Comparison of Implosion Velocities for Be, C, and CH Ablators Measured in Direct-Drive Implosions

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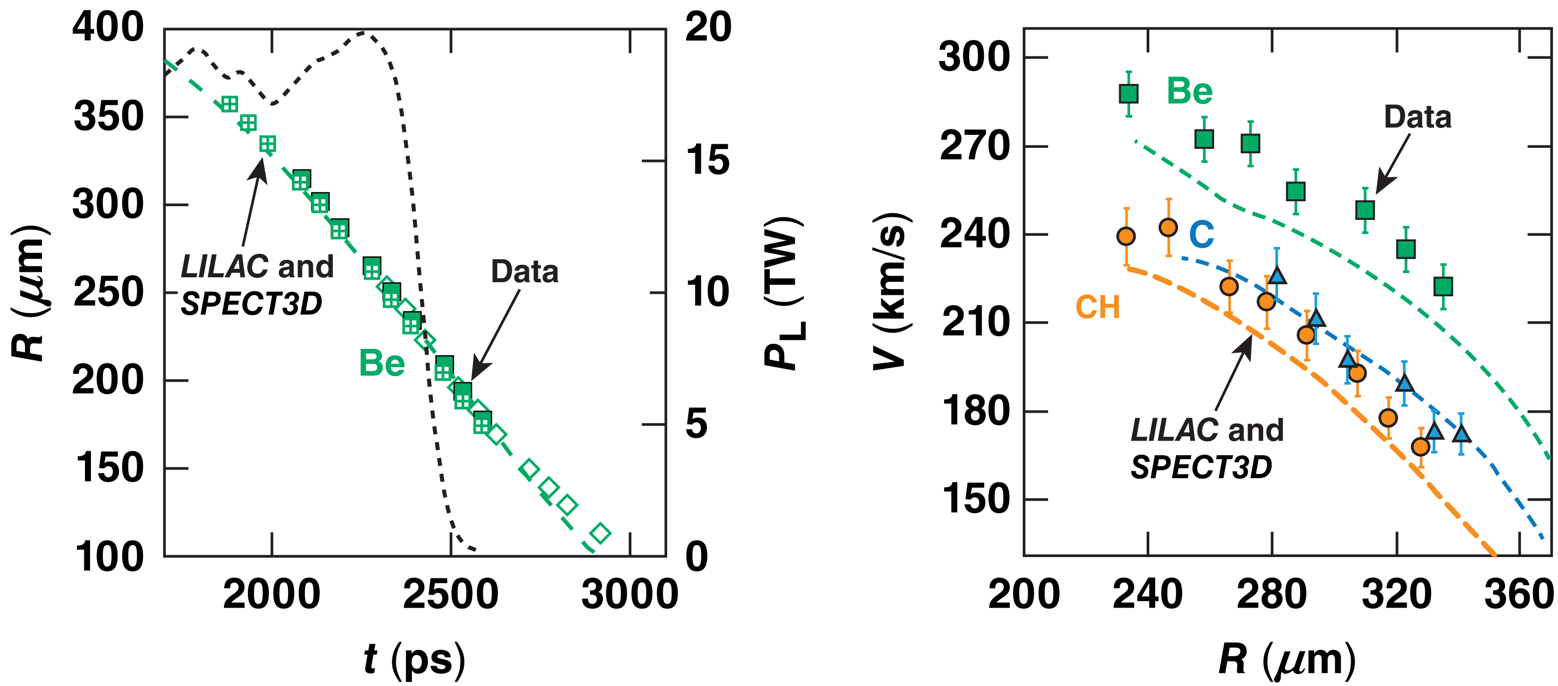

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55th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Denver, CO
11–15 November 2013

Summary

Increasing the ablator *A/Z* increases the velocity of direct-drive implosions

- A 20% increase in shell velocity was measured for Be ablators compared to C and CH ablators when maintaining a constant shell mass
- The measured absorbed laser power is similar in all three ablators
- *LILAC* simulations that include cross-beam energy transfer (CBET) and nonlocal heat transport accurately reproduce the measurements
- A further increase in ablation pressure is obtained by reducing CBET using multilayer targets

The increase in implosion velocity is a result of the increase in the conversion of the absorbed laser energy into kinetic energy of the shell (rocket efficiency).

