The PPPL Highlights for the week ending March 18, 2016 are as follows:

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

Steady State Electric Network (SSEN):

Uninterruptible Power Supply (UPS) system and DC Distribution: Preparation of the RFPs is underway, after which they will be submitted for approval by Pacific Northwest National Laboratory (PNNL) and the Department of Energy (DOE). Issue date is forecast for April 8.

Power Transformers: The punch-list of minor items 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, has been rectified by the supplier and will be confirmed by our QC inspector next week. Soon thereafter, the QC packing inspection of the items will be performed prior to shipment. In the meantime the Release for Shipping (RFS) documentation package was submitted and is under review. Present forecast shipping date is April 19. Note that there is still ample float with respect to the delivery milestone (June 15).

NSTX (M. ONO):

FY 2016 NSTX-U plasma operations update: The department has completed 4.81 run weeks and 482 plasma shots. The total operation targets are to be decided.

A. Diallo and B. LeBlanc of PPPL visited the Physical Science Laboratory during the week of March 13 in Madison, Wisconsin to participate in the integration of the pulse-burst laser system and the custom power supplies. This is part of Diallo's Early Career Research Program Award. During this week, the alignment and testing of the oscillator were performed. Parameter scans (flash-lamps voltages and timings) were performed to evaluate the optimum settings for maximum output pulse energy at the oscillator. These tests were successfully performed for 30 Hz. An initial test was successfully done at 1 kHz (with only a subset of the pulses). So far, the results are encouraging with energy per pulse of about 0.6 J before the amplifier stage. These tests will be extended to 10 kHz at the output of the oscillator. Subsequently, the output beam from the oscillator will be fed to the amplifier and final characterization of the near- and far-field beams will be performed in preparation for its commissioning on NSTX-U.

Significant progress was made on the mechanical and electrical installations of the LLNL EUV spectrometer suite. The vacuum manifold for the UV spectrometers was installed and leak

checked. The system is being pumped down in preparation for operations. Initial data is expected to be collected during the next operations period.

Significant progress was made on the mechanical and electrical installations of the Granule Injector. The Granule Injector chamber is installed and under vacuum, and mechanical/electrical installations continue. The injector itself was installed on the machine, and conduit and cable runs were completed.

The repair and recalibration of the Synthetic Aperture Microwave Imaging (SAMI) diagnostic (University of York) was completed.

Installation of the new Argon Dump System (APS) needed for future lithium operations has been completed and has been reviewed by the PPPL Activities Certification Committee (ACC). The APS was operated manually for the recent argon vent to remove the BN pieces.

A complete fit-up of the Massive Gas Injector (MGI) assembly at Bay I mid plane was performed. Proper fit of all components was confirmed, and mounting holes for the valve stand were drilled in the platform. A trial fit of the lower MGI assembly was performed. All of the components will fit as planned, and a fixture for precise location of the assembly and its mounting studs is being developed. Both valves will be assembled to their insulators and spool pipes this week, and hi-potted and leak checked in preparation for final installation.

NSTX-U has completed a two-week maintenance period and will resume plasma operations during the week of March 21. During the last week of this maintenance period, repairs of the neutral beam (NB) 2A and 2C transmission lines were completed, and the NB2B autotransformer was replaced with a spare unit. All six of the NB ion sources are expected to resume conditioning and injection operations this coming week. Detailed inspections of the Motor Generator #1 rotor weld repairs made during the NSTX-U Upgrade Project were performed and found that all 21 locations are good after 73 start/stop cycles and 1893 hours of operation. Repairs and upgrades to the Gas Injections Systems have been completed, and all injectors have been calibrated. Upgrades to the lower TF water fittings have been completed, and all water systems are operational. Good progress was made on the fast voltage measuring system needed for CHI operations and new cameras/fiberoptics. A vacuum vessel boronization was performed on March 20.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

Progress has been made in the interpretation of experiments of ELM pacing by Lithium Granule Injection (LGI) in DIII-D. Recent studies focused on fast-imaging data of the ablation of Li granules, and specifically on events showing fast jets of droplets appear before the granule reaches the plasma boundary. The phenomenology was observed only during counter-current NB injections in high-density plasmas. Simulations with the full-obit code SPIRAL indicated that, in the experimental scenario, the density of fast-ions from counter beams in the outer gap could be sufficiently high to cause a partial melting of the Li granule and accelerate fragments or droplets in a way that is consistent with the fast-camera observations. The mechanism is likely to play a

role to explain the lower ELM triggering efficiency obtained with Lithium Granule Injection in DIII-D discharges with balanced applied torque.

E. Kolemen and D. Eldon upgraded the real time error field correction and RMP phasing control algorithm on DIII-D based on vacuum (SURFMN) calculations of the fields induced by control coils. The controller identifies the amplitude and phase of the n=1 or n=2 intrinsic error field and of the field from selected 3D coils and computes a solution to constructively interfere (optimal RMP phasing) or destructively interfere (Error Field Correction). A q95 ramp demonstrated the ability of the controller to adapt to evolving plasma conditions by tracking changes in the optimal RMP angle and adjusting currents accordingly. Using this method, ELM suppression windows at three different q values were observed during the ramp.

D. Eldon led snowflake divertor (SFD) control development and then supported the physics experiment to improve understanding of radial transport in the SFD. The development work allowed the outer strike point to be visible to the IRTV camera for heat flux measurements by moving the strike point radially inward while scanning the separation of the field nulls.

