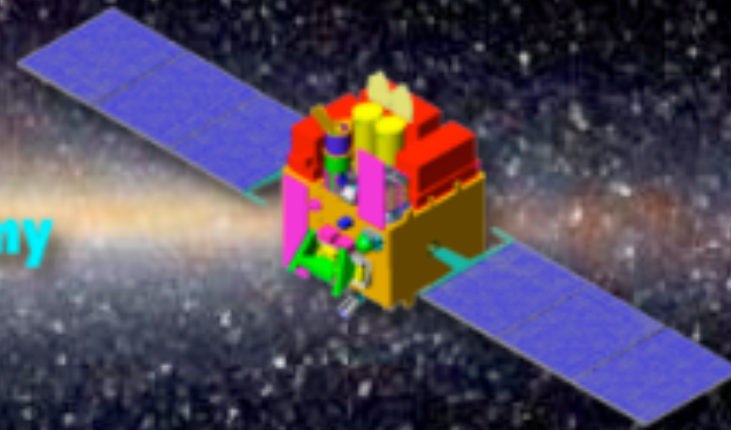


ASTROSAT

A Satellite Mission for Multi-wavelength Astronomy

Indian Space Research Organisation

<http://www.iucaa.ernet.in/~astrosat/>



ASTROSAT

A forthcoming Indian Astronomy Mission

Dipankar Bhattacharya

Inter-University Centre for Astronomy and Astrophysics
(IUCAA), Pune, India

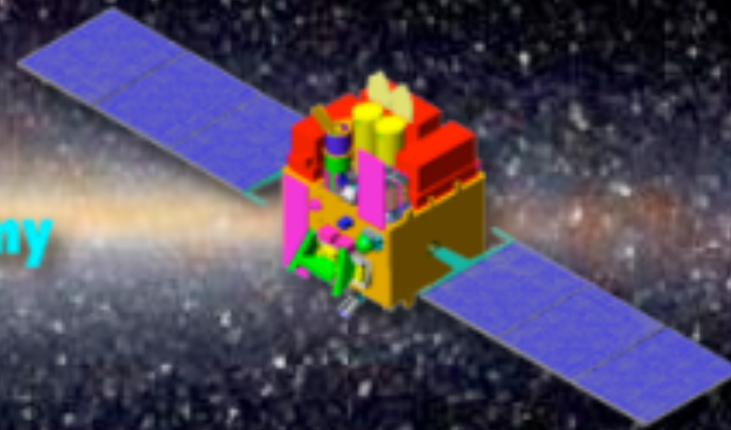
on behalf of the ASTROSAT collaboration

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Indian Space Research Organisation

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**ASTROSAT is an Indian satellite
scheduled for launch in 2011**

**It will carry five astronomy payloads covering
optical, UV, soft-X ray and hard X-ray bands**

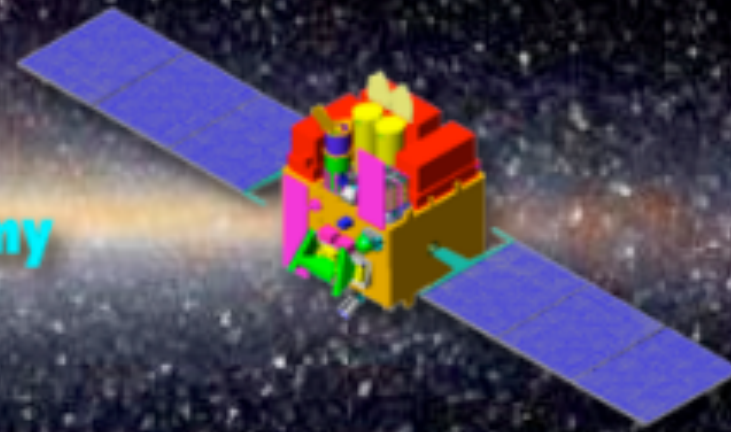
**Near-equatorial 650 km circular orbit
> 5 year mission life**

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Indian Space Research Organisation

<http://www.iucaa.ernet.in/~astrosat/>



ASTROSAT project history

- Conceptualization began in 1996
- Project Report submitted 2000
- ISRO acceptance 2002; seed funding started
- Mission approval 2004 by Govt of India, full funding sanctioned (~50 M Euro)
- Launch expected 2011

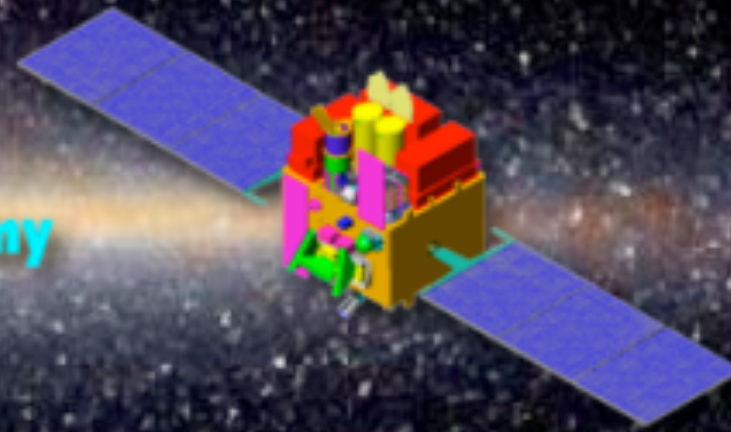


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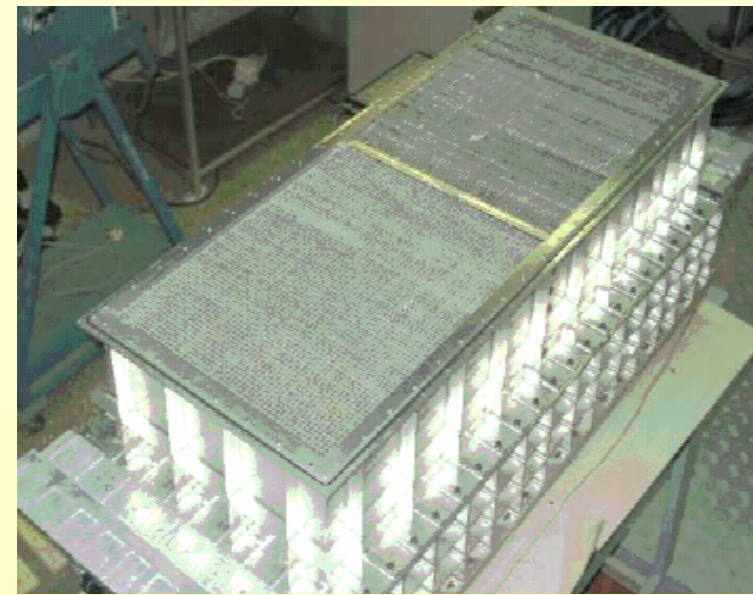
ASTROSAT Mission Concept

- Multiwavelength capability - wide range of science to engage diverse Indian science community
- Simultaneous multiwavelength (Opt - hard X) capability not commonly available; but possible with technology accessible to India
- Time variability a major thrust: Strong gravity, Dense Matter, Radiation mechanisms - Compact Stars to AGNs
- Broadband spectroscopy: Cyclotron lines, Non-thermal emission, Comptonization
- UV-imaging: Ly-break / starburst galaxies, Star Formation, Extinction

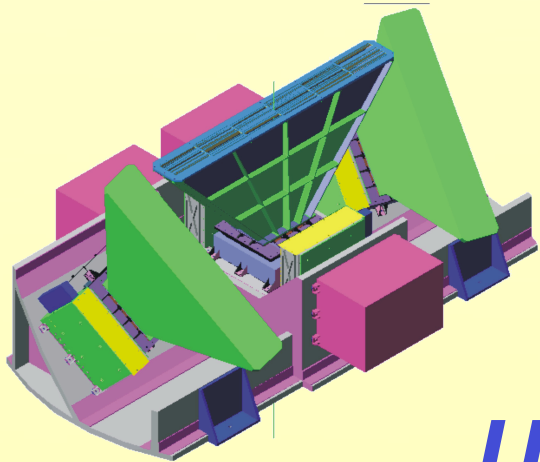
Similarities with: *RXTE*, *SWIFT*, *GALEX*

ASTROSAT INSTRUMENTS

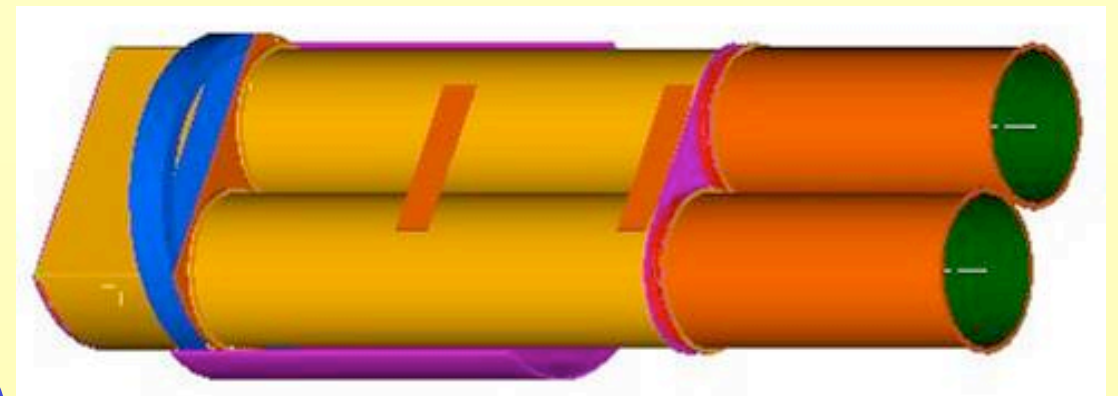
Large Area X-ray Proportional Counter
(TIFR-RRI)



