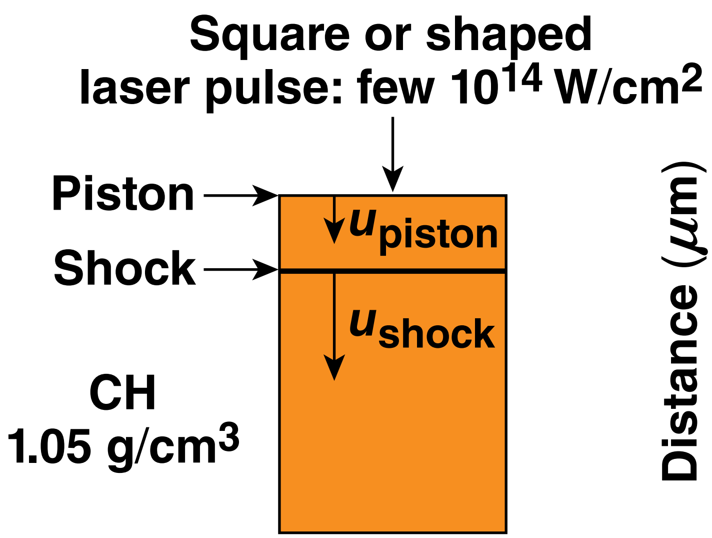
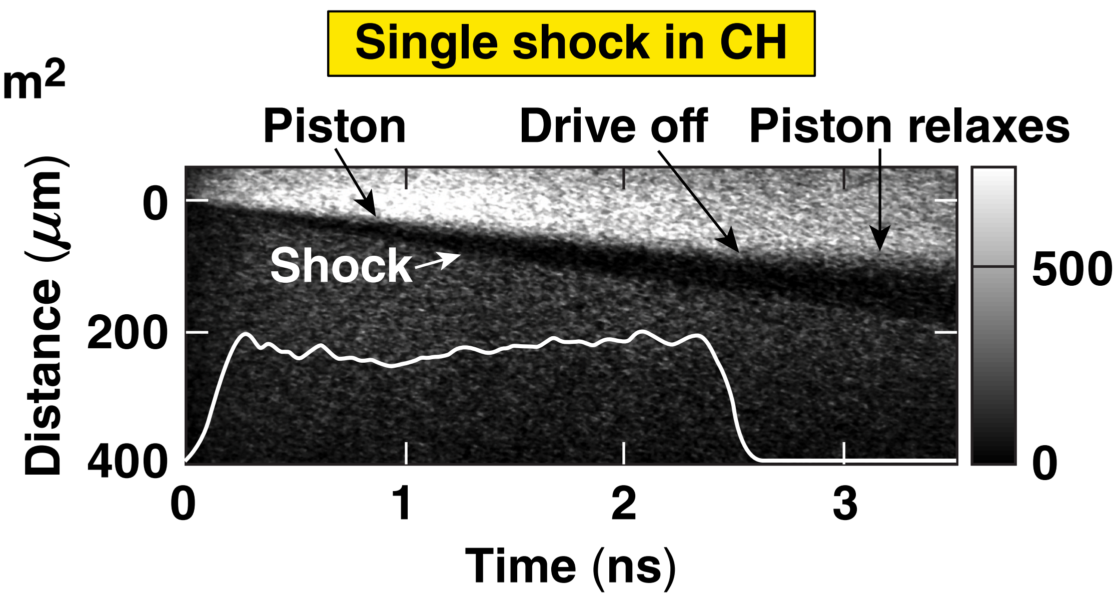
Direct Piston- and Shock-Timing Measurements in CH Using Streaked X-Ray Radiography





P. M. Nilson
University of Rochester
Laboratory for Laser Energetics

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Summary

Piston and shock trajectories have been tracked in laser-driven CH targets

- Material response to ablation was investigated using massive plastic targets irradiated with square or stepped laser pulses
- Streaked x-ray radiography shows the piston and shock dynamics over a several nanosecond period
- Preliminary *DRACO* simulations based on flux-limited transport are in broad agreement with the shock data; the piston data lags predictions late in time

This platform can test laser–plasma coupling and dynamic compressibility models using a simple target geometry.

