ACIS Contaminant and Cross-Cal Implications

Now, with even more Oxygen!

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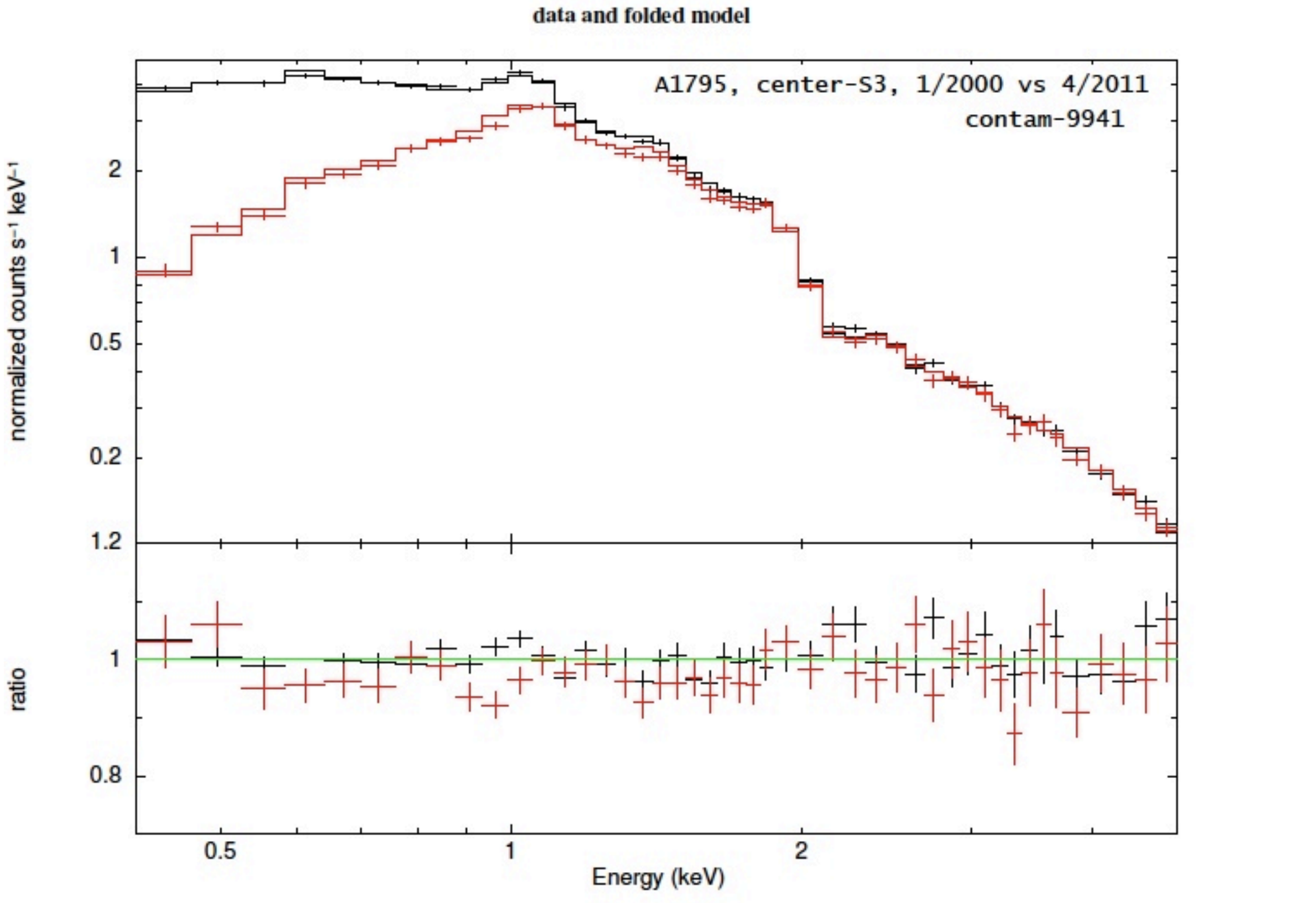
A Short History

- 1999: Chandra Launch
- 2000: Anomalous C-K edge — LETG only?
- 2001: Contaminant thickens
- 2002: Composition determined (COF), edge NEXAFS indicates C-C single bonding
- 2003: Spatial variation found: thin at FoV center
- 2004: Fluffium invented as LETG/ACIS and cal source disagree; new model released
- 2010: Deposition accelerates, Gaussium replaces fluffium
- 2014: Deposition rate acceleration still positive

Recent Progress

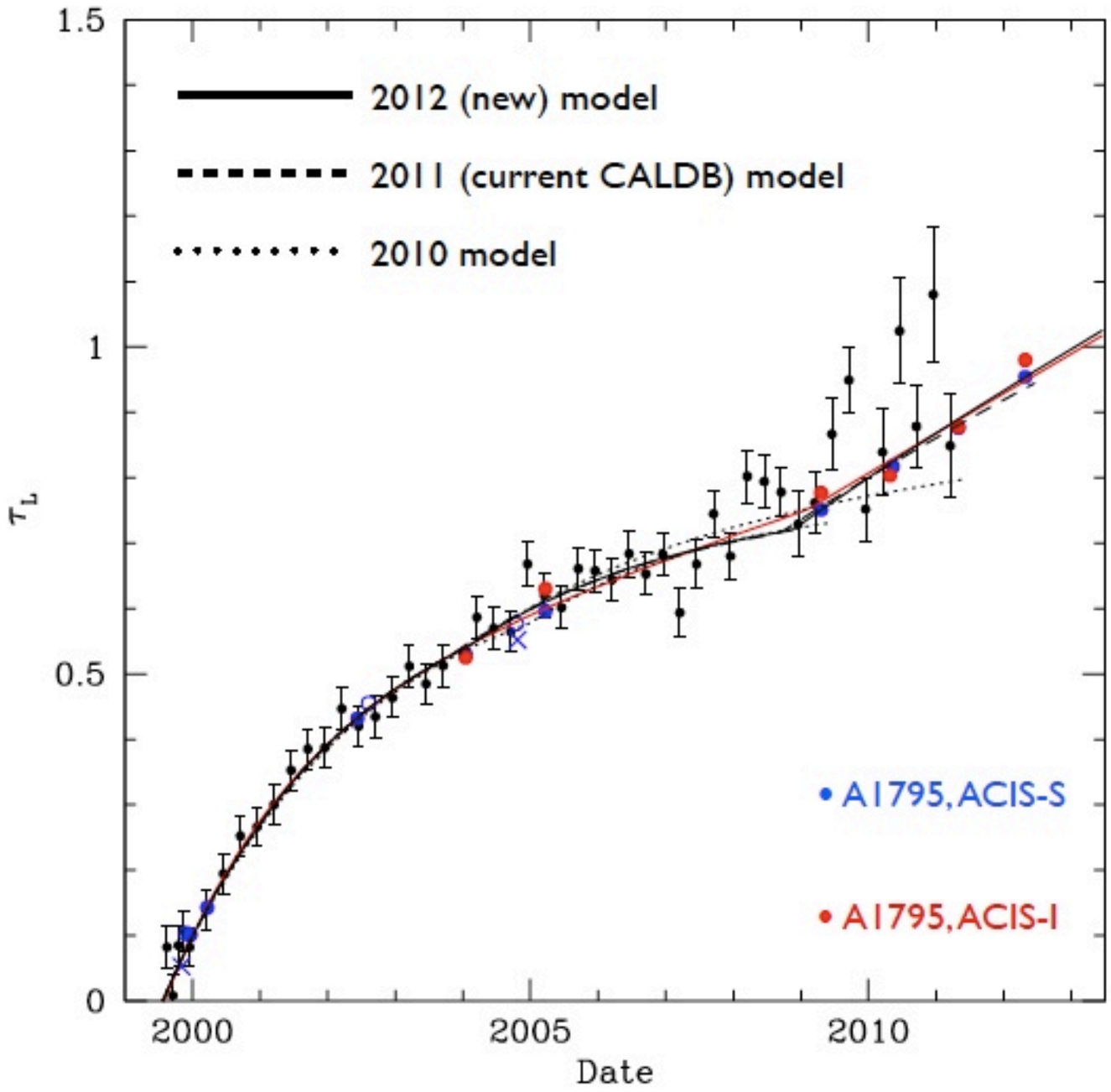
- LETG/ACIS: N_O/N_C varies in time
- 2013 Released Model
  - Foundation is Cluster based, Gaussium is eliminated
  - Adjusted nonphysically to fit LETG/ACIS data
    - Verified with 1E0102, Clusters
- Developments
  - A1795 observations continue
  - LETG/ACIS of Mk 421 (3/14): "Big Dither"
  - Deposition rate increases

Clusters Drive Model



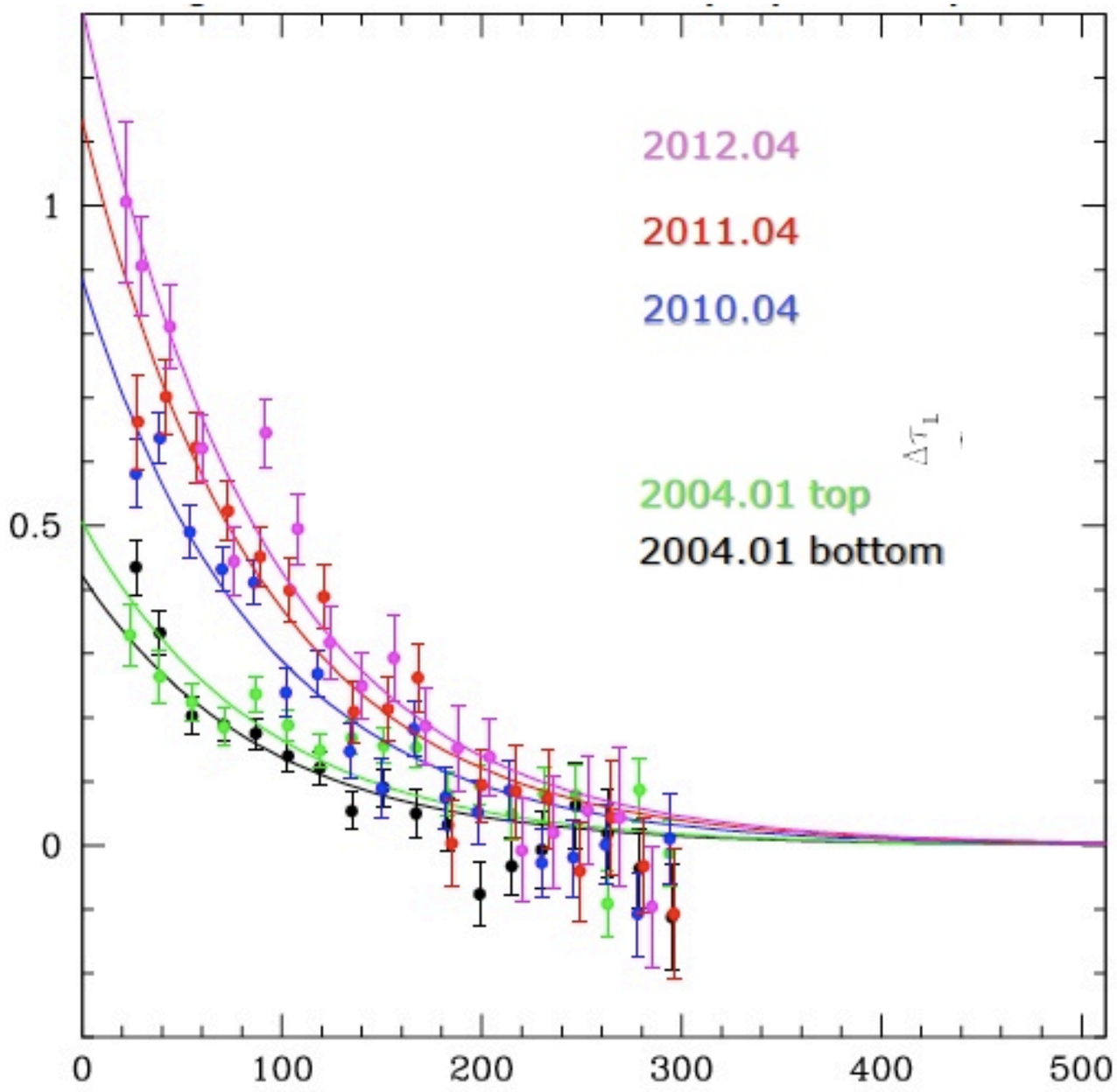
Clusters replace ECS

- External Cal Source gives τ(700 eV) using Mn-L/Mn-K
- ECS Mn-L is getting too faint
- Cluster spectral model is simple
- Problem: τ at launch?



