Weekly HIGHLIGHTS

**The PPPL Highlights for the week ending June 30, 2017 are as follows:**

## U.S. ITER FABRICATION (H. NEILSON):

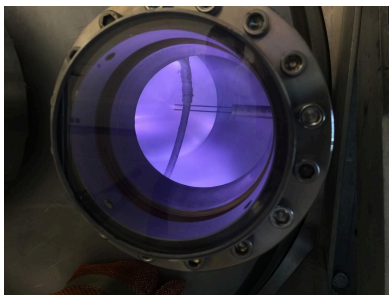
### Steady State Electrical Network (J. Dellas):

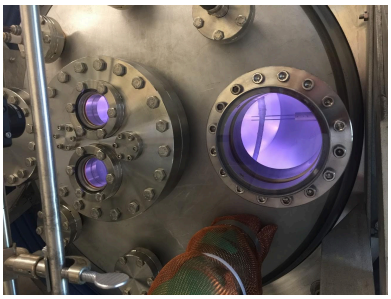
Following successful factory acceptance testing of the DC Distribution and 600 kVA uninterruptible power supply (UPS), work continues preparing Release for Shipment packages. The preliminary packing list and pro forma invoice for DC Distribution have been received from the supplier.

### Diagnostics (R. Feder):

Low Field Side Reflectometer (LFSR): The PPPL LFSR engineering team is working closely with the Russia DA Equatorial Port 11 integration team and supporting staff at ITER. The RFDA is working to lock interfaces in EP11 while satisfying nuclear shielding and structural performance requirements. Each tenant system needs to play its part in this optimization. Changes have been made to the LFSR system that maintain required measurement performance while complying with EP11 integration constraints. For example, the LFSR system was reduced from seven to six total microwave transmission lines to help relieve component congestion that would hinder EP11 maintenance and remote handling.

Motional Stark Effect (MSE): We have completed the design and fabrication of a new mirror holder to accommodate several sample coupons. The MSE mirror cleaning test facility is in L-112. The coupons are 1-inch in diameter and the holder is about 4 inches square. The mirror holder has been mounted to a copper block with a dielectric insulator to prevent the mirror from being grounded. The system has been operated with the new mirror support holder in argon for initial evaluation. Data has been obtained with various RF powers, fill pressures, and magnetic fields. We are in the process of analyzing the data now. A summer student, Dan Alexander, has joined our group for the summer under the SULI program hosted by PPPL.





Toroidal Interferometer and Polarimeter (TIP): The testing of the ITER TIP Prototype diagnostic on DIIID is nearing completion with very good results. During July, the development team will stop making performance optimization changes and adjustments and let the system run, in order to check long-term stability/reliability issues.

**NSTX-U RECOVERY PROJECT (R. HAWRYLUK):**

Recommissioning of the coil winding facility continued with the completion of the new soft-walled clean room. PPPL staff was at Everson Tesla to witness conductor cleaning and priming. A pre-proposal teleconference for the Inner PF coil prototype RFQ was held on June 29.

Good progress was made on the work packages installing cabling and fiber optics for the instrumentation needed for PF Inner Coil power testing.

In vessel, set-up and pre-tests of metrology for spacial measurements of the passive plates and outboard divertor were completed. Actual measurements will be made upon arrival of the new calibration standard.

A new calibration probe is being installed on the vessel to complete Multi-Pulse Thompson Scattering (MPTS) diagnostic calibrations prior to the removal of port covers to replace vacuum seals.

Also this week, on-site vacuum technology and ANSYS training courses were held for NSTX-U staff.

R. Hawryluk attended the EPS meeting in Belfast and chaired a meeting of the Nuclear Fusion Board of Editors.

**NSTX-U RESEARCH (J. MENARD):**

A team of physicists and engineers from PPPL (C. Ciummo, A. Jariwala, M. Jaworski), ORNL (T. Gray, M. Reinke, D. Youchison) and General Atomics (C. Murphy, B. Fischler) visited the Applied Research Laboratory (ARL) at Penn State University on June 26. Discussions were held regarding use of the 240 kW electron beam coating facility PVD-1 to test the material properties of various grades of graphite being considered for new PFC tiles in NSTX-U. Testing of

prototype divertor targets for NSTX-U seems possible assuming additional instrumentation and personnel is provided by PPPL/ORNL. Future collaborations at ARL utilizing its facilities for diagnostic development and testing also seemed possible and discussions are ongoing.