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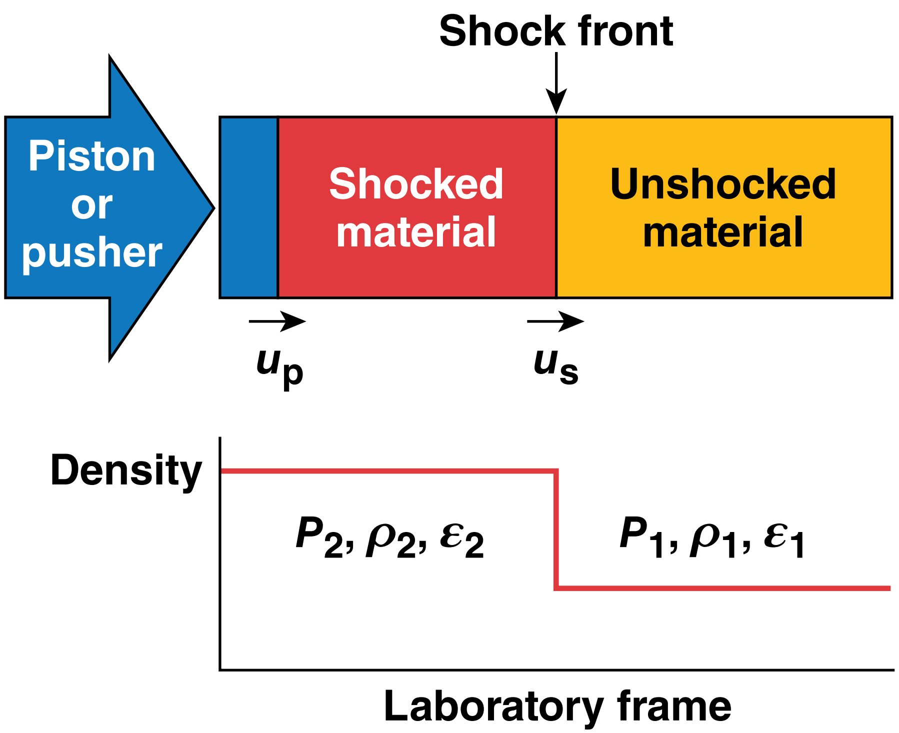
Collaborators

M. Lafon,[1] C. Stillman,[1,2] C. Mileham,[1] R. Boni,[1]
T. R. Boehly,[1] D. H. Froula,[1,2] and D. D. Meyerhofer[1,2,3,4]

[1]Laboratory for Laser Energetics
[2]Department of Physics
[3]Fusion Science Center for Extreme States of Matter
[4]Department of Mechanical Engineering
University of Rochester

Dynamic compression of materials is achieved using shock waves*

A single-shock drives a sample to a point on the principal Hugoniot.



