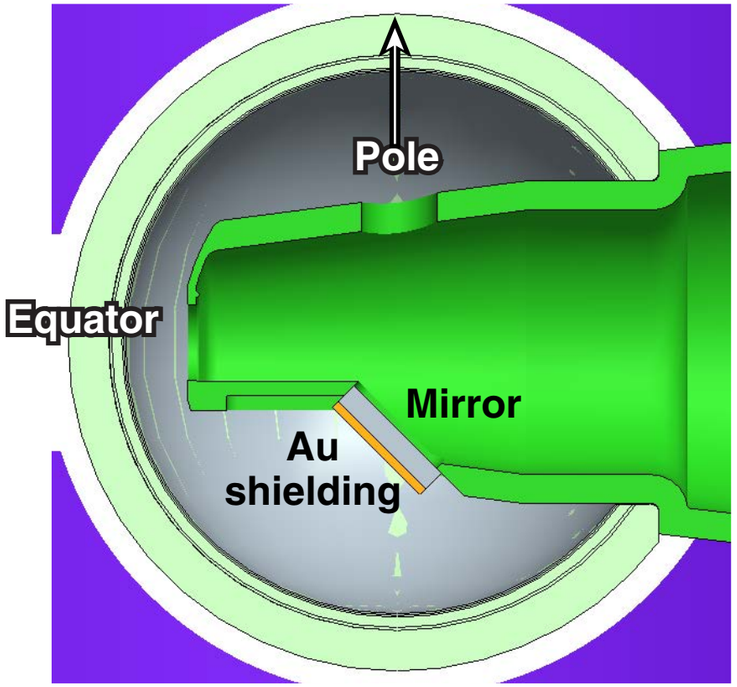
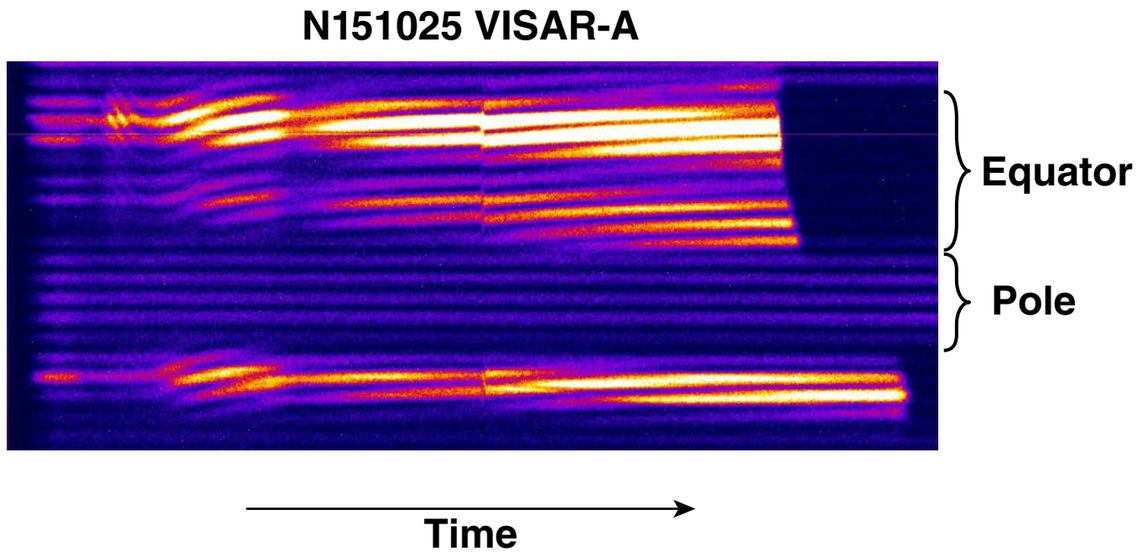
Polar-Direct-Drive Shock-Timing Measurements at the National Ignition Facility





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57th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Savannah, GA
16–20 November 2015

Summary

Shock-timing measurements for polar-direct-drive (PDD) implosions have begun at the National Ignition Facility (NIF)

- Direct-drive–implosion adiabats are controlled with multiple 100-ps pulses ahead of the main drive
- Shock-timing measurements validate simulation predictions of the adiabat; additionally, the shock strengths are good measures of the laser–target coupling
- A fundamental issue for PDD is low-order (P2) nonuniformity created by the nonsymmetric beam configuration
- Two-axis velocity interferometer system for any reflector (VISAR) measurements provide shock timing (adiabat) and velocities at the pole and equator (P2 nonuniformity)
- This technique was successfully demonstrated on the NIF using warm CH targets; these will suffice until cryogenic D_2 targets are available

Collaborators

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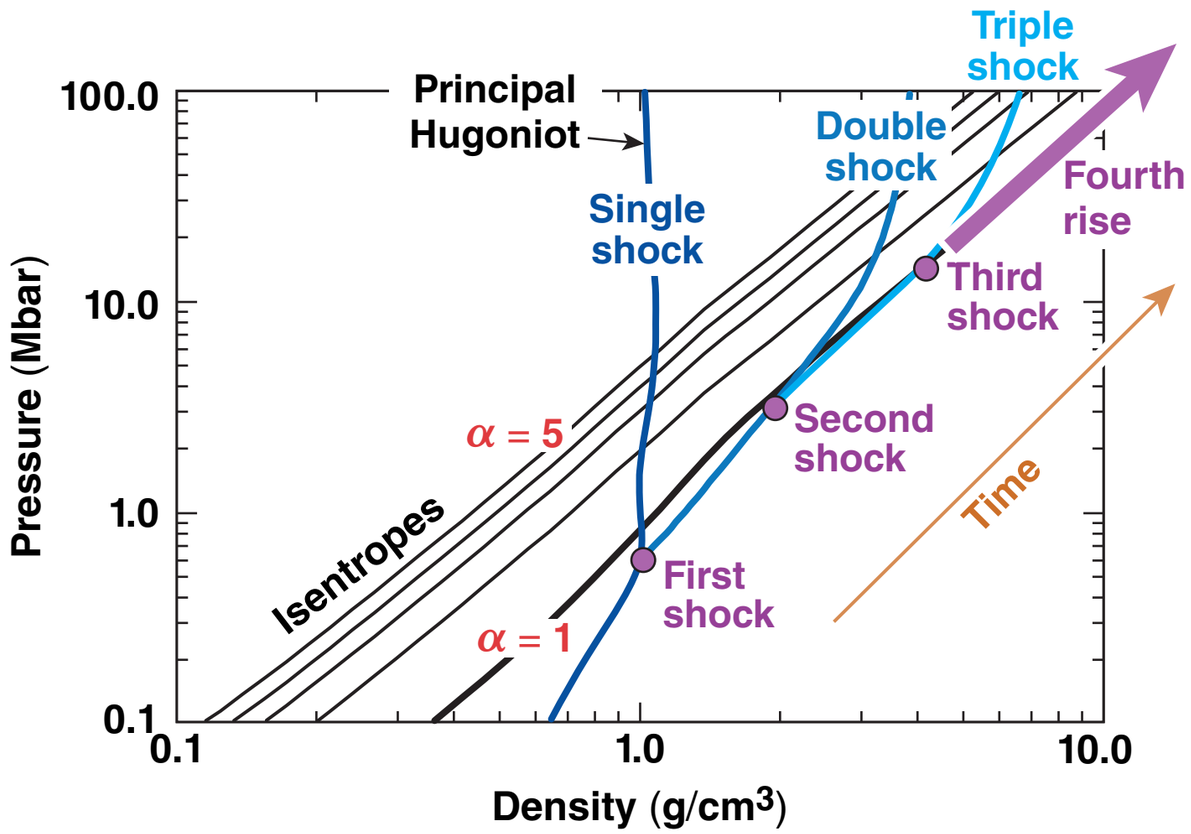
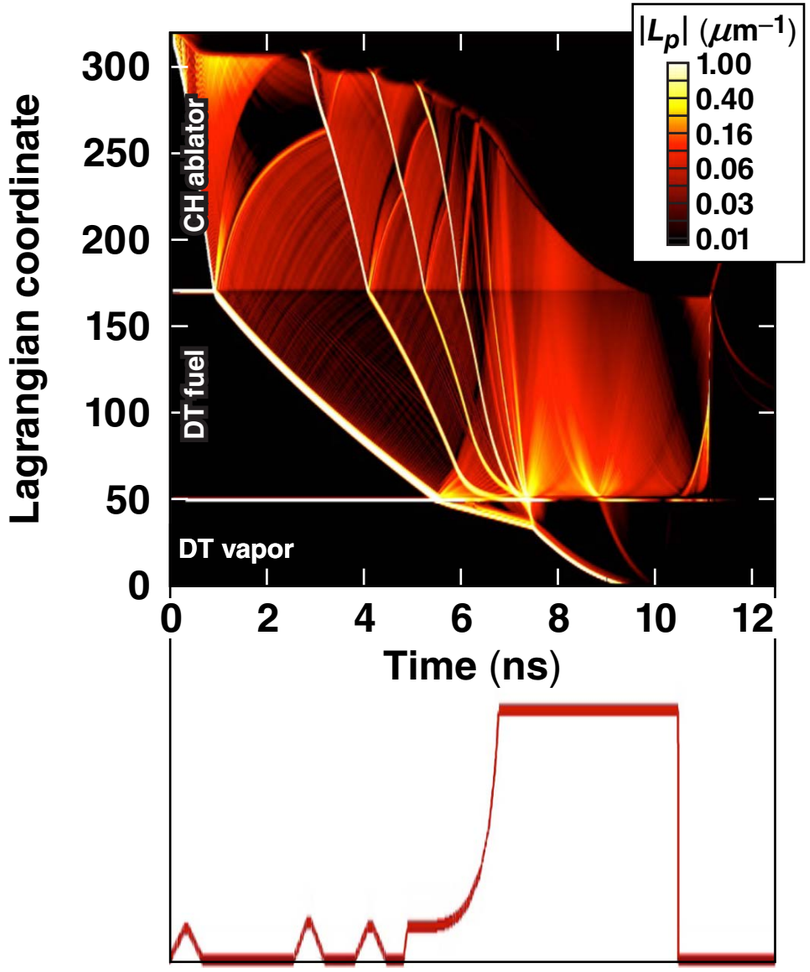
Lawrence Livermore National Laboratory

