The Swift GRB MIDEX Mission,

A Multi-frequency, Rapid-Response Space Observatory

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May 23, 2004

Mission Collaboration

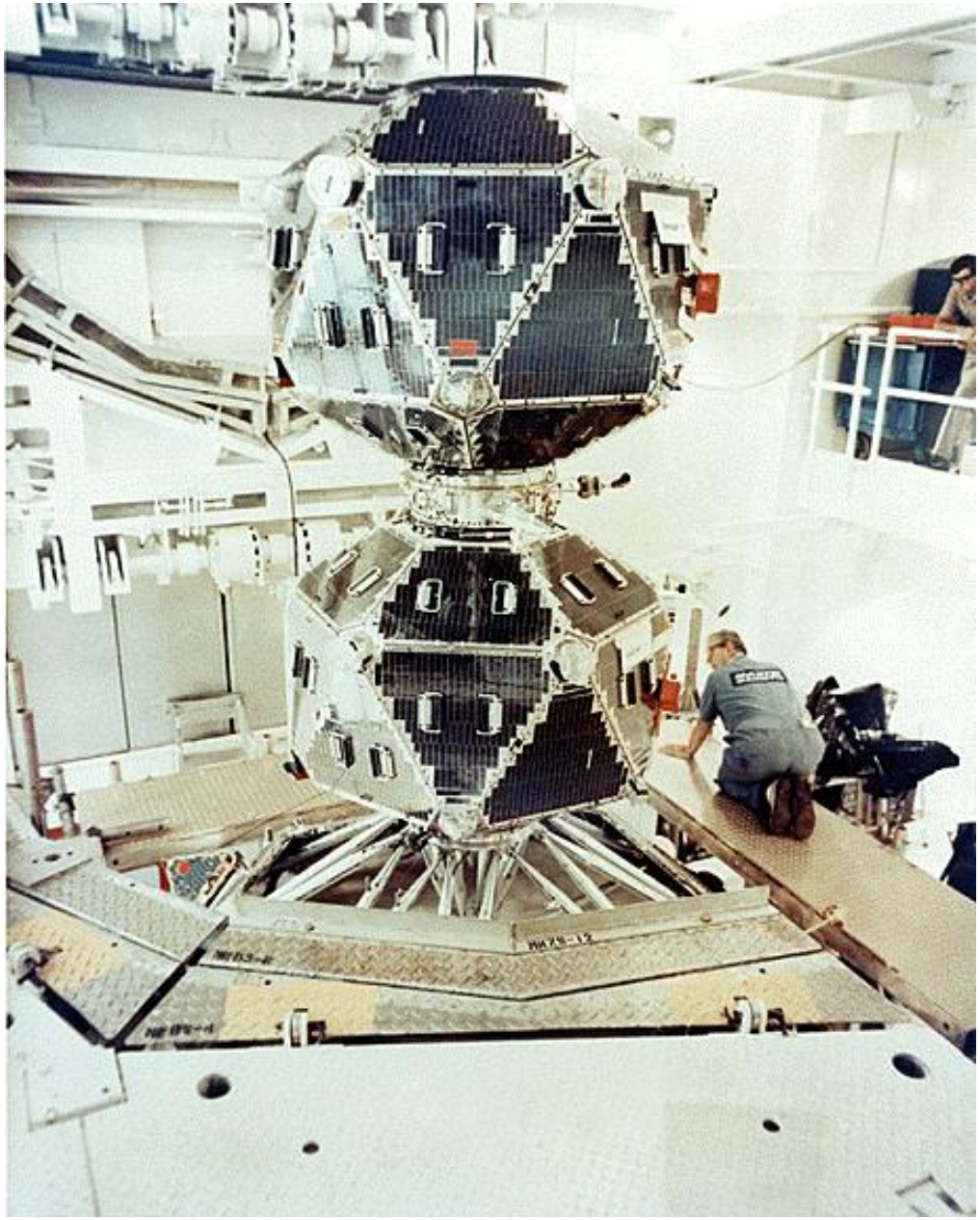
NASA MIDEX in collaboration with Italy and UK

Main Institutions

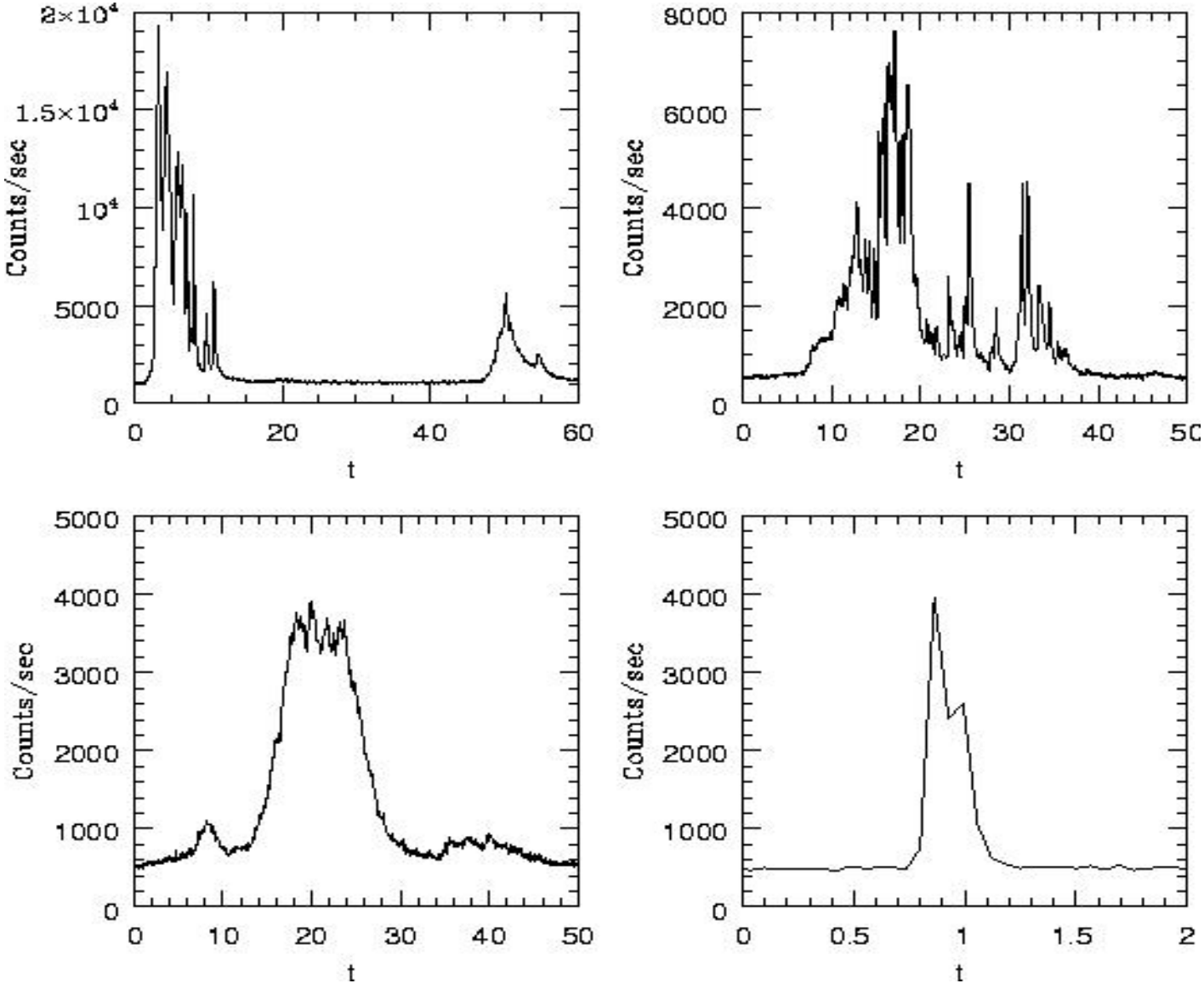
- NASA-GSFC
- Penn State University
- Brera Observatory-INAF
- ASI-ASDC
- Univ. Leicester
- MSSL

Fundamental Steps

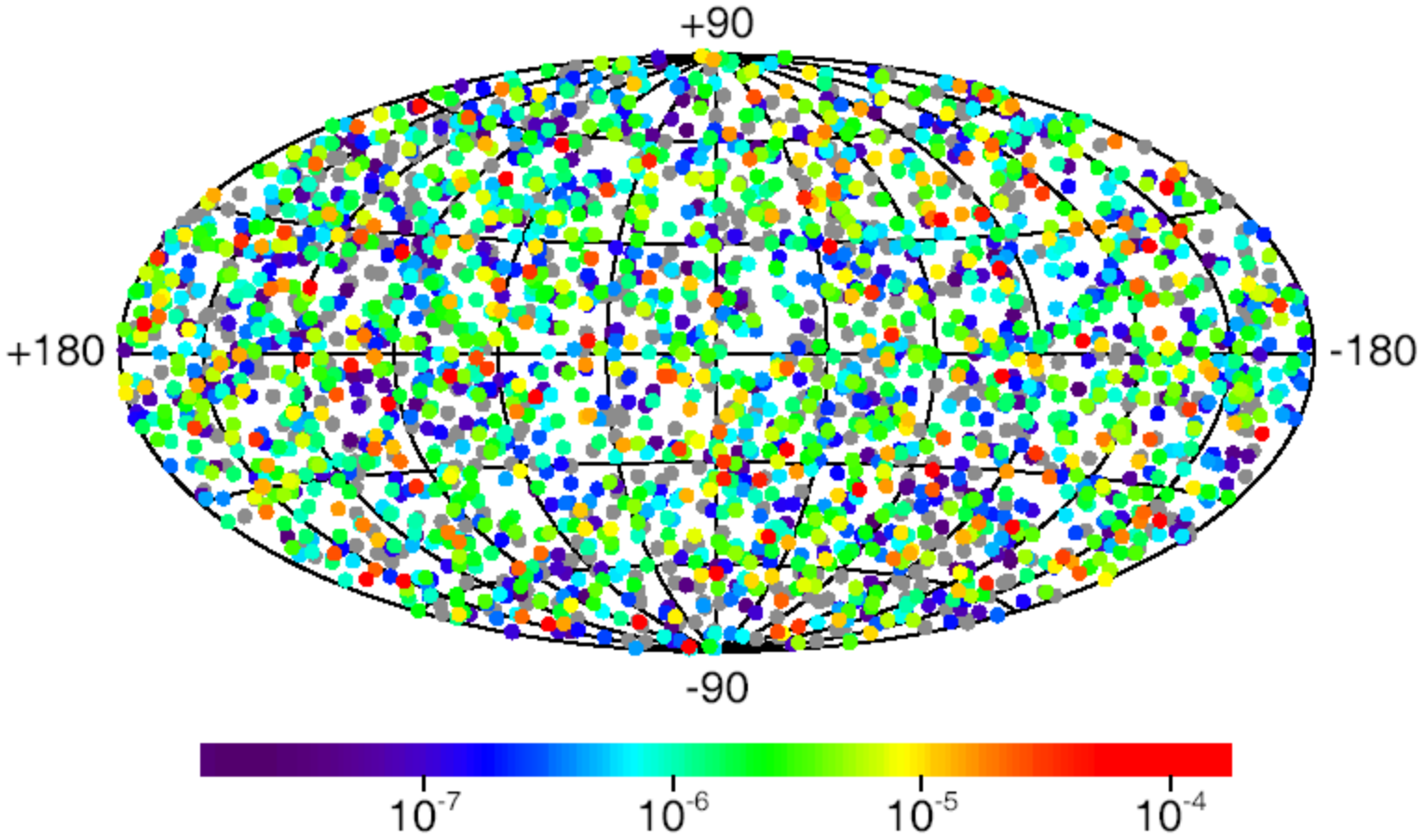
GRB were discovered by the VELA satellites in the late 1960's and published in 1973



