PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending October 23, 2015 are as follows:

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

Steady State Electric Network (SSEN):

The department has now received all input documentation for the Release for Manufacturing of the SSEN Power Transformers under subcontract with Schneider Electric, Çayirova-Kocaeli, Turkey.

Diagnostics:

Motional Stark Effect (MSE) Diagnostic: A kickoff meeting was held between PPPL, Nova Photonics, and the IO for the start of Phase I of the MSE system design contract. J. Klabacha presented the project management and documentation requirements for contract fulfillment. Bill DeVan presented MSE I&C planning to date and B. Stratton presented work done at General Atomics on MSE-LS analysis. Maarten DeBok from the IO presented the status of mirror cleaning, neutral beam developments, and MSE developments at the IO since the MSE CDR. PPPL Quality Assurance is working with Nova Photonics on the project quality document and detailed resource loaded schedules will be developed next week to get the technical work started.

Diagnostic Residual Gas Analyzer (DGRA): DRGA prototype testing continues at Oak Ridge National Lab. The hardware required for the magnetic field effects testing has been reviewed and approved by ORNL Electrical, so the equipment is ready for use. All vacuum components for the gas mixing station have been received and should be assembled within the next week. A new valved flange has been prepared for the analysis chamber which will allow the introduction of mixed gases as well as provide the ability to remove hardware without venting the vacuum chamber.

Toroidal Interferometer and Polarimeter (TIP): The TIP mirrors closest to the plasma must be water-cooled to avoid thermally induced optical distortion. Ideally, they would also be adjustable to allow initial alignment of the beams to the retroreflectors after the port plug is fully assembled. R. Wood is developing a concept that would permit adjustment and locking of these mirror positions, using a long tool reaching through the diagnostic aperture in the first wall of the port plug.

Upper Wide Angle Viewing System (UWAVS): General Atomics, PPPL's UWAVS vendor, completed the field of view (FOV) evaluation for determining the divertor coverage vs.

performance requirements. The current design exceeds the required divertor coverage. TNO (General Atomics' vendor) continued detailed design of the mirror cleaning test chamber. General Atomics has begun to design the bullnose connection to the FEOT, following the remote handling code of practice.

NSTX (M. ONO):

J. Menard (PPPL) travelled to the Culham Centre for Fusion Energy (CCFE) in Culham, England to attend a status and review meeting for the MAST Upgrade project and to serve on the CCFE Program Advisory Committee (the dates for this visit were October 20-23). He then travelled to Morgantown, West Virginia (October 24-25) to attend the annual meeting of the APS Mid-Atlantic Section to present an invited talk entitled “Progress and Plans for NSTX Upgrade and Prospects for Next-step Spherical Tori”.

S. Sabbagh (Columbia University) attended the Meeting of the ITPA Topical Group on MHD, Disruptions and Control held October 19-22 in Naples, Italy. He presented on the progress of the ITPA joint experiment MDC-21 “Global MHD Mode Stabilization and Control” on behalf of the international researchers in the group. The results included analysis of the NSTX database partially addressing a critical ITER need regarding the maximum allowable global mode perturbation amplitude tolerable by tokamak plasmas before a disruption occurs. The analysis was processed in part by a new Disruption Event Characterization and Forecasting code (DECAF) being developed on NSTX and used here for the first time to analyze a tokamak database. Initial results from this code that automatically characterized disruption event chains were sent to joint experiment MDC-22 on Disruption Prediction, and Gabriella Pautasso, the leader of that group, reported the results at the meeting.

R. Raman (University of Washington) visited the University of Washington from October 1-16 to assemble and test the prototype of a compact power supply to be used for powering the new MGI valves on NSTX-U. Duplicates of the capacitor bank components to be used on NSTX-U were assembled inside two 19-in rack mount boxes, and the assembled hardware used to operate an MGI valve mounted on a test stand with a 1.3m^3 vessel volume. All power components were successfully tested. The design of the power supply system was also discussed during a Conceptual Design Review held at PPPL on October 16. Some of the changes recommended during the review were then incorporated into the power system hardware, and the system tested again to demonstrate successful operation. In previous tests, the MGI valve has been operated in the presence of 1 T magnetic fields, as well as on the University of Washington test stand (but using a different, non-compact power supply).

S. Kaye (PPPL) participated in the Transport and Confinement ITPA meeting held in Garching, Germany on October 23-24. Prior to the ITPA meeting, he coordinated a small group discussion on updating and reanalyzing the International H-mode database. The motivation for doing this was to close gaps that existed in the present database, which contains very few discharges that approach the conditions of the ITER-baseline H-mode plasma. The reanalysis will also take a critical look at intra-machine vs. inter-machine parametric trends to understand the source of differences. One such trend is the density scaling. Kaye reported on the discussions that took place and action items that were identified at the ITPA meeting.

