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Preliminary results of the analysis of the BATSE TTE data(*)

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Summary. — The Compton Gamma Ray Observatory (CGRO) observed many types of data and one of them is the time-tagged photon events (TTE data). We use the Bayesian block analysis, using Bayesian statistics, analyses the TTE data. Our results; calculations of duration (T100), count rates (burst photon numbers in different channels) and count peaks (in 64, 16 and 4 ms). We present the duration, the peak duration and the distance between peaks distributions. Principal Component Analysis (PCA) has been also applied. The PCA shows interesting results, such as channel 4 (highest energy channel) probably is very important.

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1. – Introduction

The CGRO/BATSE observed many types of data about gamma-ray bursts (GRBs), and their statistical analyses gave several useful results. For example, the logN-LogS analyses [5, 2] gave useful information about the spatial distribution of GRBs. The study of the time behavior of the spectra [7, 8] led to the better understanding of the time dependence of GRBs. In this paper the time-tagged photon events (TTE) will be studied. The TTE data recorded the arrival time (within a two microsecond bin), energy (within four discriminator channels) and detector of each photon. The Bayesian block analysis, using Bayesian statistics, analyses the TTE data and the output is the most

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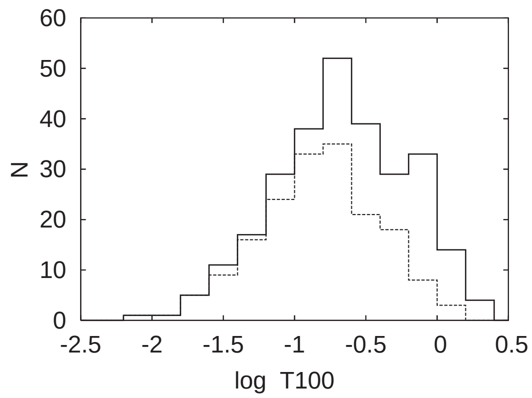

Fig. 1. – The duration distribution of the analyzed 273 bursts (solid line) and the duration distribution of the 174 one-peak bursts (dashed line).

probable segmentation of the observation into time intervals during which the photon arrival rate is perceptibly constant.

In the BATSE database there are 532 burst TTE (time tagged event) data. The TTE data contains the detection time as many as 32 768 photons with a 2 microsecond time resolution in four energy channels. Many cases there were more than 32 768 photons during the burst time or there were bursts photons before the starting time of TTE. We used the 273 bursts TTE data, which were complete (covered the whole burst).

2. – The Bayesian block analysis

The Bayesian block (BB) analysis has been already developed in the literature for analyzing different data types [4, 10, 9, 6]. It is a method to find optimal changepoints (times at which the count rate is modeled as abruptly changing). The marginal posterior probability of the model is:

$$L(M_i, D) = \int P(D/\Theta_i M_i) P(\Theta_i/M_i) \mathrm{d}\Theta_i, \tag{1}$$

where M_i refers to the parameters specifying the changepoint locations, and all other parameters—specifying the photon rates—represented by Θ_i are marginalized as indicated by the integration in the equation. The explicit form of this posterior for a block of data depends on only two *sufficient statistics*, namely the number of photons in the block, and the length (in time) of the block. The algorithm in [3] yields the optimal block segmentation of the TTE data.

3. – Calculation of the burst parameters

Once one has the BB representation of the burst, one can calculate the burst parameters. First we have T100 rather than T90, since BBs show us the start and the end points of the burst. Second we need a background counts. Firstly we adjust the TTE data with cat64ms data. Secondly two 0,64 second long intervals were chosen. One

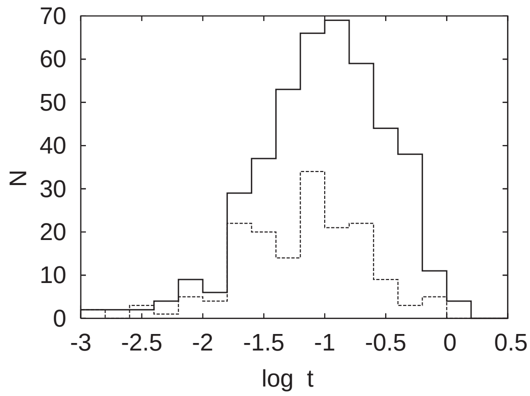

Fig. 2. – The peak length distribution of the 431 well-defined peaks (solid line) and the distance distribution between these peaks (dashed line).

before the burst and one after the burst. In other words ten consecutive bins were chosen before the burst and also after the burst from the cat64ms data for calculating the background. Third we assume during the burst the background rate was constant. After these one can calculate similar burst parameters then the BATSE catalog contains. One can calculate the counts in the four channels (like fluence) and also find the highest bin in different timescales. This can be called peakcounts (like peakflux). This was done in three timescales 64ms, 16ms and 4ms. The natural definition of pulse width using a block representation might be called T100 rather than T90. Figure 1 shows the duration distribution of the 273 bursts and the duration distribution of the 174 one-peak bursts. For peaks one can calculate the peak width or length rather than FWHM. Figure 2 shows the peak length and the distance between peaks distributions.

4. – Principal Component Analysis (PCA)

Using the logarithm of these 8 parameters one can make a PCA. The Principal Component Analysis can show us which parameters are important to characterize the bursts.

TABLE I. – *The eigenvalues of the principal component analysis of the 8 quantities of Gamma-Ray Bursts (T100, four count rates, three count peaks). The first three PCs are important and the cumulative percentage is 96%, which means only three variables can explain 96% of the whole information.*

Principal component	Eigenvalues	% of variance	Comulative percentage
1	**5.299**	**66.23**	**66.23**
2	**1.723**	**21.54**	**87.77**
3	**0.676**	**8.45**	**96.22**
4	0.119	1.50	97.71
5	0.070	0.88	98.6
6	0.066	0.82	99.4
7	0.027	0.34	99.74
8	0.011	0.24	100.0

TABLE II. – *The eigenvectors of the principal-component analysis of the 8 quantities of Gamma-Ray Bursts (T100, four count rates (Ch1-4), three count peaks (P64, P16, P4)).*

Eigenvectors	lg T100	lg Ch1	lg Ch2	lg Ch3	lg Ch4	lg P64	lg P16	lg P4
1	0.54	0.88	0.92	0.93	0.7	0.91	0.8	0.75
2	0.8	0.29	0.27	0.26	0.12	−0.35	−0.58	−0.62
3	−0.07	−0.32	−0.21	0.16	0.7	−0.06	−0.04	−.05

Table I shows the PCA eigenvalues and table II shows the eigenvectors. The first PC is the sum of the all parameters. The second PC is mainly the difference between duration and peakcounts. The third PC is mostly channel 4 just itself.

However our analysis use different timescale and only for the short bursts these results are a good agreement with [1]. This does not means short and long bursts are similar. Our result meaning is the same 2-3 parameters can describe the BATSE observed parameters for all bursts. But the short and the long ones can be in different place in this 3D space.

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