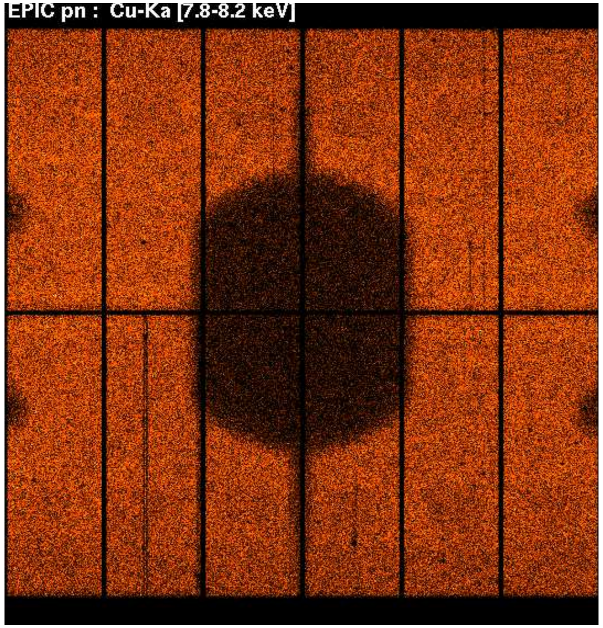
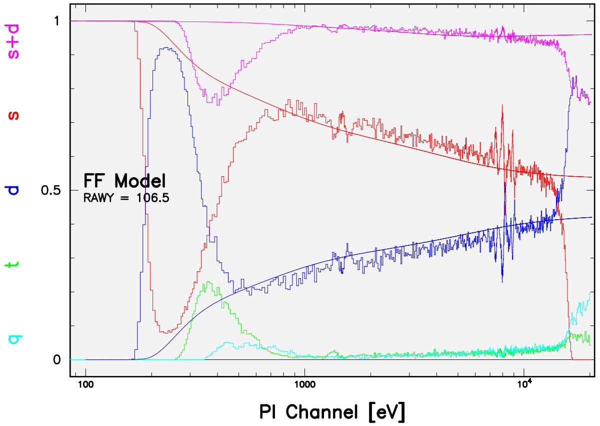
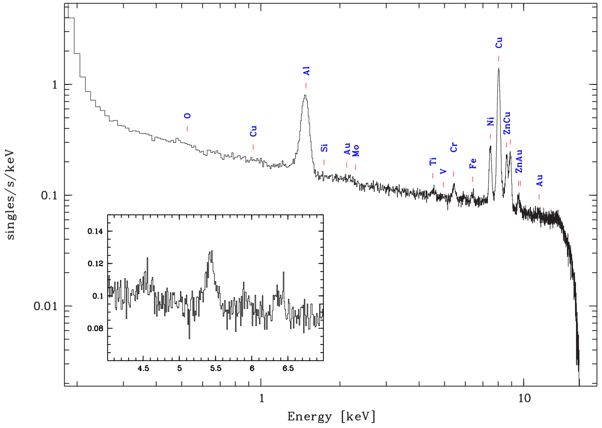
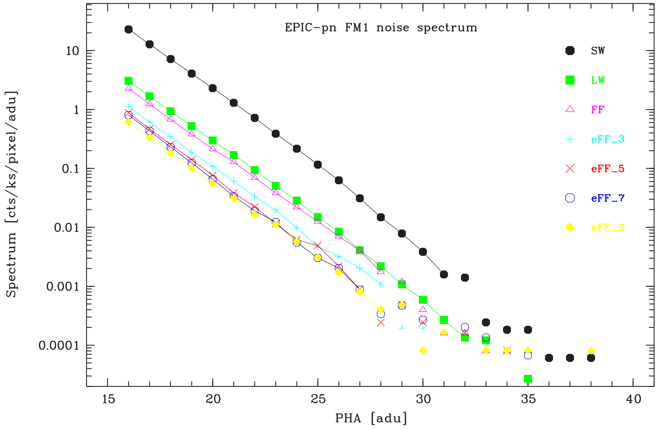
EPIC-pn background: general remarks









What is “background” ?

Background ...

is everything ...

but the target

Therefore there is a lot of background to be considered!

EPIC-pn background items

- particle induced background
- detector (read-out) noise
- noisy pixels and columns
- soft proton background
- out-of-time events
- cosmic X-ray background
- solar wind X-ray background
- single reflections

EPIC background workshop in Milano (6-8 Oct 2003)