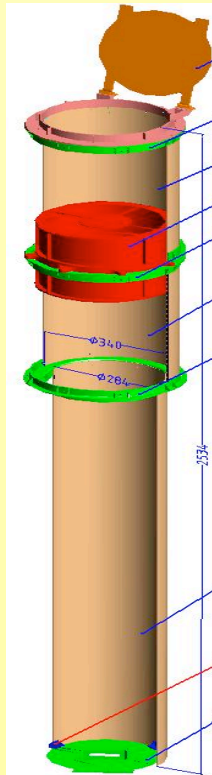
Scanning Sky Monitor (SSM)
(ISRO-IUCAA-RRI)



UV Imaging Telescope
(IIA-IUCAA-ISRO-CSA)

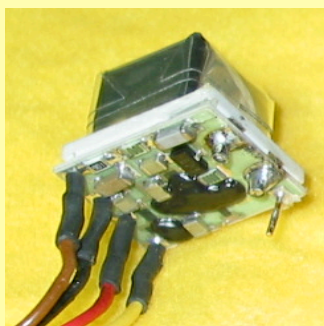
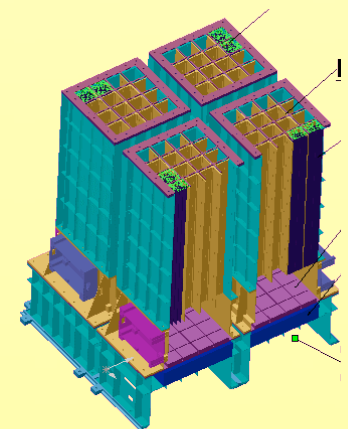


Soft X-ray telescope (SXT) (TIFR-UOL)



Cadmium Zinc Telluride Imager
(TIFR-IUCAA-RRI)

Charged Particle Monitor
(TIFR)

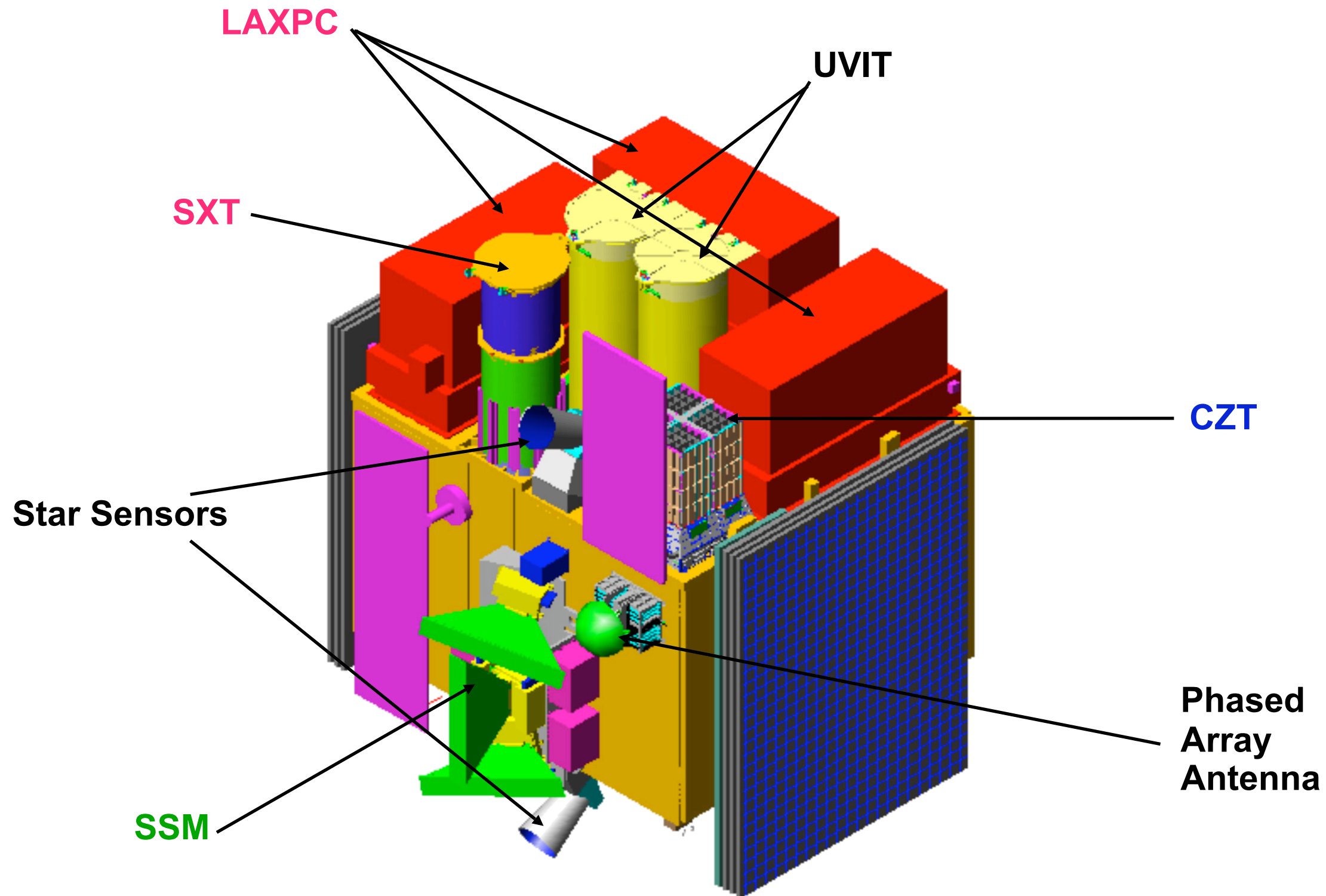
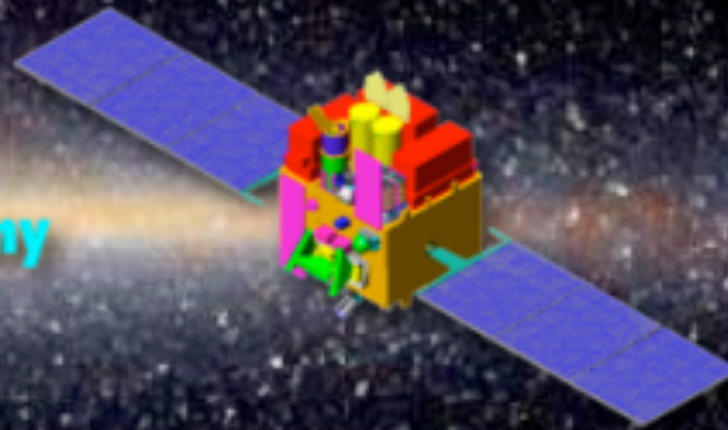


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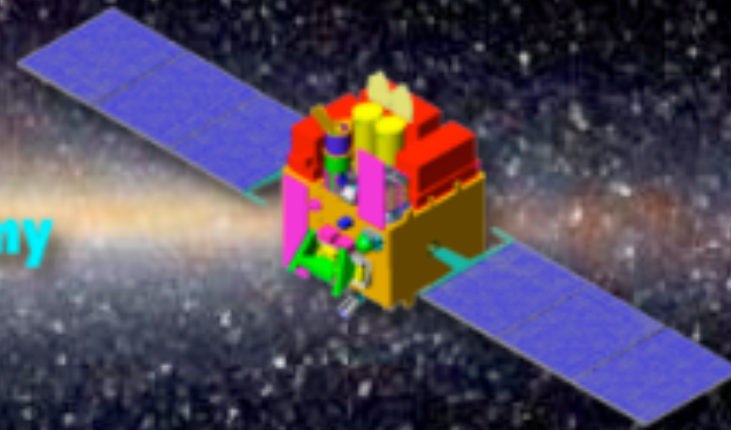


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ASTROSAT LAXPC: *Primary timing instrument*

Large Area X-ray Proportional Counters (3 units)

60 anode cells of 3.0 cm x 3.0 cm cross-section arranged in 5 layers and surrounded on 3 sides with veto layers



