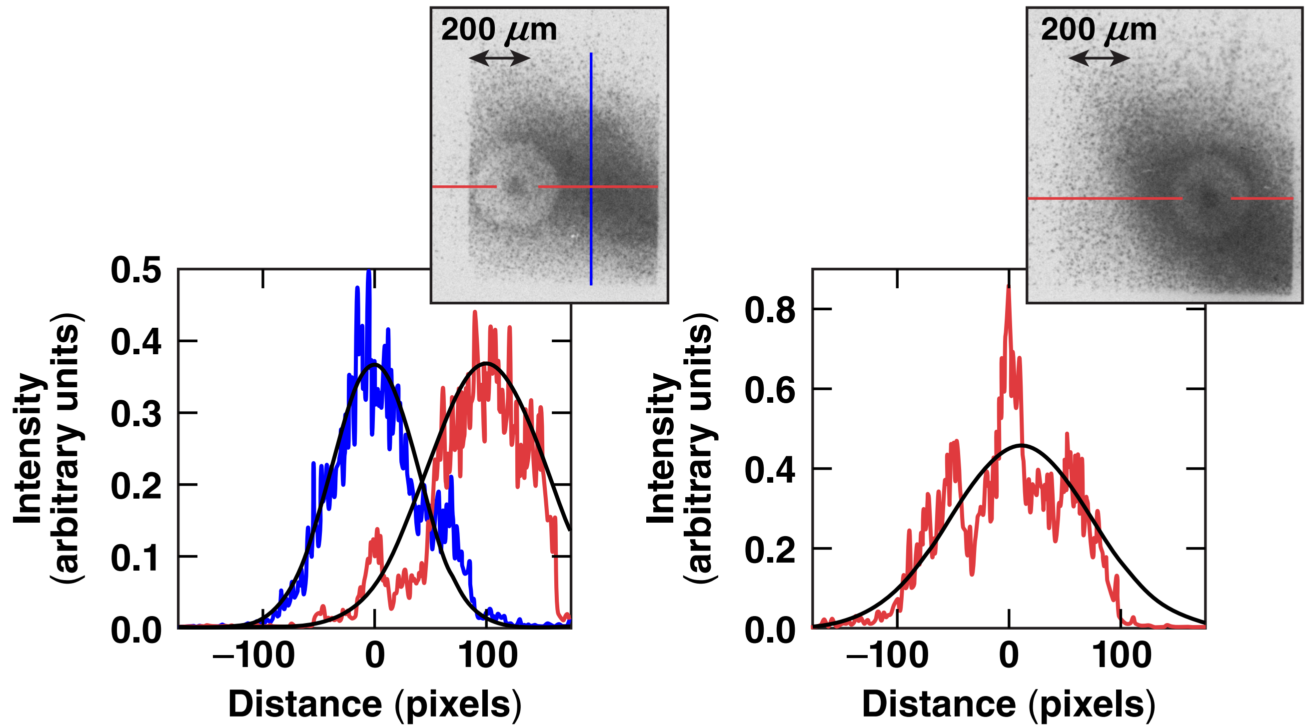
Simulation and Analysis of Backlit Images of Cryogenic Implosions on OMEGA

Shot 54395: 10.1-μm shell, 95-μm cryo D_2, 866-μm diam



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Summary

Radiographs of cryogenic implosions have been obtained on OMEGA with an OMEGA EP driven Al backlighter

- **Analysis of the first OMEGA/OMEGA EP backlit cryogenic shots provides useful results at times well in advance of peak compression.**
- **The analysis is based on the Abel inversion of radiographs circularly averaged from the entire image.**
- **Detailed 1-D simulation of the implosions and their radiographs provides input parameters for the analysis, takes into account instrumental effects, and anticipates potential complications.**

