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Title: LITER Cha	racterization and ELM N	Vitigation	
OP-XP-827	Revision: 0	Effective Date: 4/6/09 Expiration Date: 4/6/11	
	PROPOSAL AP	PROVALS	intess oner wise supuritient
Responsible Author:	H. Kugel	Kusel	Date 4/06/09
ATI – ET Group Lea	der: V. Soukhanovskii	mbers, Table 1	Date
RLM - Run Coordina	ator: M. Bell	n ames side sine	Date
Responsible Division	: Experimental Research Op	erations	
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Princeton Plasma Physics Laboratory NSTX Experimental Proposal					
Title: LITER Characterization and ELM Mitigation					
DP-XP-827 Revision: 0 Effective I Expiration (2 yrs. unless)			Date: 5/5/08 Date: 5/5/10 otherwise stipulated)		
	PROPOSAL API	PROVALS			
Responsible Author: H. K	ugel		Date		
ATI – ET Group Leader:	V. Soukhanovskii		Date		
RLM - Run Coordinator:	M. Bell		Date		
Responsible Division: Exp	erimental Research Op	erations			
MINOR MODIFI	CATIONS (Approved	by Experimental R	esearch Operations)		

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NSTX EXPERIMENTAL PROPOSAL

TITLE: LITER Characterization and ELM Mitigation

No. OP-XP-827

AUTHOR: H. Kugel

DATE: 4/30/08

1. Overview of planned experiment

This XP will characterize 2 LITER operation and ELM mitigation with increasing lithium deposition rate and total deposition. Figure 1 shows the experimental sequence to determine effect of deposition rate and one- and two-LITER coverage on ELMs and density.

Figures 2 and 3 show the reference discharges. Figure 4 shows the simulated evaporation rate. Tables 1 and 2 shall be used to record the shot numbers. Table 3 shows the evaporation rate versus temperature. Table 4 shows LITER control times and shutter and vessel accumulation.

2. Theoretical/ empirical justification

TFTR, CDX-U/LTX, and NSTX demonstrated the ability of lithium to control density.

3. Experimental run plan

3.1 The Preliminary Test Procedure (PTP) shall bake LITER-Bay F and LITER-Bay K in their respective Garage spools with the TIV closed for at least 48 hours at 150° C. During this time the respective units shall be operated at 220°C for 1 hour to outgas absorbed gases (e.g. air, and Ar).

3.2 The Integrated System Test Procedure (ISTP) shall be performed by inserting both LITER units into NSTX to their Parked Positions. Close the Shutters. With the shutters closed, raise the operating temperature of each unit to deliver an evaporation rate of about 1 mg/min (510°C) for 1 minute, as fast as machine vacuum conditions will allow. Then the LITER power shall be shut off using the LITER computer programmed sequence.

3.3 On the morning of XP-827, insert the two LITER units to their Parked Positions with the Shutters closed. Raise their operating temperatures to 400°.

3.4 Before introduction of lithium, establish the Day-1 and Day-2 baseline conditions. First perform up to 3 reference discharges for Day-2 (128026). Repeat if necessary until at least 2 reproducible shots are obtained. Then perform up to 3 reference discharges for Day-1(125269 at 4 MW). Repeat Keep fueling the same. Repeat if necessary until at least 2 reproducible shots are obtained.

- a) Option-A: The Day-1 reference is 125269 at 4 MW instead of the original 6 MW.
- b) Option-B: If desirable, the Day-1 reference is 125269 at the original 6 MW (this may be a possible end of day test).
- c) Option-C: The backup reference shot is 127889 with Bt =0.45 T.

3.5 If H-mode and ELMs are obtained reliably in the Day-1 reference discharges (125269) proceed with the LITER lithium deposition rate sequence illustrated in Fig.1. Record the shot numbers and associated data in Tables 1 and 2.

3.6 On Day-2, perform up to 3 Day-1 reference discharges. Repeat if necessary until at least 2 reproducible shots are obtained to document the effect of overnight conditions on the occurrence of ELMS.

3.7 Then perform 3 Day-2 reference discharges (128026). Repeat if necessary until at least 2 reproducible shots are obtained. The proceed with the LITER lithium deposition rate sequence illustrated in Fig.1. Record the shot numbers and associated data in Table 2. Following Day-2, prior to switching over to the next XP, conduct 2-3 reference shots to assess residual lithium effects.

3.8 Proceed with steps 3.4-3.6 until locked modes prevent suitable discharges, or the H-mode low density limit is reached, or as determined by experimenters from review of diagnostic data.

- 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 SGI 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) If necessary, or time allows, apply optimized EFC to suppress adverse MHD and/or locked modes if they appear as density is reduced and/or change edge conditions.

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

On Day-1, D LSND H-mode shot 125269 with 3 NBI (Day-1) and on Day-2, D LSND H-mode shot 128026 with 3 NBI. HeGDC during LITER operation as outlined in Tables 1 and 2.

5. Planned analysis

UEDGE, TRANSP, etc.

