NSTX Weekly Report (April 23, 2004)

FY 2004 weeks of operation planned: - 18 weeks, Completed: - 9.8 weeks

Department, Project, Program (M. Ono, M. Peng, M. Williams, E. Synakowski)

• The 15th Topical Conference on High Temperature Plasma Diagnostics was held this past week in San Diego, CA with four NSTX related invited papers and twelve contributed papers presented. The following four invited talks highlighted results from NSTX:
- "Spatially Resolved Spectra from an X-ray Imaging Crystal Spectrometer for Measurements of Ion and Electron Temperature Profiles" by M. Bitter.
- "Fast and Energy Resolved 2-D X-ray Imaging for MFE Plasmas" by D. Pacella (ENEA/Frascati).
- "Visible to X-Ray Spectroscopic Diagnostics for Burning Plasmas Experiments" by D. Stutman (Johns Hopkins University).
- "Deposition Diagnostics for Next-Step Devices" by C. Skinner.

The following contributed poster presentations discussed present and planned hardware and measurements on NSTX: "Edge Density Fluctuation Characterization in H-Mode and Polarimetry Measurement via FIReTIP System on NSTX" by K. C. Lee (U. of California at Davis), "The Motional Stark Effect (MSE) Diagnostic on NSTX" by F. Levinton (Nova Photonics, Inc.), "Neutral Particle Analyzer Diagnostic on NSTX" by S. Medley, "Solid State Neutral Particle Analyzer Array on NSTX" by K. Shinohara (Japan Atomic Energy Research Institute), "First Experimental Results from a High Resolution Bragg Imaging Spectrometer on NSTX and Alcator C-Mod" by K. Hill, "Least-Squares Fit Analysis Program for the Evaluation of Spatially-Resolved X-Ray Spectra from Tokamak Plasmas" by D. Mastrovito, "Microwave Scattering Measurement of 'rho(e)'-Scale Turbulence on NSTX" by D. Smith, "Radial Correlation & Quadrature Reflectometry on NSTX" by S. Kubota (UCLA), "Initial Operation of the NSTX Fast Tangential Soft X-Ray Camera" by B. Stratton, "Optical" Soft X-Ray Arrays For Fluctuation Diagnostics in MFE Experiments" by L. Delgado-Aparicio (Johns Hopkins University), "A High-Speed Optical Diagnostic for Measuring Doppler Shift Using Interference Filters" by S. Paul, "NSTX Tangential Divertor Camera" by A. L. Roquemore, "Supersonic gas injector for fueling and diagnostic applications on NSTX" by V. Soukhanovskii (Lawrence Livermore National Laboratory), "NSTX Low-Z Pellet Injector" by H. Kugel, and "Fast Neutral Pressure Gauges in NSTX" by R. Raman (University of Washington).

• Last week represented a period of full and efficient experimentation on NSTX. Three experiments were performed pertaining to different aspects of H mode transition physics and H mode formation. High harmonic fast wave (HHFW) experiments were also performed that focused on current drive at different toroidal wave phase velocities, as were experiments on the coupling of HHFW to neutral-beam-heated discharges. Rotation damping physics was studied in plasmas above and below the no-wall stability limit. Finally, tests shots were taken to provide information regarding the vertical control requirements of the plasma. See the details below. (E. Synakowski)

• The NSTX Physics Meeting will be held on Monday, April 26, 2004 at 1:30 P.M, in B318. **Dr. G. Bertschinger from TEXTOR, will visit PPPL from April 26 - 29, 2004, after the High Temperature Plasma Diagnostics Conference in San Diego. Dr. Bertschinger will present a seminar at the NSTX Physics Meeting entitled: "X-ray Spectroscopy on TEXTOR and Tore-Supra".** This meeting will be available for remote participation. (C. K. Phillips)

Run Coordination (S. Kaye, J. Menard)