Collaborators

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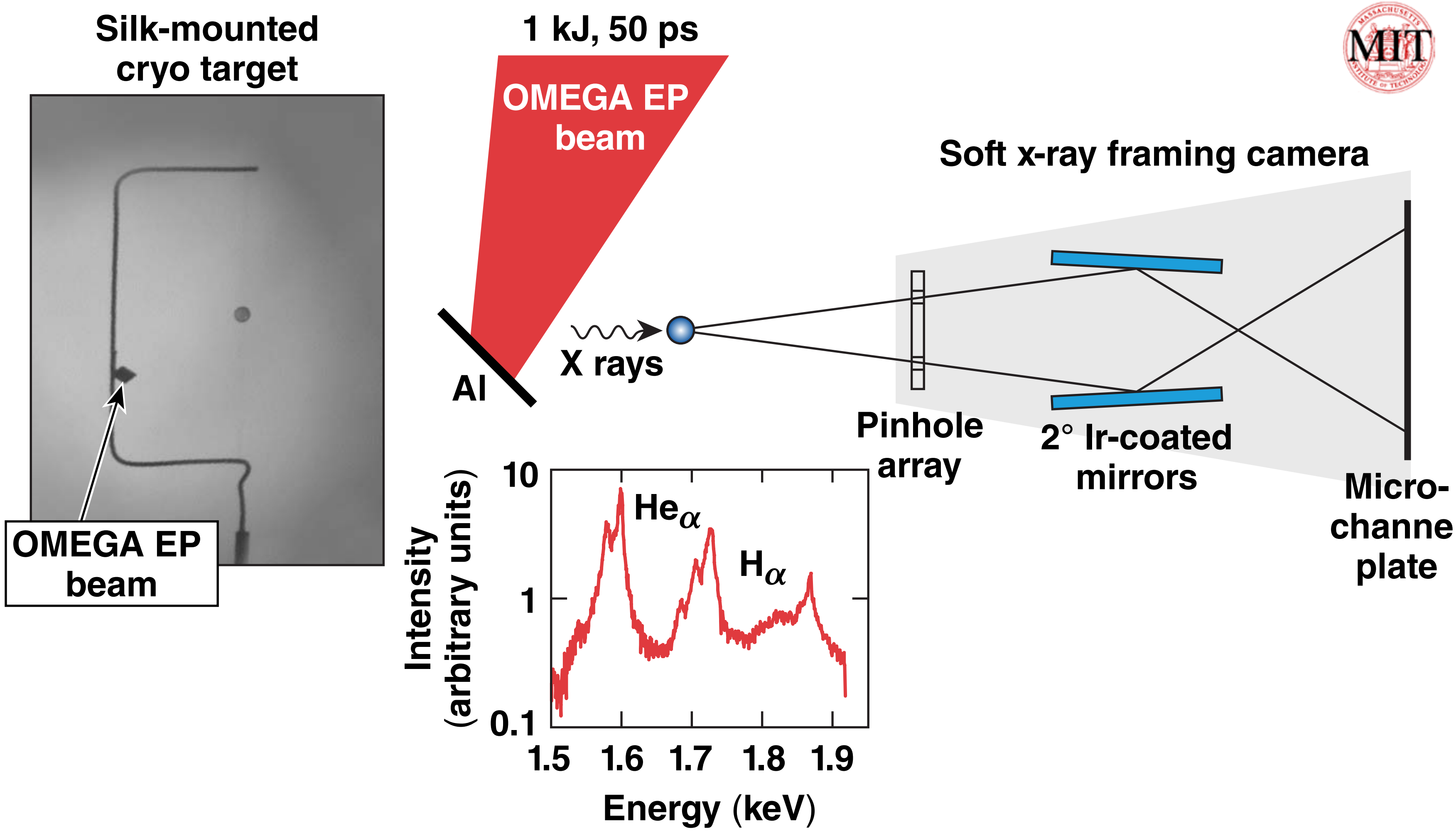
*See F. J. Marshall (UO5.00008).

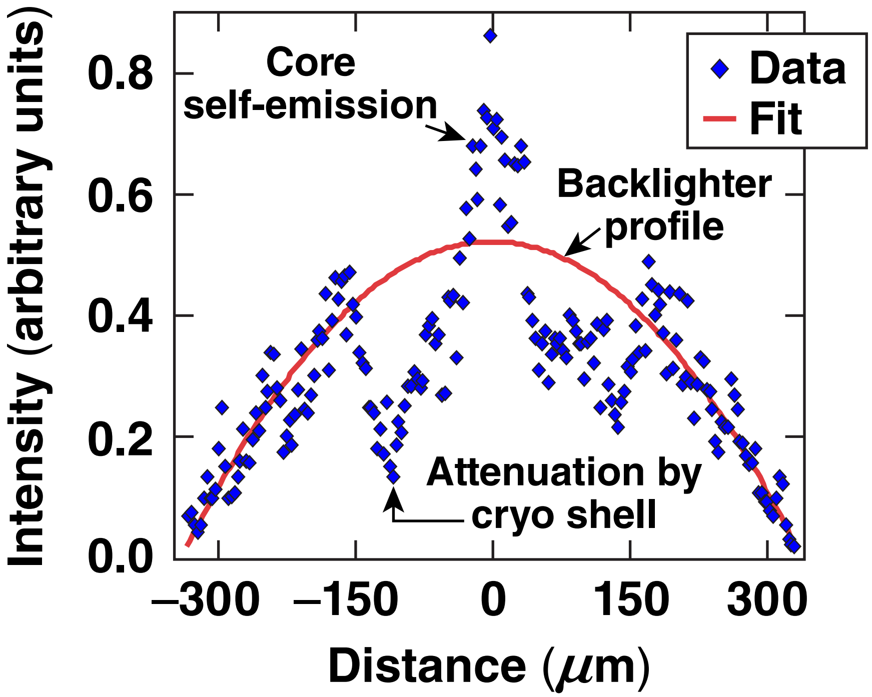
Backlit images of imploding cryogenic targets are captured by a soft x-ray framing camera



