Princeton Plasma Physics Laboratory **NSTX Experimental Proposal**		
Injection of Lithium Powder in NSTX		
OP-XP-828	Revision: **0**	Effective Date: **6/25/08** *(Approval date unless otherwise stipulated)* Expiration Date: **6/25/10** *(2 yrs. unless otherwise stipulated)*
PROPOSAL APPROVALS		
Responsible Author: D. K. Mansfield		Date 6/25/08
ATI – ET Group Leader:		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: Injection of Lithium Powder in NSTX No. **OP-XP-828**

AUTHORS: **D. K. Mansfield, A.L. Roquemore, R. Maingi, H. Kugel** DATE: **6/25/08**

1. Overview of planned experiment

Briefly describe the scientific goals of the experiment.

This work will allow an assessment to be made of the efficacy of Li powder for the purposes of improving plasma performance and/or reducing plasma density.

2. Theoretical/ empirical justification

Brief justification of activity, including supporting calculations as appropriate. Describe *briefly* any previous or related experiments.

There are at least 4 reasons to attempt the injection of lithium powder into NSTX. They are in order of importance:

(1) Recent experiments involving the shuttered LITER system on NSTX have demonstrated the effectiveness of "just in time" Li coatings for improving plasma performance. Moreover, while the LITER experiments have demonstrated a sustainable reduction in density, a secular density rise can still be seen in the data. Based on the TFTR experience with injected lithium aerosols, there is reasonable cause to speculate that the introduction of Li powder (a dry aerosol) into the SOL of an NSTX H-Mode plasma might lead to improvements in plasma performance which were similar to those demonstrated during the LITER experiments while simultaneously causing a further reduction in the plasma density. If such improvement in performance can be demonstrated, it will allow NSTX to have a more flexible Li conditioning capability than is presently available. Such a system could then be incorporated into an advance performance scenario most likely involving a high elongation, high triangularity discharge that at least begins to *approach* a double null configuration. In this type of discharge, there may be some advantage to introducing lithium into the upper divertor in addition to the lower divertor. Base on our experience with injecting lithium powder using the LPI, it can be anticipated that a substantial fraction of the injected lithium will be transported along open filed lines terminating in the upper divertor.

(2) If a *steady* flow of lithium powder can be evaporated in the edge of a stable discharge with an outer strike point located where the LLD will be when it is installed, then it is *conceivable* that such a flow of particles could be used to re-supply the LLD in real time because some fraction of the injected lithium will follow open field lines that terminate in the vicinity of the LLD - thus obviating the need to resupply by using LITER.

(3) If some unspecified temporal profile of injected lithium particle flux could be used to perturb the plasma edge /SOL such that small grassy or random ELMS where to appear in response, then such ELMS could *conceivably* purge the core of accumulated impurities brought on by lithium conditioning with LITER.

(4) Because the dropper system should work with any reasonably behaved collection of particles. It could be used to inject small amounts (<< 1 mg/sec) of dust into the NSTX SOL in a controlled manner. Such a system has the advantage of introducing dust of known size, morphology, composition location and velocity. The types of dust injected can be also be rather exotic and could be used to address some basic physics issues concerning dust in fusion devices. For example S. Krasheninnikov has suggested injecting small amounts of binary particles (i.e. a single sphere comprising two half spheres of different materials) so as to study the physics of differential ablation. A fair approximation to this might be, for instance, diamond powder that has be sprayed on one side only with (lets say) aluminum.

The aim of XP-828 is to make an initial assessment of the effects of lithium powder injection while addressing as many of the points discussed as practical. To that end we propose using two target discharges (1) a reliable ELMing H-mode discharge that has an outer strike point located where the LLD will be when it is installed and (2) a discharge that is more elongated, and more triangular and thus more nearly like an advanced scenario discharge. The two discharges templates will be therefore, (1) 129019 and (2) 129059. These were the no-lithium reference discharges employed during the 2008 initial Dual LITER experiments. They will directly address items 1 and 2 above and, if successful, will address item 4. Addressing item 3 make require a separate experiment.

3. Experimental run plan

Describe experiment in detail, including decision points and processes.

The experiment will be divided into two halves – each comprising 12 - 15 discharges:

Lithium powder will be systematically injected into 129019. The temporal profile of injected particle fluxes will be as shown in Figs 1 - 4 below.

In all cases, He Glow will be used *only if necessary*.

If any positive results are obtained during the first half of the experiment, rather than running the shot list to completion, an identical initial scenario will be undertaken using 129059. The total number of shots is anticipated to be about 30.

