NSTX

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Present Status of the Effort to Trigger ELMs using Injected Lithium Granules

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and the NSTX Research Team

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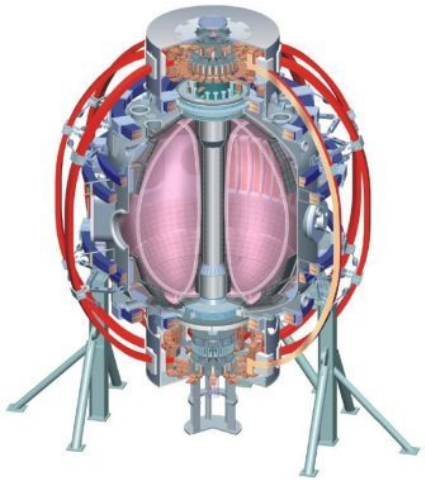
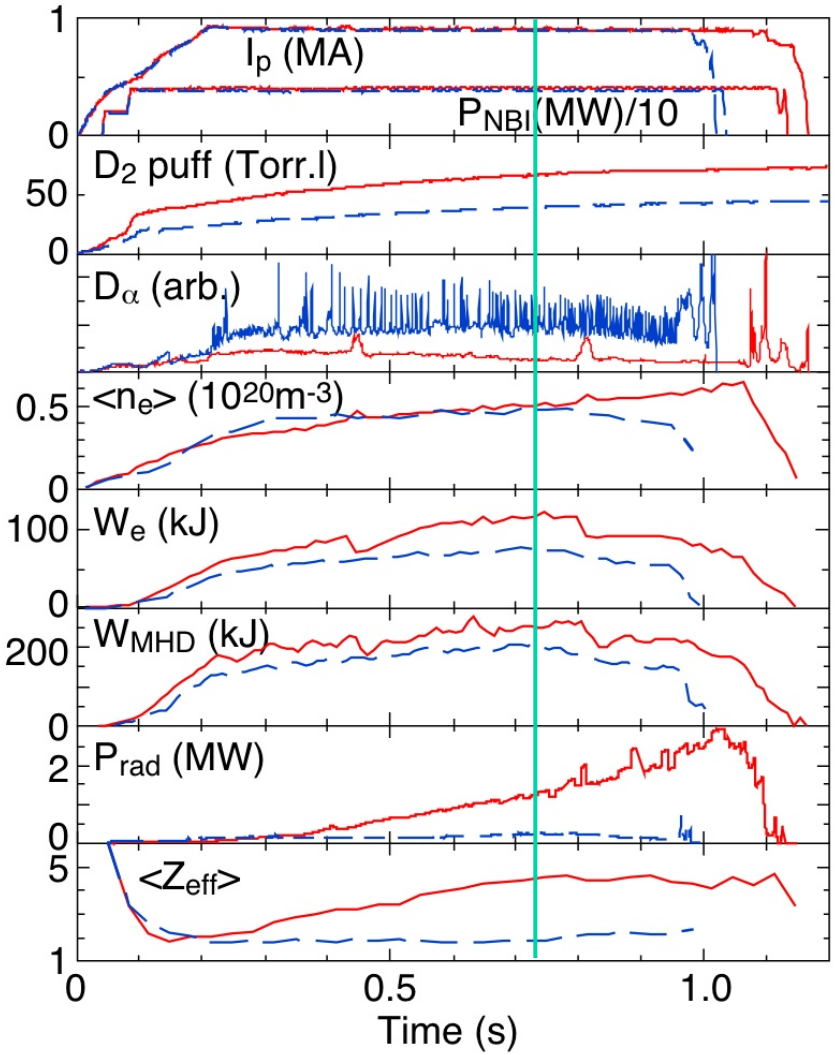


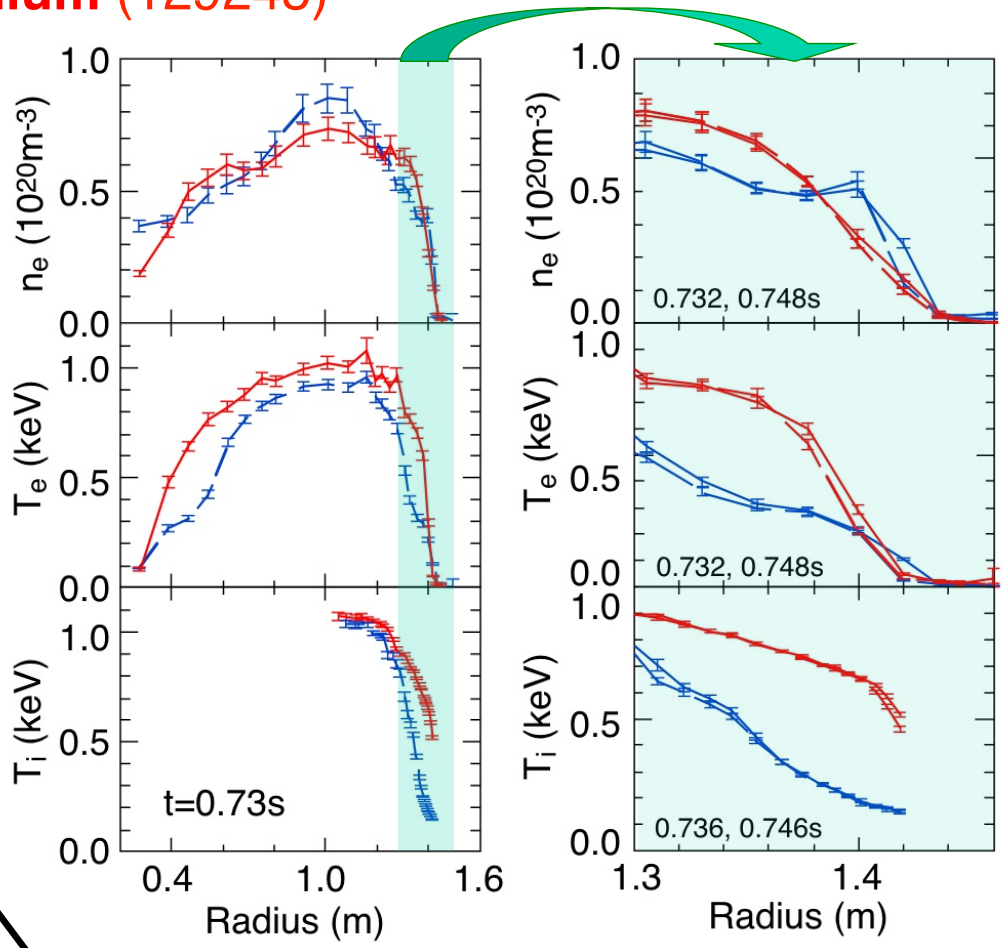
Points to be Made

- Injecting small, slow Li granules should trigger ELMs
- A simple prototype injector allows scans of size, speed and frequency so ELM physics can be explored efficiently
- Long-pulse injection possible for Dia = 0.2 - 1.5 mm, Vel = 0 - 100 m/s, Pacing Frequency = 0 - 500 Hz
- This concept allows other non-cryogenic "pellets" to be injected (Li, LiD, Be, B …)
- "Synchronized engineering masterpiece" will follow…

