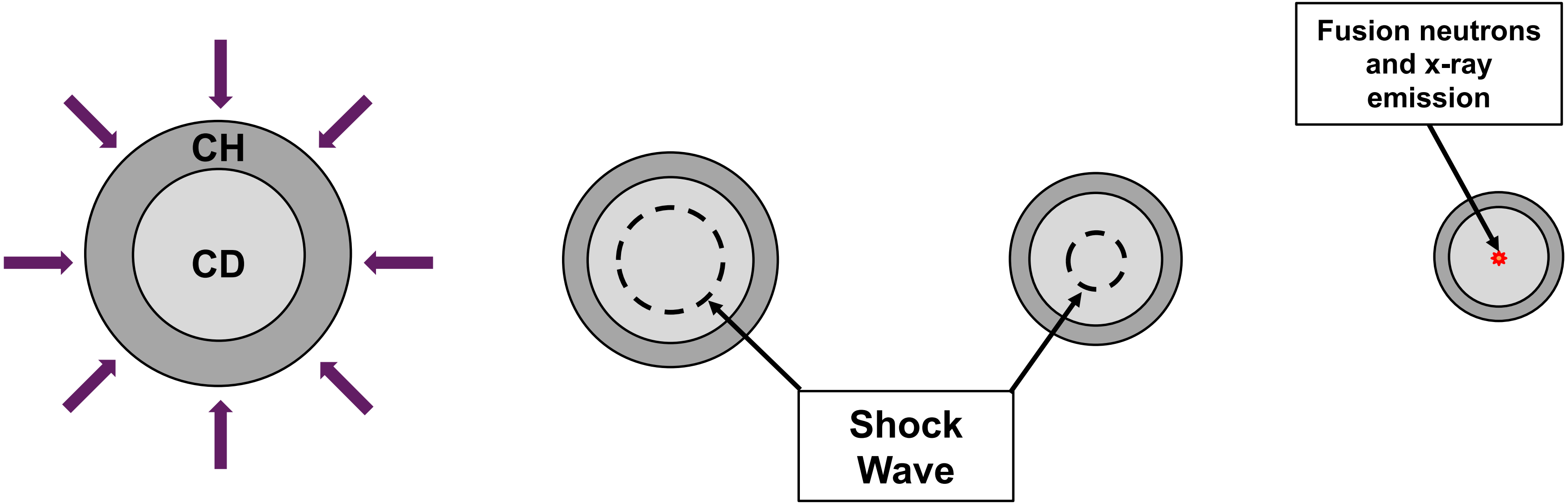
# Measurement of Plasma Conditions at Shock Collapse on OMEGA

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60th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Portland, OR
5-9 November 2018

Summary

# Plasma conditions generated by a collapsing radiative shock in spherical geometry have been measured via self-emission on OMEGA

- Constraint of electron temperature and density at the time of shock collapse is dependent on temporally and spatially measuring the x-ray self-emission.
- The hydrodynamics simulation code *Lilac* is used to inform x-ray observations and the conditions where x-rays are generated.
- Spectral content of x-ray emission is used to measure temperature at the time of shock collapse.
- An average ionization of a carbon-deuterium plasma at .89 keV is measured to be 2.4.

