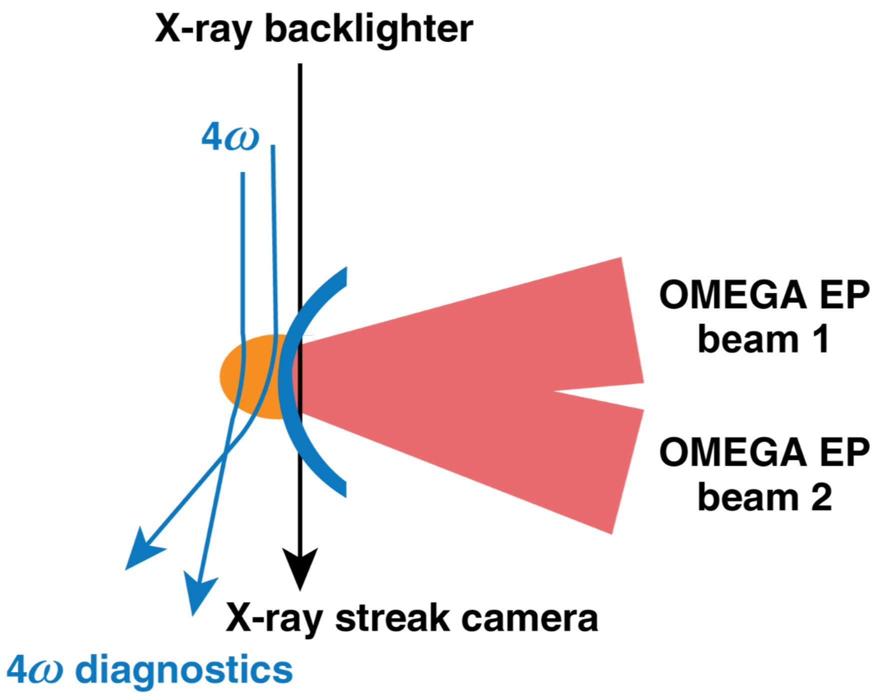
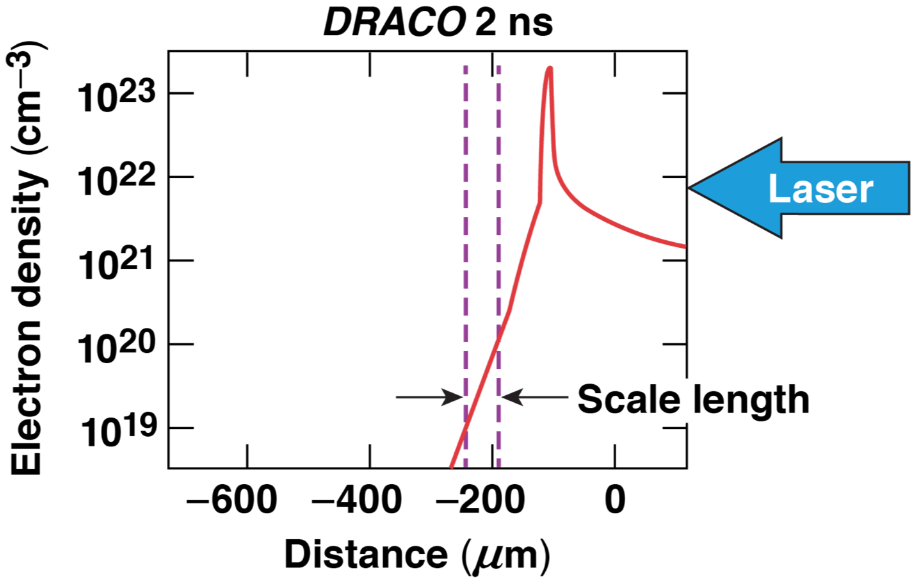
Analysis of Shock-Release OMEGA EP Experiments





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Summary

Density relaxation ahead of the shock can explain the enhanced material release observed in the experiments as compared with simulations