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

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

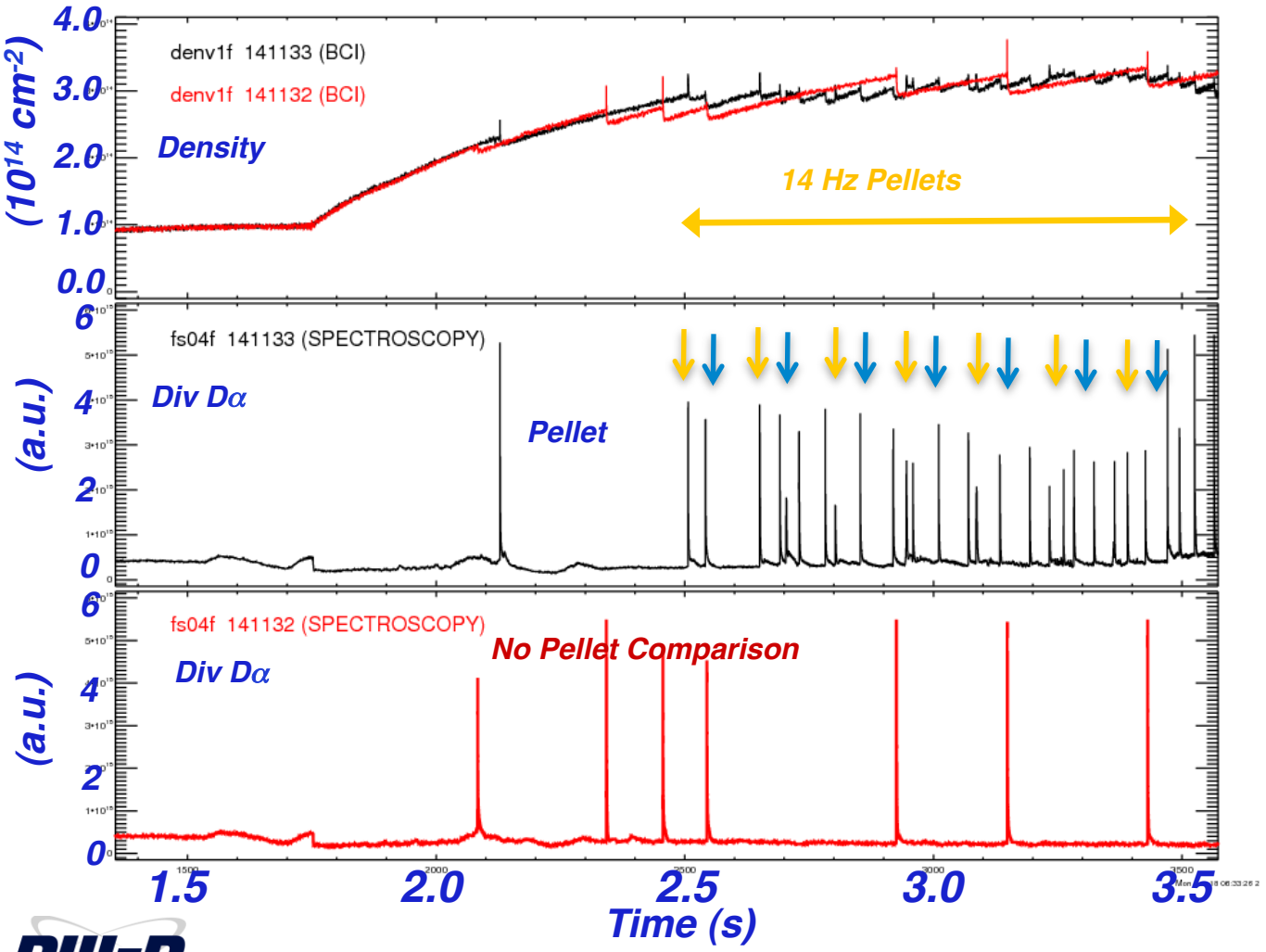


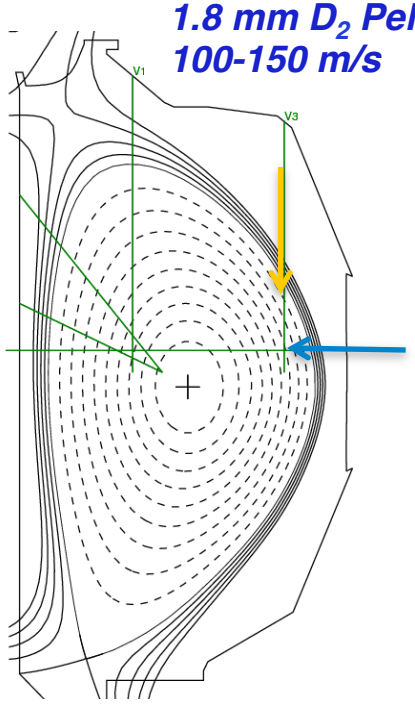


Without ELMs, impurity accumulation increases radiated power and Z_{eff}

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

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





1.8 mm D_2 Pellets
100-150 m/s

ITER shape
β_N = 1.8

Larry Baylor

DIII-D NATIONAL FUSION FACILITY SAN DIEGO

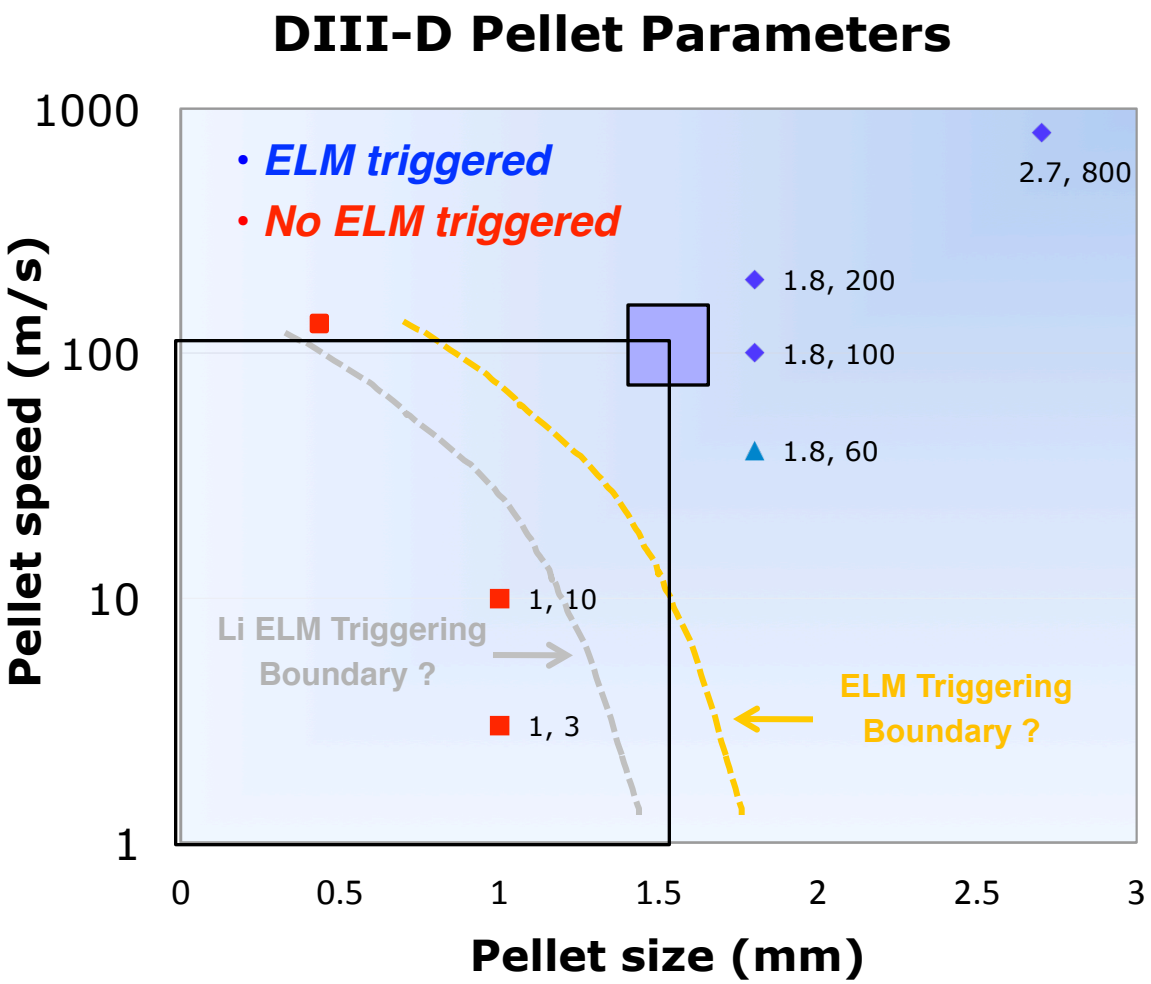
Lessons Learned from Successful ELM Pacing Experiments on DIII-D using D Pellets

- 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.



