X project. Gates presented a summary of recent budget developments to the IPP management and summarized the planned new efforts. He also discussed schedule issues, control and data acquisition issues and plans, plans for the upcoming U.S. pellet injector program, and numerous individual research activities. He also organized a meeting of the on-site U.S. collaborators. The list of invitees included 20 U.S.-supported personnel who are currently onsite for the OP1.2b run campaign which officially started on July 18.

System Studies (C. Kessel):

C. Kessel and H. Neilson met by videoconference with colleagues from S. Korea’s National Fusion Research Institute (NFRI) to report progress on work for the K-DEMO concept study. Kessel reported the development of fiducial plasma equilibria for the plasma ramp-up and on time-dependent, free-boundary plasma simulations using the Tokamak Simulation Code (TSC). The simulations included both ohmic and auxiliary heating and current drive and calculated time-dependent responses including current profile evolution, L-H model transition, and volt-second consumption. It was found that ohmic discharges require volt-seconds beyond the central solenoid (CS) coil's capability,

but that about 10 megawatts of injected power during the ramp-up is sufficient to significantly reduce volt-second consumption. Higher power levels have a much weaker effect. Stress analysis in the central solenoid and poloidal field coils, performed by P. Titus, indicated that the forces in the central solenoid were too high without a more stringent current limit in the coils. The central solenoid coils utilize the conductor jacket for their strength and, unlike the toroidal field coils, do not have a coil case. The coil limits and impact on the plasma current ramp-up are being examined to make recommendations for improvements to the design. PPPL's work is supported through a Strategic Partnership Project (SPP) agreement with NFRI.

COMMUNICATIONS (L. BERNARD)

The Office of Communications posted one press release to the PPPL website. The story focused on PPPL postdoctoral associate I. Krebs, who helped simulate the magnetic flux pumping process. Magnetic flux pumping helps cause sawtooth swings in the temperature and density of plasma. Krebs used the PPPL-developed M3D-C1 code to simulate the process on the high-performance computer cluster at PPPL, working closely with theoretical physicists S. Jardin and N. Ferraro, developers of the code. The story was also posted to the *EurekaAlert!* and *Newswise* press release distribution services.

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