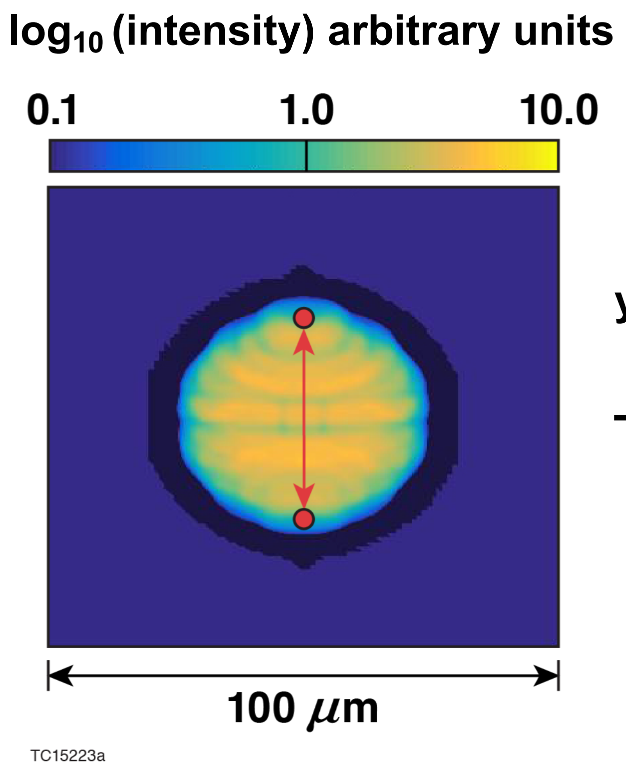
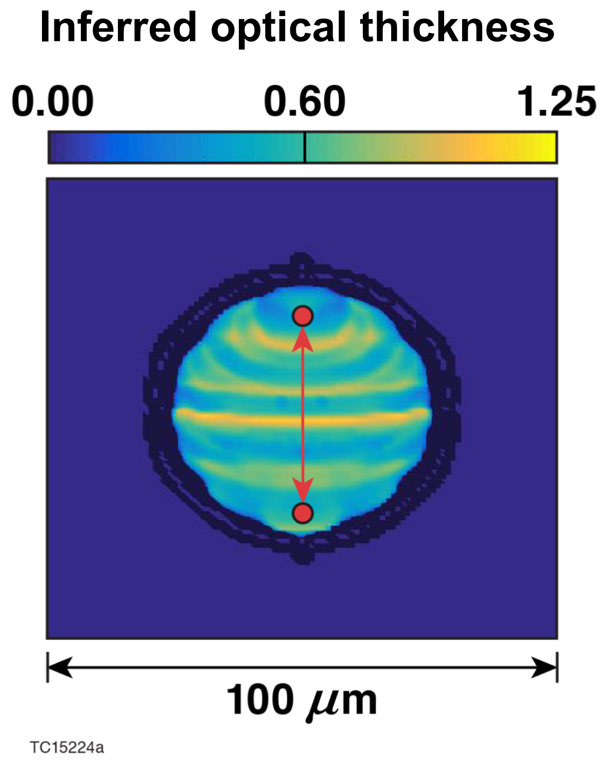
Self-Radiography of Imploded Shells on OMEGA Based on Additive-Free Multi-Monochromatic Continuum Spectral Analysis

Three images at
$h\nu$ = 2.2, 2.4, and 2.6 keV



yield a shell radiograph



R. Epstein
University of Rochester
Laboratory for Laser Energetics

61st Annual Meeting of the
American Physical Society
Division of Plasma Physics
Fort Lauderdale, FL
21–25 October 2019

Summary

The imploded cold shell structure can be radiographed using spatially resolved continuum spectroscopy of the hot core emission

- **Core self-emission is the backlighter in self-radiography, unlike externally backlit radiography, where self-emission is the limiting background**
- **Continuum self-radiography applies to pure cryo implosions without relying on the spectral K edges or spectral lines of additives***
- **This radiography technique has been demonstrated using multi-monochromatic imaging (MMI) of a warm CH shell implosion on OMEGA**

* F. J. Marshall *et al.*, Phys. Rev. E 49, 4381 (1994).
V. A. Smalyuk *et al.*, Phys. Rev. Lett. 87, 155002 (2001).
L. A. Pickworth *et al.*, Phys. Rev. Lett. 117, 035001 (2016).

