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GAMMA RAY BURSTS AND ACTUAL DATABASES

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Abstract. Nature of Gamma Ray Bursts (hereafter GRBs), are very demanding for observational and recording purpose. That is why we need refined observational equipment for recording of data, as well as intelligent system for early warning and initialization of interplanetary observational network. Such collected data are placed in to the sophisticated databases to be accessible for detailed analyze among the scientist. In this paper we have examined the actual databases for Gamma Ray Bursts events, their organization and accessibility. Also, we reviewed the actual process of acquiring the data from satellites and observational network.

1. INTRODUCTION

In recent years, multi-wavelength observations of afterglow emission of Gamma-Ray Bursts (GRBs) have provided great advancement in our knowledge of GRB progenitor, afterglow emission mechanism, and their environment. Nonetheless, the physical mechanism that creates the prompt gamma-ray emission with extremely short variability is still not resolved, thus understanding GRB prompt emission spectra remains crucial to revealing their true nature.

Currently, the most favored GRB emission mechanism is the simple emission scenario of optically-thin synchrotron radiation by shock-accelerated electrons ("synchrotron shock model"; Tavani, 1996). While the synchrotron shock model can account for many of the observed spectra, a considerable number of spectra exhibit behavior inconsistent with this theoretical model. Meanwhile, it is also true that many observed spectra could be fitted with various photon models statistically as well as each other, due to the limited spectral resolution of available data and detector sensitivity. Since the photon models usually used in GRB spectral analysis are parameterized differently, the resulting spectral parameters are found to be highly dependent on photon model choices (Preece et al., 2002; Ghirlanda et al., 2002). Additionally, to deduce the emission mechanism from observations, spectra with fine time resolution are necessary because of the short timescales involved in typical emission processes (i.e., the radiative cooling time, dynamical time, or acceleration time). This is also indicated by the extremely short variability observed in GRB lightcurves (e.g., Bhat et al., 1992), although the detectors' finest time resolution is still longer than the shortest physical timescales involved to produce GRBs. The integration times of spectra certainly depend on the capabilities of the detector systems as well as the brightness of events and photon flux evolution. GRB spectral analyses, therefore, have been performed on various timescales, yet a comprehensive study of the relations between time-averaged and time-resolved spectra, and the effects of various integration times on spectral properties has not been done. Thus, in order for the spectral parameters to meaningfully constrain the physical mechanisms, a comprehensive spectral study with finest possible spectral and temporal resolution, using various photon models, should be carried out with a sufficiently large database.

With such a large amount of data it is difficult to work, so they must be organized in to a database, with search functionality. This was the reason for formation of some of the largest databases of recorded GRBs. One of the most promising and used databases is the BATSE 4B catalog, consisting a several thousand of bursts with appropriate light curves and 4-channel spectra. However, in the recent years a new instruments like SWIFT satellite or XMM Newton has proven in the quality.

In this article we will analyze the available databases from two satellites, one obsolete (CGRO observatory) and one still functional (SWIFT satellite) in order to present current state for future investigations.

2. THE DETECTION AND BIRTH OF INTERLANETARY NETWORK

During the years immediately following the discovery of gamma-ray bursts (GRBs), many researchers believed that a few accurate locations would lead quickly to an understanding of the GRB phenomenon. Thus, beginning in the late 1970s GRB detectors were placed on various interplanetary and solar system probes, achieving interplanetary networks (IPNs) that produced arcminute sized error boxes calculated by arrival time analysis. While the original optimistic expectations were not realized, accurate locations continue to be of paramount interest.

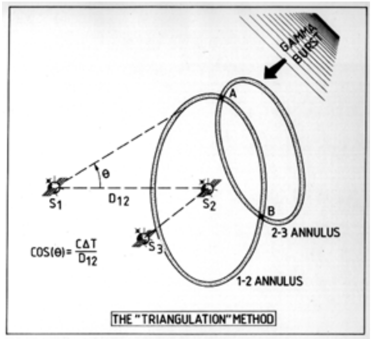

Figure 1. Principles of triangulation.

The group of spacecraft equipped with gamma-ray burst detectors is shown in the Fig. 1. By timing the arrival of a burst at those spacecrafts, its precise location can be found. The farther apart the detectors are, the more precise the location can be determined. The principle is illustrated in the figure above. Each pair of spacecraft, like S1 and S2, gives an annulus of possible arrival directions whose center is defined by the vector joining the two spacecraft, and whose radius theta depends on the difference in the arrival times divided by the distance between the two spacecraft.