Collaborators

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A simple model indicates that increasing *A*/*Z* increases the mass ablation rate and the ablation pressure*

Laser-energy deposition:

$$\rho_c c_s^3 = \frac{I}{4}$$

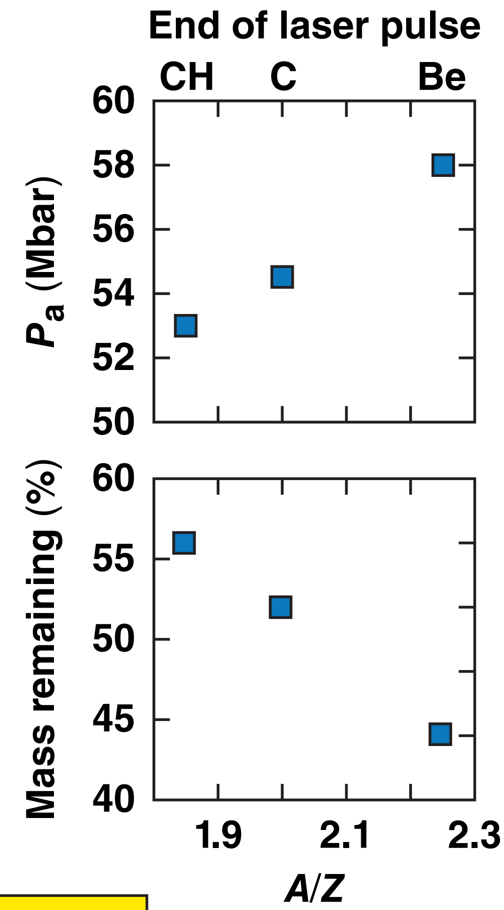
Ablation pressure:

$$P_a = 2\rho_c c_s^2 \sim \left(\frac{A}{Z}\right)^{1/3}$$

Mass ablation rate:

$$\dot{m}_a = \rho_c c_s \sim \left(\frac{A}{Z}\right)^{2/3}$$

$$\frac{dV_s}{dt} = \frac{P_a}{\left(M_s/4\pi R^2\right)}$$



The increased mass density where the laser is absorbed results in a higher rocket efficiency.

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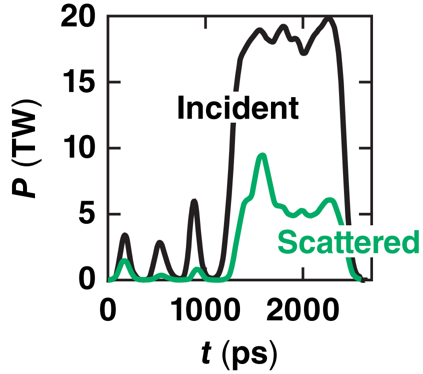
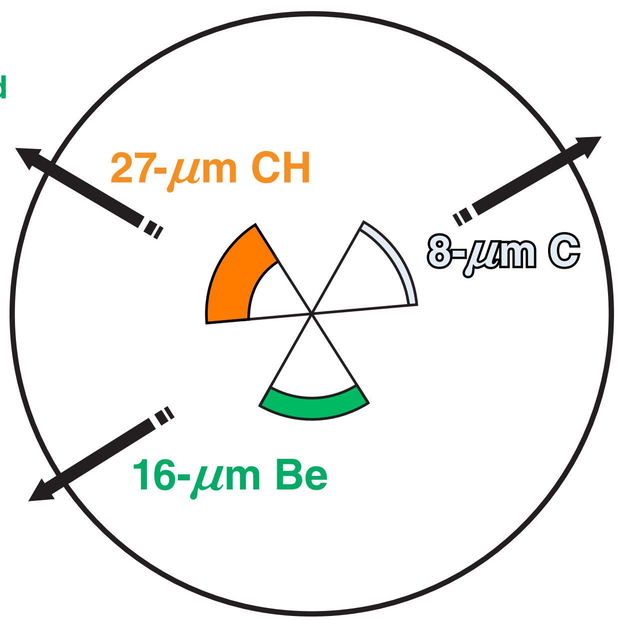
*W. M. Manheimer, D. G. Colombant, and J. H. Gardner, Phys. Fluids 25, 1644 (1982).