# Collaborators


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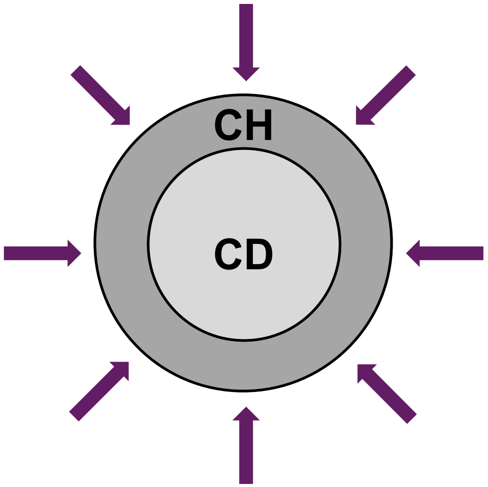
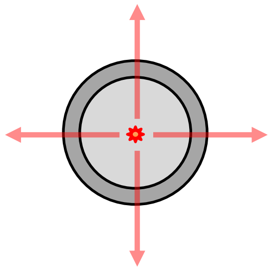
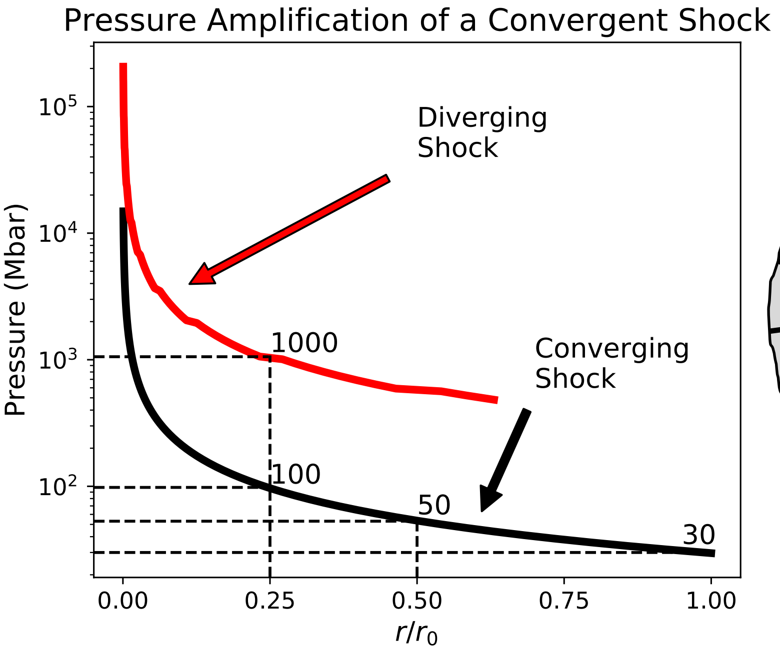
# The OMEGA laser is used to drive a single spherically symmetric shock wave in a solid plastic ball at an initial pressure of about 30 Mbar

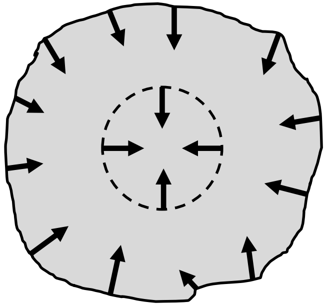
- **Laser-drive configuration:**
  - 2-ns square pulse
  - 21-kJ total energy
  - 60-beam symmetric drive
- **Primary diagnostics:**
  - X-ray framing camera
  - Filtered x-ray pinhole array
  - Neutron counting diagnostics
- **Target parameters:**
  - Central sphere of deuterated plastic (CD) with ~ 270 micron radius
  - Outer shell of plastic (CH) with ~170 micron thickness

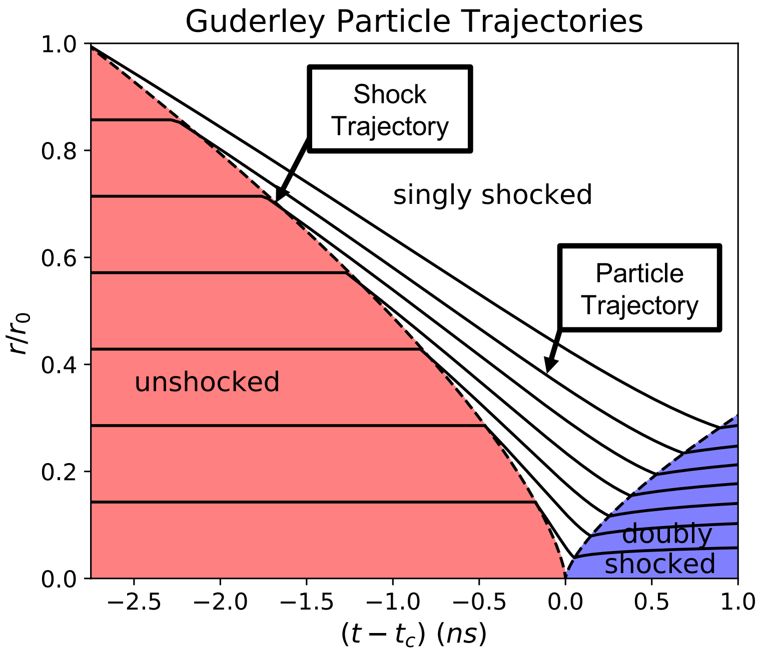


# Spherically collapsing shock waves amplify the initial pressure, are hydrodynamically robust[+*], and have a simple solution developed by Guderley[**]

