PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending January 29, 2016 are as follows:

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

Steady State Electric Network (SSEN):

For the remaining three SSEN procurements—Uninterruptible Power Supply (UPS) system, DC Distribution, and Low Voltage (LV) Distribution and Sub-distribution Panels procurements—a draft memo was prepared that presents a revised cost estimate and optimized procurement strategy. Procurement of some of the items (battery banks associated with UPS and DC distribution, plus the LV Distribution and Sub-distribution Panels) will be transferred to the ITER Organization (IO) for future procurement action to avoid long storage times (battery banks) and to allow more time for the load consumers' designs to evolve (LV panels). Princeton Plasma Physics Laboratory will sign contracts for the other items before the end of FY16. After incorporation of comments, a final memo will be prepared and serve as the basis for a Project Change Request (PCR) will be submitted to US ITER to authorize the optimized strategy and associated cost and schedule.

Diagnostics:

There were two important Diagnostic Port Integration meetings this week. Several members of the PPPL ITER Diagnostics engineering staff attended. Y. Zhai and J. Chen traveled to ITER and R. Feder, A. Basile, A. Jariwala, and M. Smith attended remotely.

First, a System Integration and Design Peer Review was held for Safety Important Components (SIC). SIC components are the parts of the diagnostic systems that penetrate the primary machine vacuum and confinement barriers. For example, most diagnostics use glass vacuum windows to transmit diagnostic signals from inside the port plugs to equipment in the port interspace. These SIC windows must be carefully designed and controlled to provide nuclear confinement safety. Other SIC components include mechanical actuators and electrical power feedthrough connectors. U.S. ITER is designing special electrical power and mechanical motion SIC components for the ECE diagnostic.

Next, the second meeting of the Port Integration Coordinating Team (PICT) was convened. The PICT meets regularly to focus on specific topics that are driving the port plug design and integration activities. This PICT meeting focused on Electromagntic and Structural Analysis of the Port Plug Structures led by Princeton Plasma Physics Laboratory's Y. Zhai. The primary loads on port plugs and diagnostics are the electromagnetic forces induced by plasma

disruptions. It is important that the IO controls the quality and accuracy of this analysis to ensure all the port plugs and diagnostics are being designed correctly.

NSTX-U (M. ONO):

A FY 2016 NSTX-U plasma operations update: The department has completed 2.33 run weeks and 241 plasma shots. The total operation targets are to be decided.

The NSTX-U Program Advisory Committee (PAC) Meeting was held January 26-28 at Princeton Plasma Physics Laboratory. The PAC addressed four charges including assessments of: (1) the research planned to be carried out for the NSTX-U FY 2016 experimental campaign; (2) the alignment between the NSTX-U research plans and goals and the FESAC / FES initiatives, research opportunities, and ITER urgent research needs; (3) progress and plans for the NSTX-U / PPPL theory partnership and how well this partnership and the broader NSTX-U research activities support integrated predictive capability; and (4) team prioritization of planned facility enhancements including a lower divertor cryo-pump, non-axisymmetric control coils (NCC), a 28GHz ECH/EBW gyrotron, and conversion to all high-Z PFCs and liquid metals research. The NSTX-U team gave 11 presentations and two question-and-answer presentations to assist the PAC in addressing the charges. PAC members also gave seminars on JET and MAST-U status and plans prior to the meeting. PAC and seminar presentations are archived on the PAC-37 website: http://nstx-u.pppl.gov/program/program-advisory-committee/pac-37

A new paper "Blob structure and motion in the edge and SOL of NSTX" by S. J. Zweben (PPPL), J. R. Myra (Lodestar Research), et al. has just been published in Plasma Physics and Controlled Fusion, and is located at: http://dx.doi.org/10.1088/0741-3335/58/4/044007. In this paper, the structure and motion of discrete plasma blobs (a.k.a. filaments) in the edge and scrapeoff layer of NSTX is studied for representative Ohmic and H-mode discharges. Individual blobs were tracked in the 2D radial versus poloidal plane using data from the gas puff imaging diagnostic taken at 400 000 frames s^{-1}. A database of blob amplitude, size, ellipticity, tilt, and velocity was obtained for ~45 000 individual blobs. Empirical relationships between various properties are described, e.g. blob speed versus amplitude and blob tilt versus ellipticity. The blob velocities are also compared with analytic models.

