Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending March 3, 2017 are as follows:

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

ITER Steady State Electrical Network (J. Dellas):

The DC Distribution contract was officially "Released for Manufacturing" on February 28.

ITER Diagnostics (R. Feder):

Equatorial Port 09: Meetings for the TIP diagnostic system resulted in strategy and planning progress for providing integration loads to three individual systems in EP09. This load definition will enable diagnostic tenant DAs to continue in their design efforts.

Toroidal Interferometer/Polarimeter (TIP): Commissioning of the prototype TIP system on DIIID is continuing, producing density data on a large fraction of DIIID shots. Initial fluctuation data has also been obtained. Efforts are underway to improve the S/N ratio and long-term stability for both interferometer and polarimeter. A Test Plan is in draft, to map out a strategy to use this prototype to optimize the ITER design.

I&C Support Team: Held I&C planning meetings for TIP and ECE; Reserved US ITER Document numbers for all diagnostics SRS and SDS documents and requested ITER IO placeholders for same; Continued work on a how-to presentation for EA-derived engineering; Collected Integration Kit information.

NSTX-U RECOVERY PROJECT (R. HAWRYLUK):

The seventh of the twelve planned Design Verification and Validation Reviews (DVVR), this one reviewing the NSTX-U power systems, was held this week, and observation/ suggestions (chits) are now being organized into corrective actions. J. Dellas, the responsible engineer for the power systems, was the main presenter at the DVVR. External reviewers attending the meeting at PPPL included Dave Terry, of MIT and Heinrich Boenig, a retired engineer from the Los Alamos National Laboratory and National High Magnetic Field Laboratory. Jim Irby of MIT, and Tom Todd, the chair of the external review committee, participated by videoconference.

The NSTX-U Extent of Condition (EoC) meeting will be held over four days starting March 6. Presentations were posted on Friday afternoon, and drafts of Corrective Actions have been forwarded to the NSTX-U Recovery EoC Committee.

Individual off-line flow tests of the PF1C upper and lower coils were performed this past week, and results were nominal to original design criteria and manufacturer test results.

Regarding test cell work, installation of waveguides and the configuration of electrical systems for the FIReTIPS diagnostic continue, and preparations to install the Poloidal-CHERS passive plates in-vessel have started. Recommissioning of the coil winding facility also continued with the mounting of a copper coil to the tension skid brake system for winding tests where the tensioning skid will accept and pull copper.

Maintenance (Voith Hydro) of the Motor Generator (MG#1) Thrust Bearing resumed this week with the completion of the rebuilding of the four heat exchangers (Fluidics Inc.), and the re-assembly and successful testing of the oil pressure and temperature monitoring systems.

Ion Source work continues in the Neutral Beam (NB) shop with the successful assembly and alignment of an ion source accelerator grid module. The full assembly of the arc/accelerator modules will be completed this coming week, which will then be brought to the clean room mezzanine to be prepared for hydrostatic and electrical testing.

NSTX-U RESEARCH (J. MENARD):

Nick Lopez (Princeton University graduate student) gave an NSTX-U Physics Meeting talk on February 27 on the feasibility of using O-mode ECH for non-inductive startup on NSTX-U. The 28 GHz system would be a key component in this startup scheme, which would prepare plasmas for HHFW and NBI. To perform this study, TRANSP simulations were used to self-consistently evolve plasma parameters in response to injected EC power, as calculated by GENRAY and CQL3D. Simulations were based on plasmas, one with a fast and one with a slow density ramp up rate, performing angular scans in EC deposition location in both scans. The simulation results indicate that the waves should be launched in the upper half plane. At the optimum injection angle, determined by a metric that accounts for first pass absorption and driven current, up to 95 kA could be driven by the ECH. These scenarios are stable to kink and ballooning modes. The shape of the density profile has a significant effect, however, especially on the poloidal injection angle. Future work will involve developing simple control equations for adjusting poloidal injection angle based on observations of the density profile, as well as modeling EBW startup scenarios.

The paper “A reduced resistive wall mode kinetic stability model for disruption forecasting” by J. Berkery, S. Sabbagh, and others has been published in the journal Physics of Plasmas. In recent years, analysis with the authors’ MISK code has shown the importance of kinetic effects, such as resonances between plasma rotation and bounce and precession particle motions, as well as the effects of collisions, on resistive wall mode stability in tokamaks. The paper describes efforts to take this physics and incorporate it in a “reduced” kinetic model streamlined for fast computation in DECAF, the new Disruption Event Characterization and Forecasting code, also developed by the authors. The reduced model performed well in its first iteration on NSTX data, finding instability 84 percent of the time for experimentally unstable cases, and stability in 77 percent of experimentally stable cases. The paper is associated with Dr. Berkery’s invited talk at the 2016 APS Division of Plasma Physics meeting in San Jose, California.

R. Perkins visited the Basic Plasma Science Facility at University of California Los Angeles to prepare for an upcoming experiment on RF rectification. The experiment will be performed on the Large Plasma Device using a recently constructed single-strap antenna and will focus on measuring rectified currents, rectified voltages, and heat fluxes on different field lines connecting various plasma-facing components. Discussions focused on instrumentation, and the experiment will likely be conducted in early May.

