

## GRB210619B – ASIM spectral analysis

V3 – M. Marisaldi, UiB, 01/07/22

**Change with respect to v2: used correct response matrix. The correct ASIM DRM to be used is HED\_drm\_mats\_135.00\_-135.00.txt**

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### Text for the paper:

#### ASIM spectral analysis.

Figure X1 shows the light curve of ASIM HED data. Because of the characteristics of the ASIM trigger logic, only part of the burst has been collected. A data gap is evident between 4.5 and 8 seconds after  $T_0$ . Only limited data are available prior to  $T_0$ , therefore the background estimation for spectral analysis is based on the data in the time interval  $(-420 \text{ ms}, 0)$  with respect to  $T_0$ . To assess the spectral evolution of the burst, ASIM HED data were divided in seven time intervals, as shown in Figure X1. The choice of the intervals has been made in order to include in separate intervals all the peaks evident in the light curve (intervals 2, 3, 4 and 5). Spectral fitting has been carried out using XSPEC v12.12. To estimate the flux, the convolution model cflux has been used. All time intervals from 1 to 6 can be well fit with a simple power law in the energy range 0.5 to 10 MeV. The best fit parameters and the fluxes in the energy range 0.5 to 10 MeV are shown in Table X2. Figure X3 shows the spectra, data points and best fit models, as well as the residuals for all intervals. The time-resolved spectral analysis shows evidence for hard to soft evolution.

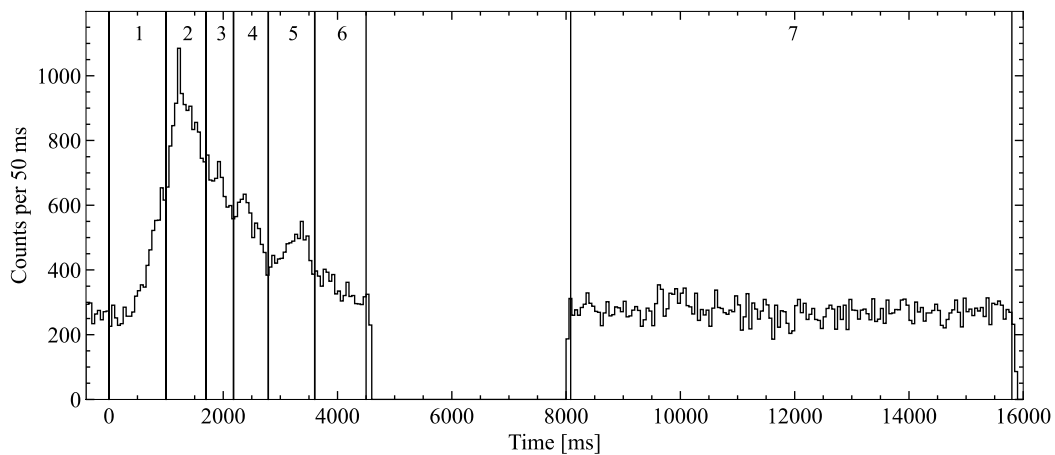


Figure X1. Light curve of the GRB as seen by ASIM. Vertical lines separate the time intervals used for spectral analysis, labeled by numbers on top of the panel.

Table X2. Spectral fit parameters for ASIM data.

Interval	Time interval (s)	Photon Index	$\chi^2$ (d.o.f.)	Flux 0.5 – 10 MeV ( $10^{-5}$ erg/cm <sup>2</sup> s)
1	0.00 – 1.00	$2.11^{+0.12}_{-0.11}$	11.69 (16)	$1.31^{+0.23}_{-0.19}$
2	1.00 – 1.70	$2.254^{+0.032}_{-0.031}$	15.92 (12)	$6.89^{+0.27}_{-0.26}$
3	1.70 – 2.18	$2.493^{+0.062}_{-0.059}$	6.99 (12)	$4.02^{+0.30}_{-0.28}$
4	2.18 – 2.79	$2.604^{+0.089}_{-0.082}$	7.43 (12)	$2.56^{+0.56}_{-0.46}$
5	2.79 – 3.60	$2.56^{+0.11}_{-0.10}$	13.31 (12)	$1.81^{+0.51}_{-0.40}$
6	3.60 – 4.50	$2.97^{+0.37}_{-0.30}$	9.31 (12)	$0.69^{+0.12}_{-0.11}$

