GRB 060117: reverse + forward shock solution

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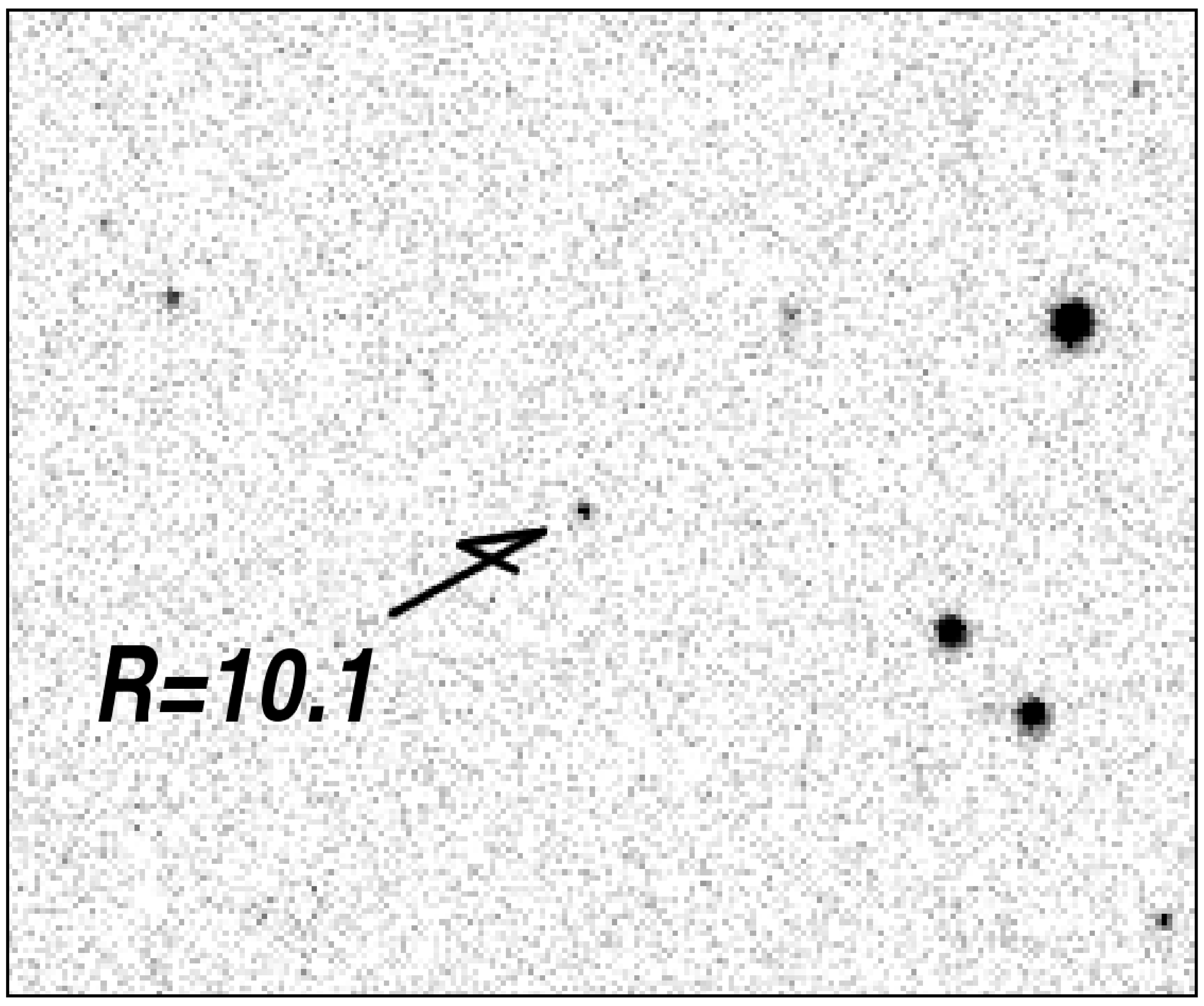
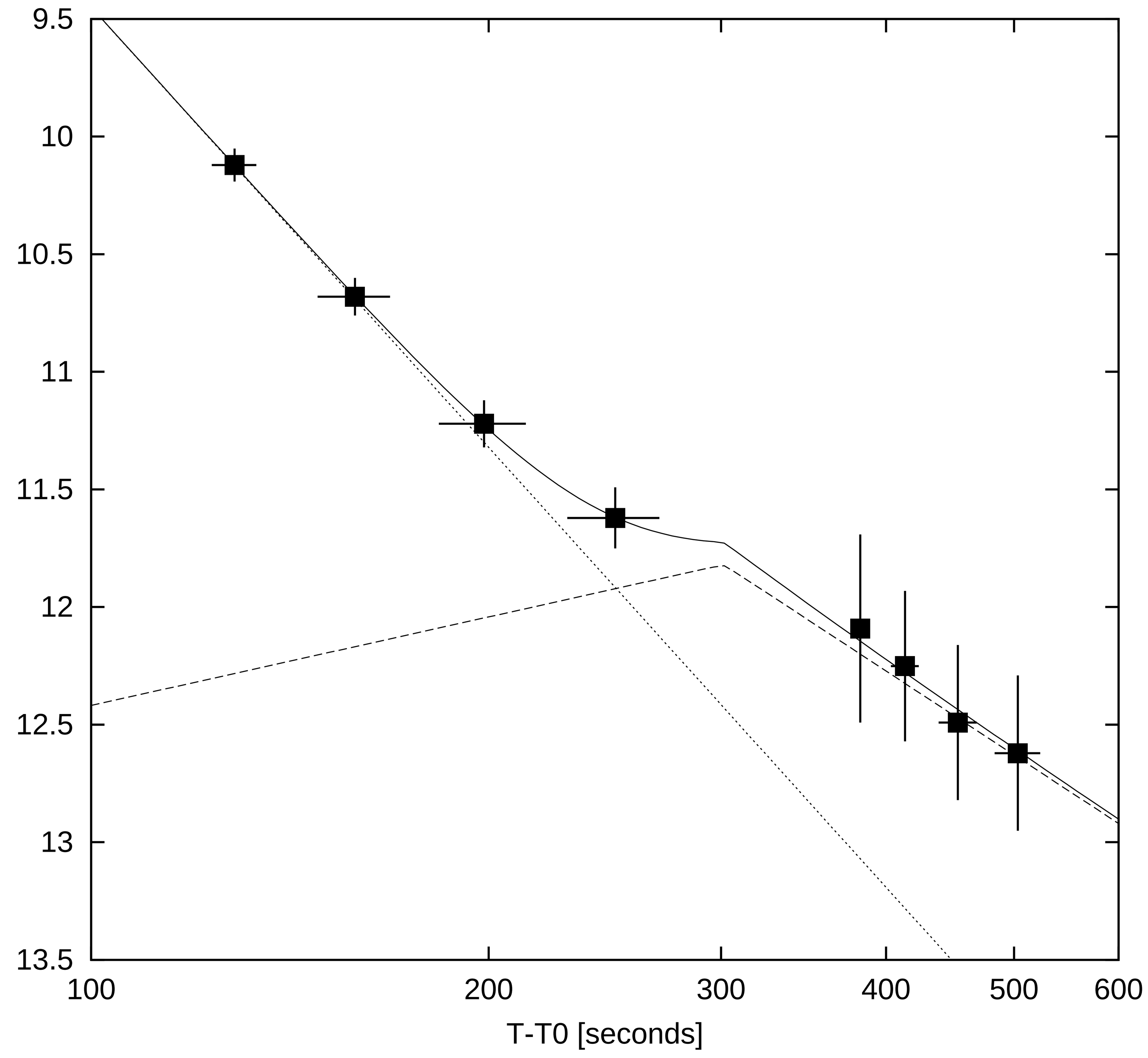
Pierre Auger Observatory is a cosmic-ray detecting facility built and operated by Auger Collaboration near Malargue in Argentina. The observatory consists of two cooperating, but observationally independent detectors: Surface detectors (SD) are water Čerenkov tanks with photomultipliers covering in a regular grid an area of ∼3000 km^2; Fluorescence detectors (FD) is a system of 24 segmented 3.6 m telescopes observing fluorescence in the atmosphere above the SDs. The image is taken from the comunication tower shows an one of four FD Los Leones (containing 6 telescopes), where FRAM is located (small white square in the corner).

