The PPPL Highlights for the week ending October 2, 2015, are as follows:

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

Steady State Electric Network (SSEN):

The department received comments on the first submittal of "Red Book" recommending an award of contract for the Reactive Power Compensators procurement.

A videoconference was held involving PPPL, Schneider Electric, ITER IO, and F4E that led to the resolution of issues related to seismic qualification of Power Transformers being procured for the Investment Protection (IP) power distribution system. This clears the last significant technical issue prior to moving forward with the Release for Manufacturing (RFM) approval.

Diagnostics:

Electron Cyclotron Emmission (ECE): The University of Texas, Austin completed the ECE hot calibrations source test fixture evaluation of the prototype concept. The evaluation showed two options allowable for the heater debugging of the thermal models, and initial runs began of the thermal model of a prototype calibration source attached to the DSM walls. The high frequency power supply for the hot sources was tested with dummy loads, as well as in two remotely programmable configurations.

Upper Vis/IR Wide Angle Viewing System (UWAVS) project: An electromagnetic simulation of the revised integrated Upper Port 14 and Upper WAV-VIR components was completed, including detailed models of the UWAVS bull nose and Front End Optics Tube (FEOT). In parallel to the EM analysis work, a new set of UP14 neutronics analysis using Attila software was completed. Results for neutron and prompt gamma flux, as well as component nuclear heating and damage, were provided to the General Atomics UPP WAV-VIR engineering team. Now the EM and neutronics results will allow for a revision to the CDR Upper WAV-VIR load specification and structural integrity reports.

Upper Port 11 and 14 System Integration Review: A successful System Integration Review (SIR) held at the ITER PBS 55 offices was completed this week. The SIRs are formal peer reviews addressing the complex integration issues in the diagnostic ports. Key objectives are to identify clashes, installation issues, and maintenance issues with associated actions assigned to the tenant systems. Other significant activities include reviewing the master port plug integration schedule, "freeze" dates for the configuration of tenant systems, and generic structures.

Equatorial Port 9 Integration and Engineering: Activities focused on the design of Diagnostic Shield Module #4 (DSM-4) including the water distribution piping for DSM-1, 2, and 3. PPPL engineers and designers are working together in CATIA and ANSYS to iterate through piping designs and configuration optimization. The basic design of the equatorial port Diagnostic Shield modules (DSMs) advanced significantly. The team also completed revisions to an important Load Specification document for the Interspace and Port Cell regions of the diagnostic ports.

Core Imaging X-Ray (CIXS): PPPL is in the process of acquiring X-ray imaging detectors from Dectris for magnetic and nuclear testing. A loaned detector will be used for magnetic field testing while a purchased detector will be used for nuclear testing. "Survivability" testing is critical to the continuation of the CIXS project, since the detectors have to be positioned in a high magnetic and radiation field environment to obtain the required ITER measurements. These detectors will also be subjected to high vacuum bake temperatures near 200 C. If the detectors survive the magnetic and nuclear testing, the purchased unit will be set up in thermal cycle testing.

Diagnostic RGA: The ORNL DRGA team started R&D testing to validate the location of the Optical Penning Gauge (OPG) at the inter-stage port of the turbo-molecular pump. Pressure at the inter-stage port was verified to be within the operational limits of the OPG, although the desired differential pressure between the main chamber of the turbo pump and the inter-stage port was not as large as expected; this reduces the brightness of the OPG plasma and makes it more difficult to achieve the OPG measurement. Existing filters and instrumentation were used with this initial OPG testing but need further optimization, and plans are being made to procure the needed hardware. This will provide the capability to discriminate various gas species at the required levels during subsequent sensitivity tests. A working prototype of the LP12 RGA heated aperture pipe will be fabricated as part of the RGA R&D testing. After heating/baking tests are concluded, the pipe will be connected to the RGA Prototype system for conductance/performance tests. A subcontract was just awarded to Thermocoax to fabricate this heated pipe, with delivery expected near the end of CY15. PPPL CATIA designers advanced DRGA integration design.

