

**Preliminary Report  
XP 515  
Recycling Measurements Following  
Repeated Lithium Pellet Injection**

**H. W. Kugel, et al.  
August 15, 2005**

## Reduced Recycling Following TFTR Lithium Deposition Not Observed in Diverted Experiments



- Lithium deposition reduced TFTR recycling and enhanced performance significantly.
- Lithium Pellet Injection directly into DIII-D, C-MOD, TdeV, and NSTX diverted deuterium discharges yielded no performance improvement other than small decrease in impurities.
- The goal of this XP was to make contact with the TFTR experience with reduced recycling following lithium deposition on the inner toroidal limiter.
- This XP investigated recycling from the NSTX inner toroidal limiter (Center Stack) following repeated lithium pellet injection.

## Experimental Method Was Guided by the TFTR Lithium Experience

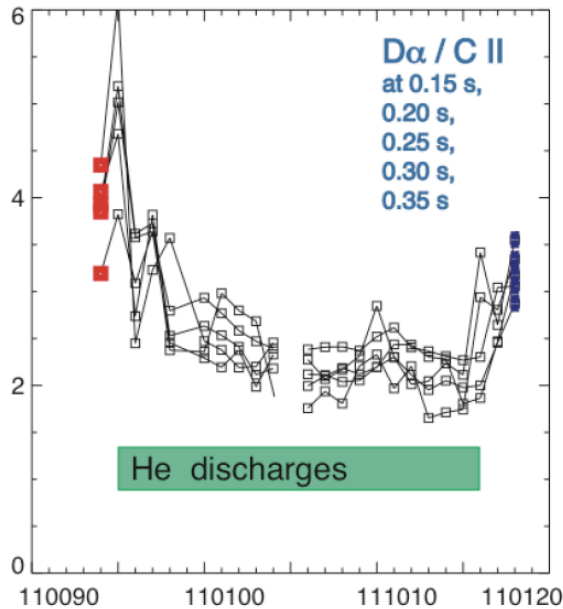


- Center Stack Limited discharges and LSN discharges used.
  - CSL: Exp-1 & -2
  - LSN: Exp-3
- Ohmic Helium Conditioning discharges used to condition the power deposition surfaces (CS or lower divertor).
- Lithium Pellets injected into Ohmic Helium discharges to coat the power deposition surface and prevent lithium saturation by the fuel gas.
- Low density, D NBI fiducial were applied to measure recycling changes due to lithium pumping of the edge plasma.
  - A low density fiducial was used to avoid saturating the available lithium pumping capacity.

# The Small Area NSTX Center Stack Conditions Faster Than The Large Area TFTR Toroidal Limiter



NSTX



C.H.Skinner, NSTX XP304, 2/2003.

- **Evaluation of D $\alpha$ /CII**  
17 helium conditioning discharges gave modest change in D $\alpha$  intensity. NSTX D $\alpha$  decreased by 40% cf x10 TFTR plot.

