PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending March 7, 2014, are as follows:

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

At the C-MOD Ideas Forum, a proposal was made to assess the capability of the active spectroscopy systems to do precision line fitting of the motional stark lines of the beam emission. If sufficient spectral resolution is achieved in 'beam into gas' spectra by narrowing the viewing aperture and the entrance slits, then consideration will be given to making measurements with field and plasma. Ultimately, if sufficient precision can be achieved with the line fittings, the line shifts could be used as constraints in the equilibrium reconstruction. This approach is being considered for constraining the equilibrium on ITER, and if successful, the C-MOD efforts would aid in the development of the ITER MSE system.

At a monthly meeting between U.S. and IO diagnostics groups, changes to the diagnostic first wall (DFW) and the diagnostic shield module (DSM) were discussed that would make it feasible to substitute a 'blank' DSM+DFW into any one of the three positions within the equatorial port plug structure. To enable this, 1) DSMs would all be the same width, 2) interlocking 'ribs' between DSMs would be eliminated, and 3) the DFW panels would all be coplanar at the plasma-facing surface, rather than forming a faceted surface conformal to the outer plasma surface.

C. Neumeyer from PPPL and IO representatives visited companies in Europe under contract to produce US ITER Steady State Electric Network components. They met with representatives of Alstom and Eaton to discuss Release for Manufacturing submittals.

NSTX (M. ONO):

NSTX-U is in the Upgrade Project outage in FY14. NSTX Upgrade construction activities continued this week and are highlighted in the engineering section below.

R.Kaita presented a PPPL seminar at the liquid metal PFC seminar series titled "The NSTX Liquid Lithium Divertor: A Study in Addressing Technical and Programmatic Challenges". The motivations and goals of the NSTX liquid lithium divertor deployment were discussed, along with important considerations for future liquid lithium deployment in NSTX-U.

R. Raman (University of Washington) visited Kyushu University in Japan from February 24 - March 5 to complete the CHI engineering design for the QUEST ST, which is now finalized. On March 3, he gave the talk “Overview of Research Plans for NSTX Upgrade” to the QUEST

Research Team.

A test installation of the Materials Analysis and Particle Probe Upgrade (MAPP) was completed. The MAPP is a collaborative effort involving researchers from the University of Illinois at Urbana-Champaign and PPPL, with the goal of in situ analysis of samples exposed to tokamak plasmas. The MAPP chamber containing instruments for surface analysis was mounted on a port on the lower NSTX-U dome, and attached to a probe drive used for sample positioning. The successful alignment of the MAPP components was demonstrated by the insertion of the sample holder into the divertor gap that allows access to the plasma chamber. The MAPP has been moved to the Lithium Tokamak Experiment (LTX), where further commissioning of surface analysis diagnostics will occur prior to final implementation on NSTX-U.

Preparations for plasma operations in the NSTX-U configuration also continued with the preparations of the Field Coil Power Conversion (FCPC) rectifiers for upcoming power testing. Testing of the FCPC incoming power protective relays is now complete. New fiberoptics between FCPC and the Controls Junction Area are being installed. Parts lists for the new plasma current calculator have been finalized, and parts are being ordered.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

An analysis of the optical alignment and imaging quality of the ECEI/MIR system was completed this week by Benjamin Tobias (PPPL) and Chris Muscatello (UC Davis). This entailed detailed measurements of the antenna field patterns, including minimum spot size, viewing angles and zoom capability. These were all found to be within specifications. This data is critical for mapping diagnostic signals to the plasma and also for improving the accuracy of synthetic diagnostics. Areas for improvement in resolution, image uniformity, and signal power were also identified and corrected, yielding a significant improvement in the viewing geometry.

Analysis has been carried out by G. Kramer (PPPL) and Mike VanZeeland (GA) on the effect of non-axisymmetric fields on deuterium beam ion loss. The SPIRAL code was used to model the beam ion orbits, including the actual beam geometry with classical slowing down and pitch angle scattering. The plasma response to an n=3 resonant field from the I-coils was calculated using the linear two fluid M3D-C1 code and linear MHD IPEC code and compared with vacuum field calculations. The beam analysis includes the full, 1/2 and 1/3 energy components. In the absence of 3D magnetic perturbations, the calculated beam power loss was only 1.6%. However, with the addition of the external n=3 field typically used for ELM suppression, the losses rose to 6% using the calculated vacuum field and 10%, 12% for the M3D-C1 and IPEC calculated fields, respectively. Losses are confined to particles deposited in the outer 30% of the plasma radius. The higher power loss for the IPEC and M3D-C1 fields is due to the plasma response that tends to amplify certain components of the applied field. Future work will attempt to measure accurately the beam ion loss to the outer wall of DIII-D using IR cameras in order to test models of the plasma response and fast ion loss.

