Status of Swift Operations & Instruments

John Nousek

Penn State University

San Diego AAS Meeting

January 12, 2005

Outline

- Operational status
- Spacecraft status
- Instrument status
  - Burst Alert Telescope (BAT)
  - X-Ray Telescope (XRT)
  - UV/Optical Telescope (UVOT)
- Science Operations plans

MOC Facility

Located in Bristol Office Park, State College, PA

~ 2 mi. from Penn State campus

Houses FOT & SOT:

Flight Operations Team (FOT)

– responsible for observatory Health & Safety

Science Operations Team (SOT)

- responsible for Scientific operation of Swift

Has continuously operated Swift successfully from L+80 minutes to now!

Mission Operations Personnel

- **Flight Operations Team – Mark Hilliard (Lead)**
  - **Harry Anderson, Chuck Cooper, Rob LaVerghetta, Justin Knavel, Doug Spiegel**
- **SpectrumAstro Spacecraft Team – Lisa Nelson (L&EO Director)**
  - **Jeff Schieler, Kent Mitterer, John Jordan, Eric Orrill, Igor Lazbin**
- **Science Operations Team – David Burrows (SOT Lead)**
  - **Sally Hunsberger, Jaime Kennea, Judy Racusin, David Morris, Mariya Ivanushkina**
- **Burst Alert Telescope Team – Scott Barthelmy (BAT Lead)**
  - **D. Palmer, E. Fenimore, C. Markwardt, J. Cummings, A. Parsons, J. Tueller, H. Krimm**
- **X-Ray Telescope Team – David Burrows (XRT Lead)**
  - **Joe Hill, Tony Abbey, Andy Beardmore, Claudio Pagani, Jaime Kennea**
- **UV/Optical Telescope Team – Pete Roming (UVOT Lead)**
  - **Phil Smith, Barry Hancock, Pat Broos, Scott Koch, Howard Huckle, Mary Carter**
- **NASA Swift Project Team – Joe Dezio (Project Manager)**
  - **Frank Marshall, Tim Gehringer, Renan Borelli, Dave Bundas, John Ong**
- **Swift Mission Operations Manager – Lou Parkinson (Mission Readiness Lead)**
- **Swift Mission Director – John Nousek**
  - **Margaret Chester, Tom Taylor, Alan Wells**
- **Swift Principal Investigator – Neil Gehrels**

Swift Activation Timeline

- **Week 1 – Nov 20 - 27**
  - **Activate spacecraft**
  - **Turn on instrument electronics**
- **Week 2 – Nov 28 – Dec 4**
  - **Spacecraft attitude control testing**
  - **BAT module activation**
- **Week 3 – Dec 4 – 11**
  - **XRT activation**
  - **Figure of Merit process testing**
- **Week 4 – Dec 12 – 19**
  - **Autonomous slew testing**
  - **UVOT activation**
- **Week 5 – Dec 20 – 27**
  - **GRB observations**
  - **XRT radiator orientation thermal tests**
- **Week 6 – Dec 28 – Jan 3**
  - **XRT Target of Opportunity test**
  - **Automated Target slewing enabled**
- **Week 7 – Jan 4 – Jan 11**
  - **UVOT High Voltage enabled**

Swift Milestones:

Dec 3 – BAT first source (Cyg X-1)

Dec 12 – XRT first light (Cas A)

Dec 17 – BAT first imaged GRB (GRB 041217)

Dec 23 – XRT first afterglow (GRB 041223)

Jan 12 – UVOT first light

See details at Mission Director's Daily Status Reports:

http://swift.gsfc.gov/docs/swift/operations/status_log

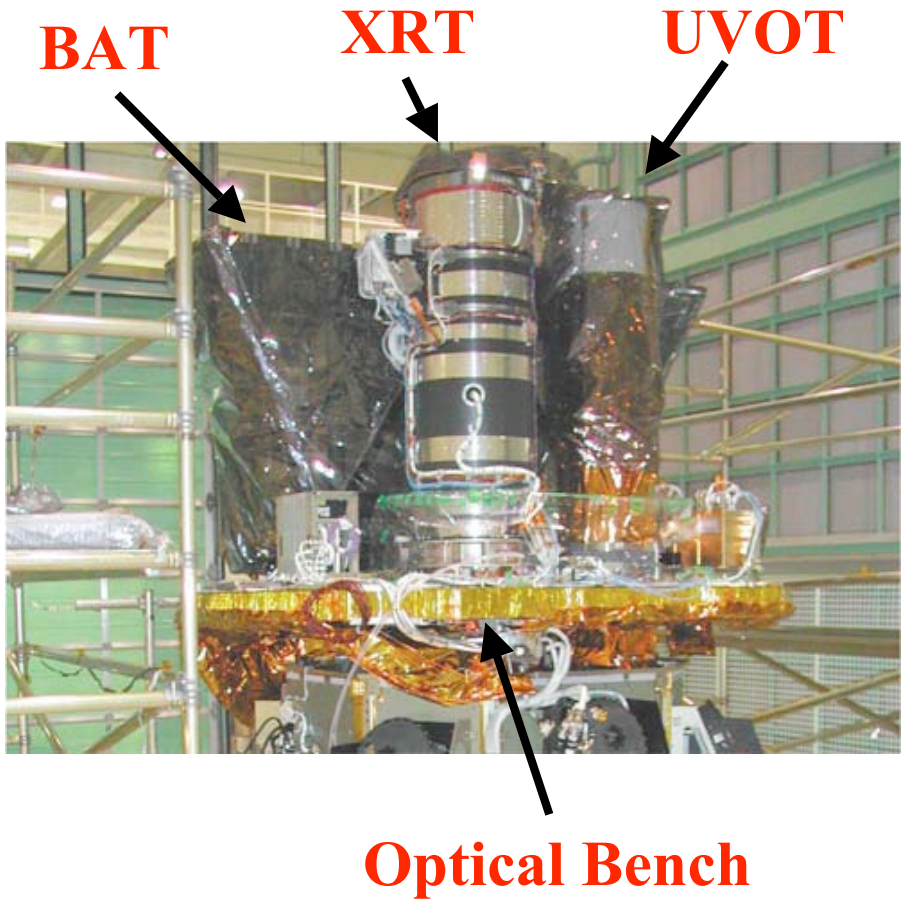
Spacecraft Status

- Spacecraft placed into 584 x 601 km orbit; 20.6° inclination
- Swift has full power capability; operates in both Sun & Eclipse at full capability
- Star trackers consistently and reliably lock on stars
  - Attitude stability during lock is better than tracker ability to measure
  - Attitude accuracy meets or exceeds requirement (3')
  - Attitude knowledge & stability all exceed requirements across all orbital events (i.e. slews, eclipse entry & exits)
  - No observable attitude disturbances correlated with Solar Array stepping
  - ACS settling after slewing is very rapid (<30 seconds)
- Spacecraft RF communications; Thermal control; On-board clock
  - all exceeding requirements
- Space & Ground Networks working very well
  - More than 600 Malindi contacts - >99% reliable
  - TDRSS forward links through 4 TDRS satellites using WDISC - >95% reliable
  - TDRSS Demand Access System - >85% reliable

Swift Instruments

Instruments

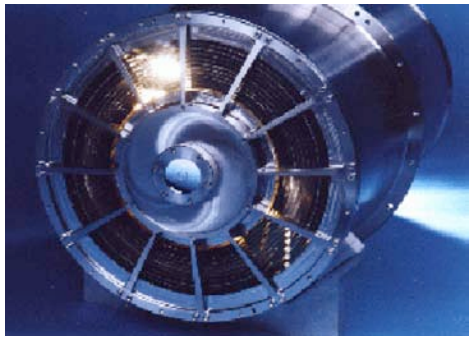
- **Burst Alert Telescope (BAT)**
  - New CdZnTe detectors
  - Most sensitive gamma-ray imager ever
- **X-Ray Telescope (XRT)**
  - Arcsecond GRB positions
  - CCD spectroscopy
- **UV/Optical Telescope (UVOT)**
  - Sub-arcsec imaging
  - Grism spectroscopy
  - 24th mag sensitivity (1000 sec)
  - Finding chart for other observers

