

PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights



The PPPL Highlights for the week ending December 19, 2014, are as follows:

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

The Procurement Package for the Physics and Engineering Design Support for ITER Motional Stark Effect (MSE) Diagnostic has been submitted to DOE for approval prior to releasing the Request for Proposals.

Several Project Change Requests were submitted to USITER reflecting revised planning of PPPL diagnostic effort consistent with recent awards of design support subcontracts.

NSTX (M. ONO):

NSTX-U is in the Upgrade Project outage in FY14. NSTX Upgrade construction activities continued this week and are highlighted in the Engineering section below.

The paper “Rotation and kinetic modifications of the tokamak ideal-wall pressure limit” by J. E. Menard (PPPL) et al., has been published in Physical Review Letters 113, 255002 (2014). In this paper, the impact of toroidal rotation, energetic ions, and drift-kinetic effects on the tokamak ideal wall mode stability limit is considered theoretically and compared to experiment for the first time. It is shown that high toroidal rotation can be an important destabilizing mechanism primarily through the angular velocity shear, non-Maxwellian fast-ions can also be destabilizing, and drift-kinetic damping can potentially offset these destabilization mechanisms. These results are obtained using the unique parameter regime accessible in the spherical torus NSTX of high toroidal rotation speed relative to the thermal and Alfvén speeds and high kinetic pressure relative to the magnetic pressure. Inclusion of rotation and kinetic effects significantly improves agreement between measured and predicted ideal stability characteristics and may provide new insight into tearing mode triggering. This work involved substantial collaboration with Dr. Yueqiang Liu from the Culham Centre for Fusion Energy and was also inspired in part by the Max-Planck/Princeton Center for Plasma Physics. The paper is available at: <https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.113.255002>.

M. Podestà (PPPL) submitted the FY15 Joint Research Target (JRT-15) First Quarter Report to the Office of Fusion Energy Science. The report summarizes recent analysis from the three facilities (C-Mod, DIII and NSTX-U) in support of the JRT goals of quantifying the impact of broadened pressure and current profiles on plasma stability and performance. In particular, the goal of the First Quarter was to begin analysis of previously collected data to define initial plans for new joint experiments and analysis in FY15. Following team discussions at the three

facilities, topics for collaborative research have been identified as (i) effects of on- vs. off-axis current drive from both Neutral Beams (DIII-D and NSTX-U) and LH waves (C-Mod), (ii) effects of broadened profiles on fast ion driven mode stability during NB-CD and, pending definition of the experimental schedule, (iii) sustainment of operations with peaked pressure profile. The JRT-15 coordination team is composed of M. Podestà and S. Gerhardt for NSTX-U, C. Holcomb and W. Solomon for DIII-D, and G. Wallace and S. Scott for C-Mod.

W. Guttenfelder (PPPL) visited General Atomics December 15-17 to participate in the DIII-D experiment "Physics studies of TEM with electron heating" led by Darin Ernst (MIT), an extension to a previous National Fusion Science Campaign experiment in 2013. To further probe the nature of trapped electron mode (TEM) behavior in the inner core of QH mode plasmas, ECH deposition was varied ($r/a=0.2-0.4$) to increase and alter the profile of electron temperature, which leads to a corresponding decrease in electron density gradient due to density gradient driven TEMs. ECH modulation was used to probe perturbative electron transport in the same region. DBS turbulence measurements at different wavenumbers appear to reproduce the presence of coherent fluctuations associated with the TEMs observed previously.

A continuation of the Lithium Granule ELM pacing experiment begun in November was performed on December 17 at DIII-D. The experiment was led by members of the NSTX-U team (A. Bortolon, R. Maingi, D. Mansfield, A. Nagy, L. Roquemore, R. Lunsford) and supported by on site contributions from the DIII-D staff from GA, ORNL, and LLNL. Granules (0.7 mm and 0.9 mm sizes) were injected at controlled velocities ranging from 50-100 m/s and were found to increase the natural ELM frequency of the discharge from 20-25 Hz to 50-100 Hz. The increased ELM frequency led to an observed clamping of the high Z impurity content and a reduction of the peak ELM heat flux. An expected concomitant reduction in the global energy confinement was also observed with increasing ELM frequency. The experiment further compared the ELMs generated with D2 pellets with those created by the 0.7mm and 0.9mm Lithium granules. These experiments were run under the ITPA Pedestal and Edge Physics Joint Experiment #30, to which NSTX-U will contribute with its own granule injector when operations commence in 2015.

