Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: Error-field and locked-mode physics studies using RWM/EF coils		
OP-XP-503	**Revision:**	Effective Date: 5/29/2005 *(Ref. OP-AD-97)* Expiration Date: 5/29/2007 *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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ATI – ET Group Leader:	**D. Gates**	Date
RLM - Run Coordinator:	**J. Menard**	Date

Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

Error-field and locked-mode physics studies using RWM/EF coils OP-XP-503

1. Overview of planned experiment

This experiment will attempt to infer any residual vacuum error fields in NSTX from the response of locked and rotating tearing modes to external non-axisymmetric field perturbations. The amplitude and static toroidal phase angle of externally applied n=1 mid-plane field will be scanned to find any variation in the locking threshold with applied error field phase. With any intrinsic error fields minimized, the experiment will then attempt to determine the error-field penetration threshold scaling with B-field, shape, q, and density to compare to conventional aspect ratio scaling.

2. Theoretical/ empirical justification

Resonant error fields can destabilize tearing modes by increasing the mode Δ' and cause the mode to lock from the induced electromagnetic braking torque at the resonant mode rational surface. Thus, vacuum error field reduction could potentially reduce tearing and locked mode activity in NSTX. Further, if some confidence can be gained that error fields have been minimized in NSTX, the penetration threshold for error fields can be systematically determined and compared to standard tokamak results. The results of this research should also contribute to developing both pre-programmed and feedback-driven compensation algorithms for correcting any residual error fields.

3. Experimental run plan

Day 1 – 30 shots

1. Develop target plasma: **(4 shots)**
   a. Ohmic PF2L LSN from 109926 with κ=1.8, 4.5kG, 0.8MA, q* = 2.8
   b. $n_e = 1 \times 10^{19} cm^{-3}$ or 1.5 × above locking threshold, whichever is higher
      i. n_e will be controlled with He glow and by minimizing the gas injection
2. Find amplitude and phase angle of any intrinsic error field at 4.5kG **(12 shots)**
   a. Linearly ramp applied *n*=1 field from 0-2kA in 60ms starting at t=180ms at 3 different phases separated by 60 degrees and with both polarities.
      i. See Table in "Operations Request" below for the desired programming
   b. Reduce maximum current if locking threshold is far below 2kA.
   c. Obtain 2 shots for each applied error field direction and polarity.
3. Repeat scan in 3.2 at 3kG and 500kA to determine any B_T dependence **(12 shots)**
4. Use MSE to document q profile during flat-top for 1 shot at each B_T value **(2 shots)**
   a. Inject 60ms Source A blip starting at t=180ms with no applied error field

Day 2 – 30 shots

Determine optimal error field correction vs. PF coil current from scans above, and use these correction gains for remainder of experiment. Then, apply *n*=1 field in some fixed direction to find EF threshold for all steps below:

5. Find EF threshold dependence on plasma elongation at fixed n, B_T, q*, δ **(7 shots)**
   a. Scan κ and I_P together: κ=1.6 & 650kA, and κ=2 & 900kA, κ=2.1 & 1MA
6. Find EF threshold dependence on q* at fixed n, B_T, κ, δ **(9 shots)**
   a. Fix κ=1.9-2.0, scan I_P = 0.6MA, 1.0MA, and 1.2MA
      i. Increase ramp-rate to reach flat-top current at t=160ms for higher I_P shots or use higher current reference shots 106954 (1MA) and 106955 (1.2MA)
   b. Use MSE to document q profile during flat-top for 1 shot at each q* value
      i. Inject 60ms Source A blip starting at t=180ms with no applied EF
7. Find EF threshold vs. δ and q_{95} at fixed n, B, q*, and κ = 2.0 or higher **(6 shots)**
   a. Use highest (stable) elongation discharge above at 800kA as reference
   b. Increase δ_L → 0.6 at fixed κ - use PF1B LSN shot 115869 - remove I_P pause
   c. δ_L and δ_U → 0.7 at fixed κ - use PF1A DND shot 115856 - reduce I_P to 800kA
8. Find EF threshold dependence on density at fixed B_T, q*, and shape **(8 shots)**
   a. Use target plasma from Section 3.1 above
   b. Scan density downward then upward and ramp EF to find threshold
      i. Try 0.25×, 0.5×, 2×, 4× but avoid locked modes with no applied EF
      ii. Decrease q* or increase κ if necessary to achieve locking at all densities

4. Required machine, NBI, RF, CHI and diagnostic capabilities

The usual diagnostic coverage is required, and NBI Source A blips of the shortest usable duration will be used for a subset of the discharges to obtain MSE data.

5. Planned analysis

EFIT, TRANSP, MPTS, CHERS, and internal magnetic sensor analysis will be performed.

6. Planned publication of results

Results will be published in conference proceedings and/or journal such as Nuclear Fusion or Physics of Plasmas within one year of experiment.

