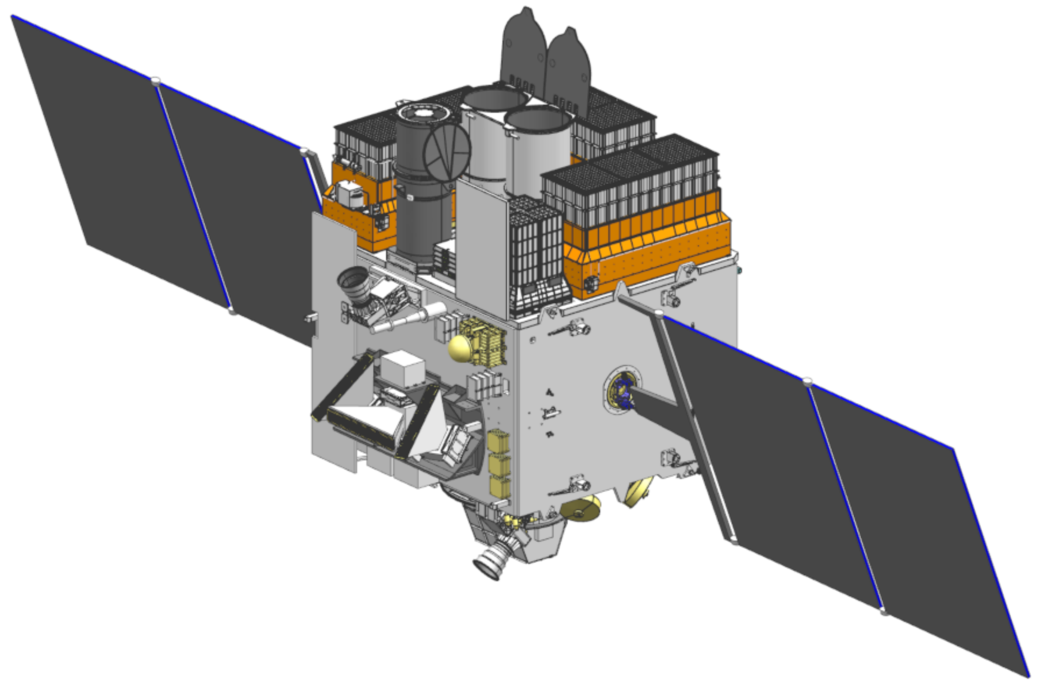
Advanced AstroSAT data analysis workshop

Study of temporal and spectral behaviour of Blazar 1ES 0229+200

With

AstroSAT

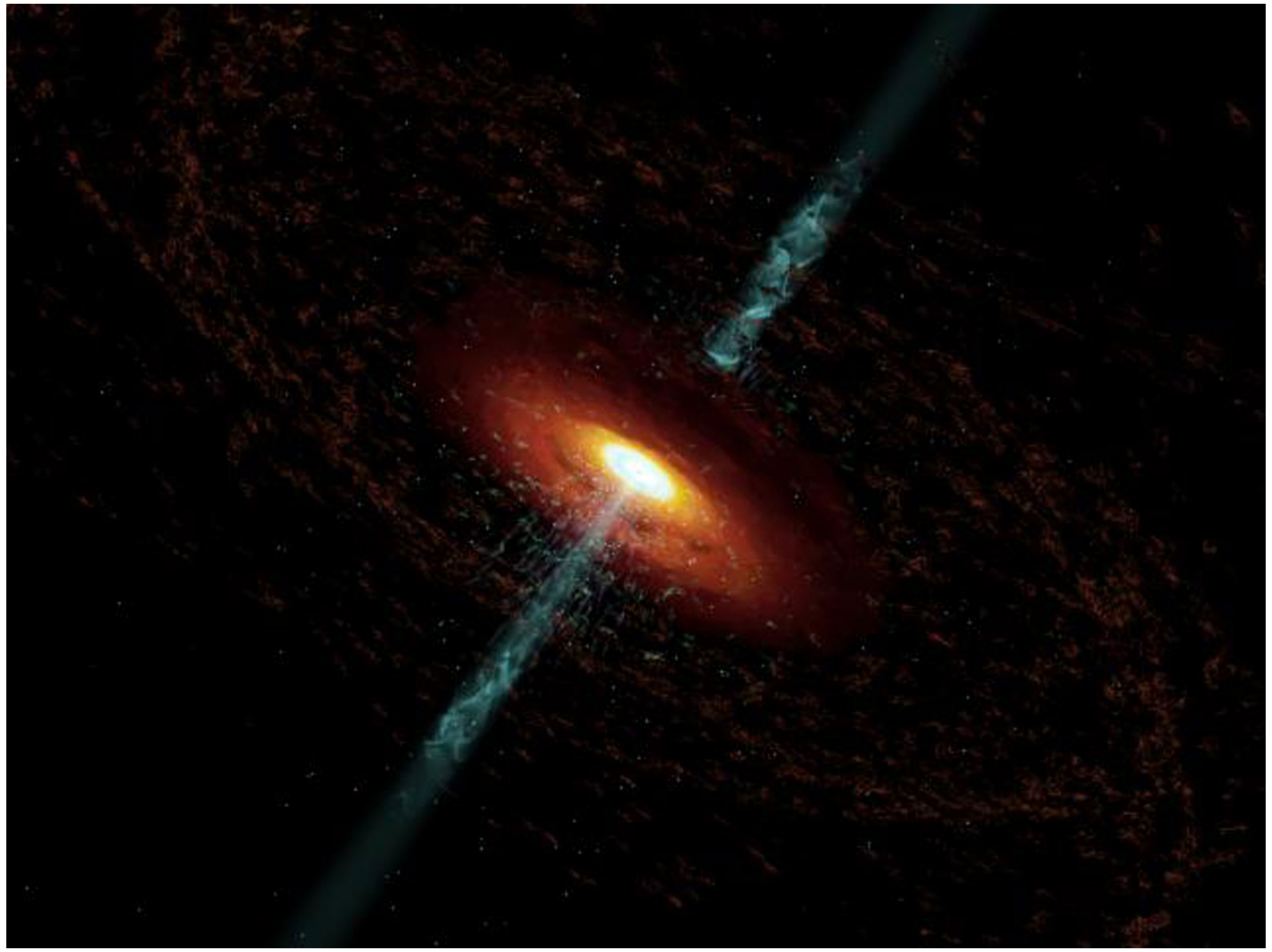


Javaid Tantray, Hritwik Bora, Ajay Sharma, Dr. Zahir Shah

Jan 15th, 2023

Contents

What are the Active Galaxies and Normal Galaxies ?



Normal Galaxy	Active Galaxy
It has a dormant SMBH at its center which is not accreting matter from it surroundings.	Active supermassive black hole at the center of galaxy, accreting matter from its surrounding due to its high gravitational field.

Blazar

- A blazar is an AGN with a relativistic jet aligned to the line of site of observer.
- Relativistic beaming of electromagnetic radiation from the jet makes blazar appear much brighter.
- Highly variable source, often undergo rapid or dramatic fluctuation in brightness in short time scales (hours to days).
- Blazar also exhibit apparent superluminal motion.

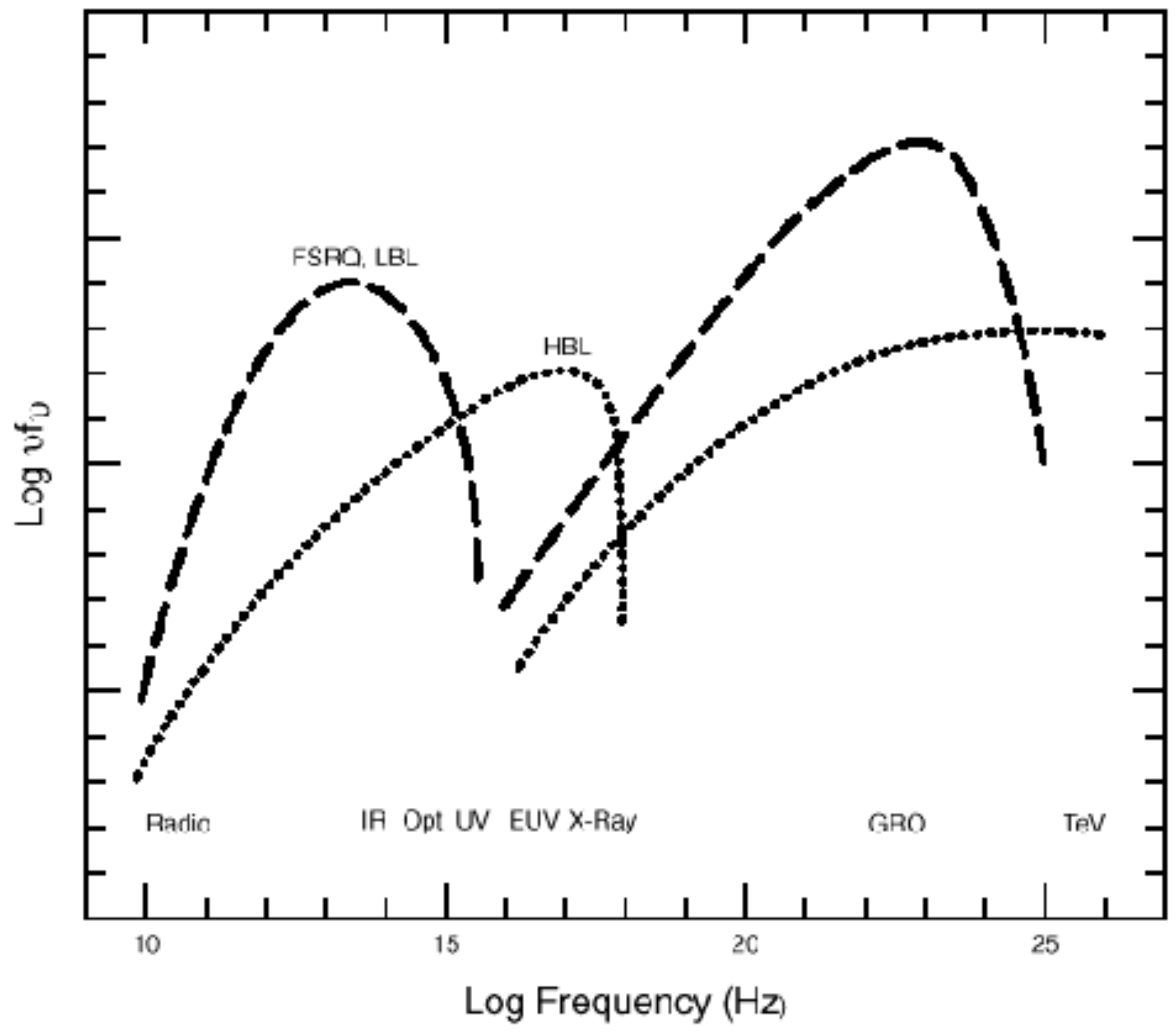
$$L_{app} = \delta^4 L$$
$$\delta = \gamma^{-1}/(1 - \beta cos\theta)$$
$$\beta_{app} = \beta sin\theta/(1 - \beta cos\theta)$$

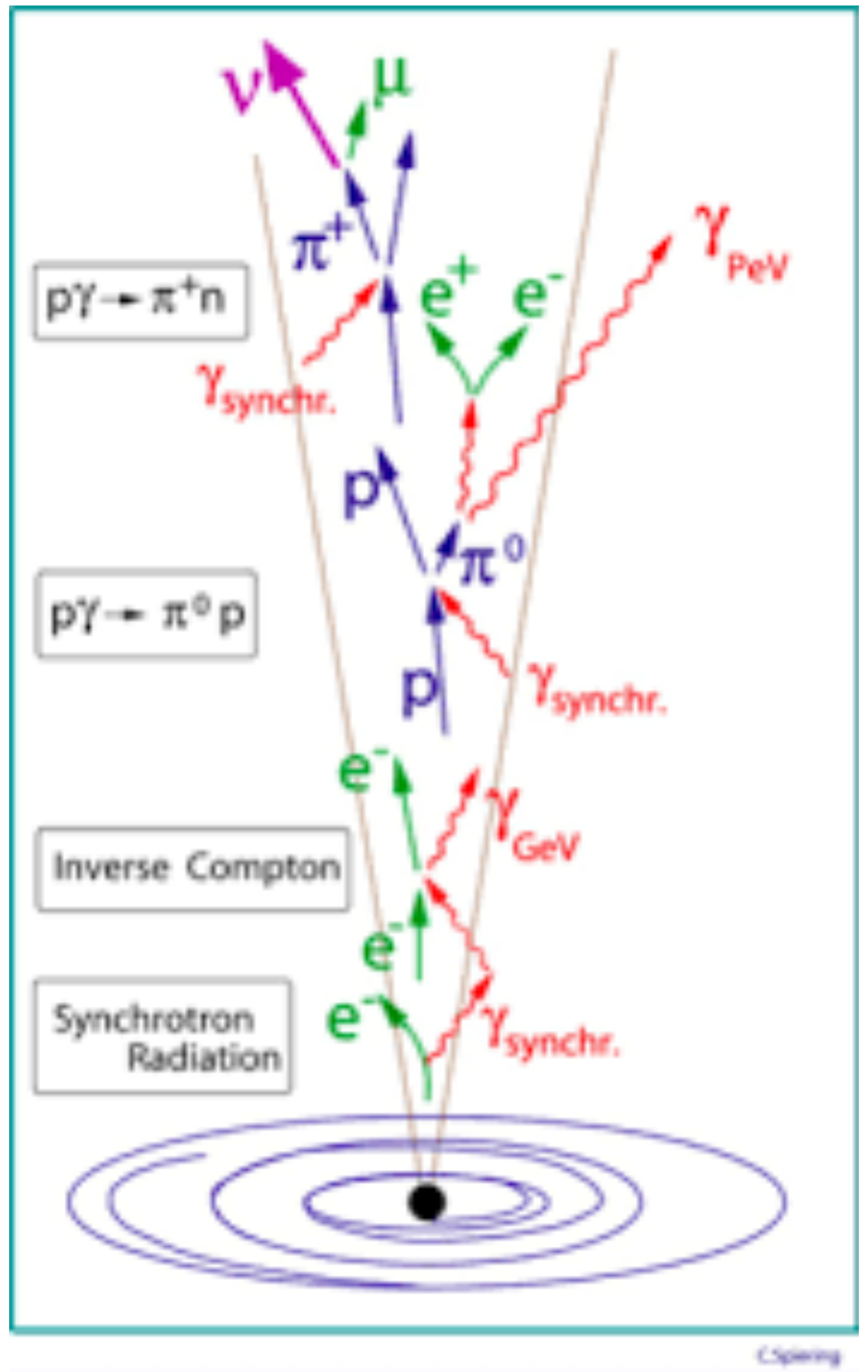
✸ Types of Blazars:

<u>BL Lacertae</u>	<u>Flat Spectrum Radio Quasar</u>
Featureless or absent emission lines in their spectra	Strong broad emission lines present in their spectra
BL Lac objects are often divided two classes according to the position of the location of the peak in their spectral distribution	

Properties of Blazar

- Basic characteristics of blazars are double hump structure in their spectral energy distribution (SED), where lower-frequency peak at radio-to-x-ray energies and a high-frequency peak at x-ray-to γ-gamma energies.





