GRB duration distribution considering the position of the Fermi

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INTRODUCTION

NASA's Fermi Gamma-ray Space Telescope is designed to measure the position of a burst in seconds and change the detectors' orientation so that the orientation of the effective area of the main detector (LAT) and the celestial position of the burst have the smallest angle (Meegan et al., 2009). The problem is that the secondary detector (GBM) measure a quickly varying backgroung superponed on the substantial data because of the rapid motion of the satellite. Though, the work with the GBM data must be anticipated by the removing of the backgorund, the ordinary used methods, like fitting the background with a polynomial function of time, are too simple and poorly effective in the case of Fermi. We made a model that involves real motion and orientation of the satellite during its flight and the position and contribution of the main gamma-ray sources to the background.

THE DATA AND THE MODEL

After some basically data transformation, we can plot a GBM lightcurve as shown in Fig. 1, which is typical.

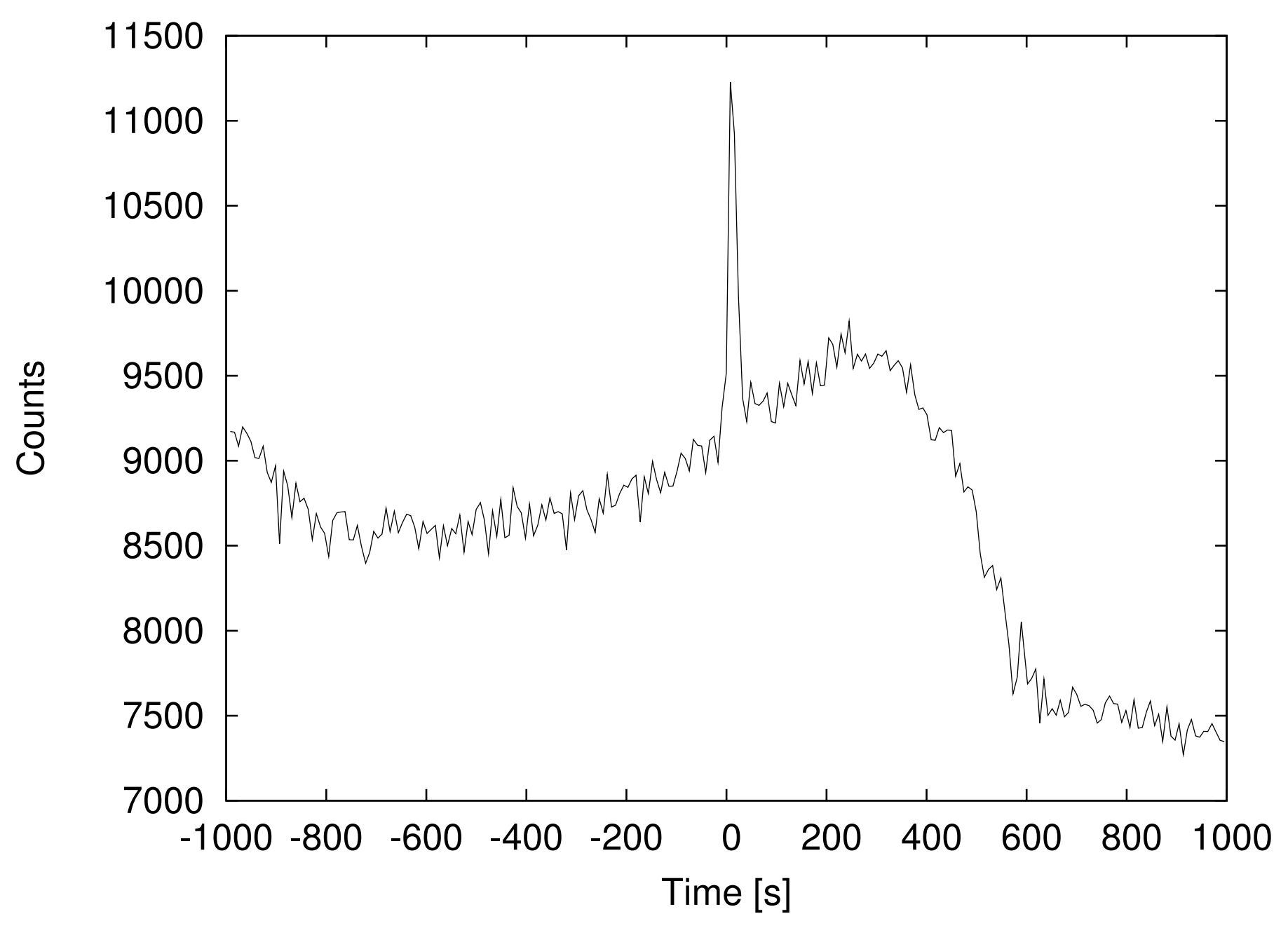

Fig. 1: Lightcurve of the Fermi-burst 091030613 measured by the 3rd GBM detector. The burst is at **0 s** but the varying of the background is comparable with its height and cannot be modelled by a simple polynomial function of time of degree 2 or 3.