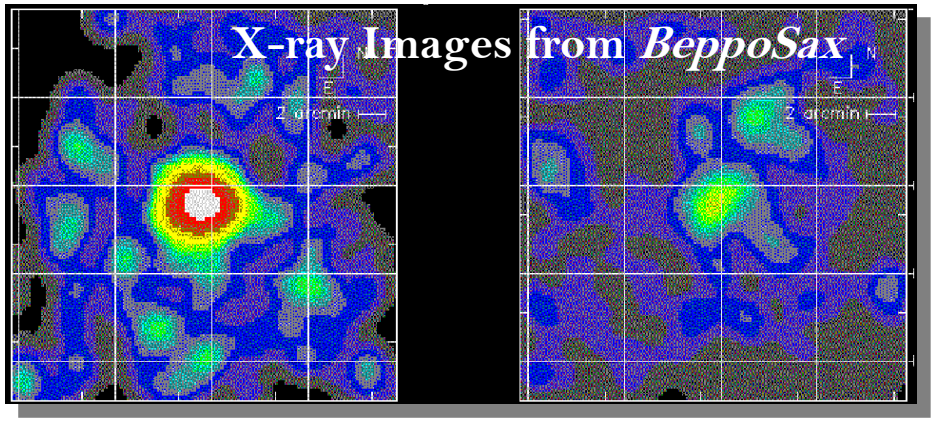
GRB Light Curves



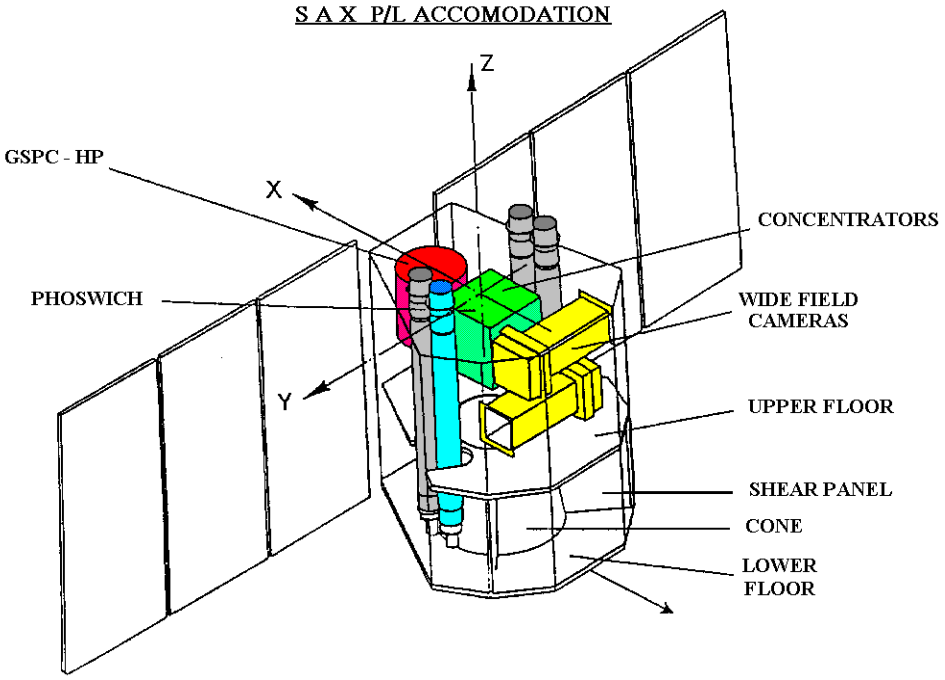
Space Distribution of GRBs - BATSE

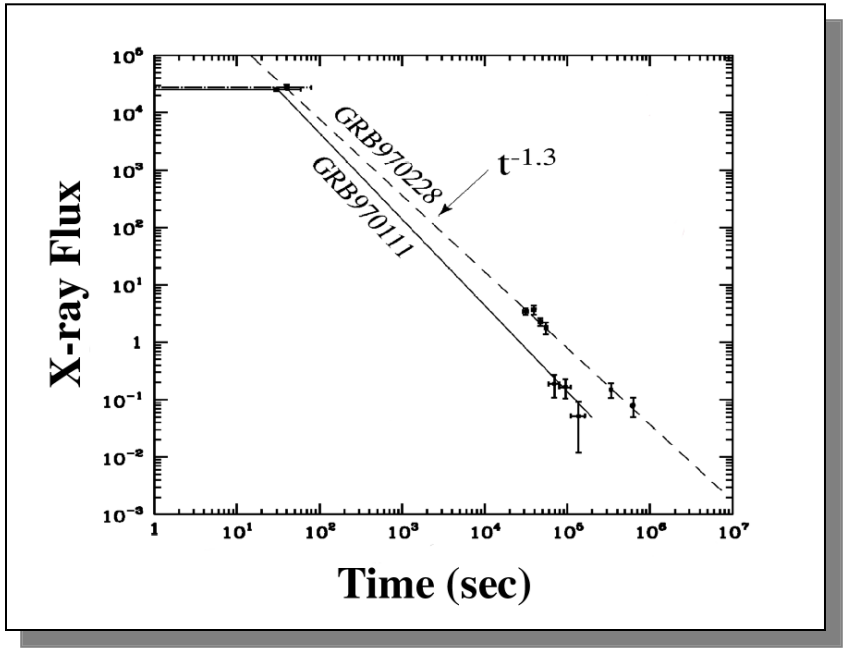


Gamma Ray Burst Breakthrough 1997!

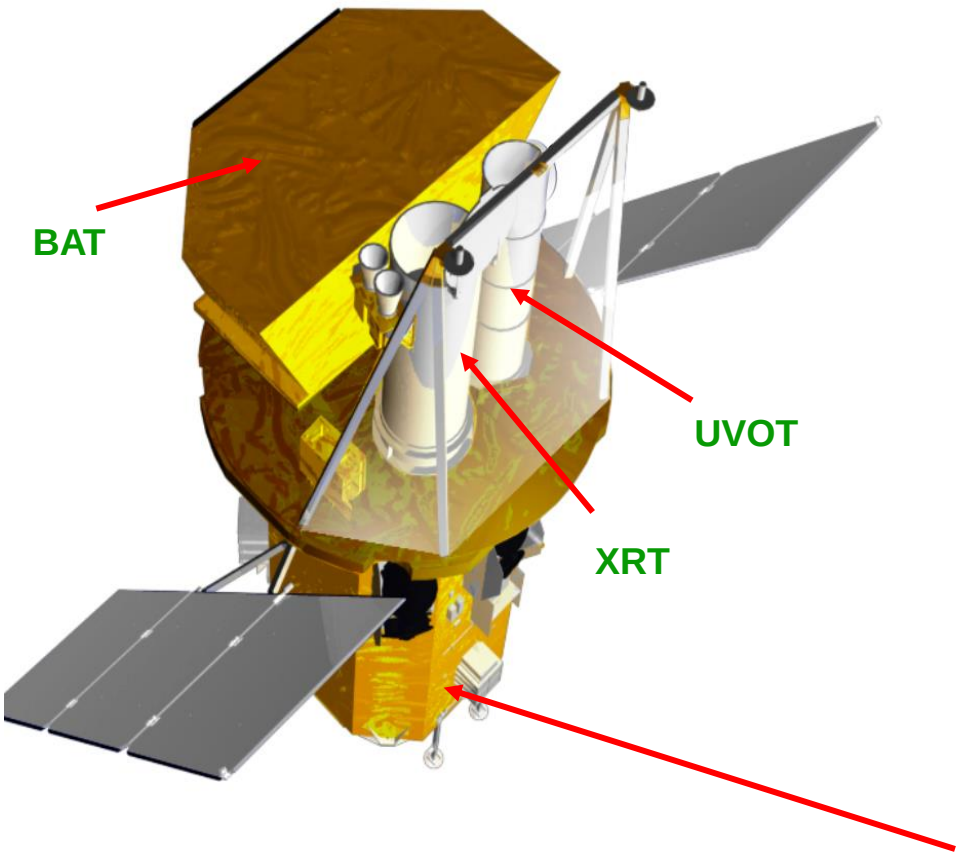


- *BeppoSAX* wide field & narrow field instruments give ~ 8-hr response
  - X-ray afterglow discovery
  - Optical afterglow identified from X-ray positions
  - **Discovery of host galaxies**
  - **Measurement of redshift ($z \approx 0.5 - 3$)**
  - **Great diversity of GRBs**





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**
  - **24th mag sensitivity (1000 sec)**
  - **Finding chart for other observers**

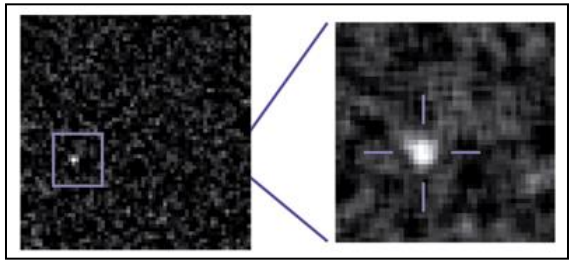
Spacecraft

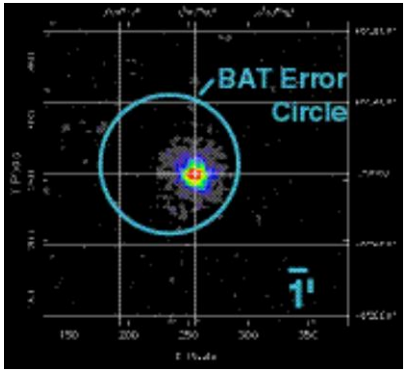
- Autonomous re-pointing, 20 - 75 sec
- Onboard and ground triggers

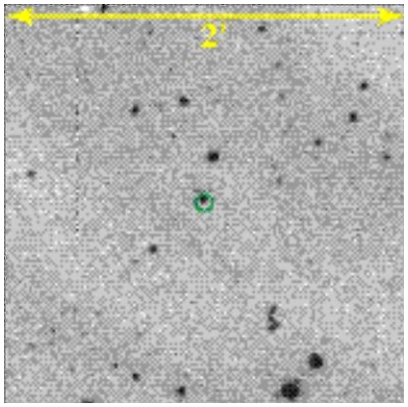
Swift Data

Notification	Time (sec)	Event
	0	GRB
Rapid position	20	BAT position
		Spacecraft slew
Arcsec position	70	XRT position
Spectra, light curves, images	~110	XRT & BAT
UVOT finding chart	240	UVOT image

Cascade of Images







A few Swift dates

- Selected for Phase A study: January 1999.
- Selected for flight October 1999.
- Scheduled for launch September 2004.