- The OMEGA EP 4ω probe diagnostic was used to study low-density plasma in the rarefaction wave formed by the shock released from the back surface of a laser-driven CH shell*
- The extent of material release is insensitive to the EOS and Z tables used in the simulations
- Kinetic effects cannot explain the enhanced material release if the shock breaks out from the sharp interface
- Coronal preheat is the leading hypothesis for the density relaxation ahead of the shock

*D. J. Haberberger *et al.*, YO6.00009, this conference
EOS: equation of state

Collaborators

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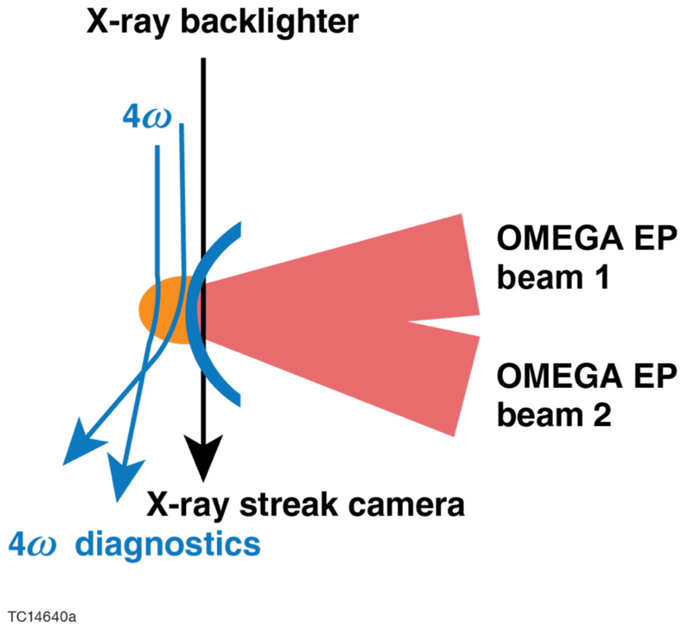
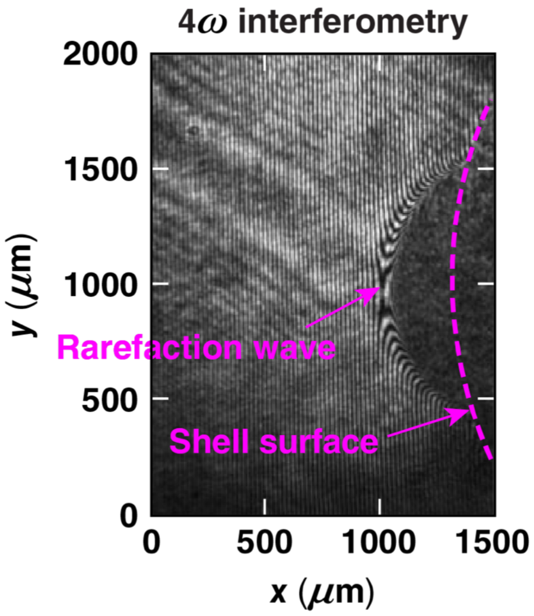
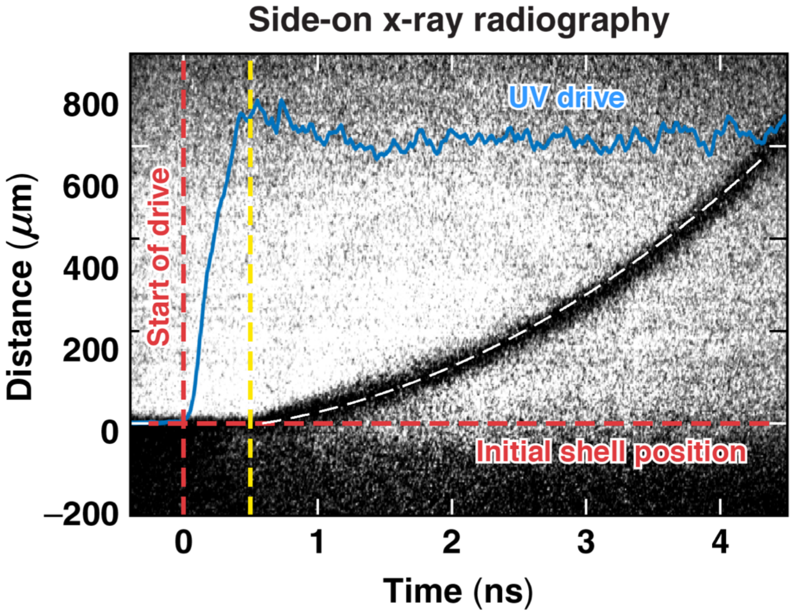
The shock-release experiments used a 4ω probe to measure the low-density plasma profile and side-on x-ray radiography to measure the shell trajectory



