Final Report on the OTKA Grant 48870

During the 2004-2008 period the focus of our work was the statistical analysis of gamma-ray burst (hereafter GRB or simply burst) properties. The main direction of the studies was analyzing the various gamma-properties of the bursts from samples of different satellites. We have also started working on GRB afterglow related topics, continued on cosmological and spectral studies of the bursts.

1 Afterglows

Since 1997 we know that bursts have counterparts at other frequencies called afterglows. We have investigated a few topics in this field.

The origin of dark bursts — i.e. that have no observed afterglows in X-ray, optical/NIR and radio ranges — is unclear yet. We have discussed different possibilities — instrumental biases, very high redshifts, extinction in the host galaxies — and we have shown that they are important. On the other hand, the dark bursts should not form a new subgroup of long gamma-ray bursts themselves. (A. Mészáros, Z. Bagoly, S. Klose, F. Ryde, S. Larsson, L.G. Balázs, I. Horváth, L. Borgonovo,: On the origin of the dark gamma-ray bursts., Nuovo Cimento C, 28, 311,2005)

Furthermore, using the discriminant analysis of the multivariate statistical analysis we compared the distribution of the physical quantities of the optically dark and bright GRBs, detected by the BAT and XRT on board of the Swift Satellite. We found that the GRBs having detected optical transients (OT) have systematically higher peak fluxes and lower HI column densities than those without OT. (L. G. Balázs, I. Horváth, Z. Bagoly, A. Mészáros, P. Veres: Observational difference between gamma and X-ray properties of optically dark and bright GRBs, GAMMA-RAY BURSTS 2007: Proceedings of the Santa Fe Conference;1000, 44, 2007)

In a systematic search of the OTs at GRBs the Swift satellite determined only an upper limit of the apparent brightness in a significant fraction of cases. Combining these upper limits with the really measured OT brightness we obtained a sample well suited for survival analysis. Performing a Kaplan-Meier product limit estimation we obtained an unbiased cumulative distribution of the V visual brightness. The $\log_{10}(N(V))$ logarithmic cumulative distribution can be well fitted with a linear function of V in the form of $\log_{10}(N(V)) = 0.2341V + const.$ We studied the dependence of V on the gamma-ray properties of the bursts. We tested the dependence on the fluence, T_{90} duration and peak flux. We found a dependence on the peak flux on the 99.7% significance level. (L.G. Balázs, I.

Horváth, Z. Bagoly, A. Mészáros,: Survival analysis of the Swift Optical Transient data, Nouvo Cimento B, 121, 1433, 2007)

With the early afterglow localizations of gamma-ray burst positions made by Swift, the clear delimitation of the prompt phase and the afterglow is not so obvious any more. It is important to see weather the two phases have the same origin or they stem from different parts of the progenitor system. We will combine the two kinds of gamma-ray burst data from the Swift-XRT instrument (windowed timing and photon counting modes) and from BAT. A thorough description of the applied procedure is given. We apply various binning techniques to the different data: Bayes blocks, exponential binning and signal-to-noise type of binning. We present a handful of lightcurves and some possible applications. (P. Veres, Z. Bagoly, J. Kelemen, J. Řipa: Joining Swift BAT and XRT Lightcurves, Proceedings of the 6th Huntsville Gamma-Ray Burst Symposium, eds. C.A. Meegan, N. Gehrels, and C. Kouveliotou, 2009)

2 Cosmology

Another aspect of studies carried out in the 2004-2008 interval is the use of bursts and supernovae as probes of cosmology.

We observed 50 high-z ($0.1 < z < 1$) SN Ia host galaxies with the MIPS camera on board the Spitzer Space Telescope at the three photometric bands (24, 70 and 160 μm). The galaxies were selected to be detectable up to $z \sim 1$. Their 24, 70 and 160 μm Hubble-diagrams (redshift versus apparent brightness) provides information about the dust content of the galaxies, and show whether the visible-light observations should be corrected for an unexpected dust content. (L.G. Balázs, P. Mészáros, P. Ábrahám, A. Moor, C. Kiss, Z. Bagoly, I. Horváth, A. Mészáros,: Far Infrared Study of SN Ia host galaxies, in proceedings of conference "Vision for Infrared Astronomy", 20-22 March 2006, Paris - France)

