BRIGHT OPTICAL FLASH FROM GRB 060117 - AN EXAMPLE OF EVENT DETECTED WITH OMC CLASS INSTRUMENT

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ABSTRACT

We present observations of a very bright (magnitude 10) optical transient associated with GRB 060117. These observations were obtained with an *OMC*–class ground based device – wide–field CCD camera atop the FRAM robotic telescope, operated by the Pierre Auger collaboration at Los Leones site, Malargüe, Argentina. The detected optical counterpart of GRB is presented and discussed, together with consequences for probability of detection of analogous event by *INTEGRAL OMC*.

Key words: gamma ray bursts; robotics telescopes; INTEGRAL.

1. THE INSTRUMENT

The FRAM telescope is a part of the Pierre Auger cosmic-ray observatory [9]. Its main purpose is an immediate monitoring of the atmospheric transmission. FRAM works as an independent, RTS2 driven [5], fully robotic system. It performs a photometric calibration of the sky on various UV to optical wavelengths using a 0.2 m telescope and a photoelectric photomultiplier. As a primary objective FRAM observes a set of chosen standard stars and a terrestrial light source. From these observations are calculated instant extinction coefficients and the wavelength dependence of extinction. As an additional activity FRAM is able to follow GCN alerts, using its wide-field camera with a fixed *R*-band filter.

The wide-field camera consists of a Carl Zeiss Sonnar 200 mm $f/2.8$ telephoto lens, SBIG ST7 imager and Bessel R-band filter. The ST7 camera has a 768×512 Kodak KAF-0402E CCD which covers a field of view (FOV) of $120' \times 80'$ with a scale of $9.6''$/pixel. The effective diameter of the lens is 71 mm and the 3σ limiting magnitude under optimum conditions reaches $R \sim 15.0$ for 120 s exposure.

The optical Monitoring Camera, located on board *INTEGRAL* satellite, has similar parameters as FRAM wide-field camera - it is 50 mm lens system, with 1024×1024 CCD, which is capable to reach 15 mag in 100 sec exposure.

Similar to FRAM's capabilities, the *OMC* is able to work in fast follow-up mode. When a GRB is detected at the *INTEGRAL Science Data Center (ISDC)* by the *INTEGRAL Burst Alert System (IBAS)*[7] and its coordinates lie inside the *OMC* FOV, *IBAS* commands *OMC* to start taking exposures centred on the interesting region. Those frames are then downlinked to ground stations and stored at *ISDC* for future processing.

So far, the fast follow-up mode was activated only once in now almost three years long *INTEGRAL* mission, for GRB 050626. Unfortunately, the location of GRB was very close to bright star, which saturated obtained frames.

2. GRB 060117

A bright long-soft GRB 060117 was detected by *Swift* satellite on January 17, 2006, at 6:50:01.6 UT.

Coordinates computed by *Swift* were available within 19 s and immediately distributed by GCN. *Swift* itself could not observe the GRB with its X-ray and optical instruments, because of the Sun observing constraint [2]. It was the most intense (in terms of peak flux) GRB ever detected by *SwiftBAT*[1], and had one of the few brightest optical transients ever observed. It was GRB with brightest peak flux detected by *BAT*, with one of the brightest optical transient.

FRAM started to observe the GRB location 128s after the burst. It detected a rapidly decaying transient, which had the R-band magnitude 10.2 at the first image. The decay is studied in detail in [4]. as a combination of reverse and forward shock. For the lightcurve plot see figure 1.

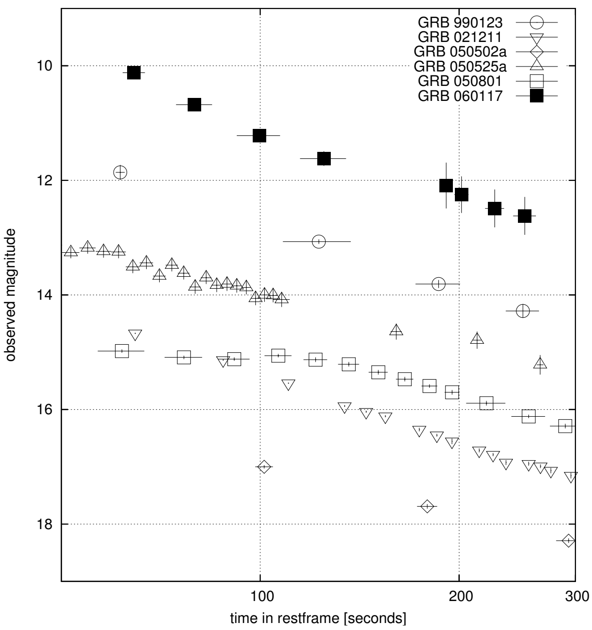

Figure 1. Light curves of bright optical transients of GRBs Observed R magnitude are shown, except for GRB 050525a, where the V-band values are plotted.

