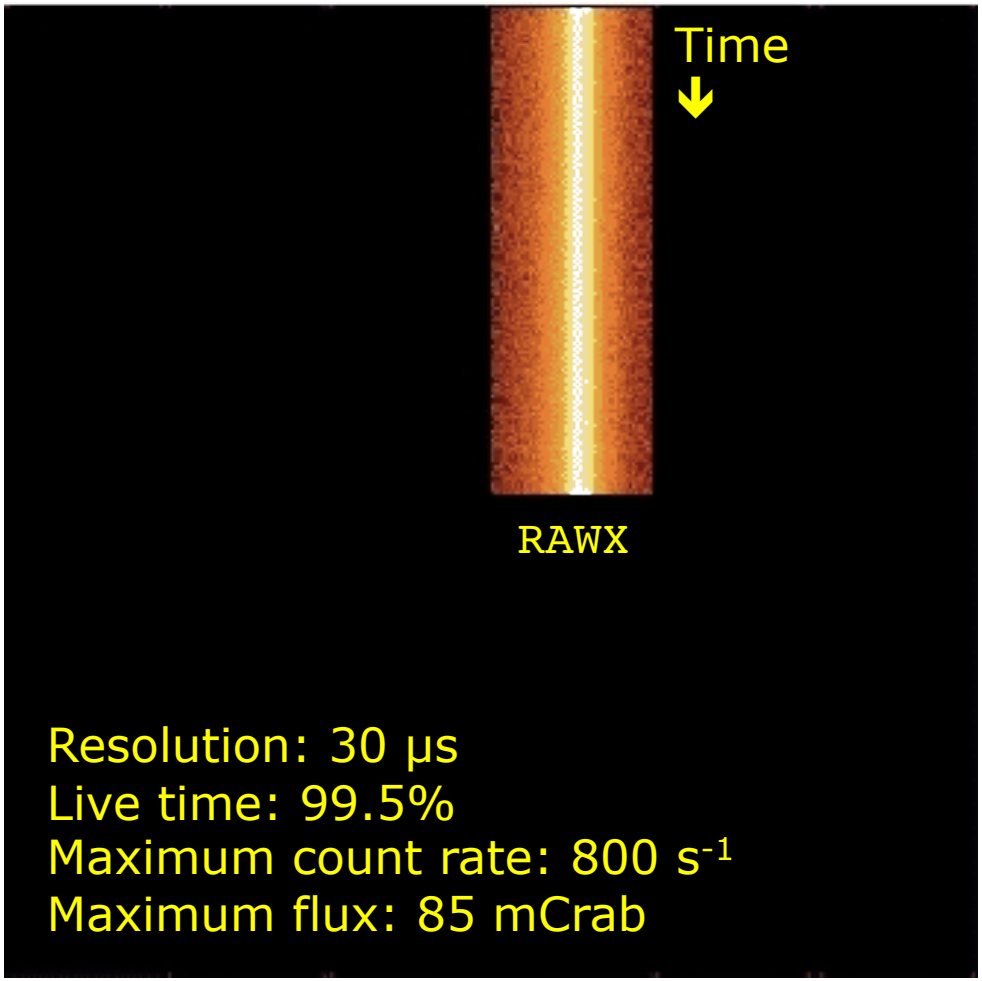
FAST MODES IN EPIC-PN

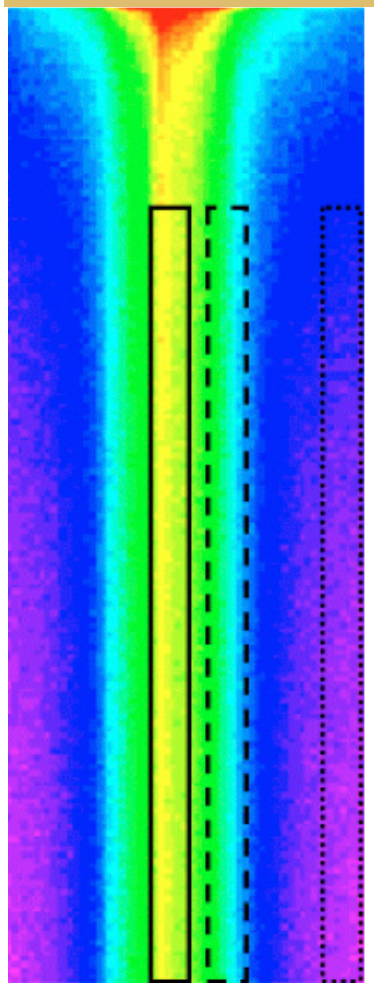
Matteo Guainazzi
XMM-Newton Science Operations Centre

Two flavours of Fast Modes

Timing Mode (CCD#4 only)



Burst Mode (CCD#4 only)



Resolution: 7 μs
Live time: 3%
Maximum count rate: 6×10^4 s^{-1}
Maximum flux: 6.3 Crab

(Kirsch et al. 2006)

Timing Mode: how it works

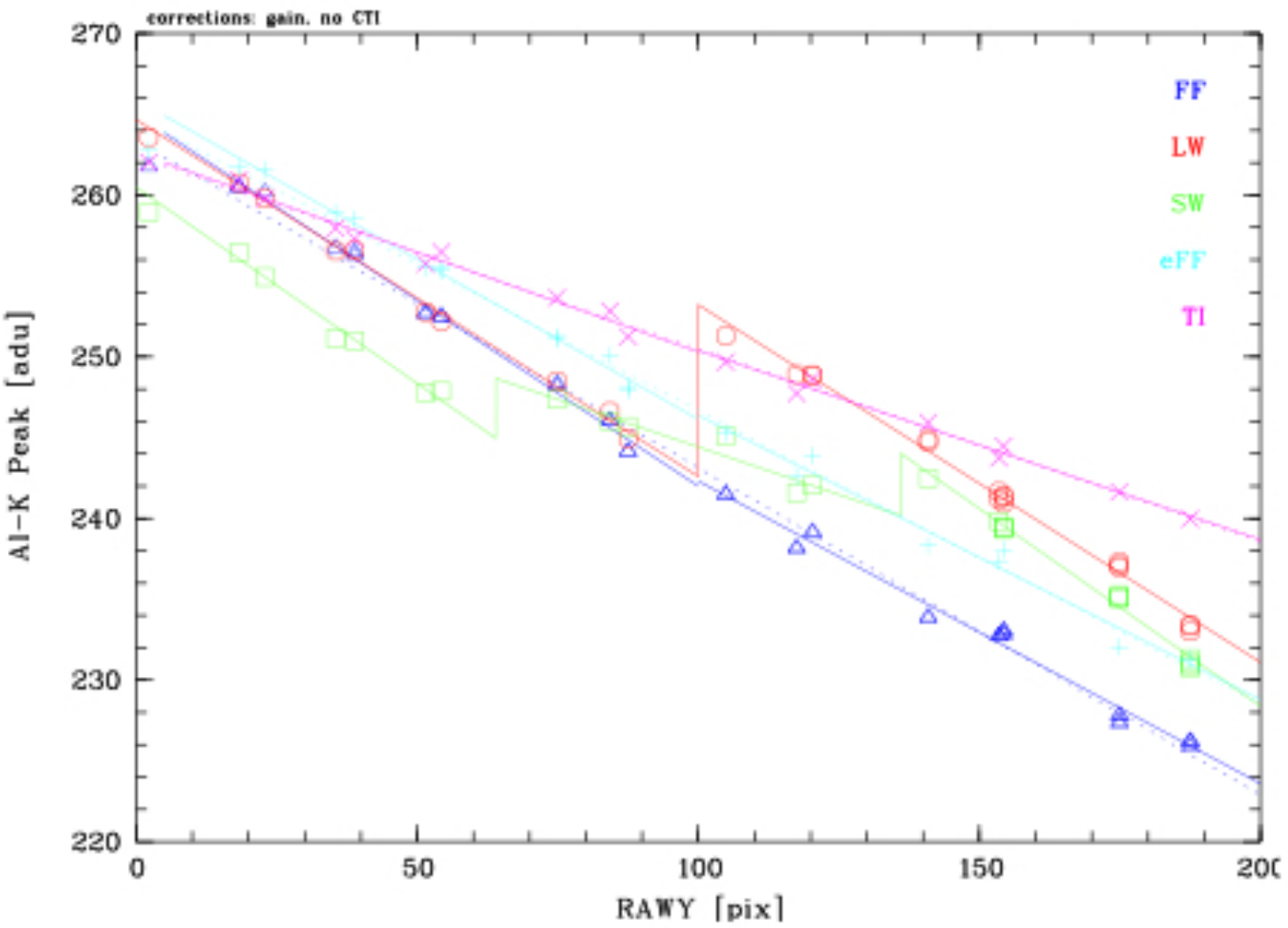
- 10 lines are shifted towards the anodes
- The integrated signal is read as a single line ("macropixels")
- During a frame time 200 lines are read (corresponding to 2000 "physical" lines)
- The original spatial information (`RAWX`, `RAWY`) is collapsed along the Y-axis
- Mode-dependent calibration elements:
  - CTI
  - PATTERN (i.e., grade) fraction as a function of energy
  - Noise

