NSTX-U Weekly Report (April 24, 2015)

NSTX-U is in the Upgrade Project outage in FY 2015.

A paper on "Overview of recent physics results from NSTX" by S. Kaye (PPPL) et al has been published online in Nuclear Fusion **55** 104002 (2015) (http://stacks.iop.org/0029-5515/55/104002). NSTX is currently being upgraded to operate at twice the toroidal field and plasma current (up to 1 T and 2 MA), with a second, more tangentially aimed neutral beam for current and rotation control, allowing for pulse lengths up to 5 s. Recent NSTX physics analyses have addressed topics that will allow NSTX-Upgrade to achieve the research goals critical to a Fusion Nuclear Science Facility. These include producing stable, 100% non-inductive operation in high performance plasmas, assessing Plasma Material Interface (PMI) solutions to handle the high heat loads expected in the next-step devices and exploring the unique Spherical Torus (ST) parameter regimes to advance predictive capability. Noninductive operation and current profile control in NSTX-U will be facilitated by Coaxial Helicity Injection as well as RF and NB heating. CHI studies using NIMROD indicate that the reconnection process is consistent with the 2D Sweet-Parker theory. Full wave AORSA simulations show that RF power losses in the SOL increase significantly for both NSTX and NSTX-U when the launched waves propagate in the SOL. Toroidal Alfvén Eigenmode avalanches and higher frequency Alfvén Eigenmodes can affect NB driven current through energy loss and redistribution of fast ions. The inclusion of rotation and kinetic resonances, which depend on collisionality, is necessary for predicting experimental stability thresholds of fast growing Ideal Wall and Resistive Wall Modes. Neutral beams and Neoclassical Toroidal Viscosity generated from applied 3D fields can be used as actuators to produce rotation profiles optimized for global stability. PMI studies have focused on the effect of ELMs and 3D fields on plasma detachment and heat flux handling. DEGAS-2 has been used to study the dependence of gas penetration on SOL temperatures and densities for the MGI system being implemented on the Upgrade for disruption mitigation. Simulations indicate that snowflake and impurity seeded radiative divertors are candidates for heat flux mitigation in NSTX-U. Studies of lithium evaporation on graphite surfaces indicate that lithium increases oxygen surface concentrations on graphite, and deuterium-oxygen affinity, which increases deuterium pumping and reduces recycling. In-situ and test-stand experiments of lithiated graphite and molybdenum indicate temperature-enhanced sputtering, although that test-stand studies also show the potential for heat flux reduction through lithium vapor shielding. Non-linear gyro kinetic simulations have indicated that ion transport can be enhanced by a shear-flow instability, and that non-local effects are necessary to explain observed rapid changes in plasma turbulence. Predictive simulations have shown agreement between a microtearing-based reduced transport model and measured electron temperatures in a microtearing unstable regime. Two Alfvén Eigenmode-driven fast ion transport models have been developed and successfully benchmarked against NSTX data. Upgrade construction is moving on schedule with initial operation of NSTX-U planned for early calendar year 2015. (S. Kaye)

A paper on "Effects of MHD instabilities on NB current drive" by M. Podestà (PPPL) et al has been published online in Nuclear Fusion **55** 053018 (2015) (http://iopscience.iop.org/0029-5515/55/5/053018). The paper investigates the effects of Alfvenic and other (lower frequency) MHD modes on NB-CD in NSTX. A new fast ion transport model, which accounts for particle transport in phase space as required for resonant AE perturbations, is utilized to obtain consistent simulations of NB-CD through the tokamak transport code TRANSP. It is found that instabilities do indeed reduce the NB-driven current density over most of the plasma radius by up to ~50%.

