Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: Effect of Proximity to Double-Null on L-H Power Threshold		
OP-XP-418	**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)

1. Overview of planned experiment

The primary goal of this experiment is to measure the L-H power threshold (P_{LH}) as a function of "drsep", the distance between the two X-points mapped to the outer midplane. A secondary goal is to measure the power threshold in a high current double-null (DN) to provide information needed for other experiments run in DN. This experiment is the NSTX part of the first MAST/NSTX identity experiment. The MAST portion was executed in May, 2003.

2. Theoretical/ empirical justification

Early studies on DIII-D indicated that P_{LH} was lowest in a lower-single null configuration with the ion grad-B drift toward the X-point. The P_{LH} increased by about a factor of 2 in double-null and perhaps even a little more in upper-single null with the same grad-B drift

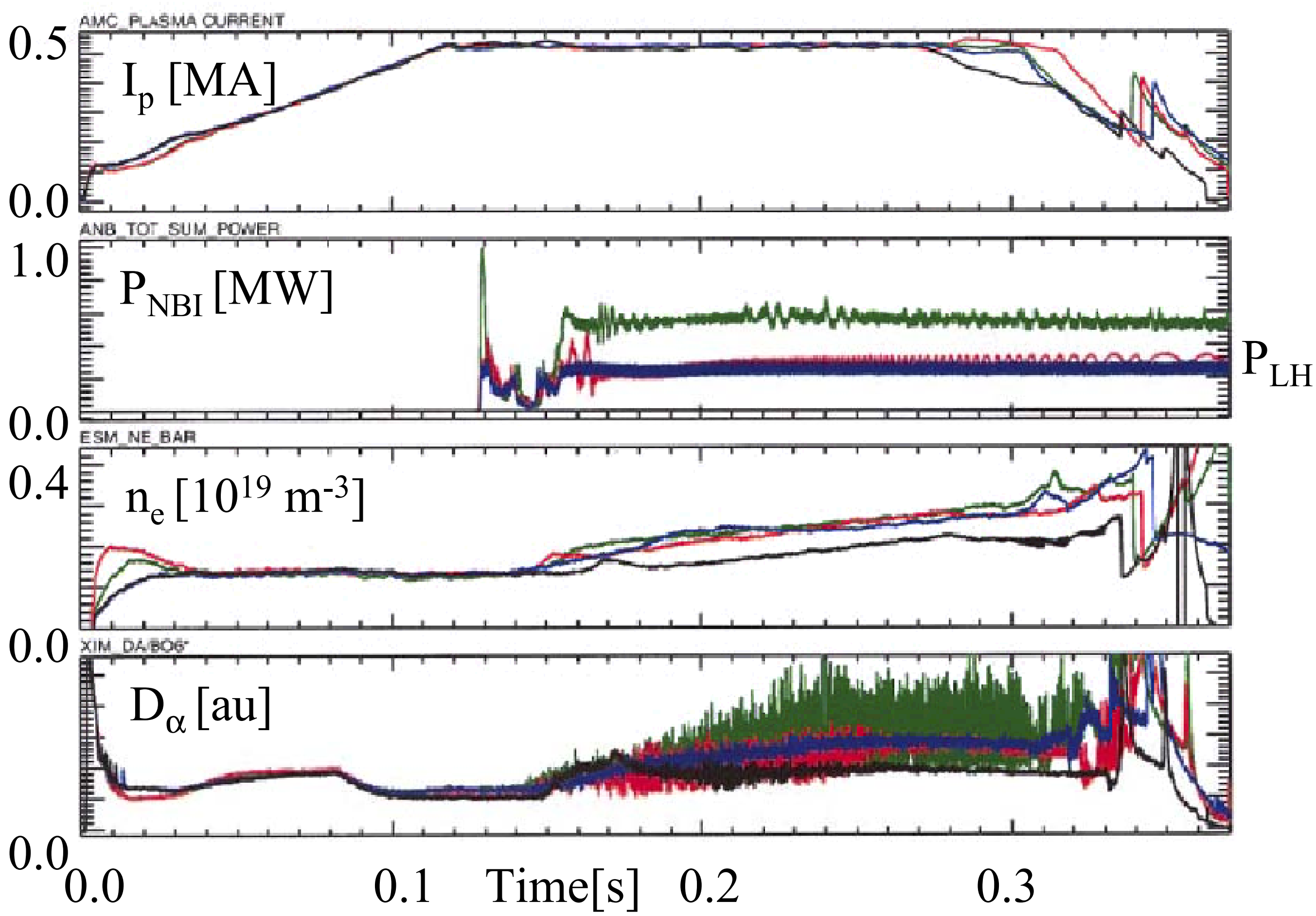

Fig. 1 – LH power threshold measurement in DN. The red and green curves show dithery or ELMy behavior signaling an H-mode. The black and blue curves did not have an L-H transition. LSN measurement yielded an LH NBI power of about 1.4 MW.

direction. Many of those early power threshold studies did not look carefully at the role of particle and heat pulses (e.g. sawteeth or fishbones) in triggering L-H transitions.

