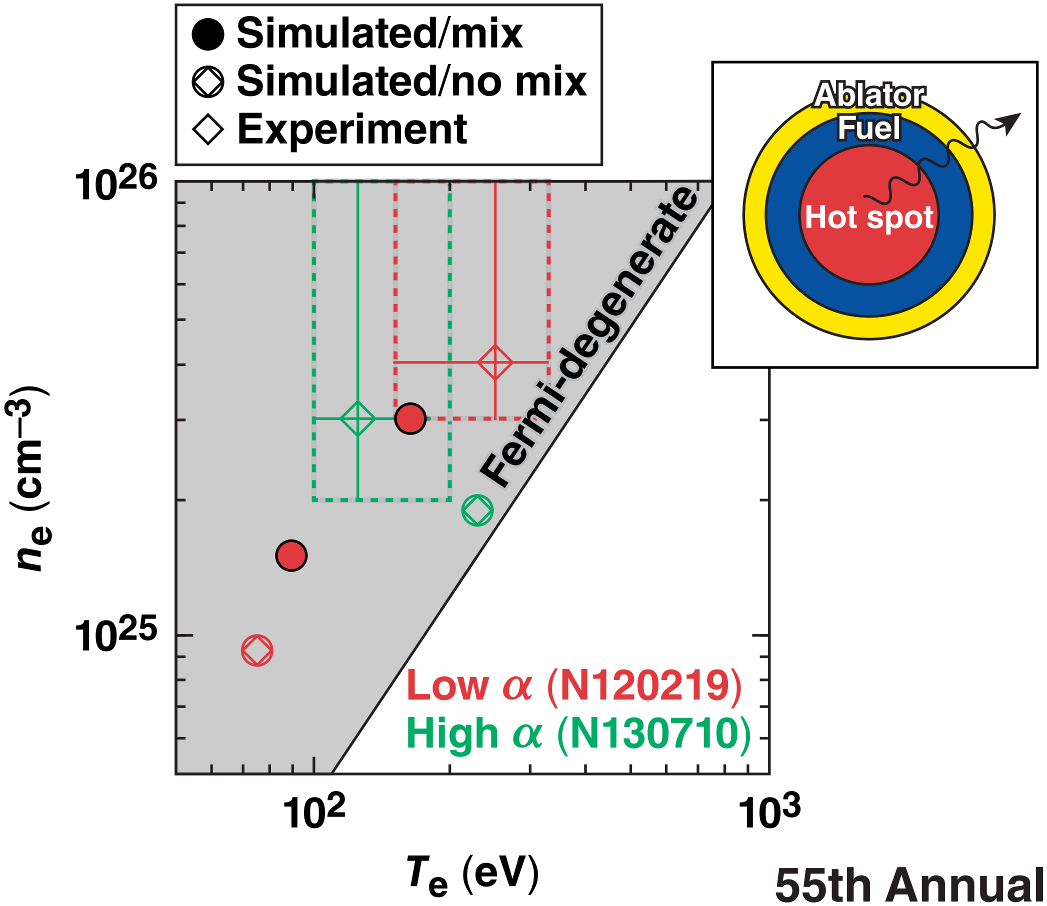
Plasma Conditions of the Compressed Ablator at Stagnation in NIF Implosions



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Summary

ρR, n_e, and T_e of the compressed, Ge-doped ablator are probed with x-ray continuum from the hot spot

- The measured Ge K edge, 1*s*–2*p* and 1*s*–3*p* absorption features are analyzed to infer the compressed ablator conditions around stagnation
- The Ge opacity is calculated using the *VISTA** code
- Low- and high-adiabat ($\alpha \equiv P_{fuel}/P_{Fermi}$) indirect-drive implosions are explored at the National Ignition Facility (NIF)

Hydrodynamic mixing of the ablator and fuel layers increases the inferred T_e and n_e of the compressed ablator.

*B. G. Wilson and M. H. Chen, J. Quant. Spectrosc. Radiat. Transf. 61, 813 (1999).

