Hypervelocity Dust Injection (HDI) for NSTX internal magnetic field mapping

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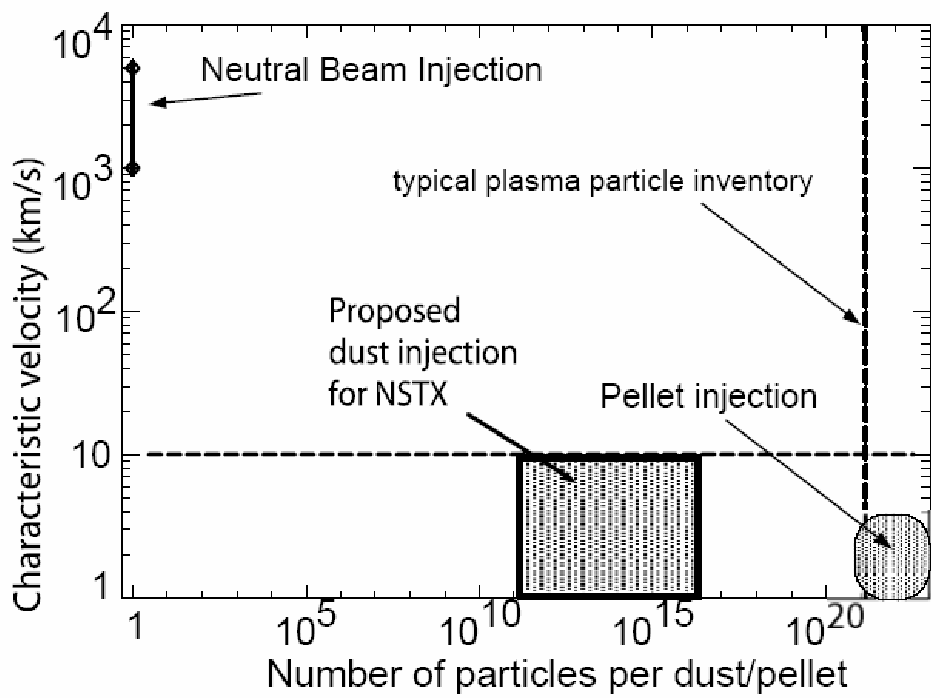
What is HDI?

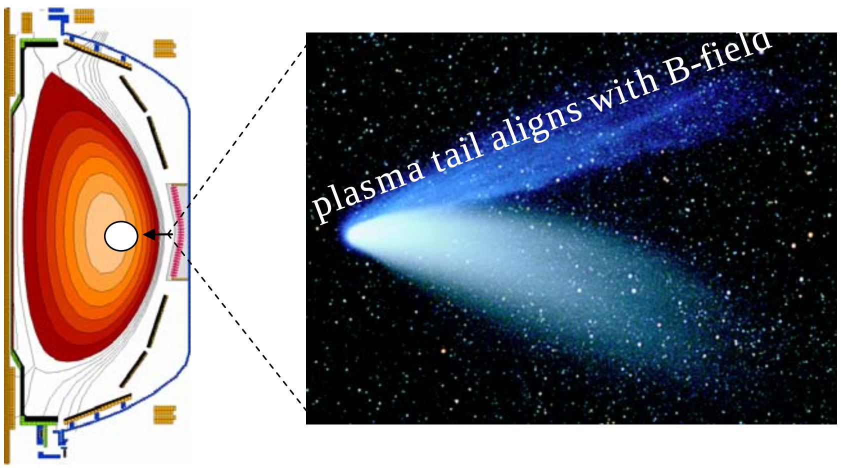
- Use C or LiD dusts to be compatible (non-invasive) with NSTX and other high-temp. plasmas, R_d = 1 - 50 μm, V_d up to 30 km/s.
- Dust trajectories unaffected by magnetic field, $Q_d/M_d \ll e/M_p$



