Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending September 22, 2016 are as follows:

U.S. ITER FABRICATION (C. NEUMEYER):

Steady State Electric Network (SSEN):

Uninterruptible Power Supply (UPS) system and DC Distribution: Contracts and supporting materials have all been prepared and transmitted for approval prior to signature. The UPS package requires DOE approval, whereas the DC Distribution package is below the threshold. Our objective is to award the contracts before September 30.

Arrangement for UPS + DC Distribution Battery Banks and for LV Distribution & Sub-Distribution Panels: An "Arrangement" will be used to transfer these items for future procurement by the ITER Organization because the storage life of the battery banks is limited and because the distribution panel requirements are not yet mature. The Arrangement document has been prepared and a memo establishing the cost basis has been submitted for approval by the ITER Organization. Our objective is to sign the Arrangement as soon as the contracts for the UPS and DC Distribution are signed.

Power Transformers: Shipment of Group 1 and 2 transformers (that comprise shipping lots number 1 and number 2) from the Schneider Electric factory near Istanbul, Turkey, was targeted to begin on September 26 but has slipped again due to logistics complexities and holiday closure of the factory in Turkey this past week.

NSTX-U (M. ONO):

The NSTX/ NSTX-U Results Review was held on September 21 and 22, in which members of the Research Team (both on and off-site) gave short summaries of research accomplishments and ongoing studies over the last year. These summaries included analysis of NSTX data as well as research and Experiment summaries from the initial operational period on NSTX-U. In all, fifty-four presentations were made, with the following breakdown: Materials and PFC (six presentations), Energetic Particles (eight presentations), Waves (three presentations), Advanced Scenario Control (nine presentations), Pedestal and Divertor (six presentations), Macrostability and Solenoid-Free Start Up (ten presentations), and Transport and Turbulence (twelve presentations). (S. Kaye, PPPL)

Felipe Bedoya successfully completed his preliminary examination for the doctoral program in the Department of Nuclear, Plasma, and Radiological Engineering at the University of Illinois at

Urbana-Champaign (UIUC). Bedoya presented the proposal for his thesis research, which included the examination of samples exposed during boronization and NSTX-U plasma operations. He was able to analyze them without exposure to air with the Materials Analysis and Particle Probe (MAPP) while at PPPL. Bedoya will continue studying the MAPP samples at UIUC, where he can do a comparison with samples from NSTX-U divertor tiles. (R. Kaita, PPPL)

R. Churchill, A. Fil, R. Lunsford, and R. Maingi of PPPL visited DIII-D from September 12–16 to discuss enhancing and expanding collaboration opportunities during the ongoing NSTX-U outage. Michael Churchill presented a talk entitled "Kinetic simulations of scrape-off layer physics in the DIII-D tokamak" to the Boundary and Plasma Materials Interaction Center. In addition Fil presented "Modeling of lithium granule injection with M3D-C1" and Lunsford presented "Multi-species granule injection on DIII-D and NSTX-U" to the PedELM group. Productive discussions were had with both DIII-D researchers and PPPL scientists stationed at GA about the most beneficial way to utilize the contributions of PPPL scientists during the upcoming year. They also examined the operational prototype of a new method of regular frequency granule delivery developed by PPPL engineer A. Nagy and discussed the possibility of its implementation in upcoming DIII-D experiments. (Lunsford)

Rob La Haye of General Atomics visited PPPL for the NSTX-U results review and to work with Lucas Morton (ORAU) on preliminary analysis of n=1 tearing modes in NSTX-U (for comparison to NSTX). (R. LaHaye)

Engineering Operations (A. von Halle, P. Titus):

CHERS/FIDA and BES spatial calibrations have been completed, and electrical installations for the S-Flip and I-Flip diagnostics continue. IR camera calibrations have been completed. The rack for the RF Langmuir diagnostic has been installed and electrically tested. Set-up of the coil winding facility continues. The neutral Beam helium refrigerator compressors have been removed for scheduled maintenance. A cost/schedule review of the design/installation plans of the new Cryopump Divertor (CPD) was held this week.

