Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending July 29, 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 under evaluation. Included in the proposals were quotations for battery banks in support of an "Arrangement" document that will transfer procurement of the same to the ITER Organization. The objective is to sign the two contracts and the Arrangement prior to the end of FY2016 so that U.S. ITER can obligate the funds.

Power Transformers: Shipment of Lot #1 and Lot #2 oil-filled units (eight @ 35MVA and four @ 7MVA) from the Schneider Electric factory near Istanbul, Turkey is scheduled for August 24.

6.6kV Switchgear: Shipment of the remaining 110 cubicles in Lot #3 and #4 from the Schneider Electric factory in Manisa, Turkey, was postponed to August 5 due to extra time needed for mobilization of Logistics Support Provider (LSP, ITER's shipping contractor).

Diagnostics:

Low Field Side Reflectometer (LFSR): A. Zolfaghari visited General Atomics (GA) to review progress of GA/UCLA subcontractors on the I&C activities and high frequency testing of the Low Field Side Reflectometer (LFSR) prototype transmission line, as well as the upgrade of the innovative solid-state mm-wave instruments loaned by PPPL to the subcontractor. Zolfaghari and the GA/UCLA staff also reviewed the FPGA activities funded under LFSR and TIP projects and explored how LFSR can benefit from TIP FPGA work and FPGA integration into ITER CODAC. Finally, meetings were held to discuss the integration of the Gaussian telescope prototype under development at PPPL into the larger LFSR transmission line test stand.

Diagnostic RGA (DRGA): Another FY2016 WBS 1.5.3 DOE Performance Plan Milestone was completed this week with the DRGA R&D final report being officially uploaded to iDocs and opened for review. Several years of work have gone in to this report, which will also help guide DRGA project work in to the next fiscal year.

Equatorial Port 9 Integration and DSM Engineering: Interspace Structure and Bioshield Plug design work has commenced and will update these structures to current ITER definition. The configurations were given tentative ITER approval during this month's EP09 integration meeting. CATIA model files will next be shared with ITER for more detailed comment. TIP

front mirror integration progressed with revised positioning of four cooled "wedge" mirrors within the DSM3 optics cassette. Mirror design will continue with detail optimization supported by thermal analysis of installed, operating heat loads. The mirror installation also provides a basis for further coolant channel design within the TIP cassette. Also this week, the USDA has requested INDA to begin review of their maintenance zone requirements for ECE equipment in the Interspace and Port Cell regions. TIP diagnostic models have been shared so that ECE maintenance access across this neighboring diagnostic can be assessed.

Toroidal Interferometer and Polarimeter (TIP): As part of a U.S./Japan collaborative agreement, T. Akiyama from NIFS worked with the ITER TIP GA development team to install a CO2 laser based heterodyne dispersion interferometer on DIII-D, temporarily using the ITER TIP prototype beam path. Measurements of the DIII-D plasma were made and compared to the standard two-color measurement.

NSTX-U (M. ONO):

The FY2016 NSTX-U plasma operations were completed. The department has completed 10.06 run weeks and 1066 plasma shots.

The NSTX-U team meeting was held on July 29 at PPPL. The NSTX-U team was updated on the ongoing PF 1A related issues and the near and longer term plans. The meeting material is available on the web at:
http://nstx.pppl.gov/DragNDrop/NSTX_Meetings/Team_Meetings/2016/2016-07-29.

S. Sabbagh (Columbia University) made the presentation "Disruption Event Characterization of Global MHD Modes in NSTX and Plans for Instability Avoidance in NSTX-U" at the recent IEA Workshop on the Theory and Simulation of Disruptions (sponsored by the PPPL Theory Division) conducted July 20-22. C. Myers (PPPL) presented a poster entitled, "A multi-machine analysis of non-axisymmetric and rotating halo currents," which is a progress report on an ITPA activity to understand the scaling of halo current dynamics across various devices in preparation for ITER.

Plasma operations have concluded for FY2016 after the determination that there is at least one shorted turn in the PF1aU coil. Based on detailed analysis of the magnetics data, it appears that the PF1AU coil self inductance has been slowly degrading over the last few months, and had its lowest values just prior to the PF1AU water flow blockage. NSTX-U diagnostic calibrations are now in progress in preparation for the machine outage to analyze and replace the PF1aU coil, as well as to complete work scope planned for the FY2017 run. The Switching Power Amplifiers (SPA's) were operated at varying frequencies this past week to calibrate the Resistive Wall Mode (RWM) sensors. All six neutral beam ion sources injected into a gas filled torus for a spectrometer calibration, which also provided a beam species mix measurement, as well as a full verification of vessel armor thermocouples. All six neutral beam ion sources operated well at the rated 90kV, and in Voltage scans down to 60kV. A calibration of the Materials Analysis Particle Probe (MAPP) was performed utilizing a vacuum vessel boronization. Also this week, testing and recommissioning of the MG#2 Cycloconverter was successful completed.

