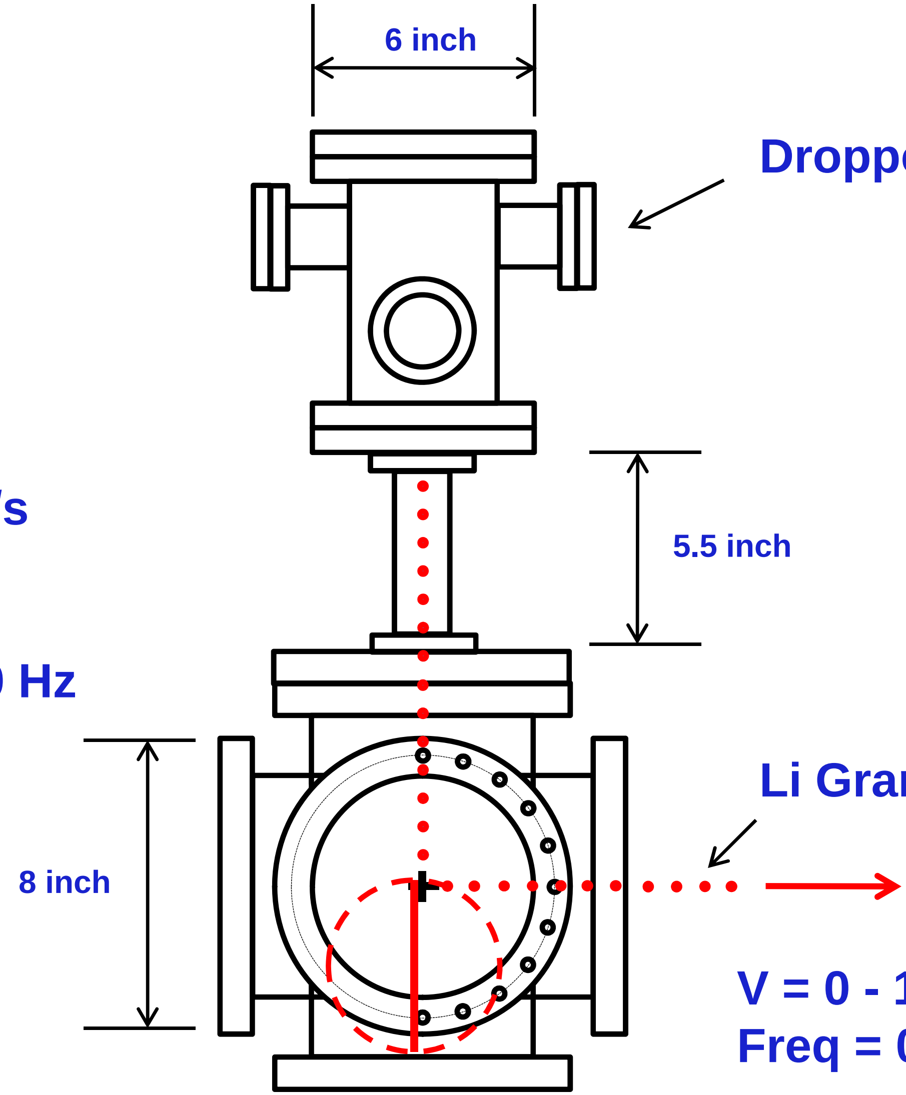
<u>Independent Control</u>:

- Granule Size : 0.5 - 1 mm
  (change between shots)

- Injection Speed: 0 - 100m/s
  (ramp during shots)

- Pacing Frequency: 0 - 100 Hz
  (ramp during shots)



1 mm Scale
Li Granules

Calculated Pedestal Deposition for 1 mm Li Granules with Injection Speeds from 30 m/s to 100 m/s

