# Hypervelocity Impact Phenomena

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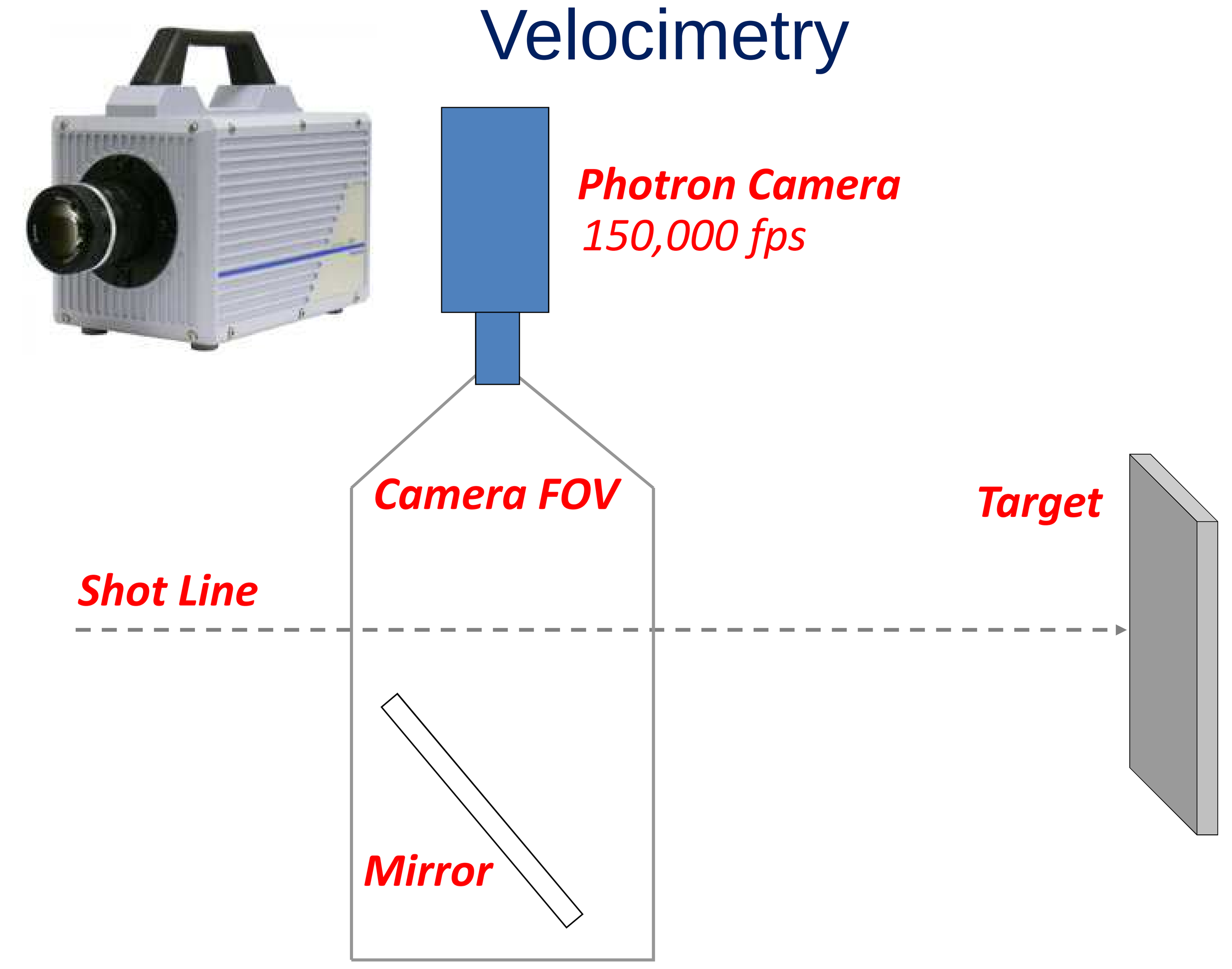
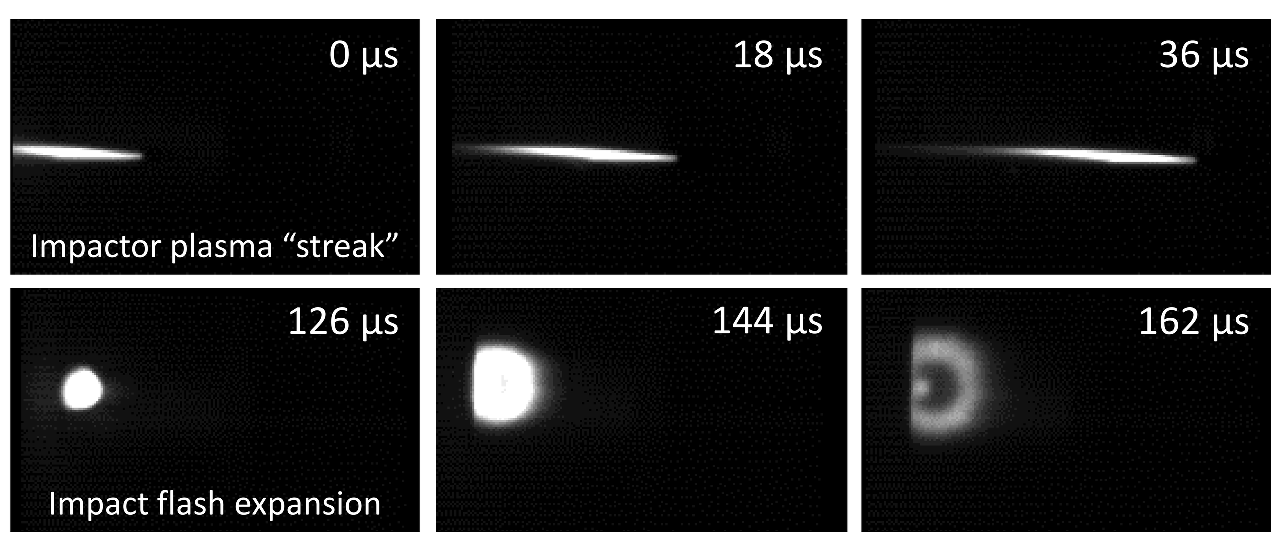
## Velocimetry

