Updating the HETGS Effective Area

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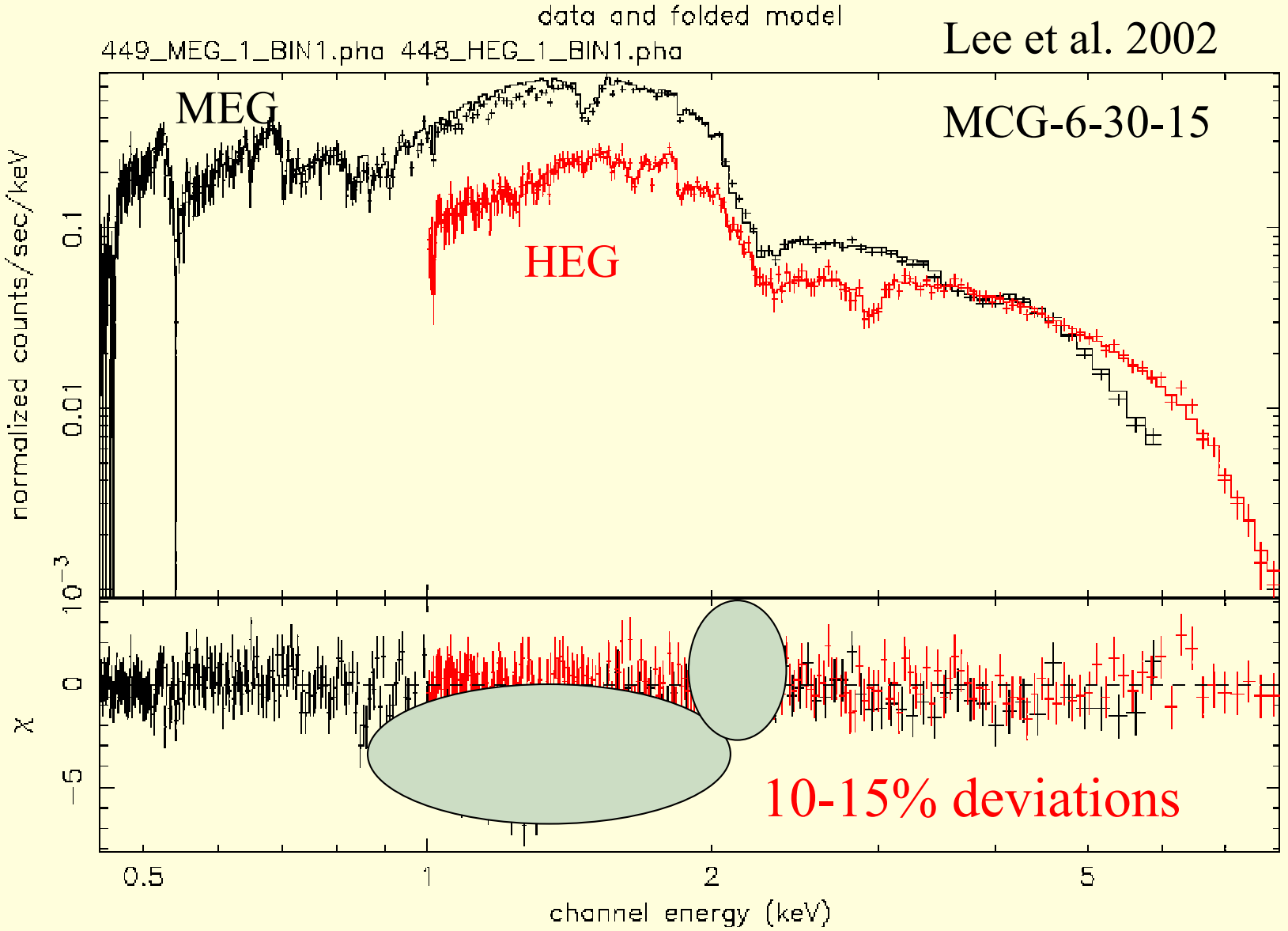
MIT CXC

Motivation for EA Adjustments



Components of Effective Area

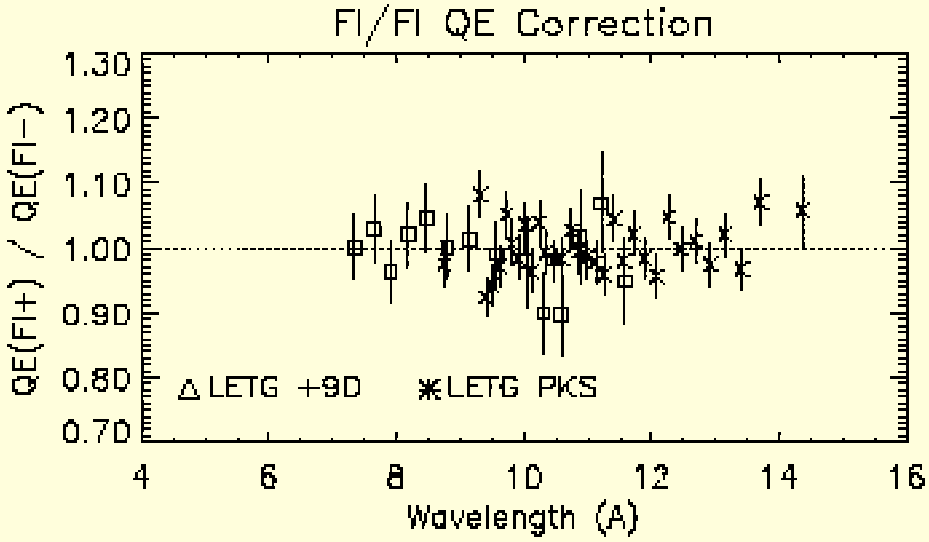
- Define $C_\lambda = A t \varepsilon c T Q\, n_\lambda \delta\lambda$
  - LRF wings are weak —> ignore the RMF
- HRMA Area (A)
  - Ir-M edge testable using continuum sources
  - Absolute area checked with cross-calibration
- Grating Efficiencies (ε)
  - Compare MEG against HEG using any source
- OBF (T) and Contaminant (c) Transmission
  - Test at edges (C-K, N-K, O-K, Si-K, Al-K)
- ACIS Quantum Efficiency (Q)
  - Test by comparing chips in +1 order to those in -1
  - Require $Q < 1$

