Using Splines to Characterize Unmodeled Systematic Errors

Herman L. Marshall
(MIT Kavli Institute)

Previous Presentations

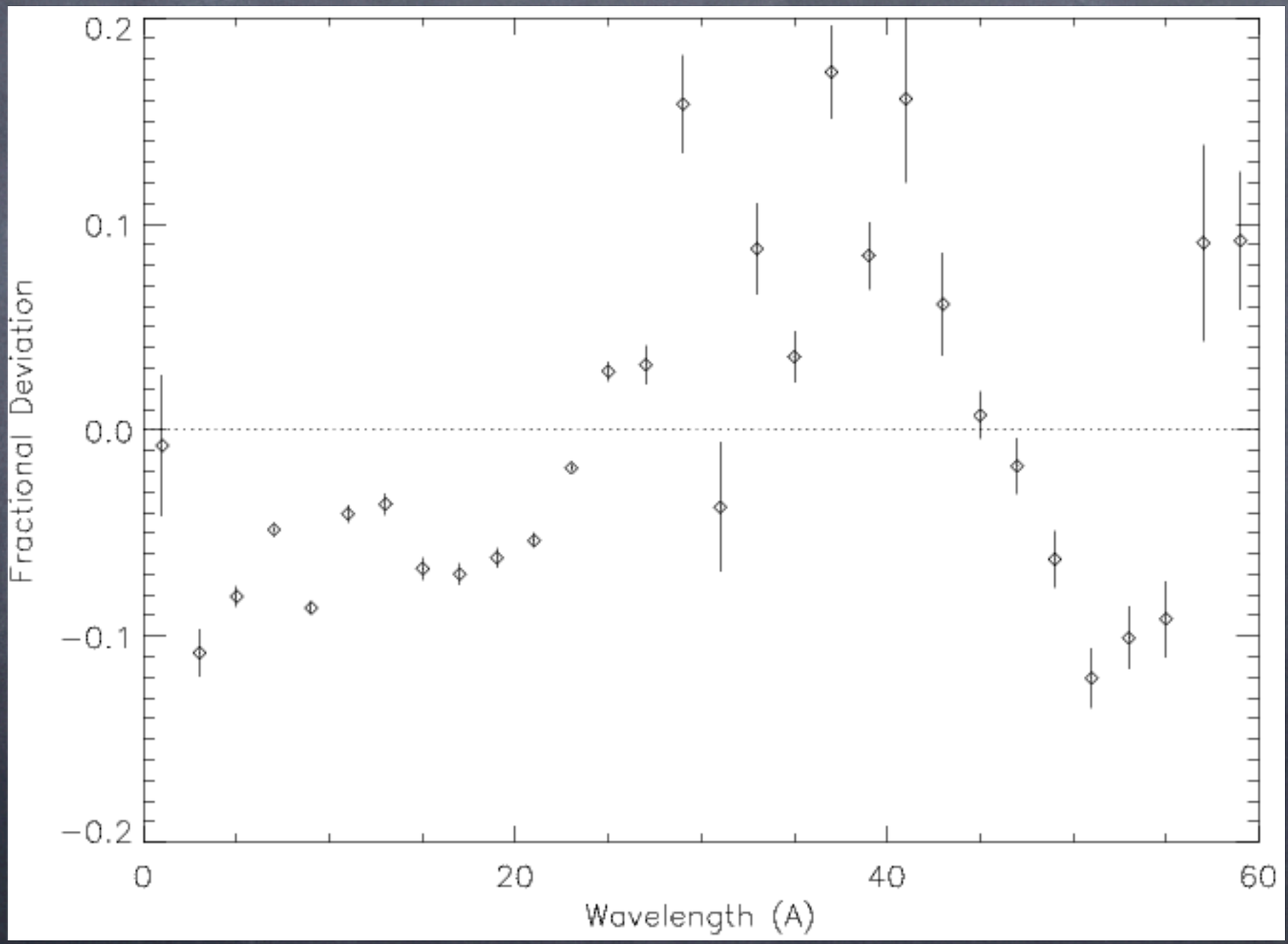
- IACHEC1: Goal is to avoid two problems
  - A: claims of new physics due to calibration errors
  - B: features ignored due to presumed systematics
- IACHEC2: Two new tools
  - Multiple adjustment functions (HLM) — bad
  - Vary instrument models (Drake et al.) — good
- IACHEC3: Update
  - Dewey's "science relevance" χ^2/ν adjustment
  - More of Drake's method
- IACHEC4: no update

OLD Adjustment Method

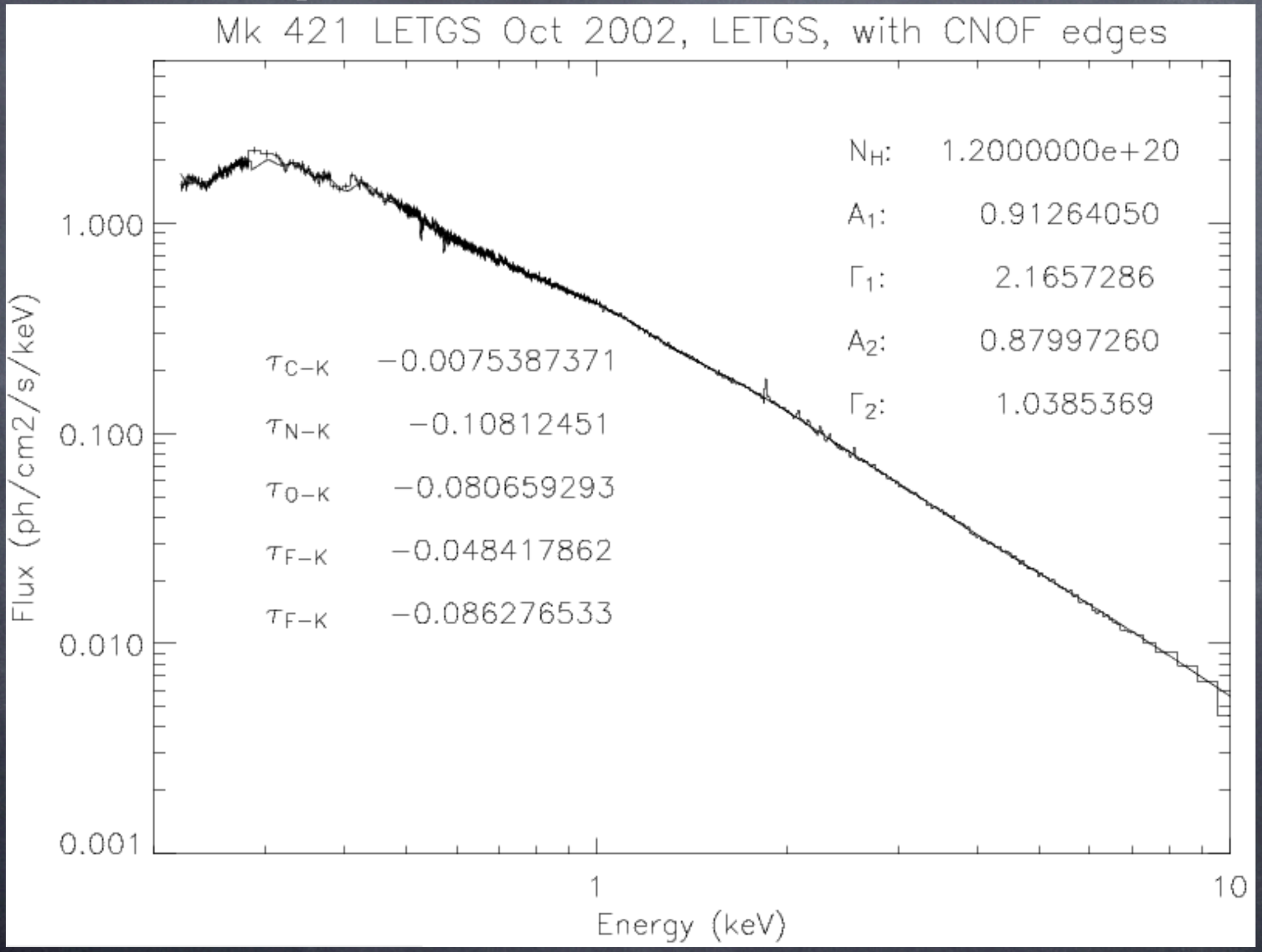
- Method proposed: Use penalty function
  - Minimize $\Lambda = \sum_j A_j^2 + \exp(\frac{(\chi^2_{\nu j} - 1)^2}{\nu_j})$
  - where $\chi^2_{n\nu} = \frac{1}{\nu_n} \sum_{i=1}^{I_n} \frac{[y_{in} - f(x_{in};\vec{\alpha})(1 + \sum_j A_{nj} g(x_{in};\vec{\beta_j}))]^2}{s^2_{in}}$
- Problems:
  - min χ^2/ν achieved jointly: 2.62, 1.48
  - Model is "ugly"
- Solutions?
  - Different basis functions
  - Evolve toward Drake et al. method

