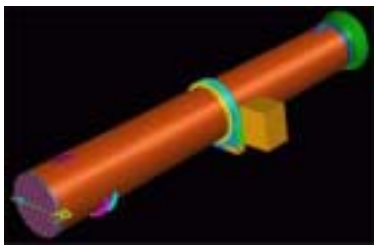
X-ray Telescope (XRT)



1. Instrumental Requirements for XRT

The instrumental requirements for the Solar-B/X-ray telescope (XRT) are:

- In order to isolate coronal structures that correspond to magnetic elements seen in the optical telescope, the pixel size must be of order 1 arcsec.
- Because coronal events are often global, XRT must provide full Sun imaging.
- In comparison to Yohkoh/SXT, the low T response must be increased.
- Because both hot and cool features need to be observed, the telescope should cover a broad range of temperatures.
- The XRT temperature coverage should include that of the EIS.

These requirements can be accomplished with an optimized Wolter I grazing-incidence telescope similar to that used on Yohkoh, although with certain modifications, plus a large format back-illuminated CCD detector and appropriate entrance aperture and focal plane filters.

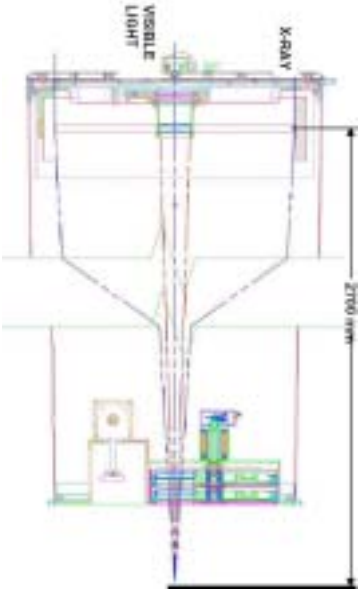
2. Optics

XRT has two optical systems. One is for X-ray and the other is for visible light (G-band). The optics is similar to Yohkoh/SXT and these optical systems make X-ray and G-band images on one CCD.

X-Ray	
	Optimized Wolter-I Grazing Incidence Optics
Focal Length	2708 mm
Aperture Size	> 340 mm
Band Width	2 – 200 Å
Effective Area	> 3.0cm^2 @ 0.56 keV & 1 keV
Field of View	>30 arcmin
Visible Light	
Focal Length	2708 mm
Wavelength	4305 Å
Field of View	>30 arcmin

Reference: XRT ICD (ICD Requirements)

XRT Optics (XRT-T)

