PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights

PPPL

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending November 21, 2014, are as follows:

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

One ITER HV Substation Transformer is in shipment to France, and a second has passed Factory Acceptance Tests at Hyundai and is awaiting completion of Release for Shipment documentation.

Responses were received on two "Expressions of Interest" calls for ITER diagnostic design support, one for the Upper Camera Sensors and Software and one for the Motional Stark Effect (MSE) Diagnostic. The Statement of Work for the MSE design support was signed off, as part of the Request for Proposal package to be submitted soon to the DOE Princeton Site Office for approval.

UCLA has assembled nearly 40 meters of corrugated waveguide with 10 miter bends designed and fabricated by ORNL, in order to measure, in a reasonable mock-up of the ITER transmission line, the losses in the low frequency range of this system. Such losses may have to be offset by increased microwave source power in this range.

Several alternatives to the baseline upper camera optical design are being compared by the design team at TNO. This team will make a presentation of the pros and cons at a meeting planned for early December. Among the concepts is an all-reflective system with an off-axis relay.

NSTX (M. ONO):

The paper "Dependence of recycling and edge profiles on lithium evaporation in high triangularity, high performance NSTX H-mode discharges" by R. Maingi (PPPL) et. al. was published in the Journal of Nuclear Materials. The paper is available at http://dx.doi.org/10.1016/j.jnucmat.2014.10.084. Performance of high triangularity, high elongation discharges was compared with medium triangularity, low elongation plasmas as a function of pre-discharge lithium evaporation. Overall the trends in recycling reduction, ELM elimination, and performance enhancement were very similar between these discharges, while the absolute stored energy/temperature were higher in the highly shaped discharges, owing to higher Ip and acceptable NBI heating before reaching the global stability limits. These results are favorable for the highly shaped discharges planned in NSTX-U.

J.-W. Ahn (ORNL) visited KSTAR for November 1-11 and performed experiment for the interaction of RMP fields and divertor detachment. Record long ELM suppression (~6 sec) was successfully achieved with mid-plane n=2 configuration. It was found that different plasma shape was necessary to reproduce ELM suppression, depending on the wall condition. Initial attempt of divertor gas puff to produce detachment during the ELM suppression period revealed that confinement degradation was weaker or delayed in the presence of RMP fields compared to the gas puff only reference shot.

On November 7, the neutron diagnostic system on NSTX-U was calibrated, in preparation for the forthcoming experimental campaign. The calibration was performed with a neutron source mounted on a model train car and run on a set of circular tracks inside the NSTX-U vacuum chamber. Dr. Kunihiro Ogawa from the LHD group (NIFS, Japan) observed the calibration, in anticipation of a similar calibration that is to be done on LHD a few months from now.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

The Lithium Granule Injector was commissioned in L-mode and H-mode plasmas in DIII-D. Lithium granules were injected into three discharges, two with 0.7 mm granules and one with 0.5 mm granules. There was clear evidence of the granules penetrating the edge plasma, and substantial Lithium was deposited in the plasma core. Magnetic perturbations with signatures similar to small ELMs were measured for both granule sizes, indicating that small ELMs were destabilized.

An experiment was run this week on DIII-D to investigate the correlation between the core and edge plasma rotation using the new edge main-ion CER diagnostic and plunging mach probes. T. Stoltzfus-Dueck visited DIII-D from Princeton to participate in the experiment and provide theory support for the investigation. All discharges were executed with balanced neutral beam torque imparting minimal momentum to the plasma in order to measure the “intrinsic” rotation in the core and correlate with the intrinsic edge rotation. ECH heating power, density and plasma current scans produces clear changes in the core toroidal velocity including velocity profile peaking and hollowing, as well as reversal of the central rotation velocity.

C-Mod (S. Scott):

Assembly of all ten polychrometers as well as relay alignment and detector alignment for the MSE background polychrometer is complete and no issues were uncovered during assembly or alignment. Assembly of the rack, which will house the ten polychrometers is complete, and integration of the polychorometers into the rack will be completed by November 24. Assembly of the control box for filter ovens and detector power supplies is about 60% complete. Assembly of the 50 filter ovens will commence on November 24. Shakedown and testing of the integrated control system, ovens, and detectors will start the week of November 24.

ADVANCED PROJECTS (D. GATES):

C. Kessel attended the ANS Technology of Fusion Energy meeting in Anaheim California, presenting The Fusion Nuclear Science Facility - The Critical Step in the Pathway to Fusion Energy. This outlined the visions of the FNSF, how it fits into the program to commercial power plant, how it differs from ITER, why it is a smaller facility, what its program looks like and how blankets are tested. In addition, the beginning of the plasma strategy was presented, and the pre-FNSF R&D. FESS team members also had a number of papers at the conference, including Y. Zhai on the magnets assessment for an FNSF. The program progresses through a series of operating phases marked by increasing plasma pulse length, duty cycle, neutron exposure, and blanket temperatures, developing the operating scenarios and fusion nuclear technologies needed for DEMO. Kessel's was one of five TOFE papers presented by members of the national Fusion Energy System Studies program reporting on aspects of the current FNSF study.

