# GRB Detection & spectral analysis in DC1 Data

Nicola Omodei

Francesco Longo, Monica Brigida

INFN Pisa

# Outline

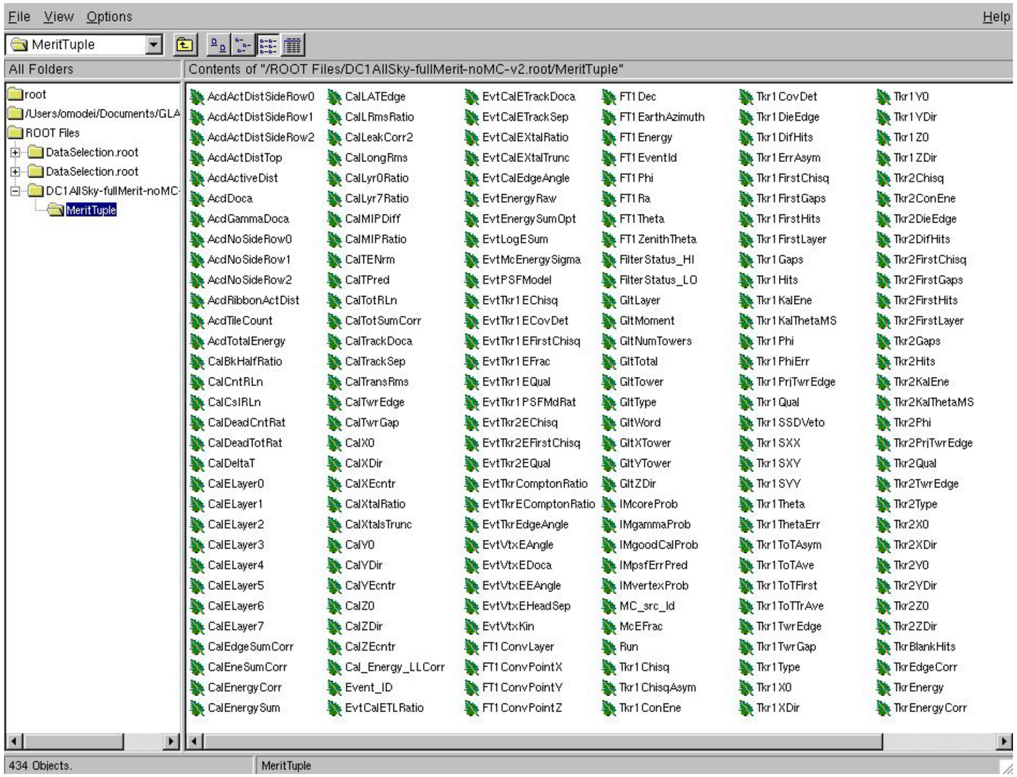
- FT1 Tree Visualizer
- The trigger algorithms
  - First results
  - Improvement of the algorithm
- GRB Detection
- Conclusions
  - Lesson Learned
  - Future development

# TF1 Tree Visualizer

- I developed a ROOT macro to view the FT1 Tree (starting from the DC1 ROOT files).
- Select a subset of events applying cuts and getting rid of the unused branches (to speed up the computation)
- Visualize the time series, the *spectrum*, the *sky map* in both *Ra, Dec* and *l, b*.
- Applying cuts to one of those quantities will affect all the plots (iteratively).

http://www.pi.infn.it/~omodei/GRB_and_DC1/

# The Data selection




- The *MeritTuple* contains several branches, some of those are not necessary for my analysis. For this reason a "prune" the Tree obtaining a smaller Tree (much faster)
- Other cuts can be used to select subset of data.
- To analyze GRB I chose **to use as much photon as I can, so I cut only the galactic center, ant the anticenter**.

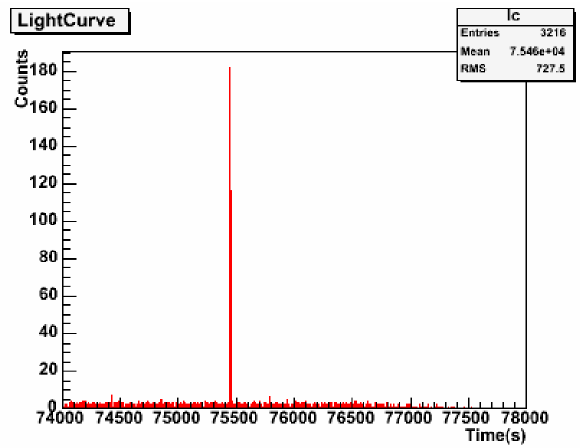
**root [0] .L EventSelector.cxx**
**root [1] EventSelector("myData/DC1AllSky-FT1Merit-noMC.root","DataSelection.root")**
(root [2] EventSelector("myData/DC1AllSky-FT1Merit-noMC.root","DataSelection.root","elapsed_time>70000"))

