Measuring the Gas and Dust Phases in the ISM

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From Chandra to Lynx, Cambridge, MA, Aug. 8 2017

Wilms, Allen & McCray 2000, ApJ, 542, 914:

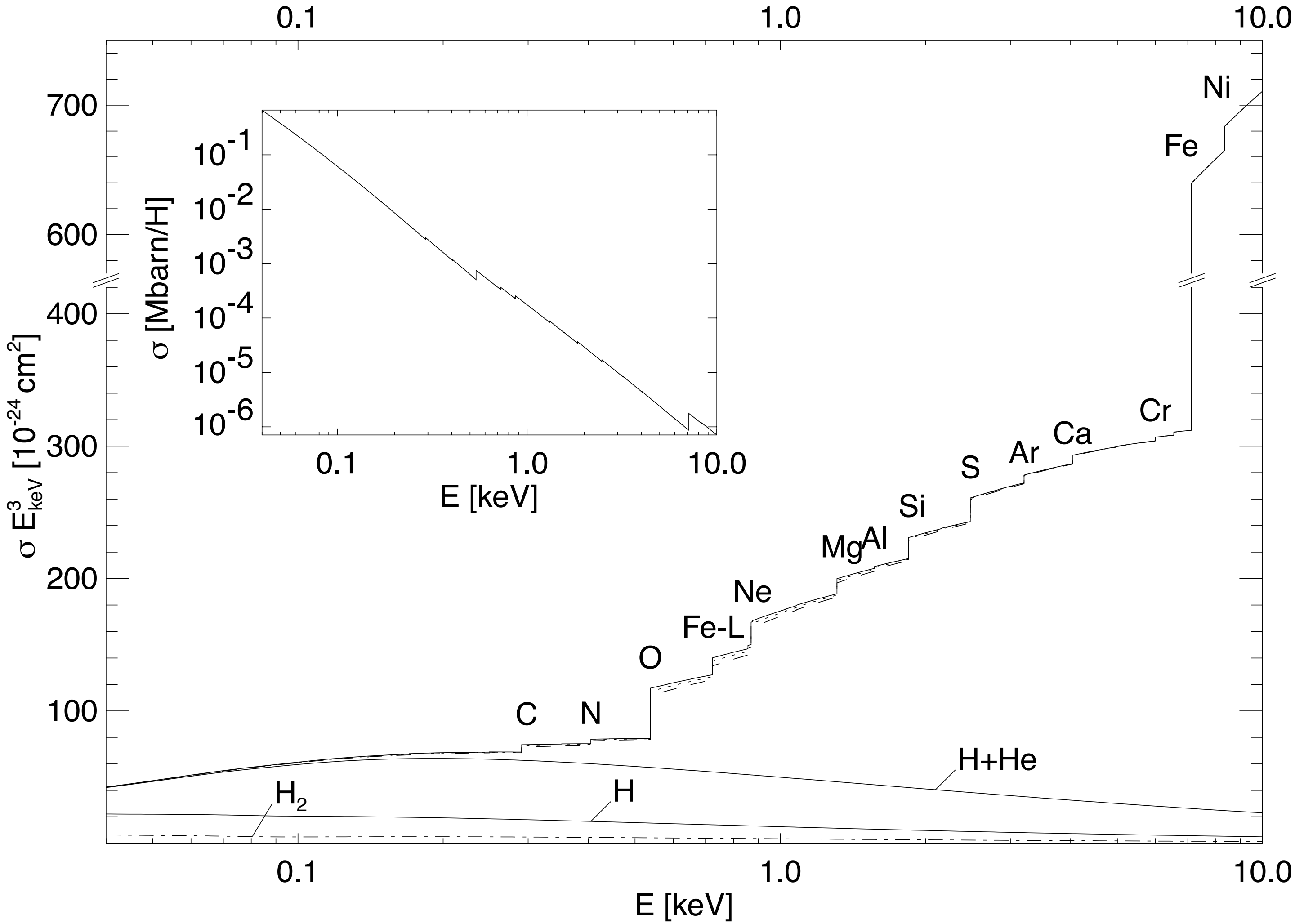


FIG. 1.—Absorptivity per hydrogen atom of the ISM using the assumptions described in the text. The dotted line is the absorptivity including grains with an MRN distribution, and the dashed line is the absorptivity assuming that all grains are of radius $a = 0.3\ \mu$m. The inset shows the cross section without the multiplication by E^3. We also illustrate the contribution of hydrogen and hydrogen plus helium to the total cross section. The contribution of the H_2 cross section to the total hydrogen cross section is indicated by the dot-dashed line.

Hoffman & Draine 2015, arXiv:1509.08987v1:

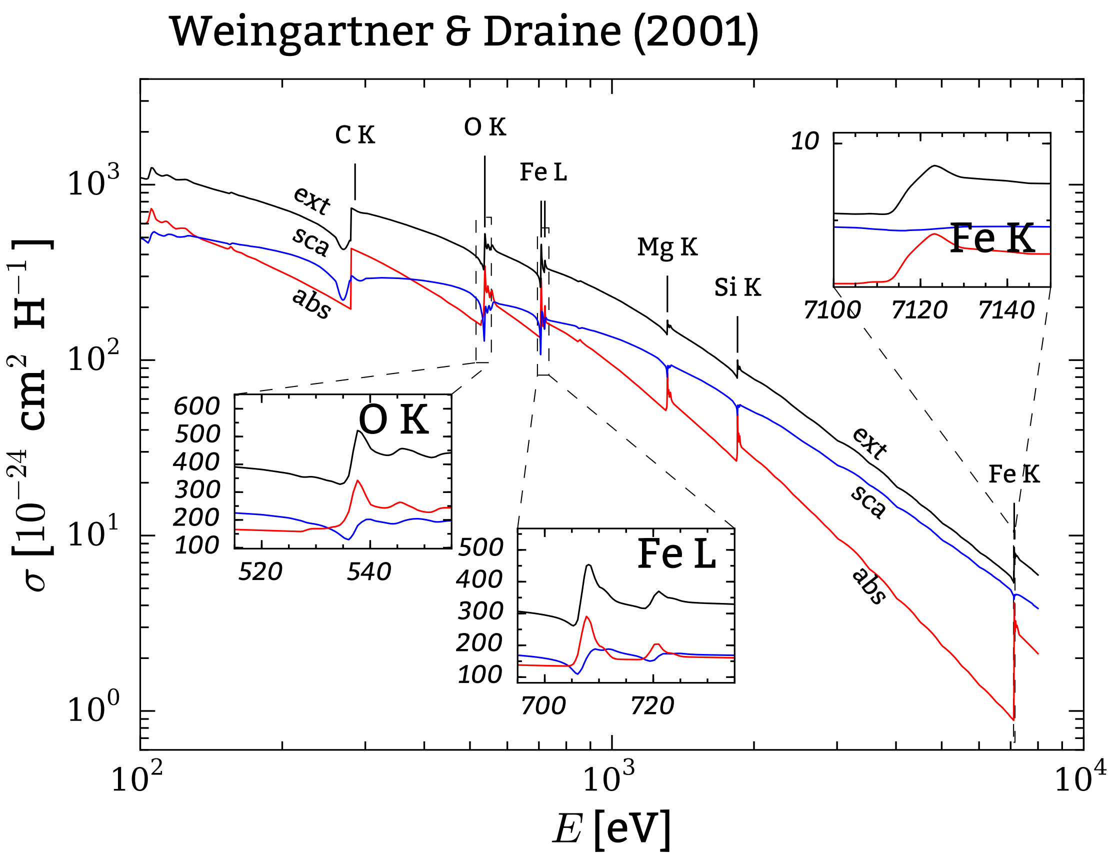


Fig. 2.— Cross sections per Hydrogen nucleus for the Weingartner & Draine (2001) ($R_V = 3.1$) dust model. Scattering contributes significantly to the extinction, with significant variation across the O K and Fe L absorption edges.

Hoffman & Draine 2015, arXiv:1509.08987v1:

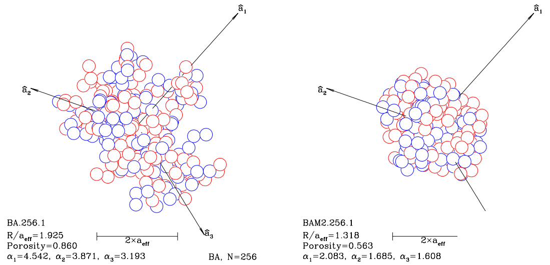


Fig. 7.— Two random aggregates used to investigate the effects of grain geometry and p
Both figures are from Shen et al. (2008). *Left*: a porous BA grain composed of $N = 25$
porous random aggregate produced by the BAM2 algorithm, also containing $N = 256$ m

