AstroSat Soft X-ray Telescope

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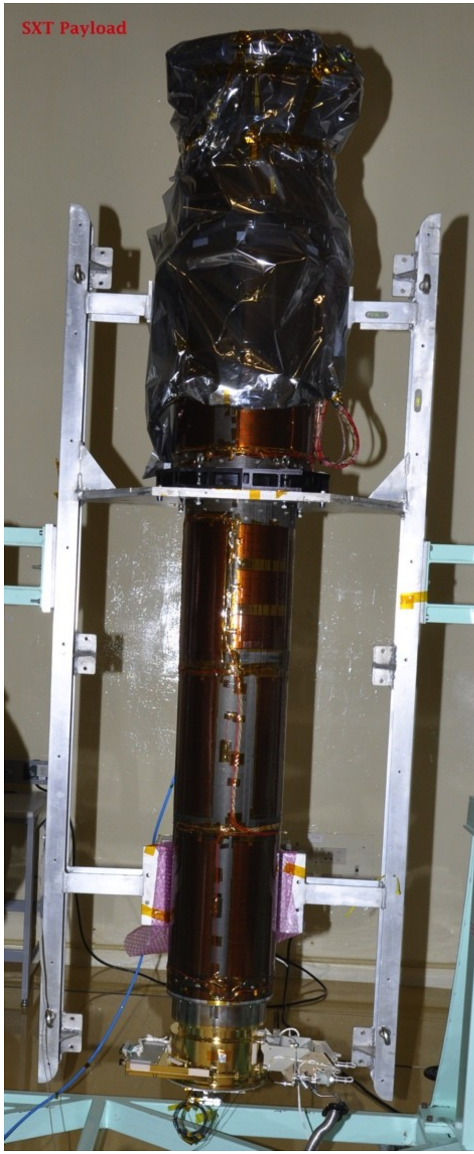
Soft X-ray Telescope (SXT)



Why SXT?

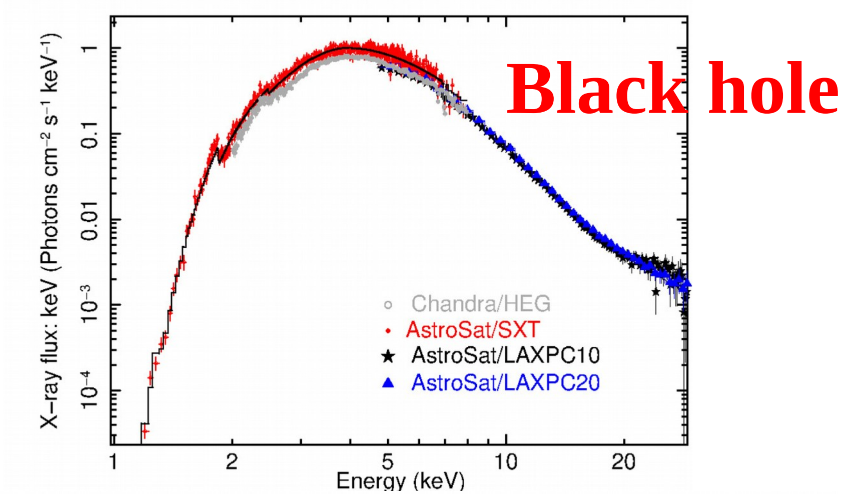
(1) SXT is the first Indian X-ray telescope.

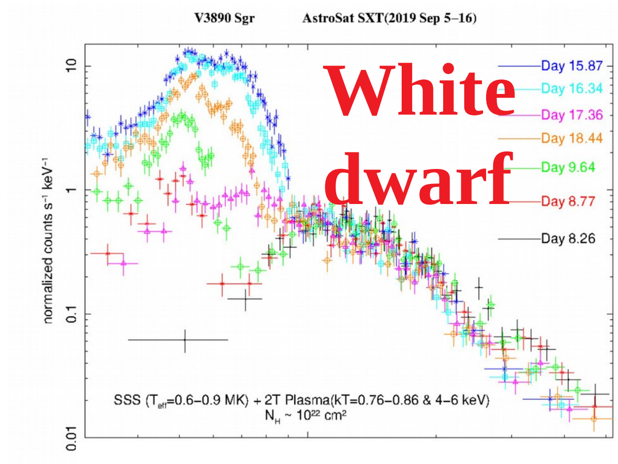
(2) SXT is an essential component to make AstroSat a broadband (optical to hard X-rays) observatory. SXT covers the important range of soft X-rays (0.3-8 keV).

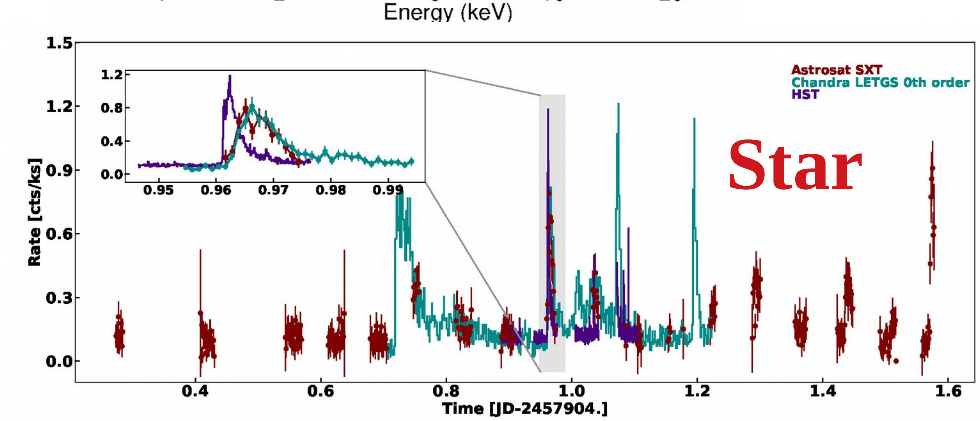
(3) SXT is an imaging instrument.

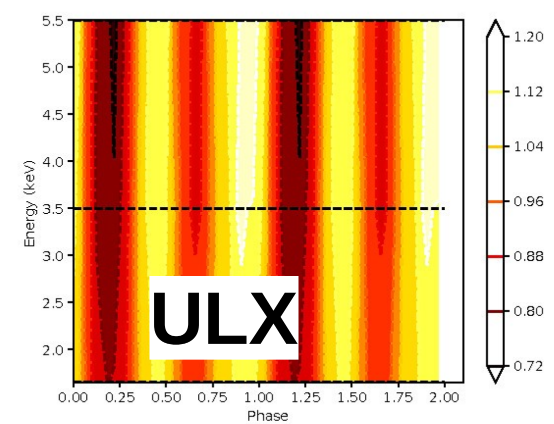
(4) SXT has moderate timing capabilities (time resolution : about 0.3 s).

Scientific capabilities of SXT have been demonstrated for many types of sources: black holes, neutron stars, white dwarfs, ultra-luminous X-ray sources, active galactic nuclei, stars, etc.









Bhattacharyya et al. (2021), JAA, 42, 17 and references therein

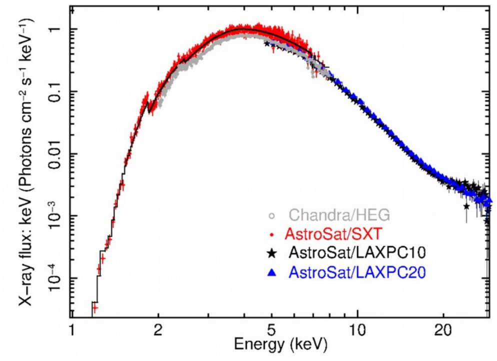
What makes SXT special?

SXT is ideal to observe bright X-ray point sources.

SXT is a modest size X-ray telescope with a charge coupled device (CCD) camera in the focal plane.

