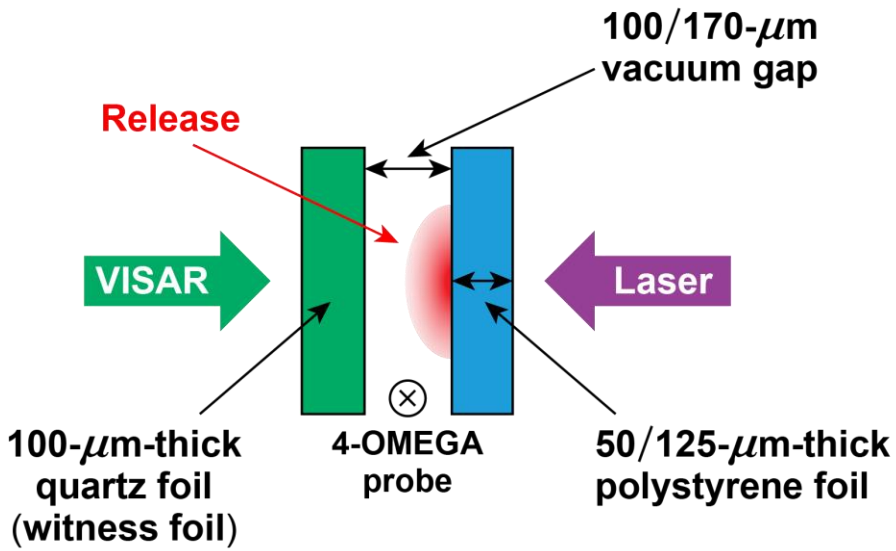
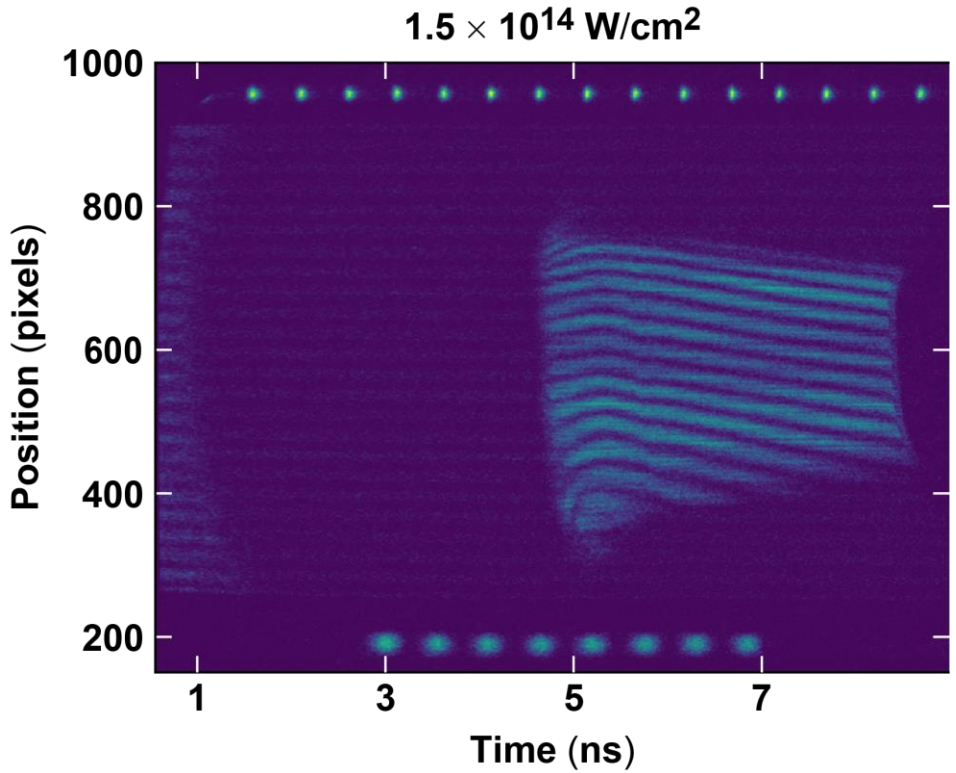
Measurements of Shock-Release Dynamics in Polystyrene Foils





