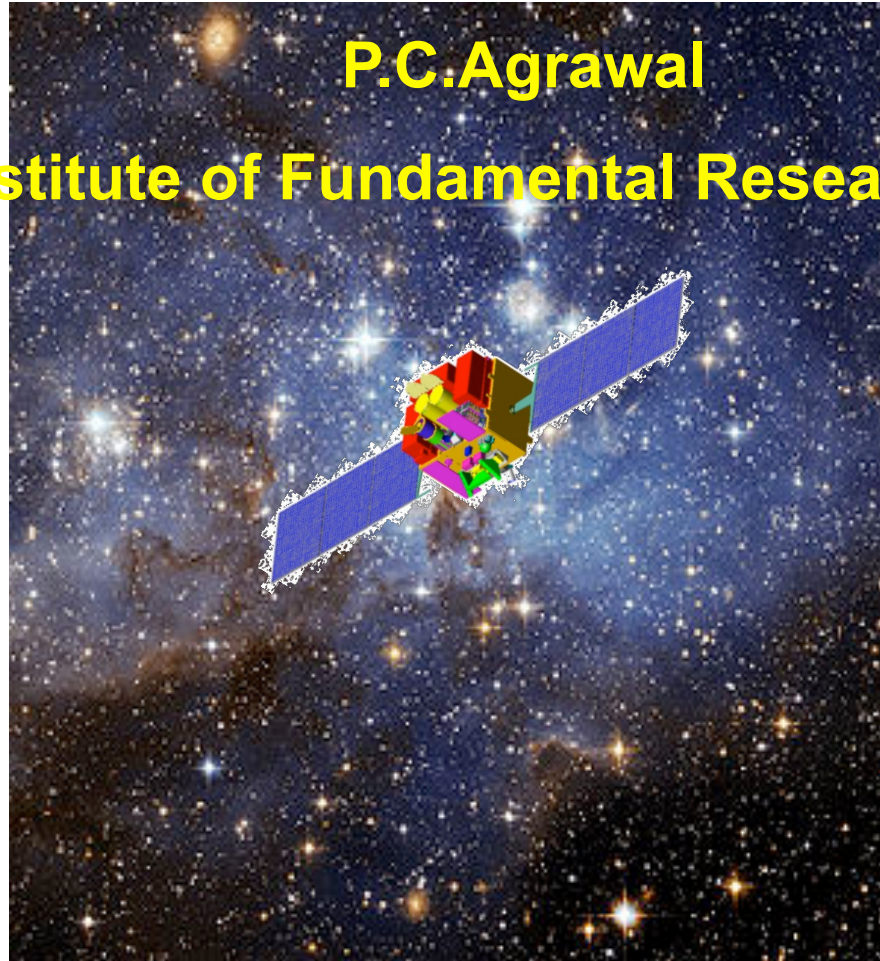


# An Overview of Astrosat

P.C.Agrawal

Tata Institute of Fundamental Research, Mumbai



Talk at IUCAA , Pune , January 13 , 2011

# **ASTROSAT : A Broad Spectral Band Indian Astronomy Satellite**

## **An Indian National Space Observatory**

A Collaborative Project of

**Tata Institute of Fundamental Research (TIFR), Mumbai**

**ISRO Satellite Centre (ISAC), Bangalore**

**Indian Institute of Astrophysics (IIA), Bangalore**

**Inter-University Centre for Astronomy & Astrophysics, Pune.**

**Raman Research Institute, Bangalore**

**Canadian Space Agency, Canada**

**Leicester University, U.K.**

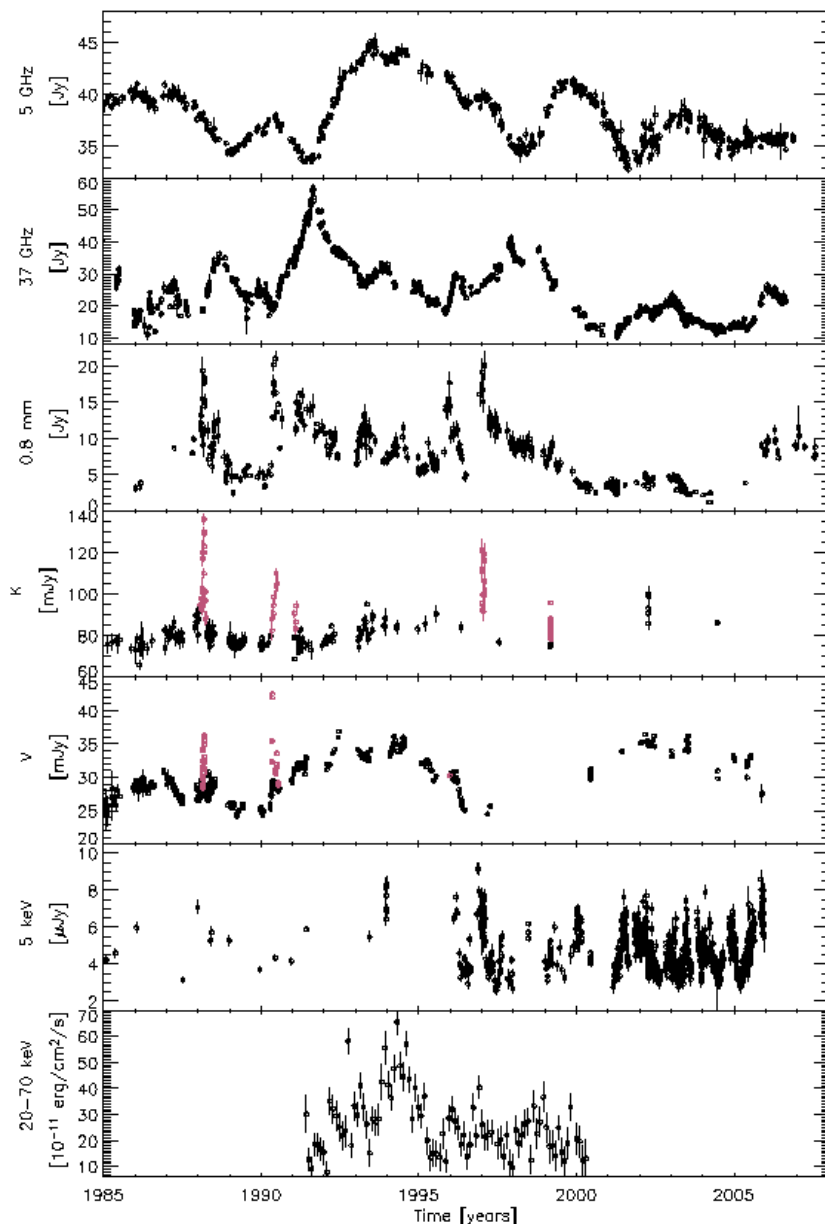
With participation of

**Many Indian Universities and research centres**

## **Salient Features of Astrosat**

- **Multi-wavelength observation capability with four co-aligned instruments covering Visible, Near-UV, Far-UV, Soft X-ray and Hard X-ray bands.**
- **Broad Spectral coverage in X-rays from 0.5 keV to 100 keV for timing and spectral studies with 3 X-ray instruments.**
- **Large collecting area in 2-20 keV (  $\geq 6000$  cm sq. ) for timing studies in X-rays.**
- **Largest area detector for hard X-ray studies (  $\sim 5000$  cm sq. at 50 keV ), important for studying high frequency QPOs and non-thermal component in Black Hole sources.**
-

# Light Curves of quasar 3C 273 over 20 year period in different spectral bands



**Fig. 2.** Examples of light curves from the 3C 273 database for the last 23 years of observations, at 5 GHz, 37 GHz, 0.8 mm, in the K band, in the V band, at 5 keV and in the 20–70 keV range (this latter rebinned to 1-month bins).

The data during strong synchrotron flares (Flag = 1) are indicated in grey (red in the electronic version) for the optical and IR data sets.

( From S. Soldi et al. A&A, 486, 411-425,2008 )

- **High angular resolution telescopes (  $\sim 2$  arc sec ) in the UV region. Two telescopes each of 38 cm aperture, one in Visible and Near-UV and other in Far-UV with photon counting detectors for high sensitivity observations.**
- **Soft X-ray Imaging Telescope and CZT Imager for medium energy resolution spectral studies and localization of Transients in soft and hard X-ray bands.**
- **A Scanning Sky X-ray Monitor to detect and monitor Transients and known objects.**
- **High time resolution (10  $\mu$ s ) and high count rate capability ( 25 k Counts with PHA and 40 k Counts without PHA ) with LAXPC instrument.**
- **Stable and lower background due to equatorial orbit (  $i < 8$  degree )**



**Ultraviolet image of Galaxy M 33 with Galex. Credit:  
NASA/JPL-Caltech/GALEX**

# **Astrosat Science Objectives**

## **Multiwavelength Observations**

- **ASTROSAT will be a powerful mission for Multiwavelength studies of various types of sources using 5 co-aligned telescopes covering broad X-ray , near- UV , far- UV and Optical bands.**
- **AGNs, Xray Binaries and CVs will be prime targets for this as only a small number of bright AGNs and other objects studied in campaign mode so far.**
- **Correlated UV , Optical and X-ray variations , measure time lags and do reverberation mapping.**
- **Construct energy distribution curves of AGNs over 5 decades in energy**

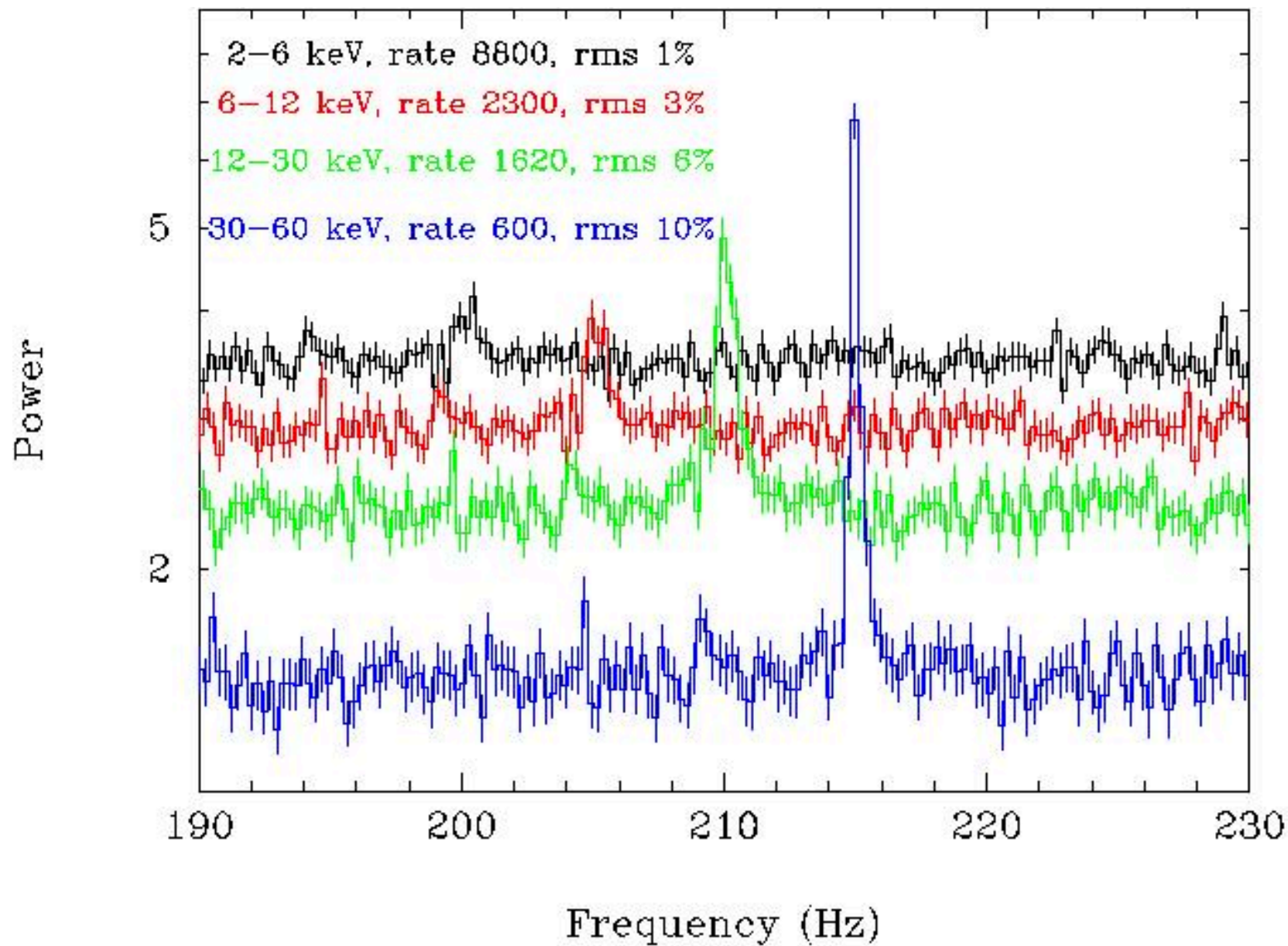
# **Astrosat Science Goals**

## **High resolution timing studies :**

- **Periodic and chaotic variability, Evolution of pulse and orbital periods in X-ray binaries, Accreting Millisec Pulsars and AXPs.**
- **Detection and measurements of of low and high frequency QPOs in soft and hard X-ray bands in Black Hole and other X-ray Binaries .**

