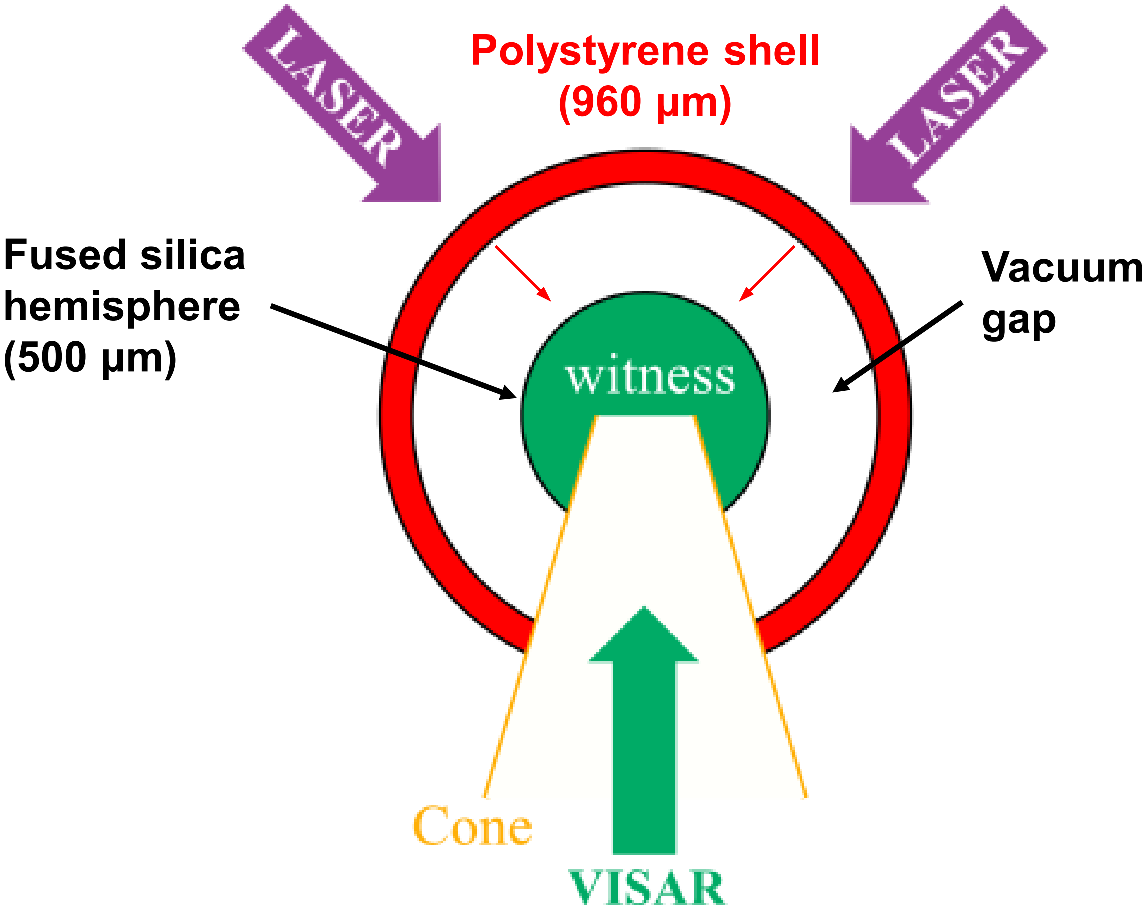
Measuring the Rarefaction Wave Dynamics from Shock Release in Spherical Geometry



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Summary

The kinetic energy of shock release was measured in warm polystyrene targets using a spherical cone-in-shell platform

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- **The kinetic energy of shock release material determines the stagnation pressure in an ICF* implosion**
- **Measurements indicate moderately lower kinetic energy in the shock release than predicted by hydrocodes**
- **The effect of radiation preheat on the shock release measurements was found to be insignificant**

No indication was found that the shock release could be responsible for lower-than-expected implosion convergence

