Initial NSTX Lithium Pellet Injection

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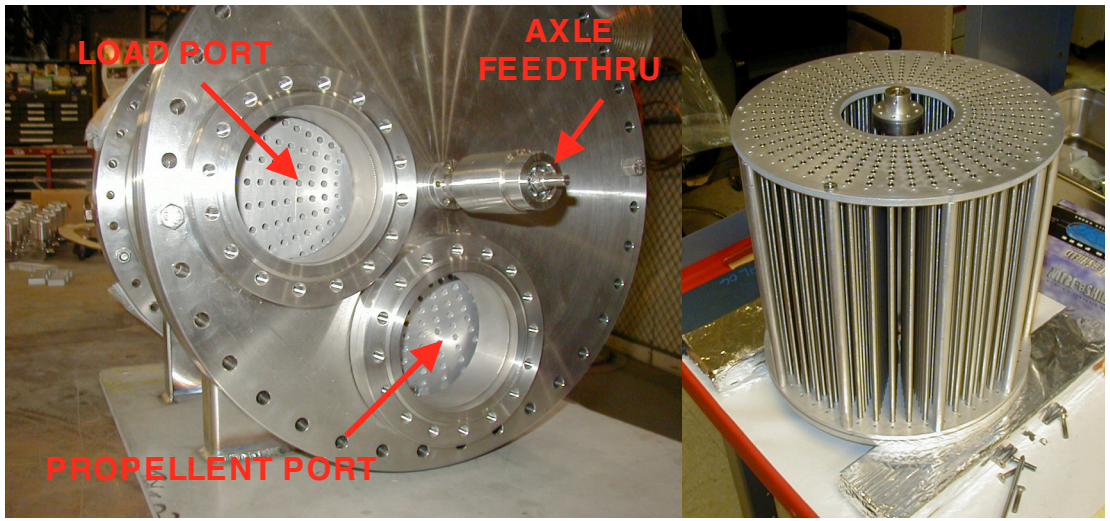
Abstract

A cartridge style Lithium Pellet Injector was installed on NSTX for midplane radial injection. Deuterium gas was used to propel a Li pellet-bearing cartridge down a barrel to a cartridge stop, and the pellet continued into the NSTX plasma at about 100 m/s. 17 lithium pellets, about 2 mg each were injected into LSN and DND, NBI-heated, H-mode plasmas, and into L-mode LSN Ohmic plasmas, and were observed with a Li I filtered Plasma-TV. Li pellets injected into NBI-heated LSN and DND plasmas appeared to ablate in the outer boundary. The pellets injected into OH plasmas exhibited good penetration to the HFS region. Lastly, a NBI preheat was added prior to pellet arrival, and the penetration depth was found to be very sensitive to the NBI turn-off time relative to pellet arrival. As this work progressed, Li luminosity started to be observed from the very initiation of discharges, due to depositions from preceding discharges. Initial modeling results will be presented.
* This work supported by US DOE Contract DE-AC02-76CH03073.

Lithium Pellets Injected into NSTX Discharges



OUTBOARD VIEW

400 BARREL TURRET

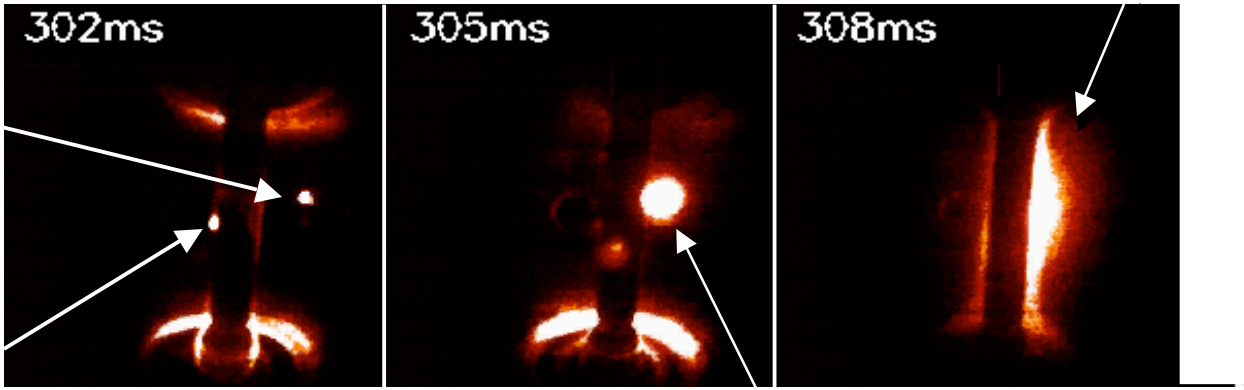
- Cartridge style injector for injecting solid pellets (<1 – 5 mg) & powder (micro-pellets)
- 10 – 200 m/s radial injection
- 1 – 8 pellets per discharge
- 400 pellet capacity

Illustrative Injection into Ohmic Discharge

Lithium Pellet moving through plasma after entering boundary

In-board gas injector

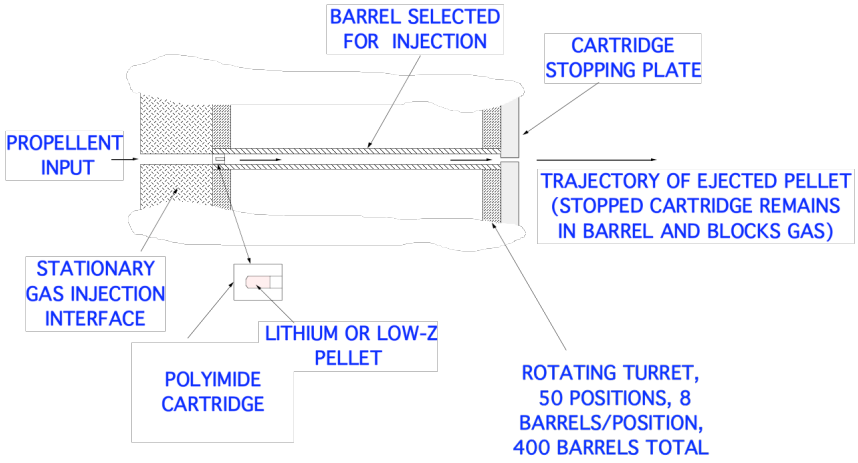
Li I luminosity spreading along the center-stack