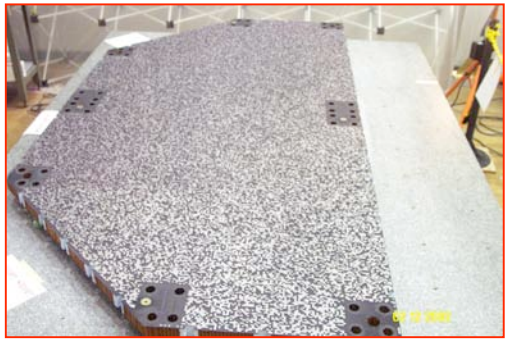


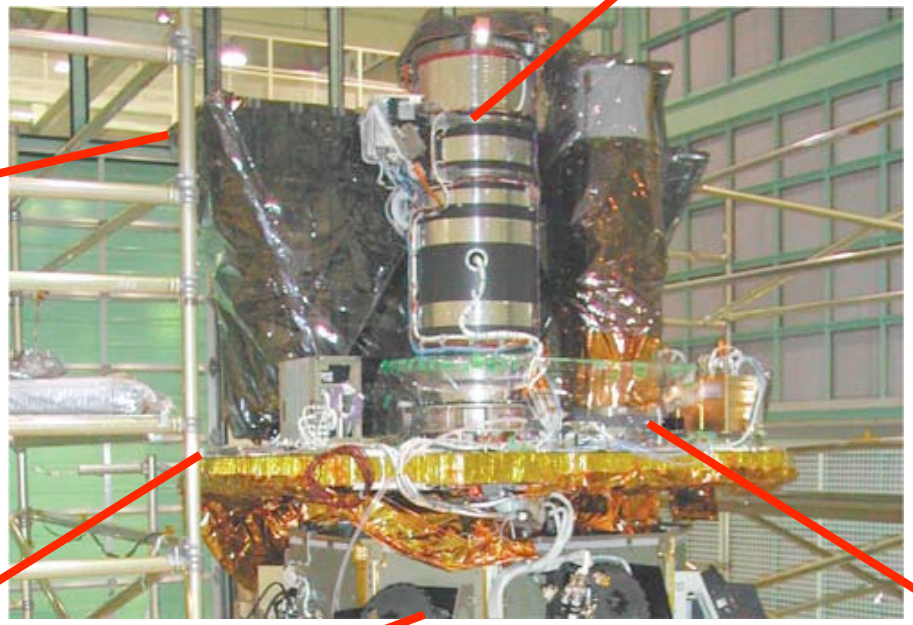
Spacecraft

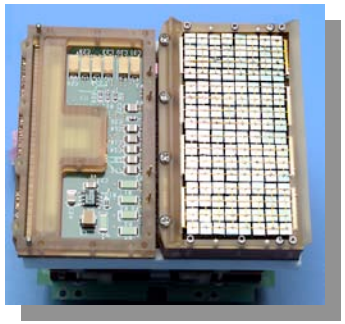
- **Autonomous re-pointing, 20 - 75 s**
- **Onboard and ground triggers**

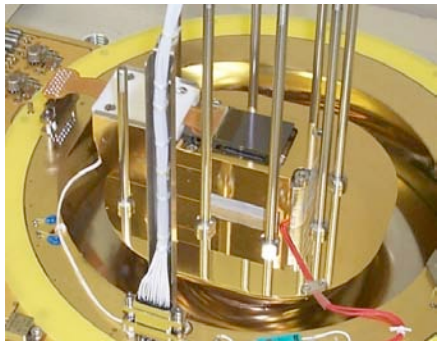
Swift Instruments

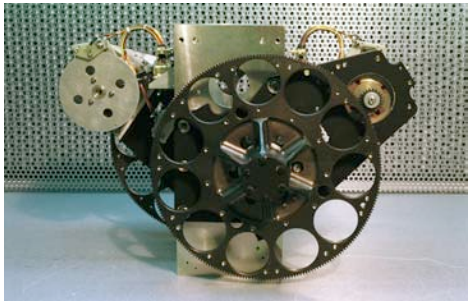




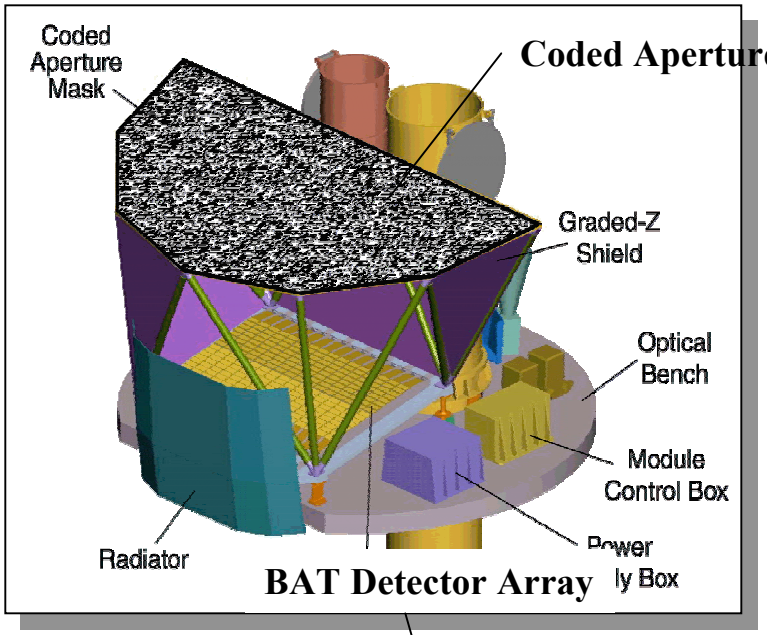


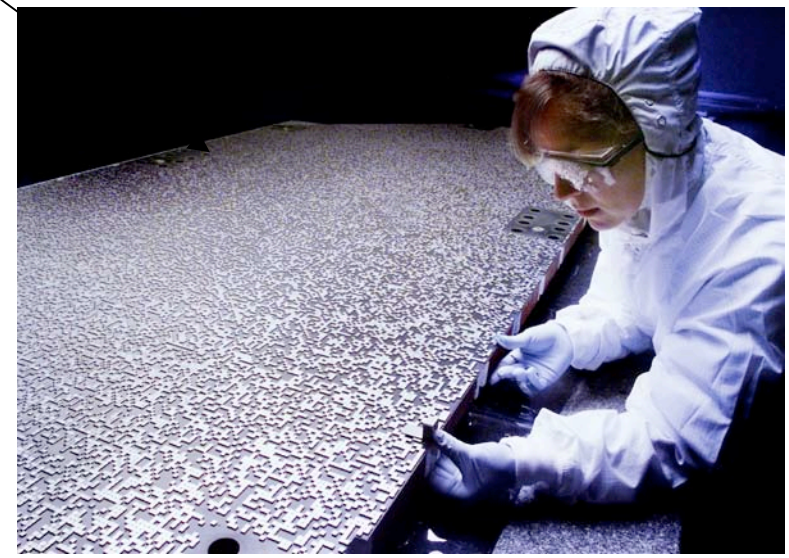


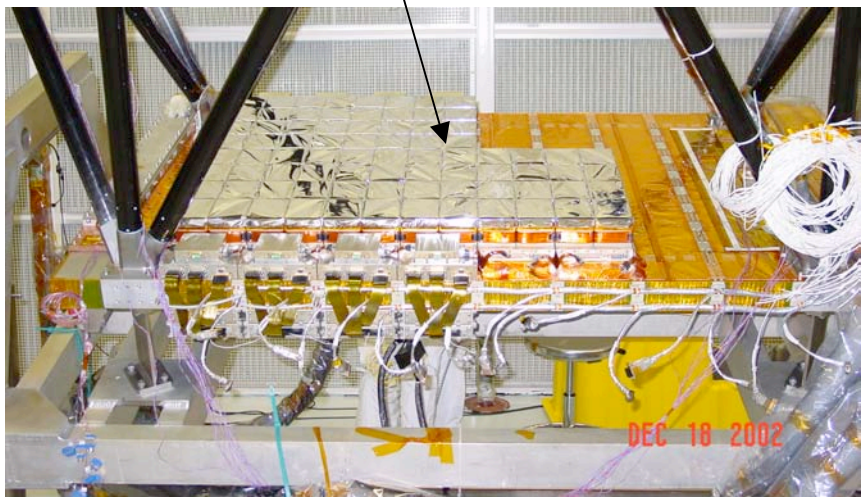




BAT Instrument – Scott Barthelmy, Lead
Developed at GSFC, with software at LANL







BAT Characteristics

- 15 - 150 keV (300 keV) energy range
- 22 arcmin angular resolution
- 2 steradian field of view
- 2-5 times BATSE sensitivity