We have carried out a Monte Carlo simulation of type Ia supernova data. It was shown earlier that the data of SNe Ia might contain a possible correlation between the estimated luminosity distances and internal extinctions. This correlation was shown by different statistical investigations of the data. In order to remove observational biases (for example the effect of the detection limit of the observing instrument) and to test the reality of the effect found earlier we developed a simple routine which simulates extinction values, redshifts and absolute magnitudes for Ia supernovae. We pointed out that the correlation found earlier in the real data between the internal extinction and luminosity distance does not occur in the simulated sample. Furthermore, it became obvious that the detection limit of the observing devices used in supernova projects does not affect the far end of the redshift-luminosity distance relationship of Ia supernovae. This result strengthens the earlier conclusions of the authors that SN Ia supernovae alone do not support the existence of dark energy. (L.G. Balázs, Z. Hetesi, M. Korsós,: Monte Carlo Simulation of a Possible Correlation between the Estimated Luminosity Distances and Internal extinctions of Type Ia Supernovae, Astronomische Nachrichten, 328, 858, 2007)

We have collected the redshifts of gamma-ray bursts in the BATSE Catalog and compared with the star formation rate. We aimed to clarify the accordance between them. We also studied the case of comoving number density of bursts monotonously increasing up to redshift $\sim 6-20$. A method independent of the models of the gamma-ray bursts was used. The short and the long subgroups were studied separately. We got that the redshift distribution of the long bursts may be proportional to the star formation rate. For the short bursts this can also happen, but the proportionality is less evident. For the long bursts the monotonously increasing scenario is also less probable but still can occur. For the short bursts this alternative seems to be excluded. (A. Mészáros, Z. Bagoly, L.G. Balázs, I. Horváth: Redshift distribution of gamma-ray bursts and star formation rate, Astronomy and Astrophysics, 455, 785-790, 2006)

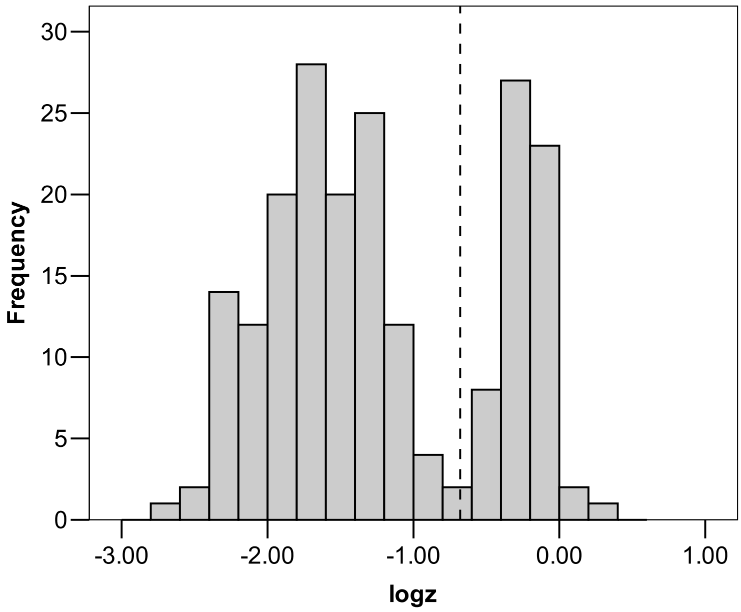

Figure 1: Histogram of z distribution in the data set. The vertical dashed line indicates a cut between the low and high redshift part of the sample.

