Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending February 24, 2017 are as follows:

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

R. Feder, E. Nassar, M. Viola, A. Basile, and H. Neilson traveled to the U.S. ITER Project Office for a focused Diagnostics project review led by Federal Project Director Bill Cahill. The review was very thorough with a deep focus on WBS 1.5.3 technical scope, progress, and project management. Control account managers (CAMs) for four PPPL Diagnostic's projects were interviewed, involving a close inspection of cost and schedule estimates, basis of estimates and important project management practices. There were also pointed discussions on diagnostic system subcontract management and the future strategy for fabrication subcontracts. Overall, the review was deemed successful in giving Department of Energy's ITER Project Office a better understanding of the responsibilities and challenges within the Diagnostics and Port Plug Integration work scope.

ITER Steady State Electrical Network (J. Dellas):

Power Transformers: All shipments have arrived at the ITER site. The IO has inspected the last shipping batch, which contains the accessories, and the preliminary inspection report is satisfactory. The supplier has reviewed a report on IO's inspection of the contents of the weathered crates and will visit the IO on February 27 to inspect the accessory items for which some minor water infiltration occurred.

Reactive Power Compensators: Manufacturing at the Schneider Pringy, France, factory is ongoing. The factory acceptance tests (FATs) for the first two lots have been completed. Documentation towards achieving release for shipment (RFS) approval for the first two shipping lots are being received from the supplier but extra effort continues to be required, as the supplier has been very slow in producing. However, documentation is now close to completion and the supplier's upper management has been engaged to help facilitate the final preparation. The packaging inspection for the first two shipping lots (1 & 2) and the FAT for the last two lots (3 & 4) have been scheduled for March 14-17 at the supplier's factory in Pringy, France.

Uninterruptible Power Supply (UPS) and DC Distribution: Regular coordination meetings for both contracts are ongoing to facilitate preparation of Release for Manufacturing documentation packages. For UPS, testing will be required to be performed at two locations. The factory in Wettingen, Switzerland will perform some tests, and for the higher power testing, a facility in Montbonnet, France will be used (equipment to be shipped between locations by supplier). Documentation for obtaining RFM for the DC Distribution has been approved in IDM. UPS documentation continues to be prepared and uploaded in iDOCS/IDM for approval.

ITER Diagnostics (R. Feder):

Diagnostic Residual Gas Analyzer (DRGA): Hiden 80-m cable testing was initiated. Early indication is that system performance is consistent with MKS RGA system used on the R&D prototype.

Upper Wide Angle View VIS-IR Cameras (UWAVs): Significant progress was made on two fronts. The visible and infrared camera selection has been finalized in the Back End Optical Chamber. The final mirror cleaning experiment has been very successful. After 15 hours of cleaning using 5 Pascal of He gas at a frequency of 37 Hz, 100% of the Aluminum, Aluminum Oxide and about 50% of the Tungsten contamination was removed from the Molybdenum mirror test sample.

Upper Port Plugs 11 & 14: Response to the PPPL's QA Audit findings for Document Deliverable Check-List (DDCL) was submitted. Each ITER Diagnostic System has a DDCL that needs to be submitted prior to PDR/FDR. The ITER Diagnostic team has created such a list and is going to update & track this list for upcoming PDRs. UP14 team had a monthly meeting with the IO to resolve DMS integration issues. A follow-up meeting is scheduled on March 6 at ITER.

Toroidal Interferometer/Polarimeter (TIP); Initial interferometer and polarimeter data was successfully obtained using the single channel TIP prototype on DIIID. This prototype mimics most of the design features of the ITER TIP system, and a test program is being drafted to use the system over the next six months to optimize the ITER design.

Core Imaging X-Ray Spectrometer (CIXS): The MIT CIXS subcontract for additional research and development work has come to a close. Work is continuing on the report that will cover the subcontract work.

Motional Stark Effect (MSE): There was difficulty with the turbo pump that will be used for the mirror coating chamber. The PPPL shop inspected the pump and spare parts were found. The pump was repaired and seems to be working fine. A stress test will be done to confirm that the pump will be functional. Also a replacement pump was found through the NSTX project, this pump would be used if the repaired pump fails.