A. Lees
University of Rochester
Laboratory for Laser Energetics

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Summary

A novel experimental platform was developed to measure the dynamics of shock release

- Experiments were conducted over a wide parameter range, measuring the kinetic energy of the shock release
- Radiation preheat of the quartz witness foil poses a challenge in interpreting the results at higher laser intensities
- The release dynamics were successfully measured in low-intensity experiments, where the radiation preheat was sufficiently mitigated
  - comparison with radiation-hydrodynamics simulations indicates discrepancies in the release velocity and profile

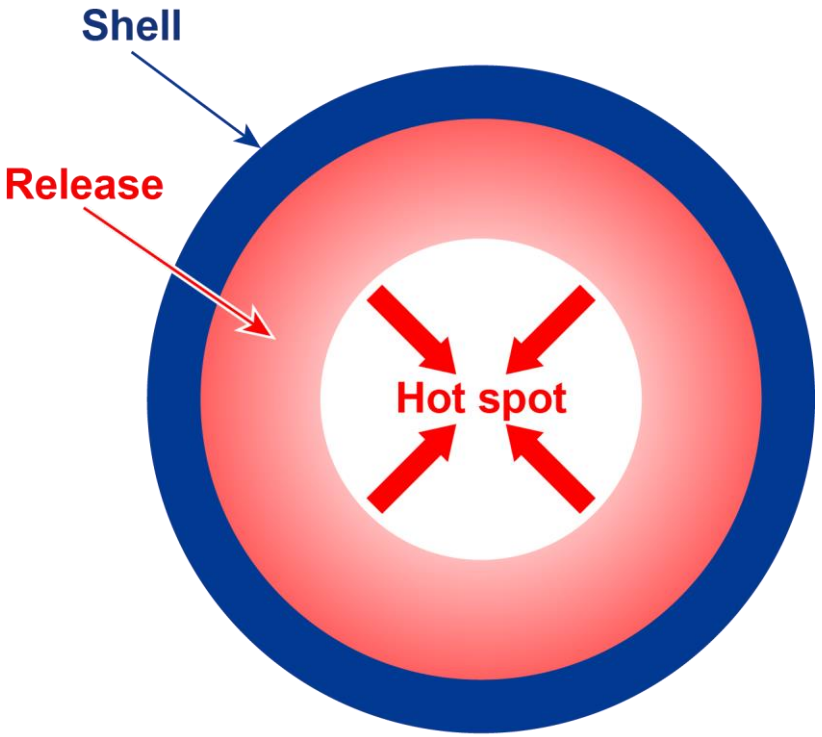
Collaborators

