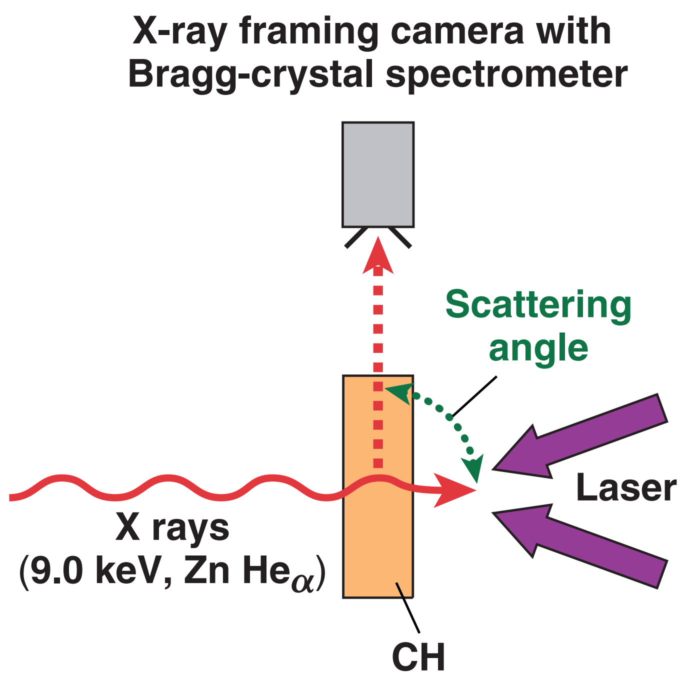
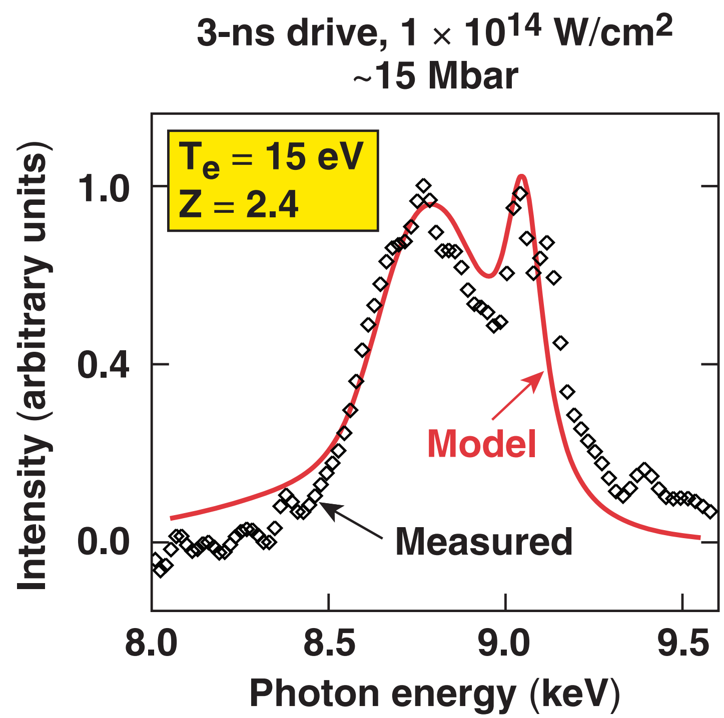
Measurements of T_e and Z in Direct-Drive, Shock-Heated Planar Targets





H. Sawada *et al.*
University of Rochester
Laboratory for Laser Energetics

47th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Denver, CO
24–28 October 2005

Summary

The electron temperature (T_e) of shock-heated CH was measured with an uncertainty of ±5 eV

- CH foil targets designed to have a low adiabat ($\alpha = 1.5, 3$) were driven with intensities of 1×10^{14} W/cm^2.

- The compressed foil conditions (T_e, Z) were diagnosed with spectrally resolved x-ray scattering (XRTS).

- The lowest ionization (Z) of CH that can be resolved in this experiment is Z ~ 2.

- Adding a high-Z dopant to the drive foil has a strong influence on the scattered x-ray spectra, which may increase the T_e, Z sensitivity of the XRTS diagnostic technique.