BAT Imaging Performance

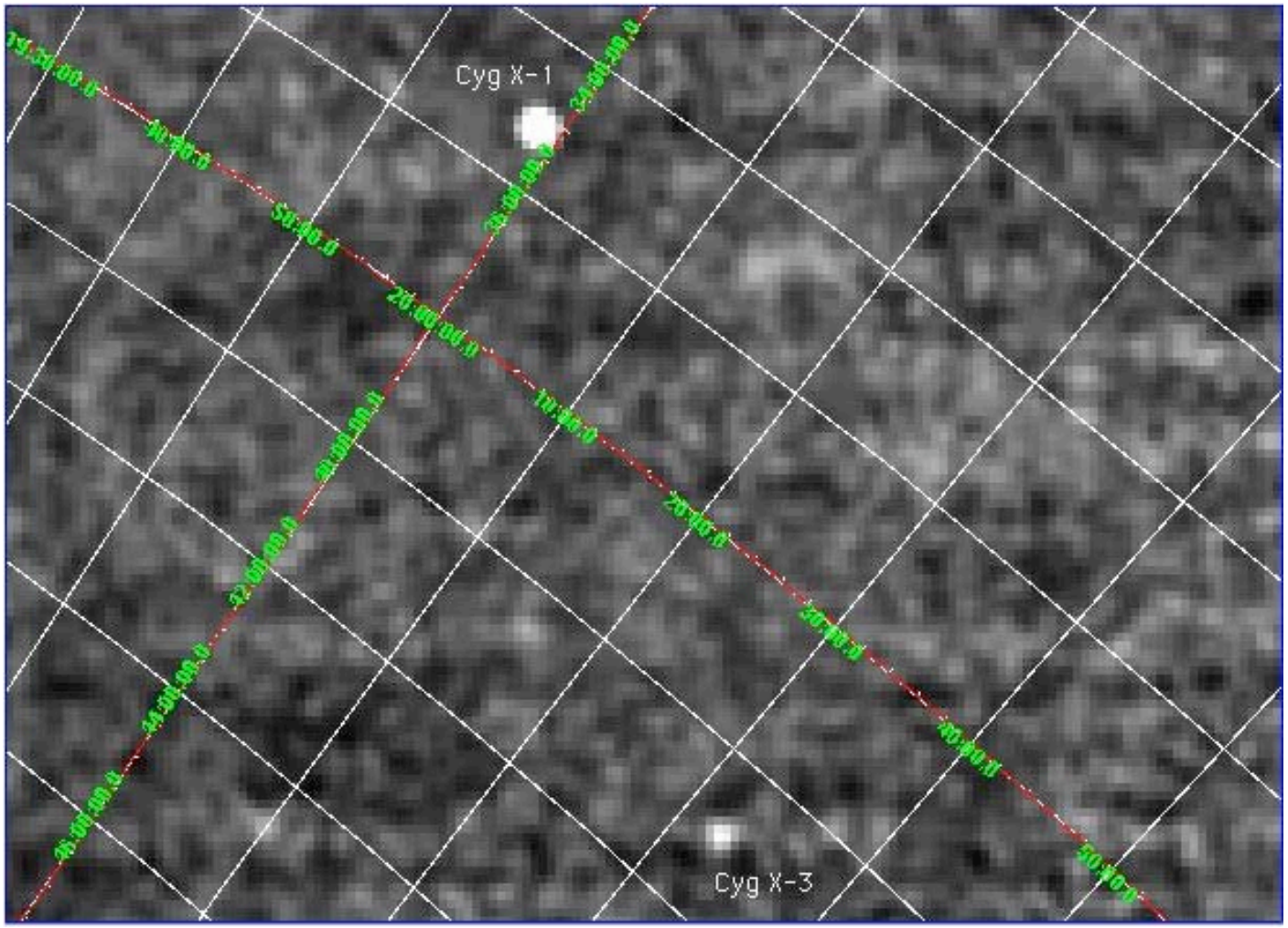
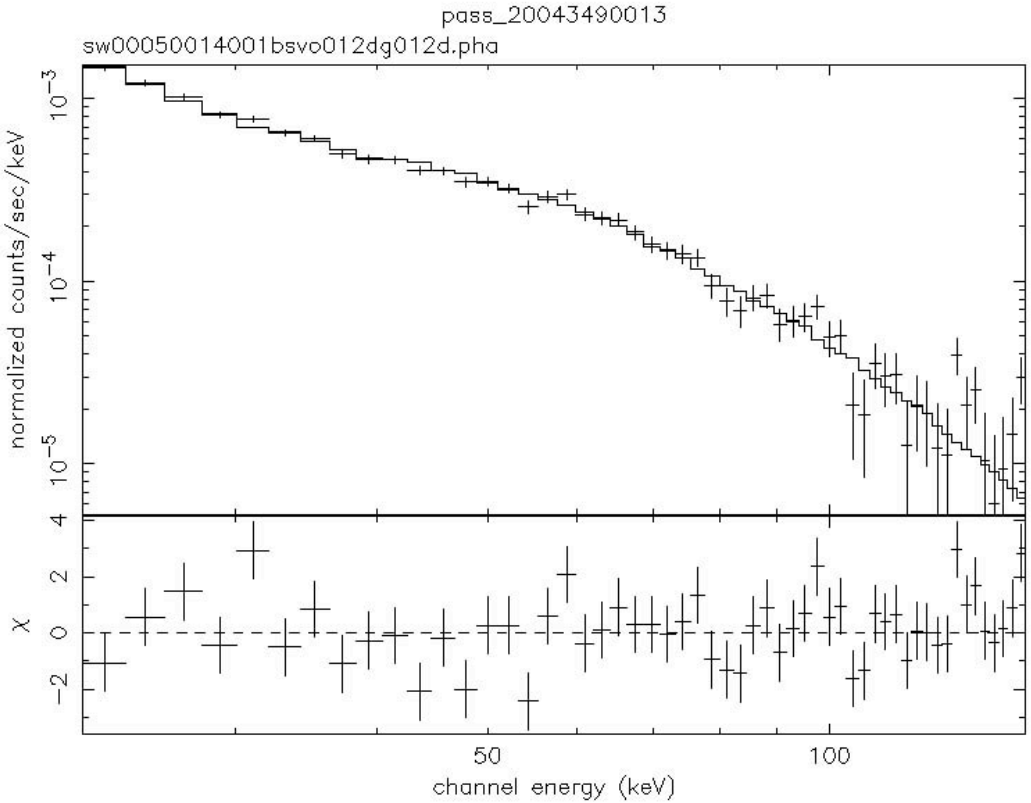