The Menu: what is it all about

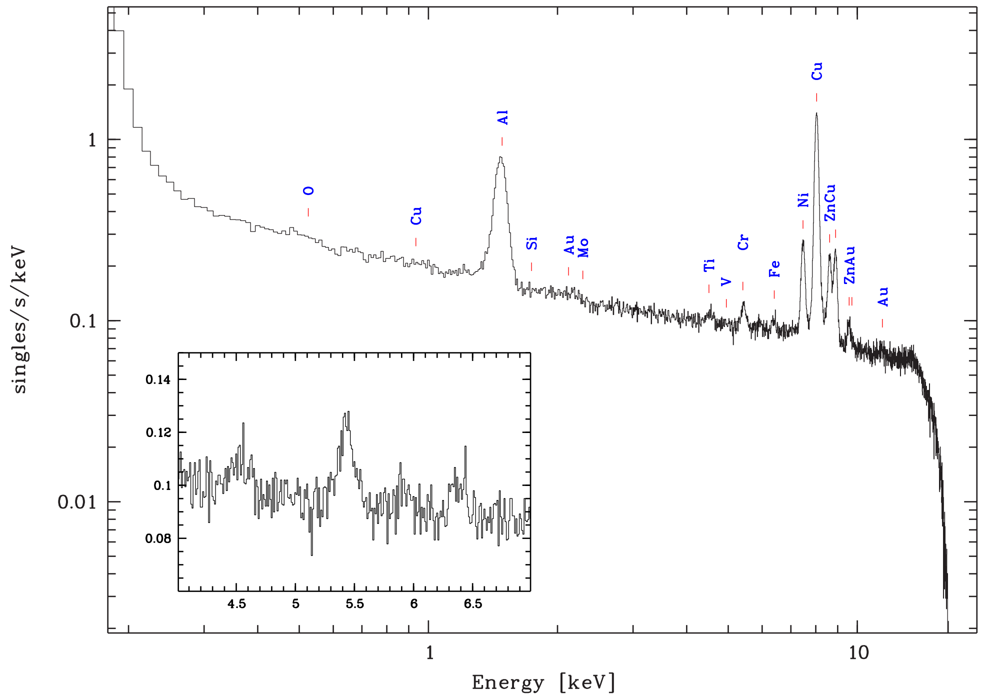
- particle induced background

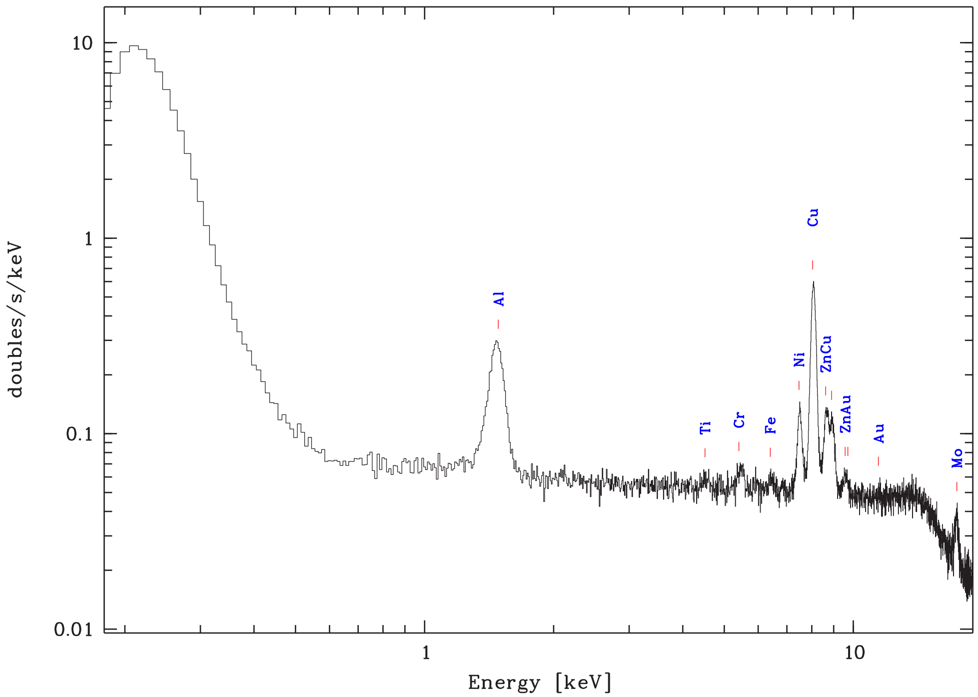
- detector noise

- soft proton background
- out-of-time events

- cosmic X-ray background

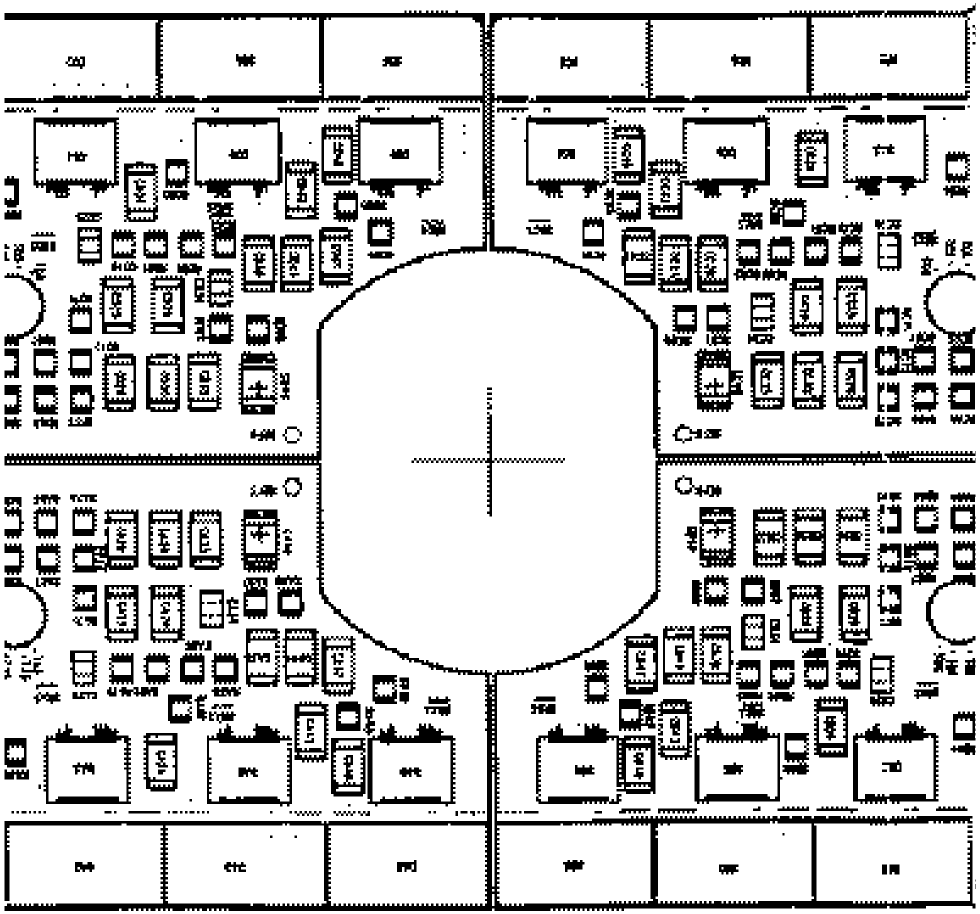
EPIC-pn: Closed filter observation

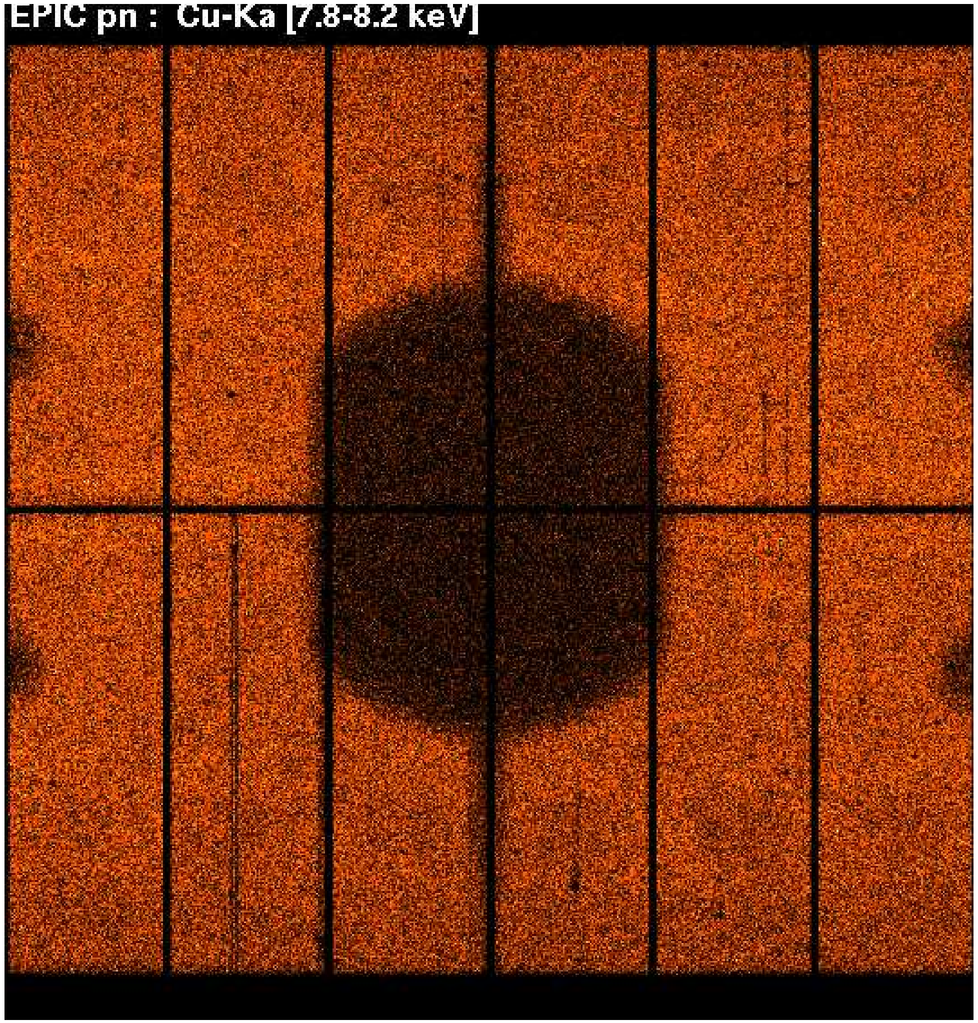




singles, doubles, 313 ks, FF mode
Al-K, Ni-K, Cu-K, Zn-K, Mo-K
Ti-K, Cr-K, Fe-K, Au-L
Mo-K only in doubles, line position better than 0.3%
background higher than in MOS (factor 2-4)
could “easily” be reduced (factor ~ 5, graded shielding)

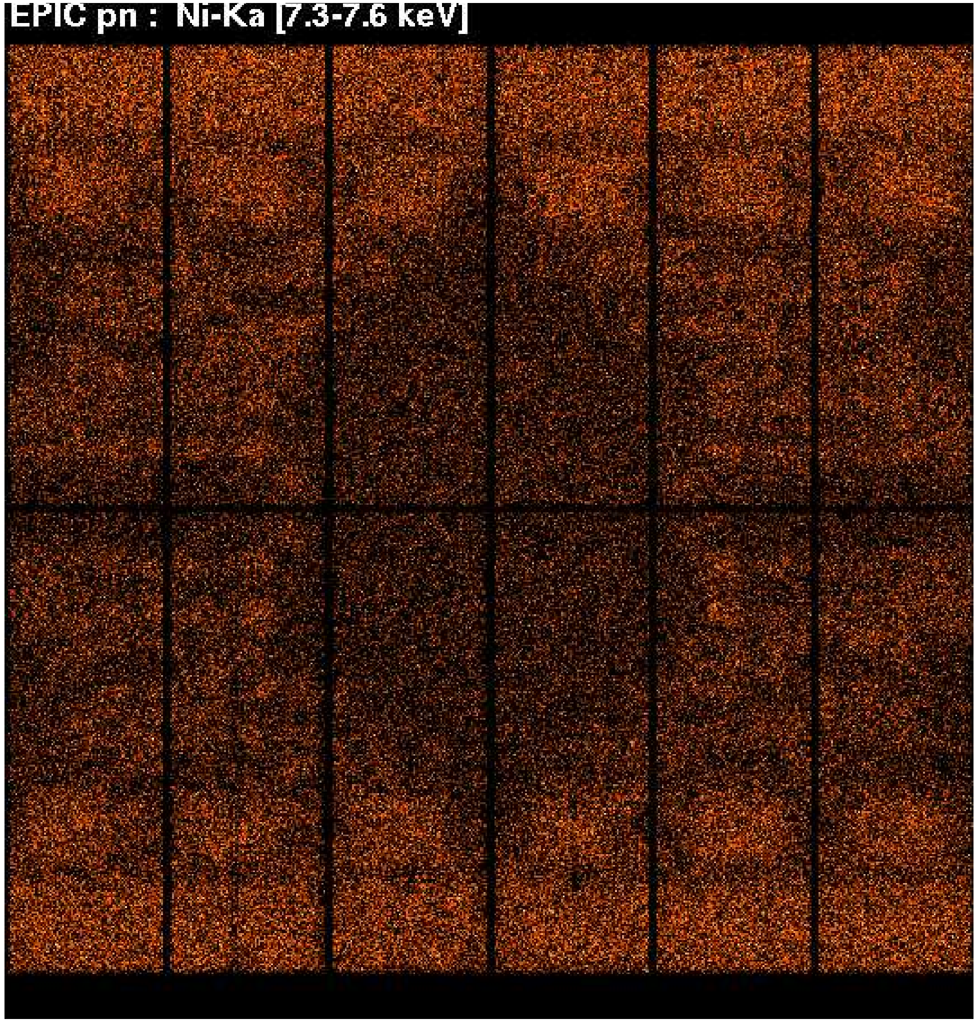
EPIC-pn: particle induced background

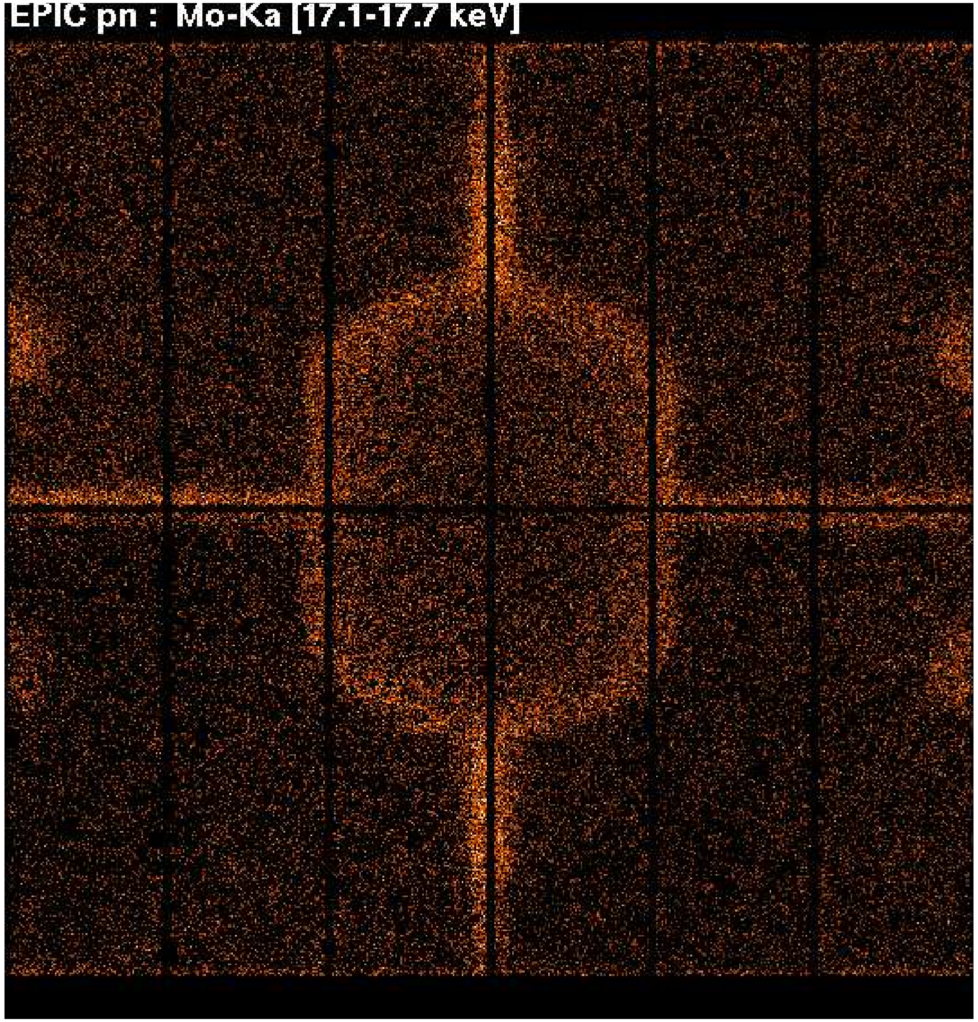




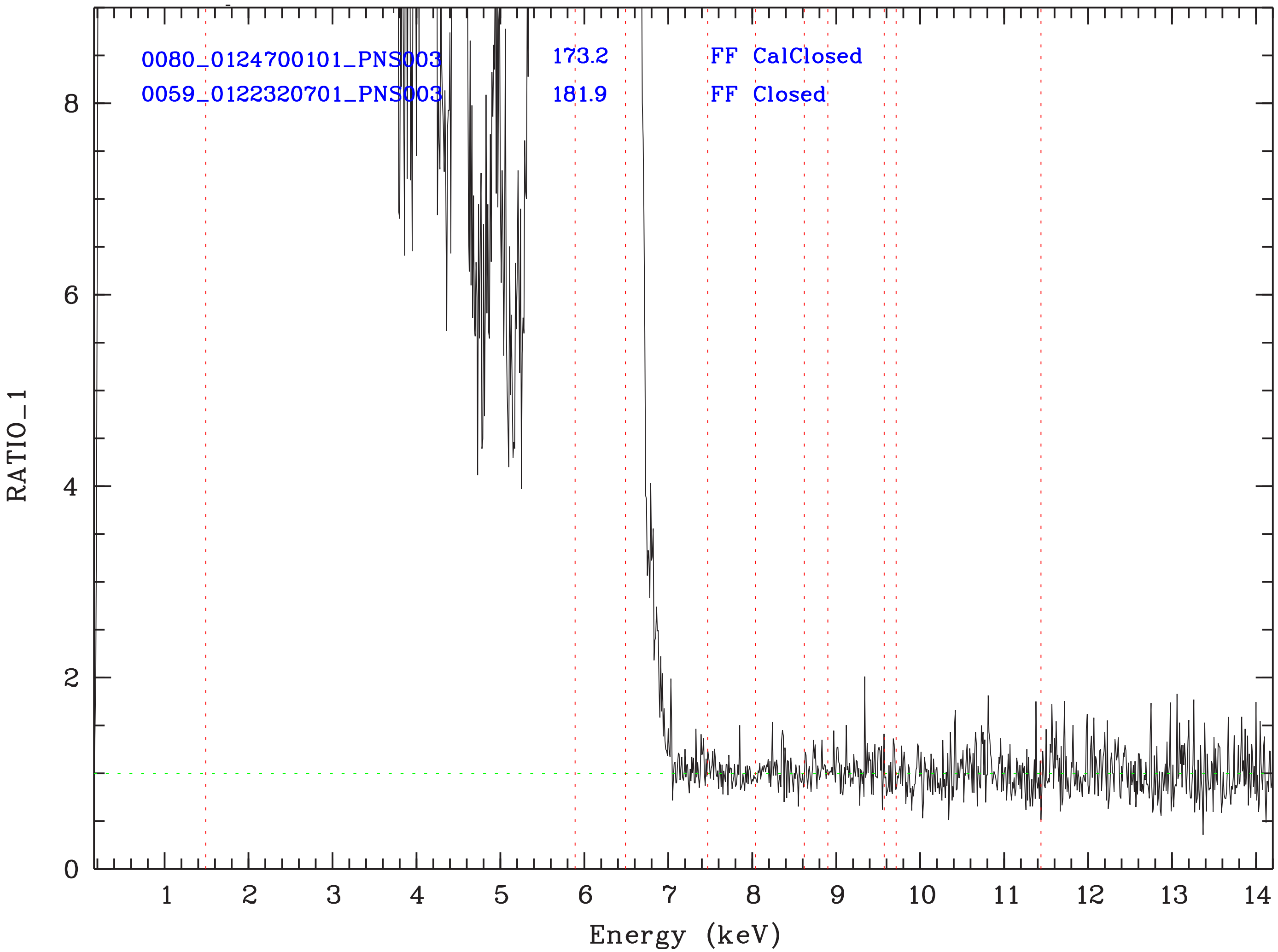
Printed circuit board: Cu + Mo (Ni + Au)

