

PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights



**The PPPL Highlights for the week ending May 23, 2014, are as follows:**

### **U.S. ITER FABRICATION (D. JOHNSON):**

The divertor RGA sampling tube is being designed at ORNL in advance of several interfacing systems. This week this design was frozen in a configuration that minimizes the risk of impacts of changes to interfacing systems.

The topic of this week's meeting on the Procurement Arrangement Annex B for the Core Imaging X-ray Spectrometer (CIXS) diagnostic was the sharing of the effort needed to plan for maintenance of this system, some of which will have to utilize long-handed tools during DT operation.

At a Low-Field-Side Reflectometer (LFSR) progress meeting, the US design team presented thermal analysis done to determine how long the windows could safely tolerate stray electron cyclotron heating radiation. Such considerations inform a decision on whether a shutter is needed to protect the window. Also at this meeting, the US received guidance on the criteria needed to determine whether the LFSR antenna assemblies at the first wall are classified as nuclear pressure vessels, requiring periodic field inspection of welds. It appears that such classification is avoidable.

### **NSTX (M. ONO):**

Three papers have been recently published by Columbia University Collaboration researchers on NSTX-U and are available online: "Measured improvement of global magnetohydrodynamic mode stability at high-beta, and in reduced collisionality spherical torus plasmas" by J.W. Berkery et al., *Physics of Plasmas* 21, 056112 (2014), (<http://scitation.aip.org/content/aip/journal/pop/21/5/10.1063/1.4876610>), showing the remarkable results of increased stability in NSTX at the highest BetaN values; "Benchmarking kinetic calculations of resistive wall mode stability" by Dr. J.W. Berkery, et al., *Physics of Plasmas* 21, 052505 (2014), (<http://scitation.aip.org/content/aip/journal/pop/21/5/10.1063/1.4873894>), which documents a multi-year kinetic resistive RWM mode stability code benchmarking effort, which was requested by, and coordinated through ITPA MHD Stability Group MDC-2; and "Resistive wall mode active control physics design for KSTAR" by Young-Seok Park, et al., *Physics of Plasmas* 21, 012513 (2014), (<http://scitation.aip.org/content/aip/journal/pop/21/1/10.1063/1.4862140>), covering high beta stability and RWM control physics design on KSTAR, setting the stage for our joint research between NSTX-U and KSTAR on plasmas exceeding ideal no-wall stability limits.

The paper entitled "Full wave simulations of fast wave heating losses in the scrape-off layer of NSTX and NSTX-U" by N. Bertelli (PPPL) et al., was published in Nuclear Fusion 54, 083004 (2014) <http://stacks.iop.org/0029-5515/54/083004>). Recent experimental studies of high harmonic fast wave (HHFW) heating on the NSTX have demonstrated that substantial HHFW power loss can occur along the open field lines in the scrape-off layer (SOL). In this paper, fast wave heating losses in the SOL of NSTX and NSTX-U was examined by the full wave code AORSA. Numerical simulations show a direct correlation between the location of the fast-wave cut-off, radiofrequency (RF) field amplitude in the SOL and the RF power losses in the SOL observed in the NSTX. In particular, the RF power losses in the SOL increase significantly when the launched waves transition from evanescent to propagating in that region. Subsequently, a large amplitude electric field occurs in the SOL, driving RF power losses when a proxy collisional loss term is added. A 3D reconstruction of absorbed power in the SOL is presented showing agreement with the RF experiments in NSTX. A prediction for the NSTX-U experiment is also presented, indicating a favorable condition for the experiment due to the higher magnetic field and, consequently, a wider evanescent region in edge density.

Preparations for plasma operations in the NSTX-U configuration also continued with the preparations of the Field Coil Power Conversion (FCPC) and Neutral Beam Power systems for upcoming power testing. The procedure to configure NSTX-U coil connections/polarities (D-NSTX-OP-G-141) has been approved, and links are being configured for the CD-4 run. Test procedures for NB system power recommissioning are in review/approval. Systems and crews are now ready to start the D-Site MG#1 weld repairs on the week of June 2nd. In-vessel work on the new HHFW Antenna Compliant Center Conductors also continued.

### **ITER & TOKAMAKS (R. HAWRYLUK):**

C. Kessel and F. Poli participated in a kick-off meeting, this week at Fusion for Energy in Barcelona, for the ITER Task on Electron Cyclotron (Heating and Current Drive) Modeling. Kessel and Poli gave presentations on simulating discharge scenarios, strategy for examining them in terms of H/CD, and the transport evolution and H/CD modules for analysis. Representatives for each of the three H/CD sources, and IO representatives for the research plan also gave presentations. For the next six months, an initial set of discharge scenarios were agreed upon, based on the philosophy to develop the basis for the Q=10 15 MA scenario in He/H and DD operation as the highest priority. Various tasks to clarify and update information about these H/CD sources are also taking place.