- **Linear Temperature and Density Profiles Assumed for Pedestal:**

Te (r/a = 1) = 0
Te(r/a = 0.94) = 1 keV

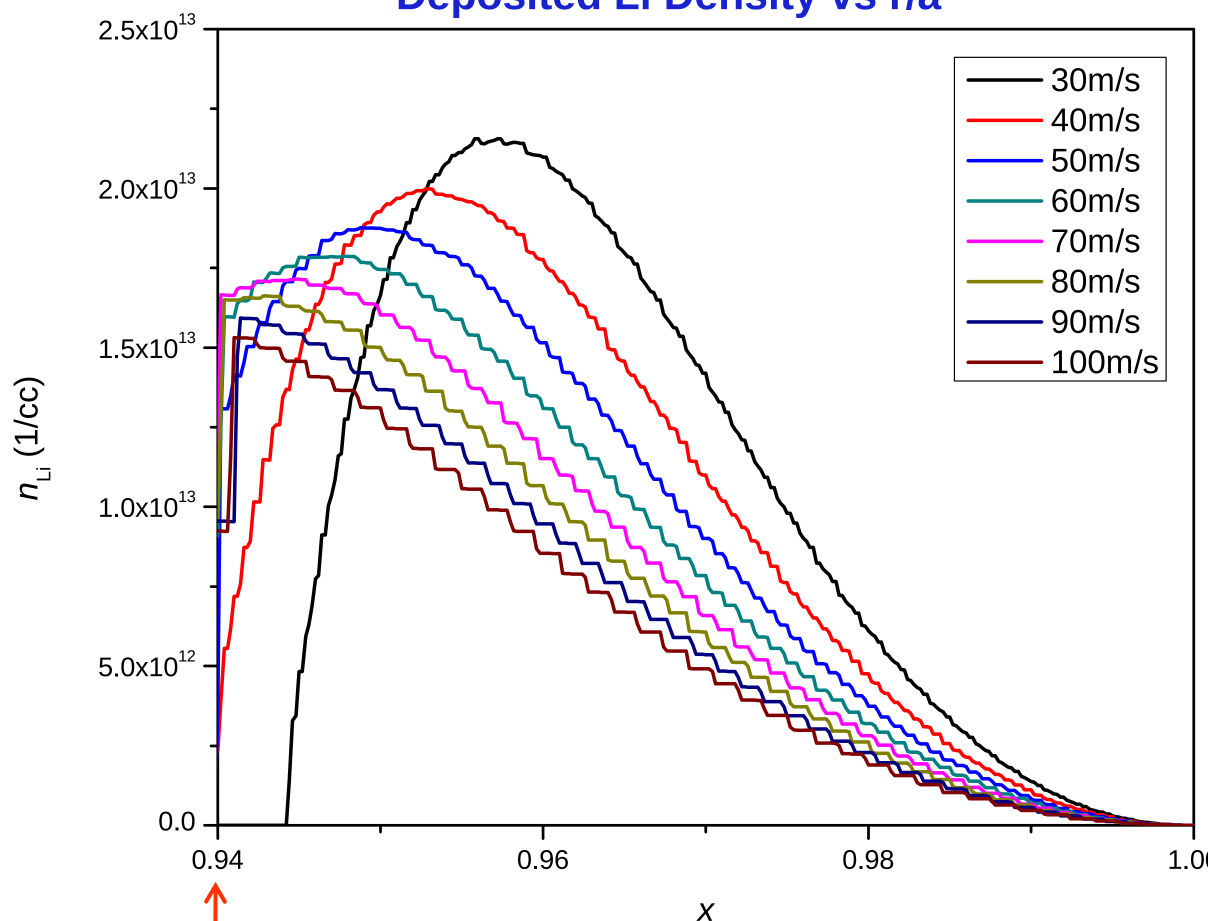
ne(r/a = 1) = 0
ne(r/a = 0.94) = 5×10^{13} cm^{-3}