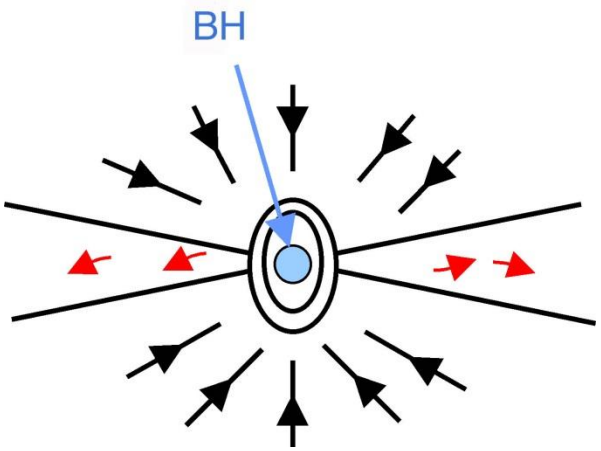

H-Series

Mission Capabilities

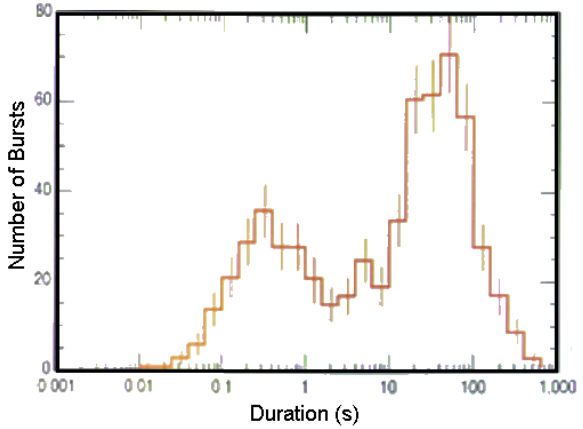
- Multiwavelength follow-up observations on all time scales
- >100 GRBs per year of all types with rapid localizations
- BAT sensitivity factor of 2 to 5 better than BATSE
- Nominal mission lifetime of 2 years, with orbital lifetime of > 8 years
- Upload capability to slew to GRB and transients detected by other observatories
- Arcsec positions and counterparts for 100's of GRBs
- Identification of host galaxies and measurement of offsets
- Multiwavelength observations on all timescales
- X-ray and UV/optical spectroscopy
- Rapid GRB notifications via GCN

Swift Designed to Answer GRB Key Questions

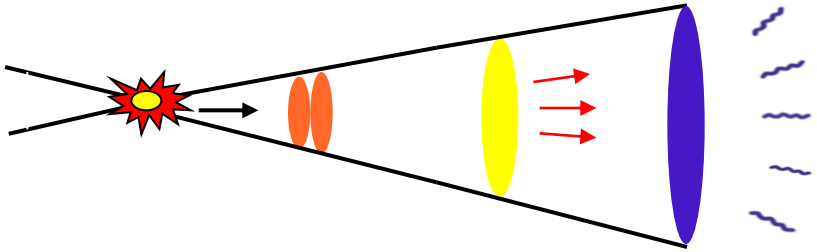
What causes GRBs?



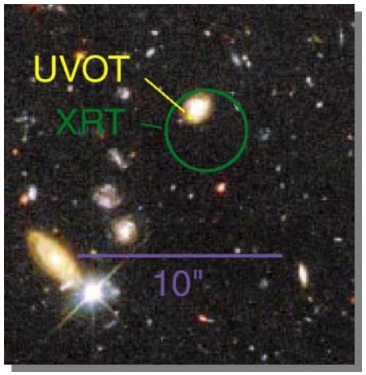
What is the nature of subclasses?



What physics can be learned about BH formation and ultra-relativistic outflows?



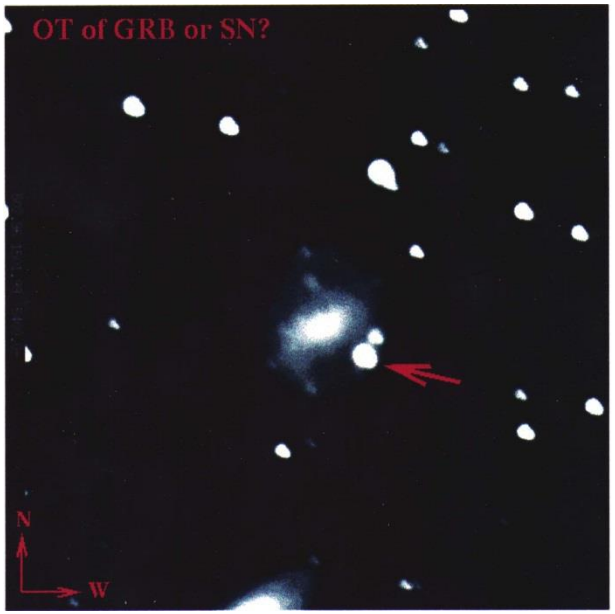
What can GRBs tell us about the early universe?



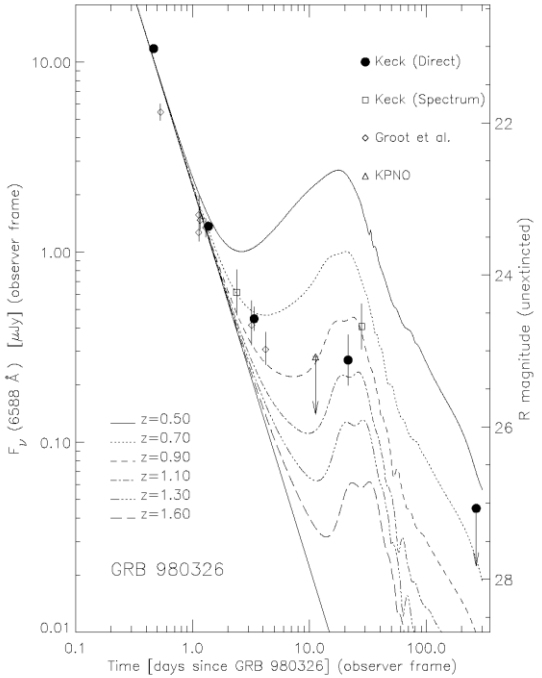
Swift Science (1)

- Supernova-GRB connection
  - Connections between SNe Ic and GRB are emerging.
  - GRBs are contributing to fundamental understanding of
    core collapse, BH formation, the role of spin in stellar evolution, origin of jets and origin of elements
  - Swift's rapid subarcsec positions and lightcurve monitoring will allow SN searches on 100's GRBs.
    Questions addressed: What fraction and what kinds of GRBs have underlying SN?
  - Searches for X-ray lines from GRBs will probe the circumstellar environment to determine pre-explosion history.

SN1998bw - GRB 980425

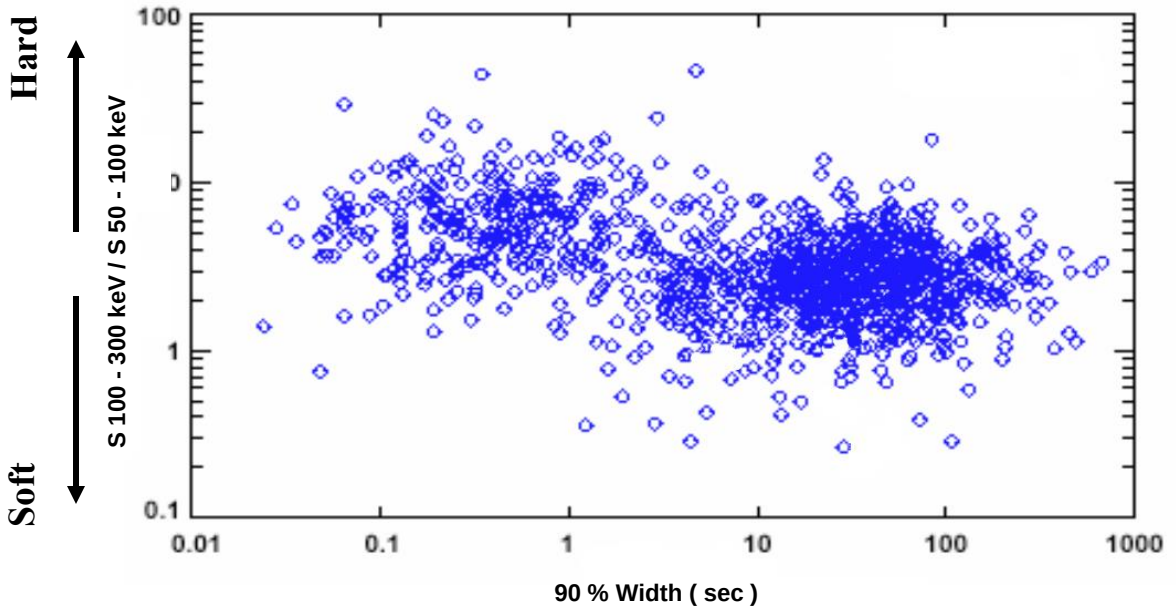


GRB 980326



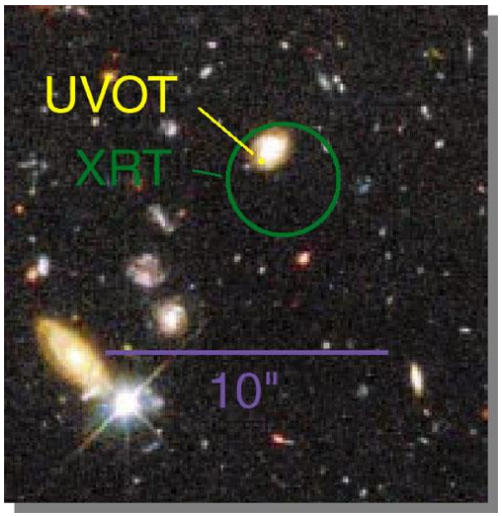
Swift Science (2)