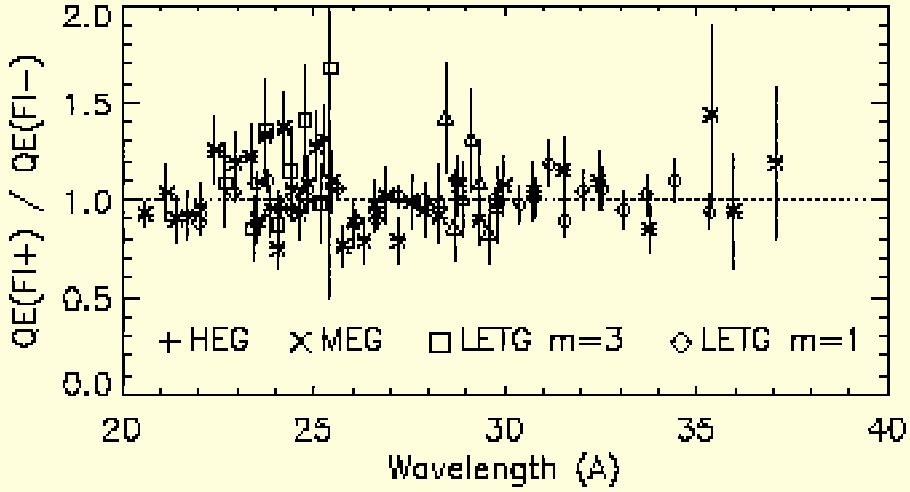
Method for Adjusting ACIS QEs

- Define EA via $C_i^+ = n_i A t \varepsilon c T Q^+ \delta\lambda$
  - $[\lambda, \lambda+\delta\lambda]$ is the wavelength interval
  - Q^+ is the (pileup corrected) ACIS QE on +1 side
  - n_i is the flux of source i at λ (in ph/cm^2/s/Å)
  - Ci+ gives the counts in the bin
  - t is the exposure time
  - ε is the grating efficiency, which has no +/- asymmetry
- Form ratios independent of all but Q
  - $r_i = C_i^+ / C_i^- = Q^+ / Q^-$
  - Sum over source: $R = \Sigma_i C_i^+ / \Sigma_i C_i^-$ (bias, variance better than $\Sigma_i r_i$)
  - Sum over short wavelength intervals
- When $R \neq 1$, then adjust Q^+ or Q^-
  - No absolute reference yet
  - I currently correct FI chips (see later)
- See: http://space.mit.edu/ASC/calib/letg_acis/letg_acis_cal.ps.gz

FIs Have Good Relative QEs

- Compare +1 to -1 when both are FI chips
- R is consistent with 1
- Pileup is no concern
- CTI-induced QE variations minor for these offsets, energies





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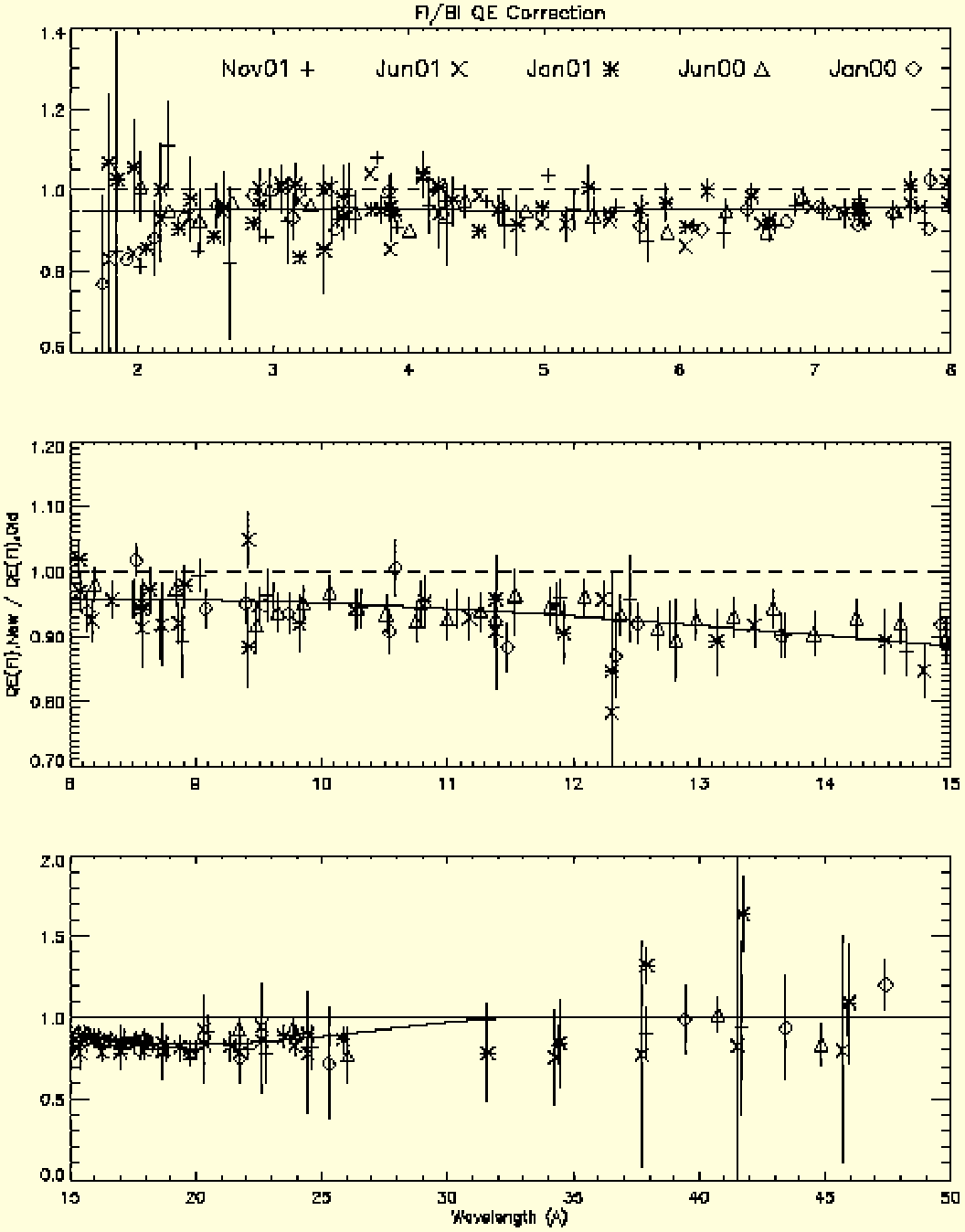
- Compare BI to FI
- 8-20% differences found
- Corrected BI QE is 99-101% in 0.7-1.5 keV range —> fix FI QEs as a group
- Obtain correction in ascii file at: http://space.mit.edu/ASC/calib/ficorr.txt



