

PRINCETON PLASMA PHYSICS LABORATORY

**WEEKLY** highlights



**The PPPL Highlights for the week ending May 9, 2014, are as follows:**

**FEATURED HIGHLIGHT:**

B. Grierson has received an Early Career Research Program award for his proposal entitled, "Exploration of Main-ion Properties at the Boundary of Fusion Reactors". This research program will build on Grierson's earlier work on core main-ion spectroscopic measurements aimed at understanding main ion thermal, particle and momentum transport. The funding over a course of five years will address main ion temperature, density and velocity profile measurements in the plasma edge and apply these towards the understanding of main ion transport including the physics of intrinsic torque.

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

The PPPL port integration team met with representatives of the EU-DA and the CEA teams working on the wide angle viewing system (WAV) housed in US port plugs E3 and E9. The U.S. team presented plans for a System Integration Review of Equatorial Port 9 in October or November of 2014.

Further piping analysis scoping studies indicate that the addition of a "u-bend" in the sampling pipe of the divertor RGA will reduce the bending moment on the associated vacuum flanges below acceptable limits, and permit a simpler bellows configuration to be used downstream of isolation valves.

The LFS Reflectometer "kick-off" meeting is scheduled for June 17-18 at General Atomics. Design team members from PPPL, ORNL, and UCLA will attend.

**NSTX (M. ONO):**

The APS-DPP invited paper entitled "Physics of forced magnetic reconnection in coaxial helicity injection experiments in National Spherical Torus Experiment" by F. Ebrahimi (PPPL) et al., was published in *Physics of Plasmas* 21, 056109 (2014) (<http://scitation.aip.org/content/aip/journal/pop/21/5/10.1063/1.4875337>). Using resistive MHD simulations in a comprehensive study, the physics of fast flux closure in transient CHI experiments in NSTX was examined. These MHD simulations show that in the right parameter regimes, a local 2-D Sweet-Parker type reconnection is triggered in the injector region and closed flux surfaces are formed in the global domain. Critical requirements for magnetic

reconnection and flux closure were studied in detail. These primary effects, which are magnetic diffusivity, injector flux, injector flux footprint width, and rate of injector voltage reduction, were simulated for transient CHI experiments. It was found that as injector flux footprint becomes narrower, the ratio of closed flux current increases and the largest closed flux is obtained with the most rapid reduction of injector voltage. For a complete picture of the reconnection process, both local and global length scales, as well as both ideal Alfvénic and resistive time scales, are resolved in these simulations.

Princeton University graduate student Tyler Abrams recently returned from a four-week experimental visit to FOM-DIFFER laboratory in the Netherlands. During his stay, Tyler completed eight days of experiments on Magnum-PSI, a linear plasma device capable of conditions similar to those in the NSTX-U divertor. These results are important for NSTX-U because lithium and boron coatings on high-Z metals are planned plasma facing components (PFCs) in NSTX-U. Tyler measured the gross erosion rate of lithium and boron coatings on TZM molybdenum during high-flux plasma bombardment and found that the temperature limits of these materials may be significantly higher than previously thought.

J. Menard (PPPL) visited the Culham Centre for Fusion Energy in Culham, United Kingdom on May 7-9 to participate in the UK's Fusion Advisory Board and to collaborate on NSTX-U MHD stability issues.

Preparations for plasma operations in the NSTX-U configuration also continued with the preparations of the Field Coil Power Conversion (FCPC) and Neutral Beam Power systems for upcoming power testing. In the neutral beam yard, an autotransformer with a failed tank to tap changer seal was lifted out of position and replaced with a spare. In FCPC, new OH system current feedback transducers (DCCT's) have been installed. Preparations are underway to begin the D-MG#1 weld repairs. PPPL Emergency Services has completed emergency response plans and conducted confined space rescue drills. The weld contractor, Voith Hydro, will be on site next week for kick-off meetings and to complete required PPPL Safety training. In the NSTX-U vessel, the first compliant center conductor has been fit up on an HHFW antenna.

## **ITER & TOKAMAKS (R. HAWRYLUK):**

### **DIII-D (R. Nazikian)**

W. Solomon was beam operator on a Quiescent H-mode experiment aimed at investigating the critical shear needed for maintaining an edge harmonic oscillation (EHO). Slow torque ramps were performed with the beams, with the power adjusted to account for improved confinement at reduced torque in this regime. Interesting results were obtained on the properties of the EHO at low rotation. Surprisingly, ELM-stable operation was maintained as the toroidal rotation crossed through zero, even without the use of additional 3D fields for NTV torque.

B. Grierson obtained first spectroscopic data with the prototype edge main-ion CER system on DIII-D. Preliminary analysis indicates a Doppler shift of the thermal charge-exchange emission in the co-current direction, observed in both forward and reverse current discharges, indicating co- $I_p$  plasma rotation in a thin edge layer, similar to previous observations using Mach probes on DIII-D. These observations motivate planned future upgrades for sixteen sightlines

with a spatial resolution of 6-7 mm.

