

# Swift Observations of GRB 121209A

A. Maselli, V. Mangano (INAF-IASFPA), T. N. Ukwatta (MSU), S. Immler (NASA/CRESST/GSFC), S. D. Barthelmy (GSFC), D. N. Burrows (PSU), M.H. Siegel (PSU) and N. Gehrels (NASA/GSFC) for the Swift team

## 1. Introduction

Maselli *et al.* (GCN Circ. 14045) reported the initial Swift results. At 21:59:11 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 121209A (trigger=540964). Swift slewed immediately to the burst. **Table 1** contains the best reported positions from Swift. The latest XRT position can be viewed at [http://www.swift.ac.uk/xrt\\_positions](http://www.swift.ac.uk/xrt_positions).

A faint source has been detected within the UVOT-enhanced XRT position (Goad *et al.*, GCN Circ. 14051) in the i' filter by GROND at la Silla observatory (Kruehler *et al.*, GCN Circ. 14049) roughly 2.4 hr after the trigger with magnitude  $i' = 23.6 \pm 0.4$  mag. At the same position Perley *et al.* (GCN Circ. 14056) report the detection at Keck observatory, 1.36 day after the burst, of a source in the I filter with magnitude  $I = 23.2 \pm 0.2$  mag. This suggests that this source may not be the optical afterglow of this GRB. **Table 2** is a summary of GCN Circulars about this GRB from observatories other than Swift.

Standard analysis products for this burst are available at [http://gcn.gsfc.nasa.gov/swift\\_gnd\\_ana.html](http://gcn.gsfc.nasa.gov/swift_gnd_ana.html).

## 2. BAT Observations and Analysis

Analysis of the BAT data was reported by Ukwatta *et al.* (GCN Circ. 14052). The BAT ground-calculated position is RA, Dec = 326.800, -8.232 deg, which is RA(J2000) = 21h 47m 12.0s Dec(J2000) = -08d 13' 55.8" with an uncertainty of 1.7 arcmin, (radius, sys+stat, 90% containment). The partial coding was 60%.

The mask-weighted light curve (**Figure 1**) shows multiple peaks starting at  $\sim T-5$  s, max peak at  $\sim T+28$  s, and ending at  $\sim T+80$  s.  $T_{90}(15-350 \text{ keV})$  is  $42.7 \pm 2.0$  s (estimated error including systematics).

The time-averaged spectrum from T-2.16 to T+44.28 s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $1.43 \pm 0.08$ . The fluence in the 15-150 keV band is  $2.9 \pm 0.1 \times 10^{-6} \text{ erg cm}^{-2}$ . The 1-s peak photon flux measured from T+27.91 s in the 15-150 keV band is  $3.4 \pm 0.3 \text{ ph cm}^{-2} \text{ s}^{-1}$ . All the quoted errors are at the 90% confidence level.

The results of the batgrbproduct analysis are available at [http://gcn.gsfc.nasa.gov/notices\\_s/540964/BA/](http://gcn.gsfc.nasa.gov/notices_s/540964/BA/).

## 3. XRT Observations and Analysis

Analysis of the XRT data was reported by Stroth *et al.* (GCN Circ. 14053). We have analysed 23.1 ks of XRT data for GRB 121209A, from 95 s to 63 ks after the BAT trigger. The data comprise 15 s in Windowed Timing (WT) mode (the first 9 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode.

The late-time light curve (**Figure 2**) (from T0+5.2 ks) can be modelled with a power-law decay with a decay index of  $\alpha = 1.21 \pm 0.05$ .

A spectrum formed from the PC mode data can be fitted with an absorbed power-law with a photon spectral index of  $2.30 \pm 0.14$ . The best-fitting absorption column is  $4.9 \pm 0.6 \times 10^{21} \text{ cm}^{-2}$ , in excess of the Galactic value of  $3.8 \times 10^{20} \text{ cm}^{-2}$  (Kalberla *et al.* 2005). The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is  $4.0 \times 10^{-11}$  ( $9.0 \times 10^{-11}$ )  $\text{erg cm}^{-2} \text{ count}^{-1}$ .

The results of the XRT team automatic analysis are available at [http://www.swift.ac.uk/xrt\\_products/00540964](http://www.swift.ac.uk/xrt_products/00540964).

#### 4. UVOT Observations and Analysis

Analysis of the UVOT data was reported by Immler and Maselli (GCN Circ. 14086). The Swift/UVOT began settled observations of the field of GRB 121209A 96 s after the BAT trigger. No optical afterglow consistent with the optical position (Kruehler et al. GCN Circ. 14049) is detected in the initial UVOT exposures. **Table 3** gives preliminary magnitudes using the UVOT photometric system (Breeveld *et al.* 2011, AIP Conf. Proc., 1358, 373). No correction has been made for the expected extinction in the Milky Way corresponding to a reddening of  $E_{B-V}$  of 0.05 mag. in the direction of the GRB (Schlegel *et al.* 1998).

