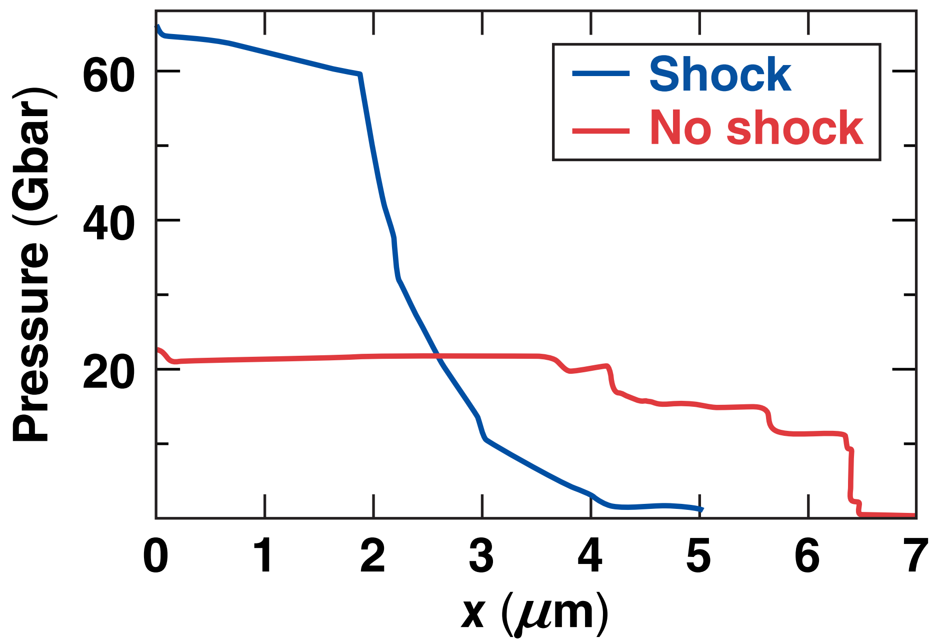
A One-Dimensional Planar Model of Shock Ignition

Planar stagnation profiles



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Summary

A planar hydrodynamic model is used to understand the basic physics behind shock ignition

- The peak hot-spot pressure is the optimization metric (model does not include any burn physics)
- An optimum shell thickness (Δ_{crt}) exists that maximizes the conversion of shell kinetic energy into hot-spot internal energy (i.e., hot-spot pressure)
- Implosions augmented with their optimal ignitor shock are shown to have an increase in the Δ_{crt} resulting in ~3× higher-peak hot-spot pressures over conventional hot-spot ignition

