



**The PPPL Highlights for the week ending February 23, 2019 are as follows:**

### **NSTX-U RECOVERY AND RESEARCH (J. MENARD)**

#### *Recovery:*

Preparations continued for the upcoming Basis of Estimate Review (BOER) to be held March 18-20 at PPPL. The risk registry was finalized in preparation for the BOER, revised cost and schedule contingency estimates were developed in support of the integrated project plan, and project milestones have been updated.

#### *Maintenance and Run Preparation:*

A successful dummy load test on High Harmonic Fast Wave (HHFW) Systems 5 and 6 was completed on February 21. Systems 5 and 6 were tested at 500 kW for 500 ms individually and as a pair. Repairs and tests were made on a number of the system components in the previous weeks. In order to restore the systems to an operating state, ignitrons in the crowbar were conditioned and tested, filaments were heated, water run through the systems, and breakers were exercised and tested. Dummy load testing is an important operational activity supporting timely re-commissioning of the NSTX-U facility.

#### *Research:*

Collaborations - Stan Kaye visited Tokamak Energy, UK on Monday, February 18 to discuss collaborative activities between U.S. and Tokamak Energy researchers on the ST40 spherical tokamak that Tokamak Energy is developing. On February 19 and 20, he participated in a subgroup of the Culham Centre for Fusion Energy (CCFE) Program Advisory Committee to review the MAST-U Enhancements projects.

### **U.S. ITER FABRICATION (H. NEILSON)**

The Low Field Side Reflectometer (LFSR) team continues to develop the design details of its In-Vessel Assembly, a system of antennas, waveguides, and support structures that will be installed in Equatorial Port 11 prior to first plasma. The team completed a first iteration of design refinements to the LFSR antenna block assembly attachments, enabling the start of preliminary stress analysis and initiation of file sharing with ITER-appointed Remote Handling consultants. In addition, preparation of mockups and test articles progressed with a detailed review and markup of drawings. The mockups, which mimic the configuration of antennas and neighboring surfaces surrounding an

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antenna, will be installed in the LFSR microwave test facility at General Atomics, and used to assess the level of back-reflections in a realistic scattering environment. A manufacturing test article will be used to develop key processes, assess the manufacturability of the design, and identify possibilities for improvement.

A LFSR deliverable document, known as the “ESPN report,” has been approved by the ITER Organization. The report summarizes the various mechanical loads acting, both singly and in combination, on the actively water-cooled in-vessel equipment. It concludes that the stresses due to water internal pressure are small compared to other loads, providing a basis for proper classification of the LFSR under the French order concerning nuclear pressure equipment, or Equipements Sous Pression Nucléaire (ESPN). Preparation of the report was led by PPPL engineer Wenping Wang.

## **ITER & TOKAMAKS (R. NAZIKIAN)**

R. Nazikian and Steve Cowley traveled to Daejeon, S. Korea to participate in the KSTAR Program Advisory (PAC) Committee. The PAC reviewed and commented on recent progress and KSTAR program priorities for the next few years. Steve Cowley gave a plenary talk at the KSTAR conference in Seoul immediately following the KSTAR PAC.

## **DIII-D (B. Grierson):**

### *Research:*

B. Grierson traveled to Vienna, Austria, to participate in second IAEA research coordination meeting (RCM) on “Data for Atomic Processes of Neutral Beams in Fusion Plasma.” Grierson presented comparisons of the atomic data used on NSTX-U and DIII-D tokamaks for determining the neutral beam stopping and charge-exchange emission from the dominant light impurity carbon. He showed that the rate coefficients used by both tokamaks do not have any systematic differences. On DIII-D, operation at low neutral beam voltage (down to 50 kV) exhibits an anomalously high carbon impurity emission and exhibits high inferred impurity density. Two potential causes for this enhanced emission were identified as beam neutrals in higher n-states ( $n>2$ ), and charge-exchange between fully stripped carbon and excited halo neutrals ( $n>1$ ). Rate coefficients for other light impurities currently being used on DIII-D (Li, B, N, F, Ne, Al, Si, Ar) were shown and discussed, as well as new DIII-D capabilities with improved high-field-side measurements of neutral beam emission and main-ion and impurity charge-exchange emission.

A new FES science web highlight entitled “Not All Ions in Tokamaks Go with the Flow” was published online <https://science.energy.gov/fes/highlights/2019/fes-2019-02-c/>. This web highlight displays the new measurements of main-ion rotation spanning the



H-mode pedestal available on DIII-D, which are being used to characterize the high bulk ion rotation observed near the plasma separatrix and validate theoretical models of intrinsic rotation generation in tokamaks.

A new FES science web highlight entitled “Steady as She Goes” was published online <https://science.energy.gov/fes/highlights/2019/fes-2019-02-e/>. This web highlight shows how 3D magnetic fields can suppress Edge-Localized-Modes in DIII-D in conditions conducive to high pressure fully non-inductive plasmas required for a tokamak reactor.