- Most of the radiation is emitted by non-thermal processes

A. First hump is generally produced by the synchrotron process.

B. Second hump: we have two possible models which are responsible for the 2nd hump.

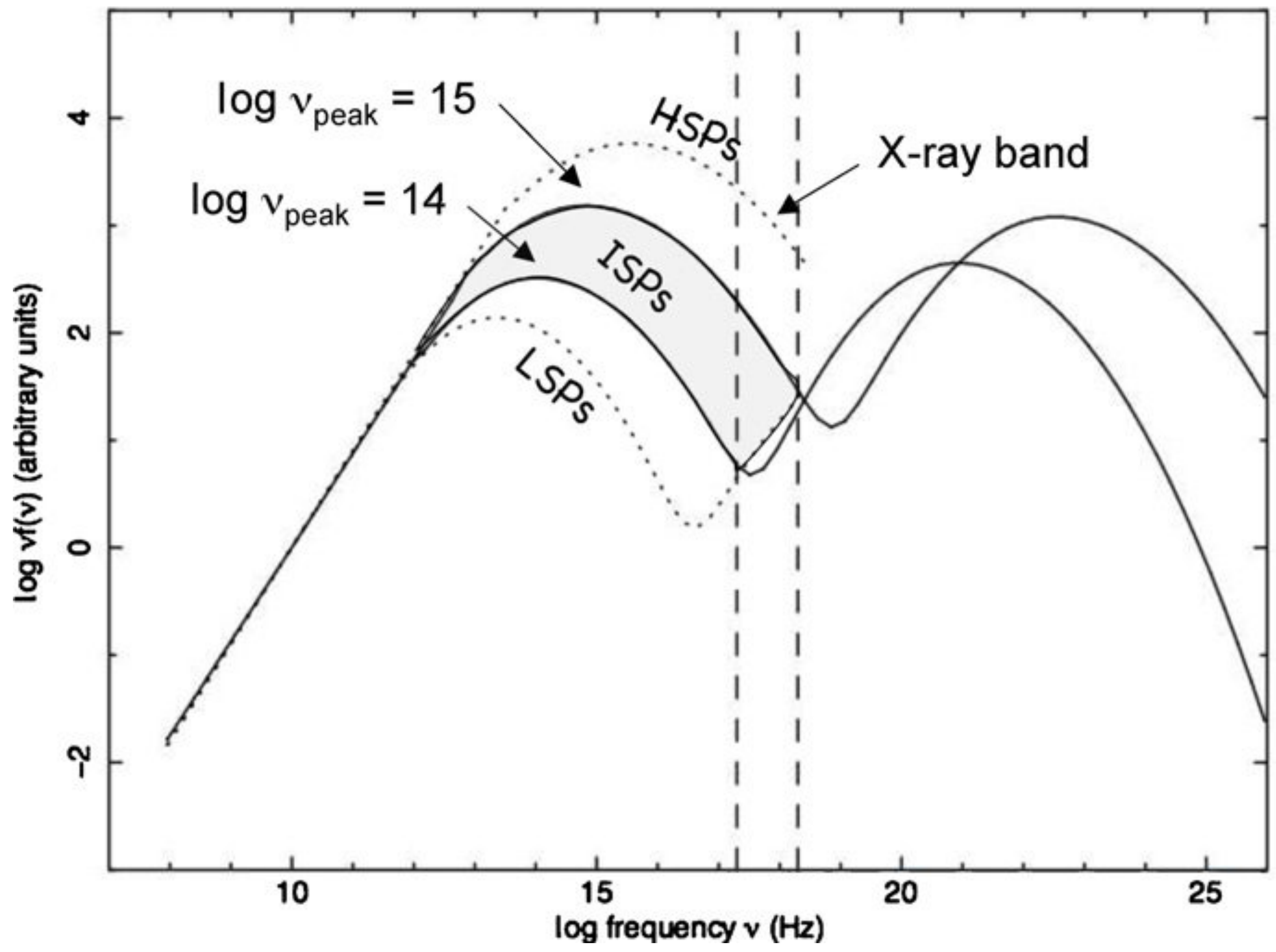
Laptonic models

Hadronic models

Type of Blazar

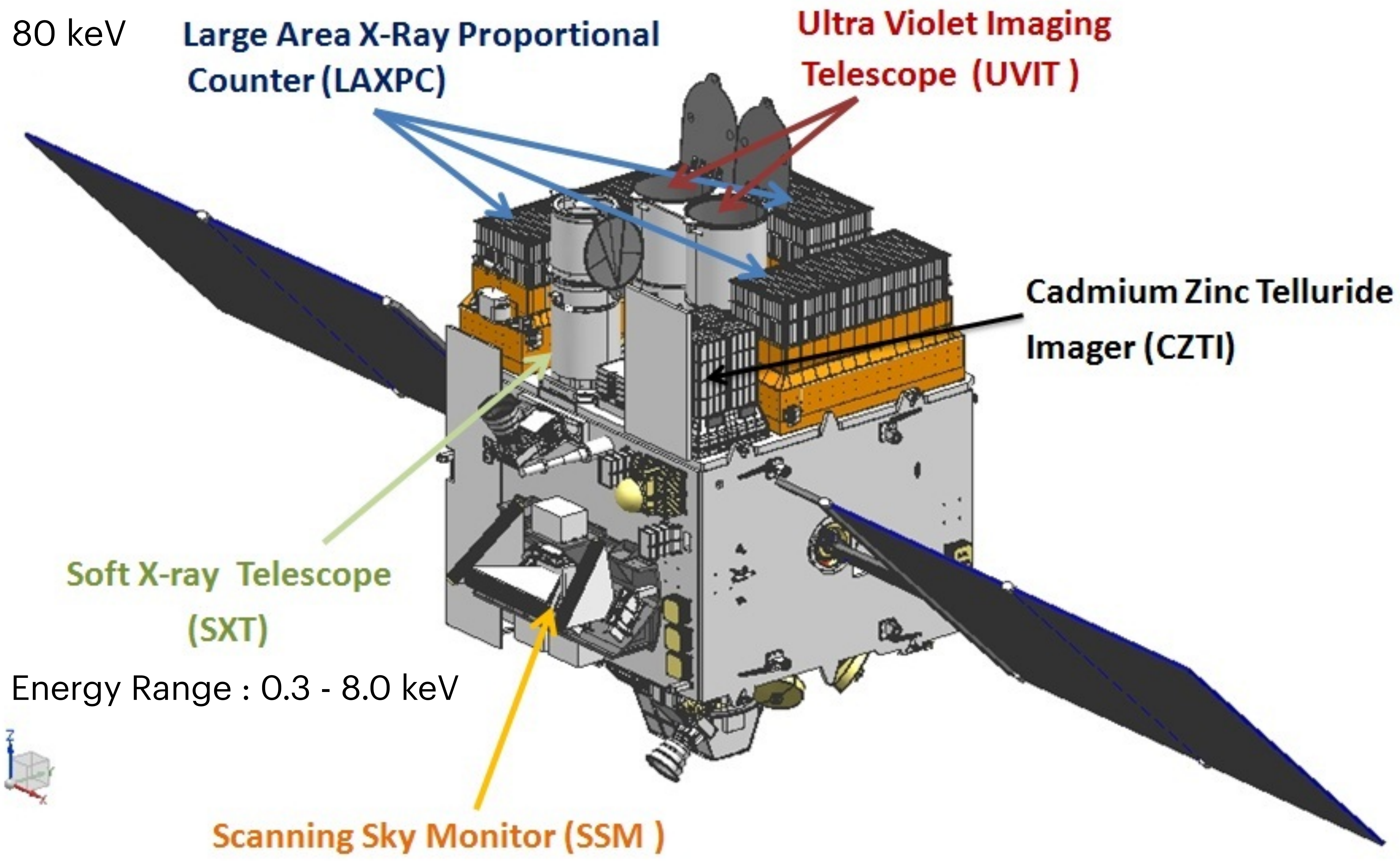
❋ Based on the position of the first hump (synchrotron peak), we can further classify blazars into subgroups:

- Low-frequency peaked blazar.
- Intermediate-frequency peaked blazar.
- High-frequency peaked blazar.



AstroSAT observatory

Energy Range : 3 - 80 keV

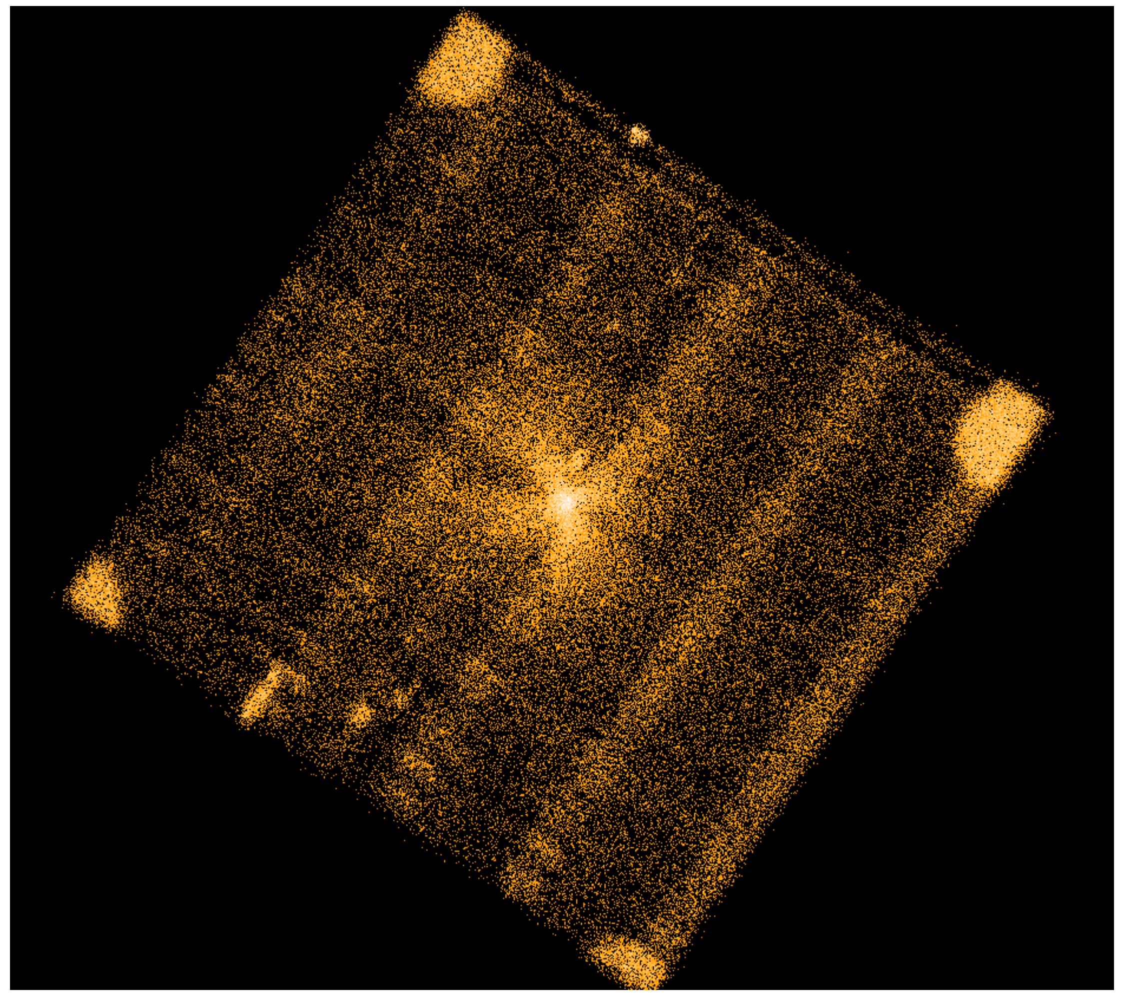


Energy Range : 0.3 - 8.0 keV

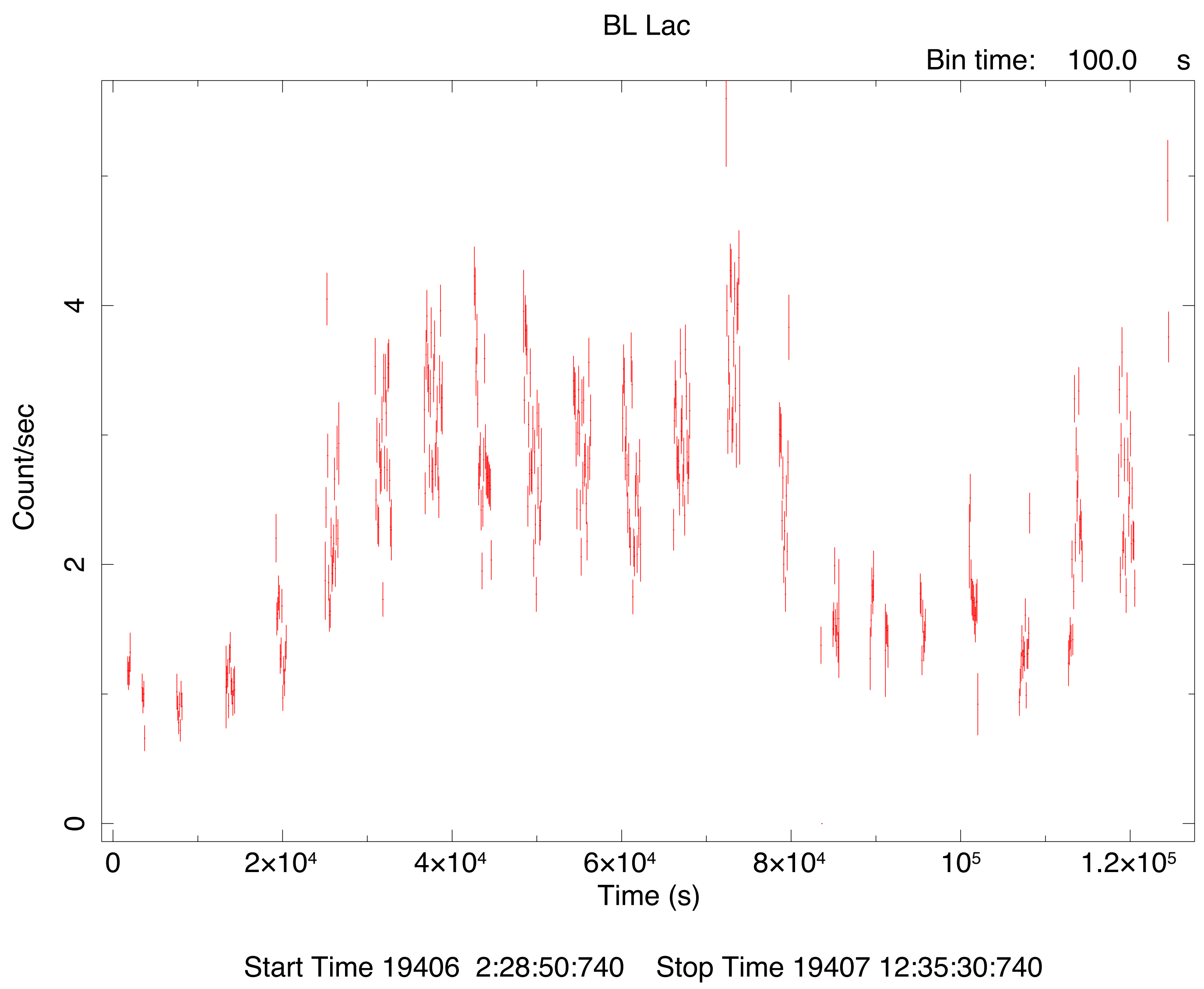
BL Lac

✷ Basic Details:

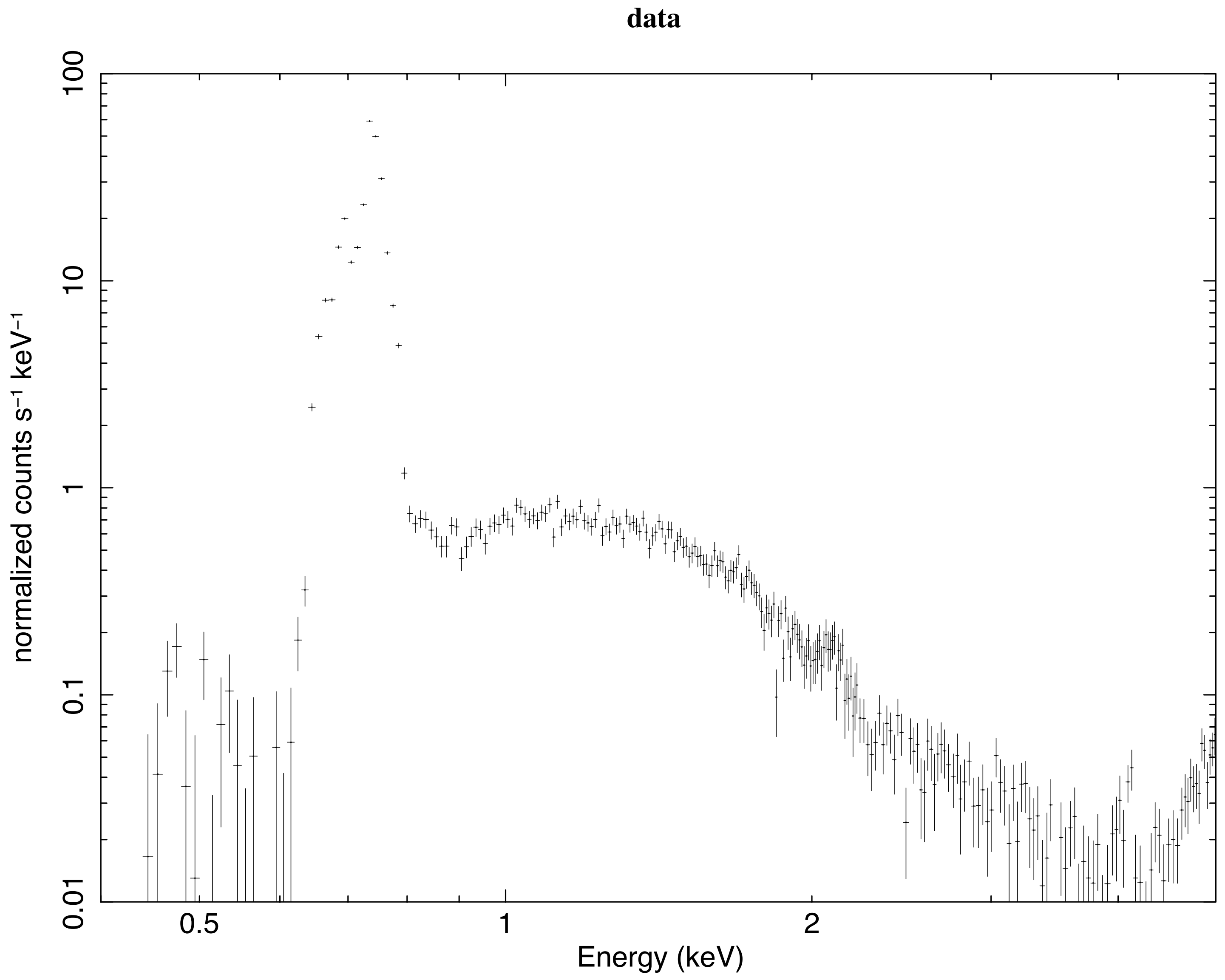
- 4FGL J2202.7+4216
- Redshift : 0.069
- Located at ->   Ra : 330.68 Dec : 42.2778
- Observed time duration : 11-07-2021 (29873 sec.)



✷Light curve



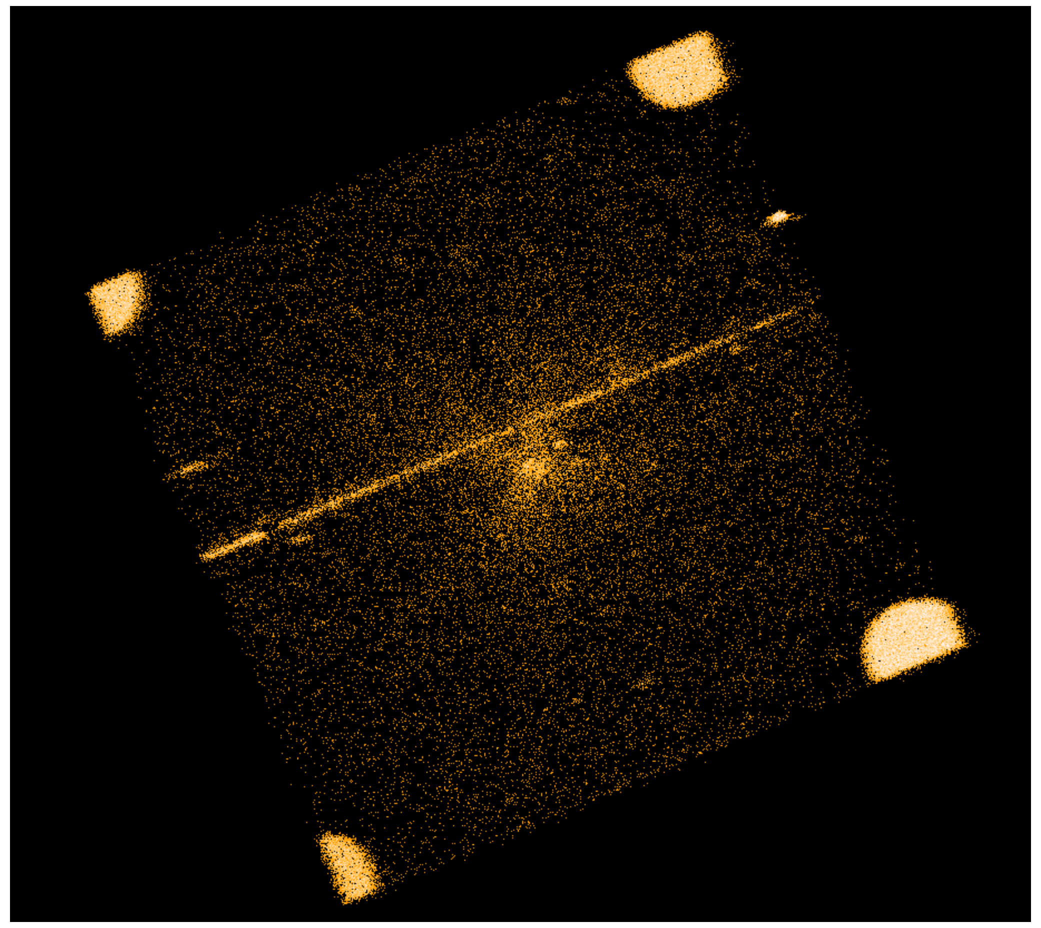
✷ SED



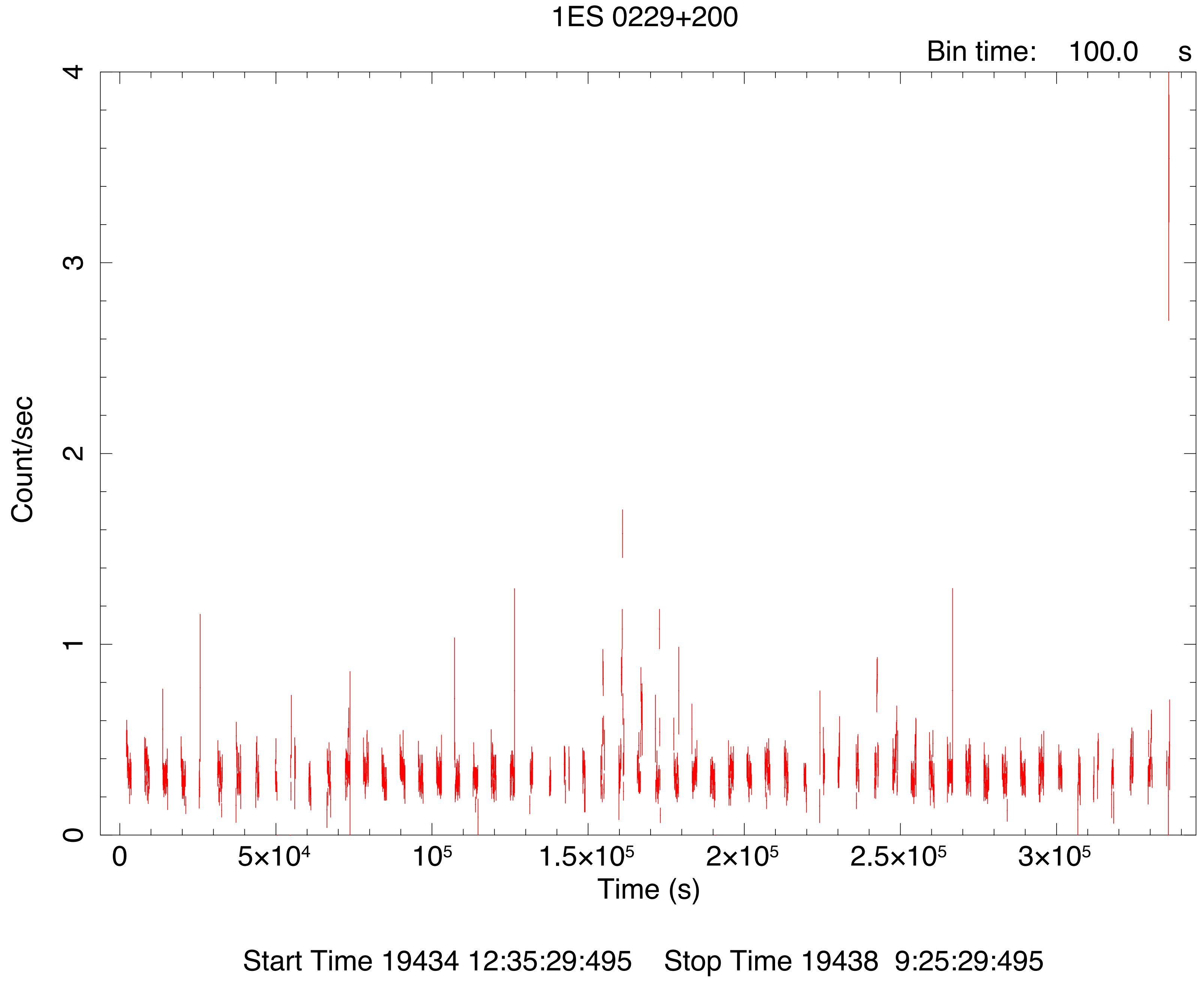
1ES 0229+200

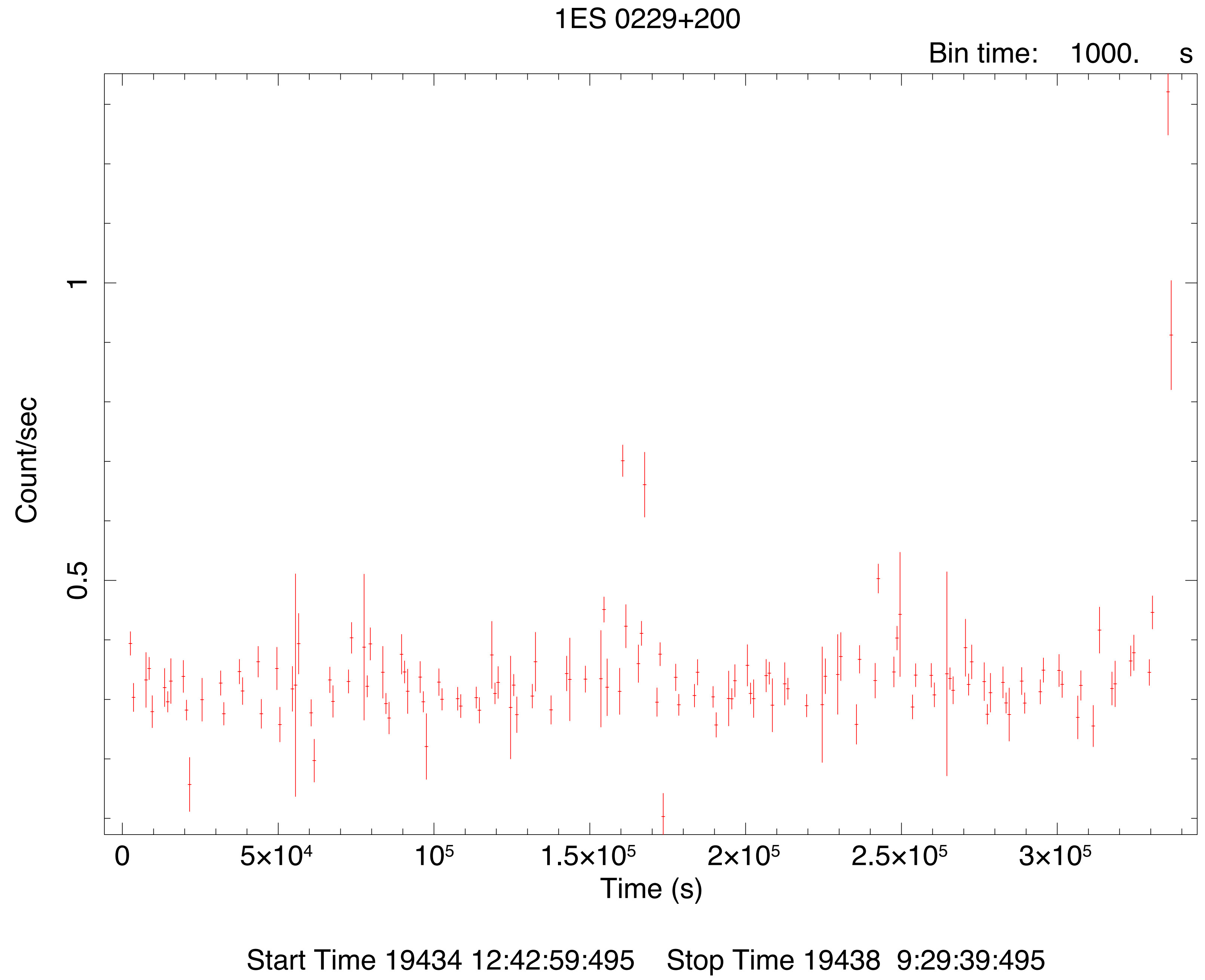
❋ Basic Details :

