PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending June 28, 2013, are as follows:

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

The Steady State Electric Network Team at PPPL held a kick-off meeting with HV Transformer Manufacturer (Hyundai Heavy Industries), and sent them a design review requirements document. PPPL issued a consulting subcontract to power transformer expert to assist with, and participate in, the ITER HV Transformer design review to be held at Hyundai Heavy Industries in Ulsan, Korea, mid-Sept. Note: this is standard operating procedure when procuring these items.

In weekly Conceptual Design Review follow-up meetings for the Motional Stark Effect (MSE) and Core Imaging X-ray Spectrometer (CIXS) diagnostics, discussions began on the scope of supply tables for the associated Procurement Arrangements.

Electron Cyclotron Emission (ECE) diagnostic experts at University of Texas and University of Maryland reported success, working with IN-DA experts, in modifying the collection optics to reduce the diameter of the active area of the hot calibration source from 20 to 15 cm. This alleviates crowding in the diagnostic shield module which houses two viewing labyrinths, each with access to a hot source.

PPPL engineers L. Dudek and D. Loesser served on the panel for a Final Design Review (FDR) of the Upper Port Plug Generic Structure. R. Feder (PPPL) made a presentation at the review on radiation leakage in the gap between the port plug and the vacuum vessel extension. There were no class 1 chits resulting from the FDR.

The Subcontract Evaluation Review Board for RFP 13-031-A - "ITER Low-Field Side Reflectometer (LFSR) R&D, Physics and Engineering Design Support and Diagnostic Hall Instrumentation Development" met to discuss initial evaluations and began compiling a list of questions for the offers to be sent out next week.

NSTX (M. ONO):

C.S. Chang (PPPL) made a presentation at the June 17 NSTX-U Physics Meeting on the capabilities and applications of the XGC1 that his group has been developing. The XGC suit of code capabilities span the range from non-turbulent neoclassical transport (XGC0), to turbulent regimes in simple, circular geometries (XGC-p) and in general geometries (XGC1). In the more general incarnation, the code can `handle both X-point geometry, transport along open field

lines, and impurities. The codes use a simplified Monte-Carlo neutrals code ("Baby DEGAS2") or the full DEGAS2. The full electromagnetic effects will be fully implemented within ~1 year, although this implementation can be accelerated if necessary (which for NSTX it is, owing to the importance of microtearing modes). Proper treatment of neutrals have been shown to be important in the resulting charge-exchange cooling near the edge and on their effect on the ExB shearing rate, which modifies the turbulence. One validation issue that needs to be studied is the effect of Finite Larmor Radius near the plasma edge in the low toroidal field NSTX plasmas, and whether these FLR effects impact the gyrokinetic ordering in this region. Possible high leverage studies for NSTX/NSTX-U using XGC1 include studying the dynamics of the L-H transition, assessing the role of Electron Temperature Gradient modes, especially near the edge, turbulence spreading in the central core that affects the electron transport there, impurity transport and the formation of internal transport barriers. Results from first gyrokinetic simulations of H-mode blobs were shown, with the blob dynamics shown to be associated with turbulent as well as neoclassical processes.

Preparations for plasma operations in the NSTX-U configuration continued with the ongoing fabrication and power testing of the new firing generators for the field coil power conversion (FCPC) system rectifiers. Testing has been completed on more than half of all the planned firing generators, and test results for all units have been identical giving us confidence that we can rely on bench testing for the remaining units. Power testing will continue to confirm Firing Generator operation with both the old and new fault detectors, and current balancing on multiple rectifiers. Autotransformer and transformer rectifier maintenance continues in the Neutral Beam yard.

ITER & TOKAMAKS (R. WILSON):

DIII-D (R. Nazikian):

W. Solomon led an experiment to investigate the density threshold associated with QH-mode access. The threshold was found to have a strong dependence on q95 and triangularity. In strongly shaped double null plasmas, the QH-mode was maintained with Greenwald fractions of up to 80%.

A. Nagy held a successful FDR on the optional B-coil Bus. The final details of the design were presented including corrections from the PDR. This optional bus will be fabricated if the repairs to the existing B-coil bus are unsuccessful.

ADVANCED PROJECTS (H. NEILSON):

Advanced Projects activities were well represented at the IEEE Symposium on Fusion Engineering, held June 10-14 in San Francisco. Progress in an ongoing study of a next-step fusion nuclear facility, K-DEMO, being carried out in collaboration with South Korea's National Fusion Research Institute, was reported in several papers: C. E. Kessel, et al., “Systems Analysis Exploration of Operating Points for the Korean Demo Program; T. Brown, et al., “Progress in Developing the K-DEMO Device Configuration;” K. Kim, et al., “A Preliminary Conceptual Design Study For Korean Fusion DEMO Reactor Magnets;” and G. S.

Lee, et al., “Korean Fusion Roadmap: K-Demo Design and R&D Plan.” Work in collaboration with Germany's Max Planck Institute for Plasma Physics was reported in "W7-X Trim Coils - Component Safety Aspects and Commissioning Strategy," by K. Risse, et al. In addition, results of a PPPL study motivated by FESAC's call for new research in quasi-symmetric stellarators was reported in "Facilities for Quasi-Axisymmetric Stellarator Research," by G. H. Neilson, et al.