Box: 120 cm x 50 cm x 70 cm

Collimator: square

Al: 4mm x 4mm x 30 mm

Sn+Cu: 4mm x 4mm x 450 mm

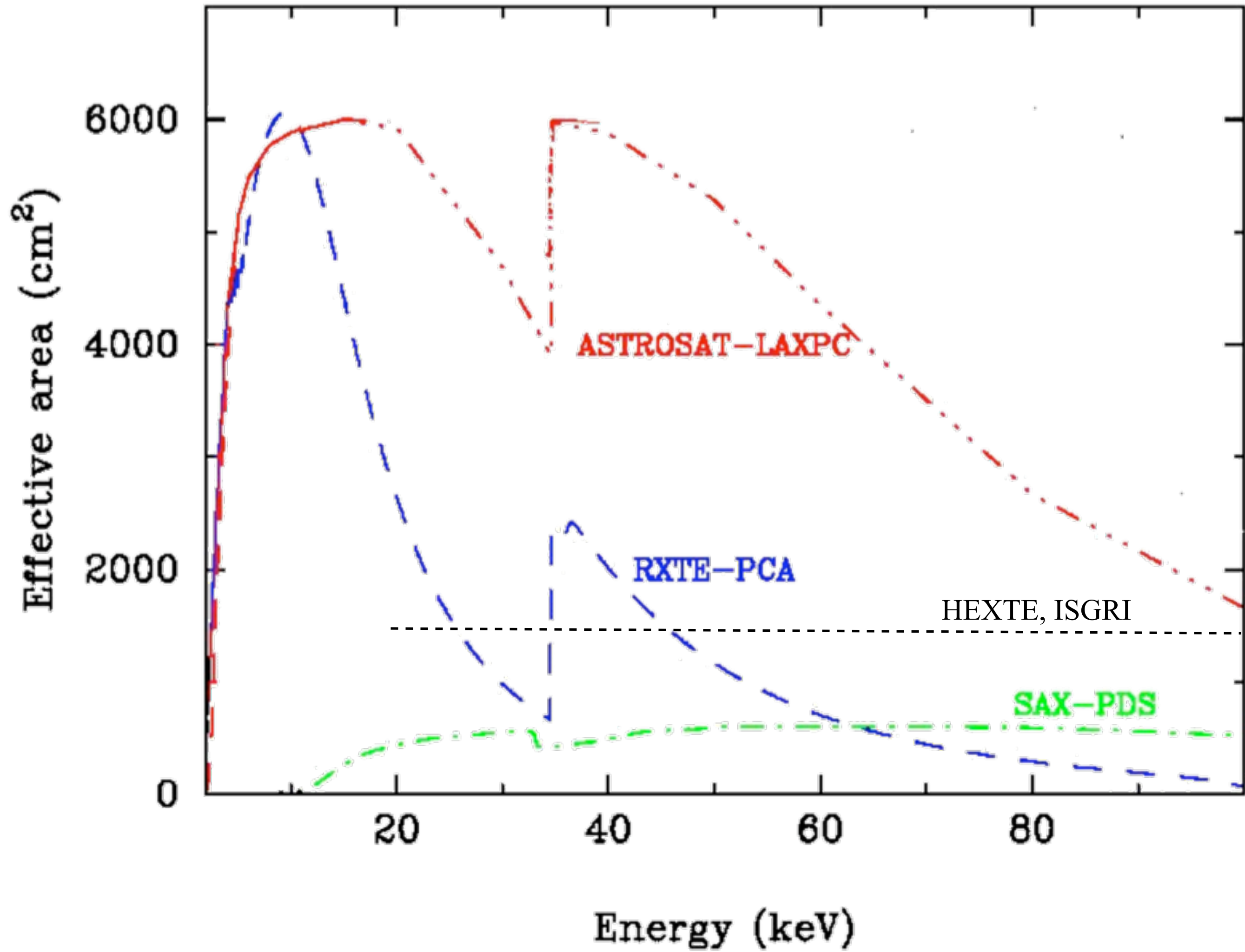
FOV 1°x1°

3 – 80 keV

$A_{\text{eff}} \sim 6000 \text{ cm}^2 @ 20\text{keV}$

$E/\Delta E \sim 5 \text{ to } 12$

Events time tagged to 10 microsec accuracy

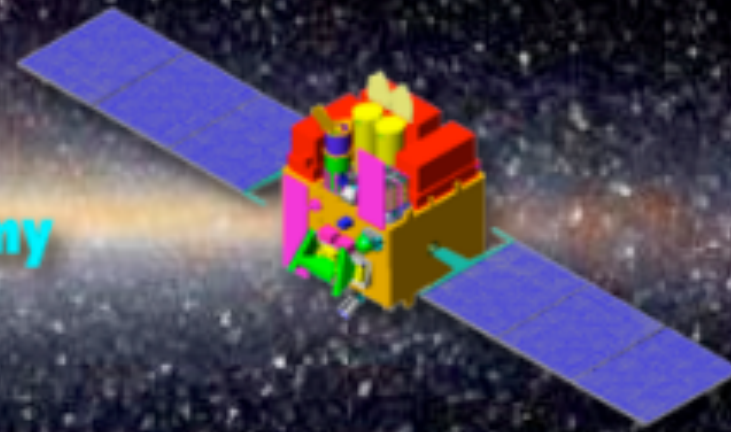


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LAXPC modes of operation:

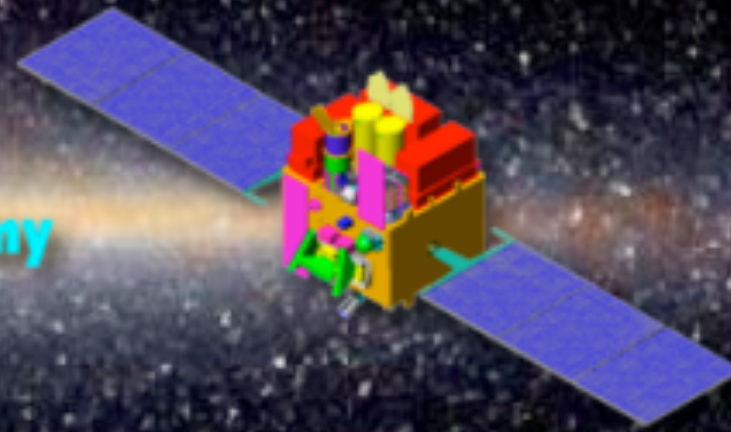
- Light curves: integration time 64 ms (8ms.... 1s)
total 35 counters
- Spectra: 5 per detector, every 8 sec (1,2.....128)
- Events: 10 μ s tag, full spectral/ID, double events
- Events: no spectra, high rate
- Fast counting: high rate, 160 μ s, 4 bands, top layer

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ASTROSAT UVIT

Ultra Violet Imaging Telescopes (2 units)

Detectors: Microchannel Plate
+ Photon-counting CMOS

3 channels: FUV,NUV,VIS simultaneous
Multiple filters, low-resol grating

Sensitivity: ~ 20 mag

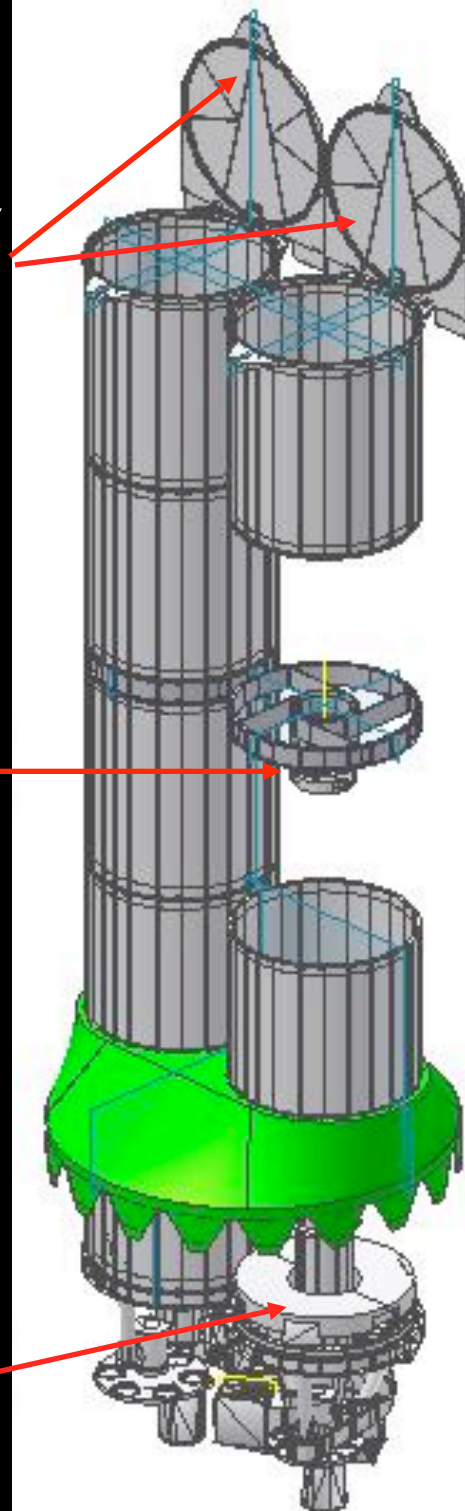
Image resol: 1.8 arcsec

Temporal resolution:
30 ms, full frame,
< 5 ms, small window

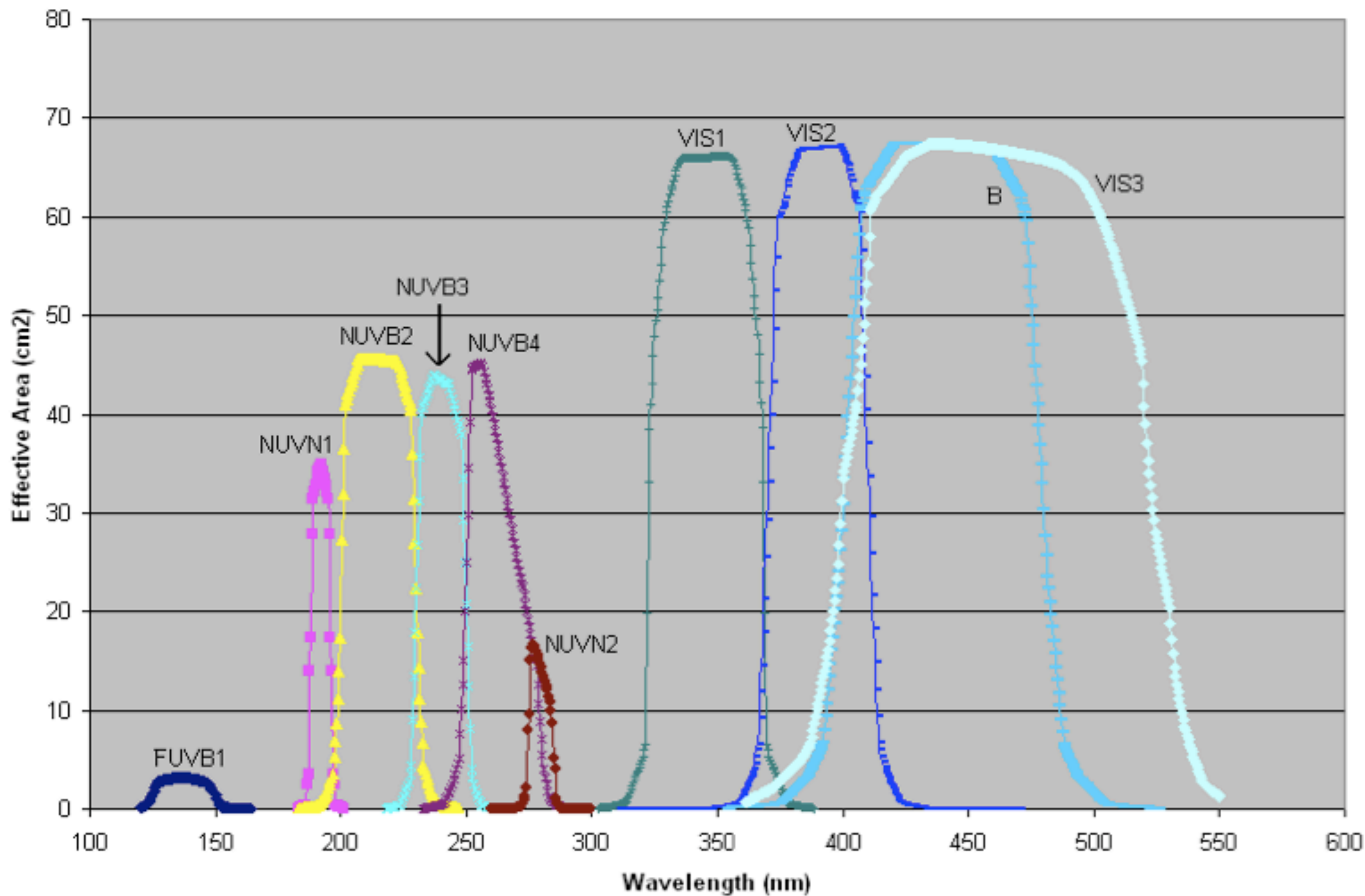
*Doors /
Sun shield*

*Secondary
Mirror*

*Primary
Mirror*



Effective Telescope Area for FUV / NUV / VIS Interference Filters



Drift/Jitter correction required to obtain final resolution in UVIT images

- drift $< 0.2''/\text{s}$; jitter rms $\sim 0.3''$ ($> 1 \text{ Hz}$)

Drift correction by tracking the motion of 1-s VIS channel images; jitter estimated every 0.1 s using gyro signals.

