RXTE/PCA Calibration Status

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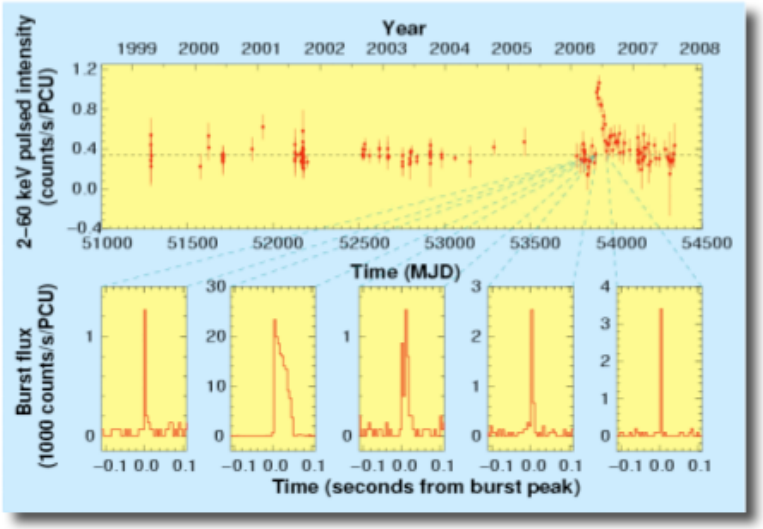
Outline

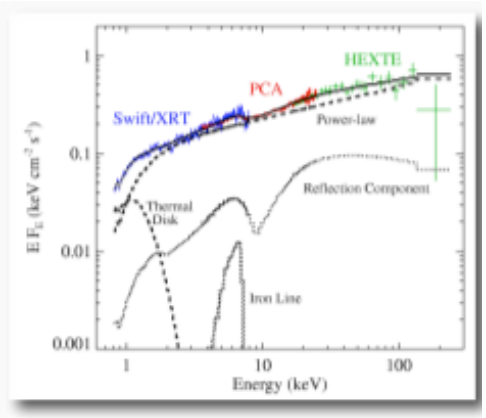
- PCA is a mature instrument undergoing a calibration update
  - Launched December 30, 1995
  - Operations currently approved through Sept 2009
  - Operations in FY 2010 are under NASA HQ consideration
- Previous presentations concentrate on our calibration successes
- Ringberg talk concentrated on what is left undone, and which may be left to the archival users
- This talk summarizes recent improvements to the approach, and results, of the energy calibration (Nikolai Shaposhnikov)

RXTE/PCA characteristics

- Large area: ~7000 cm^2
- Dynamic range:
  - ~10^{-11} to 10^{-7} erg/s/cm^2
  - ~μ-sec to years
- Flexible, "all" sky pointing enables multiwavelength campaigns



PSR 1846-0248, a rotation powered pulsar that shows magnetar behaviour. (Gavriil et al. 2008) - an example of an investigation that uses dynamic range in timing, scheduling flexibility



Smeared reflection features (in the hard state) with Swift.

Simultaneous observations of Galactic Black Hole (GRO J1650-500)

Energy response

Slab elements

- Xe in Propane layer
  - L1
  - L2, L3
  - Boundary layers
- Window (Mylar, Al)

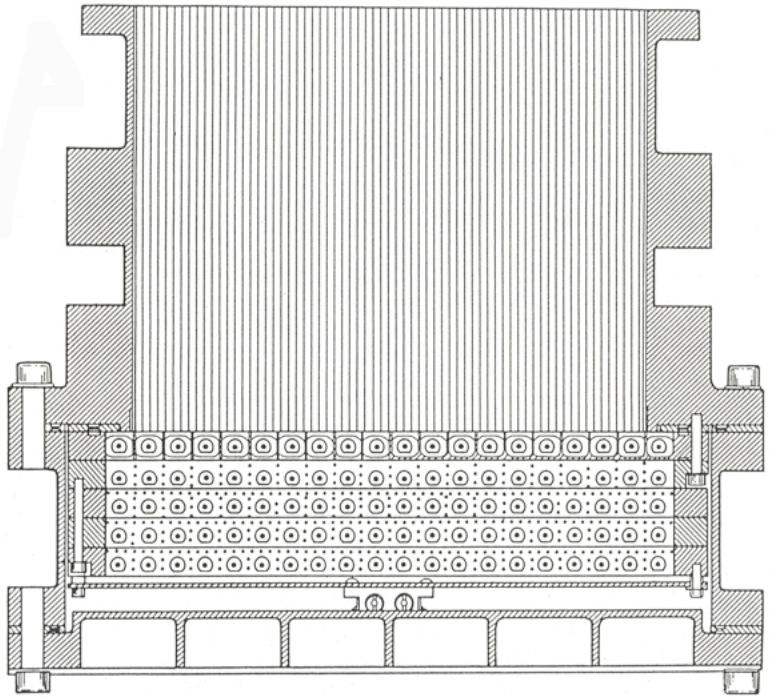
Redistribution Function

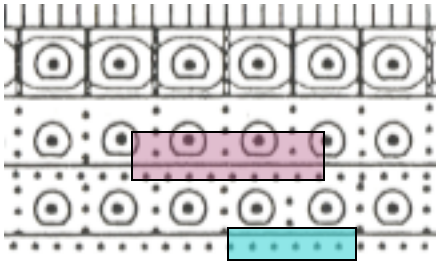
- Resolution
- Xe Kα,Kβ, L escape fraction
- Partial charge
- Self veto (photo-electron range)