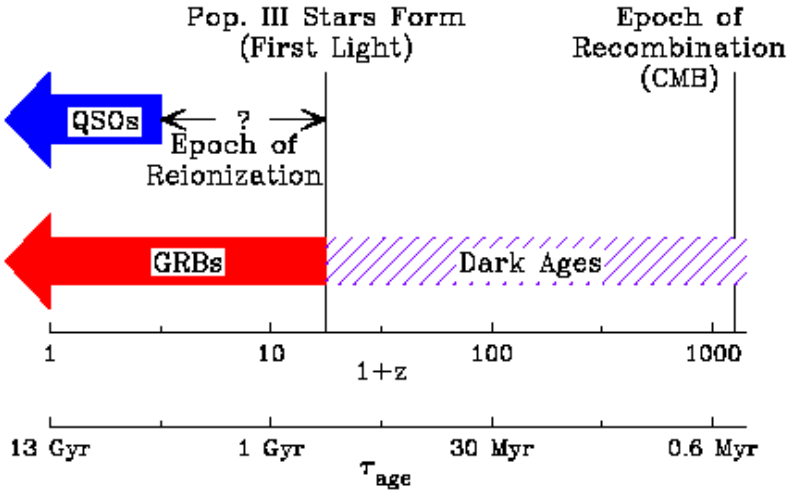
- GRBs subclasses - example: short GRBs
  - Not understood. No counterparts detected.
  - Appear to be a separate class. May have different physical origin.
  - Non-detection of afterglow for GRB 020531 indicates that afterglow is weak or rapidly declining.
  - Swift will perform rapid follow-up observations of ~100 short GRBs



Swift Science (3)

- Early Universe
  - GRBs are the brightest events in universe.
  - Afterglow is detectable to z~15 by Swift (3 to15 per year at z>10)
  - Topics addressed:
    - Epoch of first stars (GRB may be unique probe of PopIII stars)
    - Star formation history
    - Re-ionization of IGM z = 17 +/- 5 (Spergel et al. 2003)
    - Metallicity history
    - Dust and gas content of early galaxies
    - Large-scale structure of universe



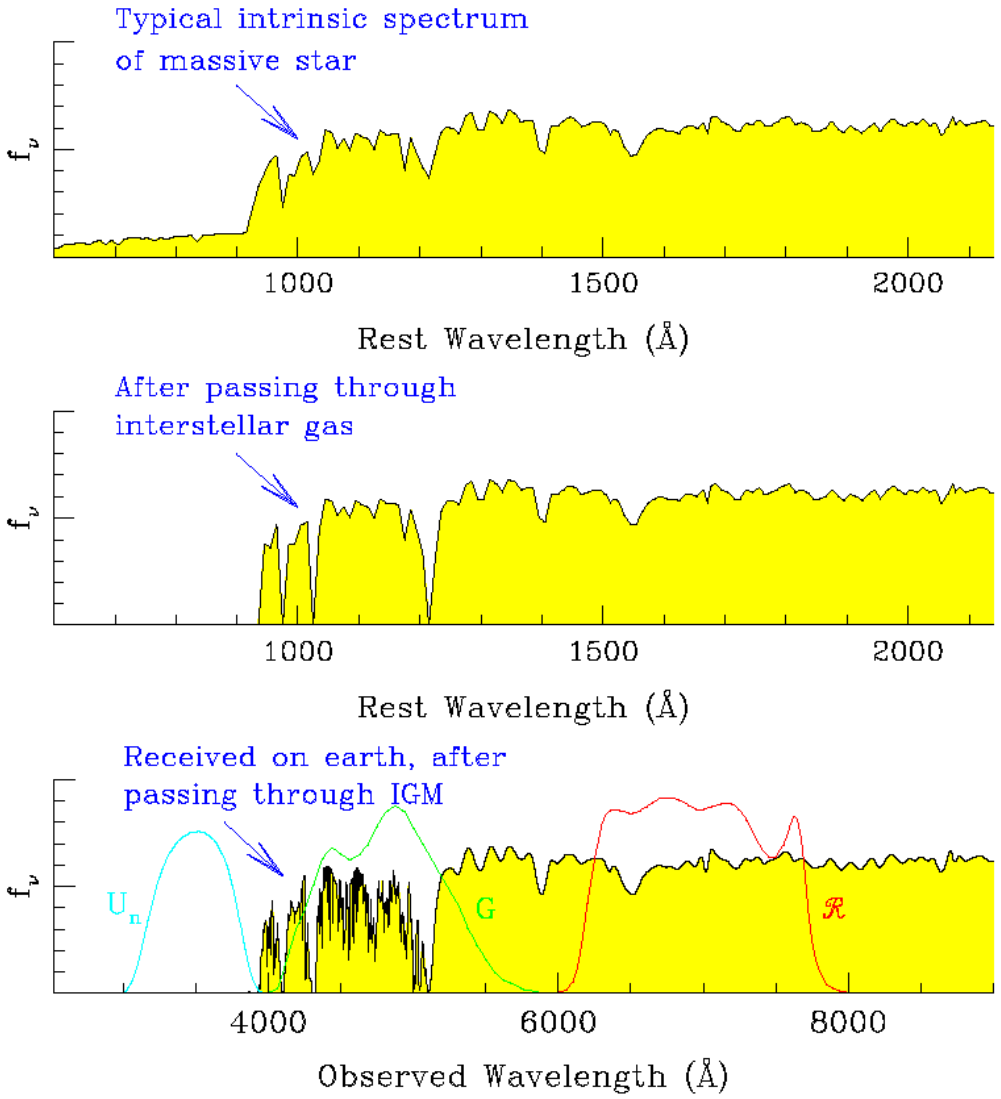


Lamb & Reichart (2000)

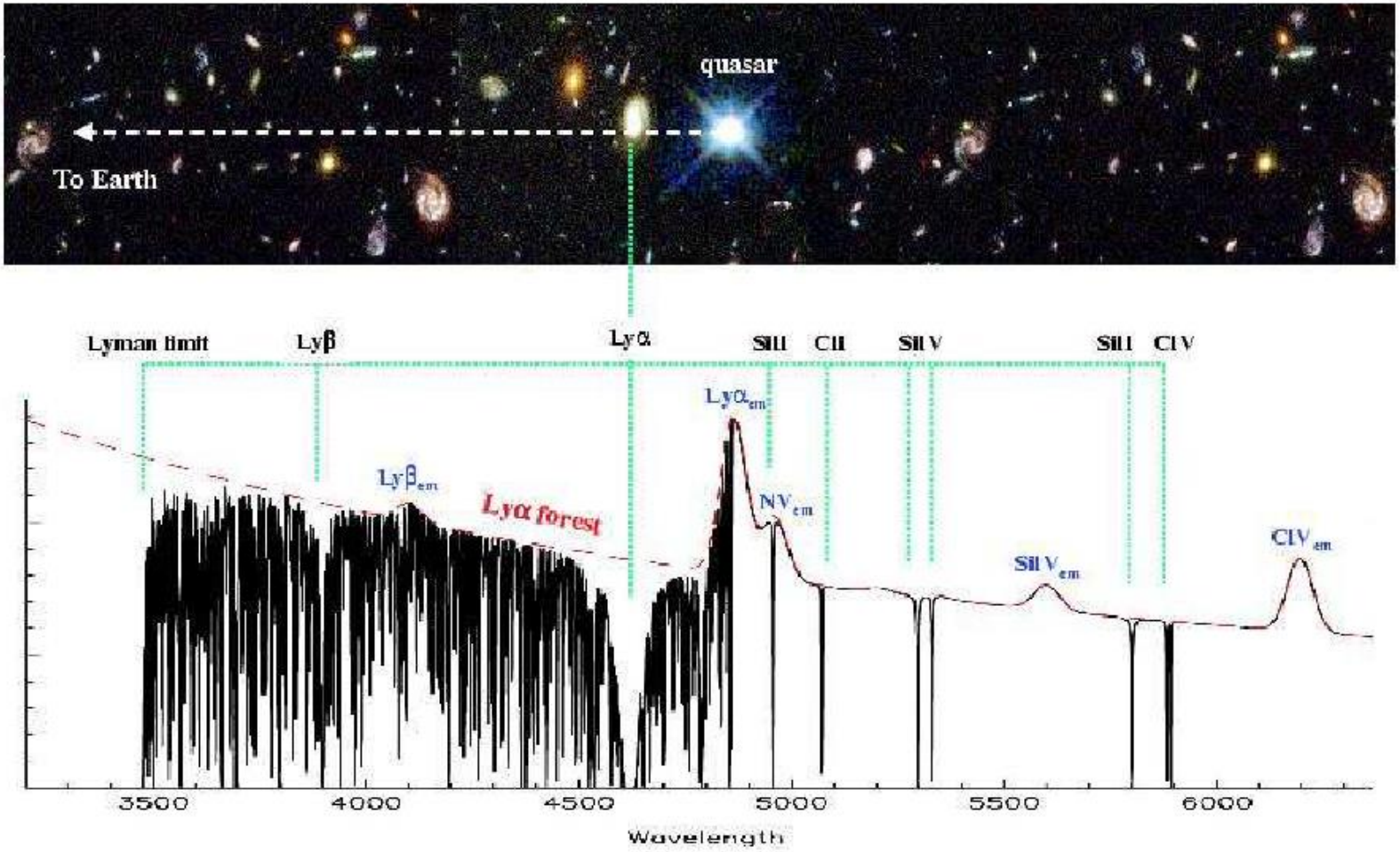
How the spectrum of a star is modified passing through the interstellar medium and the intergalactic medium.

The redhift of the objects shifts the short wavelength radiation (only UV in this case) out of some of the filters passbands.

To observe very distant objects it is therefore mandatory to have bright sources in order to be able to detect their flux and sensitivity in the infrared.



