GRB Detection & spectral analysis in DC1 Data

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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, and the anticenter.

```c
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"))
```
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

Time selection: 74000 , 78000

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

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 easiest way to remove the modulation is computing the rate fixing a certain number of events “M”:

  \[ R_j = \frac{M}{t_{(j+1)M} - t_jM} \quad \text{for } j=1, \frac{N}{M} \]

  And compute the difference between 2 consecutive rates:

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

  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

<table>
<thead>
<tr>
<th>GRB Number</th>
<th>T Start</th>
<th>T End</th>
<th>Ra</th>
<th>Dec</th>
<th>Nph</th>
<th>Flux (\text{erg/cm}^2/\text{s})</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRB050718a</td>
<td>3003</td>
<td>3006</td>
<td>200.3</td>
<td>-32</td>
<td>48</td>
<td>2.66E-6</td>
</tr>
<tr>
<td>GRB050718b</td>
<td>7020</td>
<td>7030</td>
<td>91</td>
<td>-1</td>
<td>599</td>
<td>5.43E-7</td>
</tr>
<tr>
<td>GRB050718c</td>
<td>11044</td>
<td>11048</td>
<td>327</td>
<td>26</td>
<td>37</td>
<td>9.13E-7</td>
</tr>
<tr>
<td>GRB050718d</td>
<td>23138</td>
<td>23141</td>
<td>19</td>
<td>27</td>
<td>30</td>
<td>1.08E-6</td>
</tr>
<tr>
<td>GRB050718e</td>
<td>27210</td>
<td>27216</td>
<td>259</td>
<td>-16</td>
<td>53</td>
<td>2.25E-6</td>
</tr>
<tr>
<td>GRB050718f</td>
<td>43252</td>
<td>43262</td>
<td>147</td>
<td>34</td>
<td>121</td>
<td>1.65E-6</td>
</tr>
<tr>
<td>GRB050718g</td>
<td>47271</td>
<td>47278</td>
<td>26</td>
<td>-3</td>
<td>41</td>
<td>8.89E-7</td>
</tr>
<tr>
<td>GRB050718h</td>
<td>71371</td>
<td>71413.6</td>
<td>225</td>
<td>-30</td>
<td>214</td>
<td>1.89E-7</td>
</tr>
<tr>
<td>GRB050718i</td>
<td>75415</td>
<td>75473</td>
<td>92</td>
<td>57</td>
<td>700</td>
<td>2.64E-6</td>
</tr>
<tr>
<td>GRB050718j</td>
<td>83500</td>
<td>83550</td>
<td>200</td>
<td>-32</td>
<td>115</td>
<td>2.20E-7</td>
</tr>
</tbody>
</table>

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.
GRB050718a

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

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
GRB050718b

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

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Chi-Squared = 4.438633 using 7 PHA bins.
Reduced chi-squared = 0.8877266 for 5 degrees of freedom
Null hypothesis probability = 0.488
Very weak burst (about 30 photons)!
Day One, 18th of July 2005

GRB050718e

Model: powerlaw<1>

<table>
<thead>
<tr>
<th>Model Fit</th>
<th>Model Component</th>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>par</td>
<td>par</td>
<td>par</td>
<td>comp</td>
<td></td>
</tr>
<tr>
<td>1 1 1</td>
<td>powerlaw</td>
<td>PhoIndex</td>
<td>1.71826</td>
<td>+/- 0.861568E-01</td>
</tr>
<tr>
<td>2 2 1</td>
<td>powerlaw</td>
<td>norm</td>
<td>3.67267</td>
<td>+/- 3.35589</td>
</tr>
</tbody>
</table>

Chi-Squared = 79.89644 using 7 PHA bins.
Reduced chi-squared = 15.97929 for 5 degrees of freedom
Null hypothesis probability = 8.821E-16
GRB050718g

Model: powerlaw<1>

| Model Fit | Model Component | Parameter  | Unit | Value       | 1.60546 +/- 0.273156
|------------|-----------------|------------|------|-------------|
| par        | par comp        | 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 Fit | Model Component | Parameter  | Unit | Value       | 1.99143 +/- 0.914785E-01
|------------|-----------------|------------|------|-------------|
| par        | par comp        | 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
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