Energy Scale

- Quadratic charge to channel
- High Voltage changes (epoch)
- Physical model for $q(E_\gamma)$

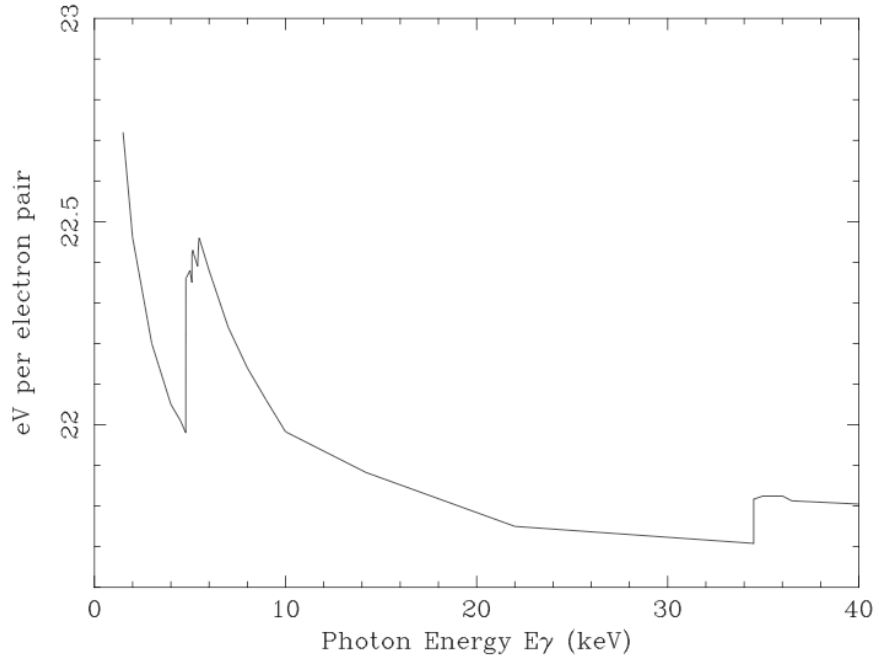
Time dependent quantities in blue





Released Method

- Energy to channel relationship derived from gaussians from Am-241 data, and edge fit to Xenon data (matrix ignores Xe in Vp layer)
  - Requires setting “contrast factor”
  - Requires good edge model
- Quantum efficiency, redistribution parameters now fit to many Crab observations
- 2 steps are not completely independent, so there may be a need to iterate
- V11.4 (released version) has epoch boundaries in addition to HV changes, no method to ensure smooth behaviour at boundaries