Recently, MAST has reported that P_{LH} is lowest in a truly balanced double-null, by a factor of two or more. A balanced DN does not always occur with the EFIT computed drsep=0, i.e. there can be an offset in drsep by several mm. The P_{LH} is observed to increase as the shape is moved away from a balanced DN. Here the balancing is judged by the ratio of power fluxes measured by Langmuir probes at the upper and lower divertors.

MAST conducted these same experiments in an NSTX size/shape, namely a ~ 0.6m, κ ~ 1.8 and δ ~ 0.5, and with ohmic induction as the main startup technique. Because MAST observed ohmic H-modes in this shape for I_p > 0.6 MA, the experiment was conducted at I_p ~ 0.5 MA (B_t = 0.45 T). For this condition, the NBI power threshold was measured at ~ 0.3 MW (Fig. 1) corresponding to P_{LH}=0.53±0.03 MW. This same DN shape was shifted downward so that drsep ~ 1 cm. The NBI power threshold was measured to be between 1.0 and 1.5 MW in that case corresponding to P_{LH}=1.2±0.1 MW, i.e. much higher than the DN.

We plan to reproduce the MAST conditions and measure the P_{LH} as a function of drsep. In addition, we will measure the power threshold at a higher I_p ~ 0.9 MA as these data are needed for other experiments during the run, and it will allow us to touch base with our previous LSN power threshold studies.

3. Experimental run plan

Some shape and discharge development is required since we have only a few low δ DN discharges. Start with shape from 109999 (δ ~ 0.44) and modify discharge in steps to match MAST outer boundary. The power threshold will be compared using NBI modulation vs. NBI voltage scan, and the technique which yields the lowest power threshold will be used for the rest of the scans.

I. Restore #109999, except run at I_p = 0.9 MA, B_t = 0.45 T, and with first NBI (early beam – src. A or B preferred) at 80ms and second at 300ms. (3 shots)

II. Branch (i.e. either step III or IV) to measure P_{LH}, based on whether P_{LH}< 1 src or P_{LH}>1 src; compare P_{LH} with NBI modulation vs. NBI voltage scan (8 shots)

III. If P_{LH}< 1 src, measure P_{LH} by turning off early beam at 140ms and turning second src. on at 200ms. Adjust power as needed to localize. Skip to step 5.

IV. If P_{LH}> 1 src, measure P_{LH} by adding second beam at 200ms and then third as needed. Change power of second/third beams, if needed.

V. Drop I_p = 0.5 MA and measure P_{LH} with drsep ~ 0; start NBI at ~ 200ms after I_p and divertor flattop. Use early beam for CHERs blip, if needed, or put in a notch at 300ms. (5 shots)

VI. Repeat above for drsep = +/- 1 cm (effectively LSN and then USN). Start with a drsep ramp, as in #108476. (10 shots)

VII. Repeat above for drsep = +/- 0.3 cm. (10 shots)

Listed below are some considerations:

A. Try to avoid disruptions during ramp-down to maintain wall conditions.

B. The drsep scan will be accomplished by changing coil current ratios, starting from the DN, so that the same startup can be used.

C. A drsep scan was done on 5/17/02, i.e. 108472-76; the last shot had a nice drsep ramp from ~ 0.2cm-1.0cm.

D. The minimum on/off time for modulation is 10 ms on/10 ms off. The on/off timing will be maintained in multiples of 10ms for CHERs and edge rotation data. The maximum off time will be 20ms, and a finer power scan will be done by reducing the voltage in small increments.

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. We require HeGDC between shots of nominally 7 minutes.

5. Planned analysis

Confinement and power threshold analysis requires EFIT and TRANSP. We would like to get 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.

PHYSICS OPERATIONS REQUEST

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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 / Upper SN / Double Null**

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

Elongation κ: **1.8**, Triangularity δ: **0.45-0.5**

Z position (m): **0.00**

Gas Species: **D / He**, 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: **109999 (DN)**

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 Proximity to Double-Null on L-H Power Threshold **OP-XP-418**

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			