Setting Spatial Model

- Again, ECS Mn-L is now too faint
- A1795 used at different positions
- Jump apparent in 2010
- ACIS-I and ACIS-S are similar



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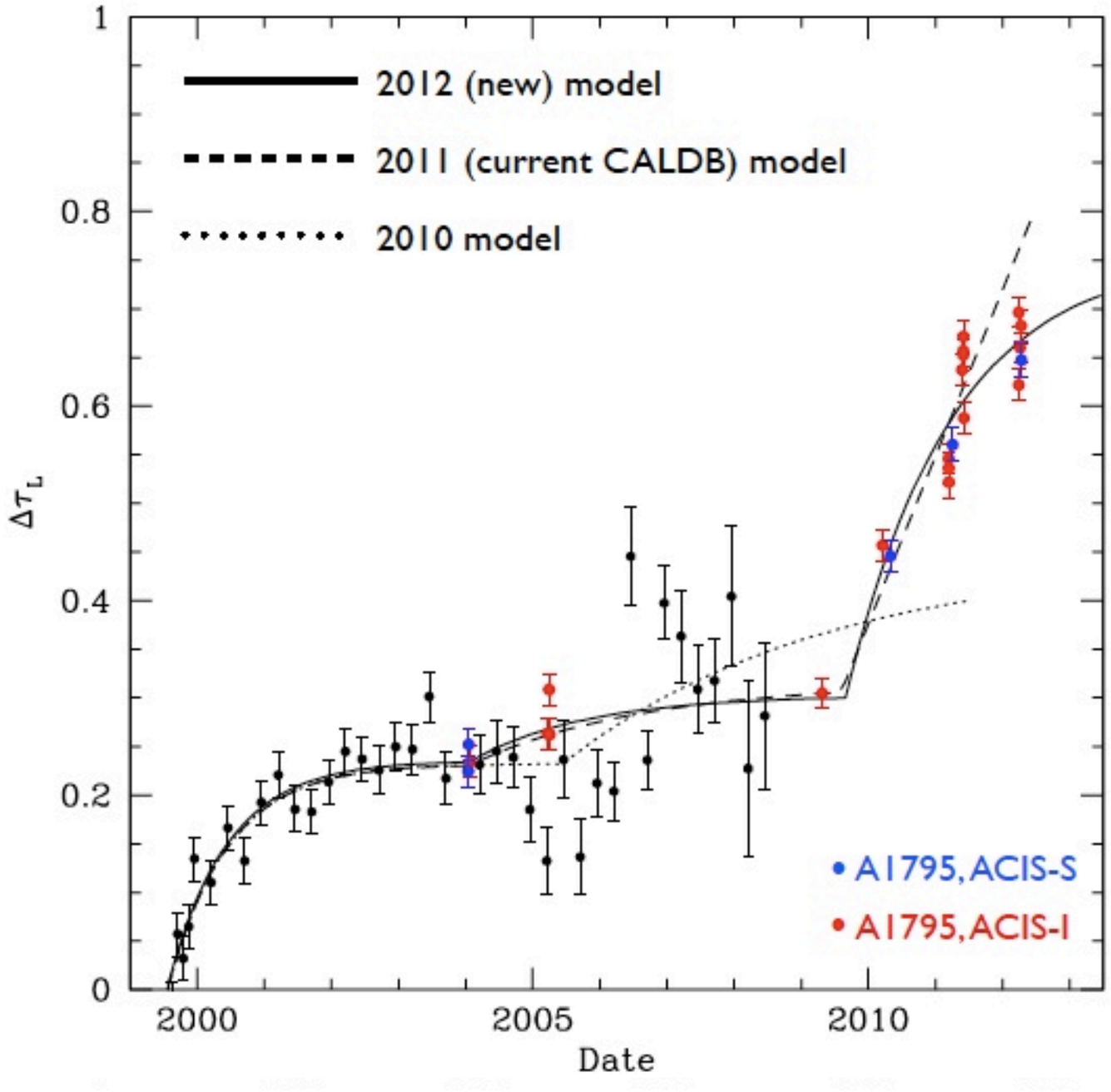
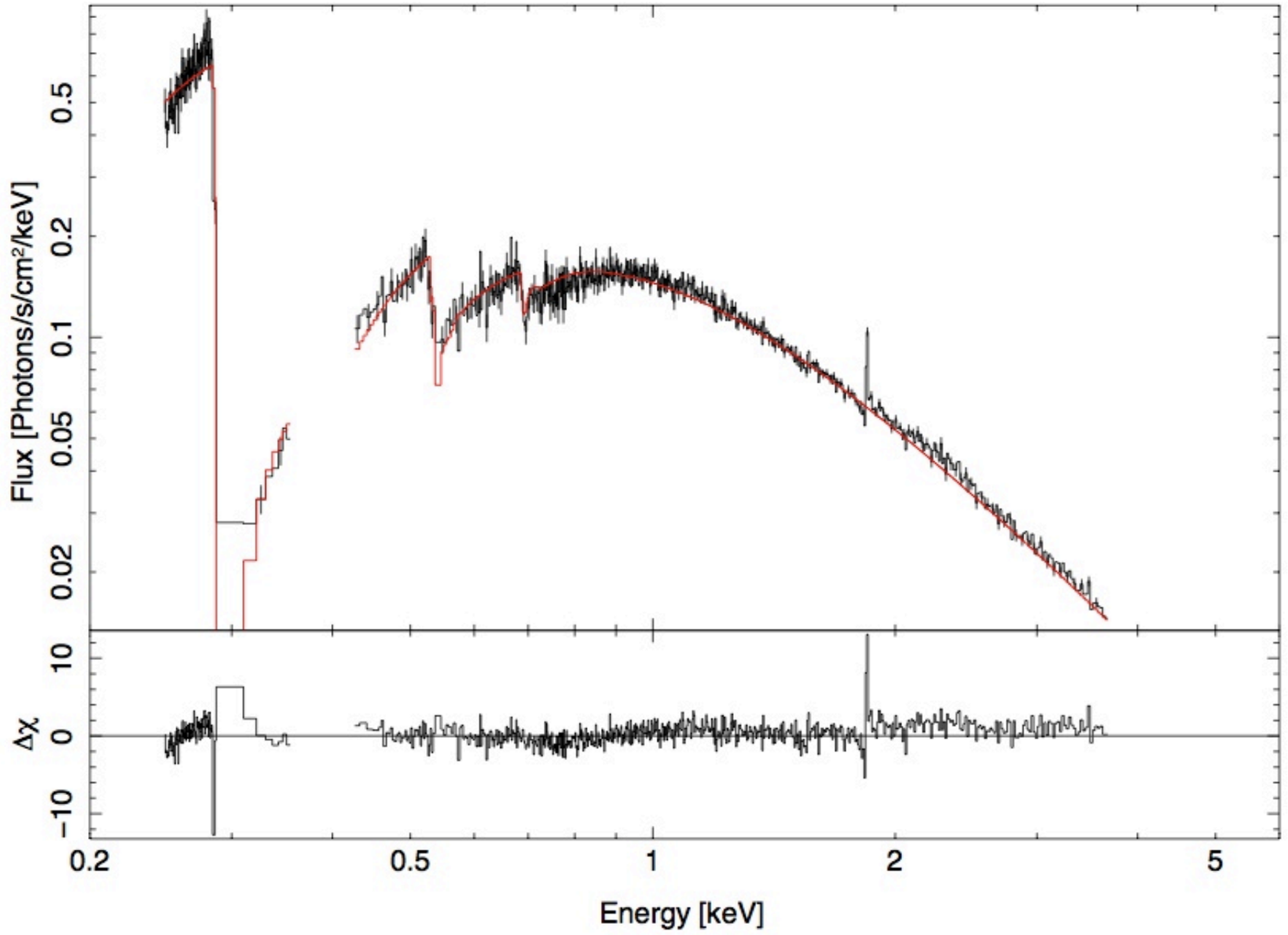
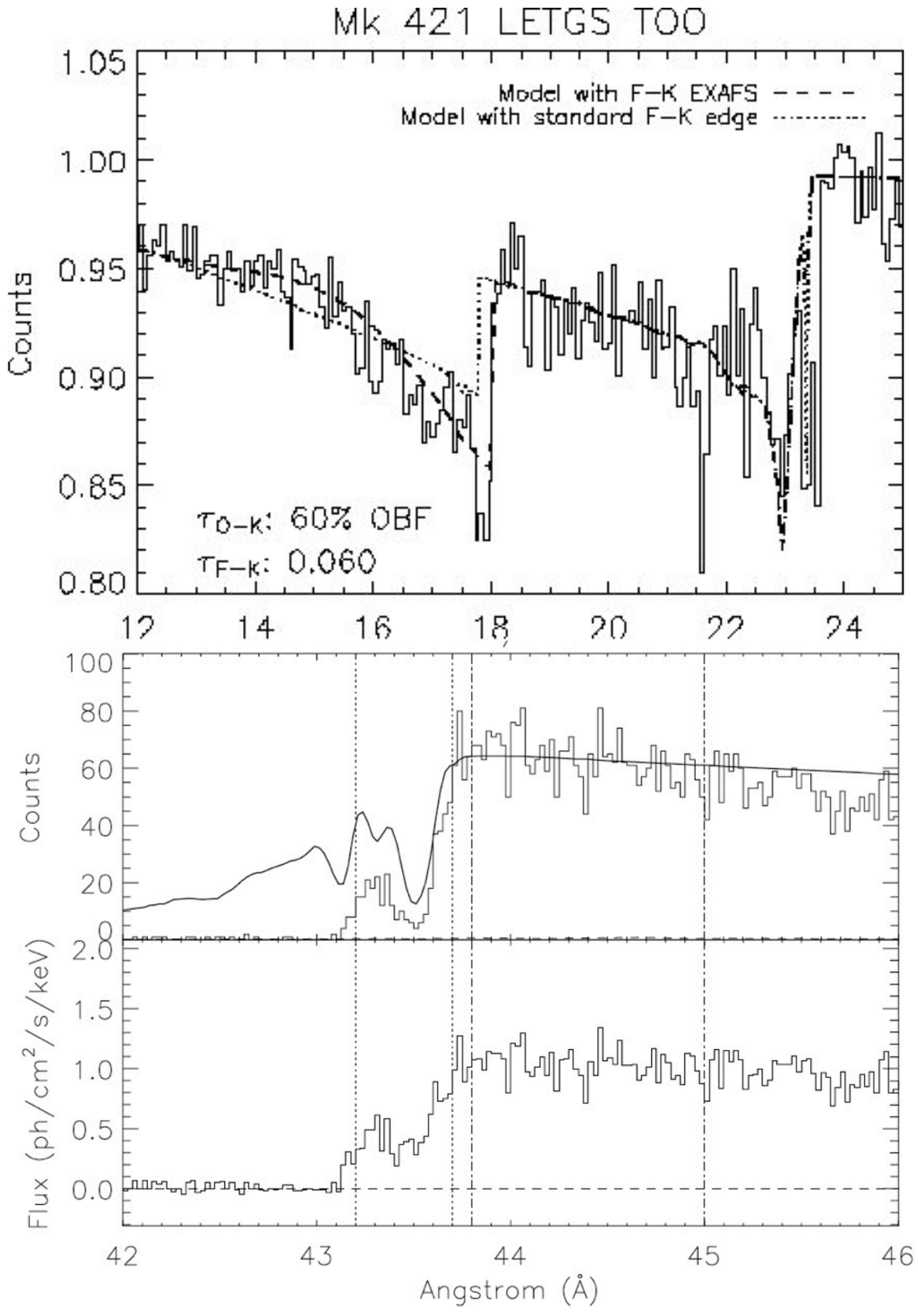