An experiment was designed to measure the conversion of absorbed laser energy into the shell's kinetic energy for different ablator materials

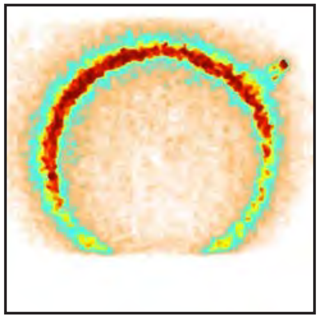
Streak camera



$I = 7 \times 10^{14}$ W/cm^2 with smoothing by spectral dispersion (SSD)



X-ray framing camera (XFRC)



Trajectory/ velocity

Five calorimeters

Scattered-light energy

To determine the effect of *A*/*Z* on target performance, the target mass and the laser pulse were kept the same.

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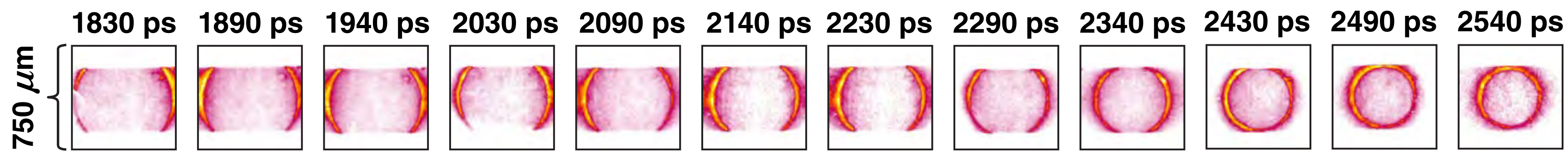
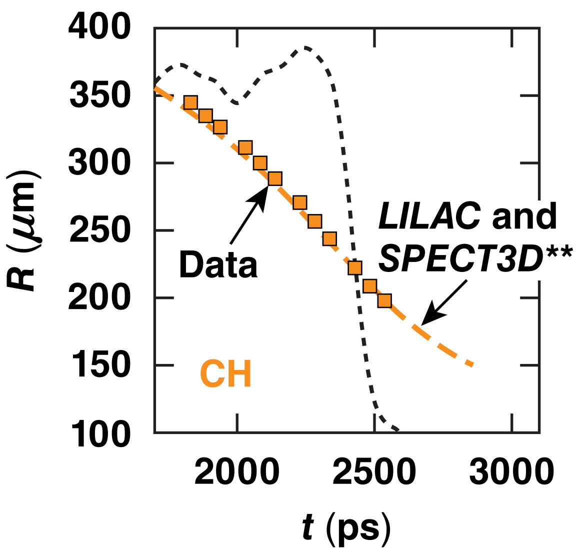
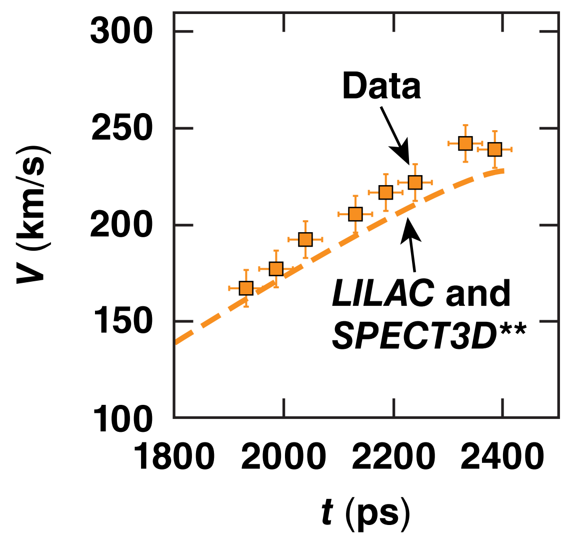
Self-emission x-ray images are used to measure the trajectory and velocity of the implosions







