

Hypervelocity Dust Injection (HDI) for dust transport study and internal plasma probing

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Dust poses a new challenge to magnetic fusion

☞ Safety

- ☞ a carrier of radioactivity (tritium, neutron activation)
- ☞ explosion.

☞ Contamination.

- ☞ raise Z_{eff} of plasma
- ☞ induce disruptions to fusion plasma
- ☞ induce run-away electrons

Dust in fusion plasmas is a multi-facet problem

☞ *Dust characterization and control*

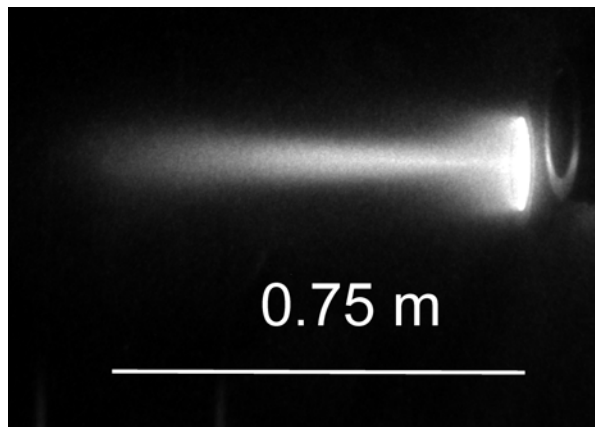
- ☞ monitor dust generation
- ☞ understand how and where dust is produced.
- ☞ identify ways to control dust inventory

☞ *Dust dynamics and its effect on fusion plasmas*

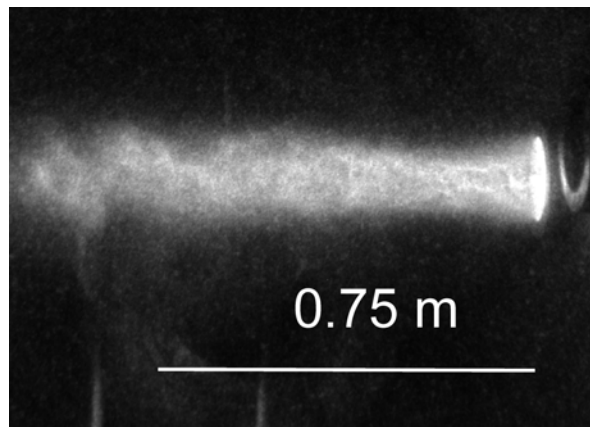
- ☞ macroscopic dust physics (effect of dust on overall performance of fusion plasma)
- ☞ microscopic dust physics
 - ☞ how does dust interact with fusion plasmas?
 - ☞ how far does dust penetrate into fusion plasmas?
 - ☞ does dust interact with fusion plasmas repetitively?

HDI performance summary

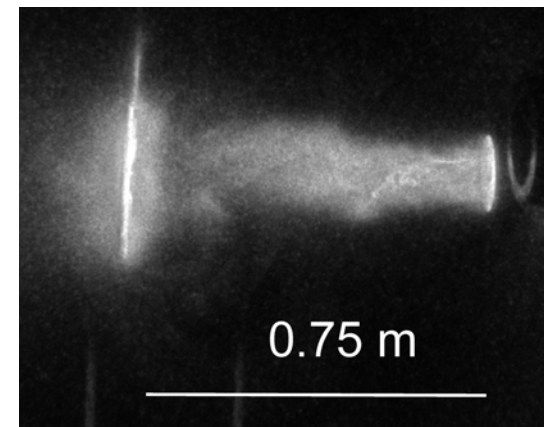
- ➡ Up to ~ 100 pieces of C dusts, $R_d = 1 - 50 \mu\text{m}$, $U_d = 1-30 \text{ km/s}$.
- ➡ High speed plasma injection $\sim 30-50 \text{ km/s}$, $n_i \sim 10^{16} - 10^{18} \text{ cm}^{-3}$
- ➡ Peak injection power $\sim 200 \text{ MW}$
- ➡ Injection duration $< 1 \text{ ms}$; one injection per NSTX shot
- ➡ Fast imaging cameras, exposure time $\leq 10 \mu\text{s}$.



