NSTX-U Weekly Report (July 1, 2016)

FY 2016 NSTX plasma operations
Operation Targets: Total – 18 run weeks
Completed: 10.06 run weeks and 1066 plasma shots

The paper "Phase coherence of parametric-decay modes during high-harmonic fast-wave heating in the National Spherical Torus Experiment" by J.A. Carlsson (Crow Radio and Plasma Science) et al., in Physics of Plasmas 23, 062519 (2016) (available online at http://scitation.aip.org/content/aip/journal/pop/23/6/10.1063/1.4954825). The paper demonstrates that higher-order spectral analysis can be a valuable complement to power-spectrum analysis for studying parametric-decay instability (PDI) during HHFW heating. The auto bicoherence of probe signals was computed and used to show quantitatively to which degree the suspected PDI modes are related. The bicoherence-analysis software tool is expected to help extract more information from probe data and facilitate a more detailed comparison with theory. (J.A. Carlsson)

Several NSTX-U researchers attended the 18th International Congress on Plasma Physics (ICPP 2016) held June 27 to July 2, 2016 at the Kaohsiung Exhibition Center in Kaohsiung, Taiwan. Four invited talks were given: Jon Menard (PPPL) presented "Key physics issues and opportunities for next-step spherical torus devices", Jack Berkery (Columbia University) presented "Kinetic resistive wall mode stabilization physics in tokamaks", Yang Ren (PPPL) presented, "Recent progress in understanding electron thermal transport in NSTX and NSTX-U", and Ahmed Diallo (PPPL) presented "Development of medium and fast burst laser systems for laboratory and fusion plasmas". (J. Menard)

NSTX-U researchers have participated in the 8th US-PRC Magnetic Fusion Collaboration Workshop, held at PPPL, June 28-20, 2016. The following NSTX-U related presentations were given at the workshop: "Comparing helium glow discharge cleaning with Li evaporation in NSTX" by R. Maingi (PPPL) and "NSTX-U Overview" by M. Ono (PPPL). In addition, results and future plans from PPPL-ASIPP collaborations on lithium research were described. (R. Maingi)

M. Podesta (NSTX-U/PPPL) participated to the 16th ITPA Energetic Particle Topical Group meeting, held at the ITER Headquarters (France) on June 27-30. The meeting included a 1-day workshop on diagnostics for alpha particle measurements in ITER, aimed at defining the physics requirements for fast particle measurements. Status and plans for potential diagnostics that would fulfill those requirements were discussed. The status of ongoing ITPA-EP joint experiments was discussed, including an experiment on "validation of Neutral Beam current drive and projections to ITER" coordinated by M. Podesta. NSTX-U is expected to provide data for the experimental database, and PPPL is actively involved in developing and validating improved tools to account for 'non-classical' effects in the computation and prediction of NB-CD (e.g. using TRANSP). M. Podesta also presented a summary of recent work by V. Duarte and N. Gorelenkov (PPPL) on the formulation of a new criterion for the emergence of so-called 'chirping' Alfvenic modes. The proposed criterion, which improves previous models and reproduces trends observed in experiments (NSTX, DIII-D, TFTR), was well received and the possibility of extending its validation to other devices was discussed. Engagement of NSTX-U and PPPL theory in other EP-related activities was discussed. In particular, NSTX-U/PPPL can contribute to the

interpretation and modeling of Ion Cyclotron Emission associated with energetic particles, which is foreseen as a possible fast ion diagnostic tool for ITER. (M. Podesta)

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

NSTX-U plasma operations continued this past week with experiments on H-mode access and inner gap control, error field correction, and initial checkouts of the Fast Ion Diagnostics (SSNPA/FIDA) and new Granule Injector. All utilized neutral beam injection, successfully using fast beam modulation when needed. On Monday, we recorded 30 plasmas in 30 attempts, a high point for NSTX-U. All six neutral beam ion sources conditioned and/or supported operations this week at an average operating level of >90kV, and a total combined neutral power of ~ 12 MW. We elected not to run on Wednesday to allow operating personnel to attend small group safety meetings to review last year's accident at the FSU Magnet Lab, and to discuss possible weak points or blind spots in our internal programs. We also used this time to provide test cell access for the commissioning of the new Massive Gas Injector (MGI) system. The MGI controls are now operational, vacuum leak checking complete, and integrated system testing in progress. Upon attempts to return to operations later in the week, we discovered a contaminant-based blockage in the PF1aU coil cooling path. That cooling path was isolated and flushed, but we are still addressing varying flow rates and remnants of the contaminant. Electrical insulation tests of the coil itself have been successful completed. Isolated flushing of the PF1aU coil continues, and an analysis of samples of the contamination is underway. All other coil cooling paths have been inspected and are clean. Also this week, conditioning of the High Harmonic Fast Wave (HHFW) antennas continued in parallel with plasma operations, and good progress was made on the pre-operational testing of the Lithium Evaporator (LITER) probes. Our cyclic MPTS Laser interlock testing was successfully completed, and two new category 3 (inner vacuum vessel) magnetic integrators were brought on line.

