

PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights



The PPPL Highlights for the week ending June 14, 2013, are as follows:

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

The Upper Diagnostics Port Neutronics Report was submitted to the ITER IDM system, completing a US ITER Performance Plan Milestone.

Follow-up meetings were convened with both the ITER Organization and US experts, to discuss the resolution of class 1 chits resulting from the recent Conceptual Design Reviews for the ITER MSE and the CIXS diagnostics.

Bids were received in response to PPPL RFP 13-031-A - "ITER Low-Field Side Reflectometer (LFSR) R&D, Physics and Engineering Design Support and Diagnostic Hall Instrumentation Development."

NSTX (M. ONO):

The Symposium on Fusion Engineering (SOFE) was held June 11-14 in San Francisco, California. Several presentations were given by NSTX-U researchers describing research progress on NSTX and plans for NSTX-U. Roger Raman (Univ. Washington) presented a poster on the "Design Description of the Coaxial Helicity Injection System on NSTX-U", L. Roquemore (PPPL) presented a poster on "Upward Facing Lithium Flash Evaporator for NSTX-U", and Dan Andruczyk (Univ. Illinois) presented a poster on a "Method to Produce Lithium Pellets for Fueling and ELM Pacing in NSTX-U". Several presentations were also given describing the latest results from the LDRD-funded ST-FNSF mission and configuration study. J. Menard presented a poster on "ST-FNSF Mission and Performance Dependence on Device Size", T. Brown (PPPL) presented a poster on "Progress in Developing the ST-FNSF Configuration", Laila El-Guebaly (Univ. Wisconsin) presented a poster on "TBR and Shielding Analyses in Support of ST-FNSF Study", and John Canik (ORNL) presented a poster on "Power and Particle Exhaust in an ST-FNSF". Robert Woolley (PPPL) gave an oral presentation on "Radial Cooling of a Spherical Torus (ST) TF Centerpost". Numerous NSTX Upgrade Project engineering presentations were also given.

On June 12, S. Gerhardt (PPPL) presented NSTX data on a conference call of participants in ITPA-MHD JA-1 on flow shear and NTMs (JA-Joint Activity). The talk focused on data in his 2008 APS poster, and showed that the onset criterion for 2/1 NTMs in NSTX had some correlation with rotation-related variables, and that the correlation was best with normalized flow shear. He also presented analysis of soft X-ray signal from these modes, illustrating that they

have a strong 1/1 component in addition to the 2/1 island. Other presentations were given with data from DIII-D, AUG, and TCV, with the ultimate goal of guiding theory and modeling research on the role of flow and flow shear in the stability of NTMs.

G. Taylor (PPPL) visited MAST on June 3-7 to collaborate on 28 GHz electron Bernstein wave (EBW) plasma startup experiments. These experiments are being conducted in collaboration with the Culham Centre for Fusion energy and Oak Ridge National Laboratory. There also are additional collaborators from Japan and Russia. Previous EBW startup experiments on MAST had been limited by transmission line arcs and low, ~ 50%, transmission line efficiency. In these earlier experiments only 50 kW were coupled to the plasma generating up to 33 kA of non-inductive current, which was a world record at that time. Since the 2009 experiments the performance of the transmission line components have been significantly improved and transmission efficiencies ~ 80% are now routinely achieved. In the recent experiments 75-85 kW of gyrotron source power were used with pulse lengths up to 400ms being achieved on some shots. A new record non-inductive current of 75 kA was achieved with only 75 kW of gyrotron source power, more than doubling the previous record in 2009.

Preparations for plasma operations in the NSTX-U configuration with the completion of the schematic diagrams and printed circuit board layouts for the new diagnostic system Stand-Alone Digitizers. Fabrication and power testing of the new firing generators for the field coil power conversion (FCPC) system rectifiers continues. To date, 18 of the 34 planned new firing generators have been delivered to FCPC, and 13 of those have completed dummy load testing.

ITER & TOKAMAKS (R. WILSON):

DIII-D (R. Nazikian):

The B-coil bus failure significant event review was chaired by A. Nagy. The root cause of the bus failure is the joint loosening over years of service. A. Nagy was assigned to develop a coax bus bar design as a backup if the repair of the B-coil coax tube design has trouble in meeting its schedule. The initial bus bar design review is scheduled for June 17.

Approximately 90% of the Gyrotron 8 water manifold parts have been ordered, with the manifold pipe weldment purchase order awarded this week to Astro of Ephrata, Pennsylvania. The delivery date is August 31.

ADVANCED PROJECTS (H. NEILSON):

In the Wendelstein 7-X (W7-X) trim coil collaboration, the power supply supplier, Applied Power System (APS) of Hicksville, NY, reports that assembly of the first trim coil power supply unit (PSU) is essentially complete. Control circuit testing is being finished up this week and full in-house system testing of the PSU is scheduled for the week of June 17. Representatives from PPPL and Max Planck Institute for Plasma Physics, the W7-X host, are scheduled to travel to APS during the week of June 24 to witness acceptance testing of the first PSU.