Example: Mk 421 LETGS

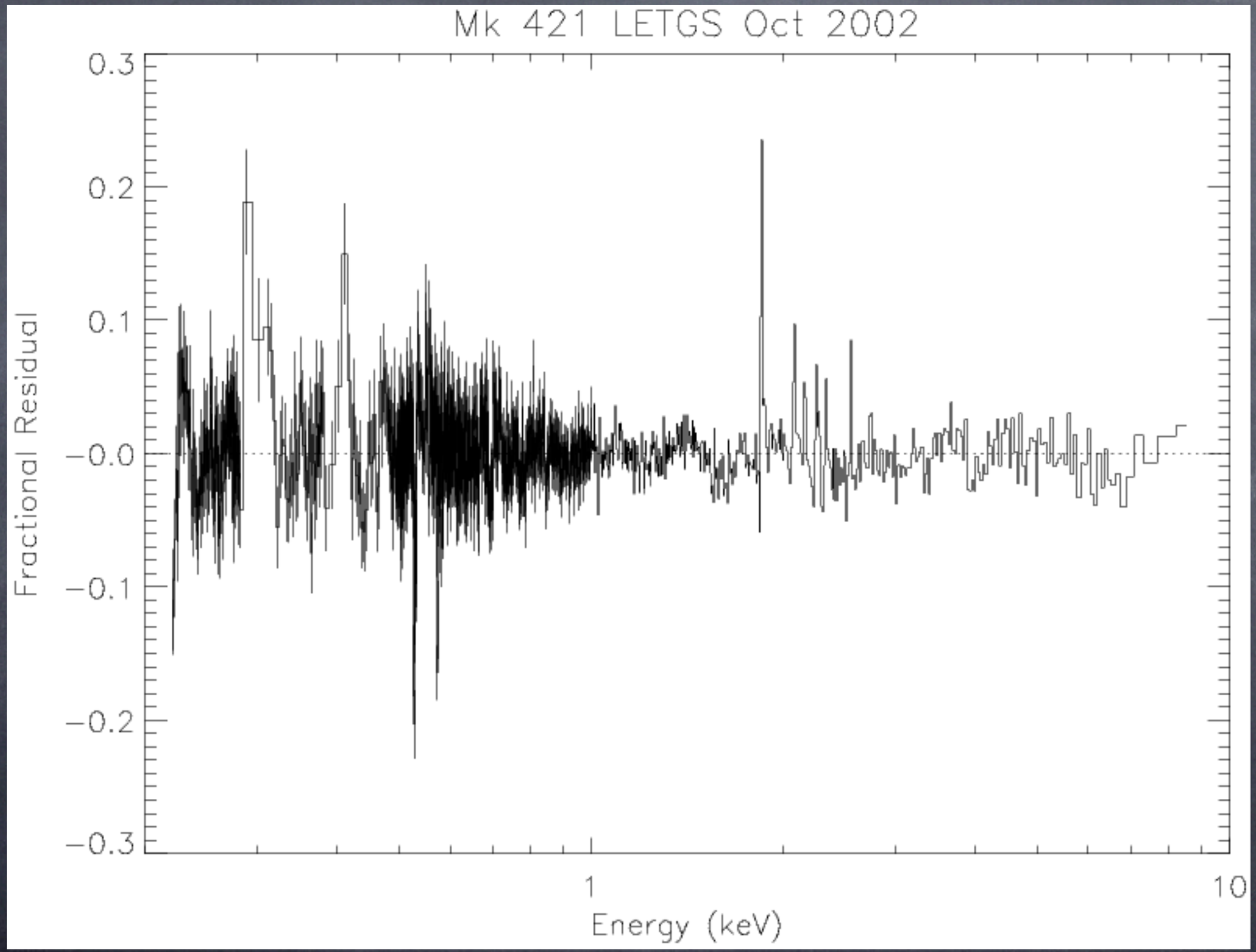
- Gaussian normalizations computed
- Not consistent between LETGS observations



