Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Long pulse development in strongly-shaped LSN plasmas		
OP-XP-432	**Revision:**	Effective Date: *(Ref. OP-AD-97)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS		
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RLM - Run Coordinator: S. Kaye	Date	2/26/2004
Responsible Division: Experimental Research Operations		

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

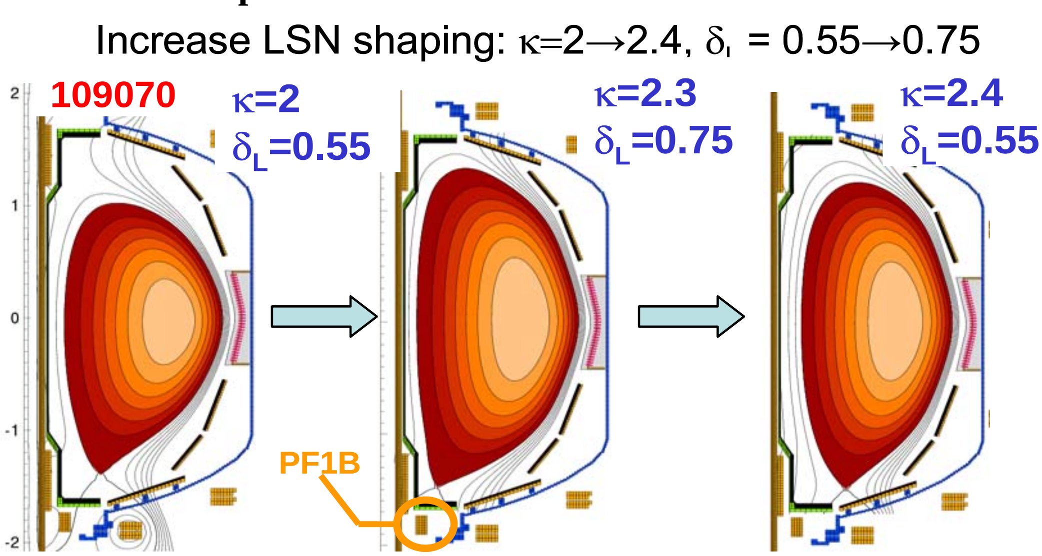
1. Overview of planned experiment

The goal of this experiment is to increase the plasma pulse-length and β_T at high β_P starting from discharges developed in XP-229: "Pulse-length limits of NBI-heated LSN H-mode plasmas". First, extending the total discharge pulse length beyond one second will require operating the TF below 5kG to avoid the thermal limits of the TF coil. This will decrease the safety factor (all other things being equal) and will likely lead to earlier disruptive MHD activity. This motivates the development of methods of increasing the global safety factor. In this experiment, the plasma elongation and triangularity will be systematically increased in a LSN configuration in an attempt to raise q and improve MHD stability at lower TF. These shape modifications should also result in higher toroidal beta if similar normalized beta values are obtained since I/aB will be lower.

2. Theoretical / empirical justification

Using LSN H-mode target discharges with optimized early and flat-top elongation and other shape modifications, I_P flat-top plasmas with β_N up to 6.4 and β_P = 1.4 have been generated. Long-pulse discharges with slowly evolving profiles have also been sustained for a current redistribution time using the LSN shape. Early LSN shape optimization focused on increasing the elongation to values near 2, and increasing the lower triangularity to 0.5. These changes increased confinement and global stability without degrading favorable ELM characteristics. This experiment will attempt to take advantage of recent control system improvements and enhance the shaping even further. This experiment will also give further insight into how boundary shape modifies confinement and ELM characteristics. Finally, the divertor heat flux (P/R) and strike point geometry of the highest triangularity LSN shape are similar to that expected in the ITER lower divertor, and can be studied in this context (J. Strachan).

3. Experimental run plan - 50 shots total



A. Produce baseline discharge with 95kV on sources A & B with B_T = 4.5kG **(4 shots)**
   a. Injecting B at 100ms, A at 180ms, reproduce shot 111388 with P_{NBI} = 5MW
      i. Use rt-EFIT during I_P ramp-up to reproducibly divert by 100ms
      ii. Adjust HFS gas puff to match density evolution shot 111196

B. Beta scan in baseline discharge **(2 shots)**
   a. Increase power by adding third source (Source C at 85kV) at 250, 350ms
      i. Document beta limit and corresponding heating power

C. Increase lower triangularity in longest duration discharge using PF1B coil **(12 shots)**
   a. Note changes in confinement, pulse duration, and ELM behavior in δ scan:
      i. Increase lower triangularity from 0.55 to 0.65 (6 shots)
      ii. Increase lower triangularity from 0.65 to 0.75 (6 shots)

