Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**		
Title: Core impurity density and radiated power reduction using variations in divertor conditions		
OP-XP-1002	Revision:	Effective Date: *(Approval date unless otherwise stipulated)* Expiration Date: *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS	
Responsible Author: V. A. Soukhanovskii	Date **15 June 2010**
ATI – ET Group Leader: C. H. Skinner	Date
RLM - Run Coordinator: E. Fredrickson	Date
Responsible Division: Experimental Research Operations	

RESTRICTIONS or MINOR MODIFICATIONS

(Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: Core impurity density and radiated power reduction using variations in LLD divertor conditions | No. **OP-XP-1002**

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1. Overview of planned experiment

This experiment aims at reducing carbon and metal impurity accumulation typically observed in lithium-enabled ELM-free H-mode discharges, by means of divertor D_2 injection. An operational objective is to develop a long ELM-free H-mode discharge scenario with optimized rate and timing of the divertor gas puff. The physics objective is to clarify the mechanism of the core impurity reduction by diverotr gas injection. This would be accomplished by detailed spectroscopic measurements of impurity (Li, C, O, Fe, Mo) sources at several poloidal locations (CS, outer midplane, lower and upper divertors), as well as impurity density profile measurements in the core, and impurity transport modeling.

2. Theoretical/ empirical justification

Previous NSTX divertor experiments that demonstrated divertor peak heat flux reduction by means of either the radiative divertor with D_2 injection [1,2] or the divertor geometry in the “snowflake” divertor configuration [3,4] showed significant core impurity density and radiated power reductions. The experiments were conducted in ELMy H-modes without any lithium conditioning. The reduction of core impurities was attributed to a reduction of the divertor impurity source at very low T_e attained in the detached divertor. However, no systematic studies were performed, and a number of other effects, e.g., neoclassical convection at the edge of confined plasmas due to increased neutral pressure, changes in the SOL transport and flows, improved impurity compression, and other effects, could play a role. This experiment will attempt to clarify the physics of the observed effect.

3. Experimental run plan

1 Obtain a reference discharge, 3-5 MW NBI, high triangularity shape w/ PF1A, LITER rate 10-20 mg/min (100-200 mg), R_{OSP}=0.40-0.55 m, nearly ELM-free H-mode, long pulse (~ 1s), HFS fueling

- 1 MA, similar to discharges 138178, 138180
- Optional, time permitting - 0.8 MA, similar to discharges 138239-1380241
- If available, use PCS strike point control
- Use LITER rate 100-200 mg per shot to obtain ELM-free H-mode

2 Use Bay E divertor gas injector at 5000 Torr (up to 200 Torr l /s) for divertor gas injections. Gas delay in respect to the valve opening time is about 100 ms.

- Injection in the flattop phase of discharge

Number	Plenum pressure	Injection time wrt t0 in PCS (s)	Gas pulse duration (ms)
1	500	0.300	100
2	5000	0.300	50-100
3	1000	0.300	100
4	4000	0.300	100
5	1500	0.300	100

- Injection in the initial phase of discharge – use best injector rate and start at t=0.100-0.150 ms

3. Optional, time permitting – obtain data for lower-end NBI power (2-3 MW) and higher-end NBI power (4-5 MW)
4. Optional, time permitting, pending administrative approval – use a medium-δ discharge target with OSP at *R*=063-0.70 m to take advantage of the Langmuir probe array. Example discharge 137622 (5-2 MW NBI, small ELMs, P_{rad} up to 0.8 MW)
5. Optional, time-permitting – use CD_4 injection instead of D_2 (not on the same day).

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

5. Planned analysis

EFIT, LRDFIT, TRANSP, MIST, UEDGE

6. Planned publication of results

Results will be presented in upcoming fusion meetings and major refereed publications.