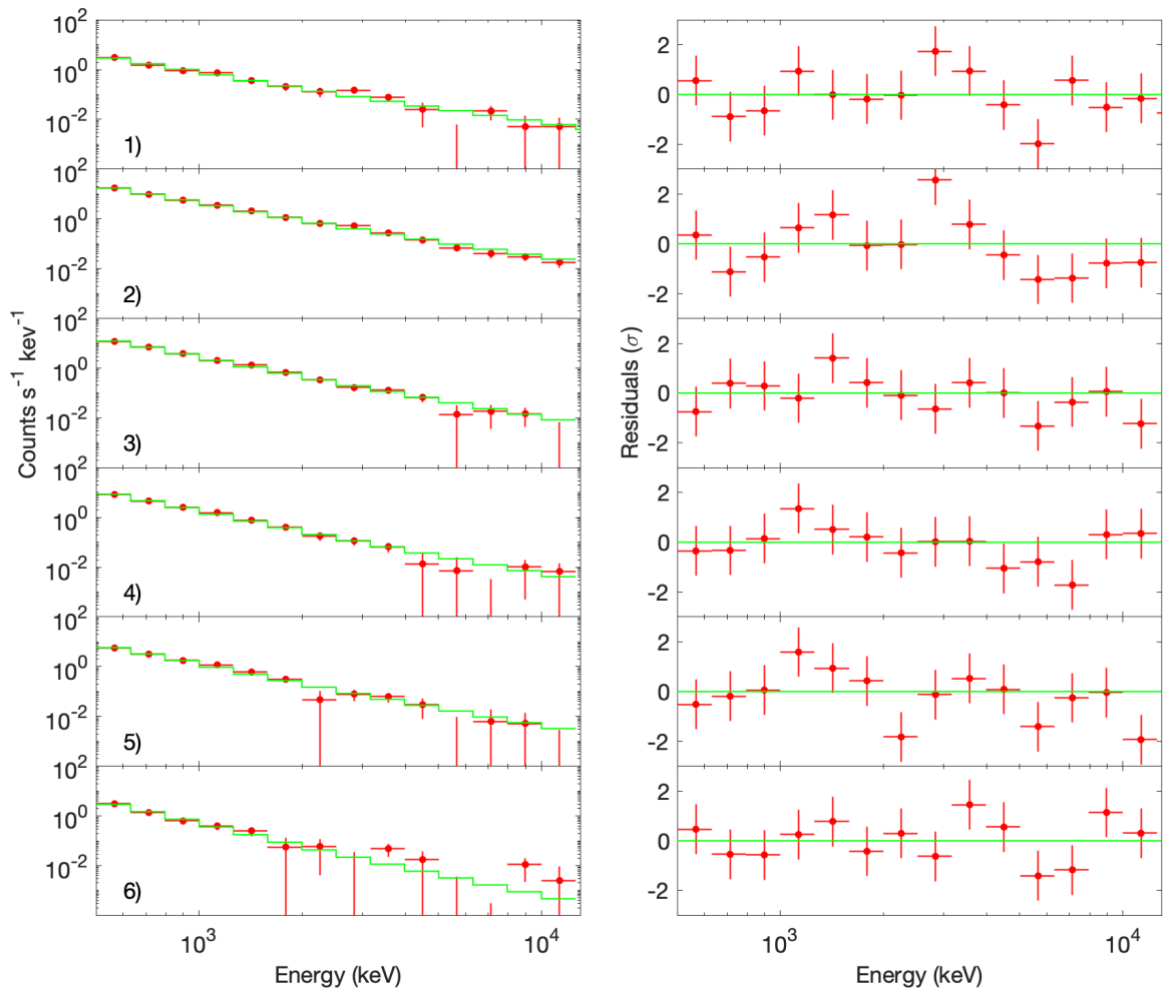


Figure X3. Time resolved spectra for ASIM data. Left panels: data points (red) and best fit power law model (green). The labels indicate the corresponding time interval. Right panels: residuals.