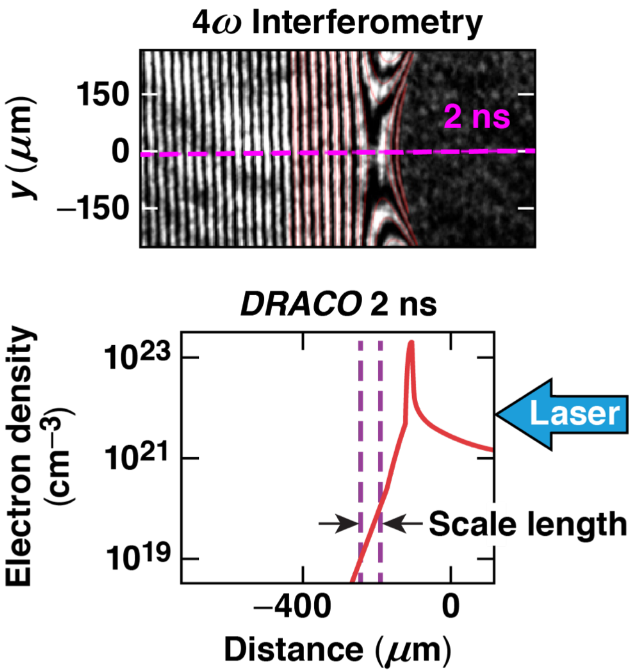




- 37 μm CH
- 4.1-mm-diam spherical cap
- 5-ns square pulse (two beams)
- 3×10^{14} W/cm^2

The shock transit time of ~600 ps and shell trajectory agree with *DRACO* simulations

The experimentally measured extent and scale length of the electron density profiles in the rarefaction wave are significantly longer than those predicted by simulations



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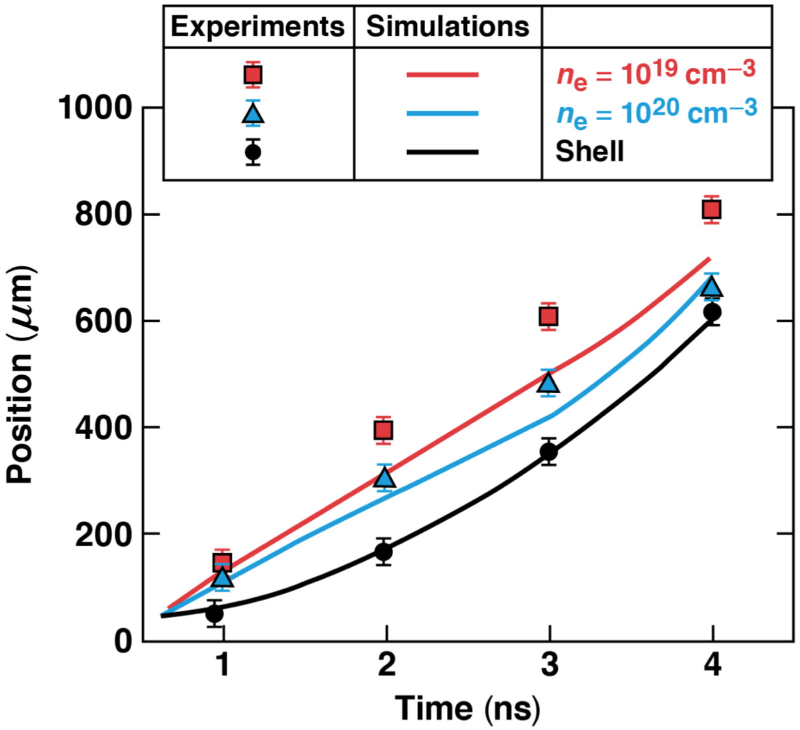