D. Barnak, R. Betti, V. Gopalaswamy, A. Shvydky, and Z. K. Sprowal

Laboratory for Laser Energetics
University of Rochester

Shock release in inertial confinement fusion implosions

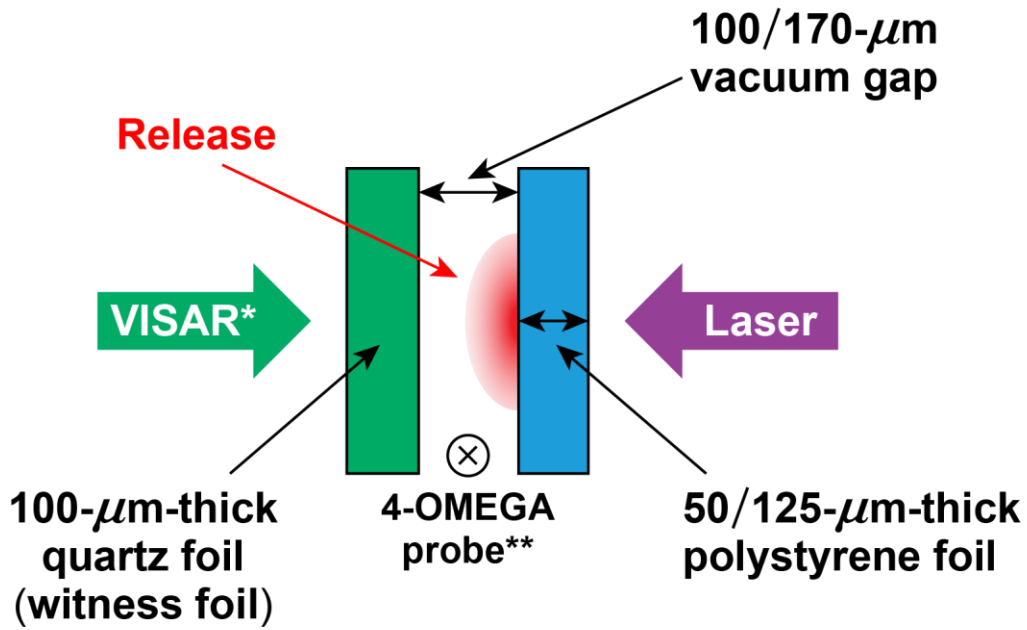
- Released material from the inner shell surface converges to the center of the hot spot, raising the pressure prior to shell compression (P_0)
- $P_{stag} \propto P_0^{-3/2}$
- Previous experiments* indicate a significantly faster leading edge of the release than predicted by radiation-hydrodynamics codes
  - possible causes include radiation preheat or species separation**

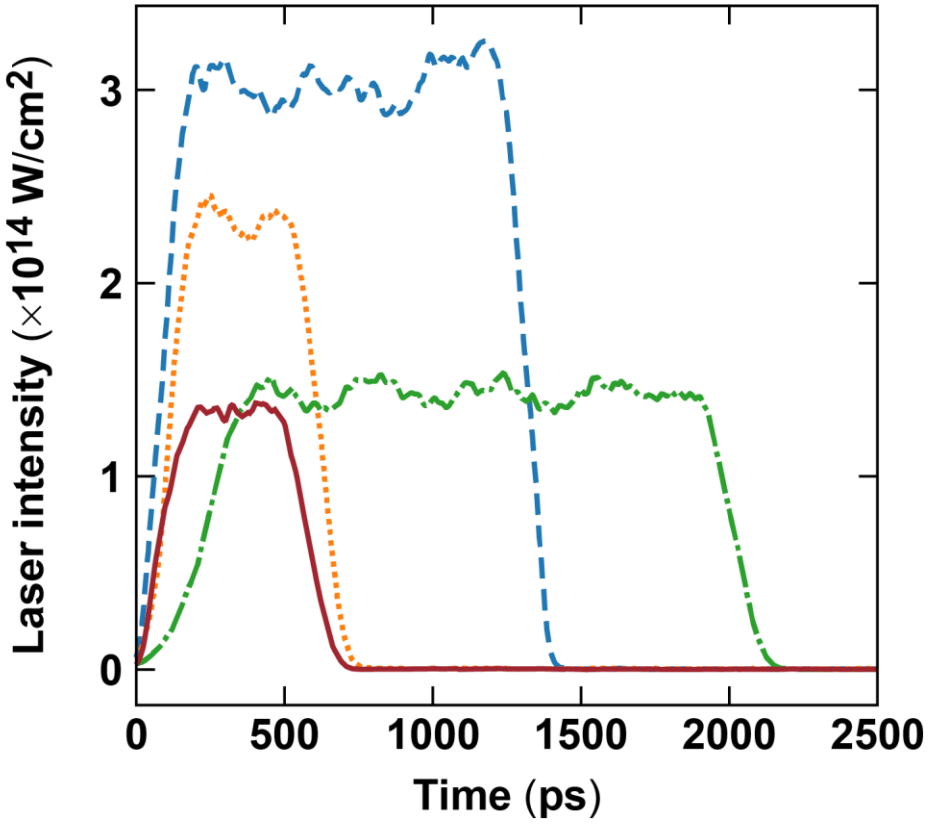


The current experiments measure the kinetic energy of the bulk of the release material responsible for the hot-spot pressure

