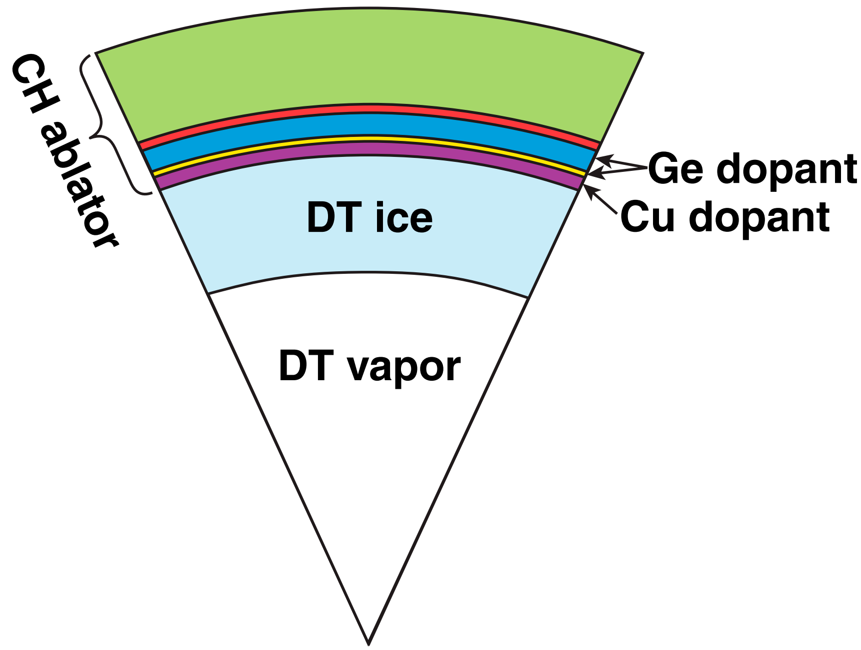
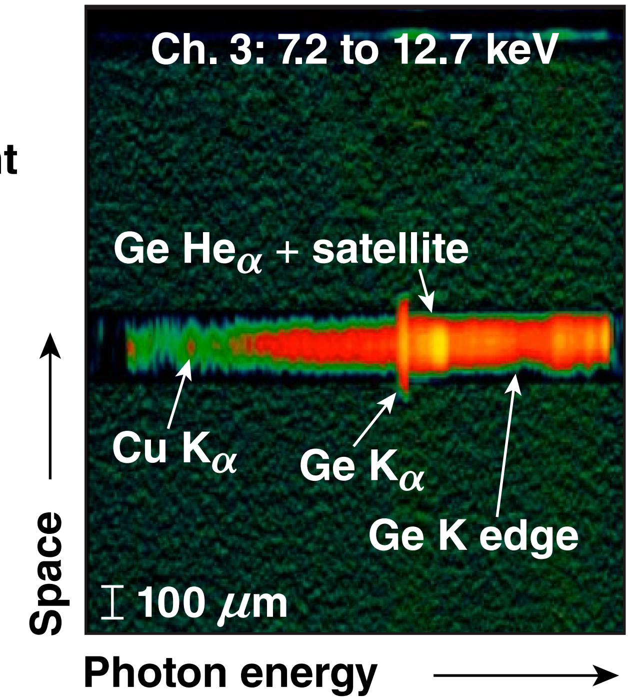
Hot-Spot Mix and Compressed Ablator ρR Measurements in Ignition-Scale Implosions

Tri-doped CH ablator (N120219)



1-D spectral image



S. P. Regan
University of Rochester
Laboratory for Laser Energetics

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Summary

Hot-spot mix and compressed ablator ρR are diagnosed with x-ray spectroscopy

- Cu and Ge dopants placed at different radial locations in the plastic ablator are used to study the origin of hot-spot mix[1] via He_{α} + satellite emission spectroscopy[2]
- Low neutron yields and hot-spot mix mass around the 75 ng limit[3] are observed
- A compressed ablator ρR of 0.35 to 0.5 g/cm^2 is inferred from Cu and Ge K-edge absorption

Shell material near the ablation surface comprises most of the hot-spot mix mass.

[1]B. A. Hammel *et al.*, High Energy Density Phys. 6, 171 (2010).
[2]S. P. Regan *et al.*, Phys Plasmas 19, 056307 (2012).
[3]S. W. Haan *et al.*, Phys Plasmas 18, 051001 (2011).