On September 19, a Peer Review was held to review the status of the forensic investigation of the failed NSTX-U PF1A-U coil. The Peer Review served two purposes. First, it reviewed all of the non-destructive evidence obtained to date, including a summary of anomalies uncovered by extensive radiography. Second, based on these results, it was proposed to initiate the destructive part of the investigation by cutting the coil into three distinct sections that would preserve all of the potential evidence in the coil. Cutting methods were reviewed and end mill cutting at PPPL was agreed as the best approach. During the cutting process, care will be taken to capture any coolant and/or residue released by the coil. Following coil sectioning, a series of initial tests will be performed including individual turn borescoping, electrical and pressure/vacuum tests. These tests will hopefully indicate compromised locations within the coil that may have either caused or led to the coil's failure. Braze joints and joggles will be examined as part of this investigation. Presently, procedures and documents (NEPA, JHA, etc.) are being prepared for review that will outline the sectioning and initial testing processes. A Package Review is planned to assure that a consensus is reached by all stakeholders. Depending on the results, initial testing may be followed by additional testing, including CT scanning of coil sections. The investigation is fluid

depending on the evidence found, however, additional steps will not be taken without being reviewed by a peer group first. (I. Zatz, PPPL)

Experimental Research Operations (S. Gerhardt, R. Kaita):

In vessel diagnostic calibrations started on Monday 9/19, with the completion of the BES (beam emission spectroscopy) spatial calibration (D. Smith, UW). On Tuesday early morning, photos were taken to support the spatial alignments of the University of Tennessee spectroscopy system (K. Gan, UT). The bulk of time on Tuesday, Wednesday, and Thursday was dedicated to spatial calibration of the vertical FIDA (fast ion D-Alpha), ERD (edge rotation diagnostic), rtV (real time velocity), poloidal CHERS (charge exchange recombination spectroscopy), and toroidal CHERS systems (M. Pedesta, PPPL, R. Bell, PPPL, D. Liu, UI). Time was also spent on Thursday early morning on the ORNL IR (Infrared) camera calibrations (T. Gray, J-W. Ahn, ORNL), and on Friday morning on the ORNL reflectometer (C. Lau). Time was also spent on Thursday and Friday to complete the spatial calibration of the two T-FIDA (tangential-) system. Finally, Friday ended with the start of spatial and photometric calibrations for the various LLNL spectroscopic imaging systems which will continue over the weekend and into next week (F. Scotti, LLNL).

ITER & TOKAMAKS (R. HAWRYLUK):

C-Mod (S. Scott)

The MSE system was used in support of LHCD experiments last week data. Quality was excellent despite moderate density (nebar = 1.0 to 1.4 e20) with pitch-angle error bars typically 0.2 – 0.3 degrees. At a plasma density (nebar = 0.8-0.9e20) less than the historical LHCD density 'limit' of ~ 1.e20, application of ~600 kW of LHCD generated clear changes in the pitch-angle profile in the mid-radius (between q=1 sawtoothing radius and the edge) of 1-2 degrees. The change in loop voltage was modest, about 20-25%.

ADVANCED PROJECTS (H. NEILSON):

A draft community report, "Stellarator Research Opportunities," was issued to members of the National Stellarator Coordinating Committee (NSCC) for comment. The report outlines a program of U.S. stellarator research for the next decade or more, building on the current U.S. partnership with Germany's Wendelstein 7-X stellarator and capitalizing on recent physics and technology advances that can dramatically improve reactor candidates. Critical research needs are described in detail and a vision of a world-leading U.S. stellarator research program, including new experimental facilities, is presented. The report was an outgrowth of the stellarator community research needs workshop held in February. Preparation of the draft was led by NSCC co-chairs D. Gates of PPPL and Professor David Anderson of the University of Wisconsin.

The Advanced Projects Department issued a report of its accomplishments in Fiscal Year 2016. The report highlights PPPL activities managed by the Department, including leadership of the United States collaboration on Wendelstein 7-X and contributions to the first experimental

campaign, leadership of the national Fusion Energy System Studies program, and strategic partnerships in fusion engineering science with S. Korea and China.