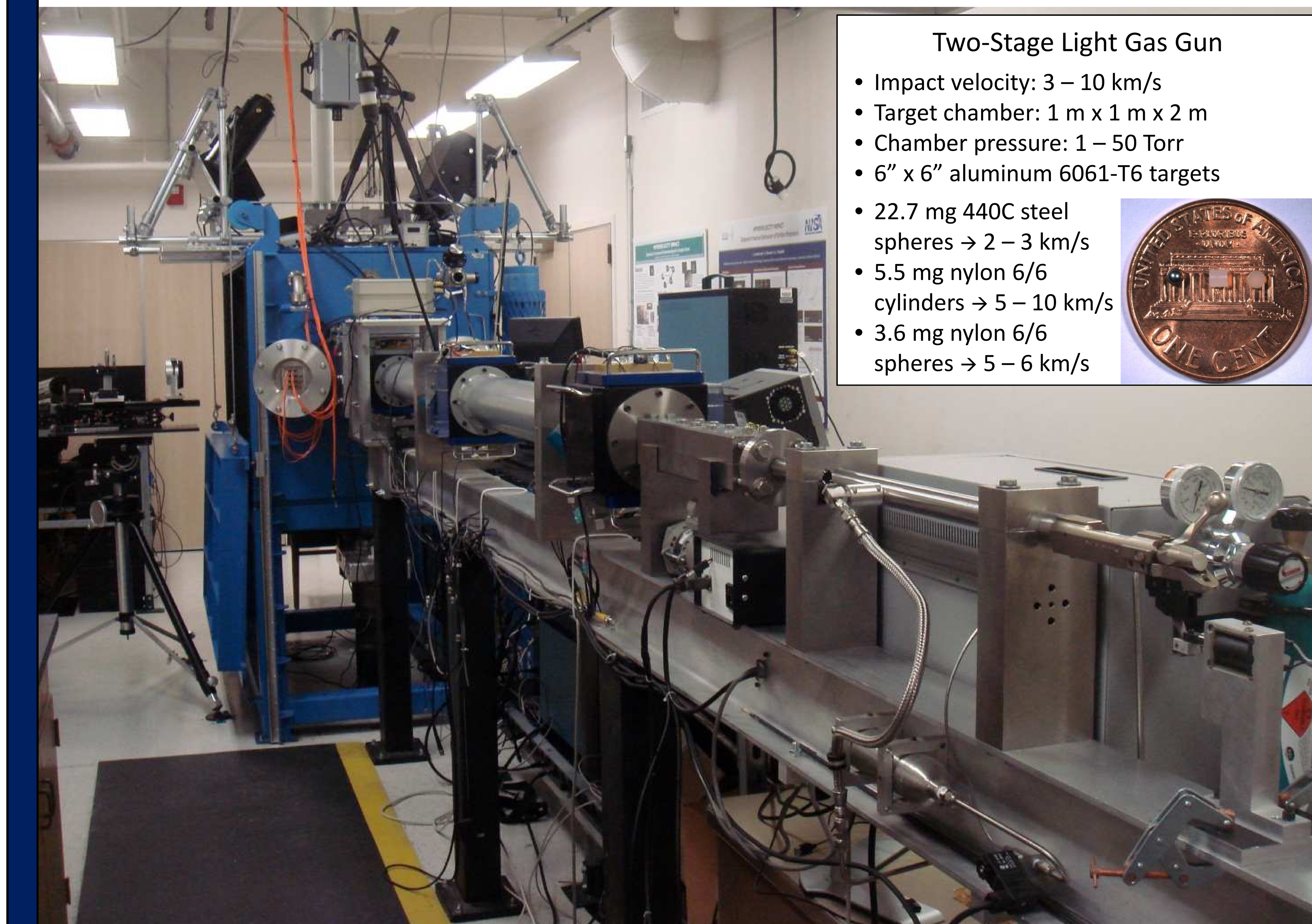



Impactor ionizes atmosphere, producing a plasma sheath

Impact speed determined by