Composition of the Chandra ACIS Contaminant

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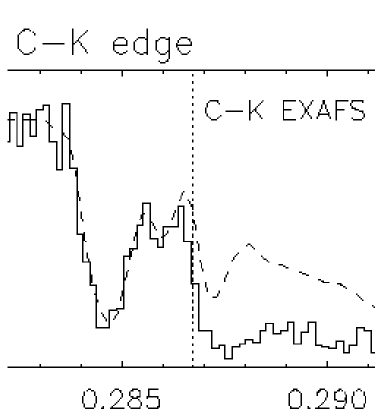
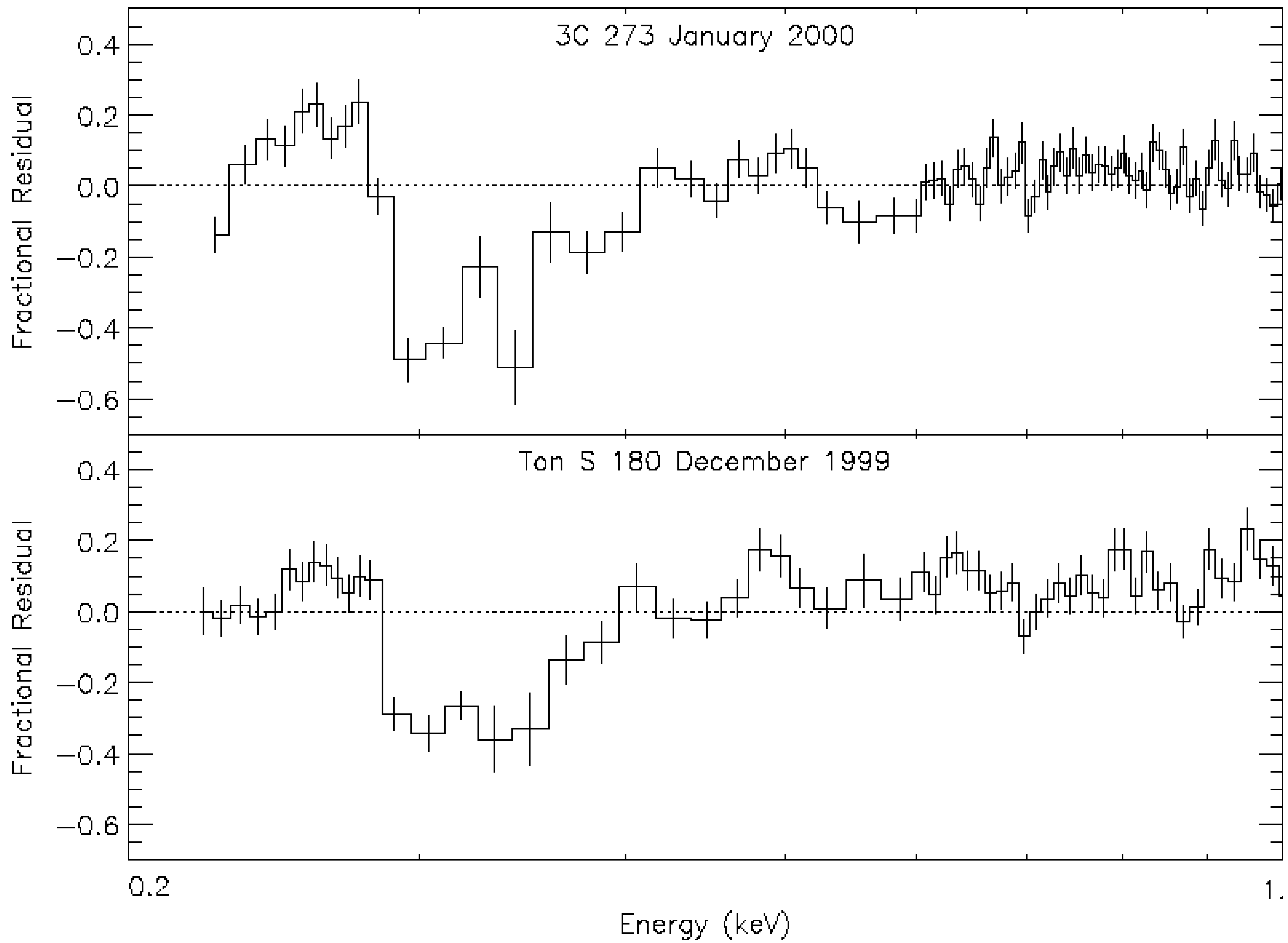


