The PPPL Highlights for the week ending March 25, 2016 are as follows:

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

Management Visit:

The U.S. ITER Project Manager (N. Sauthoff) and Head of Non-Nuclear System Division (Graeme Murdoch) visited Princeton Plasma Physics Laboratory. Sauthoff presented a talk entitled "Burning for Fusion Energy: In Pursuit of Self-heated Plasmas and Beyond" at the Andlinger Center on the Princeton University campus. Murdoch presented a status report about the progress of ITER to the PPPL staff. Meetings were held to discuss topics related to PPPL ITER Fabrication Department management and procurements being performed by PPPL.

Tokamak Cooling Water System (TCWS) Electrical Engineering Support:

PPPL provides review and consultation on electrical engineering matters related to the TCWS as part of an existing agreement between PPPL, U.S. ITER, and ORNL. The TCWS design scope, including electrical engineering and other disciplines, has been transferred to the IO by way of an arrangement. PPPL was asked to review the status of the IO TCWS electrical engineering work and has identified some significant issues that will need to be addressed. A videoconference will be held next week to develop an overall U.S. ITER strategy to address the issues.

Steady State Electric Network (SSEN):

Uninterruptible Power Supply (UPS) system and DC Distribution: Preparation of the RFP's is underway.

Power Transformers: A punch-list of minor items was developed during the Factory Acceptance Tests (FAT) of the ten transformers that comprise the Lot 3 shipment from the factory of Schneider Electric, near Istanbul, Turkey. The punch list items have all been corrected. PPPL's subcontract QC inspector will visit the factory next week to confirm that the punch list items have been correctly remedied and to inspect the final packaged units. The Release for Shipping (RFS) document package was submitted and reviewed by PPPL with comments. The shipping date had to be postponed again, now forecast for April 19. However, there is still ample float with respect to the milestone. Note that the delivery of this this shipment (by June 15) is an important ITER Council and PEMP milestone, and progress is well ahead of schedule.

Diagnostics:

Upper Port Wide Angle View Vis-IR Cameras (UWAVs): Subcontractor TNO has performed stress analysis of the Mirror #1 mount based upon the EM loads. Contact stresses are high and require a solution. TNO presented several solutions with the additional comment to rerun of the EM loads with the mirrors electrically isolated. General Atomics (GA) continues the SDC-IC assessment of the integrated FEOT: Bullnose, torque connector, and cask. GA performed thermal hydraulic and stress analysis of the FEOT bullnose torque connector and Cask assembly. Completion of the FEOT preliminary design is estimated for April.

Low Field Side Reflectometer (LFSR): The LFSR design team has made preliminary determination that the diagnostic system's transmission line can be installed above the cable trays in the ITER gallery and as such can not be classified as a trapped or captive component of the system for building 11 construction purposes. This can save time and money that otherwise will be spent on early design and manufacturing reviews and partial delivery of the LFSR transmission line.

Field-Programmable Gate Array (FPGA) based data acquisition and processing tests on the reflectometer on DIII-D was successful in providing phase delays that were identical to those obtained using the existing system. The activity that was done as R&D in support of the ITER LFSR, is being projected forward toward designing a FPGA based data acquisition and processing system with interface to ITER PCS, CODAC, and data archiving.

Electron Cyclotron Emission (ECE): Shutter mirrors were redesigned and are now also working as protective shutters for the calibration hot sources during operation. Initial design of the alternative push rod mechanism for the shutter mirrors is introduced. Analysis of the front optics mirror position and angular tolerances was performed. Design of front mirror mount is underway including angular adjustment mechanism. Hot source design and testing continues including the design of the L-shaped EP9-integration mounting bracket.