We present a discovery and observation of an extraordinarily bright prompt optical emission of the GRB 060117 obtained by a wide-field camera atop the robotic telescope FRAM of the Pierre Auger Observatory from 2 to 10 minutes after the GRB. We found rapid average temporal flux decay of $\alpha = -1.7 \pm 0.1$ and a peak brightness $R = 10.1$ mag. Later observations by other instruments set a strong limit on the optical and radio transient fluxes, unveiling an unexpectedly rapid further decay. We present an interpretation featuring a relatively steep electron-distribution parameter $p \simeq 3.0$ and providing a straightforward solution for the overall fast decay of this optical transient as a transition between reverse and forward shock.

With the maximum brightness of $R = 10.1$ mag, FRAM has discovered one of the optically brightest prompt optical emissions ever detected. The initial optical decay was found to be one of the steepest of an early GRB optical afterglow observed.

FRAM is part of the Pierre Auger cosmic-ray observatory (Pierre Auger Collaboration 2005), and its main purpose is to immediately monitor the atmospheric transmission. FRAM works as an independent, RTS2-driven (Kubánek et al. 2004), fully robotic system, and 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 to obtain extinction coefficients. Additionally, FRAM is able to follow GCN alerts, using its wide-field camera with a fixed *R*-band filter.





References

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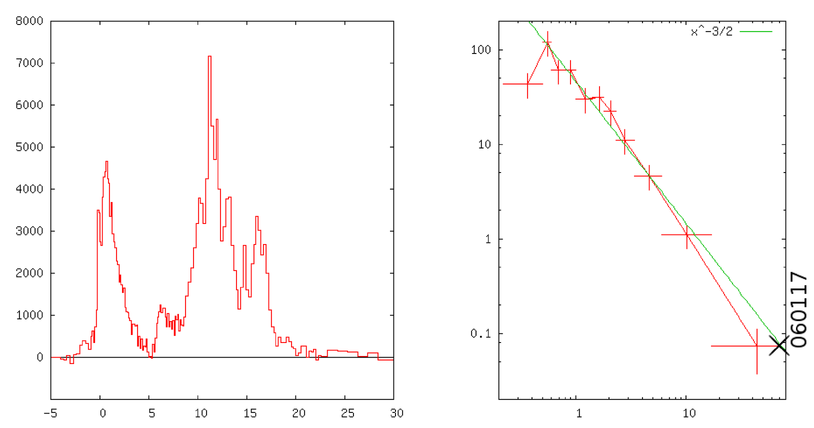
Project home page: http://www.auger.org/
http://www-hep2.fzu.cz/Auger/fram.html

We interpret the data (after Shao & Dai 2005) as a Type I lightcurve (as given by Zhang et al. 2003), which depicts a transition between the reverse and the forward shock with the passage of the typical frequency break ν_m through the observed passband at time $t_{m,f}$. We assume the lightcurve is initially dominated by a rapidly falling reverse-shock emission with $F_{\nu,r} \sim t_d^{-(27p+7)/35}$, followed by a forward-shock emission that rises as $F_{\nu,r} \sim t_d^{+1/2}$ before $t_{m,f}$ and then decays with $F_{\nu,f} \sim t_d^{-(3p-3)/4}$. Using a χ^2 minimization fit to this scenario, we obtain $p = 2.96 \pm 0.06$, a magnitude of forward shock maxima $m_{m,f} = 11.82 \pm 0.04$, a time of the maxima $t_{m,f} = 301 \pm 4$ s (after trigger), and a magnitude of the reverse shock at $t = t_{m,f}$ $m_{m,r} = 12.43 \pm 0.05$ ($\chi^2/d.o.f.$ for this fit is 0.015). Corresponding decay indices are α_{R}=2.49±0.05 and α_{F}=1.47±0.03 (see Fig 3). If the crossing time $t_\times$ (Zhang et al. 2003) coincides with the end of the GRB (i.e. ~ 20 s), then we can estimate the peak magnitude of this OT as $R \sim 5$ mag by backward extrapolation.

Swift detection: GRB 060117 was, in terms of peak flux, the most intense GRB detected so far by Swift. The following graphics shows the distribution of Swift-detected GRB peak-fluxes (right). Also it shows this GRBs gamma-ray lightcurve.



More information Jelinek et al. 2006, A&A in press (astro-ph/0606004)

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