PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending September 13, 2013, are as follows:

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

At a progress meeting for the RGA diagnostic, a new layout was presented for the system which shares a port cell with an ITER cryopump. The proposed rails which support the remote handling of the pump have now been brought into the model. These rails present some constraints on the access for RGA maintenance, underlying the importance of "system integration reviews" (SIRs). The US will propose an SIR for this port cell at the next meeting with the IO.

Several years ago, Nova Photonics proposed an alternate to the present approach in constraining the tokamak equilibrium with local measurements of the internal magnetic field from line polarization due to the Motional Stark Effect (MSE-LP). The alternative was to measure the Lorentz electric field from precision spectroscopic measurements of the line shift (MSE-LS) and use this measurement as the equilibrium constraint. One advantage of the LS approach is lower sensitivity to the effects of coatings on the viewing mirrors. At the CDR for the MSE, the choice of approaches was identified as a critical design decision, and demonstration of LS measurements as an equilibrium constraint on an operating devices was deemed highly desirable. This week data from the JET tokamak was discussed by EU, US, and IO experts to determine whether a serious attempt should be made to do this demonstration on JET. It was suggested that this issue be raised at the upcoming diagnostics topical meeting of the International Tokamak Physics Activity (ITPA).

In order to refine interface definitions in the outer wall blanket area, the PPPL design of the toroidal interferometer polarimeter (TIP) corner cube reflectors (CCRs) was discussed with US experts, prior to revision of the interface sheets and prior to development of specifications and a Statement of Work for fabricating a TIP CCR prototype.

NSTX (M. ONO):

A number of NSTX and NSTX-U related talks were presented at the PFC meeting at ORNL on September 11-13. M. Jaworski (PPPL) presented "Materials and PFCs R&D in the NSTX-U program." R. Maingi (PPPL) presented "The dependence of discharge performance on pre-discharge lithium evaporation in high triangularity H-mode discharges on NSTX". J-W. Ahn and T.K. Gray of ORNL presented "Heat flux width study for ELM-free and ELMy H-mode plasmas in NSTX." T.D. Rognlien (LLNL) presented "Particle and heat fluxes to PFCs during snowflake divertor operation."

In addition to attending the PFC meeting, NSTX-U scientist M. Jaworski (PPPL) and Princeton University PhD-candidate T. Abrams attended the International Workshop on Plasma-Material Interaction Facilities. Abrams presented the talk, "Erosion and re-deposition of Lithium coatings on TZM molybdenum and graphite during high-flux plasma bombardment" based on experiments conducted at the Magnum-PSI linear plasma device at FOM-DIFFER in the Netherlands. One key finding of the work was that under the divertor-like plasma conditions in the Magnum-PSI device, the total erosion yields derived from optical emission spectroscopy and Thomson scattering measurements were found to be much lower than might be calculated from Langmuir-law evaporation into vacuum. These latter evaporation rates have long been used as a baseline for estimating temperature limits of liquid lithium PFCs and these new measurements indicate those temperature limits may require revision.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

E. Kolemen and R. Hawryluk led a National Campaign experiment this week on DIII-D with participation by Steve Wolfe from MIT. The experiment aimed to control confinement with n=3 resonant magnetic perturbations (RMPs) using the I-coils in an ELMy H-mode discharge. The initial test of the I-coils for feedback control of the plasma stored energy proved successful, maintaining the stored energy to within 2.5% of the prescribed level. The method holds promise for the use of non-axisymmetric field coils on ITER or a power plant for controlling confinement and fusion power.

R. Budny visited DIII-D this week to continue collaborative work with B. Grierson on predictive modeling of DIII-D discharges.

R. Maingi attended the Plasma Facing Components annual meeting in Oak Ridge, Tennessee from Sep 11-13. He presented a talk on behalf of the D3D boundary physics program, "DIII-D Boundary and Pedestal Program for 2013." He also served on the PFC Steering Committee, and as an on-site reviewer of the PFC program priorities as requested by FES.

ADVANCED PROJECTS (H. NEILSON):

In PPPL's collaboration on trim coils for Germany's Wendelstein 7-X stellarator, planning of future tasks for the installation, testing, and commissioning of the Power Supplies at IPP has begun. The five power supply units are currently en route to the Max Planck Institute for Plasma Physics and are scheduled to arrive at the project's Greifswald site in September. The units will be installed this Fall and commissioned using dummy loads in April 2014. PPPL is preparing installation and commissioning procedures for this U.S. equipment, and will lead the commissioning with an on-site team.

S. Lazerson gave a talk entitled "3D Equilibrium Reconstruction for Stellarators and Tokamaks" at Tri Alpha Energy in Foothill Ranch, CA. This talk provided an overview of recent efforts to reconstruct the plasmas of the LHD and DIII-D device using the STELLOPT code. The talk was

well received and prompted much discussion regarding diagnostic modeling and equilibrium reconstruction for their FRC (field reversed configuration) devices.