THEORY (A. BHATTACHARJEE):

This week's theory seminar "Naval Research Laboratory, Space Science Division Research" was presented by Dr. Jill Dahlburg, Superintendent of the Space Science Division at Naval Research Laboratory. She presented a highlight of major research activities of the three research branches of SSD: geospace science, heliospheric physics, and high energy space environment. The importance of the basic research program was emphasized. Most of these research activities (about 85%) are funded externally. For information on individual research and the lead persons, seminar chair Dr. Fatima Ebrahimi (ebrahimi@pppl.gov) has a copy of her talk. Dr. Dahlburg said in her talk: "From the beginning of the Division in 1952 to the present, the Naval Research Laboratory (NRL) Space Science Division (SSD) has pursued a broad-spectrum research, development and experimentation program to study the atmospheres of the sun and the earth, the physics and properties of high energy space environments, and solar activity and its effects on the earth's atmosphere, and to transition capabilities to operational use." She continued "The importance of basic research in the service of the Navy was robustly championed by Homer Newell, the Division's 2nd Superintendent, who noted to Congress in 1957 that "a strong basic research program is essential to continuing vitality of applied R&D in missiles or any other military or peacetime applications. New facts, new ideas, new techniques, new materials, new instruments, all come from the basic research effort...". Extraordinary ranges of research and results have been achieved. Now in its 7th decade, the SSD vigorously continues to envision, design, integrate, test, launch, operate, and experiment with space science RDT&E capabilities for our world's most extreme environments."

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

The new (P)TRANSP nonlinear profile advance routine PTSOLVER has now been extended by X. Yuan to include angular momentum prediction. Test runs have been performed using JET L-mode, H-mode and Hybrid discharges using TGLF and NEO simultaneously to compute turbulent and neoclassical fluxes to predict electron density, electron and ion temperature, together with angular momentum. Results for the shots simulated show good agreement with experimental data and expected dependences. The jobs are being run at PPPL using 64 cores of the Dawson cluster. Results using this capability will be presented at the EPS meeting later this month by R. Budny. This capability can be made available to other, beta-test, users by request.

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

Low Temperature Science Center:

Seven PPPL employees (A. Cohen, P. Efthimion, I. Kaganovich, Y. Raitses, A. Khrabrov, and students: E. Tokluoglu and Y. Shi) visited the annual meeting of the DOE Center for Predictive Control of Plasma Kinetics: Multi-phase and Bounded Systems, which took place May 16-17, at the University of Maryland. The purpose of the meeting was to provide an opportunity for the Co-PIs of the Center to share their results within the Center, with the advisory board, with interested colleagues and with DOE OFES staff. The DOE Plasma Science Center: Control of Plasma Kinetics is currently in the fourth year of a five-year research activity. The Center's mission is advancing the study of low temperature plasmas and discovering how those plasmas

can be shaped and controlled in order to achieve scientifically and technologically desirable outcomes. The Center addresses a previously unmet need to perform collaborative scientific research in plasma science on topics of foundational scientific importance across plasma science, which has broad technical, economic, and societal benefit.

(LTX):

Erik Granstedt successfully defended his thesis for his doctorate from the Program in Plasma Physics at Princeton University on June 8. Granstedt's advisors are B. Kaita and G. Hammett. The title of Erik's dissertation was "The Low-Recycling Lithium Boundary and Implications for Plasma Transport." Granstedt's thesis research covered two major areas. First, he performed gyrokinetic simulations where transport is dominated by density-gradient plasma profiles. The transport in such discharges is characterized by a small linear critical gradient, large particle flux, and preferential diffusion of cold particles. Granstedt investigated profiles predicted for the Lithium Tokamak Experiment (LTX) if ion thermal transport was neoclassical, while electron thermal transport and particle transport were a fixed ratio above the neoclassical level. His modeling indicated that a robust trapped electron mode (TEM) instability was found for the outer half radius, while the ion temperature gradient (ITG) instability was found to be driven unstable as well during gas puff fueling. This suggests that TEM transport will be an important transport mechanism in high-temperature low-recycling fusion experiments, and in the absence of stabilizing mechanisms, may dominate over neoclassical transport. Second, Granstedt developed a diagnostic suite to measure hydrogen and impurity emission in LTX. He used them to determine the lower bound on recycling that can be achieved in a small tokamak using solid lithium coatings, assess its dependence on the operating condition of the lithium surface, and evaluate its impact on the discharge. Granstedt combined the measurements from these diagnostics with a novel approach he developed, using neutral modeling, for the inverse problem of determining the distribution of recycled particle flux from PFC surfaces given a large number of emission measurements. His analysis revealed that extremely low levels of recycling ($R(\text{core})$ of about 0.6 and $R(\text{plate})$ of about 0.8) have been achieved with solid lithium coatings. Together with impurity emission measurements, Granstedt's modeling suggests that during periods of particularly low electron density, influx of impurities from the walls contributes substantially to the global particle balance.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: The aluminum castings have been bonded to TF14. The first phase of modifications to stiffen the 109' platform for the Thompson Scattering diagnostic has been completed. The balance of this work will take another week and it will involve access restrictions on the south side of the machine. The upper PF4/5 clamp upgrades have been completed and the lower ones are in progress. Studs have been welded to the outside of the vessel for later installation of thermocouples and flux loops. Tray is being installed from the north side of NSTX to the north wall. The re-installation of racks is beginning.

