The PPPL Highlights for the week ending August 5, 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 were quotations for battery banks in support of an “Arrangement” document that will transfer procurement of 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 again to August 8 due to extra time needed for mobilization of Logistics Support Provider (LSP, ITER’s shipping contractor).

**Diagnostics:**

Electron Cyclotron Emission (ECE): UT group continues testing of the emissivity enhancements of the inconel heater front surface. The current results of the extended testing of the grooved inconel plate at high temperature were presented on the weekly teleconference. The coating of the inconel samples is in progress. Samples have arrived at the vendor for Cerablake coating. Coating with Armenco paint is proceeding at CEM. Vantablack coating and dendritic rhenium coating have both been eliminated. An update for the Gaussian Beam analysis of the radial portion of the front-end optics was completed. The oblique part will be completed this week. The two will be combined into a single 3D CAD drawing and made available to PPPL for inclusion in the DSM design as a reality check. Suggestions for revisions to the FMECA table were sent to the IN-DA. The revisions sent to the IN-DA were to assure inclusion of the system redundancy for making Te profile measurements.

Upper Port 11 and 14 Integration and DSM Engineering: One important aspect of port plug engineering is the design and analysis of water distribution piping and fittings. The port plugs are filled with water for cooling the front-end components, for vacuum-baking the entire port plug and for nuclear shielding. The Upper Port Integration team has been working on upgrading various water piping component designs including the water manifold box for DSM piping which needs to be attached to the rear DSM frame. In order to withstand vibration and shock due
to inertial loads and displacements due to high temperatures various mounting options were considered including springs, wire rope isolators and other options. Most of these options have been ruled out and now bellows are being considered to get the flexibility needed.

**NSTX-U (M. ONO):**

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

A paper entitled “Kinetic corrections from analytic non-Maxwellian distribution functions in magnetized plasmas” by O. Izacard (LLNL, assignment at PPPL) has been published in Physics of Plasmas 23, 082504 (2016) (dx.doi.org/10.1063/1.4960123) containing some results presented at the Nathaniel Fisch’s Symposium (PPPL, March 2016). “This work uses the well-known Kappa distribution function and the sum of two Maxwellian distribution functions (MDFs) for the description of non-Maxwellian distribution functions (NMDFs). In addition, an interpreted analytic non-Maxwellian called INMDF has been constructed from new non-orthogonal basis sets. The physical and experimental existence of INMDFs is proved particularly by new understandings of the electron temperature discrepancy between ECE and TS diagnostics in JET and TFTR. The advantage of using an analytic NMDF is shown in the paper by our ability to analytically compute velocity phase space integrals resulting in a small number of simple terms as function of the fluid parameters of the NMDFs. As applications, we show the effects of different super-thermal tails on the secondary electron emission, the Langmuir probe characteristic curve and the entropy. As main results, it is shown that (i) the empirical formula for the secondary electron emission is not consistent with a MDF due to the presence of super-thermal particles, (ii) the super-thermal particles can replace a diffusion parameter in the Langmuir probe current formula, and (iii) the entropy can explicitly decrease in presence of sources only for the introduced INMDF without violating the second law of thermodynamics. Some of these results can be used for better interpretations of NSTX-U Langmuir probes and other diagnostics in presence of NMDFs. Finally, new techniques can be developed in NSTX-U for the measurement of NMDFs.”

The Finite-orbit-width (FOW) extensions for the CQL3D bounce-average Fokker-Planck code have been developed in the past few years. Last month, an extensive manuscript has been submitted to PPCF with detailed description of the theoretical formulation and initial verification tests in conditions of NSTX plasma with NBI and HHFW heating—“A Fully-Neoclassical Finite-Orbit-Width Version of the CQL3D Fokker-Planck code” by Y. Petrov and R.W. Harvey—available as a CompX report from http://www.compxco.com/cql3d.html. “The calculations for the ionic portion of the bootstrap current show a good match with (Sauter et al) fit model equations in the plasma core, and there is a noticeable difference at the plasma edge region where the ion orbital+gyro losses become significant. The focus of the tests was the fully-neoclassical radial transport from both collisions and the quasilinear diffusion by RF waves, particularly at high-energy non-Maxwellian region of the deuterium distribution function.”


R. Maingi (PPPL) presented a seminar at the Nuclear, Plasma, and Radiological Engineering Department at the University of Illinois: “The Effect of Lithium on Edge Plasma Performance and Stability in NSTX.” Lithium collaborations between NSTX-U and UI-UC were also discussed.