In the Wendelstein 7-X (W7-X) trim coil collaboration, acceptance testing of the first trim coil power supply unit (PSU), fabricated by Applied Power Systems, Inc. (APS) of Hicksville, New York, was performed this week. Engineering and quality assurance staff from PPPL and the Max Planck Institute for Plasma Physics (IPP) witnessed the testing, which was judged successful pending APS providing final documentation for PPPL to review and approve. Minor control logic programming changes were adopted as a result of the testing, but these did not affect the success of the test. The second PSU is scheduled for final acceptance testing during the second week of July.

The Laboratory hosted a K-DEMO project meeting, attended by study team members from PPPL and from South Korea's National Fusion Research Institute (NFRI). As part of the ongoing evaluation of the current reference K-DEMO design point, PPPL's Peter Titus reported the status of magnet structure modeling and analysis. In addition, Kihak Im from the NFRI team reported initial neutronics calculations for blanket module design. Currently a solid breeder option is being investigated, and Im's calculations are being used to optimize the arrangement of blanket elements, i.e. first wall, neutron multiplier, breeder, manifolds, structure, and shield. The meeting resulted in several decisions regarding machine layout, which will be incorporated in computer-aided design (CAD) models as the study proceeds. With the first phase of the joint study coming to an end, an agreement on final report contents was reached. The second phase, scheduled to start in August, will lead to a conceptual study report of the K-DEMO facility in 2014.

THEORY (A. BHATTACHARJEE):

The Basic Plasma Physics Group gathered together on June 27. Graduate student J. W. Burby presented a talk titled "The Hamiltonian Mechanics of Stochastic Acceleration" on his recent research performed together with A. I. Zhmoginov (UC Berkeley) and H. Qin (PPPL). The research shows how to find the physical Langevin equation describing collisionless stochastic acceleration. These stochastic differential equations give a more complete description than the Fokker-Planck equation, as they determine the *n*-particle distribution function for any *n* and inherit the Hamiltonian nature of the underlying microscopic equations. This opens the door to using stochastic variational integrators to perform Monte-Carlo simulations of collisionless stochastic acceleration processes. The theory was illustrated by an application to a simple toy problem.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: The coolant tube leaks on TF13 have been repaired and the coil has passed hydro tests. The aluminum blocks have been installed on TF 13 and it will be meggered and installed

next week. This is the last TF outer leg to be installed, so once it is in the electrical cabling and TF outer support structure work can begin. The 109" platform modifications for MPTS have been completed. Set-up for the bays FG vessel cut for MPTS is in progress and the cut will occur next week. The welding of the upper umbrella stiffeners continues.

CS Upgrade: The completed TF quadrants are now being sanded in preparation of the full mold assembly and test. Sanding of the first two assemblies is nearly complete. The support fixtures for the full mold have been installed in the stands and are awaiting the delivery of the full mold. OH winding fixture tensioning table fabrication continues in the Tech Shop and is now down to punch list items. The oven stand for the Full Mold is also being fabricated in the Tech Shop. The CHERS modified passive plates have tested low for hardness due to the modifications made by brazing in a splice plate. The parts can be used as-is for the initial runs until replacements are fabricated from spare material on hand in the warehouse.

NBI Upgrade: TTC HVAC duct reinstallation is in progress. Fabrication and leakchecking of LHe and LN cryo line continues in the NB shop. Installation in the NTC continues. Fabrication and welding continues on the NB/TVPS duct and bellows shield components in the Tech Shop. The DI water system subcontract continues with pipe fitting, welding, and installations in the Pump Room. Planning for MER work is in progress. The power system cable and tray requisition has been processed and the drawing package is in final review. The JK VV reinforcements and SFLIP pieces are on order. A successful FDR was held for the SFLIP port installation. The IP is in progress. LCC Controls work continues.

BUSINESS OPERATIONS (K. FISCHER):

PPPL submitted its FY2014 execution Field Work Proposals (FWPs) to the DOE. The purpose of these FWPs is to describe the work to be performed in FY2014 at the project funding levels included for PPPL in the President's budget for FY2014.

ENVIRONMENT, SAFETY, HEALTH & SECURITY (J. LEVINE):

SPD generated an Implementation Plan to respond to the recommendations from the "PPPL Physical Protection System Risk Assessment" Report. The report summarizes the results of a DOE Office of Science led effort to conduct a physical protection system assessment of PPPL that was held in November 2012. The Implementation Plan responds to the 13 recommendations and was provided to DOE/PSO.

SPD responded to one data call from the DOE Safeguards and Security Division regarding an FS-10 Budget Exercise.