tracking the plasma sheath

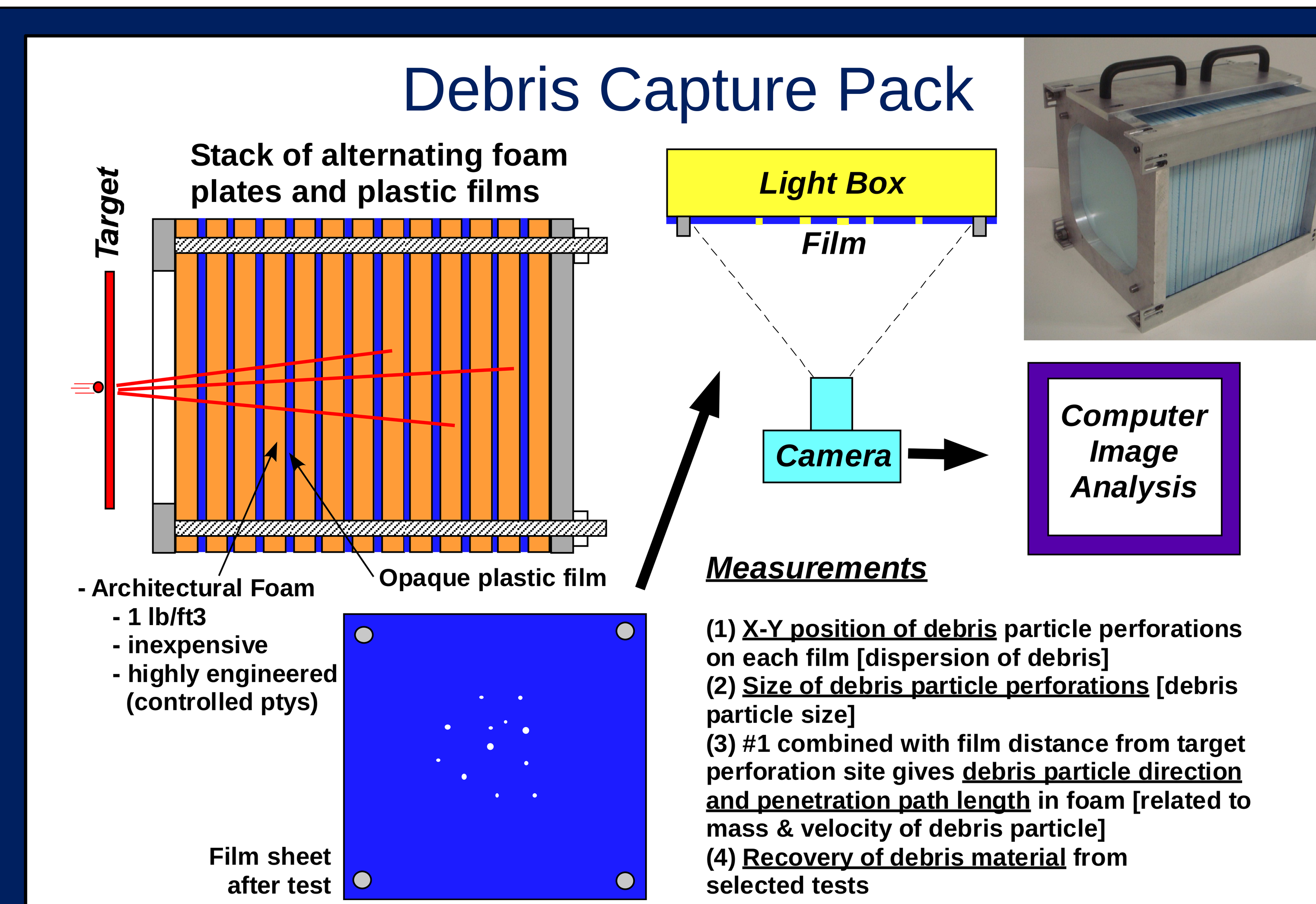
## Small Particle Hypervelocity Impact Range (SPHIR)



