

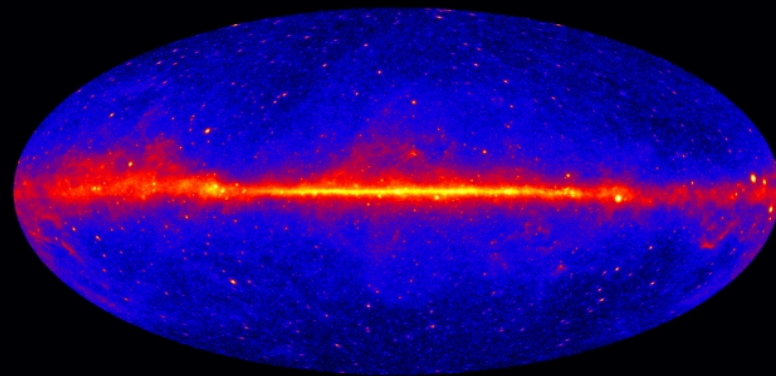
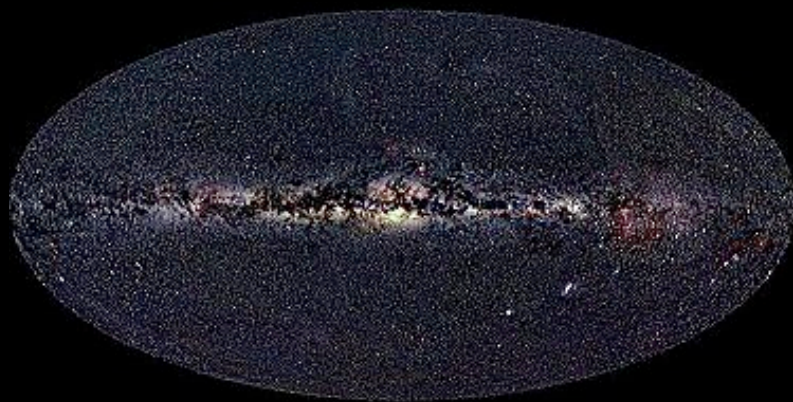
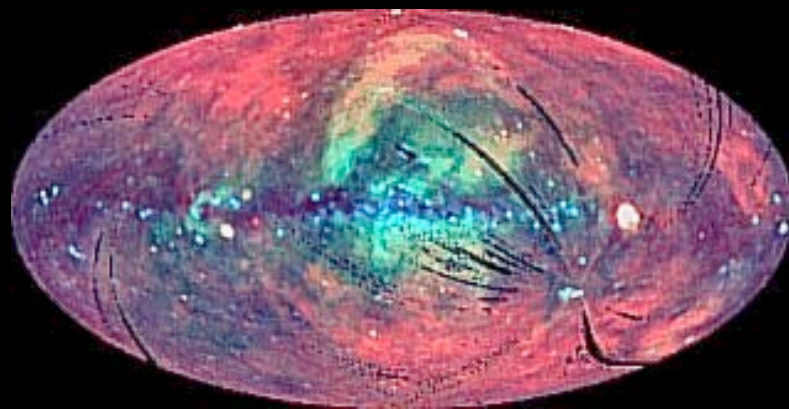
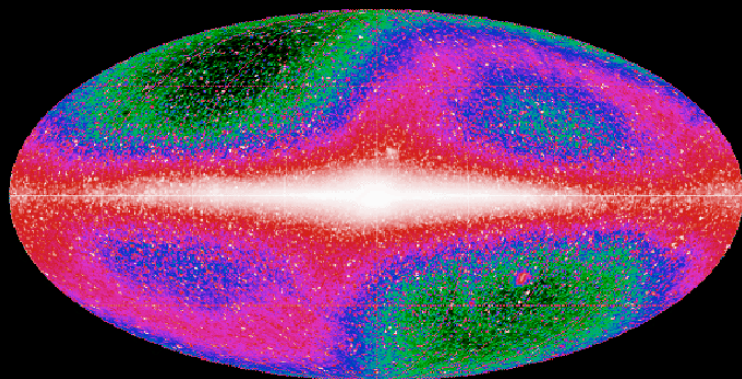
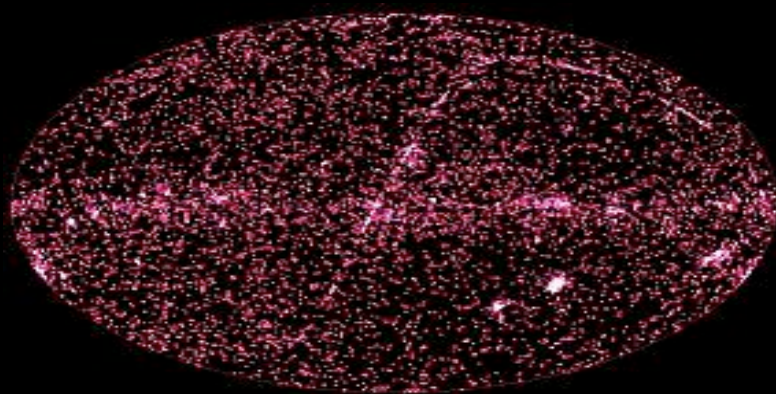
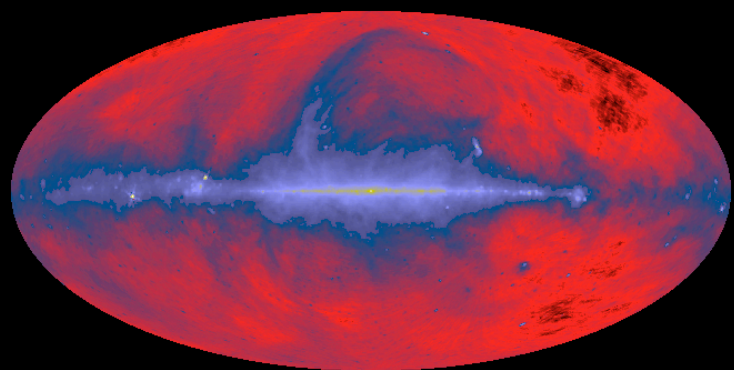
High Energy All-Sky Monitoring

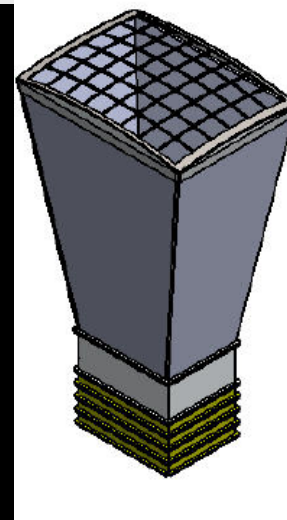
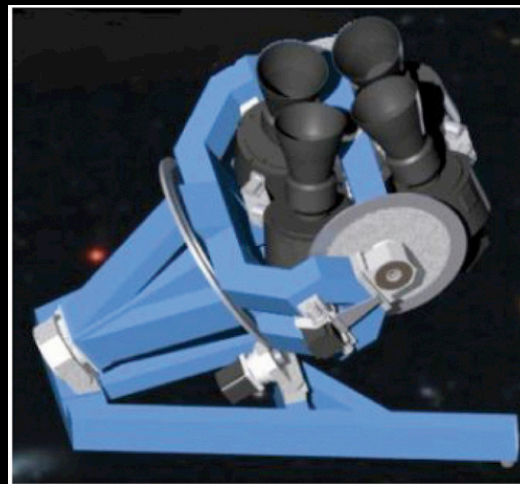
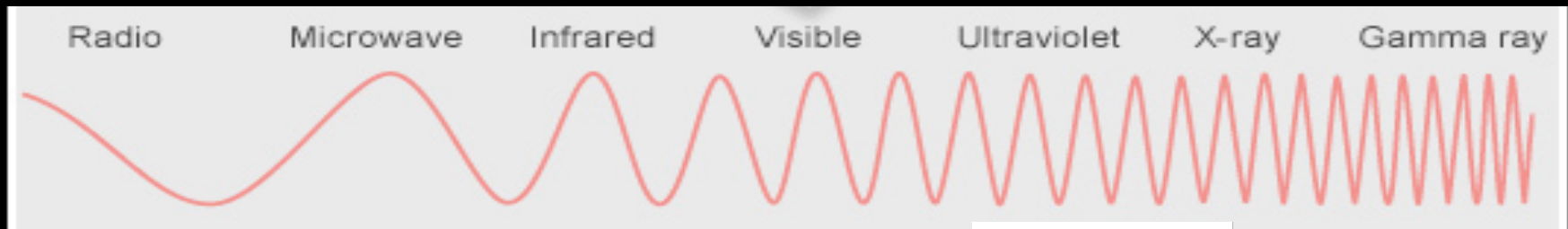
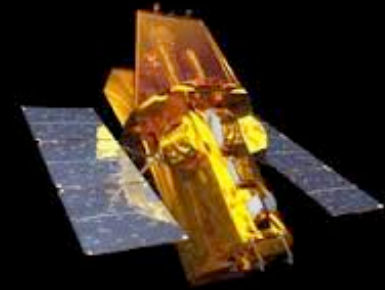
Neil Gehrels