**High Freq. QPOs studies put constraints on mass and spin of Black Holes.**

- **Detection of QPOs above 10 keV in Black Hole and Neutron star binaries is an unexplored area. QPOs above 10 keV detected so far only in 3 BH Binaries. kHz QPOs above 10 keV reported so far only in GRO J1655-40.**
- **Do AGNs show Bimodal states similar to that of Stellar- mass Black Holes ? Repeated observations of AGNs required to answer this.**
- **Search QPOs in AGNs. Reports of a few detections so far.**



# **Astrosat Science Goals**

## **Broad band Spectral measurements :**

**Spectra of the continuum emission from all classes of UV and X-ray sources**

- Emission and absorption features with medium energy resolution capability in 0.3 – 100 keV spectral band with 3 co-aligned X-ray instruments.**
- Understand the Complex Multi-component energy Spectra of galactic and extragalactic Black Hole sources to understand the origin of radiation from various processes.**
- Measuring non-thermal spectral component in Accreting NS and BH Binaries, SNRs and AGNs**

# Astrosat Science Goals

- **Measure Magnetic Field of Neutron Stars in X-ray Binaries**

From detection and energy of Cyclotron lines in the X-ray spectra of Pulsars. Cyclotron absorption lines in  $\sim 12 - 60$  keV detected in the X-ray spectra of  $\sim 20$  X-ray Pulsars

$$B \sim (2-8) \cdot 10^{12} \text{ Gauss}$$

- **High resolution ( $\leq 2$  arc sec ) UV imaging** studies of Star Burst Galaxies, Normal Galaxies ,AGNs, Hot stars, SNRs etc.
- **Deep UV survey of selected regions of sky**
- **X-ray scans of Galactic Plane and Center** for detection of new transients and other variable sources
- **X-ray Monitoring of Sky** for detection of Transients, Bursts and Flaring activity and studies of persistent sources

# Astrosat Instruments

## Four X-ray Astronomy Instruments and one Ultraviolet Instrument with two Telescopes

- 1. LAXPC :** Large Area X-ray Proportional Counters with  $A_{\text{eff}} \approx 6000 \text{ cm}^2$  at 20 keV, FOV =  $1^\circ \times 1^\circ$ , sensitive in 3-80 keV band with low spectral resolution ( $E/\Delta E \approx 5$  to 12) .
- 2. CZT Imager :** X-ray detector CdZnTe (Cadmium-Zinc-Telluride) array with a coded mask aperture having  $A_{\text{eff}} = 500 \text{ cm}^2$  and medium spectral resolution ( $E/\Delta E \approx 15$  to 20).
- 3. SXT :** Soft X-ray Imaging Telescope using conical-foil mirrors with medium angular ( $\sim 3'$ ) and spectral ( $E/\Delta E \approx 20$  to 40) resolution in 0.3-8 keV with  $A_{\text{eff}} \approx 200 \text{ cm}^2$  at 1 keV.

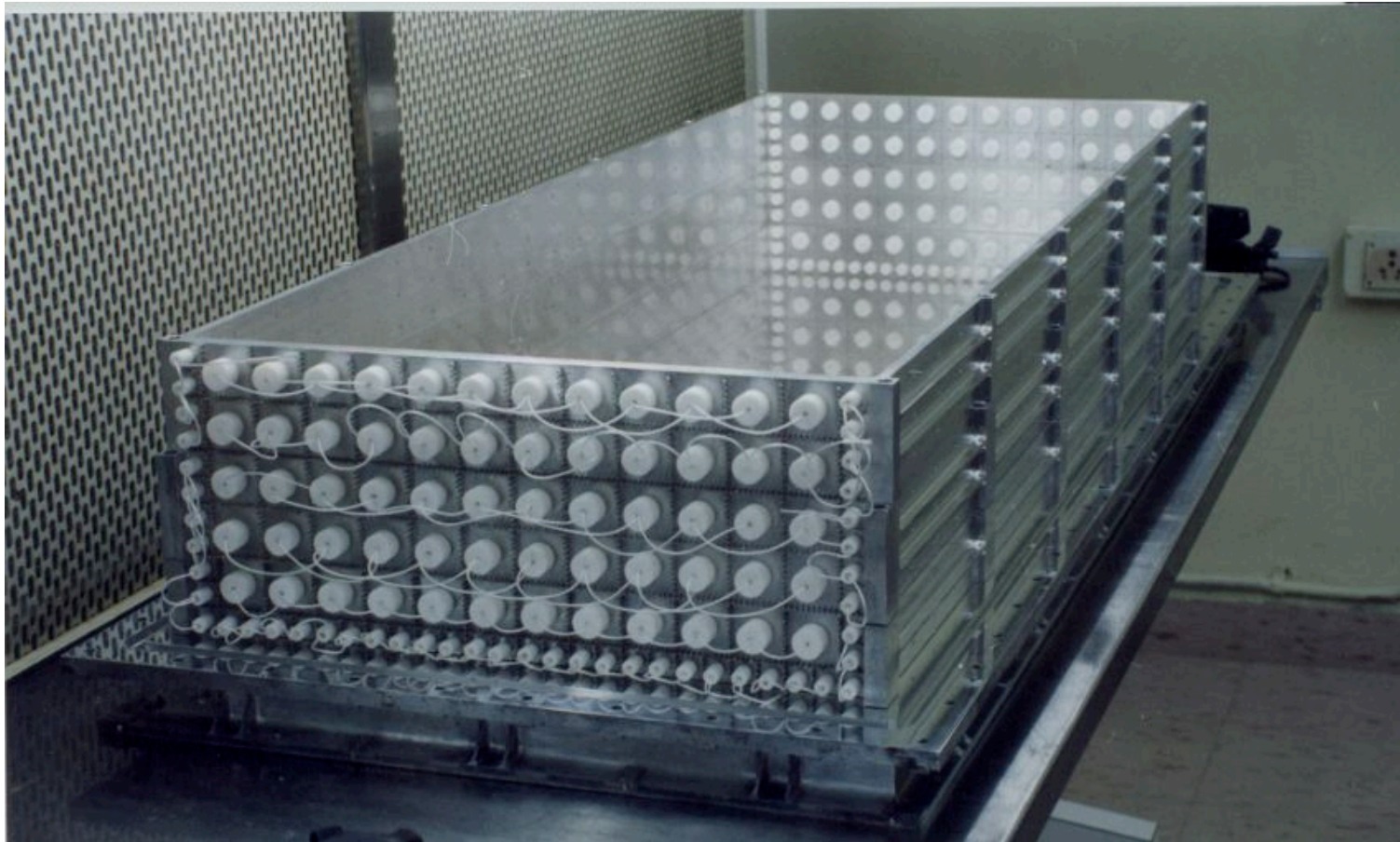
4. **SSM** : Scanning Sky Monitor (SSM) using 3 PSPCs with coded mask aperture , each with  $A_{\text{eff}} = 30 \text{ cm}^2$  and energy band of 2-20 keV.
5. **UVIT** : Ultraviolet Imaging Telescope (UVIT) has two similar telescopes each with 38 cm aperture primary mirror and photon counting imaging detectors covering simultaneously near-uv , far-uv and visible bands.

**A Charged Particle Monitor (CPM) as an auxiliary instrument for the control and operation of the Astrosat Instruments.**

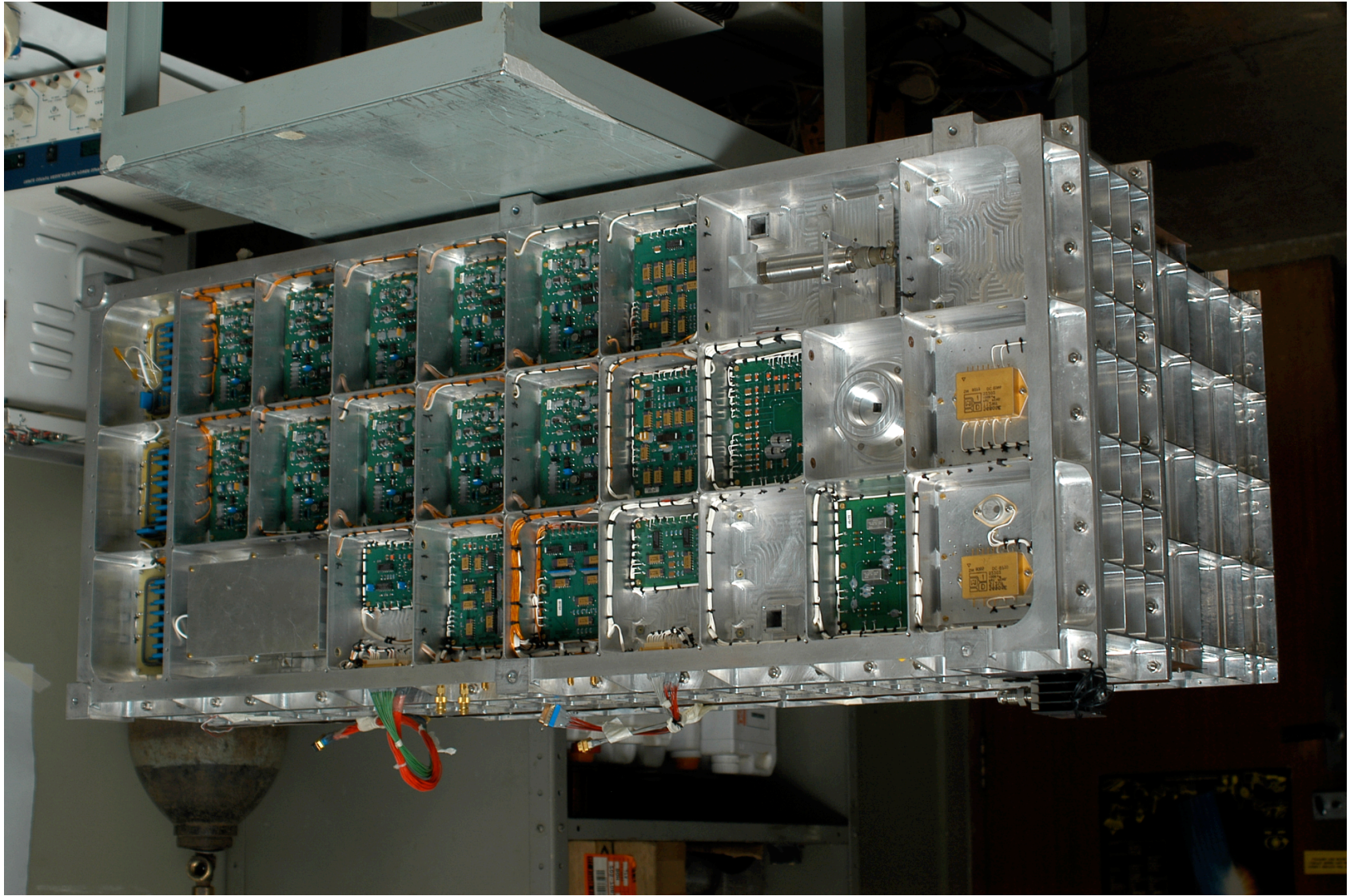
# LAXPC Instrument Characteristics

|   |   |  |
|---|---|--|
| Energy Range  | : | 3-80 keV   |
| Detector Gas  | : | Xenon (90% + Methane 10% ) at 1520 torr              |
| Effective Area  | : | > 6000 cm <sup>2</sup> (2-20 keV) , ~ 5000 at 50 keV |
| Energy Resolution   | : | About 10% FWHM at 22 keV                             |
| The purity of xenon gas is important for the energy resolution and its maintenance. |   |  |
| Field of View   | : | 1° x 1° FWHM ( ± 20%)                                |
| Timing Accuracy   | : | 10 μsec in time tagged mode                          |
| Life Time   | : | 5 years  |