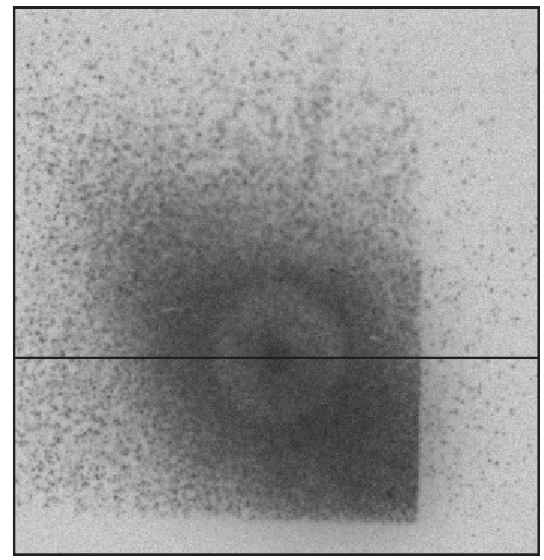
- Ir-coated mirrors significantly reduce the hard x-ray background by reflecting x rays below 2 keV.

E18121c

X-ray radiography is used to infer target areal density during a cryogenic implosion



Shot 54395

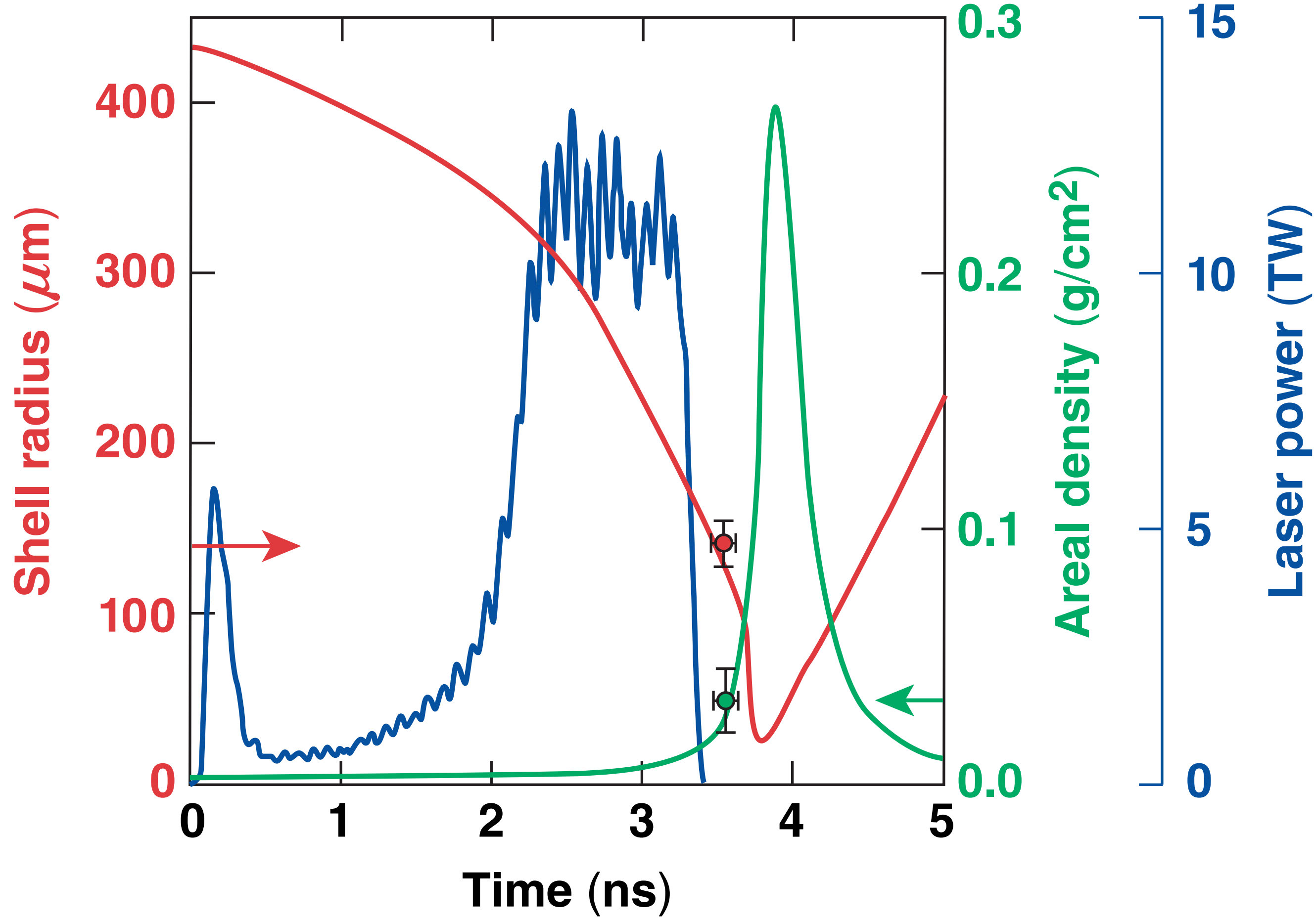


- The backlit image was Abel inverted
- A $\rho^2 R$ of ~0.097 g^2/cm^5 was inferred from the optical depth
- A ρR of ~33 mg/cm^2 was inferred using the radius of the measured image of ΔR ~ 110 μm and an ice-block model
- A ρR of ~33 mg/cm^2 is consistent with the simulated imploded mass within the inner and outer shadow radii

E18130d

The radius of the shell radiograph and the inferred ρR are consistent with simulated values at a time well before peak compression

- **Measured shell radius = 140 μm**