A Conceptual Design Review for the NSTX-U Cryo-pumped Divertor (CPD) was held at PPPL on August 3. J. Menard described programmatic justification and physics motivation as well as design of the CPD. S. Raftopoulos described CPD Project Management and the overall system description and safety considerations. N. Atnafu gave an overview of the Systems Requirements Document. R. Vieira (MIT) described the design of the cryo-ring/pump, T. Stevenson described the planned CPD connections to the cryo-plant and new He refrigerator, M. Mardenfeld described the conceptual design of the CPD support structures, baffle plates, bakeout needs, and PFCs. S. Gerhardt described the diagnostics, PFC sensors and plasma viewing, and S. Langish gave a presentation describing the cost, schedule and manpower needs for the project.

Post-run calibrations were performed this past week in preparation for the NSTX-U outage. Magnetic diagnostic calibration shots have been completed, and several shots supporting the Motional Stark Effect Laser Induced Fluorescence (MSE-LIF) calibration utilizing the Diagnostic Neutral Beam (DNB) injection into a gas filled torus were performed. Multi-pulse Thomson Scattering (MPTS) diagnostic Rayleigh and Raman calibrations have been completed. The neutral beam (NB) cryo-panels have been warmed to room temperature, and the helium refrigerator secured.

On July 27, about 11 beam-into-gas shots were taken under XMP-157 (Characterization of neutral beam fractions). The Fast Ion D-Alpha (FIDA) spectrometers and fast cameras were used to measure spectra in the D-alpha wavelength range and to take images of D-alpha emission respectively. A scan of neutral beam source, injection energy and background pressure was performed. The data is very useful for the check of v-FIDA and t-FIDA spectra response and assessment of beam emission signals to assist the design of “D-alpha monitor” system. Initial data analysis shows that the active t-FIDA system has observed Doppler shifted D-alpha signal from three energy components of neutral beam line one, as expected. More detailed analysis is underway to estimate beam species of three energy components as a function of beam injection energy.
ITER & TOKAMAKS (R. HAWRYLUK):

C-Mod:

Jinseok Ko (NFRI/KSTAR) visited S. Scott (PPPL), R. Mumgaard (PSFC), A. Hubbard (PSFC) and L. Sugiyama (MIT) on Thursday to compare MSE diagnostic and I-mode physics issues that are common between KSTAR and Alcator C-Mod.

DIII-D (R. Nazikian):

B. Grierson gave a remote presentation to OFES on the progress in his Early Career Award focusing on the physics of main-ion rotation and transport in the H-mode pedestal. The diagnostics has already identified large differences in the rotation of the main-ions and impurities across the L-H transition and in stationary ELMy H-modes, and inferred a spatial inward shift of the impurity density relative to deuterium on the outboard midplane, as predicted by XGC0 neoclassical simulations. The next step is model validation to identify the physics of intrinsic rotation in DIII-D.

A. Ashourvan was recently hired under B. Grierson’s Early Career Award to test models of intrinsic rotation generation and momentum transport using the main-ion CER capability on DIII-D. Ashourvan and T. Stoltzfus-Dueck (Princeton) have recently implemented the intrinsic velocity prediction model developed by Stoltzfus-Dueck (PRL 2012) into OMFIT. The model uses the plasma equilibrium geometry (X-point, q95) and pedestal scale length as a proxy for the turbulence intensity to predict the toroidal velocity at the top of the pedestal. A set of DIII-D ECH H-modes and balanced NBI conditions have been identified for validating this model.

The DIII-D Microwave Imaging Reflectometer (MIR) was returned to UC Davis this week for testing and improvements at the Davis Millimeter-wave Research Center. Student researchers there will be able to evaluate the system side-by-side with the EAST MIR system that is in the final stages of preparation. Imaging reflectometry can be very sensitive to optical alignment, and lessons learned while operating the system on DIII-D will guide laboratory tests aimed at improving the ease and reliability of attaining optimum alignment to the plasma while reducing the impact of competing reflections from lenses and vacuum windows. The stability, gain, and noise characteristics of the receiver system will also be re-characterized and compared to the “system-on-chip” circuit that is currently being developed for DIII-D’s ECE-Imaging diagnostic.

