

PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights



The PPPL Highlights for the week ending March 14, 2014, are as follows:

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

For several of the subcontract awards placed last year for ITER Steady State Electric Network components, Release for Manufacture submittals are currently being finalized or under review.

The SSEN and Diagnostics WBS manager presented uncertainty risks and event risks at a Risk Workshop held at the USIPO on March 11-12. Subject matter experts and risk experts scrutinized the major risk elements and provided feedback, to be used by the PPPL teams to refine their risk inputs.

Proposals are under evaluation for RFP 13-025C Design, Fabrication and Optical Evaluation of Copper Prototype Front-Surface Retroreflector for ITER TIP Diagnostic.

Dates were selected for the L12 Diagnostic RGA Sampling Pipe Readiness Review and Final Design Review, and a preliminary agenda was created. The Readiness Review will be March 31, and the FDR will be May 6-7.

NSTX (M. ONO):

On March 10, S. Kaye (PPPL) participated in a workshop on Peer Review of Data, which was held at the American Astronomical Society office in Washington D.C. The meeting was attended primarily by editorial board members from astronomical and astrophysical journals, as well as some from AIP, including R. Davidson. The meeting was held to discuss different aspects of a data peer review process, including which data should be shared publicly, what is meant by a data peer review and what should the expectations be for the reviewer, framework for data storage and access, etc. The astronomy and astrophysics communities are in a similar state as that of fusion energy, that is, waiting for specific guidance and expectations from their respective funding agencies. However, unlike fusion energy, the A&A communities have been, for some time now, voluntarily submitting data to large repositories for public access. It is believed that about 50% of the scientists are submitting their research data, and there is a very circumspect review of these data sets by independent reviewers before the data are publicly shared. It is the case, however, that the data coming from the A&A communities (star maps, asteroid imaging, etc) are starkly different than those from fusion, and the same level of review and comprehensiveness of datasets should not be required for the fusion community. In many cases in the A&A communities, the comprehensive dataset itself is the research deliverable, and the concept of private, PI-owned data is obsolete. However, it is also the case in these communities

that the researchers generally do not deposit their datasets into a public repository until at least some research papers are published by the measurement team. Finding out about the types of data coming from fusion experiments and theory was a learning experience for most of the A&A members on the discussion panel, and they recognized that our framework for data sharing will necessarily be different from theirs.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

The Perturbed Equilibrium Nonambipolar Transport (PENT) code has been developed in order to accurately model the toroidal NTV torque using the plasma response predicted with the IPEC code. PENT+IPEC has been used to provide accurate predictions of NTV. The NTV is found to depend strongly on the component of the applied 3D field that couples to the least stable kink response of the plasma. Further analysis shows that even the torque induced by non-resonant fields is strongly determined by the component that couples to the dominant kink response of the plasma. Extensive IPEC-PENT modeling is being used to support the 2014 JRT, including TBM experimental planning. A goal of these experiments is to apply optimal error field correction to the TBM field to minimize NTV torque. The effort will focus on applying $n=1$ and $n=2$ error field corrections that minimize the coupling to the kink mode. Analysis also shows a strong dependence of the NTV torque on collisionality and beta, to be tested in the 2014 experiments.

Progress is being made on the new mirror control system that will allow each EC launcher mirror to be independently controlled for simultaneous stability and current profile control. All of the new faster motors and motor control boards have been installed. Also, two of the new encoders in one launcher have been installed. The one fully installed system of motors and encoders is currently being tested. The new PCS computer and the rest of the encoders are scheduled to be installed before experimental operations.

This week Nevell Greenough visited DIII-D to perform tests on a power supply that is used to run the internal I-coils. The tests were directed at reproducing a trip mode of the power supply at low voltage. Internal power supply diagnostics were installed and tests performed. It was found that a feedback integrator delay of 30-50 ms was perhaps too long and associated with the trip mode. The delay was shortened to ~ 10 ms by making a change to a capacitor in the feedback network. Preliminary assessment is that the change resolved the issue of the low voltage trip of the power supply.

C-Mod:

D. Mikkelsen visited MIT to participate in Ideas Forum follow-up meetings on the Transport and Pedestal/Boundary topical areas, and to discuss several I-mode and L-mode experiments in C-Mod. PPPL researchers will use measurements from these plasmas as inputs for the XGC1, GTS, and GYRO codes, and simulate turbulence that will be compared with fluctuation measurements.

