ACIS Contaminant:
A Physical Model!

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A short history

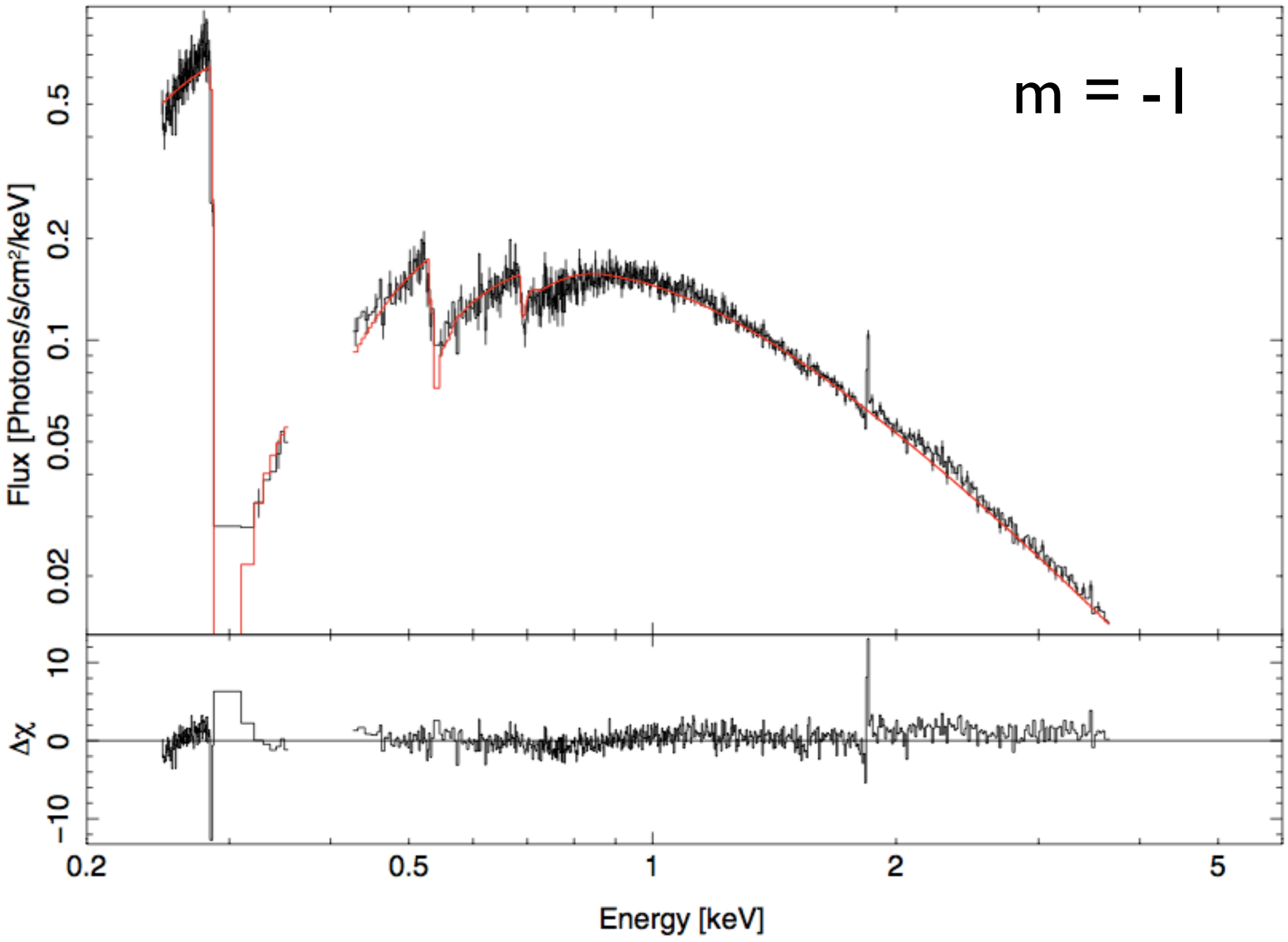
- 2000: C-K edge found in LETG/ACIS data
- 2001-2
  - Cluster fluxes are time dependent
  - Gratings: composition from C-K, O-K, F-K edges
- 2003-4
  - ECS shows more absorption at edge
  - tau from gratings lower than ECS, clusters
  - Fluffium!
- 2008: Gaussium! (Gaussian absorber)
- 2014: Edgium! (C-K and F-K only)
- 2016: Carbon edge adjustment: a physical model

Approach

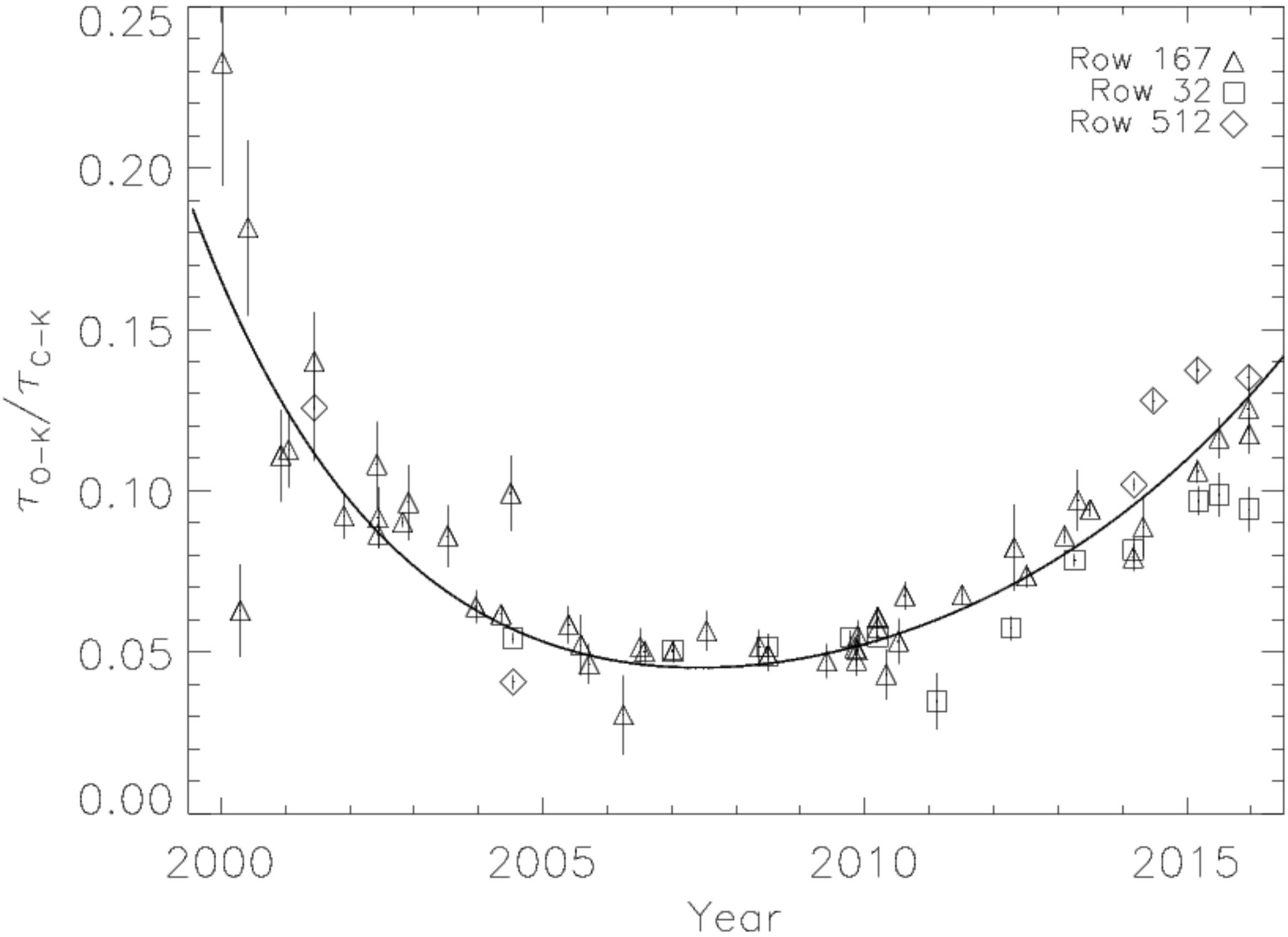
- Model: $\tau_C = \tau_{C0} + t_{C1}(t)\ f(x,y)$
- Cluster data give $\tau(0.66\ \mathrm{keV}) = f(t, y)$
  - assume $\tau_F/\tau_C = 0.033$
  - assume $\tau_O/\tau_C = g(t)$
- LETG/ACIS of blazars, 'Big Dither'
  - measure O-K as h(t,y)
  - measure F-K as k(t,y)
- Determine τ_{C-K} from tau(0.66), corrected for τ_{O-K}, τ_{F-K}
- Adjust C-K edge

$$f(x,y) = e^{-y/a_1} + e^{(y-1024)/a_2} - e^{-512/a_1} - e^{-512/a_2}, a_1 = 106.25, a_2 = 129.62$$

