Study of the Very Short Time Structure in Three BATSE Events Using TTE Data*

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The short time structure (possibly shot noise) might reveal much about the spatial nature of the GRB source. In the case of GRBs from Primordial Black Holes (PBHs), the initial explosion region is $\sim 10^{-13}$ cm in size, much smaller than any other known compact object. The BATSE team has already reported on one interesting event. We report here on the study of the TTE data from three BATSE events that may be PBH candidates. The latest results will be presented at the meeting.

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INTRODUCTION

This paper presents a preliminary analysis of the time structure of three short duration Gamma Ray Burst (GRB) events. The data analyzed was the Time Tagged Event (TTE) data from the BATSE 2B Catalog (1). By studying the time structure of short duration GRBs one can look for a periodicity and high frequency structure that would indicate an object of small size.

It is hoped that this analysis will indicate that there is an object with a size much smaller than any known compact object. If so, this would be consistent with the model of an explosion from the evaporation of a Primordial Black Hole (2). In this model the size of the initial explosion would be on the order of 10^{-13} cm.

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ANALYSIS

The analysis presented in this paper was performed using the following procedures. The TTE data was sorted by the energy of the γ-ray. The γ-rays were divided into four energy bins; $20 < E < 50$ keV, $50 < E < 100$ keV, $100 < E < 300$ keV and $E > 300$ keV.

The structure of the GRB may be shown by plotting the number of γ-rays versus time for time-bins of 1 millisecond width. An example for one energy range, $100 < E < 300$ keV, is shown in Figure 1 for the first second of the burst. This figure shows the plot of the number of γ-rays versus time for the

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three TTE events; burst numbers 432, 480 and 512. It should be noted that for burst number 432 the remaining data was overwritten by burst number 433.

To examine the fine time structure of short duration Gamma Ray Bursts, the Power Spectral Density (PSD) is calculated for both the peak and the background of the event. This is done by performing a Fourier Analysis of the time distribution.

The Fourier Analysis is performed using a discrete Fast Fourier Transform (FFT) of the distribution of counts versus time from an array of selected time bins. The peak selection contains counts from the full time duration of the peak. The background selection contains the counts from an equal time duration.

The Fourier Transform takes a Real function of time and transforms it into a Complex function of frequency, $F(t) \rightarrow C(\omega)$. Therefore, to examine the Power Spectral Density, the normalized magnitude of $C(\omega)$ is plotted versus the frequency, using the method of Belli (3). The normalization, N, is the integration of the background counts for same time duration as the given peak. Thus, $|C(\omega)|/N$ is plotted versus the $f = \omega 2\pi$ for both the peak and the background. Due to the space available only a sample of the Fourier Analyses, for one energy range, is shown. These plots, shown in Figure 2, are the Fourier Analysis of the time distributions plotted in Figure 1.

FUTURE PLANS

The future plans entail a more detailed examination of the three events presented in this paper followed by the examination of more short duration TTE events. This will include careful examination of effects of different binning in an attempt to use the smallest possible time bins. As part of this examination generation of Monte Carlo simulations of the background radiation will be performed. As part of the background examinations a few longer duration bursts will be examined. An additional test that may be used is an auto-correlation function to examine periodicity of multiple spikes in a peak.