EPIC-pn: particle induced background

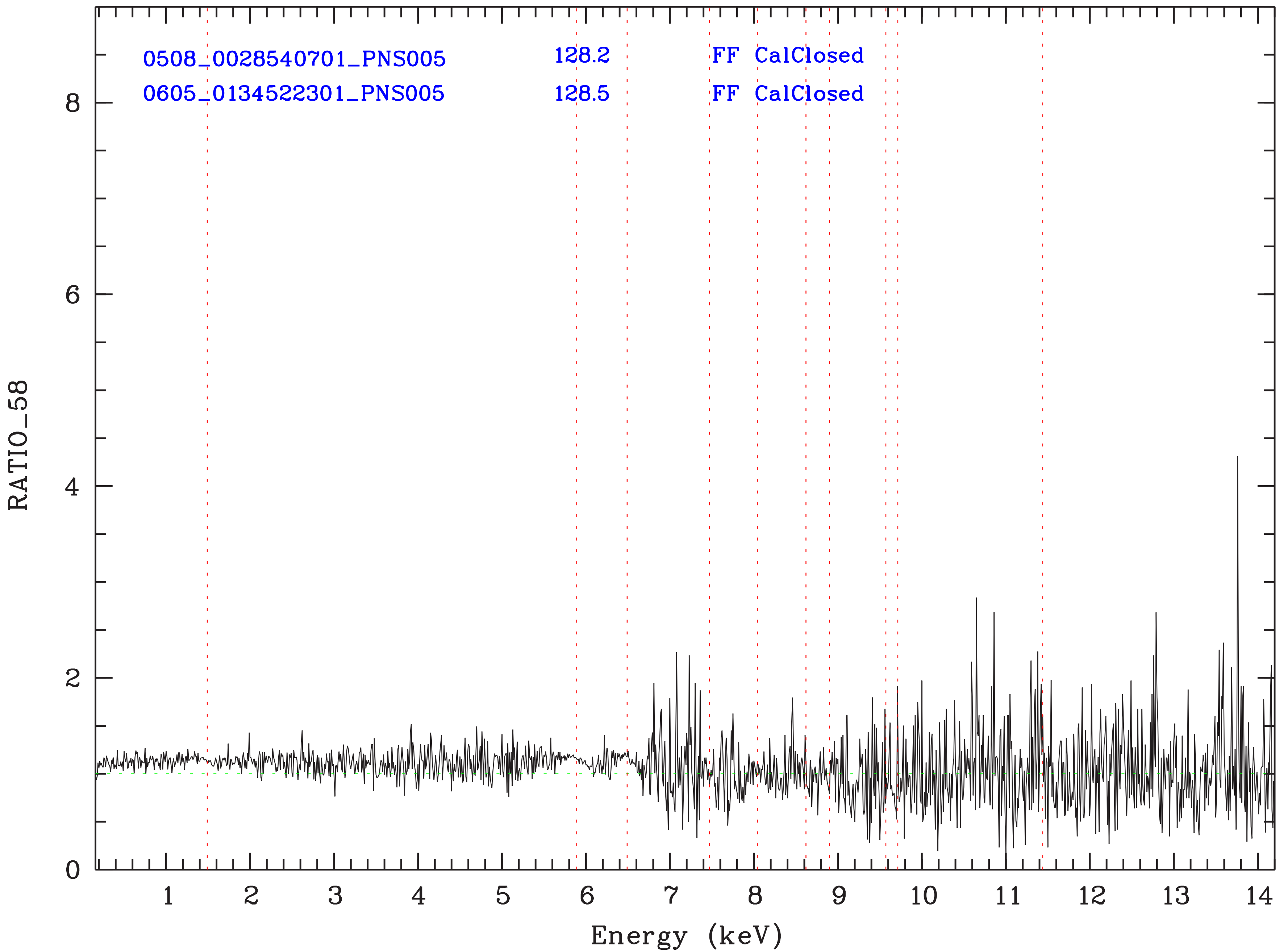


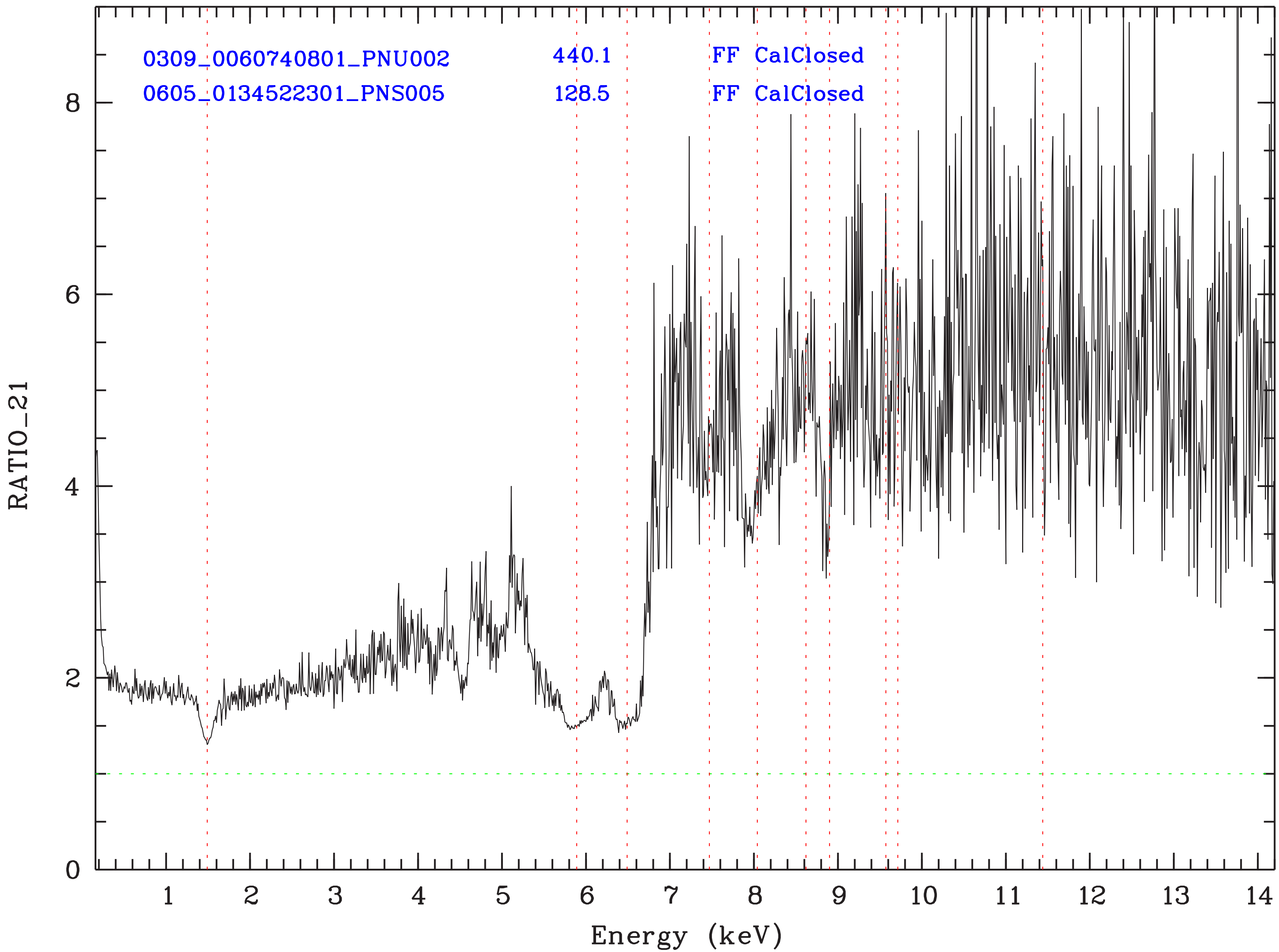


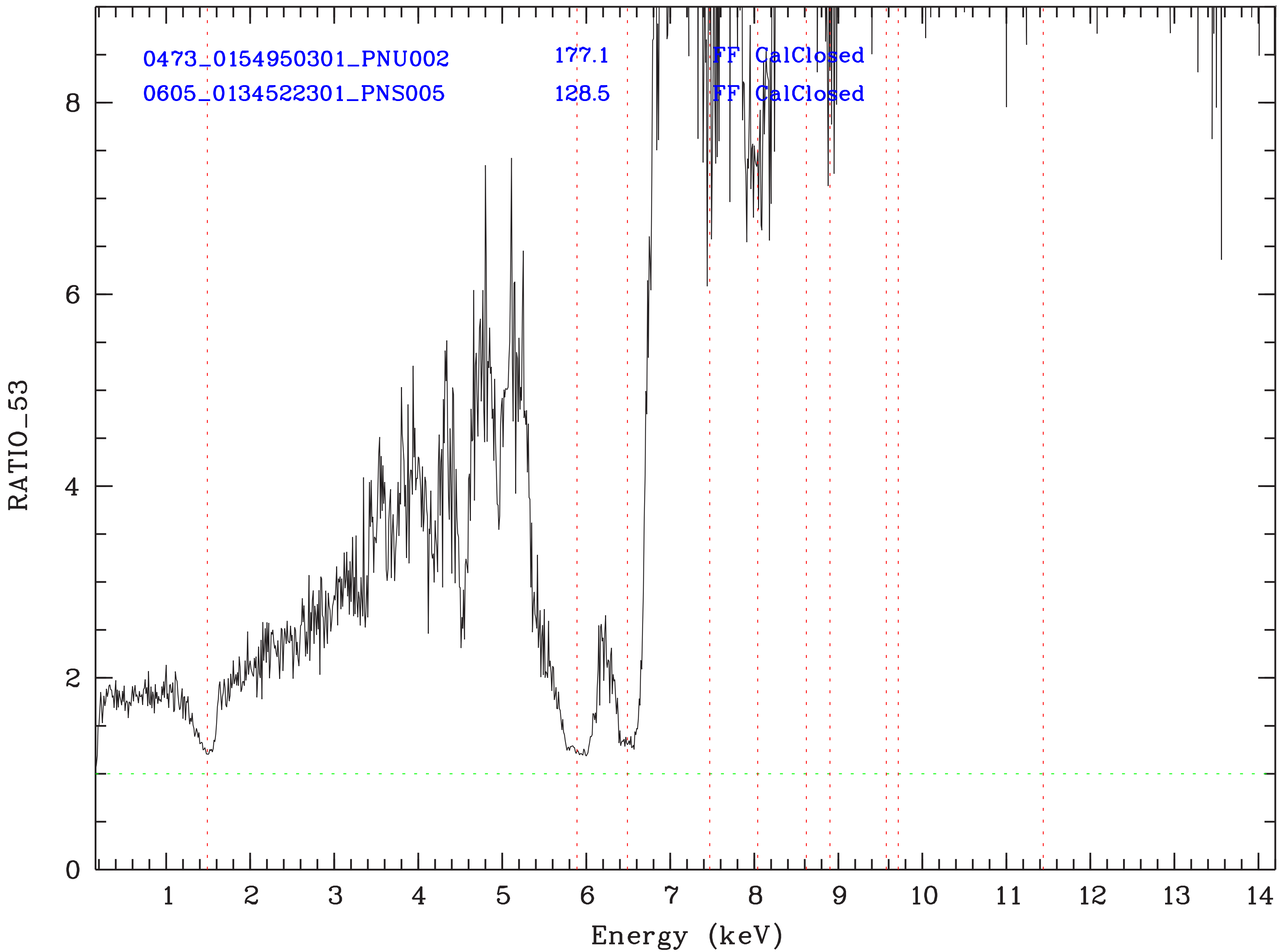
Ratio of spectra: 10 eV bins

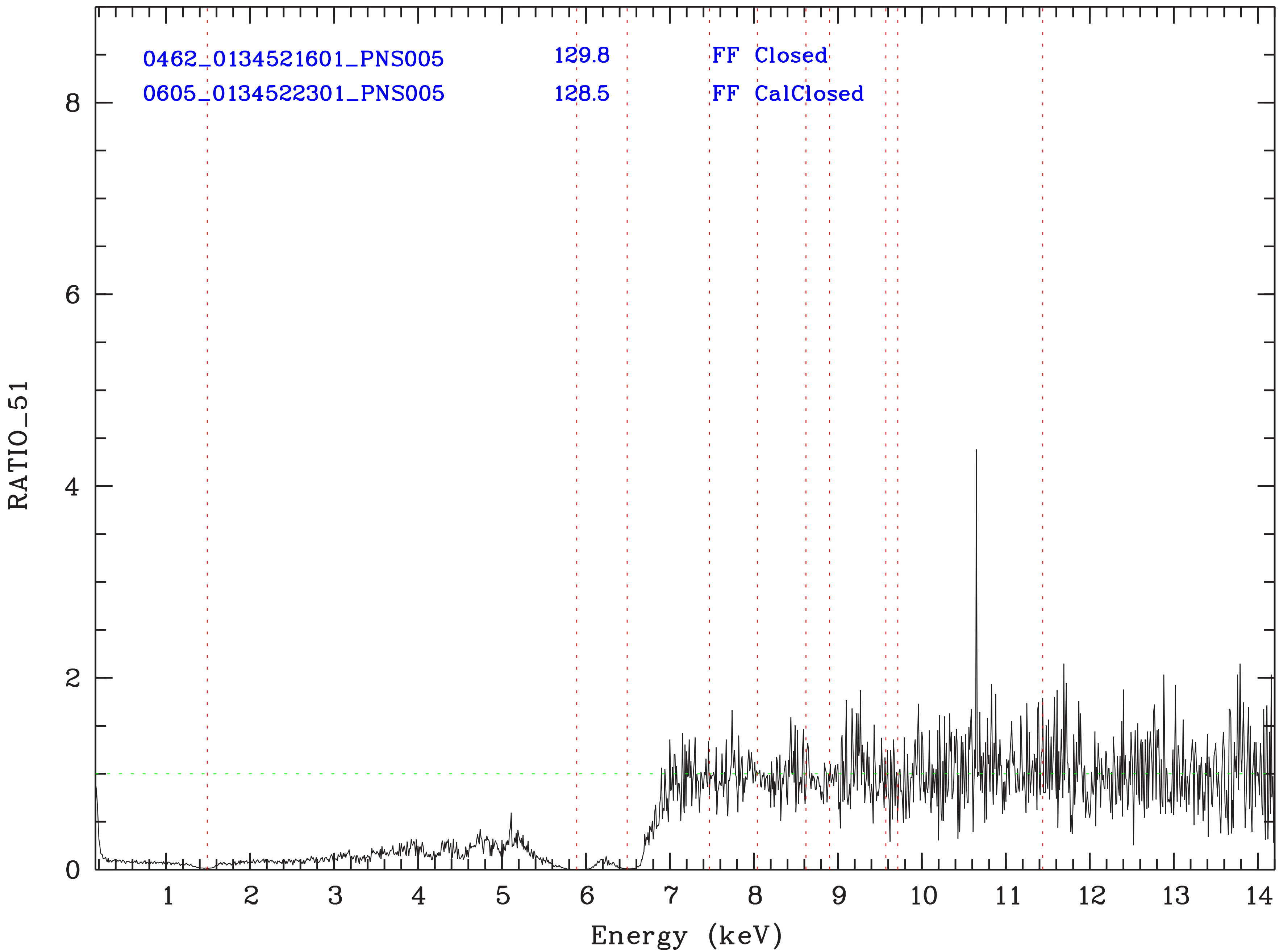


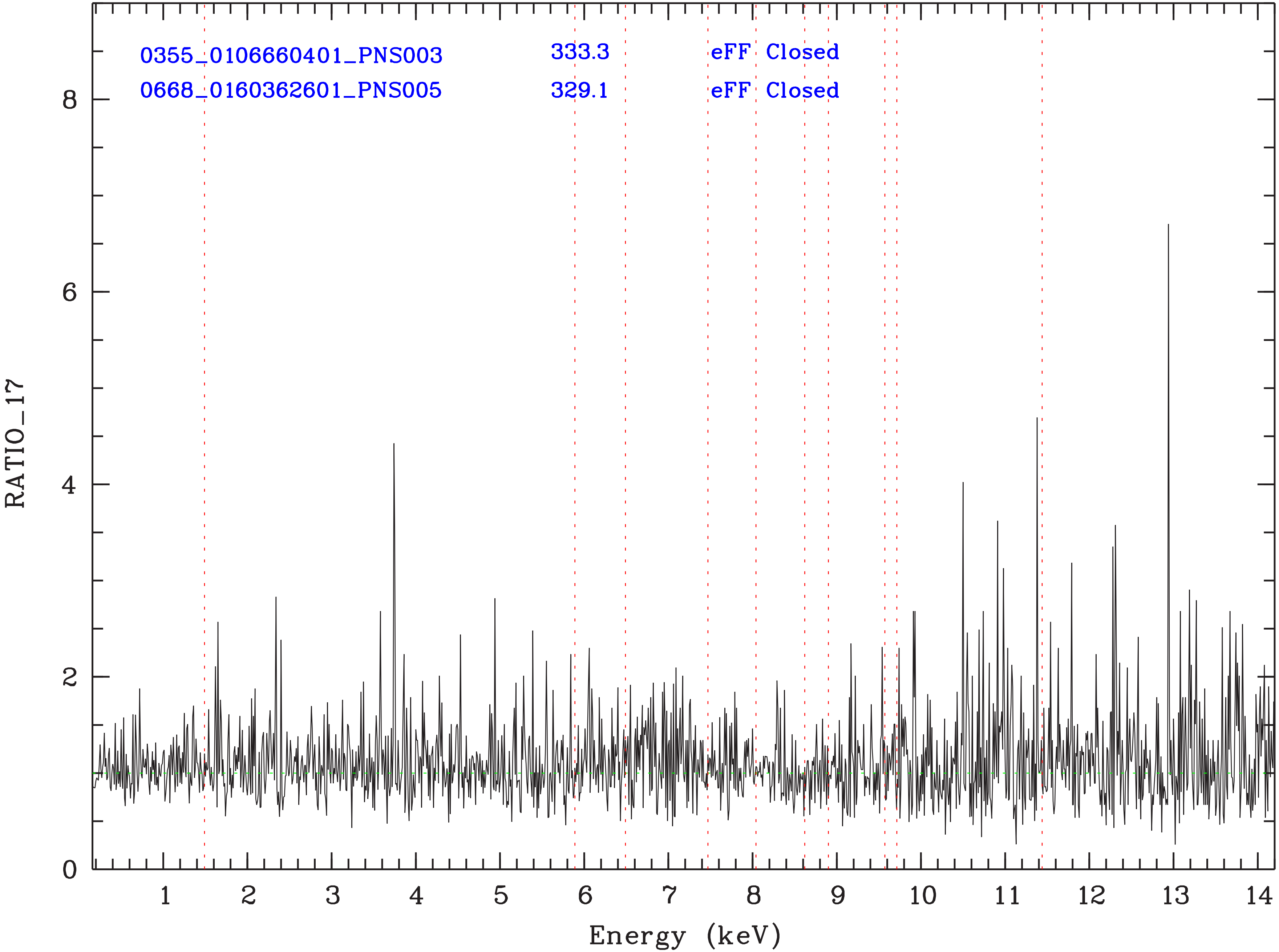
CalClosed (Rev.80) / Closed (Rev.59): cts/s/10eV
identical above 7 keV

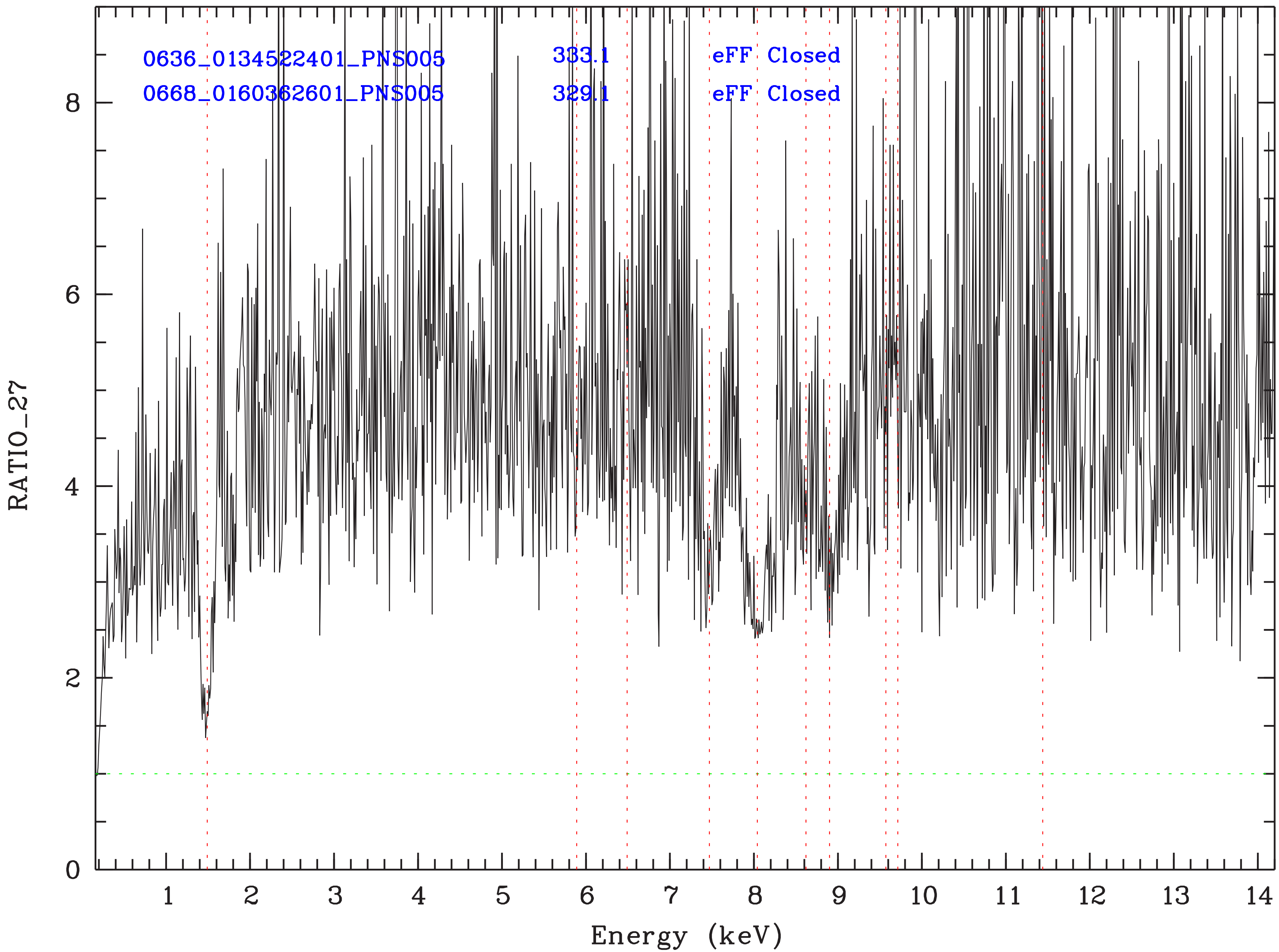