Spectral Model

- LETG/ACIS used
- C, F, O edges observed
- Composition doesn't match on-board materials
- LETGS doesn't match ECS



EXAFS & NEXAFS



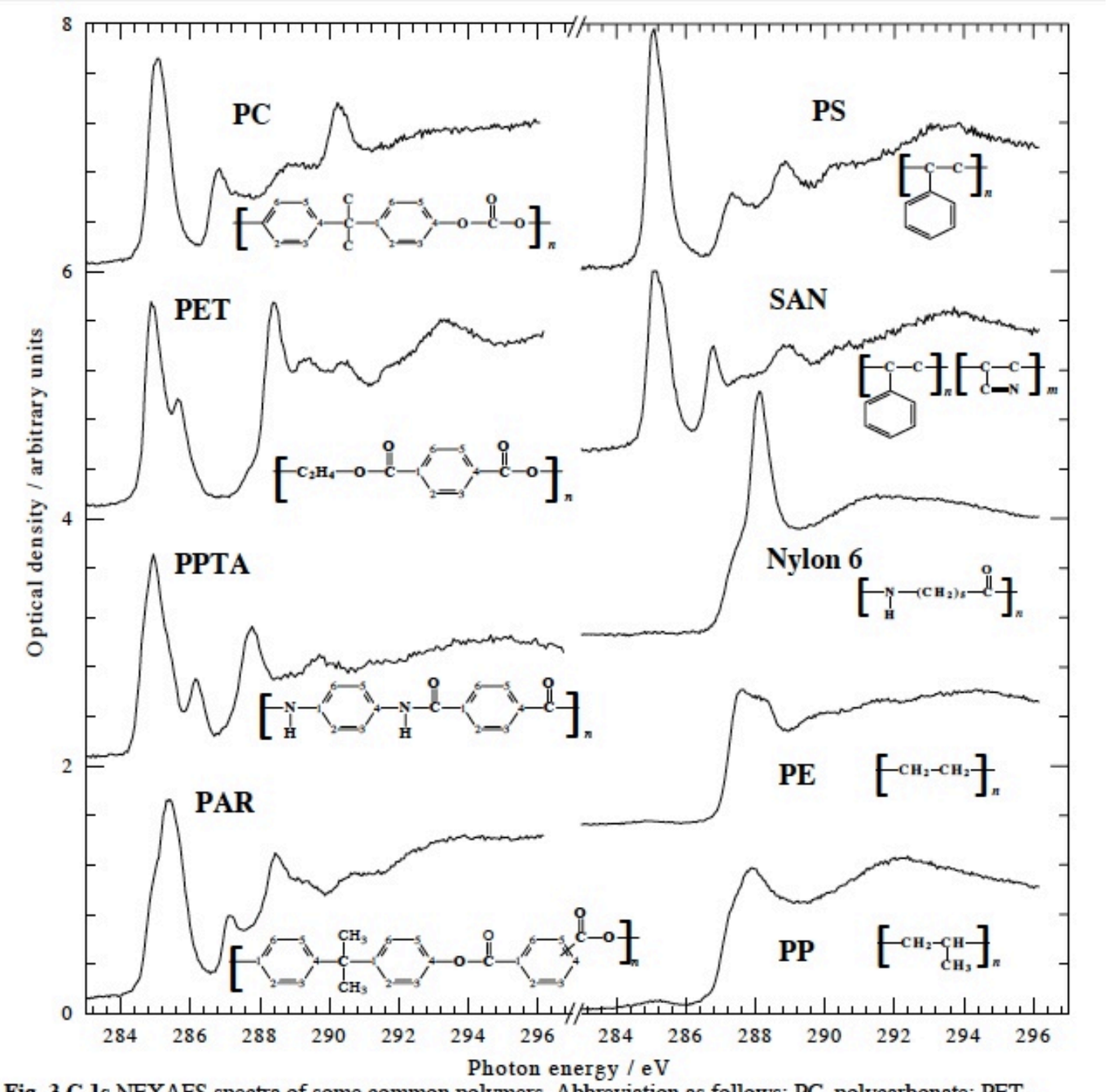
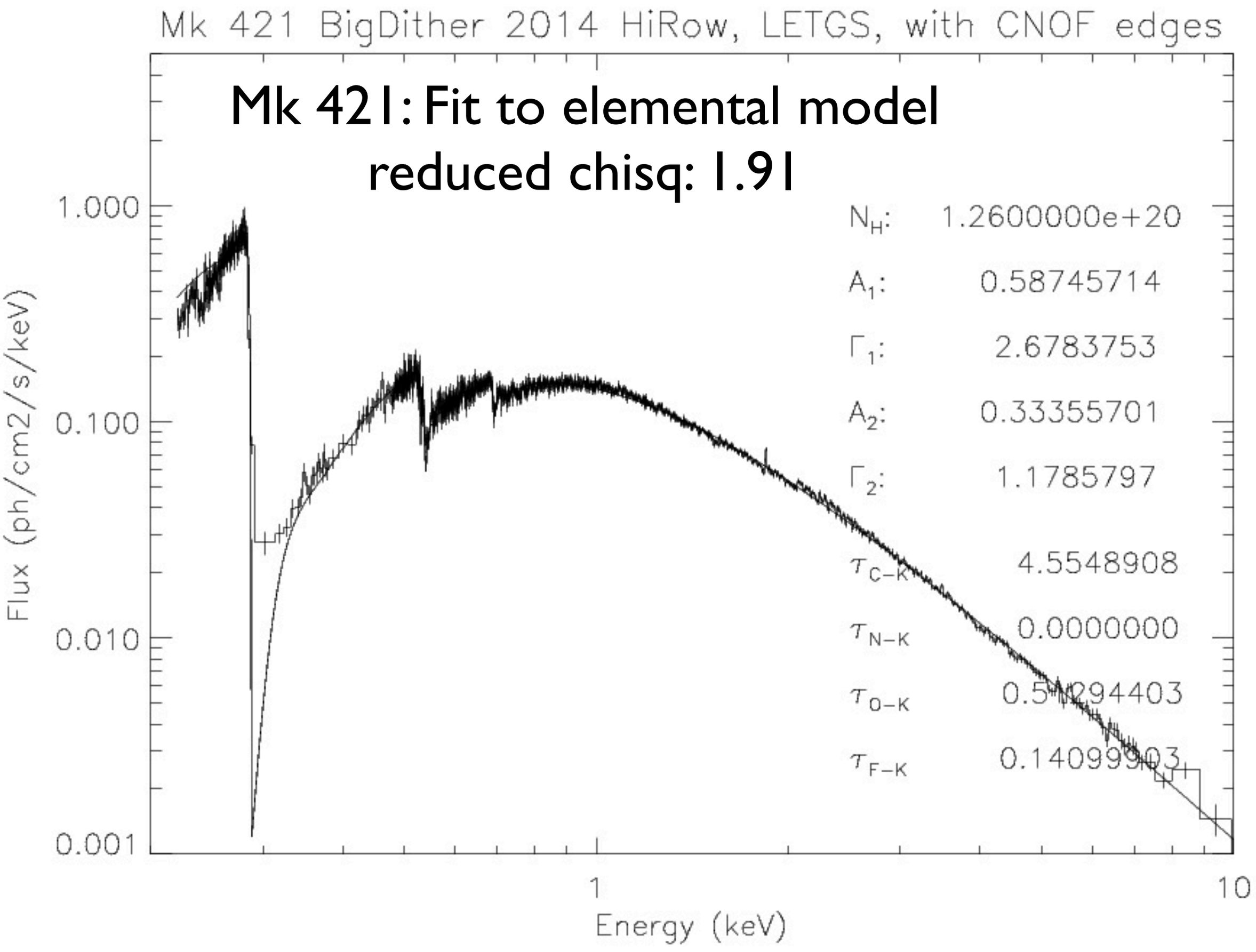
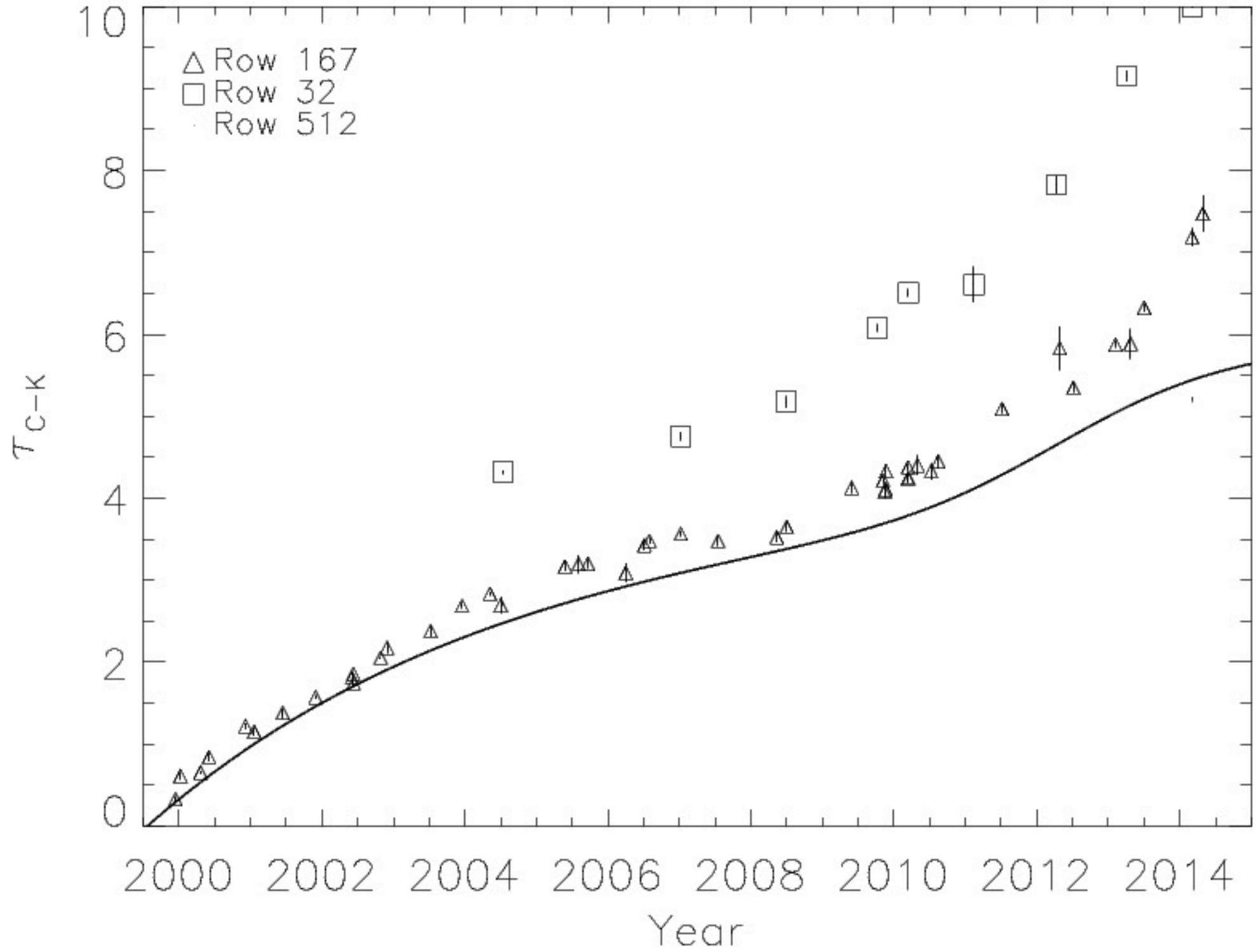


