

# Swift Observations of GRB 140629A

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## 1. Introduction

At 14:17:30 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 140629A (trigger=602884) (Lien *et al.* GCN Circ. [16477](#)). Swift slewed immediately to the burst. At the time of the trigger, the initial BAT position was  $109^\circ$  from the Sun (10.0 hours East) and  $104^\circ$  from the 5%-illuminated Moon. **Table 1** contains the best reported positions from Swift, and the latest XRT position can be viewed at [http://www.swift.ac.uk/xrt\\_positions](http://www.swift.ac.uk/xrt_positions).

Lien *et al.* (GCN Circ. [16477](#)) reported the discovery with UVOT of an optical afterglow. Moskvitin *et al.* (GCN Circ. [16489](#)) determined a redshift of 2.275 from BTA, and D'Avanzo *et al.* (GCN Circ. [16493](#)) determined a redshift of 2.29 from TNG. **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

As reported by Cummings *et al.* (GCN Circ. [16481](#)), the BAT ground-calculated position is RA, Dec = 249.017, 41.897 deg, which is RA(J2000) =  $16^{\text{h}}36^{\text{m}}04.1^{\text{s}}$  Dec(J2000) =  $+41^\circ53'49.6''$  with an uncertainty of 1.8 arcmin, (radius, sys+stat, 90% containment). The partial coding was 41%.

The mask-weighted light curve (**Figure 1**) shows several overlapping peaks starting at  $\sim T-8$  s, peaking at  $\sim T+12$  s, and ending at  $\sim T+90$  s.  $T_{90}$  (15-350 keV) is  $42.0 \pm 14.3$  s (estimated error including systematics).

The time-averaged spectrum from  $T-7.53$  to  $T+56.47$  s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is  $1.86 \pm 0.11$ . The fluence in the 15-150 keV band is  $2.4 \pm 0.2 \times 10^{-6}$  erg  $\text{cm}^{-2}$ . This fluence is larger than that of 65% of the long GRBs in the Second BAT GRB Catalog (Sakamoto *et al.* 2011). The 1-s peak photon flux measured from

T+12.47 s in the 15-150 keV band is  $4.2 \pm 0.4$  ph cm<sup>-2</sup> s<sup>-1</sup>. 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/602884/BA/](http://gcn.gsfc.nasa.gov/notices_s/602884/BA/).

### 3. XRT Observations and Analysis

Analysis of the initial XRT data was reported by Osborne *et al.* (GCN Circ. [16490](#)). We have analysed 50 ks of XRT data for GRB 140629A, from 80 s to 328.5 ks after the BAT trigger. The data comprise 136 s in Windowed Timing (WT) mode (the first 10 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode. The enhanced XRT position for this burst was given by Evans *et al.* (GCN Circ. [16479](#)).

The light curve (**Figure 2**) can be modelled with a series of power-law decays. The initial decay index is  $\alpha=0.75 \pm 0.07$ . At T+2904 s the decay steepens to an  $\alpha$  of 1.32 (+0.09, -0.11) before breaking again at T+29.6 ks to a final decay with index  $\alpha=2.4$  (+0.9, -0.3).

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of  $1.82 \pm 0.15$ . The best-fitting absorption column is  $5.1 (+4.8, -4.3) \times 10^{21}$  cm<sup>-2</sup>, at a redshift of 2.275, in addition to the Galactic value of  $9.3 \times 10^{19}$  cm<sup>-2</sup> (Willingale *et al.* 2013). The PC mode spectrum has a photon index of  $1.96 \pm 0.09$  and a best-fitting absorption column of  $5.5 (+2.7, -2.6) \times 10^{21}$  cm<sup>-2</sup>. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is  $3.3 \times 10^{-11}$  ( $3.6 \times 10^{-11}$ ) erg cm<sup>-2</sup> count<sup>-1</sup>.

A summary of the PC-mode spectrum is thus:

Galactic foreground:  $9.3 \times 10^{19}$  cm<sup>-2</sup>

Intrinsic column:  $5.5 (+2.7, -2.6) \times 10^{21}$  cm<sup>-2</sup> at  $z=2.275$

Photon index:  $1.96 \pm 0.09$

The results of the XRT team automatic analysis are available at [http://www.swift.ac.uk/xrt\\_products/00602884](http://www.swift.ac.uk/xrt_products/00602884).

### 4. UVOT Observations and Analysis

The Swift/UVOT began settled observations of the field of GRB 140629A 101 s after the BAT trigger (Breeveld and Lien GCN Circ. [16494](#)). A fading source consistent with the XRT position (Evans *et al.* GCN Circ. [16479](#)) 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 0.01 mag. in the direction of the GRB (Schlegel *et al.* 1998).

