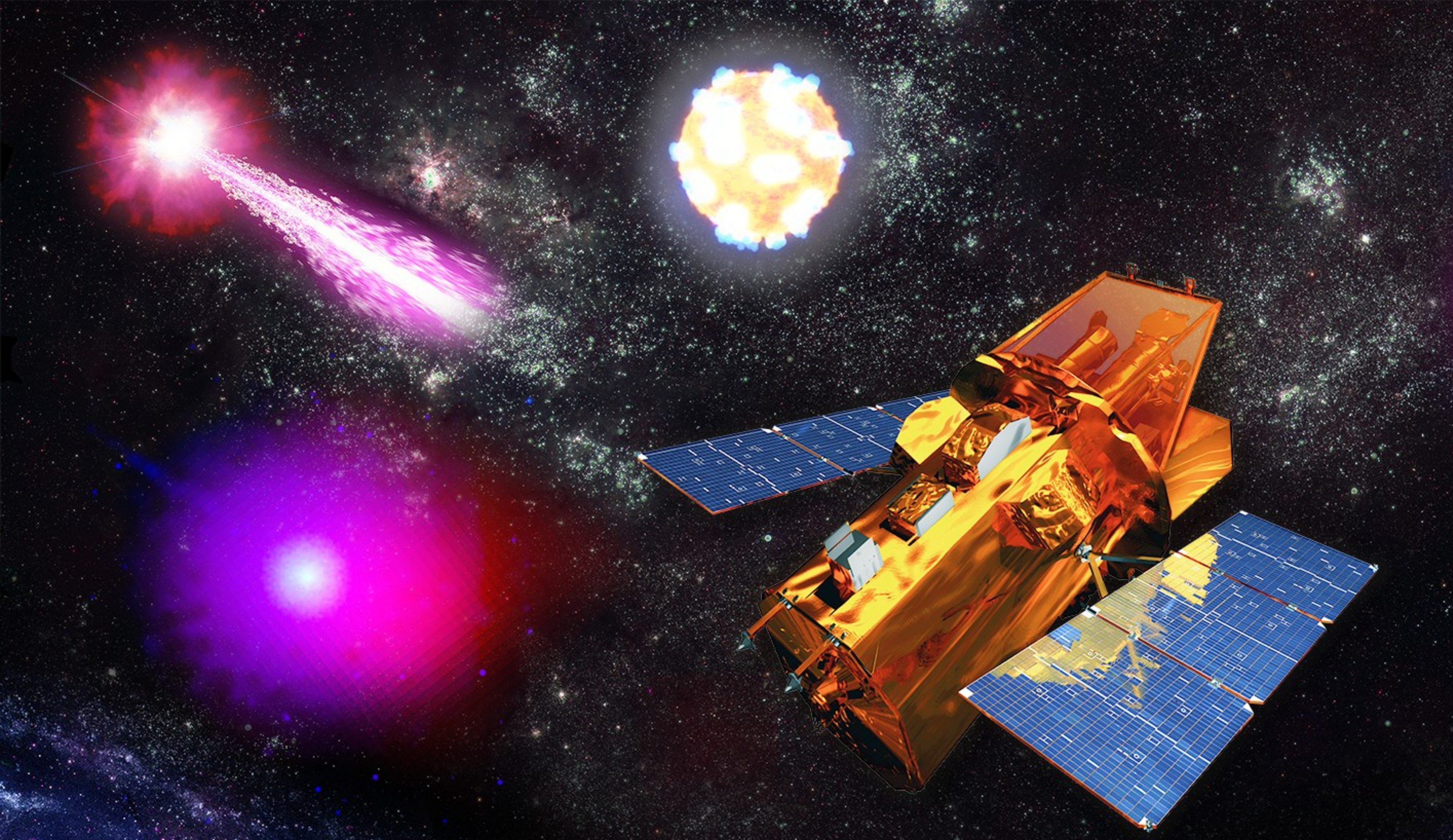


Swift Data Analysis

Kim Page
University of Leicester

Credit: NASA/GSFC

Swift was launched 20 years ago (in 4 weeks and 1 day from now!), with the main goal of detecting and monitoring Gamma-Ray Bursts.

Over the years this expanded to all manner of EM transients – and multi-messenger follow-up.

Swift – XRT data analysis

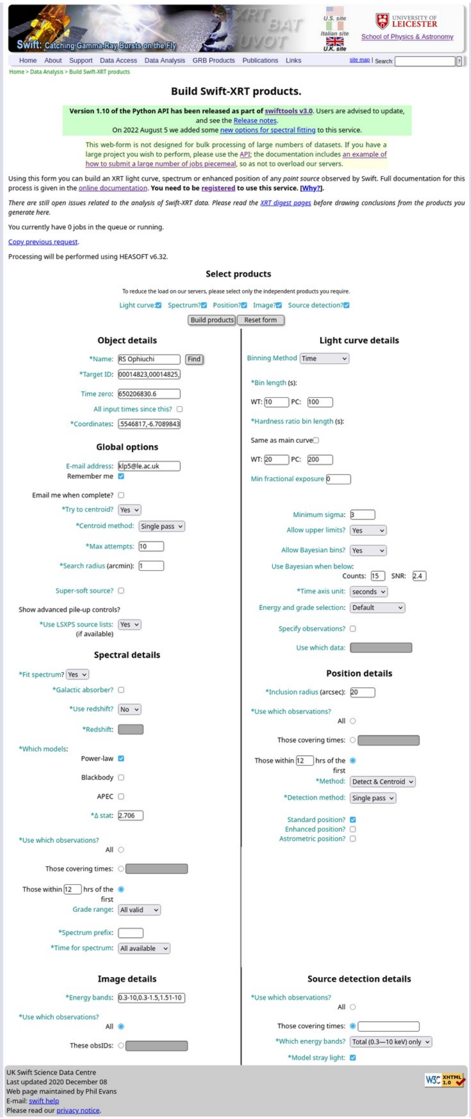
The University of Leicester provides an online XRT product generator (for light-curves, spectra, images, positions and source detection), which can either be accessed via a web form at
https://www.swift.ac.uk/user_objects/
or through the swifttools API
https://www.swift.ac.uk/API/

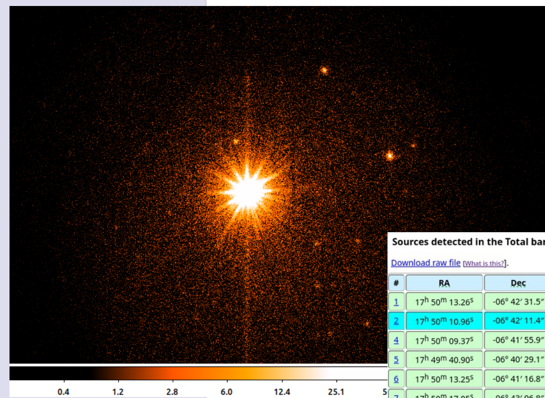
GRBs (both BAT triggers and those we follow up from other missions) are automatically analysed, with the results available at
https://www.swift.ac.uk/xrt_products/

There is online documentation, and even more details in
Evans et al. (2007, A&A, 469, 379)
Evans et al. (2009, MNRAS, 397, 1177)
Evans et al. (2010, A&A, 519, A102).

These products are completely suitable for scientific analysis and the tools are relied upon by the Swift team on a daily basis.

