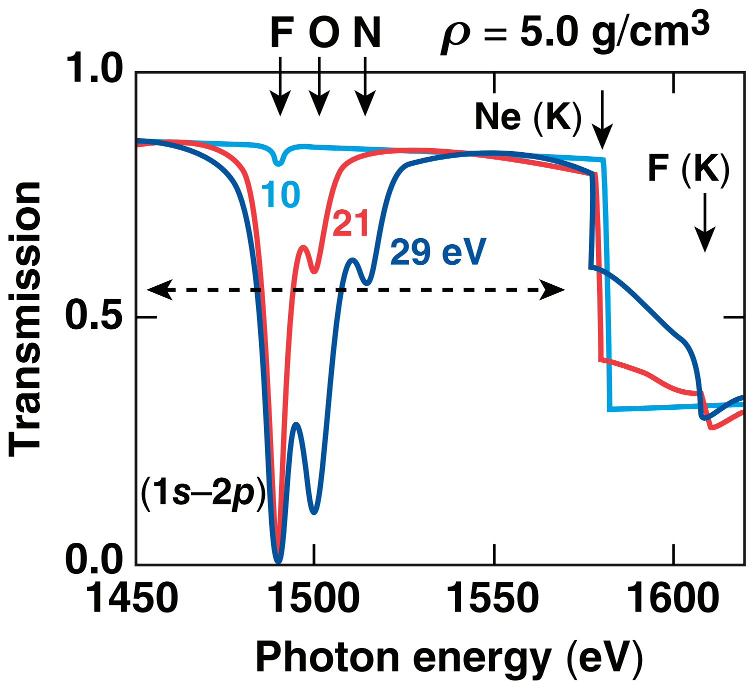
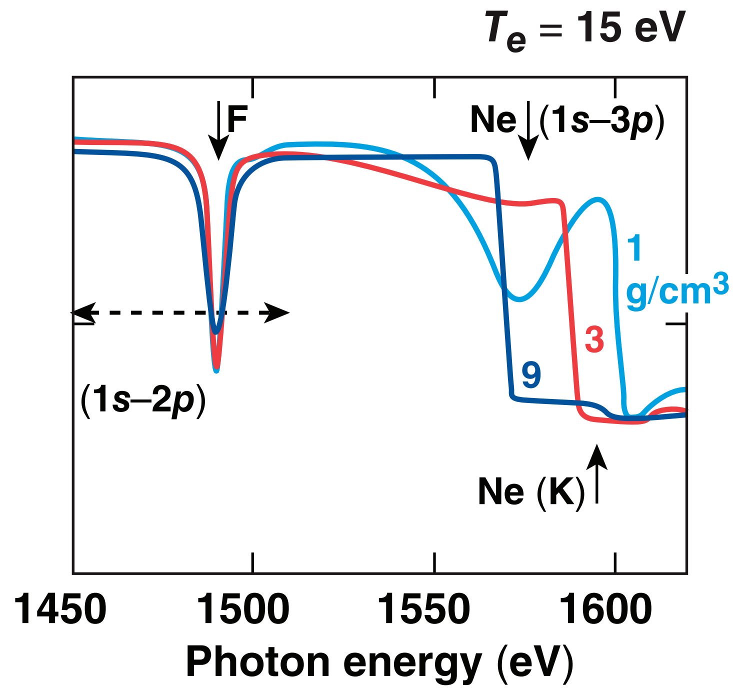
K-shell Absorption Spectroscopy at Low Temperatures in Preheat Experiments

Temperature-dependent transmission 1-μm Al



Density-dependent transmission 1-μm Al



R. Epstein *et al.*
University of Rochester
Laboratory for Laser Energetics

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Summary

Aluminum absorption spectroscopy has been extended to low-temperature and high-density shock-heated conditions

UR LLE

- The ionization state indicated by the presence of absorption lines provides well-understood constraints on temperatures above 10 eV.
- The Stark linewidth of the absorption lines is a direct indication of electron density.
- The disappearance of the Ne-like 1*s*–3*p* line provides an additional density signature.
- Density estimates from linewidths alone exceed factor-of-two precision above 2 g/cm^3 and can be refined significantly using density-dependent K-edge shifts.