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

A double-foil geometry is used to measure the shock release





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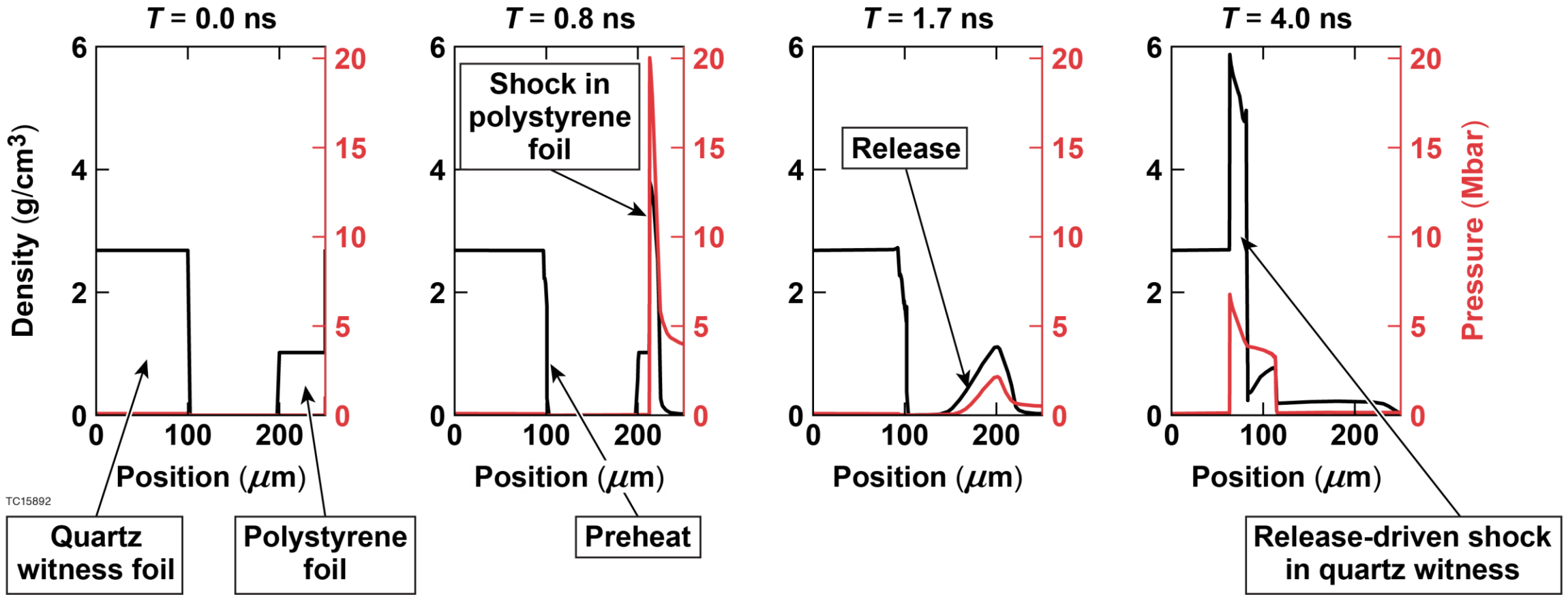
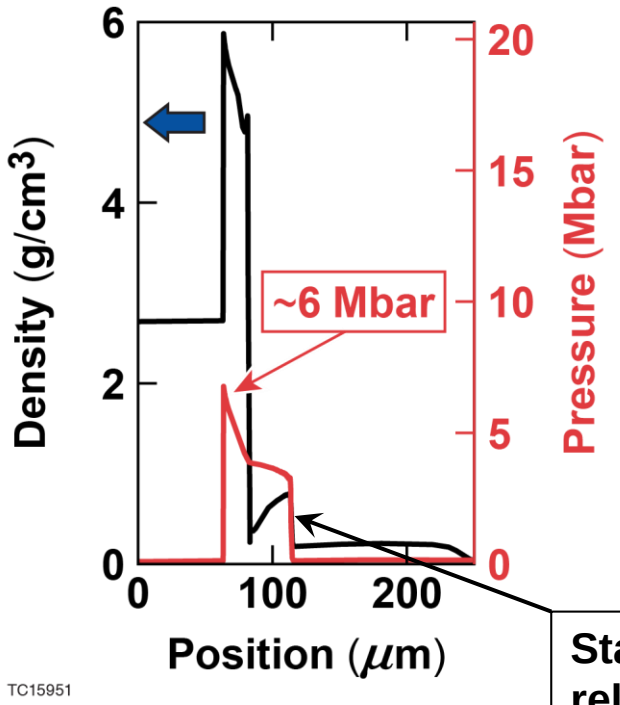
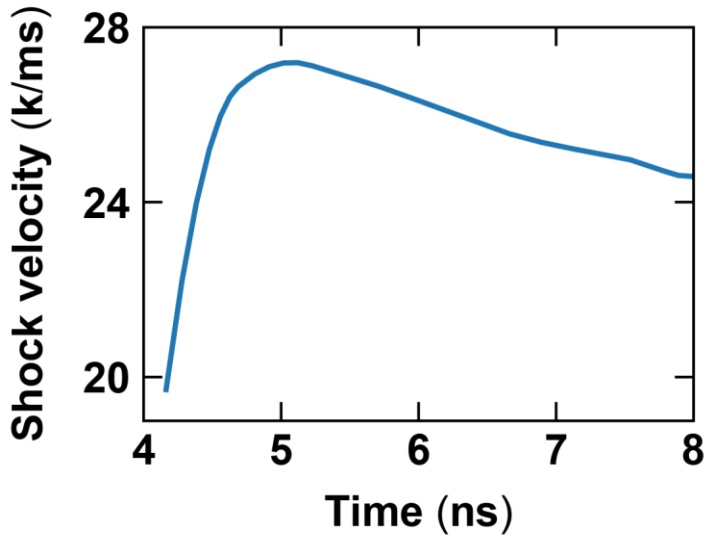
VISAR: velocity interferometer system for any reflector