$$\frac{\delta v}{v} = \frac{\delta(\Delta R)}{\Delta R} + \frac{\delta(\Delta t)}{\Delta t} = \frac{0.5\ \mu m}{40\ \mu m} + \frac{5\ ps}{200\ ps} = 5\%^*$$

*D. T. Michel *et al*., Rev. Sci. Instrum. 83, 10E530 (2012).
**J. J. MacFarlane *et al*., High Energy Density Phys. 3, 18 (2007).

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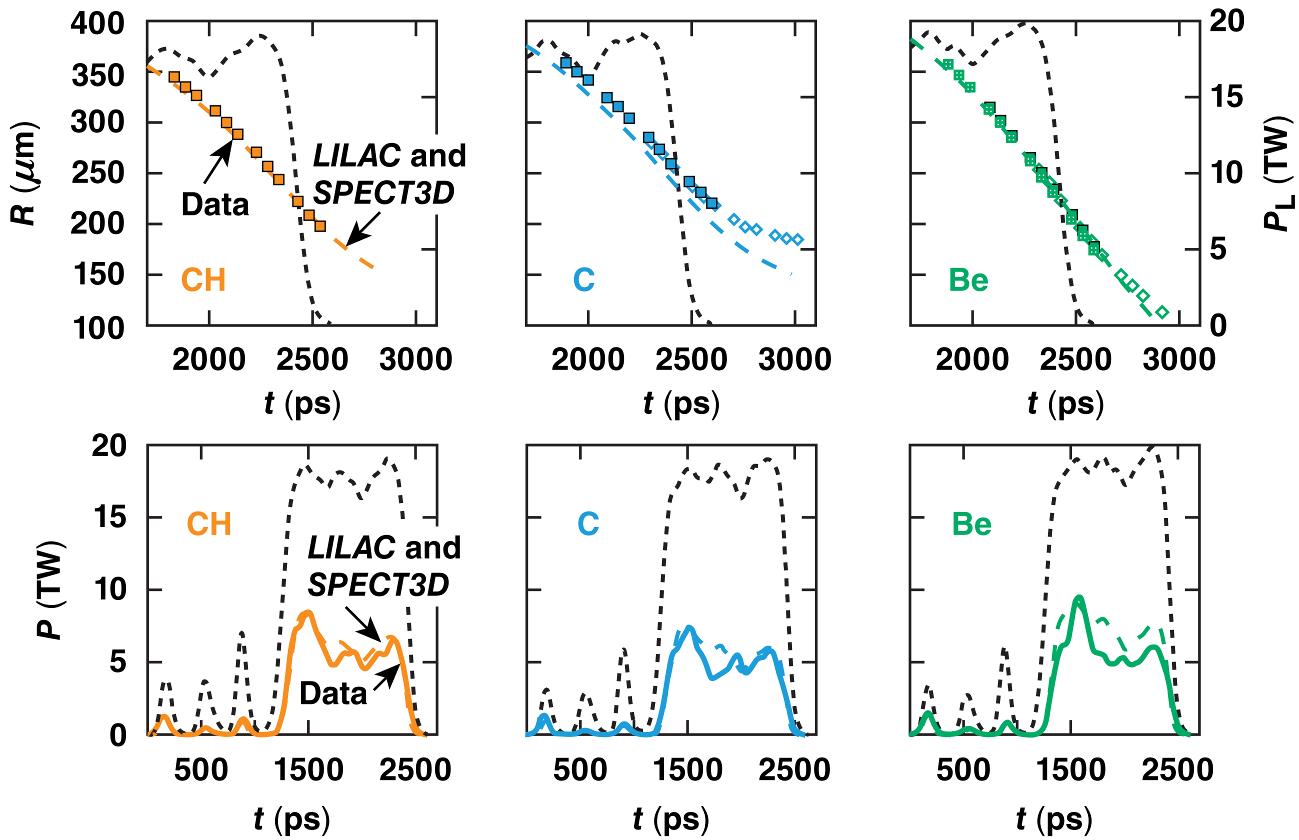
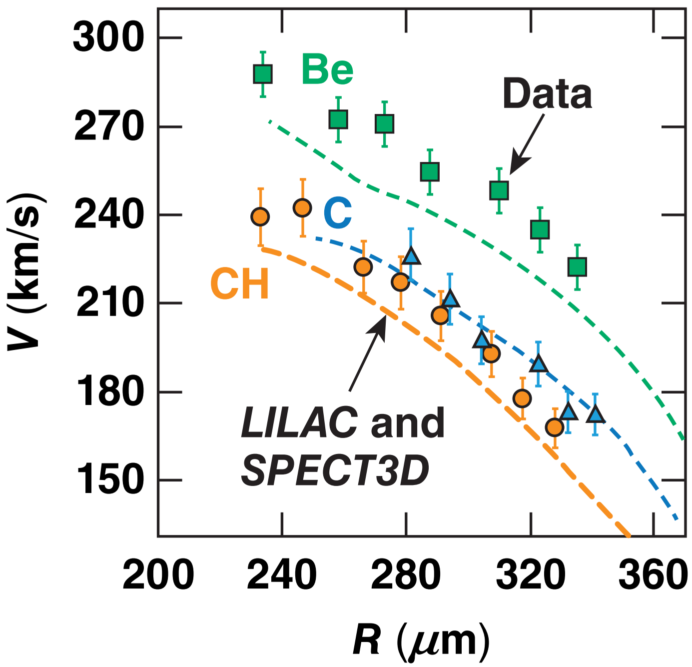
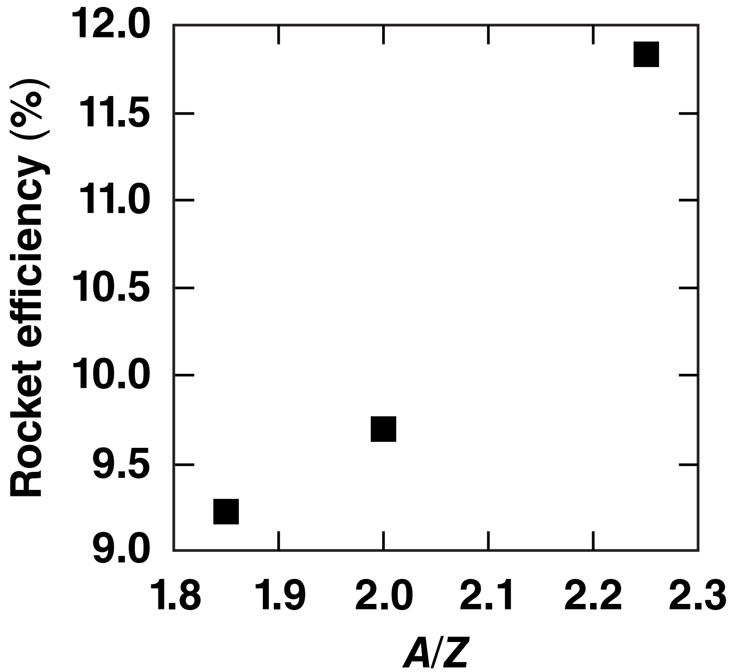
The simulated trajectories and absorbed laser energy for all three ablators are in good agreement with the measurements



The good agreement between simulations and experiments indicates that the absorbed laser energy and its transfer to the motion of the shell is well modeled.

A 20% increase in the shell velocity is observed for Be compared to CH and C ablators*





Simulations show that the 20% increase in implosion velocity is a result of the 28% increase of the rocket efficiency.

