A&A 473, 347–349 (2007)
DOI: 10.1051/0004-6361:20077495

Astronomy & Astrophysics

The complete catalogue of GRBs observed by the wide field cameras on board BeppoSAX

L. Vetere[1,⋆], P. Soffitta[2], E. Massaro[3,1], P. Giommi[1], and E. Costa[2]

[1] ASI Science Data Center, ASDC c/o ESRIN, via G. Galilei, 00044 Frascati, Italy
e-mail: paolo.giommi@asdc.asi.it
[2] INAF - IASF, Sezione di Roma, via del Fosso del Cavaliere, 00133 Roma, Italy
[3] Dipartimento di Fisica, Sapienza Università di Roma Piazzale A. Moro 2, 00185 Roma, Italy

Received 16 March 2007 / Accepted 11 June 2007

ABSTRACT

Context. We present the complete on-line catalogue of gamma-ray bursts observed by the two Wide Field Cameras on board *BeppoSAX* in the period 1996–2002.

Aims. Our aim is to provide the community with the largest published data set of GRB's prompt emission X-ray light curves and other useful data.

Methods. This catalogue (BS-GRBWFCcat) contains data on 77 bursts and a collection of the X-ray light curves of 56 GRB discovered or noticed shortly after the event and of other additional bursts detected in subsequent searches. Light curves are given in the three X-ray energy bands (2–5, 5–10, 10–26 keV).

Results. The catalogue can be accessed from the home web page of the ASI Science Data Center-ASDC (http://www.asdc.asi.it).

Key words. X-rays: bursts – gamma-rays: bursts – catalogs

1. Introduction

The *BeppoSAX* satellite, an Italian mission for X-ray astronomy with a contribution from the Netherlands Agency for Aerospace Programs (NIVR) and the Space Research Organisation Netherlands (SRON) (Boella et al. 1997), was launched on April 30, 1996 and remained operative for six years up to April 30, 2002. The scientific payload consisted of two Wide Field Instruments (WFI) and four Narrow Field Instruments (NFI). The WFI instruments consisted of two Wide Field Cameras (WFC), pointing at opposite directions in the sky and perpendicular to the NFIs, and the Gamma-ray Burst Monitor (GRBM).

One of the most important results obtained by the *BeppoSAX* mission was the discovery of the X-ray afterglows of GRBs (Costa et al. 1997) which led to the detection of the associated optical emission (van Paradijs et al. 1997) and to the measurement of GRB redshifts (Djorgovski et al. 1997). In the six years of the *BeppoSAX* lifetime the WFIs detected several GRBs and provided light curves down to the energy of 2 keV. This also led to the discovery of a new class of bursts, called X-ray Flashes (XRF), because these are much brighter at energies lower than 30 keV than in the low energy gamma rays (Heise et al. 2001).

Up to now this is the largest published data set of GRB X-ray light curves useful to investigate their time and spectral properties, particularly in comparison with data at higher energies. We have collected all these data in a catalogue, named BeppoSAX GRB-WFC Catalogue (shortly BS-GRBWFCcat), available on-line either from the Home page of the ASDC (ASI Science Data Center) at the URL: http://www.asdc.asi.it or at the direct URL http://www.asdc.asi.it/grb_wfc. This catalogue is complementary to that of GRBM presented by Guidorzi et al. (2004), which covers the energy range 40–700 keV. In this note we give a brief presentation of the BS-GRBWFCcat and of its content. More information on the use of this catalogue is available directly from the web pages given above.

⋆ *Current address:* Department of Astronomy and Astrophysics, Pennsylvania State University, 5252 Davey laboratory, University Park, PA 16802 USA

2. Wide Field Cameras

Each WFC (Jager et al. 1997) was a Multi-Wire Proportional Counter with an open area of 25×25 cm^2 and a useful energy range of 2–26 keV. The two-dimensional position- and energy-sensitive counter was placed behind an opaque screen with a pseudo random array of holes, a so-called shadow or coded mask. X-ray sources in the field of view cast shadows of the mask on the detector, each displaced according to the position of the source. A cross-correlation (Fenimore et al. 1978) carried out on the ground, reconstructs the positions and fluxes of all sources in the field. The WFCs had a good sensitivity over a large field of view and a good angular resolution within the entire field (due to small mask holes and to the good resolution of the detector). The transparency of the mask was 33% and the field of view was limited by a collimator with no flat field to 40°× 40°. The effective area was ∼150 cm^2 at the centre of the field of view. The sensitivity for burst detection has been estimated at a flux level of $\sim 4 \times 10^{-9}$ erg cm^{-2} s^{-1} (De Pasquale et al. 2006).