0508_0028540701_PNS005
128.2
FF CalClosed
0605_0134522301_PNS005
128.5
FF CalClosed
RATIO_58
Energy (keV)
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14

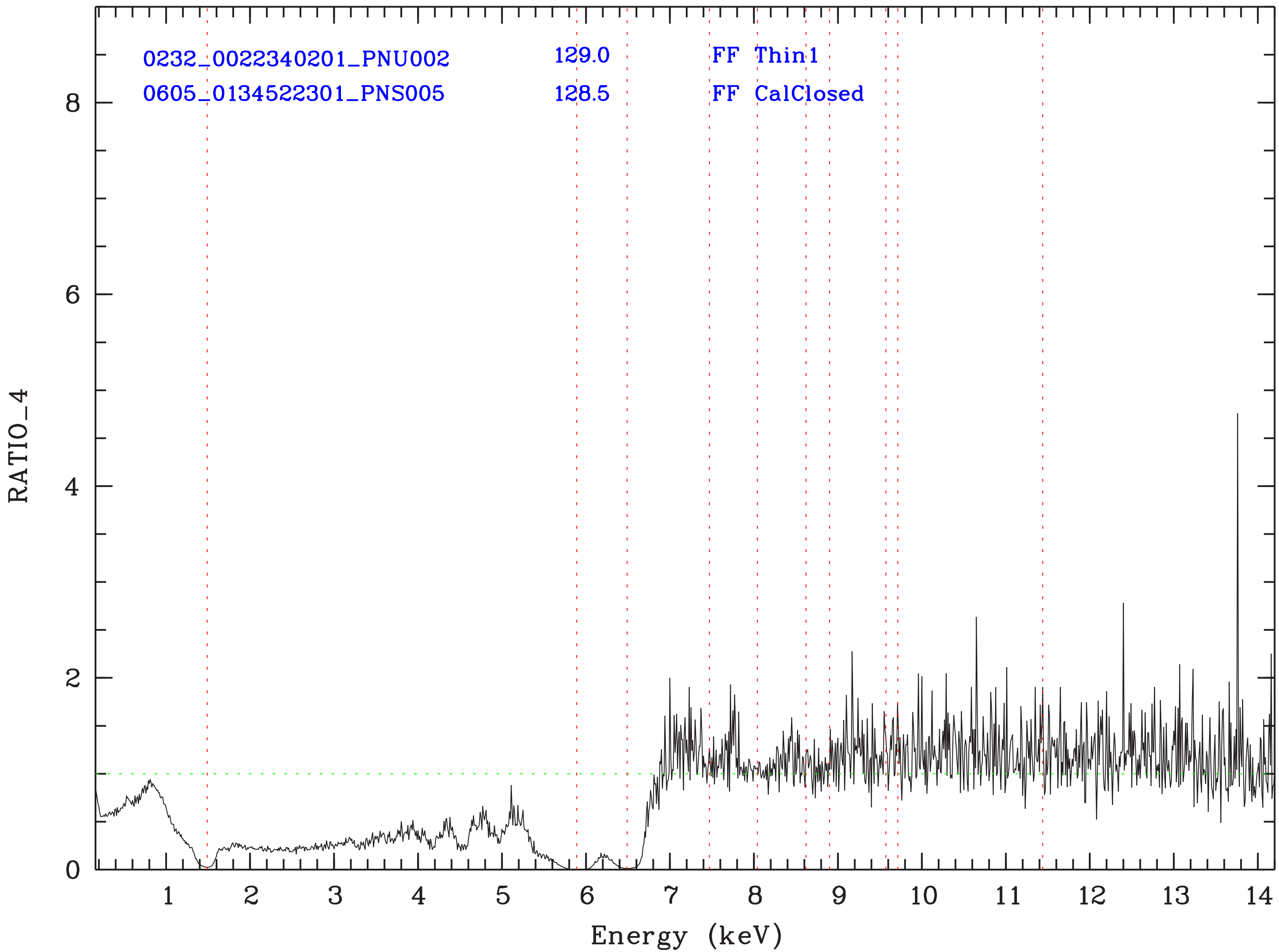

0309_0060740801_PNU002
440.1
FF CalClosed
0605_0134522301_PNS005
128.5
FF CalClosed
RATIO_21
Energy (keV)
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14

