



# The Swift X-ray Telescope (XRT)



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## Abstract:

The Swift Gamma-Ray Burst Explorer will make prompt multiwavelength observations of Gamma-Ray Bursts and Afterglows. The X-ray Telescope (XRT) provides key capabilities that permit Swift to determine GRB positions with several arcsecond accuracy within 100 seconds of the burst onset. The XRT is designed to observe GRB afterglows covering over seven orders of magnitude in flux in the 0.2-10 keV band, with completely autonomous operation. GRB positions are determined within seconds of target acquisition, and accurate positions are sent to the ground for distribution over the GCN. The XRT can also measure redshifts of GRBs for bursts with Fe line emission or other spectral features. Swift will be launched in 2003.

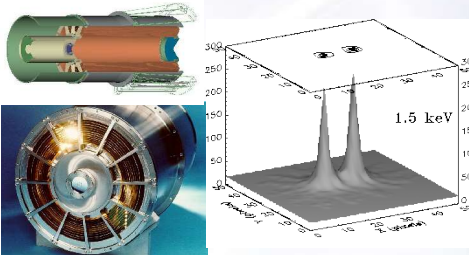


Above: Focal Plane Camera mounted on telescope tube.  
Below: flight CCD mounted in flight package.



The Swift XRT has three key science goals:

- 1) Determine GRB position with 5 arcsecond accuracy and transmit position to the ground within 100 s of the burst.
- 2) Measure the afterglow lightcurve
- 3) Obtain X-ray spectroscopy of the afterglow

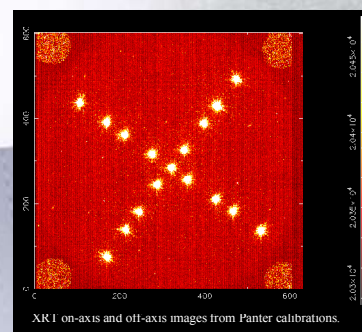


XRT mirror module design (top); XRT mirror (bottom); Measured PSF (right)

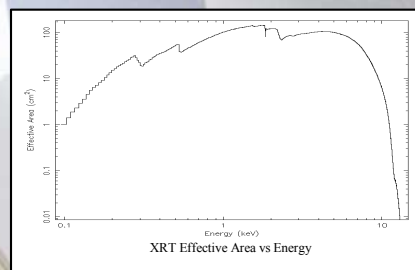
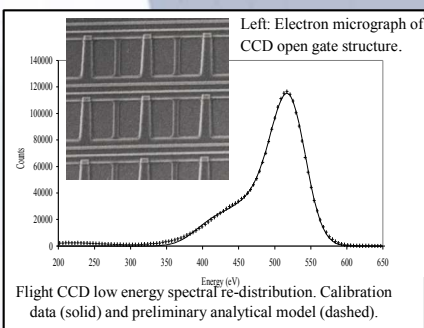
The table to the upper right summarizes the science performance of the XRT. The Swift XRT uses a 12 shell Wolter Type I grazing incidence mirror (shown above) developed for the JET-X telescope and an open electrode CCD detector (shown at left) developed for XMM-Newton. The mirror has been calibrated at the Panter facility in Munich (surface plot above shows PSF at 1.5 keV; figure to right shows the PSF vs. off-axis angle) and the flight detector has been calibrated at the University of Leicester. End-to-end calibration was performed in September 2002 at the Panter facility, and measured the PSF as a function of off-axis angle and energy, timing characteristics, energy resolution, effective area (see figure at right for preliminary effective area curve), and dynamic range. We also tested the autonomous mode-switching software (see lower right flow chart) using a simulated GRB afterglow.

The in-flight performance of the instrument will be monitored continuously using  $^{55}\text{Fe}$  calibration sources illuminating the corners of the CCD. An image collected during thermal vacuum testing in July 2002 is shown below left. The central circular region shows the circular field of view of the instrument (slightly truncated by the edges of the CCD), which is illuminated by Mn K- and K- $\beta$ -X-rays at 5.9 and 6.4 keV (see spectrum below), produced by a  $^{55}\text{Fe}$  source located on the camera door. During flight this source is moved away when the camera door is opened, and this portion of the CCD views the sky. The four circular regions in the corners of the detector (also seen in the Panter images) are the in-flight calibration sources, which permit us to measure resolution, gain, and charge transfer efficiency as a function of time during the mission.

Telescope	3.5 m Wolter I, 12 shells
Telescope PSF	15 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 / 1.8 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 <sup>2</sup> @ 1.5 keV
Sensitivity	2x10 <sup>-14</sup> erg cm <sup>-2</sup> s <sup>-1</sup> in 2x10 <sup>4</sup> s
Max Flux	> 45 Crabs (45,000 cps)
Operation	Autonomous

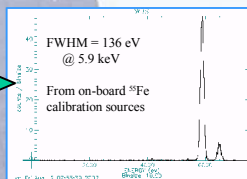
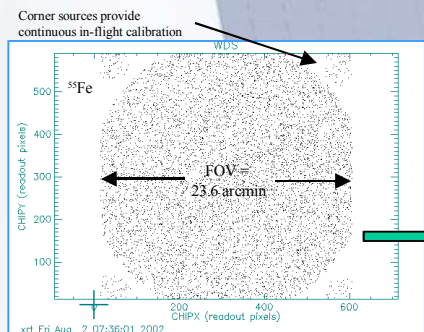


XRT on-axis and off-axis images from Panter calibrations.



## Data Products:

- ~100 s: GRB position, flux (GCN)
- ~105 s: X-ray snapshot image (GCN)
- ~300 s: X-ray raw spectrum (GCN)
- ~2 h: X-ray timing mode event data (FITS), providing lightcurve and spectra (Web)
- ~1 d: Full data set from automated observation of new GRB (Web): FITS events files: image, lightcurve, spectra
- ~4 d: Full data set from GRB (Web): FITS events files: image, lightcurve, spectra



The XRT instrument is shown schematically in the lower left figure. The photo in the lower right shows the XRT installed in the Swift observatory. Below is a photo of the Swift Optical Bench with the XRT, UVOT, and BAT installed.

