The PPPL Highlights for the week ending May 24, 2013, are as follows:

U.S. ITER FABRICATION (D. JOHNSON):

Work on the integration of diagnostics in the interspace of US diagnostics port plug E9 continues. A meeting was convened with US experts to discuss the configuration of optics and alignment components in the E9 interspace for the 5 chords of the toroidal interferometer/polarimeter (TIP) diagnostic. As with many of the ITER diagnostics, space is very tight in this region.

NSTX (M. ONO):

The NSTX Upgrade Five-Year Plan Review was held May 21-23 at PPPL. The five year plan proposal was assessed by a nine person review panel for a range of criteria including: scientific and technical merit, appropriateness of the proposed research plan, competency of personnel and adequacy of resources, reasonableness of proposed costs, and performance during previous five-year period. The panel also provided specific comments related to each topical area presented in the five year plan. Particular attention was paid to the three main proposed upgrades of the plan (lower divertor cryopump, 1 MW ECH/EBW system, and the partial non-axisymmetric control coil set), and these upgrades were evaluated (preliminary) to be important to meeting the five-year plan goals of achieving reduced collisionality, developing non-inductive start-up and ramp-up, and sustaining high beta operation. Panel members will submit written peer review reports to DOE within the next month, and FES will evaluate these individual reports and prepare a summary report that will be provided to the NSTX-U team. The review presentations are archived at: http://nstx-u.pppl.gov/five-year-plan/five-year-plan-2014-18/review

C. Skinner (PPPL) and Tyler Abrams (Princeton University) attended the conference on Plasma Facing Materials and Components May 13-17 in Juelich, Germany. C. Skinner presented plans for PFC research on NSTX-U (with M. Jaworski) and results on laser cleaning of candidate diagnostic mirrors for ITER. T. Abrams presented results of experiments on Magnum-PSI, a linear plasma device in the Netherlands, that measured the erosion and re-deposition rates of lithium films on graphite and TZM molybdenum.

PPPL graduate student T. Abrams (Princeton University) has returned from a four-week experimental collaboration with FOM-DIFFER laboratory in the Netherlands. During his stay, Tyler completed nine days of experiments on Magnum-PSI, a linear plasma device capable of plasma conditions similar to those in the NSTX-U divertor. Tyler measured the gross erosion rate and re-deposition fraction of lithium and aluminum coatings on TZM molybdenum and

graphite substrates. These results are important for NSTX-U because lithium-coated graphite and TZM molybdenum are planned plasma-facing components (PFCs) for the NSTX-U divertor and these results will help predict how long these lithium coatings will last and where they will start to disappear first.

Brian LaBombard (MIT) presented two physics seminars at PPPL on Friday, May 24 entitled "Observations of boundary plasma turbulence and the Quasi-Coherent Mode in Alcator C-Mod using a Mirror Langmuir Probe" and "Alcator C-Mod Shoelace Antenna System for active probing of boundary plasma turbulence". Presentation materials are downloadable from: http://nstx.pppl.gov/DragNDrop/NSTX_Meetings/Monday_Physics_Meetings/2013/2013_05_24/

The TGLF transport model is being exercised within TRANSP for prediction of both Te and Ti profiles in NSTX discharges. NSTX operates at low aspect ratio, and thus provides a high leverage test of TGLF for configurations with high toroidicity. At this stage, the testing is focused on understanding the effect of various model input parameters on the prediction, not so much on the actual agreement with data. It is a necessary first step to identify the highest leverage model parameters for this configuration. A following step is to calibrate these parameters against full GYRO simulations of these discharges. Over the next several months this will be done for both L- and H-mode plasmas both with and without lithium conditioning.

Preparations for plasma operations in the NSTX-U configuration also continued with the power testing of the new firing generators for the field coil power conversion (FCPC) system rectifiers, and the recommissioning of the three autotransformer and transformer rectifier sets that will provide the primary power for the NB2 ion sources.

ITER & TOKAMAKS (R. WILSON):

DIII-D (R. Nazikian):

B. Grierson has worked with the DIII-D neutral beam group to implement newly measured neutral beam efficiency curves for DIII-D discharges. New power waveforms based on the revised transmission and neutralization efficiency curves has been used in the TRASNP/NUBEAM analysis for reference discharges for validating the accuracy of the reported power against measured neutron rates and beam emission intensity.

