GRB with INTEGRAL

Nicolas Produit,[1]
(1) INTEGRAL Science Data Centre, Chemin d'Ecogia 16, CH-1290 Versoix, Switzerland

Abstract

The INTEGRAL gamma ray satellite was launched in 2002. One of the goals of INTEGRAL is to detect and study GRBs in all wavelengths from optical to MeV gamma rays.
The possibilities and performances of INTEGRAL for detecting GRBs are described. Some preliminary results on GRB030227 are used as an example.

1. Introduction

INTEGRAL[1] is a European Space Agency gamma ray satellite launched in October 2002. Gamma Ray Bursts (GRBs) are not the prime scientific objective of INTEGRAL but currently INTEGRAL is the largest GRB detector in space.
INTEGRAL provides many very desirable features for studying Gamma Ray Bursts.

- Its sensitivity of 2 10^{-4} $ph\ cm^{-2}\ s^{-1}\ KeV^{-1}$ @1 MeV for 1 sec observation is sufficient for measuring the faintest known GRB.
- Its energy range (2 KeV to 10 MeV) covers the energy where we expect breaks in the power law distribution of typical GRBs.
- Its timing accuracy (50 μsec) opens a new window for studying fast features in GRBs.

2. The multiple ways of studying GRB with INTEGRAL

INTEGRAL features 4 Co-aligned cameras (JEMX[2], IBIS[3], SPI[4], OMC[5]) that are complementary in their capabilities. The SPI camera is protected by a huge anticoincidence system.

pp. 2701–2704

2.1. GRB in the anti-coincidence systems

The anti-coincidence systems of SPI[6] cover most of the 4π steradian solid angle with a 3000 cm^2 effective area. They are made out of BGO and are sensitive to all photons with energy $>$ 100 KeV. A specific data stream is monitoring the overall rate of the BGO crystals. More then one GRB per day is discovered in this data. Unfortunately, no angular information can be inferred from just this rate. The timing accuracy (50 msec) is sufficient to participate to the IPN[7] network which provides localization of GRBs by triangulation.

2.2. Real time GRB from IBAS

INTEGRAL is the first gamma-ray spacecraft with high precision imaging capabilities and a permanent real time telemetry link. This opens the possibility of providing accurate positions of GRBs in near real time. Imaging in coding mask[8] telescopes is a delicate and very CPU intensive operation. It was decided that detection of GRB bursts and other transient phenomena in the data will be performed on earth. As soon as the data packets arrive at the INTEGRAL Science Data Center(ISDC [9]) a special data stream is built and fed to the INTEGRAL Burst Alert Monitor (IBAS[10]). This system is able to discover transient phenomenon on many different time scales. Transients are confirmed by building images. Once a highly statistically significant image localization is discovered an alert is distributed on the INTERNET. One of the client is the GCN[11] that is redistributing IBAS alerts. If the localization was dubious for any reason (satellite is slewing, data gaps in the transmission, GRB near the border of the FOV...) the data is analysed offline and alerts are issued by hand.
The total time between the arrival of the first GRB photon on the satellite up to the reception of a localization packet to 3 arc minutes accuracy by a subscriber could be as short as a few seconds but this still has to be confirmed by a real event.

3. GRB in IBIS

The IBIS imager has localized one GRB per month since the launch in October 2002. IBIS is a coded mask detector, it provides a fully coded field of view (FCFOV) of 9X9 degrees. The effective area of the detector in the FCFOV amounts to 960 cm^2. Around this FCFOV the effective area of the detector decreases and reaches 0 at 29X29 deg. This region is called the Partial Coded Field of View (PCFOV). The PCFOV covers 8 time as much sky as the FVFOV so most of the GRB occur in this region. A source anywhere in the FOV of IBIS will create 9 images: the true image and 8 “ghosts”. Great care is taken to ensure that there is no ghost confusion since such an error would amount to the wrong localisation by many degrees. The location accuracy of IBIS depends on the signal to noise ratio but for a typical GRB we can reach 30 arcsec. We estimate our systematic error (due to the calibration, alligment and reconstruction program) for the moment at 3 arcminutes, confirmed by independant localistaion of GRBs (XMM, IPN, optical telescopes). The spectral performance of IBIS (10%) is good enough to perform some spectral fitting. In addition, for bright bursts a time evolution of the spectra can be attempted.