The U.S. Wendelstein 7-X partners (PPPL, ORNL, and LANL) prepared drafts of five task agreements documenting the planned collaboration tasks for next one to two years. The tasks and U.S. lead partners are: 1. Scraper Element Program (ORNL), 2. X-ray imaging crystal spectrometer (PPPL), 3. On-Site U.S. Engineering Collaboration (PPPL), 4. Magnetics and Control (PPPL), and 5. Infrared Imaging (LANL). The drafts were submitted to DOE Fusion Energy Sciences and to the Max Planck Institute for Plasma Physics for review.

THEORY (A. BHATTACHARJEE):

This week's theory seminar was presented by Dr. Paul Schmit from Sandia National Laboratories, and Princeton University Plasma Physics Alumn, on "Magnetic fields and tail-ion depletion in inertial confinement fusion". With a good introduction of Z pinch driven Inertial Confinement Fusion targets, he presented the physics of tail-ion transport (losses of fast ions) in ICF. He showed the numerical results of solving the tail-ion kinetic equations and compared with the analytical model of a simple threshold criteria [1]. The effect of B-field on tail-ion trajectories and losses was demonstrated through numerical kinetic modeling and shown that the Maxwell-averaged fusion reactivities are recovered more fully in uniformly magnetized cylindrical targets. Here is the abstract of this talk, "The impact of embedded magnetic fields on Knudsen layer formation and tail-ion depletion [1] near steep density and temperature gradients in inertial confinement fusion is investigated for the first time. Magnetic fields change the energy scaling of the ion diffusivity in a way that eliminates the preferential losses of fast ions compared to thermal ions. Simple threshold criteria give conditions such that the restoration of the ion tail distribution is sufficient to recover much of the lost fusion reactivity. The tail-ion kinetic equations are solved for hot fuel bounded by a cold, nonreacting wall using a numerical stochastic differential equation solver, and the modified fusion reactivities are calculated. We find that modest magnetic fields too weak to magnetize thermal ions are still sufficient to restore much of the lost reactivity, consistent with the threshold conditions. We also find that the Maxwell-averaged fusion reactivities are recovered more fully in uniformly magnetized cylindrical targets compared to uniformly magnetized spherical targets. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. [1] K. Molvig et al., PRL 109, 095001 (2012)."

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: Welding of the upper support ring for the TF outer legs was completed this week. Final shims are being fabricated to lock this ring in place. Bushings for the TF turnbuckle ends are being designed and fabricated by the field crew. Welding of the tFIDA diagnostic to the vacuum vessel continued this week. Re-insulating the outer TF flags continues. Welding of the

centerstack lift fixture and modifications to the centerstack tilt fixture continue in the Tech Shop. Bus bar fabrication has been started in the Tech Shop.

CS Upgrade: TF Bundle has been lifted into the mold, the mold covers have been installed and sealed. The bundle is being leak tested on Friday and installed into the oven on Saturday. The changeover from TF Bundle assembly to OH winding has begun in the CS area. The Priming room, TF Taping station have been removed to make room for the OH Winding station. The OH Winding station shop work is complete, the remaining work must be completed after the winder is moved into the CS winding area. The bundle tilt fixture installation in the CS winding area has commenced with the floor surveys for anchor installations. Fabrication of buss work is underway in the Tech Shop.

NBI Upgrade: Installation of the cryogenics services is complete. Vacuum jacket leak checking is in progress. The DI water system subcontract continues with final welding. After some flanges are installed, hydrostatic testing will occur. The Ion Source and Ion Dump DI H2O Pump procurement continues. Vacuum system installation detailed drawings are in progress and a package is being developed for installation. The power system cable and tray subcontract kickoff meeting was held this week and staff training and layout work has started. Progress on the rectangular duct shields continued. Thermocouple installation on armor tiles continues. Management preparations and dry run reviews are underway for the upcoming Office of Science review scheduled for early October 2013.

DIRECTOR'S OFFICE (C. AUSTIN):

September 9-10 - A. Cohen conducted a review at Brookhaven National Laboratory at their Center for Functional Nano Materials (CFN).

September 10-11 - A. Cohen attended the DOE Deputy Director for Field Operations meeting (DDFO) - at Brookhaven National Laboratory.

September 12-13, A. Cohen traveled to Berkeley, California to conduct a review of the Lawrence Berkeley National Laboratory business system upgrade.

PUBLICATIONS:

W. Deng (coauthored with Dr G.Y. Fu) titled "Optimization by marker removal for δf particle simulations" has been accepted for publication by Computer Physics Communications and has been available online at http://dx.doi.org/10.1016/j.cpc.2013.08.019 . This paper reports a technique for δf marker particle simulations to save markers and computing time by removing unimportant markers. The technique can be used for phase spaces of arbitrary geometry and dimension. Particularly, the technique has been tested in two particle-in-cell (PIC) simulations: a bump-on-tail simulation in 2D phase space and a toroidal Alfvén eigenmode (TAE) simulation in 5D gyrokinetic phase space. The latter one is performed by the kinetic/MHD hybrid code M3D-K. In these two simulations, the technique has saved markers by about 75% and 95%, respectively. In general, the more localized δf is in the phase space, the more markers can be saved.

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