D. Increase elongation of discharge to 2.2 **(4 shots)**
   a. Modify boundary control points in rt-EFIT to increase elongation starting at t=180ms (start of flat-top) and hold at 2.2 for t > 220ms.
      i. Modify gas fueling, control gains, and gaps to maximize duration free of large-scale MHD activity
      ii. Document quiescent pulse duration relative to κ=2 discharge

E. Beta limit scan in κ=2.2 discharge **(2 shots)**
   a. Increase power by adding third source at 250, 350ms - document beta limit

F. Further increase elongation of discharge **(4 shots)**
   a. Increase elongation from 2.2 to 2.4 (or as high as possible) for t > 250ms.

G. Beta limit scan in highest elongation discharge **(2 shots)**
   a. Increase power by adding third source at 250, 350ms - document beta limit

H. Scan upper triangularity in longest duration discharge **(4 shots)**
   a. Note changes in confinement, pulse duration, and ELM behavior in δ scan:
      i. Scan upper triangularity from 0.3 to 0.4 & 0.5 using PF1AU coil

I. Decrease lower triangularity from 0.75 to 0.55 in highest κ discharge **(4 shots)**
   a. Note changes in confinement, pulse duration, and ELMs at high κ and lower δ

J. Pulse length optimization with increased beta **(6 shots)**
   a. Use beta limit and pulse duration data from 3.A-I above to determine maximum input power consistent with longest-pulse disruption free operation, and modulate source C (or B) accordingly to operate at this power to extend pulse.

K. Long-pulse operation at lower TF and increased beta **(6 shots)**
   a. Decrease flat-top TF to 0.425T and document MHD-stable pulse-length (2 shots)
   b. Decrease flat-top TF to 0.4T and document MHD-stable pulse-length (2 shots)
   c. Decrease flat-top TF to 0.35T and document MHD-stable pulse-length (2 shots)

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

PF1AL current limit should be set to reduced value when PF1B is used. The rt-EFIT development should be sufficiently mature that the proposed shape changes do not pose a major challenge to the control system. Beams should be reliable at 95kV on sources A and B, and 85kV on source C.

5. Planned analysis

EFIT, TRANSP, MPTS, and CHERS are essential for subsequent analysis of current profile evolution and stability (both global and edge-localized).

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 in strongly-shaped LSN plasmas **OP-XP-432**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **41-53kA** Flattop start/stop (s): **-0.010s/1.0s**

I_P (MA): **0.8MA** Flattop start/stop (s): **0.18s/1.0s**

Configuration: **Lower Single Null**

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

Elongation κ: **2-2.4**, Triangularity δ: **0.55-0.75 (lower x-point)**

Z position (m): **0.00**

Gas Species: **D**, Injector: **Midplane + Inner wall**

NBI - Species: **D**, Sources: **A,B,C** Voltage (kV): **95,95,85** Duration (s): **1s**

ICRF – Power (MW): **0MW**, Phasing: , Duration (s): **_____**

CHI: **Off**

Either: List previous shot numbers for setup: **111388**

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 in strongly-shaped LSN plasmas OP-XP-432

Diagnostic	**Need**	**Desire**	**Instructions**
Bolometer – tangential array			
Bolometer array - divertor			
CHERS	**X**		
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	**X**		
Gas puff imaging			
Infrared cameras			
Interferometer - 1 mm			
Langmuir probe array			
Magnetics - Diamagnetism	**X**		
Magnetics - Flux loops	**X**		
Magnetics - Locked modes	**X**		
Magnetics - Pickup coils	**X**		
Magnetics - Rogowski coils	**X**		
Magnetics - RWM sensors		**X**	
Mirnov coils – high frequency		**X**	
Mirnov coils – poloidal array			
Mirnov coils – toroidal array	**X**		
MSE		**X**	
Neutral particle analyzer			
Neutron measurements	**X**		
Plasma TV	**X**		
Reciprocating probe			
Reflectometer – core			
Reflectometer - SOL			
RF antenna camera			
RF antenna probe			
SPRED			
Thomson scattering	**X**		
Ultrasoft X-ray arrays	**X**		
Visible bremsstrahlung det.			
Visible spectrometers (VIPS)			
X-ray crystal spectrometer - H			
X-ray crystal spectrometer - V			
X-ray PIXCS (GEM) camera			
X-ray pinhole camera			
X-ray TG spectrometer			