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GRB 061121: The Brightest Swift Burst So Far.

Broad-band spectral evolution through the prompt and afterglow phases.

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Swift triggered on a precursor to the main burst of GRB 061121, leading to observations of the prompt emission from optical to gamma-rays, all of which showed a peak around 75 seconds after the trigger. Konus-Wind also detected the main event. Spectral evolution was seen throughout the burst, with the Spectral Energy Distribution (SED) hardening at later times. The isotropic energy is estimated to be 2.8×10^{53} erg over 1 keV – 10 MeV. A probable jet break is seen at ~2.5 days; this GRB satisfies the Ghirlanda relationship linking the afterglow jet angle to the prompt spectral energy peak. Before this break, the hardening optical and X-ray behaviour is inconsistent with standard GRB afterglow models.

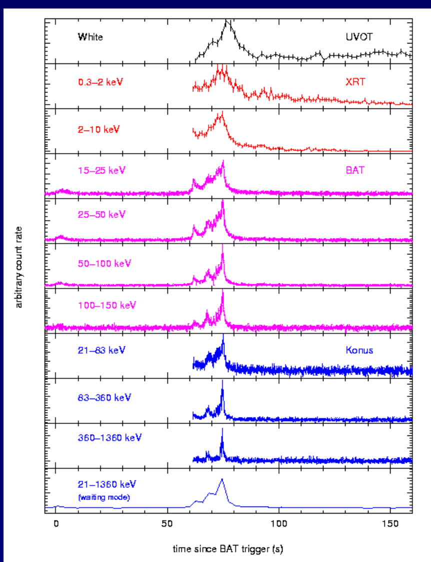


Fig 1. Swift and Konus-Wind light-curves, showing the prompt emission of GRB 061121.

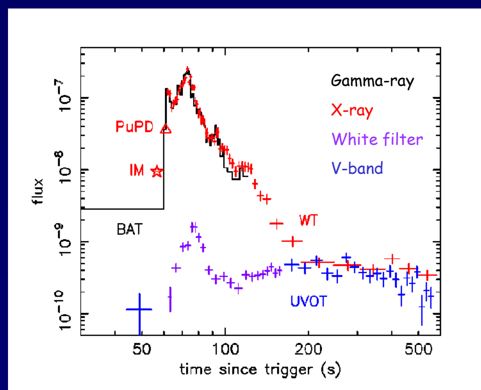


Fig 2. Swift flux light-curves, with the BAT data extrapolated into the XRT band. The UVOT flux-density data have been scaled to the XRT "plateau" flux.

GRB 061121 has the best broad-band coverage of the prompt emission obtained to date (Figs. 1 & 2) and reached the highest instantaneous peak flux of all long BAT bursts so far.

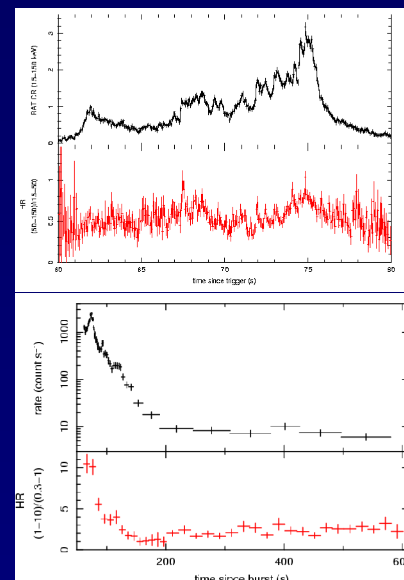
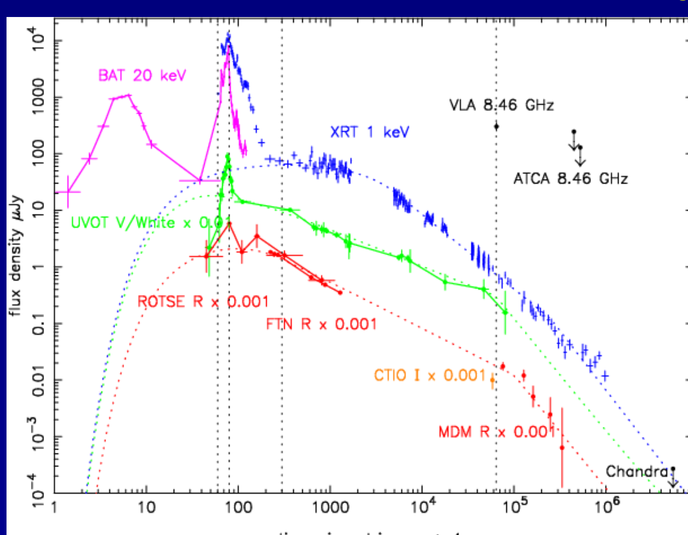


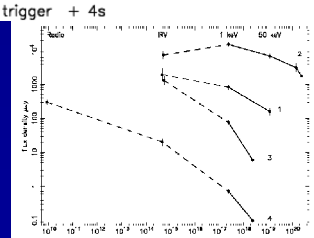
Fig 3. Spectral evolution seen by the BAT (top) and XRT (bottom) during the main emission (and start of the afterglow in X-rays). The gamma-ray data are found to be harder when brighter (pre-cursor and main emission).

As shown in Fig. 5, the optical-to-X-ray spectra are best fitted with a broken power-law. The curved dotted lines in Fig. 4 show that the afterglow component starts early on – before, or during, the main pulse of the burst.

At the time of the main emission, the SED peaks between the optical and X-ray bands, and is harder than the standard synchrotron model predicts. The afterglow closure relations do not fit the data well, with the X-ray and V-band decays being slower than expected.

About 200 ks after the trigger, a possible jet-break is seen, implying $E_\gamma \sim 10^{51}$ erg. Before this break, the optical and X-ray data appear to harden over time (V decays more slowly than R: $\alpha_V \sim 0.66$; $\alpha_R \sim 0.84$. Γ_X flattens from ~ 2.1 to 1.9). This could be due to Synchrotron Self Comptonisation, though this would require densities of 5×10^3 to 10^5 particles cm^{-3}, similar to a molecular cloud.





Figs 4&5. Flux density light-curve, showing gamma-ray, X-ray, optical and radio data. Curved dotted lines are exponential-to-power-law models (O'Brien et al., 2006, ApJ, 647, 1213); vertical ones show the times of the SEDs (right panel). An achromatic (probable jet) break is seen around 2×10^5 s.

Conclusions

Swift triggered on a precursor to GRB 061121, leading to the most detailed broad-band observations of the prompt emission so far.

- The SED of the peak of the prompt emission peaks around 1 keV and is harder than standard models predict.
- The afterglow component starts early on – possibly before the main pulse.
- There is a probable jet break at $\sim2\times10^5$ s.
- The broad-band SEDs reveal gradual and unexpected hardening as the afterglow evolves.
- The standard afterglow models (1 or 2 jets) cannot readily explain the data before the jet break. Late prompt emission (i.e. continuing central engine activity at a lower power level; e.g. Ghisellini et al., 2007, ApJ, 658, L75) could help to explain the plateau seen only in X-rays.

More details in Page et al. (2007), ApJ, in press (arXiv:0704.1609).