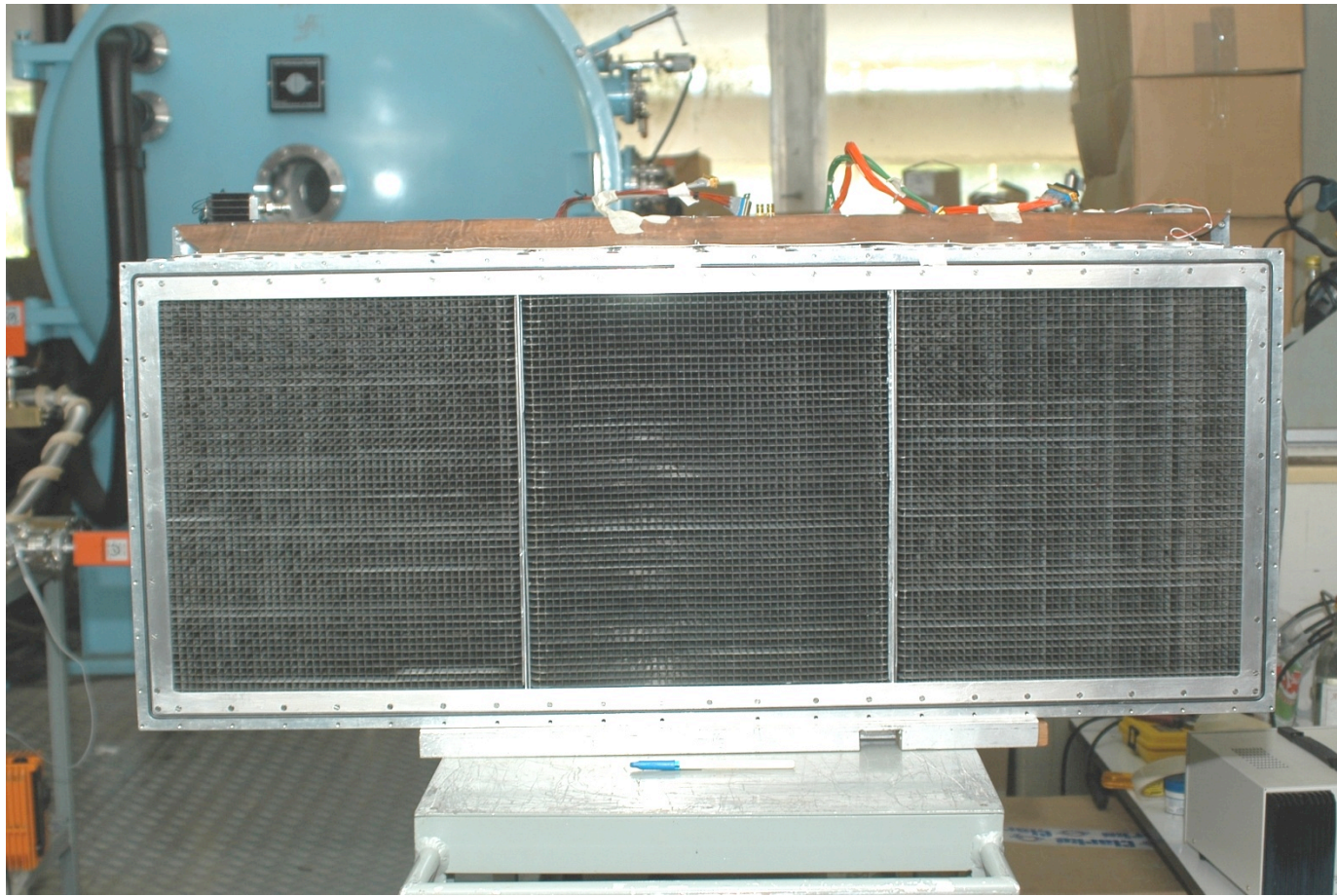
- LAXPC has high detection efficiency up to  $\sim 80$  keV ( $> 50$  % upto 70 keV)
- Deep Detector (15 cm arranged in 5 layers each 3 cm deep vs 3.3 cm for the PCA on RXTE)
- Xenon filled at a pressure of 2 atmosphere



**LAXPC X-ray detector Anode Assembly with veto layer on 3 sides mounted on the back plate. 60 Anode cells are arranged in 5 layers to make the X-ray detection volume. 37 Micron dia. Au-plated SS wires under tension used for anodes.**



**A View of the Assembled E-c-F LAXPC unit**



Light weight FOV Collimator made of 175 micron thick multilayer of Sn + Cu + Al glued by low outgassing epoxy. Slits cut by laser and cross assembled to make honey comb shaped collimator of 1 degree X 1 degree FOV.

**Top View of Assembled LAXPC E-c-F Unit showing FOVC**

# Other Features of LAXPC

- **Gas Purifier with each LAXPC**

Bellow pump driven by a DC motor to circulate Xenon gas through an Oxisorb cartridge to remove molecules of oxygen , water vapour etc to purify the gas and restore energy resolution. Controlled by command.

- **Three independent LAXPC Units**

Each with its own FE , HV and signal processing electronics. Entire unit replaced in case of malfunction before launch.

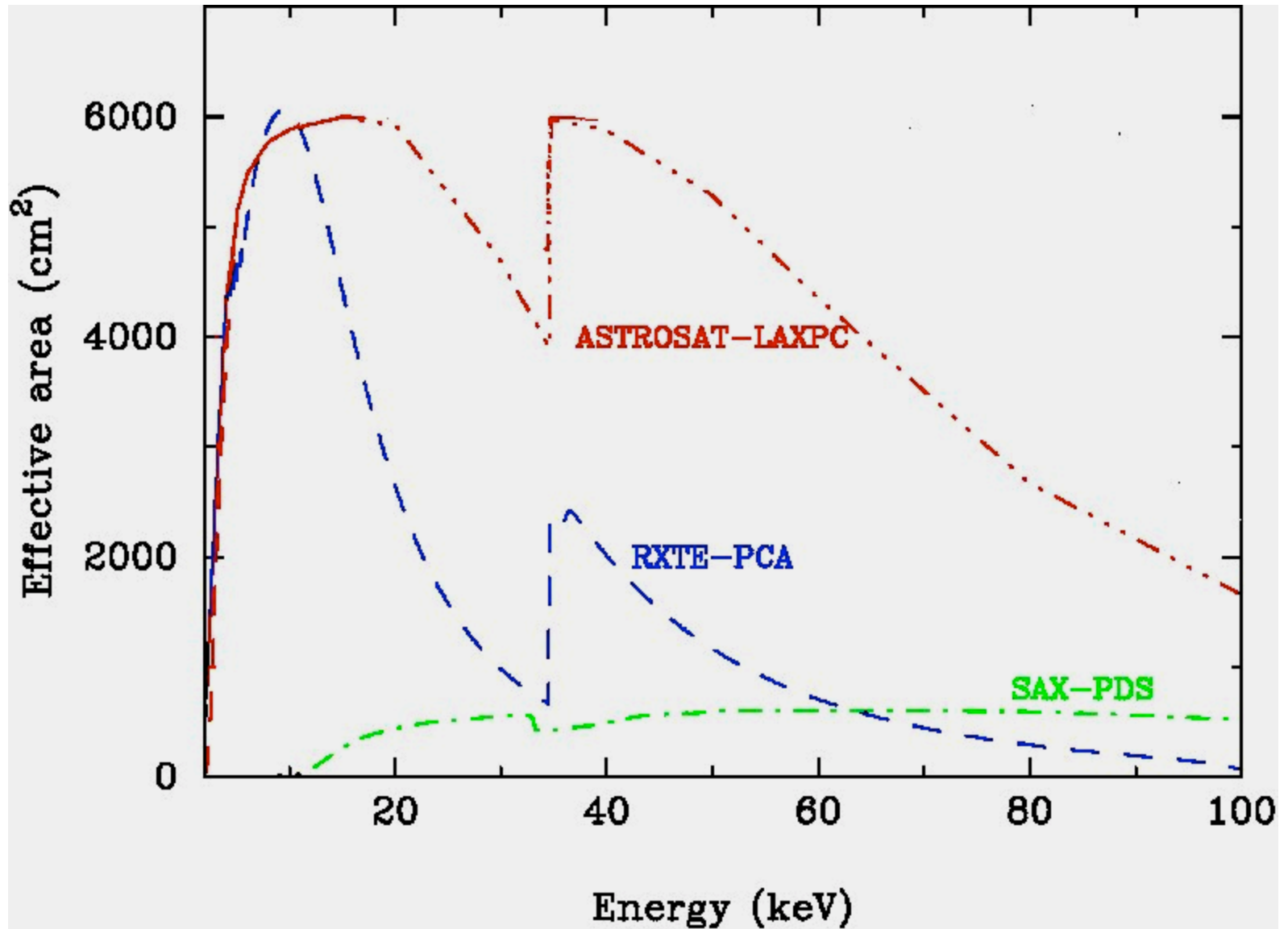
- **Four Modes of operation**

Broad band counting with variable integration time in many energy channels

Onboard pulse height histograms with variable integration time

Time tagging of each photon to 10 microsec accuracy

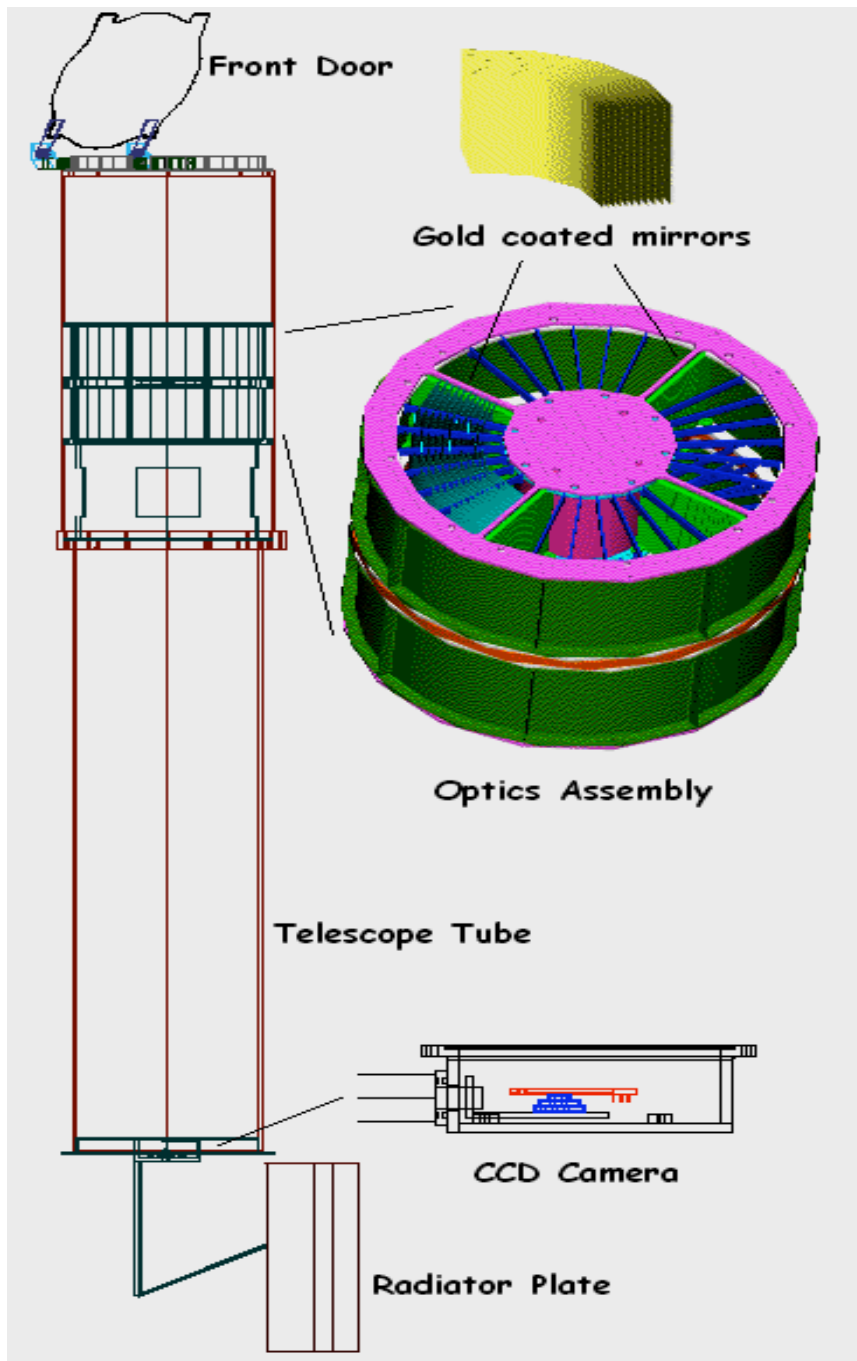
Fast counting mode to handle high counting rates from bursts