Collaborators

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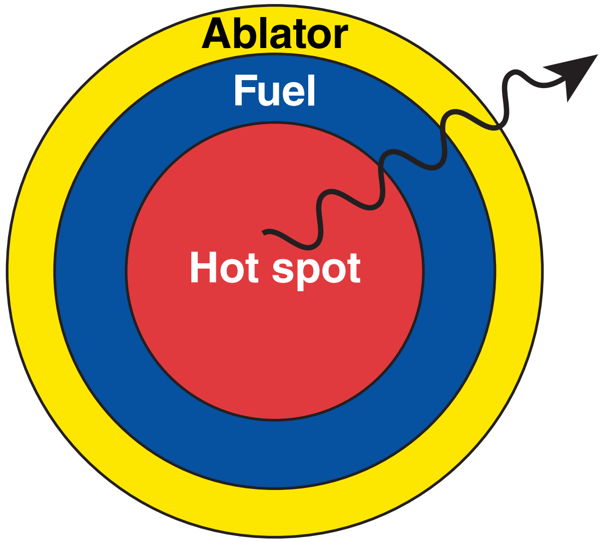
High-Z dopants are used to diagnose the compressed ablator near stagnation

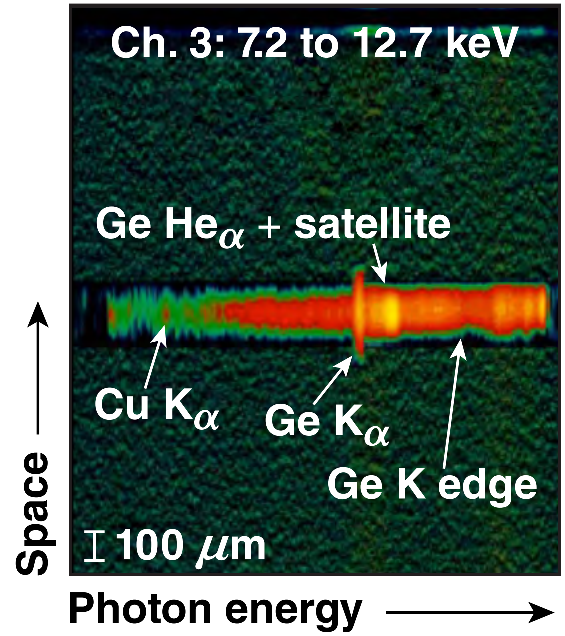
Compressed target at stagnation

Measured x-ray spectrum around stagnation

Ablator: CH with high-*Z* dopant (Cu, Ge)



1-D spectral image



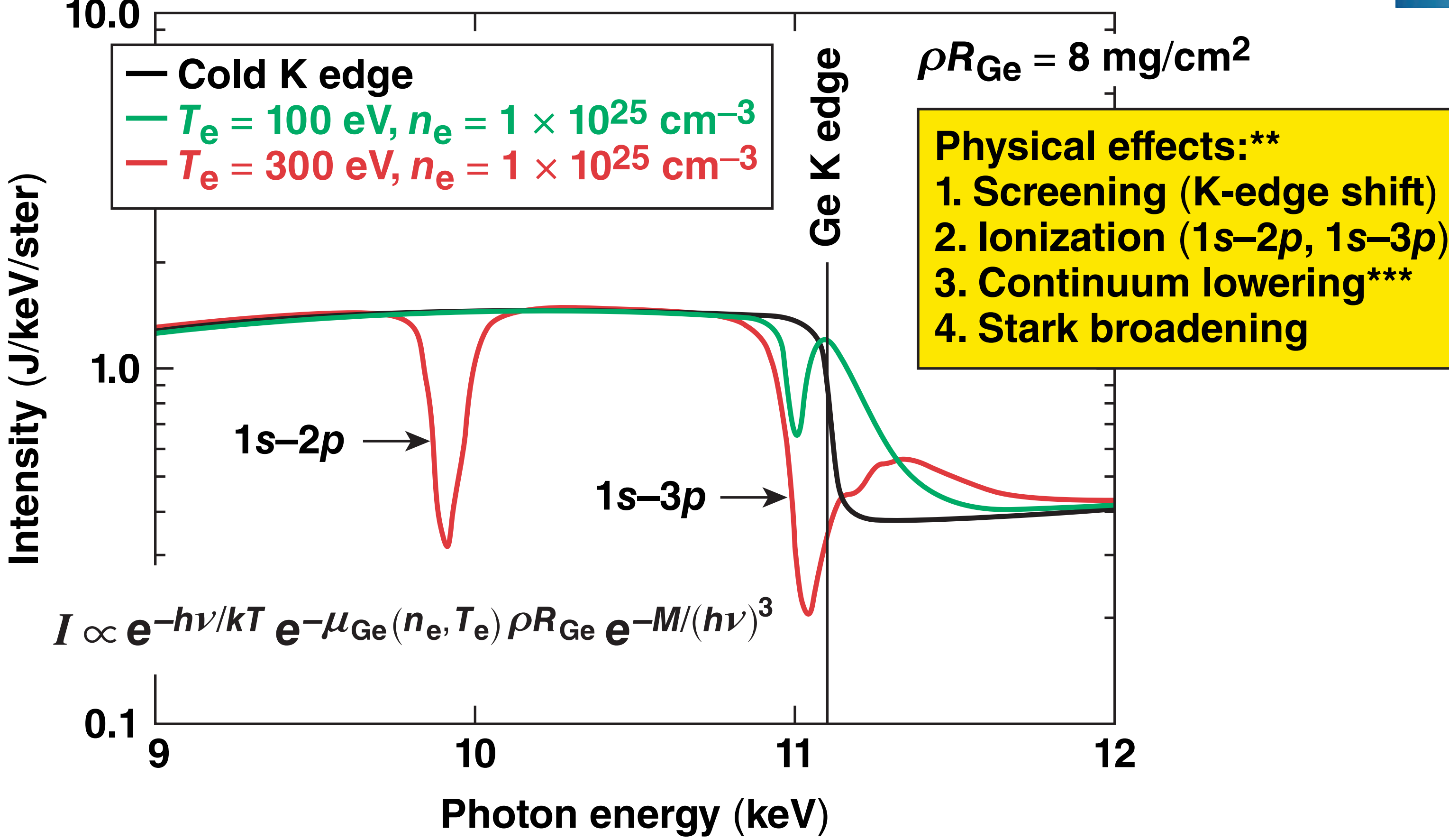
$$I \propto e^{-h\nu/kT}\, e^{-\mu_{Ge}(n_e,T_e)\,\rho R_{Ge}}\, e^{-\mu_{Cu}\,\rho R_{Cu}}\, e^{-\mu_{CH}\,\rho R_{CH}}$$