We studied the statistical properties of the luminosity distance and internal extinction data of type Ia supernovae in the lists published by Tonry *et al.* and Barris *et al.*. After selecting the luminosity distance in an empty Universe as a reference level we divided the sample into low $z < 0.25$ and high $z > 0.25$ parts (see Fig.1.). We further divided these subsamples by the median of the internal extinction. Performing sign tests using the standardized residuals between the estimated logarithmic luminosity distances and those of an empty universe, on the four subsamples separately, we recognized that the residuals were distributed symmetrically in the low redshift region, independently from the internal extinction. On the contrary, the low extinction part of the data of $z > 0.25$ clearly showed an excess of the points with respect to an empty Universe which was not the case in the high extinction region. This diversity pointed to an interrelation between the estimated luminosity distance and internal extinction. To characterize quantitatively this interrelation we introduced a hidden variable making use of the technics of factor analysis. After subtracting that part of the residual which was explained by the hidden variable we obtained luminosity distances which were already free from interrelation with internal extinction. Fitting the corrected luminosity distances with cosmological models we concluded that the SN Ia data alone did not exclude the possibility of the $\Lambda = 0$ solution. (Balázs L.G., Hetesi Zs., Regály Zs., Csizmadia Sz., Bagoly Zs., Horváth I., Mészáros A.,: A possible interrelation between the estimated luminosity distances and the internal extinctions of type Ia supernovae, Astronomische Nachrichten, 327, 917-924, 2006)

Until 6 October 2005 sixteen redshifts had been measured of long gamma-ray bursts discovered by the Swift satellite. Further 45 redshifts have been measured of the long gamma-ray bursts discovered by other satellites. We have performed five statistical tests comparing the redshift distributions of these two samples assuming as the null hypothesis an identical distribution for the two samples. Three tests (Student's t-test, Mann-Whitney test, Kolmogorov-Smirnov test) rejected the null hypothesis at significance levels between 97.19 and 98.55%. Two different comparisons of the medians showed extreme $(99.78 - 99.99994)\%$ significance levels of rejection. This meant that the redshifts of the Swift sample and the redshifts of the non-Swift sample are distributed differently - in the Swift sample the redshifts are on average larger. This statistical result suggests that the long GRBs should on average be at the higher redshifts of the Swift sample. (Z. Bagoly, A. Mészáros, L.G. Balázs, I. Horváth, S. Klose, S. Larsson, P. Mészáros, F. Ryde, G. Tusnády,: The Swift satellite and redshifts of long gamma-ray bursts, Astronomy and Astrophysics, 453, 797-800., 2006)

The measured redshifts of GRBs, which were first detected by the Swift satellite, seemed to be bigger on average than the redshifts of GRBs detected by other satellites. We analyzed the redshift distribution of GRBs triggered and observed by different satellites (Swift, HETE2, BeppoSax, Ulyssses). After considering the possible biases significant difference was found at the $p = 95.70\%$ level in the redshift distributions of GRBs measured by HETE and the Swift. (Z. Bagoly, L. G. Balázs, I. Horváth, J. Kelemen, A. Mészáros, P. Veres, G. Tusnády: Different satellites different GRB redshift distributions?, 2008 NANJING GAMMA-RAY BURST CONFERENCE 1065, 119, 2008; Z. Bagoly, P. Veres: Optical observational biases in the GRB redshift, Proceedings of the 6th Huntsville Gamma-Ray Burst Symposium, eds. C.A. Meegan, N. Gehrels, and C. Kouveliotou, 2009)

3 Spectral analysis

We have discussed the Gamma Ray Inverse Problem. Four methods of spectral deconvolution were studied and applied to the BATSE's MER data type. We compared these to the Band spectra. (P. Veres, I. Horváth, Z. Bagoly, L.G. Balázs, A. Mészáros, G. Tusnády, F. Ryde: Model Independent Methods of Describing GRB Spectra Using BATSE MER Data, Nouvo Cimento B, 121, 1609, 2007)

We have analyzed the spectral lags of a sample of bright gamma-ray burst pulses observed by CGRO BATSE and compared these with the results of high-resolution spectroscopical investigations. We found that pulses with hard spectra had the largest lags, and that there was a similar, but weaker correlation be-

