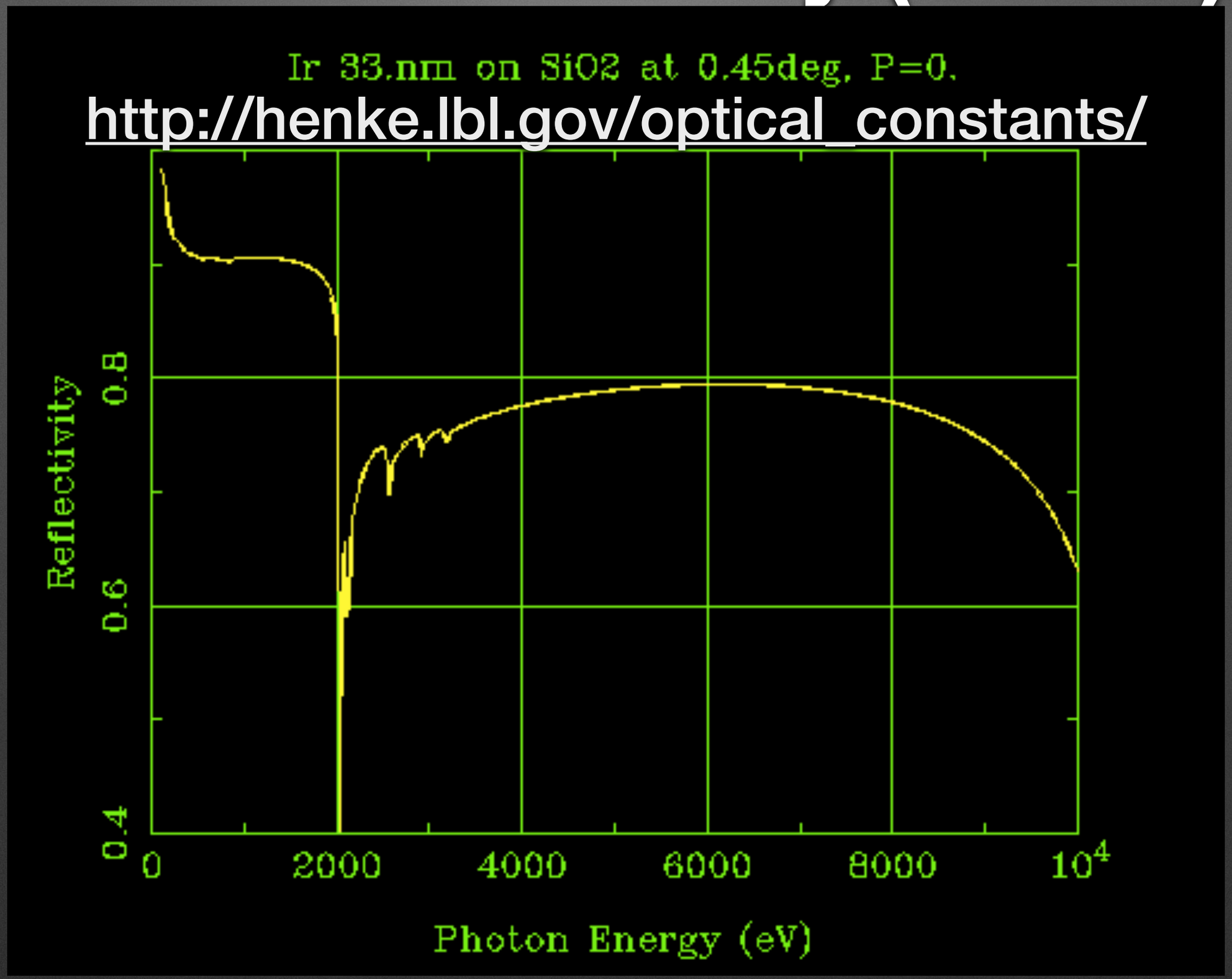
Effective Areas

Herman L. Marshall
Nov. 17, 2014

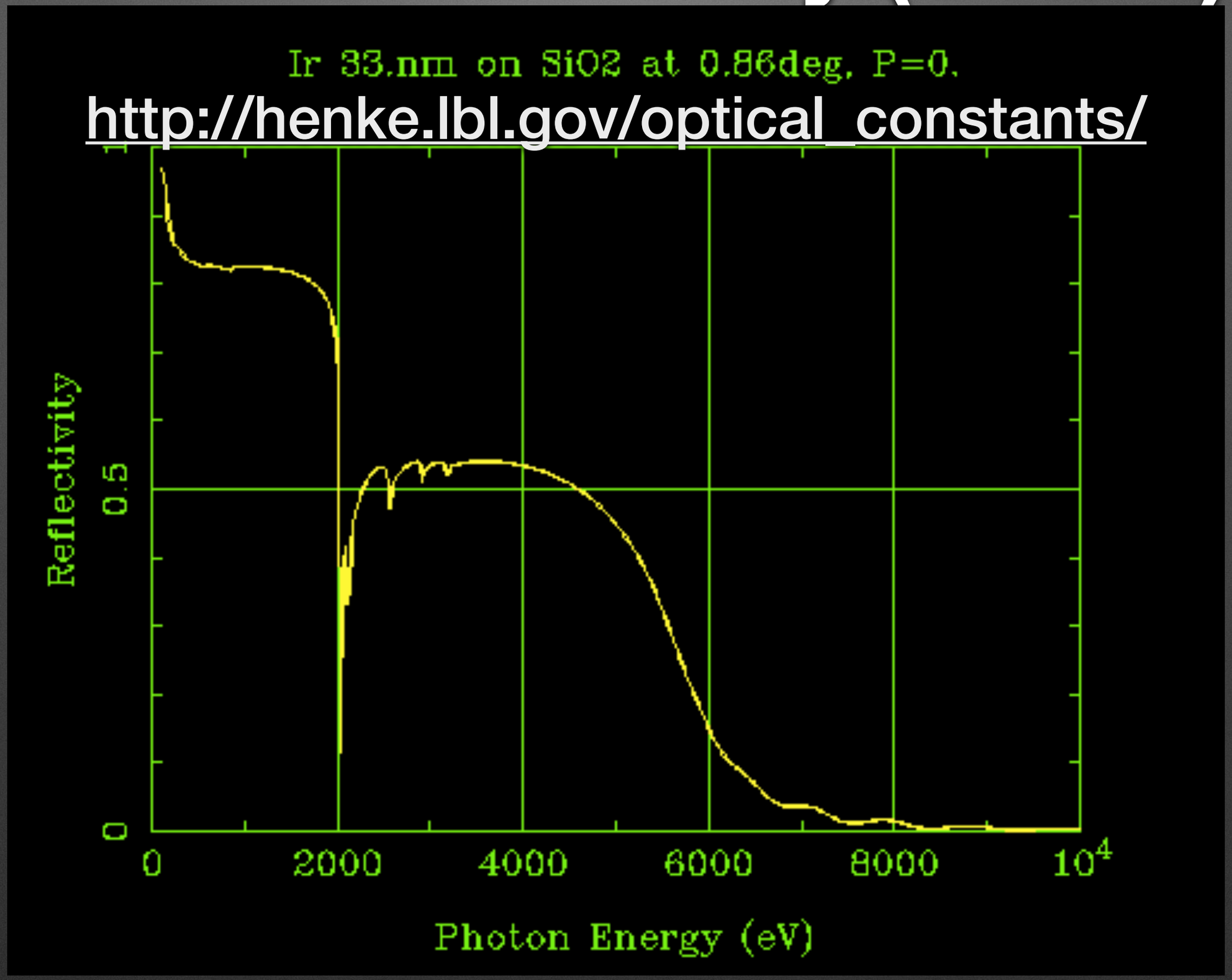
Effective Area Overview

- Geometric Area (entrance annuli - strut area = A_g)
- Two mirror bounces (R_{Ir}^2)
- Grating Dispersion Efficiency (T_{TG})
- ACIS/HRC Optical Blocking Filter ($T_{Al} * T_{lexan}$)
- ACIS detector quantum efficiency ($T_{contam} Q_{ACIS}$)
  - Absorption by SiO_2 dead layer, gate structure (FI)
  - Interaction probability in 1 micron thick Si
- HRC detector quantum efficiency (Q_{HRC})
- Result: $A_{eff} = A_g R_{Ir}^2 [T_{TG}] T_{Al} T_{lexan} [Q_{ACIS}][Q_{HRC}]$
- Also: HRMA overlayer, PSF, OSIP, chip gaps, bad pixels

Mirror Reflectivity (CXRO)

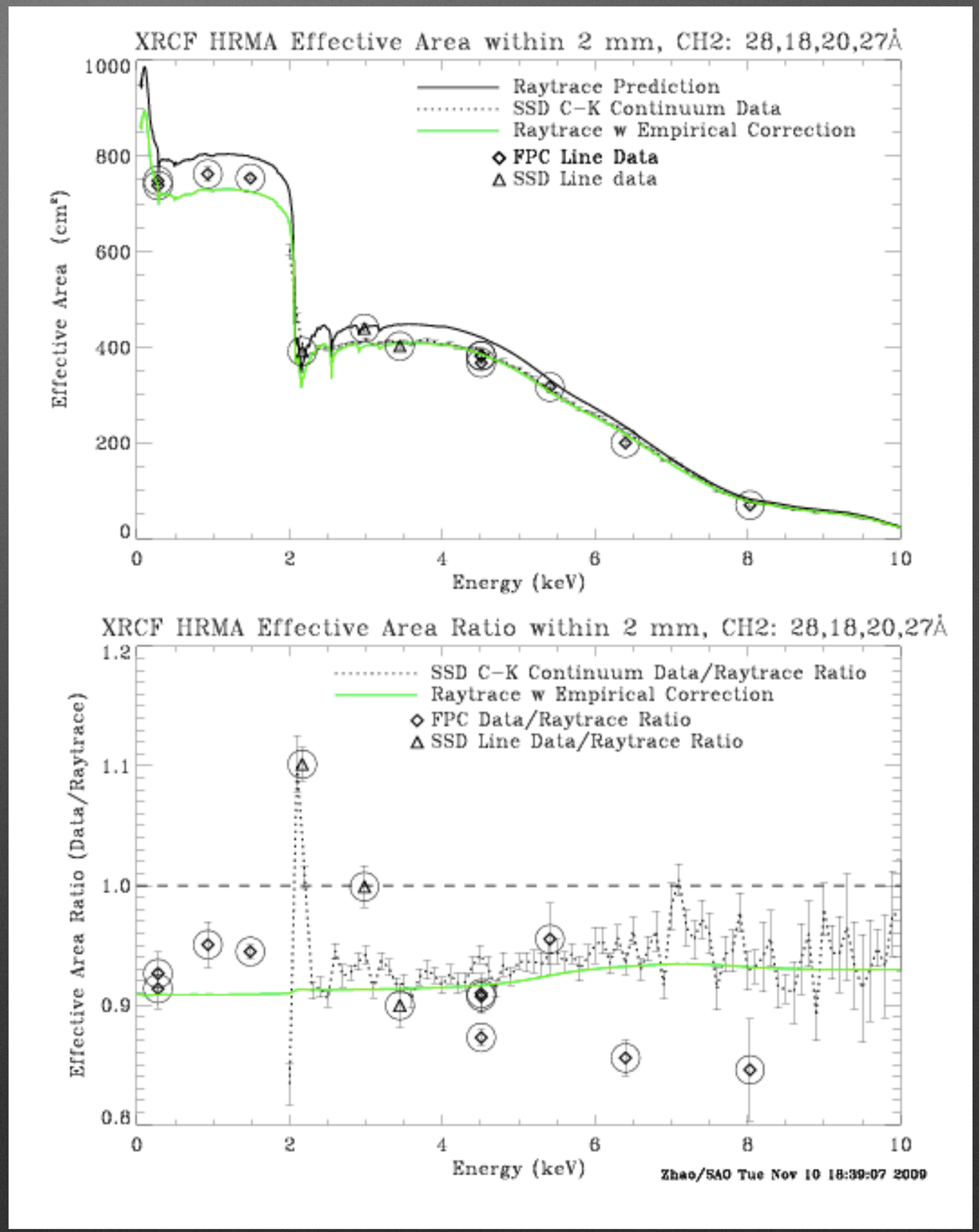


Mirror Reflectivity (CXRO)