Image by Hans Krimm

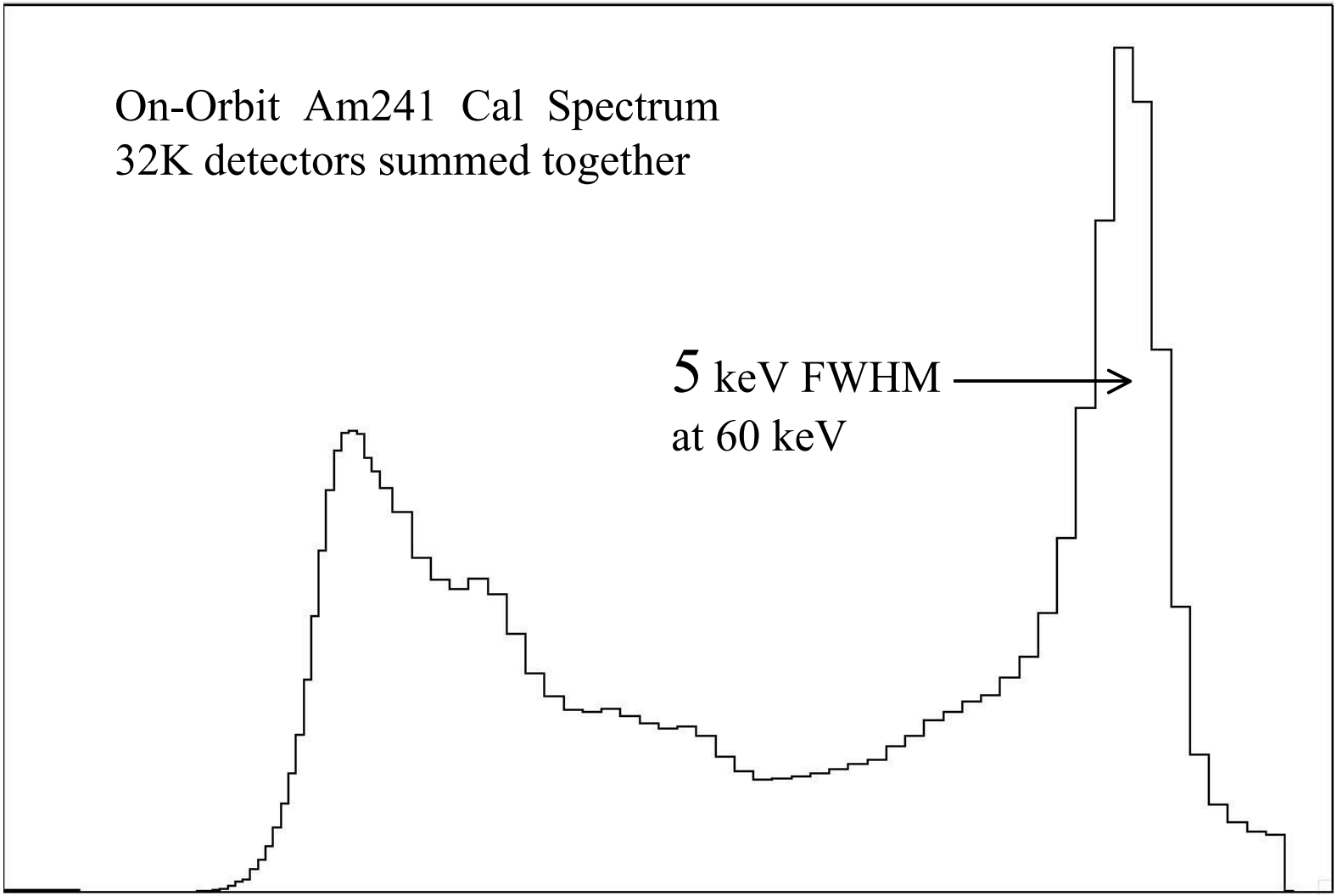
BAT Spectral Performance



- Power law fit
- Index = 2.13 ± 0.03
- Normalization = 9.70 ± 0.86 @ 1 keV
- Reduced Chi2 = 1.48 (53 DOF)

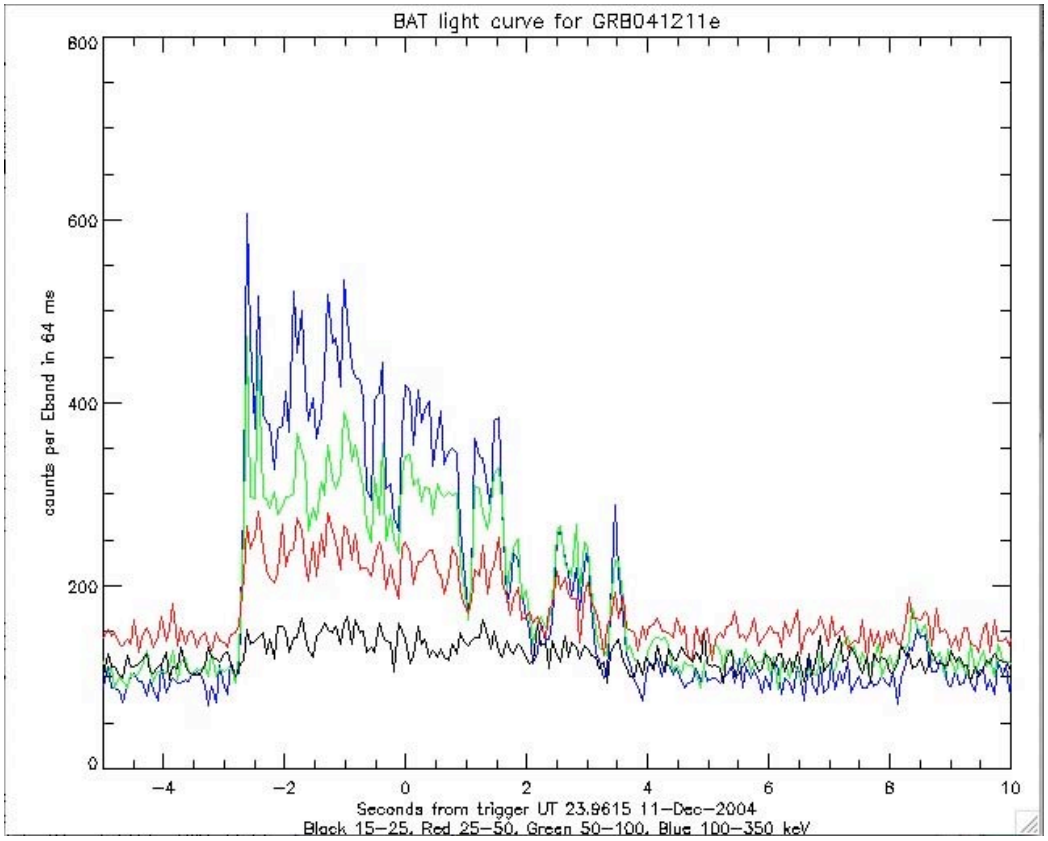
Analysis by G. Sato

BAT Detector Spectral Resolution



BAT's First Burst

- GRB041211e
- Also detected by HETE, RHESSI, Odyssey, & KONUS
- Rate Trigger: ~200 sigma
- No imaging possible; burst came up through the bottom of the instrument



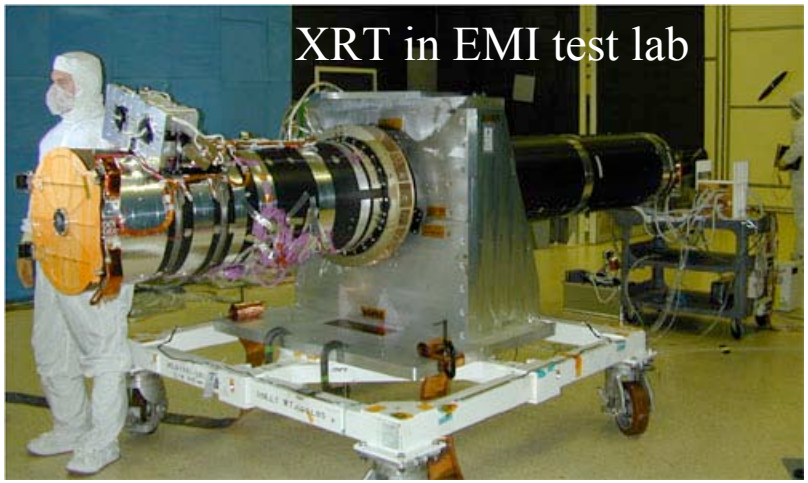
Plot by H.Krimm

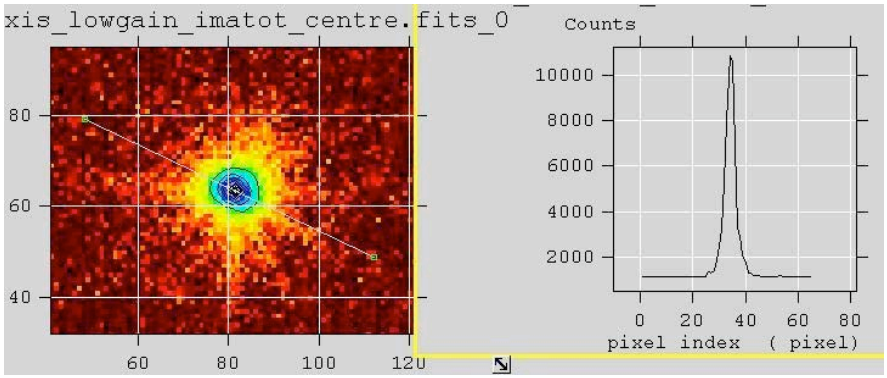
BAT GRBs and SGR – see talk S. Barthelmy