Larry Baylor

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:

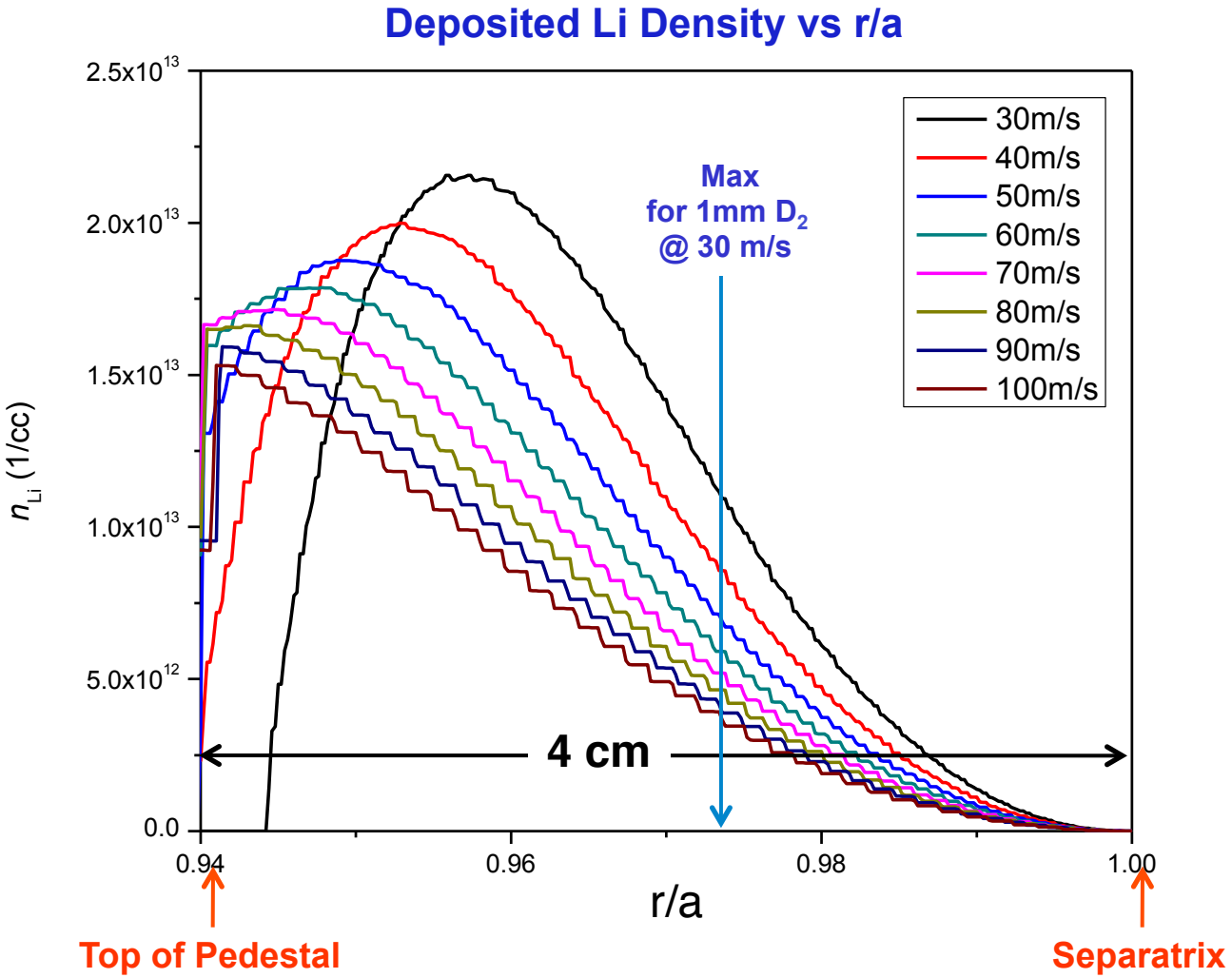
Te (r/a = 1) = 0
Te(r/a = 0.94) = 1 keV

ne(r/a = 1) = 0
ne(r/a = 0.94) = 5 x 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



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Calculated Pedestal Deposition for 50 m/s Li Granules with Diameters from 0.5 mm to 2.5 mm

Linear Temperature and Density Profiles Assumed for Pedestal:

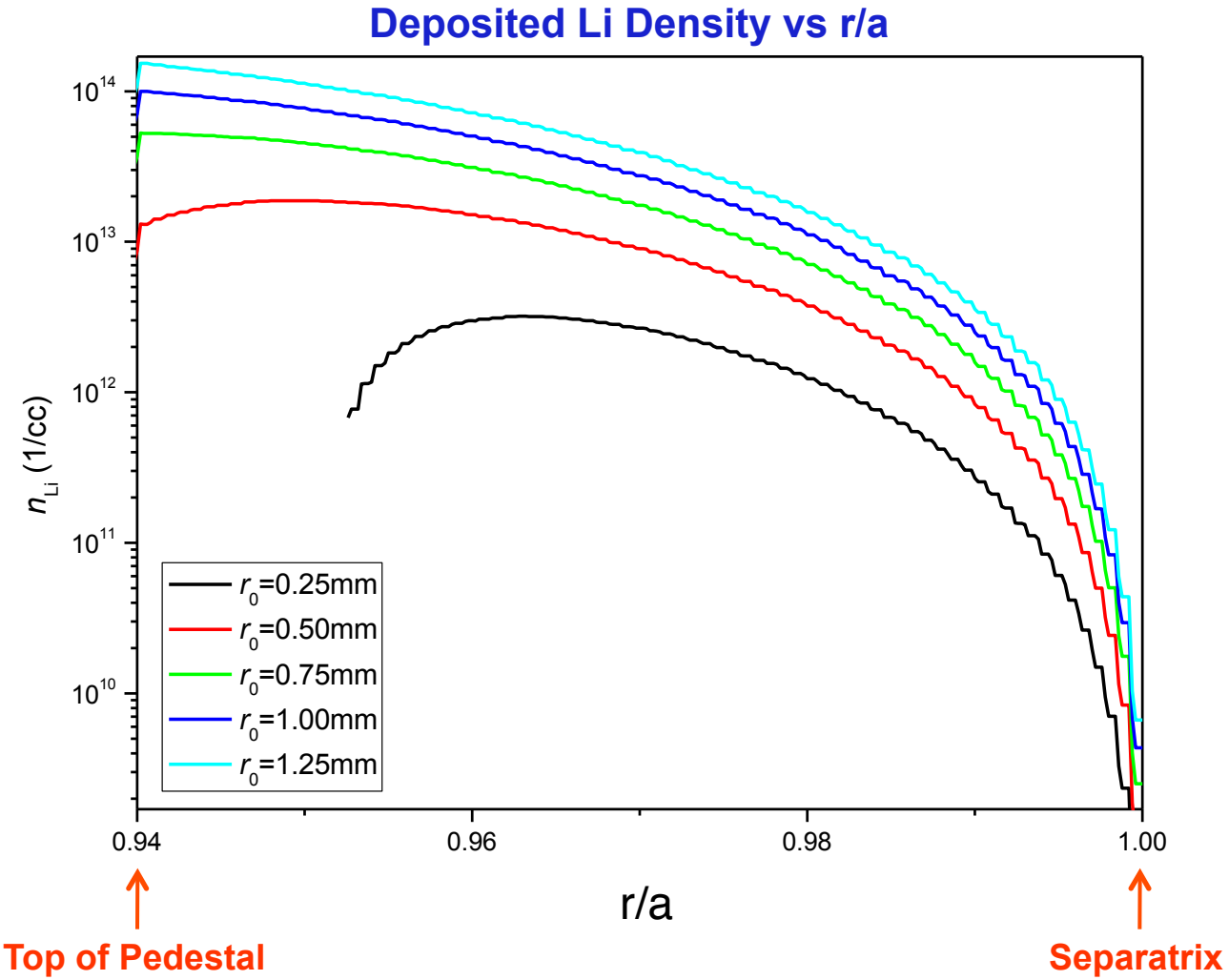
Te (r/a = 1) = 0
Te(r/a = 0.94) = 1 keV

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

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

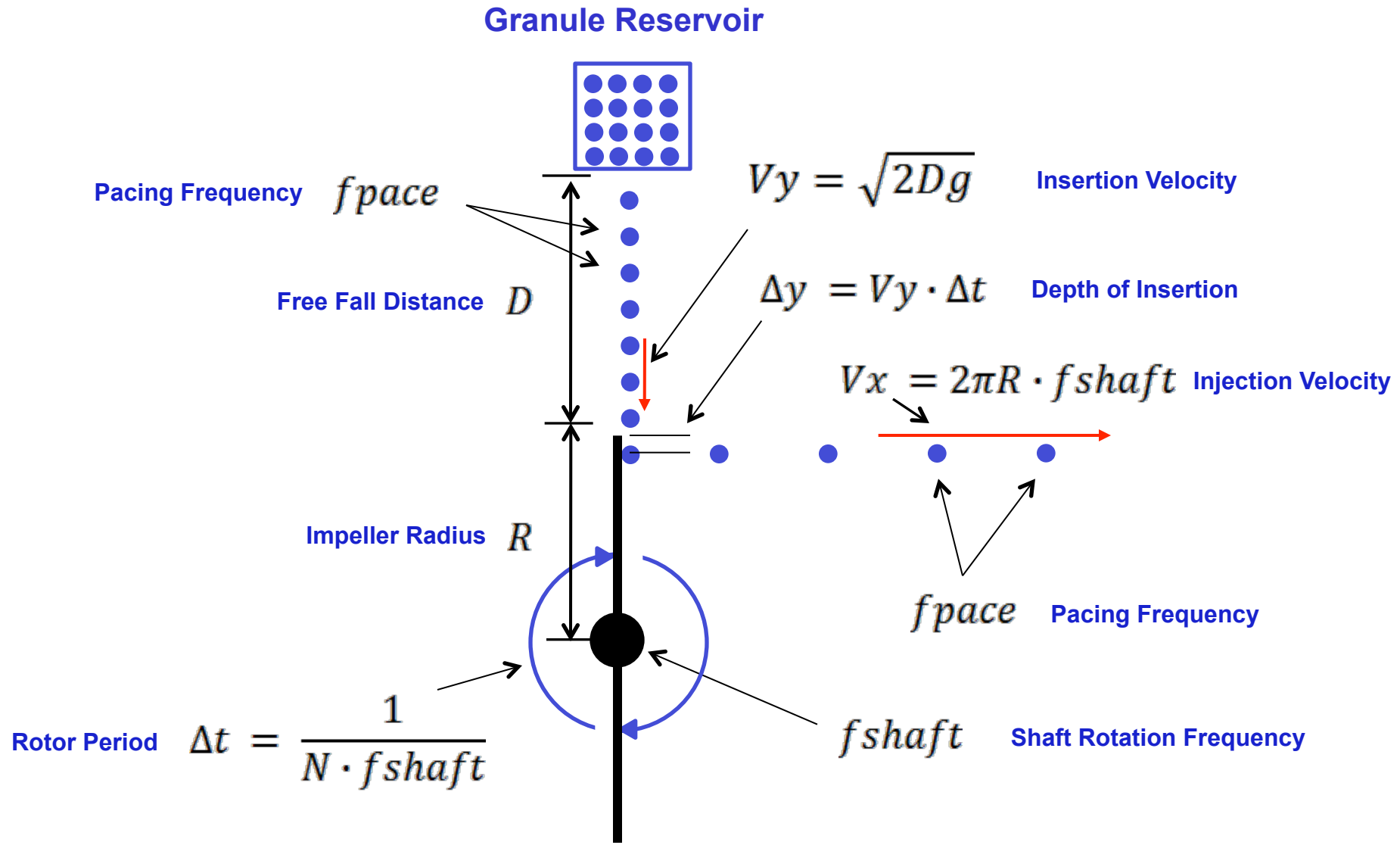
Neutral Gas Shielding Ablation Model for Li Employed

