PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights

PPPL

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending June 17, 2016 are as follows:

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

Steady State Electric Network (SSEN):

Power Transformers: The punch list of open items on the Lot #1 and Lot #2 oil-filled units (eight @ 35MVA and four @ 7MVA), along with the final packaging, was inspected at the Schneider Electric factory near Istanbul, Turkey, on June 14 and all items were found to be satisfactory. However the shipping date has been postponed to the week of July 17 in order to allow more time for ITER to prepare to receive and store the transformers.

6.6kV Switchgear: The 48 cubicles in Lot #2 are ready for shipment from the Schneider Electric factory in Manisa, Turkey on June 23. Factory Acceptance Testing (FAT) of the remaining 110 cubicles in Lot #3 and #4 commenced on June 15.

Diagnostics:

The Diagnostic and Port Plug Engineering team continues to work with PPPL engineering management on interviewing and hiring new personnel to fill several key roles.

Upper Port Wide Angle View Vis-IR Cameras (UWAVs): TNO is progressing on the mirror cleaning test set up. A preliminary, low power, plasma discharge at 13.56 MHz was created in the chamber in Ar, He, and H2. Work is ongoing in preparing for the commissioning test. Preliminary fluid and electrical routing was completed for the FEOT including all known bullnose routing, panel and mirror assembly coolant lines, and service box interfaces. Remote handling of the bullnose was envisioned in this iteration, with some additional optimization still required to show feasibility using updated weld tool dimensions.

Motional Stark Effect (MSE): While assisting Nova Photonics in positioning the MSE optical system in Equatorial Port #1 (An EUDA Port Plug) it was discovered that there was an error in the field of view end point assumed for the optical ray-trace analysis. This change affects both the Diagnostic Neutral Beam (DNB) view in EPP03 and the Heating Neutral Beam view in EPP01. This problem has hopefully been resolved with clarification from the IO. Work is continuing on the front-end design focusing on mounting and structure. With the new update on the field of view end-point values, the ray-traces are being reworked.

Electron Cyclotron Emission (ECE): In parallel with the mechanical design and testing of ECE in-vacuum components, the ECE team is also engaged in investigating important aspects of real time data analysis and control. One functional requirement for ECE is to participate in the real-time control for Neo-Classical Tearing Mode Instabilities (NTMs) in ITER. Josh Stillerman met with Guillermo de Arcas Castro from Technical University of Madrid (UPM) this week to discuss his work on real-time computation for both JET and ITER, such as real time detection of L-H transitions and real-time disruption prediction. He has been working with ITER CODAC on the specification and implementation of the real-time computing framework for the plant systems, and has experience with National Instruments tools. Given that the ECE plant systems will need to perform some real time calculations to provide inputs to the Plasma Control System (PCS), it is useful to hear from experts about the current state and near term plans for the tools. Another important aspect of ECE operation is the rapid detection of stray ECH radiation that can damage sensitive ECE equipment. There have been changes in design of the ECRH heating system for ITER with subsequent changes in the available ECH sensors that might be used for ECE protection. The UT ECE team has reopened discussions with IO and India DA experts on ways to detect and protect against stray ECH radiation.

Upper Port 11 and 14 Integration and DSM Engineering: A major challenge in ITER Port Integration is the incorporation of systems in to a port plug when the system is coming from another country and also outside the Diagnostics organization management. In Upper Port 14 there are three systems, one of which is the China DA provided Glow Discharge Electrode (GDC). For some time there have been two competing designs, one from the IO and one from China. This has lead to inefficiencies and schedule lags for the UPP14 project. This week Mike Walsh, the ITER Diagnostics Program Manager, stepped in and is taking over management of this issue. The GDC is an important component housed in four port plugs such that a single consistent design is needed. This new involvement from upper management should help UPP14 integration and PDR planning proceed.