Collaborators

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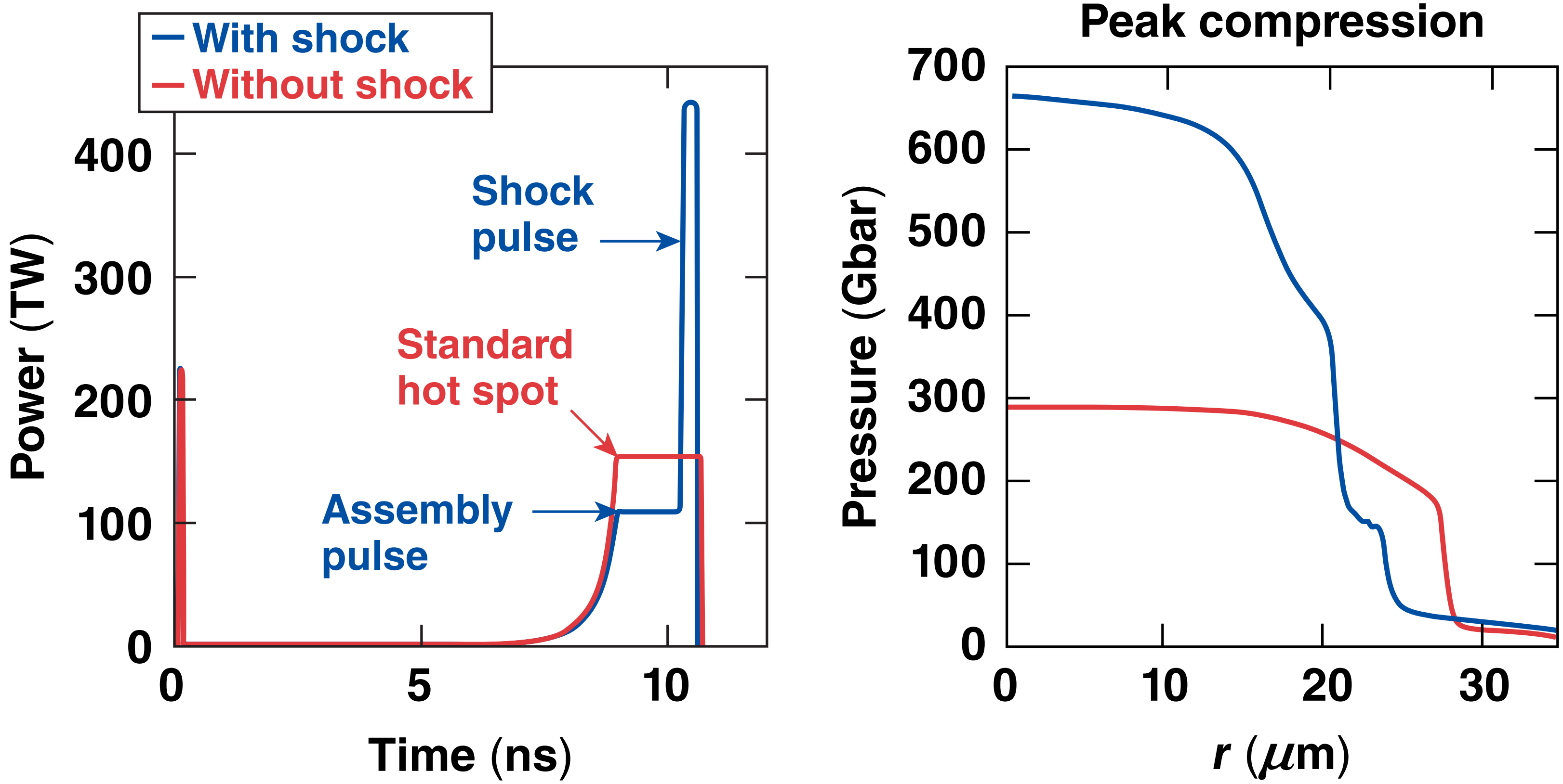
With the same kinetic energy, SI increases the peak hot-spot pressures versus conventional hot-spot ignition

