Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: Early divertor and H-mode development for long pulse in LSN		
OP-XP-507	**Revision:**	Effective Date: 05/02/05 *(Ref. OP-AD-97)* Expiration Date: 05/02/07 *(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

Early divertor and H-mode development for long pulse in LSN OP-XP-507

1. Overview of planned experiment

This experiment will attempt to further increase the pulse-length at high-β in long-pulse NSTX plasmas. This work is a continuation of previous proposals XP432 (long-pulse development), XP440 (develop early H-mode startup), and XP451 (very early LSN). We will attempt to divert the plasma by t=50ms with good gap control. An I_P ramp-rate scan will be utilized to maximize I_P by t=50ms. A pause in the current ramp will then be used to attempt to induce H-mode. NBI timing and X-point position will be scanned if early H-mode is not easily obtained. The plasma lower triangularity and squareness will then 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), and early H-mode have resulted in NSTX record pulse-length discharges at high current ($I_P \geq$ 1MA) in a lower-single-null divertor configuration. However, these discharges suffer from increased tearing activity in the flat-top and larger ELMs than obtained previously in lower κ=2-2.1 LSN plasmas. The experiment aims to further reduce both ohmic flux consumption and deleterious MHD activity.

3. Experimental run plan

Day 1 – 30 shots

a) Re-obtain FY04 long-pulse discharges at 4.5kG and document *q* profile **(10 shots)**

- **i) <u>Multiply all PF1AL and PF1AU normalized current waveforms × 2.0</u>**
- ii) Reproduce 0.8MA (112546), 0.9 (112570), 1.0 (112581) and 1.2 MA (112596)
- iii) Document *q*(R,t) of existing early H-mode scenarios with MSE

b) Modify early discharge evolution to divert ASAP and reduce flat-top I_P **(5 shots)**

- i) Reproduce 113460 with 1.2MA flat-top and diverted boundary at 50ms
- ii) Reduce flat-top current to 1MA at t=230ms
  - (1) Remove source C, move source A as early as possible without flat-top disruption

c) Find highest stable I_P ramp-rate before t=50ms in 1MA target from 3.b.ii **(15 shots)**

- i) Increase I_P request at t=50ms from 350kA in 100kA increments
- ii) Increase current linearly from I_P value at t=50ms to 1MA at t=230ms
- iii) Control inner gap = 8cm, outer gap = 10cm during ramp and flat-top

Day 2 – 30 shots

d) Attempt to induce H-mode at t=50ms at highest stable current from 3.c **(10 shots)**

i) Add current pause after t=45ms for 15ms

ii) Move source A start-time to t=35ms if it is not already on that early

iii) If H-mode transition is not obtained, add source B beam at t=40ms

iv) If transition still not obtained, reduce bottom X-point height

v) If transition still not obtained, increase bottom X-point major radius with PF2

e) Scan I_P ramp-rate after t=50ms to minimize tearing (w/ or w/o early H-mode) **(5 shots)**

f) Scan lower squareness during ramp and flat-top to determine impact on MHD **(5 shots)**

g) Maximize plasma flat-top duration **(8 shots)**

i) If pulse-length is limited by TF coil, reduce TF in 0.25kG steps at fixed I_P

ii) If pulse-length is limited by OH coil or MHD, reduce I_P in 0.50kA steps at fixed TF

h) Increase I_P to 1.2MA to document OH, TF, and/or MHD limits at high current **(2 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, 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

Early divertor and H-mode development for long pulse **in LSN** **OP-XP-507**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **42-53kA** Flattop start/stop (s): **_-0.02s_/_1-1.5s____**

I_P (MA): **0.8-1.2** Flattop start/stop (s): **0.12-0.18 / 0.4**

Configuration: **LSN**

Outer gap (m): **5-10cm**, Inner gap (m): **4-6cm**

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): **1s**

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

CHI: **Off**

Either: Previous shot numbers for setup: **112546, 112570, 112581, 112596, 113460**

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

Early divertor and H-mode development for long pulse in LSN **OP-XP-507**

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		✓	