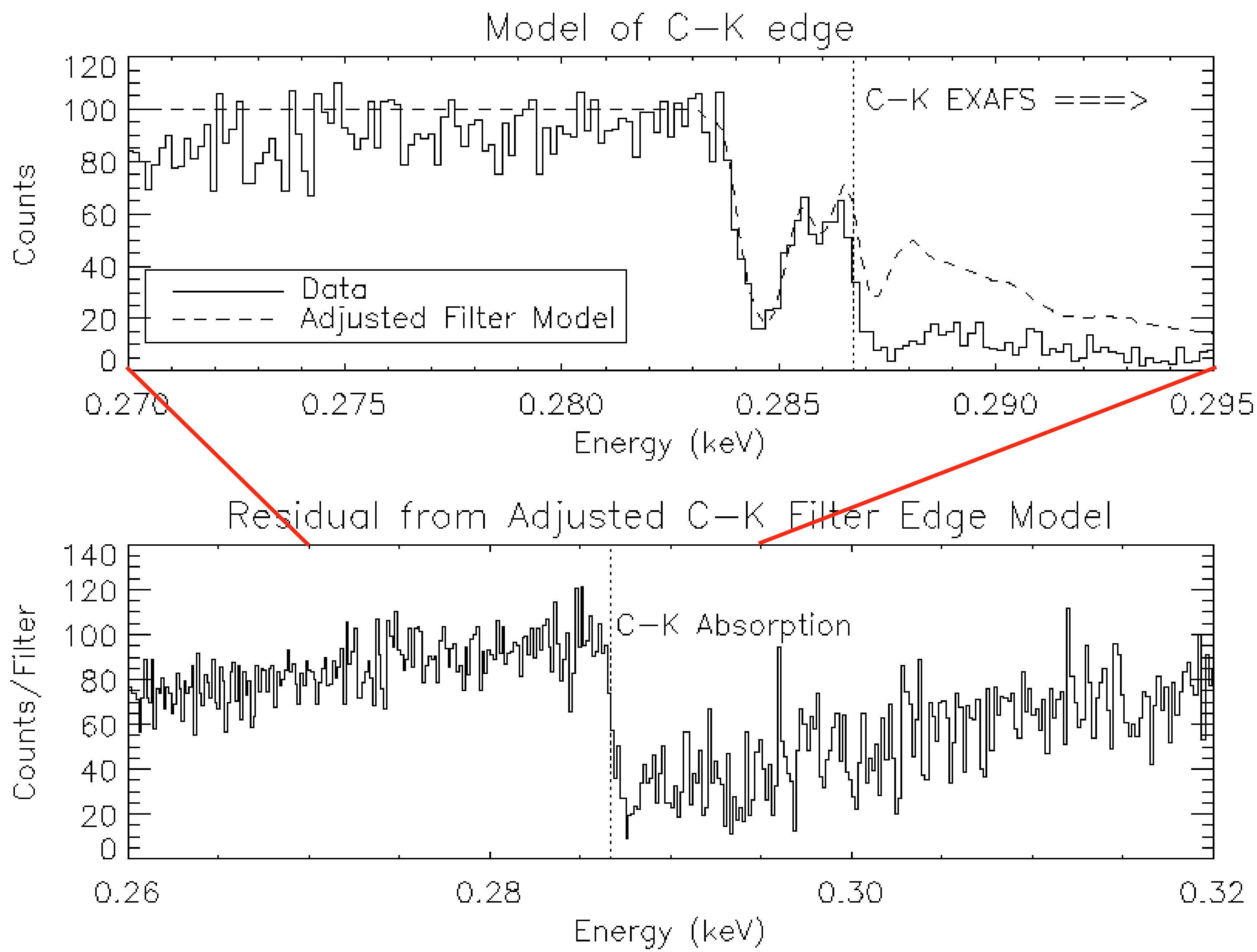
Early Findings

- 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



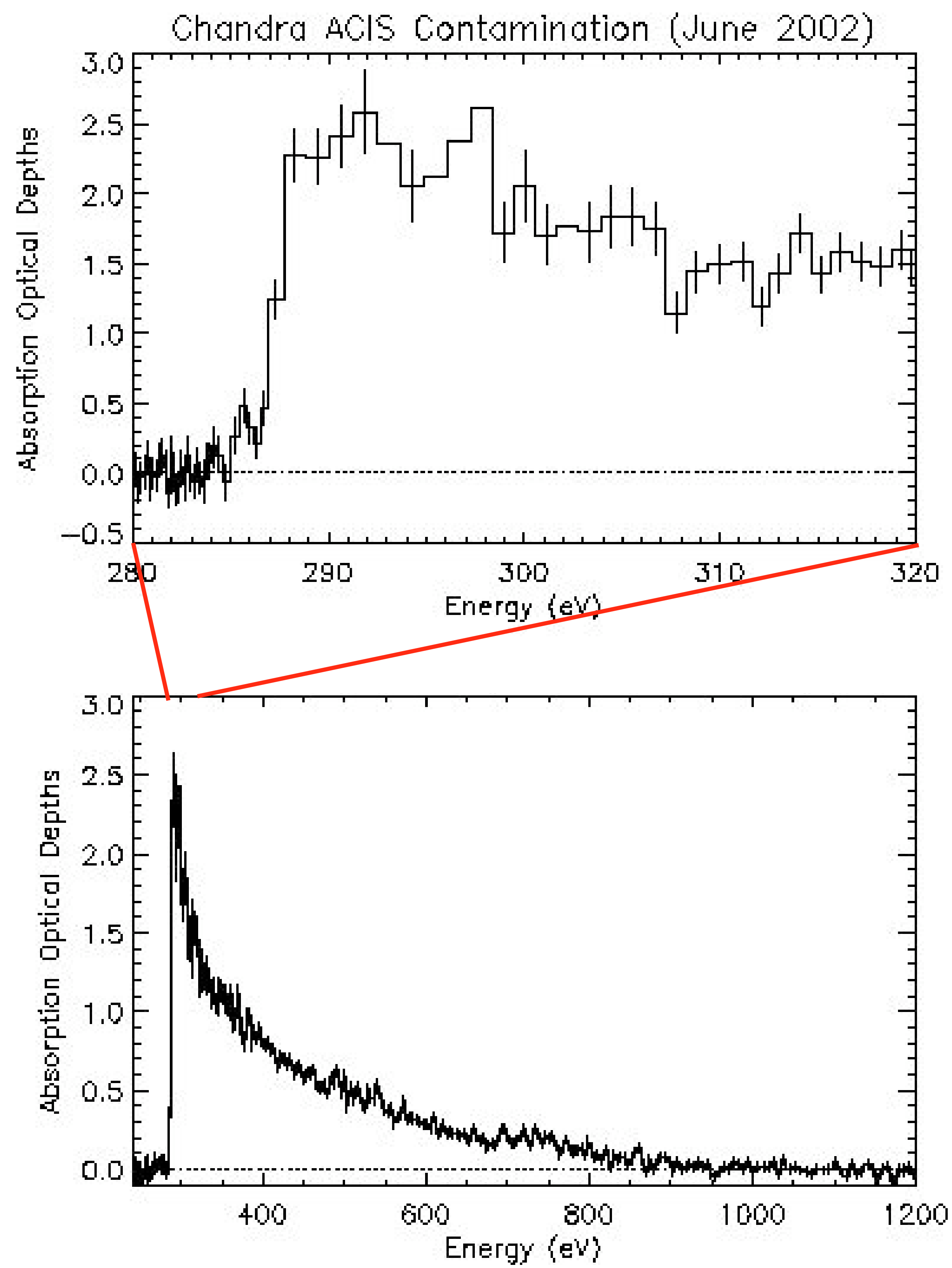
C-K Edge is Unlike the Edge in the ACIS Filter