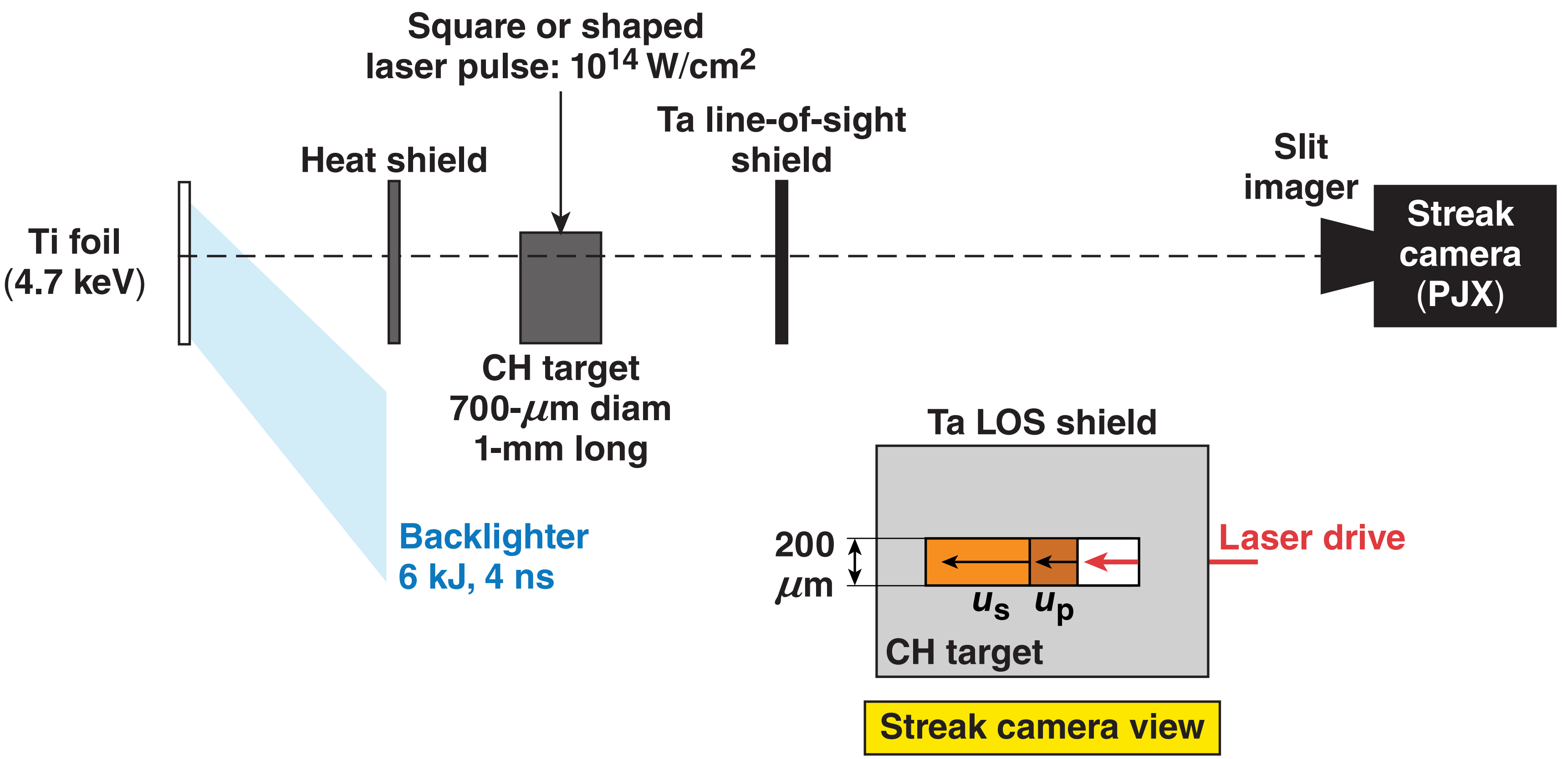
The fluxes in density (ρ), pressure (P), and energy (ε) must be conserved across the shock front

