

Intermediate internship report

Analysis of X-Ray and UV/optical observations of TXS 0506+056 from the SWIFT observatory

The objective of this analysis is to fit the spectral energy distribution of the active galactic nucleus (AGN) TXS 0506+056. This object is a very high energy blazar – a quasar with a relativistic jet pointing directly towards Earth – of BL Lac-type [4]. TXS 0506+056 gained notoriety as the first known source of high-energy astrophysical neutrinos [3], identified following the IceCube-170922A neutrino event in an early example of multi-messenger astronomy [2].

Downloading data

I first accessed SWIFT database and searched for observation of TXS 0506 + 056 with UV / optical filters U, B, V, UW1, UW2 and UM2, as well as X-ray observations in PC mode. Therefore, during the search, I set the exposure time criteria in these filters to be greater than 0. Then I choose the data set with the highest exposure time in most filters. This corresponds to the observation 00095333005 with the characteristics shown in the table 1.

Name	target_id	xrt_expo_pc	expo_uu	expo_bb	expo_vv	expo_w1	expo_w2	expo_m2
TXS0506+056	95333	5322.452	427.084	427.106	427.106	855.051	1714.107	1365.941

Table 1: Results of the query for the largest exposure time for the TXS 0506 + 056 observations.

Then I downloaded the files `sw00095333005xpcw3po_cl.evt.gz`, `sw00095333005xpcw3po_uf.evt.gz`, `sw00095333005xwtw2st_cl.evt.gz`, `sw00095333005ubb_sk.img.gz`, `sw00095333005um2_sk.img.gz`, `sw00095333005uuu_sk.img.gz`, `sw00095333005uvv_sk.img.gz`, `sw00095333005uw1_sk.img.gz`, `sw00095333005uw2_sk.img.gz`.

Extracting X-ray spectra

First, I opened the X-ray image with the DS9 program to select the source and background region. We can see the selected regions in Figure 1.

Then I followed these steps on the terminal to extract the spectrum:

```

1 > xslect
2           **  XSELECT V2.5b  **
3
4 > Enter session name >[test3] test
5 test:SUZAKU > read event sw00095333005xpcw3po_cl.evt