- **Experimentally inferred ρR = 33 mg/cm^2**



I1905a

The analysis of cryogenic implosion radiographs is guided by hydrodynamic and radiation simulations

- *LILAC* simulates the hydrodynamics of the implosions
  - the simulated imploded shell mass is a useful input parameter[1]
  - the simulated shell temperature is needed to infer density from opacity, but the results are only weakly sensitive to it

$$\kappa_{\text{free-free}} \sim \frac{\left[\rho/(kT)^{1/4}\right]^2}{(h\nu)^3}$$

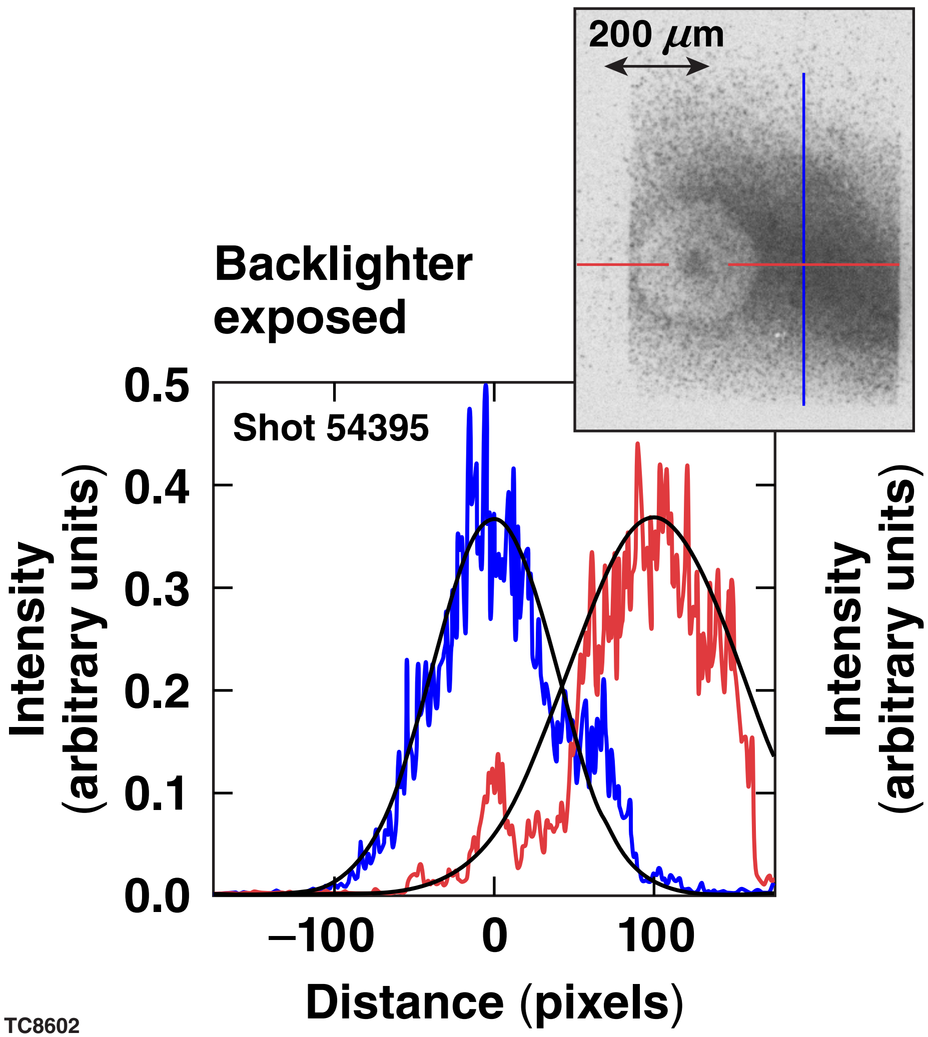
- Implosion radiographs are simulated by Spect3D[2]
  - the backlighter spectrum, the instrumental spectral response, and the space and time resolutions are taken into account
  - the appropriate spectrum-averaged opacity is applied to the radiograph analyses

