The PPPL Highlights for the week ending June 12, 2015, are as follows:

FEATURED HIGHLIGHT:

PPPL hosted the ITPA Divertor and Scrape-off Layer Topical Group Meeting on June 9-12. The ITPA DivSOL is the forum where the ITER parties work together to address ITER's plasma-material interaction (PMI) challenges. The international progress will also benefit the PMI challenges on NSTX-U. Sixty-eight scientists attended from China, European Union, Japan, South Korea, India, Russia, and United States. Progress in addressing issues in Edge/SOL physics, modeling, ELMs, and PFC materials were presented in 3.5 days of sessions on: Steady-state divertor and 1st wall heat loads, boundary modeling, Far SOL & turbulence modeling, ELM physics, Heat loads to leading edges, PFC deterioration by ELMs, Synergistic effects on surface dynamics, PMI and dust modeling, Plasma facing components testing, DSOL joint tasks and ITER action plan. From PPPL, J. Menard gave a presentation on the NSTX-Upgrade capabilities, T. Gray on NSTX heat flux width and diverter spreading, and C.S. Chang on heat flux transport studies with XGC. C. Skinner was the local host.

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

The 22kV Switchgear was shipped and delivered to destinations at ITER site and F4E factory in Spain, satisfying a DOE FY15 Performance Plan Milestone.

The Upper Port Wide Angle View Visible-IR Camera (UPP WAVs) system is US ITER's largest diagnostic project. The UPP WAVs are distributed to five upper port plugs and provide Visible and Infrared views of the divertor and blanket shield modules for machine protection. General Atomics is the prime contractor through final design and has subcontracted with LLNL for system physics support and the Dutch company TNO for optical and mechanical engineering services. This week Mark Smith organized a gathering at PPPL that brought together to full technical team from PPPL, GA and TNO. Many important optical and mechanical engineering details were discussed with an eye on locking in the designs for the early 2017 PDR.

Karen Andrews and Gayla Creasey from USITER visited PPPL this week to work with K. Lukazik and M. Messineo on the use of the iDocs document management system. Lukazik manages the documents for diagnostics and SSEN at PPPL. Messineo manages the CATIA design office and documentation system. It is critical that PPPL uses iDocs efficiently to make sure documents can be reviewed, approved and shared in a timely manner. It is also an important QA mechanism for tracking documents, models and drawings that are inputs to the complex diagnostic system design and analysis. Lukazik and Messineo will work closely with

the 10 Diagnostic CAMs to implement iDocs procedures. Andrews and Creasey's visit also marks the start of a new closer relationship between the PPPL and US ITER administrative teams.

Mike Walsh, the head of the ITER Diagnostics Division, visited PPPL this week. The USDA is providing seven diagnostic systems and four port plug packages to ITER. The PPPL staff holds regular web meeting with Walsh and his IO team but face-to-face meetings allow for more in depth detailed discussions. Walsh also presented a status of ITER diagnostics to the PPPL community at the weekly lab-wide colloquium.

D. Johnson was invited to represent the USDA at a series of technical meetings on the EUDA ITER diagnostics and port plugs. Attending this meeting at the F4E Barcelona offices was important for learning about innovative European design approaches, discussing common ITER requirements issues and checking in on EUDA systems that are being integrated in to USDA port plugs.

NSTX (M. ONO):

NSTX-U is in the Upgrade Project outage in FY15

The NSTX-U Team Meeting was held on June 5 at PPPL. The NSTX-U team was updated on the recovery activities of the OH electrical fault event and the associated repair plan. An updated schedule toward research operation and the research program plan were also discussed. The meeting material is available on the web at: http://nstx.pppl.gov/DragNDrop/NSTX_Meetings/Team_Meetings/2015/2015-06/.