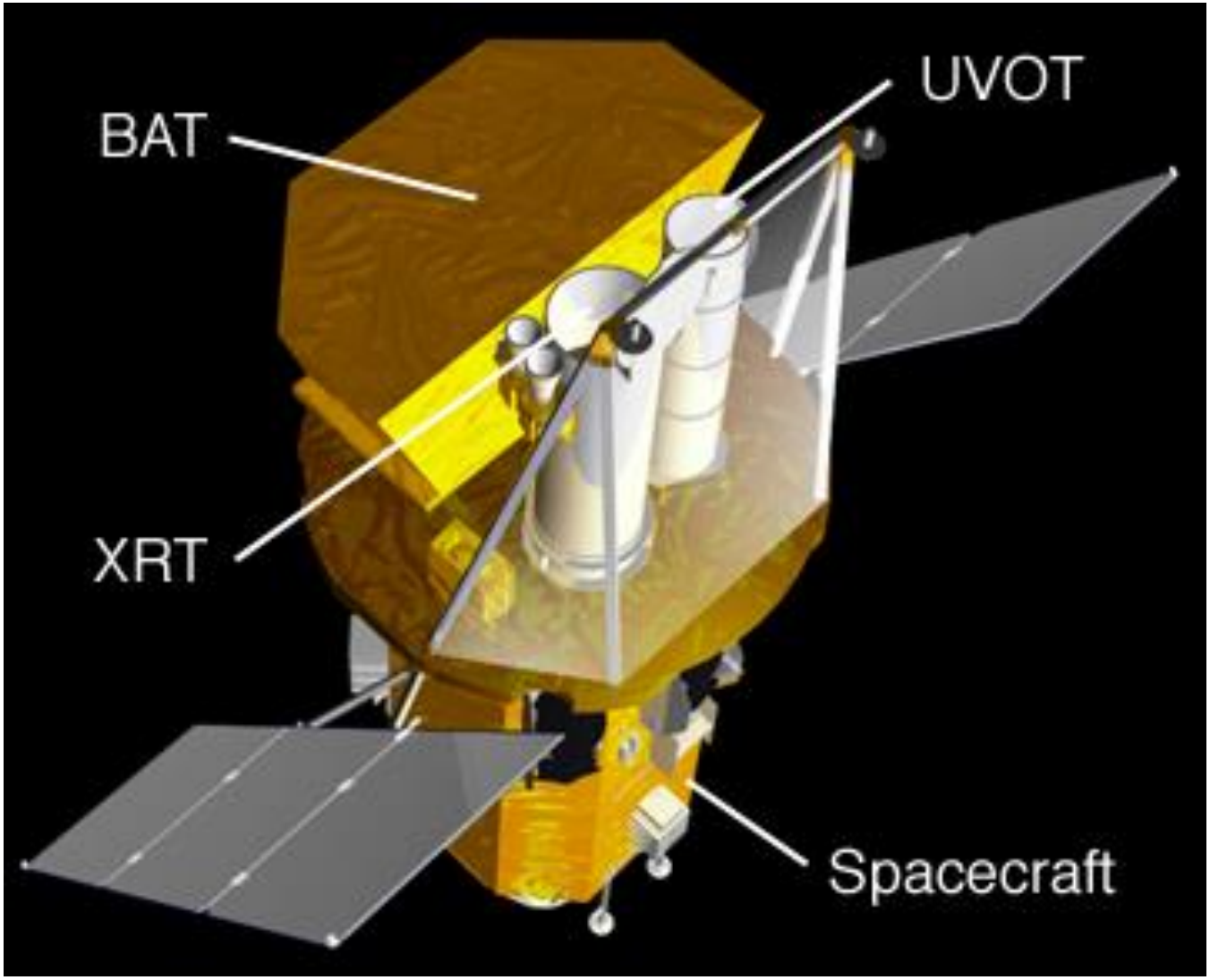
GRBs =>The IGM and Quasars



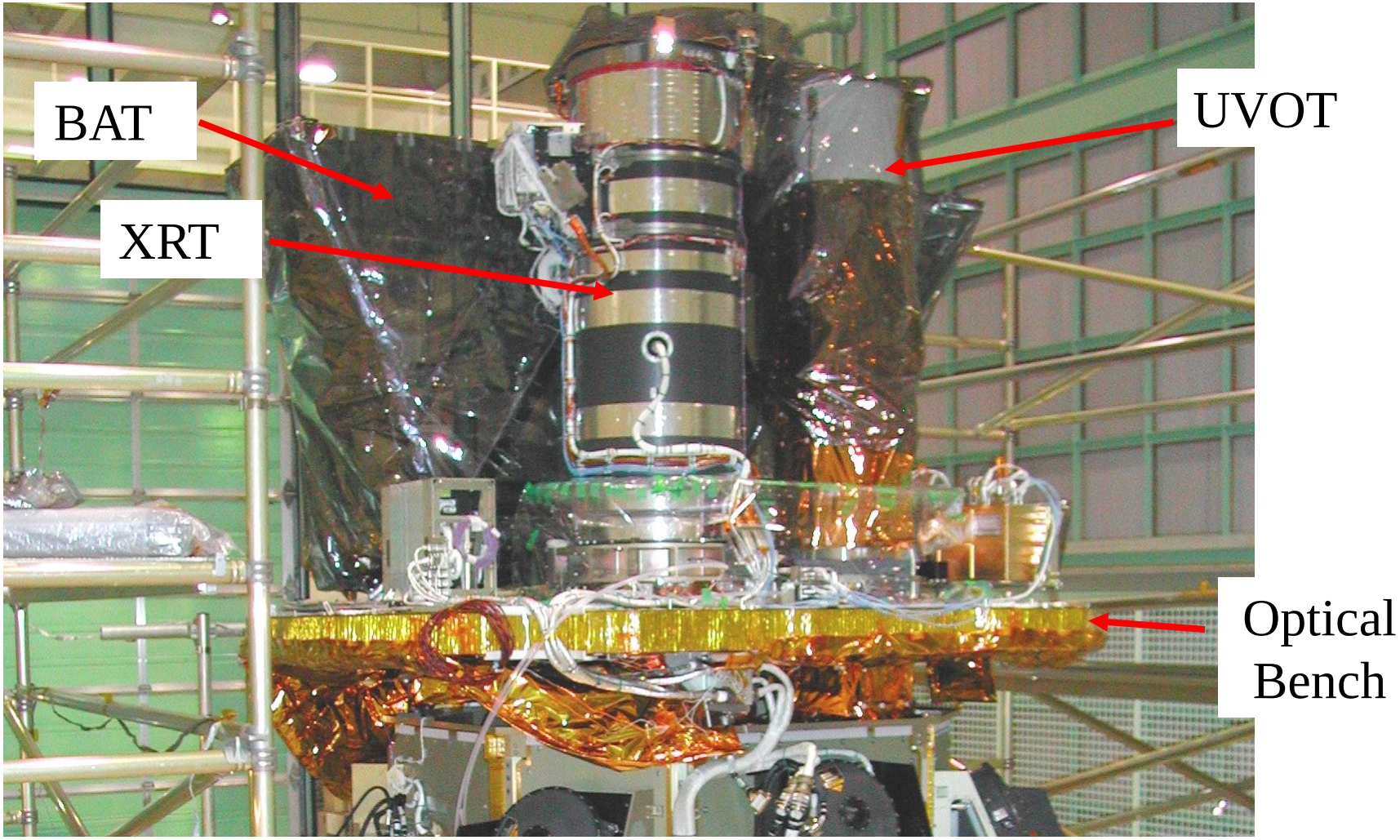
Guest Investigator Program

- It is expected that there will be a substantial interest of the astronomical community in the Swift Mission.
- Support for the US community involvement will be provided by a NASA Guest Investigator Program.
- Support for the Italian and UK community involvement will be provided by a ASI and PPARC Guest Investigator Program.
- The Italian Program will be organized by ASI and INAF.
- Area of research interest for non team members are:
  - Correlative observations with non Swift instruments and observatories.
  - New GRBs projects non duplicative of Swift Team K.P.s and not requiring specific pointings.
  - Theoretical investigations that advance science return in the GRBs field.