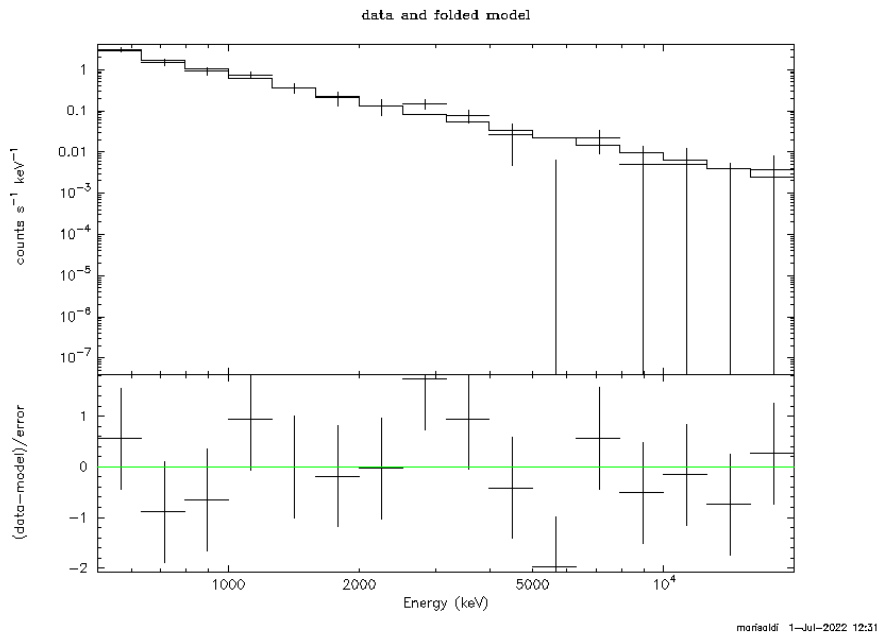
**Support material (not to be included in the paper)**

**Note:** with respect to previous version v1 we have merged intervals 1 and 2 into a single interval (now interval 1). This is because interval 1 was not significant above background. Numbering of all other time intervals must therefore shift back by 1 with respect to version v1 of this document (i.e. interval 3 in previous document is now interval 2, and so on).

The numbering of xspec files is NOT modified. It is now added the interval 1-2, including data for both previous intervals 1 and 2.

**Interval 1 – 0 – 1000 ms – script sp1-2.xcm – best fit model: power law**

(joint previous intervals 1 and 2. Previous Interval 1 had very few counts, nothing significant above 1 sigma when using setplot rebin 1 10)



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Model pegpwlw<1> Source No.: 1 Active/On  
Model Model Component Parameter Unit Value  
par comp  
1 1 pegpwlw PhoIndex 2.10548 +/- 0.115986  
2 1 pegpwlw eMin keV 500.000 frozen  
3 1 pegpwlw eMax keV 2000.00 frozen  
4 1 pegpwlw norm 6.53515E+06 +/- 4.82603E+05

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Fit statistic : Chi-Squared 11.69 using 16 bins.

Test statistic : Chi-Squared 11.69 using 16 bins.

Null hypothesis probability of 6.31e-01 with 14 degrees of freedom

!XSPEC12>plot data delchi

!XSPEC12>error 2.706 1

Parameter Confidence Range (2.706)

1 1.93694 2.31256 (-0.168544,0.207073)

!XSPEC12>error 1. 1

Parameter Confidence Range (1)

1 1.99959 2.22536 (-0.105891,0.119876)

!XSPEC12>flux 500 10000 error 100

Parameter distribution is derived from fit covariance matrix.

