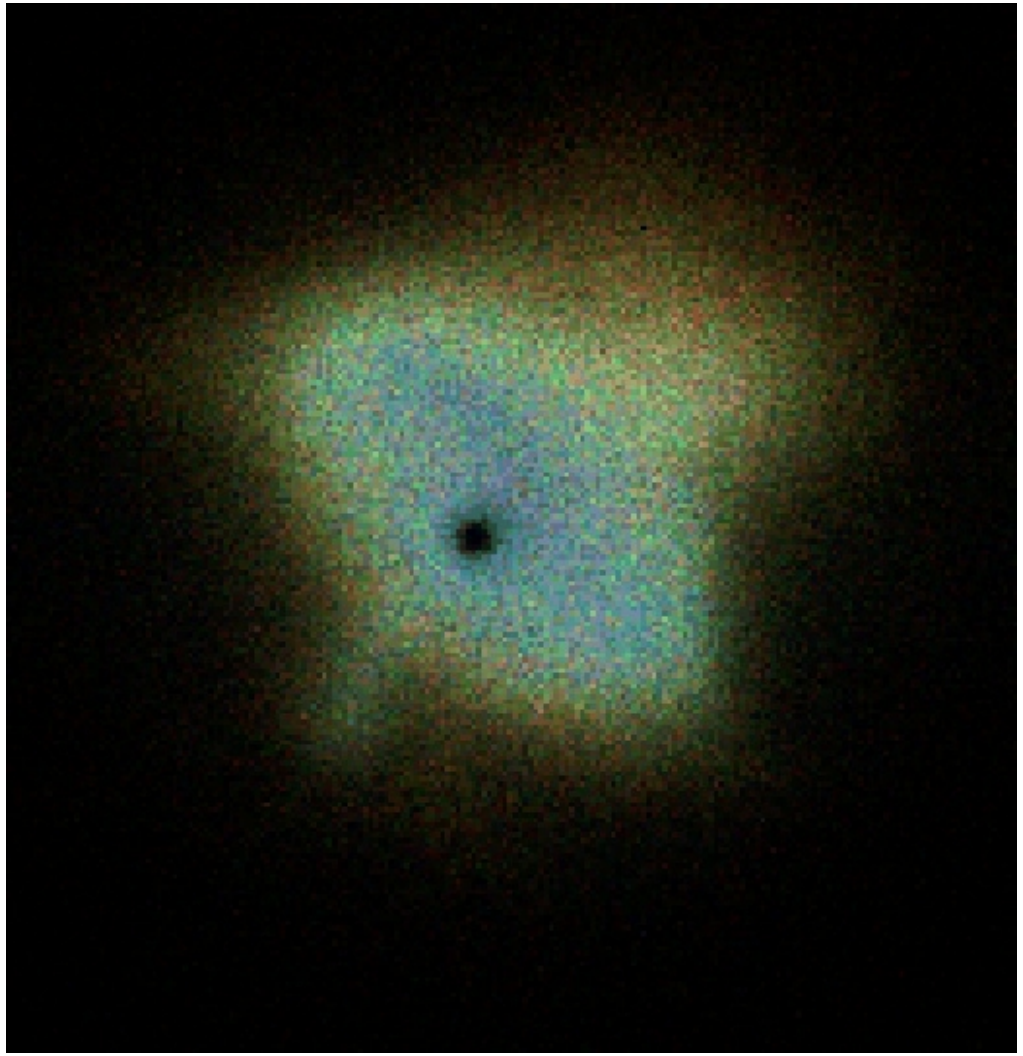
Spectral and spatial deformations on piled-up sources

"a one case study, of MOS data"

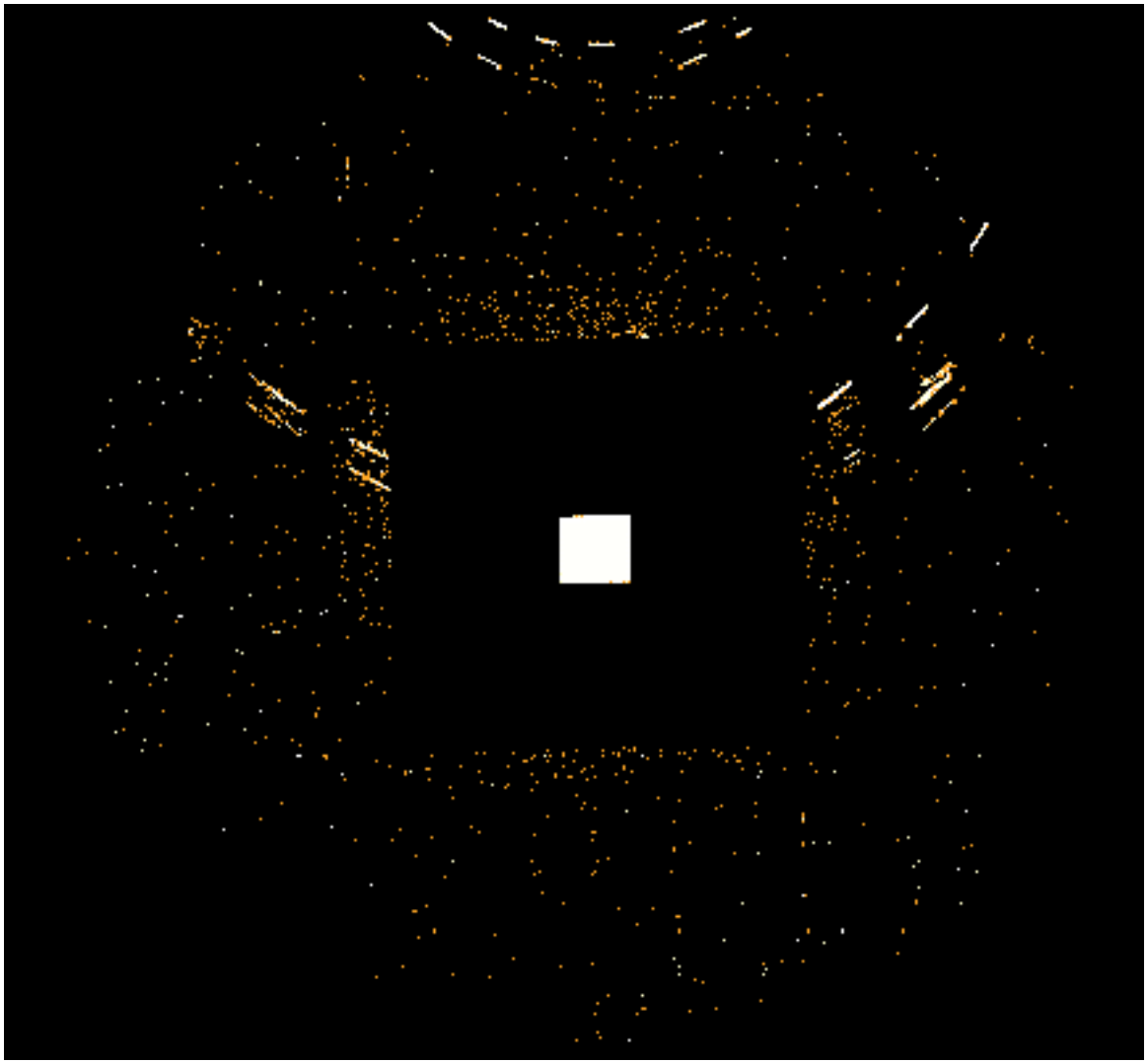


Motivations :