*D. T. Michel *et al*., "Experimental Optimization of the Rocket Efficiency in Direct-Drive Implosions Using Different Ablator Materials," to be published in Physical Review Letters.

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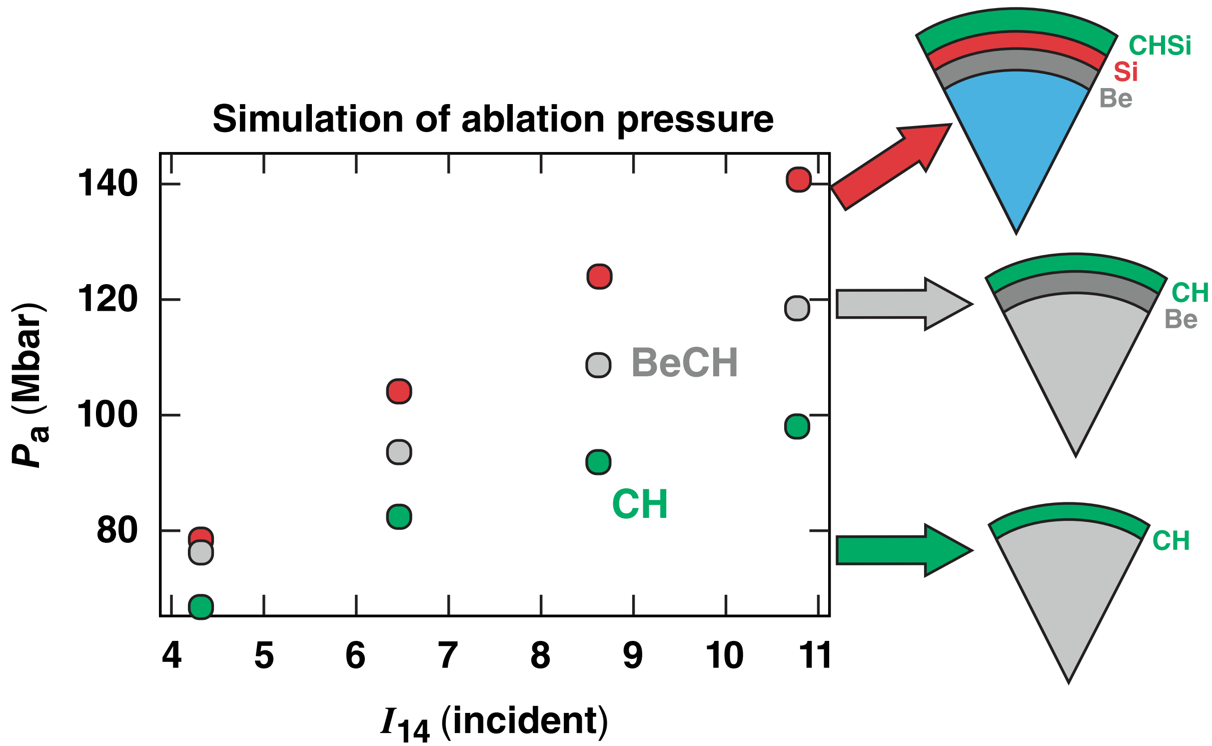
To further enhance the ablation pressure, multilayer targets were designed to reduce CBET by increasing the coronal electron temperature



Simulations show that the ablation pressure is increased by 17% in a multiple-ablator compared to a mass-equivalent Be target.