Collaborators

S. P. Regan, T. R. Boehly, I. V. Igumenshchev, V. N. Goncharov, T. C. Sangster, D. D. Meyerhofer, and B. Yaakobi

Laboratory for Laser Energetics
University of Rochester

G. Gregori

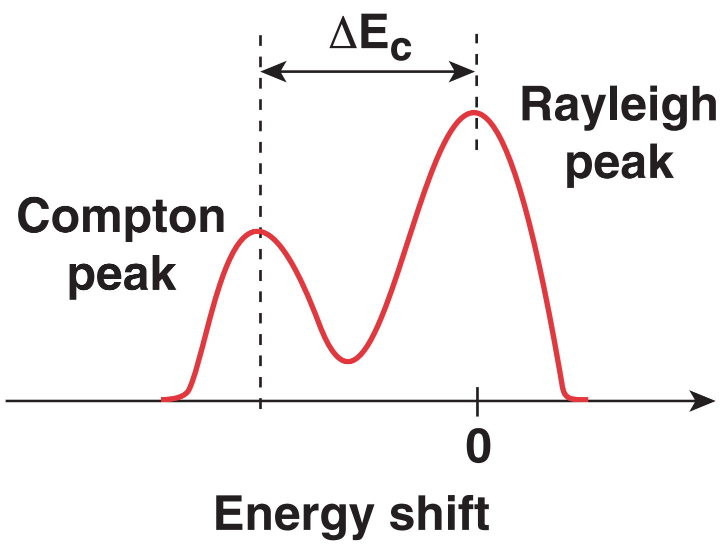
CCLRC
Rutherford Appleton Laboratory

S. H. Glenzer, O. L. Landen, and D. G. Hicks

Lawrence Livermore National Laboratory

Plasma conditions of shock-heated matter can be diagnosed with spectrally resolved x-ray scattering

- The spectral line shapes of the elastic Rayleigh and the inelastic Compton components are fitted to infer T_e and Z.*
- The Doppler-broadened Compton feature is sensitive to T_e for $T_e > T_F$.
- The ratio of Rayleigh and Compton intensities is sensitive to Z.



Compton downshifted energy (eV)

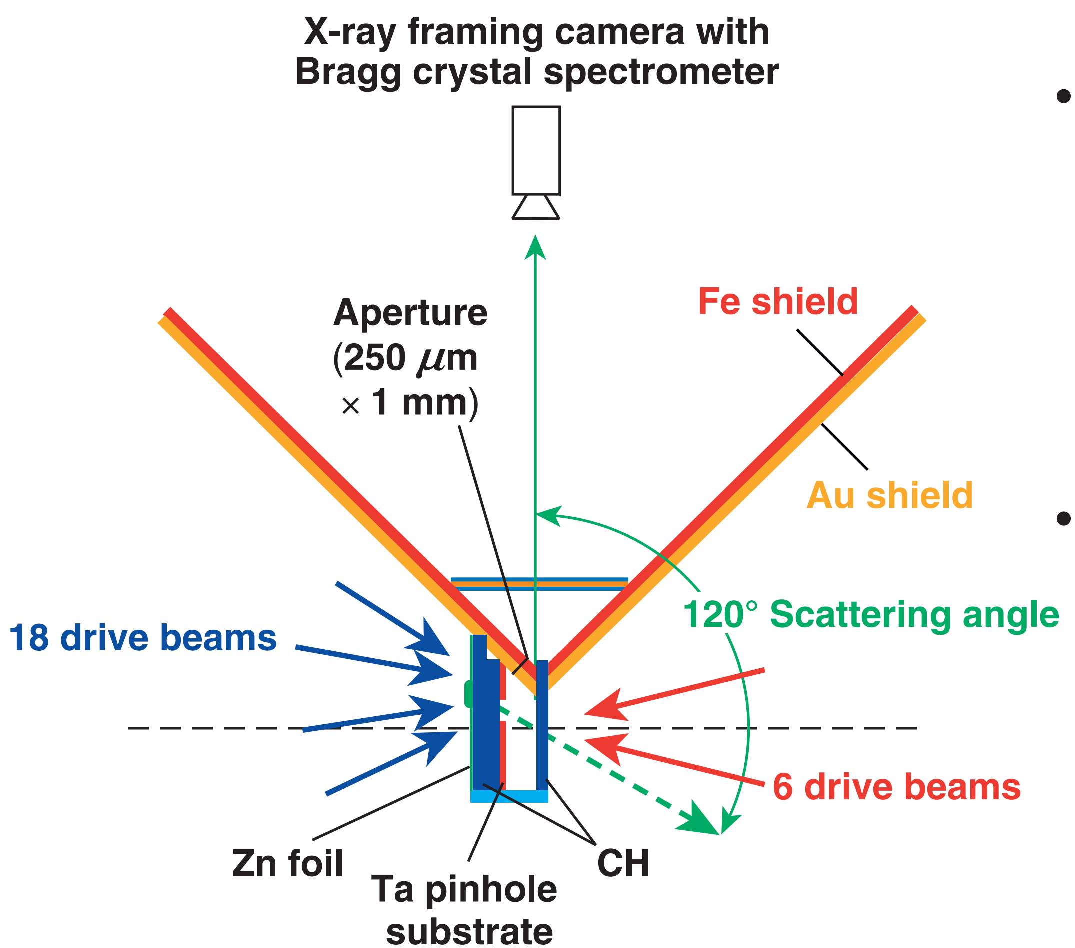
$$\Delta E_c = \frac{\hbar^2 k^2}{2m_e} \qquad k = \frac{4\pi}{\lambda_0} \sin\left(\frac{\theta}{2}\right)$$