- A number of sources are with high flux, generating pile-up
- Standard spectral and spatial analysis is no more valid,
- Large corrections to get absolute flux, spectral shape, spatial distribution...

Plan for this study :

- Step 1 : measure pile-up effects on spectra and spatial distribution … `done`
- Step 2 : check against theoretical predictions… `started`
- Step 3 : provide “standard analysis” route for piled-up sources... `future`



GRS 1758-258

MOS 1 & 2 in small window
PN in large window

Count rate ~ 20 c/s

MOS 1

21.87 ± 0.03 c/s (stable)
(~ 6.6 counts/frame)

MOS 2

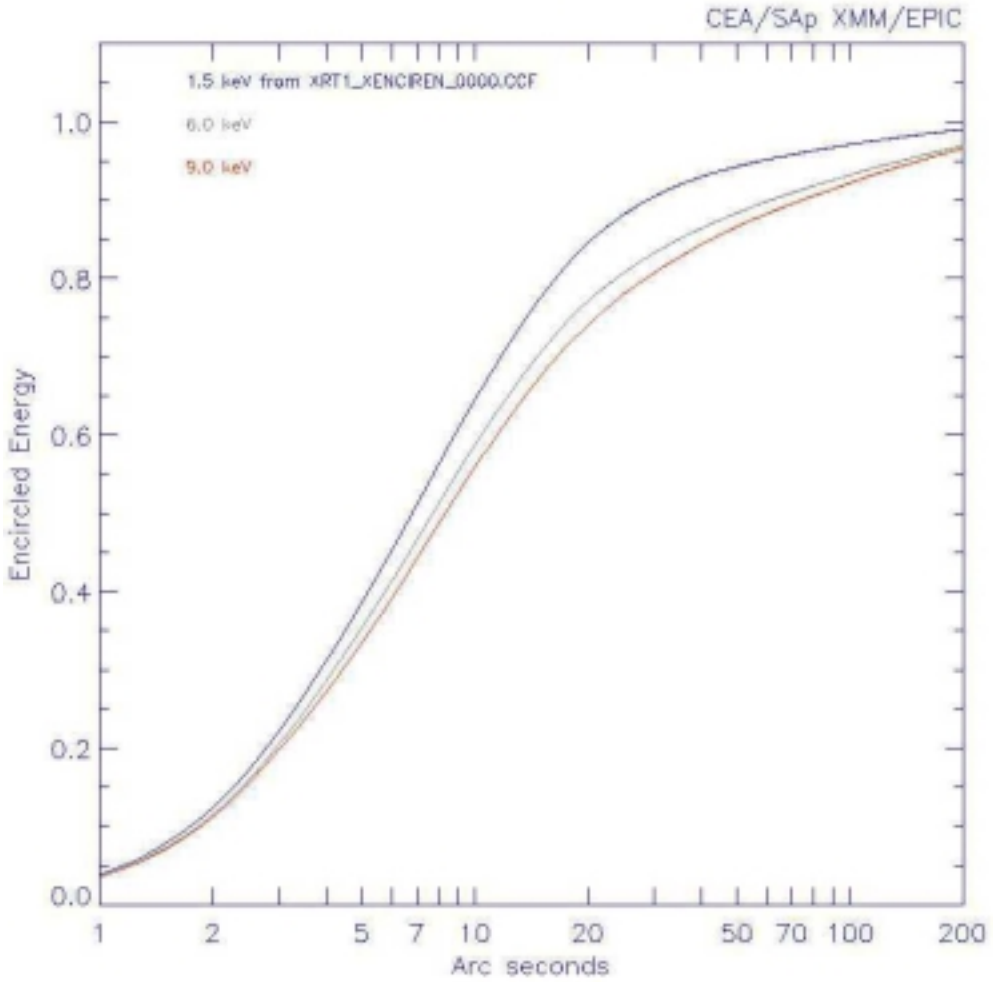
21.65 ± 0.03 c/s (stable)
(~ 6.6 counts/frame)

• Spectra and counts studied in concentric rings with following characteristics, with counts being for pattern 0 events :

R_in arcsec	R_out arcsec	Physical pixels	counts /frame	c/frame /pixel
0	3	23	0.73	3.12e-2
3	6	70	1.04	1.48e-2
6	12	280	1.42	5.07e-3
12	24	1122	1.03	9.15e-4
24	44	3531	0.64	1.80e-4