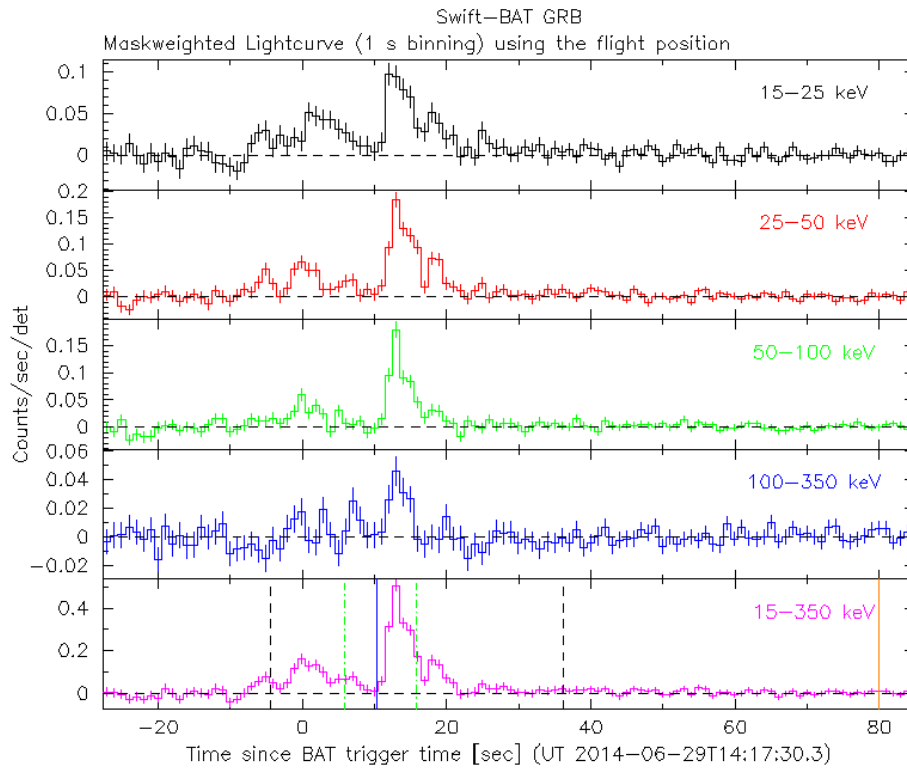


Figure 1. The BAT mask-weighted light curve in the four individual and total energy bands. The units are counts  $s^{-1}$  illuminated-detector $^{-1}$ .

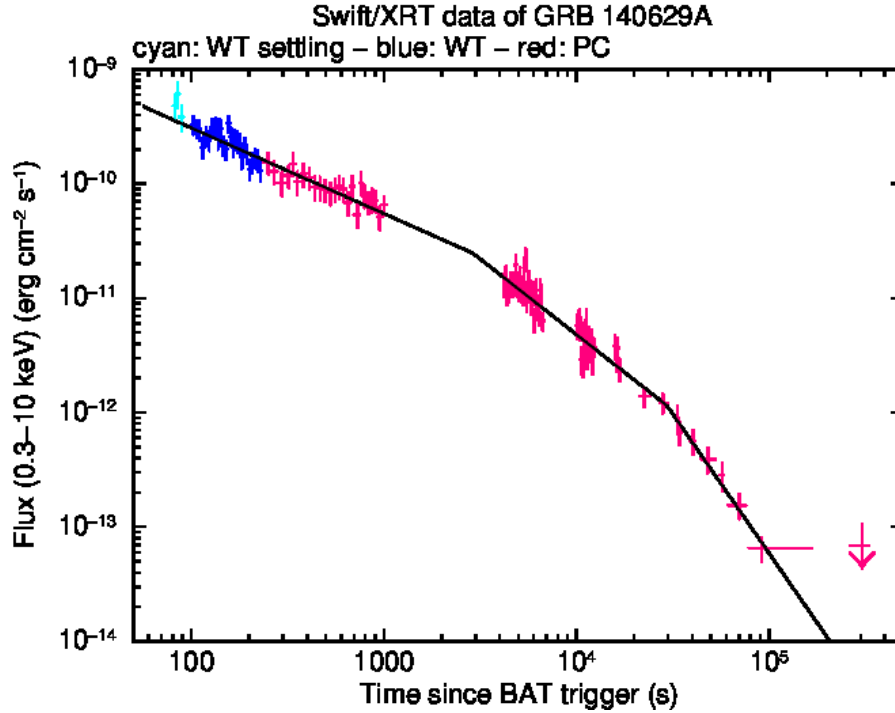


Figure 2. The XRT light curve. Any data from a crosshatched region are not included in the fit.