D. Battaglia has performed kinetic neoclassical transport simulations of the H-mode pedestal during the ELM-free period right after the L-H transition using XGC0 with fully kinetic main ion deuterium, carbon 6+ impurity ions and electrons. One significant result is that the measured pedestal intrinsic main-ion and impurity-ion flows on the outboard midplane are quantitatively reproduced using XGC0. Calculations show that kinetic effects around the separatrix contribute to the total intrinsic torque but that some additional mechanism is needed to account for the intrinsic rotation profile.

The TGLF capability for momentum transport prediction is now installed in the TRANSP solver PT_SOLVER and calculations are being verified against XPTOR for several DIII-D discharges.

A. Nagy is supporting the B-coil bus repair team using his experience as a PPPL Lift Engineer to design the B-col bus extraction procedure. The lift is complicated by the parts 1/2 ton weight, 12 foot length and location. Preparation work for the lift is underway, involving moving heavy cabling, modifying brackets for clearance, and preparing situational fixtures.

ADVANCED PROJECTS (H. NEILSON):

On May 20, C. Kessel led a meeting with ARIES team members, materials community members, and DOE representatives, to discuss a study to begin in 2014 on the Fusion Nuclear Science Facility (FNSF). Kessel presented a general set of goals and perspectives for the study, focusing on cooperation with the materials, FNST, and PFC/PMI communities. The FNSF study will be a departure from the traditional 10th of a kind power plant study, and several aspects of this were discussed. Of particular importance will be the generation of possible missions for the FNSF, metrics for measuring progress toward a first power plant, how choosing a mission for FNSF significantly affects the DEMO mission, and making same assessment of the pathway in terms of risks and costs.

At the ARIES quarterly project meeting in Germantown, MD, C. Kessel presented progress on the systems analysis to determine an operating point for the conservative physics and conservative technology tokamak reactor design point. The range of plasma major radii are ~ 8.5-9.5 m. The primary parameter for identifying this physics operating space is that betaN-tot < 3.25, and does not require a close-by conductor for stabilization. A comparison was made with ARIES-I, also a conservative physics configuration, and identified several differences that led to the higher major radii in the present study. Free-boundary plasma equilibria were generated to begin Tokamak Simulation Code (TSC) simulations, ideal MHD studies were reported indicating difficulty finding stable cases within the current profile constraints, and the ARIES-I current drive assumptions with ICRF FW were reviewed against present day experience indicating they were optimistic.

THEORY (A. BHATTACHARJEE):

Snezhana I. Abarzhi, from University of Chicago gave a seminar titled “Rayleigh-Taylor mixing”. The abstract reads: “Rayleigh-Taylor (RT) mixing plays important role in a variety of plasma systems, spanning astrophysical to atomistic scales and low to high energy densities. Examples include fusion, supernovae, and light-material interaction. We apply the novel theoretical concept, the invariance of the rate of momentum loss, to describe the transports of mass, momentum and energy in RT mixing flow and to capture its anisotropic and inhomogeneous character. We find that invariant, scaling and spectral properties of statistically unsteady RT mixing differ substantially from those of isotropic and homogeneous turbulence. Time- and scale-invariance of the rate of momentum loss leads to non-dissipative momentum transfer, to 1/3 and 3/2 power-law scale-dependencies of the velocity and Reynolds number and to non-Kolmogorov spectra. RT mixing exhibits more order compared to isotropic turbulence, and its viscous and dissipation scales are finite and set by flow acceleration. We suggest how to describe the random character of the unsteady mixing flow and show that the rate of momentum loss is the statistic invariant and a robust diagnostic parameter for either sustained

or time-dependent acceleration. Some criteria are outlined for the estimate of the fidelity and information capacity of the experimental and numerical data sets."

A special Theory seminar was presented by Predrag Krstic (University of Tennessee and TheoretiK) on "Atomistic Science for the Plasma-Material Interface". Recent work with lithium coatings deposited on a variety of metallic and graphitic surfaces, in a number of tokamak fusion machines around the world, has provided evidence of the sensitive dependence plasma behavior has on these ultra-thin deposited films. Krstic's computer simulations, done in collaboration with Japanese and French scientists, and validated by in-situ experiments at Purdue University and at NSTX have contributed to unraveling the mystery of this high fidelity control. Krstic presented quantum-classical atomistic calculations which elucidated the roles of lithium and oxygen in amorphous-carbon on retention of hydrogen and showed that the presence of oxygen in the surface plays the key role in the uptake chemistry, while lithium's main role is to bring the oxygen to the surface. D atoms preferentially bind with O and C-O when there is a comparable amount of oxygen to Li at surface. This finding well matches a number of experimental results, obtained within the last decade.