CS Upgrade: The procurement subcontract for the Centerstack up righting assembly fixture was awarded to Astro machine. The promised delivery date is July 26. Quadrant 4 was successfully

potted this week and is presently in the final oven cure cycle. The OH mold schedule was delayed approximately two weeks from the vendors accelerated schedule but is still on track to arrive to meet project schedule date. Measurements were taken on the OTF coils to record their as built locations. The data will be used to locate the mounting hardware for the new OTF legs. OH winding fixture tensioning table fabrication continues in the Tech Shop. Sanding of the quadrants and setting up for OH brazing trials has begun in the oil winding area.

NBI Upgrade: Installation of the water manifolds on the source platform continues. Fabrication and leak checking of LHe cryo line continues in the NB shop. LHe cryogenics line installation, welding, and leak checking on the TFTR Test Cell East wall continues. Piping has been built and set through the penetrations into NSTX Test Cell. Fabrication continues on the NB/TVPS duct components in the Tech Shop. The DI water system subcontract continues with pipe welding and installations. Drafting work on NTC power cable and tray drawings continues. The Armor Bay H port cover has been cleaned in the VPL. JK VV reinforcements are on order. SFLIP design and analysis has been completed in preparation for an FDR and materials are on order. LCC Controls work has resumed.

BUSINESS OPERATIONS (K. FISCHER):

A proposal titled "Turbulent Energy Transfer, Scaling, and Intermittency in the Solar Wind and Magnetosphere" was submitted to NASA. The Principal Investigator is Jay Johnson. The total budget request is \$385,100 for the three-year period of performance.

A proposal titled "Electromagnetic Ion Cyclotron Waves Generation and Propagation under Different Geomagnetic Activities" was submitted to NASA. The Principal Investigator is E.H. Kim. The total budget request is \$403,800 for the three-year period of performance.

One-year renewal proposals for FY2014 funding were submitted to the Office of Fusion Energy Sciences for the PPPL projects funded under the Experimental Plasma Research Program: Lithium Tokamak eXperiment (LTX), Offsite University Research Support, Princeton Field-Reversed Configuration (PFRC-2) and Advanced Simulation of Innovative Confinement Experiments (FRC Theory).

OFFICE OF COMMUNICATIONS: (K. MACPHERSON):

C. Cane participated in a teleconference of the DOE National Labs' Digital Group on June 14. Several items were discussed, including: Ben Dotson is the new social media coordinator for the DOE website; a new DOE national labs Tumblr account has been created; and efforts are being focused to align with consistent, regular themes. In addition to PPPL, participants included representatives from Ames, Berkeley, Brookhaven, INL, Joint Genome Institute, Los Alamos, National High Magnetic Field Laboratory, and Oak Ridge.

Cane also participated in the June 13 meeting of the DOE Web Council, led by T. O'Neill. Topics centered on the energy.gov website, which had some recent feedback: response design (looks good on smartphones and tablets, as well as laptops and desktop screens); site was made for 'scientists' - they are looking into making it appeal to a broader audience; visitors

viewed energy.gov as a 'trusted source' of non-biased, credible information; and energy-saving 'coupons' were a popular website visitor destination (so it's now easier to find on the web).

G. Czechowicz designed and produced the brochure for the Patent Awareness Program. J. DeVoe provided editing services.

J. DeVoe and G. Czechowicz edited, designed, and produced the PPPL Weekly, which included a profile of new CFO K. Fischer and photos of tours and summer college students.

DeVoe assisted a Princeton Patch reporter who produced a story on PPPL that appeared in Princeton Patch, <http://princeton.patch.com/articles/pppl-shows-progress-toward-perfect-energy-source>.

J. Greenwald wrote captions and worked with E. Starkman to select and deliver photos to the Princeton Alumni Weekly for an article on the NSTX Upgrade that PAW plans to publish in its July 10 issue. Poly bagged with the July 10 issue will be PPPL's "Quest" magazine, edited by J. Greenwald.