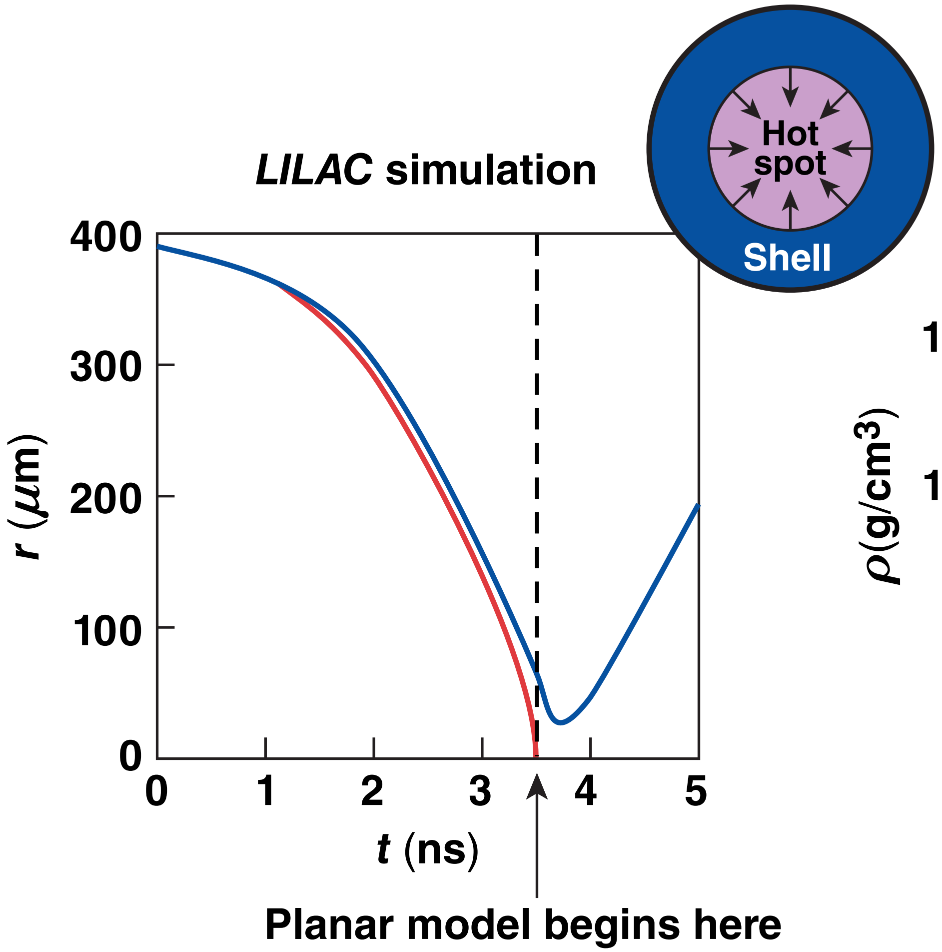
Spherical

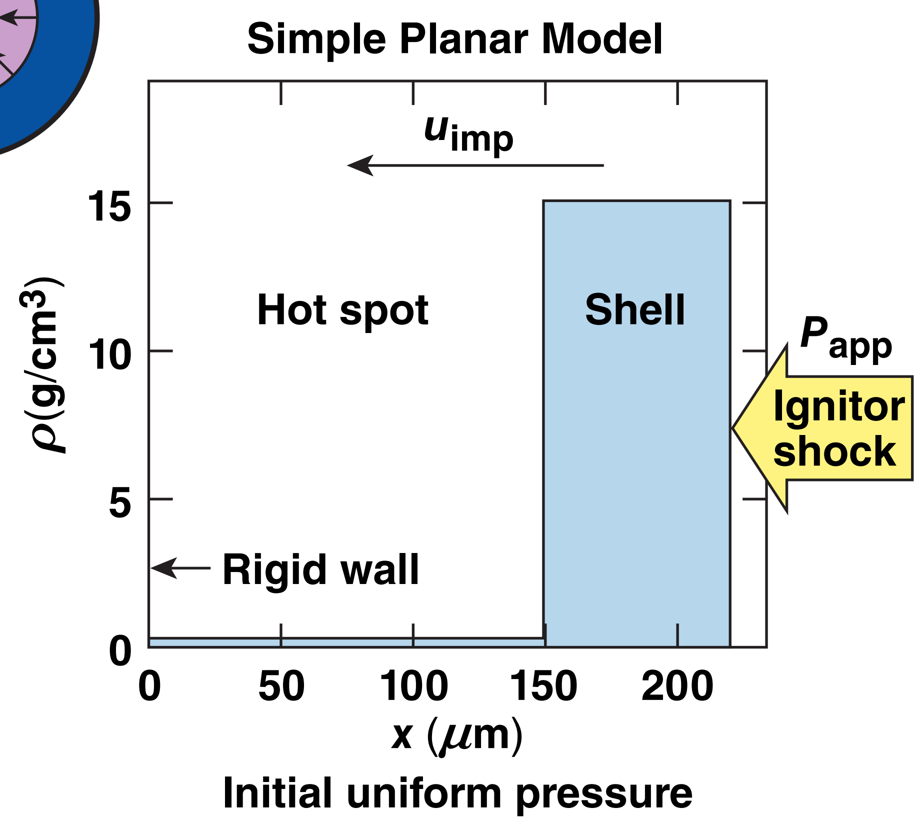


TC9081

R. Betti *et al*., Phys. Rev. Lett. 98, 155001 (2007).

A planar slab hydrodynamic model has been developed to understand the basic physics of the increase in shock-ignition pressure