Mode-dependent CTI

CTI in Timing Mode calibrated on-flight using observations of the Crab Nebula.

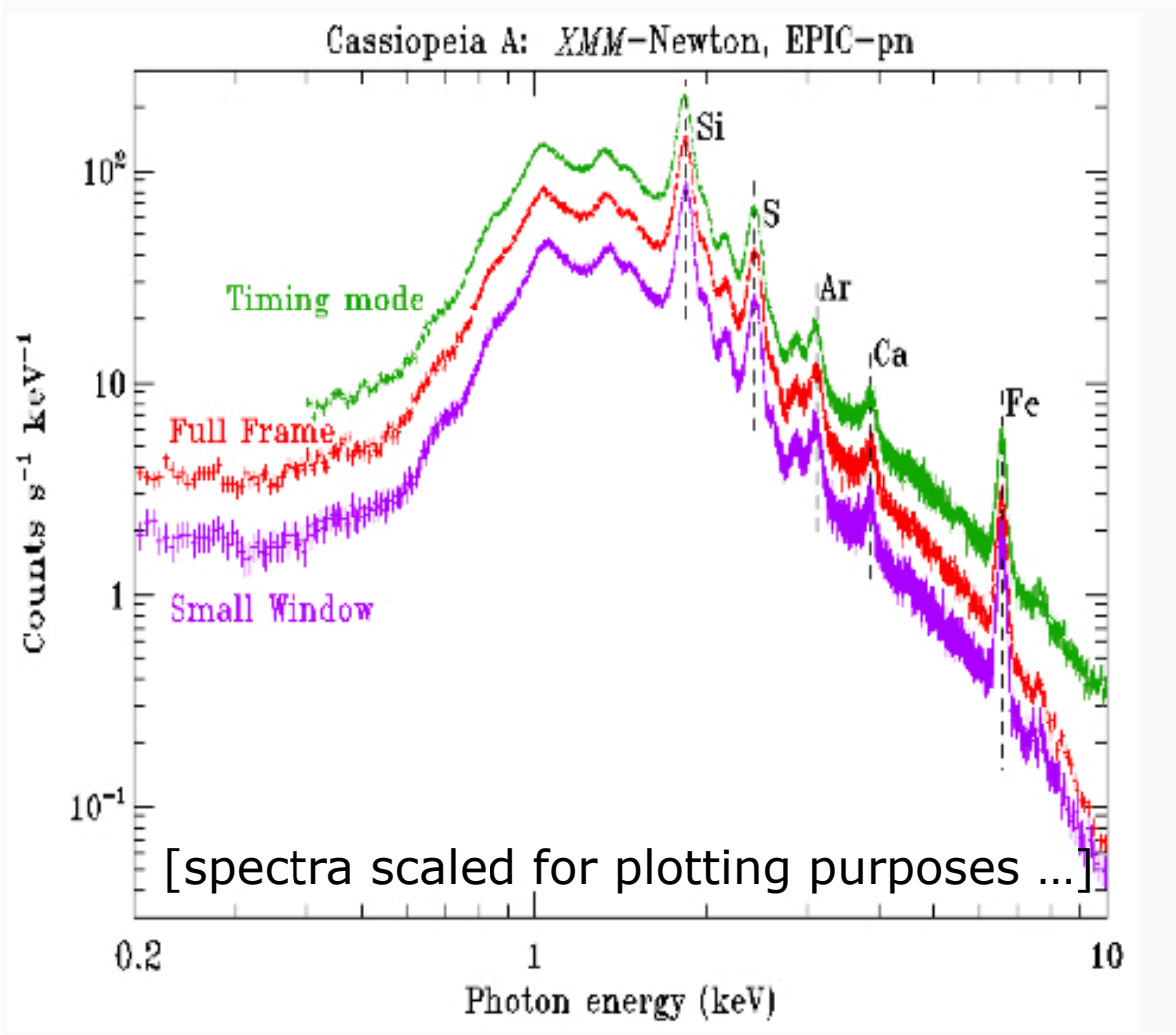
Calibration driven by smoothing residuals at the instrumental Si- and Au-edge.

CTI as en energy-dependent correction function relative to Full Frame



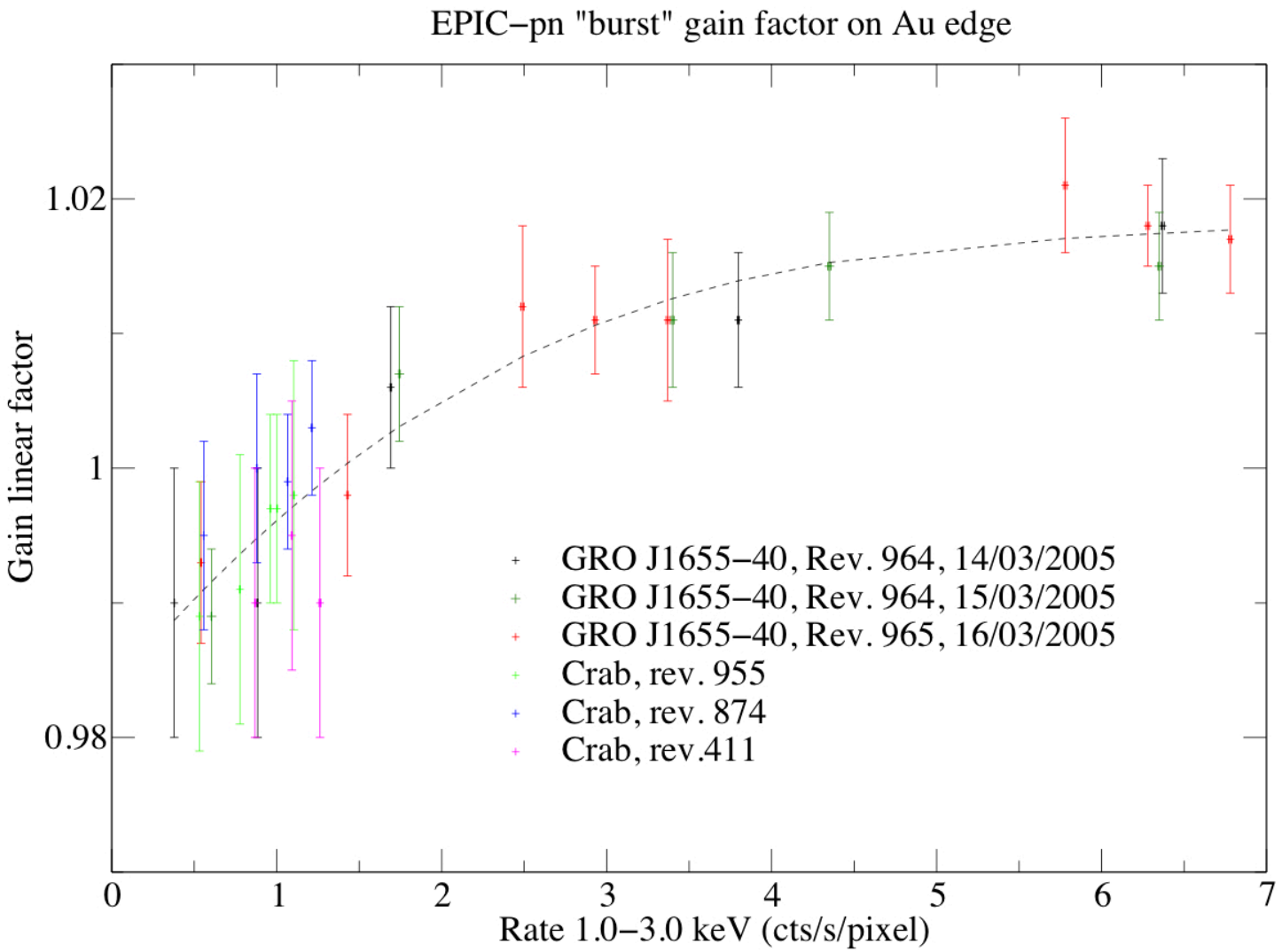
(Freyberg et al. 2005)