Rankine–Hugoniot equations

$$\rho_1 u_s = \rho_2 (u_s - u_p)$$
$$P_2 - P_1 = \rho_1 u_s u_p$$

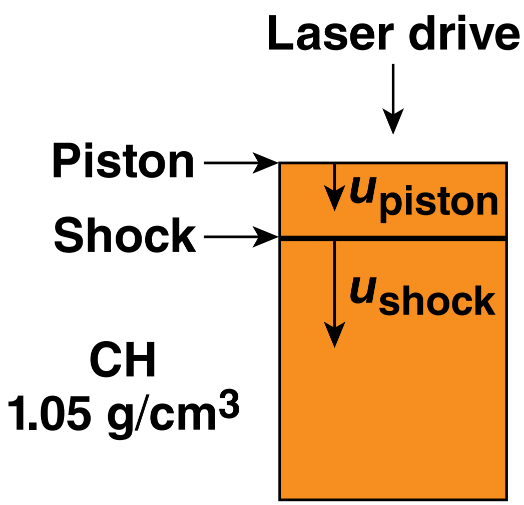
*Ya. B. Zel'dovich and Yu. P. Raĭzer, in *Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena*, edited by W. D. Hayes and R. F. Probstein (Dover Publications, Mineola, NY, 2002).

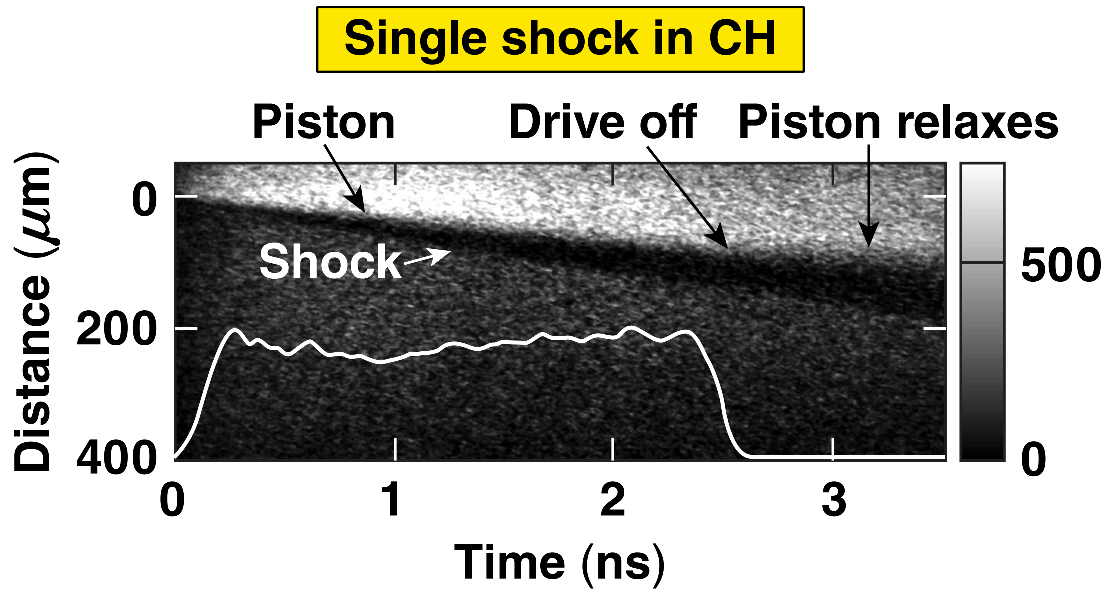
Piston and shock trajectories are tracked using time-resolved x-ray radiography on OMEGA EP



The open-drive geometry allows for radiographic access to the ablatively driven piston.

The piston and shock dynamics were measured during and after the laser drive





- Laser: 2.5-ns square pulse, 2×10^{14} W/cm^2
- At the end of the drive u_{piston} = (37±4) μm/ns, u_{shock} = (53±5) μm/ns
- From the Rankine–Hugoniot relations:* ρ = (3.5±1.1) g/cm^3, P = (21±3) Mbar