Collaborators

R. Epstein
University of Rochester
Laboratory for Laser Energetics

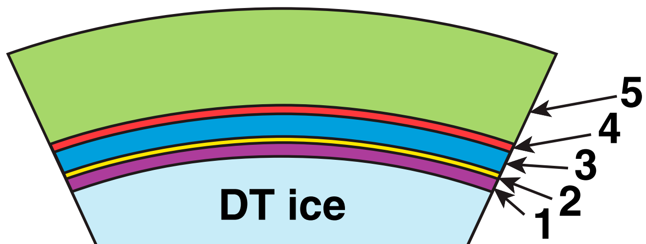
B. A. Hammel, L. J. Suter, J. E. Ralph, H. Scott, M. A. Barrios, D. K. Bradley, C. Cerjan, T. Doeppner, S. H. Glenzer, S. W. Haan, O. S. Jones, J. D. Kilkenny, J. L. Kline, O. L. Landen, H.-S. Park, B. A. Remington, V. A. Smalyuk, P. T. Springer
Lawrence Livermore National Laboratory

I. E. Golovkin J. J. MacFarlane
Prism Computational Sciences

R. C. Mancini
University of Nevada, Reno

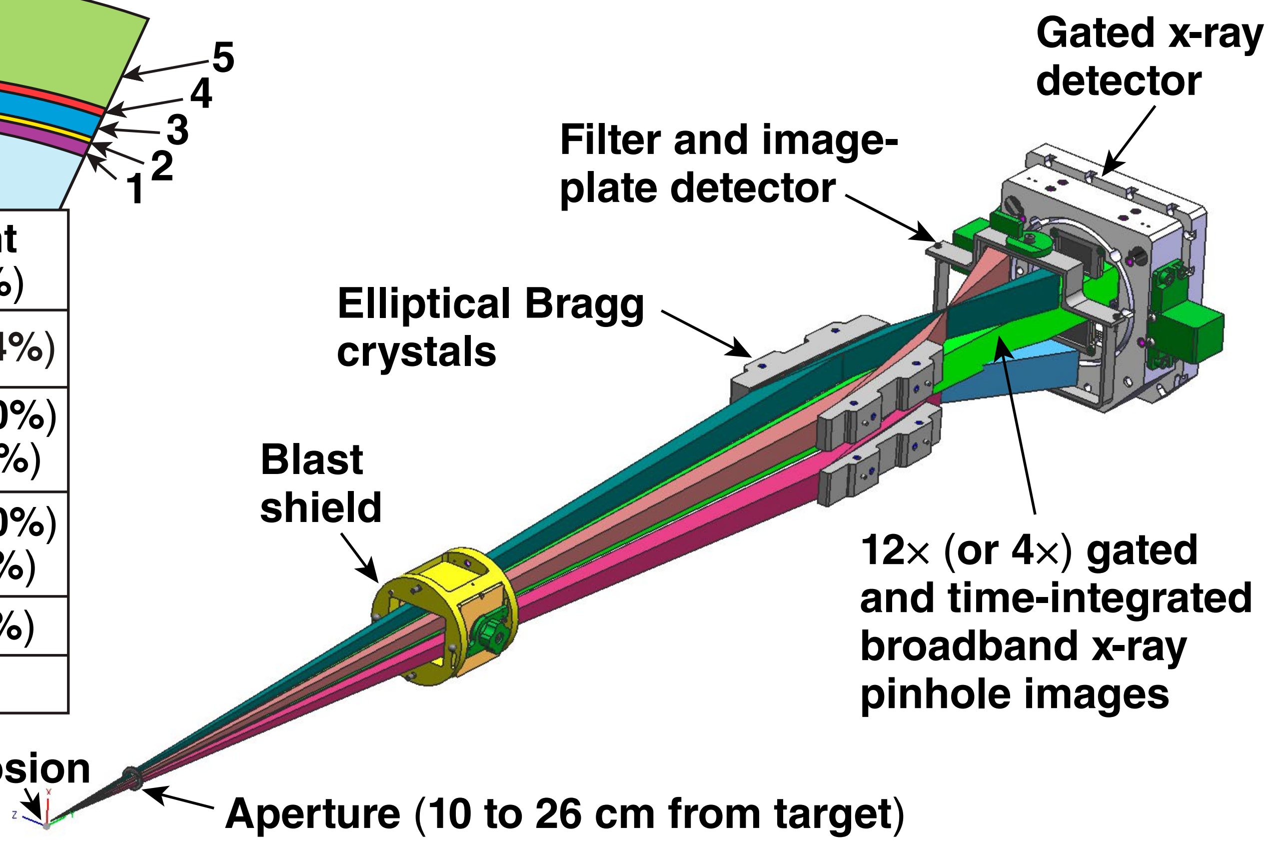
Cu and Ge dopants are placed at different radial locations in the plastic ablator to study the origin of hot-spot mix