Since the varying of the background is caused by the rapid motion of the satellite, we need a specific model involving the position and orientation of the Fermi in every second. We made such a model considering the detector's orientation and the celestial position of the burst, the Sun and the Earth limb. The effect of every other gamma-source is included into an isotropic constant gamma-ray background in this approximation.

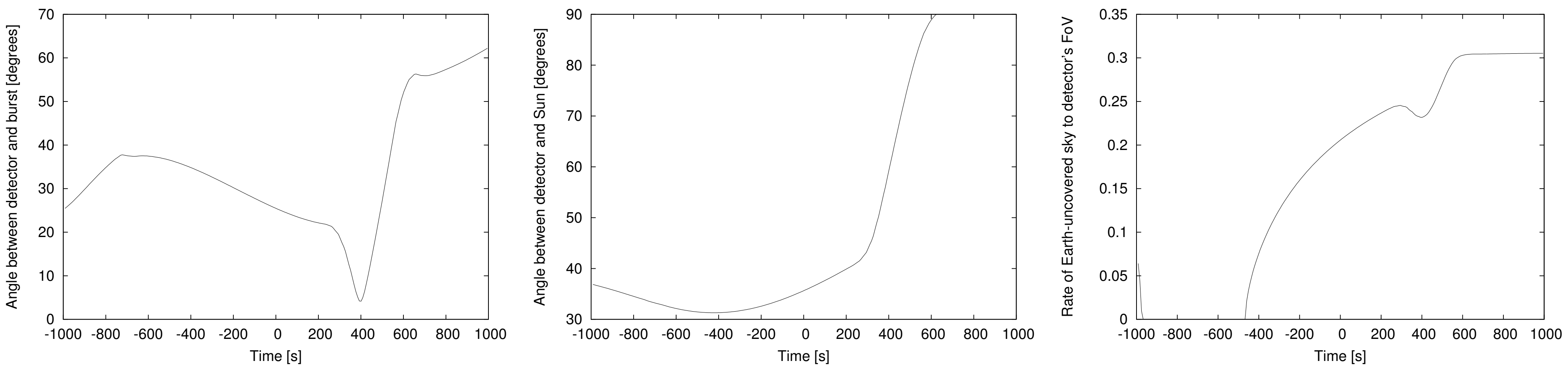

Fig. 2: *From left to right:* The celestial distance of the 3rd GBM detector and the position of Fermi-burst 091030613; the same with the Sun; and the rate of the Earth-uncovered sky to the 3rd GBM detector's field of view, both in the function of time. It is worth comparing to Fig. 1.

Comparing Fig. 1 to Fig. 2, we can realise the connection between them: where the angles and the Earth limb's uncovering are varying, the background of the lightcurve is varying, too.

FITTING THE BACKGROUND

In order to separate the background from the burst's real data, we fitted a 3-dimensional hypersurface of degree 3 to the lightcurve's background. After subtracting the hypersurface from the lightcurve, we get the background-free lightcurve shown in Fig. 3.