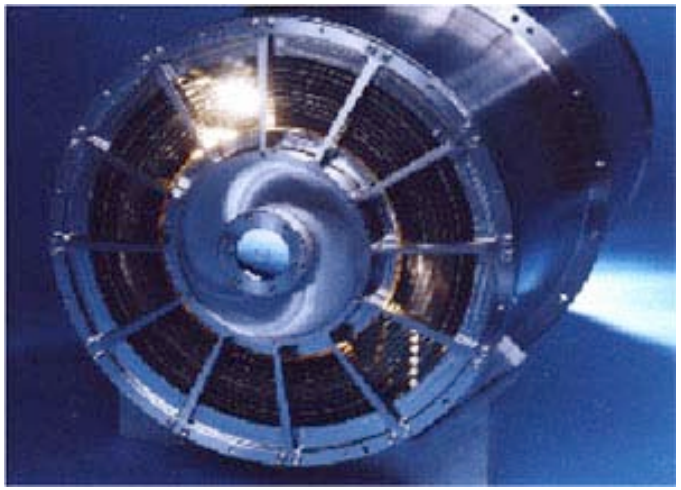
GRB	Time [UT]	RA (J2000)	Dec (J2000)	T90 [sec]	Fluence [10^{-7}erg/cm2]	Comments
041211e	23:57:41	n/a	n/a		n/a	Bottom of the instrument.
041217	07:28:30	164.79	-17.95	7.5	65.7	Our first imaged burst
041219	01:42:18	6.51	62.85	(520)	1000	Bright, multi-peak
041219b	15:38:48	167.67	-33.46	(30)		1 big spike, 3 little spikes; IPN
101219c	20:30:33	343.97	-76.80	(40)	20	3 spikes
041220	22:58:26	291.24	60.69	5	8.3	FRED
041223	14:06:18	100.12	-37.03	107	509	Multi-peak, bright
041224	20:20:57	56.20	-6.62	235	218	
041226	20:34:19	79.77	73.32	~15	n/a	Weak spike
041227	21:30:25	n/a	n/a	(400)	[10^6]	SGR1806-20 Giant Flare
041228	10:49:13	336.65	5.04	62	78	
050105	00:45:53	n/a	n/a	(8)	n/a	Weak detection (6 sigma); not issued
050107a	02:08:21			(0.1)		SGR1806-20 -- still active
050107b	13:12:26			(0.1)		SGR1806-20 -- still active

GCN Circulars issued on all 9 gold-plated GRBs in T+3-4 hrs.

XRT Instrument- David Burrows, Lead
Developed at U. Leicester, Brera & PSU







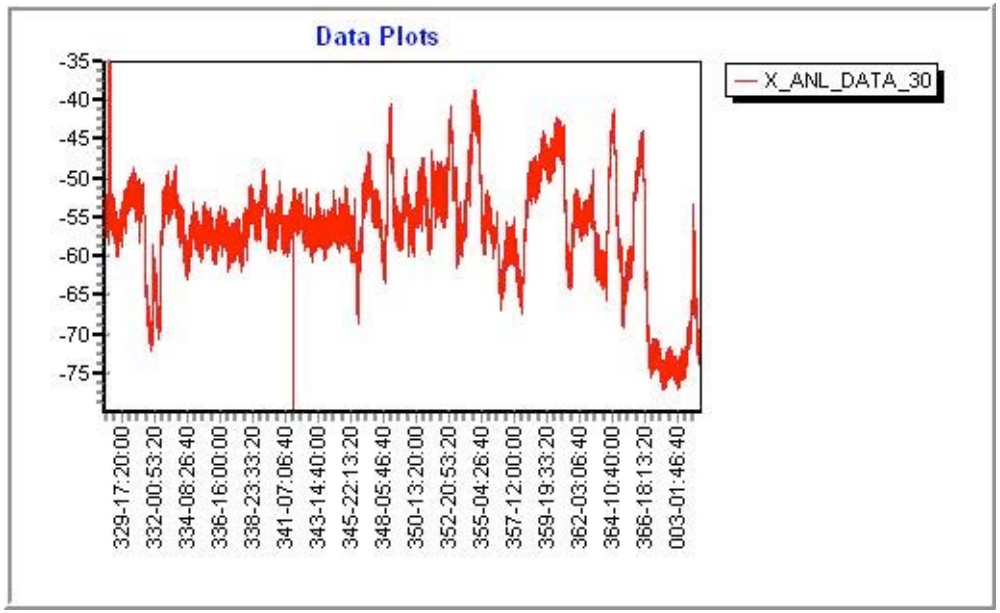
XRT Characteristics

- 0.2 - 10 keV energy range
- 18 arcsec angular resolution
- 130 cm^2 eff. area at 1.5 keV
- 24' x 24' field of view
- $2x10^{-14}$ erg cm^{-2} s^{-1} sensitivity (20 ksec)

XRT TEC Anomaly

- **On Day 343 Voltage to XRT Thermo-Electric Cooler dropped to 0 Volts, shortly prior to first cooling of CCD**
- **Cause of anomaly still under investigation**
- **Repeated attempts have failed to get TEC to operate**

- **Current operational situation:**
  - **XRT is forced to operate at temperature established by passive XRT radiator cooling**



XRT TEC Anomaly Impacts

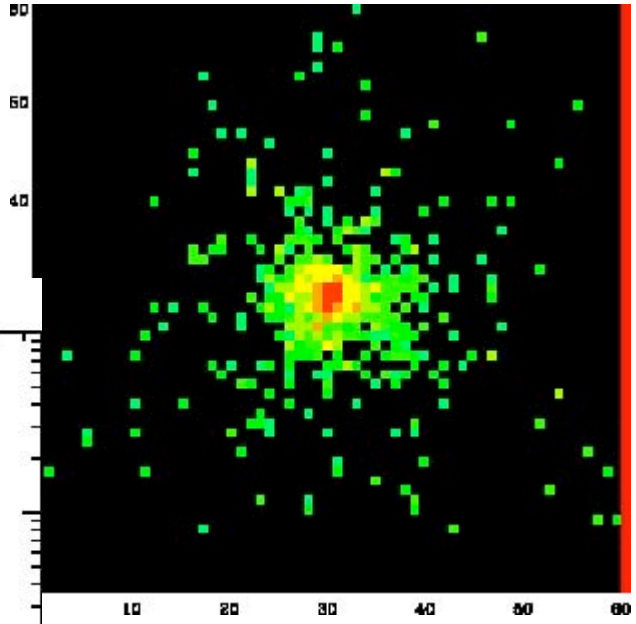
- **Passive XRT radiator cooling will result in CCD temperatures in range of -40 to -75C**
- **XRT flight parameters have been adjusted to give satisfactory results for T < -50C**
- **Operational management can result in CCD temperatures reliably below -50C**

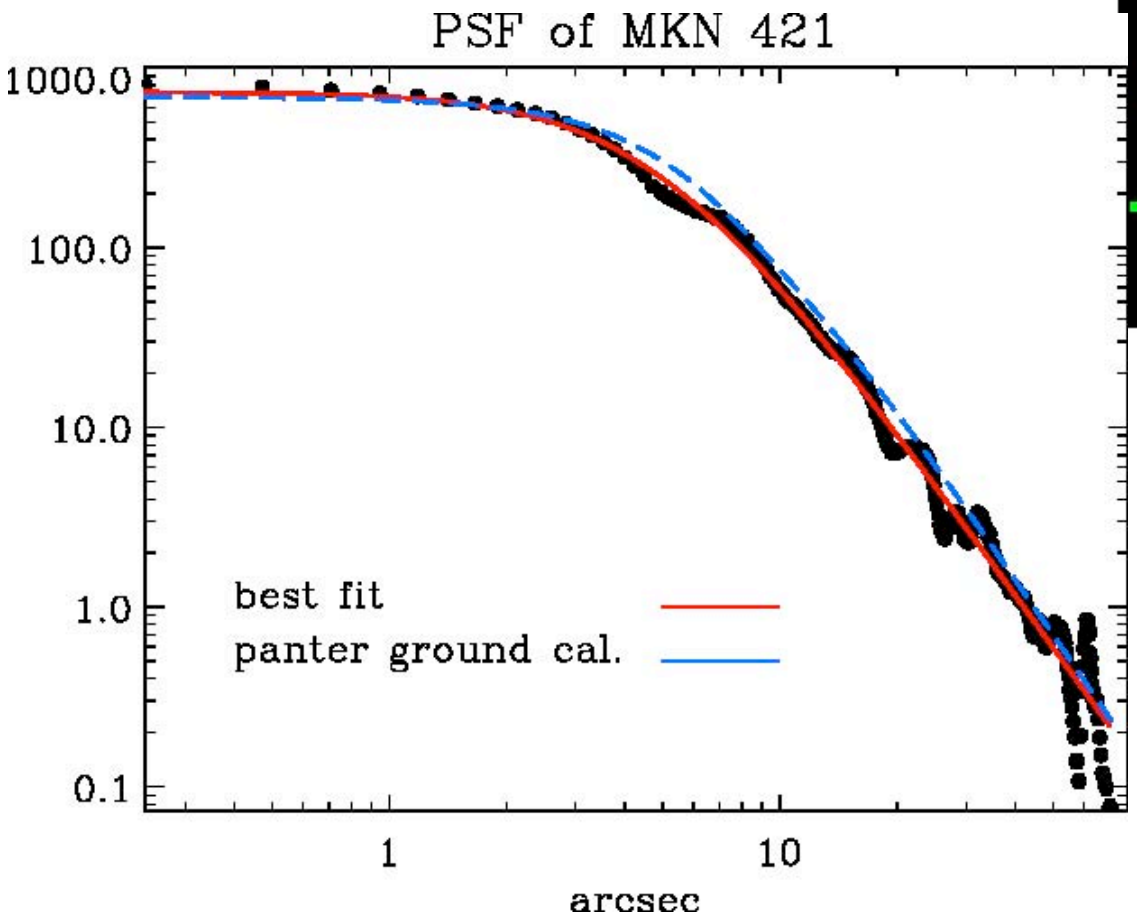
- **Impacts:**
  - **XRT will require more in-flight calibration data & ground analysis to produce calibration products for the new operating parameters**
  - **Science planning tools will need modification to constrain target observations to ensembles which result in cool CCD thermal orientations**