In support of a NSTX-U National Campaign experiment on DIII-D led by D. Boyer, a new algorithm has been designed and implemented in the DIII-D PCS that uses the new variable beam voltage and perveance capabilities of the neutral beam injectors. The algorithm determines the optimal combination of voltage, perveance, and duty cycle for each of the beams to achieve requested total torque or power waveforms, taking into account transmission and neutralization losses, drift-duct losses, re-ionization losses, and beam overlap losses. Fast adjustments in perveance and duty cycle are used to compensate for the slow response of beam voltage to requested changes, which arises due to bending magnet power supply limitations. The power and torque control capabilities are also used for feedback control of the stored energy and rotation (from a selected channel of the real-time CER system), enabling feedback control of these quantities without perturbative beam modulations (modulations can still be used for feedback control if desired). A constrained optimization scheme is used to determine the voltage, perveance and duty cycle requests to account for the limits on the range of voltage and perveance changes allowed for reliable beam operation. Experimental testing of the new algorithm is scheduled for July 13.

V. Soukhanovskii (LLNL) visited General Atomics June 19-23 to participate in the NSTX-U experimental campaign on DIII-D. He led the experiment “Divertor detachment studies in highly-shaped NSTX/NSTX-U-like plasmas,”aimed at the comparison of divertor detachment between NSTX and DIII-D. This work is in support of the Joint Research Target (JRT) 2017. An NSTX-like high-triangularity double null shape with strong bias toward the lower divertor (and ion grad B drift toward the lower divertor), and with high divertor poloidal flux expansion was developed. Preliminary results obtained in the first half-day of the experiment indicated that the deuterium gas puff location used to detach the divertor had less influence on DIII-D than on NSTX.

**ITER & TOKAMAKS (R. NAZIKIAN):**

DIII-D: The NB 210 Pole shields, designed by PPPL engineering and fabricated by Martinez and Turek were completed on schedule and delivered to General Atomics on June 30. These shields are similar to the ones provided two years ago for NB330 and have proven to be very successful. The NB330 tiles have shown no signs of heat damage or wear since being installed two years ago. The pole shields have ten solid molybdenum tiles in the heat-affected zone, held together using a novel rounded tongue and groove interleave design. The tiles can be removed and replaced in approximately two hours through an access flange without requiring beam line disassembly.

**THEORY (A. BHATTACHARJEE):**

F. Ebrahimi attended the “2017 International Workshop on the Interrelationship between Plasma Experiments in the Laboratory and in Space (IPELS 2017),” held in San Diego June 19 - 23. She presented an invited talk entitled, “Three-dimensional coherent plasmoids in current-carrying plasmas." The abstract reads: “Plasmoid-mediated reconnection is examined using nonlinear

three-dimensional resistive MHD simulations in a global toroidal geometry. An initial poloidal flux is created, in this case utilizing the helicity injection technique, in the presence of a toroidal guide field. We explore the physics of plasmoids reconnection for flux closure during plasma formation. Two types of current sheets are formed during flux expansion. First, a rare, classical example of plasmoid formation in a tokamak is demonstrated during helicity injection, where the injected magnetic field lines are oppositely directed near the injection region and form elongated Sweet-Parker current sheets (primary reconnecting current sheet). At high Lundquist number a transition to plasmoid instability has been shown in a large-scale toroidal fusion plasma.1 Consistent with the theory, fundamental characteristics of the plasmoid instability, including fast reconnection rate, have been observed in these realistic simulations. Second, edge current sheets are formed due to the poloidal flux compression near the plasma edge and shown to provide the free energy for non-axisymmetric magnetic fluctuations, the 3-D edge current-sheet instabilities. The role of these 3-D magnetic fluctuations in the onset of axisymmetric current-carrying plasmoids is examined. It is found that 3-D magnetic fluctuations can cause local flux amplification to trigger axisymmetric reconnecting plasmoids formation at the reconnection site. 2 We also show coherent current-carrying filament (ribbon-like) structures wrapped around the torus that are nonlinearly formed due to nonaxisymmetric reconnecting current sheet instabilities, the so called peeling-like edge localized modes. 3 These fast growing modes saturate by breaking axisymmetric current layers isolated near the plasma edge and go through repetitive relaxation cycles by expelling current radially outward and relaxing it back. The 3-D coherent current-carrying filament structures and their nonlinear dynamics due to the dynamo effect are relevant to flares, which also exhibit ejection of field-aligned filamentary structures into the surrounding space. [1] F. Ebrahimi, R. Raman, Phys. Rev. Lett. 114, 205003 (2015), [2] F. Ebrahimi, Phys. Plasmas 23, 120705 (2016), [3] F. Ebrahimi, arxiv.org/abs/1702.02696.