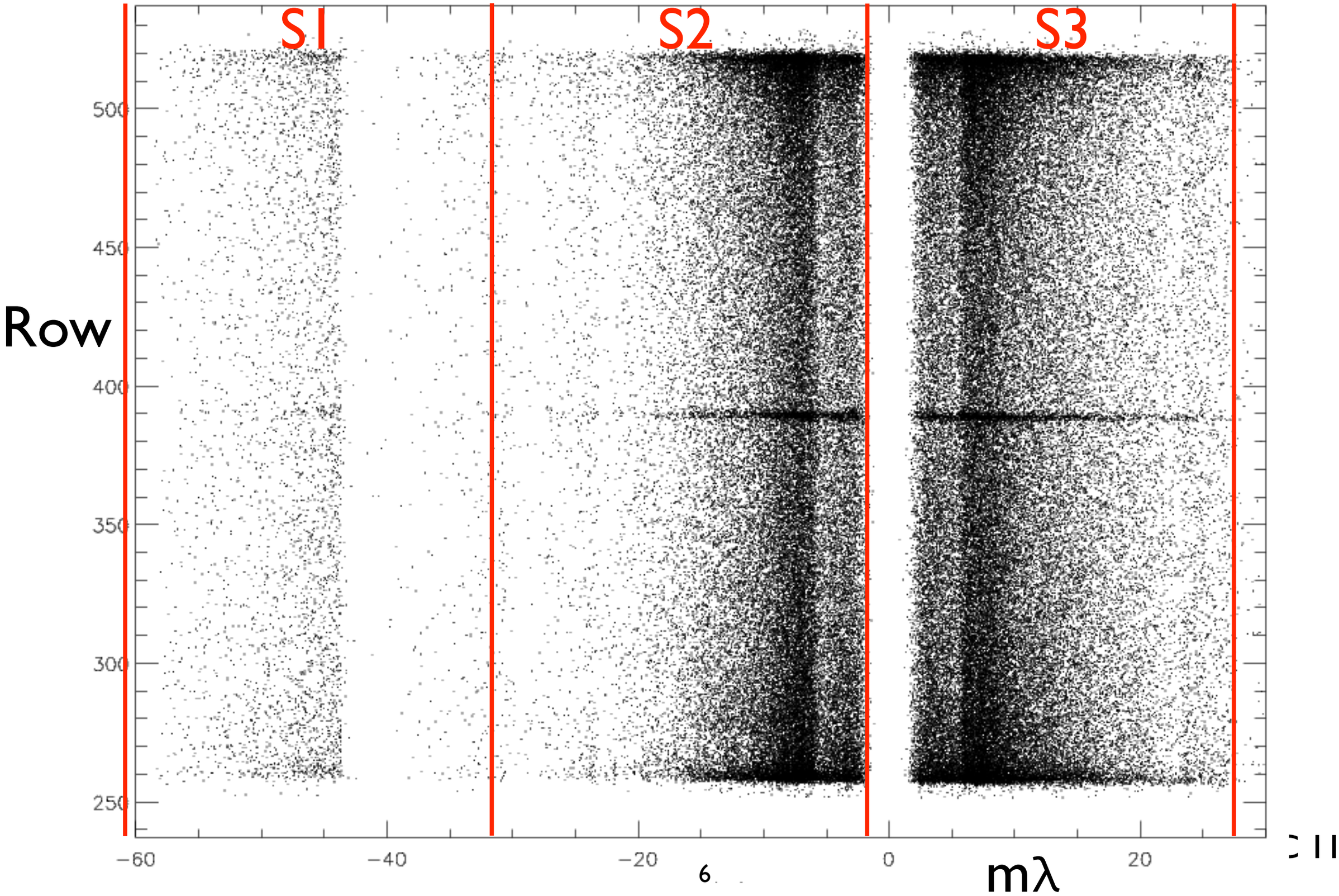
Uncorrected Spectrum

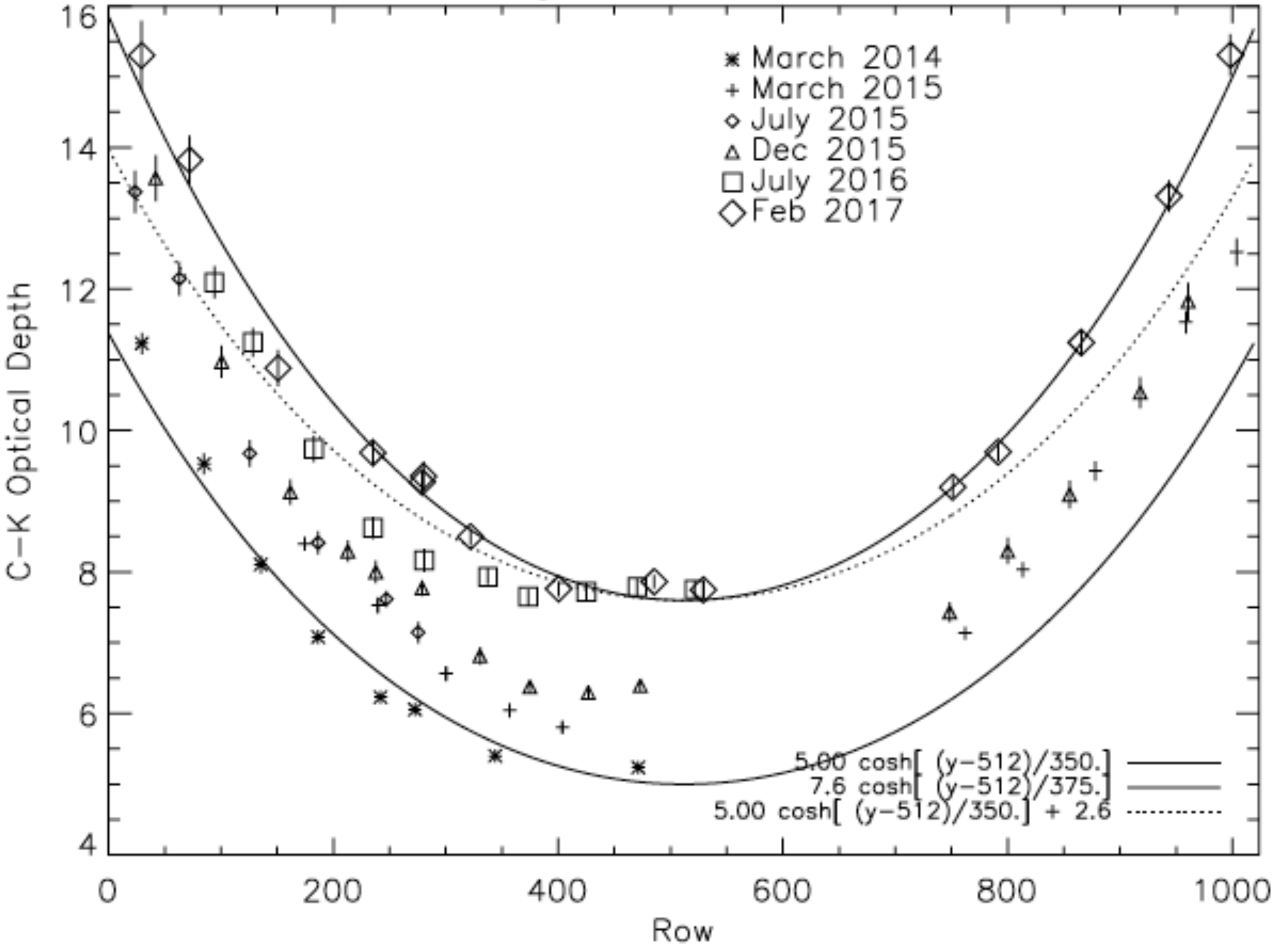


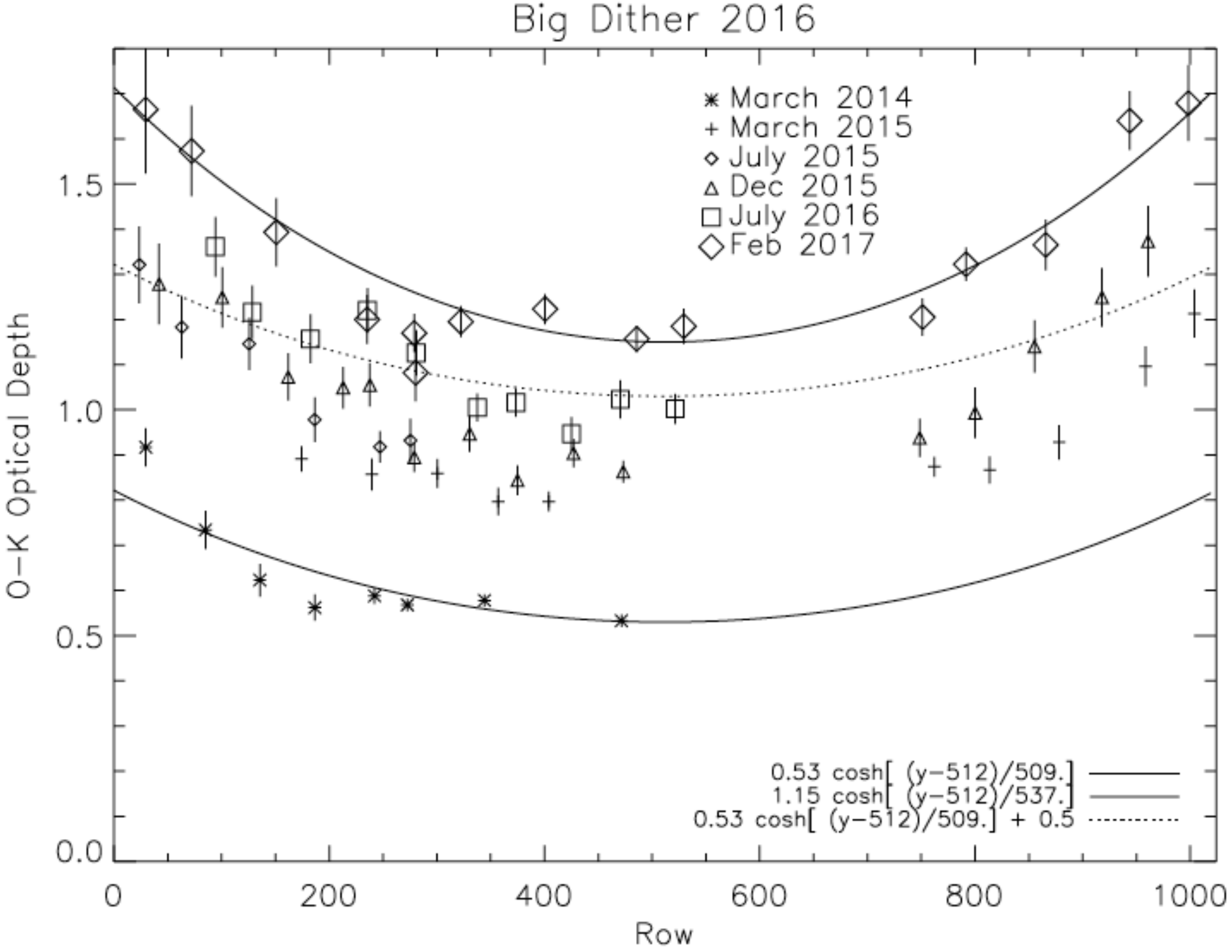
Time Dependences



High Row




Big Dither 2014–6
March 2014
March 2015
July 2015
Dec 2015
July 2016
Feb 2017
5.00 cosh[(y–512)/350.]
7.6 cosh[(y–512)/375.]
5.00 cosh[(y–512)/350.] + 2.6
C–K Optical Depth
Row
16
14
12
10
8
6
4
0
200
400
600
800
1000