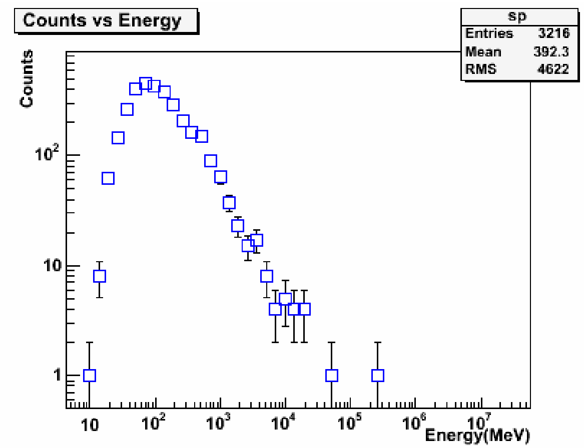
# FT1Viewer

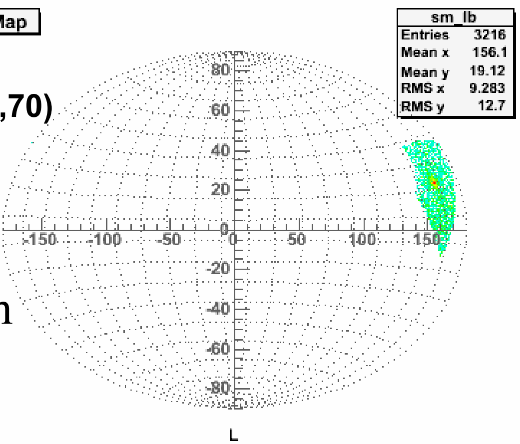
**root [1] .x compile.C**
**root [2] FT1Viewer a("DataSelection.root")**
**922782 Merit entries**
**Time selection: 30.0276 , 86429.9**
**Energy selection: 4.29641 , 5.85475e+07**
**Galactic Region: Ra :0 , 360**
**Dec :-90 , 90**
**root [2] a.Replot()**

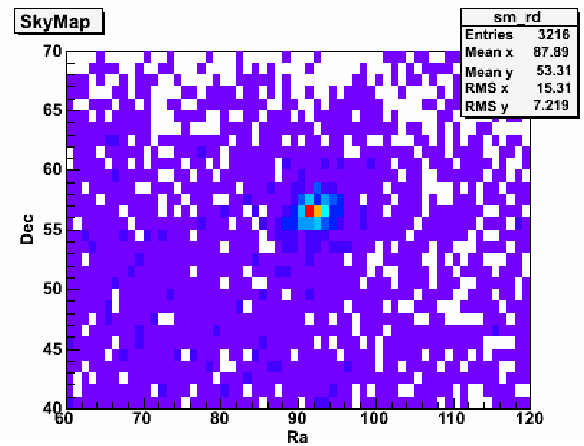
**root [3] a.SelectTimeInterval(74000,78000)**
**Time selection: 74000 , 78000**
**root [4] a.Replot()**

**root [5] a.SelectGalacticRegion_RaDec(60,120,40,70)**
**Galactic Region: Ra :60 , 120**
**Dec :40 , 70**
**root [6] a.Replot()**




Other current facilities: Fit the spectrum with a Power Law
Change the histogram binning.
Make “animations”…

QuickTime™ and a
Video decompressor
are needed to see this picture.

# Gamma-Ray Burst Analysis

- First simple algorithm: Trigger on differential count rate
- The dataset contain the orbital modulation -> the easies way to remove the modulation is computing the rate fixing a cerain number of events “M”:

$$R_j = \frac{M}{t_{(j+1)M} - t_{jM}} \quad \text{for j=1, N/M}$$

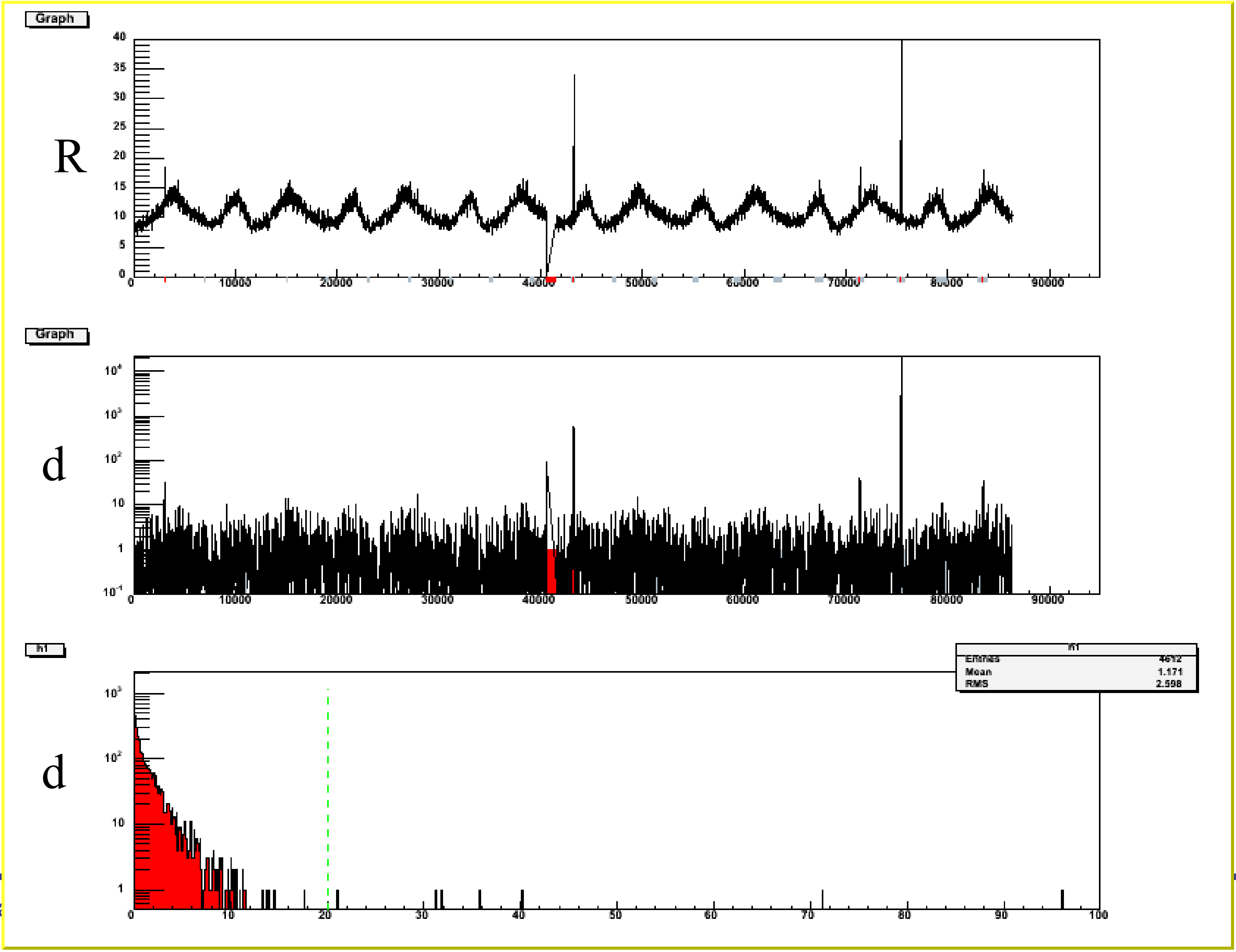
And compute the difference between 2 consecutive rates:

$$d_l = (R_{l+1} - R_l)^2 \quad \text{for l=1, N/M-1}$$

The value for the window “M” is typically 200

The distribution of “d” shows “rare” events, that are far from the RMS => GRBs !

