PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending January 9, 2015, are as follows:

U.S. ITER FABRICATION (D. JOHNSON):

R. Feder replaced D. Johnson as US ITER Diagnostics WBS Leader, January 1, 2015. Feder was accompanied by six ITER diagnostics CAMs attended a one-day CAM training session at the US ITER Project Office.

The baseline mechanical design of the ECE shutter/mirrors was deemed deficient in that the reflective surface of these shutters would be exposed to the plasma during plasma operation, potentially impacting the long-term stability of the microwave reflectivity of these components. A study was initiated to shift the pivot points, allowing the reflective surfaces to be protected from seeing the plasma during plasma operation. If the new pivot placement is implemented, the actuation of the shutters may become more complex.

Researchers at General Atomics successfully tested a commercial system for feedback control of a laser beam over a short distance. They plan to implement this system in a much longer path length with more complex geometry to simulate the path of the lasers used in the Toroidal Interferometer/Polarimeter diagnostic. The initial tests will be done with a visible laser. Subsequent testing will feature the infrared lasers to be used in the diagnostic on ITER.

The first of four high voltage transformers was delivered to the port of Fos sur Mer on December 19, and is awaiting special transport to the ITER site. Fabrication at Hyundai Heavy Industry is complete for the second transformer, but shipment is delayed due to bottlenecks at the testing facility.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

A. Bortolon visited PPPL and presented a seminar at the NSTX-U physics meeting: "ELM pacing experiments on DIII-D using the Lithium Granule Injector." The ability of different granule sizes between 0.3 and 0.9 mm diameter was presented. Granules were shown to successfully trigger ELMs, and in some cases, pace ELMs. The peak ELM heat flux was generally reduced with increasing ELM frequency, although the distribution of ELM sizes varied substantially, depending on the discharge scenario. In a separate meeting, the technical aspects of the LGI implementation and operation were discussed, in view of the upcoming LGI installation and experiments on NSTX-U.

Initial testing of the adaptive ELM control and real-time Error Field Correction (EFC) were performed at DIII-D on a control session. The adaptive ELM control consists of two parts: magnitude of the I-coil current and phasing of the upper and lower I coil sets (due to the power supply constraints these are the only parameters we can control). Previously, using the real-time ELM frequency detection the part of the algorithm to control the I coil current magnitude was commissioned where the current was reduced to the minimum possible level while still keeping sustained ELM suppression. This allowed minimal perturbation to the plasma, which led to increased beta and confinement. For the I-coil phase control, the kink resonant and the pitch resonant components of the 3D perturbations are calculated based on the linear vacuum response using real-time SURFMN code. The ELM control algorithm maximizes either the kink-resonance or the Chirikov parameter (island overlap) by adjusts phasing between the upper and the lower I coils sets. The I-coil phasing is adjusted every ~50 ms to optimize the ELM suppression as the plasma profile/shape evolves. EFC algorithm adjusts the 3D coils to minimize the n=1 component of the error field. The n=1 kink component of the vacuum field due to bus, PF, I and C coils are calculated and C coil is controlled in real-time to minimize it. The algorithm will be extended to I-coil EFC in the future. Testing will continue in January.

Two new CCD cameras have been delivered to DIII-D for use on FIDA and the edge main-ion CER upgrade. These cameras are able to read four spectroscopic sightlines on each camera and will increase the number of sightlines available for main-ion CER on DIII-D. After conformance testing on the delivered units, further units will be shipped and tested. These first cameras will be operational for the next DIII-D experimental campaign.

The remaining tiles for the neutral beam pole shield upgrade have been received and inspected this week, and appear to meet the drawing specifications, with final a report expected the week of January 12. Work continues on wiring the NBLCS8 control racks. Two PC modules have been wired, and the wire harnesses pre-fabricated with labeling applied. A ground bus strip and plug strip were installed. The wiring database that includes all wiring has been completed except for a handful of satellite system terminal block connection points awaiting confirmation.

Nikolas Logan, a new PPPL post-doc, arrived at DIII-D this week. He did his thesis on electromagnetic torque on tokamak plasmas, and is joining the Dynamics and Control group at DIII-D. He will bring his expertise to the ITER baseline development effort, studying long timescale effects of momentum transport observed in the scenario.