The Vela group of satellites was originally designed to detect covert nuclear tests, possibly at the Moon's altitude. Thus, the Velas were placed in high orbits, so that a time delay would occur between spacecraft triggers. In addition, each satellite had multiple gamma-ray detectors across their structures; the detectors facing a blast would register a higher gamma count than the detectors facing away.

A gamma-ray burst was detected by the Vela group on June 3, 1969, and thus referred to as GRB 690603. The location was determined to be clearly outside of the satellites' orbit, and probably outside of the Solar system. After reviewing archived Vela data, a previous burst was determined to have occurred on July 2, 1967. Public reports of initial GRBs were not disclosed until the early 1970s.

3. GRB DATABASES

3.1. CGRO observatory

Gamma-rays can only be detected in space due to the atmospheric absorption of the high-energy photons. Starting from the Vela satellite, which discovered the phenomenon of GRB, a few dozen space-based gamma-ray detectors have observed GRBs. One of the most important was CGRO (Compton Gamma Ray Observatory). The CGRO was launched in April 1991, as one of NASA's Great Observatories: a series of four space-based observatories to study astronomical objects or phenomena in visible, gamma-ray, X-ray, and infrared energy bands. The CGRO observed the sky in high-energy gamma-rays and detected thousands of GRBs as well as many other high-energy transient phenomena in its nine-year lifetime that ended in June 2000.

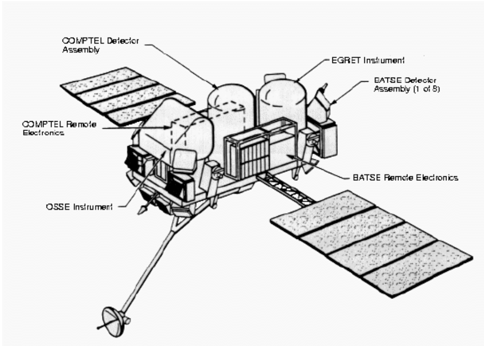

Figure 2. Sketch of the Compton observatory.

The Burst And Transient Source Experiment (BATSE) located at the CGRO was specifically designed to detect GRBs and study their temporal and spectral characteristics in much greater resolution than the previous experiments. Some of the observed events are shown in the Fig. 3., where we can see high variability of the released output energy in the first phase of event lasting a few tens of seconds.

After the launch of CGRO in 1991, BATSE began detecting one GRB a day, on average. Soon, the observations revealed an isotropic angular distribution (Fig. 4) and inhomogeneous spatial distribution for GRBs, with better and better statistics as more numbers of bursts were observed. The isotropy of GRB locations rejected the galactic disk population hypothesis, and confirmed homogenous distribution on the sky.

Along with the inhomogeneity, the indicated GRB distribution was a geocentric spherical distribution with decreasing number density at further distance. The distribution was not consistent with any known population of galactic objects. It was, however, consistent with a cosmological origin hypothesis since isotropy is naturally expected from the cosmological distribution and the inhomogeneity could be explained by the non-Euclidean geometry at very far distances.

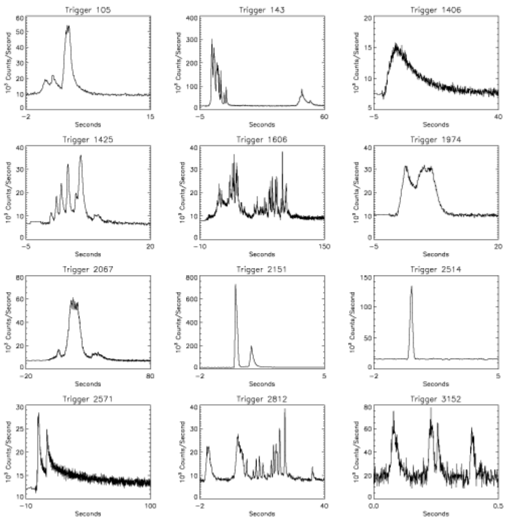

Figure 3. Examples of recorded GRB events in gamma phase.

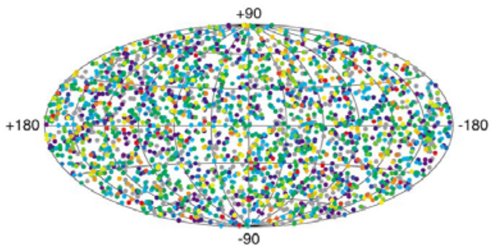

Figure 4. Homogenous distribution of GRB events throughout the whole sky.

3.2. BATSE database

Following the Internet link ftp://legacy.gsfc.nasa.gov/compton/data/ one can find the raw data from the CGRO observatory. They are separated in four directories regarding the on board instrument.

