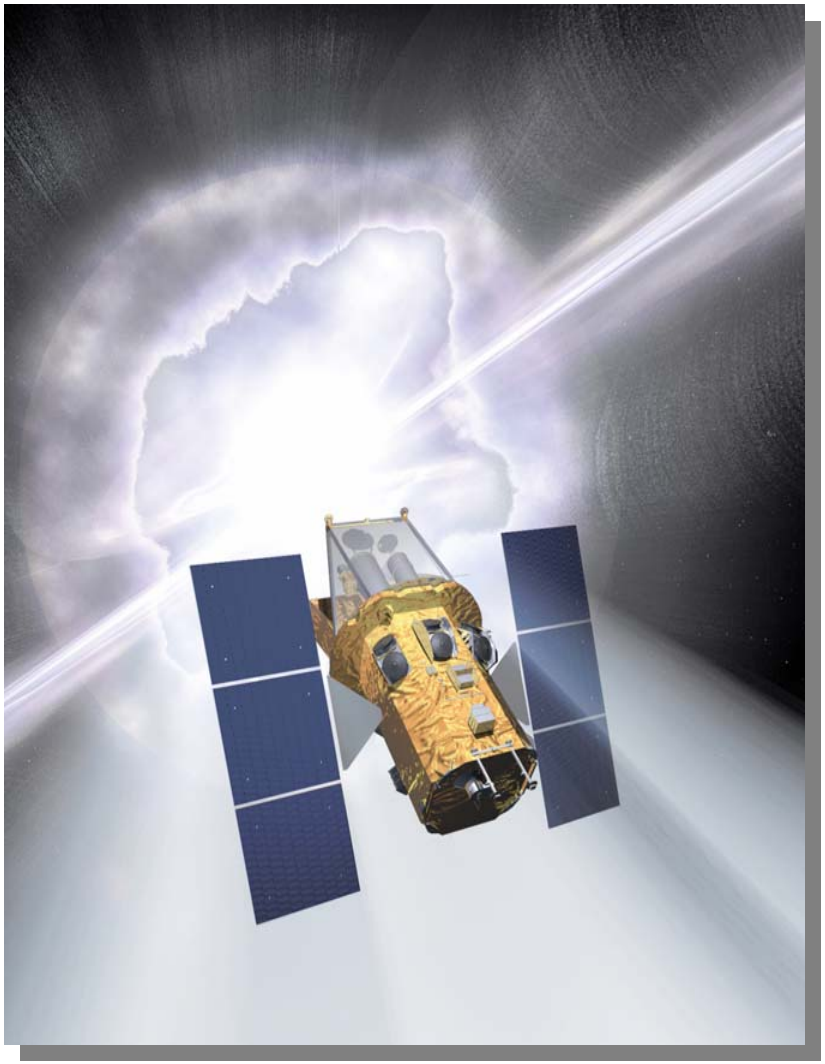


Swift-BAT Post-Launch Status

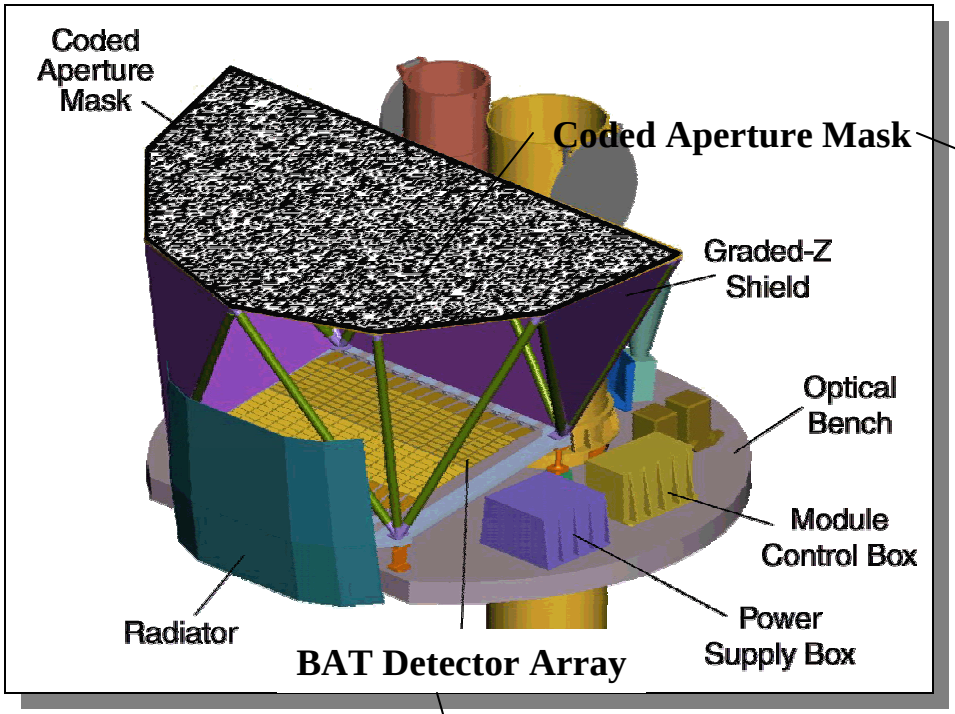
Scott Barthelmy

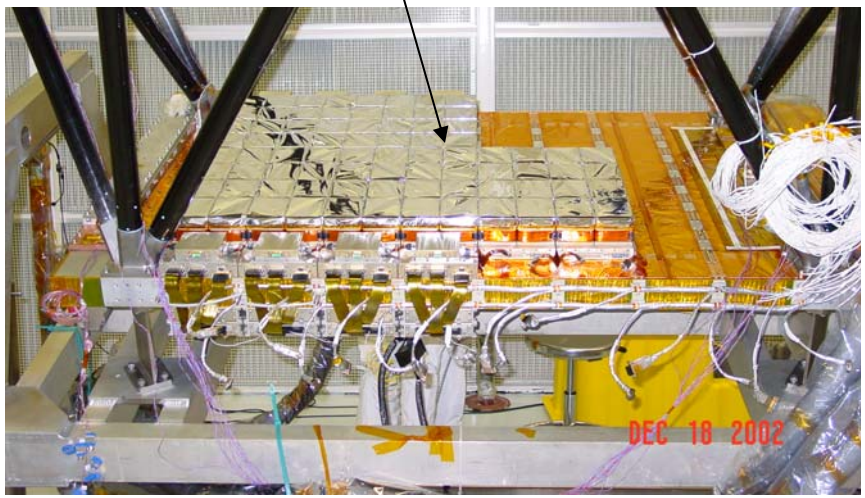
J.Cummings, E.Fenimore, D.Hullinger, H.Krimm, C.Markwardt, K.McLean, D.Palmer, A.Parsons, T. Sakamoto, G.Sato, M.Suzuki, J.Tueller

and many others

14 Jan 2005

Burst Alert Telescope (BAT)





BAT Characteristics

- E Range: 15 - 150 keV (12-300)
- E Resoln: 7 kev (5)
- Loc Resoln: 1-4 arcmin (1-4)
- PSF: 22 arcmin (21.8)
- 2 steradian field of view
- 32K CZT dets, 5200 cm2
- Autonomous operations

BAT Activation Chronology

- **Launch 20 Nov 04, 17:16 UT**
- **L+4 Computer (Image Processor (IP)) and Power Box (PCB) turned on**
- **L+5 Thermal Control System started**
- **L+7 First Detector Module turned on (1 of 128) (HV @ L+8)**
- **L+9 Second DM**
- **L+11 Completed 1st Block (8 DMs) turn-on (1 of 16)**
- **L+14 Cyg X-1 detected with only 1/4 of the Det Array on at half HV**
- **L+26 Completed Full Detector Array (all 16 Blocks)**
- **L+26 Triggers enabled (Rate- & Image-); "tuning" done in about 2 weeks**
- **L+27 First GRB detected (GRB041211e)**
  - **Through the bottom of the instrument**
- **L+28 First Imaged GRB (GRB041217)**
- **Since then Triggers enable most of the time; Auto slewing enabled about 20% of the time.**
- **Sky observing efficiency has been complicated by XRT and UVOT commissioning (especially in the last 3 weeks). And Non-Safe_Pointings.**

BAT GRBs and SGR

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	Multi peaks
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	Milti peaks
050105	00:45:53	n/a	n/a	(8)	n/a	Weak detection (6 sigma); not issued
050107a	02:08:21	272.15	-20.37	(0.1)		SGR1806-20 -- still active
050107b	13:12:26	272.16	-20.41	(0.1)		SGR1806-20 -- still active