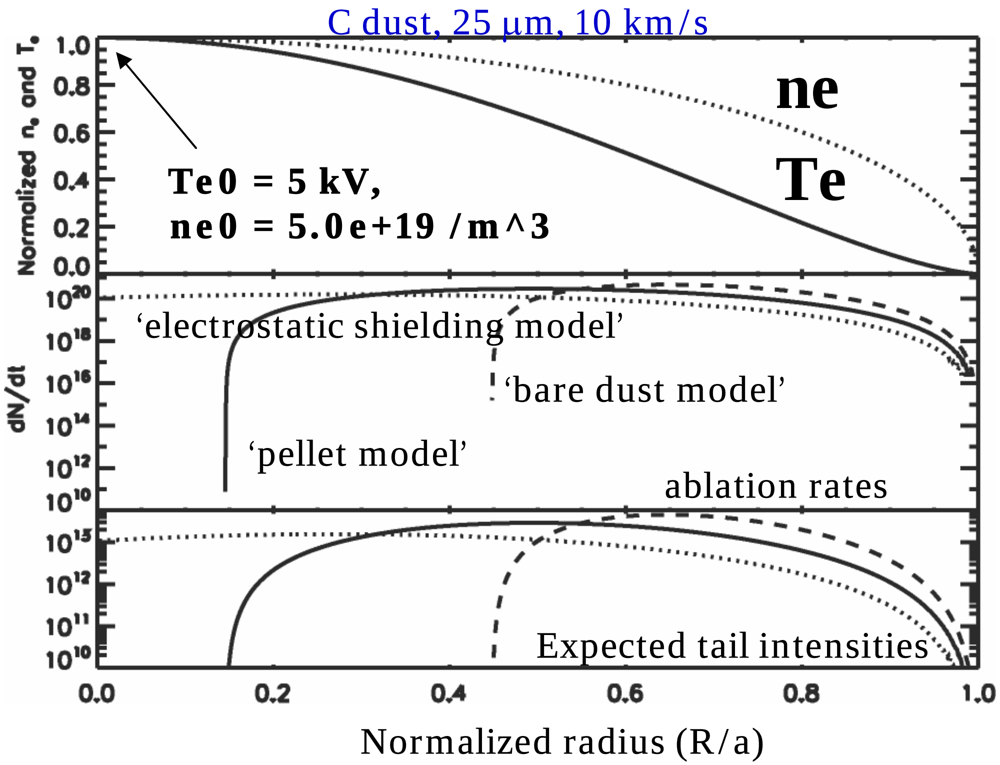
Z. Wang and G. A. Wurden, *Rev. Sci. Instrum*. **74**, 1887 (2003).

How does HDI measure internal B?

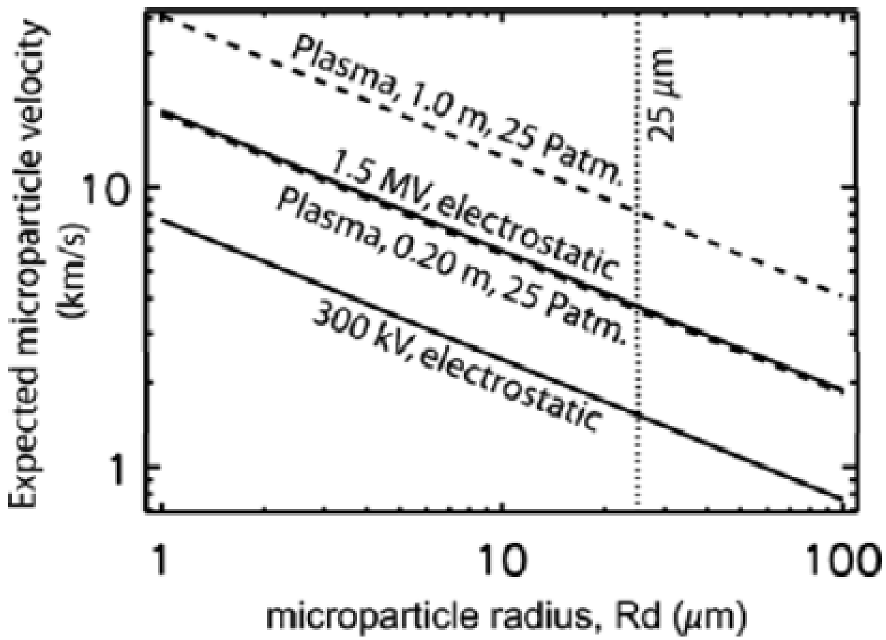
- High resolution imaging of the emitted dust plumes formed due to ablation can provide the orientation of the local magnetic field.
- mapping of the field lines ("plasma tails of each dust") is possible when multiple plumes (~ 100 dust pieces) are recorded using fast cameras.
- Dust will be accelerated to hypervelocities (up to 30 km/s) so that they can reach the core of the NSTX plasma