NASA-GSFC

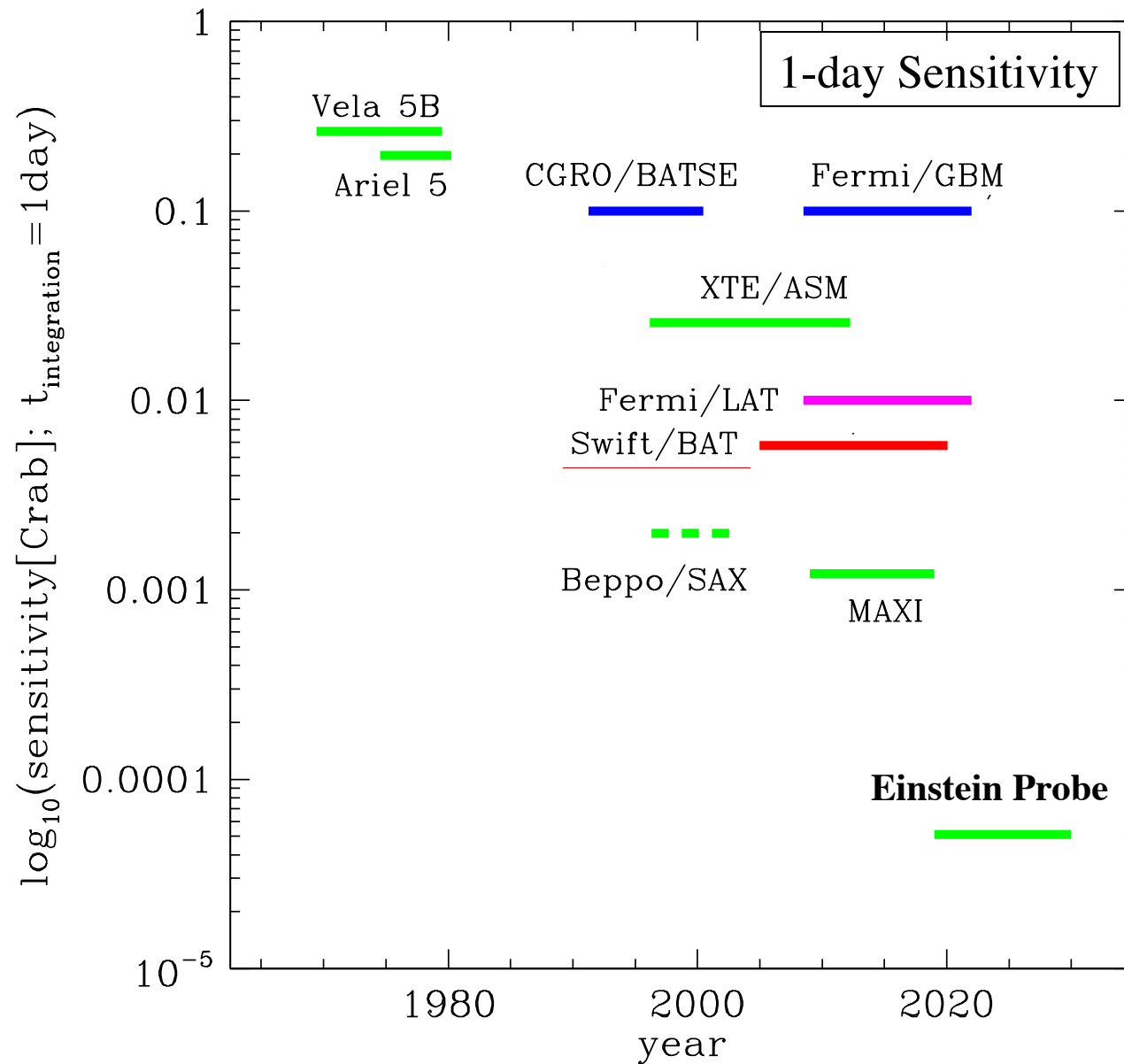
ISSI Beijing Dynamic Universe Forum

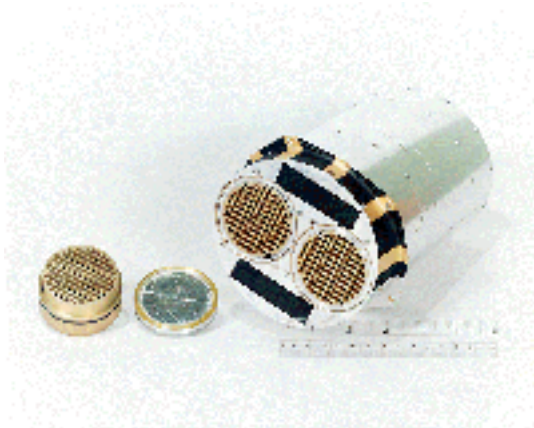
May 6, 2014





High Energy All-Sky Monitors

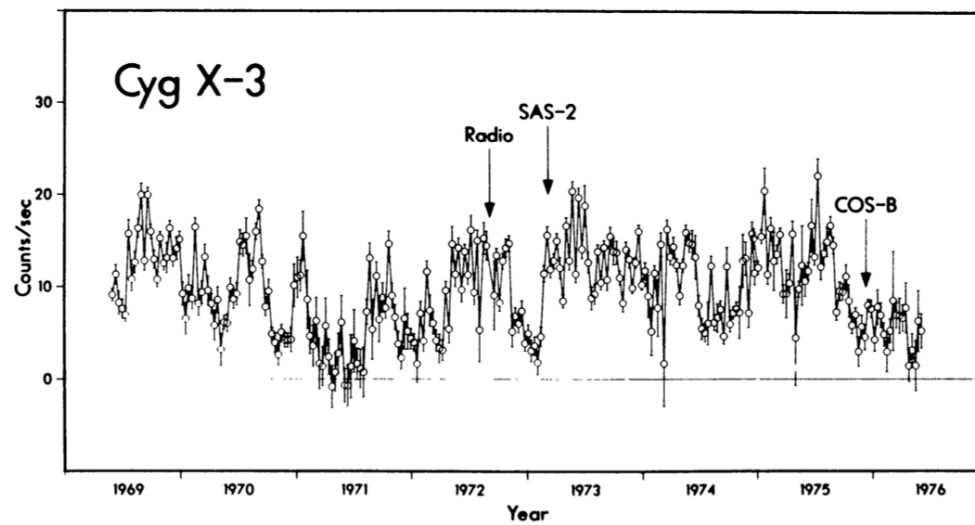
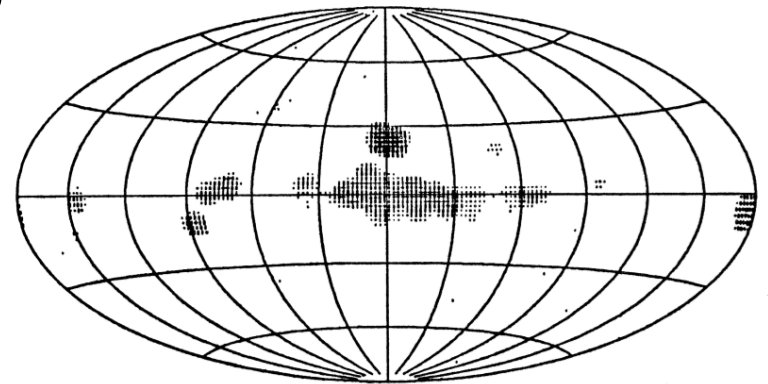




