Weekly HIGHLIGHTS

The PPPL Highlights for the week ending May 19, 2017 are as follows:

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

Steady State Electrical Network (J. Dellas):

The supplier has signed the transfer of ownership of the SSEN power transformers to the ITER Organization. The transfer also includes ownership of the supplier's warranty and site support acknowledgement. Assembly of the first uninterruptible power supply (UPS) system is complete and assembly of the DC Distribution network is planned to be completed this month. Factory acceptance testing of these items is being planned.

Diagnostics (R. Feder):

Electron Cyclotron Emission (ECE): The ECE system requires an in-situ calibration source, basically a 680 C radiator that will be used to calibrate the ECE system. A prototype calibration source was fabricated and tested by the University of Texas at Austin team, and preliminary design is nearing completion. A peer review of the calibration source design and prototyping results is planned and, in preparation, the review materials have been submitted to the IO-Central Team Diagnostics unit.

Equatorial port integration: The Equatorial Port 9 team continues to work with its tenant systems, the toroidal polarimeter-interferometer (TIP) and electron cyclotron emission (ECE). Design refinements for these systems' in-vessel components are being made in order to better adapt designs to remote handling requirements.

NSTX-U RECOVERY PROJECT (R. HAWRYLUK):

The second Extent of Condition review was held this past week. The review committee that participated included Tom Todd (retired CCFE) [Committee Chairman], Dennis Youchison (ORNL), Brian LaBombard (MIT), Ron Parker (retired MIT), Heinrich Boenig (retired LANL), Remmelt Haange (retired ITER), Michel Huguet (retired ITER), Martin Cox (CCFE), David Humphreys (GA), Arnie Kellman (GA) and Rich Callis (GA). Reviewer recommendations are being evaluated and work plans will be generated.

Recommissioning of the coil winding facility continued this week with the mounting of an upper PF1A mandrel in the winder, and trials of conductor bending and setting into a lead

block. Installation of insulation on the oven extension as needed for the VPI of a PF-1A prototype has been completed, and the oven is in bake-out operations.

The sealing of the FIReTIPS diagnostic waveguides has been completed, and preparations are underway for the metrology of the outer PF coils and the tiles on the centerstack.

Leak checking the Neutral Beam #1 calorimeter bellows assemblies has been successfully completed, and reassembly of drive mechanisms is in progress. The three freshly rebuilt Helium Cryo-plant compressors have been lifted into place on their skids, and piping is being reconnected.

Voith Hydro continued to make good progress this week on the cleaning of the Motor Generator (MG#1) bearing journal. GE has presented a proposal to PPPL for the modernization of the MG set cylcoconverter system. Other proposals are expected.

NSTX-U RESEARCH (J. MENARD):

The article "Multi-species impurity granule injection and mass deposition projection in NSTX-U discharges" by R. Lunsford, A. Bortolon, A. L. Roquemore, D. K. Mansfield, M. A. Jaworski, R. Kaita, R. Maingi, and A. Nagy has been published in Nuclear Fusion, Vol 57, (2017) 076008. In this paper the duration of ablation events recorded on experiments performed at DIII-D are used to calibrate a neutral gas shielding(NGS) model for lithium, boron, and carbon granules. This species-specific granule shielding constant is then used to model granule ablation within NSTX-U discharges. Simulations of 300, 500 and 700 micron diameter granules injected at 50 m s^{-1} are presented for NSTX-U L-mode type plasmas, as well as H-mode discharges with low natural ELM frequency. In H-mode discharges these simulations show that the majority of the injected granule is ablated within or just past the edge steep gradient region. At this radial position, the perturbation to the background plasma generated by the ablating granule can lead to conditions advantageous for the rapid triggering of ELM crashes

ITER & TOKAMAKS (R. NAZIKIAN):

International: A new collaboration on the deployment of a powder dropper on ASDEX-Upgrade has been initiated, building on the original work pioneered by D. Mansfield and implemented on EAST, NSTX-U and DIII-D. The collaboration on AUG has two main goals: (1) assess the effect of low-z impurities on pedestal pressure and transport, and (2) the assess the efficacy of such a system for wall conditioning. The status of the dropper development for boron-based materials, mostly BN but also pure boron, was presented. A refined design with demonstrated reproducible drop rates for BN was discussed. The plans and needed agreements to deploy the Dropper on ASDEX-Upgrade in the late summer or early fall were briefly discussed.

Shaun Haskey visited PPPL to work with D. Battaglia on continued modeling of main ion and impurity properties in H-mode plasmas with XGC0. The goal of this work is to compare the main ion CER measurements with nonlocal neoclassical predictions of main ion properties in the DIII-D tokamak. Additionally, N. Pablant made progress on updating and increasing the speed of

his spectral fitter, which is used to fit the complex D-alpha spectra, measured on the main ion CER system.

ADVANCED PROJECTS (H. NEILSON):

Stellarators (D. Gates):

The May team meeting for the Future Stellarator Configuration was held on May 18. Significant progress was reported on several topics. A new constraint on inter-coil forces has been implemented and verified in the stellarator coil design code Coilopt++ by Josh Breslau. Minimizing these forces will reduce the peak stress on the coil, lowering materials costs and simplifying device design. Additionally, an initial result from a scan of plasma elongation was presented. This work was performed by a group of scientists including S. Lazerson, N. Pomphrey, and visiting post-doctoral researcher Z. Feng.