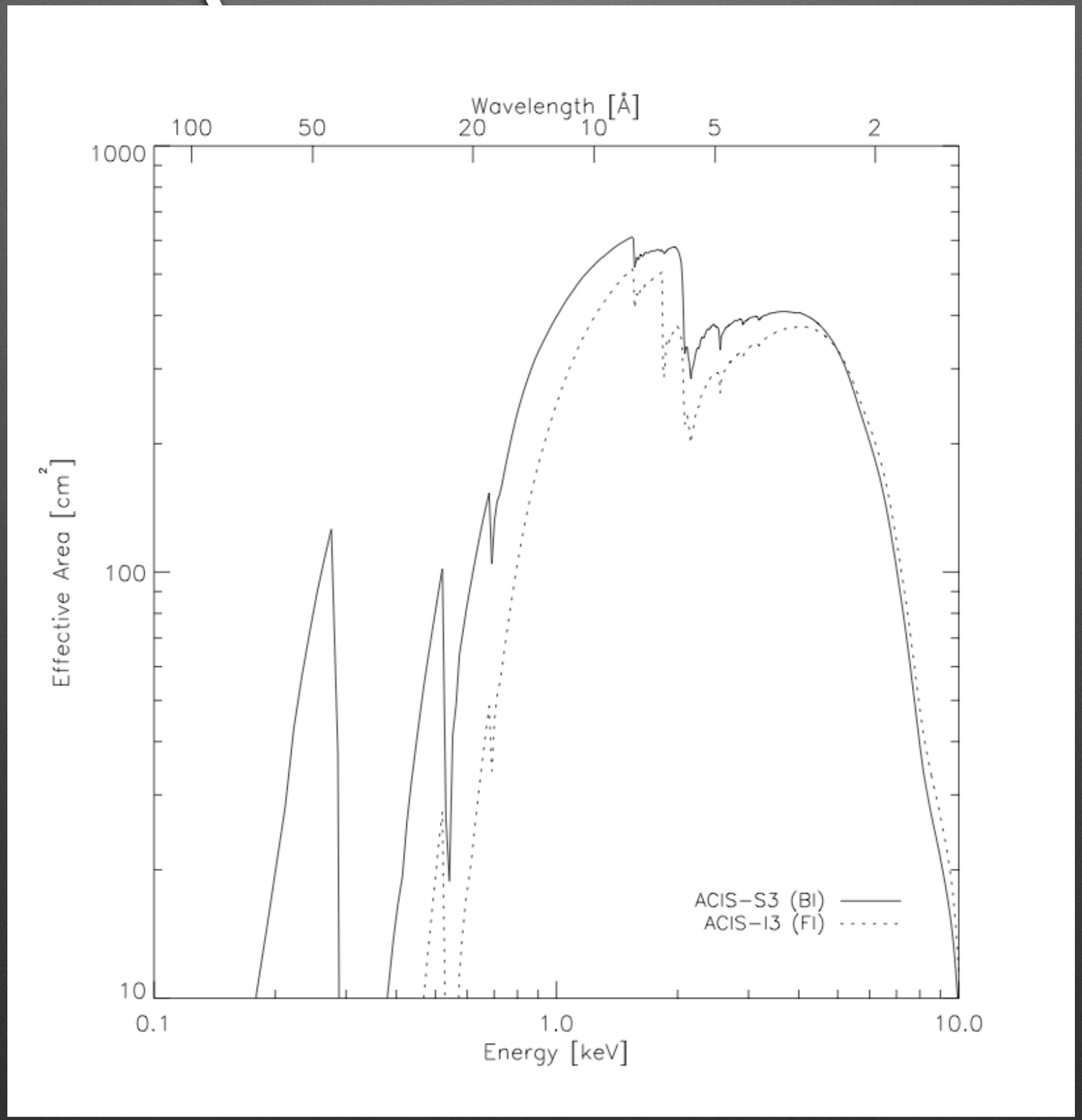


HRMA Calibration

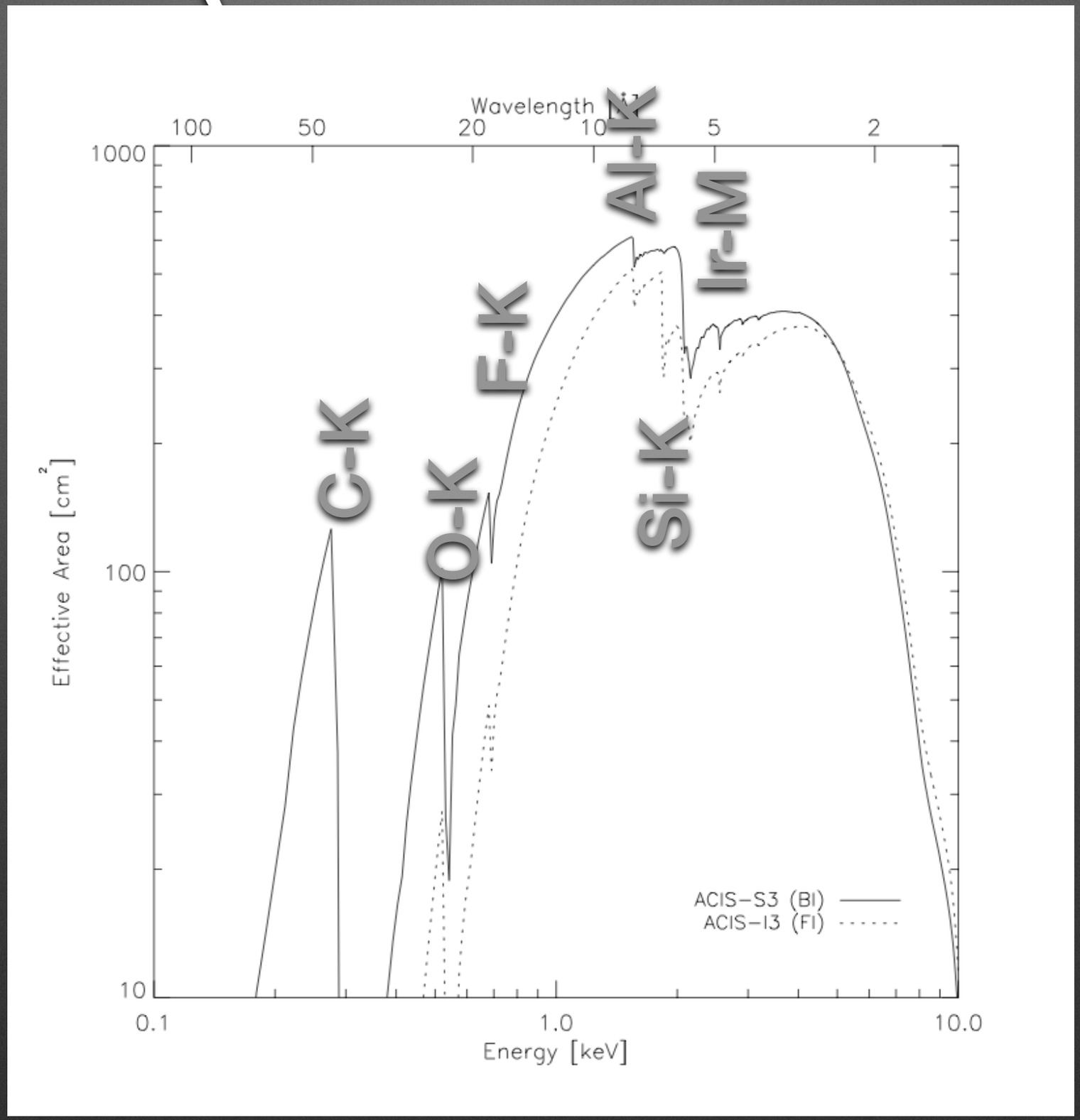
- Measured at MSFC
- Calibrated SSD and Prop. counters used
- Emission line source with various materials
- Empirical correction needed, still not understood
- See POG for details



ACIS EA (with contamination)

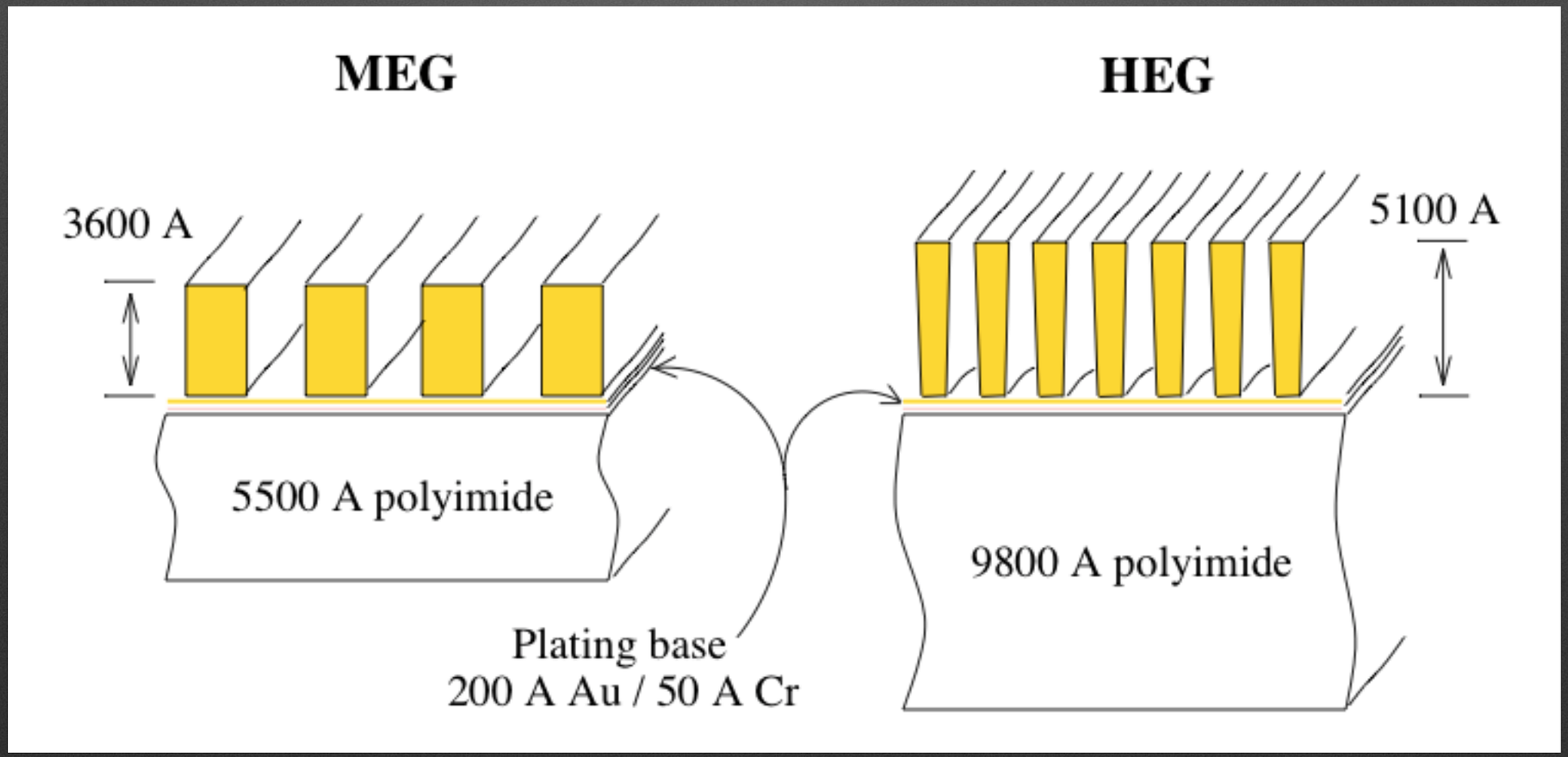


ACIS EA (with contamination)

