The PPPL Highlights for the week ending May 1, 2015, are as follows:

NSTX (M. ONO):

NSTX-U is in the Upgrade Project outage in FY 2015.

A paper on "Overview of recent physics results from NSTX" by S. Kaye (PPPL) et al has been published online in Nuclear Fusion 55 104002 (2015) (http://stacks.iop.org/0029-5515/55/104002). NSTX is currently being upgraded to operate at twice the toroidal field and plasma current (up to 1 T and 2 MA), with a second, more tangentially aimed neutral beam for current and rotation control, allowing for pulse lengths up to 5 s. Recent NSTX physics analyses have addressed topics that will allow NSTX-Upgrade to achieve the research goals critical to a Fusion Nuclear Science Facility. These include producing stable, 100% non-inductive operation in high performance plasmas, assessing Plasma Material Interface (PMI) solutions to handle the high heat loads expected in the next-step devices and exploring the unique Spherical Torus (ST) parameter regimes to advance predictive capability. Noninductive operation and current profile control in NSTX-U will be facilitated by Coaxial Helicity Injection as well as RF and NB heating. CHI studies using NIMROD indicate that the reconnection process is consistent with the 2D Sweet-Parker theory. Full-wave AORSA simulations show that RF power losses in the SOL increase significantly for both NSTX and NSTX-U when the launched waves propagate in the SOL. Toroidal Alfvén Eigenmode avalanches and higher frequency Alfvén Eigenmodes can affect NB driven current through energy loss and redistribution of fast ions. The inclusion of rotation and kinetic resonances, which depend on collisionality, is necessary for predicting experimental stability thresholds of fast growing Ideal Wall and Resistive Wall Modes. Neutral beams and Neoclassical Toroidal Viscosity generated from applied 3D fields can be used as actuators to produce rotation profiles optimized for global stability. PMI studies have focused on the effect of ELMs and 3D fields on plasma detachment and heat flux handling. DEGAS-2 has been used to study the dependence of gas penetration on SOL temperatures and densities for the MGI system being implemented on the Upgrade for disruption mitigation. Simulations indicate that snowflake and impurity seeded radiative divertors are candidates for heat flux mitigation in NSTX-U. Studies of lithium evaporation on graphite surfaces indicate that lithium increases oxygen surface concentrations on graphite, and deuterium-oxygen affinity, which increases deuterium pumping and reduces recycling. In-situ and test-stand experiments of lithiated graphite and molybdenum indicate temperature-enhanced sputtering, although that test-stand studies also show the potential for heat flux reduction through lithium vapor shielding. Non-linear gyro kinetic simulations have indicated that ion transport can be enhanced by a shear-flow instability, and that non-local effects are necessary to explain observed rapid changes in plasma turbulence. Predictive simulations have shown agreement between a microtearing-based reduced transport model and measured electron temperatures in a microtearing unstable regime. Two Alfvén

Eigenmode-driven fast ion transport models have been developed and successfully benchmarked against NSTX data. Upgrade construction is moving on schedule with initial operation of NSTX-U planned for early calendar year 2015.

A paper on "Effects of MHD instabilities on NB current drive" by M. Podestà (PPPL) et al has been published online in Nuclear Fusion 55 053018 (2015) (http://iopscience.iop.org/0029-5515/55/5/053018). The paper investigates the effects of Alfvenic and other (lower frequency) MHD modes on NB-CD in NSTX. A new fast ion transport model, which accounts for particle transport in phase space as required for resonant AE perturbations, is utilized to obtain consistent simulations of NB-CD through the tokamak transport code TRANSP. It is found that instabilities do indeed reduce the NB-driven current density over most of the plasma radius by up to ~50%. Moreover, comparisons with results from the ad-hoc diffusive model implemented in TRANSP show the details of the current profile evolution are sensitive to the specific model used to mimic the interaction between NB ions and instabilities.