The adiabat of an ICF* implosion is "set" by a series of shock waves that precompress the shell and fuel before they implode

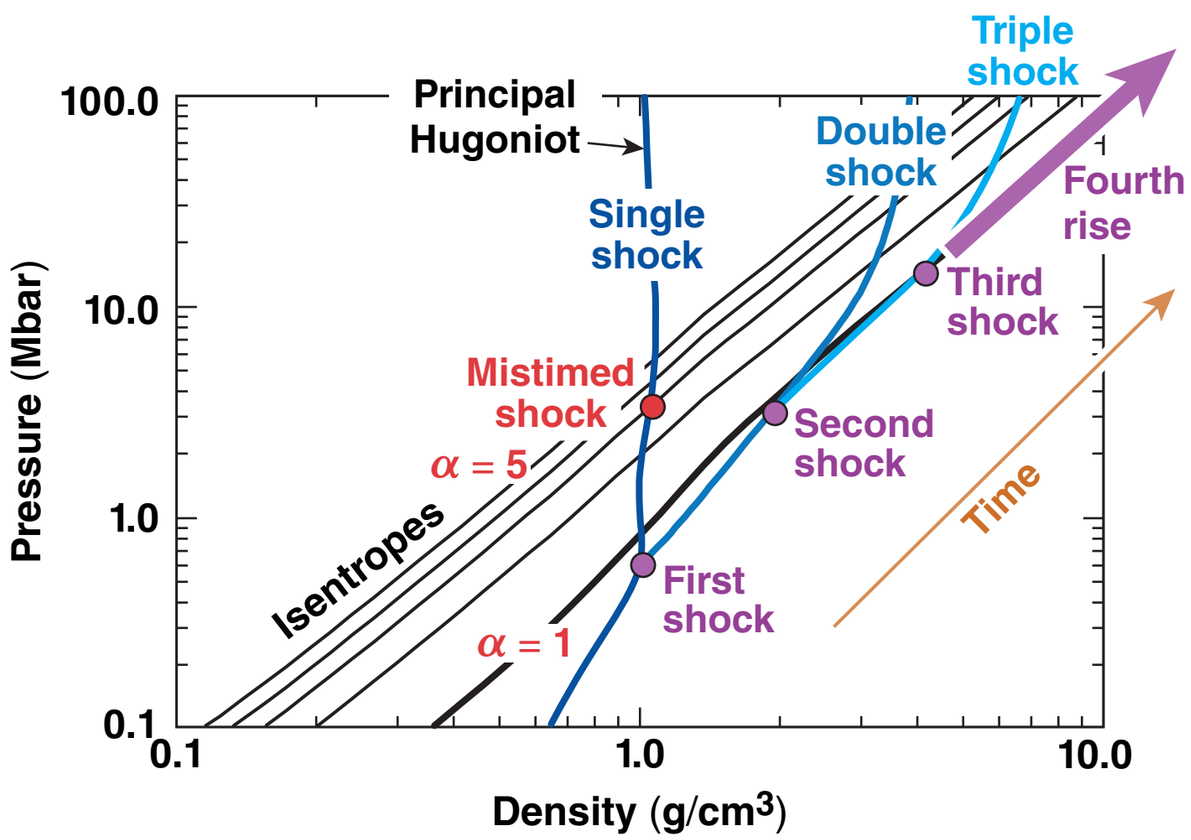


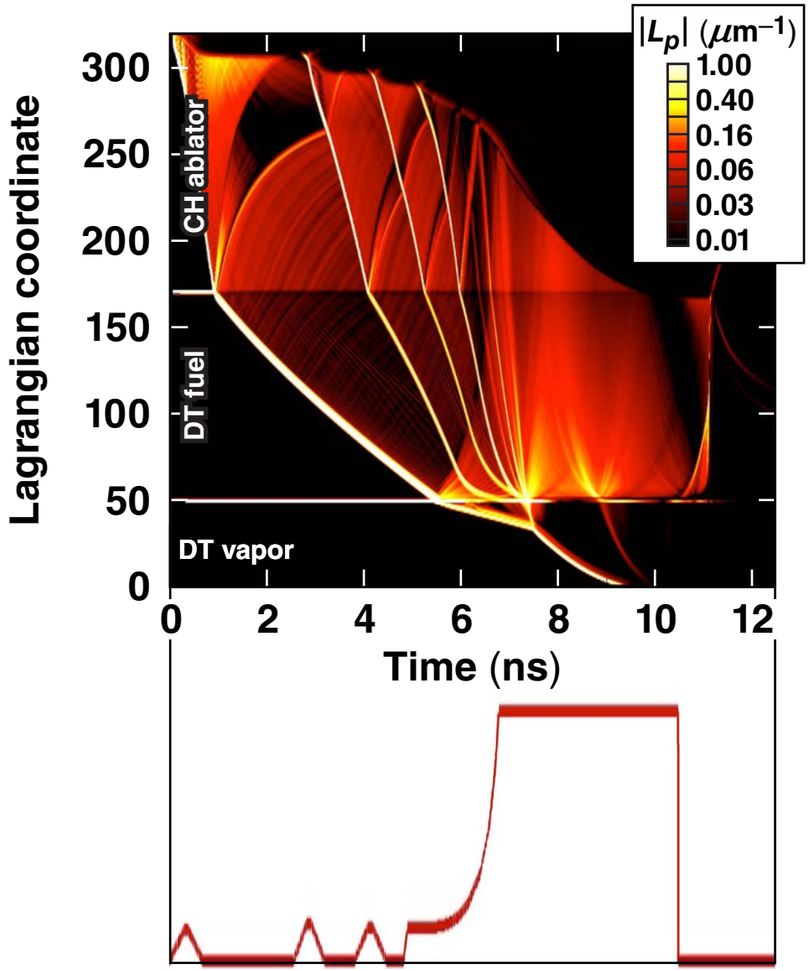


E24581

*ICF: inertial confinement fusion

The adiabat of an ICF implosion is “set” by a series of shock waves that precompress the shell and fuel before they implode





