Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending August 12, 2016 are as follows:

NSTX-U (M. ONO):

The FY2016 NSTX-U plasma operations were completed. The department has completed 10.06 run weeks and 1066 plasma shots.

S. Sabbagh (Columbia University) attended and co-chaired one of four working groups for the ITER Research Plan Workshop held at ITER Headquarters in St. Paul-lez-Durance, France, on July 26-28. The workshop conducted work to update the ITER Research Plan to conform to the new Staged Approach schedule for ITER.

Y. Tajiri (a graduate student from the University of Tokyo) visited the NSTX-U RF group for four weeks under the Princeton University–University of Tokyo student exchange program. During his stay, Tajiri learned the fundamentals of the NSTX HHFW system and matching algorithm. He also helped analyze the transient response of the outer gap due to step-changes in auxiliary heating and also transitions from L- to H-mode in NSTX-U. This analysis will be important in preparing for HHFW experiment on NSTX-U, as the impedance match is quite sensitive to the outer gap size.

NSTX-U post-run calibrations were completed this past week with an experiment utilizing stray fields from PF5 to document impacts on the Diagnostic Neutral Beam neutralization cell, the documentation of low-frequency impedance measurements of the PF coils, and a Raman scattering calibration of the new Pulse Burst Laser Scattering system. The neutral beam (NB) helium refrigerator cold box is at room temperature, and all NB power, vacuum and cryogenic systems have been secured for maintenance. The Lithium Evaporator (LITER) systems are being secured for the outage, and the LITER probes themselves will remain in place on NSTX-U for spatial calibrations until after the vessel vent. Preparations are now underway to perform in-situ TF joint resistance measurements to be done next week, and procedures for the disconnection of water lines and removal of bolts at the upper machine umbrella have been started. The schedule to remove the NB duct to provide in-vessel access has been accelerated to start by September 15, and will help to get the in-vessel diagnostic calibrations done by mid October.

Rayleigh and Raman calibrations of the multi-pulse Thomson scattering system were successfully completed on August 4. The data collected will be used to ascertain the viewing window condition at the end of the run; density correction might ensue. In view of the commissioning the data acquisition for the pulse burst laser system, we performed a Raman calibration for a subset of the edge channels in order to test the acquisition system and compare with the current acquisition system data.

The MSE-LIF system has accomplished a number of tasks over the past several weeks. Installation and testing of detectors for 10 sightlines was completed. Data acquisition hardware and software has been tested, and beam-into-gas calibrations were done to tune APD circuit gains. Improvements to the remote control and telemetry for the MSE-LIF laser system were implemented and tested. On August 1, checkout of the full operation of the MSE-LIF diagnostic was performed. All systems were tested successfully at operational levels. XMP-158 for MSE-LIF stray fields assessments and LIF measurements was completed. Full operation of MSE-LIF diagnostic, including concurrent operation of the laser and modulation of the beam acceleration voltage, into a gas filled torus was performed, and LIF data was recorded on ten sightlines. Testing of the diagnostic neutral beam with vertical field from PF-5 was also completed, and signal levels were observed to decrease by 66% with vertical field. The need for additional magnetic shielding, to be installed during this outage, is being investigated.

Samples of plasma-facing component materials were exposed during boronization using the Materials Analysis and Particle Probe (MAPP). They are made of ATJ graphite, which matches the composition of the outboard divertor tiles. The samples have been removed for study using a variety of surface analysis techniques at the University of Illinois at Urbana-Champaign (UIUC). The results will have a key role in interpreting data from MAPP samples exposed to plasmas during NSTX-U operations in a UIUC-PPPL collaboration.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

Spencer Gibson, a Princeton Plasma Physics Laboratory student engineering intern working with A. Nagy, gave a successful presentation at a Preliminary Design Review for the NB210 neutral beam source housing door opening mechanism. Gibson developed a novel design to open the 300 pound doors. One door opens upward against gravity and the other downward with gravity. In his design the doors are coupled via a cable, pulley and brake mechanism. As the weights are balanced, only 14 pounds of force is required to fully open them. Gibson also gave a successful presentation at a Final Design Review on enlarging the neutral beam access port. The new design allows for a 17” x 29” rectangular access port, compared to the previous 14” ID port, enabling larger individuals to enter the neutral beam housing.

The PPPL supplied neutral beam Local Control System (LSC8) is being installed in the neutral beam system. Approximately 70 percent of the satellite cables have been connected and the project is progressing on schedule. Testing is expected to start in a few weeks and ahead of schedule. “Hot” testing should commence in late September. The new LSC will be the first upgrade to the DIII-D NB high voltage control system since the original units were installed in 1977. There are two more LCS systems in the process of assembly that will be installed next year.

A. Ashourvan, B. Grierson, S. Haskey, and General Atomics (GA) collaborators recently completed in-vessel intensity and spatial calibrations for the main ion CER system on DIII-D as part of the post FY2016 run campaign calibrations. The process was completed over two days and was performed alongside the impurity CER system calibrations. These calibrations are

important for assessing if any changes have occurred to the sight locations or light throughout during plasma operations.