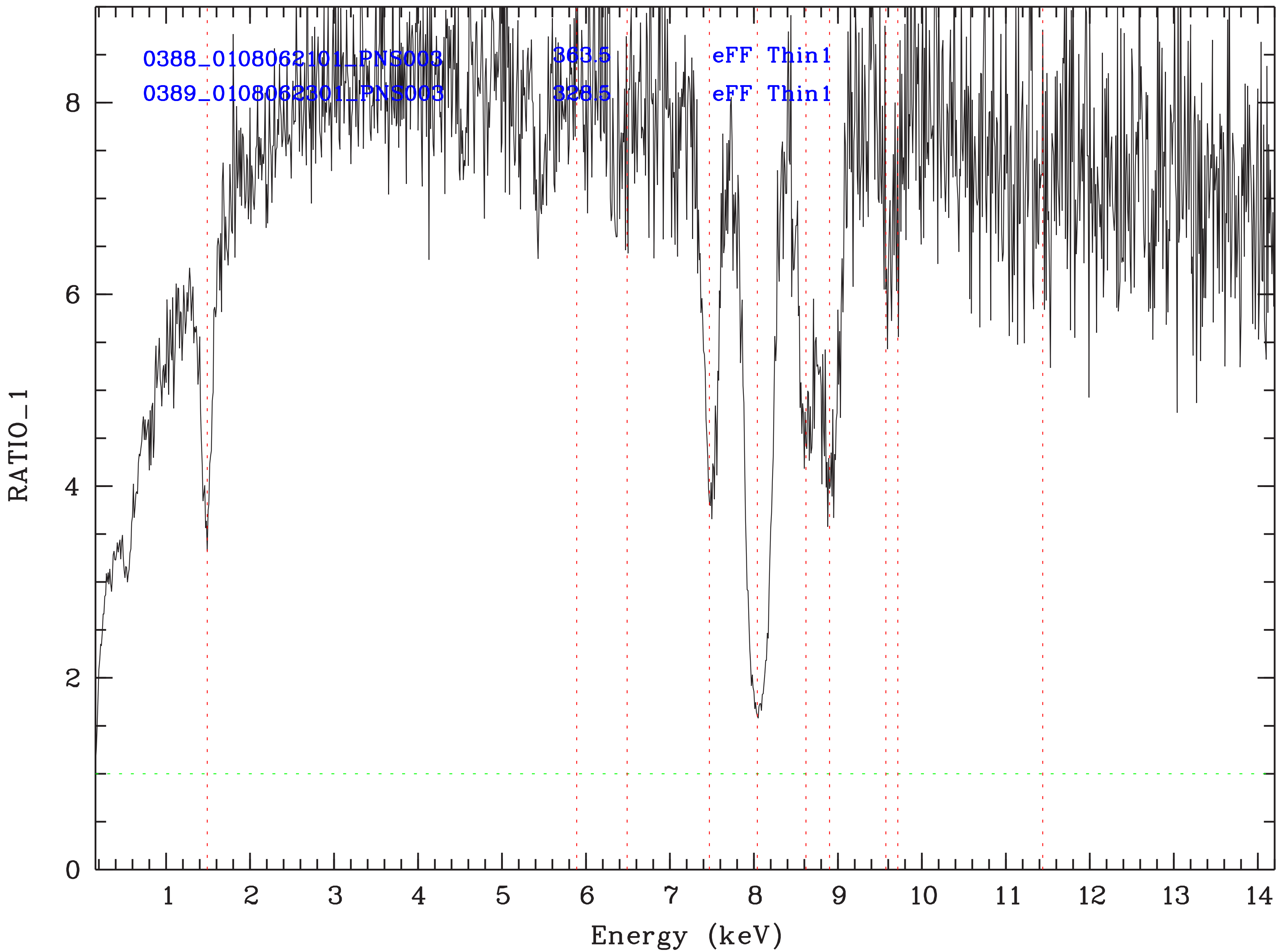

0473_0154950301_PNU002
177.1
FF CalClosed
0605_0134522301_PNS005
128.5
FF CalClosed
RATIO_53
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Energy (keV)


0462_0134521601_PNS005
129.8
FF Closed
0605_0134522301_PNS005
128.5
FF CalClosed
RATIO_51
Energy (keV)
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14

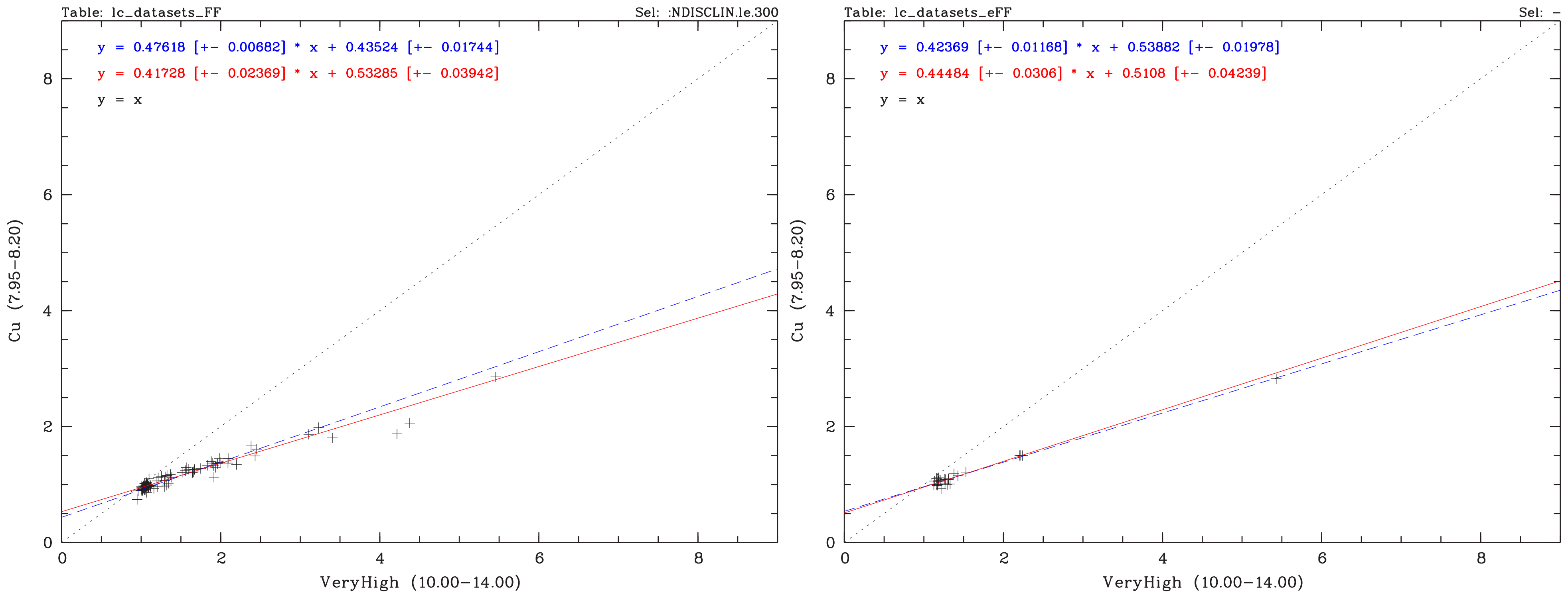

0355_0106660401_PNS003
333.3
eFF Closed
0668_0160362601_PNS005
329.1
eFF Closed
RATIO_17
Energy (keV)
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14


0636_0134522401_PNS005
333.1
eFF Closed
0668_0160362601_PNS005
329.1
eFF Closed
RATIO_27
Energy (keV)
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14


0232_0022340201_PNU002
129.0
FF Thin1
0605_0134522301_PNS005
128.5
FF CalClosed
RATIO_4
Energy (keV)
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14

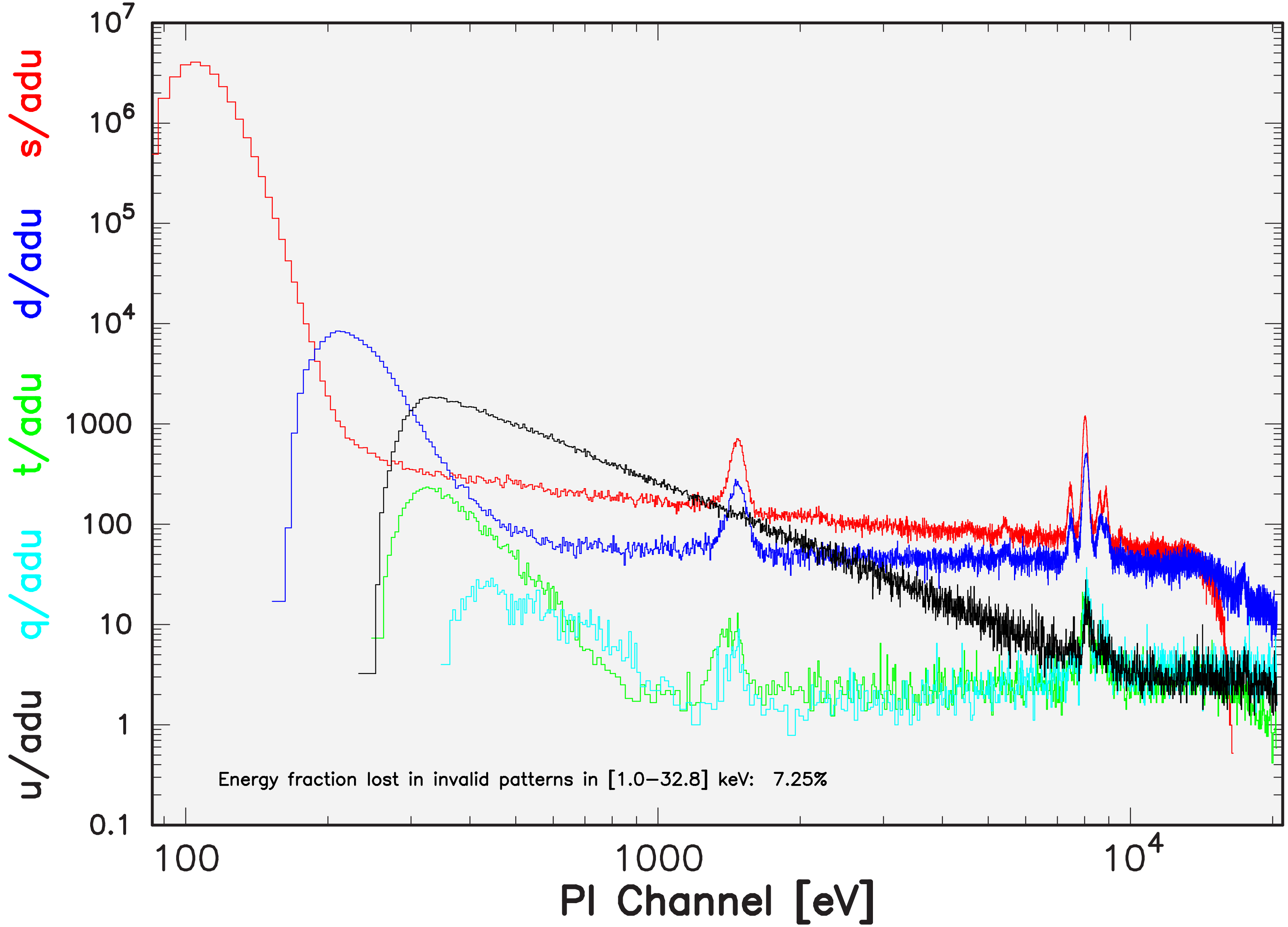

0388_0108062101_PNS003
363.5
eFF Thin1
0389_0108062301_PNS003
328.5
eFF Thin1
RATIO_1
Energy (keV)
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14