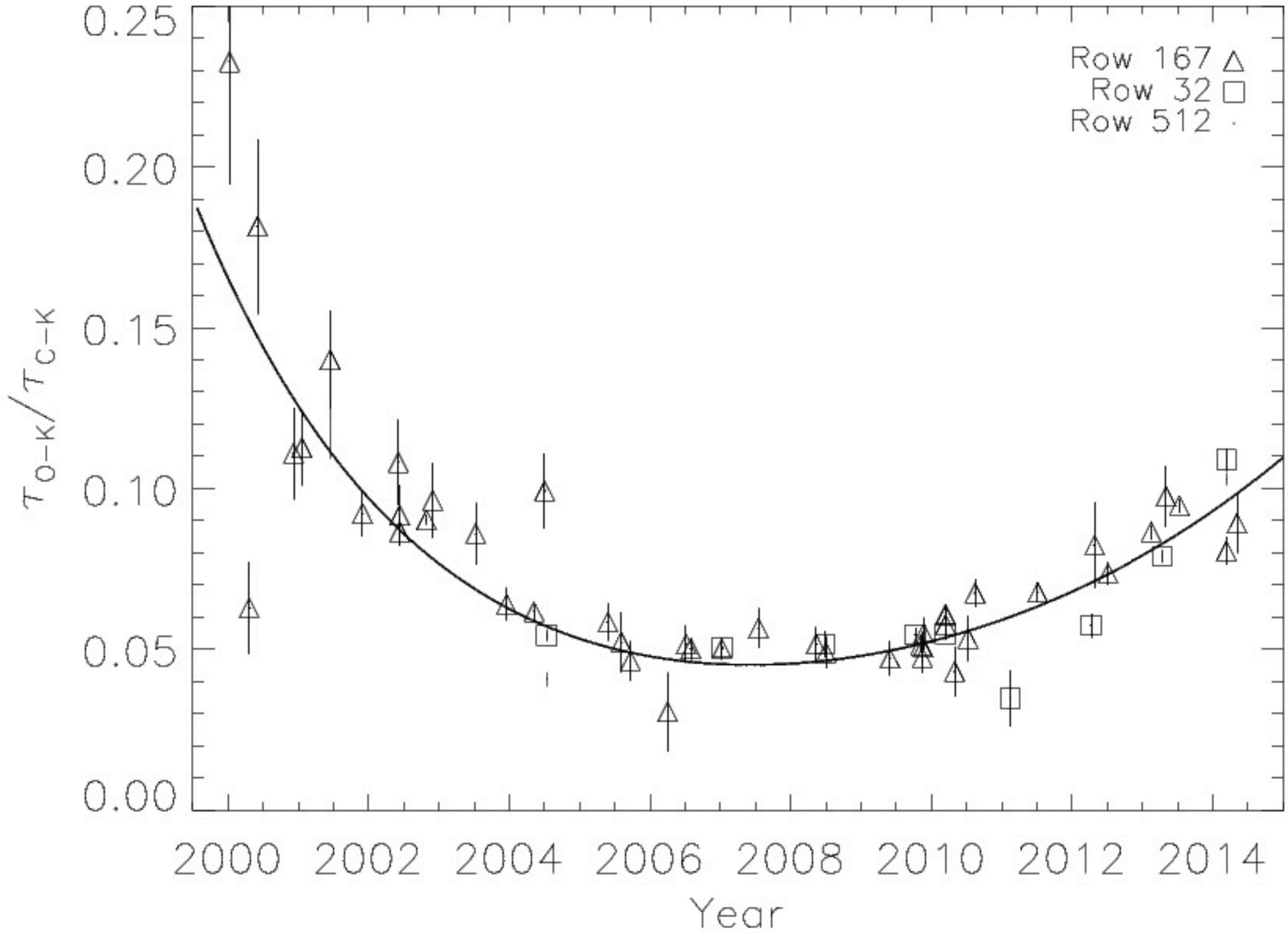
Fig. 3 C 1s NEXAFS spectra of some common polymers. Abbreviation as follows: PC, polycarbonate; PET, poly(ethylene terephthalate); PPTA, poly(p-phenylene terephthalamide); PAR, polyacrylate; PS, polystyrene; SAN, styrene-acrylonitrile; Nylon-6, poly(ε-caprolactam); PP, polypropylene; PE, polyethylene. (Figure adopted from [Ade 97])

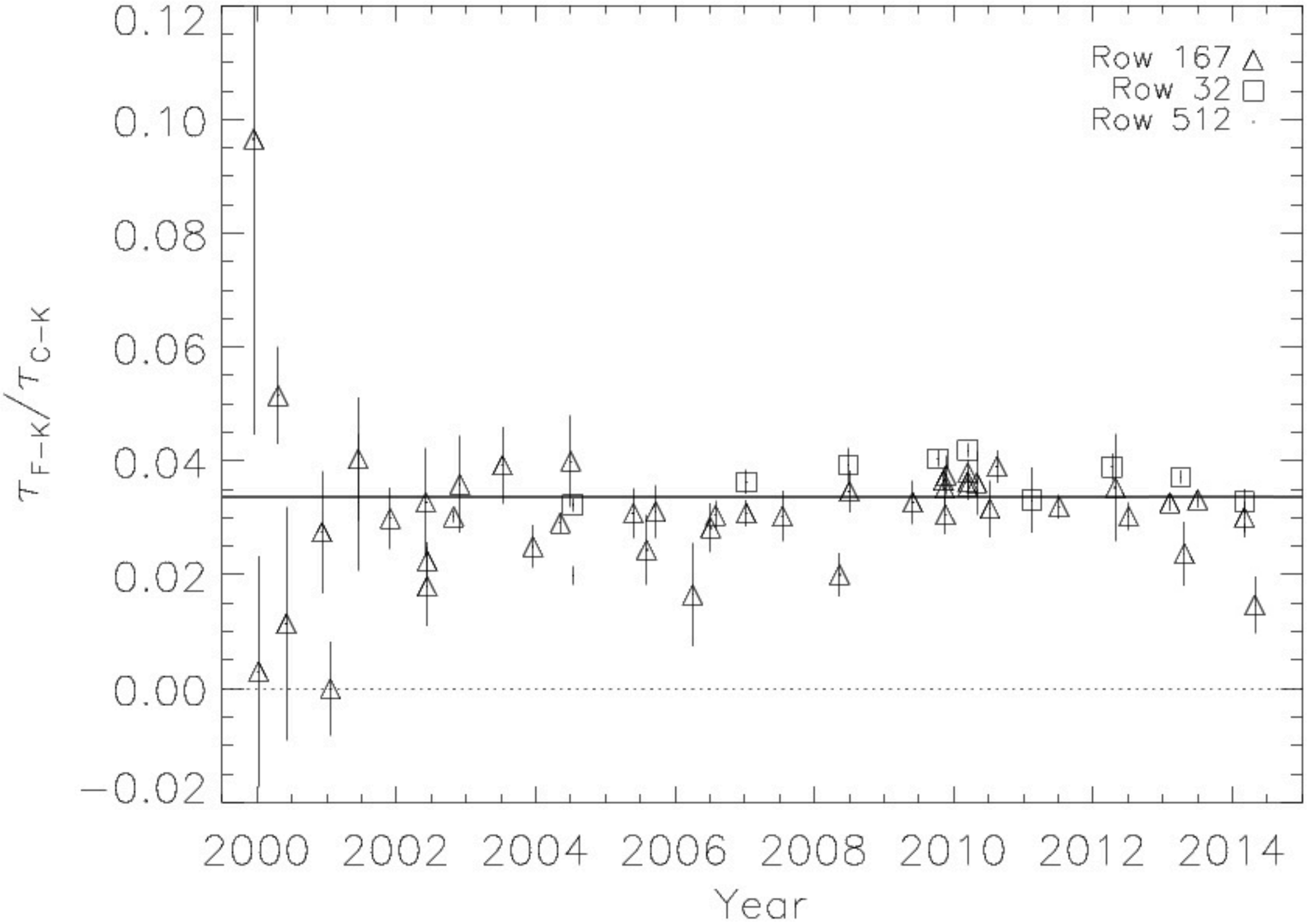
Mk 421: Fit to elemental model
reduced chisq: 1.91