PHYSICS OPERATIONS REQUEST

Error-field and locked-mode physics studies using RWM/EF coils **OP-XP-503**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **36kA, 53kA** Flattop start/stop (s): **_-0.050_/_0.8__**

I_P (MA): **0.5-1.2** Flattop start/stop (s): **0.12-0.18 / 0.4**

Configuration: **LSN and DND**

Outer gap (m): **__5cm___**, Inner gap (m): **__4cm___**

Elongation κ: **__1.6-2.2___**, Triangularity δ: **0.25-0.8**

Z position (m): **0.00**

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

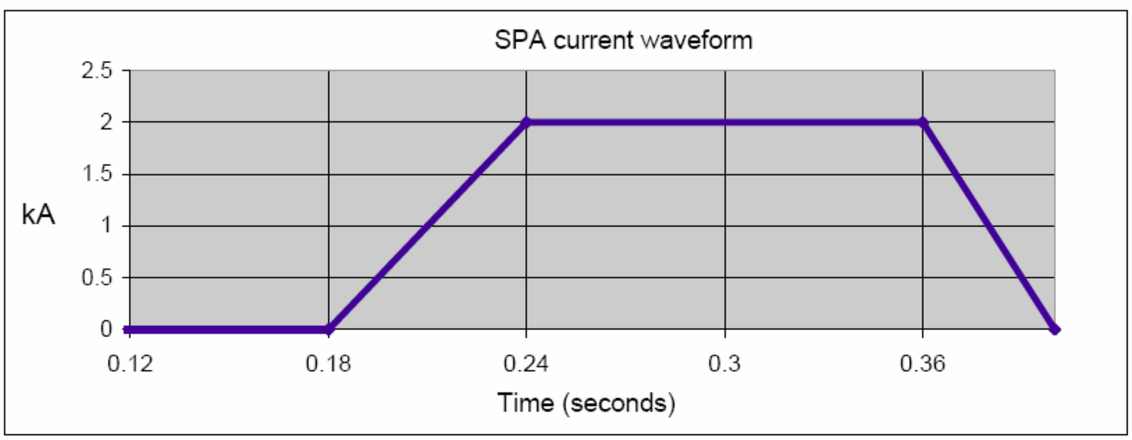
NBI - Species: **D**, Sources: **A**, Voltage (kV): **__90kV___**, Duration (s): **_0.1_**

ICRF – Power (MW): **__0__**, Phasing: **N/A**, Duration (s): _____

CHI: **Off**

Either: List previous shot numbers for setup: **109926, 106953-106955**

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.



Coils Used:	4+5	1+2	5+6	2+3	6+1	3+4
SPA #1	0	0	+	–	+	–
SPA #2	+	–	0	0	–	+
SPA #3	+	–	+	–	0	0

DIAGNOSTIC CHECKLIST
Error-field and locked-mode physics studies using RWM/EF coils OP-XP-503

Diagnostic	Need	Desire	Instructions
Bolometer - tangential array		✓	
Bolometer array - divertor		✓	
CHERS	✓		
Divertor fast camera		✓	
Dust detector		✓	
EBW radiometers		✓	
Edge deposition monitor		✓	
Edge pressure gauges		✓	
Edge rotation spectroscopy		✓	
Fast lost ion probes – IFLIP		✓	
Fast lost ion probes – SFLIP		✓	
Filtered 1D cameras		✓	
Filterscopes	✓		
FIReTIP	✓		
Gas puff imaging		✓	
High-k scattering		✓	
Infrared cameras		✓	
Interferometer – 1 mm		✓	
Langmuir probes - PFC tiles		✓	
Langmuir probes - RF antenna		✓	
Magnetics – Diamagnetism	✓		
Magnetics – Flux loops	✓		
Magnetics – Locked modes	✓		
Magnetics – Pickup coils	✓		
Magnetics - Rogowski coils	✓		
Magnetics - RWM sensors	✓		
Mirnov coils – high frequency	✓		
Mirnov coils – poloidal array	✓		
Mirnov coils – toroidal array	✓		
MSE	✓		
Neutral particle analyzer		✓	
Neutron Rate (2 fission, 4 scint)	✓		
Neutron collimator		✓	
Plasma TV	✓		
Reciprocating probe		✓	
Reflectometer - FM/CW		✓	
Reflectometer - fixed frequency homodyne		✓	
Reflectometer - homodyne correlation		✓	
Reflectometer - HHFW/SOL		✓	
RF antenna camera		✓	
RF antenna probe		✓	
Solid State NPA		✓	
SPRED		✓	
Thomson scattering - 20 channel	✓		
Thomson scattering - 30 channel		✓	
Ultrasoft X-ray arrays	✓		
Ultrasoft X-ray arrays - 2 color		✓	
Visible bremsstrahlung det.		✓	
Visible spectrometers (VIPS)		✓	
X-ray crystal spectrometer - H		✓	
X-ray crystal spectrometer - V		✓	
X-ray pinhole camera		✓	