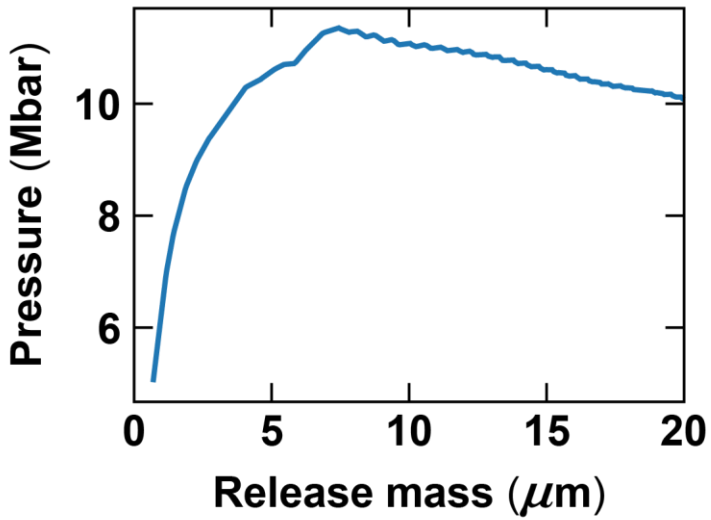
The release material drives a strong (>1-Mbar) shock in the witness foil



