NSTX-U Weekly Report (April 1, 2016)

FY 2016 NSTX plasma operations
Operation Targets: Total - TBD
Completed: 6.45 run week and 664 plasma shots

Graduate student Yusuke Yoshida from the University of Tokyo completed his visited to PPPL under the Princeton University / University of Tokyo Student Exchange Program (Feb. 26 to March 29). Yusuke worked with S. Kubota (UCLA) on adapting ray tracing and beam tracing codes to determine the propagation characteristics of millimeter-wave beams launched for the UCLA Doppler backscattering diagnostic on NSTX-U. Target plasmas used current and previous shots from NSTX and NSTX-U. This work will aid in the qualitative analysis of the experimental data (once the diagnostic is in place), and his future participation in this project is also anticipated. (S. Kubota)

Run Coordination (J. Menard, S. Gerhardt)

On Monday 3/28/2016, 4 shots were taken at the beginning of the day under XMP-143 (Assess Machine Conditions). These 1 MW L-mode shots were used to recover from the boronization on 3/26/2016. The discharges for the remainder of the day were dedicated to XMP-142 (Reduced MHD H-Mode Development) toward developing a reproducible H-mode scenario that achieves low li and high elongation via an H-mode transition during the I_p ramp up. This scenario can result in long periods of reduced MHD activity during the H-mode flattop that enable future transport studies. The first discharges to put power on the inner divertor following boronization achieved H-mode flattop with frequent small ELMs (203957 - 203963). Later discharges transitioned to larger, infrequent type-I ELMs (203971). It was observed that 3.5 MW heating resulted in ELM-free operation, 4.0 MW generated ELMy discharges, while greater than 4.5 MW prior to the start of ELMs led to a disruption at I_p = 800kA, B_t = 0.63T. The timing of diverting and H-mode was moved earlier in the discharge enabling the lowest sustained l_i value (~ 0.6 on 203980) and the highest instantaneous stored energy yet in NSTX-U (~250 kJ on 203981). Some progress was made on implementing X-point and drsep control in the H-mode scenario. Discharge repeatability was hindered by evolving beam availability and wall conditions.

On Tuesday, the first six shots continued XMP-142 to investigate the impact of drsep on the ELM character and continue developing ISOFLUX control in H-mode. The power threshold for ELMs was higher as the impurity content had steadily risen from the previous day. The remainder of the day was dedicated to XMP-145 (Development of Scenarios with Flat-Top H-mode). These shots suffered from some beam timing issues, as well as radial control problems and an elevated L->H threshold, prevented significant progress. However, the final shot of the day produced the highest value of betaN yet achieved (~4.8) in NSTX-U.

On Wednesday 3/30/2016, 8 shots were taken in the morning under XMP-110 (FIDA/ssNPA/sFLIP checkout). Isolated short pulses (20ms, 1MW power) of four neutral beams at different tangential radii were injected into L-mode plasmas to assess fast ion confinement and check/optimize FIDA and ssNPA diagnostics. Data was collected from the neutron detectors, MPTS, FIDA and ssNPA diagnostics. The neutron rise and decay rate during beam modulations will be used to compare the confinement of fast ions form NB line #1 and new NB line #2. Clear

active and passive response have been observed on FIDA and ssNPA diagnostics. Some shots, however, suffered from the neutral beams failing to fully produce the requested modulation patterns. The dataset is a good starting point for XP-1522 (Beam ion confinement) and will enable initial estimation of fast ion confinement time. The second ½ of the day was spent on the 9th vacuum vessel boronization.

Eighteen shots were taken toward XMP-142 aimed at establishing low-li, highly shaped ELMy H-mode with about 4.4 MW from three neutral beams. Variations in the early density (before 200ms) established a narrow range for the present scenario, presumably due to the dependence of the neutral beam absorption with density. At low density the power absorption is reduced and the L-H transition is delayed or missed entirely. At high density the power absorption is improved leading to increased normalized beta and MHD mode activity during the ramp-up. A number of good shots (204047,204049,204051,204056) with heating variations in the flattop established a normalized beta limit near 3.5 ($\sim 5\ l_i$ at kappa ~ 2.2) for the present scenario. As was observed on Monday, the first few H-mode shots following boronization had small, frequent ELMs, while the later shots had regular type-I ELMs. Oxygen levels rose through the day, leading to less reproducible L-H entry and longer ELM-free periods at the end of the day. Continued progress was made in establishing X-point control in highly-shaped H-mode discharges. The final shot of the day was a 1.8 second 700 kA L-mode, demonstrating that elevated oxygen levels are benign for L-mode discharges. In addition, implementation of "slow-ramp-down" that executes a soft-landing of the discharge was integrated into the morning fiducial.

On Friday 4/1/2016, an n=1 compass scan was conducted under XP-1506 (low-beta n=1 error field correction). The target plasma for this scan was the 1 MW beam-heated, sawtoothing L-mode fiducial discharge. After the onset of sawtoothing, the applied n=1 fields were ramped in amplitude at selected phases to induce locking. Clear mode locking and disruptive behavior was observed throughout the compass scan, and a good circular error field correction pattern was obtained. The optimal correction as indicated by the compass scan is shifted slightly from the results of XMP-140 (PF5 proportional error field correction), which was conducted in ohmic rather than beam-heated plasmas. After the completion of the XP-1506 compass scan, three shots toward XMP-146 (initial n=2,3 error field correction) were taken. In these 2 sec. discharges, the amplitude and phase of n=2,3 fields were modulated in 250 ms increments to assess whether the discharge was impacted by these higher order applied fields. Preliminary analysis from the rtVphi diagnostic indicates that core and edge rotation were impacted, especially with certain phases of n=2 applied fields. These results motivate further studies of n=2,3 error field correction.

On Friday afternoon, eight shots continued XMP 110 (FIDA/ssNPA/sFLIP checkout) to measure the stationary fast ion slowing-down distribution function with FIDA and ssNPA diagnostics. Instead of short beam blips, ~100ms (> slowing-down time) pulses were injected to center-stack limited L-mode plasmas. Three good shots (204090-204092) were obtained with the most tangential neutral beam 2A and the most perpendicular beam 1C respectively. The neutron generation rate shows a clear difference between these two beams. The dataset is complementary to that obtained on Wednesday morning. More detailed data analysis is underway to check fast ion distribution and to compare with classical theory.

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

NSTX-U plasma operations continued this past week after a weekend vessel boronization. Neutral beam injection and the Switching Power Amplifier (SPA) driven Resistive Wall Mode coils were used in support of experiments on H-mode development, error field correction, and long pulse L-mode plasmas. All six neutral beam ion sources are operational and are being actively conditioned in the 60 to 90kV range. Vessel boronizations have proved to be highly effective in controlling oxygen levels during discharges, and procedures/training are being updated to allow for limited, shorter boronizations that could be performed during the latter parts of weekday second shifts.

The NSTX-U Test Cell will be in restricted access this coming week during plasma operations. Access will be available in the evenings for approved work.