- **Reasonable Approximation to DIII-D Pedestal R = 1.67 m a = 0.65 m**

- **Neutral Gas Shielding Ablation Model for Li Employed**

- **Results Similar to D Pellet Ablation Which Does Trigger ELMs on DIII-D**

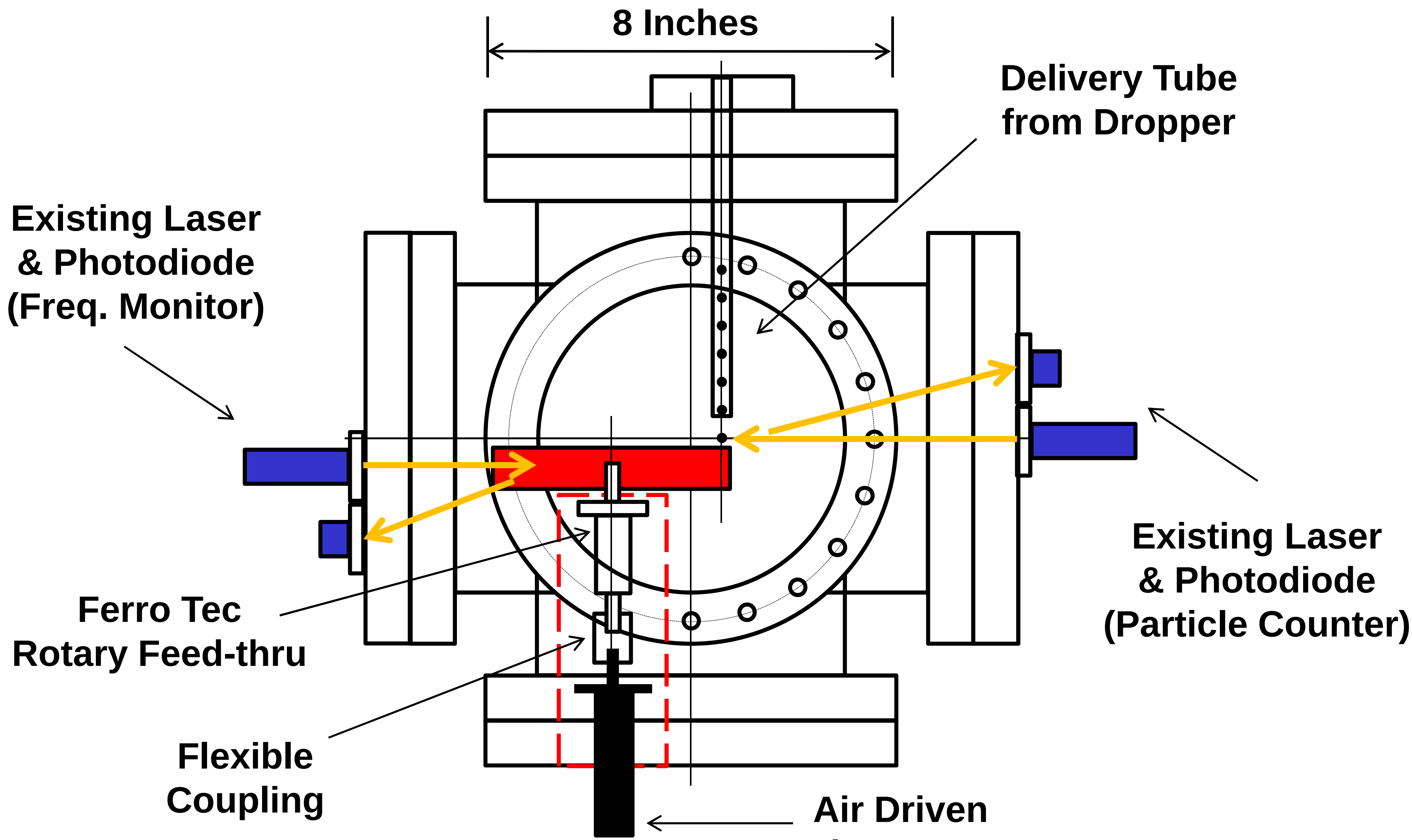
Deposited Li Density vs r/a



Top of Pedestal

Paul Parks, Wen Wu

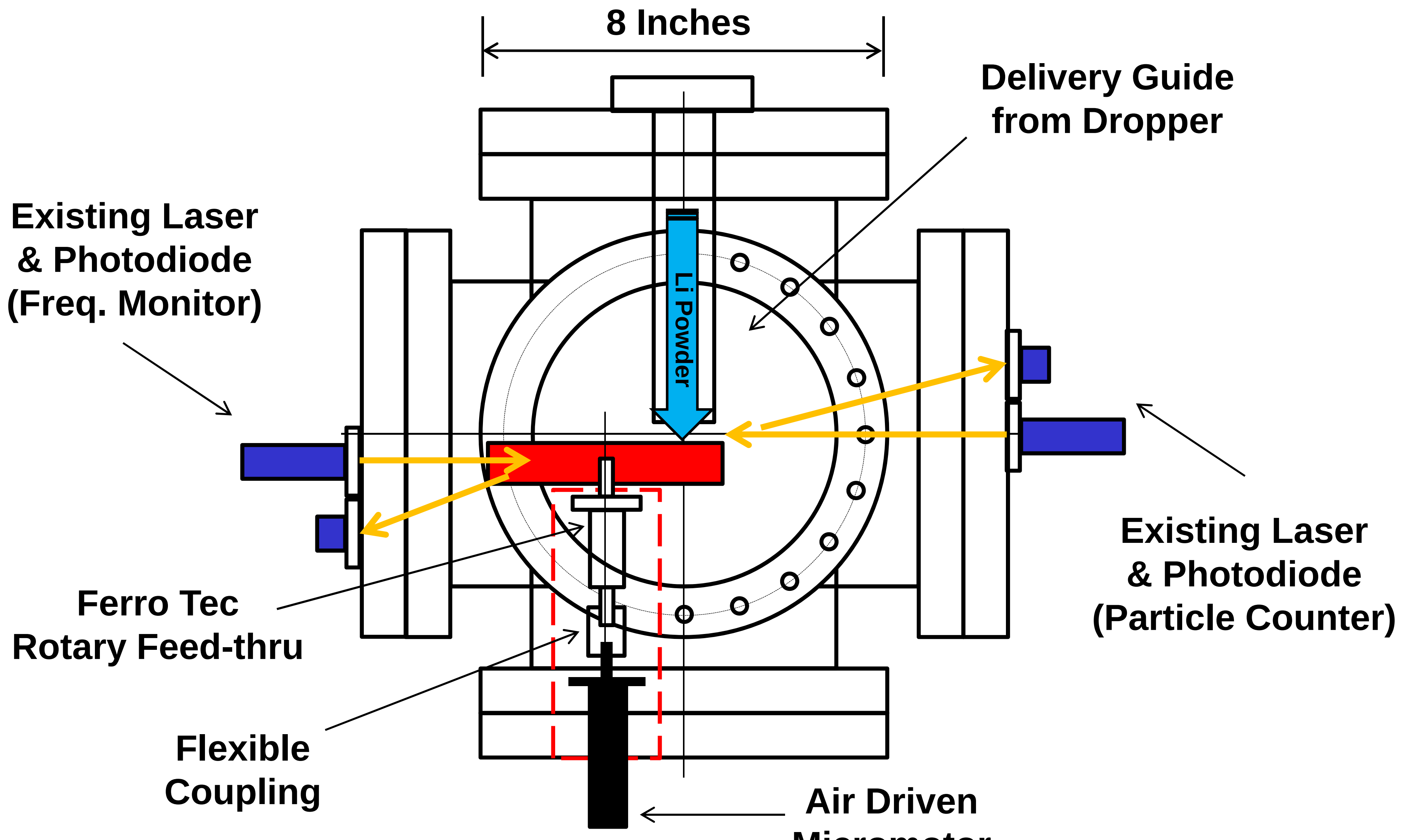
The Granule Injector



Granule Injection Run Plan

- Systematic scan of granule size and velocity
  - Do granules trigger ELMs?
  - What kind of ELMs?
    - Is the evaporated Li swept toward the LSN?
- Systematic scan of pacing frequency
  - Is Prad reduced?
- 1 day requested