J.-W. Ahn (ORNL) visited GA for December 15-17 and led, along with A.R. Briesemeister (ORNL) and O. Schmitz (University of Wisconsin), an experiment for the effect of 3D fields on divertor footprints and divertor plasma characteristics. The dimensional fields with both $n=3$ even and odd parities were applied to three plasma shapes (high, medium, and low triangularity) in medium powered H-mode plasmas. 2D Te and ne plots from divertor Thomson scattering showed lobe structures induced by 3D fields for the first time in DIII-D. It was confirmed that high triangularity shape produced plasma response for stronger strike point splitting, which is consistent with theoretical interpretation in terms of plasma response. The impact of 3D fields on upstream and downstream relation is also to be investigated.

On December 15-17, W. W. Heidbrink of UC Irvine visited NSTX-U for discussions with PPPL personnel and onsite UC Irvine collaborators. He also gave a PPPL experimental seminar entitled "Fast-ion transport by many small amplitude Alfvén eigenmodes".

All 12 of the high harmonic fast wave (HHFW) mid-plane resonant loops, connecting the upper and lower feed-through of each current strap, have been installed. Initial measurements of resonant frequency indicate a small shift for each loop, due to the new center conductor

geometry inside the feed-throughs. Tuning of the loops will take place in January 2015.

The UC Irvine group has successfully installed a new compact and multi-channel Solid State Neutral Particle Analyzer (SSNPA) system on NSTX-U, which will be one of the key diagnostics for the energy particle physics study on NSTX-U. The SSNPA diagnostic includes three subsystems at Bay I, Bay L and Bay B, and each subsystem has 15 radial sightlines. The new SSNPA system will provide fast-ion distribution measurements with fast temporal resolution (~120 kHz bandwidth) and coarse energy information in three bands of > 25 keV, > 45 keV, and > 65 keV. The subsystems at Bay I and Bay L aim at separating the response of passing and trapped fast ions. The subsystem at Bay B is used to monitor passive signals produced by fast ions that charge exchange with background neutrals.

The Digital Coil Protection System (DCPS) and the Power Supply Real Time Control (PSRTC) development efforts are working towards the start of Field Coil Power Conversion System dummy load testing. DCPS pre-operational testing and burn-in continues, now in its final configuration with the Plasma Control System's Concurrent Inc. computer and data streams. The operation procedure to exercise, set, and verify fault protection algorithms has been completed and is in final sign-off. PSRTC software testing also continues, and procedures for I/O testing, and to simulate and verify the real-time outputs against recorded shots are being exercised.

Preparations for plasma operations in the NSTX-U configuration also continued. Open circuit testing of the Field Coil Power Conversion System rectifiers is in progress, and systems are being configured for dummy load testing. Run-ups and testing of the D-MG#1 are in progress. Testing of the neutral beam (NB) power systems also continued, and the three NB2 modulator regulators have been conditioned to operating levels needed to complete the NB CD-4 milestone. The SF6 piping for NB2 has been completed. NB Helium refrigerator operations continues around the clock. The process gas has been purified, and the refrigerator has begun to make liquid. The cabinet for the new deuterated trimethylboron (dTMB) injection system has been installed in the test cell, and power, fire protection systems and co-axial vacuum lines are being installed. New brackets for Lithium Evaporators (Liters) are being completed in the shops and should be ready to install next week. Installation of the Multi-Pulse Thompson Scattering (MPTS) diagnostic flight tubes is in progress.

