Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Impact of error-field reduction on NSTX lower single null discharges

OP-XP-207	**Revision: 0.0**	Effective Date: 2/11/2002 *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Author:	**J. Menard**	Date 2/12/2002
ATI - Task Force Leader:	**J. Menard**	Date 2/12/2002
RLM - Run Coordinator:	**R. Maingi**	Date 2/12/2002

Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

Impact of error-field reduction on NSTX lower single null discharges

1. Overview of planned experiment:

A large effective shift of the PF5 coil set was discovered during the FY2001 NSTX run period. This shift introduced a significant n=1 error field (> 5 Gauss) throughout the NSTX plasma volume. This error field has been implicated in suppressing edge rotation and causing locked-mode disruptions during ohmic and lower-single-null (LSN) discharges. Early in the FY2002 run period, the PF5 coil shape was modified to significantly reduce the n=1 error field component. The goal of this experiment is to assess the impact of this error-field reduction on NSTX plasma performance. Specifically, the goal is to determine the maximum achievable flat-top duration for LSN discharges as a function of plasma current, NBI injection timing (rotation), and applied toroidal field (safety factor).

2. Justification:

During previous operational periods on NSTX, it was found that the best machine performance (highest beta, longest pulse-length, highest current, etc.) was obtained with early beam injection and with the last-closed flux surface limited on the center-stack. Subsequent experiments showed that NBI-induced rotation was an essential element of a successful discharge, presumably due to suppression of locked tearing modes. Lower-single-null discharges were routinely utilized to facilitate H-mode access, but the plasma current flat-top phase was frequently disrupted by "reconnection-events" for plasma currents above approximately 800kA. Subsequent locked-mode data analysis (R. Maingi) showed that the onset of locked modes routinely induced disruptions in LSN discharges. In light of the predicted factor of 10 reduction of the n=1 error field in NSTX, and given the importance of achieving long H-mode discharges, it is important to assess if LSN operation has been improved.

3. Plan:

The dependence of the plasma current flat-top duration will be determined as a function of plasma current, applied toroidal field, and neutral beam induced rotation. The results from this scan will be used to determine which MHD modes limit the flat-top duration and to determine the role of safety factor and plasma rotation velocity. The experiment will be performed as follows:

1. Establish baseline LSN to match ohmic shot 105944 which had locked mode in previous run: 6cm inner gap, 5cm outer gap, 0.45T, 0.8 MA, κ=1.8, δ=0.35, $n_e(0) = 2\times10^{19}m^{-3}$

2. Plasma density:
   a. To compare directly to ohmic discharge 105944, scan central density in 4 shots in range $1\text{-}5\times10^{19}m^{-3}$ in 800kA, 0.45T, ohmic configuration from section 3.1 above.
   b. For all other shots in systematic scan, keep central electron density $\approx$ $3\text{-}5\times10^{19}\,m^{-3}$.

3. Use nominal I_p ramp-rate of 5MA/s, or whichever start-up scheme is routinely used at the time of execution of this XP.

4. Perform scan – document flat-top duration, locked mode signatures, and rotation profiles.

	Beam Injection Setup (source and injection time)						
I_P (MA)	No beams		Source A only at 100ms		Add source B at 150ms		TF (T)
0.6							0.45
0.8							0.45
1.0							0.45
1.2							0.45
0.6							0.30
0.8							0.30
1.0							0.30
1.2							0.30

5. Shot order and number:
   a. Scan I_P with no NBI and 0.45T, then repeat with 0.3T.
   b. Scan I_P with source A starting at t_{INJ}=100ms and 0.45T, then repeat with 0.3T.
   c. Scan I_P with sources A+B: source A starting at 100ms and source B starting at 150ms and lasting for 50ms, then repeat with 0.3T.
   d. Minimum number of shots = 30.

4. Required machine, beam, ICRF and diagnostic capabilities:

Machine: 3.0 - 4.5 kG

Beams: 80keV deuterium, sources A & B

No ICRF.

Diagnostics: Toroidal mirnov array, locked mode coils, full kinetic profiles of electrons, ions, and impurities are essential.

5. Planned analysis:

Data will be used to determine rotation requirements for suppressing locked modes and will determine dependence of discharge pulse length and achievable current on safety factor. Results will be compared to theoretical expectations from TSC runs and PEST-III tearing mode stability predictions.

6. Planned publication of results:

An article based on these results is anticipated within one year of completion of the experiment.

PHYSICS OPERATIONS REQUEST

Title: Impact of error-field reduction on NSTX LSN discharges **XP No.: 207**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **36, 53kA** Flattop start/stop (s): **0 / 0.4**

I_p (MA): **0.6-1.2MA** Flattop start/stop (s): **0.18 / 0.3**

Configuration: **LSN**

Outer gap (m): **0.05**, Inner gap (m): **0.06**

Elongation κ: **1.8**, Triangularity δ: **0.35**

Z position (m): **0.00**

Gas Species: **D**, Injector: **Midplane**

NBI - Species: **D**, Sources: **A + B**, Voltage (kV): **80**, Duration (s): **0.3**

ICRF – Power (MW): **0**, Phasing: **Heating / CD**, Duration (s): **0**

CHI: **Off**

Either: List previous shot numbers for setup: **105944, 106686**

Or: Sketch the desired time profiles, including inner and outer gaps, κ, δ, heating, fuelling, etc. as appropriate. Accurately label the sketch with times and values.

DIAGNOSTIC CHECKLIST

Title: Impact of error-field reduction on NSTX LSN discharges **No. 207**

Diagnostic system	**Need**	**Desire**	**Requirements** (timing, view, etc.)
Magnetics	✔		
Fast visible camera		✔	
VIPS-1		✔	
VIPS-2		✔	
SPRED		✔	
GRITS		✔	
Visible filterscopes		✔	
VB detector	✔		
Midplane bolometer	✔		
Diamagnetic flux		✔	
Density interferometer (1mm)		✔	
FIReTIP interf'r/polarimeter	✔		
Thomson scattering	✔		
CHERS	✔		
NPA		✔	
X-ray crystal spectrometer		✔	
X-ray PHA		✔	
EBW radiometer		✔	
Mirnov arrays	✔		
Locked-mode detectors	✔		
USXR arrays	✔		
2-D x-ray detector (GEM)		✔	
X-ray tangential camera		✔	
Reflectometer (4 ch.)		✔	
Neutron detectors	✔		
Neutron fluctuations	✔		
Fast ion loss probe		✔	
Reciprocating edge probe		✔	
Tile Langmuir probes		✔	
Edge fluctuation imaging		✔	
H-alpha cameras (1-D)		✔	
Divertor camera (2-D)		✔	
Divertor bolometer (4 ch.)		✔	
IR cameras (2)		✔	

Tile thermocouples		✔	
SOL reflectometer		✔	