Big Dither 2016
March 2014
March 2015
July 2015
Dec 2015
July 2016
Feb 2017
0.53 cosh[(y−512)/509.]
1.15 cosh[(y−512)/537.]
0.53 cosh[(y−512)/509.] + 0.5
O−K Optical Depth
Row
0.0
0.5
1.0
1.5
0
200
400
600
800
1000

Procedure for v9972

- Use same spatial model from v9973
- Fit models to LETG/ACIS O-K data

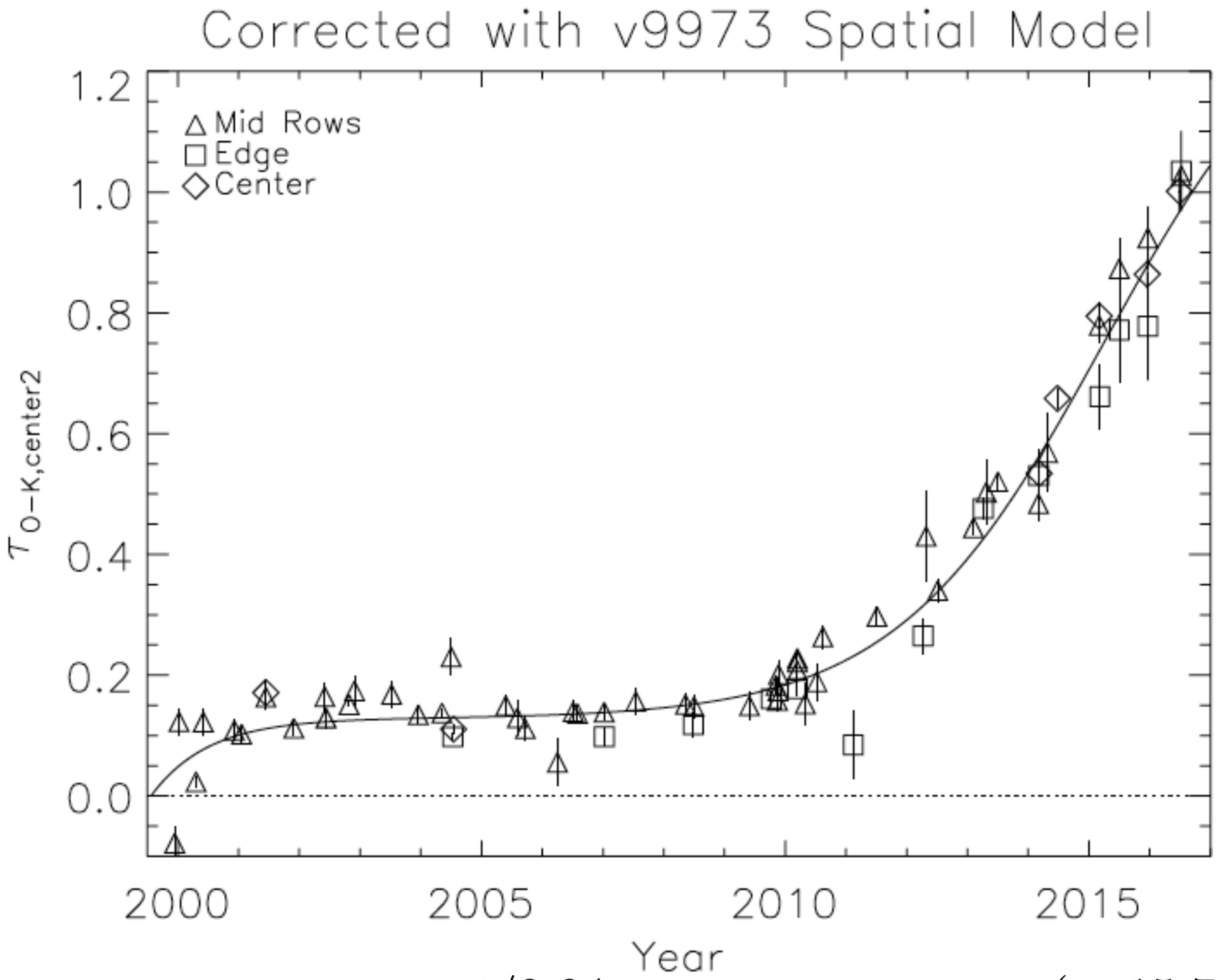
$$\tau_{0\mathrm{O}} = 0.128(1 - e^{-t/0.94}) + 1.25/(1 + e^{-(t-15.7)/1.72})$$
$$\tau_{1\mathrm{O}} = 0.102(1 - e^{-t/0.94}) + 0.50/(1 + e^{-(t-15.7)/1.72})$$

- Fit models to LETG/ACIS F-K data

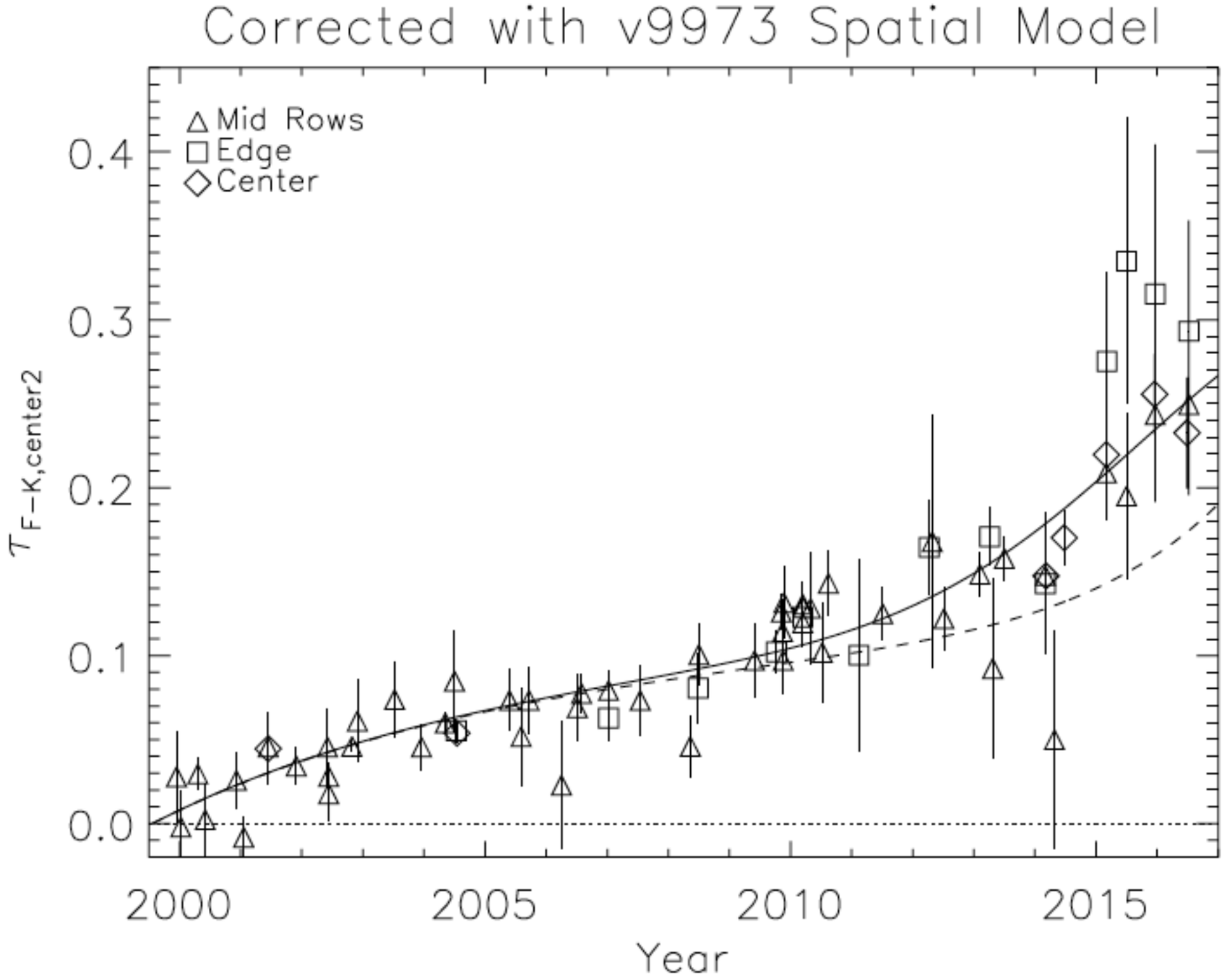
$$\tau_{0\mathrm{F}} = \tau_{1\mathrm{F}} = 0.11(1 - e^{-t/5.9}) + 0.25/(1 + e^{-(t-16.2)/2.0})$$