Early calibration results



(Cortesy M.E.Zavlin)

Early evidence for rate-dependent CTI



(Sala et al. 2005)

Implementation RDCTI

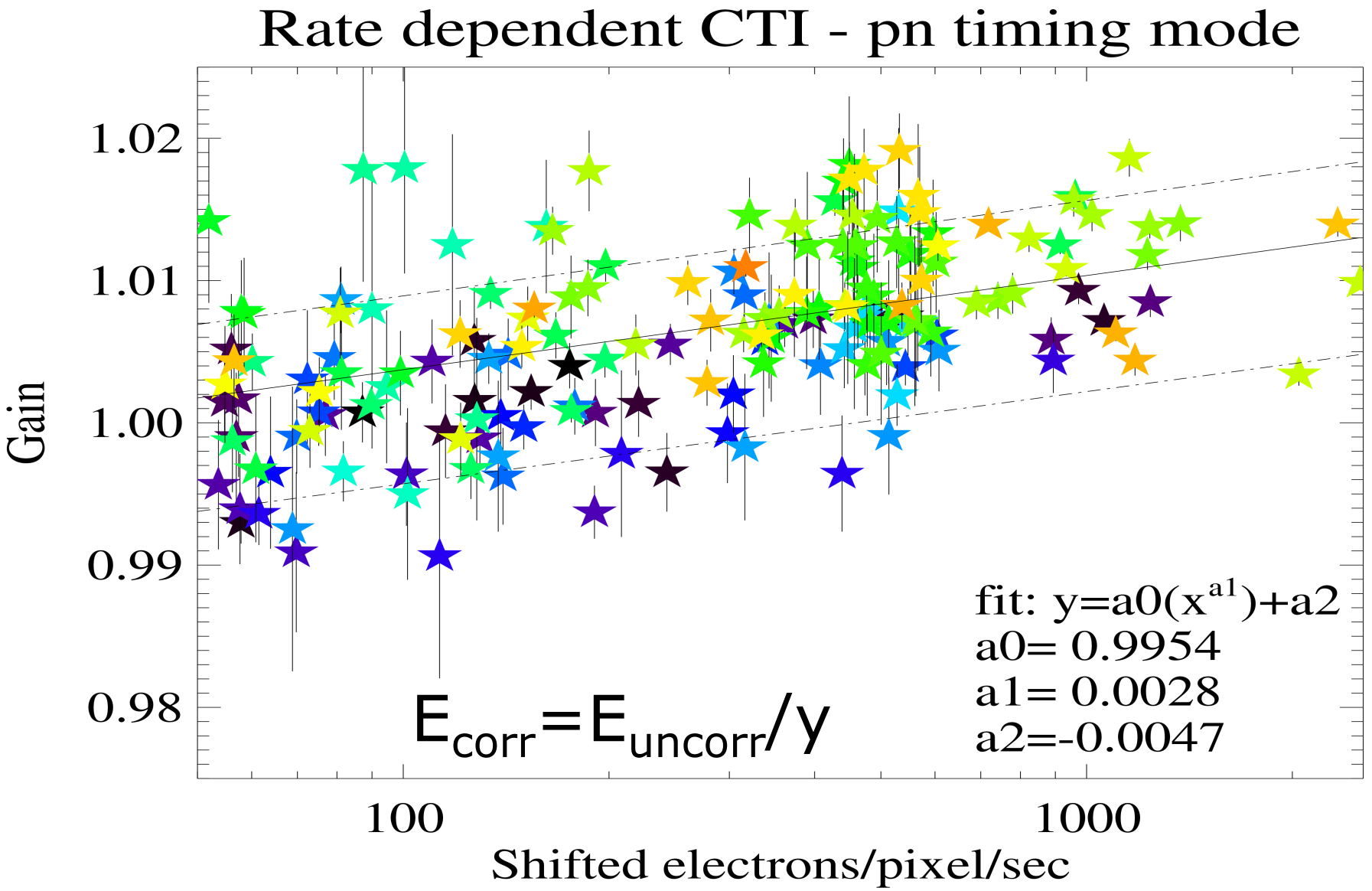
- a sample of 36 exposures in EPIC-pn Burst Mode and 42 exposures in EPIC-pn Timing Mode has been selected on the basis that the background-subtracted net source light curve was statistically consistent with being constant
- for each of the sample source, spectra have been extracted from each of the four columns surrounding the boresight column (this included)
- each spectrum was fit in the 1.5–3 keV energy band with a simple continuum model: power-law+black body corrected for photoelectric absorption. A constant gain shift G_{corr} was applied to the spectral model (through the `gain` function in XSPEC) and calculated for each spectrum under the condition to minimise the χ^2
- for each spectrum, the number of equivalent shifted electrons N_e was calculated, according to the following formula:

$$N_e = \frac{\Sigma_{i=1}^{N_p} E_i}{N_{pixels} \times T_{exp} \times 3.6}$$

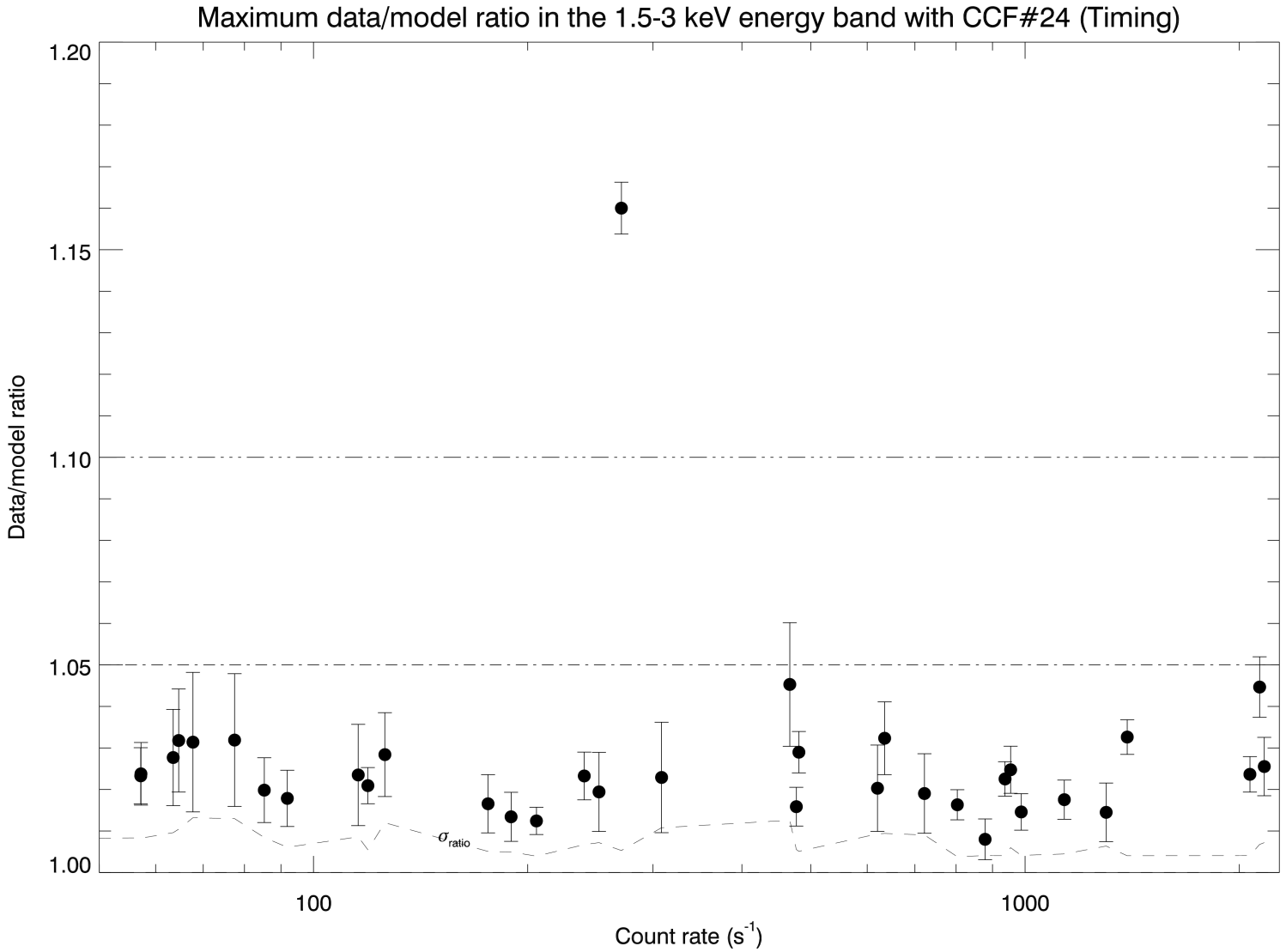
where E_i is the energy of the i-th photon, N_{pixels} is the number of pixels of the column whence each spectrum was extracted, N_p is the number of detected photons, T_{exp} is the exposure time and the factor 3.6 (in eV) represents the energy required to produce an electron-hole pair.

(Kirsch 2006; Guainazzi et al. 2008)

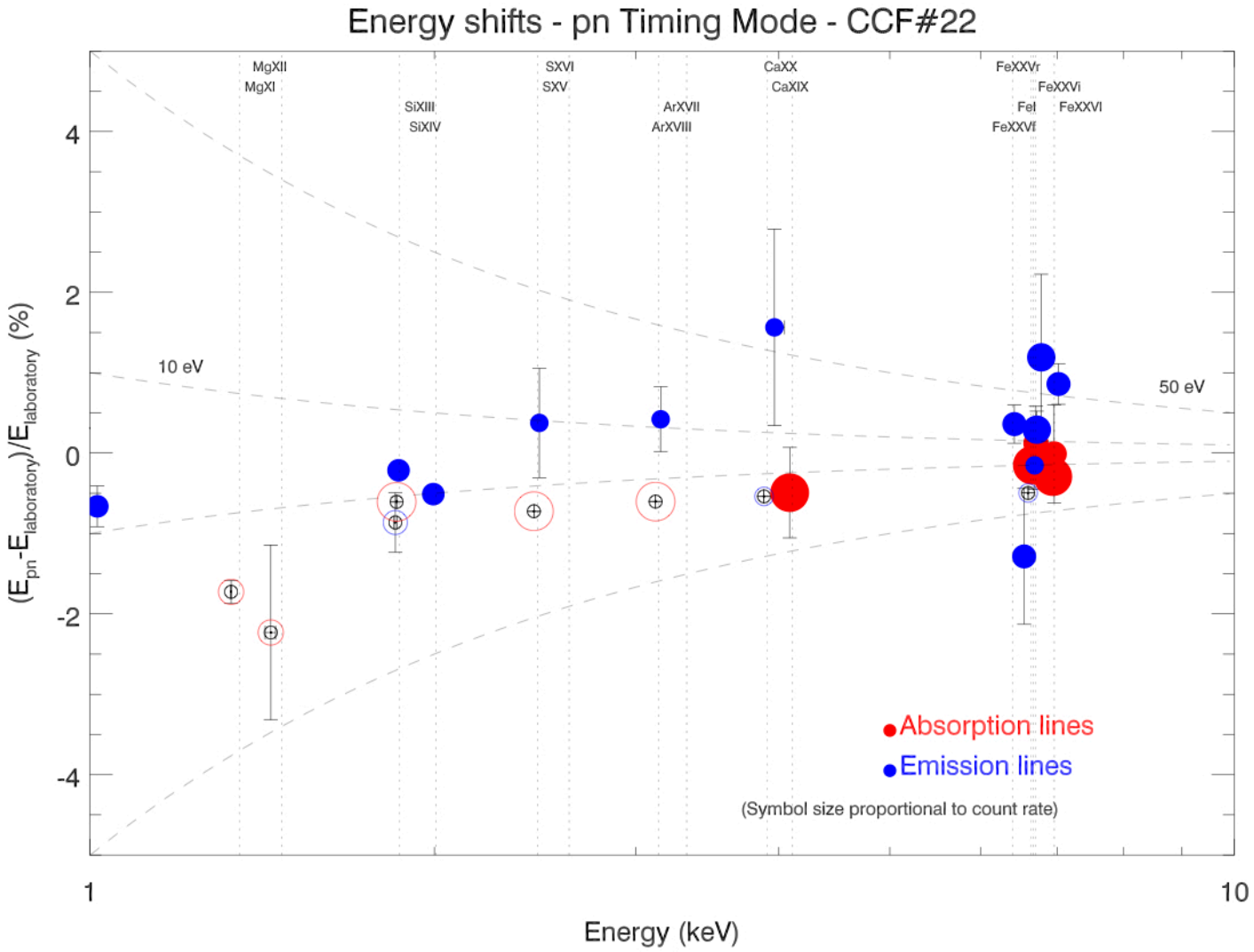
Results RDCTI



Validation: instrumental edges



Validation: spectral accuracy – I.



Validation spectral accuracy – II.