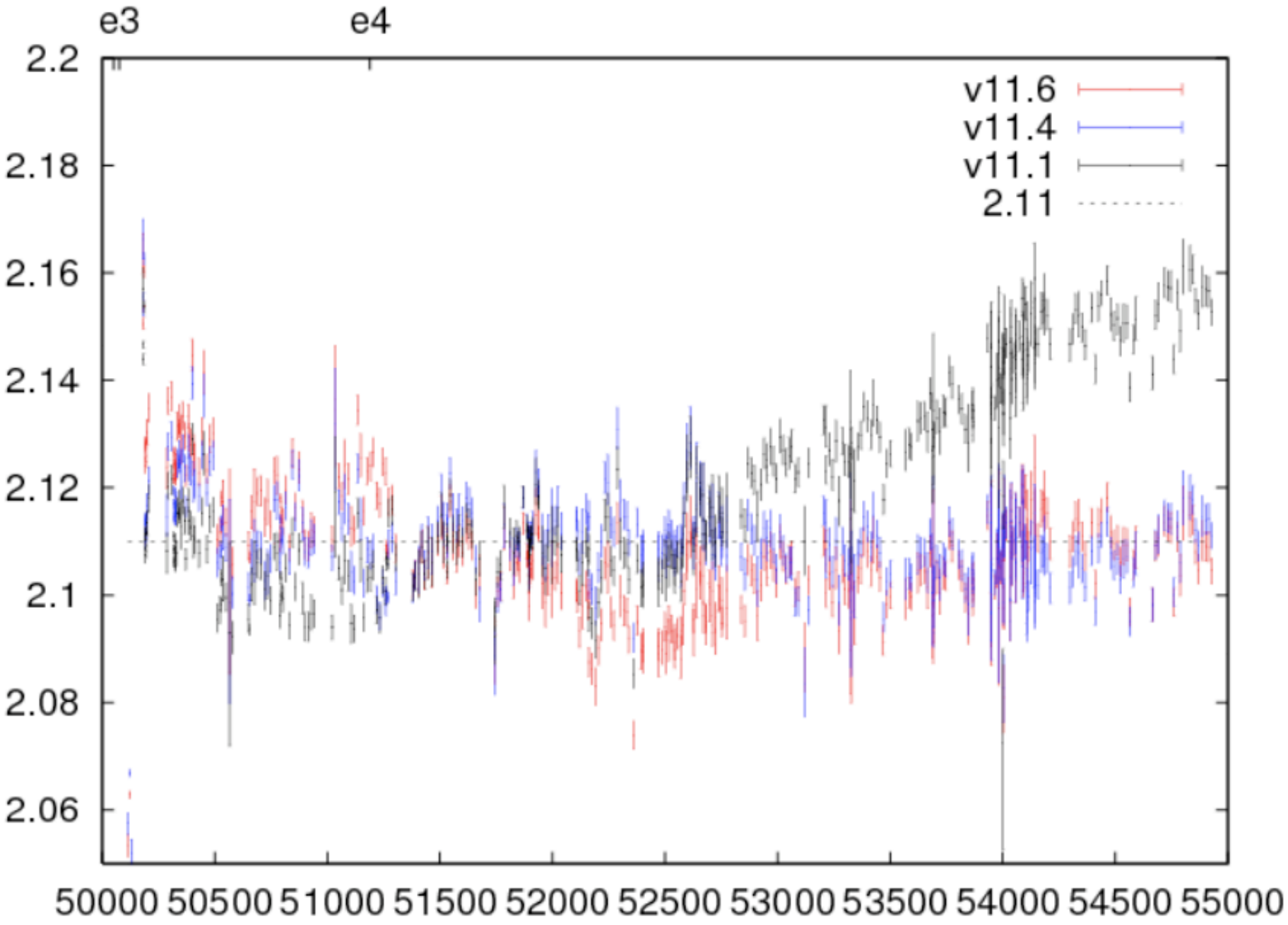


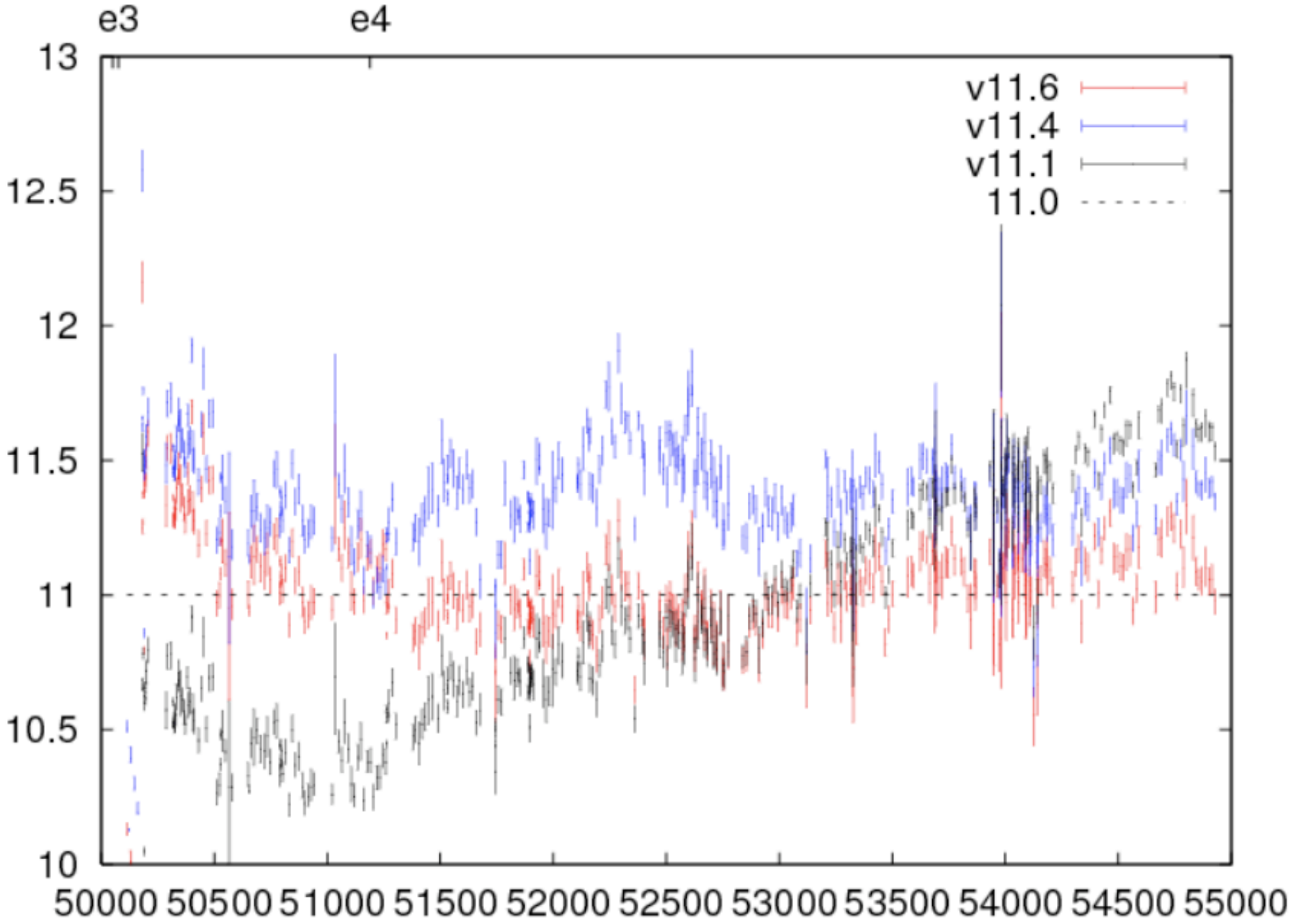
- Energy to channel is coupled to other parameters by edge behaviour
- w’(E) = (w(E) – 22) * f + 22