Article published by EDP Sciences and available at http://www.aanda.org or http://dx.doi.org/10.1051/0004-6361:20077495

3. Observations and data reduction

All the GRB light curves (LC) in the BS-GRBWFCcat were taken with the two WFCs on board *BeppoSAX*. There are two different ways to extract a LC from the WFC data:

i) consider the whole detector image and subtract the background component deconvolving it using the mask response function;
ii) select only the region concerned by the burst, without subtraction of the background component, including the pixel occulted by the mask in the direction of the source.

The first method gives LCs without background, while the second method gives LCs where counts are distributed according to the Poisson statistics. Note that in the majority of WFC fields the integrated count rate of instrumental background is ~130 counts/s 85% of which are due to the cosmic X-ray background and undetected sources. In a few sky areas, like the Galactic Centre or the Cygnus region, this value is significantly higher and can even double. The burst's count rate depends not only on the incident flux and spectrum but also on the mask transparency, the detector efficiency and on the burst location in the field of view. We decided, therefore, to use the first method of LC extraction which gives a controlled background subtraction. For each burst we created three LCs in the three energy bands 2–5, 5–10, 10–26 keV, selected to have approximately the same number of counts in each band for a typical GRB. The integration time was usually 1.0 s.

4. Catalogue description

GRB data in the BS-GRBWFCcat are given in two tables. The first one contains general information and gives access to LCs of 62 bursts (two are classified as X-ray Flashes, XRF) observed from July 1997 to February 2002: 56 of these GRBs were either triggered by the onboard software of the GRBM or discovered through the quick look analysis or by alerts from other satellites, while the other 6 were detected in a subsequent analysis of GRBM count rates. The latter bursts are indicated as *off-line* events and are marked by an asterisk. No information on them can be found in the GCN archive and no follow-up observations were performed.

The second table contains 15 bursts found in the off-line analysis for which only very few data are available in the literature (Kippen et al. 2004 (KP04); in 't Zand et al. 2004 (TZ04); Heise & in 't Zand 2004 (HTZ04); D'Alessio, et al. 2006 (DAPR), Rossi et al. 2005 (RS05)) and many of them are classified as XRF (reference codes in parentheses are those reported on the web page). DAPR, in particular, published a catalogue of XRF-XRR bursts selected according to the criterion proposed by Lamb & Graziani (2003) where the discriminant parameter is the hardness ratio H_h between the fluence in the 2–30 keV energy range and that measured in the 30–400 keV range. When H_h is in the interval 0.32–1.0 the burst is classified as an X-Ray Rich GRB (XRR), while for H_h higher than 1.0 it is an XRF. The classification in the DAPR catalogue is also given.

All GRBs are listed in chronological order and are named in the usual way, i.e. GRB or XRF followed by the date. For the GRBs in the first table the following information is given: trigger MJD and UT time, duration, coordinates (J2000), peak flux in the 2–10 keV range (from Frontera 2004), the redshift, when known, with the relative reference, and some short notes.

The sky distribution in galactic coordinates of all GRBs with known coordinates listed in the BS-GRBWFCcat is shown in Fig. 1: it is highly anisotropic with two major concentrations in the direction of the ecliptic poles. This is due to the non uniform exposure of WFC that pointed in a direction perpendicular to NFIs. The same figure also appears on the web page of Table 1 as an interactive slot. By clicking on the plot one can open a window and on the individual GRB positions it is possible to see the LCs.

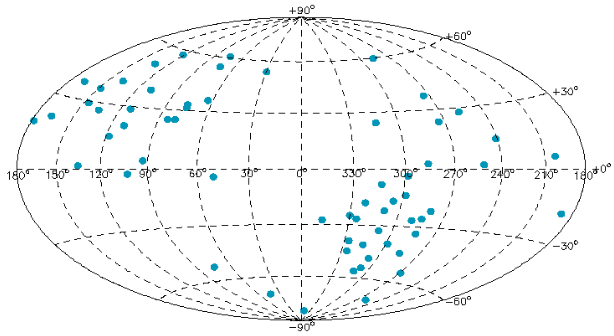

Fig. 1. The sky distribution in galactic coordinates of the GRBs in the Sect. 1 of BS-GRBWFCcat.