**Effective area of LAXPC Instrument as a function of energy**

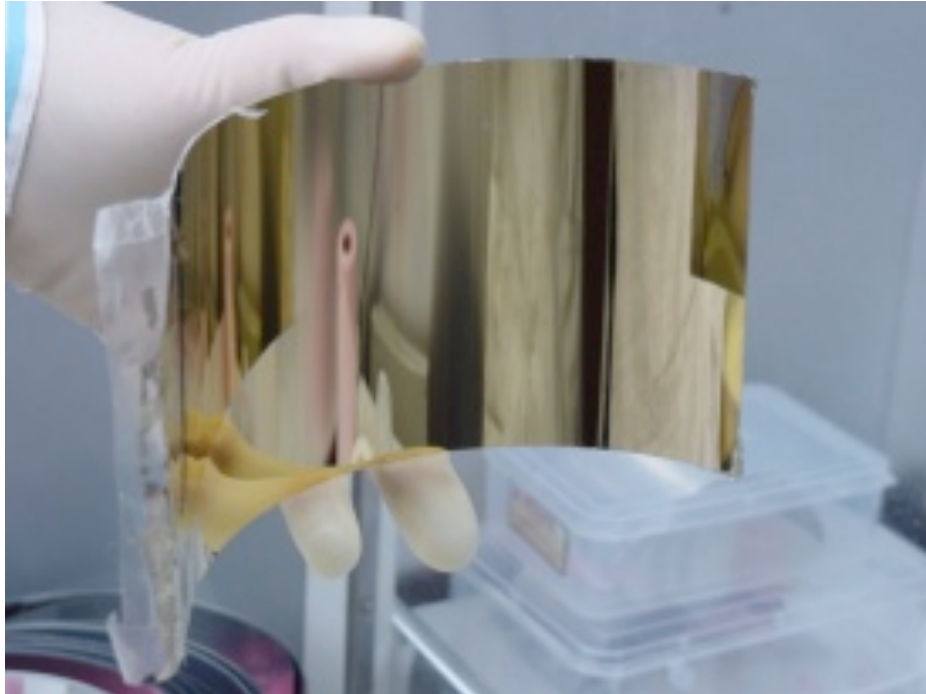
# LAXPC Status

- All the hardware for flight units made and assembled
- LAXPC EM unit successfully vibrated and under thermovac test
- First flight unit assembled, filled with xenon gas and undergoing long duration test
- Second flight unit fully integrated and ready for filling gas
- Third flight unit undergoing integration
- Signal processing electronics of EM tested and ready for use
- All cards for flight units wired and ready for integration in packages
- Plan to deliver all 3 flight detectors to ISRO for the tests and integration with satellite by June 30,2011



**Soft X-ray Imaging Telescope employs X-ray Reflecting Optics and an X-ray CCD to record X-ray Images and measure energy of individual X-ray photons.**

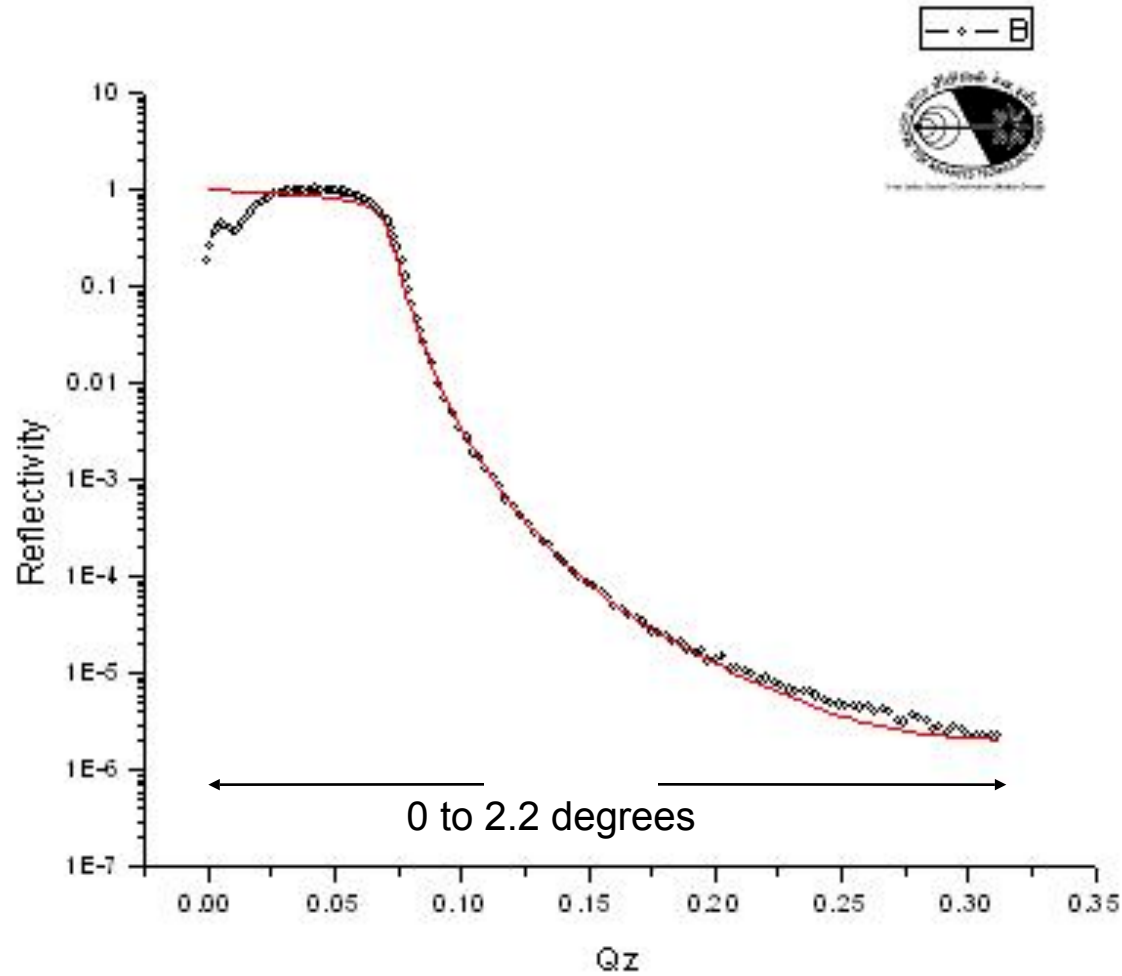
# Manufacture of Mirrors by the Replication technique



## SXT Optics

|                                      |         |
|--------------------------------------|---------|
| Telescope Length:                    | 2465 mm |
| (Telescope + camera + baffle + door) |         |
| Top Envelope Diameter:               | 386 mm  |
| (Max at Middle flange)               |         |
| Focal Length:                        | 2000 mm |
| Maximum radius of foils:             | 130 mm  |
| Minimum radius of foils:             | 65 mm   |
| Reflector Length:                    | 100 mm  |
| Minimum reflector spacing:           | 0.5 mm  |
| Number of nested shells of foils:    |         |
| $40 \times 8 = 320$                  |         |

# Successful X-ray Testing of Foil Mirror at CAT

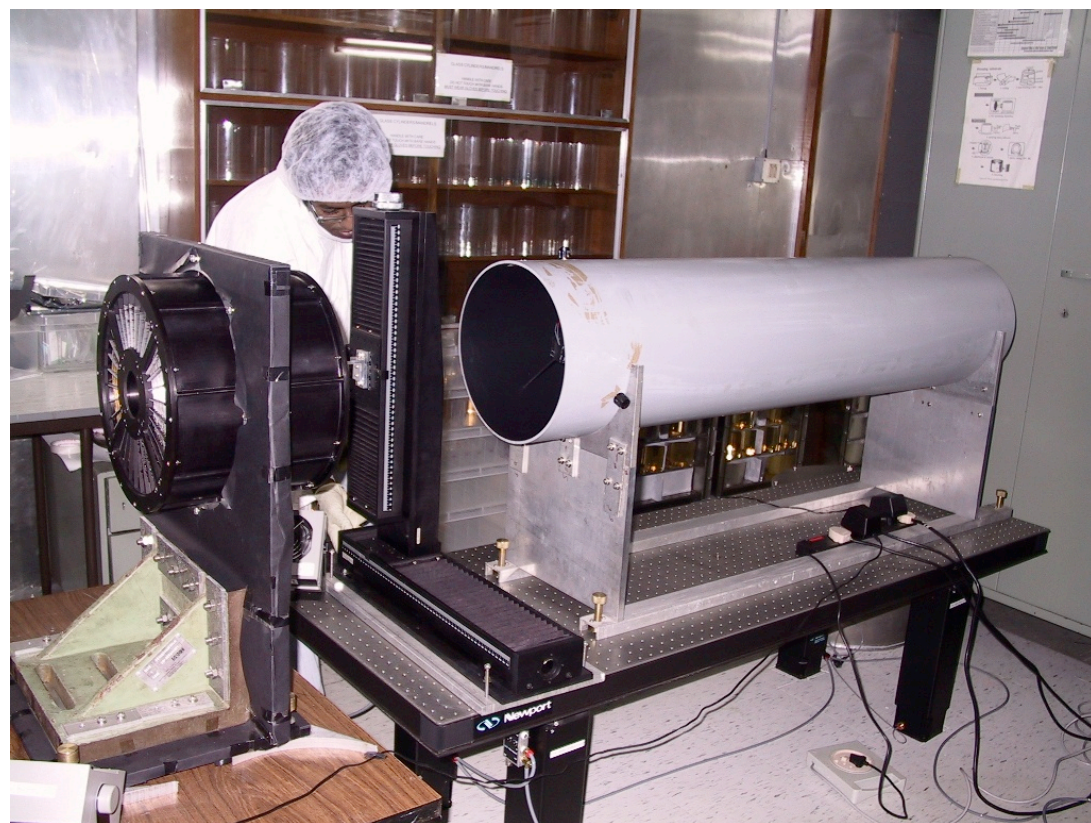


# Design of SXT: Conical Approximation to Wolter I optics

**EQM** – 1 quad fully gold + 18 gold mirrors in other 3 quads.- Qualified with 320 mirrors thru Vibration and Shock tests