Example: Mk 421 LETGS



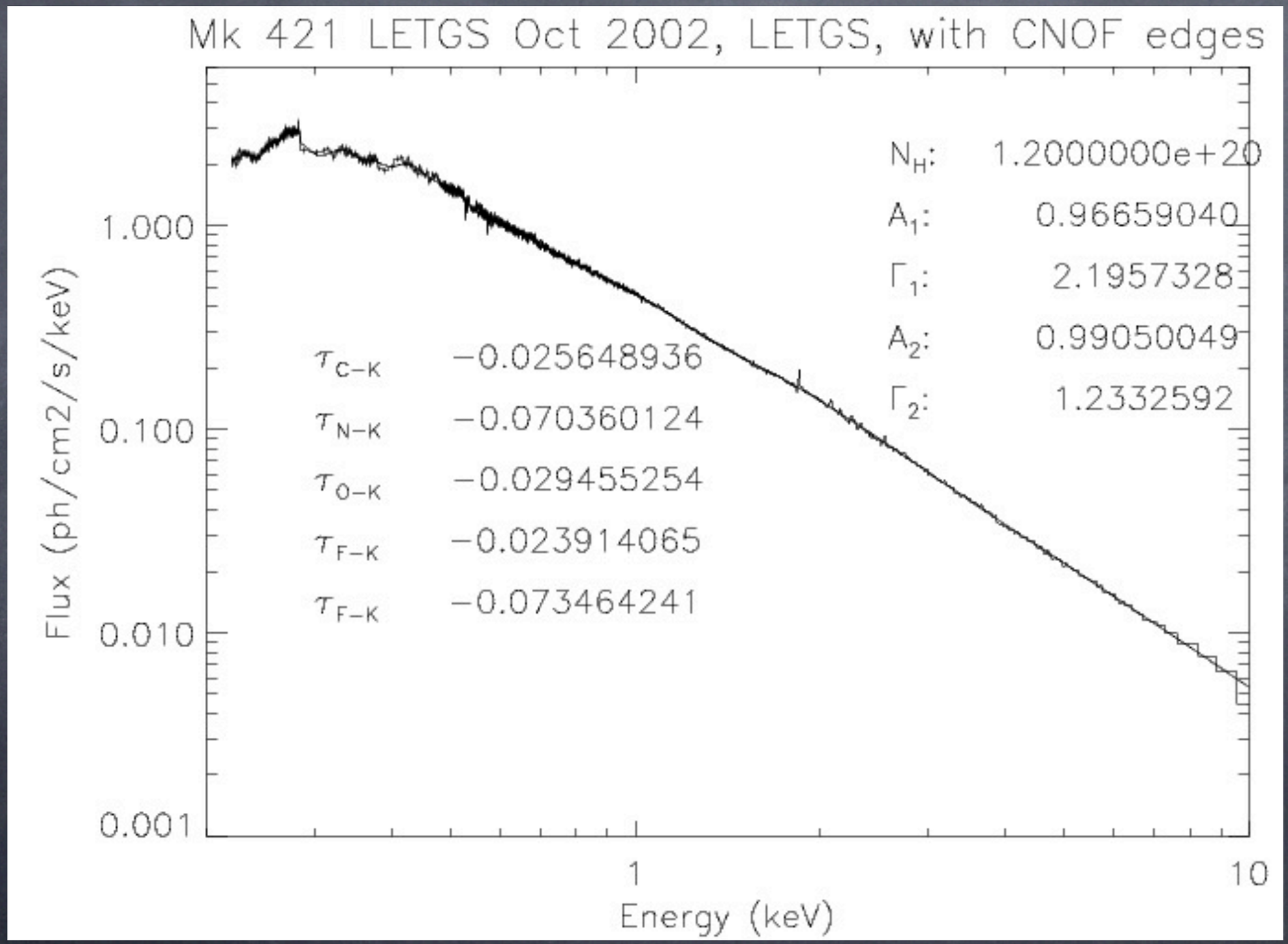
Example: Mk 421 LETGS



NEW Adjustment Method

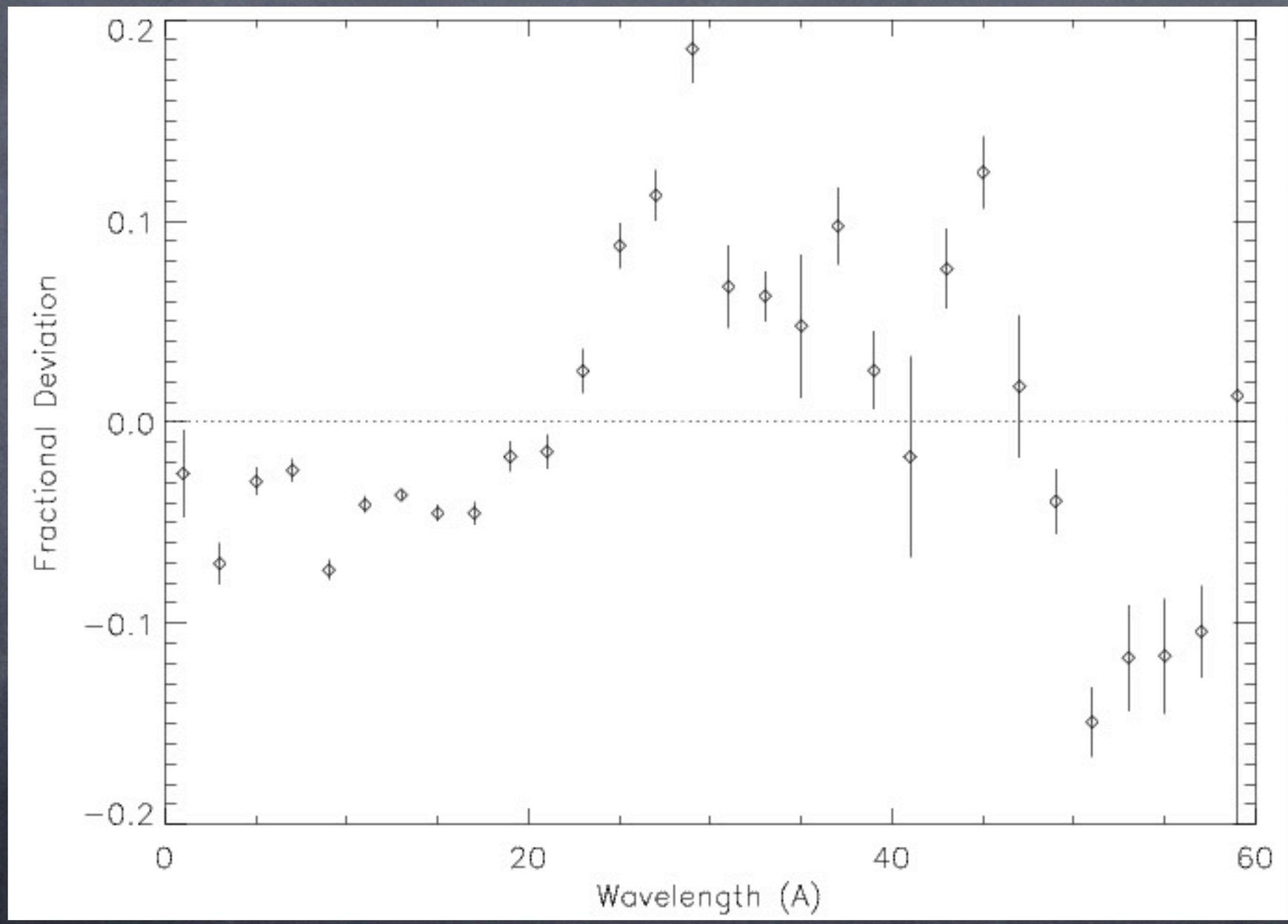
- Method: spline amplitudes
  - Define correction grid (wavelength, energy, ...)
  - Correction amplitudes defined on grid (init = 0)
  - Adjust A_{eff} by spline through amplitudes
    - Creates a smooth adjustment with arbitrary shape
- Method succeeds at a "reasonable" level
- Future:
  - Examine distribution of amplitudes
  - Centroids of amplitudes --> fix EA
  - Standard deviations --> characterization of errors

