PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights

PPPL

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending July 8, 2016 are as follows:

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

Steady State Electric Network (SSEN):

Uninterruptible Power Supply (UPS) system and DC Distribution: Proposals are due on July 15.

Power Transformers: Lot #1 and Lot #2 oil-filled units (eight @ 35MVA and four @ 7MVA) are ready for shipment from the Schneider Electric factory near Istanbul, Turkey The Release for Shipping documentation package is in final review, and a delivery planning meeting was held on July 1. Shipping is now scheduled for July 26.

6.6kV Switchgear: The 48 cubicles in Lot #2 were shipped from the Schneider Electric factory in Manisa, Turkey and delivered on July 4 to a factory in Barcelona, Spain, where the EU team will install them in modular substation containers. Shipment of the remaining 110 cubicles in Lot #3 and #4 is scheduled for July 29. As soon as PPPL signs the shipping release it can declare completion of the last of the DOE SSEN performance plan milestones for FY2016.

Diagnostics:

The team has been busy preparing information and documents (spending plan, schedule, revised WBS dictionary, revised cost estimates, revised risk analysis, and revised procurement plan), due to the U.S. ITER project office by July 15, for an upcoming Independent Project Review (IPR), and an Independent Cost Review (ICR), in support of DOE's objective to achieve approval of a CD2A/3A baseline by December. The new plan being developed subdivides the scope of the project into First Plasma, and Post-First Plasma elements.

Upper Port Wide Angle View Vis-IR Cameras (UWAVs): The RF Argon Discharge Sputtering Mirror cleaning prototype rig set up, assembly and commissioning is progressing steadily at TNO. Various parts are installed and functional and qualification tests are being performed. The top part of the setup was assembled in the vacuum chamber. Capacity measurements were performed on the cleaning setup to validate the matching to the RF generator. Differential pressure sensors are connected and tested with the data acquisition system. The gas delivery system was connected and tested successfully. A test plasma was ignited using the 13.56 MHz RF generator. The team is working towards completing the commissioning of the mirror cleaning test stand by the end of August, which will fulfill a DOE Performance Plan Milestone for FY2016.

Electron Cyclotron Emission (ECE): PPPL group had a site visit to UT for status evaluation of the ECE hot source development project. The one-day meeting included presentations on the current developments in hot source model analysis, experimental testing, and design. Emissivity enhancement of the hot source heating element was determined as a critical aspect in developing a hot source which will be able to provide 700C emitting surface with sufficient margins. Encapsulated heating element design was chosen based on the structural characteristics. There is a possibility of testing a molybdenum heating element, operating at higher temperatures than current Inconel heater. A molybdenum heater can further increase safety margins of the design, however, it can delay development further. At this stage the Inconel encapsulated heater design with enhanced emissive surface is defined as a primary path forward. PPPL is developing a fixed mirror alignment mechanism, which was intended to comply with remote handling. However, there is a possibility of replacing the whole ECE DSM with a new one in cases where repairs in the hot cell are required. This possibility will be discussed and include some cost analysis.

Diagnostic RGA (DRGA): Revisions to the rough draft of the DRGA R&D report are well underway with the aim that a refined draft version will be ready for upload to iDocs next week. Approval of this document is a DOE Performance Plan Milestone for FY2016. A decision has been made that the DRGA units will not be required for first plasma. For the LP12 system only those bits required to mate to the vacuum vessel (pipe, blanking flanges, etc.) will be provided. Otherwise, design activities will continue through the Final Design acceptance. A concern that the Penning OGA system is based on hardware no longer manufactured is being addressed. Discussions thus far indicate that a near term focus on upgraded electronics is warranted.

Port Plug Test Facility (PPTF): U.S. ITER and PPPL informed the ITER Project this week that a 2020 PPTF delivery to PPPL will not be possible under current budget constraints and project focus on First Plasma Scope. Hosting one of the four PPTFs at PPPL remains a critical part of the port plug integration and testing activities. Once a Post First Plasma project and budget are reestablished within the U.S., a new plan to host the PPTF will be developed.