INVITED TALKS:

E. Kolemen gave an invited talk at the RF Conference in Sorrento, Italy on real time NTM control on DIII-D, “Neoclassical Tearing Mode Control by Electron Cyclotron Current Drive

Using Dynamic Alignment To Access Higher Performance", by E. Kolemen, A.S. Welander, R.J. La Haye, R.A. Ellis, N.W. Eidietis, D.A. Humphreys, J. Lohr, V. Noraky, B.G. Penaflor, R. Prater and F. Turco. [ITER & TOKAMAKS – DIIID]

F. Poli gave an invited talk at the RF Conference in Sorrento, Italy on predictive modeling of the ITER fully non-inductive plasma performance utilizing various combinations of heating systems. The title of her talk was "Heating and Current Drive Requirements Towards Steady State Operation in ITER", by F.M. Poli, C.E. Kessel and P.T. Bonoli [ITER & TOKAMAKS – ITER]

PUBLICATIONS:

The paper "Plasma Facing Surface Composition During NSTX Li Experiments" by C.H. Skinner (PPPL) et al., R. Sullenberger, B.E. Koel, M.A. Jaworski, and H.W. Kugel has been published in the Journal of Nuclear Materials (vol. 438 (2013) pp.S647-S650). It reports laboratory studies of the chemical composition of lithium surfaces exposed to typical residual gases found in tokamaks. Solid lithium and a molybdenum alloy (TZM) coated with lithium were examined using X-ray photoelectron spectroscopy, temperature programmed desorption, and Auger electron spectroscopy both in ultrahigh vacuum conditions and after exposure to trace gases. Lithium surfaces near room temperature were oxidized after exposure to 1–2 Langmuirs of oxygen or water vapor. Lithiated PFC surfaces in tokamaks will be oxidized in about 100 s depending on the tokamak vacuum conditions. [NSTX]

The paper "Study of Non-axisymmetric Divertor Footprints Using 2-D IR and Visible Cameras and a 3-D Heat Conduction Solver in NSTX" by J-W. Ahn (ORNL), et al., has been published in the Journal of Nuclear Materials (vol. 438 pp. S317-S320). It presents data for toroidally non-axisymmetric divertor profiles during the 3-D field application and for ELMs with simultaneous observation by a new wide angle visible camera and a high speed IR camera. This confirmed the validity of vacuum field line tracing on the prediction of split strike point pattern by n=3 fields. A newly implemented 3-D heat conduction code was also used to obtain 2-D divertor heat flux, which allowed for defining the degree of asymmetry (e_{DA}) to quantify the asymmetric heat deposition on the divertor surface. e_{DA} is found to have a strong positive dependence on peak heat flux for all cases of investigation. [NSTX]

The paper "Overview of Innovative PMI Research on NSTX-U and Associated PMI Facilities at PPPL" by M. Ono (PPPL) et al., has been published in the Transaction of Fusion Science and Technology (vol. 63 pp.21-28, 2013). It describes an overview of the NSTX-U PMI research that is focused on developing innovative divertor heat flux solutions for future devices. With ~ 15 MW of auxiliary heating power, NSTX-U will be able to test the PMI physics with the peak projected divertor plasma facing component (PFC) heat loads of up to 40-60 MW/m^2. The snow-flake configuration can produce exceptionally high divertor flux expansion of up to ~ 50. Another area of active PMI investigation is the effect of divertor lithium coating (both in solid and liquid phases). The overall NSTX lithium PFC coating results suggest exciting opportunities for future magnetic confinement research. To support the NSTX-U PMI research, a comprehensive set of PMI diagnostic tools are being implemented. To support the NSTX-U/PPPL PMI research, there are also a number of associated PMI facilities implemented at PPPL/Princeton University including the Liquid Lithium R&D facility, Lithium Tokamak Experiment, and Laboratories for Materials Characterization and Surface Chemistry. [NSTX]

The following PPPL reports were published to the web:

Progress in Developing the STFNSF Configuration PPPL-4919
Authors: T. Brown, J. Menard, P. Titus, A. Zolfaghari, L. El Guebaly, L. Mynsberge
Submitted to: SOFE 2013 Proceedings (June 2013) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Progress in Developing the K-DEMO Device Configuration PPPL-4920
Authors: T. Brown, et. al.
Submitted to: SOFE 2013 Proceedings (June 2013) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Hardwired Control Changes For NSTX DC Power Feeds PPPL-4921
Authors: S. Ramakrishnan, Xin Zhao, C. Neumeyer, J. Lawson, R. Hatcher, R. Mozulay, E. Baker, W. Que
Submitted to: 2013 Proceedings (June 2013) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Power Supply Changes for NSTX Resistive Wall Mode Coils PPPL-4922
Authors: S. Ramakrishnan, C. Neumeyer, R. Mozulay, E. Baker, R. Hatcher, J. Lawson, W. Que, X. Zhao
Submitted to: 2013 Proceedings (June 2013) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Design Analysis and Manufacturing Studies for ITER In-Vessel Coils PPPL-4923
Authors: M. Kalish, et. al.
Submitted to: SOFE 2013 Proceedings (June 2013) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Novel Use of Water Soluble "Aquapour" As A Temporary Spacer During Coil Winding For The NSTX-U Centerstack PPPL-4924
Authors: M. Mardenfeld, J. Chrzanowski, M. Anderson, E. Kearns, C. McFarlane, S. Raftopoulos, W. Reese and R. Tucker
Submitted to: SOFE 2013 Proceedings (June 2013) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

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