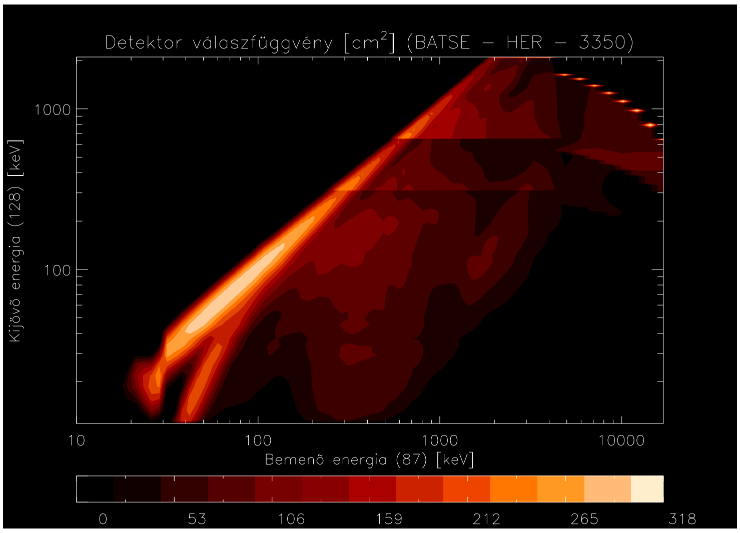

Figure 2: Example for BATSE's DRM.

tween hardness-intensity correlation index, η and lag. We have also found that the lags differ considerably between pulses within a burst. Furthermore, the peak energy mainly decreases with increasing lag. Assuming a lag-luminosity relation as suggested by Norris et al., there is thus a positive luminosity-peak-energy correlation. We also found that the hardness ratio, of the total flux in two channels, only weakly correlates with the spectral evolution parameters. These results were consistent with those found in the analytical and numerical analysis in a previous. Finally, we found that for these bursts, dominated by a single pulse, there is a correlation between the observed energy-flux, F, and the inverse of the lag, $\Delta t : F \propto \Delta t^{-1}$. We interpreted this flux-lag relation found as a consequence of the lag-luminosity relation and that these bursts have to be relatively narrowly distributed in z. However, they still had to, mainly, lie beyond $z \sim 0.01$, since they do not coincide with the local super-cluster of galaxies. We have discussed the observed correlations within the collapsar model, in which the collimation of the outflow varies. Both the thermal photospheric emission as well as non-thermal, optically-thin synchrotron emission should be important. (F. Ryde, D. Kocevski, Z. Bagoly, N. Ryde, A. Mészáros,: Interpretations of gamma-ray burst spectroscopy. II. Bright BATSE bursts, Astronomy and Astrophysics, 432, 105, 2005)

The principal-component analysis is a statistical method, which may lower the number of important variables in a data set. We have discussed the use of this method for the bursts' spectra and afterglows. The analysis indicated that three principal components are enough to describe the variability of the data. The correlation between the spectral index α and the redshift suggests that the thermal emission component becomes more dominant at larger redshifts. (Z. Bagoly, I. Horváth, L.G. Balázs, L. Borgonovo, S. Larsson, A. Mészáros, F. Ryde,: Principal Component Analysis of Gamma-Ray Bursts' Spectra., Nuovo Cimento C, 28, 295, 2005)

We have studied a sample of 197 long BATSE GRBs, where 11 variables, describing the time behavior of the spectra and other quantities, were collected. The application of the factor analysis on this sample showed that five factors describe the sample satisfactorily. Both the pseudo-redshifts coming from the variability and the Amati-relation in its original form are disfavored. (Z. Bagoly, L. Borgonovo, A. Mészáros, L.G. Balázs, I. Horváth,: Factor analysis of the long gamma-ray bursts, Astronomy and Astrophysics, 493, 51, 2009).

4 Lightcurves

The Compton Gamma Ray Observatory (CGRO) observed many types of data and one of them is the time-tagged photon events (TTE data). We used the Bayesian block analysis, using Bayesian statistics, on the TTE data. We have calculated total duration ($T100$), count rates (burst photon numbers in different channels) and count peaks (in 64, 16 and 4ms). We presented the duration, the peak duration and the distance between peaks distributions. Principal Component Analysis (PCA) has been also applied. The PCA showed interesting results, such as the fact that channel 4 (highest energy channel) probably is very important. (I. Horváth, J.P. Norris, J.D. Scargle, L.G. Balázs,: Preliminary results of the analysis of the BATSE TTE data., Nuovo Cimento C, 28, 291, 2005)

We estimated the T_{xx} quantiles of the cumulative GRB light curves using our recalculated background. The basic information of the light curves was extracted by multivariate statistical methods. The possible classes of the light curves were also briefly discussed. (B. Varga, I. Horváth, L.G. Balázs,: A new approach of Analyzing GRB light curves., Nuovo Cimento C, 28, 861, 2005)

5 GRB statistics

The main focus of our studies was the statistical approach to the study of the bursts general properties. In this section we present the work done in the above period.