Tri-doped CH ablator (N120219)



	Layer	Dopant (atm. %)
(Inner)	1	Cu (0.14%)
	2	Ge (0.20%) Si (0.87%)
	3	Ge (0.20%) Si (1.64%)
	4	Si (1.15%)
(Outer)	5	None

Supersnout II (5.75 to 16.5 keV)



The x-ray ablation front reaches the Ge-doped layer, but not the Cu-doped layer.

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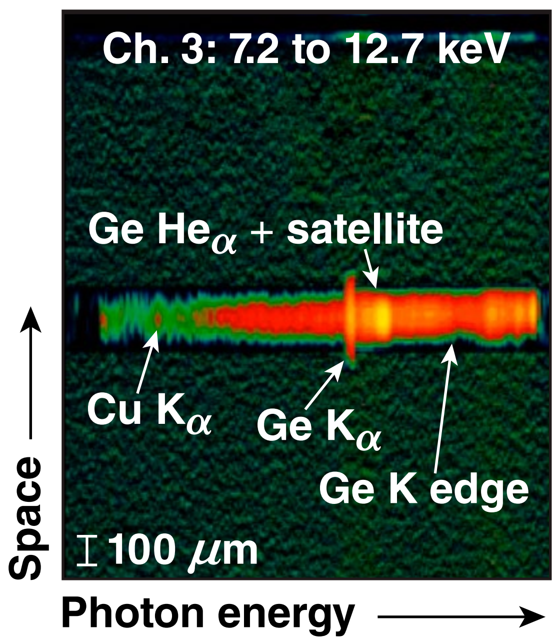
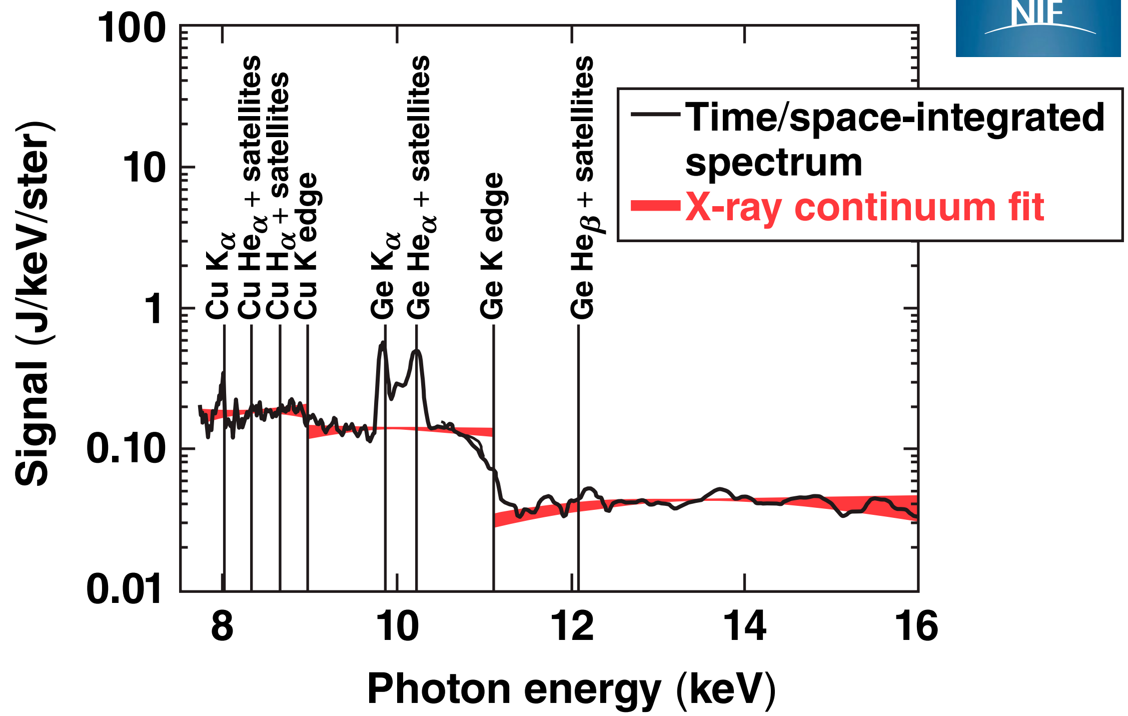
The measured spectrum has features from the shell (Cu, Ge K edge; Cu, Ge K_α) and the hot spot (Ge He_α + satellite emission)*