A summary: XPs 418 and 419, which measured the L-H threshold dependence on configuration and fueling, were completed. LFS and HFS fueled discharges were compared using identical fueling waveforms. The L-H threshold power in both cases was found to be comparable, despite significant differences in the edge rotation profiles. The XP to study the dependence of L-H threshold power on configuration reproduced the balanced double null threshold found earlier, with low threshold powers (1 beam source). However, the unbalanced double null with drsep=1 cm stayed in the L-mode, even with 2 NBI sources. Shots comparing the density rise with HFS and LFS fueling, and with the LFS fueling cut off early in the discharge were taken in H-mode. The density rise was found to be almost identical in all the cases, indicating that it is particle confinement, and not fueling source, that controls the density rise. XP425 studied H-mode transitions in HHFW-only plasmas at higher currents than previously. At 700 kA, no transition was observed with 7 m-1 phasing, although 14 m-1 phasing led to a transition. Transitions were also observed at 800 kA with 14 m-1. No sustained H-mode was observed in any case. RF powers were limited to 2 MW and below. The second day of XP403, which studied HHFW current drive, was performed. Since H-modes were to be avoided in this XP, helium plasmas were employed. The HHFW phasing programmed to change from 7 m-1 to 3 m-1, and mixed phasing of 7 and 3 m-1 were investigated. A co- vs counter- current drive comparison in the first scenario produced central electron temperatures up to 1.7 keV with 2.7 MW of HHFW power, and led to current drive results similar to those obtained previously. It was found that the mixed phase spectrum case did not drive current as effectively as single phase scenarios. Less edge ion heating was observed for 3 than for 7 m-1, raising the question of whether power is getting into the plasma for 3 m-1. Sideband fluctuations were observed on the RF probe during the 7 m-1 scenario, and this observation is possible evidence for the edge parametric decay mechanism suggested as the source of the edge ion heating. The first experiment to study the compatibility of simultaneous HHFW and NBI injection was performed (XP413). Because of fast ion impact on the RF antenna at 800 kA, the plasmas had to be run with a large outer gap. For these gaps, the 14 m-1 phasing did not couple well to the plasma. Attempts were made with 7 m-1 phasing, and there was some indication that this was a promising avenue, although further investigations need to be performed. Attempts were made to increase the current to 1 MA to decrease the fast ion loss, but MHD activity prevented these plasmas from being good targets for the RF. A set of single coil shots were taken as the first part of XP423, a study of the vertical control of the plasma. Only a couple of OH only shots need to be taken to complete this phase of the XP. The final XP run during the week, XP408, studied rotation damping physics in 1 MA plasmas with approximately 90% of the XP being completed. A variety of rotation damping scenarios for plasmas above and below the no-wall limit were observed and will be studied. The neutral beams were run at 100 kV for this XP, reaching powers of up to 7 MW. High toroidal beta (>35%) and normalized beta (>6.5) were attained along with the longest current flattops observed at 1 MA (>500 msec). Elongations of up to 2.5, with low (.05 Volts) loop voltages were also achieved. Central densities of up to 8 10^19 m^03 were observed in these discharges.

XP-425 conducted on Tuesday April 20, 2004. We were able to extend the experimental range of the HHFW driven H-mode plasmas. While in the past these plasmas were found at lower Ip namely 0.3 and 0.5 MA, we now have HHFW driven H-mode transitions observed at 0.6, 0.7 and one at 0.8 MA. Furthermore, while previously such H-mode transitions were obtained with k// = 14/m, we also observed it with 7/m. One must add here that while good power level were achieved on the previous Friday, such was not the case for the run on Tuesday. Hence the H modes obtained on Tuesday were "just above threshold". The RF operation was marked by many dropouts (Tuesday). The power threshold appears to be 1.5 MW. And as I can remember it is not a strong function (if any) of Ip. (B. LeBlanc)

Tests of current drive efficiency at the highest available phase velocities for HHFW were performed (XP 413). While 3 m-1 phasing is predicted to be the most efficient of the available phasings at current, it is also expected to be depositied at relatively high electron temperatures. Therefore, the capability of varying the phase during the discharge was employed to heat first at 7 m-1, followed by a prompt switch to 3 m-1 during the discharge. At 7 m-1, central electron temperatures of 1.7 keV were obtained. However, the switch to 3 m-1 following this heating yielded a collapse of central temperature and no observable current drive. Together with the observation that less edge ion heating was observed for 3 than for 7 m-1, this raises the question of whether less power is getting into the plasma at 3 m-1 than expected. At 7 m-1, with co- and counter current drive phasings, results similar to those obtained previously were reproduced. Notably, although the working gas was helium, power levels had to be kept below 3 MW to avoid H modes that altered the wave deposition. Mixed phasings of 7 and 3 m-1 were employed that yielded heating and signatures of current drive that were more modest than those obtained at 7 m-1. Sideband fluctuations of the 30 MHz launched waves were observed on an RF probe during the 7 m-1 scenario, providing evidence that the edge parametric decay mechanism may be the source of the edge ion heating. (P. Ryan, ORNL)

