PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights

PPPL

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending October 30, 2015 are as follows:

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

Steady State Electric Network (SSEN):

Award of a subcontract for the Reactive Power Compensators procurement is pending resolution of a comment with regard to the payment schedule.

A replacement for the low voltage compartment door that was damaged during shipment of HV Substation Transformer Unit #4 was received at the ITER site.

Diagnostics:

Upper Port Wide Angle View Visible-IR Camera (UPP WAVs): A kick-off meeting was held this week between PPPL RF engineering and the ITER Diagnostics and Port Plug engineering teams. Radio-Frequency and Electrical Engineering is needed for the design of diagnostic first-mirror cleaning systems. A work scope is under development that will initially focus on the "back-end" of the mirror cleaning system. The integration of RF Power and Water Cooling lines in to the mirror cleaning circuit is one important aspect. Another is sizing and analysis of the RF power vacuum feedthrough components. Work is expected to start in January 2016, once the job is planned out in more detail.

Low Field Side Reflectometer (LFSR): PPPL is working closely with the Russian Federation DA (RFDA) on the integration of the Low Field Side Reflectometer (LFSR) diagnostic in to Equatorial Port 11. In one meeting last week issues with integration of LFSR and DRGA piping and waveguide in the EP11 interspace and port cell were resolved. Transmission line layouts were updated to clear clashes with the RFDA NPA and H-Alpha systems. PPPL also met with RFDA port plug engineers to review the LFSR in-vacuum transmission line layout. Some adjustments are needed to accommodate EP11 nuclear shielding requirements. Also this week on the physics side of the project, G. Kramer resolved using FWR3D code a discrepancy that UCLA team had in predicting the reflectometer beam pattern between Genray and Torbeam codes. The HF testing is proceeding well. Testing of the self aligning Gaussian Telescope invented at PPPL is planned on the high frequency test stand for late November.

Diagnostic Residual Gas Analyzer (DRGA): Ted Biewer, visiting PPPL for another collaboration, provided an update to the Diagnostic RGA testing ongoing at ORNL. The ORNL DRGA team is evaluating the performance range and sensitivity of an ITER-like DRGA test rig. Optical Penning Guage, Ion Trap Mass Spectrometer and Quadrupole Mass Spectrometer

units are being tested. On a seperate test stand a Helmholtz coil is being used to test the DRGA equipment magnetic sensitivity.

Equatorial Port 3 Integration: K. Tresemer and M. Duco visited ITER this week for meetings and discussions around Equatorial Port 3 tenant system integration and DSM design. The RFDA presented a new CXRS optical layout and lens design where the first mirrors are getting smaller, the magnification is being increased, and the lenses are actually placed outside the vacuum. The impacts to the DSM design and the DFW tabs will need to be reviewed with the new mirror sizes, but initial scans look very promising, seeming a win-win for integration and CXRS.

NSTX (M. ONO):

The paper "Simulations towards the achievement of non-inductive current ramp-up and sustainment in the National Spherical Torus Experiment Upgrade", by F. Poli et al, Nucl. Fusion 55 (2015) 123011, has been published online and is available at http://stacks.iop.org/0029-5515/55/123011. Time-dependent free-boundary simulations have been performed with TRANSP to project non-inductive ramp-up and sustainment with a combination of EC, HHFW and NB. An interesting synergy has been found between EC and HHFW which indicates that, with 1 MW of EC, and with the smallest launched wavenumber from the HHFW antenna, the requirements on the amount of HHFW power that needs to be absorbed in the plasma to drive 300 kA of direct fast wave current are relaxed from 6 MW to below 2 MW. A dynamical changing of the launched wavenumber of the antenna can be beneficial to optimize the transition between the RF and the NB phase.

M. Ono (PPPL) visited the Plasma Research Center at Tsukuba University, Japan on October 30. He met with Professor T. Imai and his colleagues at the University to discuss the 28 / 35 GHz gyrotron development at the Center. He also discussed the NSTX-U collaboration with the Plasma Research Center.

The Far-Infrared Tangential Interfereometer-Polarimeter (FIReTIP) diagnostic is being installed through a UC Davis-PPPL collaboration for line-averaged plasma density measurements. A key element is an enclosure ("cage") immediately outside of the NSTX-U Test Cell to house the laser. The dimensions and access requirements that satisfy safe egress specifications and electrical utility needs have been finalized. Construction will begin once the fabrication drawings are completed.

