A Search for Non-Triggered Gamma-Ray Bursts in the BATSE Continuous Records: The Current Status

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Abstract. We present our current results of an off-line search for non-triggered gamma-ray bursts (GRBs) in the BATSE daily records (obtained with 1024 ms time resolution) covering about 8.6 years of observations. We found 1713 non-triggered and 1963 triggered GRBs. The scan was done with artificial test bursts added to the data which allowed us to measure the efficiency of the search. We extended the $\log N - \log P$ distribution down to $P \sim 0.1$ ph/s/cm^2. Previous indications of a turnover of the $\log N - \log P$ distribution at small P are not confirmed.

INTRODUCTION

Many gamma-ray bursts which were too weak to trigger the Burst and Transient Source Experiment (BATSE) on the *Compton Gamma-Ray Observatory (CGRO)* (see [1]) or were missed due to other reasons (data readouts, etc.) can be confidently identified in the BATSE daily records which cover the full period of the *CGRO* operation. The search for non-triggered bursts can substantially extend the GRB sample and, even more importantly, can extend the $\log N - \log P$ distribution of GRBs to smaller peak fluxes, P. The first sample of non-triggered GRBs was found by Rubin et al. [2]. A systematic search for non-triggered GRBs was initiated by Kommers et al. ([3], hereafter K97). Recently, Kommers et al. ([4], [5], hereafter K98 and K99) completed their data scan of 6 years of observations. A similar search with trigger criteria close to the BATSE those was done by Schmidt [6].

Here we report intermediate results of the search for non-triggered bursts in the BATSE daily records started by our group in 1997 [7-9].

THE DATA SCAN

We used the 1024 ms time resolution BATSE data (DISCLA) from the ftp archive of the Goddard Space Flight Center at cossc.gsfc.nasa.gov/pub/data/batse/daily/.

The procedure of our scan is described in details in [8]. The first advance of our scan as compared to K97 and K98 is a more selective off-line trigger which reduces the number of false triggers to an easily manageable level. The second advance is the test burst technique (i.e., we add artificial bursts to the data and then detect them together with the real bursts) which allows us to control the scan and to measure the detection efficiency function.

We scanned 3130 days (Apr 23, 1991 to Nov 17, 1999, i.e., 8.6 years) of the BATSE daily records. A few days were missed because of technical problems (corrupted data). The last 500 days were scanned with an improved procedure (a more convenient visual control) which slightly increased the efficiency of the scan.

We revised our GRB sample stored during the scan using stronger classification criteria and removed ~ 40 events as being of non-GRB origin or because the events had insufficient significance level.

RESULTS

Our sample contains 1713 non-triggered events which were classified as GRBs, as well as 1963 BATSE-triggered GRBs. K98 and K99 scanned 2200 days (Dec 9, 1991 to Dec 16, 1997) and found 873 non-triggered GRBs as well as 1392 BATSE-triggered events.

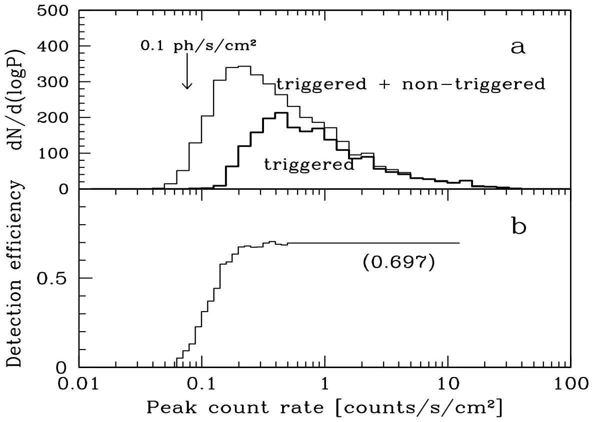

FIGURE 1. a) Peak count rate distribution, $dN/d(\log P)$, of the 1963 BATSE-triggered GRBs (thick histogram) and of all 3676 GRBs detected in our scan (thin histogram). The average ratio between the peak count rate and the photon flux in the 50 - 300 keV range is 0.75 with a dispersion of 0.05. The arrow shows the count rate corresponding to an average photon flux of 0.1 ph/s/cm^2. b) The efficiency of the off-line burst detection defined as the fraction of test bursts detected in our scan versus the peak count rate, P. The efficiency is normalized to the total number of events occurring above the Earth's horizon.

We also found about 5250 of the 10083 test bursts added to the data. About 30% of the test bursts fell into data gaps, and $\sim$ 20% were lost being in the peak flux range of low detection efficiency.

The peak count rate distribution of the events found in the scan is presented in Figure 1a. The detection efficiency of the scan is shown in Figure 1b. Note that the BATSE trigger missed some strong events due to readout dead time.

The resulting $\log N - \log P$ distribution in absolute units is presented in Figure 2 in comparison with the results of K98. K98 also detected events below 0.2 ph/s/cm^2. They, however, only presented data having an efficiency larger than 0.8. The efficiency curve used by K98 is a sharper function of the peak flux as compared to our curve.