1-D spectral image





- The compressed ablator ρR is inferred from the K-edge absorption and the hot-spot mix mass is inferred from Cu, Ge He_α + satellite emission
- Cu, Ge K_α emission is from a compressed ablator photopumped by x-ray continuum from the hot spot

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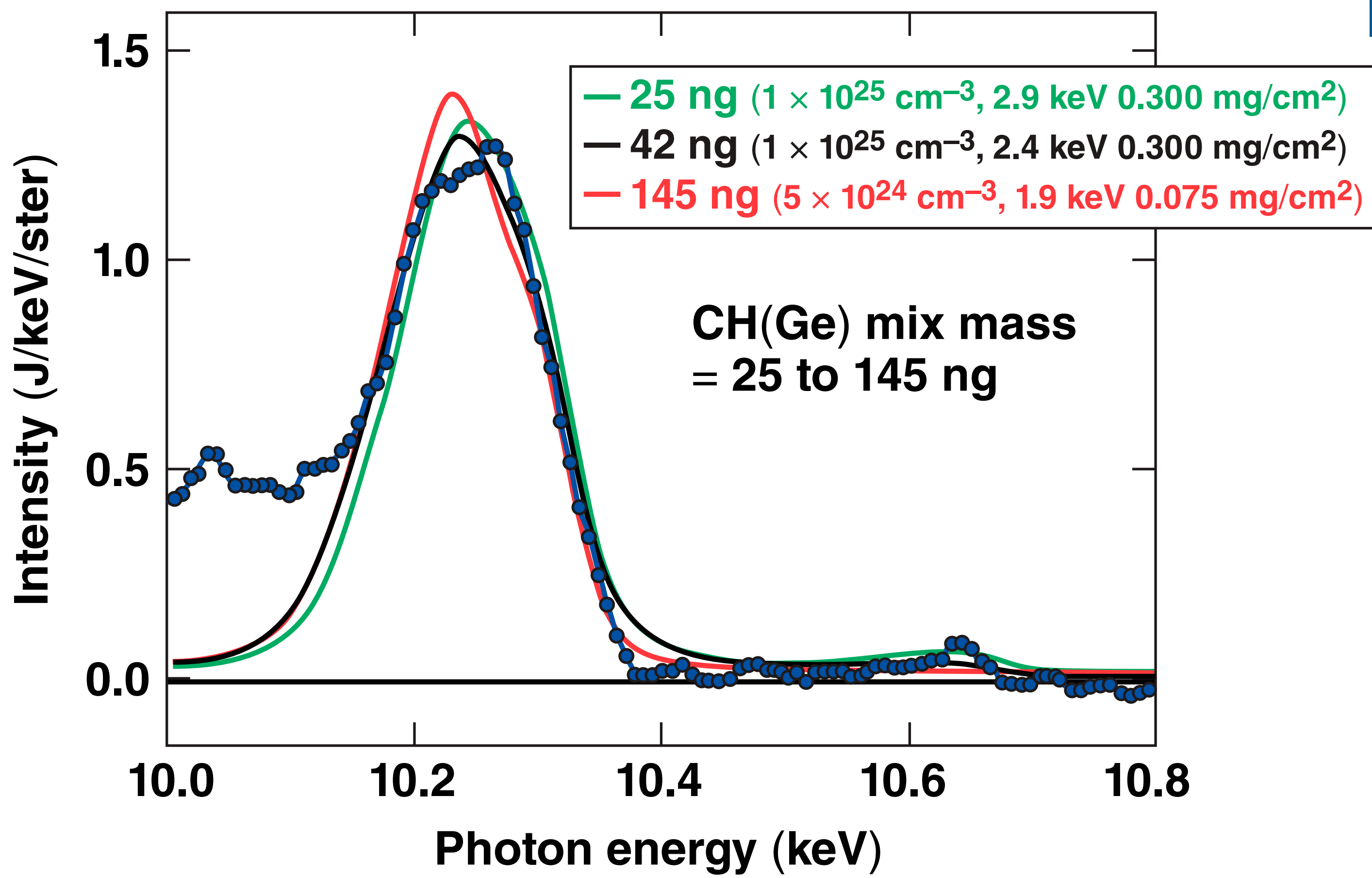
* Regan *et al.*, Phys. Plasmas 19 056307 (2012); R. Epstein, PO4.00008, this conference

