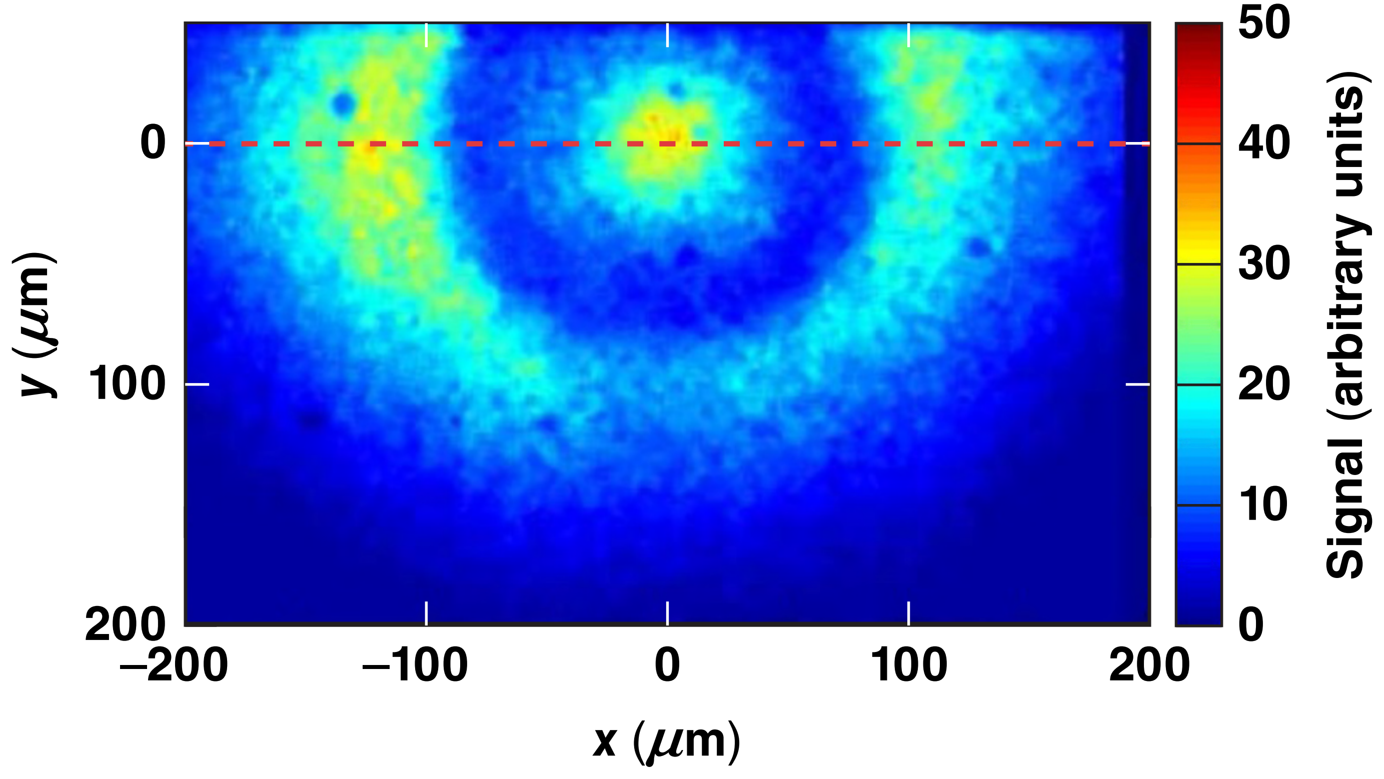
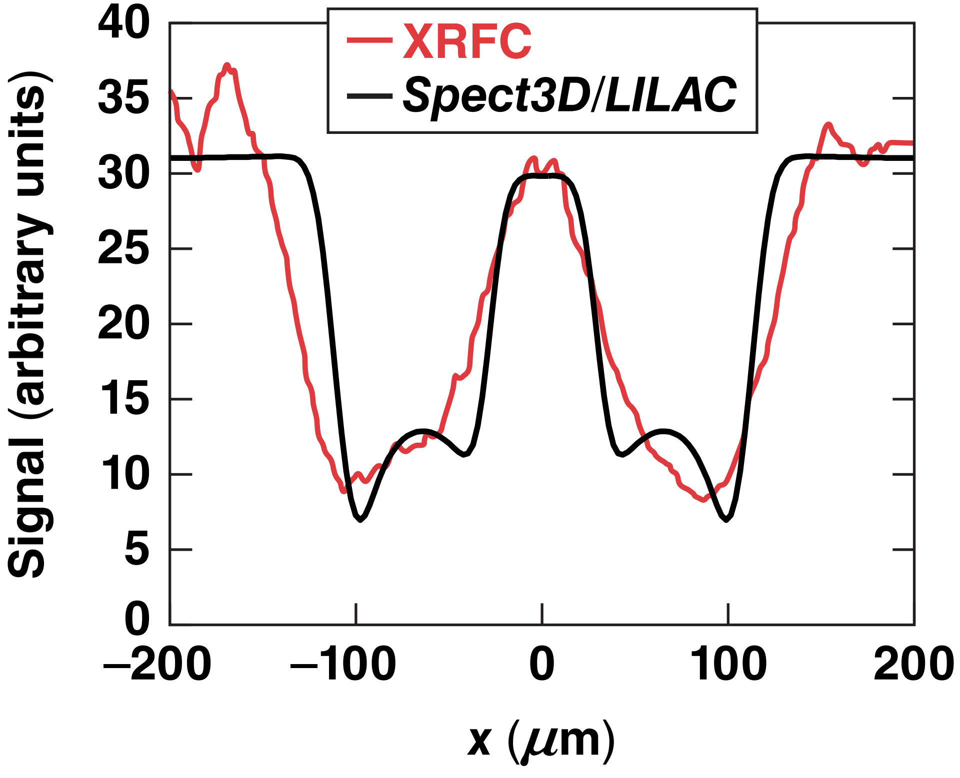
Simulation and Analysis of Time-Resolved Narrowband Radiographs of Cryogenic Implosions on OMEGA

OMEGA cryo shot 81590 XRFC



Flattened data and simulations



R. Epstein
University of Rochester
Laboratory for Laser Energetics

58th Annual Meeting of the
American Physical Society
Division of Plasma Physics
San Jose, CA
31 October–4 November 2016

Summary

The in-flight characteristics of converging cryogenic DT shells have been observed with monochromatic soft x-ray radiography on OMEGA

- Radiographs of the converging DT shell and the unablated trace of the CH polymer shell in some implosions provide diagnostics of implosion dynamics and mix
- Self-emission by the central hot spot and spatial resolution are the main effects limiting the ability of soft x-ray radiography to image the stagnating DT shell
- The measured radiographs are interpreted and analyzed using comparisons with the predictions of hydrodynamic simulations

TC13001

Collaborators

C. Stoeckl,* V. N. Goncharov, P. W. McKenty, S. P. Regan,
S. X. Hu, and I. V. Igumenshchev

University of Rochester
Laboratory for Laser Energetics

*C. Stoeckl, NI2.00004, this conference (invited).

