The PPPL Highlights for the week ending May 29, 2015, are as follows:

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

All four of the HV Substation Transformers procured from Hyundai in Korea have now been delivered to ITER. The last three arrived at the ITER site on May 21. This delivery satisfies a DOE 'Notable Outcome' for PPPL. As featured in the ITER Newsline (see http://www.iter.org/newsline/-/2199#3547), two of these large transformers, which step down the voltage from the 400 kV transmission line to 20kV, were recently placed on their pads, and are considered the first large 'plant components' to be installed at the site.

J. Klabacha and R. Feder started work this week on diagnostic port plug Port Cell neutronics modeling. Results from the C-Lite core-machine neutronics will be used to create boundary sources at the inner wall of the bio-shield. Dose rates in the port cell, the rooms just on the outer side of the bio-shield, can be calculated in a separate analysis model. The shut down dose rate in the Port Cell is required to be 10 micro-Sv/hr. This will require careful design of the diagnostic labyrinths through the bio-shield concrete. The model will also be used to design shielding around electronics in the port cell.

Y. Zhai and J. Chen completed scans of electromagnetic disruption scenarios to determine the worst case loading on diagnostic components in the port plugs. To save time and money the analysis team wants to minimize the number of analysis runs by identifying a small sub set of load cases. Interestingly the worst-case disruption for the port plug structures are not the worst case of the small diagnostic components. This is due to the frequency content of the disruption shocks and how the structures and components respond to the shocks and oscillation.

NSTX (M. ONO):

On May 20, an NSTX collaborator, Ramona Perez, successfully defended her PhD dissertation in the physics department at Florida International University. The dissertation described the measurement of lost 1 MeV DD fusion protons from MAST plasmas and provided a reconstruction of the radial profile of the fusion reactivity within the plasmas. The provision of experimental time on MAST was arranged through the auspices of the NSTX-MAST collaboration during the interval when NSTX was undergoing its upgrade. Werner Boeglin was Dr. Perez' major professor for this work. The successful results from this instrument and set of experiments have now formed the basis of the design of a larger array of detectors to be installed in NSTX-U to allow the fusion rate profile to be measured there as well.

The paper “Benchmarking kinetic calculations of resistive wall mode stability” by J. W. Berkery (Columbia University), et al. that was published in Phys. Plasmas 21, 052505 (2014) appeared on the top 20 list of most cited Physics of Plasmas papers in 2014. The paper summarizes a multi-year benchmarking effort of leading kinetic resistive wall mode computational analyses (including MISK and MARS-K), and includes calculations for ITER. All of the 20 articles have been made free to download for a limited time.

D. Darrow (PPPL) visited Florida International University (FIU) on March 20 to meet with NSTX-U collaborators there and to give a talk in the university's Distinguished Nuclear Lecture series. The talk was entitled “Magnetically Confined Plasmas for Controlled Thermonuclear Fusion and Current Research Topics at the National Spherical Torus Experiment-Upgrade”. Professor Werner Boeglin, of the physics department at FIU has collaborated with the NSTX group since 2007 and was able to test a prototype fusion source rate profile diagnostic on MAST in 2013 in advance of designing such a diagnostic for NSTX-U. Boeglin's group included a doctoral student and four undergraduate research assistants. The doctoral student has finished her dissertation based on the data collected at MAST. Of the four undergraduate students, three have gone on to pursue graduate degrees in plasma physics, including two in the University of Michigan Applied Physics department and one at the University of Texas, Clear Lake, which collaborates with NASA's Johnson Space Flight Center on space plasma physics.

A new postdoctoral researcher from Lawrence Livermore National Laboratory, Dr. Michael Weller has arrived on assignment to PPPL. Dr. Weller will be responsible for operating three extreme ultraviolet spectrometer diagnostics and analyzing core impurity spectra in support of the planned wall conditioning and impurity transport studies in NSTX-U.

The Multi-Pulse Thomson Scattering (MPTS) system PVC flight tube along the south wall has been adjusted for the new configuration. The installation of the laser-beam delivery optics in the enclosure at the south wall has begun. Reference marks have been made in order to install the optical components themselves and a positioning test of the large mirror mount has been complete. The moveable beam shutter is now in place and operational. A laser operation permit for the Nd:YAG beams reaching up to the enclosure has been obtained. The installation of baking equipment on the input flight tube is complete. The input flight tube will be baked during the machine bake. The heat tape, thermocouples and insulating wrap have been install on the exit flight tube. There are eight out of ten controllers for the bake out installed.