```

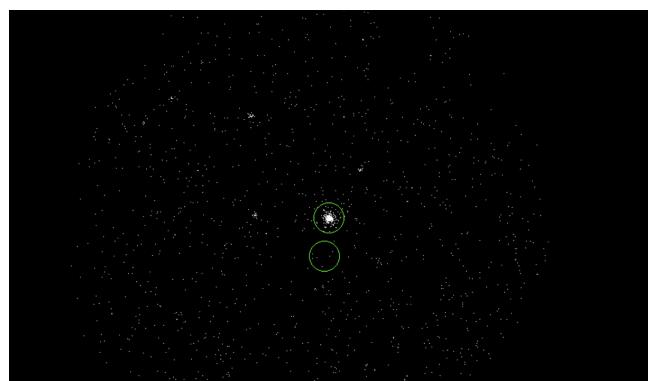


Figure 1: Source and background regions selected for X-ray spectra.

```

6 > Enter the Event file dir >[/home/idies/workspace/Storage/thara20/persistent/second/xrt/event
7   ]
8 Got new mission: SWIFT
9 > Reset the mission ? >[yes]
10
11 Notes: XSELECT set up for      SWIFT
12 Time keyword is TIME          in units of s
13 Default timing binsize =     5.0000
14
15 Setting...
16   Image keywords = X           Y           with binning = 1
17   WMAP keywords = X           Y           with binning = 1
18   Energy keyword = PI          with binning = 1
19
20 Getting Min and Max for Energy Column...
21 Got min and max for PI:      0    1023
22
23 Got the minimum time resolution of the read data: 2.5073
24 MJDREF = 5.1910000742870E+04 with TIMESYS = TT
25 Number of files read in:      1
26 **** Observation Catalogue ****
27
28 Data Directory is: /home/idies/workspace/Storage/thara20/persistent/second/xrt/event/
29 HK Directory is: /home/idies/workspace/Storage/thara20/persistent/second/xrt/event/
30
31
32   OBJECT      OBS_ID      DATE-OBS      DATAMODE
33   1 TXS0506+056 00095333005 2019-10-28T07:45:01 PHOTON
34
35 test:SWIFT-XRT-PHOTON > set image sky
36 test:SWIFT-XRT-PHOTON > filter region xrt_src.reg
37 test:SWIFT-XRT-PHOTON > extract spectrum
38 extractor v6.11      12 Dec 2023
39 Getting FITS WCS Keywords
40 Doing file: /home/idies/workspace/Storage/thara20/persistent/second/xrt/event/
41   sw00095333005xpcw3po_cl.evt[regfilter("test_region.xsl",X,Y)]
42 100% completed
43
44   Total      Good      Bad: Time      Phase      Grade      Cut
45   293       293        0         0         0         0
46 =====
47   Grand Total      Good      Bad: Time      Phase      Grade      Cut
48   293       293        0         0         0         0
49   in 5308.0 seconds
50 Spectrum has 293 counts for 5.5200E-02 counts/sec
51 Keyword TLM2FITS has two values: 'V6.4' and 'V6.4'
52 ... wrote the PHA data Extension
53 test:SWIFT-XRT-PHOTON > save spectrum xrt_src.pha
54 Wrote spectrum to xrt_src.pha
55 test:SWIFT-XRT-PHOTON > clear region
56 test:SWIFT-XRT-PHOTON > filter region xrt_bkg.reg
57 test:SWIFT-XRT-PHOTON > extract spectrum
58 extractor v6.11      12 Dec 2023
59 Getting FITS WCS Keywords
60 Doing file: /home/idies/workspace/Storage/thara20/persistent/second/xrt/event/
61   sw00095333005xpcw3po_cl.evt[regfilter("test_region.xsl",X,Y)]
62 100% completed
63
64   Total      Good      Bad: Time      Phase      Grade      Cut
65   6         6         0         0         0         0
66 =====
67   Grand Total      Good      Bad: Time      Phase      Grade      Cut
68   6         6         0         0         0         0
69   in 5308.0 seconds
70 Spectrum has 6 counts for 1.1304E-03 counts/sec
71 Keyword TLM2FITS has two values: 'V6.4' and 'V6.4'
72 ... wrote the PHA data Extension
73 test:SWIFT-XRT-PHOTON > save spectrum xrt_bkg.pha
74 Wrote spectrum to xrt_bkg.pha
75 test:SWIFT-XRT-PHOTON > exit
76 > Save this session? >[no]

```

Then I downloaded calibration files `swxpc0to12s6_20130101v014.rmf` and `swxs6_20010101v001.arf`. Finally, I grouped all these files into one to let XSPEC know which file represents the source and background spectra,

