The duration measurements of gamma-ray bursts observed by Suzaku WAM

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Abstract

One of the most important observational results in gamma-ray bursts (GRBs) is the duration distribution. The previous GRB survey with CGRO/BATSE revealed the presence of short-hard and long-soft GRBs, and it is believed that origins for the two categories are different. However, Swift/BAT measurements do not show such bimodality. This difference might be due to the difference in the observational energy band and/or in the detection method. To clarify the presence of short and long GRBs, we performed temporal studies using 687 GRBs observed by the Suzaku Wide-band All-sky Monitor (WAM) in the 50–5000 keV range from August 4, 2005 to February 25, 2010. The Suzaku WAM results show a clear bimodality in three energy ranges (50–110, 110–240, and 240–520 keV), but not in the 520–5000 keV range, probably due to limited detection sample. The short-hard and long-soft GRBs are also found in the Suzaku-WAM hardness-duration relation, and the Kolmogorov-Smirnov test indicates that the WAM duration distribution looks more like the CGRO/BATSE one rather than the Swift/BAT one. We will discuss the differences in the duration distributions among instruments in terms of the energy range and detection sensitivity.

Key words: workshop: proceedings — Duration — Gamma-ray burst

1. Introduction

The Gamma-ray bursts (GRBs) are the most powerful explosion among observed astronomical phenomena. One of the most important observational results is the duration and distribution and its relation with the spectral hardness. The duration ($T_{90}$) distribution shows bimodality, which is classified into two categories: long-soft and short-hard GRBs. These results are clearly shown in the first CGRO/BATSE catalog. However, Swift/BAT measurements of $T_{90}$ distribution do not show clear bimodality. It is not clear whether this is caused by a different sensitivity of the GRB trigger or energy dependence of $T_{90}$ duration or both.

2. Analysis

To clarify the presence of bimodality in duration distribution, we analyzed the data of Suzaku Wide-band all-sky Monitor (WAM), which is designed to monitor the all-sky flux in the 50–5000 keV band, and has a large effective area of 400 cm$^2$ at 1 MeV. The WAM data is accumulated for each energy band of 50–110 (TH0), 110–240 (TH1), 240–520 (TH2), 520–5000 (TH3) keV. The effective area and flux are calculated from the background variation with 4th-order polynomial functions to subtract from the energy resolved light curves. The detection threshold is above 5σ. In this work, we used 687 GRB data detected by WAM from August 4, 2005 to February 25, 2010. Using these data, we estimated the duration $T_{90}$ (25% to 75% in total counts), $T_{90}$ (5% to 95%), and $T_{100}$ (0% to 100%) utilizing the tool battblocks based on the Baysian algorithms.

3. Results

3.1. $T_{90}$ distribution

Figure 1 shows $T_{90}$ distribution of TH0123. This distribution shows clear bimodality. Figure 2 shows $T_{90}$ distribution in the four energy band TH0, TH1, TH2, TH3.
and TH3. While the duration distribution in TH3 does not show a clear bimodal distribution, because the number of events detected in this energy band is much less than those obtained in other energy bands, the distributions in TH0, TH1, and TH2 showed a clear bimodality.

Fig. 1. $T_{90}$ distribution of TH0123 of triggered data. The solid line is two gaussian model.

Fig. 2. $T_{90}$ distribution for different energy band TH0 (black), TH1 (red), TH2 (blue), and TH3 (purple).

3.2. $T_{90}$ vs Hardness ratio

Figure 3 shows scatter plot of $T_{90}$ versus hardness ratio of WAM in the TH1/TH0, BAT in the 50-100 keV/25-50keV, BATSE in the 100-300 keV/50-100 keV, PHEBUS in the 400-1000 keV/100-400 keV from top to bottom. The short-hard and long-soft GRBs are also found in the WAM hardness-duration relation.

3.3. KMM test and Kolmogorov Smirnov (KS) test

Table 1 shows the results of bimodal distribution test (Ashman et al. 1994) and comparison of WAM distribution test for each data. KMM test shows the one gaussian distribution is inconsistent with $T_{90}$ distribution of WAM and other detector except HETE/FREGATE. $T_{90}$ distribution of WAM is similar to the ones of INTEGRAL/SPI-ACS and Granat/PHEBUS.

4. Discussion

The short-to-long ratio of GRB number which are detected simultaneously by GBM to February 25 2010 are consistent, while ratio of WAM and BAT are not consistent. The WAM ratio converted from TH0123 to 15-350 keV band is 0.18:0.82 (11:49). The difference between WAM and BAT in short GRB is caused by 7 GRBs. The 6 GRBs out of 7 GRBs among them have extended emission (E.E.) (Gompertz et al. 2013; Sakamoto et al. 2011; Ukwatta et al. 2009). This suggests that the apparent discrepancy between BAT’s duration distribution and WAM’s and others are, at least partially, due to the soft E.E. components.

References


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