The probe drive for the Materials Analysis and Particle Probe (MAPP) to be used for exposing samples to NSTX-U plasmas has been installed. It is attached to the analysis chamber already on a lower dome port, and is undergoing leakchecking. Felipe Bedoya, a doctoral student from the University of Illinois at Urbana-Champaign (UIUC), also arrived at PPPL this past week. The MAPP is a collaborative effort with UIUC, and Bedoya will be in residence during the summer to continue preparing it for use on NSTX-U.

Recovery from an external arc fault at the Ohmic Heating (OH) coil terminals continued this past week. All of the lower TF flex buses, supports and connectors have been removed from the lower umbrella. The OH Coil coaxial connection has been removed and a process for epoxy potting the OH Coax assembly is being developed. Electrical insulation tests (Hi-Pots) of a prototype OH cooling tube bracket were successfully completed, and a peer review of that design was conducted. Field Coil Power Conversion (FCPC) rectifier dummy load testing of additional

TF parallel circuits continued this week, and the capability of using individual parallels as diodes to limit circulating fault currents (needed for > 4 parallels in subsequent higher power TF operation) was successfully tested. New coil current dI/dt limit algorithms were tested this week in unipolar supply dummy load tests, successfully suppressing/bypassing the rectifier under test when an out of range coil impedance was introduced. Additional tests will be performed for bipolar power supply operation. Engineering reviews of the existing Lithium Evaporator (LITER) mounting brackets indicate that the in-situ brackets are appropriate for use on NSTX-U with some modification. Drawings are now being prepared for the modified assemblies. Commissioning of the Multi-Pulse Thompson Scattering (MPTS) diagnostic, and the installation of components for the Purdue Material Analysis Particle Probe (MAPP) diagnostic is in progress.

ITER & TOKAMAKS (R. HAWRYLUK):

R. Hawryluk participated in an ITER External Management Advisory Board meeting on May 18-19.

DIII-D (R. Nazikian):

The ECE-I antennas damaged by ECRH in the last campaign have been repaired and fully characterized with new mixing elements and a new ECH 110 GHz filter. Similar service has been performed on the MIR antenna array, and upgrades are proceeding on schedule for plasma operations with alignment of major optical components in the machine hall to begin on June 1.

A CDR on the Super Spa Patch Panel being designed by A. Nagy, was held on May 26. This patch panel will provide connection points between two new super SPAs being built at ASIPP for DIII-D, four exiting SPAs from PPPL, 24 Audio Amps, and 3 C-power supplies with 12 I-coils, 6 C-coils, and 14 F-coils for various experimental configurations. This task will eliminate the old I-coil patch panel and locate all of these connections in a monolith patch panel nominally five feet high by 14 feet long. It is scheduled for installation during September/ October 2015.

C-Mod (R. Hawryluk):

S. Zweben co-authored a new paper "Comparison of 3D flux-driven scrape-off layer turbulence simulations with gas-puff imaging of Alcator C-Mod inner wall limited discharges", by F D Halpern, J L Terry, S J Zweben, B LaBombard, M Podesta and P Ricci (Plasma Phys. Control. Fusion 57 (2015) 054005). This paper carried out a quantitative comparison between gas-puff imaging (GPI) turbulence measurements in Alcator C-Mod inner-wall limited discharges (Zweben et al 2009 Phys. Plasmas 18 082505) and 3D flux-driven drift-reduced Braginskii turbulence simulations of scrape-off layer dynamics. The comparison is carried out for a series of inner-wall limited discharges where the magnetic field and the density are varied. The comparison between GPI data and non-linear simulations yields overall good agreement for several observables, such as the Dα emission levels and intermittency, the radial and poloidal correlation lengths and propagation velocities, and the power and frequency spectral density.

