



**The PPPL Highlights for the week ending January 30, 2015, are as follows:**

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

NSTX-U is in the Upgrade Project outage in FY14. NSTX Upgrade construction activities continued this week and are highlighted in the Engineering section below.

Professor Oliver Schmitz from University of Wisconsin - Madison visited to present and discuss the research plan for work at NSTX-Upgrade on "Optimization of Neutral Fueling and Exhaust by 3D Magnetic Control Fields" funded by the Department of Energy under grant DE-SC0012315. Heinke Frerichs, Assistant Scientist from University of Wisconsin – Madison, was visiting to start collaboration on EMC3-Eirene modeling for QUASAR and for initial discussions on NIMROD modeling for NSTX-Upgrade. BSc Kurt Flesch, PhD student UW Madison visited to start work on neutral gas characterization in NSTX-U with optical Penning gauges in collaboration with Vlad Soukhanovskii.

Preparations for plasma operations in the NSTX-U configuration also continued. Balancing of D-MG#1 was completed this week, and the set was successfully run to its rated speed of 375 RPM with measured vibrations within specified allowables. The set is now ready to support NSTX-U operations. Commissioning of the four lithium evaporators (LITERs) and lithium lifters continued in the CS High Bay shop, and preparations are underway to fit-up the LITER mounting brackets on the NSTX-U vessel. Construction of the new shield wall outside the North door of the NSTX-U Test Cell has been completed.

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

R. Hawryluk participated in the ITER External Management Advisory Board meeting, which was held in Paris, France.

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

B. Grierson led an experiment to investigate impurity transport in hybrid plasmas on DIII-D. The goal was to determine changes in impurity accumulation in hybrid plasmas with and without saturated 3/2 modes. Real-time ECCD steering with active tracking was used to suppress the core-tearing mode and cause the discharge to sawtooth. Additionally, central ECH was used to reduce the density peaking while maintaining the 3/2 NTM. This allows the impact of the density peakedness and the presence of the 3/2 tearing mode on impurity transport to be studied independently. Impurity injections of helium, fluorine, chlorine and argon were used and

impurity density profile evolution was measured with charge-exchange spectroscopy.

B. Tobias traveled to University of California-Davis to participate in the testing of components critical to major upgrades of the ECEI and MIR diagnostics on DIII-D. New detector arrays for ECE-Imaging have been fabricated, assembled, and passed basic checks that will allow them to replace those damaged during experiments last year. In addition, both MIR and ECE-Imaging are to be outfit with new microwave sources. Transmitter and local oscillator sources that have now been assembled and tested will provide significantly more power, improve signal to noise in both systems, and eliminate multiple sources of frequency drift. These upgrades are on schedule for installation at DIII-D in April, and will allow step-tuning of ECEI and MIR center frequencies for fine radial scans of plasma fluctuations and coherent modes.

Work continues on the assembly of the Neutral Beam Local Control System (NBLCS) with wiring between the PLC and the main terminal block complete, and PLC to the fast controller in progress. The deliverables of the racks containing the control system are expected to be complete in March following a wiring walkdown/ checkout.

The DIII-D LGI will be removed after this campaign and reinstalled in about one year. Plans are being developed for improvements to the LGI in preparation for the FY16 run.

#### **International (J. Hosea):**

The Ulsan National Institute for Science and Technology (UNIST) contract for supporting a two-channel 2 MW ECH launcher design for KSTAR has been signed off.

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

A figure from a paper recently published by S. Lazerson and the DIII-D Team 2015 (Nuclear Fusion 55 023009) will be highlighted on the cover of the February issue of Nuclear Fusion. This work is part of an effort to develop three-dimensional equilibrium reconstruction tools for high performance plasmas. In the paper, the STELLOPT code was applied to an H-mode plasma from the DIII-D device with applied RMP's. In this work, the STELLOPT code was modified to fit free boundary three-dimensional VMEC equilibria to the measurements obtained from magnetic field probes, flux loops, Thomson scattering, Motional Stark Effect and charge exchange diagnostics. This work builds upon work on the Large Helical Device and lays the groundwork for equilibrium reconstruction on the W7-X experiment later this year.

P. Titus, T. Brown, and H. Neilson visited the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) in Hefei, China to kick off a new collaboration involving joint research on fusion machine design issues. The focus of the collaboration is China's Fusion Engineering Test Reactor (CFETR), a concept for the next step in China's fusion roadmap and the subject of an ongoing study involving ASIPP and other Chinese institutions. While China's national CFETR team has already established an initial mission and conceptual design, ASIPP now wishes to investigate design options to support a second phase mission with higher performance: fusion power approaching 1,000 MW steady state, and net electricity generation. A joint ASIPP-PPPL team will follow a research strategy aimed at increasing the magnetic field strength of the device, while using moderately advanced physics ( $\beta_N \approx 3.5$ ) and fully non-

inductive operation and retaining the machine dimensions and geometry of the current reference design. In addition, a mixed-blanket configuration that permits simultaneous testing of two concepts, e.g. water-cooled and He-cooled ceramic breeders, will be investigated. The kickoff meeting concluded with the adoption of a joint work plan and a schedule for future meetings of the joint team.