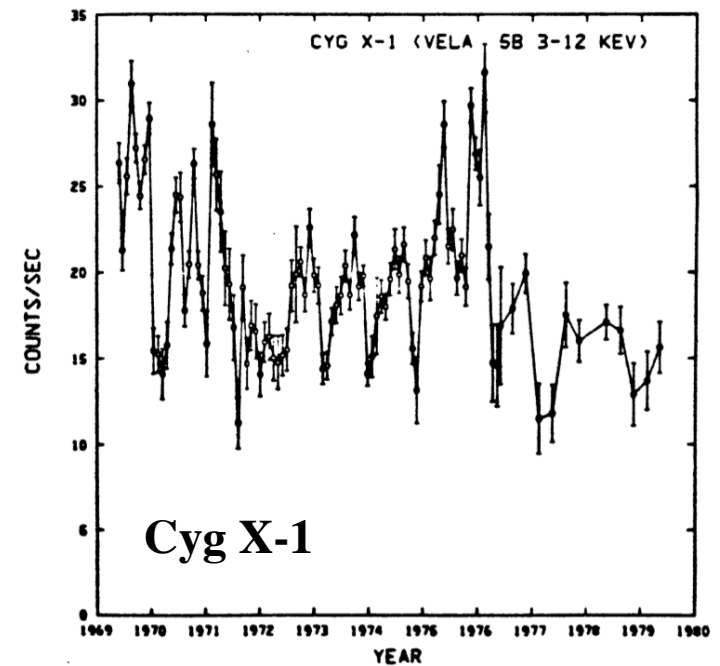
NaI 6° collimator
56 hour sky scan
3 – 12 keV

Vela 5B

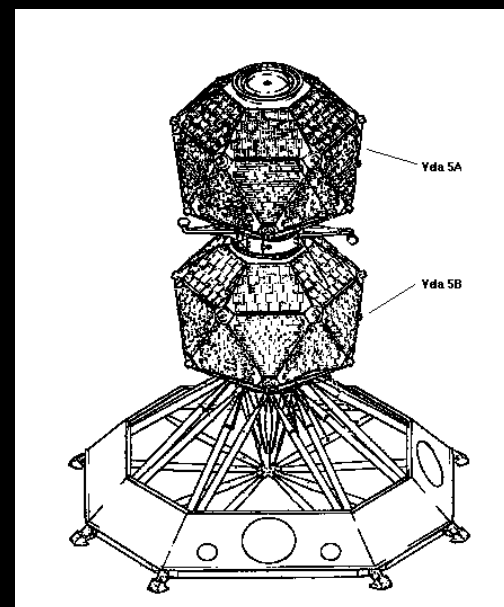
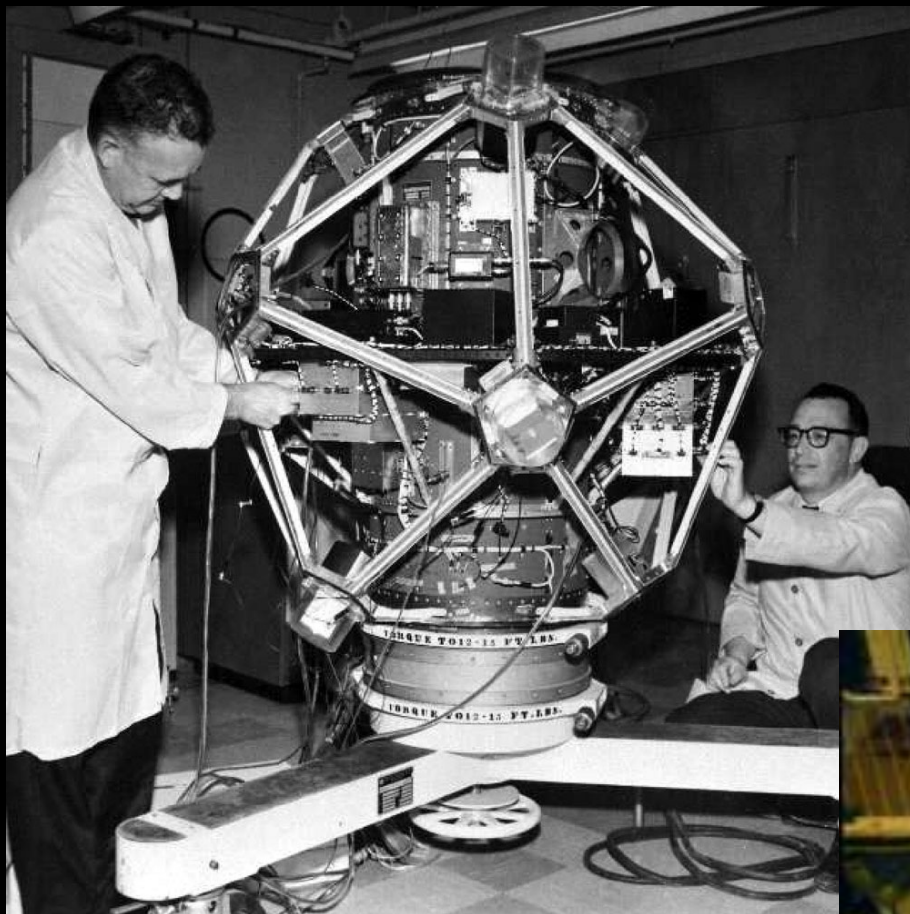
1969 - 1979



Priedhorsky 85



Terrell+ 82





Ariel 5

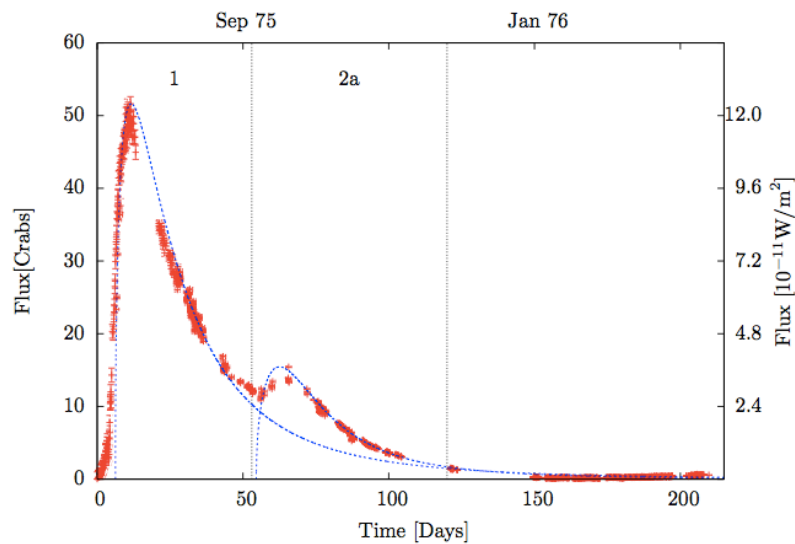
1974 - 1980

All Sky Monitor + 3 instruments

ASM parameters:

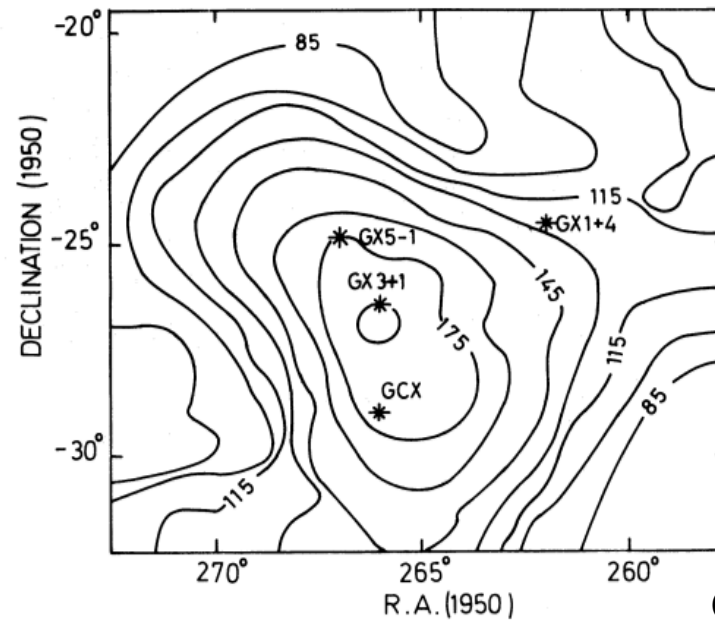
- pin-hole camera
- 1 cm^2
- 3-6 keV
- sky scan every 90 minutes

X-ray nova A 0620-00



Elvis+ 75, Kaluziński+ 77,
Coronado & Mendoza 14

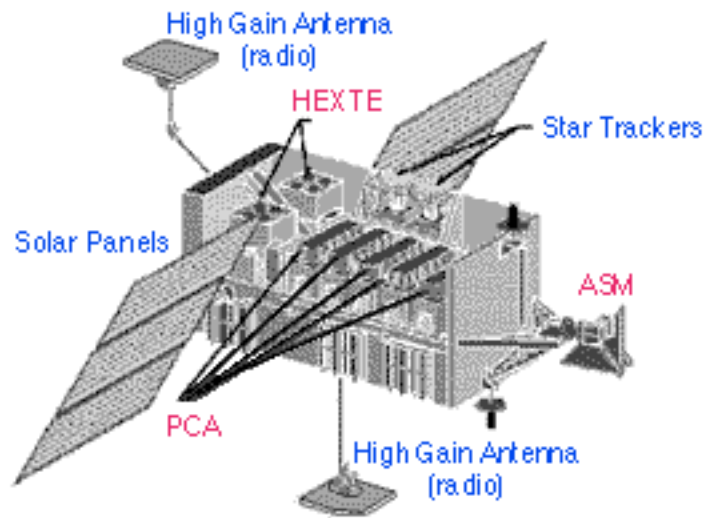
Galactic Center Region



Coe+ 81

RXTE - ASM

1995 - 2012



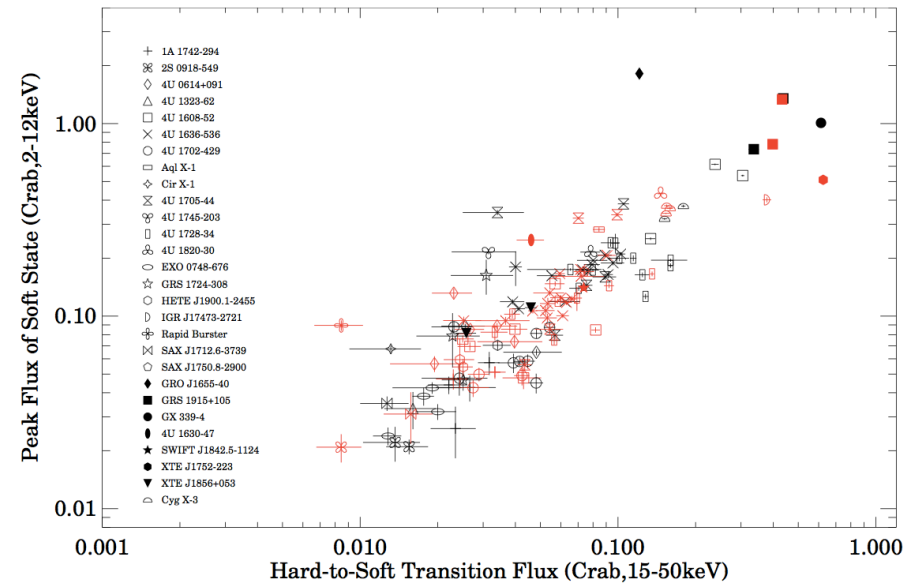
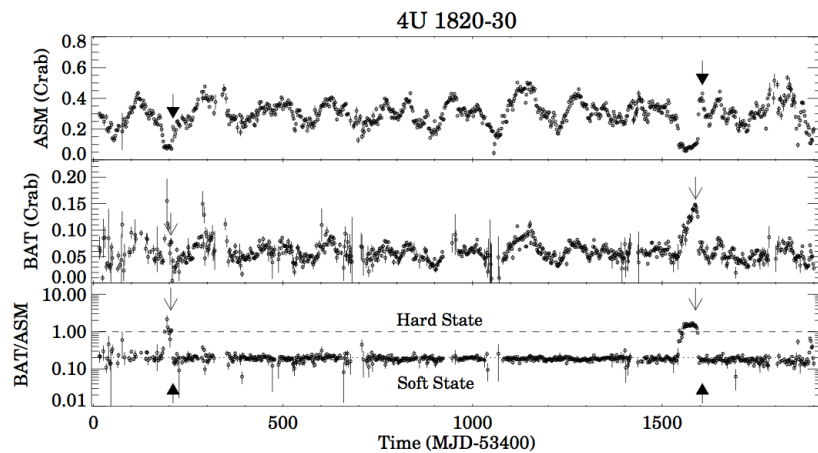
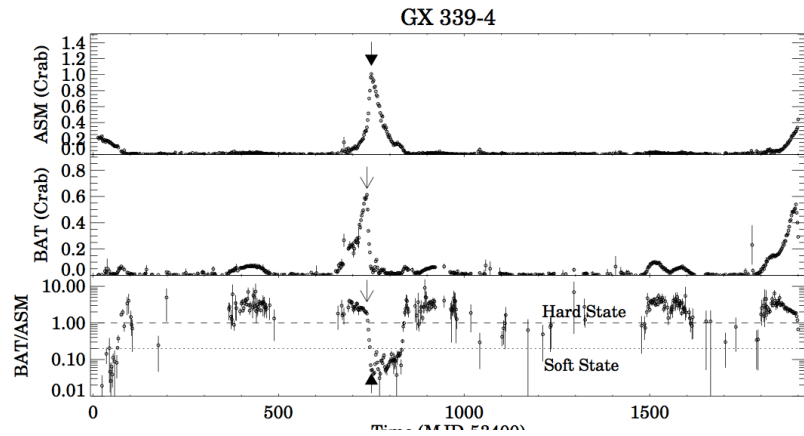
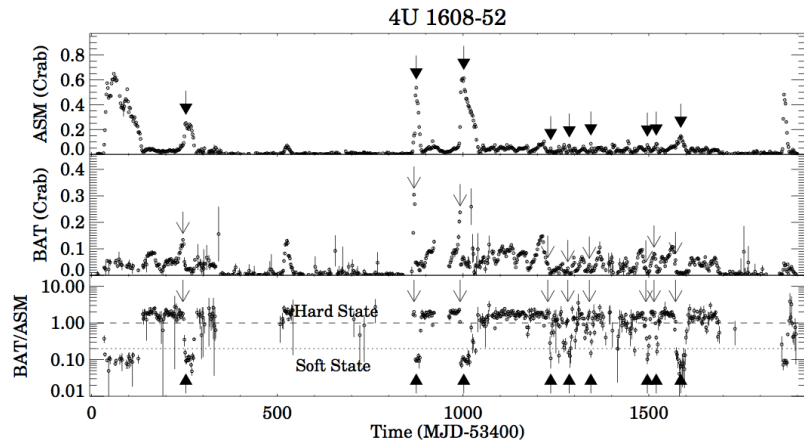
ASM parameters:

- scanning shadow camera
- PSPC detector
- 1-4 keV
- $6^\circ \times 90^\circ$ FOV