ADVANCED PROJECTS (D. GATES):

The national Fusion Energy Systems Studies team submitted a report to DOE, summarizing progress made in 2014, the first year of a study examining the mission and technical metrics for a fusion nuclear science facility (FNSF)I oducing the mission, or range of possible missions, for an FNSF, the report placed in context by contrasting it with ITER and explaining its role as a precursor to an eventual fusion DEMO. The key mission elements are described both in narrative and in quantitiative terms. R&D activities in both plasma and materials science, needed to prepare for FNSF, are described, highlighting fundamental science character of the near-term needs. The report was compiled by PPPL's C. Kessel, the national team leader, with contributions from the team.

In the Laboratory's collaboration with South Korea's National Fusion Research Institute, a joint manuscript, "Design concept of K-DEMO for near-term implementation," has been submitted for publication in Nuclear Fusion. The paper describes progress in the development of the K-DEMO design in the last two years, as reported in four papers at the IAEA Fusion Energy Conference in October. The Laboratory's main contributions are reflected in the machine configuration description, physics assessment, and magnet structure analysis sections of the paper.

THEORY (A. BHATTACHARJEE):

The Theory Department Research & Review Seminar entitled "Edge Turbulence in Tokamaks" was given by S. Zweben on January 9. This talk gave an overview of edge turbulence measurements in tokamaks, with a focus on gas puff imaging (GPI) data from NSTX. It also discussed the relationship between these results and theory, and suggested directions for further comparisons.

On January 5, Nathaniel Ferraro from General Atomics presented a talk on progress in modeling non-axisymmetric response in tokamaks: The application of non-axisymmetric magnetic fields has proven to be a powerful and versatile tool for modifying the stability and transport properties of tokamak plasmas. Predictive models of the salient effects of the application of these fields, including ELM suppression and enhanced particle transport (“pump-out”), require validated models both of 3D magnetic equilibria, and of transport in these 3D magnetic geometries. Recent efforts to validate equilibrium and transport calculations against measurements from dedicated experiments on tokamaks including DIII-D, NTSX, Alcator C-Mod, and ASDEX-U have led to significant progress in understanding the plasma response to non-axisymmetric fields and the physics of ELM suppression. Linear, ideal-MHD is found to describe the plasma response well at low beta. Non-ideal, and non-linear effects are confirmed to play an important role at higher beta or lower rotation. The response in these non-ideal regimes is found to be less well quantitatively described by existing models. Development and validation of the M3D-C1 code, which implements a non-ideal MHD model, are discussed in detail. In particular, we describe a new resistive wall model in the M3D-C1 code allows both quantitative comparison of simulation results with magnetics data. Both completed and ongoing efforts to couple the M3D-C1 code to a wide range of codes for integrated modeling of transport in 3D fields, the ultimate aim of which is obtaining predictive models of ELM suppression and particle transport, are also discussed.

Additional highlights describing last year workshop on the electromagnetic gyrokinetic particle-in-cell simulations conducted by the Theory Department on December 9-11: Edward A. Startsev presented a recently developed perturbative particle simulation scheme for finite-beta plasmas in the presence of background inhomogeneities. The proposed scheme is most suitable for studying shear-Alfven physics in general geometry using straight field line coordinates for microturbulence and magnetic reconnection problems and is now being implemented into general geometry turbulence code GTS. The results of initial GTS simulations of linear low-(m,n) shear-Alfven modes and current driven tearing modes in large aspect ratio circular cross section tokamaks were presented. The initial simulations of micro-tearing modes in slab geometry with sheared magnetic field were also discussed. W. W. Lee gave a short talk about the mathematical origin of the so-called cancellation problem. It came from the singularly perturbed equation used in the simulation, where the highest spatial derivative of the equation is multiplied

by a smallness parameter. It is related the electron skin depth. Numerically, the cancellation problem is avoidable, if the electron skin depth is used as the grid size for the simulation. A detailed discussion of the problem can be found in a recent paper [Startsev and Lee, Phys. Plasmas 21, 022505 (2014)].

