PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

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

U.S. ITER FABRICATION (C. NEUMEYER):

Steady State Electric Network (SSEN):

The department received DOE comments on its second submittal of the "Red Book" recommending award of contract for Reactive Power Compensators procurement.

The department submitted DOE Performance Plan Milestones for FY16.

Diagnostics:

Electron Cyclotron Emission (ECE): Optical analysis of the turning flat mirror design showed inferior focusing performance in operation mode because the distance from the elliptic mirror to the plasma increased. A decision was made to return to original shutter/mirror design, with a new actuation mechanism. At the University of Texas, Austin, testing of the hot calibration source started with conditioning of the Inconel heater in atmosphere.

Equatorial Port 9 (EP09) Integration and Engineering: Two significant developments for EP09 this week are the site visit by IO's Julio Guirao and a separate IO briefing on the latest generic equatorial port plug dimensions. Guirao has shared significant analytical results that will guide EP09 design and analysis going forward and he has offered a detailed description of the updated generic DSM mount design. The DSM mounts will now be incorporated into the EP09 design. The IO briefing provided several dimensional revisions to port plug and DSM structures that will update the EP09 integration.

Diagnostic RGA (DGRA): THERMOCOAX was recently awarded a subcontract to provide a prototype heated aperture weldment that is similar to the one that will be provided as part of the LP12 DRGA. A preliminary fabrication drawing was provided by THERMOCOAX for review, and feedback was provided; final design drawings are expected within a few weeks. A working meeting between H-alpa, LFSR, and DRGA was held to discuss clashes within the EP11 PCSS, and a means of resolving the clashes was agreed. Work is underway to implement the changes and verify the solution is acceptable to all parties.

Toroidal Interferometer and Polarimeter (TIP): D. Johnson and Christopher Watts (IO) met this week with the developers of the ITER TIP diagnostic at General Atomics. The newly constructed prototype beam line, real time alignment system, and interferometer/polarimeter were operational and demonstrated. This prototype will be used over the next year to investigate a

number of design issues.

CATIA/ENOVIA: M. Messineo travelled to ITER last week. He spent the week meeting with various members of the ITER CATIA design and administrative staff. Effective use of CATIA within the ITER model and drawing management system is a critical part of the US ITER work in diagnostics and port plugs. Some of the issues discussed were the embedded TIP CCR interface with heating beam blankets, the use of SolidWorks by General Atomics for the preliminary design of the Upper Port Wide Angle cameras, and the status of P&ID and cabling diagrams for all the diagnostic systems.

The department submitted DOE Performance Plan Milestones for FY16.

NSTX (M. ONO):

The Final Report on the FY15 JRT was sent to DOE/FES summarizing joint activities by C-Mod, DIII-D, and NSTX-U staff to study the impact of broadened current and pressure profiles on tokamak plasma confinement and stability. NSTX-U was the coordinating facility, with M. Podesta (PPPL) leading the Coordination Committee and redacting the Final Report. Activities by NSTX-U and collaborators included work on all three facilities. Joint research with DIII-D mainly focused on the unification of kinetic RWM stabilization physics and on the assessment of AE mode effects on reduction of plasma performance in high q-min scenarios. Both areas of research are expected to benefit from—and be complemented by—planned experiments on NSTX-U in FY16. NSTX-U staff also developed improved tools for the analysis of scenarios with LH current drive, with direct applications to C-Mod scenarios. New tools have been developed to (i) quantify LHCD through the TRANSP code and (ii) to assess the role of impurity accumulation and its dependence on heating and non-inductive current profiles.

High Harmonic Fast Wave (HHFW) transmitters one and two were operated up to 1MW, 500mS successfully. Number two did show some RF arc-downs at low power as we started it up but "cleaned up" as we went to high power. Some investigations were done at low frequencies with an FFT oscilloscope to see if the "arc-down" might be a low-frequency instability phenomenon. Nothing was observed ~200MHz and below (CB, NG, AC, GD). We are now ready to begin vacuum conditioning of the HHFW antenna on NSTX-U as soon as bakeout is completed.

The NSTX-U vessel bake resumed this week after the installation of the rebuilt roots blower on the GHe skid. The GHe skid pressures and temperatures have been optimized for peak tile temperatures, and operation has been stable throughout the week. Vacuum vessel helium glow discharge cleaning was also performed once we were up to temperature.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

Efforts to parallelize DCON are intended to accelerate its runtime sufficiently to enable its use for real-time stability control on tokamaks. Thus far, this parallelization has been implemented using OpenMP API on DCON's Fortran code. Parallelizing calls to some of DCON's more costly

linear algebra calculations (undertaken at singular surfaces) has already achieved a 25% reduction in DCON's runtime (from 5.54s to 4.14s) when DCON is run using 50 modes. The greatest benefit of parallelization is expected to be achieved by parallelizing each of DCON's modes as they are integrated across magnetic surfaces. This work is underway to reduce DCON's runtime significantly further.

Simulations using the fully kinetic code XGCa are being undertaken to explore the impact of kinetic effects on scrape-off layer (SOL) physics in DIII-D H-mode plasmas. Currently, a sheath-limited SOL regime DIII-D discharge is under investigation. Time and spatial convergence simulations were run to verify initial simulations, showing only a modest change in divertor plasma parameters for the higher spatial resolution simulation. A new simulation incorporating an improved boundary potential solver and improved treatment of the effect of recycling neutrals is currently in-process on the Mira supercomputer at Argonne National Laboratory.