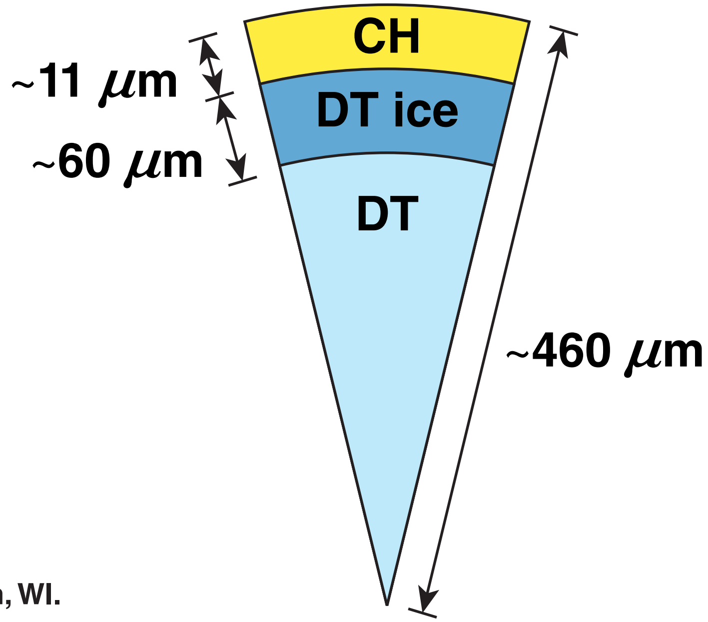
A silicon He-α backlighter produces radiographs with distinct DT shell and CH absorption peaks during the late convergence phase of the implosion

- 25-kJ, 3-picket low-adiabat pulses
- 20-ps, 1.5-kJ backlighter pulse
- Si He-α backlighter (1865 eV)
- Crystal imaging with 40-ps XRFC shutter, 15-μm spatial resolution

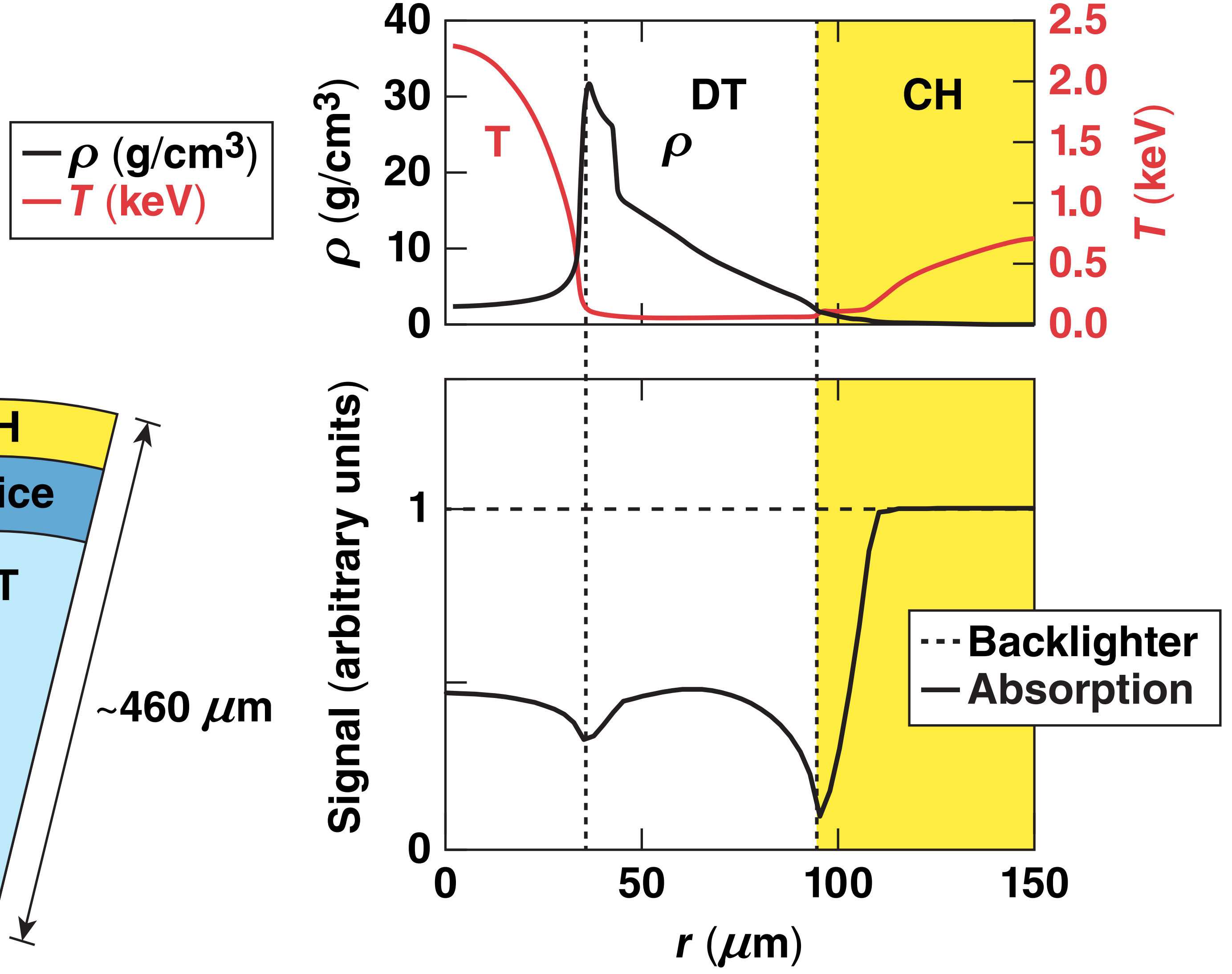
- C outshines and out-absorbs H, per ion, by

$$\frac{Z_C^4}{Z_{DT}^2} \sim \frac{\text{C Bound-Free}}{\text{H Free-Free}}$$

$$\sim 1300$$



*LILAC/Spect3D** profile and image at CR = 11



Spect3D, Prism Computational Sciences, INC. Madison, WI.
CR: convergence ratio
XRFC: x-ray framing camera

TC13002

A silicon He-α backlighter produces radiographs with distinct DT shell and CH absorption peaks during the late convergence phase of the implosion

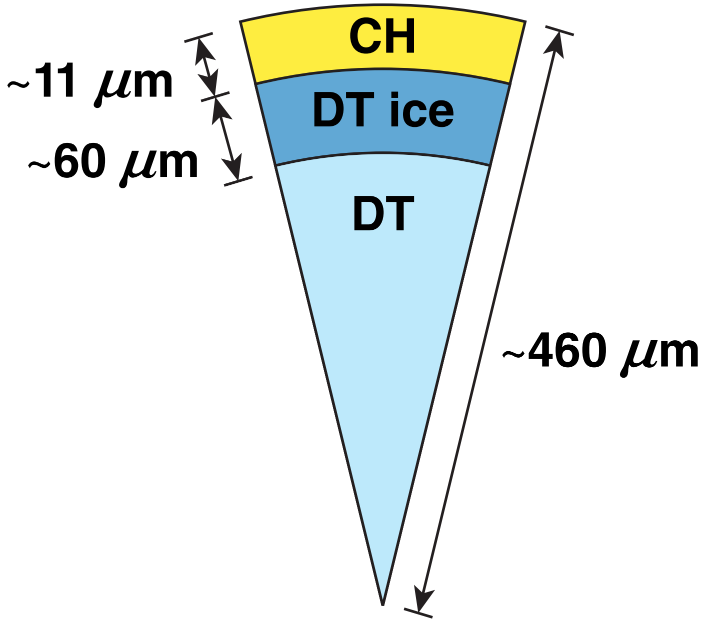
UR LLE

- 25-kJ, 3-picket low-adiabat pulses
- 20-ps, 1.5-kJ backlighter pulse
- Si He-α backlighter (1865 eV)
- Crystal imaging with 40-ps XRFC shutter, 15-μm spatial resolution