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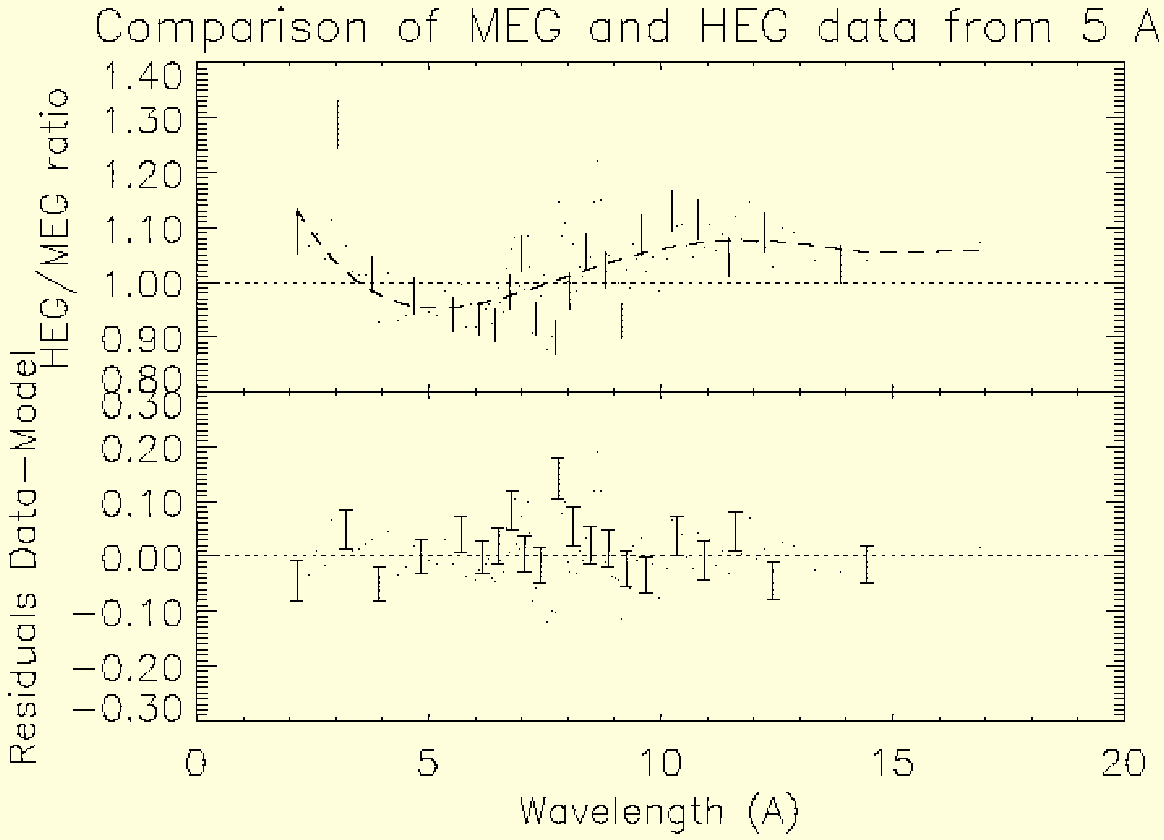
Comparing MEG to HEG

- Before efficiency update, analysis gave 5-8% differences
- Result needs to be updated and released
- MCG data already corrected for BI/FI, implicates MEG
- See POG fig. 8.26



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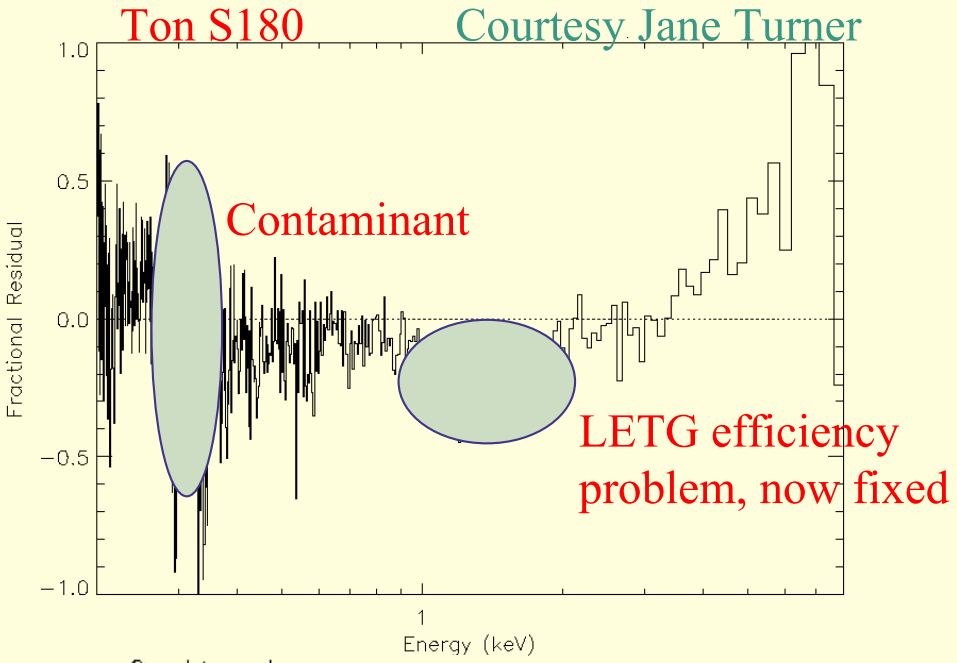
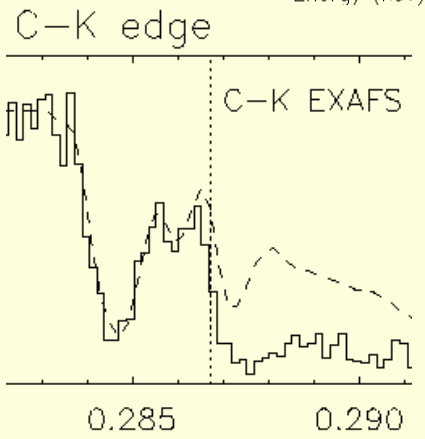
OBF and Contaminant Edges