C-Mod (S. Scott):

The newly-commissioned MSE background polychrometer, jointly developed over the past 16 months between the Plasma Science and Fusion Center and PPPL, performed its first measurements in support of physics experiments on the last run day of the Alcator C-Mod FY15 scientific campaign. It measured the polarized emission from visible synchrotron radiation produced by relativistic runaways in MP#730, "Runaway Electron Growth and Decay during Quiescent Flattop". The emission is observed to be intense (orders of magnitude brighter than the emission generated by the diagnostic neutral beam) and highly linearly polarized. The polarization direction changes by ~90 degrees across the emitting region, as predicted by theoretical modeling.

International (R. Hawryluk):

R. Hawryluk attended an ITER External Management Advisory Board (EMAB) meeting, whose focus was the upcoming assembly work by the IO-CT.

J.-K. Park has participated in various 3D field and momentum transport experiments in the 2015 KSTAR campaign and led the two experimental sessions: MP2015-06-02-030 (“Coherent and Continuous Phase-shift Sweeping Using All Three Rows of Internal Coils”) and MP2015-06-02-002 (“Variation of Parametric Dependency of Magnetic Braking”).
In the first group, experiments were designed to rotate n=1 field at the top row and counter-rotate n=1 field at the bottom row of coils, while holding the n=1 field phase at the midplane coils, in order to effectively create all possible n=1 field configurations periodically during a single discharge. The goal was to identify the optimal n=1 configuration, i. e. phase-shifts (phasing) among 3 rows, for ELM mitigation and possibly full ELM suppression. The experiments show that ELM mitigation, as well as density pumping, can be maximized near 150 phasing. However, the full ELM suppression could not be achieved, mainly because such a favorable phasing for ELM modification was also favorable to mode locking in the studied target discharges. The observation is rather consistent with the ideal response prediction, which indicates the difficulty in separating multi-modes when using n=1, while in the past it was possible to separate coupling to ELMs from coupling to mode locking in the successful n=1 ELM suppression. There are many differences between the present and past discharge conditions, such as shapes and heating powers, which will be further investigated in details.

The second group of experiments were proposed to establish magnetic rotation braking characteristics in KSTAR and build comprehensive database to verify and validate NTV physics in conventional tokamaks. New 3D-coil power supplies and long shot durations enabled various braking pulse applications during a single shot, and in total near a hundred braking profiles were obtained in various discharge conditions without tearing or mode locking. Interestingly, most of magnetic braking accompanied substantial density pumping, similarly to what has been observed in RMP ELM experiments, except highly non-resonant n=2 zero-degree phasing configuration. NTV alone is typically not expected to provide strong enough particle transport to modify density profiles. Moreover, more resonant configurations led faster evolution and relaxation in density and rotation, possibly also indicating other transport mechanisms. Several response and NTV modeling codes will be applied for comparison, but possibly additional modeling such as fast ion losses might also be important to explain and understand the various observations in both particle and momentum channels.

ADVANCED PROJECTS (H. NEILSON):

The department's stellarator team contributed strongly to the International Stellarator-Heliotron Workshop held from October 5-9 in Greifswald, Germany. N. Pablant made an invited oral presentation, "Evolution of the Radial Electric Field in High-Te Electron Root Plasmas on LHD". Poster presentations included the following: "Error Field Detection and Correction on W7-X" by S. Lazerson, et al; "Recent Advances in Stellarator Optimization" by D. Gates, et al.; and "Overview of the US Wendelstein 7-X Program" by H. Neilson, et al. Overall, workshop participation exceeded the organizers' expectations by almost 40%, a measure of the growing importance of stellarator research internationally and expectations for the newly commissioned Wendelstein 7-X (W7-X) experiment. The workshop included a tour of the W7-X facility and a review of the project history by Project Director T. Klinger. The government operational readiness review process is pacing the W7-X schedule and first plasma is now forecast for mid-November.

THEORY (A. BHATTACHARJEE):

A. Reiman gave a talk and presented a poster at the International Stellarator and Heliotron Workshop, held in Greifswald, Germany. The title of the talk was "A Cross-Benchmarking Initiative for Tokamak 3D Equilibrium Calculations". The title of the poster was "Effects of Weak Pressure Gradients along Magnetic Field Lines, and of Stellarator Symmetry, in Plasma Equilibria with Magnetic Islands".

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

N. Bertelli and E. Valeo attended the Annual RF SciDAC workshop at ORNL from September 28 to October 2. Four contributions have been presented: "Effect of the Scrape-off Layer in AORSA Full Wave Simulations of Fast Wave Minority, Mid/High Harmonic, and Helicon Heating Regimes"; "Finite Element Methods for Simulating RF Wave Propagation in Plasmas";

"Non-Maxwellian Extensions of TORIC v.5 in HHFW and Minority Heating Regimes"; and "Overview of the Kinetics Only Delta-f Method".

BUSINESS OPERATIONS (K. FISCHER):

Budget Office:

The DOE Office Science approved PPPL's Laboratory Directed Research & Development (LDRD) plan for FY2016 at a maximum funding level of $3.0 million.

DOE approved the renewal of eighteen LDRD projects for FY 2016. The total budget allocated for these projects is $2.15 million against the $3.0 million LDRD funding ceiling approved by DOE.

A Strategic Partnership Project agreement with Corning Incorporated entitled “Corning Glass Analysis” was approved by DOE. The total funding to be provided to PPPL is $25,000; the Principal Investigator is G. Ascione.

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