#### **International PMI (R. Maingi):**

E. Gilson and R. Maingi attended the KSTAR conference in Seoul, S. Korea, Feb. 20-22. Gilson presented an oral, “Initial Experimental Results on Boron and Boron Nitride Powder Injection Into KSTAR Discharges.” With BN injection, significant periods of ELM quiescence were observed, with no apparent change in stored energy from EFIT. With B injection, strong drops in lower divertor baseline D-alpha emission, i.e. up to 50 percent, were observed, along with short periods of ELM quiescence. The talk also compared the KSTAR results with those from ASDEX-Upgrade and DIII-D for additional context.

A. Bortolon and R. Lunsford traveled to ASDEX-Upgrade to restore the impurity powder dropper for reliable performance. After debugging and correction, the powder dropper was successfully used in a plasma to drop B at low rates down to  $\sim 1$  mg/sec. Discussions on the scheduling of the next set of experiments on wall conditioning and pedestal modification in the spring, to be co-led by Bortolon and Lunsford, were continued.

Zhen Sun traveled to EAST at the end of the previous week for a four-month stay. Zhen is restoring the various PPPL impurity injection tools to full capability, and preparing to add new capabilities for new experiments in the Spring.

#### **International Scenarios and Control (R. Nazikian):**

The article by D. Mueller (PPPL), Sang-Hee Hahm et al., titled “Improved fast vertical control in KSTAR” is now published online in the journal Fusion Engineering and Design. The paper details the various advances that led to achievement of record elongation in



KSTAR, a key metric for advanced tokamak operation. The article is available online for open access <https://authors.elsevier.com/a/1YcHQ3HHIKH5jG> .

R. Nazikian and F. Poli presented invited talks at the KSTAR conference held in Seoul South Korea. Nazikian's presentation focused on recent advances in developing the DIII-D Hybrid regime and its relevance to KSTAR. Poli's talk discussed recent progress in integrated modeling and issues relevant to preparing for ITER first operation. Dan Boyer and Keith Erickson presented contributed talks on advanced plasma control using neural net algorithms for faster than real-time simulation and advanced real-time architectures. Steve Scott presented a poster on recent advances in the MSE system development on KSTAR. Two presentations by KSTAR researchers (Jisung Kang, Tongnyeol Rhee) highlighted the recent progress made in installing and validating the OMFIT-TRANSP and NOVA-K workflows at KSTAR.

#### **ADVANCED PROJECTS (D. GATES)**

##### **Stellarators (D. Gates):**

Last week an article was published in the magazine *Superconductor Week* highlighting recent results on W7-X from N. Pablant. The article, entitled "Tests Show Wendelstein 7-X Capable of Peak Performance," focuses on measurements taken with the XICS diagnostic, which have been critical in verifying high performance ion-root operation on W7-X. Pablant was interviewed over email for this article and is extensively quoted. The article can be found in the February 7 , 2019 Vol. 33, No. 1 Issue of *Superconductor Week*. This article is available by subscription only and can be found at <http://www.superconductorweek.com>.

S. Lazerson presented a talk entitled "Fast ion physics at Wendelstein 7-X" at the U.S. W7-X collaborators webinar during the week of February 23. His talk reviewed the status of fast-ion physics at W7-X. In particular, he focused on his work to validate the BEAMS3D code against NBI discharges, development of fast-ion loss detectors for W7-X, and newly developed capabilities to optimize the W7-X configuration for improved particle confinement. The talk was well received.

F. Laggner visited the National Institute for Fusion Science (NIFS) in Toki, Japan, from Feb. 18 to Feb. 22 to discuss and prepare the implementation of the real time Thomson



Scattering system on the Large Helical Device (LHD). The previously shipped data acquisition hardware was inspected, and the components were installed and put into operation during the last run days of the LHD campaign. The timeline for diagnostic operation in the upcoming campaign (starting in Oct. 2019) was outlined and coordinated with the NIFS collaborators.

D. Gates visited Culham Laboratory in the United Kingdom Feb. 18- 22 to discuss future collaborations for system code analysis of fusion reactor designs. Gates' host was H. Lux, who leads the research and development team for the PROCESS code, a code originally developed at Oak Ridge National Laboratory and later substantially further developed by the European Union. Lux went over the code capabilities, development plans, and demonstrated the use of the code in a series of meetings over the week. Licensing and code access issues were discussed and the process of sharing the code was initiated.

#### **THEORY (S. HUDSON)**

J. TenBarge attended and gave an invited talk at the 18th Annual International Astrophysics Conference in Pasadena, CA. The title was "Energy Dissipation and Phase-Space Dynamics in Eulerian Vlasov-Maxwell Shocks," and the slides were uploaded to the slide drive.

#### **SITE PROTECTION (M. SONNE)**

ESU completed training regarding SPD policies and procedures review.

Engine 66 responded to (4) four mutual aid assignments in Princeton and Plainsboro Townships.

#### **DIRECTOR'S OFFICE (S. COWLEY)**

February 13-15, S. Cowley, I. Kaganovich and Y. Raitses - visited Samsung Megatronics in Hwaseong, South Korea - to discuss current and future collaborations.

February 18-19, S. Cowley and R. Nazakian participated in the KSTAR PAC meeting in Daejeon, South Korea. On February 20, S. Cowley and R. Nazikian attended the 10th Anniversary Ceremony of KSTAR advanced tokamak experiments, held in Seoul, South Korea.

**This report is also available on the following web site:**

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