Follow-up with X-ray telescopes

Phil Evans
(University of Leicester)

With grateful thanks to: Amy Lien, Sam Oates, Kim Page, Jamie Kennea
and everyone else on the *Neil Gehrels Swift Observatory* team.

All mistakes in this presentation are by own.

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(aka “How to respond to GRBs with Swift”)

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Motivation

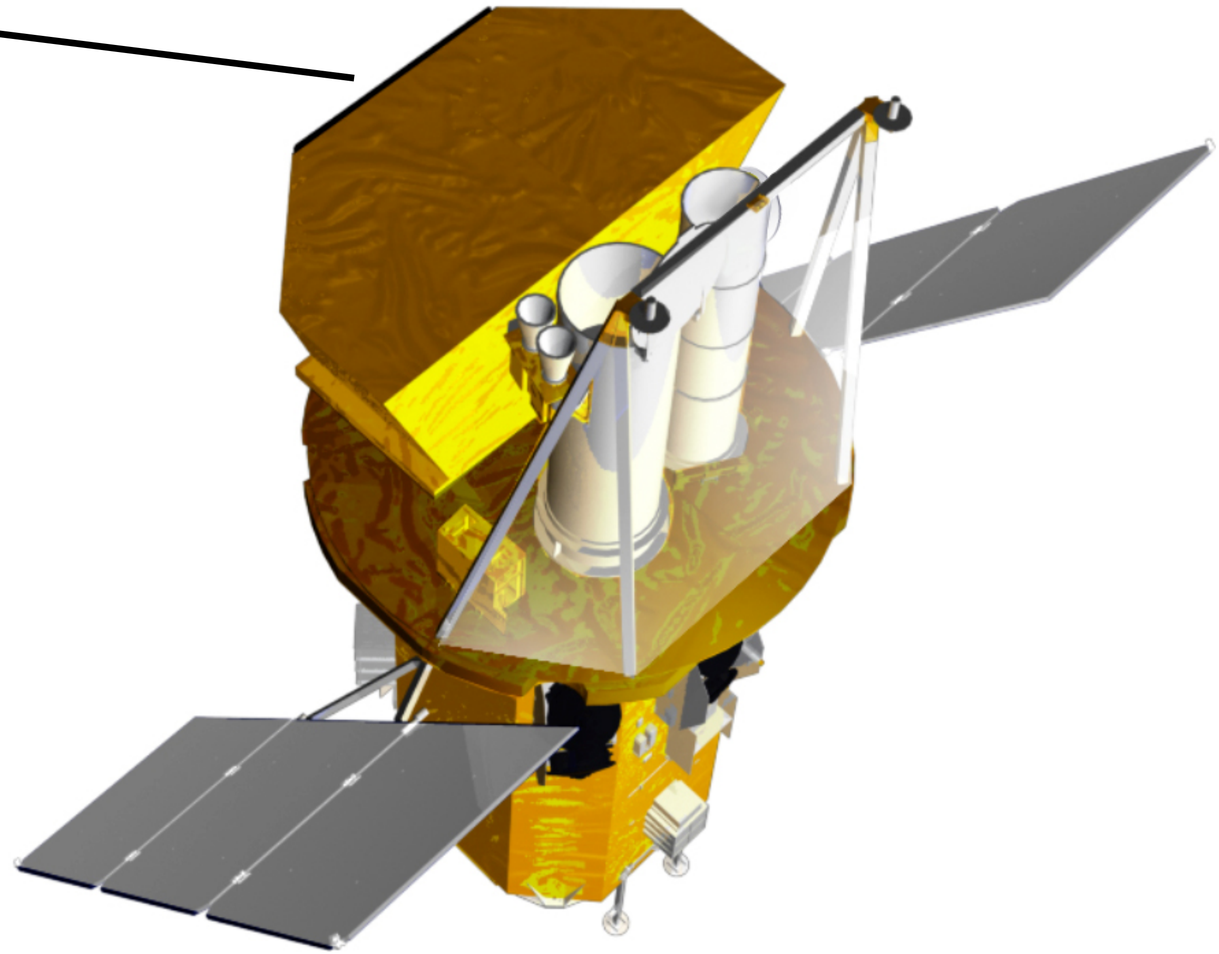
- Premise: *Swift* is similar in many respects to SVOM
- Pressure: the time criticality of the initial GRB response has effects.
- Practise: an opportunity to become familiar with the steps and the scenario helps mitigate the pressure.

Part of the response is the art of balancing speed and detail / accuracy.

Introducing *Swift*

Burst Alert Telescope (BAT)

- 15-350 keV, coded mask - 3’ positions.
- Field of view: 1/6 sky



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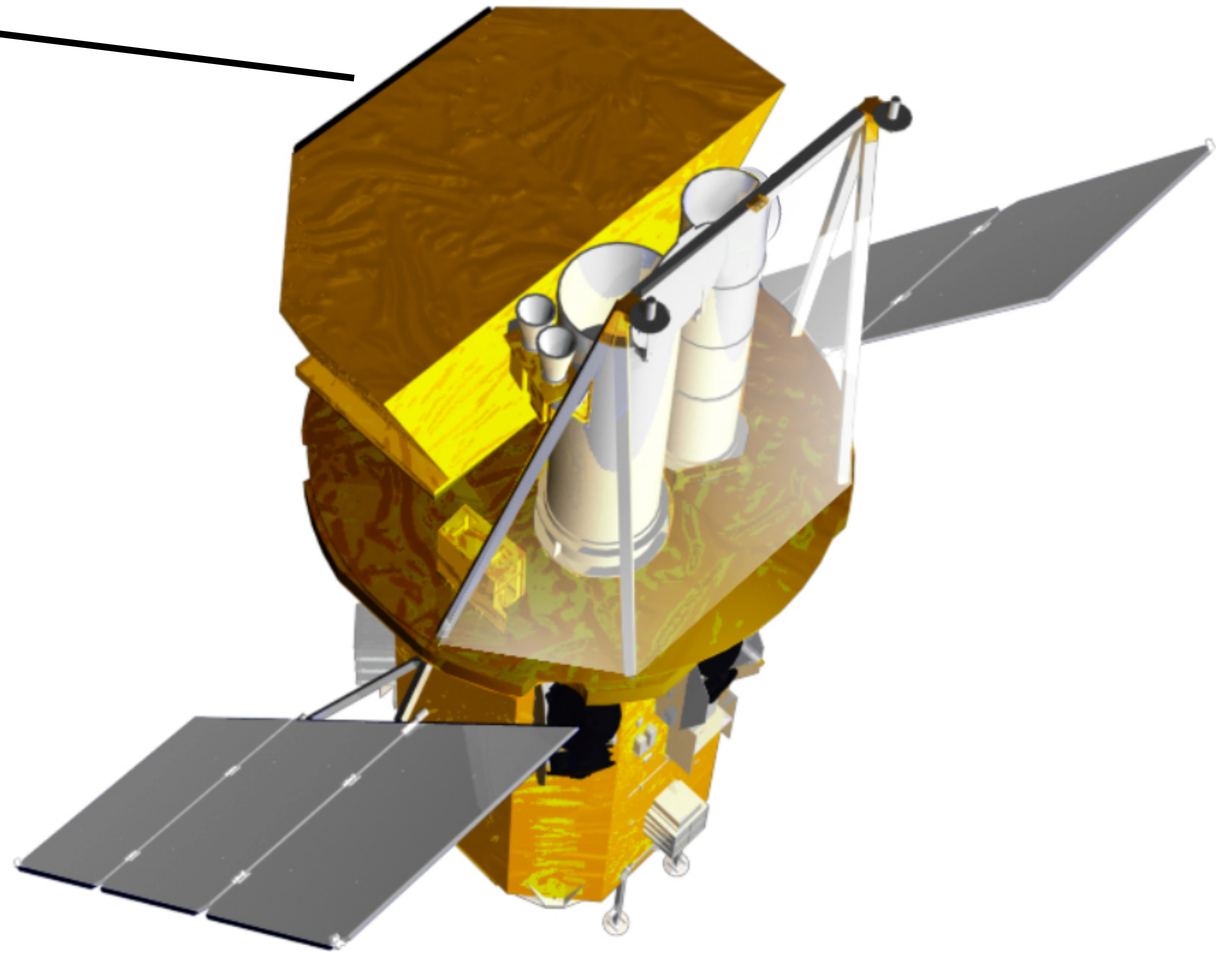
=ECLAIRs



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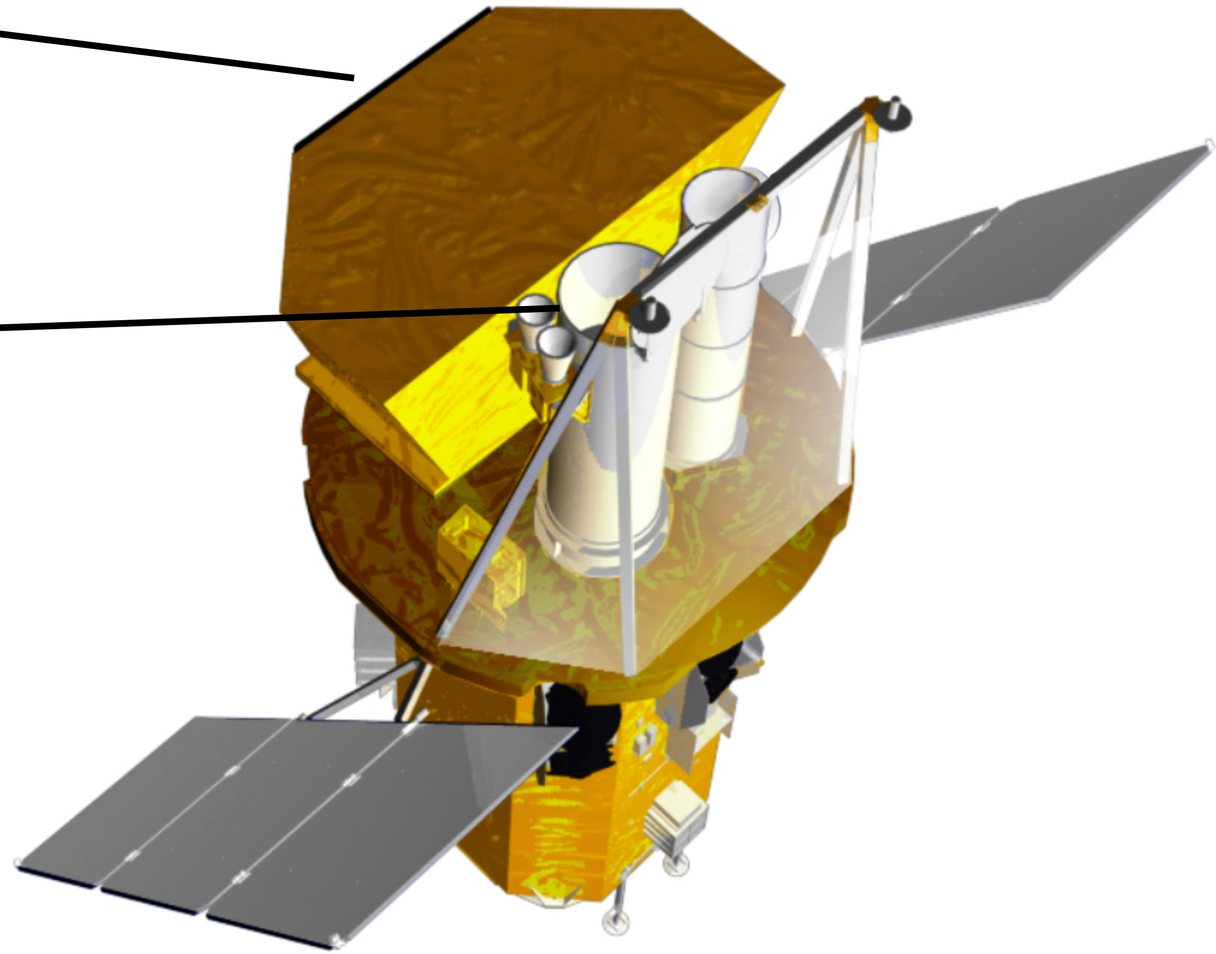
X-ray Telescope (XRT)