TFTR

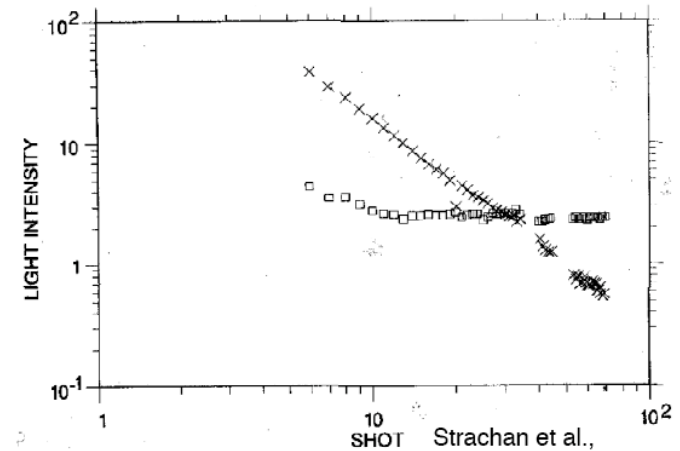


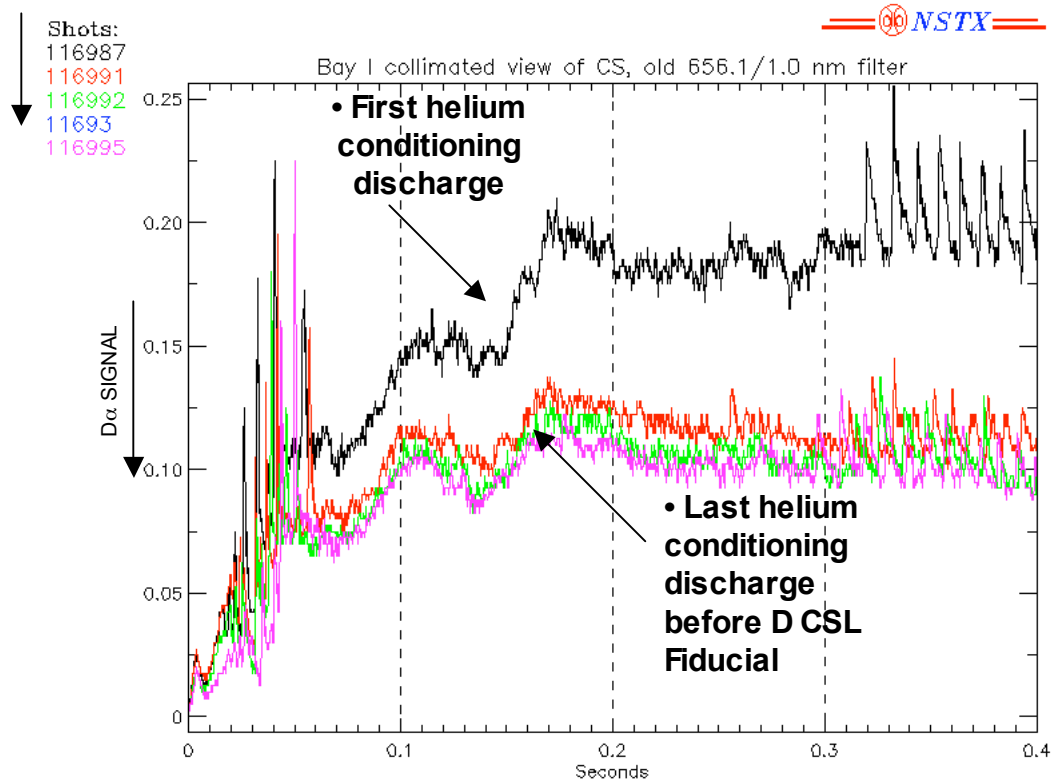
Fig. 11. Hydrogen (x) and carbon (□) influx in helium discharge cleaning pulses following a 1 MA ohmic disruption near the end of a disruptive discharge cleaning campaign.

J.D.Strachan, et al, J.Nucl. Mater., 196-198 (1992) 28.

- In NSTX, after an initial large change, a residual D $\alpha$  base line luminosity is observed after 6-10 Helium Conditioning discharges.

- This may be due in part to outgassing from near-plasma edge structures (e.g. RF Antennas, Passive Plates, NB Armor), a small deuterium prefill, and blob transport to walls.

# Exp-1: Ohmic Helium Discharge Conditioning Quickly Reduced Inner Limiter D $\alpha$ Luminosity to a Base Level



- D $\alpha$  luminosity from Inner Limiter after an initial large change decreases slowly.
- CIII luminosity from Inner Limiter remained ~constant.

# Exp-1: During LPI into Limited Ohmic Helium Discharges, Li I Luminosity from Limiter Increased, but D $\alpha$ Remained at Base level