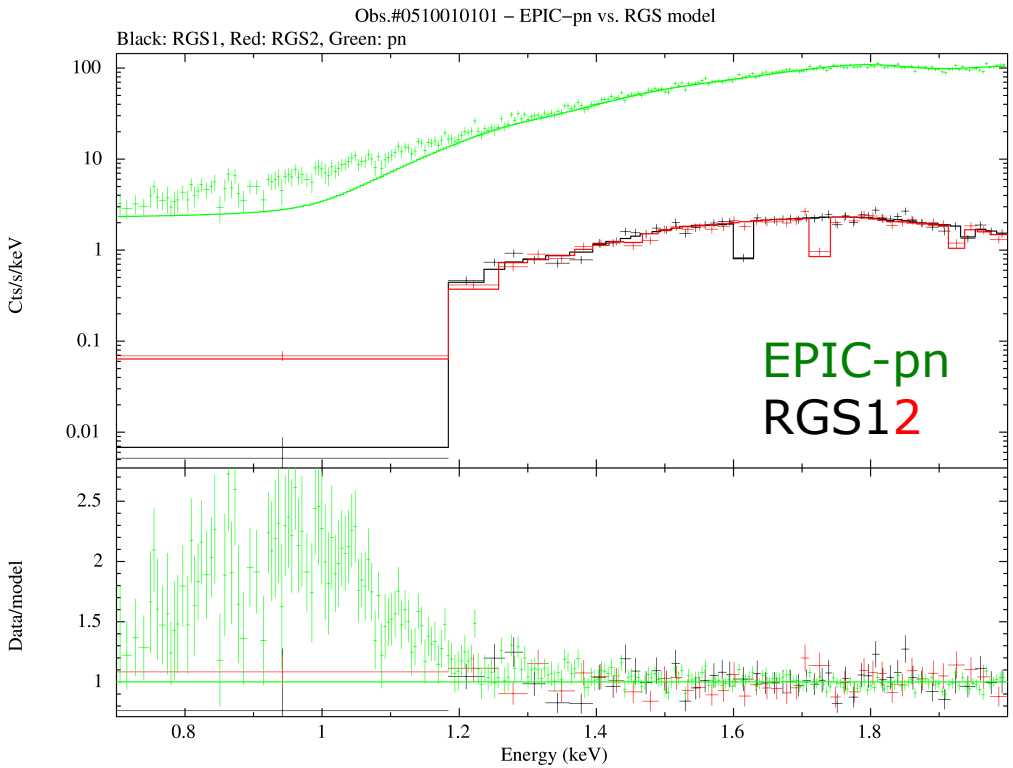
Table 1: Iron line measurements in EPIC-pn Timing Mode exposures

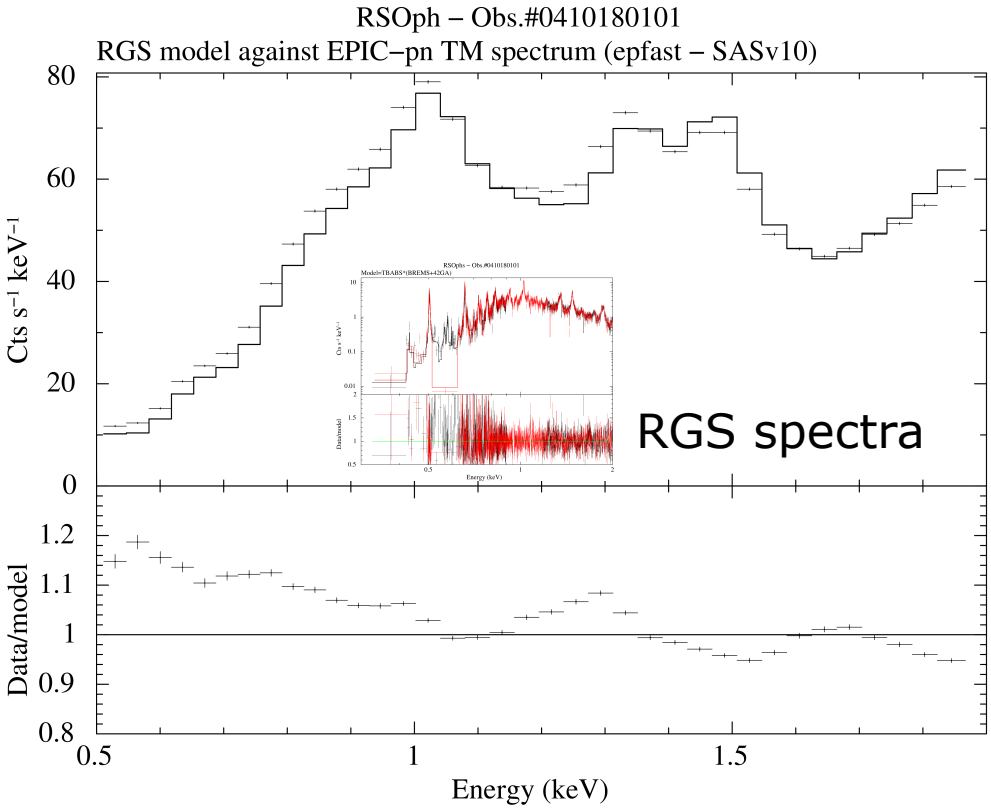
Obs.#	Source	E_c (keV)	Identification
0036140201	X1323-619	$6.720\pm^{0.016}_{0.009}{}^{a}$	Fe xxv (r)
0085290301	4U1915-05	$6.70\pm^{0.04}_{0.02}{}^{a}$	Fe xxv (r)
0085290301	4U1915-05	$6.96\pm^{0.03}_{0.04}{}^{a}$	Fe xxvi
0111230101	X1822-371	$6.432\pm^{0.010}_{0.015}{}^{b}$	Fe i
0111230101	X1822-371	$6.55\pm^{0.06}_{0.05}{}^{b}$	Fe xxv (f) (?)
0111230101	X1822-371	$7.020\pm^{0.016}_{0.018}{}^{b}$	Fe xxvi (?)
0122340901	GX13+1	$6.660\pm^{0.010}_{0.013}{}^{a}$	Fe xxv (i/f)
0111390301	UX Arietis	$6.690\pm^{0.014}_{0.020}{}^{b}$	Fe xxv (r)
0137550301	CasA	6.603 ± 0.010^{b}	Fe xxv (f)
0405510301	XB1254-69	6.78 ± 0.07^{a}	Fe xxv (r)