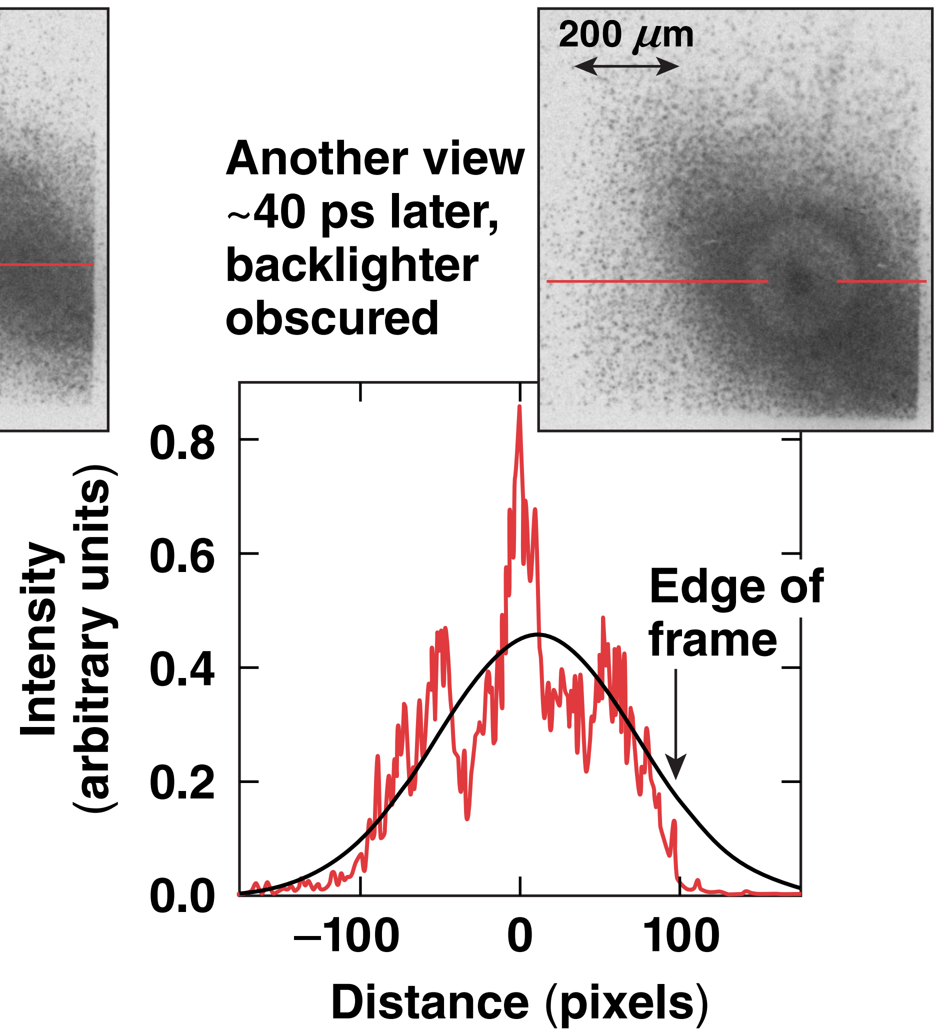
[1] F. J. Marshall *et al*., Phys. Rev. Lett. 102, 185004 (2009); See UO5.00008.