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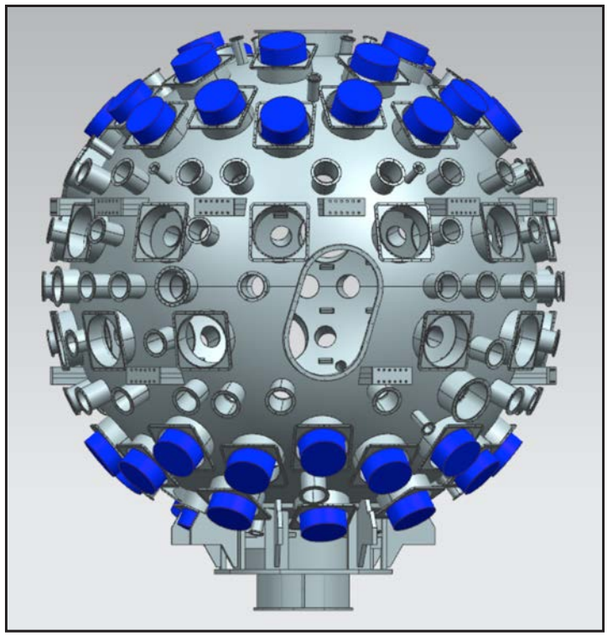
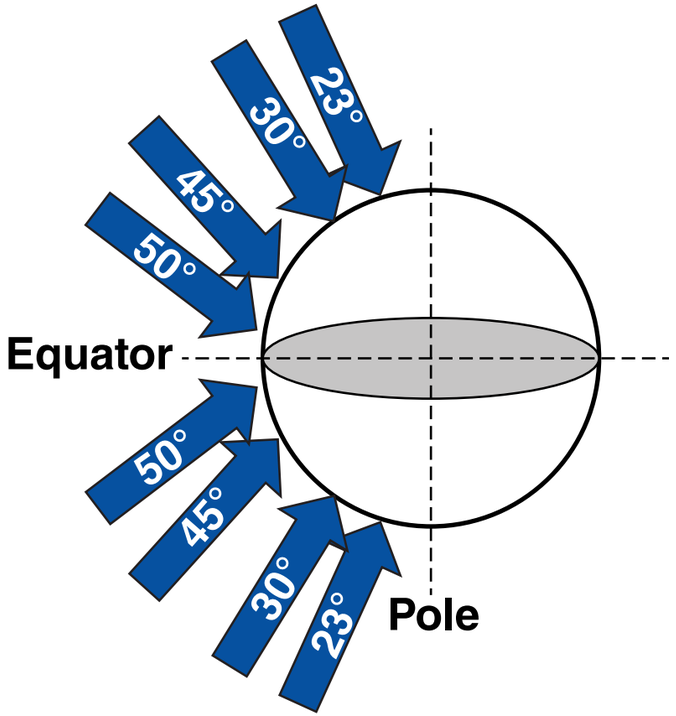
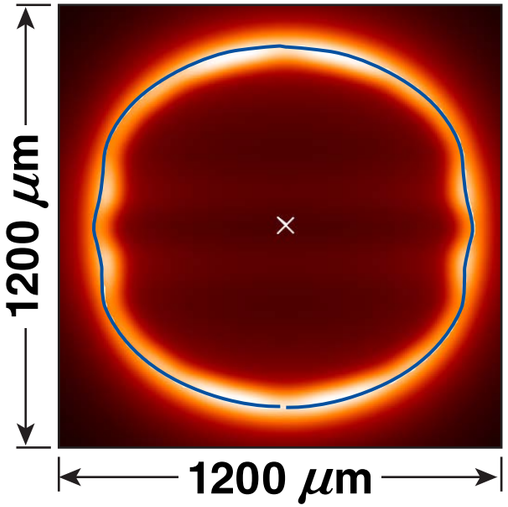
Motivation

PDD* is an alternative approach to achieving ignition on the NIF

NIF beams configured for indirect drive (arranged around the poles)



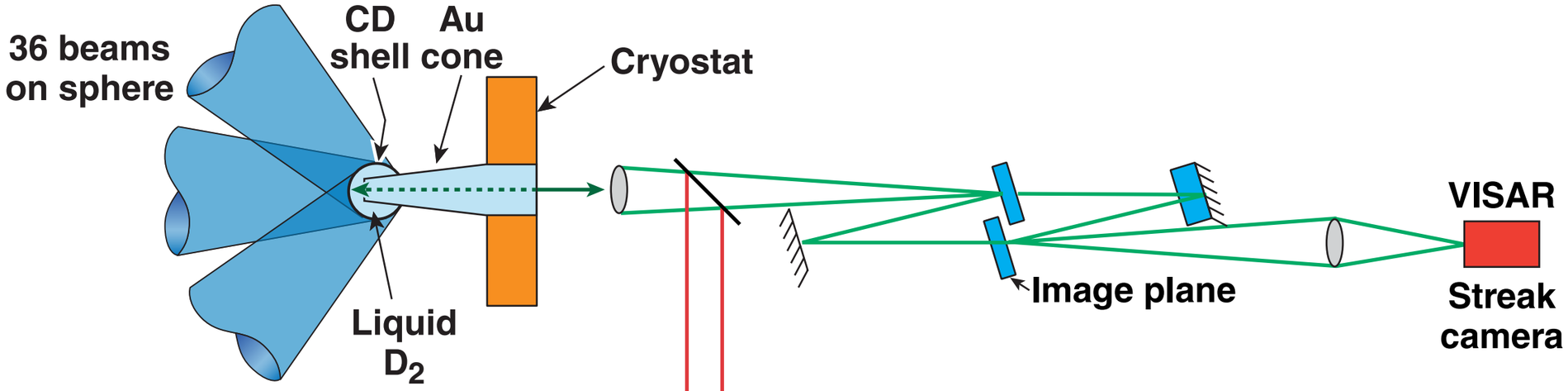




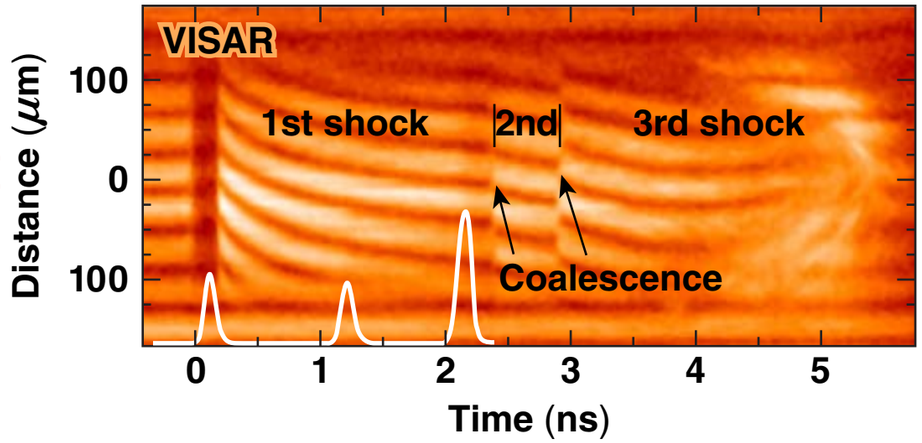
*S. Skupsky *et al.*, Phys. Plasmas 11, 2763 (2004); M. Hohenberger *et al.*, Phys. Plasmas 22, 056308 (2015).