Collaborators

H. Sawada, V. N. Goncharov, D. Li, P. B. Radha, and S. P. Regan

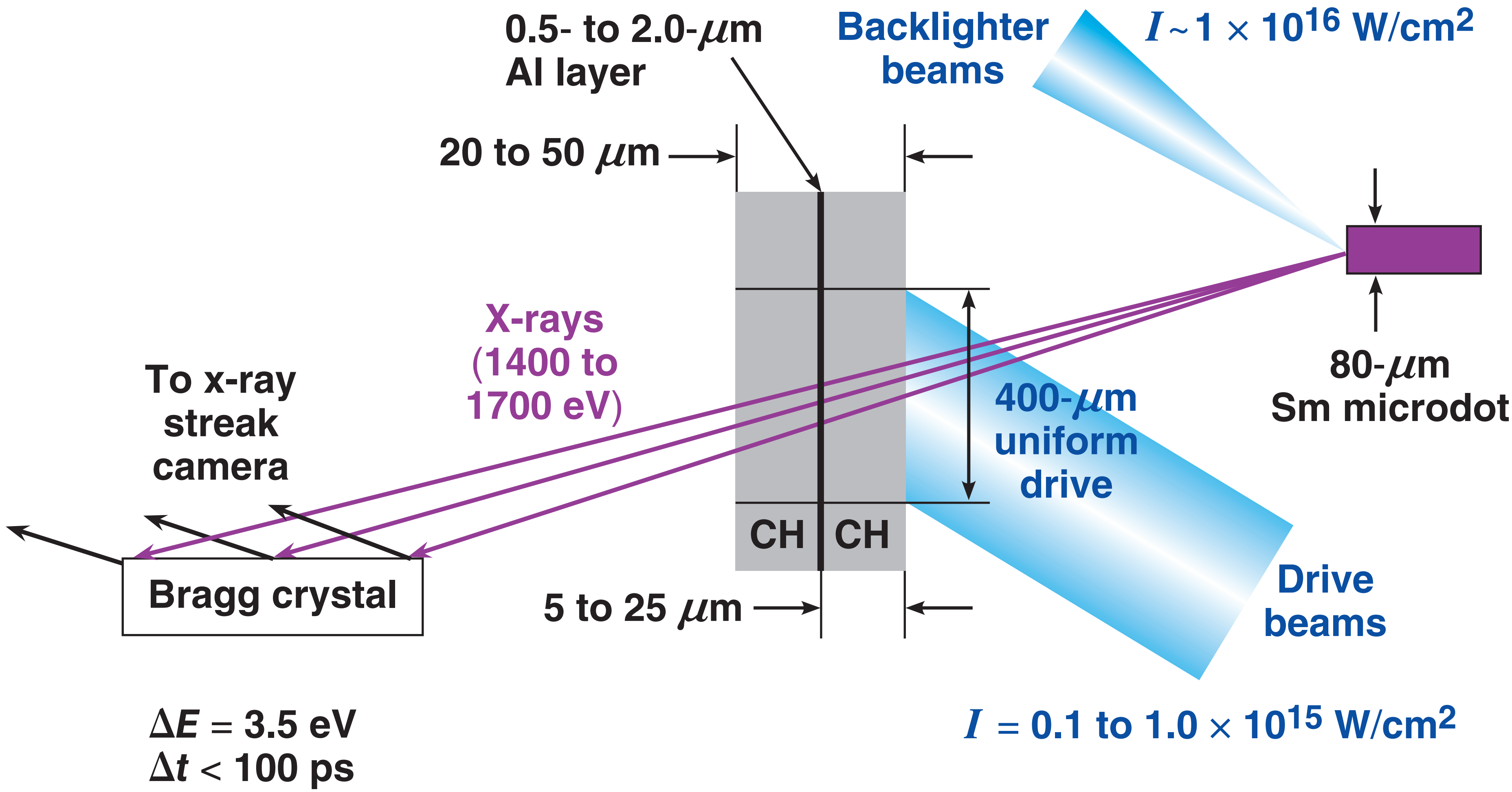
University of Rochester
Laboratory for Laser Energetics