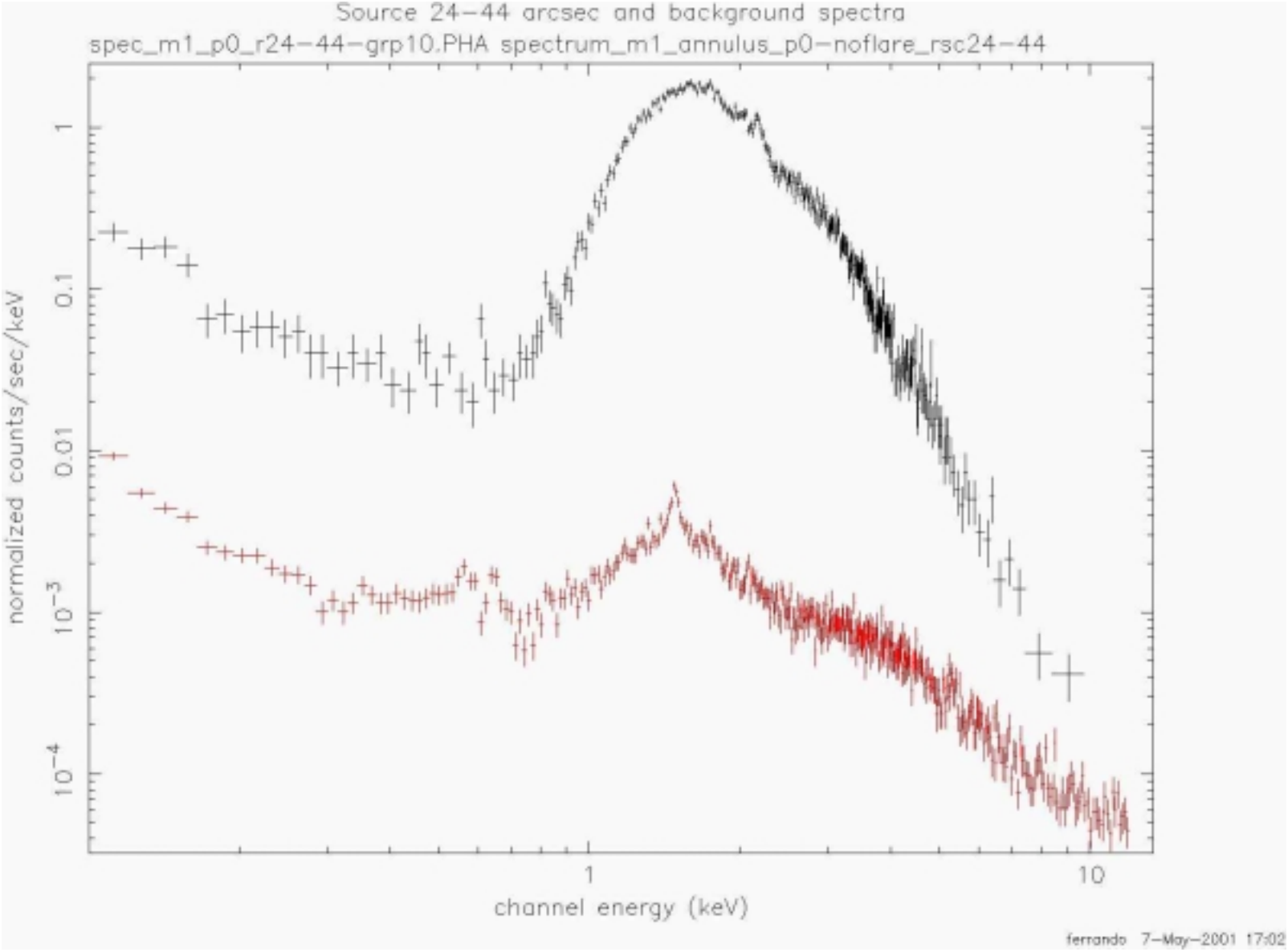
• Look for spectral differences in different rings

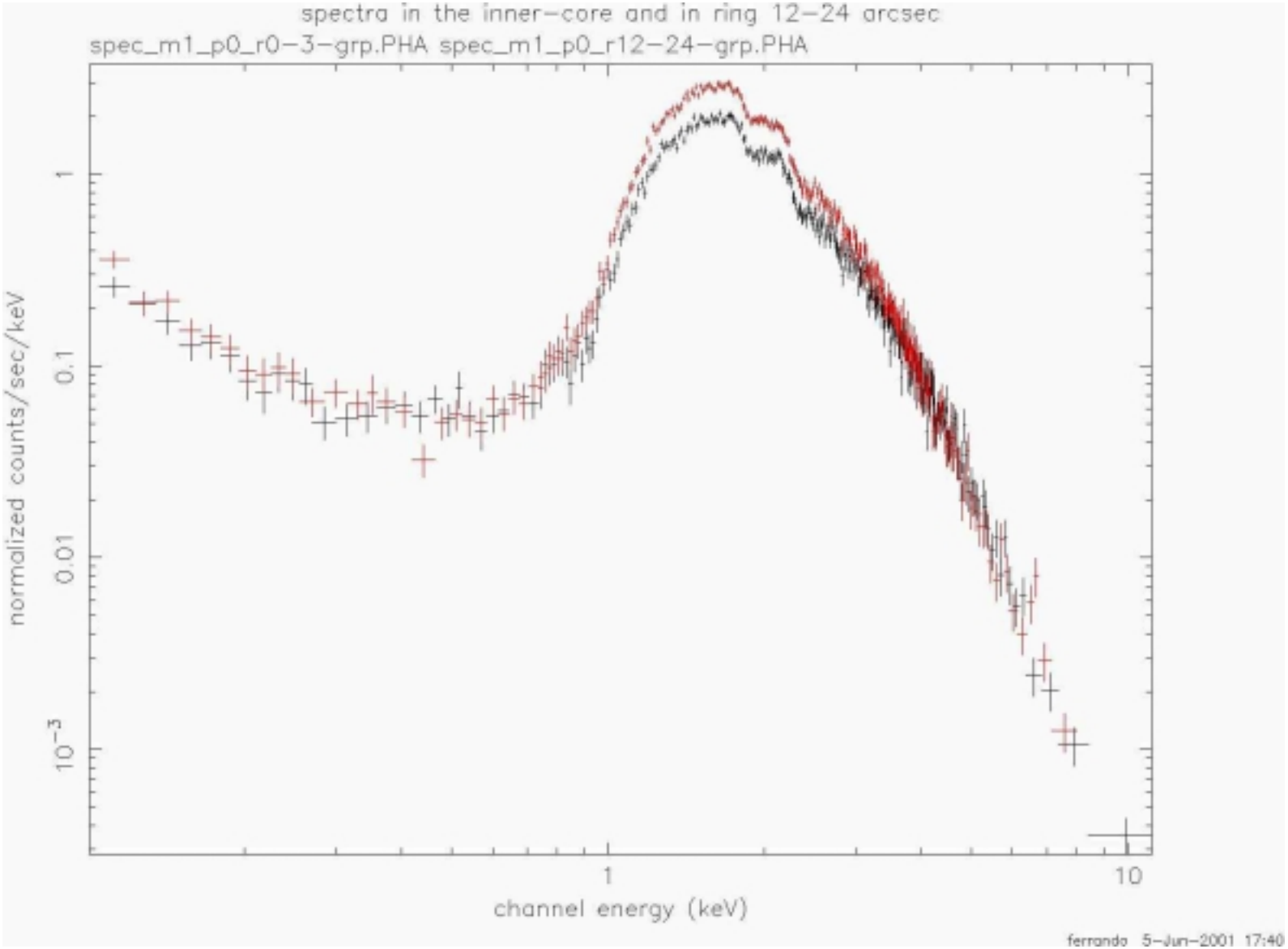
• All study performed with pattern 0 events only, since pattern 0 the less sensitive to pile-up, especially regarding spectral effects