A series of 17 talks for new Physics Operators on NSTX-U that began in July was completed last week. 20-30 scientists and engineers attended each talk, only a few with the intent of becoming operators. Most came to learn more about NSTX-U and/or how they could use that knowledge to perform better experiments on NSTX-U. The course schedule and the presentations are available at: http://nstx.pppl.gov/DragNDrop/Operations/Physics_Operations_Course/. These presentations provide a rich set of reference materials about machine capability, configuration details, and operational techniques and limitations that can be hard to find elsewhere. Videos of the presentations can be viewed from the internal PPPL Employees Services Home page by clicking on PPPL Videos and then clicking on Training (http://cctest.pppl.gov/KalturaAPI.aspx?x=PPPL%3ECourses%3Ephysics%20Operators%20Training%20Course).

The NSTX-U vessel bake was completed this past week, and systems are being configured for operations. Technicians are checking for a small air leak that developed during the machine cool-down. There will now be a two-week period of diagnostic system installations and calibrations before "scrubbing" the test cell areas and resuming coil system testing and operations.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

R. Nazikian presented an overview talk at the H-mode workshop in Garching on recent progress in the use of 3D fields for ELM control. B. Grierson presented a talk on the progress in predictive modeling of high beta poloidal plasmas on DIII-D with internal transport barriers. He also presented a talk on modeling the high poloidal beta steady state scenario indicating successful recovering of the non-inductive current and ion energy transport and challenges with electron thermal and particle transport with TGLF. R. Maingi presented a talk on the latest results in lithium granule pacing. Maingi also presented a poster by A.Bortolon on "High Frequency ELM Pacing by Lithium Pellet Injection on DIII-D".

Grierson attended the Transport & Confinement ITPA meeting in Garching, Germany. Recent research on electron heating in the DIII-D ITER baseline was presented at the ITPA and indicates that the TGLF transport model captures changes in core confinement. Specific links between energy, particle and momentum transport have been made that associate electron heating with increased momentum transport, as well as possible density peaking. An intrinsic rotation database of low torque DIII-D discharges for a variety of conditions (βN, ν^*, L-mode and H-mode) has been compiled and will contribute to an ITPA database. In some of these discharges, core rotation "reversals" of main-ion and impurities have been observed and are being explored with gyrokinetic and quasi-linear models. Also, first results from the DIII-D edge main-ion CER system were reported. Nazikian and Maingi also participated in the ITPA Pedestal and Edge Physics (PEP) and Transport and Confinement (T&C) group meetings in Garching.

Professor N.C. Luhmann, Jr. (University of California, Davis) visited DIII-D this week to meet with PPPL collaborators and DOE program managers to discuss ongoing scientific efforts in the areas of energetic particle confinement, ELM physics, and disruption prediction/avoidance. Two University of California, Davis graduate students, Ming Chen and Xing Hu, will visit DIII-D in the coming months to explore ways in which MIR and ECEI data can contribute to the validation

of computational modeling of coherent and broadband EHO types observed in recent QH-mode experiments. Additionally, Luo Chen, a University of California, Davis post-doctoral researcher, will collaborate on-site to support FY16 experiments with new ECE-Imaging and MIR capabilities, including tests of recently developed CMOS and liquid crystal polymer (LCP) sub-assemblies that promise improved signal-to-noise and diagnostic resolution at reduced cost.

B. Tobias has shown that the coupling of tearing modes on DIII-D produces substantial nonlinear torque density that redistributes momentum in the core, flattening and even inverting the rotation profile in hybrid and ITER baseline scenario development discharges. Modes of different n-number, such as 3/2 and 2/1 neoclassical tearing modes, are linearly independent in a simplified, axisymmetric geometry. However, their nonlinear coupling is shown to produce forces that easily cancel neutral beam injection in the core and produce a phase-locked composite structure. Anomalous momentum transport of this kind has also been observed for low amplitude, core localized modes of higher order, such as nonlinearly coupled 5/4 and 4/3 tearing modes, and it is suspected to contribute to the evolution of these discharges toward core momentum collapse, 2/1 instability, and eventual locked-mode disruption.

A team led by A. Nagy and comprised of A. Borotolon, W. Brown, and M. Vornkamp held a successful FDR on the PPPL Lithium Granular Injector Upgrade on DIII-D (LGI); it covered aspects needed to make the LGI fit into a much tighter footprint. Upgrades included a granule dropper/counter, a plasma ablation monitor, an adjustable drop tube/impeller interface (enabling both lithium and carbon granules to be injected without breaking LGI vacuum, which can be changed between shots), an impeller electric motor drive, and narrowing the foot print to 10 in. nominal. The LGI was successfully tested for injecting carbon granules and is being prepared for installation in time for the next DIII-D experimental campaign.