- 4FGL J0232.8+2018
- Redshift : 0.14
- Located at -> Ra : 38.2026 Dec : 20.2882
- Observed time duration : 2021-08-07 to 15-08-2021



❋ SXT light curve:





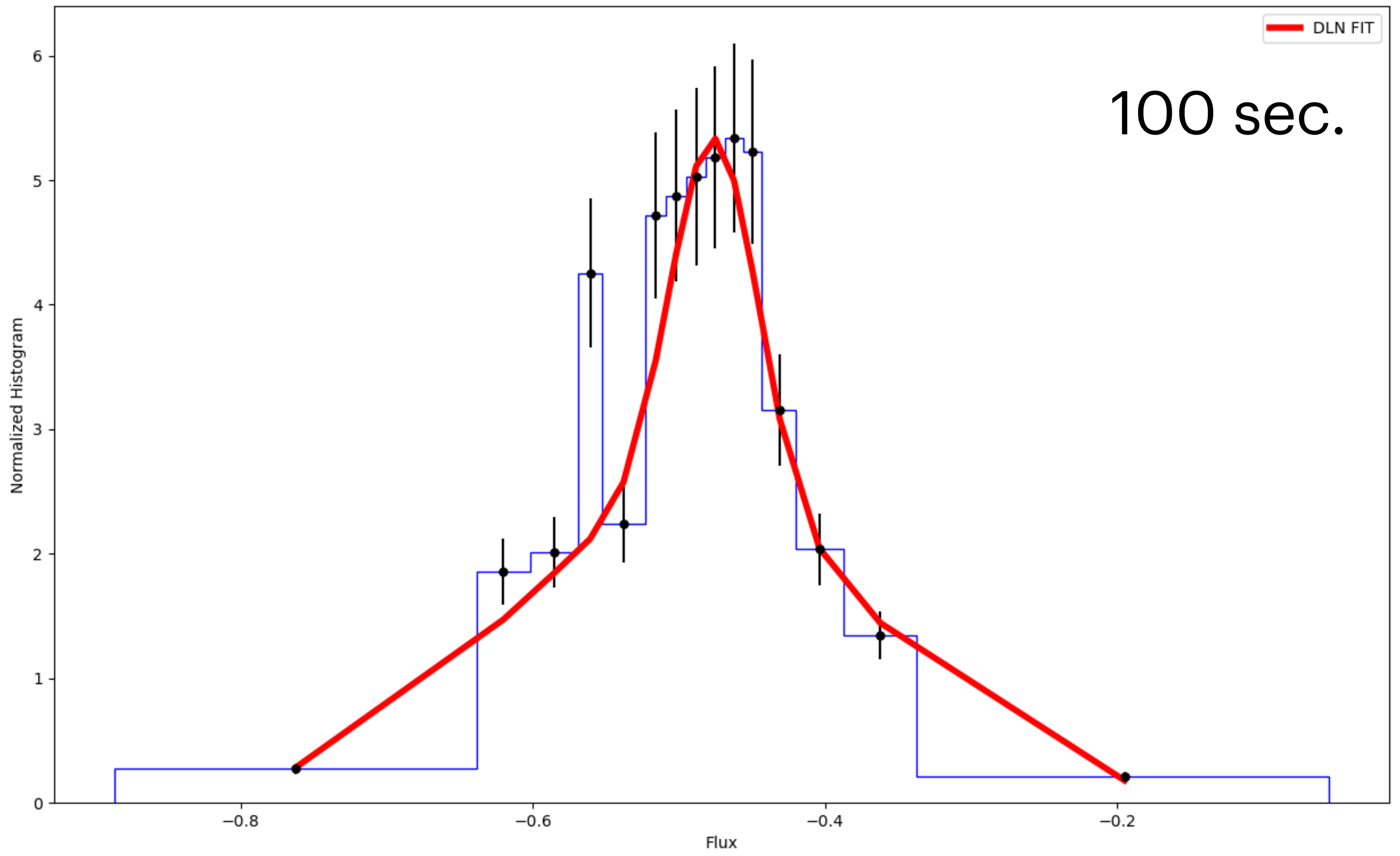
- # Flux Distribution SXT light curve:-

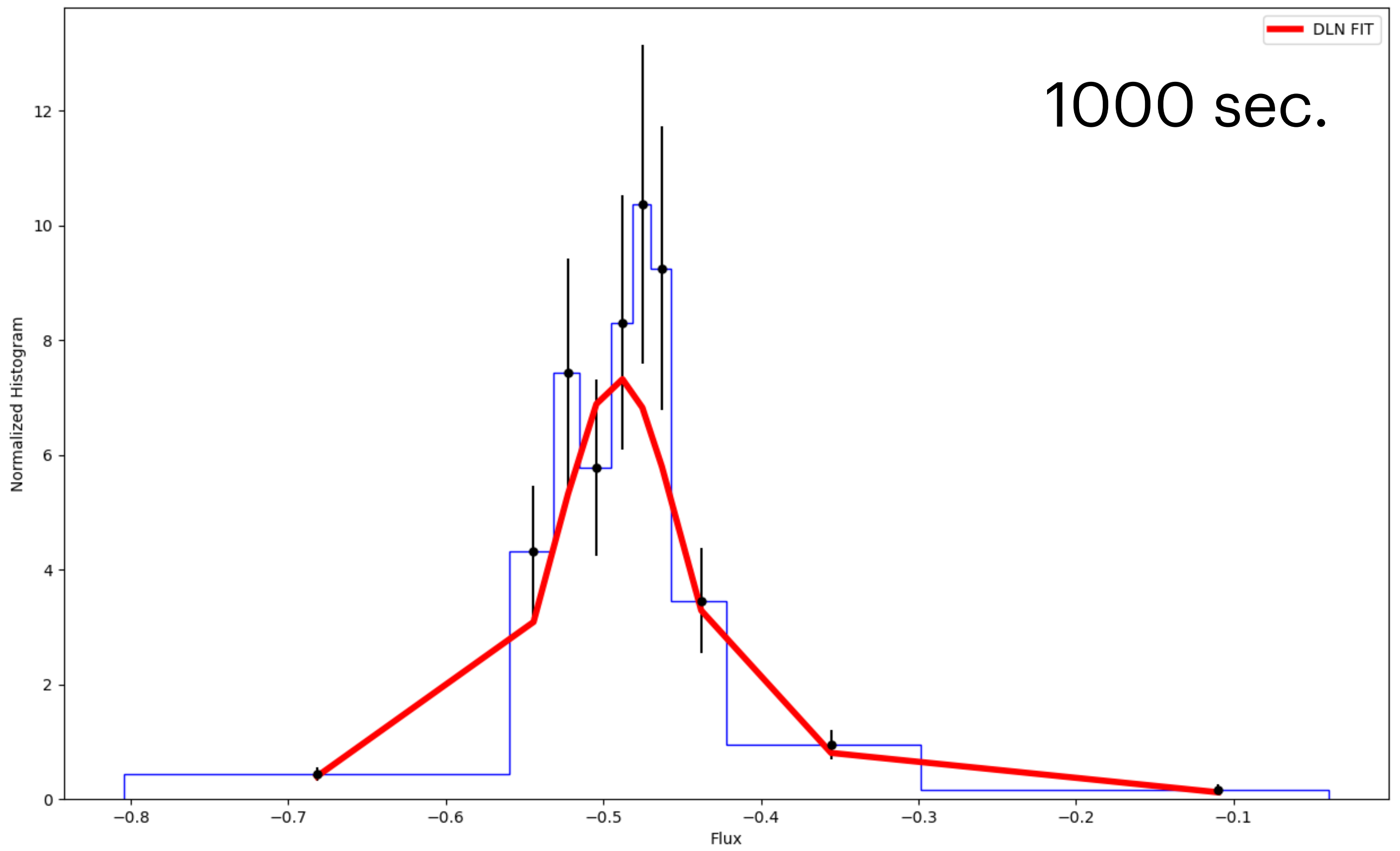
```
Skewness and AD test values for normal and lognormal distribution.

skewness of sxt flux dist and error 3.7425208358822393 0.43133109281375365
skewness of  sxt  log-flux 1.322790813691468 0.43133109281375365

AD test of sxt flux dist AndersonResult(statistic=9.416713616957935, critical_values=array([0.559, 0.637, 0.764, 0.892, 1.061]),
significance_level=array([15. , 10. ,  5. ,  2.5,  1. ]))
AD test of sxt log flux AndersonResult(statistic=4.419114165671232, critical_values=array([0.559, 0.637, 0.764, 0.892, 1.061]),
significance_level=array([15. , 10. ,  5. ,  2.5,  1. ]))
```

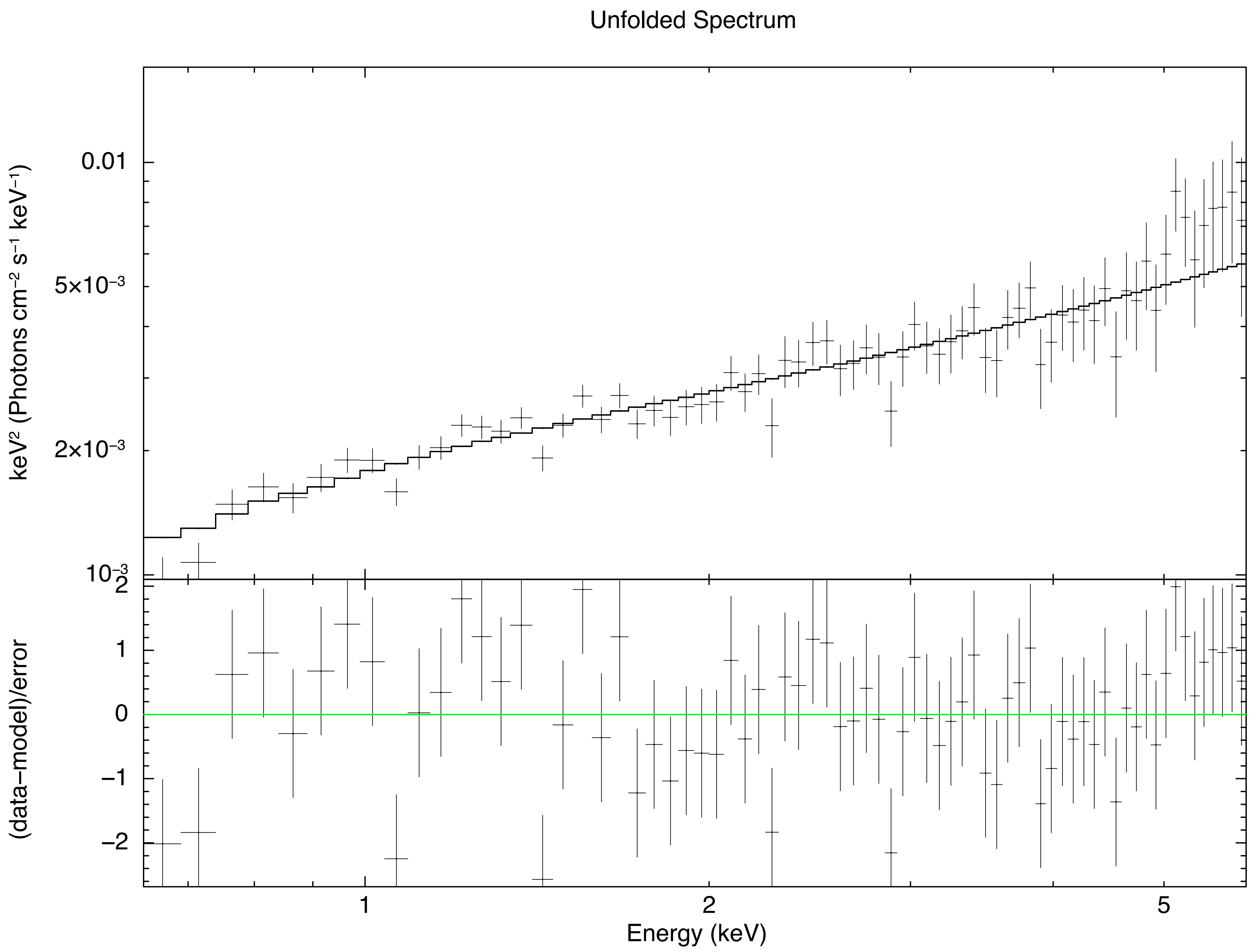
- Double log normal distribution

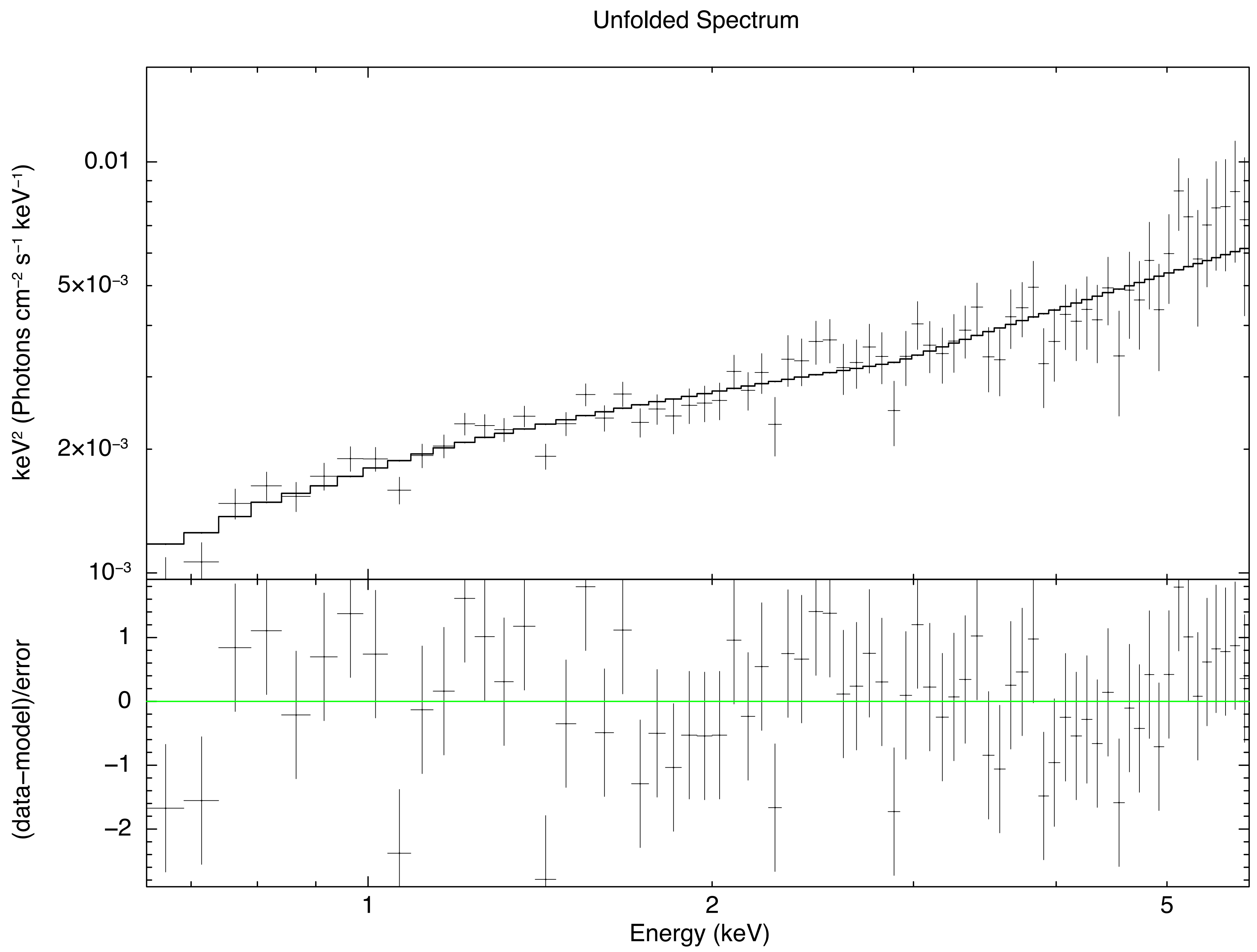




- Log-normal distribution of the observed flux explain the emission processes to be of multiplicative rather than additive.
- A log-normal flux distribution can directly hint the linkage of blazer jet with accretion phenomena .
- Double log normal distribution suggest for two flux state even in quiescent state.