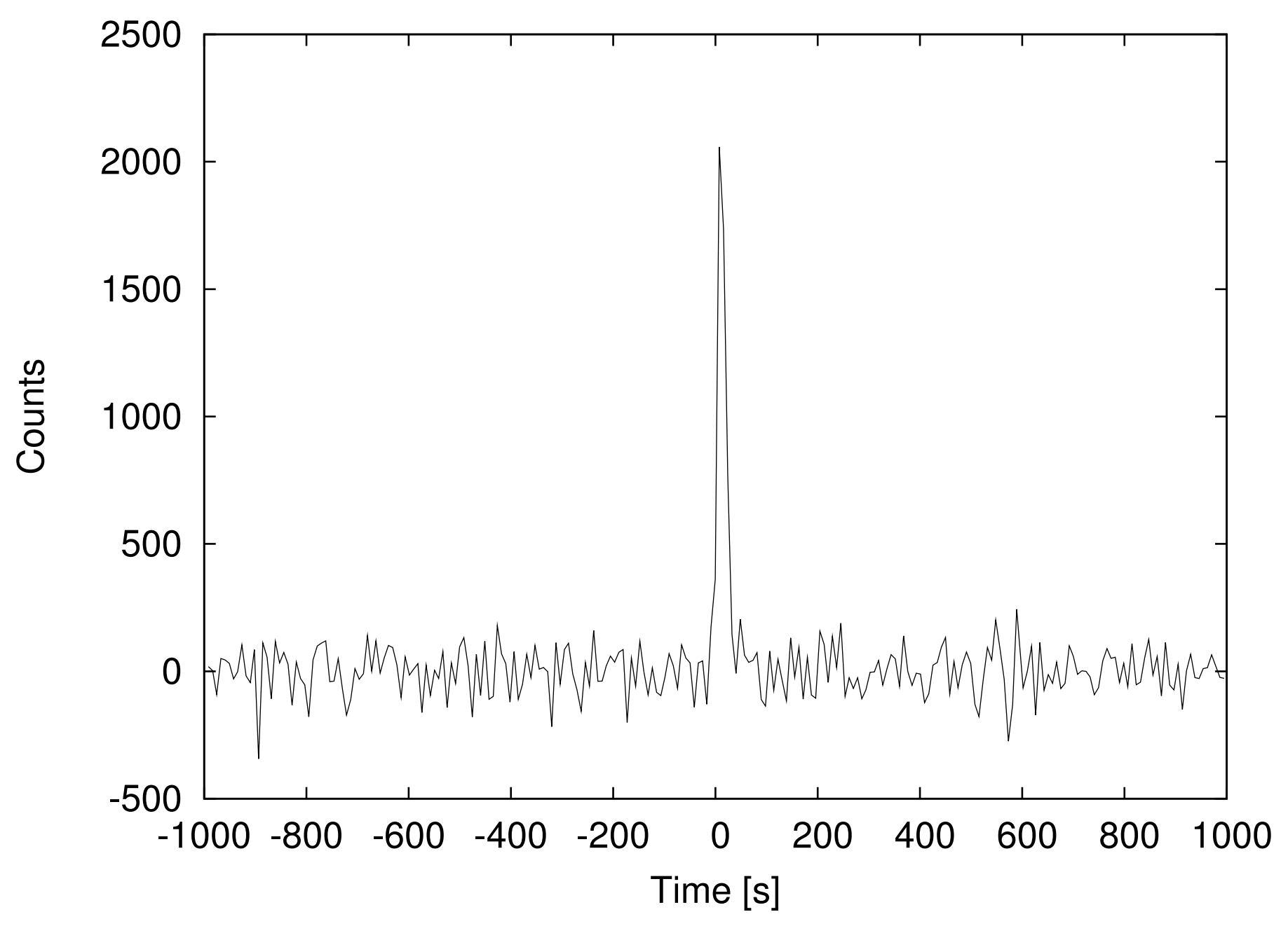

Fig. 3: After the background fitting: lightcurve of the Fermi-burst 091030613 measured by the 3rd GBM detector. Comparing Fig. 1 to Fig. 3, we can make a statement that our background filtering was successful since the resulted lightcurve is perfectly background-free.

ABSTRACT

The Fermi satellite has a particular motion during its flight in order to catch the gamma-ray bursts mostly well. The side-effect of this favourable feature is that the leghtcurves of the GBM detectors are stressed by rapidly and extremely varying background. Before processing this data, it needs to be separated from the background. The commonly used methods were useless for most cases of Fermi, so we developed a new technique based on the motion and orientation of the satellite. The background-free lightcurve can be used to perform statistical surveys, hence we showed the efficiency of our background-filtering method presenting a statistical analysis known from the literature.

TESTING THE METHOD

In order to verify our method described above, we made a statistical analysis based on our background-filtered data set. Since we investigated the temporal characteristics of the lightcurve, it was obvious to compute the T_{90} statistical parameter (see Horvath et al. (1996)). We run our background filtering method on 332 Fermi-bursts and computed the T_{90} values for them. It is well-known from the literature that the (logarithmic) distribution of the gamma-ray bursts' duration shows 2 or 3 peaks (see for example Balazs et al. (1998) or Horvath et al. (2002)). We present the distribution of the $\log T_{90}$ variable computed by us in Fig. 4.