# Simple Algorithm to the day 1



# Algorithm 1 Report (1 Day Only)

5 Burst found:

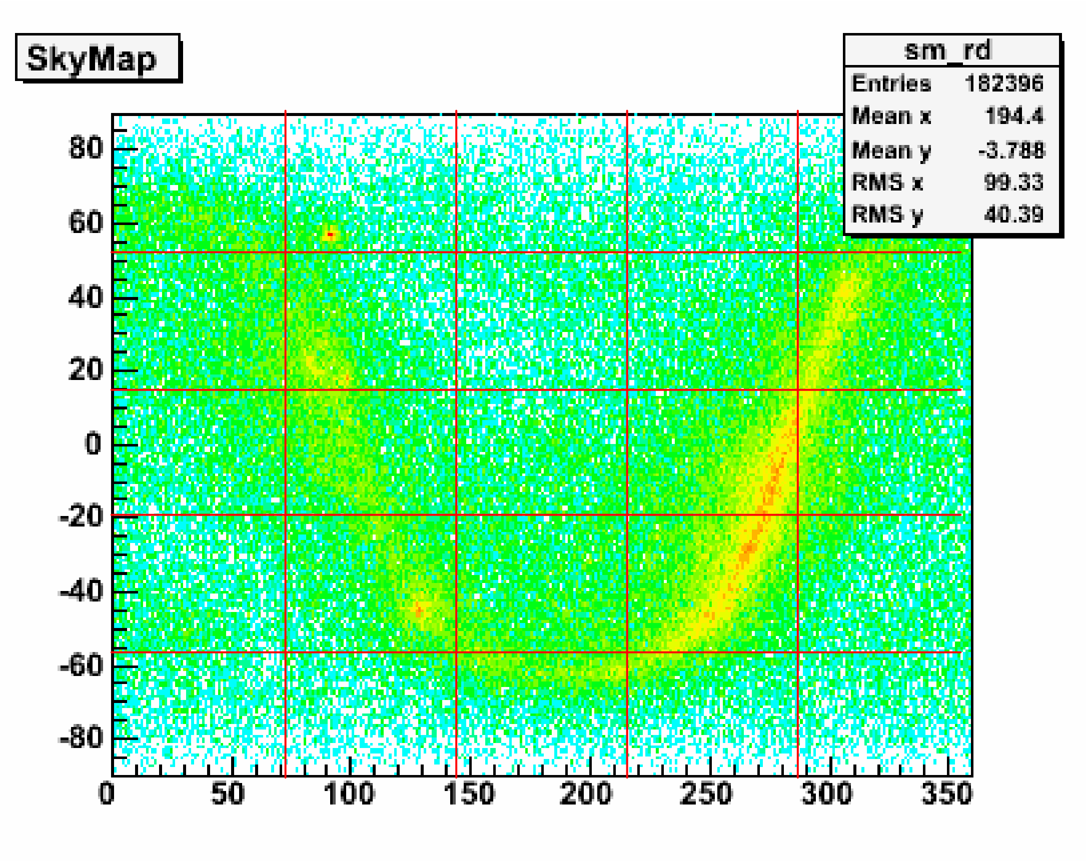
| | |
|---|---|
| Time = 3002 | ok |
| Time = 40607 | no (The hole in the data !!) |
| Time = 43234 | ok |
| Time = 71371 | ok |
| Time = 75415 | ok |
| Time = 75473 | ok |
| Time = 83488 | ok |

(ok = There effectively is a burst…)
(no = There is no burst, false trigger)

- It is very fast and easy to implement
- It works fine with intense bursts
- It takes into account all the sky -> High "background" !
- It works bad with faint burst
- No information on the direction

# Algorithm 2: Dividing the Sky Map

- The immediate extension of the Algorithm 1 is to divide the Sky in regions.