and which ones are the calibration files. To do this, I ran the `grppha` package and typed the following:

```

1 > grppha
2 ** grppha 3.1.0
3 ..... using pha_gp Ver 1.1.1
4 Please enter PHA filename[xrt.pha] xrt_src.pha
5 Please enter output filename[xrt.pi] xrt.pi
6
7 -----
8 MANDATORY KEYWORDS/VALUES
9 -----
10 -----
11
12 EXTNAM - SPECTRUM Name of this BINTABLE
13 TELESCOP - SWIFT Mission/Satellite name
14 INSTRUME - XRT Instrument/Detector
15 FILTER - NONE Instrument filter in use
16 EXPOSURE - 5286.7 Integration time (in secs) of PHA data
17 AREASCAL - 1.0000 Area scaling factor
18 BACKSCAL - 1.25300E-03 Background scaling factor
19 BACKFILE - none Associated background file
20 CORRSCAL - 1.0000 Correlation scaling factor
21 CORRFILE - none Associated correlation file
22 RESPFILE - none Associated redistribution matrix file
23 ANCFILE - none Associated ancillary response file
24 POISSERR - TRUE Whether Poissonian errors apply
25 CHANTYPE - PI Whether channels have been corrected
26 TLMIN1 - 0 First legal Detector channel
27 DETCHANS - 1024 No. of legal detector channels
28 NCHAN - 1024 No. of detector channels in dataset
29 PHAVERSN - 1.2.0 OGIP FITS version number
30 STAT_ERR - FALSE Statistical Error
31 SYS_ERR - FALSE Fractional Systematic Error
32 QUALITY - TRUE Quality Flag
33 GROUPING - FALSE Grouping Flag
34 -----
35 -----
36 GRPPHA [bad 0-29] bad 0-29
37 GRPPHA [quit] group min 20
38 GRPPHA [group min 20] chkey BACKFILE xrt_bkg.pha
39 GRPPHA [chkey BACKFILE xrt_bkg.pha] chkey RESPFILE swxpc0to12s6_20130101v014.rmf
40 GRPPHA [chkey RESPFILE swxpc0to12s6_20130101v014.rmf] chkey ANCFILE swxs6_20010101v001.arf
41 GRPPHA [chkey ANCFILE swxs6_20010101v001.arf] exit
42 ... written the PHA data Extension
43 ..... exiting, changes written to file : xrt.pi
44 ** grppha 3.1.0 completed successfully

```

UV/optical photometry of AGN

Since I aim to obtain the SED of the AGN, I am interested in finding out how many photons are detected per second (object flux). To calculate this, I need to sum all exposures, which also reduces the uncertainty⁵. However, typically the image will rotate or slightly shift between two exposures, thus the object on two exposures will not be on the same position. For this, HEASOFT contains packages that will sum all exposures and correct for the object position shift between two exposures. This package is `uvotimsum`, which I uses as follows:

```

1 > uvotimsum sw00095333005uuu_sk.img uuu_sum.fits chatter=1
2 uvotimsum: running uvotimsum1
3 uvotimsum: running fthedit
4 uvotimsum: running ftemplate
5 uvotimsum: running ftappend
6 uvotimsum: running ftchecksum

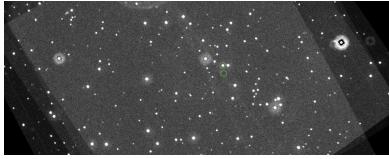
```

and repeat the same for all the filters. In the end, this package will return a summed AGN image in the given filter in the `.fits` format.

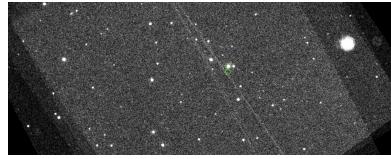
Then I choose source and background regions for all the filters. The regions can be found in the following Figure 2.

Then I downloaded the calibration files `swubb_20041120v105.rsp`, `swum2_20041120v106.rsp`, `swuuu_20041120v105.rsp`, `swuvv_20041120v105.rsp`, `swuw1_20041120v106.rsp`, and `swuw2_20041120v106.rsp`.

Then I converted the files into `.pha` files with the following command:



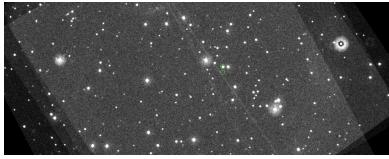
(a) Source and background regions for the ubb filter.



(b) Source and background regions for the um2 filter.



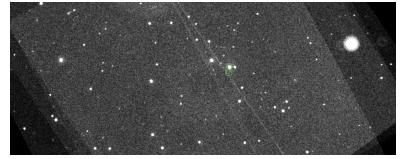
(c) Source and background regions for the uuu filter.



(d) Source and background regions for the uvv filter.



(e) Source and background regions for the uw1 filter.



