

Duration distributions for gamma-ray bursts registered in various experiments since VENERA11/KONUS up to Fermi/GBM.

I V Arkhangelskaja

National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe highway 31, Moscow, 115409, Russia

E-mail: irene.belousova@usa.net

Abstract. Gamma-ray bursts duration distributions properties for events registered by experiments CGRO/BATSE, VENERA11/KONUS, VENERA12/KONUS, Swift/BAT, GRANAT/PHEBUS, Suzaku/WAM, RHESSI and Fermi/GBM are considered. GRBs observed since 1967 and now several thousands of events were listed in more than 30 catalogues. Gamma-ray bursts duration distribution was the first analysed using data of BATSE instrument onboard the CGRO. The GRBs duration distribution analysis had shown the existence of two bursts classes: long and short separated by $t_{90} = 2$ s. But results of similar distributions for bursts observed by other detectors have shown shifting of boundary between short and long events from value of 2 s. For example, Swift/BAT GRBs subset analysis gives the value of ~ 1 s for this separator point. Moreover, t_{90} has dependence from instrument registered this burst – it is function of detector sensitivity threshold and operation energy band. For instance, the duration of GRB060418 burst t_{90} is ~ 52 s according to Swift/BAT data and only 36 s according to RHESSI data. Therefore, the type of GGB (whether it short or long) should be defined only taking into account distinctive features of instrument detected this event. Also attributes of third intermediate GRBs subgroup appearance in events subsets for various detectors are discussed. Firstly this subgroup was found some years ago in BATSE GRB duration and duration-hardness distributions.

1. Introduction

Gamma-ray bursts (GRBs) were first registered by Vela series satellites launched in 1969 and 1970 [1]. The first GRB with duration ~ 1 s was observed on July 2, 1967 by detectors onboard Vela-4A in energy range 0.1 - 1 MeV [2]. GRBs characteristics vary in very large intervals. For example, bursts duration lies in the interval $10^{-2} - 10^3$ s, registered near the Earth fluence varies in the range $10^{-8} - 10^{-3}$ erg/(cm²×s). Several thousand GRBs were detected up to now (see, for example, [3]) by more than 30 instruments onboard various satellites in both near-Earth and interplanetary space.

2. GRBs properties based on various satellite data The examples of GRBs subsets observed in several experiments are presented in table 1.

The first detailed GRB catalogue (1B) was obtained as a result of BATSE experiment onboard the Compton Gamma Ray Observatory (CGRO) [4]. Gamma-ray bursts duration distribution was the first analysed using its data.



Table 1. GRBs detected by various satellites.

Satellite	Operation period ^a		Detector name	Energy band	Time resolution	Number of GRBs detected ^b
	start	end				
Vela satellite series [1, 2, 1963 5]	October 1963	March 1972	CsI scintillator counter	0.2 – 1.0 MeV (Vela 5a, 5b) 0.3 – 1.5 MeV (Vela 6a, 6b)	0.05s	73
VENERA 11-12	September 1978	April 1980	KONUS [3, 6] Signe 2M (SNEG-2MZ) [3, 7]	50.0-200 keV 80-800 keV	15.625 ms 1/512 s	141 ~50
Pioneer Venus Orbiter [3, 8]	December 1978	August 1992	Gamma Ray Burst Detector (OGBD)	0.2 to 2.0 MeV	64 ms	~270
Granat	December 1989	December 1996	PHEBUS [9] GIGMA [10]	10 ² keV – 1.6 MeV 35 – 1300 keV	~10 ms	206 ~90
Ulysses [11]	October 1990	June 2009	Solar X-Rays and Cosmic Gamma-Ray Bursts (HUS/GRB)	15.0 - 150 keV (scintillation counters) 5.0 - 15 keV (solid state detectors)	From 0.25 to 2s depending on telemetry rate	1889
CGRO	April 1991	June 2000.	BATSE (LAD and SD) [12] OSSE [13] COMPTEL [14] EGRET (TASCS) [15]	20 keV-2.0 MeV 50 keV-10 MeV 0.7–30 MeV 1.0 - 2×10 ² MeV	2 μs 4 ms 0.1s 1s	~2700 Several GRBs ~30 ~50
Wind [16]	November 1994	operated	KONUS	50.0-200 keV	64 ms	2556
HETE-2 [17]	October 2000	March 2006	Fregate WXM SXC	7 - 4×10 ² keV 2.0-30 keV 1.5-12 keV	20 ms 80 ms 200 ms	~300 ~80
INTERGRAL [18]	October 2002	operated	Spectrometer SPI Imager IBIS JEM-X	20 keV - 15 MeV 15 keV - 10 MeV 3- 35 keV	single photon counting - -	~300 Several GRBs
Suzaku [19]		operated	HXD-WAM	12-300 keV	4 ms	~750
RHESSI [20]	February 2002	February 2010	RHESSI	3 keV–20 MeV	2 ms	522 [20, 21]
Swift	November 2004	operated	BAT [22, 23]	15.0 - 150 keV	200 μs	1128
Agile [24]	April,	operated	GRID	30 MeV – 30 GeV	10 ms	Several

