Very Short Gamma Ray Bursts and Primordial Black Holes

David. B. Cline and Stan Otwinowski
UCLA Department of Physics & Astronomy

Abstract: We show the locations of the SWIFT short hard bursts (SHB) with afterglows on the Galactic map and compare with the VSB BATSE events. As we have pointed out before, there is an excess of events in the galactic map of BATSE VSB events. We note, that none of VSB SWIFT era events fall into this cluster. More SWIFT events are needed to check this claim. We also report a new study with KONUS data of the VSB sample with an average energy above 90 keV showing a clear excess of events below 100 ms duration (T90) that have large mean energy photons. We suggest that VSB themselves consists of two subclasses: a reaction of events have peculiar distribution properties and have no detectable counter parts, as might be expected for exotic sources such as Primordial Black Holes. New results from SWIFT will be compared with the BATSE VSB data.

Introduction

GRBs from detector BATSE we divide into three classes according to time duration (T_{90}): long, L ($T_{90} > 1$ s); short, S (1 s $> T_{90} > 0.1$ s); and very short, VS ($T_{90} < 0.1$ s). See Fig. 1. We assume that the VSGRBs constitute a separate class of GRBs and fit the time distribution in Fig. 1 with a three-population model. The fit is excellent but does not give significant evidence for a three-population model.

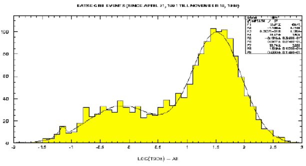


Fig. 1. The time distribution T_{90} for all GRBs from BATSE detector [1].

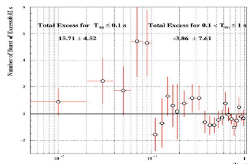


Fig. 3. BATSE GRB events (1991 Apr 21 – 2000 May 26). Exccess in GRBs inside the chosen region (see Fig. 2) (30° < b < -30°; 90° < l < 180°) as a function of T_{90} [2].

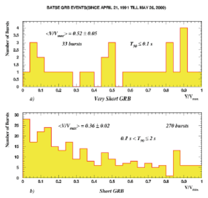


Fig. 4. Distribution of the V/V_{max} for BATSE events (1991 April 21 – 2000 May 26) [2].

We have also reanalyzed the overall radial distribution of the VSGRBs and the SGRB using the standard $\langle V/V_{max}\rangle$ test [2]. We used the C_{max}/C_{min} table from BATSE catalog as an

The Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) is a NASA satellite. Its spectrometer consists of nine germanium detectors (7.1 cm diameter and 8.5 cm height). They are lightly shielded only, thus making RHESSI also very useful to detect non-solar photons from any direction. The energy range for GRB detection extends from about 50 keV up to 17 MeV depending on the direction. An effective area for near axis direction of incoming photons reaches up to 200 cm^2 at 200 keV.

With a field of view of about half of the sky, RHESSI observes about one or two gamma-ray bursts per week."[1].

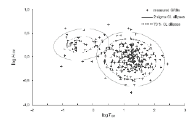
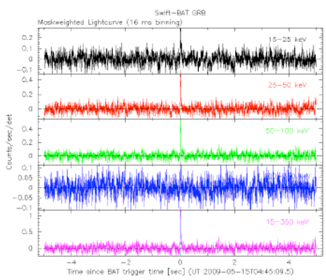


Fig. 8.

Hardness ratio vs. durations of the RHESSI GRBs with the best fit of two bivariate log-normal functions. There was used 358 GRBs observed by the RHESSI and covered the period from February 2002 to April 2008. The used hardness ratio as the ratio of fluencies in the bands: (120 - 1500) keV / (25 - 120) keV. [1].



Now we analyze the angular distribution of two classes, S and VS events, Fig.2. In this figure we see, that SGRBs (0.1 s < T_{90} < 2 s) are well described by Poisson distribution, but VSGRBs (T_{90} < 0.1 s) are strongly grouped in 1/8 of the whole space, with probability 0.00007 to be fluctuation from Poisson distribution.

In Fig. 3 we present an excess in the GRBs in the chosen region in Galactic plane. BATSE trigger works with 64 ms shortest time interval [3], so all GRBs with duration shorter than 64 ms are detected with smaller efficiency. The shorter duration the efficiency of the observation is smaller. If trigger time is shorter we should observe more events with duration shorter 64 ms – what suggest the data presented in Fig. 3, really, we observe decreasing the number of bursts shorter 64 ms, in part because of the trigger inefficiency. We have not included the BATSE detection efficiency to VSGRBs analysis.

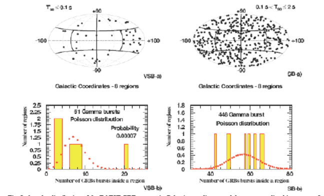


Fig. 2. Angular distribution of the BATSE GRBs events in Galactic coordinates and the corresponding histograms of Poisson distribution prediction (filled circles) for two GRB classes: S and VS events [2].

fluctuation from uniform distribution. This is in agreement with our earlier, simple estimation: $7\cdot10^{-5}$ (see Fig. 2, VSB-b). It means the effect itself is on about 4σ level.

The authors analyze, with cumulants method, up to 5th order, if there is any structure within this cluster. Analysis are consistent with the lack of any genuine correlation of 4th and 5th order and suggests that the group (groups?) consists probably of few smaller groups of multiplicity about of 2-3. These results are "scale-free".