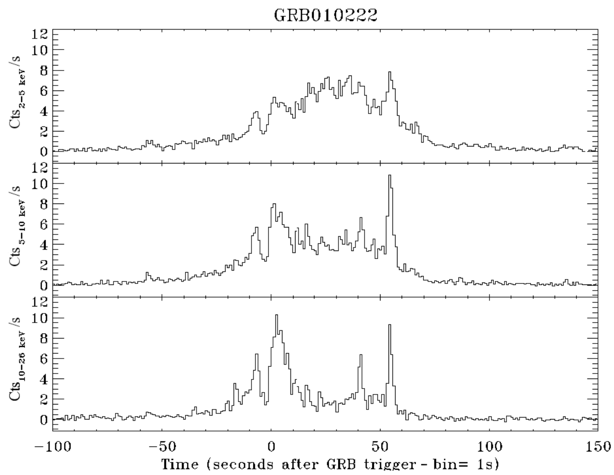

Fig. 2. An example of the three X-ray light curves given in the three energy ranges (2–5, 5–10, 10–26 keV, *top to bottom*) in the BS-GRBWFCcat. Here are shown the LCs of GRB 010222, characterized by a time evolution strongly dependent on energy. Note the significant excess of counts before the triggertime.

It is possible to select a GRB in the first table of BS-GRBWFCcat and to visualize three background subtracted WFC light curves (1 s time bin) in the energy bands given above. It is also possible to retrieve the LC data as ascii files. In the case of GRB000214, however, the only available LC is in entire energy range 2–26 keV without background subtraction. The zero time of each light curve was fixed at the trigger, but sometimes a clear signal is detectable well before this time and, for this reason, LCs start several tens of seconds before the trigger. Only the LC of the famous GRB 990123 is incomplete because its radiation was strongly absorbed by the Earth atmosphere at the end of the LC. An example of a GRB light curve is shown in Fig. 2.

The durations of GRBs given in the catalogue are not the T_{90} frequently reported in the literature. We estimated the duration of the 2–5 keV prompt emission from the time integrated (cumulative) light curve, considering the duration of the interval where it differs from a constant value by means of linear fits. These estimates, however, depend on the S/N ratio and are uncertain in some cases. Moreover, in several events there is a clear indication of a pre/post burst emission and the beginning and the end of the burst cannot be clearly distinguished from background fluctuations. In any case, the durations must be considered as an estimate of the time in which we have a detectable signal in the X-ray LC of a GRB. Only for two bursts (GRB 010220 and GRB 02032,1 which have LCs highly changing with energy) the durations were estimated in the 10–26 keV range because the signal in the lowest band was too low for a reliable measure. Some short comments on the duration estimates are also given in the table. The shortest event is about 13 s long, whereas the longest one reaches 248 s. A histogram of the burst durations in the catalogue is shown in Fig. 3. More precise evaluations can be derived by the users from the LC data using criteria consistent with the particular problem under investigation.

For the 10 GRBs studied by Vetere et al. (2006) we reported also the X-ray photon indices derived from the hardness ratios between the three energy bands used. We plan to add this information, at least for the bursts with a good S/N ratio, in future updates of the catalogue.

The BS-GRBWFCcat also provides a link to the GRB web page at MPE-Garching (care of J. Greiner) when available. Tools for an on-line spectral analysis are planned to be available in future versions of the BS-GRBWFCcat.

5. Conclusion

The nature of sudden explosions producing GRBs is one of the most mysterious phenomena in the universe. Despite several space instruments have collected up to now a large amount of data, a full understanding of the physical processes occurring in these huge explosions has not been reached yet. To provide the astrophysical community with some useful data on these events we prepared a web accessible catalogue (BS-GRBWFCcat) containing the X-ray LCs of all GRBs detected by the Wide Field Cameras on board *BeppoSAX*. This table includes information on several events, mainly of XRF type, discovered through an off-line analysis. Unlike other catalogues, it provides data in the 2–26 keV band that are generally not available for the majority of GRBs. It is remarkable that X-ray LCs are generally different from those at higher energies suggesting that either other emission components or physical processes are relevant in this band.