E24121a

Shock-timing measurements use VISAR to detect multiple converging shock waves *within* a spherical capsule



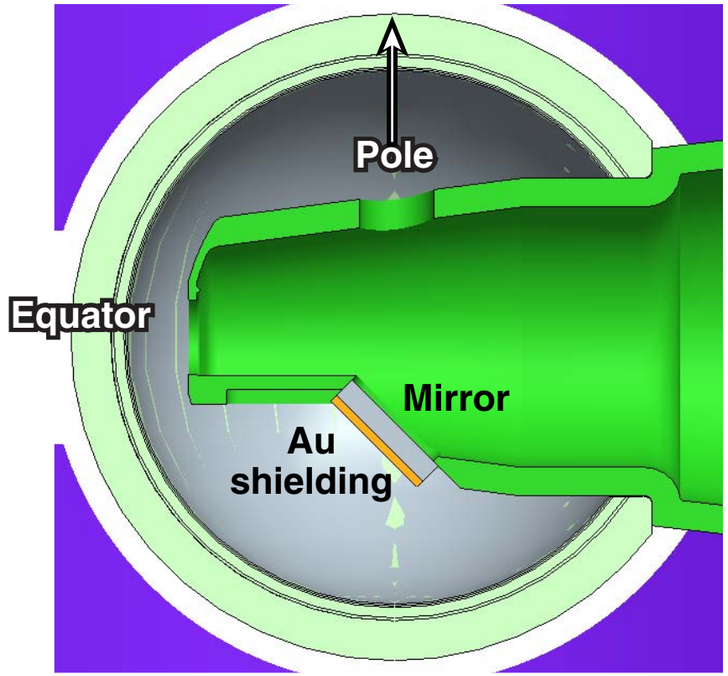
Capsule/cone detail

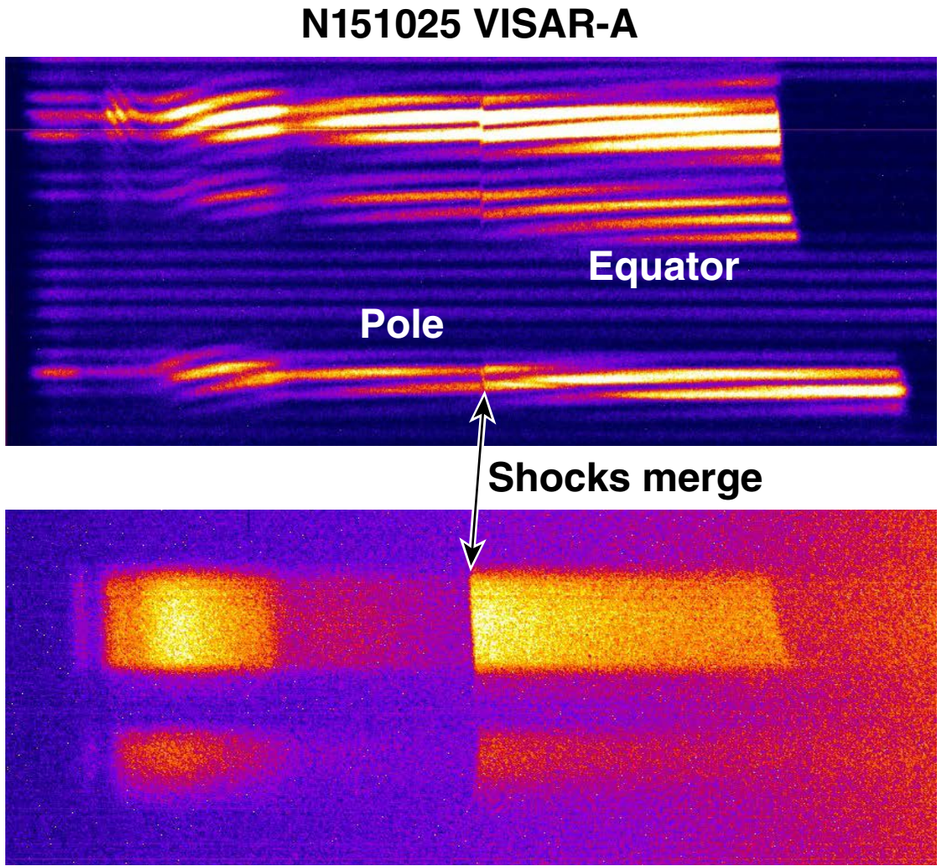


T. R. Boehly *et al*. Phys. Rev. Lett. 106, 195005 (2011);
T. R. Boehly *et al*. Phys. Plasmas 18, 092706 (2011).

E16636l

The two-axis VISAR/SOP* provide shock-timing and strength measurements at the equator and pole