(f) Source and background regions for the uw2 filter.

Figure 2: Source and background regions for the uvot filters.

```
1 > uvot2pha infile=uvv_sum.fits srcpha=uvv.pha bkgpha=uvv_bkg.pha srcreg=uvv_src.reg bkgreg=
  uvv_bkg.reg respfile=swuvv_20041120v105.rsp clobber=y chatter=1
```

and the same for all the other filters.

SED of AGN

To fit and plot the SED I followed these commands:

```
1 > xspec
2 XSPEC version: 12.14.1
3   Build Date/Time: Thu Aug 22 22:23:14 2024
4
5 XSPEC12>data 1:1 uuu.pha 1:2 ubb.pha 1:3 uvv.pha 1:4 uw1.pha 1:5 uw2.pha 1:6 um2.pha 2:7 xrt.pi
6 Number of spectra read ..... 6***Warning: Detected response matrix energy bin value = 0 (or neg
  ).
7   XSPEC will instead use small finite value (response file will not be altered).
8 Number of spectra read ..... 7
9 7 spectra in use
10
11 Spectral Data File: uuu.pha Spectrum 1
12 Net count rate (cts/s) for Spectrum:1 2.238e+01 +/- 4.517e-01 (89.9 % total)
13 Assigned to Data Group 1 and Plot Group 1
14 Noticed Channels: 1
15 Telescope: SWIFT Instrument: UVOTA Channel Type: PHA
16 Exposure Time: 420.3 sec
17 Using fit statistic: chi
18 Using Background File           uuu_bkg.pha
19   Background Exposure Time: 420.3 sec
20 Using Response (RMF) File      swuuu_20041120v105.rsp for Source 1
21
22 Spectral Data File: ubb.pha Spectrum 2
23 Net count rate (cts/s) for Spectrum:2 2.545e+01 +/- 5.531e-01 (74.0 % total)
24 Assigned to Data Group 1 and Plot Group 2
25 Noticed Channels: 1
26 Telescope: SWIFT Instrument: UVOTA Channel Type: PHA
27 Exposure Time: 420.4 sec
28 Using fit statistic: chi
29 Using Background File           ubb_bkg.pha
30   Background Exposure Time: 420.4 sec
31 Using Response (RMF) File      swubb_20041120v105.rsp for Source 1
32
33 Spectral Data File: uvv.pha Spectrum 3
34 Net count rate (cts/s) for Spectrum:3 1.268e+01 +/- 3.249e-01 (80.8 % total)
35 Assigned to Data Group 1 and Plot Group 3
36 Noticed Channels: 1
37 Telescope: SWIFT Instrument: UVOTA Channel Type: PHA
38 Exposure Time: 420.4 sec
39 Using fit statistic: chi
40 Using Background File           uvv_bkg.pha
41   Background Exposure Time: 420.4 sec
```

```

42 Using Response (RMF) File           swuvv_20041120v105.rsp for Source 1
43
44 Spectral Data File: uw1.pha Spectrum 4
45 Net count rate (cts/s) for Spectrum:4 8.278e+00 +/- 1.945e-01 (91.5 % total)
46 Assigned to Data Group 1 and Plot Group 4
47 Noticed Channels: 1
48 Telescope: SWIFT Instrument: UVOTA Channel Type: PHA
49 Exposure Time: 841.6 sec
50 Using fit statistic: chi
51 Using Background File             uw1_bkg.pha
52 Background Exposure Time: 841.6 sec
53 Using Response (RMF) File         swuw1_20041120v106.rsp for Source 1
54
55 Spectral Data File: uw2.pha Spectrum 5
56 Net count rate (cts/s) for Spectrum:5 5.732e+00 +/- 1.278e-01 (88.7 % total)
57 Assigned to Data Group 1 and Plot Group 5
58 Noticed Channels: 1
59 Telescope: SWIFT Instrument: UVOTA Channel Type: PHA
60 Exposure Time: 1687 sec
61 Using fit statistic: chi
62 Using Background File             uw2_bkg.pha
63 Background Exposure Time: 1687 sec
64 Using Response (RMF) File         swuw2_20041120v106.rsp for Source 1
65
66 Spectral Data File: um2.pha Spectrum 6
67 Net count rate (cts/s) for Spectrum:6 3.822e+00 +/- 1.000e-01 (90.0 % total)
68 Assigned to Data Group 1 and Plot Group 6
69 Noticed Channels: 1
70 Telescope: SWIFT Instrument: UVOTA Channel Type: PHA
71 Exposure Time: 1344 sec
72 Using fit statistic: chi
73 Using Background File             um2_bkg.pha
74 Background Exposure Time: 1344 sec
75 Using Response (RMF) File         swum2_20041120v106.rsp for Source 1
76
77 Spectral Data File: xrt.pi Spectrum 7
78 Net count rate (cts/s) for Spectrum:7 5.429e-02 +/- 3.271e-03 (98.0 % total)
79 Assigned to Data Group 2 and Plot Group 7
80 Noticed Channels: 1-232
81 Telescope: SWIFT Instrument: XRT Channel Type: PI
82 Exposure Time: 5287 sec
83 Using fit statistic: chi
84 Using Background File             xrt_bkg.pha
85 Background Exposure Time: 5287 sec
86 Using Response (RMF) File         swxpc0to12s6_20130101v014.rmf for Source 1
87 Using Auxiliary Response (ARF) File swxs6_20010101v001.arf
88
89 XSPEC12>cpd /xw
90 XSPEC12>setplot en
91 XSPEC12>plot ldata
92 XSPEC12>ignore bad
93
94 ignore:    0 channels ignored from source number 2
95 ignore:    0 channels ignored from source number 6
96 ignore:    0 channels ignored from source number 1
97 ignore:    0 channels ignored from source number 3
98 ignore:    0 channels ignored from source number 4
99 ignore:    0 channels ignored from source number 5
100 ignore:   218 channels ignored from source number 7
101 XSPEC12>plot
102 XSPEC12>model phabs*powerlaw
103
104 Input parameter value, delta, min, bot, top, and max values for ...
105          1      0.001(      0.01)          0          0     100000    1e+06
106 1:data group 1::phabs:nH>1
107          1      0.01(      0.01)         -3         -2          9        10
108 2:data group 1::powerlaw:PhoIndex>
109          1      0.01(      0.01)          0          0     1e+20    1e+24
110 3:data group 1::powerlaw:norm>
111
112 Input parameter value, delta, min, bot, top, and max values for ...
113          1      0.001(      0.01)          0          0     100000    1e+06
114 4:data group 2::phabs:nH>2

