PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending June 10, 2016 are as follows:

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

Steady State Electric Network (SSEN):

Uninterruptible Power Supply (UPS) system and DC Distribution: The Request for Proposal (RFP) packages have been issued and a pre-proposal conference call has been scheduled for June 15.

Power Transformers: Target date to begin shipping the Lot #1 and Lot #2 oil-filled units (eight @ 35MVA and four @ 7MVA) was changed to week of July 18 to allow more time for storage preparations at the ITER site.

6.6kV Switchgear: Forecast shipping date for the 48 cubicles in Lot #2 from the Schneider Electric factory in Manisa, Turkey is June 17. Fabrication of the remaining 110 cubicles in Lot #3 and #4 are nearing completion and the FAT will commence on June 17.

Diagnostics:

Project and Administrative Notes and Highlights: The U.S. ITER project will be pushing for a CD-2 Baseline decision for all U.S. ITER hardware scope needed to complete ITER construction or to enable First Plasma by 2025. Completion of the design of Diagnostics and Port Plugs will also be included in the CD-2 scope but not fabrication. We are awaiting new budget profile guidance from DOE and U.S. ITER. In the meantime we continue to interview candidates for open Project Engineering, Design, and Nuclear Analysis positions to replace departing personnel and to enhance the team.

Upper Port Wide Angle View Vis-IR Cameras (UWAVs): DOE Princeton Site Office approval for the award of the UWAVs Software and Detectors Subcontract was received this week. Final sign-off from the new vendor is now the final step. Once this happens we will make an announcement on the award to the US diagnostics community and schedule a subcontract kick-off meeting.

Electron Cyclotron Emission (ECE): Calibration Hot Source Development is continuing at University of Texas with preparations underway for testing of various emissivity-enhancing options so that parameters of the hot source fall within the specified criteria. PPPL is working closely with the IO diagnostics analysis team to define transient load histories that can be applied to the ECE Hot Source so that the design is robust but not overly conservative. Test preparations

are continuing at PPPL for upcoming piezo motor thermal and magnetic testing. PPPL engineers are considering using in-vacuum piezo motors to actuate the ECE hot source calibration mirrors rather than using a mechanical feedthrough actuator.

Upper Port 11 (U11) and 14 (U14) Integration and DSM Engineering: A PPPL internal review of the E9 and U14 load spec (LS) was successfully conducted this week. The LS serves as the basis for port integration and structural integrity assessment for PDR and FDR. The review was mostly focused on the in-vessel part of the E9 and U14 and scope is to review design driving loads (including EM, thermal and VDE inertial loads), as well as nuclear shielding requirements to finalize the DSM design. Interface loads for in-port system design (ECE, TIP in E9 and WAV, GDC, DMS in U14) were also summarized. Critical issues such as DSM stiffness, impact to EM load distribution among in-port components, and spaces needed between front components to avoid electrical arcing were also presented. Primary review comments or chits call for clear input guidance from IO to minimize impact to cost and schedule.

Toroidal Interferometer and Polarimeter (TIP): General Atomics (GA) engineers have nearly completed the first iteration of a CAD model of the TIP relay system. This model will be sent to PPPL, converted to CATIA, and assessed for interferences in the context of other ITER systems. Over the next 6-8 weeks, a joint analysis strategy will be developed between PPPL and GA, aimed at defining design-driving loads and assigning institutional analysis responsibilities to validate the design.

Core Imaging X-Ray Spectrometer (CIXS): Testing of the detector performance in a magnetic field using a PPPL FCPC power supply and dummy load inductor continued. Preliminary results suggest that the sensor is immune to the field exposure level that will be encountered in ITER service but the electronics are not. Whether or not the electronics can be located far enough away from the sensor so as to be located in a sufficiently reduced field remains to be determined.

Diagnostic I&C Integration Engineering (ORNL, Bill DeVan): The ITER organization has distributed a set of computing and data acquisition equipment to each diagnostics team. This collection of equipment is called the mini-CODAC Integration Kit and is used to show how each diagnostic system will be coupled into the ITER plant-wide computing and data acquisition infrastructure.