[2] Prism Computational Sciences, Inc., Madison, WI.

TC8601

Backlighter profile information obtained from exposed views can be applied to radiographs where the backlighter is obscured

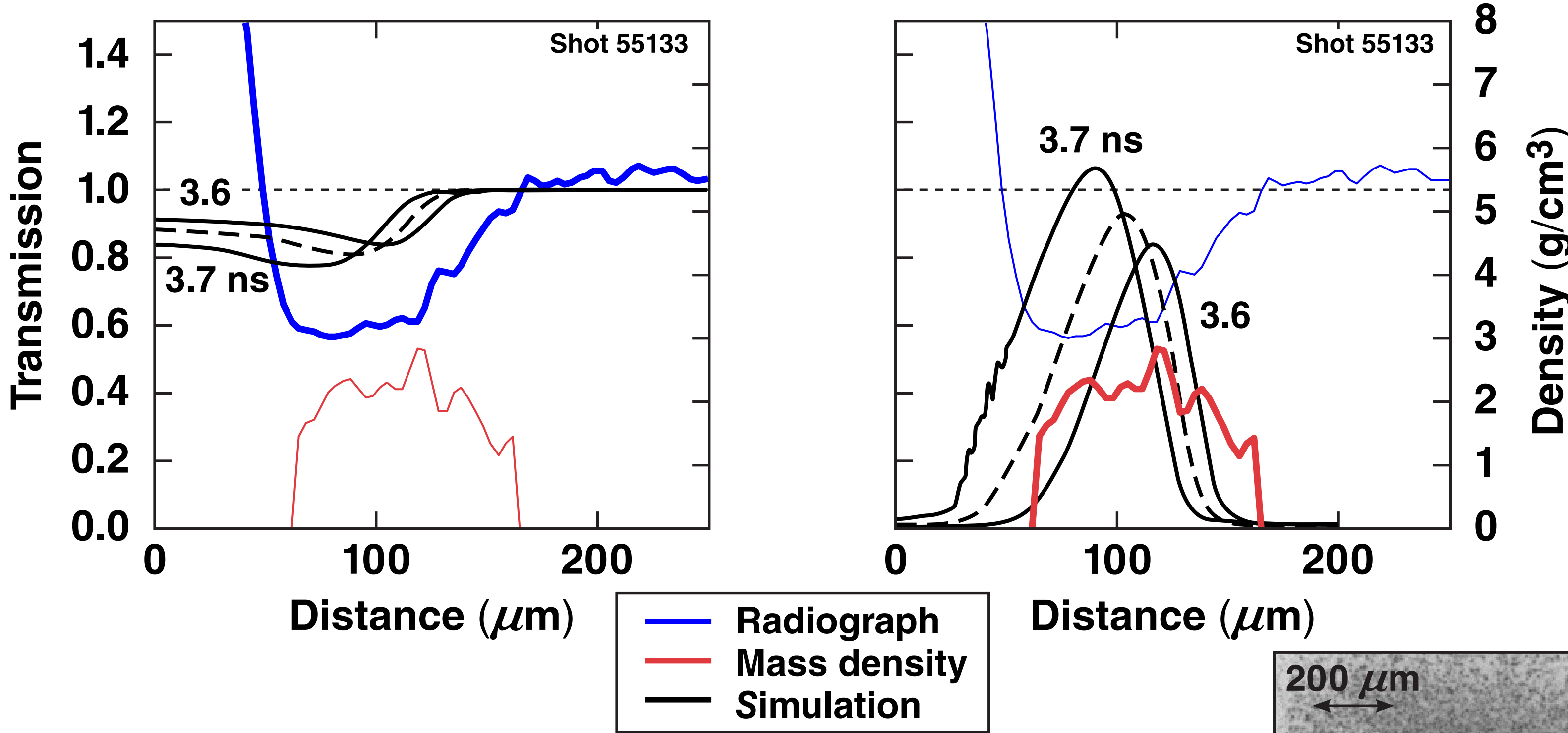


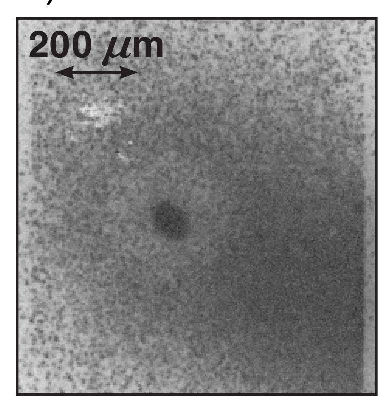


TC8602

Simulation results are closer to measured radiographs and inferred mass density profiles with thinner CD shells