ICF: Inertial Confinement Fusion

Collaborators

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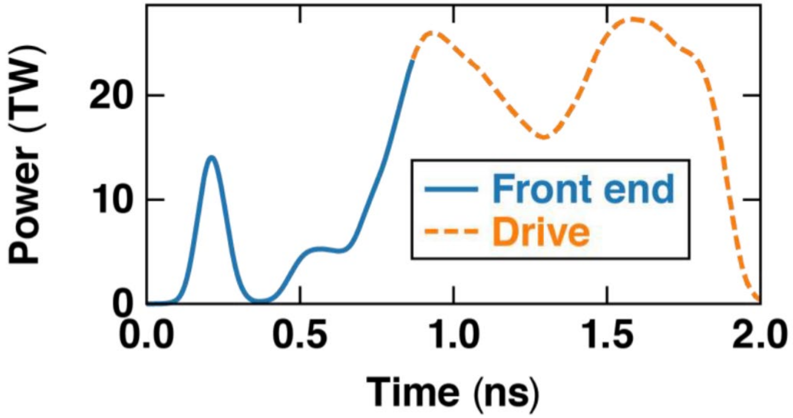
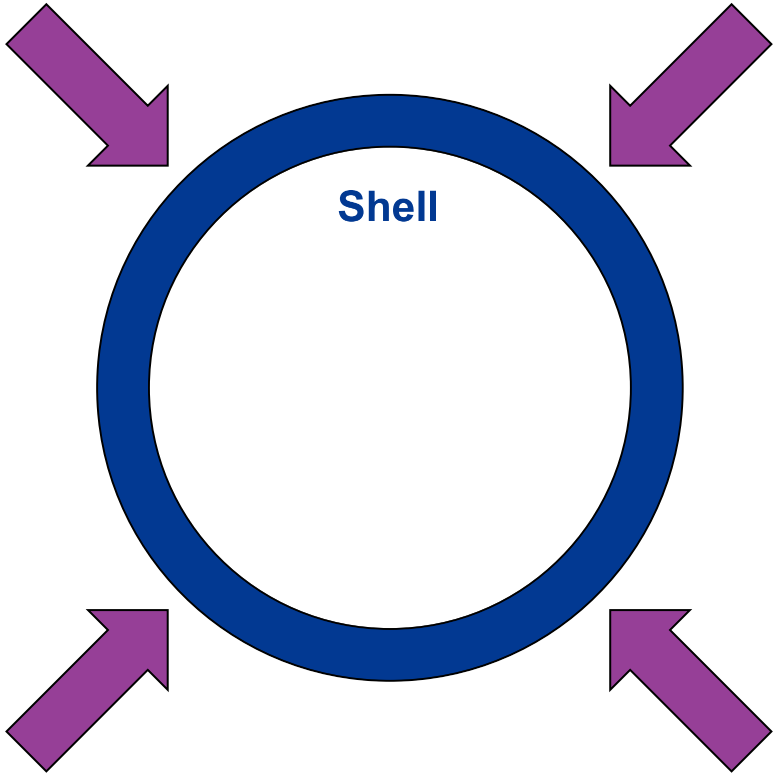
Shock release in inertial confinement fusion implosions

- The laser is used to drive a shock in the shell, setting the adiabat
- Material from the inner shell surface is released at shock breakout





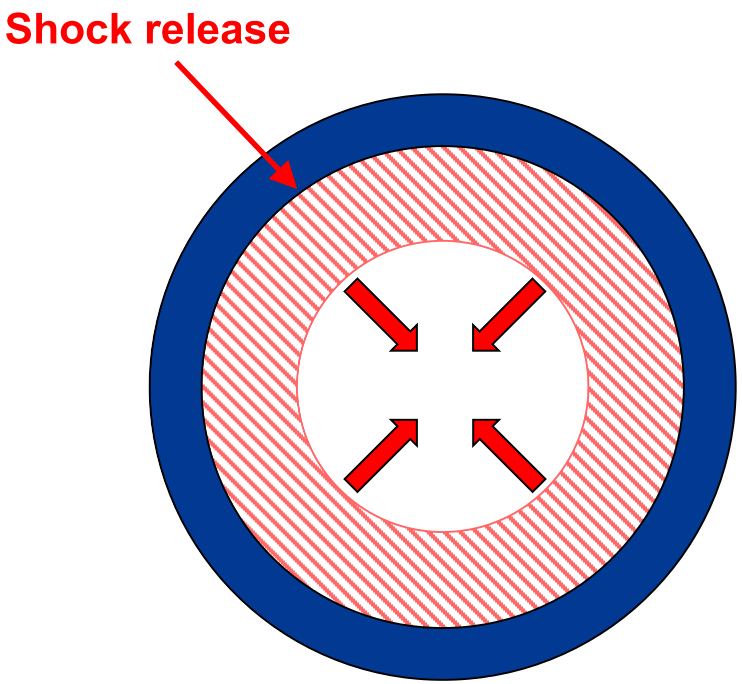
Shock release in inertial confinement fusion implosions

- **The kinetic energy of the converging release material is converted to internal energy of the hotspot**
- **The initial hotspot pressure P_0 determines the final pressure at stagnation P_{stag}**