R. C. Mancini

University of Nevada, Reno

Related Talks: S. P. Regan – ZO1.0003
H. Sawada – RI1.00001

X-ray absorption spectroscopy of a CH planar target with a buried Al tracer layer was performed with a Sm backlighter



E14880

Absorption spectra are fit to PrismSPECT* model spectra based on detailed atomic modeling

- Level populations of a detailed-configuration, multispecies atomic model obtained for collisional-radiative equilibrium.
- Spectra of backlit uniform foils are obtained over a T_e–ρ grid.
- Parameter values and error estimates are obtained from least-squares fitting.
- Line shape modeling includes Doppler, natural, and Stark broadening.
- Dense plasma effects include continuum lowering and the corresponding reduction in statistical weights.

*Prism Computational Sciences, Inc., Madison, WI 53711

E14882

Our application of absorption spectroscopy makes direct use of density-dependent spectral features

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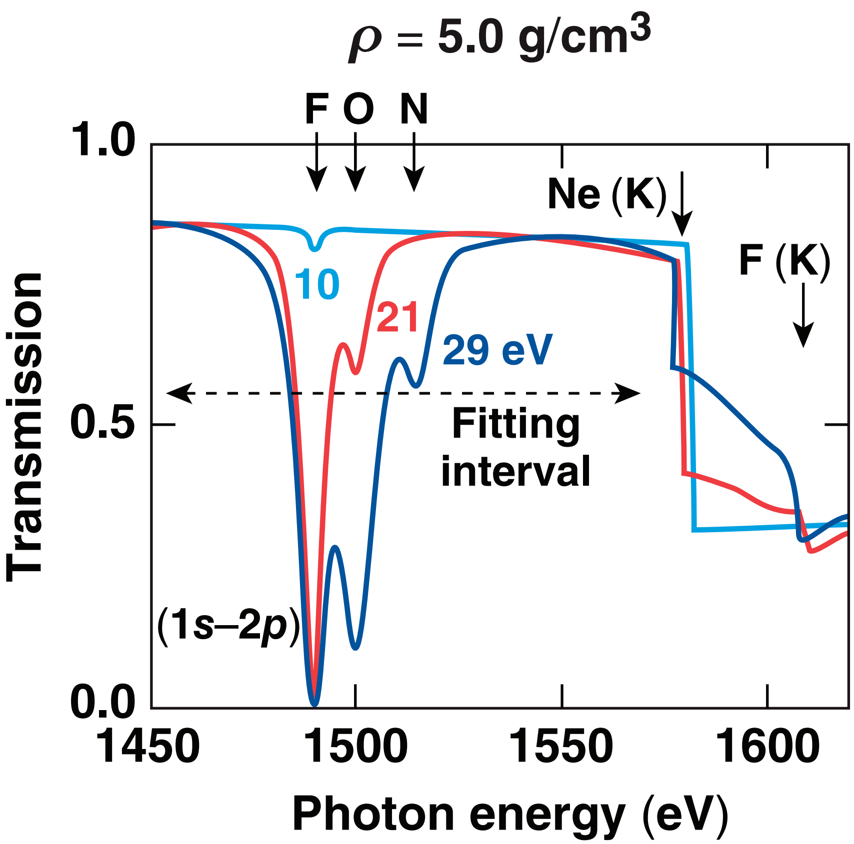
- The 1*s* – 2*p* absorption line broadening is visible in the F-like – Li-like species above ~1 g/cm^2.
- The 1*s* – 3*p* absorption line in Ne-like Al is extinguished by loss of the *n*=3 shell to continuum lowering.
- The density sensitivity of continuum-lowering $\Delta\chi$ exceeds that of the ionization shift of the unperturbed K-edge χ_K above ρ ~ 1.0 g/cm^3 .