Our whole sample is not homogeneous because it contains short events where the peak flux estimate in 1 s resolution is wrong. To eliminate the corresponding bias we removed all events consisting of one 1.024 s bin (i.e., the second brightest

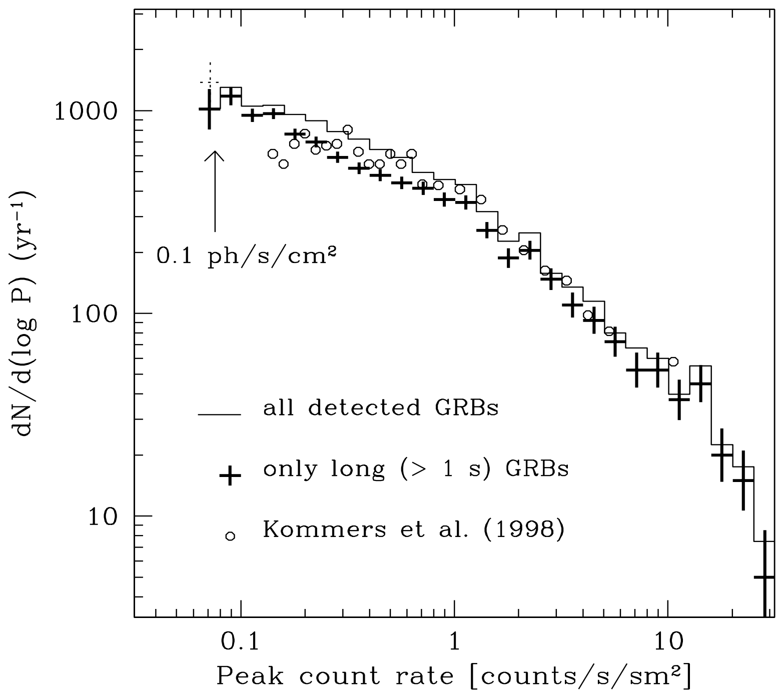

FIGURE 2. The differential $\log N - \log P$ distribution corrected for the efficiency in absolute units for all 3676 GRBs detected in our scan (histogram) and for the 3028 events in our sample with a duration longer than 1 s. The corresponding distribution in absolute units for the 2265 GRBs (of any duration) found by K98 is shown by circles (the K98 data were transformed to the count rate by applying the factor 0.75, see the caption of Fig. 1). The leftmost data point is affected by threshold bias arising from errors in the peak count rates. Its real position preliminary estimated by a forward folding fit with a realistic error/efficiency matrix is shown by the dotted cross. The bias for the second data point is less than 10 %.

bin has a peak count rate below 0.5 of that in the brightest bin). The resulting log N - log P for long bursts (Fig. 2) cannot be fitted in the simplest cosmological scenario using the standard candle assumption for a non-evolving parent population [8]. The general catalog of all (triggered and non-triggered) GRBs that we found and all numerical data for the distributions presented here are available at http:://www.astro.su.se/groups/head/grb_archive.html, or via anonymous ftp at ask.astro.su.se/pub/grb.

Test distributions

Plotting hardness ratios vs peak fluxes (see [7-8]) shows a brightness - hardness correlation in approximate agreement with Nemiroff et al. [10] and demonstrates that new weak bursts has a distribution that smoothly extends the distribution of stronger GRBs (the non-GRB events are softer on average) and indicates that non-triggered bursts are intrinsically identical to triggered GRBs.

The detected events show no excess towards the Sun, no significant excess in the direction of Cyg X-1 (see Fig. 3a), and have a reasonable distribution in geocentric coordinates (uniform above the Earth's horizon). The polar angular distribution is consistent [9] with the sky exposure function given in [1]. The distribution of detected events over the *CGRO*-latitude at the time of detection is shown in Figure 3b. It is sensitive to the possible contribution of ionospheric events in our sample

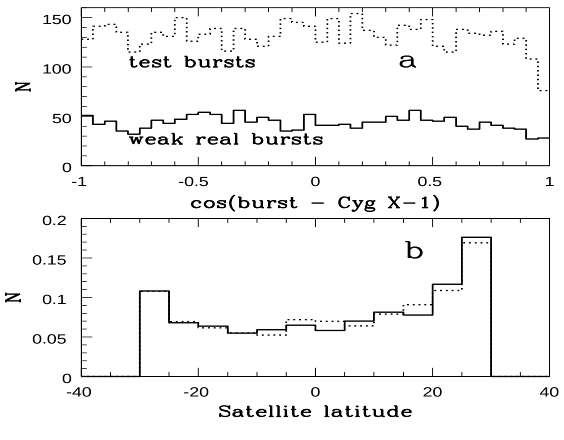

FIGURE 3. a) The angular distribution of detected events with respect to the Cyg X-1 direction. b) The distribution of detected events over *CGRO*-latitude at the time of detection. The asymmetric shape is caused by the South Atlantic anomaly. Solid and dotted line histograms represent real bursts and test bursts, respectively.

as their rate sharply increases with latitude. The distribution over the *CGRO*-latitude should be compared to that for test bursts as the latter accounts for the dependence of the detection efficiency on latitude. There is no excess of real events respectively to test bursts at high latitudes. An approximate 1σ upper limit for the contamination of the sample by events of ionospheric origin at latitudes above $\pm 20^o$ is 50 events of ~ 3700 GRBs.

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