Remillard 97

ASM + BAT BH and NS Transients



Tang, Yu & Yan 10

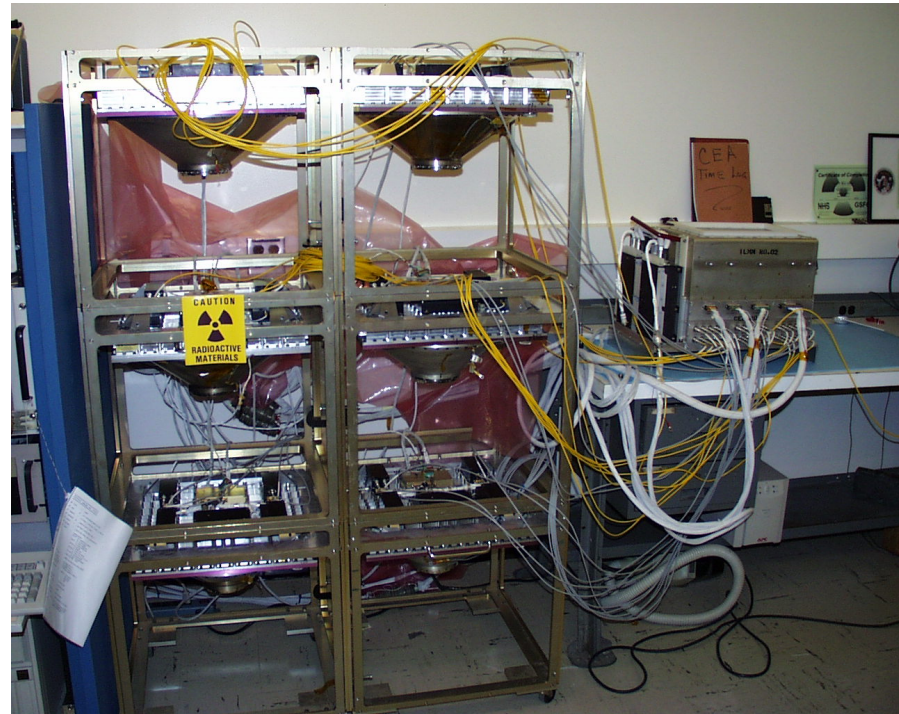
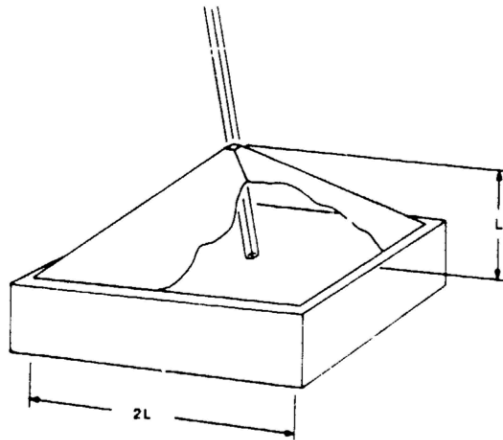
MOXE – Spectrum X- γ

MOXE Instrument at GSFC

Pin-hole ASM

Fabricated

Never flown

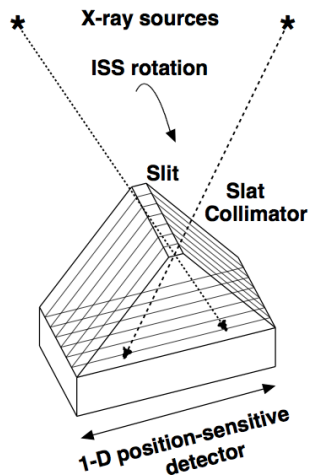
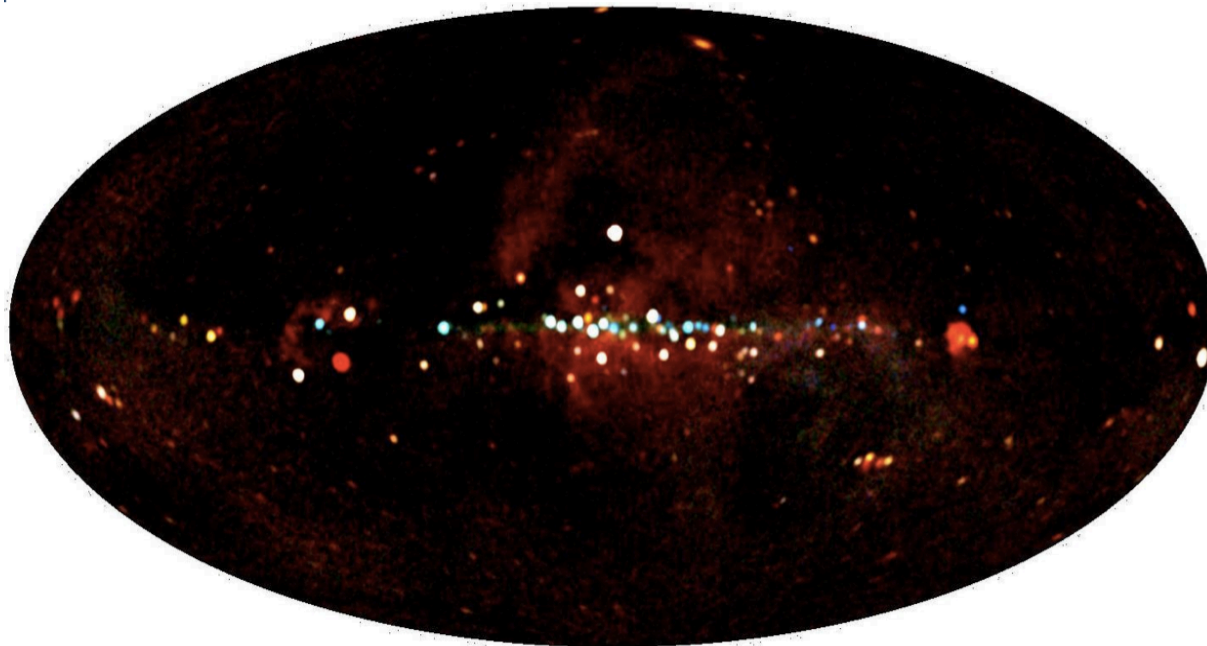


Kelley, Priedhorsky+ 89

GSFC - LANL

MAXI - ISS

2009 - present



Gas Slit Camera

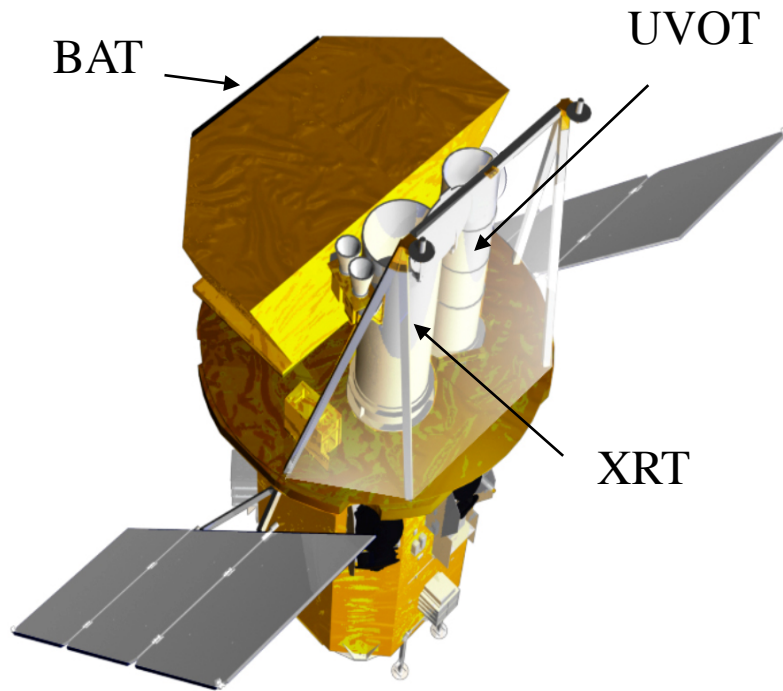
- Xe + CO₂
- 2 – 30 keV
- 5350 cm²
- 1.5° x 160°
- 18% E resolution