$$P_{stag} \propto P_0^{-3/2}$$

Initial hotspot pressure set by the kinetic energy of the release mass

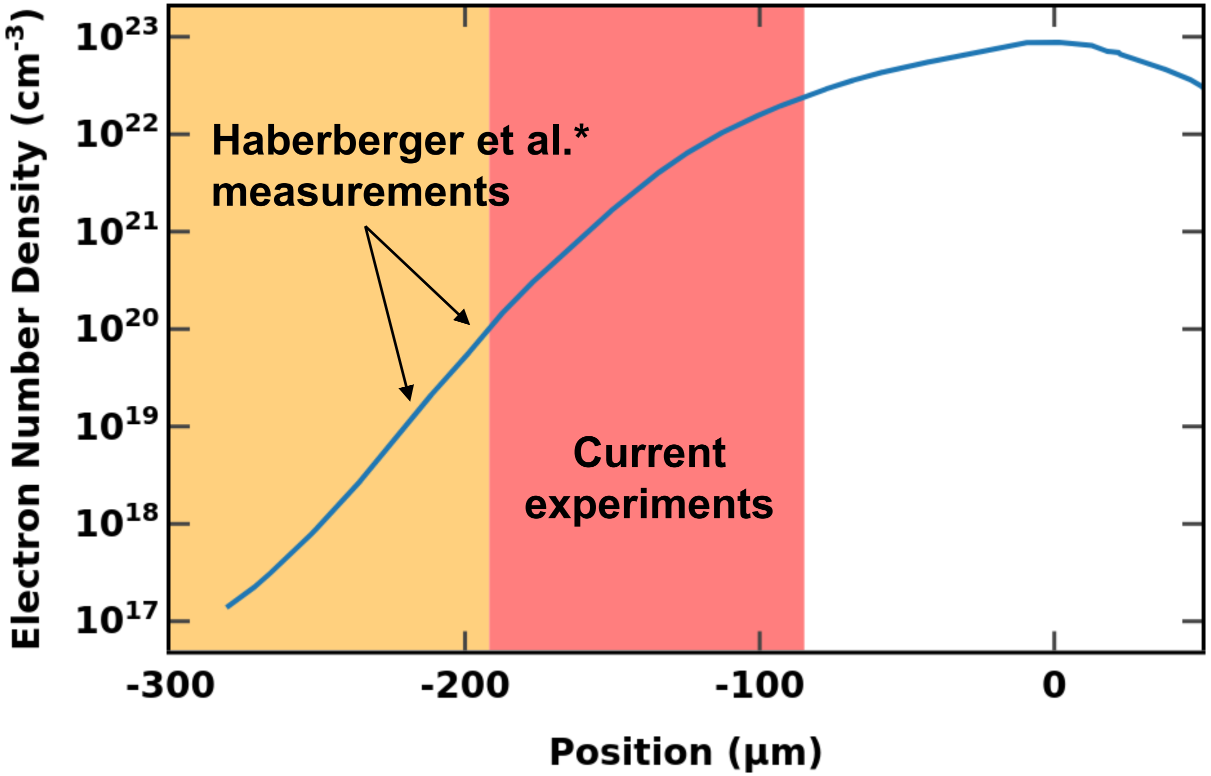
$$E_{kin} \approx \frac{1}{2} M_{release} V_i^2$$



Experiments were designed to probe the material in the bulk of the shock release

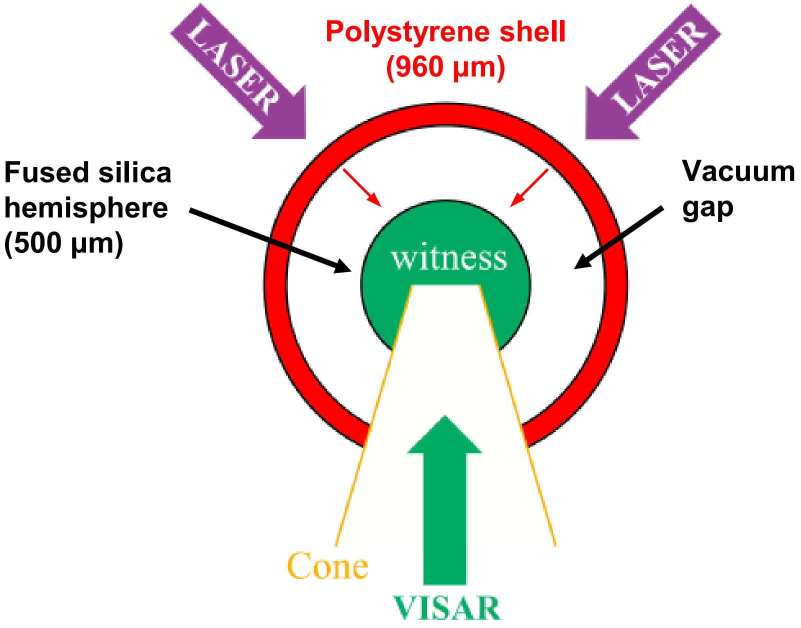
- Haberberger et al. experiments indicate the leading edge of the release moving faster than predicted
  - Material originates within a fraction of a micron from the surface
- Possible causes include:
  - Radiation preheat*
  - Species separation**
- The current experiments measure the kinetic energy of several microns of release material