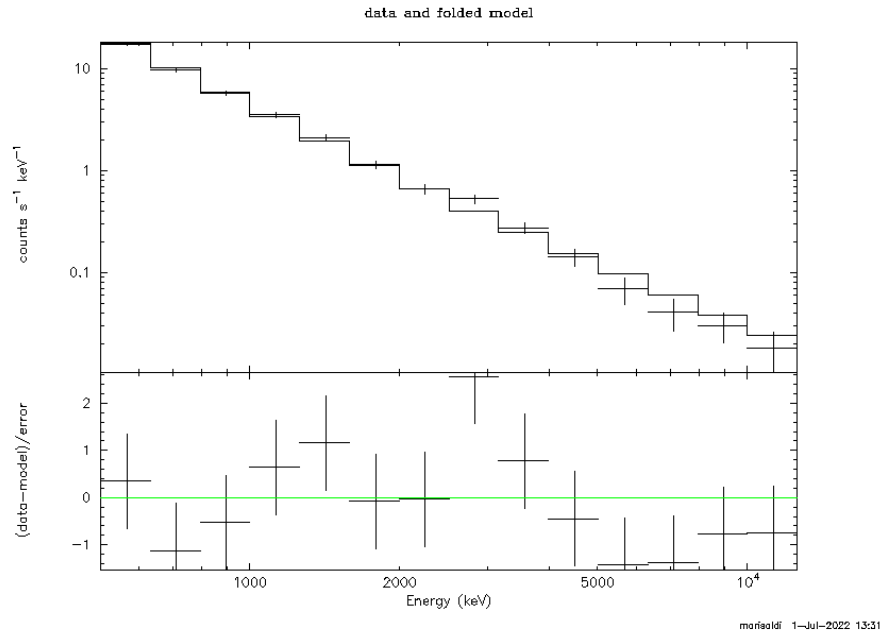
Model Flux 5.5179 photons (1.3142e-05 ergs/cm^2/s) range (500.00 - 10000. keV)

Error range 5.089 - 5.880 (1.188e-05 - 1.439e-05) (68.00% confidence)

Using cflux:

3 1 cflux lg10Flux cgs -4.88401 +/- 6.94507E-02

**Interval 2 – 1000 – 1700 ms – script sp3.xcm – best fit model: single power law**



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=====
Model pegpwlw<1> Source No.: 1 Active/On
Model Model Component Parameter Unit Value
par comp
1 1 pegpwlw PhoIndex 2.25387 +/- 3.26292E-02
2 1 pegpwlw eMin keV 500.000 frozen
3 1 pegpwlw eMax keV 2000.00 frozen
4 1 pegpwlw norm 3.79984E+07 +/- 7.24553E+05
=====

```

Fit statistic : Chi-Squared 15.92 using 14 bins.

Test statistic : Chi-Squared 15.92 using 14 bins.

Null hypothesis probability of 1.95e-01 with 12 degrees of freedom

!XSPEC12>plot data delchi

!XSPEC12>error 2.706 1

Parameter Confidence Range (2.706)

1 2.20282 2.30759 (-0.0510651,0.0537067)

!XSPEC12>error 1. 1

Parameter Confidence Range (1)

1 2.22252 2.28622 (-0.03136,0.0323338)

!XSPEC12>flux 500. 10000. err 100

Parameter distribution is derived from fit covariance matrix.

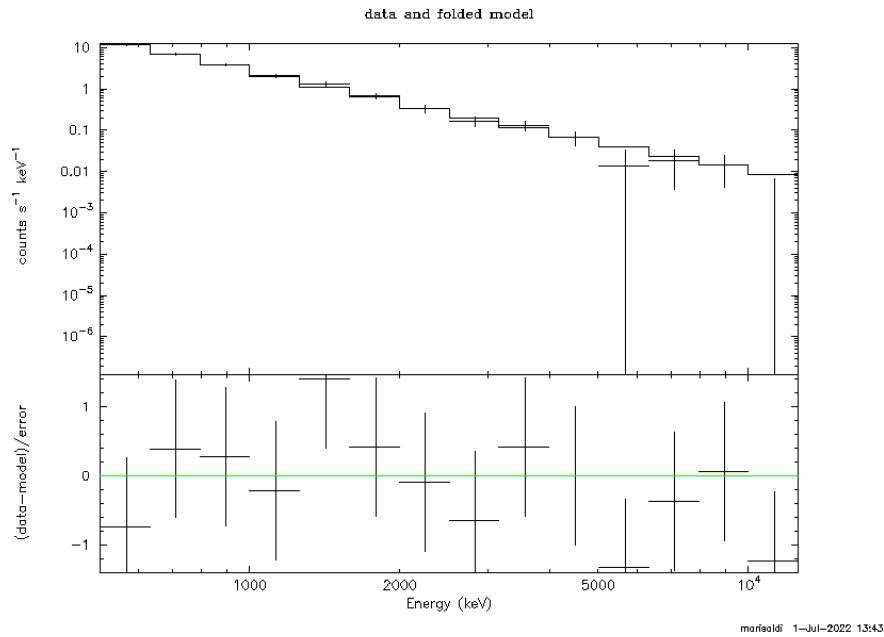
Model Flux 31.647 photons (6.8924e-05 ergs/cm²/s) range (500.00 - 10000. keV)

Error range 31.18 - 32.24 (6.761e-05 - 7.051e-05) (68.00% confidence)

Using cflux

3 1 cflux lg10Flux cgs -4.16163 +/- 1.63991E-02

### Interval 3 – 1700 – 2180 ms – script sp4.xcm – best fit model: single power law




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Model pegpwlw<1> Source No.: 1 Active/On  
Model Model Component Parameter Unit Value  
par comp  
1 1 pegpwlw PhoIndex 2.49343 +/- 6.30887E-02  
2 1 pegpwlw eMin keV 500.000 frozen  
3 1 pegpwlw eMax keV 2000.00 frozen  
4 1 pegpwlw norm 2.55093E+07 +/- 7.29244E+05

---

Fit statistic : Chi-Squared 6.99 using 14 bins.

Test statistic : Chi-Squared 6.99 using 14 bins.

Null hypothesis probability of 8.58e-01 with 12 degrees of freedom

!XSPEC12>plot data delchi

!XSPEC12>error 2.706 1

Parameter Confidence Range (2.706)

1 2.39803 2.59741 (-0.0953868,0.103994)

!XSPEC12>error 1. 1

Parameter Confidence Range (1)