- Observations of AGN with ACIS/LETG led to discovery of contaminant C-K edge
- Early repair was a one-time fix, good for observations in early 2000
- Later observations showed systematic edge deepening
- Depth now up to x10, still no sign of N-K

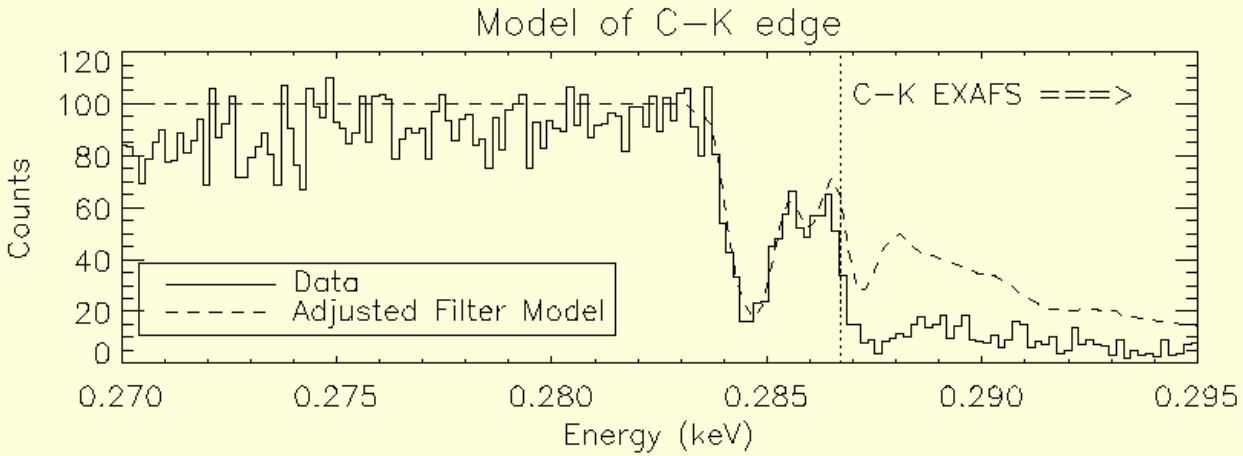


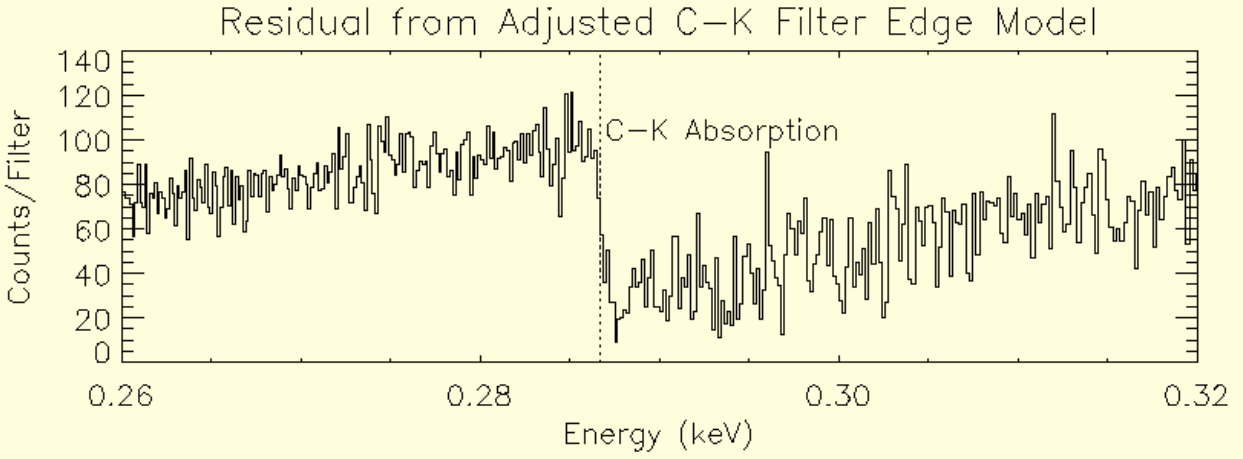


- Count spectrum from XTE J1118+480
- Filter dominates below .2867 keV, contaminant above

