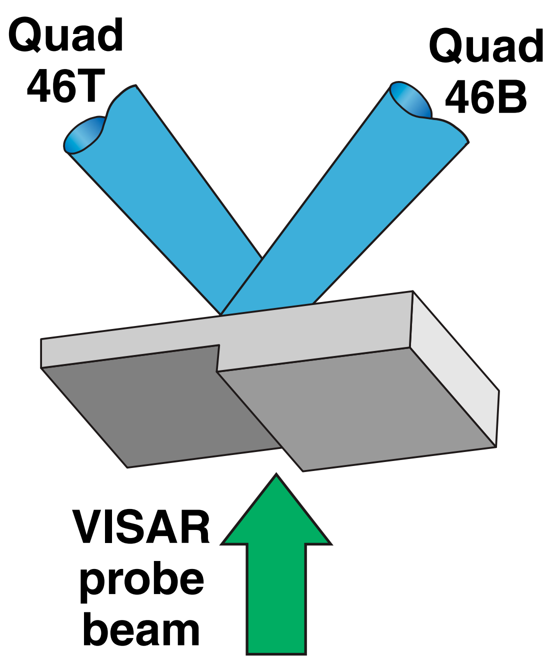
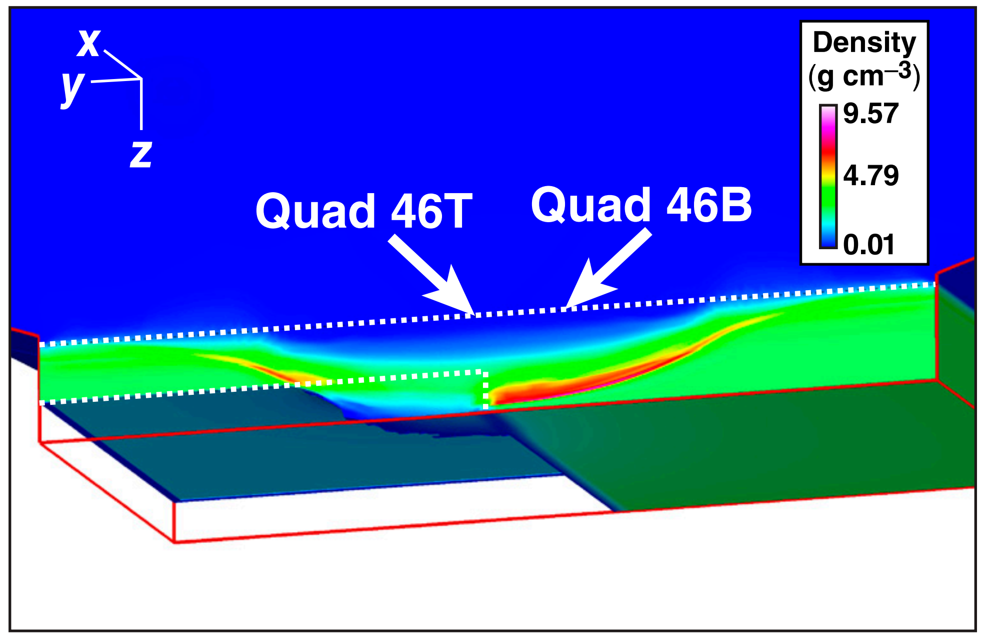
Three-Dimensional Simulations with HYDRA of the Direct-Drive NIF Shock-Timing-Diagnostic Commissioning Experiments





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Summary

- The direct-drive VISAR qualification experiments on the NIF have been simulated using *HYDRA* 3-D
- The shock-speed variation due to shock curvature is comparable to the VISAR shock-speed precision
- The edge rarefaction from the step has minimal impact on the VISAR image region
- A ramp pulse has been designed for greater shock steadiness in the aluminum step