The CGRO/BATSE database includes many types of data such as the 16-channel continuous background or medium energy resolution burst data (CONT and MER data types). We have calculated some four hundred burst's medium energy resolution spectra and Principal Component Analysis has been applied. We found that five components can describe GRBs' spectra. (P. Veres, I. Horváth, L.G. Balázs,: Analysis of the BATSE continuous MER data., Nuovo Cimento C, 28, 355, 2005)

Gamma-ray bursts can be divided into three groups ("short" "intermediate" "long") with respect to their durations. The third type of gamma-ray bursts - as known - has intermediate duration. We showed that the intermediate group is the softest one. An anti-correlation between the hardness and the duration was found for this subclass in contrast to the short and long groups. (I. Horváth, F. Ryde, L.G. Balázs, Z. Bagoly, A. Mészáros,: Properties of the intermediate type of gamma-ray bursts., Proc. of the 16th Maryland conference "Gamma-Ray Bursts in the Swift Era", eds. Holt, Gehlers, Nousek, AIP Conf. Ser. Vol. 836. Melville New York p125, 2006)

The classification of bursts in the three classes above is somewhat imprecise, since the subgroup of intermediate duration has an admixture of both short and long bursts. In a paper a physically more reasonable definition of the intermediate group was presented, using also the hardnesses of the bursts. It was shown again that the existence of the three groups is real, no further groups are needed. The intermediate group was the softest one. From this new definition it followed that $\sim 11\%$ of all bursts belong to this group in the BATSE sample. (I. Horváth, L.G. Balázs, Z. Bagoly, F. Ryde, A. Mészáros,: A new definition of the intermediate subgroup of gamma-ray bursts, Astronomy & Astrophysics, , 447, 23-30., 2006)

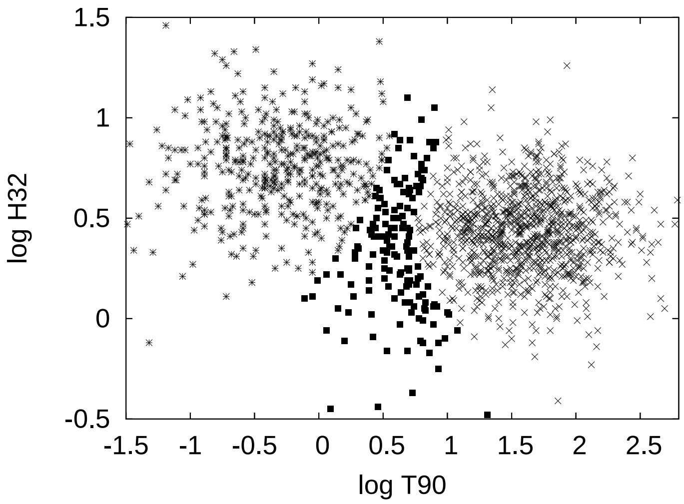

Figure 3: The three groups on duration-hardness distribution.