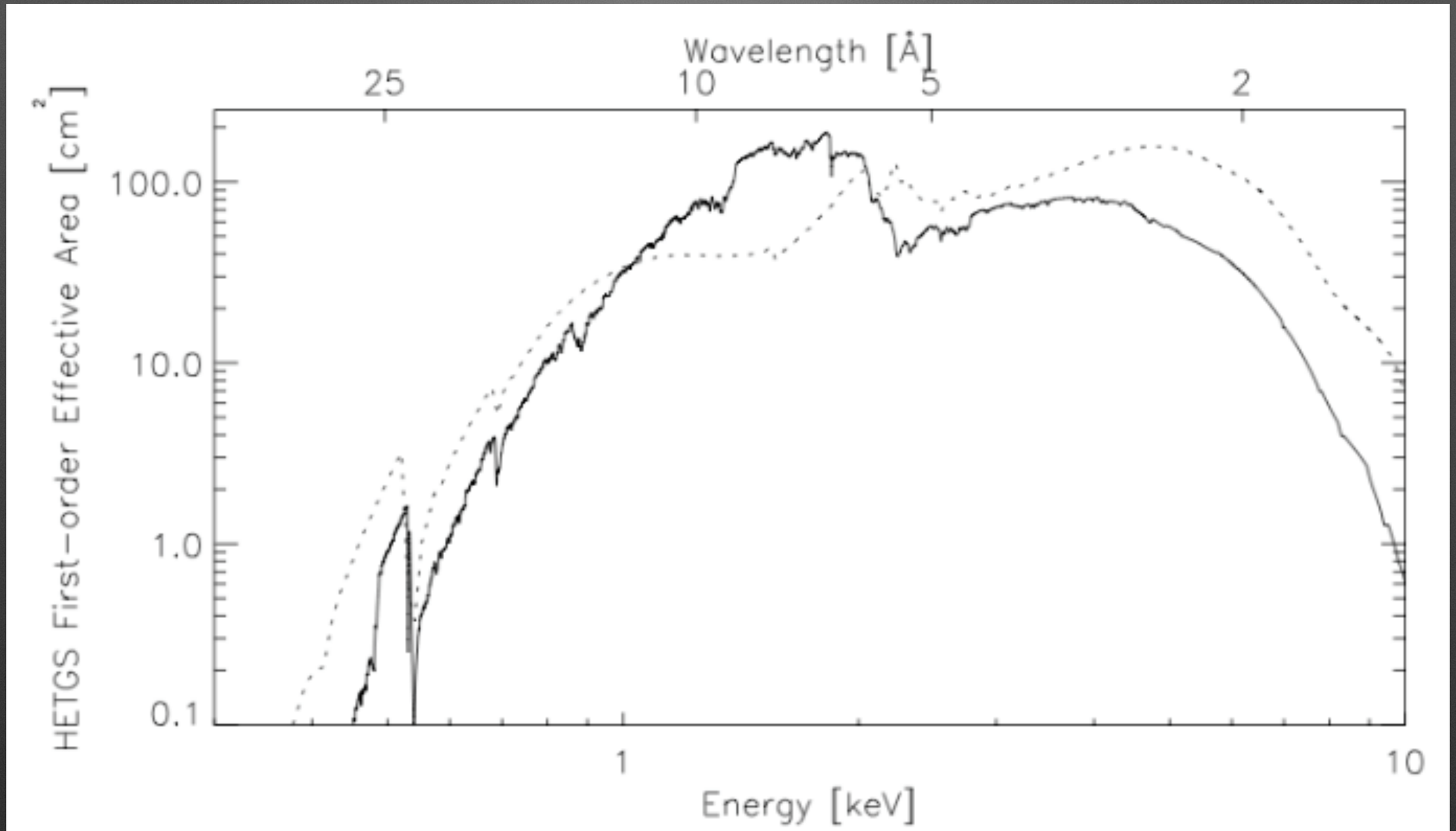


HETG Schematic

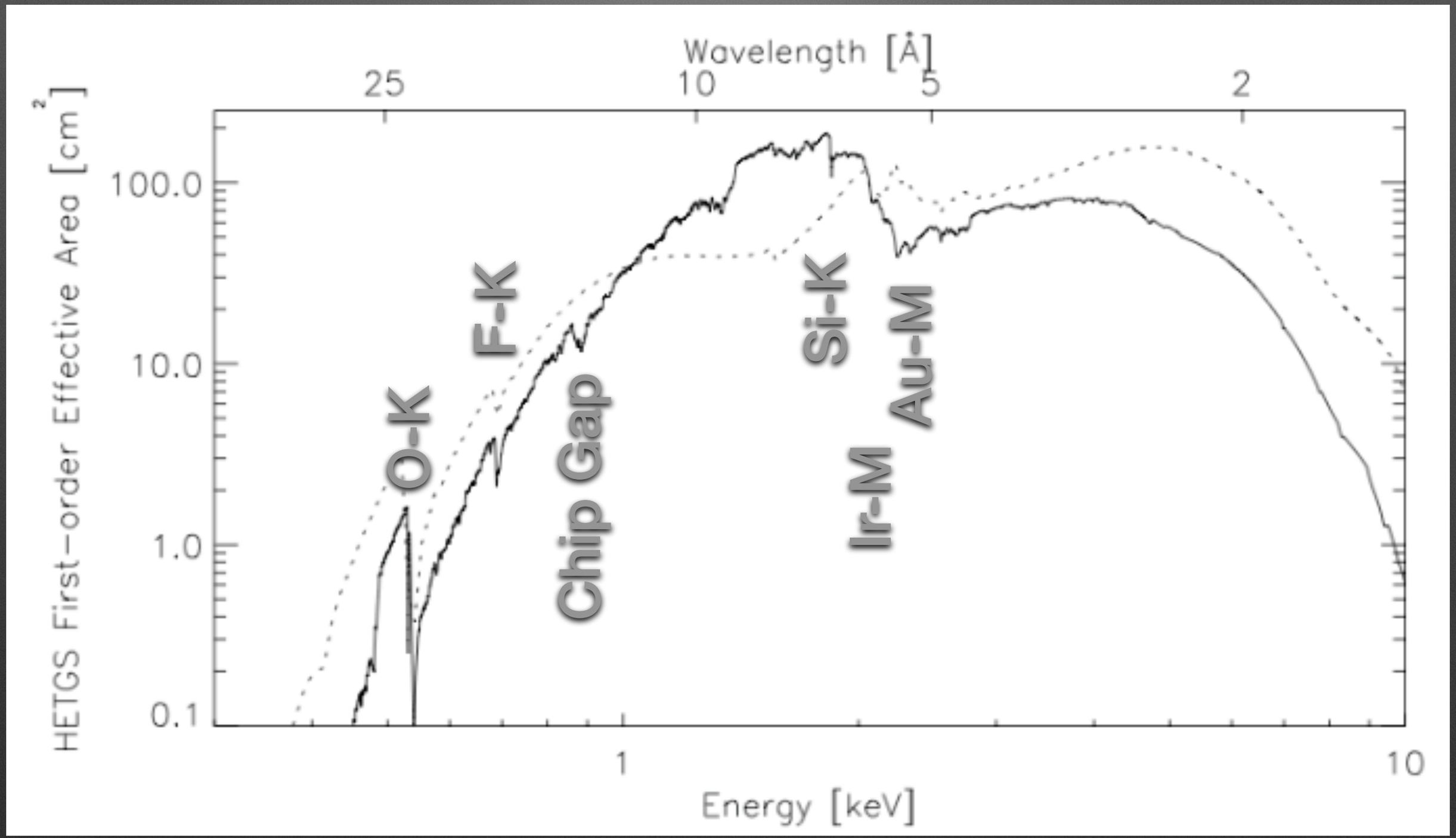
- Two types of gratings on HETGS
- Au bars stand on plating base, on polyimide