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



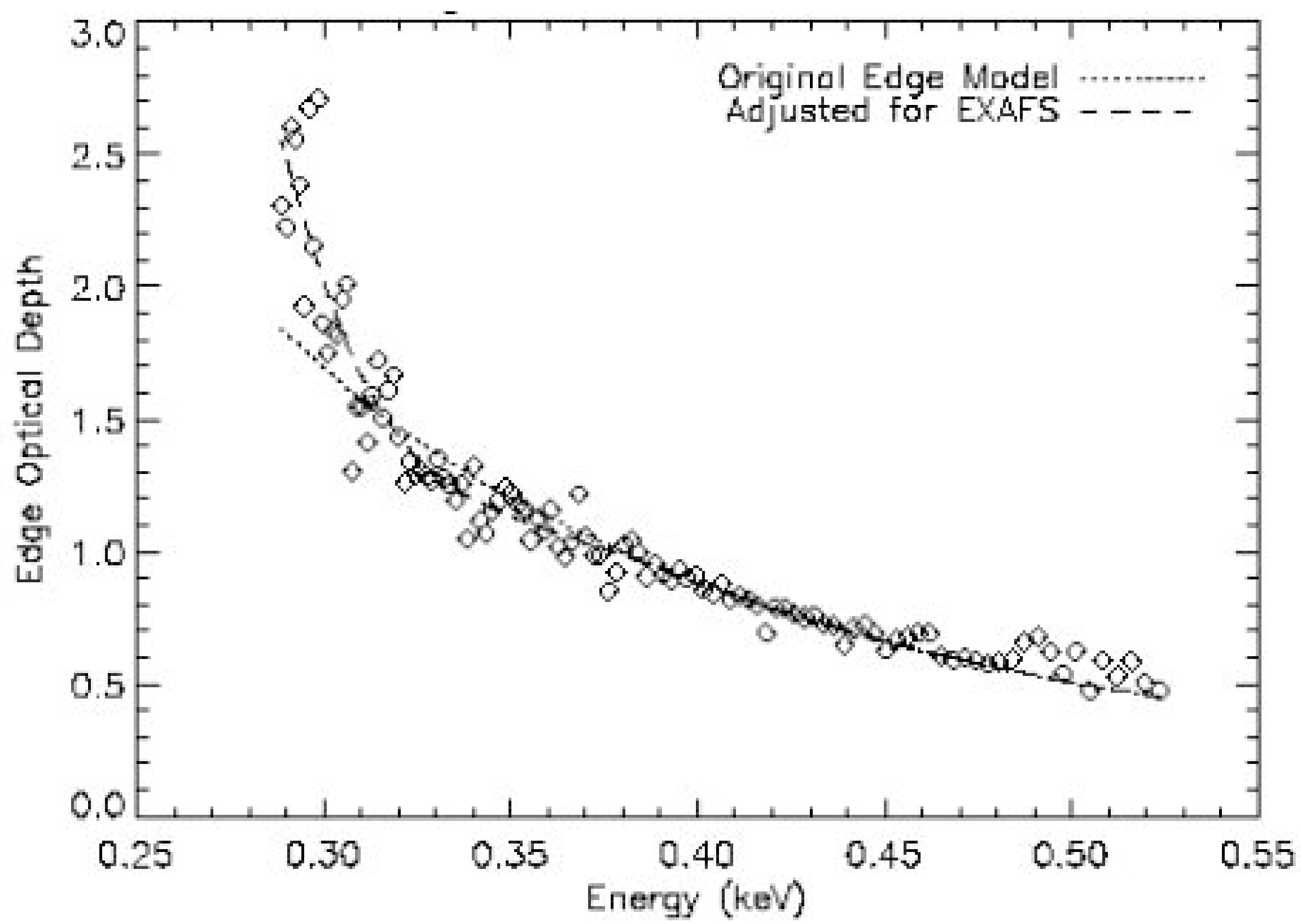
Modeling the C-K edge: EXAFS

- Data taken from June 2002 observation of PKS 2155-304
- Fit to power law without the 0.28-1.0 keV region
- Henke constants used above 0.4 keV
- Slight feature in 0.285-0.287 keV region added
- No N-K to <5%