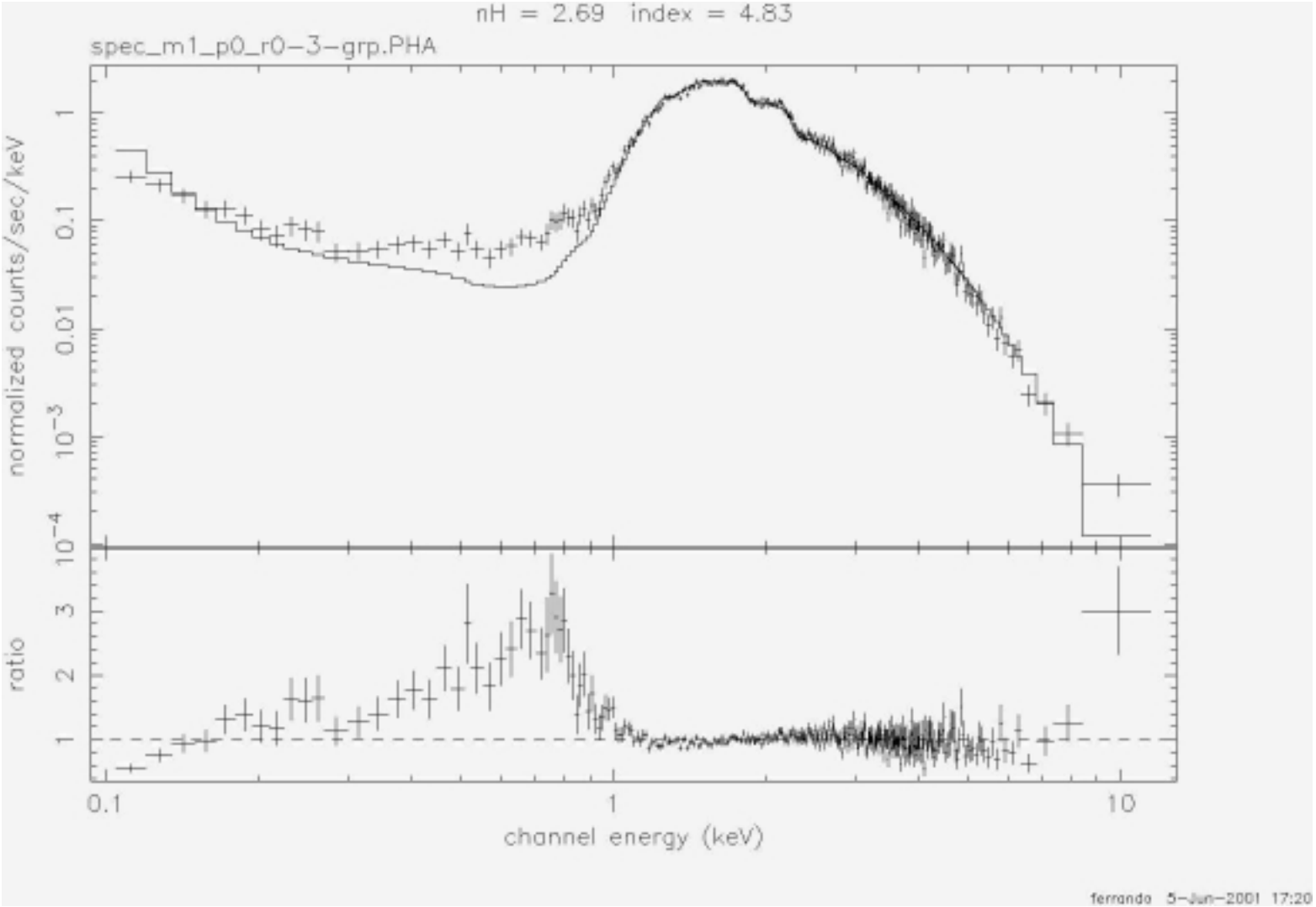


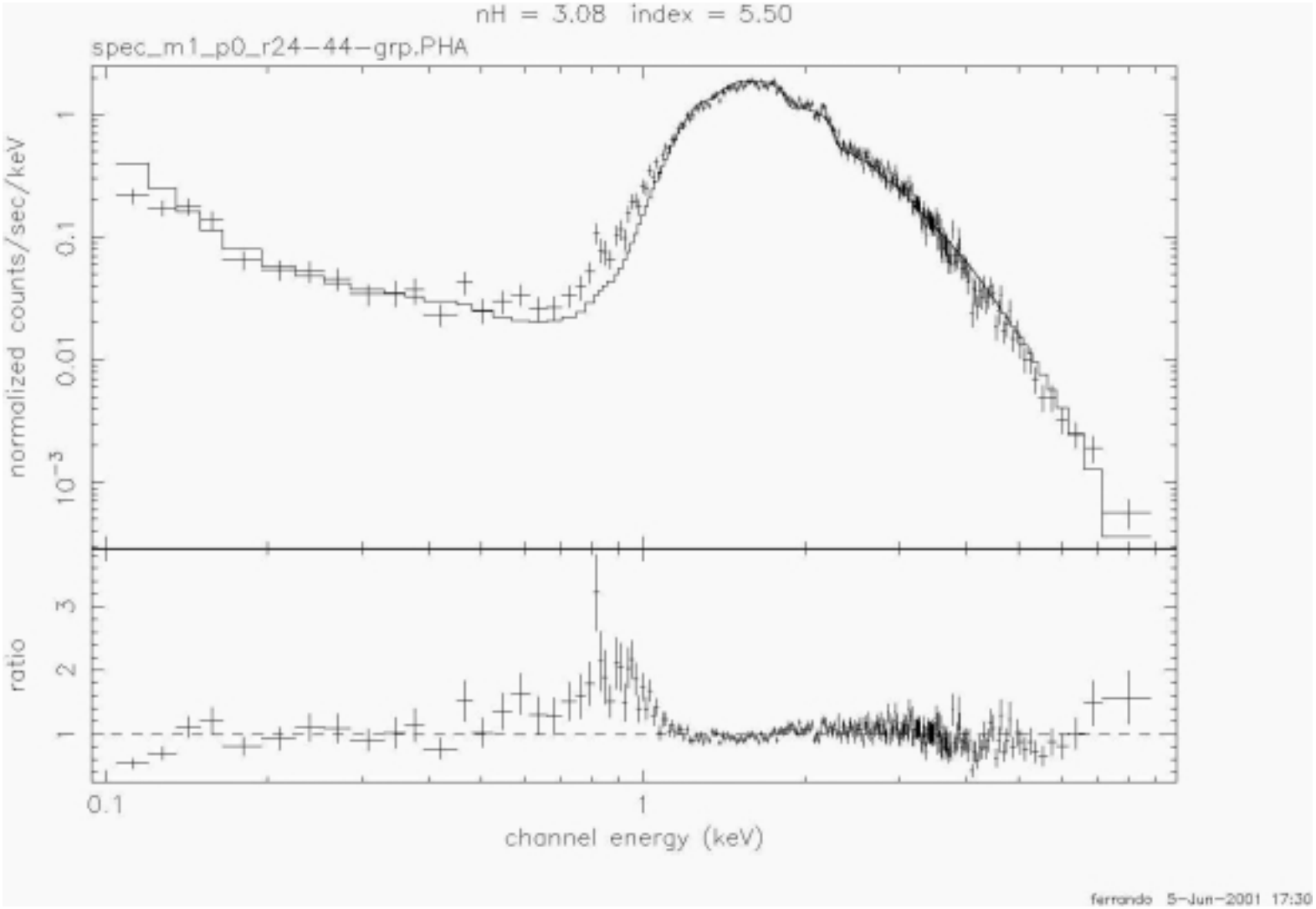
Results will be compared to encircled energy data from file XRT1_XENCIREN_0000.CCF (merci Jean)