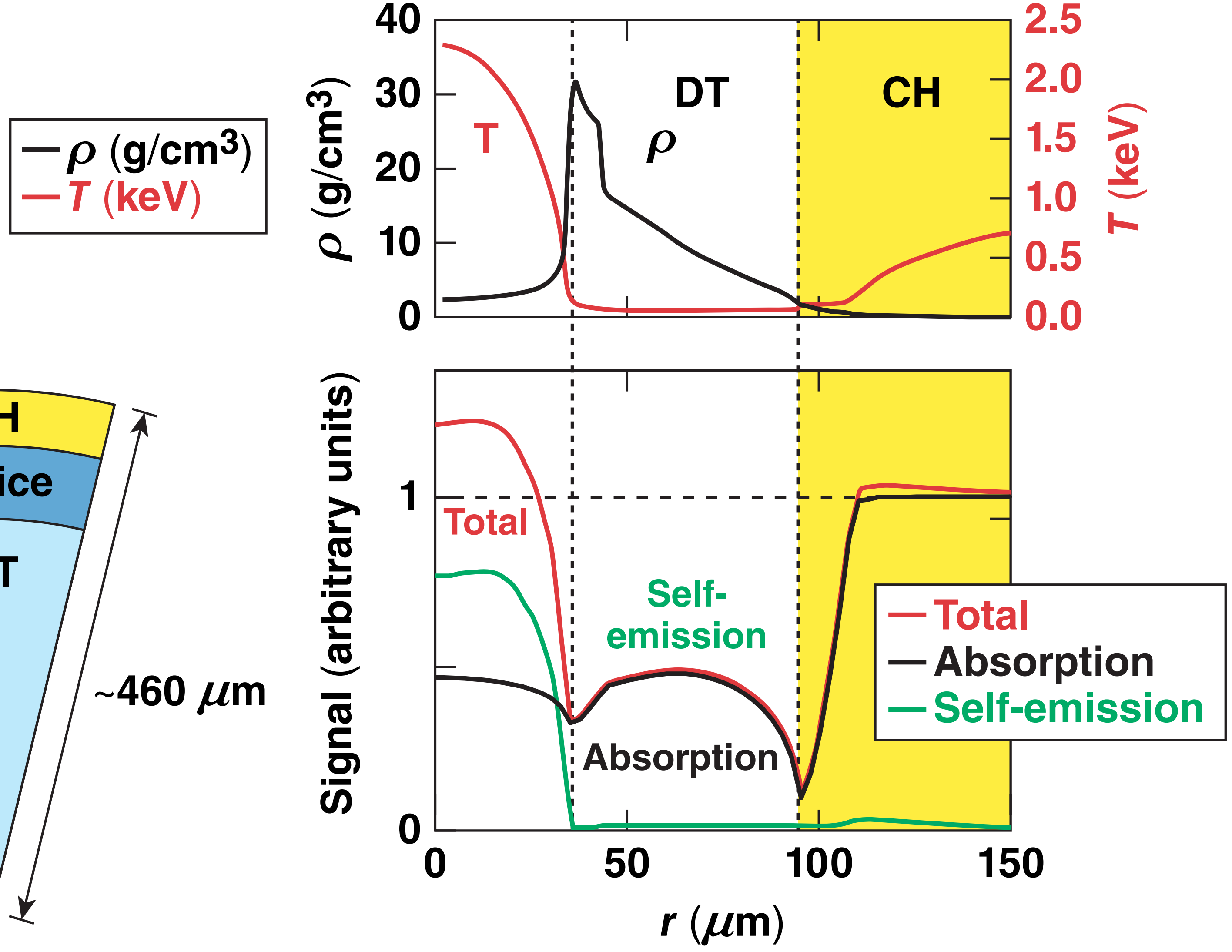
- C outshines and out-absorbs H, per ion, by

$$\frac{Z_C^4}{Z_{DT}^2} \sim \frac{\text{C Bound - Free}}{\text{H Free - Free}}$$