Equatorial Port 9 Integration and DSM Engineering: Y. Zhai, W. Wang, and J. Chen visited ITER this week to participate in several working meetings on Diagnostic Shield Module (DSM) Design and Analysis. The ITER DSM engineering team has proposed a new DSM design that is somewhat different than the PPPL approach. Zhai, Wang, and Chen are verifying that the same analysis inputs and results are being used for the IO design as were used for the PPPL design. Also this week the PPPL EP9 CATIA and Design Engineering Team held an informal peer review to check on the design maturity status of Shield Module #2 and #3. The goal is to lock the designs at a preliminary level so that a new round of nuclear shielding analysis can start. The DSM-2 design, housing the ECE diagnostic, is very close to being ready. The DSM-3 design, housing the TIP diagnostic mirrors, still needs some refinement and this will be the team focus.

Toroidal Interferometer and Polarimeter (TIP): The TIP active alignment system utilizes a quadrant detector mounted near the vacuum window to keep the lasers aligned, compensating for thermal motions. Currently, a search is underway for a rad hard quadrant detector. Another approach is to use commercially available detectors embedded in a radiation shield. The geometry of the mounting scheme has been optimized to provide the maximum volume for this shielding.

NSTX-U (M. ONO):

A FY2016 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.

M. Podestà (PPPL) presented a summary of results from the initial operation of the NSTX-U Real-Time Velocity (RTV) diagnostic at the NSTX-U Monday meeting on June 13. The RTV system, based on active charge-exchange recombination spectroscopy, provides toroidal plasma velocity data from four radial locations at a maximum sampling rate of 5kHz. Analysis is performed in real-time during a discharge and velocity data are provided to the NSTX-U Plasma Control System (PCS), as required for future implementation of rotation feedback. Post-discharge analysis tools have also been developed to complement regular CHERS results with velocity, carbon temperature and carbon density at high sampling rate. Initial data from the FY16 run confirm that the design goals have been met or exceeded, with rotation data routinely dispatched to PCS and the possibility of supplying ion temperature data in real-time under consideration. Examples from post-discharge analysis illustrate the capabilities of the RTV system to capture fast dynamic of events such as sawteeth and plasma response to instabilities.

J. Lovell (Durham University/CCFE) visited PPPL from June 10-20 to work with M. Reinke (ORNL), and G. Tchilinguirian (PPPL) on getting the new D-tAcq FPGA-based bolometer analyzer hardware integrated into MDSPlus and demonstrate its capabilities relative to existing analog solutions.

A dry run for lithium loading of the NSTX-U lithium evaporators (LITERs) with the "lithium filler for LITER" (LIFTER) was successfully conducted in the South High Bay. The LIFTER system is used to pump liquid lithium into the LITER reservoir using argon gas. The hardware for controlling the argon flow and the lithium reservoir heaters was determined to be operational. The two LITERs used in the LIFTER dry run have been exchanged with the two that have already been checked with the remote insertion system on NSTX-U. Once remote insertion control is tested for the second two LITERs, all four of them will ready for lithium evaporation.

The Johns Hopkins University Transmission Grating Imaging Spectrometer (TGIS) has been installed on the machine at Bay I and under vacuum for several weeks. The TGIS is designed to measure spatially resolved spectral lines in the XUV-VUV range, 50-700A with frame rates up to 50Hz. Using these measurements, the TGIS will provide important information with regard to impurity concentration profiles and transport, Z_{eff}, as well as support the fast Te profile measurements with the ME-SXR neural network analysis. This past week the electrical installation of the TGIS was completed, including an extension of the camera power cable and routing of an active USB cable and USB-fiber media converter, with installations at racks 435 and 400. The diagnostic gate valve was opened to the vessel. Diagnostic checkout with a local laptop system was completed successfully.

Work on the electrical and mechanical installations for the Bay-J Upper Infrared Video Bolometer (IRVB) are nearing completion, with final tests of remote operation of the IR camera during NSTX-U operations to be completed early next week. The IRVB is ready to open to NSTX-U vacuum and take data following demonstrations that show camera triggering and data collection are robust.