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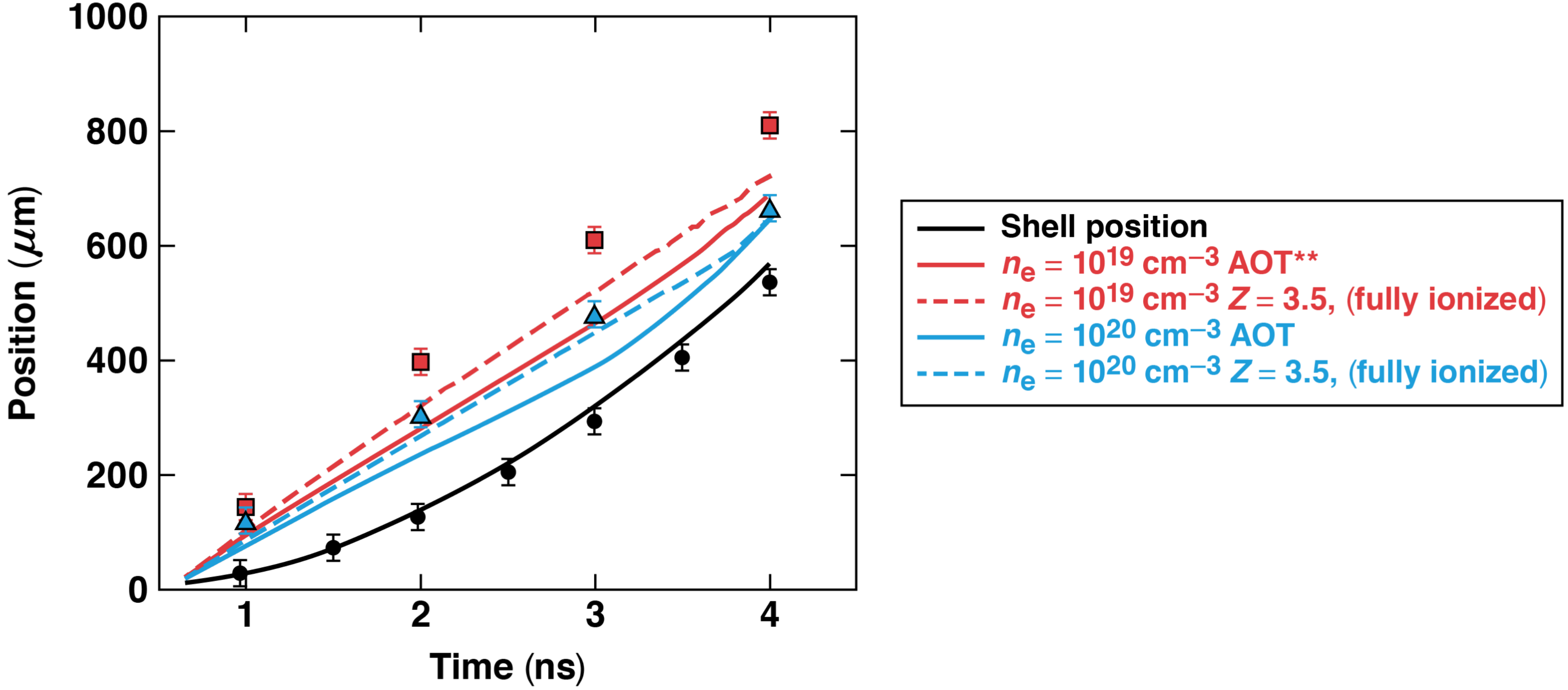
- Possible reasons for the discrepancy
  - incorrect shell adiabat, sound speed
  - incorrect plasma *Z*, index of refraction, EOS
  - kinetic effects
  - conditions on the back surface

Assuming plasma index of refraction* applies under rarefaction wave conditions, errors in Z tables used in simulations cannot explain the extended density profile