3.1. GRB in SPI

SPI is the spectrometer of INTEGRAL, so its use for GRBs will be mostly to study in detail (2 KeV resolution) the energy distribution evolution during the burst. As it's field of view is somewhat larger then IBIS we expect 20% more bursts in SPI then IBIS.

3.2. GRB in JEMX

The two JEMX monitors cover the lower energy range. Their field of view is much smaller (4.8 deg FCFOV) then the IBIS one, missing most of the GRBs. Even so, it is just a matter of time before there will be a GRB in JEMX. In this case, JEMX will contribute to the constraining of the GRB spectra in the 2KeV to 20 KeV range. The location accuracy of JEMX will also complement the ISGRI one.

Unfortunately JEMX is sensitive to solar activity and it will be difficult to tune an automatic alert from this instrument.

3.3. GRB in OMC

The Optical Monitor Camera (OMC) is an unfiltered 5 cm optical camera. Unfortunately OMC is only monitoring a list of predefined location in a very limited FOV. Most of the INTEGRAL GRB are not falling into the FOV of the camera but someday there will be one, IBAS will send to space a reconfiguration command in matter of seconds to insure that the pixels around the GRB are monitored. In this case (we expect one per year) we will have prompt full coverage of all photon wavelengths from optical to MeV with four different instruments.

4. GRB030227

As an example of the possibilites, GRB030227 data is shown as seen by SPI and IBIS(figure 1)

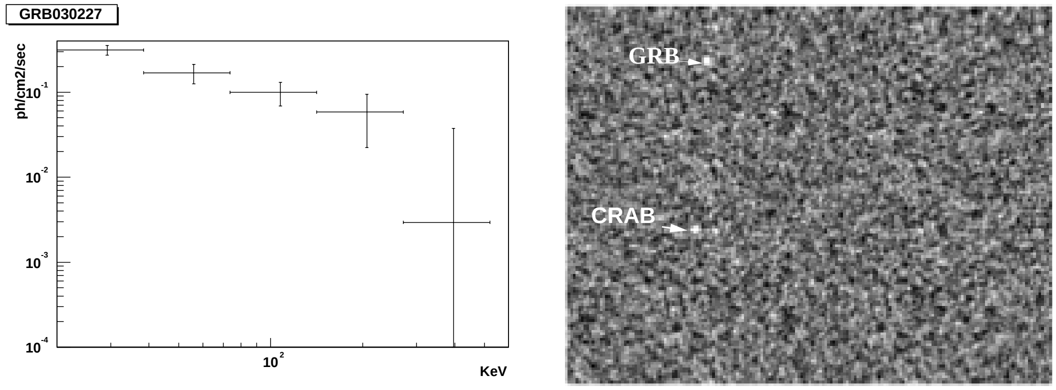

Fig. 1. SPI spectrum and IBIS image of GRB030227

5. Conclusions

INTEGRAL is still a very young mission but is has already demonstrated very good GRB burst capabilities. It already contributed to the timing of about one burst per day and the localization of one burst per month. GRB030227 was discovered by INTEGRAL,its afterglow was followed by many telescopes. We hope INTEGRAL will sustain his rate of one prompt localization per month and we think that many undiscovered GRBs are still concealed in the collected data.

6. References

1. N. Produit these proceedings.
2. Schnopper, H et al, Proceedings of SPIE, 1996, 2806, 297-307.
3. Ubertini, P. et al., 1999, Astrophys. Lett. Comm. 39, 799
4. Jean P., et al. *Proceedings of the fifth Compton Symposium. AIP Conference Proceedings*, Vol. 510, p.708, (2000).
5. Giménez, A. et al, Astrophysical Letters Communications, 1999, 39.
6. Licthi, G. et al in The Fifth Compton Symposium, AIP Conf. Proc. 510, AIP (New York), p 722, 2000
7. Hurley, K., proceedings of the 4th INTEGRAL Workshop, ESA SP Conference Series, 2001
8. E. Caroli, et al. *Space Sci. Rev.*, 45 , 349 (1987).
9. T. Courvoisier, et al. Astro. Lett. and Comm, **39**, 355
10. Mereghetti et al., 1999 Astro. Lett. Comm. **39**, 769
11. http://gcn.gsfc.nasa.gov