Mk 421 LETGS again

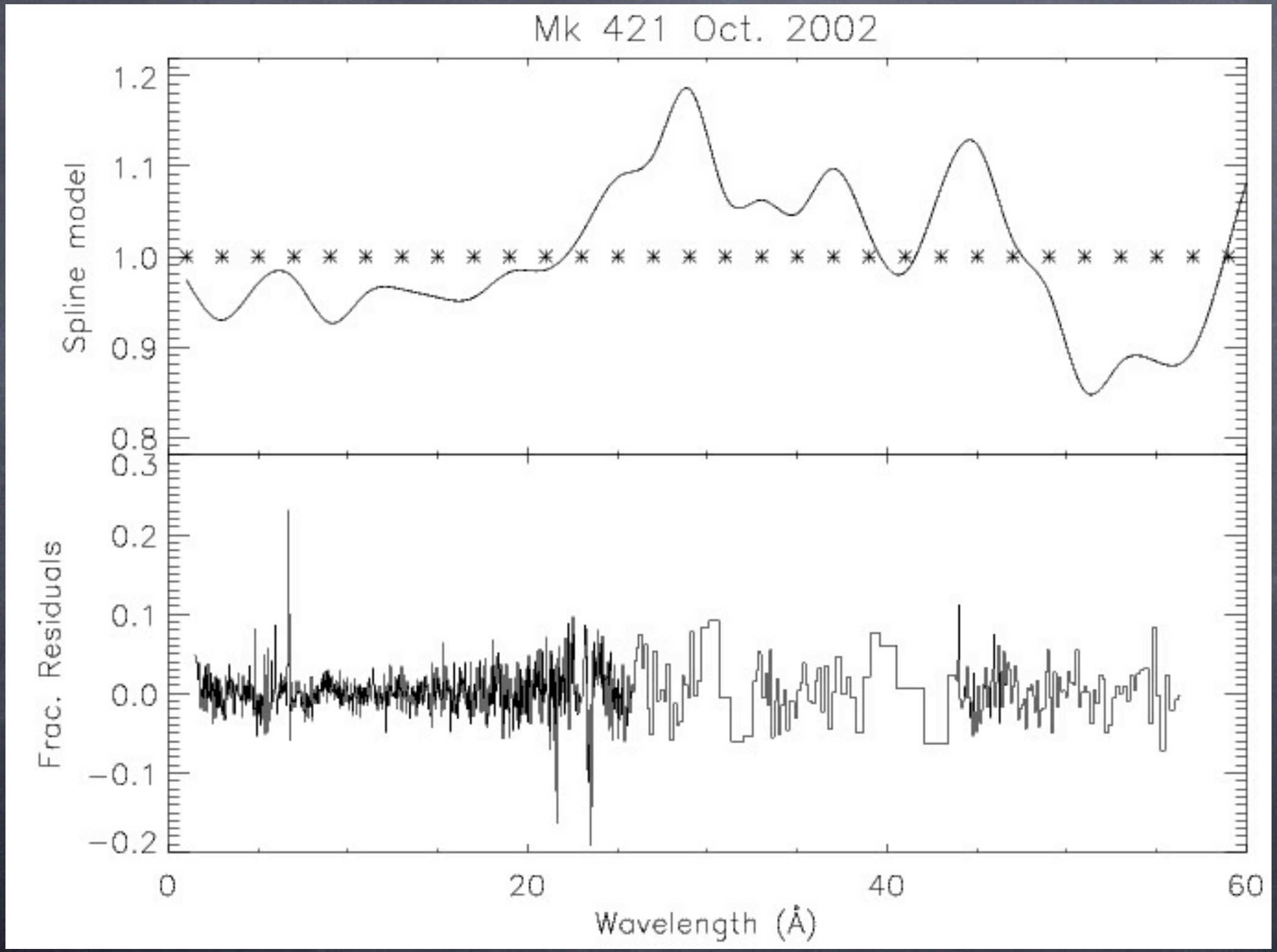


Normalizations

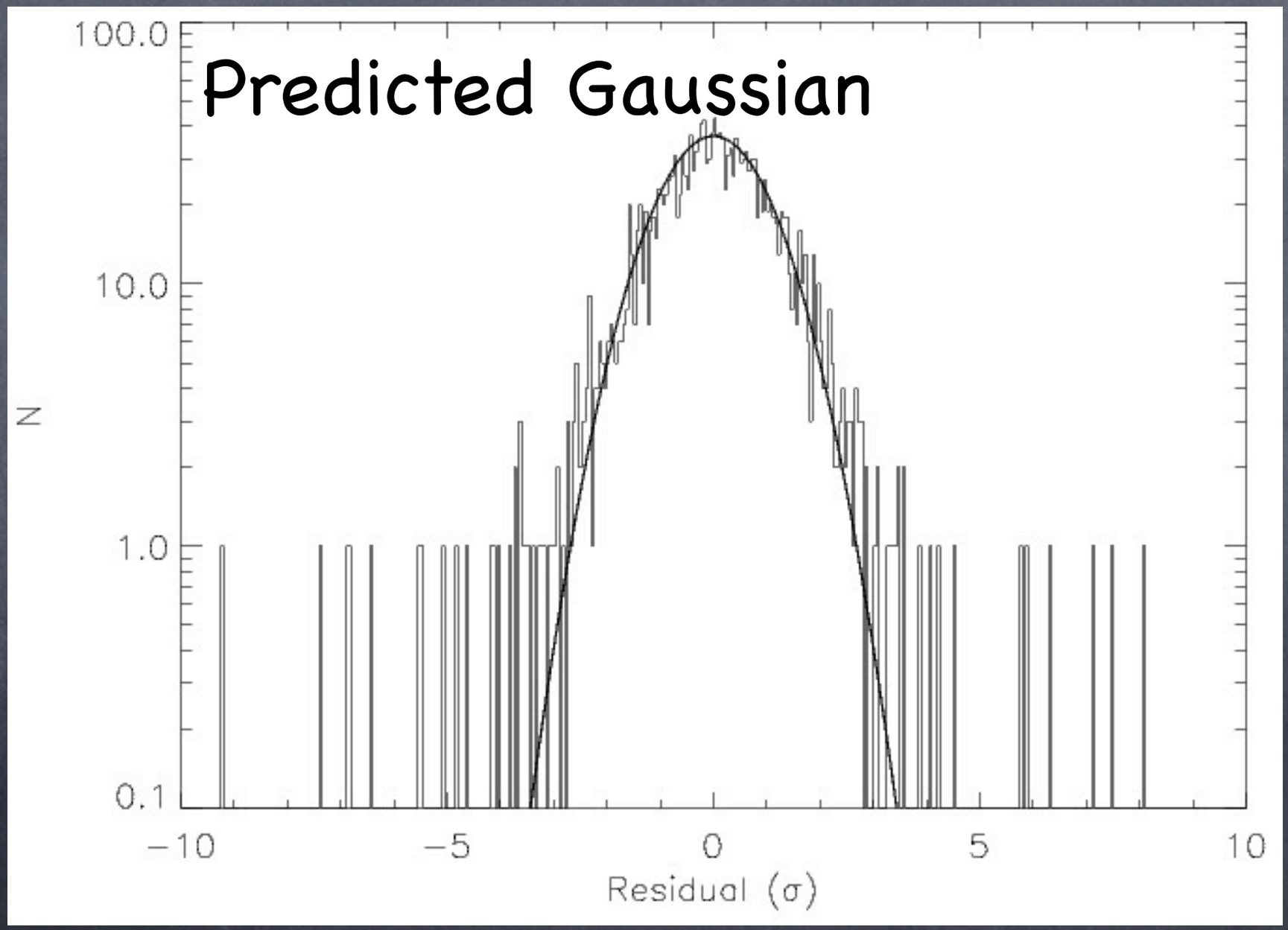
- Spline amplitudes ~ Gaussian norms



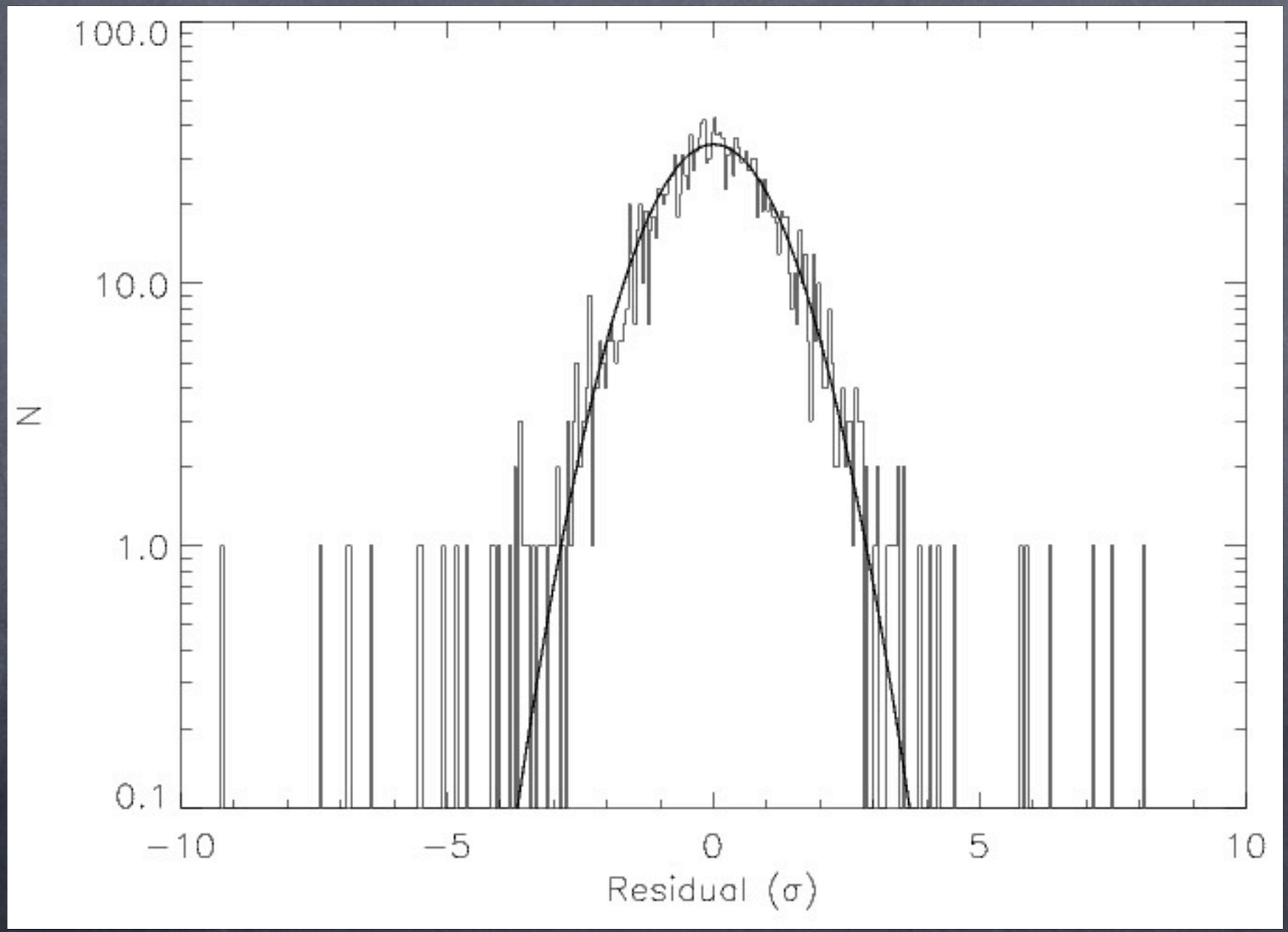
