



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

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

*Recovery:*

Magnets — The Inner PF Coil evaluation and ranking and the coil procurement plan are both complete. A meeting was held with ETI on Oct. 4 to discuss coil sectioning and inspection. The Tesla prototype coil will be sectioned one more time for further vacuum pressure impregnation (VPI) inspection, and the final report on coil testing is complete. Samples are being cut from the PPPL PF1A prototype for a push-out test. The Change Review Board drawings were signed off, and the prototype water fitting is in fabrication.

*Research:*

Publications — The paper titled, “Initial results from solenoid-free plasma start-up using Transient CHI on QUEST,” by K. Kuroda, R. Raman, K. Hanada, et al., was published in *Plasma Physics and Controlled Fusion* 60 (2018) 115001. The paper describes the first results from the operation of transient CHI in a new electrode configuration that should be easier for implementation in reactor configurations. CHI research on QUEST is a collaborative effort between the University of Washington, PPPL, and the QUEST research teams.

Collaboration Activities — R. Maingi served as a Ph.D. committee member for the final defense of I. Waters (University of Wisconsin-Madison), “Particle Exhaust and Neutral Fueling in Spherical Tokamaks with Resonant Magnetic Perturbation Fields.” The research focused on analysis of data from the MAST device using the EMC3-EIRENE and MARS-F codes, along with simple models to help interpret the data and calculation results.

Science Updates — S. Sabbagh (Columbia University) attended the 32nd ITPA Topical Group Meeting on MHD, Disruptions, and Control in Naples, Italy, and gave two presentations representing group efforts: “Progress on Disruption Event Characterization and Forecasting (DECAF) in Tokamaks,” and “MDC-21: Global Mode Stabilization Physics and Control – Status and Progress.” Analysis was shown for three devices, including initial event probability analysis for large databases (thousands of shot seconds, and millions of individual test instances) from three machines (KSTAR, MAST, and NSTX), and disruption chain analyses for specific shots, now including a new automated rotating MHD analysis model presently comprising 15 test elements.

Weekly

# HIGHLIGHTS



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

The Low Field Side Reflectometer (LFSR) design team this week submitted several important deliverables in preparation for next month's preliminary design review (PDR). The PPPL-General Atomics team completed refinements and internal reviews of the project's entries into its Design Compliance Matrix (DCM), the key document that ties each of more than 280 system requirements to the analysis, R&D report, or drawing where compliance is documented. The DCM was entered into the U.S. ITER document management system iDocs, to begin the formal review process. The development of the DCM has been a team-wide effort led by PPPL engineer A. Basile.

Other LFSR deliverables submitted this week include two instrumentation and control (I&C) specifications, the System Requirements Specification and System Load Specification, both developed by the General Atomics (GA) team. These submissions complete GA's documentation assignments for the PDR. Load specification documents for both in-vessel and ex-vessel components were revised by PPPL engineer Wenping Wang in response to ITER Central Team review comments and submitted. Finally, an update of the LFSR project's Quality Assurance (QA) Plan, led by QA engineer A. Amaya, was submitted to U.S. ITER and approved.

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

PPPL staff presented the year-end summary of ITER & Tokamak department activities to the DOE's Fusion Energy Sciences division in Germantown, MD. Presentations were made by the leaders in various collaborations such as B. Grierson for DIII-D, F. Poli for JET and International Long Pulse research, S. Scott on MSE system development for KSTAR, and J-K. Park on 3D physics collaborations on EAST and KSTAR.

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

The US-based EAST PMI collaborative team gave a presentation in Germantown, MD about the results from the first two years of funded effort. The three main areas of research are plasma/PFC performance and optimization of impurity delivery tools, design of cryopump and lithium pumping comparisons, and PFC surface physics analysis. Portions of the presentation were given by D. Andruczyk (UI-UC), J. Canik (ORNL), R. Maingi, K. Tritz (JHU), K. Woller (MIT) and Z. Wang (LANL), with contributions from B. Wirth and S. Zinkle (UT-K). Performance metrics include 27 refereed journal articles (12 first author) and 12 invited/selected talks at international conferences.

R. Maingi presented a plasma seminar colloquium at UW-Madison titled, "Real-time impurity injection for wall conditioning, ELM and H-mode pedestal control, and divertor exhaust enhancement." A newly designed impurity dropper capable of injecting a range



of powders (boron-based, lithium, carbon-based, etc.) has been deployed on ASDEX-Upgrade, DIII-D, and EAST. Details of the dropper design and initial results from each experiment were presented.