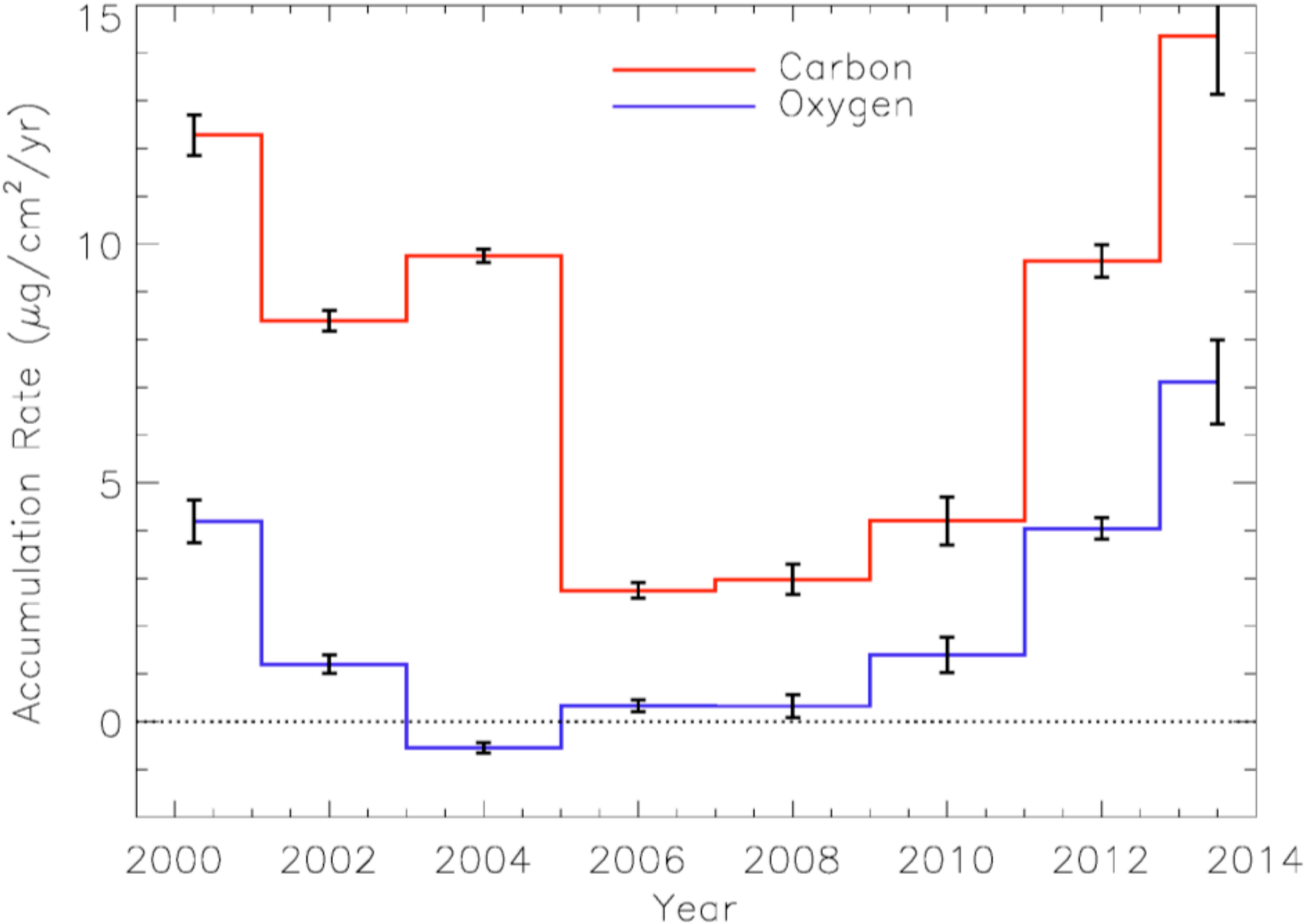


LETG/ACIS Fit Results

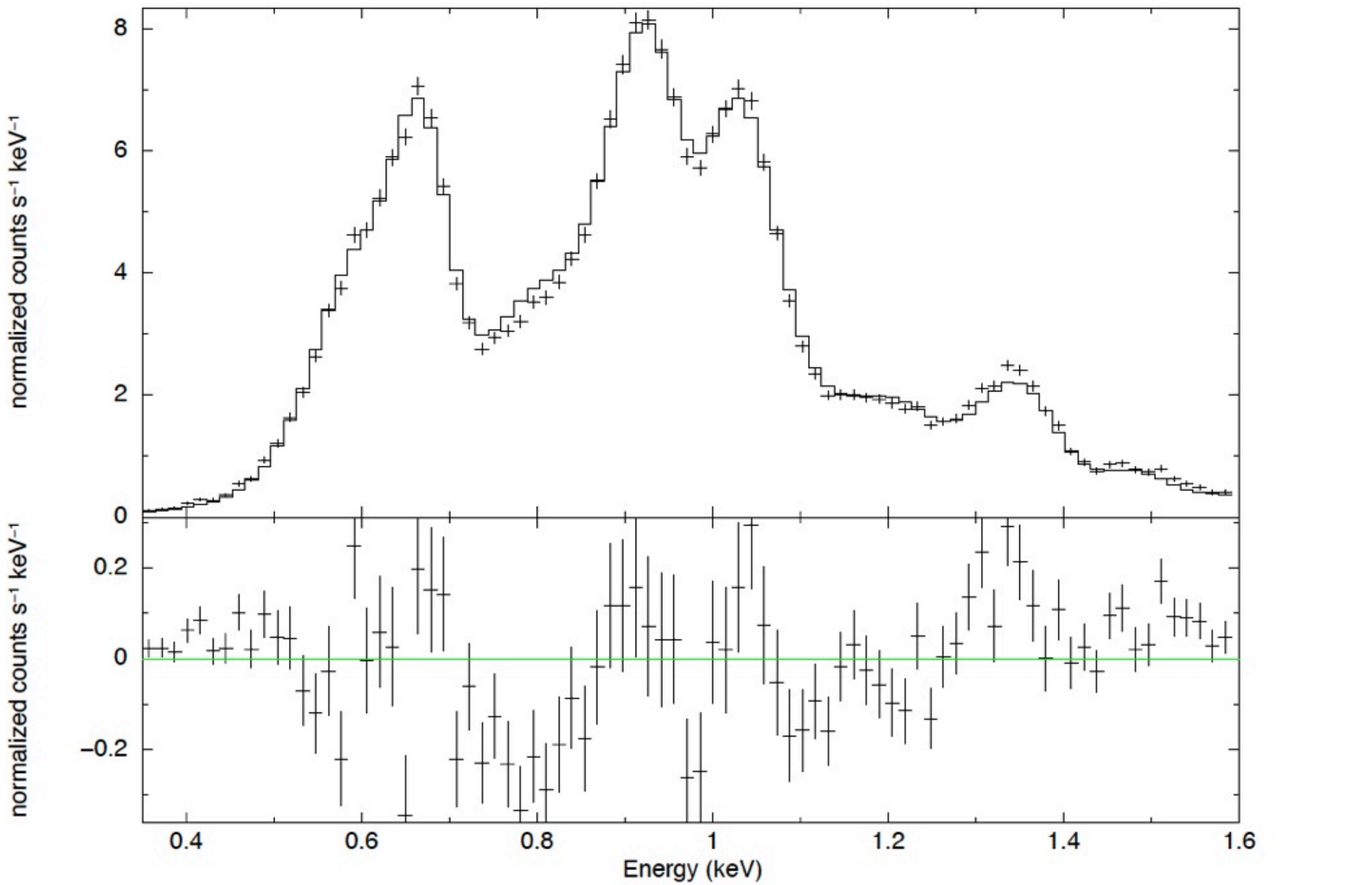



Row 167
Row 32
Row 512
τ_{O-K}/τ_{C-K}
0.25
0.20
0.15
0.10
0.05
0.00
2000
2002
2004
2006
2008
2010
2012
2014
Year


Row 167
Row 32
Row 512
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−0.02
T_{F-K}/T_{C-K}
2000
2002
2004
2006
2008
2010
2012
2014
Year


Carbon
Oxygen
Accumulation Rate (μg/cm²/yr)
15
10
5
0
2000
2002
2004
2006
2008
2010
2012
2014
Year

