Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: **B_t scaling of electron transport change with heating power**

OP-XP-822	Revision:	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: D. Stutman	Date 02/18/08
ATI – ET Group Leader: S. Kaye	Date
RLM - Run Coordinator: M. Bell	Date

Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: **B_t scaling of electron transport change with heating power** No. **OP-XP-822**

AUTHORS: **D. Stutman, L. Delgado-Aparicio, K. Tritz,**
M. Finkenthal (*JHU);* S. Kaye, B. LeBlanc,
M. Bell, R. Bell *(PPPL)* DATE: **02-18-2008**

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1. Overview of planned experiment

A large change in perturbed electron transport with beam heating power was observed in NSTX H-modes, by changing the beam power at fixed q-profile (XP 612). The planned experiment will explore how this change scales with toroidal magnetic field, which was shown to directly influence the electron transport in NSTX. Our experiment will consist in preheating the plasma at 4 MW in order to freeze in the current profile and then varying the beam heating at different toroidal fields.

To study also eventual changes in particle transport with beam power will use Neon injection and the multicolor OSXR system. The high-k scattering system will also be used to document changes in fluctuations after the beam power changes.

The estimated run time is one day.

2. Theoretical/empirical justification

Electron transport is the dominant loss channel in beam heated NSTX plasmas. An unusual effect is also that the T_e profile broadens with increasing beam power in the typical NSTX H-mode. The TRANSP calculations, as well as perturbative experiments, show that this is due to a large increase in the central electron transport, coupled with a decrease in the peripheral one.

Since together with beam power, the q-profile also changes in these plasmas, in XP 612 we tried to separate the role of electron heating from that of the q-profile in the Te profile broadening. To study the effect of heating power changes at fixed q, the plasma was preheated for 420 ms at fixed power (4 MW) and then power stepped up and down.

The results at fixed q show that at high power the central χ_e reaches several tens of m^2/s, while at low power it decreases by a large factor (Fig. 1a). These trends are confirmed by the perturbative experiments using Li pellets. At high power the pellet cold pulse rapidly propagates to the plasma center, while at low power the pulse is strongly damped in the inner plasma. The estimated critical T_e gradient in the plasma center is very low (~0.25 keV/m) compared to that typical at large aspect ratio (few keV/m). For the scaling to a next step ST it is thus important to see how the electron transport degradation with power scales with magnetic field, since it was shown that B_t can directly affect electron transport in NSTX [S. Kaye et al., PRL 2007].

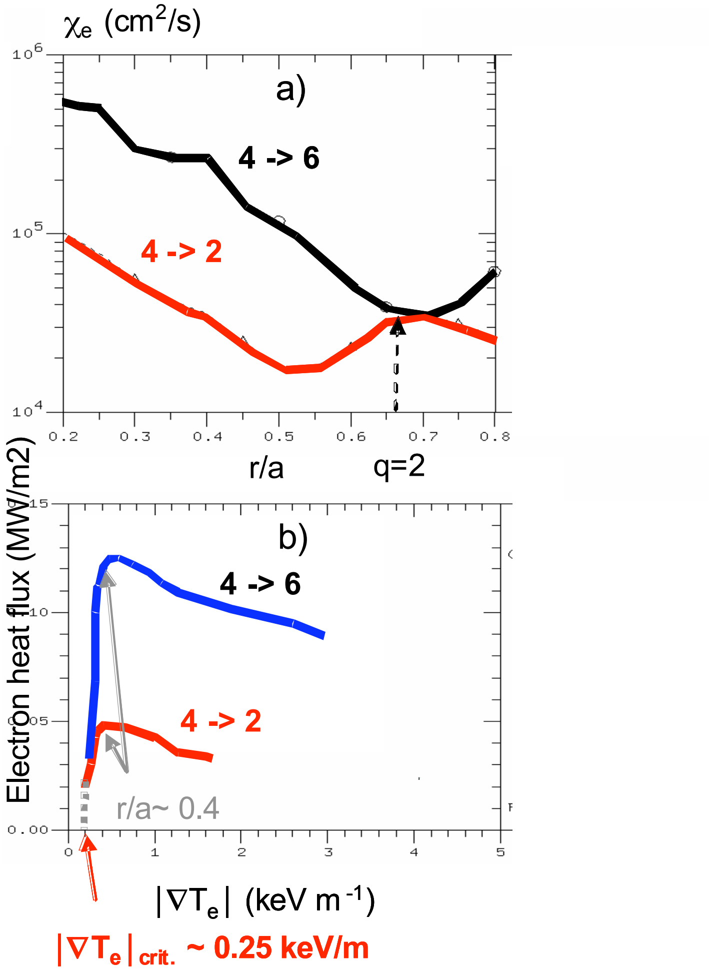

Fig. 1 a) Electron heat diffusivity following power step (4 MW -> 6 MW) and power drop (4 MW ->2 MW) at fixed q -profile (1 MA, 4.5 kG small -ELM H-mode).

b) Critical temperature gradient in the central plasma, obtained by extrapolating to zero the TRANSP calculation of electron heat flux vs. Te gradient.