Hot-spot backlighter	Ge shell attenuation	Cu shell attenuation	CH shell attenuation

Adiabat: $\alpha \equiv P_{fuel}/P_{Fermi}$ (set by laser pulse shape)

The Ge opacity is sensitive to changes in n_e and T_e of the compressed ablator

Simulated emergent spectrum using *VISTA** opacity calculations



*B. G. Wilson and M. H. Chen, J. Quant. Spectrosc. Radiat. Transf. 61, 813 (1999).
**D. K. Bradley *et al.*, Phys. Rev. Lett. 59, 2995 (1987).
***J. C. Stewart and K. D. Pyatt, Jr., Astrophys. J. 144, 1203 (1966).

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Continuum lowering* reduces the 1*s*–3*p* and 1*s*–2*p* absorption features

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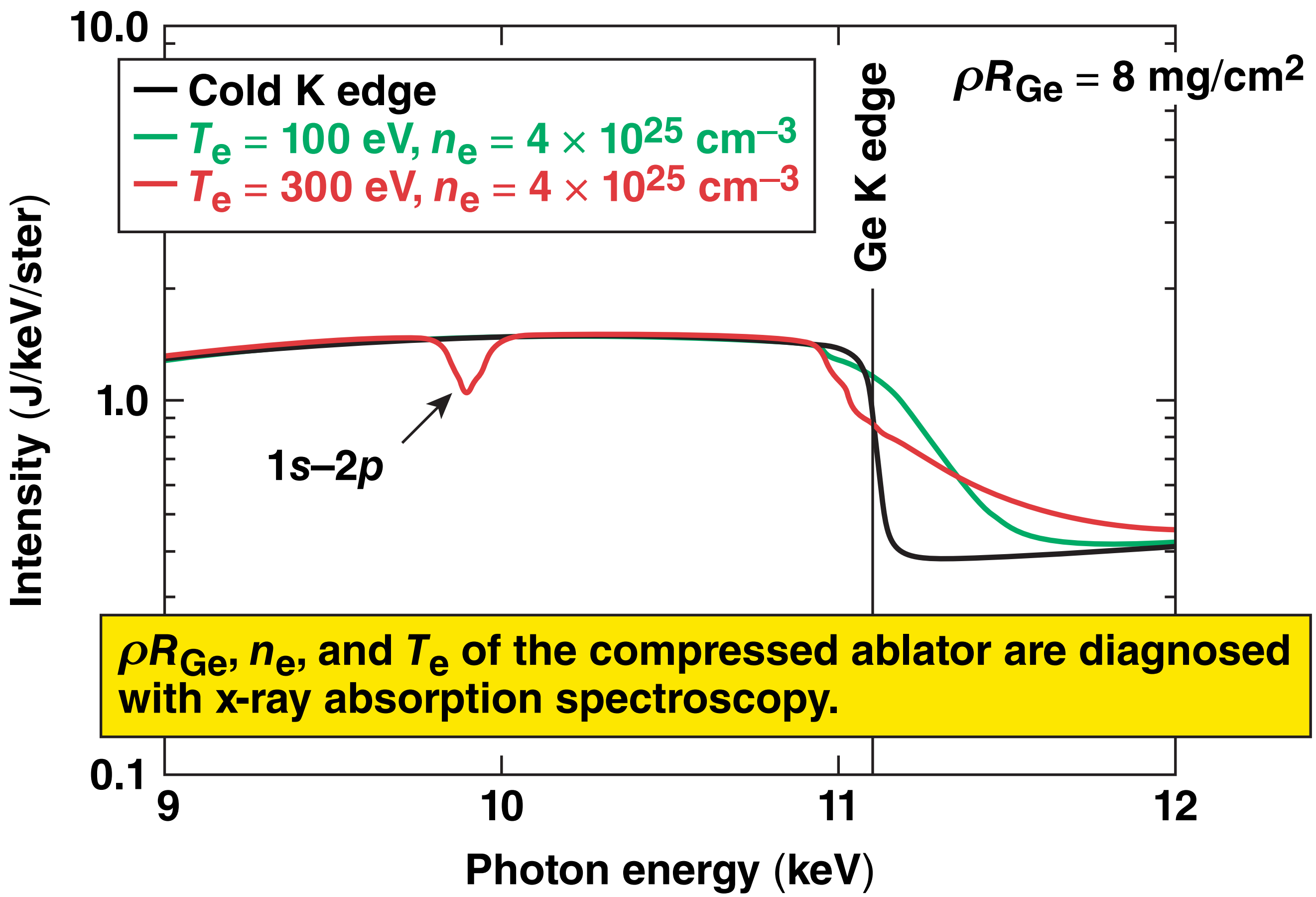
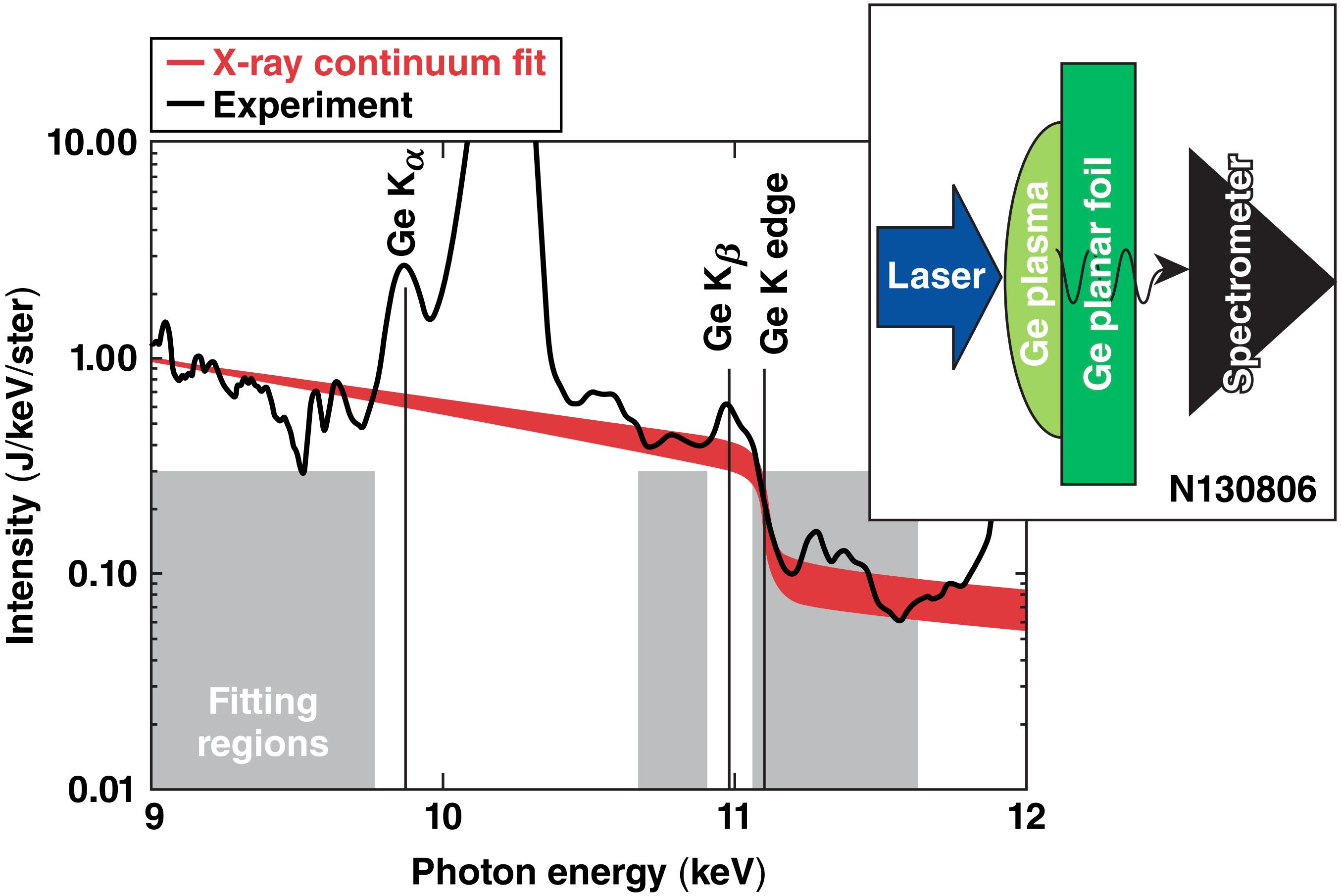
Simulated emergent spectrum using *VISTA*** opacity calculations