The Impurity Granule Injector (IGI) project took a step forward this week with the addition and successful testing of a granule recycling feeder developed by D. Mauzey (PPPL Student Intern). Mauzey developed an improved granule dropper system for the IGI by incorporating two granule feeders, one for the main granule feeder and the other for recycling rejected granules from the main feeder. The result is an improved IGI with more regular granule delivery than past designs. The regularity of granule delivery with the new feeder is being assessed for a spectrum of sizes and materials, including lithium. Drop rates of 70 Hz have been achieved so far, with a goal of 200 Hz desired.
International (R. Maingi):

R. Maingi visited the University of Illinois in Urbana, Champaign, and met with Professors Daniel Andruczyk, David Ruzic, and Davide Curreli, and students at the Nuclear, Plasma, and Radiological Engineering Department on August 4. He also visited ORNL (J. Canik, J. Lore, Larry Owen, and Phil Ferguson) and the University of Tennessee in Knoxville (Professors Brian Wirth and Steve Zinkle) on August 5. Good progress was made on the planning of activities related to the international collaboration on PMI topics with the EAST device.

ADVANCED PROJECTS (H. NEILSON):

Fabrication of two divertor scraper units for our collaboration with Germany’s Wendelstein 7-X stellarator continues to make progress toward completion by the end of this fiscal year. The last major fabrication contract—with MWI, Inc. of Rochester, New York for machining of the graphite tiles and pre-assembly onto their backing plate—is nearly complete. Both sets of tiles have been machined and dimensionally inspected. The most critical requirement, namely the contour of the plasma-facing surface, is found to be within the specified +/- 0.2 mm tolerance envelope. Fabrication of a spare set of tiles is currently in progress. At PPPL, manufacture and dimensional inspections of the mockup assembly, which will be used by IPP to develop installation procedures, has been completed.

Dr. Iván Vargas Blanco, Head of the Plasma Laboratory for Fusion Energy and Applications at the Costa Rica Institute of Technology (in Spanish, TEC), completed his stay at PPPL on July 29. During his visit, Dr. Vargas acquired and learned how to use key tokamak and stellarator data analysis codes that will support research using his Laboratory’s two experimental devices. It was agreed that continued collaboration between TEC and PPPL will be beneficial, and planning for visits by other TEC scientists are already underway. Dr. Vargas extended an open invitation for U.S. colleagues to visit his Laboratory in Costa Rica.

The Laboratory and South Korea’s National Fusion Research Institute (NFRI) executed a new one-year agreement to continue our collaboration in fusion engineering science research in the framework of their K-DEMO study. During a visit to PPPL by Drs. Keeman Kim and Kihak Im of NFRI, the team reviewed the work plans for this new phase of the collaboration. PPPL’s efforts will focus on plasma heating and current drive and selected tokamak configuration issues. In addition, several joint papers will be presented at upcoming conferences.

THEORY (A. BHATTACHARJEE):

On August 4, Farrukh Nauman (Niels Bohr International Academy, Copenhagen) presented a theory seminar on turbulence in shear MHD flows. The abstract reads: “Implications for accretion disks: Accretion flows are found in a large variety of astrophysical systems, from protoplanetary disks to active galactic nuclei. Our present understanding of such flows is severely limited by both observational and numerical resolution. I will discuss some new numerical results on zero magnetic flux shear MHD turbulence and its relation to the magnetic Prandtl number. I will then briefly discuss the effects of rotation on large scale magnetic fields.
**My talk will end with some speculations about how one might construct a self-consistent model for accretion flows based on our current understanding.”**

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.”

N. Ferraro and J. Breslau attended a NERSC Dungeon Session at Intel’s Jones Farm Conference Center in Oregon to optimize key kernels of the flagship M3D-C1 code for maximum performance on the upcoming “Knights Landing”-based Cori Phase II machine at NERSC. Using the VTune Amplifier XE tool to identify hotspots, they were able to rewrite the kernels to improve vectorization, achieving speedups by a factor of 3.5 to 4 for both.

**COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):**

TRANSP builds and runs on all common Linux distributions, as well as on commercial Unices, including Mac OS X. On August 2, Microsoft released the Windows 10 Anniversary Update, which introduces a compatibility layer for Linux executables called the Windows Subsystem for Linux (WSL). By taking advantage of the WSL, only slight modifications were needed to successfully get TRANSP built and running on Windows 10. This was done to make TRANSP more accessible to developers. There are no present plans (or requests) to make this available to users. We expect that other PPPL codes could also be easily ported to Windows 10 in this way. Contact J. Carlsson for more details.
PLASMA SCIENCE & TECHNOLOGY (P. EFTHIMION):


DIRECTOR’S OFFICE (C. AUSTIN):

A Director’s Review was conducted in preparation for an independent project review for the IOI CD-3 approval. The review was successful. The independent review should occur in late August.

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