Adding O-K Variation



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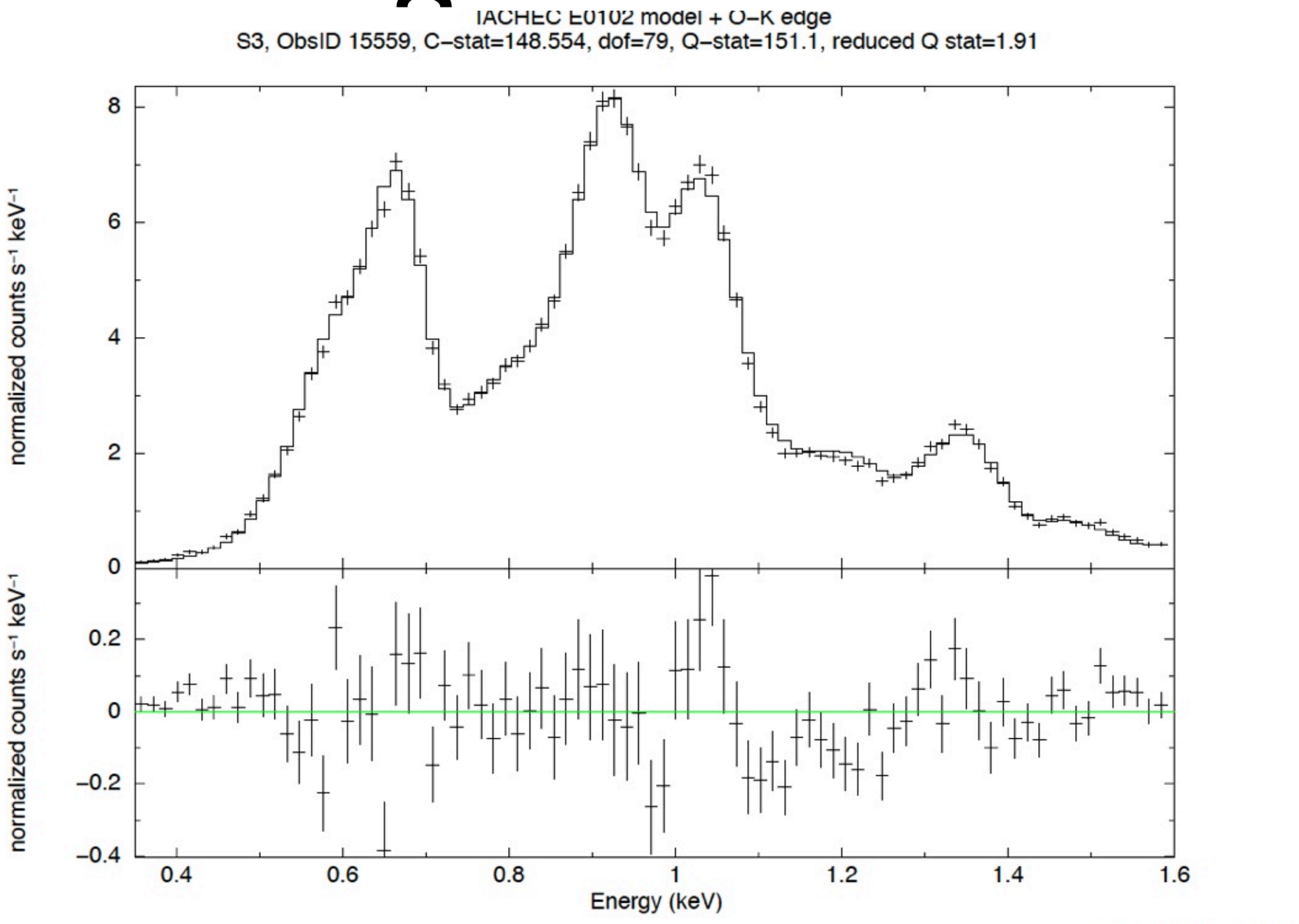
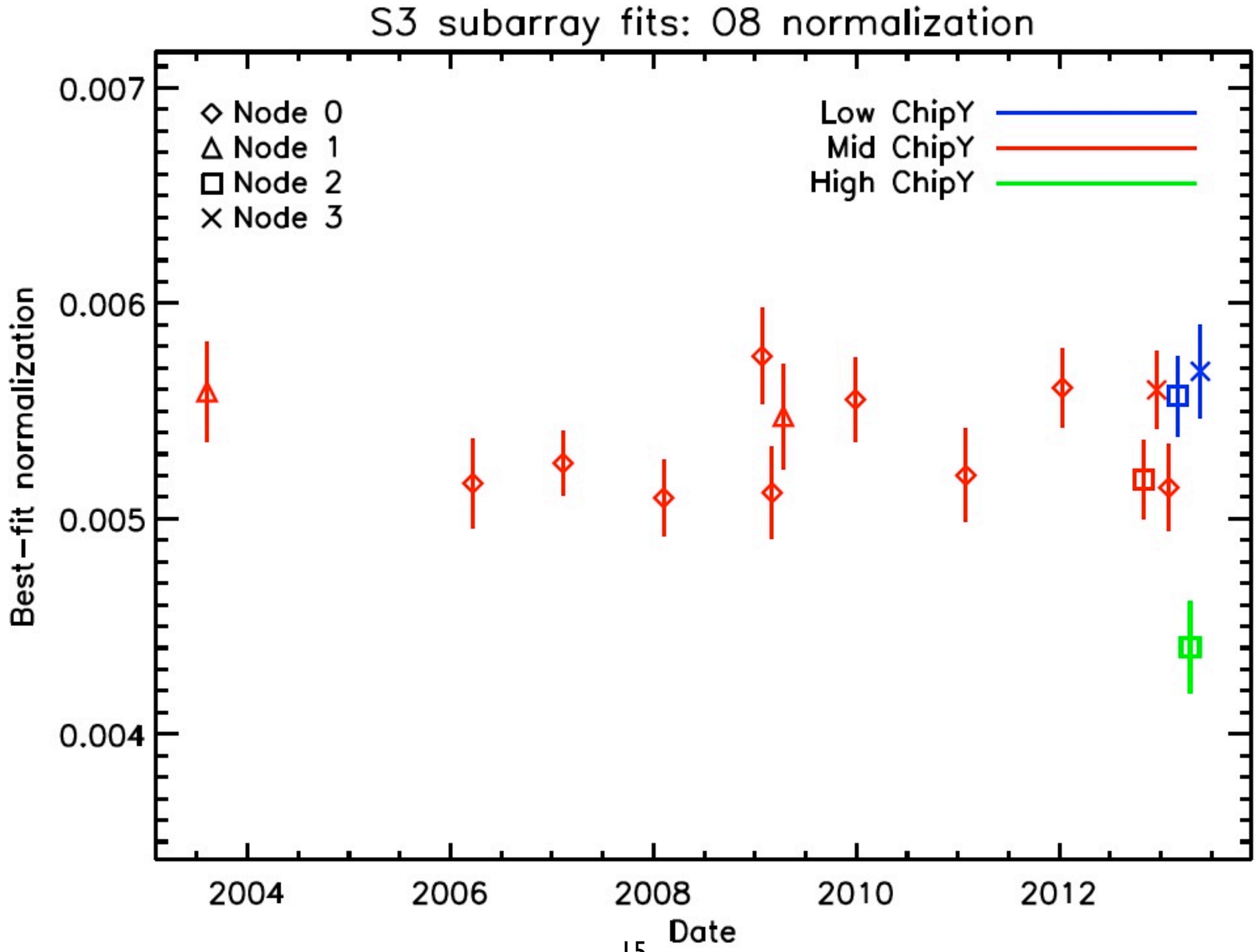
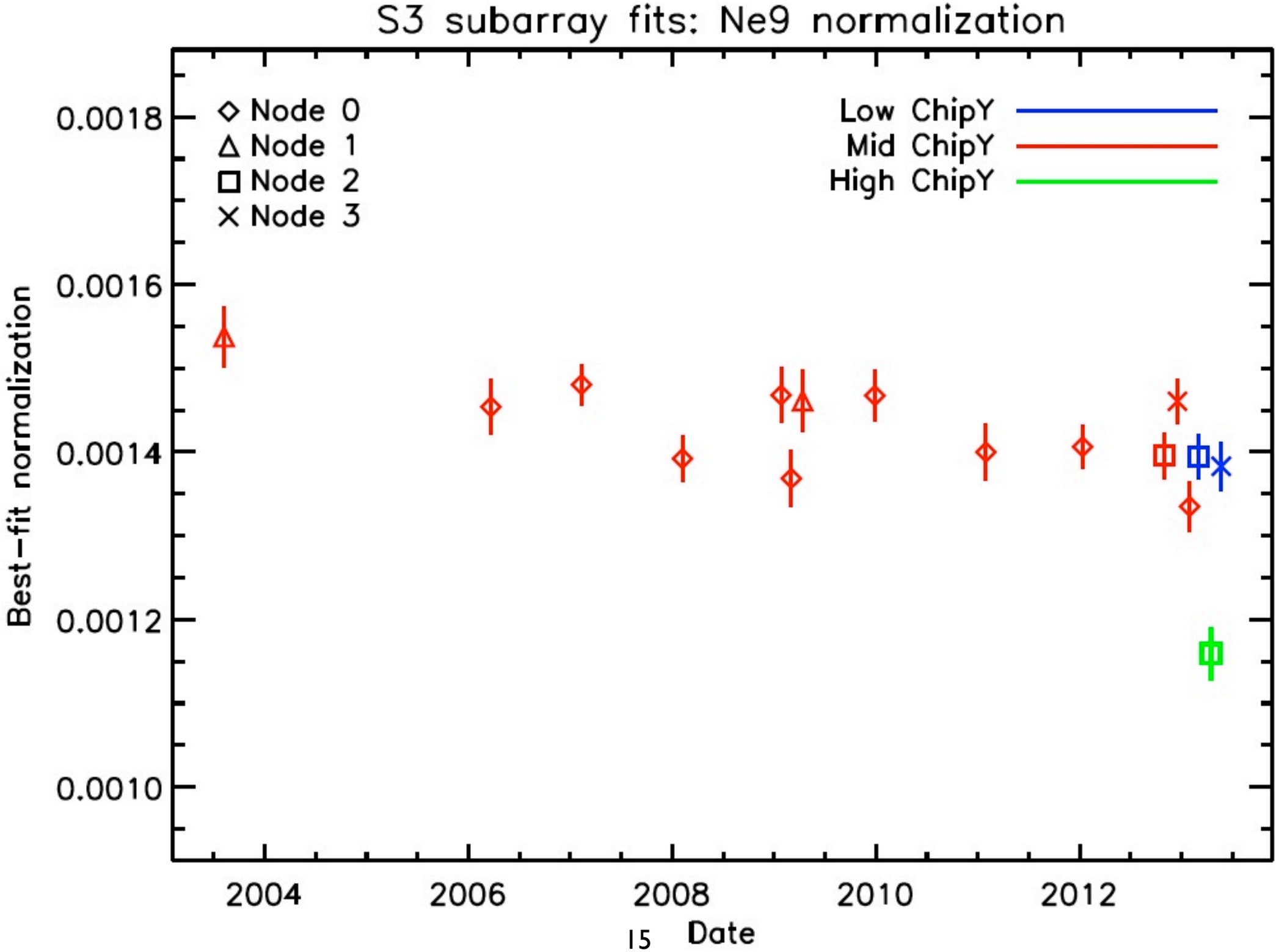