ρR_{Ge}, n_e, and T_e of the compressed ablator are diagnosed with x-ray absorption spectroscopy.

*J. C. Stewart and K. D. Pyatt, Jr., Astrophys. J. 144, 1203 (1966).
**B. G. Wilson and M. H. Chen, J. Quant. Spectrosc. Radiat. Transf. 61, 813 (1999).

The cold Ge K edge was measured using a laser-driven, planar Ge target



ρR_{Ge} = 8.3 (–2.8, +0.1) mg/cm^2 is inferred from this calibration shot using the cold opacity.*

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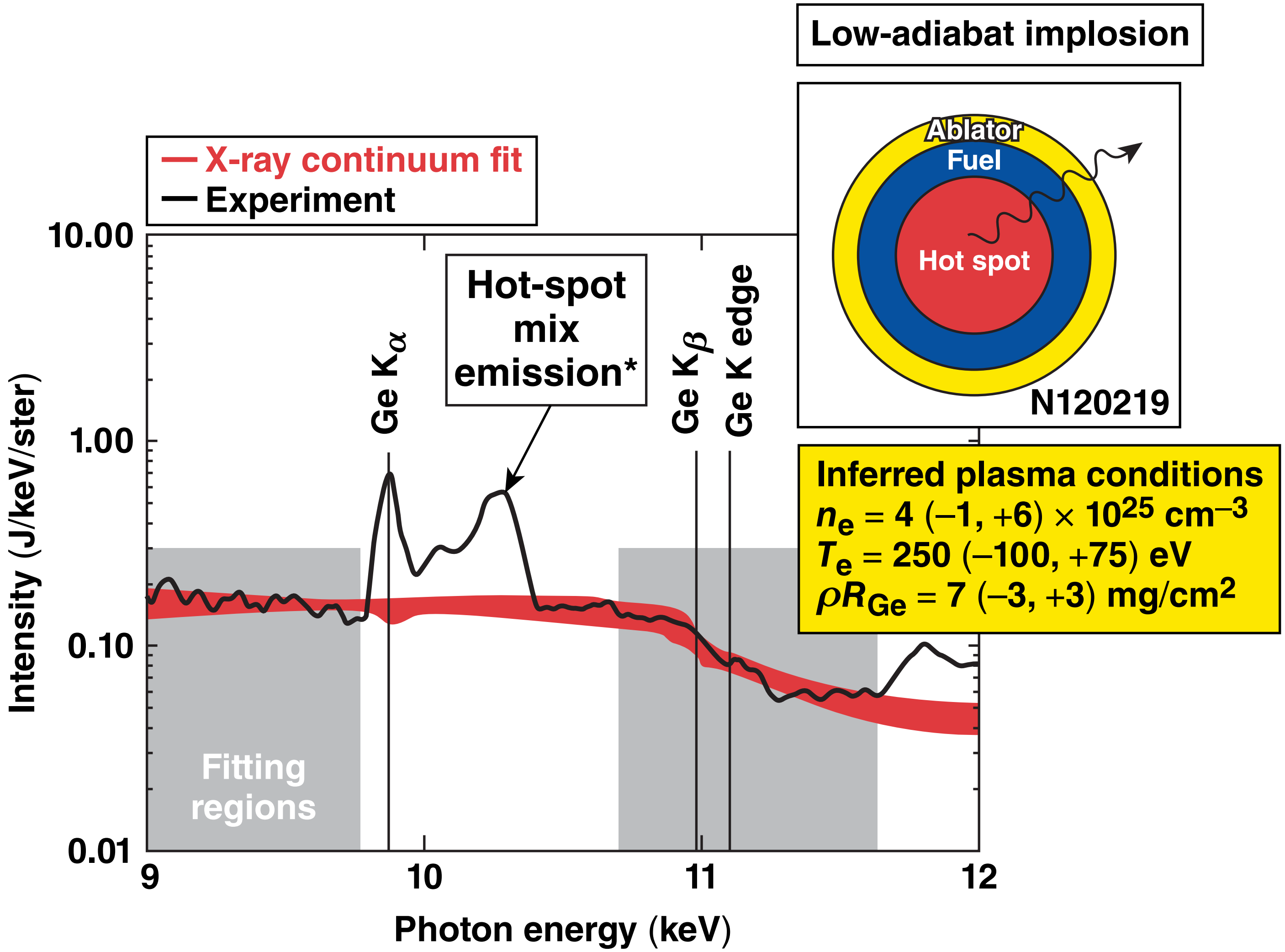
*http://henke.lbl.gov/optical_constants/filter2.html.