Two-Stage Light Gas Gun

- Impact velocity: 3 – 10 km/s
- Target chamber: 1 m x 1 m x 2 m
- Chamber pressure: 1 – 50 Torr
- 6" x 6" aluminum 6061-T6 targets
- 22.7 mg 440C steel spheres → 2 – 3 km/s
- 5.5 mg nylon 6/6 cylinders → 5 – 10 km/s
- 3.6 mg nylon 6/6 spheres → 5 – 6 km/s

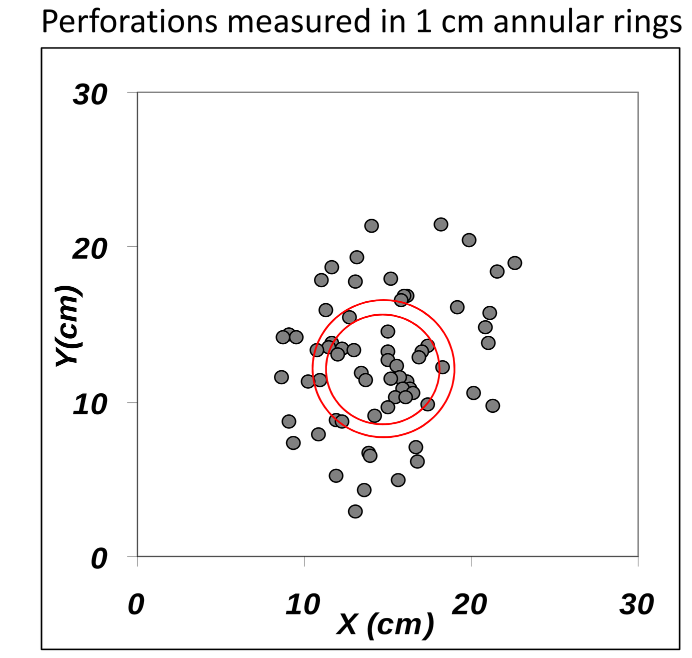
## Debris Capture Pack

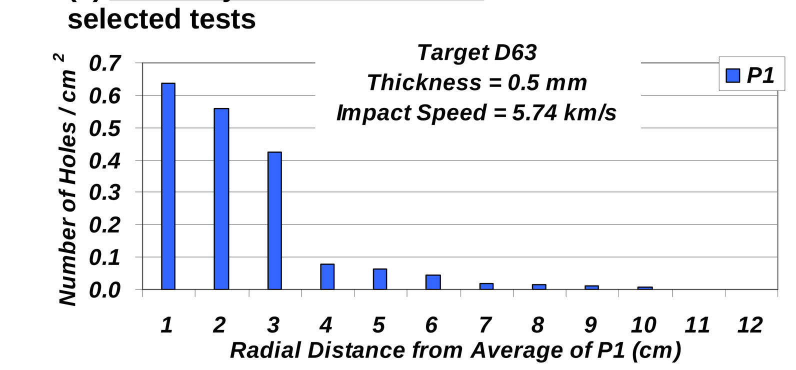


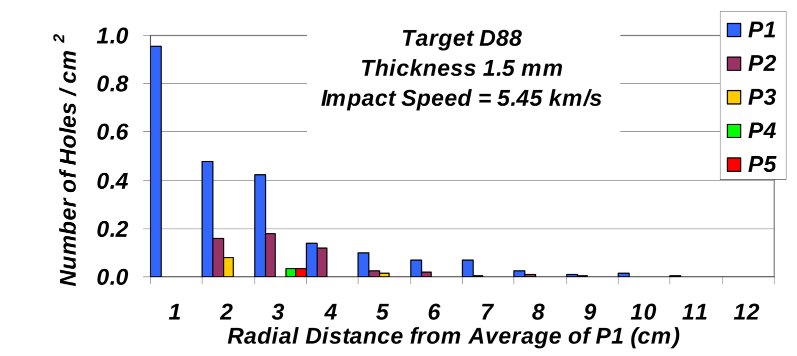