Collaborators

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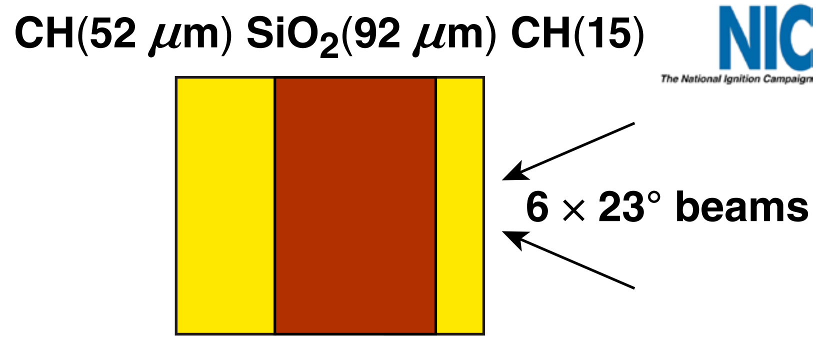
Shock timing of ignition experiments for the National Ignition Facility (NIF) will be confirmed using surrogate targets

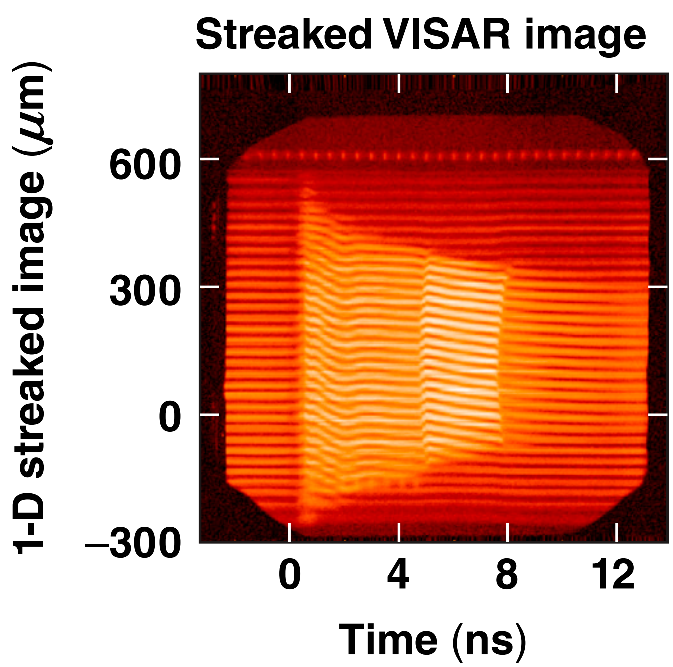
- As inertial confinement fusion targets are imploded, they generate several shock waves
- The shock waves must be precisely timed to maintain a low target adiabat while achieving the necessary fuel compression
- The shock speeds are measured using the VISAR* optical interferometer and a streaked optical pyrometer
- Based on previous experiments on OMEGA, this platform will be tested on the NIF with direct drive, using impedance-matching experiments of a quartz sample and a stepped aluminum layer as a standard

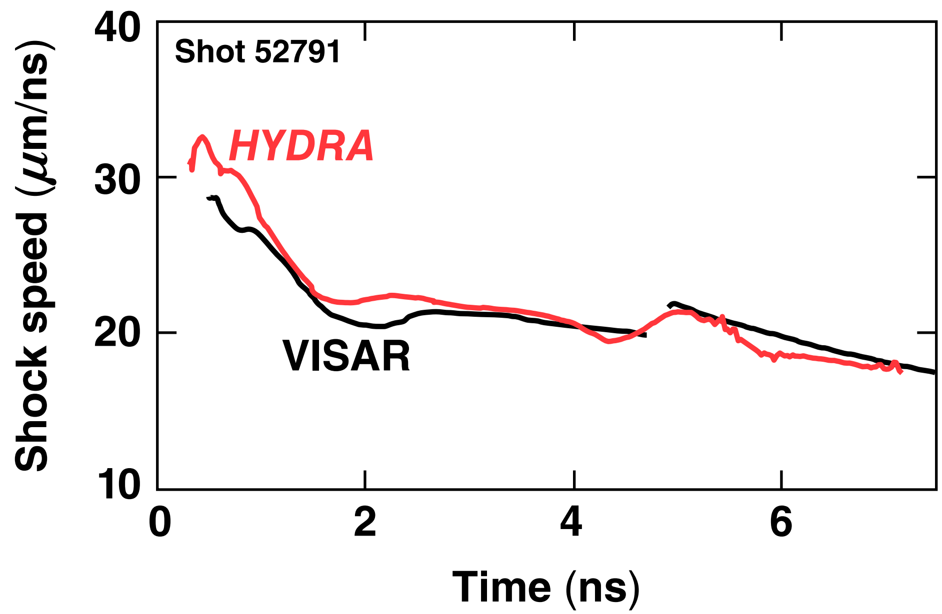
*Velocity Interferometer System for any Reflector