The PPPL Theory Department is hosting Hyeon Park (KSTAR/POSTECH) and three of his Ph.D. students for the month of January as part of a Theory/ NSTX/ KSTAR collaboration on macroscopic stability. The focus of the collaboration is to apply PPPL codes such as M3D-C1 to explain experimental phenomena measured on KSTAR with the high-resolution electron cyclotron emission imaging system. As part of this visit, Minwoo Kim presented a seminar on "Comparative study of the observed ELMS with the synthetic images from the BOUT++ simulation in KSTAR H-mode plasma". Work is now underway to reproduce and extend the BOUT++ simulation results with M3D-C1.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

NSTX Upgrade (R. Strykowsky, E. Perry, L. Dudek, T. Stevenson):

Construction: Work continues on the final piece of PF bus inside the umbrellas and upper PF1B. Trial fit-ups of TF bus components inside the umbrellas continues with the focus on determining the extent of the machining required to make each of the 72 assemblies fit. The centerstack tilt fixture has been removed from the south high bay area and assembly tables for the TF bus have been set-up there. The installation of the TMB vacuum piping continues, as does electrical work for the TMB and RGA systems. The rough pumpdown of the vacuum vessel pointed out that the seal for the bay J mid-plane port had an issue, so the port cover has been removed and the seal is being replaced. Leak checking of the vacuum vessel continues. The replacement of the upper centerstack to vessel o-ring will be the next step. Trial fit-ups of the lower TF bus continues and machinists are adjusting the shims as each location is worked on. A sample rework for the upper center TF lead extensions is being tested before re-work begins. All PF bus is ready for final installation. The OH vertical bus is being insulated and will be available for final installation in a few days. TIV and gas injector wiring is being checked. Work on the PF hoses continues. Work on the ground switch monitor has been completed.

CS Upgrade: Tests for the torquing and pressure testing continued in the Material Test Laboratories. The torque required has been identified and is repeatable. As a verification of the pressure generated FUJI pressure sensing film has been ordered and received to perform one final set of tests. The fit up of the flex connections and OTF extensions continued this week. The TF Flag connection for the center leads at the top of the machine will require plugging and drilling of the existing holes. Samples are being fabricated from the rejected lot of lead extensions to verify the structural integrity of the repair. The OH water heater procurement is underway. The vendor drawings of the heater are on track to be completed by the end of the week. At PPPL the piping P&ID drawing and the calculation to support the design are underway. Once they are completed a FDR will be held in January. At CTD the first creep test was performed on OH test samples with good results and the modulus appears to be much lower then was used in the analysis so the stresses in the joints would also be lower. The remaining tests are underway.

NBI Upgrade: The VV and BL2 were pumped down for leak checking and VV leaks were identified. Work to ameliorate them is in progress. The BL2 vacuum integrity looks good at this time. Services work remaining includes finishing platforms and installing and connecting boxes and duct for elephant trunk stack stations. NBI DI water system repair on the piping on the MER mezzanine is in progress. Power testing of M/Rs continues. Controls work and troubleshooting continues with installation of cable, trays, and terminations in NTC and gallery. Work continues on the N gallery shield wall procurement with start of work imminent. Progress continues on BL PLC software pages. The NB and TVPS PLCs were made operational and connectivity established. I/O troubleshooting and testing is in progress. Cryogenics system Helium gas operations continues and all eight dewars of Helium were loaded into the tanks. Development of NB procedures continues and nears completion.

Digital Coil Protection System: A meeting was held to address all work needed to allow rectifier dummy load testing to commence. Two key DCPS items were discussed and will be addressed. These items were build integrity of the code and access security. Steps will be taken to address both issues. The Pre Testing Procedure continues. PTP and Operations procedure development for and including setup and startup of DCPS continues in preparation for rectifier dummy load testing. The SDD reliability assessment document is in approvals. Work continues on the DCPS buffer chassis implementation. DCPS integration into the PCS environment continues as part of RTC and PCS development. Consideration of parameter tree development to support PTP, dummy load, ISTP, and CD4 is in progress.

DIRECTOR'S OFFICE (C. AUSTIN):

On January 7, Edward Michael Campbell, Sandia National Laboratory, presented a colloquium entitled, "NIF An Unexpected Journey or Lessons Learned to Secure Projects of Scale".

S. Smith, S. Prager, A. Cohen and M. Zarnstorff traveled to Germantown, Maryland on January 8 to meet with DOE management about the PPPL program.

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