XP-413 conducted on Thursday April 23 2004. During this day where we tried to couple HHFW to a NBI H-mode plasma with beta_t = 10 - 15%, we had very limited luck. At k// = 14/m, it was found that too much interaction between the antenna and the plasma (lost fast particles) occurs to pursue such operation. Parts of the antenna were glowing in the dark after the shot. Some metallic impurity was observed. While the radiated power reached close to 2 MW on Thursday, I am happy to see that today this is back to normal with Prad below 1 MW. Increasing the gap between plasma and antenna resulted in (too) low loading. That is for a certain power request the RF power supply had to provide such a HV that an operational limit was reached. Basically the available HHFW power was typically below 2 MW. We may have had a slightly better luck with k// = 7/m. But I would strongly recommend caution here. Only one plasma (maybe two) actually shows some sign of heating. I am not convinced at the moment that such is the case. On the other hand the loading was better at k// = 7/m than at 14/m. Still the available power was capped by hardware limitation at below 2 MW, because of poor loading. We also had difficulties caused by large elms. (B. LeBlanc)

XP408 "Rotation Damping Physics in High BetaN ST Plasmas" examined the toroidal rotation evolution in many scenarios (high beta toroidal, high normalized beta, low beta, high toroidal field and low toroidal field (q-scan)). Many shots were created with betaN > 6 and toroidal beta exceeded 35%. In most cases, the full toroidal rotation evolution was tracked down to nearly zero rotation with the new 51 channel, 10 ms time resolution CHERS system. Exceptional detail of the rotation dynamics was provided by this diagnostic. RWM detection was available with the new internal RWM sensor array. The influence of several different modes including tearing modes, RWMs, and ELMs on toroidal rotation damping was examined. Rotation damping at lower NBI power (momentum input) and betaN followed what would be expected from electromagnetic interaction between rotating islands and eddy currents and the static error field. However, the rotation damping was significantly altered in different operating regimes - accelerated damping potentially due to pressure driven modes, as well as reduced damping, with mode rotation held constant for significant periods. Analysis of these tailored scenarios will give greater understanding of the causes of the rotation damping due to the variety of modes in the plasma. (W. Zhu, Columbia University)

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

NSTX plasma operations continued this past week with experiments selected to take advantage of the machine's good vacuum conditions. Experiments on H-mode access XP-419) and comparisons of MAST/NSTX H-modes (XP-418) were completed early in the week before moving on to experiments on HHFW H-modes (XP-425), HHFW current drive (XP-403), and the combination of HHFW heating to neutral beam produced H-mode plasmas (XP-423). The RF filters installed in the real-time digitizers for the magnetic diagnostics performed well allowing good rtEFIT control during high power HHFW operation. Machine operations were extended to 9:00PM on Thursday to perform a series of field only shots in support of an upcoming vertical stability experiment. The week concluded with an experiment on the control of Resistive Wall Modes (XP-408). A vacuum vessel boronization was performed over on Saturday.

Access to the NSTX test cell will be restricted during plasma operations this week. Test cell access will be available from 5:00PM to 10:00PM each evening, except for Tuesday, April 27th, when plasma operations will be extended to 9:00PM. The next maintenance week is scheduled for May 3rd-7th. (A. von Halle)

Research Operations (M. Bell)

Physics Operations (D. Mueller)

• Installation of new filters on the inputs to the real time control system permitted control of plasmas heated with HHFW at high power.

• The XP on Rotation Damping was very successful; using the lower single null plasma developed using PF1B, well behaved long pulse (1 MA until ~ .78s), high kappa (up to 2.55), plasmas were used to study plasma rotation and MHD.

• rtEFIT/isoflux control was used to make double null discharges during the RF heating/current drive XPs this week. Control of the plasma antenna gap was accurate to 4mm (standard deviation over ~ten shots) in shots with power <2MW and accurate to ~8mm in plasmas with <4MW. The increased perturbation at high power was caused by sporadic RF source trips. Several gap scans and Ip scans were performed without additional development time required. Both helium and deuterium plasmas were controlled. (D. Gates)

Boundary Physics Operations (H. Kugel)

• The reassembly of the Lithium Pellet Injector was started and is in progress. (G.Gettelfinger)

• Machining of parts for offline testing of the NSTX Supersonic Gas Injector (SGI) was started and is in progress. (T. Provost)

• The vacuum fore-pump on the Lithium Resistive Evaporator (LRE) test chamber was energized, and the chamber passed a preliminary leak check. The fabrication of hardware fixtures for inside the test chamber was started. (R.Majeski)

Diagnostic Operations (R. Kaita)

Danilo Pacella from the ENEA/Frascati Laboratory in Italy visited NSTX last week to work on the PIXCS soft X-ray imaging system. By varying the energy range of the detected X-rays, the diagnostic was used to successfully obtain electron temperatures as a function of time. The measurements compared favorably with data from the multipoint Thomson scattering system. Pacella reported these results at a PPPL seminar and in an invited talk on April 21 at the High Temperature Plasma Diagnostics Conference in San Diego, CA.