R. Hawryluk gave a presentation to the IPP Board of Trustees and visited the W7-X team in Greiswald.

An experimental seminar was held entitled "Perspectives on the TFTR DT Experiments." D. Meade talked about the "TFTR Time Line." R. Hawryluk on "Preparing for DT on TFTR", M. Bell on "The First DT Experiments in TFTR" and R. Hawryluk on "Implication of TFTR DT Experiments for ITER."

### **DIII-D (R. Nazikian):**

Controlled plasma shutdown was tested after the onset of NTM mode locking in ITER base-line plasmas with  $q_{95} \sim 3.5$ . Feedback-based mode rotation control using the I-coils trained to the NTM prevented the plasma from disrupting during the current ramp down through the edge magnetic safety factor  $q_{95} = 4$ . However, a rapidly growing  $n=2$  mode was excited at  $q_{95} = 4.5$  during the ramp down. Efforts will be made to reduce the  $n=2$  intrinsic error field and to feedback control the  $n=2$  perturbation to avoid mode locking during the current ramp-down.

E. Kolemen worked with DIII-D researchers to implement and test advanced magnetic snowflake divertor geometry control. The real-time feedback control algorithm first finds the two null-points of the snowflake configuration. Then, the effect of the change in the PF coils on the distance and the angle of the null-points is calculated. The PF coils are then commanded to reach the user requested snowflake configuration. This iteration is repeated every 250 microseconds. The control was used to move the two null-point around each other by 90 degrees and to change from a negative to a positive snowflake configuration while keeping the distance between the null-points roughly constant.

The PPPL Pole Shield design team meeting this week focused on the redesign of the serpentine water cooling path for the copper portion of the pole shield. The original cooling path, while very efficient at reducing the pole shield temperature, caused high thermal stress concentrations due to the proximity of the cooling path to the high temperature region of the copper plate. A change to the cooling path to a simpler design for edge cooling of the plate resulted in longer cool down times but reached almost the same temperature as the original cooling design within the 12-minute duty cycle of the beams and with much reduced stress levels.

G. Kramer visited DIII-D this week to collaborate on planned experiments with the ITER-like Test Blanket Module (TBM) on DIII-D. Good imaging data was obtained using the NSTX-ORNL IR camera viewing the TBM. The combined effect of core Alfvén eigenmodes with the TBM was studied and extensive data was collected for more detailed analysis.

W. Solomon was the beam programmer for two experiments this week, one aimed at investigating the relative role of rotation versus current profile in low torque ITER baseline plasma stability, and the other to assess the negative impact on confinement and rotation resulting from the error fields produced by the test blanket module.

A. Nagy served as chief operator on DIII-D for two days this week.

### **ADVANCED PROJECTS (H. NEILSON):**

Advanced Projects staff are intensively engaged in preparing input for the FESAC 2014 Strategic Planning Panel. C. Kessel and numerous U.S. fusion materials experts co-authored an extended abstract, "Critical Fusion Nuclear Material Science Activities Required Over the Next Decade to Establish the Scientific Basis for a Fusion Nuclear Science Facility," for proposed presentation at one of the panel's public meetings. D. Gates and H. Neilson are members of a National Stellarator Coordinating Committee (NSCC) that has been engaged for many years in strategic planning for stellarator research. The committee is preparing a "status and priorities" white

paper as requested by the panel, and has proposed a series of talks describing a coherent set of initiatives for the coming decade.

In the Laboratory's collaboration with Germany's Wendelstein 7-X stellarator program, preparations were completed for on-site commissioning of the U.S. trim coil power supplies at the project's Greifswald site. Wendelstein 7-X project staff have completed the installation and service connections for the power supply units. A PPPL procedure, "W7-X Trim Coil Power Supply Testing/Commissioning," was approved. A subcontract with the manufacturer, Applied Power Systems, Inc. (APS), to lead the tests at the project site, is in place. Arrangements have been made for an APS engineer to arrive at the project site on June 2 to begin the commissioning program, which is expected to take about a week.

### **THEORY (A. BHATTACHARJEE):**

A paper entitled "Ponderomotive forces on waves in modulated media", by I. Y. Dodin and N. J. Fisch, was published in Physical Review Letters [Phys. Rev. Lett. 112, 205002 (2014)]. It is shown there that nonlinear interactions of waves via instantaneous cross-phase modulation can be cast in the same way as ponderomotive wave-particle interactions in high-frequency fields. The ponderomotive effect arises when rays of a probe wave scatter off perturbations of the underlying medium produced by a second, modulation wave, much like charged particles scatter off an oscillating electromagnetic field. Parallels with the point-particle dynamics, which itself is subsumed under this theory, lead to new methods of wave manipulation, including asymmetric barriers for light.

### **ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):**

#### **NSTX Upgrade (R. Strykowski, E. Perry, L. Dudek, T. Stevenson):**

Construction: The in-vessel crew supported CHERS calibrations this week. The centerstack ceramic breaks did not pass leak checking and when disassembled it was found that the o-rings needed to be replaced and parts need to be re-worked and replaced. The new JK RWM coil is in place on the vessel. The potting of the upper aluminum blocks on the outer TF legs has been completed. The bus and bus mockups under the machine need to be removed so the lower aluminum blocks can be potted. The installation of the vacuum system cables continues.