Swift – XRT data analysis

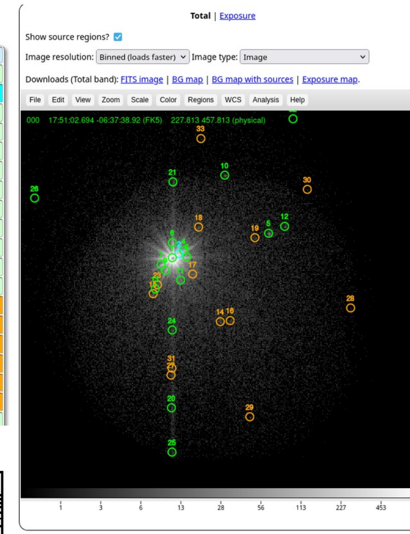


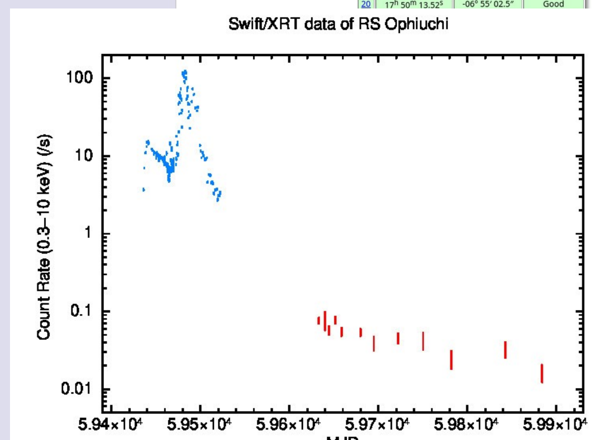


Sources detected in the Total band

Download raw file (What is this?).

#	RA	Dec	Det flag
1	17ʰ 50ᵐ 13.26ˢ	-06° 42′ 31.5″	Good
2	17ʰ 50ᵐ 10.96ˢ	-06° 42′ 11.4″	Reasonable
4	17ʰ 50ᵐ 09.37ˢ	-06° 41′ 55.9″	Good
5	17ʰ 49ᵐ 40.90ˢ	-06° 40′ 29.1″	Good
6	17ʰ 50ᵐ 13.25ˢ	-06° 41′ 16.8″	Good
7	17ʰ 50ᵐ 17.05ˢ	-06° 43′ 06.8″	Good
8	17ʰ 50ᵐ 08.38ˢ	-06° 42′ 27.2″	Good
9	17ʰ 50ᵐ 15.57ˢ	-06° 43′ 35.0″	Good
10	17ʰ 49ᵐ 55.65ˢ	-06° 35′ 38.8″	Good
11	17ʰ 50ᵐ 10.47ˢ	-06° 44′ 24.0″	Good
12	17ʰ 49ᵐ 35.53ˢ	-06° 39′ 54.6″	Good
13	17ʰ 50ᵐ 19.01ˢ	-06° 45′ 08.0″	Good
14	17ʰ 49ᵐ 57.12ˢ	-06° 47′ 51.6″	Poor
15	17ʰ 50ᵐ 19.70ˢ	-06° 45′ 31.6″	Poor
16	17ʰ 49ᵐ 53.81ˢ	-06° 47′ 46.1″	Poor
17	17ʰ 50ᵐ 06.42ˢ	-06° 43′ 53.8″	Poor
18	17ʰ 50ᵐ 04.38ˢ	-06° 39′ 58.5″	Poor
19	17ʰ 49ᵐ 45.48ˢ	-06° 40′ 51.7″	Poor
20	17ʰ 50ᵐ 13.52ˢ	-06° 55′ 02.5″	Good

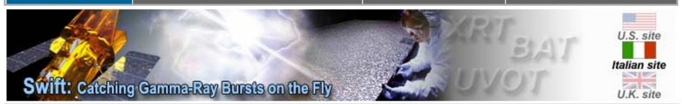




There is no direct UVOT equivalent of the XRT product generator, but the Italian SSDC provide links on their versions of the Quick-look site and archive for online interactive UVOT image analysis.

SSDC Quick Links
---Quick Links---

HOME | ISAC Documentation | Data Archive | Quicklook Data



About Swift | Swift XRT simulator | SSDC main page | GCN

Thu Sep 26 07:03:17 2024 GMT

Instructions:

- Click on a sequence number to access data for that sequence.
- Click on a column header to sort the table by that column.
- Rows with a gray background have been replaced by a more recent reprocessing.
- After one week the data are archived at HEASARC, ISAC, and UKDC and removed from this list.
- The columns are described at the bottom of the table.

Sequence	Version	Object	Observed	Processed	Comment	XRT Interactive Archive	UVOT Interactive Archive
00016492050	010	ZTF20abwtifz	2024-09-07T00:06:57	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look
00031480011	007	XSer	2024-09-07T01:07:57	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look
00076634002	007	saa-cold-251-00	2024-09-07T01:17:55	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look
00016281031	010	IGRJ06074+2205	2024-09-07T01:51:57	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look
00097689001	012	SDSSJ1323	2024-09-07T02:19:56	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look
00021711001	013	GRB240905b	2024-09-07T02:30:19	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look
00097377028	010	NGC5907ULX1	2024-09-07T02:47:56	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look
00031222033	005	1A1744-361	2024-09-07T02:49:46	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look
00016552029	005	GX339-4	2024-09-07T04:25:22	2024-09-17	FINAL FOR ARCHIVE	XRT Interactive Quick Look	UVOT Interactive Quick Look

https://swift.ssdc.asi.it/cgi-bin/ql/createqlhtml?sortcol=Observed

UVOT On-line Analysis

UVOT filters available for the analysis

☐ V ☐ U ☐ B ☐ W1 ☐ M2 ☐ W2

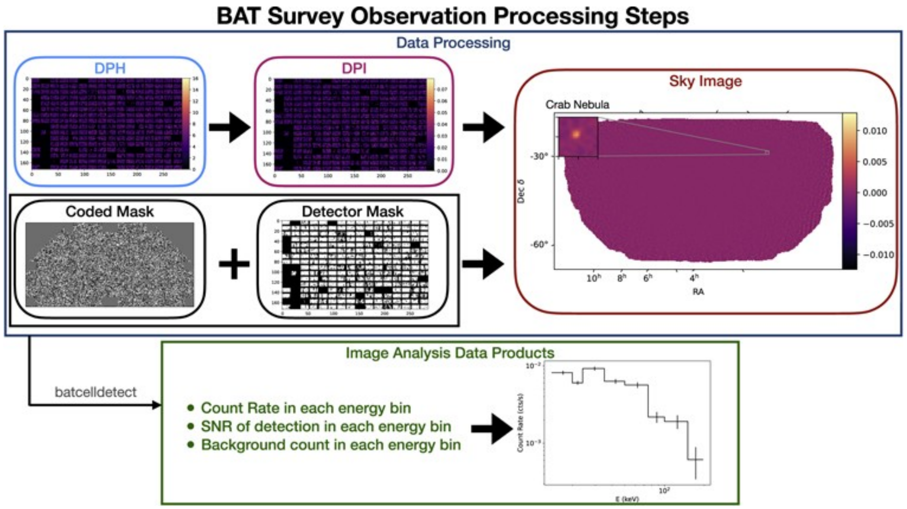
V filter has 3 exposure slices
U filter has 3 exposure slices
B filter has 3 exposure slices
W1 filter has 3 exposure slices
M2 filter has 3 exposure slices
W2 filter has 3 exposure slices

☐ use the longest exposure slice only (in case of problems in slice summing)