```

```

115      1      0.01(      0.01)      -3      -2      9      10
116 5:data group 2::powerlaw:PhoIndex>1.5
117      1      0.01(      0.01)      0      0      1e+20      1e+24
118 6:data group 2::powerlaw:norm>1e4
119
120 =====
121 Model phabs<1>*powerlaw<2> Source No.: 1 Active/On
122 Model Model Component Parameter Unit      Value
123 par comp
124          Data group: 1
125 1 1 phabs      nH      10^22      1.00000      +/- 0.0
126 2 2 powerlaw   PhoIndex      1.00000      +/- 0.0
127 3 2 powerlaw   norm      1.00000      +/- 0.0
128          Data group: 2
129 4 1 phabs      nH      10^22      2.00000      +/- 0.0
130 5 2 powerlaw   PhoIndex      1.50000      +/- 0.0
131 6 2 powerlaw   norm      1.00000E+04      +/- 0.0
132 -----
133
134
135 Fit statistic : Chi-Squared      740.93      using 1 bins, spectrum 1, group 1.
136           Chi-Squared      1090.60      using 1 bins, spectrum 2, group 1.
137           Chi-Squared      963.57      using 1 bins, spectrum 3, group 1.
138           Chi-Squared      46.45      using 1 bins, spectrum 4, group 1.
139           Chi-Squared      329.72      using 1 bins, spectrum 5, group 1.
140           Chi-Squared      84.86      using 1 bins, spectrum 6, group 1.
141           Chi-Squared      7.284945e+16      using 14 bins, spectrum 7, group 2.
142 Total fit statistic      7.284945e+16      with 14 d.o.f.
143
144 Test statistic : Chi-Squared      7.284945e+16      using 20 bins.
145 Null hypothesis probability of 0.000000e+00 with 14 degrees of freedom
146 Current data and model not fit yet.
147 XSPEC12>fit 100
148          Parameters
149 Chi-Squared |beta|/N      Lvl      1:nH      2:PhoIndex      3:norm      4:nH      5:
150           PhoIndex      6:norm
151 ***Warning: Zero alpha-matrix diagonal element for parameter 1
152 Parameter 1 is pegged at 1 due to zero or negative pivot element, likely
153 caused by the fit being insensitive to the parameter.
154 11536.2      1635.41      6      1.00000      1.48030      1.39879e-07      2.00000
155      1.50000      0.000405140
156 11536.1      21292.3      5      1.00000      1.59816      2.24949e-07      2.00000
157      1.50000      0.000405140
158 11533.9      40110      4      1.00000      1.99608      6.88492e-07      1.99997
159      1.50000      0.000405140
160 11525.6      344103      3      1.00000      2.15820      1.27522e-06      1.99974
161      1.50001      0.000405140
162 11300.6      829979      2      1.00000      2.52829      3.77478e-06      1.99736
163      1.50011      0.000405140
164 10440.3      6.20741e+06      1      1.00000      2.69473      7.17059e-06      1.97381
165      1.50111      0.000405133
166 1763.07      1.48792e+07      0      1.00000      2.98316      1.84521e-05      1.75811
167      1.51134      0.000404584
168 199.671      2.87331e+07      0      1.00000      3.01892      2.20974e-05      0.610041
169      1.59018      0.000392067
170 71.7256      7.93201e+06      -1      1.00000      3.02758      2.29789e-05      0.210531
171      1.63255      0.000309919
172 51.2213      103750      -2      1.00000      3.03343      2.22608e-05      0.0815759
173      1.53542      0.000280838
174 47.0145      40123.3      -3      1.00000      3.05305      1.98371e-05      0.0950821
175      1.67959      0.000340083
176 46.3464      770812      -4      1.00000      3.06251      1.89263e-05      0.0956403
177      1.67463      0.000343485
178 46.3268      156711      -5      1.00000      3.06273      1.89283e-05      0.0954422
179      1.67411      0.000343262
180 46.3268      600.409      -4      1.00000      3.06272      1.89288e-05      0.0954707
181      1.67418      0.000343293
182 ***Warning: Zero alpha-matrix diagonal element for parameter 1
183 Parameter 1 is pegged at 1 due to zero or negative pivot element, likely
184 caused by the fit being insensitive to the parameter.
185 46.3268      11.3418      -2      1.00000      3.06272      1.89288e-05      0.0954671
186      1.67417      0.000343289
187 =====