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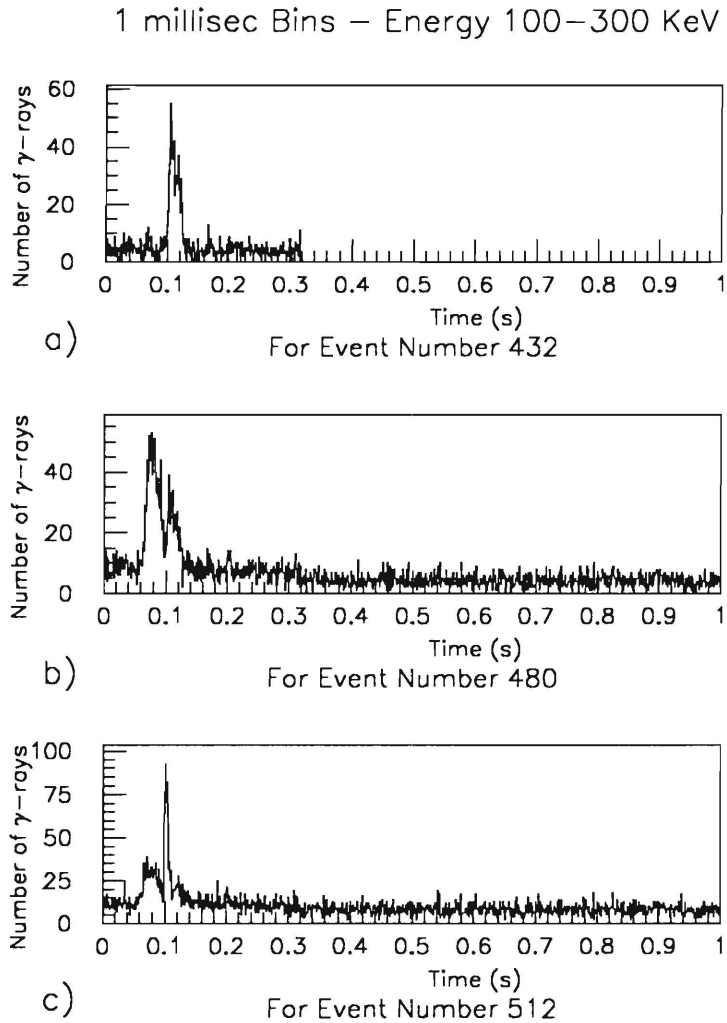

FIG. 1. The number of γ-rays versus time for burst number a) 432, b) 480 and c) 512; for the energy range $100 < E < 300$ keV.

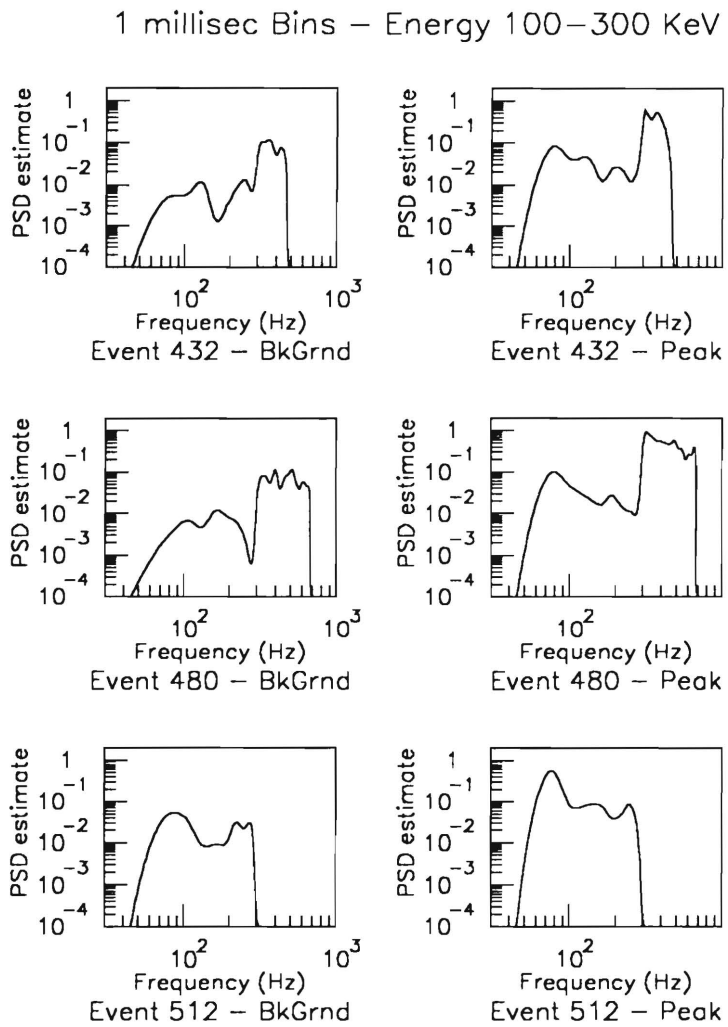

FIG. 2. The Power Spectral Density versus frequency of the background and the peak for burst number a) 432, b) 480 and c) 512 for the energy range $100 < E < 300$ keV.

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