Collaborators

C. Stoeckl, P. B. Radha, T. J. B. Collins, D. Cao, and R. C. Shah

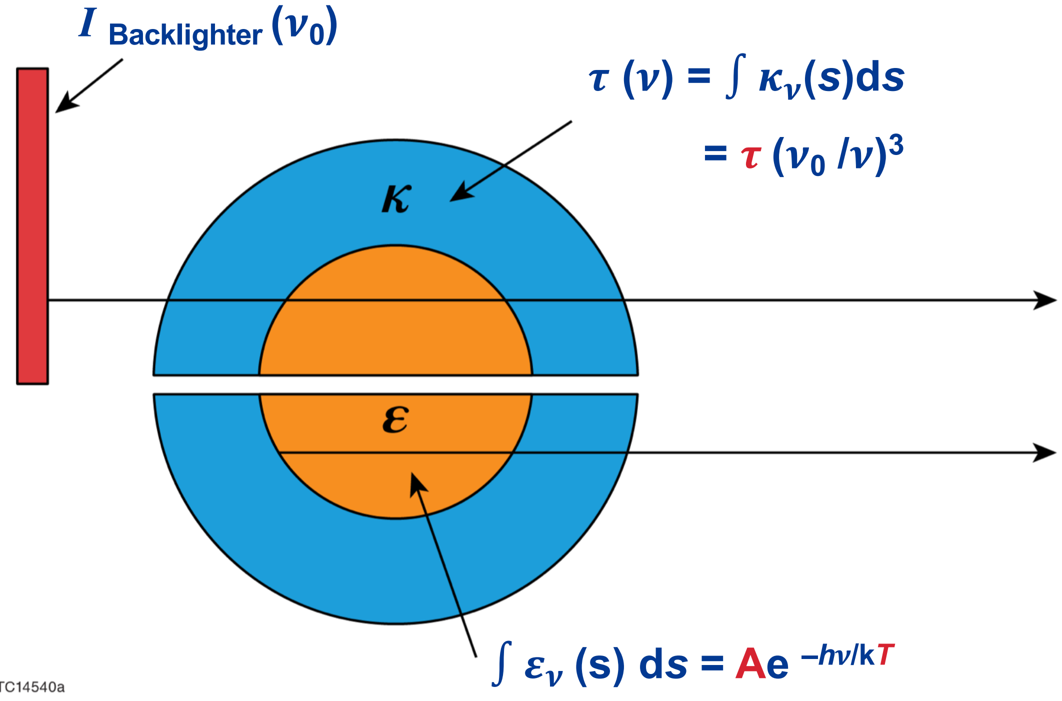
University of Rochester

Laboratory for Laser Energetics

D. Cliche and R. C. Mancini

University of Nevada, Reno

Core self-emission is the limiting background in externally backlit radiography, but in self-radiography, core self-emission is the backlighter



External monochromatic backlighting

Radiographic signal   Background

$$I(\nu) \cong I_{\text{backlighter}}(\nu_0)\, e^{-2\tau} + Ae^{-h\nu/kT} e^{-\tau(\nu_0/\nu)^3}$$