As part of an ongoing stellarator collaboration with the University of Wisconsin, Heinke Frierichs visited PPPL to learn the VMEC/STELLOPT codes and develop an interface between VMEC and the EMC3/EIRENE edge modeling code. Heinke received instruction from S. Lazerson on the use of the VMEC code along with the FIELDLINES code. The reconstruction of the NCSX equilibrium database also began. The collaboration has also included developing interfaces between the VMEC code and EMC3/EIRENE. This has resulted in development of such an interface and has begun to address the difficulty of modeling field lines near and across the VMEC edge. This work was funded by the PPPL University support program.

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

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

Construction: Work continues in both umbrellas on the electrical isolation and supports for the Poloidal Field and Ohmic Heating bus. Final fit-up of the Coaxial Helical Injection bus has been completed. Cooling hose fittings for the Ohmic Heating coil are being fabricated and installed. The stainless braid hoses have been received and they will be hydro tested, insulated and installed during the next several days. Machining of the Toroidal Field bus spacers continues and the final installation of the Toroidal Field bus is underway. Installation of the gas delivery system piping continues. The welding of the flange for the upper umbrella lid has been completed. Three welders are working on neutral beam water piping and three welders are working on parts for the Multi Point Thompson Scattering (MPTS) diagnostic. The Vacuum Prep Laboratory is cleaning and coating the MPTS exit tubes and testing the input window housing.

CS Upgrade: Stainless steel hoses arrived this week, and the first batch was successfully tested with others remaining to be tested over the weekend. A quote was obtained for the high temperature, high-pressure nonconductive hoses. However, the hose specifications needed to be changed to meet the new requirement of being able to swap the inlet and outlet connection if needed. The vendor is working on the new quote. CTD, our insulation system manufacturer, conducted tests that were completed to 35,000 cycles. The preliminary results were provided for Mechanical Engineering to review. CTD is working on the final report. A few of the lead extensions were dye penetration tested when a crack was noticed on the backside of one of the beam welds. The tests indicate the voids are very shallow. Some minor hand filing is being performed on the area to take out the imperfections. The remaining parts will be inspected and reworked if needed. Busswork installation under the machine continued this week.

NBI Upgrade: The deionized water system repairs continued on Mechanical Equipment Room mezzanine. Fabrication of the strainers for the NSTX Test Cell (NTC) are in progress in the shop. Stack duct installation is scheduled to begin in approximately one week. Control cabling for thermocouples has been pulled from NTC into the gallery racks where terminations are in progress. Troubleshooting of all cabling in support of various stages of Preoperational Test

Procedure testing is in progress. Modulator/ Regulator power supply testing and tuning continues. Software efforts continue on Programmable Logic Controller pages. Two Tech Shop work orders were submitted for beam brace and gate and cage installations.

Digital Coil Protection System (DCPS): Testing and troubleshooting continued in preparation for support of dummy load testing. Glitches on Real Time Control (RTC) outputs continue to be investigated. DCPS PTP rerun continues. RTC continued with further testing of PTP-ECS-034 and 035. Work continues on the DCPS buffer chassis implementation. Consideration of parameter tree development to support Pre Test Procedure, dummy load, ISTP, and CD4 continued including details regarding the tree number nodes and pairings. A draft of the procedure for setup and daily startup of the DCPS system was completed for review and comments.

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

PPPL executed a Work for Others Agreement with the National Fusion Research Institute (NFRI) in South Korea, under which PPPL will perform physics and engineering analyses to support the K-DEMO Concept Study. The Principal Investigator is H. Neilson. The budget is \$250,000 for the one-year period of performance.

PPPL executed a Work for Others Agreement with the Ulsan National Institute of Science and Technology (UNIST) in South Korea, under which PPPL will complete the conceptual design of a new 2 beam, 2MW steady state launcher, and perform analyses and calculations in support of this design. The Principal Investigator is R. Ellis. The budget is \$110,000 for the fifteen-month period of performance.

DOE approved a Research Ordering Agreement (ROA) between PPPL and Princeton University (Main Campus) under which Main Campus Departments can perform research for the Laboratory. The ROA has been signed by PPPL and the University. Under the ROA individual work orders will be issued for each research task to be performed by Main Campus.