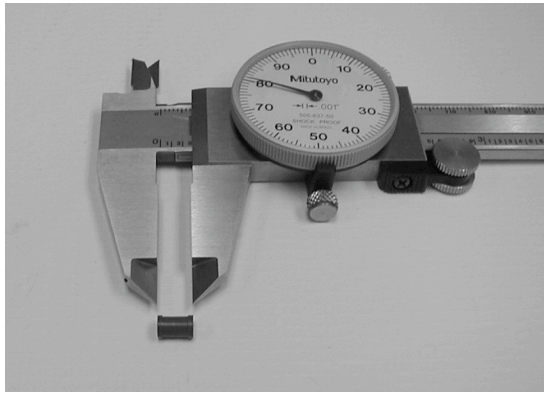
Pellet plasmoid approaches center-stack

Li I Plasma-TV -C.Bush ,ORNL

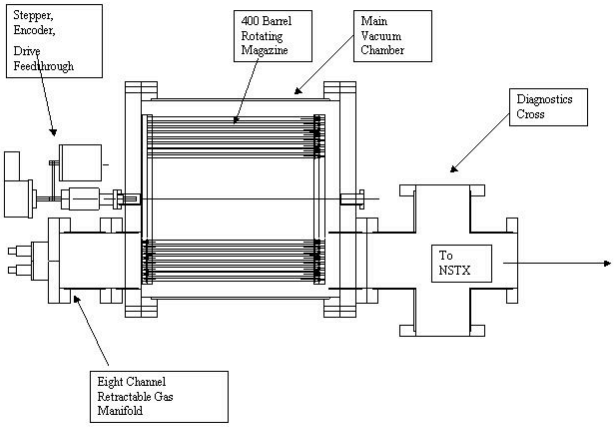
Lithium Pellet Injector (LPI) Details



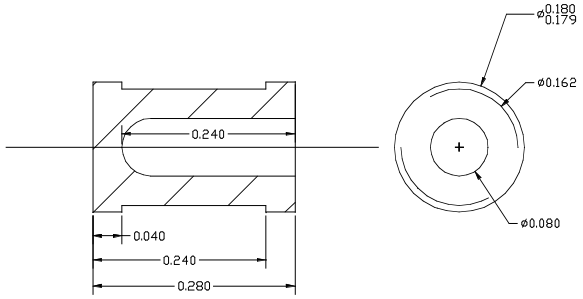
- Cartridge (Shabot) Style Injector



- Photo of Cartridge (Sabot)

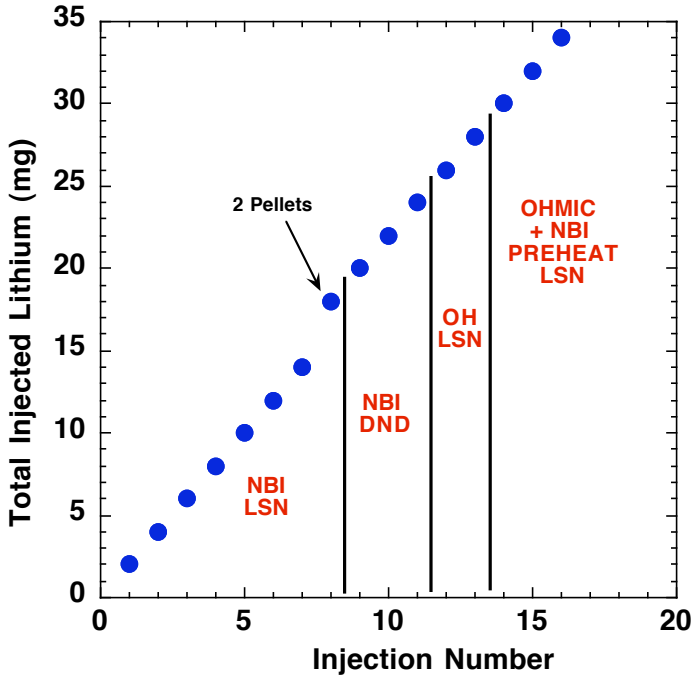


- Pellet Injector Assembly



- Typical Sabot dimensions (inches)

Experimental Sequence for Initial Lithium Pellet Injection in NSTX



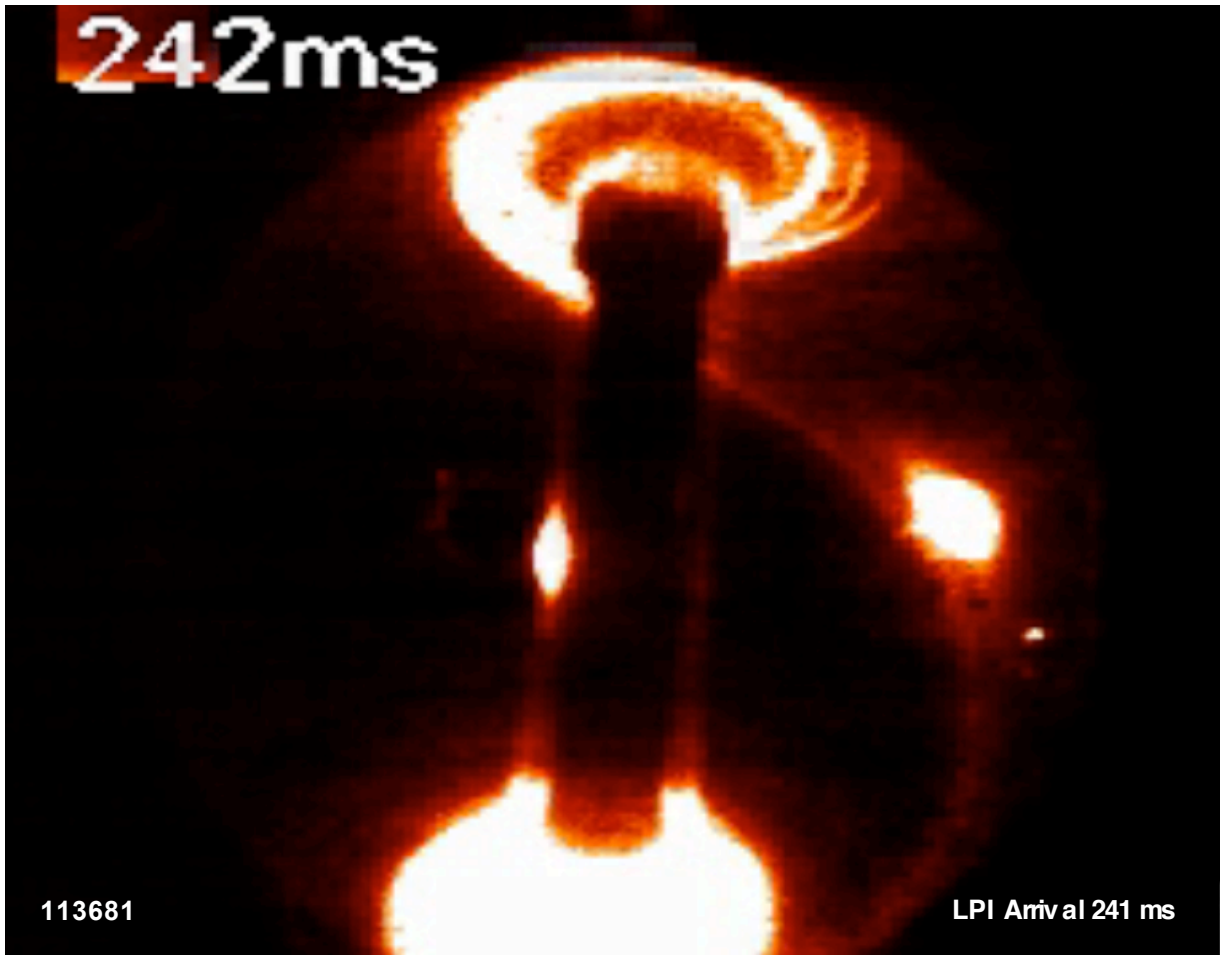
- One 2 mg pellet injected into 15 discharges.
- Two 2 mg pellets injected into 1 discharge.