References

[1] V. A. Soukhanovskii *et al.,* Phys. Plasmas 16 (2009) 022501

[2] V. A. Soukhanovskii *et al.,* Nucl. Fusion 49 (2009) 095025

[3] V. A. Soukhanovskii *et al.,* Taming the Plasma Material Interface with the "Snowflake" divertor in NSTX, U.S. Burning Plasma Organization eNews, March 17, 2010 (Issue 42), http://burningplasma.org/enews031710.html

[4] V. A. Soukhanovskii *et al.,* "Snowflake" divertor in NSTX, submitted to J. Nucl. Mater., May 2010

PHYSICS OPERATIONS REQUEST

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Brief description of the most important operational plasma conditions required:

Previous shot(s) which can be repeated: 1 MA: 138178, 138180; 0.8 MA: 138235-138241

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: **LSN**

Equilibrium Control: **Outer gap / Isoflux** (rtEFIT) **/ Strike-point control** (rtEFIT)

Outer gap (m): Inner gap (m): Z position (m): **0.00**

Elongation: Triangularity (U/L): OSP radius (m): **0.4-0.55**

Gas Species: **D2** Injector(s): **HFS, 2, 3, Bay E divertor**

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

ICRF Power (MW): Phase between straps (°): Duration (s):

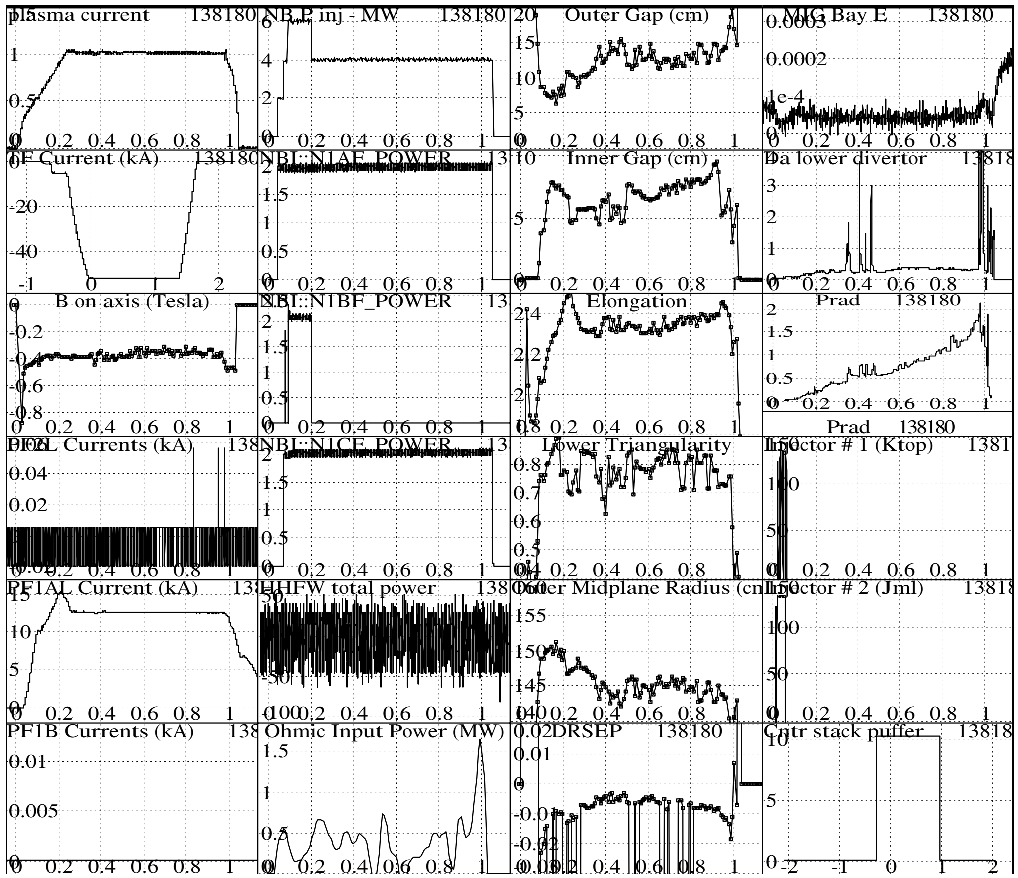
CHI: **Off / On** Bank capacitance (mF):

LITERs: Off / On Total deposition rate (mg/min):