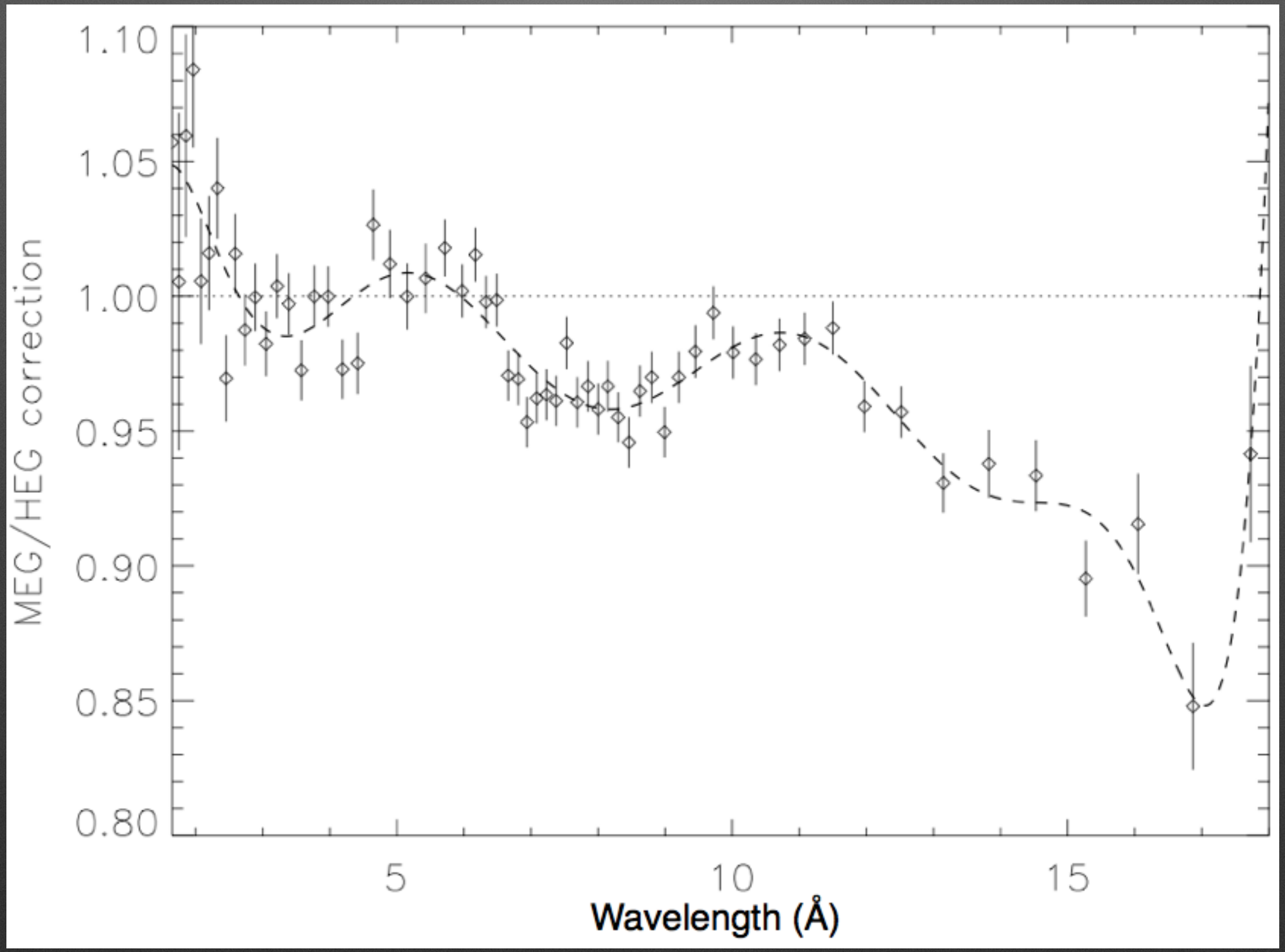
HETGS Effective Area



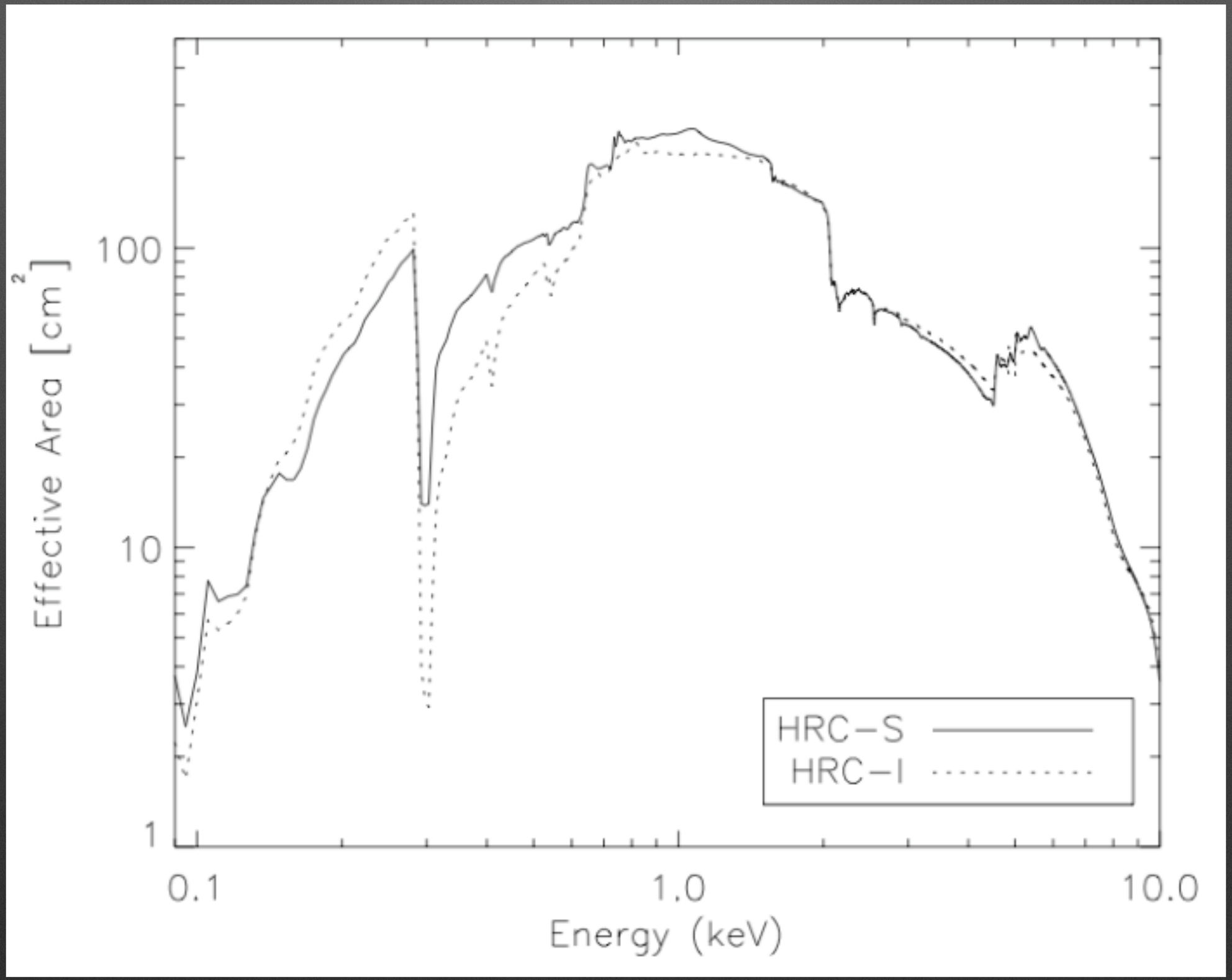
HETGS Effective Area



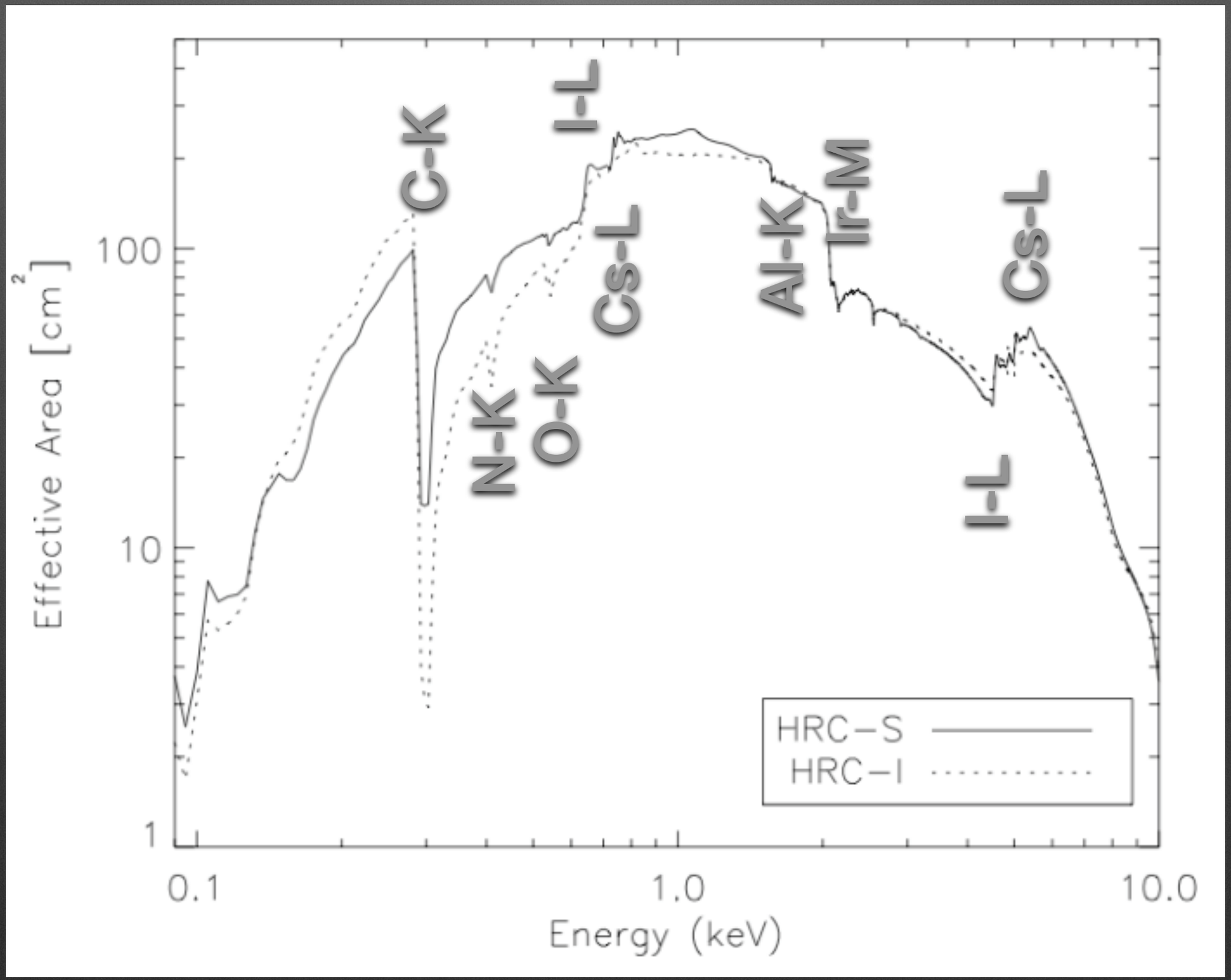
Internal Cross-cal of HETGS



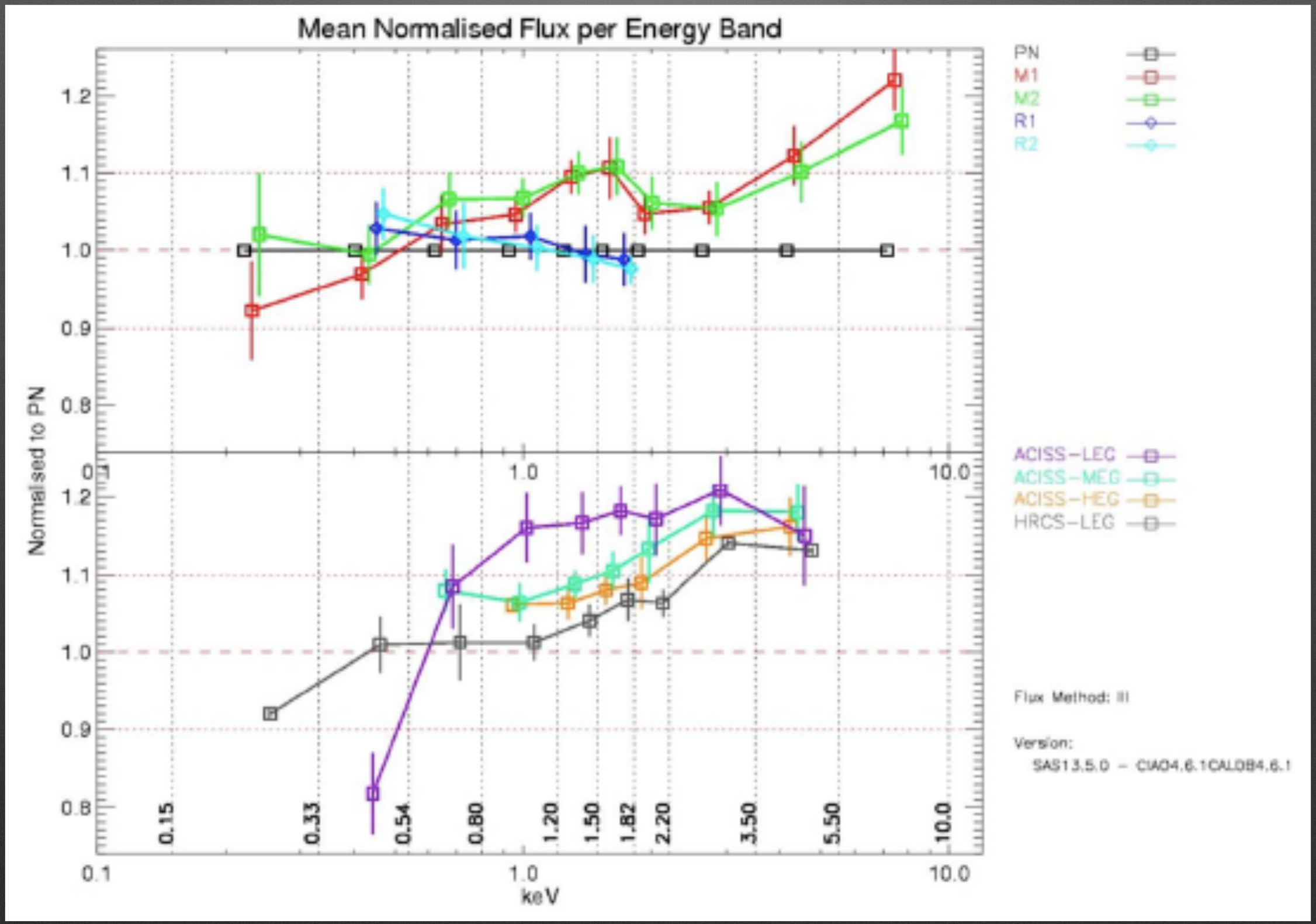
HRC Effective Area



HRC Effective Area



Cross-Cal with XMM



IACHEC: International Astronomical Consortium for High Energy Calibration

Defining High Energy Calibration Standards and Procedures

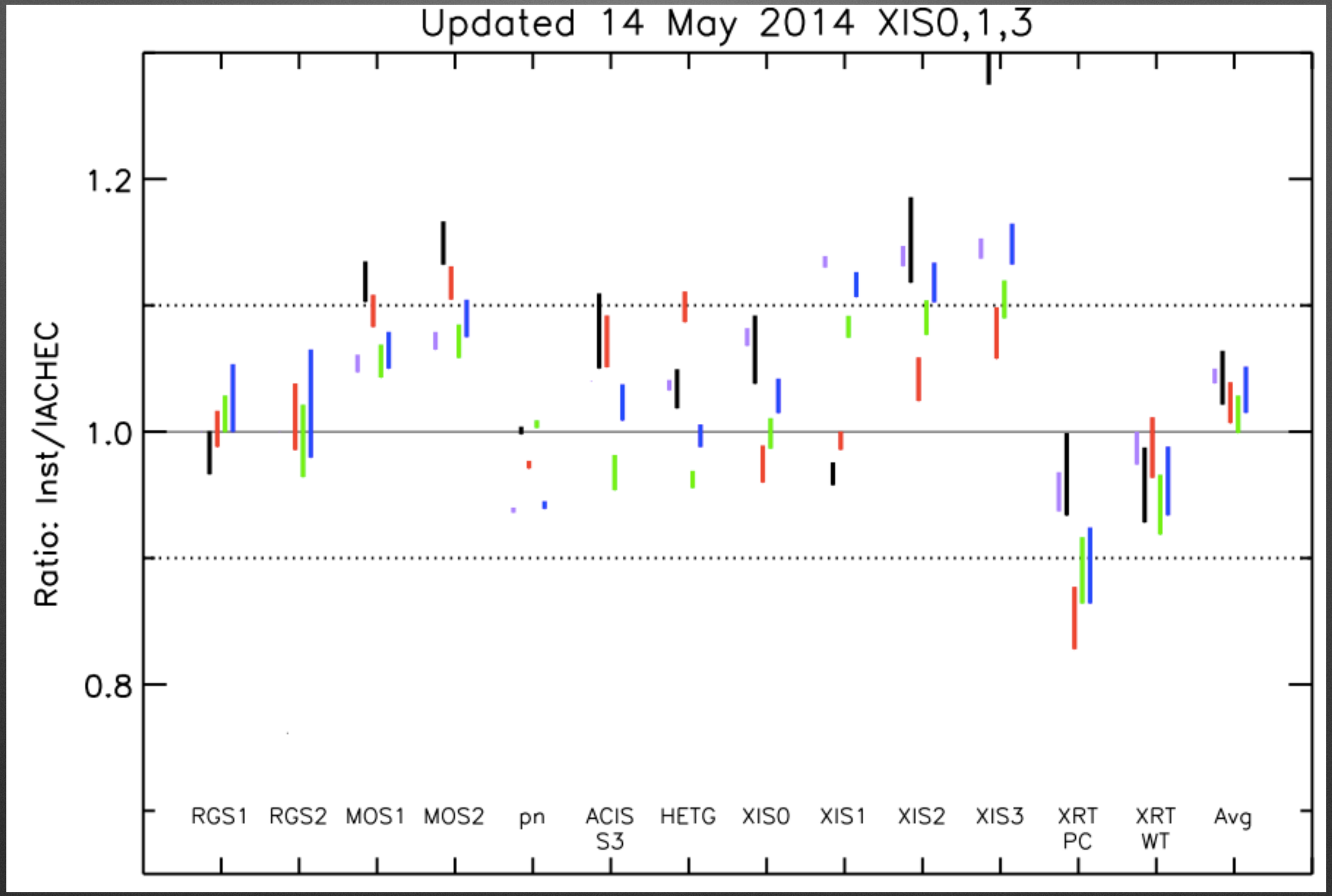
IACHEC

- Annual international meetings
  - Started by 2 largest X-ray groups (Chandra & XMM)
  - First meeting in Iceland in 2006
  - Support comes from projects (XMM, Suzaku, etc.)
  - Next meeting: Beijing, PRC
  - Meetings involve reports and working groups
  - All major X- & gamma-ray missions represented
  - 35-45 attendees/meeting, 70% give talks
  - 9 papers published (2008-14), several in progress
  - URL: http://web.mit.edu/iachec/ with Wiki

What IACHEC Does

- Reviews ground calibration plans for new missions
  - Previous meetings: NuSTAR, Swift,
  - This year: Astro-H, eROSITA
- Reviews flight calibration plans and results
  - Investigate optics and detector physics
    - Examine methods, systematic errors
- Define new calibration standards
  - Characterize sources physically
  - Compare & publish results from different missions
- Arrange coordinated observations
- Consider infrastructure: statistics, archives

Cross-Cal with 1E0102



Contamination

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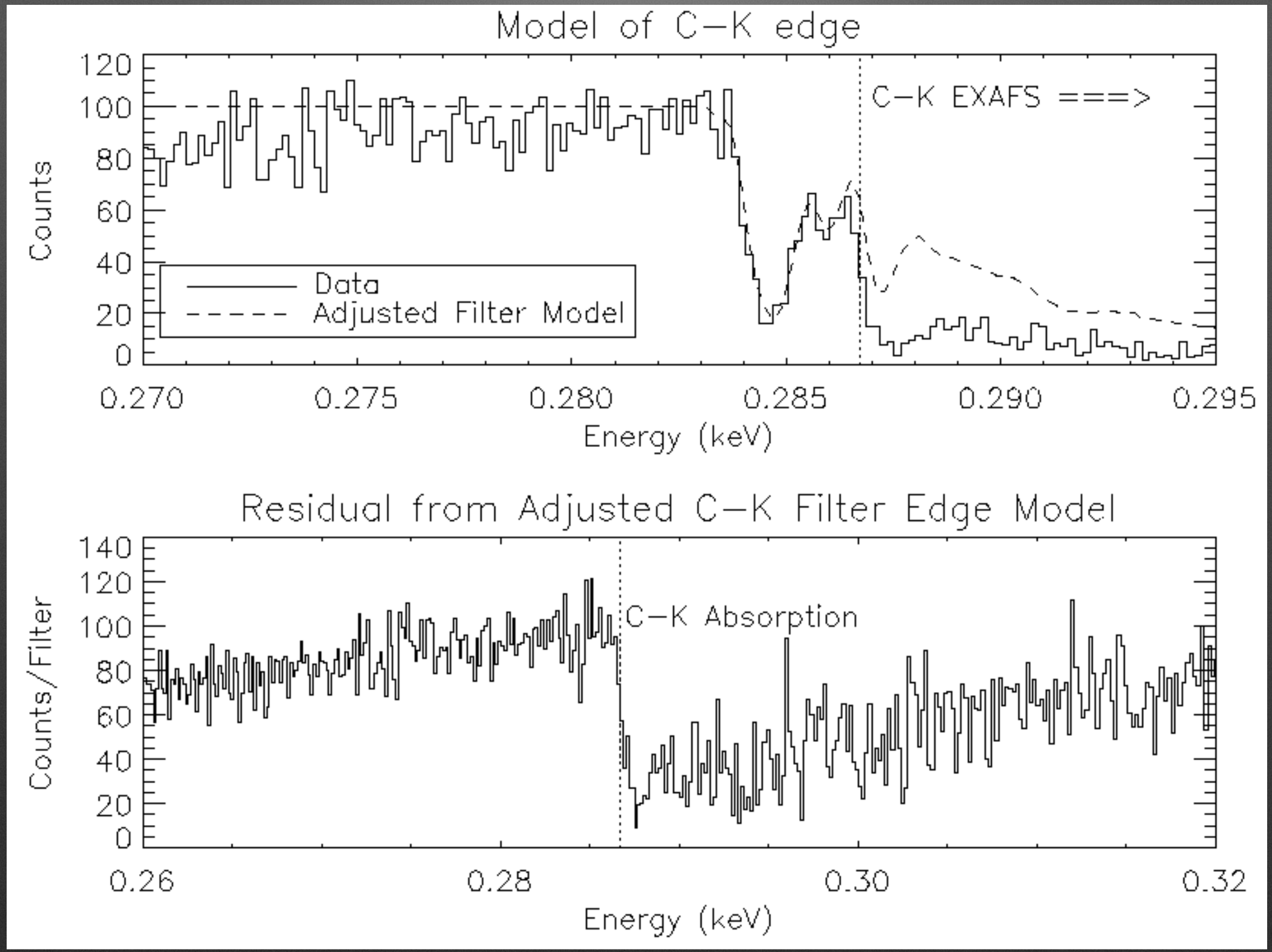
Nov. 17, 2014