A range of compressed plasma conditions is inferred for the low-adiabat implosion

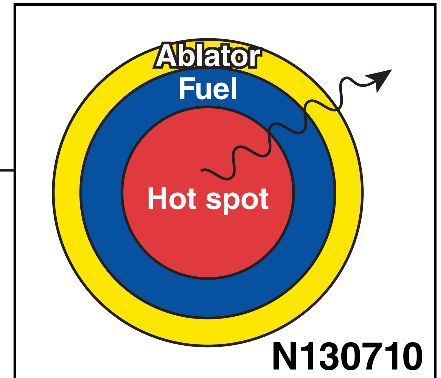


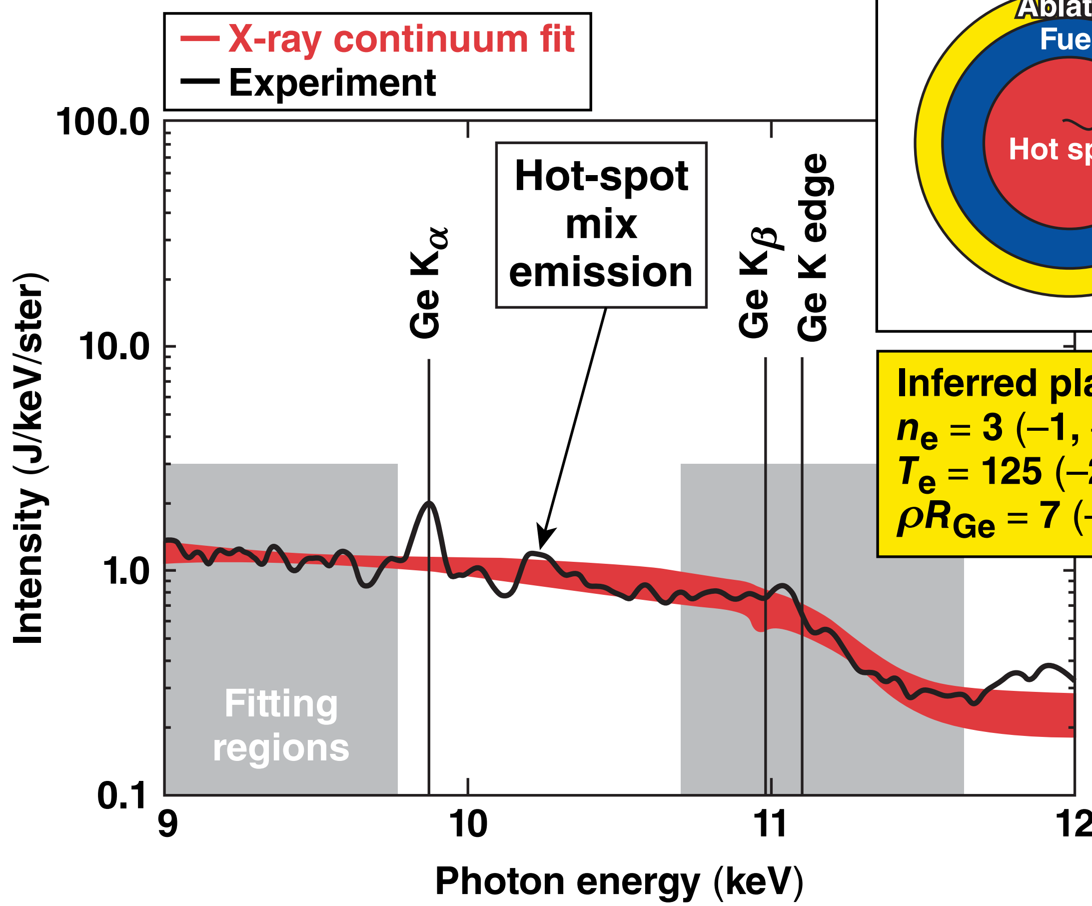
Inferred plasma conditions
n_e = 4 (–1, +6) × 10^{25} cm^{-3}
T_e = 250 (–100, +75) eV
ρR_{Ge} = 7 (–3, +3) mg/cm^2

*S. P. Regan *et al.*, Phys. Rev. Lett. 111, 045001 (2013).

