Weekly HIGHLIGHTS

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

The PPPL Highlights for the week ending February 9, 2019 are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

Magnets — The inner poloidal field (PF) procurement schedule has been reviewed and revised, with document links adjusted for the final baseline. The pre-bid meeting was held with potential subcontractors for the PF production coil procurement, the G11 coil spacer RFP is out, and the mandrel wedge procurement has been placed. The grit blasting and priming of all five PF1c and PF1a conductors is complete, and the remaining three PF1b spare conductors will begin fabrication next week at ICAS Tratos. The co-winding procedure in the coil shop is in its final round of reviews, and the clean room is being prepared to begin co-winding the insulation and Kapton tape.

Research:

Collaborations — After attending the last workshop on QUEST at Kyushu University, Fukuoka, Japan, and related spherical tokamak radio-frequency startup and sustainment plasma research, N. Bertelli spent three additional days at Kyushu University to work with H. Idei (Kyushu University), A. Fukuyama (Kyoto University), and some QUEST students. A benchmark was performed between the ray-tracing code GENRAY and the TASK code. The GENRAY code was installed and built on a QUEST computer in order to continue the collaboration. Bertelli also gave a presentation on HHFW full-wave simulations in NSTX-U to the QUEST team during the visit.

Publications — The paper, "Compact Steady-State Tokamak Performance Dependence on Magnet and Core Physics Limits," by J. Menard has been published in the journal *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences:* http://doi.org/10.1098/rsta.2017.0440. In this paper, the performance of the tokamak fusion system is assessed using a range of core physics and toroidal field magnet performance constraints to better understand which parameters most strongly influence the achievable fusion performance. This article is part of a discussion meeting issue, "Fusion energy using tokamaks: can development be accelerated?"

U.S. ITER FABRICATION (H. NEILSON)

The Low Field Side Reflectometer (LFSR) team is moving forward with plans for manufacturing tests aimed at improving the manufacturability of the in-vessel equipment design and developing key processes. Specifications for a test article that encompasses key manufacturing challenges are being developed. A critical design

parameter is the aiming accuracy of the antennas that launch the probing microwaves into the plasma and receive the reflected wave. Scans of antenna aiming angle are performed by the physics team to assess the impact of aiming errors on coupling and overall performance. Because the LFSR antenna assembly will be installed in a diagnostic shield module, which is itself installed in an equatorial port plug support structure, there is a stack-up of tolerances that determine the angular aiming accuracy of the antennas, which is being evaluated by the engineering team. The results of this joint physics-engineering study, led by LFSR team leader A. Zolfaghari, will provide a basis for setting manufacturing tolerances on the in-vessel assembly.

In a meeting with Procurement and Quality Assurance leads at the U.S. ITER Project Office at Oak Ridge National Laboratory, H. Neilson presented the LFSR team's strategy for launching its manufacturing test activity, leading eventually to manufacture of the LFSR in-vessel equipment. The discussions resulted in valuable feedback regarding procurement requirements, supplier qualification, and contracting strategy. Other meetings during the one-day visit addressed ITER configuration management issues affecting LFSR, as well as staffing, budget, and schedules.

DIII-D (B. Grierson):

Research:

A paper by R. Lunsford titled, "Supplemental ELM control in ITER through beryllium granule injection," has been accepted for publication in the *Journal of Nuclear Materials and Energy*. The paper utilizes a spherically symmetric vapor shielding model of granule ablation, benchmarked with data from impurity granule injections on DIII-D to simulate the injection of beryllium granules into ITER baseline discharges. By comparing the granule-induced ELM triggering size required for deuterium and non-fuel pellets on DIII-D and cross-correlating with a previously simulated JOREK calculation of D pellet size required for ELM triggering in ITER, it is estimated that a beryllium pellet of 1.5mm diameter delivered at 200 m/s should penetrate 3.5 cm past the separatrix. This location within the H-mode steep gradient region has been found to be advantageous for ELM triggering with minimal pellet size.

F. Laggner visited the PSFC at MIT from Feb. 4 to 8 to support the test assembly and alignment of the Ly-alpha diagnostic, which is being developed in collaboration with MIT for installation and use at DIII-D. Laggner worked with J. Hughes (MIT), A. Rosenthal (MIT), M. Reinke (ORNL) onsite at MIT, and A. Bortolon (PPPL) and T. Wilks (MIT) participating remotely from DIII-D. The diagnostic timeline towards the in-vessel installation was outlined and action items were identified for timely installation.

Proposals for use of the diagnostic for the upcoming DIII-D research opportunities forum (ROF) are being developed.

S. Haskey, B. Grierson, and General Atomics colleagues C.S. Collins and C. Chrystal finalized the assembly and in-vessel focusing of an upgraded fiber clamp that includes three tiers of fibers for VB, impurity CER, and main-ion CER. The clamp is part of an upgrade to the DIII-D CER system that includes an additional impurity and main-ion CER chords on the high-field side of the magnetic axis. These new chords will provide details of temperature and density asymmetries as well as main ion poloidal rotation by using the difference in the toroidal rotation measurements from a low- and high-field side CER chord that is on the same flux surface. This upgrade is expected to be in operation for the upcoming FY19 DIII-D run campaign.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

A prototype real-time multi-pulse Thomson scattering system developed at PPPL by Experimental Control researchers and the Instrumentation and Control engineering group has been shipped to collaborators at the National Institute for Fusion Sciences in Japan to be put to use on their Large Helical Device (LHD). This system, originally devised in a collaboration between Princeton University and PPPL's NSTX-U team under a grant from the DOE, can provide up to 10 spacial channels of data, in real time, for a 30-minute pulse. This new measurement capability, provided by PPPL, will be now integrated in the Thomson scattering diagnostic at LHD.

On Feb. 6, D. Gates participated as an examiner on the general exam committee for Mechanical and Aerospace Engineering student D. Dudt. Dudt presented an outline of his thesis research entitled, “Definition of Stellarator Equilibrium with Minimal Unknowns and its use for Numerical Applications.” Daniel’s advisor is E. Kolemen.

THEORY (S. HUDSON)

J. Dominski attended the JET Task Force Meeting at Culham Laboratory in Abingdon, United Kingdom. At the meeting, Dominski presented a seminar titled, “Neoclassical impurity transport in JET modelled with XGC.”

A paper by Y. Zhou has been published in *Physics of Plasmas*: http://aip.scitation.org/doi/10.1063/1.5068778

J. TenBarge had an online publication of the CollShocks paper: http://dx.doi.org/10.1017/S0022377819000023 or https://www.cambridge.org/core/journals/journal-of-plasma-physics/article/effect-of-

a-weak-ion-collisionality-on-the-dynamics-of-kinetic-electrostatic-shocks/03D4C71ECDEE12B8E1FD511723952476

H. Qin has a paper titled, "A necessary and sufficient condition for the stability of linear Hamiltonian systems with periodic coefficients" published on Feb. 6 in the *Journal of Mathematical Physics:* https://aip.scitation.org/doi/10.1063/1.5067391. The last time a PPPL author published in this journal was 37 years ago.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted one press release to the PPPL website. It focused on research performed on the Magnetorotational Instability Experiment using a spring-tethered ball that seemed to provide evidence for the existence of the magnetorotational instability. The press release was also posted to the *EurekAlert* and *Newswise* distribution services.

DIRECTOR'S OFFICE (S. COWLEY)

On Feb. 7, C. Ferguson attended a DOE S&T policy workshop at DOE headquarters in Washington, D.C.

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