Contamination Overview

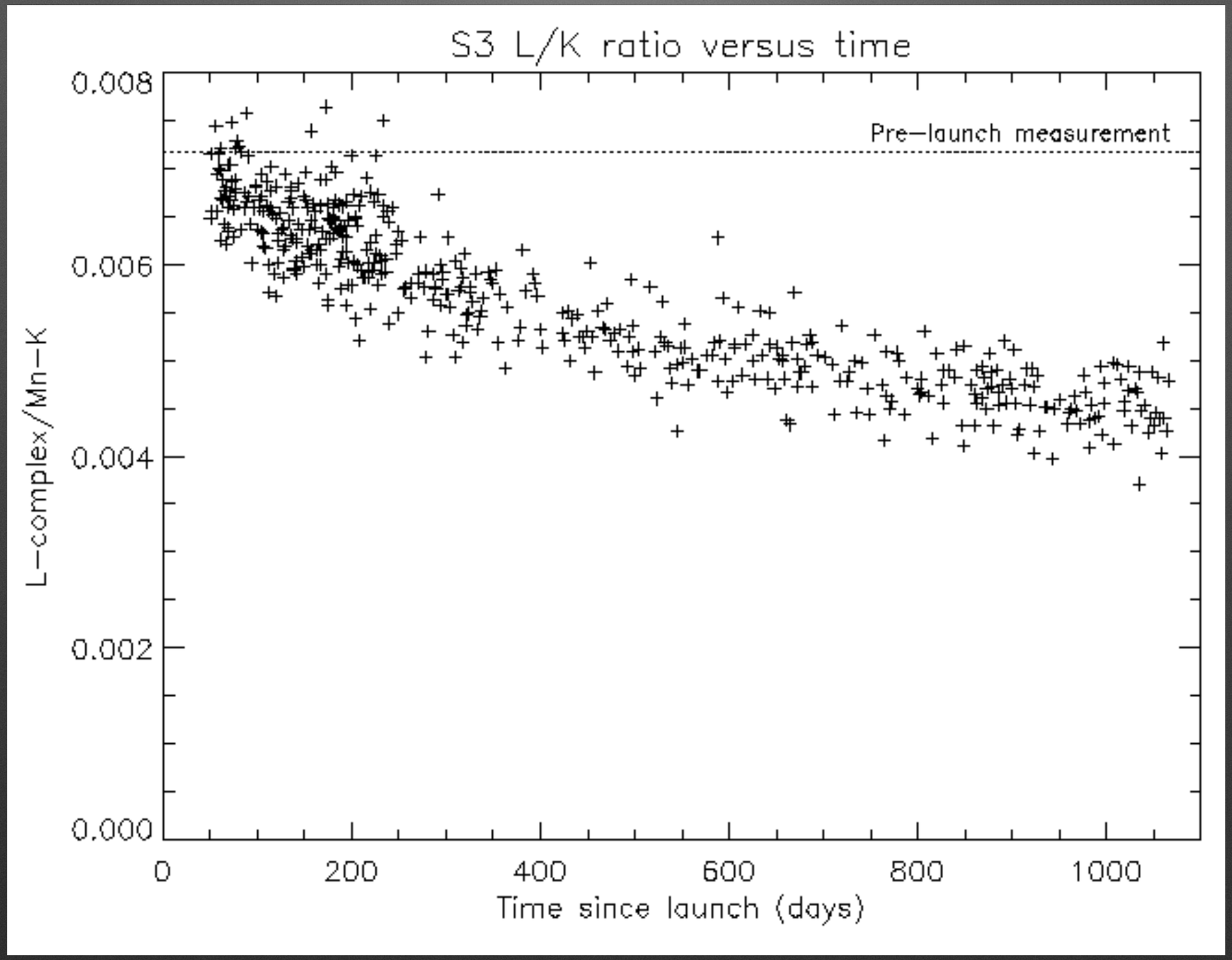
- 1999: Chandra Launch
- 2000: Anomalous C-K edge — LETG only?
- 2001: Contaminant thickens
- 2002: Composition determined (COF), edge NEXAFS indicates C-C single bonding
- 2003: Spatial variation found: thin at FoV center
- 2004: Fluffium invented as LETG/ACIS and cal source disagree; new model released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