NSTX-U (M. ONO):

A FY2016 NSTX-U plasma operations update: The department has completed 10.06 run weeks and 1066 plasma shots. The total operation target is 18 run weeks.

S. Sabbagh (Columbia University) delivered the 2016 Landau-Spitzer Award lecture on behalf of fellow awardees J. Berkery, Yueqiang Liu (CCFE), and H. Reimerdes (EPFL) at the EPS Conference on Plasma Physics, held July 4-8 in Leuven, Belgium. The lecture, titled "Establishing a verified understanding of kinetic MHD theory to determine global mode stability in tokamak plasmas," highlighted the research recognized by the award, which covers a time period of approximately one decade. S. Sabbagh and H. Reimerdes accepted the award in person during the opening ceremony of the meeting, with explicit recognition given to all awardees.

S. Kaye (PPPL) authored a chapter on NSTX and NSTX-U in the book "Magnetic Fusion Energy: From Experiments to Power Plants," which was published by Elsevier in late June. The chapter presented highlights of NSTX research since device inception to culmination, focusing on the physics that that addressed the critical issues for establishing the basis of ST research. The chapter also covered issues unaddressed or identified by NSTX, as setting the design and

goals for NSTX-U. R. Maingi (PPPL) authored a chapter for the same book titled "Plasma Exhaust."

A paper by G. J. Kramer (PPPL) et al. on "Mitigation of Alfvénic activity by 3D magnetic perturbations on NSTX," was published in Plasma Physics and Controlled Fusion (http://dx.doi.org/10.1088/0741-3335/58/8/085003). The abstract reads: "Observations on NSTX indicate that externally applied non-axisymmetric magnetic perturbations (MP) can reduce the amplitude of TAEs and GAE in response to pulsed n=3 non-resonant fields. From full-orbit following Monte Carlo simulations with the 1- and 2-fluid resistive MHD plasma response to the magnetic perturbation included, it was found that in response to MP pulses the fast-ion losses increased and the fast-ion drive for the GAEs was reduced. The MP did not affect the fast-ion drive for the TAEs significantly but the Alfvén continuum at the plasma edge was found to be altered due to the toroidal symmetry breaking which leads to coupling of different toroidal harmonics. The TAE gap was reduced at the edge creating enhanced continuum damping of the global TAEs, which is consistent with the observations. The results suggest that optimized non-axisymmetric MP might be exploited to control and mitigate Alfvén instabilities by tailoring the fast-ion distribution function and/or continuum structure."

M. Jaworski (PPPL) begins a month-long visit at the University of Illinois collaborating with the research groups of Professors Jean Paul Allain and David Ruzic. The research is dedicated to developing technologies and procedures for implementing pre-filled liquid metal targets for the NSTX-U, capable of maintaining lithium purity even through the bake-out process. The work will also include diagnostic development to examine the structure of the lithium vapor-cloud previously observed during high-temperature lithium experiments.

NSTX-U plasma operations were on hold this past week after discovering what appears to be a water leak in a winding of the PF1aU coil. The PF1aU coil has been taken out of service for the remainder of this year's run campaign, and experimental proposals have been modified to use PF2 for similar plasma shape control. Pre-operational testing of the new Massive Gas Injector (MGI) system was successfully completed, and gas injection testing into NSTX-U vacuum is in progress.

The limit switches on the linear probe drive for the Materials Analysis and Particle Probe (MAPP) have been attached in their final positions. The final step for enabling MAPP remote position control is to check probe operation using NSTX-U EPICS real time control software.

The vacuum bake of the two Lithium Evaporator (LITER) probes currently mounted on the fill stand has been completed, and the motion controls of the two LITER probes mounted on the NSTX-U vessel have been successfully synchronized to the shot clock and tested.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

B. Grierson led an experiment on DIII-D to assess the impact of ECH heating and toroidal rotation on core tungsten accumulation during the DIII-D Metal Rings Campaign. Discharges were executed with the strike point positioned on tungsten coated tiles that encircle the

lower divertor and a range of ECH heating and deposition were explored from mid-radius (rho=0.5), near-axis (rho=0.2) and on-axis (rho<0.1). Indication of a strong reduction of on-axis core tungsten accumulation was observed for on-axis ECH heating and as the electron density profile inside of rho=0.2 was flattened.