θ: scattering angle
λ_0: wavelength of probe

*S. H. Glenzer *et al.*, Phys. Rev. Lett. 90, 175002 (2003); G. Gregori *et al.*, Phys. Rev. E 67, 026412 (2003).

E13470b

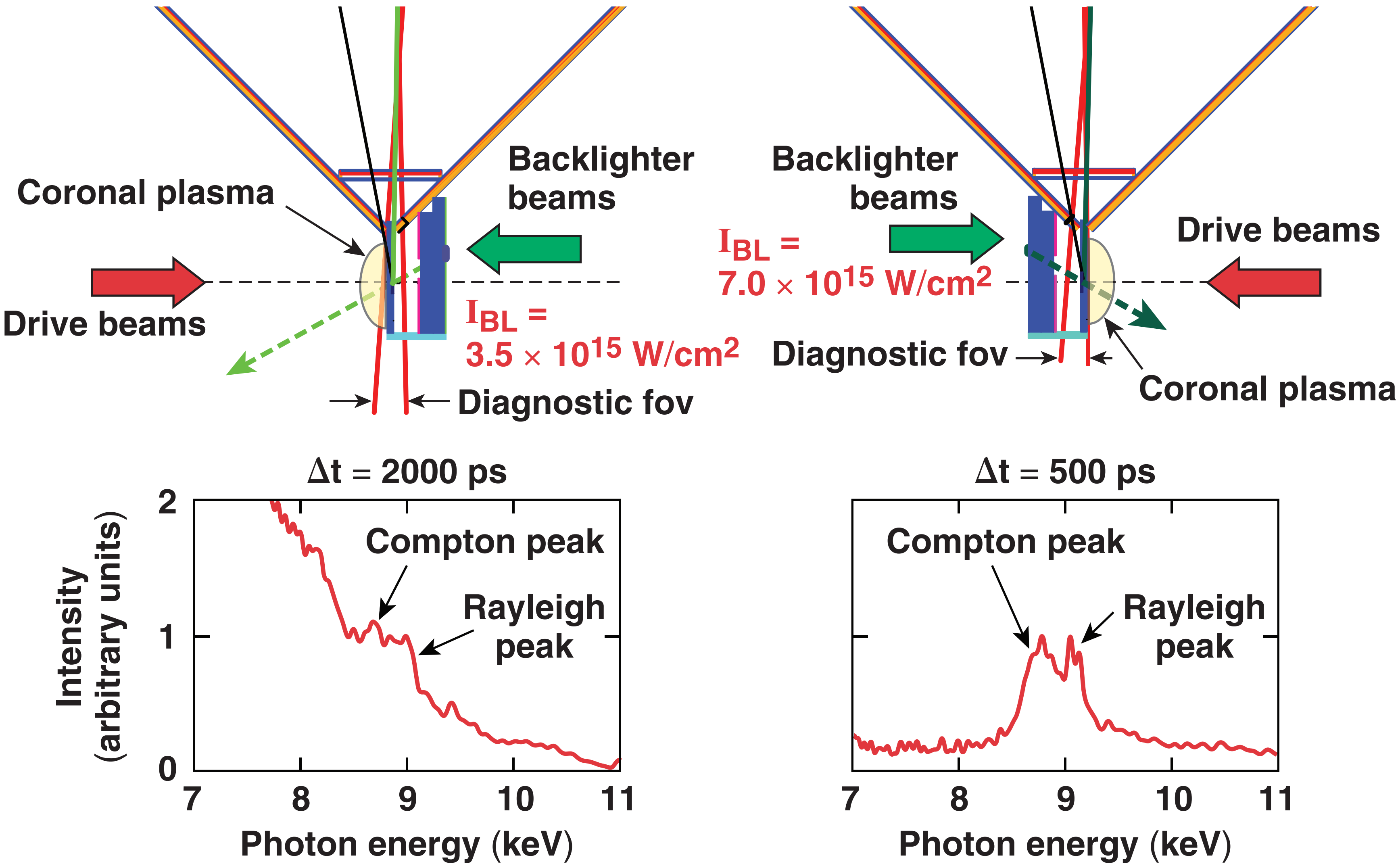
Zn He$_{\alpha}$ emission scattered from a direct-drive, shock-heated CH foil was recorded