Diagnostic RGA (DRGA): Diagnostic RGA (DRGA) R&D activities continue. The H/D/T isotopic discrimination capability of the Optical Penning Gauge (OPG) was investigated. The emission spectrum from the OPG was observed for varying concentrations of H2 in D2. The Balmer alpha emission lines for H and D were readily measured using a one meter McPherson spectrometer: (1) At 50:50 concentrations this measurement serves as a resolution-check proxy for D/T discrimination; (2) At lower concentrations of H:D, this measurement is used to ascertain the detection threshold of H "impurity" in a DT fueled plasma. Concentration of H:D down to 1:99 was examined.

Also this week, the heated aperture weldment being fabricated by THERMOCOAX has been completed and is being prepared for shipment from France to ORNL.

Upper Port 11 and 14 Integration and DSM Engineering: The analysis team ran a bake-out thermal analysis for Upper Port#14 without the UPP Tenant systems. Per the results reported, the rear DSM support frame does not meet the project requirement of reaching bake-out temperature (>180 degrees Celsius). To meet the bake-out requirement, additional water cooling pipes for the frame and the tenant systems will be needed, which in turn will take away much needed cooling water for the systems in DSM during operation. As during operation these parts (Frame and other

Tenant components) do not need much cooling in Upper port. A. Jariwala will contact IO-CT team to check if there is a way to relax the bake-out requirement for this area.

Equatorial Port 9 Integration and DSM Engineering: EP09 port integration has completed a conceptual CATIA model of a double bellows attachment between the port Closure Plate and pass-thru DSM water piping. This concept can potentially solve problems with designing water piping to allow sufficient flex under thermal loads and operating displacements. The concept will soon be reviewed with IO.

This week, a new PCR for updated planning and budget of EP09 integration was approved by PPPL management. The PCR is now submitted for USITER approval.

Toroidal Interferometer and Polarimeter (TIP): The ITER Organization is seeking to better define the layout and services needed for equipment in the diagnostic hall. Generally, each diagnostic system will have a dedicated room. This week information about the TIP room was exchanged. The GA-led design team presented a preferred layout of optical tables and cubicles, and also specified the need for AC power, water, and dry air. They also specified the heat exhausted to the water and air. The routing of the TIP reference legs along a North-South enclosed pathway was also discussed. An open issue is the temperature control of the room, with the U.S. requesting tighter control than the IO building group is willing to guarantee.

Core Imaging X-Ray Spectrometer (CIXS): Work is progressing on bringing a Transrex power supply online for use in magnetic field testing using the PPPL FCPC building “Dummy Load” electromagnet. Preliminary bracket design finished for mounting detector in magnetic field. Finalized bracket design and manufacturing drawings to start next week. Programming for DSP used to control the power supply is underway. A peer review is to be set up in the next one to two weeks.

Equatorial Port 3 Integration and DSM Engineering: These are updates for E3 integration for the last few weeks. The Glow Discharge Probe (GDC) tenant system has been moving on design and integration and Gabor Kiss has been communicating back and forth on iterations of the GDC design and location in E3. This is the first real update in a few years and is a good opportunity to find an optimal spot in DSM1 for the GDC array. The last update showed a couple of clashes, which are being resolved. The China DA is responsible for the GDC systems with help from the IO.

NSTX-U (M. ONO):

FY 2016 NSTX-U plasma operations update: The department has completed 5.53 run weeks and 557 plasma shots. The total operation targets are to be decided.

W. Guttenfelder (PPPL) attended the ITPA Transport Confinement meeting hosted by IPR in Ahmedabad, India, on March 16-18. Topics discussed included: updates on the H-mode confinement scaling database to include ITER-baseline scenarios and data from metal wall machines, low-Z impurity transport, rho-star scaling of intrinsic torque, and transport modeling. Multiple sessions were held jointly with the ITPA Pedestal and Edge Physics group including those on I-modes, L-H transitions, and 3D effects on transport. Some topics being

considered for the next ITPA T&C meeting (following IAEA) are intrinsic rotation, updates on joint experiments, and updates on the confinement scaling DB revision. There will also likely be joint sessions held with the Integrated Operation Scenarios group to discuss the status of transport models (e.g. particle transport, neural net modeling, and revisiting current ramp-up/ramp-down).