Our aim is to extend the observational knowledge of this phenomenon while a mission like *Swift*, mainly devoted to GRB studies, and others such as *INTEGRAL*, *Suzaku*, *Chandra* and *XMM-Newton* are currently providing new important data. Even more data are expected in the near future when the γ-ray window will be explored by *AGILE* and *GLAST*.

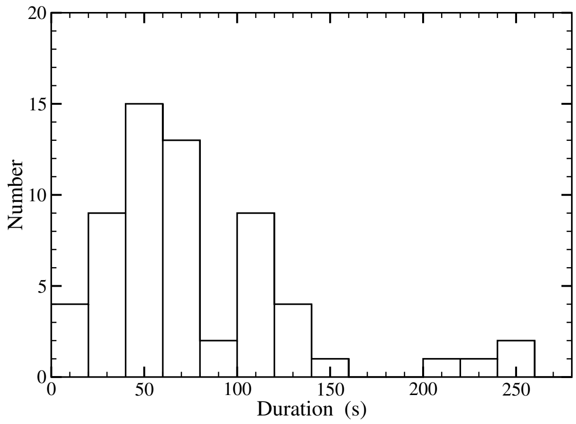

Fig. 3. Histogram of the GRB duration in the BS-GRBWFCcat estimated from the 2–10 keV light curves.

Acknowledgements. This work has been partially supported by INAF under the ASI contract for the scientific activity at ASDC.

References

Boella, G., Butler, R. C., Perola, G. C., et al. 1997, A&AS, 122, 299
Costa, E., Frontera, F., Heise, J., et al. 1997, Nature, 387, 783
D'Alessio, V., Piro, L., & Rossi, E. M. 2006, A&A, 460, 653
De Pasquale, M., Piro, L., & Gendre, B. 2006, A&A, 455, 813
Djorgovski, S. G., Metzger, M. R., Kulkarni, S. R., et al. 1997, IAUC, 6660
Fenimore, E. E., & Cannon, T. M. 1978, Appl., Opt., 17, 337
Fiore, F., Guainazzi, & M., Grandi, P. 1999, Cookbook for BeppoSAX NFI Spectral Analysis, BeppoSAX Science Data Center, version 1.2
Frontera, F. 2004, Proc. 3rd Rome Workshop on Gamma-Ray Bursts in the Afterglow Era, ASP Conf., Ser., 312, 3
Guidorzi, C., Montanari, F., Frontera, F., et al. 2004, Proc. 3rd Rome Workshop on Gamma-Ray Bursts in the Afterglow Era, ASP Conf., Ser., 312, 39
Heise, J., in 't Zand, J., Kippen, R. M., & Woods, P. M. 2001, Proc. 2nd Rome Workshop on Gamma-Ray Bursts in the Afterglow Era, 16
Heise, J., & in 't Zand, J. 2004, Nucl., Phys., B (Proc. Suppl.), 132, 263
in 't Zand, J., Heise, J., Kippen, R. M., et al. 2004, Proc. 3rd Rome Workshop on Gamma-Ray Bursts in the Afterglow Era, ASP Conf. Ser., 312, 18
Jager, R., Mels, W. A., Brinkman, A. C., et al. 1997, A&AS, 125, 557
Kippen, R. M., Woods, P. M., in 't Zand J. J. M., et al. in Proc. of the 2003 Santa Fe Gamma Ray Bursts Conference 2004, AIP Conf. Proc., 727, 119
Lamb, D. Q., & Graziani, C. 2003, A&AS, 202, 450
Rossi, S., Moretti, G., Ghirlanda, G., et al. 2005, Proc. 4th Rome Workshop on Gamma-Ray Bursts in the Afterglow Era, Nuovo Cim. C, 28, 331
Schmidt, M. 2005, Proc. 4th Rome Workshop on Gamma-Ray Bursts in the Afterglow Era, Nuovo Cim. C, 28, 347
van Paradijs, J., Groot, P. J, Galama, T., et al. 1997, Nature, 386, 686
Vetere, L., Massaro, E., Costa, E., et al. 2006, A&A, 447, 499