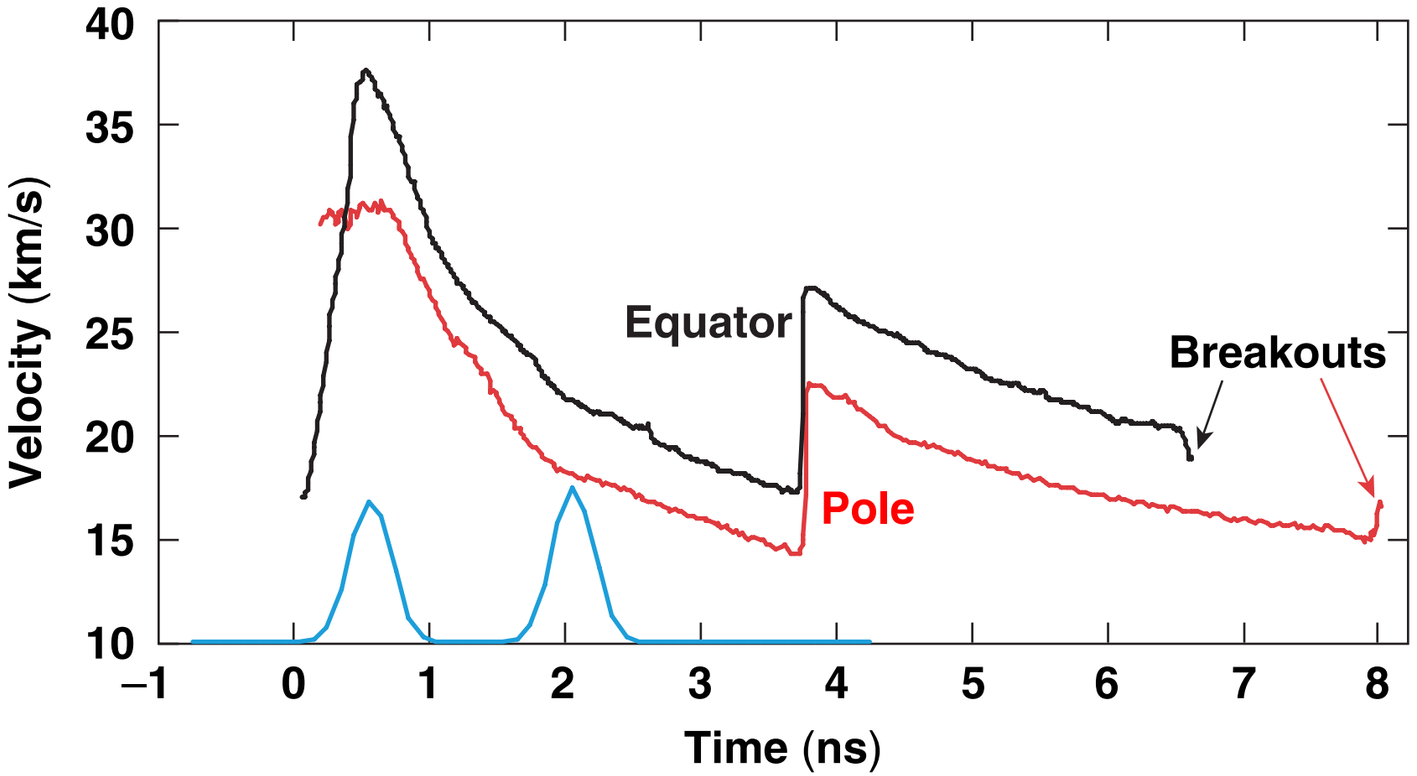


*Streaked optical pyrometer

E24583

N151025-003

Shock velocity at the equator was higher than at the pole, suggesting less PDD compensation is required

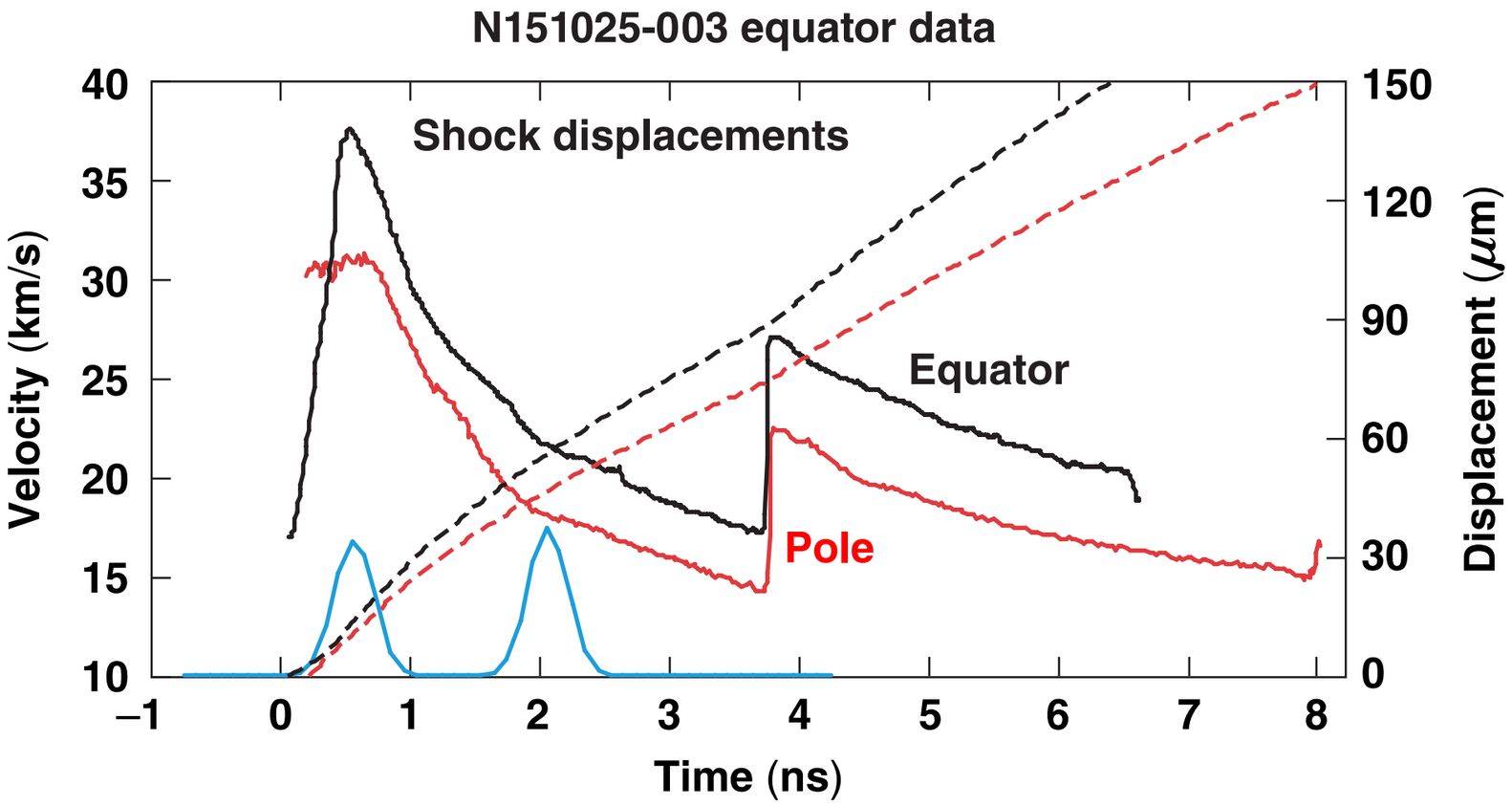


Simultaneous mergers at the pole and the equator are a coincidence.

E24717

N151025-003

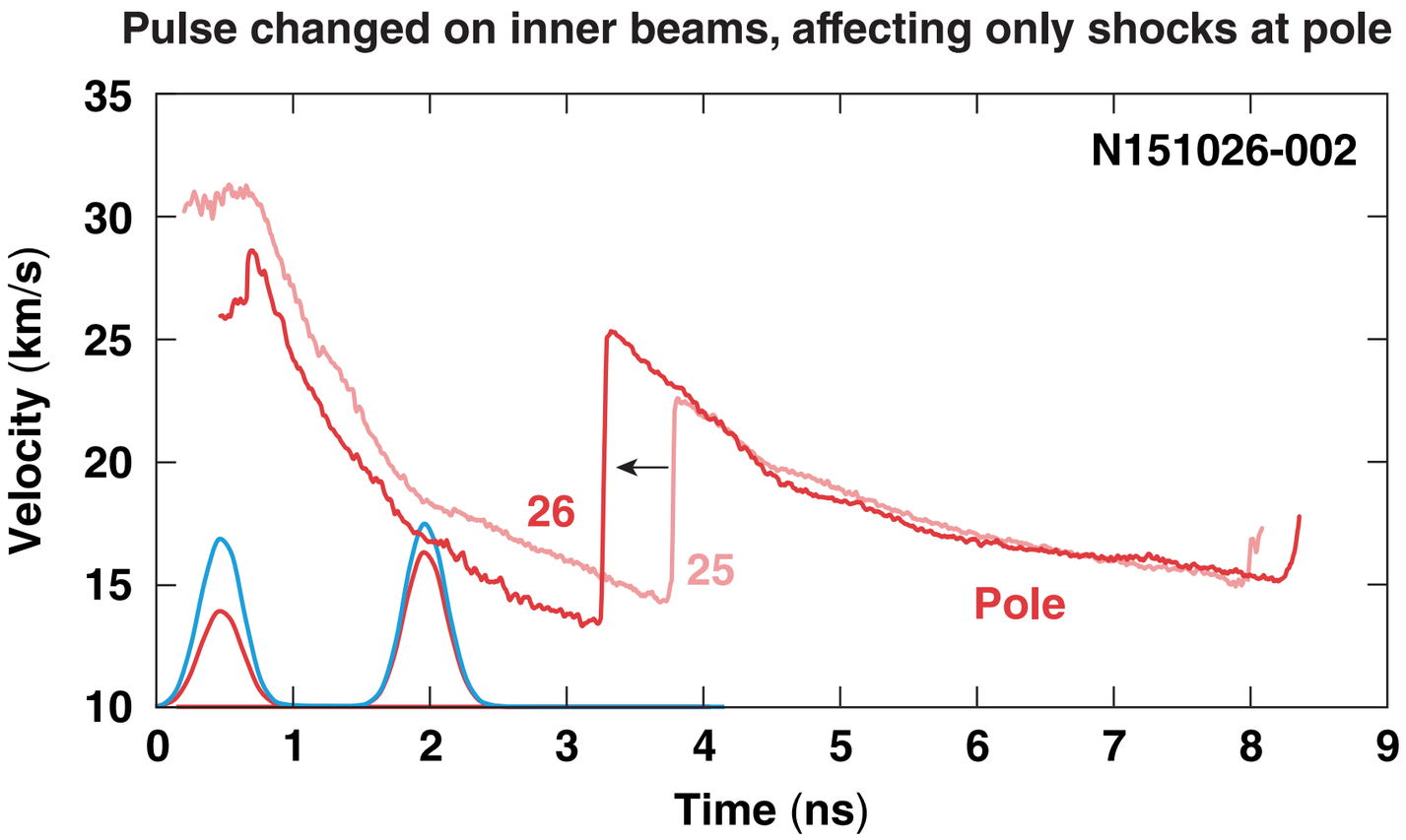
Both shock-velocity profiles integrate to 150 μm (the shell thickness) at their breakout times