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

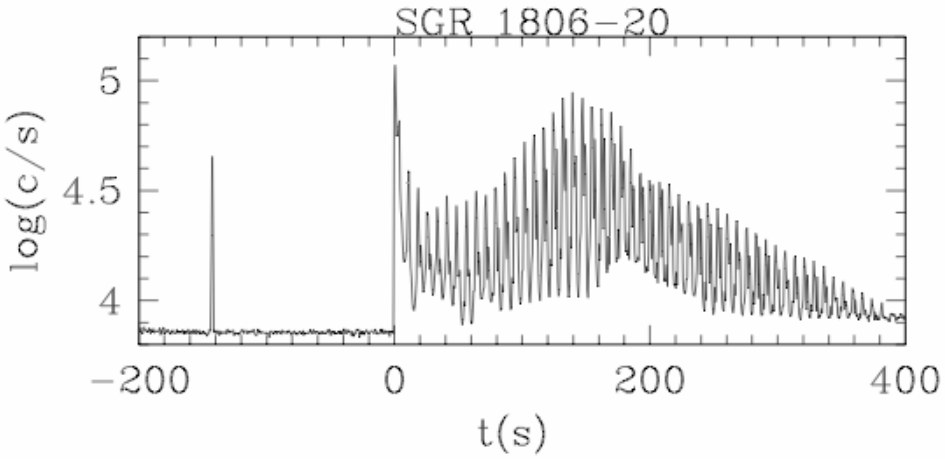
A Couple BAT GRB Lightcurves

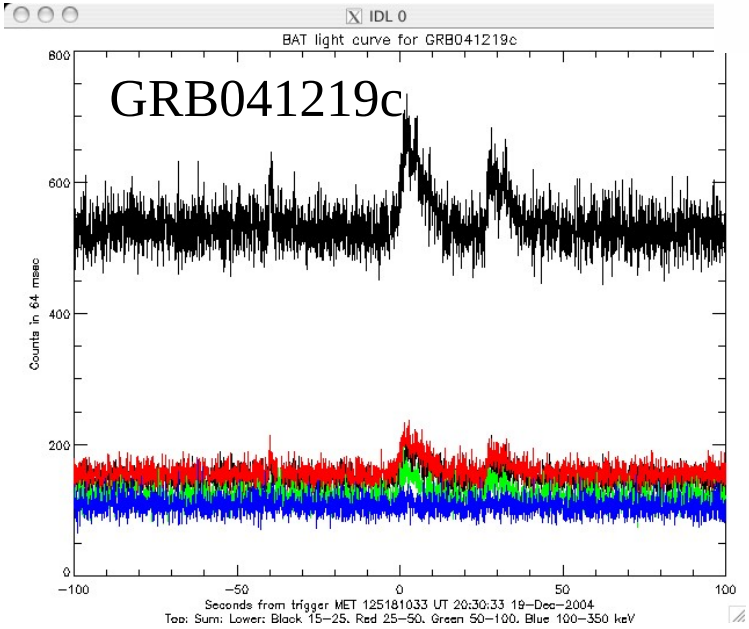
GRB041217

counts/cm2/sec

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

SGR1806-20 Giant Flare





QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Plots by BAT Team

Survey: First Light: Cyg X1 & X3 (3/4 Array)

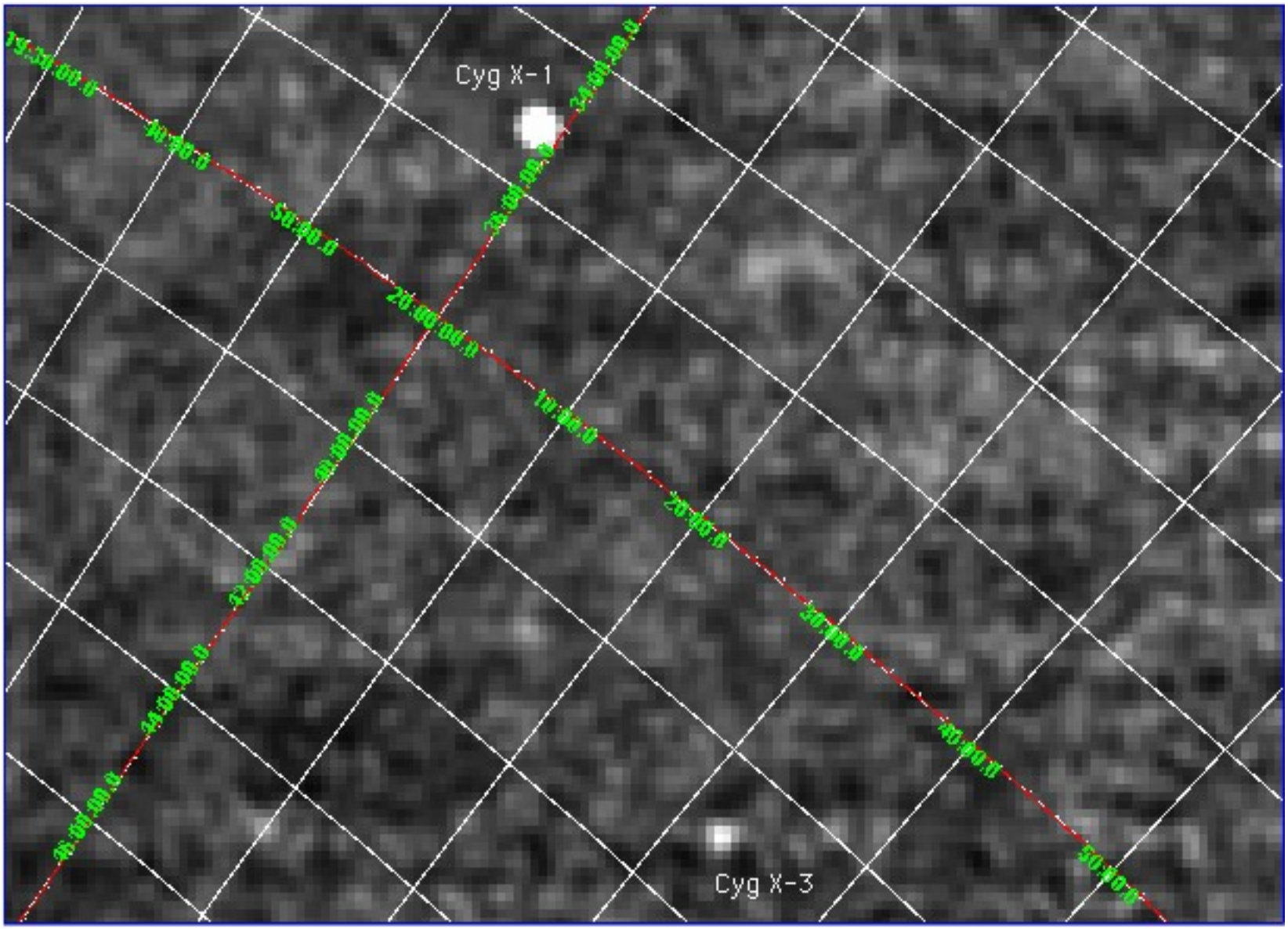
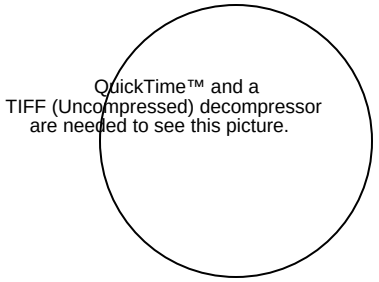


Image by H.Krimm

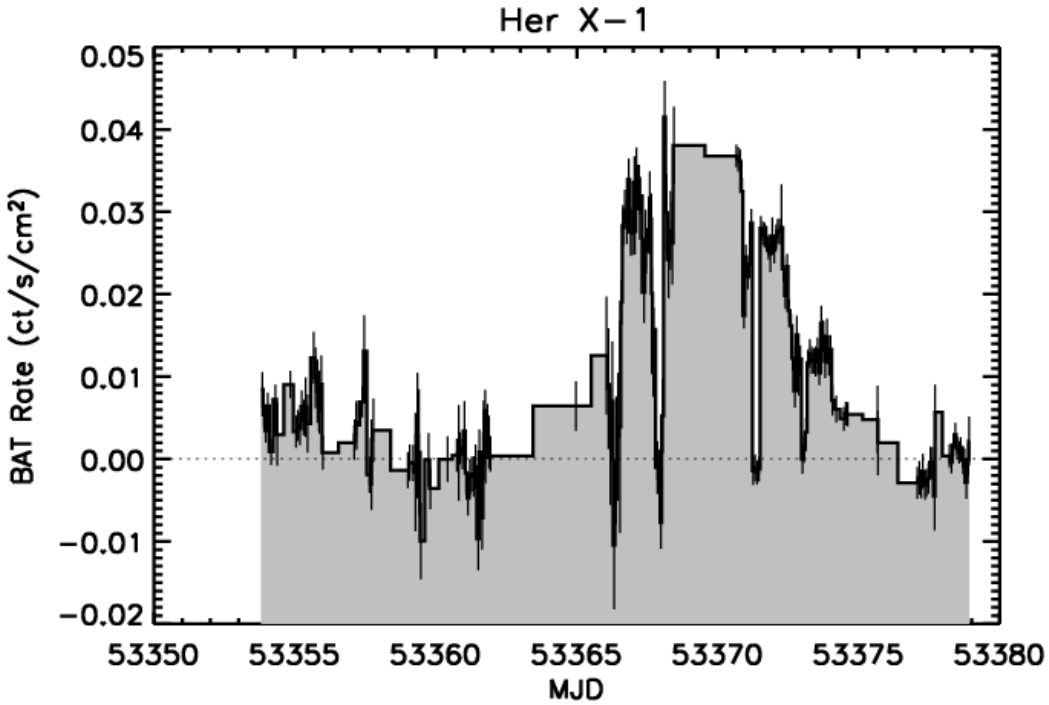
BAT Position Accuracy



* Steady-state source: Vela X-1
* 4-min observations
* Near-threshold detections
  6-13 sigma
* Systematic offset has been fixed
  Alignment matrix
* Statistical: 2.3 arcmin, radius
  Will be reduced, ~1.8arcmin