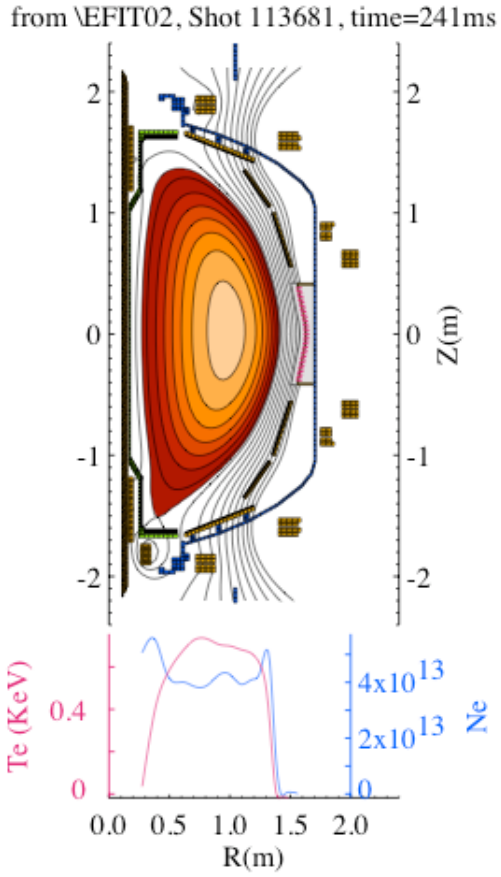
- Deuterium gas was used to propel a Li pellet-bearing cartridge down a barrel to a cartridge stop, and the pellet continued into the NSTX plasma at about 100 m/s.
- 17 lithium pellets, about 2 mg each were injected into LSN and DND, NBI-heated, H-mode plasmas, and into L-mode LSN Ohmic plasmas .

In Lower Single Null NBI Discharges, Li Was Transported Along Open Field Lines Toward *Upper X-point*

NSTX

Unfiltered





- Considerable ablation outside LCFS

Unfiltered Plasma-TV
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- S. Sabbagh, Columbia U

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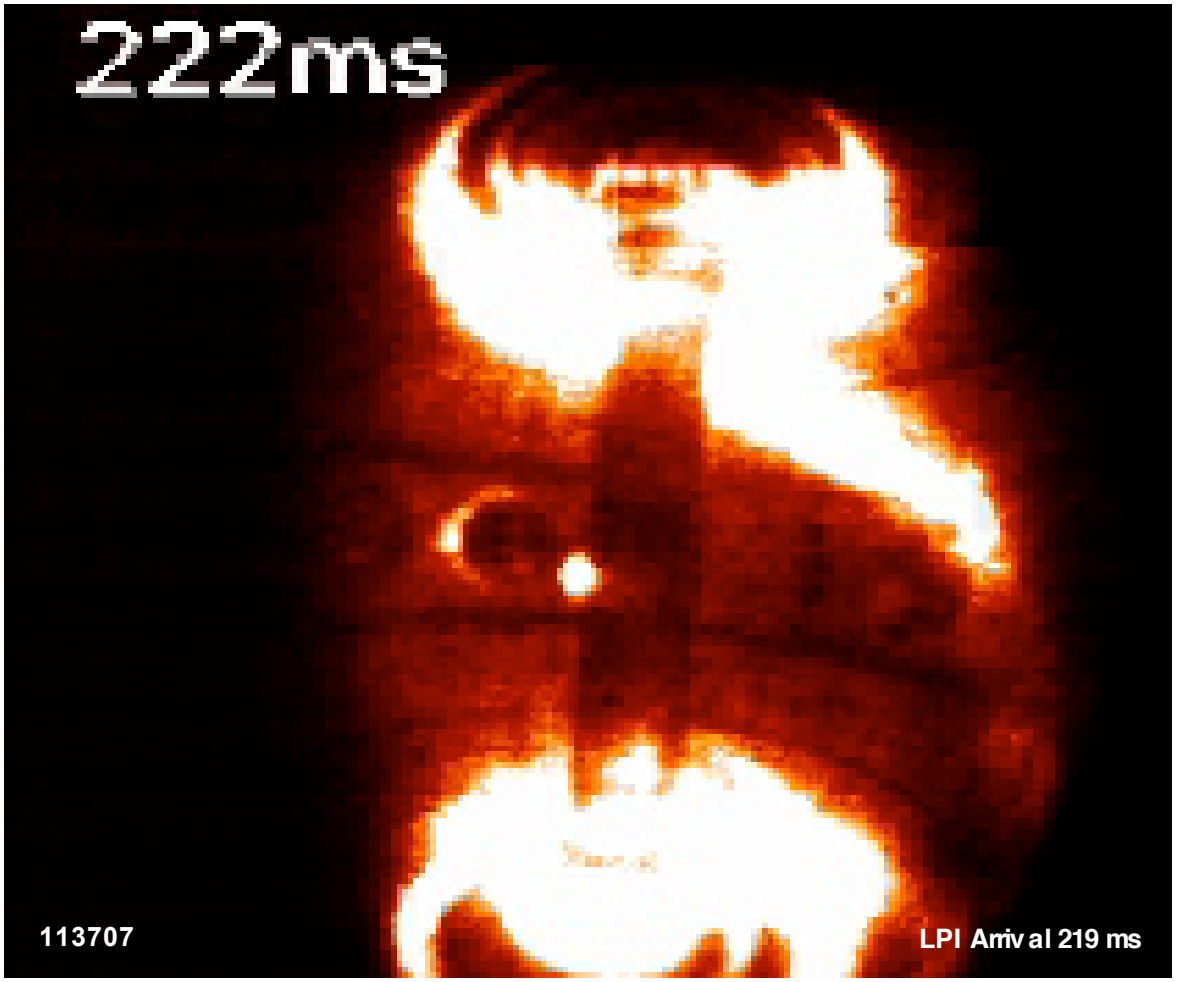
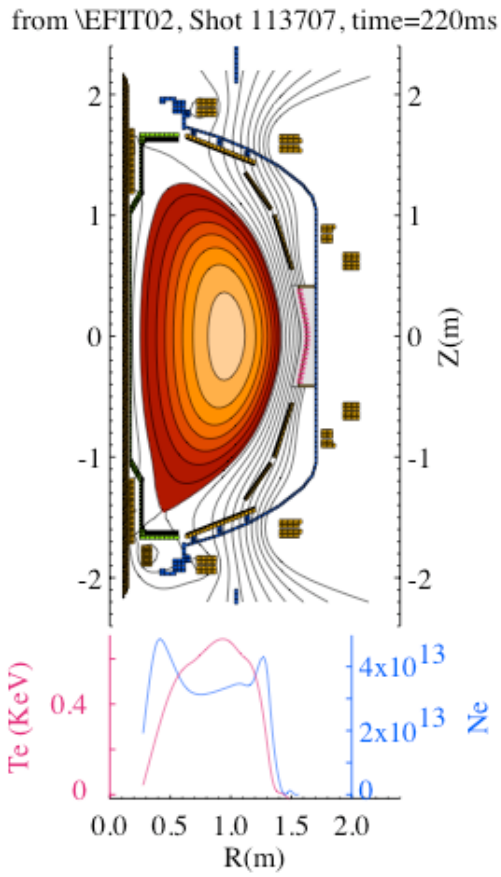
In Lower Single Null NBI Discharges, Li Was Transported Along Open Field Lines to the *Upper Divertor*

