

PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights



The PPPL Highlights for the week ending December 5, 2014, are as follows:

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

TNO optical designers have developed an alternative optical design, for the ITER upper visible/IR cameras, that splits the visible and IR images in the port cell rather than in the port plug. This eliminates the need for two separate relay systems and two vacuum windows. It also uses an all-reflective, off-axis relay telescope, which eliminates the central obscuration that existed in the baseline cassegrain design. This alternate approach significantly improves the image quality. A detailed comparison of the two approaches is being prepared for review in mid-December.

Final preparations are underway for two reviews the week of December 8 in Cadarache, France, a final design review for the generic diagnostic first wall, and a system integration review for equatorial port plug 9.

A kickoff meeting was held with performers of a project to use precision spectroscopy of the spatially resolved, beam emission D-alpha spectrum to constrain the equilibrium reconstruction. This requires a modification of the EFIT code to utilize existing spectroscopy data for a range of DIII-D discharges. Lang Lao and Keith Burrell from GA are working with B. Grierson from PPPL on this project.

NSTX (M. ONO):

Princeton University graduate student Tyler Abrams successfully defended his doctoral thesis entitled "Erosion and Re-Deposition of Lithium and Boron Coatings under High-Flux Plasma Bombardment" on November 24. His advisors were NSTX-U physicists M. Jaworski and R. Kaita. High-Z plasma-facing components (PFCs) are planned for NSTX-U, and Abrams studied lithium and boron coatings on them under ion bombardment on the Magnum-PSI linear plasma device at the Dutch Institute for Fundamental Energy Research. He observed that with deuterium plasmas, lithium eroded at a far lower rate than expected if it was the only constituent of the coating. The data, however, are better matched if the surface is modeled as a mixed material containing both deuterium and lithium. Abrams' results thus have promising implications for significantly extending the temperature range over which lithium can be used as a PFC in the presence of hydrogenic plasmas.

The NSTX-U Team Meeting was held on December 4. The meeting material is available on the web at http://nstx.pppl.gov/DragNDrop/NSTX_Meetings/Team_Meetings/2014/12_04_2014/ where the NSTX-U team was updated on the NSTX-U activities including the up-coming NSTX-U Research Forum and the preparation toward plasma operation. The NSTX-U organization chart was also discussed.

The paper “Active Radiative Liquid Lithium Divertor Concept” by M. Ono (PPPL) et al. was published in Fusion Engineering and Design 89, 2838 (2014). In this paper, we examine an active version of the previously proposed radial liquid lithium divertor (RLLD) concept, which we term ARLLD, where LL is injected in the upstream region of divertor. We find that the ARLLD has similar effectiveness in reducing the divertor heat flux as the RLLD, again requiring only a few moles/sec of LL to significantly reduce the divertor peak heat flux for a reactor. An advantage of the ARLLD is that one can inject LL proactively even in a feedback mode to insure the divertor peak heat flux remains below an acceptable level, providing the first line of defense against excessive divertor heat loads which could result in damage to divertor PFCs. Moreover, the low confinement property of the divertor (i.e., < 1 ms for Li particle confinement time) makes the ARLLD response fast enough to mitigate the effects of possible transient events such as large ELMs.

The Digital Coil Protection System (DCPS) and the Power Supply Real Time Control (PSRTC) development efforts are working towards the start of Field Coil Power Conversion System dummy load testing. DCPS pre-operational testing is nearing completion, and the operation procedure to exercise, set, and verifies fault protection algorithms is being developed. PSRTC software testing continued, and procedures for I/O testing, and to simulate and verify the real-time outputs against recorded shots are being exercised.

Preparations for plasma operations in the NSTX-U configuration also continued. The exit side flight tube of the Multi-Pulse Thompson Scattering (MPTS) diagnostic has been welded in place. Work packages are being prepared to recommission the system to make the inner to outer Voltage fast measurements needed for CHI operations, and the vacuum vessel Ground Fault Monitoring System. Neutral Beam (NB) Power Supply recommissioning continued with dummy load testing of the Modulator Regulators, and open circuit testing of the TF magnet power supplies has started. NB Helium refrigerator operations continues round the clock to circulate/cleanup process gas. Gas is circulating through both of the beam-line cryo-panels and measured purity is improving.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

The GA Neutral Beam magnet poles shields have been delivered to GA. These pole shields were redesigned for GA by PPPL as a collaboration project this year. The new design (rated at 3.2MW/Source 6s) uses replaceable molybdenum tiles in the beam strike zone to eliminate heat stress cracking in this zone that used to be copper plate. The tiles are replaceable without removing the pole shields from the beam line. The pole shields were delivered on time for installation on NB330 this upcoming vent.