International (D. Mueller):

D. Mueller visited KSTAR from June 15 to June 25 to perform an experiment on "Fast vertical control in KSTAR." One-half run day was assigned for the experiment to qualify the new electronics that provide a relative flux measurement for pairs of loops symmetrical about the mid plane for use as the sensors in the vertical control loop acting upon the fast internal control (IVC) coil in KSTAR. The experiment was successful in demonstrating the use of the new signals, which have better signal-to-noise and larger vertical separation than the previously used sensors.

The short run-time allocation meant that only part of the originally proposed measurements could be completed, however, the use of the new sensors in limited, elongated plasmas was demonstrated and 90 percent of that was finished. These results provide a template for extending the use of the new sensors in elongated, diverted plasmas where better fast vertical control will permit operation at higher elongation. In single null discharge shapes, the new sensors' larger vertical separation will allow for more up/down asymmetric plasma to be controlled without concern that the plasma vertical center is outside the measurement range of the sensors.

ADVANCED PROJECTS (H. NEILSON):

A paper entitled "First measurements of error fields on W7-X using flux surface mapping" by S. Lazerson, et al., has been accepted for publication as a Nuclear Fusion regular article. This paper details flux surface mapping experiments performed by S. Lazerson and Dr. Matthias Otte of the Max Planck Institute for Plasma Physics (IPP) designed to probe the existence and magnitude of error fields in the Wendelstein 7-X (W7-X) stellarator. To achieve this, a new magnetic configuration was developed by S. Lazerson (the iota=1/2 configuration), which met the operational constraints of the first experimental campaign. This configuration placed the iota=1/2 resonant surface at the mid radius of the device which was then imaged using the flux surface mapping diagnostic. By applying a probing n=1 magnetic field from the U.S. supplied trim coil system, an m=2 island chain could be opened and imaged. Using a compass-scan technique the amplitude and phase of the intrinsic error field could be determined. This was done as part of S. Lazerson's 11-month stay at IPP-Greifswald.

This week, S. Lazerson visited W7-X to continue work on error field studies, energetic particles, and equilibrium reconstructions. In collaboration with Glen Wurden (LANL), the limiter camera data has begun to be analyzed for experiments in which trim coil perturbing fields were applied. Initial analysis suggests the phase of the error field is similar in amplitude to that determined during flux surface mapping. A benchmarking activity for the BEAMS3D and ASCOT energetic particles codes has begun in collaboration with Simppa Äkäslompolo (IPP) to better understand various deposition models and particle loss estimates from neutral beam injection in W7-X. A conference call was held regarding equilibrium reconstruction and magnetics data processing. This call was attended by K. Rahbarnia and T. Andreeva of IPP, J.

Schmitt of Auburn University, and S. Lazerson. Additional meetings regarding data access were held with J. Svensson (IPP) to better understand the storage of processed data.

THEORY (A. BHATTACHARJEE):

On July 7, George Livadiotis (Southwest Research Institute) gave a theory seminar on the statistical origin and properties of kappa distributions: "Classical particle systems reside at thermal equilibrium with their velocity distribution function stabilized into a Maxwell distribution. On the contrary, collisionless and correlated particle systems, such as space and astrophysical plasmas, are characterized by a non-Maxwellian behavior, typically described by kappa distributions, or combinations thereof. Empirical kappa distributions have become increasingly widespread across space and plasma physics. A breakthrough in the field came with the connection of kappa distributions to non-extensive statistical mechanics. Understanding the statistical origin of kappa distributions was the cornerstone of further theoretical developments and applications, some of which will be presented in this talk: (i) The physical meaning of thermal parameters, e.g., temperature and kappa index; (ii) the multi-particle description of kappa distributions; (iii) the generalization to phase-space kappa distribution of a Hamiltonian with non-zero potential; (iv) the Sackur-Tetrode entropy for kappa distributions, and (v) the existence of a large-scale phase-space cell, characteristic of collisionless space plasmas, indicating a new quantization constant, ħ*~10-22 Js."

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