A review of the cost and schedule for the fabrication and installation of the Lithium Granule Injector (LGI) for DIII-D was held at PPPL. The design modification for a smaller diameter flight tube was discussed and approved following test results indicating a modest (30%) reduction in the granule delivery rate to plasma. The review was successfully concluded and fabrication is proceeding. A port assignment on DIII-D is still to be determined.

The linear actuator for the poloidal steering of a PPPL ECH launcher mirror failed this week due to the breaking of a tack weld on the drive shaft. A. Nagy is working with R. Ellis, E. Kolemen and the GA ECH team to understand the root cause of the failure and to develop a repair procedure that minimizes the impact on operations.

W. Brown, working with A. Nagy, refurbished ten patch panel pins using spare multi-lam contact strips. An additional 190 pins will be refurbished by Brown when new multi-lam contacts arrive at DIII-D.

The PPPL pole shield design team discussed their latest analysis in a peer meeting on May 9. This analysis showed that the moly insert design would meet the requirements for the peak heat loads expected for 3.2 MW beam operation. A remaining issue is the concentration of thermal stress on one side of the copper plate adjacent to the moly inserts. Several solutions were discussed and analysis will be reviewed the week of May 12.

#### **ADVANCED PROJECTS (H. NEILSON):**

The Laboratory and Korea's National Fusion Research Institute (NFRI) launched the third phase of their collaboration on a scoping study for a next-step fusion nuclear facility, K-DEMO, with a videoconference meeting on May 7. An update of the design work at NFRI was presented by K. Im, focusing on progress in the divertor and blanket configuration. PPPL's plans for this phase include development of a heating and current drive configuration for K-DEMO, considering neutral beams, as well as electron cyclotron, ion cyclotron, and lower hybrid waves. In addition, PPPL will study potential cost-saving improvements in the tokamak configuration for consideration in future design point updates. These plans were presented by C. Kessel and T. Brown, respectively. P. Titus reported progress in developing a global model of the conducting structures and plasma that will be used to simulate plasma disruptions.

In its collaboration with the Wendelstein 7-X project at Germany's Max Planck Institute for Plasma Physics (IPP), the project team is moving forward from the recent successful preliminary design review (PDR) of the x-ray imaging crystal spectrometer. An inventory of system components and estimated costs was prepared for inclusion in the Laboratory's equipment loan agreement with IPP. Notification of concurrence with the draft Project Execution Plan was received from IPP. Once any cost and schedule adjustments resulting from the PDR are determined, the estimates will be updated and a performance baseline will be established.

## **THEORY (A. BHATTACHARJEE):**

The APS-DPP invited paper by F. Ebrahimi et al., entitled "Physics of forced magnetic reconnection in coaxial helicity injection (CHI) experiments in National Spherical Torus Experiment", was published in PoP online (see NSTX highlight and Publications listing at end).

The theory seminar on May 8 was presented by Professor Huishan Cai from the University of Science and Technology of China, entitled "Influence of energetic ions on resistive wall mode in reversed field pinch". The abstract of the talk is "A stability analysis of the circulating energetic ions (CEIs) on resistive wall mode is carried out in the reversed field pinch (RFP). In contrast to the minor resonant effects of CEI on resistive wall mode (RWM) in tokamak, the resonant interaction between RWM and CEI is important for high toroidal mode number in RFP with high beta value. The resonance provides an energy dissipation channel of free energy, and stabilizes RWM. As the fraction of CEI is large enough, the RWM is fully suppressed by CEI in the low plasma rotation, even vanishing rotation. Further, a possibility to suppress the RWM by CEI is suggested."

## **COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):**

A finite element based Poisson solver has been developed in flux coordinates in GTS code. Various boundary conditions, including Dirichlet boundary condition, Neuman boundary condition, or mixed Dirichlet-Neuman boundary condition, are provided. The new Poisson solver has been rigorously tested against analytical solutions and benchmarked with the original solver in nonlinear ITG and TEM simulations. It is now routinely used for GTS production runs. The same finite element structure/framework can be applied to solving additional equations needed for finite-beta simulations in GTS. Finite element operators to find derivative and zonal flow are also implemented.

## **ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):**

### **NSTX Upgrade (R. Strykowski, E. Perry, L. Dudek, T. Stevenson):**

Construction: The upper and lower row one tiles have been removed from the machine to protect them during centerstack installation. Installation of the first new RF antenna has been started. The potting of the TF outer leg aluminum blocks to the umbrella structure has been started. Diagnostic fiber optic cables have been installed and vacuum system cable installation continues. Bus bar fabrication and trial fit-ups continues and all TIVs for gas injection have been installed.