John Jenkins from North Carolina State University gave a Theory seminar on May 23 on "Optimization Techniques for Extreme-scale Analytics." The following is a highlight from his seminar. Recent trends in I/O in an HPC context present significant, multi-dimensional challenges: coping with huge increases in the amount and complexity of scientific data produced, effectively using increasingly complex I/O subsystems and hardware configurations, and allowing for swift data analysis under varying access patterns, to name a few. To address these challenges, advanced data reorganization and analytics techniques must be explored, placing particular focus on data reduction as a first-order constraint. He presented two technologies made to accelerate different data access workloads. First, he introduced a precision-based technique for multi-resolution analysis, extracting favorable performance and accuracy characteristics by exploiting the floating-point data format. He additionally explored the implications of performing varying analyses on reduced-precision GTS and XGC1 electrostatic turbulence potential data, highlighting the efficacy of providing a configurable, multi-resolution data decomposition. Second, he discussed a parallel system for query-driven analysis that drives down storage and query processing costs by operating directly in a compressed data space. He then presented ongoing works that aim to tame the data complexity problem inherent in data layout optimizations: how transparent can these tools be made to the end-user, and can I/O libraries support them effectively?

On May 14, L. Zakharov gave a talk "Are Transport Barriers a Zone of Good Confinement or of its Collapse" to the PPPL Experimental Seminar. He addressed the key issue of understanding sharp electron temperature pedestals the plasma edge in H-mode which for more than three decades are being interpreted as regions with suppressed transport – "transport barriers". RMP experiments, SoL currents and direct measurements of particle deposition to the divertor target plates indicate invalidity of the background assumption of this interpretation, i.e., the existence of the perfect magnetic surfaces at the plasma edge. The theory presented in the talk, emphasizes the role of parallel transport and gives an explanation to (a) the lack of sensitivity of electron temperature pedestal to magnetic perturbations, (b) reduction in the temperature and density gradients in the core near the pedestal, (c) reduction of the width of the pedestal with increase in the amplitude of RMP, etc, all of which are being considered as puzzles associated with the temperature pedestals. The theory also gave the kinetic criterion when the

parallel transport destroys the notion of diffusive transport. As a result, in contrast to the widespread interpretation, the pedestal region is located outside the confinement zone with no diffusive transport.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

A milestone in the development of the new PTRANSP parallel predictive profile solver, PT_SOLVER, has been met this week by X. Yuan. It was demonstrated that the neoclassical routine NEO (E. Belli, et al) and the turbulent flux routine TGLF (Stabler, et al) can be simultaneously invoked through PT_SOLVER for a predictive simulation to account for both neoclassical and turbulent transport. The routines NEO and TGLF are treated as independent components with their own communicators. The SOLVER component, which advances the transport equation, controls the NEO and TGLF components. A communication layer is dynamically established to exchange the data from the SOLVER component to the NEO and TGLF components, and to collect the neoclassical and turbulent flux from NEO and TGLF. A test case using a total of 64 cores (32 cores for the TGLF component, 31 cores for NEO component --serial NEO run but parallelized over flux surfaces-- and 1 core for the SOLVER component) produced the same converged profiles with much less wall clock time compared to the same case using the serial PT_SOLVER. This component layer in PT_SOLVER has been developed with flexibility to allow easy extension to include other parallel and/or serial components in the future. This capability is presently in the beta-test mode, and will be made available to select users by request.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

NSTX Upgrade (R. Strykowsky, E. Perry, L. Dudek, T. Stevenson):

Construction: TF13 is on stands in the south high bay and both sets of aluminum castings have been installed. NB armor fit-ups continue in-vessel. Metrology monuments are being relocated as required. The vertical cable tray run installation on the north side of the machine continues. OH winding fixture assembly, bay l cap welding and NB2 duct fabrication continue in the Tech Shop. MPTS modifications are on-hold until after the Open House on June 1.