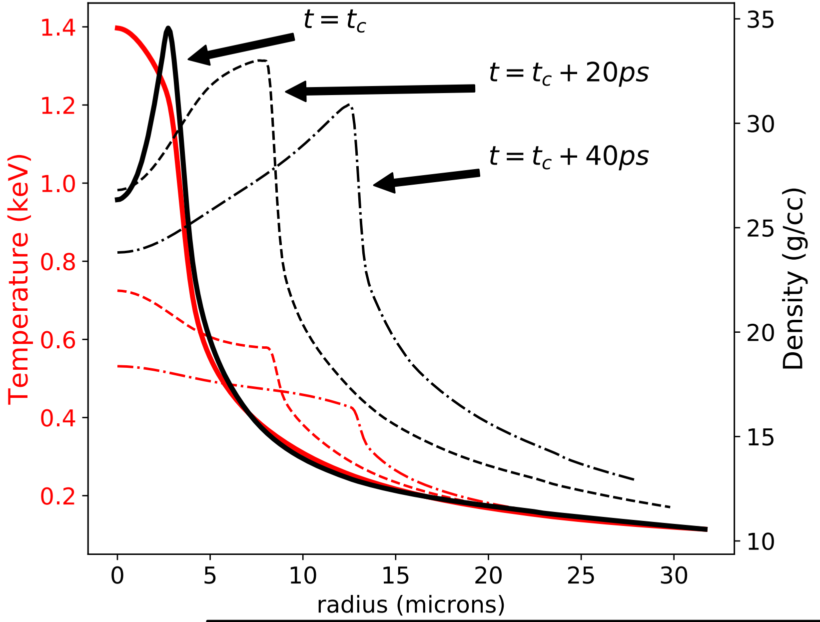


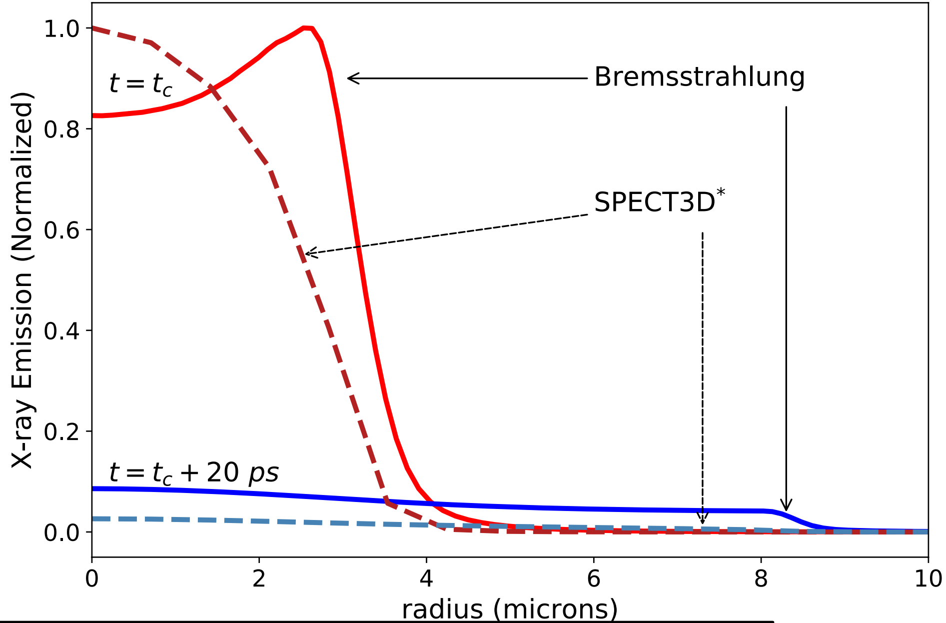






+ J.R. Rygg *et. al*. Phys. Plasmas. 15, 034505 (2008).
* J. H. Gardner, D. L. Book, and I. B. Bernstein, J. Fluid Mech. 114, 41 (1982).
** G. Guderley, Luftfahrtforschung 19, 302 (1942).