NSTX

Li I Filtered





- Considerable NBI power at outer edge

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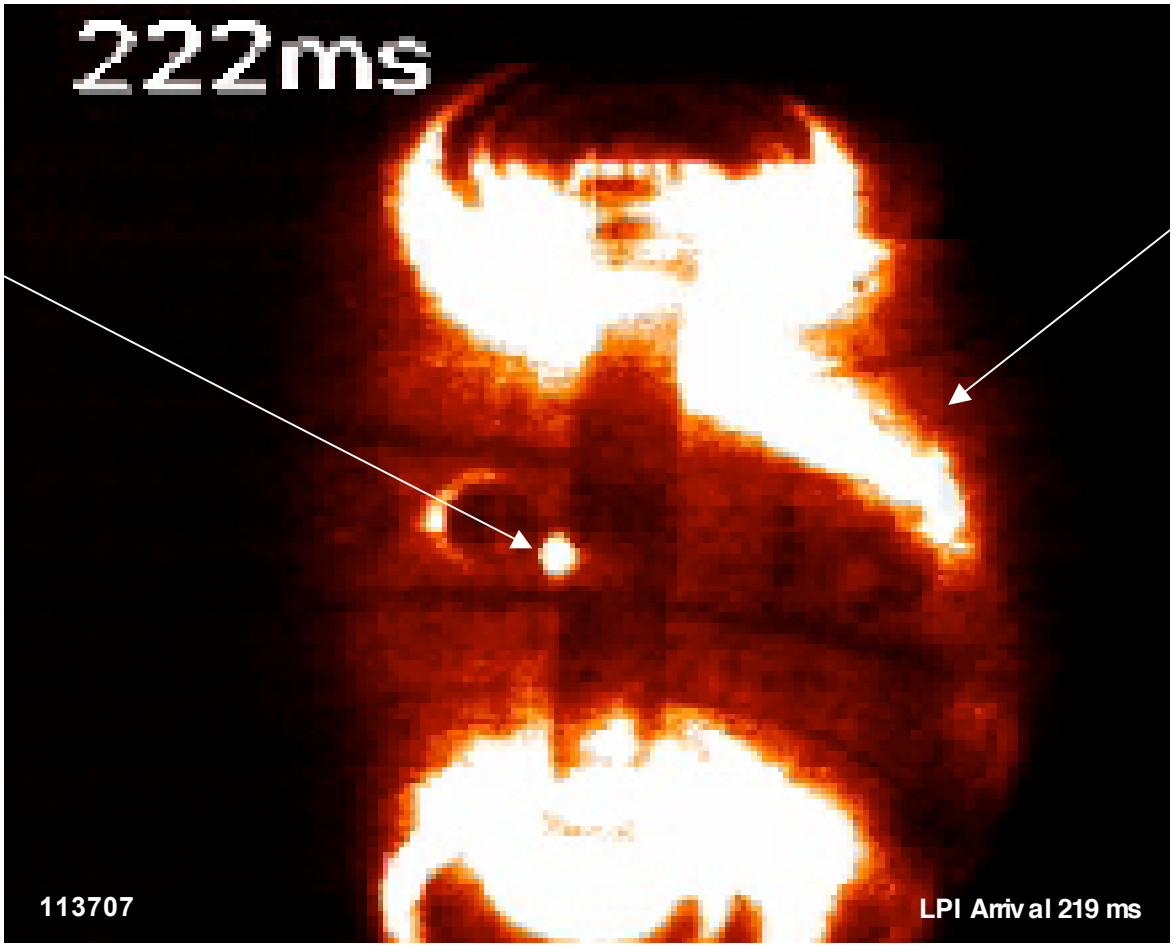
Li Ion Charge Exchange in Plume of Midplane Center Stack Gas Injector

Li I Filtered

- Li I luminosity from Li charge exchange in the plume of the midplane Center Stack Gas Injector.
- May be used to measure HFS edge temperature and density.



- Open field lines during LSN discharge.
- Li I luminosity is product of neutral gas and Li