Zn He$_{\alpha}$ at 9 keV

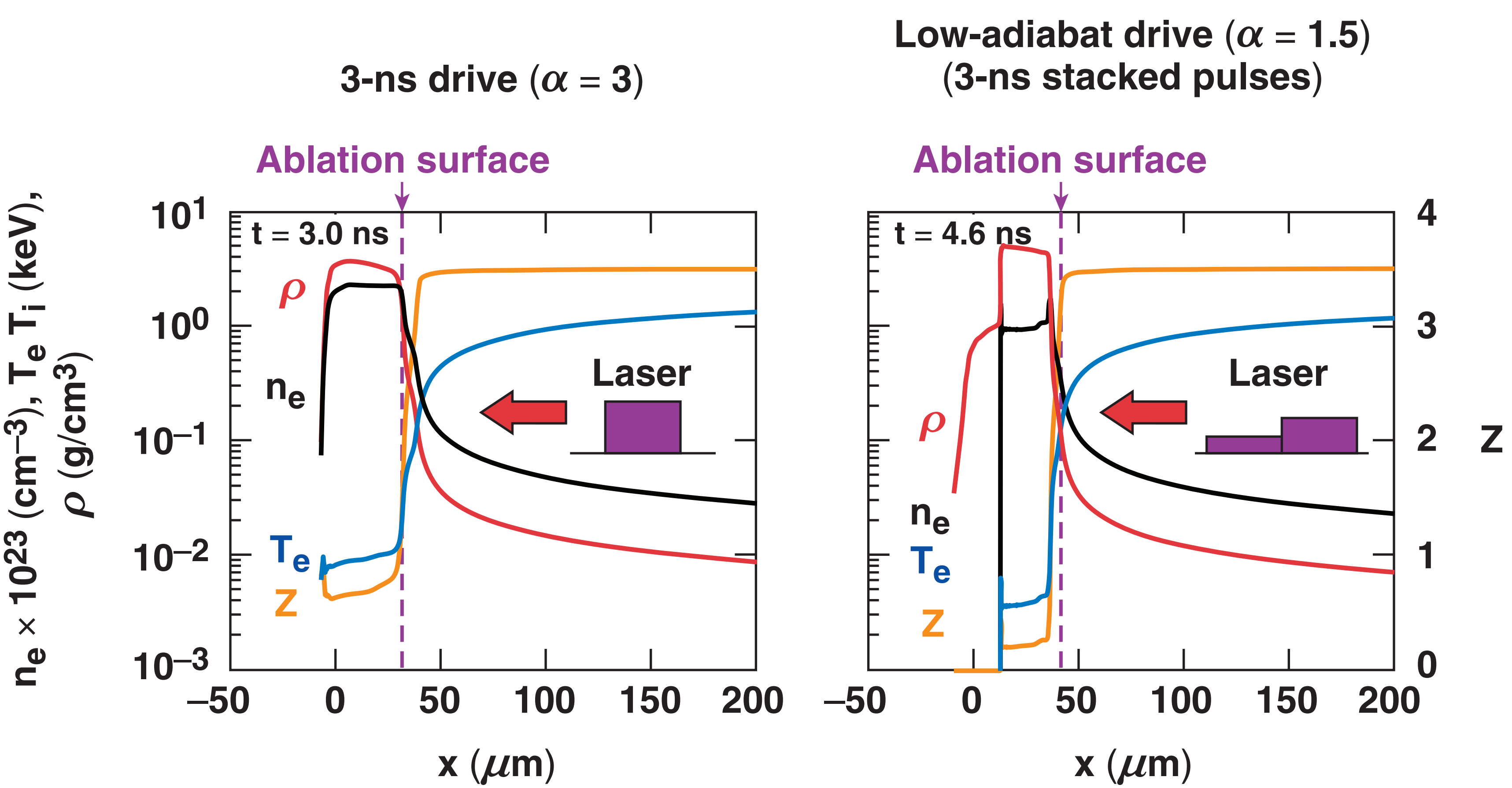
- Target
  - 125-μm CH (2.25 × 3 mm)
  - 6 × 8 mm Au/Fe shields (100-μm Au, 50-μm Fe in thickness)
  - 250-μm viewing slit
  - 400-μm pinhole size
  - 5-μm Zn foil
- Laser conditions
  - 3-ns square pulse
  - 280 J/beam
  - 400-μm flattop drive for drive foil
  - 100-μm spot for backlighters