The GRB database based on the data by the RHESSI satellite provides a unique and homogeneous database for future analyses. In years 2006-07 we presented the preliminary results on the duration and hardness ratio distributions for a sample of 228 GRBs observed with RHESSI (J. Řípa, R. Hudec, A. Mészáros, W. Hajdas, C. Wigger, Statistical Analyses of RHESSI GRB Database, in proceedings of the 16th Maryland conference "Gamma-Ray Bursts in the Swift Era", Washington DC, Nov.29 - Dec.2, 2005. eds. S.S. Holt, N. Gehlers, J.A. Nousek, AIP Conf. Series, Melville, New York (2006), 129; J. Řípa, R. Hudec, A. Mészáros, W. Hajdas, C. Wigger: Statistical analysis of RHESSI GRB database, Nouvo Cimento B, 121, 1493, 2007). Later we used the statistical χ^2 test and the F-test to compare the number of GRB subgroups in that database with the BATSE and Swift results. Similarly to the BATSE database, the short and long subgroups are well detected in the Swift and RHESSI data. However, contrary to the BATSE data, we have not found yet a statistically significant intermediate subgroup in either Swift or RHESSI data (Řípa J., Mészáros A., Hudec R., Wigger C., Hajdas W. The RHESSI Satellite and Classes of Gamma-ray Bursts, in GAMMA-RAY BURSTS 2007: Proceedings of the Santa Fe Conference, 05-09 November 2007, eds. M. Galassi, D. Palmer, E. Fenimore, AIP Conf. Proc. Vol. 1000, 56-59 (2008); Řípa J., Huja D., Mészáros A., Hudec R., Hajdas W., Wigger C., A Search for Gamma-ray Burst Subgroups in the Swift and RHESSI Databases, in 2008 Nanjing Gamma-Ray Burst Conference, Nanjing, China 23-27 June 2008, eds. Y.-F. Huang, Z.-G. Dai, B. Zhang, AIP Conf. Proc. Vol. 1065, 71-74 (2008); Huja D., Mészáros A., On the Intermediate Subgroup of the Gamma-Ray Bursts in the Swift Database, HIGH ENERGY GAMMA-RAY ASTRONOMY: Proceedings of the 4th International Meeting on High Energy Gamma-Ray Astronomy, Heidelberg, AIP Conference Proceedings, Volume 1085, 668 (2008)). Finally, in the RHESSI database the third intermediate subgroup was already found (Řípa J., Mészáros A., Wigger C., Huja D., Hudec R., Hajdas W. Search for Gamma-Ray Burst Classes with the RHESSI Satellite, Astronomy and Astrophysics, in press, (2009)).

Two classes of gamma-ray bursts have been identified in the BATSE catalogs characterized by durations shorter and longer than about 2 s. There are, however, some indications for the existence of a third class. Swift satellite detectors have different spectral sensitivity than pre-Swift ones for gamma-ray bursts. Therefore we reanalyzed the durations and their distribution and also the classification of GRBs. We have analyzed the bursts' duration distribution, published in The First BAT Catalog, whether it contains two, three or more groups. The maximum likelihood estimation was used to on the duration distribution of GRBs. The three log-normal fit was significantly (99.54% probability) better than the two for the duration distribution. Monte-Carlo simulations also confirm this probability (99.2%). Similarly, in previous results we found that the fourth component is not needed. The relative frequencies of the distribution of the groups were 7% short 35% intermediate and 58% long. Three components were needed to explain the BAT GRBs' duration distribution. Although the relative frequencies of the groups were different than in the BATSE GRB sample, the difference in the instrument spectral sensitivities could explain this bias. This meant theoretical models may be needed to explain three different type of gamma-ray bursts. (I. Horváth, L.G. Balázs, Z. Bagoly, P. Veres: Classification of Swift's gamma-ray bursts, Astronomy and Astrophysics, 489, 1, 2008)

The primary scientific goal of the GRIPS mission is to revolutionize our understanding of the early universe using gamma-ray bursts. We propose a new generation gamma-ray observatory capable of unprecedented spectroscopy over a wide range of gamma-ray energies (200 keV - 50 MeV) and of polarimetry ($200 - 1000$ keV). The gamma-ray sensitivity to nuclear absorption features enables the measurement of column densities as high as $10^{28} cm^2$ 2. Secondary goals achievable by this mission include direct measurements of all types of supernova interiors through gamma-rays from radioactive decays, nuclear astrophysics with massive stars and novae, and studies of particle acceleration near compact stars, interstellar shocks, and clusters of galaxies. (J. Greiner, A. Iyudin, G. Kanbach, A. Zoglauer, R. Diehl, F. Ryde, D. Hartmann, A. v. Kienlin, S. McBreen, M. Ajello, Z. Bagoly, L.G. Balázs, I. Horváth, A. Mészáros, et. al.: Gamma-ray burst investigation via polarimetry and spectroscopy (GRIPS), Experimental Astronomy, 22, 23, 2008)

