Princeton Plasma Physics Laboratory
NSTX Experimental Proposal

Title: **Diffusive Lithium Injection**		
OP-XP-951	Revision:	Effective Date: **6/8/09** *(Approval date unless otherwise stipulated)* Expiration Date: **6/8/11** *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: Charles H. Skinner	Date: 6/8/09
ATI – ET Group Leader: C.H. Skinner	Date 6/8/09
RLM - Run Coordinator: R. Raman	Date 6/8/09
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: Diffusive Lithium Injection No. **OP-XP-951**
AUTHORS: Charles H. Skinner et al., DATE: **6/8/09**

1. Overview of planned experiment

The goal of this XP is to increase Li coverage of NSTX vessel wall by using LiTER to inject Li into low pressure helium. The mean free path of Li in He will be adjusted by varying the helium pressure to produce a diffusive coating of the upper vessel, midplane and any regions not in line-of-sight to LiTER.

2. Theoretical/ empirical justification

Density and impurity control is goal of multi-year Li program on NSTX but so far elimination of ELMs by Li has caused impurity accumulation late in discharge e.g. 133816. Core carbon levels actually increase with Li. (R. Bell). Asdex experience showed that carbon impurities were not reduced without complete W coating of C [A. Kallenbach Nucl. Fus. 49 (2009) 045007]. Complete Li wall coverage in NSTX may be essential to reap full benefits of Li.

Li coverage is currently impeded by the stuck TIV on the Bay K LiTER since 5/29/09. This XP will be run with the Bay F LiTER only.

Previous quartz microbalance (QMB) measurements [C. H. Skinner, J. Nucl. Mater., 390-391 (2009) 1005] showed that a 1.3 mtorr puff of D_2 caused deposition on the upper QMB that was out of sight of LiTER and that had not shown deposition earlier. The D_2 puff also interrupted deposition on the lower QMB that was in line-of-sight of LiTER. The behavior was consistent with the D_2 mean free path from an atomic physics calculation by P. Krstic reported in the same paper.

3. Experimental run plan

Plan on ½ day XP.

1. Establish baseline LSN, Li conditioned, ELM-free H-mode with impurity accumulation.
   Model shot 133816. Alternative model shot is 134135 (9mg/min LiTER on a 12.5min clockcycle with no heGDC). After running the model shot, operate Bay F LiTER at 25 mg/min, 10-12.5 min between shots, no intershot HeGDC (note: 12.5 min between shots may be preferred).
   Document:
    a. He 304 line on SPRED
    b. Radiated power: tagname -\PASSIVESPEC::BOLOM_totpwr
    c. VB Zeff: \passivespec::zeff
    d. Metals Zeff from bolometer: \PASSIVESPEC::BOLOM_ZEFFM
    e. Carbon Zeff from: \CHERS_BEST:zeff)[10,*]
    f. QMB deposition from: persec09_today
2. Perform staged Li deposition:
   Fill to 2.5 mtorr He with GDC system (no glow discharge), close TMPs, then partial pump out to:
    1. 0.225 mtorr He (0.30 m mfp), 3 minutes then partial pump out,

2. 0.096 mtorr He (0.70 m mfp), 3 minutes then partial pump out,
3. 0.045 mtorr He (1.50 m mfp), 3 minutes then full pump out,
4. base vacuum, 3 minutes.

5. Wait 5 mins for any helium pump out (note no HeGDC and low pressure He will reduce chance of helium entrapment in Li).
6. Note deposition on upper QMB. If appropriate adjust highest pressure to be optimal for maximum upper QMB deposition. Expect best He pressure for midplane coverage will be ½ - 1/3 best pressure for upper QMB deposition.
7. Repeat ELM free H-mode.
    a. if no increase in He 304 line can skip the 5 min wait. If large increase in He 304 line extend wait to 10 mins.
    b. Compare on impurity accumulation and core carbon levels (a-f) to previous shot.
8. If no change increase LiTER to 40 mg/min and repeat steps 2-6.
9. If some difference perform 3 discharges at longer mfp (1, 1.5, 2 m) to coat sides of centerstack.