$$I(\nu) \cong Ae^{-h\nu/kT} e^{-\tau(\nu_0/\nu)^3}$$

Multi-monochromatic self-backlighting signal

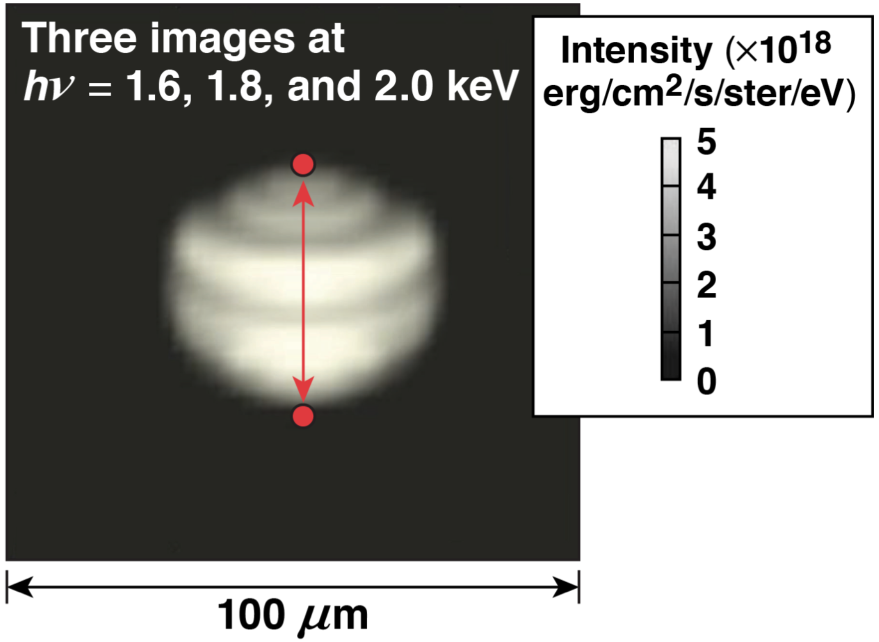
- Three intensities $I(\nu_1)$, $I(\nu_2)$, $I(\nu_3)$ determine the parameters A, T, and τ at each pixel
- T is a chord-averaged, emission-weighted harmonic mean of a highly variable temperature profile

We rely on the simple spectral form of continuum opacity and emissivity; no additives are needed.

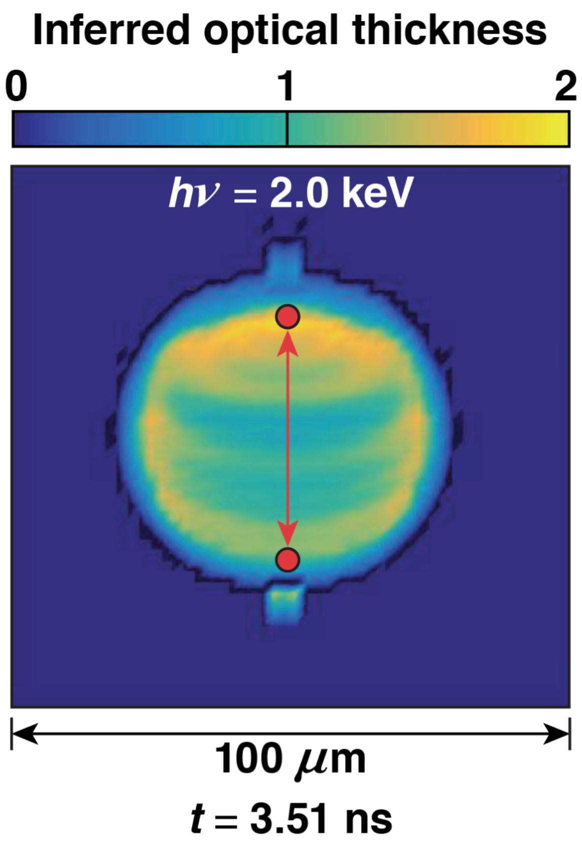
With multi-monochromatic images, the emission and absorption contributions to the total image can be separated

- An inhomogeneous core and shell test the simplicity of the three-parameter continuum model
- 2-D geometry tests the simplifying assumption that absorption follows emission