International Collaborations (R. Hawryluk):

D. Mueller, R. Ellis and J. Hosea attended the 2014 KSTAR conference February 24-26. Ellis presented a talk, "Some Considerations for the Design of a 2-Channel Steady-State ECH Launcher for KSTAR." On February 27-28, Ellis and Hosea visited KSTAR, and held discussions regarding collaborations on ECH and, possibly, ICRF. Ellis presented a successful final design review of a water-cooled steady-state fixed mirror that will be installed on the existing 170GHz KSTAR ECH launcher, a successful conceptual design review of a steady-state steerable mirror, and discussed a pre-conceptual design for a proposed new ECH launcher.

R. Ellis, J. Hosea, G. Taylor and R. Perkins visited EAST [ASIPP] March 3-5, and discussed ECH, ICRF, and LHCD on EAST, and opportunities for PPPL to collaborate.

C-Mod (S. Scott)

PPPL contributed 14 proposed experiments to the Alcator C-Mod 2014 Ideas Forum, held March 5-6 at MIT. PPPL staff also participated by video-conference in the meeting.

S. Scott presented a short talk at the C-Mod Weekly Science Meeting, “A simple 0-D model to predict Vsurf(t) and to compute LHCD efficiency”. The model is based solely on the measured Ip(t), nebar(t), V_surface(t), T_eo(t), and P_LH(t). It assumes that the amount of current driven by the transformer is proportional to Ip * Vsurface *Te^1.5. By comparing these parameters at an Ohmic time just before the start of LHCD to an LHCD ‘reference’ period 200-250 ms into the LHCD phase, it computes the current driven by the transformer at the reference time. The difference between the total Ip at that time and the inferred transformer-component is attributed to the current driven by LH. At other times, the LH-driven current is scaled from the value at the ‘reference’ time by P_LH(t) / nebar(t). The model is helpful to identify when changes in the measured surface voltage are ‘anomalous’, i.e. not attributable to simple classical changes in P_LH, nebar, or Te. In the future, it may also be useful to study rough trends in the LHCD efficiency, such as the dependence on nebar, launched n-parallel spectrum, Ip, and Te.

ADVANCED PROJECTS (H. NEILSON):

In the Fusion Energy Systems Studies program, the last ARIES study, ARIES-ACT (advanced/conservative tokamak), has been completed and physics basis papers for the ACT1 and ACT2 configurations have been submitted for publication. In addition, the ARIES-ACT study overview paper was also completed and submitted. The ACT1 assumes advanced physics with advanced technology, and ACT2 assumes conservative physics and conservative technology. The other combinations were also identified using systems code analysis. The physics regime is mainly determined by betaN and H98, while the technology is mainly determined by the allowed diverter peak heat flux, and the blanket concept and corresponding thermal conversion efficiency. The major radius of the advanced version is 6.25 m, and the conservative one is 9.75 m. The project has a number of simultaneous goals, 1) examine 4 configurations with combinations of advanced and conservative assumptions, 2) update detailed physics assessments and assumptions since ARIES-AT (1999), 3) update detailed engineering assessments with a series of advances in analysis. In addition, a new systems analysis was developed that uses a database approach, which showed clearly that there were always operating

points around the lowest COE point, with differing parameters but very close COE values. Optimizing to a single operating point does not allow these nearby points to be identified, and does not take into account the significant uncertainty in projecting what physics or technologies will be successful in the future.

On February 28, D. Gates participated in a meeting of the "Working Group OP 1.1" which is a group planning the initial run of the W7-X device, currently planned to take place in early 2015. The group has been developing a list of run priorities. Input from the U.S. collaboration team has been accepted as part of the planning process.

Gates gave a talk entitled "The Path to Magnetic Fusion" to the Central NJ Mensa "Snowflake" meeting the evening of February 28. The talk was well attended and there was a lively question and answer session.

THEORY (A. BHATTACHARJEE):

A paper, "Turbulent optimization of toroidal configurations", by H. Mynick (PPPL), coauthored by P. Xanthopoulos, B. Faber, M. Lucia, M. Rorvig, and J. Talmadge, has been accepted for publication in Plasma Physics and Controlled Fusion. The work describes the current status of the ongoing effort in "turbulent optimization" (designing stellarators and tokamaks to have substantially reduced turbulent transport).

The theory seminar on March 6 was presented by Dr. Kimin Kim from PPPL, entitled "Rotational resonances in 3D perturbed tokamaks, and their impact on neoclassical toroidal viscosity and kinetic stability". The abstract of the talk is "Resonance of perturbed orbits with toroidal ExB rotation, called the bounce-harmonic resonance, changes trapped bounce orbits to closed circuits. It dominantly contributes to perturbed pressures and neoclassical toroidal viscosity (NTV) torque in the rotating plasmas with nonaxisymmetric magnetic perturbations, while random phase-mixing reduces the nonambipolar particle transport for off-resonance particles. Such driving mechanism of NTV also plays an important role in the kinetic stabilization of slowly growing MHD modes such as the resistive wall mode (RWM), but acts differently due to shifts of resonance frequency condition. This talk will discuss the mechanism of bounce-harmonic resonance in perturbed tokamaks and its impacts on NTV transport and kinetic potential energy, using a guiding-center particle code, POCA. Theoretical and experimental analyses on the magnetic braking and kinetic stability modification of RWM in NSTX will be presented."