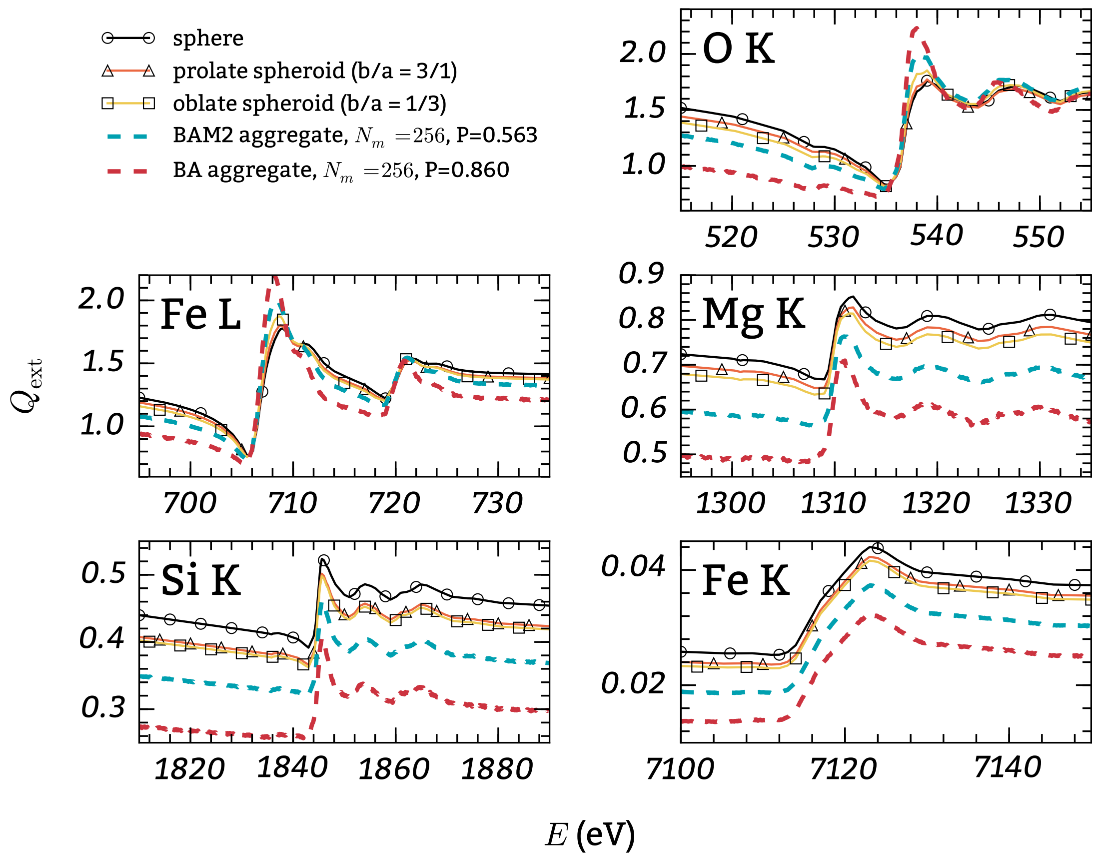
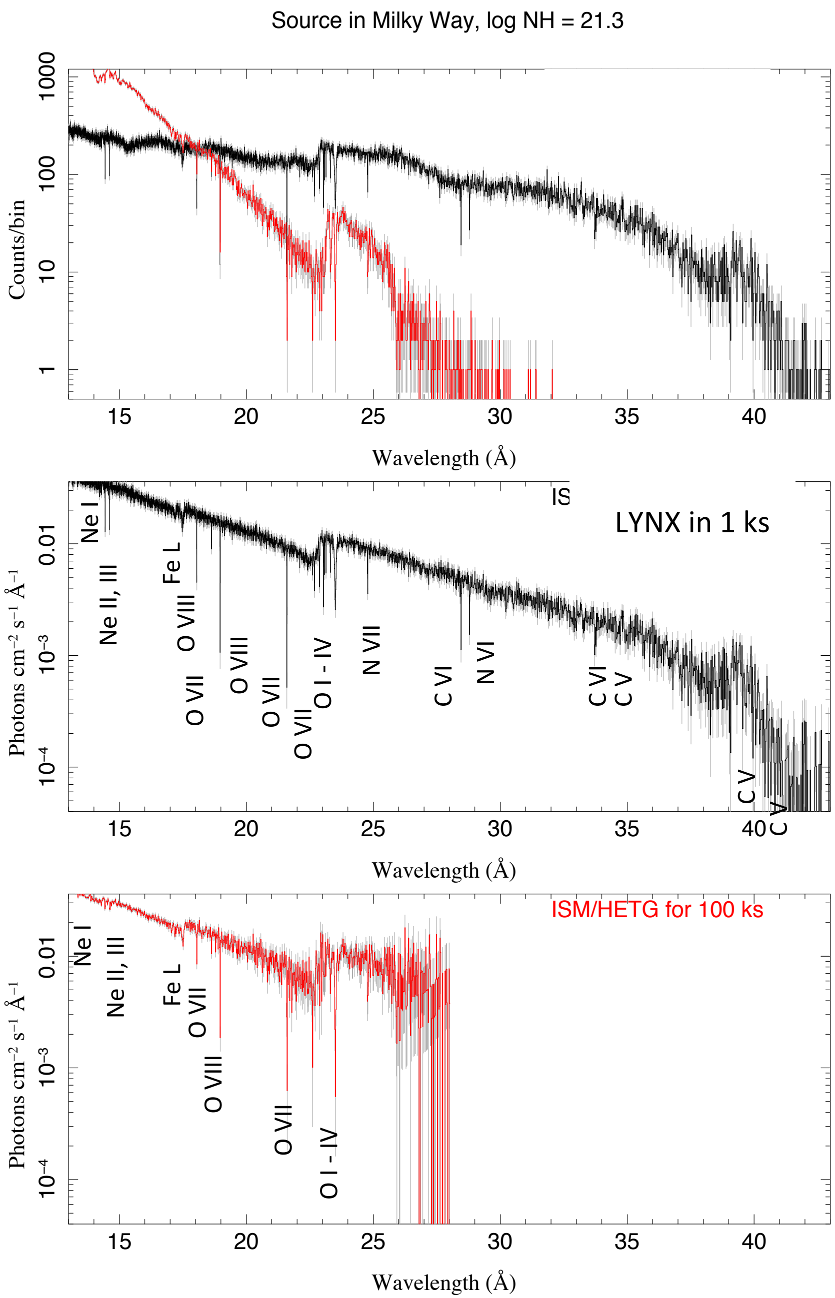


Fig. 9.— Orientation-averaged $Q_{\rm ext}$ for equal-mass $a_{\rm eff} = 0.2\mu$m silicate grains with different geometries. A 256×256 grid was used for the shadow function in all cases, and calculations were averaged over 64 random orientations. Porous, extended grain geometries significantly alter the fine structure of the absorption edges (except for the Fe K edge). Moderately prolate/oblate spheroidal grains, on the other hand, have $Q_{\rm ext}$ very similar to spherical grains.



Typical source in Milky Way:

Flux: 10^{-9} ergs cm^{-2} s^{-1} (~ GX 9+9)
NH: $3x10^{21}$ cm^2
Model: powerlaw + ngauss(16)
Abundance: solar

The black simulation shows an **LYNX** exposure for **1 ks** in the relevant band-pass between 13 and 43 Angstrom showing expected line absorption from