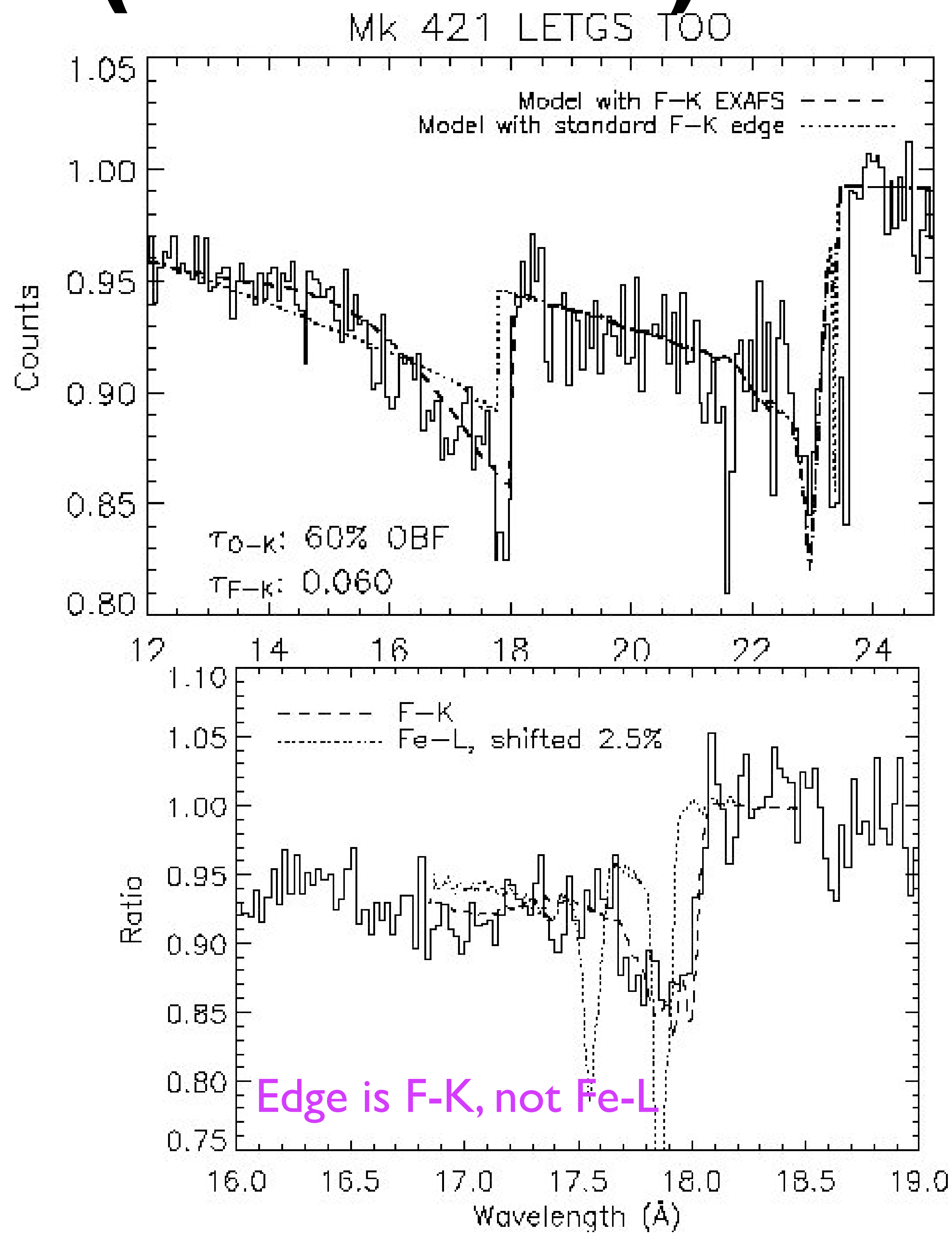
Modeling the C-K edge: EXAFS

- Opacity due to C-K edge in contaminant is adjusted near the edge
- Adjustment has "ripple" and exponential drop away from edge
- Edge is at 0.2867 keV



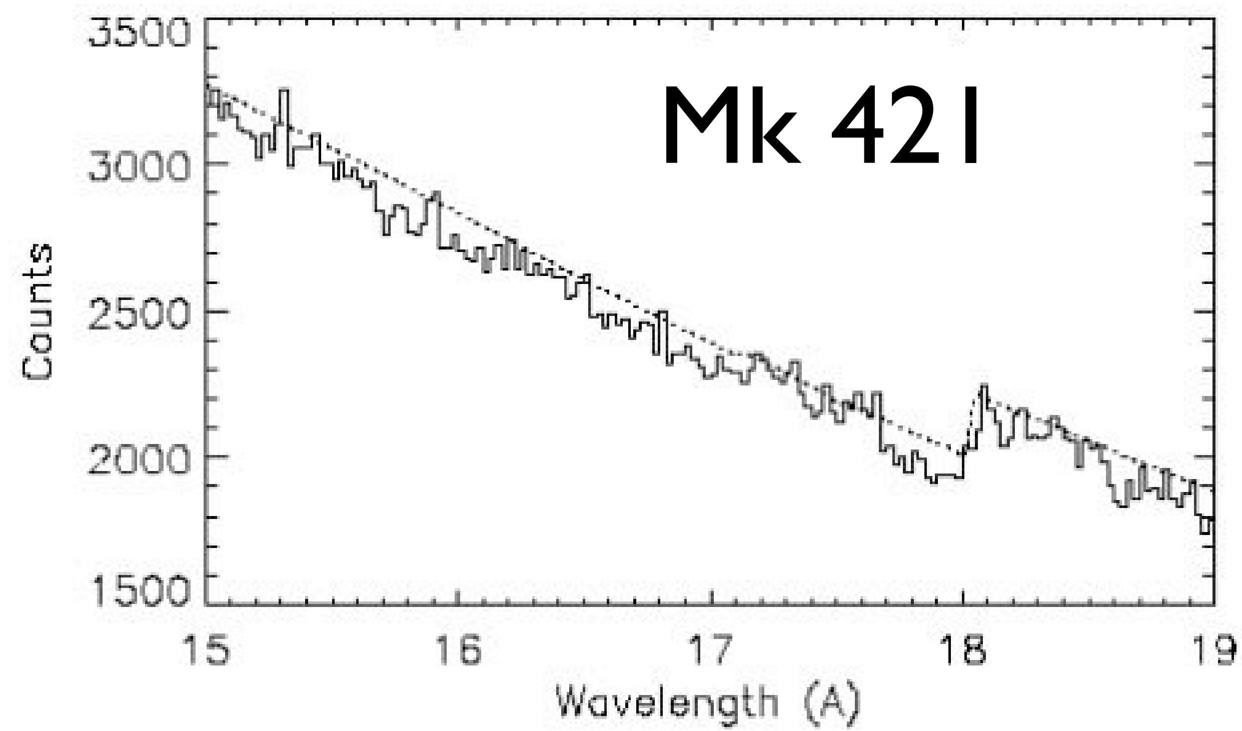
Modeling the O-K and F-K edges (Mk 421)