XMP-143 (Assess Machine Conditions) was run on March 21. The goal of these shots was to assess the vessel conditions and recover operations following the two-week outage that included a quick vent to argon and vessel opening for removal of the BN shutter parts. Ohmic scenarios with both 8 kA and 20 kA ohmic current pre-charge levels were examined. The oxygen levels in these discharges were initially elevated, but decreased through the day. By the end of the day, good ohmic plasma conditions were recovered with reproducible discharges running out past 1.2s, indicating that the impact of the Ar vent and opening on vessel conditions was manageable.

Shots were taken towards XMP-120 (X-point and Strike-point Control) on March 22. Ohmic and 1 MW L-mode shots were used. Control of the lower X-point radius and height was established using the PF-1aL and PF-2L coils as actuators. Once this was tuned, the algorithm was used to additionally control the upper X-point position and height, using the upper versions of those same coils. Good control was achieved, and with this development, all PF-coils in use during the shot were controlled by the ISOFLUX algorithms. The final shot of the day set a record pulse length of a 1.9 second I_P flat-top, exceeding in duration of any shot achieved in NSTX.

Further shots were taken towards XMP-120 on March 23. These 1 MW L-mode shots demonstrated simultaneous control of the outer strike-point in and the X-point height. Good control was demonstrated, as manifest by matches between steps in the lower outer strike-point radius and steps in the radius of divertor C II emission, a non-magnetic measure of the strike-point radius. In parallel with this activity, breakdown at lower toroidal field was assessed: breakdown and ramp-up was achieved at fields as low as $B_T = 0.55$ T with a 20 kA OH current pre-charge, and at fields as low as $B_T = 0.35$ T with an 8 kA OH pre-charge. These breakdown studies demonstrate a required capability for future XPs that desire to scan the toroidal field. The PCS was used to program a notch in the beam power, which demonstrates this capability for use in future XPs and XMPs.

On March 24, a few discharges were taken towards XP-1506 (Low-beta Error Field Assessment). However, problems with plasma vertical stability, followed by a long period of rectifier troubleshooting, prevented completion of a fully applied error field scan. In spite of the limited run time, a reference fiducial shot was developed, and two locked-mode-terminated discharges at a single applied field phase were obtained.

On March 25, the L-mode morning fiducial discharge to be used in XMP-144 (NSTX-U Morning Fiducial), was further refined by using the 1B source at 1 MW (instead of the 1C source), and by refining the fuelling. This resulted in a discharge that can be used as the morning fiducial discharge for the remaining run period before the next maintenance period. Work was then done on XMP-142 (Reduced MHD H-mode Development), but progress was limited by comparatively high impurity levels and some facility intermittencies. It is anticipated that the boronization scheduled for March 26 will result in improved PFC conditions for operations next week.

NSTX-U resumed plasma operations this past week after a two-week maintenance period that included a brief argon vent of the vessel. Neutral beam injection was utilized this week with all six NB ion sources operational and being conditioned at total power levels of >6MW. All six NB ion sources were able to inject power into the plasma. HHFW RF sources 1-4 have completed pre-op testing, and recovery of sources 5 and 6 is nearing completion. A vacuum vessel boronization will be performed on March 26.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

B. Grierson made a remote presentation to the ITPA Transport and Confinement topical group on fluorine (Z=9) gas puff experiments in hybrid plasmas and comparison with TGLF predictions. He showed that TGLF captures the inward fluorine particle pinch associated with ITG dominant core turbulence however the model underestimates the turbulent impurity particle diffusion in the outer region of the plasma. More recent experiments with argon injection into hybrid plasmas showed increased core impurity diffusion when ECH is applied, promoting a more rapid impurity exhaust. Modeling is currently underway to determine the role of the ECH in affecting core particle transport.