Background correlations: lines and continuum



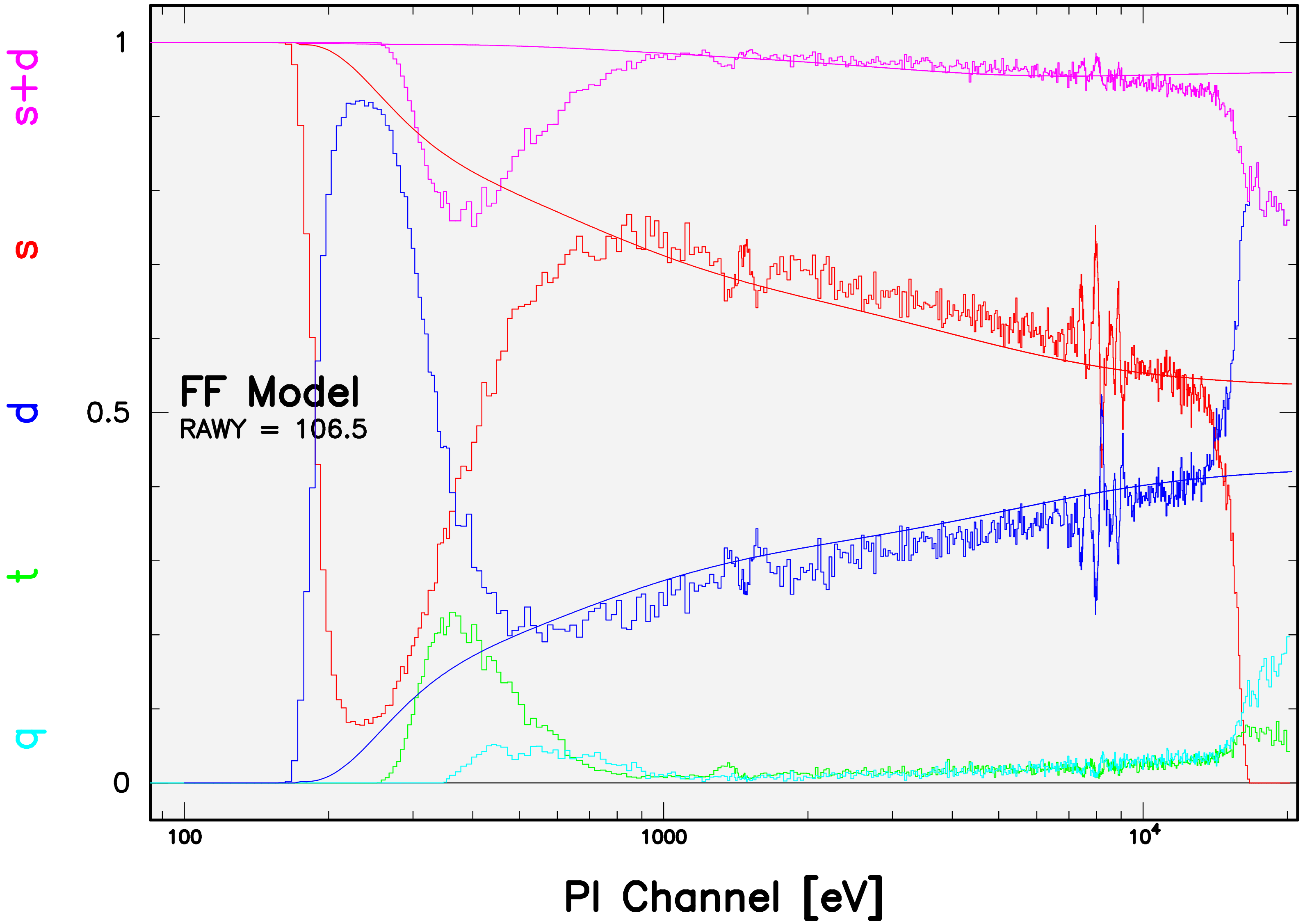
high-energy continuum more increased than Cu line, i.e. below 1-to-1
dotted line: 1-to-1 correlation
blue dashed line: all data used for linear regression
red solid line: low-intensity data used for linear regression

Pattern distributions



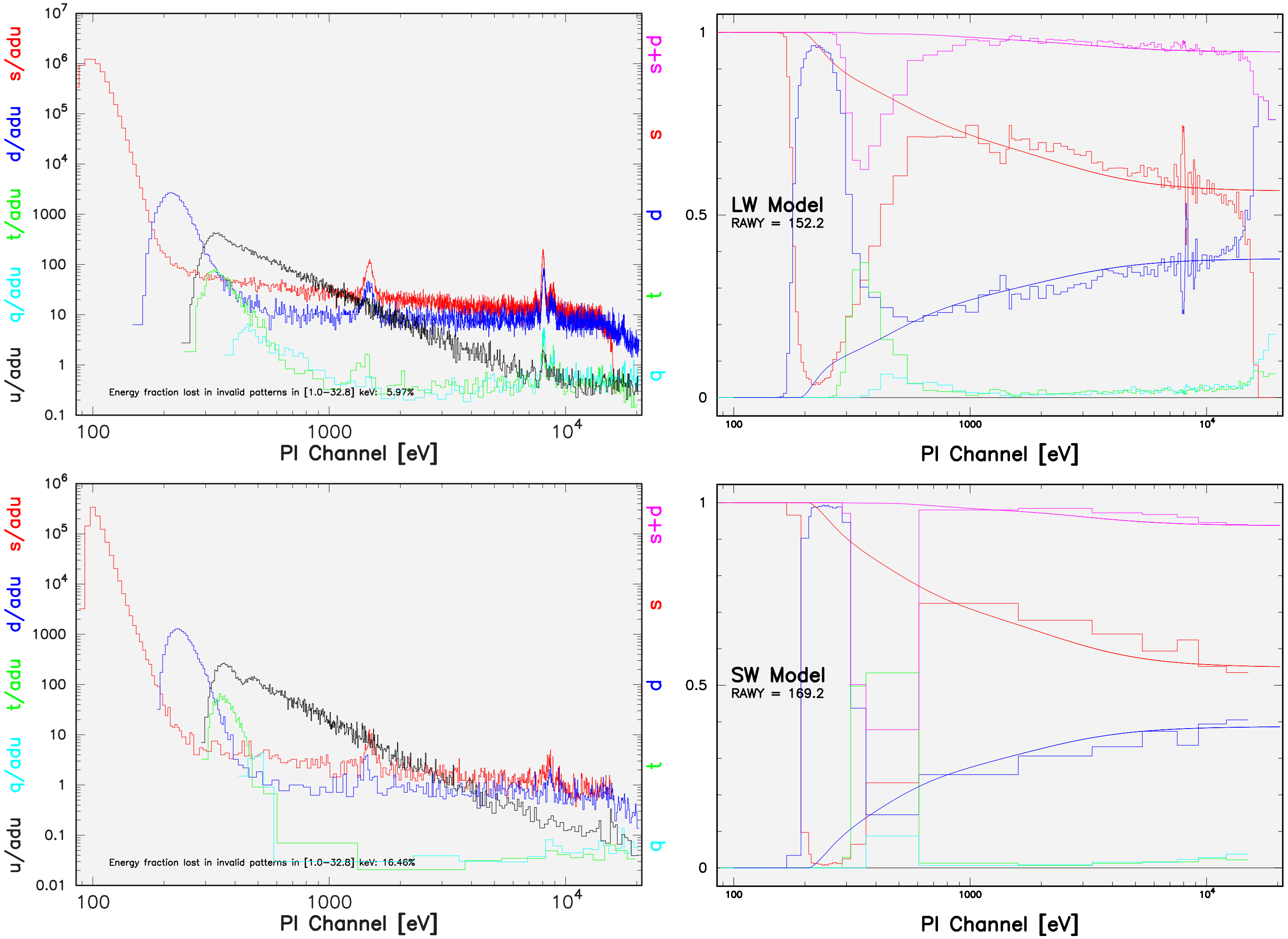
singles + doubles + triples + quadruples + invalid patterns

Pattern fractions



singles more abundant, doubles less abundant than for mirrored X-rays

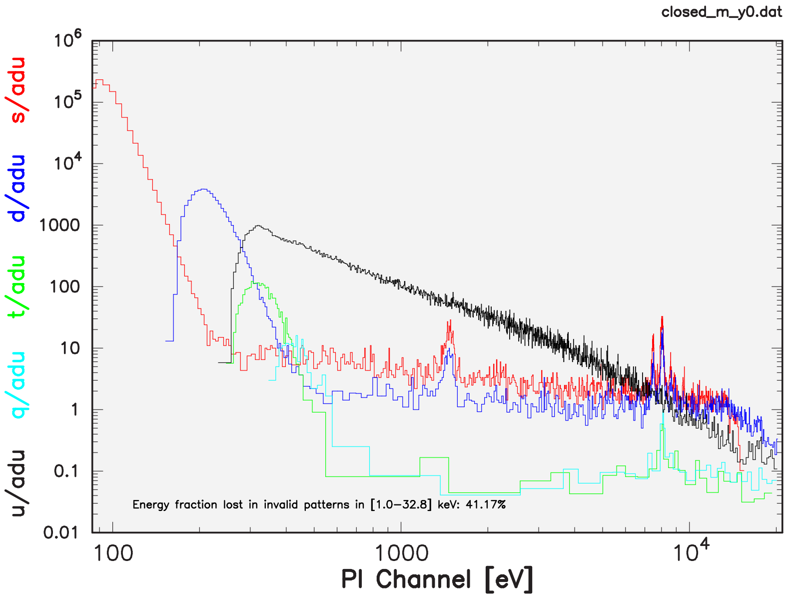
Pattern distribution + fraction: LW + SW modes

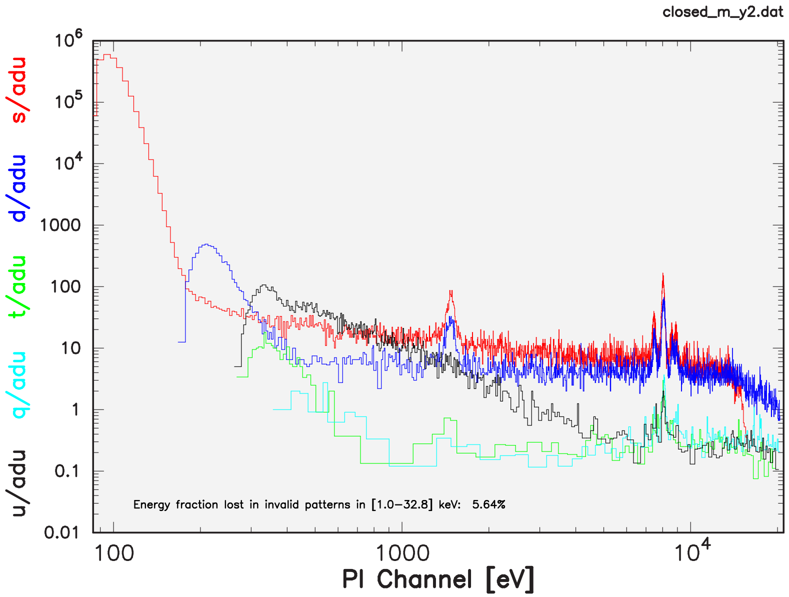


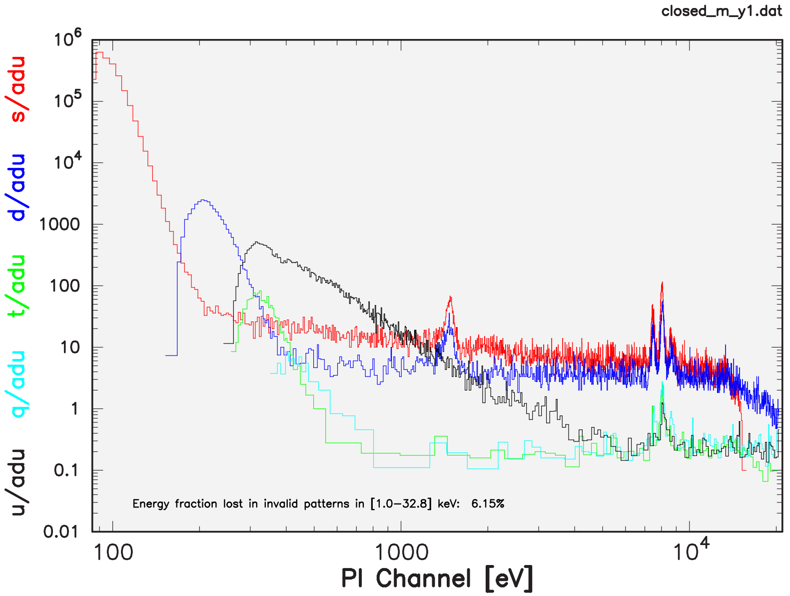
note the deficiency in Ni-K and Cu-K lines compared to FF/eFF mode because of the ventilation hole at the center