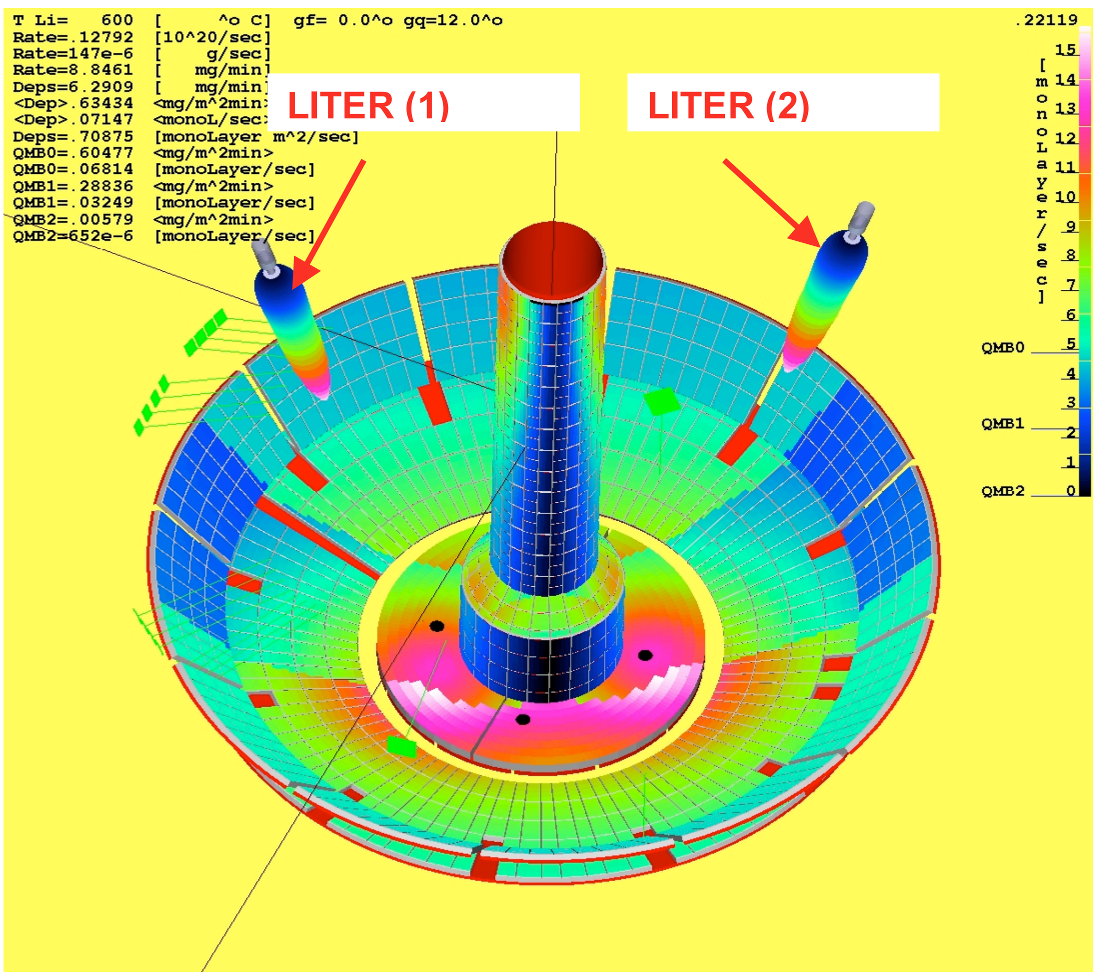

Figure 1. Calculation of lithium deposition in NSTX lower vessel. Note Li poor coverage of sides of centerstack and some areas on passive plates. [L. Zakharov].