Li I Plasma-TV
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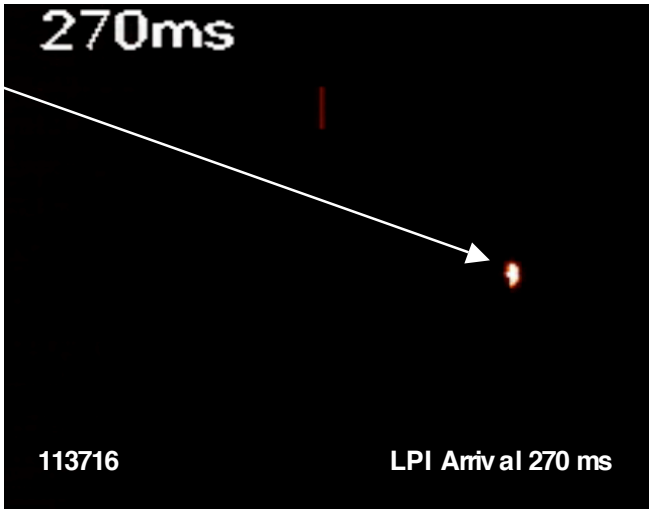
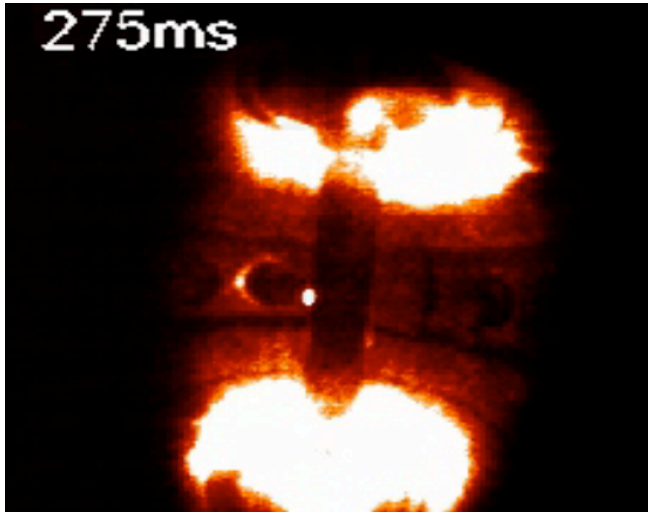
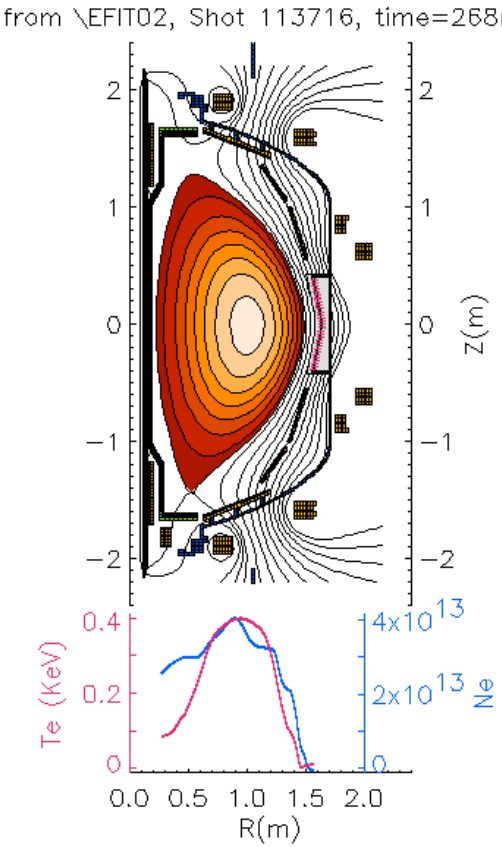
During DND NBI Discharges, Li Appeared to Be Transported More Uniformly to Both Divertors

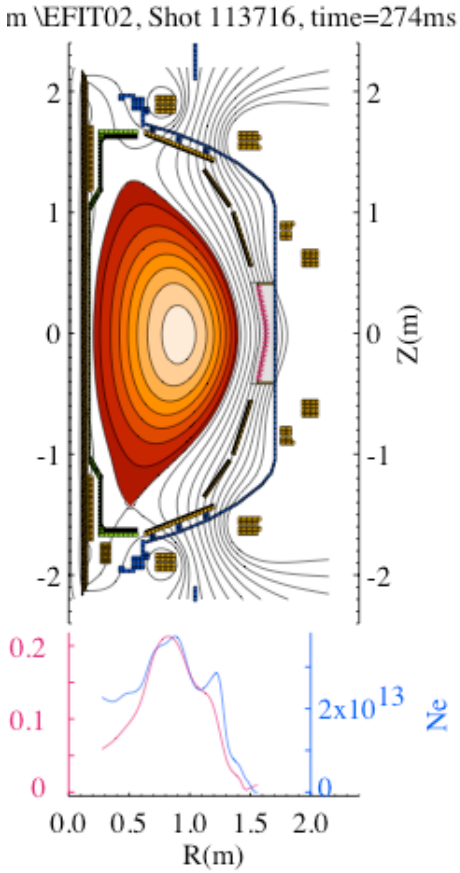
- LPI ablation at edge, appears vertically elongated



- Ablation transported to both divertors







-B. LeBlanc

- S. Sabbagh, Columbia U

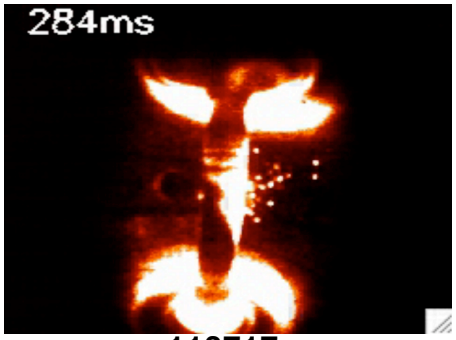
Li I Plasma-TV
- C. Bush, ORNL

• A Controlled Experiment Was Preformed to Vary the LPI Penetration by Pre-heating the Plasma With NBI

NSTX

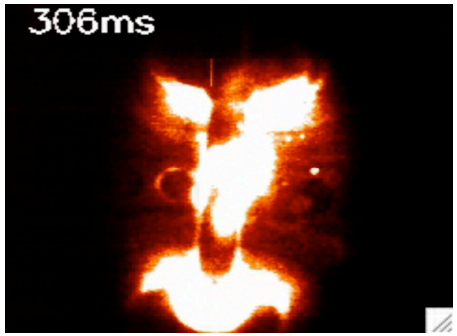
• LPI Penetration Depth into Ohmic Discharges Pre-heated with NBI, Was Found Sensitive to 10 ms change in NBI Off-Time Relative to Pellet Arrival

Li I Filtered Plasma-TV



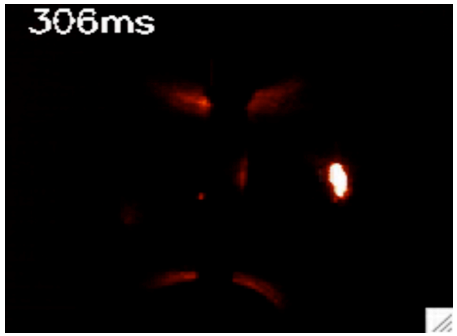
113717
LPI Arrival 272 ms

- **Ohmic Only**
- **LPI Reaches HFS**



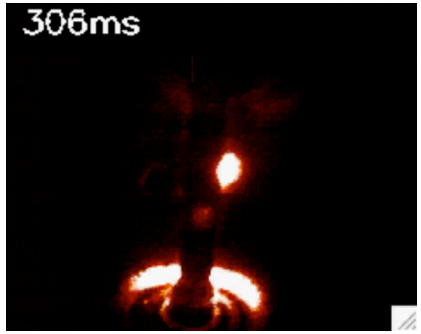
113720
LPI Arrival 294 ms

- **NBI Preheat Off @250ms**
- **LPI Reaches HFS**



113722
LPI Arrival 294 ms

- **NBI Preheat Off @275ms**
- **Penetration greatly decreased; LPI Ablates Near Outer Boundary**