	2007		MCAL	18 – 60 keV	tens GRBs
Fermi [25]	July, 2008	operated	GBM [26]	~ 8 keV $\div$ ~ 30 MeV	1710
			LAT [27]	~ 20 MeV to >300 GeV	104

^a For RHESSI interval of processed data is listed.

^b This table lists total amount of observed GRBs while figures 3 – 5 shows only bursts with defined duration t_{90} .

2.1. The dependence of burst duration from detector distinctive features

According to [4], bursts duration was described by the time intervals t_{50} and t_{90} in which the integrated counts from the burst increase from 25% to 75% and from 5% to 95% correspondingly. The GRBs duration distribution analysis had shown the existence of two bursts classes: long and short separated by $t_{90} = 2$ s.

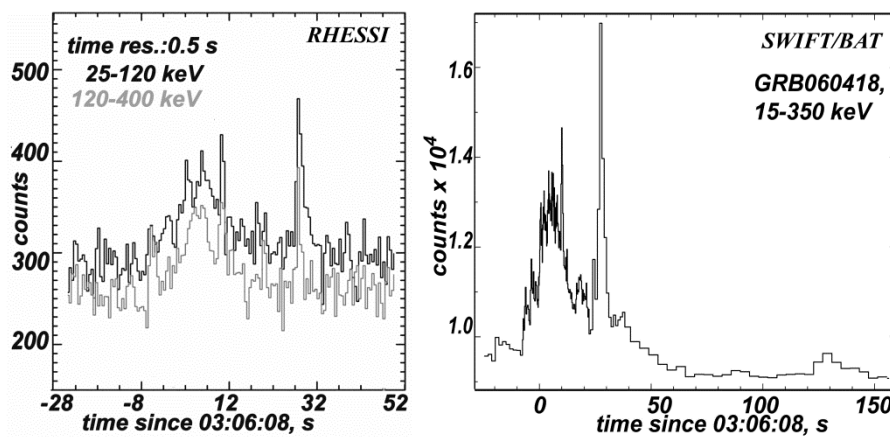


Figure 1. Temporal profiles for GRB060418 on RHESSI [20] and SWIFT [22] data. The duration of this burst t_{90} GRB060418 SWIFT/BAT ≈ 52 s and t_{90} GRB060418 RHESSI ≈ 36 s.