The Anomalous C-K Edge

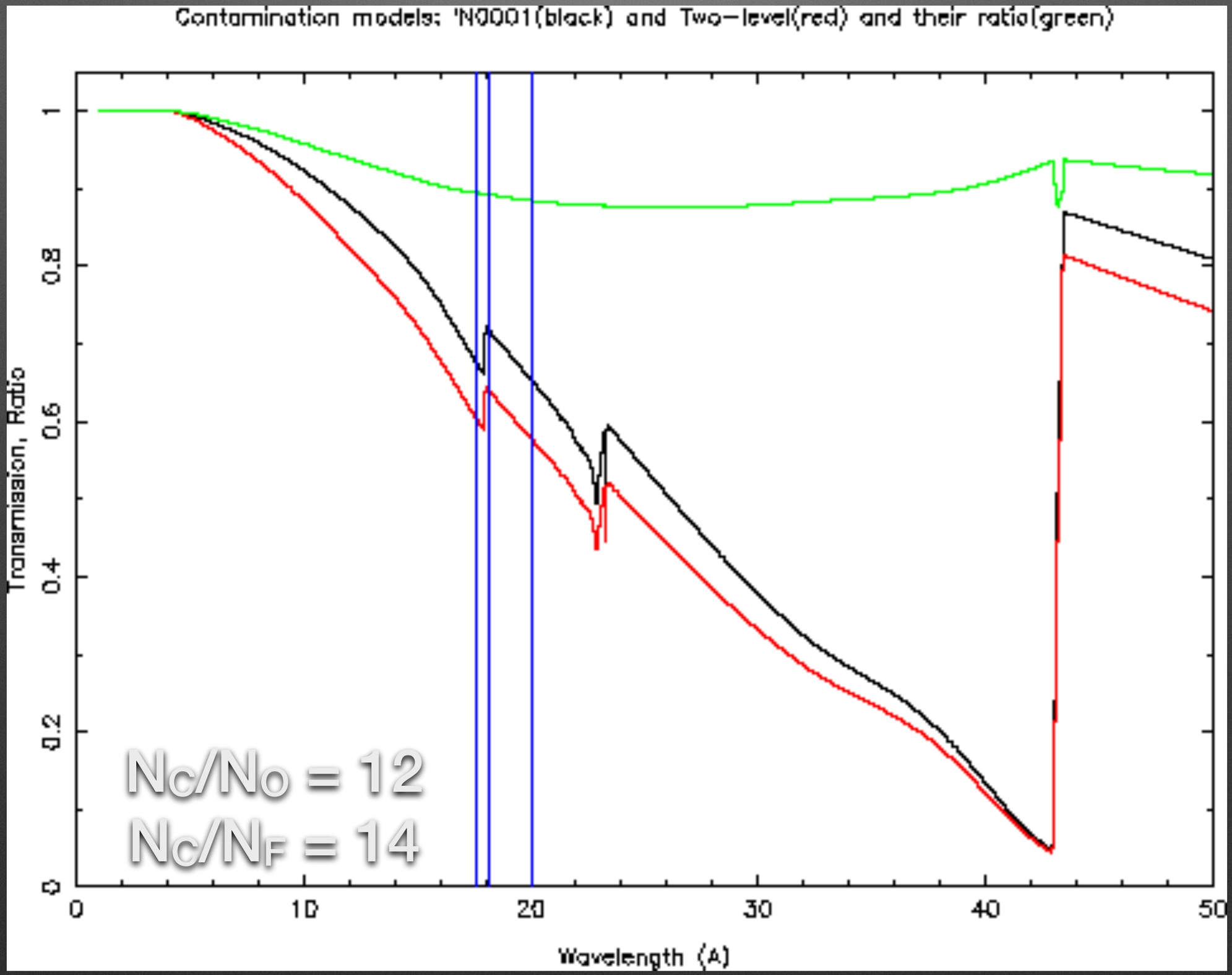


ACIS External Cal Source

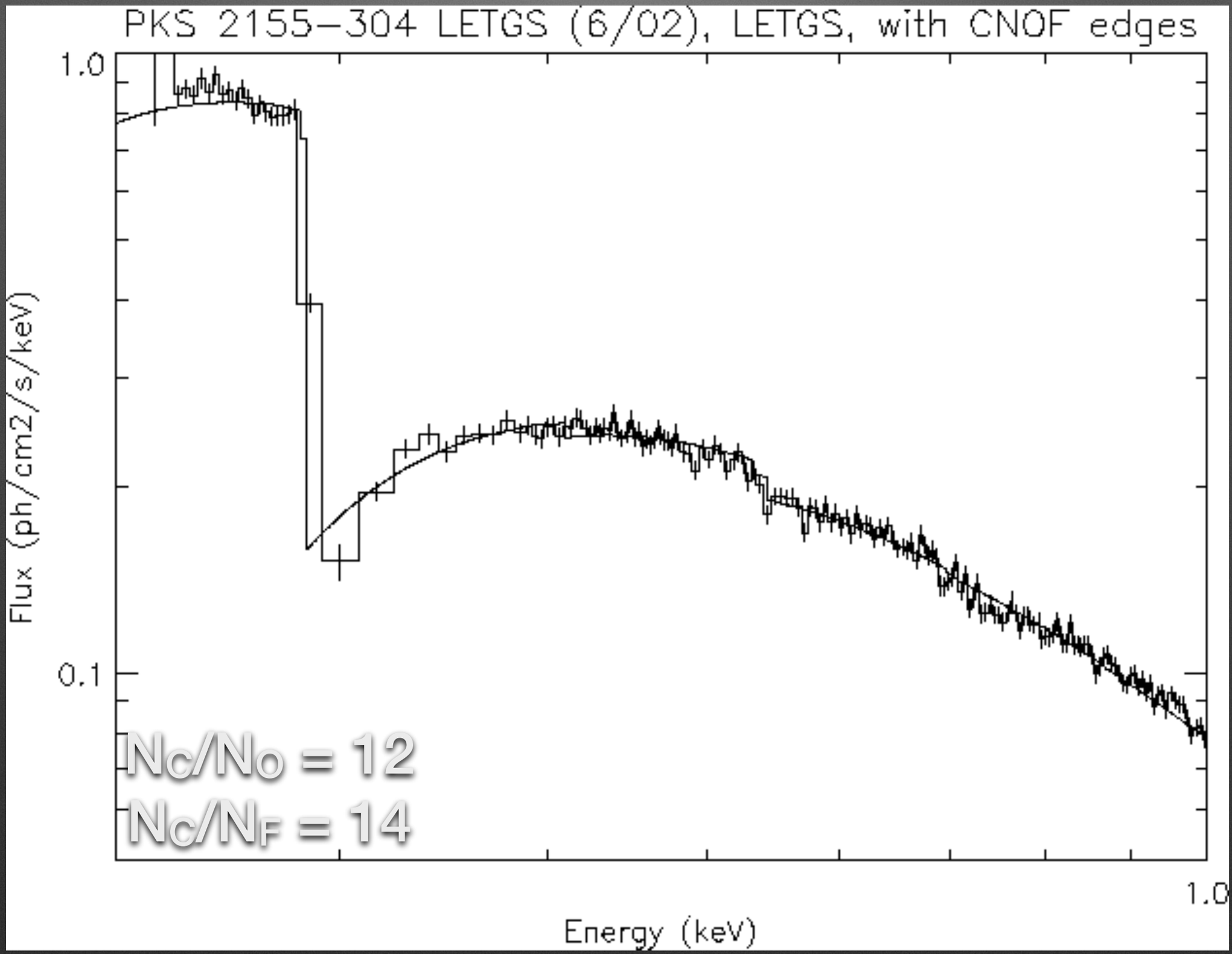
700eV / 5.9keV

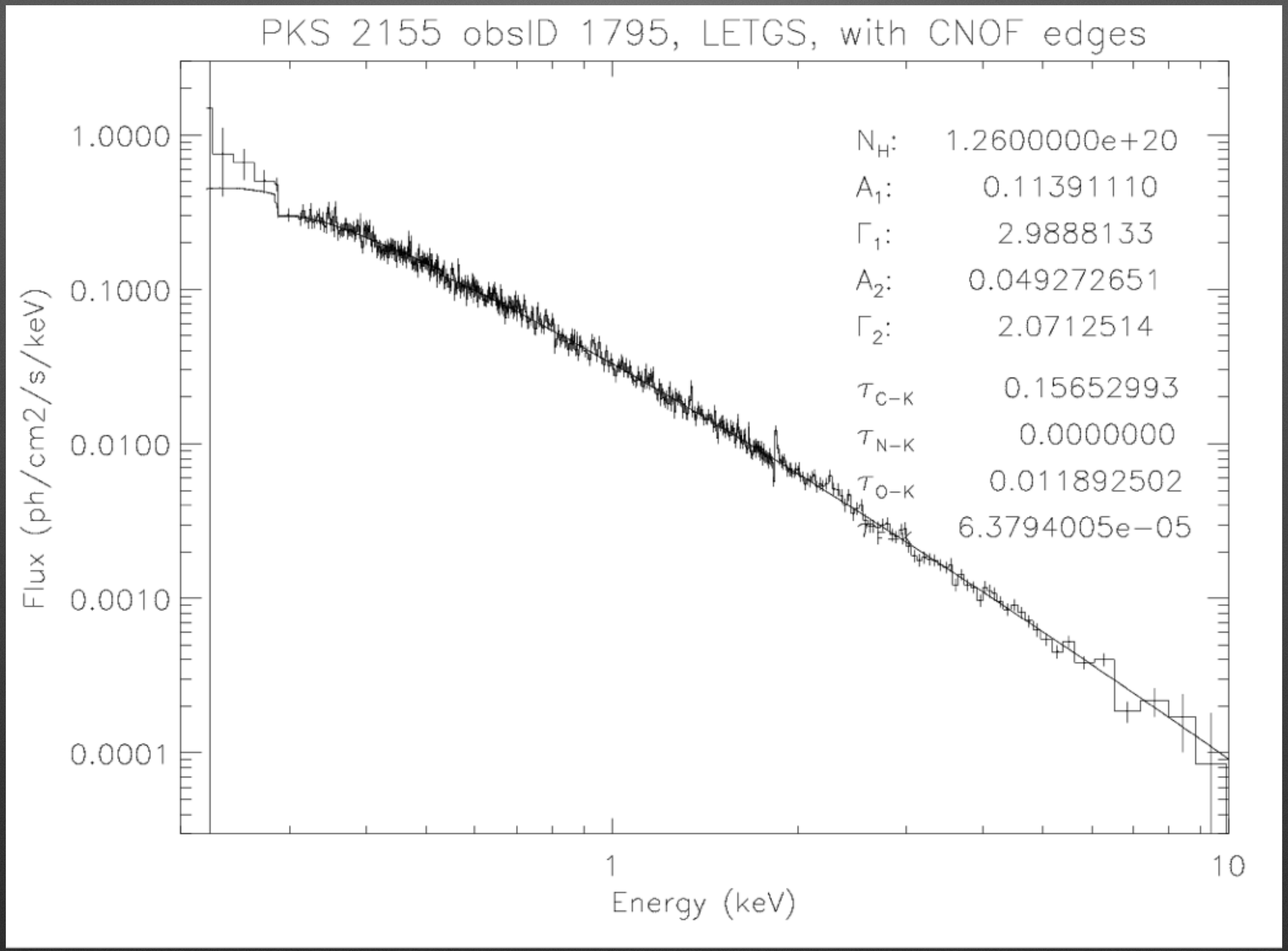


The Model

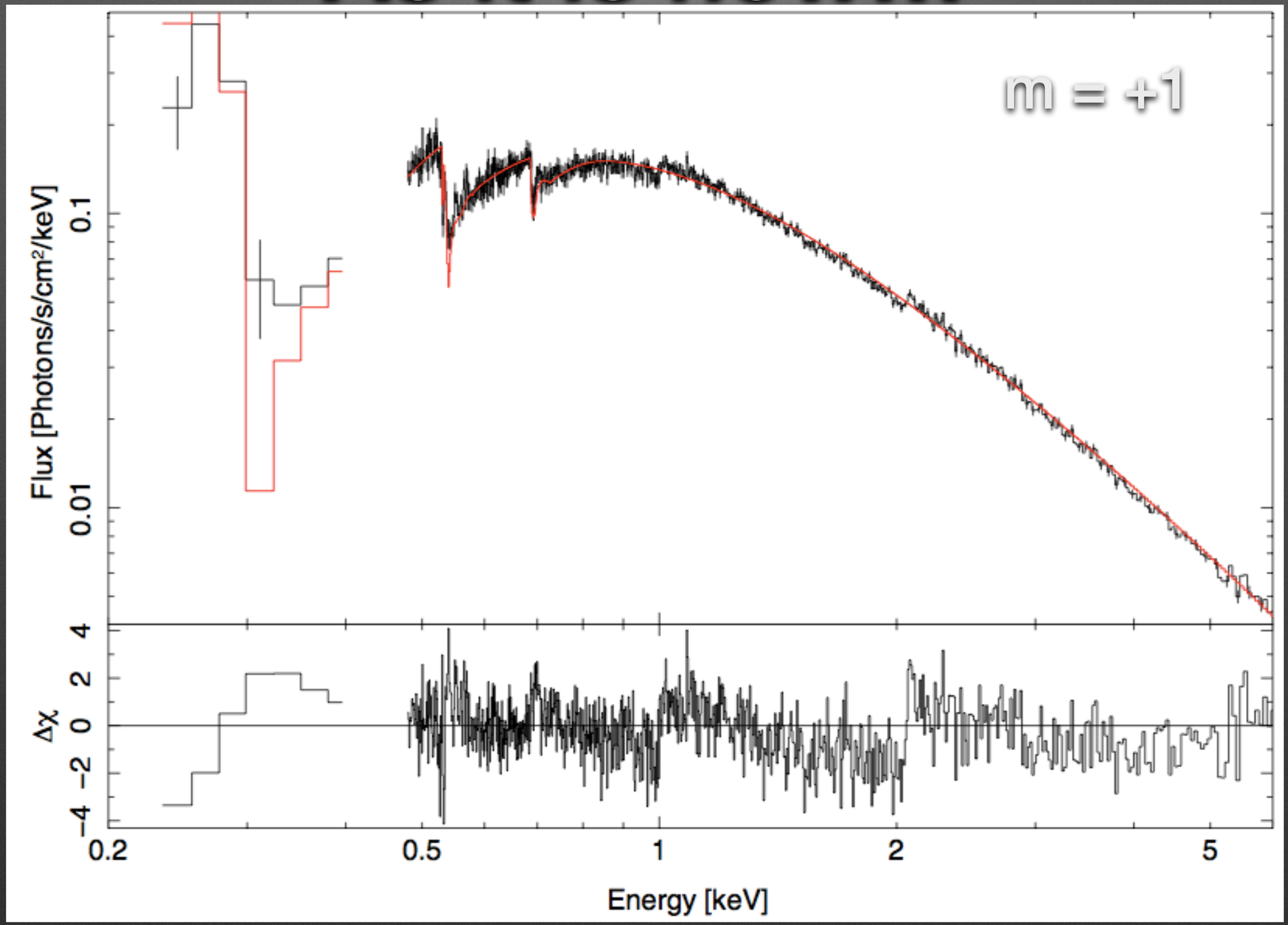

Contamination models: 'N0001(black) and Two-level(red) and their ratio(green)
Tranamission, Ratio
0
0.2
0.4
0.6
0.8
1
0
10
20
30
40
50
Wavelength (A)
Nc/No = 12
Nc/NF = 14

The Model

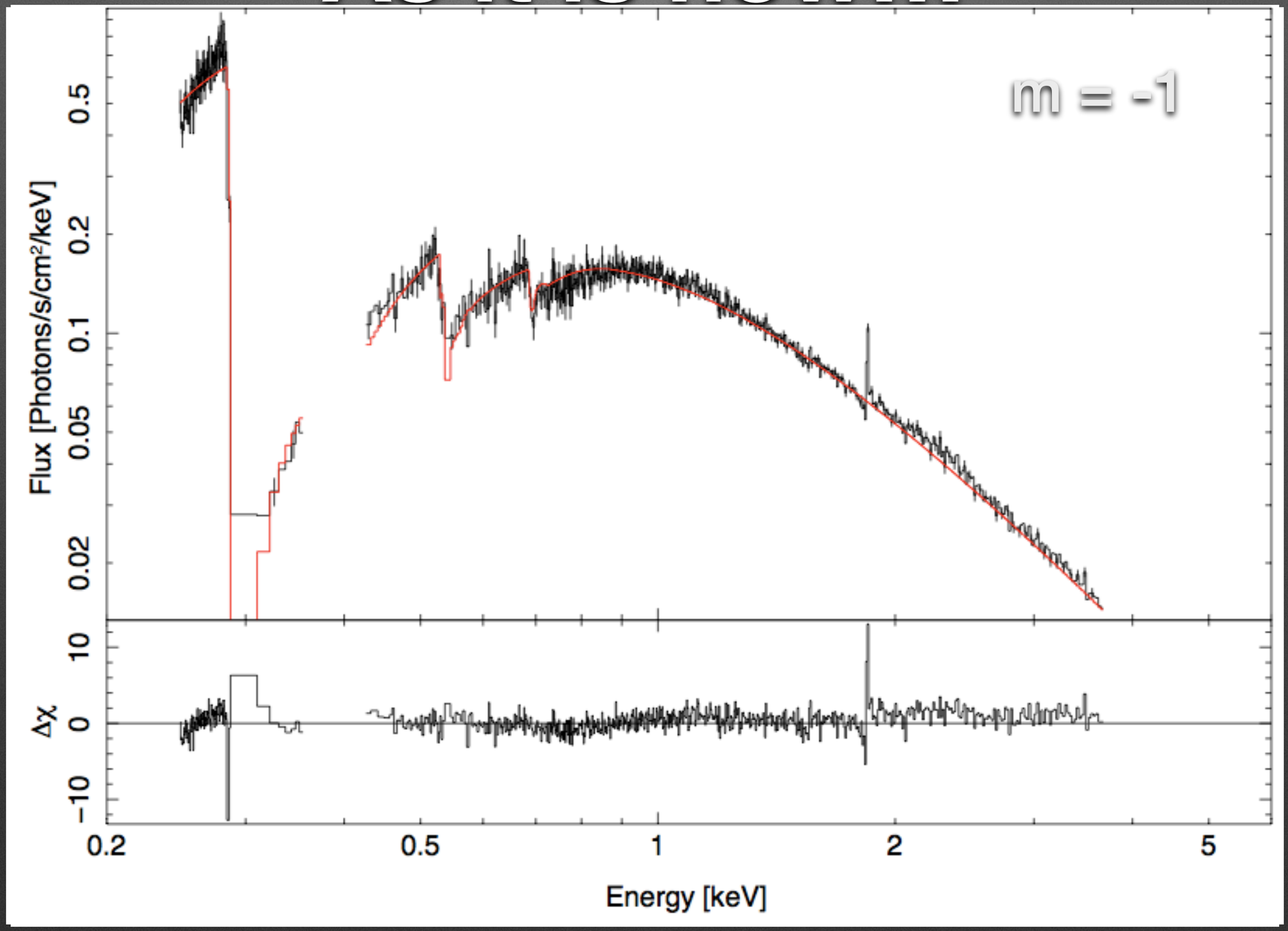

PKS 2155−304 LETGS (6/02), LETGS, with CNOF edges
1.0
0.1