Soft excess in obscured objects

X-ray obscured binary

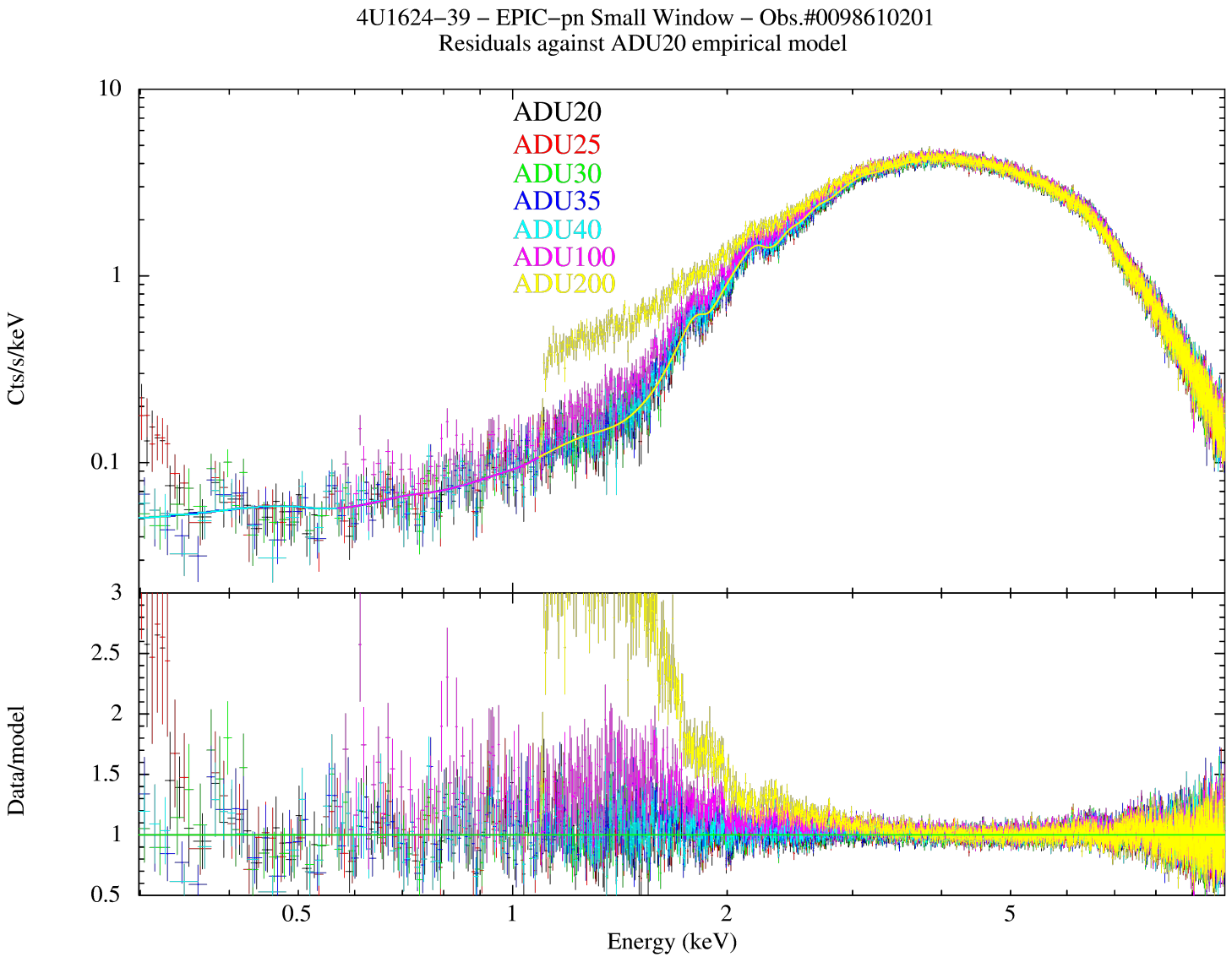
RSOph in Super-Soft state



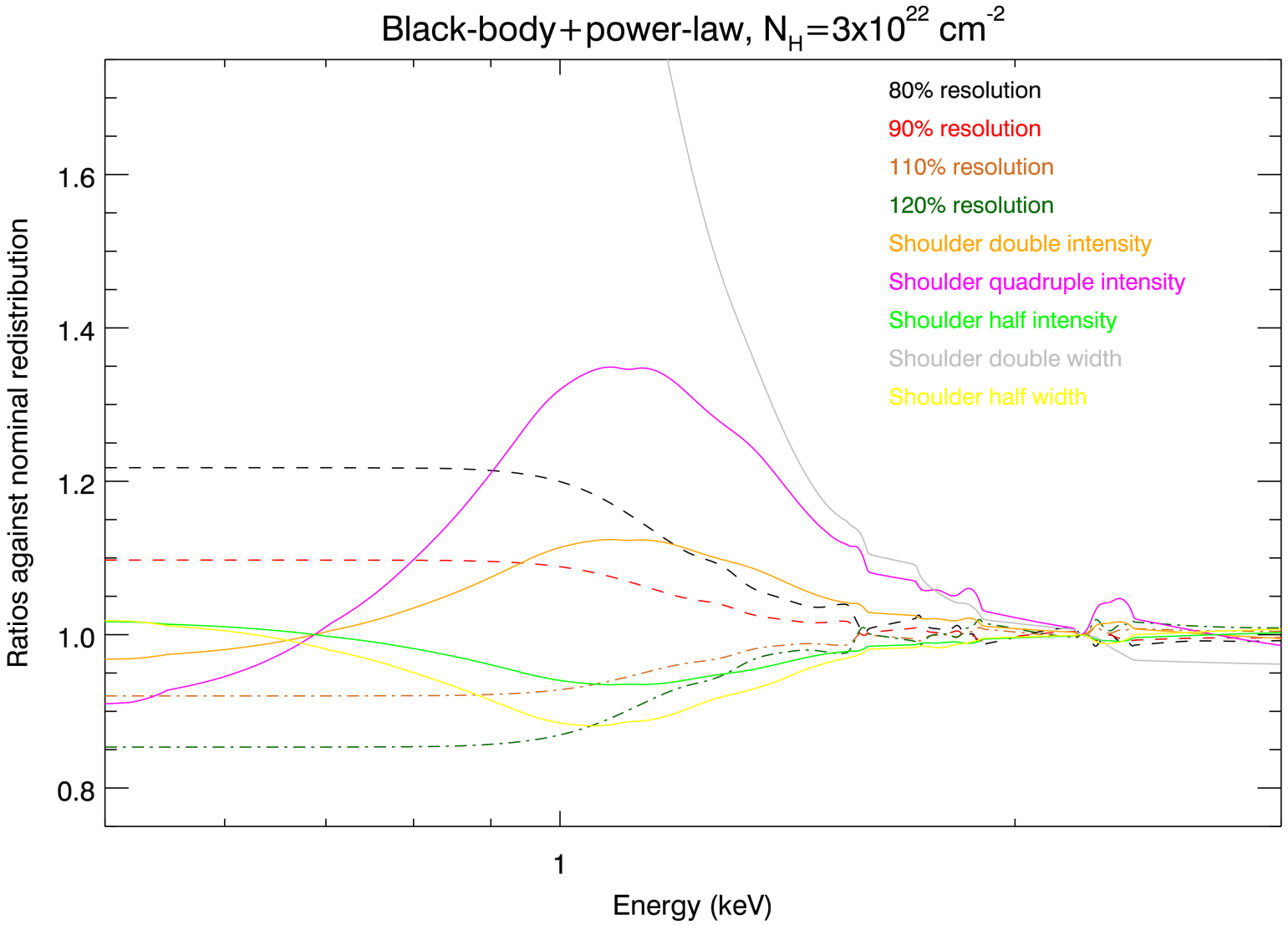


Residuals against the best-fit RGS model

Threshold effect?

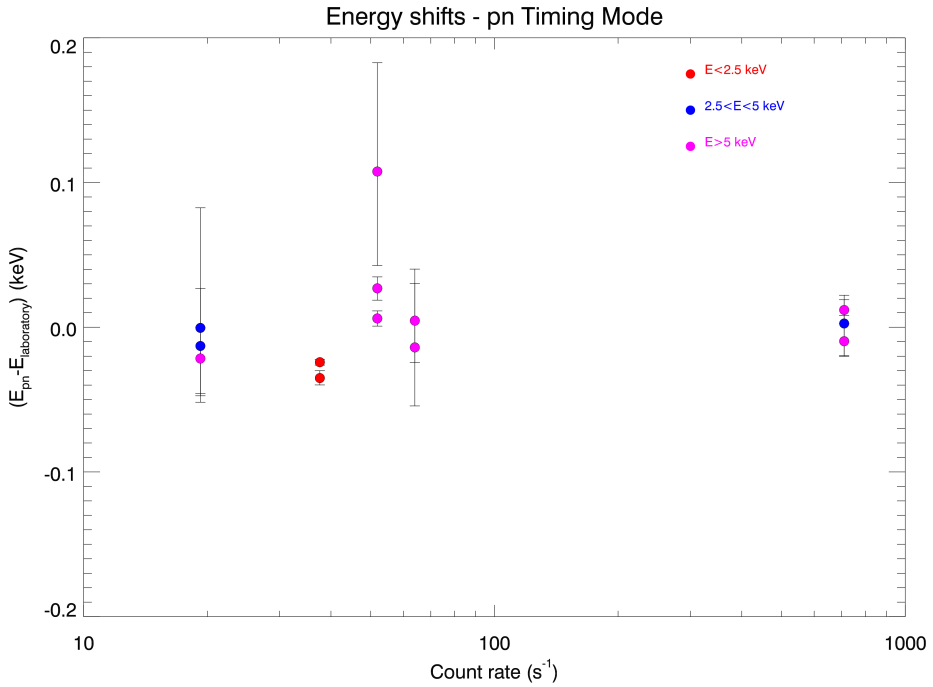


Resolution effect?