~1300

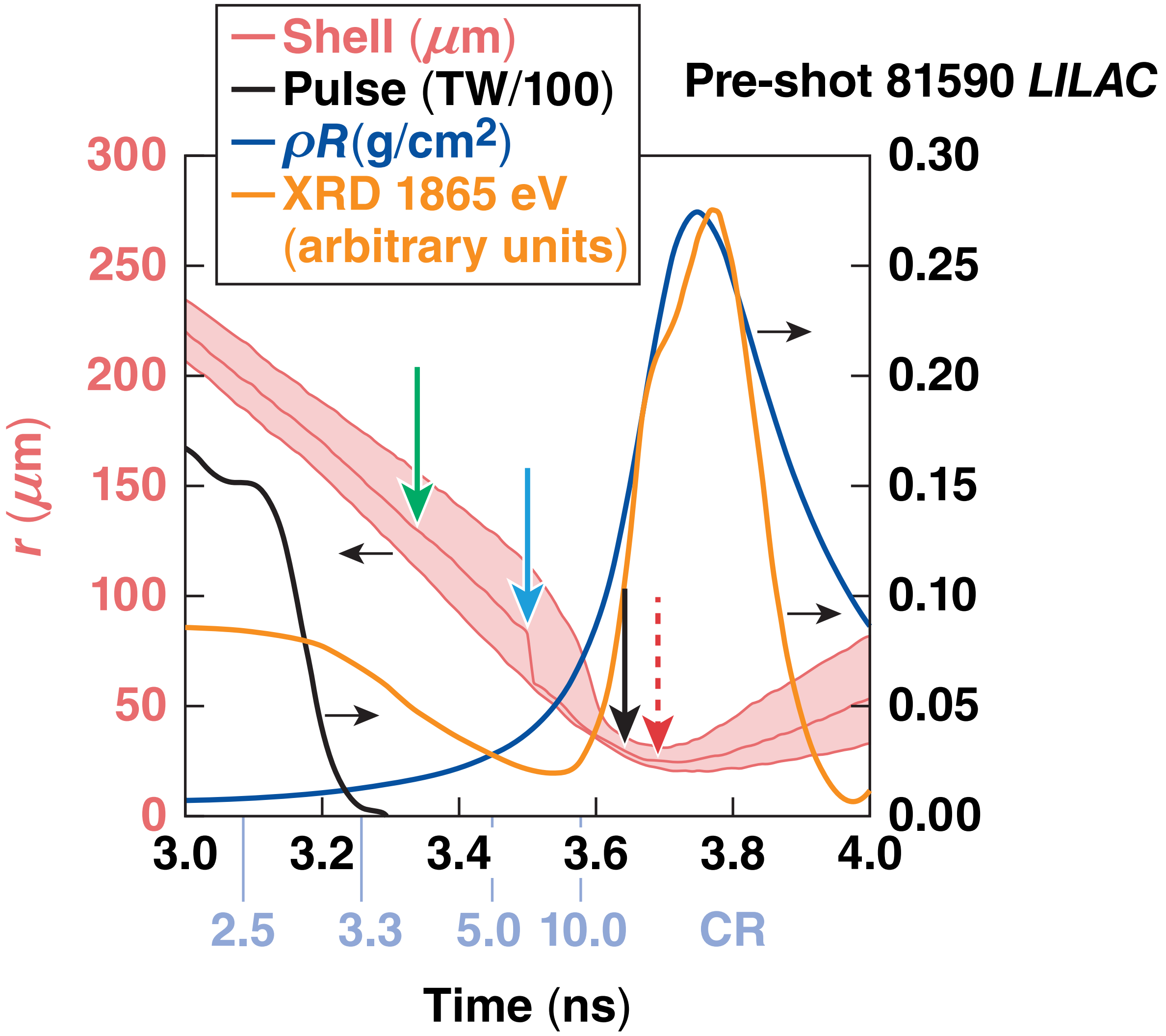


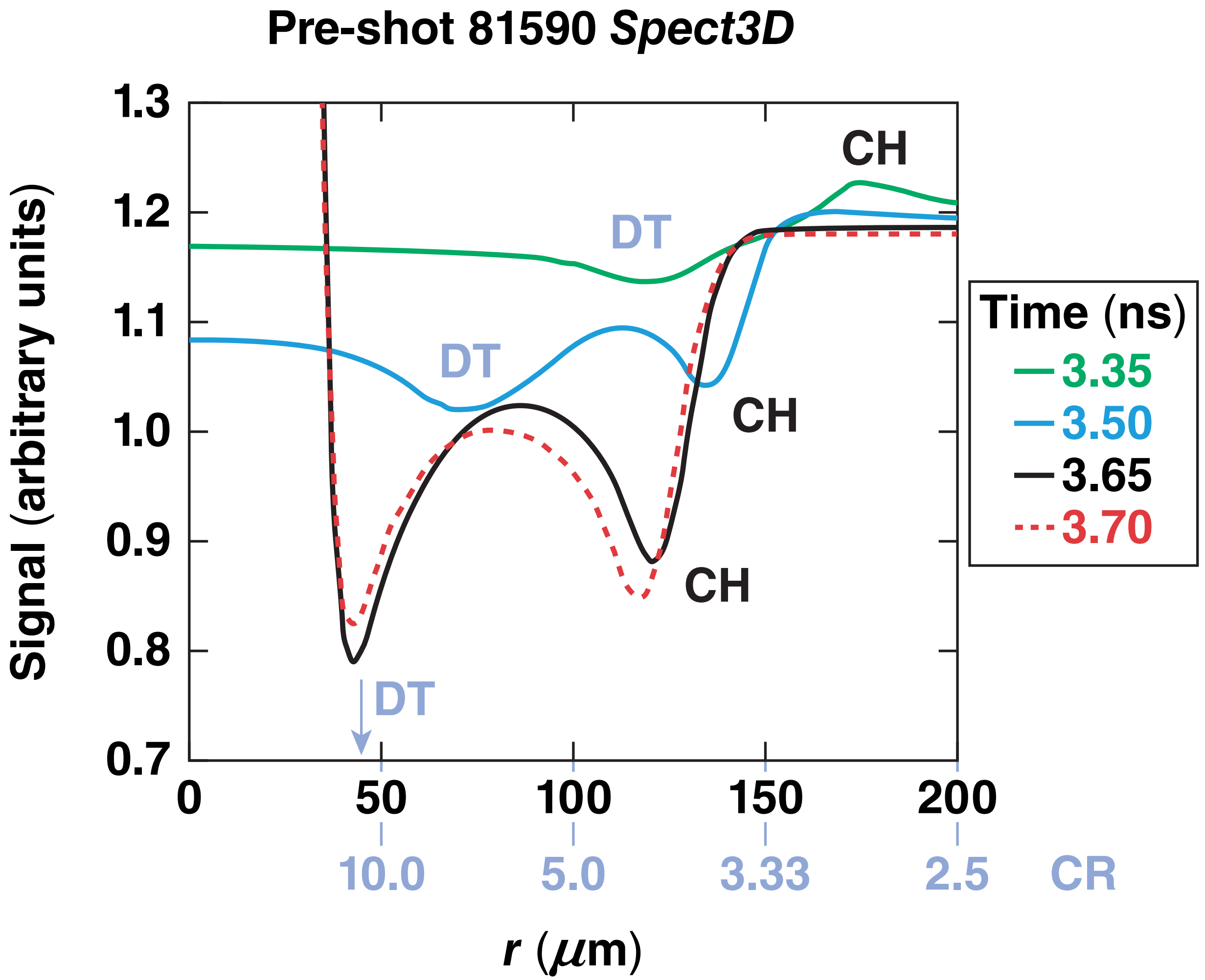
LILAC/Spect3D profile and image at CR = 11



TC13002c

This radiographic technique can be used to follow the converging shell until self-emission overwhelms the backlighter brightness