PPPL received DOE approval to participate in a Small Business Innovative Research proposal titled "Optimal Coil Configurations for Magnetic Nozzle Steering" which was submitted to NASA by Princeton Satellite Systems. The budget for the PPPL effort, led by S. Cohen, is \$40,000.

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

On January 16-18, Rutgers University hosted the region's Conference for Undergraduate Women in Physics, a national initiative of the American Physical Society. PPPL Science Education team members D. Ortiz and S. Greco helped organize the event and arranged for the tour of the Laboratory. S. Greco also served as a panel member for the conference's Work/Life Balance panel discussion with 140 young female physicists.

Dr. Emily Carter, Princeton University, presented the Science on Saturday lecture, "The Road to Sustainable Energy Future," to 320 participants at the lab, and more streaming on line.

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

On January 30, A. Cohen, S. Langish, D. Pryor, and A. Indelicato (PSO) traveled to Germantown, Maryland to make a presentation on the Business Case for concrete removal in the C-Site MG Building. Representatives from DOE Headquarters and the Princeton Site Office also participated in this meeting.

On January 26, A. Cohen hosted Jeff Sims from SLAC. Sims visited PPPL to advise on IOI and other management matters. This included several meetings with PPPL staff on the topics.

On January 27 and 28, John DeLooper participated as a member of the Independent Project Review of the Utilities Infrastructure Modernization Project at the Thomas Jefferson Accelerator Facility.

R. Goldston will be serving as Acting Director of the Princeton Woodrow Wilson School's Program in Science and Global Security (SGS), from February 1 - June 30. Since stepping down as PPPL director, Goldston has been engaged with this distinguished group, first studying non-proliferation characteristics of fusion energy and more recently developing a Zero-Knowledge Protocol for warhead verification for arms control. He will continue his research in fusion plasma physics in parallel with his new responsibilities at SGS.

## **PUBLICATIONS:**

The following reports were posted to the PPPL web site:

M.D. Boyer, R. Andre, D.A. Gates, S. Gerhardt, I.R. Goumiri, and J. Menard, Central Safety Factor and  $\beta_N$  Control on NSTX-U via Beam Power and Plasma Boundary Shape Modification, using TRANSP for Closed Loop Simulations, PPPL-5080

Leonid E. Zakharov and Xujing Li, Tokamak Magnetohydrodynamics and Reference Magnetic Coordinates for Simulation of Plasma Disruptions, PPPL-5081

D.R. Mikkelsen, M. Nunami, T.-H. Watanabe, H. Sugama, and K. Tanaka, Verification of Gyrokinetic Microstability Codes with an LHD Configuration, PPPL-5082

E.D. Fredrickson, M.G. Bell, R.V. Budny, D.S. Darrow, and R. White, Anomalous fast ion losses at high  $\beta$  on the Tokamak Fusion Test Reactor, PPPL-5083

J.W. Burby, A. J. Brizard, P.J. Morrison, and H. Qin, Hamiltonian Formulation of the Gyrokinetic Vlasov-Maxwell Equations, PPPL-5084

Leonid E. Zakharov and Xujing Li, Comment on "Velocity Boundary Conditions at a Tokamak Resistive Wall" [Phys. Plasmas 21, 032506 (2014)] PPPL-5085

B.A. Grierson, K.H. Burrell, R.M. Nazikian, W.M. Solomon, *et al.*. Impurity Confinement and Transport in High Confinement Regimes without ELMs on DIII-D, PPPL-5086

Andrei Khodak, Michael A. Jaworski, Numerical Analysis and Optimization of Divertor Cooling System, PPPL-5087

Peter Porazik, Jay R. Johnson, Igor Kaganovich, Ennio Sanchez, Modification of the Loss Cone for Energetic Particles, PPPL-5088

A. Diallo, *et al.*, Quasi-Coherent Fluctuations Limiting the Pedestal Growth on Alcator C-Mod: Experiment and Modeling, PPPL-5089

J.C. Schmitt, R.E. Bell, D.P. Boyle, B. Esposti, R. Kaita, *et al.*, High Performance Discharges in the Lithium Tokamak eXperiment with Liquid Lithium Walls, PPPL-5090

Peter H. Titus, H. Zhang, A. Lumsdaine, W.D. McGinnis, J. Lore, H. Neilson, T. Brown, J. Boscary, A. Peacock, and Joris Fellingner, Analysis of the Wendelstein 7-X Inertially Cooled Test Divertor Unit Scraper Element, PPPL-5091

S.M. Kaye, *et al.*, Overview of Recent Physics Results from NSTX, PPPL-5092

D.P. Stotler, F. Scotti, R.E. Bell, B.P. LeBlanc, R. Raman, Reconstruction of NSTX Midplane Neutral Density Profiles from Visible Imaging Data, PPPL-5093

This report is also available on the following web site:

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