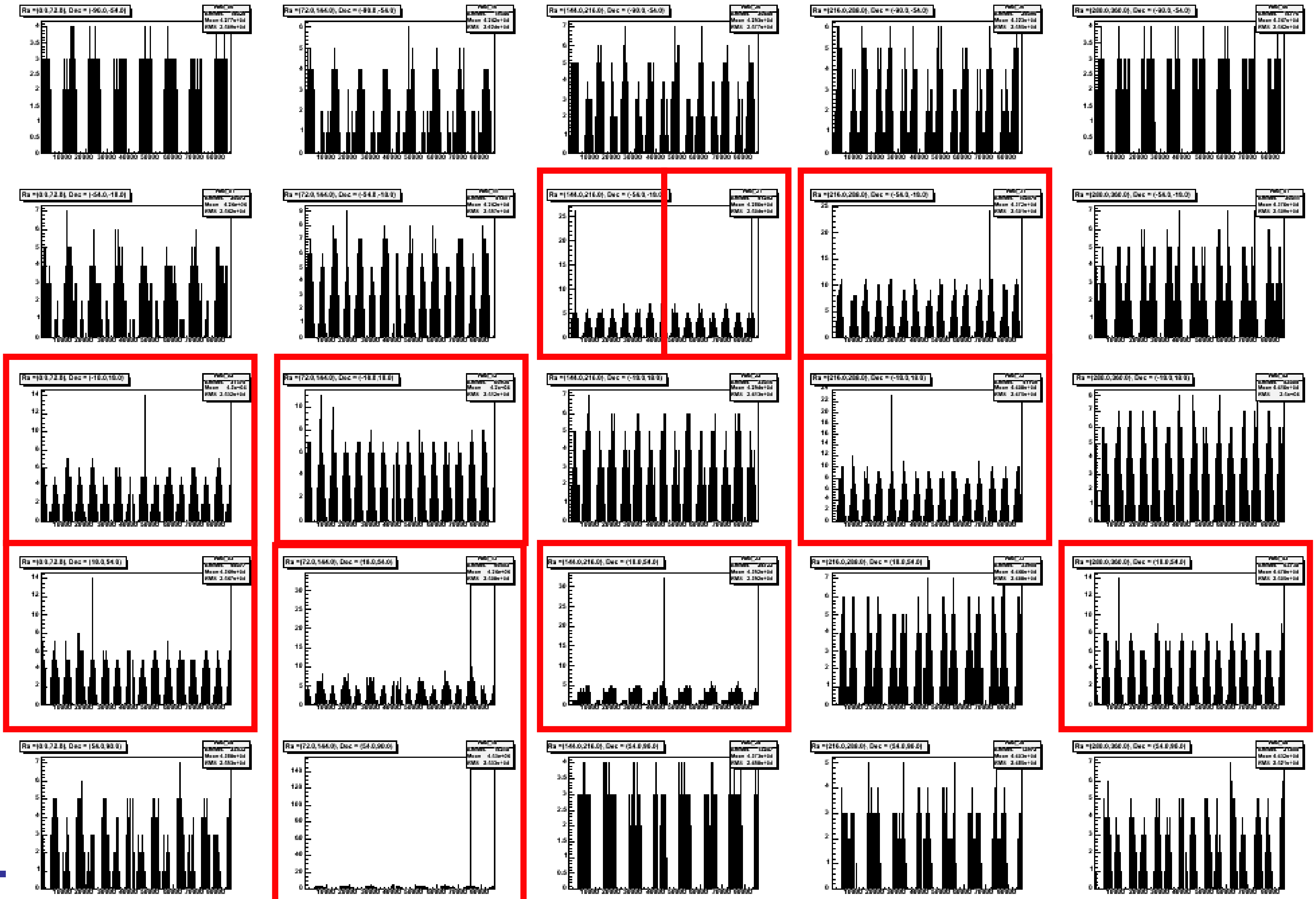



5 x 5 array reduces the "background" by a factor 25.

Also faint burst can be detectable.

Direct (70° x 36°) information on the localization.

# The 25 “light curves”



# Results: Overview

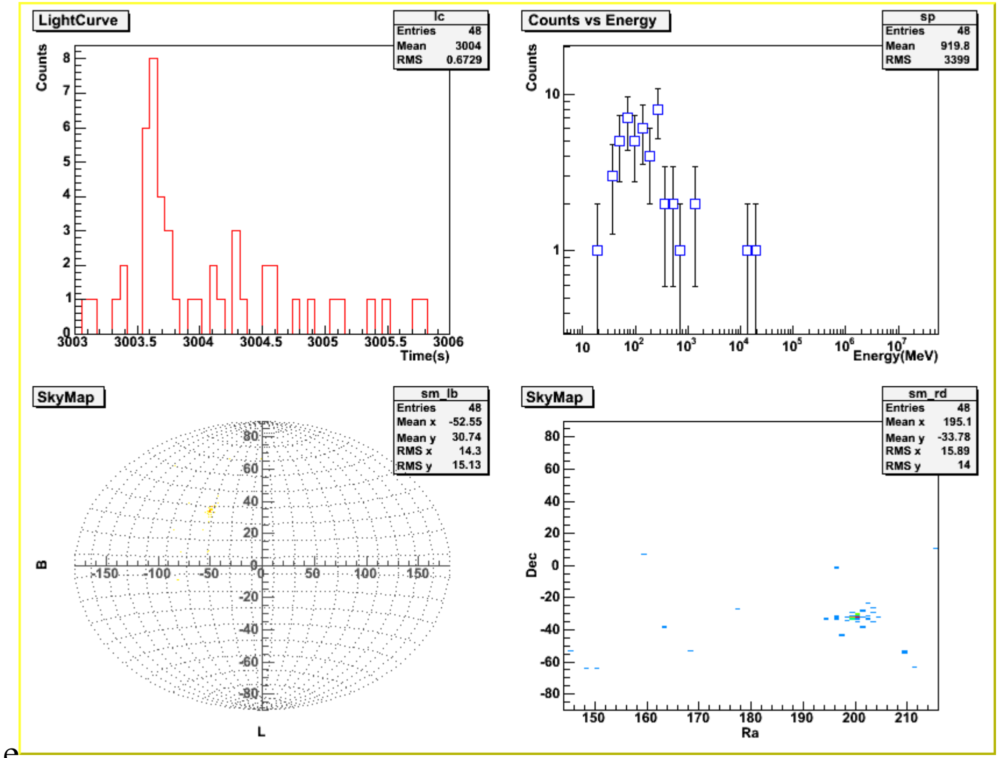
| GRB Number | T Start | T End | Ra | Dec | Nph | Flux ($erg/cm^2/s$) |
|---|---|---|---|---|---|---|
| GRB050718a | 3003 | 3006 | 200.3 | -32 | 48 | 2.66E-6 |
| GRB050718b | 7020 | 7030 | 91 | -1 | 599 | 5.43E-7 |
| GRB050718c | 11044 | 11048 | 327 | 26 | 37 | 9.13E-7 |
| GRB050718d | 23138 | 23141 | 19 | 27 | 30 | 1.08E-6 |
| GRB050718e | 27210 | 27216 | 259 | -16 | 53 | 2.25E-6 |
| GRB050718f | 43252 | 43262 | 147 | 34 | 121 | 1.65E-6 |
| GRB050718g | 47271 | 47278 | 26 | -3 | 41 | 8.89E-7 |
| GRB050718h | 71371 | 71413.6 | 225 | -30 | 214 | 1.89E-7 |
| GRB050718i | 75415 | 75473 | 92 | 57 | 700 | 2.64E-6 |
| GRB050718j | 83500 | 83550 | 200 | -32 | 115 | 2.20E-7 |
| GRB050720a | 176761 | 176880 | 128 | 65 | 1634 | |
| GRB050720b | 215703 | 215753 | 134 | 4 | 629 | |
| GRB050720bc | 220440 | 220440 | 134 | 4 | 491 | |
| GRB050721a | 327096 | ? | 325 | 16 | 17 | |
| GRB050722a | 386281 | 386380 | 199 | 32 | 185 | |
| GRB050722b | 410280 | 410320 | 236 | 41 | 640 | |