- Fit models to Cluster $\tau_0(E_0)$, E_0 = 0.65 keV:

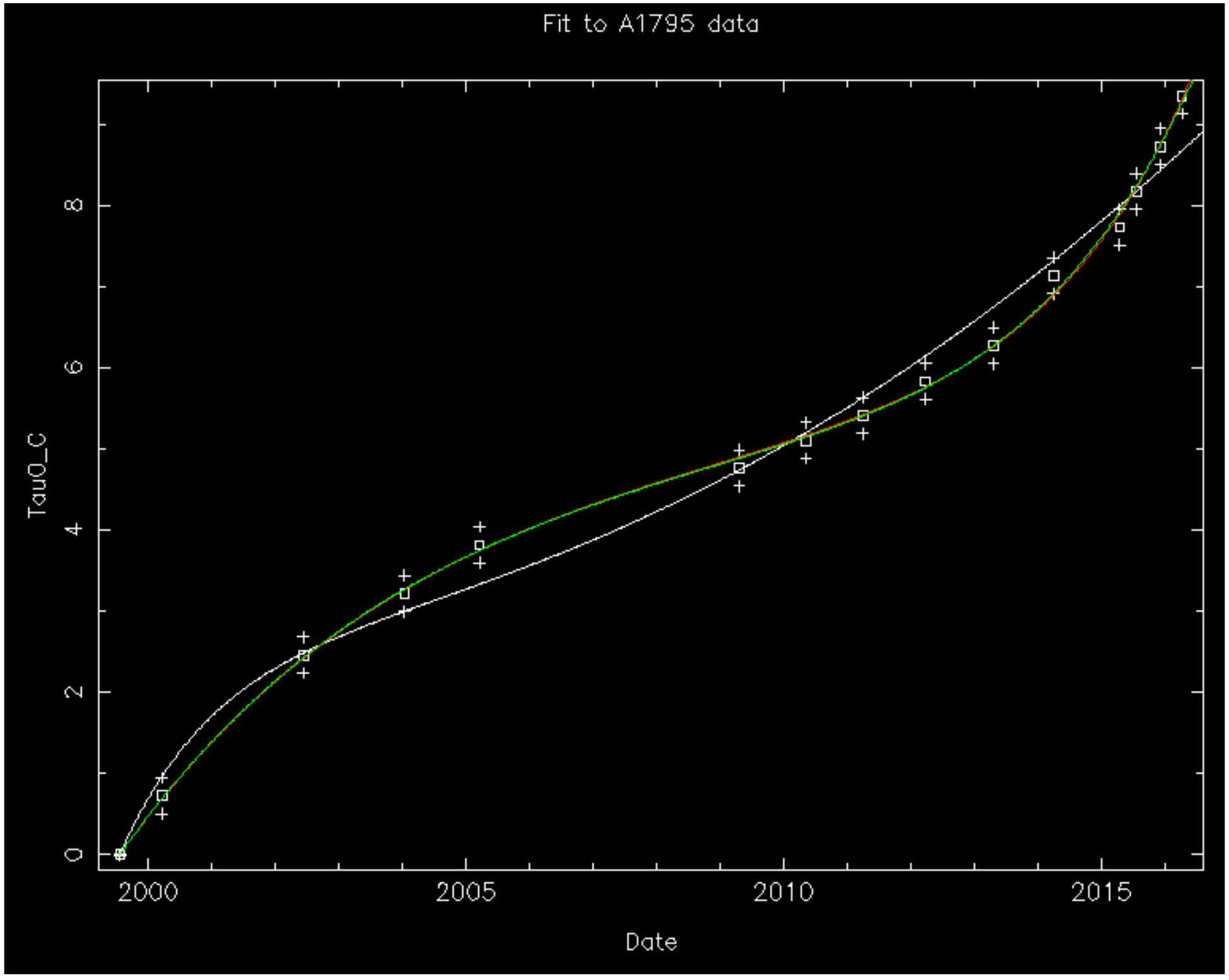
$$\tau_{0\mathrm{C}} = [\tau_0(E_0) - \mu_O(E_0)\tau_{0\mathrm{O}} - \mu_F(E_0)\tau_{0\mathrm{F}}]/\mu_C(E_0)$$
$$\tau_{1\mathrm{C}} = [\tau_1(E_0) - \mu_O(E_0)\tau_{1\mathrm{O}} - \mu_F(E_0)\tau_{1\mathrm{F}}]/\mu_C(E_0)$$