- 0.3-10 keV; Wolter-I. 12.5’ fov



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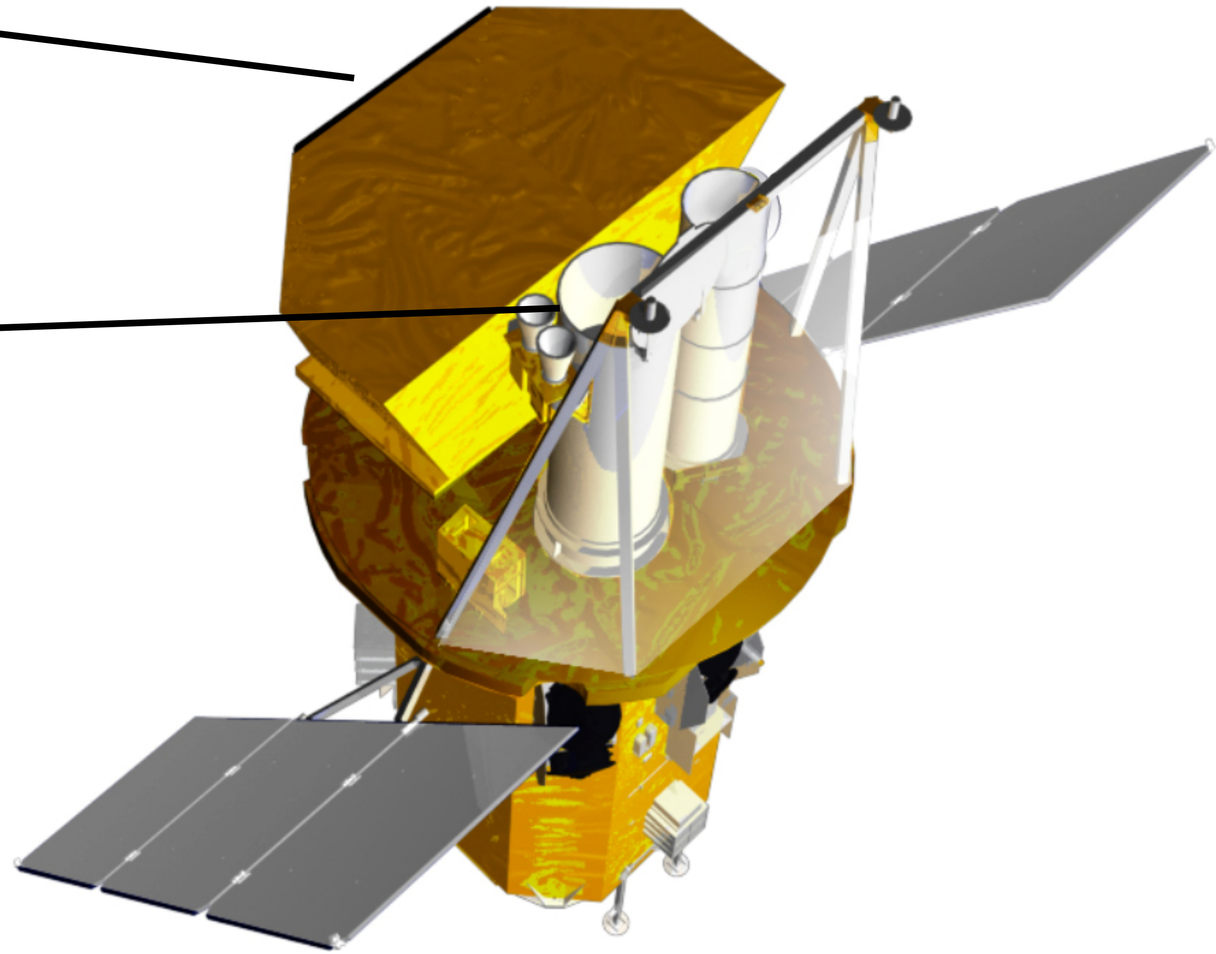
=MXT



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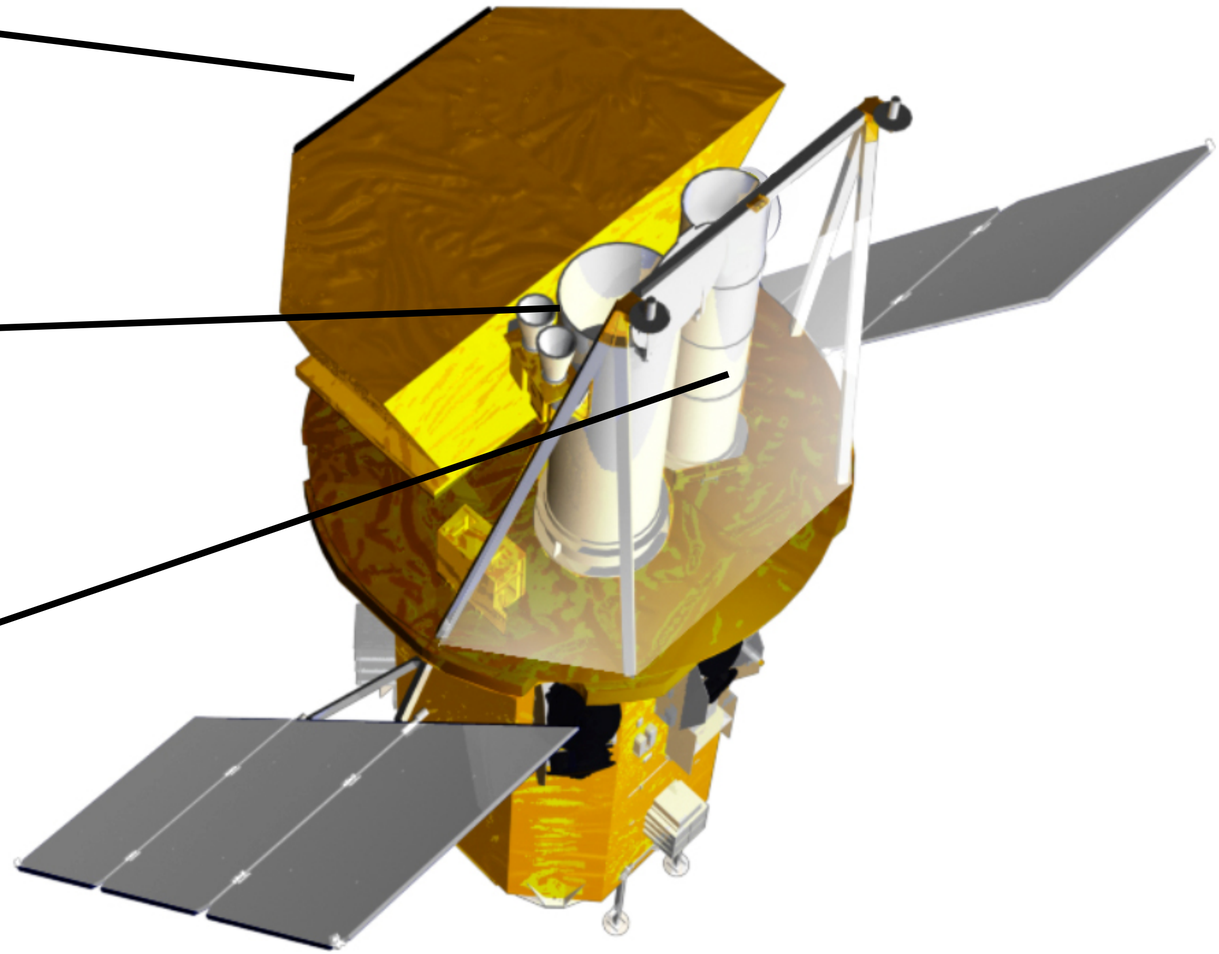
=MXT

UV/Optical Telescope (UVOT)

- 170-650mm. 17’x17’ fov



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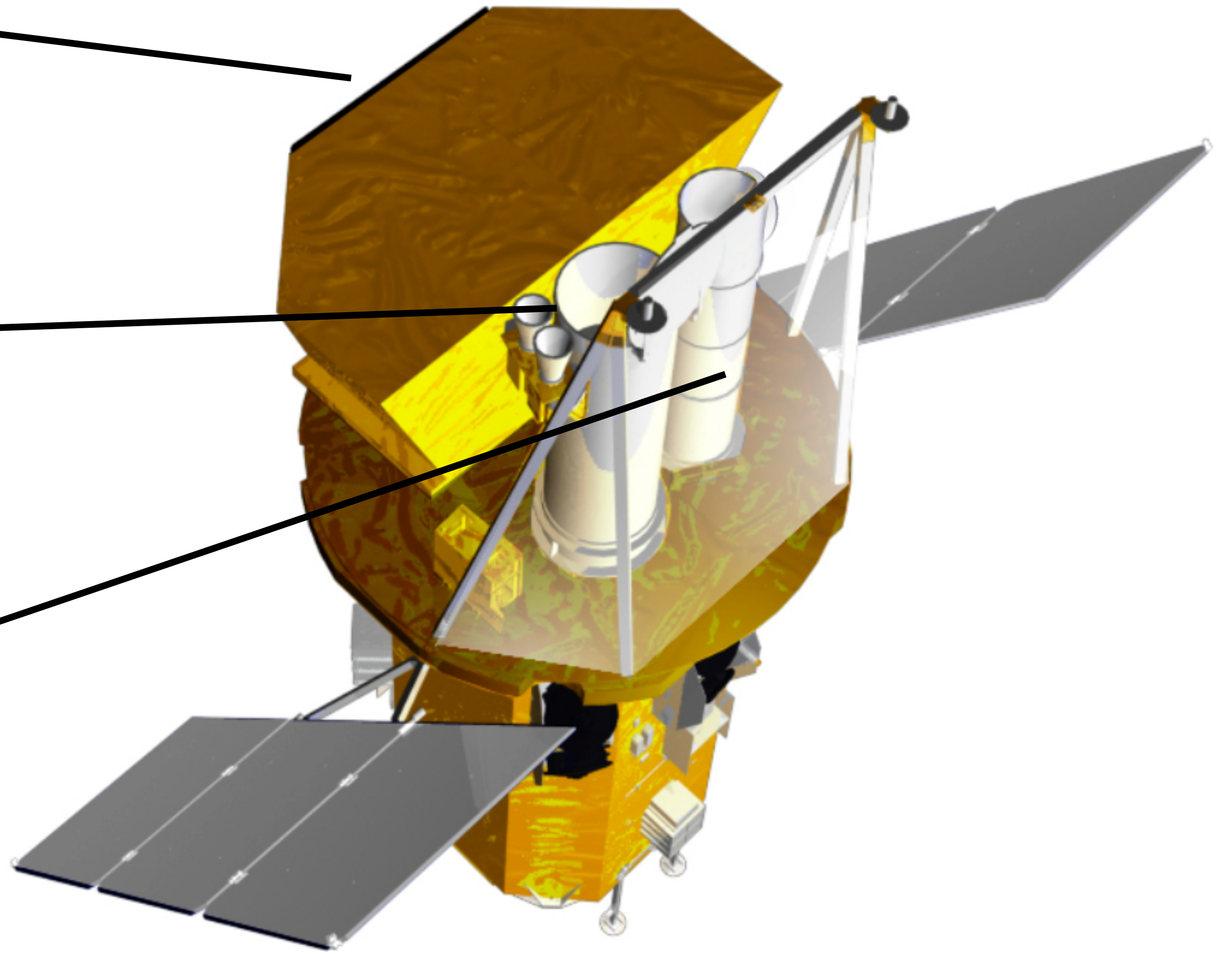
=VT



GRB response (1): synposis

- T_0 BAT triggers on the GRB; SMS alerts sent to on-call team.
- T_0+2 min On-call team convene telecon, log into web tools.
- … Limited data products downlinked over TDRSS.
- T_0+20-30 min Initial GCN Circular produced.

…

- T_0+2+hr Full dataset downlinked via ground stations.
- T_0+12-24 hr “Refined anlaysis” circulars produced.

…

- Daily Reports on evolution and external follow up, decisions made about further observations.

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Nowadays, much of this is automated for *Swift.* We will be practising the “olden days”!

GRB response (2): Response Team

A standard GRB response team for Swift requires 5 people:

- Burst Advocate (BA) — Overall responsibility for the burst and daily reporting.
- BAT Specialist (BBS)
- XRT Specialist (XBS)
- UVOT Specialist (UBS)
- Observatory Duty Scientist (ODS)

  Checks safety of observations / interaction with other observations, and performs/ kills “Automated Target” observations until the GRB is in the daily science plan.

GRB response (2): Response Team

Our training will involve 4 people.

- Burst Advocate (BA)
- BAT Specialist (BBS)
- XRT Specialist (XBS)
- UVOT Specialist (UBS)

Can be one of the below.

These work together to produce the initial circular: each instrument specialist responsible for one section. The BA is responsible for various checks and final sign-off.