Serving Double Duty to Inject Li Powder at the Midplane (Li Swept by SOL Flow Toward LSN)

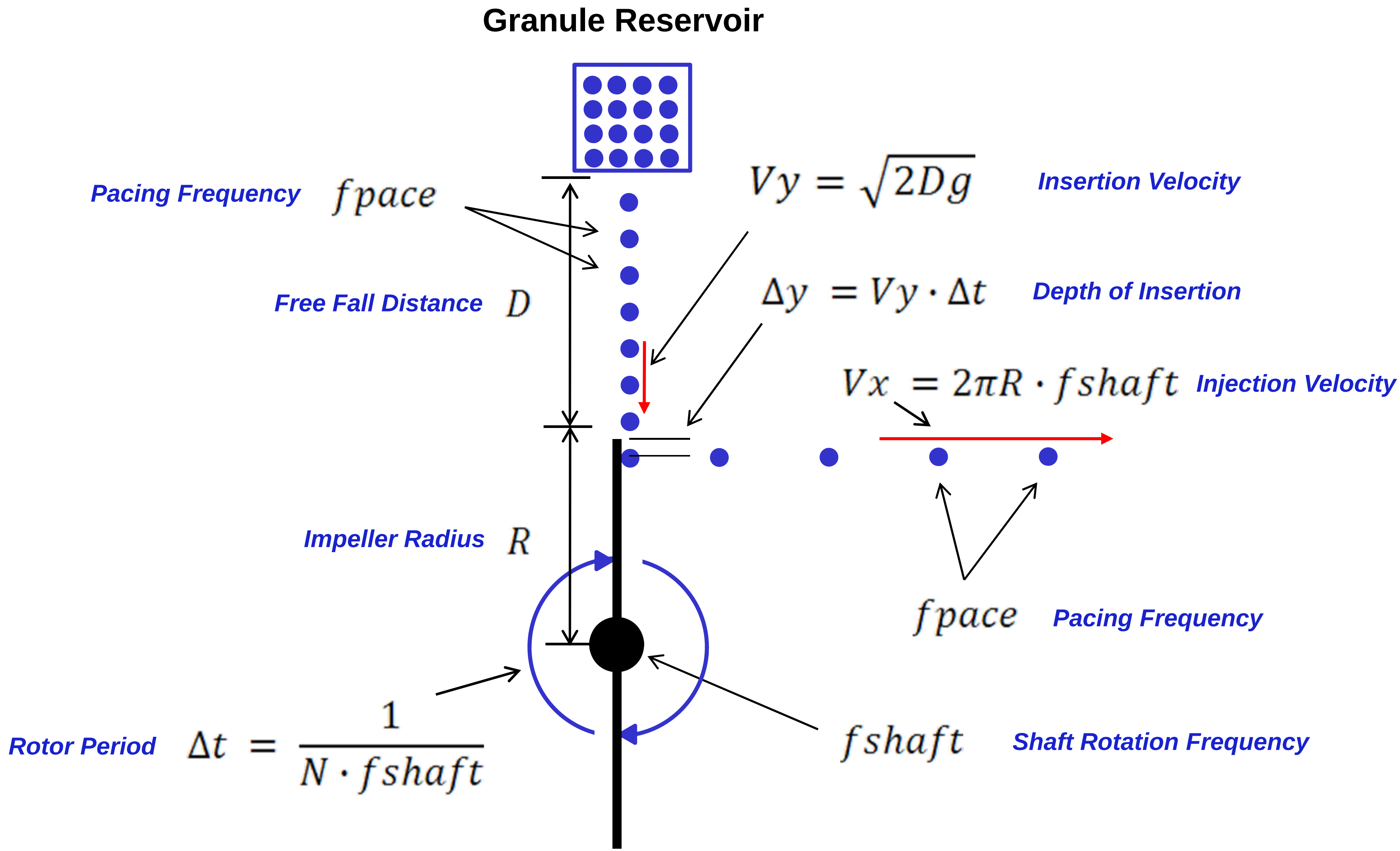


Midplane Powder Injection Run Plan

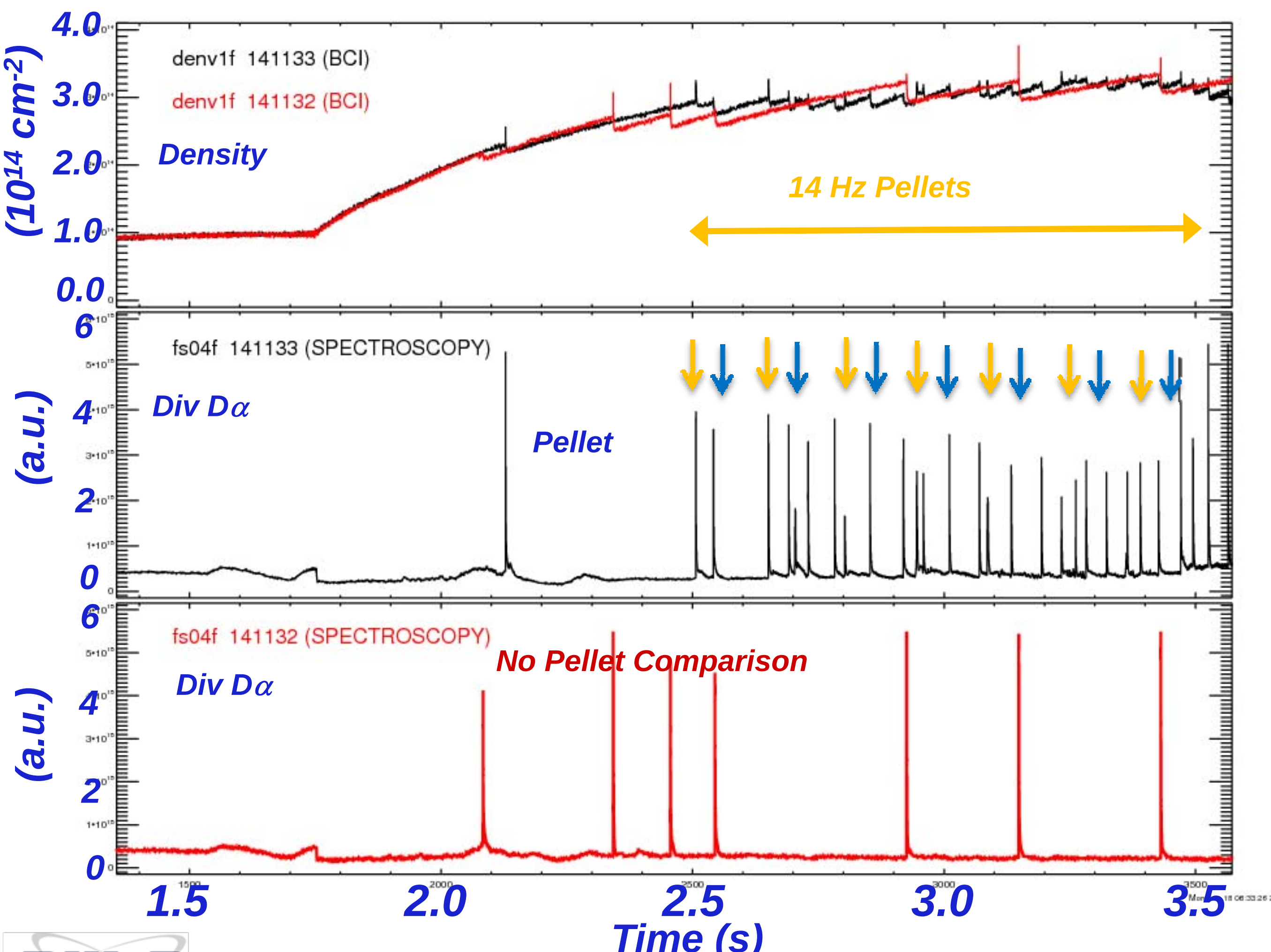
- Systematic scan of powder size and velocity
  - Does midplane injection cause the evaporated Li to be swept toward the LSN?
- Systematic scan of powder flux
  - Signs of improved plasma performance
  - Elms triggering?
- 1 day requested

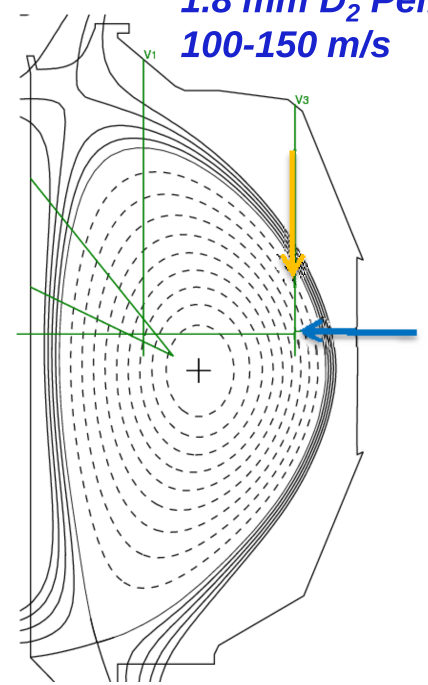
Extra Slides

The Scheme: Redirecting a Regular Stream of Falling Lithium Granules with a Rotating Impeller