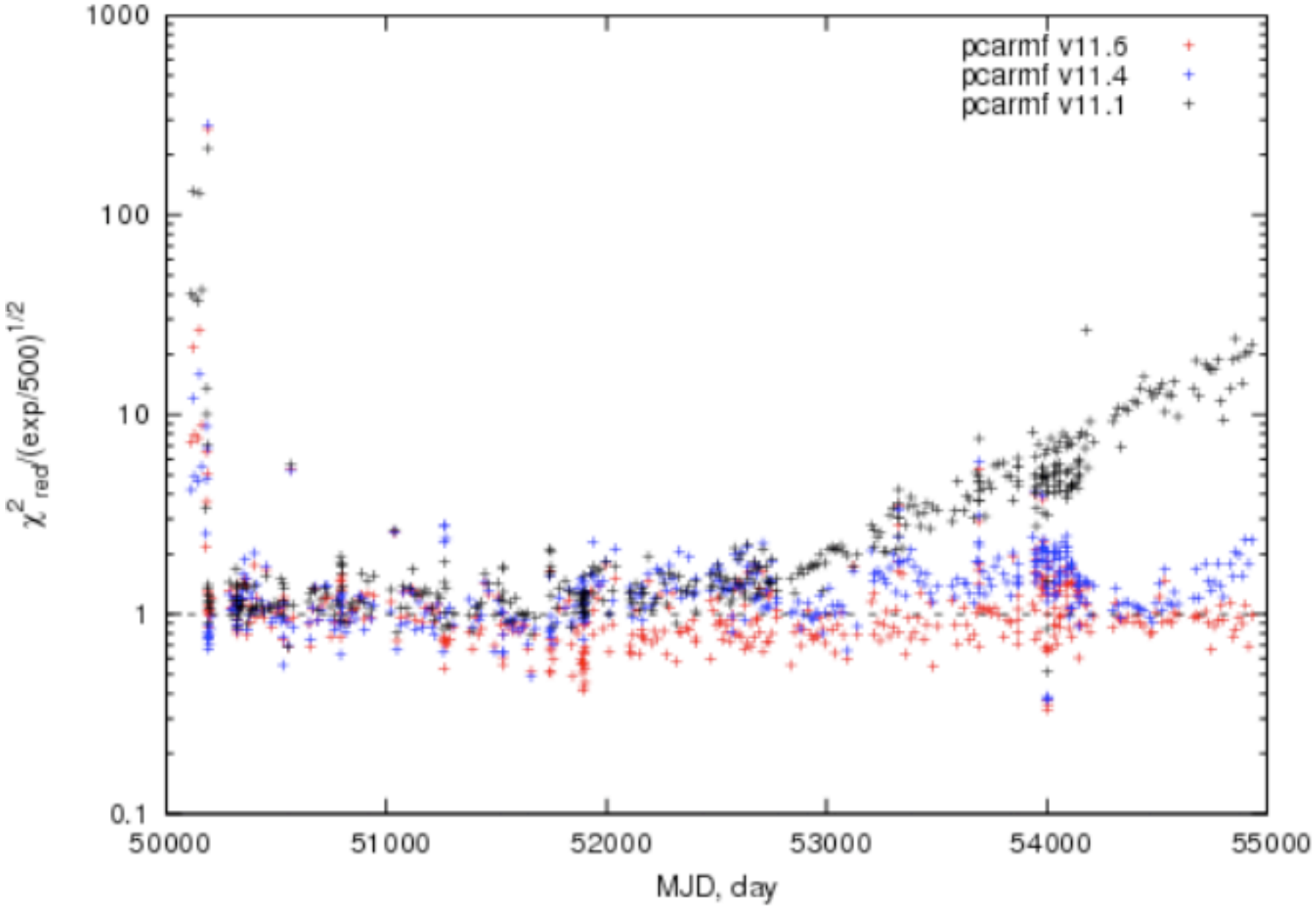
Soon to be Released Method

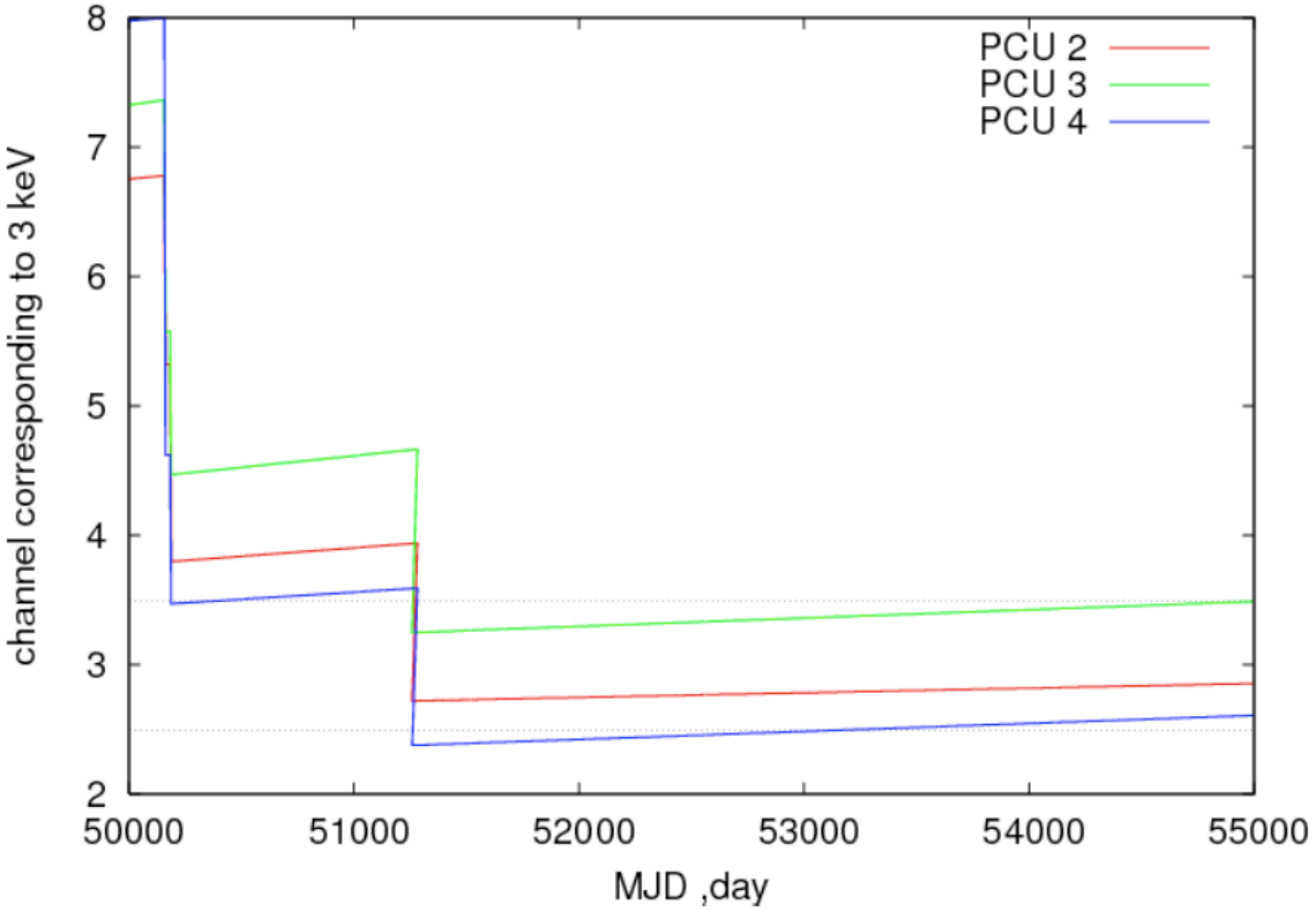
- Pcarmf implemented as an XSPEC model
- Simultaneous fits to Crab data (quantum efficiency, redistribution parameters, energy to channel) and Am-241 data (energy to channel)