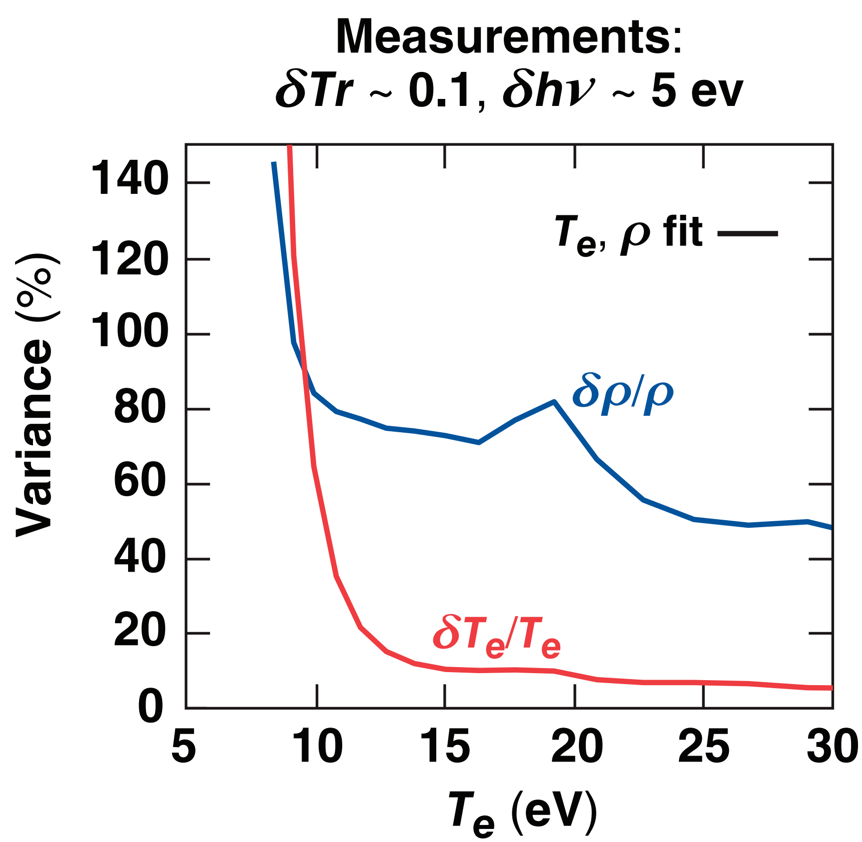
Shifted K-edge: $\chi = \chi_K(Z) - \Delta\chi; \quad \Delta\chi \propto \rho^{1/3}$

$$\frac{\partial \Delta\chi}{\partial \ln\rho} \approx -25\,\mathrm{eV}\left(\rho / \mathrm{g/cm^3}\right)^{1/3}$$

TC7499

Temperature is inferred from the ionization-state represented by the 1*s*–2*p* lines of the individual ionization species