C V, C VI
N VI, N VII
O I, O II, O III, O IV, O VII, O VIII
Ne I, Ne II, Ne III

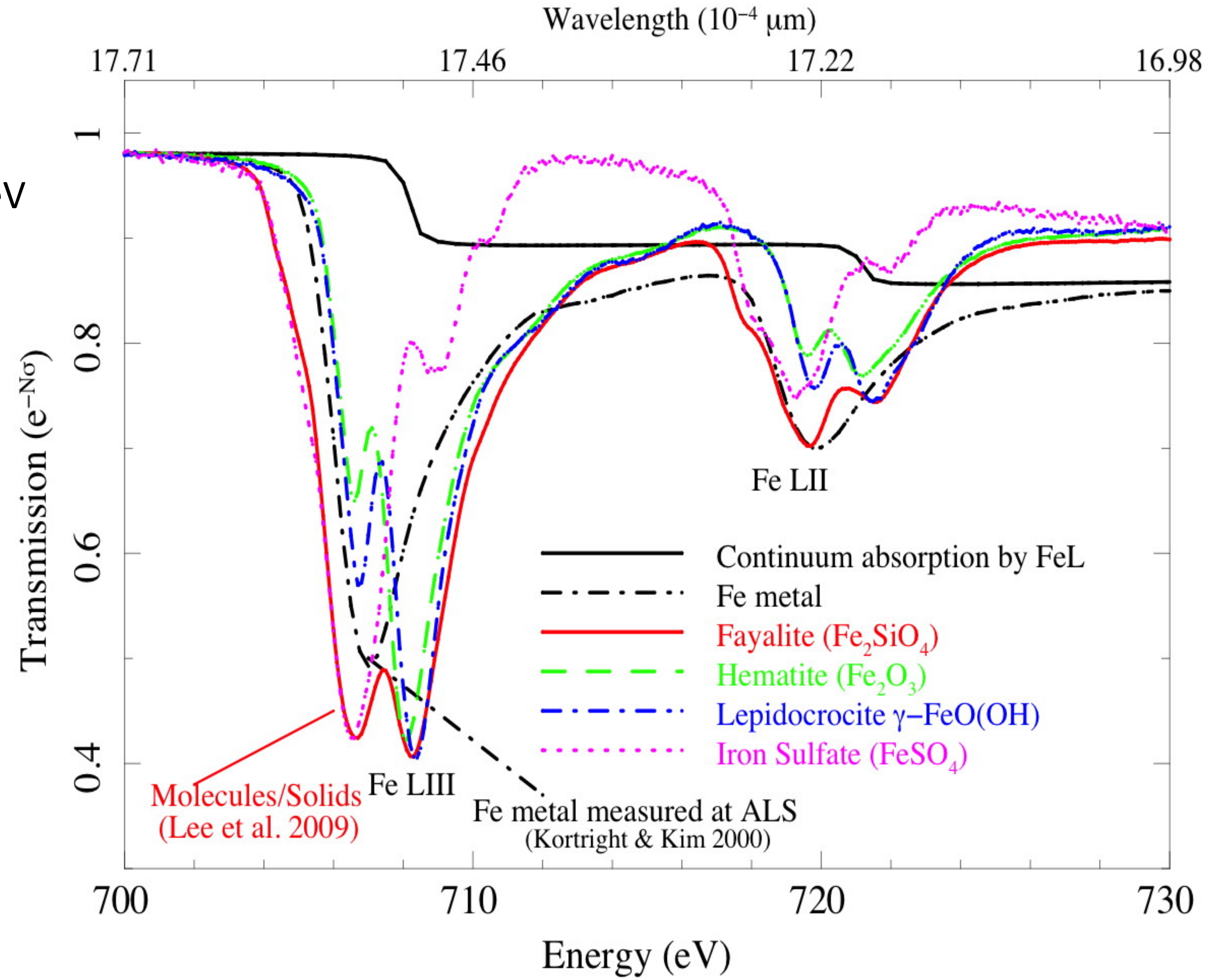
The red simulation shows the same for a **100 ks** exposure with the **HETG** onboard **Chandra**. The **HETG** bandpass usually cuts off below 30 Angstrom