Analysis by H.Krimm

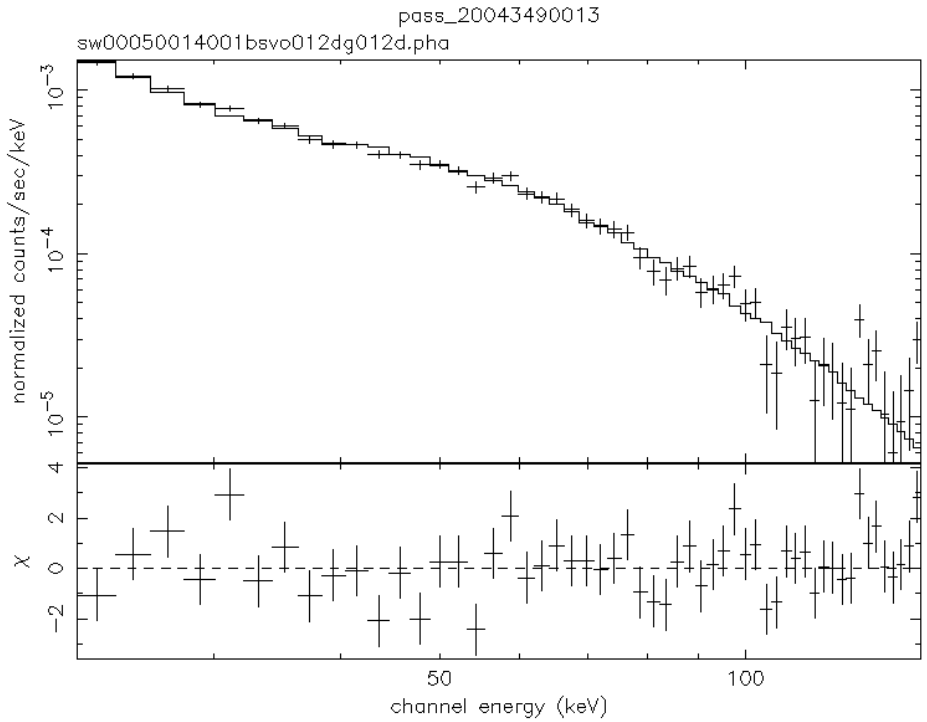
All-Sky Survey Data Products



- **BAT will monitor a large fraction of the sky**
- **Light curves will be built up for sources we detect**
- **Example: Hercules X-1, 35-day outburst cycle, 1.7-day eclipse cycle lasting 5.5 hrs**
- **Flat regions are times when BAT was pointing such that Her X-1 was not in the FOV**

Analysis by C.Markwardt

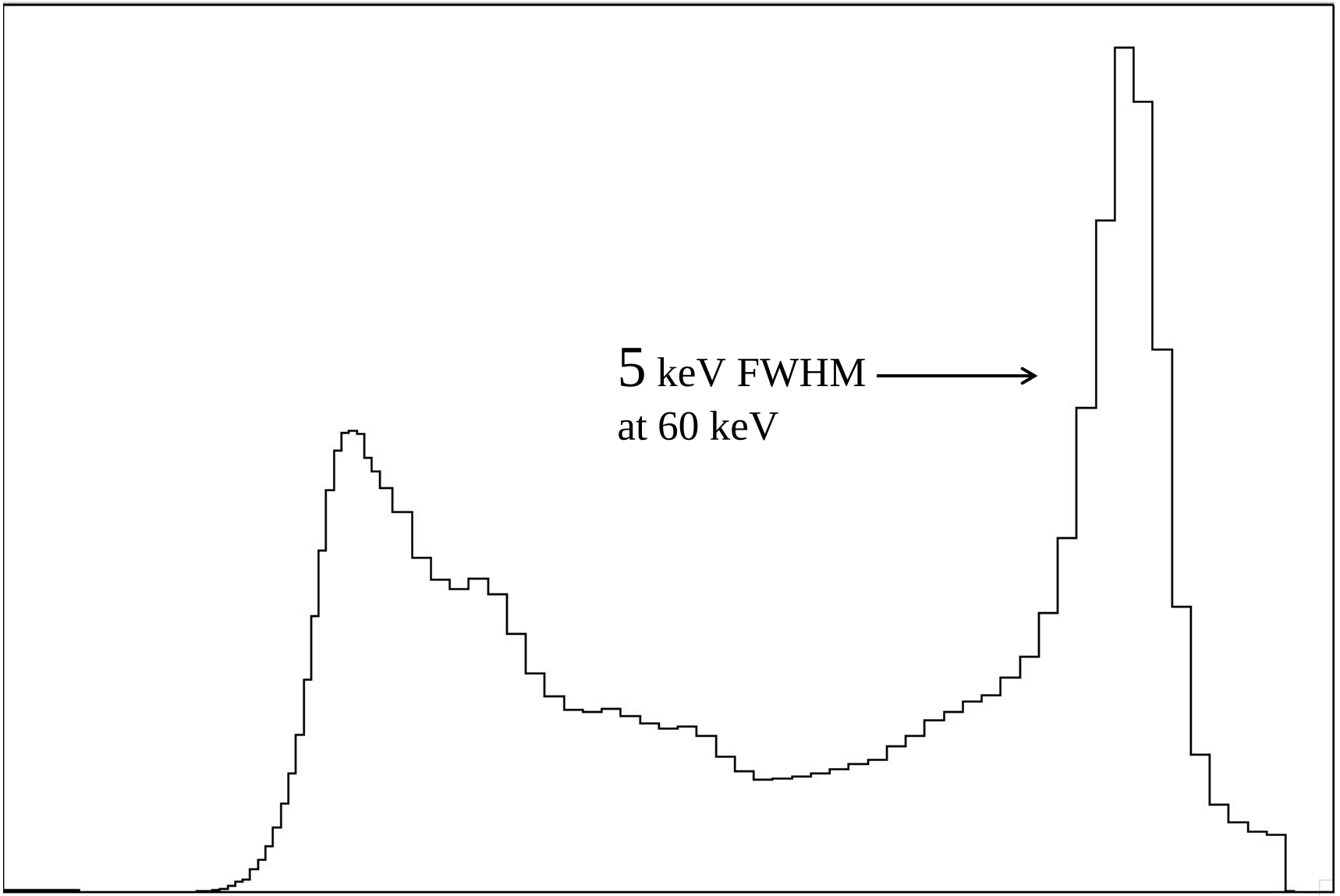
Crab Spectrum



- **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

On-Orbit Am241 Cal Spectrum
32K detectors summed together



BAT Energy Threshold

Near-Threshold Spectrum
for 1 detector

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Threshold Distribution
for 32K detectors

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Analysis by G.Sato

Status and Future Developments

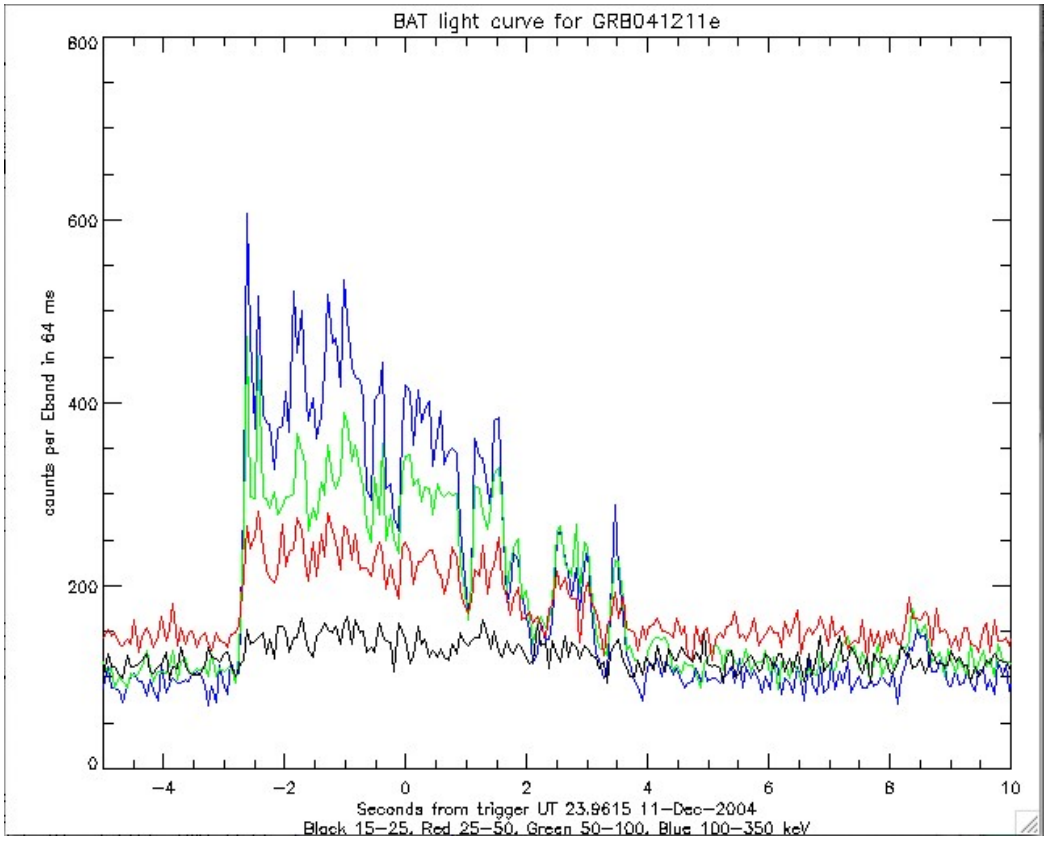
- **BAT is fully operational**
  - **All Det Array on; At temperature; HV fully up;**
  - **Trigger adjustments 90% done**
- **BAT is detecting bursts and steady-state sources**
  - **It is waiting the NFIs to complete their check-out phases so we can begin full autonomous mission operations.**