The shock velocity in the witness foil is measured with VISAR



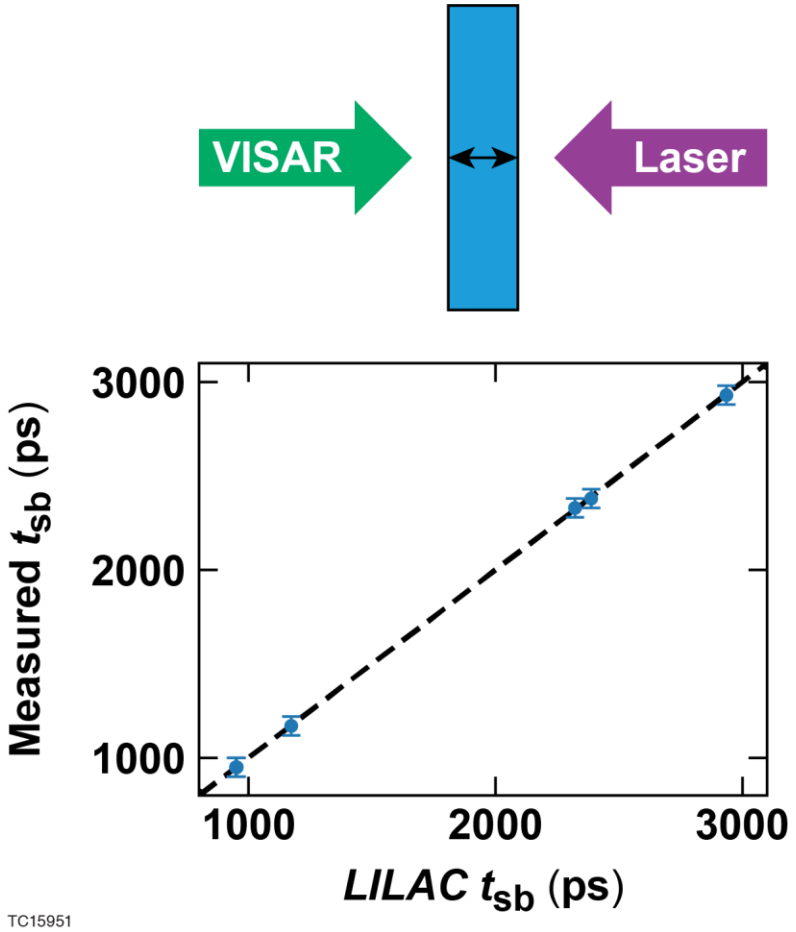




Stagnating release material

Standalone foils were used to calibrate shock breakout times

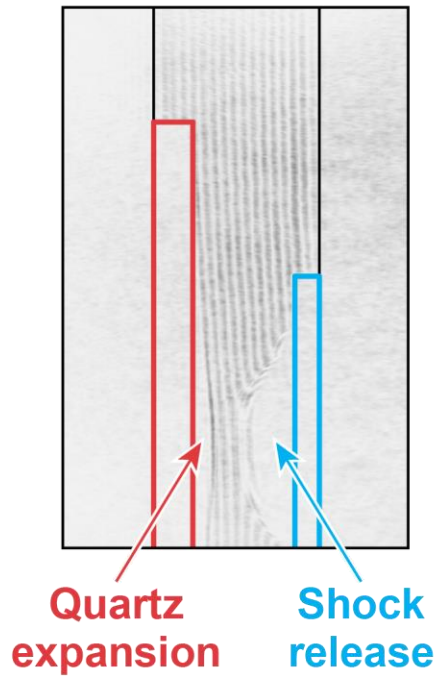
- Laser drive in 1-D *LILAC* was adjusted to account for transverse thermal conduction matching 2-D *DRACO* simulations
- VISAR and SOP measurements were used to determine the shock breakout time in standalone experiments
- The flux limiter in *LILAC* was adjusted to match the measured shock breakout time



SOP: streaked optical pyrometry

Radiation preheat causes expansion of the quartz witness foil

- 4ω interferometry images show expansion of the quartz witness foil prior to the release collision
- Radiation preheat of the outer layer of the quartz foil is apparent in simulations
- The preheated layer causes a change in the refractive index of quartz, complicating the VISAR analysis, or a temporary signal loss as the ionized layer absorbs the VISAR probe laser



