Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending August 12, 2017, are as follows:

NSTX-U RECOVERY PROJECT (R. HAWRYLUK)

Following the successful completion of a Conceptual Design Review last week, the process of planning for the Cost & Schedule Review, scheduled for September 6-8, has commenced. A preparatory meeting was held with the team of Responsible Engineers to settle on the review agenda and to explain the use of templates for overview presentations and inputs to the risk register. An external review committee, consisting of 16 persons with appropriate project management and engineering experience, was identified and an invitation sent to confirm availability and initiate arrangements.

Activities of the Subcontract Proposal Evaluation Board (SPEB) for the Inner PF Coil Prototypes are underway, with four meetings convened thus far. Two rounds of questions and answers have been completed, and feedback from prior customers has been received. The board plans to converge on its final recommendation next week.

NSTX-U RESEARCH (J. MENARD)

The paper "Suppression of Alfvén Modes on the National Spherical Torus Experiment Upgrade with Outboard Beam Injection" by E.D. Fredrickson, et al. has been published in Physical Review Letters [https://doi.org/10.1103/PhysRevLett.118.265001]. In this Letter data from experiments on the National Spherical Torus Experiment Upgrade is shown for the first time indicating that small amounts of high pitch-angle beam ions can strongly suppress the counter-propagating global Alfvén eigenmodes (GAE). GAE have been implicated in the redistribution of fast ions and modification of the electron power balance in previous experiments on NSTX. The ability to predict the stability of Alfvén modes, and developing methods to control them, is important for fusion reactors like the International Tokamak Experimental Reactor, which are heated by a large population of non-thermal, super-Alfvénic ions consisting of fusion generated α's and beam ions injected for current profile control.

R. Raman (U-Washington) visited the DIII-D facility from July 24 to 26 to conduct an experiment as part of the NSTX-U/ITER experimental campaign on DIII-D. R. Sweeney (ITER Organization) was also on site to participate in these experiments. The primary goals of the experiment were to study the penetration depth of Shattered Pellet Injection (SPI) fragments into two discharges with vastly different parameters. For this experiment, a recently developed Super H-Mode target was used. SPI was carried out into the same discharge at times corresponding to 0.2 and 2 megajoules of plasma-stored energy. Clear penetration differences were observed during a 400 Torr-liter pure neon SPI injection in

these two configurations. The second part of the experiment studied the minimum required quantities of neon for full radiation saturation. For these studies, compound pellets composed of varying fractions of neon and deuterium were injected into the high-energy portion of the discharge.

Graduate student Ryota Yoneda from Kyushu University completed his three weeks visit to PPPL as part of the collaboration between NSTX-U and QUEST. The main purpose of his visit was to continue to work on EC/EBW modelling for QUEST plasmas employing ray tracing and Fokker-Planck codes. This work was done in collaboration with the PPPL hosts, N. Bertelli and M. Ono.

Dr. Kengoh Kuroda, who is a post-doctoral fellow at QUEST, Kyushu University visited NSTX-U from July 10 to August 4, and worked with R. Raman (U. Washington) and S.C. Jardin (PPPL) to develop a TSC model of CHI start-up on QUEST. Dr. Kuroda built TSC models that ranged from a simple vessel configuration to one that contained more detailed elements of the QUEST vessel. The code was successfully run with the simplified geometry in which the insulator positions were arranged to be like on NSTX and like the ones on QUEST. Comparative studies in both these configuration are in progress and will be reported in upcoming conferences, and in a NSTX-U FY18 milestone document. With the help of Mike Jaworski (PPPL), Dr. Kuroda also learned to operate the fast color camera, which will be used during the next CHI run campaign on QUEST. Dr. Kuroda's primary research activity is to develop CHI start-up on QUEST.

U.S. ITER FABRICATION (H. NEILSON)

Steady State Electrical Network (J. Dellas)

DC distribution: The release for shipment (RFS) has been submitted and is in the approval process in preparation for shipment later this month.