Flux (ph/cm2/s/keV)
Nc/No = 12
Nc/NF = 14
1.0
Energy (keV)


PKS 2155 obsID 1795, LETGS, with CNOF edges
1.0000
0.1000
0.0100
0.0010
0.0001
Flux (ph/cm2/s/keV)
1
10
Energy (keV)
N_H: 1.2600000e+20
A_1: 0.11391110
Γ_1: 2.9888133
A_2: 0.049272651
Γ_2: 2.0712514
τ_C-K 0.15652993
τ_N-K 0.0000000
τ_O-K 0.011892502
6.3794005e-05

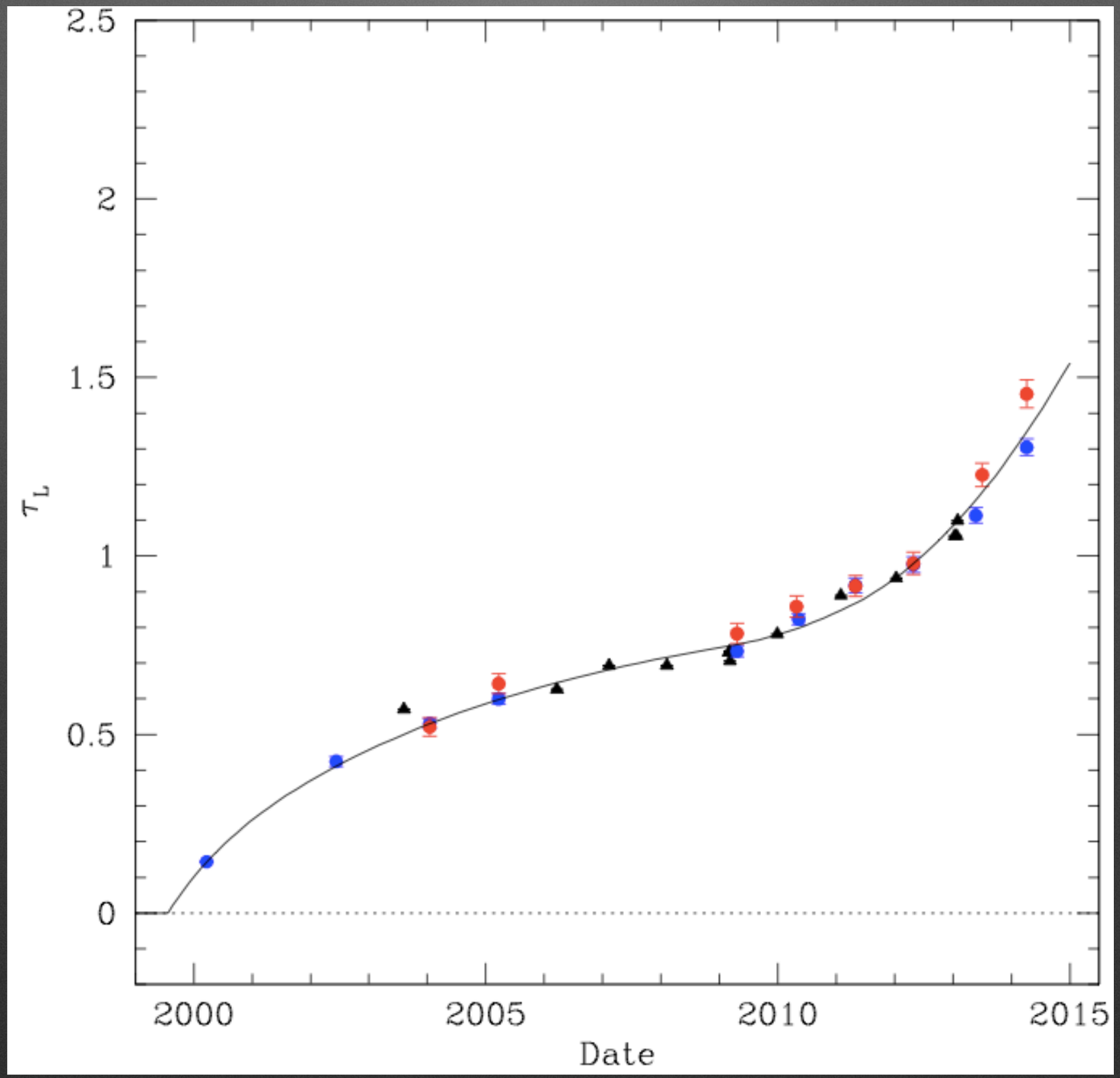
As it is now…



As it is now…

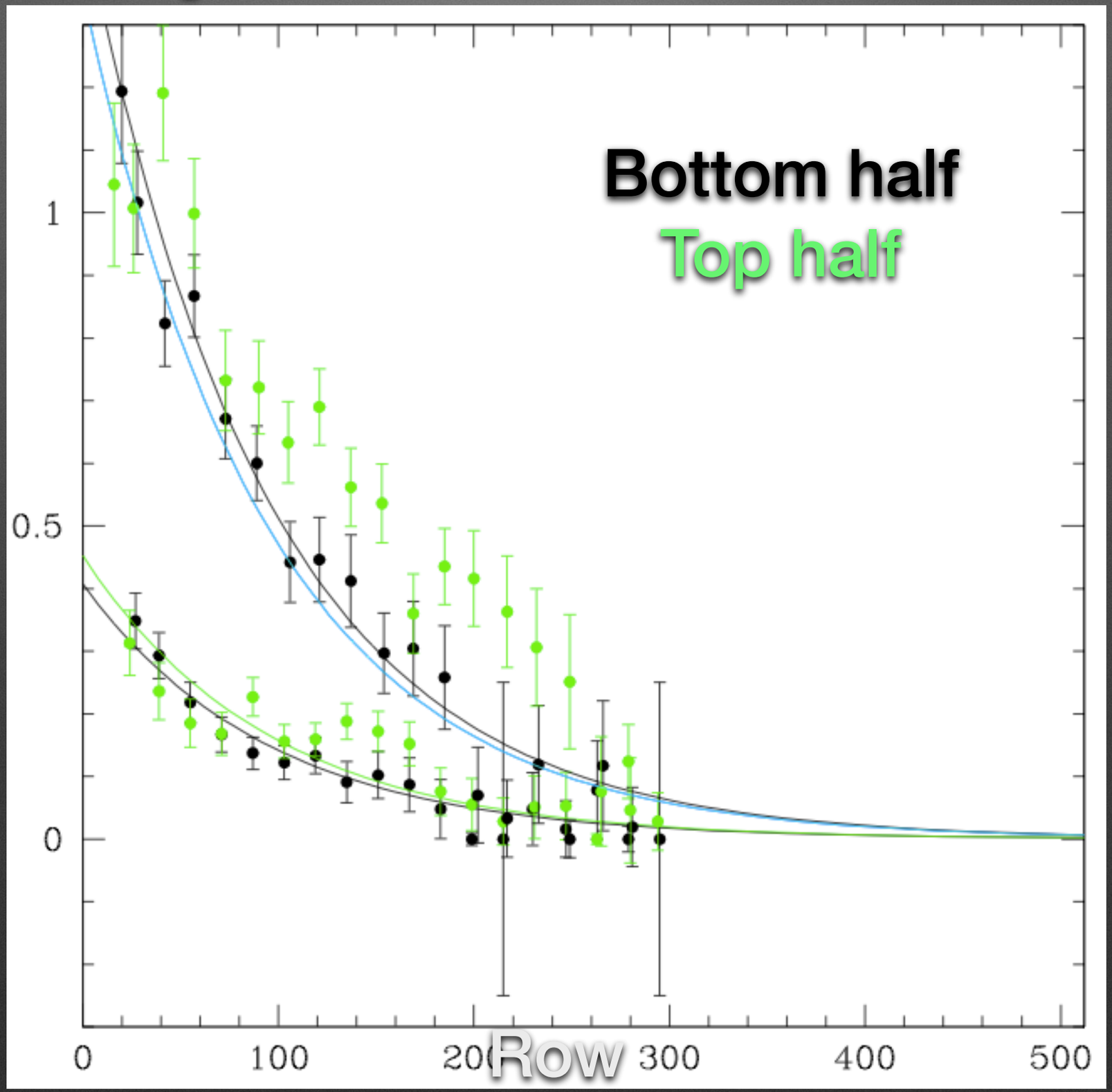

m = -1
Flux [Photons/s/cm²/keV]
0.5
0.2
0.1
0.05
0.02
Δχ
10
0
−10
0.2
0.5
1
2
5
Energy [keV]

