



The PPPL Highlights for the weeks ending November 24 and December 1, 2018 are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

Magnets — The source selection plan for the inner poloidal field (PF) coil is under revision to include procurement concerns, and the vendor oversight plan is being written. The drawings and specifications were signed off and submitted to procurement, along with a G11 coil spacer requisition. Magnet team members are still on site in Italy at ICAS Tratos. Line was prepared in Italy at the vendor, and processing for the first conductor is scheduled for Dec. 5. A final wash station was added to better remove leftover grit after sandblasting, which has greatly improved conductor performance. The corona testing report on the ETI prototype coil section is complete, as well as the report for the PPPL prototype strain test. The report on the water fitting test samples is nearing completion. The glass tape underwent compression testing last week. The coil delta final design review (FDR) has been moved to the first week of Jan. so that magnet team members can help with preparations for the center stack casing FDR, which is a PEMP notable.

Central Instruments & Controls — Installation of the course wave division multiplexing (CWDM) equipment in the NSTX-U test cell and diagnostic room (DARM) was completed. Long-term network tests have begun and will continue until the spring of 2019.

Metrology — The metrology mount final design review (FDR) was held on Nov. 26. The FDR was held in order to review locations of the permanent monuments and provide assurance that new products used for welding monuments onto the ex-vessel are NSTX-U compatible. The FDR was deemed successful. There were no chits generated at previous reviews, and no additional chits were generated during the Nov. 26 review.

Research:

Collaborations — O. Asunta of the UK's Tokamak Energy visited PPPL Nov. 12-15 to discuss startup and plasma control of ST40, a potential 3T spherical tokamak built and operated by Tokamak Energy. Asunta also discussed possible areas of collaboration in boundary and core science with NSTX-U researchers. Discussions with Tokamak Energy about these collaboration possibilities will continue.

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A collaborative discussion between NSTX-U staff and HL-2A staff occurred involving a shared interest in the use of powder droppers for wall conditioning, divertor dissipation, pedestal modification, and high-Z (tungsten) injection and impurity transport. PPPL is refurbishing an original powder dropper for use in this collaboration. The participants included R. Maingi, D. Mansfield, Y. Ren, Z. Sun (PPPL) and M. Xu, Y. Feng, Z. Huang, and L. Yan (HL-2A).

S. Kaye participated in two videoconference meetings with CCFE on Nov. 28 as a member of the CCFE program advisory committee. One of the meetings was on a preliminary review of the MAST-U Enhancement Project and the other was an interim meeting of the CCFE PAC.

Conferences — M. Ono attended the National Institute for Fusion Science Research Meeting on “Theories and Applications of Divertor” on Nov. 30 in Gifu, Japan. He gave an invited talk entitled, “NSTX-U/PPPL Liquid-Lithium PFC/Divertor Research Activities and Plans.”

Publications — N. Lopez and A. Ram’s paper titled, “Mode-conversion of the Extraordinary Wave at the Upper Hybrid Resonance in the Presence of Small-Amplitude Density Fluctuations” was published in the journal *Plasma Physics and Controlled Fusion* (<http://iopscience.iop.org/article/10.1088/1361-6587/aae95e/meta>). In NSTX-U plasmas, heating and current drive in the core by waves in the electron cyclotron range of frequencies is possible if power is coupled to the electron Bernstein waves (EBW). Since EBWs do not propagate in a vacuum, power must be coupled to EBWs via mode conversion of the ordinary or extraordinary waves at the upper hybrid resonance. This paper puts forth a new model for the mode conversion of the extraordinary wave to EBWs that has several advantages.

U.S. ITER FABRICATION (H. NEILSON)

A closeout briefing for the Low Field Side Reflectometer (LFSR) Preliminary Design Review was conducted on Nov. 29. In summarizing the conclusions of the review, which opened with a meeting at the ITER site on Nov. 7-8, panel chair M. Graham (ITER Organization Central Team) noted “the high technical level of the team who demonstrated their sound technical knowledge and coherency throughout the design review.” At the same time, Graham highlighted concerns needing the design team’s continued attention, including the impact of vacuum windows on system performance, the potential for encroachments on the system’s space claims, and completion of the design documentation package. A total of 29 chits was issued of which three were in Category 1, identifying issues that must be closed as a condition of approval to proceed to the next phase of the LFSR project, final design. There were 21 Category 2 chits,



which will have to be closed at future final design reviews, and 5 Category 3 chits, which do not require formal tracking and closure.