1 2.4346 2.55552 (-0.0588215,0.0621063)

!XSPEC12>flux 500. 10000. err 100

Parameter distribution is derived from fit covariance matrix.

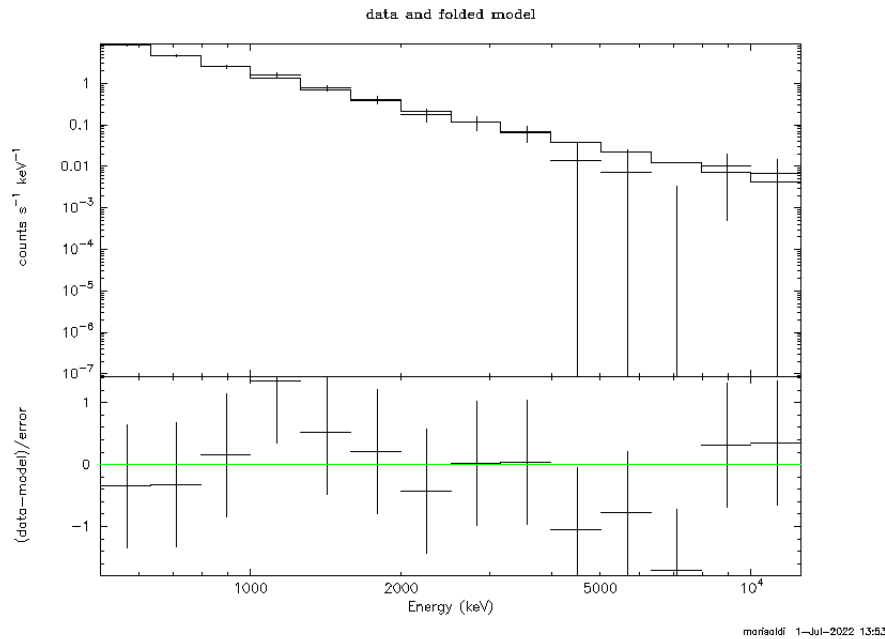
Model Flux 21.021 photons (4.0211e-05 ergs/cm²/s) range (500.00 - 10000. keV)

Error range 20.47 - 21.63 (3.857e-05 - 4.204e-05) (68.00% confidence)

Flux using cflux:

3 1 cflux lg10Flux cgs -4.39565 +/- 3.10325E-02

**Interval 4 – 2180 – 2790 ms – script sp5.xcm – best fit model: single power law**




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Model pegpwlw<1> Source No.: 1 Active/On

Model Model Component Parameter Unit Value

par comp

1	1	pegpwlw	PhoIndex	2.60404	+/- 9.00809E-02
2	1	pegpwlw	eMin	keV	500.000 frozen
3	1	pegpwlw	eMax	keV	2000.00 frozen
4	1	pegpwlw	norm		1.71693E+07 +/- 6.06540E+05

---

Fit statistic : Chi-Squared 7.43 using 14 bins.

Test statistic : Chi-Squared 7.43 using 14 bins.

Null hypothesis probability of 8.28e-01 with 12 degrees of freedom

!XSPEC12>plot data delchi

!XSPEC12>error 2.706 1

Parameter Confidence Range (2.706)

1 2.47094 2.75306 (-0.133074,0.149044)

!XSPEC12>error 1. 1

Parameter Confidence Range (1)

1 2.52166 2.69253 (-0.0823509,0.0885192)

!XSPEC12>flux 500. 10000. err 100

Parameter distribution is derived from fit covariance matrix.

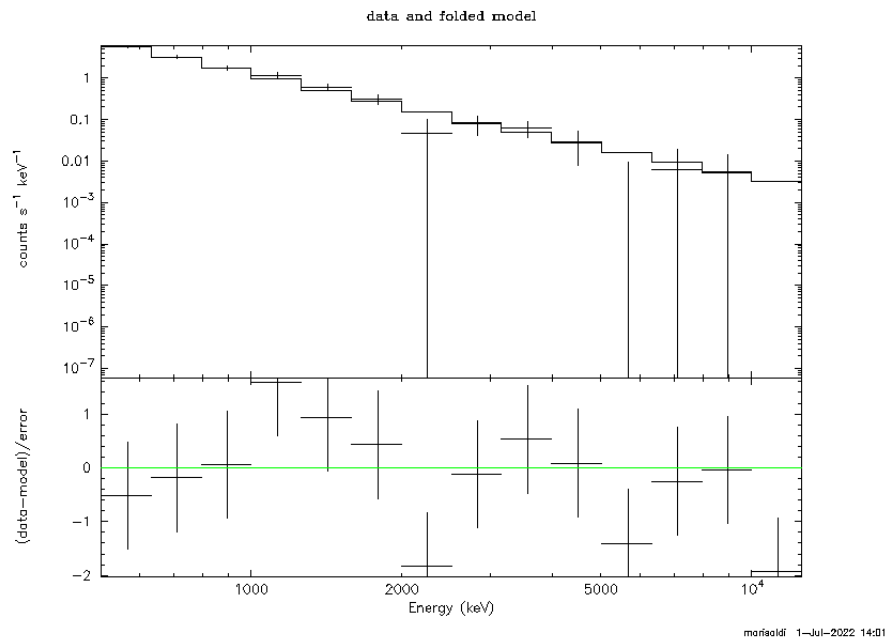
Model Flux 14.134 photons (2.5627e-05 ergs/cm²/s) range (500.00 - 10000. keV)

Error range 13.61 - 14.67 (2.443e-05 - 2.702e-05) (68.00% confidence)

Using cflux:

3 1 cflux lg10Flux cgs -4.59131 +/- 8.53321E-02

**Interval 5 – 2790 – 3600 ms – script sp6.xcm – best fit model: single power law**



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=====
Model pegpwlw<1> Source No.: 1 Active/On
Model Model Component Parameter Unit Value
par comp
1 1 pegpwlw PhoIndex 2.55929 +/- 0.112568
2 1 pegpwlw eMin keV 500.000 frozen
3 1 pegpwlw eMax keV 2000.00 frozen
4 1 pegpwlw norm 1.19001E+07 +/- 5.21766E+05
=====