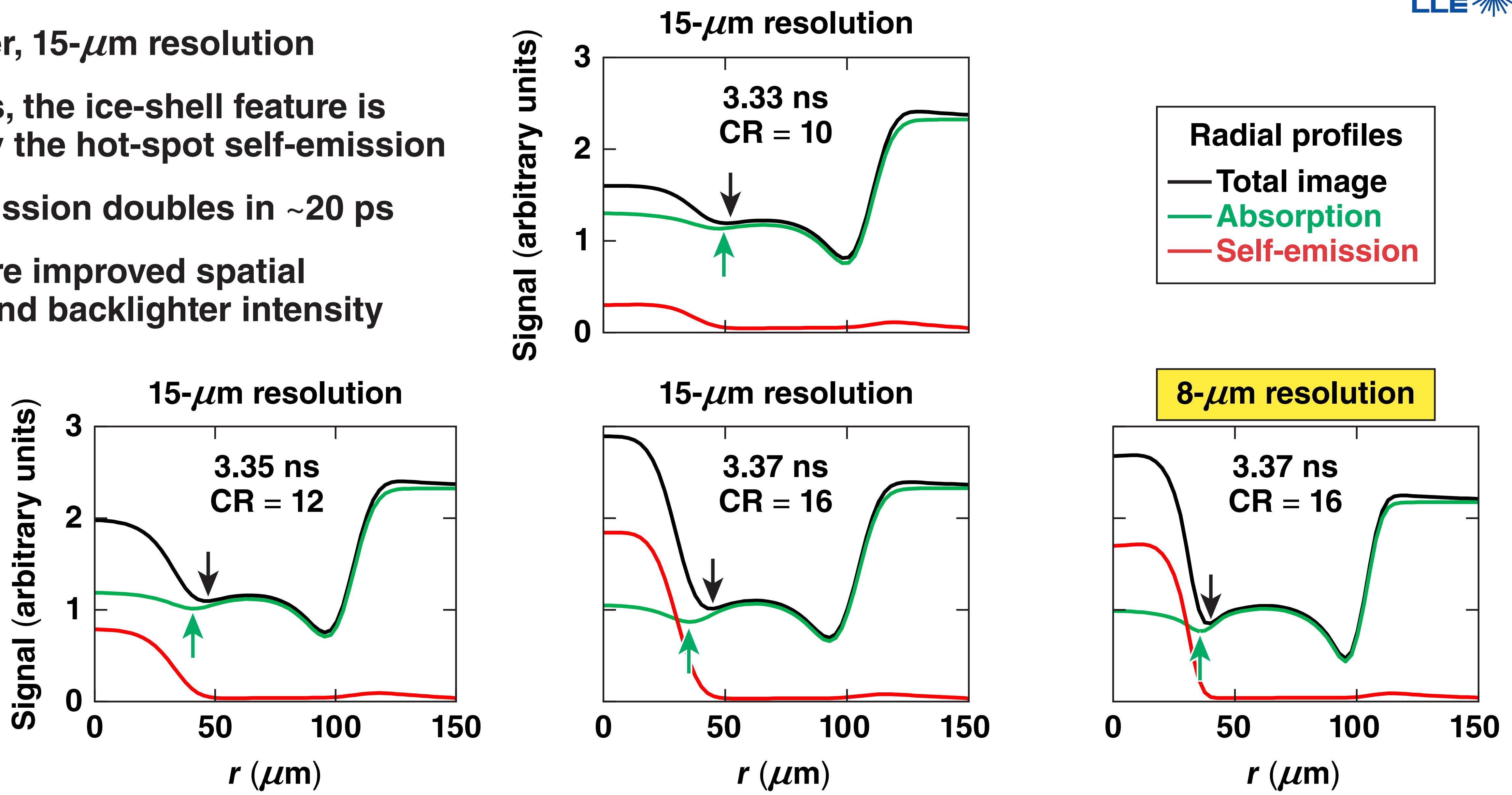


XRD: x-ray diffraction

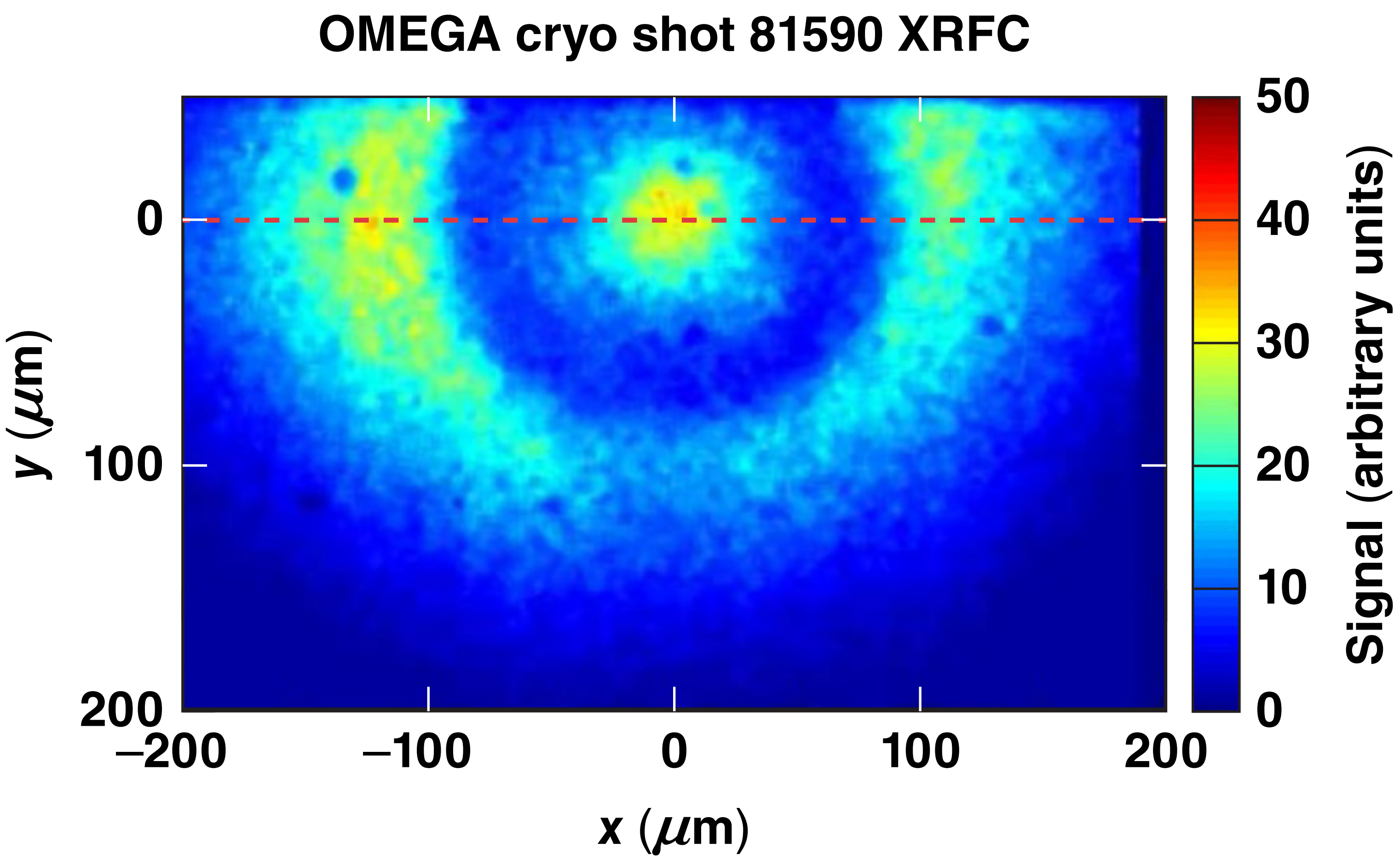
TC13003

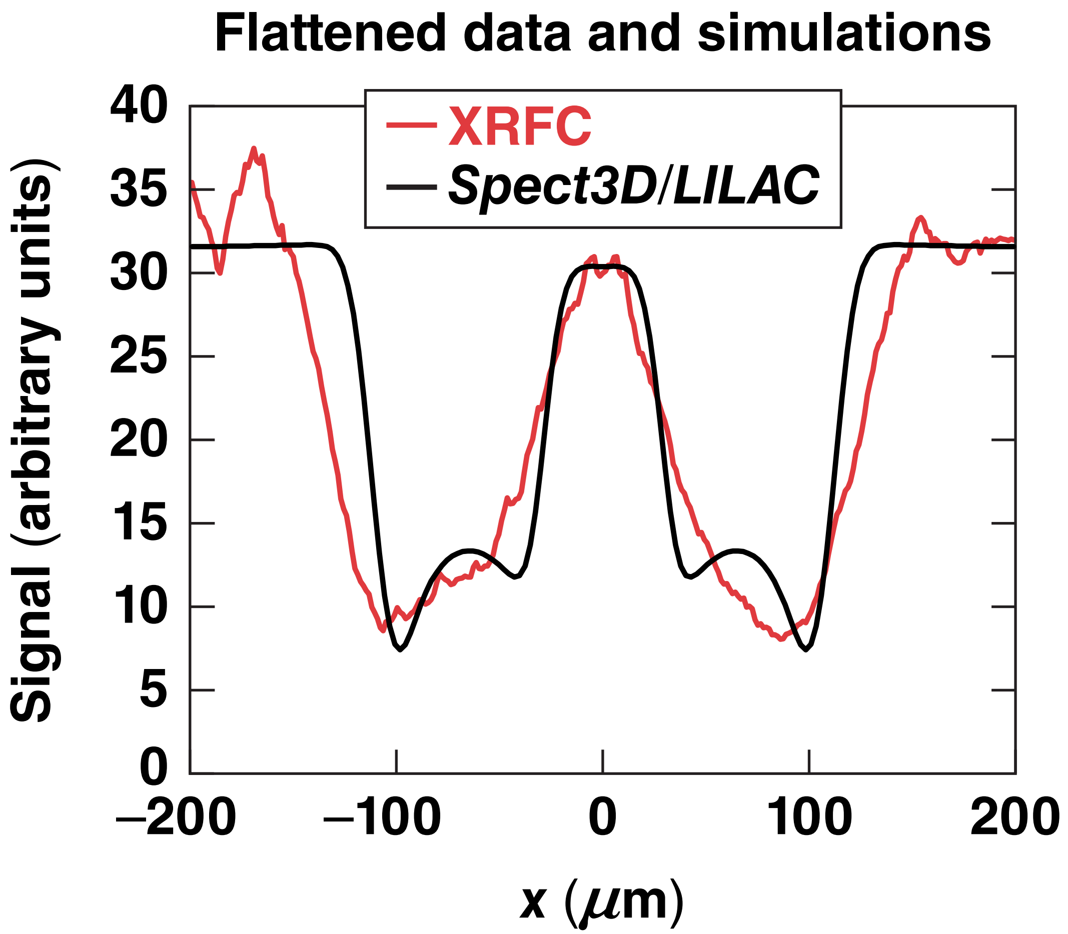
Hot-spot self-emission and instrument spatial resolution both limit how far soft x-ray radiography can follow the DT ice toward stagnation