The anisotropy of VSGRBs suggests the question if we observe any correlation with other phenomenon.

In [5] the possible correlations of VSGRBs with CMB, cosmic rays and particular kind of astronomical objects (Polars) is shown. This correlations show particularly that in Quadrant 2 "all astronomical indicator are stronger" [6]. It is in accordance with our observation of the VSGRBs concentration in this region. Is it by chance? We cannot exclude that such concentration of matter was relic from the time of the Big Bang.

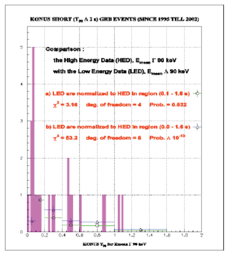


Fig. 6. KONUS data with different cuts on the average gamma energy <γ> [7].

3. SWIFT data: SB and VSB angular distributions

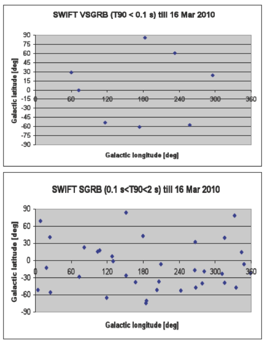


Fig. 9.

SWIFT data, for 0.1 s < T_{90} ≤ 2 s gives in 1/8 of all angular area (for isotropic distribution) 35/8=4.375 events. We observe 3,5,2,5,4,3,9,4 GRBs in equal angular area (for isotropic distribution).

It confirms isotropic distribution for 0.1 s < GRB < 2 s.

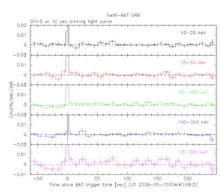


Fig. 12

GRB090417A – SWIFT
http://gcn.gsfc.nasa.gov/notices_s/349447/BA/

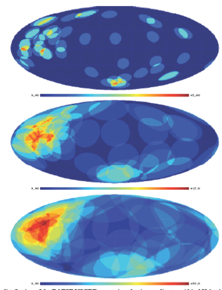


Fig. 5. Angular distribution of the BATSE VSGRB events in galactic coordinates within 10° (top), 25° (middle), and 40° (bottom), radius cone around each event [4].

The BATSE VSGRB angular Galactic coordinate distribution was reanalyzed using factorial moments and cumulants analysis [4].

Authors present VSGRB angular distribution with very suggestive method, extending around each GRB coordinate point to 10°, 25° and 40° radius cone Fig. 5. The detailed first four factorial moments analysis gives as a result the probability < $3\cdot10^{-5}$ for the chance of such

We have also analyzed GRBs from KONUS-WIND detector, which nominal energy range of gamma-ray measurements covers the interval from 12 keV up to 10 MeV. It gives the possibility to compare SGRBs (T_{90} < 2 s) of Low Energy Data (LED), <γ> < 90 keV, with High Energy Data (HED), <γ> > 90 keV. LED are normalized to HED in region (0.1 – 1.6 s) and agreement between them are good (probability = 0.523), but if we normalized LED to HED in region (0.0 – 1.6 s) and compare both distribution we see strong disagreement (prob. < 10^{-16}). We observe big excess of VSGRBs with <γ> > 90 keV. KONUS use, like BATSE, shortest trigger of 64 ms, so we should observe even bigger excess – detector lost detection efficiency at T_{90} < 64 ms, like in the BATSE case. This is an additional argument to treat VSGRBs as separate class of events.

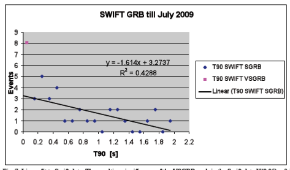


Fig. 7. Linear fit to Swift data. The resulting significance of the VSGRB peak in the Swift data Y(0.05) = 3.193, from fit; observed are 8 events => σ ≈ (8-3.193)/√3.193 ≈ 2.69.

GRBs observed by Swift also show some excess in region of VSGRBs. So we have three big experiments which confirm independently our proposition to treat the VSGRBs as distinct class of events.

As a candidate mechanism for possible source of such events we will suggest PBH evaporation. The duration of VSGRBs < 100 ms, their composition from relatively harder gammas and local origin as a distinction from neighboring SGRBs strongly support this hypothesis.

2. Observation GRBs with BATSE, SWIFT and RHESSI

The rate of GRBs with T_{90} < 2 s is for RHESSI ' 14.0 %, for Swift ' 7.6 % and for BATSE 4B ' 26 %; therefore the ratio short/long GRBs obviously depends on the sensitivity of the instrument.[2].

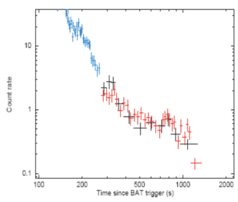
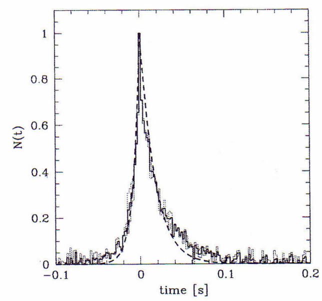


Fig. 10

GRB090515A – SWIFT
http://gcn.gsfc.nasa.gov/notices_s/352108/BA/
TRIGGER_DUR: 0.032 [sec]
Image S/N = 9.79 No afterglow
GCN#9364 The BAT light curve shows a single spike with T_{90} (15-350 keV) = 0.036 +- 0.016 sec (estimated error including systematic). Peak not seen in 100-350 keV channel.



References

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