Streaked X-Ray Imager for Observation of Oscillations of Perturbed Ablation Fronts in Planar ICF Targets During Shock Transit

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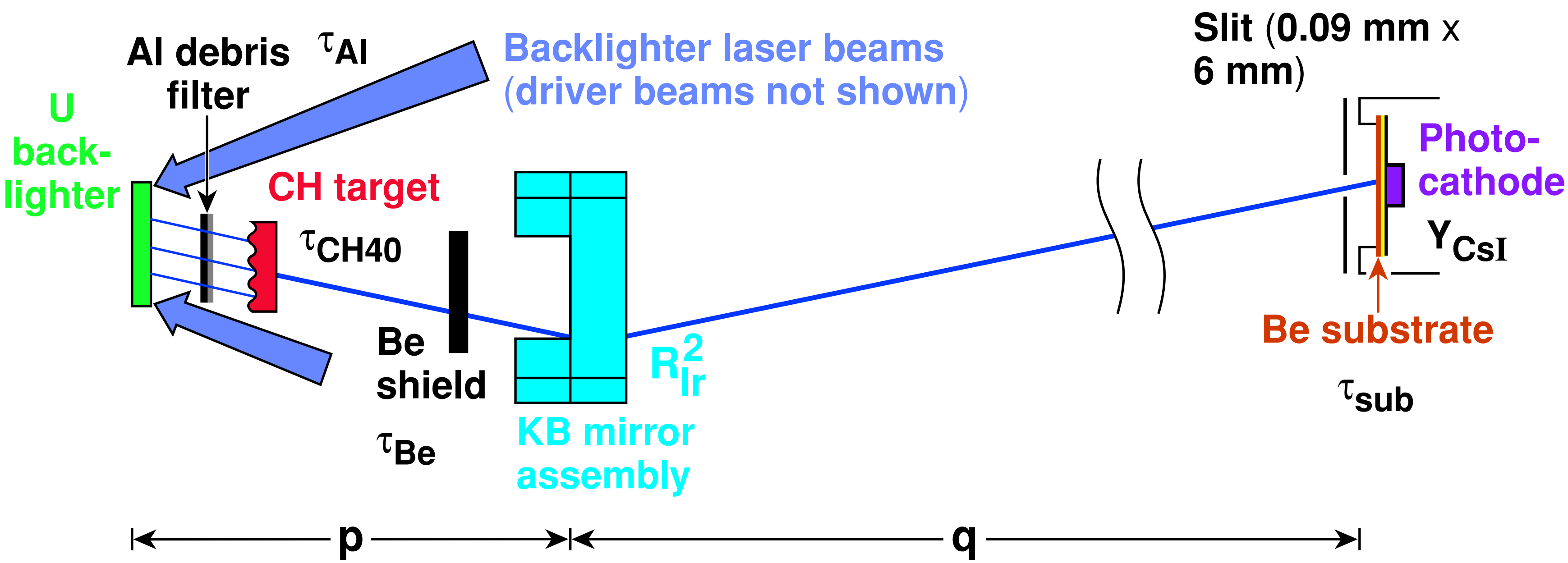

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Summary

Experimental observation of oscillations at the ablation front will confirm the dynamic overpressure effect

- An experiment is proposed to confirm the oscillations of ablation- front perturbations, caused by the dynamic overpressure of the blowoff plasma.
- A new x-ray diagnostic system is being developed for this experiment.
- The experimental requirements, setup, and diagnostic are described here.

*Also known as rocket effect [V. N. Goncharov, Phys. Rev. Lett. 82, 2091 (1999)].

Outline

- Motivations for experimental observation
- Experimental requirements
- Experimental setup
  - diagnostic components
  - characterization
- Conclusions

Dynamic overpressure is the main physical mechanism stabilizing ablative Richtmyer–Meshkov (RM) growth