- **Lower the Thresholds another 1-2 keV**
  - **Select a subset of Sandwiches for extra low energy operations**
- **Lower the Rate-Trigger thresholds**
  - **Maybe 20-30% in some time/energy/geography domains**
- **Begin delayed-distribution of Notices soon (1-2 weeks)**
- **Auto-distribution of Notices in a about a month**

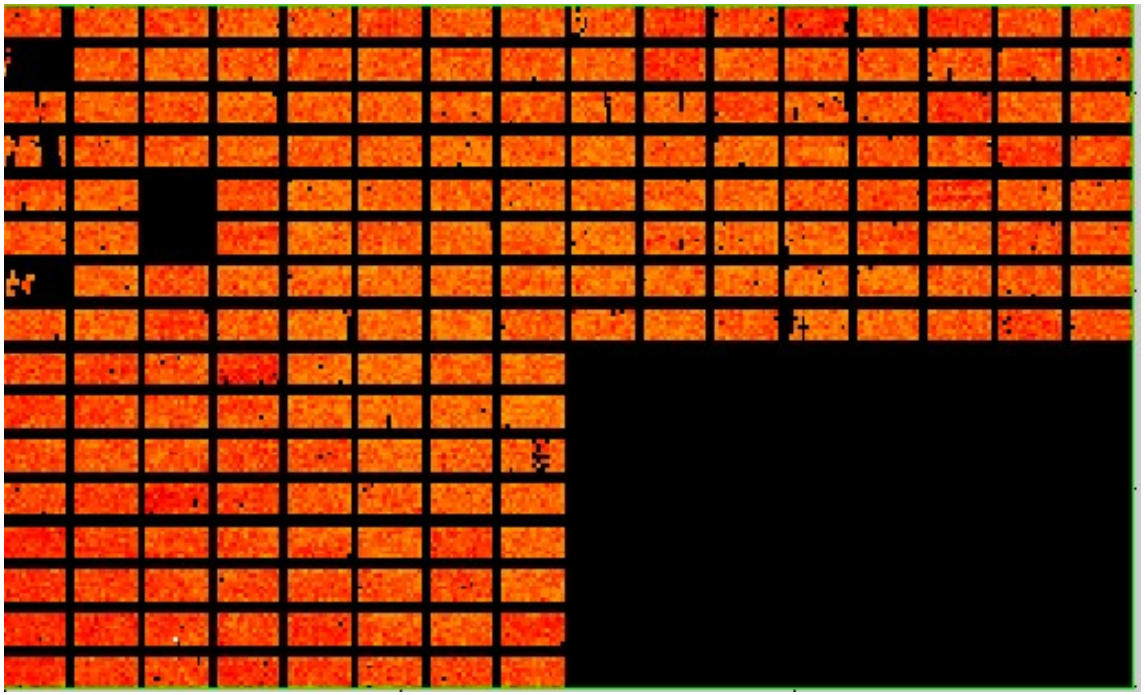
Backup/Optional Slides

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**

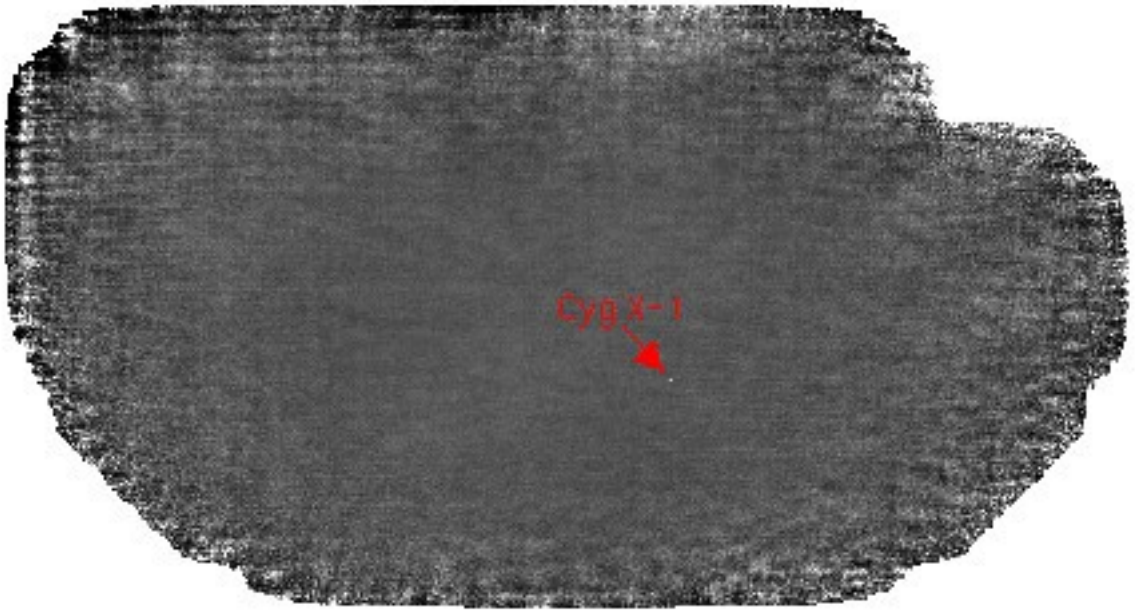


Plot by H.Krimm

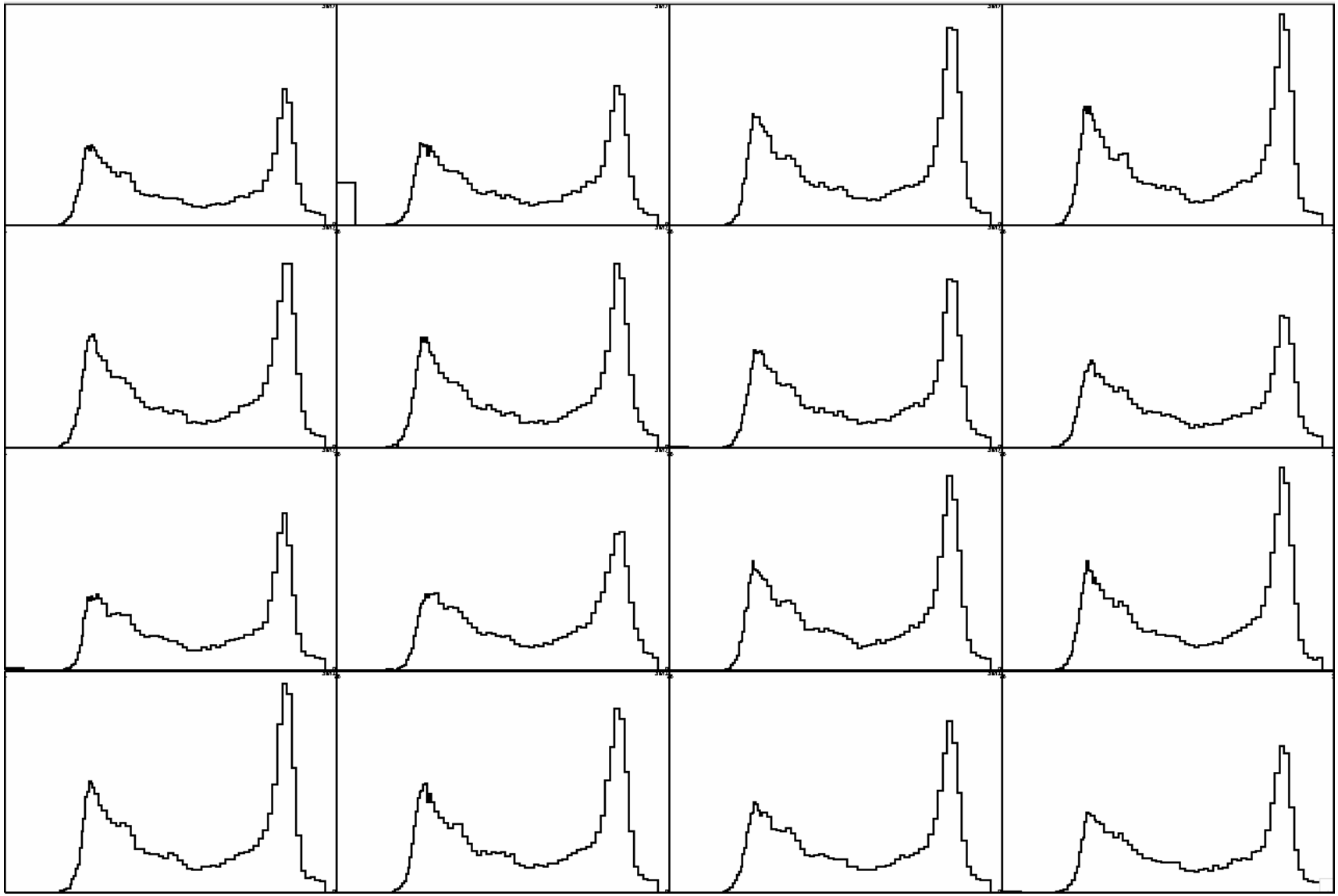