SUBMIT

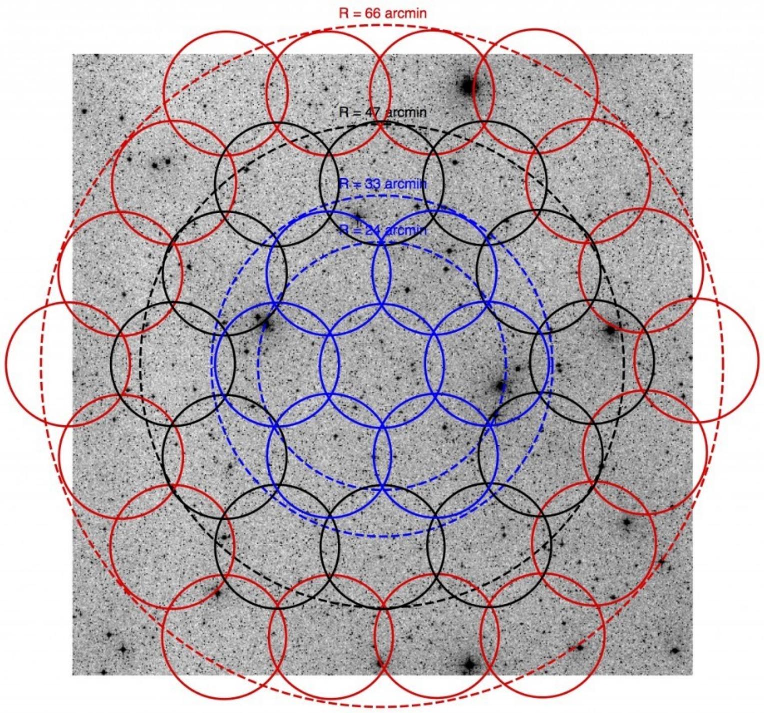
If BAT triggers on a gamma-ray source (typically a GRB, but sometimes other sources), then Swift saves event files and TDRSS data, and the standard batgrbproduct script can be used.

Most of the time, however, BAT operates in survey mode, collecting Detector Plane Histograms. There is now an API to analyse these data, called BatAnalysis, available at https://github.com/parsotat/BatAnalysis
See Parsotan et al. (2023, ApJ, 953, 15) for details.



Swift – Large Area Tiling

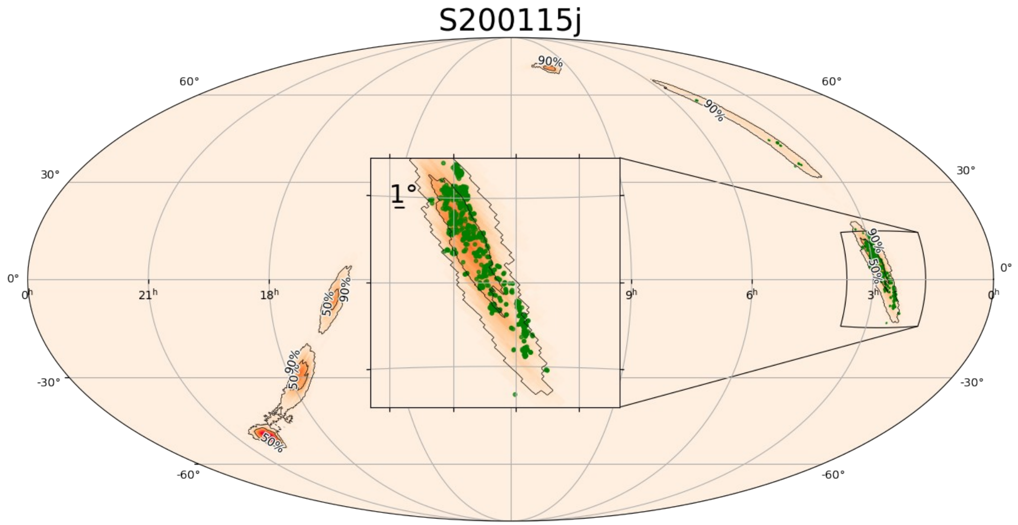
LVK error regions are large, even when all 3 observatories are functioning; ditto IceCube regions. (Waiting for KM3NeT to improve things...) The XRT FOV is circular, with diameter 23.6 arcmin, while UVOT has a square FOV, 17 arcmin each side.

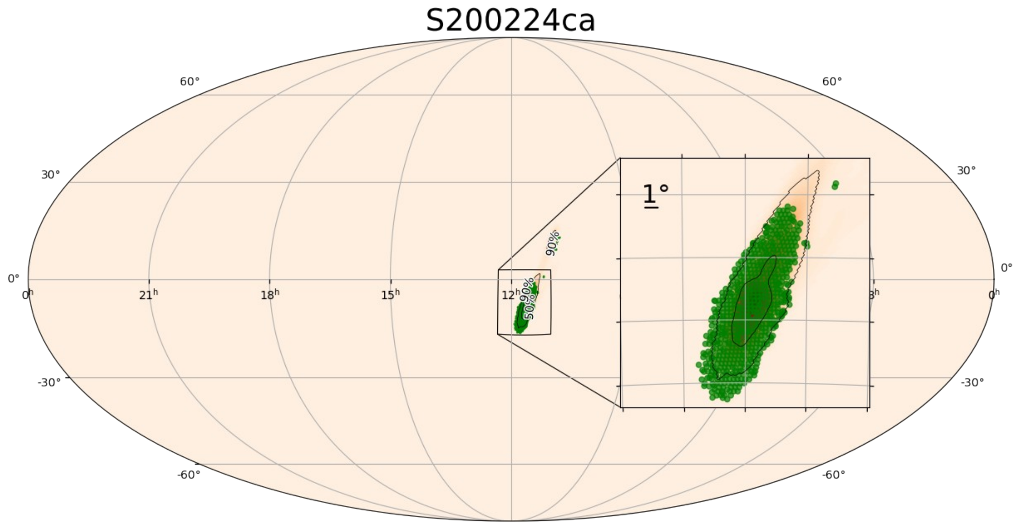


Over the GW observing runs, the ability of Swift to tile large areas of the sky has been implemented and improved.

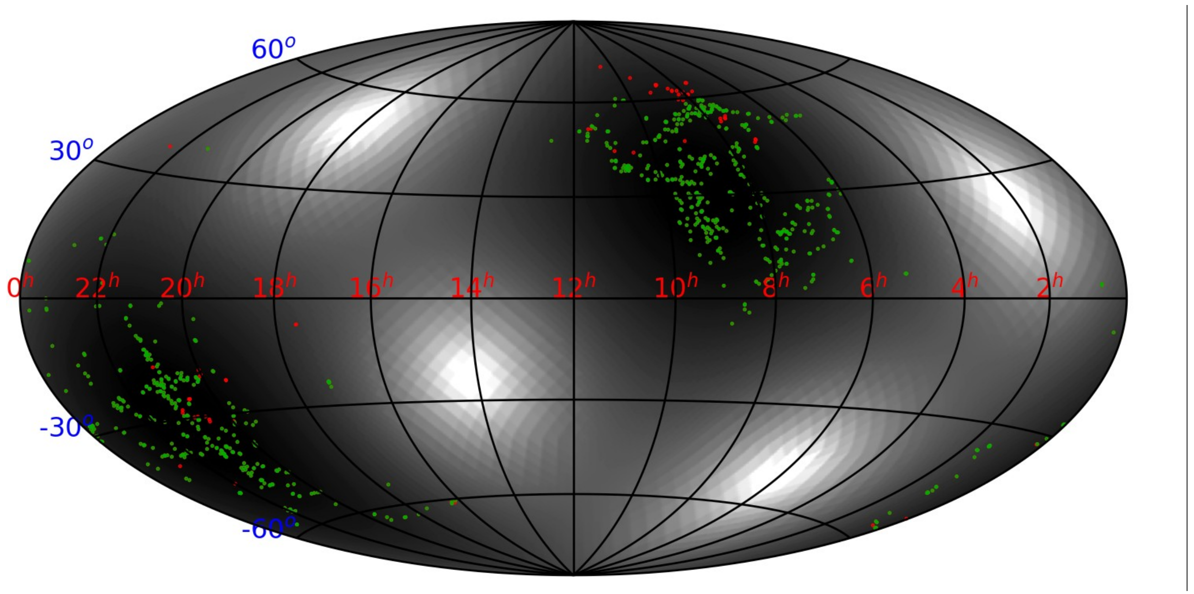
We are now not even constrained to use our network of ground stations to upload the commands, but have a method known as “Continuous Commanding”, which involves “joysticking” Swift around the sky, uploading tile by tile via TDRSS.