Solid-state Slit Camera

- CCDs
- 0.5 – 12 keV
- 200 cm²
- 1.5° x 90°
- 3% E resolution

Swift - BAT

2004 - present

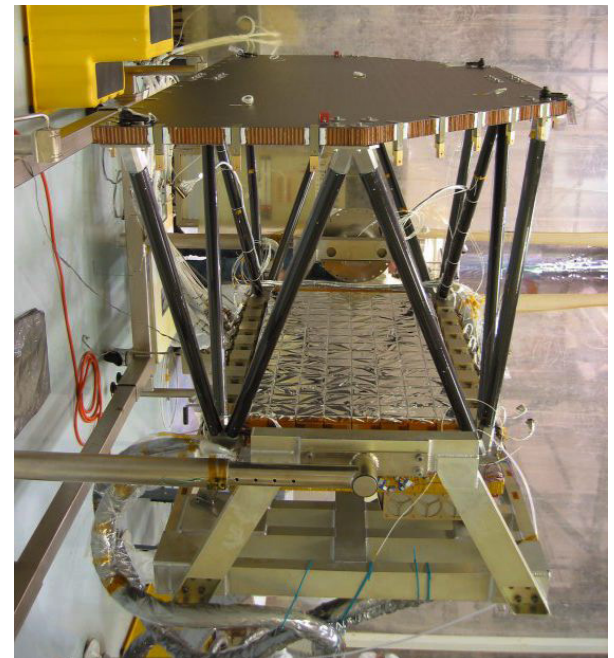
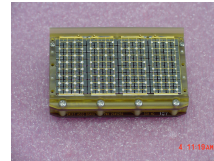


BAT parameters:

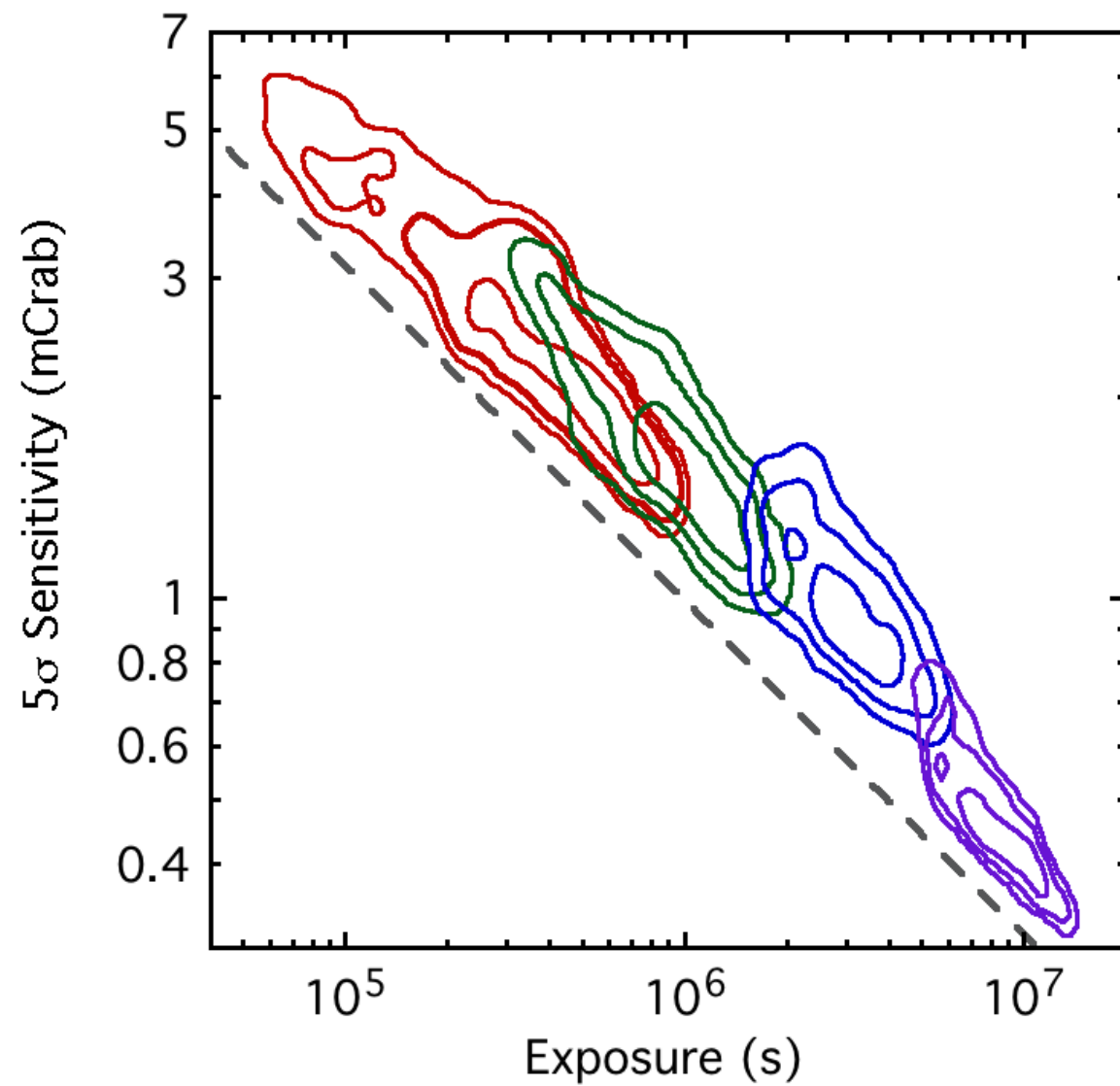
- CdZnTe 5000 cm²
- 2 sr FOV
- 70% daily sky coverage
- 13 – 300 keV

3.3 average BAT triggers per week

- **1.8 GRBs**
- **1.0 transients**
- **0.5 noise**



BAT Sensitivity



Swift TOO List – Last Week

4906	iPTF14ans	supernova	Cao (GI)	Apr 29, 2014
4905	Mrk 421	blazar flare	Paneque	Apr 28, 2014
4904	Nova Sco 2014	nova	Kuulkers	Apr 28, 2014
4903	FAVA J0641-032	LAT transient	Ajello	Apr 28, 2014
4902	1156+295	quasar optical	Jorstad (GI)	Apr 28, 2014
4901	PKS 1730-13	blazar flare	Gonzalez (GI)	Apr 26, 2014
4900	ASASSN-14ar	optical transient	Holoien	Apr 26, 2014
4899	iPTF14ans	supernova	Cao (GI)	Apr 26, 2014
4898	SDSS J080941.7	LAT transient	Stalin	Apr 26, 2014
4897	Mkn 421	blazar flare	Paneque	Apr 26, 2014
4896	GRB100816A host	GRB host	Oates	Apr 25, 2014
4895	1E 2259+589	magnetar flare	Kaspi	Apr 25, 2014
4894	SSNinNGC4134	supernova	Brown	Apr 24, 2014
4893	FAVA J0641-0320	LAT transient	Ajello	Apr 24, 2014
4892	IPTF14aoi	supernova	Cao (GI)	Apr 24, 2014
4891	1E 1547.0-5408	magnetar flare	Kaspi	Apr 23, 2014
4890	TXS 1530-131	AGN flare	Gonzalez (GI)	Apr 23, 2014
4889	iPTF14aki	supernova	Kasliwal (GI)	Apr 23, 2014
4888	V369 Cen	nova	Schwarz	Apr 23, 2014
4887	RX Oph	nova	Osborne	Apr 23, 2014
4886	MAXI J0057-720	X-ray transient	Kennea	Apr 22, 2014
4885	PSR J1023	blazar flare	Altimirano	Apr 22, 2014

Target of Opportunity

BAT Trigger

XRT "Trigger"

Swift Transients

Gamma Ray Burst (866)