These are a team, not working in isolation; each instrument's results inform the others.

Interlude: the initial circular

The immediate responsibility of the on-call team when BAT triggers is to determine:

- Is this a GRB? If not, what is it?
- Where is it?
- Which instruments saw it, and roughly how bright.

Accuracy is vital; generally speed is more important than precision.

The target audience are astronomers trying to decide whether and how to observe, not people trying to write a paper.

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i.e. “~19 mag” is OK, if “19.21 mag” is going to take a while.

“~19 mag” is not OK if the source is actually 17th mag!

Interlude: the initial circular

Authors

J.D. Gropp (PSU), S. D. Barthelmy (GSFC), D. N. Burrows (PSU),
J. A. Kennea (PSU), S. Laha (GSFC/UMBC/CRESST),
A. Y. Lien (GSFC/UMBC), F. E. Marshall (NASA/GSFC),
D. M. Palmer (LANL), B. Sbarufatti (PSU), M. H. Siegel (PSU) and
A. Tohuvavohu (U Toronto) report on behalf of the Neil Gehrels Swift
Observatory Team:

BAT paragraph

At 22:50:39 UT, the Swift Burst Alert Telescope (BAT) triggered and
located GRB 200306C (trigger=960102). Swift slewed immediately to the burst.
The BAT on-board calculated location is
RA, Dec 198.582, +11.255 which is
RA(J2000) = 13h 14m 20s
Dec(J2000) = +11d 15' 18"
with an uncertainty of 3 arcmin (radius, 90% containment, including
systematic uncertainty). The BAT light curve showed a complex
structure with a duration of about 50 sec. The peak count rate
was ~1800 counts/sec (15-350 keV), at ~3 sec after the trigger.

Interlude: the initial circular

XRT paragraph

```
The XRT began observing the field at 22:52:35.9 UT, 116.9 seconds after
the BAT trigger. Using promptly downlinked data we find a fading,
uncatalogued X-ray source located at RA, Dec 198.55562, 11.26981 which
is equivalent to:
   RA(J2000)  = 13h 14m 13.35s
   Dec(J2000) = +11d 16' 11.3"
with an uncertainty of 3.5 arcseconds (radius, 90% containment). This
location is 107 arcseconds from the BAT onboard position, within the
BAT error circle.
```

Interlude: the initial circular

UVOT paragraph

UVOT took a finding chart exposure of 250 seconds with the U filter starting
117 seconds after the BAT trigger. There is a candidate afterglow in the list
of sources generated on-board at
  RA(J2000) = 13:14:13.44 = 198.55602
  DEC(J2000) = +11:16:11.5 = 11.26985
with a 90%-confidence error radius of about 1.10 arc sec. This position is 1.4
arc sec. from the center of the XRT error circle. The estimated magnitude is
17.47. No correction has been made for the expected extinction corresponding to
E(B-V) of 0.02.

Extra paragraph

Burst Advocate for this burst is J.D. Gropp (jdg44 AT psu.edu).
Please contact the BA by email if you require additional information
regarding Swift followup of this burst. In extremely urgent cases, after
trying the Burst Advocate, you can contact the Swift PI by phone (see
Swift TOO web site for information: http://www.swift.psu.edu/)

GRB response (3a): BBS job

The BAT Burst Specialist carries out the BAT analysis and produces the BAT paragraph. 😳

- GRB time/date.
- Report BAT position.
- Did the satellite slew?
- Some details of the trigger / light curve.

They should also provide an expert opinion on various questions:

- Was the trigger an astrophysical event, or something else?
- Is it a short or long GRB?
- Is it definitely a GRB or possibly something else?
  - For example, a long trigger near the Galactic plane may well be a Galactic event.

GRB response (3b): XBS job

The XRT Burst Specialist carries out the XRT analysis and produces the XRT paragraph. 😳

- XRT position (or how much data with no detection).
- Position relative to the BAT position.
- Is the XRT source catalogued?
- Is it bright / fading?

The XRT data and situation evolve more frequently than either other instrument, with deliveries of data as often as every 2 minutes.

GRB response (3c): UBS job

The UVOT Burst Specialist carries out the UVOT analysis and produces the UVOT paragraph.

- UVOT position, or report of its absence.
- Position relative to the BAT & XRT positions.
  - Coverage of those regions.
- Magnitude.
  - Upper limit

GRB response (3d): BA job

The BA has the overall responsibility for the burst, including daily reporting and ‘advocating’ for whether to keep observing it. They will also coordinate the initial response.

- Check the title of the circular.
  - Is the name correct (midnight!!)? Is the trigger classified OK?
- Ultimately decides if it’s reported as a {probable,possible,definite} GRB; Galactic event; noise, uncertain.
- Will make the call when the submit the circular.

Then submit the circular

Then submit the circular

But, err, how do we do all of that?

Buckle your seatbelt…

Data delivery

The limited data products we have in real time for *Swift* come through TDRSS, and are distributed by GCN as *Notices*.

These can be received as TCP packets (machine readable) or emails (human readable).

Anatomy of a notice

A notice contains 3 key parts:

- Type (= title / subject)
- Body
- Attachments (optional)

As well as being received by email, the GCNs are posted online.

For the hands-on sessions we'll be using a website to get the data.

GCN notices for target: GRB 200306C

- Click on GCN date to see whole message
- Click on individual part to view/download

GCN Date	Notice Type	parts
2020-03-06 22:51:20	Swift-BAT GRB Position	[body.txt]
2020-03-06 22:51:32	Swift-FOM Will_Observe	[body.txt]
2020-03-06 22:51:38	Swift-S/C Will_Slew	[body.txt]
2020-03-06 22:52:50	Swift-XRT Nack-Position	[body.txt]
2020-03-06 22:53:12	Swift-XRT Thresholded-Pixels	[body.txt][xrt_raw_threshpix1.fits.gz] [xrt_raw_threshpix_1.ps][png] [xrt_raw_threshpix_2.ps][png]
2020-03-06 22:53:18	Swift-XRT Processed Thresholded-Pixels	[body.txt]
2020-03-06 22:53:18	Swift-XRT Processed Thresholded-Pixels	[body.txt][xrt_proc_threshpix1.fits.gz] [xrt_proc_threshpix_1.ps][png] [xrt_proc_threshpix_2.ps][png]
2020-03-06 22:53:23	Swift-XRT Spectrum	[body.txt][xrt_raw_spec1.fits.gz] [xrt_raw_spec1.ps][png]
2020-03-06 22:53:30	Swift-XRT Processed Spectrum	[body.txt][xrt_proc_spec1.fits.gz] [xrt_proc_spec1.ps][png]
2020-03-06	Swift-XRT Spectrum	[body.txt][xrt_raw_spec2.fits.gz] [xrt_raw_spec2.ps][png]

Anatomy of a notice

```
TITLE:                GCN/SWIFT NOTICE
NOTICE_DATE:          2020-03-06T22:51:20
NOTICE_TYPE:          Swift-BAT GRB Position
TRIGGER_NUM:          960102
SEG_NUM:              0
GRB_RA:               198.582d {13h 14m 20s}
GRB_DEC:              +11.255d {+11d 15' 18"}
GRB_ERROR:            3.00 [arcmin radius, statistical only]
GRB_INTEN:            10731 [cnts]    Image_Peak=262 [image_cnts]
TRIGGER_DUR:          4.096 [sec]
TRIGGER_INDEX:        307     E_range: 50-350 keV
BKG_INTEN:            83343 [cnts]
BKG_TIME:             82183.44 SOD; {22:49:43.44} UT
BKG_DUR:              40 [sec]
GRB_DATE:             18914 TJD;   66 DOY;   2020/03/06
GRB_TIME:             82239.06 SOD; {22:50:39.06} UT
GRB_PHI:              58.49 [deg]
GRB_THETA:            30.63 [deg]
SOLN_STATUS:          0x2003
RATE_SIGNIF:          14.10 [sigma]
IMAGE_SIGNIF:         7.35 [sigma]
```

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2020-03-06 22:53:18	Swift-XRT Processed Thresholded-Pixels	[body.txt]
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GRB “walkthrough”

I’m going to go through an example GRB now - taking simply the most recent one as of when I wrote this talk (GRB 200306C).

I am **not** going into details of how to execute specific scripts and calculate specific values - those will be covered in the hands-on sessions.

With the hands-on training there are some materials giving guidance, by instrument, about every notice type you need to deal with.

This talk is not to turn you into experts, it’s to give you a feel for what happens, that we will build on in the hands-on.

This is Swift-specific, so the details are not as important as the principles and approach, which will — I hope! — be helpful when you have real, live, SVOM data.

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S/C Will_Slew notice

```
TITLE:              GCN/SWIFT NOTICE
NOTICE_DATE:        2020-03-06T22:51:38
NOTICE_TYPE:        Swift-S/C Will_Slew
TRIGGER_NUM:        960102
SEG_NUM:            0
GRB_RA:             198.582d {13h 14m 20s}
GRB_DEC:            +11.255d {+11d 15' 18"}
GRB_DATE:           18914 TJD;   66 DOY;   2020/03/06
GRB_TIME:           82239.06 SOD; {22:50:39.06} UT
TRIGGER_INDEX:      307
RATE_SIGNIF:        14.10 [sigma]
IMAGE_SIGNIF:       7.35 [sigma]
SLEW_QUERY:         0x0
WAIT_TIME:          0.00 [sec]
OBS_TIME:           2079.00 [sec]
INST_MODES:         BAT: 0=0x0   XRT: 0=0x0   UVOT: 32768=0x8000
MERIT:              100.00
SUN_POSTN:          347.88d {+23h 11m 32s}   -5.20d {-05d 11' 52\"}
SUN_DIST:           148.81 [deg]   Sun_angle= 9.9 [hr] (West of Sun)
MOON_POSTN:         131.36d {+08h 45m 28s}  +20.90d {+20d 53' 54\"}
MOON_DIST:          65.15 [deg]
MOON_ILLUM:         89 [%]
GAL_COORDS:         322.75, 73.24 [deg] galactic lon,lat of the burst (or transient)
ECL_COORDS:         192.68, 17.66 [deg] ecliptic lon,lat of the burst (or transient)
```

S/C Will_Slew notice

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GRB walkthrough: BAT (1).

BAT position notice

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GRB walkthrough: BAT (1).

BAT position notice

```
RATE_SIGNIF:          14.10 [sigma]
IMAGE_SIGNIF:         7.35 [sigma]
MERIT_PARAMS:         +1  +0  +0  +2  +3  -3  +0  +0 +85  +0
SUN_POSTN:            347.88d {+23h 11m 32s}   -5.20d {-05d 11' 53\"}
SUN_DIST:             148.81 [deg]   Sun_angle= 9.9 [hr] (West of Sun)
MOON_POSTN:           131.36d {+08h 45m 27s}  +20.90d {+20d 53' 56\"}
MOON_DIST:            65.16 [deg]
MOON_ILLUM:           89 [%]
GAL_COORDS:           322.75, 73.24 [deg] galactic lon,lat of the burst (or transient)
ECL_COORDS:           192.68, 17.66 [deg] ecliptic lon,lat of the burst (or transient)
COMMENT:              SWIFT-BAT GRB Coordinates.
COMMENT:              This is a rate trigger.
COMMENT:              A point_source was found.
COMMENT:              This does not match any source in the on-board catalog.
COMMENT:              This does not match any source in the ground catalog.
COMMENT:              There is a bright star (mag=5.67) 5.42 arcmin from this position.
COMMENT:              This is a GRB.
COMMENT:              This trigger occurred at longitude,latitude = 358.67,17.28 [deg].
```

GRB walkthrough: BAT (1).