Lee et al. 2009

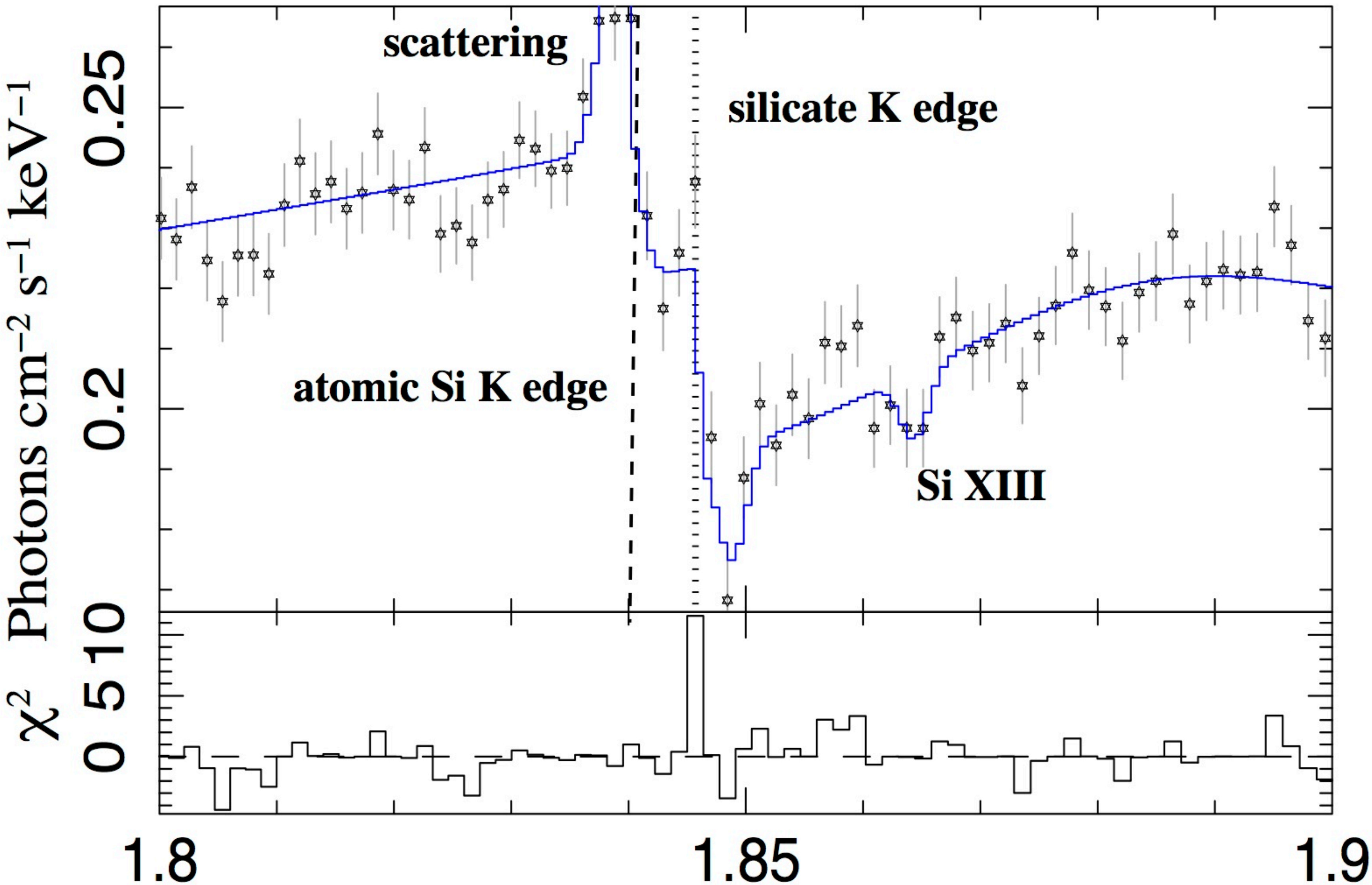
measure Fe $L_{II\&III}$ shape/depths

$\Delta E/E$ of MEG @ Fe L_{III} ~ 1 eV

Lynx gratings << 1 eV

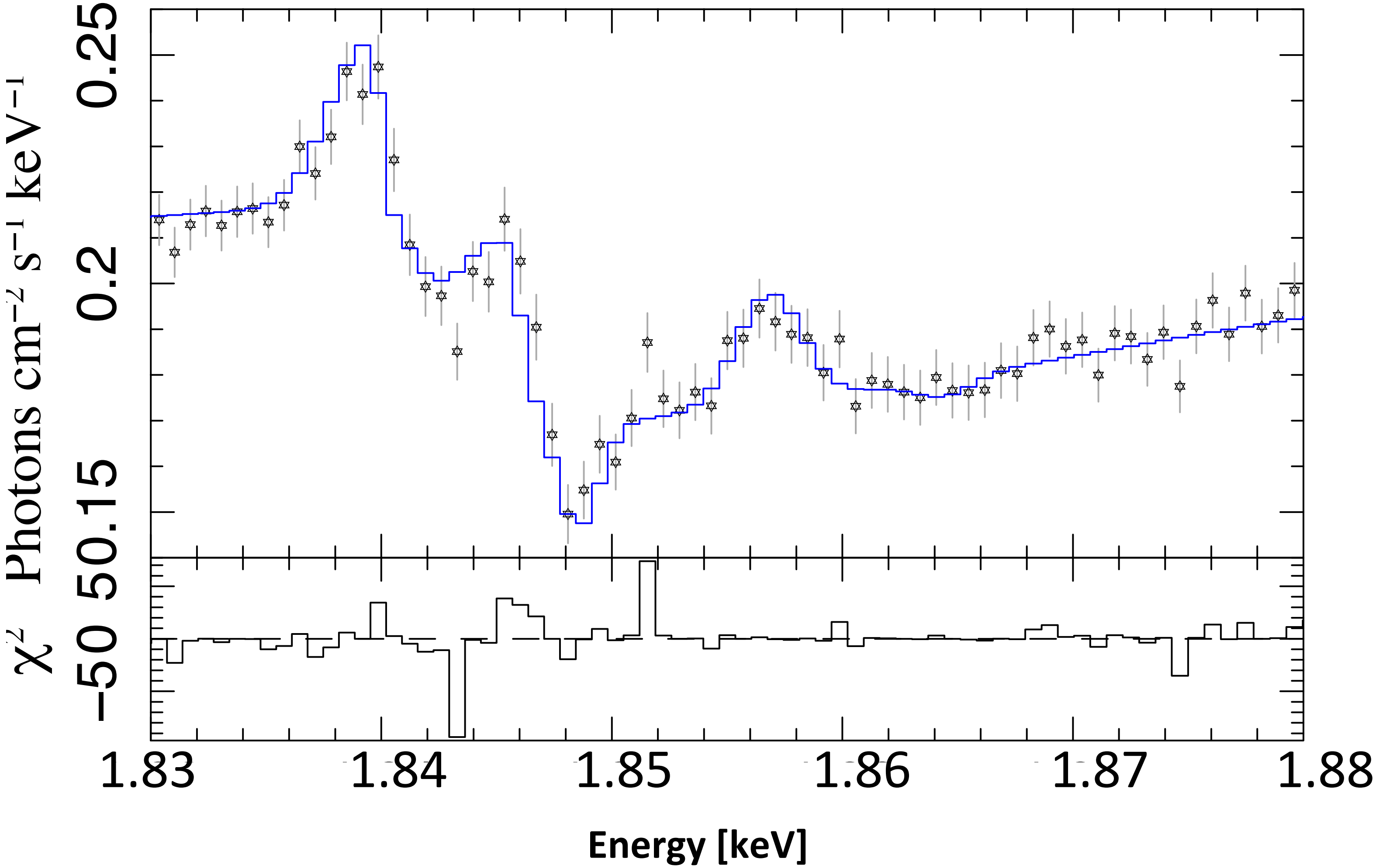


Schulz, Corrales & Canizares 2016 :



Obtain a highest resolved edge structure at sufficient statistic in the smallest possible data bin:

GX 3+1: 213ks



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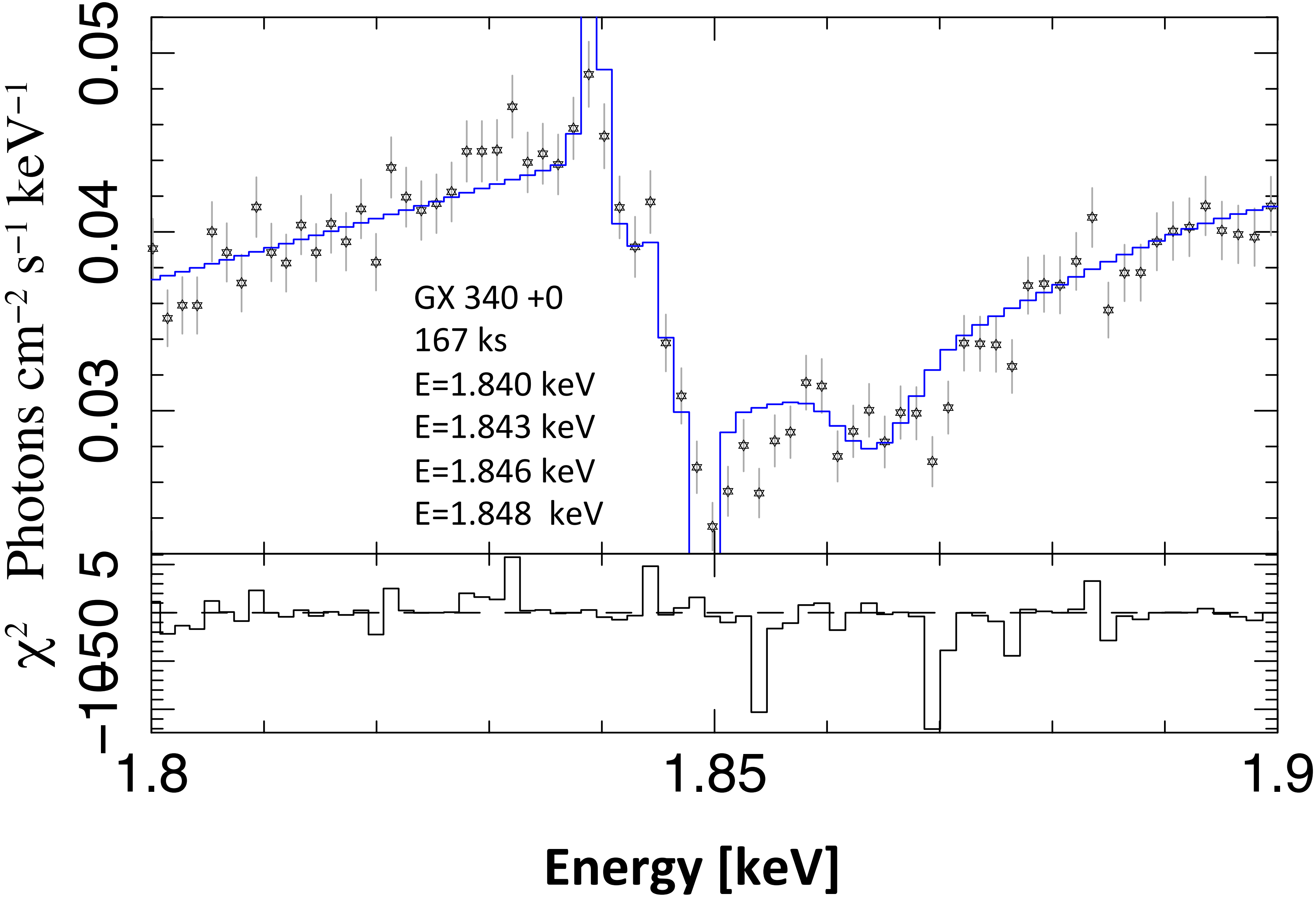


Photons cm⁻² s⁻¹ keV⁻¹
0.05
0.04
0.03
χ²
5
GX 340 +0
167 ks
E=1.840 keV
E=1.843 keV
E=1.846 keV
E=1.848 keV
1.8
1.85
1.9
Energy [keV]

Li et al., Phys. Chem. Minerals, 1995: Silicon K-edge XANES Spectra of Silicate Minerals

