PROCEEDINGS OF SCIENCE

INTEGRAL detection and follow-up observations of GRBs 080414 and 080603

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INTEGRAL detected GRB 080414 during an open time observation of the Galactic disk. The long (duration $\sim$10 s) GRB occurred at an off-axis angle of 11.5 degrees with a peak 20-200 keV flux of 1 ph cm^{-2} s^{-1} as reported by [1]. The Watcher robotic telescope started observations of GRB 080414 33 sec post GCN trigger. Initial analysis of the first images shows no new source down to 14 magnitude [2]. The burst location was coincidentally very close (30 arcminutes) to XTE J1810-189, which was active at the time. A common origin has been ruled out.

GRB 080603 was detected by *INTEGRAL* during the Key Programme Observation of the North Ecliptic Pole. The burst occurred at about 3 degrees off-axis with a peak 20-200 keV flux of 0.5 ph cm^{-2} s^{-1} [3] and a fluence over the same energy range of $\sim 10^{-6}$ erg cm^{-2}. The GRB was within the JEM-X field of view and is well detected between 3 and 35 keV, with a lightcurve consisting of 2 main pulses of emission.

Detailed spectral and temporal analyses of the γ-ray emission from both bursts, along with the X-ray characteristics of GRB 080603 and the results of the search for an optical afterglow of GRB 080414 in the Watcher data are presented.

7th INTEGRAL Workshop
September 8-11 2008
Copenhagen, Denmark

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1. Introduction

The *INTEGRAL* Burst Alert System (IBAS, [4]) is an automatic ground-based system for the accurate localisation of GRBs and the rapid distribution of GRB coordinates, providing, on average, 0.8 GRBs per month with an error radius of $\sim$3 arcminutes. Since its launch in October 2002, *INTEGRAL* has detected 52 long-duration GRBs (T_{90} > 2s) and 2 short-duration GRBs (T_{90} < 2s), GRB 070707 [5] and GRB 071017. Many of these are included in the first *INTEGRAL* GRB catalogue [6]. Only 13 of these bursts occurred within the JEM-X Fully Coded Field of View (FCFOV, 5 degrees), allowing simultaneous studies in the X-ray regime.

Watcher is a 40 cm automated telescope located at Bodyen Observatory South Africa [7], designed to detect GRB optical afterglows. It began operating in May 2006 and to date more than 15 GRB afterglows have been rapidly observed, with the detection of prompt optical emission in two cases [8].

2. Observations

2.1 GRB 080414

GRB 080414 was detected by IBAS in IBIS/ISGRI at 22:33:32 UT on 14 April 2008 at a location of R.A.=18h08m32s, Dec=-18°49′45″ [1]. The Watcher telescope responded 2m 50s after the burst trigger, 33 s after receipt of the GCN notice [2]. No optical counterpart down to 14.5 magnitude (3σ) was detected. The *Swift* UVOT and XRT instruments automatically slewed to the burst location 56 ks after the IBAS trigger but no new optical or X-ray source was detected. A limit of 1.9×10^{-13} erg cm^{-2} s^{-1} was determined for the X-ray flux, assuming a power-law spectrum of photon index 2 [9] and an upper limit of 19th magnitude was placed on the optical emission by UVOT. There is a high Galactic column density (N_H=1.21 $\times 10^{22}$ cm^{-2} [10] in the direction of this burst. The burst location was coincidentally very close to XTE J1810-189, which was active at the time (Figure 1). On the short timescale of the burst the transient does not affect the INTEGRAL analysis.