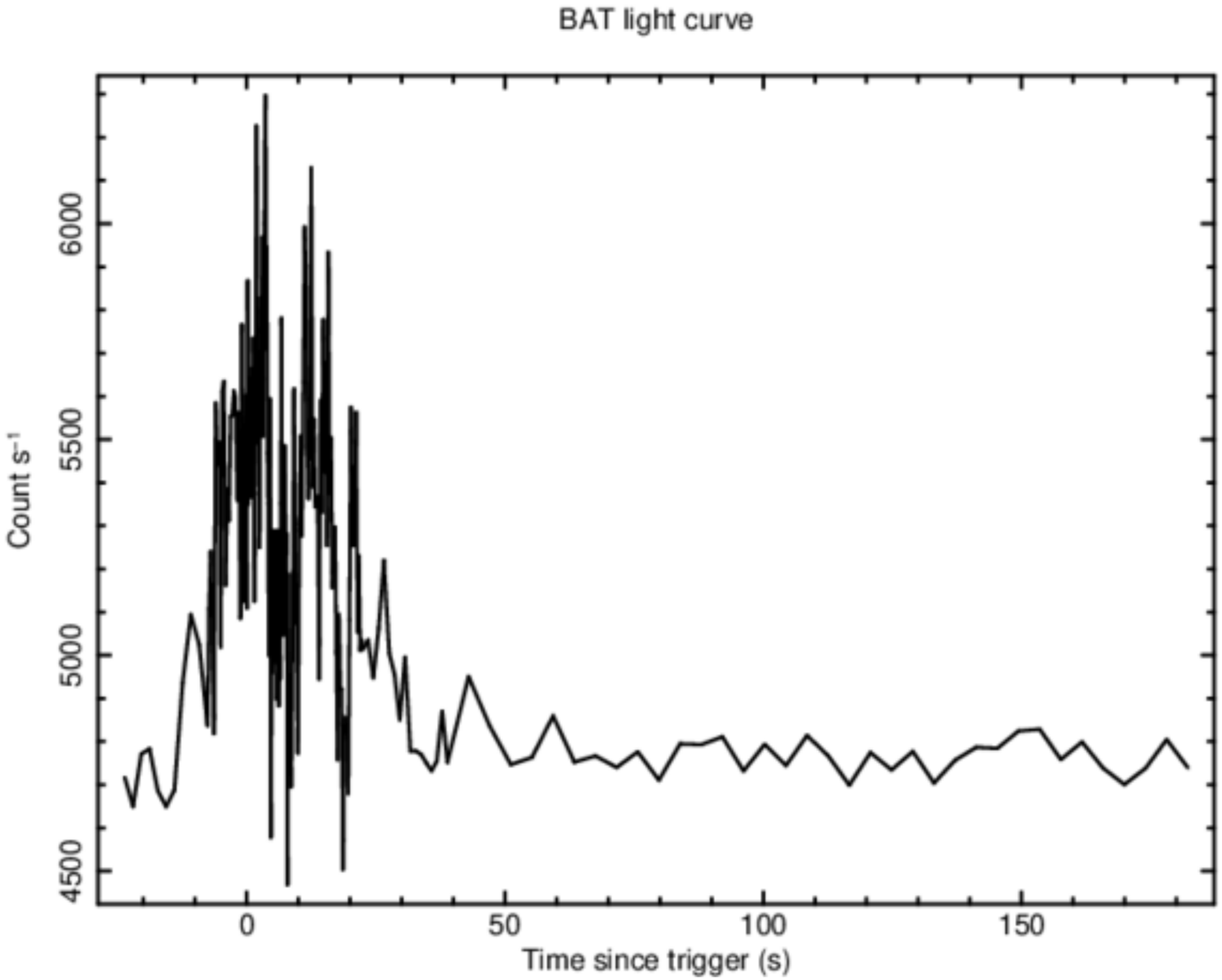
BAT position notice

```
* RATE_SIGNIF:          14.10 [sigma]
* IMAGE_SIGNIF:         7.35 [sigma]
  MERIT_PARAMS:         +1  +0  +0  +2  +3  -3  +0  +0 +85  +0
  SUN_POSTN:            347.88d {+23h 11m 32s}   -5.20d {-05d 11' 53\"}
  SUN_DIST:             148.81 [deg]   Sun_angle= 9.9 [hr] (West of Sun)
  MOON_POSTN:           131.36d {+08h 45m 27s}  +20.90d {+20d 53' 56\"}
  MOON_DIST:            65.16 [deg]
  MOON_ILLUM:           89 [%]
* GAL_COORDS:           322.75, 73.24 [deg] galactic lon,lat of the burst (or transient)
  ECL_COORDS:           192.68, 17.66 [deg] ecliptic lon,lat of the burst (or transient)
  COMMENT:              SWIFT-BAT GRB Coordinates.
  COMMENT:              This is a rate trigger.
  COMMENT:              A point_source was found.
  COMMENT:              This does not match any source in the on-board catalog.
  COMMENT:              This does not match any source in the ground catalog.
  COMMENT:              There is a bright star (mag=5.67) 5.42 arcmin from this position.
  COMMENT:              This is a GRB.
  COMMENT:              This trigger occurred at longitude,latitude = 358.67,17.28 [deg].
```

GRB walkthrough: BAT (2).

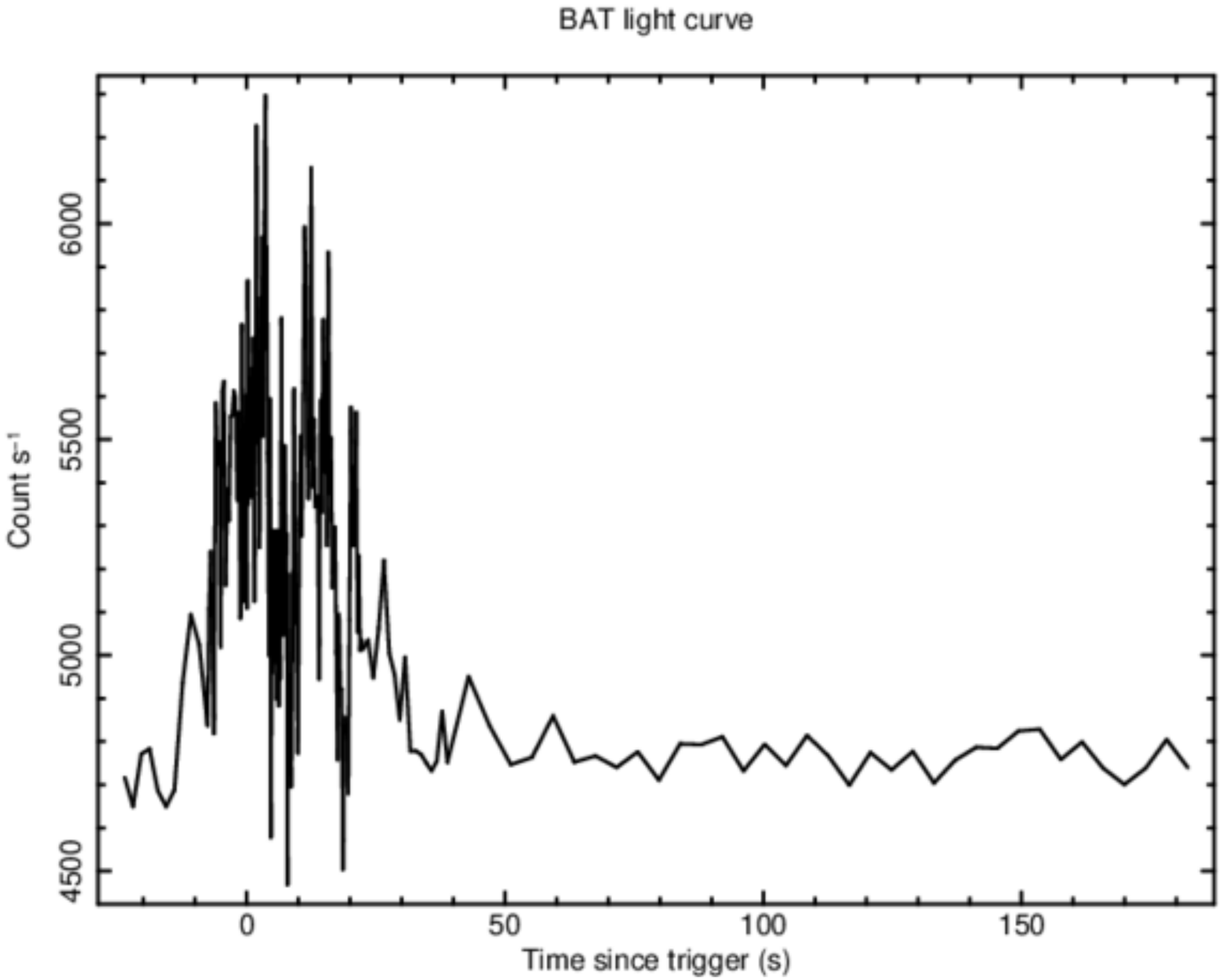
22:53:18	Thresholded-Pixels	[xrt_proc_threshpix_2.ps][png]
2020-03-06 22:53:23	Swift-XRT Spectrum	[body.txt][xrt_raw_spec1.fits.gz] [xrt_raw_spec1.ps][png]
2020-03-06 22:53:30	Swift-XRT Processed Spectrum	[body.txt][xrt_proc_spec1.fits.gz] [xrt_proc_spec1.ps][png]
2020-03-06 22:53:41	Swift-XRT Spectrum	[body.txt][xrt_raw_spec2.fits.gz] [xrt_raw_spec2.ps][png]
2020-03-06 22:53:53	Swift-XRT Processed Spectrum	[body.txt][xrt_proc_spec2.fits.gz] [xrt_proc_spec2.ps][png]
2020-03-06 22:54:24	Swift-BAT GRB Lightcurve	[body.txt][bat_attitude.fits.gz] [bat_raw_lc.fits.gz] [bat_raw_lc.ps][png] [bat_raw_lc_multiband.ps][png]
2020-03-06 22:54:33	Swift-BAT GRB Lightcurve	[body.txt][bat_raw_lcx.fits.gz] [bat_attitudex.fits.gz] [bat_raw_lcx.ps][png] [bat_raw_lcx_multiband.ps][png]
2020-03-06 22:56:12	Swift-XRT Single-Pixel-Event-Report	[body.txt]
2020-03-06 22:56:12	Swift-XRT Single-Pixel-Event-Report	[body.txt][xrt_raw_sper.fits.gz] [xrt_raw_sper_image.fits.gz][png]
2020-03-06 22:56:19	Swift-XRT Lightcurve	[body.txt][xrt_raw_lc.fits.gz] [xrt_raw_lc.ps][png]

GRB walkthrough: BAT (2).



BAT light curve notice

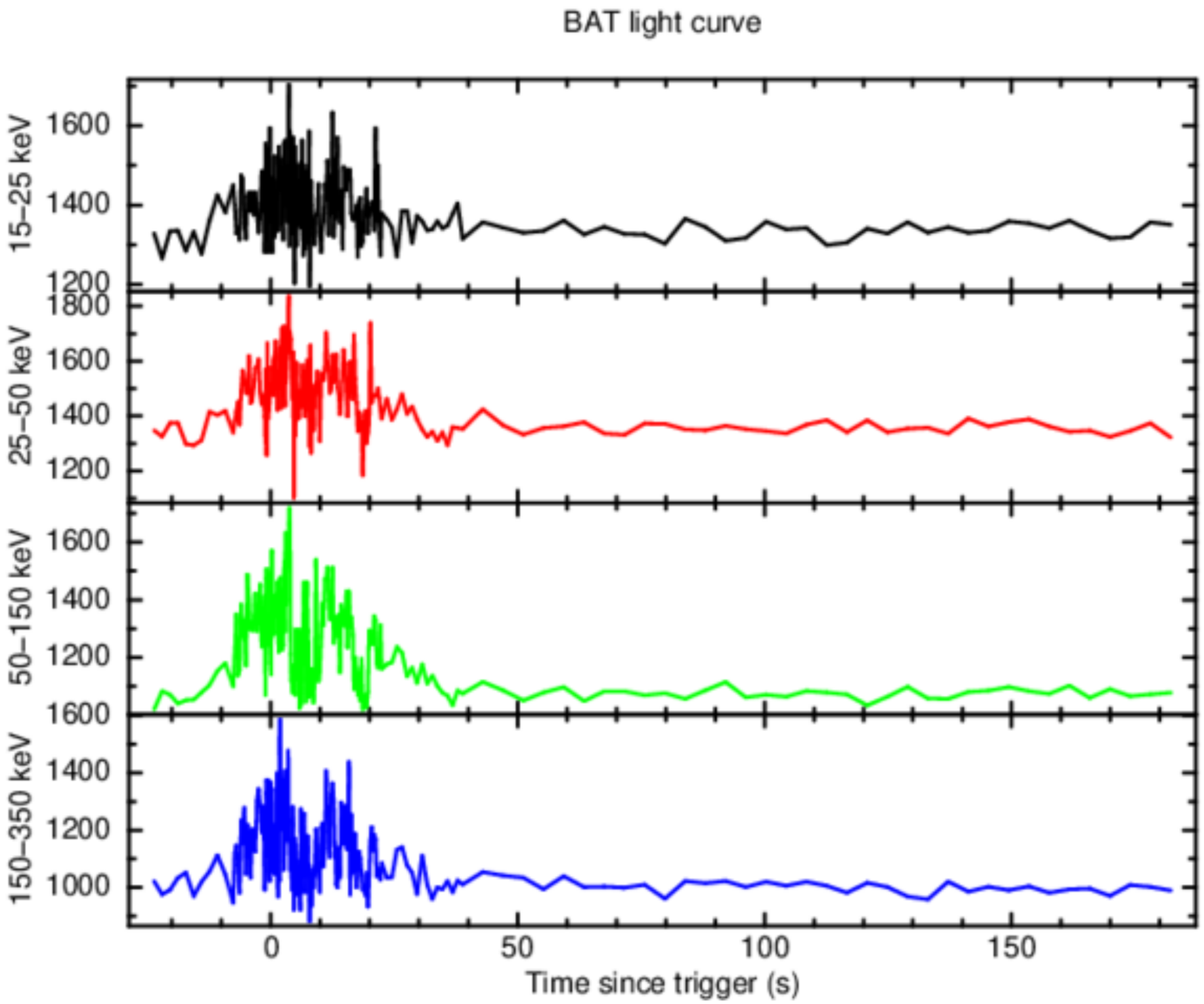
GRB walkthrough: BAT (2).