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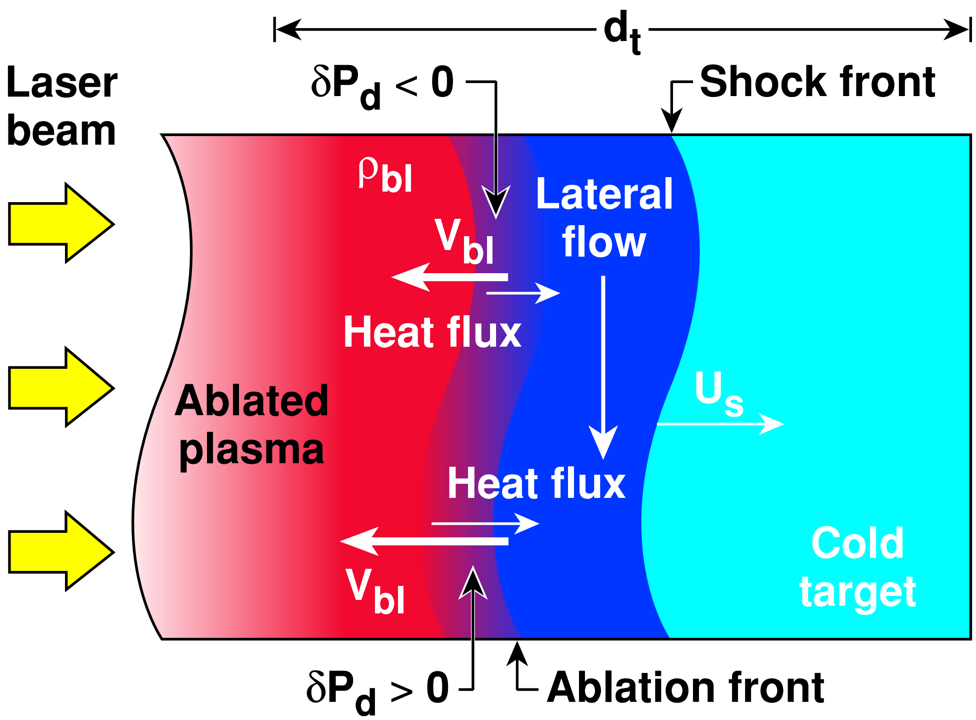

- **Classical RM:**

$$\xi \sim kU_s\xi_0 t$$

- **With ablation:**

$$V_a \sim \nabla T \sim I^{1/3}$$

$$\delta(\nabla T) \rightarrow \delta V_a \rightarrow \delta V_{bl} \rightarrow \delta P_d$$

$$\xi \sim \xi_0 \cos\omega t,\ \omega = k\sqrt{V_{bt} V_a}$$

- **A thermally induced increase in the exhaust velocity at the peak creates dynamic overpressure δP_d.**

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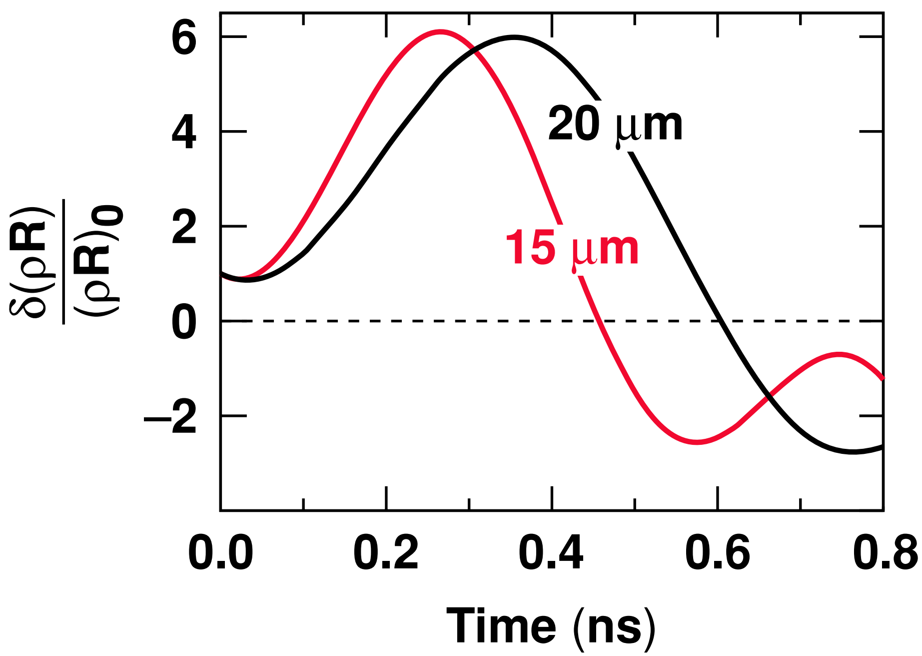
Oscillations induced by dynamic overpressure are easier to detect for short-wavelength modes

Theoretical results



Single mode surface perturbations on a 40-μm CH foil

$I = 2 \times 10^{14}$ W/cm^2

- The oscillations are observable only before the onset of RT growth.
- 40- or 60-μm-thick planar CH foils are used to provide sufficient shock transit time.
- The period[1] of oscillations $T_{CH} \approx 3/[V_a(\mu m/ns)\sqrt{k(\mu m^{-1})}]$ ns.
- Phase variation $<\pi/4$ observed in reference 2.