Results at a Glance



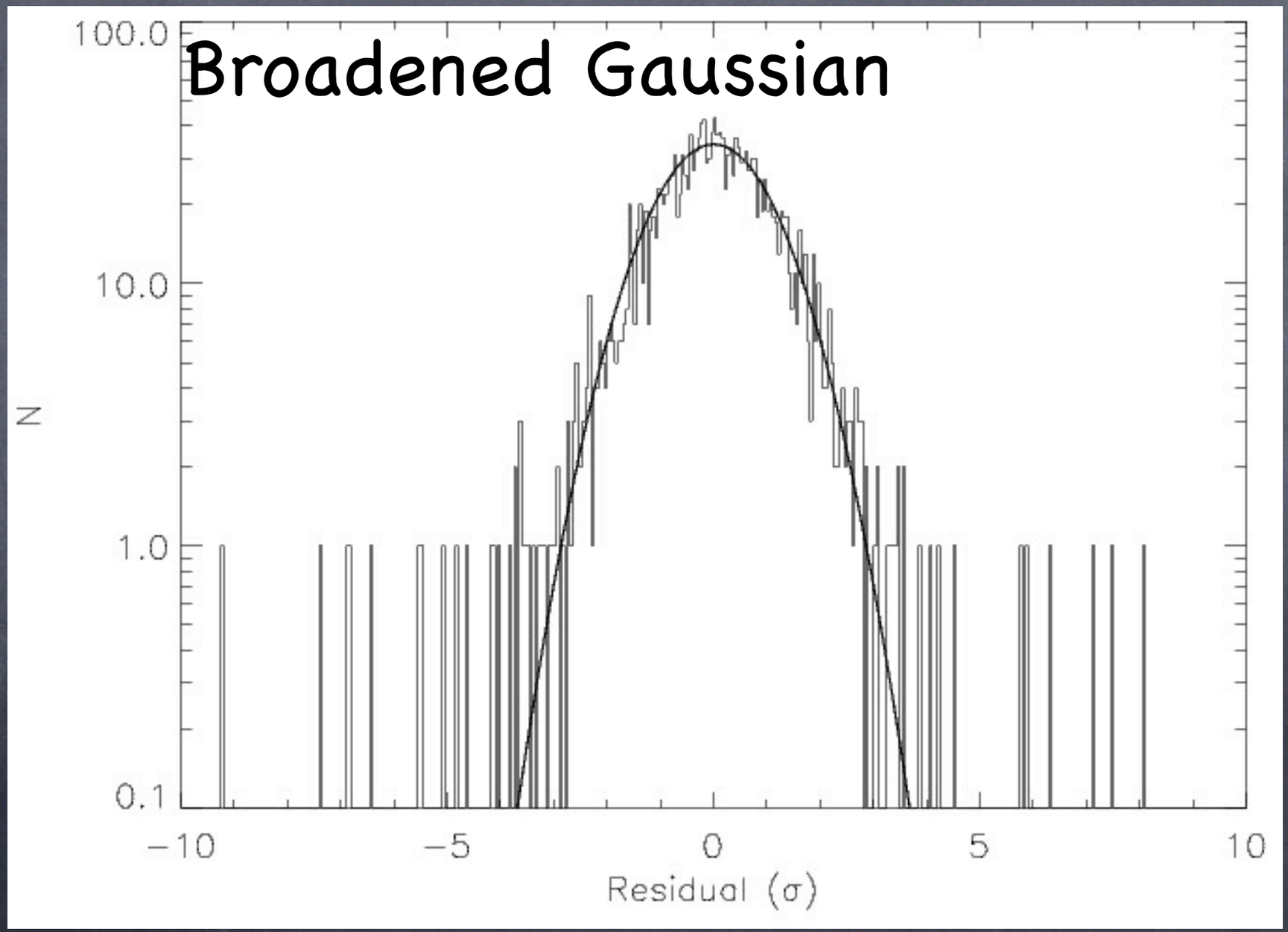
Are We There Yet?



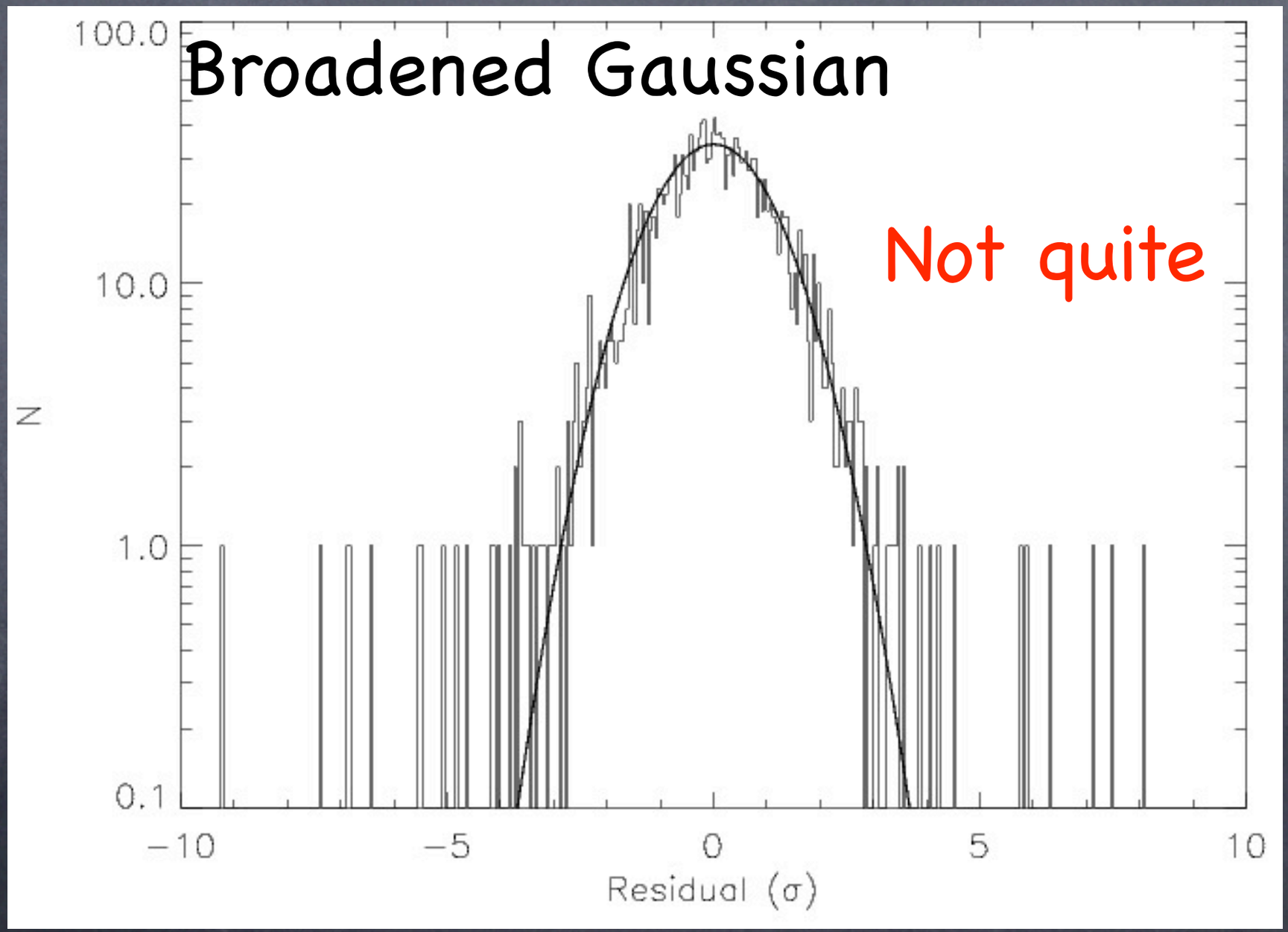
Are We There Yet?



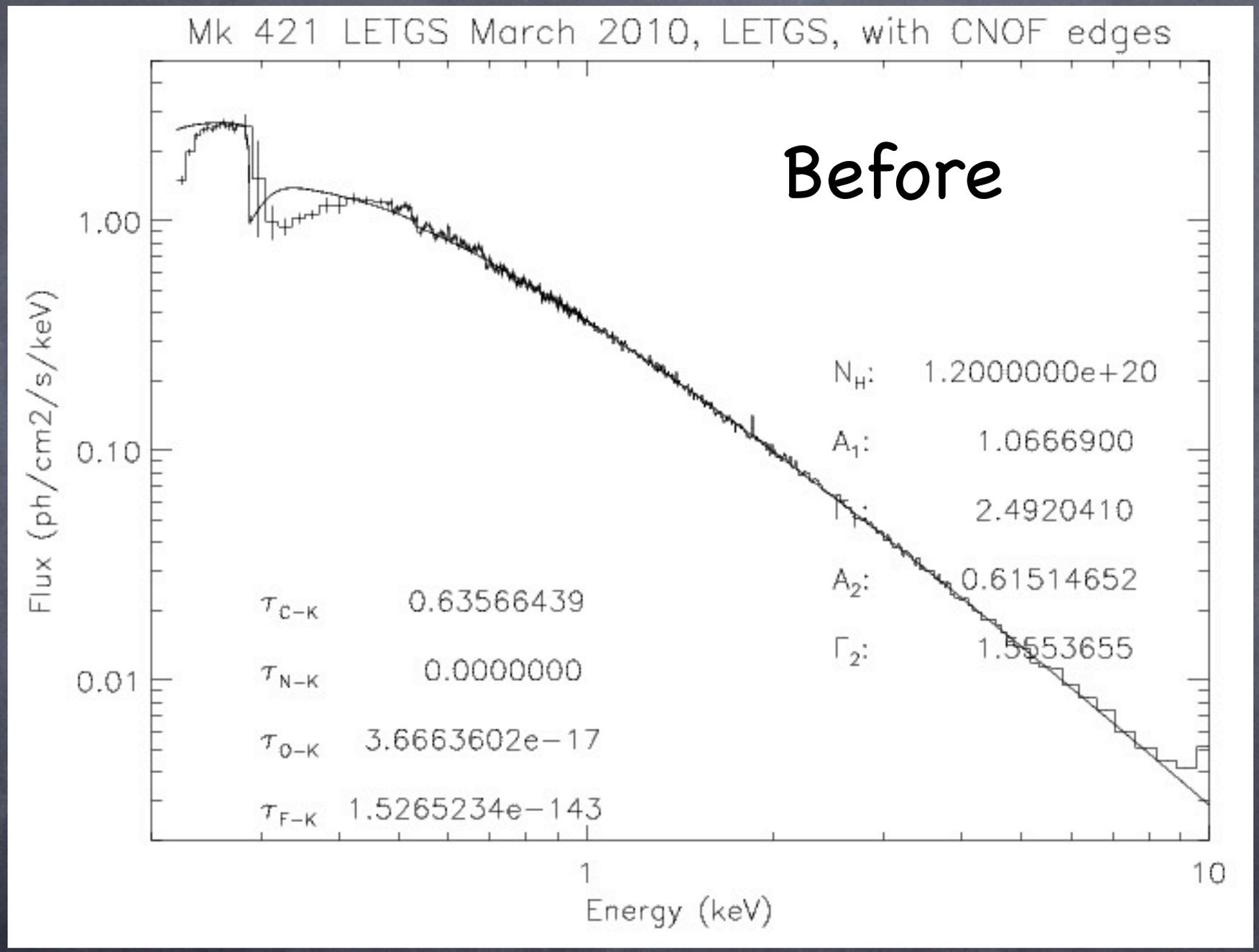
Are We There Yet?