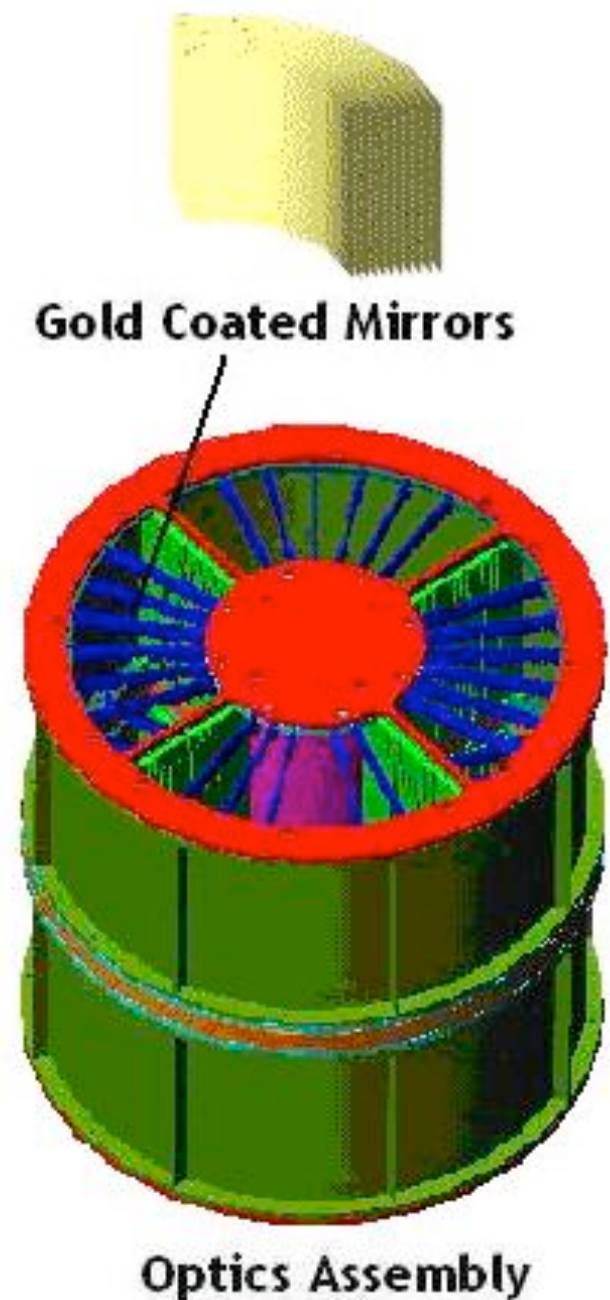
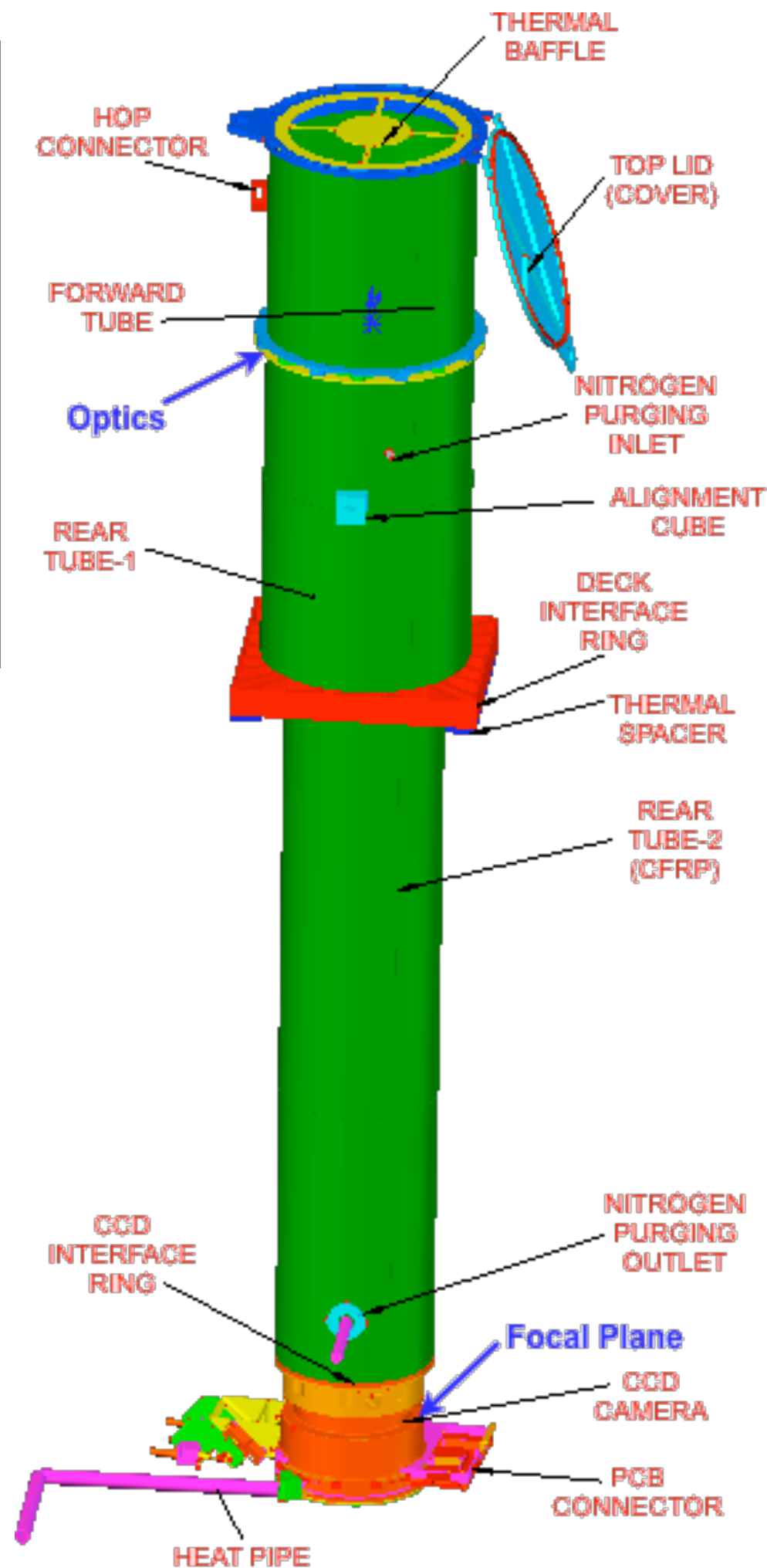
1.5 arcsec resolution should be typically achievable; target 1.8 arcsec

SXT on ASTROSAT

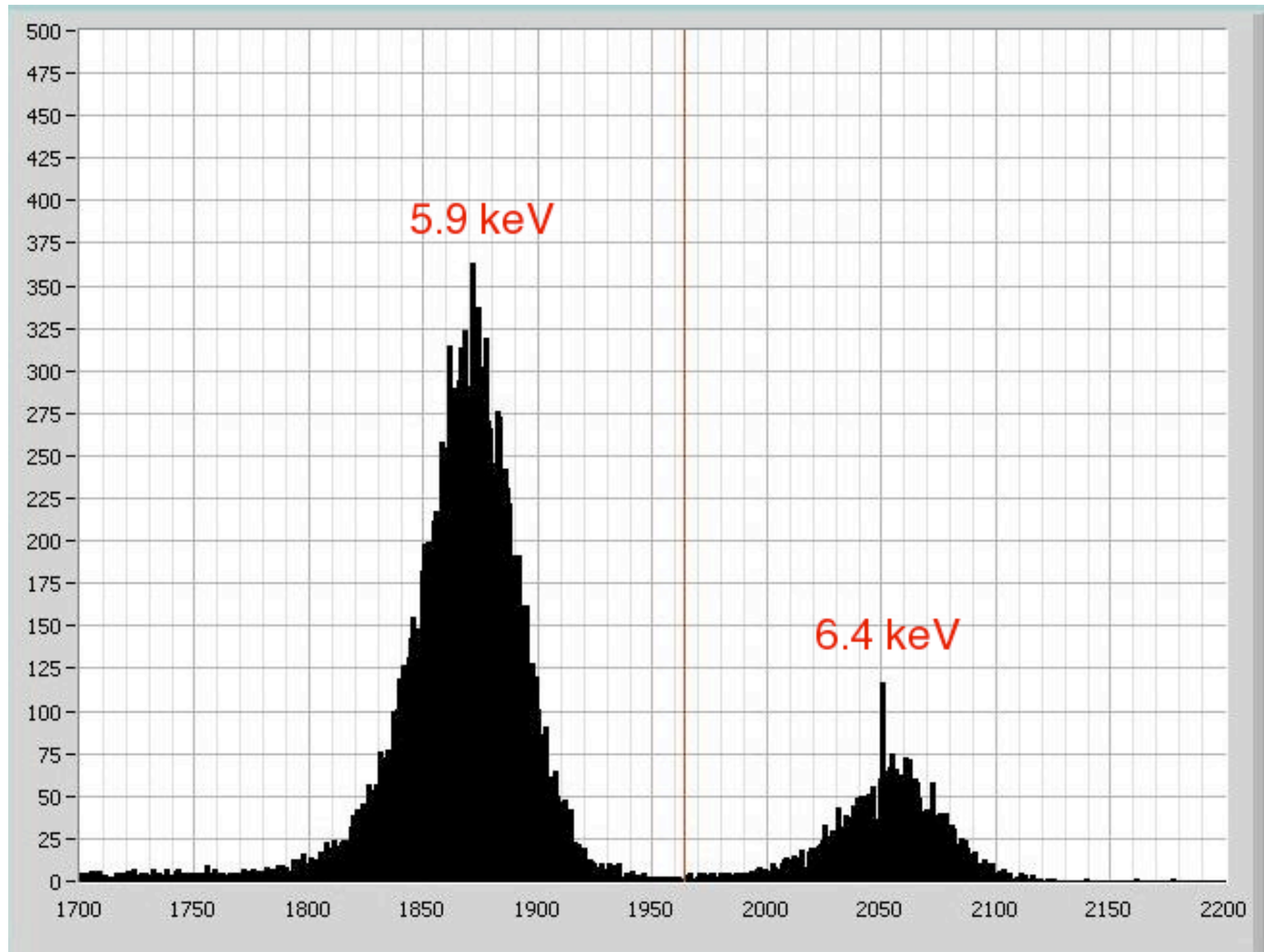
0.3 – 8 keV
 $A_{\text{eff}} \sim 200 \text{ cm}^2 @ 1 \text{ keV}$
 $E/\Delta E \sim 20 \text{ to } 50$