Similar analysis was performed for the high-adiabat implosion

High-adiabat implosion





Inferred plasma conditions

n_e = 3 (–1, +7) × 10^{25} cm^{-3}

T_e = 125 (–25, +75) eV

ρR_{Ge} = 7 (–2.5, +2) mg/cm^2

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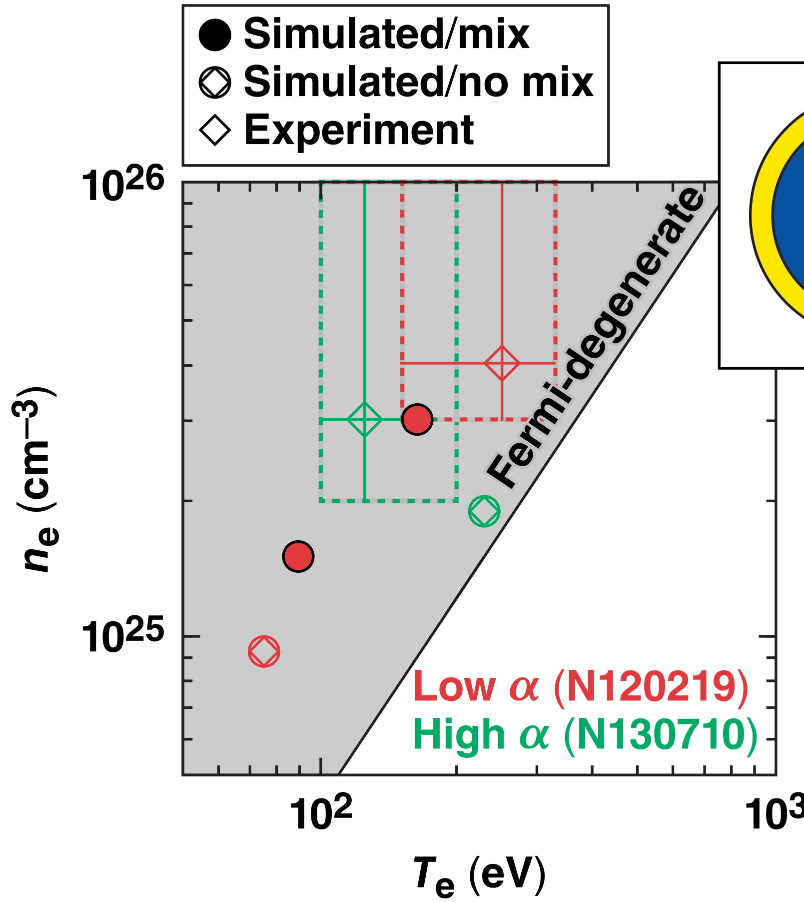
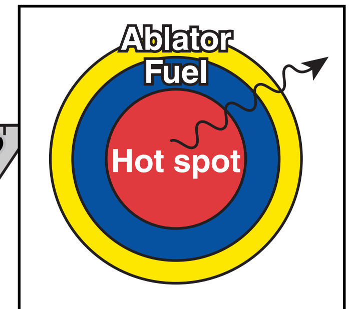
The simulated plasma conditions are closer to the inferred ones for the high-adiabat implosion

Mass-averaged, time-integrated, simulated plasma conditions are calculated using 2-D *HYDRA*

Compressed ablator and fuel

Low α	High α
CH (Ge doped)	CH (Ge doped)
CH (Ge doped)	CH (Ge doped)
CH (Cu doped)	CH (Ge doped)
DT ice	DT ice





Hydrodynamic mixing of the ablator and fuel layers increases the inferred T_e and n_e, indicating there is more mix for the low-adiabat implosion.

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Summary/Conclusions

ρR, n_e, and T_e of the compressed, Ge-doped ablator are probed with x-ray continuum from the hot spot

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- The measured Ge K edge, 1*s*–2*p* and 1*s*–3*p* absorption features are analyzed to infer the compressed ablator conditions around stagnation
- The Ge opacity is calculated using the *VISTA** code
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Hydrodynamic mixing of the ablator and fuel layers increases the inferred T_e and n_e of the compressed ablator.