BAT First Light

3/4 of the Array activated

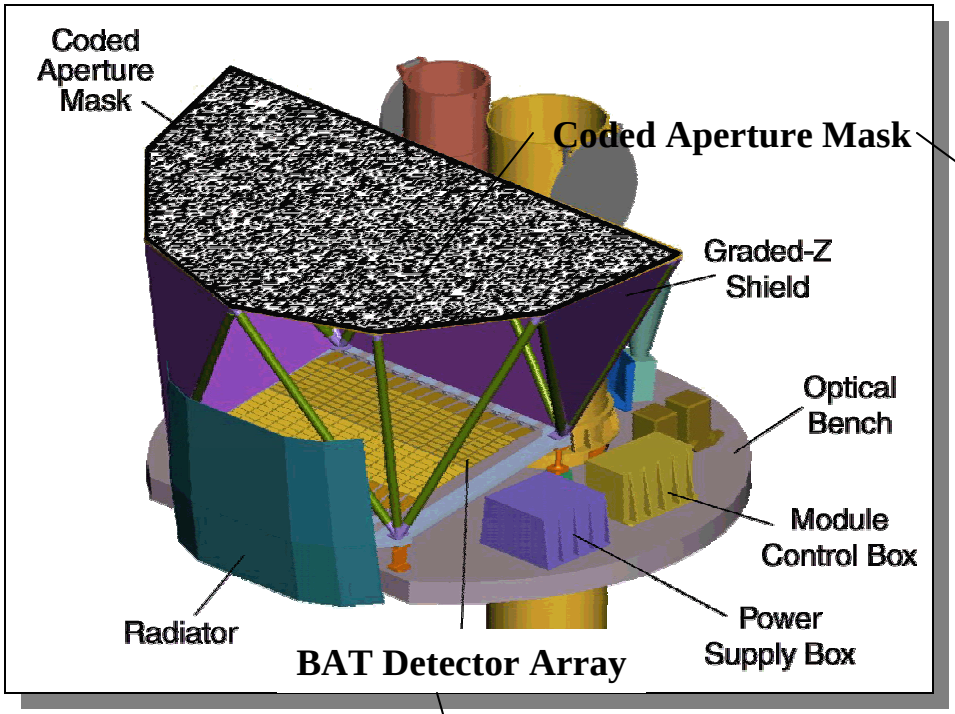


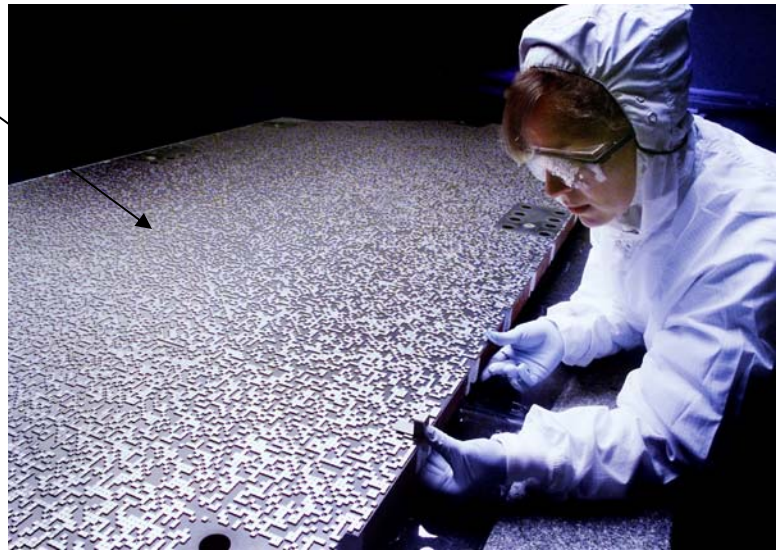
On-Orbit Am241 Cal Spectrum

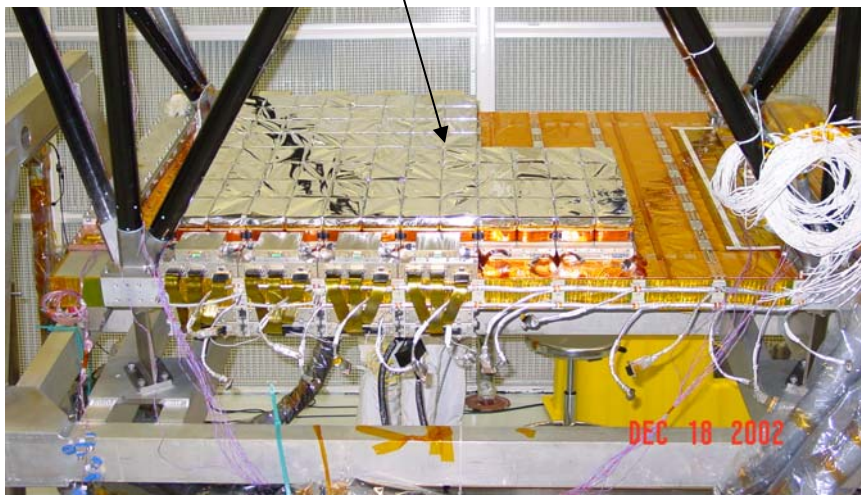


16 Blocks

Burst Alert Telescope (BAT)







BAT Characteristics

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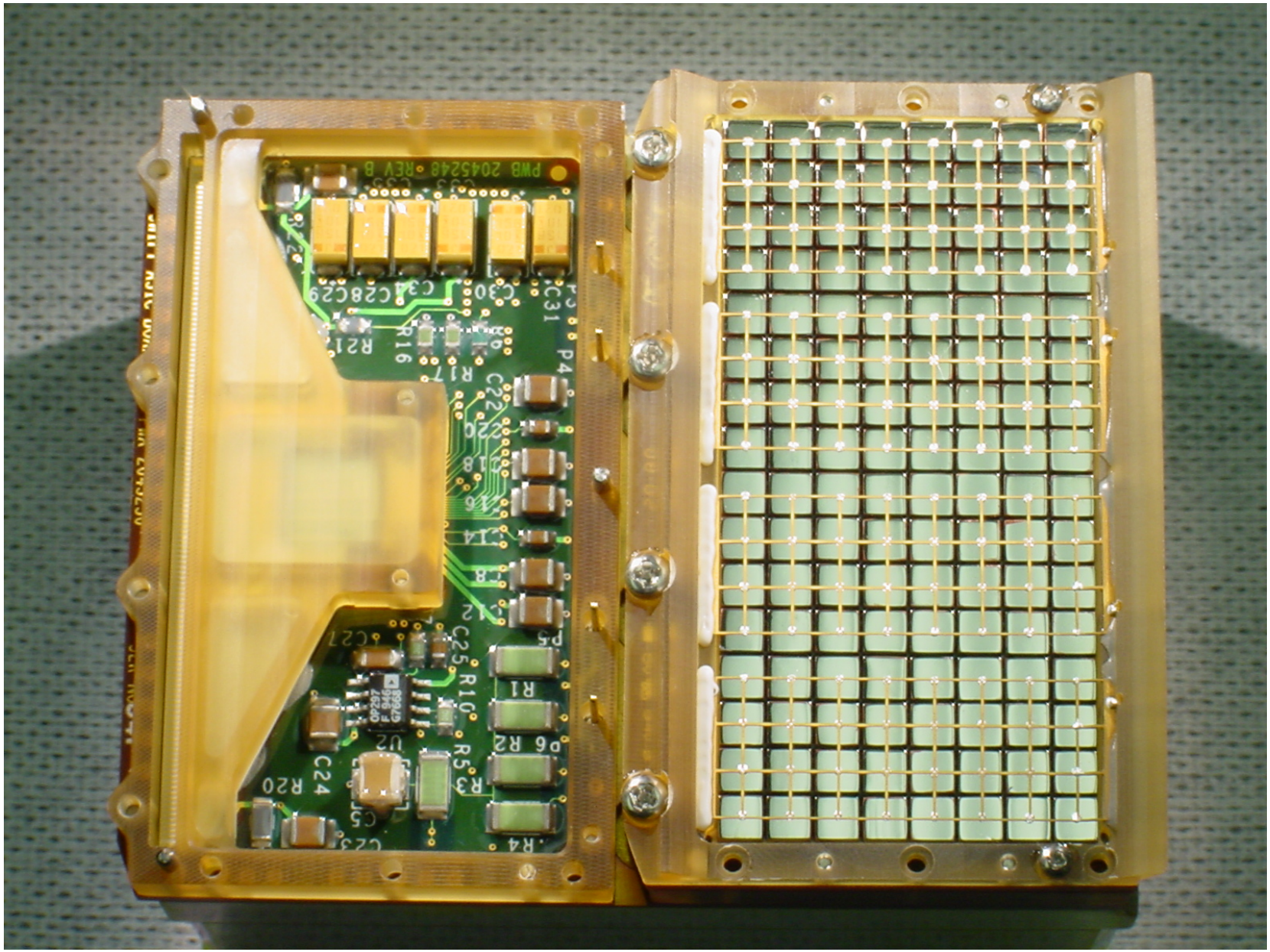
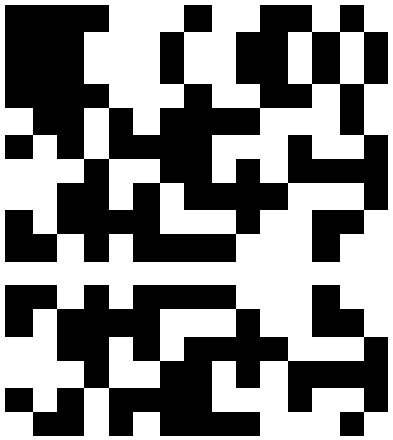
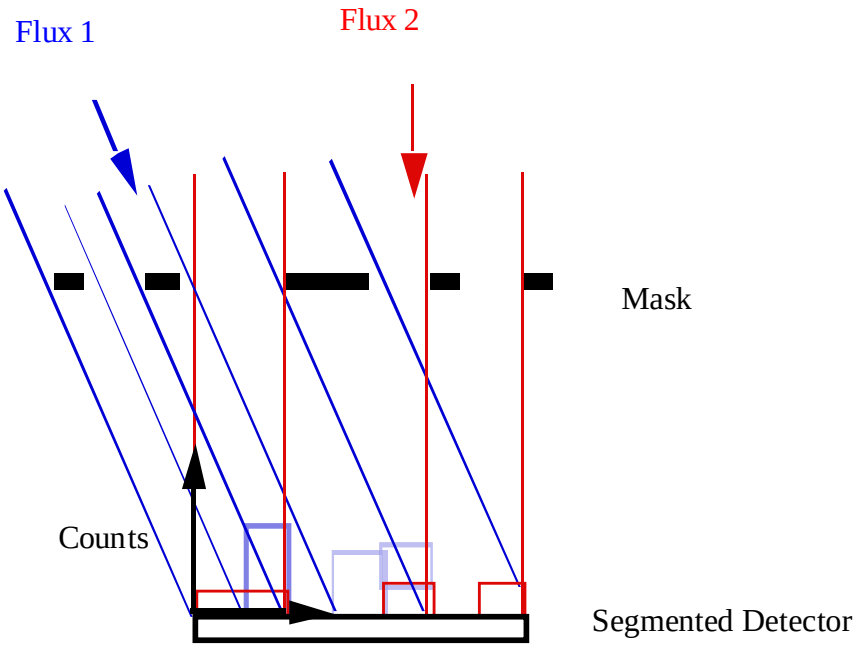
- PSF: 22 arcmin (21.8)
- 2 steradian field of view
- 32K CZT dets, 5200 cm2
- Autonomous operations