# The experiment is simulated using the 1-D hydrodynamics code *Lilac* to produce temperature and density profiles and synthetic x-ray images

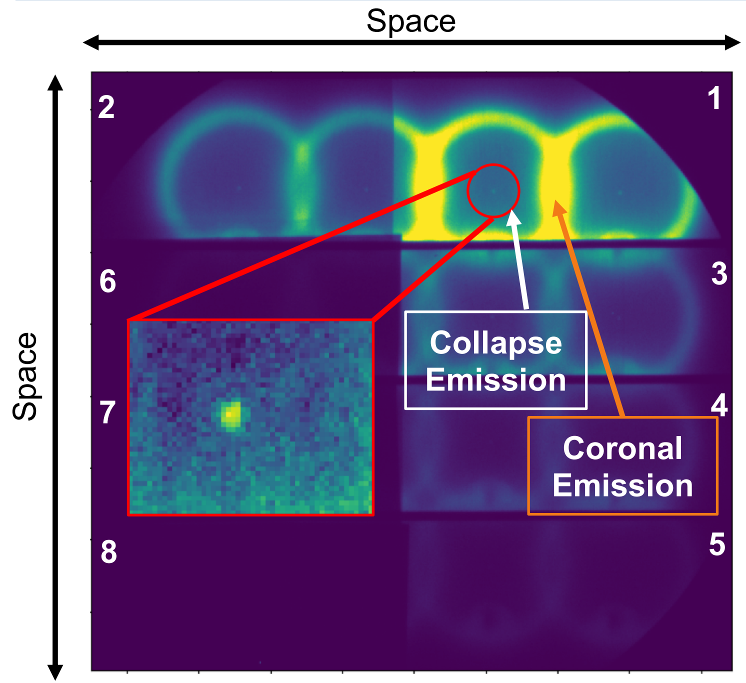


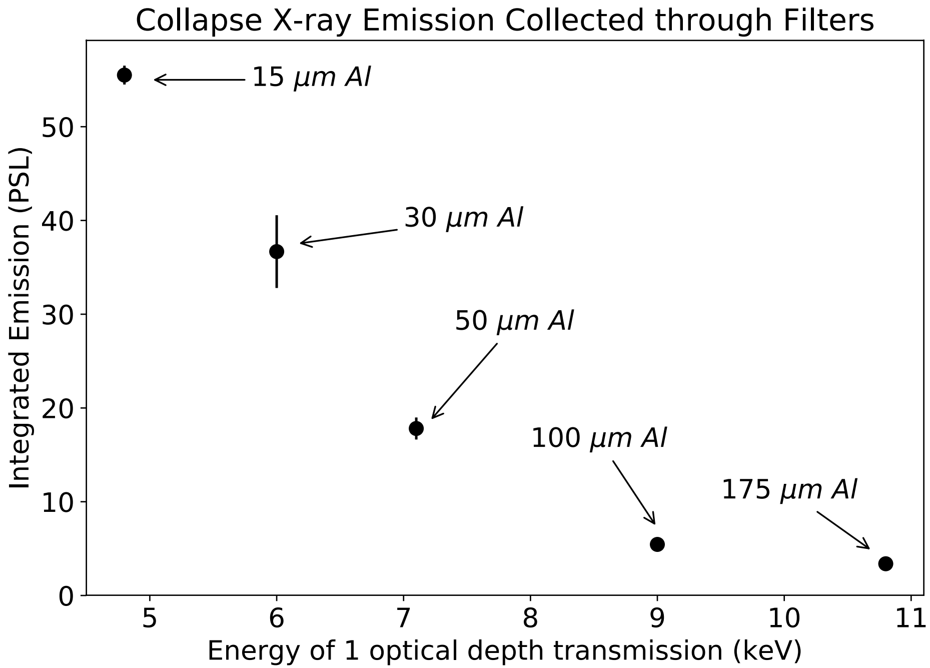




**Simulated x-ray emission is confined to a narrow region spatially and temporally when the density peak is matched to the temperature peak.**

* Spect3D, Prism Computational Sciences, INC. Madison, WI.