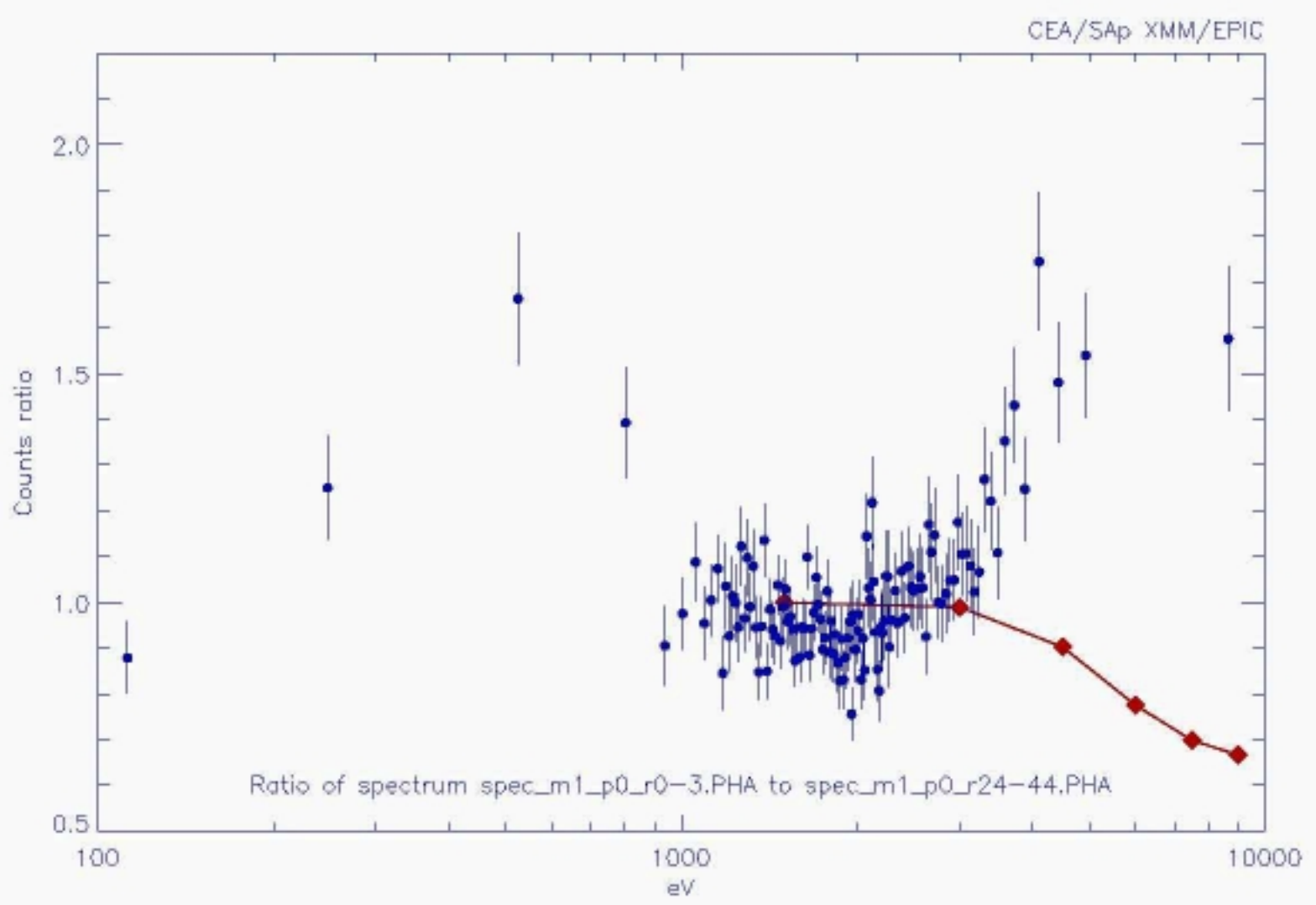
This file show a strong energy dependence in the encircled energy