Demonstration of ELM Pacing by Deuterium Pellets with No Fueling on DIII-D



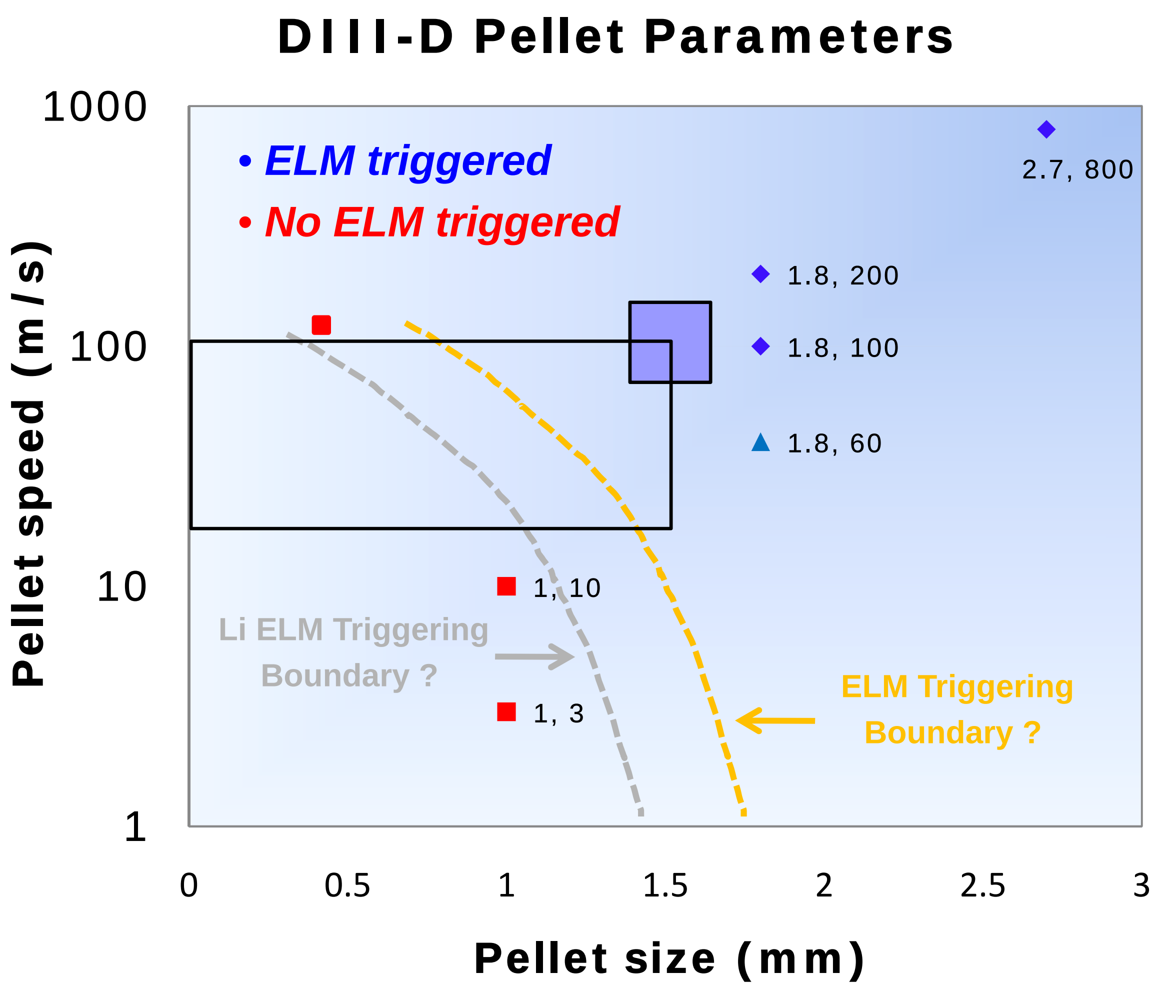


ITER shape
$\beta_N = 1.8$

Larry Baylor

Lessons Learned from Successful ELM Pacing Experiments on DIII-D using D Pellets

- DIII-D results indicate thresholds of D pellet sizes and speeds exist for reliable ELM pacing.
- A hypothetical curve is drawn by hand on the right indicating where a threshold boundary may exist. (shown in yellow)
- A second hypothetical curve for Li granules is shown (in grey). This curve is meant to indicate that lower speeds and small sizes may be needed with Li granule injection.
- The crossed lines indicate the chosen design parameters for the prototype Li.



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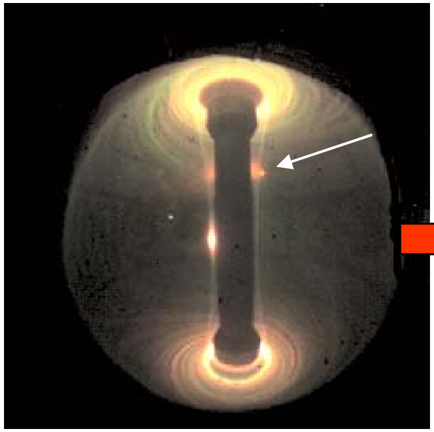
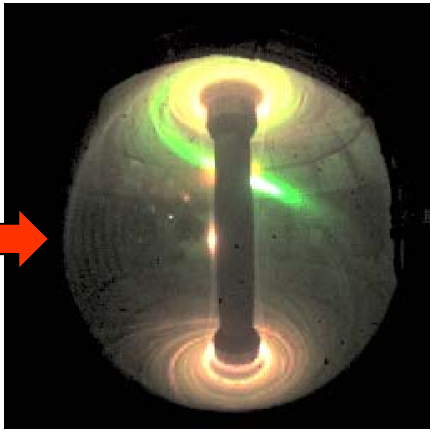
Examples of Edge Perturbations from Low-Velocity (~ 5m/s) Lithium Clumps (~ 2mm) in Four Discharges (2008)