Revised 1E0102 Fluxes



Herman

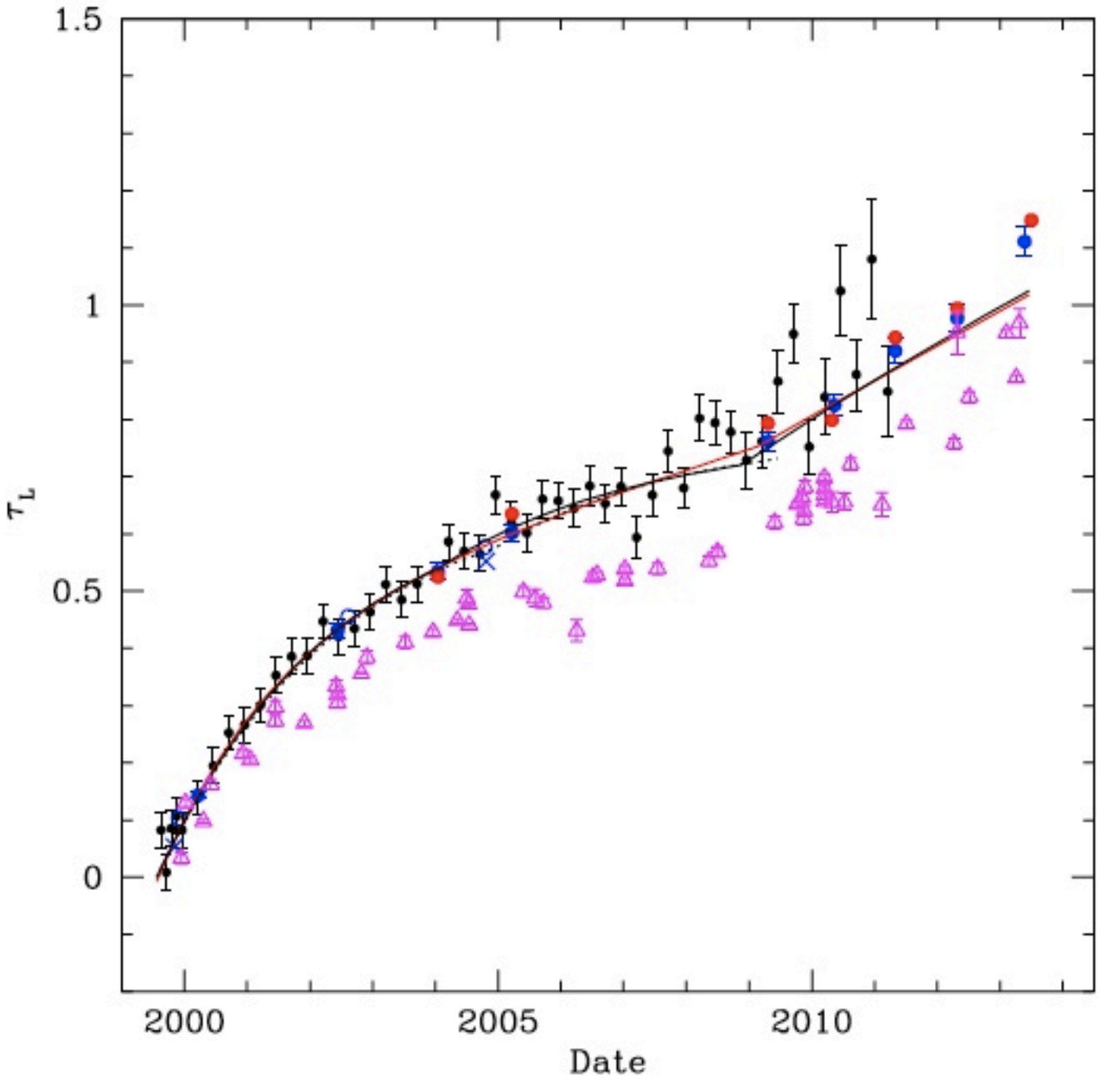
Revised 1E0102 Fluxes



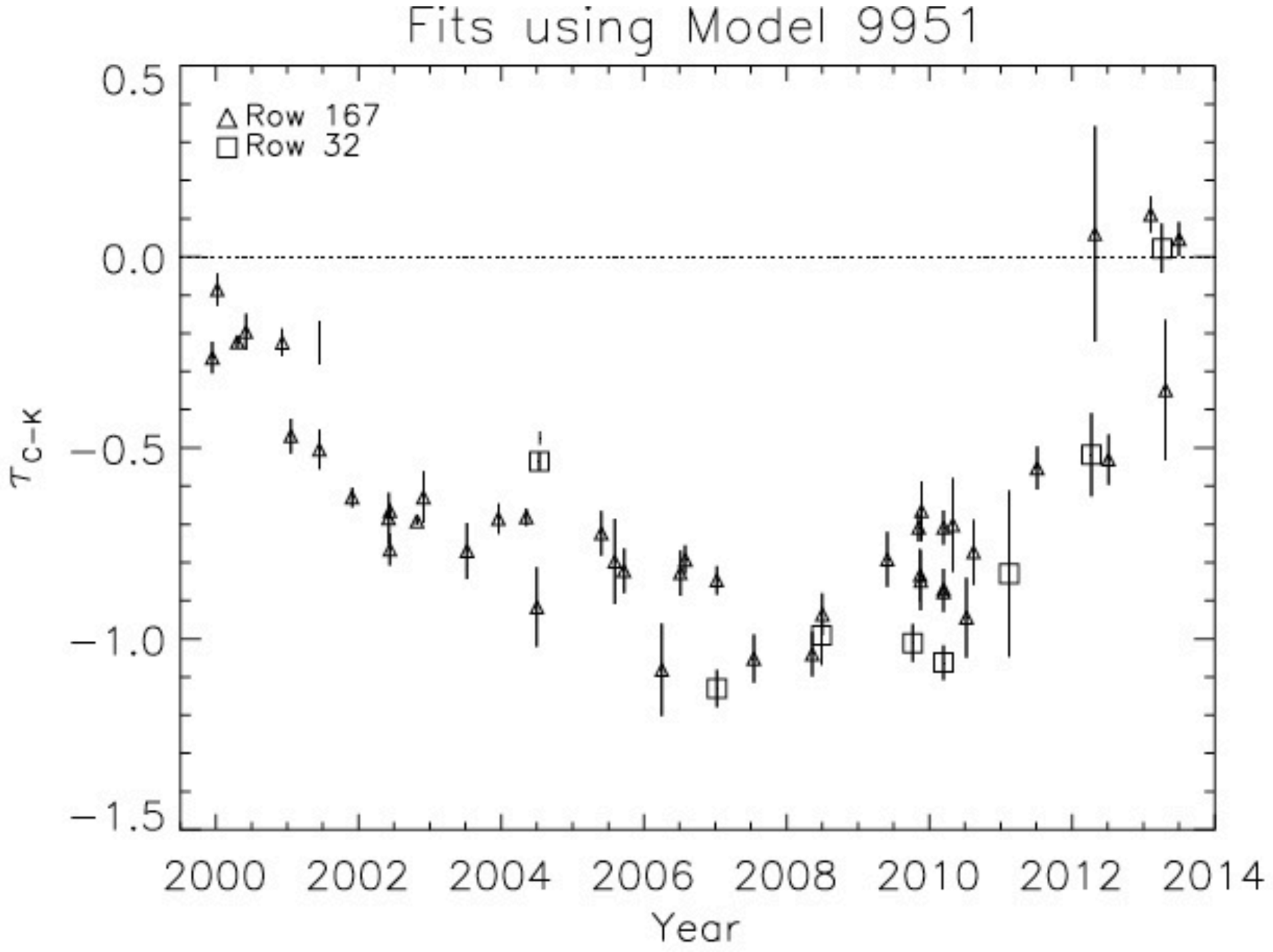
Hermar

LETG-ECS Problem

- Model fitting ECS and clusters doesn't fit LETGS (purple)
- Offsetting ECS doesn't fix problem entirely

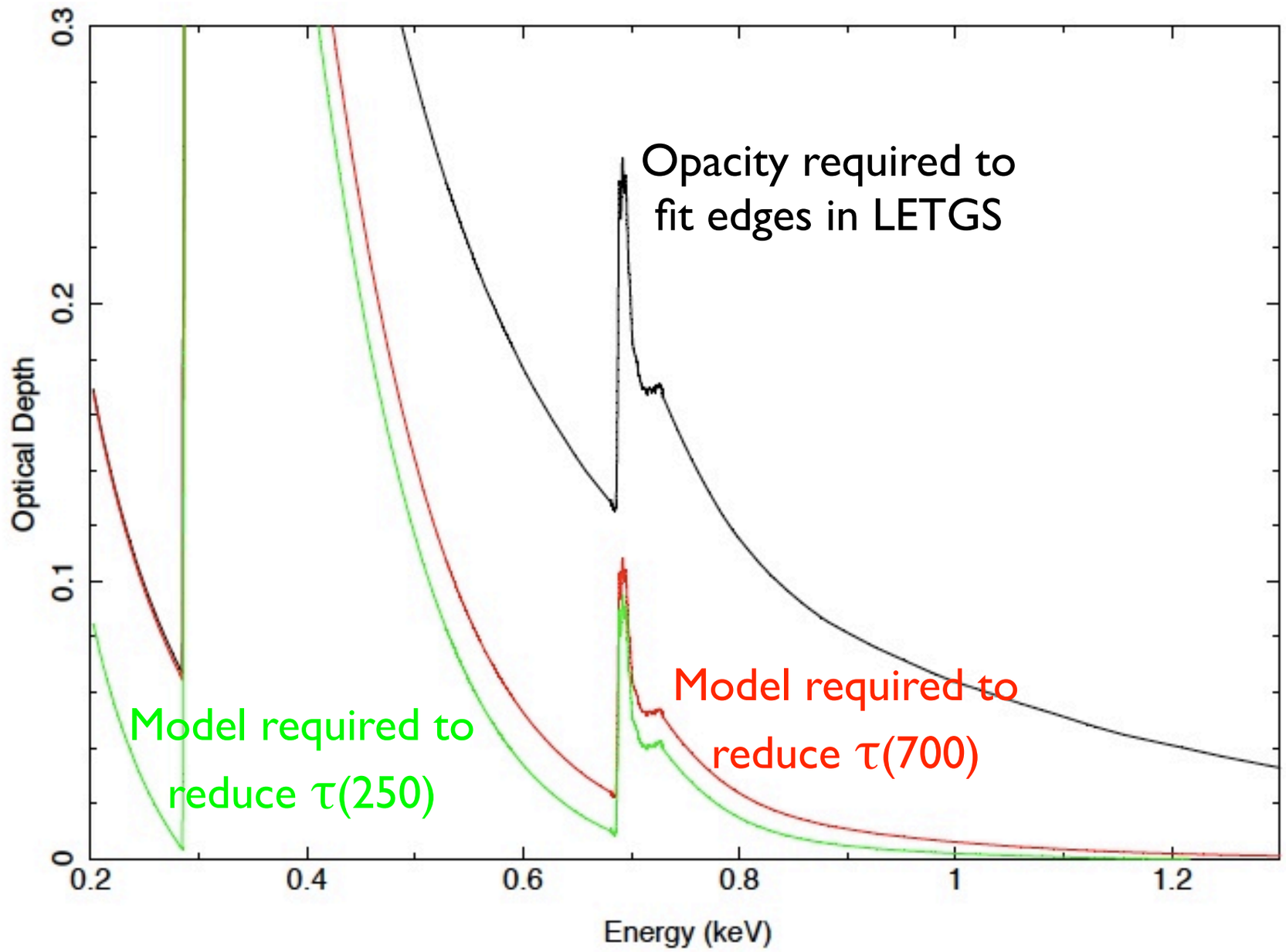


Less C-K needed!