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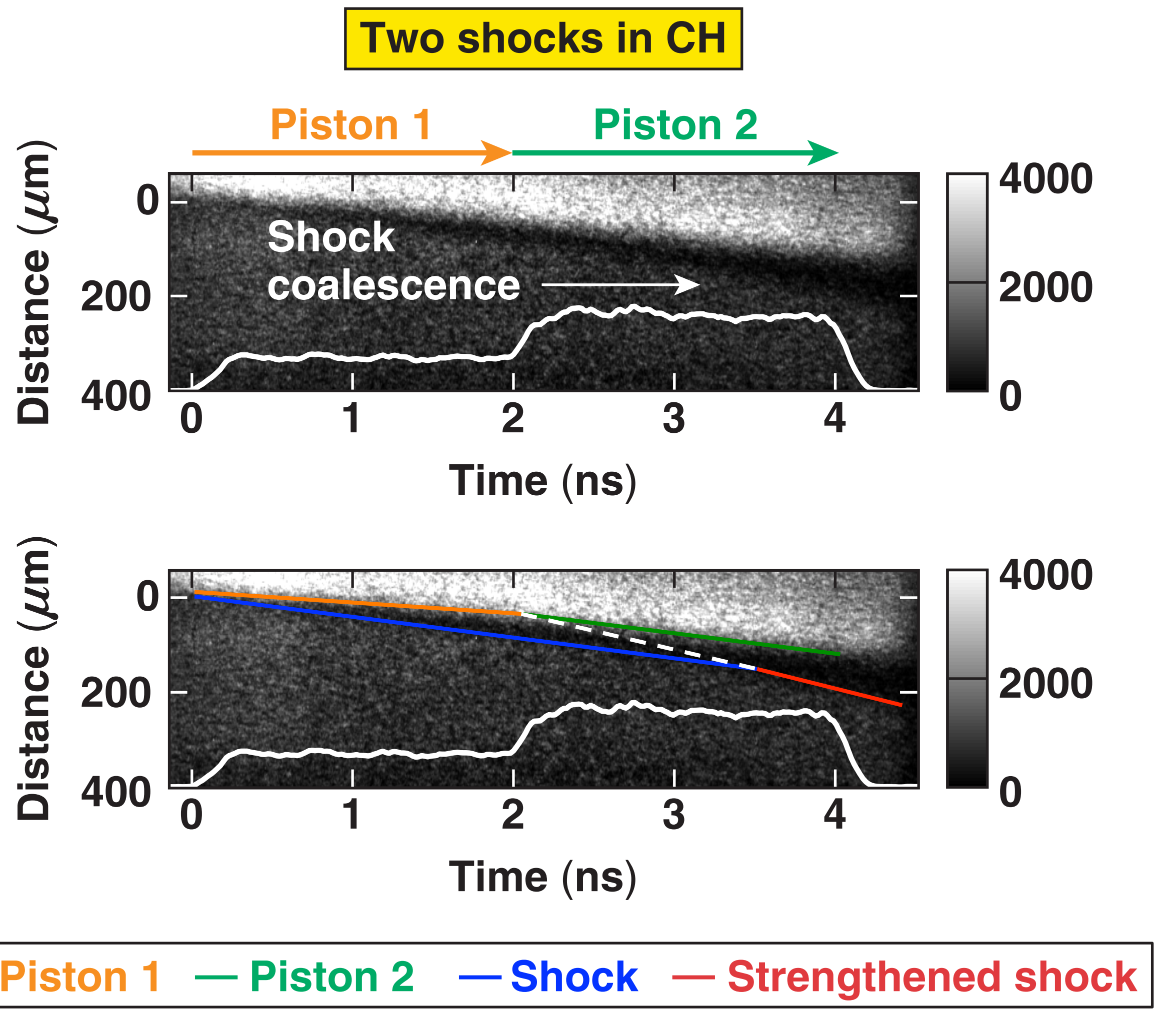
*Leaky piston

