

PRINCETON PLASMA PHYSICS LABORATORY

**WEEKLY** highlights



**The PPPL Highlights for the week ending October 3, 2014, are as follows:**

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

The ECE design team discussed procedures for aligning the optical components during assembly. Several stages of subassembly/test must be considered. These ideas will next be presented to the IN-DA ECE team, since microwave optics are also within its scope.

A kickoff meeting for the TIP design team will be held at General Atomics on October 21.

**NSTX (M. ONO):**

The Topical Review paper, "Solenoid-free plasma start-up in spherical tokamaks," by R. Raman (U-Washington) and V F Shevchenko (CCFE, Culham Science Centre), was published on-line in Plasma Physics and Controlled Fusion 56 (2014) 103001, <http://iopscience.iop.org/0741-3335/56/10/103001/article>. The paper reviews research to-date in the areas of helicity injection, radio frequency and outer poloidal field induction for initiating plasma currents in spherical tokamaks.

S. Sabbagh and Young-Seok Park of Columbia University visited NFRI to run an experiment on the KSTAR tokamak attempting to access higher normalized beta and to extend past  $n = 2$  non-resonant neoclassical toroidal viscosity (NTV) studies in the device. The machine was successfully operated at reduced toroidal field as low as 0.9T, and record values of normalized beta for the device reaching 4 were produced transiently in a range of internal inductance from 0.75 – 0.85 as computed using full KSTAR equilibrium reconstructions. These values are expected to be at least 30% over the  $n = 1$  ideal no-wall beta limit computed from past analysis. Initial examination of the non-resonant  $n = 2$  NTV indicates a favorable lack of hysteresis as the applied 3D field magnitude is changed.

Preparations for plasma operations in the NSTX-U configuration also continued. The Neutral Beam (NBPC) and Field Coil (FCPC) power conversion power supplies are being prepared for power testing. The fabrication of ex-vessel MPTS diagnostic equipment such as the Collection Optics Box and the Flight Tube Assembly continues in several PPPL shops.

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

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

A recent article by B. A. Grierson et. al entitled "High speed measurements of neutral beam turn-on and impact of beam modulation on measurements of ion density" has been published in Review of Scientific Instruments. The article resolves the time dependent properties of the beam pulse from the analysis of the photoemission from rapid neutral beam modulations. Previously inferred anomalies in the inferred ion density have been resolved by using improved calibration methods and accurate characterization of the transients in the beam pulse.

The replacement fiber optics cables for the Beam Emission Spectroscopy system were received at DIII-D, inspected, and accepted this week. These 18 channels, 120 meters long, will replace a similar set that have darkened due to neutron radiation. This set will be installed during the 2015 vent in January.

All nine Magnet Current Monitors for monitoring currents in the DIII-D gyrotrons are in final assembly at PPPL and the electrical tests are about 50% complete.

The Lithium Granular Injector team is visiting DIII-D this week to complete the assembly and calibration of the system in the lab prior to installation on DIII-D, scheduled for October 20. The LGI assembly and leak check is complete with calibration of the moving parts to be performed prior to the tests with lithium planned next week.

### **ADVANCED PROJECTS (D. GATES):**

S. Lazerson and D. Gates visited IPP-Greifswald in Germany from September 28-October 3. The purpose of the trip was to develop a detailed research plan for Sam Lazerson's extended assignment to work on W7-X, which will begin early next year. Various planned research activities were discussed including vacuum magnetic field line mapping, equilibrium reconstruction using the STELLOPT code, and turbulent transport optimization in Stellarators. Gates also discussed several ongoing collaboration topics including the US X-ray Imaging Crystal Spectrometer diagnostic currently under construction, the temporary divertor scraper element currently being designed, and use of the US supplied trim coils for the upcoming initial run campaign of W7-X.

While visiting Greifswald S. Lazerson gave a seminar on October 2 to the IPP theory department. The title of the talk was "Ongoing benchmarking of 3D equilibrium codes". The talk discusses a multi-institutional activity to understand the results of several different 3D codes that have been used to understand the effects of Resonant Magnetic Perturbation (RMP) fields in tokamaks.

The national Fusion Energy Systems Studies team held a teleconference project meeting on October 2. Study leader C. Kessel outlined plans for producing a report on the first year of the Fusion Energy Science Facility (FNSF) Mission and Metrics study. Accomplishments to be reported include the establishment by the team of quantitative metrics for technical progress toward fusion power plants, and a phased testing program on an FNSF and DEMO to reach

commercial readiness goals. Critical R&D activities in preparation for and in parallel with operation of an FNSF have also been defined and will be addressed in the report. System code improvements are being made in preparation for the second year of the study. M. Tillack reported progress in overhauling the code to make it more flexible and capable of the parameter scans that will be needed to support the study, and Kessel reported on a flexible tokamak configuration representation that can allow exploration of a wide range of design variants.