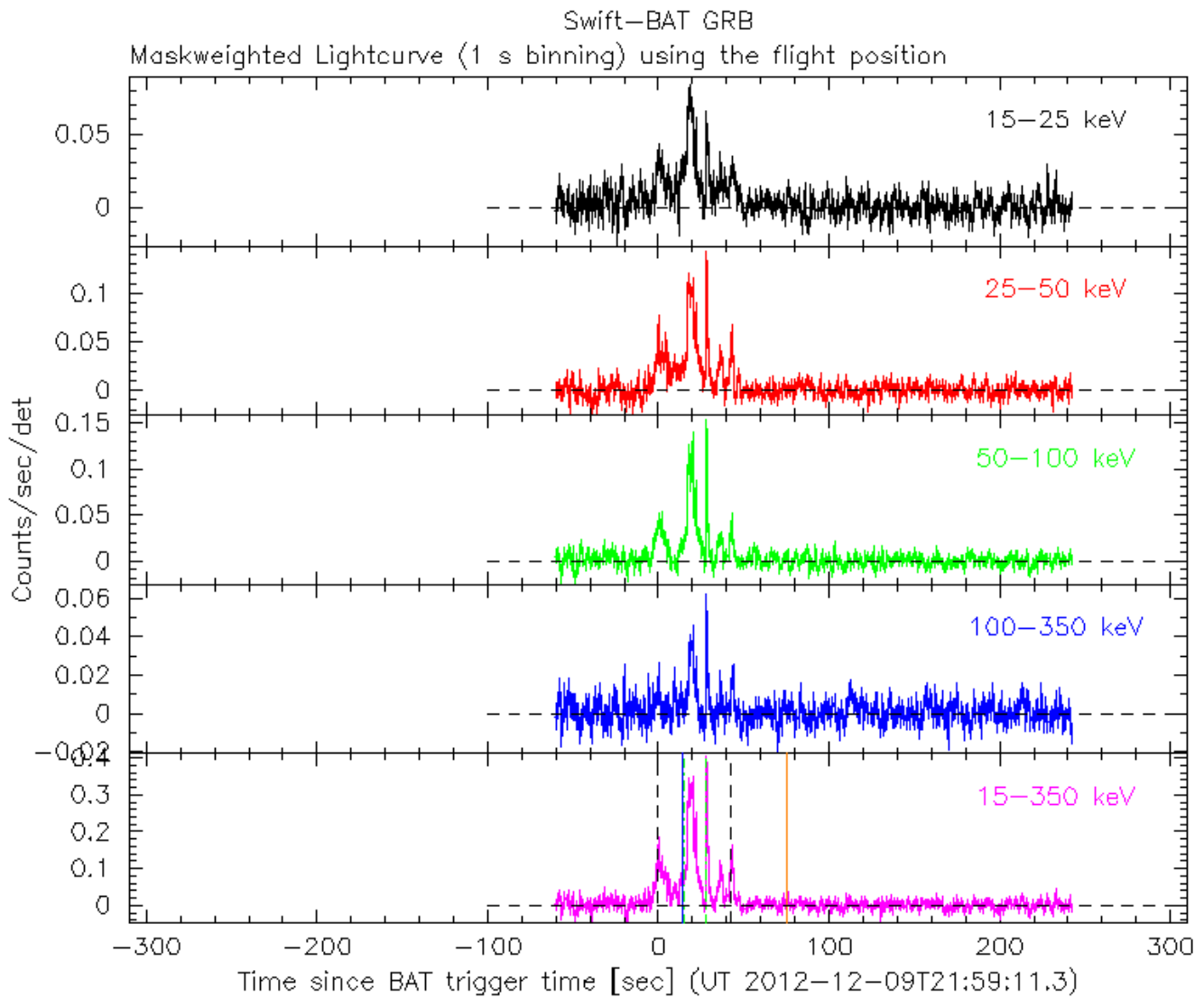


Figure 1. The BAT mask-weighted light curve in the four individual and total energy bands. The units are counts  $s^{-1}$  illuminated-detector $^{-1}$ .