Vacuum leak checking for a small air leak that developed during the cool-down after the vessel bake continued this week. Secondary volumes and internal cooling lines are being isolated and pumped. Commissioning of controls on diagnostic system Torus Isolation Valves (TIV's) is in progress, and the vacuum controls for the deuterated trimethylboron (dTMB) system are being configured for operations. Pre-operational testing of the dTMB system is scheduled to start this coming week. Checkout of the Resistive Wall Mode (RWM) coil current sensors has started, and any loop faults associated with the Category 2 (diagnostic), 3 (inner vessel), and 4 (outer vessel) grounds have been identified and corrected. The NSTX Test cell was locked up for ~ 4 hours a day this past week for neutral beam and HHFW antenna conditioning.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

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. An updated XGCa simulation was completed, which included 90% neutral recycling and an improved XGCa source routine. These updates improved the simulated density in the divertor region. Comparisons to two-point model estimates are ongoing.

This week work progressed on the LGI upgrade, fabrication, analysis, and installation of a linear actuator to relocate the granule drop tube required to account for granules with different hardnesses. The Lithium granules require an advanced impeller impact position since their collision is semi-elastic and pulled, like a baseball to left field, into the drift tube. Carbon granules however, do not require this advance, but a 90 degree hit position since they are almost totally elastic collisions. Installation of this linear actuator will enable switching between lithium and carbon between shots instead of an LGI vacuum vent to change drop tube positions, thereby improving run efficiency. Testing of both lithium and carbon granules in vacuum is expected next week.

R. Nazikian visited the Max-Planck-Institut für Plasmaphysik in Garching, Germany this week to collaborate with Wolfgang Suttrop in developing a joint DIII-D AUG experimental proposal to test RMP ELM suppression in similar plasma conditions. The experiments on both AUG and DIII-D are planned for early December.

C-Mod (S. Scott):

Bob Mumgaard (PSFC) is visiting ASDEX this week and has integrated the one-spatial-channel MSE background polychrometer into the ASDEX MSE diagnostic. He has verified the filter-heater operation, taken data on a handful of ASDEX shots, and shipped the dataset to the PSFC MDSPLUS tree, where it can—in principle—be analyzed by existing software developed for the C-Mod MSE background polychrometer. Small upgrades to the software are needed to deal with the situation on ASDEX that the MSE diagnostic views multiple beams, only one of which has the beam orientation and beam energy consistent with the chosen filters. The other beams essentially pollute the measurement, which complicates the software that identifies beam “on” versus beam “off” times. The software has successfully processed one dedicated ASDEX shot (S. Scott). The results are being evaluated to assess whether or not the polychrometer actually reduces the previously-observed “drift” in measured pitch angle.

ADVANCED PROJECTS (H. NEILSON):

C. Kessel, Y. Zhai, K. Young, and H. Neilson participated in the US/JA Workshop on Power Plants/Next Steps and Fusion Technology, held from October 28-30 in Denver, Colorado. The workshop continues a long tradition of collaborations with Japanese colleagues established under the ARIES Power Plant studies. Seven Japanese scientists, representing the National Institute for Fusion Sciences, the Japan Atomic Energy Agency, and different universities, attended, as well

as 10 members of the U.S. Fusion Energy System Studies (FESS) team. C. Kessel presented a description and status of the FESS Fusion Nuclear Science Facility (FNSF) study; he also led a discussion session covering several technical issues for the FNSF. Zhai presented the status of the TF and PF coil options and analysis, including low and high temperature superconductors. Young presented an assessment of the reference FNSF operating plan, offering suggestions to shorten the timeline. Neilson presented a “lessons learned” summary derived from the IAEA DEMO Workshop which occurred in May 2015, making the case that international collaboration in fusion is essential and inevitable. Each of the FESS members gave presentations including nuclear analysis, fusion core maintenance, thermo-mechanics, CAD and facility layout, plasma SOL/divertor, tritium and safety, disruption analysis, liquid metal MHD analysis, FNSF program activities, and materials issues. The Japanese scientists presented similar topics, allowing for stimulating discussions about technical approaches.

THEORY (A. BHATTACHARJEE):

On October 29, Jugal Chowdhury (University of Colorado, Boulder) presented a theory seminar on a study of microtearing modes using particle-in-cell delta-f gyrokinetic simulations. The study of microtearing modes using the electromagnetic gyrokinetic PIC code GEM was discussed, and two sets of experimental parameters from NSTX were used for this purpose. One set corresponds to the edge where the microtearing mode was observed to be unstable at the pedestal top without lithium coating of plasma facing components. The other set of parameters corresponds to the core of NSTX. The dependence of the microtearing mode on various equilibrium quantities was studied in the two regions.