Reactive power compensators: All lots were delivered to ITER and the final inspection reports were received some time ago. This week, the final delivery reports were approved and the supplier acknowledgement of transfer of ownership and warranty is in the final approval stages.

Diagnostics (R. Feder)

Low Field Side Reflectometer (LFSR): This week the LFSR team at General Atomics (GA) completed Frequency Modulated Continuous Wave (FMCW) transmission line testing, one of the U.S. ITER Project's Level 3 milestones. The goal of the FMCW testing was to verify that the baseline waveguide diameter and corrugation design works

for all expected LFSR frequency ranges (at full operating power) and that the losses that govern the accuracy of the spatial resolution are acceptable in the transmission line. A key element in completion of the testing was the provision of innovative solid-state microwave electronics developed by Virginia Diodes (VDI) in partnership with the University of California at Los Angeles, GA, and PPPL. Through a series of developments, the VDI source designs evolved into transceivers with both send and receive functions necessary for reflectometry testing. It was these updated instruments that enabled the FMCW testing and successful accomplishment of the milestone.

Design integration: New interface definitions for the LFSR were received from the Russia DA's (RFDA) Equatorial Port 11 (EP11) design team. Updates to in-vacuum and in-air support structures, requiring adjustments to the transmission line layouts, were incorporated by PPPL into the CAD design models. The PPPL LFSR team is working closely with the RFDA port plug engineering team to lock down all interfaces and major design features in preparation for an EP11 preliminary design review scheduled for November 2017.

ITER & TOKAMAKS (R. NAZIKIAN)

PPPL hosted the final community input workshop for the FESAC Transformative Enabling Capabilities (TEC) panel from July 19-21, chaired by Rajesh Maingi.. Sixteen additional talks were presented to the panel, followed by panel deliberations over all of the talks and white papers presented at all three community workshops. Daren Stotler (PPPL), in collaboration with Davide Curreli (UIUC) and P. Krstic (Stony Brook), presented "Plasma-Material Interface Modeling" to the PMI subpanel. R. Maingi chaired the meeting, and J. Menard served as a panelist.

International (R. Maingi)

The replacement of Faraday cups on the PPPL JET Lost Alpha diagnostic was completed this week by JET engineers. The repaired detector will soon be re-installed in the JET vacuum vessel in preparation for experiments in 2018.

Francesca Poli traveled to the ITER Headquarters the week of August 07 to report on the completion of her work on an ITER contract focusing on electron cyclotron heating and current drive power management for the optimal control of tearing modes. Extensive discussion took place on the implications of the work on the ITER research plan.

A final design review was held for the third generation flowing liquid lithium limiter to be deployed on EAST. The FDR was successful and the project will move to the procurement stage with a target delivery date of Dec. 2017 - Jan. 2018.

DIII-D (B. Grierson)

A paper by L. Cui, R. Nazikian, B. Grierson et al., titled "The confinement response of DIII-D plasmas to Resonant Magnetic Perturbations (RMP)" has appeared online in journal Nuclear Fusion. The paper demonstrates that over several energy confinement times the plasma confinement can be restored to its pre-RMP level while maintaining ELM suppression. The confinement recovery is observed in the ion transport channel and is linked to an increase in the edge ion temperature and edge ExB shearing rate. http://iopscience.iop.org/article/10.1088/1741-4326/aa7efe/meta

A paper by W. Wang, B. Grierson, et al., titled "Understanding and Predicting Profile Structure and Parametric Scaling of Intrinsic Rotation" has appeared online in the journal Physics of Plasmas. This paper reports first-principles-based model predictions of core deuterium rotation due to turbulence driven Reynold's stress. The work is complementary to recent results published in PRL by B. Grierson, W. Wang, et al., demonstrating quantitative agreement between main ion rotation and theory predictions of turbulence induced rotation in the core of DIII-D L-mode plasmas. http://scitation.aip.org/content/aip/journal/pop/24/9/10.1063/1.4997789 DOI: 10.1063/1.4997789).