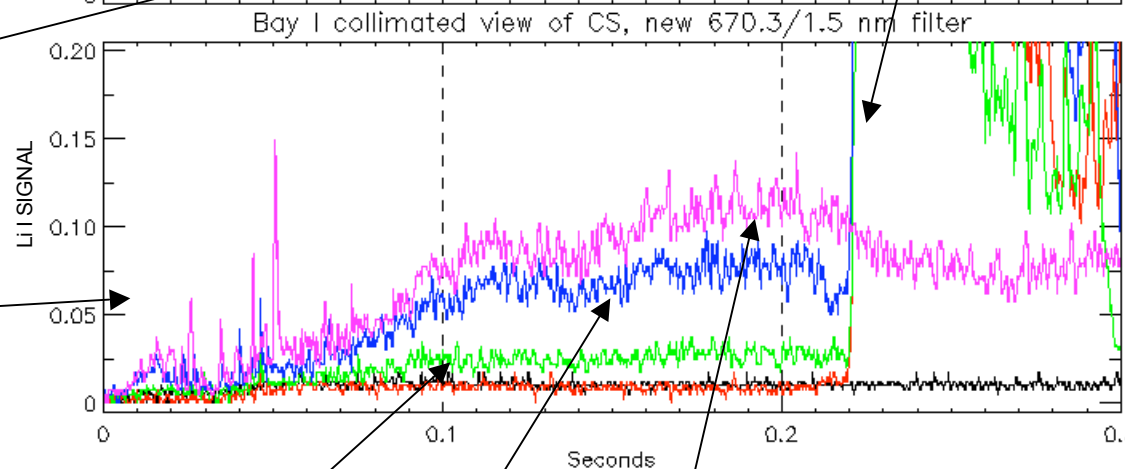
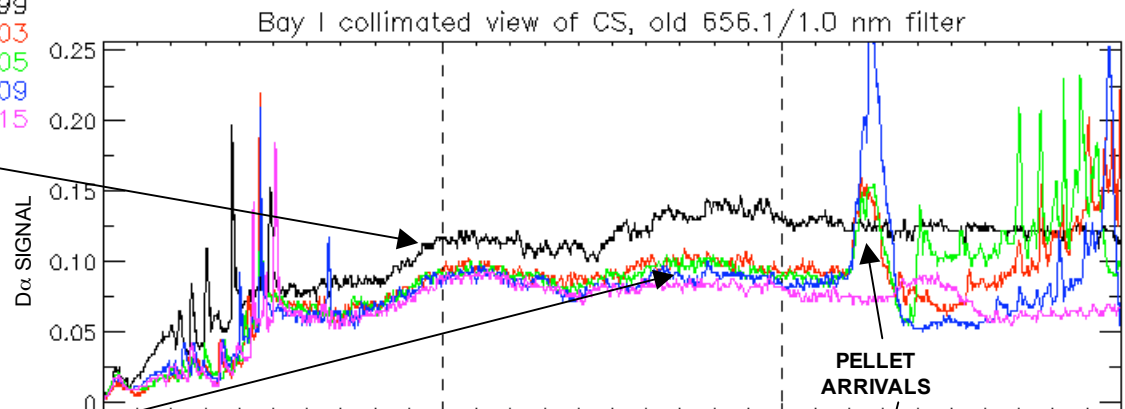


- **First helium conditioning discharge after NBI D CSL fiducial following initial helium conditioning sequence (Fig.5).**

- **12 helium discharges, 9 with LPI of either 1.7, 3.4, or 5.0 mg. D $\alpha$  luminosity decreased slightly. 117015 is No-LPI discharge.**

- **Li I luminosity from Inner Limiter increased as total lithium injection increases from 0 to 30.2 mg.**

Shots:  
 116999  
 117003  
 117005  
 117009  
 117015



Total Li  
3.4 mg

Total Li  
20.2 mg

Total Li  
30.2 mg

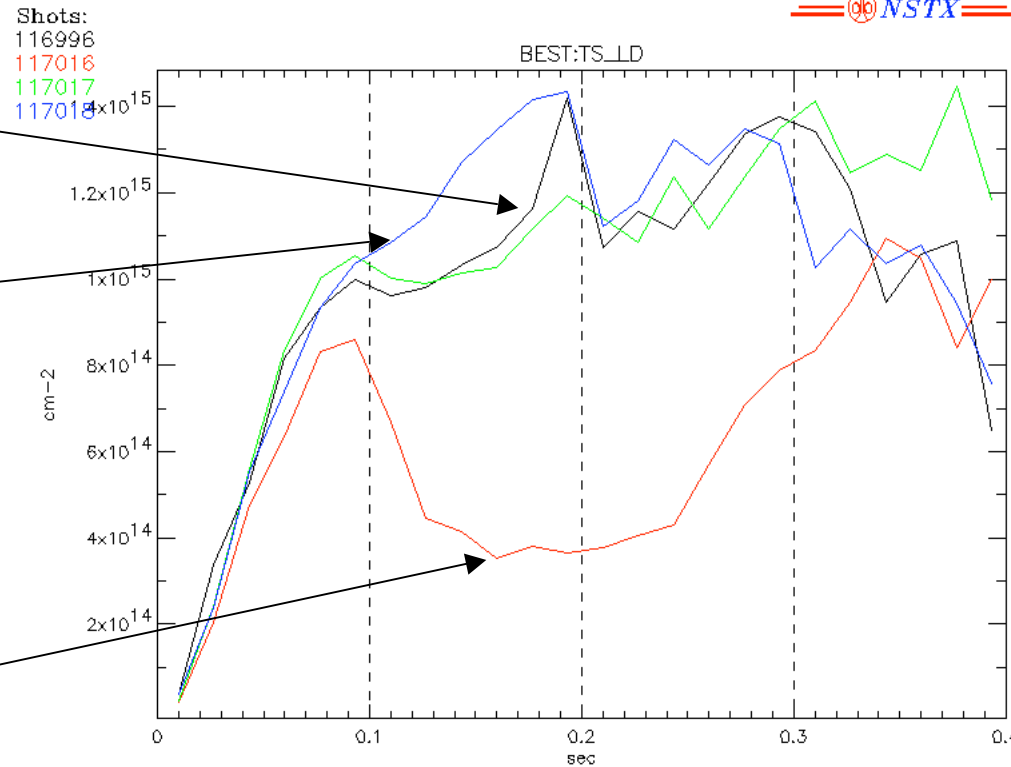
# Exp-1: Initial CSL NBI Deuterium Fiducial Following 30 mg of Lithium Deposition on Inner Limiter Exhibited ~x4 Decrease in Density