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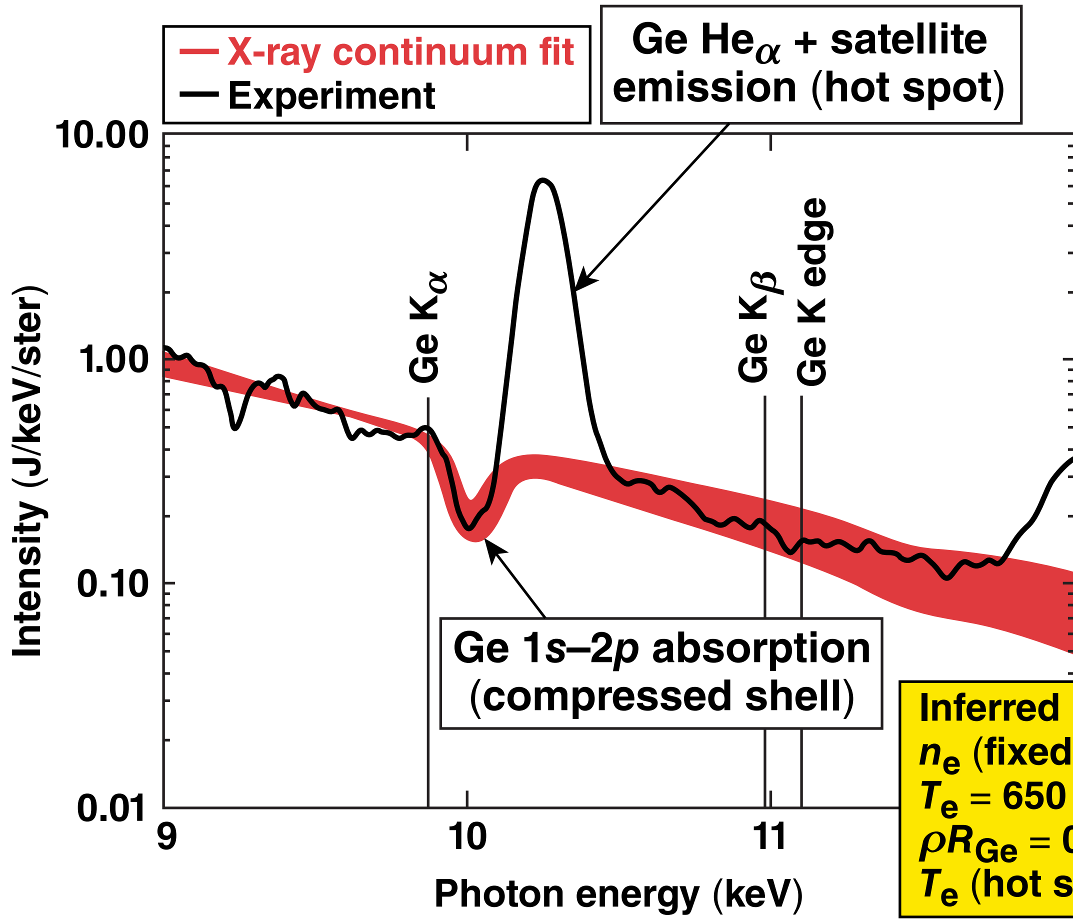
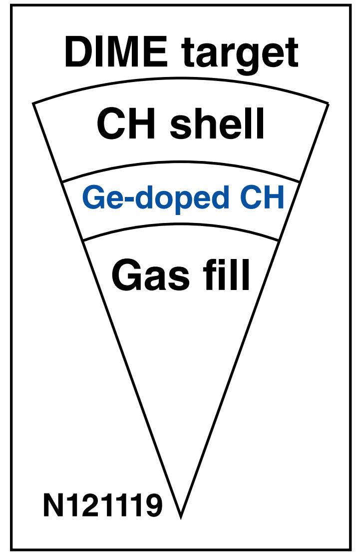
* B. G. Wilson and M. H. Chen, J. Quant. Spectrosc. Radiat. Transf. 61, 813 (1999).

The Ge 1s–2p absorption becomes dominant as T_e of the compressed ablator increases





Inferred plasma conditions
n_e (fixed) = 1 × 10^{25} cm^{-3}
T_e = 650 (–50, +50) eV
ρR_{Ge} = 0.6 (–0.1, +0.2) mg/cm^2
T_e (hot spot) = 1.25 (±0.25) eV

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