A new paper on the "*Non-resonant destabilization of 1/1 internal kink mode by suprathermal electron pressure*", by L. Delgado-Aparicio, *et al.*, has been published as a letter in the May issue

of Physics of Plasmas. New experimental observations are reported on the structure and dynamics of short-lived periodic (1,1) "fishbone"-like oscillations that appear during radio frequency heating and current-drive experiments in tokamak plasmas. For the first time, measurements can directly relate changes in the high-energy electrons to the mode onset, saturation, and damping. Suprathermal electron energies are measured directly using the downshift of electron gyrofrequency due to relativistic effects, and correlate with the mode. The results suggest that the fishbone-like mode is a marginally stable internal kink that is destabilized by the non-resonant suprathermal electron pressure contribution to the central beta thus offering an alternative explanation for the mode-onset and evolution for cases where the wave-particle resonances of traditional electron fishbones are weak. The independence of the fast-electron pressure from the thermal pressure that drives the conventional internal kink also explains its varied co-existence with the sawtooth crash and precursor oscillations. The PoP letter can be found at: http://scitation.aip.org/content/aip/journal/pop/22/5/10.1063/1.4919964

International (S. Scott):

S. Scott traveled to JET to work with J. Strachan (PPPL), Hyun-Tae Kim (JET) and Henri Weisen (JET) on JET's neutron-deficit issue. Steve is learning how to run TRANSP for JET pulses.

ADVANCED PROJECTS (H. NEILSON):

A paper authored by D. A. Gates, D. P. Brennan, L. Delgado-Aparicio, and R. B. White entitled: "The Tokamak Density Limit: a Thermo-resistive Disruption Mechanism" has been accepted for publication in Physics of Plasmas as a letter. The paper discusses new developments in modeling radiation driven islands that have now reached the state where a complete dynamic model of the growth mechanism has been developed. Major new developments include: 1) a semi-analytic model that shows the correct dynamics for the density limit island growth mechanism including the effects of island asymmetry, 2) a full numerical treatment of the mode growth using a modified version of the DEBS code (a cylindrical fully non-linear resistive-MHD code), and 3) a discussion of the effects of impurities on the radiation driven island threshold. These new developments bring the cylindrical theory to a mature state. The first development 1) is the subject of a more detailed paper authored by R. B. White, and items 2) and 3) will be covered in follow on papers authored by L. Delgado-Aparicio and D. P. Brennan respectively.

A peer review was held on 26 May to consider recent design changes, manufacturing plans, and estimates for the W7-X TDU Scraper project. The Scraper is a component, which will be used to support edge and divertor plasma research on the Wendelstein 7-X (W7-X) stellarator as part of the U.S. collaboration with the W7-X program. The Laboratory was assigned responsibility for completing the final design and fabrication of two scraper units, following a successful preliminary design review (PDR) in February. In the first few months of final design, the project has focused on design improvements intended to reduce manufacturing risks. At the peer review, cognizant engineer D. Loesser described a set of changes resulting in a simpler, easier to manufacture design compared to the PDR design. Analysis was presented showing that design would meet requirements, even with the changes. Cost and schedule estimates were presented by project manager R. Strykowsky showing a dramatic reduction in cost and a delivery schedule compatible with W7-X needs. Peer review participants from Oak Ridge National Laboratory,

Max Planck Institute for Plasma Physics, and PPPL found that the presented design provides a sound basis for execution and made a number of suggestions in the form of chits. The review was deemed successful pending resolution of chits.

THEORY (A. BHATTACHARJEE):

A paper written by A. Reiman, entitled "Tokamak Plasma High Field Side Response to an n = 3 Magnetic Perturbation: A Comparison of 3D Equilibrium Solutions from Seven Different Codes", has been accepted for publication in Nuclear Fusion. The coauthors are: N.M. Ferraro, A. Turnbull, T.E. Evans and M.J. Lanctot (GA); J.K. Park and D. Monticello (PPPL); A. Cerfon (NYU); E.A. Lazarus (ORNL); Y. Liu (Culham, UK); G. McFadden (NIST); Y. Suzuki (NIFS, Japan). The abstract is as follows: In comparing equilibrium solutions for a DIII-D shot that is amenable to analysis by both stellarator and tokamak 3D 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 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 currents at low order rational surfaces, with such currents being absent in VMEC and present in the perturbative codes. The significant differences seen in the global equilibrium solutions associated with the presence or absence of delta function 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.