ADVANCED PROJECTS (H. NEILSON):

As part of the Laboratory's collaboration with the Wendelstein 7-X (W7-X) project at Germany's Max Planck Institute for Plasma Physics (IPP), a joint project is under way with the aim of significantly improving remote collaboration capabilities for U.S. participants. The most urgent task under this project is to improve access to W7-X online resources from off-site. Requirements include fast and convenient access to experimental data, web services, real time monitoring data, information systems, and logbooks. At the same time, control over access to these resources must be limited to only those to whom access has been granted by IPP via membership in the W7-X team. This week, agreement between PPPL and IPP was reached on a solution that will make use of commercial virtual private network (VPN) authentication tools, basically an adaptation of the solution used by PPPL staff and collaborators to access PPPL resources from offsite.

In the joint PPPL-IPP divertor scraper project, the report "Design and Analysis of the Wendelstein 7-X Inertially Cooled Test Divertor Unit Scraper Element," was approved and issued this week. The report concludes that "The scraper element as designed and presented at the FDR meets all the specified requirements for the component."

THEORY (A. BHATTACHARJEE):

A paper entitled "Magnetohydrodynamics for collisionless plasmas from the gyrokinetic perspective," by W. Lee has just appeared in Physics Plasmas 23, 070705 (2016). The abstract is as follows: "The effort to obtain a set of MHD equations for a magnetized collisionless plasma was started nearly 60 years ago by Chew et al. Many attempts have been made ever since. Here, we will show the derivation of a set of these equations from the gyrokinetic perspective, which we call gyrokinetic MHD, and it is different from the conventional ideal MHD. However, this new set of equations still has conservation properties and, in the absence of fluctuations, recovers the usual MHD equilibrium. Furthermore, the resulting equations allow for the plasma pressure balance to be further modified by finite-Larmor-radius effects in regions with steep pressure gradients."

Dr. Gorelenkov has visited the University of San Paulo (USP) as a part of USP-Princeton University Strategic Partnership Grant. The goal of this visit was to establish closer ties between PPPL and Institute of Fusion of USP (IFUSP) plasma physics group. This visit included two lectures given by Dr. Gorelenkov to IFUSP staff and students—Introduction to Energetic Particle Physics in Magnetic Fusion: (1) classical confinement and equilibrium distribution function, and (2) collective effects. As a result of discussions with the researchers from USP, the planned workshop for 2016 at PPPL is moved to the second week of January 2017. Several USP researchers will come to Princeton to make their presentations at the workshop and have discussions with PPPL scientists. The USP delegation is expected to include Professors Ricardo Galvao and Artour Elfimov, students V. Duarte (will be present at PPPL by that time for a long term visit), and Fabio Camilo de Souza. Two more specific topics were discussed in detail with

immediate implications to PPPL experiments on NSTX-U. The first topic is on the work V. Duarte is doing at the moment together with Dr. Gorelenkov. The second topic is on the calculations of the low-frequency geodesic acoustic mode (GAM) -like solutions in the presence of energetic beam ions and the instabilities caused by EPs. Professor Elfimov and his student, Fabio Camilo de Souza, will focus on this topic in 2017.

PLASMA SCIENCE & TECHNOLOGY (P. EFTHIMION):

On August 11, Joseph Triana from the University of Wisconsin in Madison presented a seminar on measurements of two-fluid relaxation in Reversed-Field Pinch plasmas. The abstract reads: "Recent measurements and extended MHD simulations expose the importance of two-fluid physics in the relaxation of the current and momentum profiles in RFP plasmas. A hallmark of relaxation is that the inductive electric field is not balanced by resistive dissipation, prompting the study of fluctuation-induced emfs in Ohm's law. The Hall emf is measured in the outer half of the MST plasma minor radius using an armored deep-insertion probe. The emf matches previous measurements in the edge (r/a>0.8) but in the new region examined (0.8>r/a>0.6) it is much larger than E-eta*J, implying the MHD dynamo must also be large and oppositely directed. Recent nonlinear simulations that include two-fluid effects using the NIMROD code show complex radial structure for the emf terms, but the size of the measured Hall emf is much larger than predicted by the simulations. In the two-fluid model, the Hall dynamo couples to the parallel momentum as the mean-field Maxwell stress."

Princeton and PPPL were awarded a grant from the Air Force Office of Scientific Research (AFOSR) in the amount of about $1M for three years. The project title is "Developing Methods of Control of Self-Organized Plasma Structures in Devices Relevant to Electric Propulsion." This is a collaborative project between Princeton University, PPPL, and Stanford University. Princeton University is the lead organization on this project. Y. Raitses is the lead PI, while I. Kaganovich and Professor Mark Cappelli (Stanford University) are co-PIs on this project. This project is in collaboration with Professor Andrei Smolyakov (University of Saskatchewan, Canada), who is also supported by the AFOSR.

Science Education (A. Zwicker):

On August 10, approximately 40 undergraduate and high school students presented posters of their summer projects to PPPL staff. The poster presentation was the culmination of 2016 summer internship at the lab.

DIRECTOR'S OFFICE (C. AUSTIN):

A DOE Fire Protection Assist Visit occurred on August 9-11.

M. Zarnstorff attended the ARPA-E ALPHA annual review meeting in Seattle, Washington on August 9-10.

On August 12, T. Brog, Deputy Director of Operations, traveled to Pacific Northwest National Laboratory (PNNL) in Richland, Washington to discuss a possible collaboration opportunity

between PNNL and PPPL. On August 15, Brog then traveled to Fermi Laboratory in Warrenville, Illinois. There he attended a workshop for the Department of Energy Order 413.3b, where he discussed the changes and impact on all national laboratories.

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