CS Upgrade: The OH Coil busbar connection was successfully test fitted and G10 fillers were cut and installed around the ends of the coil. Hollis is redoing the weld qualification samples for the OTF Finger Supports using a different heat treat cycle. The test samples will arrive at the test laboratory the morning of May 23 and the delivery schedule is holding for the end of June. The lower PF1C coil was delivered to PPPL from Everson Tesla and the upper PF1A coil came off of the winding machine and is being prepared for VPI process. A fixture to hold and position the OTF finger support brackets during welding was designed. Major Tool formed the PCHERS passive plate. The second G10 crown piece was delivered from Imperial Machine and passed incoming inspection.

NBI Upgrade: High Voltage Transmission Line relocation (three units) has been completed and installation continued in NTC. In addition, BL2B was completed. BL2C installation is in progress and rework on the pressure plate was completed and the pressure plate was re-installed in the C position. Transmission line support and ground wire installation continues. VV RWM coil installation continues for the Bay JK area and meggering is imminent. The vacuum system roughing line fabrication and installation continues in the NTC. The NB Armor thermocouple scanning system software development is in progress. The Mod/Reg controls work, fiber optics, and preparation continues and water skids have been tested. The NB Controls fabrication and installation work on rack, cable, and wiring continued in NTC and gallery. Telemetry fiber optics termination and polishing is in progress in NTC. OMA hardware installations continued on BL2 source platform. Additional NB installation procedures are in development and review including PTP-NB-212 needed for power testing.

Digital Coil Protection System: DCPS software builds continued for code cleanup changes. DCPS PTP testing continued in FCC including tests of the new builds. Work continued on the DCPS GUI with steady progress. LabView was installed for the Autotester. Hardware and I/O layout and design continues toward completion. Work on hardware drawings continues and is also nearing completion. The HW user interface panel design updates are in progress. PCB design is in progress, several PCBs were ordered, and parts ordering continues. The water PLC testing continues and documentation nears completion. HSC testing development continues. A Lemo connector cable order was received; another larger order is planned. DCPS procedure development continues. Review of development of reliability, failure modes, and administrative control continued.

#### **BUSINESS OPERATIONS (K. FISCHER):**

PPPL executed a Work-for-Others agreement with Ras Labs, LLC titled "Intelligent Materials - Radiation Evaluation and Plasma Treatment of Metal Coupons/Electrodes." The Principal Investigator is L. Meixler. The total budget is \$3,500.

#### **OFFICE OF COMMUNICATIONS: (K. MACPHERSON):**

J. J. DeVoe covered the Girl Scout STEM Fair on May 17 and hosted Times of Trenton photographer Andrew Miller. Photos by Miller of the event appeared at [N.J.Com](http://N.J.Com) on May 17 and in the Times of Trenton on May 18. A story about the event also appeared on the Princeton Alumni website blog on May 22.

#### **BEST PRACTICES & EXTERNAL AFFAIRS (J. DELOOPER):**

The PPPL Work Planning and Control (WP&C) effectiveness review will be held June 23-27. The team will include experts from Oak Ridge National Laboratory, Picatinny Arsenal, Princeton University and PPPL. Two teleconferences have been held.

## **DIRECTOR'S OFFICE (C. AUSTIN):**

On May 21, Dr. Benjamin Gross of the Chemical Heritage Foundation presented a colloquium entitled, "David Sarnoff, RCA Laboratories, and the Dawn of the Information Age".

The PPPL campus planning meetings continue - one was held on May 22 at DOE offices in Germantown, Maryland. Participants from DOE included: E. Synakowski, J. May, S. Short, M. Dikeakos, B. Sullivan, J. McBrearty and C. Ackerman. PPPL participants included: S. Prager, A. Cohen, M. Williams, and M. Viola.

On May 23, S. Prager hosted a meeting with Ann Satsangi and James Van Dam from DOE (and others from PPPL) to discuss general plasma science at PPPL.

## **PUBLICATIONS:**

Berkery, J.W. (Columbia); et al., "Measured Improvement of Global Magnetohydrodynamic Mode Stability at High-beta, and in Reduced Collisionality Spherical Torus Plasmas," *Physics of Plasmas* 21, 056112 (2014), <http://scitation.aip.org/content/aip/journal/pop/21/5/10.1063/1.4876610>)

Berkery, J.W. (Columbia); et al., "Benchmarking Kinetic Calculations of Resistive Wall Mode Stability" *Physics of Plasmas* 21, 052505 (2014), (<http://scitation.aip.org/content/aip/journal/pop/21/5/10.1063/1.4873894> ),

Bertelli, N. (PPPL); et al., "Full Wave Simulations of Fast Wave Heating Losses in the Scrape-off Layer of NSTX and NSTX-U," *Nuclear Fusion* 54, 083004 (2014) <http://stacks.iop.org/0029-5515/54/083004>).

Dodin, I.Y.; and Fisch, N.J., "Ponderomotive Forces on Waves in Modulated Media," *Physical Review Letters* 112, 205002 (2014)

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