#### **International Long Pulse (F. Poli):**

The development of the Fusion Flight Simulator for KSTAR is proceeding very well. During the past two weeks, D. Boyer and X. Yuan have tested the TRANSP-Simulink interface and expanded the set of exchanged data to include all those originally in the previous implementation base on file exchange. Work will continue this week to include additional variables.

The TRANSP group has worked this week with the KSTAR group and successfully completed tests for submission of TRANSP runs from NFRI to the PPPL cluster. KSTAR is now officially added to the list of tokamaks that can use the computational resources on the PPPL cluster. This development will allow for submission of TRANSP runs to the PPPL cluster in support of experimental planning and data analysis of the upcoming KSTAR campaign.

#### **ITER-JET (F. Poli):**

JET's plasma operation resumed on Oct. 3. Full neutral-beam-injection power will be available, however, only in February and an experimental campaign with full power is not expected before the end of April 2019.

#### **International 3D (J-K Park):**

T. Liu, Ph.D. student from Dalian University of Technology (DUT), and Z.R. Wang collaborated to develop an equilibrium refiner based on a new method that pushes the flux surface. The code successfully improves the convergence of reconstructed equilibria provided by the equilibrium solvers like the CHEASE code, and largely reduces the equilibrium error, particularly near the plasma edge which the CHEASE code typically has a hard time resolving. The refined equilibrium can greatly help improve the numerical stability and reliability of plasma simulations, for example, the MHD eigenvalue problem and plasma response simulation when  $q_{95}$  is high. At present, T. Liu and Z.R. Wang are working on the improvement of code efficiency for better computational performance and the application of code in MHD simulations.



### **KSTAR Stability (S. Scott):**

The cause of peculiar features of the beam-into-gas calibration of the MSE background polychromator at KSTAR has been identified: Secondary emission from beam neutrals. The unusual features include sensitivity of the measured polarization angle to the location of the filter passband relative to the MSE spectroscopic lines, and an unexpected decrease of the polarization fraction as the filter center wavelengths are moved to the blue. Both trends are highly sensitive to polarization angle and both trends are most pronounced at low BT (1.2 Tesla). Secondary beam emission, first identified on Alcator C-Mod, refers to the process by which a beam neutral ionizes, gyro-orbits thru some angle thereby changing the  $V \times B$  direction, and then re-neutralizes and emits a polarized photon with a suitable Doppler shift to pass thru the MSE filters. It was confirmed on KSTAR by the observation of polarized light in the blue background filters (651 nanometers) during the beam-into-gas shots, which can only come from ions that gyro-rotate nearly 180 degrees before re-neutralizing.

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

R. Hager visited Japan's National Institute of Fusion Science last week and gave a talk about XGCa simulations with RMP fields titled, "Gyrokinetic-MHD Coupled Simulation of RMP Plasma Interaction Reproduces Density Pump-Out Seen in the Tokamak Edge."

S. Jardin attended the 32nd meeting of the ITPA MHD group in Napoli, Italy. He made two presentations: "Using M3D-C1 to calculate the disruption forces on ITER" and "M3D-C1 progress on Joint Activity (JA) 2." He also visited Fabio Villone of the Consorzio CREATE to discuss issues related to coupling the M3D-C1 MHD code with the CARRIDI structures code.

### **TRANSP (F. Poli)**

The TRANSP group has worked this week with the KSTAR group and successfully completed tests for submission of TRANSP runs from NFRI to the PPPL cluster. KSTAR is now officially added to the list of tokamaks that can use the computational resources on the PPPL cluster.

### **COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)**

#### **Communications (L. BERNARD)**

The Office of Communications posted three press releases to the PPPL website. One noted that PPPL had been designated by the American Society of Mechanical Engineers as an historic mechanical engineering landmark for its achievements in the quest to



develop magnetically controlled fusion energy. Another noted that PPPL physicist S. Cohen and Princeton Satellite Systems won a Federal Laboratory Consortium award for their joint efforts to develop rocket propulsion technology. The third detailed how PPPL received part of a \$200,000 grant to develop superconducting magnetic technology for propulsion technology. These articles were also posted to the *Newswise* and *EurekaAlert!* press release distribution services.

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

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