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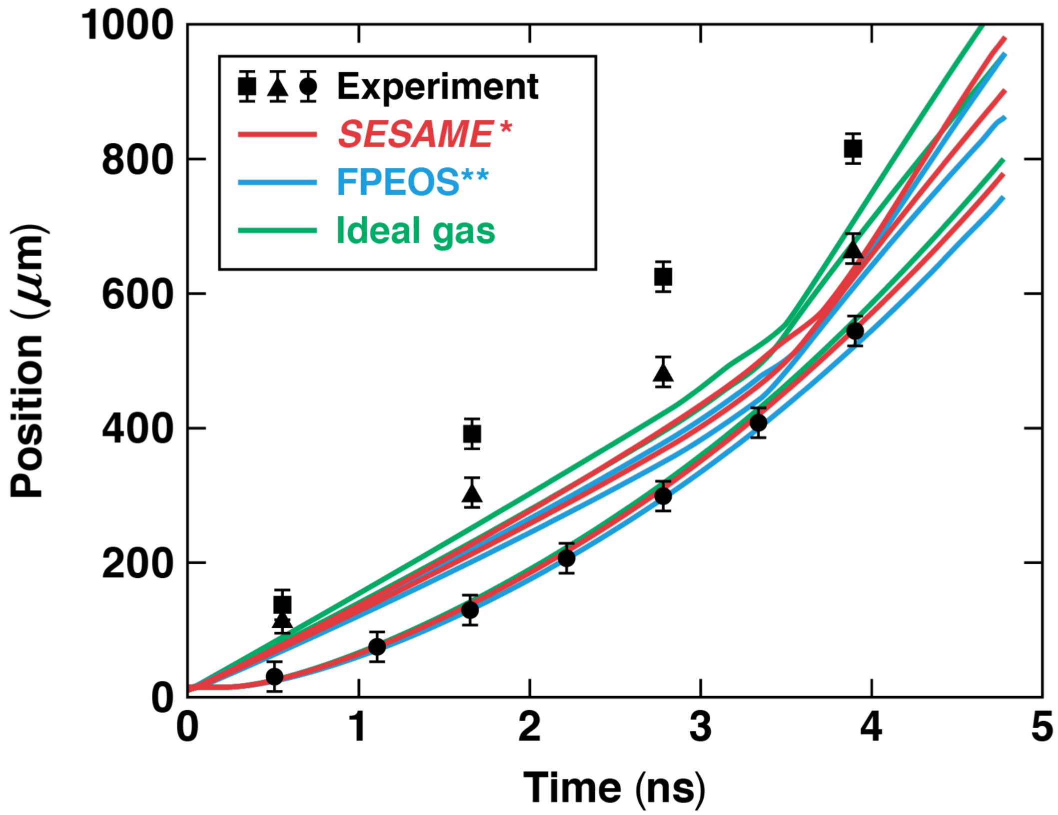
* $n = \sqrt{1 - n_e/n_c}$

** AOT: astrophysical opacity tables

Shell trajectory and rarefaction wave expansion weakly depend on the EOS model



TC15201

* B. I. Bennett, J. D. Johnson, G. I. Kerley, and G. T. Rood, LANL, Report LA-7130 (1978).
** S. X. Hu *et al.*, Phys. Rev. E 93, 043104 (2015).
FPEOS: first-principles equation of state

Kinetic ($\lambda \gtrsim 0.1L$) effects are only important during a very short time after shock release and affect only a small mass of material in the tail of the rarefaction wave