**FM** – Fully assembled and scanned with laser and full optical beam

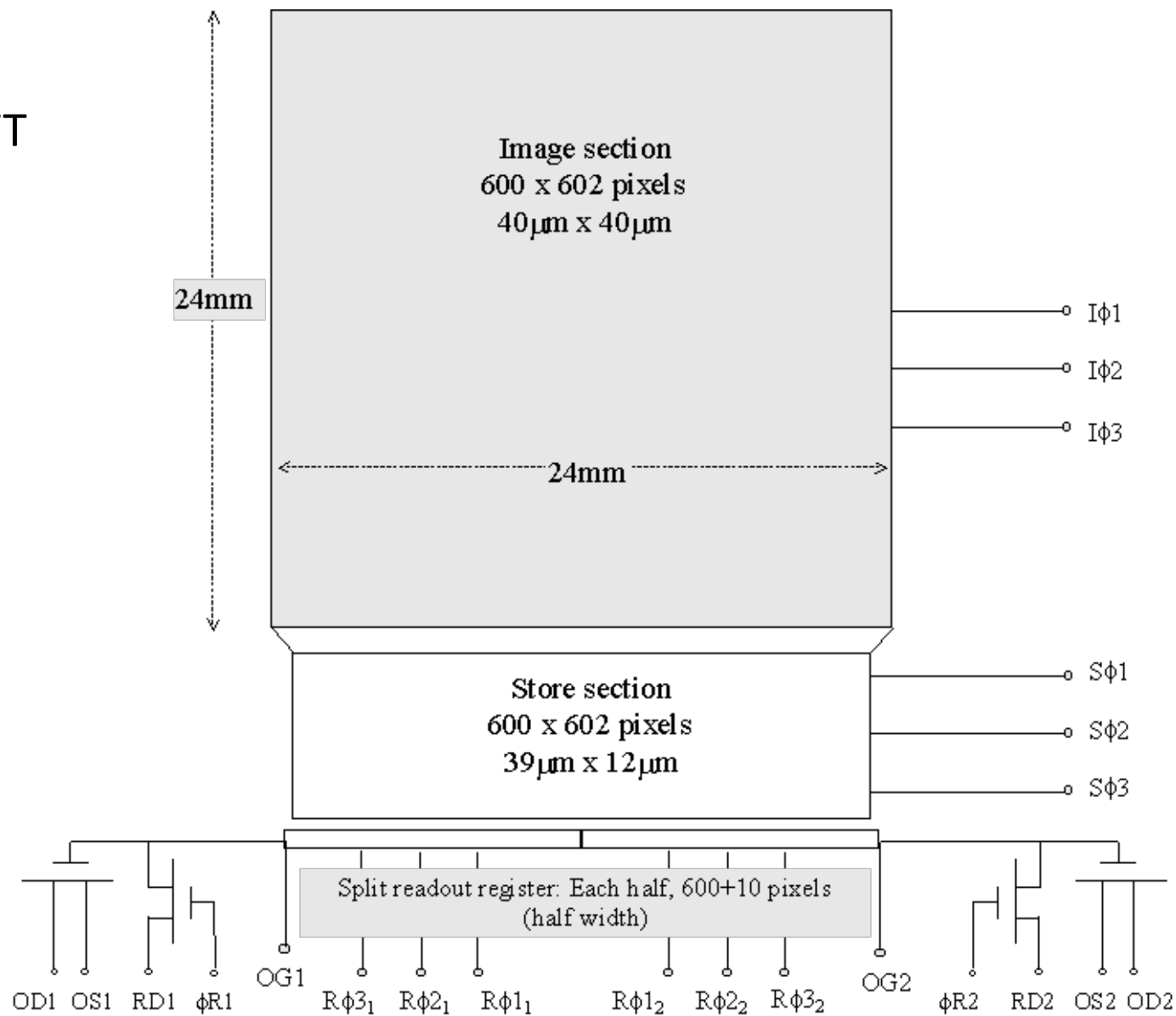


# **MAT CCD22**

L.U.: XMM & SWIFT

# MAT CCD22

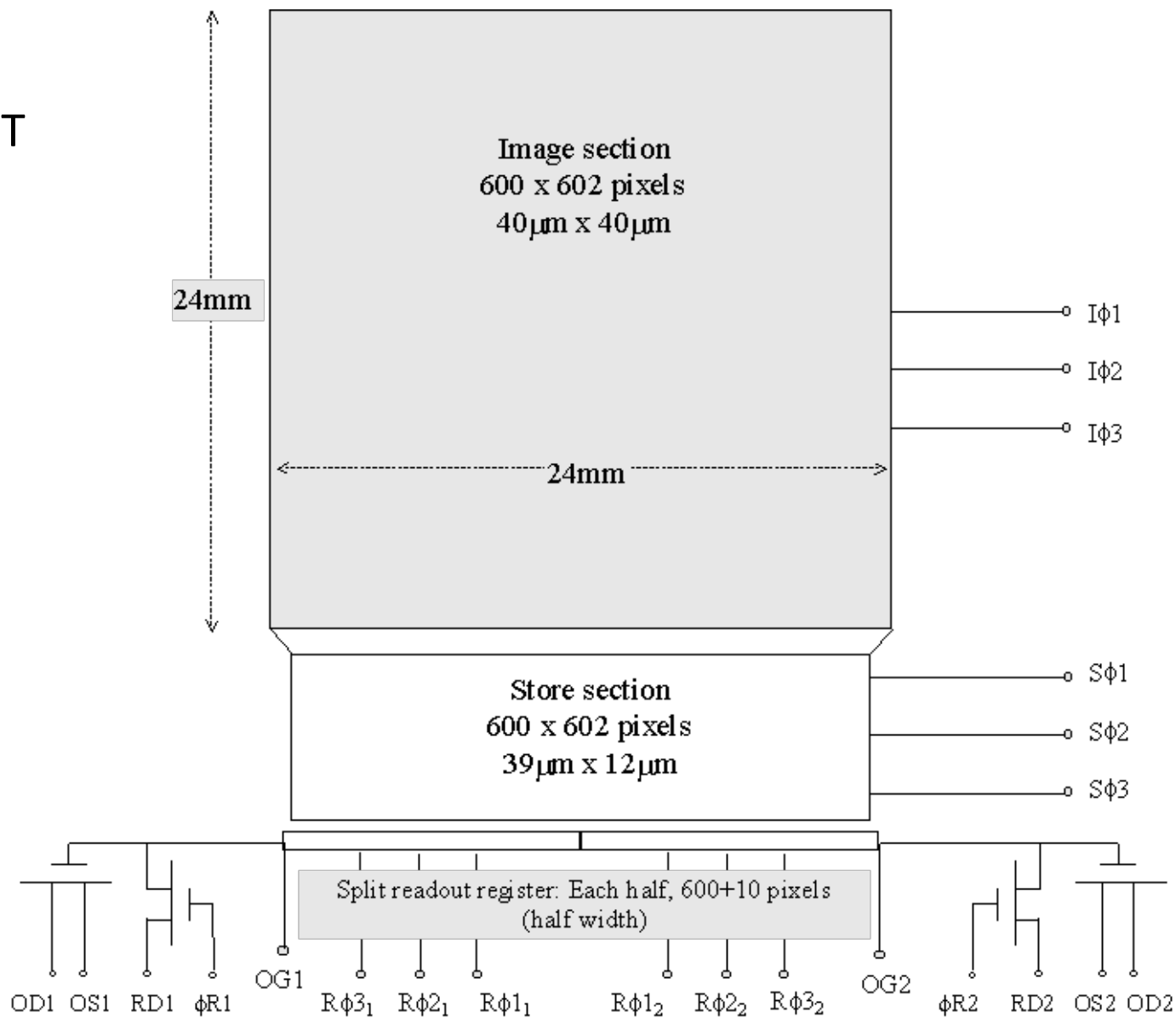
L.U.: XMM & SWIFT



# MAT CCD22

L.U.: XMM & SWIFT

Scale: 4.13 arcsec/pixel.

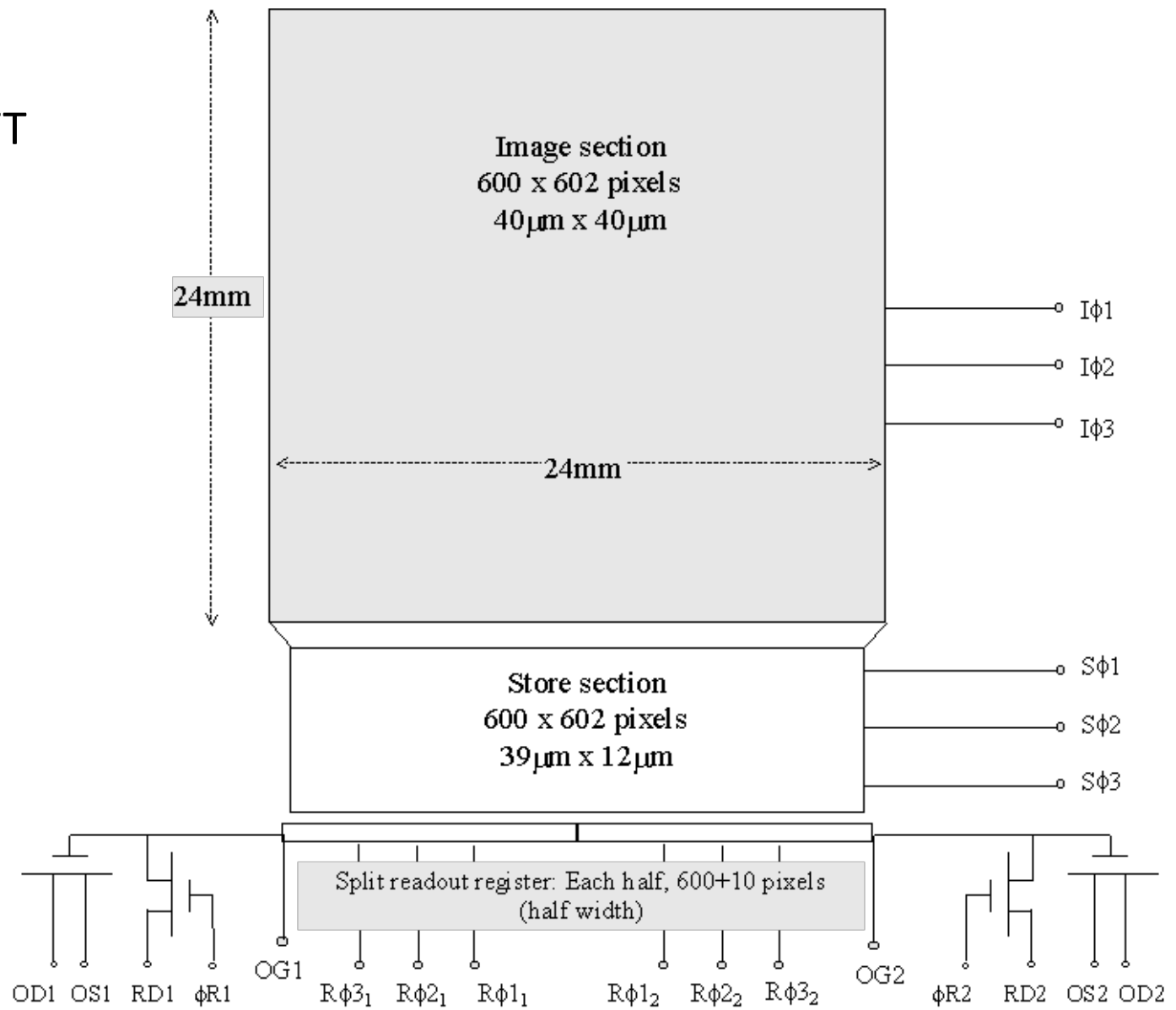


# MAT CCD22

L.U.: XMM & SWIFT

Scale: 4.13 arcsec/pixel.

Field of view = 41.3 arcmin



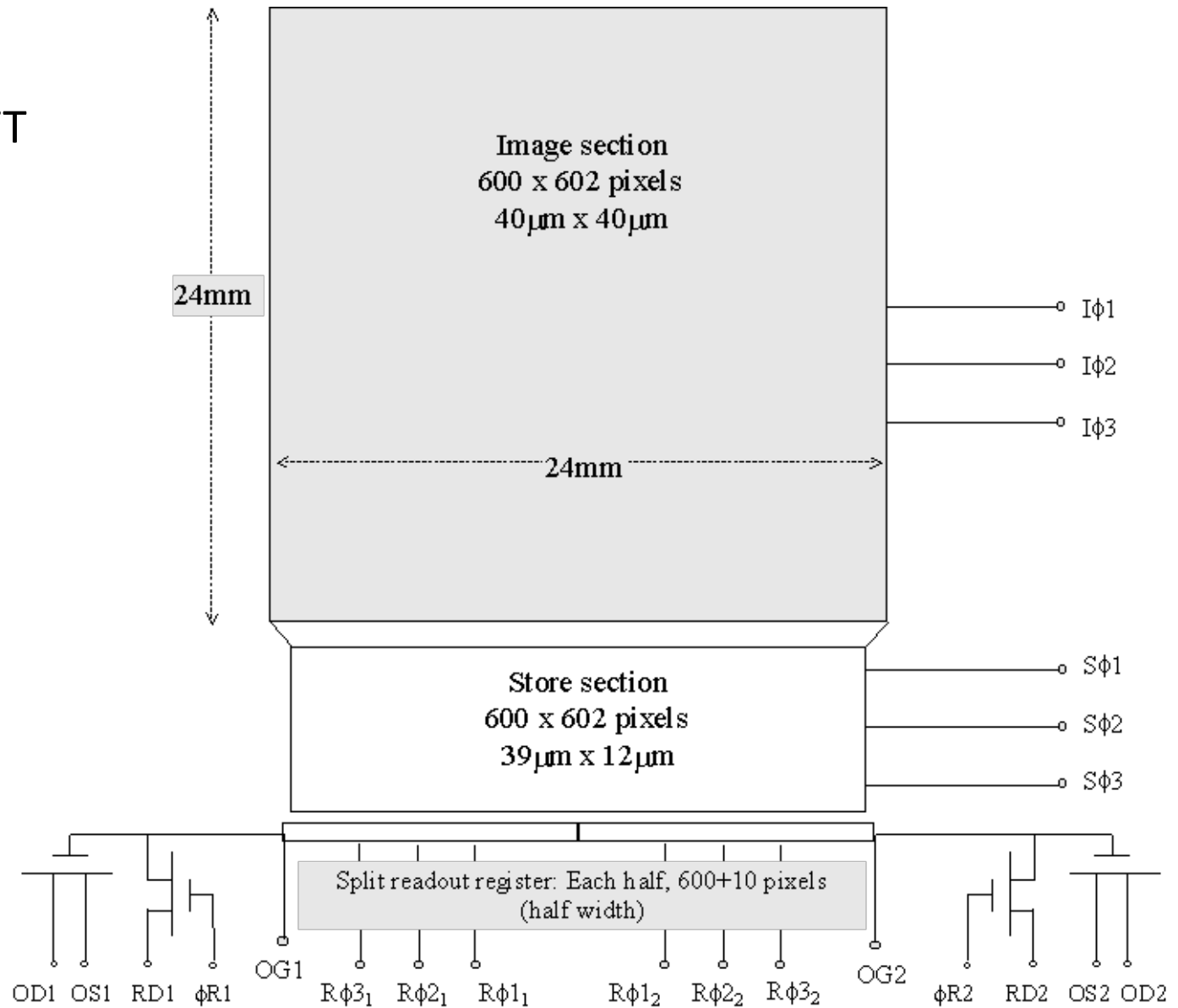
# MAT CCD22

L.U.: XMM & SWIFT

Scale: 4.13 arcsec/pixel.