- **Summary:**
  - **XRT will be able to accurately position GRB counterparts & measure their spectra**
  - **TEC Anomaly will not reduce the portion of the sky viewable by XRT**

XRT Point Source Response

XRT PSF same as ground tests



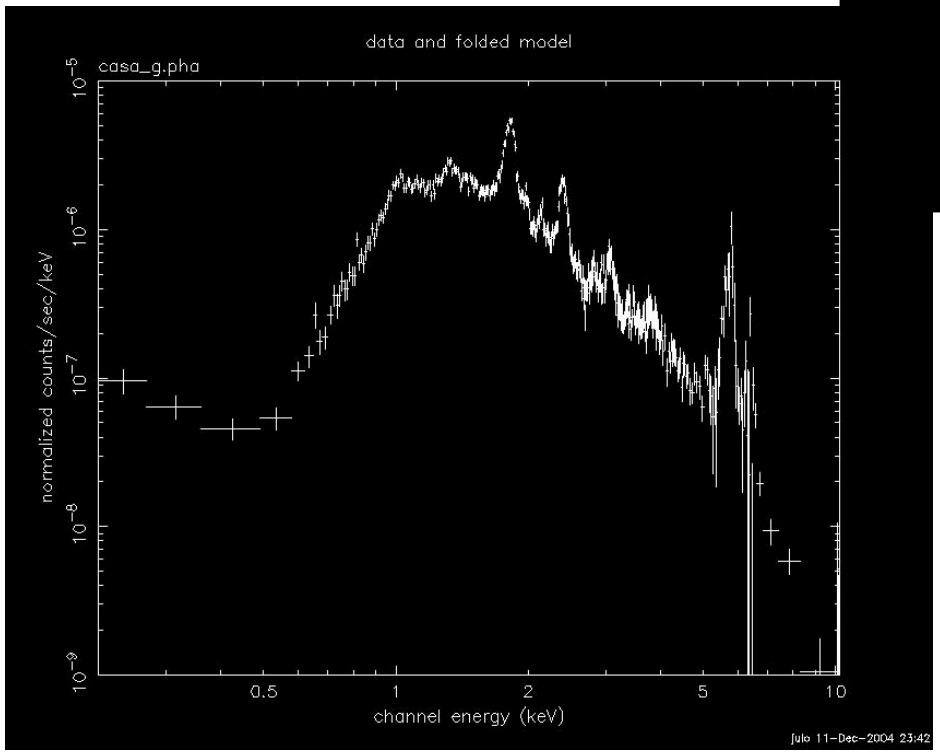


Analysis by Alberto Moretti – OA Brera

XRT Image of Cas A

- **Cas A first light image**
- **13 ks integration time**

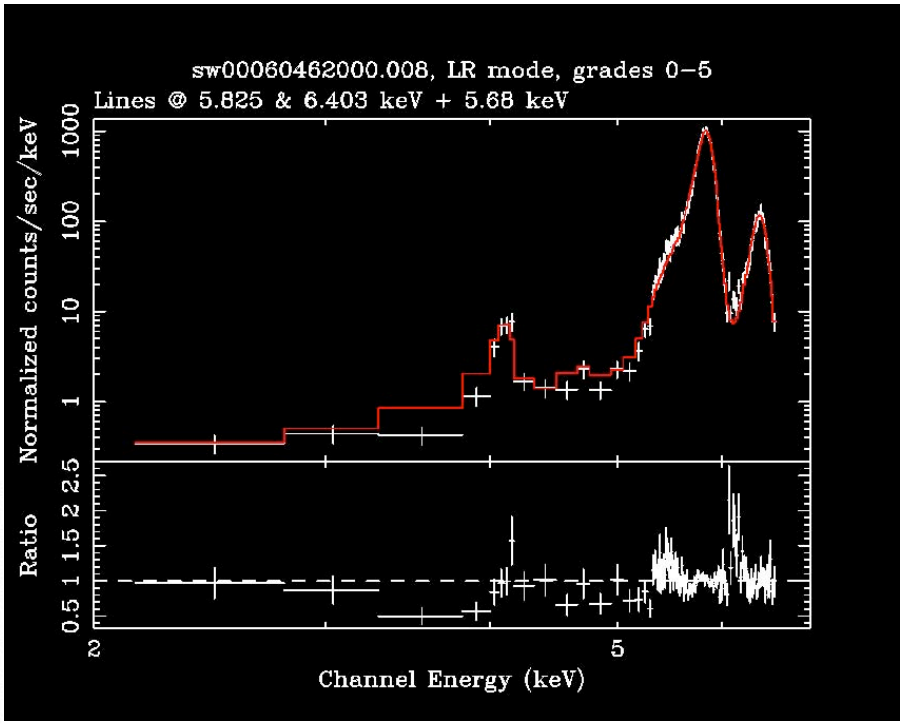
- **Analysis by Pat Romano – OA Brera**
  J. Osborne, Mike Goad – U. Leicester