**For the first day:** 10 bursts detected/21 Generated.

Some of the burst generated are outside the GLAST FoV

# Day One, 18th of July 2005

## GRB050718a

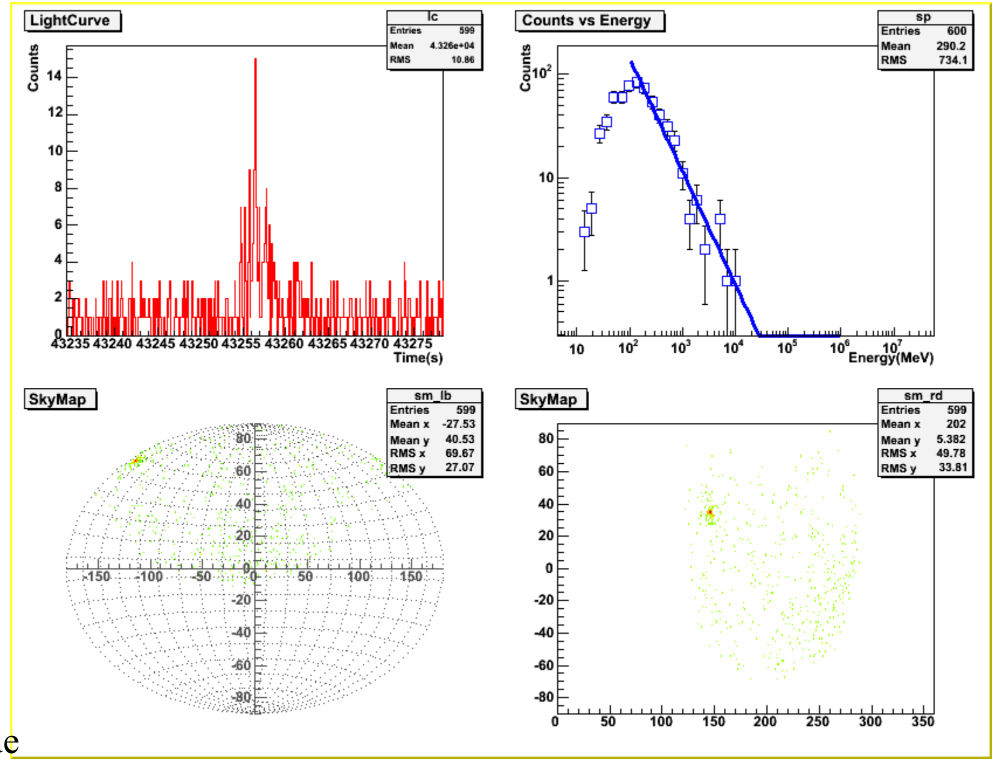



```
Model:  powerlaw<1>
 Model Fit Model Component  Parameter  Unit     Value
 par   par comp
   1    1    1   powerlaw   PhoIndex          1.64115     +/-  0.844458E-01
   2    2    1   powerlaw   norm             1.91446     +/-   1.42548
 ---------------------------------------------------------------------------
 ---------------------------------------------------------------------------
Chi-Squared =      10.60472     using     7 PHA bins.
Reduced chi-squared =      2.120943     for      5 degrees of freedom
Null hypothesis probability = 5.981E-02
```

Weak burst,
No Inverse Compton
was simulated.
Fit with a PL not bad!

# Day One, 18th of July 2005

## GRB050718b




odel: powerlaw<1>

| Model par | Fit par | Model comp | Component | Parameter | Unit | Value | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | powerlaw | PhoIndex | | 1.94143 | +/- | 0.252338 |
| 2 | 2 | 1 | powerlaw | norm | | 29.7816 | +/- | 61.5003 |

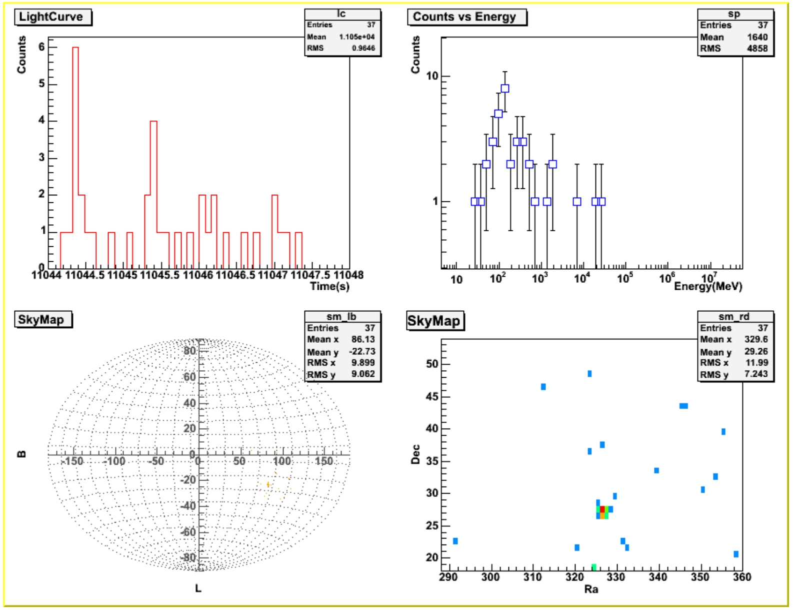
---------------------------------------------------------------------------
---------------------------------------------------------------------------