10. Try 3 discharges at shorter mfp (0.1, 0.2, 0.3 m). Use QMB response as guide

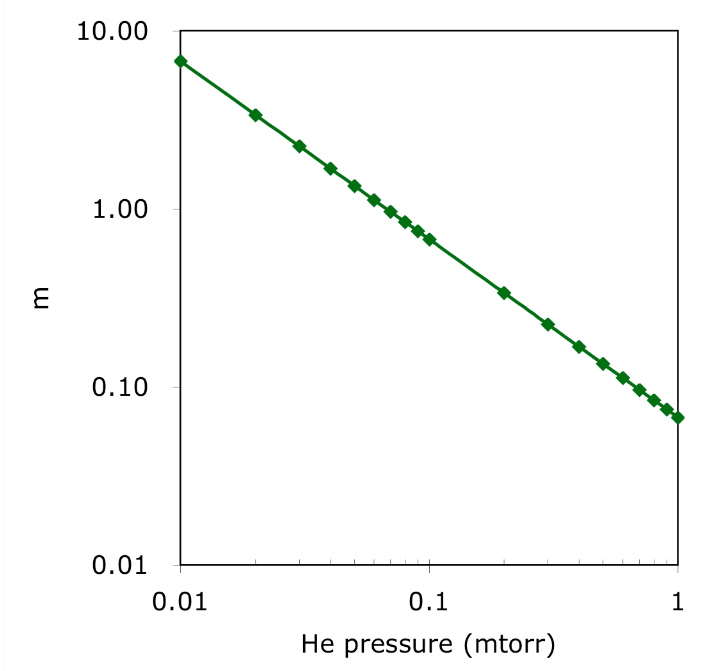

Figure 2. Mean free path of neutral lithium at 627°C in helium gas at 27 °C (from J. Nucl. Mater., 390-391 (2009) 1005].

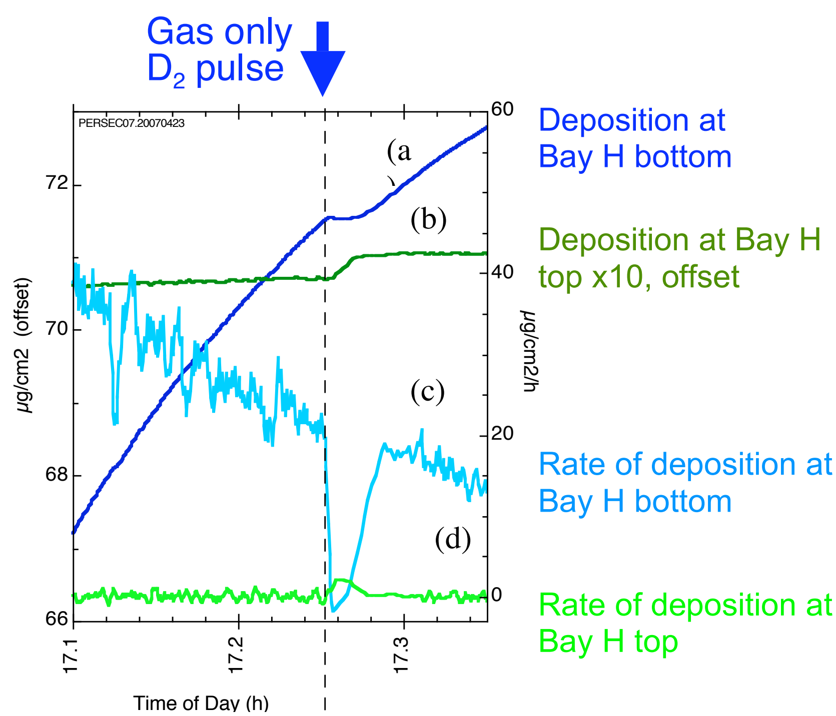

Figure 3. QMB data. Curve (a) shows the rise in mass on lower QMB during lithium evaporation interrupted by a deuterium gas-only pulse 123521. In contrast the upper QMB (b) that is shadowed from the evaporator shows a small rise during the gas pulse. The data for (b) has been multiplied x10 and offset by -155 μg/cm^2 to bring the curves to the same frame. Curves (c) and (d) show the respective deposition rates. The LiTER temperature cooled from 671 °C at 17.1h to 657 °C at 17.35 h.

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

This XP would best follow a XP that used high performance LSN, Li conditioned ELM-free H-mode discharges. It is based on 133816.

Key diagnostics are bolometer for radiated power, visible bremstrahlung Zeff, CHERS core carbon density and carbon Zeff, and SPRED & XEUS and deposition monitors.

5. Planned analysis

Analysis will be based on comparisons of the radiated power, core carbon density, Z-effective, and SPRED spectra in discharges with the use of helium and without helium for diffusive Li injection.

6. Planned publication of results

What will be the final disposition of the results; where will results be published and when?

The results will be presented at the DPP APS 2009.

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:

Baseline LSN, Li conditioned, ELM-free H-mode with impurity accumulation

Model shot 133816

Previous shot(s) which can be repeated: 133816 or 134135

Previous shot(s) which can be modified: 133816

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): **25 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	√	
X-ray spectrometer-LoWEUS	√	