An EOS experiment performed on OMEGA* was simulated to calibrate *HYDRA*'s modeling of the VISAR commissioning experiment

- This shot was chosen because it had a particularly clear VISAR trace
- The simulated shock speeds agree with the VISAR-inferred experimental shock speeds to within ~10%





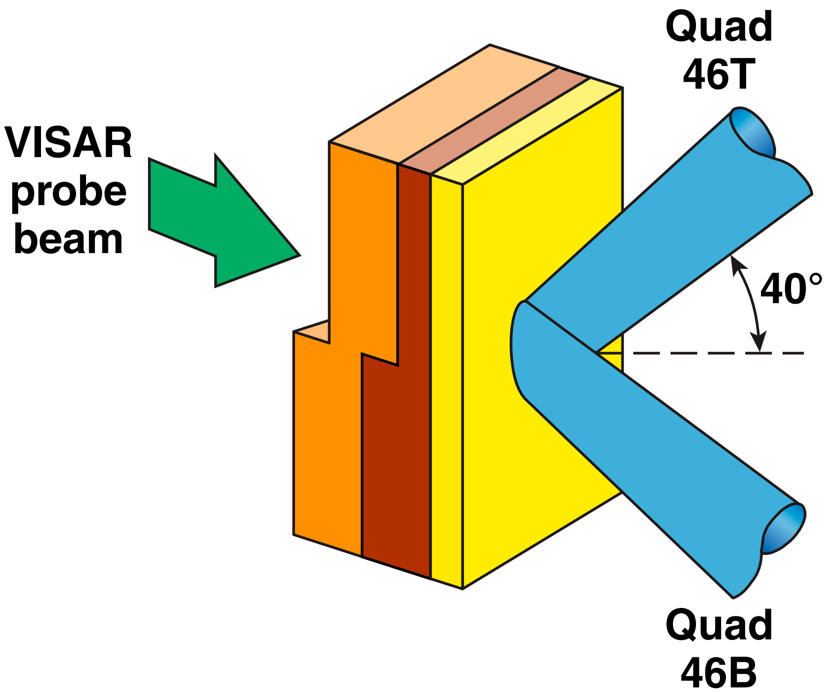


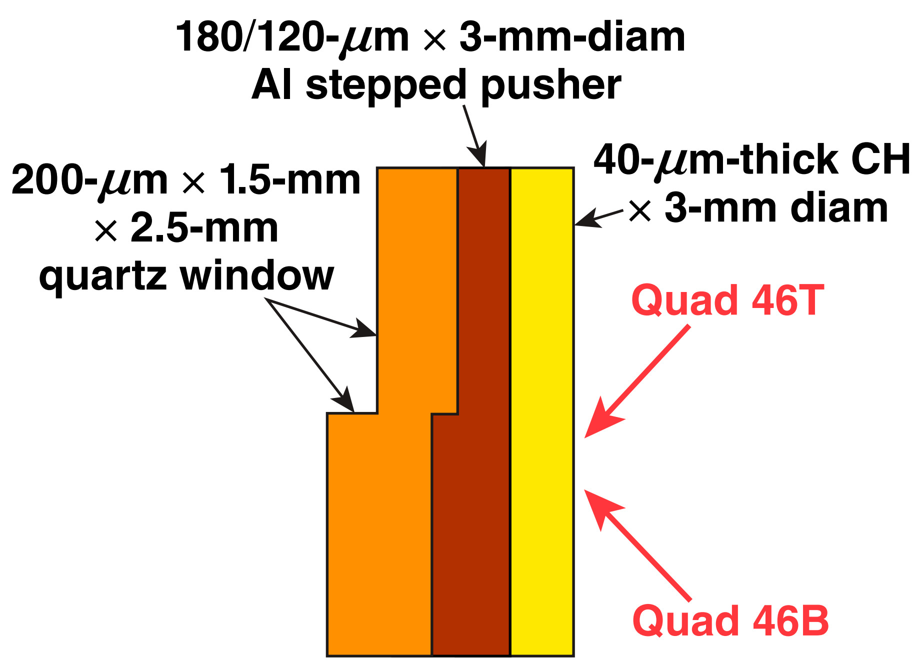
TC8575

*M. A. Barrios (JI2.00002).