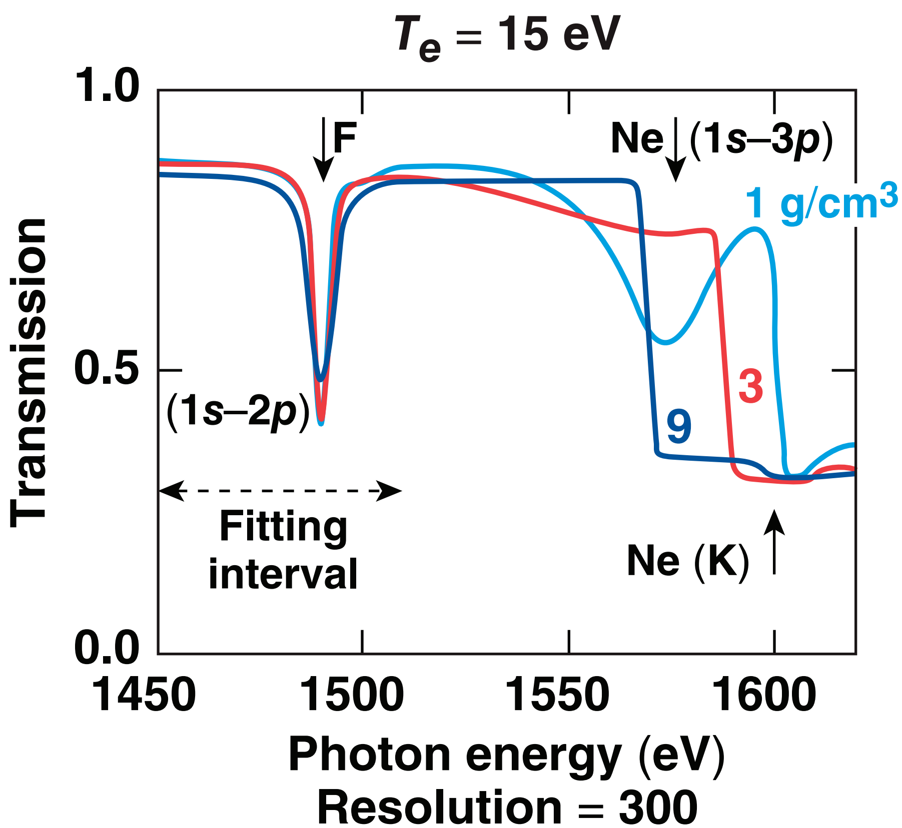


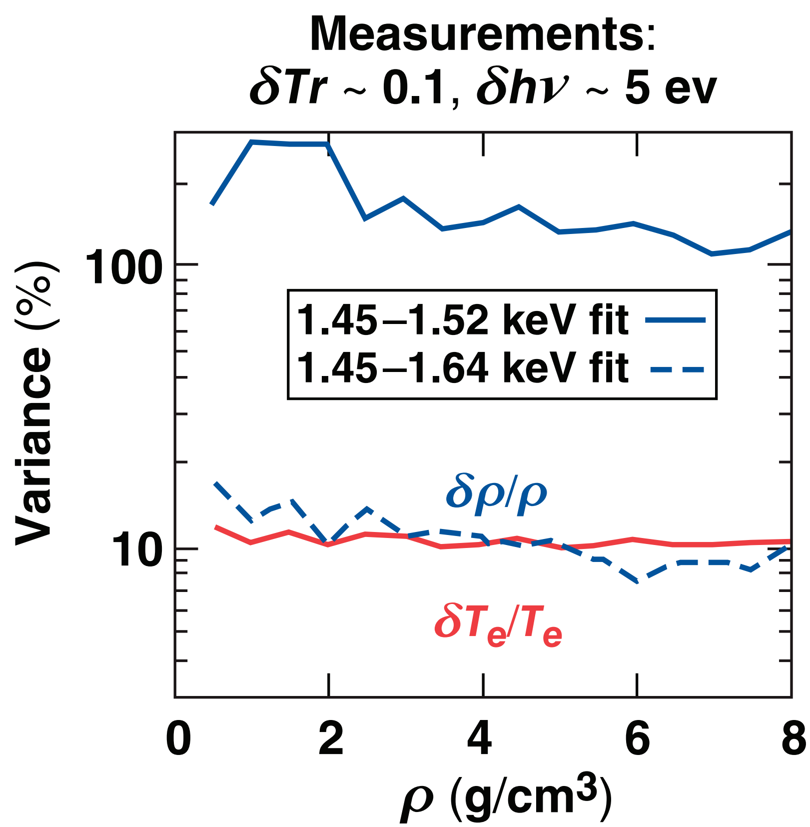


- T_e and ρ measurements are possible above T_e ~ 10 eV.

