Weekly HIGHLIGHTS

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

The PPPL Highlights for the week ending November 2, 2019, are as follows:

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

Recovery (J. Galayda):

Aerodag Alternative Peer Review — After the 2016 NSTX-U run campaign, it was discovered that the Aerodag coating used to darken areas of the vacuum vessel did not remain intact after exposure to in-vessel conditions. Diagnostic tools used inside the vessel must be aimed at dark targets for the best results. A redesign was presented at a conceptual design review (CDR) held on Aug. 22 that proposed covering relevant areas of the vacuum vessel with blackened, stainless-steel plates covered with Mil-C-13924 Class 3 black oxide treatment. The peer review held this week addressed a chit to survey other facilities that have used this method of blackening and to survey other facilities that have used other methods. The review also examined survey results to determine if there is a satisfactory and economical in-situ solution to use before committing significant time and personnel resources to the proposed design.

Bakeout Modelling — NSTX-U engineers have developed a comprehensive model of torus bakeout to confirm that target temperatures are obtained and clearances are adequate to accommodate thermal expansion of subassemblies with sufficient mechanical clearances.

Purchasing — The request for proposals for manufacture of PFC tiles was submitted for DOE review. PPPL has provided responses to comments received from the PSO.

Staffing — A structured interview process will be applied to candidates for project field engineer positions. Four applicants have been selected for interview.

Research (S. Kaye):

NSTX-U researchers attended the 20th International Spherical Torus Workshop in Frascati, Italy, Oct. 28 to 31. Extended oral talks were given by S. Kaye (PPPL, “NSTX-U Recent Results and Plans”); J. Ruiz Ruiz (Oxford University, “Variation of Gyro Kinetic Simulations in NSTX, Including Comparisons with a Synthetic Diagnostic for High-K Scattering”); N. Bertelli (PPPL, “3D HHFW Full Wave Simulations with Realistic Antenna Geometry and SOL Plasma in NSTX-U”); J. Menard (PPPL, “Configuration Studies for a Low-Aspect-Ratio Liquid Metal Wall Sustained High Power-Density Tokamak Facility”); and M. Ono (PPPL, “Modeling of 2nd Harmonic Electron Cyclotron Heating and Current Drive Solenoid-Free Startup Experiment in QUEST”). An oral talk was given by R. Raman (U. Washington) titled, “Transient CHI Startup of Low-Inductance Plasmas for Advanced

ST Scenarios." Posters were given by S. Kaye (for S. Gerhardt, et al., "Status and Plans for the NSTX-U Recovery Project"); D. Battaglia ("Enhanced Pedestal H-mode Regime on NSTX"), and R. Maingi ("Proposed Liquid Metal PFC Development Program on NSTX-U.")

U.S. ITER FABRICATION (H. NEILSON)

For ITER in-vessel components, a determination must be made about whether they can be considered lifetime components, for which failures requiring remote handling operations to repair are sufficiently improbable that remote handling compatibility is not required. In the Low Field Side Reflectometer (LFSR) in-vessel antenna assembly, the highly loaded plasma-facing antennas and antenna support block have been designed to be installed in or removed from the enclosing shield box using remote handling tools. Those components feature complex networks of internal channels to carry cooling water at high velocity, with welded plugs to seal the channels against water leakage into the vacuum. They are designed to be remote-handling-compatible, since the consequences of failure mandate that there be a credible plan for repair and recovery of these components once activated. The in-vessel waveguide systems that feed the antennas are simpler and lack water cooling channels. They are designed to be sufficiently robust and to make failure sufficiently improbable that they can be classified as lifetime components not required to be remote-handling-compatible. The LFSR remote handling classification scheme was presented at a recent meeting with ITER Central Team colleagues by PPPL design engineer A. Basile.

U.S. ITER Technical Systems Division Director G. Rossano visited PPPL on Oct. 28-29 for discussions with the Laboratory's ITER Diagnostics team. Team members A. Zolfaghari and A. Basile led in-depth discussions on the design choices for the LFSR in-vessel antenna assembly and the status and future plans for manufacturing trials intended to buttress the final design. M. Duco demonstrated and pointed out key details of test articles already manufactured by the Laboratory's Fabrication Group. E. Nassar led a discussion on plans for the coming year, including procurement of both raw materials and the final antenna assembly. While current work in ITER diagnostics is limited to first-plasma deliveries, Rossano and the PPPL team discussed strategies for moving forward with design work on the full scope of U.S. diagnostic and port responsibilities once resumption of that work is authorized.

