Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**		
Title: **Edge characterization in highly shaped plasmas**		
OP-XP-816	Revision:	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS	
Responsible Author:	Date
ATI – ET Group Leader:	Date
RLM - Run Coordinator:	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

1. Overview of planned experiment

This experiment has three different goals:

- Characterize the edge and scrape-off layer of high performance (i.e., high elongation) plasmas with high flux expansions. This has relevance for extrapolation to NHTX.
- Study divertor heat flux and radiation/detachment characteristics in these plasmas.
- Study H-mode edge turbulence and intermittency (blobs).

The main part of the experiment consist in a power scan (0 to 6 MW of NBI) with fixed magnetic topology and involves a concerted effort from the Edge Group with the best possible diagnostic coverage.

2. Theoretical/ empirical justification

The edge of NSTX's low elongation ($\kappa \sim 2$), low triangularity ($\delta \sim 0.4$) plasmas was characterized in 2004 during the very successful XP-434. The current experiment will involve a similar "group" effort for high-elongation ($\kappa \sim 2.3$), high triangularity ($\delta \sim 0.7$) lower-single-null plasmas. The results of this experiment, apart from its own merits, have relevance for NHTX where the flux expansion introduced by the high elongation in a "fixed wall" device is key for management of plasma-wall (i.e., divertor) interactions. In particular, modeling by J. Canik shows that the magnetic geometry strongly affects the heat flux and divertor parameters. As such it also affects the divertor radiation and detachment characteristics.

In 2007 NSTX has an improved set of diagnostics relative to 2004. These include: 30 point Thomson scattering, better IR cameras, midplane and lower divertor imaging, lower divertor bolometer and more (absolutely calibrated) 1-D CCD cameras. The proposed experiment will use only LSN discharges in order to obtain a good power balance characterization reducing the uncertainties that DN or USN discharges introduce. Of particular interest is the relationship between the power radiated in the divertor region, the heat flux to the target plates and the detachment characteristics as the net input power and the scrape-off layer "loss" power are changed. In addition, this experiment intends to characterize the divertor performance parameters as the footprint at the lower divertor is changed.

Finally, it has been shown in NSTX that the edge turbulence and intermittent activity (i.e., blobs) is much reduced in H-modes respect to L-mode. Nevertheless, the H-mode edge ranges from "quiescent" with no blob activity in the case of Ohmic H-modes to increasing levels of intermittent activity, depending (based on preliminary results) on the pedestal height. This description refers to inter-ELM periods since an ELM is characterized by a level of turbulence similar to that seen during L-modes. It has also been seen that the level of activity increases as the pedestal is "built" after the L-H transition. The early times after this transition being generally blob-less. The proposed experiment intends to characterize both the "pedestal build-up" phase as well as the quasi-steady late phases within the H-mode period. This has a direct relevance to the mechanism by which, first, edge turbulence is generated within the edge and, second, blobs are born from this turbulence …or other interchange/ballooning modes. Understanding these processes are key for the development of theoretical models that would, in turn, allow predictive capabilities to be applied in future experimental devices.

3. Experimental run plan

The main scan in this XP is a power (NBI) scan with additional shots taken at the intermediate value of 4.0 MW. **Each successful shot will be run 2 times** (except for the Ohmic and 1 MW NBI cases). A maximum of 2 attempts will be made to obtain Ohmic H-modes and 1 MW NBI H-modes.

BASE shot:

The base shot has the following characteristics: **900 kA, 5.0 KG, LSN (Δr_{sep} ~ -1.0 cm), κ ~ 2.2, δ_{bot} ~ 0.7, 4.0 MW NBI, with HFS fuelling (1000 T)**. Coil configuration should be similar to **shot 127124** with the following changes:

- 2 sources of NBI (A and B) at 4 MW total.

Note: Except for Step #12 below (lower X-point, high flux expansion) X-point should be maintained at Z = -1.45 to -1.5 m.

Shot sequence:

NBI source power (MW) indicated in last three columns. (See "Physics Operation Request" section for timing of sources.)