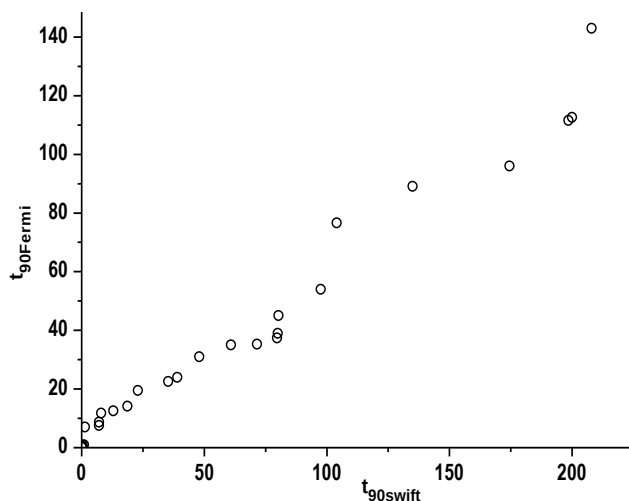


Figure 2. GRBs duration on SWIFT/BAT and Fermi/GBM data for subset of bursts simultaneously registered by these instruments.

Unfortunately t_{90} depends on instrument registered this burst. The detector sensitivity threshold and operation energy band influences to its value. Figure 1 presents the temporal profiles for GRB060418 by RHESSI and SWIFT data as illustration of this fact. The duration of this burst was $t_{90_GRB060418_SWIFT/BAT} \approx 52$ s according to SWIFT data [22] and $t_{90_GRB060418_RHESSI} \approx 36$ s according to

RHESSI data [20]. This difference was caused by GRB spectral behavior and differences of sensitivity threshold and operation energy band between RHESSI and SWIFT.

The other example of burst duration ambiguity is shown at the figure 2. The subset of 28 GRBs observed simultaneously by SWIFT/BAT and Fermi/GBM was analysed: for 14 of them $t_{90_SWIFT/BAT} > t_{90_Fermi/GBM}$, for 9 bursts the opposite situation occurred and only for 5 GRB these values are comparable [22, 26]. So, we must take into account these differences in our investigation of various GRBs distributions in duration.

2.2. Short and long GRBs on data of various satellites

The GRBs duration distribution analysis on BATSE data since 1B catalogue [4] up to finally updated 5B [12] has shown the existence of 2 bursts classes: long and short separated by $t_{90} = 2$ s – see figure 3a.