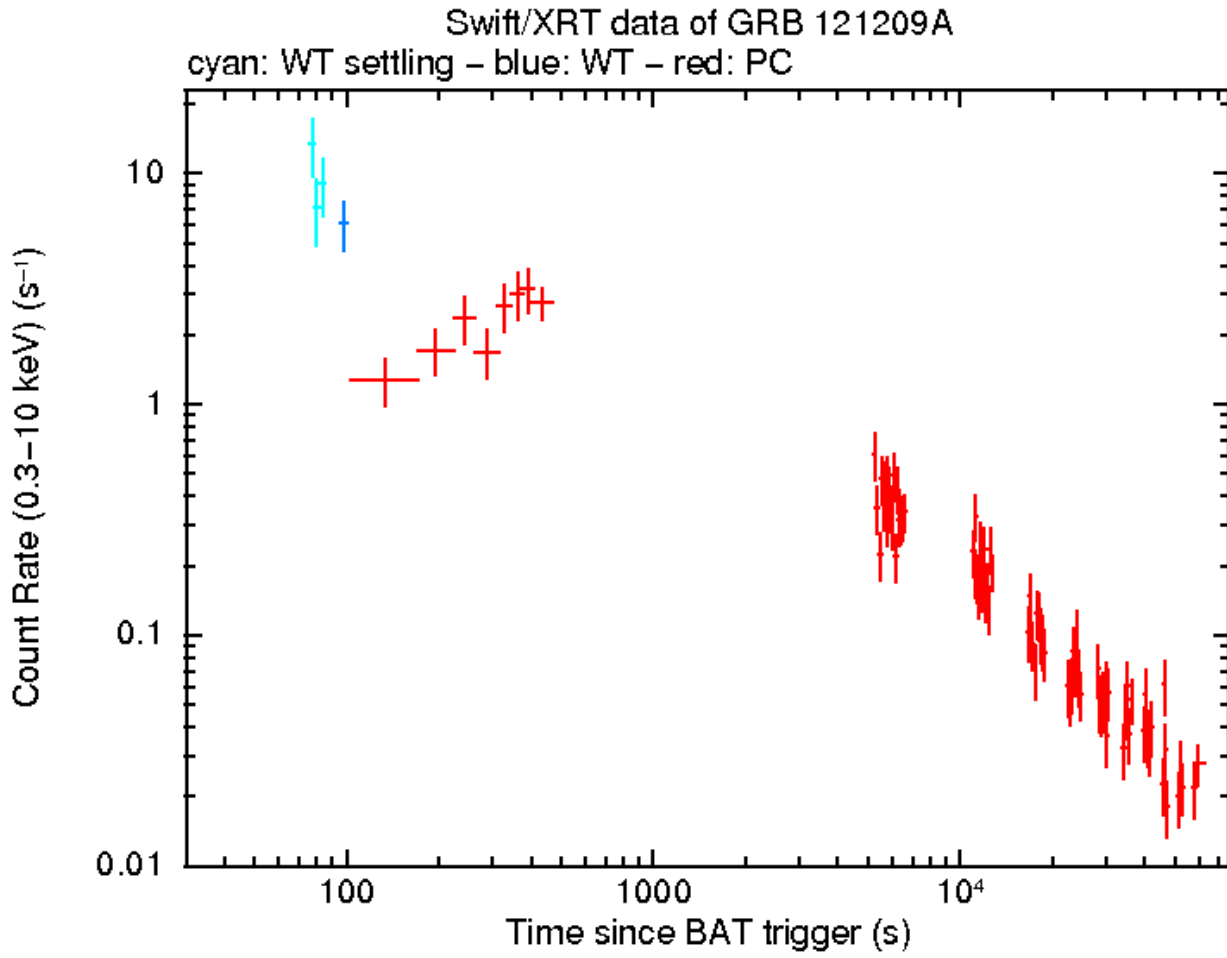


Figure 2. The XRT light curve.

RA	Dec	Error	Note	Reference
21 <sup>h</sup> 47 <sup>m</sup> 08.94 <sup>s</sup>	-08°14' 07.6"	1.5"	XRT-enhanced	Goad <i>et al.</i> GCN Circ. 14051
21 <sup>h</sup> 47 <sup>m</sup> 12.0 <sup>s</sup>	-08°13' 55.8"	1.7'	BAT-refined	Ukwatta <i>et al.</i> GCN Circ. 14052

Table 1. Positions from the Swift instruments.

<b>Band</b>	<b>Authors</b>	<b>GCN Circ.</b>	<b>Observatory</b>	<b>Notes</b>
Optical	Morgan	14047	PAIRITEL	upper limits
Optical	Fong <i>et al.</i>	14048	Gemini	upper limits
Optical	Kruehler <i>et al.</i>	14049	GROND	detection (host?)
Optical	Butler <i>et al.</i>	14050	RATIR	upper limits
Radio	Laskar <i>et al.</i>	14054	VLA	upper limit
Radio	Zauderer <i>et al.</i>	14055	CARMA	upper limit
Optical	Perley <i>et al.</i>	14056	Keck	detection (host?)
Radio	Perley and Horesh	14081	CARMA	upper limit
X-ray	Sato <i>et al.</i>	14084	MAXI	detection
Optical	Seong-Kook <i>et al.</i>	14087	LOAO	upper limits

Table 2. Summary of GCN Circulars from other observatories sorted by circular number.

<b>Filter</b>	<b>T_start(s)</b>	<b>T_stop(s)</b>	<b>Exp(s)</b>	<b>Mag</b>
white <sub>FC</sub>	96	246	147	>21.4
white	96	12808	1217	>21.7
v	5857	35749	1967	>20.3
b	5241	24926	1784	>21.1
u	308	30697	1959	>21.6
w1	6267	29936	1968	>21.5
m2	6062	36468	2314	>22.3
w2	5652	34835	1968	>21.8

Table 3. UVOT Observations. The start and stop times of the exposures are given in seconds since the BAT trigger. The preliminary 3- $\sigma$  upper limits are given. No correction has been made for extinction in the Milky Way.