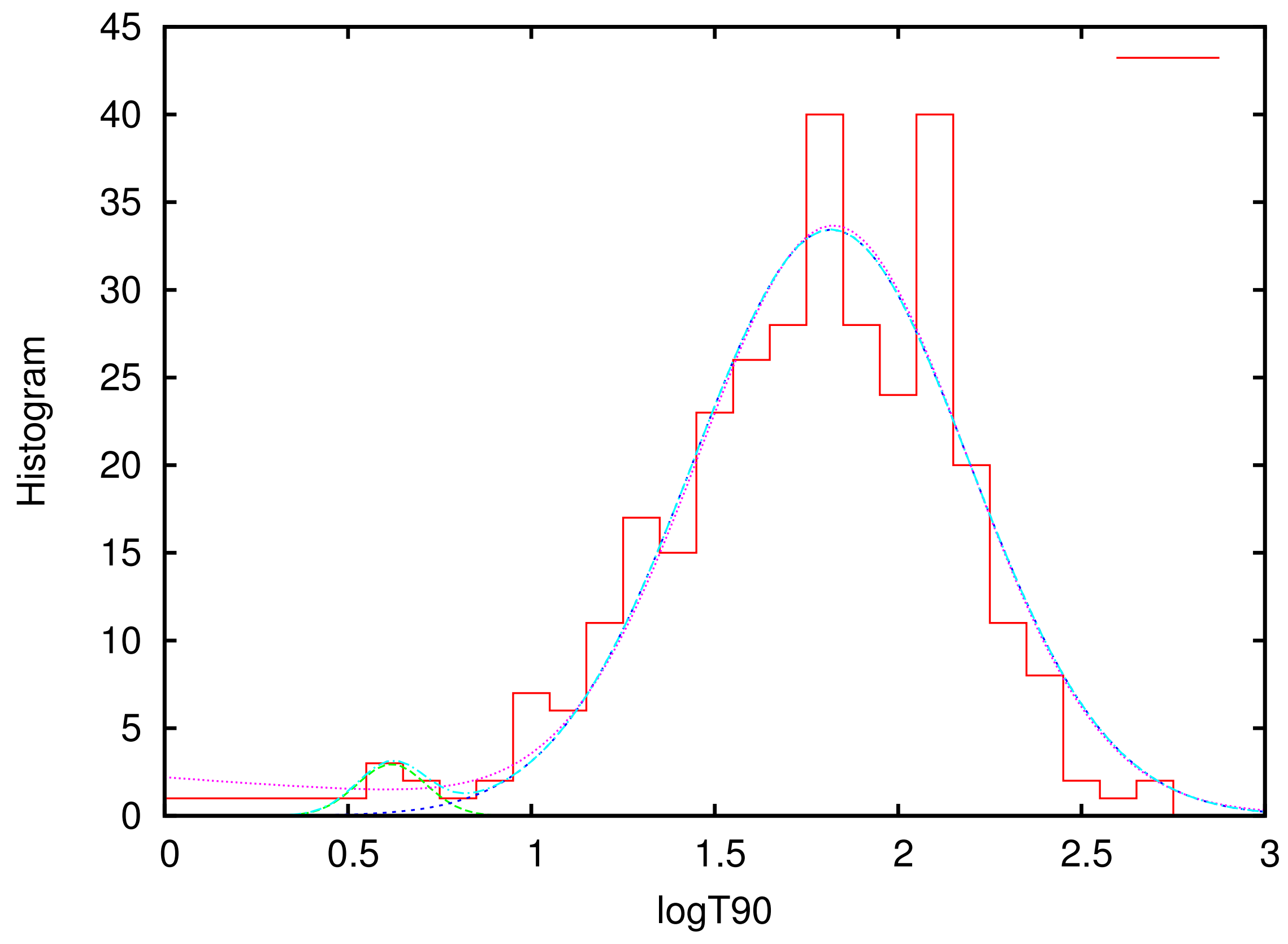

Fig. 4: The distribution of the $\log T_{90}$ statistical parameter for 332 bursts according to our method. The coloured curves show the fitted Gaussian functions: green and blue for the short and long peak, light blue and purple for together. The result is analogous to the literature showing that our method is correct.

In Fig. 4, the duration distribution of our data set has two peaks. The greater peak on the right-hand side surely represents the long/soft bursts, while the smaller peak on the left-hand side can represent the short/hard bursts or the intermediate group as well (see Balazs et al. (2004) and Horvath et al. (2008)). We need further investigations to decide this question, but the shape of the distribution proves the efficiency of our method.

CONCLUSION

The method can be further developed by the effects of other gamma-ray sources, like the Moon, some galactical sources or near supernova remnants. However, we can pronounce that we succesfully created a method, which is able to separate the Fermi data from the motion-based background in such an effective way, than statistical analyses can be made using the data.

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This work was supported by OTKA grant K077795, by OTKA/NKTH A08-77719 and A08-77815 grants (Z.B.), by the GAČR grant No. P209/10/0734 (A.M.), by the Research Program MSM0021620860 of the Ministry of Education of the Czech Republic (A.M.) and by a Bolyai Scholarship (I.H.).

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