E24718

Second Shot

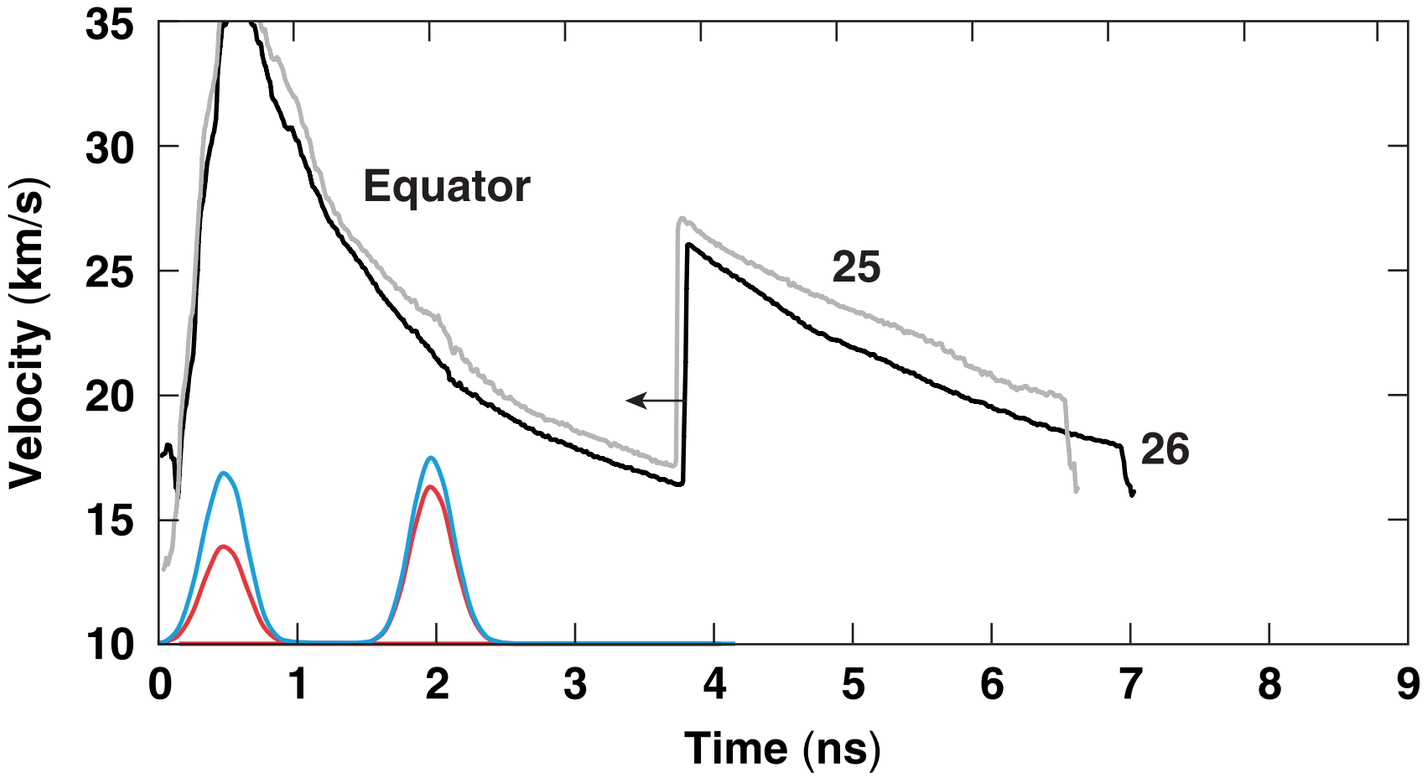
A pulse with a lower-power first pulse reduced the first shock velocity and moved the merge time earlier



E24719

Second Shot

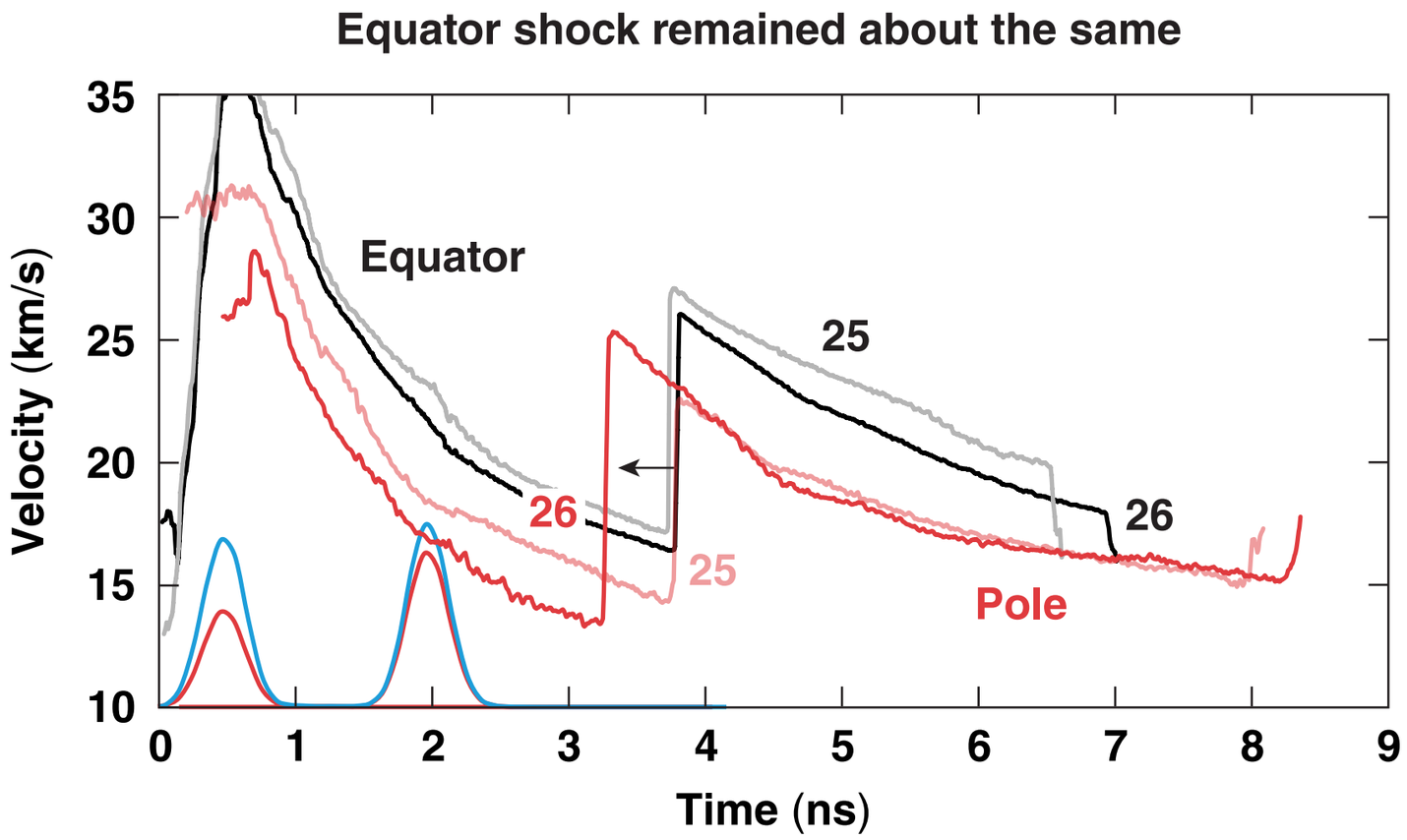
Power for equatorial beams was similar as were the resulting velocities