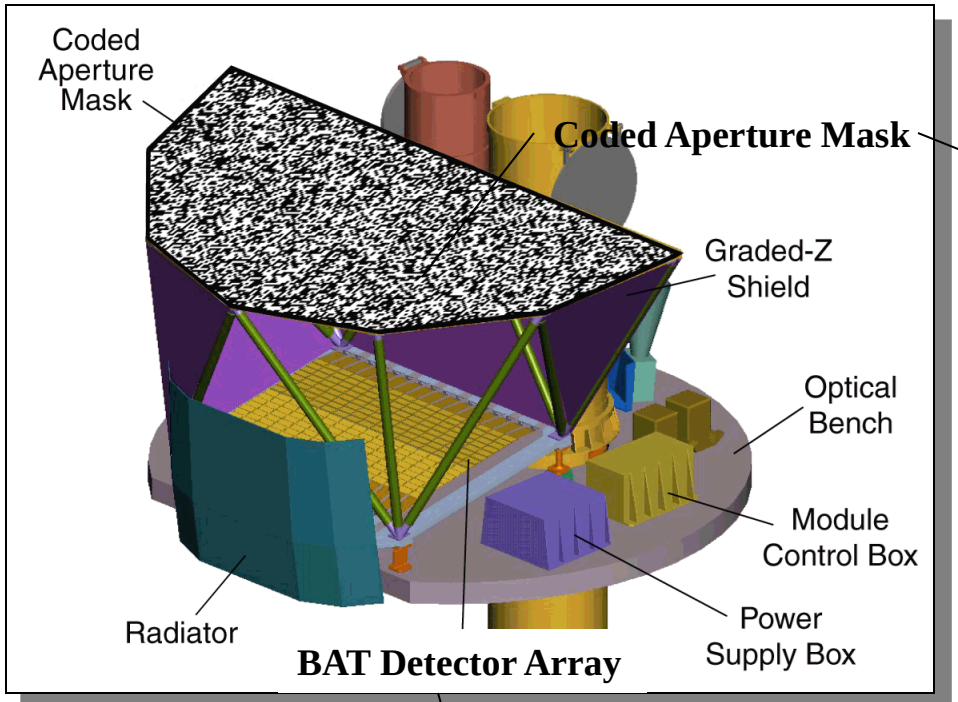
The Spacecraft

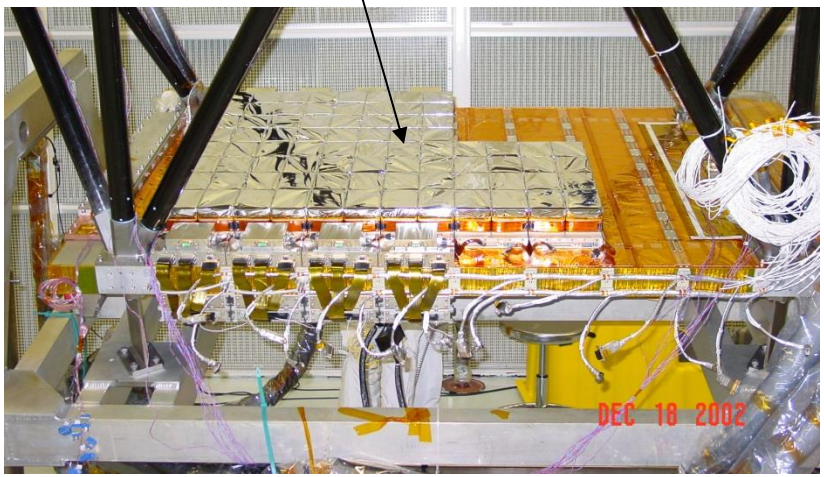


All Instruments On-Board



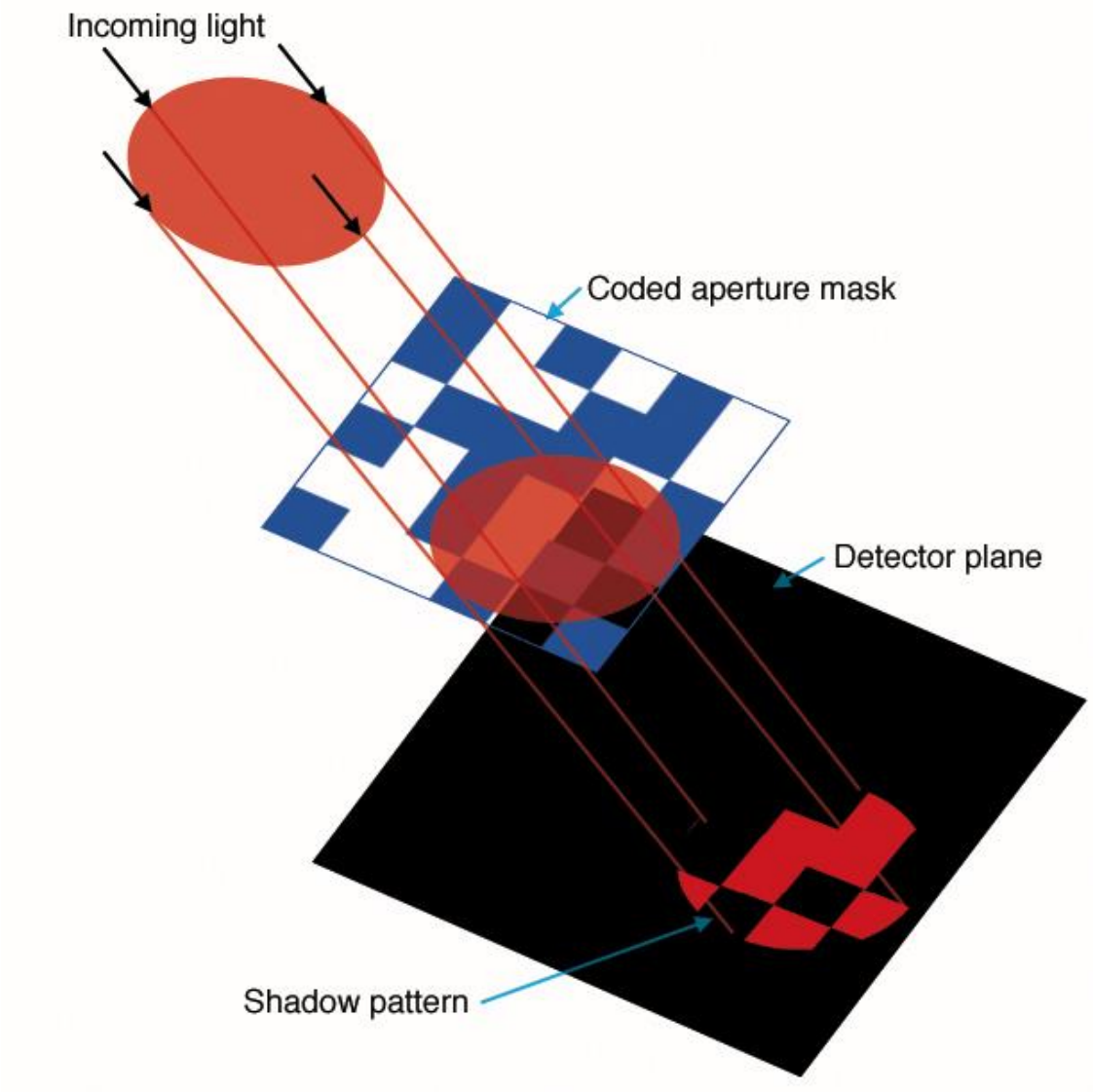
Burst Alert Telescope (BAT)

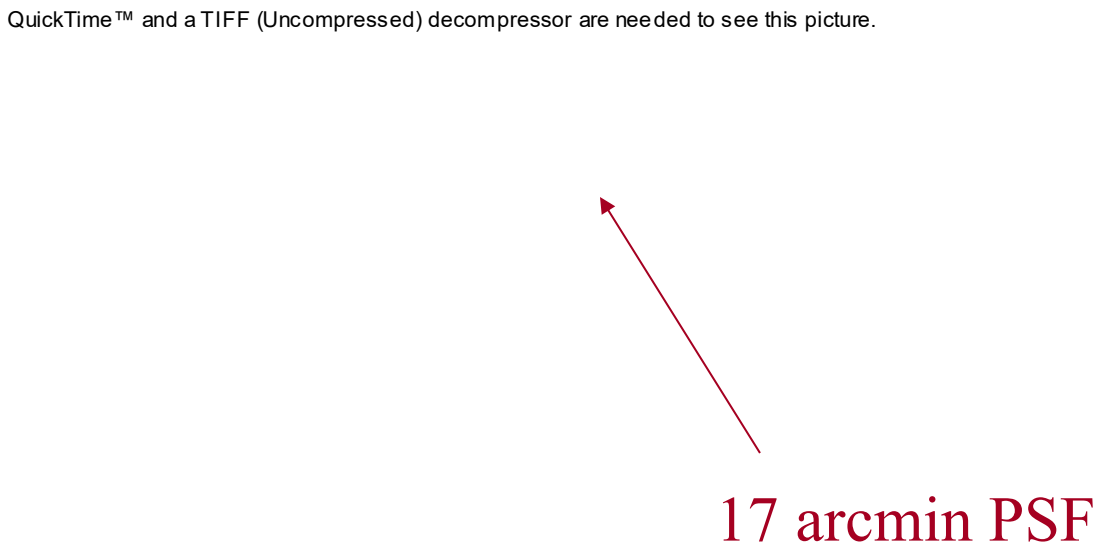




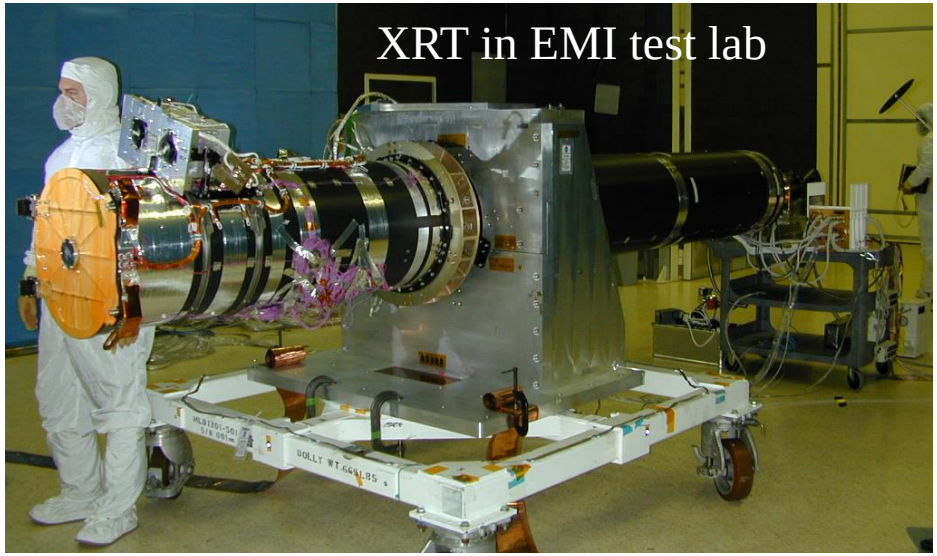
BAT Characteristics

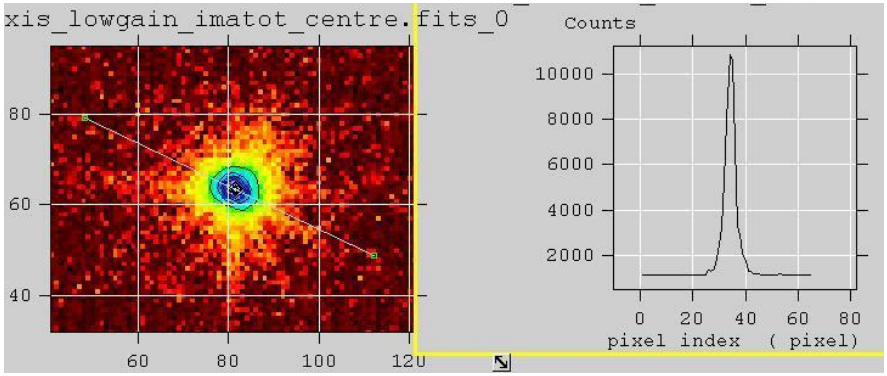
Telescope	Coded Aperture
Telescope PSF	17 arcmin FWHM
Position Accuracy	1-4 arcminutes
Detector	CZT
Detector Format	32768 pixels
Energy Resolution	7 keV FWHM (ave.)
Timing Resolution	100 microseconds
Field of View	2 Steradians, partially-coded
Energy Range	15 – 150 keV
Detector Area	5200 cm^2
Sensitivity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

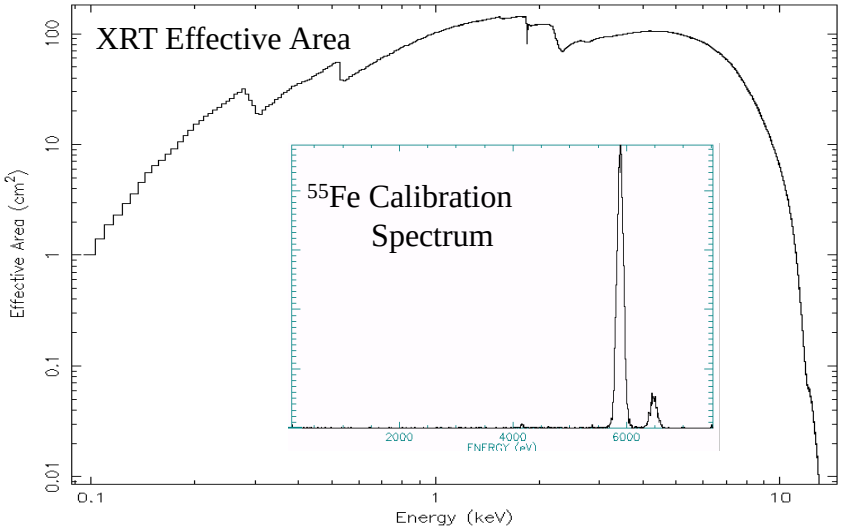

Incoming light
Coded aperture mask
Detector plane
Shadow pattern


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

X-ray Telescope (XRT)