Motivation for C-K Edge Analyses

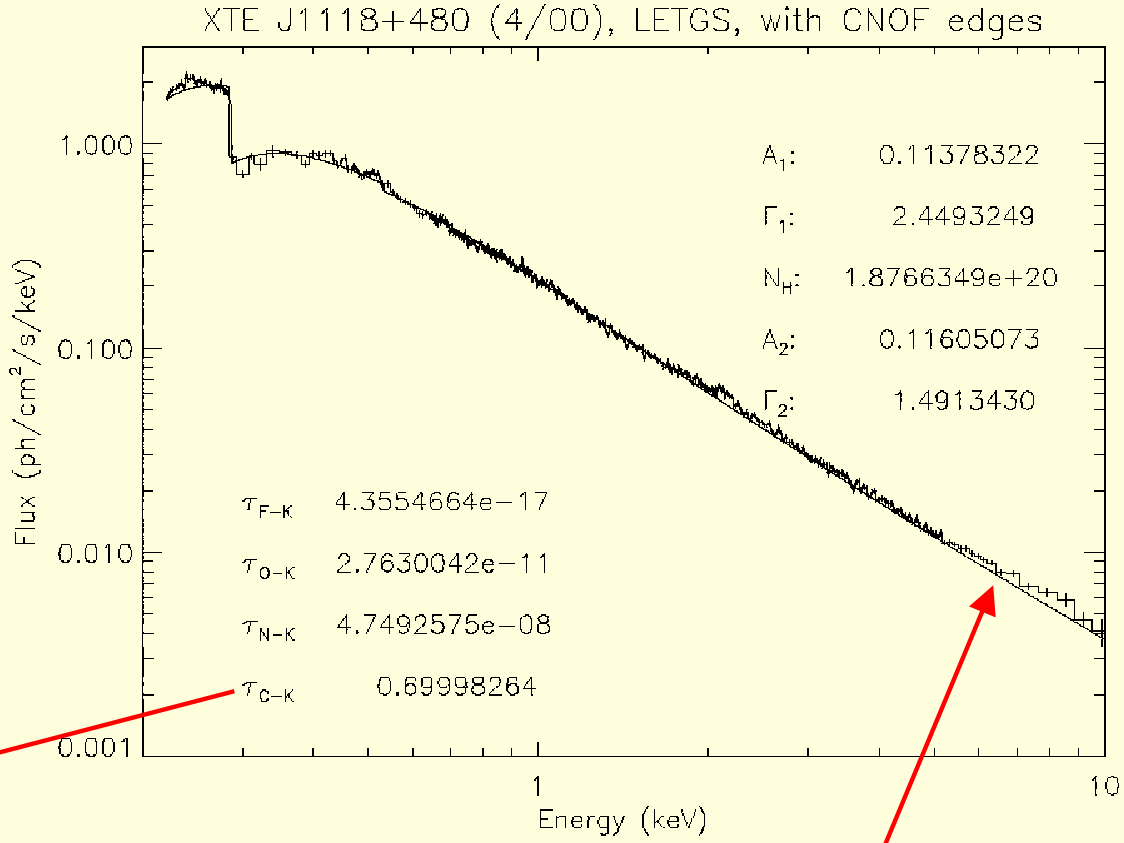
- Current composition shows little N, F and possible O from K edges
- Large optical depth at C-K shows NEXAFS in many compounds
- NEXAFS shape is related to bonding within compound