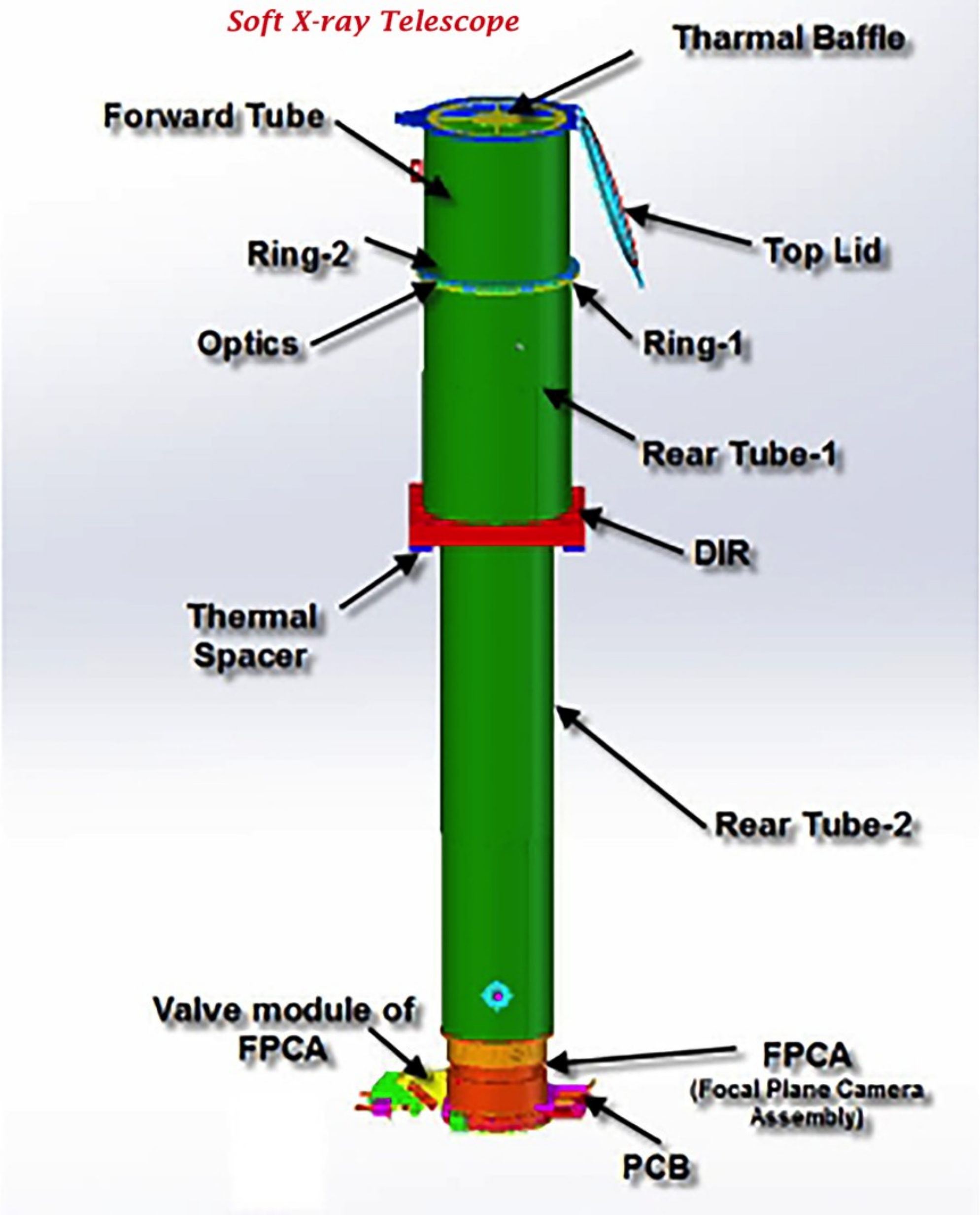
However, SXT has a much smaller pile-up compared to current large soft X-ray imaging telescopes.

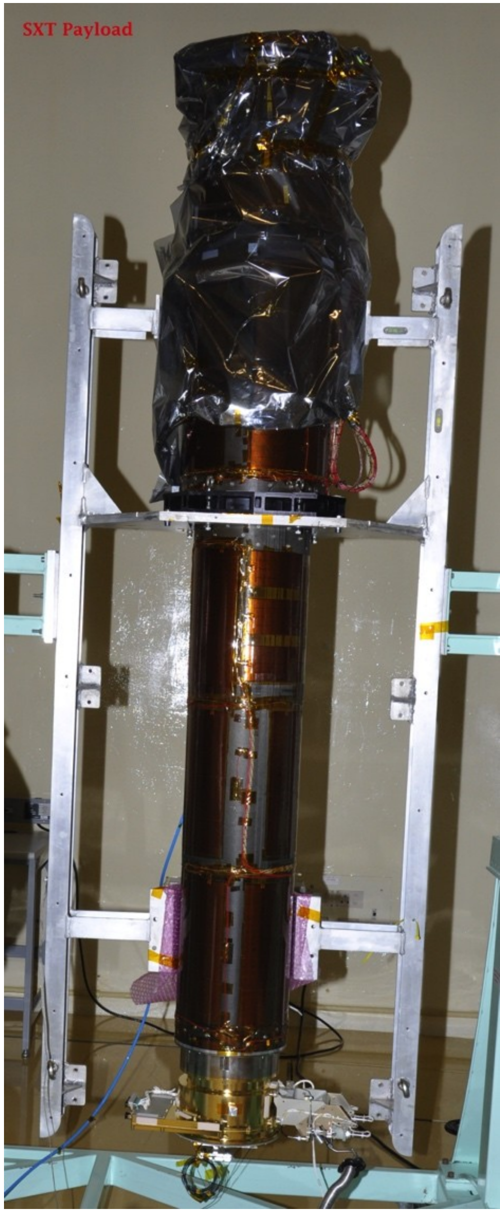
Therefore, SXT can provide undistorted spectra of relatively bright X-ray sources, in which it excels over some current large CCD-based X-ray telescopes.



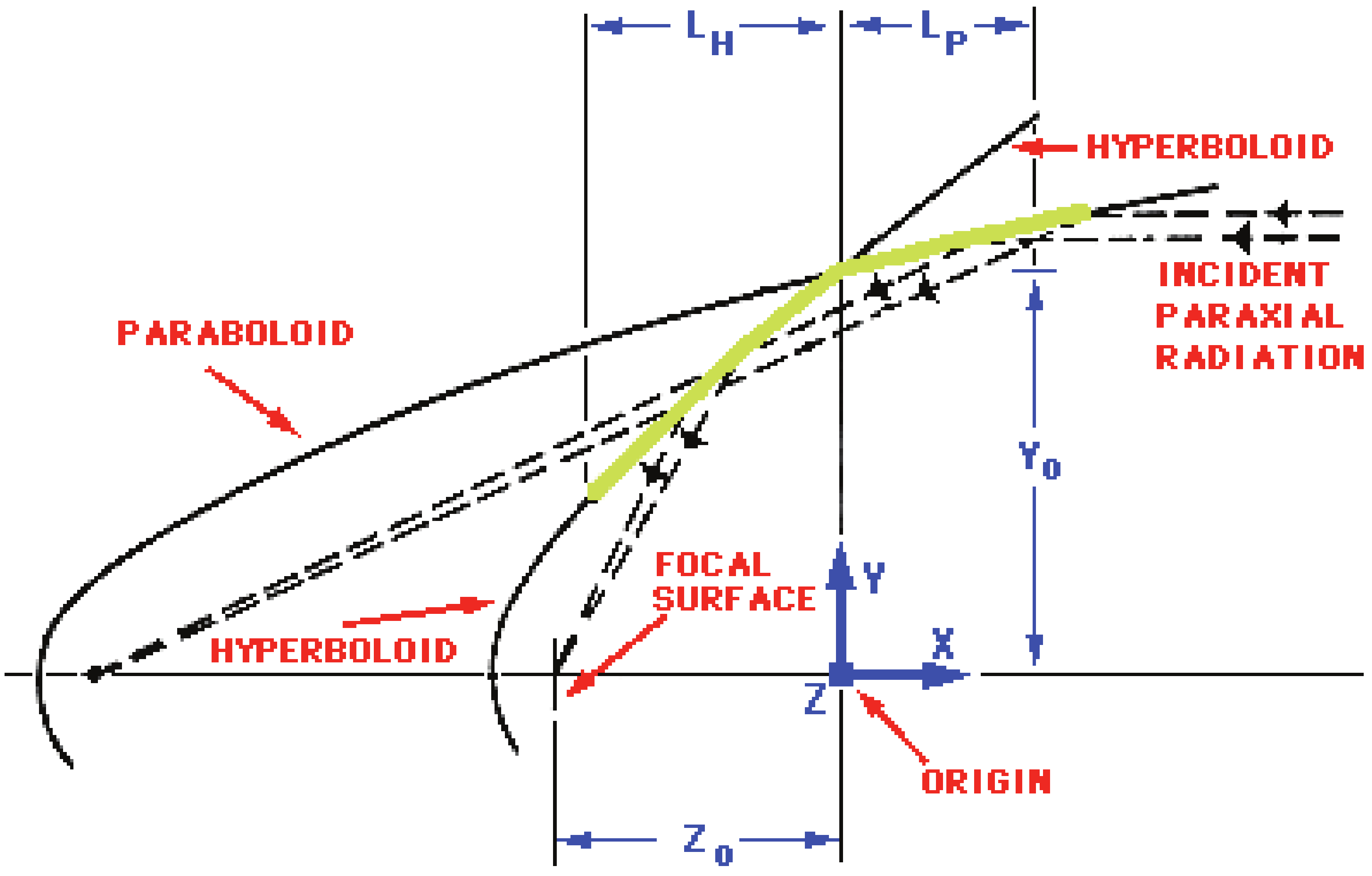
Pahari et al. (2018)