Swift – GW Follow-up



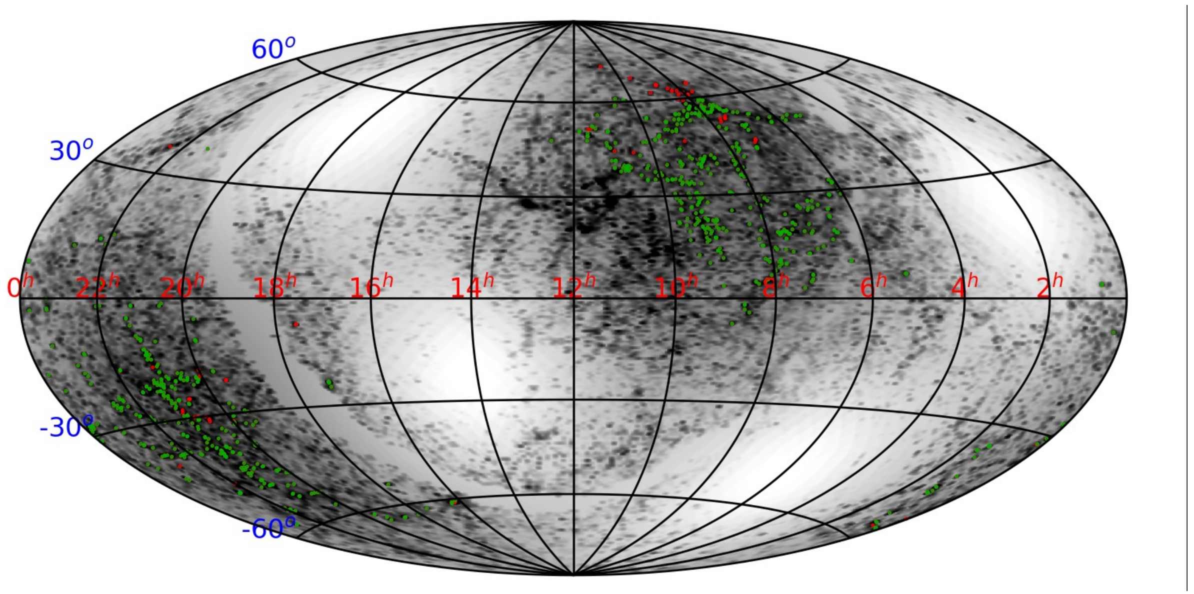


S190930t



Convolved GW Skymap

S190930t



One of the main difficulties when trying to identify a counterpart to a multi-messenger trigger is knowing whether a source is new, or just hadn't been observed previously to an equal depth (ie if there is an upper limit, it is not deep enough to be useful). We really need archival images to perform image differencing – particulaly for the UVOT data.

To help with this, we implemented the Swift Gravitational Wave Galaxy Survey.

SGWGS is a pre-imaging survey of 4773 fields, containing the ~14,000 most likely host galaxies for BNS mergers within ~100 Mpc (from the GWGC), to obtain both X-ray and UV templates.

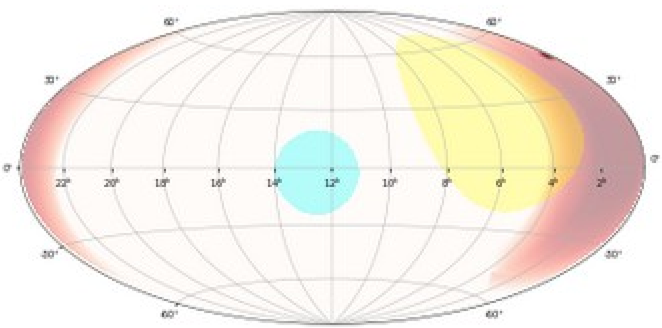
For XRT, we also have LSXPS: the Living Swift-XRT Point Source catalogue – which updates every time we observe anything in Photon Counting mode – and the Transient Detector, with which to compare MM follow-up.

https://www.swift.ac.uk/LSXPS/
https://www.swift.ac.uk/LSXPS/transients/

GW 240615dg

BBH, FAR = 1 in 100 yr, distance = 1420 ± 235 Mpc
Convolved map covered 8 sq. deg. We observed 199 tiles, covering 84% of the map.
Results at https://www.swift.ac.uk/LVC/

Raw GW map | **Convolved with 2MPZ**

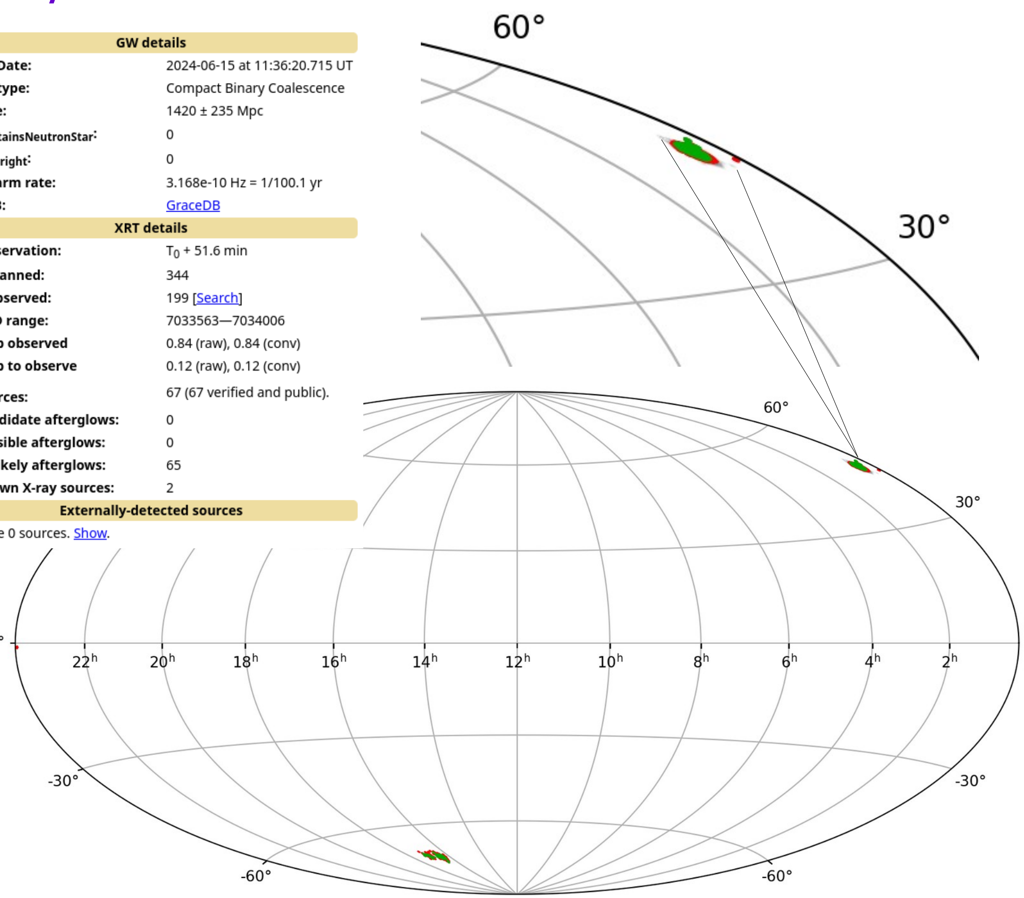


The red area is the BAT field of view at the LVC trigger time. Yellow and cyan circles are the Sun/Moon constrained regions.