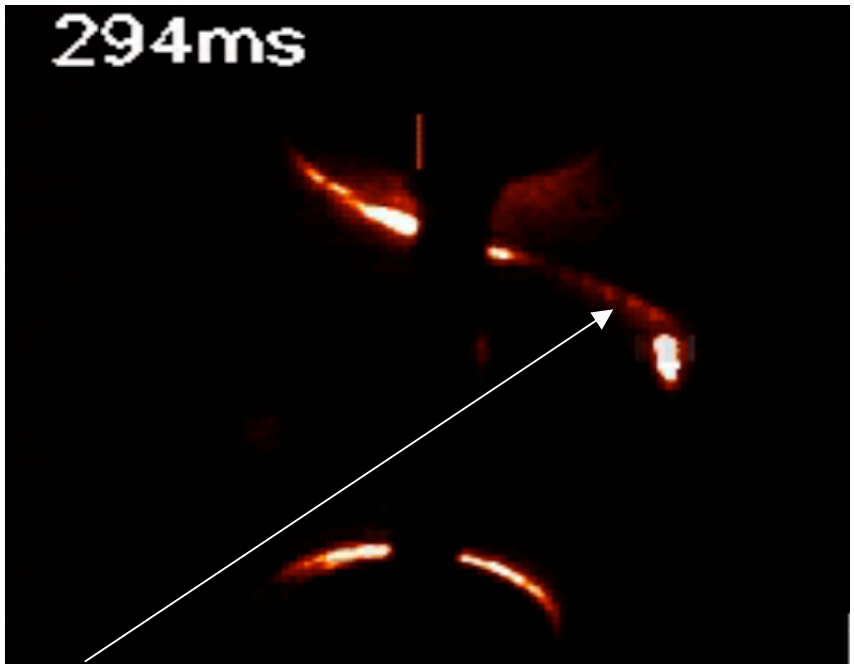


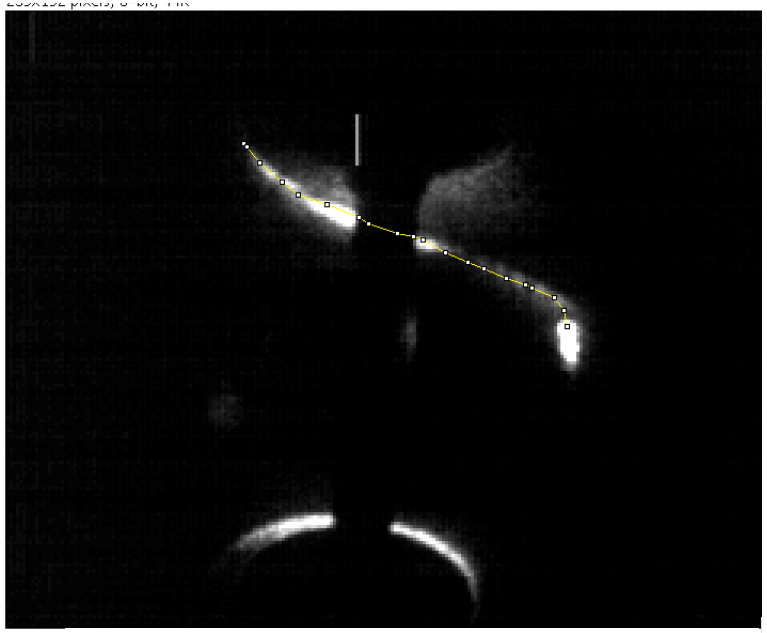
113723
LPI Arrival 294 ms

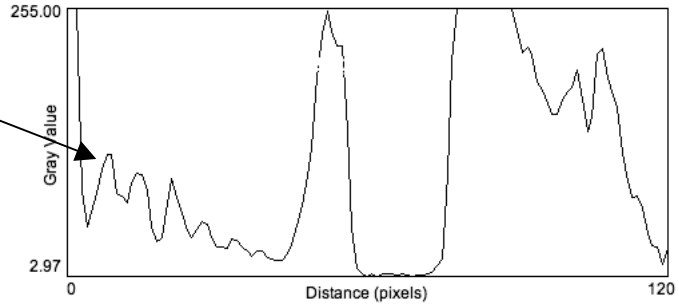
- **NBI preheat Off @260 ms**
- **LPI Plasmoid reaches HFS**

- R. Raman, U Wa
- C. Bush, ORNL

Li I Luminosity Profile Along Open Field Line of LSN Ohmic with NBI Preheat







Li I Intensity Along Field Line

- Apparent oscillations in Li I emissions as Li undergoes charge exchange along field line
- Possible explanations
  - Ablation blobs
  - Edge blobs