[1]Goncharov, Phys. Rev. Lett. 82, 2091 (1999).
[2]Aglitsky *et al.*, 31st Annual Anomalous Absorption Conference, June, 2001.

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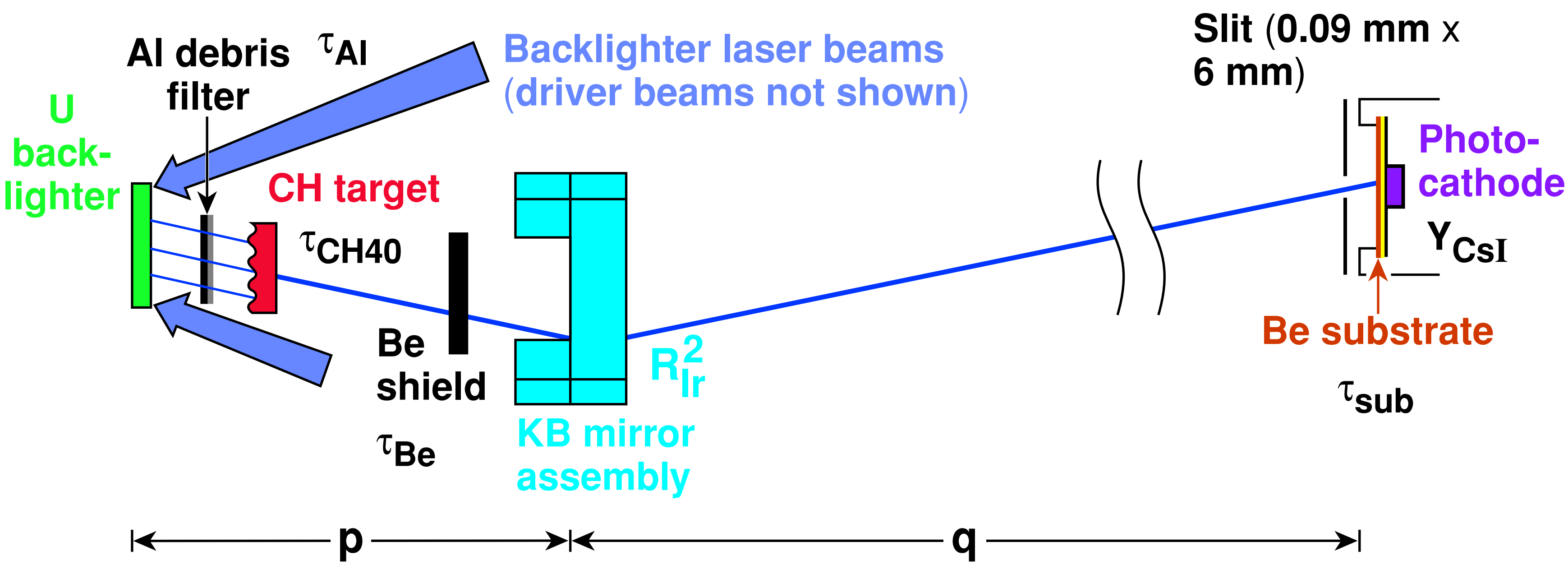
Grazing-incidence x-ray optics with a high collecting angle will be coupled to a high-dynamic-range streak camera

- Current x-ray pinhole framing cameras do not provide optimal throughput to diagnose mass perturbations on > 40-μm-thick CH foils.
- A streaked device will allow for continuous record revealing details in the evolution of ablation-front pertubations.
- A Kirkpatrick–Baez microscope with Ir-coated mirrors is the front end of the apparatus while a high-current streak tube (PJx) coupled directly to a high-resolution CCD is the detector.
- The KB resolution is ~ 3 μm on axis (6× magnification).
- The PJx has a PSF with a FWHM of 18 μm. A magnified image will be registered at the PJx photocathode.