A Theory Department Research Review Seminar was given by L. Comisso on June 23. The title of the talk was, “Plasmoid instability as a tearing instability in time-evolving current sheets.” The abstract reads: “The plasmoid instability has had a transformative effect in our understanding of magnetic reconnection in a multitude of systems. By preventing the formation of highly elongated reconnection layers, it has proven to be crucial in enabling the rapid energy conversion rates that are characteristic of many plasma phenomena. In the well-known Sweet-Parker current sheets, the growth of the plasmoid instability occurs at a rate that is proportional to the Lundquist number (S) raised to a positive exponent. For this reason, in large-S systems, Sweet-Parker current sheets cannot be attained as current layers are linearly unstable and undergo disruption before the Sweet-Parker state is attained. Here, we present a quantitative theory of the plasmoid instability in time evolving current sheets based on a principle of least time [1]. We obtain analytical expressions for the growth rate, number of plasmoids, plasmoid width, current sheet aspect ratio and onset time for fast reconnection. They are shown to depend on the Lundquist number, the magnetic Prandtl number, the noise of the system, the characteristic rate of current sheet evolution, as well as the thinning process [2]. We validate the obtained analytical scaling relations by comparing them against the full numerical solutions of the principle of least time. Furthermore, we show that the plasmoid instability comprises of a relatively long period of quiescence followed by rapid growth over a shorter timescale. [1] L. Comisso, M. Lingam, Y.-M. Huang, A. Bhattacharjee, Phys. Plasmas 23, 100702 (2016). [2] L. Comisso, M. Lingam, Y.-M. Huang, A. Bhattacharjee, to be submitted (2017).”

Another Theory Department Research & Review Seminar was given by R. White and A. Hassam, on June 30, who talked about “Centrifugal particle confinement in Mirror Geometry.”

The abstract reads: "The use of supersonic rotation of a plasma in mirror geometry has distinct advantages for thermonuclear fusion. The device is steady state, there are no disruptions, the loss cone is almost closed, sheared rotation stabilizes magneto hydrodynamic instabilities as well as plasma turbulence, and the coil configuration is simple. We report on the experiments done at the University of Maryland and examine the effect of rotation on mirror confinement using a full cyclotron orbit code. Both collisionless loss as a function of rotation and the effect of collisions are investigated."

**ENGINEERING (V. RICCARDO):**

Collaborations: Four sets of neutral beam pole shields, which were designed by PPPL and fabricated under their supervision, were delivered to General Atomics on June 30 to upgrade the existing pole shields in DIII-D. This is the second group of pole shields delivered by PPPL utilizing a new design that incorporates replaceable Molybdenum interlocking tiles in the most severely loaded region of the actively cooled copper plate. The first group of pole shields was delivered to General Atomics in 2014 and has performed extremely well.

Power Systems: A lab infrastructure project to replace the aging 13.8kV cabling that provides primary power to NSTX-U was successfully completed. Protective relaying has tested, and the S1/S2 bus has been energized from the main switchyard to D-Site. Contractors (Foley Power) were on site this week to complete quarterly maintenance on the 900kW standby generator.

Training: On-site vacuum technology and ANSYS training courses were held this week.

**DIRECTOR'S OFFICE (S. ZELICK):**

**Site Protection (F. White):**

Engine 66 responded to Princeton for four mutual aid assignments.

Engine 66 responded to Plainsboro for two mutual aid assignments.

Ambulance 66 responded to Plainsboro for two mutual aid assignments.

Members of the Site Protection Division (SPD) and the Emergency Services Unit completed all candidate interviews for the Emergency Services Officer position.

Members of Site Protection Division conducted an Emergency Management Review Committee (EMRC) meeting.

SPD conducted an Emergency Management Review Committee forum to discuss future Emergency Exercise Drill activities and current changes to the Emergency Response System, including updated DOE orders that will affect the SPD Emergency Preparedness Plan and the newly established primary Emergency Operations Center. Members of the Occurrence Reporting and Processing System (ORPS) Facility Manager group attended the EMRC meeting and lead discussions on operational improvements to ORPS reporting pertaining to Emergency Response incidents.

SPD/ESU completed its annual physical agility testing for the year.

ESU conducted training on security patrol procedures.

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