H. Neilson presented a seminar, "Engineering Optimization of Stellarators," as a guest lecturer for Germany's International Helmholtz Graduate School for Plasma Physics. The talk addressed a number of topics studied by PPPL and U.S. collaborators aimed at improving the vision of future stellarator reactors, including quasi-axisymmetry as a route to more compact size, magnetic field accuracy requirements and field error control, control of the plasma-divertor interface, and engineering optimization of coil geometries. The Helmholtz school is a graduate school for doctoral candidates at the Max-Planck-Institute for Plasma Physics (IPP) in Garching and Greifswald, Germany and its partner universities, the Technical University of Munich and the Ernst-Moritz-Arndt University of Greifswald. Neilson's lecture was well attended by students and staff at both the Greifwald and Garching sites, the latter by video connection.

D. Gates presented a Research and Review seminar to the Theory department entitled "Origins of Tokamak Density Limit Scalings". In the talk he gave a review of the extensive experimental data for the ubiquitous tearing mode driven disruptions, which are observed at the density limit. He also went over the results of a recent publication, which proposes a root cause for the threshold. This talk will be followed by a joint seminar to be given by R. White and D. Brennan on recent theoretical work verifying the mechanism proposed generate tearing mode dynamics similar to those observed in experiment.

THEORY (A. BHATTACHARJEE):

Y.-M. Huang gave Theory Department Research & Review Seminar entitled "Plasma Instabilities in Large-Scale Magnetic Reconnection, Formation of Plasmoids and Supra-Arcade Downflows" on November 21. Abstract: "In recent years, theoretical analysis and numerical simulations indicate that large-scale magnetic reconnection is susceptible to plasma instabilities and becomes sporadic and even turbulent, therefore the traditional picture of two-dimensional laminar reconnection needs a major revision. In this talk I will discuss two types of instabilities: the plasmoid instability in the reconnection layer and the Rayleigh-Taylor type instability in the exhaust region. I will first review key results from previous work on 2D plasmoid instability in both linear and nonlinear regimes. I will discuss the roles of the plasmoid instability in enabling fast reconnection in resistive MHD, as well as in triggering even faster Hall reconnection. Then I will present more recent results on turbulent reconnection induced by 3D plasmoid instabilities. Finally, I will talk about Rayleigh-Taylor type instability in the exhaust region of reconnection,

which we propose to be the mechanism for supra-arcade downflows usually observed above post-eruption coronal arcades."

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

Professor Rod Boswell from Australian National University gave two seminars on November 17 and 19.

The first talk was titled "A review of plasma thruster work at the Australian National University: Abstract: "The Space Plasma Power and Propulsion Laboratory is research yin two types of plasma thruster. The first is the Helicon Double Layer Thruster, which produces a beam of low energy ions and a group of neutralising electron and is a true plasma thruster. Measurements in vacuum on thrust balances show a thrust of about 1 mN/100 Watts input rf power. The second uses the plasma to heat the gas to create a form of electrothermal thruster, which has much lower ISP but much greater efficiency in producing thrust. Molecular spectroscopy for temperature measurements will be presented. The three space simulation chambers will also be described including WOMBAT XL, a three-meter diameter six-meter long system."

And the second was titled "Nuclear Forensics: how a university developed plasma ion beam system became a world beater in nano-TOF SIMS". The abstract is: "Surprisingly, high current, high brightness ion beams for use in Focussed Ion beams were not successfully developed until the 21st century. A proof of concept system comprising an inductively coupled plasma and a three electrode extraction was demonstrated by the Space Plasma Power and Propulsion laboratory of the ANU by the mid-1990's (2005) and was successfully commercialized by Oregon Physics, a small start up in Portland, Oregon, by 2010. Many of these systems are now in use worldwide. A new system has been recently developed as a source of negative oxygen ions for a nano Secondary Ion Mass Spectroscopic system using time-of-flight techniques to obtain resolutions of better than 0.1% of an Atomic Mass Unit. This Hyperion II equipped nano TOF SIMS at LLNL is being used to determine the isotopic composition of actinides originating from a variety of redundant and out of date devices. The development of the ion source will be described along with it's present applications."