Chi-Squared = 4.438633 using 7 PHA bins.
Reduced chi-squared = 0.8877266 for 5 degrees of freedom
Null hypothesis probability = 0.488

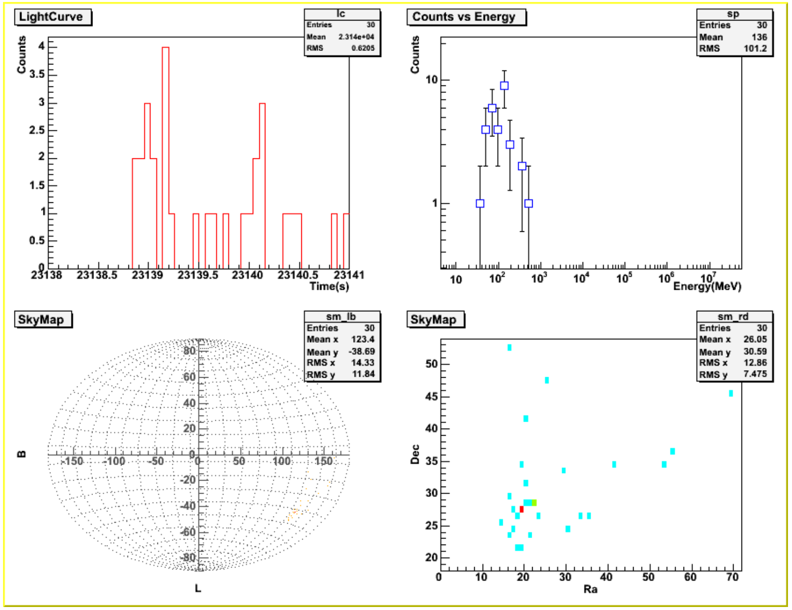
Intense burst,
Inverse Compton was simulated.
The fit with a PL is bad!

# Day One, 18th of July 2005

GRB050718c



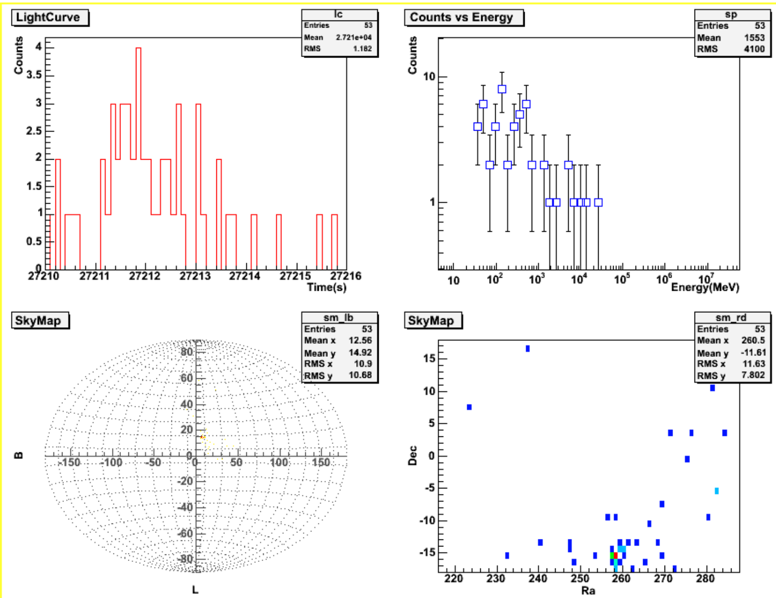

GRB050718d



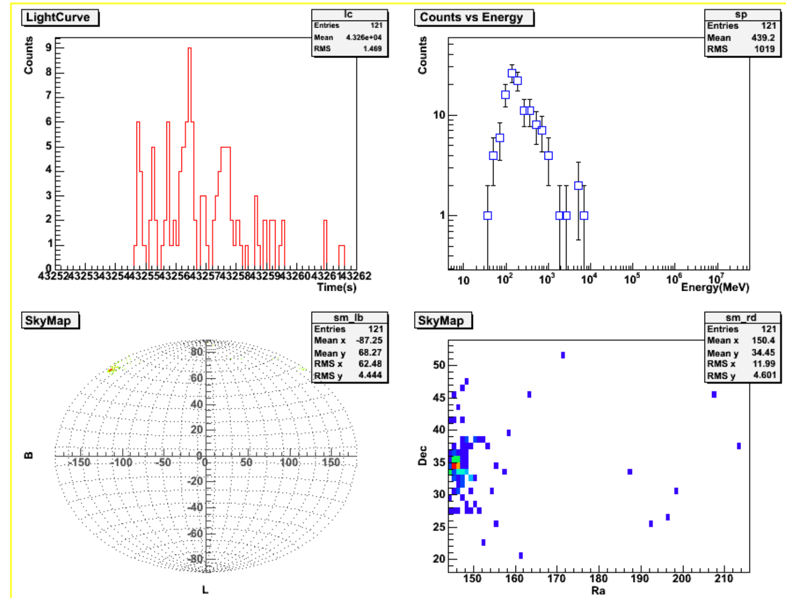

Very weak burst (about 30 photons)!