Sun/moon constraints were calculated on 2024-167-11:36:20.724000, when the LIGO ligo-skymap-from-samples map was received. Update.

GW map (HEALPix) | GW map (FITS) | ligo-skymap-from-samples_convolved map (HEALPix) | ligo-skymap-from-samples_convolved map (FITS)

GW details	
Trigger Date:	2024-06-15 at 11:36:20.715 UT
Trigger type:	Compact Binary Coalescence
Distance:	1420 ± 235 Mpc
$Prob_{ContainsNeutronStar}$:	0
$Prob_{EMBright}$:	0
False alarm rate:	3.168e-10 Hz = 1/100.1 yr
GraceDB:	GraceDB
XRT details	
First observation:	T_0 + 51.6 min
Fields planned:	344
Fields observed:	199 [Search]
TargetID range:	7033563—7034006
LVK Prob observed	0.84 (raw), 0.84 (conv)
LVK Prob to observe	0.12 (raw), 0.12 (conv)
XRT sources:	67 (67 verified and public).
Candidate afterglows:	0
Possible afterglows:	0
Unlikely afterglows:	65
Known X-ray sources:	2
Externally-detected sources	
There are 0 sources. Show.	



XRT Source Detection

XRT source detection is run automatically as the data come down to the ground. Sources are assigned a rank, depending on how likely they are to be a counterpart of the GW trigger (see https://www.swift.ac.uk/ranks.php), as well as a flag (Good, Reasonable or Poor, depending on false positive rate: 0.3%, 7%, 35%, respectively).

All X-ray sources

Coordinate style: Sexagesimal Filter by position: Radius: 20″ Go Clear

Include: Unvetted sources Poor sources

#	Position	Err[1]	Flag[2]	Class[3] (Rank)	Exp (s)	Cat source?	Fdiff (σ)[4]	Near Galaxy?	Near 2MASS	Near SIMBAD	Search /build	Notes
1	00h 29m 35.98s +46° 06′ 38.2″	6.9″	Good	U (3)	276	N	⩽0	N	N	No	V | S | N | X | LS | 3X [build]	
4	00h 24m 34.85s +46° 01′ 51.6″	8.4″	Good	U (3)	2437	N	⩽0	N	N	No	V | S | N | X | LS | 3X [build]	
5	00h 23m 43.15s +46° 00′ 40.9″	9.8″	Good	U (3)	2728	N	⩽0	N	Y	Yes	V | S | N | X | LS | 3X [build]	
6	16h 35m 45.42s -72° 36′ 59.3″	7.3″	Good	U (3)	139	N	⩽0	N	Y	No	V | S | N | X | LS | 3X [build]	
8	00h 34m 53.24s +45° 43′ 44.5″	6.6″	Good	U (3)	571	N	⩽0	N	Y	No	V | S | N | X | LS | 3X [build]	
11	16h 35m 48.47s -71° 28′ 36.4″	8.5″	Good	U (3)	117	N	⩽0	N	Y	No	V | S | N | X | LS | 3X [build]	
12	00h 25m 17.22s +45° 34′ 26.4″	6.1″	Good	U (3)	1041	N	⩽0	N	N	No	V | S | N | X | LS | 3X [build]	
14	00h 24m 18.85s +45° 25′ 10.0″	5.1″	Good	U (3)	4834	N	⩽0	N	N	No	V | S | N | X | LS | 3X [build]	
15	00h 25m 03.91s +45° 24′ 20.8″	5.3″	Good	U (3)	5271	N	⩽0	N	N	No	V | S | N | X | LS | 3X [build]	

58	00h 31m 05.12s +46° 33′ 25.6″	13.3″	Reasonable	U (3)	314	N	⩽0	N	Y	No	V | S | N | X | LS | 3X [build]	
60	00h 35m 42.54s +45° 48′ 05.6″	5.7″	Good	U (3)	506	N	1.5	N	N	No	V | S | N | X | LS | 3X [build]	
64	00h 28m 43.62s +45° 01′ 49.1″	5.6″	Good	U (3)	783	N	⩽0	N	N	No	V | S | N | X | LS | 3X [build]	
66	00h 33m 53.13s +46° 45′ 28.6″	7.7″	Good	U (3)	514	N	⩽0	N	N	Yes	V | S | N | X | LS | 3X [build]	
68	00h 25m 25.85s +45° 33′ 41.3″	5.9″	Good	U (3)	7914	N	⩽0	N	Y	No	V | S | N | X | LS | 3X [build]	
70	00h 28m 46.16s +46° 05′ 15.6″	8.3″	Reasonable	U (3)	687	N	⩽0	N	N	No	V | S | N | X | LS | 3X [build]	
71	00h 28m 30.50s +46° 19′ 12.1″	6.2″	Good	U (3)	1433	N	⩽0	N	N	No	V | S | N | X | LS | 3X [build]	
72	00h 28m 09.61s +46° 18′ 20.6″	7.4″	Reasonable	U (3)	1433	N	⩽0	N	N	Yes	V | S | N | X | LS | 3X [build]	
9	00h 27m 42.35s +45° 14′ 56.5″	7.5″	Good	K (4)	228	Y	0.7	N	Y	Yes	V | S | N | X | LS | 3X [build]	

Notes:

[1] Error is 90% confidence, radius

[2] G=Good, R=Reasonable, P=Poor (What?)

[3] AG = Candidate afterglow, I=Interesting source, U=Uncatalogued X-ray source, K=Known X-ray source.

[4] For uncatalogued sources this is how many sigma above the historical upper limit the source is, for known sources this is how many sigma above the catalogued flux the source is.

XRT Source Page

Swift: Catching Gamma-Ray Bursts on the Fly

U.S. site | Italian site | U.K. site

UNIVERSITY OF LEICESTER
School of Physics & Astronomy

Home | About | Support | Data Access | Data Analysis | GRB Products | Publications | Links | site map | Search:

Home > Gravitational wave followup > S240615dg > S240615dg_X4

About this page.

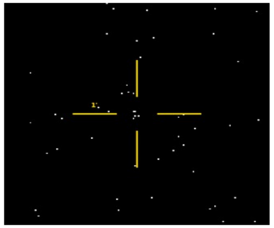
Source S240615dg_X4

Please see the usage policy before using these data.

Build custom XRT products for this source.