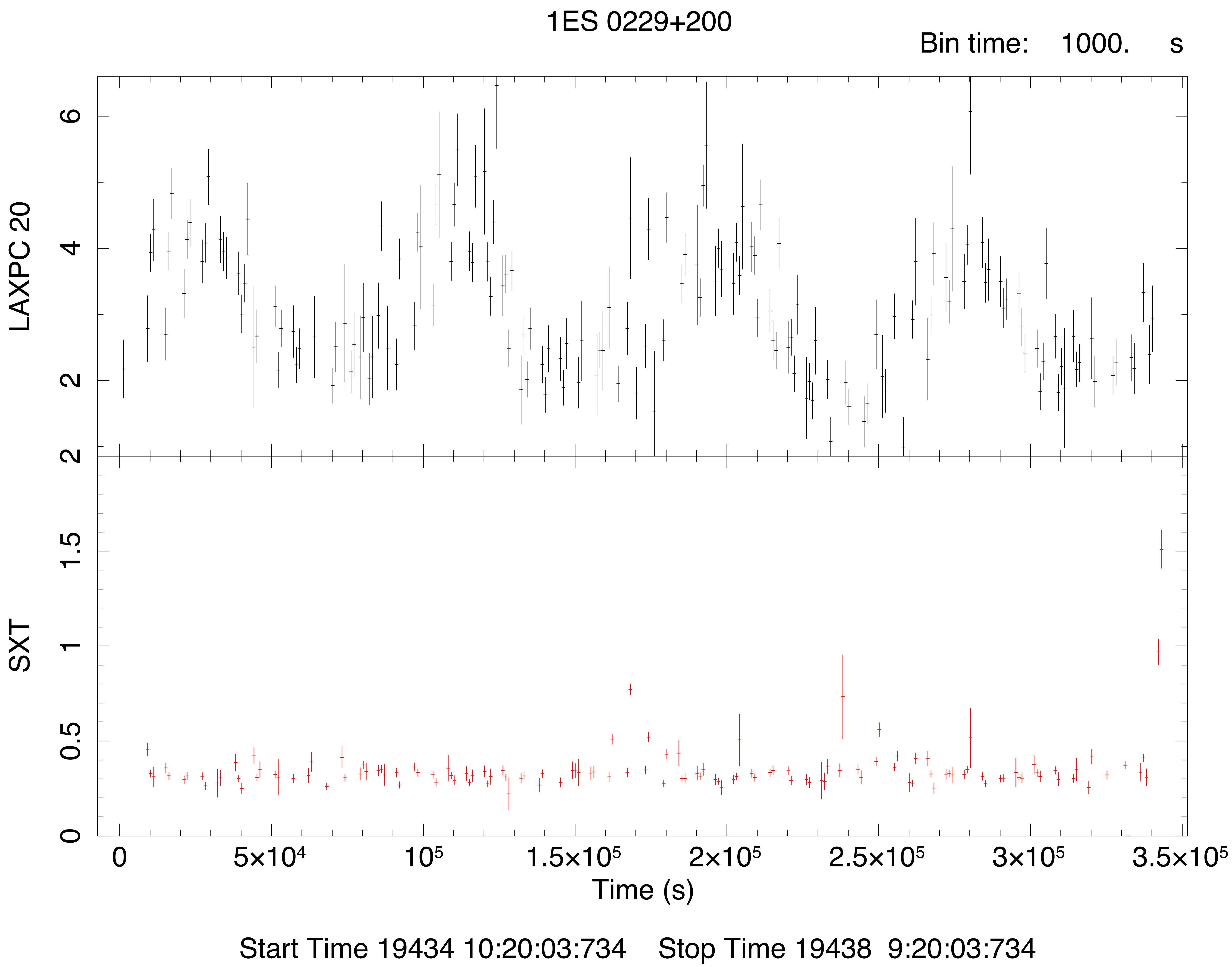
- SXT spectral Analysis :-





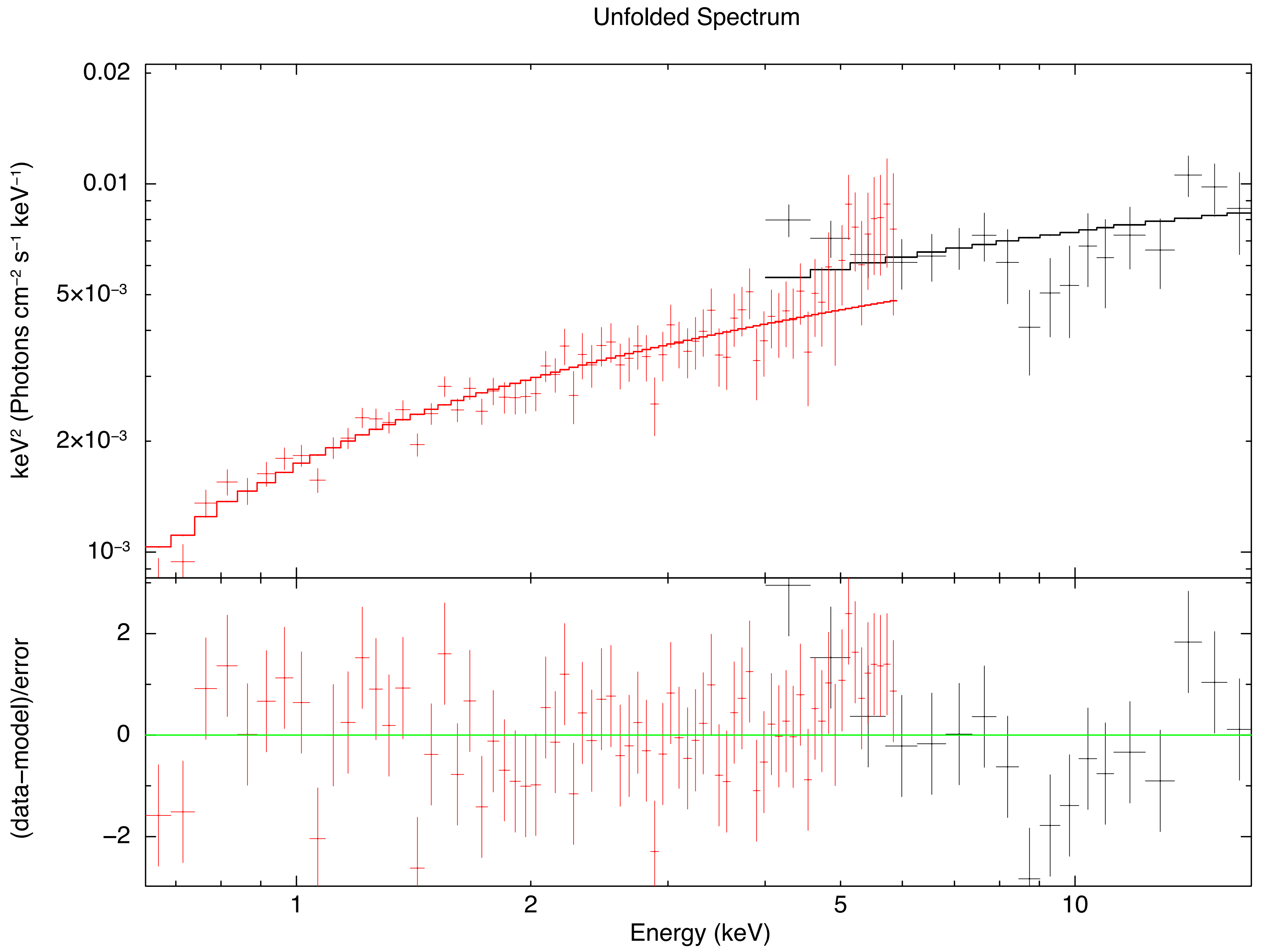
SXT								
Log Parabola				Broken Power Law				
α	β	Norm	χ^2_{red} (dof)	Γ_1	Γ_2	E_{break}	Norm	χ^2_{red} (dof)
$1.67^{+0.10}_{-0.10}$	$-0.29^{+0.19}_{-0.18}$	$0.002^{+0.00006}_{-0.00006}$	1.06 (69)	$1.60^{+0.06}_{-0.06}$	$1.10^{+0.22}_{-0.21}$	2.90	$0.002^{+0.00007}_{-0.00007}$	1.01 (69)

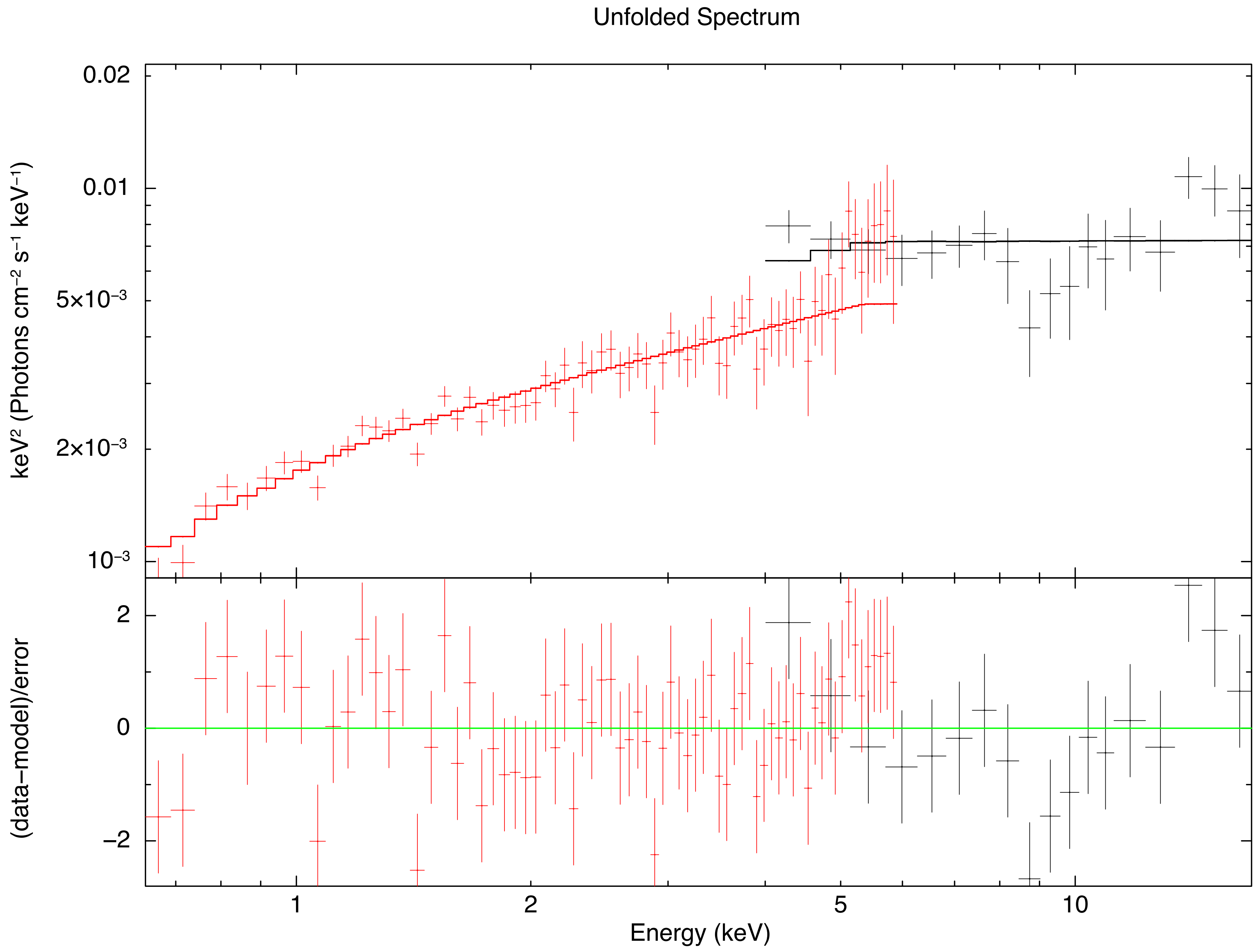
- SXT and LAXPC 20 light curve :-



❋ Spectral Analysis:

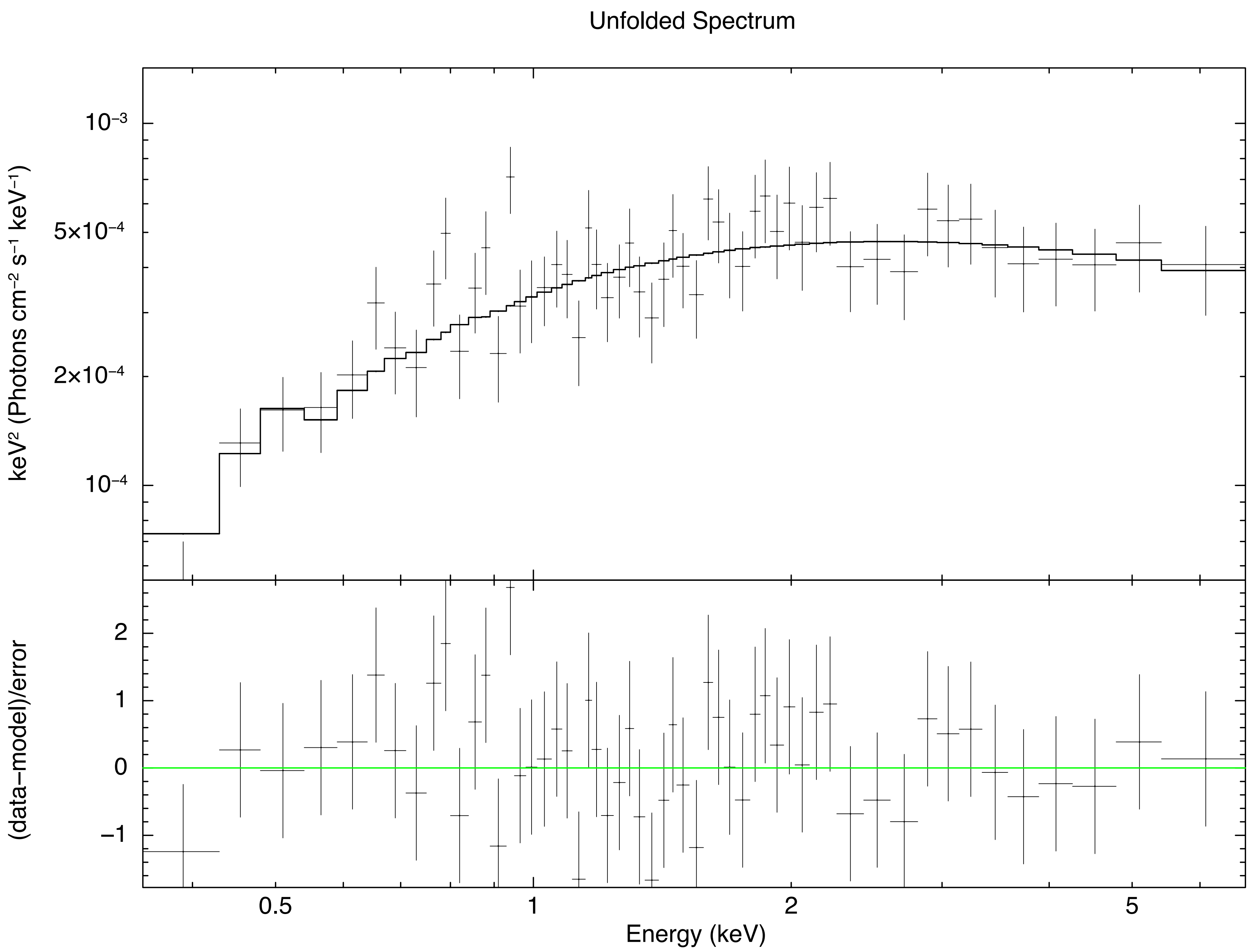
- Astrosat SED :-

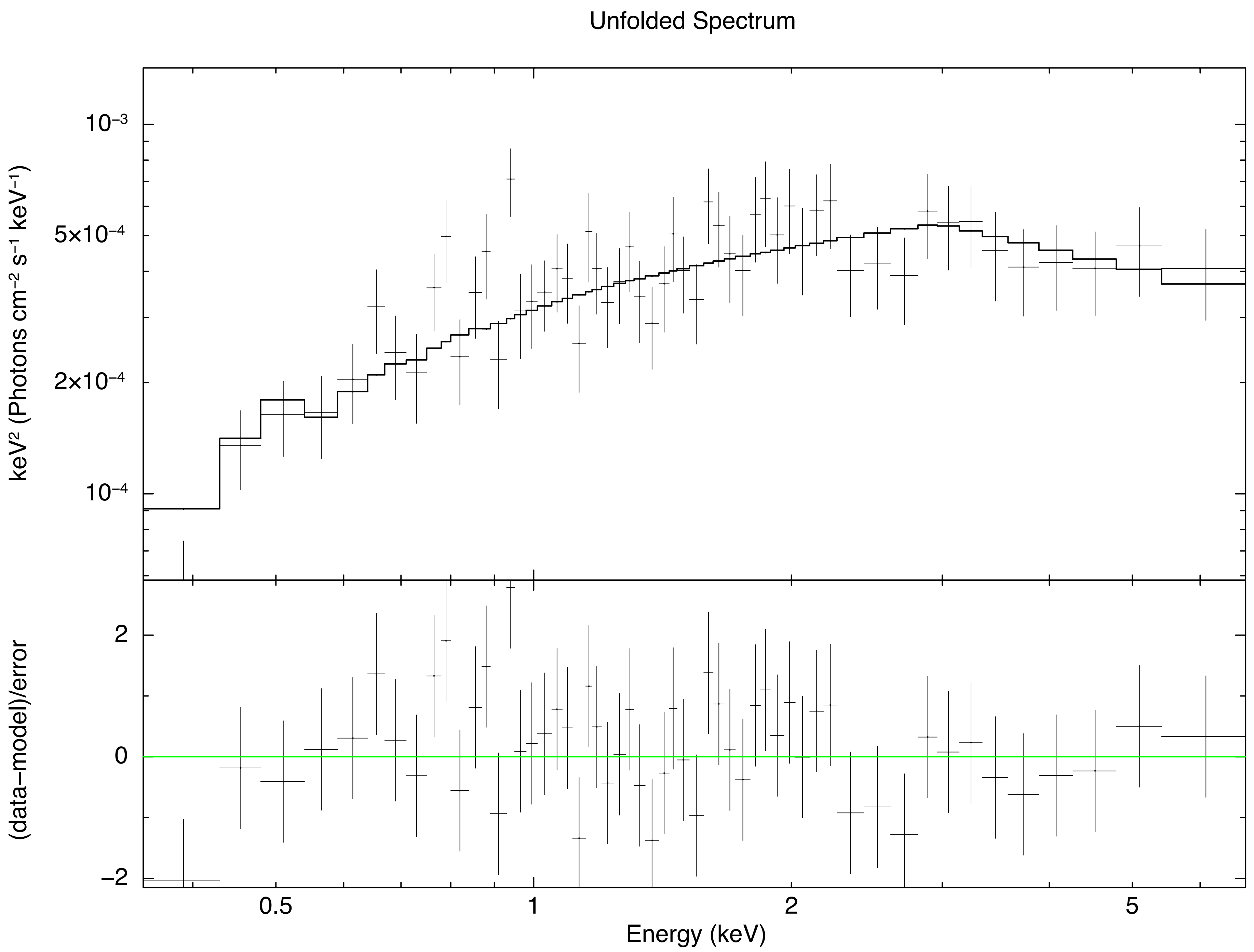




Astrosat								
Log Parabola				Broken Power Law				
α	β	Norm	χ^2_{red} (dof)	Γ_1	Γ_2	E_{break}	Norm	χ^2_{red} (dof)
$1.40^{+0.08}_{-0.09}$	$0.16^{+0.12}_{-0.11}$	$0.0027^{+0.0002}_{-0.0005}$	1.21 (85)	$1.49^{+0.04}_{-0.05}$	$1.98^{+0.21}_{-0.23}$	5.35	$0.003^{+0.0004}_{-0.0006}$	1.13 (84)

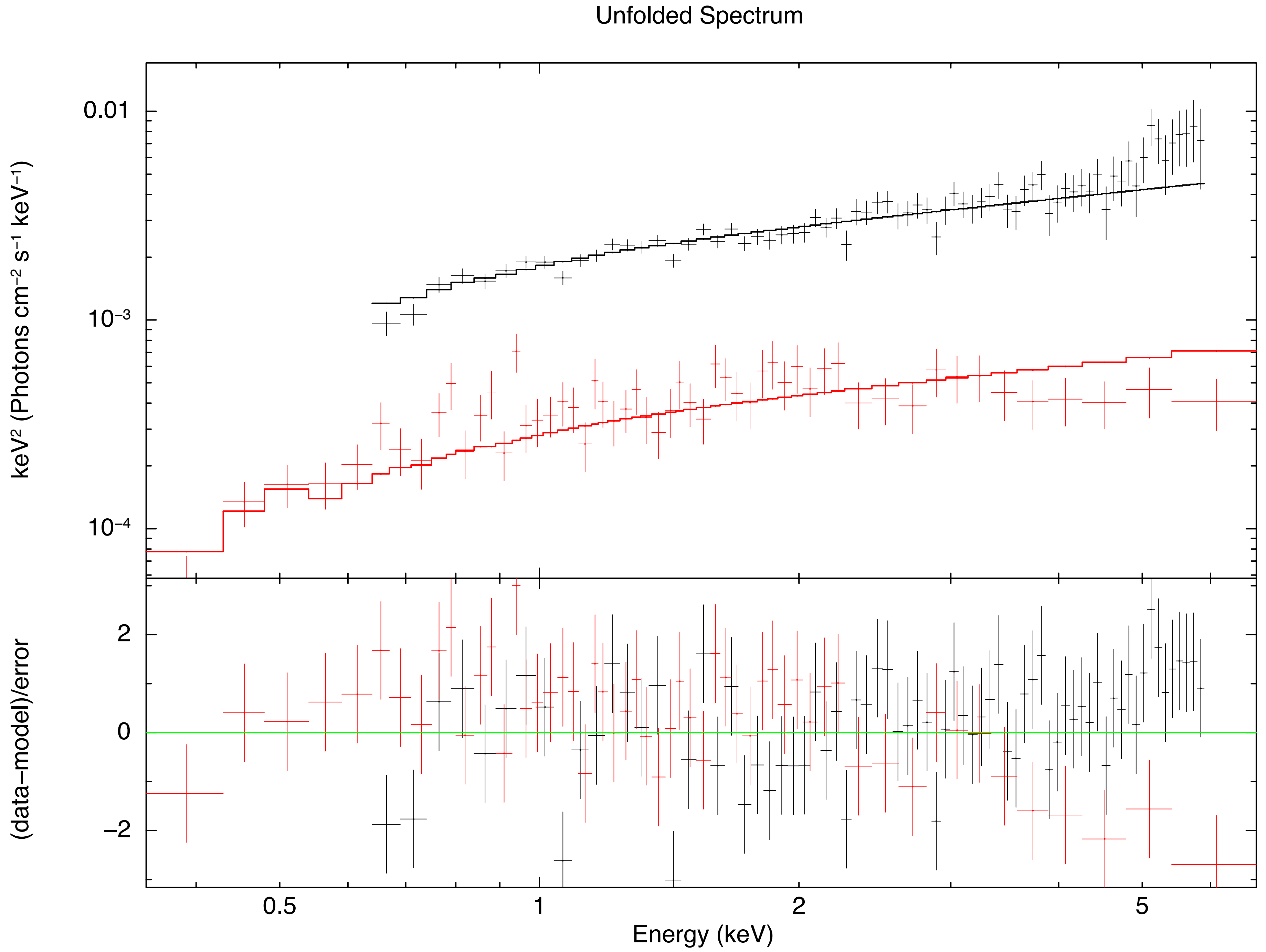
- SWIFT-XRT SED :

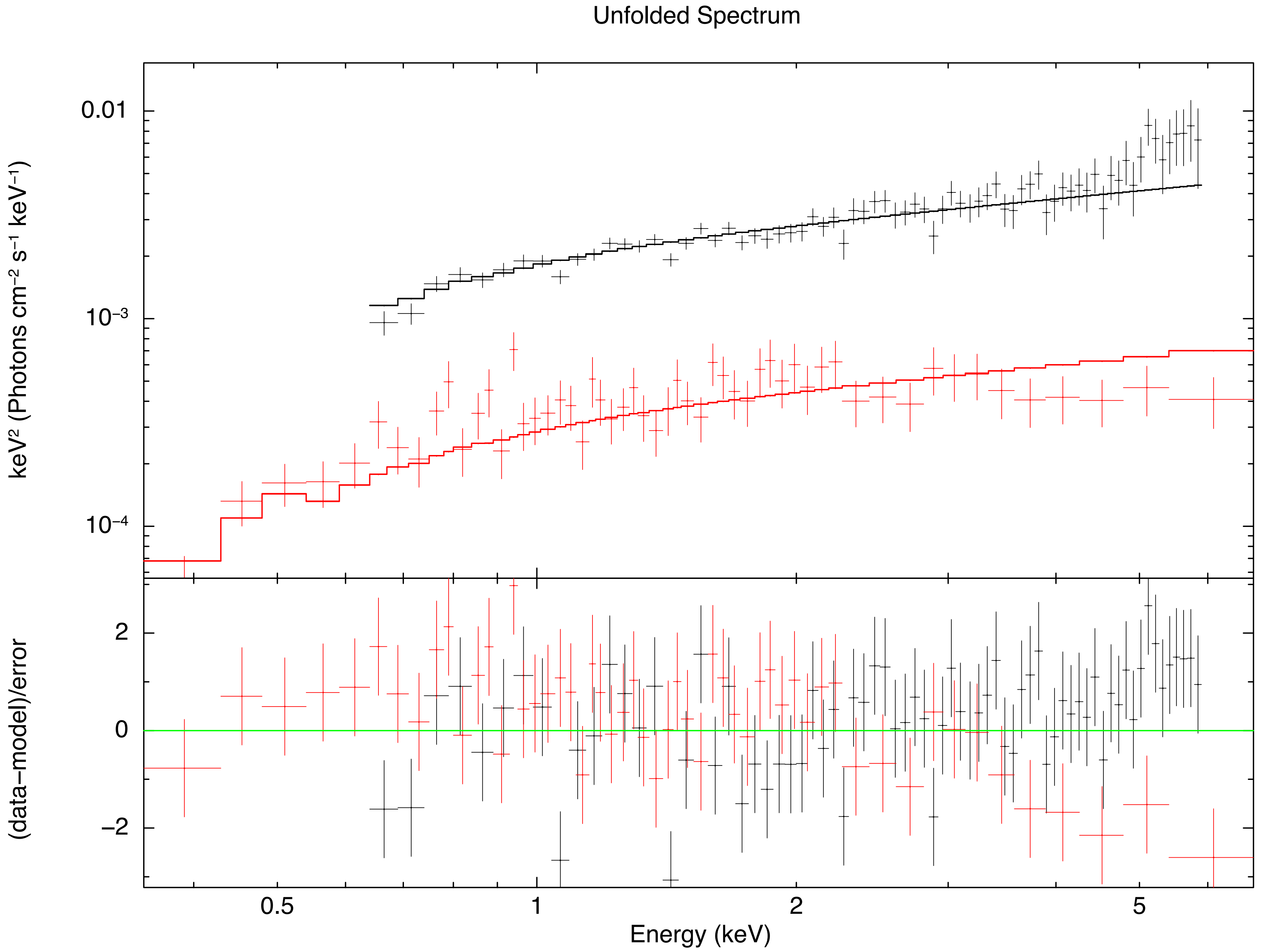




Swift-XRT								
Log Parabola				Broken Power Law				
α	β	Norm	$\chi^2_{\rm red}$ (dof)	Γ_1	Γ_2	$E_{\rm break}$	Norm	$\chi^2_{\rm red}$ (dof)
$1.60^{+0.13}_{-0.15}$	$0.52^{+0.29}_{-0.27}$	$0.0004^{+0.00002}_{-0.00002}$	0.78 (52)	$1.67^{+0.11}_{-0.11}$	$2.54^{+0.56}_{-0.47}$	2.96	$0.0003^{+0.00002}_{-0.00002}$	0.84 (52)