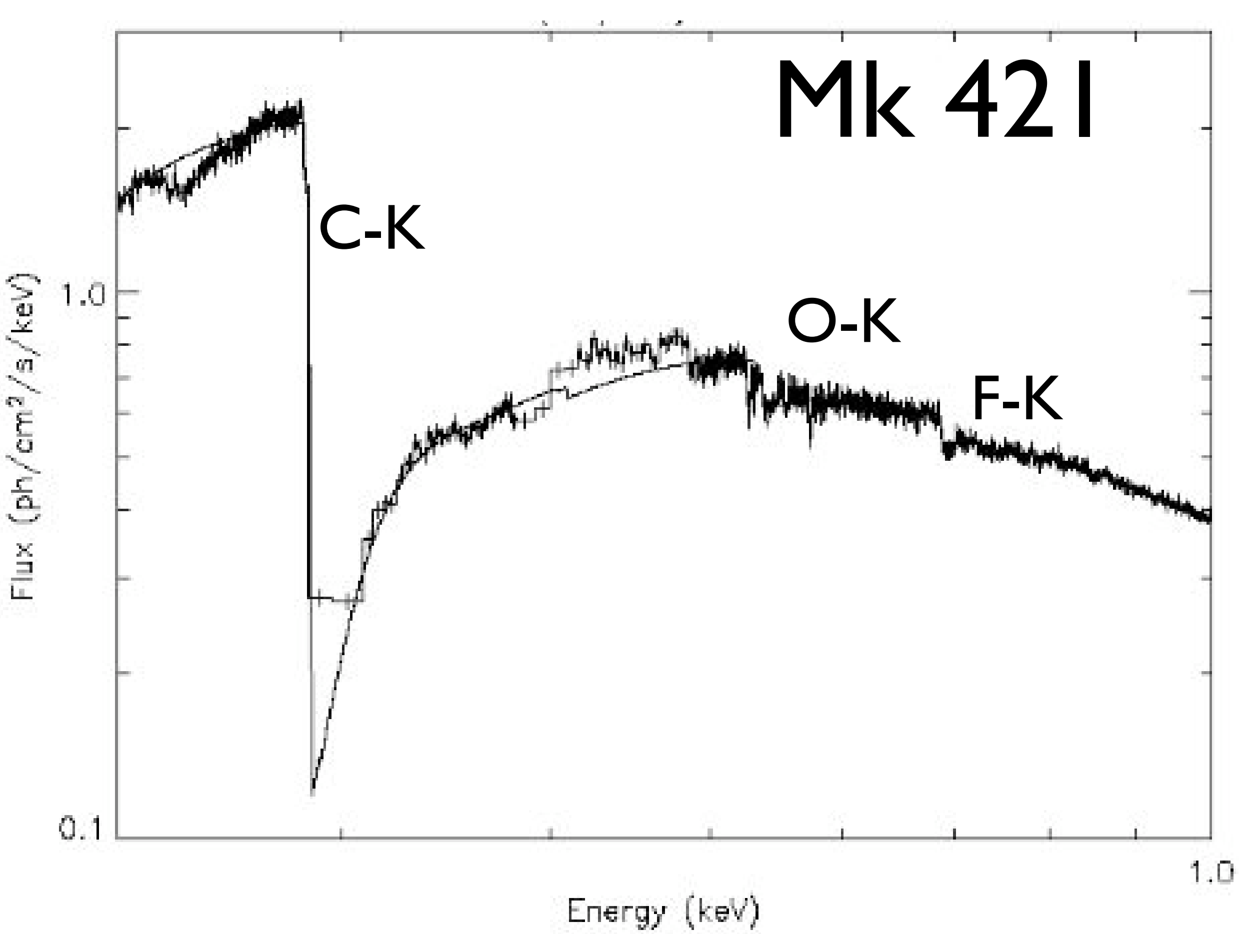
- TOO on Mk 421 gave a very good spectrum: over 4e6 counts
- Accounting for new C-K edge, O-K and F-K detected
  - F-K is not ID'ed with Fe-L in source frame
- O-K edge model derived from O in polyimide
- F-K edge constructed as in C-K, with NEXAFS & EXAFS

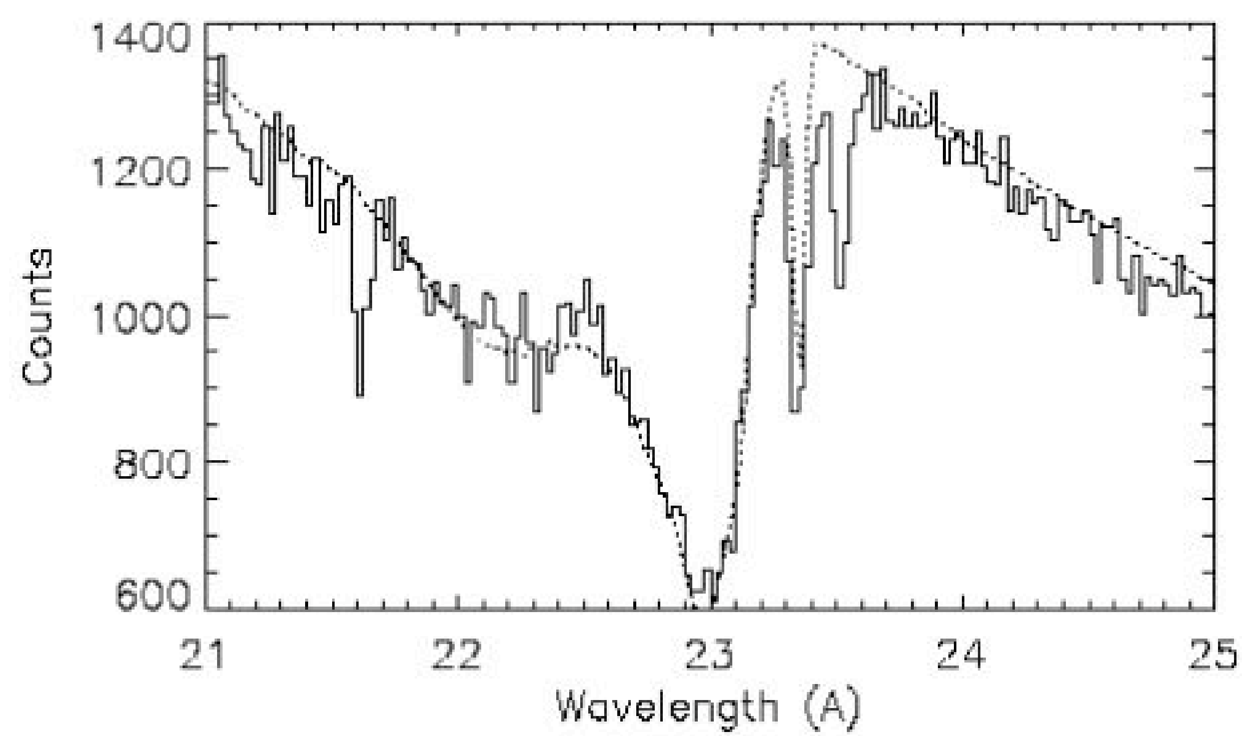


Checking the Model Fit

- Good fits obtained in F-K and O-K edge regions
- Features that remain are
  - intrinsic (ISM), or
  - due to uncorrected BI/FI relative errors