Field of view = 41.3 arcmin

A novel open gate design  
for better low energy Q.E. +  
a number of radiation  
tolerant-design features for  
a longer life in space.



# MAT CCD22

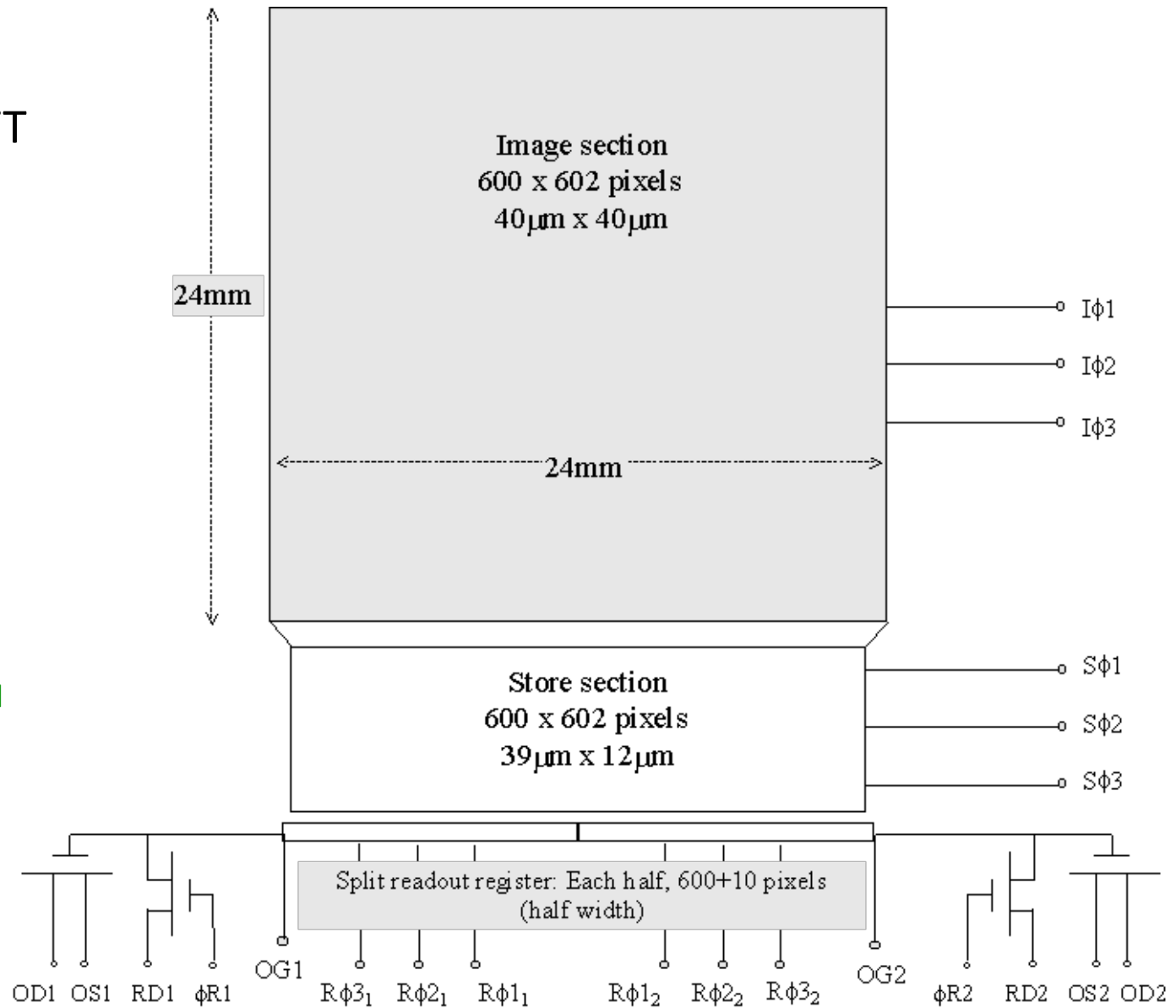
L.U.: XMM & SWIFT

Scale: 4.13 arcsec/pixel.

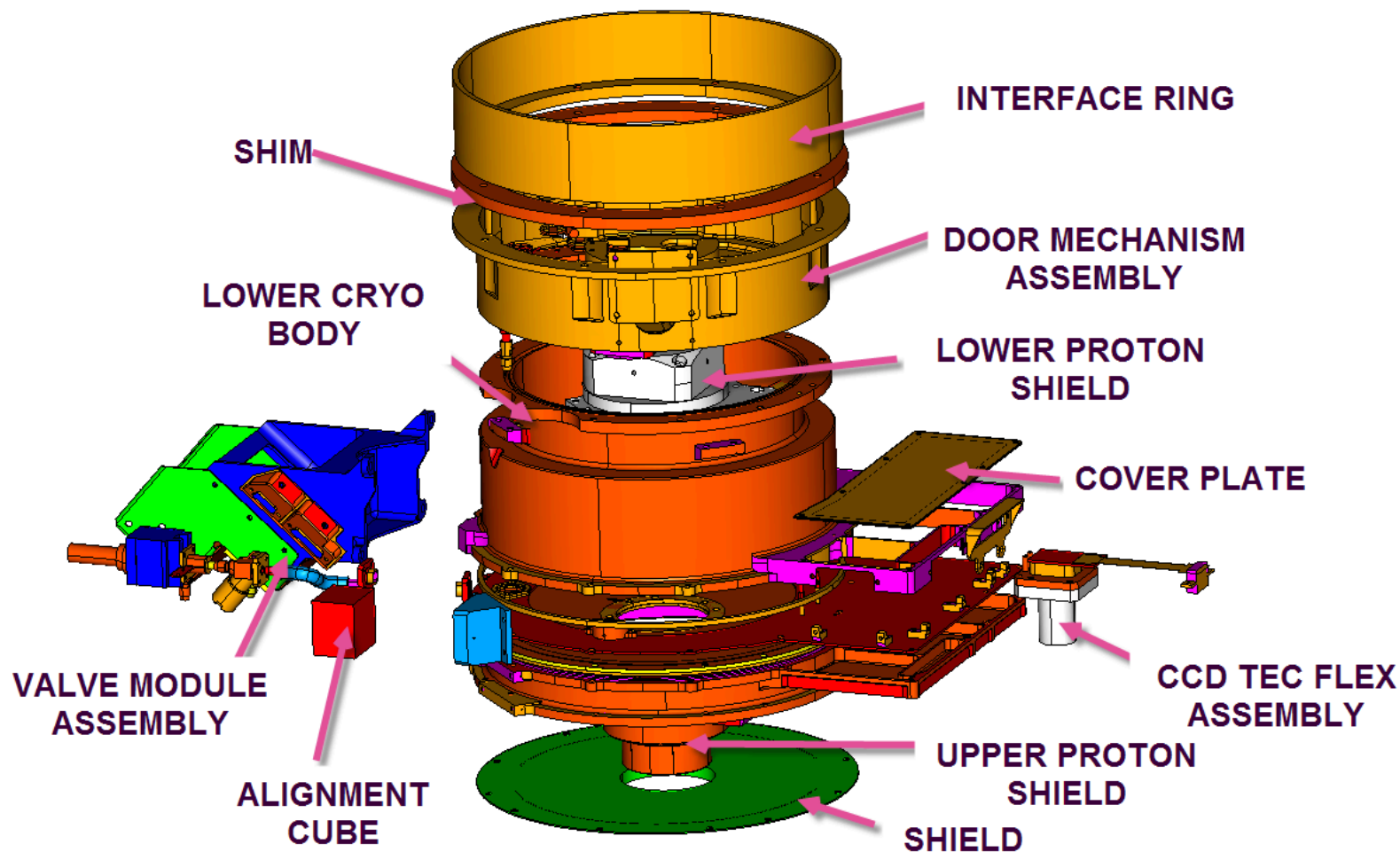
Field of view = 41.3 arcmin

A novel open gate design for better low energy Q.E. + a number of radiation tolerant-design features for a longer life in space.

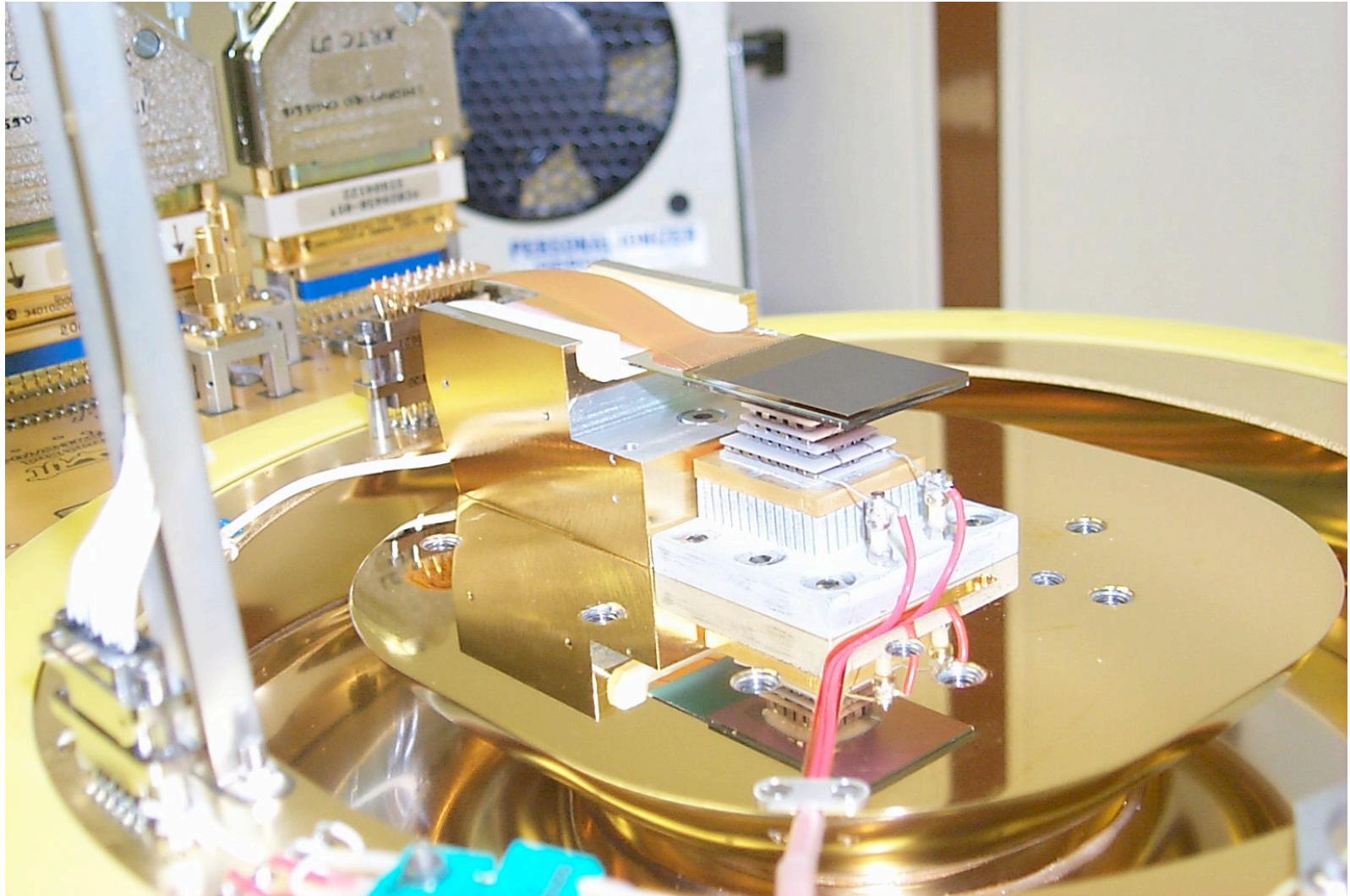
Frame-transfer operation between the image section and the store section enables the acquisition of a new image while the previous frame is being read out and thus avoids image smear. This mode with a pixel readout time of 7  $\mu$ s permits use of 2.6 s exposures (minimum).