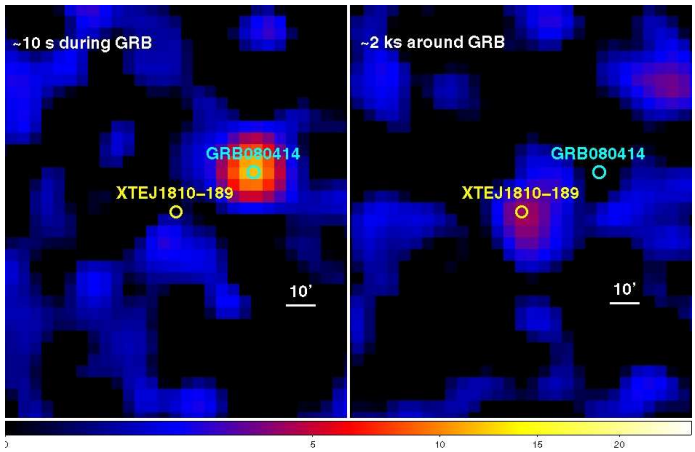

Figure 1: IBIS image of GRB 080414 showing the detection of the active transient XTE J1810-189 in the same field of view but only detectable with a much longer integration time compared to the GRB.

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2.2 GRB 080603

GRB 080603 was detected at 11:18:11 UT on 3 June 2008 by IBAS in IBIS/ISGRI, within 3 degrees of the spacecraft pointing direction, allowing analysis of the burst with the JEM-X detector. The GRB was located at R.A.=18h37m38s, Dec=+62°44′06″ [3] making it too northerly for follow up with Watcher. In this case, an optical and X-ray counterpart was found by *Swift*/XRT-UVOT with an X-ray flux of 3.23 $\times 10^{-12}$ erg cm^{-2} s^{-1} [11] and an optical magnitude of 19.16 [12] and other ground-based telescopes [13], [14]. The optical observations of the afterglow enabled a redshift constraint between z=1.271 and z=1.688 to be determined. A radio counterpart was also detected by the Very Large Array at a frequency of 8.46 GHz and a flux density level of 116 μJy two days after the burst trigger from *INTEGRAL* [15].

3. Results

All data sets were processed using the Off-line Science Analysis software, *OSA 7.0*. Background was subtracted in all cases. IBIS lightcurves for both GRBs are shown in the 20-200 keV energy range (Figure 2). The IBIS spectra of the GRBs were extracted in the 20-200 keV energy range and four different models were fit to the data in both cases: power-law (PL), Band model (GRBM), Black body + PL (BB+PL) and cutoff power-law (CPL).

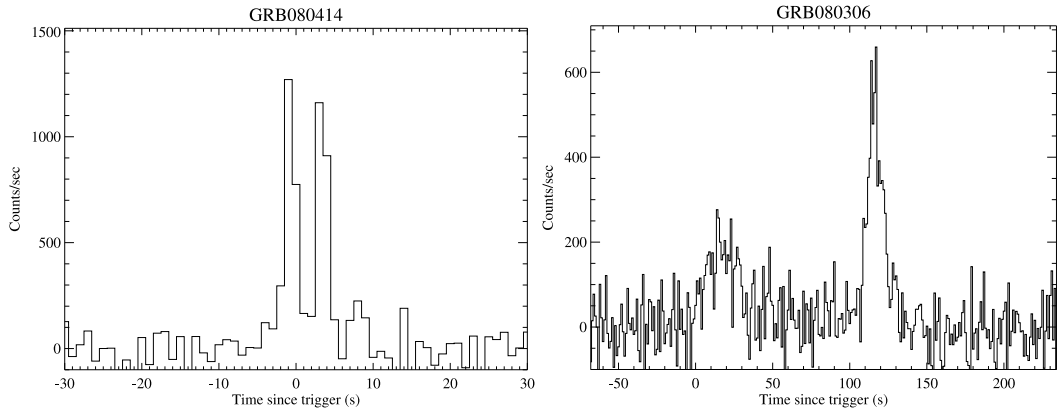

Figure 2: IBIS lightcurves of GRB 080414 (left) and GRB 080603 (right) in the 20-200 keV energy range in 1 s intervals.

GRB 080414 was detected as a 9.5σ source in the IBIS field of view. The lightcurve (Figure 2) shows two pulses separated by 2 seconds. A T_{90} of approximately 8 seconds was determined. The results of the IBIS spectral analysis in the 20-200 keV energy range are shown in Table 1. The PL model fit is shown in Figure 3. All models provide a good fit to the data, with similar reduced χ^2 values.