Moreover, comparisons with results from the ad-hoc diffusive model implemented in TRANSP show the details of the current profile evolution are sensitive to the specific model used to mimic the interaction between NB ions and instabilities. (M. Podestà)

Steve Sabbagh (Columbia University) attended the spring ITPA MHD Stability meeting, held for the first time at ITER Headquarters in St-Paul-lez-Durance, Provence, France (April 14-17th) presenting a milestone summary of results and international contributions on the joint experiment/analysis task MDC-21 on Global Mode Stabilization Physics and Control. Separate small meetings were also conducted with Peter de Vries (ITER) and Gabriella Pautasso (AUG) regarding guidance for the continuing effort of disruption prediction and avoidance on NSTX-U championed by the Disruption PAM Working Group. The main meeting also included an extensive discussion regarding the need for an update to the ITER Physics basis document (published in 2007). While a minority opinion argued to not create a new document, the majority opinion to update the document carried. Further excitement at the meeting included discussion of planned re-organization of the ITER organizational structure by the new Director General, and also the flurry of construction activity at the ITER site, including progress on the main structural elements of the machine assembly hall which is located adjacent to the main torus hall. (S. Sabbagh)

Francesca Poli (PPPL) attended the 14th ITPA-IOS meeting on April 20 – 23, 2015 in Barcelona, Spain. She reported on the implementation of a pedestal model in time-dependent simulations, using a lookup table based on EPED1 and a fitting procedure, which can be used both in analysis and predictive model. There was discussion on new joint experiments and joint modeling activities. One of these joint activities to which NSTX-U will contribute (including existent database from NSTX) is on the ramp-down phase and fast termination, on both modeling and experimental characterization, for projections to ITER. (F. Poli)

R. Maingi (PPPL) presented a guest lecture at Cornell University on the Principles of Magnetic Fusion and the Plasma-Material Interface on 4/20/15. The lecture concluded with a description of the use of lithium in NSTX to improve the edge stability and overall device performance. The trip was supported by the APS Distinguished Lectures in Plasma Physics program. (R. Maingi)

R. Kaita (PPPL) gave a colloquium lecture on magnetic fusion that included a description of NSTX-U research at Messiah College in Mechanicsburg, PA on April 23. Among the research areas at Messiah College is thin film physics, so there was particular interest in materials for fusion applications. The speaker received many questions from students about graduate study and careers in plasma physics, and he is working with the faculty in organizing a tour of PPPL for them in the fall. (R. Kaita)

Charles Skinner (PPPL) visited the Yale Climate and Energy Institute, New Haven, CT on April 24th to attend the Conference on Climate Change and the Future of Nuclear Energy. He gave a special invited talk on '*Fusion: Energy for the Future*'. The talk presented progress in magnetic fusion and the potential role of fusion in meeting the energy needs of the coming century and the societal response to climate change. (C. Skinner)

P. Rindt returned to the Technical University of Eindhoven in the Netherlands on April 22. During the past year, he designed and fabricated prototype high-Z tiles for future use in NSTX-U liquid lithium divertors. Using isopropyl alcohol as a substitute for liquid lithium, his studies

included the determination of the wetting properties of different tile surfaces. This work is part of Rindt's requirements for a master's degree at his home institution. (R. Kaita, PPPL)

Experimental Research Operations (S. Gerhardt, R. Kaita)

During the completion of the ISTP, continued work was done on the NSTX-U magnetic. The final sensor and polarity corrections were made on the loops that are used to infer the vessel current; now numerical adjustment of the vessel model is required in order to fully calculate the vessel-current corrections to the vessel current. Other flux loops and magnetic field sensors, or their associated electronics, were also repaired.

Testing of gas injection from the plasma control system also continued. It was verified that injector commands entered at the plasma control system manifest themselves as high-voltage applied to piezo valves in the test cell, demonstrating that the realtime data links and valve driver hardware are all functional.

XMP-100 "NSTX-U CD-4 plasma" was approved, and a run copy issued. Additional XMPs are also now under review.

Engineering Operations (A. von Halle, P. Titus)

Start-up of NSTX-U for plasma operations had to be halted late this week to address an external arc fault and water leak at the top of the machine. Recovery efforts began immediately, and the umbrella lid is being removed for water fitting inspections and fault diagnosis. Preparations for plasma operations will resume upon completion of repairs. This event followed the successful completion of individual and combined field coil power testing (ISTP), and the commissioning of the Gas Injection System.

Access to the NSTX-U Test Cell is expected to be available this coming week. Access must be arranged through Work Permits approved by the D-Site Shift Supervisors.