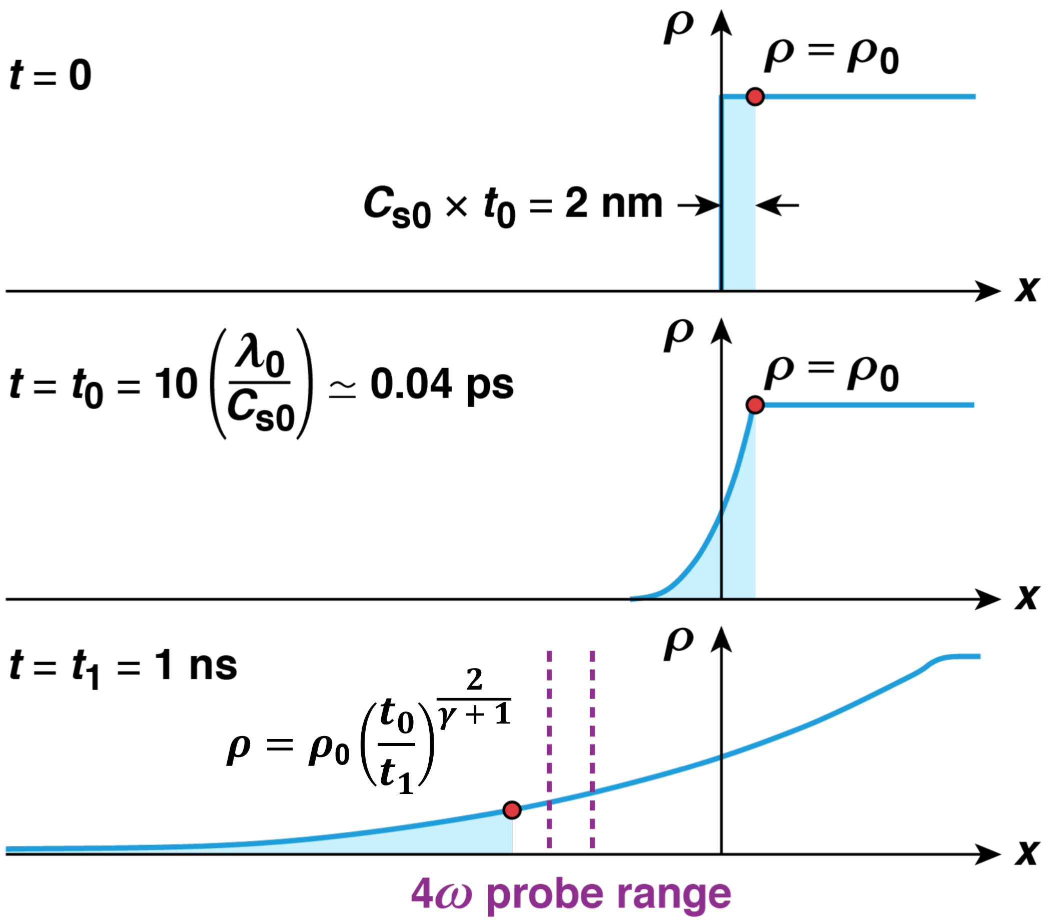
- Ion-collision mean free path

$$\lambda = \lambda_0 \left(\frac{T}{T_0}\right)^2 \frac{\rho}{\rho_0},$$