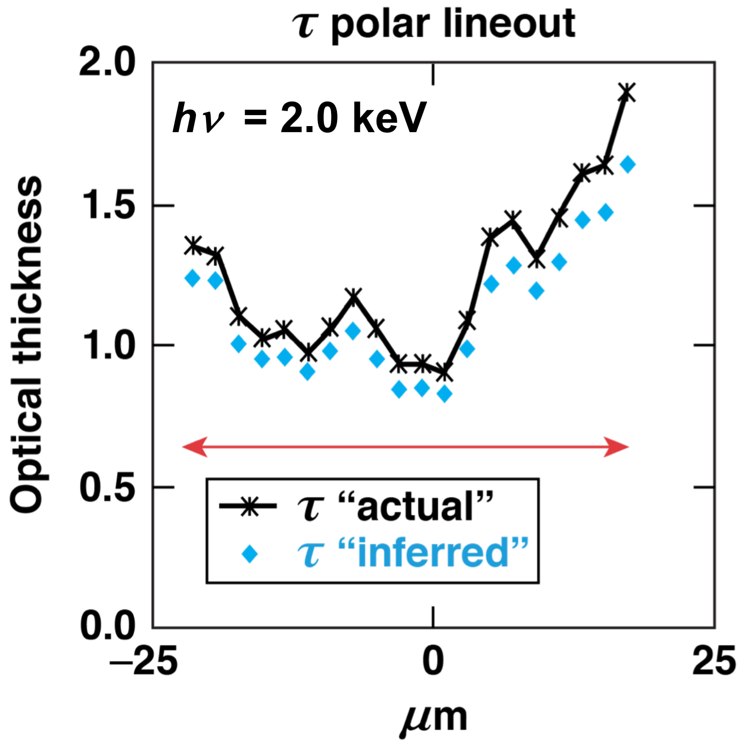
Shot 81590, *DRACO/Spect3D*,*
α = 2.5, IFAR = 10



