Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**		
Title: Long-pulse development at reduced density using EF correction		
OP-XP-602	**Revision:**	Effective Date: 1/31/06 *(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

Long-pulse development at reduced density using EF correction **OP-XP-602**

1. Overview of planned experiment

This experiment will attempt to further increase the pulse-length at high-β_N in long-pulse NSTX plasmas. This work is a continuation of previous proposals XP507, XP432, XP440, XP451 which optimized early H-mode access and pulse-length. In FY04, early H-mode studies clearly demonstrated the benefits of reduced density for reducing OH flux consumption. However, at sufficiently low density, early locked MHD modes typically disrupted the plasma during the current ramp or early in the flat-top. In FY05, error field experiments demonstrated that a residual error exists, and that this error field can be reduced and performance improved with error field correction (EFC). In this experiment we will attempt to use EFC to improve long-pulse operation at reduced density. A density scan will be performed to find the disruptive density threshold, and error field correction will be employed to attempt to reduce the density. The plasma magnetic balance and lower triangularity will be adjusted to try to reduce tearing and ELM activity in the discharge. Scans of TF and/or plasma current will then be performed to find the maximum achievable flat top duration.

2. Theoretical/ empirical justification

High elongation, stronger shaping (via PF1B + new PF1A), and early H-mode have resulted in NSTX record pulse-length discharges up to 1.5s in a lower-single-null divertor configuration. However, these discharges suffer from increased locked MHD activity in the current ramp when the density is reduced. The experiment aims to further reduce both ohmic flux consumption and deleterious MHD activity at low density using EFC.

3. Experimental run plan

Day 1 – 30 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) Document plasma evolution and q(R,t) with MSE, compare to reference discharge

b) Scan ramp-up density to determine MHD locking/disruption threshold **(8 shots)**

  i) Decrease CS gas plenum pressure from 1300 Torr in 100 Torr decrements

c) Scan EFC phase and amplitude (SPA currents) during locking disruption **(18 shots)**

  i) Scan EFC current ramp-rate: Try 0.7, 1.0, 1.5 × rate predicted to correct EF

    (1) Start with EFC phase predicted to cancel EF from OH-induced TF motion

  ii) Scan EFC phase in 60° steps while repeating EFC amplitude scan

Day 2 – 30 shots

d) If EFC enables operation at reduced density w/o disruption, reduce density again **(12 shots)**

  i) Decrease CS gas plenum further in 100 Torr decrements, or use LITER-1

  ii) Find new (reduced) density limit in scenario utilizing optimized EFC

  iii) Scan EFC current ramp-rate at fixed EF phase angle

  iv) Maximize plasma flat-top duration at low density including EFC

e) Increase I_P to 0.9, 1.0, 1.2MA **(18 shots)**

  i) Start with density 10% above disruption threshold

  ii) Scan EF current ramp-rate as needed at each plasma current to optimize early EFC

  iii) Optimize fueling (minimum density) to maximize pulse-length at each current

  iv) Document OH, TF, and/or MHD limits at higher I_P

Day 3 (1/2 day) – 15 shots

f) Obtain density flat-top in longest-pulse discharge obtained with EFC at 0.8MA

  i) Scan Li deposition rate to achieve desired pumping rate for density control **(10 shots)**

  ii) Increase fueling rate to maintain constant line-average density = $3\text{-}4\times10^{19}\ m^{-3}$ **(5 shots)**

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

The usual diagnostic capabilities are required, NBI voltages are A, B, C = 90, 90, 80kV

5. Planned analysis

EFIT/LRDFIT, TRANSP, MPTS, 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

Long-pulse development at reduced density using EF correction **OP-XP-602**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **42-53kA** Flattop start/stop (s): **_-0.02s_/_1-2s____**

I_P (MA): **0.7-1.2** Flattop start/stop (s): **0.12-0.18 / 0.4**

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

Long-pulse development at reduced density using EF correction **OP-XP-602**

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		✓	