- Scale length

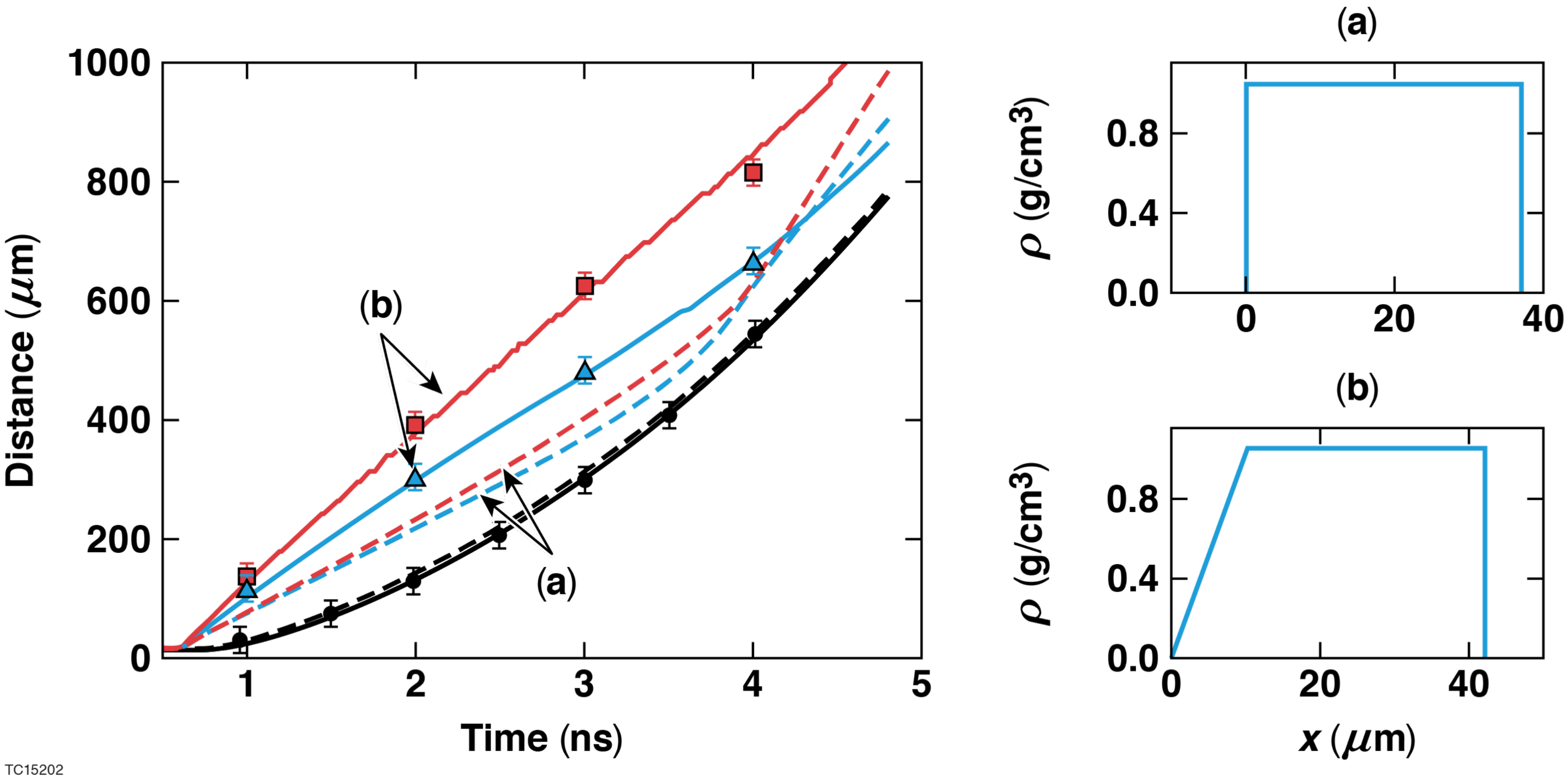
$$L = \frac{\gamma+1}{2}\left(\frac{\rho}{\rho_0}\right)^{\frac{\gamma+1}{2}} C_{s0}t,$$

