Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending January 6, 2018, are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

On Dec. 19, 2017, a core engineering peer review was held to look at several integrated electro-mechanical engineering and plasma performance constraints on final design optimization of the inner PF coils, plasma-facing components (PFCs) and TF/OH bundle re-assembly. A preliminary design review (PDR) was held on Dec. 20 for the interspace pumping system. The system will be used to pump the space between a set of O-rings on the NSTX-U vessel flange. A peer review was held on Dec. 21 to present an evaluation of two methods of turn-to-turn factory acceptance testing that have been evaluated for the NSTX-U inner PF coils. Since a turn-to-turn fault was the failure mode of the original PF1AU coil, turn-to-turn factory acceptance testing is a high-priority and high-visibility task. A preliminary design review (PDR) was held on Jan. 4, 2018, for the plasma facing component (PFC) diagnostics. A final design review (FDR) of the TVPS backing pump is scheduled for Jan. 12, 2018.

Electrical testing was performed on the straight bundle prototype that was fabricated as a test prior to the PPPL PF prototype fabrication. A megger test was performed, and the turn insulation resistivity was approximately 1500 giga-ohms. Additionally, a hi-pot test was performed. Electrical breakdown occurred at approximately 40 kV (outside the bundle at the test leads). Both tests have been deemed satisfactory. In the magnet area, PPPL staff traveled to a vendor in England to participate in a manufacturing readiness review (MRR) in preparation for winding of one of the PF1 prototype coils. Preliminary / non-magnified examination of the sectioned vacuum pressure impregnation (VPI) log test-bundle indicates resin penetrated and saturated the glass/Kapton turn insulation. Preparation of the glass/Kapton co-wound insulation for prototype PF1A coils using the PPPL co-winding machine continues.

Research:

Members of the Univ. of Washington (R. Raman, B.A. Nelson, and J.A. Rogers) and PPPL (M. Ono) Coaxial Helicity Injection (CHI) team traveled to Kyushu University to conduct transient CHI experiments on QUEST from Dec. 4-15, 2017. A primary objective for this run campaign was to observe toroidal current persistence after the CHI injector current was reduced to zero. Based on results from the previous run campaign, it was determined that to achieve this goal, it was necessary to more rapidly reduce the injector current after the CHI plasma was initiated. Modifications used to improve discharge conditions included changing the current limiting resistors, limiting the maximum operating voltage, reducing the gas injection plenum volume, and

reconfiguring the poloidal field coil power supplies. A PPPL fast color camera was used to obtain full coverage of the CHI plasma growth into the vessel. With these several changes, the total amount of injected gas was reduced by a factor two. Initiation of CHI discharges as sufficient low levels of injected gas is quite important, and necessary, as described in a recent NSTX CHI paper (K.C. Hammond, et al., 2018 *Nuclear Fusion* 58 016013). Toroidal currents up to 50 kA were generated and exhibited current persistence after injector current was reduced to zero, and absorber-arc-free discharges were obtained more reliably. Members of the QUEST Team, including a number of students, and members from the University of Hyogo and Tokyo participated in and supported the experiments.

R. Maingi hosted a program committee meeting (Jan. 4-5) for the 2018 International Plasma-Surface Interactions Conference, to be held on the Princeton University campus June 17-22, 2018. Ten committee members from all over the world participated in person, with one remote participant, to discuss the nearly 500 abstracts submitted for consideration. Evaluations on the technical abstracts were conducted, and updates on the conference planning and organization were reviewed.

U.S. ITER FABRICATION (H. NEILSON)

Toroidal Interferometer-Polarimeter (TIP): Spawr Industries, Inc., of Lake Havasu City, Arizona, completed a contract deliverable to develop a molybdenum corner cube reflector as a prototype component for the ITER Toroidal Interferometer/Polarimeter (TIP) diagnostic. To produce this full-scale prototype, Spawr developed an in-house design, built an aluminum prototype, revised the design, and built an optically tuned molybdenum version. They also tested this prototype to demonstrate that it meets optical requirements. In the future, the prototype will be tested to validate its performance under ITER-relevant thermal and mechanical loads.