Access to the NSTX test cell will be available only through previous arrangement with the Upgrade Work Control Center.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

A notable outcome for PPPL was accomplished with the completion of lithium granule injection experiments this calendar year. Lithium granules of 0.7 and 0.9 mm were injected into plasmas with a natural ELM frequency of 20-25 Hz. The ELM frequency was increased up to 100 Hz and the high-Z impurity content was clamped or reduced. Peak ELM heat flux decreased with increasing ELM frequency.

Significant improvements to Microwave Imaging Reflectometry (MIR) on DIII-D have been made. G. Kramer visited DIII-D last week to assist in the re-characterization of the MiR and improve the optical alignment. Signal to noise has been improved more than an order of magnitude, and degenerate signals have been identified and corrected. New analysis methods for the extraction of reflectometer phase have also been implemented, resulting in better identification and tracking of signals.

C-Mod (S. Scott):

This week, the control system for the MSE background polychrometer, which controls the 40 filter ovens and 40 Avalanche photodiodes (APDs) was successfully integrated with the ovens & APDs themselves. All units were successfully tested in local mode, i.e. manually defining values for oven temperature and APD gain from switches on the control system. We continue our search for a vendor to pot the ten MSE optical fiber bundles (16 fibers each) into ferrules manufactured by the PSFC machine shop, work that must be done on-site.

THEORY (A. BHATTACHARJEE):

I. Y. Dodin presented a Research and Review Seminar titled "Variational Methods in Modeling Plasma Waves: Basic Physics and Applications". The presentation described how basic physics of plasma waves is simplified through the application of a variational field-theoretical approach. Wave Lagrangians can be deduced from first principles and reveal one-to-one quantitative correspondence between (nondissipative) classical waves and quantum particles. For example, photons and plasmons can be assigned linear polarizabilities and experience ponderomotive forces much like electrons and ions. The classical wave action emerges as the density operator, and the corresponding equations have a Hamiltonian form. Unlike Maxwell's equations, they conserve the wave total action (i.e., the trace of the density matrix) manifestly, even for noneikonal and certain nonlinear waves. These properties render the variational theory particularly promising as a means for improving the robustness of modeling waves numerically, e.g., through the application of symplectic integrators, which is a future work. The presentation outlined selected aspects of the general theory and also its analytical applications to linear and nonlinear waves such as those found in fusion plasmas. Specific examples included adiabatic dynamics and instabilities of waves with autoresonantly trapped particles, RF-driven plasma rotation, and photon Landau damping.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

S. Ethier visited the Institute for Plasma Research (IPR) in India as part of an on-going collaboration with Professor R. Ganesh. Ethier installed the GTS code on the local cluster at IPR along with all the required libraries. Professor Ganesh and his students will use GTS for turbulence studies in collaboration with PPPL physicist Weixing Wang. Ethier also gave a talk entitled Global Gyrokinetic Simulations of Intrinsic Torque Reversal with the GTS Particle-in-Cell Code.

S. Ethier attended the IEEE HiPC Conference on High Performance Computing in Goa, India, where he gave an invited presentation at the Indo-U.S. Workshop on Virtual Institutes for

Computational and Data-Enabled Science & Engineering. The presentation, entitled MONA: Performance Monitoring and Analysis for Exascale Data Management Workflows, described a new ASCR-funded project led by Professor Karsten Schwan of the Georgia Institute of Technology and which Ethier is part of.

S. Jardin attended the Integrated Modeling Expert Group Meeting at ITER HQ as one of the two U.S. representatives. Each of the 7 ITER parties gave a presentation on their domestic IM activities, and the ITER IM team gave presentations on its progress since last year in developing an Integrated Modeling and Analysis Suite (IMAS) at ITER. At the party's request, the ITER team has agreed to develop a plan to support the installation of IMAS on members local computer clusters.