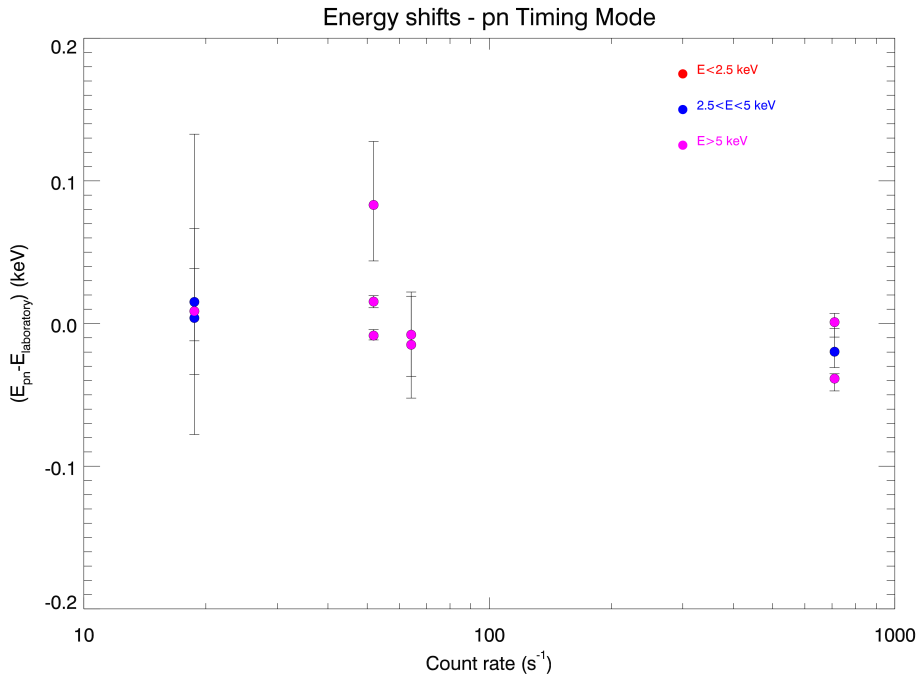


RDCTI does not work at 6 keV

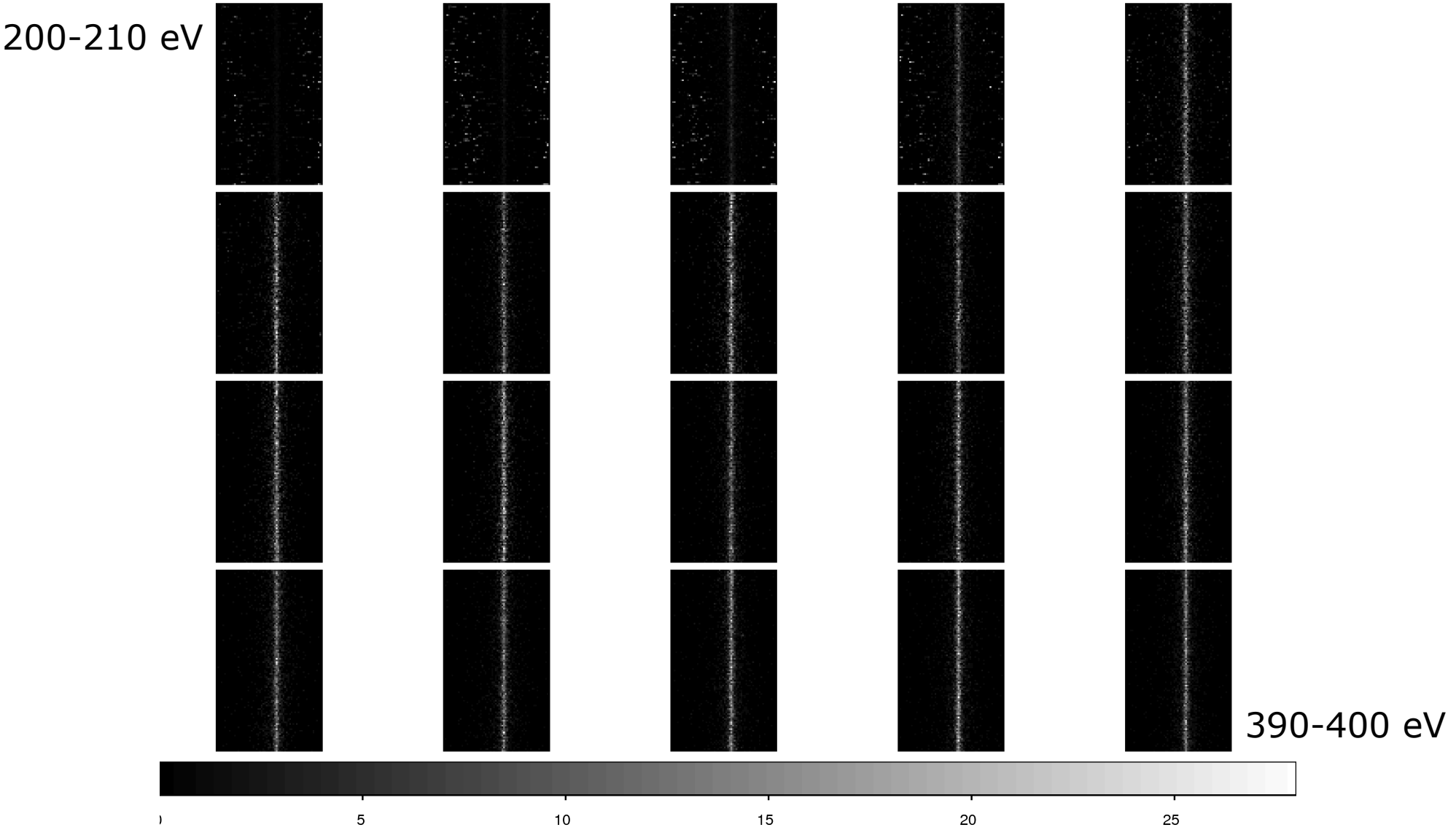
Without RDCTI



With RDCTI

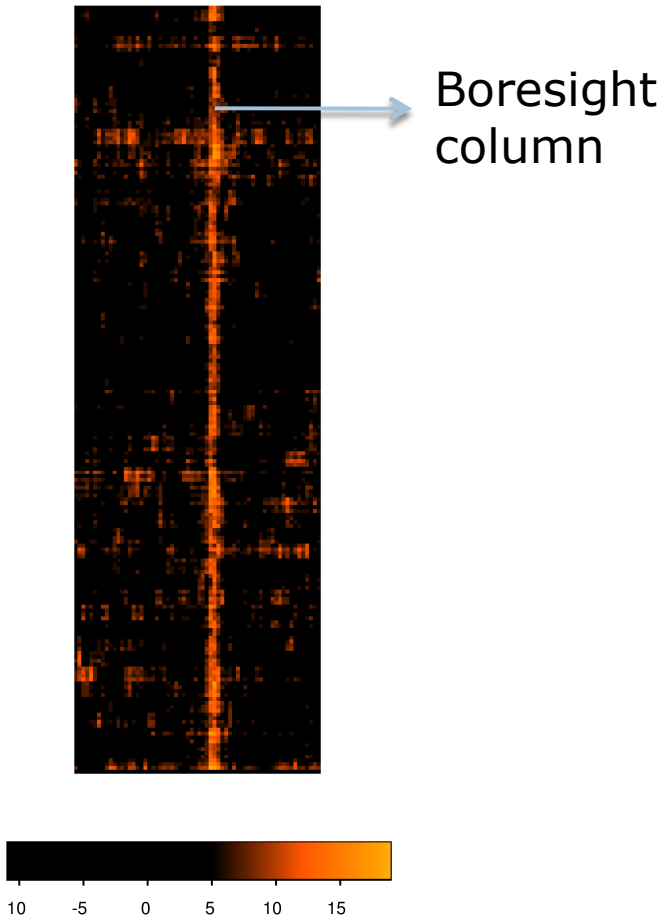


X-ray loading

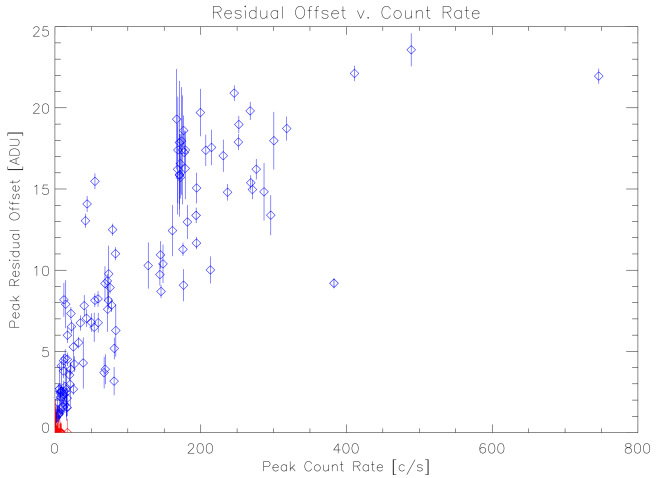


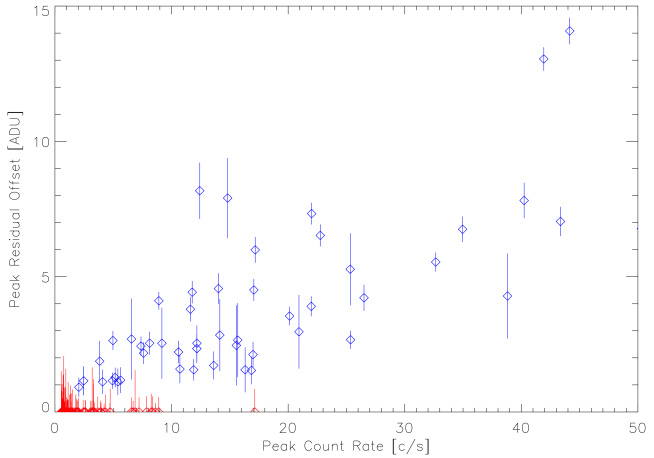
Rate-dependent X-ray loading

Offset map in Timing Mode



Rate-dependent X-ray loading

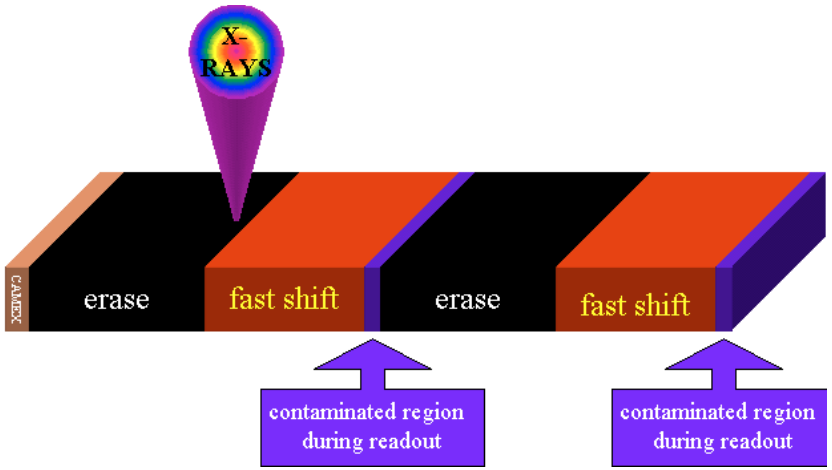