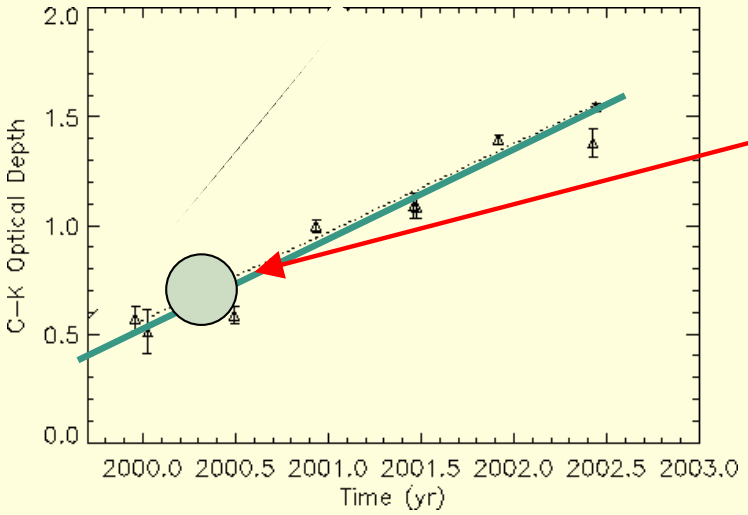




LETG/ACIS Spectral Fits

- Nine continuum sources: 2PL fits
- C-K edge depth measured for all





Spectrum curves upward — suspected to result from broad Fe-K

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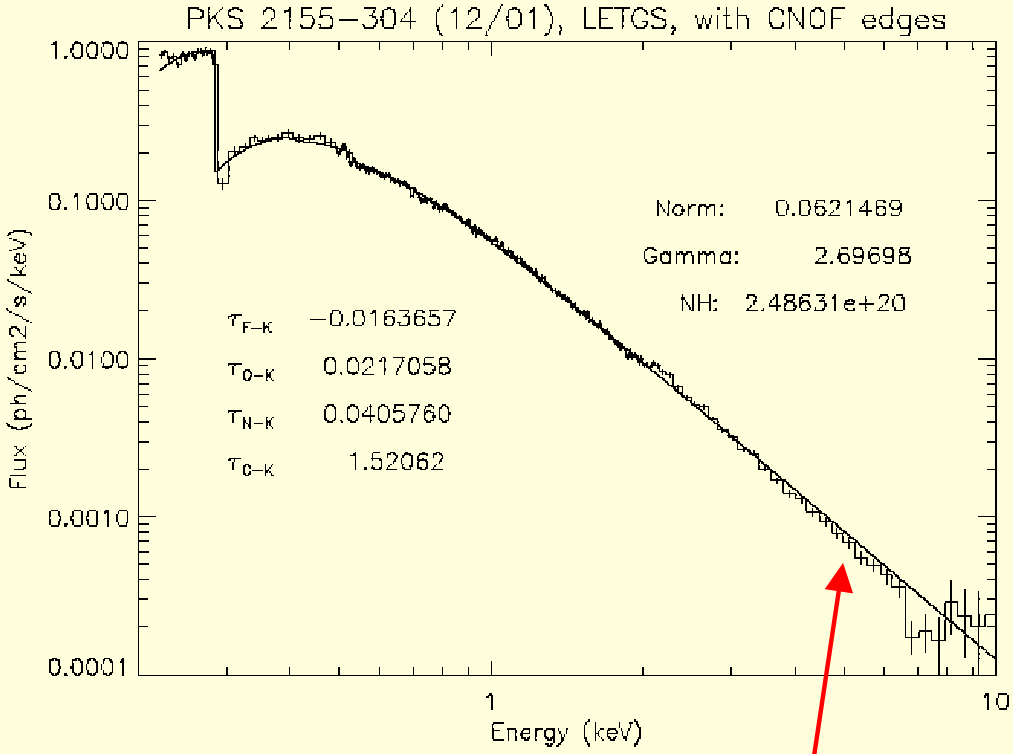
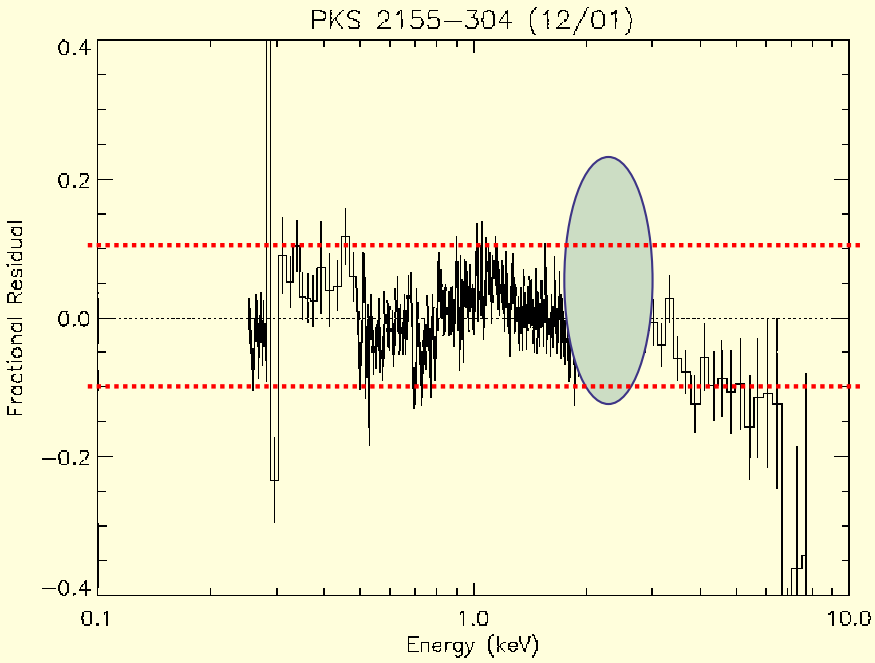
LETG/ACIS Fit Residuals





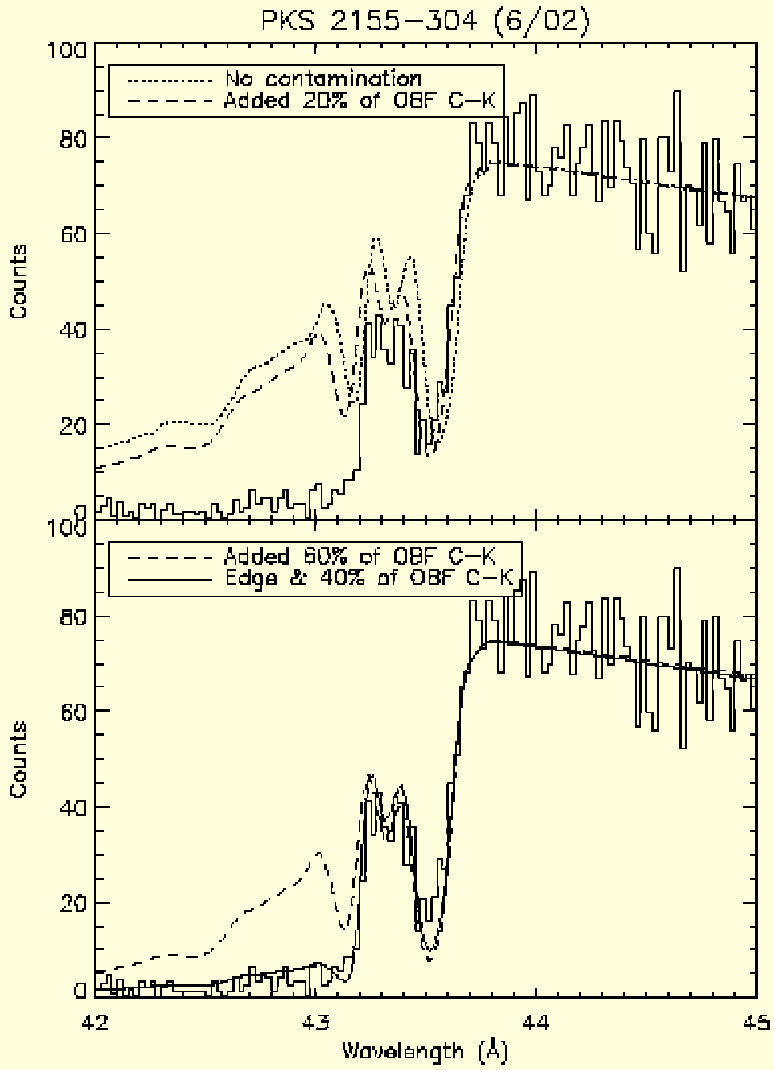
Spectrum curves downward

Refits use 2PL model

- Systematic relative errors down to ±10%
- Ir-M edge appears

C-K Edge in Recent PKS 2155-304 data

- Edge now shows deviation in resonance structure
- Additional component is not like C in OBF
  - Matching at 43.3 Å gives problem at 43.5 Å
  - Contaminant has no resonant feature at 43.5 Å