A three-level optical table to house the lasers for UC Davis diagnostics was installed in the enclosure ("cage") in the gallery outside the west wall of the NSTX-U test cell. The table will first be used for a 100 W, 9.695 micron carbon dioxide pump laser and three 100 mW, 118.8 micron methanol lasers that are part of the FIReTIP plasma density diagnostic. A high-power carbon dioxide laser and far infrared laser will be added later to the table for the high-k turbulence diagnostic.

ITER & TOKAMAKS (R. HAWRYLUK):

R. Maingi participated in the ITER Research Plan Workshop, held at the IO in Aix-en-Provence, July 26-28. R. Hawryluk chaired the EUROfusion Plasma Exhaust Assessment Panel, which met in Garching, Germany to review ten proposals to address plasma exhaust issues.

DIII-D:

L. Delgado-Aparicio visited DIII-D this week to collaborate on the analysis of data and to present a talk on results from the recent experiment on "Radiatively induced magnetic islands at the density limit."

B. Grierson published a recent article entitled "High Resolution Main-ion Charge-Exchange Spectroscopy in the DIII-D H-mode Pedestal" accepted for publication in Review of Scientific Instruments. The article details the design, implementation, and first results of the main-ion temperature, rotation and photoemission in the pedestal region (rho > 0.8 to SOL) of an ELMy H-mode discharge. There are clear indications of large, order unity differences between the impurity and main-ion toroidal velocity in the steep gradient region and at the separatrix, with the main-ions rotating more rapidly in the co-Ip direction. These measurements will be used in upcoming experiments on momentum transport and intrinsic torque generation.

A re-design for the OMFIT TRANSP workflow has enabled support for multiple tokamaks by providing both general OMFIT-supported equilibrium and profiles, as well as device-specific fetching of equilibrium and profiles from MDSplus or other machine specific data storage. This enables support of both JET and C-Mod tokamaks, with B. Grierson and O. Meneghini coordinating with scientists from JET and C-MOD. The implementation has also incorporated the between-shot DIII-D profile analysis tool "ZIPFIT," which permits TRANSP submissions immediately after the diagnostic data is automatically fit after each DIII-D shot.

The neutral beam power supply controller upgrade NBLCS8 (led by A. Nagy) is currently being installed. The old control system, dating back to the 1970s, has been removed to make way for the new controller. W. Brown, PPPL engineering interns, and GA technical staff built the new system. It will undergo testing in the summer and is planned to be fully operational in October.

D. Mauzey, (PPPL summer intern) has designed and produced a new granule dropper using a unique method for recirculating granules that are rejected from the injection stream. This new method uses a second vibrator table to recirculate the granules to the start of the line.

Alcator C-Mod (F. Poli):

An article entitled "Experimental and modeling uncertainties in the validation of Lower Hybrid Current Drive" by F. Poli, et al., has been published in Plasma Physics and Controlled Fusion, and is available online at http://dx.doi.org/10.1088/0741-3335/58/9/095001. This article reports on validation of lower hybrid current drive using GENRAY-CQL3D in TRANSP. By evolving self-consistently the magnetic equilibrium and the LH heating and current drive profiles including a 3D Fokker-Planck model, discrepancies observed previously in standalone comparisons on time slices have been addressed. The analysis shows a very good agreement with measured macroscopic quantities, and indicates that evolving self-consistently the electric field is very important. Some discrepancies remain in the comparison of the simulated and measured hard X-ray profiles.

An article entitled, "Tokamak-independent software analysis suite for multi-spectral line-polarization MSE diagnostics" by S. Scott and R. Mumgaard has been published in RSI (Vol. 87 11D405).

ADVANCED PROJECTS (H. NEILSON):

C. Kessel participated in the Fusion Materials PI Meeting at the University of Tennessee and Oak Ridge National Laboratory. He presented an overview of the FESS-FNSF study with particular emphasis on materials issues emerging from the examinations. The first half of the meeting included sessions on institution summaries, structural materials, steels, composites, silicon carbide, copper and alternative materials, tungsten, and simulations. The second half of the meeting started with Integration of the materials and other program elements, and then went into plasma material interactions with liquid metals as plasma facing components (PFC), institutional summaries, and international collaborations. The final day covered tungsten PFC and liquid PFC action plans. The systems studies were recognized as an important component in helping to define priorities in the materials and PFC programs.