TC14515a



TC14516a



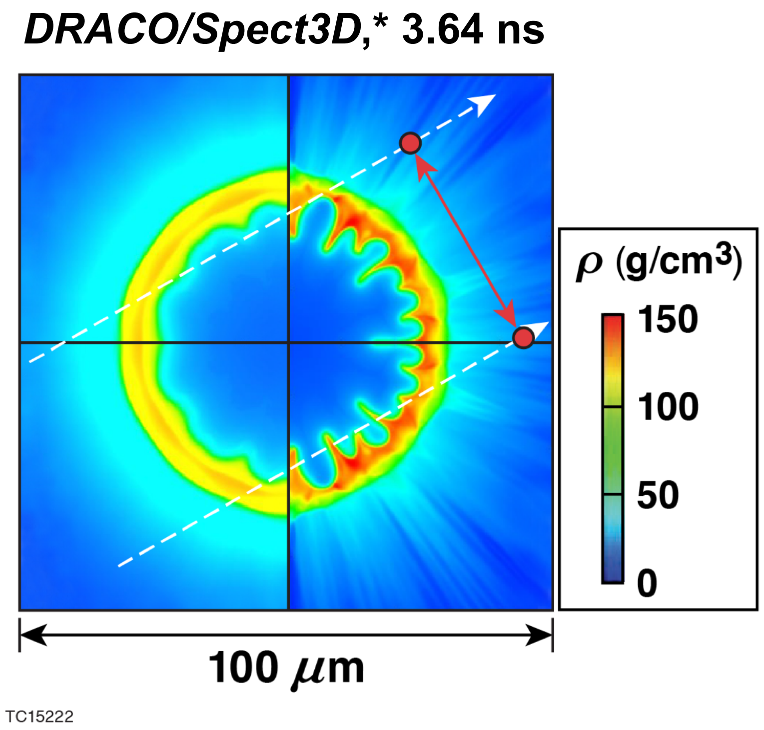
TC14599a

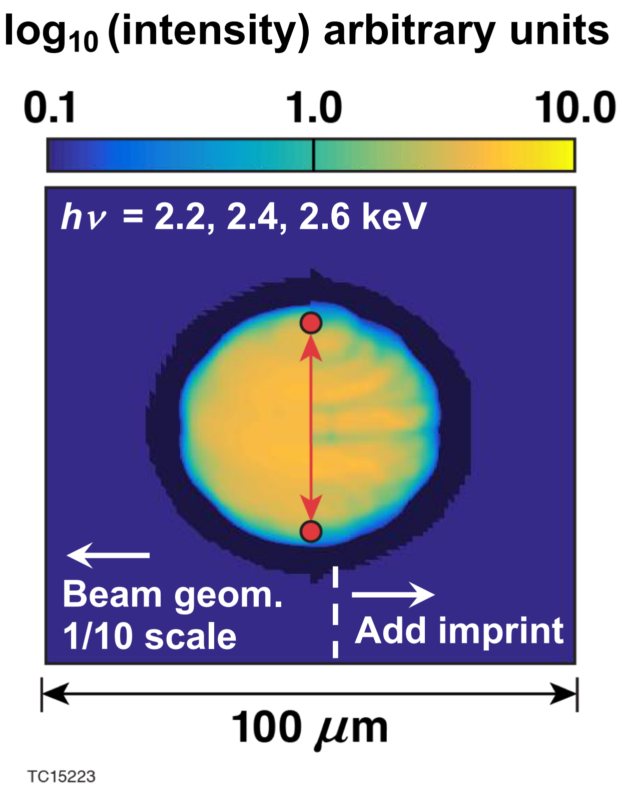
IFAR: in-flight aspect ratio

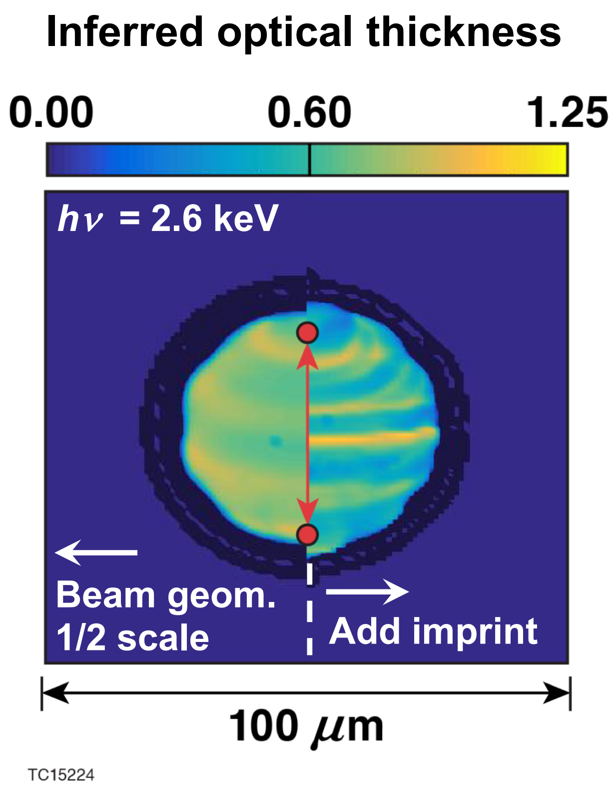
* Prism Computational Sciences, Inc., Madison, WI.

Simulated self-radiographs of a less-stable implosion indicate that features attributable to imprint will be visible

Shot 82717 is a less-stable (α = 1.9, IFAR = 14) version of shot 81590 (α = 2.5, IFAR = 10)