• **Before lithium CSL NBI D fiducial**

• **3 rd CSL NBI D fiducial following 30 mg lithium deposition on Inner Limiter**

• **1st CSL NBI D fiducial following 30 mg lithium deposition on Inner Limiter**



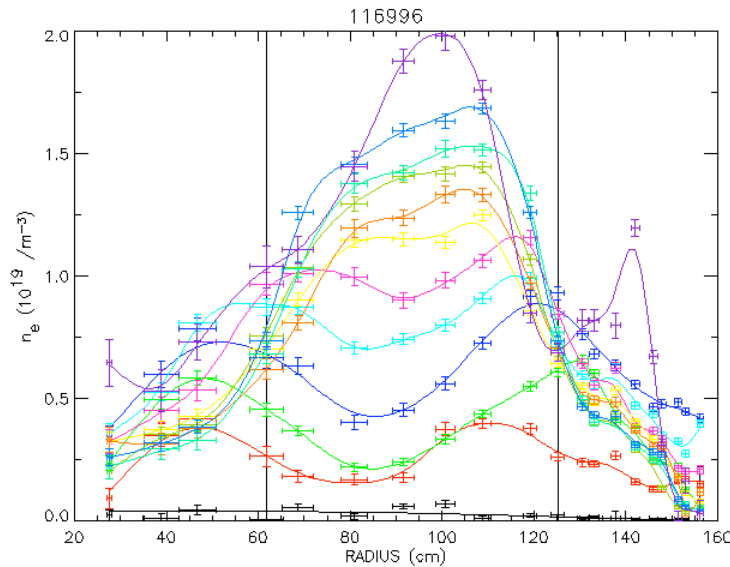
*After Li saturates, discharge returns to pre Li wall conditions following helium conditioning*

• **30 mg of lithium pumping of edge density saturated after 3 discharges and discharge returns to pre Li wall conditions.**

# Exp-1: Edge Pumping of CSL Discharges, first, via Helium Conditioning, and then, Helium Conditioning Plus Lithium Deposition Exhibited Peaked Profiles



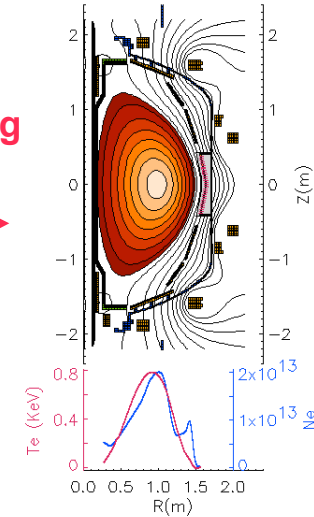
CSL D NBI  
fiducial after 8  
CSL helium  
conditioning  
discharges