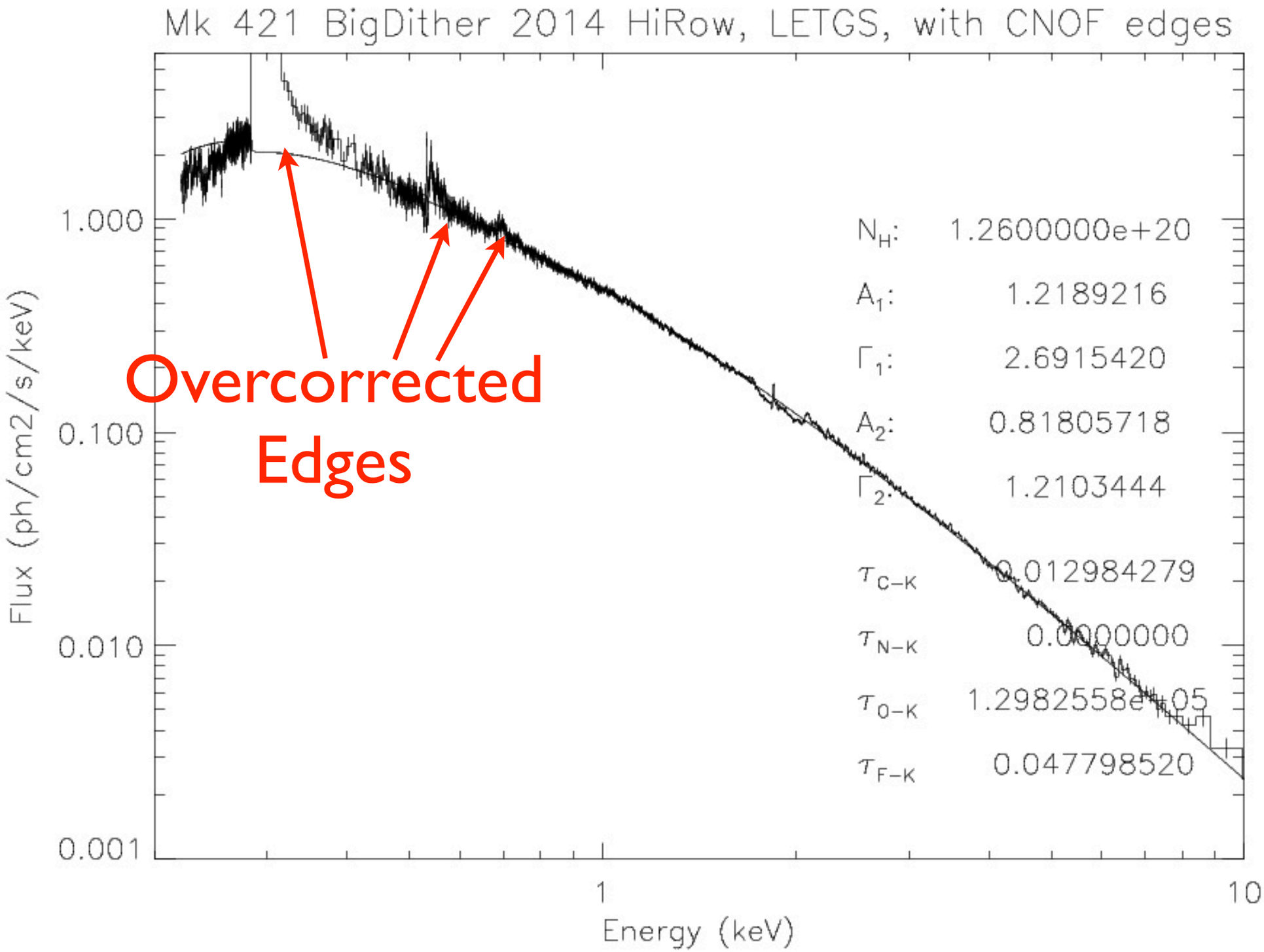


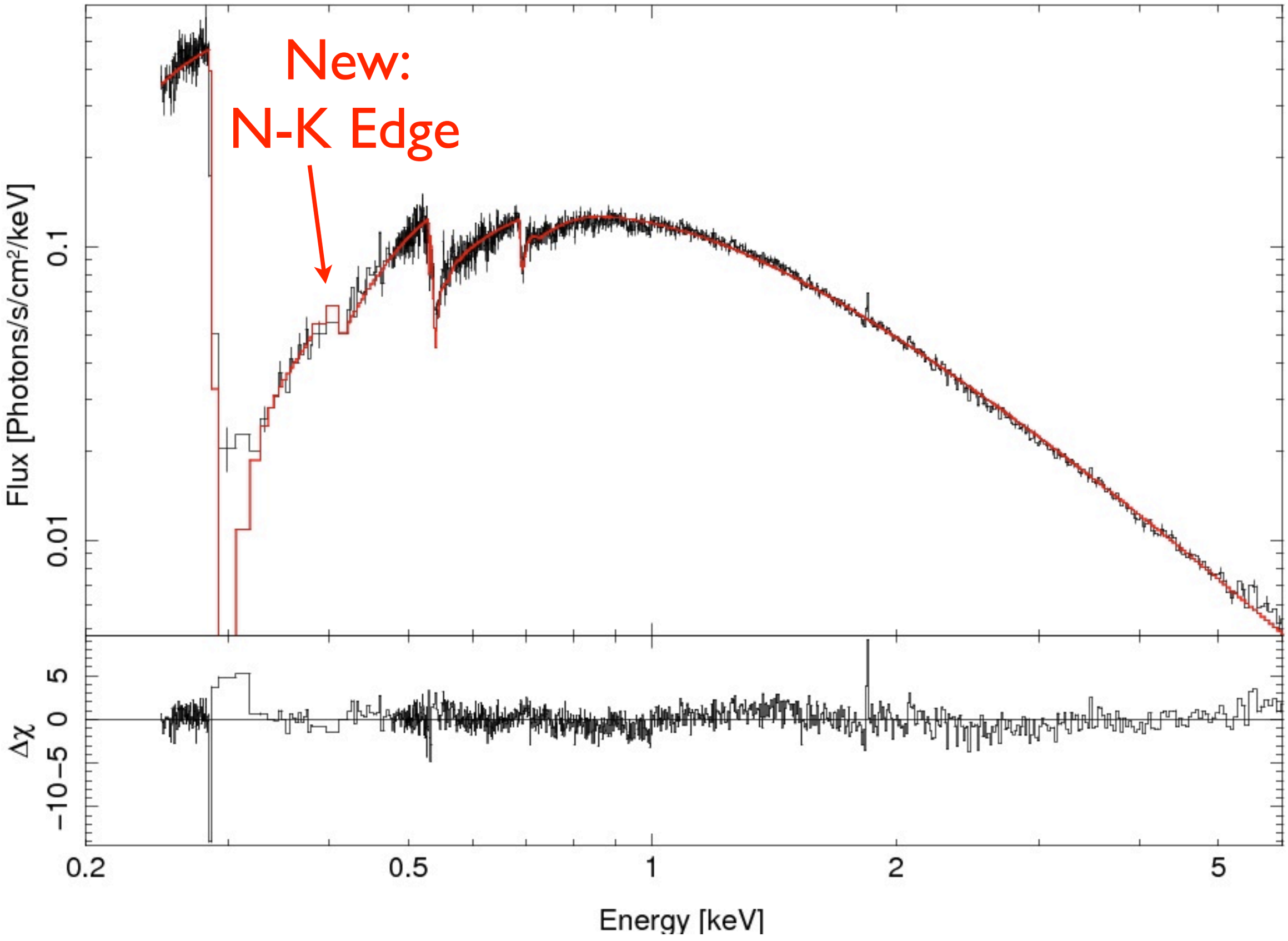
Hack in Released Model

- Adjust edges of C-K, F-K to match LETGS
- Force $\tau(700)$ to below 2%
- Component varies with time

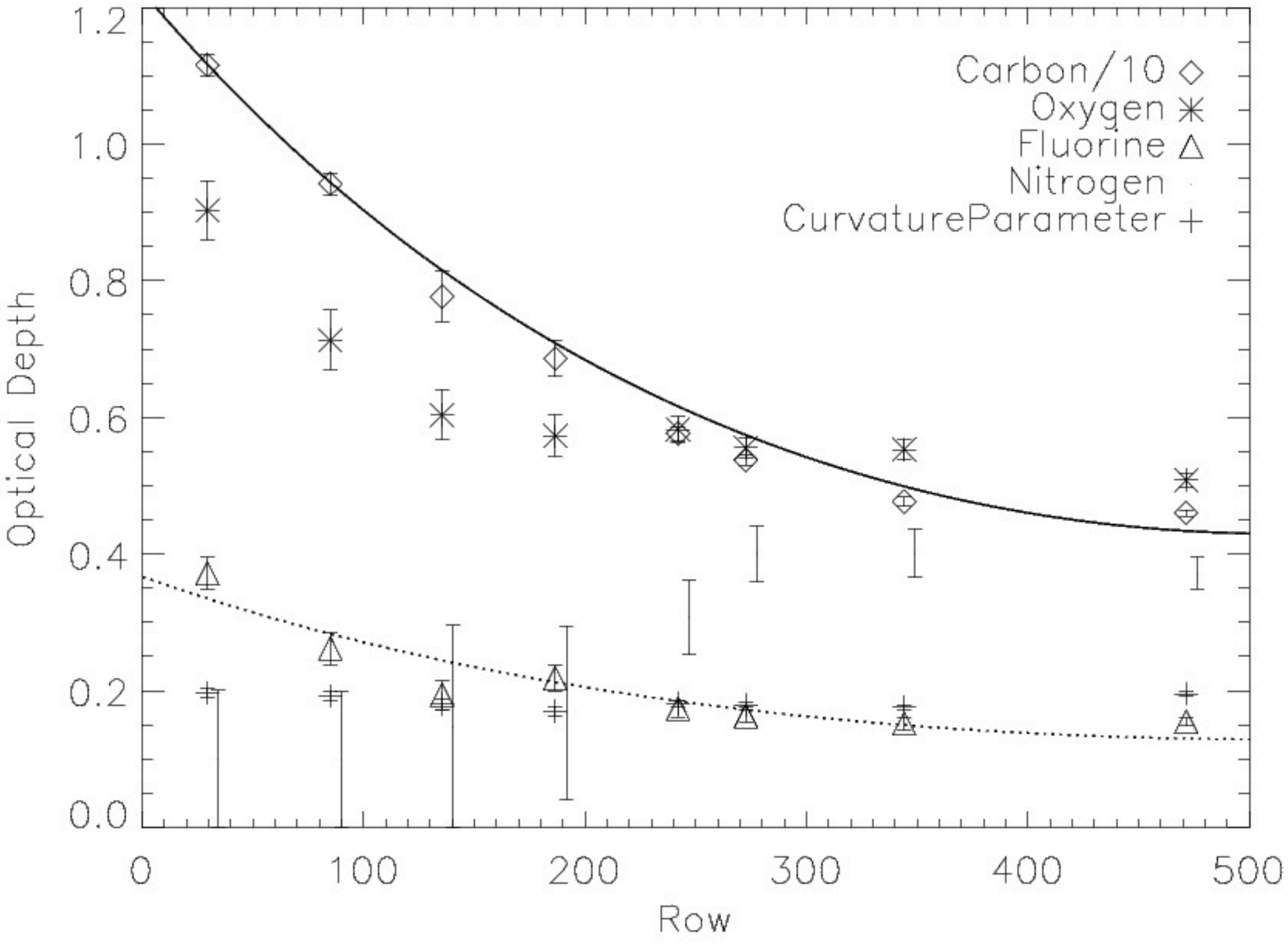


Spectra fit now bad



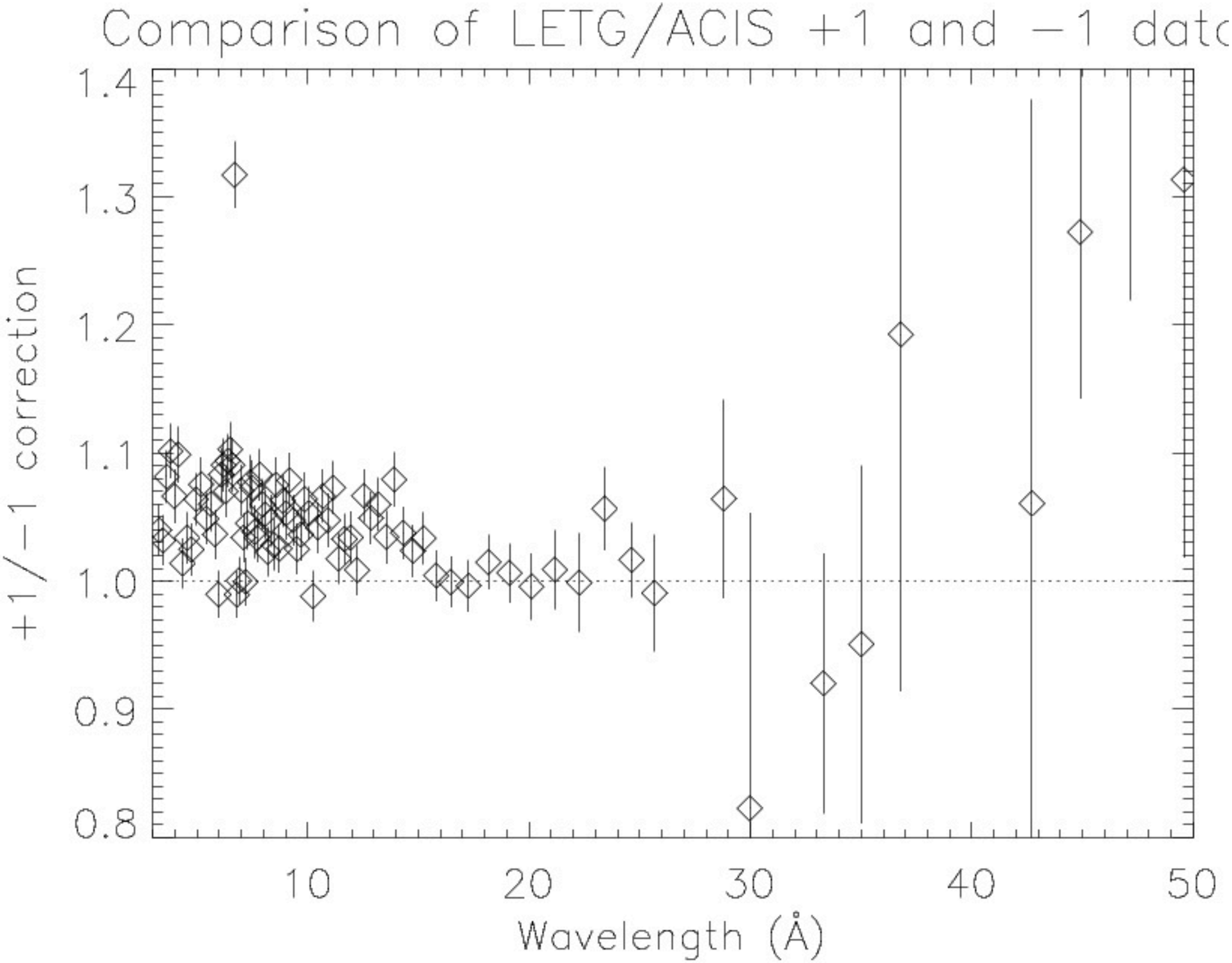

New:
N-K Edge
Flux [Photons/s/cm²/keV]
0.1
0.01
Δχ
5
0
−5
−10
0.2
0.5
1
2
5
Energy [keV]

Big Dither!


Carbon/10 ◇
Oxygen ✳
Fluorine △
Nitrogen
CurvatureParameter +
Optical Depth
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
Row

Edge Depths

	C-K	N-K	O-K	F-K
+1	4.81±0.16	0.11±0.08	0.54±0.01	0.186±0.007
-1	4.36±0.06	0.291±0.036	0.55±0.02	0.121±0.009


Comparison of LETG/ACIS +1 and −1 data
+1/−1 correction
1.4
1.3
1.2
1.1
1.0
0.9
0.8
10
20
30
40
50
Wavelength (Å)

Contaminant Summary

- It's still growing: Why? Filter is colder? S/C hotter?
- Spatial variations are time-dependent
  - CCD/housing temperature difference?
  - N and O don't match C and F
  - S3 matches S2 mostly
- Composition is time-dependent
  - Two components implicated, one is C-rich
  - ECS-LETGS disagreement unresolved
- Origin is unknown — not in original form
  - No on-board substance has contaminant's CFO ratios
  - Radiation-induced organic fracturing?