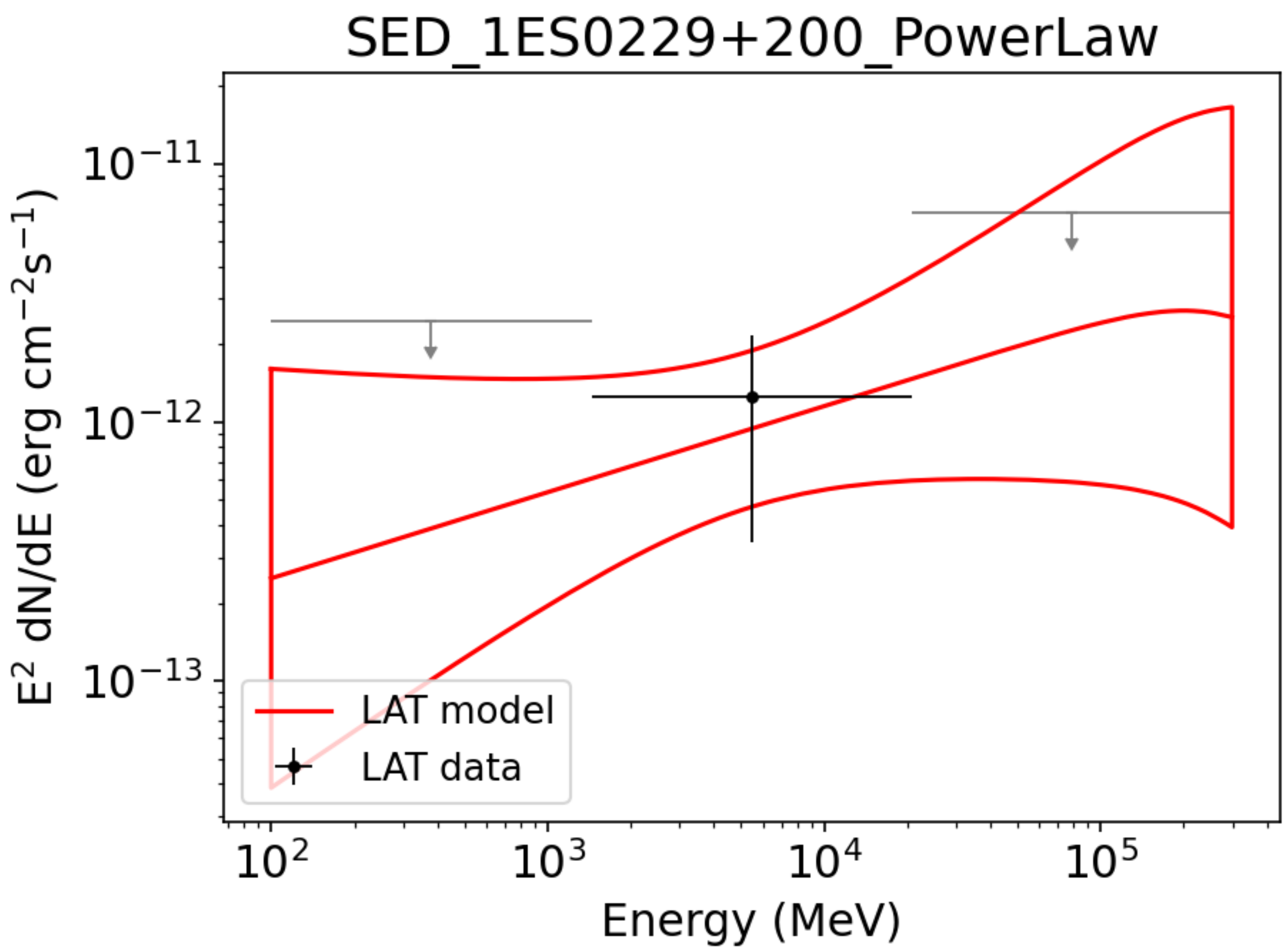
- Combined spectral analysis of SXT and Swift-XRT:



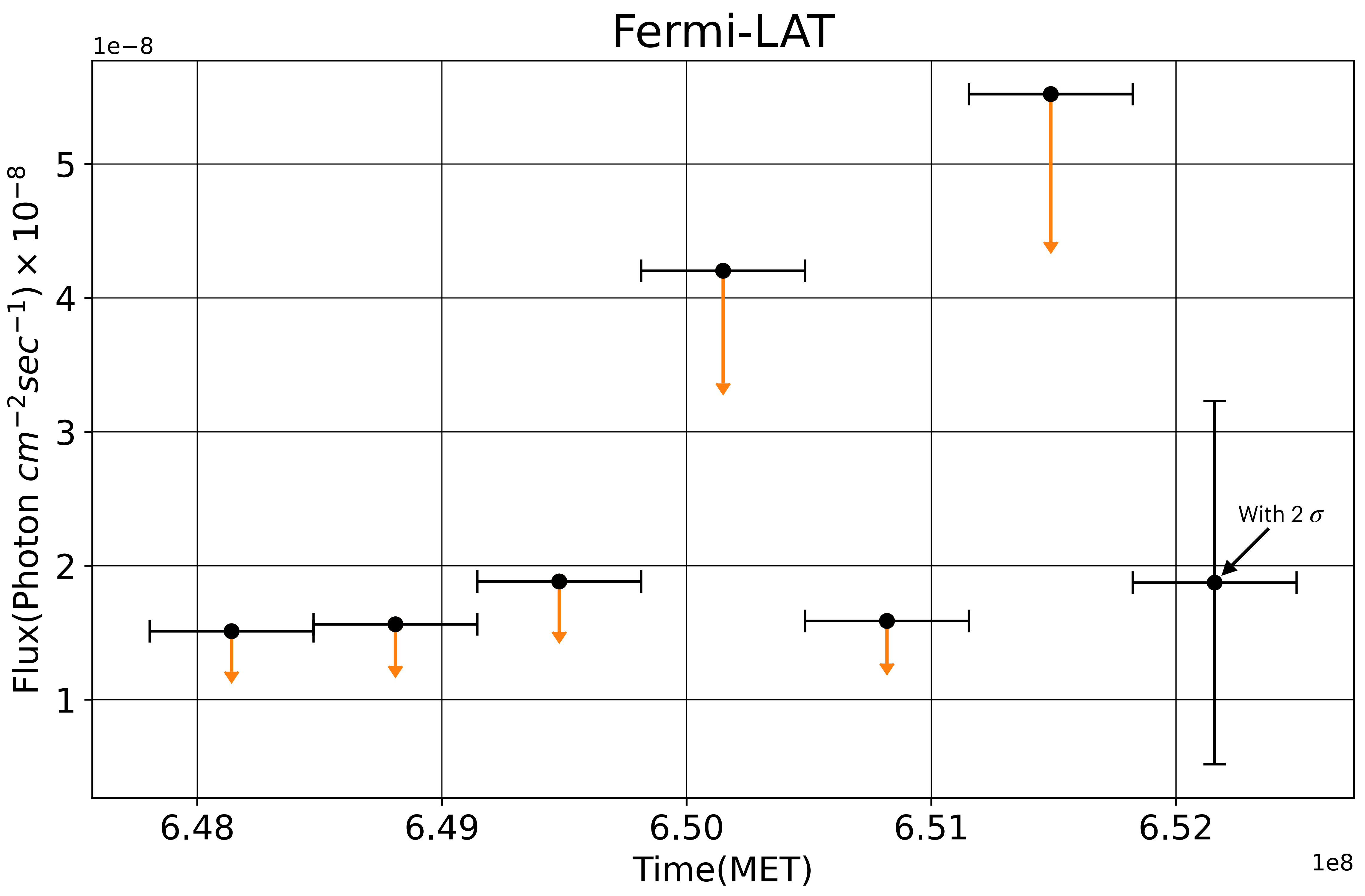


Swift-XRT and SXT								
Log Parabola				Broken Power Law				
α	β	Norm	χ^2_{red} (dof)	Γ_1	Γ_2	E_{break}	Norm	χ^2_{red} (dof)
$1.61^{+0.08}_{-0.08}$	$-0.02^{+0.16}_{-0.15}$	$0.002^{+0.00006}_{-0.00006}$	1.26 (123)	$1.63^{+0.07}_{-0.07}$	$1.55^{+0.09}_{-0.09}$	1.88	$0.002^{+0.00006}_{-0.00006}$	1.26 (123)