9.6-μm shell, 95-μm cryo D_2, 878-μm diam, 80-ps framing camera gate





- From the shell mass (33.5 μg, *LILAC*) and the density profile: ρR = 20 mg/cm^2
- From the inferred opacity profile alone: ρR = 56 mg/cm^2
- Much of the observed absorption is not yet accounted for

Summary/Conclusions

Radiographs of cryogenic implosions have been obtained on OMEGA with an OMEGA EP driven Al backlighter

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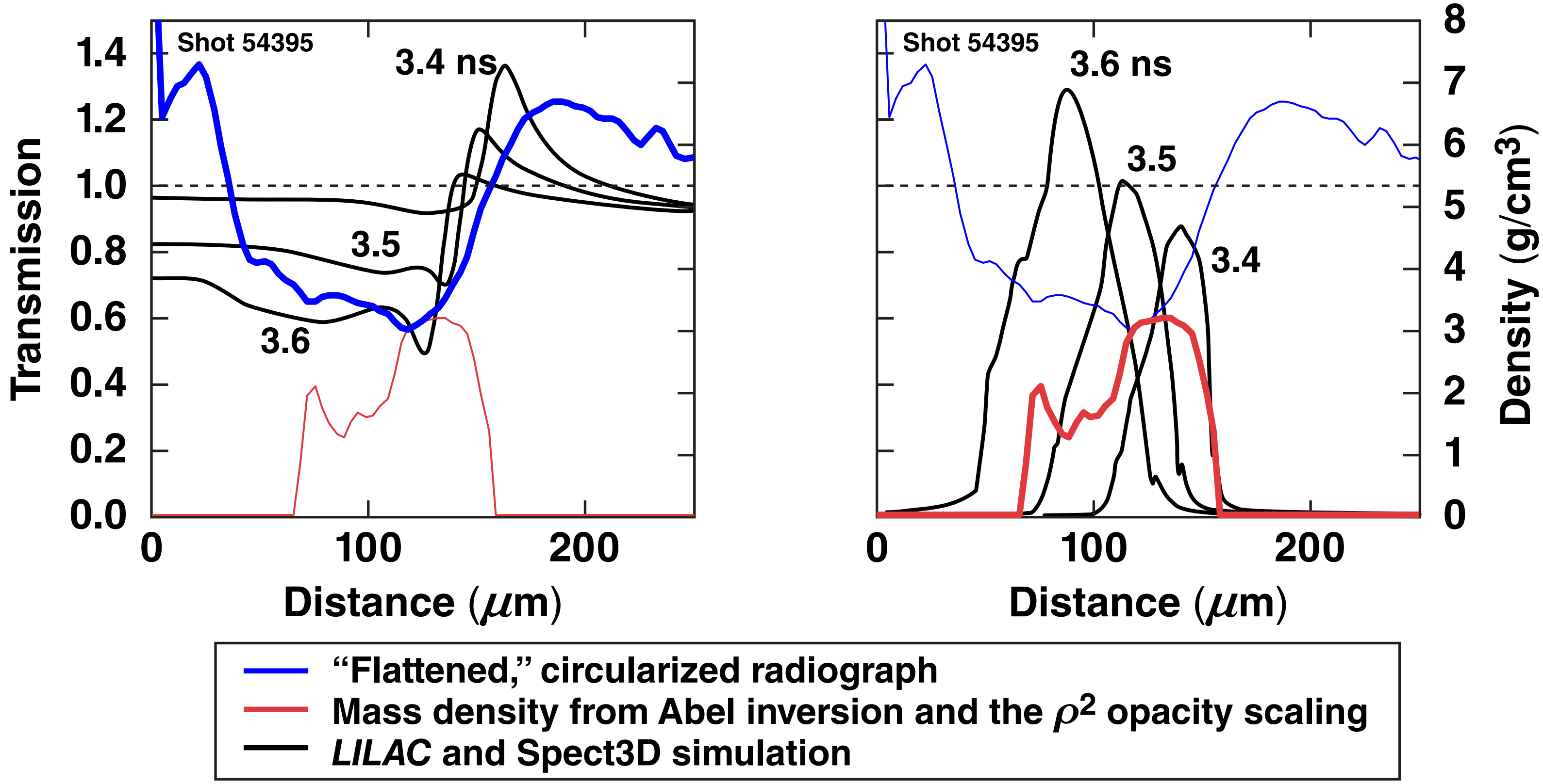
- The analysis is based on the Abel inversion of radiographs circularly averaged from the entire image.
- Detailed 1-D simulation of the implosions and their radiographs provides input parameters for the analysis, takes into account instrumental effects, and anticipates potential complications.