Li granules larger than d ~ 1 mm penetrate well beyond the pedestal at 50 m/s



Paul Parks, Wen Wu

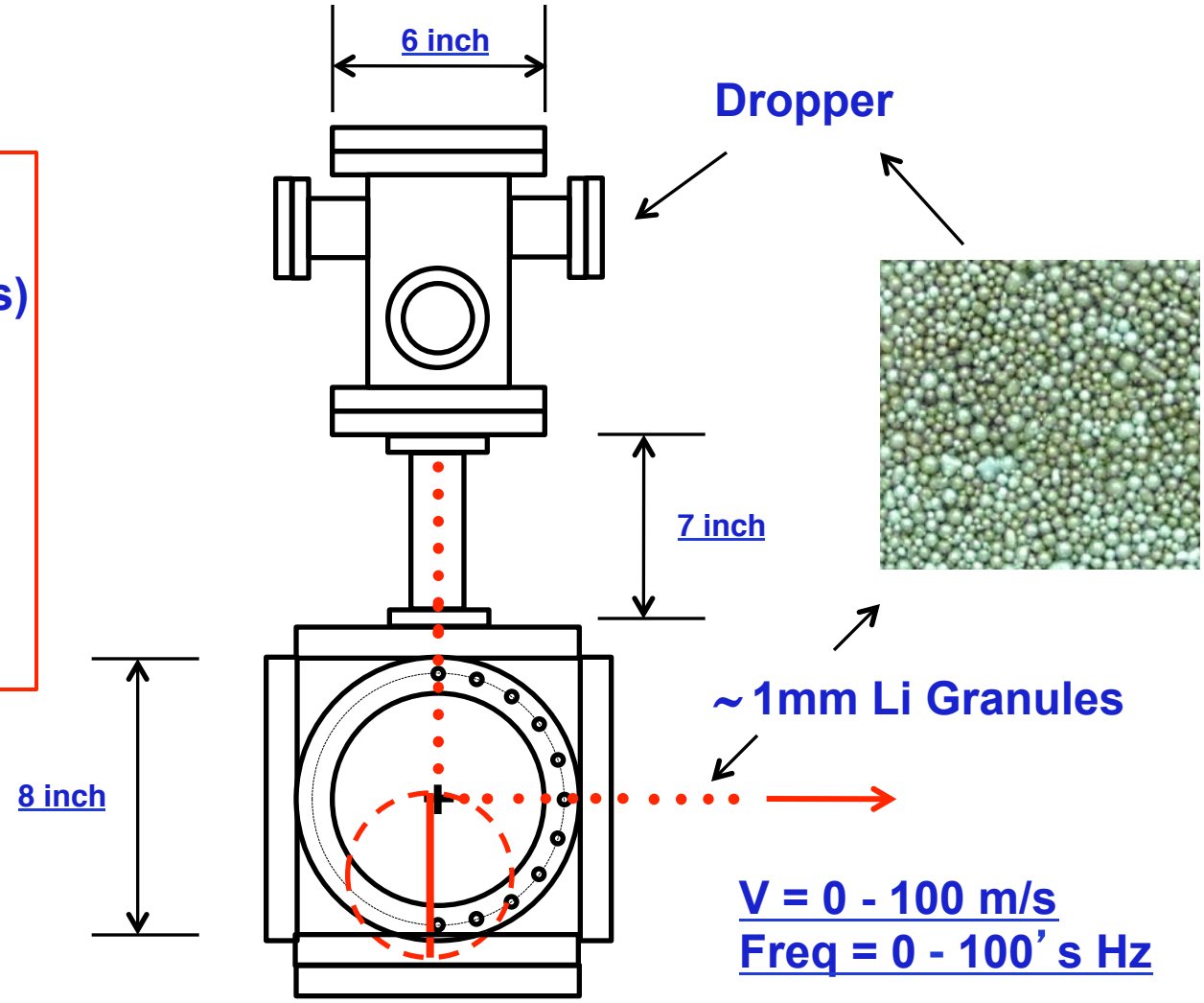
The Scheme: Redirecting an Unsynchronized Stream of Falling Li Granules with a Rotating Impeller



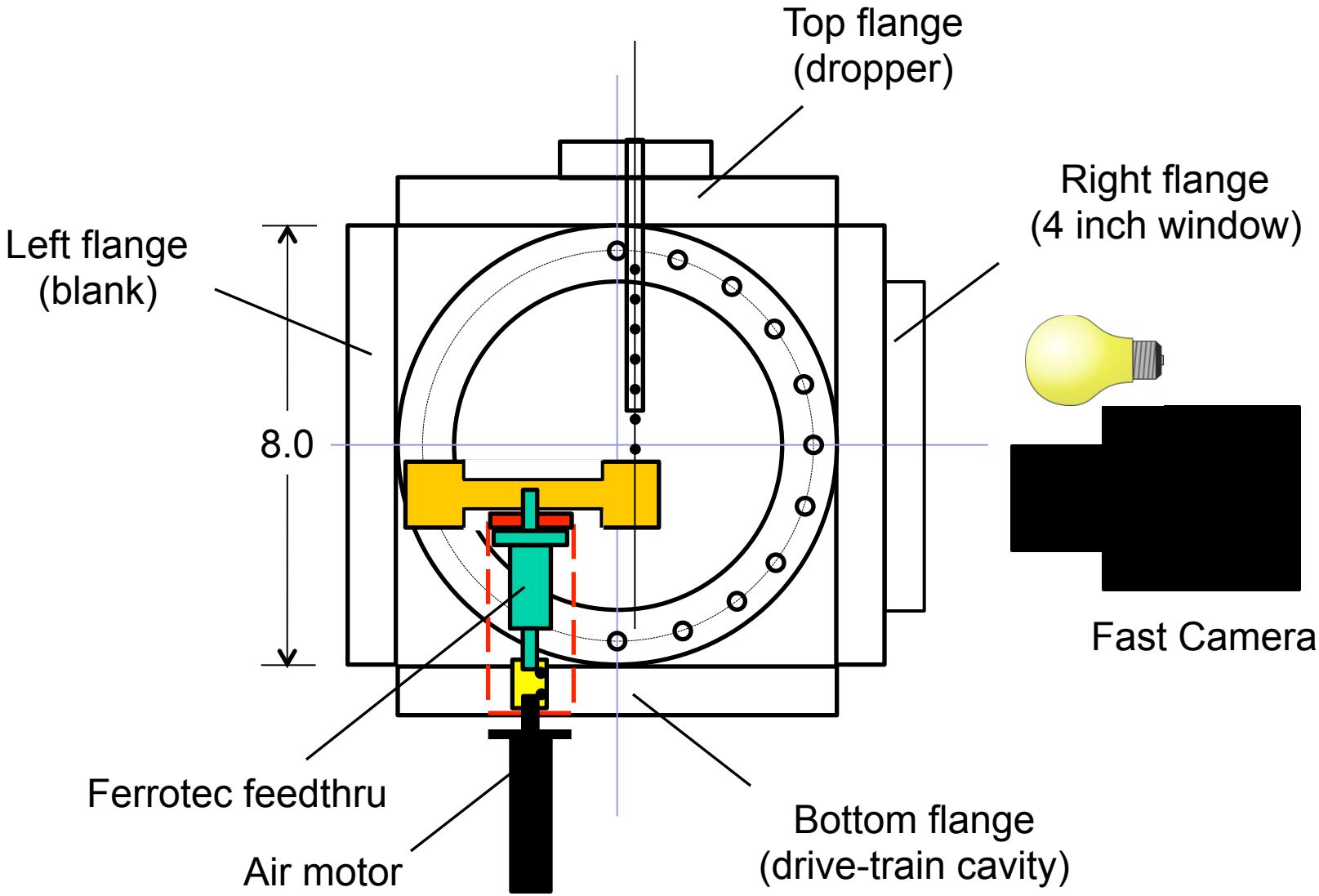
The Concept Hardware

Independent Control:

- Granule Size
  (change between shots)
- Injection Speed
  (ramp during shots)
- Pacing Frequency
  (ramp during shots)