The impact of nonaxisymmetric magnetic fields on plasma rotation, stability and transport is being studied in DIII-D using the newly developed 3D MHD Generalized Perturbed Equilibrium Code (GPEC) and axisymmetric TRANSP code. A key accomplishment by N. Logan this week was the development of an interface between these two codes that allows the NTV torque profiles from GPEC to be read into TRANSP in order to predict the momentum transport in the presence of 3D magnetic fields. This work contributes to two high level milestones for DIII-D in FY17.

A major obstacle for efficient analysis of main ion spectroscopic data is the time intensive step of fitting all the relevant spectral lines in order to extract the main ion feature. This week Shaun Haskey completed a project to greatly speed up the analysis time for spectral fitting. H has written a new code that achieves an ~500x speed-up over the previous method by using a combination of multi-processing and rewriting the analysis code in C. This reduces the spectral fitting time for the 16 channel edge system for a single shot from a whole day to a few minutes. The new fitter has been successfully verified on DIII-D data against the old fitter. The fitter has the potential to greatly expand the utilization of main ion spectra in the DIII-D program.

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ADVANCED PROJECTS (H. NEILSON)

Stellarators (D. Gates)

On August 8, the Laboratory hosted a planning video conference with colleagues representing China's Southwest Jiaotong University (SWJTU) and the University of Wisconsin. The SWJTU team is making plans to construct a stellarator experiment of the quasi-axisymmetric (QA) type which, once constructed, would be the world's first of that type. They are working in partnership with Japan's National Institute for Fusion Science (NIFS) who, like PPPL, developed a mature design for a QA stellarator over a decade ago. Plans for a SWJTU team visit to PPPL and the University of Wisconsin later this year, focussed on stellarator engineering issues, were finalized. In addition, discussions on collaboration in stellarator physics and code development were initiated and will continue in preparation for the team visit. The SWJTU initiative is one of several new stellarator activities in China and signifies a substantial step by China into this important area of fusion energy science research. For PPPL, the meeting marked the start of a new chapter in its international stellarator research collaborations.

THEORY (A. BHATTACHARJEE)

F. Ebrahimi attended the Exploratory Plasma and Fusion Research Workshop (EPR 2017) August 1-4 held in Vancouver, Canada, and presented an invited talk entitled "Three-dimensional plasmoid-mediated reconnection in tokamaks." She also attended the Madison community workshop for U.S. magnetic fusion research strategic directions, July 24-28, and served on the program committee.

E. Belova attended "The Exploratory Plasma and Fusion Research Workshop" August 1-4 in Vancouver, Canada, with a poster presentation titled "3D hybrid simulations of spheromak merging."

On Aug. 9, Professor Z. Ma (Zhejiang University, Hangzhou, China) presented a special Theory seminar on tearing mode dynamics and sawtooth oscillation in Hall-MHD. The abstract and presentation are available on the Theory Department website, http://theory.pppl.gov/news/seminars.php?scid=1&n=research-seminars

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COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard)

PPPL posted and distributed three press releases this week. One focused on a former Science Undergraduate Laboratory Internship student who received a Fulbright Scholarship to do research at D3D at General Atomics in California and at the Wendelstein 7-X stellarator in Germany. Another described PPPL's continuing studies in nanoparticles in plasma that shows, in collaboration with Princeton University and others, how plasma causes growth of strong microscopic structures known as carbon nanotubes, found in everything from electrodes to dental implants and transistors. The story focused on research of I. Kaganovich. Finally, a press release describes a computer code used by physicists around the world to analyze and predict tokamak experiments that now can approximate the behavior of ions more accurately than ever, reflecting research of M. Podesta. All three press releases were posted on www.pppl.gov and distributed to the media through EurkeAlert! and newswise distributions services.

This report is also available on the following web site:

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