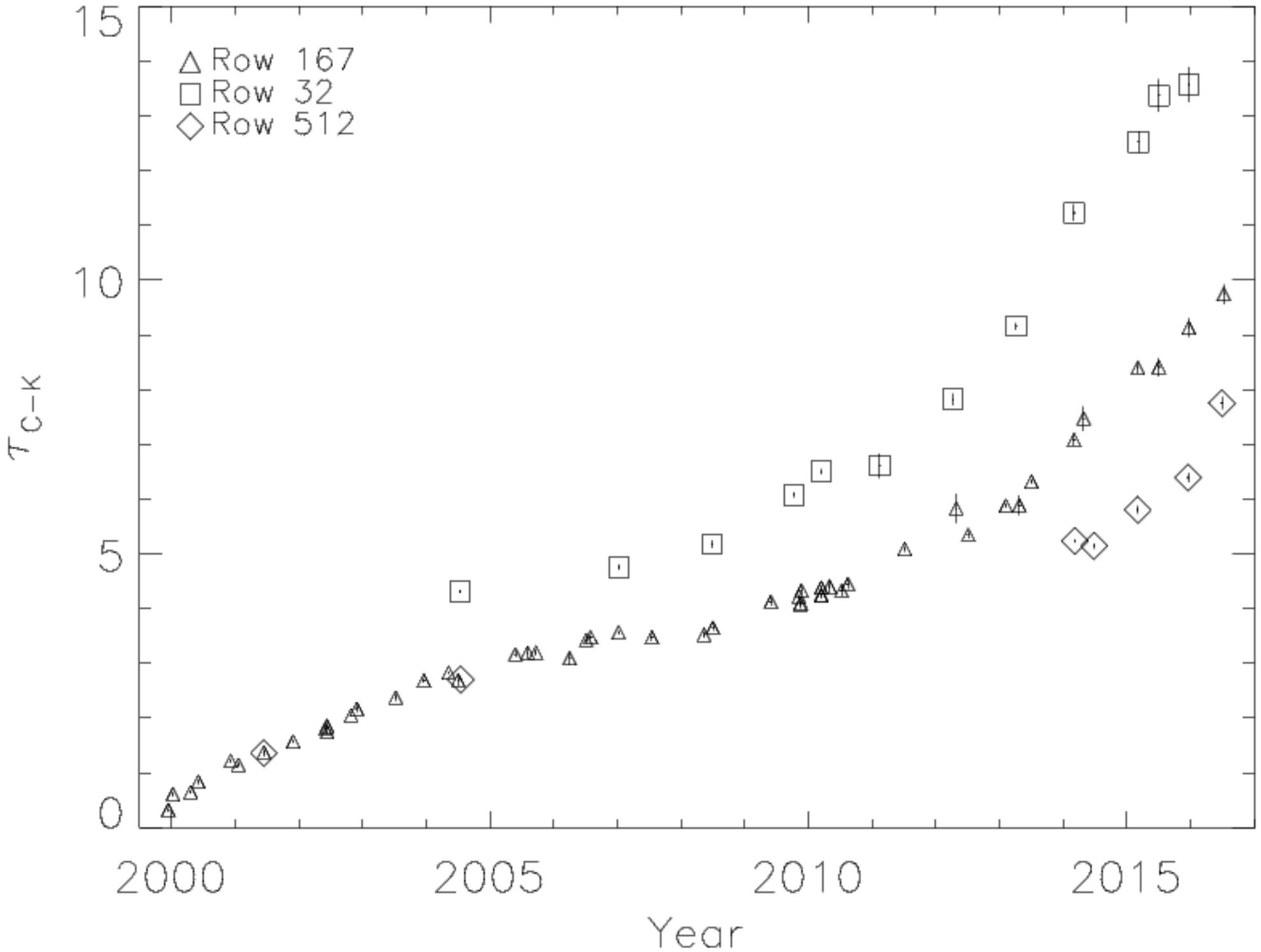


$$\tau_{0O} = 0.128(1 - e^{-t/0.94}) + 1.25/(1 + e^{-(t-15.7)/1.72})$$



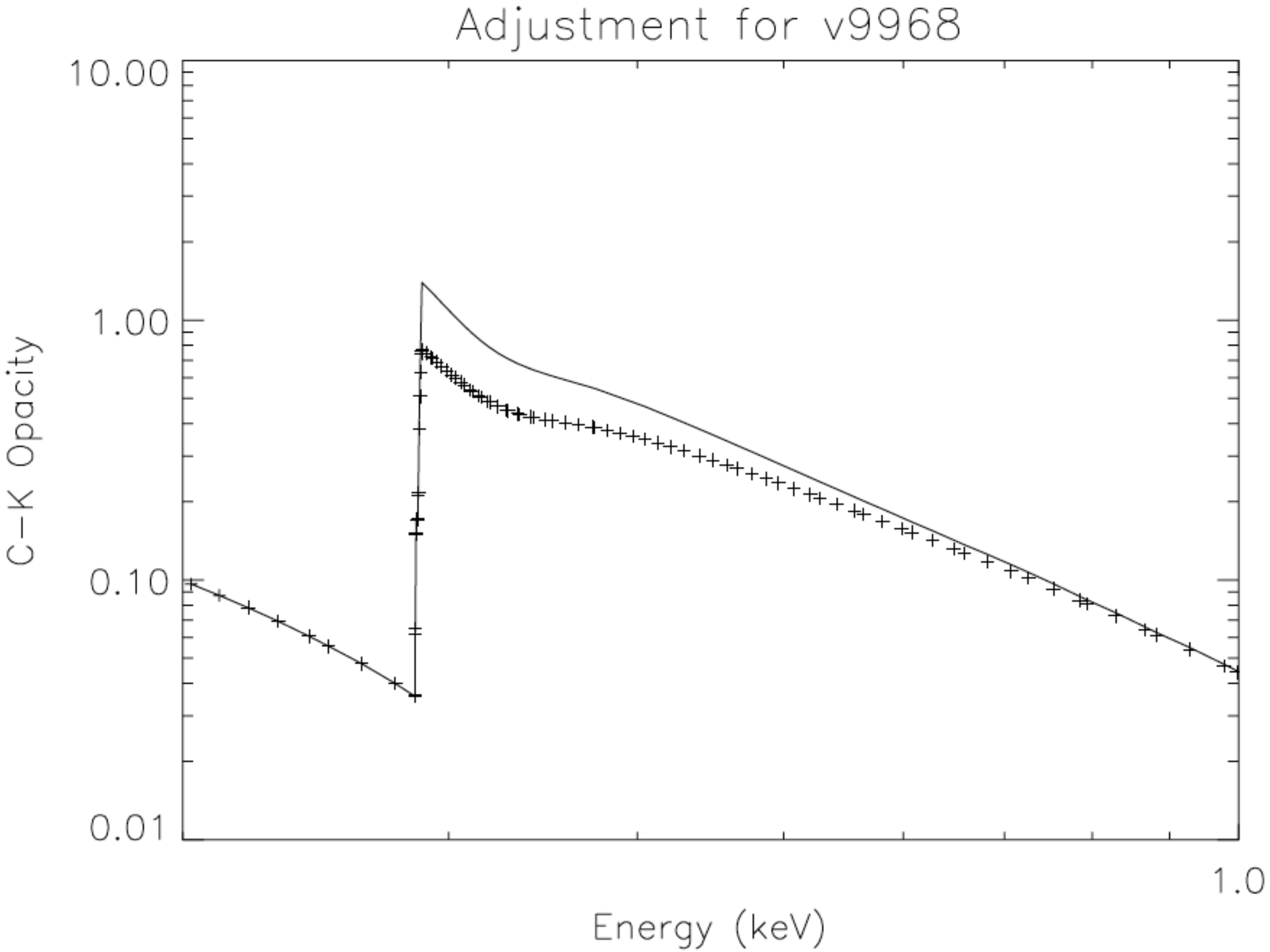
$$\tau_{0\mathrm{F}} = \tau_{1\mathrm{F}} = 0.11(1 - e^{-t/5.9}) + 0.25/(1 + e^{-(t-16.2)/2.0})$$


Fit to A1795 data
TauO_C
0
2
4
6
8
2000
2005
2010
2015
Date

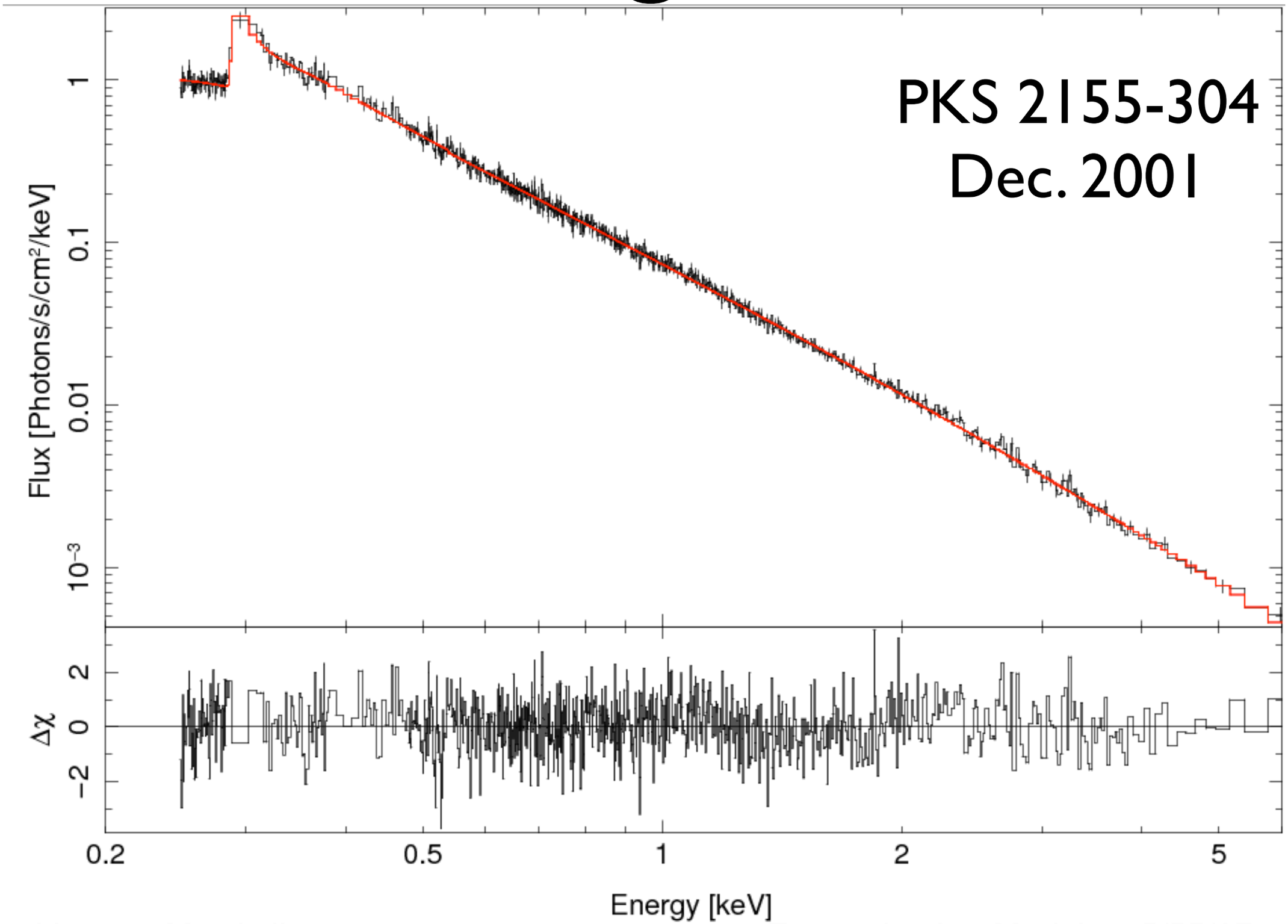

Row 167
Row 32
Row 512
15
10
5
0
τ_{C-K}
2000
2005
2010
2015
Year

Versions 9968

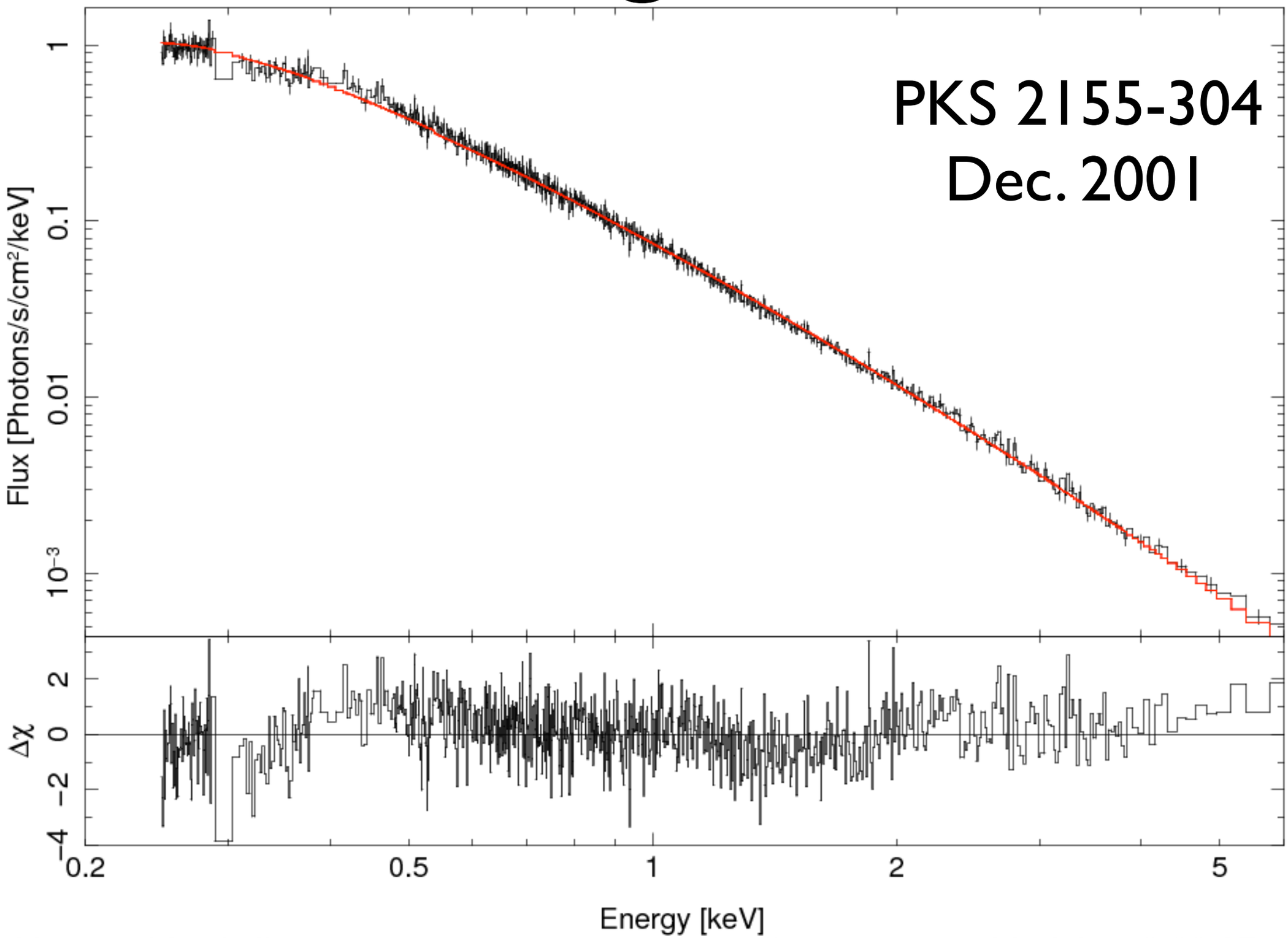
- Modify C-K opacity model
- Goal: reduce edge, maintain 0.5-1.0 keV
- Informed by
  - Adjustment seems related to C-K in t, y
  - 1E0102 fluxes in 2006
  - LETG/ACIS 0.4-0.6 keV residuals