SXT: Optics + CCD based FPCA (~65 Kg)

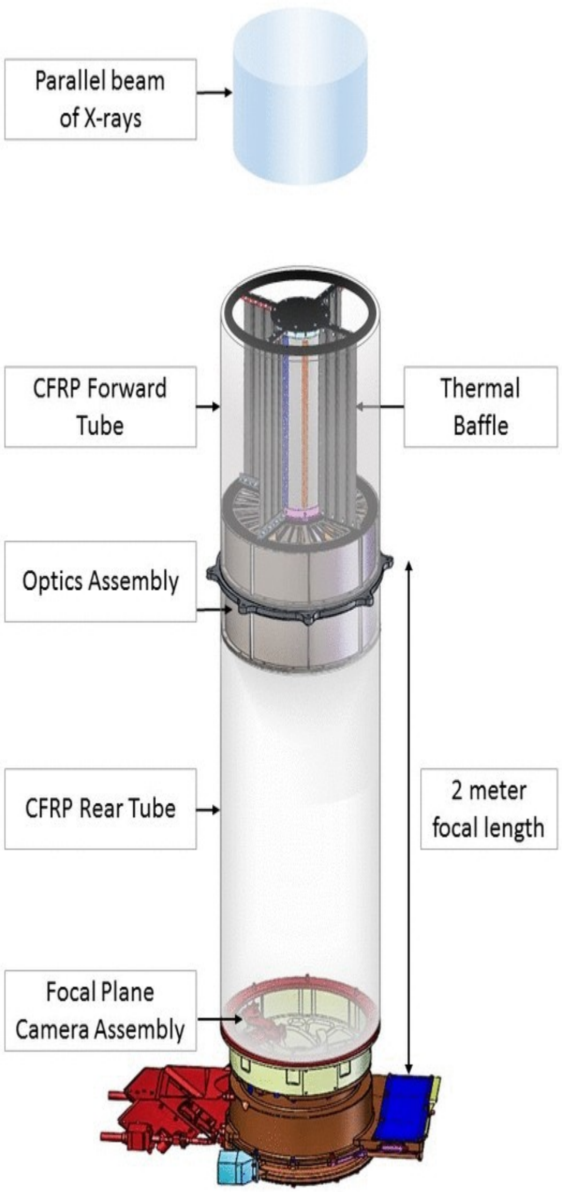




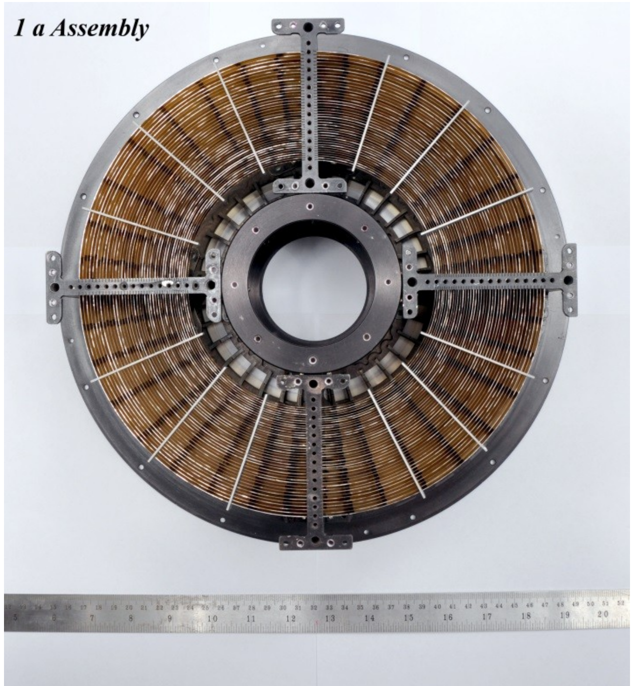
The principle of the Wolter I optics using ray diagram