We made an attempt to combine the two kinds of data from the Swift-XRT instrument (windowed timing and photon counting modes) and the from BAT. A thorough description of the applied procedure was given. We applied various binning techniques to the different data: Bayes blocks, exponential binning and signal-to-noise type of binning. We presented a handful of lightcurves and some possible applications. (P. Veres, Z. Bagoly, J. Kelemen, I. Horváth, L. G. Balázs, A. Mészáros, G. Tusnády: Combined Swift BAT-XRT Lightcurves, 2008 NANJING GAMMA-RAY BURST CONFERENCE 1065, 35, 2008)

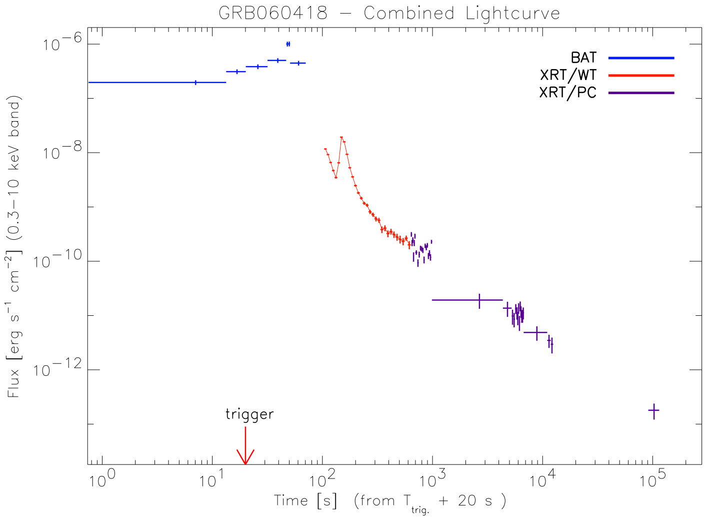

Figure 4: The combined X-ray lightcurve of GRB060418.

We have studied the complete randomness of the angular distribution of GRBs detected by BATSE. We divided the sample into five subsamples (short1, short2, intermediate, long1, long2) based on their durations and peak fluxes, and we studied the angular distributions separately. We used three methods, Voronoi tessellation, minimal spanning tree and multifractal spectra, to search for non-randomness in the subsamples. To investigate the eventual non-randomness in the subsamples, we defined 13 test variables (nine from the Voronoi tessellation, three from the minimal spanning tree and one from the multifractal spectrum). Assuming that the point patterns obtained from the BATSE subsamples are fully random, we made Monte Carlo simulations taking into account the BATSE's sky-exposure function. The Monte Carlo simulations enabled us to test the null hypothesis (i.e. that the angular distributions are fully random). We tested the randomness using a binomial test and by introducing squared Euclidean distances in the parameter space of the test variables. We concluded that the short1 and short2 groups deviate significantly (99.90 and 99.98%, resp.) from the full randomness in the distribution of the squared Euclidean distances; however, this is not the case for the long samples. For the intermediate group, the squared Euclidean distances also give a significant deviation (98.51%). (R. Vavrek, L.G. Balázs, A. Mészáros, I. Horváth, Z. Bagoly,: Testing the Randomness in the Sky-Distribution of Gamma-Ray Bursts., MNRAS, 391, 1741, 2008) The impact of these behaviors on the validity of the cosmological principle is also investigated. (A. Mészáros, L.G. Balázs, Z. Bagoly, P. Veres: Anisotropy in the sky distributions of the short and intermediate gamma-ray bursts: Breakdown of the cosmological principle?, Proceedings of the 6th Huntsville Gamma-Ray Burst Symposium, eds. C.A. Meegan, N. Gehrels, and C. Kouveliotou, 2009).