This week, the Theory Department Research and Review Seminar was given by T. Stoltzfus-Dueck, on "Edge Intrinsic Rotation: Theory and Experiment ". The abstract reads: " Plasma near the last closed flux surface of a tokamak often rotates at Mach numbers of several tenths, even in the absence of applied torque. The relative magnitudes of various quantities in the tokamak edge lead to a physical model where the edge rotation is caused by the interaction of drift orbit excursions of passing ions with the amplitude of transport-causing turbulent potential fluctuations. Analysis of the model reveals that the major-radial position of the X-point adjusts the relative orbits of co- and counter-current passing ions in a way that should strongly modify the edge rotation, changing it from strongly co-current for an inboard X-point to zero or weakly counter-current for an outboard X-point. Motivated by these theoretical predictions, recent dedicated experiments on the Swiss Tokamak à Configuration Variable (TCV) have indeed directly observed the predicted X-point position dependence of the edge intrinsic rotation, in qualitative and even reasonable quantitative agreement with the theoretical predictions. Other popular heuristic models of edge intrinsic rotation, in particular ion orbit loss and transport-driven scrape-off-layer flows, fail to reproduce the observations."

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

The external Review of the NSTX-U arc event was completed. Findings were generally supportive of the Laboratory's internal review activities. There were no new surprises.

Construction: The upper ceramic break has been cleaned and the vacuum vessel hi-pots have been successfully performed.

CS: The week was spent preparing for and participating in the external review of the OH Arc Fault. A debriefing was held on May 29. The ground to the internal VV was located and cleared on May 28. It was found to be in one of the bolts in the G10 spacers on the ceramic break. Initial measurements of the OH Ground plane paint indicate the resistance is two to three order of magnitude greater than anticipated. Measurements of various paint thicknesses on G10 show that the paint needs to be eight coats thick in order to have resistivity in the range of 150 ohm/sq. Initial test of the epoxy injection of the OH Coax was performed with good results.

NBI: Efforts continue to repair and perform system hi pots on N2A and N2C The Fast Vacuum Interrupter and bending magnet power supply troubleshooting and repairs are underway. Troubleshooting of BL thermocouples continued this week. Source shop activities include completion of Decon Room preparation, completion of a repaired and reassembled source, and crane moves of sources for drying, testing, and disassembly. Cryogenics operations continue including loading new dewars of Helium into the process system.

DCPS: The DCPS system has supported ongoing dummy load testing. During a break in dummy load testing, the DCPS interconnection chassis and expansion chassis were taken out of service to change power supplies and boards. The new units were bench tested and burned in with pre-operational test procedures before installation. The system was returned to service and is ready for use.

BUSINESS OPERATIONS (K. FISCHER):

A. Bleach met with representatives from Princeton University and PNC Bank to discuss the extension of the current bank agreement for PNC Bank to manage the DOE Letter of Credit account on behalf of Princeton University.

PPPL awarded the contract for Pre-Construction Services for the IOI Project (facilities upgrade). These services will be in conjunction with the Architectural / Engineering services that have already been awarded.

NASA provided second year funding of $36,614.00 for the research project entitled "Large-Scale Radial Plasma Transport and Heating in Planetary Magnetospheres." The principle investigator for this effort is J. Johnson.

PUBLICATIONS:

Berkery*, J.W.; Liu, Y.Q.; Wang, Z.R.; Sabbagh, S.A.; Logan, N.C.; Park, J.-K.; Manickam, J.; and Betti, R., "Benchmarking kinetic calculations of resistive wall mode stability, Physics of Plasmas 21, 052505 (2014)

Halpern, F.D.; Terry, J.L.; Zweben, S.J.; LaBombard, B.; Podesta, M.; and Ricci, P., "Comparison of 3D flux-driven scrape-off layer turbulence simulations with gas-puff imaging of Alcator C-Mod inner wall limited discharges," Plasma Phys. Control. Fusion 57 (2015) 054005

Delgado-Aparicio, L.; Sugiyama, L.; Shiraiwa, S.; Irby, J.; Granetz, R.; Parker, R.; Baek, S.G.; Faust, I.; Wallace, G.; Gates, D.A.; Gorelenkov, N.; Mumgaard, R.; Scott, S.; Bertelli, N.; Gao, C.; Greenwald, M.; Hubbard, A.; Hughes, J.; Marmar, E.; Phillips, P.E.; Rice, J.E.; Rowan, W.L.; Wilson, R.; Wolfe, S.; and Wukitch, S., "Non-resonant destabilization of 1/1 internal kink mode by suprathermal electron pressure," Physics of Plasmas **22**, 050701 (2015); http://dx.doi.org/10.1063/1.4919964

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