Source details	
Rank/Classification:	3: Uncatalogued X-ray source
RA (J2000):	00h 24m 34.85s (= 6.14521°)
Dec (J2000):	+46° 01′ 51.6″ (= +46.0310°)
Error (radius, 90%):	8.4″
Detection flag:	Good
XRT exposure:	4081 s (vignetting corrected)
Peak rate:	3.4 (±1.4) $\times10^{-3}$ ct s^{-1}
Peak flux:	1.5 (±0.6) $\times10^{-13}$ erg cm^{-2} s^{-1}
LVK dist towards this source:	μ=1326.3; σ=257.5 Mpc
Peak L at 1326.3 Mpc:	3.1 (±1.3) $\times10^{43}$ erg s^{-1}
LVK prob at this pos[1]:	1.319e-4
Convolved prob at this pos:	1.277e-4
Catalogue information	
Known X-ray emitter?	No.
RASS upper limit[3]	0.020 XRT ct s^{-1}
Obs rate/RASS UL	⩽0 σ
Matches SGWGS source?	Not at analysis time [Search SGWGS]
SGWGS upper limit:	Position not in SGWGS data at analysis time
Gal Completeness[4]	3.3%
Near GWGC/2MPZ galaxy?	No
Near 2MASS source?	No
Near SIMBAD source?	No.
Catalogue Search	Cone search radius 25″ Vizier | Simbad | NED | X-ray master | LSXPS | 3XMM-DR5

Image | Exposure map



This source is detected in 2 blocks. Show all images.

Show observations of this source.

Notes

All XRT count rates and fluxes are 0.3—10 keV

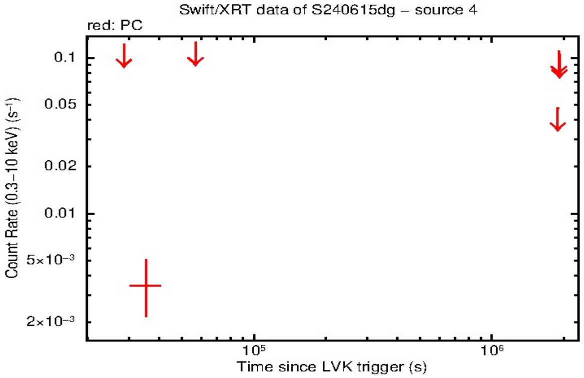
1 Distance from the LVC skymap to this position;D= Gaus(μ, σ) R^2.

2 Count-rates have been converted to XRT equivalents using the spectrum in note 3.

3 Fluxes have been deduced assuming a power-law spectrum with $N_H=3\times10^{20}$ cm^{-2}, Γ=1.7.

4 The completeness of the galaxy catalogue along the line of sight to this source.

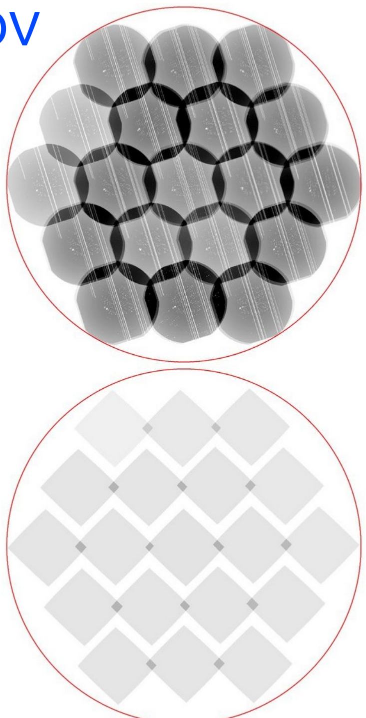
Light curve



UVOT Analysis

Historically, the tiling pattern used by Swift was optimised to enable the greatest coverage with XRT. However, UVOT has a smaller FOV, and – after the discovery of the blue kilonova for GW 170817 (AT2017gfo; Evans et al., 2017, Sci, 358, 1565) – we believe UVOT is more likely than XRT to discover a counterpart.

XRT FOV



UVOT FOV

Therefore, since O3, galaxies with a high probability of being the host will fall completely within the UVOT FOV.

The UVOT GW pipeline uses the standard files from the Swift Data Centre (SDC), along with the standard suite of FTools. The sources are run through a series of steps to check if they were previously known, extended, or image artefacts. Those which pass, are then compared with Gaia DR2 and the Minor Planet Checker.

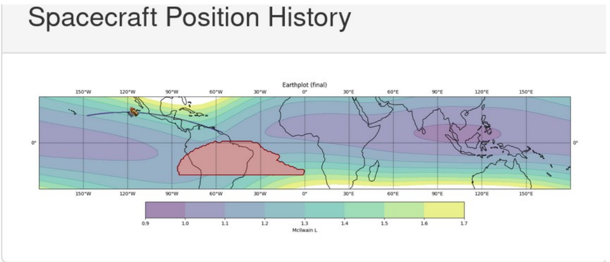
Sources are assigned Quality flags, Q0 or Q1 being most likely counterparts (depending on brightness).

BAT GUANO

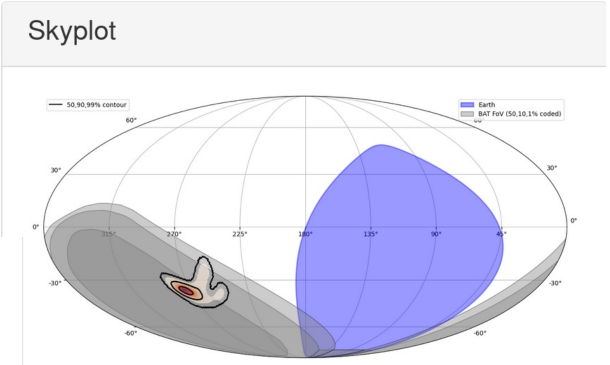
While we obviously hope there will be a simultaneous (significant) BAT sGRB detection and GW trigger, there is also a method to perform targeted searches in BAT event data around the time of a non-BAT trigger (other GRB missions, FRBs or MM), searching for sub-threshold events.

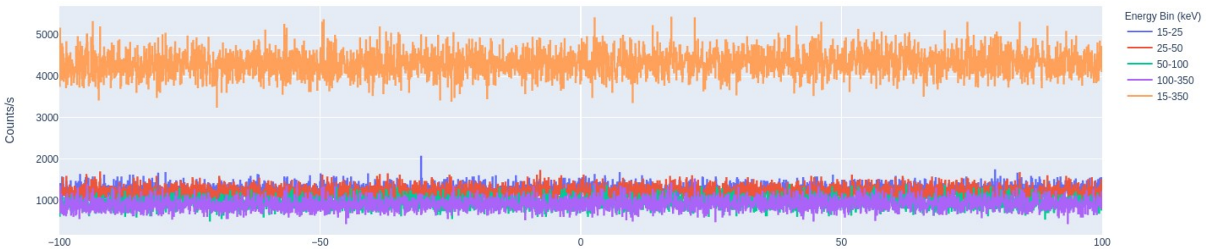
GUANO = Gamma-ray Urgent Archiver for Novel Opportunities (Tohuvavohu et al., 2020, ApJ, 900, 35)

NITRATES = Non-Imaging Transient Reconstruction And TEmporal Search (DeLaunay & Tohuvavohu, 2022, ApJ, 941, 169)



Following a trigger, an automated command to save BAT event data around the trigger is sent up to Swift and, once the data are on the ground, automated analysis is posted online: https://guano.swift.psu.edu/





Summary of Multi-Messenger Follow-up

Swift will plan to tile any GW or neutrino triggers which satisfy certain criteria, and automatically analyse the XRT and UVOT data collected; if BAT GUANO data are available, they will also be analysed.