Cluster Measurements

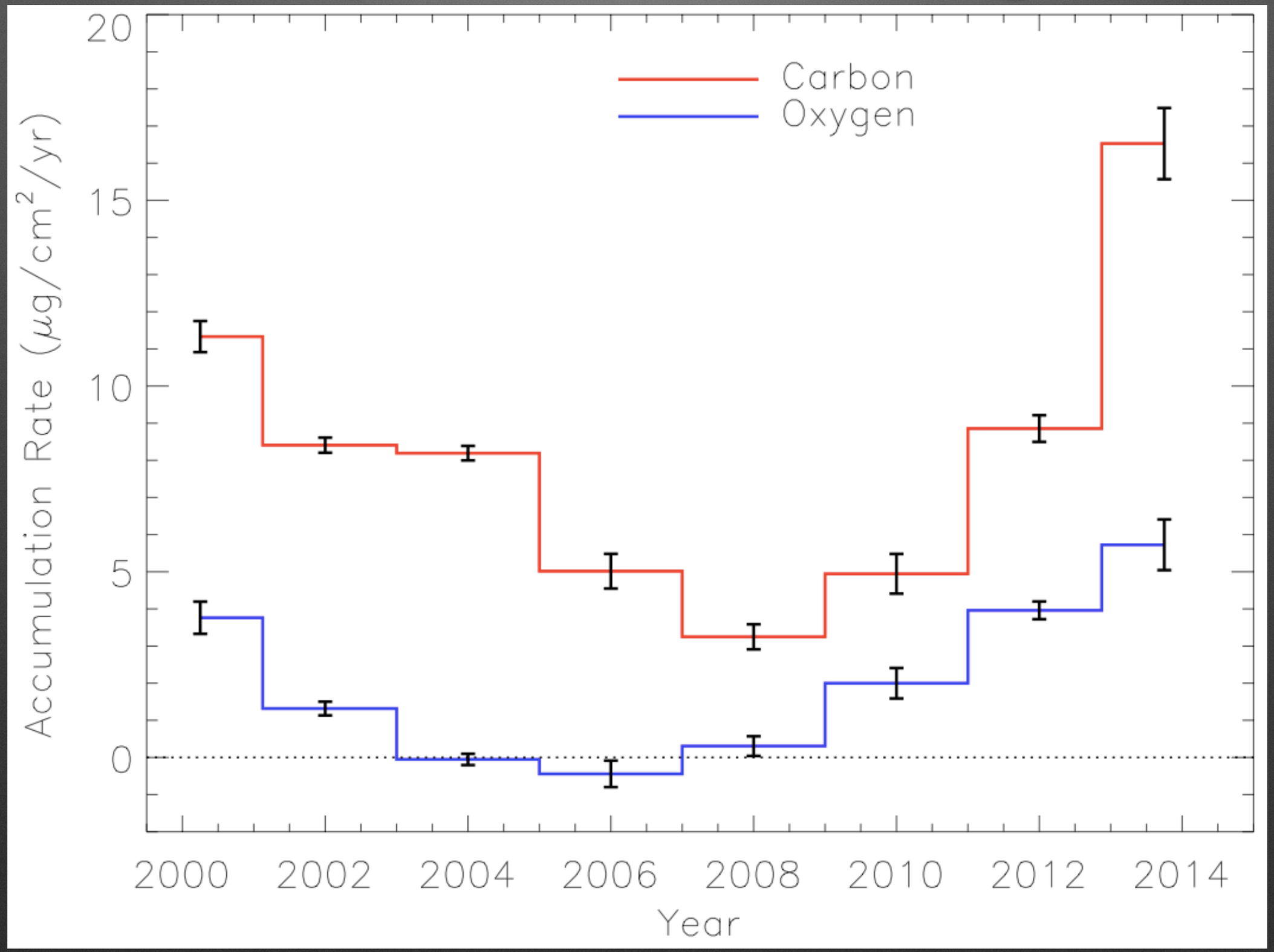


Spatial Variation

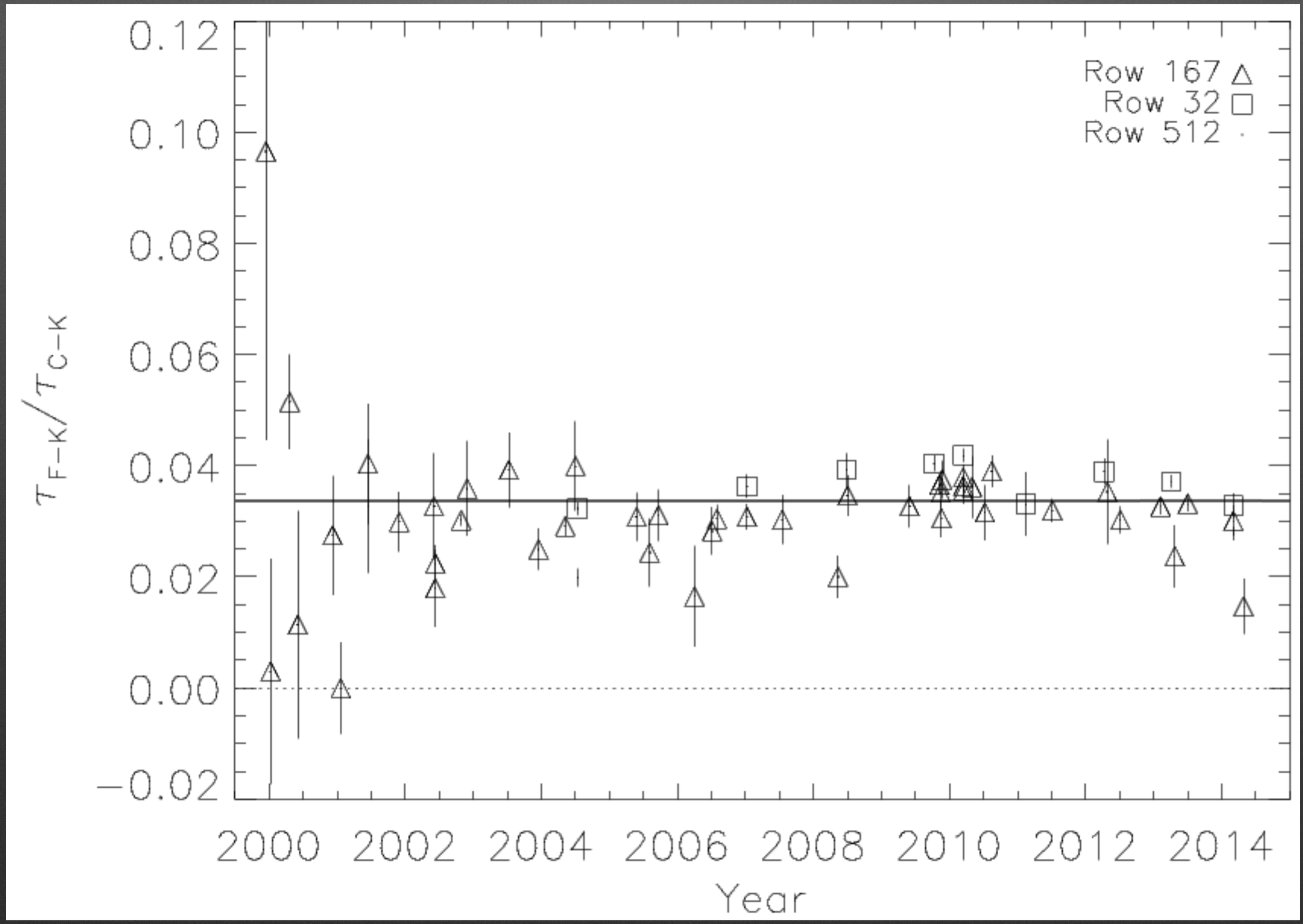
Optical Depth at 700 eV



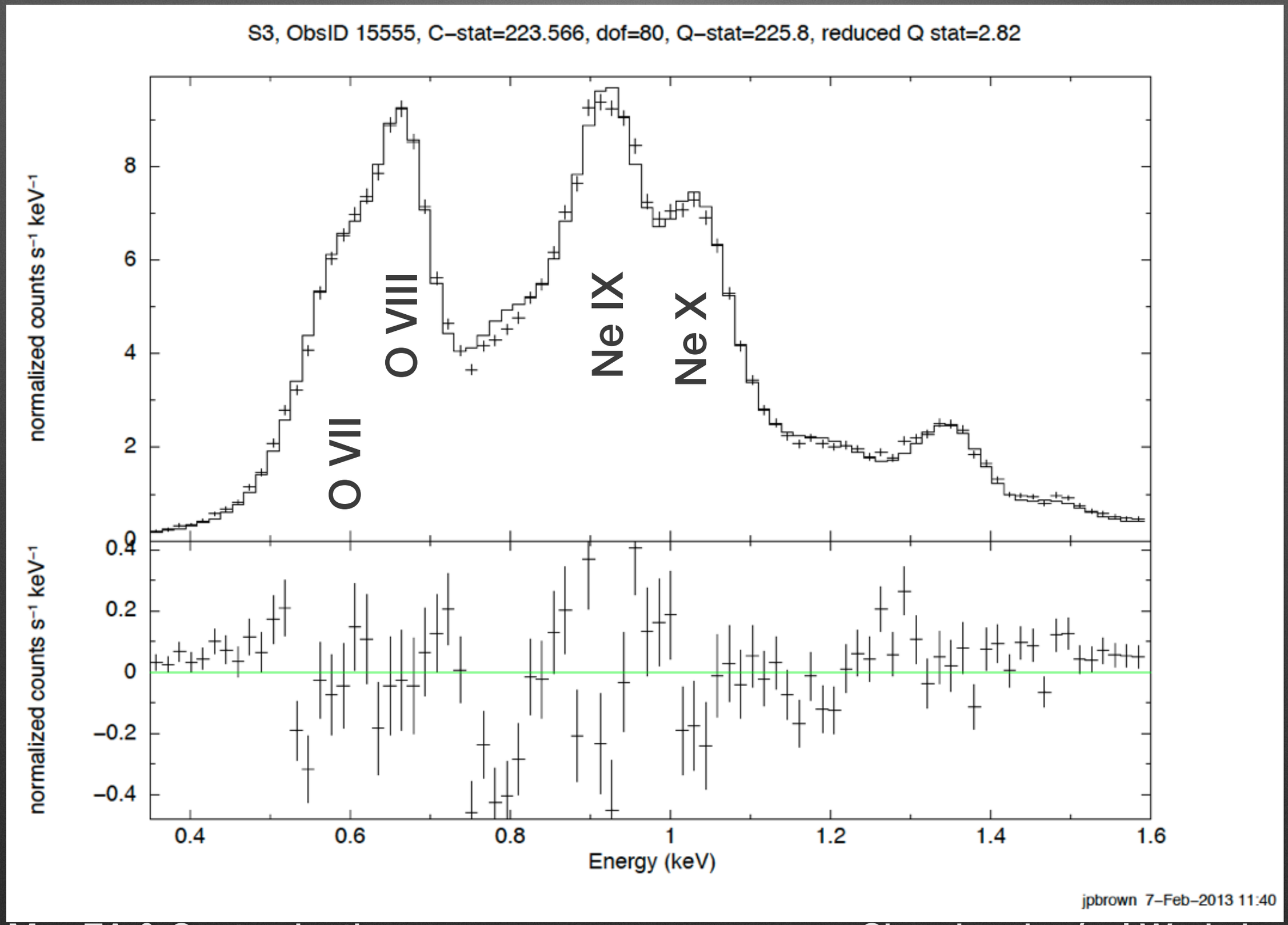
Composition Changes



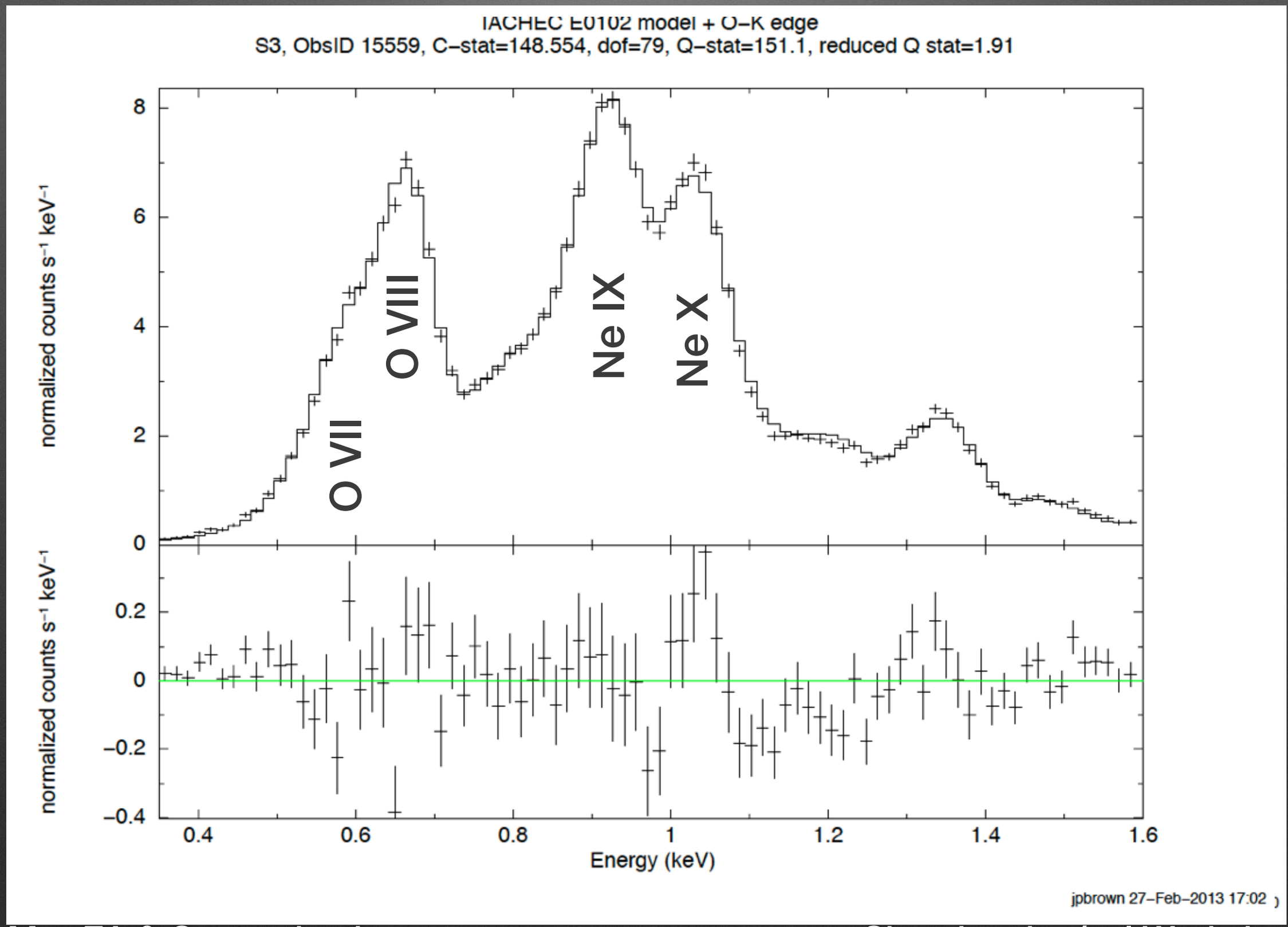
Constant Fluorine/Carbon



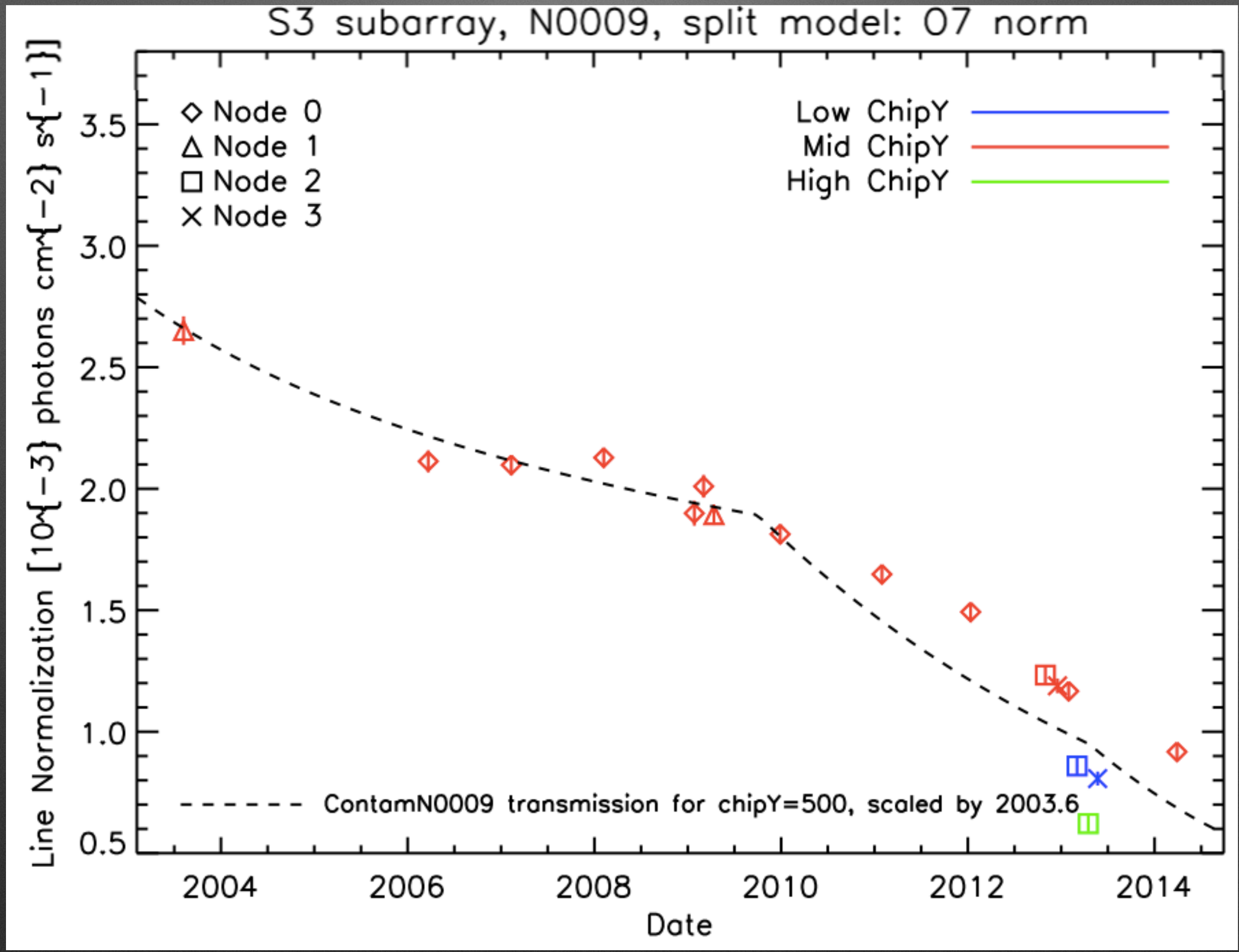
ACIS Fits to 1E0102



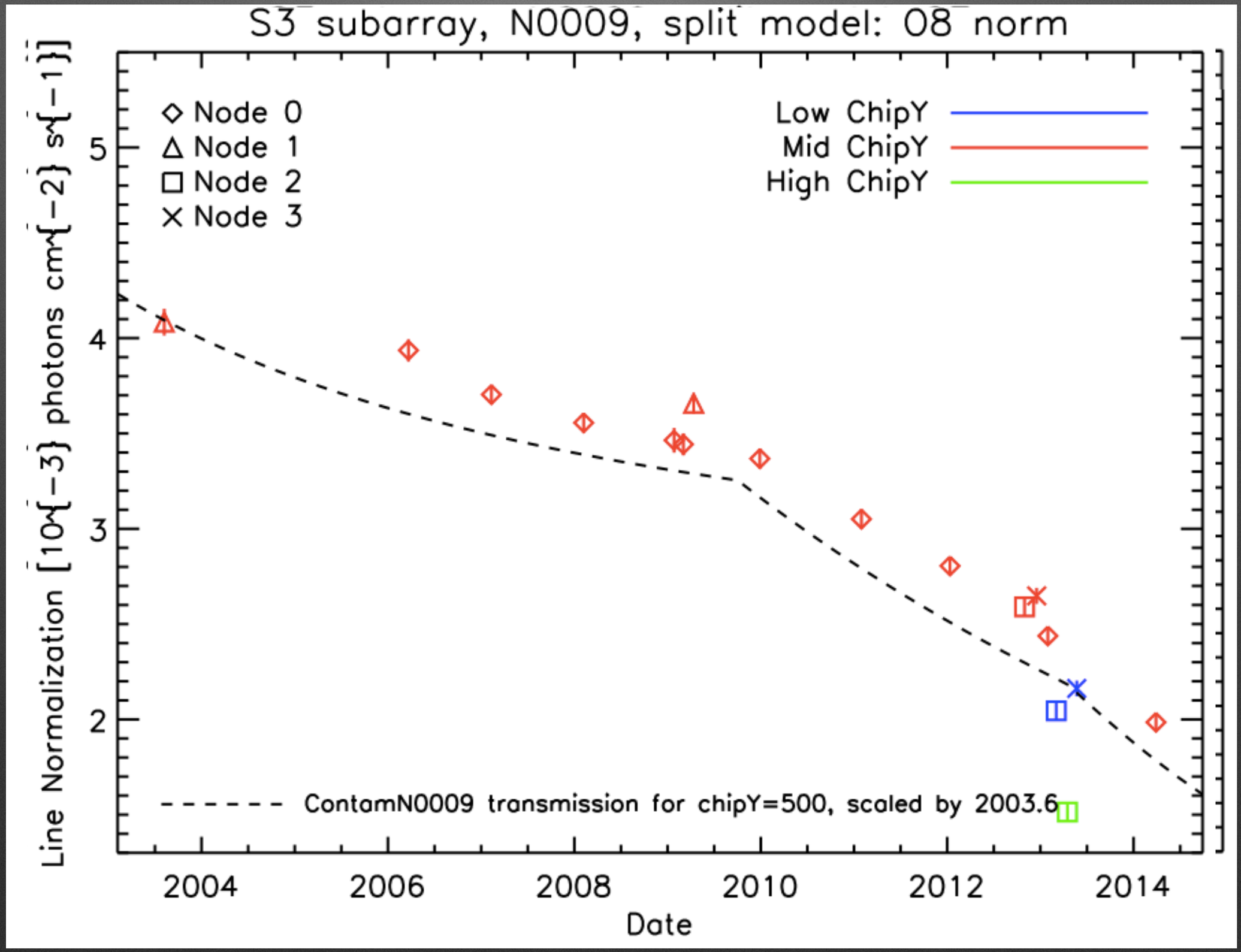
ACIS Fits to 1E0102



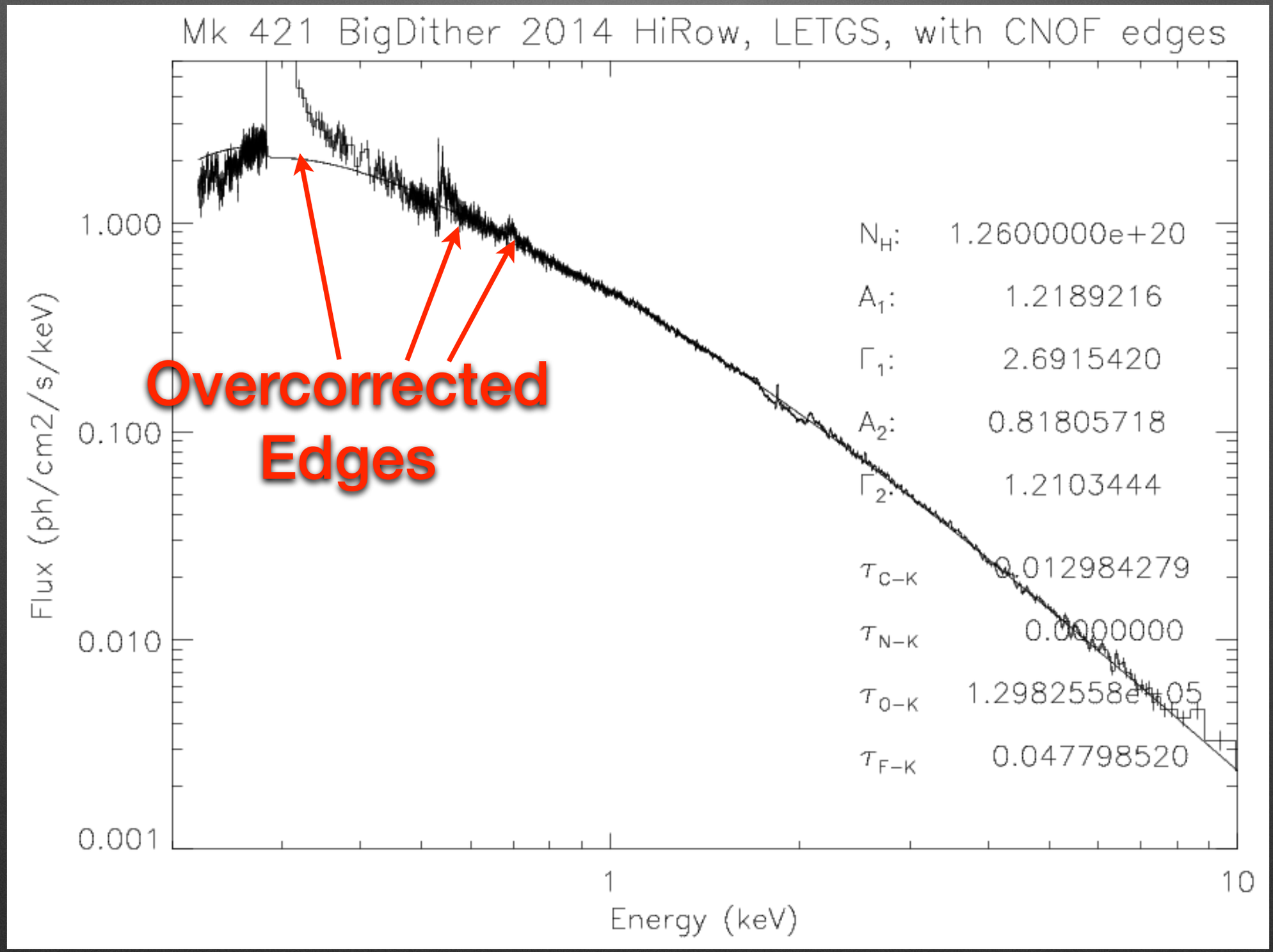
1E0102 Line Fluxes



1E0102 Line Fluxes



Possible Edge Residuals



Contamination Summary

- It is mostly made of C, smattering of F & O
  - Origin is unknown, composition doesn't match any on-board substance
  - About the same on ACIS-I and ACIS-S
  - Thicker at detector edges
- Optical depth at 700 eV is now about 1.5 and climbing
  - Effect at 1 keV is noticeable
  - Time dependence is not predictable
- Model is not completely physical
- Uncertainties in exact shape of correction remain