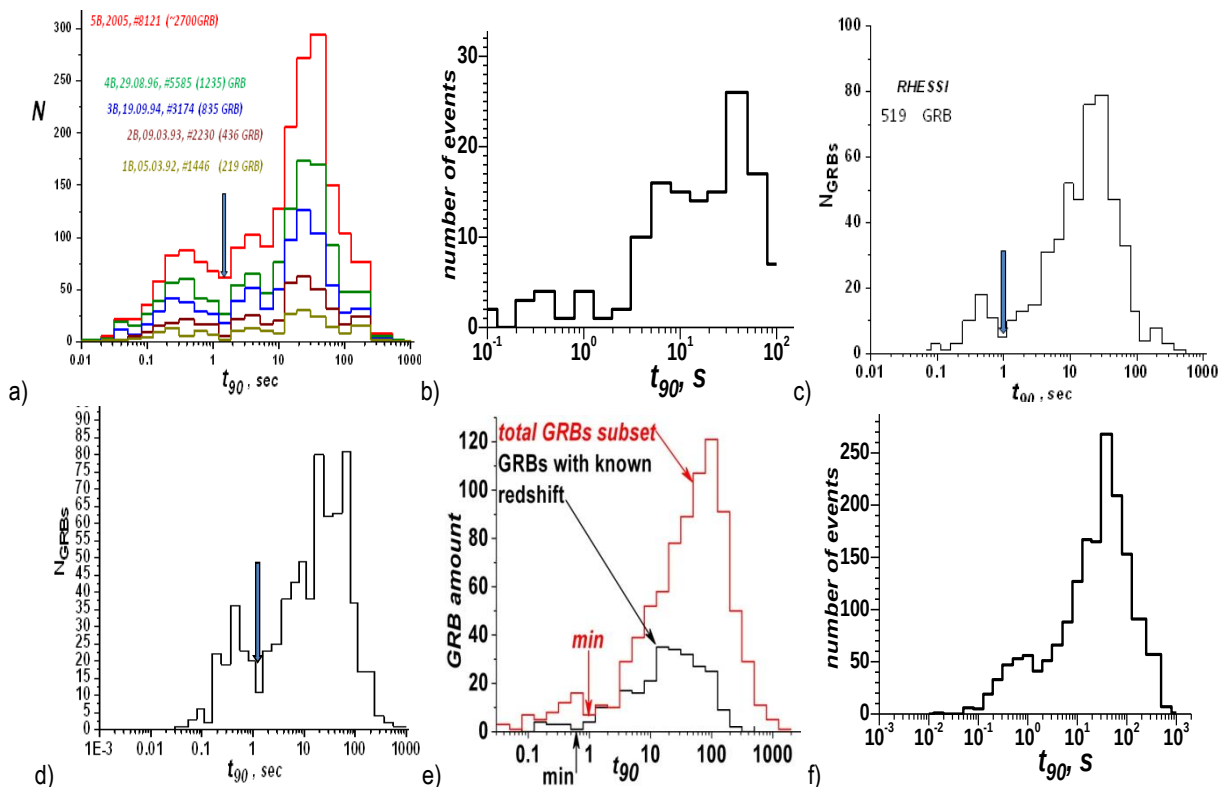


Figure 3. Duration distributions for bursts from subsets registered by BATSE (a), WIND/VENERA_11-12 (b), RHESSI (c), Suzaku/HXD-WAM (d), Swift/BAT (e), Fermi/GBM (f).

Taking into account obtained in subsection 2.1 ambiguity of GRBs duration we suppose for bursts observed in other experiments this boundary shifting. Figure 3 also shows duration distributions for bursts from subsets registered by WIND/VENERA_11-12 (b), RHESSI (c), Suzaku/HXD-WAM (d), Swift/BAT (e), Fermi/GBM (f). The analysis of several subset duration distributions presented at figure 3 allows concluding the difference of boundary between short and long events from value of 2 s obtained from CGRO/BATSE bursts catalogue. Durations of 1 s more likely correspond to this separator point for Swift/BAT and RHESSI GRBs subsets distributions.

2.3. The dependence of burst duration from redshift

Figure 4 presents duration distributions for Swift GRBs with known redshift (274 bursts from 1128) without and with events t_{90} correction to z . The analysis of figure 3 shows that value of 1 s more likely correspond to this separator point for Swift/BAT GRBs subset duration distributions without correction on redshift.

However real cosmological sources time properties should be investigated only taking into account its redshift. The figure 4 indicates value ~ 0.6 s more likely as separator point between short and long GRBs after its duration correction on redshift for Swift/BAT catalogue events.

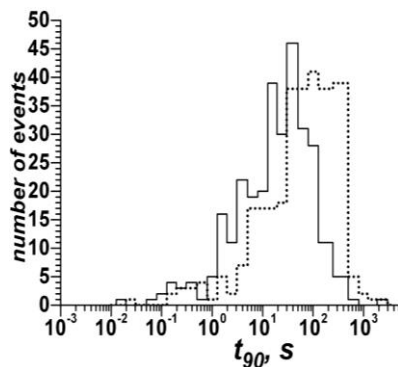


Figure 4. Swift GRBs (274 bursts with known redshift) subset duration distributions without (dotted histogram) and with (solid one) correction on redshift.

Thus, the data analysis allows concluding sufficiently changing of duration distribution and shifting the separator point between short and long GRBs again after bursts duration correction to redshift.

2.4. Intermediate GRB subgroup

The subgroup of intermediate GRBs was first found in 1999 [28] during 4B current BATSE catalogue (lately published as 5B one [12]) analysis. Later this type GRBs are widely discussed - see, for example, [29].