- 20-ps shutter, 15-μm resolution
- At late times, the ice-shell feature is obscured by the hot-spot self-emission
- The self-emission doubles in ~20 ps
- Our goals are improved spatial resolution and backlighter intensity



A symmetric cryo DT implosion matches 1-D simulations closely with strong absorption by a trace of unablated shell CH





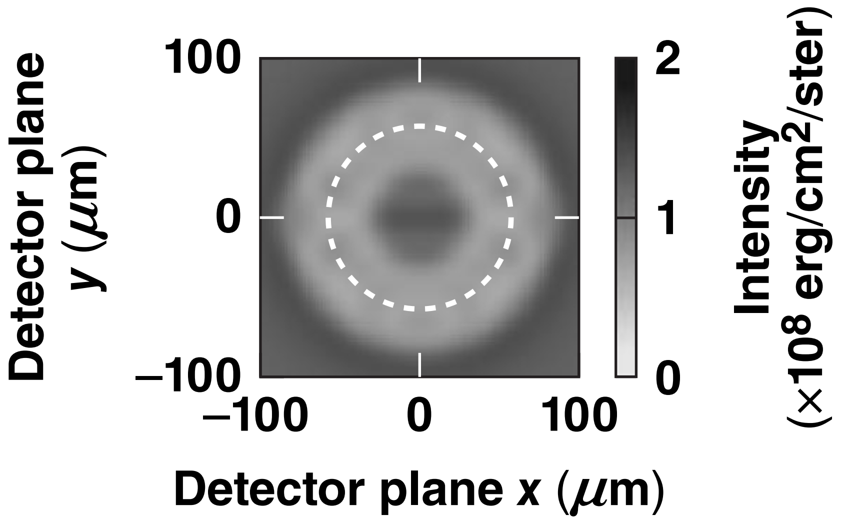
Adiabat α = 2.5
IFAR = 10
CR = 7

TC13005

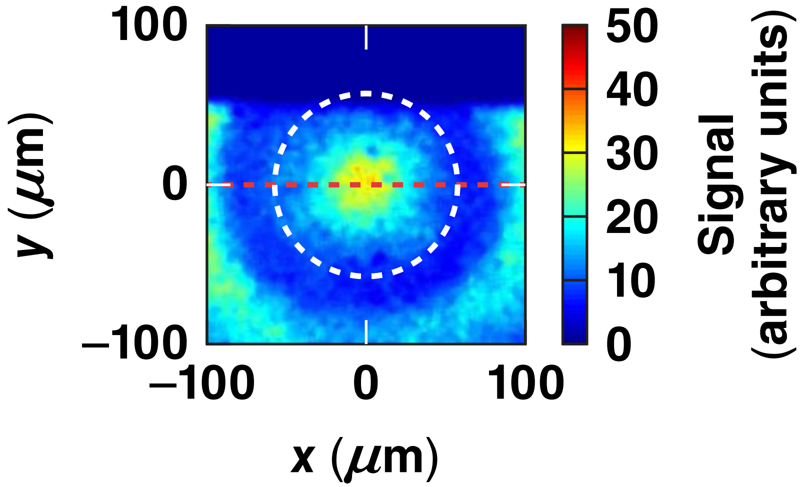
IFAR: in-flight aspect ratio

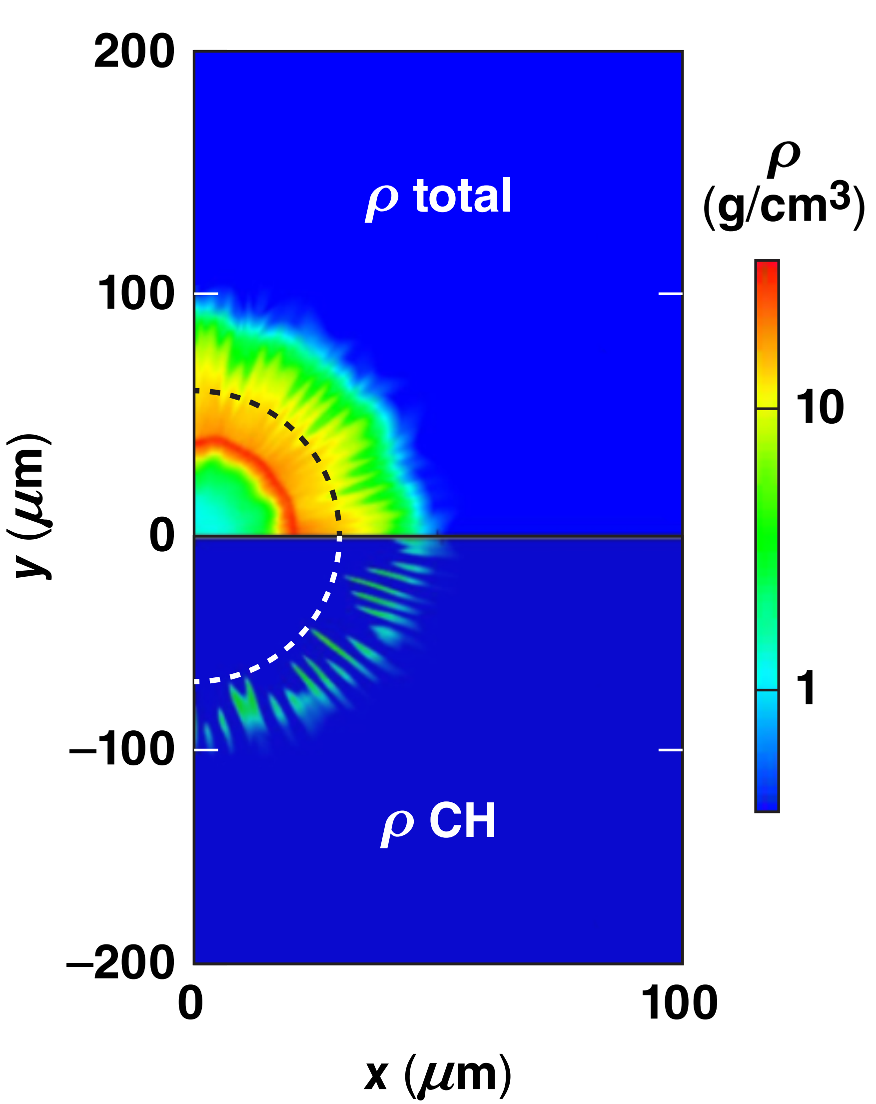
Laser nonuniformity imprint perturbs the implosion, which blurs and broadens radiographic features