On May 20, a paper by F. Ebrahimi (PPPL) and Roger Raman (University of Washington) entitled "Plasmoids formation during simulations of coaxial helicity injection in the National Spherical Torus Experiment" was published online in Physical Review Letters 114, 205003 (2015). Plasmoids can form under different circumstances in fusion and astrophysical plasmas. Anytime oppositely directed magnetic field lines in a plasma are pushed together and reconnect via some dynamical process and form a long current sheet, the plasmoid instability might occur and cause plasmoids to form. For the first time we have simulated plasmoid instability in a realistic tokamak geometry and have shown that plasmoids can even form during helicity injection in a large fusion device when no other dynamical process (or instability) is initially present. Through resistive MHD simulations, it is demonstrated that during transient Coaxial Helicity Injection (CHI) discharges at high Lundquist number, the elongated current sheet formed through a Sweet-Parker forced reconnection process breaks up, and a transition to spontaneous reconnection (plasmoid instability) occurs. Motivated by the simulations, experimental camera images have been revisited and suggest the existence of reconnecting plasmoids in NSTX. As CHI is a promising candidate for plasma start-up and may ultimately also have the potential for steady-state current drive, it is thus important to understand the CHI physics to be able to correctly model it in simulations of NSTX/NSTX-U and to be able to extrapolate its viability to a reactor. In this paper, our simulations show that plasmoid-mediated reconnection may be the leading mechanism for fast flux closure. For a good start-up plasma current, we need all of the injected open field lines (injector flux) to rapidly reconnect and form closed flux surfaces, and our most recent simulations show that this is possible.

The following NSTX-U physicists attended the DOE FES/ASCR Workshop on Integrated Simulations for Magnetic Fusion Energy Sciences, held in Rockville, Maryland from June 2-4, participating in the following panels: S. Kaye (PPPL): Panel C: Whole Device Modeling, Panel F: Data Management, Analysis and Assimilation. F. Poli (PPPL): Panel C: Whole Device Modeling, Panel G: Software Integration and Performance. S. Jardin (PPPL): Panel A: Disruptions. G.-Y. Fu (PPPL): Panel A: Disruptions. J. Canik (ORNL): Panel B: Boundary. C.S. Chang (PPPL): Panel B: Boundary.

Installation of the Multi-Pulse Thompson Scattering (MPTS) hardware is complete. The laser exit flight tube is being baked and is now open to the NSTX-U vacuum chamber. The alignment of the entire system is being checked and adjusted using a He-Ne laser aligned to be co-linear with the YAG laser beam trajectories. The next activity will be to fire the YAG laser through the system and further check/adjust the alignment. This will be followed by an assessment of the stray laser light and calibration of the system using Rayleigh and Raman scattering.

Reinstallation has begun for the Lithium Evaporator (LITER) mounting brackets, which had to be removed when the upper umbrella structure was modified for NSTX-U. The first step was to move both LITERs to their ports on the upper dome, and tack-weld their brackets in place. Final welding will occur after the LITER alignments are completed. A Final Design Review (FDR) was conducted for the control system for the Lithium Granule Injector (LGI). There was agreement on the use of a National Instruments (NI) PXI system for remote control of the LGI

Recovery from an external arc fault at the Ohmic Heating (OH) coil terminals continued this past week. Drawings and installation procedures for the newly fabricated upper OH water tube supports are ready. The design for the OH Ground Connection and the OH Compression Ring grounding has been reviewed, and a prototype of the OH ground connection is being fabricated. A conceptual design for new OH ground braid supports has been reviewed. Drawings for the new OH coax bus are nearing completion, and additional tests of the epoxy application are being set-up. Silver-plating of TF bus connections is in progress, and the plating procedure is being updated to include verification techniques. Work has started on the mechanical installations associated with the new LLNL spectrometers.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

The FES workshop on Transients in Fusion Plasmas took place at General Atomics from June 8-11. The workshop addressed the current status, gaps and future directions in disruption and ELM physics and methods for their mitigation. R. Nazikian was a co-chair of the workshop with Chuck Greenfield (GA). PPPL researchers W. Solomon and D. Gates were co leaders of workshop sub panels in ELMs and disruptions, respectively. In addition a number of PPPL researchers (D. Mansfield, R. Maingi, A. Bortolon, C.S. Chang, E. Kolemen, J.K. Park, D. Brennan) were strongly engaged in the workshop, in preparing the white papers, reports and summaries.