5 kV, 30 μs exposure,
4 ms puff gas



8 kV, 2 exp.s of 0.5 μs ,
40 μs apart

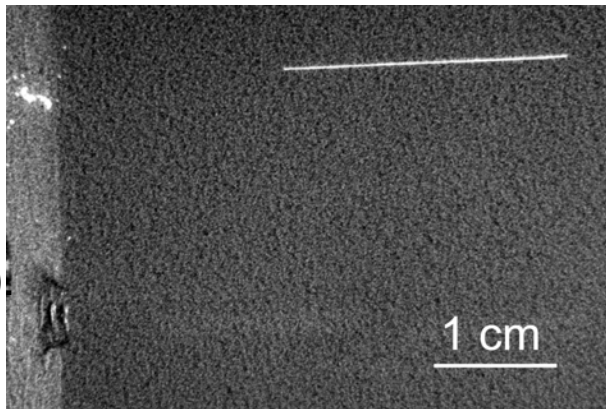


5 kV, 2 exp.s of 0.5 μs
40 μs apart, $B \sim 200 \text{ G}$
The plasma hits a target plate

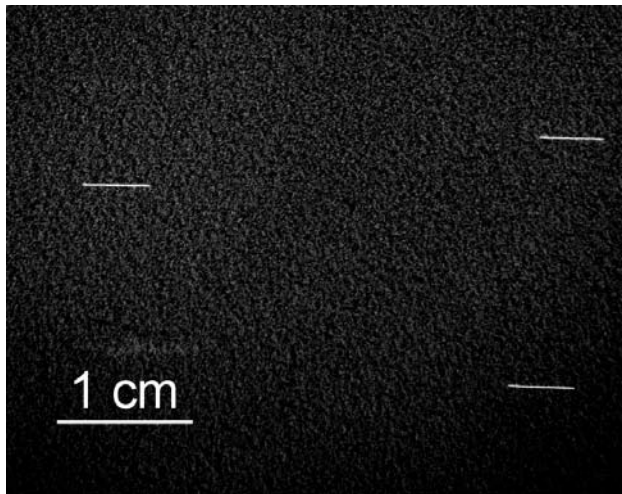
In-situ and probe measurement of dust

(Glowing grains at 1.5 m from the gun muzzle, imaged with 500 mm f/4 lens)

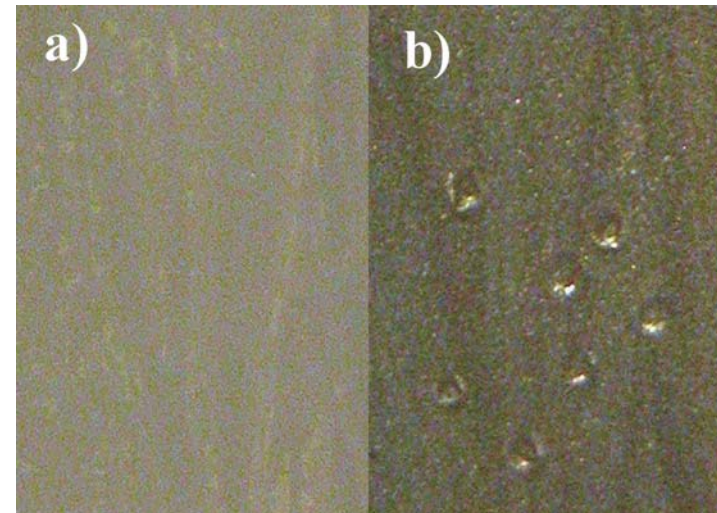
$v_d = 2.3$ km/s
(exposure $10 \mu\text{s}$)



$v_d = 1.1$ km/s
(exposure $5 \mu\text{s}$)



- dust collector probe before dust injection (a)
- thin layer of dust after 10 shots (b)
- craters with sizes of 10-100 times the dust diameter (b).