Work began to identify, characterize, and eliminate sources of baseline drift and noise that remain in data from the DIII-D Mm-wave Imaging Reflectometer. B. Tobias and G. Kramer, working with Chris Muscatello from University of California - Davis, eliminated multiple sources of noise associated with electrical grounding and imperfections in the optical alignment and oscillator tuning. A strategy for correcting this noise in existing data with improved post-processing, and also eliminating the remaining sources of hardware instability, are to be implemented immediately. Preliminary results show a greatly reduced incidence of distortion and diagnostic artifacts.

E. Kolemen went to DIII-D to develop and test the adaptive ELM control. The control will be tested in the next couple of weeks.

International (R. Hawryluk):

A conference call was held with EAST to discuss preliminary results using the flowing liquid lithium limiter. These experiments were conducted at the end of the recent research campaign using the limiter fabricated by PPPL and the infrastructure fabricated by ASIPP.

ADVANCED PROJECTS (D. GATES):

An important milestone was achieved this week in the Laboratory's collaboration with the Wendelstein 7-X (W7-X) project at Germany's Max Planck Institute for Plasma Physics (IPP). Commissioning of the U.S.-supplied trim coil system was completed up to the performance level need for the first operating campaign. The system of five coils and their associated power supplies and switches was designed by PPPL, fabricated by U.S. manufacturers, and installed in the W7-X facility by IPP. Previously the power supplies were commissioned into a dummy load and coolant flow through the coils was tested. With the successful commissioning campaign, the system is being operated for the first time as a fully integrated system, including integration with the W7-X central control system. A temporary administrative limit of 60% of rated trim coil current has been adopted since this is sufficient for the goals of the first campaign; commissioning to full current will be carried out at a later time based on physics program needs.

D. Gates participated in the Committee of Visitors held December 3-5 at DOE in Germantown, Maryland. The Committee of Visitors has a charge to evaluate the efficiency and quality of awards processes, the effect of those processes on the breadth and depth of the program and the national and international standing of the program, and FES's management of its portfolio of projects including its US contributions to the ITER program. A summary of the Committee's findings was presented to DOE at the end of the meeting. A summary report will be presented to the FESAC Committee in the near future.

THEORY (A. BHATTACHARJEE):

During November 12-20, A. Bhattacharjee visited the National Institute for Fusion Science (NIFS), the University of Tokyo, and gave a plenary talk at the Plasma 2014 Conference in Nilgata, Japan. At NIFS, he gave a talk on "Highlights of PPPL Theory Department," and at the

University of Tokyo on "Plasmas and Supra-Arcade Downflows: Secondary Instabilities in Eruptive Solar Reconnection Events." His plenary talk at the Plasma 2014 Conference was on "The Dynamo Effect in Laboratory and Astrophysical Plasmas." Other plenary speakers at the Plasma 2014 Conference, which is an interdisciplinary conference organized by three professional societies in Japan, were David Campbell (ITER Organization), John Edwards (NIF), and Masaru Hori (Nagoya University).

Susan Clark from Columbia University presented a theory seminar on exploring the saturation of the MRI via weakly nonlinear analysis: Understanding the mechanism by which the magnetorotational instability (MRI) saturates is key to understanding the process by which it drives anisotropic MHD turbulence and transports angular momentum. Previous work has laid down the framework necessary to perform a weakly nonlinear analysis of the MRI near onset (that is, when the background magnetic field is just weak enough for the MRI to be unstable to its most unstable mode). Such analyses have been essential for understanding the turbulent transport of heat by convection in the Rayleigh-Benard problem, and we seek to extend those successes to the transport of angular momentum by the MRI. Our setup yields a global solution in a radially bounded domain designed to be relevant to Taylor-Couette experiments. We derive the equation for perturbation growth in the weakly nonlinear case and then solve the equation using the general-purpose spectral code Dedalus. We compare this to a fully nonlinear simulation using Dedalus. One major advantage of analytic studies such as these is that we can capture the behavior despite the scale separations caused by large ratios of molecular viscosities and resistivities (magnetic Prandtl numbers). We will present early results on the saturation properties of the MRI for a variety of dimensionless parameters, as well as a preliminary analysis of a related instability, the helical MRI.

W. Tang participated in the SC'14 Conference, November 16-20 in New Orleans, Louisiana and presented an invited keynote talk on "Data Intensive Science Challenges in Fusion Energy Research" at the International SC Workshop on Big Data Analytics: Challenges and Opportunities."