Z. Wang and G. A. Wurden, *Rev. Sci. Instrum.* **75**, 3436 (2004).



A coaxial plasma gun is chosen to accelerate the dust



Z. Wang, C. M. Ticos, L. A. Dorf, and G. A. Wurden, IEEE Trans. Plasma. Sci. **34**, 242 (2006).

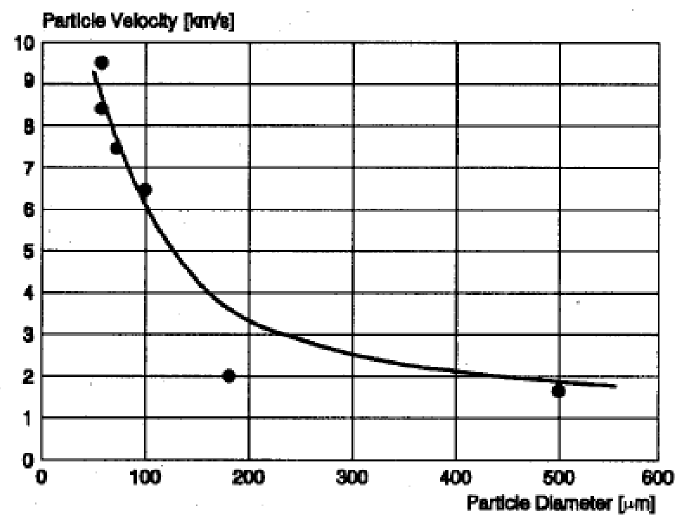
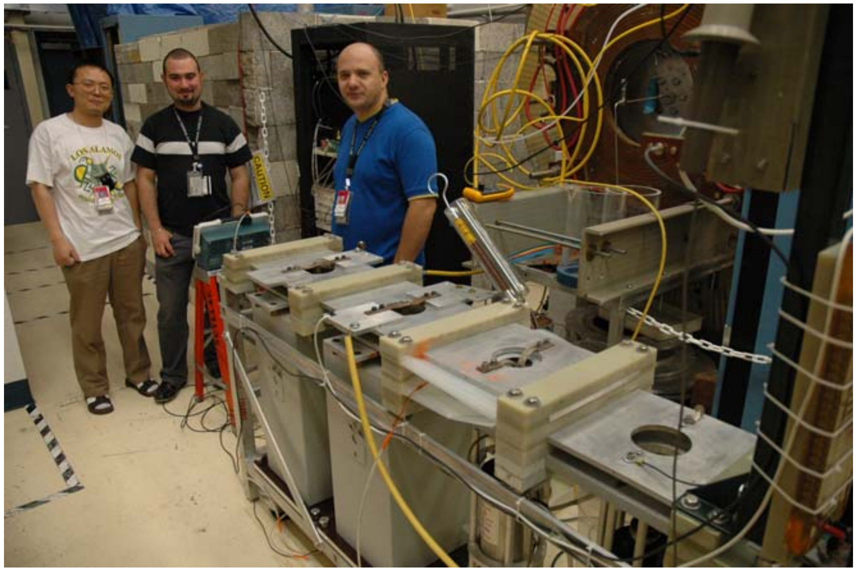


Fig. 4: Performance of the accelerator at LRT compared to experimental data (charging voltage 15 kV).

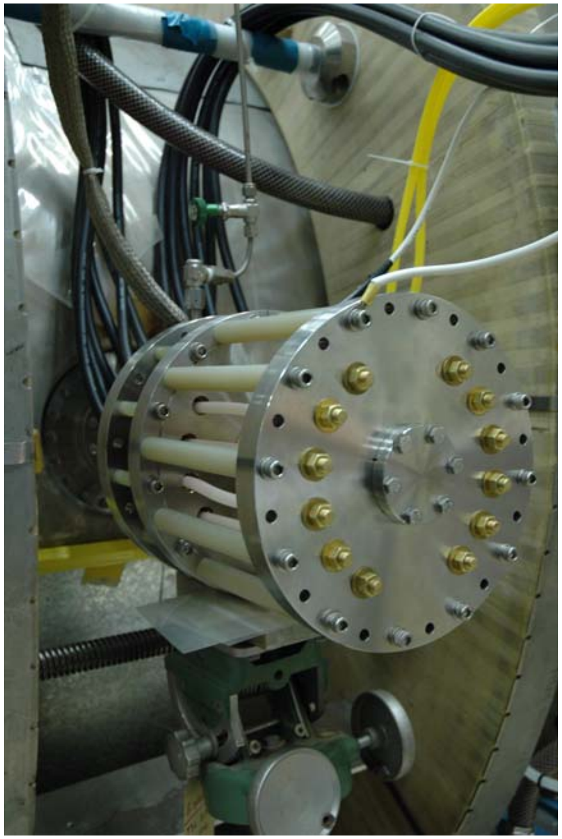
P. Thomas, E. Igenbergs, H. Tamura, and A. B. Sawaoka, IEEE Trans. Mag. **29**, 609 (1993).