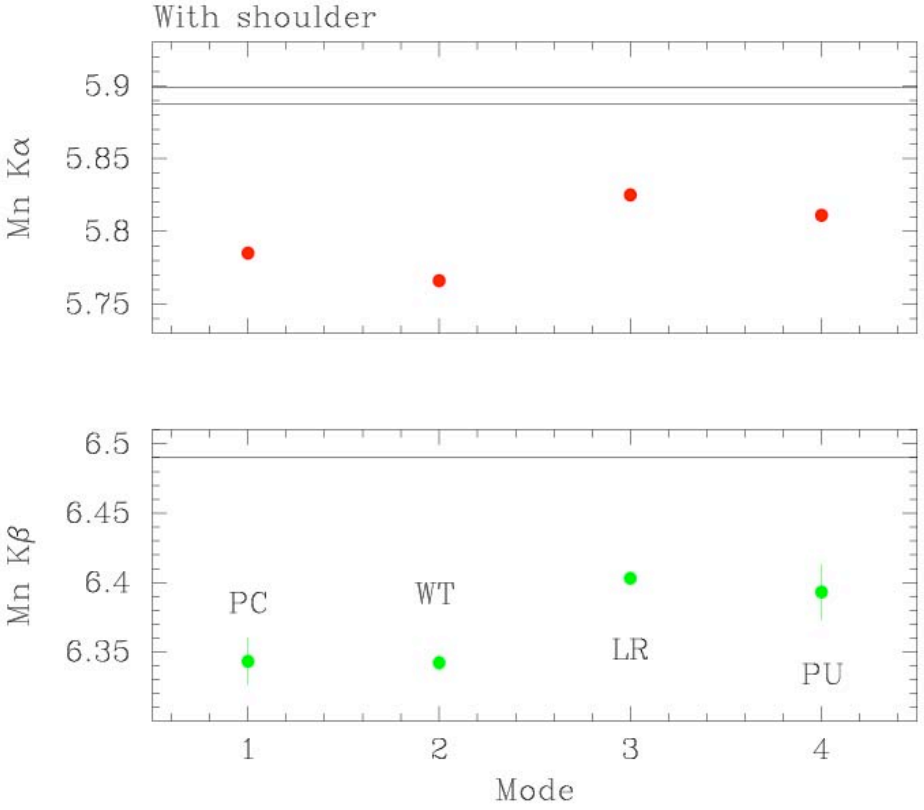


XRT Spectrum of Cal Sources

XRT spectral response is good in all modes

Some recalibration required due to temperature change effects





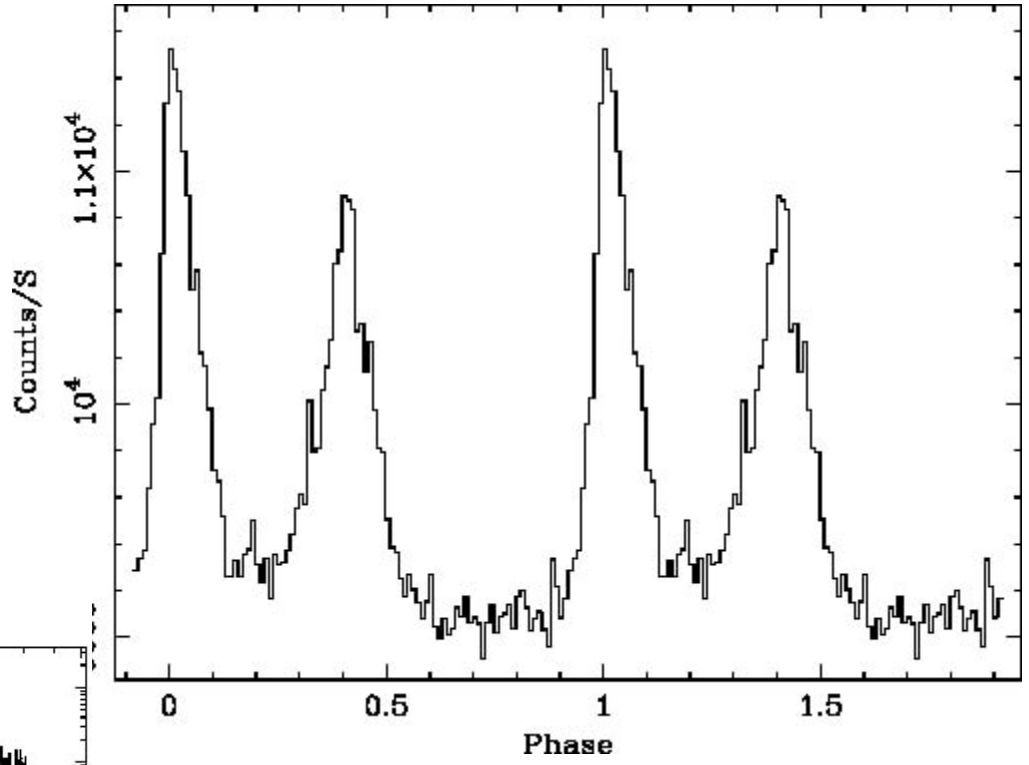
Analysis by Pat Romano – OA Brera

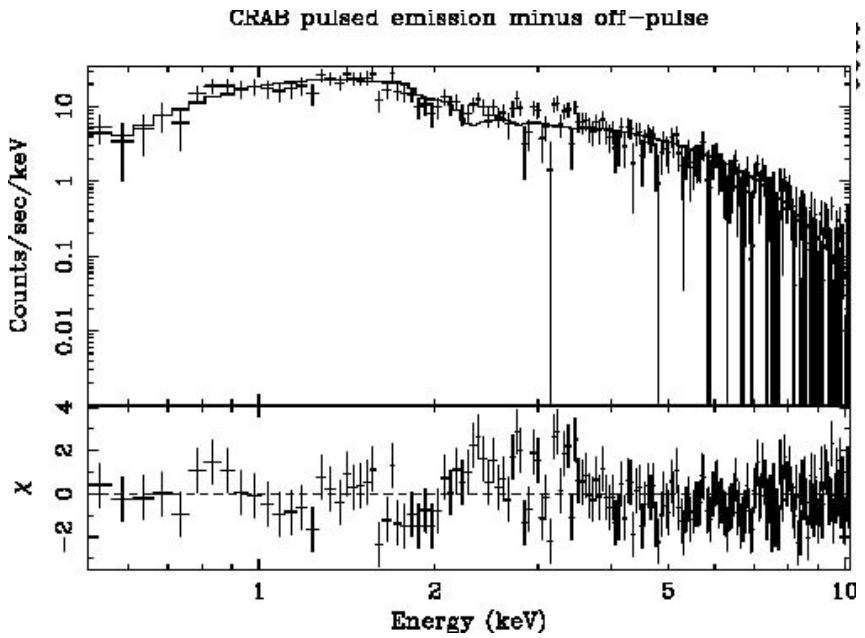
XRT Timing/Spectral Performance

Folded light curve of emission from Crab Nebula

Low-Rate Photo-Diode mode

1130 seconds of data





Spectrum fit using SDC pipeline data

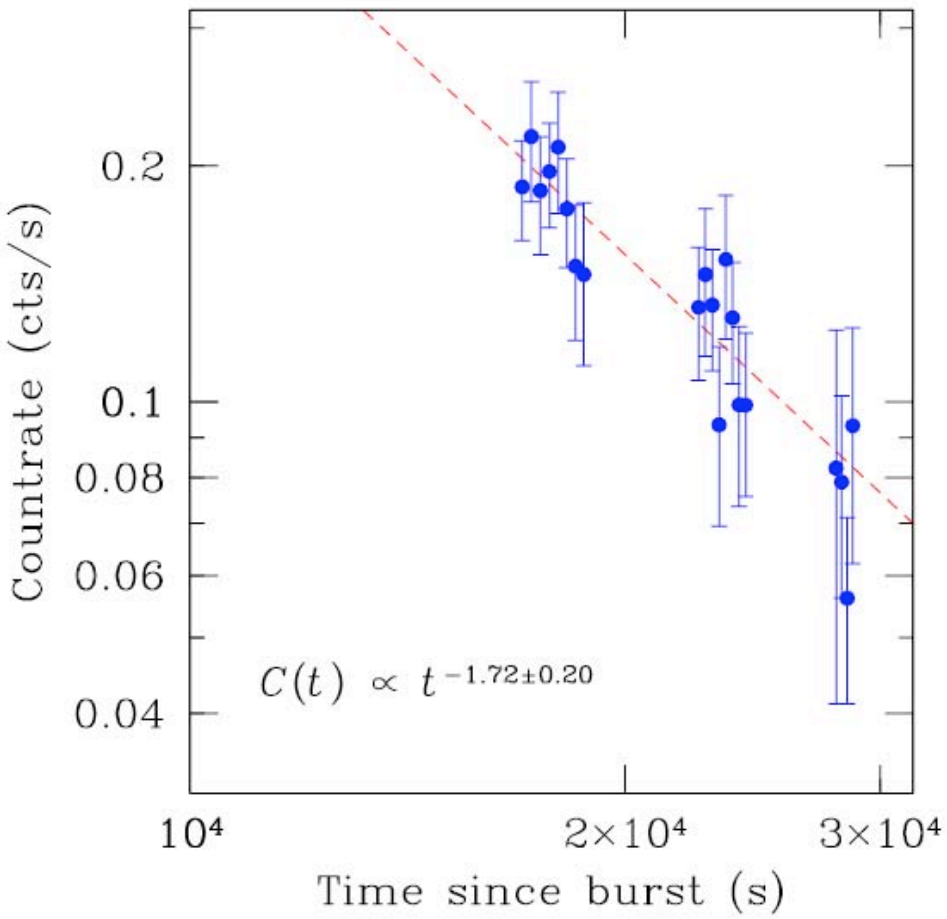
Response matrices will require adjustment for CCD temperature change

Analysis by Giancarlo Cusumano – I.A.S.F. C.N.R.