NSTX-U (M. ONO):

The NSTX-U team meeting was held on June 10 at PPPL. The NSTX-U team was updated on the ongoing PF 1A flex bus recovery activity and the restart of plasma operations and the run plan for FY2016 and beyond. The meeting material is available on the web at: http://nstx.pppl.gov/DragNDrop/NSTX_Meetings/Team_Meetings/2016/2016-06/

NSTX-U was well represented at the Topical Conference on High Temperature Plasma Diagnostics, held June 5-9 in Madison, Wisconsin. Three invited talks and twelve posters on work performed on NSTX and NSTX-U were presented. The invited talks were: “Investigation of ELM evolution patterns with beam emission spectroscopy measurements on NSTX-U” by D. Smith (University of Wisconsin-Madison), “Synthetic aperture microwave imaging of the

plasma edge in MAST and NSTX-U" by R. Vann (University of York), and "Multi-energy SXR cameras for magnetically confined fusion plasmas" by L. Delgado-Aparicio (PPPL).

The testing of the remote control for the insertion of two (F2 and K2) of the four Lithium Evaporators (LITERs) has been successfully completed. This restores the capability to evaporate lithium into the NSTX-U vacuum vessel between shots. When the remote control insertion testing for the two remaining LITERs (F1 and K1) is completed, the ability to replace empty units with prefilled ones will also be restored.

Time has been taken each day to condition the neutral beam ion sources, and all six of the HHFW RF sources, now equipped with new protective relaying, were operated into a dummy load. The F1 and K1 LITER probes have been lifted into place onto the fill stand for pre-operational testing in preparation for initial lithium fills. In parallel, we continue the integrated system testing of the F2 and K2 LITERs currently installed on NSTX-U. Initial Laser alignments of the MSE-LIF diagnostic were performed and data is being reviewed. The Diagnostic Neutral Beam was operated into a background deuterium gas fill in the NSTX-U vessel, and data has now been taken on all 10 sight lines. Four new video cameras with archiving capability have been installed at the top and bottom of the vessel, and one additional camera is being installed at mid-plane. Mounting of the strain gauges on the outer TF coils as needed to confirm design criteria for increasing our TF Field strength is making good progress, and is expected to be completed before operations resume this coming week. Also this week, electrical installations packages were completed for the new Massive Gas Injector, the FIReTIP diagnostic, and the IR Video Bolometer (IRVB).

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

B. Tobias presented a poster at the Topical Conference on High Temperature Plasma Diagnostics in Madison, Wisconsin, describing mm-wave integrated circuit technology that has been developed in partnership with the UC Davis Mm-wave Research Center for application in ECE-Imaging and MIR systems. Specifically, a new heterodyne receiver circuit for imaging ELMs and other edge-localized MHD will be implemented on DIII-D during an upgrade later this year to eliminate out-of-band electromagnetic interference, improve system noise temperature, and simplify the overall system layout by eliminating the need to optically couple local oscillator power through many meters of costly, low-loss waveguide. This and other advanced technologies are being incorporated into the ECEI and MIR systems on the EAST tokamak described in an invited talk by Yilun Zhu (USTC with PPPL co-authors).

L. Shi (Princeton University) presented an invited talk describing the open-source Plasma Synthetic Diagnostics platform that he has developed during his graduate thesis work in collaboration with Professor Tang, G. Kramer, E. Valeo, and B. Tobias of PPPL. This valuable software package provides standardized modules for interfacing plasma simulation codes such as GTC, M3D-C1, and XGC-1 with synthetic beam emission spectroscopy, microwave reflectometry, and ECE radiometry diagnostics to provide time-dependent synthetic data for comparison with experiment. A centerpiece of this presentation was the new synthetic ECE-imaging module that applies a novel reciprocal model of emission and radiation transport in

order to self-consistently include second order paraxial diffraction and refraction of a realistic, 2D microwave beam.

A meeting was held between PPPL and General Atomics (GA) to review the NB210 calorimeter heat loads and the status of the pole shield MOU.

The Super Spa Patch Panel is now ready for cabling installation, to start July 15.

The Impurity Granular Injector (IGI) development is moving forward. A new design suggested by Randy Nguyen and fabricated by Will Brown, has proved very workable. The new design worked for all three granule sizes.

Peter Fisher, a high school student, is completing his month long internship working on the impurity granule injector. Fisher has made a significant impact on the prototyping and testing of the new dropper mechanism for the IGI.

