| Princeton Plasma Physics Laboratory<br>**NSTX Experimental Proposal** | | |
|---|---|---|
| **Title: Dependence of L-H Power Threshold on X-point height and drsep** | | |
| **OP-XP-505** | **Revision:** | Effective Date: 01/27/2005<br>*(Ref. OP-AD-97)*<br>Expiration Date:<br>*(2 yrs. unless otherwise stipulated)* |

| **PROPOSAL APPROVALS** | |
|---|---|
| **Author: R. Maingi, H. Meyer (UKAEA), T. Biewer** | Date |
| **ATI – ET Group Leader: S. Kaye** | Date |
| **RLM - Run Coordinator: J. Menard** | 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

The primary goal of this experiment is to measure the L-H power threshold ($P_{LH}$) as a function of X-point height and "drsep", the distance between the two X-points mapped to the outer midplane, for both NBI and RF heated discharges. This experiment is the NSTX part of the MAST/NSTX L-H threshold identity experiment. The MAST portion was executed in May, 2003, and a first attempt of the previous XP#418 was made at this experiment in 2004. This experiment is also the follow-on to XP447, which attempted to determine the effect of drsep on power threshold with RF heating, to compare with C-MOD results.

## 2. Theoretical/ empirical justification

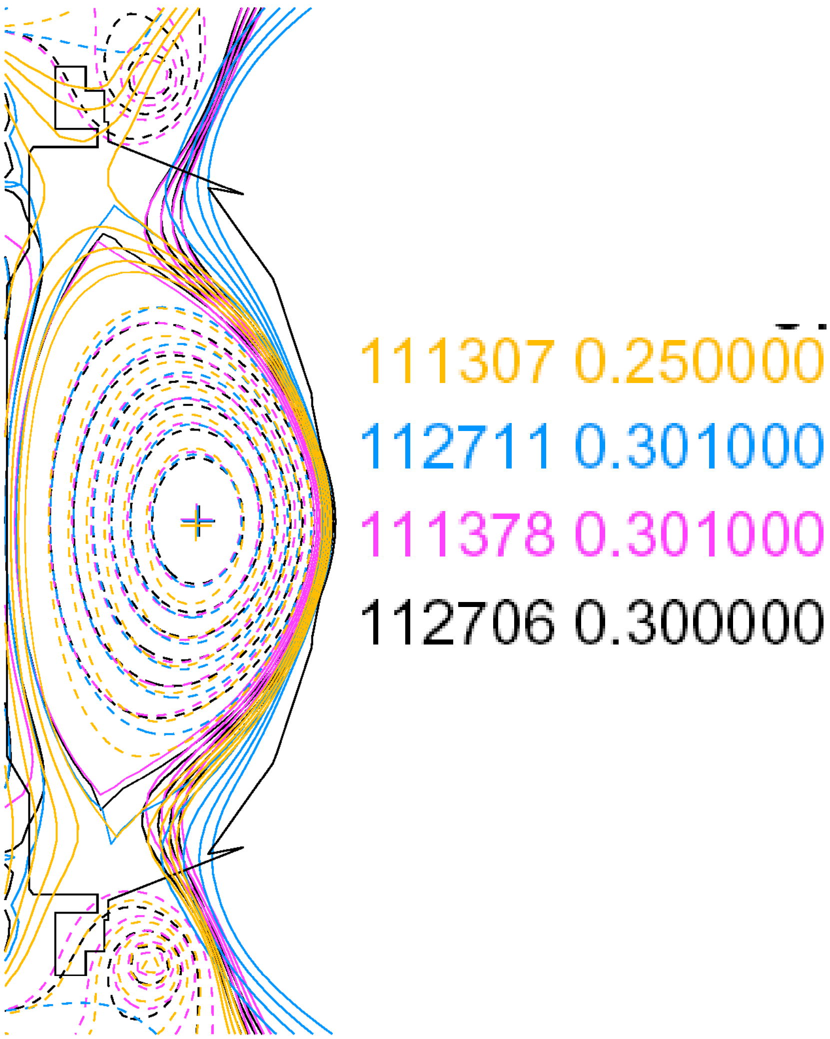


Fig. 1 – Comparison between MAST-like shape #111378 and ohmic H-mode shape #111307, showing different X-point heights. Also included are two other rtEFIT isoflux-feedback discharges developed during an elongation scan.

Recently, MAST has reported[1] 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, $\kappa$ ~ 1.8 and $\delta$ ~ 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.

In NSTX the power threshold[2] in DN with parameters close to the MAST shape were $P_{LH}$=0.58±0.11 MW, i.e. very close to the MAST values. However an L-H transition could not be obtained at all in LSN or in USN with drsep ~ +/-1 cm. The same result was observed in XP 447 with RF heating instead of NBI heating.