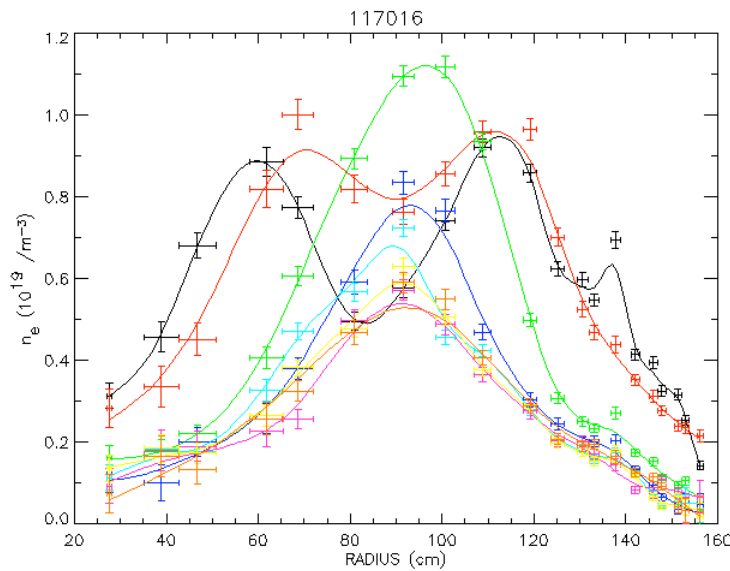
Helium  
Conditioning  
Only



from \EFIT02, Shot 116996, time=189ms



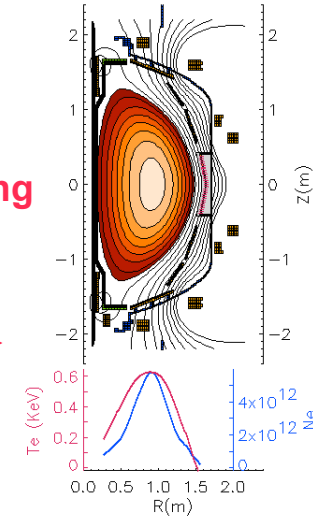
CSL D NBI  
fiducial after  
12 CSL helium  
conditioning  
discharges  
with 9 LPI for  
30 mg total



Helium  
Conditioning  
Plus  
30 mg Li



from \EFIT02, Shot 117016, time=185ms



• Peaked density profile (peaking factor 4-5).



## Exp-2: Initial CSL NBI D Fiducial Following Additional 24 mg LPI (54 mg total) Exhibited similar ~x4 Decrease in Density and Profile Peaking



### Exp-2 Exhibited Same Results as Exp-1

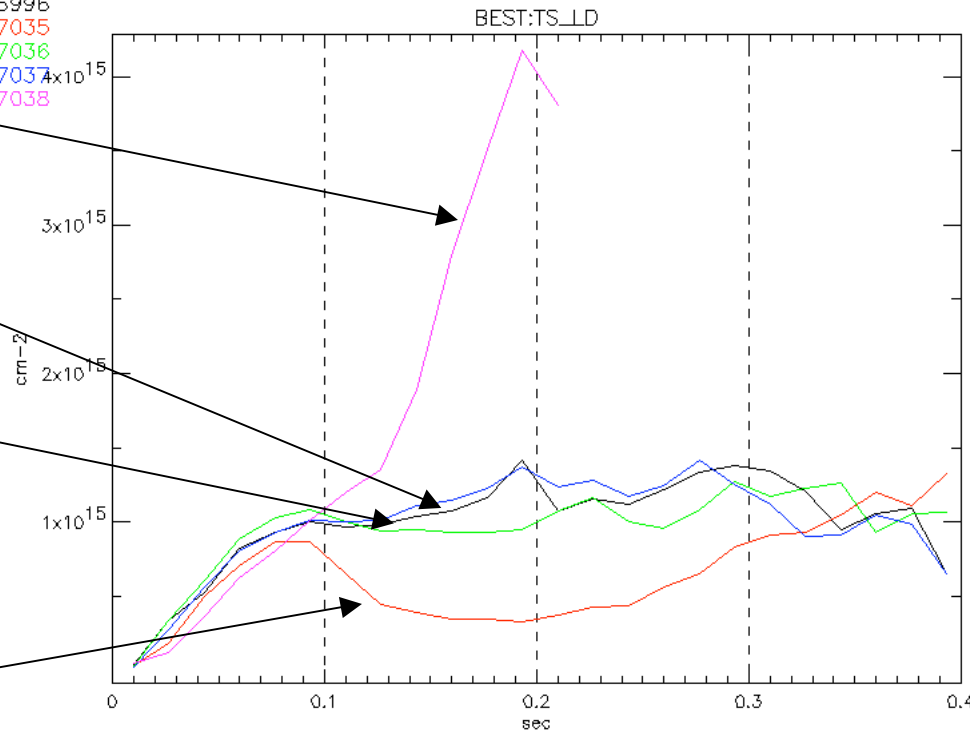
• Density rise following 1.7 mg LPI into CSL NBI D fiducial

• 3rd CSL NBI D fiducial for Exp-2

• Before lithium CSL NBI D fiducial following helium conditioning

• 1st CSL NBI D fiducial following 24mg addition lithium deposition on Inner Limiter (54 mg total)