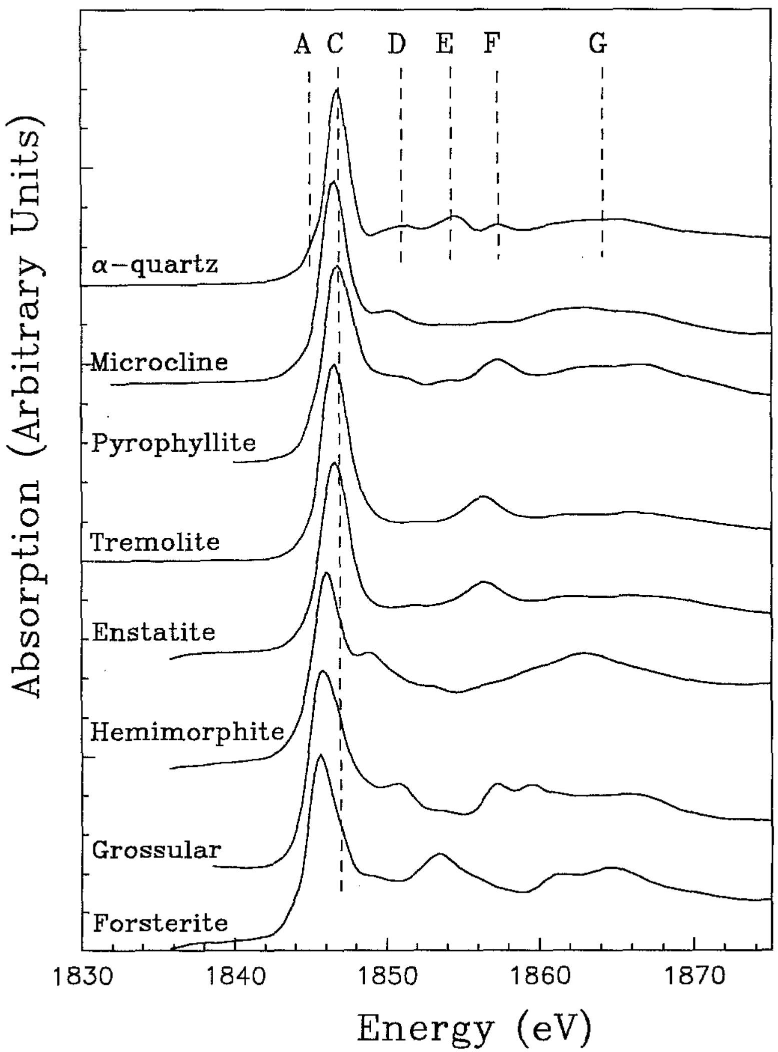


Fig. 1. Si K-edge XANES spectra of some representative silicate minerals with different degree of polymerization

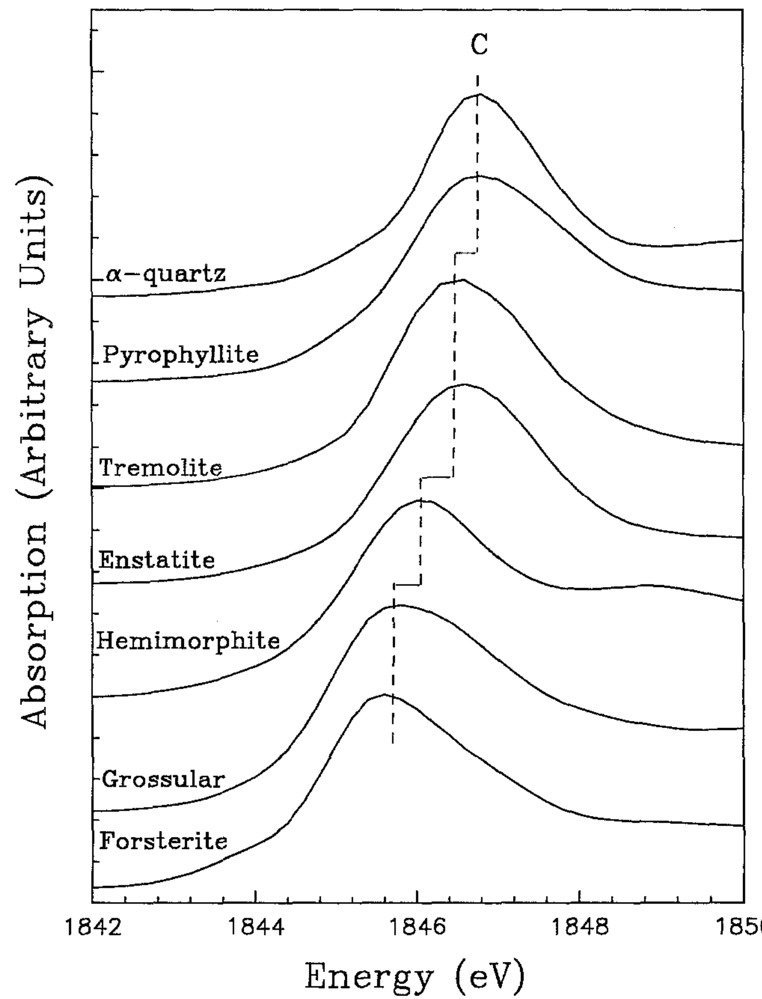
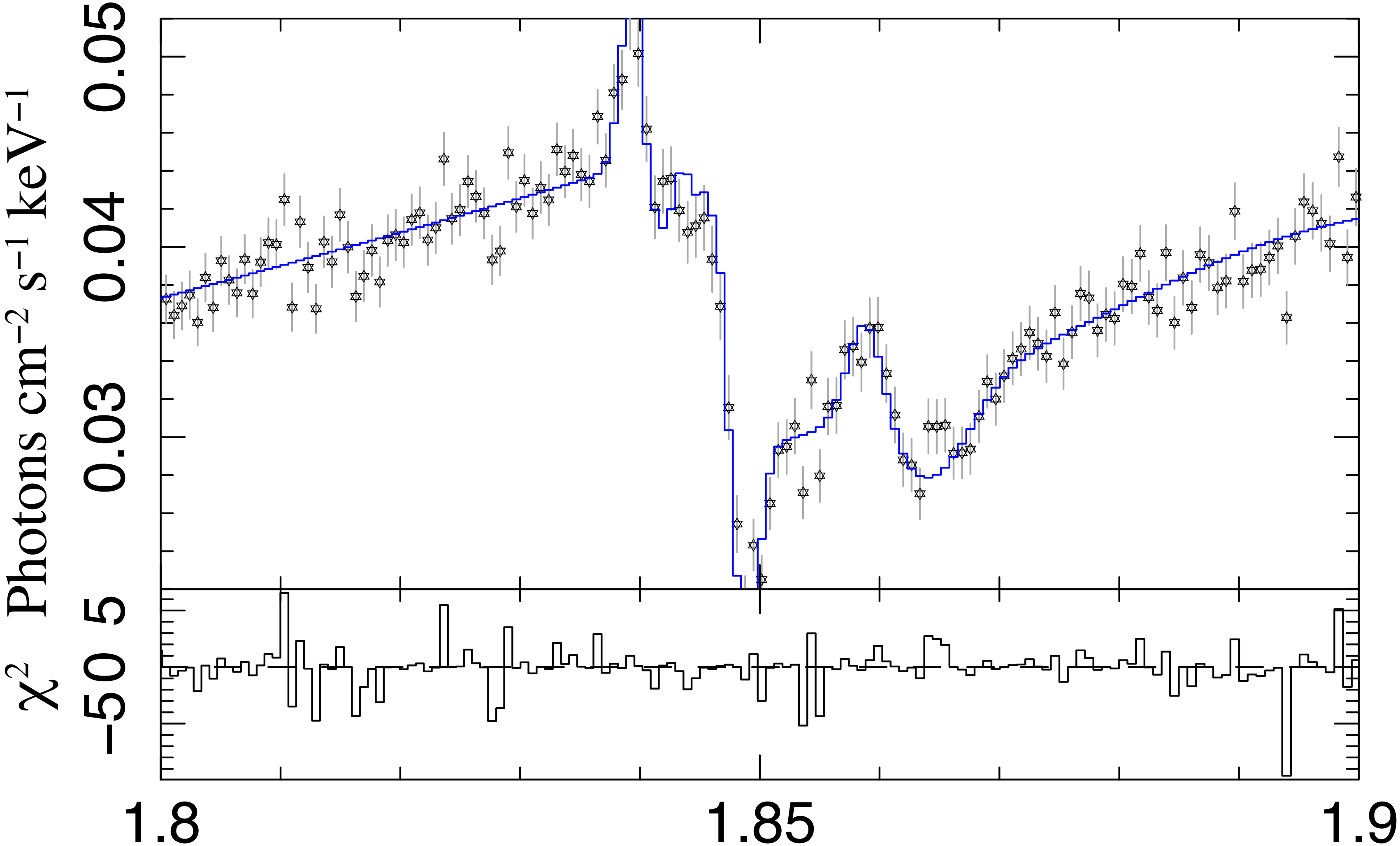