I&C Support Team: Held I&C meetings with TIP team to review their EA progress, and with ECE team to ascertain R2A2's. Reviewed IO-written Interface Sheets for each diagnostic and fwd to s/c principals. Began process to reserve IDM and iDoc numbers for SRS; DeVan requested SDS numbers. Continued work on getting-started aids for the IO's EA tools. WAF work on hold while Emil is at US-ITER offices.

Vacuum Electrical Integration; DM model is finished. First Contact to RSDA for MI cable termination and implementation development was made.

Hard Core Components (HCC): Preparing documentation for Meeting at IO next week

ITER Analysis Team: Significant progress has been made on the EM and structural analysis for the upper port 11 to provide independent load inputs to the Load specification. The U14 ISS/PCS

CAD model integrated with tenant system for seismic analysis has been set up and ready for review of the attachment boundary condition. A review meeting of the CAD model will be scheduled later this week. The ISS/PCS analysis will provide input loads to the tenant systems.

NSTX-U RECOVERY PROJECT (R. HAWRYLUK):

The sixth Design Verification and Validation Review (DVVR), reviewing the NSTX-U Cooling Systems was held this week. The review was chaired by V. Riccardo, head of engineering. External reviewers included Geoffrey Gettelfinger, department manager of the Physics Department at Princeton University; as well as Seokho Kim, of the ITER project office at Oak Ridge; Jim Irby and Brian La Bombard, of MIT's Plasma Science and Fusion Center; Dennis Youchison, of Oak Ridge National Laboratory; and Tom Todd, chair of the Extent of Condition Committee. The next DVVR will review the NSTX-U power systems. The chits are now being organized into corrective actions for the upcoming external Extent of Condition review.

Silver-plating of the upper and lower umbrella outer TF Bus connecting surfaces has been completed in the Test Cell, and plating of the CHI bus connections is in progress. Installation of waveguides and the configuration of electrical systems for the FIReTIPS diagnostic continues, and the installation of Pulse Burst Laser System (PBLS) equipment in Diagnostic racks in the Gallery has been completed. Recommissioning of the coil winding facility also continued with the completion of the painting and insulation of the bake-out oven, and the successful leak checking and hydrostatic test of conductor copper for the PF1A coil. Alignments of the pivot beam and tape winder have been completed, and final adjustments of the tape machine are in progress.

Voith Hydro contract work on the MG#1Thrust Bearing work is expected to resume on Monday. Fluidics representatives have successfully tested the first two MG heat exchangers to 75 PSIG and are assembling the third today. The PPPL Tech Shop is expected to complete a new baffle plate today as needed to assemble the fourth and last heat exchanger. Ion Source work continues in the Neutral Beam (NB) decon facility, and testing of the NB#1 calorimeter drive is in progress.

NSTX-U RESEARCH (J. MENARD):

Tariq Rafiq visited PPPL on February 21 and discussed with S. Kaye and W. Guttenfelder the numerical results obtained with a reduced transport model for microtearing modes. The reduced microtearing mode model, developed at Lehigh University, employs a unified fluid/kinetic approach and allows the inclusion of nonlinear effects due to magnetic fluctuations in the derivation of the nonlinear dispersion relation. The objective is to efficiently describe, in integrated predictive model studies, the evolution of the plasma in devices in which microtearing modes have a significant role. The dependence of the microtearing mode real frequency and growth rate on plasma parameters, appropriate for high collisionality NSTX discharges, is obtained using the reduced transport model. The results obtained are compared and found to be consistent with the microtearing mode results obtained at PPPL using the gyrokinetic code GYRO. The electron temperature gradient along with the collision frequency and plasma beta are sufficient for microtearing modes to become unstable in NSTX high collisionality discharges.

The effects of low current density, low density gradient, and large magnetic shear are found to be destabilizing resulting in increased transport.