ITER & TOKAMAKS (R. NAZIKIAN)

R. Nazikian visited KSTAR in Daejeon, Korea, to collaborate on energetic particle and RMP physics and to coordinate PPPL involvement in optimizing high-beta poloidal scenarios in KSTAR during the remainder of the KSTAR 2018 campaign.

DIII-D Research (B. Grierson):

The article, “Fast and pervasive heat transport induced by multiple core-to-edge locked modes in DIII-D” by Q. Hu has been published online: <https://doi.org/10.1088/1741-4326/aaeb57> This paper shows the impact of multiple edge magnetic islands on heat transport during the thermal quench using the nonlinear two-fluid MHD simulation code TM1.

DIII-D Operations (A. Nagy):

The calorimeter for the 150 degree tiltable off-axis neutral beam has been delivered to General Atomics. This is the second set of calorimeter plates of this design delivered to replace leaking calorimeters at DIII-D. The calorimeter will be subject to quality control review and stored. This calorimeter will not be installed during this long torus opening (LTO) but retained until the next opportunity for installation.

International PMI (R. Maingi):

Four members from the PPPL powder dropper team — A. Bortolon, A. Diallo, E. Gilson, and R. Maingi — traveled to KSTAR for collaborative experiments on the effects of impurity injection on long pulse H-mode discharges. The KSTAR technical team led by S.-H. Park was extremely effective in providing the necessary on-site guidance and support. The impurity powder dropper final preparation was completed; the impurity powders were baked and loaded; and planning for experiments next week was finalized.

R. Lunsford traveled to ASDEX-Upgrade for continuing analysis on previous experiments, and to participate in wall-conditioning experiments with the impurity powder dropper there. Boron powder was prepped and re-loaded, and new control wiring was checked and modified as needed. Experiments with the dropper will likely be carried out next week.

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KSTAR 3D and Stability:

Z. Wang and E. Kolemen visited KSTAR this week to explore real-time MHD spectroscopy and multimodal response in high-performance KSTAR plasmas. 3D MHD spectroscopy is performed by scanning the rotating frequency and spatial spectrum of the applied $n=1$ field to experimentally extract the multi-mode transfer function based on magnetic sensor measurements. A more efficient 3D spectroscopy analysis has been implemented for these experiments that should allow the transfer function to be determined in about 100 ms. Preliminary results show low noise and good signal response. Data analysis will seek to verify the feasibility of MHD spectroscopy for real-time control.

R. Nazikian led an experiment on KSTAR exploring $n=1$ RMP ELM control in high beta plasmas. He worked with Y. M. Jeon who was the physics operator for the experiment. The aim was to get to $\beta_n > 3$ and $\beta_p > 2$ to enter the wide pedestal grassy ELM regime encountered on DIII-D. While β_p reached the target, β_n remained around 2. Nonetheless, long-pulse ELM suppression (up to around 10 s) was achieved with the full toroidal rotation of the $n=1$. Good ECE-Imaging data was obtained for further analysis.

KSTAR Control:

Progress continues on the KSTAR coil monitoring system, which will demonstrate the real-time calculation of machine-critical parameters such as superconducting magnet coil forces and peak fields. This will enable monitoring and eventually active avoidance of machine limits while optimizing plasma shape control. D. Boyer defined detailed algorithm requirements for a prototype real-time coil force and field monitoring calculation for KSTAR and derived coefficients needed for the calculations. K. Erickson developed the real-time Plasma Control System code based on these requirements. The next step is to assess and optimize calculation execution times and to compare with more detailed offline models developed by NFRI.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

On Nov. 21, D. Gates presented an invited talk entitled, "The Tokamak Density Limit: a Thermoresistive Disruption Mechanism," at the combined 27th International Toki Conference and the 13th Asia Pacific Theory Conference in Toki, Japan. The talk summarized work done by Gates and a team of scientists on a new theory of the tokamak density limit that was first proposed in a paper by Gates and Delgado-Aparicio in 2012. The theory has progressed to the point of quantitatively predicting the density limit (often called the Greenwald limit) using a simple model of island evolution that

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incorporates an appropriate model of the non-linear evolution of the resistivity in an island. Recent work has reproduced the basic behavior of the model using the 3D resistive MHD code M3D-C1. The talk was attended by more than 100 scientists, mostly from the Asia Pacific area. Gates also met briefly with scientists from the Large Helical Device to discuss ongoing collaborative activities.