X-ray radiation from the coronal plasma must be shielded from the spectrometer



E14210

The 1-D hydrodynamics code *LILAC* was used to predict plasma conditions at shock breakout

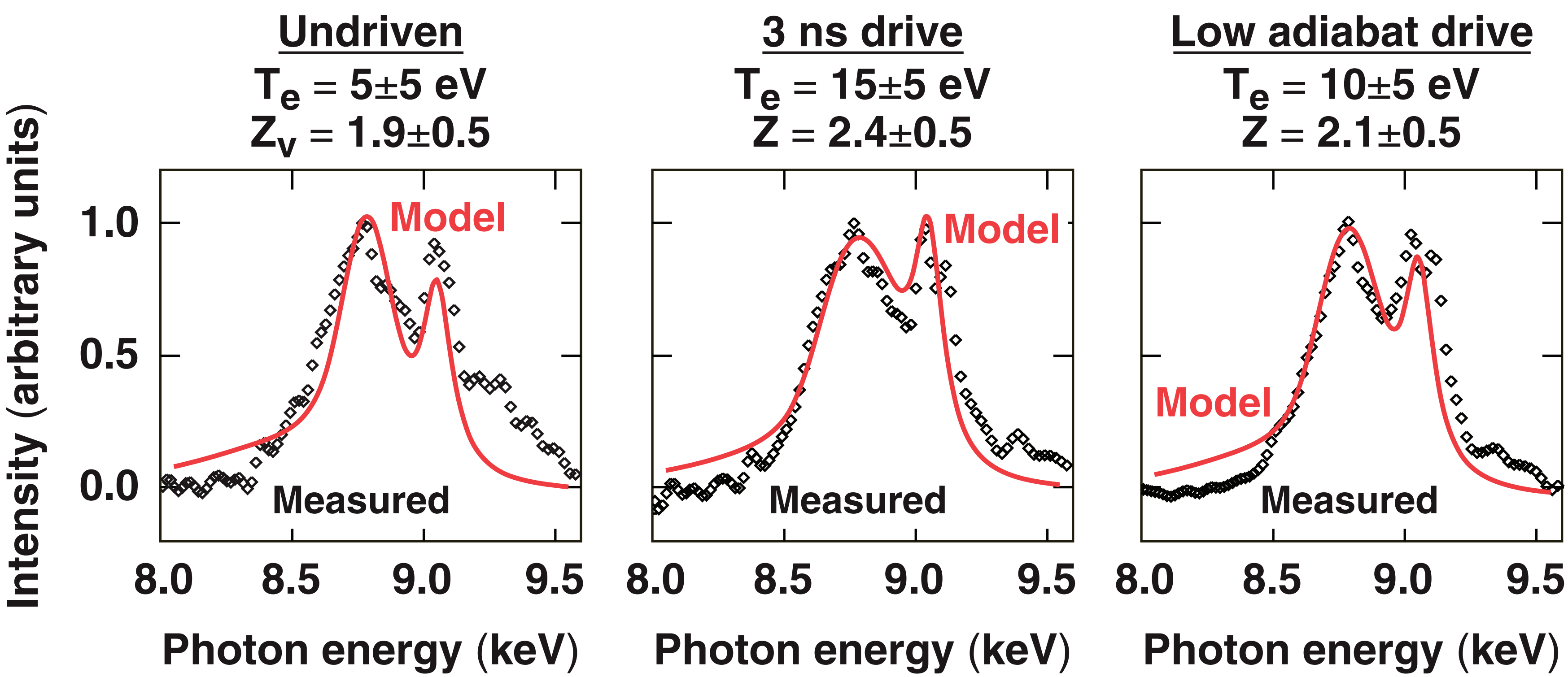


T_e = 10 eV Z = 0.75	T_e = 4 eV Z = 0.25

- The compressed foil has nearly uniform conditions

E13873a