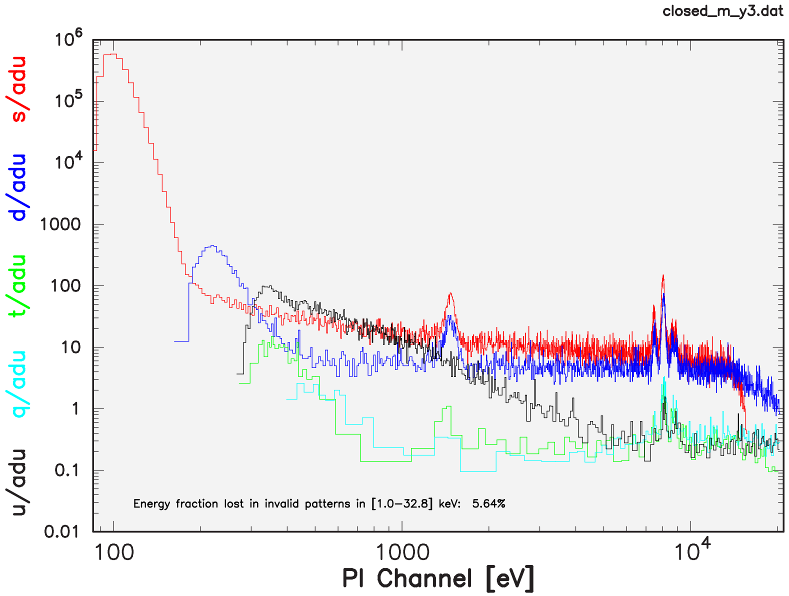
singles more abundant, doubles less abundant than for mirrored X-rays

Pattern distribution + fraction: FF spatial: close to CAMEX









labelled Y# with
`# = INT(RAWY/20)`
as for response matrices
here: # = 0,1,2,3

EPIC-pn frame times for FF + eFF modes

Frame time parameter `F1294`: FF → eFF mode

FF is special case of eFF mode : `F1294` = 0 :

$$FT(\mathrm{eFF}_{\mathtt{F1294}}) = 73.36432 + \mathtt{F1294} \times 41.94304\,[\mathrm{ms}]$$

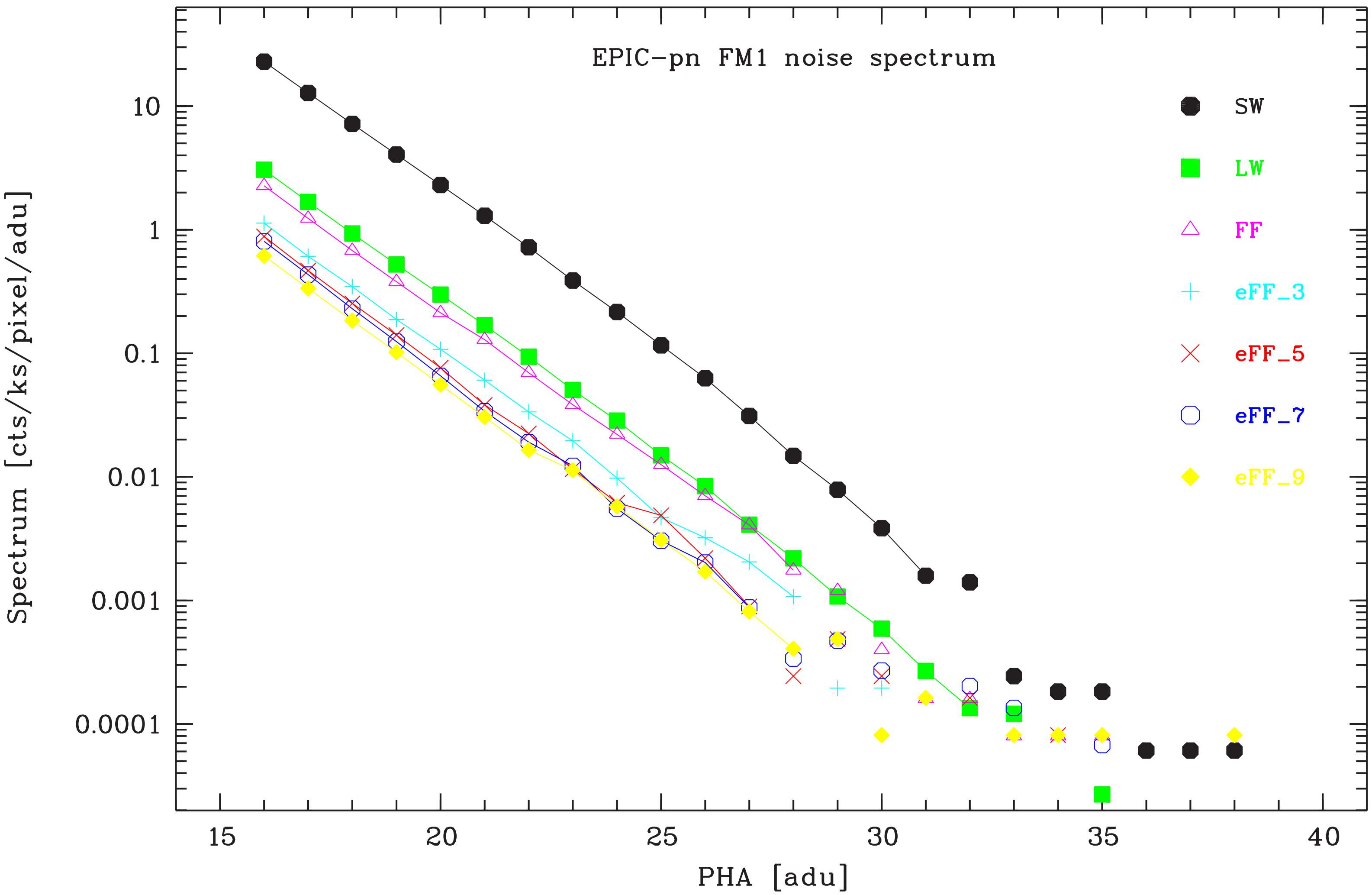
Mode	integration time [ms]	cycle time [ms]
eFF_0	**68.702**	**73.36432**
eFF_3	**194.531**	**199.19344**
eFF_5	**278.417**	**283.07952**
eFF_7	**362.303**	**366.96560**
eFF_9	**446.190**	**450.85168**
eFF_{15}	**697.848**	**702.50992**

EPIC-pn: detector noise

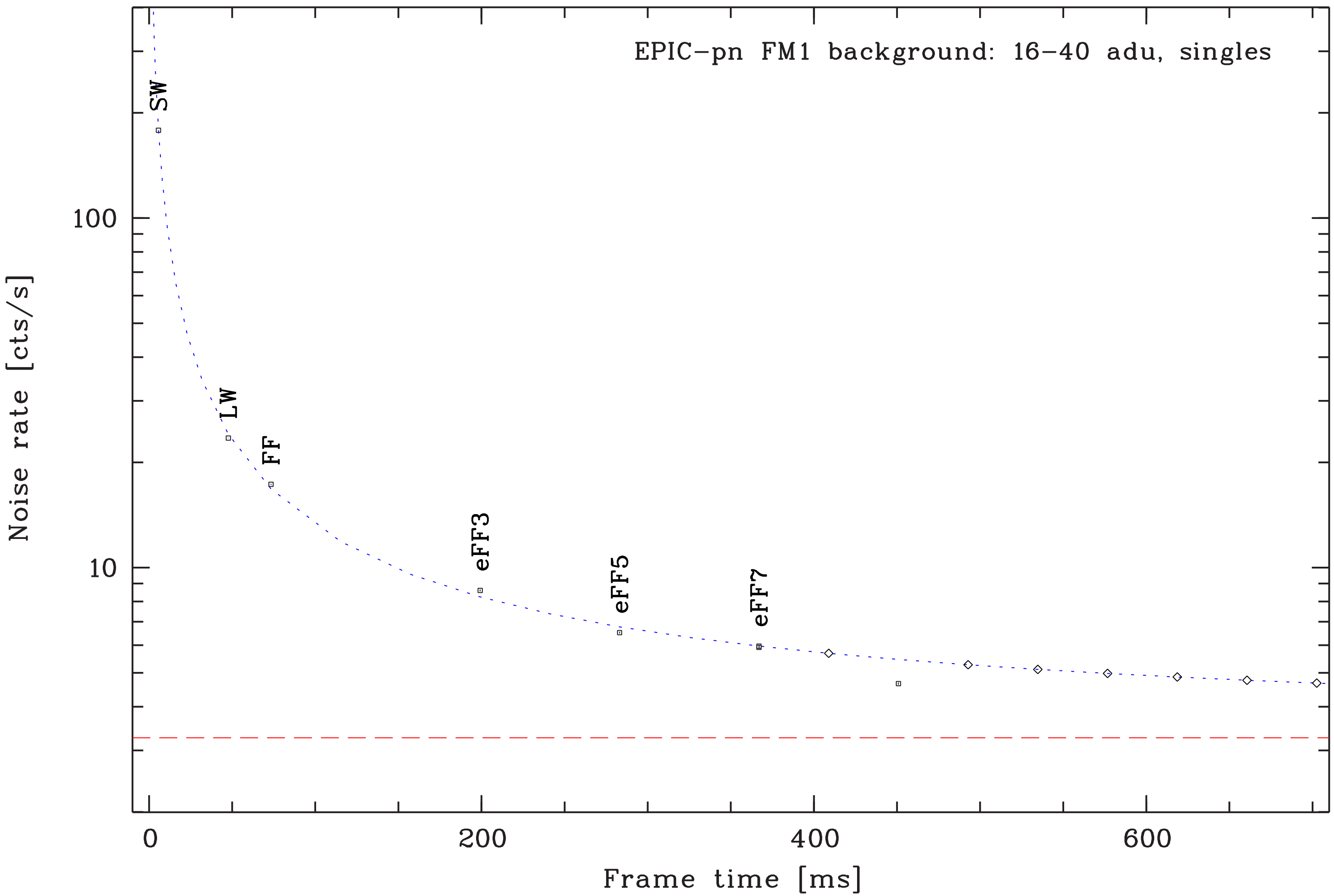
Mode	cycle [ms]	data set	exposure [s]	counts	rate [cts/s]
SW	**5.67176**	**HK040324.012**	**4793**	**854421**	178.25 ± 0.19
LW	**47.66464**	**HK040325.004**	**21766**	**510944**	23.475 ± 0.033
FF	**73.36443**	**HK031029.001**	**3662**	**63365**	17.301 ± 0.069
eFF$_3$	**199.19344**	**HK040407.013**	**3000**	**25817**	8.605 ± 0.054
eFF$_5$	**283.07952**	**HK040420.002**	**3600**	**23456**	6.515 ± 0.043
eFF$_7$	**366.96560**	**HK041014.005**	**1800**	**10637**	5.910 ± 0.057
eFF$_7$	**366.96560**	**HK041014.005**	**2530**	**15086**	5.962 ± 0.049

- `CCDNR.eq.4 .and. PAT_TYP.eq.1`
- `PHA.ge.16 .and. PHA.le.40`
- `RAWX.ge.3 .and. RAWX.le.62`
- `RAWY.ge.139 .and. RAWY.le.198`
- `RAWX.ne.18 .and. RAWX.ne.39 .and. RAWX.ne.56`
- `.not. (RAWX.eq.61 .and. RAWY.eq.179)`