On October 30, E. Startsev gave a Theory Department Research and Review Seminar entitled "Taming Electrons in Finite-beta gyro-kinetic Particle-in-cell Simulations". The abstract reads: “Electromagnetic effects at increasing β have theoretically been demonstrated to lead to important changes in traditional electrostatic instabilities (e.g., stabilization of the ion-temperature-gradient (ITG) modes) and also to entirely new instabilities (e.g., micro-tearing (MTM) and kinetic-ballooning (KBM) modes). Therefore, for studies of high-performance, high-β NSTX-U H-mode plasmas it is imperative that electromagnetic effects be included in any theoretical or numerical studies of microturbulence. To this end, we have recently developed a new "double-split-weight" perturbative particle simulation scheme for finite-β plasmas in the presence of background inhomogeneities. The idea behind the scheme is that in the high-β regime (β > me/mi), the collective electron response to a perturbation is to provide an inductive component of the parallel electric field to nearly neutralize the electrostatic component everywhere except near rational surfaces. Therefore, to correctly simulate this regime, we reformulate the electron field–particle dynamics in such a way that large terms are combined together, so that the remaining terms are either proportional to E_|| or are small. The resulting scheme is free from the large terms that lead to the cancellation problem that plagues most of the electromagnetic particle-in-cell codes in this regime. I will give a detailed description of the scheme in cylindrical geometry, valid for large-aspect-ratio tokamak plasmas with cylindrical cross section. This version has already been implemented in the toroidal code GTS, and I will present some recent tests that have been conducted with that code.”

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

Reynolds number scaling of boundary layer effects has been studied experimentally in Hydrodynamic Turbulence Experiment, HTX, a sister device of the liquid metal experiment to study Magnetorotational Instability (MRI). Understanding fast angular momentum transport has been a longstanding problem for plasma astrophysics to explain the observed fast accretion in a wide range of phenomena. It has been found previously that the boundary layers can have profound effects on stability of laboratory quasi-Keplerian flows in which angular velocity decreases radially while angular momentum increases radially as in accretion disks. When activating independent axial rings minimizes such boundary effects, ideal quasi-Keplerian flows exhibit robust nonlinear stability against external perturbations [E. Edlund & H. Ji, Physics Review E. (2014).] In a newly published paper this month in Physical Review E, it was reported that the ideal quasi-Keplerian flows exhibit self-similar behavior when Reynolds number was increased by more than an order of magnitude. This further strengthens our implication that Keplerian flows in astrophysical disks, which have enormous Reynolds numbers, should be robustly stable in hydrodynamics. Non-optimum quaso-Keplerian flows have been also studied as a function of Reynolds number, and it was found that deviations from the ideal flow get worse when Reynolds number was increased, due to increased imbalance of angular momentum flux in and out of flow from boundaries. A quantitative model was developed to capture these behaviors.

ENGINEERING AND INFRASTRUCTURE (L. DUDEK):

Fabrication and Operations Division (E. Perry, L. Dudek):

Y. Zhai attended the Magnet Technology conference in Korea.

PPPL has received a request from ASIPP to design and build a Flowing Liquid Lithium Limiter. Gentile is organizing a meeting early in November to discuss engineering requirements.

BUSINESS OPERATIONS (K. FISCHER):

Budget:

DOE approved five new Laboratory Directed Research and Development (LDRD) projects for FY2016. Including the budget requested for these new projects, the total budget allocated to LDRD projects in FY2016 is $2.7 million against the $3.0 million LDRD funding ceiling approved by DOE.

An amendment to the Strategic Partnership Project Agreement with UCLA titled “Micro-Engineered Material Surfaces for Electric Propulsion and Pulsed Power” was executed to add year 5 funding and work scope. The funding to be provided for the final year of this agreement is $135,000. The principle investigator for this project is Y. Raitses.

A Strategic Partnership Project agreement with Corning Incorporated titled “Corning Glass Analysis” was fully executed. The funding to be provided by Corning is $25,000; the principle investigator is G. Ascione.

A one-year, no-cost extension was approved by DOE for the Strategic Partnership Project With Tri Alpha Inc. titled “Plasma Physics Topics of Importance to Advancing the C-2 Program”. The principle investigator for this project is B. Stratton.

An amendment to the Strategic Partnership Project Agreement with ASIPP to perform engineering analyses related to design options for China's Fusion Engineering Test Reactor was approved by DOE. The amendment extends the period of performance by six months and adds language requested by the sponsor to the statement of work.

DIRECTOR’S OFFICE (C. AUSTIN):

On October 28, Professor Bruce Partridge of Haverford College presented a colloquium entitled “Seeing the Big Bang More Clearly: The Evolution of Observational Techniques in CMB Studies”.

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