Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: Optimize error field correction vs. rotation		
OP-XP-618	**Revision:**	Effective Date: 3/16/06 *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

Optimize error field correction vs. rotation **OP-XP-618**

1. Overview of planned experiment

This experiment develops empirical error field correction with the non-axisymmetric correction coil based on optimization of plasma rotation, instead of the traditional criterion of locked-mode onset. The goals are (1) to demonstrate the feasibility of quick (1-2 shots) error field optimization, and (2) to begin accumulation of a database for empirical error correction under varying discharge parameters.

The basic approach is to apply a slowly rotating n=1 magnetic perturbation with constant amplitude, and observe the modulation of toroidal plasma rotation as the net error field (vector sum of the intrinsic error field, static correction field, and the rotating perturbation) varies in magnitude. Analysis then determines the optimal error correction, defined as the error correction that minimizes the drag on the plasma rotation.

The analysis of the data must account for phase delays between the applied field and the plasma rotation, resulting from eddy currents in conducting structures and from plasma inertia.

2. Theoretical/ empirical justification

This approach has the advantage that a range of correction fields is tested in a single shot, allowing more efficient optimization of error correction; in principle, 1-2 shots can yield enough information to determine the optimum error correction for a given plasma. The technique should be applicable to a range of discharges, and should allow the quick accumulation of empirical error correction coefficients under varying plasma parameters.

3. Experimental run plan

Day 1 – 1/2 day = 16 shots

a) Re-obtain FY05 or FY06 long-pulse discharge at 4-4.5kG and $I_P \leq 0.8$MA **(4 shots)**

  i) Reproduce 0.7MA (116318), 0.75 (116313), 0.8MA (117577), or best available

  ii) Choose beta low enough to avoid the onset of RWMs or low-order NTMs: betaN < 4.

  iii) Use the current best estimate for error field correction.

b) Apply rotating n=1 perturbation **(8 shots)**

  i) Add a small-amplitude n=1 magnetic perturbation with rotating toroidal phase. Requirements on the frequency are that there should be at least two complete cycles during stationary plasma conditions (lower limit on f), and that there should be at least 10 CHERS time samples during each cycle (upper limit on f). The amplitude should be small enough to avoid driving a locked mode. – Start with amplitude = 200 A and frequency = 5 Hz.

ii) If no measurable modulation of plasma rotation is observed, increase the amplitude. If plasma conditions appear to change too much during one cycle of rotation, increase the frequency to 10 Hz.

iii) Repeat at one or more other amplitudes of the n=1 perturbation that yield observable modulation of the rotation.

c) No-plasma data for eddy current estimation **(4 shots)**

i) For each separate set of n=1 coil current waveforms used in part (b), repeat with identical current programming but no plasma. To the extent possible, program the currents in the PF and OH coils to be the same as in the corresponding plasma shot.

d) Vary discharge parameters (if time permits) **(4 shots)**

i) Check linearity of error field: Reduce the toroidal field and plasma current by 20-25%. Repeat steps (b) and (c) for a single n=1 amplitude.

ii) Check dependence on q95: Return to the original toroidal field but maintain the reduced plasma current. Repeat steps (b) and (c) for a single n=1 amplitude.

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

The usual diagnostic capabilities are required, NBI voltages are A, B, C = 90, 90, 80kV. CHERS for core rotation velocity, with analysis between shots, is essential.

5. Planned analysis

EFIT, CHERS, and RWM/EF 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

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Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **42-53kA** Flattop start/stop (s): **_-0.02s_/_1.5s____**

I_P (MA): **0.7-1.2** Flattop start/stop (s): **0.12-0.18 / 1.4**

Configuration: **LSN**

Outer gap (m): **8-12cm**, Inner gap (m): **6-10cm**

Elongation κ: **2.1-2.5**, Triangularity δ: **0.5-0.7**

Z position (m): **0.00**

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

NBI - Species: **D**, Sources: A,B,C Voltage (kV): **90,90,80kV**, Duration (s): **Up to 2s**

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

CHI: **Off**

Either: Previous shot numbers for setup: **116318, 116313, 117577, or best available**

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

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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		✓	
X-ray TG spectrometer		✓	