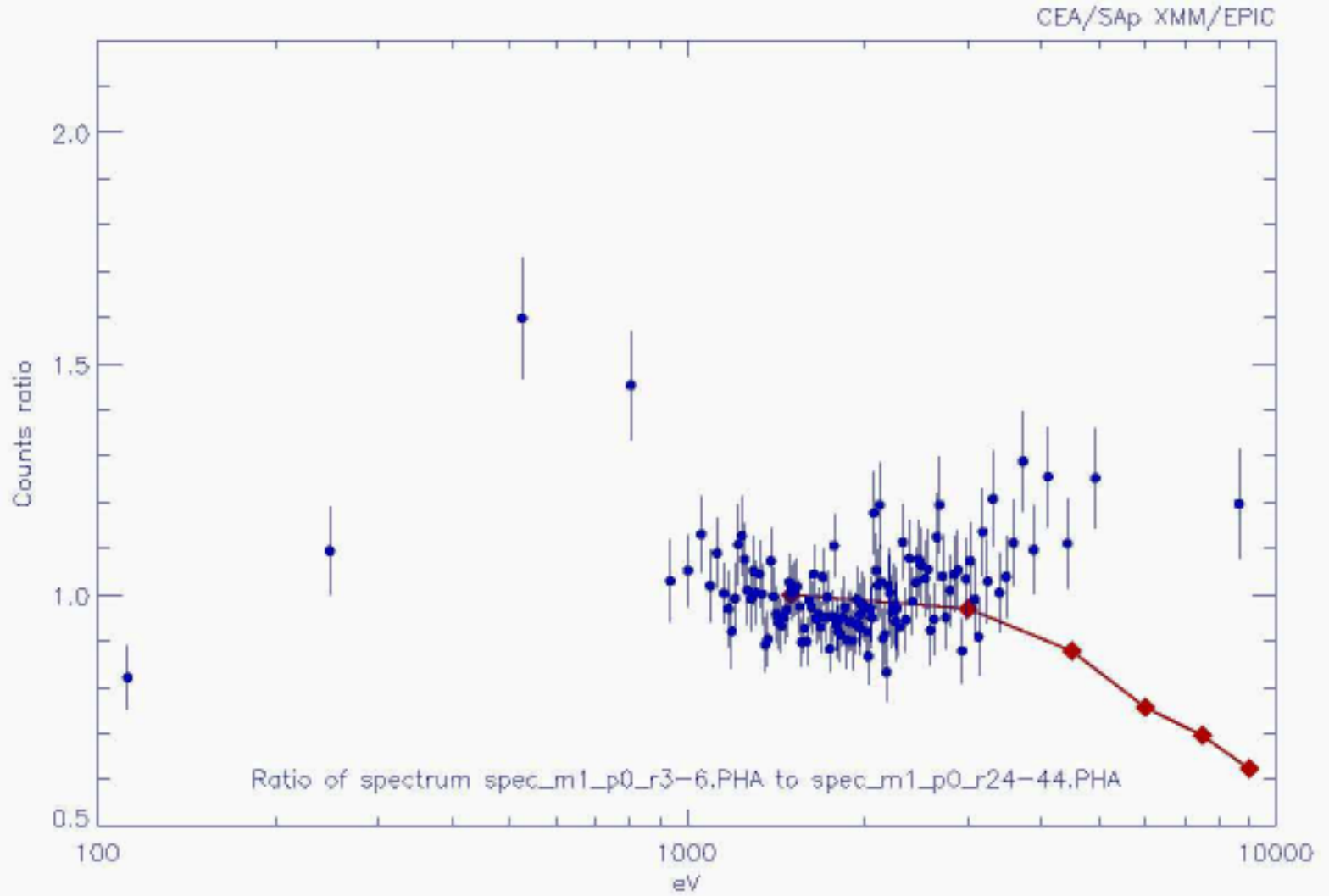

Source 24−44 arcsec and background spectra
spec_m1_p0_r24−44−grp10.PHA spectrum_m1_annulus_p0−noflare_rsc24−44
normalized counts/sec/keV
1
0.1
0.01
10^{-3}
10^{-4}
1
10
channel energy (keV)
ferrando 7−May−2001 17:02

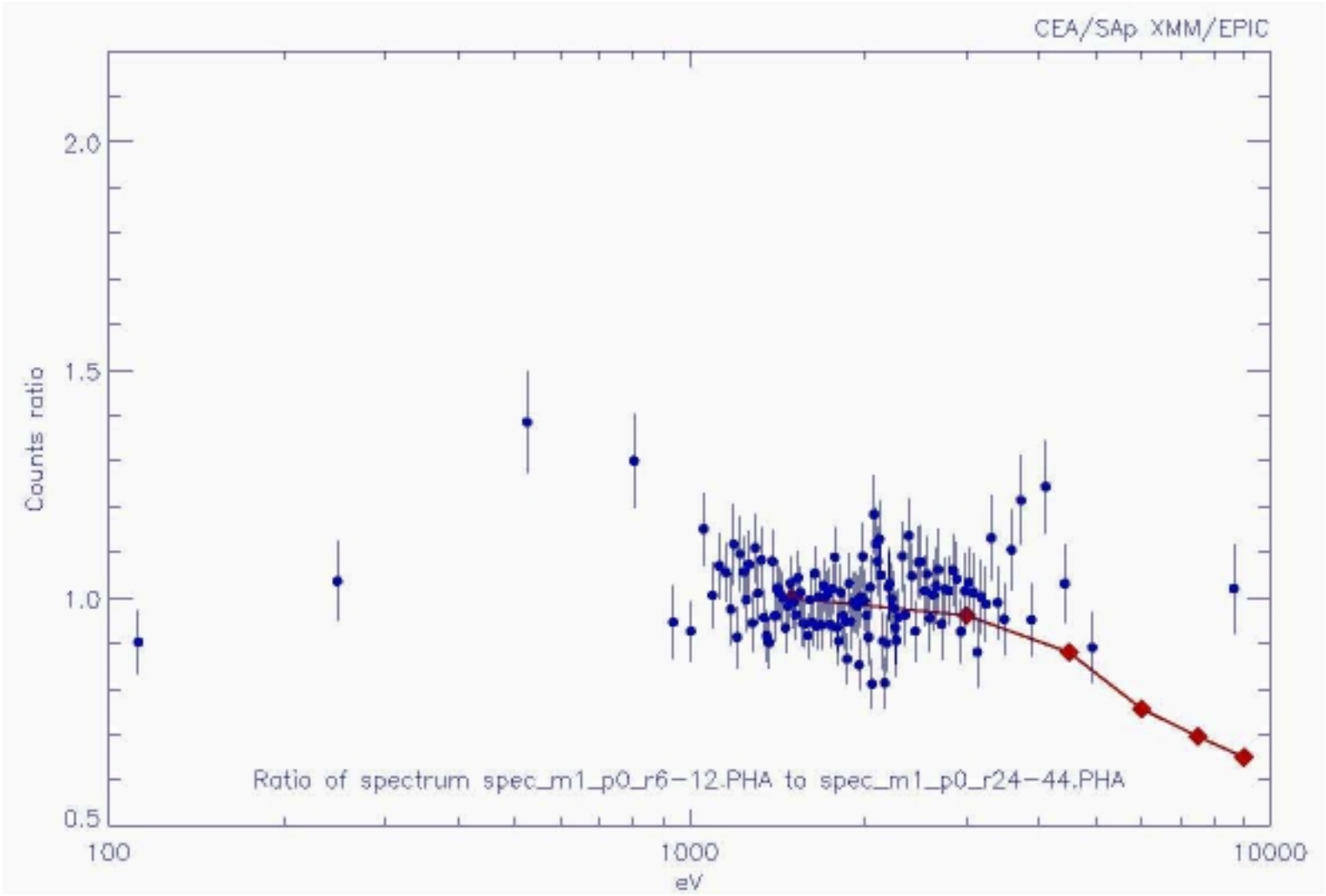

spectra in the inner-core and in ring 12-24 arcsec
spec_m1_p0_r0-3-grp.PHA spec_m1_p0_r12-24-grp.PHA
normalized counts/sec/keV
1
0.1
0.01
10^{-3}
1
10
channel energy (keV)
ferrando 5-Jun-2001 17:40

