Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: Effect of Fueling Poloidal Location on L-H Power Threshold

OP-XP-419	**Revision:**	Effective Date: 12/22/03 *(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

Effect of Fueling Poloidal Location on L-H Power Threshold OP-XP-419

1. Overview of planned experiment

The goal of this experiment is to measure the L-H power threshold as a function of poloidal fueling location, namely outer midplane, center stack midplane, center stack top, and outer top. We will measure the edge E_r at power threshold for each case, and compare with Helander's neoclassical theory on the effect of fueling location on E_r.

2. Theoretical/ empirical justification

Early H-modes on NSTX were short-lived[1], often terminated by tearing modes. Before FY 2002, three major changes were made to the facility: 1) reduction of intrinsic error fields, 2) high temperature bake-out, with some surfaces exceeding 350 ^{0}C, and 3) the installation of gas fueling from the center stack midplane or high-field side (HFS). The third upgrade was implemented after reports[2] from MAST on the improved H-mode access with HFS fueling.

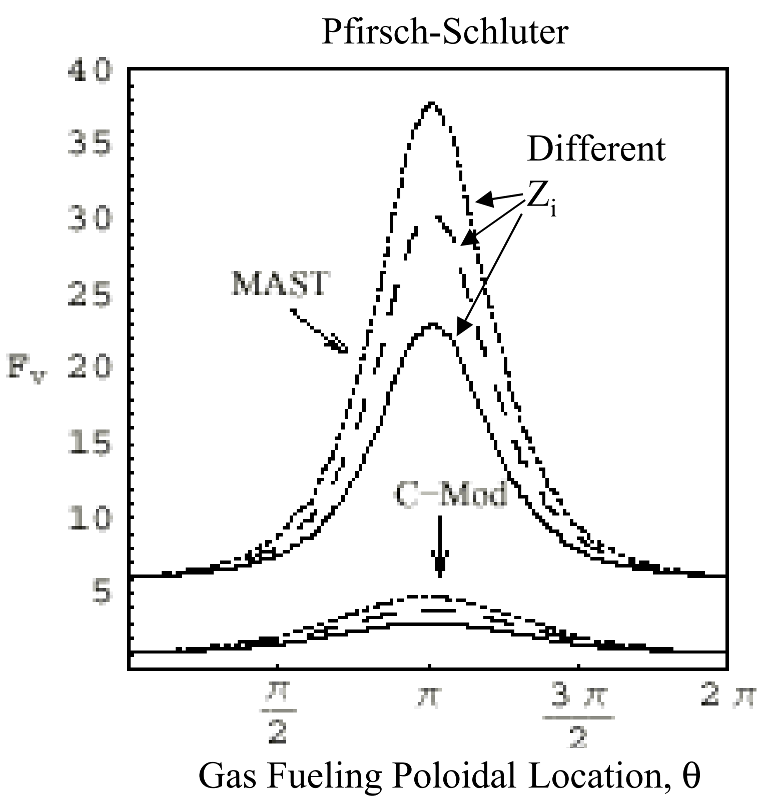

Fig. 1 – Calculation of F_v, a factor approximately proportional to E_r, as a function of neutral source location in the poloidal direction, θ. Here θ=0 is the outer midplane. To connect with this theory, the gas fueling location is

With the first HFS fueling expt. in NSTX, reproducible H-modes of > 250ms duration were achieved[3]. Subsequent experiments indicated[4] that the power threshold must be markedly higher for LFS fueling than HFS fueling, and that the edge rotation was more co-NBI prior to the L-H transition. These results were qualitatively consistent with a theory[5] by Helander, Fulop and Catto, which indicated that the toroidal rotation, E_r, and also E_r' should be higher for HFS fueled discharges than LFS discharges, and also qualitatively consistent with neoclassical Monte Carlo edge transport calculations with the GTC code[6]. However in those experiments, neither the E_r nor the power threshold were explicitly measured, hence the need for new experiments.

If E_r or E_r' is the critical threshold parameter for L-H access, then a direct connection to the theory is obvious. Hence one could expect that the transition would occur at the same E_r', which can be affected by choice of fueling location. The analytic theory indicates that the effect is much stronger in an ST than a conventional aspect ratio tokamak (Fig. 1).

3. Experimental run plan

This experiment should only be run when P_{LH} < 1 src in LSN configuration. In addition we require the ability to switch between HFS midplane and shoulder injectors without a controlled access. Also the GPI injector may be used instead of the normal LFS midplane injector, since it is closer to the plasma edge. Flow rate and timing tests of the GPI injector will need to be done before the XP is run in order to use it. It is hoped that matching the flow rates will allow match of the edge n_e/T_e profiles, as observed previously[7]. Finally the NBI power will be adjusted either via modulation (and/) or voltage, depending on the results from XP 418 (Effect of magnetic balance on power threshold). We may also opt to run this in DN, if the power threshold is found to be lowest in DN from XP#418. In that case a DN shape will be provided.