Toroidal Interferometer and Polarimeter (TIP): Construction of the laboratory TIP beamline prototype at General Atomics is now complete and commissioning has begun. PID controllers in the feedback loop are being tuned with information gained by the system response to a step-function change in beam position. Thus far, only a single beam position detector/mirror actuator loop has been implemented using a visible laser. Ultimately, two such loops are planned, and position detectors sensitive at the 10 microns will be tested to determine whether the CO2 laser can be used directly, rather than relying on a visible laser proxy. A strategy to develop the critical initial alignment procedure of the TIP in-vessel mirrors is also underway. One complicating factor is the existence of an annular “shim” between the port extension of the vacuum vessel and the port plug attachment flange. This shim is designed to compensate for “as-built” tilts in the ~2.5 m radial extensions. Such tilts are large compared to the angular precision needed for the TIP laser beam alignment. D. Johnson has made a request to the ITER organization to identify the basis for the design of this shim, in order to develop a strategy to assure the initial alignment of the TIP system during assembly of the vacuum vessel and the port plug.

Low Field Side Reflectometer (LFSR): The in-vessel design of LFSR is progressing well;

thermal expansion of the wave guides are estimated and flex joints designed to allow the expansion. The LFSR TL testing stand at General Atomics is proving that the oversized corrugated wave guides are very robust and predictable in low and high frequency. The Gaussian telescope testing is now planned on the same test stand. Front end antenna layout (including the backscattered doppler antenna) is being finalized, with modeling help from PPPL physicists. For TL Design, N. Allen visited General Atomics this week to review their capabilities for manufacturing wave guides, current implementations of transmission lines on D-IIID, LFSR test stand setup, and bench tests for the Gaussian telescope. General Atomics personnel were able to provide extensive information on manufacturing capabilities, possible delay points, installation procedures for wave guides, and invaluable information on alignment procedures. They also were able to provide some ideas for modifying their components to better meet the needs of the ITER LFSR system, including possible options for adding windows to existing components for a SIC-2 penetration.

RAMI training: RAMI Training for all PPPL-US ITER Diagnostic projects occurred on September 15. Lee Cadwallader from Idaho National Laboratory gave the training and provided an overview of the RAMI process as well as requirements related to ITER.

NSTX (M. ONO):

A number of NSTX-U researchers from PPPL attended the Fourth International Symposium on Lithium Applications to Fusion (ISLA-4) held in Granada, Spain on September 28 – 30. The NSTX-U related oral presentations were “Liquid Lithium Applications for Solving Challenging Fusion Reactor Issues and NSTX-U Contributions” by M. Ono, “Incremental Upgrades Toward High-heat Flux, Liquid Lithium PFCs in the NSTX-U” by M.A. Jaworski, “Lithium Granule Ablation and Penetration during ELM Pacing Experiments at DIII-D” by R. Lunsford, “The Effect of Progressively Increasing Lithium Conditioning on Edge Transport and Stability in High Triangularity NSTX H-mode Discharges” by R. Maingi, “In Vacuo Analysis of LTX Wall Samples Exposed to Lithium and Implications for High-Z Plasma-Facing Components in NSTX-U” by R. Kaita, “Lithium Vapor Box Divertor” by R.J. Goldston (presented by M. Jaworski), and “Peer Review of Lithium safety at Princeton Plasma Physics Laboratory and implications of Present and Future Lithium Research” by R. Kaita.

Several NSTX-U-related talks were given at the Second IAEA Technical Meeting on Divertor Concepts held from September 29-October 2 in Vienna, Austria. R. Goldston (PPPL) presented "The Lithium Vapor Box Divertor", V. Soukhanovskii (LLNL) presented "Developing Snowflake Divertor Physics Basis in the DIII-D, NSTX and NSTX-U Tokamaks Aimed at the Divertor Power Exhaust Solution", and R. Maingi (PPPL) presented, "Lithium and Liquid Metal Studies at PPPL". In addition, D. Majeski (PPPL) presented "Concepts for Fast Flowing Liquid Lithium Walls and Divertors".

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

Z. Wang visited DIII-D to collaborate on the physics of the plasma response to 3D fields

including the effects of resistivity and the thermal ions. The plasma response is calculated using the MARS-F stability code. Due to finite resistivity, the ideal kink response of the plasma leads to a significant tearing response at rational surfaces. The dependence of the linear island width to the applied I-coil spectrum is being studied. This work has relevance in demonstrating how the ideal MHD response can enhance tearing drive, leading to island formation.

