



The PPPL Highlights for the week ending October 5, 2019 are as follows:

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

Recovery (J. Galayda):

ESAAB Approval — The recovery project was given approval on Sept. 30 by the Energy Systems Acquisition Advisory Board (ESAAB) to begin reconstruction. ESAAB approved plans for the project to construct integral NSTX-U components that total \$31 million in addition to approving the project baseline. Baseline costs, including contingency, total \$199.4 million. The recovery project has an early finish date of May 2021.

NSTX-U Test Cell — Installation of the new test cell personnel doors was completed this week, and a subcontract was issued for construction of the test cell labyrinth wall.

Critical Procurements — The laboratory procurement group began issuing fabrication blanket ordering agreements needed to support the NSTX-U recovery project.

Fall Protection Anchor FDR — A successful final design review (FDR) was held Oct. 3 for a fall protection anchor design. The fall anchor design was reviewed for its adherence to OSHA fall protection standards and showed its progression since an initial peer review held in July. The conceptual design review (CDR) and preliminary design review (PDR) requirements were waived for this review.

Inner TF Bundle Twist Laser Measurement CDR — A successful CDR was held on Oct. 4 to review the design for a laser twist measurement of the toroidal field (TF) inner bundle. The TF inner bundle will twist during operation under imposed EM loads. This external measurement system would use a laser reflector system to assess the twist at the top of the machine.

Research (S. Kaye):

A number of researchers from NSTX-U/PPPL participated in the 6th International Symposium on Liquid Metals applications for Fusion (ISLA-6) at the University of Illinois at Urbana-Champaign, Sept. 30-Oct. 3: <http://conferences.illinois.edu/isla2019/> J. Menard give an invited talk entitled, "Configuration Studies for a Next-Step Liquid-Metal-Wall Toroidal Confinement Facility," which is a high-heat-flux liquid lithium facility designed to support the compact fusion reactor/pilot plant. R. Goldston gave a remote presentation titled, "An initiative to develop a liquid lithium divertor," that described a liquid lithium R&D initiative presented at the recent US community planning workshop to support the compact fusion reactor/pilot plant. E. Emdee (Princeton University) gave a talk titled, "Predictions for a simplified lithium vapor box using SOLPS-ITER," which

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described an initial modeling of the lithium vapor box. M. Ono gave a talk titled, “Rapid lithium delivery system to mitigate possible damages to vacuum vessel internal components during transient events in fusion power plant,” that described an active radiative liquid lithium divertor concept which is aimed to prevent the divertor heat flux from damaging the divertor PFCs. J. Schwarz (Princeton University) gave a poster presentation entitled, “Experimental development of the lithium vapor box divertor concept,” that reported on the status of the Lithium Vapor Box Similarity Experiment.

S. Gerhardt, Recovery Project Deputy Director and Research Operations Head, was named a Fellow of the American Physical Society this week. Gerhardt began his long association with PPPL as a summer intern almost 25 years ago.

U.S. ITER FABRICATION (H. NEILSON)

The design of the instrumentation and control (I&C) scope for the ITER Upper Wide Angle Viewing (UWAV) system has advanced to near preliminary design maturity in the past two years. The UWAV system will provide real-time, infrared, and visible images of the ITER divertor region. The I&C design scope encompasses data acquisition hardware and image analysis software, as well as the construction of a prototype to demonstrate the feasibility of the hardware-software approach and to evaluate performance. The work, which was performed by Bertin Technologies under contract to PPPL and managed by PPPL’s F. Hoffman, is documented in 23 reports that have been archived for information in the U.S. ITER and Central Team document management systems. A peer review of the work was held in July at the ITER site and chaired by A. Winter of Germany’s Max Planck Institute for Plasma Physics. The panel report, issued in late September, found that the work “showed a state of maturity well beyond the level of expectation. The prototype implementation showed that even with current technology, the requirements could almost be met and advances in computing power make it seem feasible that requirements can be fully met with hardware available in a few years.” The Bertin contract was closed in Sept. with all deliverables completed. Work on this scope is now suspended and will resume at a later date.

An abstract by W. Wang, et al., titled, “Dynamic Design Considerations of In-Vessel Diagnostic Components Integrated in a Modular Diagnostic Shielding Module of an ITER Equatorial Port Plug,” was submitted for the 2020 ANS Technology of Fusion Energy Conference, to be held April 20-23, 2020, in Charleston, South Carolina. The work supports the final design of the Low Field Side Reflectometer (LFSR) in- port components, which are designed to withstand a number of dynamic loading events, including plasma disruptions and earthquakes. The paper will describe analyses of modal behavior performed to identify the natural frequencies and mode shapes of

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antenna arrays and waveguide assemblies anchored to their support structures. In order to avoid excessive oscillations and associated damage, the desired eigenfrequencies of LFSR components must remain outside the natural frequency range of the deformable enclosing structures in the port plug assembly.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson):

Research:

F. Effenberg give a talk at the 22nd International Heliotron & Stellarator Workshop (ISHW) in Madison, Wisconsin, titled, “Radiative Power Exhaust in the Island Divertor and Access to Controlled Detachment with Impurity Seeding.” Local seeding of neon and nitrogen in the W7-X island divertor has been shown to enable global detachment of heat and particle fluxes in preparation for high-performance scenarios and future divertor upgrades based on high-Z materials. In current scenarios, neon features a higher radiation efficiency and stronger recycling accompanied by a loss in neutral compression while nitrogen indicates a lower recycling, better neutral compression, and better fine control of the radiative power exhaust. The major experimental findings agree well with EMC3-EIRENE modeling and motivate further studies to explore and optimize these radiative divertor regimes concerning different impurity species and island divertor geometries.