```

```

172 Variances and Principal Axes
173      2      3      4      5      6
174 3.1573E-14| 0.0001  1.0000  0.0000  0.0000  0.0000
175 4.5138E-10| 0.0000  0.0000 -0.0007 -0.0002  1.0000
176 5.7058E-04| 0.0000  0.0000  0.9766 -0.2153  0.0006
177 7.3910E-04| 1.0000 -0.0001  0.0000  0.0000  0.0000
178 3.0522E-02| 0.0000  0.0000  0.2153  0.9766  0.0003
179 -----
180
181 =====
182 Covariance Matrix
183      1      2      3      4      5
184 7.391e-04 -7.807e-08 0.000e+00 0.000e+00 0.000e+00
185 -7.807e-08 8.279e-12 0.000e+00 0.000e+00 0.000e+00
186 0.000e+00 0.000e+00 1.958e-03 6.296e-03 2.296e-06
187 0.000e+00 0.000e+00 6.296e-03 2.913e-02 8.739e-06
188 0.000e+00 0.000e+00 2.296e-06 8.739e-06 3.350e-09
189 -----
190
191 =====
192 Model phabs<1>*powerlaw<2> Source No.: 1 Active/On
193 Model Model Component Parameter Unit Value
194 par comp
195          Data group: 1
196 1 1 phabs nH 10^22 1.00000 +/- -1.00000
197 2 2 powerlaw PhoIndex 3.06272 +/- 2.71864E-02
198 3 2 powerlaw norm 1.89288E-05 +/- 2.87733E-06
199          Data group: 2
200 4 1 phabs nH 10^22 9.54671E-02 +/- 4.42529E-02
201 5 2 powerlaw PhoIndex 1.67417 +/- 0.170688
202 6 2 powerlaw norm 3.43289E-04 +/- 5.78812E-05
203 -----
204
205
206 Fit statistic : Chi-Squared           6.18     using 1 bins, spectrum 1, group 1.
207          Chi-Squared                   5.21     using 1 bins, spectrum 2, group 1.
208          Chi-Squared                   11.67    using 1 bins, spectrum 3, group 1.
209          Chi-Squared                   2.12     using 1 bins, spectrum 4, group 1.
210          Chi-Squared                   0.25     using 1 bins, spectrum 5, group 1.
211          Chi-Squared                   7.08     using 1 bins, spectrum 6, group 1.
212          Chi-Squared                   13.83    using 14 bins, spectrum 7, group 2.
213 Total fit statistic                  46.33    with 14 d.o.f.
214
215 Test statistic : Chi-Squared          46.33    using 20 bins.
216 Null hypothesis probability of 2.48e-05 with 14 degrees of freedom
217 XSPEC12>fit 200
218          Parameters
219 Chi-Squared |beta|/N   Lvl      1:nH      2:PhoIndex      3: norm      4:nH      5:
220          PhoIndex      6: norm
221 ***Warning: Zero alpha-matrix diagonal element for parameter 1
222 Parameter 1 is pegged at 1 due to zero or negative pivot element, likely
223 caused by the fit being insensitive to the parameter.
224 46.3268    0.293525    0     1.00000     3.06272    1.89288e-05    0.0954671
225          1.67417    0.000343289
226 ***Warning: Zero alpha-matrix diagonal element for parameter 1
227 Parameter 1 is pegged at 1 due to zero or negative pivot element, likely
228 caused by the fit being insensitive to the parameter.
229 46.3268    0.193862    4     1.00000     3.06272    1.89288e-05    0.0954671
230          1.67417    0.000343289
231 -----
232
233 =====
234 Variances and Principal Axes
235      2      3      4      5      6
236 3.1573E-14| 0.0001  1.0000  0.0000  0.0000  0.0000
237 4.5137E-10| 0.0000  0.0000 -0.0007 -0.0002  1.0000
238 5.7057E-04| 0.0000  0.0000  0.9766 -0.2152  0.0006
239 7.3910E-04| 1.0000 -0.0001  0.0000  0.0000  0.0000
240 3.0522E-02| 0.0000  0.0000  0.2152  0.9766  0.0003
241 -----