PWB 2045248 REV B
C31
P4
C22
R16
R17
C25
R10
R1
R2
R3
R5
C24
R20
R4

Coded Aperture Imaging

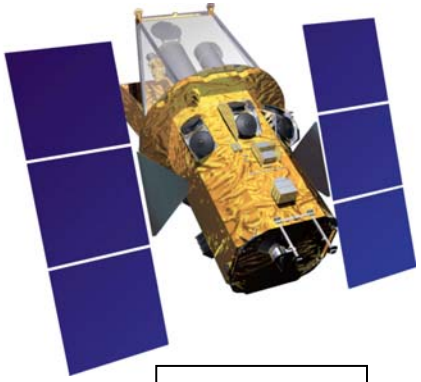
Coded Aperture
Mask Pattern





- Source Photons “Encoded” by Partially Blocked Aperture
- Can be Decoded in Data Analysis to Determine Source Position

Swift Mission

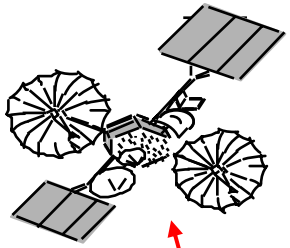


Spacecraft

Spectrum Astro
Rapid Autonomous Slews

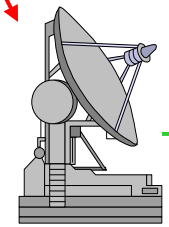
Payload

BAT
XRT
UVOT



TDRSS

Malindi



Mission Operations Center (MOC)

PSU

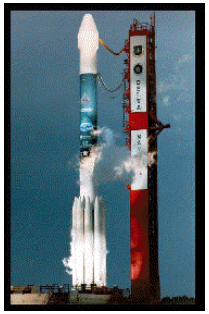
Science Center

GSFC

GCN & Web

HEASARC
UK
Italian
Archives

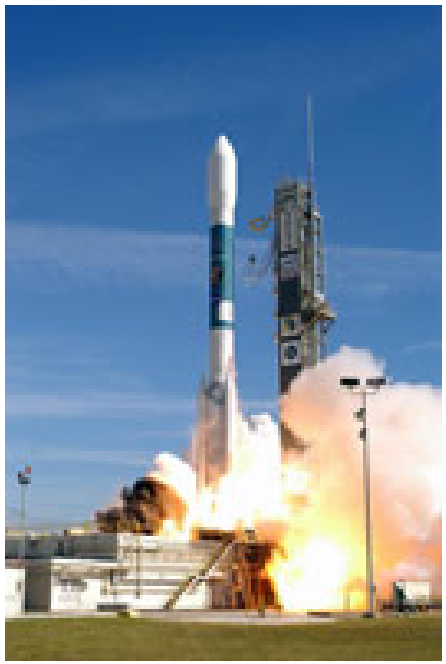
User Community



Launcher

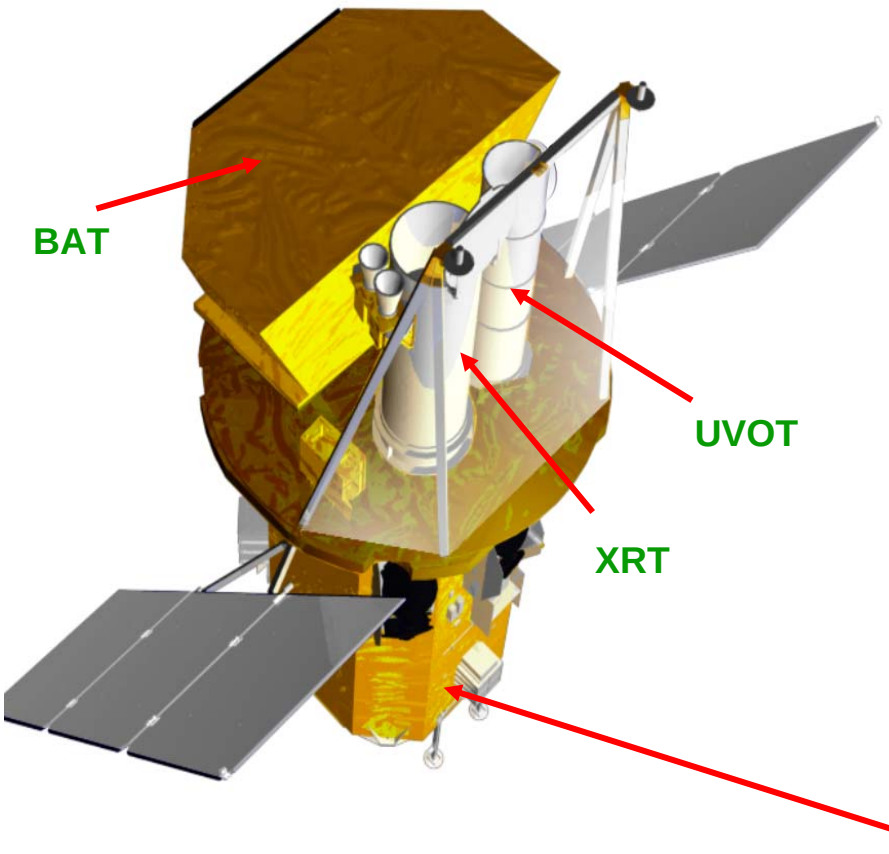
Delta 2320
600 km X 20.6^{o} inclination

Swift Launch
November 20, 2004



DeltaII with 3 solids
590 km; 20.6°

Swift Instruments

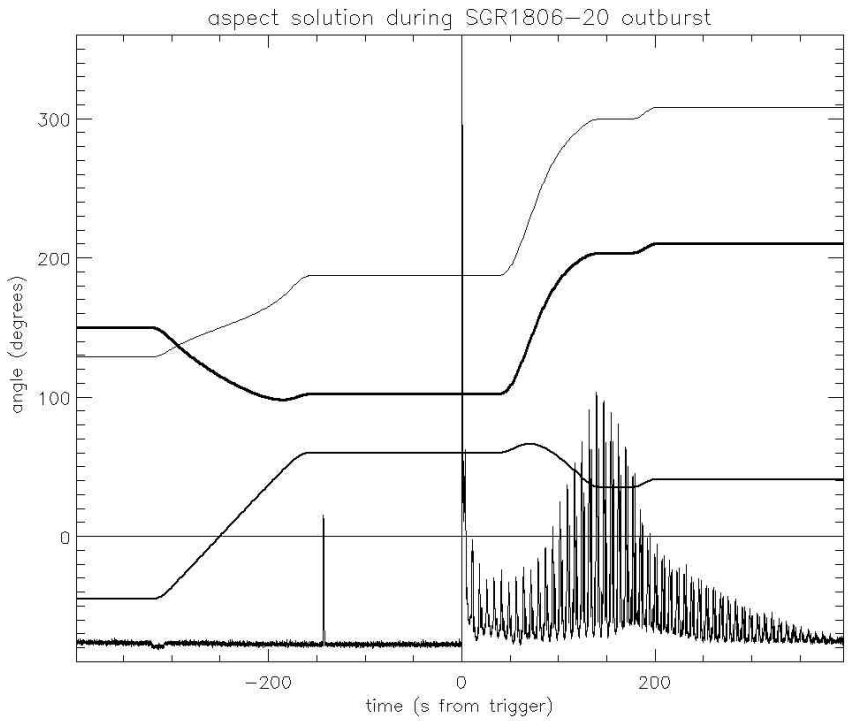


Instruments

- **Burst Alert Telescope (BAT)**
  - New CdZnTe detectors
  - Detect >100 GRBs per year depending on logN-logS
  - Most sensitive gamma-ray imager ever
- **X-Ray Telescope (XRT)**
  - Arcsecond GRB positions
  - CCD spectroscopy
- **(UVOT) UV/Optical Telescope**
  - Sub-arcsec imaging
  - Grism spectroscopy
  - 24^{th} mag sensitivity (1000 sec)
  - Finding chart for other observers

