PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights

PPPL

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending May 20, 2016 are as follows:

FEATURED HIGHLIGHT:

On May 20, U.S. Secretary of Energy Ernest Moniz came to Princeton Plasma Physics Laboratory (PPPL) to dedicate the $94 million National Spherical Torus Experiment Upgrade (NSTX-U). Secretary Moniz also had an all-hands meeting with PPPL staff. Following the all-hand meeting, a Lab-wide reception with refreshments was held in the LSB lobby. U.S. Senator Cory Booker, (D-N.J.), U.S. Rep. Bonnie Watson Coleman (D-12), Princeton University President Christopher L. Eisgruber, and other Princeton University and local officials also attended the event.

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

A team of project management and business operations experts from U.S. ITER visited PPPL. The purpose of the visit was to interview key PPPL ITER administrative staff on project management and business operations best practices. The meetings were constructive and will lead to improvements in some areas.

Steady State Electric Network (SSEN):

Power Transformers: The Lot 3 transformers, consisting of 10 dry-type units—six @ 2.5MVA and four @ 1.6MVA were shipped on May 17 from the Schneider Electric factory near Istanbul, Turkey and are expected to arrive at the ITER site on May 24. Factory Acceptance Testing (FAT) of the Lot 1 and Lot 2 transformers was completed and correction of punch-list items is underway. Target date to begin shipping the Lot 1 and Lot 2 oil-filled units—eight @ 35MVA and four @ 7MVA is June 20.

6.6kV Switchgear: The Lot 2 Release for Shipping (RFS) documentation packages under review by the ITER Organization. Forecast shipping date for the 48 cubicles in Lot 2 from the Schneider Electric factory in Manisa, Turkey is June 3. Fabrication of the remaining 110 cubicles in Lot 3 and 4 are nearing completion and the FAT will commence on June 1.

Diagnostics:

Administrative: The Diagnostics and Port Plug Engineering project has several engineering openings for Project, Design and Analysis engineers. Over the past two weeks many candidates have been interviewed and a short list of engineers have been identified.

Electron Cyclotron Emission (ECE): The ECE Hot Calibration Source configuration with a conduction-contact heating arrangement between heater and emitting surface was tested by UT at Austin. There was no measureable improvement in performance compared to radiative heating where there is a gap between heater and emitter. Improvement of heater emissivity is a chosen path forward. Several options are investigated—mechanical modification of heater surface, and surface coating with high emissivity material. A UT site visit by PPPL is scheduled for early July to determine readiness of the hot source design to peer review in November. PPPL is continuing design of the front optics including push rod option for shutter mirror actuation. PPPL is preparing test fixture and facilities for the testing of the Piezo-motor prototype. The Piezo-motor prototype is expected to arrive at PPPL by the end of June.

Diagnostic RGA (DRGA): A meeting was held with Graeme Murdoch, U.S. ITER Non-Nuclear Systems Division Director, to discuss options for a successor for the DRGA CAM role since the person who fulfilled that role up to now is no longer available. Also met with Charles Smith regarding the pneumatic valves being used in the SVS valve control boxes. RGA would likely choose to use the same valves for its calibration system. Data analysis on optical species discrimination data is underway and is validating the feasibility of using an optical gas analyzer (OGA) to discriminate down to 0.1% He in D2. Hydrogen discrimination is not quite as well defined at that level.

Toroidal Interferometer and Polarimeter (TIP): Several concepts have been considered for the TIP in-vacuum port-plug-mounted first mirrors. These mirrors are subjected to significant nuclear thermal loads and disruption-induced shock loads, and must be one-time adjustable for alignment on assembly. One concept uses a rotating wedge design for adjustment with a copper mirror clamped to a water-cooled baseplate. However, concerns have arisen concerning long-term degradation of the copper mirror surface. Hence molybdenum is now being analyzed as a substitute material with better surface durability. It is hoped that the higher nuclear heat loads will be compensated by a lower ratio of thermal expansion to thermal conduction.