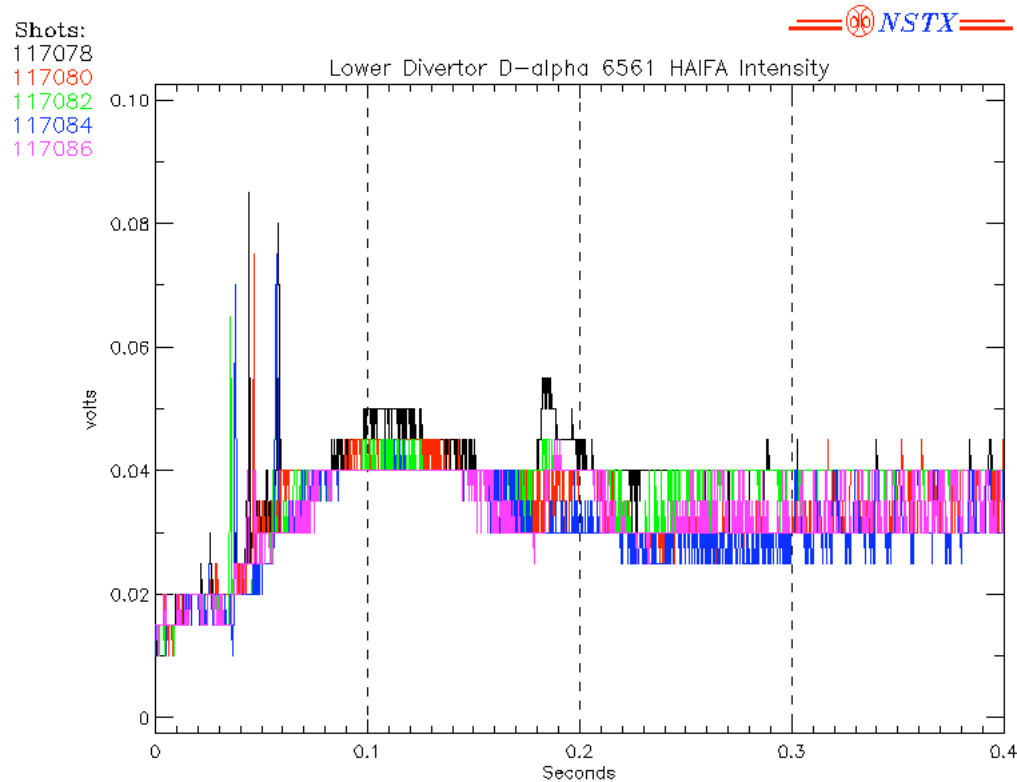
Shots:  
116996  
117035  
117036  
117037  
117038



After Li saturates, discharge returns to pre Li wall conditions following helium conditioning

- 24 mg of fresh lithium pumping of edge density saturated after 3 discharges.
- LPI directly into CSL NBI D fiducial increased density.

# Exp-3: During Lithium Pellet Injection into LSN Helium Discharge Conditioning Quickly Reduced Lower Divertor D $\alpha$ Luminosity to Base Level



- D $\alpha$  luminosity from Lower Divertor decreased slowly during 9 discharges.

# Exp-3: During LPI into LSN Helium Discharges, Li I Luminosity from Lower Divertor Increased, $D\alpha$ Remained at Base level