BAT light curve notice

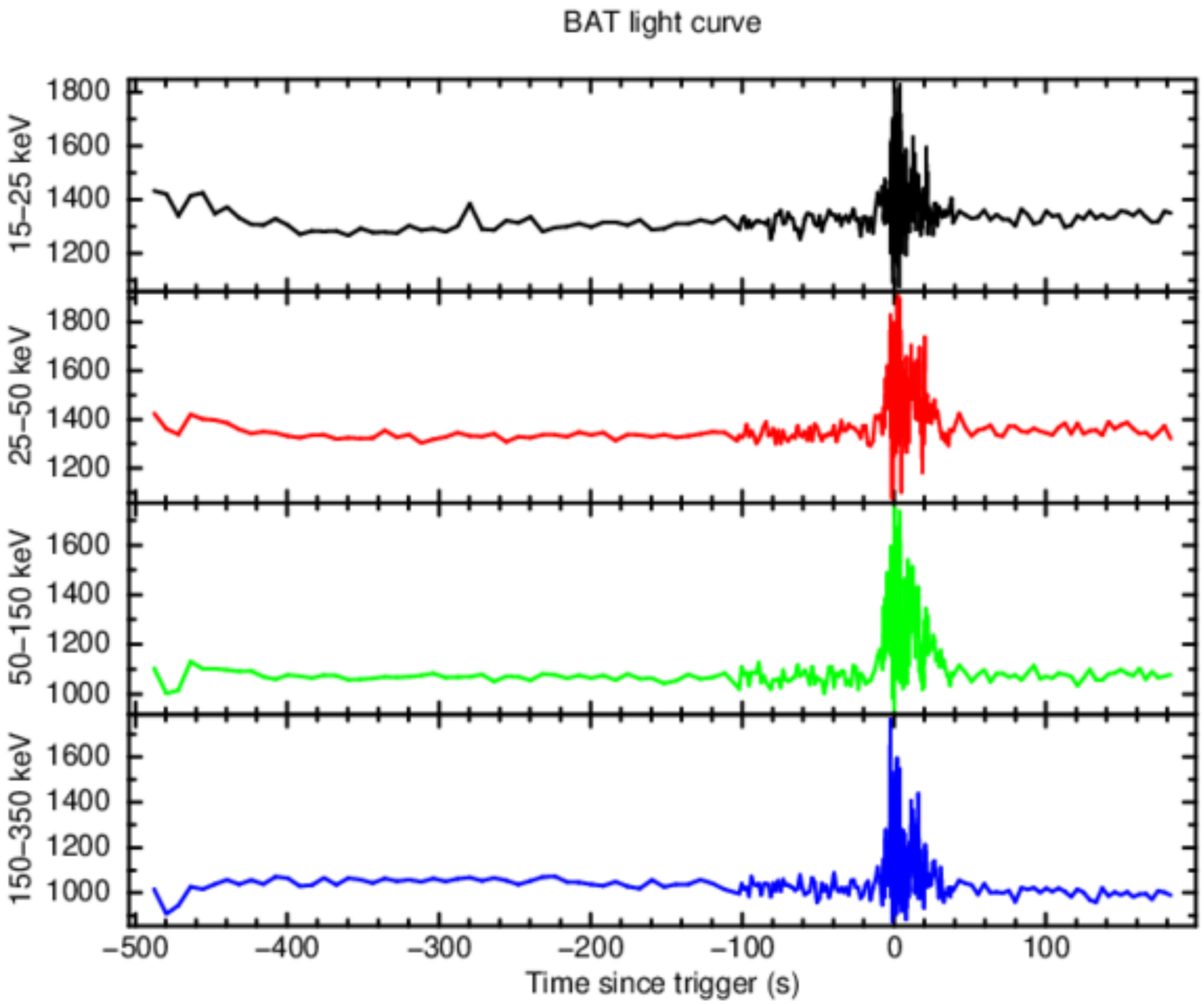
The BAT light curve shows a complex, multi-peaked structure with a duration of about 40s. The peak count-rate is ~1,400 ct/sec at ~3 sec after the trigger.

GRB walkthrough: BAT (2).



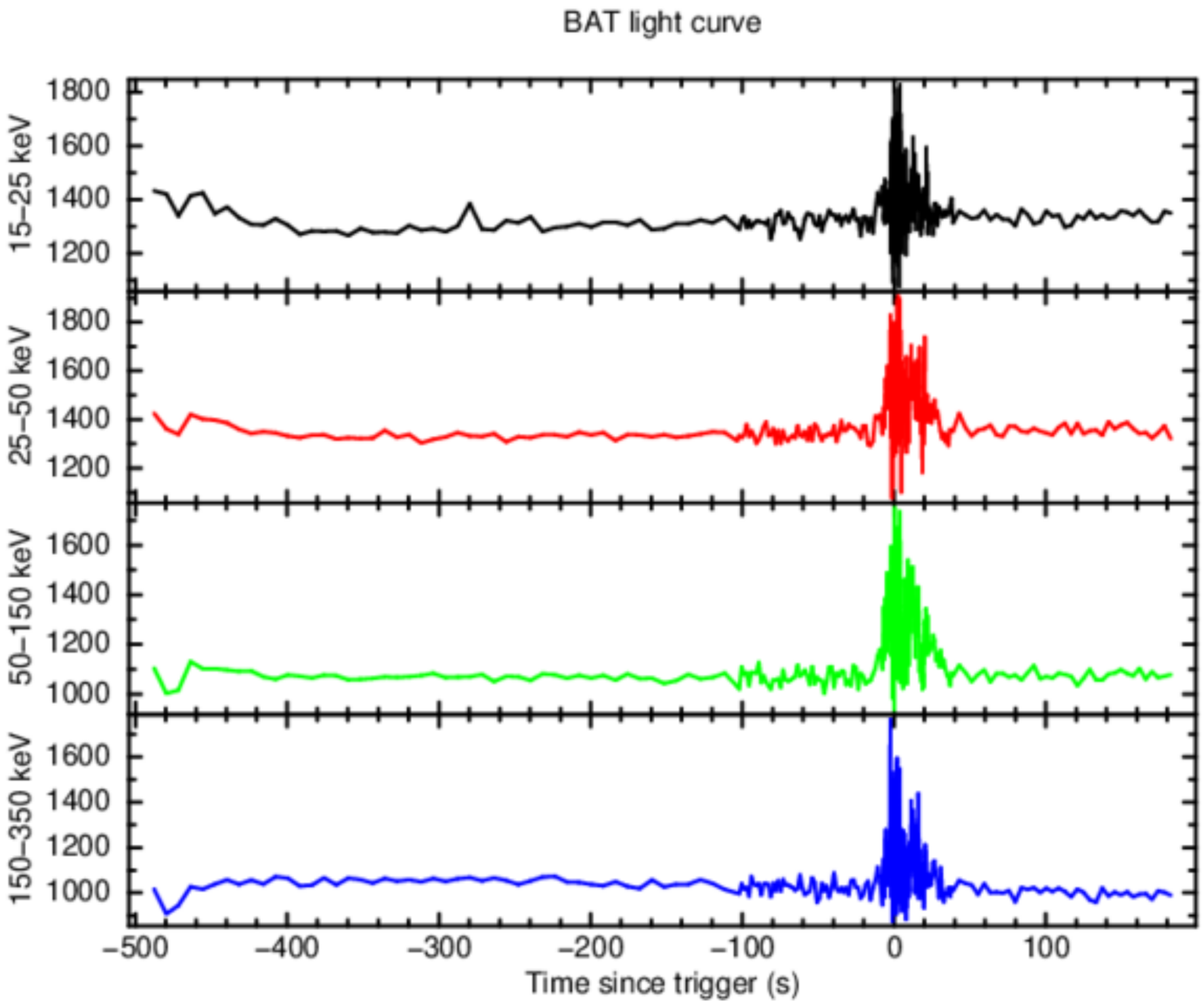
BAT light curve notice

GRB walkthrough: BAT (2).



BAT light curve notice

GRB walkthrough: BAT (2).



BAT light curve notice

The image preview is not always suitable. In that case, one has to plot it manually using the `fplot` tool.

Instructions are in the guidance notes, and the hands-on sessions.

GRB walkthrough: BAT (3).

2020-03-06 23:01:22	Swift-XRT Processed Single-Pixel-Event-Report	[body.txt][xrt_proc_sper.fits.gz] [xrt_proc_sper_image.fits.gz][png]
2020-03-06 23:02:10	Swift-BAT Scaled Map	[body.txt][bat_scaledmap.fits.gz]
2020-03-06 23:02:42	Swift-BAT GRB Lightcurve	[body.txt][bat_raw_lcx.fits.gz] [bat_attitudex.fits.gz] [bat_raw_lcx.ps][png] [bat_raw_lcx_multiband.ps][png]
2020-03-06 23:04:33	Swift-XRT Single-Pixel-Event-Report	[body.txt][xrt_raw_sper.fits.gz] [xrt_raw_sper_image.fits.gz][png]
2020-03-06	Swift-XRT Processed Single-	[body.txt][xrt_proc_sper.fits.gz] [xrt_proc_sper_image.fits.gz][png]

The scaled map can be used to make an image.
We will cover this in the hands-on session but it's somewhat esoteric so not important to us here.

GRB walkthrough: BAT (4).

Other things for the BBS to check:

- Does it look short and hard? i.e. short GRB.
- Is it near the plane/bulge
  - If yes, is it a particularly long trigger, or (for example) short and soft?

The BBS does not need to decide "This is / is not a GRB". They present their opinion, based on the BAT data, which will be combined with what the XBS and UBS find.

GRB walkthrough: BAT summary

The BBS job involves:

- Cut and paste.
- Examining and describing the light curve.
- Was it real? Was it a GRB?

```
At 22:50:39 UT, the Swift Burst Alert Telescope (BAT) triggered and
located GRB 200306C (trigger=960102).  Swift slewed immediately to the burst.
The BAT on-board calculated location is
RA, Dec 198.582, +11.255 which is
   RA(J2000) = 13h 14m 20s
   Dec(J2000) = +11d 15' 18"
with an uncertainty of 3 arcmin (radius, 90% containment, including
systematic uncertainty).  The BAT light curve showed a complex
structure with a duration of about 50 sec.  The peak count rate
was ~1800 counts/sec (15-350 keV), at ~3 sec after the trigger.
```

GRB walkthrough: XRT (1).

XRT produces a lot of notices which can feel overwhelming. We do not care about them all.

We just want to know:

- Did we find an X-ray afterglow? Where?

So there are really only 3 types of notice we need:

- XRT (Nack) position
- XRT Image
- SPER

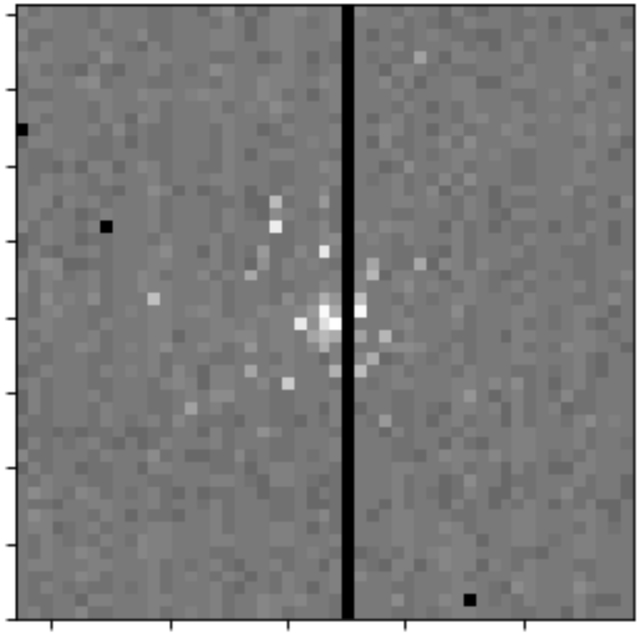
GRB walkthrough: XRT (2a).