Shell material near the ablation surface—CH(Ge)—comprises most of the hot-spot mix mass



A 15-ng upper limit of mix mass from the inner ablator is estimated from the Cu He_{α} + satellite emission.

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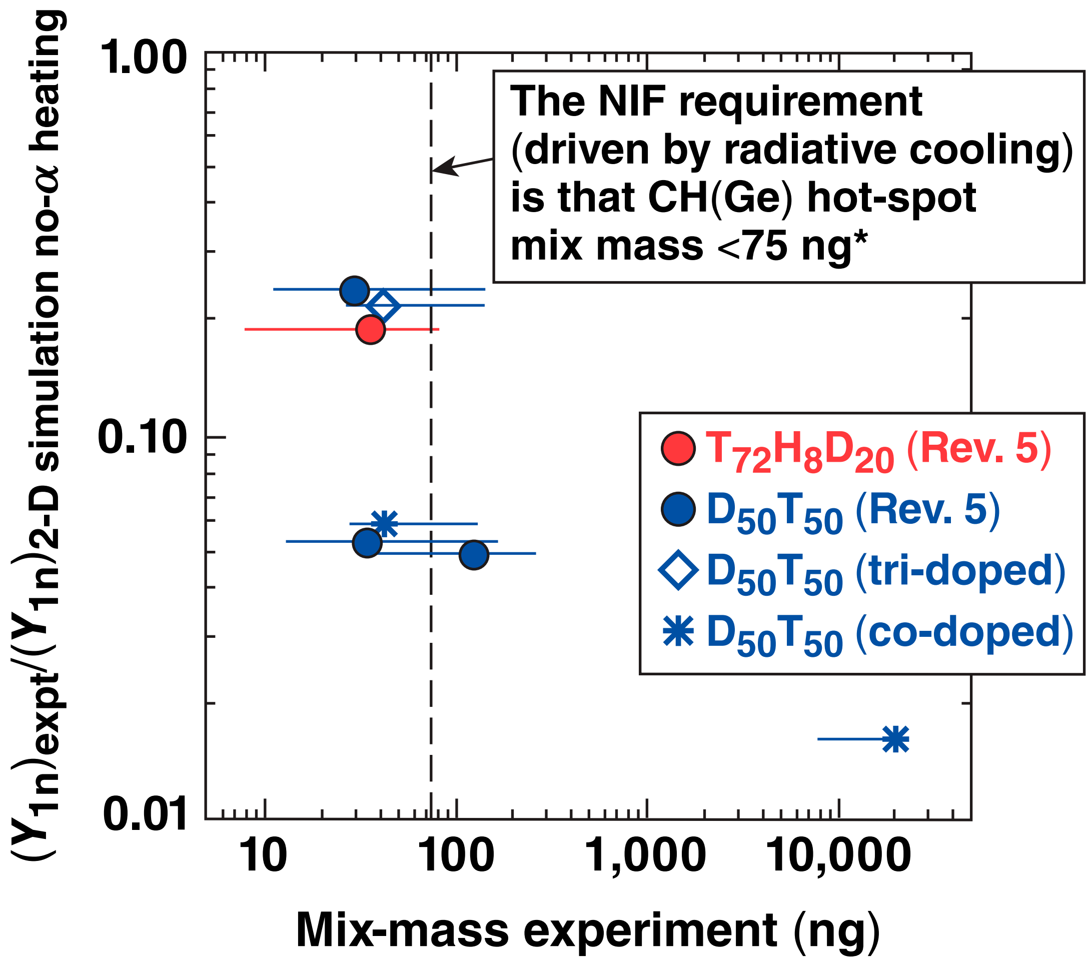
Low neutron yields and hot-spot mix mass around the 75-ng limit are observed