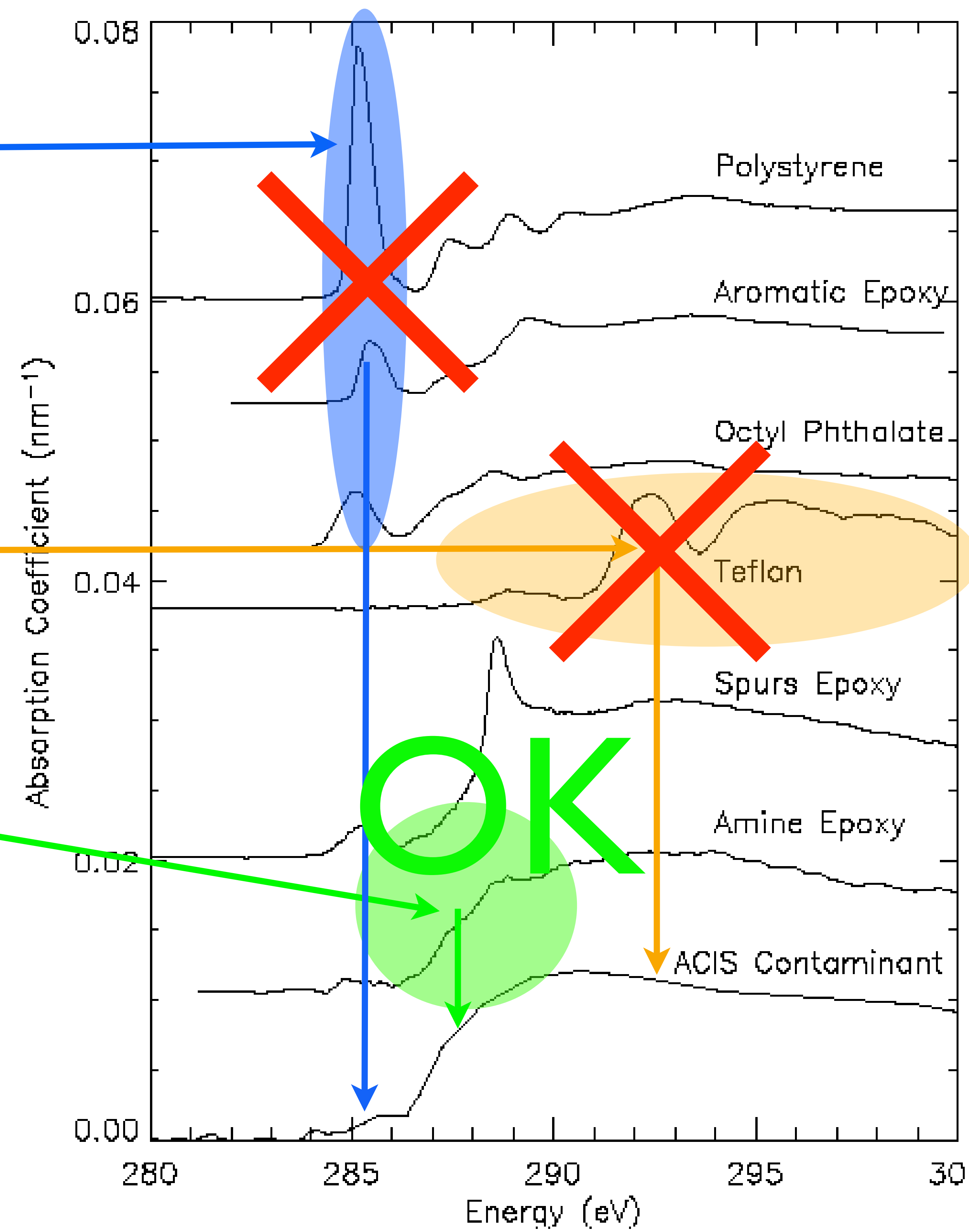


Abundances in the ACIS Contaminant

- Column densities, in atoms per sq. cm are
  - Carbon: 2e18
  - Nitrogen: < 7e16
  - Oxygen: 1.75e17
  - Fluorine: 1.45e17
- Relative to Carbon:
  - N/C < 30
  - O/C = 11.5 ± 1
  - F/C = 14 ± 1
- Fluorinated compounds in Chandra (Braycote, Krytox) do not have so little F or O relative to C
  - Fluorocarbons must comprise only a small part of contaminant
  - Fluorocarbons can "crack" due to radiation into smaller compounds that may be hydrocarbons