An optimal magnification that accommodates the resolution requirements and the size of the CCD detector is provided by the chosen geometry



- 6× magnification at current configuration
- Projected resolution of better than 5 μm over a 200-μm field of view.
- The radius of curvature for each concave mirror is $\Re$ = 4250 mm.
- f = 77.5 mm, p = 90 mm, q = 560 mm

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Optimal throughput depends on the grazing angle and the coating material

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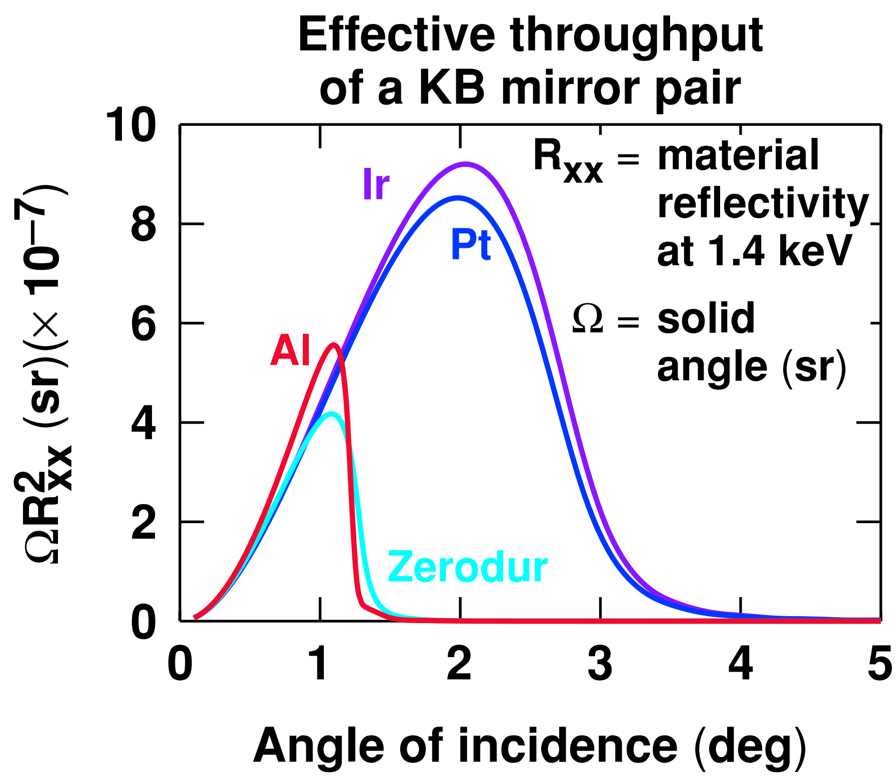

- Optimal:
  - Material is iridium.
  - Angle of incidence $i = 2.1°$.

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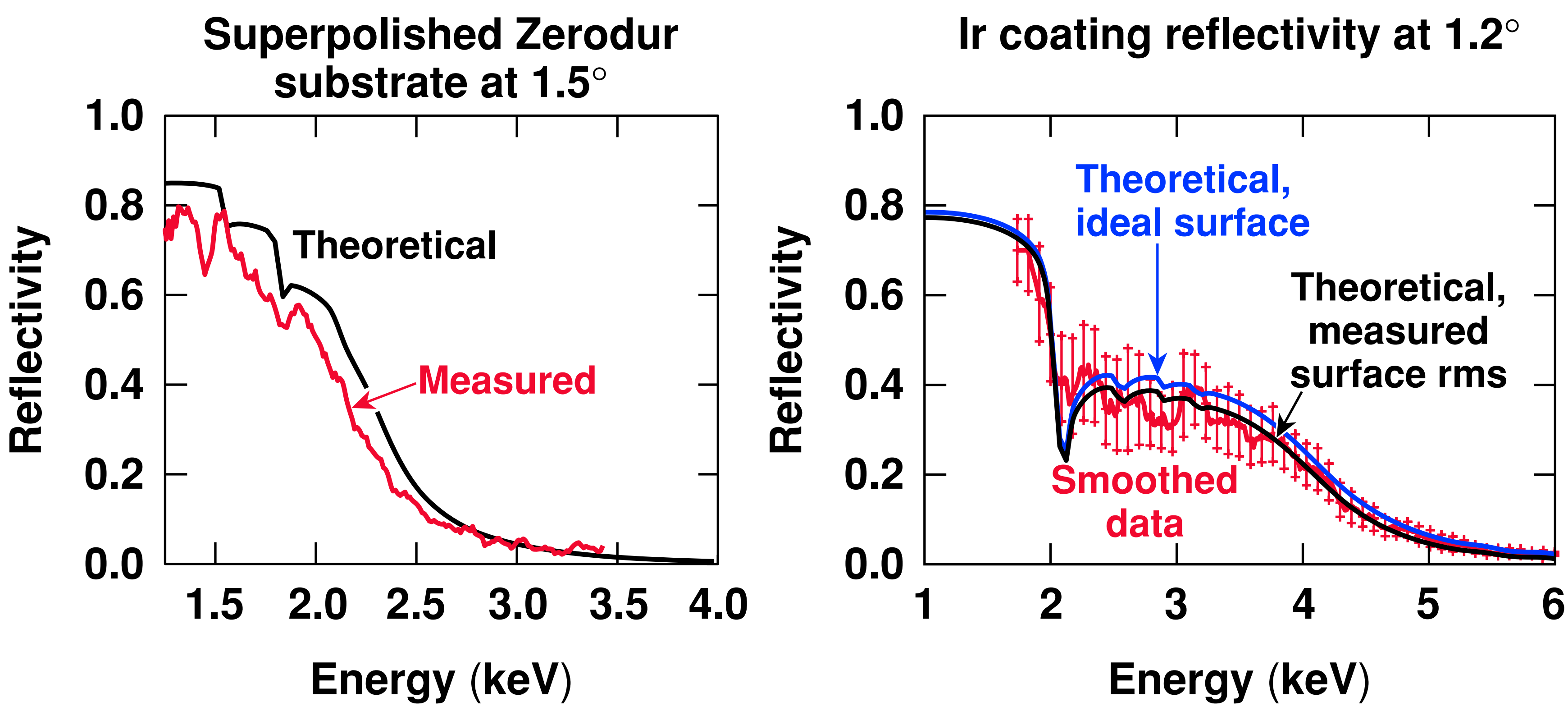
The choice of mirror material was experimentally verified



