

## NSTX-U Weekly Report (May 6, 2016)

### **FY 2016 NSTX plasma operations**

**Operation Targets: Total – 18 run weeks**

**Completed: 7.91 run weeks and 823 plasma shots**

Jack Berkery and Steve Sabbagh (NSTX-U Team collaborators – Columbia University), along with colleagues Yueqiang Liu (CCFE) and Holger Reimerdes (EPFL), were awarded the 2016 Landau-Spitzer Award, presented jointly every two years by the American and European Physical Societies (APS and EPS). The Award is given to an individual or group of researchers for outstanding theoretical, experimental, or technical contribution(s) in plasma physics, and for advancing the collaboration and unity between the European Union and the United States. The research for which the award was given comprises nearly a decade of published effort on kinetic resistive wall mode theory validation and understanding, which included experiments from NSTX and DIII-D. The award also merits an invited talk on the research to be presented at the 43<sup>rd</sup> EPS Conference on Plasma Physics, July 4 -8, 2016 in Leuven, Belgium. (S.A. Sabbagh)

J. P. Allain of the University of Illinois at Urbana-Champaign visited PPPL last Friday. His group developed the Materials Analysis and Particle Probe (MAPP). The MAPP has been installed on NSTX-U, and operated in collaboration with researchers from PPPL and Bruce Koel's group from Princeton University's Department of Chemical and Biological Engineering. It has been used to introduce samples of plasma-facing components (PFCs) into NSTX-U, and analyze their surfaces without breaking vacuum. The results for samples using X-ray photoelectron spectroscopy after boronization with deuterated trimethyl borane was discussed. The sample surfaces did evolve between boronizations, with different boron compounds forming with time. However, they appeared to recover the same characteristics after each boronization. It was concluded that surface analysis of samples should be performed with greater spectral resolution, and plans were made to remove them from MAPP after boronization for measurements in laboratory facilities with higher sensitivity. (R. Kaita, PPPL)

### **Run Coordination (J. Menard, S. Gerhardt)**

Monday 5/2 was largely spent troubleshooting problems with the OH supply. Towards the end of the day, tests were done on the PF-1c upper and lower coils, where the coil currents were measured by both the legacy Halmar transducers and the new LKAT transducers. These tests showed that the current ripple measured by all transducers was the same for the PF-1cU coil. However, the legacy Halmar transducers significantly underestimate the current ripple for the PF-1cL coil. One plasma shot was taken at the end of the day.

Tuesday 5/3 was dedicated to XMP-152 (Improved dr-sep control and rtEFIT checkout, M. Boyer), using Ohmic helium plasmas. This tested both an improved version of dr-sep control recommended by GA, and the new multi-threaded rtEFIT code. Both of these were successful, including running the new rtEFIT version which fits both coil currents and vessel currents in realtime while basically maintaining the cycle time of the previous version. However, towards the end of the day, a bug was found in the shape control code, which disabled the physics operator request for the upper X-point position. The source of the bug was only identified on the evening of 5/3, and was corrected for operation on the next day. A number of vacuum field shots were then taken under XMP-106 (Magnetics calibrations, C. Myers) with the goal of

assessing if the interaction between the OH and TF coils produces any meaningful error fields in NSTX-U. The OHxTF interaction was a substantial problem in NSTX and was therefore designed out in NSTX-U by placing the OH leads at the bottom of the coil, and using a coaxial lead system. The vacuum field shots were designed to demonstrate that the OHxTF error fields are, in fact, absent. Preliminary analysis indicates that the OHxTF error fields in NSTX-U are less than 1 G, which is substantially smaller than in NSTX.

Wednesday 5/4 started with a couple of shots of XMP-152. These demonstrated that the bug in the X-point control code was fixed. The rest of the day was spent on XMP-150 (He Density Scan for Zeff Measurements, C. Skinner & R. Bell), which continued the use of Ohmic Helium plasmas. A density scan was completed, including plasmas with Greenwald fractions up to approximately one. Preliminary analysis of the data shows that the photometric calibrations of the visible bremsstrahlung diagnostics are largely valid, with the inferred Zeff trending towards approximately 2 at higher density as expected. These Ohmic shots had high values of the internal inductance, creating a difficult operating space constrained by coil force limits and vertical stability; ultimately the best shots for this XMP was achieved in inner-wall limited plasmas.

On Thursday 5/5, shots were dedicated to XMP-151 (L-mode development, W. Guttenfelder) with a focus of establishing higher power, diverted L-mode plasmas. The day began attempting to repeat the last 650 kA L-mode fiducial run prior to the maintenance period, but the discharge exhibited many L/H & H/L transitions. Increased HFS fueling was used over many shots to raise the plasma density in a 800 kA diverted target, approaching Greenwald fraction of 0.5, which prevented transition into H-mode. Various combinations of NBI #1 sources were used to inject up to 4.3 MW of power at the higher target density. Shots with injected powers between 3.5 - 4.3 MW appeared to be limited either by transition to H-mode or strong MHD activity, establishing an effective limit around ~3 MW.

Most of Friday 5/6 was dedicated to XMP-142 (H-mode scenario development). The goal was to reproduce previous long-pulse scenarios, but using ISOFLUX control of the divertor coils. It was found that the L-H transition was more reproducible when near a double null shape with 4.5MW NBI heating, however this shape can be difficult to maintain as the shot evolves. Good progress was made in reproducing a high-triangularity H-mode scenario with 6MW NBI; however, the discharges tended to divert too early, leading to a “low-li” evolution that can disrupt due to low q-shear. Future work will ensure these discharges divert later. The end of the day was dedicated to continuing XMP-151 (L-mode development), with the goal of increasing plasma current. A number of shots were required to establish the higher density/gas fuelling conditions necessary for the 800 kA, 2.5 MW L-mode. Then 900 kA and 1.0 MA discharges were run successfully to the OH current limit, with  $q_{95} \sim 3.7$  in the 1.0 MA scenario.

### **Experimental Research Operations (S. Gerherdt, R. Kaita)**

The reinstallation of the 16-channel UCLA reflectometer system at Bay-J is nearing completion. BNC data and power cable terminations (45 cables in total) are nearly complete. One of two digitizers has developed an ethernet communication problem which is being addressed. It is anticipated that first data will be obtained next week during plasma ops. (Terry Rhodes, UCLA)

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

NSTX-U plasma operations resumed this past week with experiments utilizing helium ohmic plasmas to demonstrate X-point and rtEFIT control, and to perform baseline helium density scans while the neutral beam ion sources were conditioned back up to usable power levels. Once beams were available, neutral beam injection was used in experiments on plasma H-mode development and L-mode control. In parallel with plasma operations this week initial operation of the MSE-LIF diagnostic neutral beam on NSTX-U was performed, and conditioning of the HHFW antennas has started. Preparations are underway to install strain measuring telemetry on the outer TF coils to provide the design verification data needed to qualify NSTX-U for .8 T operation this year. Also, commissioning of the high-speed Inner and outer vacuum vessel voltage monitoring system is nearing completion.

The NSTX-U Test cell will be in restricted access this coming week during plasma operations. Limited access is expected to be available for approved work on second shift.