FOV $\sim 40 \text{ arcmin}$

resolution $\sim 3 \text{ arcmin}$

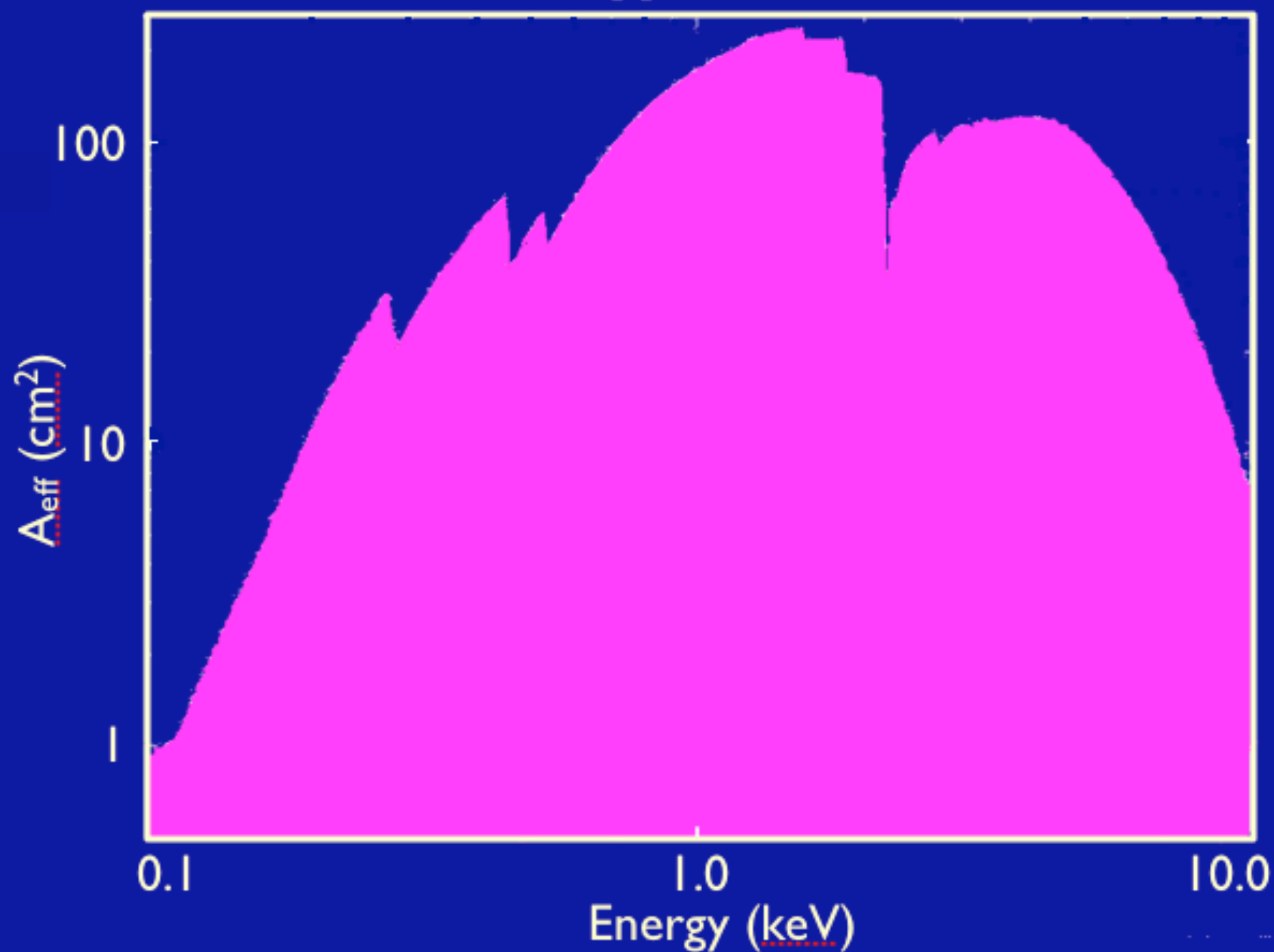


Mirrors: Nested & Segmented conical surfaces in Wolter type I geometry working at Grazing incidence
39 nested shells



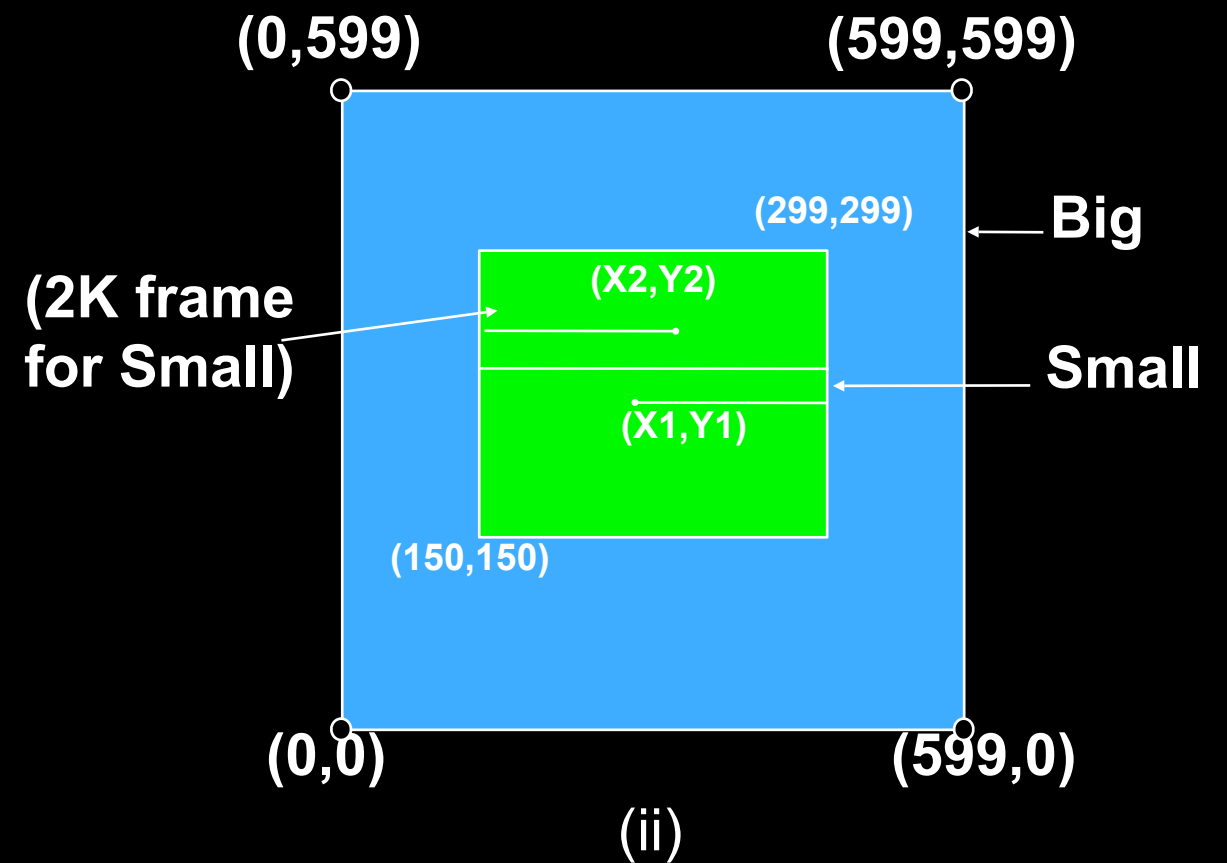
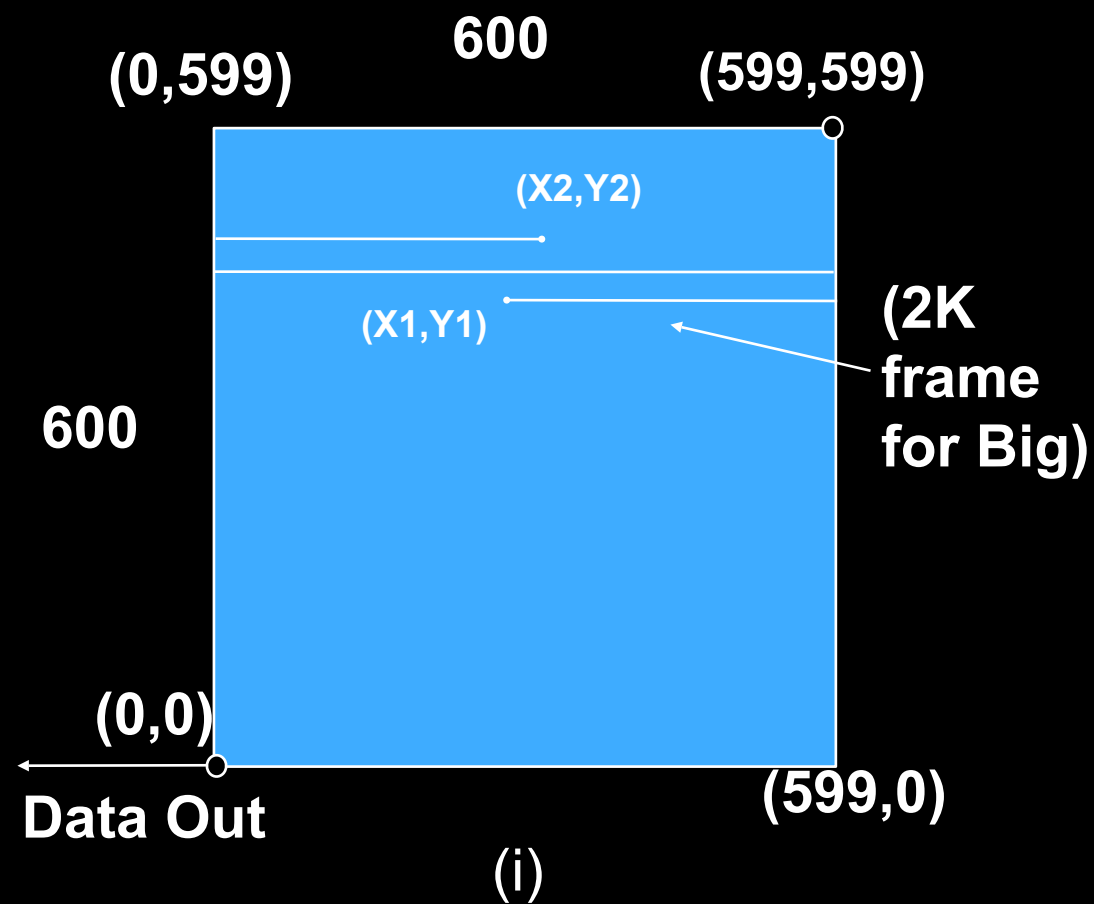
Lab test of CCD energy resolution