```

```

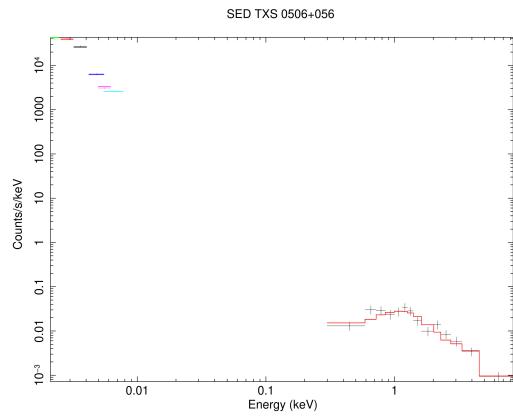
242 -7.807e-08 8.279e-12 0.000e+00 0.000e+00 0.000e+00
243 0.000e+00 0.000e+00 1.958e-03 6.296e-03 2.296e-06
244 0.000e+00 0.000e+00 6.296e-03 2.913e-02 8.739e-06
245 0.000e+00 0.000e+00 2.296e-06 8.739e-06 3.350e-09
246 -----
247
248 =====
249 Model phabs<1>*powerlaw<2> Source No.: 1 Active/On
250 Model Model Component Parameter Unit Value
251 par comp
252
253 1 1 phabs nH 10^22 1.00000 +/- -1.00000
254 2 2 powerlaw PhoIndex 3.06272 +/- 2.71864E-02
255 3 2 powerlaw norm 1.89288E-05 +/- 2.87733E-06
256
257 4 1 phabs nH 10^22 9.54671E-02 +/- 4.42524E-02
258 5 2 powerlaw PhoIndex 1.67417 +/- 0.170688
259 6 2 powerlaw norm 3.43289E-04 +/- 5.78805E-05
260 -----
261
262
263 Fit statistic : Chi-Squared 6.18 using 1 bins, spectrum 1, group 1.
264 Chi-Squared 5.21 using 1 bins, spectrum 2, group 1.
265 Chi-Squared 11.67 using 1 bins, spectrum 3, group 1.
266 Chi-Squared 2.12 using 1 bins, spectrum 4, group 1.
267 Chi-Squared 0.25 using 1 bins, spectrum 5, group 1.
268 Chi-Squared 7.08 using 1 bins, spectrum 6, group 1.
269 Chi-Squared 13.83 using 14 bins, spectrum 7, group 2.
270 Total fit statistic 46.33 with 14 d.o.f.
271
272 Test statistic : Chi-Squared 46.33 using 20 bins.
273 Null hypothesis probability of 2.48e-05 with 14 degrees of freedom