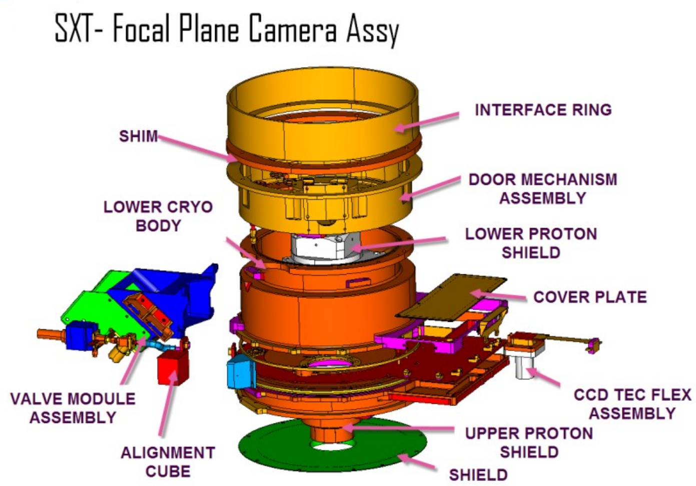
Soft X-ray Telescope



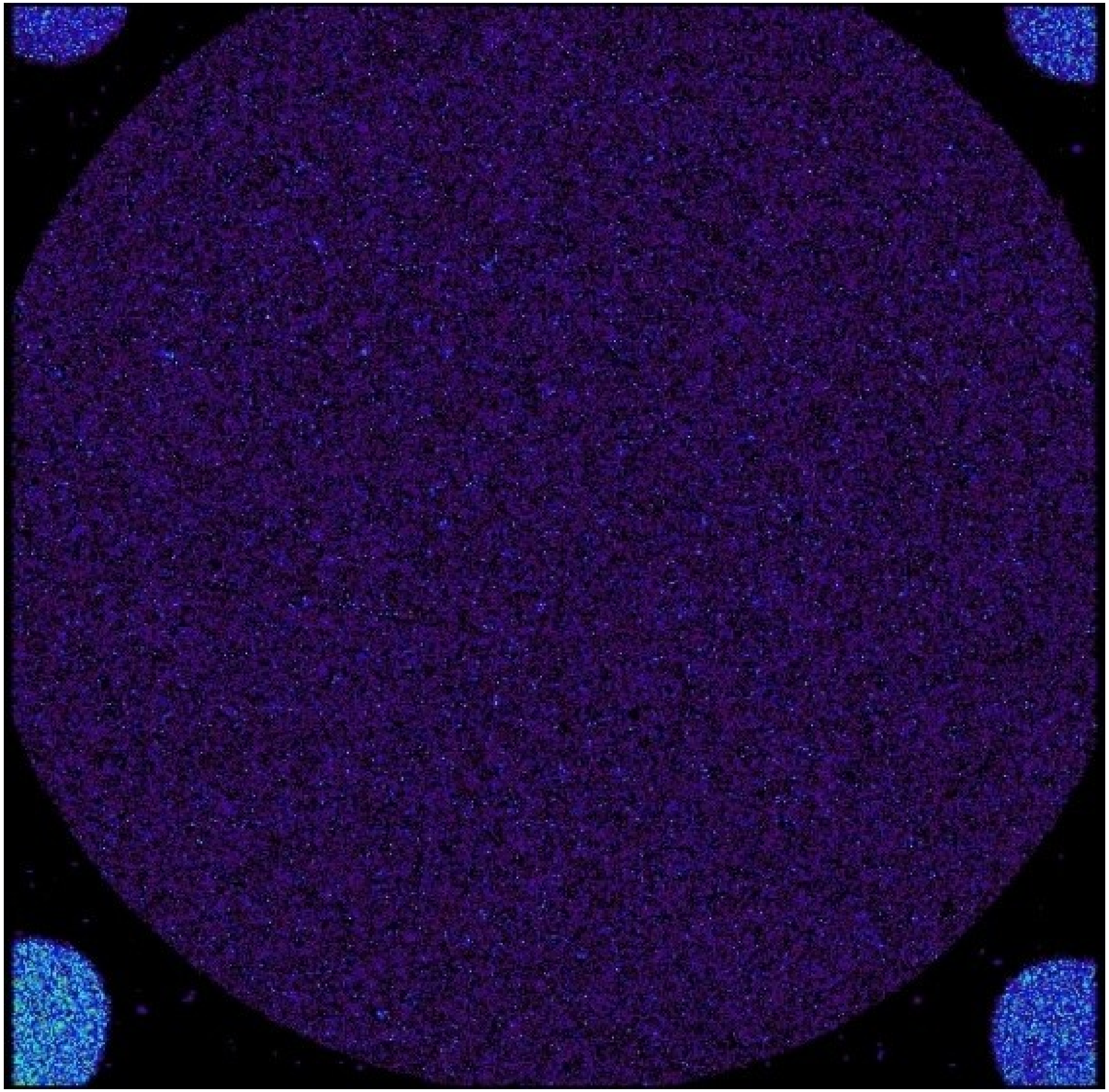
40 shells (130 – 260 mm dia)



- **Thin Optical Blocking Filter**
- **CCD Assy. including TEC**
- **PCB with front-end electronics**
- **Four Fe-55 corner sources for calibration**



The CCD illuminated by four corner sources



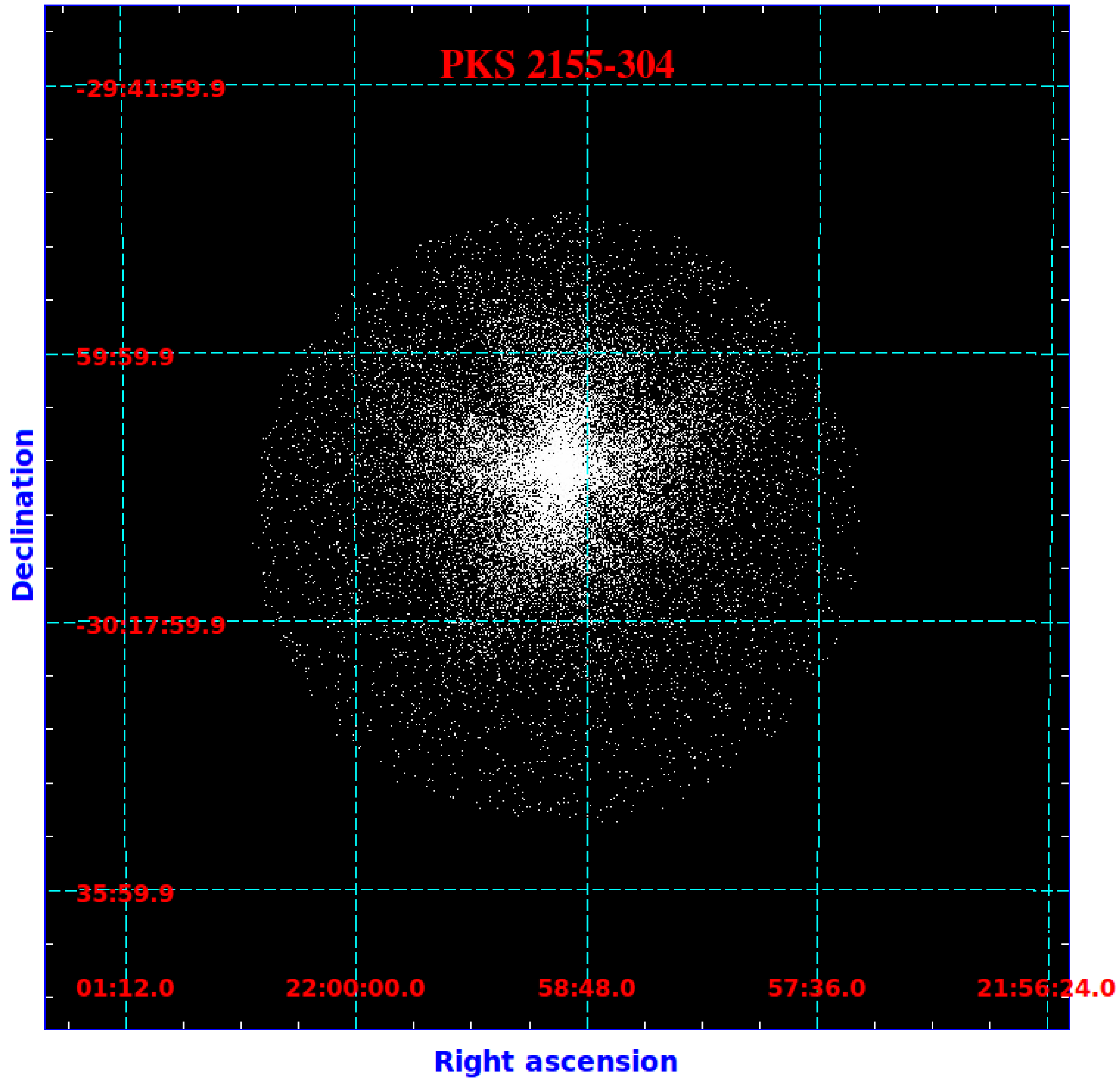
600 x 600 pixels

Field of view:
40 arcmin square

SXT FIRST LIGHT

- Telescope (Optics) Door opening - Oct 15th
- Camera Door Opening - Oct 26th @ 06:30 UT
- First Light – Oct 26th

Pointed at and observed- PKS2155-304 (Quasar) at redshift of 0.116



Readout Modes of the CCD

Science modes

1. **Photon Counting (PC) mode:** 600x600 pixels; threshold energy set; ~2.4 s time resolution (default mode)

2. **Fast Window (FW) mode:** central 150x150 pixels; threshold energy set; ~0.3 s time resolution (less pile-up)

Calibration modes

1. **Bias Map (BM) mode:** 600x600 pixels; zero threshold; ~24 s time resolution

2. **Calibration mode:** central 100x100 pixels and 80x80 pixels at each of four corners; zero threshold; ~2.4 s time resolution