```

Fit statistic : Chi-Squared 13.31 using 14 bins.

Test statistic : Chi-Squared 13.31 using 14 bins.

Null hypothesis probability of 3.47e-01 with 12 degrees of freedom

!XSPEC12>plot data delchi

!XSPEC12>error 2.706 1

Parameter Confidence Range (2.706)

1 2.39987 2.74237 (-0.159174,0.183323)

!XSPEC12>error 1. 1

Parameter Confidence Range (1)

1 2.45979 2.66725 (-0.0992525,0.108207)

!XSPEC12>flux 500. 10000. err 100

Parameter distribution is derived from fit covariance matrix.

Model Flux 9.7982 photons (1.8147e-05 ergs/cm²/s) range (500.00 - 10000. keV)

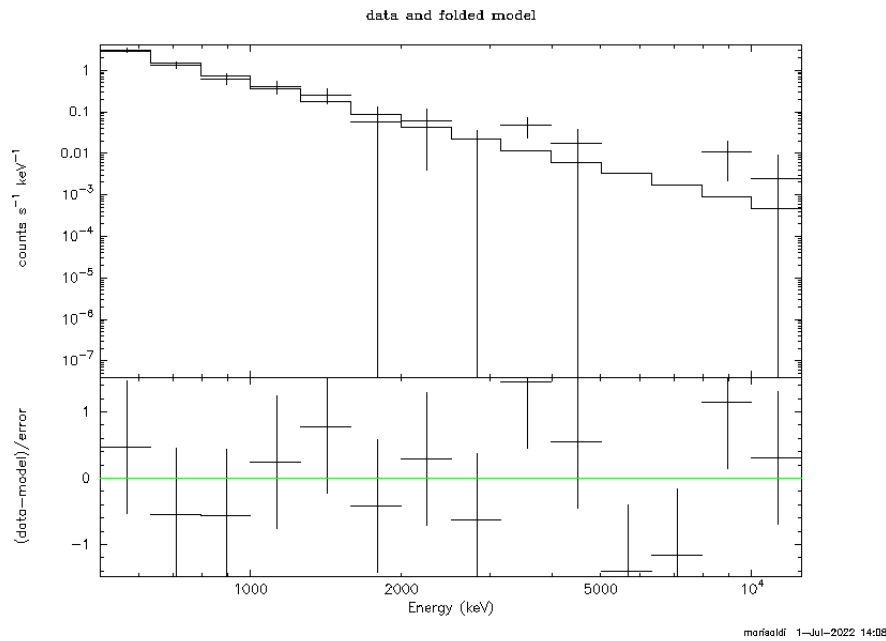
Error range 9.426 - 10.23 (1.709e-05 - 1.936e-05) (68.00% confidence)