A design review was held this week for the Liquid Crystal Polymer Heterodyne Receiver development project for the ECE and MIR Imaging system. This project is a technical collaboration between PPPL and the University of California-Davis Millimeter-Wave Research Center aimed at improving the signal quality and enhancing the flexibility of the detection system towards frequency swept measurements in a single discharge. Technical improvements have allowed a simplification of the receiver design from a five-layer to a simpler three-layer process. Fabrication of the receiver is due to begin on June 22.

Madeline Vorenkamp, an engineering major at University of San Diego, has started work on the Lithium Granule Injector upgrade as a summer intern. She will be working with A. Nagy and W. Brown focusing on the development of a reliable injected granule counter for the LGI. This will involve the development of an optical detection system and the required analysis software to provide a routine automated counter of the granules injected into the plasma.

ADVANCED PROJECTS (H. NEILSON):

N. Pablant (PPPL) and S. Massidda (Auburn University) traveled to Greifswald, Germany to install the U.S. X-ray imaging crystal spectrometer (XICS) diagnostic on the Wendelstein 7-X (W7-X) stellarator at the Max Planck Institute for Plasma Physics (IPP). Installation of the main vacuum chambers for the XICS diagnostic was completed, including final machining of all high precision mounting plates and the installation of all components requiring support from the IPP assembly team. Final vacuum assembly, crystal alignment, and final metrology measurements are planned for completion in the next few days. This represents a major milestone for the XICS diagnostic, which has been carried out as part of the U.S. collaboration in W7-X and is now nearing completion. The XICS system is expected to be operational and provide high-resolution temperature profile measurements for the first W7-X experimental campaign later this year.

THEORY (A. BHATTACHARJEE):

R. Churchill presented an invited talk at the IAEA Technical Meeting on Fusion Data Processing, Validation, and Analysis, held in Nice, France. The topic of the talk was: "Edge physics discovery and validation by synthetic diagnostics using the XGC gyro-kinetic codes". The detailed abstract is as follows: Understanding the multi-scale physics in the edge region (pedestal + scrape-off layer) is required in order to reliably predict performance in future fusion devices. The family of XGC codes, the massively parallel, full-f gyro-kinetic codes, contain many of the physics important in setting the transport in the edge region, including neoclassical and turbulent transport effects, kinetic electrons, impurities, full magnetic geometry including X-point, and neutrals with atomic cross-sections. Several important edge topics have been explored with the XGC codes, including predictions of SOL heat flux width, radial electric field wells, pedestal bootstrap current, poloidal variation of pedestal density/temperature, and blobs. To give confidence in using XGC simulations to predict plasma characteristics in future machines, these simulation results must be validated by identifying observables to compare to experiments. Synthetic diagnostics are created, focusing not only on the effects of the measuring instruments themselves, but also of the reduction algorithms used to extract physics quantities of interest. Algorithms to extract additional physics from the large data sets generated by the XGC codes will be described, along with the need for in-memory analysis. An example will be given of

applying blob detection algorithms to an entire poloidal cross-section, instead of the usual narrow experimental diagnostic window. This gives understanding of the blob birth location and dynamics, which would be difficult to obtain through experiment alone.

On June 12, Professor Masahiro Hoshino from the University of Tokyo presented a theory seminar on non-thermal electron acceleration by turbulent reconnection imbedded in a collisionless shock wave: Nonthermal particles are ubiquitous in astrophysical plasmas, and explosive phenomena such as supernova remnant shocks and solar flares have demonstrated evidence for the production of relativistic high-energy particles. However, the particle acceleration mechanism remains an unresolved issue. Historically, after the idea of the stochastic acceleration by Enrico Fermi in 1949, many acceleration models have been proposed to explain nonthermal cosmic ray particles, and the diffusive shock acceleration is believed to be primary mechanism by which particles gain nonthermal energies through stochastic scattering between the shock upstream and downstream. However, recent modern observations suggest that the diffusive shock acceleration alone cannot explain the observed cosmic ray particles, and other acceleration mechanisms with much efficient production of the nonthermal particle are needed. We present supercomputer simulations showing that efficient electron energization can occur during turbulent magnetic reconnection arising from a strong collisionless shock. Upstream electrons undergo first-order Fermi acceleration by colliding with reconnection jets and magnetic islands, giving rise to a nonthermal relativistic population downstream. These results may shed new light on magnetic reconnection as an agent of energy dissipation and particle acceleration in strong shock waves.