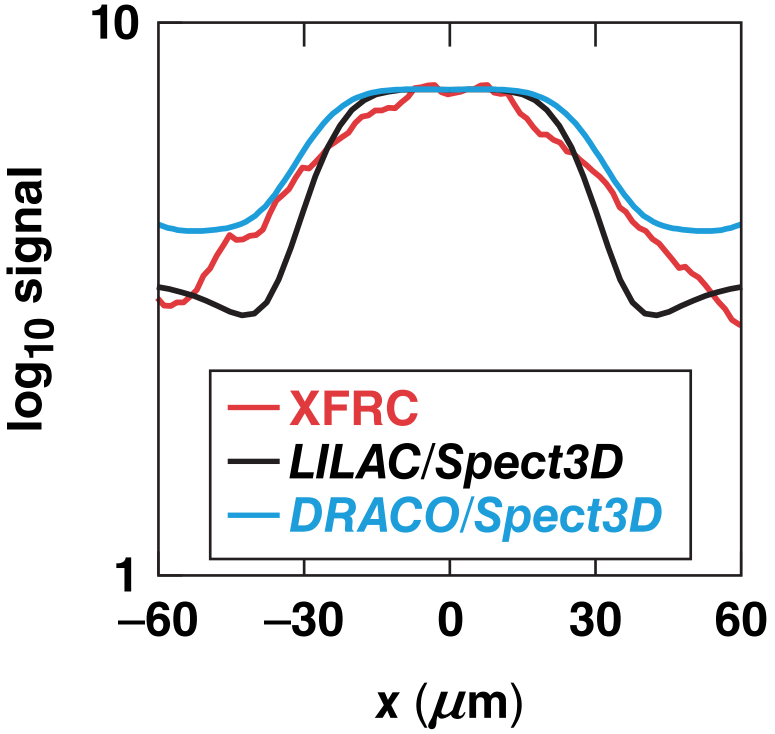
OMEGA cryo shot 81590 *DRACO*



OMEGA cryo shot 81590 XFRC





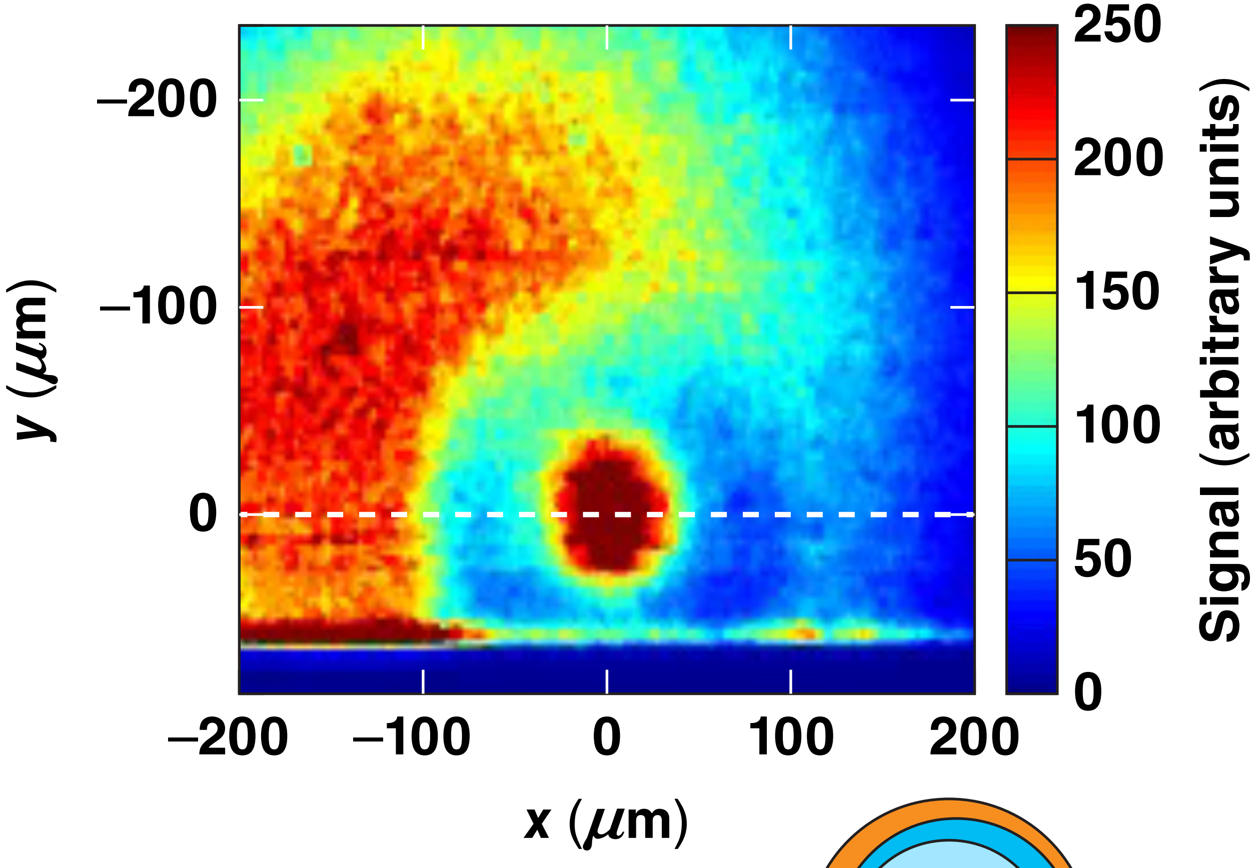


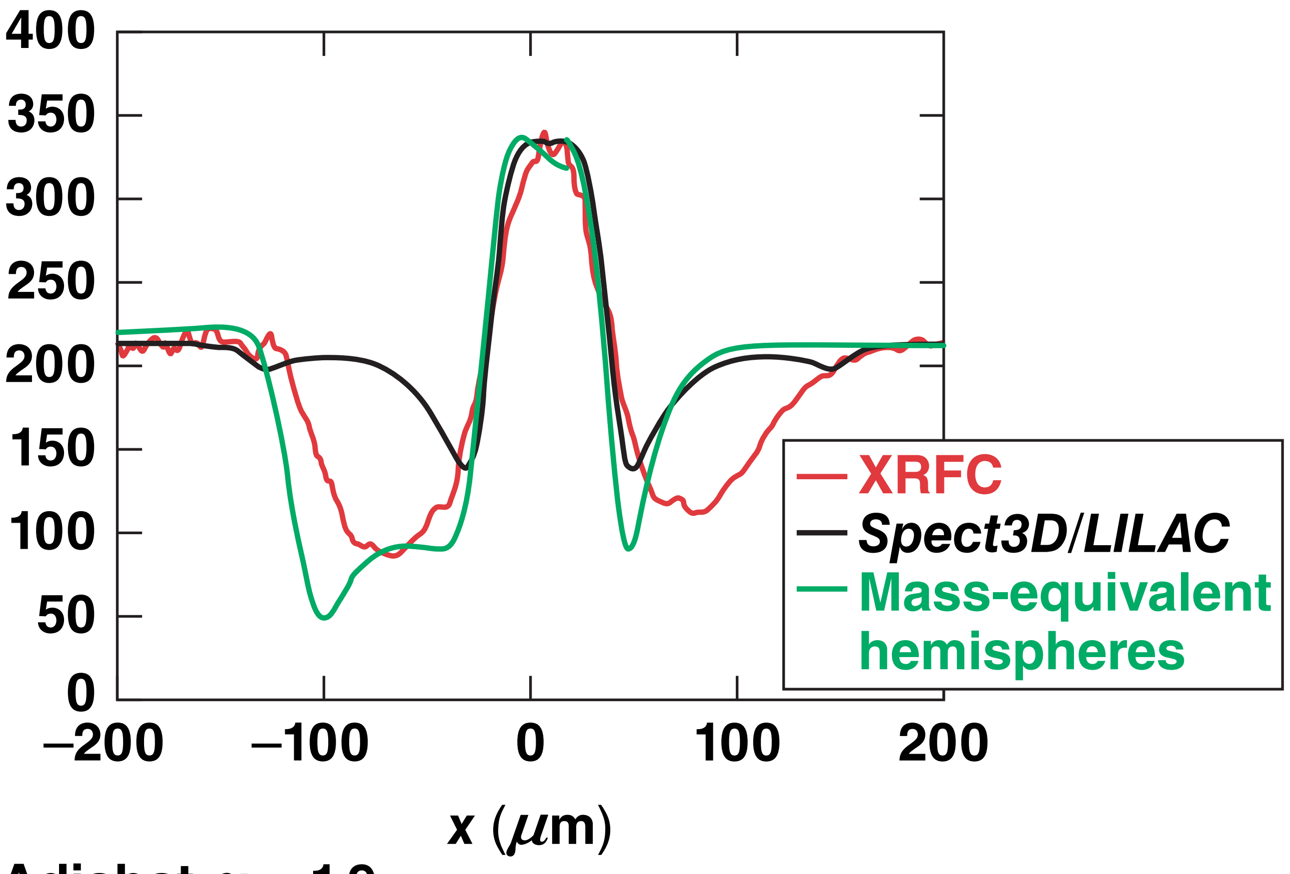
- **Mix, self-emission, and other issues affect simulation and analysis in progress**