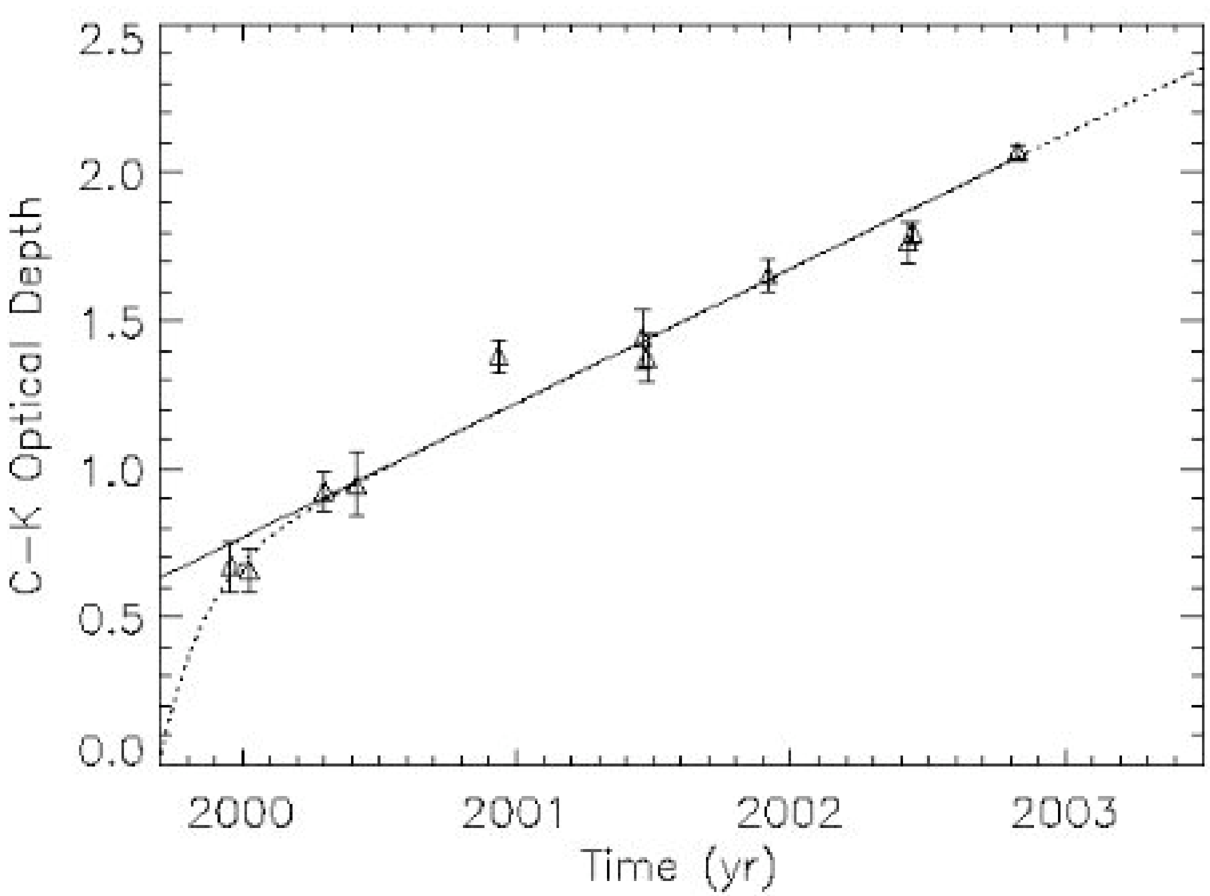
C-K NEXAFS Set by C-O and C-F Bonds

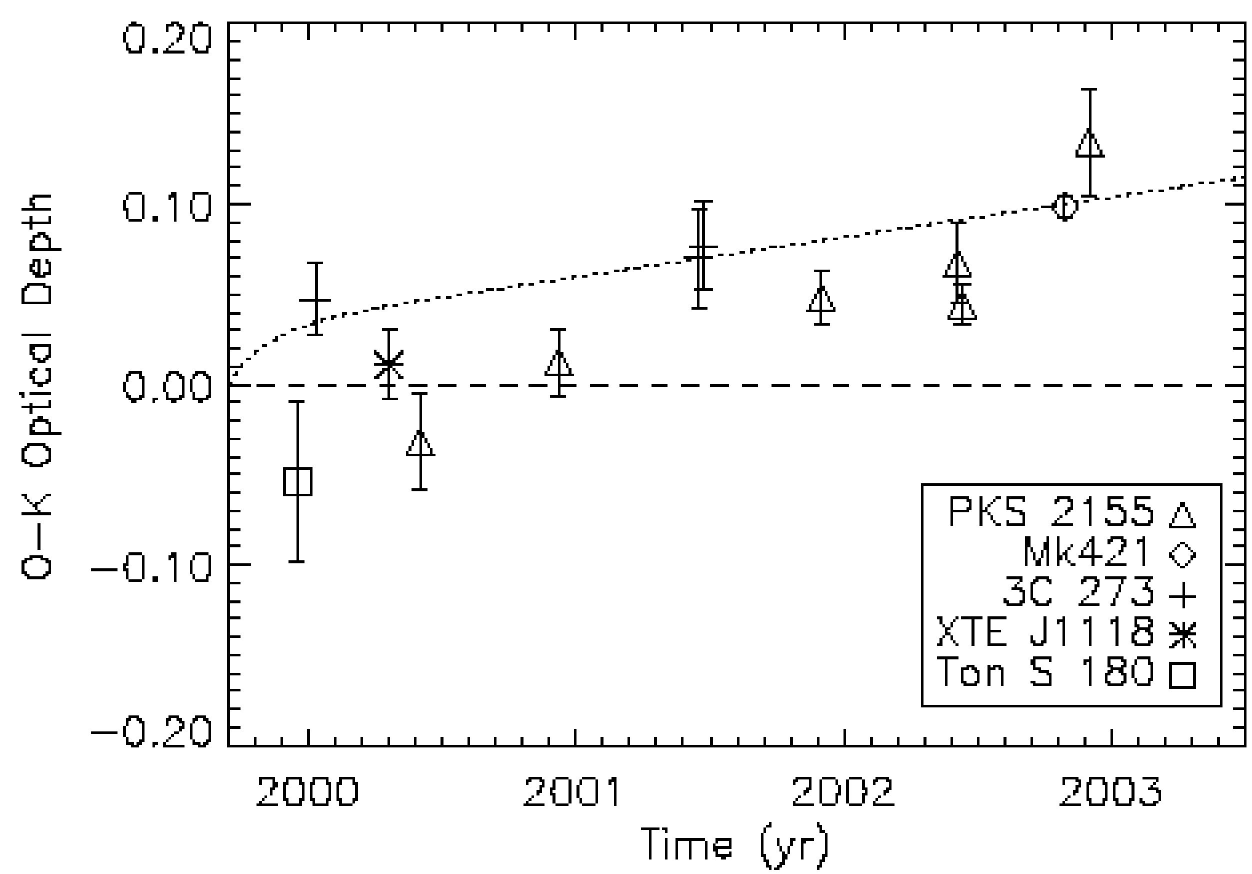
- Lack of 0.285 keV absorption spike due to C=C double bonds indicates that contaminant is not aromatic (benzene rings)
- Contaminant does not have absorption like Teflon associated with C-F bonds
- Aliphatic hydrocarbons (like amine epoxy) with simple C-H bonds gives the best match
  - ➞ Contaminant is mostly comprised of aliphatic hydrocarbons



