NSTX Weekly Report (July 31, 2009)

FY 2009 NSTX plasma operations
Planned: Base - 11 run weeks, ARRA - 5 run weeks
Completed: Base - 10.95 run weeks with 1,705 plasma shots
ARRA - 3.47 run weeks with 587 plasma shots

• The third ARRA run week milestone was completed on July 27, 2009.

• A paper "Divertor heat flux mitigation in high-performance H-mode discharges in the National Spherical Torus Experiment" by V. A. Soukhanovskii et. al. has been accepted for publication in Nuclear Fusion. The paper described recent NSTX experiments that demonstrated divertor peak heat flux reduction from 6-12 MW/m^2 to 0.5-2 MW/m^2 in a high magnetic flux expansion radiative divertor. The experiments were performed in high-performance 1.0 MA and 1.2 MA 6 MW NBI-heated highly-shaped H-mode discharges, and minimal confinement degradation during the partially detached divertor phase. (V. Soukhanovskii, LLNL)

• The paper "Investigation of Electron Bernstein Wave (EBW) Coupling and its Critical Dependence on EBW Collisional Loss in High-Beta, H-mode ST Plasmas" by S.J. Diem, et al. has been accepted for publication in Nuclear Fusion. The paper presents experimental and computer EBW emission simulation results that show EBW collisional damping is occurring prior to EBW mode conversion in the plasma scrape off, reducing the coupling efficiency during the H-mode phase when the electron temperature is less than 30 eV inside the mode conversion layer. Lithium evaporation during H-mode plasmas was successfully used to reduce this EBW collisional damping by reducing the electron density and increase the electron temperature in the plasma scrape off. Lithium conditioning increased the measured EBW to O-mode coupling efficiency from less than 10% to 60%, consistent with EBW emission simulations. The published research work was a part of the Ph.D. thesis research by S. J. Diem in the Princeton University Plasma Program. (G. Taylor)

• The NSTX PAC-26 teleconference was held on Monday, July 20, 2009 to review the NSTX Program Letter for collaboration with laboratories for FY2010-12. At the meeting, a brief overview presentation of NSTX status and plans was given, and the key collaboration opportunities for FY2010-12 were outlined for the PAC. The PAC-26 report has already been issued, and the program letter is under revision. Thanks to the NSTX PAC for their helpful and prompt recommendations. (Jon Menard)

Run Coordination (R. Raman , University of Washington, Deputy: E. Fredrickson)

NSTX Plasma Experimental Highlights for July 23 - 29, 2009**:** L-H threshold studies in deuterium and Helium, in support of an ITER task, showed similar levels of threshold power in both gas species. It was found that depositing Li-particles on the lower divertor, with the Li-dropper, before the start of the shot was beneficial to improving discharge performance. Studies were conducted in support of developing a “snowflake” divertor configuration in NSTX.

In the morning of July 23, XP941 “L-H Threshold power in HHFW heated deuterium and Helium plasmas –S.M. Kaye” was run. The goal was to compare L-H thresholds in pure Helium

and pure Deuterium plasmas using High Harmonic Fast Wave heating (HHFW). The HHFW power was ramped up and down in each shot to determine both the L-H and H-L power thresholds. It was found that the L-H threshold for He and D plasmas, as inferred from changes in the Te and ne edge profiles, depended nearly linearly on density and occurred at similar power levels. The discharges showed some hysteresis, with the back transitions occurring at slightly lower powers (normalized by density) for Deuterium than for Helium. The power levels referred to take into account the determination of the actual HHFW power heating the electrons as well as the ohmic power. These actual HHFW heating powers were deduced from the transient change in electron stored energy during RF power dropouts and turn offs.

In the afternoon of July 23rd, two and a half hours were devoted to XP932, "Influence of Hot Ions on Resistive Wall Mode Stability – J. Berkery" to obtain additional data for an APS invited talk. Discharges with 0.8MA, 0.9MA, and 1.0MA were run and RWM instability was observed in several cases. One shot in particular had a very long and steady rotation decrease from n=3 magnetic braking to an extremely low rotation profile (4kHz in the core, 0 at the edge). This may be the lowest rotation profile ever achieved in NSTX without an n=1 rotating mode present.

In the morning of July 24, XMP26 "Bring HHFW online and condition the antenna – J. Hosea" was run. -90 and -150 degree phasing RF power was coupled into NBI-fueled, deuterium H-mode plasmas at Bt=4.5 and 5.5 kG. At 4.5 kG, 2.5 MW was coupled for 200 ms with -90 degree phasing and 1.95 MW was coupled for 200 ms with -150 degree phasing. At 5.5 kG, 2.5 MW was coupled for 200 ms with -90 degree phasing and up to 3.2 MW was coupled with -150 degree phasing. The RF power typically coupled well through the frequent Edge Localized Modes (ELMs).

In the afternoon of July 24, XP913 "Lithium (Li) dropper – D. Mansfield" was run. When taking over the machine after LITER was removed and an RF experiment had been run, it was observed that the effective recycling was high. This provided a good opportunity to access the ability of Li powder injection to overcome vessel conditions with high recycling. After several Li injection profiles were attempted without clear success, the machine recycling was finally reduced by introducing Li powder onto the lower divertor surfaces before plasma breakdown.