On HHFW #5 and #6, their newly rebuilt AC power systems were successfully run last week into NSTX-U for antenna conditioning. Antenna voltages reached 20kV similar to the values reached for HHFW #1–4 earlier. HHFW #4 RF power feedback controller was extensively bench-tested. The system operated correctly up to at least a megawatt in subsequent testing. The new protective relays have been installed on the RF power yard feeder breakers Q6B5 and Q6B3. “Transfer-trip” testing of Q6B3/Q6B5 from the RF Power Yard relays will start on Monday. This involves extensive timing tests using GPS-synchronized clocks at each end. On NSTX-U, HHFW antenna conditioning and operations using all six sources will resume next Wednesday.

All new NSTX-U PF1A support installations have been completed. Coil power testing will now utilize four new cameras at the top and bottom of the vessel and a fifth at the mid-plane, all with archiving ability. The mounting of the strain gauges on the outer TF coils, as needed to confirm design criteria for increasing our TF Field strength, has been completed. Neutral beam ion source conditioning continued this past week.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

B. Grierson has developed a new predictive TRANSP interface within the OMFIT workflow manager that is now publicly available. Users will now be able to submit predictive TRANSP simulations to compare experimental temperature, density, and rotation measurements with model-based predictions from GLF23, multi-mode model and TGLF. Scenarios from recent experiments on DIII-D are being studied with this new capability including electron heated ITER baseline, hybrid, and high beta-poloidal plasmas. This OMFIT based workflow streamlines the typically labor-intensive process of repeating an interpretive transport analysis with fluid variables based on transport models, and enables self-consistent time-dependent transport-equilibrium solutions that are unavailable within other frameworks. Through OMFIT, users with permission to access TRANSP’s predictive transport solver (PT_SOLVER) can now enable this feature at the click of a button, selecting which model to use and which transport channels are simulated. Default name lists are loaded, depending on the selected transport model, with settings confirmed by the model developers. This public, community-vetted workflow ensures consistent usage of transport models for validation studies across users and machines.

A. Nagy held a meeting of the off axis NB210 project with the lead engineers and task engineers for discussion on how to break up tasks for job progress tracking purposes. A short weekly meeting will be held to assess job progress during the first month or so, then biweekly thereafter. A rolling wave planning strategy is adopted for job planning on a 3-4 month basis. The NB210 modeling of the collimators is 95% complete. Design work has started on the NB210 foundation, drift duct, and source housing. The source housing design has matured with four approaches identified for how to open and hold the 300 pound doors while the NB is elevated to 20.8 degrees. A CDR is being scheduled for next week. The NB movement is maturing. Drawings for a prototype bellows flange have been produced and will go out for bid soon. The pole shield MOU is almost complete at PPPL.

Development of the new low-field-side ECE-Imaging array for DIII-D reached an important milestone this week with the completion of several design elements. A pyramidal horn antenna with a Vivaldi-type inline feed has been selected to replace the existing miniature elliptical substrate lenses and provide > 80 dB rejection of low frequency interference. Test structures are now being fabricated to verify the radiation pattern, which is expected to match the existing array element gain with exceptionally low side-lobes. The design of the heterodyne mixing circuit has also been improved, raising the range of ECE frequencies to cover 70-80 GHz. This updated circuit takes advantage of cutting-edge technology developed for the recently allocated E-band, where the telecommunications industry has begun to invest in solutions for multi-GB point-to-point wireless backhaul. On DIII-D, this frequency range is ideal for studying ELM suppression in low-rotation ITER baseline scenario development discharges. Prototype assembly will proceed in the coming weeks in the mm-wave Research Center at UC Davis.

C-Mod (F. Ebrahimi):