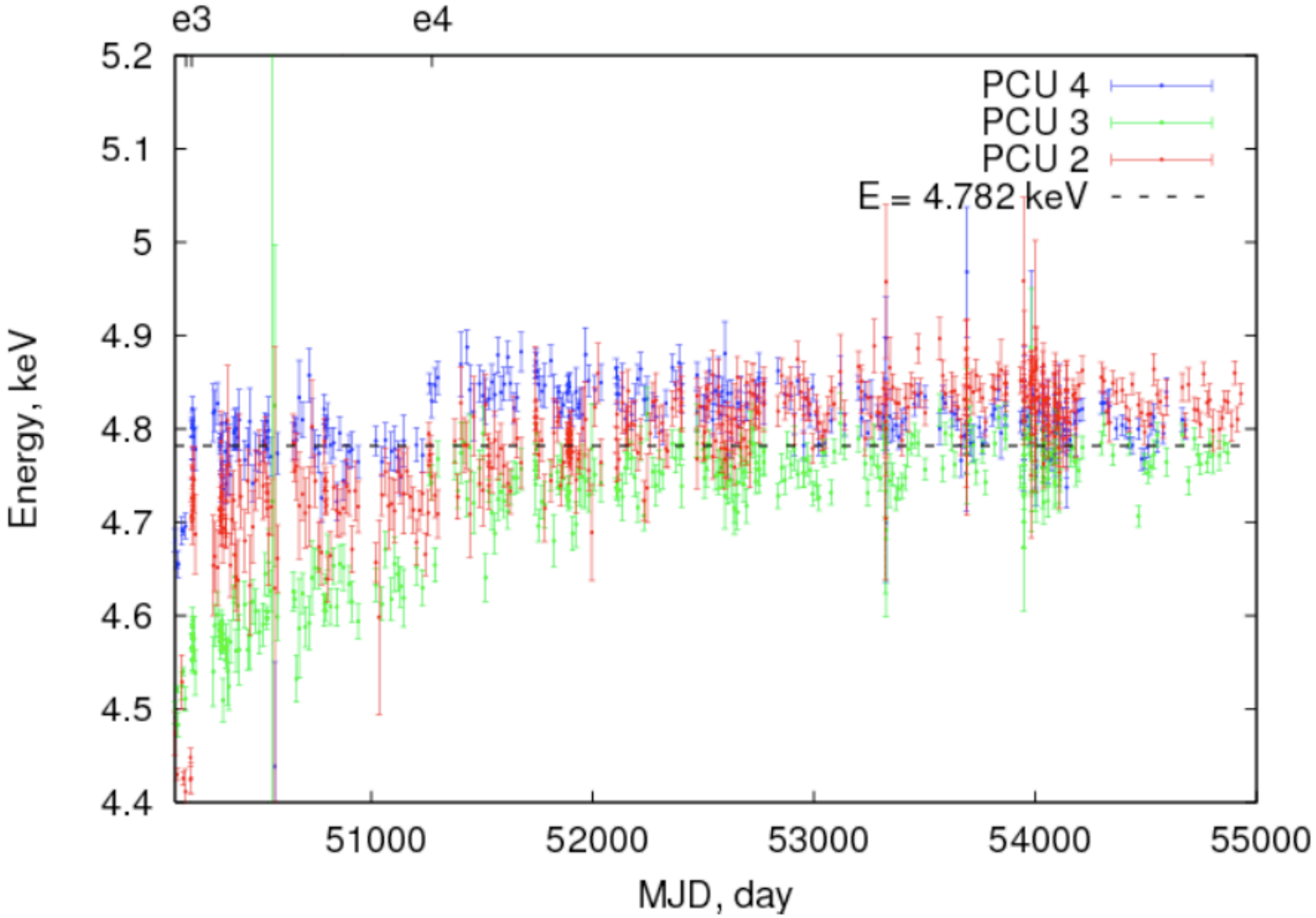
- Xenon L-edge no longer an explicit input (but useful as a check)
- Energy to channel parameters can be fit smoothly over longest epochs (1999-present for PCU2,3,4)