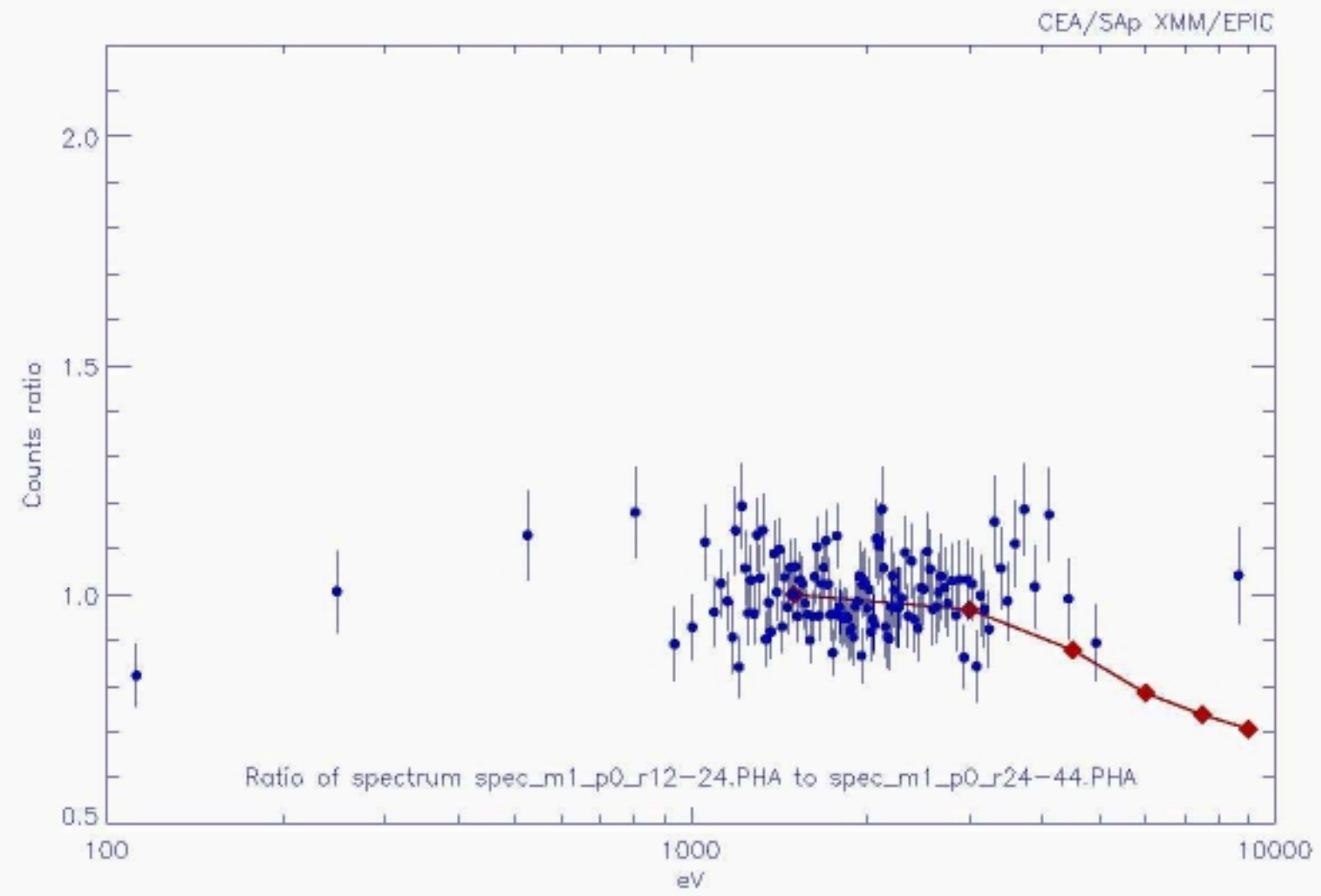

nH = 2.69 index = 4.83
spec_m1_p0_r0-3-grp.PHA
normalized counts/sec/keV
ratio
channel energy (keV)
0.1
1
10
ferrando 5-Jun-2001 17:20


nH = 3.08 index = 5.50
spec_m1_p0_r24-44-grp.PHA
normalized counts/sec/keV
1
0.1
0.01
10^{-3}
ratio
3
2
1
0.1
1
channel energy (keV)
ferrando 5-Jun-2001 17:30

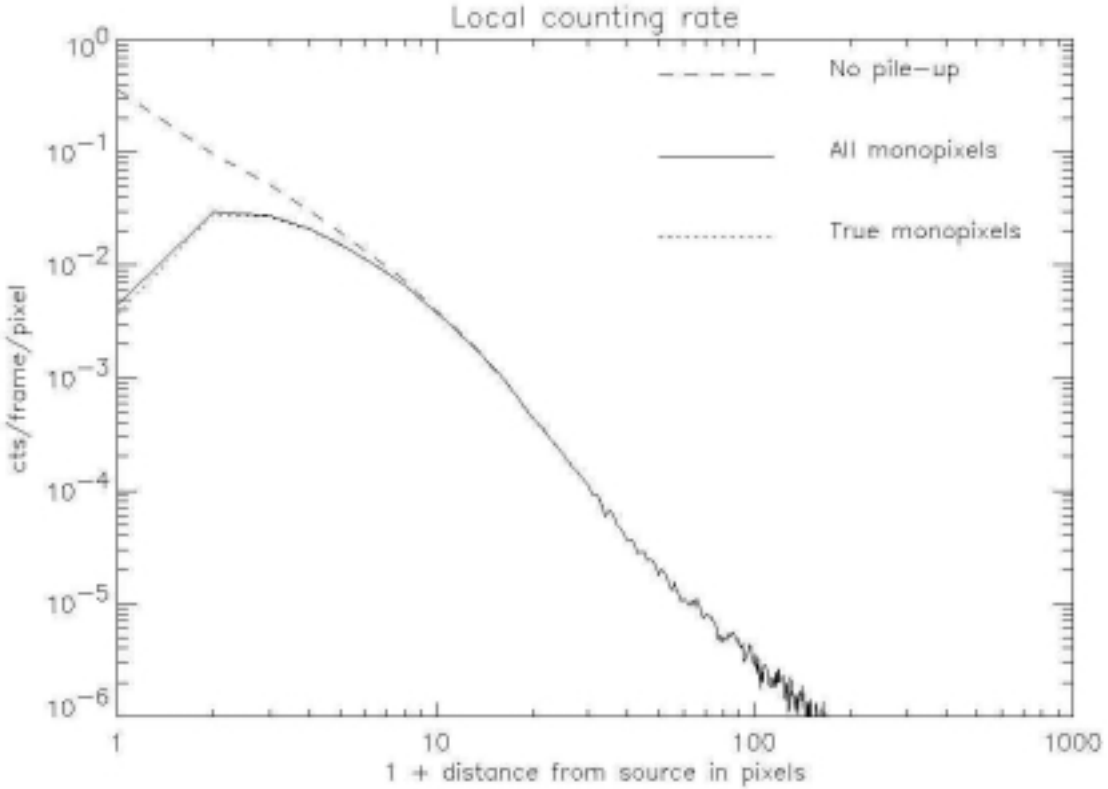

CEA/SAp XMM/EPIC
Counts ratio
2.0
1.5
1.0
0.5
100
1000
10000
eV
Ratio of spectrum spec_m1_p0_r0-3.PHA to spec_m1_p0_r24-44.PHA