THEORY (A. BHATTACHARJEE):

Professor Allen H. Boozer of Columbia University presented a theory seminar titled "Relativistic Electrons and Magnetic Reconnection in ITER." ITER, the largest scientific project ever undertaken, "has been designed to prove the feasibility of fusion" energy. That mission could be compromised if the net current in the plasma were transferred to relativistic-electron carriers, which can result in great damage to the device. Professor Boozer discussed how a sudden drop in the plasma temperature could cause such a transfer, and that the destruction and creation of magnetic surfaces is an especially dangerous situation because relativistic electrons can be lost in a short pulse along a narrow flux tube. Using Maxwell's equations, helicity conservation, and relaxation arguments, the theoretical challenge was elucidated, and the potential for damage and the importance of the atypical (e.g. incidents that occur once in a thousand shots) make theory and simulation essential for ensuring that relativistic runaway electrons will not prevent ITER from achieving its mission. The U.S. DoE Office of Science has established a Simulation Center for Runaway Electron Avoidance and Mitigation (SCREAM) with a two-year funding of $3.9M.

Various members of the Theory Department participated in the "NSTX-U Results Review" held at PPPL: Dr. N. Gorelenkov gave a presentation titled "Building 1D resonance broadened quasi-linear (RBQ) code for fast ion Alfvenic relaxation"on the progress of developing the perturbative code applicable for present day and future experiments. The new code couples existing NOVA-K calculations of the wave-particle interaction matrixes. It promises to be numerically effective to compute the relaxed profiles of beam ions. Dr. E. Kim presented a talk titled "Edge loss modeling and plans" about her recent work for fast wave propagation using the FW2D code in the scrape-off-layer (SOL). V. Duarte presented "Predicting frequency chirping for Alfvénic modes" summarizing recent advances on modeling and predictions for the likelihood of different types of nonlinear evolution of waves upon their destabilization by fast ions in tokamaks. It has been shown that micro-turbulence can play a crucial role in determining whether a mode will chirp or remain as fixed frequency oscillations. Dr. J. Breslau presented a status update on the new highly-optimized, hybrid kinetic energetic-ion module under development for the M3D-C1 code, which is nearly ready for testing on a linear benchmark case. Dr. E. Belova described fully nonlinear simulations of compressional Alfvén eigenmodes (CAEs) using the HYM code, showing that calculated power absorption at the resonance agrees with previous quasi-linear estimates, supporting the energy channeling mechanism. The absorption rate shows a very strong scaling with growth rate, predicting significant energy losses at the kinetic Alfvén wave (KAW) resonance at high beam powers in NSTX-U. Initial simulations of GAEs in NSTX-U show a complete suppression of unstable global Alfvén eigenmodes (GAEs) by off-axis beam injection in agreement with experimental findings. (E. Fredrickson GAE stabilization experiments). Dr. N. Ferraro presented evaluations of several potential sources of error fields in NSTX-U. Error fields have been found to have significant impact on NSTX-U performance, with nearly all L-mode discharges exhibiting locked modes. Most known sources of error fields, including eddy currents induced in the non-axisymmetric vessel, and non-circularity of the so-called PF5 coils, appear to be too weak to account for the observed behavior. Metrology that will be undertaken over the next few months will help to improve our understanding. Dr. D. Stotler presented initial neoclassical impurity transport calculations performed with the drift-kinetic PIC code,

XGC0. The principal finding was an increase in core impurity radiation relative to that obtained with a coronal equilibrium assumption. Dr. T. Stoltzfus-Dueck described how the parallel electron response links density and potential fluctuations on rapid electron transit timescales. Since this also links the free energy in non-zonal density and ExB fluctuations, Reynolds work cannot deplete the ExB kinetic energy in turbulence without also depleting the much larger free energy in density fluctuations. This basic physics underlies experimental results that rule out depletion of turbulent energy by Reynolds work ('predator-prey') as a physical mechanism for the L-H transition on NSTX. Dr. S. Ku's presentation was titled "NSTX studies using XGC" and described the understanding of turbulence modes in NSTX edge plasma and the divertor heat-flux width.

HUMAN RESOURCES (A. MOTEN):

The Office of Human Resources completed a Compensation Re-certification as required by the DOE Contract. The purpose of the re-certification was to assure that the total compensation system is fully documented, consistently applied, and acceptable to the Contracting Officer. The review took place over four days, and review team included PPPL Human Resources, DOE, and a Compensation Manager from Los Alamos National Laboratory. Overall, the review was successful. We expect to receive a full report at the end of October.

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