The electron temperature of shock-heated CH was measured with an uncertainty of ±5 eV

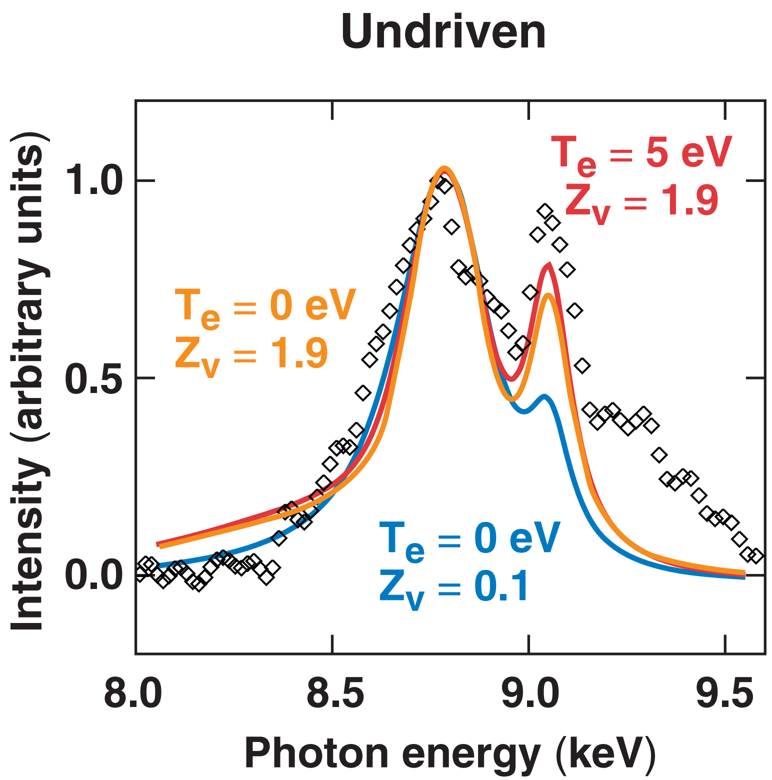


1-D prediction
T_e = 10 eV
Z = 0.75

1-D prediction
T_e = 4 eV
Z = 0.25

E14211

The lowest ionization of CH that can be resolved in this experiment is Z ~ 2



- Compton downshifted energy
  ΔE_c = 267 eV
  (9.0 keV, 120° scattering angle)