3. Experimental run plan

The experiment will consist in a B_t change at fixed I_p/B_t. As in XP 612 the plasma will be preheated at 4 MW for 420 ms in order to 'freeze-in' the current profile and then the beam power applied according to the scheme:

4 MW-> 6 MW

4 MW->4 MW

4 MW->2 MW

These power changes will be performed at three field and current conditions:

0.55 T/ 1.1 MA

0.45 T/ 0.9 MA

0.36 T/ 0.7 MA

To probe also eventual particle changes, in one of the conditions (e.g., at 0.55 T / 1.1 MA), we will also inject Neon before the beam power step. The Neon will be injected at t≈0.3 s, in order to establish an impurity gradient in the outer plasma half by the time of the power step. If there will also be a change in impurity diffusivity following the step (e.g., an increase inside r/a < 0.5, as suggested by some results from 2005-2007 runs), the increased transport should be manifest as an additional influx of impurities to the core. The change in particle transport, or lack thereof, should also be indicative of the appearance, or absence of low-k electrostatic turbulence in the region where Te flattens.

The baseline discharges will be the same as in XP 612: MHD quiescent, small ELM H-modes at high elongation and triangularity, such as 121135 at 1 MA and 121172 at 1.2 MA.

The electron temperature and impurity penetration will be measured on fast time scales using the JHU multi-color arrays and the SXR/MPTS technique developed in 2006.

All the routine transport diagnostics (MPTS, CHERS, MSE and fast EFIT) must be operational for the proposed XP. CHERS will be synchronized with the beam power steps.

Two shots per condition will be obtained to verify reproducibility. The Neon shots will be executed at the end, time permitting. Finally, due to the relevance of this XP to electron transport, the high-k scattering diagnostic must be operational and taking data. With highest priority we will aim for high-k measurements at r/a≈0.2, i.e., inside the region where Te flattens at increased power. After running a first round of shots, it will be evaluated if a controlled access is possible to move high-k to r/a≈0.65, where an electron transport change opposite to that in the center may be expected (Fig. 1a).

		P_{NB}		**#shots**
B_t / I_p				
4.5/0.9	**4->4**	**4->6**	**4->2**	**2x3**
3.6/0.7	**4->4**	**4->6**	**4->2**	**2x3**
5.5/1.1	**4->4**	**4->6**	**4->2**	**2x3**
		Neon		
5.5/1.1	**4->4**	**4->6**	**4->2**	**1x3**

The estimated run time is one day, for a total of 21 shots.

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

(1) All neutral beams operational at 90 kV; **required**

(2) Three-color tangential optical SXR array (Be 10, Be 100, Be 500 filters); **required**

(3) USXR arrays in two-color configuration: Hor. Up – Be10, Hor. Down - Be100, Re-entrant Be-100; **required**

(4) High-k scattering operational and taking data at r/a=0.2 (R~112 cm); **required**

(5) MPTS pulses at 16 ms spacing, with timing synchronized for a measurement at 420 ms; **required**

(6) CHERS operational and synchronized for frame starting at 420 ms; **required**

(7) MSE operational and synchronized for measurement starting at 420 ms; **required**

(8) NPA in fast T_i mode, for estimate of relative T_i change following injection; **desired**

5. Planned analysis

TRANSP, multi-color SXR, impurity transport, GS2.

6. Planned publication of results

This XP will finalize the results in XP612 and enable contributions in APS/DPP 2008 and in a refereed journal.

PHYSICS OPERATIONS REQUEST

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Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **max. available** Flattop start/stop (s): **-0.02/1.0 s**
I_P (MA): **0.7-1.1** Flattop start/stop (s): **0.12-0.22/0.8 s**

Configuration: **DN**

Outer gap (m): **0.05-0.10** Inner gap (m): **0.01-0.06**

Elongation κ: 2.25 Upper/lower triangularity δ: 0.6/0.6

Z position (m):

Gas Species: **D, Ne** Injector(s):

NBI Species: **D** Sources: Voltage (kV): 90 Duration (s): 1s

ICRF Power (MW): Phasing: Duration (s):

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

LITER: Off

Shots for setup: 121135, 121172

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		