TC7500

Density is inferred much more precisely from K-edge shifts than from absorption-line broadening alone



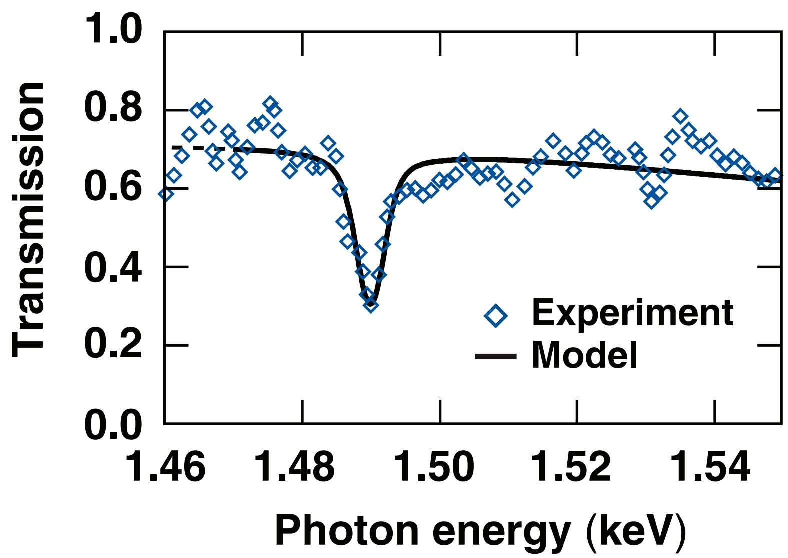


- Density measurements improve above ρ ~ 1.0 g/cm^3.
- Additional density-dependent features add precision.

TC7501

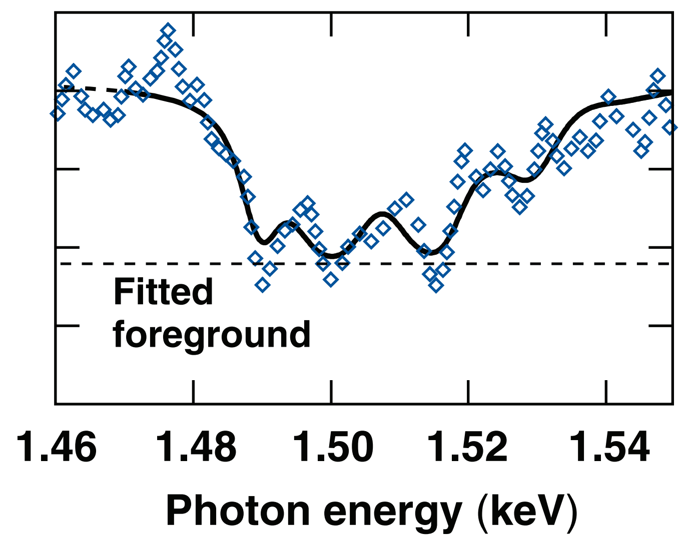
Spectral fitting works well with real data, even with an undetermined foreground

Shot 44124 CH[10]Al[2.0]CH[40]
t = 522 ps 10^{14} W/cm^2



δTr = 0.050, $\delta h\nu$ = 4 eV
T_e = 14 eV (±5%)
ρ = 7.4 g/cm^3 (±39%)

Shot 44116 CH[10]Al[1.0]CH[40]
t = 300 ps 10^{15} W/cm^2



δTr = 0.061, $\delta h\nu$ = 4 eV
T_e = 40 eV (±10%)
ρ = 3.2 g/cm^3 (±84%)

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