E24720

Second Shot

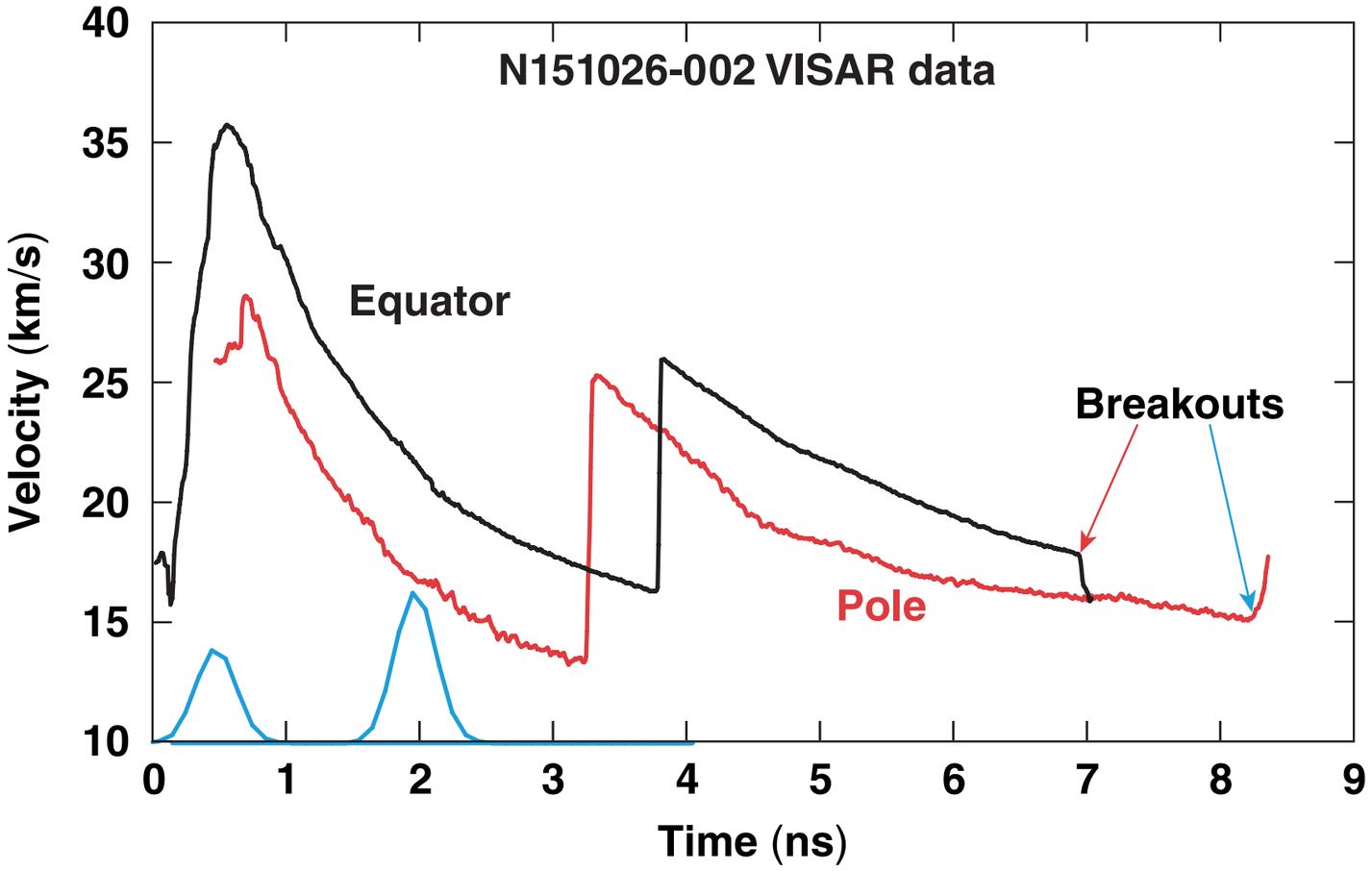
Pulses with a lower-power first pulse reduced the first shock velocity and changed the shock merge time



E24721

N151026-002

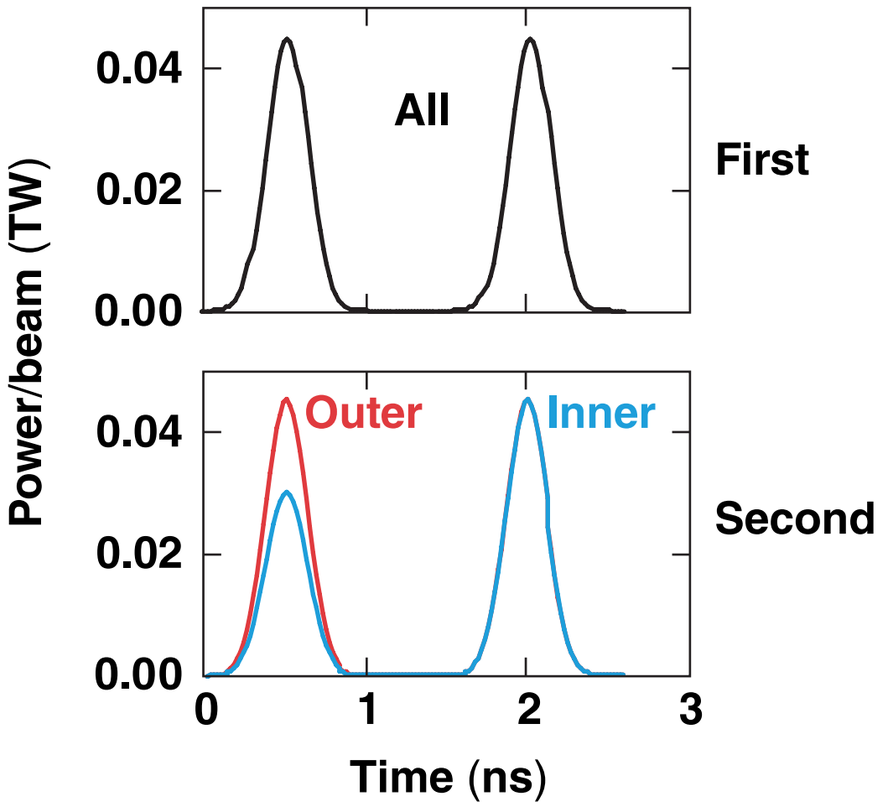
Pulses with a lower-power first pulse reduced the first shock velocity and changed the shock merge time

