Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending March 17, 2018, are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

A successful preliminary design review (PDR) was held on March 13 for the outer poloidal field (PF) coil inspection plan.

For the inner PF coils, the PPPL winding shop has begun winding the PF prototype coil.

For the plasma-facing components (PFCs), the engineering/design team has developed improvements to increase operating margin with a design that employs a low-cost, split-ring shear-pin insert that reduces stresses in graphite (15% reduction in tensile stress), and a modified T-bar provides controlled "flex" to reduce thermomechanical stresses.

Research:

R. Yasuhara (NIFS, Japan) visited PPPL from Feb. 5 to March 16. During this visit, he worked with A. Diallo to design an edge Thomson scattering polychromator that will benefit both NSTX-U and LHD. The design included the optimization of an optical filter set to target low-temperature plasma, as well as the optical layout. Possible collaborations on real-time Thomson scattering for LHD were also discussed with E. Kolemen.

A research team represented by M. Hvasta won first place in Princeton University's 2018 Innovation Forum for the team's patent-pending technology, "Calibrationless Rotating Lorentz-Force Flowmeter." The winning team members M. Hvasta, D. Dudt, A. Fisher, and E. Kolemen competed against eight other Princeton University research groups when delivering a three-minute innovation pitch. This is the second time PPPL participated in the Innovation Forum. Two years ago, C. Gentile won third place for his group's Mo-99 technology.

U.S. ITER FABRICATION (H. NEILSON)

The Low-Field-Side Reflectometer (LFSR) team completed an important step in its review preparations with the completion of a nuclear heating analysis of the ITER equatorial port 11 complete with the in-vessel components. The calculation of heat loads to the in-port LFSR components required the creation of a detailed model that included

not only those components but the port structures, shield material, and neighboring tenants as well. This is an important accomplishment because it informs the thermal and thermal-hydraulics analyses of the in-vessel hardware with the major heating load. PPPL

engineer J. Klabacha performed the analysis using the neutronics code Atilla and a CAD model created by M. Duco.

A subcontract deliverable, "Transmission Line High-Frequency Performance Report," was received from General Atomics of San Diego, CA. The report documents the results of extensive high-frequency (90-170 GHz) microwave testing of a one-channel mockup of the proposed low-field-side reflectometer (LFSR) transmission line system. It describes a microwave test stand that was constructed with waveguide type, total length, and number of miter bends that closely mimic the actual ITER system. The mockup enables quantitative testing of mode purity, power loss, frequency limits, and free-space beam diameter and cross-sectional profiles as a function of distance from the output end. It is also used to test ancillary equipment such as vacuum windows, waveguide switches, radio frequency (RF) filters and a Gaussian telescope, whose intent is to maintain low-loss signal continuity independent of ITER vacuum vessel movement. The report covers leveling and alignment procedures used and measurements of microwave beam characteristics, power loss, and mode content along the transmission line.

A paper by J. Gonzalez-Teodoro, "Progress on the Design Development for Hard Core Components for USDA Diagnostics at ITER," has been accepted for publication in the journal *IEEE Transactions on Plasma Science*. The paper explains that so-called "hard-core components" (HCC) as components which are needed to ensure safety in extreme scenarios. In the case of ITER, the applicable scenarios where HCC are needed to limit the consequences are an extreme earthquake (SL-3) at the tokamak building and multiple fires in the tritium building initiated by an SL-3 earthquake. The paper summarizes ITER's strategy for dividing the facility into zones and where penetrations between zones call for hard-core components. It discusses HCC design options, using the ITER low-field-side interferometer (LFSR) and toroidal interferometer-polarimeter as examples.

ITER & TOKAMAKS (R. Nazikian)

DIII-D (B. Grierson)

Research:

N. Logan presented a talk titled, "Impact and Scaling of Core n=2 Nonaxisymmetric Field Penetration in DIII-D and EAST" at the US-Japan MHD Workshop & 31st ITPA MHD Disruption & Control Topical Group meeting this week in Naka, Japan. The talk presented a new parametric scaling for the n=2 error field tolerances, comparing them to accepted n=1 scalings, and discussing the implications for ITER error field tolerance constraints. The subject was well received and the results will become a significant contribution to the MDC-19 joint experiment on error fields at low plasma rotation. As a

result of the presentation, discussions are ongoing to include new data from machines around the world.

B. Grierson traveled to MIT to present a seminar titled, "Advances in Measuring and Understanding Plasma Rotation." The seminar details the advancements in quantitative spectroscopy that have enabled routine measurements of the main-ion rotation in deuterium tokamak plasmas, and new insights into the generation of intrinsic rotation using global nonlinear gyrokinetic simulations.

Operations:

The neutral beam local control systems (LCS) #5 and #6 wiring diagram creation has been completed. The diagrams completion after revisions to avoid electrical noise interruptions to the control system, as experienced on the LCS 8 commissioning, were implemented. A side benefit is that it downsized the system from two racks to one, with a half rack housing the needed power supplies for both adjacent systems. The wiring will now begin and should be completed in time for the July installation.

