Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: **Dependence of L-H power threshold on X-point radius**		
OP-XP-909	Revision:	Effective Date: **08-Feb-09** *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: R. Maingi	Date
ATI – ET Group Leader: K. Tritz	Date
RLM - Run Coordinator: R. Raman	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: Dependence P_{LH} on X-point radius — No. **OP-XP-909**

AUTHORS: R. Maingi, S. Gerhardt, C.S. Chang, G. Park — DATE: **8-Feb-09**

1. Overview of planned experiment

The goal of this experiment is to measure the L-H power threshold (P_{LH}) as a function of lower X-point radius/triangularity and compare the measured Er profiles with predictions from the XGC code. Three different triangularities are being targeted: ~ 0.4, 0.5, and 0.7.

2. Theoretical/ empirical justification

The XGC-0 has shown that the thermal ion loss at the X-point increases with the X-point radius, leading to the predicted formation of a larger radial electric field, E_r ,and shear, E_r'. Operating from a premise that a critical E_r or E_r'might be needed for H-mode access, it follows that discharges with large X-point radii (i.e. reduced lower triangularity δ_L) would have a lower L-H power threshold than discharges with a higher δ_L. Experimentally such a trend has been noted in control room lore but never documented.

Fig. 1 shows the 3 target shapes envisioned for this study: a lo, mid, and high δ_L shape. The elongation and X-point height will be maintained during this triangularity scan. The low δ_L discharge has a more recent rtEFIT version, but this one was chosen because of an existing XGC calculation of the E_r.

Figure 2 shows a comparison of the computed E_r from the XGC-O code for the low and high δ_L discharges, using the EFIT02 pressure profiles as a starting point. I can be seen that the E_r and E_r' are substantially higher for the low δ_L discharge, as previously presented by C.S. Chang. We note that all three of the time slices in Fig. 1 and the analysis in Fig. 2 are from the H-mode phase; it is expected that the thermal ion loss leading to the difference in E_r would also be present in the L-mode phase prior to the L-H transition.

This experiment could be run in either lower-single null (LSN) or double-null configuration, the latter having a lower P_{LH} typically. Here we choose LSN because it will simplify analysis with XGC.

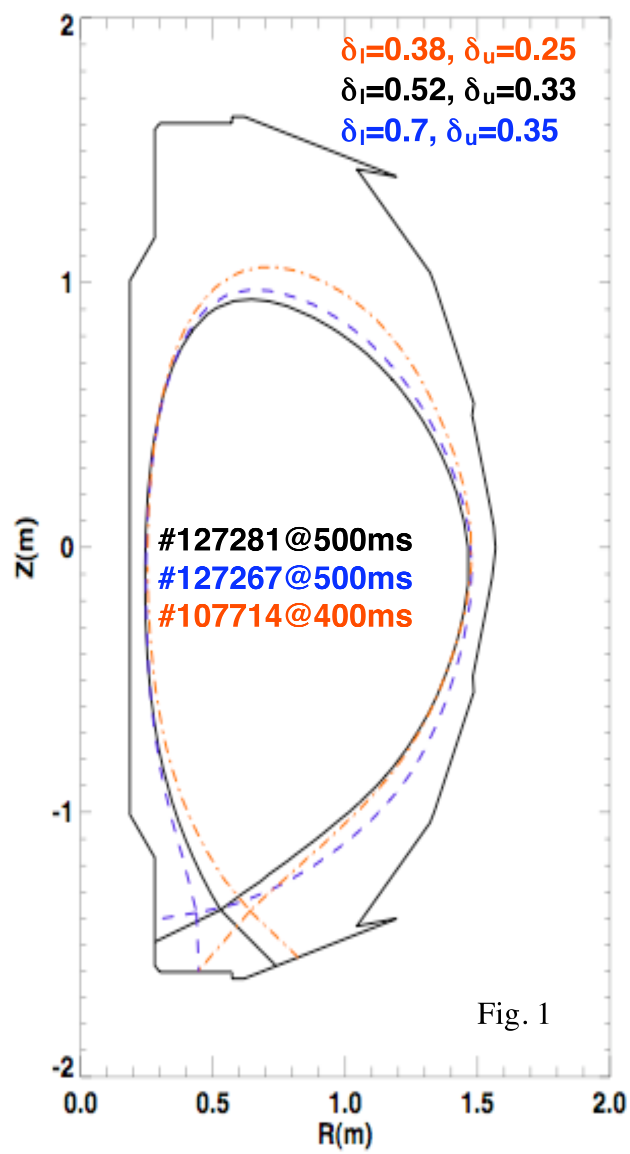

Fig. 1

3. Experimental run plan

The main scan in this XP is a power (NBI) scan at three different triangularities to localize P_{LH}. The target parameters are I_p=0.8 MA, B_t=0.45 T, κ ~ 2, δ_r^{sep} ~ -1.5cm, X-point height ~ 20cm. The intermediate and higher δ_L discharges were run in 2008, and an rtEFIT version of #107714 is #119838. S. Gerhardt has been doing ISOLVER calculations to better understand the PF coil current changes needed to insure a good shape scan.