ToO requests to follow up these large-scale events are not required, BUT if you have a specific potential counterpart you wish us to observe, please do submit a ToO request at https://www.swift.psu.edu/toop/too.php or via the API (https://www.swift.psu.edu/too_api/) - we can't keep track of everything announced in GCNs, ATels and AstroNotes ourselves!

Swift – where to get help

We provide online data analysis threads at Leicester

https://www.swift.ac.uk/analysis/xrt/
https://www.swift.ac.uk/analysis/uvot/
https://www.swift.ac.uk/analysis/bat/

as well as an email helpdesk: swifthelp@leicester.ac.uk

Home > Data Analysis > XRT

XRT Data Analysis

Ready-made products

Swift-XRT data products for GRBs
Build Swift-XRT products for any object
Information about available XRT Positions for GRBs

XRT analysis threads

- General introduction
  - Obtaining and setting up the Swift software
  - Files and directory structure
- General processing
  - Producing cleaned XRT event-files
  - Source detection and position determination
- Analysis
  - General introduction to XSELECT
    - How to extract an image
    - How to extract a spectrum
      - Pile-up walk-through
      - ARFs
      - Position-dependent WT RMFs
    - How to extract a light-curve
      - Light-curve exposure correction
      - Barycentric correction
  - Exposure Maps

Home > Data Analysis > UVOT

UVOT Data Analysis

UVOT analysis threads

This page is designed to provide a starting point for the analysis of UVOT images. UVOT data are taken in 3 modes: Image mode, Event mode and Image&Event mode. There are 7 broadband filters and 2 grisms, and various window sizes. The subsequent pages deal with analysis of Image mode data. Event mode data are treated in a similar way to X-ray data. For analysis of Event mode data and grism observations you are referred to the UVOT Software Guide, the UVOT Digest and Paul Kuin's "brief data reduction guide for UVOT grism data" (though see also limits for the grism). Online help for any of the UVOT tasks can be found with `fhelp` taskname or `plist` taskname.

Here we assume that at least the first batch of data has come down (after the TDRSS data), and we start from the Level 2 products. Steps to convert Level 1 into Level 2 products are not outlined here; for this you are referred to the Swift UVOT Software Guide. Particular care should be taken with the reduction and analysis if the field is crowded, the background is high or your source is very bright or very faint.

New DRESSCode is a python pipeline to reduce Swift UVOT images of extended sources written by Marjorie Decleir of STScI.

- General introduction
  - Obtaining and setting up the Swift software
  - Files and directory structure
- General processing
  - Position determination
- Analysis
  - Magnitude and flux determination
  - How to sum images
  - How to create a light-curve
  - How to create spectral files
  - uvotproduct

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BAT Data Analysis

This page explains the steps required to obtain sky images, spectra and light-curves from BAT **event data**. Running these scripts will result in a BAT spectrum and response matrix, which can then be used in XSPEC, along with spectra from the XRT and UVOT. **If you are interested in analysing DPH/survey data, please see the paper by Parsotan et al. (2024). Please note that the UKSSDC team are unable to provide help with the BatAnalysis Python package.**

Many of these steps are performed by the pipeline at the SDC, but these individual scripts allow users to perform the data analysis "by hand". This is useful both for understanding what the processing does (rather than accepting the outputs of a "black box") and also if a problem with the pipeline were to develop.

The individual scripts are covered below, with some detail about the input files required for each step in the production of level 2 BAT data. Although the entire set of parameters can be typed directly at the command prompt, the required files do have to be in a specific order, which is not immediately obvious. However, the BAT ones will prompt for the required inputs, which simplifies matters. For example, typing `batbinevt` will then prompt for input event file name etc. There are, however, some 'hidden' settings, which will not be prompted for; these can be shown by using the FTOOL command `plist`, which will show all the parameters, including the hidden values, given in parentheses (example). The hidden defaults can be overridden in 1 of 3 ways: the new value can be defined on the command line (this is the method which has been used below, when going through the individual scripts), the `pset` command can be used or the `par` file can be edited. For more details on the `pfiles` commands, see the FTOOLS Tutorial.

There are many other BAT tasks which can be used to perform tasks such as refining the GRB position (`batcelldetect`) and cleaning the background (`batclean`). Running `fhelp swift` lists and explains these tools.

Note that HEASoft includes a complete GRB processing script, batgrbproduct, which generates all the standard products (images, light-curves and spectra) from the observations automatically. This is the recommended method to analyse BAT data. If time-sliced spectra or different energy bands for the light-curves are required, then the relevant threads listed below can be followed.

If a GRB is detected close to the edge of the BAT field of view (low partial coding fraction), the default processing may not show any counts during this time interval. To work around this, the command **`batgrbproduct aperture=CALDB:DETECTION pcodethresh=0.01 imgpcodethresh=0.01 extractor=fextract-events`** should be run.

Instrument guides

BAT data analysis guide
XRT data analysis guide
UVOT data analysis guide

BAT help threads

General introduction
- Obtaining and setting up the Swift software
- Files and directory structure

General processing
- Energy conversion
- Quality maps, hot pixels and mask weighting

Analysis
- Creating images
- Creating light-curves
  - Duration determination
- Creating spectra

BAT documents

BAT Software Guide
BAT instrument paper

BAT help

GSFC BAT Analysis Threads
BAT Digest Page at GSFC
Attend a Swift training session.