Table 1 Shot list for the 1st half of the XP with 129019

XP828 (129019) Shot No.	Dropper mg/s (Max)	Temporal Profile	Total Lithium (mg)	HeGDC (min)
Ref #1	0	N/A	0	6
Ref #2	0	N/A	0	6
Ref #3	0	N/A	0	6
1	3	A	2	6 or TBD
2	6	A	6	6 or TBD
3	12	A	12	6 or TBD
4	12 or TBD	A	24	6 or TBD
5	12 or TBD	B	36	6 or TBD
6	12 or TBD	B	48	6 or TBD
7	12 or TBD	B	60	6 or TBD
8	12 or TBD	B	72	6 or TBD
9	12 or TBD	C	84	6 or TBD
10	12 or TBD	C	96	6 or TBD
11	12 or TBD	C	108	6 or TBD
12	8	TBD	116	6 or TBD
13	10	TBD	126	6 or TBD
14	12	TBD	138	6 or TBD
15	14	TBD	152	6 or TBD
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Table 2 Shot list for 2nd half of XP with 129059

XP828 (129059) Shot No.	Dropper mg/s (Max)	Temporal Profile	Total Lithium (mg)	HeGDC (min)
2nd Ref #1	0	N/A	0	6
2nd Ref #2	0	N/A	0	6
2nd Ref #3	0	N/A	0	6
1	3	A	2	6 or TBD
2	6	A	6	6 or TBD
3	12	A	12	6 or TBD
4	12 or TBD	A	24	6 or TBD
5	12 or TBD	B	36	6 or TBD
6	12 or TBD	B	48	6 or TBD
7	12 or TBD	B	60	6 or TBD
8	12 or TBD	B	72	6 or TBD
9	12 or TBD	C	84	6 or TBD
10	12 or TBD	C	96	6 or TBD
11	12 or TBD	C	108	6 or TBD
12	8	TBD	116	6 or TBD
13	10	TBD	126	6 or TBD
14	12	TBD	138	6 or TBD
15	14	TBD	152	6 or TBD
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4. Required machine, NBI, RF, CHI and diagnostic capabilities

Describe any prerequisite conditions, development, XPs or XMPs needed.
Attach completed Physics Operations Request and Diagnostic Checklist.

5. Planned analysis

What analysis of the data will be required: EFIT, TRANSP, etc.?

EFIT, TRANSP as appropriate

6. Planned publication of results

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

APS at a minimum.

PHYSICS OPERATIONS REQUEST

TITLE: Injection of Lithium Powder in NSTX — No. **OP-XP-828**

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Machine conditions (129019 and 129059)

I_{TF} (kA):-53 Flattop start/stop (s): -0.01/1.1

I_P (MA):0.8 Flattop start/stop (s): 0.2/1.0

Configuration: **LSN**

Outer gap (m): Inner gap (m):

Elongation κ: Upper/lower triangularity δ:

Z position (m):

Gas Species: **D** Injector(s): CS mid, OM#2

NBI Species: **D** Sources: All Voltage (kV): 90 Duration (s): 0.8

ICRF Power (MW): 0 Phasing: Duration (s):

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

LITER: Off

Either: List previous shot numbers for setup: 129019 and 129059

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

TITLE: Injection of Lithium Powder in NSTX No. **OP-XP-828**

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Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
Bolometer – tangential array	x	
Bolometer – divertor		
CHERS – toroidal	x	
CHERS – poloidal	x	
Divertor fast camera	x	
Dust detector		x
EBW radiometers		
Edge deposition monitors	x	
Edge neutral density diag.		x
Edge pressure gauges	x	
Edge rotation diagnostic		
Fast ion D_alpha - FIDA		
Fast lost ion probes - IFLIP		
Fast lost ion probes - SFLIP		
Filterscopes	x	
FIReTIP	x	
Gas puff imaging		x
Hα camera - 1D	x	
High-k scattering		
Infrared cameras	x	
Interferometer - 1 mm		
Langmuir probes – divertor		x
Langmuir probes – BEaP		
Langmuir probes – RF ant.		
Magnetics – Diamagnetism	x	
Magnetics – Flux loops	√	
Magnetics – Locked modes	x	
Magnetics – Pickup coils	√	
Magnetics – Rogowski coils	√	
Magnetics – Halo currents		
Magnetics – RWM sensors		
Mirnov coils – high f.	x	
Mirnov coils – poloidal array	x	
Mirnov coils – toroidal array	x	
Mirnov coils – 3-axis proto.		x

Note special diagnostic requirements in Sec. 4

Diagnostic	**Need**	**Want**
MSE		x
NPA – ExB scanning		
NPA – solid state		
Neutron measurements	x	
Plasma TV	x	
Reciprocating probe	x	
Reflectometer – 65GHz	x	
Reflectometer – correlation	x	
Reflectometer – FM/CW	x	
Reflectometer – fixed f	x	
Reflectometer – SOL	x	
RF edge probes	x	
Spectrometer – SPRED	x	
Spectrometer – VIPS	x	
SWIFT – 2D flow		x
Thomson scattering	x	
Ultrasoft X-ray arrays	x	
Ultrasoft X-rays – bicolor		x
Ultrasoft X-rays – TG spectr.		x
Visible bremsstrahlung det.	x	
X-ray crystal spectrom. - H	x	
X-ray crystal spectrom. - V	x	
X-ray fast pinhole camera		x
X-ray spectrometer - XEUS		x