NSTX Weekly Report (June 5, 2009)

FY 2009 NSTX plasma operations
Planned: Base - 11 run weeks, ARRA - 5 run weeks (pending funding approval)
Completed: Base -8.92 run weeks with 1362 plasma shots, ARRA - 0 run weeks

Several presentations related to NSTX physics and engineering were presented at the 23rd Symposium on Fusion Engineering held May 31 – June 5, 2009 in San Diego, California. NSTX posters included: "Dynamic Behavior of Li Dust in NSTX" by A. L. Roquemore, "Mechanical Design of the NSTX Liquid Lithium Divertor" by R. Ellis, "Simulation Results for New NSTX HHFW Antenna Straps Design by Using Microwave Studio" by C. C. Kung, "Ramp-up of CHI Initiated Plasmas on NSTX" by D. Mueller, "NSTX Protection and Interlock Systems" by X. Zhao. Posters related to the proposed NSTX Upgrade project were also presented: C. L. Neumeyer, "National Spherical Torus Experiment (NSTX) Center Stack Upgrade", "A Novel Demountable TF Joint Design for Low Aspect Ratio Spherical Torus Tokamaks" by R. D. Woolley, and "Power System Changes for NSTX Upgrade" by S. Ramakrishnan. Brian Lloyd (Culham - U.K.) gave an invited presentation entitled "Recent Advances in ST Research and Prospects for New ST Capabilities" emphasizing MAST and NSTX results and plans in the "Fusion Experimental Machines" oral presentation session, and J. Menard chaired that session. (J. Menard)

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

May 28-June 4: This was a very successful week for addressing the NSTX Research Milestone on Advanced Scenarios R(09-3): Perform high-elongation wall-stabilized plasma operation and for understanding Neoclassical Tearing Mode Physics. The capability of 3-D coils for controlled ELM triggering was further developed.
On May 28, XP943 "Optimization of ELM pacing with 3D fields- J. Canik (ORNL)" was largely completed, with ELM pacing performed in lithium conditioned plasmas, combined with improved fueling to enable density control. The plasma current was reduced to 800 kA (from 1 MA) in a further attempt to reduce the ELM size. A controlled triggering frequency scan was performed, with ELMs triggered from 10 to 60 Hz. The discharges showed only a modest decrease in confinement (~10%) at the highest triggering rates. Preliminary analysis indicates the ELMs size was indeed reduced at the lower plasma current. The gas fueling from the center stack was partially replaced by the supersonic gas injector, so that the CS fueling reduced by ~40%. This fueling optimization was successful in achieving periods in which the line-average density was stationary.
On May 29, XP904 "Strike Point Dynamics – by E. Kolemen (Prineton University)" was completed. For this XP control law for the lower outer strike point was developed and applied successfully. We implemented the strike point controller for high triangularity (δ) plasmas and also for the intermediate-δ plasmas as requested by XP-919, "Development and characterization of intermediate-δ discharge with lithium coatings" by Josh Kallman. We were able to control the flux difference between the real strike point location and the requested strike point location (in various locations ranging from 62 to 85 cm in radial position) within less than 1 milliweber. This corresponds to strike point displacement position error of within less than 1 cm.
On June 1, XP945, "ELM triggering via vertical jogs – S. Gerhardt" was run. A method was developed for jogging the plasma, using synchronous jogs in dr-sep and magnetic axis vertical

position. The ELM frequency was observed to speed up, compared to reference shots with no jogs. However, the synchronization between the triggered ELMs and plasma motion was not clear. These discharges also suffered from H->L back transitions after some period of jogging. Analysis of the data has indicated that discharges which are nearer to double-null may provide a better target for future attempts at this technique.

On June 2, XP-836 entitled "Parametric Study of Highly elongated plasmas - D. Gates" was run. The purpose of the run was to achieve discharges with high fractions of the bootstrap current by running discharges at high values of plasma elongation and at high values of beta poloidal. High levels of Lithium evaporation were used to achieve discharges with beta_poloidal values exceeding 1.9. Discharges with loop voltages of ~110mV were sustained for 0.75s. Because of low levels of central solenoid flux consumption, and limit imposed by the pulse length on the toroidal field coil, most of the discharges used only half of the available transformer flux. These discharges had the lowest pulse averaged flux consumption of any NSTX plasma to date.