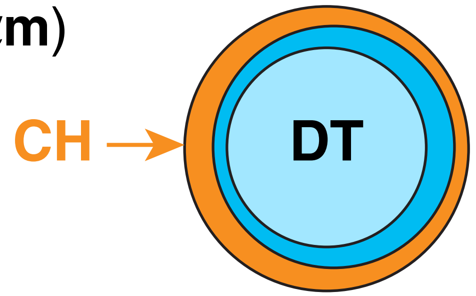
The in-flight characteristics of converging cryogenic DT shells have been observed with monochromatic soft x-ray radiography on OMEGA

- Radiographs of the converging DT shell and the unablated trace of the CH polymer shell in some implosions provide diagnostics of implosion dynamics and mix
- Self-emission by the central hot spot and spatial resolution are the main effects limiting the ability of soft x-ray radiography to image the stagnating DT shell
- The measured radiographs are interpreted and analyzed using comparisons with the predictions of hydrodynamic simulations

Unstable cryo DT implosions matches 1-D simulations, except for strong absorption by a trace of shell polymer mixed into the DT







Adiabat α = 1.9
IFAR = 14
Asymmetric CH shell 11.2±2.1 μm

TC13007

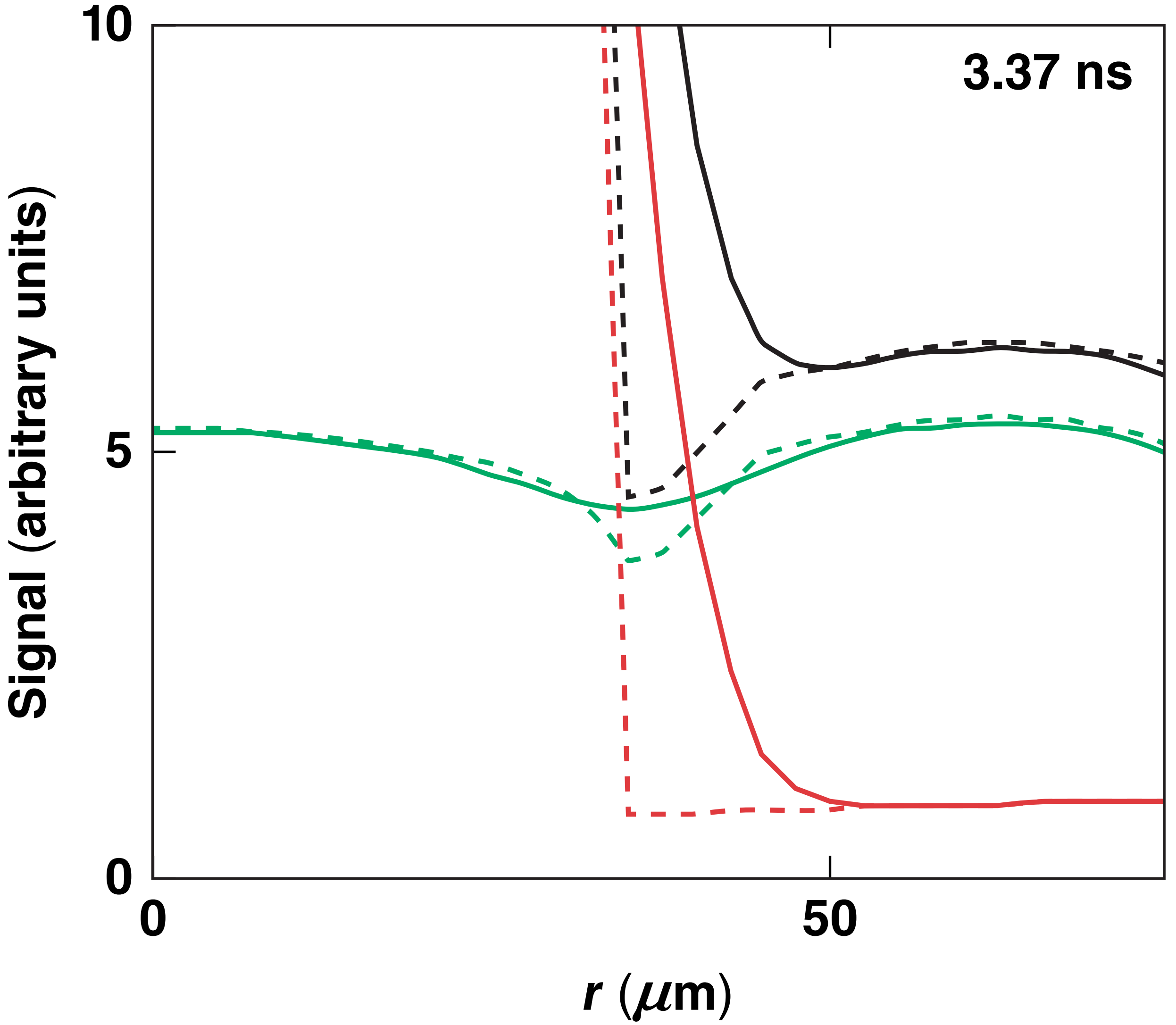
Ideally, perfect resolution reveals the ice shadow outside the hot-spot emission disc

UR LLE

- 20-ps shutter, 15-μm resolution
- 216-eV backlight temperature
- In principle, the entire cold DT shell-opacity profile can be Abel-inverted from the DT shadow

Radial profiles

- - - Total image (0 ps, 0 μm)
— Total image (20 ps, 15 μm)
— Absorption
- - - Self-emission (0 ps, 0 μm)
— Self-emission (20 ps, 15 μm)



UNIVERSITY of ROCHESTER

Excess emission and absorption in simulated radiograph explained by trace CH shell remnant in the outer tail of the DT density profile