ITER & TOKAMAKS (R. NAZIKIAN):

International:

R. Maingi presented a talk via ZOOM "Update on PPPL International Programs in I&T" to M. Lanctot, J. Mandrekas, and J. vanDam. An update on activities, connections to the domestic programs, and emerging opportunities on EAST, KSTAR, and JET was presented. Discussions on ASDEX-Upgrade, and JT-60SA addressed emerging opportunities. Work on an ITER task agreement on EC heating for NTM control was also summarized.

DIII-D:

The ECE-I imaging system on DIII-D has obtained excellent images of Alfven eigenmode activity in the variable beam experiment that was conducted on February 15 and February 16. The ECE-I cameras covered the low field side of the plasma from rho=0.2 to 0.9. The images show that at the onset of beam injection the phase fronts of the Alfven eigenmodes are strongly sheared in the poloidal direction while later in time this shearing disappears. These measurements will serve as a useful test of gyro kinetic and fluid descriptions of Alfven eigenmodes.

Jai Sachdev visited General Atomics to coordinate efforts for TRANSP analysis and simulations using OMFIT. Meetings were held with key OMFIT developers and TRANSP users at DIII-D to discuss research needs and future plans, including Sachdev's primary activity for pellet injection and ablation modeling using TRANSP. During the visit, Sachdev was able to successful run TRANSP through OMFIT for NSTX plasmas by following the online tutorials, and establish computer access to DIII-D servers and submitted TRANSP runs through the Open Science Grid.

ADVANCED PROJECTS (H. NEILSON):

Stellarators (D. Gates):

On February 23 a kickoff meeting was held for a new LDRD activity entitled "Stellarator Configuration Investigation". The purpose of this study is to explore the quasi-axisymmetric equilibrium space for a Stellarator configuration with additional optimization constraints beyond those of The National Compact Stellarator Experiment (NCSX) including: simplified coils, turbulent transport optimization, and divertor optimization while including force minimization in the coil optimization process. Initial work plans were discussed along with the overall goals of the study.

System Studies (C. Kessel):

H. Neilson, T. Brown, P. Titus, A. Khodak, D. Mikkelsen, and C. Kessel held a conference call with the Korean-DEMO design group to discuss progress on the collaboration. Helicon wave

simulations were reported by Mikkelsen, time dependent simulations of K-DEMO with TSC were reported by Kessel, and neutronics simulations were reported by Jongsung Park (NFRI). Proposals for new PPPL work during the next period were discussed, including plasma rampup phase, high field side heating and current drive, layout and maintenance topics, thermo-mechanics analysis for normal operation, disruptions and accidents.

THEORY (A. BHATTACHARJEE):

A workshop that initiated collaboration between PPPL, Princeton University and the University of São Paulo (SPU) took place on February 21 at PPPL. The workshop discussed recent research at PPPL and SPU in the areas of energetic particles and low frequency oscillations in tokamaks. Professor Ricardo Galvao of the University of São Paulo and PPPL Principal Research Physicist N. Gorelenkov provided general overviews of the work performed at each laboratory. They highlighted recent studies conducted on their own facilities and research performed on international devices in collaboration with other institutions. Subjects included low-frequency Alfvenic and sub-Alfvenic instabilities that affect the confinement of energetic ions in toroidal devices. Other subjects included, "Experimental studies of EP-driven modes with observations of their chirping," by E. Frederickson, principal research physicist at PPPL; "Geodesic mode instability driven by electron and ion fluxes during parallel beam injection in tokamaks," by Fabio Camilo de Souza, a graduate student at SPU; "Theoretical studies of low frequency GAM branches and their applications for the physics of fast particles," by SPU Professor Artour Elfimov; "EP-driven chirping and line-broadened quasilinear theory," by Vínicius Duarte, an SPU graduate student currently at PPPL; "Energy channeling of NBI power to thermal electrons via discovered coupling of compressional Alfven eigenmode to kinetic Alfven waves," by E. Belova principal research physicist at PPPL; "Simulations and theory of compressional and global Alfvén eigenmodes in NSTX," by Jeff Lestz, a graduate student at PPPL; and "Alpha channeling in advanced fusion concepts" by Professor Nat Fisch, director of the Princeton Program in Plasma Physics.