BATSE directory contains all the CGRO/BATSE data. The subdirectories are as follows:

- **SGRs** - soft gamma-repeater data (SGR 1806 only)
- **ascii_data** - simplified versions of certain burst data types for a subset of the mission
- **daily data** - Discriminator rate continuous, and corrected data from LADs and SDs
- **Occultation** - Earth occultation data products; light curves and 16-ch spectra as a function of time
- **pulsar** - Epoch (onboard and ground) folded data
- **single_sweep** - high-time resolution continuous data
- **trigger** - triggered data products, including GRBs and solar flares

Most interesting data connected with the GRB phenomena are in the ascii_data directory, especially concatenated 64-ms Burst Data in ASCII Format. This data type is a concatenation of three standard BATSE data types, DISCLA, PREB, and DISCSC. All three data types are derived from the on-board data stream of BATSE's eight Large Area Detectors (LADs), and all three data types have four energy channels, with approximate channel boundaries: 25-55 keV, 55-110 keV, 110-320 keV, and >320 keV. They are presented in the tables similar to this presented in the Figure 6.

```
trig#  npts nlasc 1preb    followed by 4-chan count rates (64-ms bins)
 3029  8187  1865     7
 1.84812500E+02  1.44437500E+02  1.13312500E+02  7.08750000E+01
 1.84812500E+02  1.44437500E+02  1.13312500E+02  7.08750000E+01
 1.84812500E+02  1.44437500E+02  1.13312500E+02  7.08750000E+01
 1.84812500E+02  1.44437500E+02  1.13312500E+02  7.08750000E+01
 1.84812500E+02  1.44437500E+02  1.13312500E+02  7.08750000E+01
 1.84812500E+02  1.44437500E+02  1.13312500E+02  7.08750000E+01
 1.84812500E+02  1.44437500E+02  1.13312500E+02  7.08750000E+01
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 1.84812500E+02  1.44437500E+02  1.13312500E+02  7.08750000E+01
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 1.84500000E+02  1.45500000E+02  1.17312500E+02  7.29375000E+01
```

Figure 5. Example of ASCII table for 64-ms data.

Another very useful functionality is presented at the address http://gammaray.nsstc.nasa.gov/batse/grb/. It allow user ability to see light curves of wanted GRB events through the suitable user interface (see Figure 6). On the list box placed left one could select GRB event and in controls in the middle and right observational channel and type of file wanted. Then pressing the **Submit** button the results are given in the form of image and file to save. This method is very beneficial when we need to quickly review the GRB events and download chosen files.

During the years of successful operation CGRO with the BATSE experiment onboard, produce the vast amount of data. These are classified in the catalogs ranging from 1B to 4B and at the end so called Current catalog. Most comprehensive data set could be found in the BATSE 4B catalog where we can examine 1637 GRBs. In this tables we could find data sets which contain basic information about location and time of event in different coordinate systems as well as trigger and identification numbers. Also, there are detailed information's about flux and fluence in the of 64, 256 and 1024ms, peak count rates, duration, exposure and data about efficiency of detector which observe the event. Together with the data collected until end of its work in june 2000., CGRO and BATSE produced most comprehensive data sets which is vastly used among the researchers in this area of science.

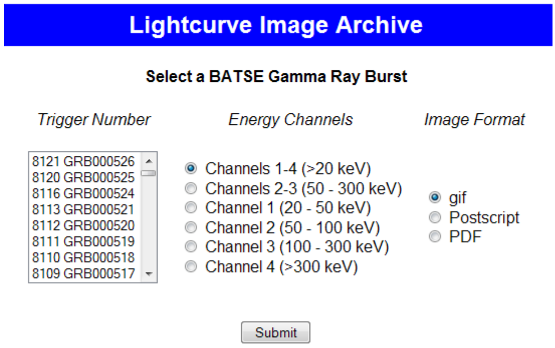

Figure 6. User interface for selecting the GRB event, channel and file tipe.

3.3. SWIFT satellite

SWIFT is a first-of-its-kind multi-wavelength observatory dedicated to the study of gamma-ray burst (GRB) science. Its three instruments work together to observe GRBs and afterglows in the gamma-ray, *X*-ray, ultraviolet, and optical wavebands.

SWIFT discovers approximately 100 bursts per year. The Burst Alert Telescope detects GRBs and accurately determines their positions on the sky. *Swift* then relays a 3 arcminute position estimate to the ground within 20 seconds of the initial detection. The spacecraft "swiftly" (in less than approximately 90 seconds) and autonomously repoints itself to bring the burst location within the field of view of the sensitive narrow-field *X*-ray and UV/optical telescopes to observe the afterglow. In addition to an accurate position, *Swift* provides multi-wavelength light curves for the duration of the afterglow, a gamma-ray spectrum of the burst, *X*-ray spectra of the afterglow, and in some cases can constrain the red shift of the burst.