Adjustment for v9968
10.00
1.00
0.10
0.01
C−K Opacity
1.0
Energy (keV)

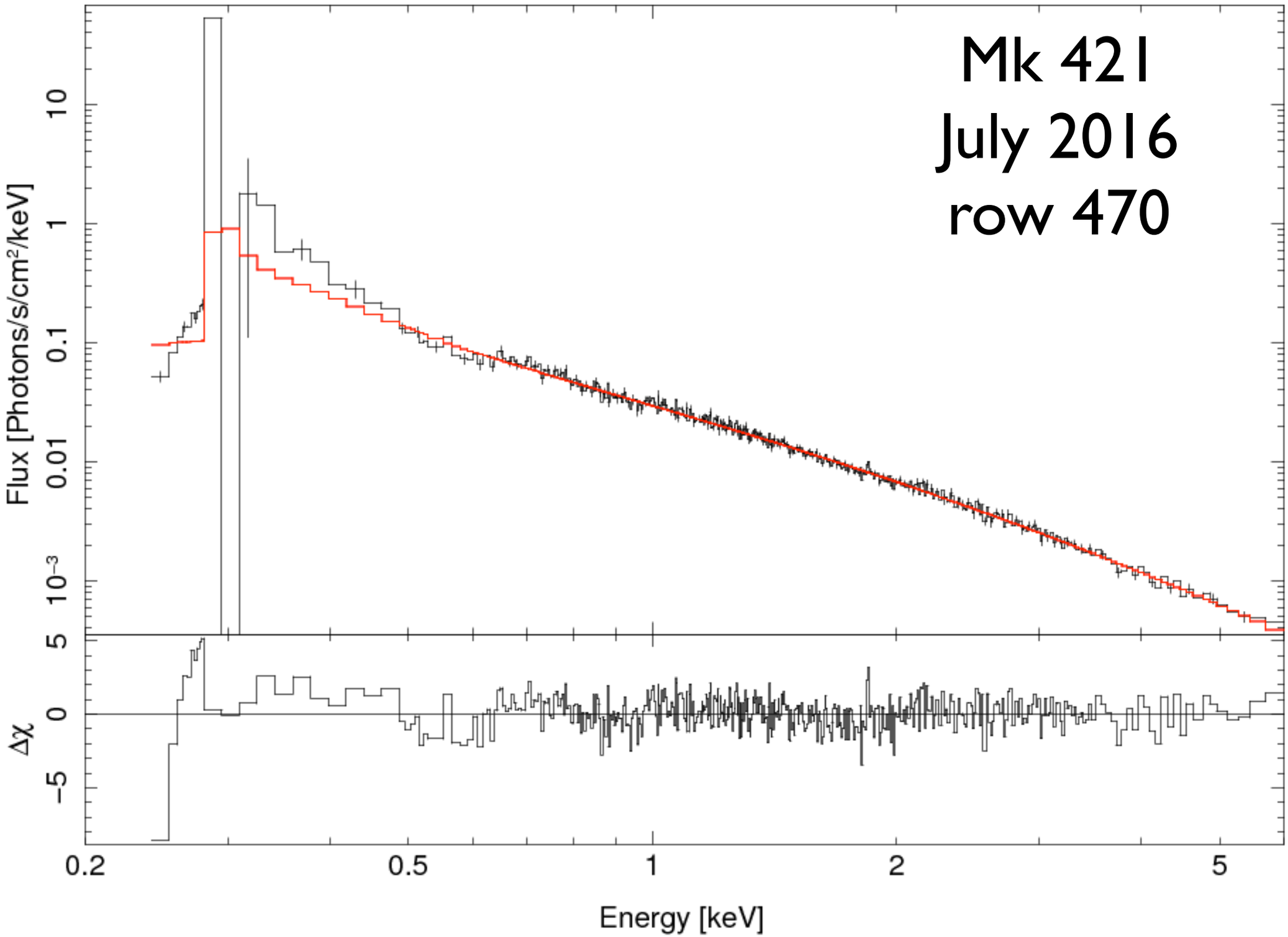
Fits using v9972



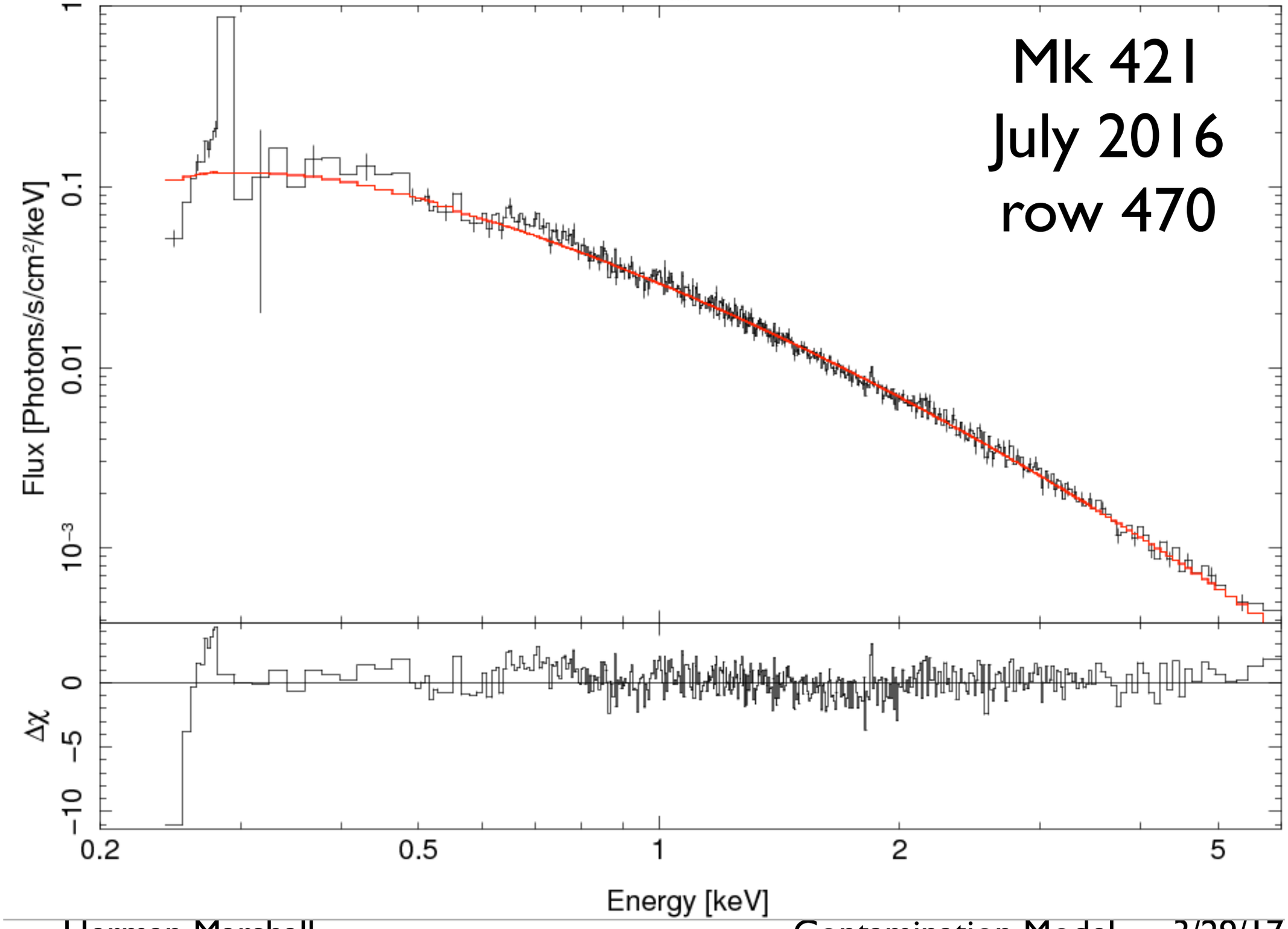
Fits using v9968



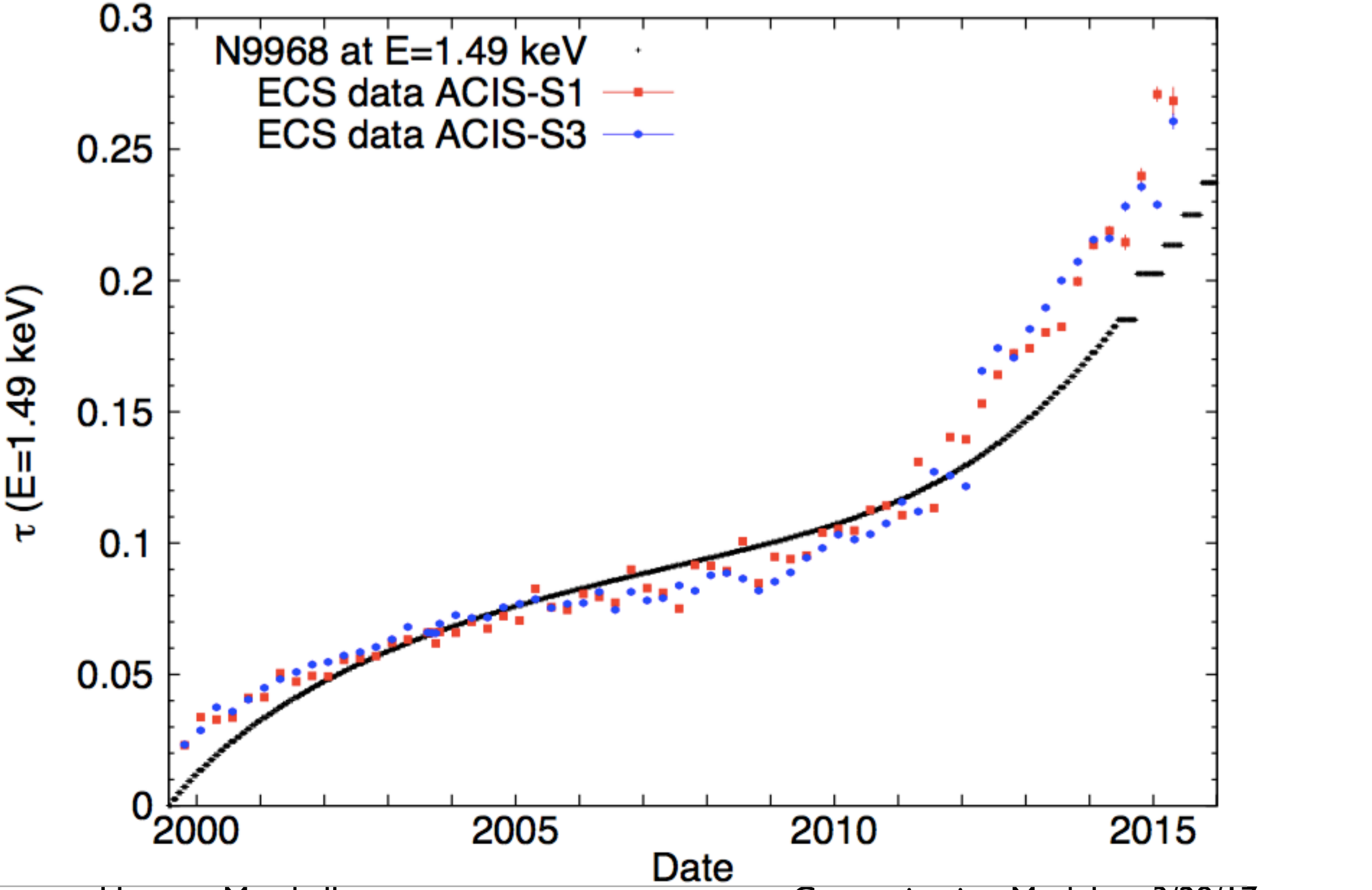
Fit using v9972



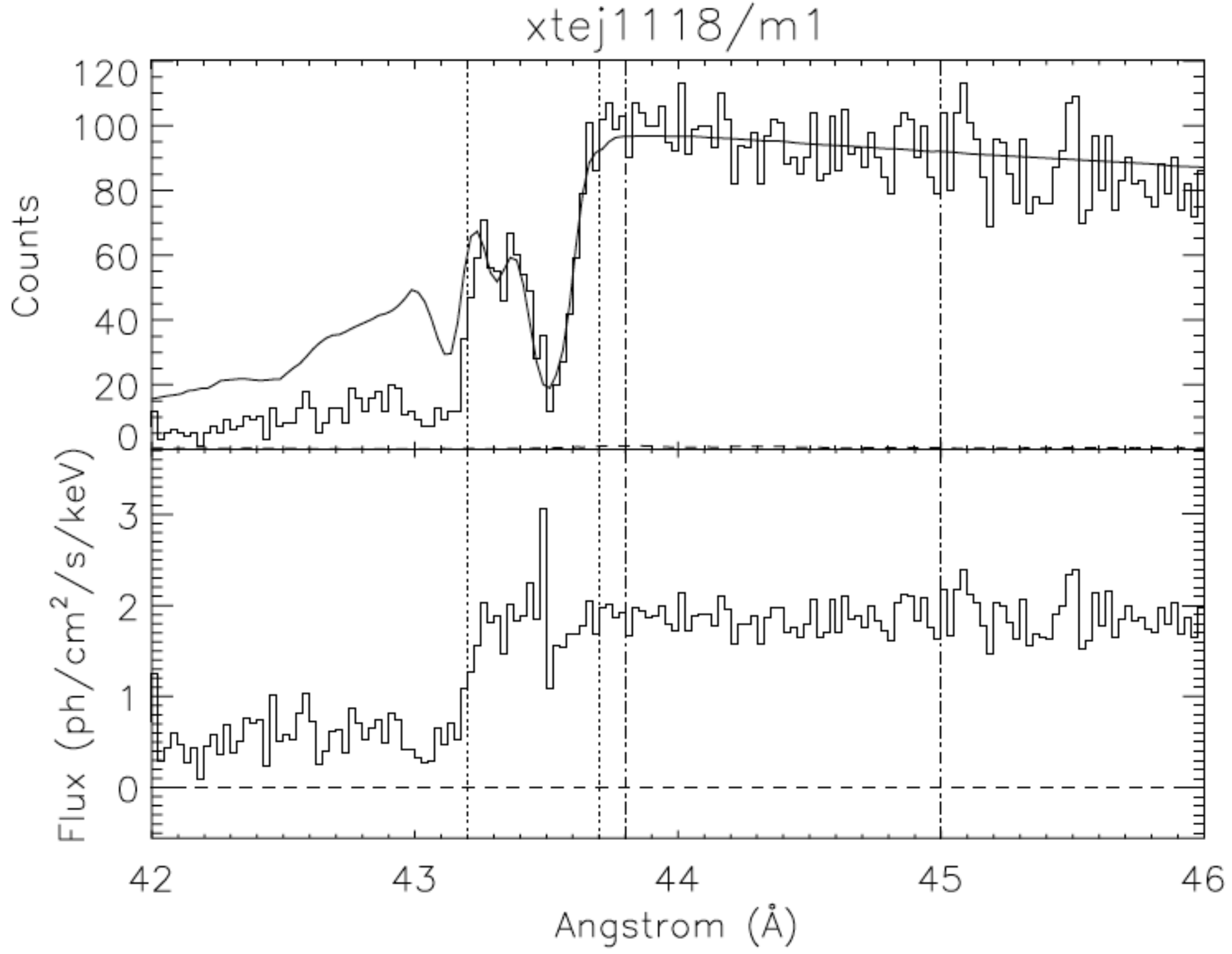
Fits using v9968



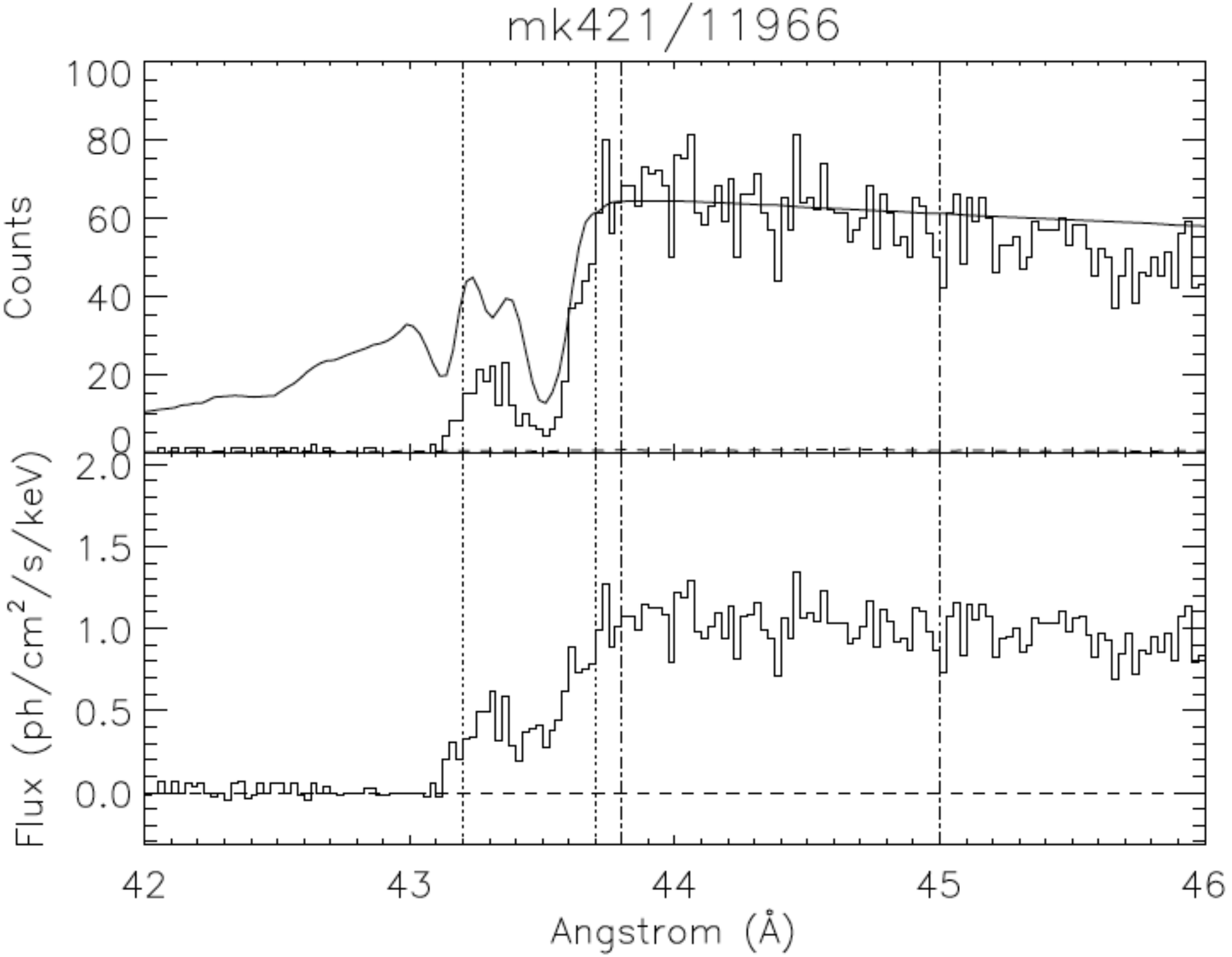