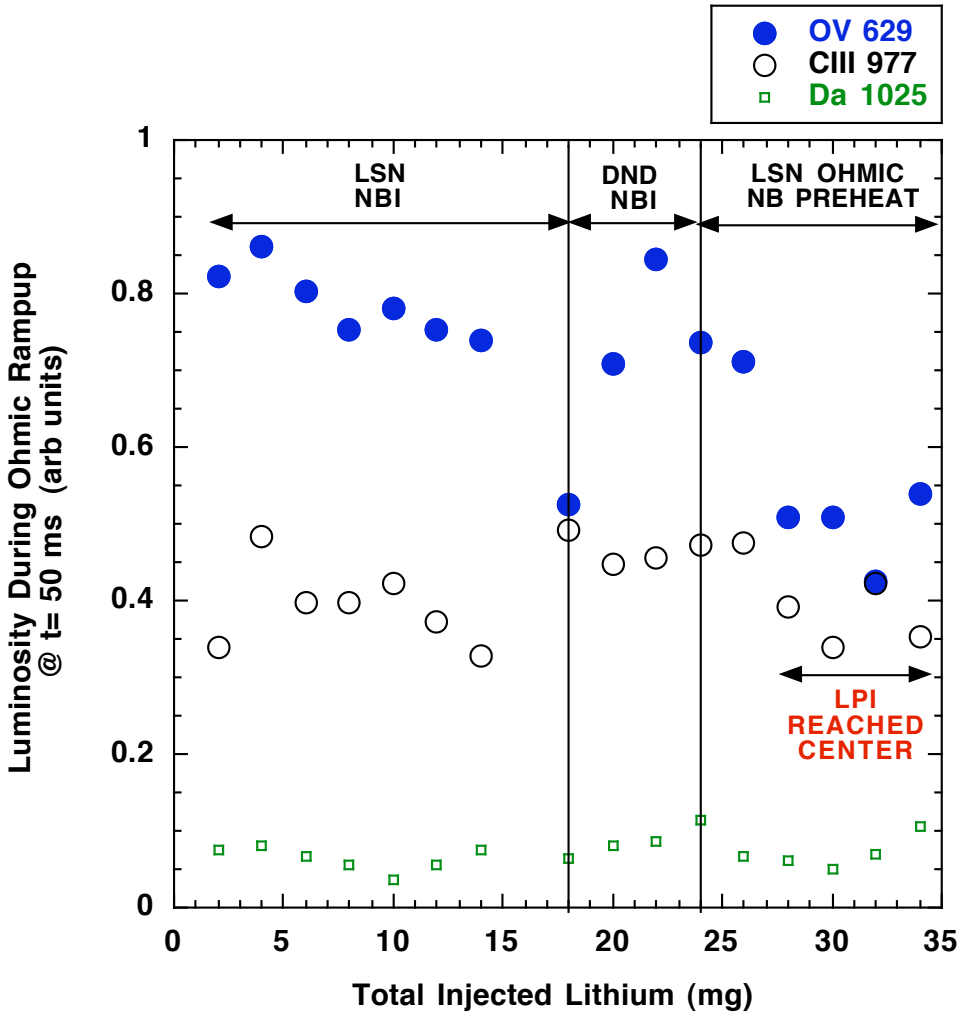
Li I Plasma-TV
C. Bush, ORNL

Estimated Lithium Deposition Thickness

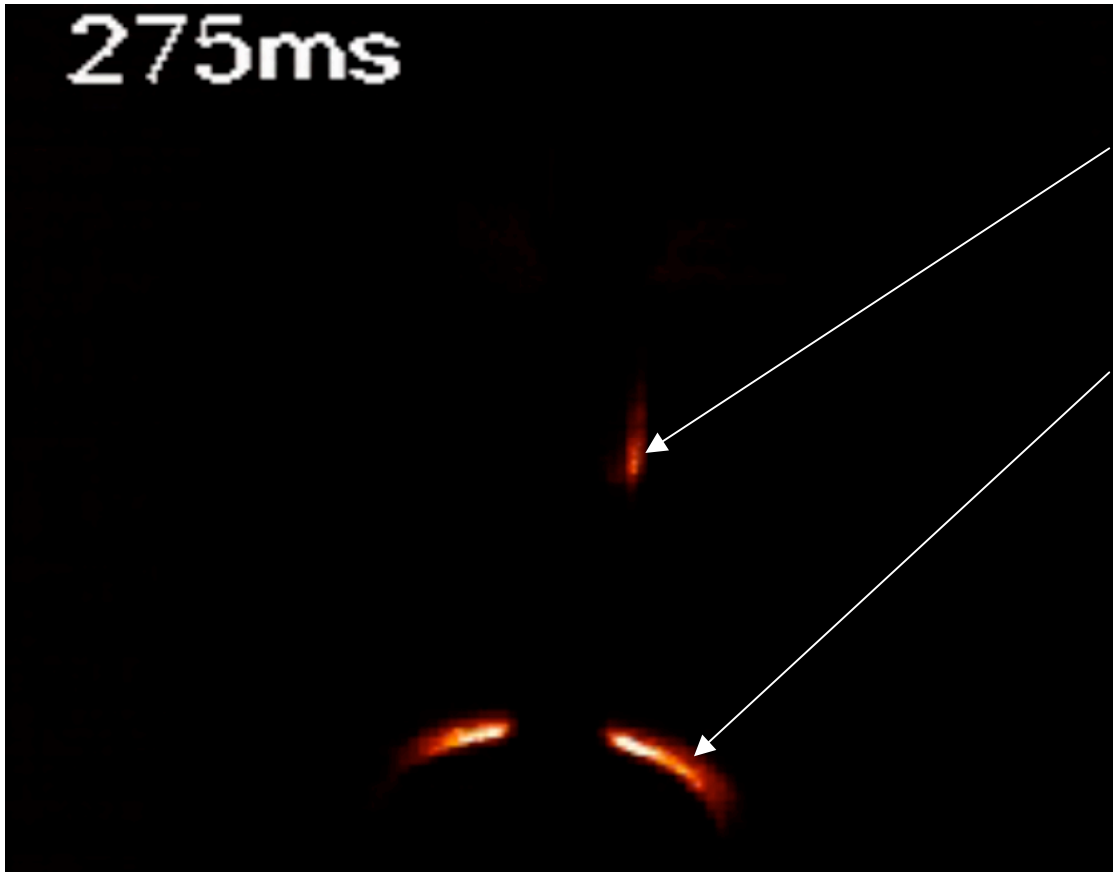
- 34 mg of Li injected using 17 pellets, 2mg ea

REGION	*AREA*	*Thickness*
If Deposited Uniformly	40x 10^4 cm^2	1.7 nm
If All Deposited on Center Stack Only	2x10^4 cm^2	32 nm
If All Deposited on Horizontal Divertors	3.6x10^4 cm^2	17 nm
If All Deposited on 1cm Wide Divertor Strip	3.5x10^2 cm^2	1703 nm

OV Luminosity During Ohmic Ramp-up Exhibits Decrease As Li Inventory Increases and LPI Reaches Center Stack



During No-pellet LSN Ohmic Discharge, Li I Luminosity on Lower Divertor from Previous LPI Discharges



- Li I Luminosity on Center Stack from previous LPI Discharges
- Li I Luminosity on Lower Divertor from previous LPI Discharges