Using cflux:

3 1 cflux lg10Flux cgs -4.74119 +/- 0.108273



**Interval 6 – 3600 – 4500 ms – script sp7.xcm – best fit model: single power law**



Model pegpwlw<1> Source No.: 1 Active/On

Model Model Component Parameter Unit Value

par comp

1	1	pegpwlw	PhoIndex	2.96834	+/- 0.309137
2	1	pegpwlw	eMin	keV	500.000 frozen
3	1	pegpwlw	eMax	keV	2000.00 frozen
4	1	pegpwlw	norm		5.28546E+06 +/- 4.82100E+05

Fit statistic : Chi-Squared 9.31 using 14 bins.

Test statistic : Chi-Squared 9.31 using 14 bins.

Null hypothesis probability of 6.76e-01 with 12 degrees of freedom

!XSPEC12>plot data delchi

!XSPEC12>error 2.706 1

Parameter Confidence Range (2.706)

1 2.5084 3.62259 (-0.460104,0.654082)

!XSPEC12>error 1. 1

Parameter Confidence Range (1)

1 2.6725 3.33438 (-0.296029,0.365855)

!XSPEC12>flux 500. 10000. err 100

Parameter distribution is derived from fit covariance matrix.

Model Flux 4.3903 photons (6.8569e-06 ergs/cm²/s) range (500.00 - 10000. keV)

Error range 4.068 - 4.864 (5.889e-06 - 8.392e-06) (68.00% confidence)

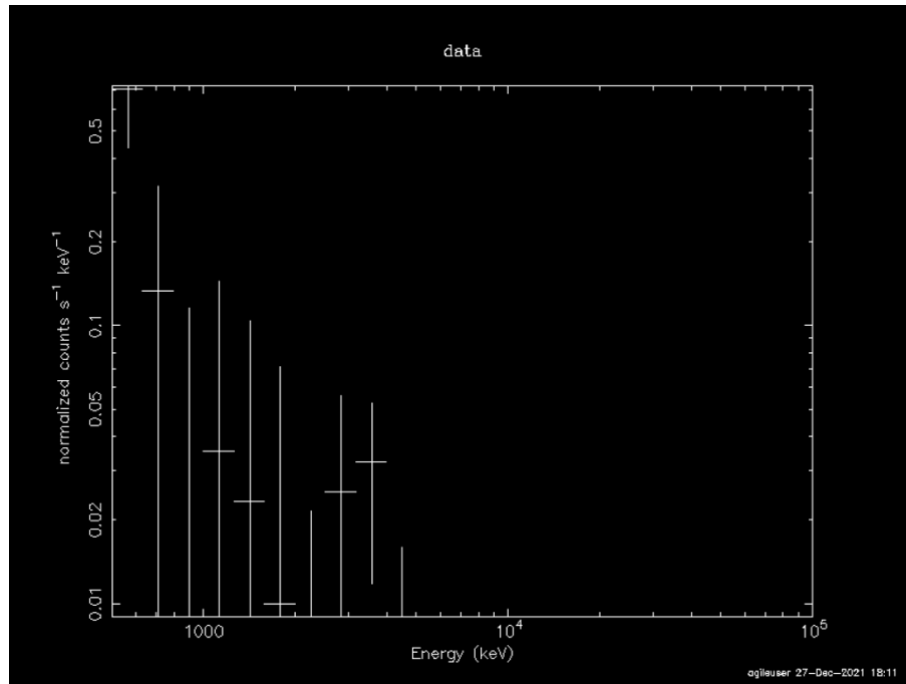
**Note: this spectrum should be rebinned above 1.5 MeV**

Using cflux

3 1 cflux lg10Flux cgs -5.16224 +/- 7.23888E-02

**Interval 8 – 8080 – 15800 ms – script sp8.xcm**

**No significant signal to fit.**



**Using setplot rebin 1 10 1 shows significant only the bin at 500-600 keV**