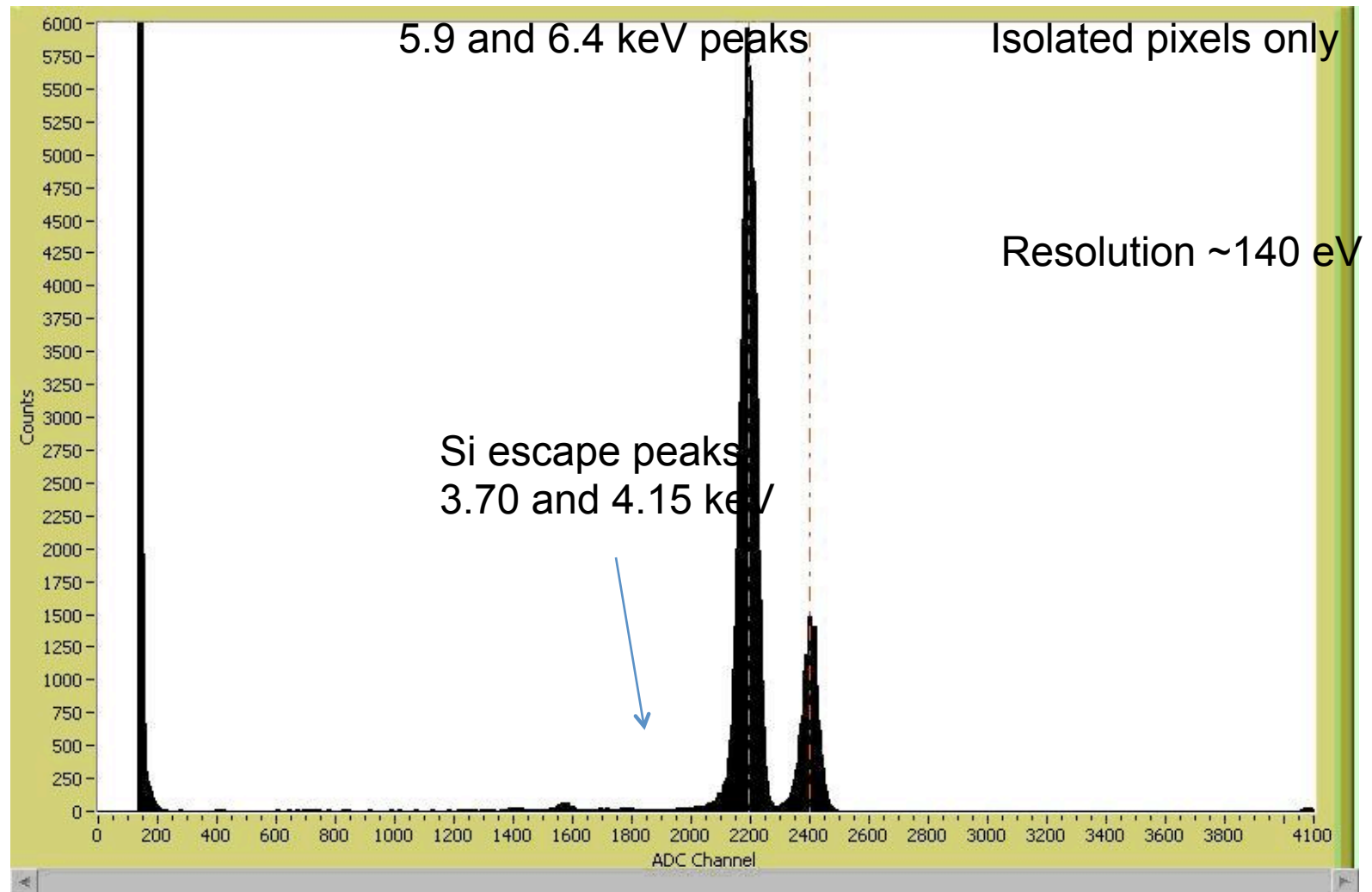
# SXT- Focal Plane Camera Assy



# CCD22 mounted in camera to be used in SXT



# CCD Data (Eng. CCD +TIFR Electronics)



**Response of the Engineering CCD to 5.9 keV X-rays from Iron-55**

# Calibration Plans for the FM

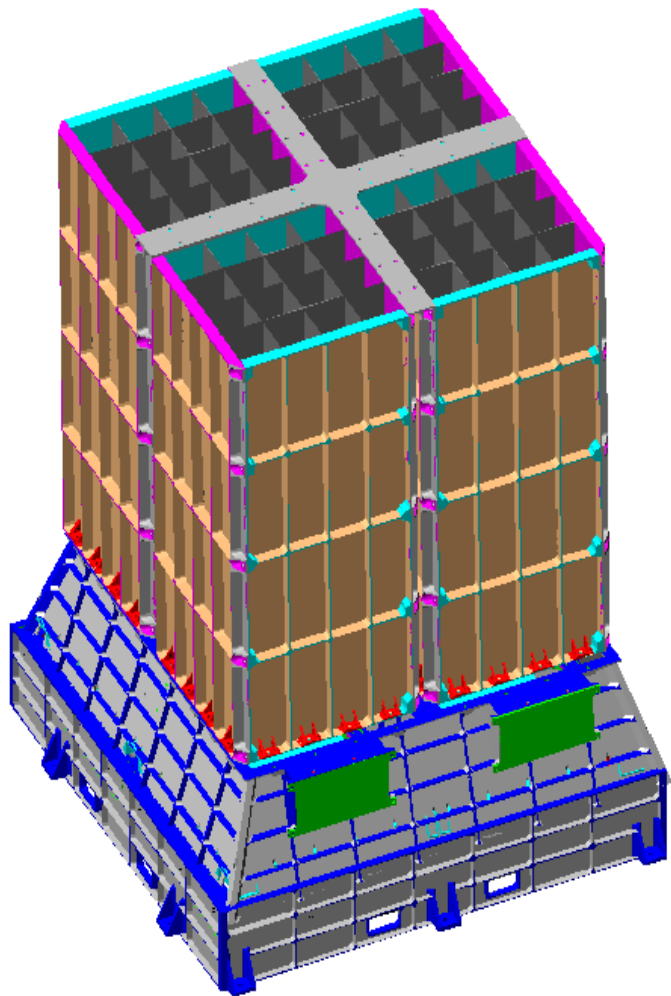
- FM and FM spare CCD Status: QE(E) calibration (UoL) - complete
- FM Filter: Trans(E) calibrated (UoL) - complete
- X-ray CCD camera tests using the internal radioactive sources at 6 keV.
- **X-ray beam raster scan of the Optics module** at NBF, Hyderabad to confirm the X-ray focal position – same procedure followed in most X-ray telescopes, e.g., Suzaku. To be done at a few selected energies between 1.5 to 8 keV

# CZT Imager characteristics

|                    |   |
|--------------------|---|
| Area               | 1024 cm <sup>2</sup>  |
| Pixels             | 16384   |
| Pixel size         | 2.4 mm X 2.4 mm (5 mm thick)  |
| Read-out           | ASIC based (128 chips of 128 channels)                                |
| Imaging method     | Coded Aperture Mask (CAM)   |
| Field of View      | 17 X 17 deg <sup>2</sup> (uncollimated)<br>6 X 6 (10 – 100 keV) – CAM |
| Angular resolution | 8 arcmin  |
| Energy resolution  | 5% @ 100 keV  |
| Energy range       | 10 – 100 keV - Up to 1 MeV (Photometric)                              |
|                    |   |

**CsI Veto detector below CZT Plane**

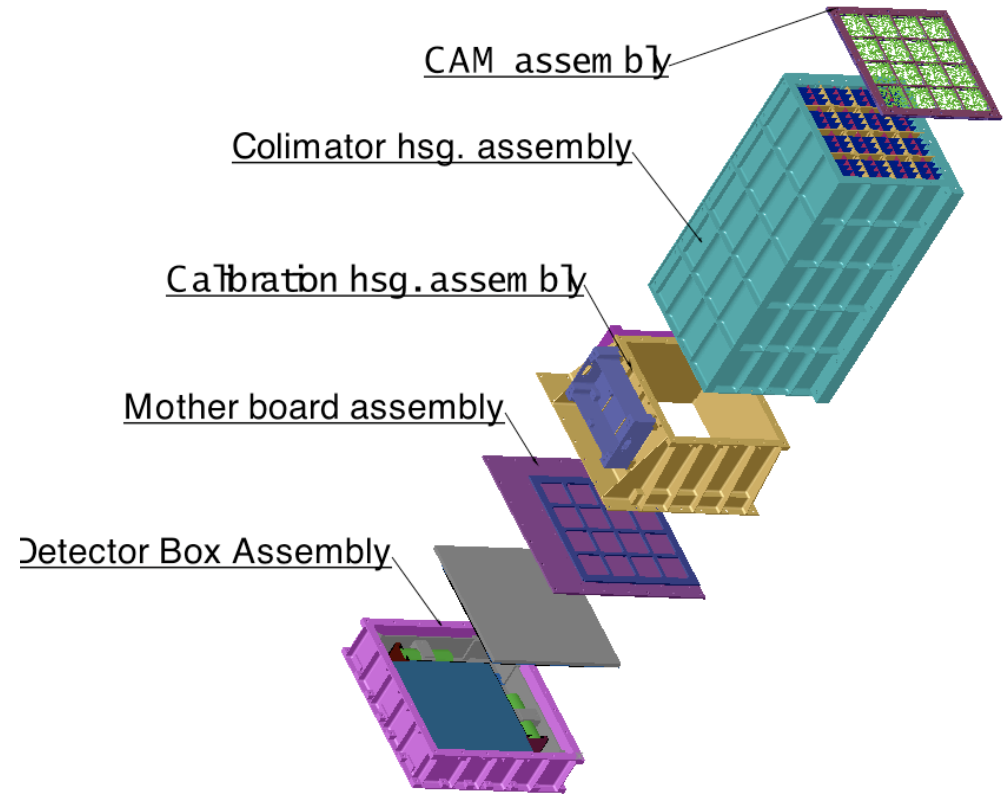
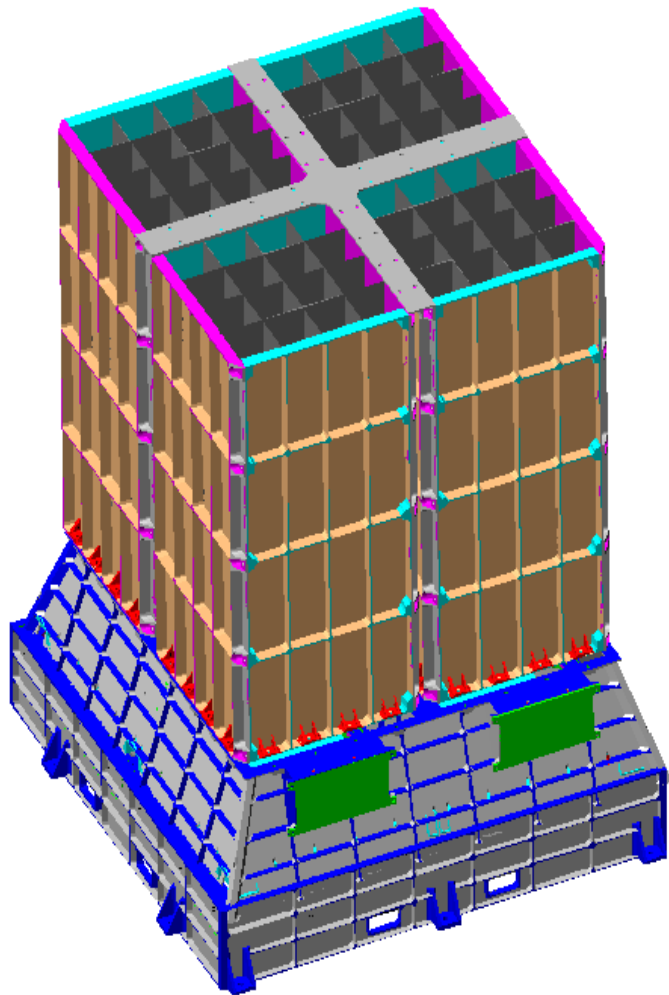
Onboard calibration with Alpha tagged Am-241 source



