The Complete Study of GRB X-ray Afterglows: energetics, time-scales and luminosity (GRBs XRT Catalogue)

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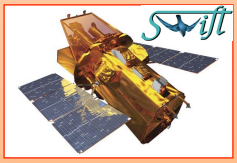


The Sample

We analysed all the Gamma-Ray Bursts (GRBs) with spectroscopic analysis observed by the X-Ray Telescope (XRT), on board *Swift* satellite, from its launch (November 2004) to the end of 2010 (437 GRBs of 658 GRBs detected by *Swift*).
In particular the sample includes:

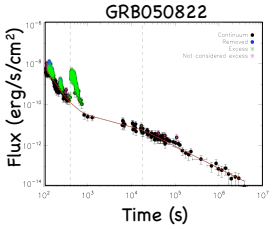
- 165 GRBs with redshift
- 414 long GRBs (153 with z)
- 23 short GRBs (12 with z)

Data Reduction

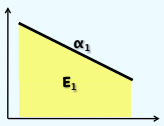
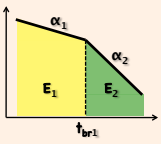
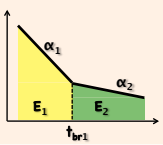
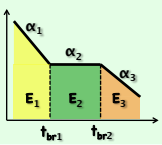
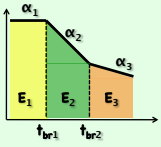
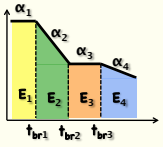
- The XRT-data have been reduced with the method reported in Margutti et al. (2010). We obtained the XRT light curves in the 0.3-10 keV total energy band and in four sub-energy bands: 0.3-1 keV, 1-2 keV, 2-3 keV and 3-10 keV.
- Our XRT archive contains light curves in count-rate, flux and luminosity (for the redshift subsample).
- The light curves in flux units are calibrated accounting for spectral evolution. This is relevant especially during the steep decay.
- The spectra have been measured both assuming NH constant and variable.

Data Analysis

- We analysed the light curves in flux units.
- The XRT light curves have been fitted with four different functions (F(t)): 0) power law; I) smoothed broken power law; II) sum of power law and smoothed broken power law; III) sum of two smoothed broken power laws. The best fit values were determined using the IDL Levenberg-Marquardt least-squares fit routine (MPFIT) supplied by C. Markwardt (Markwardt 2009). All variability and fluctuations superimposed on the basic underlying light curve have been subtracted by iteration following Margutti et al. (2011).
- Using the fit data, we calculated the total fluence or energy of our light curves as well as the one of different parts of the light curves (E_1, E_2, E_3, E_4).



Classification & Morphology

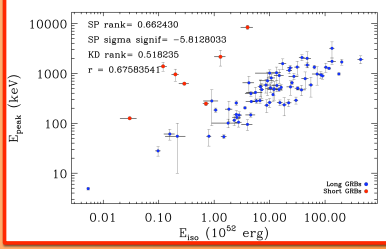
Type	0	Ia	Ib	IIa	IIb	III
Light Curve Shape						
Fit Function	$F_0(t) = N_1 t^{-\alpha_1}$	$F_{Ia,Ib}(t) = N_1\left[\left(\frac{t}{t_{br1}}\right)^{-\frac{\alpha_1}{s_1}} + \left(\frac{t}{t_{br1}}\right)^{-\frac{\alpha_2}{s_1}}\right]^{s_1}$ Ia: $s_1 < 0$ Ib: $s_1 > 0$		$F_{IIa}(t) = N_1 t^{-\alpha_1} + N_2\left[\left(\frac{t}{t_{br2}}\right)^{-\frac{\alpha_2}{s_1}} + \left(\frac{t}{t_{br2}}\right)^{-\frac{\alpha_3}{s_1}}\right]^{s_1}$	$F_{IIb}(t) = N_1\left[\left(\frac{t}{t_{br1}}\right)^{-\frac{\alpha_1}{s_1}} + \left(\frac{t}{t_{br1}}\right)^{-\frac{\alpha_2}{s_1}}\right]^{s_1} + N_2 t^{-\alpha_3}$	$F_{III}(t) = N_1\left[\left(\frac{t}{t_{br1}}\right)^{-\frac{\alpha_1}{s_1}} + \left(\frac{t}{t_{br1}}\right)^{-\frac{\alpha_2}{s_1}}\right]^{s_1} + N_2\left[\left(\frac{t}{t_{br3}}\right)^{-\frac{\alpha_3}{s_2}} + \left(\frac{t}{t_{br3}}\right)^{-\frac{\alpha_4}{s_2}}\right]^{s_2}$
Total	114	153		148		22
Flares	21	38		53		10
Complete* No Flares	28	86		86		12
Complete* Flares	17	31		49		10

* A light curve is considered complete if the XRT re-pointing time is < 300 s, the count rate is similar to the background count rate and the data cover all the observation time.

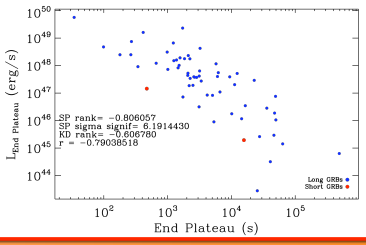
Correlations

We present here the first results of our analysis that is under completion. We derived and now are under study and analysis about 900 2x2 correlations among parameters obtained from the best fits and from the BAT data. As an example we show some of the row known correlations we derived. From the BAT data, we show the Amati relation (Amati et al. 2008), that is the correlation between the spectrum peak energy at rest frame and the isotropic energy, and the correlation between the photon index and the rest frame energy peak (Crider et al. 1997). With the X-ray data, we show the relation between the luminosity at the end of the plateau and the plateau end time (Dainotti et al. 2008, 2010). Moreover, for each parameter we analysed its distribution (see the histogram below) and we computed Monte Carlo simulation to obtain the errors for all histograms.

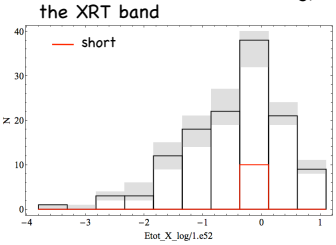
- The Amati relation



- The "Dainotti" relation



- Distribution of the total energy in the XRT band



References:
Amati L. et al., 2008, MNRAS, 391, 577
Crider A. et al., 1997, ApJ, 479, L39
Dainotti M. G. et al., 2008, MNRAS, 391, L79
Dainotti M. G. et al., 2010, ApJ, 722, L215
Margutti R.et al., 2011, MNRAS, 410, 1064
Margutti R. et al., 2010, MNRAS, 406, 2149
Markwardt, C.B. 2009, Astronomical Data Analysis Software and Systems XVIII, 411, 251