Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending June 16, 2017 are as follows:

U.S. ITER FABRICATION (H. NEILSON):

Steady State Electrical Network (J. Dellas):

Factory acceptance testing for the 600 kVA uninterruptible power supply (UPS) and DC distribution network was completed at the supplier's facility in Switzerland. Project representatives were on hand to witness the testing, which was judged successful pending completion of identified punch-list items.

Diagnostics (R. Feder):

Port integration: Construction of a computer-aided design (CAD) model for Upper Port 14 neutronics analysis was completed.

Low Field Side Reflectometer (LFSR): May was very productive for the LFSR project. The analysis team performed first iteration electromagnetic analysis, seismic analysis, and thermal hydraulics analysis on the in-vessel front-end antenna block and antennas. The CATIA team finished detailing and uploading all models of LFSR to the Enovia database. The LFSR models need to be updated and locked to support the preliminary design review (PDR) for the Russia DA's Equatorial Port 11 design, which will take place this Fall. At General Atomics, factory acceptance testing of the Virginia Diodes Incorporated (VDI) upgraded solid-state microwave sources was completed. This enables the corrugated waveguide testing at General Atomics to proceed. Also this month at General Atomics the LFSR control and data acquisition software design advanced significantly with the compiling all "use cases" in Enterprise Architect.

NSTX-U RESEARCH (J. MENARD):

The paper "Overview of NSTX Upgrade initial results and modeling highlights" by J.E. Menard, et al. has been published in the journal Nuclear Fusion. The abstract reads "The National Spherical Torus Experiment (NSTX) has undergone a major upgrade, and the NSTX Upgrade (NSTX-U) Project was completed in the summer of 2015. NSTX-U first plasma was subsequently achieved, diagnostic and control systems have been commissioned, the H-mode accessed, magnetic error fields identified and mitigated, and the first physics research campaign carried out. During ten run weeks of operation,

NSTX-U surpassed NSTX record pulse-durations and toroidal fields (TF), and high-performance ~1 MA H-mode plasmas comparable to the best of NSTX have been sustained near and slightly above the n = 1 no-wall stability limit and with H-mode confinement multiplier H98y,2 above 1. Transport and turbulence studies in L-mode plasmas have identified the coexistence of at least two ion-gyro-scale turbulent micro-instabilities near the same radial location but propagating in opposite (i.e. ion and electron diamagnetic) directions. These modes have the characteristics of ion-temperature gradient and micro-tearing modes, respectively, and the role of these modes in contributing to thermal transport is under active investigation. The new second more tangential neutral beam injection was observed to significantly modify the stability of two types of Alfven eigenmodes. Improvements in offline disruption forecasting were made in the areas of identification of rotating MHD modes and other macroscopic instabilities using the disruption event characterization and forecasting code. Lastly, the materials analysis and particle probe was utilized on NSTX-U for the first time and enabled assessments of the correlation between boronized wall conditions and plasma performance. These and other highlights from the first run campaign of NSTX-U are described."

NSTX-U physicists and engineers participated in the Mini-Course on Diagnostics for Fusion Plasmas at the Symposium on Fusion Engineering (SOFE) in Shanghai, China. The mini-course was organized by R. Kaita and B. Stratton, and targeted engineers and early-career researchers seeking an introduction to fusion plasma diagnostics. There was a particular emphasis on the requirements and practical engineering issues related to diagnostic implementation. The following topics were covered by members of the NSTX-U team: 1) Overview of diagnostics for fusion plasmas (Kaita), 2) Thomson scattering for direct and localized measurement of electron properties (A. Diallo), 3) Plasma confinement diagnostics to determine fusion device performance: ion temperature, density and plasma rotation (M. Podesta), 4) X-ray diagnostics for plasma macrostability research (K. Tritz), 5) Engineering issues for diagnostic implementation (R. Ellis), and 6) Fusion product diagnostics (Kaita). At SOFE, Kaita gave an invited talk entitled "Synergies in Liquid Metal Technology Development for Divertor Applications" that included NSTX results, and D. Cai presented a poster entitled "Lithium Evaporation System Design for the NSTX-Upgrade Fusion Device" on a system under development for coating the upper NSTX-U vacuum vessel with lithium.

ITER & TOKAMAKS (R. NAZIKIAN):

US collaborators visited EAST in China June 11-17 to continue research on plasma material interactions involving lithium. The team worked with EAST researchers to address design issues for the pumping plenum for the EAST lower divertor upgrade planned for 2019-2020. Results from the lithium campaign on EAST will be presented in a plenary talk at the EPS meeting in Belfast.

DIII-D: Two recent experiments on DIII-D led by and Nathan Howard (Massachusetts Institute of Technology) and Lothar Schmitz (University of California - Los Angeles) have leveraged between-shot plasma profile, database, and TRANSP analysis that were developed and presented at the IAEA Technical Meeting (Highlights; June 9, 2017) by B. Grierson, N. Logan and S. Haskey of PPPL. The experiment led by Nathan

Howard used profiles tools and TRANSP simulation implemented in the OMFIT framework for rapid fitting of plasma profiles and submission of between shot TGLF turbulence stability analysis to guide the experiment. Both experiments used the OMFIT database tool to display multi-shot experimental trends to help guide the experiment. These capabilities are being developed to improve the efficient utilization of the experimental facility with effective pre-experimental planning, between shot and post experiment analysis.