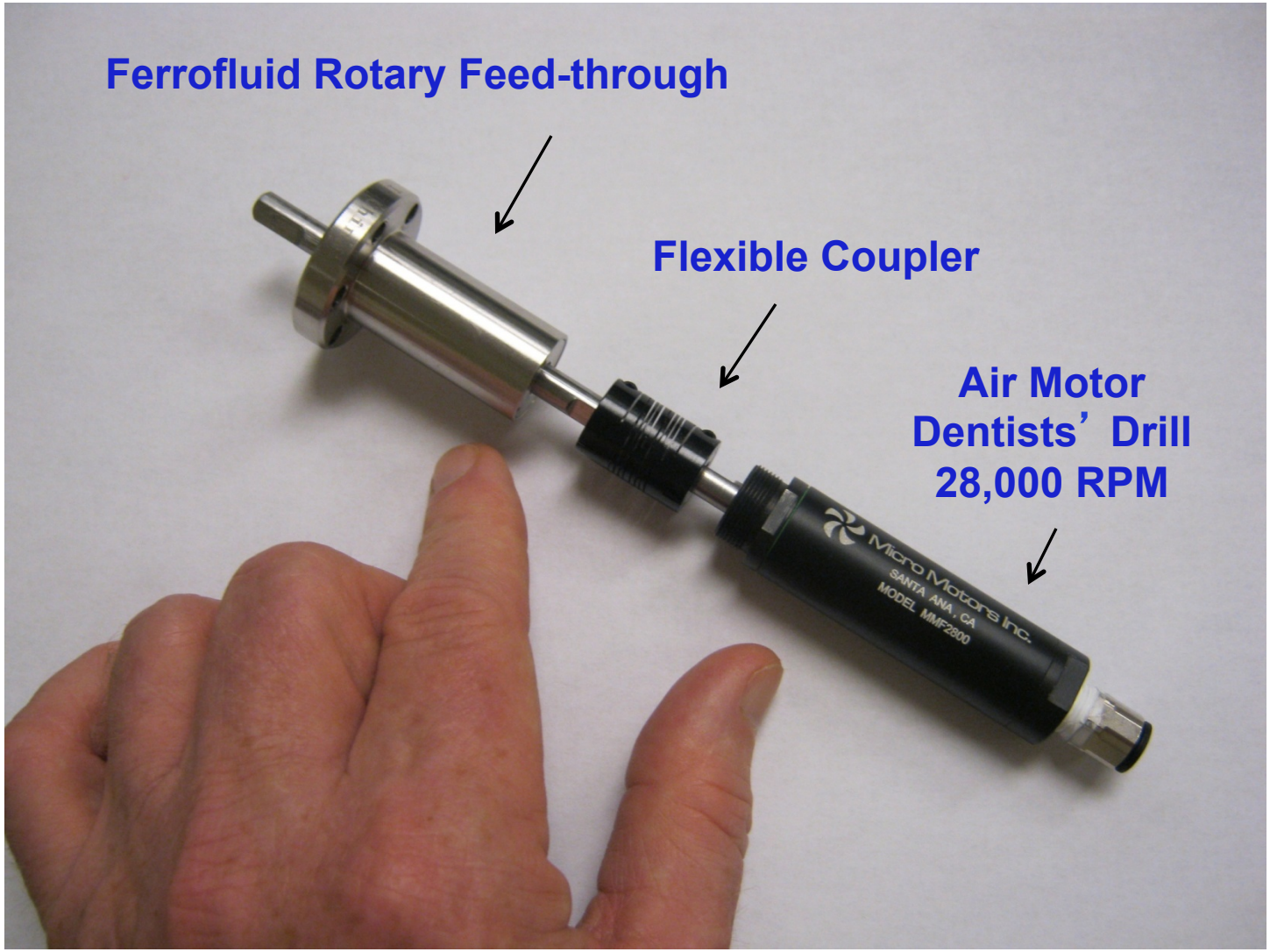


Internal Diagnostics



The Impeller / Drive Train

The Rotary Drive Train



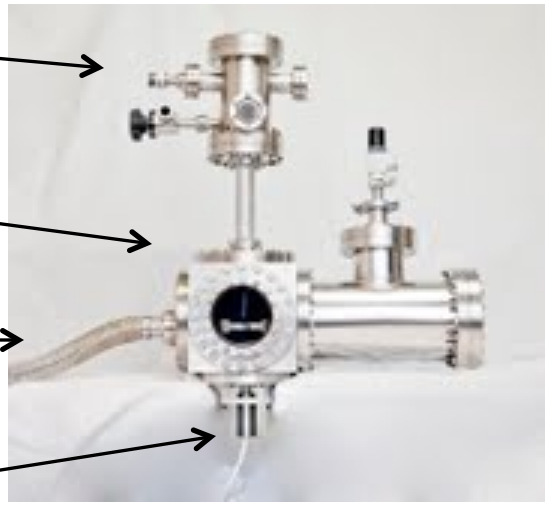
The Present Status of the Hardware

Dropper Enclosure

Impeller Enclosure

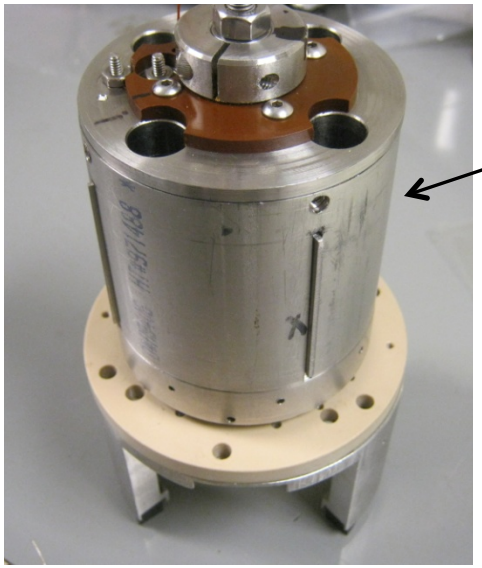
Pump-out Line

Air Motor

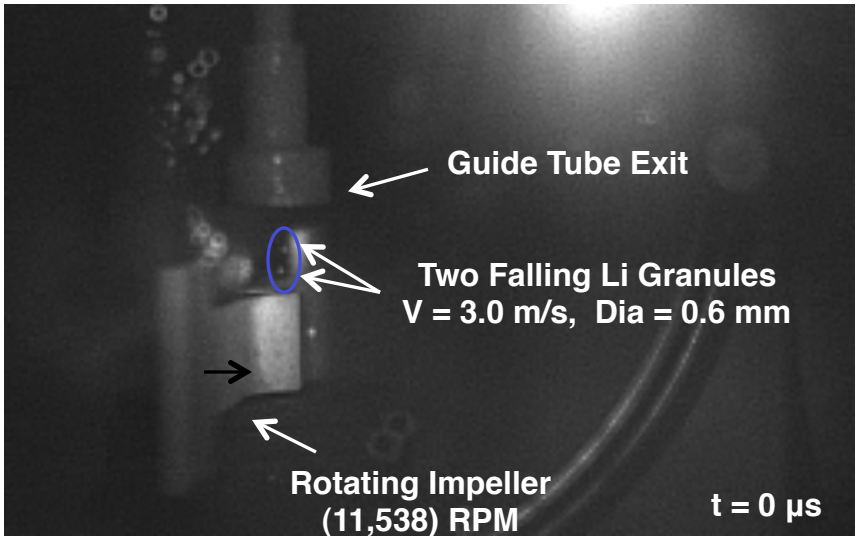


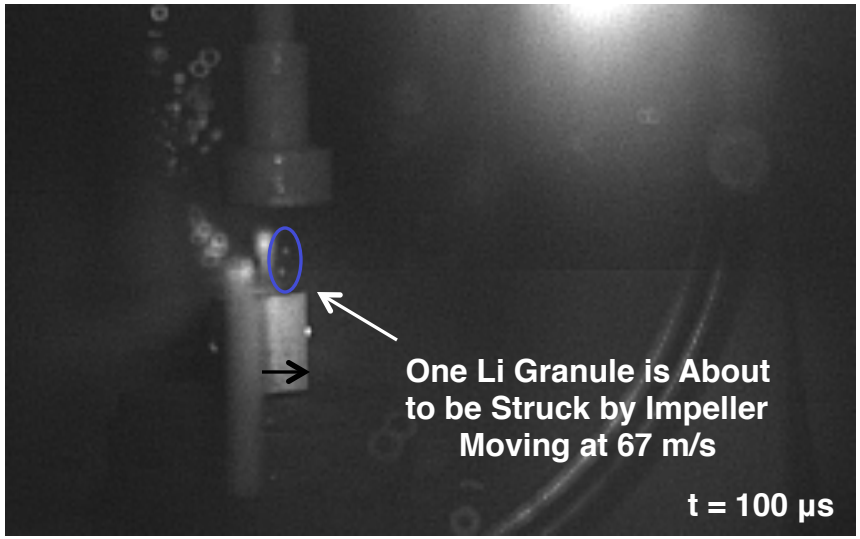
Horizontal Impeller

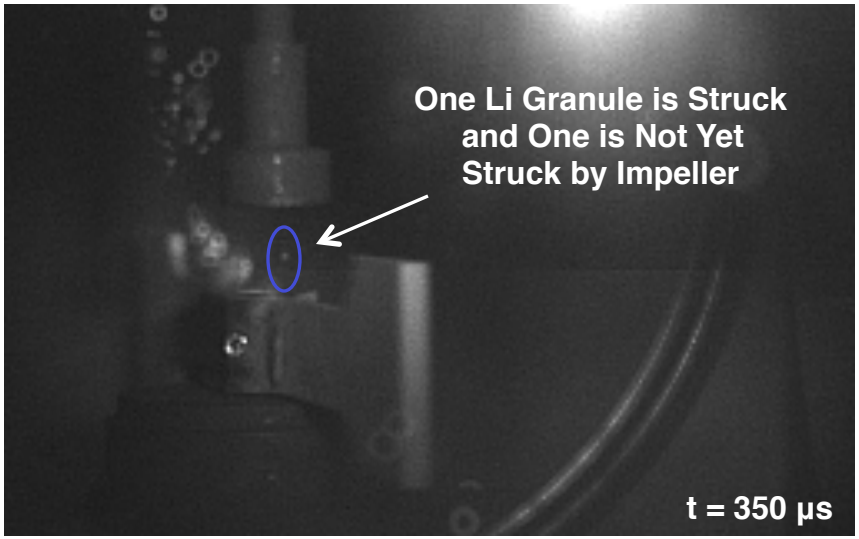
Segmented Dropper

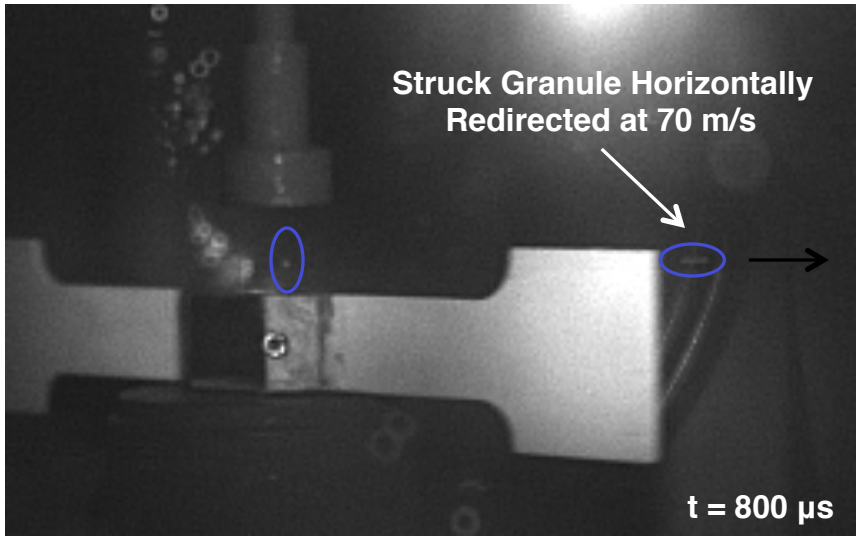


Video of Li Granules "Injected" Horizontally at ~ 70 m/s

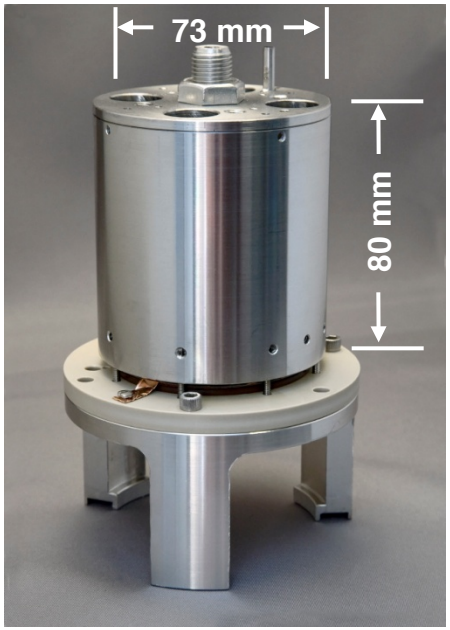