- Zerodur glass substrates with surface roughness < 2 Å rms are coated with ~500 Å Ir on top of ~100 Å Cr for improved adhesion.

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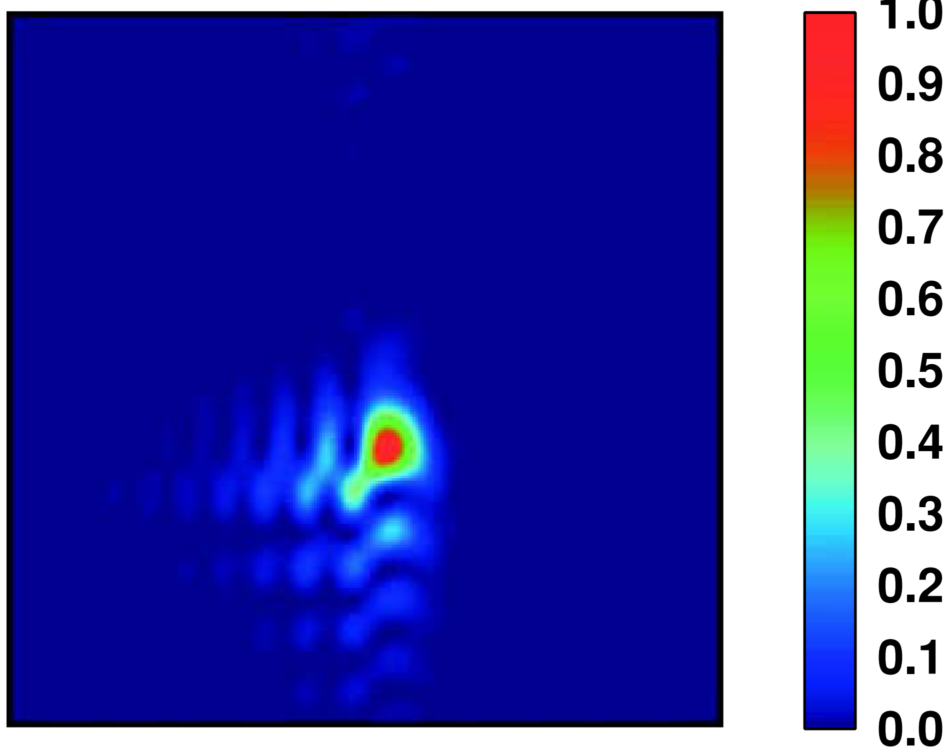
The point-spread function (PSF) for an object on axis shows better-than-5-μm spatial resolution

Raytrace calculation



- **The image spot size at the 10% level is less than 15 μm (box size is 30 μm). A division by the magnification M = 6 yields 2.5 μm resolution at target center.**

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Summary/Conclusions

Experimental observation of oscillations at the ablation front will confirm the dynamic overpressure effect

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- **Dynamic overpressure* stabilizes (RM) pertubation growth at the ablationt fron during shock transit and thus reduces the seeds of the subsequent RT growth.**
- **An experiment is proposed to confirm the oscillations of ablation-front perturbations, caused by the dynamic overpressure of the blowoff plasma.**
- **A new x-ray diagnostic system is being developed for this experiment.**
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