GRB 080603 was detected as a 10σ source in the IBIS field of view. The lightcurve (Figure 2) consists of an initial weak pulse followed $\sim$70 seconds later by a second more intense peak. The T_{90} of the burst is $\sim$150 seconds. The PL model fit of the IBIS spectrum is shown in Figure 3. The JEM-X spectrum was analysed in the 3-35 keV energy band (Figure 4). Part of the observation was made in slew mode and has not yet been analysed. Therefore, the spectrum presented corresponds only to the first peak of the burst. The JEM-X spectrum was also fit using the four models mentioned

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above adding an absorption model with a frozen N_H=1.2 $\times 10^{22}$ cm^{-2}. Results are presented in Table 1.

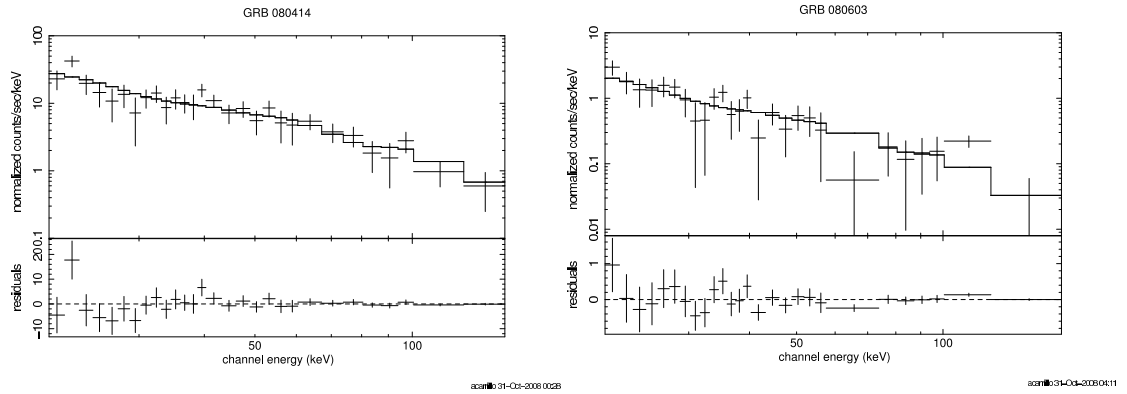

Figure 3: IBIS spectra of GRB 080414 (left) and GRB 080603 (right) both fit by the power-law model in the 20-200 keV energy range.

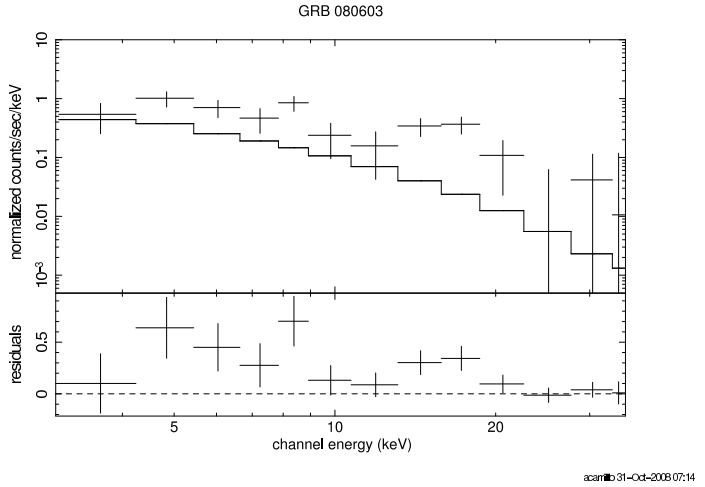

Figure 4: JEM-X spectrum of the first peak of GRB 080603 in the 3-35 keV energy range fit by a power-law model.