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

This week, the PS&T Department seminar was presented by Evgeniya H. Lock from the Plasma Physics Division, Naval Research Laboratory. The title of her talk was "Electron beam-generated plasmas characterization and applications." The abstract is "Electron beam generated plasmas have been successfully used in a wide range of materials processing applications including etching, thin film deposition and surface functionalization. Compared to conventional discharges, these plasma sources have a number of unique characteristics but, perhaps the most unique is the ability to generate high plasma densities and their inherently low electron temperatures ($> 1\text{eV}$). Thus, the source is capable of delivering a flux of very low energy ($> 5\text{eV}$) ions. This makes these sources ideally suited for next-generation applications that require atomically smooth and/or thin materials such as polymers and graphene. The first part of my talk will focus on our recent efforts to characterize the production of charged and excited species in electron beam generated plasmas, whereas the second part will discuss briefly the surface modification of polymers and their applications as platforms for biomolecule immobilization and as flexible electronics devices."

P. Efthimion, H. Ji, I. Kaganovich, K. Hill, and W. Fox traveled to Sandia National Laboratory from December 10-12, to discuss PPPL and SNL collaboration on diagnostics and theory relevant to the Z facility and the MagLIF fusion concept. Fox presented a talk, "Experiments and theory on the dynamics of magnetic fields in high-energy-density plasmas" and Hill presented a talk, "Spatially resolved high resolution x-ray spectroscopic techniques for diagnosis of high energy density plasmas."

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: All PF1 bus, except PF1B upper, have been completed inside the umbrellas. TF bus inside the umbrellas is being trial fit. All primary vacuum seals have been installed on the vacuum vessel. The Massive Gas Injector piping and TIV have been completed inside the umbrellas. The halo shim blocks have been installed. The oil in the mechanical vacuum pumps has been changed. All Rowgowskis and diagnostic cables have been run to outside the

umbrellas. Hose installation and MPTS input side flight tube supports are being installed. Installation of the gas delivery piping continues.

CS Upgrade: The PF buswork continues to be fit up on the machine in the NTC. All but one section of bus has been completed. The OH Water heater procurement was placed with Wattco with a promised delivery date by the end of January. Assembly and installation of the TF Flex Connectors and Lead extensions began this week. The first set of fit up issues have been identified and workarounds developed. Modifications to the lead extensions will be required in some areas to get the proper fit up.

NBI Upgrade: Services work was completed on BL2 source SF6 delivery line installation. Also, associated platform work between BL1 and BL2 continued with great progress. NBI DI water system maintenance and repair is being evaluated for the piping on the MER mezzanine where pinhole leaks have been identified. Power testing of M/Rs took place in preparation for NB PTPs. The LCC 4B wiring problems continue to be sorted out and resolved. Controls work continues with installation of cable, trays, and terminations in NTC and gallery. Work continues on the N gallery shield wall procurement with award imminent. Progress continues on BL PLC software pages, which are now complete for initial operations. The vacuum pump controls were tested and problems identified. Troubleshooting and corrections are underway to allow pumpdown of VV and BLs. Cryogenics system Helium gas cleanup continues on the entire system. Development of NB procedures continues and nears completion.

Digital Coil Protection System: Operations procedure development for setup and startup of DCPS continues in preparation for rectifier dummy load testing. The SDD reliability assessment draft is out for review. Work continues on the DCPS buffer chassis implementation. DCPS integration into the PCS environment continues as part of RTC and PCS development. The concurrent computer is now working. Development of new PTPs and the ISTEP-NSTX-001 with DCPS content and methodology continues. PTP-DCPS-001 will be run again due to some changes at the set up shell and processor assignment level but the core code remains the same. As part of responses to ROR recommendations, burn-in times for all of the testing performed thus far has been estimated and documented in the PTP run copies for each phase of testing. Consideration of parameter tree development is in progress.

Project Management Office (T. Stevenson):

Rollout of WP 7.1.1 took place with no issues. ENG procedure development and revision continues and several TCRs were completed. Development and preparation of the annual COG/RLM training continues with gathering of new requirements. The WP online system evaluation of problems reported by users continues. PMO response to ROR action items continues. Some of these action items will also be included in the next COG/RLM training package. The Project Status Review Board meeting was held with 18 jobs reporting. Two I&T jobs were successfully completed and will be closed.