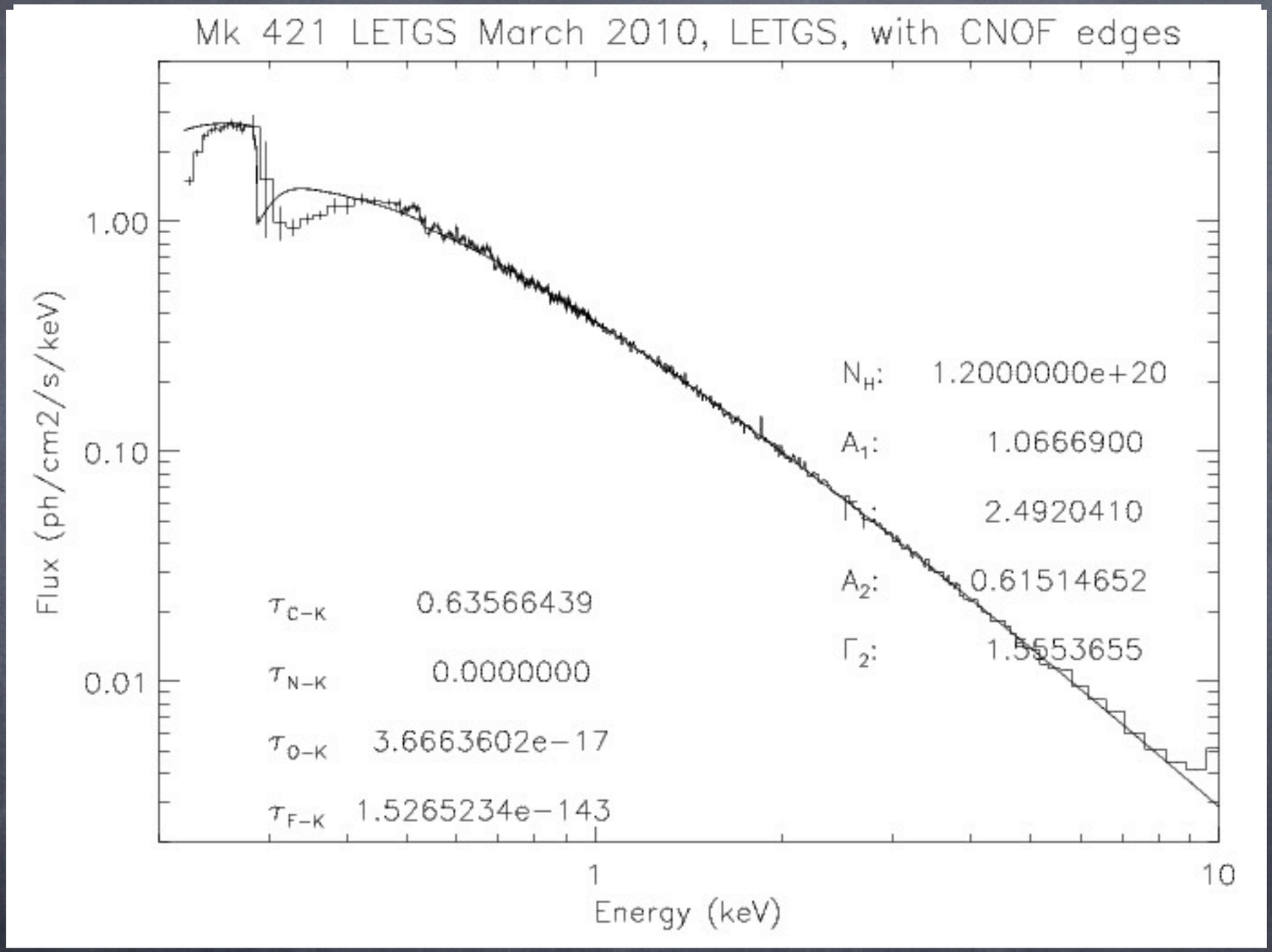
Are We There Yet?