#	NBI (MW)	Objective	A	B	C
1	2.0	Power scan (2 MW preheat)	2.0	---	---

Decision point: if shot #1 accessed H-mode then use 2 MW preheat (src. A) for rest of XP and proceed to shot #2, otherwise use 4 MW preheat (srcs. A & B) and repeat shot #1:

#	NBI (MW)	Objective	A	B	C
1'	4.0	Power scan (4 MW preheat)	2.0	2.0	---

The second shot is then either:

#	NBI (MW)	Objective	A	B	C
2	4.0	Power scan (if 2 MW preheat)	2.0	2.0	---
2'	2.0	Power scan (if 4 MW preheat)	2.0	---	---

Continue with power scan with either 2 MW preheat or 4 MW preheat:

#	NBI (MW)	Objective	A	B	C
3	6.0	Power scan	2.0	2.0	2.0
4	Ohmic	Power scan *(condition src. C down to 1 MW)*	---	---	---
5	1.0	Power scan	---	---	1.0
6	5.0	Power scan	2.0	2.0	1.0
7	3.0	Power scan	2.0	---	1.0

Density scan:

#	NBI (MW)	Objective	A	B	C
8	4.0	Reduced density (lower HFS puff: 800 Torr HFS plenum)	2.0	2.0	---
9	4.0	Increased density (increased HFS puff: 1300 Torr HFS plenum)	2.0	2.0	---

Flux expansion scan: the goal is to reduce the flux expansion

$$F_m = (B_\theta/B_{tot})^{MP}/(B_\theta/B_{tot})^{OSP}$$

down to F_m ~ 12-15 from from the base discharge for which F_m ~ 22.

#	NBI (MW)	Objective	A	B	C
10	4.0	Reduced by increasing PF1B and decreasing PF1AL (~3 kA each)	2.0	2.0	---
11	4.0	Reduced further by another increase/decrease in PF1B/PF1AL	2.0	2.0	---

Time permitting:

(* indicates shots that will be added within shot plan as progress is evaluated during XP execution)

#	NBI (MW)	Objective	A	B	C
12	4.0	Flux expansion scan: increased, use PF1B only (X-point limiter). See **note** below.	2.0	2.0	---
*	*	Obtain more shot repetitions for shots above	*	*	*

Note for Step #12: Reduce PF1B current (PF1A-lower at 0 kA) while adjusting PF1A-upper to maintain Δr_{sep} ~ -1.0 cm.

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

Well conditioned walls (as close to boronization as possible) to achieve H-mode access at low NBI power (ideally down to Ohmic H-modes). GDC between shots will be adjusted according to need (7 to 12 minutes). NBI power scanned with up to 3 sources (start with **A, B &C: 2.0 MW each**). Source C decreased for later shots to 1.0 MW.

Timing of GPI gas puff set to coincide with scanning probe plunge. This timing will be varied to:

a) include L-H transition (first shot of 2-shot repeat)
b) quasi-steady phase later in Ip flat-top, H-mode phase (set based on H-mode phase observed in timing “a”).

Note: Fast scanning probe to be used only on “known” discharges (i.e., not used during shot development). During known discharges plunge depth to be not closer than 4 cm from separatrix.

5. Planned analysis

EFIT/LRDFIT needed.

GPI and scanning probe data will be analyzed to infer characteristics of turbulence/blobs/intermittency.

6. Planned publication of results

If successful, results will be submitted to appropriate journal. More than one publication is expected from this combined experiment.

PHYSICS OPERATIONS REQUEST

TITLE: **Edge characterization in highly shaped plasmas** No. **OP-XP-816**
AUTHORS: **R. Maqueda, R. Maingi, V. Soukhanovskii** DATE: **Mar 26, 2008**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **59 (5.0 kG)** Flattop start/stop (s):

I_P (MA): **0.9** Flattop start/stop (s): **~ 0.2**

Configuration: **LSN (drsep ~ - 1 cm)**

Outer gap (m): **~ 0.08** Inner gap (m): **~ 0.08**

Elongation κ: **~2.2** Upper/lower triangularity δ: **~ 0.4/0.7**

Z position (m): **~ 0.0**

Gas Species: **D** Injector(s): **HFS midplane (SGI few shots)**

NBI Species: **D** Sources: **A/B/C** Voltage (kV): **90 (60)** Duration (s): **see sketch**