Core Imaging X-Ray Spectrometer (CIXS): For testing purposes, Xe has been injected into C-Mod plasmas with Te = 3 keV and ne = 4x10^19/m^3. The measured spectrum shows the 3D and 3F lines of neon-like Xe (and some Na-like satellites), which are candidate transitions for the ITER spectrometer. This is about the minimum electron temperature to strip Xe to the neon-like state. Investigations at higher Te and a test of a wavelength calibration technique (plasma X-ray photo-excitation of Ti K-alpha from a foil) will occur soon. Concurrently the C-Mod team is trying to perfect Xe puffing techniques that can be used on ITER.

A subcontract for nuclear testing of a CIXS X-ray imaging detector was placed this week with the University of Indiana at Bloomington Neutron Radiation Effects Facility (NREF), http://www.indiana.edu/~radeff/index.html). The detector will be irradiated by high energy neutrons with a similar neutron energy spectrum to ITER. The test will reach a fraction of the expected neutron fluence on ITER but this threshold will be well over expected damage levels. An Iron-55 X-ray source will be used periodically to test for degradation in X-ray imaging capability.

NSTX-U (M. ONO):

A FY 2016 NSTX-U plasma operations update: The department has completed 8.95 run weeks and 940 plasma shots. The total operation target is 18 run weeks.

U.S. Department of Energy Secretary Ernest Moniz dedicated the NSTX-U facility on May 20. Secretary Moniz, U.S. Senator Cory Booker (D-NJ), and U.S. Representative Bonnie Watson Coleman (D-12) toured the NSTX-U facility and visited the NSTX-U control room to learn about the NSTX-U performance and research goals for the coming decade. Secretary Moniz unveiled a plaque dedicated to the workers who have made NSTX-U a reality and will keep it operational. Additional information about the dedication ceremony can be found at the following URLs:
http://www.pppl.gov/news/2016/05/energy-secretary-moniz-launches-nation%E2%80%99s-newest-fusion-experiment-pppl and
http://www.nj.com/mercer/index.ssf/2016/05/us_secretary_of_energy_dedicates_94_million_upgrad.html

F. Poli (PPPL) was interviewed during the NSTX-U celebration event by Jeanette Beebe, journalist for WHYY. The interview has been aired on WHYY (90.9 FM) on May 23, as part of the Morning Edition newscast, and re-played a few times in the morning. The web story has been posted on Newsworks.org.

On May 20, five shots were taken towards XMP-154, aiming to demonstrate feedback control of the inner gap between the plasma and the center stack. Since the currently active shaping coils have all already been associated with feedback control of other shaping parameters (x-point locations, outer gap, squareness), PCS code changes were added to enable modification of the inner gap by adjusting the target for the other shaping parameters in real-time based on the error in the measured inner gap. The shots taken successfully demonstrate real-time modification of the target points and, as a result, tracking of the operator programmed inner gap request. Additional shots will be taken to fine-tune feedback gains and to use the new capability to actively control the time of diverting and actively limit the plasma later in a shot.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

B. Grierson has been elected to the TTF executive committee for a three-year term focusing on the “predict first” initiative. Grierson will organize sessions that highlight the use of modern tools and transport models for better optimizing the planning, execution, and interpretation of experiments in the areas of energy, particle, momentum, and impurity transport. Recent enhancements to the OMFIT suite of modules have enabled more robust and user-friendly execution of tools such as TRANSP (and predictive TRANSP), TGLF and STRAHL for both experts and new users on DIII-D.

S. Haskey and B. Grierson have developed a new method to more accurately align the Thomson and CER profiles in the pedestal region using the edge main-ion (deuterium) CER system on DIII-D. Misalignment between these profiles is a well-known problem and is due to the different

orientation and toroidal location of the Thomson scattering (vertical) and CER systems (radial). Main ion density and Zeff calculations requires an EFIT to map the Thomson scattering measurements to the CER measurement locations. This is error prone due to the assumption that the plasma is axisymmetric. Measurements of the thermal D-alpha brightness provide a new piece of information to accurately align the Thomson scattering and CER profiles in the pedestal. This is done by assuming quasineutrality with only thermal D+ and C6+, fixing the Thomson ne profile in flux co-ordinates, fixing the impurity CER profile in real-space and then shifting the EFIT radially. This moves the profiles relative to each other and changes the deuterium density calculated from quasi-neutrality. Forward modeling the thermal D+ brightness using FIDASIM allows the shift that best matches the measurements to be chosen. The optimum shift appears to also coincide with an electron temperature at the separatrix of ~80eV, an often used procedure for aligning the profiles to the separatrix in DIII-D. Details of the technique will be presented at the HTPD conference.

