Previously we proposed a novel method to inspect the isotropy of the properties of GRBs such as their duration, fluences and peak fluxes at various time scales and energy bands as well as fluences $S$ at different energy bands were analyzed. Also the GRB positions contained in the catalogs were used.

We compare distributions of a given observed GRB property for a large number of randomly spread patches on the sky with a distribution of the same GRB property for the whole sky. We use four test statistics $\xi = \chi^2_i$ (two-sample Chi-square test), $D$ (Kolmogorov-Smirnov test), $V$ (Kuiper test), and $AD$ (Anderson-Darling test). The obtained distributions of the test statistics for the measured data are compared with those for randomly shuffled data (randomly shuffled observed GRB properties while keeping their positions fixed) to infer the significance of potential anisotropies (for details see [13, 14]).

Table compares results of several tests performed on the older sample in [13] and on the new updated sample in [14] for statistic $D$ and patch radii $r = 20^\circ$ demonstrating how the signal of a feature found in [13] vanishes with the number of patches. The value $N^i_P$ for a given statistic $i$, for the measured data, is higher than a limiting value $\xi^i_0$ and the significance $P^i_\chi = 2 \times 10^{-5}$.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$N^i_P$</td>
<td>$P^i_\chi$</td>
<td>$N^i_P$</td>
</tr>
<tr>
<td>$F_{64}$</td>
<td>87</td>
<td>3.4</td>
</tr>
<tr>
<td>$S$</td>
<td>72</td>
<td>13.1</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>74</td>
<td>11.5</td>
</tr>
</tbody>
</table>

The tested GRB property is fluences $S$, and the patch radii are $r = 20^\circ$. This is the only case in the $CGRO$/BATSE sample, for which the significance $P^i_\chi$ is below 5%.

The data and the significance $P$ is proportional to the probability $P$ being tested. In different panels the results are plotted separately for different patch radii and for different thresholds $i$. For details see article [14].

Plotted are examples of the patch centers on the sky (Galactic Coordinates), for which the $\chi^2_i$ statistic, for the measured data, is higher than $\chi^2_i$ obtained from the randomly shuffled data and the significance $P^i_\chi$ is below 5%. The tested GRB property is fluences $S$, and the patch radii are $r = 20^\circ$.

The markers denote the centers of the patches for which a given statistic $\xi^i$ (in this plot $\chi^2_i$), for the measured data, is higher than $\chi^2_i$ obtained from the randomly shuffled data and the significance $P^i_\chi$ is below 5%, where $i=1$ or 2. The size of the markers is inverse proportional to the probability $P$. Different colors mean different properties of GRBs being tested. In different panels the results are plotted separately for different patch radii $r$ and for different thresholds $i$. For details see article [14].

The signal of a feature found in work [13] vanished with larger updated $Fermi$/GBM data sample used in work [14] and the results are consistent with isotropy confirming our previous conclusions.

The method was also applied to the dataset of $CGRO$/BATSE instrument. The results are fully consistent with isotropy.

The last investigated GRB data sample is from $Swift$/BAT instrument and our method together with Monte Carlo simulations show that results are consistent with isotropy as well.

**Abstract**

The distribution of Gamma-Ray Bursts (GRBs) on the sky had been initially claimed to be isotropic [1, 2, 3]. As more observational data were collected the rest of the data showed consistency with isotropy. In this work we apply our method with some minor modifications to the updated $Fermi$/GBM data sample containing 2266 GRBs (thus about 40% larger). We also test other two major GRB catalogs, the BATSE Current GRB Catalog of the $CGRO$ satellite containing about 2000 bursts and the $Swift$/BAT Gamma-Ray Burst Catalog containing about 1200 bursts. The new results show proper consistency with isotropy confirming our previous findings and discarding any statistically significant anisotropic feature in the data.

**Introduction**

The distribution of Gamma-Ray Bursts (GRBs) on the sky had been initially claimed to be isotropic [1, 2, 3]. As more observational data were collected the rest of the data showed consistency with isotropy. In this work we apply our method with some minor modifications to the updated $Fermi$/GBM data sample containing 2266 GRBs (thus about 40% larger). We also test other two major GRB catalogs, the BATSE Current GRB Catalog of the $CGRO$ satellite containing about 2000 bursts and the $Swift$/BAT Gamma-Ray Burst Catalog containing about 1200 bursts. The new results show proper consistency with isotropy confirming our previous findings and discarding any statistically significant anisotropic feature in the data.

**Data Samples and Method**

Durations $T_{90}$, fluences $F$ at various time scales and energy bands as well as fluences $S$ at different energy bands were analyzed. Also the GRB positions contained in the catalogs were used.

We compare distributions of a given observed GRB property for a large number of randomly spread patches on the sky with a distribution of the same GRB property for the whole sky. We use four test statistics $\xi = \chi^2_i$ (two-sample Chi-square test), $D$ (Kolmogorov-Smirnov test), $V$ (Kuiper test), and $AD$ (Anderson-Darling test). The obtained distributions of the test statistics for the measured data are compared with those for randomly shuffled data (randomly shuffled observed GRB properties while keeping their positions fixed) to infer the significance of potential anisotropies (for details see [13, 14]).

**Results for $Fermi$/GBM**

Figures show results for $Fermi$/GBM with 1591 GRBs from [13]. Plotted are the patch centers (Galactic Coordinates), for which the $\chi^2_i$ statistic, for the measured data, is higher than $\chi^2_i$ obtained from the randomly shuffled data and the significance $P^i_\chi$ is below 5%. For details see article [14].

**Results for $CGRO$/BATSE**

Plotted are the patch centers on the sky (Galactic Coordinates), for which the $\chi^2_i$ statistic, for the measured data, is higher than $\chi^2_i$ obtained from the randomly shuffled data and the significance $P^i_\chi$ is below 5%. The tested GRB property is fluences $S$, and the patch radii are $r = 20^\circ$. This is the only case in the $CGRO$/BATSE sample, for which the significance $P^i_\chi$ is below 5%.

**Results for $Swift$/BAT**

Plotted are examples of the patch centers on the sky (Galactic Coordinates), for which the statistical properties of GRBs are mostly deviated from randomness. The marked points denote the centers of the patches for which a given statistic $\xi$ (in this plot $\chi^2_i$), for the measured data, is higher than $\xi$ obtained from the randomly shuffled data and the significance $P^i_\chi$ is below 5%, where $i=1$ or 2. The size of the markers is inverse proportional to the probability $P$. Different colors mean different properties of GRBs being tested. In different panels the results are plotted separately for different patch radii $r$ and for different thresholds $i$. For details see article [14].

**Conclusions**

- The signal of a feature found in work [13] vanished with larger updated $Fermi$/GBM data sample used in work [14] and the results are consistent with isotropy confirming our previous conclusions.
- The method was also applied to the dataset of $CGRO$/BATSE instrument. The results are fully consistent with isotropy.
- The last investigated GRB data sample is from $Swift$/BAT instrument and our method together with Monte Carlo simulations show that results are consistent with isotropy as well.

**References and Acknowledgements**