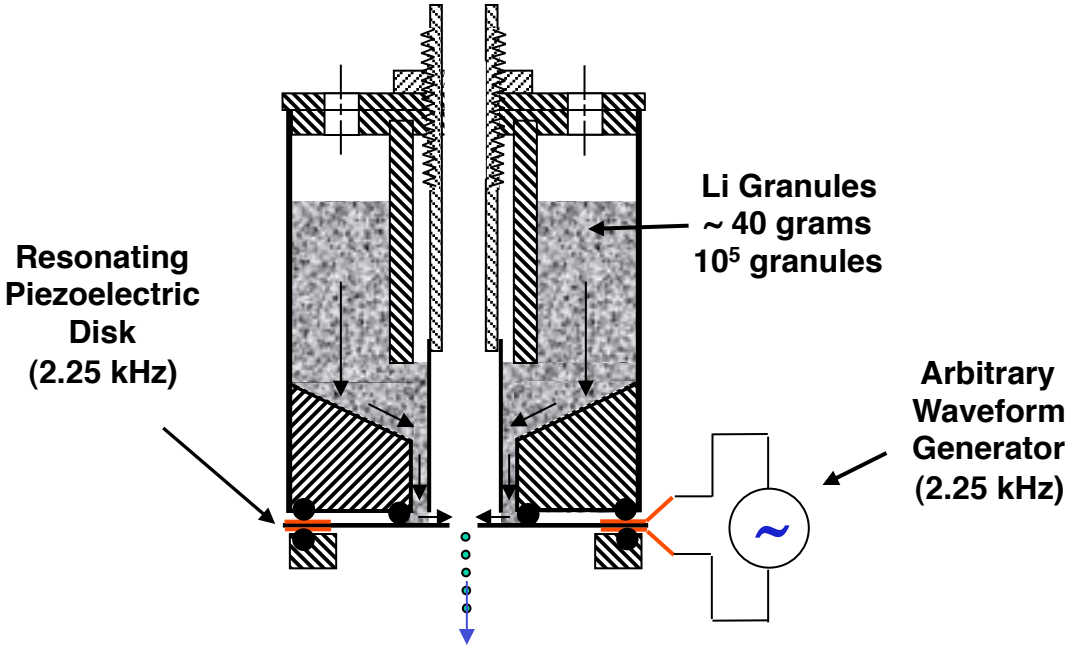






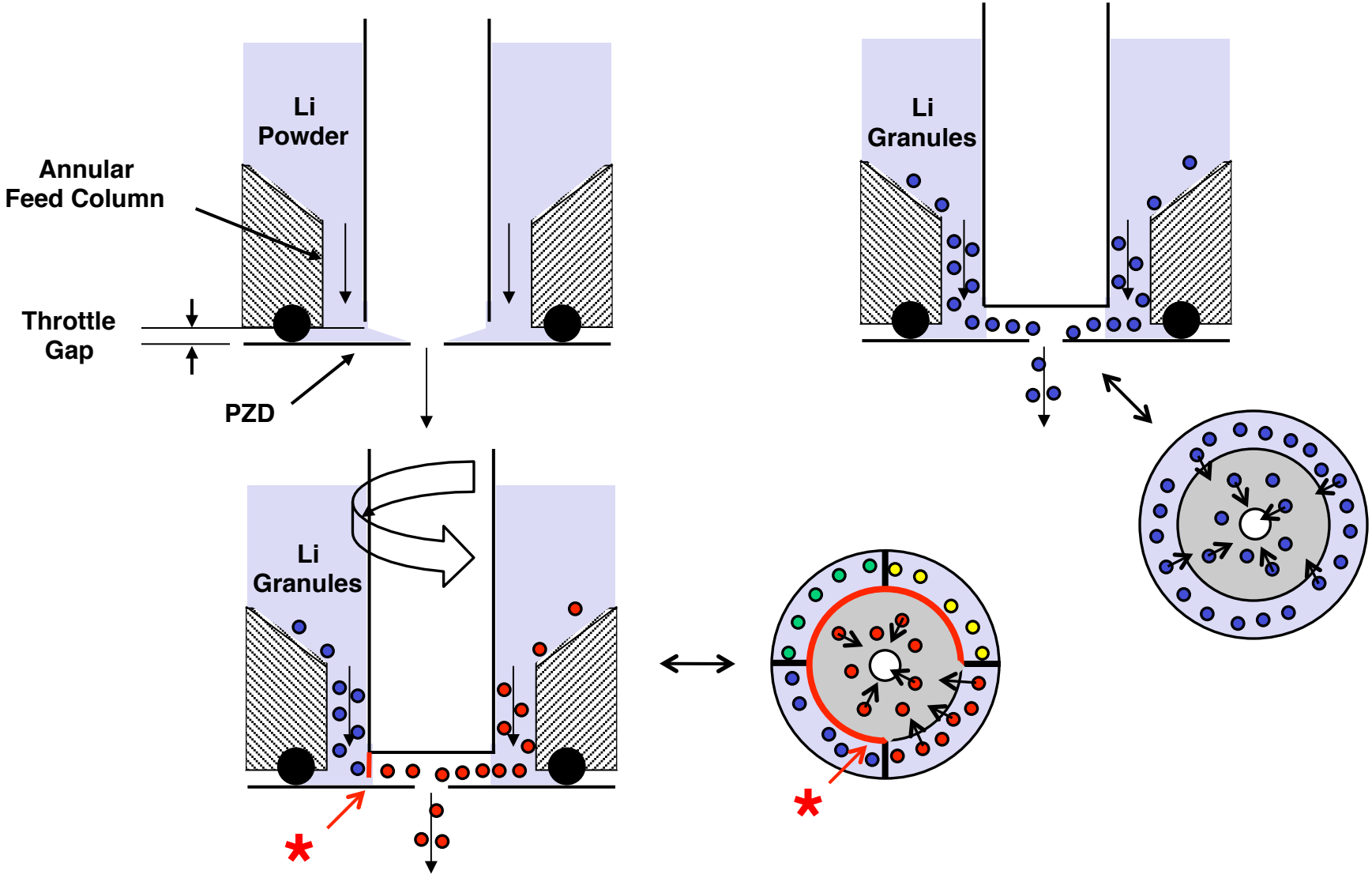
The Li Granule Dropper Apparatus (Unsynchronized)





- Has been used to inject Li powder in NSTX & EAST
- 1 mm spheres can be dropped at 0 - 150 Hz depending on voltage
- Smaller granules can drop at higher frequency - up to 500 Hz

In the Future, Granule Sizes Can be Changed Between Shots by Simple 90 Degree Rotation of Capped Throttle



Examples of Granule Injection Angular Profiles

LiD is Another Interesting Candidate for ELM Pacing

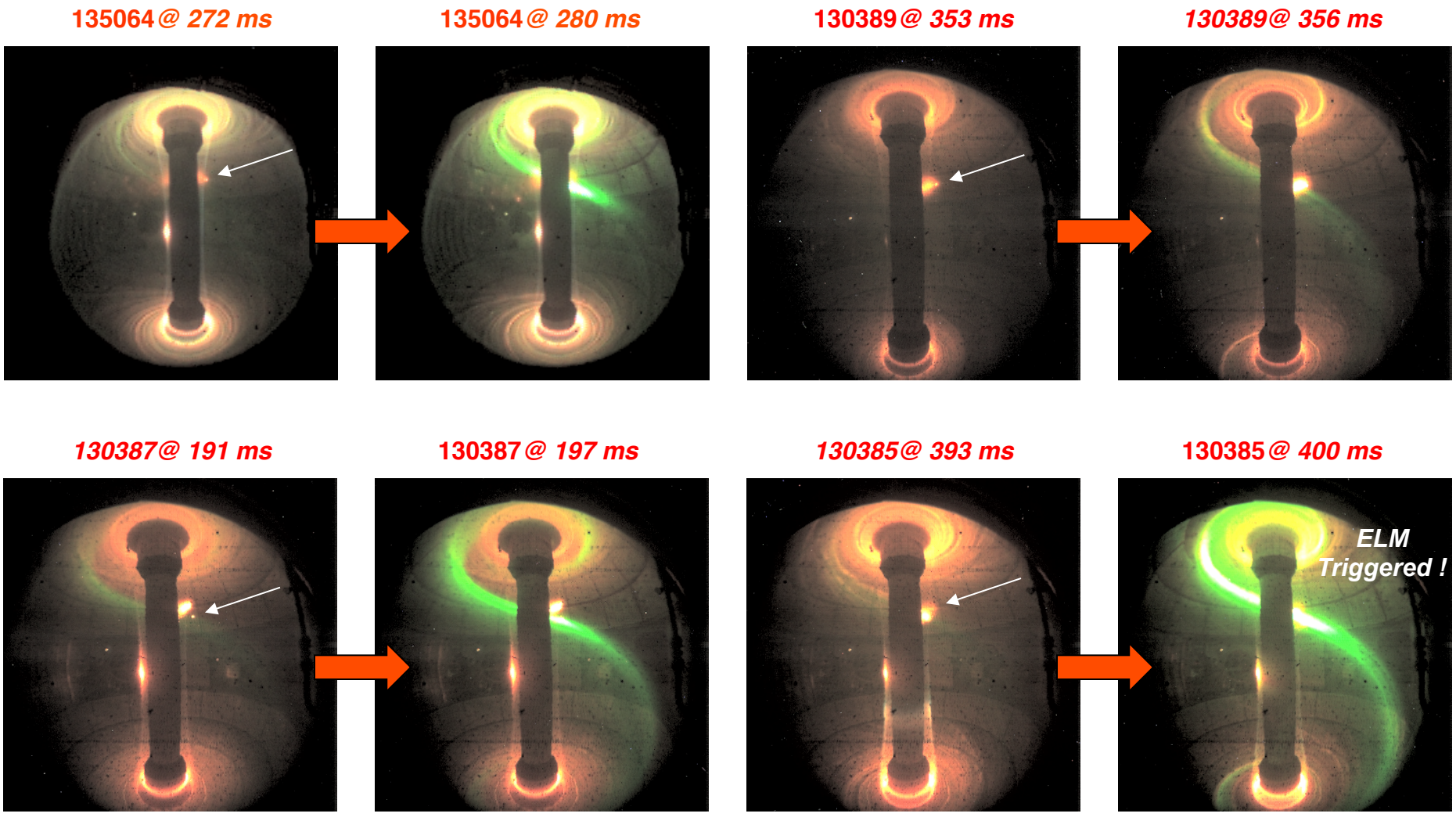
Physical Properties of D, Li and LiD

	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

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



Present Status of the Effort to Trigger High Frequency ELMs using Injected Lithium granules

- The injector hardware is built and being tested.
- Spherical Lithium granules (0.6 mm) have been horizontally redirected at speeds approaching 100 m/s.
- Dropping rates (pacing frequencies) of 500 Hz have been readily achieved.
- A dropper apparatus which allows the granule size to be changed between discharges has been built and is being tested.
- Tests on a fusion device should proceed during 2012-13.

Sign up