3. PROBABILITY OF DETECTION OF SIMILAR EVENT BY *OMC* IN GRB FOLLOWUP MODE

GRB optical brightness depends on various factors such as GRB distance, released energy, GRB environment and absorptions systems between GRB and the observer. The true observed GRB rate depends on instrumentation and detection thresholds.

INTEGRAL was designed to resolve faint point sources in the γ-ray background and to provide additional information about their properties. *INTEGRAL* GRBs are detected during γ-ray observations of knows sources. *Swift* is a satellite designed primary for GRBs observations. The *INTEGRAL ISGRI*[12] detector has a (half-coded) FOV 12 times smaller then *BAT*. *ISGRI* is the primary source of events that trigger *OMC* fast follow-up mode.

Precisely localised GRBs are usually used for fast follow-up observations. *INTEGRAL* detects on average 12 GRBs per year with few arc minutes localisation. *Swift* detects about 100 GRBs good localised GRBs per year. That is in good agreement with the smaller *INTEGRAL* FOV weighted by higher sensitivity. *INTEGRAL* GRBs detections are biased towards the Galactic core and the Galactic plane, as those are the areas of the sky where *INTEGRAL* spends most of its observing time. Due to this observational strategy, roughly 3 out of 4 of the *INTEGRAL* GRBs will lie in areas of the sky with high Galactic extinction and hence there is a low chance to see bright optical counterpart.

As can be deduced from figure 1, in the last 7 years there were only two GRBs which had an observed brightness above 11th magnitude. Given the understanding of the GRB optical transients nowadays ([8], [6]), we may estimate that the GRB 030329 optical counterpart, for which first images were obtained 75 minutes after the trigger and showed 12.0m source [11], could have reached above 11th magnitude at the time comparable with observation of GRB060117. However, in order to avoid confusion with different models, we will investigate only **observed** peak brightness, e.g. brightness measured on acquired frames.

Observed magnitude	Number of GRBs	Sum	
9	1	1	0.45%
11	1	2	0.90%
13	1	3	1.35%
14	2	5	1.96%
15	6	11	4.95%
16	8	19	8.55%
17	10	29	13.06%
18	10	39	17.57%
18+	183	222	100.00%

Table 1. Distribution of peak brightness of GRBs followed within 0.1 day.

We searched GRBlog[10] for the peak optical observed brightness of GRBs which were followed less than 0.1 day after trigger. The results binned by 1 magnitude are presented in table 1.

Out of 222 GRBs, 19 had have observed counterparts brighter than 16 magnitude. If we take 16 as a conservative magnitude limit for prompt GRB detection by the *OMC*, then 8% of GRBs have a counterpart detectable by the *OMC*. *IBAS* detects roughly 10 times fewer GRBs than *Swift*, at an average rate of one GRB per month. Out of 12 GRBs detected by *ISGRI* per year we can expect one to have optical counterpart brighter than 16th magnitude. If we take *ISGRI* half-response FOV (19°x19°), the area is more than 14 times bigger than the *OMC* FOV (5°x5°). Based on that numbers, we can conclude that the expected number of GRBs detected by *OMC* is less then one in 10 years.

Those numbers are only a very rough estimate. There are a lot of unknowns in them - not all GRBs have observations during first few tens of seconds after trigger, which the *OMC* can provide. If the counterpart brightness decays with a power law, the *OMC* can observe a GRB during a phase when it could be brighter than the above data suggests. Different filters were used in observations of sample GRBs and magnitudes were not corrected for Galactic extinction, which lowers the probability of detecting bright counterpart by *INTEGRAL*.

4. CONCLUSION

Based on the presented data, we concluded that the probability of detecting GRB optical counterpart by the *OMC* is very low, but worth trying. All the above is only calculation of probability - with our FRAM WF camera, we obtained two GRBs detections - GRB 060117[4] and GRB 060418[3], after less than one year of observation, which is well above the rate we expect.

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