6. Planned publication of results

PSI08, POP, Nucl. Fusion, IAEA08

Table 1. XP-827 Day-1 Experimental Sequence

XP827 Shot No.	LITER-F g/min	LITER-K g/min	Total Lithium (g) For 10 min Depositions	HeGDC (min)
Day-2 ref 128026	0	0	0	5
Day-2 ref 128026	0	0	0	5
Day-2 ref 128026	0	0	0	5
Day-1 ref 125269	0	0	0	5
Day-1 ref 125269	0	0	0	5
Day-1 ref 125269	0	0	0	5
1				5
2				5
3				5
4				5
5				5
6				5
7				5
8				5
9				5
10				5
11				5
12				5
13				5
14				5
15				5
16				5
17				5
18				5
19				5
20				5
21				5
22				5
23				5
24				5
25				5

Table 2. XP-827 Day-2 Experimental Sequence

Day-2 Reference Discharge = 128026 (Fig.3)

XP826 Shot No.	LITER-F a/min	LITER-K a/min	Total Lithium (g) For 10 min	HeGDC (min)
	,	,	Depositions	
Day-1 ref 125269	0	0	0	5
Day-1 ref 125269	0	0	0	5
Day-1 ref 125269	0	0	0	5
Day-2 ref 128026	0	0	0	5
Day-2 ref 128026	0	0	0	5
Day-2 ref 128026	0	0	0	5
26				5
27				5
28				5
29				4
30				4
31				3
32				3
33				2
34				2
35				1
36				1
37				
38				
39				
40				
41				
42				
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50				

PHYSICS OPERATIONS REQUEST

Title: LITER Characterization and ELM Mitigation

OP-XP-827

Machine conditions: <u>Day-1</u>: 128026 Reference, 125269 Reference (@4MW), and 125269 Operation (@4 MW) <u>Day-2</u>: 1282026 Reference, and 128026 Operation

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 k:	Triangularity δ:	
Z position (m):		
Gas Species: D	Injector(s): CS mid, OM #2	
NBI - Species: D Sou	arces: A , B , C Voltage (kV): 90	Duration (s): 0.8
ICRF – Power (MW):	Phasing:	Duration (s):
CHI:		

Either: List previous shot numbers for setup 125269 and 128026 with 3 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

No. **OP-XP-827** DATE: 4/30/08

TITLE: XP-827 AUTHORS: H. Kugel

Note special diagnostic requirements in Sec. 4

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

Note special diagnostic requirements in Sec. 4

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



LITER Deposition Rate Sequence to Determine Effect of Additional Coverage Using Two LITERs

Fig. 1



Fig.2 Reference discharge 125269 for Day-1.



Fig.3 Reference discharge 128026 for Day-2.



Fig.4 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	3. LITER-1d evaporation rate
T (C)	Rate (mg/min)
300.00 300.00 310.00 320.00 330.00 340.00 350.00 360.00 370.00 380.00 390.00 400.00 410.00 420.00 430.00 440.00 450.00 460.00 470.00 485.30 490.00 500.00 520.00 540.00 550.00 560.00 560.00 560.00 560.00 560.00 560.00 560.00 560.00 560.00 560.00 560.00 660.00 610.00 640.00 640.00 640.00 640.00 640.00 640.00 640.00 640.00 640.00 640.00 70.00 70.00 </th <th>2.12853e-04 3.69784e-04 6.30473e-04 1.05594e-03 1.73881e-03 2.81742e-03 4.49550e-03 7.06870e-03 1.09605e-02 1.67698e-02 2.53330e-02 3.78055e-02 5.57648e-02 8.13430e-02 1.17392e-01 1.67690e-01 2.37199e-01 3.32371e-01 4.61535e-01 5.47310e-01 6.35349e-01 8.67346e-01 1.17458e+00 1.57841e+00 1.68274e+00 2.10536e+00 2.78819e+00 3.66710e+00 4.79109e+00 5.93694e+00 6.21957e+00 8.02416e+00 1.02907e+01 1.31217e+01 1.66385e+01 1.79315e+01 2.09846e+01 2.63287e+01 3.28681e+01 3.52497e+01 4.08325e+01 5.04885e+01 6.21440e+01 7.61535e+01 9.29229e+01 1.12916e+02 1.36661e+02 1.97880e+02 2.36792e+02 2.82354e+02 2.82354e+02</th>	2.12853e-04 3.69784e-04 6.30473e-04 1.05594e-03 1.73881e-03 2.81742e-03 4.49550e-03 7.06870e-03 1.09605e-02 1.67698e-02 2.53330e-02 3.78055e-02 5.57648e-02 8.13430e-02 1.17392e-01 1.67690e-01 2.37199e-01 3.32371e-01 4.61535e-01 5.47310e-01 6.35349e-01 8.67346e-01 1.17458e+00 1.57841e+00 1.68274e+00 2.10536e+00 2.78819e+00 3.66710e+00 4.79109e+00 5.93694e+00 6.21957e+00 8.02416e+00 1.02907e+01 1.31217e+01 1.66385e+01 1.79315e+01 2.09846e+01 2.63287e+01 3.28681e+01 3.52497e+01 4.08325e+01 5.04885e+01 6.21440e+01 7.61535e+01 9.29229e+01 1.12916e+02 1.36661e+02 1.97880e+02 2.36792e+02 2.82354e+02 2.82354e+02

Table 4.

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

			Total		
Dep Rate	Shutter	Vessel	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 Total Shutter shutter Dep Rate Vessel 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 10 100 53.33 1333.3 2500 3833.3 15 3750 5750.0 80.00 150 2000.0 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 5333.3 15333.3 213.33 400 10000 45 6000.0 17250.0 240.00 450 11250 6666.7 50 266.67 500 12500 19166.7