CEA/SAp XMM/EPIC
Counts ratio
2.0
1.5
1.0
0.5
100
1000
10000
eV
Ratio of spectrum spec_m1_p0_r3-6.PHA to spec_m1_p0_r24-44.PHA


CEA/SAp XMM/EPIC
Counts ratio
2.0
1.5
1.0
0.5
100
1000
10000
eV
Ratio of spectrum spec_m1_p0_r6-12.PHA to spec_m1_p0_r24-44.PHA


CEA/SAp XMM/EPIC
Counts ratio
2.0
1.5
1.0
0.5
100
1000
10000
eV
Ratio of spectrum spec_m1_p0_r12-24.PHA to spec_m1_p0_r24-44.PHA

- Flux loss and pile-up was modelled using Jean Ballet pile-up program, together with the 1-D PSF calculated from the encircled energy CCF file and the pattern distribution at 1.5 keV
- Incoming flux was adjusted so that modelled observed rate equals the actual value of ~ 6 / frame

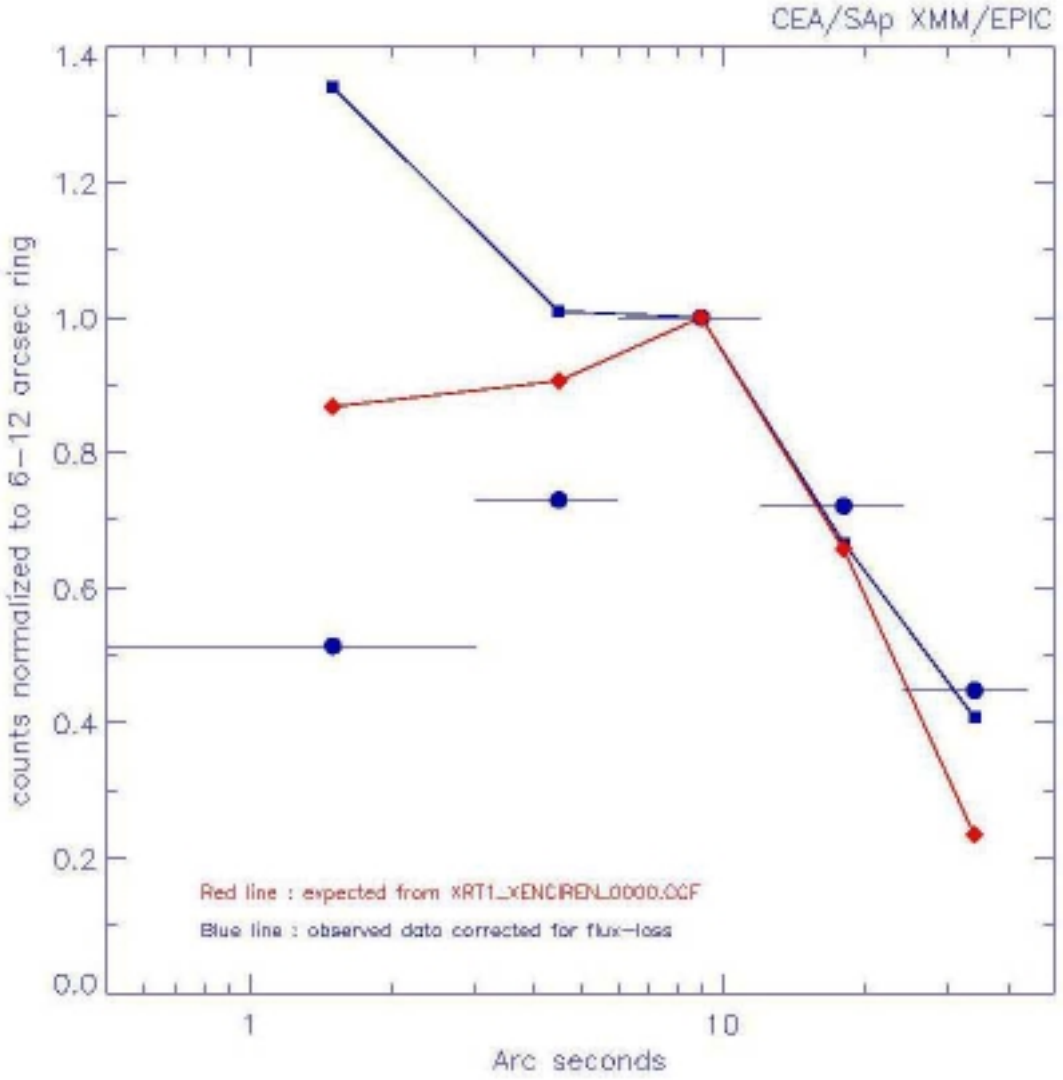


Numerical results from model are :

- Incident flux of 8.0 cts/frame needed to get 6.2 cts/frame detected, i.e. that the average flux loss is ~ 22 %for all patterns

- Pile-up and flux loss dependence for mono-pixels can be large :

Ring (arcsec)	piled-up fraction	flux-loss
central pixel	16.9 %	98.8 %
0.0 - 3.3	3.4 %	65.2 %
3.3 - 5.5	1.7 %	34.4 %
5.5 - 12.1	0.39 %	9.2 %
12.1 - 24.2	0.067 %	1.6 %
24.2 - 44.0	0.0074 %	0.2 %


CEA/SAp XMM/EPIC
counts normalized to 6-12 arcsec ring
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1
10
Arc seconds
Red line : expected from XRT1_XENCIRCLE_0000.CCF
Blue line : observed data corrected for flux-loss

Conclusions

- Spectral distorsion strong even when pattern 0 selected
- The energy dependence of the encircled energy CCF function does not seem to fit these data - A flatter energy dependence in the wings would do better…
- The first rough attempt to use Jean's model looks promising, at least for flux loss corrections.
- Pile-up is essentially a local effect, and a good 2-D PSF description is needed to go further in modelling.
- Work need to be redone on more sources...