THEORY (A. BHATTACHARJEE):

Hyeon Park (NFRI/UNIST, Korea) gave a theory seminar on the dynamics of the ELMs in pre-crash and crash suppressed period in KSTAR. The abstract reads, "Following the first operation of H-mode in KSTAR in 2009, study of the edge localized modes (ELM) has been actively conducted. A unique in-vessel control coil (IVCC) set (top, middle and bottom) capable of generating resonant (and non-resonant) magnetic perturbation (RMP) at low n (=1,2) number was successfully utilized to suppress and/or mitigate the ELM-crash in KSTAR. Extensive study of dynamics of the ELMs in both pre-crash and crash suppressed phase under magnetic perturbation with the 2D/3D Electron Cyclotron Emission Imaging (ECEI) system revealed new phenomenology of the ELMs and ELM-crash dynamics that were not available from conventional diagnostics. Since the first 2D images of the ELM time evolution from growth to crash through saturation, the detailed images of the ELMs leading to the crash together with the fast RF emission (<200MHz) signal demonstrated that the pre-crash events are complex. The measured 2D image of the ELM was validated by direct comparison with the synthetic 2D image by the BOUT++ code and non-linear modelling study is in progress. Recently, the observed

dynamics of the ELMs at both high and low field sides such as asymmetries in intensity, mode number and rotation direction casted a doubt in peeling-ballooning mode. Response of high field side ELM to the RMP was more pronounced compared to that of the low field side. Other study includes observation of multi-modes and sudden mode number transition. During the ELM-crash suppression experiment, various types of ELM-crash patterns were observed and often the suppression was marginal. The observed semi-coherent turbulence spectra under the RMP provided an evidence of non-linear interaction between the ELMs and turbulence."

PLASMA SCIENCE & TECHNOLOGY (P. EFTHIMION):

E. Gilson remotely presented two invited talks at the International Symposium on Heavy Ion Fusion held in Astana, Kazakhstan on behalf of I. Kaganovich. The talk, "Update on Beam-Plasma Interaction Research at Princeton Plasma Physics Laboratory," reviewed recent PPPL efforts to understand the physics of the two-stream instability and its impact on the Neutralized Drift Compression Experiment (NDCX-II) at Lawrence Berkeley National Laboratory, as well as the results of experiments at PPPL that elucidated the nature of plasma neutralization of ion beams. The talk, "Special Lecture in Honor of Ron Davidson," was given as a memorial lecture and included both a review of Ron's professional contributions to beam dynamics and also personal remembrances.

A. Stepanov traveled to Lawrence Berkeley National Laboratory for one week, where he participated in experiments on the Neutralized Drift Compression Experiment (NDCX-II). For the first time since operations began, sufficient simultaneous transverse and longitudinal compression was achieved, with the help of neutralizing plasmas, to create a hole in a thin metal foil. This result enables future target experiments in the warm dense matter regime of high energy density laboratory physics.

On July 29, Dan Lev of Rafael in Israel presented a seminar on electrical propulsion research at Rafael. The abstract reads: "Electric propulsion is a rapidly growing field in which plasma is generated and accelerated for space propulsion applications. Using electric propulsion many satellites and other spacecraft maneuver in space. To date the electric propulsion market is dominated by the few major technologically advanced geo-political entities in the world, i.e. the US, Russia, the EU, China and Japan. However, in recent years smaller countries are slowly entering the electric propulsion market using different technology development strategies. We present some of the developments conducted in Israel in general and at Rafael in particular. We focus on the different technological approaches and novelties that lead to the design and manufacture of some interesting new devices. Finally, we bring an example of the development of a 'Heaterless Hollow Cathode,' a high current density electron source responsible for electric thruster ignition and operation."

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

Environmental Services:

On July 28, the New Jersey Department of Environmental Protection (NJDEP) conducted an unannounced inspection of PPPL's hazardous waste management program. The inspection was

concluded with no issues, findings, or violations being identified. The NJDEP inspector complimented PPPL on the attention to detail given to our satellite accumulation areas (SAAs) and to the management of waste in the Hazardous Material Storage Facility. She also commented on the attention to safety she observed in several work areas where she was asked to don safety glasses upon entry to the area or was directed to the safest pathway through a work area.

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