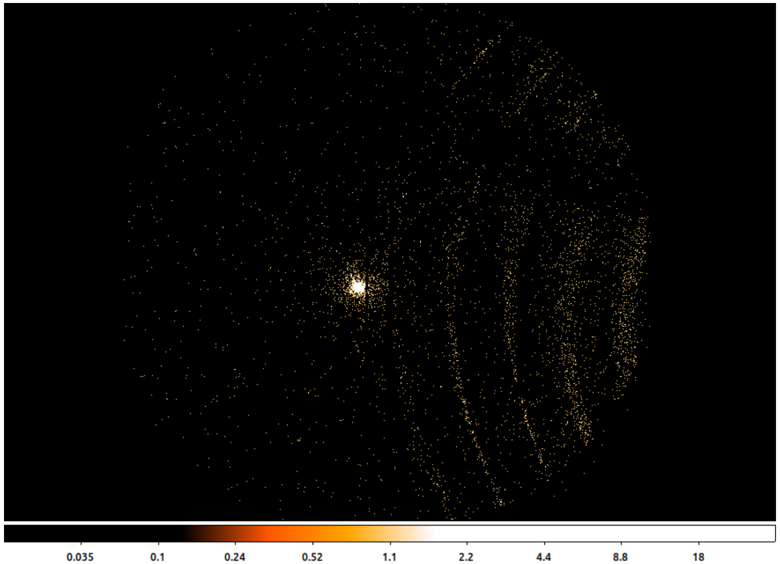
Helpdesk

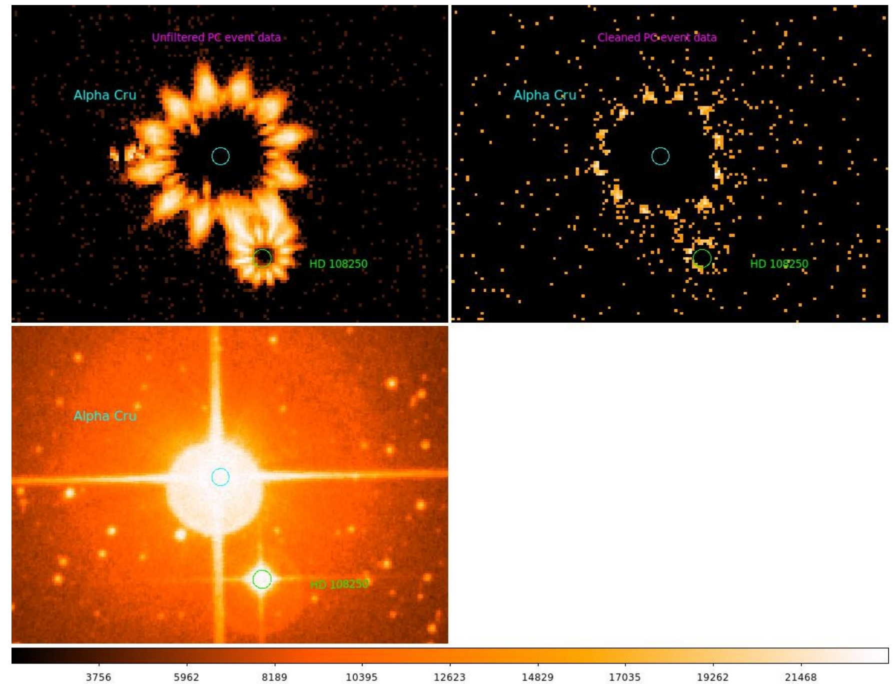
Questions about Swift? Try our guide to Swift or the guide to data processing and analysis. If these don't solve your problem, please feel free to e-mail us at swifthelp@le.ac.uk.

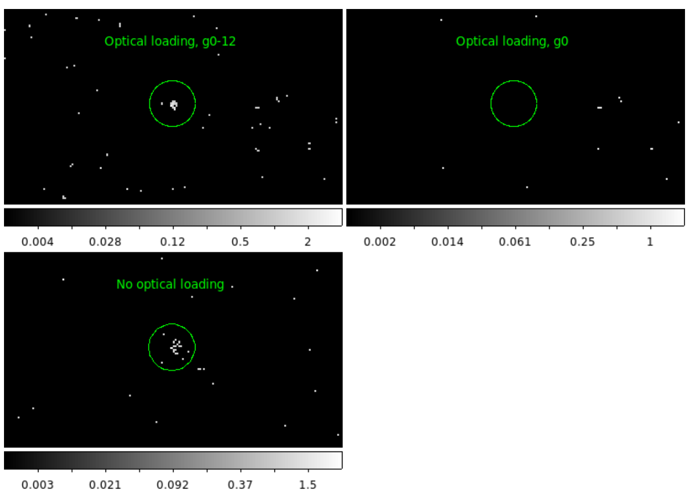
List of acronyms and abbreviations

We are located in the Department of Physics & Astronomy , at the University of Leicester (directions).

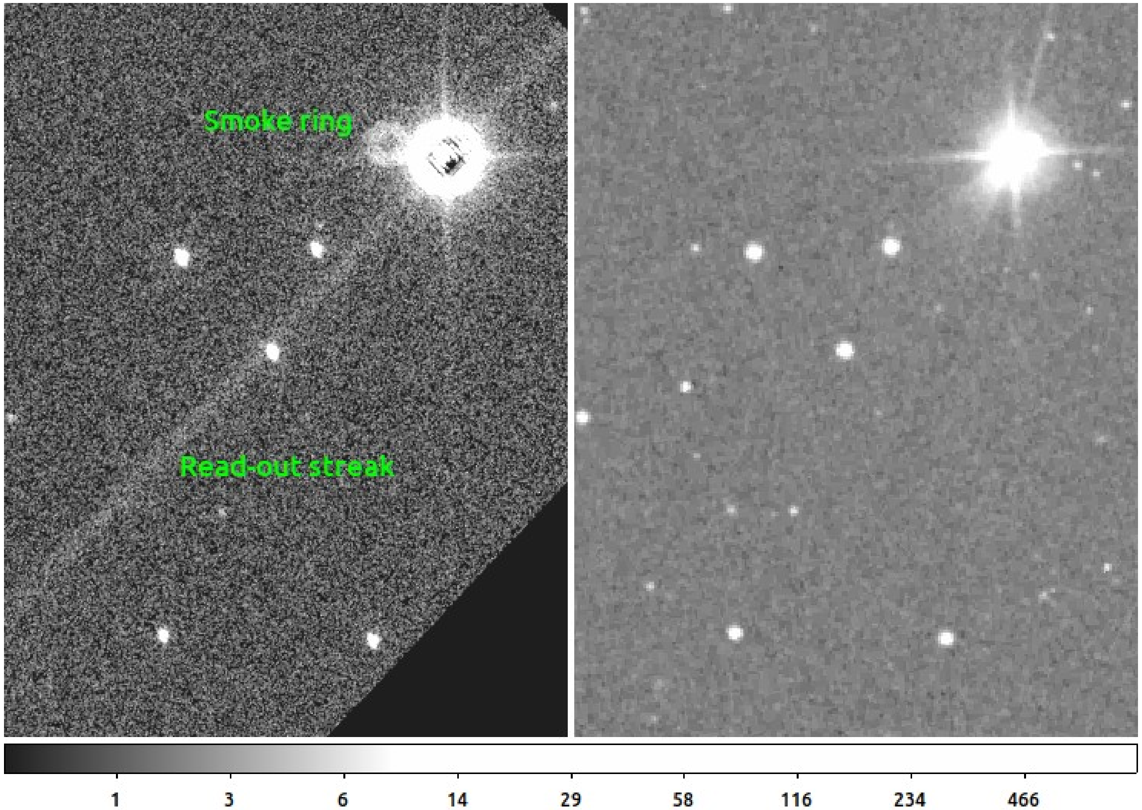
XRT: Stray Light and Optical Loading







UVOT: Image Defects



As for XRT, there are certain image defects to look out for, e.g. read-out streaks, diffraction spikes, smoke rings, (rare) “ghosts” - scattered light, resulting from secondary reflections.

XRT Ranks

XRT source detection is run automatically as the data come down to the ground. Sources are assigned a rank, depending on how likely they are to be a counterpart of the GW trigger (see https://www.swift.ac.uk/ranks.php), as well as a flag (Good, Reasonable or Poor, depending on false positive rate: 0.3%, 7%, 35%, respectively):

Rank 1 - Good GW counterpart candidate.

Sources which lie within 200 kpc of a galaxy, and are either uncatalogued and at least 5σ brighter than the 3σ catalogue limit, or catalogued but at least 5σ brighter than their catalogued flux.

Rank 2 - Possible counterpart.

As for Rank 1, except that ‘brighter’ is determined at the 3σ level, and there is no requirement for the source to be near a known galaxy.

Rank 3 - Undistinguished source.

Sources which are uncatalogued, but are fainter than existing catalogue limits, or consistent with those limits at the 3σ level.

Rank 4 - Not a counterpart.

Sources which are catalogued, and which have fluxes consistent with (at the 3σ level) or fainter than their catalogued values

UVOT Quality Flags

Sources are assigned Quality flags, Q0 or Q1 being most likely counterparts (depending on brightness).

Q0 – Passes all the quality checks and is brighter than 19.9 mag.
Q1 – Passes all the quality checks but is fainter than 19.9 mag. No lower limit, providing uvotdetect finds the source.
Q2 – A previously-catalogued Q0 source, within an angular distance of 2.5” and 2 mag of the UVOT object.
Q3 – A previously-catalogued Q1 source, within an angular distance of 2.5” and 2 mag of the UVOT object

Thumbnails of all Q0 or Q1 sources are then asssessed by humans. XRT sources are checked (and vice versa: UVOT sources are looked at in XRT data).