Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

Title: Pre-LLD Discharge Development		
OP-XP-929	Revision: **0**	Effective Date: **4/02/09** Expiration Date: **4/02/11** *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

Responsible Author: H. Kugel	Date
ATI – ET Group Leader: C. Skinner	Date
RLM - Run Coordinator: R. Raman	Date
Responsible Division: Experimental Research Operations	

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

NSTX EXPERIMENTAL PROPOSAL

TITLE: **Pre-LLD Discharge Development** No. **OP-XP-929**

AUTHOR: **H. Kugel** DATE: **4/02/09**

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1. Overview of planned experiment

Thermal analysis indicates that for the cases for the strike point on the LLD with peak Li temperature set at 400 °C:

- LLD can sustain a peak of ~2MW/m^2 for 10s and 4 MW/m^2 for ~3s.
- the less Li on the LLD, the higher the heat transfer to the substrate (but less Li reduces LiD storage capacity).

Initial operation on LLD will require H-modes with 1-2 MW NBI and minimal fueling.
The goals of this XP are

1) develop 1-2 MW, H-mode discharges with δ~0.4-0.5 and δ~0.7.
2) perform fueling scans to determine optimum fueling scenario for LLD

And if time permits, document the following as the total Li deposition increases with shot number:

3) L-H power threshold.
4) Transition to ELM-free discharges.
5) Confinement improvement.
6) MHD behavior including fast ion effects.

The Strategy: build on the results of XP827 and XP923 for low power H-mode discharges with δ~0.4-0.5 and δ~0.7.

2. Theoretical/ empirical justification

Divertor solid lithium coatings have yielded improvements in discharge performance. This XP is to develop discharges to commission and characterize the Liquid Lithium Divertor to be installed in NSTX for FY10 operations.

3. Experimental run plan

3.1 On the morning of XP-929, insert the two LITER units to their Parked Positions. Close the LITER shutters. Raise their deposition rate to 20mg/min. If after this process, the vessel does not return to the baseline partial pressure of water, perform DGDC for 30 min.

3.2 Without Li (LITER shutters closed), run ref. discharge 132208, Ip=0.9MA [δ~0.7] (4 shots)

3.3 Without Li (LITER shutters closed), run ref. discharge 132209, Ip=0.8MA [δ~0.4-0.5]

(4 shots)

3.4 Start deposit of Li between all Shots: 20 mg/min for 10 min.

3.5 Run 132209, 4MW NBI shot (4 shots)

3.6 Run 132209, 3MW NBI shot (4 shots)

3.7 Run 132209, 2MW NBI shot (4 shots)

3.8 Run 132209, 1MW NBI shot (4 shots)

3.9 Select best 1 or 2 MW shot, decrease fueling in x0.25 steps until discharge unreliable (4 shots)

3.9 Replace CS-mid fueling with CS-shoulder (4 shots)

3.10 Run 132208, 4MW NBI shot (4 shots)

3.11 Run 132208, 3MW NBI shot (4 shots)

3.12 Run 132208, 2MW NBI shot (4 shots)

3.13 Run 132208, 1MW NBI shot (4 shots)

3.14 Select best 1 or 2 MW shot, decrease fueling in x0.25 steps until discharge unreliable (4 shots)

3.15 Replace CS-mid fueling with CS-shoulder (4 shots)

DECISION POINTS:

3.16 If H-mode not obtained reliably at 20mg/min increase Li deposition rate between discharges from 20mg/min to 35mg/min.

3.17 If H-mode not obtained reliably at 35mg/min increase Li deposition rate between discharges from 35mg/min to 70mg/min.

3.18 If discharge does not perform reliably due to density pumpout, increase fueling as needed to maintain discharge.

3.19 If locked modes prevent suitable discharges, or the H-mode low density limit is reached, or as determined by experimenters from review of diagnostic data, proceed as follows:.

a) If locked modes start to occur increase LFS gas in steps of 10 Tl/s.

b) If H-mode density threshold problems occur increase HFS gas in 200 Torr steps and adjust timing as required.

c) Choose best experimental conditions for maintaining a flat density waveform. Use density normalized to fueling as a figure of merit.

d) Apply RWM as required to suppress adverse MHD if it appears as density is reduced and/or changing edge conditions.

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

D LSND H-mode reference shots 132208 (Ip=0.9MA) and 132209 (Ip=0.8MA) with 1-4 MW as indicated. DGDC if required following initial LITER outgassing. HeGDC between discharges as required to maintain stable wall conditions.