***Measurements***

(1) X-Y position of debris particle perforations on each film [dispersion of debris]
(2) Size of debris particle perforations [debris particle size]
(3) #1 combined with film distance from target perforation site gives debris particle direction and penetration path length in foam [related to mass & velocity of debris particle]
(4) Recovery of debris material from selected tests

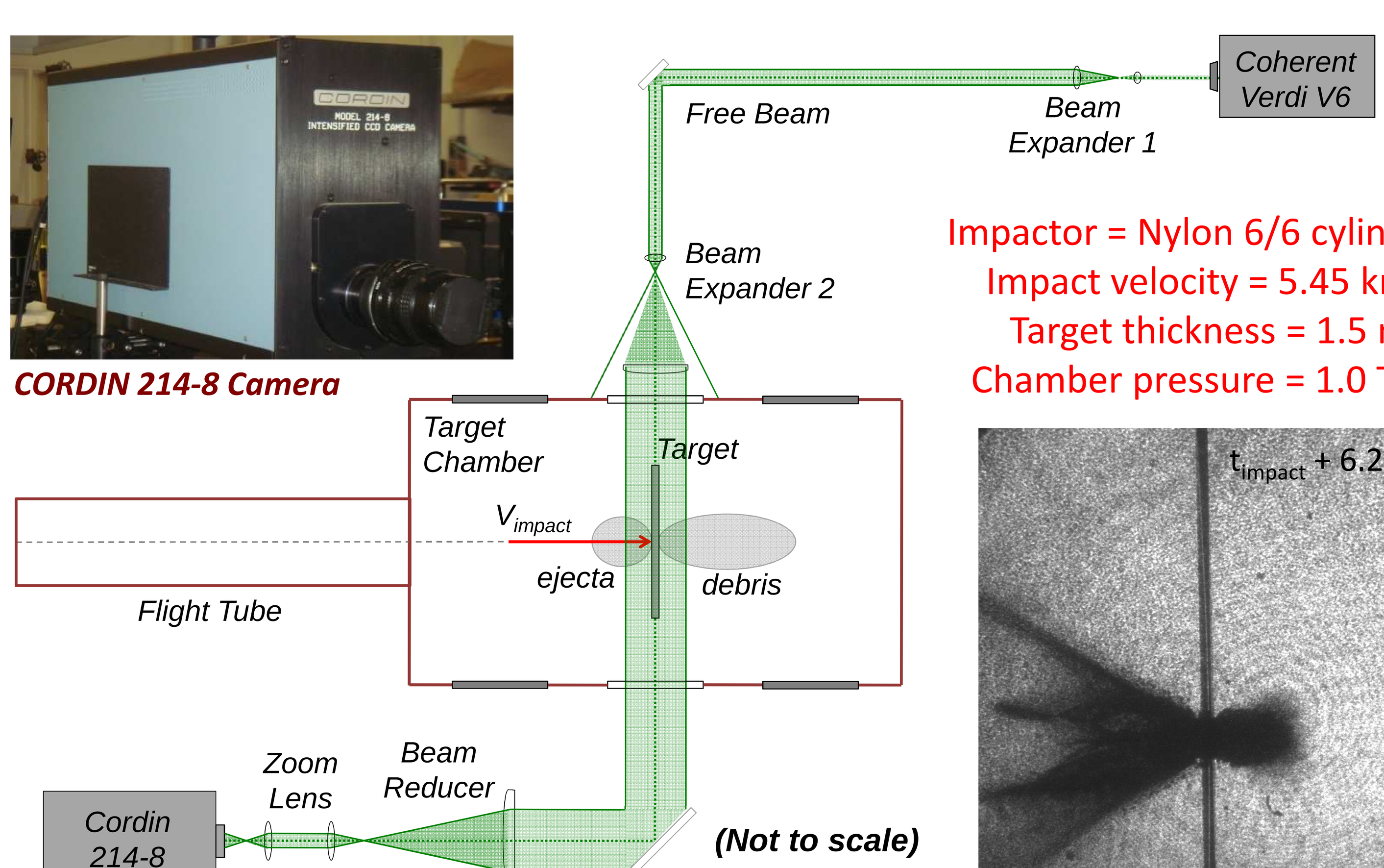
Perforations measured in 1 cm annular rings