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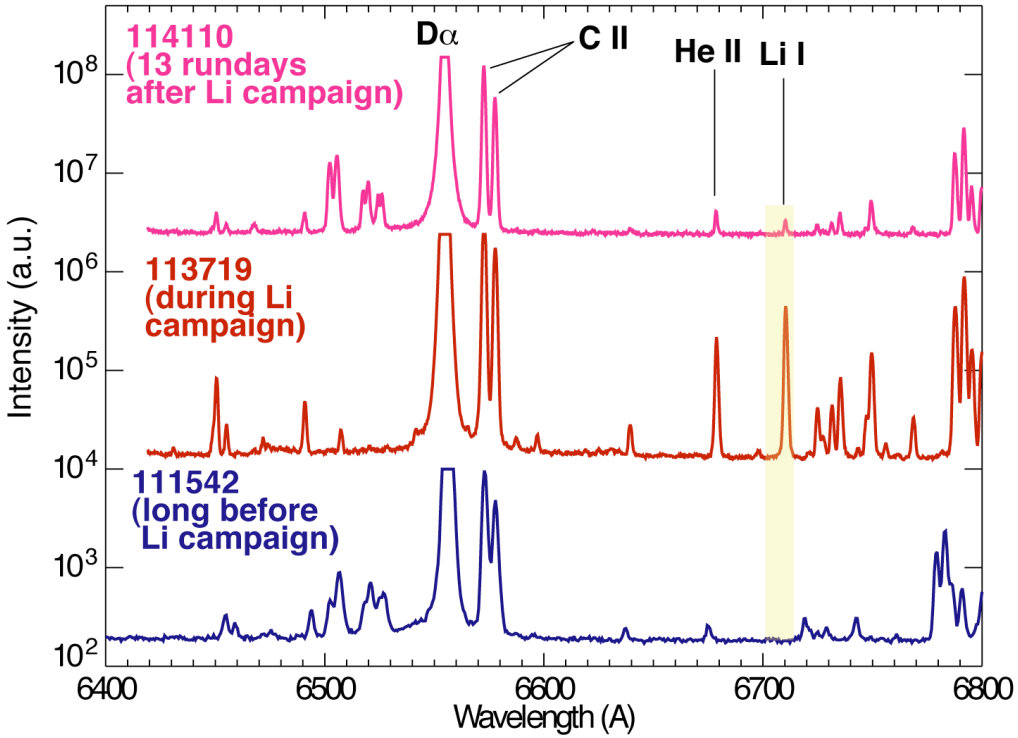
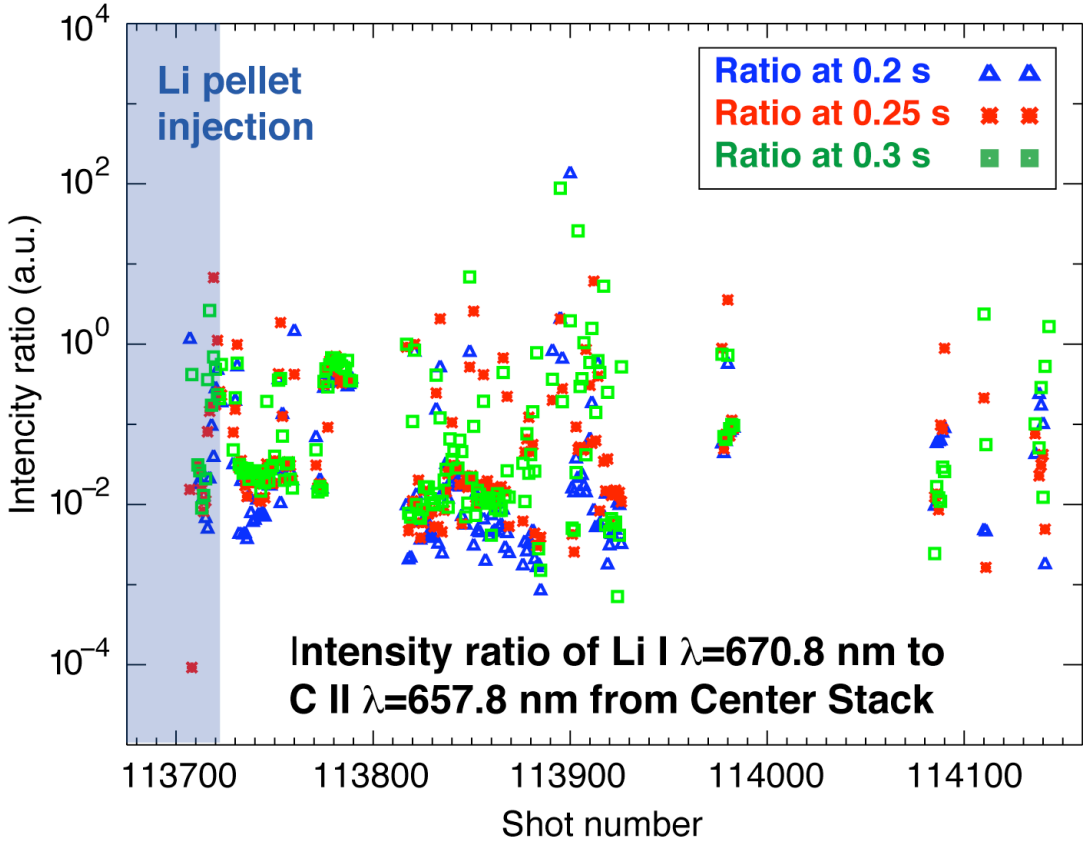
Visible Spectroscopic Li I Measured 13 Days (390 discharges) After Li Pellet Injection Campaign

• As LPI sequence progressed, VIPS2 Li I visible luminosity started to be observed from the very initiation of discharges, due to depositions from preceding discharges.



• VIPS2 spectra exhibited traces of Li I on the Center Stack long after Li pellet injection campaign.

Li I Measured from Center Stack Region 13 Days (390 discharges) After Li Pellet Injection Campaign



• **Background Li I influx (normalized to carbon influx) from Center Stack remained constant long after the Li pellet injection campaign.**

- V. Soukhanovskii, LLNL

Summary of July 04 Initial Lithium Pellet Injection

- 2 mg Li pellets injected, 34 mg total, into 16 discharges (LSN, DND, OH).
- During the LPI sequence, C luminosity ~constant, O trended downward.
- Long after LPI, Li I luminosity observed from Center Stack region.
- During LSN NBI, LPI ablated near edge and transported to *Upper Divertor*.
- During DND NBI, LPI ablated near edge and transported to both Divertors.
- Density rises were not obviously changed by the limited Li deposition, but the density exhibited interesting outboard edge profile changes.
- LPI Penetration Depth into Ohmic Discharges Pre-heated with NBI, was sensitive to a 10 ms change in NBI off-time relative to pellet arrival.
- After LPI, some discharges continued, but some discharges terminated slowly; locked modes seemed more prevalent as the Li deposition increased; the mode sequences need to be investigated.

Future Plans for Lithium Pellet Injection

- **Future Plans Include:**
  - Test LPI conditioning for improving density and impurity control.
  - Determine optimum LPI injection time for conditioning.
  - Determine Li inventory for C luminosity to decrease to lower steady state.
  - Determine how LPI parameters(m,v,t) effect discharge termination.
  - Measure Li midplane radial, and midplane-to-divertor, transport.
  - Measure changes in Li divertor deposition and erosion.
  - Measure edge turbulence and perturbation on edge during LPI.
  - Measure LPI ablation radial profile.
  - Determine beam ion contributions to LPI ablation profile