RA (J2000)	Dec (J2000)	Error	Note	Reference
16 <sup>h</sup> 35 <sup>m</sup> 54.42 <sup>s</sup>	+41°52'36.8"	0.42"	UVOT-refined	Breeveld and Lien GCN Circ. <a href="#">16494</a>
16 <sup>h</sup> 35 <sup>m</sup> 54.48 <sup>s</sup>	+41°52'36.7"	1.4"	XRT-final	<a href="#">UKSSDC</a>
16 <sup>h</sup> 35 <sup>m</sup> 54.52 <sup>s</sup>	+41°52'36.8"	1.7"	XRT-enhanced	Evans <i>et al.</i> GCN Circ. <a href="#">16479</a>
16 <sup>h</sup> 36 <sup>m</sup> 04.1 <sup>s</sup>	+41°53'49.6"	1.8'	BAT-refined	Cummings <i>et al.</i> GCN Circ. <a href="#">16481</a>

Table 1. Positions from the Swift instruments.

Band	Authors	GCN Circ.	Subject	Observatory	Notes
Optical	Yurkov <i>et al.</i>	<a href="#">16478</a>	MASTER OT detection	MASTER	detection
Optical	Xin <i>et al.</i>	<a href="#">16480</a>	Xinglong TNT optical observation	TNT	detection

Optical	Bikmaev <i>et al.</i>	<a href="#">16482</a>	RTT150 optical observations	RTT150	detection
Optical	Masi	<a href="#">16483</a>	Virtual Telescope optical observations	Virtual Telescope	detection
Optical	Maehara	<a href="#">16484</a>	KWFC z-band photometry	KWFC	detection
Optical	Malesani <i>et al.</i>	<a href="#">16485</a>	NOT optical observations	NOT	detection
Optical	Sonbas <i>et al.</i>	<a href="#">16486</a>	T100 observations	T100	detection
Optical	Takaki <i>et al.</i>	<a href="#">16487</a>	Kanata/HOWPol optical observation	Kanata	
Optical	Kuroda <i>et al.</i>	<a href="#">16488</a>	MITSuME Ishigakijima Optical Observation	MITSuME Ishigakijima	detection
Optical	Moskvitin <i>et al.</i>	<a href="#">16489</a>	BTA redshift	BTA	redshift
Optical	Perley and Cenko	<a href="#">16491</a>	P60 observations	Palomar 60-inch	detection
Optical	Garnavich and Rose	<a href="#">16492</a>	VATT optical observations		detection
Optical	D'Avanzo <i>et al.</i>	<a href="#">16493</a>	TNG redshift confirmation	TNG	redshift
Optical	Honda <i>et al.</i>	<a href="#">16496</a>	Nishi-Harima NIR Observations	Nishi-Harima	detection
Optical	Perley and Cenko	<a href="#">16498</a>	additional P60 observations	Palomar 60-inch	
Optical	Gorbovskoy <i>et al.</i>	<a href="#">16500</a>	MASTER-Net preliminary light curve	MASTER	light curve
Optical	Yano <i>et al.</i>	<a href="#">16501</a>	MITSuME Akeno Optical observation	MITSuME Akeno	detection
Optical	Pandey and Kumar	<a href="#">16517</a>	Optical observations	Nainital	

Optical	Moskvitin <i>et al.</i>	<a href="#">16518</a>	SAO RAS Rc band photometry	Zeiss-1000	
Gamma-ray	Golenetskii <i>et al.</i>	<a href="#">16495</a>	Konus-Wind observation	Konus-Wind	$E_{\text{peak}}=86 \pm 17$ keV Fluence= $3.4 \pm 0.5 \times 10^{-6}$ erg $\text{cm}^{-2}$
Other	Moskvitin <i>et al.</i>	<a href="#">16499</a>	SAO RAS monitoring		detection

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

<b>Filter</b>	<b>T<sub>start</sub>(s)</b>	<b>T<sub>stop</sub>(s)</b>	<b>Exp(s)</b>	<b>Mag</b>
white	101	251	147	$14.78 \pm 0.02$
v	643	663	20	$15.29 \pm 0.09$
b	569	589	20	$15.70 \pm 0.06$
u	313	563	246	$14.89 \pm 0.03$
w1	692	712	19	$17.5 \pm 0.3$
m2	667	687	19	$>17.5$
w2	619	639	19	$>18.0$

Table 3. UVOT observations reported by Breeveld and Lien (GCN Circ. [16494](#)). The start and stop times of the exposures are given in seconds since the BAT trigger. The preliminary detections and 3- $\sigma$  upper limits are given. No correction has been made for extinction in the Milky Way.

July 5, 2014