LMXB Superburst

X-Ray Burst

Soft Gamma Repeater

LMXB & HMXB Flare

Sgr A* flare

Tidal Disruption Event

Nova

BH Transient & X-ray Nova

Supernova Shock Breakout

Super Fast X-ray Transient

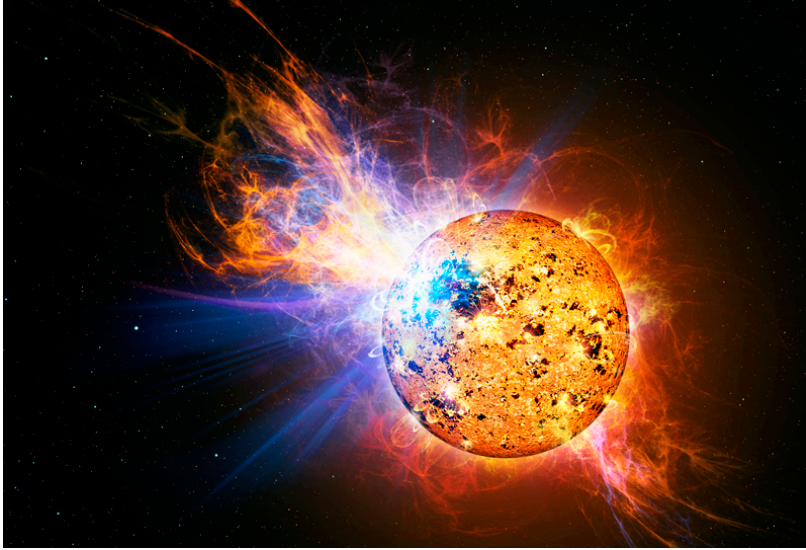
Stellar Superflare

ULX Transient

Supernova (200)

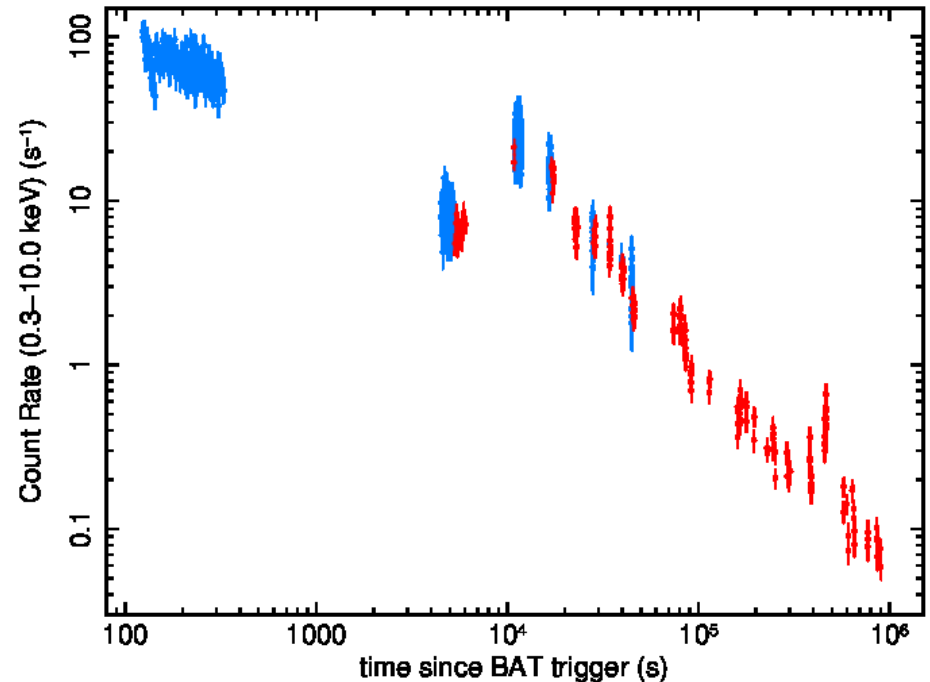
Microquasar Flare

DG CVn Large Stellar Flare



Large X-ray "super-flare"
Brighter than star luminosity
100x largest solar flare
Young star at 18 pc
Electrons accelerated by B
reconnection

DG CVn - April 23, 2014



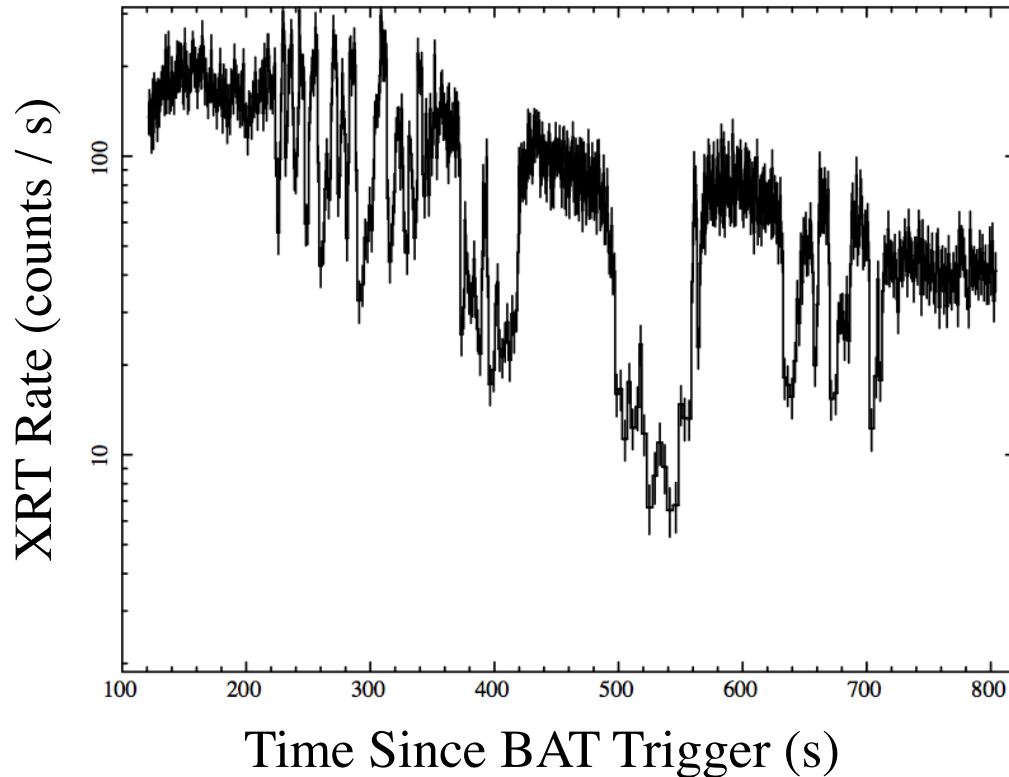
previous events: EV Lac, II Peg

Drake, Osten, Page, Oats +

LMXB Superburst

SAX J1712.6-3739 27-Sept-2011
4U 1850-08 10-Mar-2014

SAX J1712.6-3739



Large thermonuclear burn
Carbon burning of XRB ashes
Factor 1000 longer and less
frequent than XRBs
Discovered by RXTE
BAT fluence trigger

