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

All Folders	Contents of "/ROOT Files/DC1AllSky-fullMerit-noMC-v2.root/MeritTuple"									
root	AcdActDistSideRow0	髌 CalLATEdge	🔖 EvtCalETrackDoca	N FT1 Dec	💸 Tkr1 CovDet	💸 Tkr 1 V0				
/Users/omodei/Documents/GLA	AcdActDistSideRow1	💸 Cal L Rms Ratio	🔖 EvtCalETrackSep	騻 FT1 EarthAzimuth	💸 Tkr 1 Die Edge	🗽 Tkr 1 Y Dir				
ROOT Files	AcdActDistSideRow2	North Calleak Corr2	🔖 EvtCalEXtalRatio	No. FT1 Energy	💸 Tkr 1 Dif Hits	💸 Tkr 1 ZO				
DataSelection.root	AcdActDistTop	🔖 CalLongRms	🔖 Evt Cal EXtal Trunc	💸 FT1 Eventid	🦄 Tkr 1 Err Asym	🦄 Tkr 1 Z Dir				
 B- BataSelection.root C D C 1488-y-cullMerit-noMC- Meritropic 	AcdActiveDist	SalLyr0Ratio	🔖 EvtCalEdgeAngle	N FT1 Phi	🔖 Tkr 1 First Chisq	🔖 Tkr2Chisq				
	AcdDoca	🔖 CalLyr7Ratio	🔖 EvtEnergyRaw	🔖 FT1 Ra	🔖 Tkr 1 First Gaps	💸 Tkr2ConEne				
	🔖 Acd Gamma Doca	CalMIPDiff	🔖 EvtEnergySumOpt	🔖 FT1 Theta	🔖 Tkr1 First Hits	🔖 Tkr2DieEdge				
	Acd No Side Row0	Sal MIP Ratio	Not EvtLogESum	🔖 FT1 ZenithTheta	🗽 Tkr1 FirstLayer	Tkr2DifHits				
	Acd No Side Row 1	SalTENrm	🔖 EvtMcEnergySigma	💸 Filter Status_HI	🔖 Tkr 1 Gaps	💸 Tkr2FirstChisq				
	Acd No Side Row2	CalTPred	EvtPSFModel	Tilter Status_LO	🗽 Tkr 1 Hits	🗽 Tkr2FirstGaps				
	Acd Ribbon Act Dist	CalTotRLn	EvtTkr1 EChisq	SitLayer	Tkr1 KalEne	Tkr2FirstHits				
	AcdTile Count	State CalTot Sum Corr	EvtTkr1ECovDet	Sit Moment	🗽 Tkr 1 KalThetaMS	🗽 Tkr2FirstLayer				
	AcdTotalEnergy	SalTrackDoca	EvtTkr1EFirstChisq	SitNumTowers	🗽 Tkr 1 Phi	Tkr2Gaps				
	SalBkHalfRatio	Sal Track Sep	EvtTkr1EFrac	GitTotal	Tkr1 PhiErr	Tkr2Hits				
	SalCntRLn	S CalTrans Rms	🐚 EvtTkr1 EQual	SitTower	Tkr1 PriTwrEdge	Tkr2KalEne				
	CalCsIRLn	SalTwr Edge	EvtTkr1PSFMdRat	SitType	Tkr1 Qual	Tkr2KalThetaM8				
	SalDeadCntRat	🐚 CalTwr Gap	EvtTkr2EChisq	SitWord	Tkr1SSDVeto	Tkr2Phi				
	SalDeadTotRat	SalX0	EvtTkr2EFirstChisq	GITXTower	Tkr1 SXX	Tkr2PriTwrEdge				
	CalDeltaT	CalXDir	EvtTkr2EQual	GIt VTower	Tkr1 SXV	Tkr2Qual				
	CalELayer0	S CalXEcntr	EvtTkr Compton Ratio	Glt Z Dir	Tkr1 SVV	Tkr2TwrEdge				
	ScalELayer1	Scal Xtal Ratio	EvtTkrEComptonRatio	McoreProb	🐚 Tkr 1 Theta	Tkr2Type				
	CalELayer2	S CalXtalsTrunc	EvtTkrEdgeAngle	MgammaProb	Tkr1 ThetaErr	Tkr2X0				
	CalELayer3	CalV0	EvtVtxEAngle	Mgood Cal Prob	Tkr1 ToTAsym	Tkr2XDir				
	ScalELayer4	CalVDir	EvtVtxEDoca	MpsfErr Pred	Tkr1ToTAve	Tkr2V0				
	CalELayer5	Scal/Ecntr	EvtVtxEEAngle	MvertexProb	Tkr1 ToTFirst	Tkr2VDir				
	ScalELayer6	CalZ0	EvtVtxEHeadSep	MC src ld	Tkr1 ToTTrAve	Tkr2Z0				
	CalELayer7	CalZDir	EvtVt×Kin	McEFrac	Tkr1 Twr Edge	Tkr2ZDir				
	S CalEdgeSumCorr	S CalZEcntr	FT1 ConvLayer	Nun Run	Tkr 1 Twr Gap	🔉 Tkr Blank Hits				
	ScalEne Sum Corr	Cal Energy LLCorr	FT1 ConvPointX	Tkr1 Chisq	Tkr 1 Type	Tkr Edge Corr				
	CalEnergy Corr	Event ID	FT1 ConvPointY	Tkr1 ChisqAsym	Tkr1 X0	Tkr Energy				
	CalEnergy Sum	Evt CalETL Batio	FT1 ConvPointZ	Tkr1 ConEne	Tkr1 XDir	Tkr Energy Corr				

- 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"))

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FT1Viewer



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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":

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

And compute the difference between 2 consecutive rates:

$$d_l = (R_{l+1} - R_l)^2$$
 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.



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
$\operatorname{GRB050718d}$	23138	23141	19	27	30	1.08E-6
$\mathbf{GRB050718e}$	27210	27216	259	-16	53	2.25E-6
GRB050718f	43252	43262	147	34	121	1.65E-6
m GRB050718 m g	47271	47278	26	-3	41	8.89E-7
${ m GRB050718h}$	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	
$\mathbf{GRB050720bc}$	220440	220440	134	4	491	
GRB050721a	327096	?	325	16	17	
GRB050722a	386281	386380	199	32	185	
$\mathbf{GRB050722b}$	410280	410320	236	41	640	

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

Some of the burst generated are outside the GLAST FoV



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Very weak burst (about 30 photons)!

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





Model: powerlaw<1> Model: powerlaw<1> Model Fit Model Component Parameter Unit Value Model Fit Model Component Parameter Unit Value par par comp par par comp 1 1 powerlaw PhoIndex 1.60546 +/- 0.273156 1 1 1 powerlaw PhoIndex 1.99143 +/- 0.914785E-01 1 2 1 powerlaw norm 0.377648 +/- 1.08093 2 2 1 powerlaw norm 33.2825 +/- 27.8128 2 Chi-Squared = 23.04828 using 7 PHA bins. Chi-Squared = 40.60414 using 7 PHA bins. Reduced chi-squared = 4.609655 for 5 degrees of freedom Reduced chi-squared = 8.120829 for 5 degrees of freedom Null hypothesis probability = 3.305E-04Null hypothesis probability = 1.128E-07

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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:
 - <u>FT1Viewer</u>: 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!
 - <u>GRB Analysis</u>: 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