XRT Position notice

```
   TITLE:                GCN/SWIFT NOTICE
   NOTICE_DATE:          2018-06-30T11:13:38
   NOTICE_TYPE:          Swift-XRT Position
   TRIGGER_NUM:          845443
   SEG_NUM:              0
*  GRB_RA:               48.9475d {03h 15m 47.40s}
*  GRB_DEC:              -87.4786d {-87d 28' 43.0"}
*  GRB_ERROR:            6.1 [arcsec radius, statistical plus systematic, 90% containment]
   GRB_INTEN:            6.12e-10 [erg/cm2/sec]
   GRB_SIGNIF:           5.38 [sigma]
   IMG_START_DATE:       18299 TJD;   181 DOY;   2018/06/30
*  IMG_START_TIME:       40393.40 SOD; {11:13:13.40} UT ; 81.60 [sec] since BAT Trigger Ti
   <snip>
   MOON_ILLUM:           95 [%]
   GAL_COORDS:           301.23,-29.16 [deg] galactic lon,lat of the burst
   ECL_COORDS:           274.50,-68.40 [deg] ecliptic lon,lat of the burst
   COMMENT:              SWIFT-XRT Coordinates.
*  COMMENT:              The XRT position is 0.41 arcmin from the BAT position.
```

GRB walkthrough: XRT (3).

11:12:27		
2018-06-30 11:13:38	Swift-XRT Position	[body.txt]
2018-06-30 11:13:48	Swift-XRT Image	[body.txt][xrt_raw_image.fits.gz] [xrt_raw_image.ps][png]
2018-06-30	Swift-XRT Processed	



GRB walkthrough: XRT (2b).

XRT Nack-Position notice

```
TITLE:                GCN/SWIFT NOTICE
NOTICE_DATE:          2020-03-06T22:52:50
NOTICE_TYPE:          Swift-XRT Nack-Position
TRIGGER_NUM:          960102
SEG_NUM:              0
POINT_RA:             198.5820d {13h 14m 19.68s}
POINT_DEC:            +11.2670d {+11d 16' 1.2"}
IMG_START_DATE:       18914 TJD;   66 DOY;   2020/03/06
* IMG_START_TIME:     82355.97 SOD; {22:52:35.97} UT ; 116.87 [sec] since BAT Trigger T
COUNTS:               21    Min_needed= 20
STD_DEV:              32.76   Max_StdDev_for_Good=28.44 [arcsec]
ERROR_CODE:           3
COMMENT:              SWIFT-XRT Nack Position.
COMMENT:              Standard deviation too large.
```

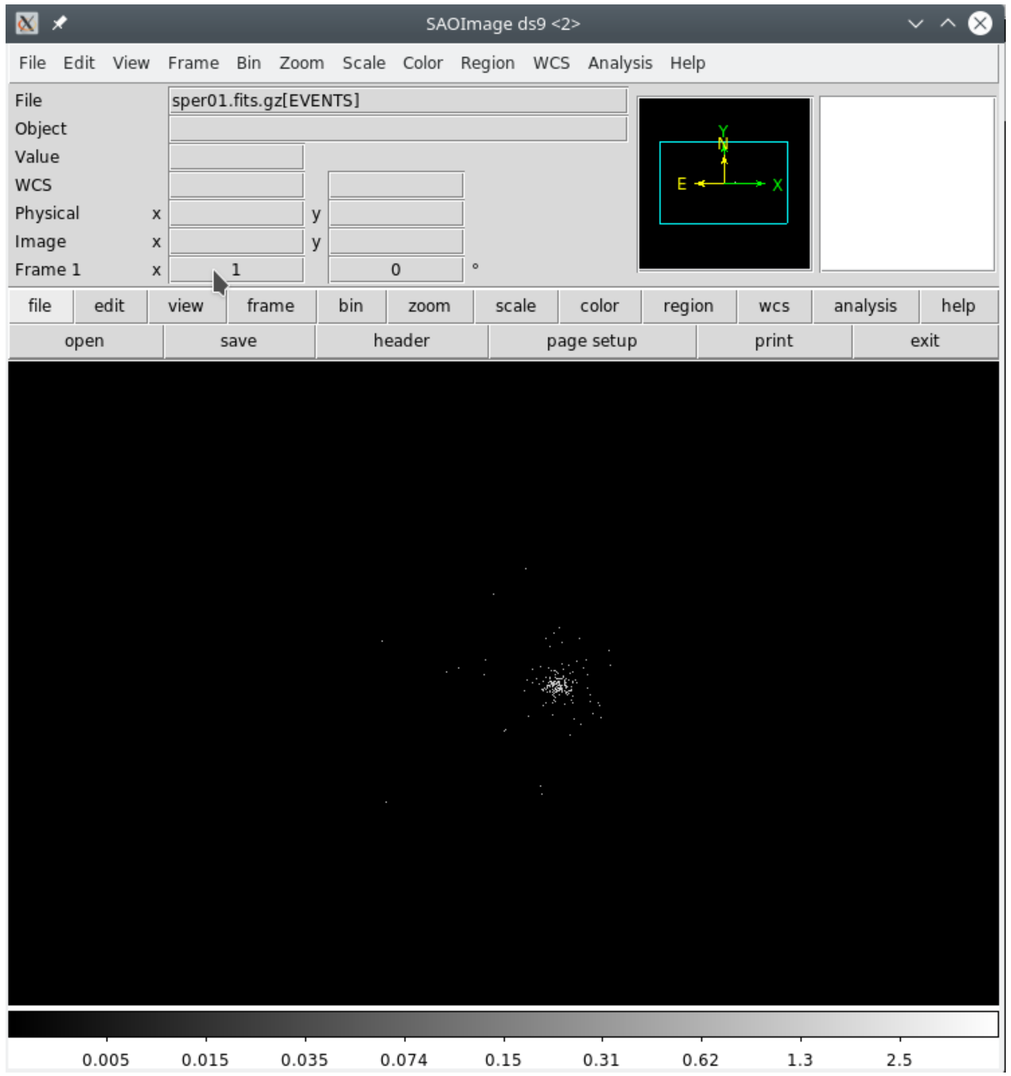
GRB walkthrough: XRT (4).

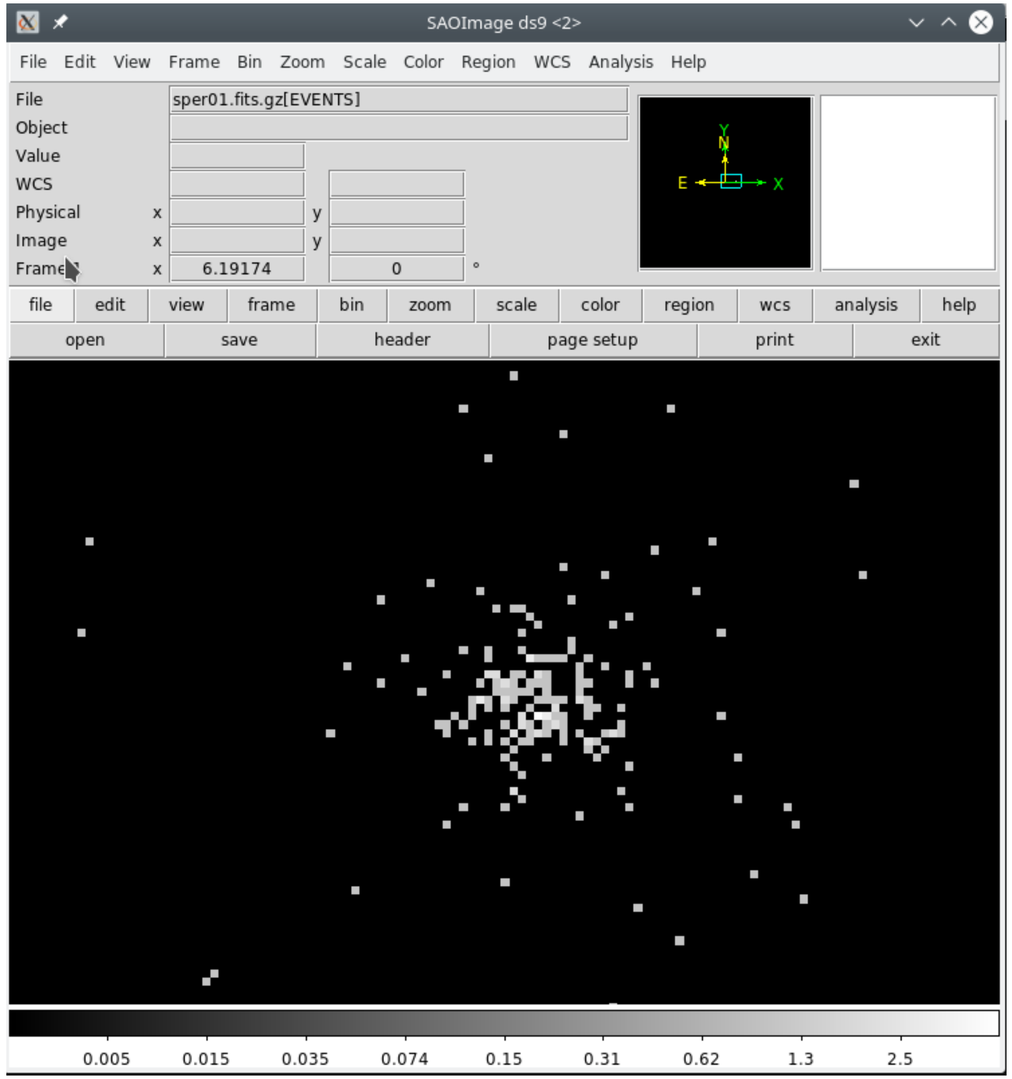
SPER data

- Single Pixel Event Report.
- Grade 0 (single pixel) events within the central 200x200 pixel window
- PC mode only.
- Not dependent on whether there was an on-board position.
- These require manual effort to analyse — `ftools` and `ds9`.

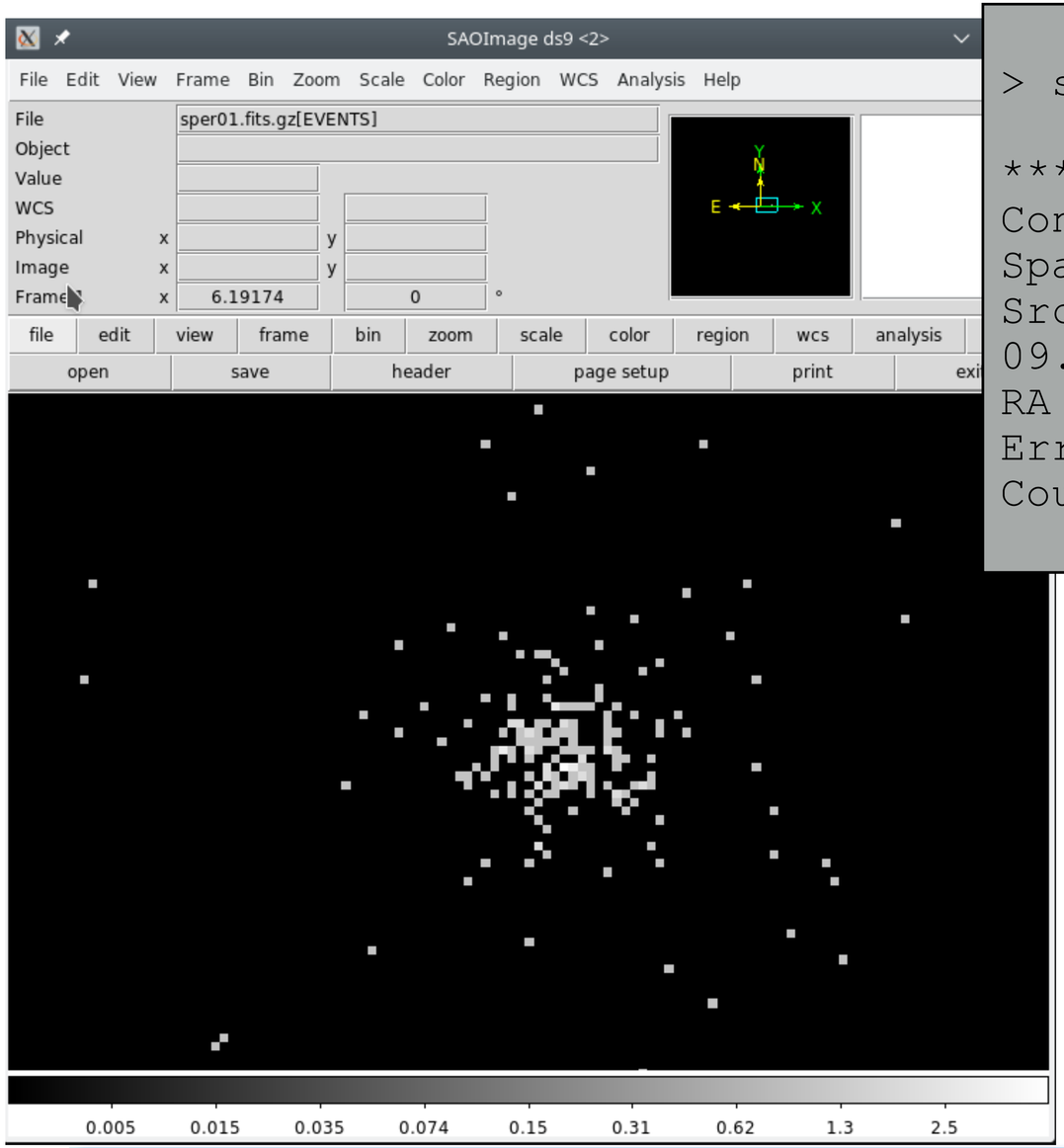
From this we will look for an afterglow and check its position.