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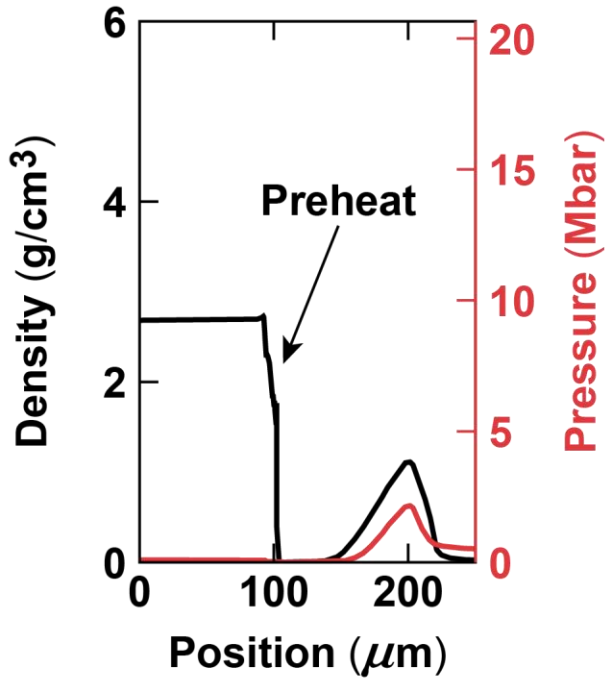
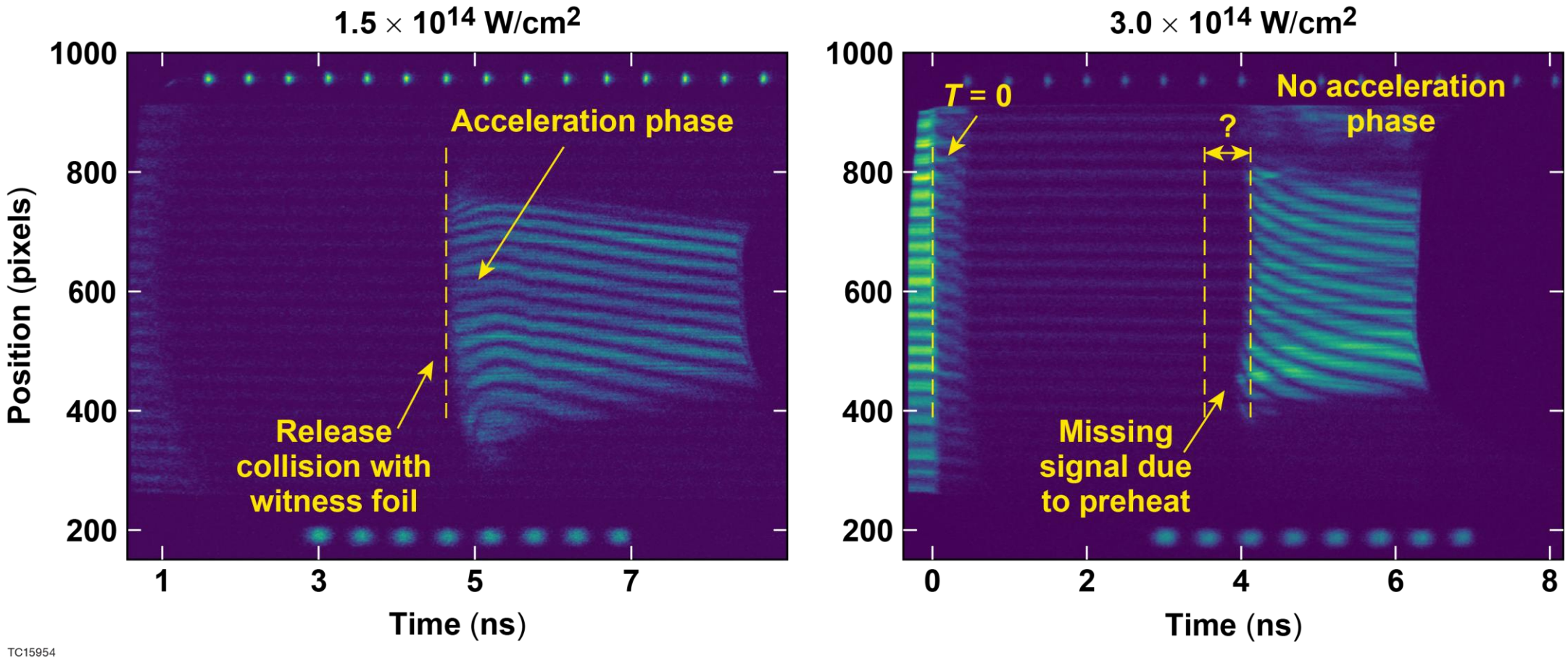
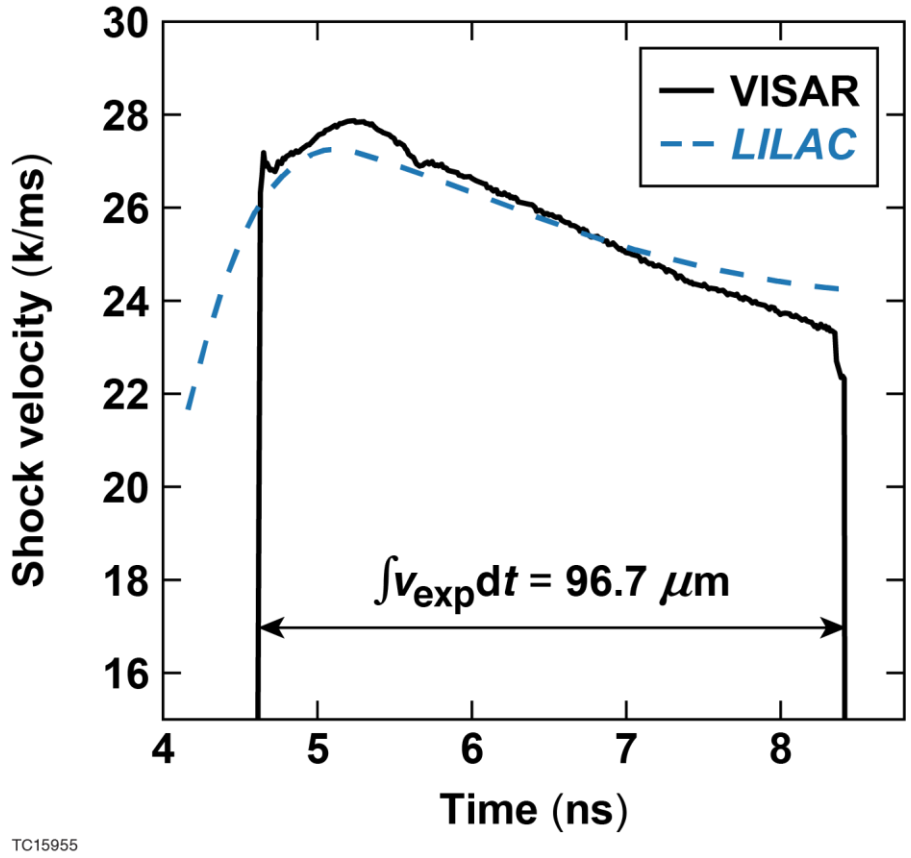


The preheated quartz layer absorbs the VISAR probe laser, resulting in a loss of signal while the shock is traversing the preheated layer



The velocity of the release-driven shock was successfully measured in low-intensity experiments

- The time scale of the initial acceleration and the velocity decay show good qualitative agreement with the simulation
- The measured peak velocity is higher than *LILAC* predicts, indicating more kinetic energy in the leading part of the release
- Faster than predicted decay of the shock velocity indicates less kinetic energy in this part of the release



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