# Day One, 18th of July 2005

## GRB050718e



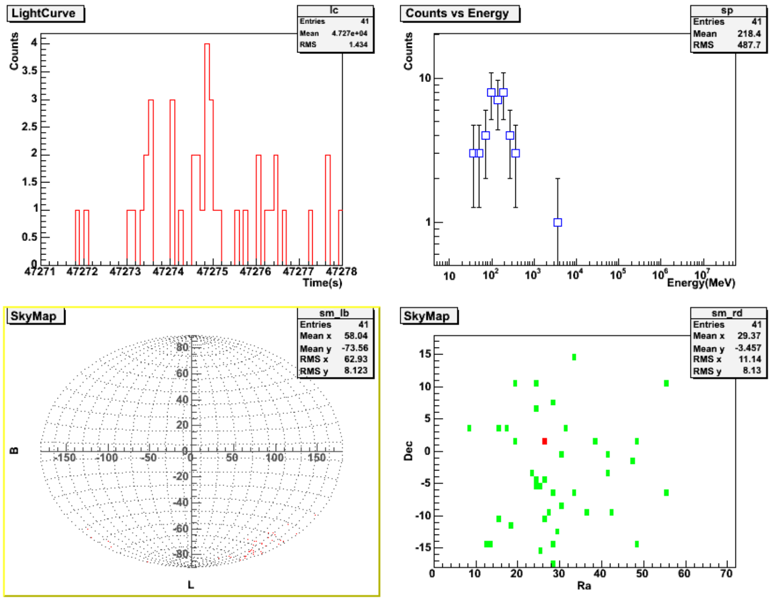

## GRB050718f



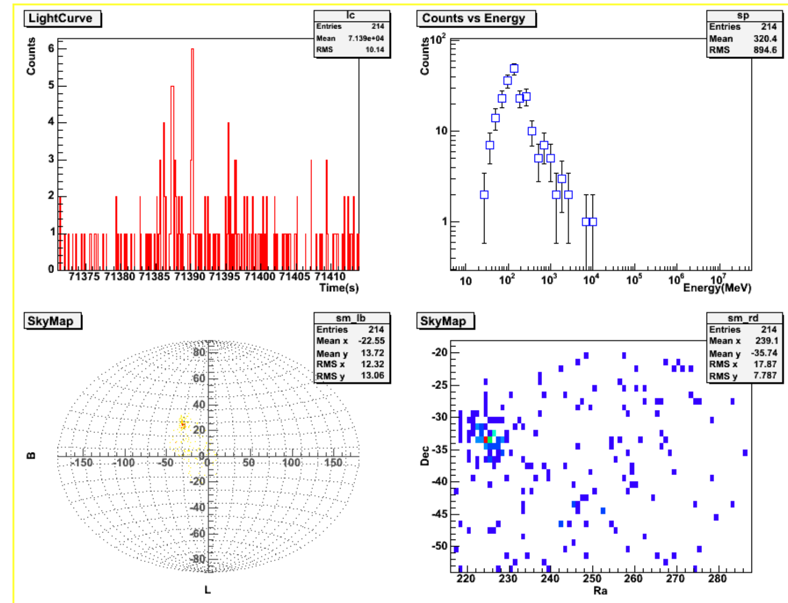

```
Model:  powerlaw<1>
  Model Fit Model Component  Parameter  Unit     Value
  par   par comp
    1    1    1   powerlaw   PhoIndex          1.71826     +/-  0.861568E-01
    2    2    1   powerlaw   norm              3.67267     +/-  3.35589
  ---------------------------------------------------------------------------
  ---------------------------------------------------------------------------
 Chi-Squared =      79.89644     using     7 PHA bins.
 Reduced chi-squared =      15.97929     for      5 degrees of freedom
 Null hypothesis probability = 8.821E-16
```

# Day One, 18th of July 2005

## GRB050718g




## GRB050718h




**GRB050718g**

Model: powerlaw<1>

| Model par | Fit par | Model comp | Component | Parameter | Unit | Value | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | powerlaw | PhoIndex | | 1.60546 | +/- | 0.273156 |
| 2 | 2 | 1 | powerlaw | norm | | 0.377648 | +/- | 1.08093 |

---------------------------------------------------------------------------

---------------------------------------------------------------------------

Chi-Squared = 23.04828 using 7 PHA bins.
Reduced chi-squared = 4.609655 for 5 degrees of freedom
Null hypothesis probability = 3.305E-04

**GRB050718h**

Model: powerlaw<1>

| Model par | Fit par | Model comp | Component | Parameter | Unit | Value | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | powerlaw | PhoIndex | | 1.99143 | +/- | 0.914785E-01 |
| 2 | 2 | 1 | powerlaw | norm | | 33.2825 | +/- | 27.8128 |

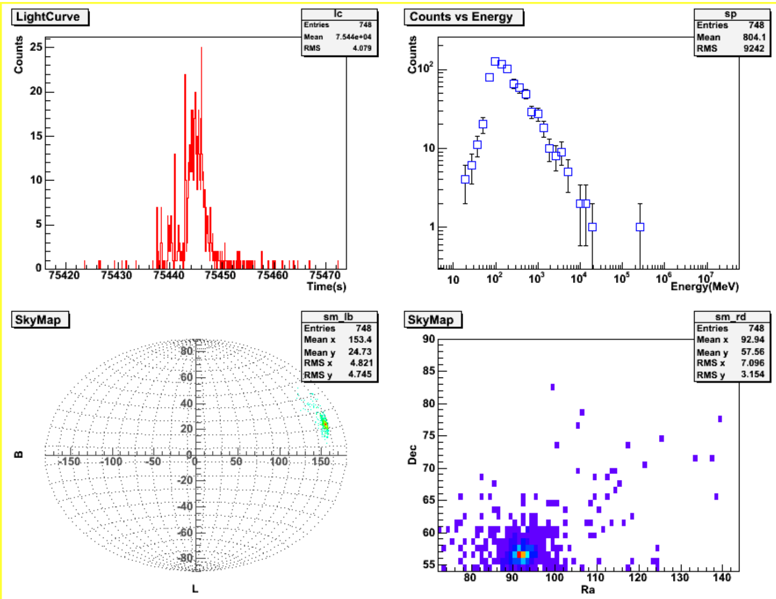
---------------------------------------------------------------------------