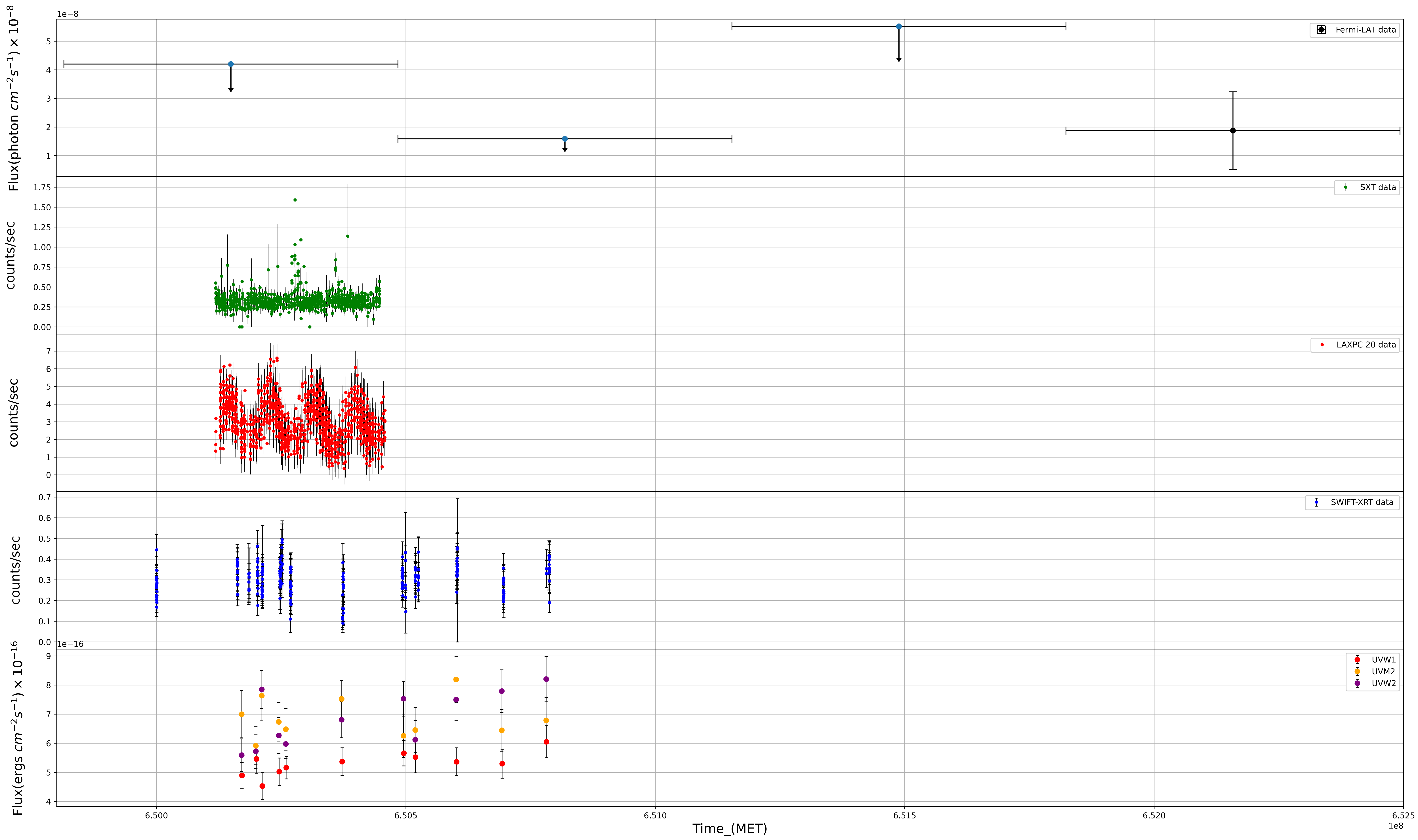
- Fermi-LAT SED :-



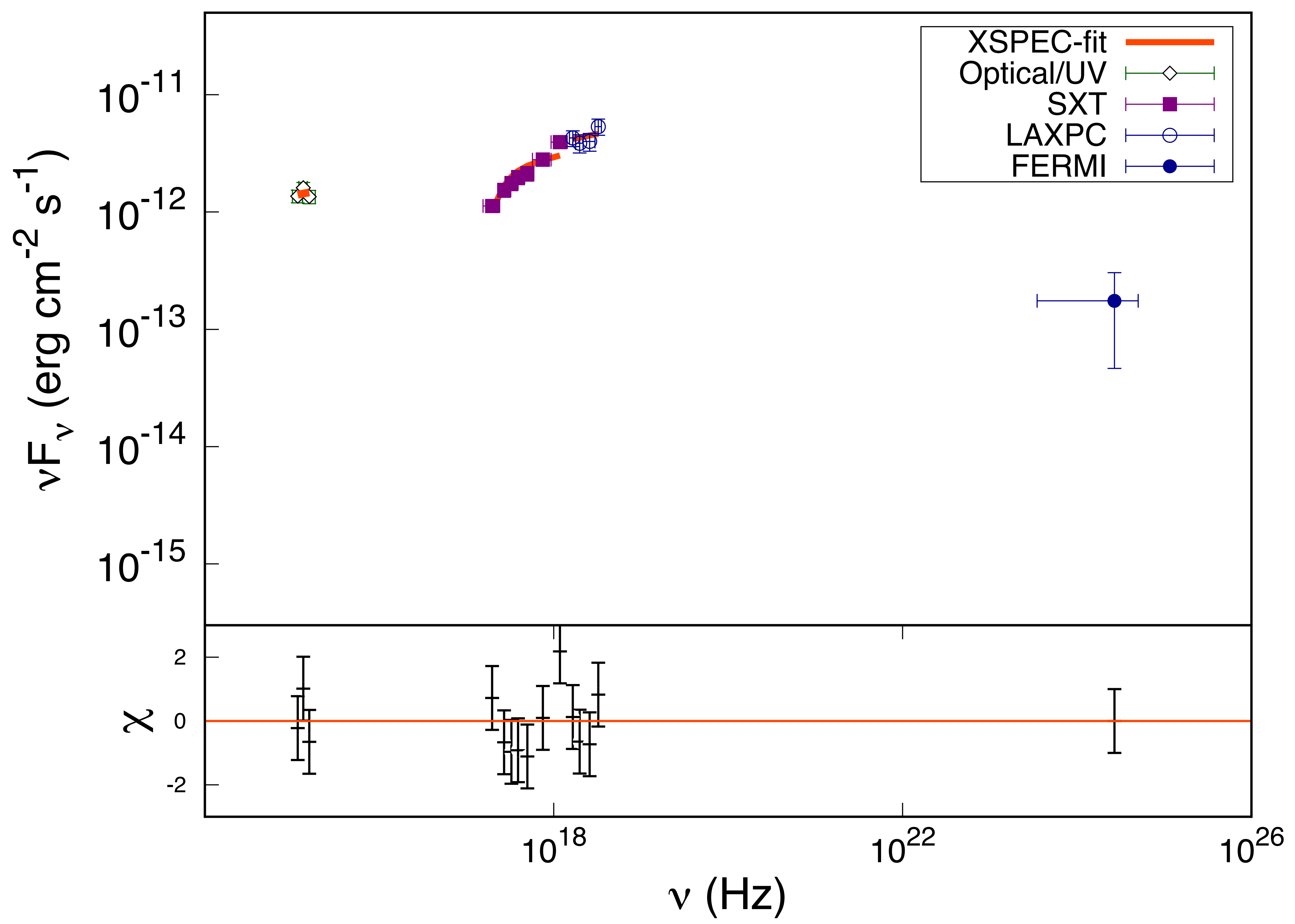
- Fermi-LAT light curve

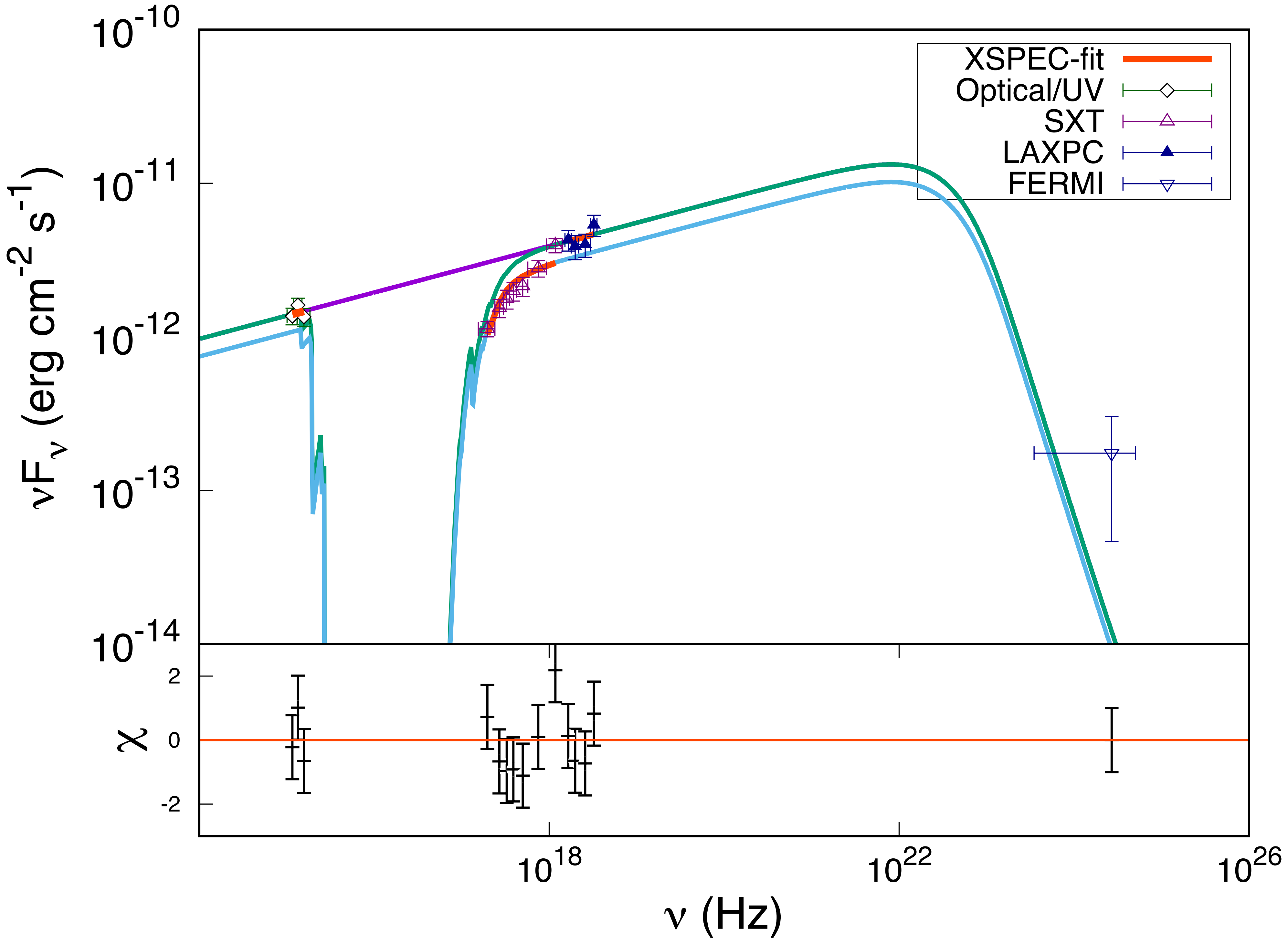


- Multi-wavelength lightcurve:



- Multiwavelength spectral analysis :-





```
Model constant<1>*TBabs<2>*sscicon<3>*bknpo2<4> Source No.: 1   Active/On
Model Model Component  Parameter  Unit     Value
 par  comp
                                 Data group: 1
  16    4   bknpo2     p                   2.69753      +/-  2.46254E-02
  18    4   bknpo2     q                   6.61444      +/-  0.787539
  21    4   bknpo2     norm                2.50980E-11  +/-  8.99718E-13
                                 Data group: 2
                                 Data group: 3
                                 Data group: 4
```

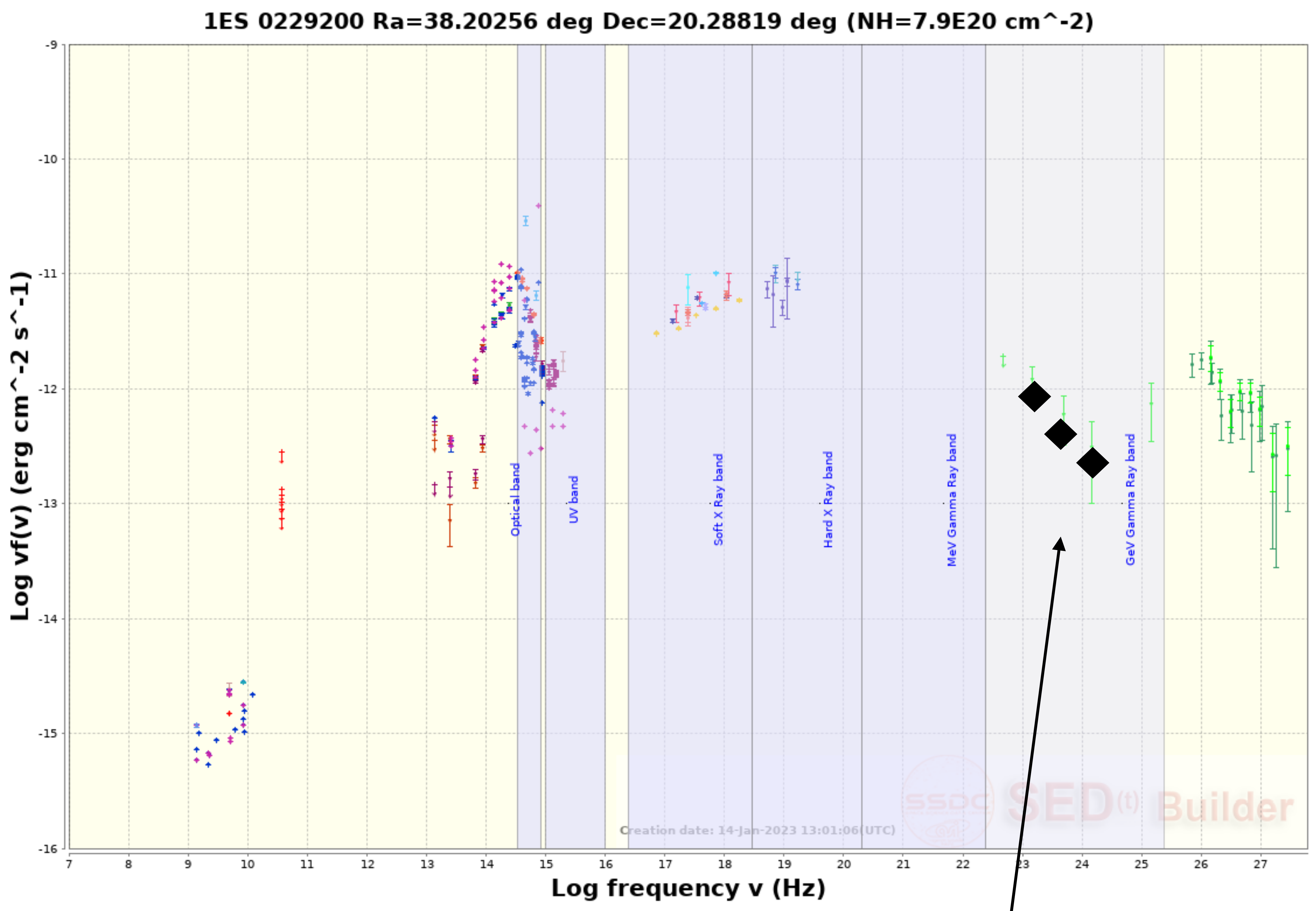
```
XSPEC12>error 16 18
 Parameter   Confidence Range (2.706)
    16      2.65759      2.73979    (-0.0399425,0.0422599)
***Warning: Parameter pegged at hard limit: 10
    18      5.75173            0    (-0.862715,-6.61444)
    ###########################################
```

```
                                   Data group: 4
  64    1   constant   factor              1.00000      frozen
  65    2   TBabs      nH         10^22    0.0          frozen
  66    3   sscicon    Gamma               20.5495      = p3
  67    3   sscicon    B          G        1.04659      = p4
  68    3   sscicon    Tedshift            0.140000     = p5
  69    3   sscicon    Theta      deg      2.00000      = p6
  70    3   sscicon    Size       log(cm)  16.5000      = p7
  71    3   sscicon    fast_flag  0/1      1.00000      = p8
  72    3   sscicon    BBtemp     K        1.00000E-40  = p9
  73    3   sscicon    BBfrac              1.00000E-40  = p10
  74    3   sscicon    slow_flic  0/1      0.0          = p11
  75    3   sscicon    Ho         (scale)  71.0000      = p12
  76    3   sscicon    omegaM     (scale)  0.270000     = p13
  77    3   sscicon    omega_l    (scale)  0.730000     = p14
  78    3   sscicon    Jetpower   log(P)   0.0          = p15
  79    4   bknpo2     p                   2.69753      = p16
  80    4   bknpo2     Ebr        keV      336.668      = p17
  81    4   bknpo2     q                   6.61444      = p18
  82    4   bknpo2     Emin       keV      1.00000E-05  = p19
  83    4   bknpo2     Emax       keV      5.32178E+07  = p20
  84    4   bknpo2     norm                2.50980E-11  = p21
```

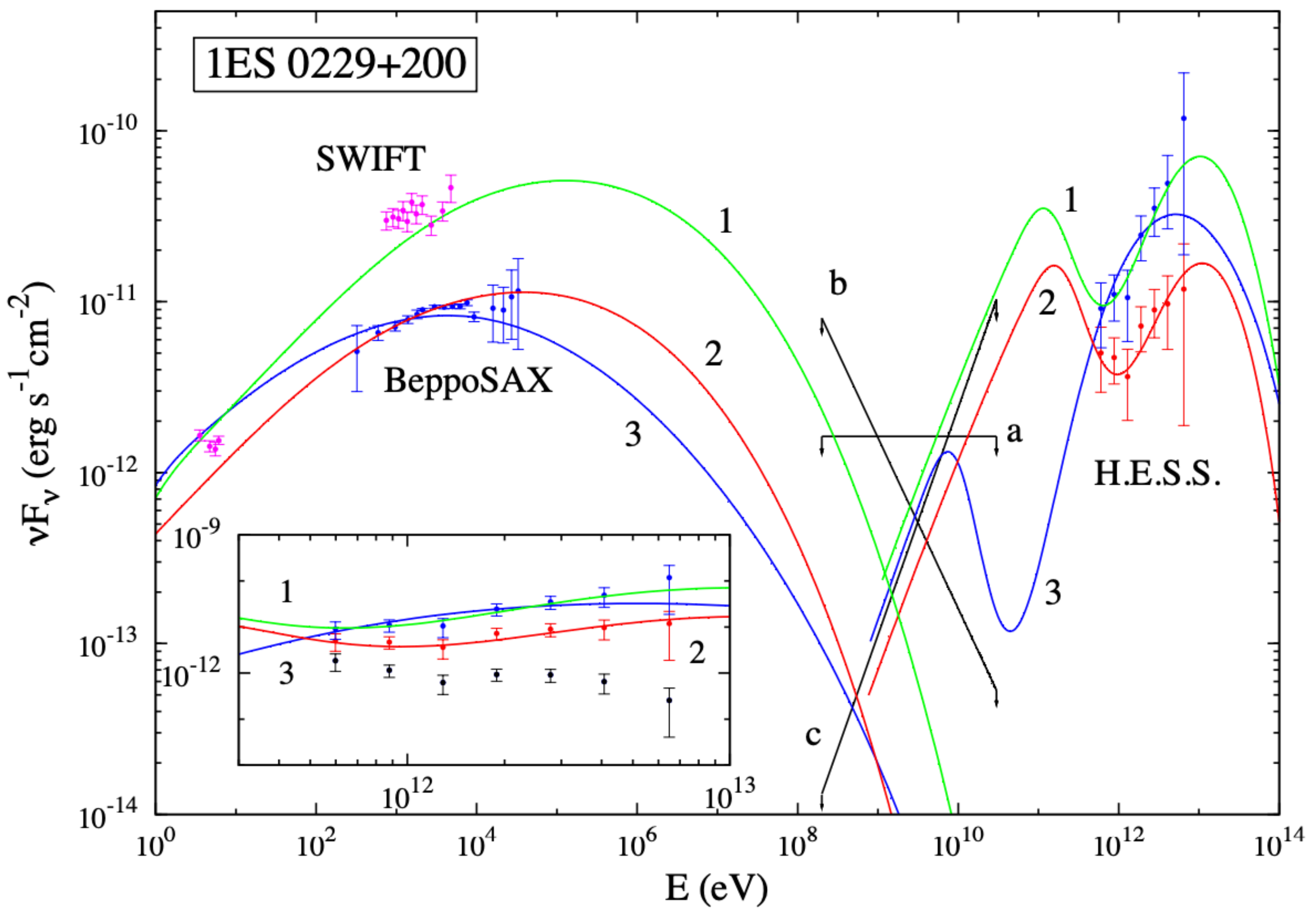
```
-- INSERT --
Fit statistic  : Chi-Squared                   1.50     using 3 bins, spectrum 1, group 1.
                 Chi-Squared                   8.74     using 7 bins, spectrum 2, group 2.
                 Chi-Squared                   1.65     using 4 bins, spectrum 3, group 3.
                 Chi-Squared                  5e-11     using 1 bins, spectrum 4, group 4.
Total fit statistic                           11.88     with 12 d.o.f.

Test statistic : Chi-Squared                  11.88     using 15 bins.
 Null hypothesis probability of 4.55e-01 with 12 degrees of freedom
```

- Literature survey :



13 year fermi-LAT observation



P.C. - *F.A. Aharonian*

-

- We need your suggestions to move forward with this source and others

Thank you everyone

Thank you Astrosat workshop