5. Planned analysis

UEDGE, TRANSP, etc.

6. Planned publication of results

PSI-10, EPS, IAEA-10, J, Nuc. Mater., POP, Nucl. Fusion,

REQUEST

Title**:** LITER Characterization and ELM Mitigation **OP-XP-929**

Machine conditions: Day-1: 132209 Reference (Ip=800kA)

Day-2: 132209 Reference (Ip=800kA),
and 132208 Reference (Ip=900kA)

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

I_P (MA): **0.8-0.9 MA** Flattop start/stop (s): **0.2/1.0**

Configuration: **LSN**

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

Elongation κ: Triangularity δ:

Z position (m):

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

NBI - Species: **D** Sources: **A, B, C** Voltage (kV): **90** Duration (s): **0.8**

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

CHI:

Either: List previous shot numbers for setup **132209 and 132208, 2 NBI**

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: XP-929 No. **OP-XP-929**

AUTHORS: H. Kugel DATE: 4/02/09

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	√	

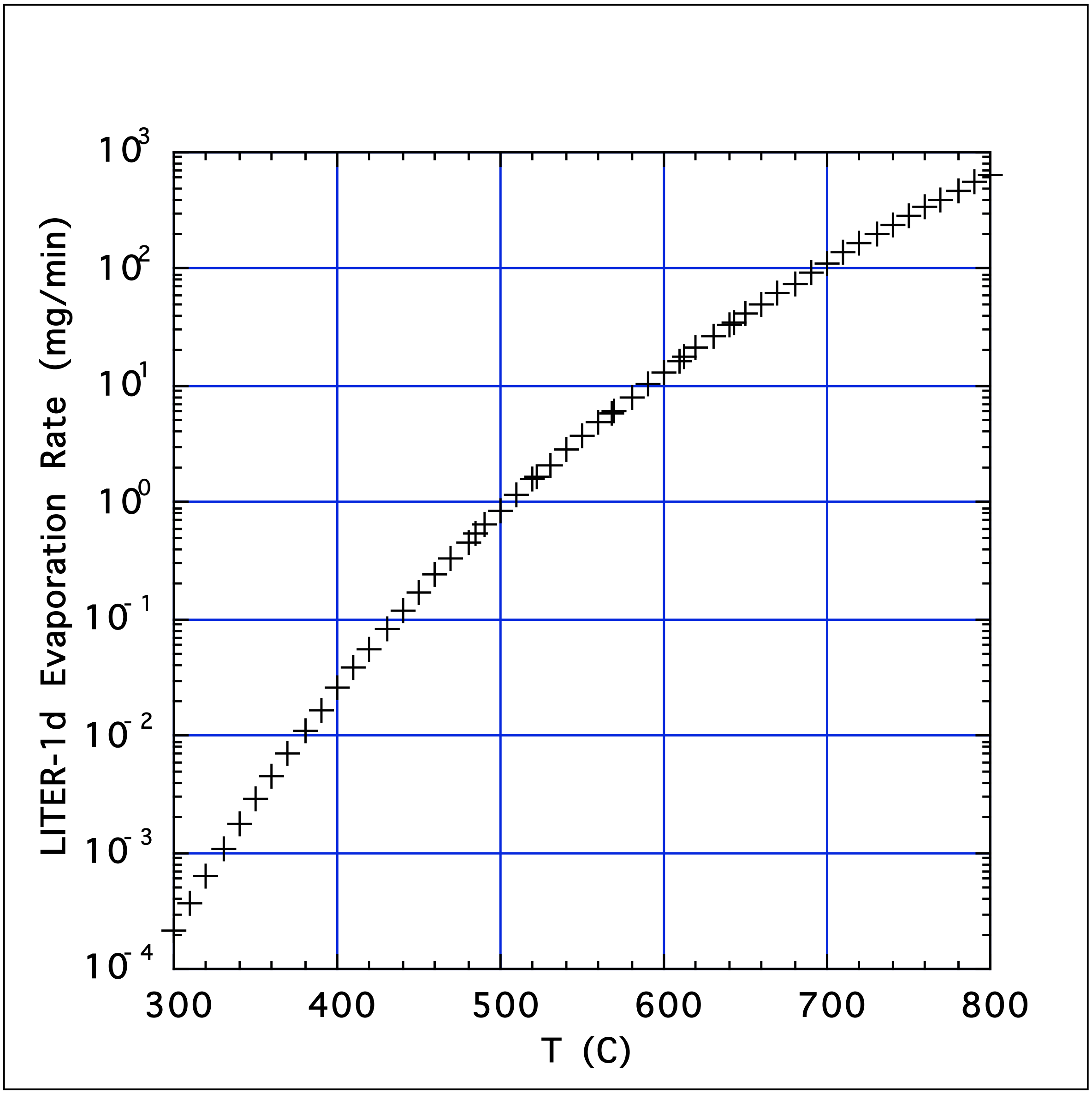

Fig.1 LITER-1d simulated evaporation rate (mg/min) versus temperature (°C) for atomic vapor flow. Evaporation rate enhancement is expected above 650° due to viscous flow effects

TABLE 1. LITER-1d evaporation rate

T (C)	Rate (mg/min)
300.00	2.12853e-04
310.00	3.69784e-04
320.00	6.30473e-04
330.00	1.05594e-03
340.00	1.73881e-03
350.00	2.81742e-03
360.00	4.49550e-03
370.00	7.06870e-03
380.00	1.09605e-02
390.00	1.67698e-02
400.00	2.53330e-02
410.00	3.78055e-02
420.00	5.57648e-02
430.00	8.13430e-02
440.00	1.17392e-01
450.00	1.67690e-01
460.00	2.37199e-01
470.00	3.32371e-01
480.00	4.61535e-01
485.30	5.47310e-01
490.00	6.35349e-01
500.00	8.67346e-01
510.00	1.17458e+00
520.00	1.57841e+00
522.20	1.68274e+00