TC9082

In conventional ICF, the hot-spot internal energy results from the conversion of shell kinetic energy

$$E_L^{ign} \sim P_{hs}^{-3}*$$

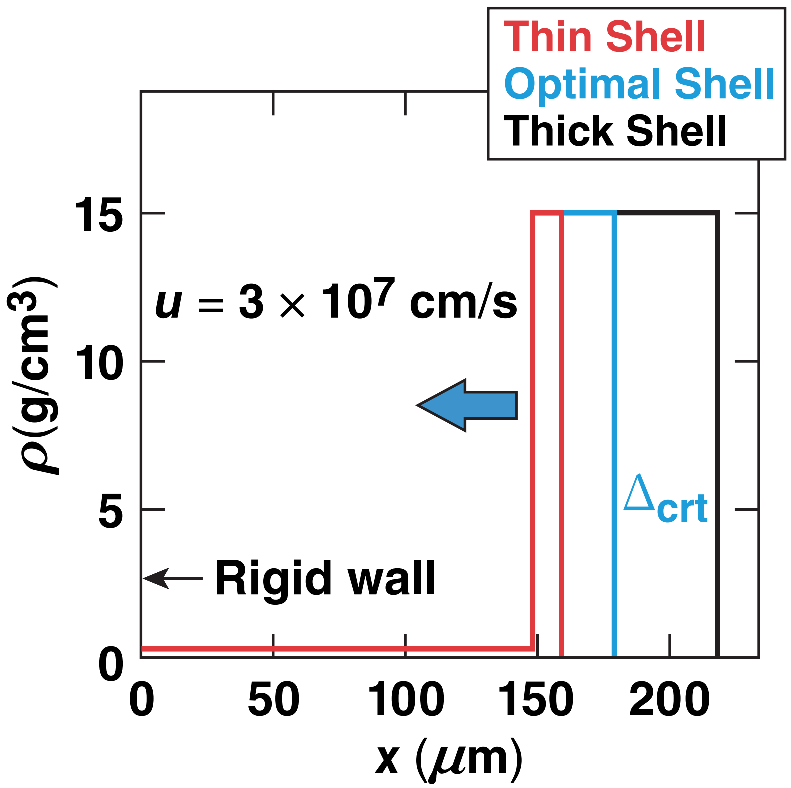
KE may be increased by

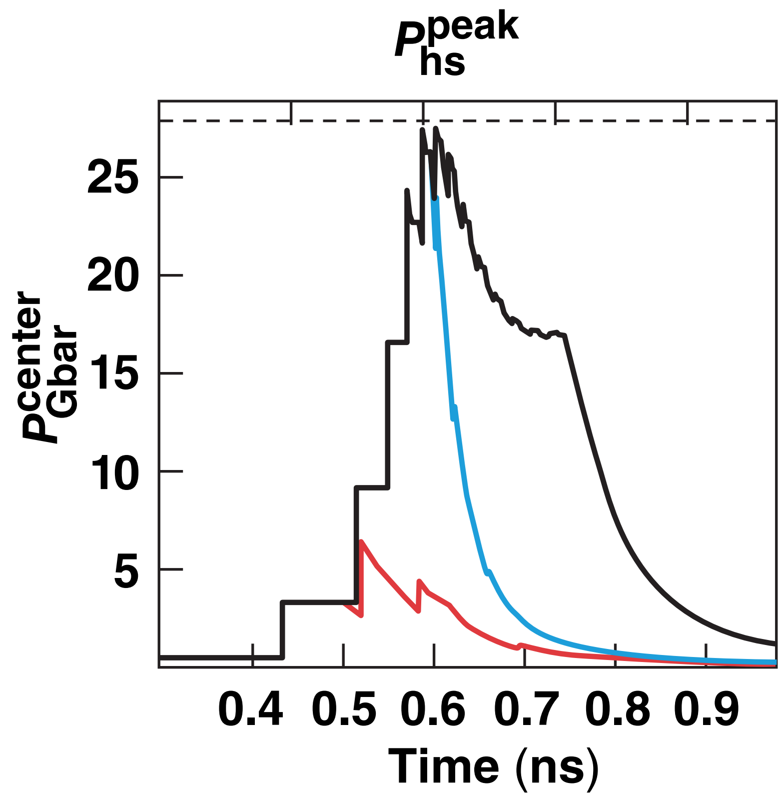
- Raising the implosion velocity
  - increases the hot-spot pressure
  - drives higher levels of hydrodynamic instabilities
- Thickening the shell
  - more fuel available to burn once ignition is reached
  - thicker shell provides better hydrodynamic stability
  - more often than not, this does not increase the peak hot-spot pressure

*C. D. Zhou and R. Betti, Phys. Plasmas 14, 072703 (2007), and M. C. Herrmann, M. Tabak, and J. D. Lindl, Nucl. Fusion 41, 99 (2001).