A number of DIII-D researchers attended the Fourth International Symposium on Lithium Applications to Fusion (ISLA-4) held in Granada, Spain on September 28 – 30. Presentations included "Lithium Granule Injection for High Frequency ELM Pacing on DIII-D" by A. Bortolon (presented by R. Maingi), “Lithium Granule blation and Penetration during ELM Pacing Experiments at DIII-D” by R. Lunsford, and "Enhanced H-mode Pedestal by Lithium Injection in DIII-D" by T. Osborne.

The DIII-D LGI technical team continued reassembly of the LGI after installation of new dropper counter, electric motor, lithium agitators, and the ablation sensor. The unit will be pumped down this week and tested with carbon granules. The installation of the TIV is scheduled for end of October and the LGI installation will begin in December in time for a planned January experiment.

C-Mod (S. Zweben):

S. Zweben completed a preliminary analysis of the edge/SOL turbulence seen in the GPI diagnostic during the inner-wall-limited shots of 2014. This analysis will be used for comparisons with the turbulence code GBS, being run by Lausanne for these specific shots. The preliminary data analysis shows that the turbulence amplitudes, autocorrelation times, size scales, and velocities are similar among the three shots analyzed, even though they had different toroidal field and currents. This is similar to a previous result on C-Mod (Zweben, Scott et al, PoP ’09), but the interest now is to compare the results quantitatively with the 3-D GBS code.

International (R. Hawryluk):

A prototype thin foil Faraday cup fast ion loss detector assembly for JET was completed in September, satisfying a milestone for the JET collaboration for FY15.

J. Hosea, N. Bertelli, R. Ellis, E. Kolemen, and G. Taylor recently visited KSTAR. Ellis presented a successful pre-conceptual design review of a proposed 2-channel, steady-state ECH launcher for the tokamak. The detailed presentation over two hours included scaled drawings and a summary of performance calculations. This was followed by a summary discussion of 1.5 hours the next day. A complete conceptual design review is planned for January 2016, so that participation in the KSTAR conference can be included in the trip. Kolemen had a successful experiment to make a stable NTM. Neutral beam injection was used to suppress and make the NTM. By applying n=1 3D perturbations, it was possible to lock the NTM to the wall. Entrainment of the mode using fast rotating (250 Hz) n=1 3D perturbation was studied. Detailed analysis will follow. During the lead up to the planned ICRF experiments, the KSTAR ICRF team attempted to increase the RF power level to support the planned experiments for the week of September 21. During this effort a feedthrough overheated and developed a vacuum leak. The system was re-configured to two strap operation for the antenna to avoid the leaking feedthrough but another feedthrough developed a leak during testing. Consequently, the ICRF experiment

was cancelled. Also, during this visit, Hyeon Park, the director of KSTAR, decided to terminate the ICRF program on KSTAR and to focus his resources on other heating and current drive techniques.

ADVANCED PROJECTS (H. NEILSON):

S. Lazerson, currently on long-term assignment at Germany's Max Planck Institute for Plasma Physics, reported new progress in flux surface mapping experiments on the Wendelstein 7−X stellarator, in which he is a key participant. The team is currently studying a modified q=2 configuration that was developed by Lazerson to increase the magnetic shear across the q=2 surface and pull the configuration away from limiter structures. This configuration allowed imaging of inner and outer flux surfaces, along with magnetic islands induced by the U.S.-supplied trim coils. Application of the trim coils opened a clear m=2, n=1 magnetic island. Scans indicate that the island chain rotates with the phase of the applied field. Scans of the trim coil current were performed showing the island width scaling with amplitude. Initial results and analysis will be presented at the International Stellarator-Heliotron Workshop next week, as well as at the American Physical Society's Division of Plasma Physics meeting in November.

THEORY (A. BHATTACHARJEE):

On September 29, Jaehong Park (Princeton University) gave a theory seminar on particle-in-cell modeling for particle acceleration in space and astrophysical environments: “Energetic particles are commonly observed in space and astrophysical objects. Collisionless shocks and magnetic reconnection have been considered as the favorable acceleration sites. However, the underlying mechanism is still not fully understood. In the first part of this talk, I present our recent progress on particle acceleration at non-relativistic strong shocks in particle-in-cell simulations [PRL 114,085003 (2015)]. Our results explain the cosmic-ray electron-to-ion ratio in nature, and how electrons overcome their small gyro-radii to be accelerated, the so-called, ‘electron injection problem’. Both electrons and ions reveal the same power distribution, remarkably in agreement to the prediction of diffusive shock acceleration. In the second part of this talk, I present our recent result about magnetic reconnection driven shocks in solar flares. Solar flares convert magnetic energy into particle energy via magnetic reconnection. The reconnection outflows generate a fast mode weak termination shock. Therefore, magnetic reconnection in solar flares is considered as an ‘acceleration environment’ rather than a single acceleration mechanism. I present how the fast mode shock forms from the standard Harris sheet with a magnetic loop boundary in particle-in-cell simulations. The reconnection outflows carry turbulent magnetic fields possibly triggered by the drift-kink instability. I also discuss about particle acceleration.”