ITER & TOKAMAKS (R. NAZIKIAN):

EAST:
Members of the EAST ICRF team, Professor Y.P. Zhao, Dr. X.J. Zhang and Dr. C.M. Qin, visited PPPL on February 20 to 22 to discuss possible improvements to the EAST ICRF system. They toured the NSTX-U ICRF system and then received presentations from the NSTX RF team. The discussion then turned to issues with the EAST ICRF system and ideas for improving the system. Very detailed and interesting discussions were held between the groups.

C-MOD:
S. Scott (PPPL) presented a talk at the C-Mod Weekly Science Meeting titled “Can we avoid MHD during LHCD by altering the current profile?” The talk discussed MSE measurements of the current profile in near fully non-inductive LHCD plasma and the conditions for when the plasma was MHD stable. The MSE measurements were made possible by using the MSE background polychromator, which allowed the partially polarized background light to be measured in real time via wavelength interpolation. Statistical error bars of a few tenths of a degree were realized with the MSE background polychromator. This measurement proved far superior to the standard ‘time interpolation’ of the background signal between two adjacent beam-off phases.

DIII-D:
L. Cui, assisted by F. Poli, has developed an interface in OMFIT for running the lower hybrid current drive modeling code LSC for TRANSP simulations of DIII-D discharges. This new capability is being used to investigate the effectiveness of current drive in super H-mode discharges. As the TRANSP interface in OMFIT is machine-independent, the new LSC capability in OMFIT is now also available for all tokamaks.

The paper titled "Prediction of Nonlinear Evolution of Energetic-Particle-Driven Instabilities" by Vinicius Duarte et al., was accepted for publication in Nuclear Fusion. The paper validates a general criterion used to predict the emergence of chirping oscillations of unstable Alfven Eigen modes in DIII-D. The model includes realistic Eigen function structure, detailed phase-space dependences of the instability drive, stochastic scattering and Coulomb drag. This work increases confidence in the applicability of such criteria for predicting different nonlinear regimes in future experiments.

The paper titled "Improving fast-ion confinement in high-performance discharges by suppressing Alfvén Eigen modes" by G. Kramer et al. was accepted for publication in Nuclear Fusion. The paper demonstrates the success of reduced models coupled to TRANSP in predicting fast ion loss

in DIII-D steady-state plasmas. The paper also outlines strategies for minimizing fast ion loss in advanced confinement regimes that will be tested in future experiments.

D. Battaglia visited DIII-D to collaborate with S. Haskey on further developing the XGC0 simulation capability for interpreting DIII-D main-ion CER measurements using the OMFIT framework. Significant progress was made on generating synthetic diagnostic outputs allowing straightforward comparisons between the simulations and experimental measurements.

D. Boyer, K. Erickson, and P. Vail visited DIII-D to meet with Tim Scoville, David Pace, Brian Grierson, and members of the DIII-D plasma control group to identify goals and development tasks for implementing a PCS algorithm to control stored energy and rotation in DIII-D using the newly implemented variable beam energy capability on DIII-D.

ADVANCED PROJECTS (H. NEILSON):

Stellarators (D. Gates):

The Laboratory hosted the quarterly United States Wendelstein 7-X Management (W7-X) meeting, with representatives from Department of Energy Fusion Energy Sciences, Oak Ridge National Laboratory, and Los Alamos National Laboratory also attending. The United States team is preparing for vigorous participation in the next W7-X operating campaign, OP1.2, with a diverse research agenda that will advance the frontiers of stellarator physics. United States scientists have submitted proposals in the areas of stellarator transport, error field effects, edge physics and plasma facing components, and equilibrium modeling. The W7-X facility has been substantially upgraded for OP1.2 with a divertor, a vastly expanded diagnostic set, and increased plasma-heating power. Opportunities to strengthen the U.S. team to take maximum advantage of these capabilities in OP1.2 were discussed. In addition, the U.S. team is looking ahead to the requirements for steady state operating, with plans to participate in pellet fueling experiments in OP1.2 and to build a continuous pellet injection system.

THEORY (A. BHATTACHARJEE):

On February 28, a Theory Seminar titled *"Development and application of BOUT++ for large scale turbulence simulation"* was presented by Jarrod Leddy, of The University of York, United Kingdom. The abstract reads "The transport of heat and particles in the relatively collisional edge regions of magnetically confined plasmas is a scientifically challenging and technologically important problem. Understanding and predicting this transport requires the self-consistent evolution of plasma fluctuations, global profiles, and flows, but the numerical tools capable of doing this in realistic (diverted) geometry are only now being developed. BOUT++ is one such tool that has had many recent develops towards this goal. A novel coordinate system has been developed to improve the resolution around the X-point and strike points in the divertor region. A 5-field reduced 2-fluid plasma model for the study of instabilities and turbulence in magnetized plasmas has been built on the BOUT++ framework that allows the evolution of global profiles, electric fields and flows on transport timescales, with flux-driven cross-field transport determined self-consistently by electromagnetic turbulence. Models for neutral evolution have also been included, and the interaction of these neutrals with the plasma is

characterized through charge exchange, recombination, ionization, and radiation. Simulation results for linear devices, MAST-U, and DIII-D are presented that shed light on the nature of plasma-neutral interaction, detachment in the super-X divertor, and turbulence in diverted geometry."

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