Spacecraft

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



BAT Characteristics

Telescope	Coded Aperture
Telescope PSF	17 arcmin FWHM
Position Accuracy	1-4 arcminutes
Detector	CZT
Detector Format	32768 pixels
Energy Resolution	7 keV FWHM (ave.)
Timing Resolution	100 microseconds
Field of View	2 Steradians, partially-coded
Energy Range	15 – 150 keV
Detector Area	5200 cm^2
Sensitivity	0.2 photons/cm^2/s
Max Flux	195,000 cps (entire array)
Operation	Autonomous

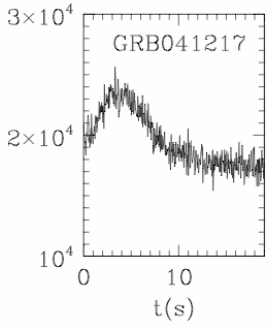
Even Later News

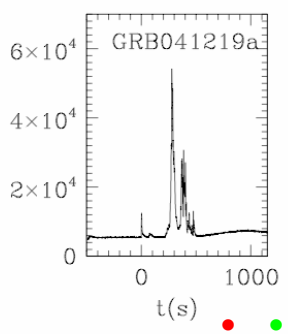
- **Array fully on: all 32,768 detectors**
- **HV at nominal -200v**
- **Temperature of the Array at nominal 20°C**
- **Thresholds at 14 keV -- will go lower within a month**
- **Energy resolution 5 keV @ 60 keV**
- **Triggers are running (rate & image)**

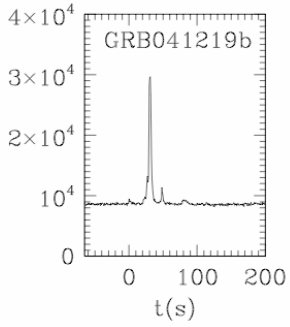
- **8 steady-state sources routinely detected (with just 1/2-3/4 array)**
  - **Crab, CygX1, CygX3, ScoX1, VelaX1, V0332+53, GX301-2, GRS1915+105**
- **As-built alignment only 7' error**
- **Measured PSF is 22'**
- **Position uncertainty:**
  - **0.4' fully coded, 0.7' at edge of FOV; for a 25-sigma source**
  - **1.9' fully coded; for a 7-sigma source**
- **One ground-detected burst so far (position not possible: thru the side?)**

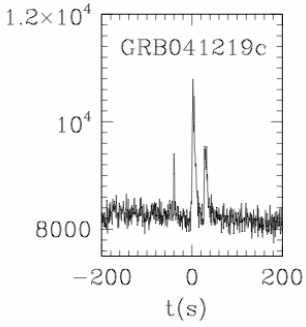
- **Fully commissioned by L+7weeks**

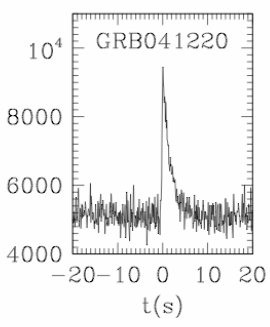
Light Curves of BAT GRBs
(incomplete - waiting for IPN detection red dots)

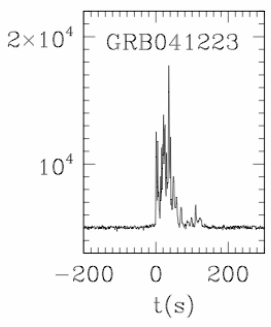


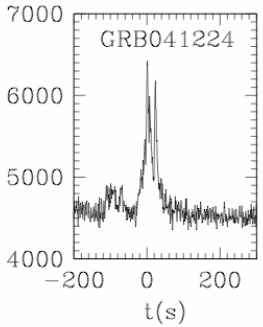


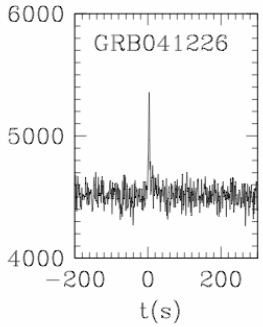


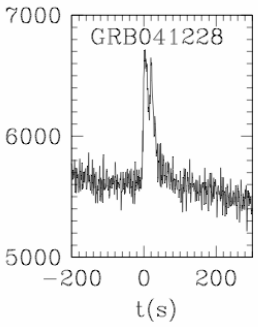








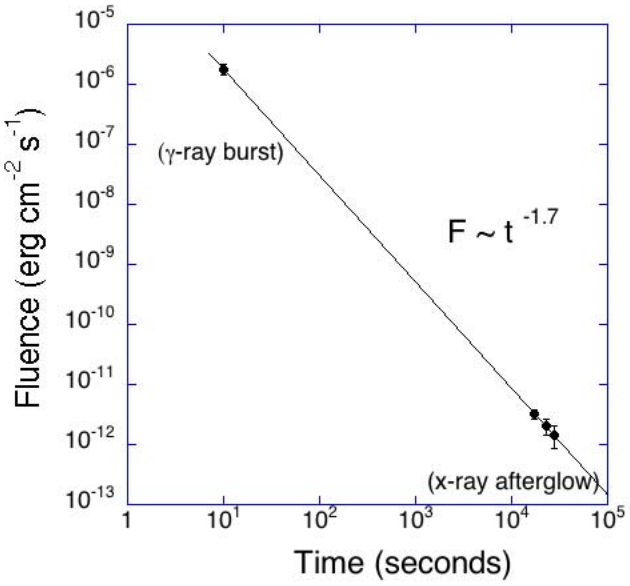




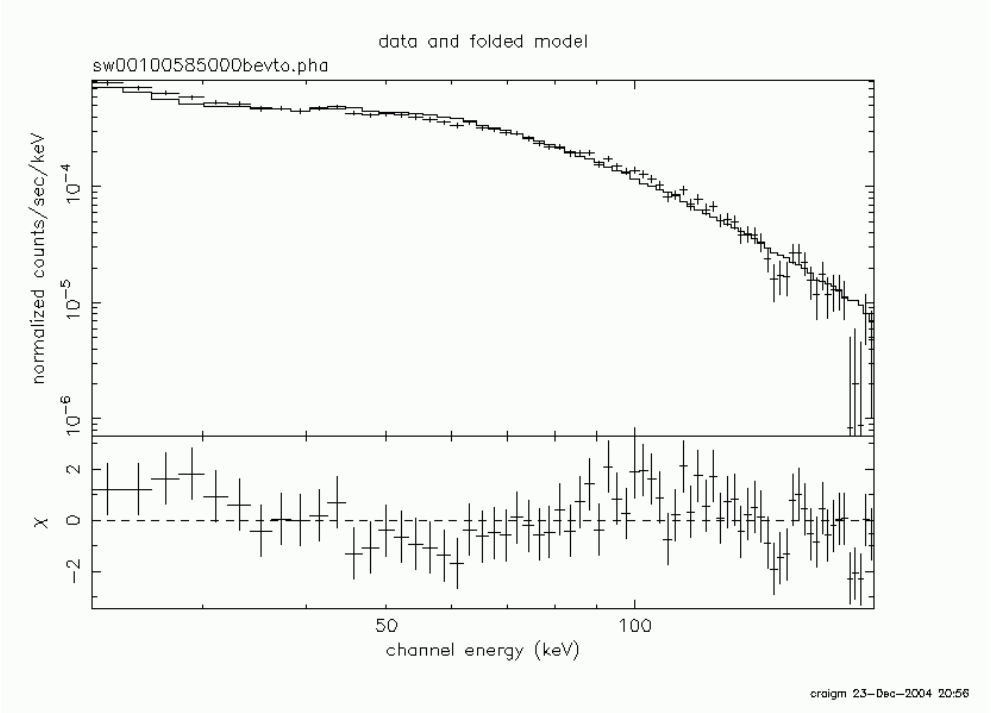
- = detected by other gamma-ray instrument
- = slewed to and imaged by XRT
- = detected by ground-based optical/IR