A New York Times reporter assisted by K. MacPherson produced a story headlined, "Agency's Crusade Against Leaks of a Potent Greenhouse Gas Yields Results." The story appeared in the A section of the Friday June 14 New York Times:

http://www.nytimes.com/2013/06/14/us/departments-crusade-against-leaks-of-a-potent-greenhouse-gas-yields-results.html?_r=0

E. Starkman took multiple photos of summer college students, of students from a South Korean high school on tour at PPPL, and other members of the staff.

BEST PRACTICES & EXTERNAL AFFAIRS (J. DELOOPER):

J. DeLooper participated in the Plainsboro Business Showcase, a program of the Princeton Regional Chamber of Commerce on June 12.

DIRECTOR'S OFFICE (C. AUSTIN):

On June 12, Dr. Francesco Romanelli, from the European Fusion Development Agreement (EFDA) – JET, presented a colloquium entitled, "The European Fusion Roadmap".

INVITED TALKS:

J. Menard (PPPL) gave an invited presentation entitled "NSTX Accomplishments and NSTX Upgrade Research Plans in Support of Fusion Next-Steps" at the Symposium on Fusion Engineering (SOFE) in San Francisco

PUBLICATIONS:

A paper by S.A. Lazerson and I.T. Chapman (CCFE), "STELLOPT modeling of the 3D diagnostic response in ITER," is set for publication in the journal Plasma Physics and Controlled Fusion. The paper reports modeling of ITER three-dimensional (3D) diagnostic response to an $n = 3$ resonant magnetic perturbation (RMP) using the stellarator analysis code STELLOPT. Forward modeling of flux loop and magnetic probe response with the DIAGNO code is used to estimate the diagnostic sensitivity to such perturbation. This work highlights an important application of stellarator knowledge and tools to tokamak problems.

The following PPPL reports were posted to the web:

Dependence of the L-H Transition on X-point Geometry and Divertor Recycling on NSTX
PPPL-4880

Authors: J.L. Battaglia et. al.

Submitted to: Nuclear Fusion (May 2013)

Generalized Courant-Snyder Theory for Charged Particle Dynamics in General Focusing
Lattices PPPL-4881

Authors: Hong Qin, Ronald C. Davidson, Moses Chung and Joshua W. Burby

Submitted to: Physical Review Letters (June 2013)

A Variational Multi-Symplectic PIC Algorithm with Smoothing Functions for the Vlasov-
Maxwell System PPPL-4882

Authors: J. Xiao, J. Liu, H. Qin and Z. Yu

Submitted to: Physics of Plasmas (June 2013)

First Observations of ELM Triggering by Injected Lithium Granules in EAST

Authors: D. Mansfield, et. al. PPPL-4883

Submitted to: Physics of Plasmas (June 2013)

Liquid Lithium Divertor Characteristics and Plasma-Material Interactions in NSTX High-
Performance Plasmas PPPL-4884

Authors: Michael A. Jaworski, et. al.

Submitted to: Nuclear Fusion (June 2013)

Systems Analysis Exploration of Operating Points for the Korean Demo Program PPPL-4885

Authors: C.E. Kessel, Keemin Kim, Jun Ho Yeom, T. Brown, P. Titus, G.H. Neilson

Presented at: Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Non-linear Modulation of Short Wavelength Compressional Alfvén Eigenmodes PPPL-4886

Authors: E. Fredrickson, et. al.

Submitted to: Physics of Plasmas (December 2012)

Reconfigurable Timing Unit for NSTX-U PPPL-4895

Authors: S. DeLuca, P. Sichta, G. Tchilinguirian

Submitted to: SOFE 2013 Proceedings (June 2013) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Identifying the Cause of the NSTX TF Coil Bundle Failure PPPL-4896

Authors: L. E. Dudek, J. H. Chrzanowski, P. Heitzenroeder, T. Meighan, S. Ramakrishnan and M. Williams

Submitted to: SOFE 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

A New High-Efficiency Stepper Motor Driver for Old Technology Stepper Motors PPPL-4897

Authors: N. Greenough and C.C. Kung

Submitted to: 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Digital Coil Protection System for the National Spherical Torus Experiment Upgrade

Authors: R.E. Hatcher, et. al. PPPL-4898

Submitted to: 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

A Magnet Current Monitor for Gyrotron Magnet Power Supplies PPPL-4899

Authors: N. Greenough and J. Lohr

Submitted to: 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Real-time Mirror Steering for Improved Closed Loop NTM Suppression by ECCD in DIII-D PPPL-4900

Authors: E. Kolemen, R. Ellis, R.J. La Haye, D.A. Humphreys, J. Lohr, S. Noraky, B.G. Penaflor, and A.S. Welander

Submitted to: 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

This report is also available on the following web site:

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