Y. Ren visited C-Mod on March 13 to attend the Turbulence/Transport follow-up meeting. He has proposed an experimental idea titled "Transport and Turbulence Responding to RF Cessation in L-mode Plasmas" in the C-Mod 2014 Ideas Forum. The experimental ideas were motivated

by experimental observations from both NSTX and LHD. Particularly, in NSTX, we observed a clear correlation between RF cessation and a drop in high-k spectral power in 300 kA NSTX RF-heated L-mode plasmas. The drop in the spectral power happens approximately 1-2 ms after the RF cessation and takes about 0.5-1 ms with no obvious change in equilibrium profiles. The idea for C-Mod is to explore turbulence response to RF modulation with PCI, CECE and reflectometer measurements in C-Mod RF-heated L-mode plasmas. Discussions with Professor White and Dr. Lin were fruitful and determined that there is no technical difficulty in carrying out the experimental ideas. Feedback from the follow-up meeting is to carry out data scoping studies with existing shots, and this will be done with the help of Professor White and Dr. Mikkelsen.

ADVANCED PROJECTS (H. NEILSON):

Professors R. Goldston and A. Glaser hosted a "Red Team Review" for their Zero-Knowledge Warhead Verification project, funded by the U.S. State Department. The review team was composed of individuals with broad and direct experience in arms control: David Chambers (UK AWE), Steve Fetter (U. Maryland), Richard Garwin (IBM Watson Research Center), Raymond Jeanloz (UC Berkeley), Duncan MacArthur (LANL), John Mihalczo (ORNL), and Richard Wallace (LANL). The team expressed enthusiasm for the Zero-Knowledge concept developed by Goldston, Glaser and Boaz Barak of Microsoft Research, and suggested key next steps, ranging from methods to reduce background signal levels during active interrogation of test objects, to encouragement to prepare a formal "Conduct of Operations" for the Zero-Knowledge concept.

W7X XICS

In the Laboratory's collaboration with the Wendelstein 7-X project at Germany's Max Planck Institute for Plasma Physics (IPP), a support concept for the U.S. x-ray imaging crystal spectrometer (XICS) was established. An attachment point will be welded by IPP to the so-called "dome" of the port where the XICS will be located. PPPL will provide the main structure, which will be bolted to the attachment to support the diagnostic. A pair of struts will be added to complete the support. An option in which the structure would be delivered on an accelerated schedule in order to be installed this year is under consideration.

THEORY (A. BHATTACHARJEE):

The theory seminar on March 13 was presented by Professor Gennady Shvets from the University of Texas at Austin, entitled "Multi-Dimensional Collective Instabilities of Laser and Particle Beams Relevant to High Energy Density Laboratory Plasma Science". The abstract of the talk is "I will discuss how two of the oldest-known plasma instabilities, the Weibel Instability and the Raleigh-Taylor Instability, manifest themselves in the context of high energy density relativistic plasmas. The RTI will be described in the context of laser acceleration of thin targets by ultra-intense laser pulses. This acceleration regime, known as Radiative Pressure Acceleration (RPA) is very promising for developing compact sources of high-energy monoenergetic ions that could potentially find numerous applications ranging from fast ignition to cancer treatment. The first analytic model of a uniformly laser-accelerated target and discuss the stability of such targets to RTI will be discussed. PIC simulations reveal that considerable deviations of the

growth rate of the RTI from the conventional scaling can emerge for ultra-high laser intensities. Paths to suppressing RTI using multi-ion species targets will be discussed. The Weibel Instability, which occurs when a beam-like plasma propagates through stationary plasma, has been proposed as a candidate for generation of strong magnetic fields and for sustaining collisionless shocks in astronomical environments. It will be demonstrated that there are severe constraints limiting the amount of directed beam energy that can be converted into magnetic field. Analytic results for relativistic beams undergoing filamentation and collisionless thermalization in dense plasma will be presented. A new type of a self-focused beam equilibrium similar to Bennett Pinch will be discussed. Because transverse temperature of the beam can suppress WI entirely, it will be discussed how quasi-electrostatic waves generated by the beam can recover the WI despite high temperature of the beam. The results of modeling WI using reduced-description codes will be presented."

On March 11, D. Stotler, W. Davis and G. Tchilinguirian ran the Robo-Cross competition at the New Jersey Science Olympiad State Tournament. Each of the 24 middle school teams participating in Robo-Cross designed and built a robot capable of moving various objects across a playing field and then placing them in a "goal" box.

A. Hakim gave a talk at the Courant Institute at NYU on "Discontinuous Galerkin schemes for a class of Hamiltonian evolution equations with applications to plasma kinetic problems" (<http://math.nyu.edu/webapps/content/mfdd/seminars>) describing work performed in collaboration with G. Hammett and graduate student Eric Shi, to develop a new approach for the difficult problem of simulating edge turbulence. While there he had discussions with Harold Weitzner, Antoine Cerfon, and others, on these and other algorithmic topics.