I. Restore standard LSN fiducial with HFS midplane fueling, e.g. #109051 (I_p = 0.9 MA, B_t = 0.45 T); use ~ 1000-1200 torr in HFS plenum (2 shots)

II. Measure P_{LH} by turning off early beam at 140ms and turning second src. on at 200ms. The early beam helps freeze in early current profile, avoids locked modes, and saves volt-seconds. Adjust power as needed to localize. If early beam is too perturbative, do expt. without it.

III. Measure P_{LH} with LFS midplane fueling (matching fueling timing) (5 shots)

IV. Measure P_{LH} with HFS shoulder fueling (matching fueling total input to L-H time and density profile at L-H time, if possible – should be ~ 500 torr) (5 shots)

V. Measure P_{LH} with LFS top fueling (matching fueling timing) (5 shots)

VI. Compare P_{LH} with HFS midplane and LFS midplane fueling for a lower fueling rate (e.g. 500-600 torr in CS plenum and matching fueling timing) (10 shots)

VII. Time permitting, compare P_{LH} with HFS shoulder and LFS top fueling for a lower fueling rate (e.g. 250-300 torr in CS plenum and matching fueling timing) (10 shots)

VIII. Time permitting, measure P_{LH} with HFS midplane fueling (plenum at 1000 torr) in an USN (5 shots)

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

This XP requires an operational NBI system, as well as the capability of generating lower-single null an double-null diverted discharges with the plasma control system. No RF or CHI will be used during this experiment.

5. Planned analysis

Confinement and power threshold analysis requires EFIT and TRANSP. We require information on Er and Er', which requires detailed analysis of the edge rotation diagnostic.

6. Planned publication of results

The results will be presented at the IAEA meeting and in APS talks.

References

[1] Maingi, R. et. al., *Phys. Rev. Letts*. **88** (21 Jan. 2002) 035003.
[2] Field, A.R. et. al. *Plasma Phys. Contr. Fusion* **44** (2002) A113.
[3] Maingi, R. et. al., *Plasma Phys. Contr. Fusion* **45** (2003) 657.
[4] Maingi, R. et. al., "Effect of Gas Fueling Location on H-mode Access in NSTX", submitted to *Plasma Phys. Contr. Fusion*, 10/03.
[5] Helander, P. et. al., *Phys. Plasma* **10** (2003) 4396
[6] C.S. Chang, et. al., "Monte Carlo Particle Simulation of Edge Pedestal and Er-Layer Formation Including Neutral Particle and Anomalous Diffusion Effects," submitted to *Phys. Plasma*, 10/03.
[7] Maingi, R. et. al., *Nucl. Fusion* **43** (2003) 969.

PHYSICS OPERATIONS REQUEST

Effect of Fueling Poloidal Location on L-H Power Threshold **OP-XP-419**

Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **52** Flattop start/stop (s): _____/_____

I_P (MA): **0.5-1.0** Flattop start/stop (s): **0.15/0.5**

Configuration: **Lower Single Null**

Outer gap (m): **5-10cm**, Inner gap (m): **2-3cm**

Elongation κ: **1.8**, Triangularity δ: **0.4-0.5**

Z position (m): **0.00**

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

NBI - Species: **D**, Sources: **A/B/C**, Voltage (kV): **55-80**, Duration (s): **<0.3 sec**

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

CHI: **Off**

Either: List previous shot numbers for setup: **109051 (LSN)**

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

Effect of Fueling Poloidal Location on L-H Power Threshold **OP-XP-419**

Diagnostic	**Need**	**Desire**	**Instructions**
Bolometer – tangential array		✔	
Bolometer array - divertor		✔	
CHERS	✔		
Divertor fast camera		✔	
EBW radiometer			
Edge pressure gauges	✔		
Edge rotation spectroscopy	✔		
Fast lost ion probes		✔	
Filterscopes	✔		
FIReTIP		✔	
Gas puff imaging	✔		(injector may be used for fueling)
H□ camera - 1D	✔		
Infrared cameras		✔	
Interferometer - 1 mm			
Langmuir probe array		✔	
Magnetics - Diamagnetism	✔		
Magnetics - Flux loops	✔		
Magnetics - Locked modes	✔		
Magnetics - Pickup coils	✔		
Magnetics - Rogowski coils	✔		
Magnetics - RWM sensors			
Mirnov coils – high frequency			
MSE			
Neutral particle analyzer		✔	
Neutron measurements			
Plasma TV	✔		
Reciprocating probe			
Reflectometer – core		✔	
Reflectometer - SOL		✔	
SPRED		✔	(highly desired)
Thomson scattering	✔		
Ultrasoft X-ray arrays		✔	
Visible bremsstrahlung det.		✔	
Visible spectrometer (VIPS)			
X-ray crystal spectrometer - H			
X-ray crystal spectrometer - V			
X-ray GEM camera			
X-ray pinhole camera			