On June 3 and for part of June 4, XP914 "NSTX and DIII-D aspect ratio comparison of NTM physics – R.J. LaHaye (General Atomics)" was run and successfully completed. Good data was obtained in about 10 NSTX shots for study of the aspect ratio physics of the marginal condition for m/n=2/1 neoclassical tearing modes. The plasma conditions at the "knee" of the decreasing n=1 Mirnov amplitude as beta is slowly reduced will be compared to the data already obtained on DIII-D at higher aspect ratio. Previously on NSTX, 1 (or perhaps 2?) examples were obtained in 2007 on another experiment and two attempts in 2008 made no progress due to 2/1 modes locking at low power/torque before stabilization, or falling out of H-mode at low power first (an undesirable condition as profiles and beta change rapidly). Good n=1 dynamic error field correction (EFC) and pre-programmed n=3 EFC have alleviated the locking, and judicious use of Li before every shot has helped discharge reproducibility to get the n=1 mode in the middle of the pulse and stay in H-mode before volt-sec run out. Some sound advice to run a better shape for staying in H-mode was also used. No attempts at the effect of rotation on the peak (before beta ramp down) n=1 mode amplitude were tried. This was to have been done with n=3 braking. However the companion XP-915 has numerous cases of initially rotating modes with different levels of n=3 (and n=1) braking that can be studied.

On June 3 and during part of June 4, XP915 "Influence of Rotation on NTM beta limit and error field sensitivities – R. Buttery (MAST Program, Culham Laborotory, UK)" was run and successfully completed. A detailed scan was made of the influence of rotation on the NTM beta limit and its interaction with error fields. n=3 braking was deployed to vary the plasma rotation, while n=1 fields were variously applied to explore the trade-off between NTM beta limit and error field level. A broad and well controlled data set was obtained, thanks in part to the use of a small amount of lithium each shot to maintain plasma conditions (and also thanks to the expertise and advice of the NSTX team). An envelope was identified in the application of n=1 and n=3 field outside of which locked modes were generated. Within this envelope rotating NTMs were seeded, but often with reduced rotation and beta. This perturbation to the NTM physics is an important confirmation of an effect only previously observed on DIII-D. However the application of a wide range n=1 and n=3 fields within this envelope, provides new scope to help deconvolve rotation profile effects (e.g. is it rotation or rotation shear that matters?) and better understand the nature of the error field interaction and sensitivity of NTM-susceptible plasmas. Thus the primary goal of a study of rotation and error field effects on the NTM was well met. Many thanks to the NSTX team for their excellent support and generous assistance.

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

NSTX operations continued this past week with extended run days on Tuesday and Thursday. Lithium evaporation (LITER), neutral beam injection and error field correction were used in an experiment to optimize the non-inductive current fraction at high plasma elongation. Good wall conditions achieved by lithium evaporation proved valuable in additional experiments on the impact of these conditions on neoclassical tearing modes (NTMs) and their effects on plasma rotation and error fields, and also on the study of NSTX/DIII-D aspect ratio comparisons of NTM physics. Experiments were also performed this week on the formation and study of ELMs introduced via a manipulation of the plasma vertical position, and on the use of supersonic gas injection for H-mode fueling.

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.

Boundary Physics Operations (H. Kugel)

• Liquid Lithium Divertor (LLD)
- Vacuum testing of a 3-heater LLD assembly using the prototype control system was started.
- The electrical work package for Test Cell power, cable, cable tray, and rack installation was approved, and the work has been scheduled to start during the next maintenance.

• Lithium Powder Dropper
- The vacuum conditioning of lithium powder for loading Unit-1 was completed.
- Unit-1 achieved vacuum conditions suitable for loading with lithium powder.
- Unit-1 was loaded with conditioned lithium powder, and the subsequent pumpdown promptly achieved good vacuum conditions.
- The computer controlled calibration of Unit-1 was started and is in progress.
- The vacuum conditioning of lithium powder for loading Unit-2 was started and is in progress.

• Divertor Region Sample Probe
- The remaining tasks for achieving remote control capability were scheduled for completion during the next maintenance.