On October 1, Binzheng Zhang (Dartmouth College) gave a theory seminar on the question “How Does Mass Loading Impact Local Versus Global Control on Dayside Magnetic Reconnection?” The impacts of magnetospheric mass loading on the control of dayside magnetic reconnection are investigated using multi-fluid, global magnetospheric simulations. The study is motivated by a recent debate on whether the integrated dayside magnetic reconnection rate is solely controlled by local processes (local-control theory) or global merging processes (global-control theory). The local control theory suggests that the integrated dayside reconnection rate is controlled by the local plasma parameters. The global control theory argues that the integrated

rate is determined by the net force acting on the flow in the magnetosheath rather than the local microphysics. Numerical simulations suggest a possible mixed-control theory, that is, 1) a small amount of mass loading at the dayside magnetopause only redistributes local reconnection rate without a significant change in the integrated reconnection rate, and 2) a large amount of mass loading reduces both local reconnection rates and the integrated reconnection rate on the dayside.

The paper "Self-organized Stationary States of Tokamaks" by S. Jardin, N. Ferraro, and I. Krebs has been accepted for publication in Physical Review Letters. In this paper, the authors demonstrate that in a 3D resistive magneto-hydrodynamic (MHD) simulation, for some parameters it is possible to form a stationary state in a tokamak where a saturated interchange mode in the center of the discharge drives a near helical flow pattern that acts to non-linearly sustain the configuration by adjusting the central loop voltage through a dynamo action. This could explain the physical mechanism for maintaining stationary non-sawtoothing “hybrid” discharges, often referred to as “flux-pumping”. An invited talk with this same title will be presented at the upcoming APS-DPP meeting.

The Monthly Newsletter of the U.S. Burning Plasma Organization (eNews of September 30, 2015) carried a Research Highlight on, "The Alpha Channeling Effect," by N. J. Fisch.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

S. Ethier and J. Lang attended the Intel Xeon Phi Users Group (IXPUG) annual meeting hosted by NERSC and held at the Lawrence Berkeley National Laboratory. IXPUG's mission is to provide a forum for the free exchange of information that enhances the usability and efficiency of scientific and technical applications running on large High Performance Computing (HPC) systems using the Intel Xeon Phi processor, which is the architecture of "Cori", the next large-scale computer at NERSC. Ethier made a presentation entitled "Lessons Learned from the Dungeon: Optimizing the XGC1 Code for Intel Hardware", which discussed the optimization work carried out during a three-day "deep-dive" session at Intel, which brought together experts from Intel, Cray, NERSC, and the XGC HPC team. PPPL's flagship codes M3D-C1 and XGC1 are both part of the NERSC Exascale Science Applications Program (NESAP), a collaborative effort in which NERSC partners with code teams and library and tools developers to prepare for the NERSC-8 Cori many-core architecture.

BUSINESS OPERATIONS (K. FISCHER):

Procurement:

PPPL has met all of its FY 2015 Small Business Goals. The details of this success are as follows:

Business Type	Actual	Goal
Small Business	34.4%	30%
Service Disabled Veterans	3.0%	1.6%
Veteran Owned Business	9.2%	3.0%
HUBZone Business	2.9%	1.6%
Women Owned Business	3.6%	3.0%
Small Disadvantaged Business	4.3%	3.0%

DIRECTOR'S OFFICE (C. AUSTIN):

On October 1-2, S. Prager hosted a PPPL Strategic Planning Retreat, which was held at 701 Carnegie Center. The purpose of the retreat was to discuss and evolve the lab strategy - from the big picture to specific topics. About 65 staff members from all sectors of the Laboratory attended. A similar retreat was held about 3.5 years ago, and it proved successful in generating ideas and achieving a unified vision.

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