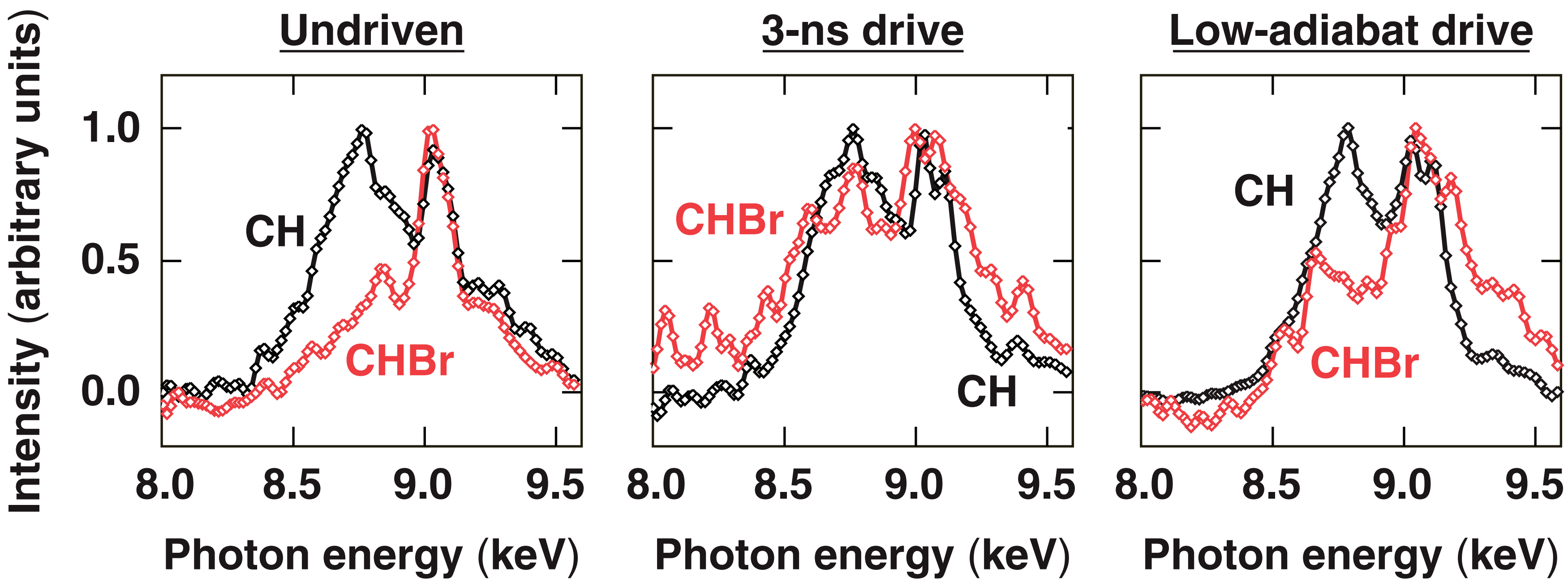
- Ionization potentials of carbon

C^{0+}	11.3 eV
C^{1+}	24.4 eV
C^{2+}	47.9 eV
C^{3+}	64.5 eV
C^{4+}	392.0 eV
C^{5+}	490.0 eV

- Bound electrons with binding energies much less than the Compton-downshifted energy scatter x rays like free electrons.

E14212

Adding a high-Z dopant to the drive foil has a strong influence on the scattered x-ray spectra



Br dopant may increase the Te, Z sensitivity of the XRTS diagnostic technique.

Summary/Conclusions

The electron temperature (T_e) of shock-heated CH was measured with an uncertainty of ±5 eV

- CH foil targets designed to have a low adiabat ($\alpha = 1.5, 3$) were driven with intensities of 1×10^{14} W/cm^2.
- The compressed foil conditions (T_e, Z) were diagnosed with spectrally resolved x-ray scattering (XRTS).
- The lowest ionization (Z) of CH that can be resolved in this experiment is Z ~ 2.
- Adding a high-Z dopant to the drive foil has a strong influence on the scattered x-ray spectra, which may increase the T_e, Z sensitivity of the XRTS diagnostic technique.