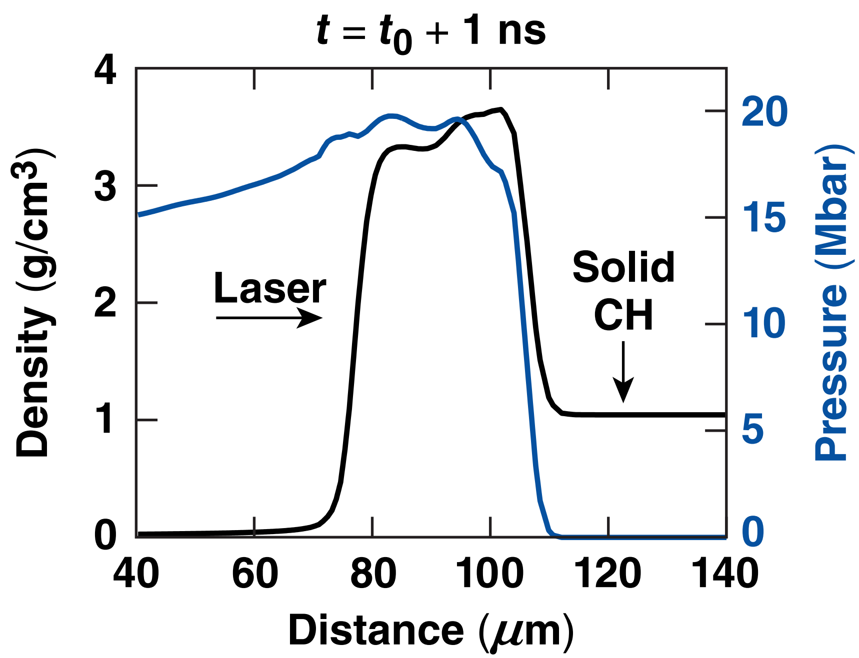
A stepped laser pulse created a time-dependent piston and two shocks; shock coalescence was measured

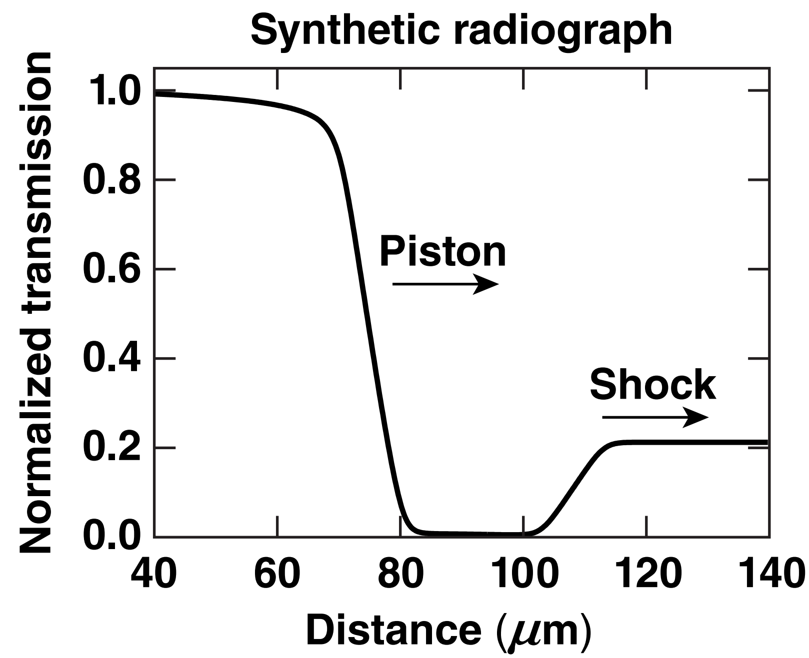


Piston and shock trajectories were calculated based on synthetic x-ray radiographs generated from *DRACO**

- Two-dimensional flux-limited ($f = 0.06$) hydrodynamic simulations
- Assumes a monoenergetic Ti backlighter at 4.7 keV
- Cold-material opacity is assumed

Laser: 2.5-ns square pulse, 2×10^{14} W/cm^2





*D. Keller *et al*., Bull. Am. Phys. Soc. 44, 37 (1999).