GRB walkthrough: XRT (4).





GRB walkthrough: XRT (4).




```
> sper_sky.pl

**** Running swifttime v1.7 ****
Converted time: 56095.6721359795483
Spacecraft clock correction (-6.328170 s) was applied
Src: 1 RA (J2000): 18 51 14.33   Dec (J2000): -00 00
09.4
RA (J2000): 282.80971 Dec (J2000): -0.00261
Err: 3.500”
Counts: 188
```

GRB walkthrough: XRT (5).

```
The XRT began observing the field at 22:52:35.9 UT, 116.9 seconds after
the BAT trigger. Using promptly downlinked data we find a fading,
uncatalogued X-ray source located at RA, Dec 198.55562, 11.26981 which
is equivalent to:
   RA(J2000)  = 13h 14m 13.35s
   Dec(J2000) = +11d 16' 11.3"
with an uncertainty of 3.5 arcseconds (radius, 90% containment). This
location is 107 arcseconds from the BAT onboard position, within the
BAT error circle.
```

Other things for the XBS to check:

- Is the onboard position a cosmic ray?
- Is the “afterglow" actually a known source? (Ignoring for this session).

GRB walkthrough: UVOT (1).

There are 2 UVOT products

- Image
- Source list

GRB walkthrough: UVOT (1).

There are 2 UVOT products

- Image
  - Not the full frame; windowed around BAT/XRT position
- Source list
  - Full frame.
  - Positions and magnitudes less accurate.

Can get multiple images and source lists, as Swift will normally take exposures in multiple filters.

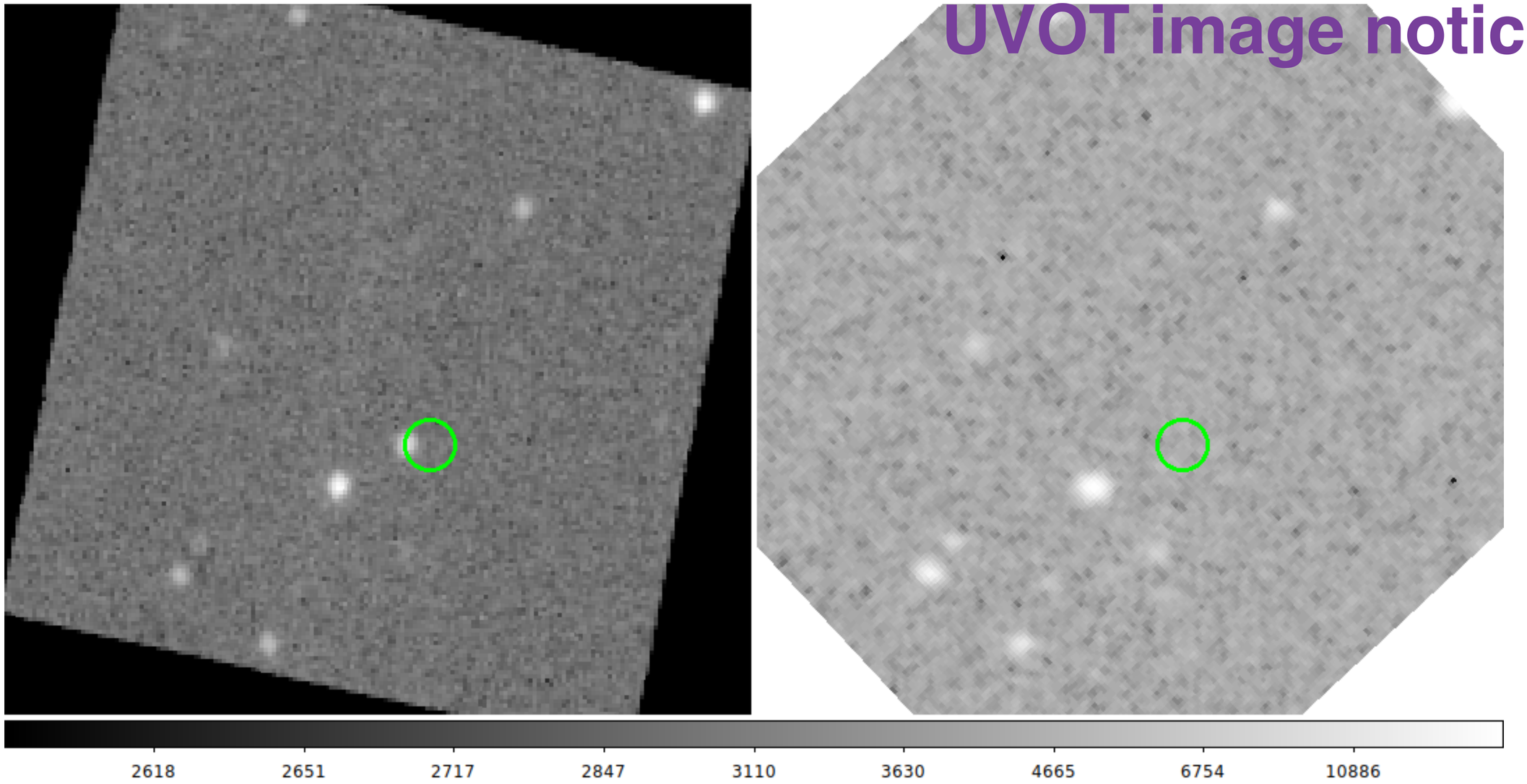
GRB walkthrough: UVOT (1).

23:09:41	Swift-BAT GRB Lightcurve	[bat_raw_lcx.ps][png] [bat_raw_lcx_multiband.ps][png]
2020-03-06 23:10:19	Swift-UVOT Source List	[body.txt][uvot_raw_srclist.fits.gz]
2020-03-06 23:10:44	Swift-UVOT Processed Source List	[body.txt][uvot_catalog_srclist.fits.gz] [uvot_field_srclist.ps.gz] [uvot_sky_srclist.fits.gz] [uvot_sources_srclist.fits.gz]
2020-03-06 23:11:33	Swift-UVOT Image	[body.txt][uvot_raw_image.fits.gz] [uvot_raw_image.ps][png]
2020-03-06 23:11:38	Swift-UVOT Processed Image	[body.txt][uvot_sources_image.fits.gz] [uvot_sky_image.fits.gz] [uvot_field_image.ps.gz] [uvot_catalog_image.fits.gz] [uvot_sky_image.ps][png]
2020-03-06	Swift-XRT Single-Pixel-	

GRB walkthrough: UVOT (2).

```
TITLE:                GCN/SWIFT NOTICE
NOTICE_DATE:          2018-06-30T11:17:40 TS:ASCII
NOTICE_TYPE:          Swift-UVOT Processed Image TYPE
TRIGGER_NUM:          845443 INT
SEG_NUM:              0 INT
POINT_RA:             48.5680d {03h 14m 16.3s}
POINT_DEC:            -87.4880d {+87d -29m -16.8s}
ROLL:                 50.006d
IMG_START_DATE:       18299 TJD; 181 DOY;  2018/06/30
* IMG_START_TIME:     40399.36 SOD; {11:13:19.36} UT; 87.56 [sec] since BAT Trigger Tim
* FILTER:             10, White
EXPOSURE_ID:          552050020
<snip>
```

GRB walkthrough: UVOT (2).



GRB walkthrough: UVOT (2).

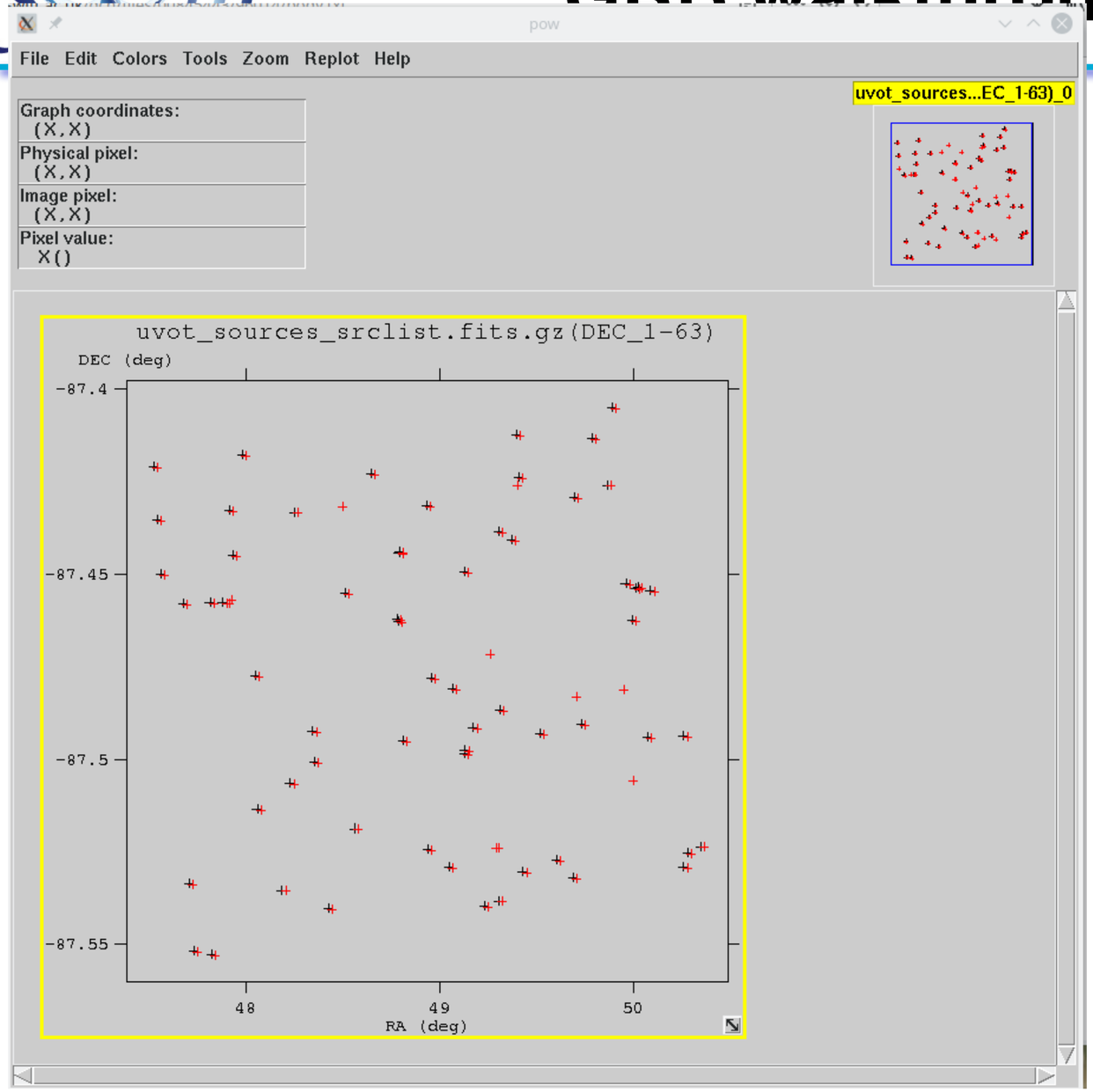
```
> uvotsource image=uvot_sky_01.fits.gz centroid=yes …

  Position: RA = 03h 15m 56.21s, Dec = -87d 28m 42.5s (J2000)
  Position: RA = 48.98421, Dec = -87.47846 (J2000)
  Exposure: 149.96 s
      Filter: WHITE

uvotsource: UVOT white magnitude (Vega system)
              Source: 17.48 +/- 0.04 (stat) +/- 0.04 (sys)
          Background: 23.65 arcsec^-2
    Background-limit: 20.75
   Coincidence-limit: 13.86
```

GRB walkthrough: UVOT (2).