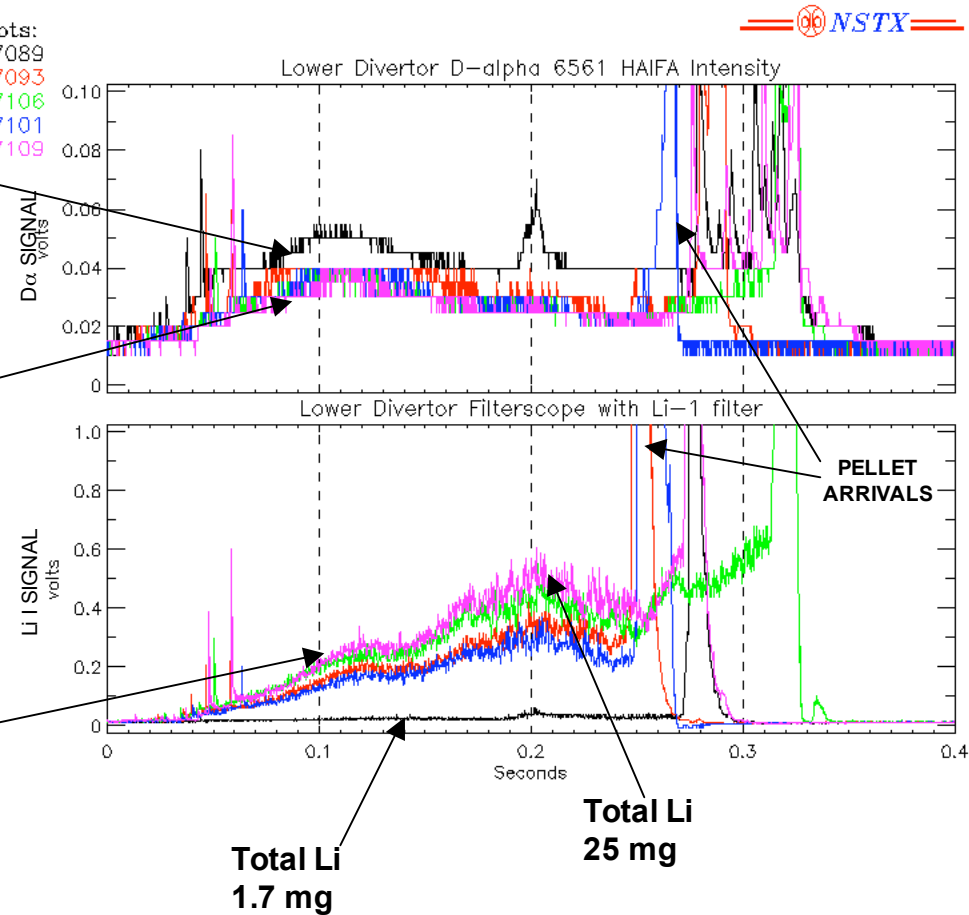


• First helium LPI discharge after NBI D LSN fiducial following initial helium conditioning sequence.

• 21 helium discharges, 10 with pellets of either 1.7, and 3.4 mg, including 3 double injections.  $D\alpha$  luminosity decreased slightly.

• Li I luminosity from Lower Divertor increased as total fresh lithium injection increased to 25 mg.

Shots:  
 117089  
 117093  
 117106  
 117101  
 117109



# Exp-3: LSN NBI D Fiducial Following 25 mg of Lithium Deposition on Lower Divertor Exhibits ~x4 Decreased in Density



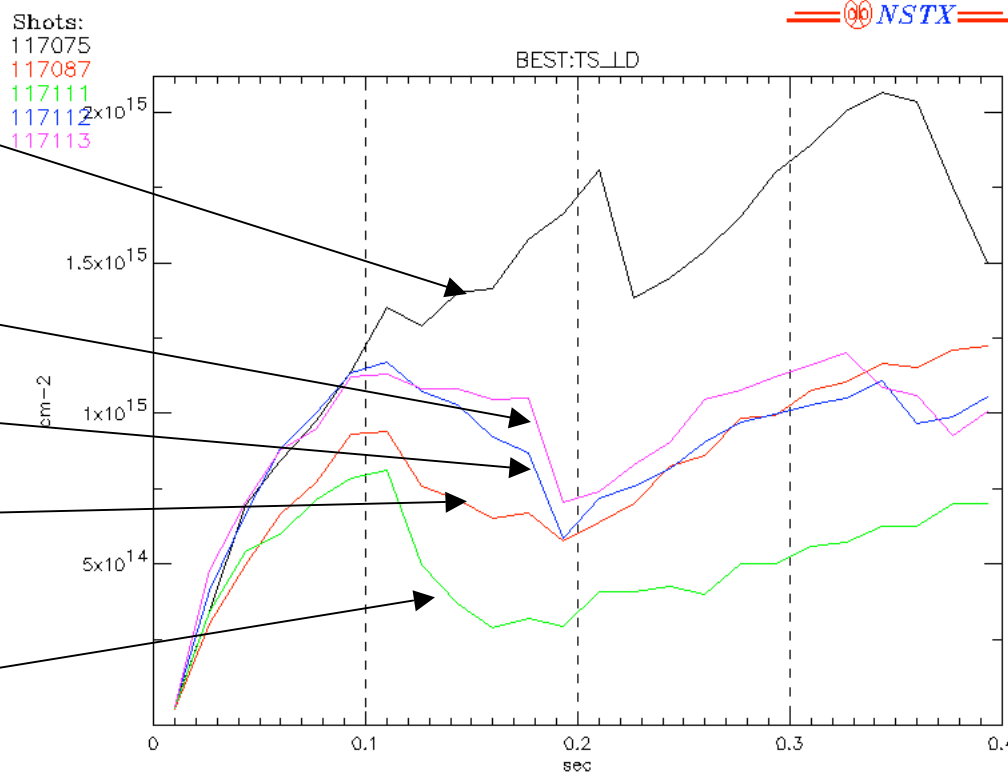
• First LSN D fiducial of the day with unconditioned lower Divertor