S. Sabbagh (Columbia University) attended the spring ITPA MHD Stability meeting, held for the first time at ITER Headquarters in St-Paul-lez-Durance, Provence, France (April 14-17) presenting a milestone summary of results and international contributions on the joint experiment/analysis task MDC-21 on Global Mode Stabilization Physics and Control. Separate small meetings were also conducted with Peter de Vries (ITER) and Gabriella Pautasso (AUG) regarding guidance for the continuing effort of disruption prediction and avoidance on NSTX-U championed by the Disruption PAM Working Group. The main meeting also included an extensive discussion regarding the need for an update to the ITER Physics basis document (published in 2007). While a minority opinion argued to not create a new document, the majority opinion to update the document carried. Further excitement at the meeting included discussion of planned re-organization of the ITER organizational structure by the new Director General, and also the flurry of construction activity at the ITER site, including progress on the main structural elements of the machine assembly hall, which is located adjacent to the main torus hall.

F. Poli (PPPL) attended the ITPA-IOS meeting on April 20 – 23 in Barcelona, Spain. She reported on the implementation of a pedestal model in time-dependent simulations, using a lookup table based on EPED1 and a fitting procedure, which can be used both in analysis and predictive model. There was discussion on new joint experiments and joint modeling activities. One of these joint activities to which NSTX-U will contribute (including existent database from NSTX) is on the ramp-down phase and fast termination, on both modeling and experimental characterization, for projections to ITER.

R. Maingi (PPPL) presented a guest lecture at Cornell University on the Principles of Magnetic Fusion and the Plasma-Material Interface on April 20. The lecture concluded with a description of the use of lithium in NSTX to improve the edge stability and overall device performance. The trip was supported by the APS Distinguished Lectures in Plasma Physics program.

R. Kaita (PPPL) gave a colloquium lecture on magnetic fusion that included a description of NSTX-U research at Messiah College in Mechanicsburg, Pennsylvania on April 23. Among the research areas at Messiah College is thin film physics, so there was particular interest in materials for fusion applications. The speaker received many questions from students about graduate study and careers in plasma physics, and he is working with the faculty in organizing a tour of PPPL for them in the fall.

C. Skinner (PPPL) visited the Yale Climate and Energy Institute, New Haven, Connecticut on April 24 to attend the Conference on Climate Change and the Future of Nuclear Energy. He gave a special invited talk on 'Fusion: Energy for the Future'. The talk presented progress in magnetic fusion and the potential role of fusion in meeting the energy needs of the coming century and the societal response to climate change.

P. Rindt returned to the Technical University of Eindhoven in the Netherlands on April 22. During the past year, he designed and fabricated prototype high-Z tiles for future use in NSTX-U liquid lithium divertors. Using isopropyl alcohol as a substitute for liquid lithium, his studies included the determination of the wetting properties of different tile surfaces. This work is part of Rindt's requirements for a master's degree at his home institution. The PPPL hosts were R. Kaita and M. Jaworski.

During the completion of the ISTP, continued work was done on the NSTX-U magnetics. The final sensor and polarity corrections were made on the loops that are used to infer the vessel current. Currently, numerical adjustment of the vessel model is required in order to fully calculate the vessel-current corrections to the vessel current. Other flux loops and magnetic field sensors, or their associated electronics, were also repaired.

Testing of gas injection from the plasma control system also continued. It was verified that injector commands entered at the plasma control system manifest themselves as high-voltage applied to piezo valves in the test cell, demonstrating that the real-time data links and valve driver hardware are all functional.

XMP-100 "NSTX-U CD-4 plasma" was approved, and a run copy issued. Additional XMPs are also now under review. Startup of NSTX-U for plasma operations had to be halted to address an external arc fault and water leak at the top of the machine.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

B. Grierson presented a talk at the TTF conference in Salem, Massachusetts on transport modeling in DIII-D ITER baseline discharges with dominant election heating using time-dependent predictive TRANSP. Modeling with TGLF and MMM (Multi-mode model) produce good validation metrics for both dominant electron and ion heating in the DIII-D discharges, whereas GLF23 under predicts the level of transport and produces higher temperature profiles compared to experiment. Studies are continuing with particle and momentum transport validation in the DIII-D ITER baseline.

A. Nagy lead a team of technicians from ORNL, General Atomics, and PPPL to remove the 180-degree antenna coaxial transmission line and tuners from the DIII-D pit and mezzanine two. This is in preparation for the high power Helicon hardware that will use the 180-degree port for the power feedthroughs. The high power Helicon system is expected to be installed and ready for operations in FY17 campaign.