SXT Effective Area



Raw Photon Counting Mode

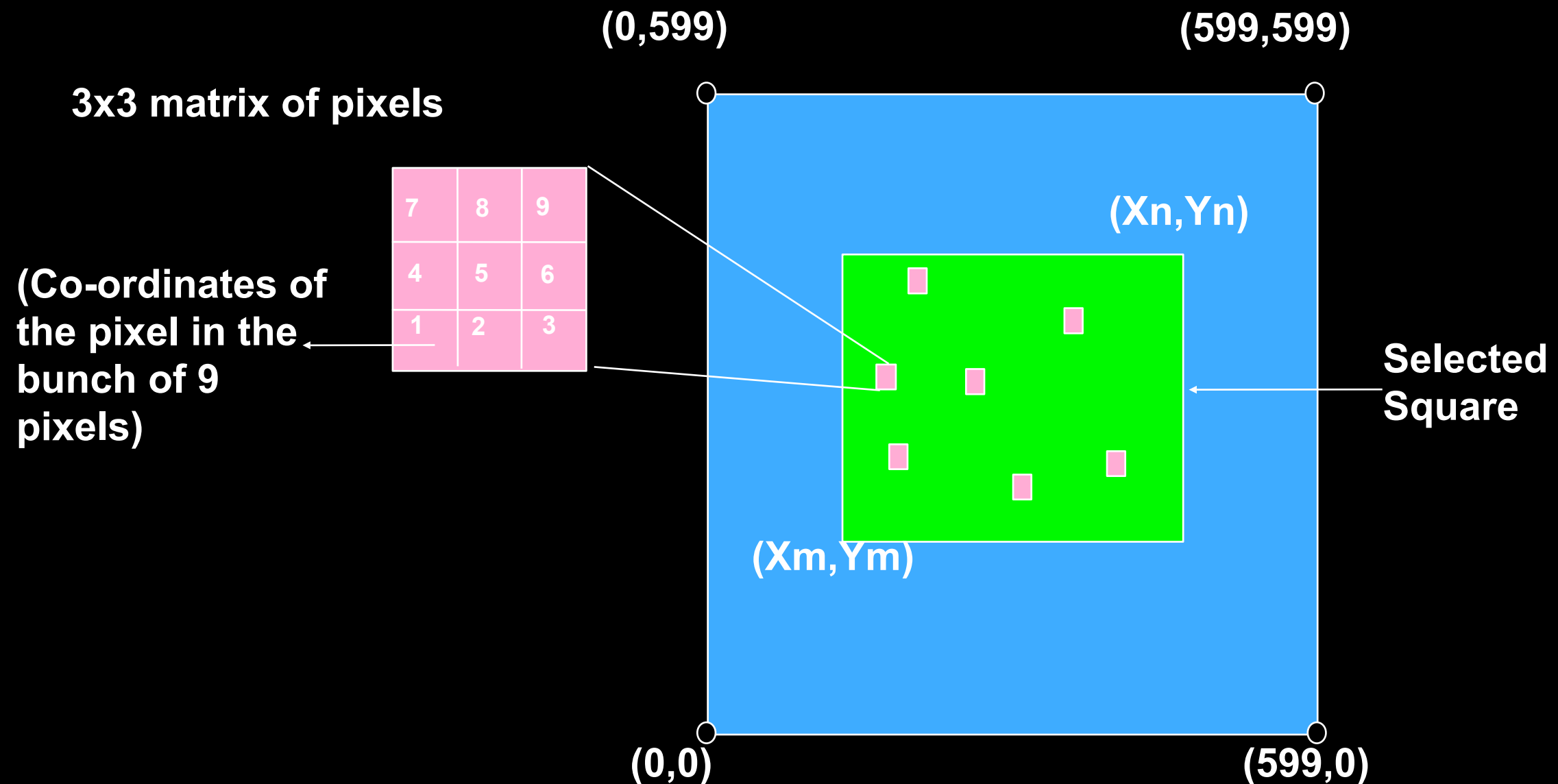
Two selected regions. (Big & Small)