International (S. Scott):

S. Scott and J. Strachan completed an eight-day visit to JET to discuss the neutron deficit issue with JET staff. Over a wide range of plasma conditions the measured JET DD neutron rate is less than that predicted by TRANSP using the measured profiles and beam parameters by 0 to 50%. Strachan presented a talk at the JET task force responsible for DT preparations that summarized our database evaluation of 100 TRANSP runs, which show that TRANSP's predicted neutron emission rate for thermonuclear, beam-target and beam-beam reactions are well fit by power-law regressions that include parameters relevant to beam thermalization physics (e.g. Pinj, Te, <E_beam>, and nd/ne for beam-target reactions). The measured neutron emission is well fit by the regression to TRANSP's predicted total neutron emission over a factor of 20, albeit with a lower magnitude given by the neutron deficit. Restricting to a narrow range in injected power, the measured neutron rate scales with temperature as one would roughly expect from fast ion slowing-down. There is no evidence that the deficit scales with parameters that correlate with drive mechanisms for beam-ion-driven instabilities. Taken together, these observations suggest but do not prove that the neutron deficit is a caused by mis-measurement of some parameter(s) that affect the actual neutron emission rate or its measurement rather than by some plasma physics effect.

R. Hawryluk participated in an ITER External Management Advisory Board video-conference meeting.

ADVANCED PROJECTS (H. NEILSON):

A PPPL study team has completed the first phase of a study which aims to identify a range of missions and associated program elements for a world-leading U.S. stellarator initiative, including a new major experimental facility. The team has documented a strawman mission need case as well as gaps in fusion science and opportunities that compel a significant U.S. move into stellarators. The mission need case is based on the fact that achieving steady state operation and avoiding deleterious transients are major challenges for MFE, and that research on tokamaks alone is unlikely to lead to solutions. Stellarators offer promising solutions to these problems. Although there exists a world program developing stellarators, including two large experiments, advances in understanding and capability since those machines were designed (circa 1990) offer opportunities to make quantum improvements in end products, relative to those lines. A U.S. initiative that takes advantage of advances and moves fusion forward could be world-leading in the 2020s and 2030s.

N. Pablant presented an invited talk at the International Stellarator-Heliotron Workshop (ISHW) in Greifswald, Germany. The talk was entitled "Evolution of the Radial Electric Field in High-Te Electron Root Plasmas on LHD". Following the conference, Dr. Pablant remained at IPP to participate in the initial formal discussions on experimental proposals for the OP1.1 experimental campaign.

THEORY (A. BHATTACHARJEE):

S. Jardin attended the ITPA MHD Topical Group meeting in Napoli, Italy and presented on "3D Modeling of NSTX Vertical /Displacement Events with M3D-C1", co-authored by N. Ferraro.

W. W. Lee attended the recent European Fusion Theory Conference in Lisbon, Portugal earlier this month and presented a poster entitled “Recent Progress on Finite-Beta Gyrokinetics” in which a set of reduced equations derived from the electromagnetic gyrokinetic Vlasov-Maxwell equations was discussed. This set of equations for collisionless plasmas, consisting of the pressure balance equation, the vorticity equation, and the Ohm’s law, is energy conserving and, in the absence of fluctuations, recovers the usual MHD equilibrium.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

E. Feibush presented "Python Programming Techniques" as a mini-course sponsored by the Princeton Institute for Computational Science and Engineering on October 21. Researchers from 14 different university departments attended. The hands-on programming session emphasized the elements and features of Python and how it can be used in a scientific workflow. Tools and techniques for self-paced learning of Python were demonstrated. PPPL interns J. Lee and Z. Stier served as teaching assistants and facilitated the programming exercises.

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

I. Kaganovich attended Frontiers of Plasma Science Workshop in the Washington DC area, where he led discussions for the Panel on Plasma Self-organization. The final workshop in the series of Frontiers of Plasma Science workshops has a finalized plan for a future report to identify compelling scientific challenges at the frontiers of plasma physics; with research tools and capabilities that exist presently, as well as the general requirements necessary to address these challenges in the next decade (http://www.orau.gov/plasmawkshps2015/).

DIRECTOR'S OFFICE (C. AUSTIN):

On October 21, Dr. James Burch, Southwest Research Institute, presented a colloquium entitled, "Reconnection at the Dayside Magnetopause from MMS".

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