**Princeton Plasma Physics Laboratory**

# NSTX Experimental Proposal

Title: **L-H threshold and edge transport and turbulence in NSTX reversed $B_t$ discharges**

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| **OP-XP-956** | Revision: | Effective Date: **8/5/09**<br>*(Approval date unless otherwise stipulated)*<br>Expiration Date: **8/5/09**<br>*(2 yrs. unless otherwise stipulated)* |

## PROPOSAL APPROVALS

| | |
|---|---|
| **Responsible Author: S. Kaye, R. Maingi, V. Soukhanovskii, K. Tritz** | Date 8/5/09 |
| **ATI – ET Group Leader: V. Soukhanovskii / K. Tritz** | Date 8/5/09 |
| **RLM - Run Coordinator: R. Raman** | Date 8/9/09 |

**Responsible Division: Experimental Research Operations**

**Chit Review Board** (designated by Run Coordinator)

## MINOR MODIFICATIONS (Approved by Experimental Research Operations)

# NSTX EXPERIMENTAL PROPOSAL

TITLE: **L-H threshold and edge transport and turbulence in NSTX reversed $B_t$ discharges** No. **OP-XP-956**

AUTHORS: **S. Kaye, R. Maingi, V. Soukhanovskii, K. Tritz** DATE: **8/5/09**

## 1. Overview of planned experiment

The goals of the experiment is to conduct initial physics scoping studies of the reversed $B_t$ effects on edge, scrape-off layer and divertor heat and particle transport and turbulence: 1) L-H power thresholds in NBI-heated discharges, 2) divertor and SOL transport and turbulence in L- and H-mode discharges in low and high triangularity configurations.

## 2. Theoretical/ empirical justification

This experiment will provide first spherical tokamak data on L-H threshold and edge physics with reversed $B_t$ for comparison with forward $B_t$ and with large aspect ratio tokamaks.

## 3. Experimental run plan

1. **SOL, divertor, and pedestal characterization in low-$\delta$ discharges (approx. 1 day)**
   - Setup: Use discharge 135169 (or long pulse version of 132721 with a larger drsep ~ -2-3 cm) as template (0.8 MA, 5 MW, $\delta_L$=0.4, drsep =-1 cm, GAPOUT=10 cm). Use LITER at 10-20 mg/min (exact rate TBD).
   1. Scan $P_{NBI}$ between 1 MW and 6 MW in steps of 1 MW to map out L- and H-mode operational space boundaries. Choose a suitable outer gap that reduces beam ion losses while allowing edge profiles to be measured (use results from XP955).
   2. In an H-mode discharge (at high $P_{NBI}$ ), scan $I_p$ between 0.6 and 1.0 MA, 0.2 MA increments. [Add data points at 0.6 and 1MA – 2 shots]
   3. In an 0.8 MA H-mode discharge, attempt to obtain radiative divertor
      - Use Bay E divertor gas injector at pressures 2000-5000 Torr, pulse duration 100-200 ms [Start with conditions similar to that used in the radiative divertor XP]

2. **L-H threshold studies (aprox. 4 hrs)**
   - Reproduce low $\delta_L$ discharge with ohmic ramp-up (132721, 800kA case), with 50-100mg Lithium between discharges, i.e. just enough to avoid HeGDC
   1. Measure $P_{LH}$ through NBI voltage scans, using src C at lowest voltage, and B at intermediate (start with a discharge developed as part of step 1, but use 50mg Li deposition)
   2. Repeat with heavy Lithium (250mg Li-deposition)

3. **SOL, divertor, and pedestal characterization in high-$\delta$ discharges (approx. 1 day)**
   - Use most recent fiducial discharge as template (0.8 MA, 4-6 MW, $\delta_L$=0.8, drsep =-1 cm, GAPOUT=10 cm). Use LITER at 10-20 mg/min (exact rate TBD).
   1. Scan $P_{NBI}$ between 1 MW and 6 MW in steps of 1 MW.
   2. In an H-mode discharge (at high $P_{NBI}$ ), scan $I_p$ between 0.8 and 1.2 MA [Add data points at 0.8MA and if possible at 1.2MA]

3. In an 1.0 MA H-mode discharge, attempt to obtain radiative divertor
    - Use Bay E divertor gas inj. at pressures 2000-5000 Torr, pulse duration 100-200 ms. [Start with conditions similar to that used in the radiative divertor XP]

**4. Test Impact of reversed TF on Impurity particle/confinement with XP950 results (4hrs)**
[About 15-18 shots]

- Use same LITER rate as XP950 (increase as needed to eliminate ELMs).
- Modify early gas fueling and NBI power and timing to achieve early H-mode at similar time as forward BT target. (3 shots)
- Avoid period of small outer gap (0-5cm) from 100-150ms. (2 shots)

a. Run 134259 (15cm outer gap, 700kA) and reproduce (2 shots)
b. Run 134258 (10cm outer gap, 700kA) and reproduce (2 shots)
c. Run 134272 (20cm outer gap, 1.2MA, if $P_{threshold}$ is adequate) and reproduce (2 shots)

Use results above to maximize pulse-length in reversed TF configuration by minimizing impurity accumulation and associated density rise at 700-800kA.

d. Starting from 700kA target above with density closest to saturation and lowest impurity concentration, increase plasma current:
    i. Increase current to 750kA (2 shots)
    ii. Increase current to 800kA (2 shots)
e. At reduced TF = 4kG, repeat above current scan:
    i. Use plasma current = 750kA, 700kA, 800kA [due to time limitations run at one value if Ip] (2 shots)

**5. Optional, time permitting studies. Priority and scope TBD after the completion of parts 1 through 3.**

- Scan LITER rate between 10 and 80 mg/min to study pumping characteristics in low and/or high triangularity discharges
- Use SGI to study ion $\tau_p^*$ at several LITER rates in high triangularity discharges
- Perform $P_{NBI}$ and $I_P$ scans in high-$\delta$ and low-$\delta$ double-null configuration.
- Use RMP in several discharges to study pumping / ELM behavior
- Obtain “snowflake” divertor, use discharge template from XP 924

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

**T**he experiment assumes that 1) plasma facing component conditioning has been performed to enable plasma operations, and 2) reliable reversed $B_t$ plasma operations have been established.

Both LITERs, SGI, and Bay E divertor gas injector will be required.

# 5. Planned analysis

What analysis of the data will be required: EFIT, LRDFIT, TRANSP, UEDGE, SOLPS, DEGAS 2, SOLT, BOUT

## 6. Planned publication of results

Results will be presented at the upcoming PSI and ITPA meetings if appropriate.

# 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:**

**Previous shot(s) which can be repeated:**

**Previous shot(s) which can be modified:**

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

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

$I_P$ (MA): Flattop start/stop (s):

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

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

Outer gap (m): Inner gap (m): Z position (m):

Elongation κ: Upper/lower triangularity δ:

Gas Species: Injector(s):

**NBI** Species: **D** Voltage (kV) **A:** **B:** **C:** Duration (s):

**ICRF** Power (MW): 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 | √ | |