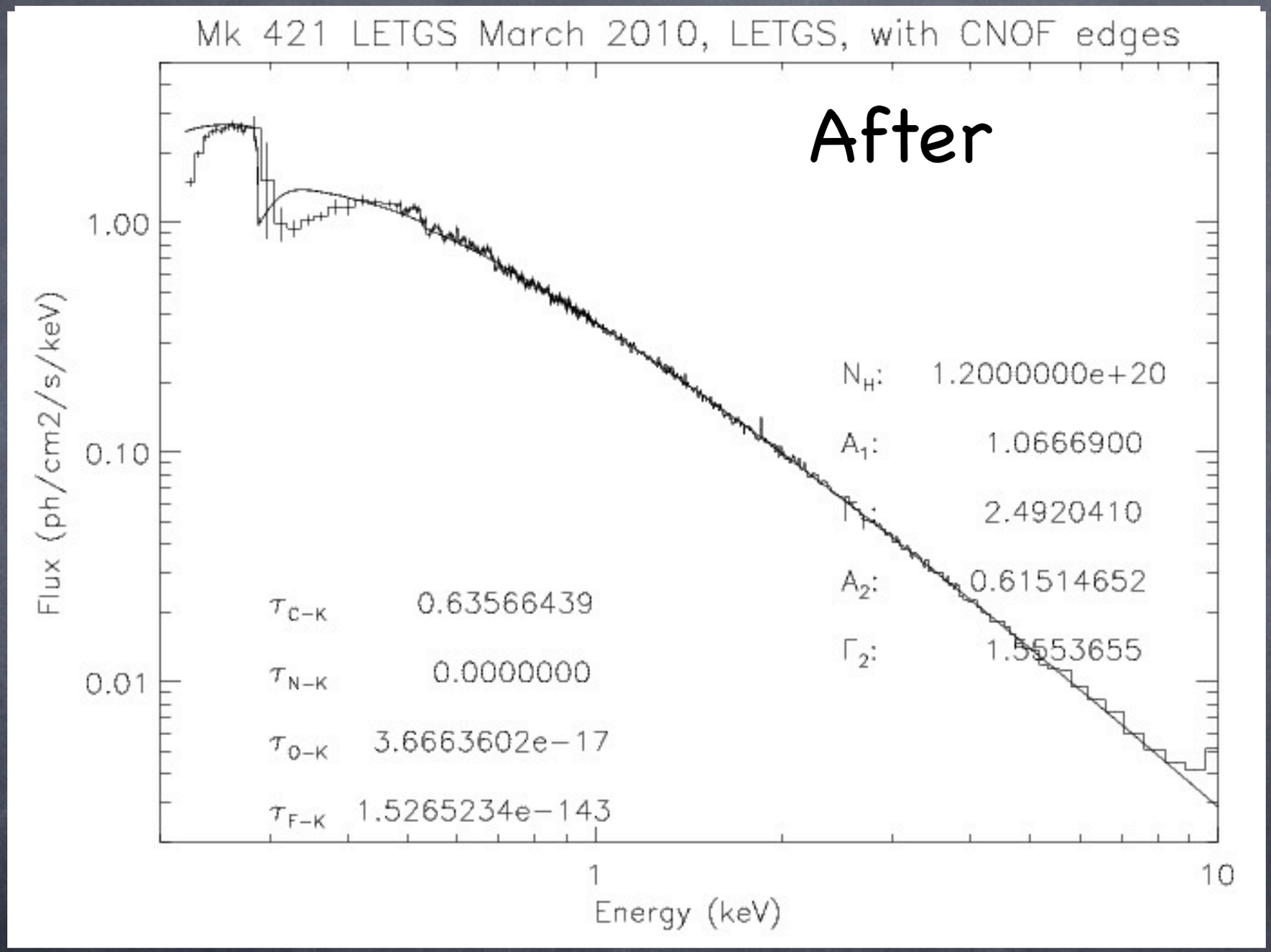
Apply to new data

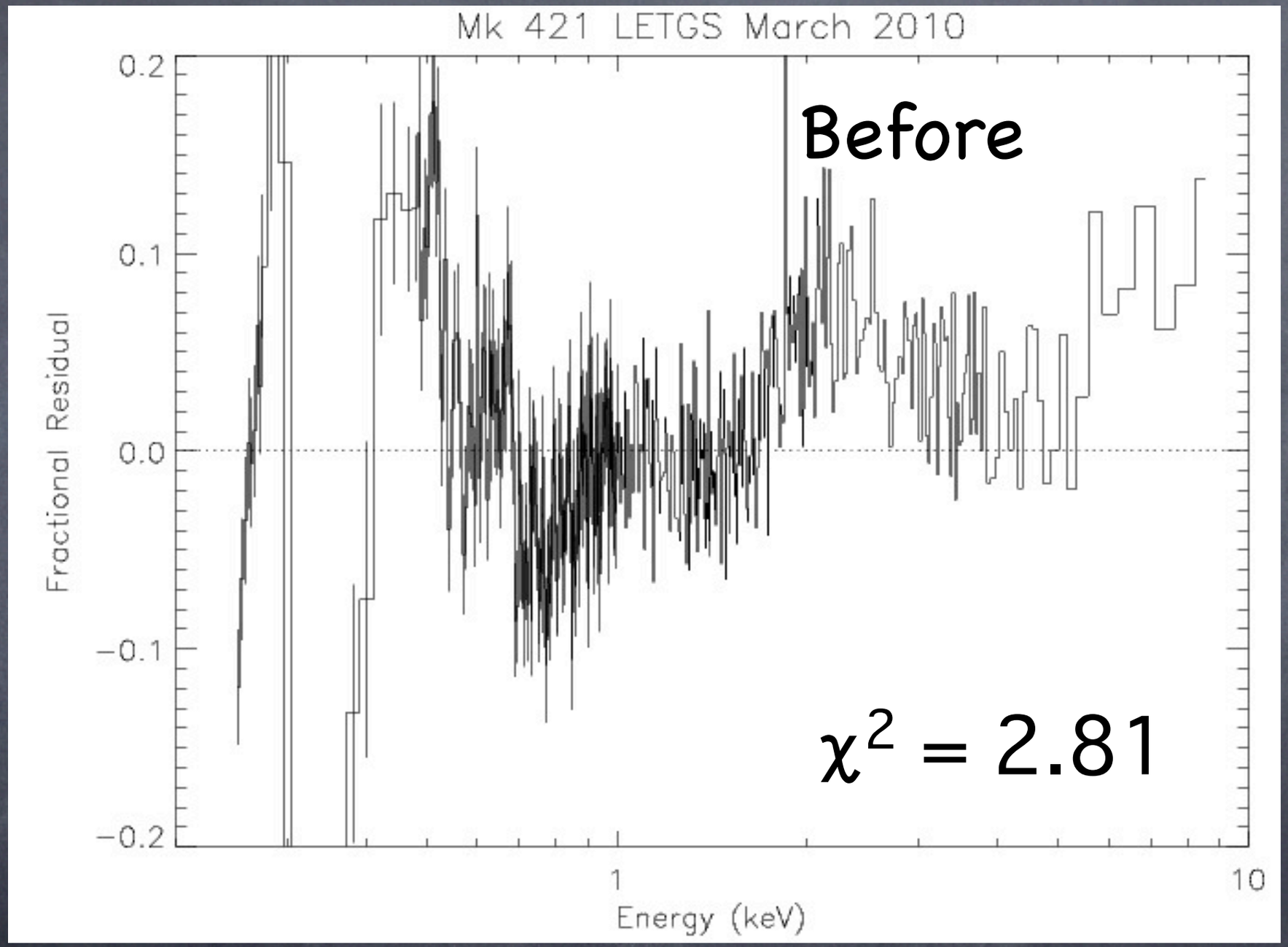


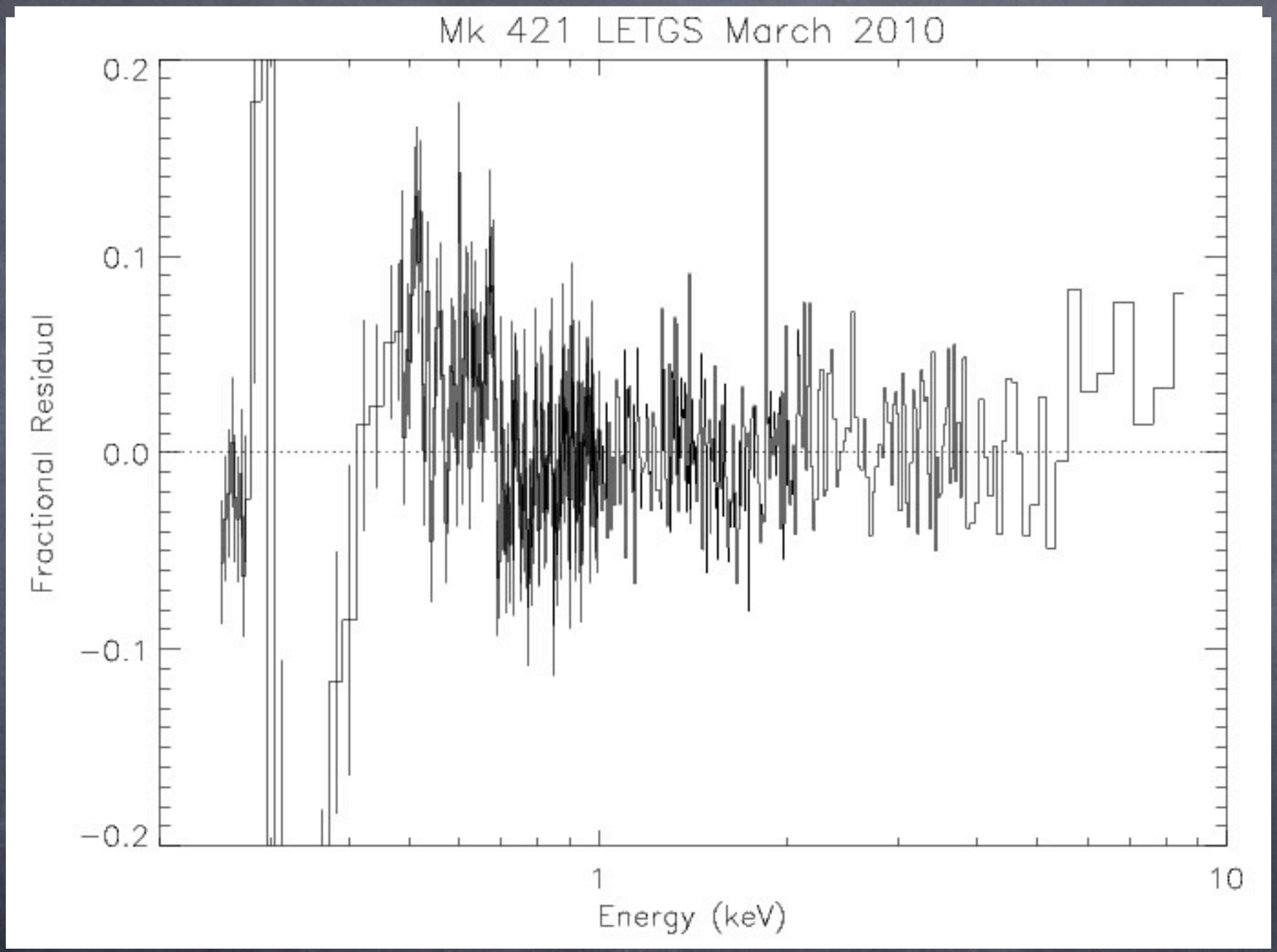
Apply to new data

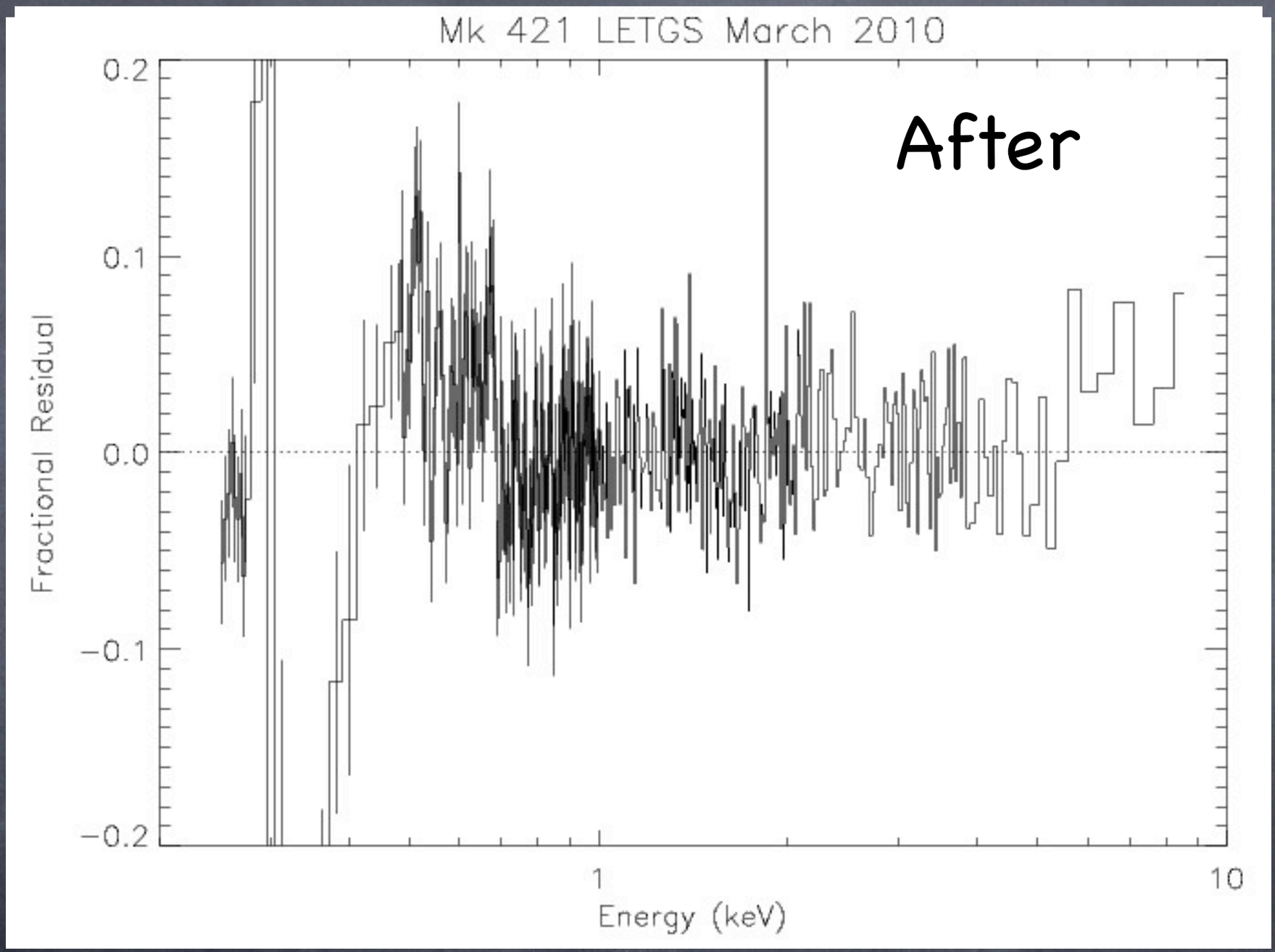


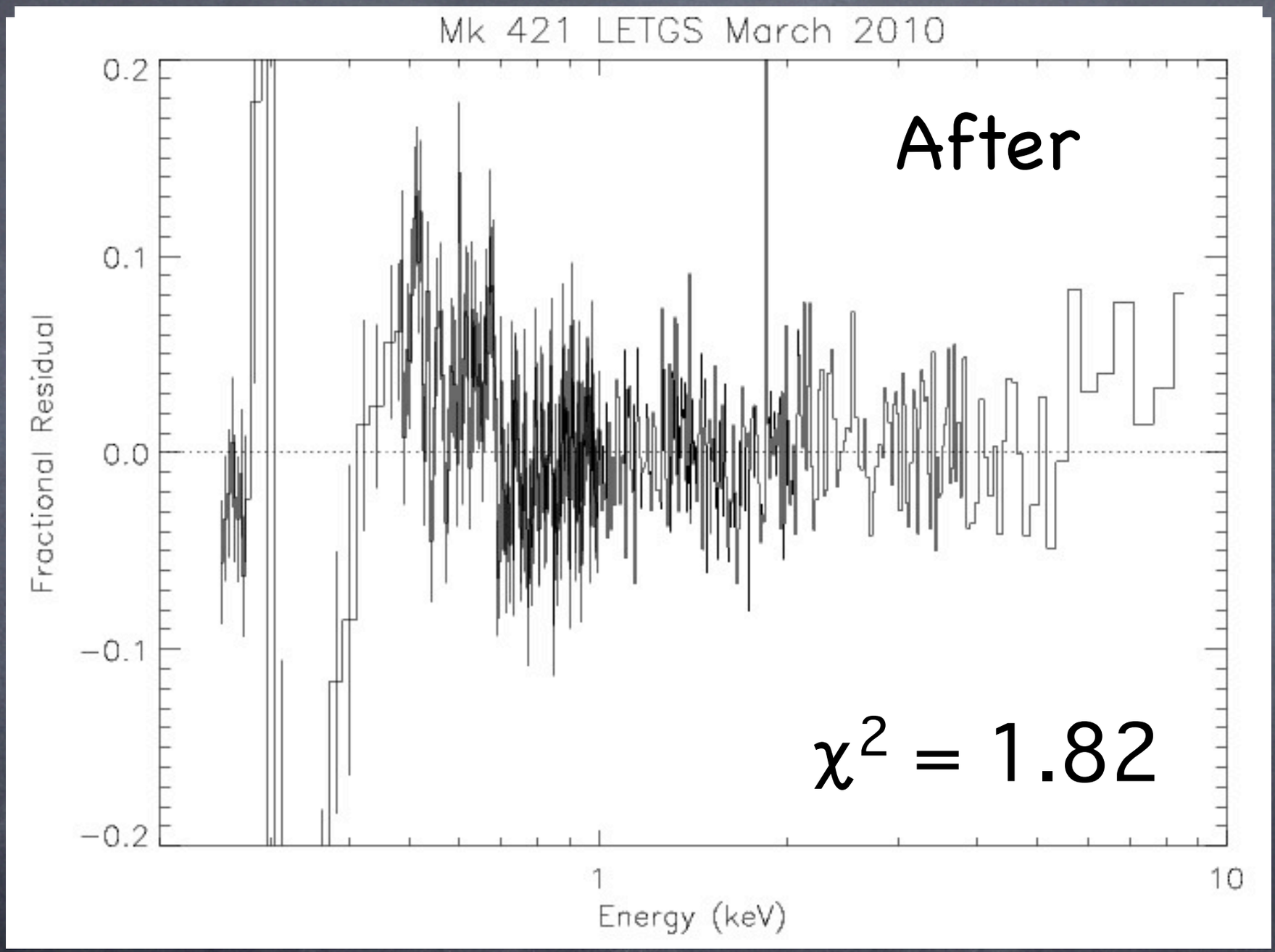
Apply to new data




Mk 421 LETGS March 2010
Before
0.2
0.1
0.0
−0.1
−0.2
Fractional Residual
1
10
Energy (keV)
$\chi^2 = 2.81$


Mk 421 LETGS March 2010
0.2
0.1
0.0
−0.1
−0.2
Fractional Residual
1
10
Energy (keV)


Mk 421 LETGS March 2010
After
0.2
0.1
0.0
−0.1
−0.2
Fractional Residual
1
10
Energy (keV)


Mk 421 LETGS March 2010
After
0.2
0.1
0.0
−0.1
−0.2
Fractional Residual
1
10
Energy (keV)
$\chi^2 = 1.82$

NEW Adjustment Method

- Method: spline amplitudes
  - Define correction grid (wavelength, energy, ...)
  - Correction amplitudes defined on grid (init = 0)
  - Adjust Aeff by spline through amplitudes
    - Creates a smooth adjustment with arbitrary shape
- Method succeeds at a "reasonable" level
- Future:
  - Examine distribution of amplitudes
  - Centroids of amplitudes --> fix EA
  - Standard deviations --> characterization of errors

For further discussion...

For further discussion...

IACHEC-5 Apr 14, 2010