M. Knolker presented the results of ELM heat load analysis on the inner and outer divertor in DIII-D at the Friday science meeting. The data was taken at ITER relevant collisionality and found to be consistent with the latest modeling on the heat flux ascaling from ASDEX-U and inconsistent with a collisionality dependence. However, the proximity of the plasma to the L-H transition threshold does correlate with the peak ELM divertor heat flux.

ADVANCED PROJECTS (H. NEILSON):

Stellarators (D. Gates):

The department's stellarator research activities were well represented in papers presented at the IEEE Symposium on Fusion Engineering, June 4 - 8 in Shanghai, China. A poster, "Final Design and Fabrication of the TDU Scraper for Wendelstein 7-X," by G. D. Loesser, et al., described the engineering aspects of the Wendelstein 7-X (W7-X) divertor scraper, a limiter-like component designed to protect weakly-cooled regions of the W7-X divertor targets. The poster describes the final design and fabrication of the inertially-cooled prototypes which will be installed in W7-X for testing during the upcoming OP1.2 campaign. A poster by T. Brown, "Three confinement systems - Spherical Tokamak, Advanced Tokamak and Stellarator: A comparison of key component cost elements," highlighted results of PPPL studies on these concepts that promote simplification of their machine configurations and improvement in their maintenance features. Regarding the quasi-axisymmetric stellarator (QAS), the paper concluded that the lack of requirements for PF coils and current drive, and reduced requirements for diagnostics, were important simplifications. It was found that a QAS reactor configuration could be compatible with vertical maintenance.

S. Lazerson was granted an award of one million hours at the National Energy Resource Supercomputing Center (NERSC) to develop and run the three-dimensional equilibrium optimization code STELLOPT. This award will allow work to proceed on optimizing the code for the Cori Knights Landing machine. Recently the architecture of the code has undergone upgrades to allow the already task parallel nature of the code to take advantage of sub-code parallelization. Recent 1024 processor simulations on the PPPL cluster are providing limited tests of the code. The NERSC Cori machine will allow the code to push past the 1024 processors limit with the goal of demonstrating +10,000 processor runs. The end goal is to demonstrate coil optimization using free boundary equilibria targeting physics parameters.

On June 16, D. Gates visited Columbia University and served on a thesis defense committee in the morning. In the afternoon he presented a seminar, "Needs for

Stellarator Research in Fusion Energy Development." The talk, based on a recent report written by the National Stellarator Coordinating Committee which is co-chaired by Dr. Gates and D. Anderson of the University of Wisconsin-Madison, outlines a series of exciting new physics research topics that would be addressed by a reinvigorated stellarator research program in the United States.

Fusion Energy Systems Studies and Next Step Activities (C. Kessel):

The department's collaborations on next-step machine studies were well represented in papers presented at the IEEE Symposium on Fusion Engineering, June 4 - 8 in Shanghai, China. Engineer A. Khodak and visiting researcher X. Cheng presented their work on beryllium-steam reactions in water-cooled ceramic breeder blankets. Khodak's paper described the physical model, its validation, and model set-up for computation fluid dynamic analysis. Cheng, a student from the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP), described simulations to assess the safety impacts of beryllium-steam reactions in the case of a loss of coolant accident (LOCA) within a blanket module ("in-box"). The work was performed under collaboration with ASIPP supporting their study of a next-step facility, the China Fusion Engineering Test Reactor (CFETR). Engineer T. Brown presented a paper, "Conceptual development of K-DEMO, highlighting maintenance and support details of in-vessel components," work performed in collaboration with South Korea's National Fusion Research Institute. The paper described an overall facility configuration for Korea's K-DEMO reactor study, including major tokamak components, heating and current drive systems, maintenance pathways, hot cell, and storage facilities. It also described options being examined for design simplification and component count reduction with the aim of minimizing cost and reliability risks.

ENGINEERING & INFRASTRUCTURE (V. RICCARDO):

Several engineers and designers are being moved from ITER work to support NSTX-U.

A teleconference was held with JLAB Pressure Systems SME to discuss how they implemented the pressure systems requirements in 10CFR851. Valuable insight was gained in system categorization, test and inspection requirements and other implementation help.

Met with the Calibrations assessment team leader to review the corrective action plan developed in response to a QA surveillance.

CAD: Real Time Stack Monitor CAD Package was released. Low Field Side Reflectometer Test Frame drawing was released. The Outboard Divertor Tile concept was placed in global model, 3D-printed and prototyped.

Power Systems: A set of requirements for the 230kV to 138kV PSGE transformer at the Plainsboro junction are being developed based on planned experimental needs and the current capabilities are being analyzed and documented, in preparation for a peer review.

Exploration: Dr. Berthold Schmidt, Managing Director and Dr. Hagen Zimer, Director Research and Development of TRUMPF Photonics Inc. visited PPPL to discuss possible uses (and collaboration) of high powered lasers for addressing various aspects of radioactive waste reduction. TRUMPF is a multi-billion dollar international company with advanced expertise in laser development, production, and Research and Development. A possible application for their developing laser technology may be the DOE high level waste (HLW) tanks located in Hanford, Washington. Also in attendance was Dr. Bill Ayers, a local entrepreneur who also has interest in this technical area.

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

Material Services recycled 1,725 pounds of electronics through UNICOR on June 14.

DIRECTOR'S OFFICE (S. ZELICK):

Site Protection (F. White):

Engine 66 responded to Princeton for four mutual aid assignments.

Engine 66 responded to Plainsboro for one mutual aid assignment.

Ambulance 166 responded to Plainsboro for one mutual aid assignment.

Members of the Site Protection Division and the Emergency Services Unit are conducting candidate interviews for the Emergency Services Officer position.

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