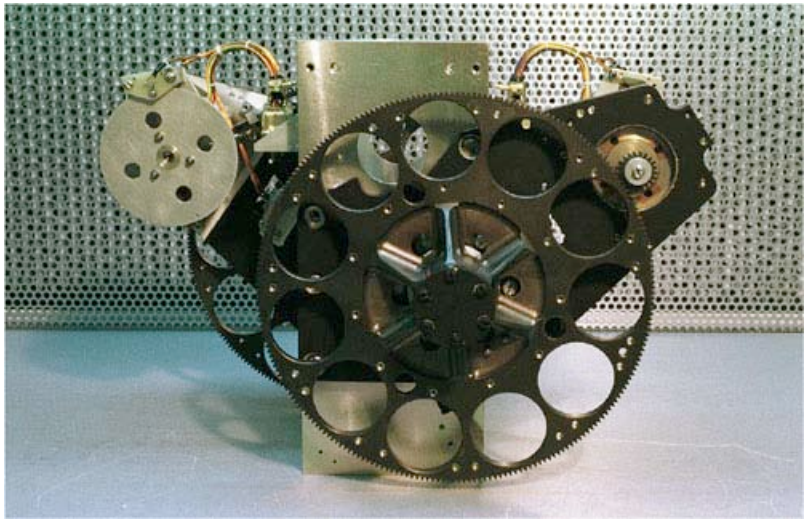
XRT Afterglow

- **BAT discovered GRB041223 at 14:06:18 UT (GCN 2898, Tueller et al.)**
- **Swift slewed to location as a Target of Opportunity**
- **XRT observations started at 18:43:59 UT**
- **Detected a fading X-ray afterglow (GCN 2901, Burrows et al.)**
- **Position confirmed by LCO40 (GCN 2902, Berger et al.) & VLT detections (GCN 2903, Malesani et al.)**

- **For more details see talk by David Burrows – 160.02**



UVOT Instrument – Pete Roming, Lead
Developed at MSSL & PSU



UVOT Characteristics

- 170 - 650 nm wavelength band
- 0.9 arcsec angular resolution
- 17' x 17' field of view
- 24th mag in 1000 s sensitivity

UVOT Performance

- **UVOT Preliminary afterglow location capability first tested on Monday**
- **UVOT activation still in progress includes focus testing & adjustment to PSF**
- **UVOT sensitivity & grism calibration will be conducted following detailed validation and adjustment of safety circuit**
- **UVOT activation planned to be completed in about two more weeks**
- **UVOT imaging positions may require 'shift & add' software**
  - **Parameters to be determined from flight experience**
  - **Build 7 software has been developed, will be implemented during Verification Phase**
- **See talk by Pete Roming – 160.03**

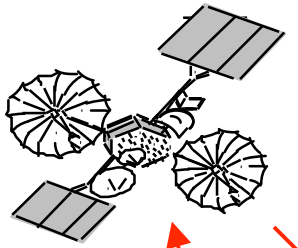
Swift Mission Ops Concept

Spacecraft

Spectrum Astro
Rapid Autonomous Slews

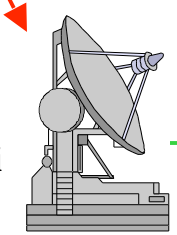
Payload

BAT
XRT
UVOT



TDRSS

GCN



Malindi
ASI

Mission Operations Center (MOC)

PSU

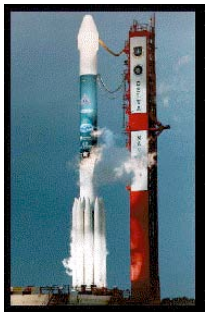
Science Center

GSFC

GCN & Web

HEASARC
UK
Italian
Archives

User Community



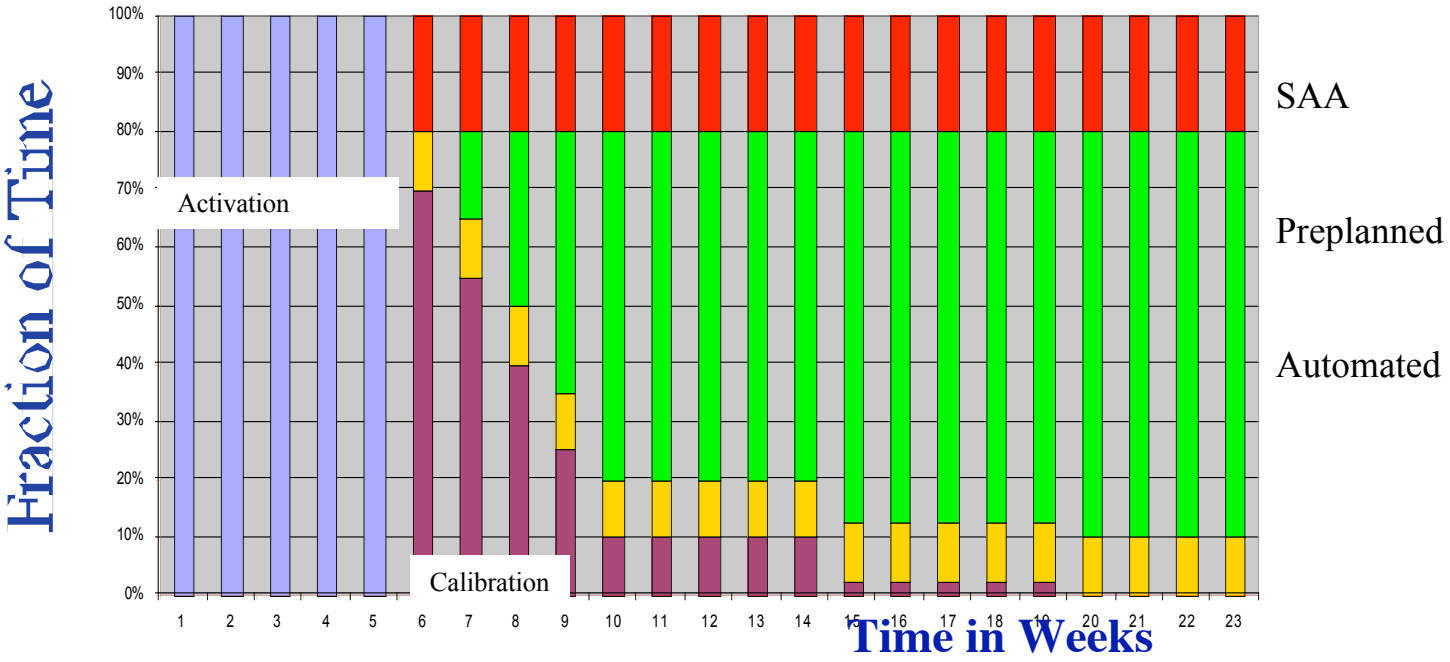
Launcher

Delta 2320
600 km X 21^{o} inclination

Swift Science Operations

- **Burst Advocates assigned for each burst. Responsibility to assure that**
  - **Swift data for the GRB are analyzed properly and promptly**
  - **Follow-up observations are coordinated**
  - **Burst notifications and publications are produced**

- **GRB observations in year 1**
  - **All BAT GRB positions slewed to if allowed**
  - **20-50 ks automated observations by XRT & UVOT,**
  - **Further planned observations scheduled from ground**



Partner Follow-up Telescopes

AEOS Telescope (Hawaii)
ARAGO Telescope (Antarctica)
ARC Telescope (New Mexico)
Brera Observatory (Italy)
Chandra
ESO (La Silla, Paranal, VLT)
ESA's INTEGRAL mission
Fast Alert MachinE (Italy)
Faulkes Telescopes (Hawaii & Australia)
Galileo National Telescope (La Palma)
Hubble Space Telescope
Hobby-Eberly Telescope (Texas)
INTEGRAL
Isaac Newton Telescopes (La Palma)
KAIT (California)
W. M. Keck Observatory (Hawaii)
Large Binocular Telescope (Arizona)
LIGO (Louisiana and Washington)
Liverpool Telescope (La Palma)
McDonald Observatory (Texas)
Milagro Gamma-ray Obs. (New Mexico)
NASA (IRTF, Hubble & Spitzer)
NOAO (CTIO, KPNO)
Nordic Optic Telescope (La Palma)
Okayama Observatory (Japan)
Rapid Eye Mount Telescope (Chile)
ROTSE-II (New Mexico)
SARA Observatory (Arizona)
SIRTF
South African Large Telescope
Super-LOTIS (Arizona)
TAOS Telescope (Taiwan)
TAROT Telescope (France)
Tenerife Observatory
U.S. Naval Observatory (Arizona)
VERITAS Observatory (Arizona)
WASP Telescope (La Palma)
WIYN Observatory (Arizona)
Wyoming Infrared Observatory
XMM Newton