Simulated radiograph shows significant absorption due to an unablated trace of shell CD

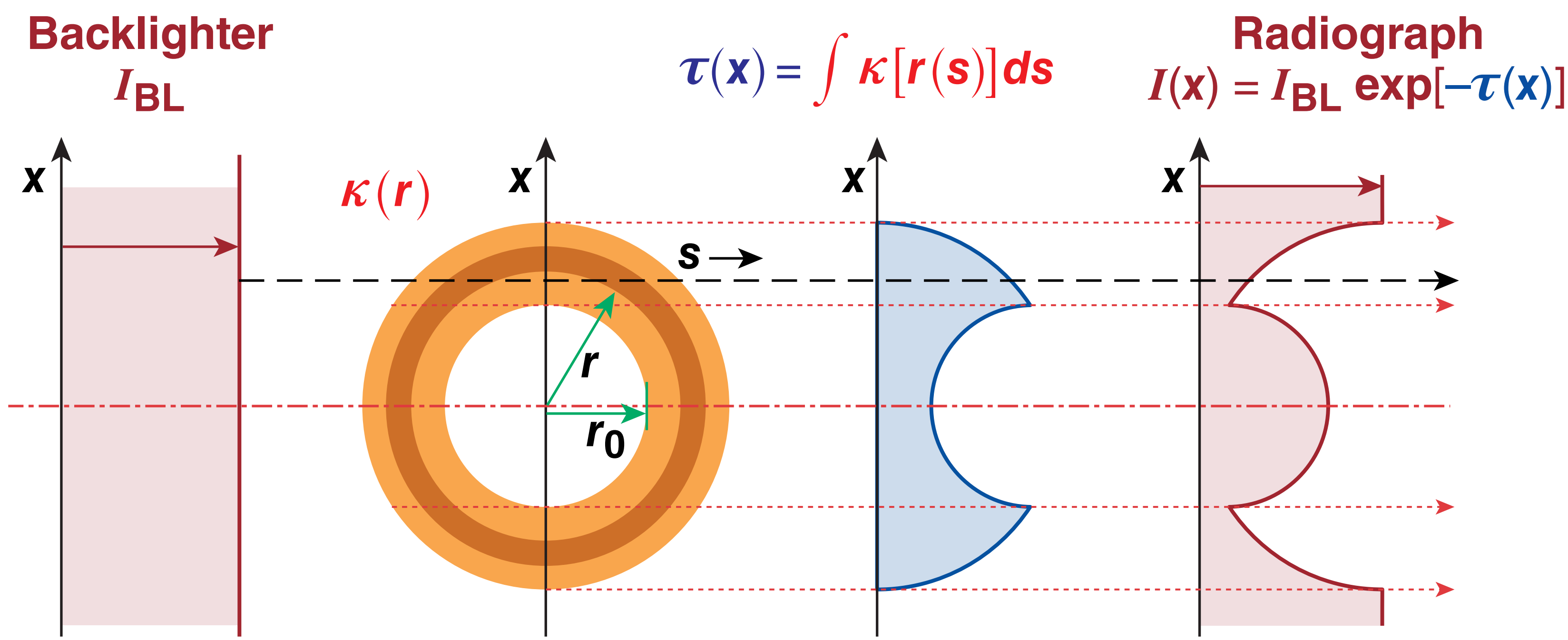
10.1-μm shell, 95-μm cryo D_2, 866-μm diam, 80-ps framing camera gate



- From the shell mass (34.8 μg, *LILAC*) and the density profile: ρR = 19 mg/cm^2
- From the inferred opacity profile alone: ρR = 47 mg/cm^2
- CD absorption complicates the analysis based on free-free D_2 opacity

TC8603

Abel inversion recovers the shell opacity profile from its radiograph



- The optical thickness $\tau(x)$ of the shell is the measured quantity
- Abel inversion recovers the radial opacity distribution $\kappa(x)$

$$\kappa(r) = -\frac{1}{\pi}\int_r^{\infty}\frac{d\tau(x)}{dx}\frac{dx}{\sqrt{x^2-r^2}} \quad \text{or} \quad \int_{r_0}^{\infty}\kappa(r)dr = \frac{r_0}{\pi}\int_{r_0}^{\infty}\frac{\tau(x)}{x\sqrt{x^2-r_0^2}}dx$$

TC8600