```

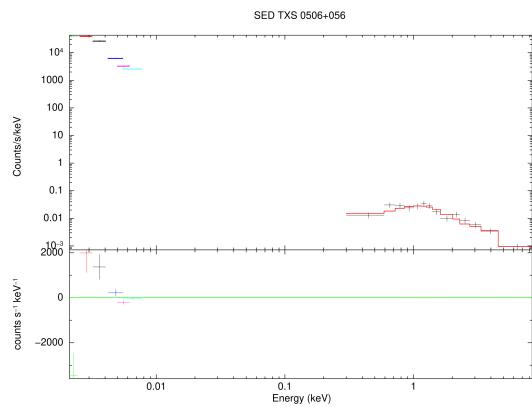
After some customization with iplot we have the final two Figures 3.

References

- [1] Xspecmanual.
- [2] Daniel Clery. Ghostly particle caught in polar ice ushers in new way to look at the universe. *Science*, 07 2018.
- [3] P Padovani, P Giommi, E Resconi, T Glauch, B Arsioli, N Sahakyan, and M Huber. Dissecting the region around icecube-170922a: the blazar txs0506+056 as the first cosmic neutrino source. *Monthly Notices of the Royal Astronomical Society*, 480:192–203, 07 2018.
- [4] Simona Paiano, Renato Falomo, Aldo Treves, and Riccardo Scarpa. The redshift of the bl lac object txs 0506+056. *The Astrophysical Journal*, 854:L32, 02 2018.



(a) SED of the AGN afterglow.



(b) Comparison of the observed data and the fitting model.
Below plot displays the residual, the difference between the data and the model.

Figure 3: Final figures of the analysis.