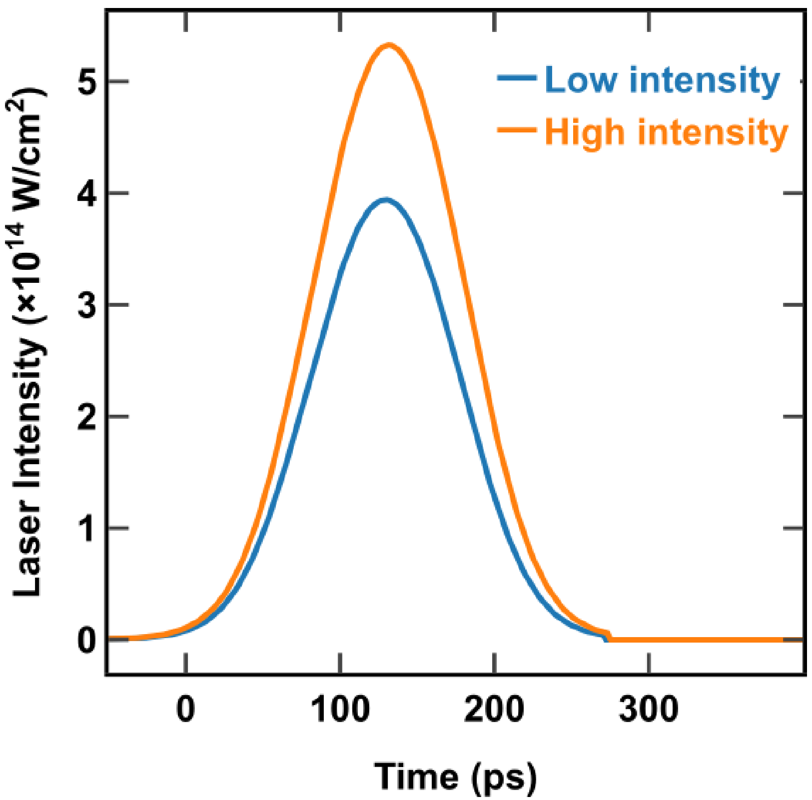
In-flight density profile of the shock release



* D. Haberberger et al., Phys. Rev. Lett. 123, 235001 (2019).
** S. Zhang and S. X. Hu, Phys. Rev. Lett. 125, 105001 (2020).

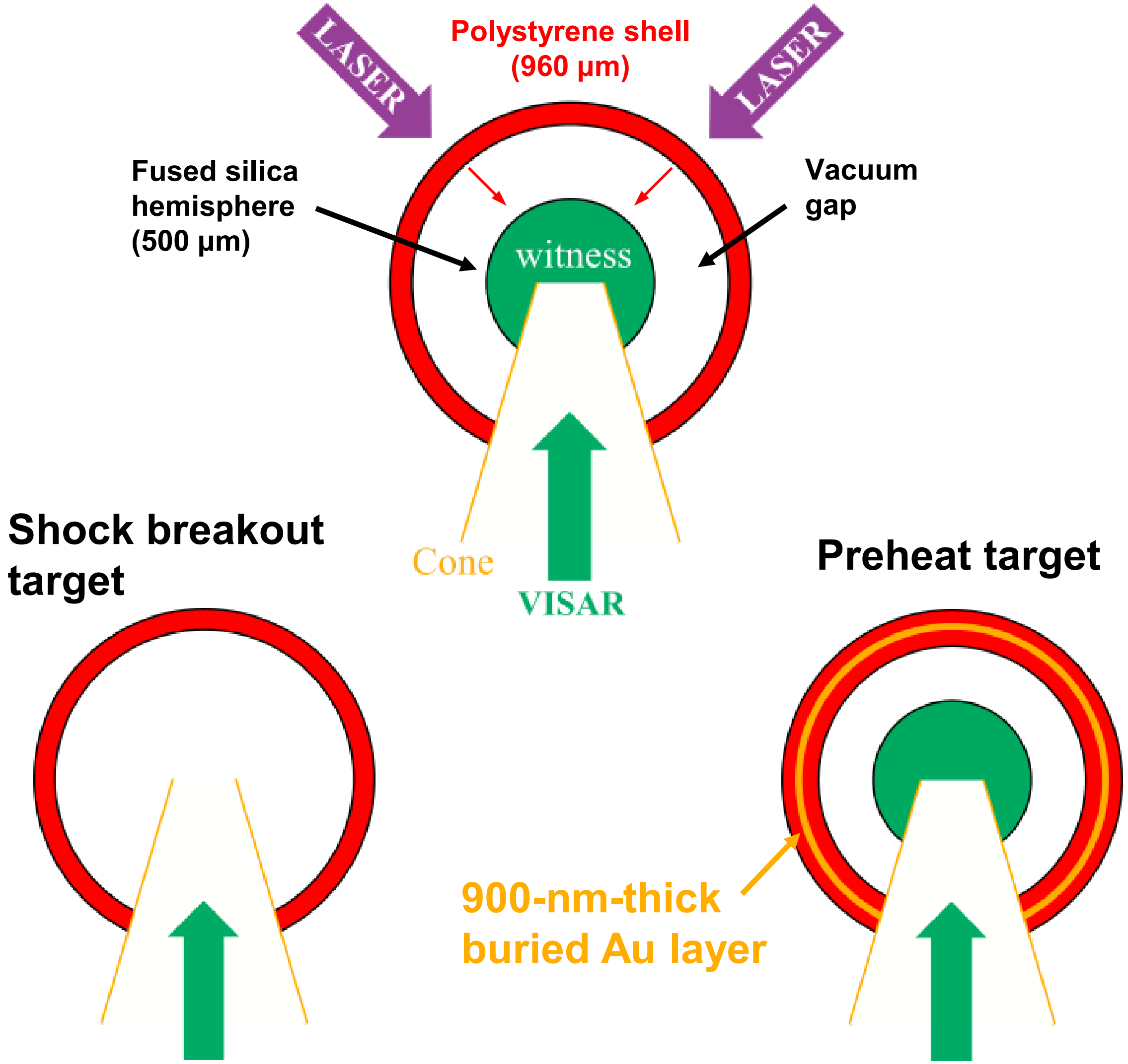
A cone-in-shell platform with a solid hemisphere witness was used to measure the shock release into vacuum