R. Shousha (Princeton University), a graduate student supervised by E. Kolemen, visited DIII-D for the last two weeks of September to implement and test an improved real-time equilibrium reconstruction code within the DIII-D plasma control system. These efforts were supported by a group of PPPL collaborators including K. Erickson, F. Laggner, Z. Xing, and E. Kolemen. These improved capabilities have been made possible by the use of real-time Thomson scattering and CER diagnostics that have been under development for the last few years, along with recently developed real-time profile fitting analysis. The upgraded real-time equilibrium reconstruction code now utilizes the new profile-fitting algorithm that combines data from multiple real-time diagnostics to generate a pressure constraint. The initial tests were successful, and pressure constrained equilibria were generated in real-time during multiple plasma discharges. These new capabilities will provide more accurate equilibria to advanced control algorithms, e.g. real-time stability calculations used for disruption avoidance.

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Operations:

A new chain clamp, which connects the DIII-D Co/Counter Off-Axis Neutral Beam adapter duct to the vessel, was fabricated at PPPL and shipped from PPPL to General Atomics this week. This clamp compresses a thin aluminum ring, about 30 inches in diameter, to form the primary vacuum seal for the neutral beam line. To move the neutral beam, this chain clamp needs to be removed and replaced. The initial chain clamp failed upon initial installation last April and was repaired by PPPL's machine shop. The new chain clamp, which features improved strength, will be received and meet the schedule needs next week.

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

R. Maingi presented an invited talk at the 6th International Symposium on Liquid Metal Applications in Fusion Devices (ISLA) at the University of Illinois at Urbana-Champaign (UIUC): "ELM suppression by boron powder injection and comparison with lithium powder injection on EAST." ELM suppression has been robustly achieved in EAST using boron powder injection; a new low-frequency edge mode with multiple harmonics accompanies ELM suppression and powder injection in these cases.

E. Kolemen presented an invited talk at the 6th International Symposium on Liquid Metal Applications in Fusion Devices (ISLA) at the UIUC in Champaign, Illinois: "Stability and control of fast flowing liquid metal divertor." This talk presented experimental results and theoretical comparisons from the Liquid Metal Experiment at PPPL. In addition, A. Khodak gave an oral presentation titled, "Free surface liquid lithium flow modeling and stability analysis for future applications," and A. Fisher presented a poster titled, "Experimental demonstration of Lorentz force propulsion on free-surface liquid metal channel flow."

THEORY (S. HUDSON)

C. Dong was awarded a NASA proposal titled, "Mercury's dynamic magnetosphere under varying external conditions," on Sept. 27 to study collisionless magnetic reconnection in Mercury's dynamic magnetosphere. This is his fourth proposal awarded by NASA since last year; the total budget for the four proposals is about \$2 million.

A paper titled, "Global Ten-Moment Multifluid Simulations of the Solar Wind Interaction with Mercury: From the Planetary Conducting Core to the Dynamic Magnetosphere," by C. Dong, L. Wang, A. Hakim, et al. was accepted for publication in *Geophysical Research Letters*: <https://arxiv.org/abs/1904.02695>



A. Reiman presented a poster titled, “Singular Currents at Rational Surfaces and Magnetic Island Separatrices,” at the 22nd International Stellarator and Heliotron Workshop in Madison, Wisconsin.

On Sept. 27, F. Ebrahimi submitted an initiative to the APS-DPP Community Planning Process entitled, “Importance of theory, computation and predictive modeling in the US magnetic fusion energy strategic plan.” This initiative is based on an original community-led whitepaper submitted to the National Academy of Sciences on theory and computation strategic elements. Per request from members of the theory-computational cross-cutting group, the whitepaper was revised and submitted. This initiative aims to stress the key role of a range of complementary tools from analytical theory to high-performance computing using a multi-fidelity hierarchy of physics models, which could help close the identified gaps in furtherance of fusion energy. Read more here:

<https://drive.google.com/file/d/1I7ZqDd07HL4EUrfIOR6d5MSdPm0Uu2LA/view>

On Sept. 24, the paper titled, “Nonaxisymmetric simulations of the Princeton magnetorotational instability experiment with insulating and conducting axial boundaries,” by D. Choi, F. Ebrahimi, K. Caspary, E. Gilson, J. Goodman, and H. Ji, was published in *Physics Review E*:

<https://journals.aps.org/pre/pdf/10.1103/PhysRevE.100.033116>

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted one press release to the PPPL website this week. It focused on S. Gerhardt being named a 2019 American Physical Society Fellow. Gerhardt heads research operations and serves as deputy director of the recovery project for NSTX-U. The APS annually recognizes as fellows no more than one-half of one percent of its more than 55,000 worldwide members. The story was also posted to the Newswise press release distribution service.

DIRECTOR’S OFFICE (S. COWLEY)

The week of Sept. 30, J. Menard participated in the International Symposium on Liquid Metals Applications for Fusion (ISLA-2019) held at the University of Illinois at Urbana-Champaign and the InnovationXLab Artificial Intelligence Summit in Chicago.

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