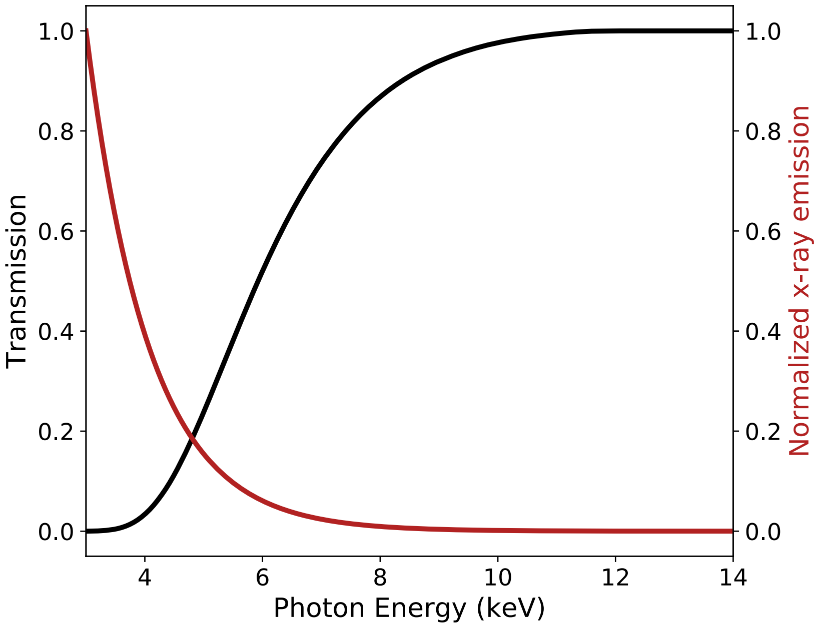
# A neutron yield of $1 \times 10^6$ and the x-ray self-emission from a spherically collapsing shock wave was measured on the OMEGA laser