- **Hot-spot mix-mass analysis assumes 125-ps x-ray burnwidth**

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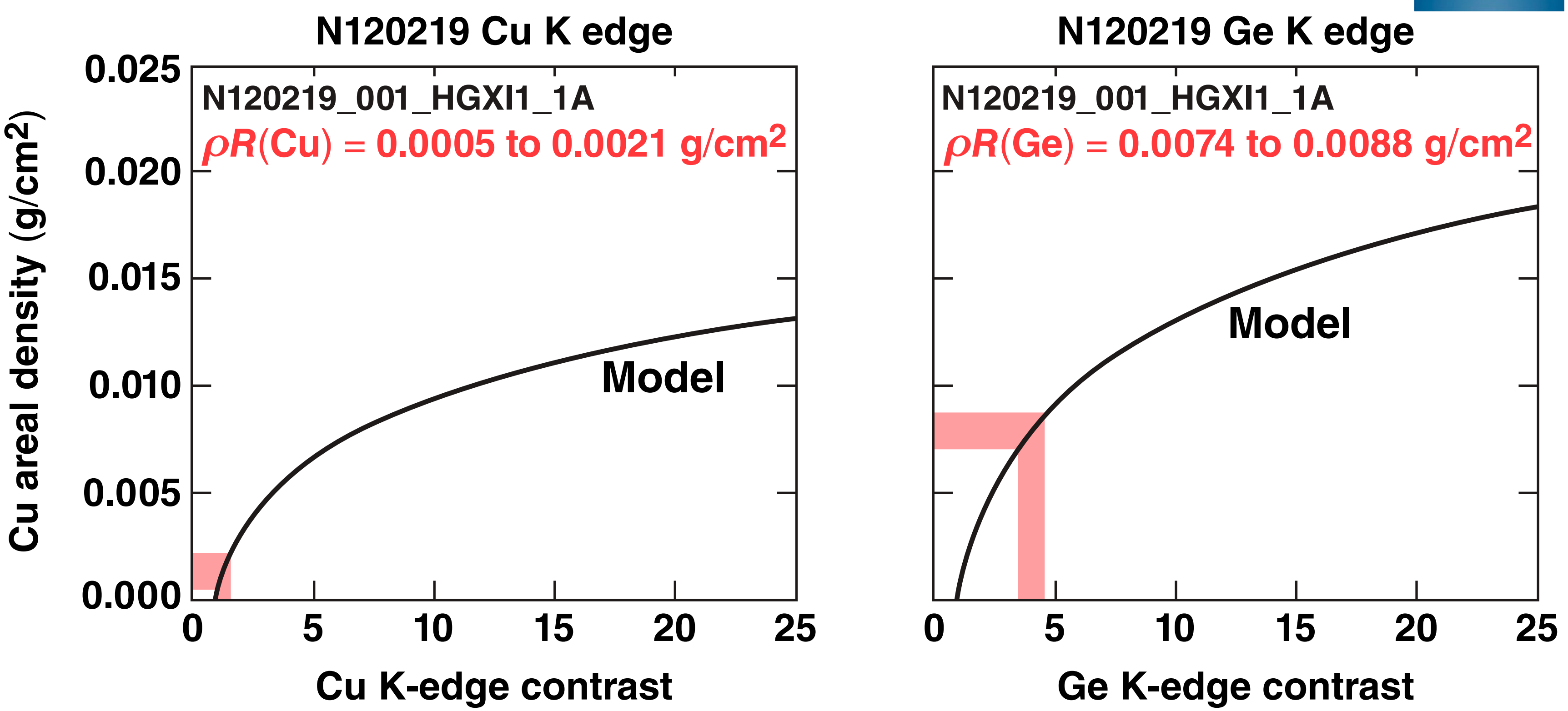
*S. W. Haan *et al.*, Phys. Plasmas 18, 051001 (2011).

The ablator ρR is estimated from Cu, Ge K edges for the tri-doped ablator



Cold opacities of Cu and Ge are used for estimate (i.e., for Cu the shell transmission is proportional to $\exp[-\rho R(\text{Cu})\ \mu_{\text{cold Cu}}]$).