(Courtesy M.Smith)

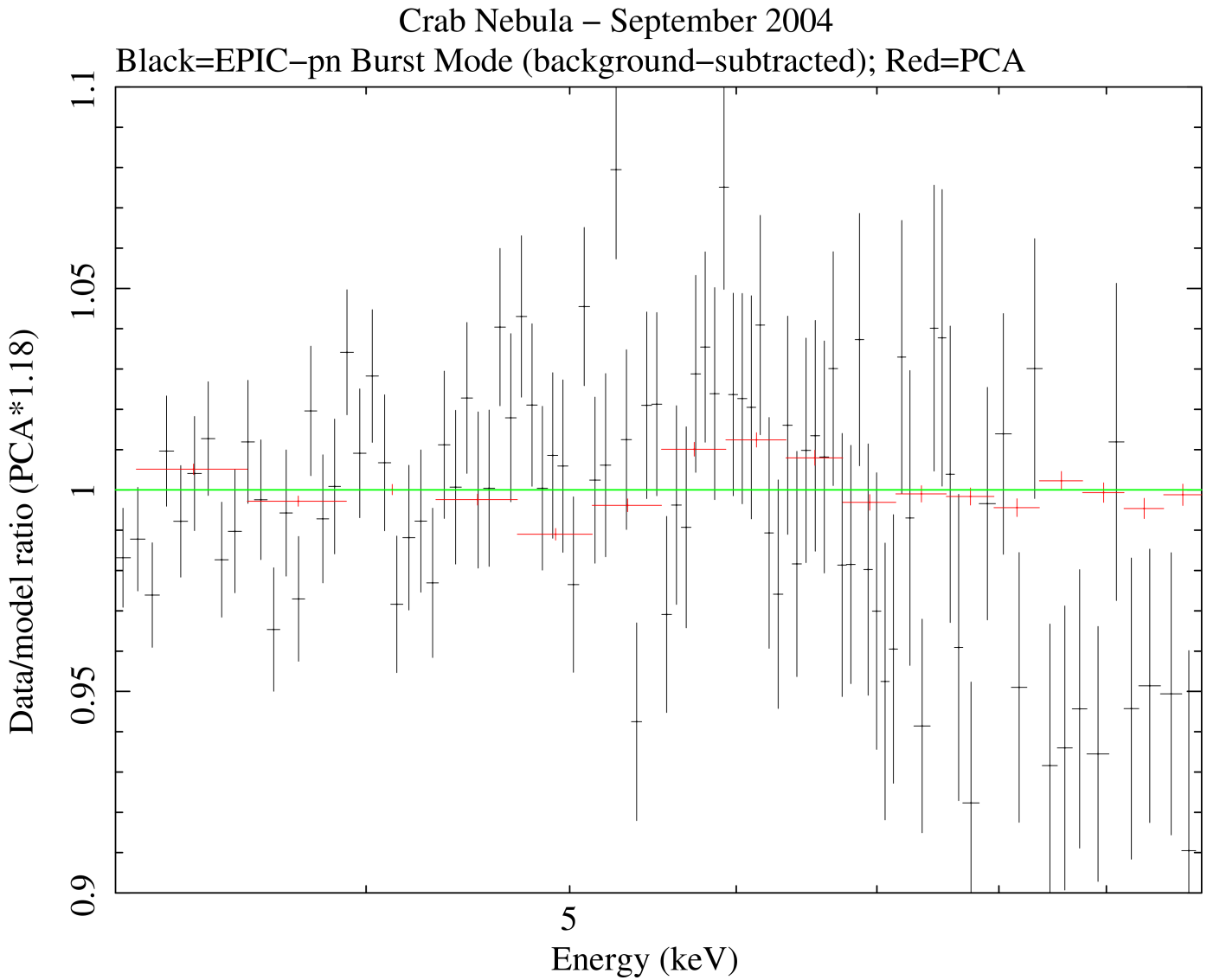
Burst Mode: how it works

- During 14.4 μs 200 lines are fast-shifted while accumulating photons from the source
- The stored information is read, removing the first 20 lines which are contaminated from the source
- The CCD is then erase with a fast shift of 200 lines
- A new cycle starts



(Kirsch et al. 2006)

Burst Mode versus RXTE/PCA: I.



X-ray loading in Burst Mode