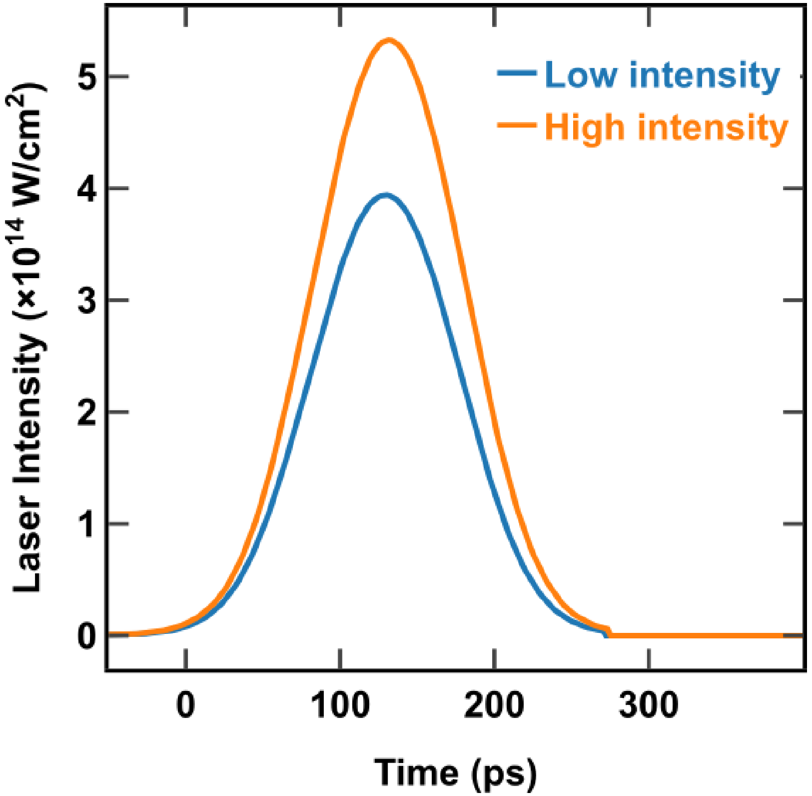


* VISAR: velocity interferometer system for any reflector

A cone-in-shell platform with a solid hemisphere witness was used to measure the shock release into vacuum