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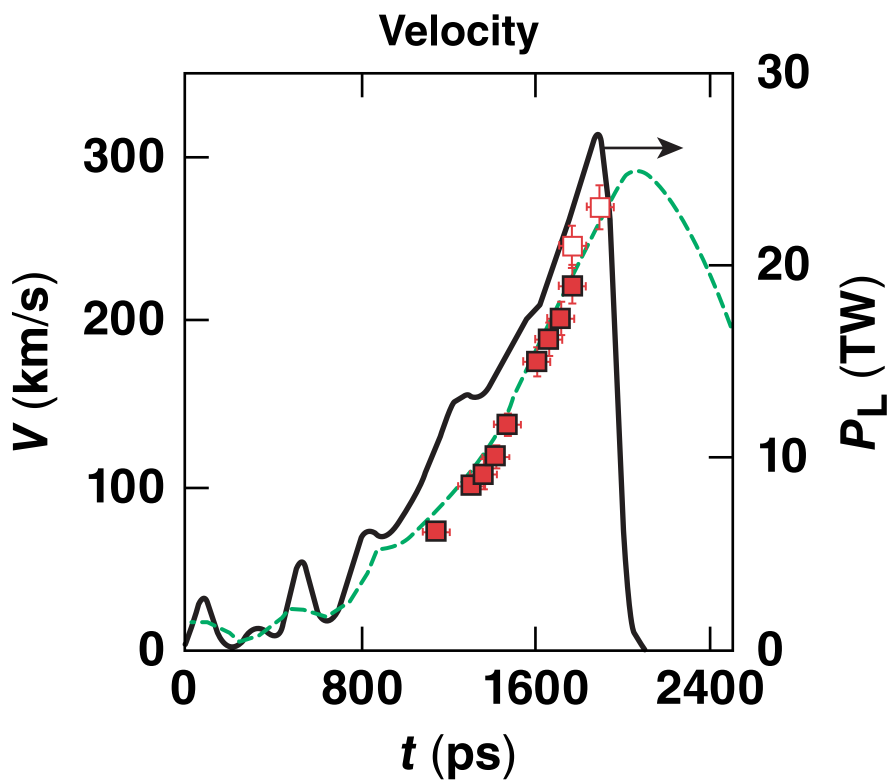
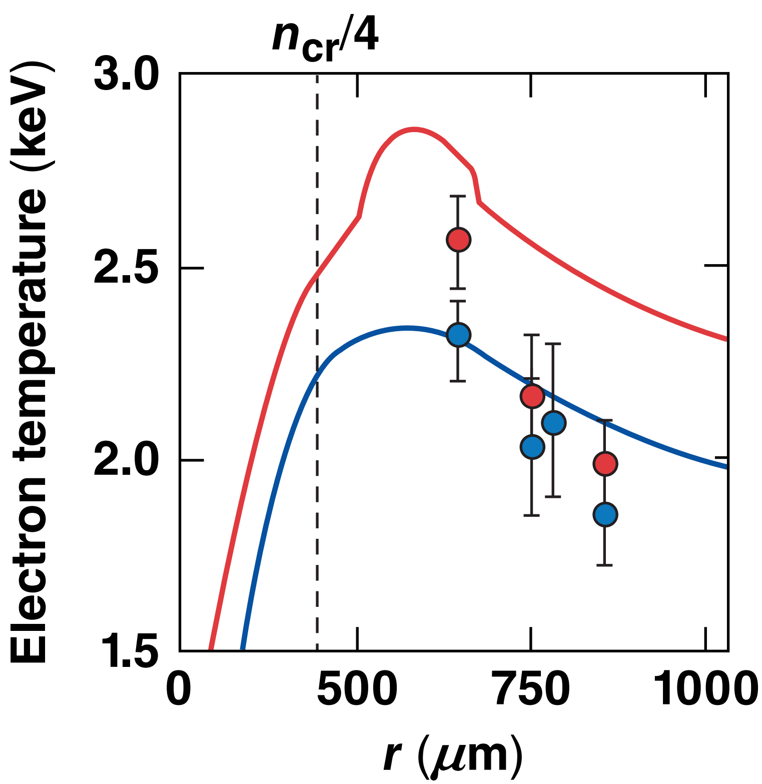
Shell velocities measured on multilayer targets agree well with simulations





The multilayer ablator increases the electron temperature around a quarter-critical density by ~15%.*

*R. J. Henchen *et al.*, JO5.00010, this conference.

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Summary/Conclusions

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