A. Bortolon prepared a talk entitled “Preliminary results of recent impurity granule injection experiments on DIII-D.” The talk was presented by R. Maingi at the ITPA-PEP meeting in Ahmedbad, India. The talk reported on recent experimental studies of ELM pacing by injection of Lithium, Carbon and Boron Carbide granules, using the PPPL Impurity Granule Injector (IGI) on DIII-D. Preliminary analysis indicates that ELM pacing was obtained with both C and Li, the latter providing the highest ELM triggering probability. The experiments also achieved the first operational demonstration of combining ELM pacing by IGI with plasma fueling by D2 pellet injection into a tokamak plasma.

R. Nazikian gave a remote presentation at ITPA-PEP meeting in Ahmedbad, India on the observation of ELM suppression by resonant magnetic perturbations in high beta poloidal hybrid plasmas in DIII-D. The suppression of ELMs occurs with minimal degradation of confinement in plasmas with full noninductive current drive, $q95 \approx 6$ and $beta\_pol \approx 2$. Future work will address suppression at low toroidal rotation and the dependence of suppression on q95 and beta poloidal.

International (J.K. Park):

J.K. Park presented a talk entitled “Self-consistent NTV with force balance and systematic NTV optimization in tokamaks” in the US-Japan MHD workshop, which was jointly held with ITPA MHD meeting in NIFS, Japan. The talk introduced a new formulation and method adopted in general perturbed equilibrium code (GPEC) and summarized the very recent applications to NSTX-U and KSTAR for NTV and coil optimization. GPEC can also be applied to stellarators and incorporate neoclassical transport codes in stellarators, as additionally discussed with LHD collaborators. N. Logan and Park have been actively involved in plasma response modeling for DIII-D, EAST, KSTAR, RFX-mod, as reported by M. Lanctot (GA).

ADVANCED PROJECTS (H. NEILSON):

The Laboratory hosted the quarterly U.S. Wendelstein 7-X Management (W7-X) meeting, with representatives from DOE Fusion Energy Sciences, Oak Ridge National Laboratory, Auburn University, and Los Alamos National Laboratory participating remotely. With the first W7-X operating campaign, OP1.1, having recently completed, the meeting featured a timely review of research highlights from the U.S. participation in that campaign. Data and predictive modeling in the areas of 1) magnetic configuration characterization, 2) impurity transport, 3) heat loading of plasma facing components, 4) particle balance, and 5) equilibrium reconstruction were discussed. The successful integration of the U.S. effort into the W7-X research program was clearly shown, as was the coherence of the U.S. team itself, evidenced by several collaborations among the U.S. partner institutions. Progress in the TDU scraper fabrication project and plans for improvement in remote collaboration capabilities were also reported at the meeting.

THEORY (A. BHATTACHARJEE):

J. Johnson gave the Theory Department Research Review Seminar on March 11, entitled "Identifying Causal Relationships." The abstract reads: "System science is an emerging interdisciplinary discipline that studies the nature of systems from an overarching perspective that is concerned with the overall evolution of a system and how it interacts with its environment. Techniques developed in system science are particularly useful for complex systems where the governing physical processes are not fully understood or where modeling from first principles is not computationally feasible. One of the key objectives of systems science is to identify variables that control system dynamics. In this talk, I will discuss tools that have been developed to examine causal relationships in systems, and I will provide specific examples from heliophysics to illustrate how the tools can provide insight into magnetospheric and solar dynamics. Such techniques may also be useful for fusion science where it is vitally important to understand processes that control disruptions and a variety of instabilities."

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

On March 18, M. Patino of PPPL and UCLA presented a seminar on Secondary Electron Emission from Fusion-Relevant Materials. The abstract reads: "The interaction of plasma electrons with plasma-confining walls causes secondary electron emission (SEE) that can adversely affect plasma performance. SEE from plasma-facing materials reduces the sheath potential and may result in a large loss of plasma electrons to the wall and significant cooling of the plasma. This talk will focus on the investigation of SEE from lithium and tungsten, which are considered as the most promising candidate materials for diverters in fusion devices. For these materials, we explored the SEE properties of complex surfaces exposed to realistic environments in plasma devices. Surface science equipment was used to prepare and characterize materials in-situ during SEE measurements. For lithium, we compared SEE properties of pure lithium and oxidized lithium, which can be produced by rapid oxidation in the presence of water. The measurements demonstrated a significant increase of SEE yield for an oxidized lithium surface as compared to a clean lithium. For tungsten, we compared SEE yield for a flat surface and for a complex surface of tungsten fuzz produced by bombardment of helium ions. The results demonstrate a significant reduction of SEE yield from fuzz surface due to trapping of secondary

electrons. Implications of our results for plasma facing components are as follows: for plasmas bounded with oxidized lithium walls, adverse SEE effects on plasma-surface interaction can be significant, while for plasma bounded with tungsten fuzz walls, SEE effects can be reduced."

BEST PRACTICES & EXTERNAL AFFAIRS (J. DELOOPER):

Science Education (A. Zwicker):

The last Science on Saturday lecture for 2016 was given by Mary Jo Ondrechen of Northeastern University on "Using Physics and Chemistry to Understand the Genome."

DIRECTOR'S OFFICE (C. AUSTIN):

On March 16, Dr. Glen Wurden, Los Alamos National Laboratory, presented a colloquium entitled, "Fusion Rockets for Planetary Defense."

John DeLooper attended the NLCOO meeting at DOE on March 15 and 16.

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