EPIC-pn: detector noise



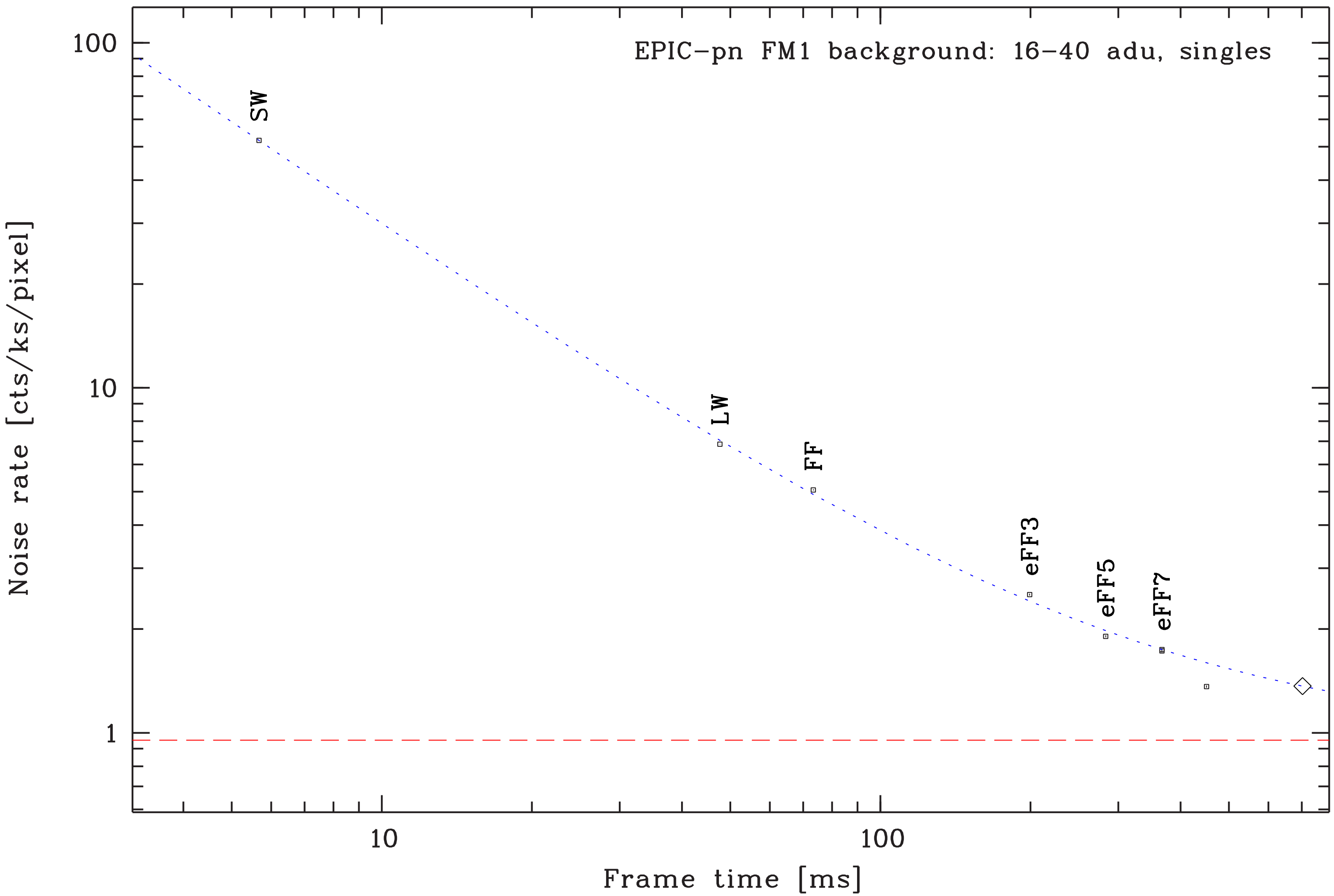
EPIC-pn: detector noise



$$\mathrm{ABS\_RATE} = C * (\mathrm{NUMBER\_OF\_READOUTS\_PER\_SECOND} + B)$$

$$C = 0.9924 \pm 0.0030 \text{ [cts s}^{-1}\text{]}, \; B = 3.28$$

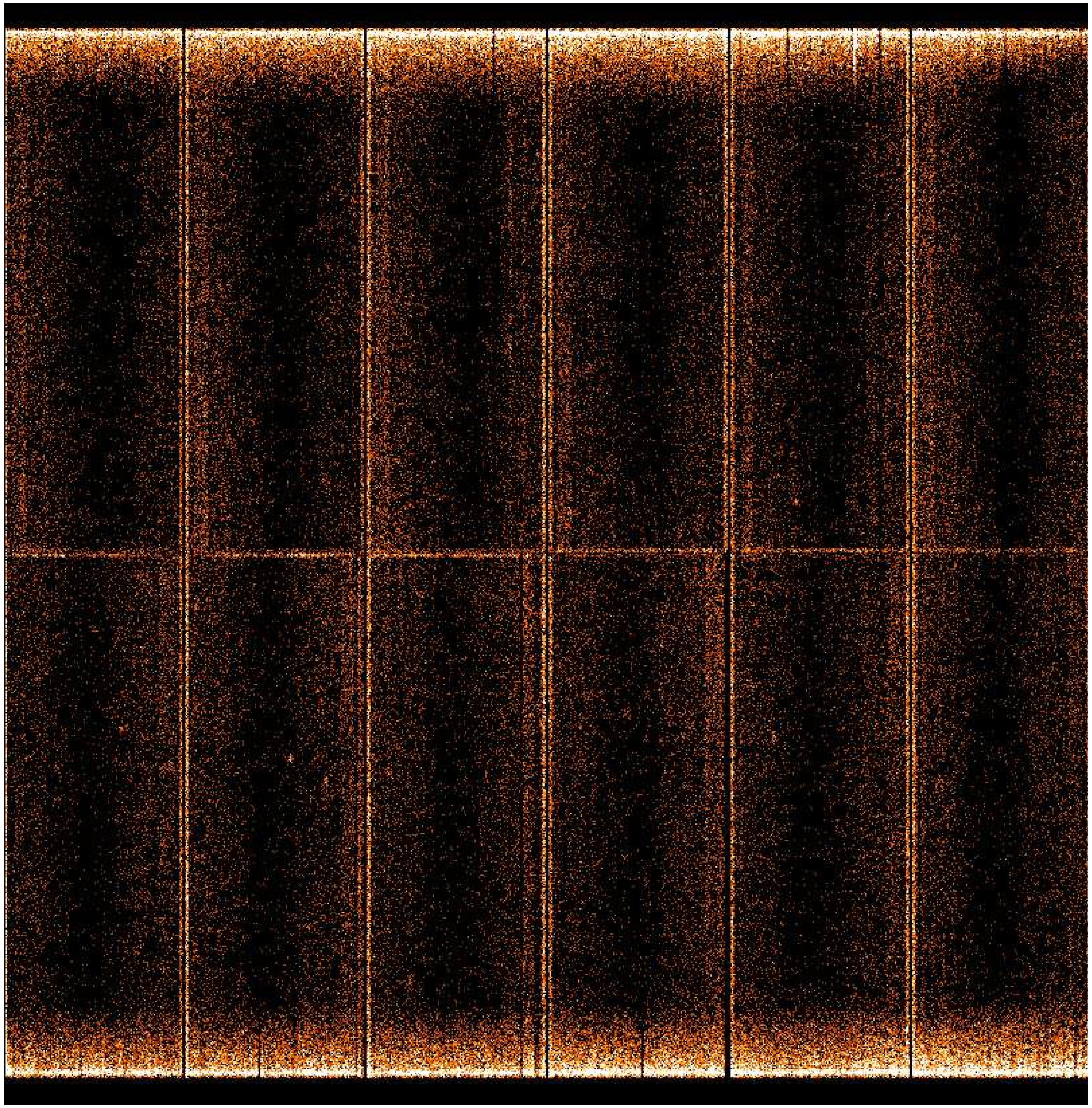
EPIC-pn: detector noise



$$\text{ABS\_RATE\_PER\_PIX} = D * (\text{NUMBER\_OF\_READOUTS\_PER\_SECOND} + B)$$

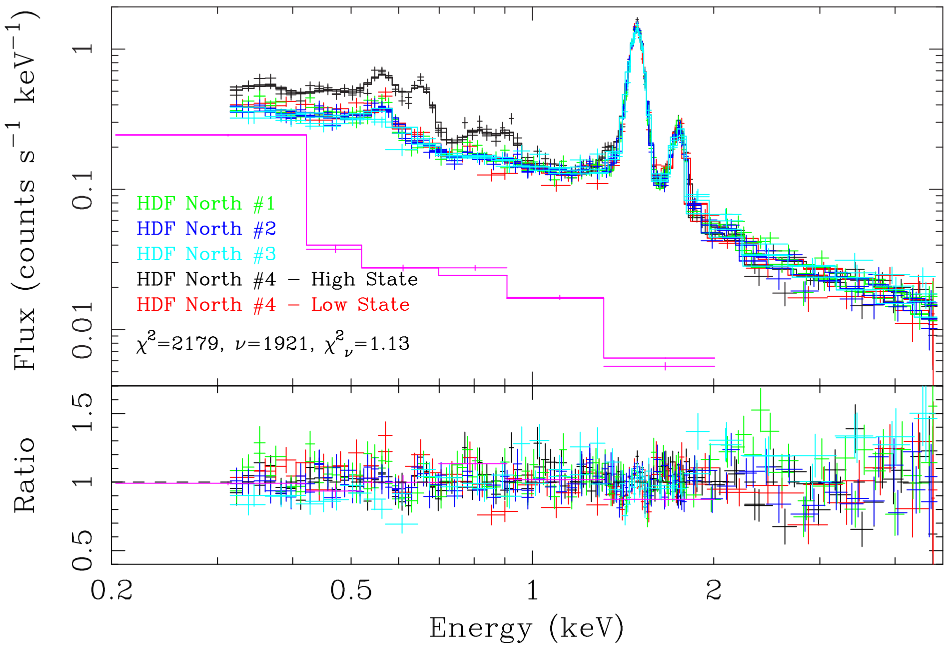
$$D = 0.2902 \pm 0.0007\ [\text{cts ks}^{-1}\ \text{pixel}^{-1}],\ B = 3.28$$

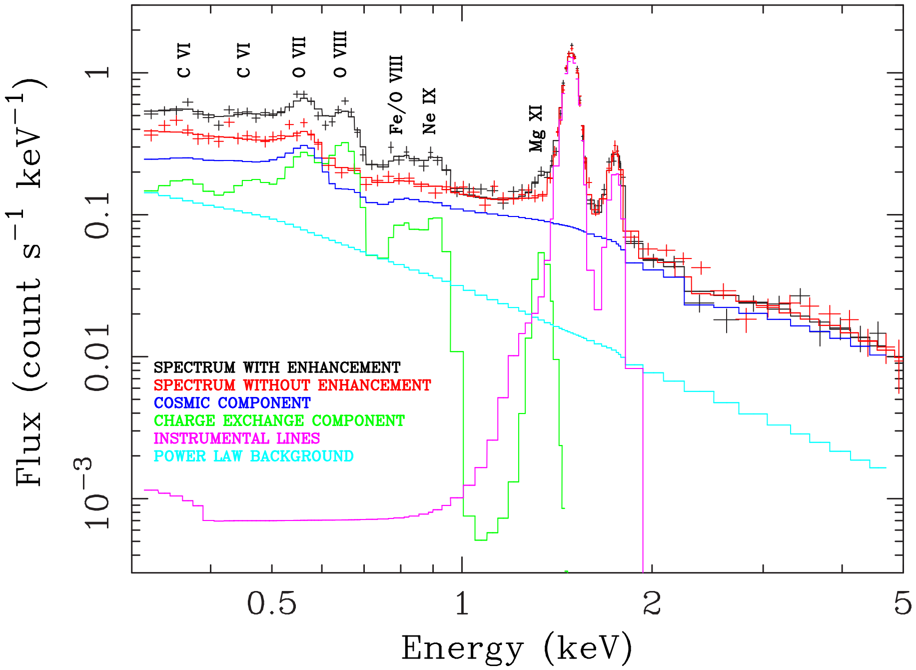
Low-energy background (0.2 – 0.5 keV): doubles



- spatial inhomogeneities in RAWX direction
- enhanced intensity close to CAMEX
- recommended to use only singles below 0.5 keV as in pipeline processing and singles + doubles above 0.5 keV

EPIC-pn: solar wind charge exchange





Snowden, Collier & Kuntz 2004, ApJ 610, 1182

EPIC-pn: low-energy comments

- **below 500 eV: PATTERN==0 (inhomogeneous PATTERN>0)**
- **above 500 eV: PATTERN$\leq$4**
- **CAMEX region has higher noise (e.g. MIPs)**
- **SAS task `epreject` to shift low-energy patches and to flag noise events**
  → cleaner low-energy images, can go down to 120 eV (KOD, HB)
- **a few columns in quadrants 0,1,2 show different gain compared to ground calibrations (KOD):**
  → this too low gain in the CCF shifts the noise to too high energies
  → columns appear too bright (CCD1, CCD5)
  quadrant 3 shows general gain scatter compared to ground calibrations
  → will be corrected in EPN_ADUCONV.CCF (MS, KOD)
- **`epatplot` now accepts background event file, e.g. Closed filter, to remove non-XRT X-rays from pattern distributions (sky background does not matter !)**

EPIC-pn: soft proton background

- **is vignetted**
- **has continuum spectrum**
- **is highly variable in intensity (and spectral slope)**
- **pattern distribution similar to genuine X-rays**
- **RMF different (escape peak): model (SM, SFS, SLS, KK) ?**

EPIC-pn: out-of-time events

- Suggestion: produce OoT event files during XSA reprocessing (`epchain`)
- useful for low SB objects, very large targets, point sources in field, etc.
- OoT also affect out-of-FOV area
- pattern distribution same as for true X-rays
- problem: extra disk space
- idea: store only information different from original event file and provide script/tool to explode/implode OoT event file
- assumes that both event files have same number of events (RAWY, PI)
- does not work in the case of a threshold like 150 eV
- solution: run `epreject` and remove flagged events in both event files to reduce (combined) size ?

Cosmic X-ray background

- **SXRB [$E < 2\,\mathrm{keV}$] one can do simultaneous fit with ROSAT Survey (or ROSAT pointed data) (ftool, SLS)**
- **CXRB [$E > 2\,\mathrm{keV}$] use blank sky fields (with brighter sources excluded) to determine power-law**