• Before lithium LSN NBI D fiducial following 8 He conditioning discharges

• 3 rd LSN NBI D fiducial for Exp-3

• 2 nd LSN NBI D fiducial for Exp-3

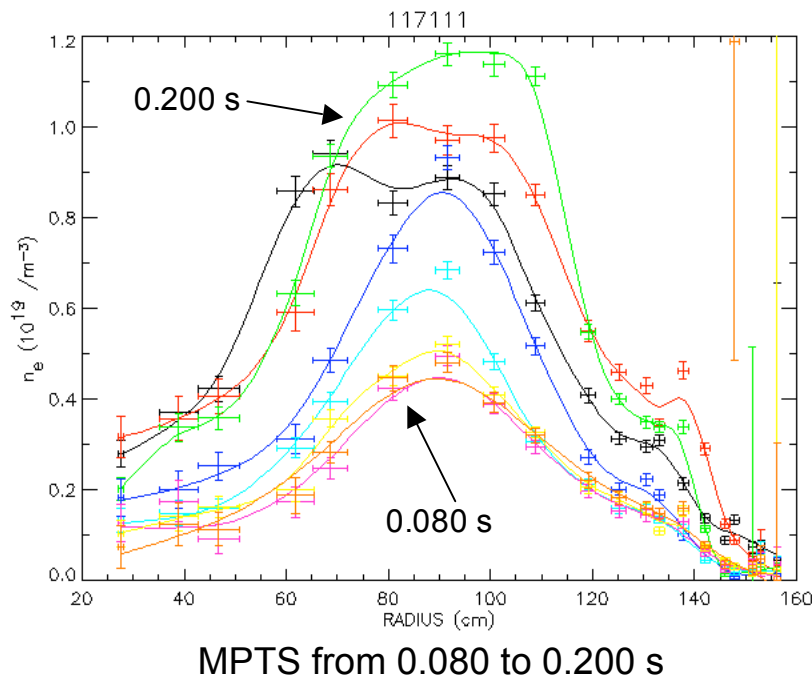
• 1st LSN NBI D fiducial for Exp-3 following 25 mg on lithium deposition on Lower Divertor (21 He discharges, 10 with LPI).



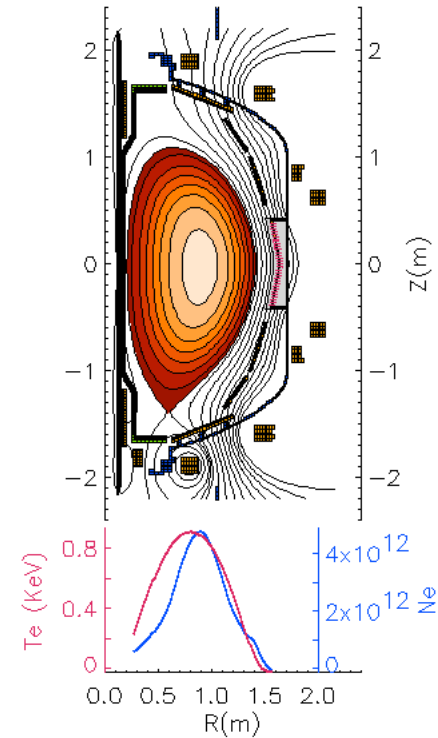
*After Li saturates, discharge returns to pre Li wall conditions following helium conditioning*

- Density decreased x2.7 after helium conditioning Lower Divertor.
- Density decreased an additional ~x2 after 25 mg Li deposition.
- 25 mg lithium pumping of edge density saturated after 3 discharges.

# Exp-3: Initial LSN NBI Deuterium Fiducial Following 25 mg of Lithium Deposition on Lower Divertor Exhibited Peaked Density profile



from \EFIT02, Shot 117111, time=185ms



- Density profile peaking for Exp-3, LSN similar to CSL Exp-1 and -2

# Conclusions



- The Center Stack Limited recycling results made contact with the TFTR lithium recycling experience.
- The Lower Single Null results extended the TFTR lithium recycling experience to a diverted configuration.
- LPI directly into LSN NBI D fiducials yielded no pumping effect (similar to previous NSTX and other diverted results).
- These experiments demonstrated that conditioned surfaces *pre-coated with lithium*, edge pumped a diverted plasma and increased the peaking of the density profile.