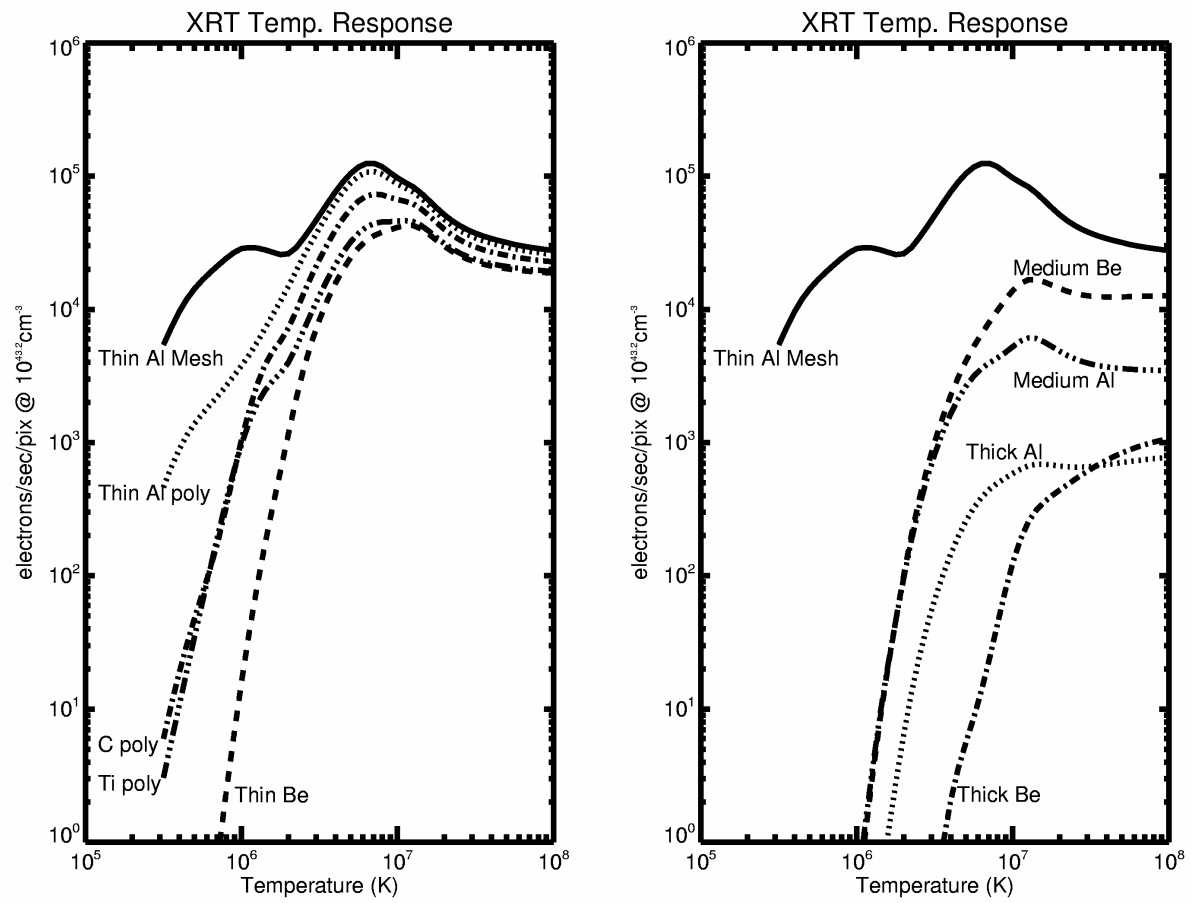


3. X-ray Analysis Filters

XRT has two filter wheels for X-ray analysis filters and a G-band filter. These filter wheels have in total 12 positions (6 position in each filter wheel). 9 positions are used for X-ray analysis filters. The X-ray analysis filters (see the following table and figures) shall provide the capability of temperature analysis over the range $6.1 < \log T < 7.5$.

Design of X-ray Analysis Filters

Name	Metal	Metal Thickness	Substrate	Substrate Thickness
Thin-Al/Mesh	Al	1600 Å	Mesh	N/A
Thin-Al/Poly	Al	1250 Å	Polyimide	2500 Å
Thin-Be	Be	9 μm	Mesh	N/A
Med-Be	Be	30 μm	N/A	N/A
Thick-Be	Be	1 mm	N/A	N/A
Thick-Al	Al	25 μm	N/A	N/A
Med-Al	Al	12.5 μm	N/A	N/A
Ti/Poly	Ti	2300 Å	Polyimide	2500 Å
C/Poly	C	4800 Å	Polyimide	2500 Å



These temperature response functions include the properties of the entrance filter, the effective area of the X-ray mirror, and QE of the CCD.

4. Camera (CCD)

In order to provide a high-resolution soft X-ray image with low noise and large dynamic range, the data acquisition system for XRT uses a single 2k × 2k pixel CCD array. The CCD will be operated under –43 °C on the orbit.

CCD Type	2k × 2k back-illuminated CCD (E2C/CCD 42-40)
Pixel Size	13.5 × 13.5 μm (Correspond to 1 arcsec × 1 arcsec)
Pixel Binning Mode	1 × 1, 2 × 2, 4 × 4, 8 × 8
Dark Current	0.4 nA/cm^2 (0.1 electrons/sec/pixel @ -65 °C)
CTE*	Parallel >0.999996, Serial > 0.999999 (–93 < T (°C) < –50)
QE* (X-ray/EUV)	0.93@13Å, 0.61@45Å, 0.46@116Å, 0.56@304Å
QE (Visible Light)	0.44@4000Å, 0.66@5000Å
Full-well Capacity	2.0 × 10^5 electrons

*The values of CTE and QE (X-ray/EUV) are preliminary results from the CCD calibration test at NAOJ.

XRT can take partial frame images. The sizes of partial frame images are 64,128, 192, 256, 384, 512, 768, 1024, 1536, and 2048 pixels. We can select not only square but also rectangular areas for the shape of partial frame images (ex. 1024 × 256, 256 × 512). The size of 64 pixels is, however, used only for the square images (64 × 64).

XRT has a focus adjustment mechanism. The range of focus adjustment is ± 1 mm. We can use the mechanism for canceling the focus shift by the launch environments.

5. Mission Data Processor (MDP)

The Mission Data Processor (MDP) of Solar-B not only handles the data from XRT/FPP/EIS, but also controls XRT using observation tables and the results of image analysis on MDP. The observation tables and the parameters for the image analysis are uploaded from the ground station.

<MDP Functions for XRT>

- **Observation controlled by observation tables.**
  - Compile exposure parameters based on the observation table and send these commands to XRT.
  - Highest time resolution of XRT is 2 sec.
  - Change the observation table for flares, automatically.
- **Automatic Exposure Control (AEC)**
  - MDP achieves the proper exposure time by analyzing intensity distribution of observed X-ray images.
  - MDP also selects the proper X-ray analysis filter (Default or Thick filter).
  - AEC can apply to an image that is smaller than 256 k pixels (= 512 × 512 image).
- **Automatic Region Selector (ARS)**
  - MDP selects the region suitable for observation by onboard image analysis.
  - ARS have two modes.

- ✧ GLOBAL search: Select the brightest region in the field of view.
- ✧ LOACL search: Track 3 specific regions

➢ MDP uses ARS patrol images for the ARS function. The time resolution of ARS depends on the time resolution of ARS patrol images. The baseline of ARS time resolution is 1.5 hour (~one orbit).

o **Flare Detection (FLD)**

➢ MDP can detect the occurrence of a flare using flare patrol images taken by XRT.

➢ Detection by intensity increase compared with previous running-averaged patrol image.

➢ When MDP detects the occurrence of a flare, MDP changes the observation table for flare observation and informs the flare to SOT and EIS.

➢ The function also detects radiation belts (SAA and HLZ).

o **Pre-Flare Buffer**

➢ Observers can select the use of the special buffer for pre-flare observations by observing tables.

➢ If MDP detects the occurrence of a flare and XRT is observing the flare site before the flare, MDP keeps the data in the pre-flare buffer until the downlink. If MDP does not detect a flare, MDP writes the data over the previous data on the pre-flare buffer.

➢ The size of the pre-flare buffer is total 5.5 Mbytes.

o **Image Compression**

➢ MDP can compress the image data using JPEG or DPCM method.