TC9083

Increasing the shell mass above a critical value in conventional hot-spot ignition does not increase the peak hot-spot pressure





For $\Delta > \Delta_{crt}$, the shell kinetic energy poorly couples to the hot spot.

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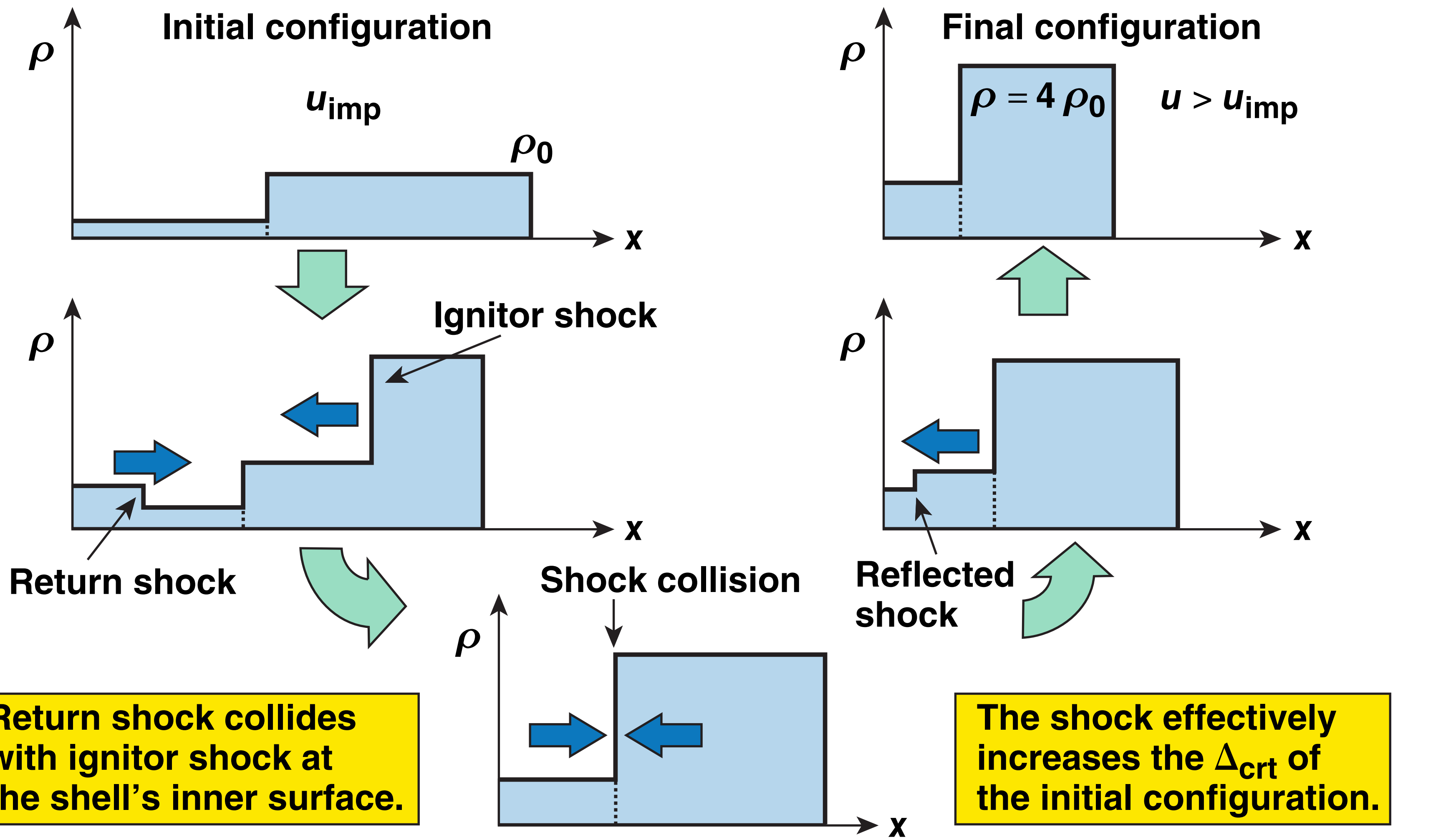
Applying a late shock increases the shell velocity just before stagnation, enhancing the coupling of shell kinetic energy to hot-spot internal energy