in't Zand, Strohmayer,

Sgr A* Flares

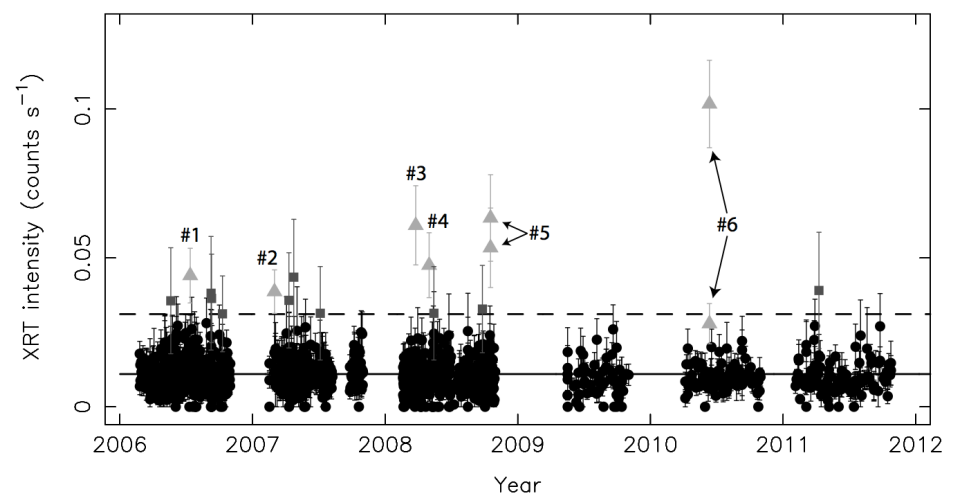
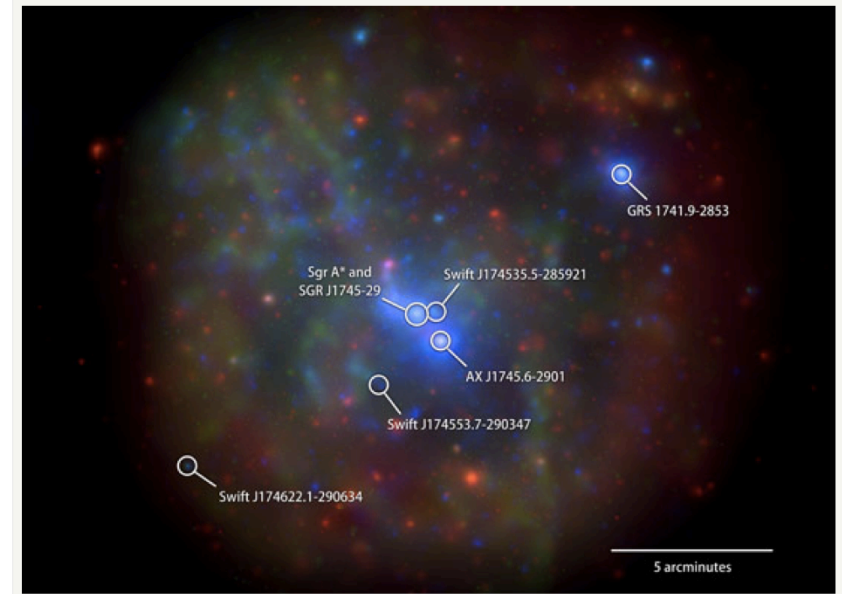
Daily monitoring of GC with XRT

6 flares seen from Sgr A*
+ 10 weak candidate flares

Sgr A* is not dormant

$L_X \sim \text{few} \times 10^{35} \text{ erg/s}$
 $\sim 1 \text{ billionth Eddington}$

No sign yet of accretion from
G2 cloud



Degenaar+ 13

Scientific Opportunities

Supernova Shock Breakout

- One detected with XRT by chance
- XRT FOV = 24 arcmin
- Type Ibc supernova with He envelope
- Event rate and dependence on SN type are highly uncertain

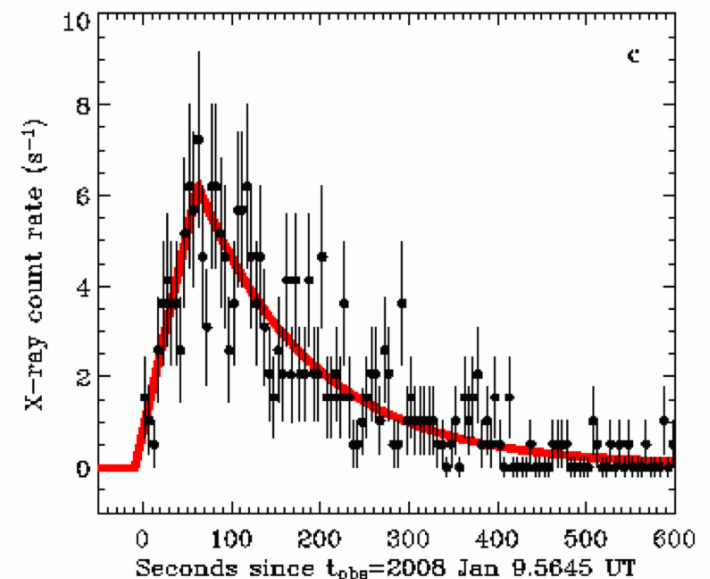
Questions:

Do all SNe have X-ray shock-break outbursts?

What is the signature of jetted vs non-jetted SNe?

Can EP/Lobster detect SN explosions seconds after core collapse?

09-Jan-2008 SN 2008D



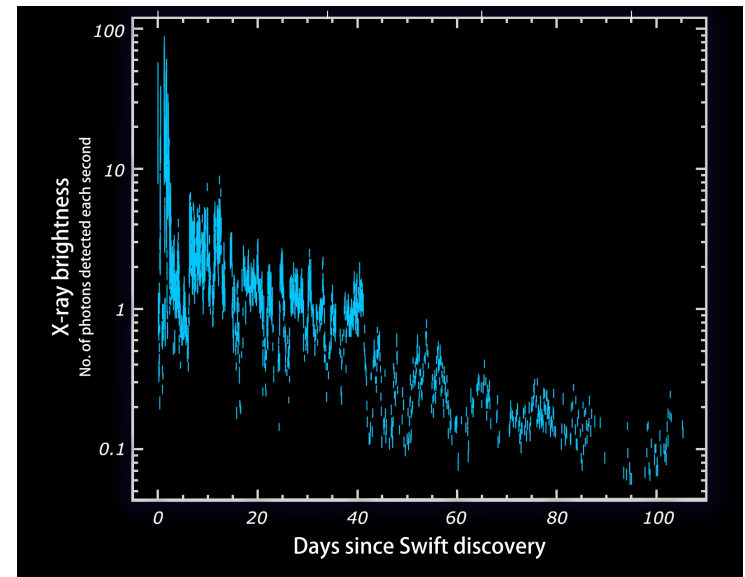
Soderberg+ 08

Scientific Opportunities

Tidal Disruption Event

28-Mar-2011 Sw J1644+57

- 3 relativistic events detected by BAT
- ~20 X-ray, UV and optical disk events
- Event rate and physics is uncertain



Bloom, Burrows, Levan, Berger,

$z = 0.35$

Questions:

Do all events have jets? Of what opening angle?

What is the signature of different types of stars / clouds?

What is the physics of the accretion instabilities?

Scientific Opportunities

Gamma Ray Bursts & Gravitational Waves

- Swift has found GRBs to high z
- Swift has shown a different origin of long and short GRBs
- There is great promise for the future in both areas

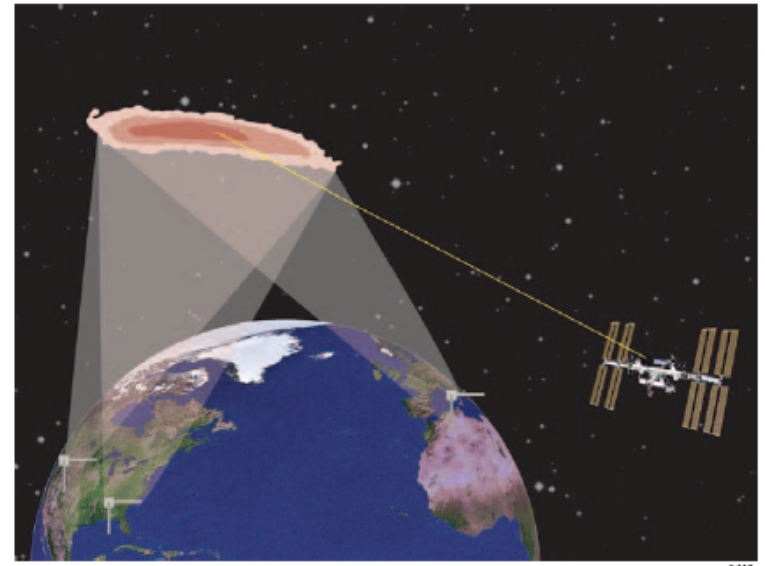
Questions:

What was the nature of the first stars?

When and how was the universe re-ionized?

Are NS-NS mergers the origin of short GRBs?

EP / Lobster observing
a GW error box



Scientific Opportunities

Compact Objects

- Galactic and AGN compact objects have variable, unstable accretion
- Wildly different luminosities depending of the system and the epoch
- Current observations are only catching bright events



Questions:

What is the physics of the accretion instabilities?

What is the prevalence of jets for NS and BH engines?

Can new systems be found to measure BH mass & spin and NS EOS?

Conclusions

- The sky is rich in transients of many types.
- Historical all-sky monitors explored the time-domain sky at the 100 mCrab level. Current instruments are pushing toward 1 mCrab.
- Wide-field focusing X-ray optics are a new technology that will improve sensitivity by $>10X$ and open up a wealth of new science.