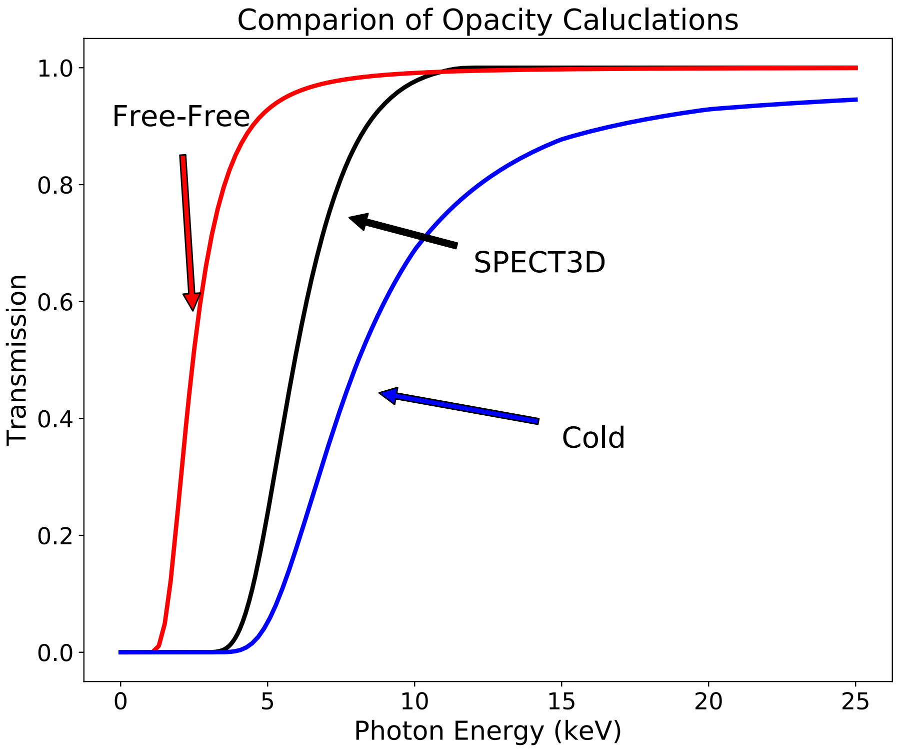


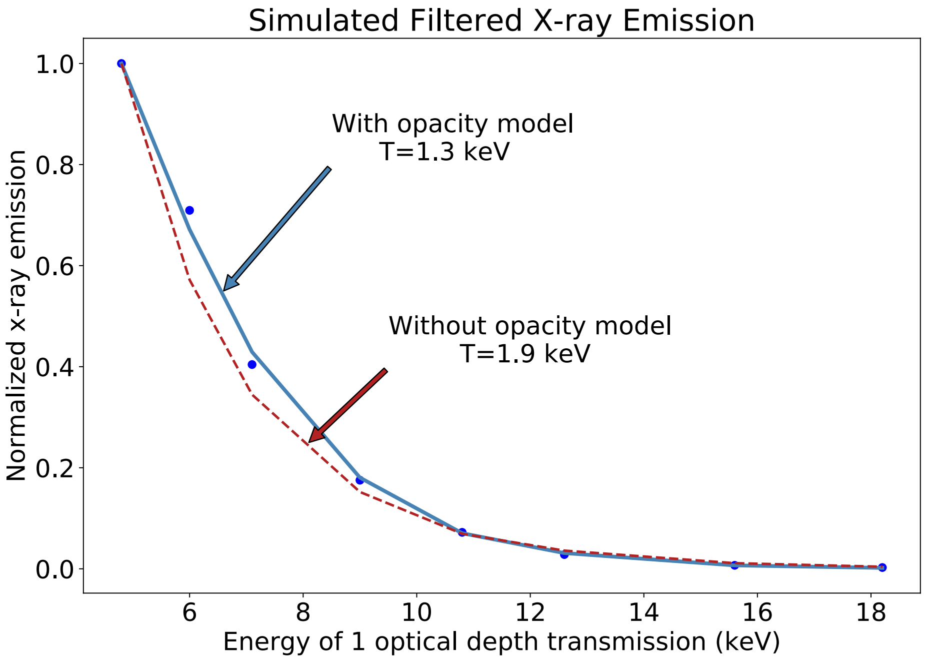
# A model for opacity must be used in order to derive information from the measured x-ray emission

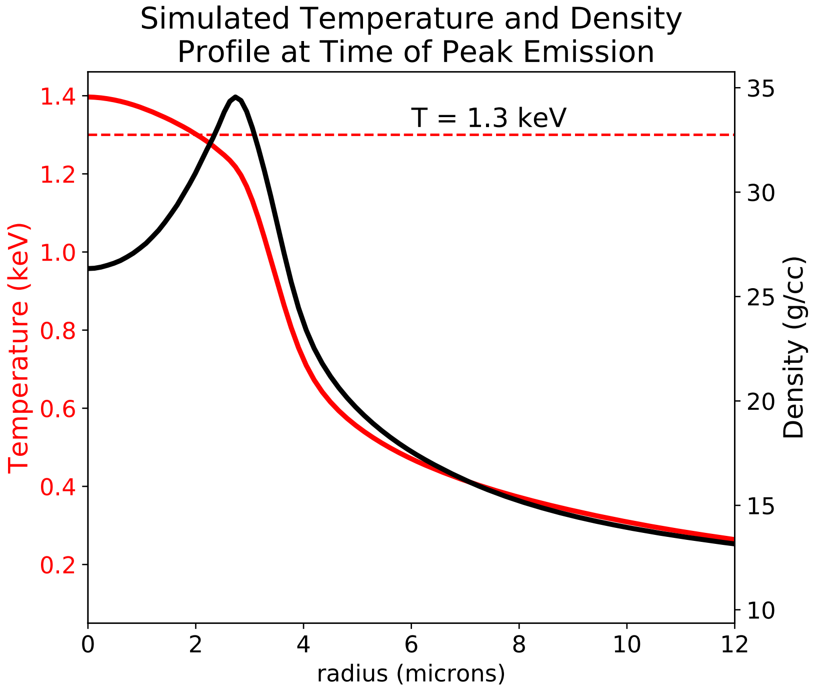
- X-ray signal <15 keV affected by opacity
- No x-ray signal >10 keV