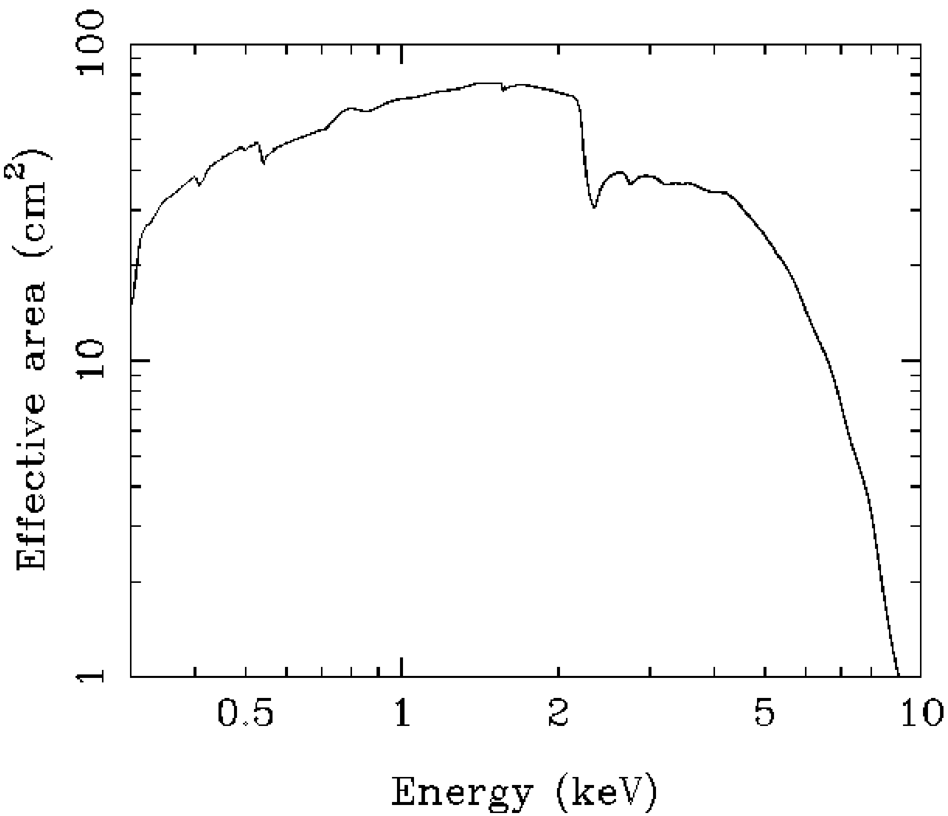
SXT characteristics

- Energy range: 0.3-7.0 keV
- Effective area

  ~75 cm^2 at 1.5keV
- Energy resolution

  90eV@1.5keV,
  136eV@5.9keV
- Sensitivity achieved is ~0.01 ± 0.0008 cps (net counts after background subtraction) in an effective exposure of 57530 s for a very soft source with intensity of ~ $5x10^{-13}$ ergs cm^{-2} s^{-1} (0.3-2 keV)

(source: K. P. Singh).



SXT Payload Operation Centre (POC) is at the Department of Astronomy and Astrophysics, TIFR, Mumbai.

SXT POC homepage (visit for all SXT related information and updates):
http://www.tifr.res.in/~astrosat_sxt/index.html

Important SXT websites at the POC:

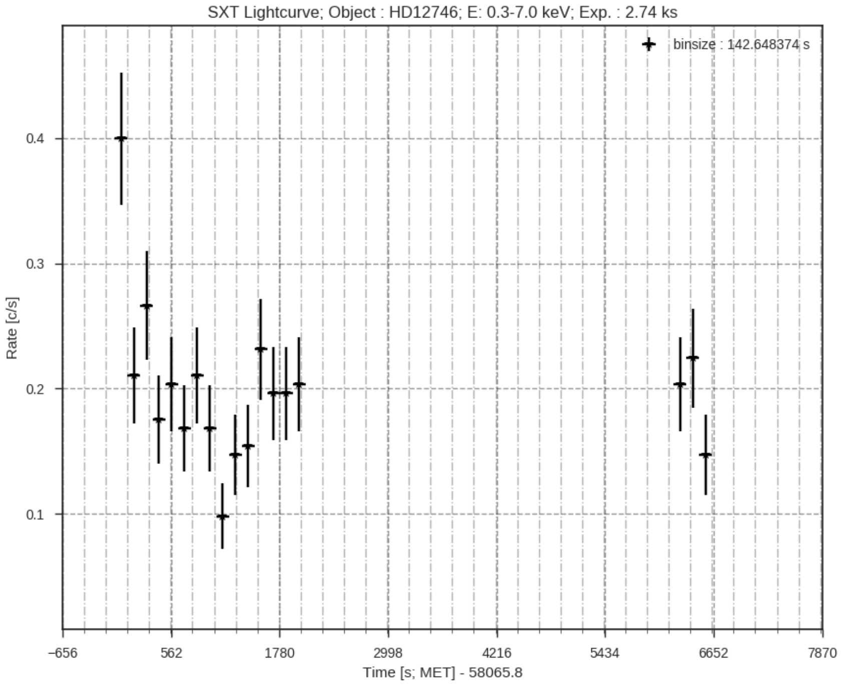
Download the latest version of the SXT pipeline from:
http://www.tifr.res.in/~astrosat_sxt/sxtpipeline.html

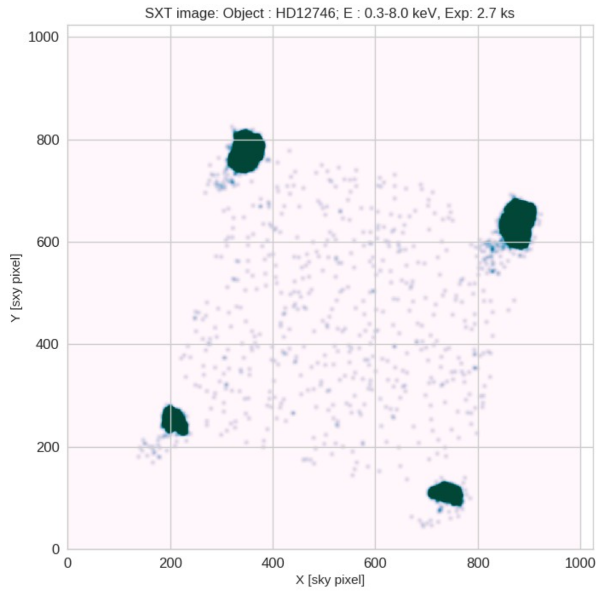
Find the observational log at:
http://www.tifr.res.in/~astrosat_sxt/obslogs.html

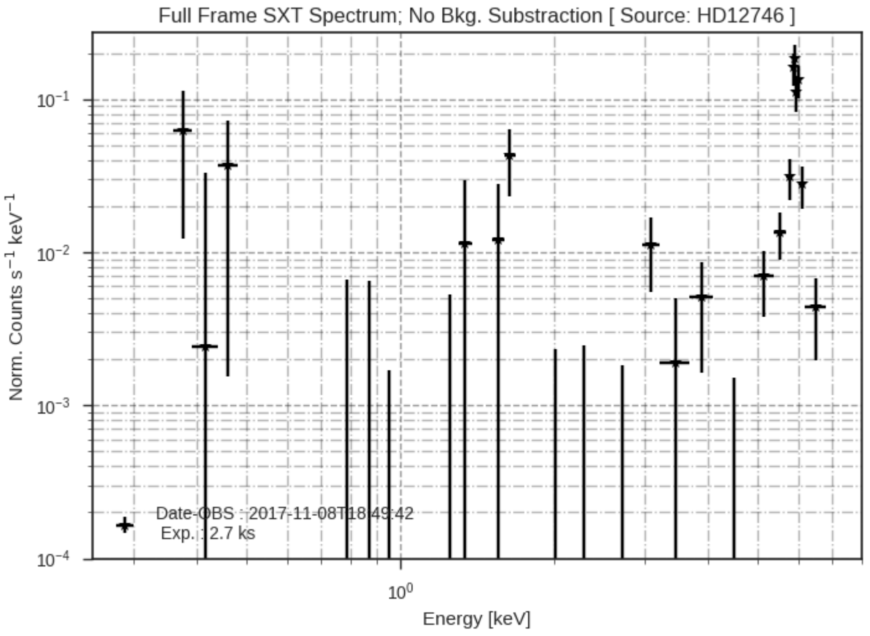
Find the Quick Look products at:
http://www.tifr.res.in/~astrosat_sxt/HTMLOUTDIR/input.html

SXT data analysis

Images in a typical Quick Look page







SXT data analysis

http://www.tifr.res.in/~astrosat_sxt/dataanalysis.html

ASTROSAT SXT

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DATA ANALYSIS

Dear Users,
Please make sure you are using level2 data from the latest level2 pipeline version 1.4b. Use the latest version of the data (XXXXX_V1.2), when multiple versions of the data are available in the same zip file on the astrobrowse link . Please also cross check the text from the log file "Running ASTROSAT SXT PIPELINE Task : SXTPIPELINE Version : 1.4b Release Date : 2019-01-04" provided in the XXXXX_V1.2 folder .