---------------------------------------------------------------------------

Chi-Squared = 40.60414 using 7 PHA bins.
Reduced chi-squared = 8.120829 for 5 degrees of freedom
Null hypothesis probability = 1.128E-07

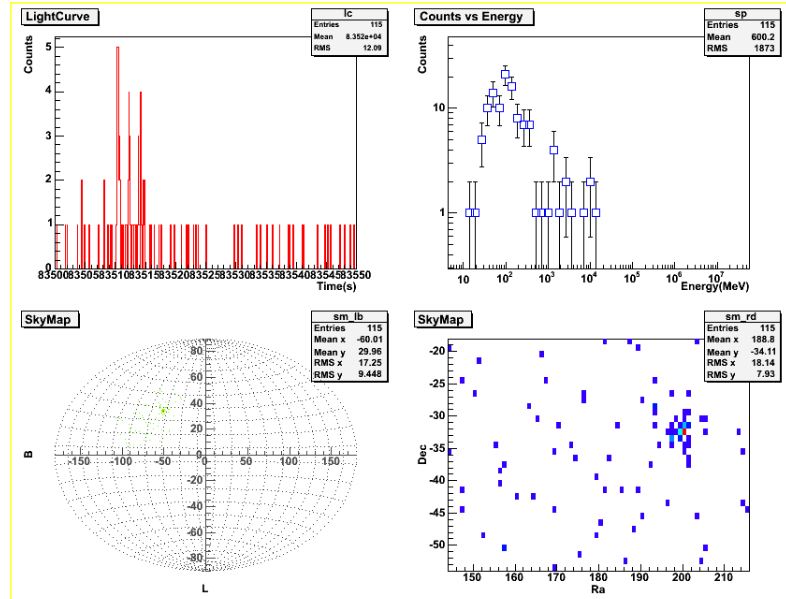
# Day One, 18th of July 2005

## GRB050718i




```
Model:  powerlaw<1>
  Model Fit Model Component  Parameter  Unit     Value
  par   par comp
   1     1    1   powerlaw   PhoIndex          1.79878     +/-  0.280451E-01
   2     2    1   powerlaw   norm             18.8932     +/-   5.67197
 ---------------------------------------------------------------------------
 ---------------------------------------------------------------------------
Chi-Squared =      212.8927     using     7 PHA bins.
Reduced chi-squared =      42.57854     for      5 degrees of freedom
Null hypothesis probability = 4.905E-44
```

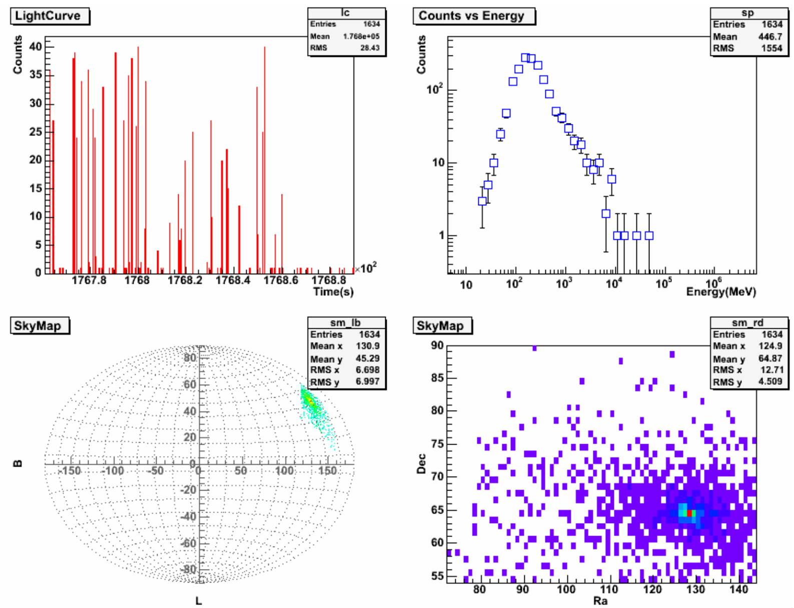
## GRB050718j




```
 ---------------------------------------------------------------------------
Model:  powerlaw<1>
Model Fit Model Component  Parameter  Unit     Value
par   par comp
 1     1    1   powerlaw   PhoIndex          1.82369     +/-  0.126513
 2     2    1   powerlaw   norm              2.25550     +/-   2.44362
 ---------------------------------------------------------------------------
 ---------------------------------------------------------------------------
Chi-Squared =      12.04965     using     7 PHA bins.
Reduced chi-squared =      2.409930     for      5 degrees of freedom
Null hypothesis probability = 3.411E-02
```

# Selected Burst

GRB050720b




GRB050720b is particularly intense (1634 counts), the spiky structure are resolved.

# Conclusions

- Lesson learned:
  - Bright burst in DC1 are detectable (easily)!
  - Faint Burst in DC1 (few photons) are also detectable.
  - Not easy to do spectral analysis with X-Spec (only power law model…).
  - Few photons of "background", and constant during the Burst duration.
  - Many alternative tools (with respect to ST) has been developed for DC1 analysis.
  - Very important to provide a feedback to the ST developers!
- Future improvements:
  - FT1Viewer: Integration in the Science Tools environment (?)
    - Fits I/O, Interaction with EventBin…
    - Exposure file for ROOT ?
    - Can begin the starting point for the people who want to use ROOT for analysis!
  - GRB Analysis: **many things can be done using the DC1 data!**
    - New trigger algorithms !
    - Spectral fitting & Spectral-temporal fitting
    - Temporal analysis
    - Interpretation with the physical model (N peaks <-> N of shells, SSC IC, Rise/Decay time <-> Shell's geometry)
    - Feedback for new models