Facilities and Site Services (M. Viola):

Engineering Services: Annual inspections are being performed on the seven (7) elevators on site. Inspection firm (USA Hoist) and Witness firm (J. Martin) are with T. Ward. Inspections will be completed December 18-19. A ceiling was repaired in the cafeteria kitchen on December

14. Design of NANO Laboratory II has commenced. Procurement of long lead items has also commenced. Plans are to complete installation in cleared out experimental bay on the first Floor RF Building adjacent to the Hal Thruster Experiment (HTX) bay by the end of March 2015. The installation of the NSTX-U Shield wall was awarded to Baker Construction. A meeting and site walk through took place with M. Kalish and E. Perry to discuss preliminary design of a platform required for the FLARE project. A layout of the platform is currently being put together.

Fire Protection: An evaluation was performed on the Annex basement meeting room to address assembly occupancy issues. The holidays were added to the ACAMX schedule. The Fire Protection Engineer assisted the electricians with a repair of the incoming barrier.

Telecommunications: The Telecommunications Officer and J. Hirsch from Cyber Security are investigating a series of outside non-business calls to Laboratory phones. The calls display a caller id number of 000-000-0000. When the call is answered, the caller confirms the person's name and hangs up. Telemarketing companies have been known to use this technique to compile and verify a database of businesses and phone numbers. The Telecommunications Office has blocked this number from the Laboratory's phone system, and is consulting with Avaya engineers to ensure the system is not experiencing a form of fraud. The Telecommunications Officer received a quote from Altura Communications for an Avaya Voice over Internet Protocol (VoIP) server system for voice communications. The Telecommunications Office and Facilities are in the process of distributing and affixing new Emergency 3333 stickers on all Laboratory phones. In addition to the Emergency 3333 number, the new stickers include the non-emergency 2536 number, and space to write the building and room locations. The Telecommunications Officer is arranging with Motorola to test their Point-to-Point RF technology as a wireless data communications solution to control and monitor pump equipment and alarms at the Canal Pump House. The goal is to have reliable communications and eliminate the current monthly fee for Verizon data circuits.

Material Services: Material Services performed a Property Pass assessment on December 17, which included 10% of the Laboratory. The results of PPPL employee awareness of the Property Pass System is 96% of the individuals surveyed. The survey also found that only 86% are aware of its location on the PPPL and Material Services Home Pages. During this survey, Property Management found areas and processes that could potentially be improved and will conduct further review for implementation. One improvement was already initiated by supplying IT department with stickers to place on loaner laptops. The stickers will remind individuals that a Property Pass is necessary prior to taking the laptops off-site. Material Services ensured all fuels were topped off at PPPL fuel service station for holiday break to accommodate ESU and other working personnel. FY15 LUO approvals were received this week from PSO with no changes to Fleet proposed mileage. Material Services met with Best Practices on December 16 and determined the proper KPI's to release for dashboard. The warehouse is presently receiving and logging in all boxes received for January shredding event. A notice was sent out to all P&C Officers with a spreadsheet to simplify the notification process to Property Administration, concerning fabrications with a value not exceeding \$500,000. Stockroom personnel will be meeting with Air Gas immediately following the holiday break to discuss future cylinder delivery requests and will discuss PPPL's additional needs for certain gases, so they are prepared to accommodate PPPL's needs.

Maintenance Services: Maintenance staff have continued with several offices moves and renovations in the LSB to accommodate personnel relocations and additions. They have also spent much of the week relocating materials from the RF Building to the CS Basement in preparation Nano Laboratory relocation. Maintenance Staff have completed December Monthly and Annual Fire and Life Safety PMs. Work continues on the annual calibration and surveillance activities of the D-Site Experimental HVAC Systems. Annual elevator inspections have been completed. Additionally, the project to restore the CS Elevator continues to move forward. The requisition has been submitted to Procurement and we anticipate working with Procurement in early 2015 to identify a contractor to complete the upgrade.

BUSINESS OPERATIONS (K. FISCHER):

Procurement participated in a User Orientation for “Visual Compliance” – a search tool that will enhance Procurement’s due-diligence of suppliers by giving us on-line access to many data bases and lists containing suppliers with legal or regulatory issues that may increase PPPL’s risks when doing business with those suppliers. Should risks be identified, Procurement will work with appropriate functions to mitigate those risks.