- Kinetic effects are important in shaded areas of the plots

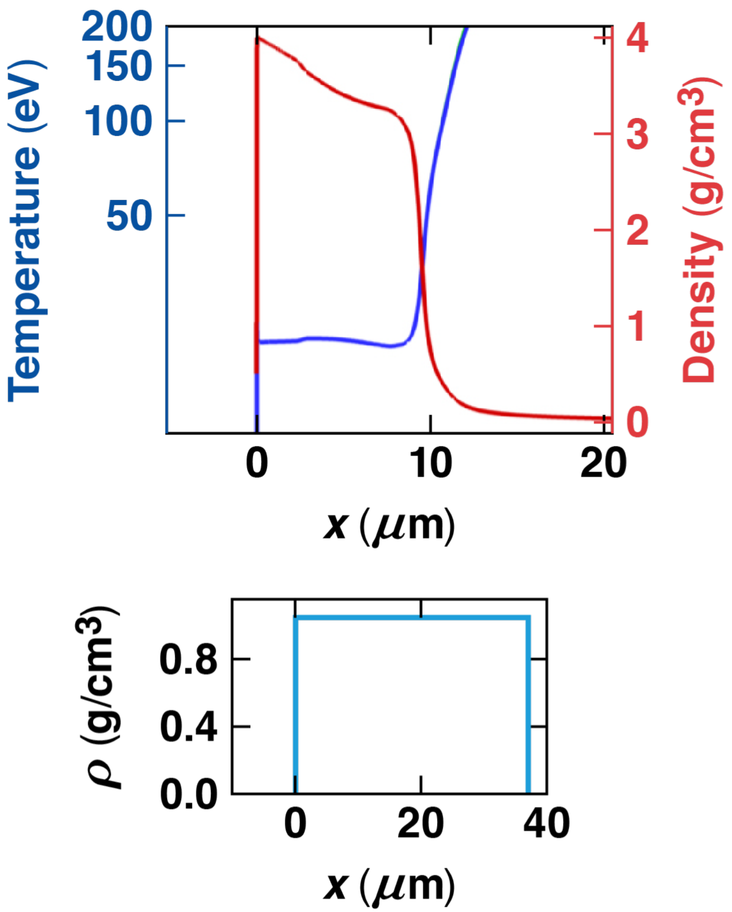


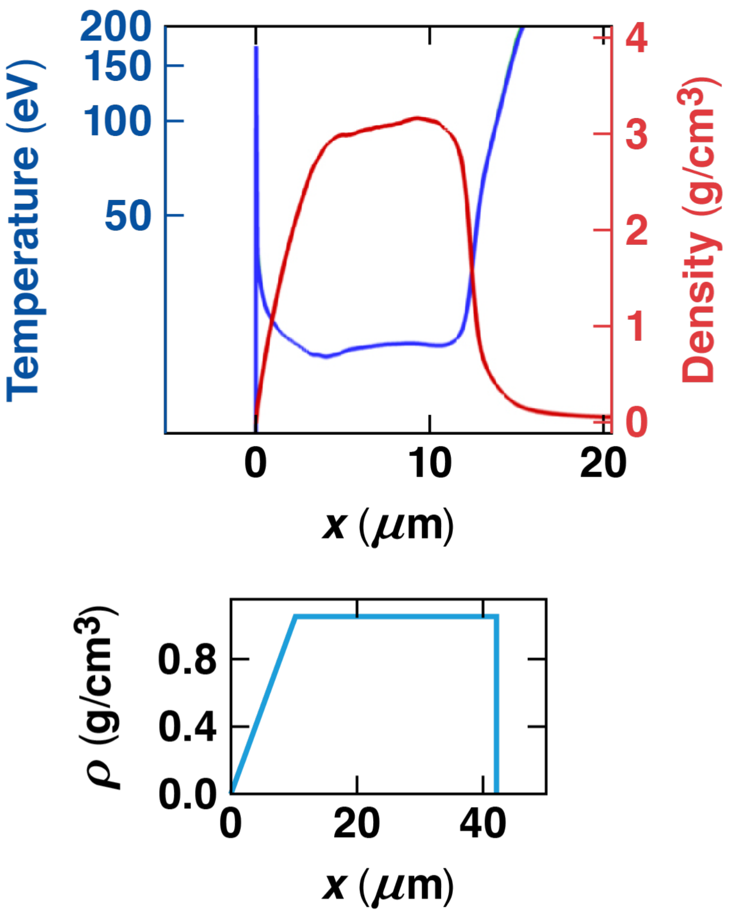
TC15204

The density profile on the back side of the shell before the shock breakout strongly affects the rarefaction expansion



The shock heats the lower-density material at the back of the shell to a higher temperature thus enhancing the rarefaction wave expansion





TC15203

Radiation preheat by coronal x rays is a possible mechanism for the relaxation of the shell ahead of the shock

- According to *LILAC* simulations, the x-ray energy density absorbed at the back side of CH shell during the shock transit time is ~10 kJ/cm^3
- The temperature increases to 0.4 to 0.6 eV
- The width of the density gradient $4C_s \times (1/2)\, t_{sh}$ = 3 to 4 μm is in the ballpark of what is required to explain experiments
- The process of melting and evaporation of 0 to 1-eV CH polymer is not expected to be modeled accurately by *LILAC* or *DRACO* hydrodynamic codes
- Shinethrough is another potential preheat mechanism

Density relaxation ahead of the shock can explain the enhanced material release observed in the experiments as compared with simulations

- **The OMEGA EP 4ω probe diagnostic was used to study low-density plasma in the rarefaction wave formed by the shock released from the back surface of a laser-driven CH shell***
- **The extent of material release is insensitive to the EOS and *Z* tables used in the simulations**
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