4. Conclusions

GRBs 080414 and 080603 are two long duration, double peaked, *gamma*–ray bursts observed by *INTEGRAL* with fluences (20-200 keV) for the T_{90} durations of $\sim$0.5-0.7 $\times 10^{-6}$ erg cm^{-2} respectively. Four different models were used for spectral fitting of the data. No significant differences between the models can be seen in the goodness of the fits. The photon index for each burst can be considered by the PL model as -1.64 and -1.72 respectively. These values fall into the common photon index values presented in the first *INTEGRAL* GRB catalogue [6].

The second pulse of GRB 080603 occurred during a spacecraft slew and the JEM-X spectral data have yet to be extracted for that pulse. Combined broadband SPI, IBIS and JEM-X spectral analysis of the first pulse and SPI and IBIS of the whole burst will be carried out. Broadband spectral fitting of GRB 080603 will allow a more thorough investigation of the nature of the possible blackbody component in this GRB's spectrum.

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Table 1: Spectral fit parameters for GRB 080414 and GRB 080603. All fluences are in the range 20-200 keV for the T_{90} of the burst (except for the JEM-X results where only the first pulse of the burst has been analyzed). α is the power law photon index below the break, β is the power law photon index above the break, E_0 is the characteristic energy in keV and kT the temperature in keV. E_{peak} is the energy of break, determined from $E_{peak}=E_0(2-\alpha)$ for the GRBM model when $\alpha<2.0$ and $\beta>2.0$. The peak flux was obtained using 1 s integration time.

GRB	Detector	Model	α	β	E_0/kT keV	E_{peak} keV	Red. χ^2 /dof	Peak Flux ph cm^{-2} s^{-1}	Fluence 10^{-6}erg cm^{-2}
		PL	-1.64	...	...	...	0.78/27	1.23	0.51
		GRBM	-1.00	-8.73	82	82	0.79/25	1.23	0.46
080414	IBIS	BB+PL	-1.65	...	3	...	0.78/25	1.25	0.47
		CPL	-1.06	...	...	90	0.76/26	1.15	0.46
		PL	-1.72	...	...	...	1.12/25	0.43	0.64
		GRBM	-1.72	-8.79	95	27	1.22/23	0.45	0.64
080603	IBIS	BB+PL	-0.55	...	6	...	1.01/23	0.49	0.82
		CPL	-1.51	...	...	199	1.24/24	0.47	0.59
		PL	-2.49	...	...	...	1.14/13	...	0.02
		GRBM	-1.90	-2.72	14	1	1.16/14	...	0.02
080603	JEM-X	BB+PL	-0.80	...	1	...	1.20/15	...	0.02
		CPL	-2.31	...	...	1	1.14/15	...	0.02

GRB time profiles have the tendency for emission in a high-energy band to lead the arrival of photons in a low-energy band ([16], [17]).The energy-dependent lag allows the temporal and spectral properties of GRB prompt γ-ray emission to be combined in a single measurement. Spectral evolution and spectral lag behaviour of these bursts will also be examined in detail in future work.

References

[1] Mereghetti et al. 2008, GCN 7618

[2] Kubanek and French et al. 2008, GCN 7619

[3] Paizis et al. 2008 , GCN 7790

[4] Mereghetti et al. 2003, A&A, 411, L311

[5] McGlynn et al. 2008, A&A, V. 486, I. 2, pp.405-410

[6] Foley et al. 2008, A&A, V. 484, I. 1, pp.143-157

[7] French et al. 2004, AIP, p.741-744

[8] French et al. 2008 PhD thesis, Univerity College Dublin

[9] De Pasquale et al. 2008, GCN 7628

[10] Dickey & Lockman 1990, ARAA 28, 215

[11] Sbarufatti et al. 2008, GCN 7810

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[12] Kuin et al. 2008, GCN 7804

[13] Rujopakarn et al. 2008, GCN 7792

[14] Perley et al. 2008, GCN 7791, 7870

[15] Chandra et al. 2008, GCN 7843

[16] Cheng et al. 1995, A&A, 300, 746

[17] McBreen et al. 2006, A&, 455, 433

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