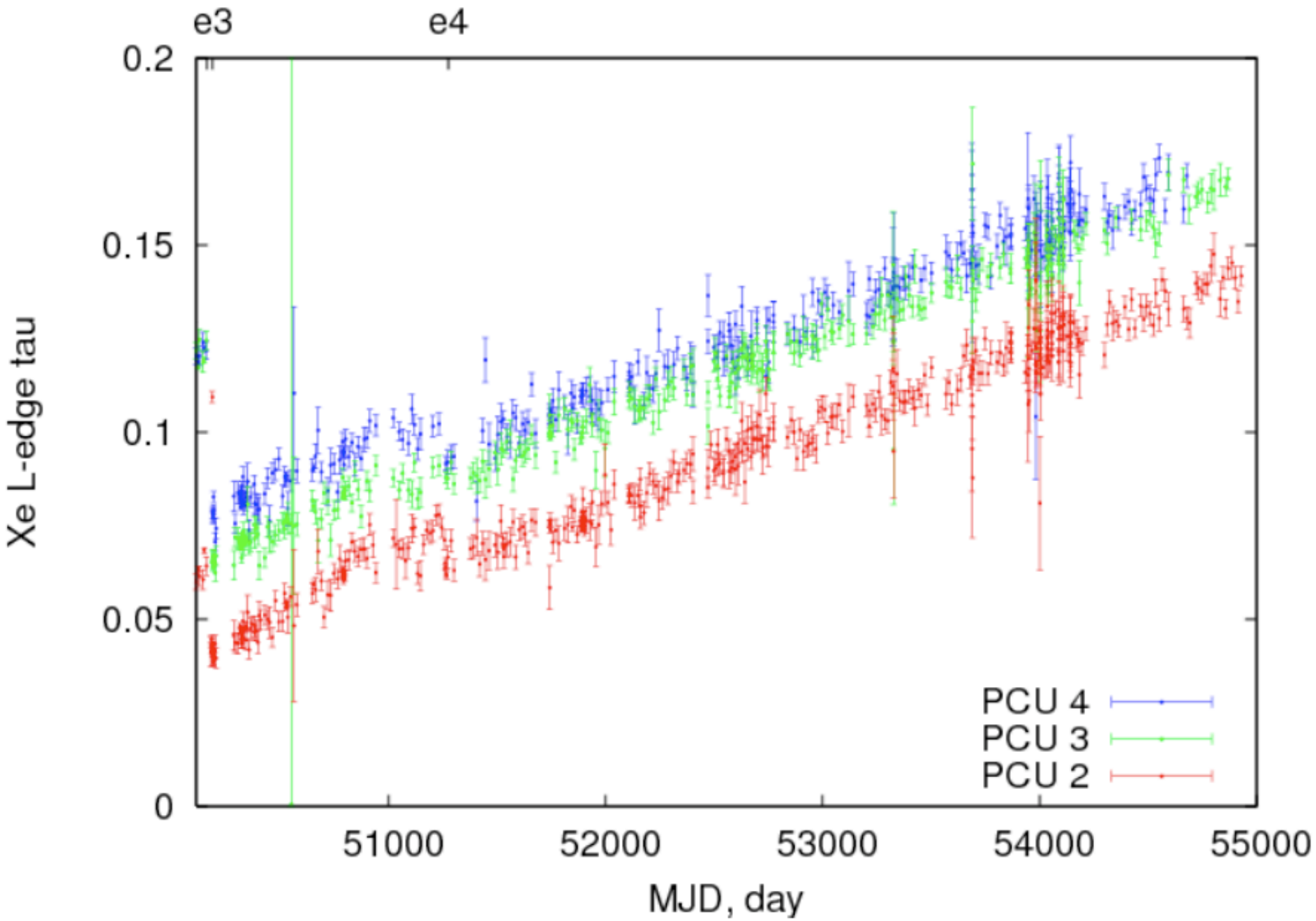

e3
e4
2.2
2.18
2.16
2.14
2.12
2.1
2.08
2.06
v11.6
v11.4
v11.1
2.11
50000 50500 51000 51500 52000 52500 53000 53500 54000 54500 55000