Shot sequence:

The δ_L ~ 0.4 discharge will be run first. P_{LH} will be localized by reducing the voltage on sources A/B/C as needed. Historically source C has the easiest time running at ~ 55kV ~ 800 kW. Sources A and B usually don't run as reliably below 65 kV ~ 1 MW. We will request source C to be at the lowest voltage possible, source B at 65 kV, and source A at 90 kV to have the possibility of MSE if $P_{LH} \geq 2$ MW. If $P_{LH} \leq 0.8$ MW, we will use pulse-width modulation to localize P_{LH}.

An important consideration is whether to use an NBI pre-heat from ~ 60-120ms, i.e. well before the I_p flat-top to save V-S. If sufficient flat-top is available at 800 kA, no pre-heat will be used. If the flat-top is limited because of the long ohmic phase, we will add in a short pre-heat phase during the I_p ramp.

A correlated decision is the choice of I_p level. In NSTX, P_{LH} increases with I_p, thus making it easier to distinguish the effects of the shape scan. On the other hand, the I_p flat-top decreases quickly with I_p, particularly if a long ohmic phase is used. The actual value of I_p used will thus be somewhere between 0.7 and 0.9 MA, depending on the flat-top duration.

1. Run 119838 with ohmic ramp-up if developed in XMP-48, or with NBI during ramp-up if not. If NBI ramp-up used, reduce NBI to 80-140ms in 2nd shot, and then run ohmic 3rd shot. Use this information to determine if XP can be run at 800 kA, 700 kA, or 900 kA and re-run base discharge (5)
2. Repeat step 1 for high δ_L discharge 127267 (5)
3. Time permitting repeat step 1 for medium δ_L discharge 127281 (5)
4. Localize PLH for low δ_L, high δ_L, and medium δ_L discharges. (15)

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

H-mode access at reasonable power is required. HeGDC between shots will be adjusted according to need, probably ~ 6.5 min for a 12.5 minute rep rate.

5. Planned analysis

EFIT/LRDFIT needed, TRANSP for absorbed power, XGC to compute Er and compare with CHERs and ERD.

6. Planned publication of results

APS; possible H-mode workshop paper.

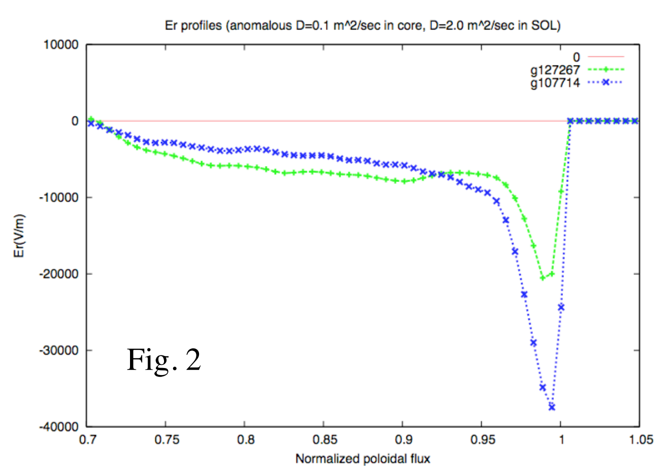

Fig. 2

PHYSICS OPERATIONS REQUEST

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(use additional sheets and attach waveform diagrams if necessary)

Describe briefly the most important plasma conditions required for the experiment:

Need 2-3 different triangularities with same X-point height, outer gap, drsep, and close to the same elongation.

Previous shot(s) which can be repeated:

Previous shot(s) which can be modified: 119838, 127281, 127267

Machine conditions *(specify ranges as appropriate, strike out inapplicable cases)*

I_{TF} (kA): 54 (0.45 T) Flattop start/stop (s):

I_P (MA): 0.8 MA Flattop start/stop (s): 180 ms

Configuration: **Limiter / DN / LSN / USN**

Equilibrium Control: **Outer gap / Isoflux** (rtEFIT)

Outer gap (m): **0.1** Inner gap (m): **varies** Z position (m):

Elongation κ: ~2 Upper/lower triangularity δ: 0.4, 0.7, 0.55

Gas Species: **D** Injector(s): any

NBI Species: **D** Voltage (kV) **A: 80-90** **B: 65-90** **C:** 55-90 Duration (s): <1 sec

ICRF Power (MW): 0 Phase between straps (°): Duration (s):

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

LITERs: Off / On Total deposition rate (mg/min):

EFC coils: Off/On Configuration: **Odd / Even / Other** *(attach detailed sheet*

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 – E‖B 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		