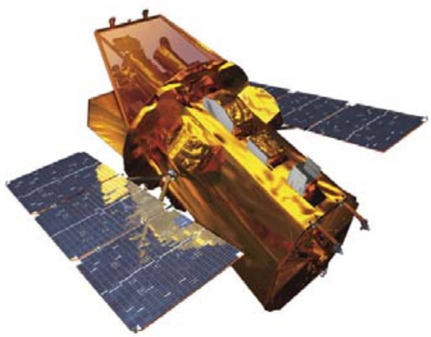

Figure 7. SWIFT satellite.

SWIFT satellite contain three main instrument which cover the electromagnetic spectrum from optical to gamma domain.

Burst Alert Telescope (BAT 15 - 150 keV): With its large field-of-view (2 steradians) and high sensitivity, the BAT detects about 100 GRBs per year, and computes burst positions onboard the satellite with arc-minute positional accuracy. Those data are recorded and passed to the other lower energy instruments in order to be properly guded. **X-ray Telescope** (XRT 0.3 - 10 keV): The XRT takes images and is able to obtain spectra of GRB afterglows during pointed follow-up observations. The images are used for higher accuracy position localizations, while light curves are used to study flaring and the long-term decay of the *X*-ray aferglow. And at the end with **UV/Optical Telescope** (UVOT 170 - 600 nm) a optical and UV observations are made. The UVOT is essentially a copy of the *XMM-Newton* Optical Monitor (OM). The UVOT takes images and can obtain spectra (via a grism filter) of GRB afterglows during pointed follow-up observations. The images are used for 0.5 arcsecond position localizations and following the temporal evolution of the UV/optical afterglow. Spectra can be taken for the brightest UV/optical afterglows, which can then be used to determine the red shift via the observed wavelength of the Lyman-alpha cut-off.

Complete process of acquiring the observation and extracting the data is shown in the Figure 8. Within minutes soon after a GRB is detected, TDRSS messages are broadcast via the GCN. After a few hours or a day telemetry arrives to the Malindi ground station and the data are available in the Quick look area on the SWIFT Internet site. Then about a week latter after an observation is completed, the data are made available in the archive and removed from the Quick-look area.

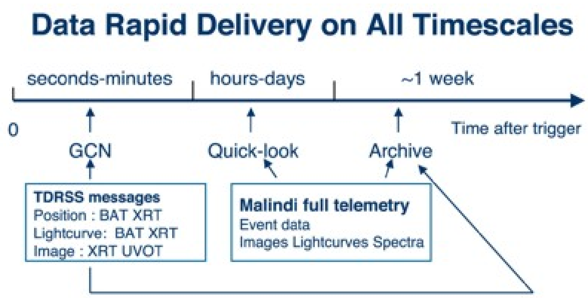

Figure 8. Data processing path in SWIFT satellite.

3.4. SWIFT database

The Swift archive can be accessed via the following interfaces (http://swift.gsfc.nasa.gov/docs/swift/archive/) (see Fig. 9). This address contains useful user interface which allow to setup query for detailed search. For example, one need to specify the some parameters which determine the object, like identification or observational number, object names, coordinates or date of observation. Also, interface offers to select what SWIFT instrument to search. Then the process is started by pressing the Start Search button.

Another way for examined the data is by using the Quick-look area located at the address (http://swift.gsfc.nasa.gov/cgi-bin/sdc/ql?). Figure 10. show example of this functionality.

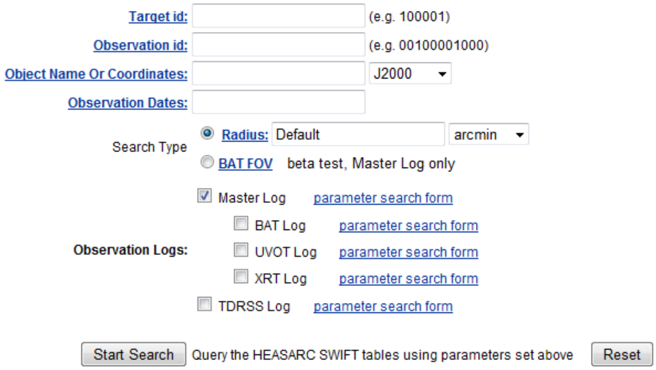

Figure 9. SWIFT user interface.

Figure 10. Data in the Quick-look area of SWIFT database.

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