The NIF target will be driven by two “quads” to achieve pressures of ~10 Mbar

- The laser beams are incident at 40°
- 12 kJ of laser energy will be delivered in a 6-ns pulse and a 1.2-mm-diam spot





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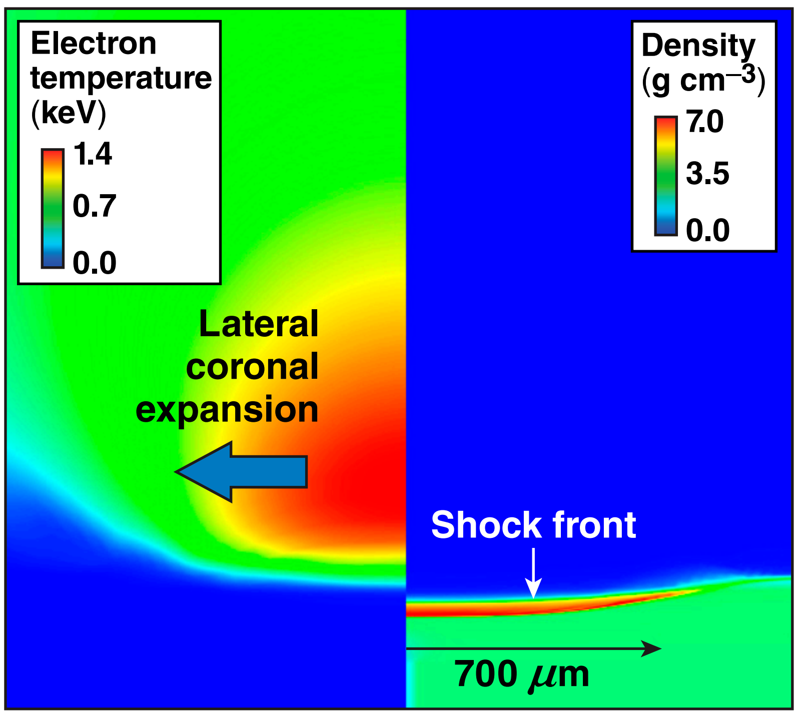
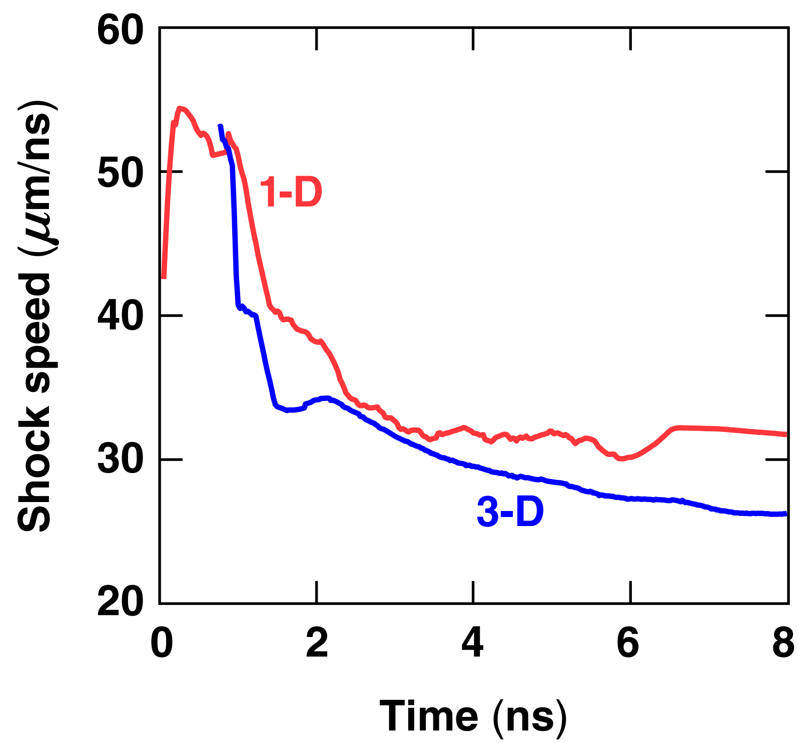
Accurate modeling of the experiment requires 3-D simulations

- 1-D modeling over-predicts target drive and shock speeds caused by lateral expansion of the corona
- 3-D modeling is necessary because of the target step and the laser-spot ellipticity