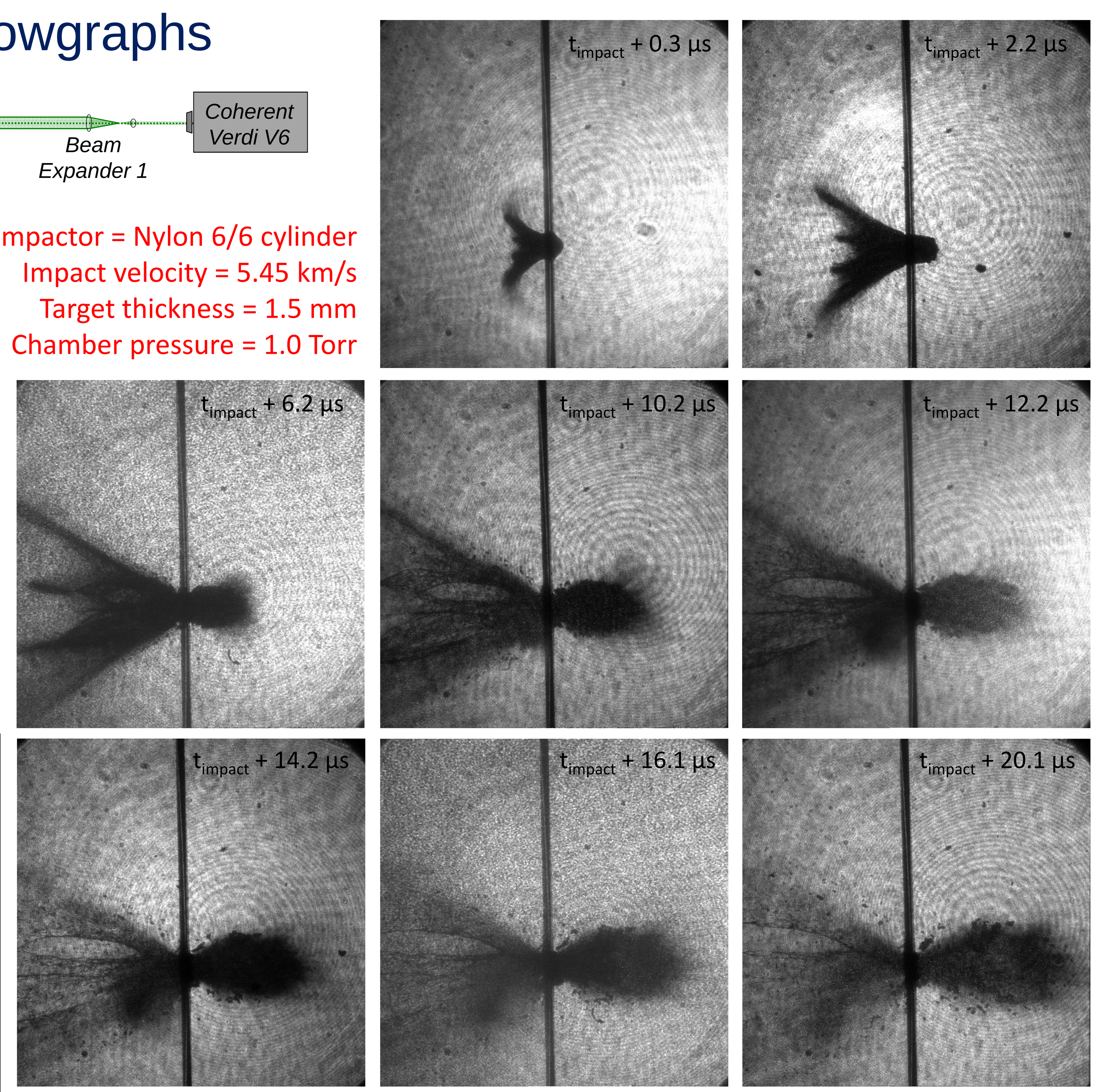




## Laser Side-Lighting Shadowgraphs




Impactor = Nylon 6/6 cylinder
Impact velocity = 5.45 km/s
Target thickness = 1.5 mm
Chamber pressure = 1.0 Torr