THEORY (S. HUDSON)

Y. Raitses and I. Kaganovich presented talks at the recent APS-DPP conference in Portland, Oregon. Raitses gave a talk titled, "Interaction of boron- and nitrogen-rich plasmas with tungsten wall." Kaganovich delivered a talk titled, "Validated modeling of plasma boundary physics coupled to surface response for atmospheric arcs." Both talks explored the synergy between divertor and arc physics to advance PMI issues for divertors.

A. Reiman gave a talk entitled, "RF Current Condensation and Suppression of Magnetic Islands" on Nov. 13 at the 2018 US-Japan Workshop on MHD Stability Control at UCLA.

S. Jardin attended the annual meeting of the Integrated Modeling Expert Group (IMEG) at ITER headquarters in France. Among items requested from the U.S. were (1) that NUBEAM be made into a component that can be used in a IMAS workflow, (2) that TRANSP ITER simulations be added to the ITER database by way of translators, (3) adaptation of the new pellet ablation module (PAM) into IMAS, (4) adaptation of OMFIT modules (in particular the Kinetic Equilibrium Reconstruction and STEP) into IMAS, and (5) demonstration of the use of IMAS in a code benchmarking exercise using 3D extended MHD codes to simulate SPI mitigation experiments on DIII-D and JET.

On Nov. 19, a proposal by C. Dong was selected for funding by NASA. The proposal was titled, "A model database of unmagnetized planetary space environment with an interactive user interface." This proposal was funded by NASA with an intrinsic merit score of "excellent." This is Dong's third successful proposal as principal investigator funded by NASA in the past year with a total budget of more than \$1.4 million.

Computational Plasma Physics Group (S. Jardin):

E. Feibush presented two minicourse seminars at the Princeton Institute for Computational Science and Engineering. "Python Programming Techniques" described the elements of the python language. Attendees from Princeton University wrote example programs and were shown how to continue learning on their own. In "Scientific Visualization with VisIt," he presented visualization techniques, examples, and instruction on how to run the VisIt program. Attendees worked on visualization



exercises to reinforce the presentation. PPPL student interns E. Liu and E. Chai served as teaching assistants for both minicourses.

PLASMA SCIENCE & TECHNOLOGY (P. EFTHIMION)

Y. Raitses gave an invited talk at the 71st Annual Gaseous Electronics Conference (GEC) the week of Nov. 5 in Portland, Oregon. The talk was titled, "Towards understanding of plasma-based synthesis of carbon nanomaterials." S. Yatom gave an invited talk at the GEC's diagnostics workshop titled, "In Situ Approaches for Diagnostics of Nanoparticles in Plasmas." And former visiting student L. Xu gave invited talk at a Joint DPP/GEC session on low-temperature plasmas titled, "Three regimes of high-voltage breakdown in a high-current plasma switch for modern electric grid." The talk reported results of work that was part of a collaboration of PPPL with General Electric.

ENGINEERING (V. RICCARDO)

Last week we welcomed new senior machinist J. Diamond and instrument and controls technician A. Fretz. We say farewell to two amazing employees who are retiring: N. Greenough and I. Zatz.

INFORMATION TECHNOLOGY (M. COHEN)

P. Bisbal attended The International Conference for High Performance Computing, Networking, Storage, and Analysis (SC18) where he presented a paper entitled, "Teaching Computational Scientists How to Build and Package Open-Source Software." The paper will be published in a special SC18 edition of the Journal of Computational Science Education (JOCSE).

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted one press release to the PPPL website, on outreach efforts by PPPL Science Education staff at the APS-DPP conference in Portland, Oregon. The story was also posted to the *Newswise* and *EurekaAlert* press release distribution services.

For the three-month period September through November 2018, the Office of Communications coordinated 14 tours with a total of 601 visitors. PPPL tour guides included A. Zwicker, W. Guttenfelder, A. Dominguez, J.-K. Park, J. Ahn, J. Yoo, S. DePasquale, M.-G. Yoo, J. Guttenfelder, D. Kim, N. Allen, A. Brereton, and C. Smiet. Tour groups ranged from South Korea's Busan and Seoul Science High Schools to the more



local Monroe Township High School and Middlesex County College, as well as the PSE&G Safety Council and local student robotics groups.

DIRECTOR'S OFFICE (S. COWLEY)

R. Hawryluk participated in a review of the UK Fusion program last week. He also visited Tokamak Energy.

This report is also available on the following web site:

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