HDI hardware overview



(1 mF, 10 kV capacitor bank)

(dust dispenser with remote control)



(compact coxial plasma gun)

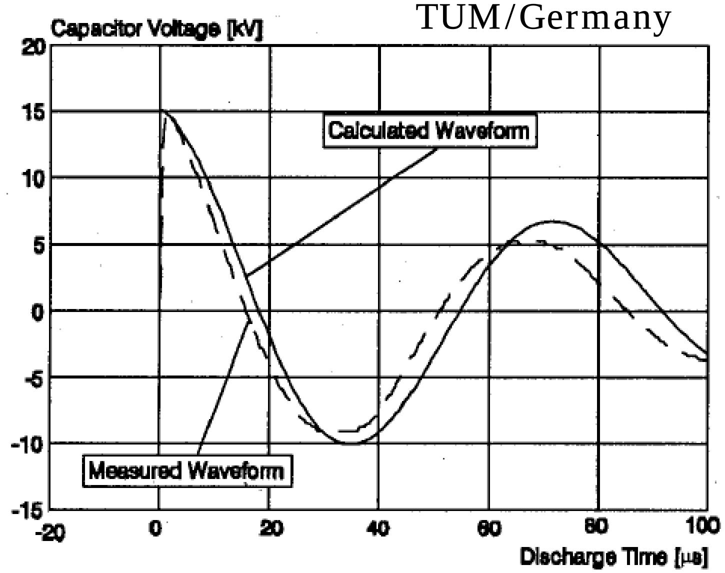
C. M. Ticos, Z. Wang, L. A. Dorf, and G. A. Wurden, '**A Plasmadynamic Hypervelocity Dust Injector for the National Spherical Torus Experiment**,' *Rev. Sci. Instrum.* accepted for publication (2006).

IV characteristics of the plasma accelerator

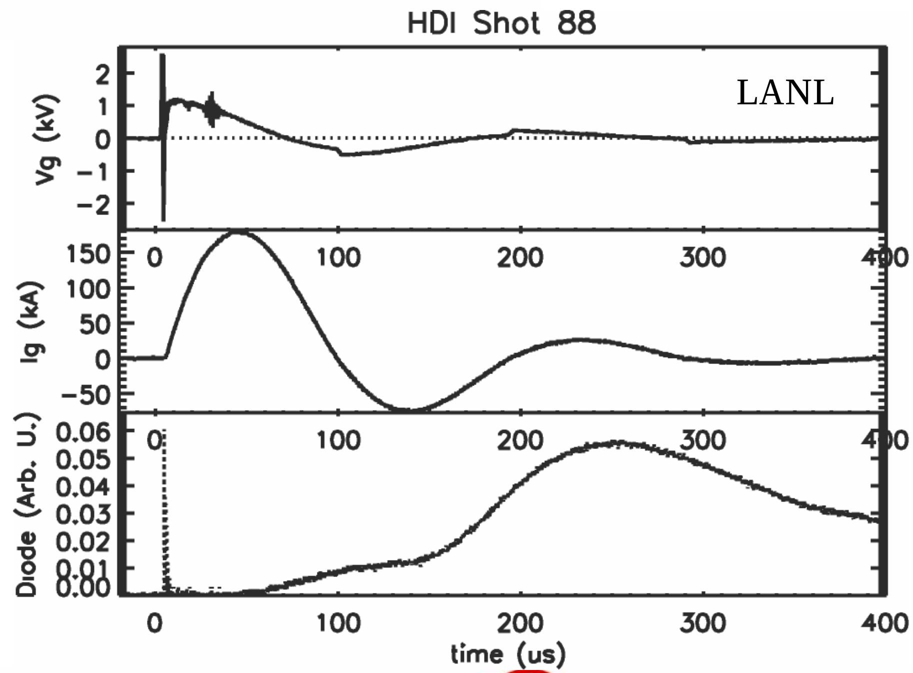
Comparison of the LANL plasma gun with a German gun