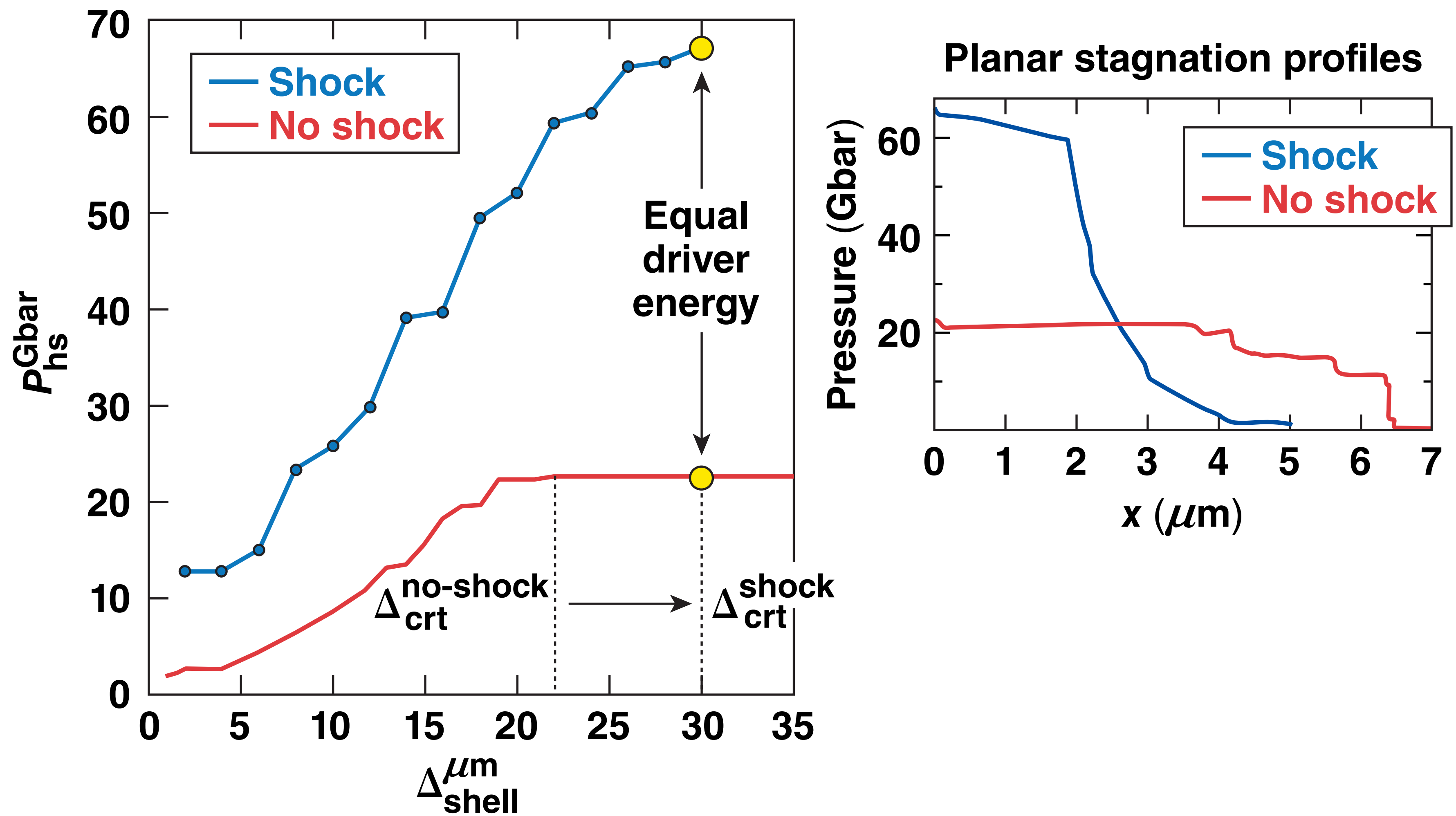


Return shock collides with ignitor shock at the shell's inner surface.

The shock effectively increases the Δ_{crt} of the initial configuration.