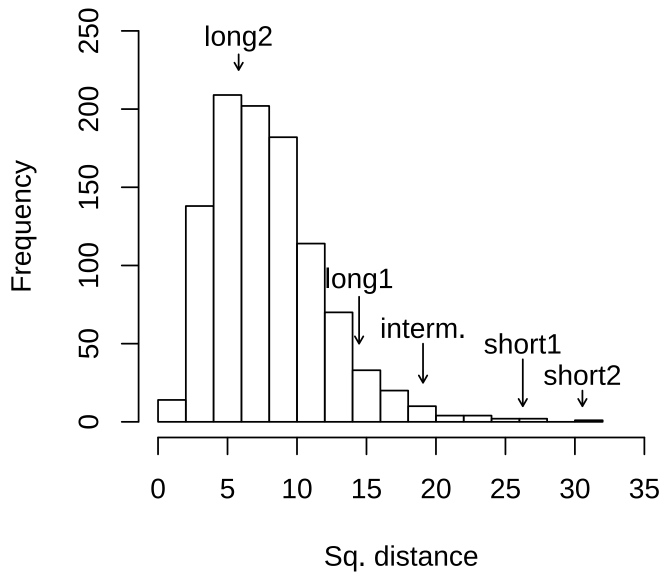

Figure 5: Distribution of the squared Euclidean distances of the simulated samples from the stochastic mean of the f_i hidden variables (factors) in the 8D parameter space.

We presented multi-wavelength observations of the most distant gamma-ray burst detected so far GRB 080913 and studied whether it can be considered a short-duration GRB and the implications for the progenitor nature and energy extraction mechanisms. Multi-wavelength (X-ray/nIR/millimeter) observations were made between 20.7 hours and 16.8 days after the event. Whereas a very faint afterglow was seen at the 3.5m CAHA telescope in the nIR, the X-ray afterglow was clearly detected in our XMM-Newton observations. An upper limit is reported in the mm range. At typical redshifts of other bursts, GRB 080913 would be found in the locus of short-duration GRBs on a hardness-duration diagram, thus strengthening its membership of this class. We also report that GRB 080913 shows lower isotropic luminosities than GRB 060121, another likely member of the short-duration class of GRB at $z \sim 4.6$. Regarding the nature of the progenitor, we found that a NS+BH was slightly preferred over a double NS merger, with the Blandford-Znajek process operating in this subclass of extremely energetic short GRBs. (D. Perez-Ramirez, A. de Ugarte Postigo, J. Gorosabel, M. A. Aloy, M. A. Guerrero, J. P. Osborne, K. L. Page, R. S. Warwick, I. Horváth, P. Veres, M. Jelinek, P. Kubanek: Detection of the ultra-high z short GRB 080913 and its implications on progenitors and energy extraction mechanisms, Astronomy and Astrophysics, 2009)

Swift satellite detectors have different spectral sensitivity than pre-Swift ones for gamma-ray bursts. Therefore it is worth to reanalyze the durations and their distribution and also the classification of GRBs. We analyzed the bursts' duration distribution and also the duration-hardness bivariate distribution, published in The First BAT Catalog, whether it contains two, three or maybe more groups. Similarly to the BATSE data, to explain the BAT GRBs duration distribution three components are needed. Although, the relative frequencies of the groups are different than they were in the BATSE GRB sample, the difference in the instrument spectral sensitivities can explain this bias in a natural way. This means theoretical models may have to explain three different type of gamma-ray bursts. (I. Horváth, L.G. Balázs, P. Veres: Gamma-Ray Burst Groups Observed by Different Satellites, Proceedings of the 6th Huntsville Gamma-Ray Burst Symposium, eds. C.A. Meegan, N. Gehrels, and C. Kouveliotou, 2009)

We used the canonical correlation analysis of the multivariate statistics to study the interrelation between the gamma (Fluence, 1sec Peakflux, duration) and X-ray (early X flux, 24 hours X flux, X decay index, X spectral index, X HI column density) data. We computed the canonical correlations and variables showing that there is a significant interrelation between the gamma and X-ray data. Using the canonical variables resulted in the analysis we computed their correlations (canonical loadings) with the original ones. The canonical loadings revealed that the gamma-ray fluence and the early X-ray flux give the strongest contribution to the correlation in contrast to the X-ray decay index and spectral index. An interesting new result appears to be the strong contribution of the HI column density to the correlation. Accepting the collapsar model of long GRBs this effect may be interpreted as an indication for the ejection of an HI envelope by the progenitor in the course of producing the GRB. (L.G. Balázs, I. Horváth, P. Mészáros, G. Tusnády, P. Veres: Canonical correlation between the gamma and X-ray data of Swift GRBs, Proceedings of the 6th Huntsville Gamma-Ray Burst Symposium, eds. C.A. Meegan, N. Gehrels, and C. Kouveliotou, 2009)