SR NO	Details (readme file kept inside each folder)	Download
1	SXT Response and Background files	Download
2	SXT Event Merger Tool	Download
3	SXT standard ARFs; ARF generation and other tools (Released on 18 July 2019)	Download
4	README file for Data Analysis	Download

SXT pipeline

http://www.tifr.res.in/~astrosat_sxt/sxtpipeline.html

SXT PIPELINE SOFTWARE

Pipeline	Release date	Version	Description	Download
AS1SXTLevel2-1.4b	03-January-2019	1.4b	Seventh Version	Download
Readme file	03-January-2019	1.4b	seventh Version	Download
AS1SXTLevel2-1.4a	06-December-2017	1.4a	sixth Version	Download
Readme file	06-December-2017	1.4a	sixth Version	Download

Important Note: G++ 4.8 is needed for SXT PIPELINE. For higher version of Ubuntu 16.06 please make sure G++ 4.8 is installed. Following are the procedures and its varies system to system.Please also crosscheck results with the SXTPOC. For example NEVENTS of clean event file of level2 products.

Some aspects of the ongoing calibration work

1. Bias value variation

2. Evolution of the charge transfer inefficiency (CTI)

3. Background model

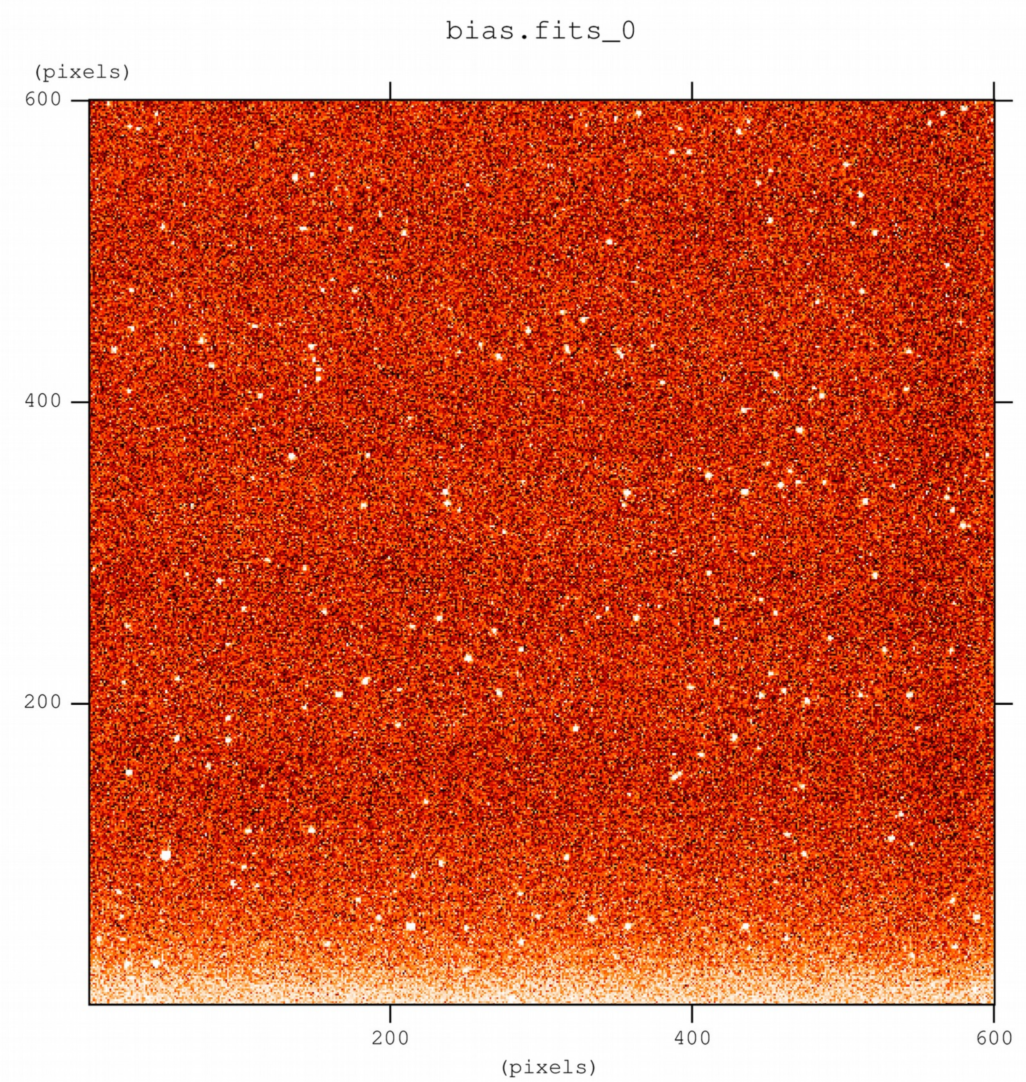
4. Auxiliary Response File (ARF)