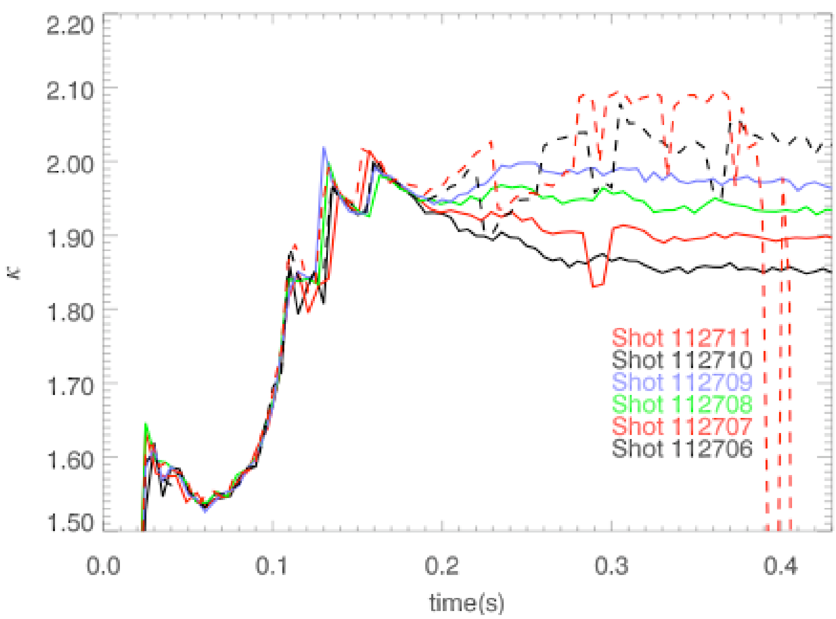


Fig. 2 – Elongation scan with rtEFIT isoflux feedback control. Data courtesy of D. Gates.

Examination of the shapes shows that the X-point height in the MAST shape was 40-45 cm, or a factor of 2-3 larger than normal for NSTX (Fig. 1). In DIII-D, a higher X-point has been shown to correlate with a higher power threshold. A lower X-point height shape, e.g. #111307, enabled ohmic H-mode access, suggesting that the same physics is important in NSTX.

The goal of this experiment is to compare the power threshold as a function of drsep at up to three different X-point heights. The shapes have already been developed under rtEFIT isoflux feedback control (Fig. 2).

## 3. Experimental run plan (1.5 days)

I. Restore #111307, and verify ohmic H-mode access in LSN – this is highest kappa. (2 shots)

II. Drop $I_p$ to 0.5 MA as in MAST experiments and repeat. If still ohmic H-mode, decrease kappa to avoid ohmic H-mode, probably to 1.95-2.0 as in #112708-09. (3 shots)

III. Measure power threshold with NBI. (4 shots)

IV. Make DN out of LSN by using up/down symmetric coil currents, and measure power threshold with NBI. (4 shots)

V. Make USN out of LSN and measure power threshold with NBI. (3 shots)

VI. Do a drsep ramp up and down (sawtooth) to +/- 1.5 cm as in #113251 to test power threshold levels at fixed NBI heating levels. (2 shots)

VII. Repeat steps III-VI for RF heating with smaller outer gap. (9 shots)

VIII. Repeat step VI for old shape, i.e. #113378, and verify preferred access in DN with NBI, and then RF heating. (4 shots)

IX. Repeat steps II-VII for an intermediate kappa between steps VI and VII. (20 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 as in XP#418 and XP#447.

C. 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.

D. Add a 10 ms on-time NBI blip every 50ms during RF heating to document profiles.

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

This XP requires an operational NBI and RF system, as well as the capability of generating lower-single null, upper-single null, and double-null diverted discharges with the plasma control system. We require HeGDC between shots of nominally 10 minutes.

## 5. Planned analysis

Confinement and power threshold analysis requires EFIT and TRANSP. We need to get information on $E_r$ and $E_r$', which requires detailed analysis of the edge rotation diagnostic.

## 6. Planned publication of results

The MAST/NSTX comparison analysis will be lead by H. Meyer, and possibly be reported at the EPS meeting. The RF power threshold analysis and comparison between RF and NBI discharges will be lead by T. Biewer, and be presented at APS and in a refereed journal if the results are solid.

# PHYSICS OPERATIONS REQUEST

**Dependence** of L-H Power Threshold on X-point height and drsep **OP-XP-505**

Machine conditions (specify ranges as appropriate)

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

$I_P$ (MA): **0.5-0.8** Flattop start/stop (s): **0.15/0.5**

Configuration: **Lower Single Null / Upper SN / Double Null**

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

Elongation κ: **1.8-2.1**, Triangularity δ: **0.4-0.5**

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: **111307 (LSN), 111378 (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

**Dependence** of L-H Power Threshold on X-point height and drsep **OP-XP-505**

| 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 | | ✓ | |
| $H_a$ 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 | | | |

References
[1] H. Meyer, et. al., 2004 *Plasma Physics Controlled Fusion* **46** A291.
[2] H. Meyer, et. al., 2004 *Proc. of 2004 IAEA Fusion Energy Conference, paper EX/P3-8.*