530.00	2.10536e+00
540.00	2.78819e+00
550.00	3.66710e+00
560.00	4.79109e+00
568.20	5.93694e+00
570.00	6.21957e+00
580.00	8.02416e+00
590.00	1.02907e+01
600.00	1.31217e+01
610.00	1.66385e+01
613.20	1.79315e+01
620.00	2.09846e+01
630.00	2.63287e+01
640.00	3.28681e+01
643.20	3.52497e+01
650.00	4.08325e+01
660.00	5.04885e+01
670.00	6.21440e+01
680.00	7.61535e+01
690.00	9.29229e+01
700.00	1.12916e+02
710.00	1.36661e+02
720.00	1.64757e+02
730.00	1.97880e+02
740.00	2.36792e+02
750.00	2.82354e+02

Table 2.

LITER CONTROL TIMES

Start retraction	T-60 toT-50s
Retraction from Op to Pk	14s (7inch @0.5inch/s)
Shutter close	T-15s
If no GDC, insert starts	T+6s
Shutter opens	T+4s
Shutter closed	T-15 to +4s

No HeGDC, Shutter Closed=20s & Total Deposition Time into Vessel = 10min						
Dep Rate		Shutter	Vessel	Total shutter	Total vessel	Total Li
(mg/min)		mg/shot	mg/shot	mg/25 shots	mg/25 shots	mg/25 shots
1		0.33	10	8.3	250	258.3
10		3.33	100	83.3	2500	2583.3
15		5.00	150	125.0	3750	3875.0
20		6.67	200	166.7	5000	5166.7
25		8.33	250	208.3	6250	6458.3
30		10.00	300	250.0	7500	7750.0
35		11.67	350	291.7	8750	9041.7
40		13.33	400	333.3	10000	10333.3
45		15.00	450	375.0	11250	11625.0
50		16.67	500	416.7	12500	12916.7

5 min HeGDC, Shutter Closed=20s +5min, & Total Deposition Time into Vessel per 10 min						
Dep Rate		Shutter	Vessel	Total shutter	Total vessel	Total Li
(mg/min)		mg/shot	mg/shot	mg/25 shots	mg/25 shots	mg/25 shots
1		5.33	10	133.3	250	383.3
10		53.33	100	1333.3	2500	3833.3
15		80.00	150	2000.0	3750	5750.0
20		106.67	200	2666.7	5000	7666.7
25		133.33	250	3333.3	6250	9583.3
30		160.00	300	4000.0	7500	11500.0
35		186.67	350	4666.7	8750	13416.7
40		213.33	400	5333.3	10000	15333.3
45		240.00	450	6000.0	11250	17250.0
50		266.67	500	6666.7	12500	19166.7