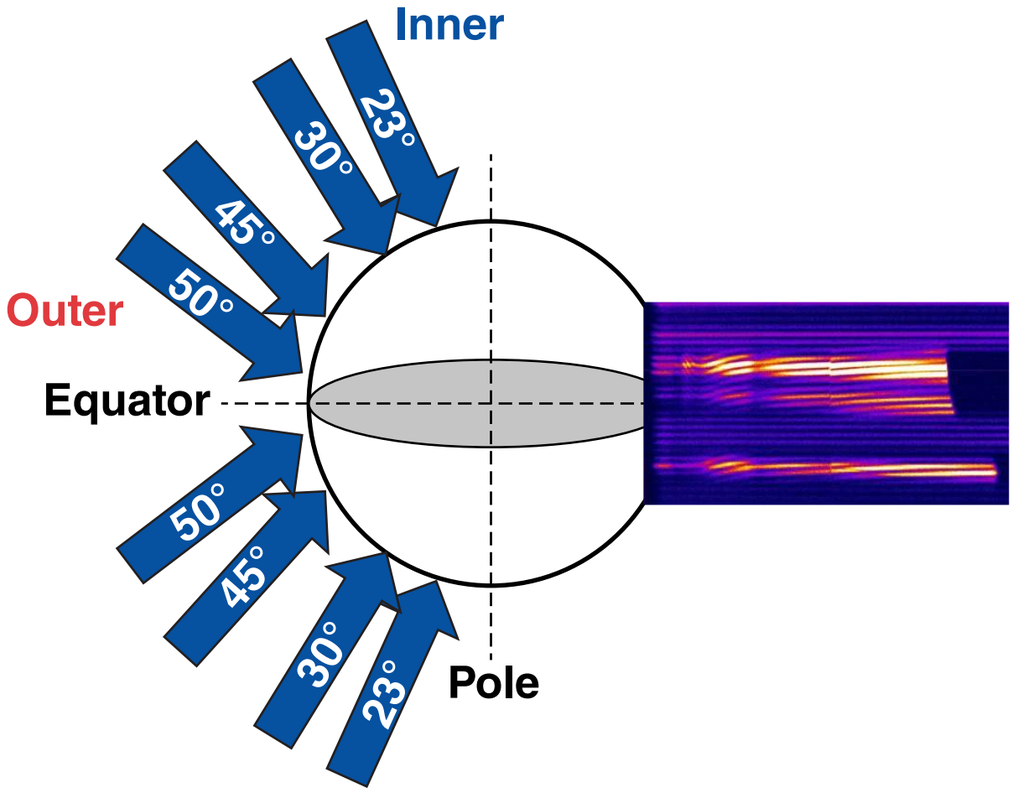


E24722

Two shots on the NIF demonstrated the use of multi-axis VISAR to measure shock timing in PDD implosion geometry

- Shot 1: equal picket pulses
- Shot 2: lower power of first pulse on inner beams only





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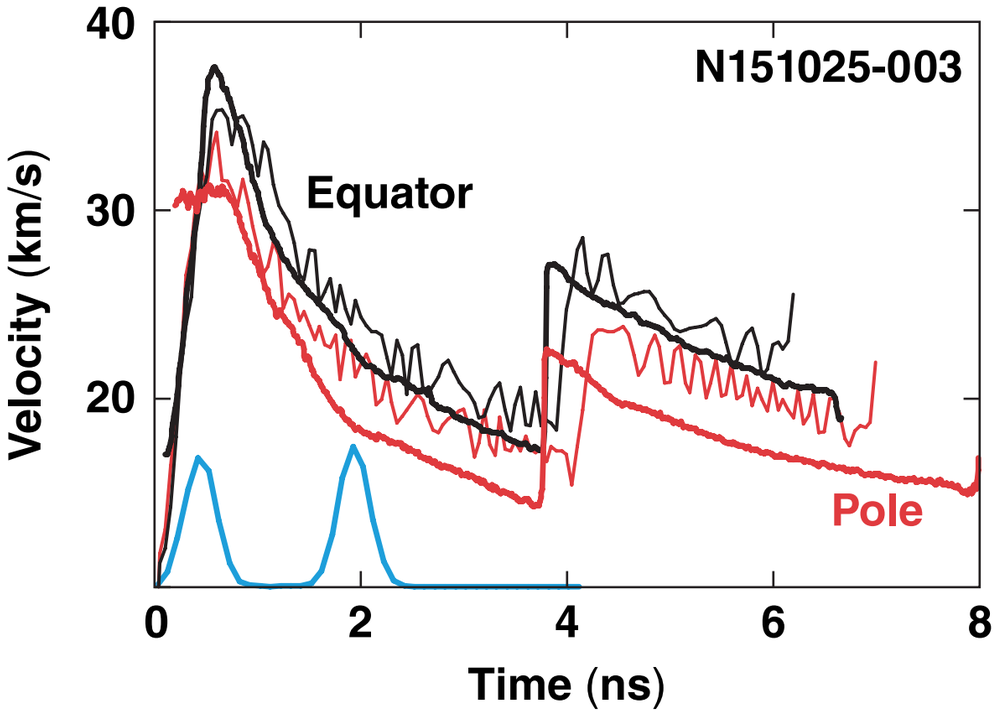
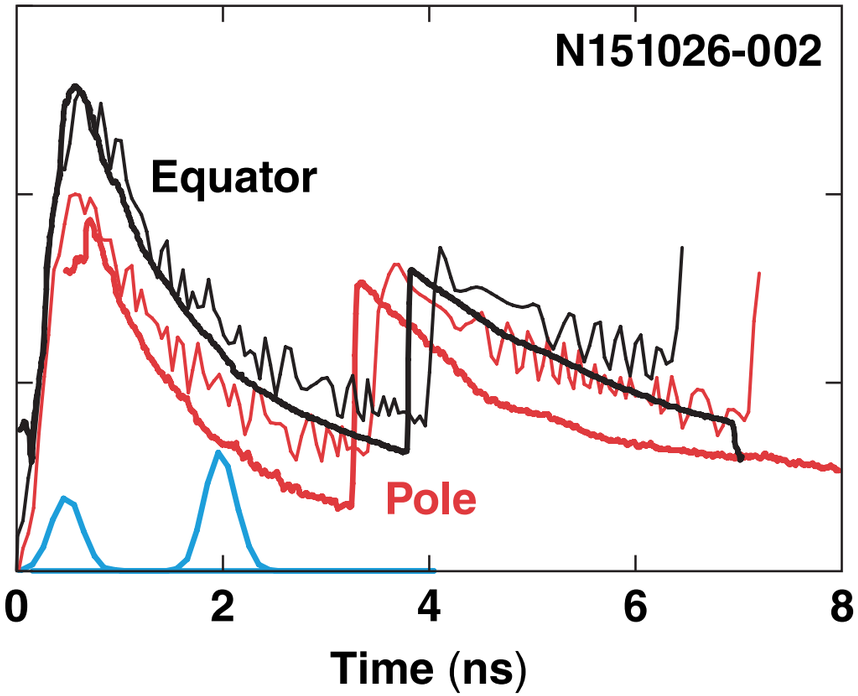
Preliminary simulations show fair agreement with results; inclusion of actual power balance is needed





E24759

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