Dr. Kunihiro Ogawa, of the LHD group at the National Institute for Fusion Science in Japan, visited D. Darrow (PPPL) and the NSTX-U group for the week of January 25. During his visit, he contributed to a refinement of the absolute calibration of the NSTX-U neutron diagnostic system. Since LHD plans to start its first-ever deuterium in the fall, absolute calibration techniques for neutron diagnostics are of interest to both research groups. In addition, Dr. Ogawa worked on improvement of a zero-dimensional model of the neutron production rate from NSTX-U plasmas. Further topics of discussion included the status of the fusion proton detector for NSTX-U, and the use of thin film Faraday cup detectors for the measurement of fast ion loss in JET, NSTX-U, and LHD.

A two-week NSTX-U maintenance period started this past week. Cabling for the Lithium Evaporator (LITER) probes has been installed, and terminations have started. Good progress is being made on electrical installations for the Coaxial Helicity Injection (CHI) Monitoring system and for the LoWeus/Zeus/MonaLisa diagnostics. Installation of piping for the new Argon Purge

system is in progress. The recent degradation of the PFIC upper coil insulation (not currently being used for NSTX-U experiments) has been traced to trapped water in the coil casing. A capillary tube was installed and the water pumped out for a corresponding improvement in electrical insulation. Dry leak checking has not yet revealed an active leak indicating the possibility that the water entered the coil casing during an unrelated water leak. Investigations will continue this coming week. The repairs to Neutral Beam (NB) 2A and 2B Trunk Lines have been completed and systems are being prepared to resume operations at the end of the maintenance period. All six NB ion sources are expected to be available to support upcoming experiments.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

E. Kolemen led a snowflake divertor evening experiment to demonstrate recent improvements in the algorithm for control of the snowflake centroid. The controller was used to shift the snowflake inward in major radius, allowing thermal imaging of the outer strike point region previously obscured by the lower shelf. Another evening control session will be used to continue improving the snowflake for simultaneous position and X-point separation control.

A. Bortolon and A. Nagy tested the Impurity Granule Injector (IGI) with carbon granules for the first time on DIII-D. Durations of 0.5 s carbon granule injection were achieved with granule size 0.5 mm, injection frequency 50-100 Hz and velocity 100 m/s. The plasma responded well to the carbon granules, tolerating the injection without radiative collapse or loss of H-mode confinement. ELMs were triggered, but at low efficiency in the plasma conditions used. This trial was in preparation for an upcoming IGI experiment next week.

M. Okabayashi led an experiment to assess the recovery of H-mode performance following a locked-tearing mode where the mode was stabilized by briefly reducing or turning off the NBI heating power. These results were achieved using either dynamic error field correction or careful pre-programmed error field correction. Provided the NBI power was reduced for a sufficiently long duration to allow the seed magnetic island to decay, both the H-mode confinement and beta could be recovered and the plasma current could later be ramped down without a disruption.

International (W. Solomon and R. Maingi):

An algorithm enabling Snowflake divertor control has been implemented in the EAST Plasma Control System by A. Fil. It uses PEFIT real-time calculations to detect the position of the second X-point and aim at controlling the distance and the angle between the two X-points. Snowflake divertor experiments were previously done in EAST but the position of the second X-point was changing during shots. The new algorithm aims to fix this and is currently being tested offline and in dedicated EAST experiments. R. Nazikian has presented this effort, among other experiment proposals, at an EAST general planning meeting.

EAST now possess many actuators and diagnostics, which could be used for adaptive ELM control in the future. Commissioning and experiments are planned for the next campaigns to test each of these actuators and their effect on ELMs on EAST. The EAST Resonant Magnetic

Perturbation (RMP) system and SMBI or Lithium Granule Injection have especially proven that they could be used for ELM control. Discussions are on-going with EAST scientists to start a collaboration on EAST modeling with non-linear codes such as M3D-C1, in particular on ELM-control related topics, such as the non-linear plasma response to RMPs on EAST or the effect of Lithium Granule on the plasma pedestal. In parallel to this modeling effort, General Atomics and Princeton Plasma Physics Laboratory PCS (Plasma Control System) teams are working closely with EAST to develop real-time profile extraction, which then could be used for real-time adaptive ELM control.