Fig. 2. Si K-edge (peak C) of representative silicate minerals of Fig. 1 in an expanded scale. The Si K-edge shifts to higher energy by 1.3 eV with increase in the polymerization of SiO_4^{4-} clusters, from nesosilicates to tectosilicates

So why Lynx?

Si K edge in GX 340+0 in 6 ks



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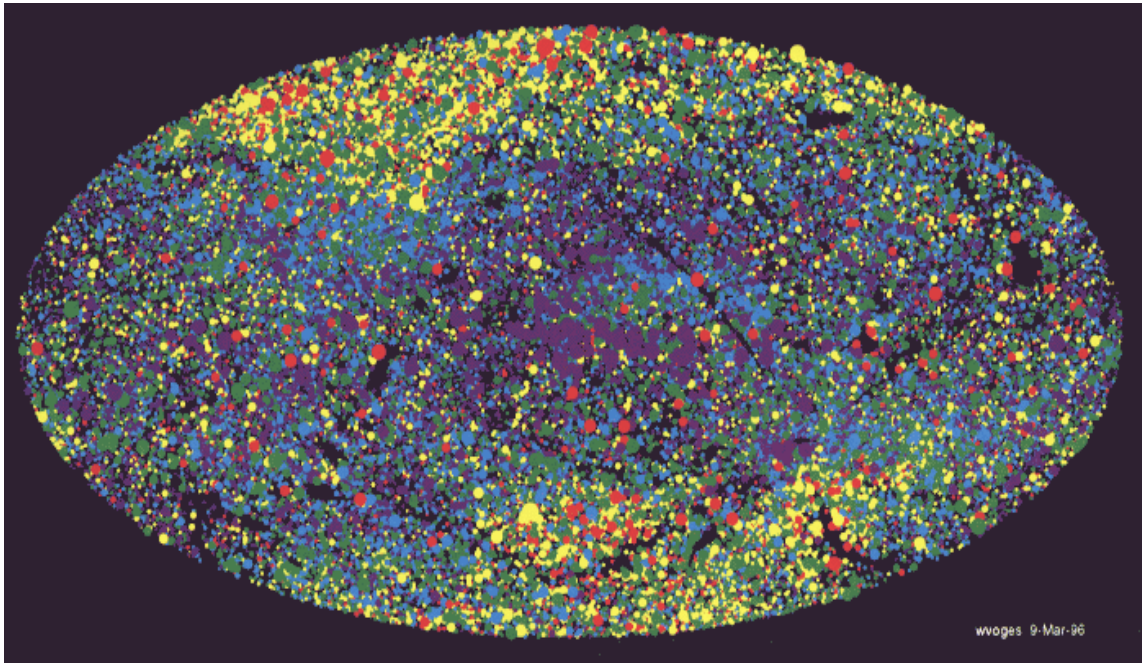
Lynx allows X-Ray Absorption Surveys

X-ray absorption spectroscopy is a powerful tool to study existing forms of matter in our Universe. LYNX allows us to perform high resolution X-ray absorption surveys as effectively as surveys are now or in very near future quite common in astronomy pursued in other wavelength bands such as optical, IR, and sub-mm.



~5000 Galactic Sources:

Log f_x = [-9, -13]

<exposure> > 1 ks

Neutral (cool) vs. lowly ionized (warm) ISM phases:	C K, O K, Ne K	$\delta E < 0.5$ eV
Dust composition and variability in the Milky Way:	Fe L, Mg K, Si K , Fe K	$\delta E < 2$ eV
Gas to dust ratio across the Milky Way:	Mg K, Si K	$\delta E < 2.5$ eV
The Fe K / L depth ratio across the Milky Way;	Fe L, Fe K	$\delta E < 2$ eV

Summary

X-ray absorption spectroscopy is a powerful tool to study existing forms of matter in our Universe. LYNX allows us to perform high resolution X-ray absorption surveys as effectively as surveys are now or in very near future quite common in astronomy pursued in other wavelength bands such as optical, IR, and sub-mm.