Parameters	LANL	TUM
Maximum charging voltage	10 kV	16 kV
Capacitance	1 mF	0.35 mF
Inductance	<1 mH	0.33 mH
Resistance	1 - 5 mΩ	4.65 mΩ
Length of coaxial accelerator	0.2 - 1.0 m	0.16 m
Center electrode diameter	1.3 cm	1.2 cm
Coaxial gap	1.0 cm	1.0 cm
Propellant	D_2, He gas	Al foil,

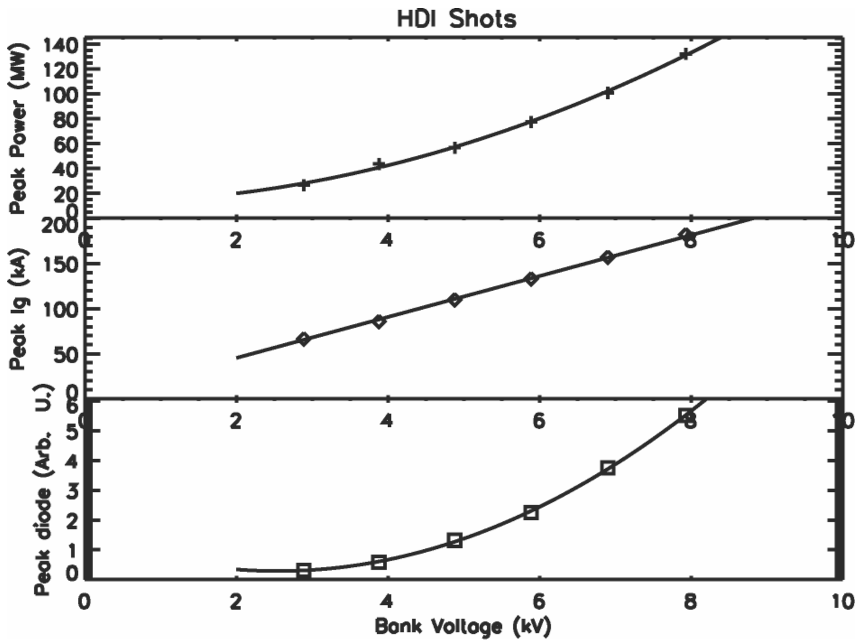
TUM/Germany

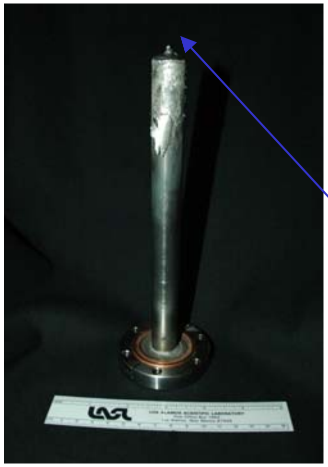


P. Thomas, E. Igenbergs, H. Tamura, and A. B. Sawaoka, IEEE Trans. Mag. **29**, 609 (1993).

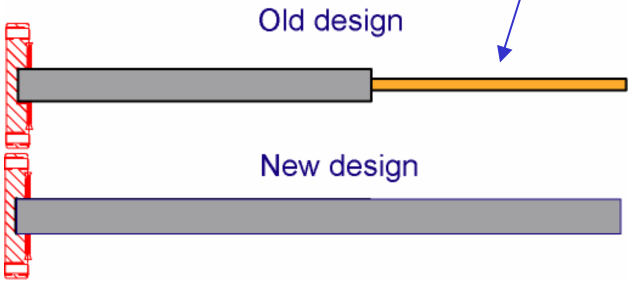


Testing of the plasma accelerator for ~ 100 shots



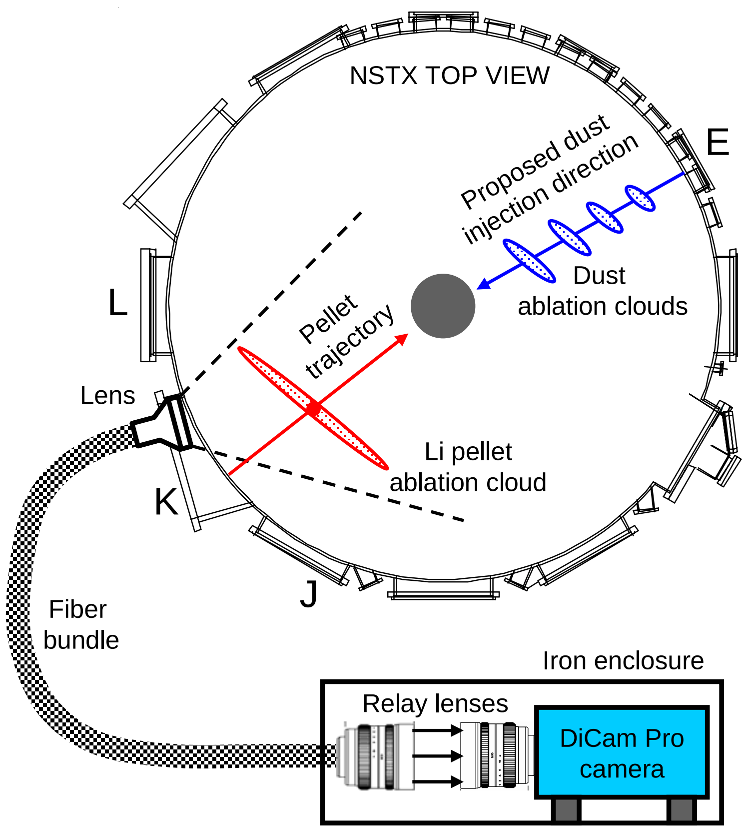


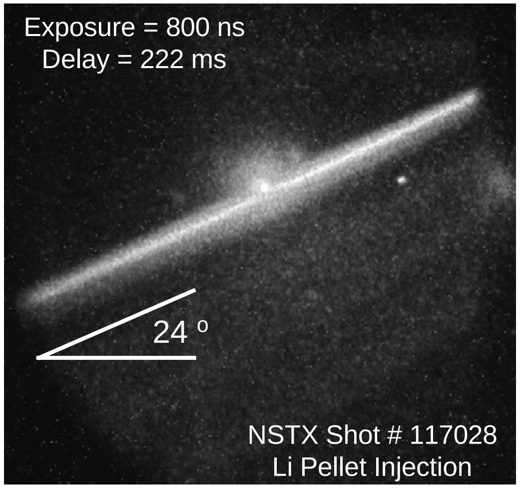
Broke off

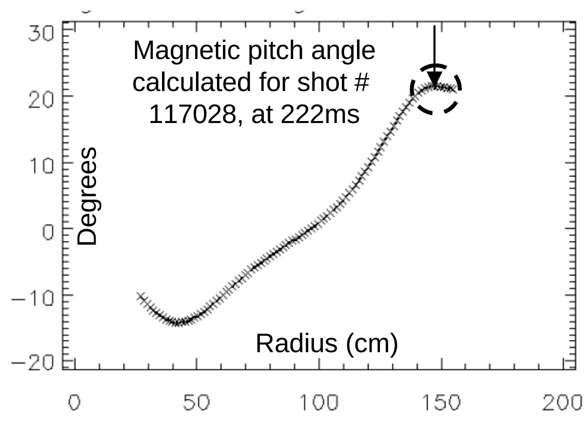


- Capacitor bank energy: up to 50 kJ, maximum power ~ 140 MW.
- Total D2 gas load, 10 to 100 TorrLiter
- Severe damage to the gun center electrode was observed.
- Second round of testing using modified coaxial gun is underway.

Imaging system has been tested in NSTX







L. A. Dorf, A. L. Roquemore, G. A. Wurden, C. M. Ticos, and Z. Wang, '**Imaging system for hypervelocity dust injection diagnostic on NSTX**.' *Rev Sci. Instrum*. Accepted (2006).

Summary

- A hypervelocity dust injection (HDI) system has been constructed at LANL for internal magnetic field line mapping in NSTX.
- The dust dispenser, imaging system, pulsed power system, and controls have been tested separately.
- Initial testing of the plasma accelerator has done.
- A second round of plasma gun operation, also with dust, is underway.
- A preliminary design review between LANL/PPPL to look at the injector specs/machine impact issues will be needed in early FY07.