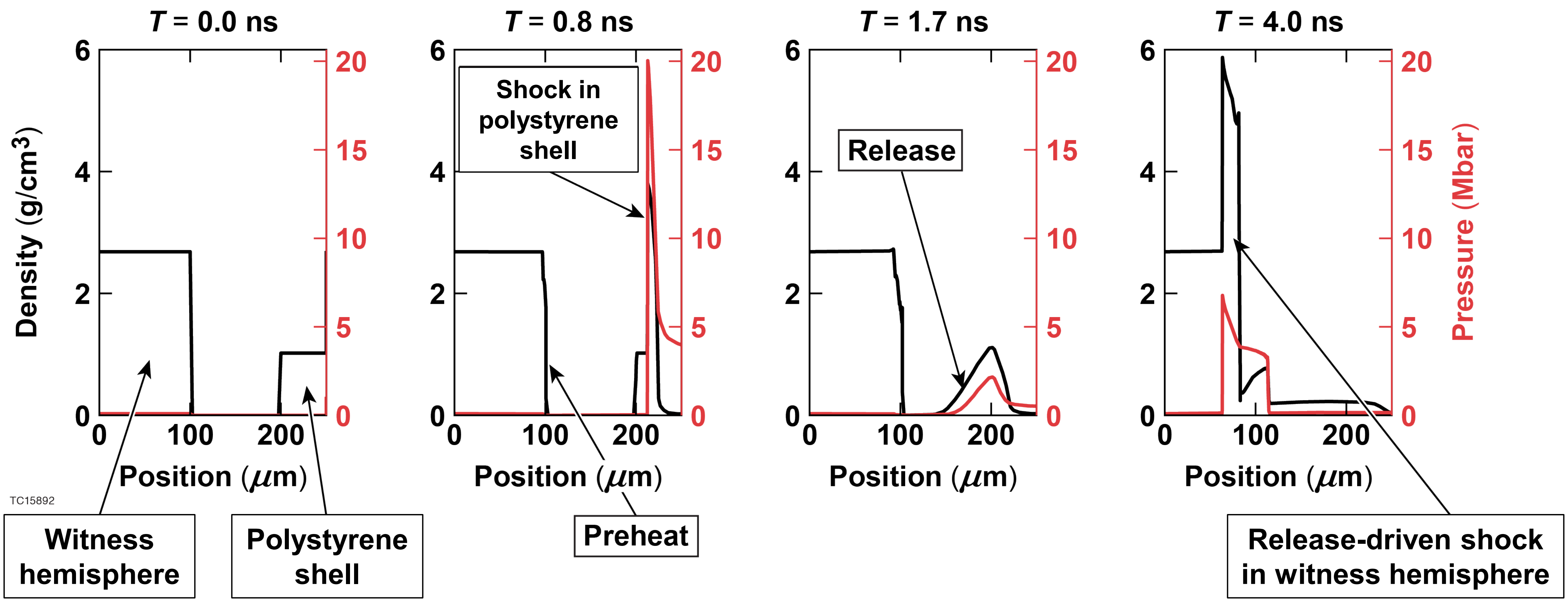


Picket pulses with varying intensity were used to drive the shock



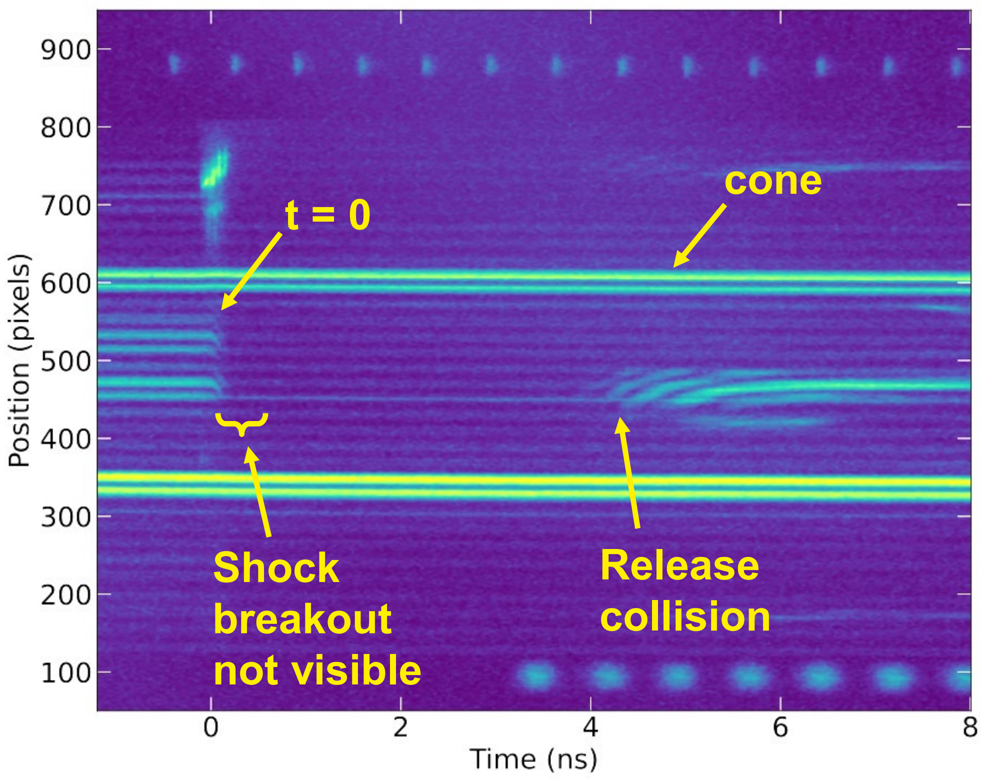
* VISAR: velocity interferometer system for any reflector