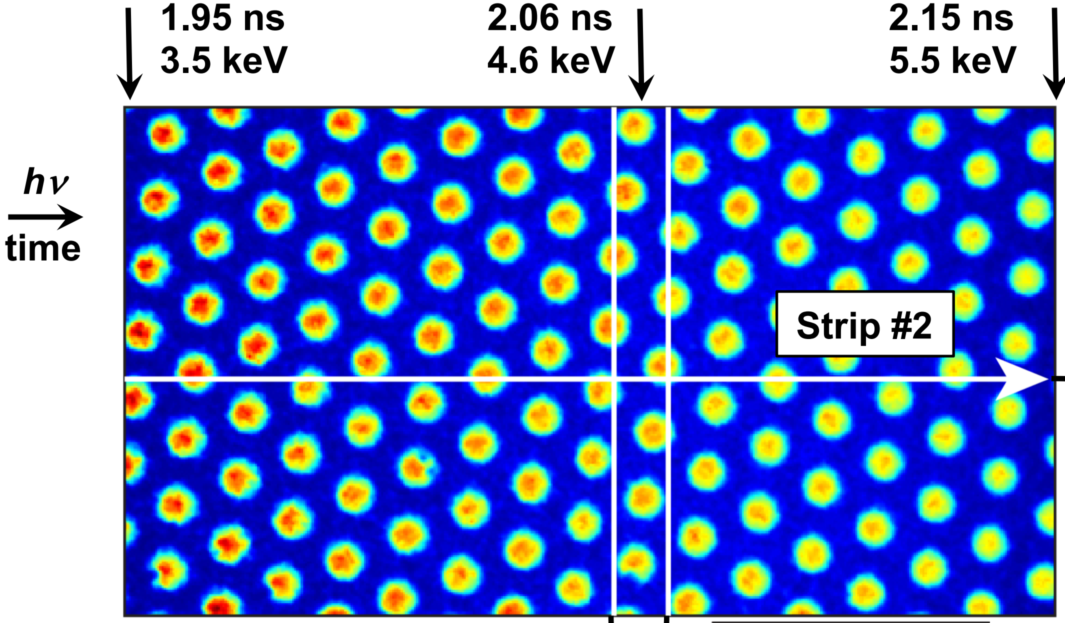




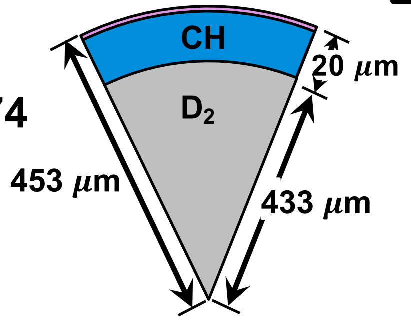
* Prism Computational Sciences, Inc., Madison, WI.

The timing of three MCP strips on the MMI* image plane provided three simultaneous monochromatic images of a warm CH shell implosion on OMEGA

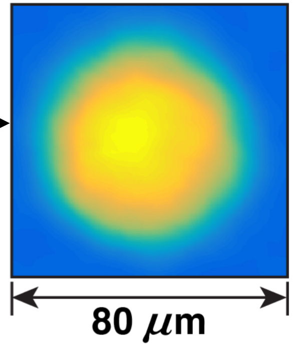
Pinhole image data from strip #2 of XRFC3 of the multi-monochromatic X-ray imager (MMI)