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

Alexander Fedotov-Gefen presented his work conducted at Technion University in Israel on underwater electrical wire explosion and shock wave generation in water. The presented work is devoted to research of underwater wire electrical explosion (UEWE) and generation of converging shock wave by explosion of a cylindrical wire array. The process of UEWE is accompanied by a rapid phase transitions (solid-liquid-gas-plasma) of the wire material, intense light emission and generation of a strong shock wave (SSW). Regarding wire array explosions the issues addressed in this research were generation of cylindrically symmetric converging SSW, efficiency of the energy deposition from planar wire array to water flow and parameters of water in the vicinity of the implosion axis in the case of cylindrical wire array explosion. The experiments were carried out using different current generators having stored energies between 500 J and 9.7 kJ and the peak powers between 5 GW and 25 GW, respectively. In the presented experiments three types of diagnostics were applied, namely, electrical (current and voltage measurements), optical (shadow imaging, visible spectroscopy, schlieren, Faraday rotation and Kerr effect) and mechanical (velocity measurement of shocked target). In this research it was shown and explained that black body radiation does not indicate the internal temperature of the exploding wire. Using 1D hydrodynamic model it was shown that maximal water pressure of 400 GPa was generated at the implosion axis of the cylindrical wire array.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

Engineering (L. Dudek, E. Perry):

FNSF Magnet Design R&D: Y. Zhai discussed with Wayne Reiersen the Nb3Sn wires to be shipped to PPPL (>400 m long - two types of ITER wires) for construction of the 3-T solenoid magnets. Staff worked with students on design of the magnet and coil winding strategy, as well as how to use the existing insulation taping machine (used for NSTX-U CS coil) for SC coil winding.

BUSINESS OPERATIONS (K. FISCHER):

DOE approved a new Laboratory Directed Research and Development (LDRD) project for FY15 titled "Scoping Study for a World-Leading U.S. Stellarator Program and Facility". Including the budget requested for this project, the total budget allocated to LDRD projects in FY15 is $2.7 million against the $3.0 million LDRD funding ceiling approved by DOE.

ENVIRONMENT, SAFETY, & HEALTH (J. LEVINE):

The State of New Jersey Department of Labor and Workforce Development informed the Laboratory that it earned two awards for safety performance in calendar year 2014. These were the Recognition Award to PPPL for low incidence of away from work injury and illness cases, and the Commissioner's Continued Excellence Award for working 8 consecutive years (over 376,000 hours) without an away from work injury or illness case.

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

Science Education (A. Zwicker):

June 8 was the first day of the weeklong Introductory Course in Plasma Physics organized by A. Dominguez for the 2015 SULI students. This year's lecture series was streamed live online via the course website http://w3.pppl.gov/scied/oneweek2015/. Lectures were also recorded and will be archived for further public viewing after the course concludes. Grad students volunteered to lead group homework sessions.

DIRECTOR'S OFFICE (C. AUSTIN):

Dr. Richard Pitts, ITER, presented a colloquium on June 8 entitled, "Handling Plasma Wall Interactions on ITER".

On June 9-10, A. Cohen attended a meeting of the DOE National Laboratories Chief Operating Officers at the Forrestal Building in Washington, D.C.

Dr. Mike Walsh, ITER, presented a colloquium on June 10 entitled, " ITER and its Diagnostics – Rising to the Challenge".

On June 11-12, Cohen participated in a Laboratory Operations Board meeting at the National Renewable Energy Laboratory (NREL) in Golden, Colorado.

PUBLICATIONS:

Ebrahimi, F.; and Raman, R., "Plasmoids formation During Simulations Of Coaxial Helicity Injection In The National Spherical Torus Experiment," Physical Review Letters 114, 205003 (2015).

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