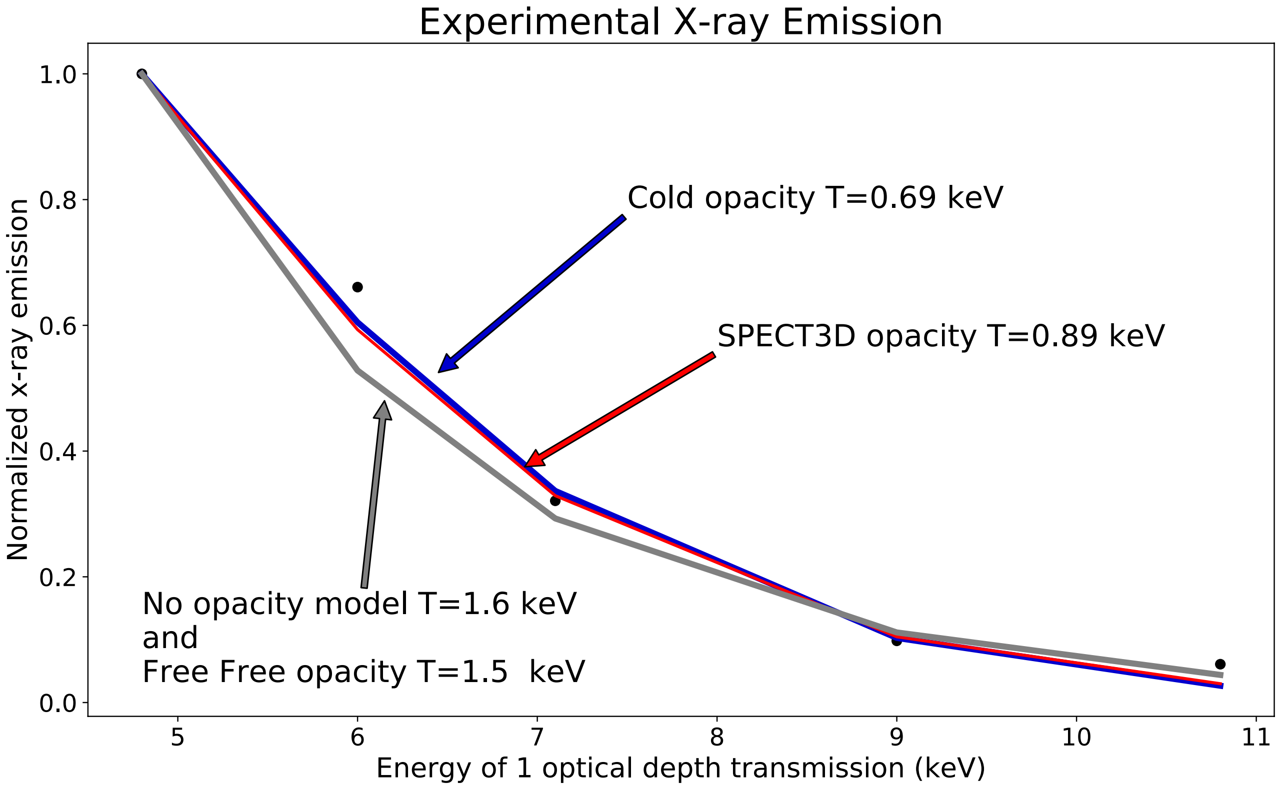



# A single temperature fit to simulated x-ray emission returns the simulated temperature around peak density when an opacity model is used