CS Upgrade: The fourth quadrant is being assembled in the quadrant mold. There are seven conductors in the mold. The last conductor to make up the bundle is now being wrapped with insulation. The welding fixture to locate studs on the CS casing arrived and passed incoming inspection. The first OTF Coil has arrived at PPPL and is being prepped for installation. The first aluminum block was installed on one end and the turnbuckle brackets are in the process of being installed. The second OTF coil is scheduled to ship from Everson next week. The TF Bundle mold at Reno passed pressure test and is scheduled to be shipped and arrive at PPPL next week. A kickoff meeting with Hollis machine was held on May 24 to begin the fabrication of the CS organ pipe extensions and ceramic break flanges. Kyocera has accepted and shipped the first CS ceramic insulator to the US. The second two are on schedule to ship from Japan in early June. The first prototype CS Tile backing plates were fabricated and approved by engineering.

NSTX-U Coils Bus Runs design has progressed well in the last week. A first draft of the updated design has been completed. The design has been released to analysis. The analysis effort has already begun. The final design review, which was scheduled for next week, will be postponed to give time for analysis. In the meantime, we will progress in the procurement of copper bus bars.

NBI Upgrade: Installation of platform, walkway, and handrails for the BL2 source platform continues in NTC. The magnetic shielding on the BL OMA boxes is being reinstalled. Fabrication and leakchecking of LHe cryo line continues in the NB shop. LHe cryogenics line installation, welding, and leakchecking on the TFTR Test Cell East wall continues. Fabrication continues on the NB/TVPS duct components in the Tech Shop. The DI water system subcontract has started with training and preparatory work. The SOW and drawings for the power supply cable and tray subcontract requisition package are in review and approval. Additional NBI Armor fit-up to resolve minor interferences in the VV continues. JK VV reinforcements are being ordered.

BUSINESS OPERATIONS (R. TEMPLON):

On May 24, Ms. Kristen Fischer began her employment with PPPL as Chief Financial Officer and Head of Business Operations.

OFFICE OF COMMUNICATIONS: (K. MACPHERSON):

J. DeVoe worked with the Trenton Times on a story about how PPPL is being honored for environmental stewardship by the New Jersey Department of Environmental Protection: http://www.nj.com/mercer/index.ssf/2013/05/princeton_plasma_physics_labor_1.html
Her news story about the honor ran as the lead news story on the Princeton University homepage: http://www.princeton.edu/main/news/archive/S36/92/59G26/index.xml?section=topstories

MacPherson assisted R. Hawryluk with a Physics Today reporter who was writing about ITER on May 22.

DIRECTOR'S OFFICE (B. SOBEL):

On May 20, M. Zarnstorff attended the Fusion Nuclear Science Facility (FNSF) held at the DOE Office of Science in Germantown, MD.

A. Cohen attended the ITER MAC 15 Meeting held in Cadarache, France, May 21-24.

On May 23, Professor Ralph Roskies, University of Pittsburg, Department of Physics and Astronomy, presented a colloquium entitled "Big Data at the Pittsburg Supercomputing Center".

AWARDS:

On May 21, Assistant Commissioner Wolfgang Skacel of the New Jersey Department of Environmental Protection (NJDEP) presented PPPL with a certificate of recognition for the Laboratory's participation in the NJDEP's Environmental Stewardship Program. PPPL was recognized for participating in 20 of the 21 program elements - the highest level of participation of any facility in the state.

C. Cane was recognized by Princeton University's Art of Science competition as one of the top winners for an image representing connections between a visualization of PPPL's website and that of the Lewis Center for the Arts.

PUBLICATIONS:

A paper titled "Collisionality Scaling of Main-ion Toroidal and Poloidal Rotation in Low Torque DIIII-D Plasmas" by B. Grierson et al., has been published in Nuclear Fusion.

A paper by D. Stotler "Energy Conservation Tests of a Coupled Kinetic Plasma-kinetic Neutral Transport Code" has been published online in Computational Science and Discovery (Vol. 6, Issue 1): URL;http://stacks.iop.org/1749-4699/6/015006 DOI:10.1088/1749-699/6/1/015006. This article describes the methods used to couple the XGC0 guiding center, neoclassical plasma transport code to the DEGAS2 Monte Carlo neutral transport code. The energy conservation properties of the coupling method are also examined. This work was primarily supported through the Scientific Discovery through Advanced Computing (SciDAC) program funded by the U. S. Department of Energy.

LEADERSHIP POSITIONS:

A. Zwicker began a 4-year term on the Advisory Board of the Princeton University Prospect House replacing Erik Gilson as the PPPL representative

This report is also available on the following web site:
http://www-local.pppl.gov/director/highlights/2013/2013-highlights.htm