Benjamin J. Sturdevant, University Colorado at Boulder, presented a Theory Seminar titled "Low-Frequency delta-f PIC Models with Fully Kinetic Ions" on February 22. The abstract reads: "A fully kinetic ion model is useful for the verification of gyrokinetic turbulence simulations in certain regimes where the gyrokinetic model may break down due to the lack of small ordering parameters. For a fully kinetic ion model to be of value, however, it must first be able to accurately simulate low-frequency drift-type instabilities typically well within the domain of gyrokinetics. In this talk, we present a fully kinetic ion model formulated with weak gradient drive terms and applied to the ion-temperature-gradient (ITG) instability. A delta-f implementation in toroidal geometry is discussed, where orthogonal coordinates are used for the particle dynamics, but field-line-following coordinates are used for the field equation, allowing for high resolution of the field-aligned mode structure. Variational methods are formulated for integrating the particle equations of motion, allowing for accuracy on a long time scale with modest timestep sizes. Finally, an implicit orbit averaging and sub-cycling scheme for the fully kinetic ion model is considered."

Shunsuke Usami, National Institute for Fusion Science, Japan, presented a Theory Seminar on February 23 titled "Studies on proton effective heating in magnetic reconnection by means of particle simulations". The abstract is: "By means of two-dimensional electromagnetic particle

simulations, ion heating mechanism is investigated in magnetic reconnection with a guide magnetic field. These simulations mimic dynamics of two torus plasmas merging through magnetic reconnection in a spherical tokamak (ST) device. It is found that protons are effectively heated in the downstream by the pickup mechanism, since a ring-like structure of proton velocity distribution, which is theoretically predicted to be formed by picked-up ions, is observed at a local region of the downstream. Furthermore, based on the theory by J. F. Drake et al., only heavy ions were believed to be heated by suffering the pickup mechanism, however it is pointed out that the pickup of protons is consistent with the theory in the cases that the plasma beta is much less than 1 in the upstream, which can be satisfied in STs".

OFFICE OF ACADEMIC AFFAIRS (N. FISCH):

Graduate Student Thesis Defense Presentations: Vasily Geyko successfully earned his PhD on January 30 by presenting his thesis project, titled, "Physics of Spinning Gases and Plasmas ". His committee members were: G. Hammett (Chair), N. Fisch, and I. Dodin. Fisch was his adviser.

Chang Liu successfully earned his PhD on February 3 by presenting his thesis project, titled, "Runaway Electron in Tokamaks ". His committee members were: I. Dodin (Chair), D. Brennan, A. Bhattacharjee, and G. Fu. Brennan and Bhattacharjee were his advisers.

James Mitrani successfully earned his PhD on February 28 by presenting his thesis project, titled, "Monitoring Nanoparticle Synthesis In A Carbon Arc Discharge Environment, In Situ ". His committee members were: B. Stratton (Chair), S. Cohen, and B. Koel. His advisers were: Y, Raitses, M. Shneider, and Stratton

Graduate Student Thesis Proposal Presentations: Yuan Shi presented his thesis proposal, "Laser Pulse Processing Using Magnetized Plasmas", on February 17. His committee members were: I. Dodin (chair), N. Fisch, H. Qin, A. Reiman, and J. Mikhailova. Fisch and Qin are his thesis advisors.

Jacob Schwartz presented his thesis proposal, "Mass and energy flow in the lithium vapor box divertor", on January 25. His committee members were: B. Kaita (chair), C. Skinner, D. Stotler. M. Jaworski and R. Goldston are his thesis advisers.

DIRECTOR'S OFFICE (S. ZELICK):

On February 20, T. Brog hosted a visit with Dr. Tony Peurrung, Associate Laboratory Director of the National Security Directorate - Pacific Northwest National Laboratory. Dr. Peurrung presented a seminar to PPPL staff entitled, "PNNL National Security Overview". Dr. Peurrung was provided with a tour of PPPL (visited and provided with an overview of various experiments/labs) and met with various PPPL departments to discuss possible collaborations.

This report is also available on the following web site:

http://www.pppl.gov/publication-type/weekly-highlights