28 big frames and 2472 small frames recorded per 100-min orbit

Thresholded Photon Counting Mode

3x3 matrix for each event is recorded



Astrosat CZTI

Coded Mask Imager

Size 484x484x600mm

Collimators 6x6 deg
CSI veto

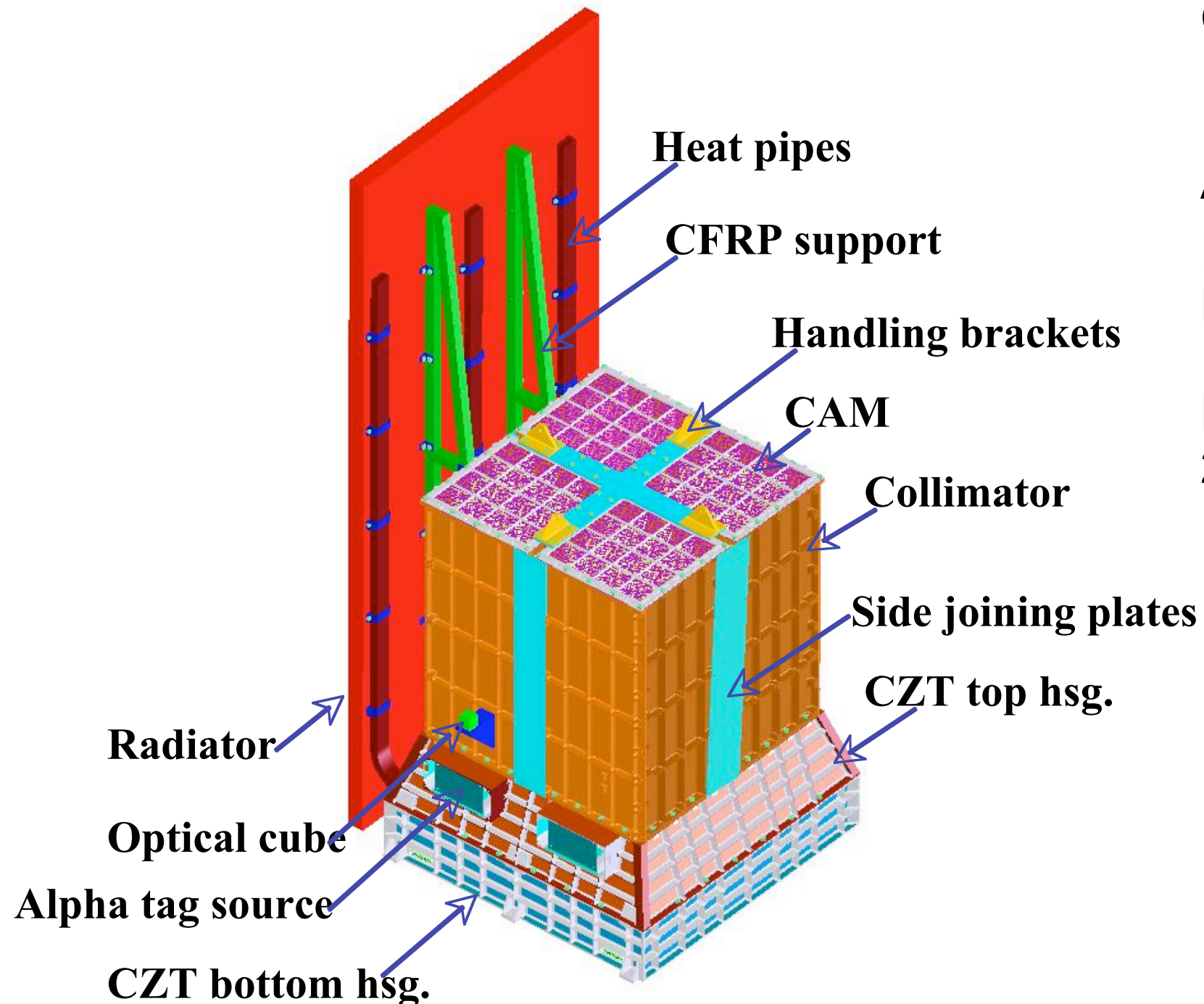
10 – 150 keV

$A_{\text{eff}} \sim 500 \text{ cm}^2$

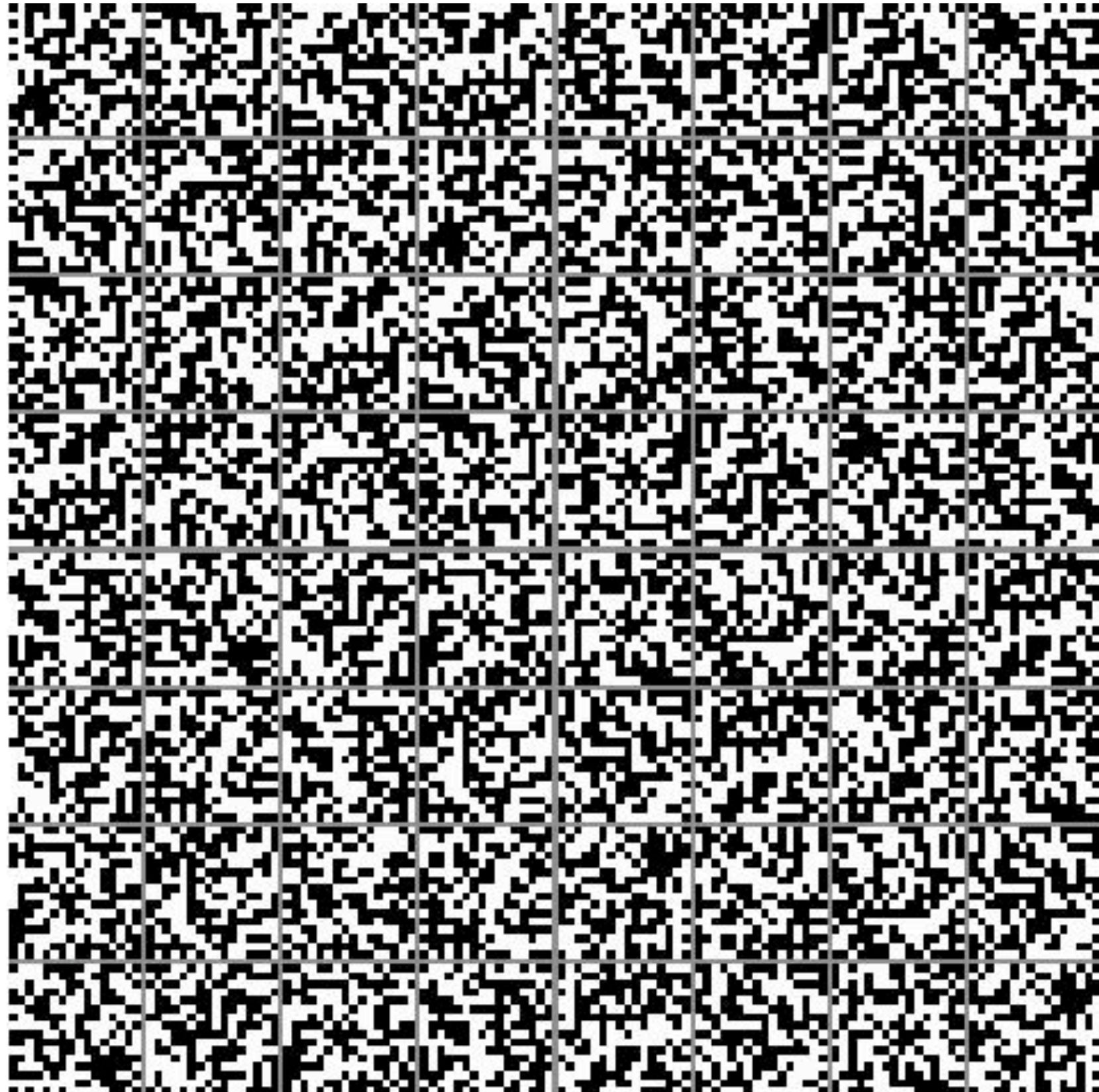
$E/\Delta E \sim 20 \text{ to } 50$

Resolution $\sim 8 \text{ arcmin}$

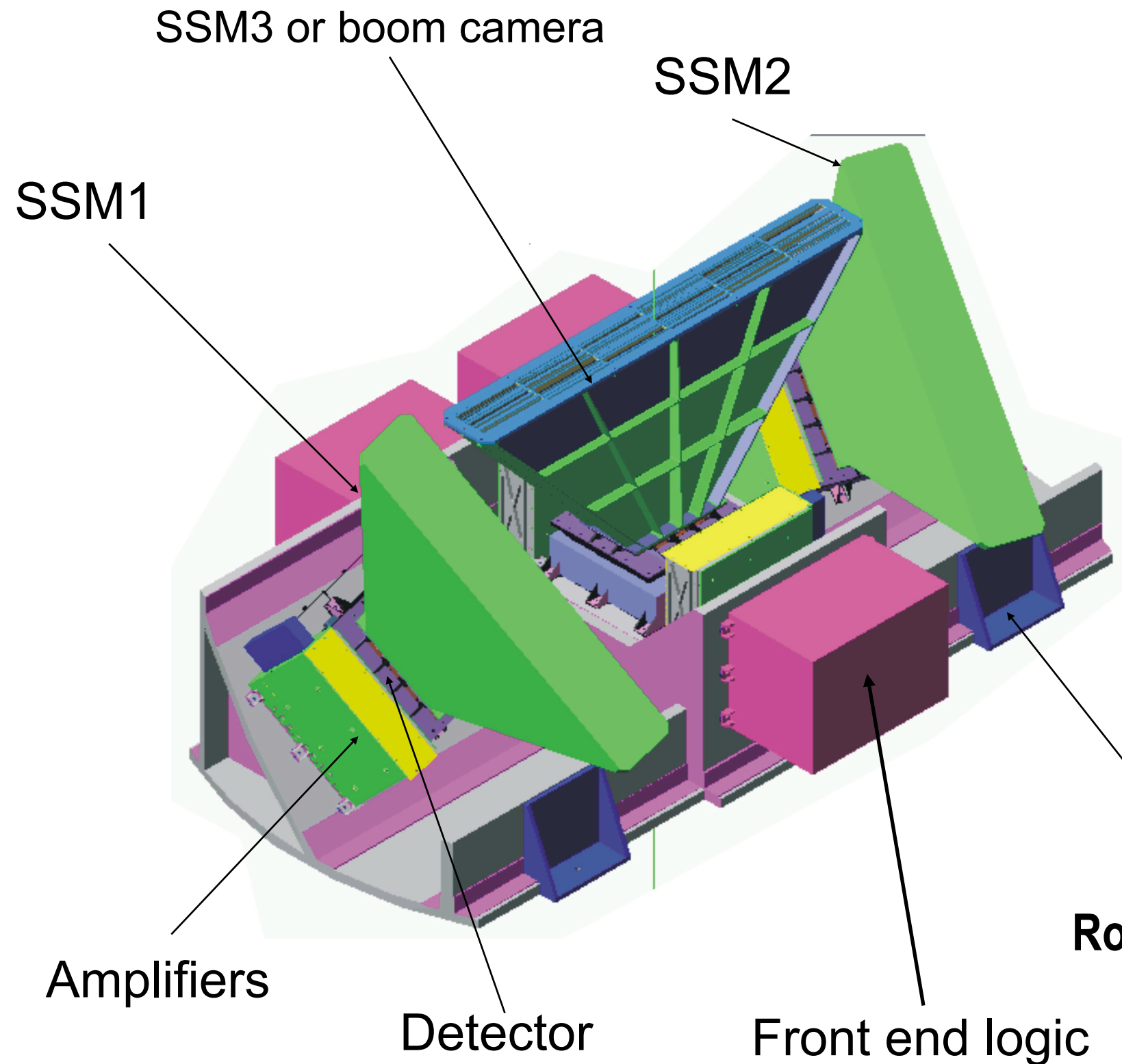
Recording: event mode
20 microsec time tag



ASTROSAT CZTI Mask



Scanning Sky Monitor (SSM)

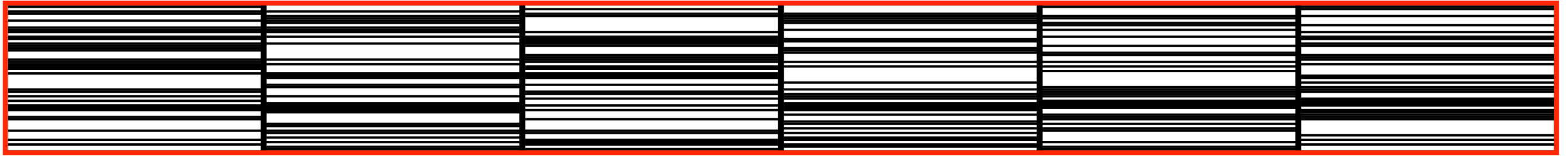


3 PSPCs with
1-d Coded Mask
2 – 10 keV, $A_{\text{eff}} \sim 80 \text{ cm}^2$
FOV $90^\circ \times 13^\circ$ each, resolu
 $\sim 10 \text{ arcmin}$