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: Diagnostics and blank off flanges continue to be installed. The Bay H port cover has been installed and the tFIDA window has been welded to the vessel. The MAPP probe has been trial fit and has been returned to storage. Work continues on the PF5 clamp at bay L. The cabling for TIVs and thermocouples continues. The repairs to the tubes on the centerstack casing are on hold while engineering determines how to resolve interferences with the TF bundle. The

centerstack pedestal has been placed below the machine.

NBI Upgrade: After the NBI Armor shinethrough tiles were installed in the VV, the Bay H port cover installation was completed. Assembly of feed-through connections has started. BL2 DI water manifold installation continued and piping for HVE was ordered. Work continues on water pump pads in the pump room and several pads were completed. The Triax terminations were installed into the HVEs and reconnected internally. The Mod/Reg controls work and preparation continues. The bending of magnet cabling on BL2 is in progress. NBPS water skid maintenance is in progress but waiting on the subcontract to finish. VV RWM coil fit-up continues for the Bay JK area. The NBI/TVPS duct flanges were successfully tested with new seal thicknesses. TVPS assembly took place and successfully passed leakcheck. The NBI duct installation is planned for the week of March 10. NB Controls tray work continued in the NTC. An installation procedure for high voltage transmission lines was completed and approved.

BEST PRACTICES & EXTERNAL AFFAIRS (J. DELOOPER):

More than 260 individuals participated in the Science on Saturday March 8 program. Professor Mung Chiang from Princeton University presented, “From MOOC to MIIC: Can Effective Learning be Big?”

OFFICE OF ACADEMIC AFFAIRS (N. FISCH):

On March 7, N. Fisch presented a Princeton Environmental Institute (PEI) Energy Group Seminar on "Energy Generation through Nuclear Fusion". The talk covered the basic physical approaches, the contemporary challenges in the field, and some thoughts on future directions.

DIRECTOR’S OFFICE (C. AUSTIN):

G. Hammett, S. Prager and R. Hawryluk attended the Helmholtz Association meeting reviewing the German fusion program. Hammett and Prager were members of the review panel. Hawryluk represented the Fachbeirat at this review.

On March 5, Dr. Bruce G. Blair from Princeton University presented a colloquium entitled, "Risks of Nuclear Weapons Use in an Era of Proliferation, Cyber Warfare and Terrorism".

On March 7, M. Zarnstorff hosted ten visitors from NIFS (the vice-director, professors, young scientists and administrative staff). They were provided with a status of NSTX-U, W7-X, PPPL fusion communications, PPPL computer security - and were given a tour of PPPL.

PUBLICATIONS:

The following PPPL Reports were posted to the web:

Reduced Fast Ion Transport Model For The Tokamak Transport Code TRANSP PPPL-5002

Authors: Mario Podesta, M. Gorelenkova and R.B. White
Submitted to: Plasma Physics and Controlled Fusion (February 2014)

Comment on "Mode Conversion of Waves In The Ion-Cyclotron Frequency Range in Magnetospheric Plasmas" PPPL-5003
Authors: Eun Kim and Jay R. Johnson
Submitted to: Physics Review Letters (February 2013)

Ponderomotive Forces On Waves In Modulated Media PPPL-5004
Authors: I.Y. Dodin and N.J. Fisch
Submitted to: Physical Review Letters (February 2014)

Electromagnetic Analysis For The Design Of ITER Diagnostic Port Plugs During Plasma Disruptions PPPL-5005
Authors: Y. Zhai, R. Feder, A. Brooks, M. Ulrickson, C.S. Pitcher and G.D. Loesser
Submitted to: Renewable Energy Global Innovations (March, 2014)

The Physics Basis For An Advanced Physics And Advanced Technology Tokamak Power Plant Configuration, ARIES-ACT1 PPPL-5006
Authors: Charles Kessel, et. al.
Submitted to: Fusion Science and Technology (March 2014)

The Physics of Basis For A Conservative Physics And Conservative Technology Tokamak Power Plant, ARIES-ACT2 PPPL-5007
Authors: Charles E. Kessel and F.M. Poli
Submitted to: Fusion Science and Technology (March 2014)

The ARIES Advanced And Conservative Tokamak (ACT) Power Plant Study PPPL-5008
Authors: Charles E. Kessel, et. al.
Submitted to: Fusion Science and Technology (March 2014)

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