E. Kolemen presented the detachment and radiation control results form DIII-D at the PSI Conference.

C-Mod (S. Zweben):

A paper on C-Mod edge turbulence has just been published in Physics of Plasmas, 23, 062305 (2016): "Mean flows and blob velocities in scrape-off layer (SOLT) simulations," by D. Russell, J. Myra, D. D'Ippolito, B. LaBombard, J. Hughes, J. Terry, and S. Zweben. In this paper two-dimensional scrape-off layer turbulence (SOLT) code simulations are compared with GPI and mirror Langmuir probe data from an L-mode discharge on the Alcator C-Mod tokamak. Mean flow profiles and density fluctuation amplitudes are consistent with those measured by the probe, and blob velocities in the simulations were also in good agreement with GPI. The saturation mechanisms operative in the simulation of the discharge are also discussed. It is found that neither sheared flow nor pressure gradient modification can be excluded as saturation mechanisms. [http://dx.doi.org/10.1063/1.4953419]

THEORY (A. BHATTACHARJEE):

On June 7, Johan Anderson (Chalmers) presented a theory seminar on statistical analysis of turbulent transport for flux driven toroidal plasmas: "During recent years an overwhelming body of evidence shows that the overall transport of heat and particles is to a large part caused by intermittency (or bursty events) related to coherent structures. A crucial question in plasma confinement is thus the prediction of the probability distribution functions (PDFs) of the transport due to these structures and of their formation. This work provides a theoretical interpretation of numerically generated probability density functions (PDFs) of intermittent plasma transport events as well as offering an explanation for elevated PDF tails of heat flux. Specifically, we analyze time traces of heat flux generated by global nonlinear gyrokinetic simulations of ion-temperature-gradient turbulence by the GKNET software. The simulation framework is global, flux-driven and considers adiabatic electrons. In the simulations, SOC type intermittent bursts are frequently observed and transport is often regulated by non-diffusive processes, thus the PDFs of e.g. heat flux are in general non-Gaussian with enhanced tails. A key

finding of this study is that the intermittent process in the context of drift-wave turbulence appears to be independent of the specific modeling framework, opening the way to the prediction of its salient features. Although, the same PDFs were previously found in local gyrokinetic simulations there are some unique features present, inherently coming from the global nature of the physics. The main part of this work consists in providing a theoretical interpretation of the PDFs of radial heat flux. The numerically generated time traces are processed with Box–Jenkins modeling in order to remove deterministic autocorrelations, thus retaining their stochastic parts only. These PDFs have been shown to agree very well with analytical predictions based on a fluid model, on applying the instanton method. In this talk, the theory and comparisons to the numerical work will be presented. The result points to a universality in the modeling of the intermittently stochastic process while the analytical theory offers predictive capability, extending the previous result to be globally applicable."

On June 9, Nishant Kumar Singh (KTH Royal Institute of Technology, Stockholm) gave a theory seminar on predicting solar magnetic activity and its implications for global dynamo models: "Using the solar surface mode, i.e. the f-mode, we attempt to predict the emergence of active regions (ARs) in the days before they can be seen in magnetograms. Our study is motivated by earlier numerical findings of Singh et al. (2014) who showed that, in the presence of a nonuniform magnetic field which is concentrated a few scale heights below the surface, the f-mode fans out in the diagnostic k-omega diagram at high wavenumbers. Here we exploit this property using data from the Helioseismic and Magnetic Imager aboard the Solar Dynamics Observatory, and show for about six ARs that at large latitudinal wavenumbers (corresponding to horizontal scales of around 3000 km), the f-mode displays strengthening about two days prior to AR formation and thus provides a new precursor for AR formation. I will also discuss ways to isolate signals from newly forming ARs in a crowded environment where existing ones are expected to pollute the neighboring patches. The idea that the f-mode is perturbed days before any visible magnetic activity occurs on the surface can be important in constraining dynamo models aiming at understanding the global magnetic activity of the Sun."

On June 10, F. Poli, presented a theory research review seminar on opportunities and challenges for integrated tokamak modeling. The abstract reads "The DOE workshop on Integrated Simulations has identified a number of critical aspects in the integration of physics modules in a whole device model for tokamak simulations. Challenge includes not only the need for physics description, but also a need for hardware infrastructure, software integration and difficulties in integrating multi scale coupling. This seminar summarizes the conclusions from the integrated simulations workshop on MHD stability and disruptions, boundary physics and core transport, as well as a need for research on innovative workflows that enable the integration."

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