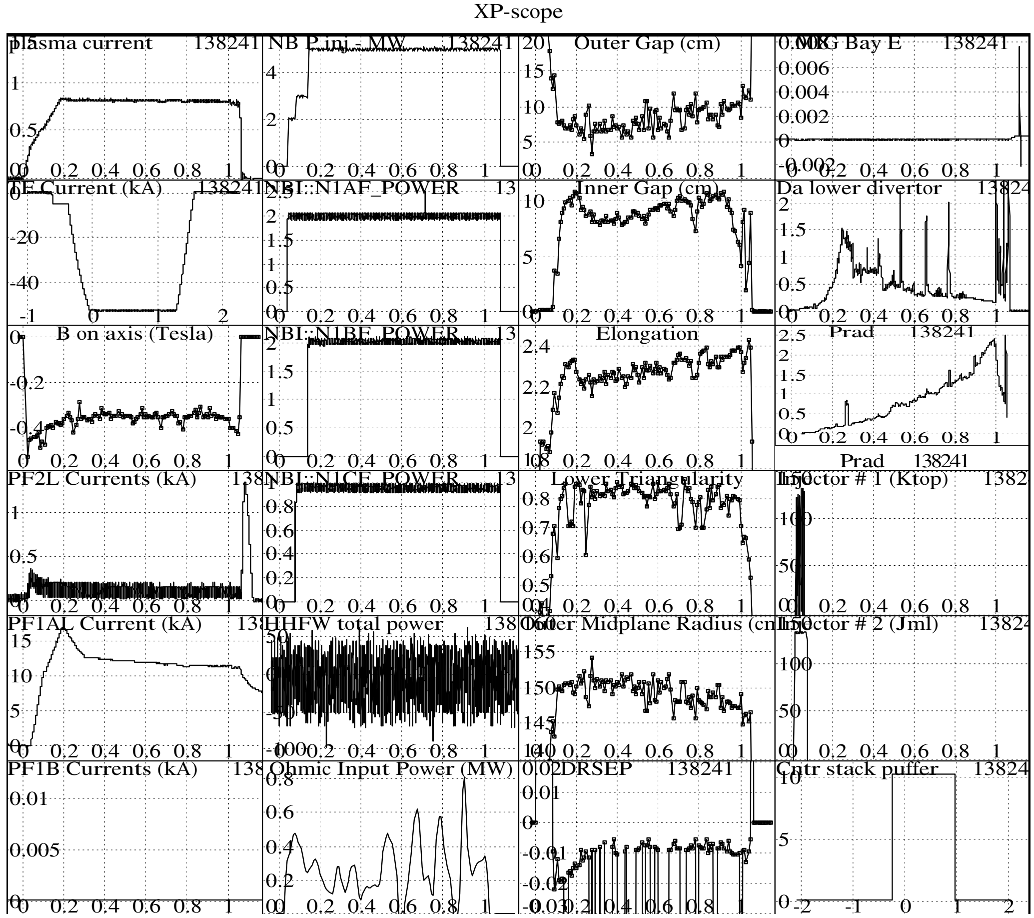
LLD: Temperature (°C):

EFC coils: Off/On Configuration: **Odd / Even / Other**

XP-scope



XP-scope



DIAGNOSTIC CHECKLIST

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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Beam Emission Spectroscopy		
Bolometer – divertor		√
Bolometer – midplane array	√	
CHERS – poloidal		
CHERS – toroidal	√	
Dust detector		
Edge deposition monitors		
Edge neutral density diag.		√
Edge pressure gauges	√	
Edge rotation diagnostic		√
Fast cameras – divertor/LLD		√
Fast ion D_alpha - FIDA		
Fast lost ion probes - IFLIP		
Fast lost ion probes - SFLIP		
Filterscopes	√	
FIReTIP		√
Gas puff imaging – divertor		√
Gas puff imaging – midplane		√
Hα camera - 1D		√
High-k scattering		
Infrared cameras		√
Interferometer - 1 mm		
Langmuir probes – divertor		√
Langmuir probes – LLD		√
Langmuir probes – bias tile		√
Langmuir probes – RF ant.		
Magnetics – B coils	√	
Magnetics – Diamagnetism		
Magnetics – Flux loops	√	
Magnetics – Locked modes		
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 detectors		
Plasma TV	√	
Reflectometer – 65GHz		
Reflectometer – correlation		
Reflectometer – FM/CW		
Reflectometer – fixed f		
Reflectometer – SOL		√
RF edge probes		
Spectrometer – divertor		√
Spectrometer – SPRED		√
Spectrometer – VIPS		√
Spectrometer – LOWEUS		√
Spectrometer – XEUS		√
SWIFT – 2D flow		
Thomson scattering	√	
Ultrasoft X-ray – pol. 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 tang. pinhole camera		