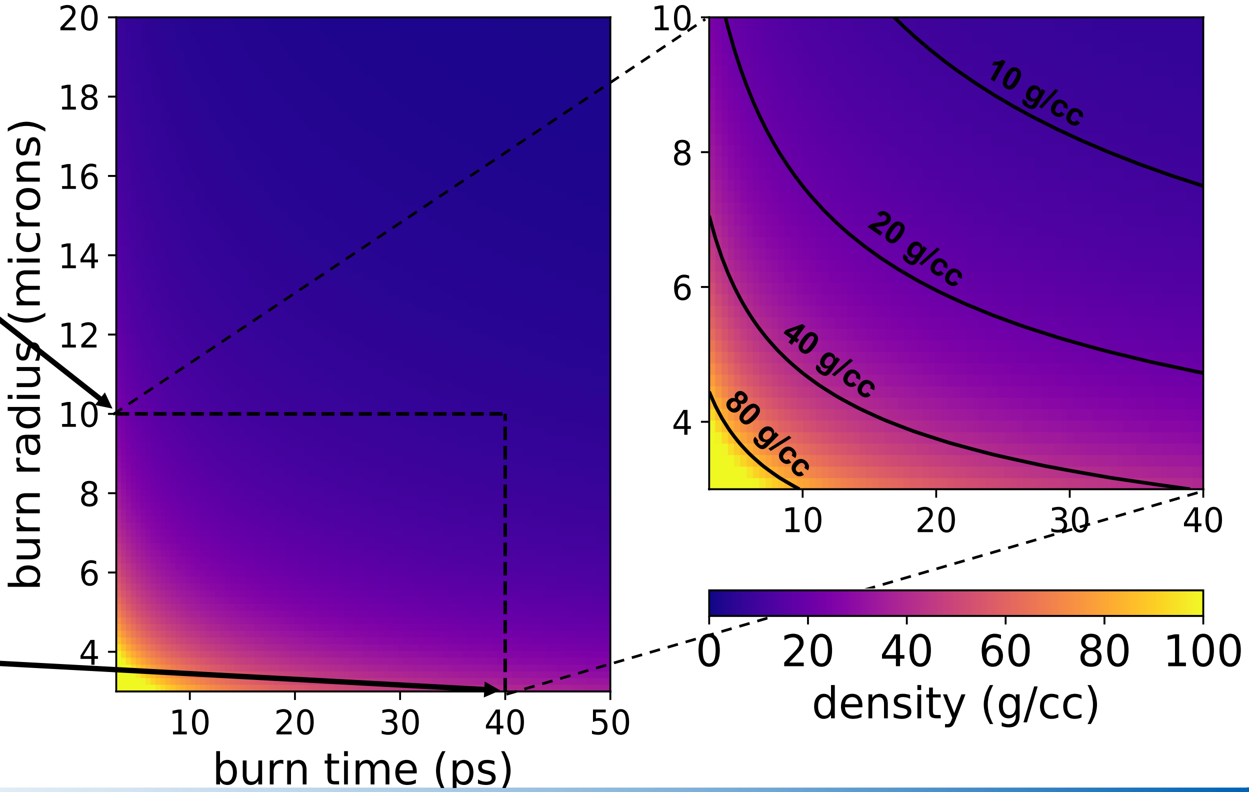
# The data fit with the simulated opacity function returns a temperature of 890 eV



# Absolute x-ray yield along with spatial and temporal extent of the emission constrain the density

**Size of emitting region constrained to <10 microns by pinhole camera**

**Duration of emitting region constrained to <40 ps by framing camera**

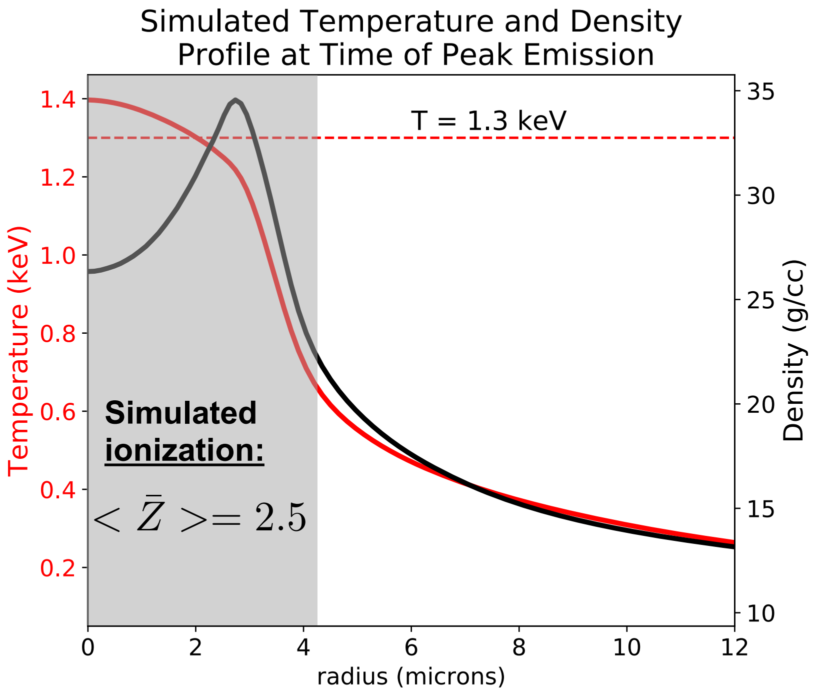


# Comparing x-ray yield and neutron yield constrains the average ionization of the emitting plasma

- **The narrow region of emission means neutrons and x-rays are emitted in the same location at the same time.**
- **X-rays and neutrons have the same dependence on mass density.**
- **Using this and the measured temperature the average ionization state can be deduced in the emitting region.**

**Measured ionization and temperature:**

$$< \bar{Z} = 2.4 > \quad T = .89\ keV$$



Summary/Conclusion

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