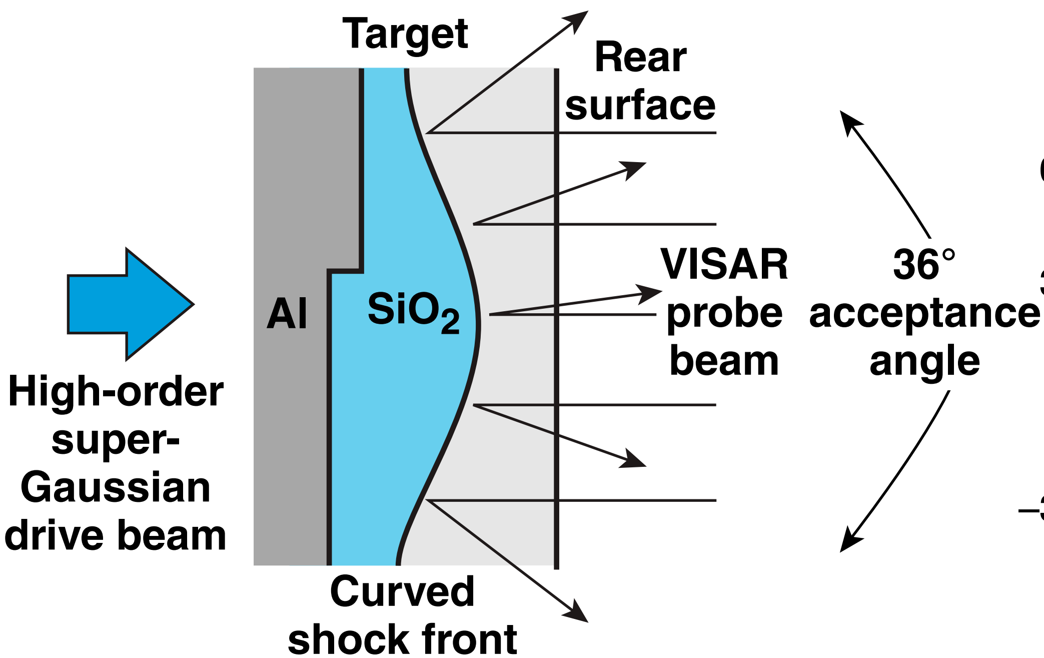


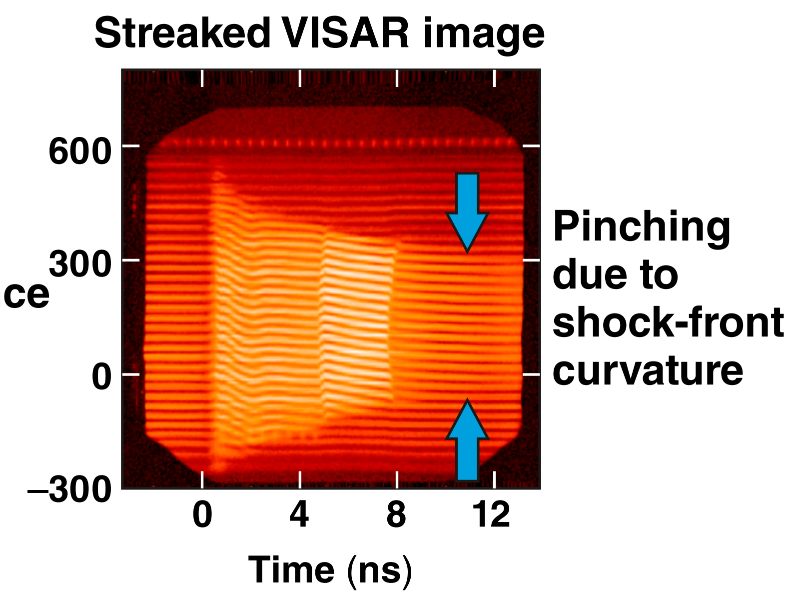


TC8577

Shock-front curvature decreases the size of the streaked VISAR image

- The 532-nm VISAR probe beam reflects off the shock front
- The edges of the spot are curved due to the spot-edge rarefaction wave
- Rays with an angle greater than 18° miss the collection optic