The release material drives a strong (>1-Mbar) shock in the witness

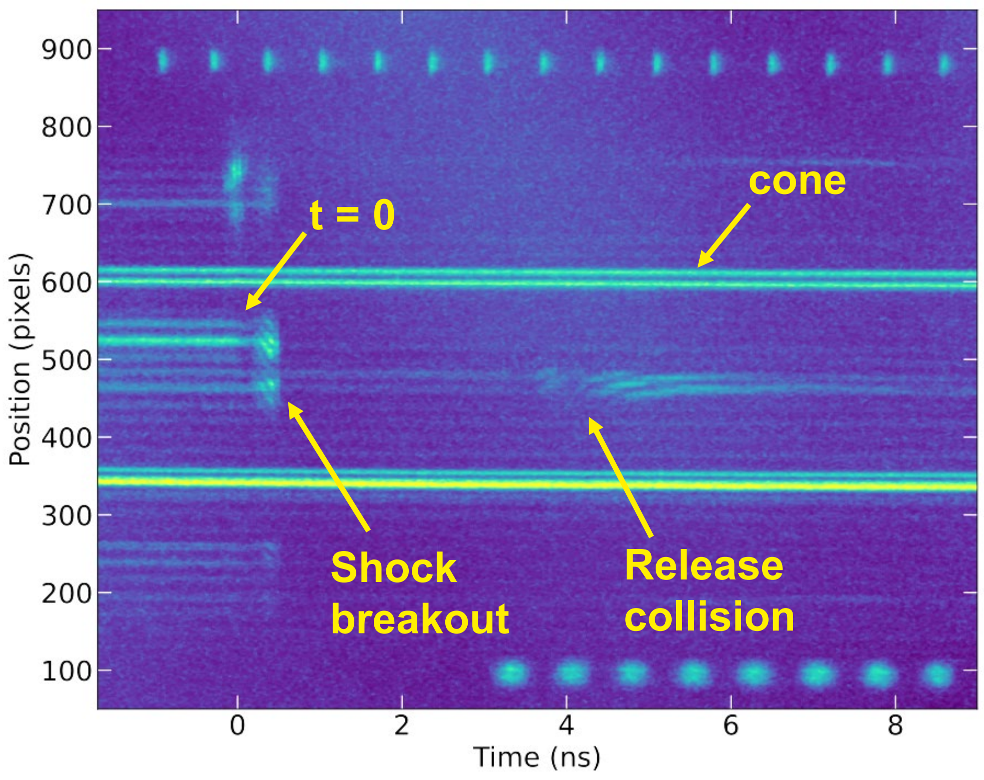


Weak signatures of radiation preheat of the witness were evident in the VISAR signal

No radiation shielding



900-nm-thick buried Au shielding

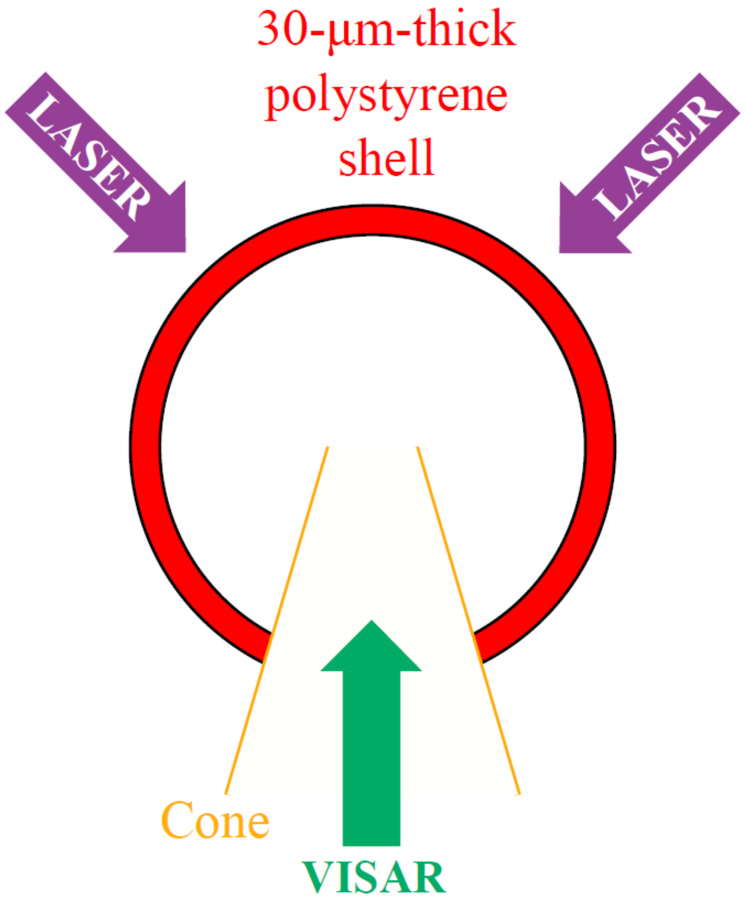


Shock velocity measurements in the witness were not affected by radiation preheat

Dedicated experiments were performed with simple cone-in-shell targets to measure the time of shock breakout from the inner shell surface