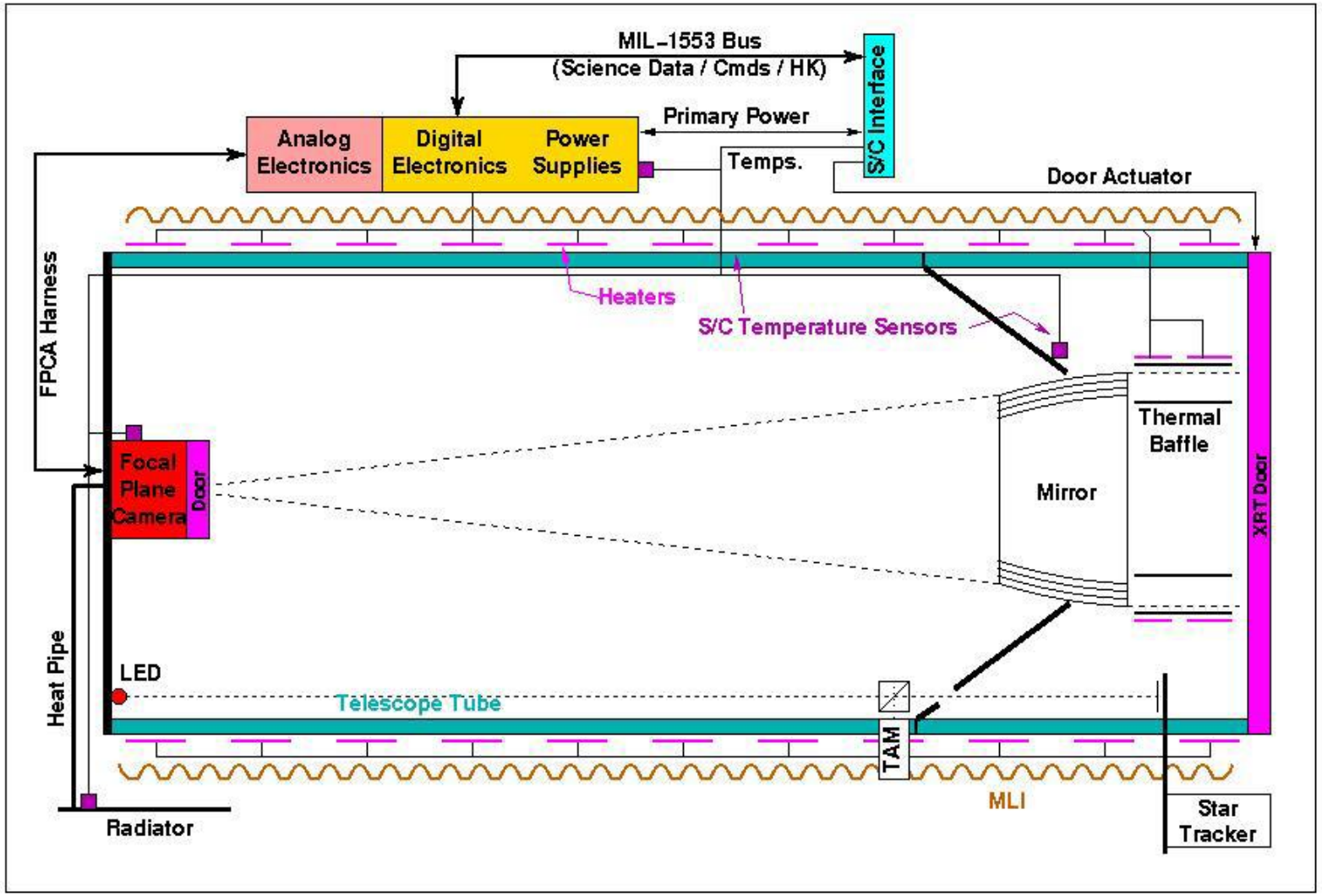




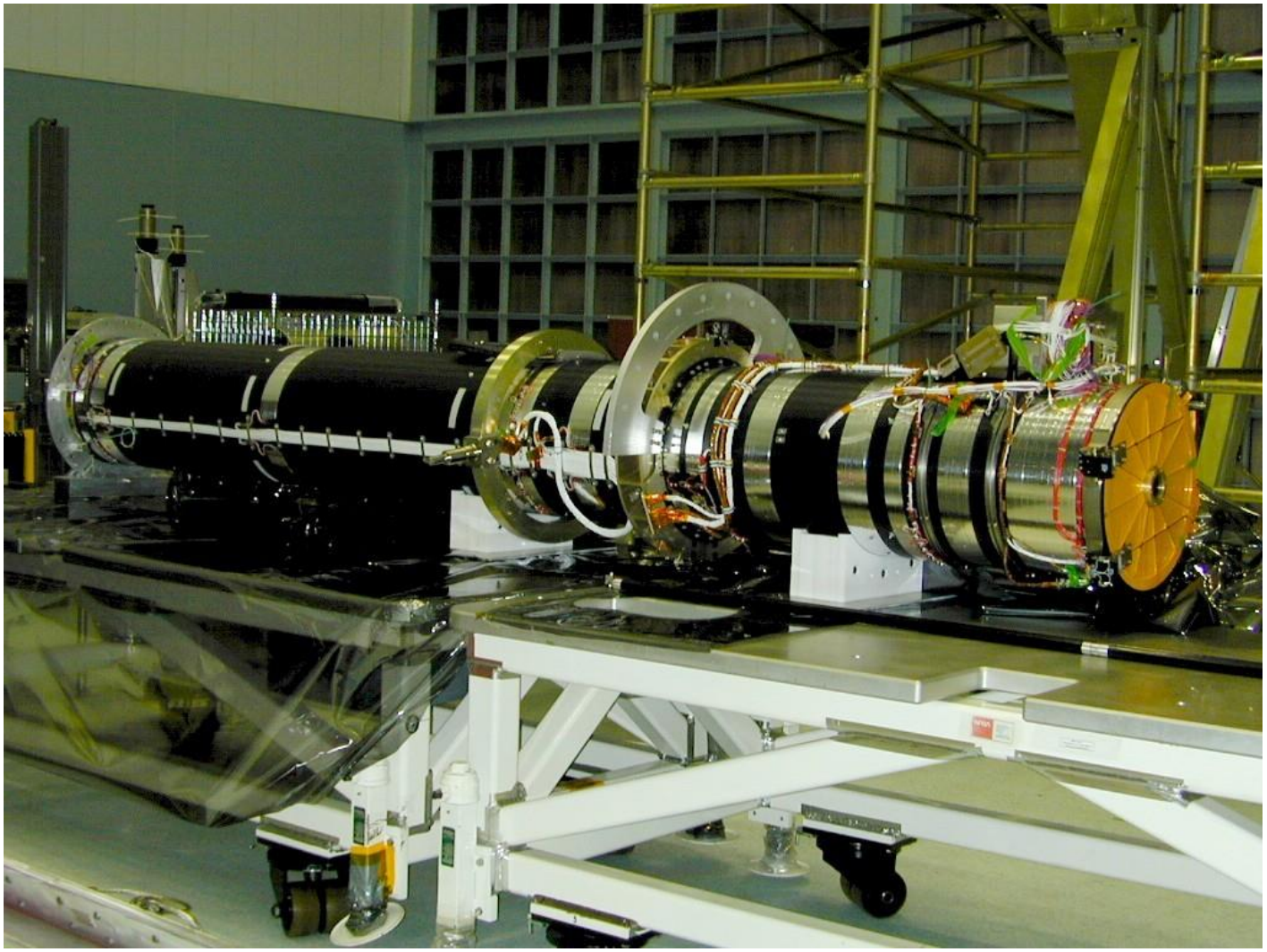
XRT Characteristics

Telescope	3.5 m Wolter I, 12 shells
Telescope PSF	18 arcsec HPD @ 1.5 keV
Position Accuracy	2.5 arcseconds (2 sigma)
Detector	E2V CCD-22
Detector Format	600 x 600 pixels
Energy Resolution	140 eV @ 5.9 keV
Timing Resolution	0.14 / 1.1 milliseconds
Field of View	23.6 x 23.6 arcminutes
Pixel Scale	2.36 arcsec / pixel
Energy Range	0.2 - 10 keV
Effective Area	110 cm^2 @ 1.5 keV
Sensitivity	$2x10^{-14}$ erg $cm^{-2}s^{-1}$ in $2x10^4$ s
Max Flux	> 45 Crabs (45,000 cps)
Operation	Autonomous

The X ray Telescope

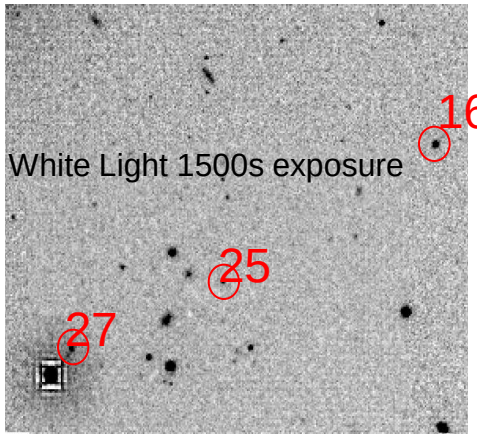


Complete XRT Instrument

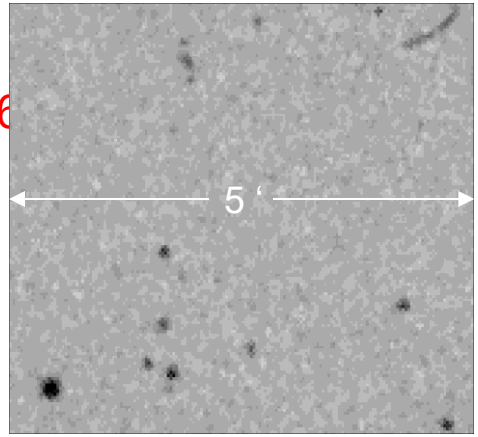


UV/Optical Telescope (UVOT)