TC9086

The ignitor shock increases Δ_{crt}, utilizing "unused" kinetic energy to boost the maximum hot-spot pressure



Summary/Conclusions

A planar hydrodynamic model is used to understand the basic physics behind shock ignition

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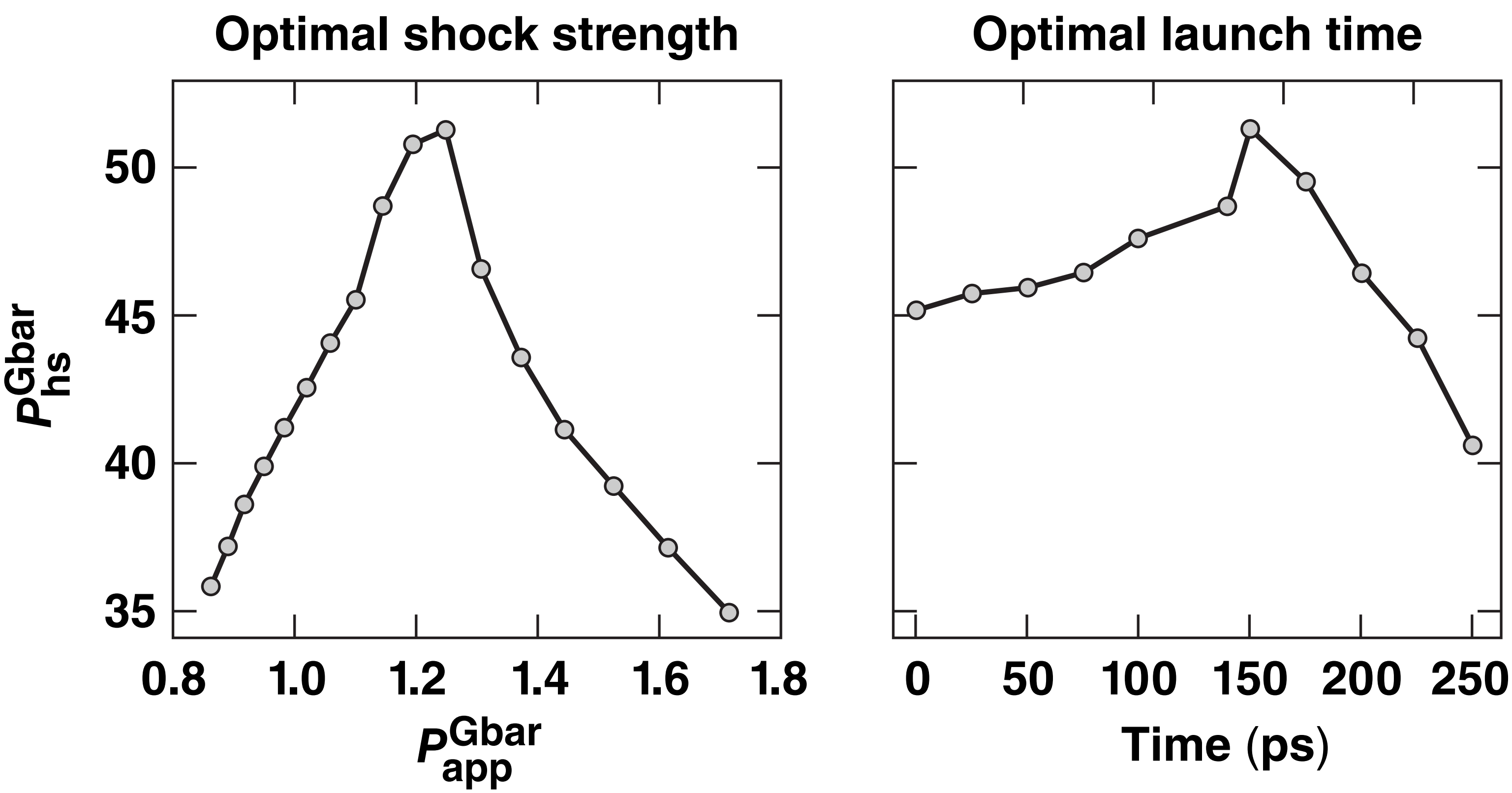
A simple planar 1-D model is used to optimize the peak hot-spot pressure in ICF implosions



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