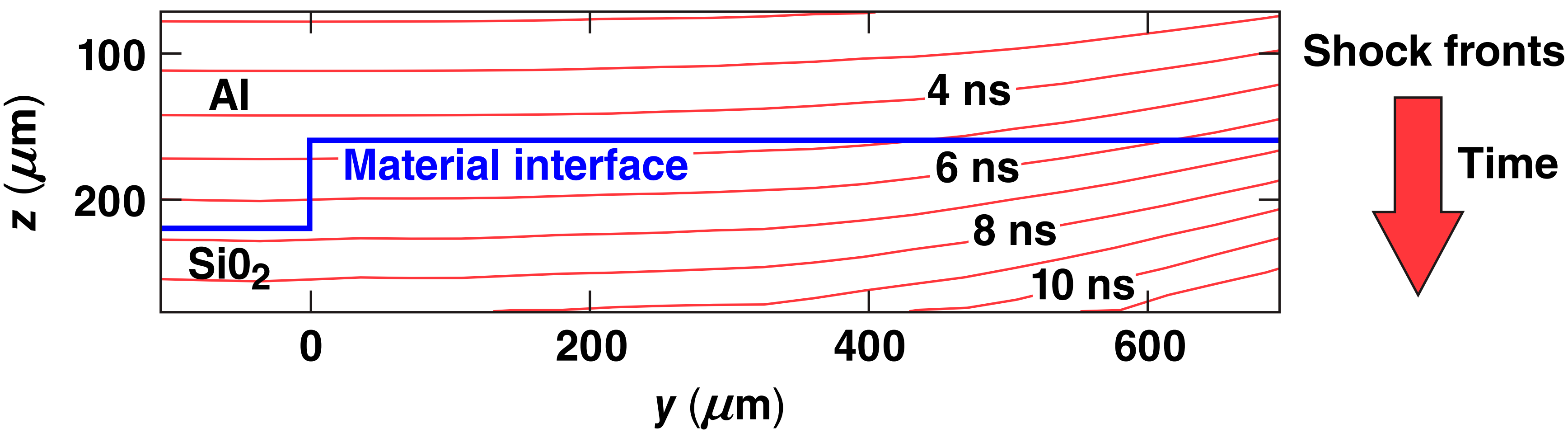




TC8717

The shock-speed variation over 200 μm is comparable to the VISAR precision

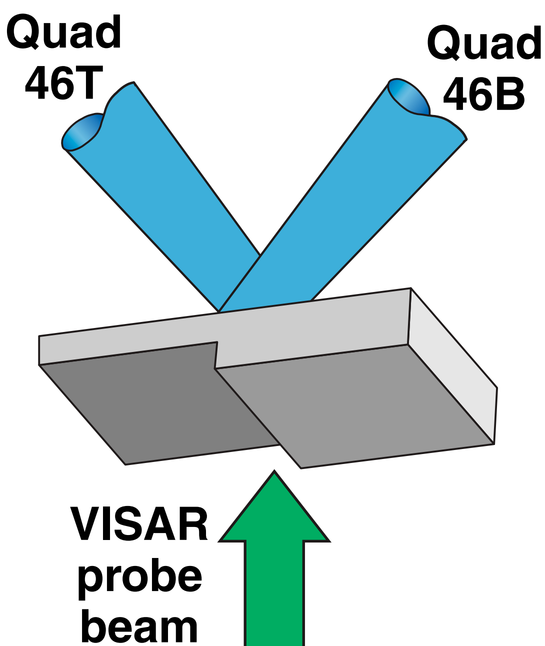
- When the shock transits into the quartz at ~5 ns, the size of the acceptance region is over 1 mm, larger than the VISAR viewing area
- The average shock speed from 4 to 5 ns is lower by 1.1% at a radius of 200 μm than the speed at the center of the shock front
- This is comparable to the ~1% shock-velocity precision of VISAR