C-Mod (R. Hawryluk):

C. Kessel participated in the ITPA Integrated Operating Scenarios (IOS) working group meeting in Barcelona, Spain. He reported on Alcator C-Mod experimental planning for the IOS joint experiments, indicating that high priority topics would be addressed, but precise experiments had not been identified yet. He also reported on the particle transport benchmark activity, which serves as a comparison of various integrated simulation codes including particle transport. Particle transport is being incorporated in a more routine fashion for ITER simulations in the IOS group and various examinations are being done to better understand this complex area. Updates on joint experiments and modeling activities and results for publication were discussed in detail.

The multi-spectral MSE system observed first plasma light this week. All forty detectors and ovens and between-shot automated analysis routines are operational on the ten MSE sightlines. The system observed the partially polarized light from reflected bremsstrahlung emission. This system will increase the MSE detected signal levels and enable the real-time measurement of the MSE background, allowing MSE measurements in a wider range of operational scenarios.

E. Edlund had a poster entitled "Modeling of EAST ICRF Antenna Performance Using the Full-wave Code TORIC" at the RF conference.

International Collaborations (R. Hawryluk):

R. Hawryluk chaired the KSTAR PAC meeting in Daejeon, Korea.

THEORY (A. BHATTACHARJEE):

On May 1, A. Reiman presented the Theory Department Research and Review Seminar entitled “Cross-Benchmarking and Validation Initiative for Tokamak 3D Equilibrium Calculations". The abstract reads: "Over the past few years, I have been organizing a cross-benchmarking and validation initiative for tokamak 3D equilibrium calculations, with 7 codes participating: the perturbative tokamak equilibrium codes IPEC and MARS-F, the extended MHD code M3D-C1, two stellarator equilibrium codes that assume nested flux surfaces, VMEC and NSTAB, and two stellarator equilibrium codes that can handle islands and stochastic regions, HINT2 and PIES. In addition, dedicated experiments for the purpose of generating data for validation have been done in the past year on the DIII-D tokamak. The calculations thus far have focused primarily on an earlier DIII-D shot that is amenable to analysis by the full range of stellarator and tokamak equilibrium codes. A significant disagreement has been seen between solutions of the VMEC stellarator equilibrium code and solutions of tokamak perturbative 3D equilibrium codes. The source of that disagreement has been investigated, and that investigation has led to new insights into the domain of validity of the different equilibrium calculations, and to a finding that the manner in which localized screening currents at low order rational surfaces are handled can affect global properties of the equilibrium solution. The perturbative equilibrium treatment has been found to break down at surprisingly small perturbation amplitudes due to overlap of the calculated perturbed flux surfaces, and that treatment is not valid in the pedestal region of the DIII-D shot studied. The perturbative treatment is valid. However, further into the interior of the plasma, and flux surface overlap does not account for the disagreement investigated here. Calculated equilibrium solutions for simple model cases and comparison of the

3D equilibrium solutions with those of other codes indicate that the disagreement arises from a difference in handling of localized screening currents at low order rational surfaces, with such currents being absent in VMEC and present in the perturbative codes. The significant differences in the global equilibrium solutions associated with the presence or absence of very localized screening currents at rational surfaces suggests that it may be possible to extract information about localized currents from appropriate measurements of global equilibrium plasma properties. That would require improved diagnostic capability on the high field side of the tokamak plasma, a region difficult to access with diagnostics."

A paper by F. Ebrahimi and R. Raman entitled "Plasmoids formation during simulations of coaxial helicity injection in the National Spherical Torus Experiment" was accepted for publication in PRL. Formation of an elongated Sweet-Parker current sheet and a transition to plasmoid instability has for the first time been predicted by simulations in a large-scale toroidal fusion plasma in the absence of any pre-existing instability. Coaxial Helicity Injection (CHI) is the leading non-inductive start-up plasma formation method in a spherical tokamak. The novel idea behind this paper is that CHI plasmas exhibit reconnecting plasmoid physics, and that a large fusion device can be used to explore fundamental reconnection physics. The theoretical results presented here are significant, because 1) for fusion applications, plasmoid instability could be the main mechanism for fast flux closure and 2) fast reconnection and formation of MHD global-system-sized plasmoids observed here are also relevant to solar observation of fast reconnecting plasmoids.