ECS at Al-K


N9968 at E=1.49 keV
ECS data ACIS-S1
ECS data ACIS-S3
τ (E=1.49 keV)
0.3
0.25
0.2
0.15
0.1
0.05
0
2000
2005
2010
2015
Date

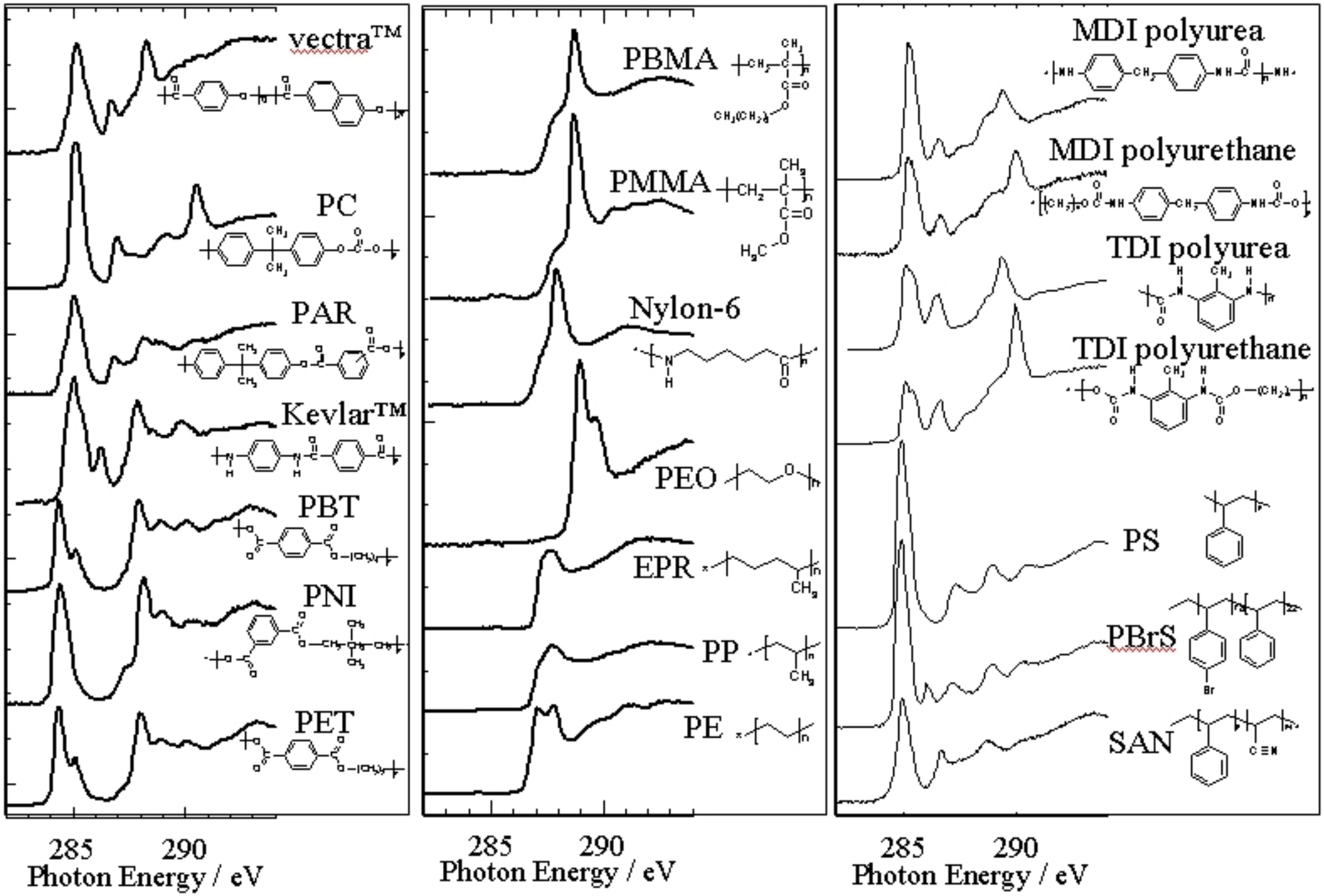
C-K Resonance Feature



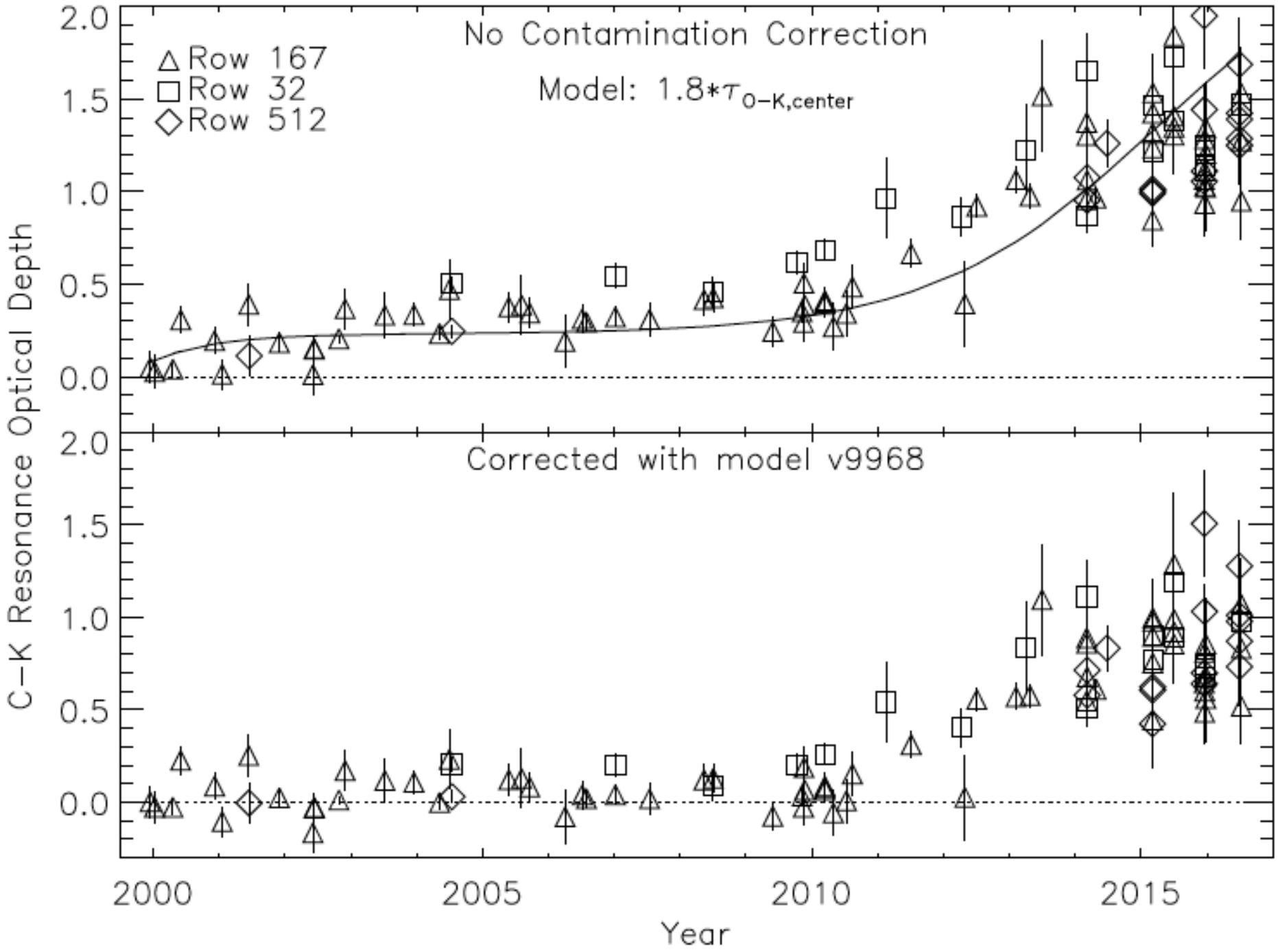
C-K Resonance Feature



Typical C-K edges



C-K Resonance Feature



Summary

- Finally: a fully physical model
  - v9968 released in caldb as version N0010
- Tested against 1E0102, clusters, grating data
- Big Dither will be done twice/yr
- Future:
  - Investigate use of Al-K data — adjust O-K?
  - Concern about continuing growth
  - Developing bakeout criteria, plan
  - Separate aliphatic and aromatic components