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

The PPPL Theory Department met for a Retreat on October 1-3 at the Carnegie Center, Princeton University and at PPPL. This Retreat was prompted in part by the recent DOE review of the Five-Year Plan of the Department, which was highly successful. The Retreat was organized around a few plenary talks in the mornings and extensive discussion sessions in the afternoons. Participants included not only the members of the Theory Department, but also a significant number of experimentalists, an external speaker who addressed the role of integrated simulations in the Earth Sciences, and graduate students. The Retreat focused on strategic research directions of the Theory Department.

### **PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):**

Klaus Widmann of the Lawrence Livermore National Laboratory (LLNL) has concluded a two-week visit to the Lithium Tokamak Experiment (LTX). During this time, data were obtained with the LLNL High-resolution Grazing-incidence Grating Spectrometer (HIGGS) (Rev. Sci. Instruments 85, 111D630 (2014)). Emission lines for singly and doubly ionized lithium lines were observed, and the intensity with a narrow (25 micron) slit may make it possible to determine lithium ion temperatures for LTX plasmas. A new detector was also installed for measurements with a time resolution in the ten-millisecond range.

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

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

Construction: The centerstack casing feed-through connectors are being completed and the casing will be moved into the NSTX Test Cell before the centerstack is brought into the south high bay of NSTX on October 6. The centerstack will be lifted into NSTX in one week. The lower ceramic break and PF1C coil have been installed and the leak check passed. Final machining of the upper PF1C can has been started. The trays for the PF cooling water hoses have been completed and most of the hose has been placed in them. Work continues on the terminations for the RGA and vacuum systems as well as for the category 3/4 ground bus.

CS Upgrade: The Centerstack assembly work at C-site was completed and the OH/TF Bundle assembly was transported to D-site on October 3 for final assembly to the Centerstack casing next week. The PF1C Upper coil weld number 2 was completed and o-ring flange seal surface machining commenced. The upgraded water system installation procedure was completed and is in the process of being signed off.

NBI Upgrade: Services work continues on turbopump flanges and turbo installation and flange preparation is underway. Platform drawings were completed and column fabrication has been completed for the catwalk between source platforms. The trial fitup is imminent. Power system work continued to focus primarily on fiber optic termination testing, remedial polishing and re-termination if needed, and channel assignment and testing; this work tests the hundreds of fibers that extend from NBPC 138-foot level to the NBPC 100-foot level and then to the NTC BL2 HVEs. Steady progress has been made. Some switchyard and Mod/Reg work was completed in anticipation of Accel reactivation. Controls work continues with installation of cable tray, cabling, installation of junction boxes, and gallery rack wiring. Cable installation from junction boxes to BL2 componentry is in progress. PLC to LCC interconnection wiring continues. Progress continues on developing the north door shield wall statement of work. Cryogenics maintenance and repairs in preparation for operations continues; the repaired leak was successfully leak-checked. The PTP procedure development continues.

Digital Coil Protection System: Autotester modifications were completed. DCPS software PTP testing awaits some software changes to fix I/O. This work is being prioritized and balanced against other DCPS and RTC jobs. Several meetings were held to discuss RTC, DCPS, changes, priority, and schedule. The need for a PTP to test real world configuration and end-to-end tests was identified, scoped, and development started. Rapid progress has been made. Hardware drawings are being finalized. The set up and startup operating procedure is being developed with additional input gleaned from the several meetings.

#### **BUSINESS OPERATIONS (K. FISCHER):**

The new Procurement Director, Wray Myers, started at PPPL on September 29.

The twelve FY14 LDRD projects that were selected for continuation into FY15 were approved by DOE. The total budget to be allocated to these projects is \$1.15 million against the \$3.0 million LDRD funding ceiling.

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

K. MacPherson participated as a member of the APS-DPP public relations committee.

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

On September 29 - October 2, A. Cohen participated as a committee member at the DOE Office of Science review of the Linac Coherent Light Source II (LCLS-II) project at Jefferson Laboratory in Newport News, Virginia.

S. Prager attended the Secretary of Energy's Advisory Board (SEAB) Task Force meeting on technology transfer. The meeting was held at Oak Ridge National Laboratory in Knoxville, Tennessee on October 2.

## **PUBLICATIONS:**

Raman R. (U-Washington) and Shevchenko, V.F. (CCFE, Culham Science Centre), "Solenoid-free plasma start-up in spherical tokamaks," Plasma Physics and Controlled Fusion 56 (2014) 103001, <http://iopscience.iop.org/0741-3335/56/10/103001/article>.

Grierson, B.A.; et. al entitled "High speed measurements of neutral beam turn-on and impact of beam modulation on measurements of ion density" has been published in Review of Scientific Instruments, 85, 103502 (2014); <http://dx.doi.org/10.1063/1.4896514>

Authors: W.M. Solomon, P.B. Snyder, K.H. Burrell, M.E. Fenstermacher, A.M. Garofalo, B.A. Grierson, A. Loarte, G.R. McKee, R. Nazikian, and T.H. Osborne  
Access to a New Plasma Edge State with High Density and Pressures using Quiescent H-mode PPPL-5043  
Submitted to: Review of Scientific Instruments

Authors: Keith G. Erickson, Gregory J. Tchilinguirian, Ronald E. Hatcher, William M. Davis  
NSTX-U Digital Coil Protection System Software Detailed Design PPPL-5044  
Published in: IEEE Transactions on Plasma Science, Conference proceedings