UVOT sourcelist notice



GRB walkthrough: UVOT (3).

UVOT took a finding chart exposure of 150 seconds with the White filter starting 87 seconds after the BAT trigger. There is a candidate afterglow in the rapidly available 2.7'x2.7' sub-image at
  RA(J2000) = 03:15:56.02 = 48.98342
  DEC(J2000) = -87:28:42.4 = -87.47844
with a 90%-confidence error radius of about 0.62 arc sec. This position is 5.7 arc sec. from the center of the XRT error circle. The estimated magnitude is 17.44 with a 1-sigma error of about 0.14.

GRB walkthrough: BA

The BA role is not tied to specific data, but as the BA you need to:

- Communicate with the instrument specialists and make sure you know their status.
- Ultimately, based on what those specialists tell you, decide whether the object is a GRB / noise / other.
- Decide when to submit the GCN circular, and run the countdown:
  - Is the title OK (inc. correct GRB name)?
  - Is the BAT paragraph complete and OK?
  - Is the XRT paragraph complete and OK?
  - Is the UVOT paragraph complete and OK?
  - Is any extra paragraph needed? If so, is it complete and OK?

Reminder: the initial circular

The immediate responsibility of the on-call team when BAT triggers is to determine:

- Is this a GRB? If not, what is it?
- Where is it?
- Which instruments saw it, and roughly how bright.

Accuracy is vital; generally speed trumps precision.

The target audience are astronomers trying to decide whether and how to observe, not people trying to write a paper.

Reminder: the initial circular

The immediate responsibility of the on-call team when BAT triggers is to determine:

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- Which instruments saw it, and roughly how bright.

Accuracy is vital; generally speed trumps precision.

The target audience are astronomers trying to decide whether and how to observe, not people trying to write a paper.

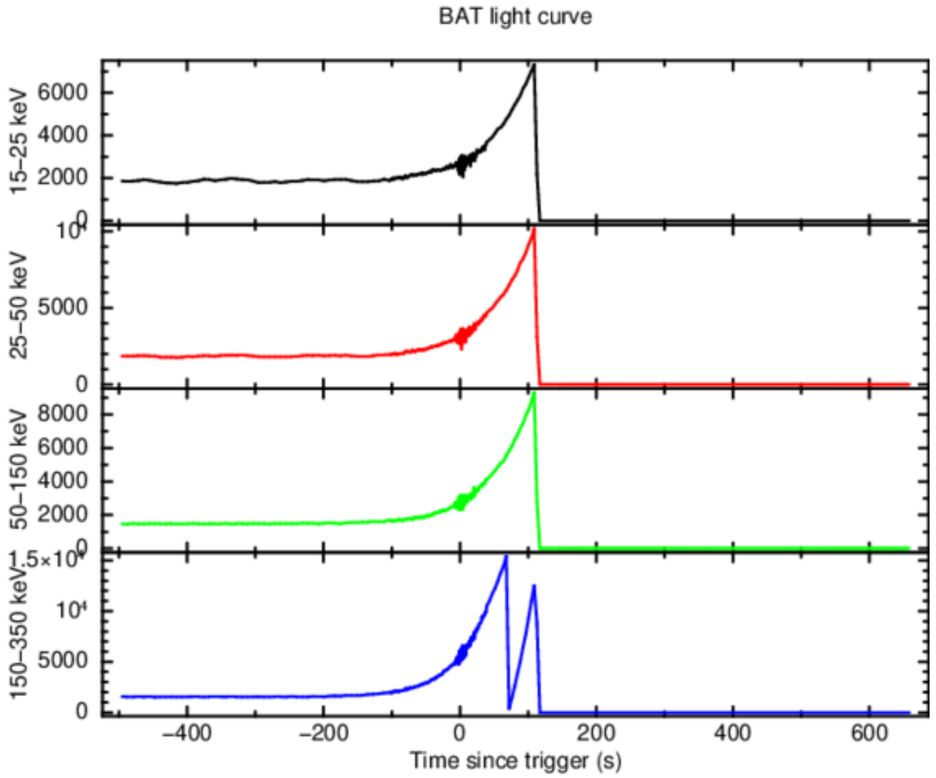
i.e. “~19 mag” is OK, if “19.21 mag” is going to take a while.

“~19 mag” is not OK if the source is actually 17th mag!

Gotchas / things to watch for

Lots of things can go wrong, or confuse the issue. A few things to look out for.

- Spurious trigger, e.g. cosmic ray, electronic noise, or SAA entry.
  - Light curve analysis! (e.g. are all events in one frame? Or gradual rise?)



Gotchas / things to watch for

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- Real trigger, but not a GRB.
  - Check trigger length, Galactic coordinates, catalogues etc.
- XRT centroid is a cosmic ray.

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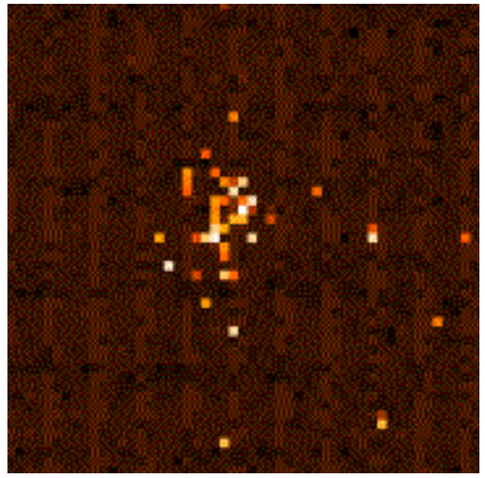
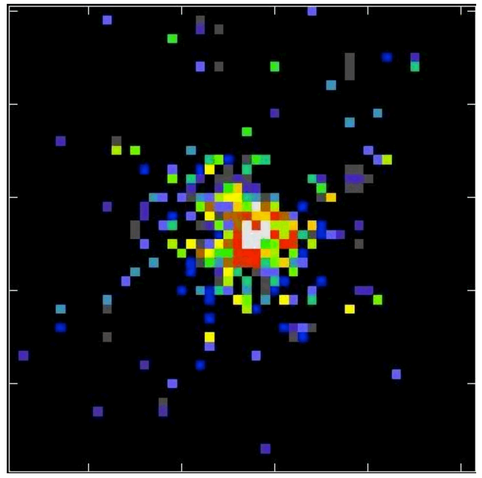
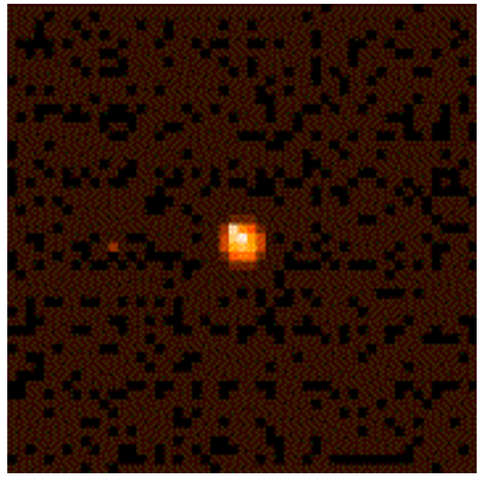
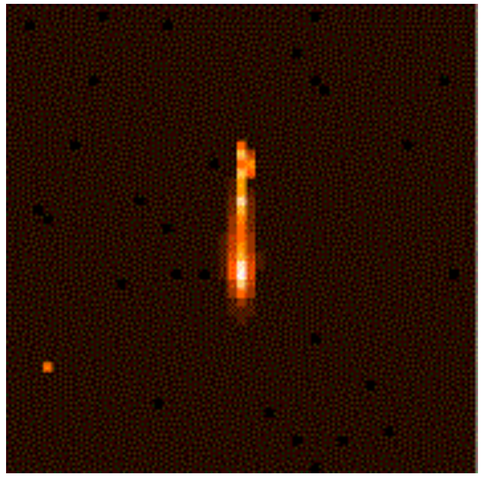

Gotchas / things to watch for

Lots of things can go wrong, or confuse the issue. A few things to look out for.

- Spurious trigger, e.g. cosmic ray, electronic noise, or SAA entry.
  - Light curve analysis! (e.g. are all events in one frame? Or gradual rise?)
- Real trigger, but not a GRB.
  - Check trigger length, Galactic coordinates, catalogues etc.
- XRT centroid is a cosmic ray.
- XRT ‘afterglow’ is a known source (may also indicate non-GRB trigger).
- (UVOT window is in the wrong place).

And last: hands-on sessions

For the hands-on sessions we will be “replaying” some real Swift BAT triggers.

Groups of 3-4 people (BBS, XBS, UBS; BA); the task will be to produce the text for an initial GCN Circular about the trigger.

Have made a GCN-like website, to which data will be drip-fed.

SVOM BA training — Swift GRB example 845443

#	Notice data	Notice type	Parts
01	2018-06-30 11:12:06	Swift-BAT GRB Position	body.txt
02	2018-06-30 11:12:18	Swift-FOM Will_Observe	body.txt
03	2018-06-30 11:12:27	Swift-S/C Will_Slew	body.txt
04	2018-06-30 11:13:38	Swift-XRT Position	body.txt
05	2018-06-30 11:13:48	Swift-XRT Image	body.txt | xrt_raw_image.fits.gz | xrt_raw_image.ps | xrt_raw_image.png
06	2018-06-30 11:13:50	Swift-XRT Processed Image	body.txt | xrt_proc_image.fits.gz | xrt_proc_image.ps | xrt_proc_image.png
07	2018-06-30 11:13:54	Swift-XRT Spectrum	body.txt | xrt_raw_spec1.fits.gz | xrt_raw_spec1.ps | xrt_raw_spec1.png
08	2018-06-30 11:14:01	Swift-XRT Processed Spectrum	body.txt | xrt_proc_spec1.fits.gz | xrt_proc_spec1.ps | xrt_proc_spec1.png
09	2018-06-30 11:14:11	Swift-XRT Thresholded-Pixels	body.txt | xrt_raw_threshpix1.fits.gz | xrt_raw_threshpix_1.ps | xrt_raw_threshpix_1.png
10	2018-06-30 11:14:15	Swift-XRT Processed Thresholded-Pixels	body.txt | xrt_proc_threshpix1.fits.gz | xrt_proc_threshpix_1.ps | xrt_proc_threshpix_1.png
11	2018-06-30 11:14:45	Swift-XRT Spectrum	body.txt | xrt_raw_spec2.fits.gz | xrt_raw_spec2.ps |

And last: hands-on sessions

For the hands-on sessions we will be “replaying” some real Swift BAT triggers.

Groups of 3-4 people (BBS, XBS, UBS; BA); the task will be to produce the text for an initial GCN Circular about the trigger.

Have made a GCN-like website, to which data will be drip-fed.

For Swift, we have a custom website for producing GCNs: quickGCN (more info on request). For hands-on we will have either a Google doc per group, or just using text editors.

And last: hands-on sessions

I don’t think it would be helpful for me, now, to go through a bunch of detailed commands to run: we will meet those in the session.

Have a look, on your machines, at `file:///home/svomba/swift/materials/guides.html` - this gives instructions for each team member, and each notice type.

There are also some template titles and paragraphs in `/home/svomba/swift/materials/templates.txt`

We will work through a few triggers (swapping roles), with Diego and me to offer support.

What we won't practise

12-24 hours after the GRB, with ground data, XBS produces:

- Light curve
- Spectrum
- Best position

Distribute these in a "refined analysis" circular (similar for other instruments).

Daily (XBS)

- Update the light curve. Fit and predict flux for coming days.
- Report on a Wiki page.
- BA gives an update on daily telecon, including external reports.
- Advocates for whether or not to keep observing.
- Final decision rests with the Swift PI.