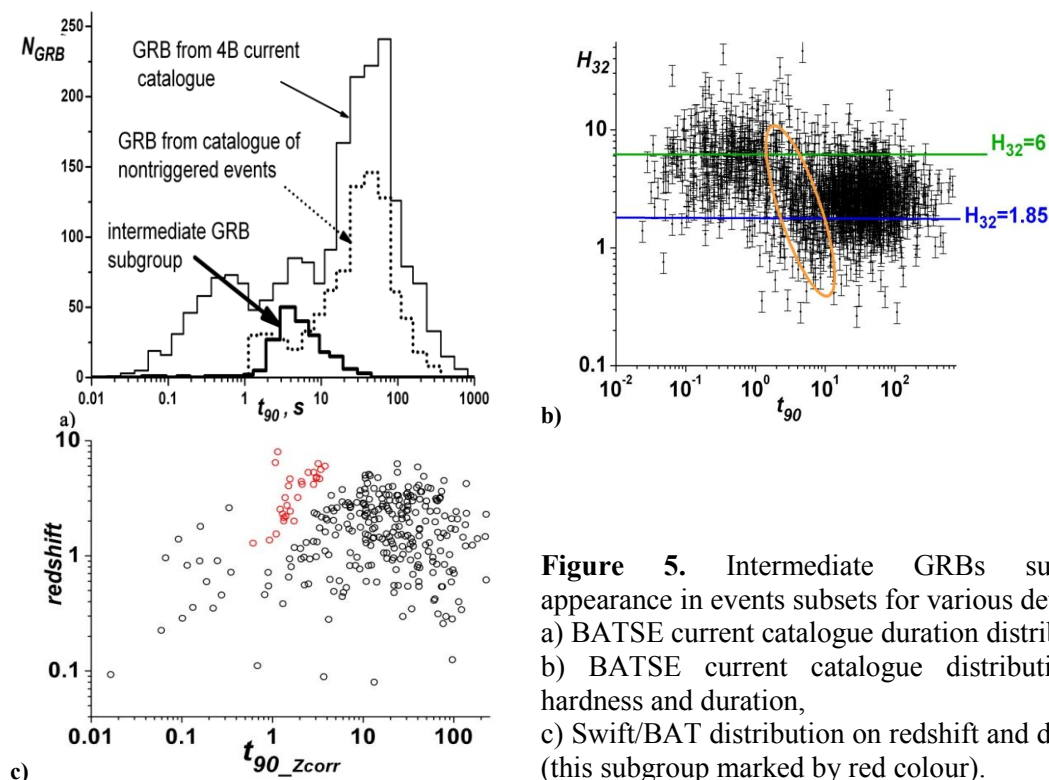


Figure 5. Intermediate GRBs subgroup appearance in events subsets for various detectors: a) BATSE current catalogue duration distribution, b) BATSE current catalogue distribution on hardness and duration, c) Swift/BAT distribution on redshift and duration (this subgroup marked by red colour).

Intermediate GRBs subgroup appearance in events subsets for various detectors is presented at figure 5. This subgroup is absent in nontriggered event catalogue [30, 31] (see dotted histogram at panel a) but clearly seen in BATSE current catalogue distribution on hardness and duration (marked by orange ellipse), and Swift/BAT distribution on redshift and duration (this subgroup indicated by red colour).

3. Conclusion

GRBs observed since 1967 and now several thousands of events were listed in more than 30 catalogues. Gamma-ray bursts duration distribution was first analyzed using data of BATSE instrument onboard the CGRO. The GRBs duration distribution analysis has shown the existence of two bursts classes: long (t_{90} more than 2 s) and short (t_{90} less than 2 s). But results of similar distributions analysis for bursts observed by other detectors have shown shifting of boundary between short and long events from value of 2 s. For example, Swift/BAT and RHESSI GRBs subsets analysis gives the value of ~ 1 s for this separation point. Moreover, t_{90} depends on instrument registered this burst. The detector sensitivity threshold and operation energy band influences to its value. Therefore, the type of GRB (whether it short or long) should be defined only taking into account distinctive features of instrument detected this event and GRB redshift. After taking into account characteristics GRB duration correction on redshift third intermediate GRBs subgroup appears also in Swift/BAT burst subset too.

Acknowledgments

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