Authors: K.G. Erickson, D.A. Gates, S.P. Gerhardt, J.E. Lawson, R. Mozulay, P. Sichta, G.J. Tchilinguirian  
NSTX-U Control System Upgrades PPPL-5045  
Published in: Fusion Engineering and Design, 89 (2014) pp 853–858

Author: Keith G. Erickson  
NSTX-U Advances in Real-time C++11 on Linux PPPL-5046  
Published in: Proceedings 2014 IEEE-NPSS Real Time (RT) Conference, Nara Japan

Authors: B. Tobias, B.A. Grierson, C.M. Muscatello, X. Ren, C.W. Domier, N.C. Luhmann, Jr., S.E. Zemedkun, T.L. Munsat, and I.G.J. Classen  
Phase-locking of Magnetic Islands Diagnosed by ECE-Imaging PPPL-5047  
Accepted for publication in: Review of Scientific Instruments

Authors: N.A. Pablant, R.E. Bell, M. Bitter, L. Delgado-Aparicio, K.W. Hill, S. Lazerson, and S. Morita  
Tomographic Inversion Techniques Incorporating Physical Constraints for Line Integrated Spectroscopy in Stellarators and Tokamaks PPPL-5048  
To be published in: Review of Scientific Instruments

Authors: N.A. Pablant, M. Bitter, R. Burhenn, L. Delgado-Aparicio, R. Ellis, D. Gates, M. Goto, K.W. Hill, A. Langenberg, S. Lazerson, M. Mardenfeld, S. Morita, G. H. Neilson, T. Oishi and T.S. Pedersen  
Measurement of Core Plasma Temperature and Rotation on W7-X made available by the X-ray Imaging Crystal Spectrometer (XICS) PPPL-5049  
To be published in a special issue of Plasma Physics and Controlled Fusion

Authors: Masaaki Yamada, Jongsoo Yoo, Jonathan Jara-Almonte, Hantao Ji, Russell M. Kulsrud, and Clayton E. Myers  
Conversion of Magnetic Energy in the Magnetic Reconnection Layer of a Laboratory Plasma PPPL-5050  
Submitted to: Nature Communications

Authors: J. Squire and A. Bhattacharjee  
Magnetorotational Instability: Non-modal Growth and the Relationship of Global Modes to the Shearing Box PPPL-5051  
Submitted to: Astrophysical Journal

Authors: I.E. Ochs, N. Bertelli, and N.J. Fisch  
Coupling of a-channeling to  $|k_{\parallel}|$  Upshift in Lower Hybrid Current Drive PPPL-5061  
Submitted to: Physical Review Letters

Authors: S.M. Kaye, W. Guttenfelder, R.E. Bell, S.P. Gerhardt, B.P. LeBlanc, and R. Maingi  
Reduced Model Prediction of Electron Temperature Profiles in Microtearing-dominated National Spherical Torus eXperiment Plasmas PPPL-5062  
Published in: Physics of Plasmas (1994-present) 21, 082510 (2014);  
[\[http://dx.doi.org/10.1063/1.4893135\]](http://dx.doi.org/10.1063/1.4893135)

Authors: Jay R. Johnson and Simon Wing  
The Dependence of the Strength and Thickness of Field-Aligned Currents on Solar Wind and Ionospheric Parameters PPPL-5063  
Submitted to: Journal of Geophysical Research

Authors: Michael Paluszek, Gary Pajer, Yosef Razin, James Slonaker, Samuel Cohen, Russ Feder, Kevin Griffin, and Matthew Walsh  
Direct Fusion Drive for a Human Mars Orbital Mission PPPL-5064  
Published in: Conference proceedings The 65th International Astronautical Congress

Authors: J.C. Schmitt, J. Bialek, S. Lazerson, and R. Majeski  
Magnetic Diagnostics for Equilibrium Reconstructions with Eddy Currents on the Lithium Tokamak Experiment PPPL-5065  
Published in: RSI 85, 11E817 (2014) [DOI: 10.1063/1.4892159](https://doi.org/10.1063/1.4892159)

Authors: G.H. Neilson, T. Brown, K. Im, C. Kessel, K. Kim, P. Titus, Y. Zhai  
Physics and Engineering Assessments of the K-DEMO Magnet Configuration PPPL-5066  
Presented at: The 25th IAEA Fusion Energy Conference, St. Petersburg, Russia, 13-18 October 2014. To be published: by the IAEA as unedited proceedings

Authors: M. Bitter, K. W. Hill, P. C. Efthimion, L. Delgado-Aparicio, N. Pablant, Jian Lu, P. Beiersdorfer, and Hui Chen  
A New Spectrometer Design for the X-ray Spectroscopy of Laser-produced Plasmas with High (sub-ns) Time Resolution PPPL-5067  
Published in: Review of Scientific Instruments 85, 11D627 (2014); [doi: 10.1063/1.4894390](https://doi.org/10.1063/1.4894390)

Author: Virginia Finley  
Annual Site Environmental Report PPPL-5068

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