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

S. Ethier was invited to submit an article to the upcoming special issue of the IEEE Computing in Science & Engineering magazine commemorating the 40th anniversary of the National Energy Research Scientific Computing Center (NERSC). The article, entitled "NERSC's Impact on Advances of Global Gyrokinetic PIC Codes for Fusion Energy Research", gives a historical description of the development of gyrokinetic PIC codes at PPPL and the role that NERSC played in pushing the computational capabilities of these codes. The co-authors are C.S. Chang, S. Ku, W.W. Lee, Z. Lin, W.M. Tang, and W.X. Wang. The special issue is scheduled to come out next Spring.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Final preparations are underway for next week's Readiness For Operations review. The review team will review the Project's processes and procedures as a prerequisite for determining project readiness for starting machine operations. High power testing start-up is presently planned for late February 2015.

CS Upgrade: The PF buswork continues to be fit up on the machine in the NTC. Installation of the PF insulation and hipot testing continues in the CS Winding area. The last of the TF Flex connectors was cleaned and silver-plated in the CS Winding area. The OH water heater design continued this week. The requisition for the water is now in procurement, a specification for the heater is out for review and approval. The OH High Temperature and high-pressure hoses have been ordered and are scheduled to arrive on December 5. The TF power supply commissioning and testing is ongoing in FCPC.

Construction: Work continues in the upper and lower umbrellas on the PF, CHI and OH bus. Installation of the Massive Gas Injector system has been started. Installation of the MPTS exist side flight tube continues. MPTS electrical work on the south wall continues. The anchoring of the centerstack pedestal continues. Termination of the category 3 cables in the racks on the 119-foot platform has been completed and termination of the air-side instrumentation at the bulkheads has been completed. Power for the TMB system is being installed and the installation of the delivery tubing will start soon. Primary seals are being completed on the vessel and rough pumpdown is scheduled for December 15.

NBI Upgrade: BL1 duct installation is complete. Services work continued on BL2 source SF6 delivery line installation; associated platform work between BL1 and BL2 made great strides also. Power testing of M/Rs took place in preparation for NB PTPs and 4A M/R is complete. Controls work continues with installation of cable, trays, and terminations in NTC and gallery. Work continues on the N gallery shield wall statement of work and drawing. Progress continues on BL PLC software pages. Cryogenics system helium gas cleanup is underway on the entire system and the 500 horsepower compressors were restarted. Development of NB procedures continues and nears completion. Preparations continue for the Readiness Review scheduled the week of December 7. The monthly job status meeting was held with notable progress reported.

OFFICE OF ACADEMIC AFFAIRS (N. FISCH):

Recently, three graduate students graduated from the Program in Plasma Physics earning their Doctor of Philosophy Degree in Astrophysical Sciences at Princeton University. Nikolas Christopher Logan presented his dissertation on November 21, entitled, "Electromagnetic Torque in Tokamaks with Toroidal Asymmetries", he was co-advised by J. Menard, J.-K. Park, and Edward J. Strait, a senior staff member from the DIII-D Experimental Science Division at General Atomics. Nik is currently employed by PPPL but working at General Atomics on DIII-D. On November 24, Tyler Edward Abrams presented his thesis, entitled, "Erosion and Re-deposition of Lithium and Boron Coatings Under High-flux Plasma Bombardment" under the guidance of M. Jaworski and R. Kaita. Tyler is currently working at General Atomics. Finally,

on December 5, Clayton Edward Myers conducted his dissertation defense on the "Laboratory Study of the Equilibrium and Eruption of Line-tied magnetic Flux Ropes in the Solar Corona". Myers was advised by M. Yamada and H. Ji. He is now working as a full-time employee at PPPL on NSTX.

DIRECTOR'S OFFICE (C. AUSTIN):

S. Smith, S. Prager, A. Cohen, and M. Zarnstorff visited the Department of Energy on December 3 to discuss the annual Laboratory evaluation.

On December 4, S. Prager and R. Goldston participated in a roundtable discussion on fusion energy hosted by the American Security Project in Washington DC.

INVITED TALKS:

Tang, W., "Data Intensive Science Challenges in Fusion Energy Research," International SC Workshop on Big Data Analytics: Challenges and Opportunities, New Orleans

PUBLICATIONS:

Ono, M.; Jaworski, M.A.; Kaita, R.; Hirooka, Y.; Andruczyk, D.; Gray, T.K.; the NSTX-U Research Team, "Active Radiative Liquid Lithium Divertor Concept," Fusion Engineering and Design 89, 2838 (2014)

LEADERSHIP POSITIONS:

Gates, G., Committee of Visitors Germantown, Maryland

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