ITER (F. Poli):

Dr. Mark Henderson, from the ITER Organization, visited PPPL on May 17-18 to work with F. Poli on EC power management in ITER. Dr. Henderson was accompanied by Mila Aung-Thwin and Van Roiko from EyeSteelFilm, who are working on the preparation of a documentary on fusion. During the visit, Henderson gave a colloquium on the design and performance of the EC system and has been given a tour of NSTX-U, guided by M. Podesta.

ADVANCED PROJECTS (H. NEILSON):

D. Gates is lead author on a paper entitled "Thermo-resistive disruptions and the tokamak density limit" that was published online in the journal Physics of Plasmas on May 17. D. Brennan, L. Delgado-Aparicio, Q. Teng, and R. White co-authored the paper which describes a detailed model for how radiation driven islands lead to the correct scaling and phenomenology for the tokamak density limit. The paper appears in the special issue of Physics of Plasmas that is associated with the invited talks at the 2015 meeting of the American Physical Society's Division of Plasma Physics. The article was also described in a press release of the Division of Plasma Physics as one of the meeting highlights.

PLASMA SCIENCE & TECHNOLOGY (P. EFTHIMION):

A paper by M. Yamada, J. Yoo, and C. Myers of the MRX group entitled "Understanding the dynamics and energetics of magnetic reconnection in a laboratory plasma: Review of recent progress on selected fronts" was published in Physics of Plasmas at the following link: http://scitation.aip.org/content/aip/journal/pop/23/5/10.1063/1.4948721. This paper was adapted from M. Yamada's address for the 2015 James Clerk Maxwell Prize for Plasma Physics. The abstract reads: "Magnetic reconnection is a fundamental process at work in laboratory, space, and astrophysical plasmas, in which magnetic field lines change their topology and convert magnetic energy to plasma particles by acceleration and heating. One of the most important problems in reconnection research has been to understand why reconnection occurs so much faster than predicted by magnetohydrodynamics theory. Following the recent pedagogical review of this subject [Yamada et al., Rev. Mod. Phys. 82, 603 (2010)], this paper presents a review of

more recent discoveries and findings in the research of fast magnetic reconnection in laboratory, space, and astrophysical plasmas. In spite of the huge difference in physical scales, we find remarkable commonality between the characteristics of the magnetic reconnection in laboratory and space plasmas. In this paper, we will focus especially on the energy flow, a key feature of the reconnection process. In particular, the experimental results on the energy conversion and partitioning in a laboratory reconnection layer [Yamada et al., Nat. Commun. 5, 4474 (2014)] are discussed and compared with quantitative estimates based on two-fluid analysis. In the Magnetic Reconnection Experiment, we find that energy deposition to electrons is localized near the X-point and is mostly from the electric field component perpendicular to the magnetic field. The mechanisms of ion acceleration and heating are also identified, and a systematic and quantitative study on the inventory of converted energy within a reconnection layer with a well-defined but variable boundary. The measured energy partition in a reconnection region of similar effective size ($L \approx 3$ ion skin depths) of the Earth's magneto-tail [Eastwood et al., Phys. Rev. Lett. 110, 225001 (2013)] is notably consistent with our laboratory results. Finally, to study the global aspects of magnetic reconnection, we have carried out a laboratory experiment on the stability criteria for solar flare eruptions, including "storage and release" mechanisms of magnetic energy. We show that toroidal magnetic flux generated by magnetic relaxation (reconnection) processes generates a new stabilizing force, which prevents plasma eruption. This result has led us to discover a new stabilizing force for solar flares [Myers et al., Nature 528, 526 (2015)]."

DIRECTOR'S OFFICE (C. AUSTIN):

The bi-annual PPPL Advisory Committee meeting was held at PPPL on May 11-12. The purpose of the PPPL Advisory Committee is to review the efficiency and effectiveness of the Laboratory science and operations.

On May 17, Dr. Mark Henderson, ITER Organization, presented a colloquium entitled, "Functional Capabilities and Design of the ITER EC H&CD system."

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