Experiments of lower hybrid current drive (LHCD) on the Alcator C-Mod tokamak are primarily designed to investigate current profile control. In these experiments, sawtooth activity could be suppressed as the safety factor q on axis is raised above unity by LHCD. However, in some of these experiments, after applying LHCD, the onset of MHD mode activity caused the current drive efficiency to significantly drop. In particular, between two shots with different LHCD timing, 1120606026 and 1120606025, the latter shows strong MHD mode activity after LHCD. Here, we study stability of these experiments by performing MHD simulations using the NIMROD code. Starting with experimental EFIT equilibria for these two experiments, we perform stability analysis as the q profile is evolved. First, consistent with the LHCD experiment with no signature of MHD activity, MHD mode activity was also absent in the simulations. Second, for experiments with MHD mode activity, we find that a core n=1 reconnecting MHD mode with poloidal mode numbers of m=2,3 is unstable. This mode is a resistive current-driven mode in nature as its growth rate scales with a negative power of S (Lundquist number) in the simulations. In addition, by using a reconstructed EFIT equilibria with further enhanced reversed-shear q profile (which is within the error bars) in the simulations, a core double tearing mode m=3, n=2 resonant is found to be unstable. It is therefore shown that the MHD activity observed in the LHCD experiment could be explained by the MHD simulations as the q profile for these two LHCD experiments may evolve differently. Further analysis is underway.

KSTAR (D. Mueller):

D. Mueller is visiting KSTAR (June 14 -24) to participate in start-up activities and vertical control experiments. The new vertical control sensor electronics (loop voltage and flux loop differences from two pairs of loops on the center stack) are in testing. The signals appear to be an improvement on the presently used pair of Mirnov coils on the inner wall in terms of signal to noise, but some electronic hardware appears to introduce a ~4 ms latency; the source of the latency is being investigated.

ADVANCED PROJECTS (H. NEILSON):

The Laboratory's TDU Scraper fabrication project for Wendelstein 7-X continues to make good progress. Assembly of the baseplate by PPPL technical staff is in progress. The first wall backplate, which will support the graphite tiles, was delivered to the graphite tile supplier, MWI, Inc. of Rochester, New York. In addition to manufacturing the tiles from PPPL-furnished materials, MWI is responsible for performing a complete pre-assembly of the tiles to the backplate in order to verify that the completed first wall assembly meets dimensional specifications, especially the shape of the contoured plasma-facing surface. Discussions were held with MWI this week to agree on details of the assembly procedure. A visit to MWI by PPPL representatives and Dr. Joris Fellinger of the Max Planck Institute for Plasma Physics is planned for the last week in June.

THEORY (A. BHATTACHARJEE):

W. W. Lee gave a Theory Seminar entitled "Equilibrium Potential Well due to Finite Larmor Radius Effects at the Tokamak Edge," where he presented a novel mechanism for producing the equilibrium potential well near the edge of a tokamak. Briefly, because of the difference in gyroradii between electrons and ions, an equilibrium electrostatic potential is generated in the presence of spatial inhomogeneity of the background plasma, which, in turn, produces a well associated with the radial electric field, Er, as observed at the edge of many tokamak experiments. This theoretically predicted Er field, which can be regarded as producing a long radial wavelength zonal flow, agrees well with recent experimental measurements on JET, NSTX, and Alcator C-Mod H-mode discharges. The work is in collaboration with R. B. White [PPPL Report No. 5254 (2016)]. For verification purposes, Lee also suggested the need to develop a global electromagnetic gyrokinetic PIC code at PPPL, which can be used for studying steady state turbulence as well as for comparing with the equilibrium MHD physics by minimizing the fluctuations.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

S. Ethier gave an invited talk at the PASC16 Conference (http://www.pasc16.org/) in Lausanne, Switzerland, as part of a mini-symposium on Advanced Computing in Plasma, Particle and Astrophysics on Emerging HPC Architectures. Ethier's presentation was entitled "Gyrokinetic Particle-in-Cell Codes at Exascale: Challenges and Opportunities." The Swiss Platform for Advanced Scientific Computing (PASC) is a structuring project jointly supported by the Swiss University Conference and the Council of Federal Institutes of Technology with the goal of promoting joint effort to address key scientific issues in different domain sciences through interdisciplinary collaborations between domain scientists, computational scientists, software developers, computing centers, and hardware developers.

DIRECTOR'S OFFICE (C. AUSTIN):

On June 15, Dr. Oliver Ford from Max Planck Institute fur Plasmaphysik, presented a colloquium entitled, "Wendelstein 7-X: Highlights from the First Operational Phase of the New Optimized Stellarator."

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