CS Upgrade: Winding of the OH Coil was completed, only the termination, ground wrap and VPI remain to complete the coil. The termination of the first conductor was completed and preparations to complete the second conductor termination are underway. The Inconel material for the OTF finger supports arrived at Hollis. The material was nonconforming, but was approved. The latest revised schedule has put the delivery of these items out past June. Procurement is working with Hollis to bring the schedule back in line. Martinez is preparing quote for a second set of Outer TF Lead Extensions. The welding of the covers onto the second PF1B coil is underway and should be completed by the end of the week. The NCR for the

machined PCHERS Passive plate was approved. The upper G10 crown piece was completed and received from Imperial Machine. The OTF Finger support brackets were completed at Carolina and the paperwork to release them for shipment is underway.

NBI Upgrade: The BL2 OMA lid hardware and lines were installed on the source platform and the VV RWM coil fabrication continues for the Bay JK area. Vacuum system roughing line fabrication and installation continues in the NTC. SF6 line fabrication and installation in the NTC has started. Water pump support pads were grouted and the TVPS turbo pump tables installation started with trial fit-ups. Reactivation and cleaning of NBPS surge rooms was started. The mod/reg controls work and preparation continues. NB Controls work on rack cable and wiring continued in NTC and gallery. Additional NB installation procedures are in development and review. In addition, management attended the monthly EVMS status meeting this week.

Digital Coil Protection System: Two successful design reviews were held this week for the Autotester interface panel and for the RCIM interface chassis. Parts were made and assembled for DCPS computer cable strain relief and work continued on the DCPS GUI with steady progress. The hardware and I/O layout and design continues and nears completion. Work on hardware drawings continues and is also nearing completion. Changes to interface with FCPC L1 fault circuitry have been designed and will be prototyped and tested. The HW user interface panel design was updated for new status and nomenclature. PCB design is in progress; procurements are planned. An electronics parts list was generated for purchase of off the shelf items. A Hardware Interface FDR has been scheduled in early June. Progress continues on the FCPC Level 1 fault circuitry drawings and plans including changes needed in the DCPS Hardware Interface chassis and rack. A Lemo connector cable order is being prepared. Management attended the very successful CDR for the PS Real Time Control software.

#### **ENVIRONMENT, SAFETY, HEALTH & SECURITY (J. LEVINE):**

Site Protection and the DOE Princeton Site Office collaborated on a PowerPoint presentation of the NightOwl Project at PPPL. The presentation was requested by the DOE Office of Health, Safety and Security. HSS plans to forward the NightOwl information to other laboratories in the DOE complex to inform them of the advantages of the project.

#### **OFFICE OF COMMUNICATIONS: (K. MACPHERSON):**

J. Greenwald reported and wrote a news release about the Early Career Research Program award bestowed upon by PPPL physicist B. Grierson. Greenwald also worked with Princeton's Digital Print Center on the remaining final stages of Quest magazine prior to printing, and the DOE's online Pulse publication posted Greenwald's article about the Princeton-PPPL project to develop a zero-knowledge nuclear warhead verification system.

## **DIRECTOR'S OFFICE (C. AUSTIN):**

Dr. Siegfried Glenzer of SLAC National Accelerator Laboratory, presented a colloquium on May 7 entitled, "Exploring the Physical Properties of Matter in Extreme Conditions".

## **PUBLICATIONS:**

Ebrahimi, F. (PPPL); et al., "Physics of forced magnetic reconnection in coaxial helicity injection experiments in National Spherical Torus Experiment," *Physics of Plasmas* 21, 056109 (2014) (<http://scitation.aip.org/content/aip/journal/pop/21/5/10.1063/1.4875337>).

The following PPPL Reports were posted to the web:

A Megawatt-level 28z GHz Heating System For The National Spherical Torus Experiment Upgrade PPPL-5024

Authors: Gary Taylor, et. al. Submitted to: Proceedings on the 18th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (April 2014)

The Status of USITER Diagnostic Port Plug Neutronics Analysis Using Attila PPPL-5025

Authors: Russell Feder, Mahamoud Youssef and Jonathan Klabacha

Submitted to: Proceedings of the American Nuclear Society (ANS) 2013 Winter Meeting, Washington, DC (November 2013)

Status Of The Design Of The ITER ECE Diagnostic PPPL-5026

Authors: Gary Taylor, et. al.

Submitted to: 18th Joint Workshop on Electron Cyclotron Emmission and Electron Cyclotron Resonance Heating, Nara, Japan (April 2014)

Inferring Magnetospheric Heavy Ion Density Using EMIC Waves PPPL-5028

Authors: Eun-Hwa Kim, Jay R. Johnson, Hyomin Kim and Dong-Hun Lee

Submitted to: Geophysical Research Letter (May 2014)

Safety Culture And Best Practices At Japan's Fusion Research Facilities PPPL-5029

Authors: Keith Rule, et. al.

Submitted to: ANS Conference Proceedings, Anaheim, CA (November 2014)

Recent Progress On Spherical Torus Research PPPL-5030

Authors: Masayuki Ono and Robert Kaita

Submitted to: *Physics of Plasmas* (January 2014)

This report is also available on the following web site:

<http://www.pppl.gov/publication-type/weekly-highlights>