Physics topics for HDI research on NSTX

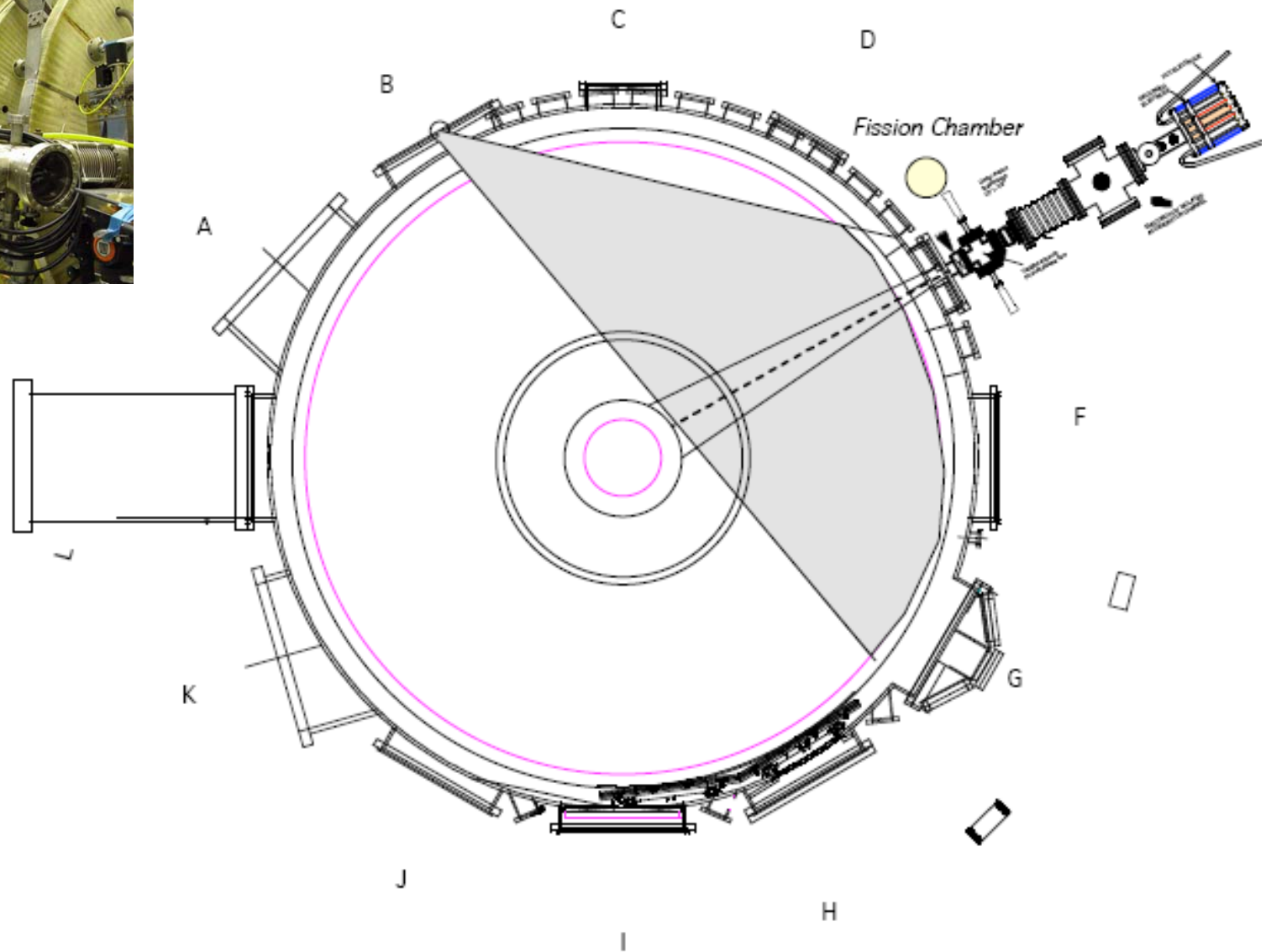
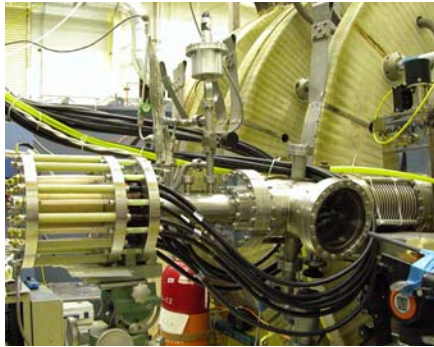
☞ *Plasma Boundary Interfaces*

- ☞ Dust transport studies in NSTX
- ☞ Dust-plasma interaction physics
- ☞ Use of HDI to probe pedestal

☞ *Macroscopic Plasma and Dust Physics*

- ☞ Internal magnetic structure measurement
 - ✦ Measurement of multiple magnetic field vectors
 - ✦ Magnetic island visualization
 - ✦ MHD mode studies
- ☞ effect of dust on Z_{eff}

Proposed HDI setup for NSTX



Research approach

👉 Piggyback and dedicated XP's

⇒ dust imaging using fast cameras (top view, Bay E; side view, Bay B, view from behind, Bay E)

⇒ Input from other diagnostics for data analysis (Thomson scattering for density and temperature distribution, fast probes for edge plasma properties, B-field, flow measurements)

👉 Collaboration with modeling.

⇒ UCSD –DUSTT code to simulate dust transport

⇒ Bench codes and achieve better understanding about dust transport in fusion plasmas