A. Nagy reviewed the DIII-D Helicon antenna design and the heating systems at KSTAR this week during his KSTAR visit. The purpose was to share Helicon antenna design experiences. KSTAR has installed and operated a Helicon antenna that ran into arcing problems at 20-30kW, which were discussed in detail, due to multipactor at their vacuum feed-through. The DIII-D Helicon design was reviewed and critiqued by the KSTAR team, resulting in some design questions needing further review. Overall the meeting was very productive for both teams, who reached an agreement to further collaboration in this evolving technology.

The neutral beam local control systems (LCS) #5 and #6 wiring diagrams have been completed. The diagrams were completed after necessary revisions to avoid electrical noise interruptions to the control system, as experienced on the original LCS 8 during commissioning. A benefit of the new wiring is that it downsized the system from two racks to one, with a half rack to house the power supplies. The wiring assembly will now commence and should be completed in time for the installation in July of this year.

ADVANCED PROJECTS (H. NEILSON)

Stellarators (D. Gates):

Progress on the LDRD project, "Future Stellarator Configuration Investigations," was reviewed in a recent meeting attended by participants from the University of Maryland, University of Wisconsin, Auburn University, and Zhejiang University of Hangzhou, China. Progress was reported on the integration of the COILOPT++ coil optimization code into the STELLOPT code (J. Breslau, PPPL), the results of a scan of plasma

elongation (Z. Feng, Zhejiang University), initial scoping of two-period stellarators (P. Porazik, PPPL), and initial use of the REGCOIL code (J. Schmitt, Auburn). A talk on results of the study to date is being prepared for presentation at two upcoming workshops in Asia (D. Gates).

THEORY (A. BHATTACHARJEE):

B. Tang attended a conference in Tokyo, Japan where he presented a well-received invited talks on deep learning research and development. He has been named one of four finalists for the NVIDIA 2018 Global Impact Awards! A link to the announcement is available here:
https://theory.pppl.gov/news/seminars.php?scid=8&n=in-the-media

The two winners will officially be announced at the upcoming national NVIDIA GPU Technology Conference ("GTC-2018") in San Jose, CA, from March 26-29.

Computational Plasma Physics Group (S. Jardin):

E. Feibush presented "Python Programming Techniques" as a mini-course sponsored by the Princeton Institute for Computational Science and Engineering on March 14. Researchers from 15 different university departments attended. The hands-on programming session emphasized the elements and features of Python 3 and how it can be used in a scientific workflow. Tools and techniques for self-paced learning of Python

were demonstrated. PPPL intern E. Yu served as teaching assistant and helped with the programming exercises.

ENVIRONMENT, SAFETY & HEALTH (J. LEVINE)

PPPL received notification from US EPA Region II that it will be receiving two sustainability awards from EPA at a ceremony planned for April 26, 2018 for our participation and performance in the Federal Green Challenge and EPA WasteWise sustainability programs.

SITE PROTECTION (F. WHITE)

Members of ESU conducted training on ropes and rigging as part of technical rescue training requirements. ESU captains and staff facilitated a tour of the firehouse and Engine 66, as well as conducted a demonstration, for a PPPL tour group of students from The Benway School. And, Ambulance 166 responded to three mutual-aid assignments in Plainsboro Township.

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SCIENCE EDUCATION (A. ZWICKER)

The Science on Saturday Lecture series held its last lecture of the year on March 17. The speaker was Michl Binderbauer, "On the Path to Clean Fusion Energy. More than 2,500 people attended the 9 lectures. Special thanks to all of the people from A/V, Communications, Security, Facilities, and Custodial that work to make the lectures one of the Lab's most successful outreach events. The series is coordinated by Deedee Ortiz.

On March 15th, 2018 Daren Stotler, Scott Doskoczynski and Greg Tchilinguirian volunteered at the New Jersey Science Olympiad held at Middlesex County College, supervising and judging the Solar Vehicle event. This new event challenged teams of High School aged youth to design and build a vehicle that could harness the power of the sun to propel wheeled "cars" a set distance. Points were awarded for construction, documentation and performance. The competition was intense, with many entries traveling 5 Meters in a few seconds.

COMMUNICATIONS (L. BERNARD)

The Office of Communications posted three press releases to the PPPL website. One focused on new research by Z. Wang et al. showing that the drifting of particles within fusion plasmas can forestall instabilities that reduce the pressure crucial to high-performance fusion reactions within tokamaks. The other noted that the new Facility for Laboratory Reconnection Experiment (FLARE) has achieved first plasma. FLARE, an experiment headed by H. Ji, is a more powerful version of the Magnetic Reconnection Experiment (MRX) with twice the diameter, and features significantly increased research capabilities. The third focused on a new paper by PPPL physicist V. Duarte about chirping, the production of high-frequency waves that signal the loss of heat in fusion plasmas. Duarte and other scientists have successfully tested a computer model on DIII-D that predicts when chirping will occur, and shows the relationship between chirping and turbulence. These stories were also posted on the *Newswise* and *EurekAlert!* press release distribution service.

DIRECTOR'S OFFICE (R. HAWRYLUK)

D. McComas, R. Hawryluk, M. Zarnstorff, J. Menard, S. Gerhardt, R. Maingi, S. Kaye and S. Sabbagh, traveled to Tysons Corner, Virginia, March 14-16 to participate in Phase 2 of the Department of Energy/Office of Science (DOE/SC) Assessment of the National Spherical Torus Experiment Upgrade (NSTX-U) Facility Recovery Plans.

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

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