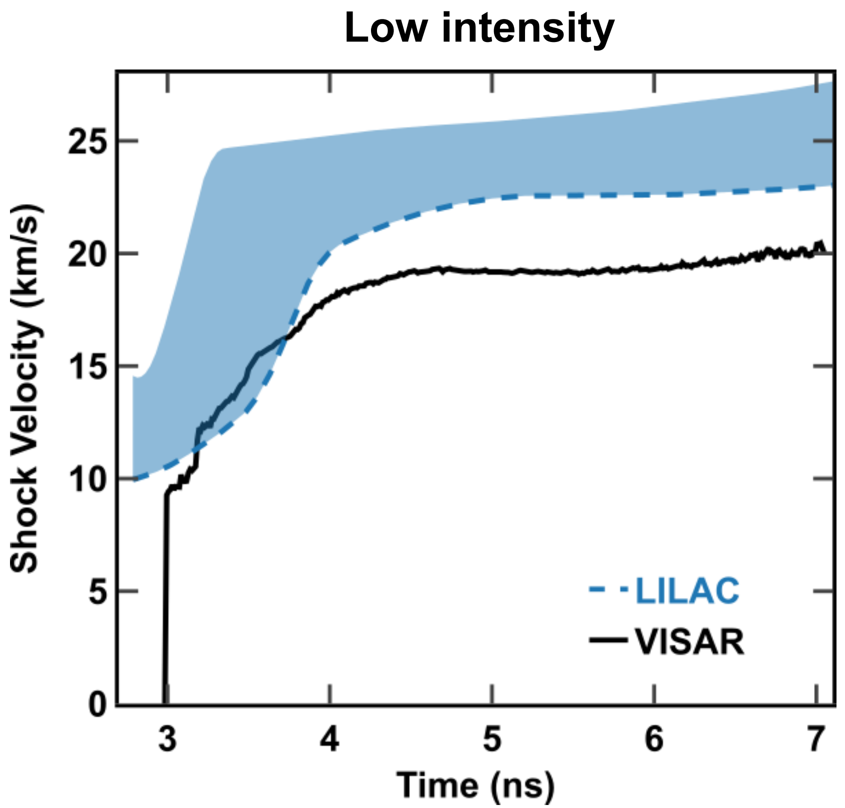
- **VISAR and SOP* measurements were used to determine the shock breakout time**

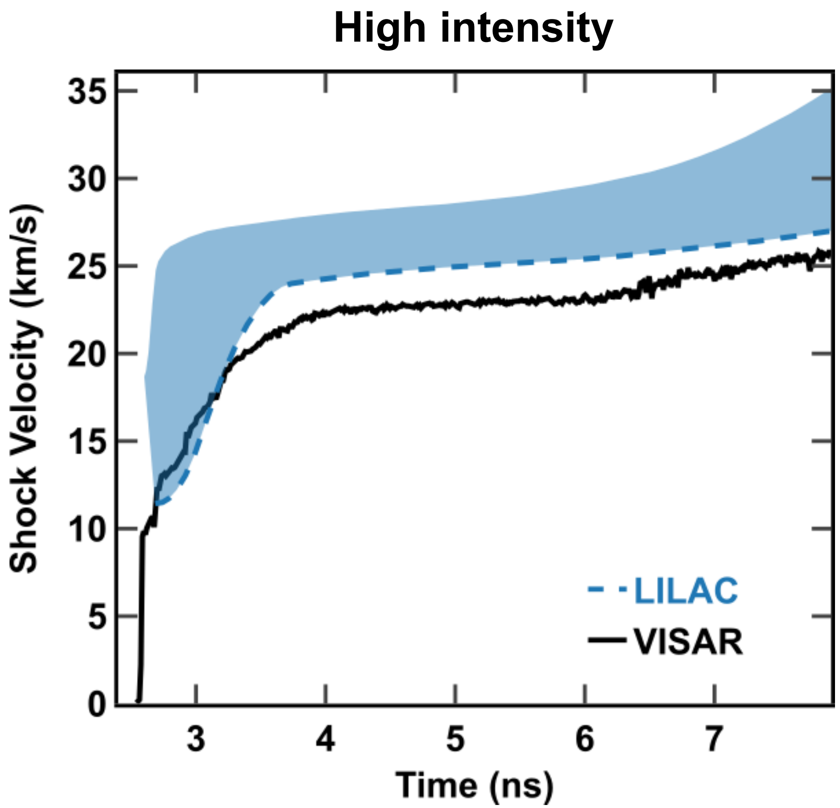
	Measured shock breakout time	Simulated shock breakout time
Low intensity	480 ± 60 ps	550 ps
High intensity	370 ± 60 ps	510 ps



* SOP: streaked optical pyrometry

VISAR measurements of release-driven shock velocity in the witness were obtained





- Time of release collision with the witness is well predicted by the simulations
- Shock velocity is over-predicted by ≈10–15% in the simulations

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