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Very Short Gamma Ray Bursts Study and Primordial Black Holes

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We present the state of current research of Very Short Gamma Ray Bursts (VSGRBs) from BATSE, KONUS and SWIFT detectors. We found that VSGRBs form a distinguished class of GRBs, which in our opinion in most cases is composed of the primordial black hole evaporation events. Arguments supporting our opinion: (a) Time duration (T_{90}) distribution of VSGRBs for BATSE, KONUS and SWIFT detectors [2]; (b) Visible anisotropy in the galactic angular distribution of BATSE VSGRB events; (c) V/ Vmax distribution for BATSE VSGRB events indicating the local distance production [3]; (d) Practically no afterglows in SWIFT VSGRB sample (25%), in contrast to the noticeable frequency in SGRB sample (78%); (e) Time profile of rising part BATSE VSGRBs in agreement with evaporation PBH model.

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We divide GRB from detector BATSE into three classes according to their time duration (T_{90}): long L (T_{90} > 1 s); short S (1 s > T_{90} > 0.1 s); and very short VS (T_{90} < 0.1 s), [1]. We assume that the VSGRBs constitute a separate class of GRBs with log normal duration distribution and we fit the time distribution, with a three-population model. The fit is excellent but does not give significant evidence for a three-population model [1].

We have also analyzed SGRBs from the KONUS-WIND detector. Nominal energy range of gamma-ray measurements covers the interval from 12 keV up to 10 MeV. This gives the possibility of comparing SGRBs (T_{90} < 2 s) of the Low Energy Data (LED), $<\gamma>$ < 90 keV, with High Energy Data (HED), $<\gamma>$ > 90 keV, Fig. 1. LED are normalized to HED in region (0.0 – 1.6 s) and comparing both distribution we see strong disagreement (prob. < 10^{-10}). We observe a large excess of VSGRBs with $<\gamma>$ > 90 keV, Fig. 1. Like BATSE KONUS uses the shortest trigger of 64 ms, so we should observe even bigger excess because the detector lost detection efficiency at T_{90} < 64 ms, as in the BATSE case. This is an additional argument to treat VSGRBs as a separate class of events.

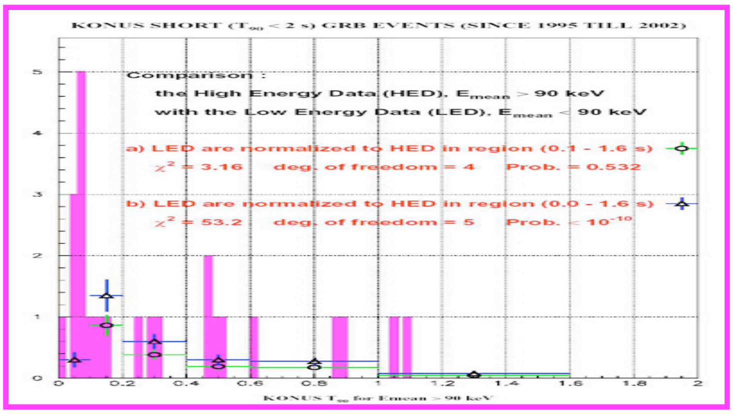

Fig. 1. KONUS data with different cuts on the average energy gamma, $<\gamma>$ [2].

Galactic angular distribution for BATSE events [3] for VSGRBs (T_{90} < 0.1 s) are strongly grouped in 1/8 of the whole space, giving an excess with probability 0.00007 to be a fluctuation from Poisson distribution. See also Fig. 3.

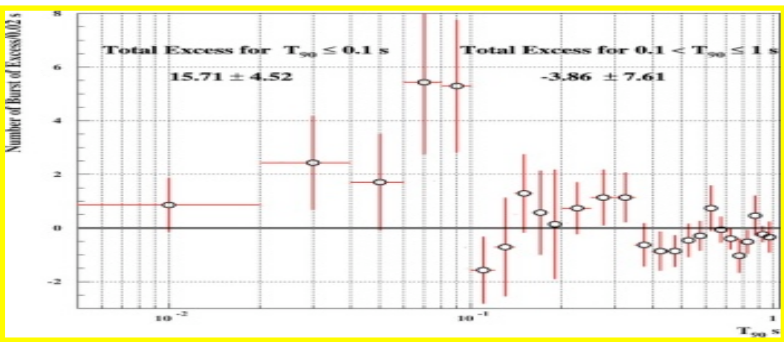

Fig. 2. BATSE GRB events (1991 Apr 21 – 2000 May 26). Excess in GRBs inside the chosen region (30º < b < -30º; 90º < l < 180º) as a function of T_{90} [3].

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Results shown in Fig. 2 support the choice of T_{90} = 0.1s to discriminate VSGRBs from SGRBs and show that the incompatibility with isotropic distribution is seen only for GRBs with T_{90} < 0.1 s. We observe the total excess of 15.71 ± 4.52 bursts in this region.

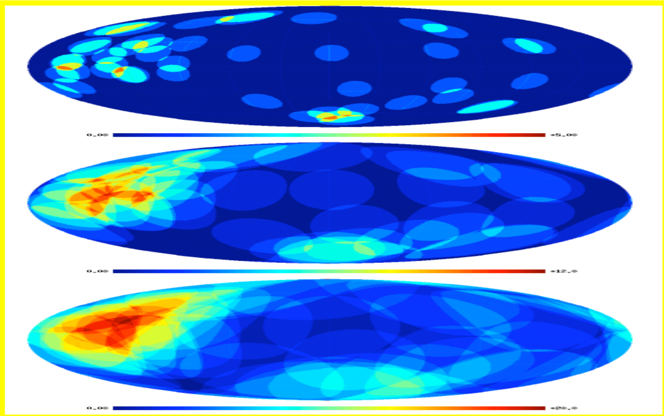

Fig. 3. Angular distribution of the BATSE VSGRB events in Galactic Coordinates within 10º (top), 25º (middle), and 40º (bottom), radius cone around each event [4].

The detailed first four factorial moments analysis gives as a result the probability < $3{\cdot}10^{-5}$ for the chance of such fluctuation from uniform distribution [4]. This is in agreement with our earlier simple estimation: $7{\cdot}10^{-5}$ [3]. It means the effect itself is on about 4σ level.

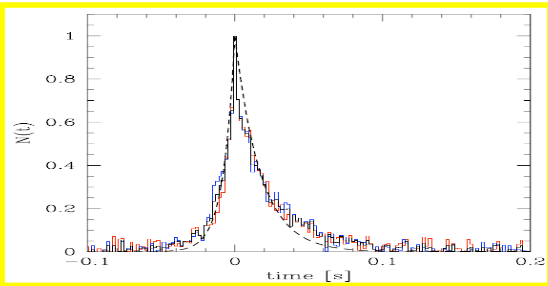

Fig. 4. Composite VSGRB time profile for BATSE; Dashed line – exponential fit [5].

The exponential fit was used twice (separately for rise and for fall). The resulting composite profile is shown in Fig. 4. It shows significant asymmetry with timescale: 0.00079 s for exponential rise and 0.0171 s for exponential decay time. If we use the evaporation PBH model, the fit to the rising part of the profile is good.

References

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[2] D.B. Cline et al, *Evidence for Primordial Black Hole Final Evaporation: Swift, BATSE and KONUS and Comparisons of VSGRBs and Observations of VSB That Have PBH Time Signatures,* astro-ph/0908.1352.

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[5] B.Czerny at al., *Observational constraints on the nature of very short gamma-ray bursts,* New Astronomy in press, [arXiv:1006.1470].

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