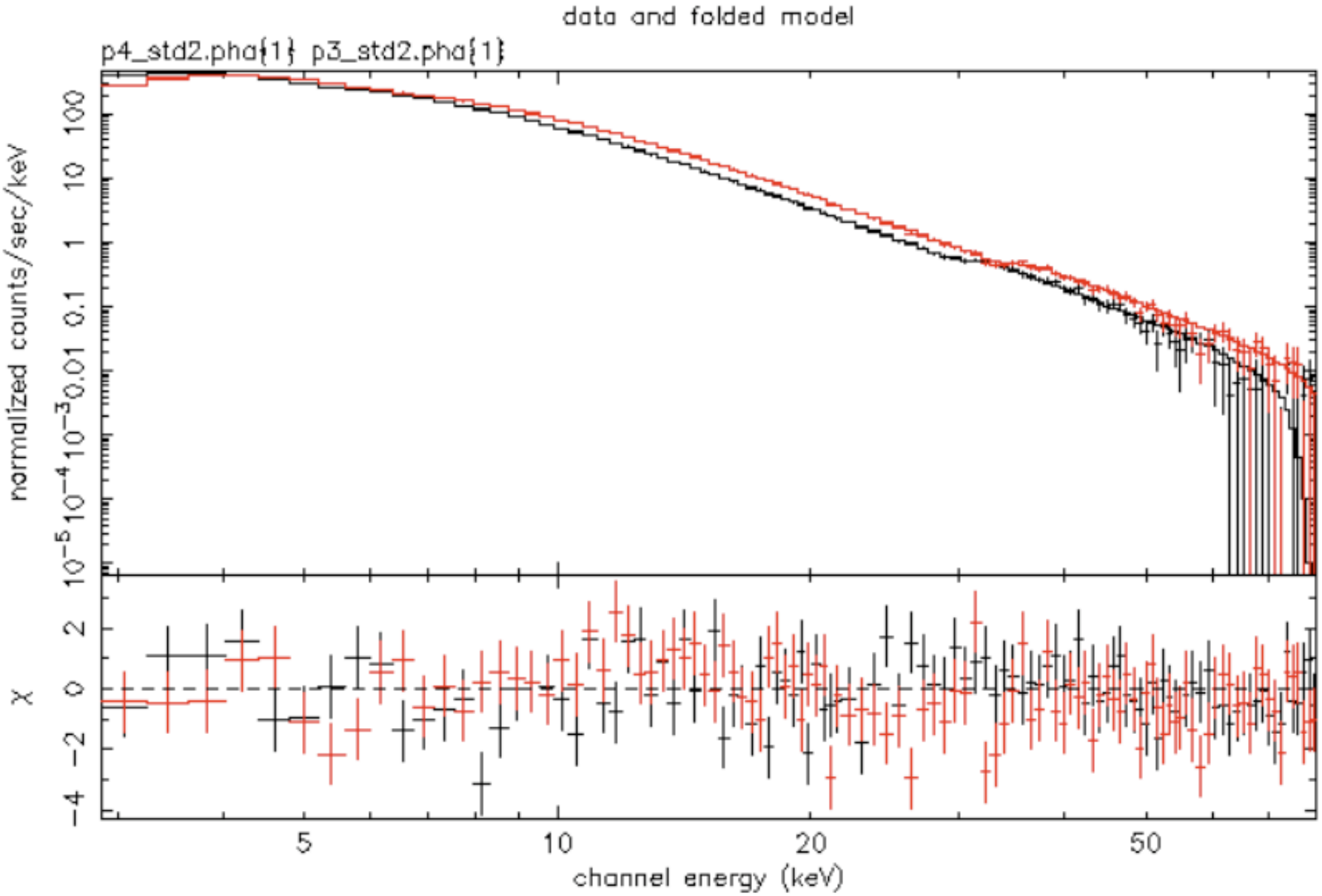

e3
e4
13
12.5
12
11.5
11
10.5
10
50000 50500 51000 51500 52000 52500 53000 53500 54000 54500 55000
v11.6
v11.4
v11.1
11.0


pcarmf v11.6
pcarmf v11.4
pcarmf v11.1
1000
100
10
1
0.1
50000
51000
52000
53000
54000
55000
MJD, day
$\chi^2_{red}/(exp/500)^{1/2}$

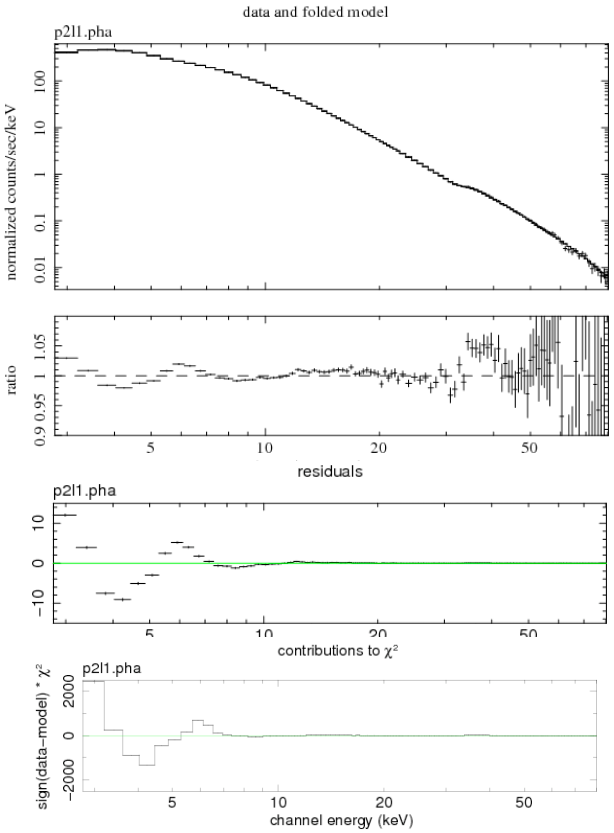

PCU 2
PCU 3
PCU 4
channel corresponding to 3 keV
MJD ,day
8
7
6
5
4
3
2
50000
51000
52000
53000
54000
55000


e3
e4
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
Energy, keV
PCU 4
PCU 3
PCU 2
E = 4.782 keV
51000
52000
53000
54000
55000
MJD, day


e3
e4
0.2
0.15
0.1
0.05
0
Xe L-edge tau
51000
52000
53000
54000
55000
MJD, day
PCU 4
PCU 3
PCU 2


data and folded model
p4_std2.pha{1} p3_std2.pha{1}
normalized counts/sec/keV
10^{-5} 10^{-4} 10^{-3} 0.01 0.1 1 10 100
χ
−4 −2 0 2
5 10 20 50
channel energy (keV)

Energy response (2008)



Power law fits to Crab show percent level deviations in “ratio”; “resid” and “chi” can be large (and are exposure dependent)

- fitting a gaussian (in “absorption”) near 4.1 keV typically produces an equivalent width ~50 eV

At Xenon-L edge, there are discontinuous changes in quantum efficiency, partial charge collection, and energy to channel relationship.

Collimator transmission

- Absolute area normalized to “Crab” (Zombeck value, which is high)
- Flux in 2-10 keV
- Crab flux plot
- No energy dependence in arf, likely a slight over simplification