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ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson)

Research:

The 24th Workshop on MHD Stability Control was Chaired by N. Logan this week. The workshop theme, "Key MHD control issues on the path towards a compact fusion pilot plant," embraced the National Academy of Sciences recommendation that "the United States should start a national program of accompanying research and technology leading to the construction of a compact pilot plant that produces electricity from fusion at the lowest possible capital cost." The program contained 11 invited speakers from magnetic confinement experiments around the world, including two invited speakers from PPPL (D. Boyer and O. Nelson) in addition to the nine contributed PPPL presentations. Participants detailed and deliberated the key challenges that need to be addressed in the prediction, avoidance and control of MHD instabilities in order to meet the goal of a compact fusion pilot plant.

Q. Hu participated in the 24th workshop on MHD stability held at Columbia University in New York City and gave an oral presentation titled, "Numerical modeling the scaling law for error field penetration." Hu introduced recent studies on core EF scaling. The nonlinear simulations find that single fluid simulation from TM1 well reproduced the analytical scaling law from recent analytical theory by R. Fitzpatrick, while two-fluid effect affected the scaling law substantially, which provides a new insight for the database analysis in multiple devices from around the world.

F. Effenberg presented the poster, "Development of impurity seeding for divertor power flux handling in Wendelstein 7-X long-pulse scenarios," at the 19th International Conference on Fusion Reactor Materials (ICFRM-19). The contribution compares and discusses the results of neon and nitrogen seeding experiments for radiative power exhaust during the first limiter and island divertor campaigns. The main finding is that impurity seeding allows achieving stable high radiative divertor regimes with heat and particle flux detachment. This is a promising finding in view of the planned long-pulse (~30 min) and high-performance scenarios currently being prepared with the installation of the high heat flux divertor.

International PMI and FES LM PFC Development Program (R. Maingi):

R. Maurizio from EPFL visited PPPL and presented a seminar titled, "Investigating scrape-off layer transport in alternative divertor geometries on the TCV tokamak." The seminar discussed power exhaust footprint studies in the TCV, including in/out divertor leg power splits, the role of flux expansion, and innovative snowflake divertors. There was

substantial interest from the audience. Discussions on the PPPL international powder dropper programs was conducted, as well as both previous NSTX heat flux scaling studies and future NSTX-U heat exhaust plans.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

R. Lunsford has completed development on a LabVIEW based control system for the newly installed LHD Impurity Powder Dropper (IPD). The control system, adapted from a version previously implemented on DIII-D, has been expanded to better support the LHD long-pulse mission. The control system has the capability of independent injection from any of the four feeders with arbitrary pulse amplitudes and durations. This allows injection of multiple species within a discharge providing additional experimental flexibility within a long pulse. It also effectively increases the powder reservoir available during any single discharge. In addition, the new control system provides a more active local monitoring and feedback of the IPD interlocks as requested by LHD collaborators. The continuous monitoring of the safety interlocks allows rapid response from the IPD in case of unexpected plasma terminating events.

THEORY (S. HUDSON)

A meeting of the SciDAC Center for Tokamak Transient Simulations was held on Oct. 20 in Fort Lauderdale, Florida. There were 16 presentations in the areas of disruption mitigation, NTM, RWM, VDE, physics model improvement, numerical model improvement, and the FY 20 Theory Milestone. A copy of the presentations can be found under the workshops page here: ctts.pppl.gov

The Theory Department attended the 61st APS-DPP Annual Meeting in Fort Lauderdale Oct. 20 to 25. We had 10 invited talks, four talks, and 20 poster presentations.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted one press release to the PPPL website. It focused on the Laboratory's research presented at the 61st annual meeting of the American Physical Society's Division of Plasma Physics in Fort Lauderdale, Florida, Oct. 21 to 25. The Lab sent 155 researchers and students to the conference, which drew more than 1,500 participants from around the world to meet with colleagues and present posters and talks on the range of plasma physics topics — from the latest research on astrophysical and nanotechnology plasmas to recent developments in magnetic and

inertial confinement fusion experiments. The press release was also posted on the *Newswise* and *EurekAlert* distribution services.

DIRECTOR'S OFFICE (S. COWLEY)

J. Menard attended the International Spherical Torus Workshop held in Frascati, Italy, Oct. 28-31.

S. Cowley presented a colloquium at the University of Colorado, Boulder titled, "Bringing Down the Cost of Fusion Power" on Oct. 30. He also visited various campus laboratories and met with students and physicists.

This report is also available on the following web site:

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