Dr. Zhen Sun from ASIPP concluded a two-week visit to test a new lithium granule dropper that will be loaned to EAST. Dr. Sun and Dr. Mansfield also continued analysis of a collaborative lithium aerosol experiment in EAST that suppressed ELMs.

ADVANCED PROJECTS (H. NEILSON):

A Princeton Plasma Physics Laboratory team visited the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) in Hefei, China, to attend a joint meeting on the China Fusion Engineering Test Reactor (CFETR) study. The Laboratory conducts engineering design and analysis tasks for CFETR under a Strategic Partnership Project agreement with ASIPP. The PPPL delegation of T. Brown, C. Kessel, A. Khodak, P. Titus, and H. Neilson presented status updates on configuration design, blanket thermal-hydraulic analysis, disruption analysis, operating space analysis, and blanket safety analysis. The ASIPP team provided an update of the CFETR machine concept and some of the supporting analysis. The ASIPP-PPPL collaboration focuses on a second phase of CFETR for which the mission is to achieve at least 1,000 MW of fusion power and demonstrate long pulse operation on time scales of a few tritium fuel cycles. To support this mission, the machine concept has been updated to feature a high toroidal magnetic field (>6.5 T on axis), copious volt-seconds through the use of advanced conductor material in the central solenoid, both water- and helium-cooled solid breeder blankets, and vertical remote maintenance. The meeting concluded with a summary of discussions and identification of tasks for continuing joint work. The CFETR project awaits government approval to begin an engineering design activity. During this phase, design tradeoffs are being examined and tools and analysis capabilities continue to be developed in preparation for the next phase.

As part of an 11-month stay at Max Planck Institute for Plasma Physics in Greifswald, Germany, S. Lazerson participated in experiments on W7-X to calibrate and commission the facility's magnetic diagnostics. The experiment, co-lead by Kian Rahbarnia (IPP) and S. Lazerson, utilized the U.S. trim coil system to create known reference magnetic fields which could be measured by the diamagnetic loops, saddle loops, and segmented Rogowski coils on W7-X. Calibrating the magnetics with known signals is an important first step in implementing them in equilibrium reconstruction.

S. Lazerson, in collaboration with Marcin Jakubowski, participated in the first plasma experiments on W7-X using the U.S. trim coil system. These experiments focused on examining the effect of applied n=1 trim coil fields on heat loads on the inboard limiter structures. Both phase and amplitude scans of the applied n=1 field were performed. The Los Alamos National Laboratory infrared camera diagnostic plays an instrumental role in these experiments.

THEORY (A. BHATTACHARJEE):

On January 25, Allen Boozer (Columbia University) presented a theory seminar on runaway mitigation issues on ITER: "The plasma current in ITER can be transferred from near thermal to relativistic electrons by the runaway phenomenon. If such a current of relativistic electrons were to strike the chamber walls in ITER, the machine could be out of commission for many months. For ITER to be operable as a research device, the shortest credible time between such events must be years. The physics of the runaway process is remarkably simple and clear. The major uncertainty is what range of plasma conditions may arise in post thermal quench ITER plasmas. Consequently, a focused effort that includes theory, experiments, and engineering could relatively quickly clarify whether ITER will be operable with the envisioned mitigation strategy and what mitigation strategies could enhance the credibility that ITER will be operable."

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

The TRANSP production system has been updated to the SLURM job scheduler in order to submit jobs to the new TRANSP dedicated cluster at Princeton Plasma Physics Laboratory. The new production system is compatible with and co-exists with the existing PBS job schedule system—it automatically determines the job scheduler and partitions/queues for submitted jobs. Users can use the same command to submit their jobs remotely and locally to the TRANSP production system. This new production system is available to all users as of this week.

BEST PRACTICES & OUTREACH (J. DELOOPER):

Science Education:

More than 250 individuals attended the Science on Saturday lecture on January 30 given by Frank von Hippel of Princeton University entitled "Dealing with Iran's Nuclear Program."

DIRECTOR'S OFFICE (C. AUSTIN):

Dr. Cris Barnes, Los Alamos National Laboratory, presented a colloquium entitled "Controlling the Production and Performance of Materials at the Mesoscale: The Matter-Radiation Interactions in Extremes (MaRIE) Capability."

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