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: The reflectometer tile modification has been completed and the tile was installed on the centerstack. The bay B CHERS window has been replaced and calibrated. The MSE shutters at bay G were replaced and the upper row one tiles were installed. The centerstack metrology has been completed. The filaments, coupons and QMB crystals have been installed in-vessel. Blackening was applied to the mid-plane in-vessel at designated areas. The entire in-vessel was photographed to document its condition. The in-vessel has been scrubbed and the vessel interior has been wiped down with alcohol. In-vessel access was brought to a close on November 19. Primary seals are nearly complete and blank-offs are being installed in locations where items have not yet been submitted for installation. Four teams continue to work on fabricating and trial fitting bus for inside the umbrellas. Vacuum side instrumentation cables

have been run to outside the umbrellas and terminations are in progress in the racks on the 119' platform. Air-side cabling continues inside the umbrellas. Final hardware was installed on the PF4/5 supports at bay L - completing the PF4/5 support modification task. Electricians are working on MPTS conduits on the south wall as well as working on the electrical items for TMB in the NW corner of the NTC.

CS Upgrade: Insulation of the PF and TF Bus bars continued in the CS Winding area. Cleaning and silver-plating of the TF Flex connectors continued in winding area, this task is now over 90% complete. A peer review of the OH water heating system is scheduled for the afternoon of November 21. Samples of the high temperature/pressure hoses was custom fabricated for PPPL but had to be rejected because of variations in the wall thickness that prevented secure swaging to the hose ends. The sample hose was being remanufactured on November 21 and is expected to arrive at PPPL that afternoon. A high voltage and high temperature water test are planned upon their arrival at PPPL.

NBI Upgrade: BL1 duct installation is in progress. Services work continued on BL2 source SF6 delivery line installation. Power testing of M/Rs took place in preparation for NB PTPs. Controls work continues with installation of cable, trays, and terminations in NTC and gallery. A concrete vendor site visit for the north door wall took place and work continues to prep the area. Progress continues on BL PLC software pages. Cryogenics maintenance and repairs in preparation for operations were completed and helium gas cleanup is underway. Development of NB procedures continues. Preparations continue for the Readiness Review scheduled next month.

BUSINESS OPERATIONS (K. FISCHER):

PPPL submitted four proposals in response to the Office of Science Early Career Research Program solicitation. The total budget request for each proposal for the five-year period of performance was approximately $2.5 million. The following are among the submitted proposals: B. Tobias submitted "Multi-Scale Visualization of the Tokamak Disruption." L. Delgado-Aparicio submitted "Active Impurity Control For Maximum Fusion Performance." A. Hakim submitted "A Gyrokinetic Code for Edge Plasma Simulations Employing Advanced Discontinuous Galerkin Algorithms." M. Jaworski submitted "Self-shielding plasma-facing components: can lithium be used as a high-temperature plasma-facing material?".

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

Independent auditors from UL-DQS conducted the triennial re-certification audit of PPPL's ISO-14001 certified Environmental Management System from November 17-21. The auditors reviewed documents, procedures and records and interviewed numerous employees throughout the Laboratory. They complimented PPPL on the willingness of employees to meet with them and our commitment to environmental stewardship. The audit identified nine best practices and seven opportunities for improvement in our EMS program. Thanks to everyone who participated in the audit.

DIRECTOR'S OFFICE (C. AUSTIN):

November 18-22, A. Cohen, S. Prager, S. Langish, and S. Rozycki participated in an IOI Project Review in Germantown, Maryland. Langish, IOI Project Director, and Rozycki, Project Manager, presented the PPPL project to the IPR Team. The review resulted in 12 recommendations, and plans are being put in place for a "mini-review" to be held early in CY15.

On November 18, PPPL celebrated TFTR's 20th Year Anniversary in the LSB lobby with ice cream and cake. TFTR set a number of world records, including a plasma temperature of 510 million degrees centigrade -- the highest ever produced in a laboratory, and well beyond the 100 million degrees required for commercial fusion. In addition to meeting its physics objectives, TFTR achieved all of its hardware design goals, thus making substantial contributions in many areas of fusion. The labwide celebration was followed by a special TFTR colloquium presented by Michael Bell entitled- "Achieving 10MW Fusion Power in TFTR: a Retrospective".

PUBLICATIONS:

Maingi, R.; Osborne, T.H.; Bell, M.G.; Bell, R.E.; Boyle, D.P.; Canik, J.M.; Diallo, A.; Kaita, R.; Kaye, S.M.; Kugel, H.W.; LeBlanc, B.P.; Sabbagh, S.A.; Skinner, C.H.; Soukhanovskii, V.A.; The NSTX Team, "Dependence of recycling and edge profiles on lithium evaporation in high triangularity, high performance NSTX H-mode discharges," Journal of Nuclear Materials, http://dx.doi.org/10.1016/j.jnucmat.2014.10.084. P

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