B. Grierson presented a Research Seminar at PPPL on intrinsic rotation studies performed on DIII-D and comparison with gyrokinetic modeling with GTS performed by W. Wang. With increased direct electron heating by ECH, main-ion toroidal velocity profiles undergo a core rotation reversal at the same power that is associated with energy confinement degradation. GTS simulations predict the onset of large-scale turbulence and the formation of residual stress in the same radial location as the measured rotation profile inversion. By computing the steady-state intrinsic rotation profile from the GTS momentum fluxes, the predicted rotation profile displays good agreement with the measured rotation profile. This work significantly advances our understanding of the role that residual stress plays in low torque plasma regimes.

G. Kramer presented a research seminar on the effects of Alfven eigenmodes on fast ion transport in reverse magnetic shear steady state plasma regimes on DIII-D and methods that the transport could be reduced by profile modification. He showed that the kick model (first applied to NSTX-U by M. Podesta) was in agreement with the large (up to 40%) fast ion loss observed in these plasmas. He found that the strong loss is associated with the alignment of qmin with steep pressure gradient of the beam ions from TRANSP analysis. He proposed a method to reduce losses by moving current off axis and this approach was attempted in recent experiments. Analysis is currently underway for these measurements.

M. Okabayashi presented the “Sustainment of Multi-layered Structure of Unlocked Tearing Modes by Feedback-based Electromagnetic Torque Injection” at the Joint meeting of ITPA MHD Disruption and Control Topical Group and U.S.-Japan MHD Workshop at NIFS in Toki, Japan March 7-11.

D. Eldon is developing an OMFIT module to manage and interpret SOLPS runs. The OMFIT module will interactively set boundary conditions for the SOLPS run using a visual interface.

The module will then perform parameter scans by launching parallel runs and provide visualizations of the output which will help the user gain insight from the simulations.

International (R. Maingi):

"First results of the use of a continuously flowing lithium limiter in high performance discharges in the EAST device" was published in Nuclear Fusion 56 (2016) 046011, in collaboration with PPPL co-authors. This paper documented the first flowing liquid lithium system in tokamaks for long time durations, using a DC electromagnetic pump that worked with the superconducting magnetic field in EAST. Plasma recycling was reduced, and performance was improved in ohmic and H-mode discharges. The concept can be extended to high power, long pulse fusion devices.

ADVANCED PROJECTS (H. NEILSON):

A milestone was achieved in the Laboratory's Wendelstein 7-X (W7-X) TDU Scraper fabrication project with the delivery this week of a sample graphite tile that will be used by Max Planck Institute for Plasma Physics (IPP) to check the thermal response of the system. Two TDU scrapers, currently in fabrication, will be installed during the next W7-X operating campaign to test their functionality as protective components and to validate models for heat flow in the 3D W7-X magnetic divertor region that were used in the design of the scrapers. During that campaign the in-vessel systems, including the scraper, will rely on inertial cooling to keep plasma-facing surfaces within acceptable temperature limits. The sample tile, which was fabricated by MWI, Inc. of Rochester, New York, will be mounted to a PPPL-fabricated fixture that simulates the actual support arrangement and tested in IPP's GLADIS high heat-flux test facility. It is expected that after inspection of the sample tile and assembly to the fixture, the sample assembly will be shipped to IPP in April.

THEORY (A. BHATTACHARJEE):

On March 23, a paper by F. Ebrahimi and R. Raman entitled "Large-volume flux closure during plasmoid-mediated reconnection in coaxial helicity injection" was published online in Nuclear Fusion as a Letter (http://dx.doi.org/10.1088/0029-5515/56/4/044002). In this paper, coaxial helicity injection (CHI), a leading candidate for plasma start-up and current formation in NSTX-U, was numerically studied in NSTX-U through resistive MHD simulations. In these simulations, a large-volume flux closure, and large-fraction conversion of injected open flux to closed flux, in the NSTX-U geometry was demonstrated for the first time. Because of the optimized location of injector flux and flux shaping coils in NSTX-U, which allow a better shaping of the initial flux and narrower injector-flux footprints, major improvements and differences are elucidated in the NSTX-U simulations: (1) the volume of flux closure is large and nearly all of the CHI-generated current is closed-flux current, (2) because of larger reconnecting magnetic field in the injection region, spontaneous reconnection, i.e. plasmoid instability, could occur at every stage of the helicity injection, but the final resulting state is a large volume of closed flux surfaces at equilibrium with a large CHI-generated closed-flux current.