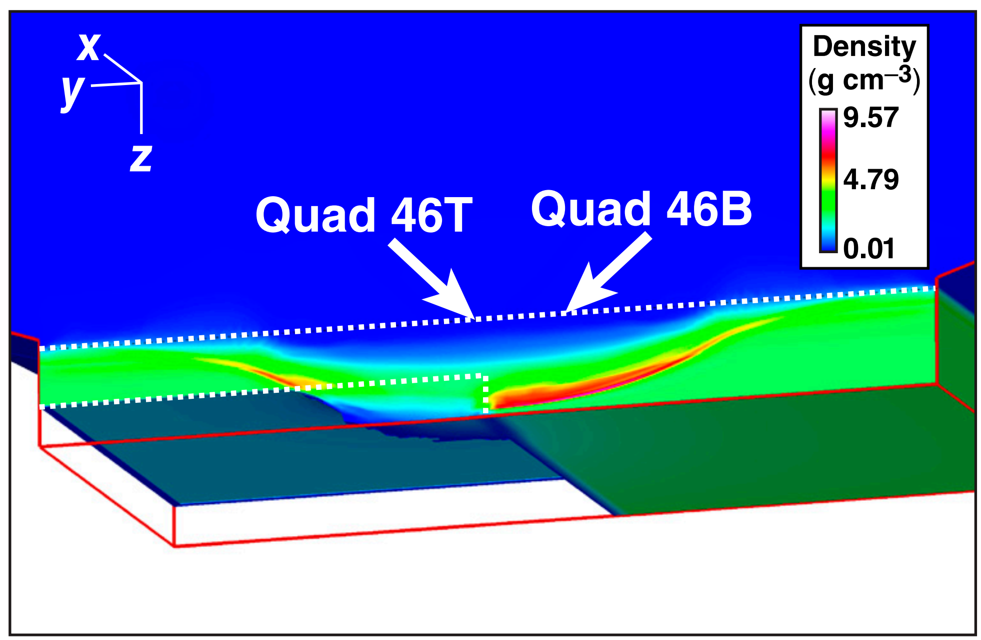


TC8718

Edge rarefactions caused by the aluminum and quartz steps have minimal effect on the VISAR detection region

- The Al layer is stepped to provide an average shock-speed measurement
- The steps in the Al and the quartz result in edge rarefaction fans
- The rarefaction expands about 40 μm perpendicular to the shock into the quartz
- This distance is much smaller than the VISAR image size and is comparable to two VISAR fringes

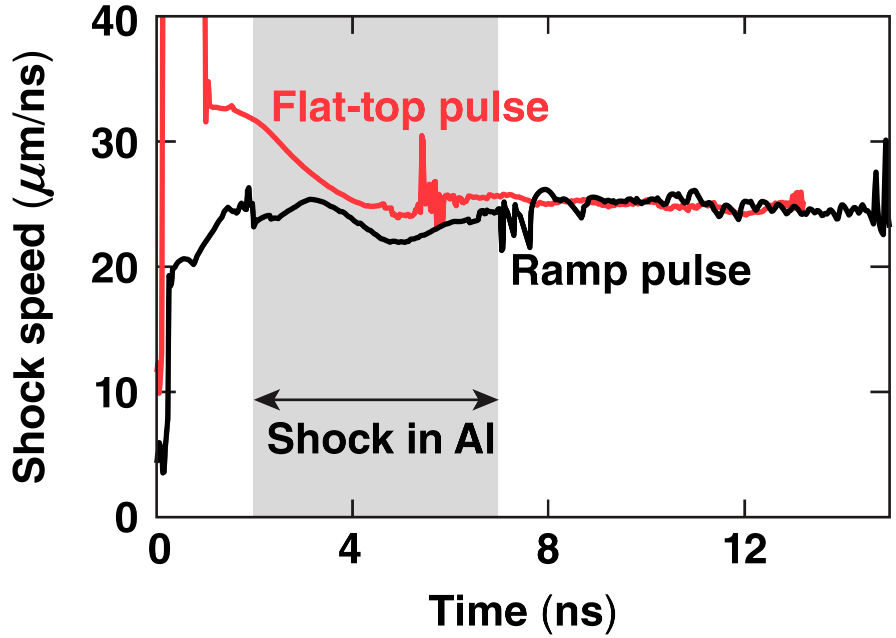




TC8579

A rising pulse has been designed to provide constant shock speed within the Al layer

- Laser coupling and shock strength decrease initially as the corona is established
- The CH–Al-layer interface causes a rarefaction wave, which also attenuates the shock
- Equation-of-state experiments using a step target with an opaque standard require a steady shock
- A rising pulse was designed in 1-D, which improves shock steadiness within the aluminum step



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Summary/Conclusions

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VISAR commissioning experiments on the NIF are scheduled for February 2010.