On July 27, the second part of XP916 "Study of TAE (Toroidal Alfven Eigenmode) and TAE-induced fast ion transport in L-mode, center-stack limited deuterium plasmas – M. Podesta" was run and completed. The reference discharge developed during the previous run on April 15 was successfully reproduced, and a NB power scan completed. Data at low density were also obtained. The main part of this XP for this run was then dedicated to collect data for an extensive comparison between experiments and numerical codes. Several scenarios have been obtained, including periods of quasi-stationary TAEs developing into a more bursting behavior as the NB power is increased. The effects of background plasma parameters and q profile changes on TAE dynamics were investigated through a quick plasma current scan (0.7, 0.9 and 1.1MA) and a HHFW power scan (Prf up to 2MW). Finally, a vertical scan of the NPA (Neutral Particle Analyzer) and a scan of the f-FIDA (fast - Fast Ion D-Alpha) filter angle was performed for the reference scenario to investigate the details of the fast ion distribution in both space and energy.

In the morning of July 28, XP836 "Parametric Study of Highly elongated plasmas – D. Gates" was run to expand the NSTX data base. Poloidal betas of up to 1.5 were sustained for 1s and up to 1.9 were obtained in transient discharges.

In the afternoon of July 28, XP948 "Optimization of long pulse, high beta-toroidal discharges – S. Gerhardt" was run for two hours. High-elongation scenarios at Ip=900 kA and Bt=0.4 T were attempted, in an attempt to increase the pulse duration. However, the achieved values of toroidal beta did not exceed those achieved previously at higher values of current and field, likely due to reduced confinement and more rapid current penetration.

In the afternoon of July 28 and 29, XP934 "Improving $<beta_N>_{pulse}$ vs. rotation under Resistive Wall Mode (RWM) control and beta feedback – S. Sabbagh" was run. It demonstrated successful operation of the new beta feedback control system, along with standard n = 1 RWM feedback and plasma rotation variation. Three levels of normalized beta (up to 6) were set for feedback, with clear blocking of the NBI power to approach these levels. Gain settings were altered to reduce lag in reaching the target normalized beta. For the few cases tested, n = 3 non-resonant braking worked harmoniously with beta feedback, including very low rotation states (4kHz at plasma core, zero over the outer portion of the plasma). Limiting modes included n = 1 rotating modes neoclassical tearing modes (NTMs) and RWMs. Further work will examine the causes for fluctuation around the target normalized beta value, and how the fluctuations can be reduced.

In the morning of July 29 XP924, "Snowflake divertor in NSTX – V. Soukhanovskii" was run. The experiment aimed at scoping studies of the novel "snowflake" divertor geometry and took advantage of the recently implemented divertor strike point control capability. The "snowflake" divertor configuration was proposed by D. D. Ryutov (LLNL) and was shown theoretically to have advantages for divertor heat and particle flux control over the standard divertor geometry (a larger magnetic flux expansion, a longer divertor connection length, and beneficial edge turbulence properties). The "snowflake" divertor geometry was created by bringing a primary and a secondary lower divertor X-points as close as possible to each other. Several "snowflake"-like divertor configurations were sustained for up to 200 ms in 4 MW NBI-heated H-mode discharges. The obtained edge and divertor measurements are being analyzed for future performance optimization and improvements in divertor control algorithms.

In the afternoon of July 29, XP827 "LITER Characterization and ELM Mitigation – R. Maingi (H. Kugel)" was run to obtain an increased data set at high levels of Li deposition. Additional ELM-free discharges in a near-DN configuration were obtained to augment an invited APS talk under XP827. These discharges were programmed to stay just below the global stability limit. Quasi-steady H-mode pedestal profiles were obtained that will augment the existing profile and stability analysis.

Engineering Operations (A. von Halle, C. Neumeyer)

NSTX plasma operations continued this past week with extended run days on Tuesday and Thursday, and with the use of the freshly refilled LITER probes, the lithium powder

shaker, HHFW and neutral beam heating, the RWM error field coils, strike point control, and the new PF Absorber Coils. In parallel with machine operations, pre-operational testing of the PCS control of neutral beam injection timing continued, and the receipt inspections of the new Sandia Liquid Lithium Divertor (LLD) trays was performed.

The NSTX Test cell will be in restricted access this coming week during plasma operations, with extended run days (to 7PM) planned for Tuesday and Thursday. Test cell access will be available each evening at the end of the run day.

Research Operations (M. Bell)

Boundary Physics Operations (H. Kugel)

• Liquid Lithium Divertor (LLD)
- The molybdenum coating of the front face of 6 divertor plates was completed, and the plates were received from the vendor.
- Molybdenum flame spray samples obtained during the calibration coating process were received.
- Plate inspection, characterization, and preparations for final assembly were started. (M.Viola)

• Lithium Dropper
- An XP that would make use of a lithium dropper converted to tungsten powder dropping for ITER relevant studies was reviewed by the Boundary Physics-TSG. (D. K. Mansfield)