5. Pile-up

6. Cross-calibration

Calibration: bias value variation

Calibration: bias value variation



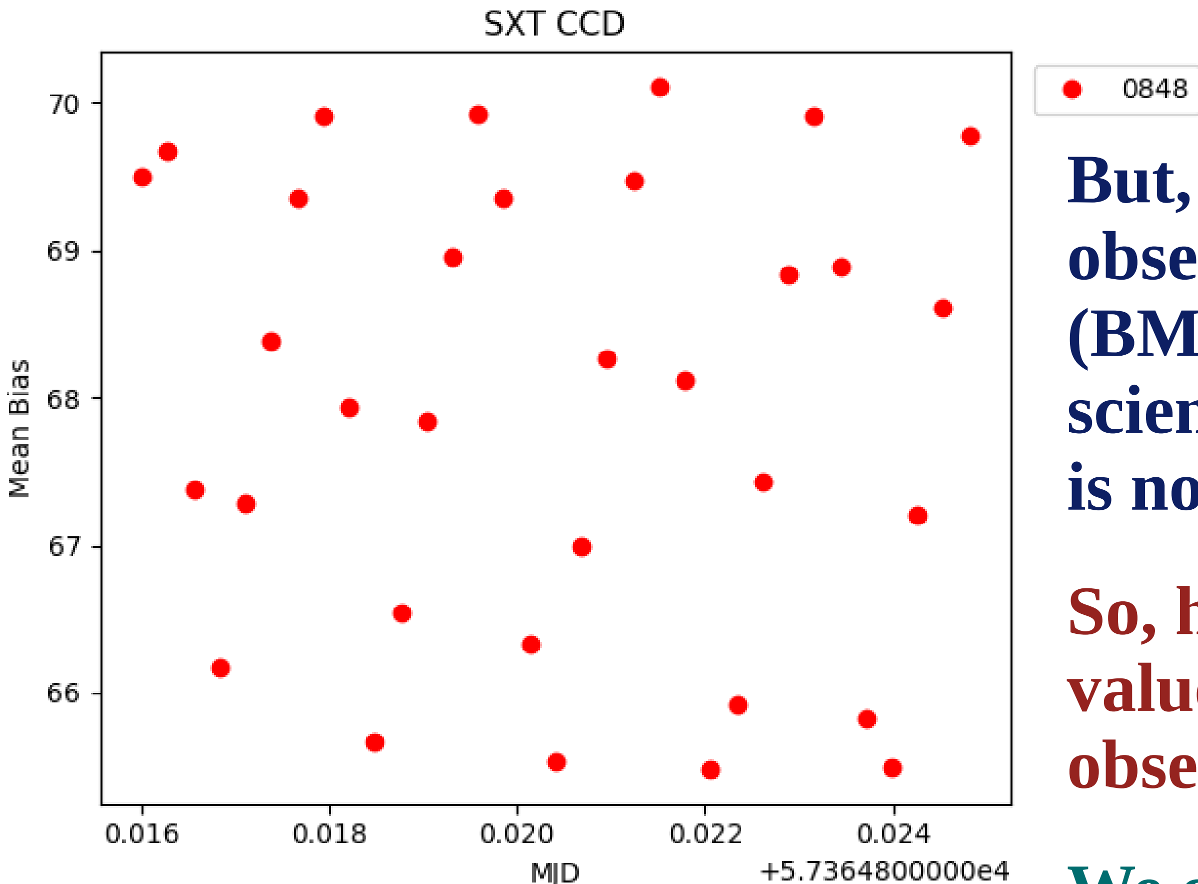
Credit: Bajpai, Kotak, Mukerjee

An example of CCD image in bias mode.

This noise level (electrons are not created from photons) has to be subtracted.

Calibration: bias value variation

However, if bias values vary with time, then one needs to know these values during a particular observation.



Credit: T. Katoch

But, simultaneous observation in bias map (BM) mode and in a science mode (PC or FW) is not possible.

So, how do we know bias values during a science observation?

We observe a pattern in the variation.

Calibration: bias value variation

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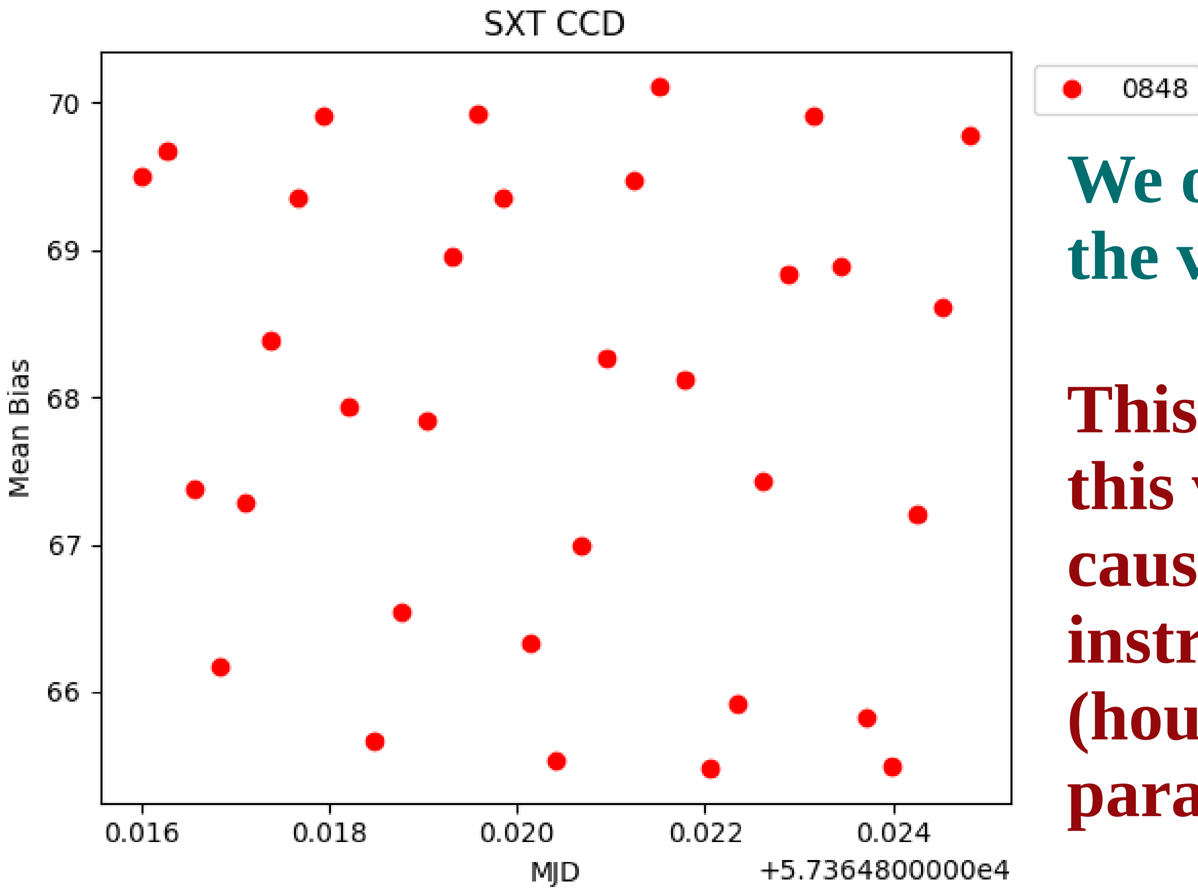

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This pattern indicates that this variation could be caused by certain instrument parameters (housekeeping (HK) parameters).

Calibration: bias value variation

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HK parameters are measured during science observations.

So, if we can find a correlation between variations of bias and certain HK parameters, we can use this to predict correct bias values during science observations.

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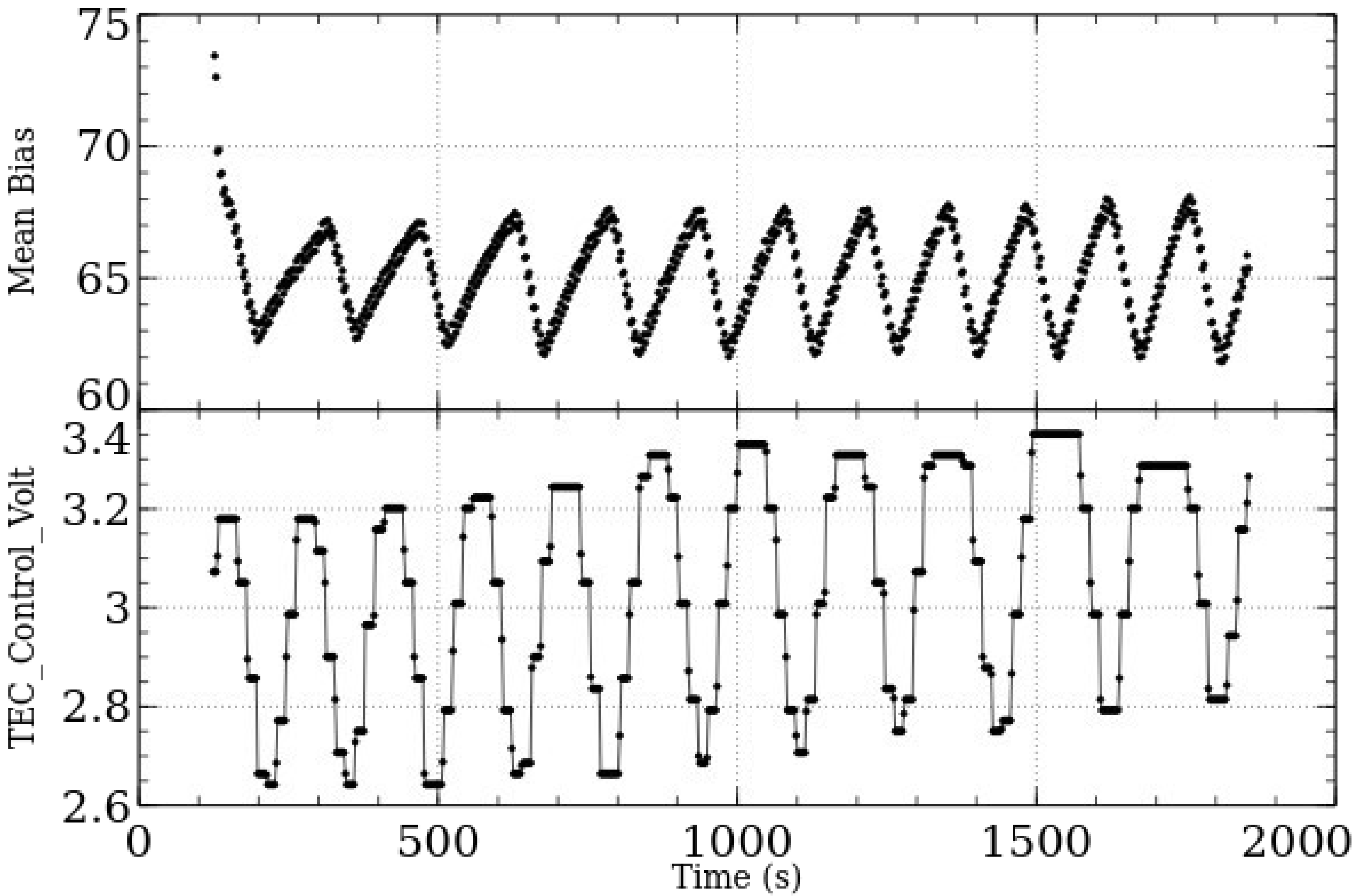
CCD temperature and properties (e.g., temperature) of electronics are expected to determine/affect the bias values.