U. Patel attended an off-site seminar entitled “Managing Multiple Priorities”.

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

A management safety walkthrough of the C-Site CS, COB and Shop Building 2nd Floor and CS High Bay Area was held on December 18.

Engine 66 responded to Princeton for one mutual aid assignment. Ambulance 166 responded to Plainsboro for one mutual aid assignment.

As a part of PPPL's security enhancements, SPD, Facilities and Area Managers completed the installation of Property Protection Area signage in designated areas to comply with the DOE Safeguards and Security recommendations.

A meeting of the Emergency Management Review Committee was conducted during which the 2014 Emergency Exercise, ICS/ERO organizational changes, the need to establish an EOC design team, and policy updates were discussed.

SPD safety discussions are continuing with the next topic being Firefighter Emergency Distress Notification Procedures.

The 2015 Site Security Plan and Continuity of Operations Plans have been drafted and submitted to the DOE.

Several pending Action Items concerning the No Notice Exercise (NNX) conducted last year by the NNSA, and the Emergency Management Support visit were completed and closed in the Q/A system.

A PAAA Screening and ORPS review were conducted on the LOTO audit, and the matter is being referred to the PAAA Review Committee for further discussion. The results were not found to be ORPS reportable.

The probationary ESO passed the physical agility test.

A member of SPD attended the Port Plug Test Facility (PPTF) presentation with personnel who oversee export control issues.

OFFICE OF COMMUNICATIONS (K. MACPHERSON):

E. Starkman produced PPPL's first ever e-video holiday card for distribution. She credits many at PPPL for making the card possible.

J.J. DeVoe & G. Czechowicz, with help from J. Greenwald and E. Starkman, prepared the December 22 Weekly with a profile of W. Myers and a story about the newly named Ronald E. Hatcher Science on Saturday, and a photo page of holiday doors in Procurement and Accounting by J.J. DeVoe, and a still from PPPL's holiday video card with a link to the card.

J. Greenwald issued a news release about the patent for an egg-pasteurization process that PPPL and USDA engineers have developed and organized a teleconference with the engineers and a freelance reporter interested in the project. Greenwald also posted his profile of H. Qin on Newswise, a science-news site.

Tours: A. Dominguez led an open public tour for 18 people on December 19. The group viewed the "Star Power" and PhD Comics video, and visited the NSTX Control Room & QUASAR and viewed plasma demonstrations in the Science Education Laboratory. J.J. DeVoe hosted.

DIRECTOR'S OFFICE (C. AUSTIN):

M. Zarnstorff visited MIT on December 19 and gave a PFSC seminar titled "Advances and Opportunities with Stellarators".

On December 15-16, S. Prager attended a retreat of DOE national laboratory directors in Denver, Colorado.

December 16-17, M. Zarnstorff and R. Davidson attended the annual Fusion Power Associates meeting and symposium, in Washington DC. The topic of the meeting was: "Fusion Energy: Recent Progress and The Road Ahead".

R. Davidson received the 2014 Distinguished Career Awards from Fusion Power Associates at an awards ceremony.

On December 17, Dr. Jeffrey Parrell, Oxford Superconducting Technology, presented a colloquium entitled, "Challenges of LTS and HTS Wire/Tape R&D and Manufacturing".

On December 18, Dr. Michel Laberge, General Fusion, presented a colloquium entitled, "Magnetized Target Fusion Work at General Fusion".

INVITED TALKS:

Ethier, S., "MONA: Performance Monitoring and Analysis for Exascale Data Management Workflows," IEEE HiPC Conference on High Performance Computing in Goa, India

PUBLICATIONS:

Menard, J.E.; Wang, Z.; Liu, Y.; Bell, R.E.; Kaye, S.M.; Park, J.-K.; and Tritz, K., "Rotation And Kinetic Modifications Of The Tokamak Ideal-Wall Pressure Limit," Physical Review Letters 113, 255002 (2014)

This report is also available on the following web site:

<https://sites.google.com/a/pppl.gov/pppl-weekly-highlights/>