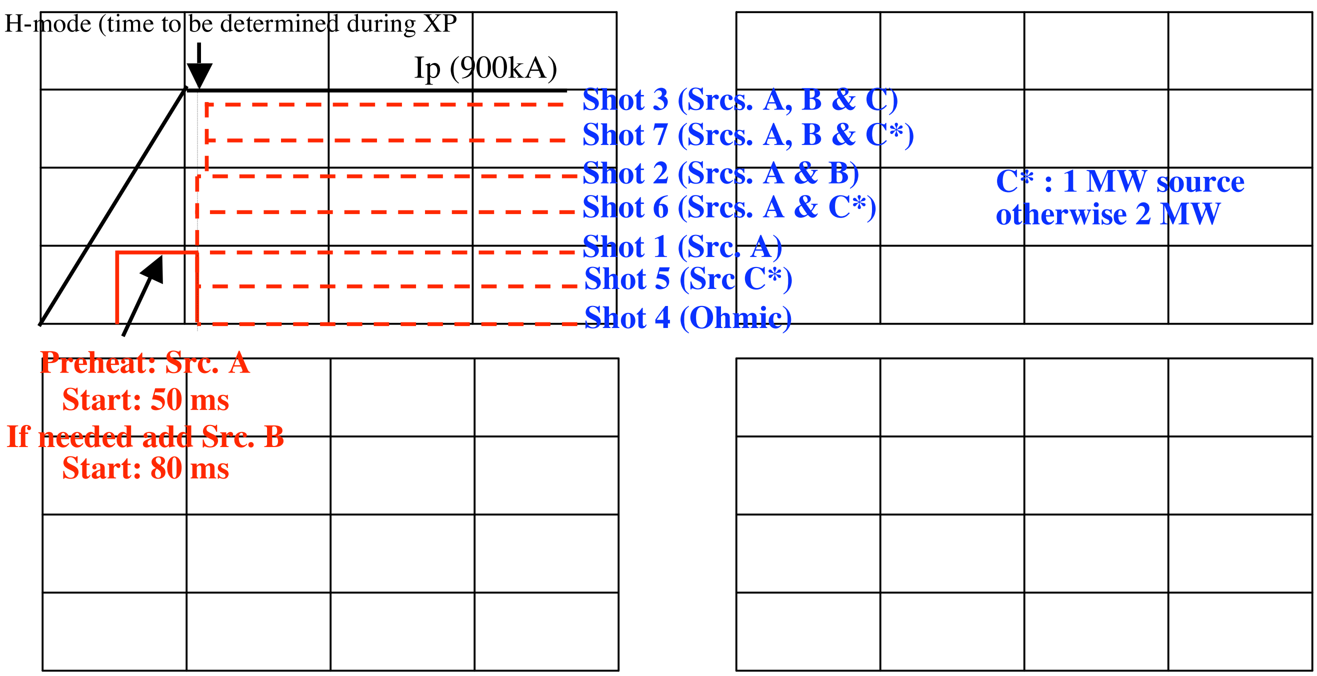
ICRF Power (MW): **no** Phasing: Duration (s):

CHI: **Off** Bank capacitance (mF):

LITER: Off

Shot numbers for setup: **127124** but reduce Ip from 1 MA to 900 kA

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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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Bolometer – tangential array	√	
Bolometer – divertor	√	
CHERS – toroidal	√	
CHERS – poloidal		√
Divertor fast camera	√	
Dust detector		
EBW radiometers		
Edge deposition monitors		
Edge neutral density diag.		√
Edge pressure gauges		√
Edge rotation diagnostic	√	
Fast ion D_alpha - FIDA		√
Fast lost ion probes - IFLIP		
Fast lost ion probes - SFLIP		
Filterscopes	√	
FIReTIP		√
Gas puff imaging	√	
Hα camera - 1D		√
High-k scattering		
Infrared cameras	√	
Interferometer - 1 mm		
Langmuir probes – divertor	√	
Langmuir probes – BEaP		√
Langmuir probes – RF ant.		
Magnetics – Diamagnetism	√	
Magnetics – Flux loops	√	
Magnetics – Locked modes		
Magnetics – Pickup coils	√	
Magnetics – Rogowski coils	√	
Magnetics – Halo currents		
Magnetics – RWM sensors		
Mirnov coils – high f.	√	
Mirnov coils – poloidal array	√	
Mirnov coils – toroidal array	√	
Mirnov coils – 3-axis proto.		

Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
MSE	√	
NPA – ExB scanning		
NPA – solid state		
Neutron measurements		√
Plasma TV		√
Reciprocating probe	√	
Reflectometer – 65GHz	√	
Reflectometer – correlation		√
Reflectometer – FM/CW	√	
Reflectometer – fixed f	√	
Reflectometer – SOL		
RF edge probes		
Spectrometer – SPRED		
Spectrometer – VIPS		
SWIFT – 2D flow		√
Thomson scattering	√	
Ultrasoft X-ray arrays	√	
Ultrasoft X-rays – bicolor		
Ultrasoft X-rays – TG spectr.		
Visible bremsstrahlung det.	√	
X-ray crystal spectrom. - H		
X-ray crystal spectrom. - V		
X-ray fast pinhole camera		
X-ray spectrometer - XEUS		