## References and Acknowledgments

[1] J. Mihaly, L. Lamberson, M. Adams, A.J. Rosakis, *A Low Cost, Small Bore Light-Gas Gun Facility*, Proceedings of the 11th Hypervelocity Impact Symposium, pp. 675 – 686, 2010.

[2] M. Adams, A. Lashgari, B. Li, M. McKerns, J. Mihaly, M. Ortiz, H. Owhadi, A.J. Rosakis, M. Stalzer, T.J. Sullivan, *Rigorous model-based uncertainty quantification with application to terminal ballistics – Part II. Systems with uncontrollable inputs and large scatter*, Journal of the Mechanics and Physics of Solids, pp. 1002 – 1019, 2012

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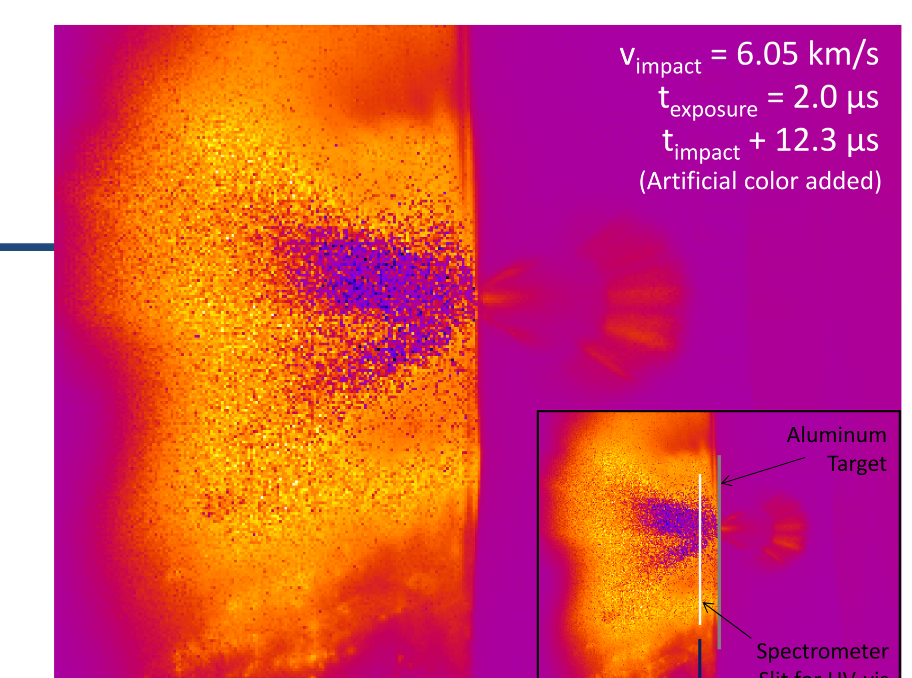
## IR Imaging and UV-vis Spectroscopy

Infrared Imaging Camera (OMA V)
- Liquid nitrogen cooled InGaAs detector array
- Spectral coverage of 0.9 µm to 1.7 µm
- 1 µs minimum exposure time
- IR images show a light and dark vapor/plasma cloud expanding at > 10 km/s

Acton SP-2560 spectrograph
- 500 mm focal length (0.05 nm resolution)
- All components operated by integrated computer control software
- Utilizes an internal mirror or diffraction grating to generate images or spectra of impact emission
- Lens systems allow various fields of view from 5.3 cm x 4.3 cm to 60.0 cm x 48.5 cm





UV-Visible High-Speed Camera (PI-MAX 3)
- 1024 x 256 pixel, gated, intensified CCD camera
- 28 ns minimum exposure time
- Spectral coverage of 275 nm to 825 nm
- Spectra measures relative intensities of atomic/molecular species present in vapor/plasma cloud

Strong emission of several small molecular fragments originating from both the aluminum target and Nylon 6/6 impactor