On March 25, John R. Cary (University of Colorado Boulder) presented a theory seminar on the Speed-Limited Particle-in-Cell (SLPIC) Method: "The Speed-Limited Particle-In-Cell (SLPIC) Method reduces computational requirements for simulations that evolve on ion time scales while keeping appropriate kinetic electron effects. This method works by introducing an ansatz for the distribution function that allows the new unknown phase-space function to be solved by the method of characteristics, where those characteristics move slowly through phase space. Therefore, the solution can be obtained by particle-in-cell (PIC) methods, where the electrons have speeds much smaller than their actual speeds, ultimately leading to a much relaxed numerical (CFL) stability condition on the time step. Ultimately, the time step can be increased by the square root of the ion-electron mass ratio. SLPIC can be easily implemented in existing PIC codes as it requires no changes to deposition and field solution. Its explicit nature makes it ideal for modern computing architectures with vector instruction sets."

PLASMA SCIENCE & TECHNOLOGY (P. EFTHIMION):

The PST department had a seminar on March 22 entitled, "The diagnostics of hot plasma in the solar atmosphere" by Pradeep Chitta from Max Planck Institute for Solar System Research, Germany. The speaker discussed the diagnostic capabilities of current space-borne telescopes that observe the solar atmosphere. He also presented examples and analyses of thermal and velocity diagnostics of plasma along with the magnetic field information crucial to understanding phenomena such as the magnetic reconnection and shocks. He also outlined the possibilities of extending such studies by using numerical models and laboratory experiments.

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

K. Rule hosted several visitors from SWIP and ASIPP as part of the China-U.S. Joint Working Group on a safety visit to U.S. Fusion Facilities. M. Zarnstorff, A. vonHalle, and J. Levine made presentations to the group on March 25.

COMMUNICATIONS & MEDIA RELATIONS (L. BERNARD):

Media:

WHYY, NPR affiliate in Philadelphia, ran a lengthy piece on PPPL's Young Women's Conference, both on air and online. J. J. DeVoe arranged coverage and interviews. The story featured photos by E. Starkman and interviews with D. Ortiz, S. Greco and middle school teacher P. Hillyer. WOR-TV's nightly news show, "News Chasers," ran a story on the Young Women's Conference on its March 18 newscast. The Times of Trenton ran a story on the YWC with photos by Starkman on March 21 on page three of the newspaper and on nj.com, http://www.nj.com/mercer/index.ssf/2016/03/pppl_brings_love_of_science_to_young_women_with_an.html. Also, CentralJersey.com, the Princeton Packet website, ran a story based on DeVoe's press release featuring photos by Starkman, A. Brereton and DeVoe on March 22, available at the following link: http://www.centraljersey.com/news/the_princeton_packet/princeton-plasma-physics-lab-scientists-provide-a-day-of-fun/article_6c37e532-f07b-11e5-b920-9f05a27df229.html

DIRECTOR'S OFFICE (C. AUSTIN):

On March 23, Dr. Christopher Clark from Cornell University presented a colloquium entitled, "Ocean Acoustic Ecology: Great Whales, Ocean Scales, Big Data."

On March 25, Dr. Cherry Murray, Director of the DOE Office of Science, visited PPPL for discussions and a Laboratory tour.

On April 4, Dr. David McComas began his appointment as Princeton University's Vice President for PPPL. He has also been appointed as a professor of Astrophysical Sciences at Princeton University.

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