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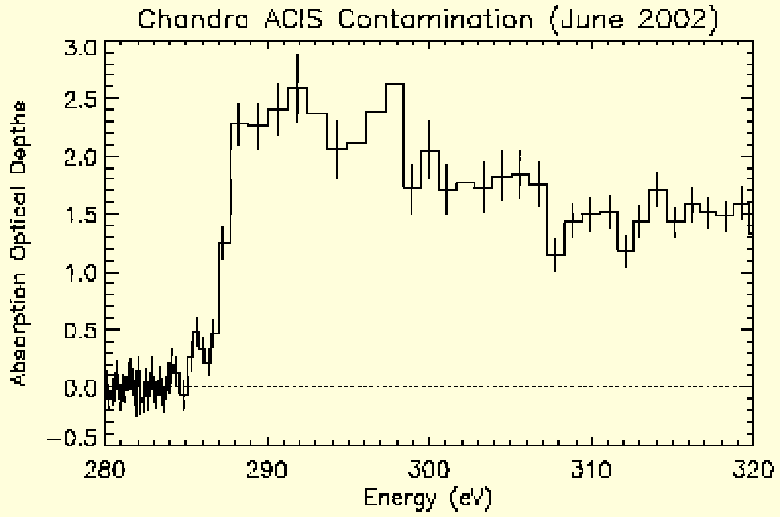
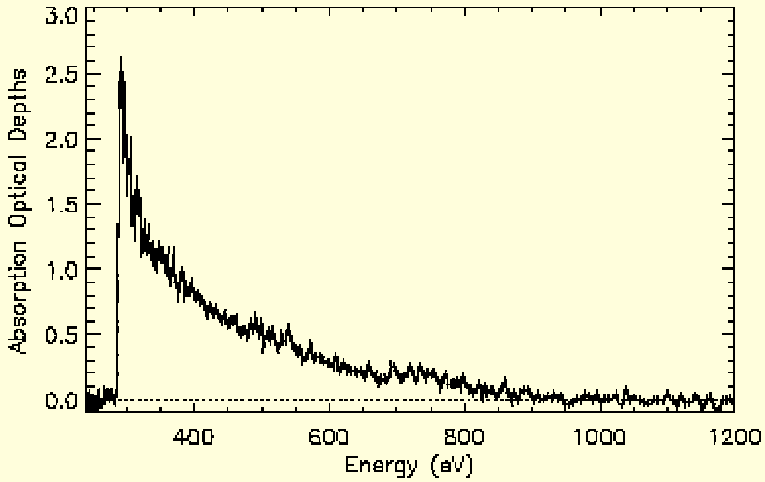
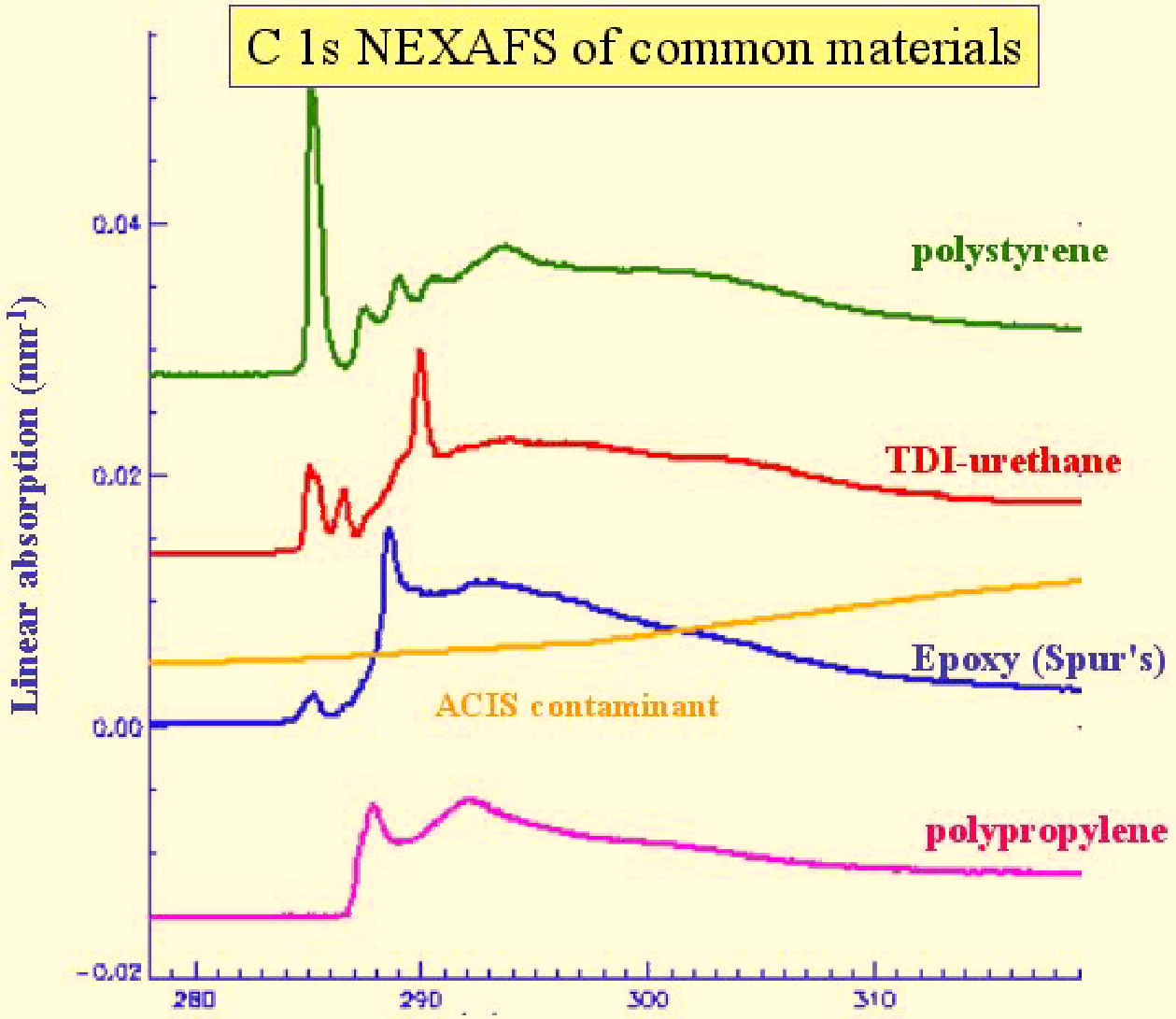
C-K Edge in Recent PKS 2155-304 data (cont'd)