Rotation axis || yaw

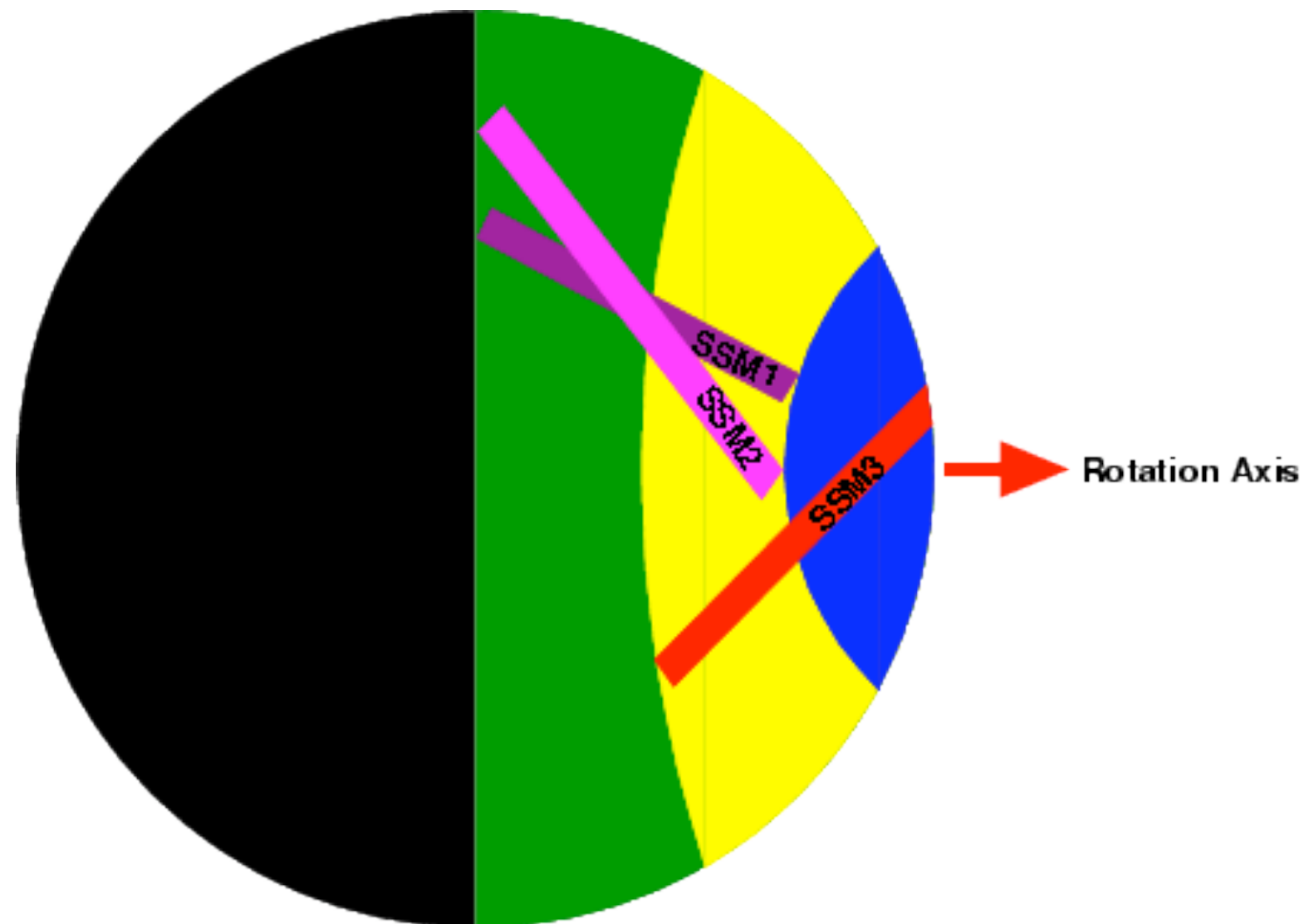
Dwell: 5 min or
continuous rotation.
No rotation if roll axis
pointing duration is $< 10 \text{ min}$

Sensitivity $\sim 30 \text{ mCrab}$



Coded Mask Pattern of Scanning Sky Monitor on ASTROSAT

ASTROSAT SSM Sky Coverage

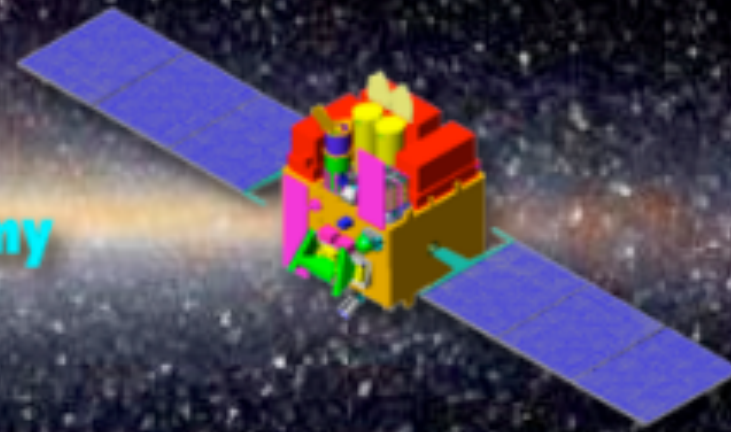


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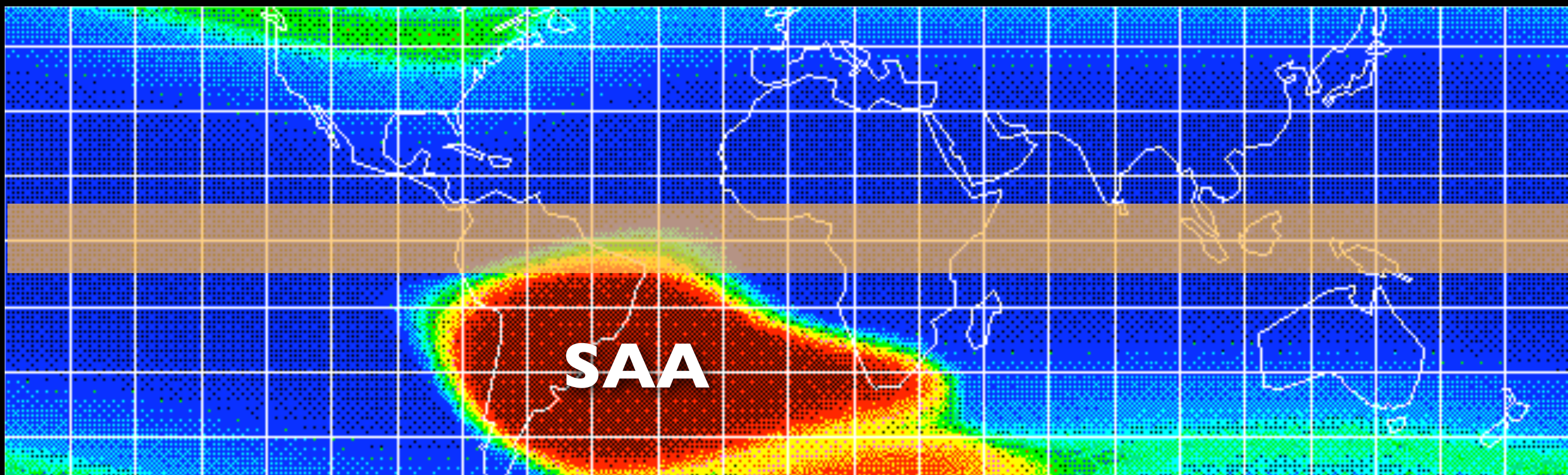
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South Atlantic Anomaly and ASTROSAT orbital trace

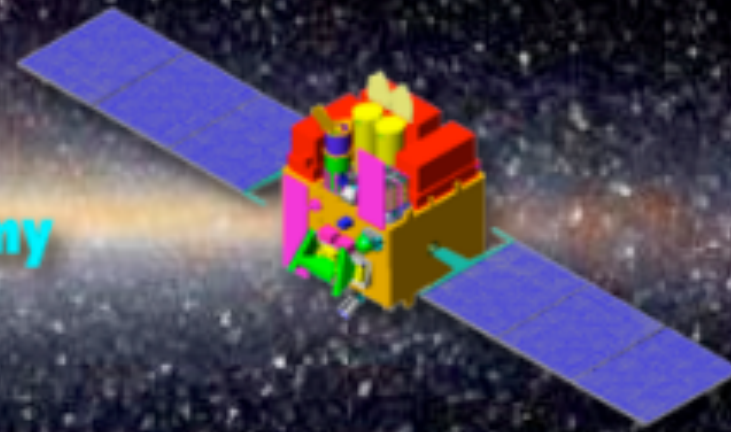


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ASTROSAT Key Niche

- X-ray timing: Only mission with high resolution timing capability immediately after RXTE
- Simultaneous multiwavelength variability: UV-X ray correlation
- Sensitive hard X-ray spectroscopy: e.g. Cyclotron lines
- Wideband spectrum: UV, 0.3-150 keV
- UV imaging

ASTROSAT will be an observatory class mission, driven by proposals received from the user community

ASTROSAT SCIENCE INSTRUMENTS

	Energy range	Description	Angular resolution	sensitivity
SXT	0.3 – 8 keV	Focussing X-ray mirror + CCD (39 shells) FOV=42'	3 – 4 arcmin	~0.01milliCrab (10,000 sec)
LAXPC	2 – 80 keV	Large proportional counters (3)	~5arcmin (scan mode)	0.1 milliCrab (1000 sec)
CZT-imager	10 – 150 keV	CZT array (hard X-ray imager)	8 arcmin	0.5 milliCrab (1000 sec)
SSM	2 – 10 keV	All sky monitor (3) on a boom	5 – 10 arcmin	50 milliCrab (300 sec)
UVIT	1300 – 6500 Ang	Twin RC telescopes – 40 cm each (NUV,VIS, FUV)	1.8 arc sec	21 magnitude (1800 sec)

ASTROSAT time allocation policy

T0 +	1st yr	2nd yr	3rd yr	4th yr
Instrument teams	6m - PV 6m - GT	50%	30%	-
CSA		5%	5%	5%
Leicester		3%	3%	3%
Open IND	-	35%	45%	65%
Open Intl	-	-	10%	20%
TOO	-	5%	5%	5%
Calib	-	2%	2%	2%