On April 30, Erik Blackman from University of Rochester presented a theory seminar on two stellar, magnetically active topics: (1) explaining the observed magnetic activity vs. rotation behavior in stars, and (2) a shock reprocessing scenario for solar flares. Part 1: Understanding coronal magnetic activity in stars is of interest for its connections to the basic physics of magnetic field amplification, reconnection and particle acceleration, and for secondary implications of determining stellar ages and influences on planetary habitability. Why the stellar magnetic activity is observed to increase with stellar rotation for slow rotators but becomes independent of rotation for fast rotators has been a long-standing puzzle. Eric discussed how incorporating two principles of modern magnetic dynamo theory into traditional thinking shows promise toward explaining this puzzle. Part 2: Eric briefly described a mechanism and predictions from a two-stage scenario for solar/stellar flare particle acceleration.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

CS: Staff spent most of the week recovering from the OH circuit arc fault and preparing for the upcoming review. A redesign is underway for bracket supporting the OH water connections and OH Ground Plane grounding clamp.

NBI: Low-level arc conditioning continued on BL2 Source 2A. During the OH recovery process, a three-hour block of time has been allocated for NB beam conditioning with NTC closed. This week, BL2 2B has been proceeding with high-voltage hipot conditioning and attempts at beam conditioning. Progress has been slowed due to power supply problems. The BL2 2C faulted source was removed and replaced with a tested spare. The new source has been installed

and pumped down. Source wiring was completed. Preparations to start low-level conditioning are in progress. NBI Armor thermocouple troubleshooting and testing continued during NTC access. An evaluation to fit an IR camera onto the Bay L 7:30 port has started with help from Diagnostics Engineering staff.

DCPS: The Watchdog Timer (WDT) for the FCC DCPS was prototyped, installed, and tested this week with successful results. Review of OP-DCPS-779 for daily startup use continues. The DCPS system is operational and will continue to support Dummy Load testing that will be performed during the OH recovery hiatus. Support continues on the analysis of the OH fault and recovery.

Fabrication and Operations Division (L. Dudek):

Y. Zhai developed the overall plan for PDR design analysis of U.S. port plugs and diagnostic systems. Dynamic analysis model of ITER ECE shutters under EM disruption loads was established and the time-dependent displacement history at DSM attachment points is imposed as boundary conditions to evaluation the impact to the system under EM disruption loads. Result evaluation is expected in 1-2 weeks. Princeton Geneva collaboration worked on generating a finite element model of the 3-D bronze and internal tin wires with and without defects using SpaceClaim (a new CAD tool). The model will be used for comparison of stresses of the bronze and internal tin wires (with and without defects) under a typical mechanical loading.

BEST PRACTICES, EXTERNAL AFFAIRS, & SITE SECURITY (J. DELOOPER):

A. Dominguez, A. Zwicker, K. Palmer and C. Cane met to begin a Science Education and Communications Department collaboration regarding the IPPEX site on April 29.

Site Protection Division (F. White):

OFFICE OF ACADEMIC AFFAIRS (N. FISCH)

On April 16, N. Fisch gave an invited talk on, "High Intensity Regimes for Resonant Raman Compression", at the SPIE 2015 Optics and Optoelectronics Meeting in Prague, Czech Republic. On April 21, he gave an invited Tutorial Lecture, "Compressing light in plasma", at NLIGHT15 (Novel Light Sources from Laser-Plasma Interactions), at the Max-Planck-Institut fur Physik komplexer Systeme, in Dresden, Germany. On April 24, Fisch attended the Board of Physics and Astronomy Meeting in Washington, DC. On April 27, he gave a Review Talk on "The Alpha Channeling Effect" at the Topical Conference of RF Power in Plasma, Lake Arrowhead, California. On April 29-30, he attended a meeting of the Science on NIF Committee at Lawrence Livermore National Laboratory in Livermore, California.