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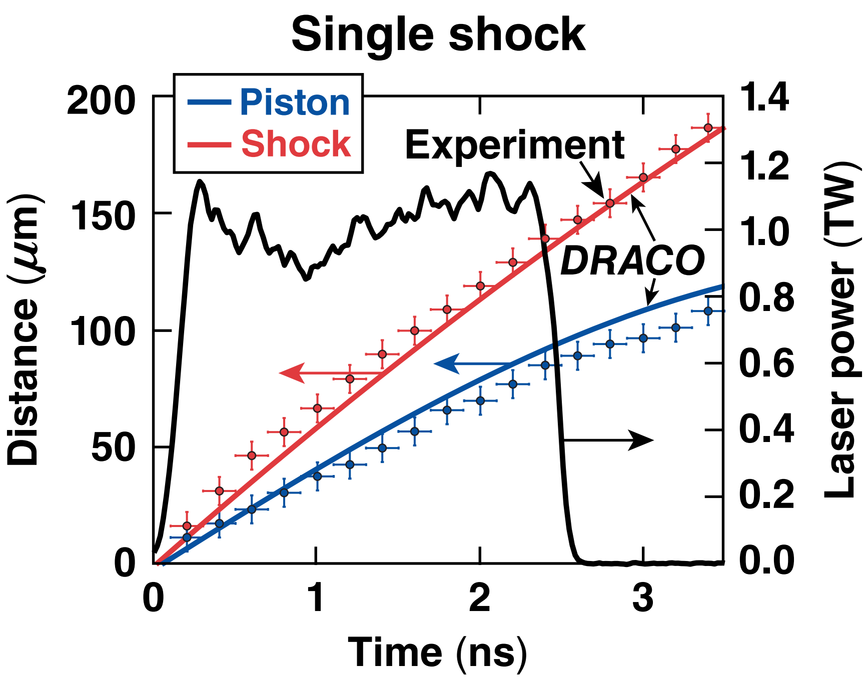
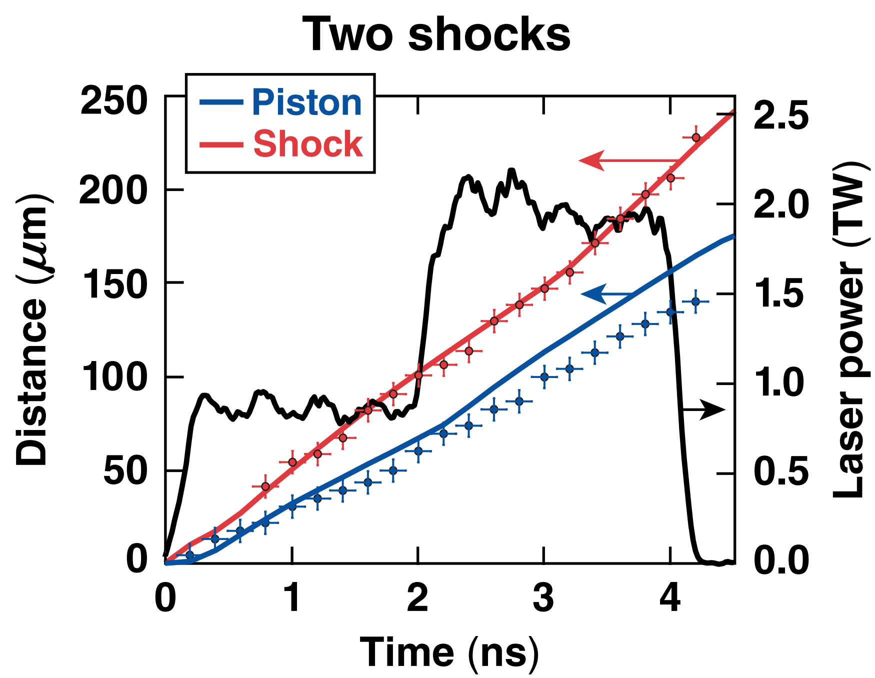
DRACO shows broad agreement with the shock data; the piston data lags predictions late in time





The *DRACO*-predicted piston velocities are higher than the experimental measurements.

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