ρR of compressed tri-doped ablator is 0.35 to 0.5 g/cm^2 for N120219 (C:H = 1:1.35)

- ρR(Cu) and ρR(Ge) are inferred from the measured drop of intensity at the K-edge
- Atomic fractions of elements in the ablator measured at General Atomics are used to infer ρR(CH) and ρR(Si)
- ρR(CH, Cu) = 0.035 to 0.139 g/cm^2
- ρR(CH, Ge, Si) = 0.306 to 0.374 g/cm^2
- Total ablator ρR = 0.35 to 0.5 g/cm^2
- Simulated ablator ρR = 0.68 g/cm^2 is comparable to experimental result

Summary/Conclusions

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The x-ray continuum is fitted with a model including the hot-spot x-ray emission and the compressed-shell attenuation

- **X-ray continuum from hot spot transmitted through the shell**

  $I(\nu) = I_0(\nu)\ \exp[-\tau]$

- **Hot-spot x-ray continuum emission**

  $I_0(\nu) = I_c\ \exp[-h\nu/kT]$

- **Optical thickness of the compressed shell**

  $\tau(h\nu < \text{Cu K edge}) = M_1/(h\nu)^3$

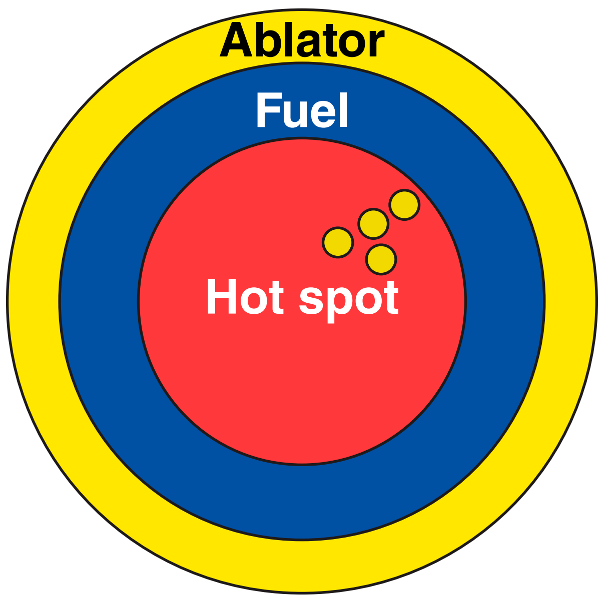
  $\tau(\text{Cu K edge} < h\nu < \text{Ge K edge}) = (M_1 + M_2)/(h\nu)^3$

  $\tau(h\nu > \text{Ge K edge}) = (M_1 + M_2 + M_3)/(h\nu)^3$

Fitting parameters for model

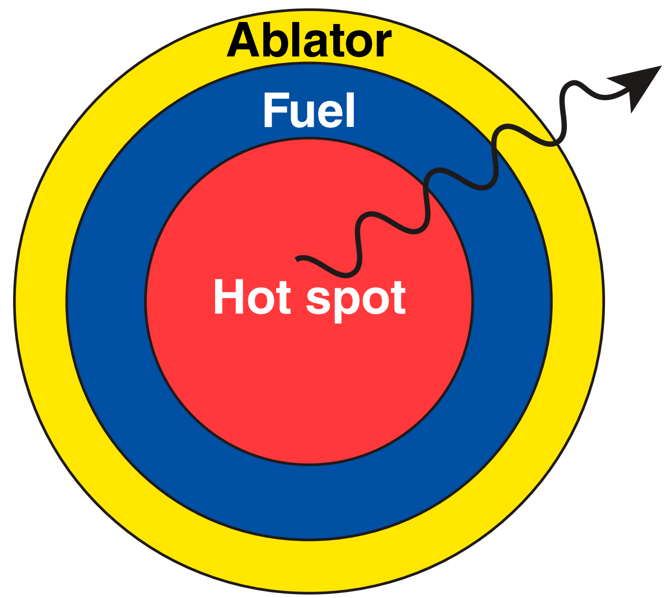
Hot-spot mix and compressed ablator ρR are diagnosed with x-ray spectroscopy around peak compression

Hot-spot mix
emission spectroscopy



High-Z–doped ablator material emits K-shell emission when mixed into the hot spot.

Ablator ρR
absorption spectroscopy



X-ray continuum from the hot spot is attenuated by the K edge of a high-Z dopant in the compressed ablator.

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