TC15225



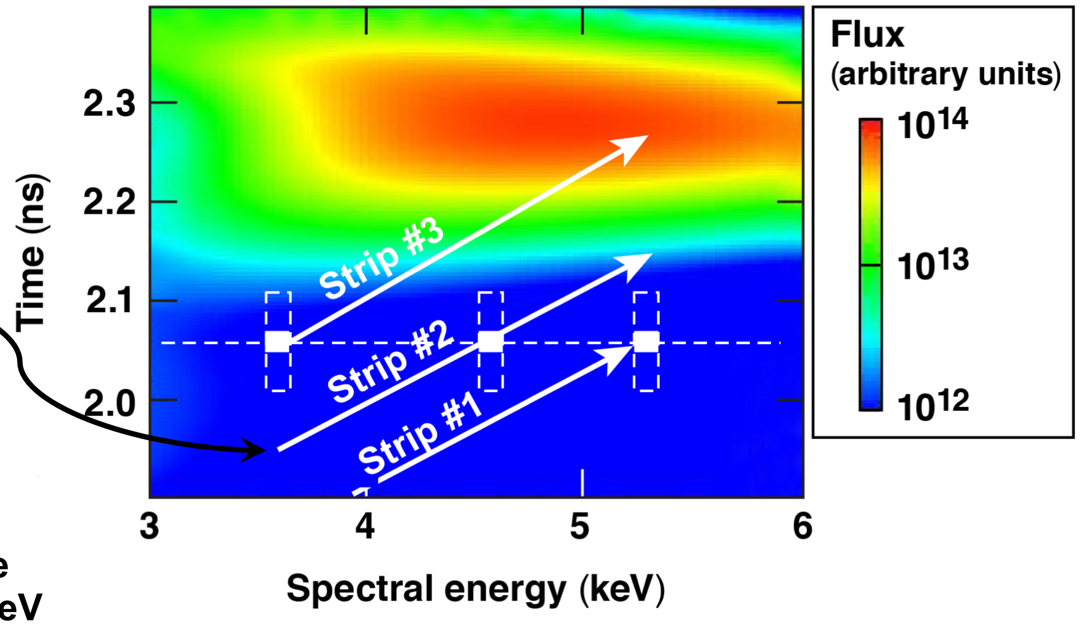
Shot 94374



Averaged image
$h\nu$ = 4.5 to 4.7 keV

TC15227a

Time-spectral location of the three simultaneous images

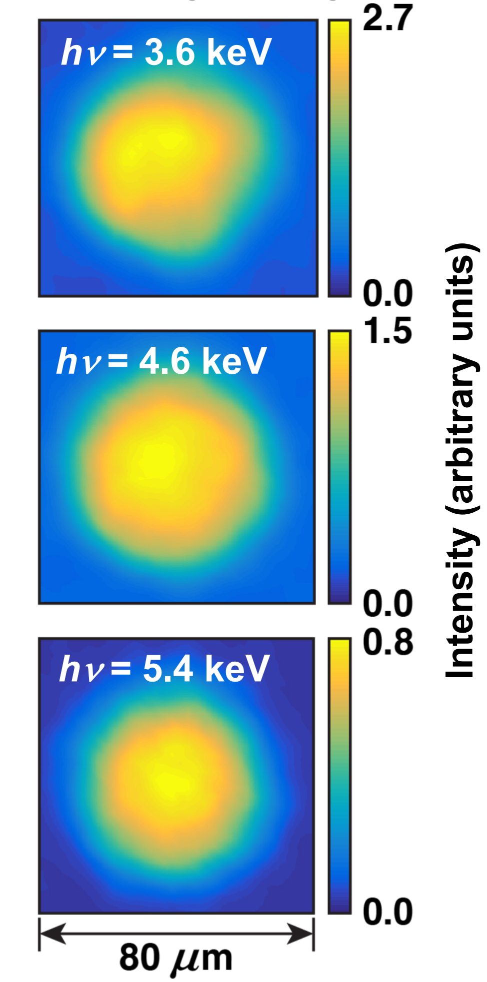


TC15226

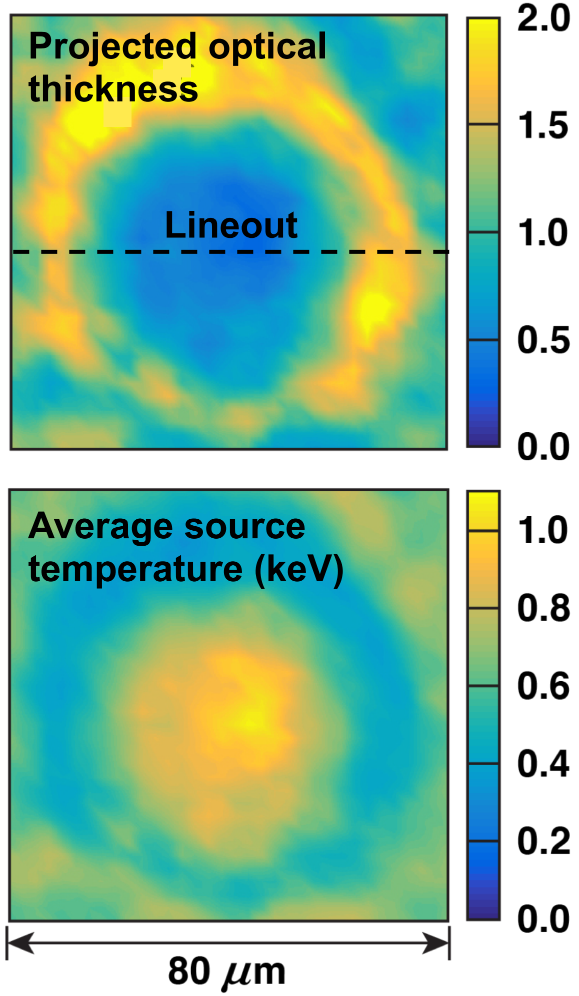
* H. Azechi *et al.*, Appl. Phys. Lett. 37, 998 (1980);
D. T. Cliche and R. C. Mancini, Appl. Opt. 58, 4753 (2019);
UO7:00006, this meeting
MCP: microchannel plate
XRFC: x-ray framing camera

Shot 94374 has been radiographed by space-resolved continuum spectroscopy using three simultaneous MMI images

MMI averaged images

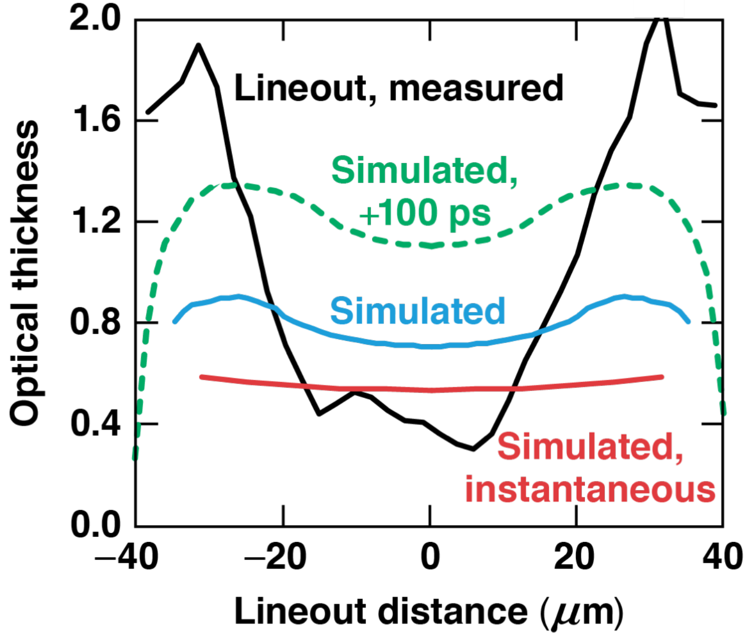


TC15227



TC15228

- Inferred central optical thickness is roughly consistent with *LILAC/Spect3D* simulation values
- Diagnostic development, implosion symmetry, etc., have yet to be fully explored
- Radiographic symmetry corroborates the symmetry of other images of this implosion earlier in time



TC15229

Imploded cold shell structure can be radiographed using spatially resolved continuum spectroscopy of hot core emission

UR LLE

- **Core self-emission is the backlighter in self-radiography, unlike externally backlit radiography, where self-emission is the limiting background**
- **Continuum self-radiography applies to pure cryo implosions without relying on the spectral K-edges or spectral lines of additives***
- **This radiography technique has been demonstrated using multi-monochromatic imaging (MMI) of a warm CH shell implosion on OMEGA**

* F. J. Marshall *et al.*, Phys. Rev. E 49, 4381 (1994).
V. A. Smalyuk *et al.*, Phys. Rev. Lett. 87, 155002 (2001).
L. A. Pickworth *et al.*, Phys. Rev. Lett. 117, 035001 (2016).