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.

Testing of the inner divertor insulation, intended to replace the GRAFOIL, is progressing. Significantly lower thermal conductivities are being achieved with a variety of combinations of stacked stainless steel screen and shim stock. The lower thermal conductivity will improve the inner divertor bake-out temperature, while protecting PF1b from excessive temperatures during bakeout. (P. Titus, PPPL)

Run Coordination (J. Menard, S. Gerhardt)

On 6/27/2016 and 6/28/2016, a number of steps were taken to try to improve the H-mode scenarios.

First, an attempt was made at optimizing the shot without any PF-2 coil currents at the time X-point control is turned on at 158 ms. Like the last shot of the previous Friday, this prevented the discharge from drifting to a large LSN bias. The feed-forward PF1A (before 158 ms) was increased faster before 100 ms in order to have the shape very close to diverting at 158 ms. Changing the feed-forward PF1A required some retuning to prevent diverting early, and it required some retuning of the outer gap and PF3/5 gains. It did succeed in having the shape

close to diverting around 150 ms, but then the shape would drift farther from diverting by 200 ms (shots 205034-9).

Next, a small optimization of the early error field correction (EFC) was attempted, and basically found a result similar to what had been seen in L-mode scenarios: that the best early correction toroidal phase was meaningfully different than that for the best later correction (shots 205040-3). This early correction was used for some subsequent shots.

Following this small EFC study, attention was turned back to control optimization, by requesting X-points closer to the mid-plane using the ISOFLUX targets. This was making good progress in establishing and maintaining an inner gap, but was starting to divert USN and going vertically unstable. Note that this change in X-point requests led to PF1A currents similar to those achieved in the feed-forward shots, but using X-point/inner gap control. In the future, the vertical instability would be addressed by adjusting the outer gap and continuing to to reduce the plasma height at the diverting time if need be (205047-50).

Next, in order to properly assess machine conditions, time was spent trying to recreate a shot that only used feedforward divertor currents and no feedback on drsep (204118). After adjusting the HFS pressure, early H-modes were achieved. Eventually, a HFS pressure 50% larger than the target shots from April was found to be optimal, suggesting there may have been a shift in the HFS gas pressure calibrations. The last shot (205062) was very close to an overlay of 204118, though without the transition, potentially due to poor wall conditions after 29 plasma shots. These scenarios will be revisited after a full boronization in the near future.

Following these H-mode studies, operations switched to XMP-110 (FIDA/ssNPA/sFLIP checkout). After taking 3 shots to get the target plasma right, 4 good shots were taken with beam modulations at an injection energy of 85 keV. Short (20 ms) pulses from neutral beam line #1 and #2 were alternatively injected into center-stack limited L-mode plasmas. Together with the data from March 31, this set of data will enable the initial assessment of fast ion confinement on NSTX-U and checkout of FIDA and SSNPA diagnostics. The next steps in this activity are some shots with longer beam on-times to obtain stationary fast ion slowing-down distribution function and to check the fast ion spatial profile.

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

The probe drives for the Lithium Evaporators (LITERs) were tested using location motion control, and it was determined that the remote control software was able to indicate the correct positions. The probe drives were then successfully operated using remote position control. The final set of limit switches and cables were installed for remote control of the probe drive for the Materials Analysis and Particle Probe (MAPP). The interface box for the permissive signals that allow remote MAPP torus interface valve was also mounted. (R. Kaita, PPPL)

PLC based gas control logic software that allows the Massive Gas Injection (MGI) gas valves to be filled to the required pressure was fully implemented. The system allows the primary and secondary plenums on the lower and mid-plane MGI gas injectors to be evacuated and then filled to the needed pressure. Other needed hardware for the MGI system, such as pressure transducers were also installed and calibrated The Pre-operational Test Procedure for operation

of the MGI power supplies was nearly completed. During these tests, the mid-plane and lower MGI valve power supplies were operated at voltages up to 1000V. The system in now very close to being able to inject gas into NSTX-U. (R. Raman, University of Washington)