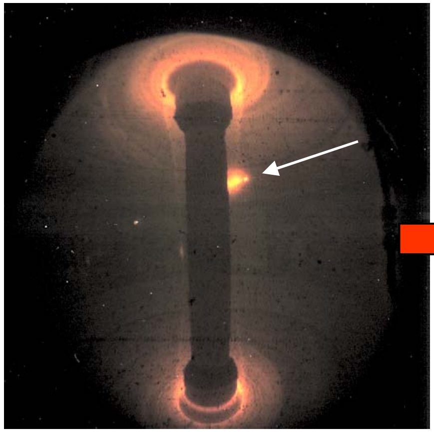
130364@ *272 ms*



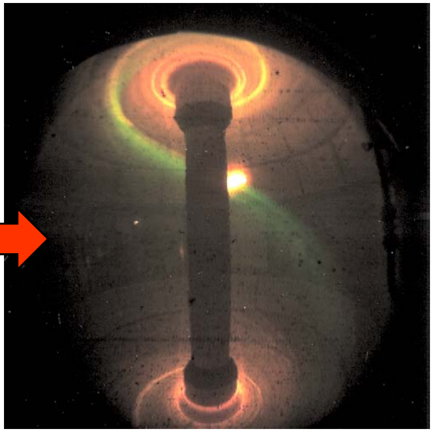
130364@ *280 ms*



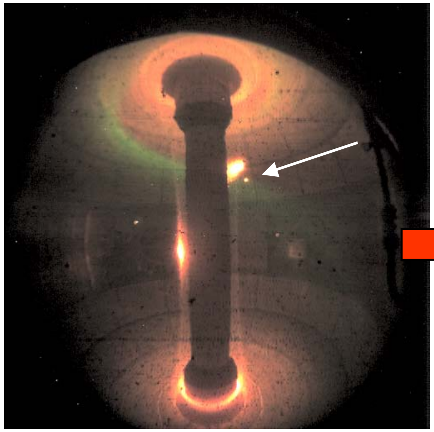
130389@ 353 ms



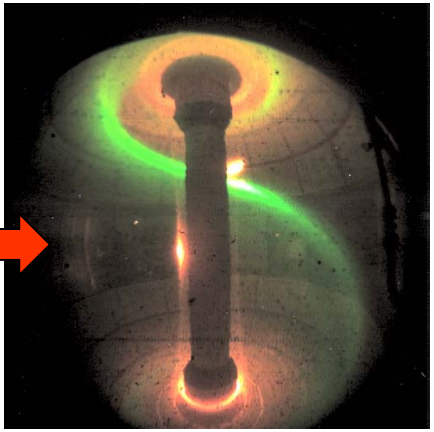
130389@ 356 ms



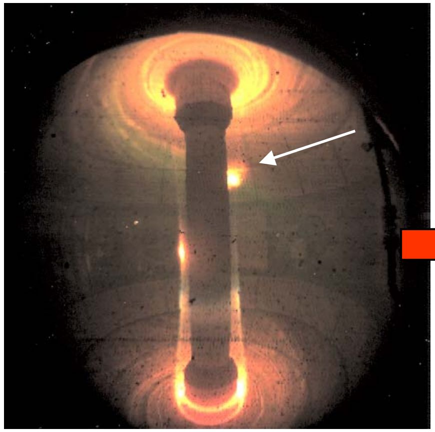
130387@ 191 ms



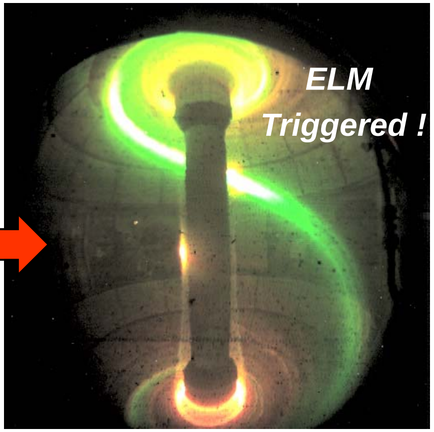
130387@ *197 ms*



130385@ 393 ms



130385@ *400 ms*



LiD is Another Interesting Candidate for ELM Pacing

Physical Properties of D, Li and LiD

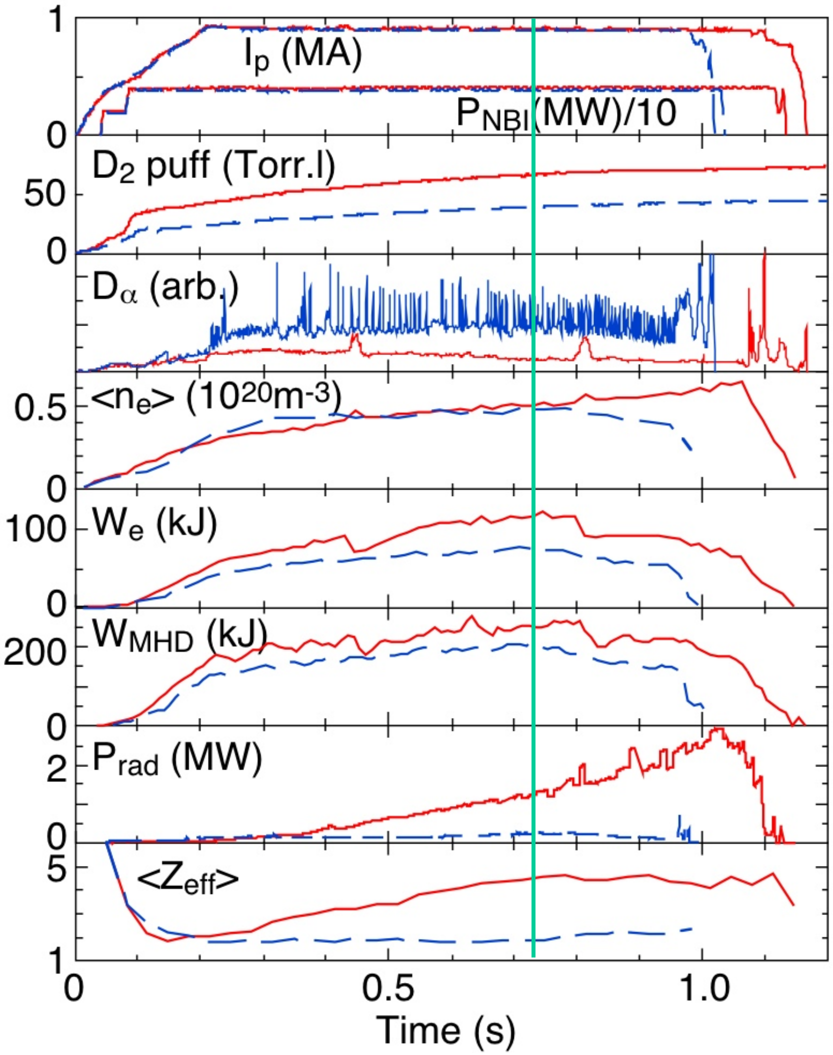