- 1-2% uncertainties obtained at high spectral resolution
  - More detail now appears at C-K
  - Model will be released after testing
- Slight edge at O-K
  - Low abundance of O relative to C
- N-K is practically absent
  - N-K was on both BI chips where QE is high and has no N-K edge; OBF is OK
  - Observations on FI chips show possible modeling error
- F-K edge, if present, is not simple





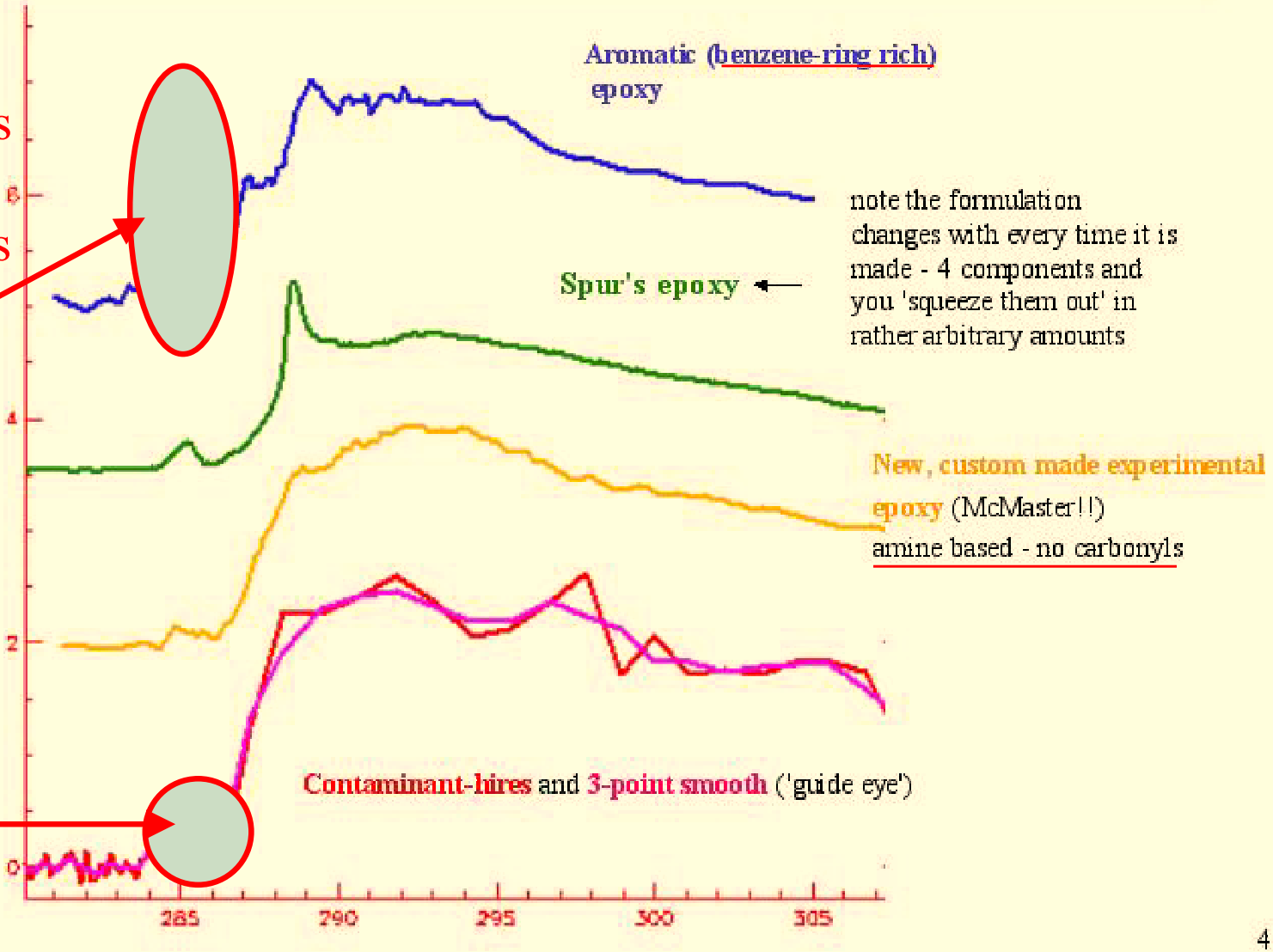
Data from Adam Hitchcock (McMaster U.)



Without higher resolution / sampled spectra, it will be very difficult to say more than already deduced

Data from Adam Hitchcock (McMaster U.)

Comparison of 3 different epoxies to high resolution ACIS data



This feature is due to C in Benzene rings and isn't strong in the contaminant

New feature

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Summary of HETGS EA Studies

- HRMA Area (A)
  - Ir-M edge : 10-15% deviation over 2.1-2.5 keV region
- Grating Efficiencies (ε)
  - MEG efficiencies require 5-10% adjustments
  - Next item to be released (12/02)
- OBF (T) and Contaminant (c) Transmission
  - OBF is fine at C-K, N-K; other edges in progress
  - Contaminant being characterized at C-K, O-K, no N-K
- ACIS Quantum Efficiency (Q)
  - FI chips appear to require 10-20% adjustments, see: http://space.mit.edu/ASC/calib/ficorr.txt
  - In progress: 10-15% off at N-K, narrow spike at Si-K
- Absolute EA: ±10% cross-check with ASCA
  - More work in progress cross-calibrating with XMM