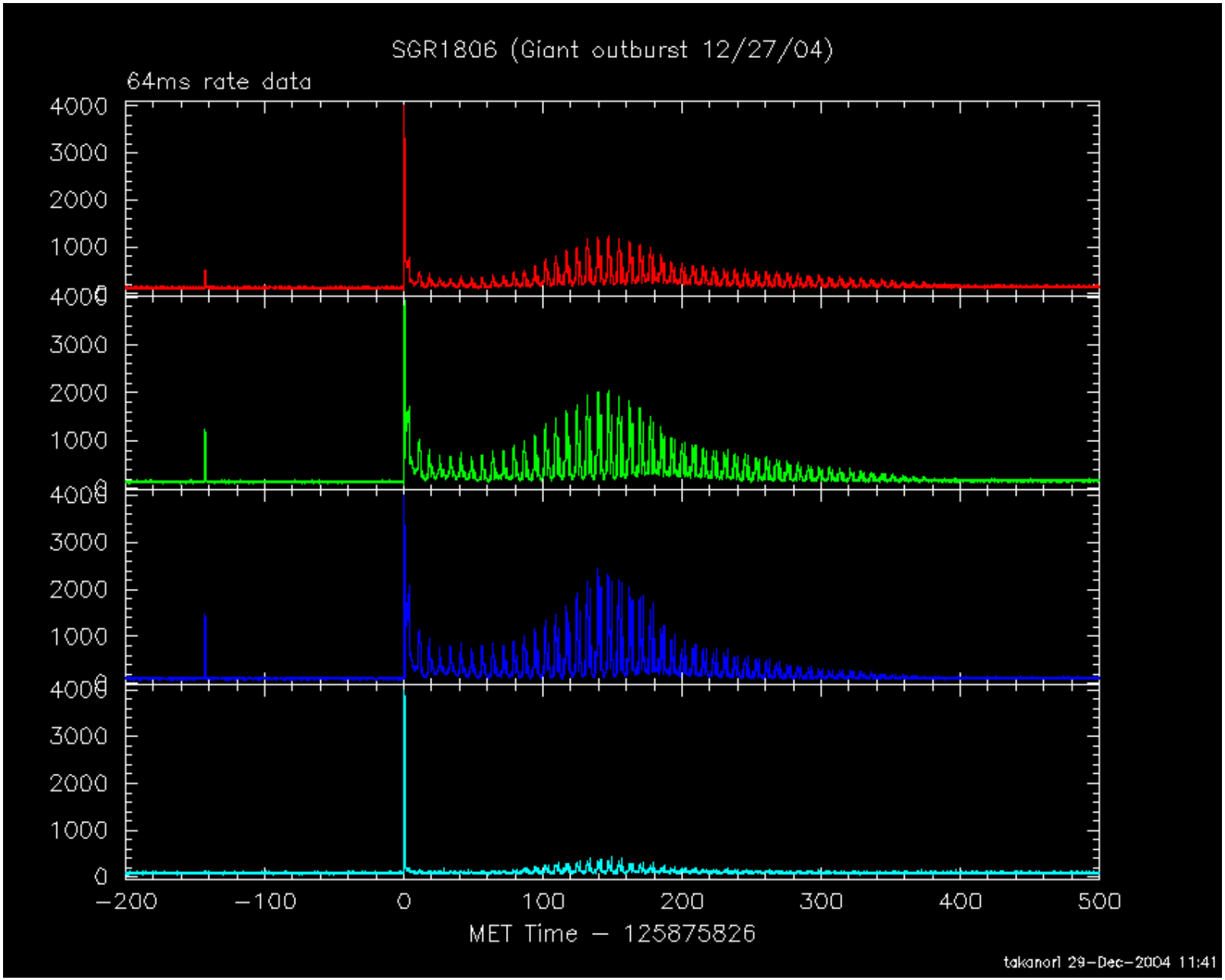
GRB 041223 cont.

Decay Lightcurve



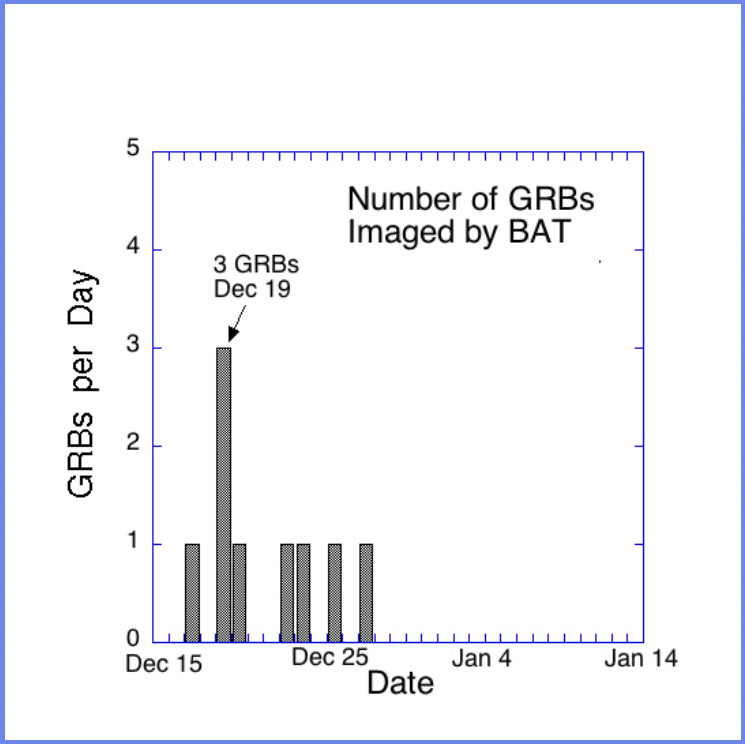
BAT Spectrum




SGR1806 (Giant outburst 12/27/04)
64ms rate data
4000
3000
2000
1000
0
−200
−100
0
100
200
300
400
500
MET Time − 125875826
takanori 29−Dec−2004 11:41

Scientific Findings To Date

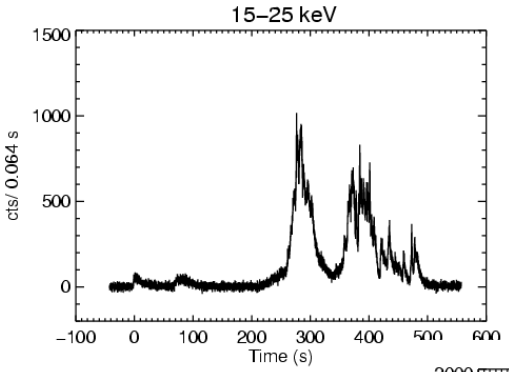
- 9 GRBs detected since Dec. 17
- Large GRB detected on Dec. 19 (GRB 041219)
- XRT pointed at GRB 041223 via ground command at ~4.5 hours. Afterglow detected.
- Giant flare detected from soft gamma repeater SGR 1806-20 on Dec. 27
- BAT is performing sensitive monitoring of hard x-ray sky

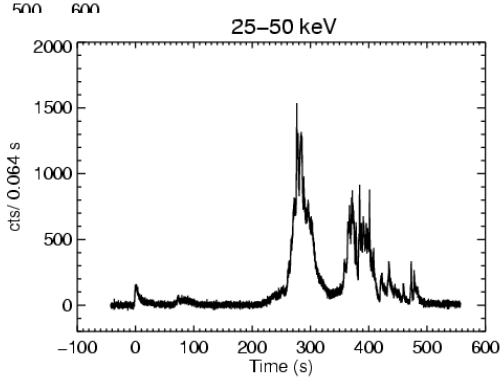


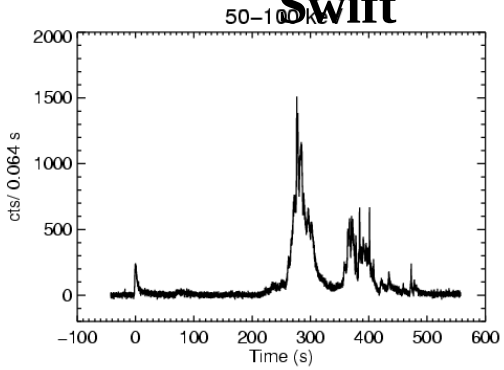
Giant Flare from SGR 1806-20

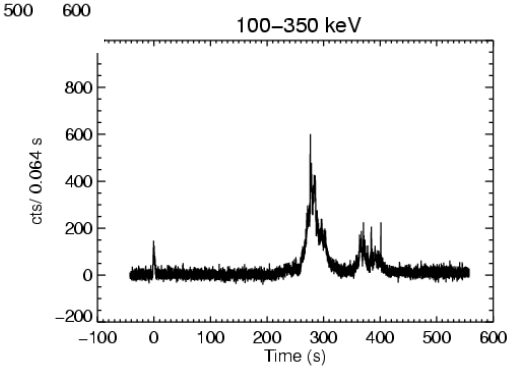
- SGRs are galactic neutron stars with huge magnetic fields (~10^{15} G) that have occasional active periods and outbursts.
- SGR 1806-20 discovered in 1986. Four known SGRs
- Detected on Dec. 27, 2004 by all non-occulted gamma-ray detectors in space
- Huge main peak lasting 0.5 sec followed by 400 sec of pulsations
- Estimate (Boggs et al. GCN 2936) puts fluence greater than ~0.1 erg cm^{-2}, 1-2 orders of magnitude greater than SGR 1900+14 1998 and SGR 0526-66 1979 flares.
- Radio transient detected. Slightly extended source. Polarization detected.

GRB 041219









- **Long duration GRB lasting 500 s**
- **Fluence of ~10^{-4} erg cm^{-2}**
- **Fluence in top 1% of CGRO/BATSE bursts**
- **Duration in top 2% of CGRO BATSE bursts**
- **Imaged by INTEGRAL & Swift**

- **IR fast-fading counterpart ("flash") discovered 2.8 min after GRB**
- **Radio counterpart also detected**
- **Campaign underway to determine host and redshift**