	Mass Density (gm/cm^3)	Atomic Density ($10^{22}/cm^3$)	Electron Density ($10^{22}/cm^3$)	Melting Temp (°K)	Boiling Temp (°K)
D	0.20	6.0	6.0	18.6	23.6
Li	0.52	4.5	13.5	454	1615
LiD	0.82	5.5	22	969	N/A*

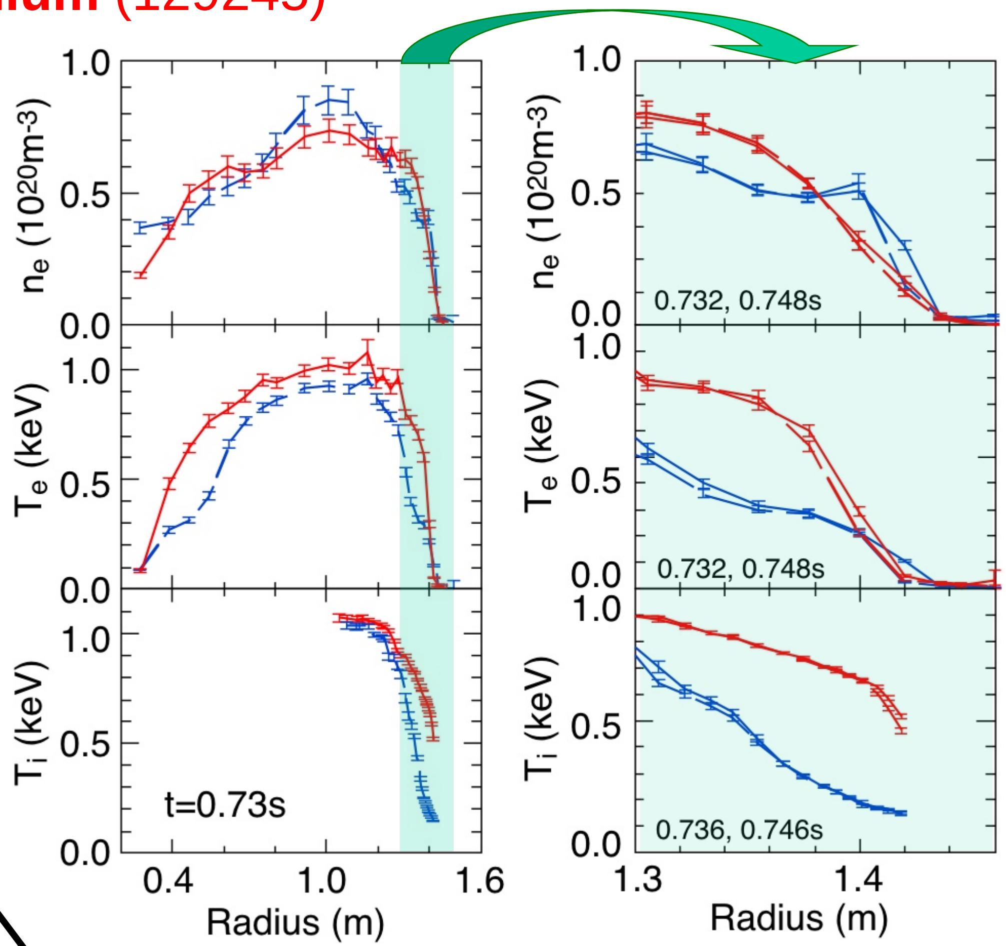
- **For the same size granule/pellet, Li (LiD) ablates 2.25 (3.66) times as many electrons as D.**

* In vacuum, LiD dissociates before it boils

Lithium Coating Reduces Deuterium Recycling, Suppresses ELMs & Improves Confinement in NSTX

No lithium (129239); **260mg lithium** (129245)





Without ELMs, impurity accumulation increases radiated power and Z_{eff}

H. Kugel, B. LeBlanc, R.E. Bell, M. Bell