Contamination Buildup

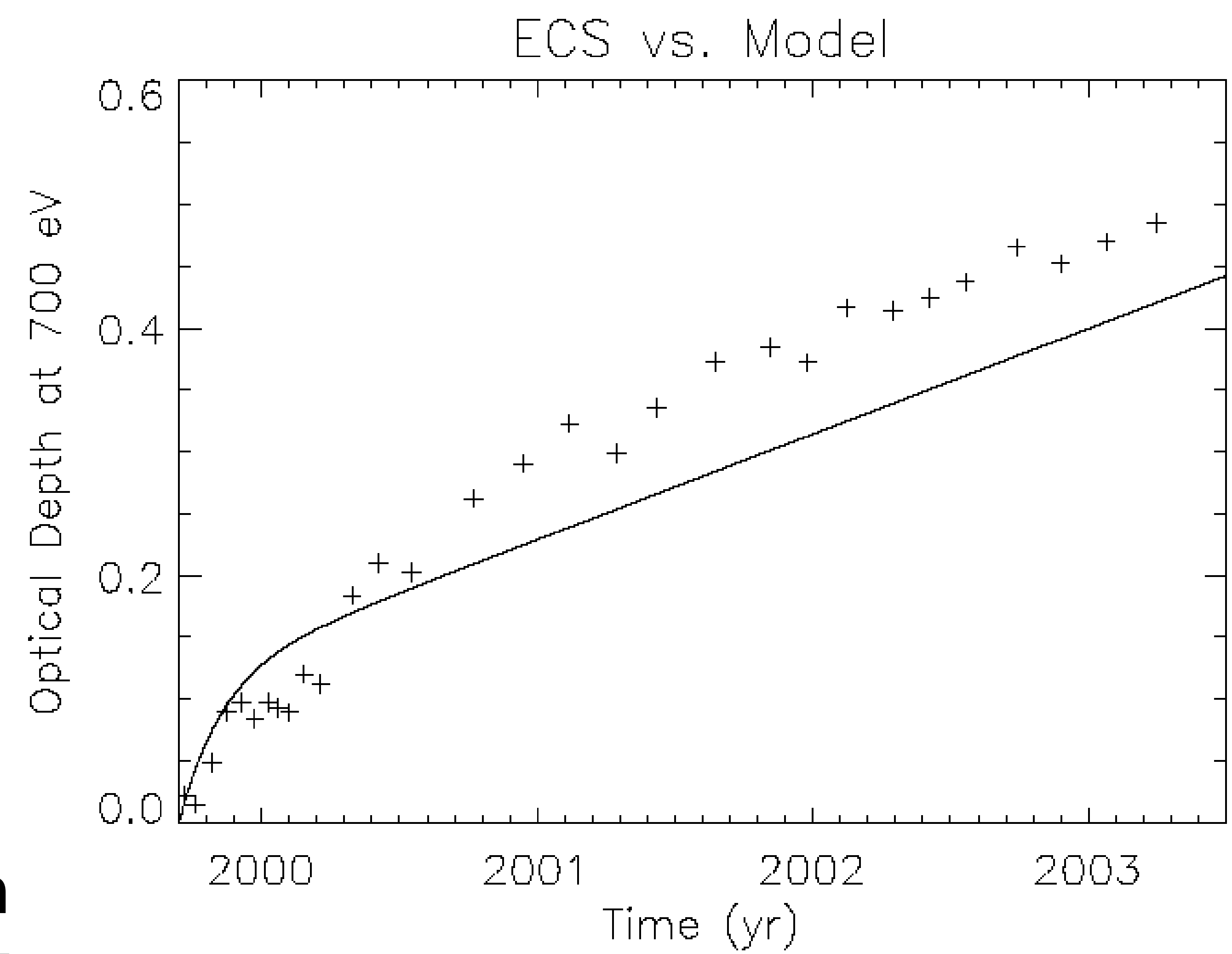
- C-K edge depth is easily measured in each LETG/ACIS data set
- Model is asymptotically linear, forced to go through zero at ACIS opening
- Model fits C-K edge data well but O-K edges are smaller than expected





Comparison to the External Cal Source

- The ACIS External Calibration Source (ECS) illuminates ACIS with Mn L & K lines for gain monitoring
- Ratio of ECS Mn L to K varies and provides an optical depth
- Optical depth in 2001-2003 is 20% higher than predicted from C-K (10-15% less throughput at 0.7 keV)
- No good explanation for difference yet ...



- Extra absorbers like Si have undetected K or L edges
- ECS may be too warm to have its own contamination
- H opacity? H/C ~ 1000 required for odd material

Conclusions & Future Work

See: http://space.mit.edu/ASC/calib/letg_contamination.html

- Chandra ACIS contaminant consists mostly of carbon with some oxygen and fluorine
  - Ratios do not match fluorinated compounds on Chandra
  - C-K edge does not match fluorinated compounds
  - We suggest that Braycote (or Krytox) cracks upon radiation damage and that mobile components are aliphatic hydrocarbons
- We are investigating spatial variations — including small-scale variations (fluffy?)
  - Scale of few mm seems consistent with ECS
  - Small-scale change investigation requires self-consistent approach
- X-ray transmission of radiation-damaged Braycote indicates aliphatics result