D. Gates participated in the governance subcommittee meeting of the United States Magnetic Fusion Research (MFR) Strategic Directions Workshop. This subcommittee is responsible for developing the reporting and organizational processes for the upcoming United States MFR Strategic Directions Workshop to be held in Madison Wisconsin July 24th-28th. The committee discussed and approved a process aimed at guaranteeing that the diverse views that are expected to be expressed are properly recorded and acknowledged and that participants are able to express their views adequately.

As part of an ongoing collaboration on W7-X Lazerson spent last week visiting IPP-HGW. While there he participated in two planning meetings as the Scenario and Integration task force leader. His role was to identify high priority experiments, which could be run in the few first weeks of plasma operation. Additionally, he helped recognized key milestones in the upcoming campaign and identify experiments on the critical path to performance extension in W7-X. He also provided technical assistance to the equilibrium reconstruction team regarding access to PPPL computational resources. As part of an ongoing benchmarking exercise, in the energetic particle group, Samuel provided an additional benchmarking data using the BEAMS3D neutral beam code. Dr. Lazerson was also able to debug the FIELDLINES and BEAMS3D codes on the Hydra supercomputer, allowing more detailed simulation of the effects of error fields on limiter and divertor performance.

THEORY (A. BHATTACHARJEE):

On May 10, Alan Glasser (Fusion Theory & Computation, Inc) presented a special theory seminar on DCON for Stellarators. The abstract reads: “We report the development of a new version of DCON for nonaxisymmetric toroidal plasmas, e.g. stellarators. The DCON code is widely used for fast and accurate determination of ideal MHD stability of axisymmetric toroidal plasmas. Minimization of the ideal MHD energy principle dW is reduced to adaptive numerical integration of a coupled set of ordinary differential equations for the complex poloidal Fourier harmonics of the perturbed normal displacement. For a periodic cylindrical plasma, both the poloidal and toroidal coordinates are ignorable, allowing for treatment of single harmonics m and n. For an axisymmetric toroidal plasma, poloidal symmetry is broken, causing different m’s to

couple and requiring simultaneous treatment of M harmonics. For a nonaxisymmetric plasma, toroidal symmetry is also broken, causing different n's to couple and requiring treatment of N harmonics. For a stellarator with field period l, e.g. l = 5 for W7X, each toroidal harmonic n is coupled to toroidal harmonics n+k*l, for all integers k. Both M and N are truncated on the basis of convergence. Singular surfaces occur at all values of safety factor q = m/n in the plasma. The DCON equations have been generalized to allow for multiple n's with coupling matrices F, K, and G. An interface has been developed for the nonaxisymmetric equilibrium code VMEC, which provides values for these matrices. Their Fourier harmonics are fit to cubic splines as a function of the radial coordinate s, allowing for adaptive integration of the ODEs. The status of the code development will be presented."

On May 11, Konstantin Kabin (Royal Military College of Canada) presented a theory seminar on modeling substrom dipolarizations and particle injections in the terrestrial magnetosphere. The abstract reads: "Increased fluxes of energetic electrons and ions in the inner magnetosphere of the Earth are often associated with sudden reconfigurations of the magnetotail, often referred to as substorm dipolarizations. We describe a novel model of the magnetotail, which is easily controlled by several adjustable parameters, such as the thickness of the tail and the location of transition from dipole-like to tail-like magnetic field lines. This model is fully three-dimensional and includes the day-night asymmetry of the terrestrial magnetosphere, however, the field lines are confined to the meridional planes. Our model is well suited to studies of the magnetotail dipolarizations which we consider to be the tailward movements of the transition between dipole-like and tail-like field lines. We also study the effects of a dipolarizing electromagnetic pulse propagating towards the Earth. The calculated electric and magnetic fields are used to describe the motion of electrons and ions and changes in their energies. In some cases, particle energies increase by a factor of 25 or more. The energized particles are transported earthward where geostationary satellites as substorm injections often observe them. The energization level obtained in our model is reasonably consistent with satellite and ground-based observation (e.g. carried out by riometers), and therefore we consider our scenario of the dipolarization process to be feasible."

W. Fox, D. Schaeffer, and A. Bhattacharjee traveled to Lawrence Livermore National Lab (LLNL) to meet with collaborators and to conduct the first of three experiment days on magnetic reconnection on the National Ignition Facility (NIF) through the NIF Discovery Science program, on May 16. The experiment is "Magnetic Reconnection in the low-dissipation, large-system-size regime on the NIF", Principal Investigator I: W. Fox. The experiment generates two high-temperature plasma plumes by laser interaction (E ~ 50 kJ) with a flat foil, which self-generates magnetic fields by the "Biermann battery effect", and which subsequently collide, driving reconnection of opposite polarity fields. A novel aspect of the experiment is to obtain and observe reconnection in very large systems as measured in units of fundamental plasma lengths (L/d_i > 300) and large Lundquist number (S > 10000), corresponding to high temperature and low plasma resistivity. The experiments will study the generation and evolution of magnetic fields, plasma density and temperature, and attempt to observe plasmoid instability in the reconnection layer and particle energization by reconnection.

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