W. Fox attended the Center for Magnetic Self-Organization Annual Meeting in Santa Fe, New Mexico, and presented an invited talk on recent results from laboratory astrophysics experiments, titled "Astrophysical Weibel instability in counter-streaming laser-produced plasmas."

A paper titled "On the nature of kinetic electrostatic electron nonlinear (KEEN) waves", by I. Y. Dodin and N. J. Fisch, appeared in *Physical Plasmas* 21, 034501 (2014). The paper reports an analytical theory for the so-called kinetic electrostatic electron nonlinear (KEEN) waves that were originally found in simulations by Afeyan et al [arXiv:1210.8105]. It is suggested that KEEN waves represent saturated states of the negative mass instability (NMI) reported recently by Dodin et al [Phys. Rev. Lett. 110, 215006 (2013)]. Due to the NMI, trapped electrons form macroparticles that produce field oscillations at harmonics of the bounce frequency. At large enough amplitude, these harmonics can phase-lock to the main wave and form stable nonlinear dissipationless structures that are nonstationary but otherwise similar to Bernstein-Greene-Kruskal modes. The theory explains why the formation of KEEN modes is sensitive to the excitation scenario and yields estimates that agree with the numerical results of Afeyan et al. It is also predicted that a new type of KEEN wave may be possible at even larger amplitudes of the driving field than those used in simulations so far.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: Installation of diagnostics continued this week as did the check-out and repair of magnetic sensors. The PF4/5 supports have been completed. The tFIDA window and shutter have been installed. Electricians worked on studs and clamps for the category 3 cables inside the umbrellas, trouble shooting cabling, and installation of the gas injection tank farm in the gallery. Work on the centerstack casing tubing has been re-started. Tooling is being fabricated for opening the laser port hole at bays FG. The vacuum preparation laboratory is preparing TIVs, windows and shutters for installation.

CS Upgrade: The OH layer 2 to 3 locking braze was successfully completed, cleaned and insulated. The only items remaining to complete the transition are the two cooling fitting brazes and one layer to layer braze scheduled for completion on March 15. The PF1B upper coil was successfully megger tested. Both PF1B coils were sent out to be radiographed to see the conductor positions relative to the casing and G10 shims. Radiographs show the defect that was corrected in the PF1B Upper does not exist in the lower coil. A final design review was held on the CS & Coil cooling water system mods for the upgrade. The Outer TF lead finger supports RFQ was sent out for quotations. Bids are scheduled to be in by the week of March 17.

NBI Upgrade: The initial Bay H port cover installation was completed; spool sections for small ports on the cover are in progress to accommodate water lines. BL2 DI water manifold installation continued; the four-inch lines were completed. Piping for HVE water lines was received. Water pump pads in the Pump Room were completed and the pumps were positioned. Pipe connections to the pumps have started. Mod/Reg controls work and preparation continues. Bending magnet cabling on BL2 is in progress. NBPS water skid maintenance is in progress but waiting on maintenance to finish. VV RWM coil fit-up continues for the Bay JK area; a pause will ensue to allow analysis to determine if extra RWM coil mounts are needed. The NBI/TVPS duct installation is in progress. Modifications to the supports were required to bolt to the floor. Lifts begin this week and require multiple steps. The supports have been lifted into place for trial fit-up. NB Controls tray work continued in the NTC.

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

Members of the DOE Integrated Support Centers (ISC) in Oak Ridge and Chicago visited the Laboratory between March 10 and March 13 to review PPPL's Emergency Management Program. The team members assisted in identifying ways that the PPPL Emergency Management Program could be enhanced and improved as well as identifying areas that PPPL surpassed assessment requirements. DOE Order 151.1C outlines emergency management program requirements for DOE sites.

BEST PRACTICES & EXTERNAL AFFAIRS (J. DELOOPER):

More than 385 individuals attended the last Science on Saturday program for the year. Professor Margaret Livingstone from Harvard presented, "What Art Can Tell Us About the Brain."

PUBLICATIONS:

Dodin, I.Y.; and Fisch, N.J., "On the nature of kinetic electrostatic electron nonlinear (KEEN) waves," *Physical Plasmas* 21, 034501 (2014).

The following PPPL Report was posted to the web:

A Zero Knowledge Protocol For Nuclear Warhead Verification PPPL-5009

Authors: Alexander Glaser, Boaz Barak and Robert J. Goldston

Submitted to: *Nature* (March 2014)

This report is also available on the following web site:

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