DIRECTOR'S OFFICE (C. AUSTIN):

On April 28-30, A. Cohen participated in an Independent Project Review (IPR) at the US ITER Project Office in Knoxville, Tennessee.

On April 28, Dr. Ramanan Laxminarayan from Princeton University (Princeton Environmental Institute), presented a colloquium entitled, "Antibiotic Resistance: A Global Challenge".

On April 29, Dr. James Green, NASA, presented a colloquium entitled, "Worlds Seen for the First Time - Ceres and Pluto".

LEADERSHIP POSITIONS:

Hawryluk, R., Chair - KSTAR PAC

PUBLICATIONS:

Kaye, S.; Abrams, T.; Ahn, J.-W.; Allain, J.P.; Andre, R.; Andruczyk, D.; Barchfeld, R.; Battaglia, D.; Bhattacharjee, A.; Bedoya, F.; Bell, R.E.; Belova, E.; Berkery, J.; Berry, L.; Bertelli, N.; Beiersdorfer, P.; Bialek, J.; Bilato, R.; Boedo, J.; Bonoli, P.; Boozer, A.; Bortolon, A.; Boyer, M.D.; Boyle, D.; Brennan, D.; Breslau, J.; Brooks, J.; Buttery, R.; Capece, A.; Canik, J.; Chang, C.S.; Crocker, N.; Darrow, D.; Davis, W.; Delgado-Aparicio, L.; Diallo, A.; D'Ippolito, D.; Domier, C.; Ebrahimi, F.; Ethier, S.; Evans, T.; Ferraro, N.; Ferron, J.; Finkenthal, M.; Fonck, R.; Fredrickson, E.; Fu, G.Y.; Gates, D.; Gerhardt, S.; Glasser, A.; Gorelenkov, N.; Gorelenkova, M.; Goumiri, I.; Gray, T.; Green, D.; Guttenfelder, W.; Harvey, R.; Hassanein, A.; Heidbrink, W.; Hirooka, Y.; Hooper, E.B.; Hosea, J.; Humphreys, D.; Jaeger, E.F.; Jarboe, T.; Jardin, S.; Jaworski, M.A.; Kaita, R.; Kessel, C.; Kim, K.; Koel, B.; Kolemen, E.; Kramer, G.; Ku, S.; Kubota, S.; LaHaye, R.J.; Lao, L.; LeBlanc, B.P.; Levinton, F.; Liu, D.; Lore, J.; Lucia, M.; Luhmann Jr, N.; Maingi, R.; Majeski, R.; Mansfield, D.; Maqueda, R.; McKee, G.; Medley, S.; Meier, E.; Menard, J.; Mueller, D.; Munsat, T.; Muscatello, C.; Myra, J.; Nelson, B.; Nichols, J.; Ono, M.; Osborne, T.; Park, J.-K.; Peebles, W.; Perkins, R.; Phillips, C.; Podesta, M.; Poli, F.; Raman, R.; Ren, Y.; Roszell, J.; Rowley, C.; Russell, D.; Ruzic, D.; Ryan, P.; Sabbagh, S.A.; Schuster, E.; Scotti, F.; Sechrest, Y.; Shaing, K.; Sizyuk, T.; Sizyuk, V.; Skinner, C.; Smith, D.; Snyder, P.; Solomon, W.; Sovenic, C.; Soukhanovskii, V.; Startsev, E.; Stotler, D.; Stratton, B.; Stutman, D.; Taylor, C.; Taylor, G.; Tritz, K.; Walker, M.; Wang, W.; Wang, Z.; White, R.; Wilson, J.R.; Wirth, B.; Wright, J.; Yuan, X.; Yuh, H.; Zakharov, L.; and Zweben, S.J., "Overview of Recent Physics Results from NSTX," Nuclear Fusion 55 104002 (2015) (http://stacks.iop.org/0029-5515/55/104002).

Podestà, M.; Gorelenkova, M.; Darrow, D.S.; Fredrickson, E.D.; Gerhardt, S.P.; and White, R.B., "Effects of MHD Instabilities on NB Current Drive," Nuclear Fusion 55 053018 (2015) (http://iopscience.iop.org/0029-5515/55/5/053018).

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