ADVANCED PROJECTS (H. NEILSON)

In December, H. Neilson participated in a review of the Fusion Engineering Research Project (FERP) at Japan's National Institute for Fusion Science (NIFS). The FERP team carries out an ongoing helical reactor design study based on the heliotron concept, and on the Large Helical Device (LHD) experiment at NIFS in particular. In addition, they serve as a Center of Excellence for fusion technology development, supporting a network of Japanese universities in performing innovative research in topics such as high T_c superconductors, liquid metal and molten salt breeders, liquid metal-based divertor concepts, tritium handling, reduced activation materials, and material joining technologies. The FERP team reported progress and synergies in these two areas.

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Stellarators (D. Gates)

Development of a prototype diagnostic to measure the loss of fast ions in the Wendelstein 7-X (W7-X) stellarator successfully passed a conceptual design review (CDR) in December, achieving a crucial milestone for the project. Engineer N. Allen and physicist S. Lazerson presented the conceptual design of a thin film detector that would measure the loss of fast ions by capturing them in conducting layers after they penetrate the detector. Traditionally such detectors use large gaps between thin conducting films. The design presented utilizes thin-film deposition techniques to place alternating 1000 angstrom layers of aluminum and aluminum oxide, reducing the overall thickness of the detector to less than 10,000 angstroms, thinner than most pieces of paper. This thin detector can then be placed inside a first wall component (in this case a carbon wall tile). The goal of this project is to demonstrate manufacture, assembly, and testing in a linear accelerator of said detector. Once demonstrated, the next step would be to fabricate an array of detectors based on this design and install them in the W7-X machine to measure the loss of fast ions in the 25 to 400 keV range.

THEORY (A. BHATTACHARJEE)

The research news story prepared by C-S. Chang et al. and written by J. Greenwald on ITER heat flux findings was among the five most popular SC national laboratory stories in 2017. Here is the link to the announcement: https://science.energy.gov/news/featured-articles/2018/01-03-18/

A paper by W. W. Lee, S. R. Hudson and C. M. Ma titled, "Gyrokinetic MHD and the Associated Equilibria," appeared in the December issue of *Physics of Plasmas* [Phys. Plasmas **24**, 124508 (2017)], in which they used a set of gyrokinetic MHD equations to describe the formation of magnetic islands in the equilibrium state in the presence of both perpendicular and parallel pressure gradients.

Three papers were published in the special issue of *Physics of Plasmas* devoted to R. C. Davidson: (i) "Excitation of a global plasma mode by an intense electron beam in a DC discharge," [D. Sydorenko, I. D. Kaganovich *et al*. Phys. Plasmas 25, 011606 (2018)]; (ii) "Nonlinear structures and anomalous transport in partially magnetized ***E×B*** plasmas," [S. Janhunen, A. Smolyakov *et al*., Phys. Plasmas **25**, 011608 (2018)]; and (iii) "Current flow instability and nonlinear structures in dissipative two-fluid plasmas," [O. Koshkarov, A. I. Smolyakov *et al*. Phys. Plasmas **25**, 011604 (2018)].

Links to the above articles can be found on the Theory website: http://theory.pppl.gov/news/seminars.php?scid=4&n=publications

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ENGINEERING & INFRASTRUCTURE (V. RICCARDO)

Plant I&C:

The bonding and elevated temperature curing of PF1A-L fiber optic sensors has been completed. Sensor baseline data compilation will be performed the first week in January. Segmented data streaming from PF coil testing instrumentation system to MDSplus, to provide near real-time and trending data with reduced latency, configuration and testing in progress.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

COMMUNICATIONS (L. BERNARD)

The Office of Communications posted two press releases to the PPPL website. The first focused on the start of the 2018 Ronald E. Hatcher Science on Saturday Lecture Series, which has taken place at the Lab for more than 30 years. The nine-week program is named for the beloved engineer Ronald Hatcher. The second details how PPPL physicists C. Swanson and I. Kaganovich have found a way to prevent plasma from causing short circuits in machines such as spacecraft thrusters, radar amplifiers, and particle accelerators. They learned that applying fractal-shaped, feather-like structures to the surfaces inside these machines keeps them operating at peak performance. Both stories were posted on the *Newswise* and *EurekAlert!* press release distribution services.

This report is also available on the following web site:

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