Mem. S.A.It. Vol. 80, 231

Memorie della

TORTORA observations of GRB 080319B

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Abstract. We present results of TORTORA wide-field camera optical observations of GRB 080319B, performed before, during and after the gamma event with high time resolution.

Key words. Gamma rays: bursts – Telescopes – Techniques: photometry

To study optical properties of cosmic gamma-ray bursts it is necessary to monitor wide fields of the sky with high time resolution (Piccioni et al. 1993). However, the monitoring systems which operated in the past and those still operating, like ROTSE (Marshall et al. 1997), RAPTOR (Borozdin et al. 2002) and *Pi of the Sky* (Burd et al. 2005), cannot resolve the temporal structure of prompt optical emission down to timescales shorter than 5-10 s. To solve this problem, the design of wide-field optical camera with high time resolution was developed. Its prototype, FAVOR (Fast Variability Optical Registrator, Zolotukhin et al. 2004), is placed at North Caucasus near Russian 6-m telescope and since 2003 has been performing systematic monitoring of the sky. A second version of the equipment, TORTORA (Telescopio Ottimizzato per la Ricerca dei Transienti Ottici RApidi), is mounted on top of REM robotic telescope at La-Silla (Chile) and has been operating since May 2006 (Molinari et al. 2006). It is able to autonomously detect and classify optical transients as bright as $10\text{-}11^{m}$ on a sub-second (0.13 sec) timescale in a 30×24 degrees field. TORTORA camera began observing the field of GRB 080319B (Racusin et al. 2008), the naked-eye burst, half an hour before the trigger, recording the images with 7.5 Hz frame rate. The burst flashed near the edge of TORTORA field of view, 24 seconds later REM started 7 seconds long automatic repointing and since then the burst position remained in the center of the camera field of view. The sequence in Fig. 1 shows the sample 2.5×2.5 degrees images centered at burst position at different phases. Although the sensitivity of *Pi of the Sky* and RAPTOR was better, the high temporal resolution of TORTORA allowed an unprecedented level of details in catching the temporal structure of the optical emission (see Fig. 2 for summary light curves of TORTORA, *Pi of the Sky* and Swift-BAT). The images were processed by a pipeline including TV-CCD noise subtraction, flat-fielding to compensate vignetting due to

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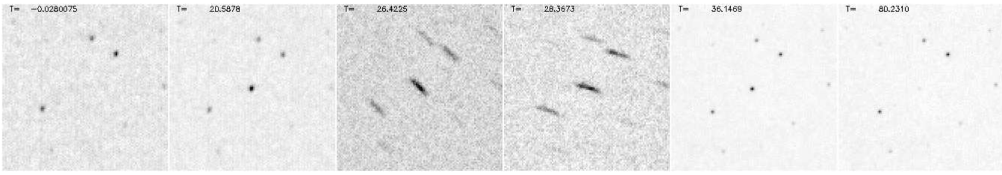

Fig. 1. Sample images (10-frames averaged) of GRB080319B as seen by TORTORA. The trigger ($T = 0$ sec), first peak ($T = 20.5$ sec), two repointing ($T = 26.4$ sec and $T = 28.4$ sec), last peak ($T = 36$ sec) and early afterglow tail ($T = 80$ sec) moments are shown. Image size is 2.5×2.5 degrees.

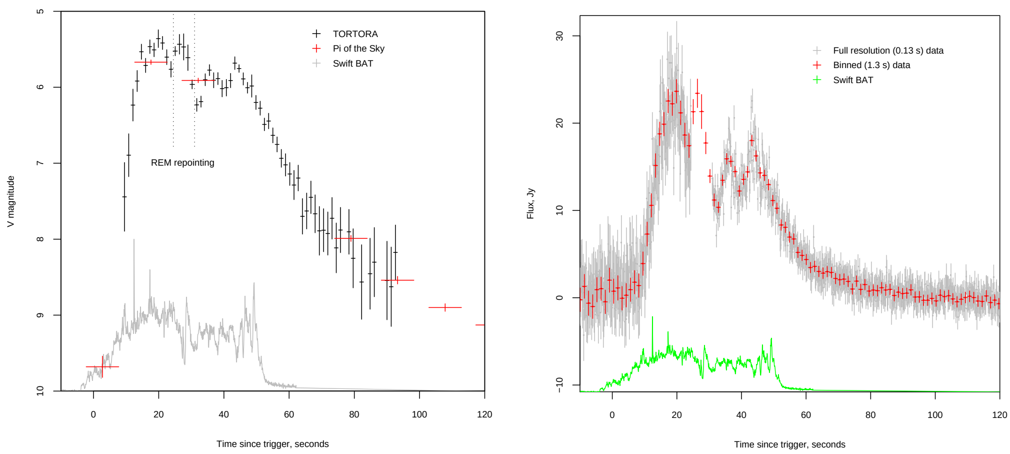

Fig. 2. Left: light curves of GRB080319B acquired by TORTORA (with 1.3 sec effective exposure), *Pi of the Sky* (10 sec exposure) and Swift BAT. Right: Full-resolution (0.13 sec exposure) light curve acquired by TORTORA.

objective design, and custom aperture photometry code taking into account non-poissonian and non-ergodic pixel statistics caused by image intensifier. For the REM repointing time interval fluxes have been derived using custom elliptic aperture photometry code after summation of 10 consecutive frames with compensated motion of the stars. The magnitude of the afterglow was calibrated to Johnson V-band using several nearby stars. TORTORA was able to detect optical emission since approximately T+10s. Then, it tracked fast $\sim t^4$ power-law emission rise from $V \approx 7.5^{\rm m}$ to $V \approx 5.5^{\rm m}$ from T+10s to T+15s, four nearly periodic peaks separated by $\sim$ 7-9 sec, and $\sim t^{-4.6}$ power-law decay since T+45s, clearly visible at least until T+100s.

Acknowledgements. TORTORA Team (A.G., C.B., G.B., S.B., G.G., S.K., A.P.) acknolewdges Università di Bologna (Funds Progetti Pluriennali) which supported the realization of TORTORA Camera and the carrying out of TORTORA Project, and Osservatorio Astronomico di Brera and the REM Team for the kind and essential collaboration.

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