XMM-OM



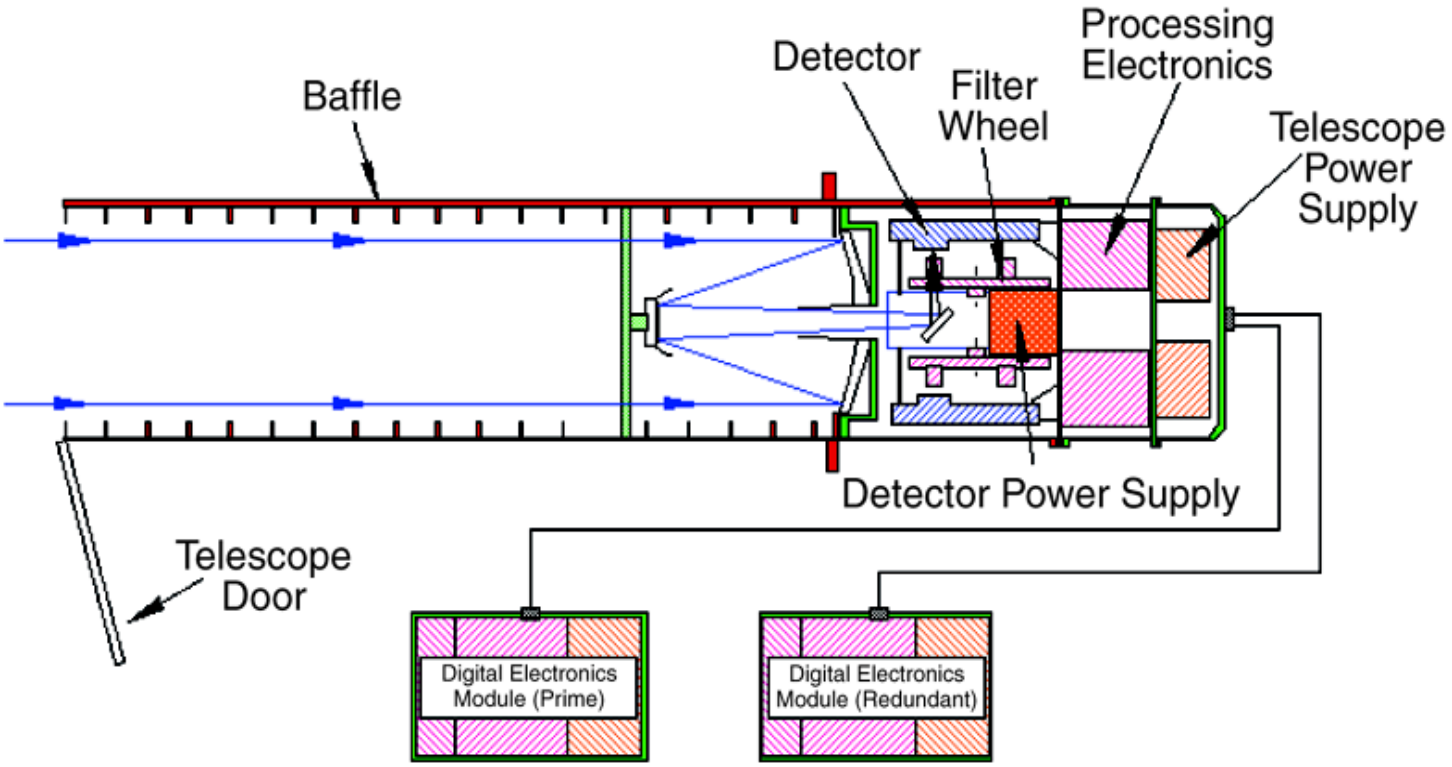
Digital Sky Survey



UVOT Characteristics

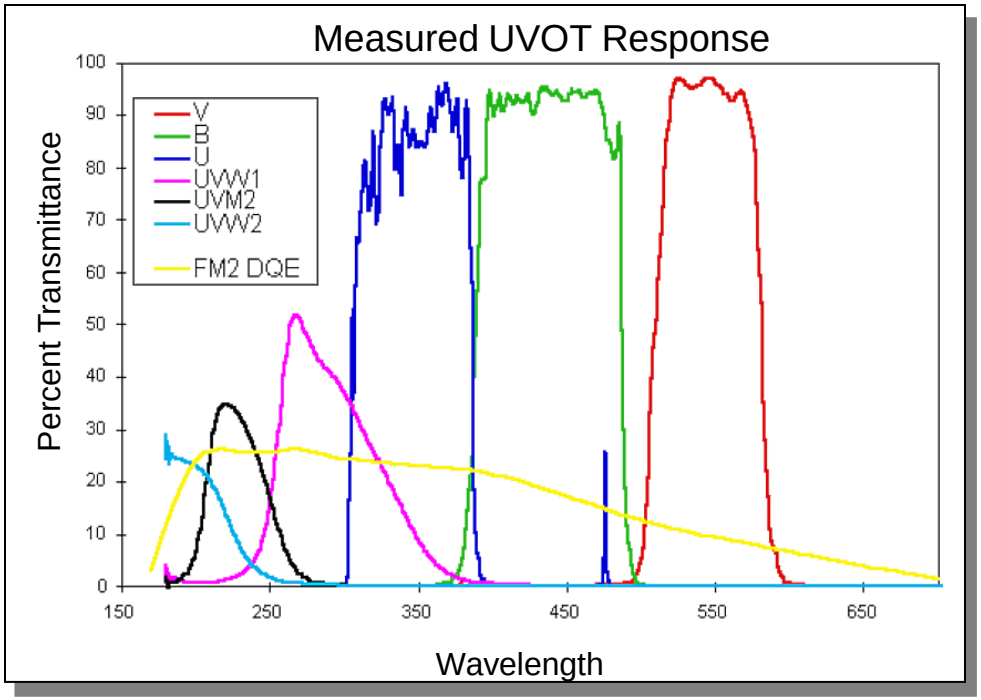
Telescope	30 cm Ritchie-Cretien
Telescope PSF	0.9 arcsec FWHM @ 350 nm
Position Accuracy	0.3 arcseconds (2 sigma)
Detector	Microchannel-intensified CCD
Detector Format	2048 x 2048 pixels
Spectral Resolutn	>300 @ 300 nm for $M_v < 17$
Timing Resolution	11 milliseconds
Field of View	17 x 17 arcminutes
Pixel Scale	0.5 arcsec / pixel
Spectral Range	170 – 600 nm
Sensitivity	24th magnitude in 1000 s
Max source	8th magnitude
Operation	Autonomous

UVOT


Baffle
Detector
Filter Wheel
Processing Electronics
Telescope Power Supply
Detector Power Supply
Telescope Door
Digital Electronics Module (Prime)
Digital Electronics Module (Redundant)

UVOT Performance

- **Positions to 0.3 arc-seconds using onboard image registrations**
- **Filters give spectral/color information and allow redshift determination from Lyman edge detection**



UVOT Sensitivity

For V = 20 B star in 1000 s get:

UVW2	**680 cts**
UVM2	**800 cts**
UVW1	**1000 cts**

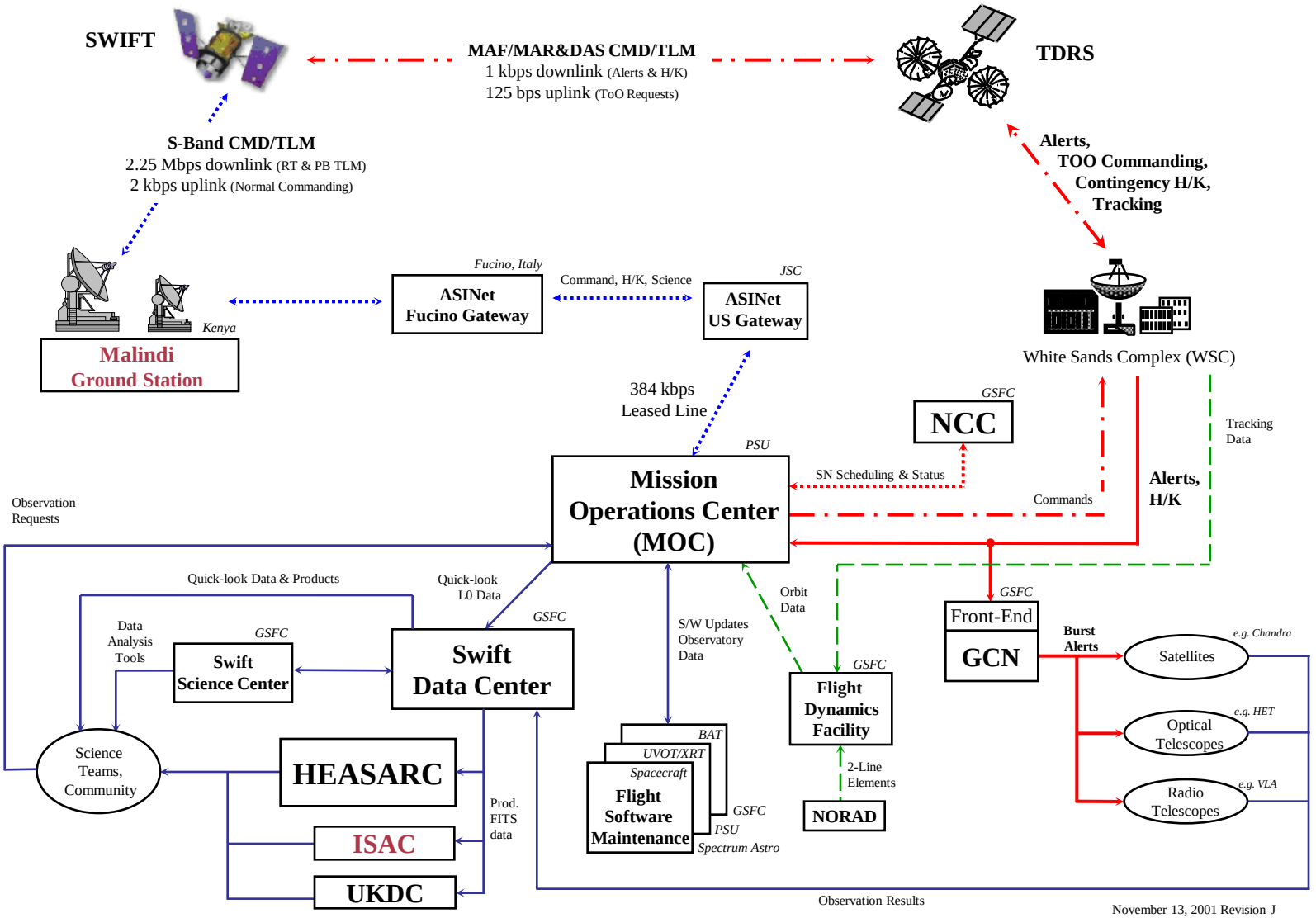
Sensitivity to Ly-α cutoff:

UVM1 - UVM2	**z ~ 1.5**
UVM1 - UVM1	**z ~ 2**
U - UVW1	**z ~ 2.7**
B - U	**z ~ 3.5**

UV and optical grisms with $\Delta\lambda$ of 0.5 nm and 1.0 nm, respectively, for $M_b < 17$

- **IUE type resolution**

System Architecture



VLT at Paranal

ESO PR Photo 46a/99 (8 December 1999)

Swift

University of Leicester

NASA

GSFC

PENNSTATE 1855

UCL MSSL

asi agenzia spaziale italiana

OSSERVATORIO ASTRONOMICO DI BRERA

SPECTRUMASTRO

eV PRODUCTS

MPE

SONOMA STATE UNIVERSITY LUX MENTIS · LUX ORBIS · 1960

THE UNIVERSITY OF CALIFORNIA LET THERE BE LIGHT 1868

SwRI

SWALES AEROSPACE

Los Alamos NATIONAL LABORATORY

OMITRON Inc.