Calibration: bias value variation

Indeed, we find a connection between the mean bias and the TEC control voltage (which determines CCD temperature).



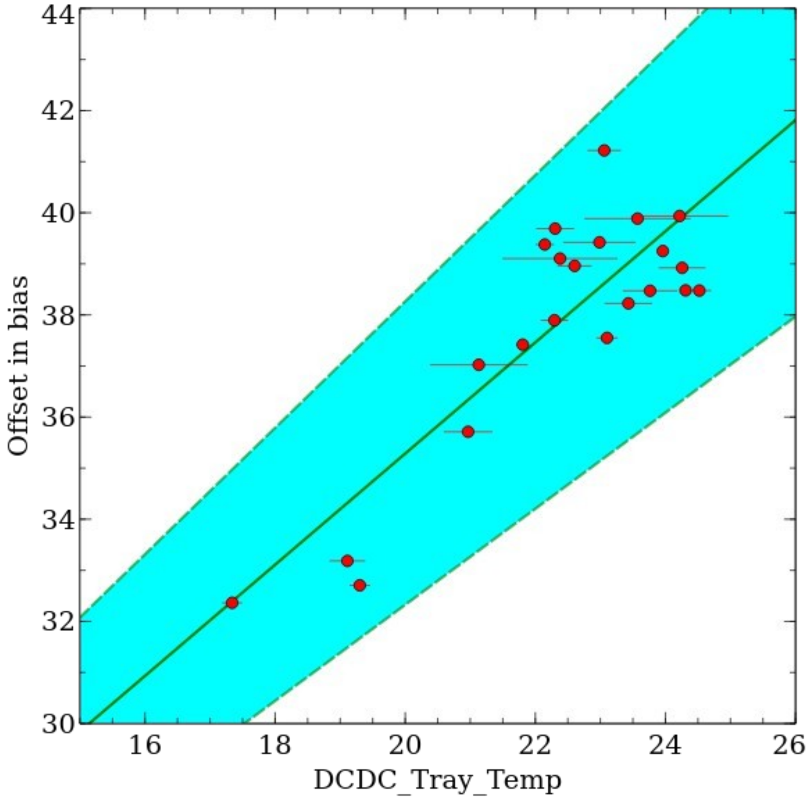
Credit: Pawar, Dewangan, Vishwakarma, Kamble, Koyande

Calibration: bias value variation

We first try to fit with the formula:

Mean bias = m1 * TEC_volt + c1

But, we find that 'c1' is not fixed and depends on the DCDC_Tray_Temp (DC-DC modules provide the regulated DC supply to all the electronic cards). This is not unexpected.



So we use the formula:

c1 = m2 * DCDC_Tray_Temp + c2

Credit: Pawar, Dewangan, Vishwakarma, Kamble, Koyande

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This gives good results for some cases, but not for all cases. Moreover, there is also long-term variation of bias values.

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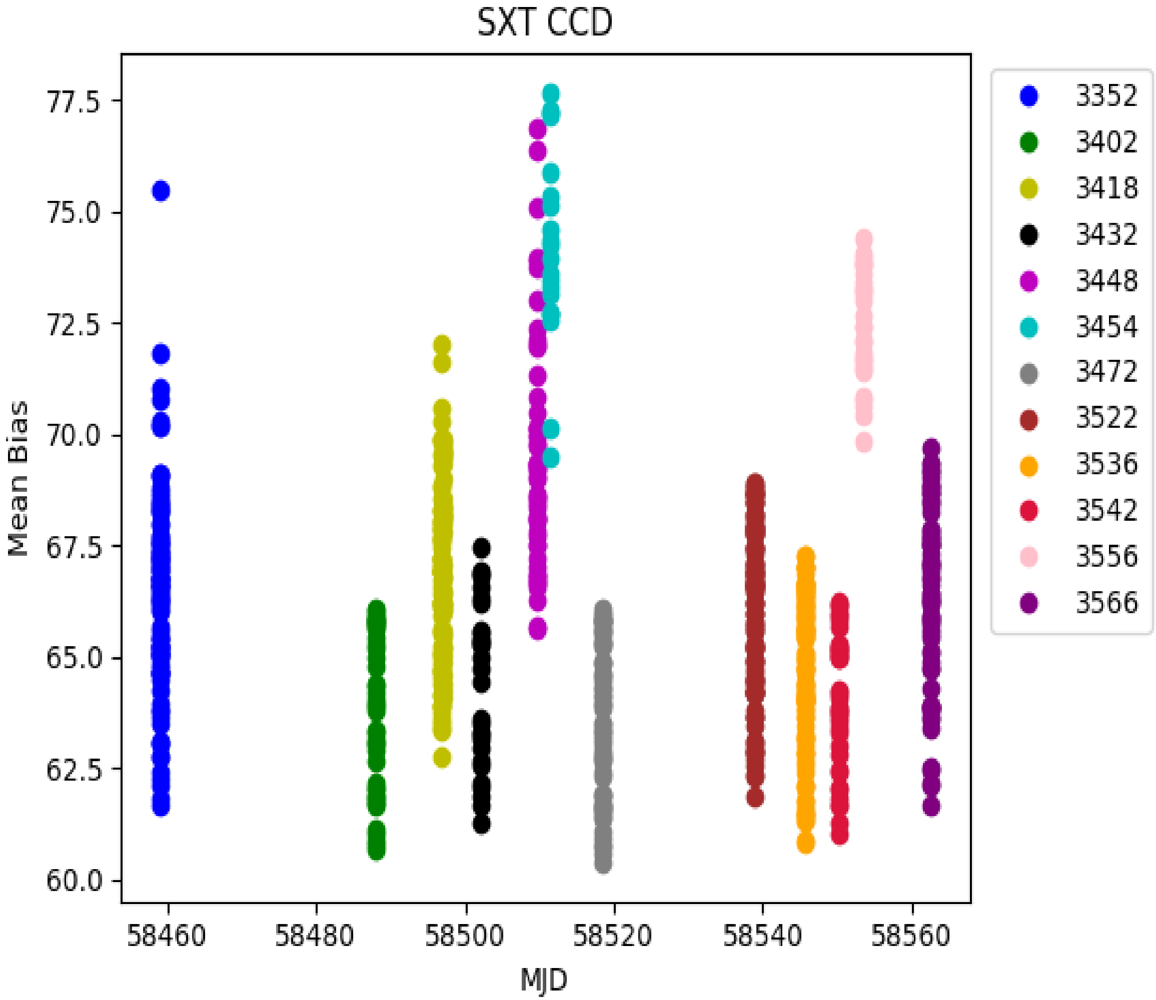

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We are collecting more bias map mode data and trying to improve the calibration.

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Thank you!