**CsI Veto detector below CZT Plane**

Onboard calibration with Alpha tagged Am-241 source

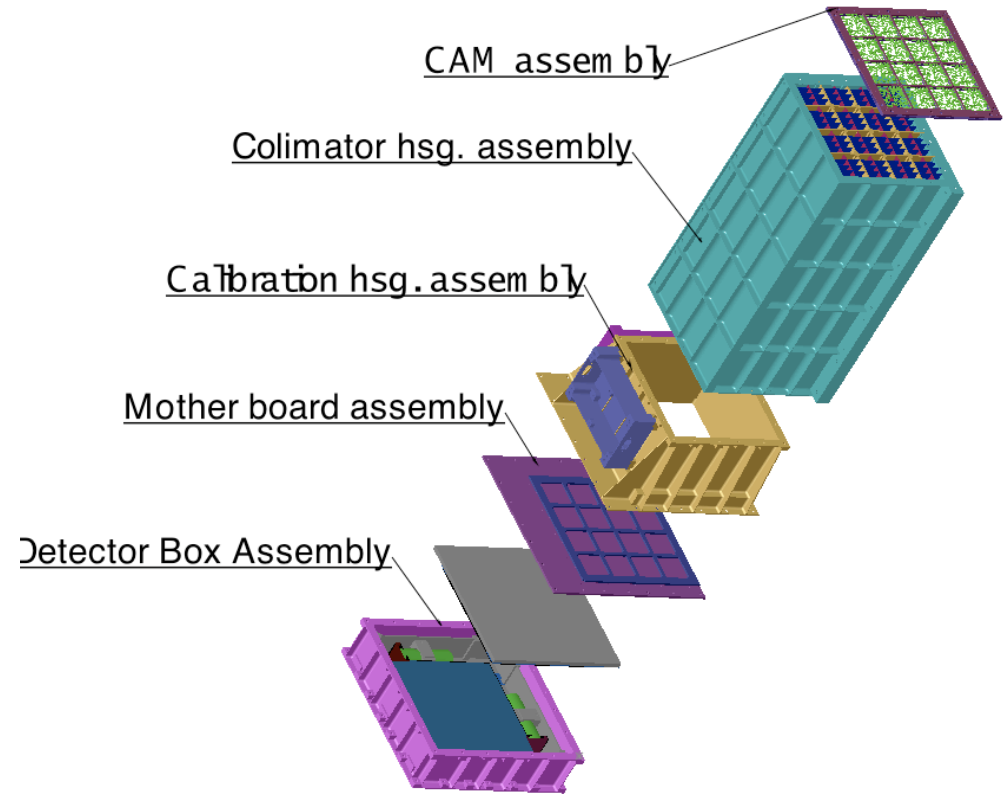
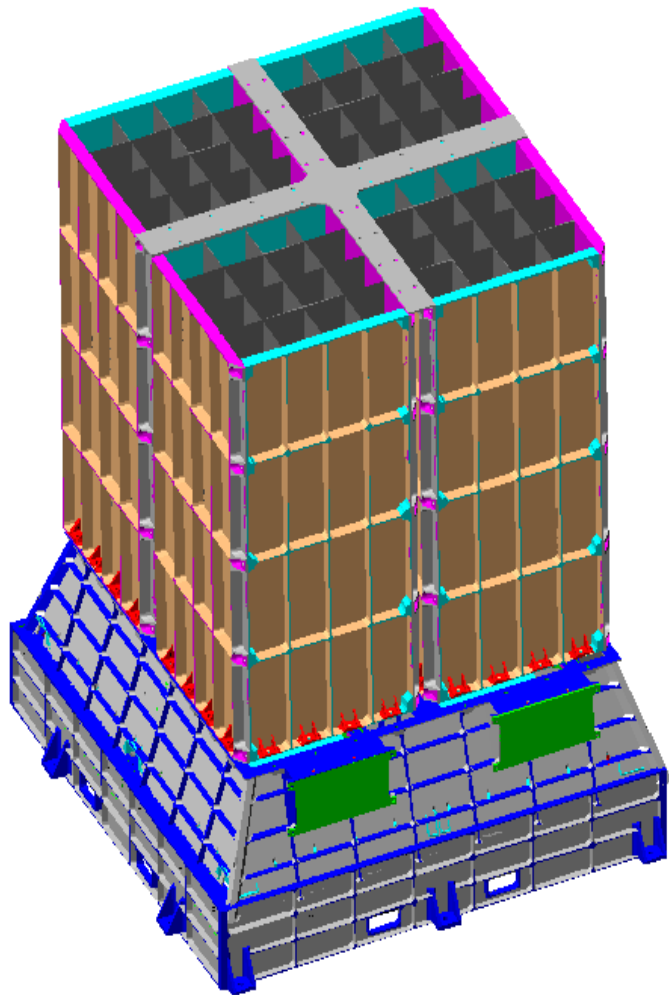
## Details of a Quadrant



**CsI Veto detector below CZT Plane**

Onboard calibration with Alpha tagged Am-241 source

## Details of a Quadrant

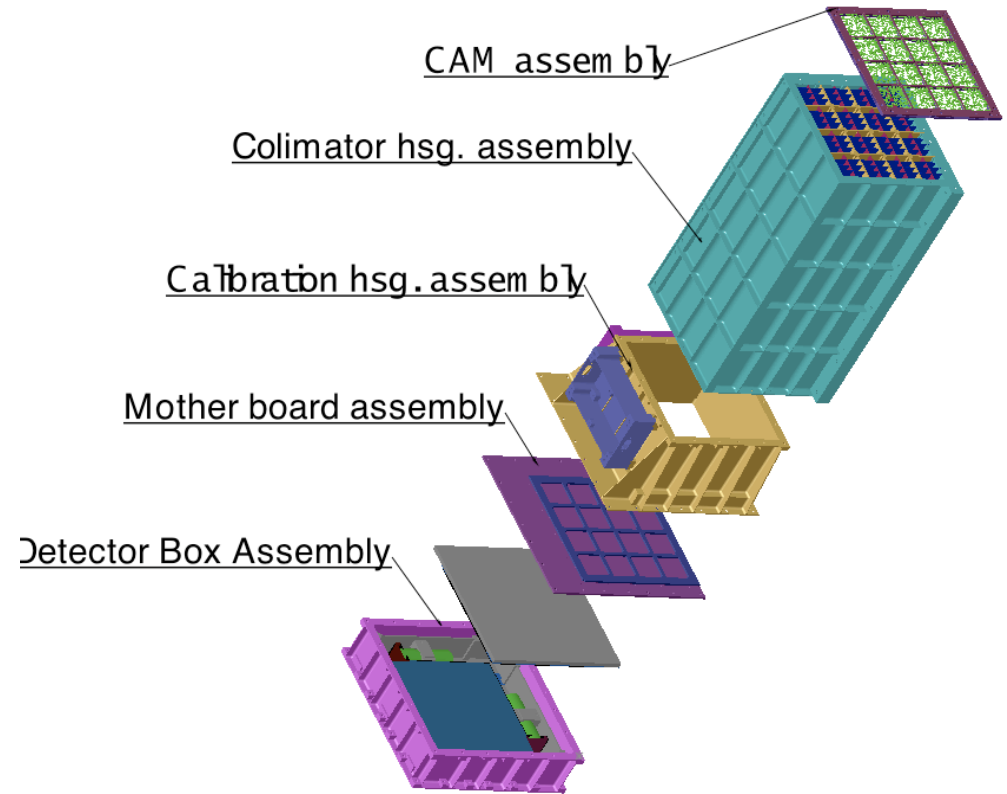
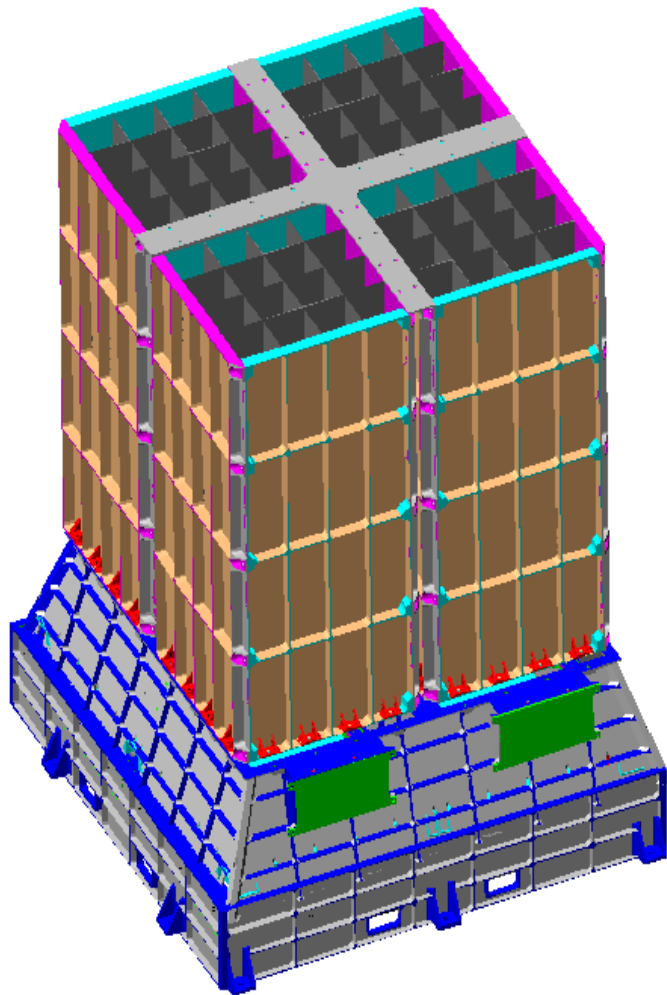


## **Four Independent Quadrants of Detector**

**CsI Veto detector below CZT Plane**

Onboard calibration with Alpha tagged Am-241 source

## Details of a Quadrant



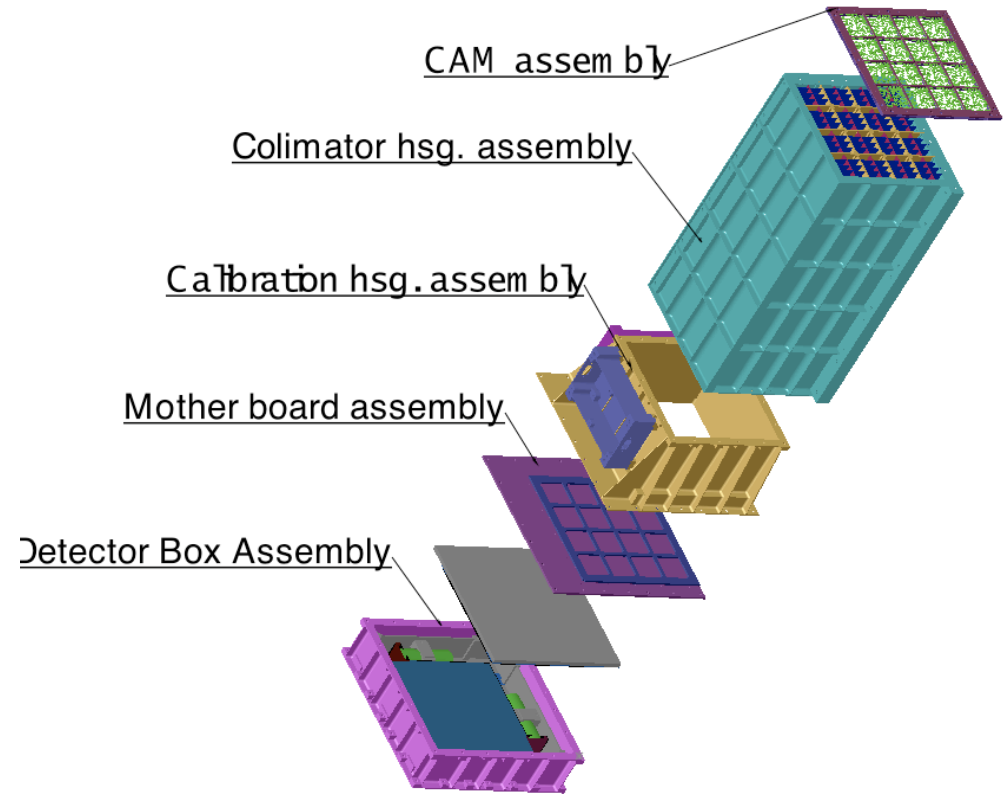
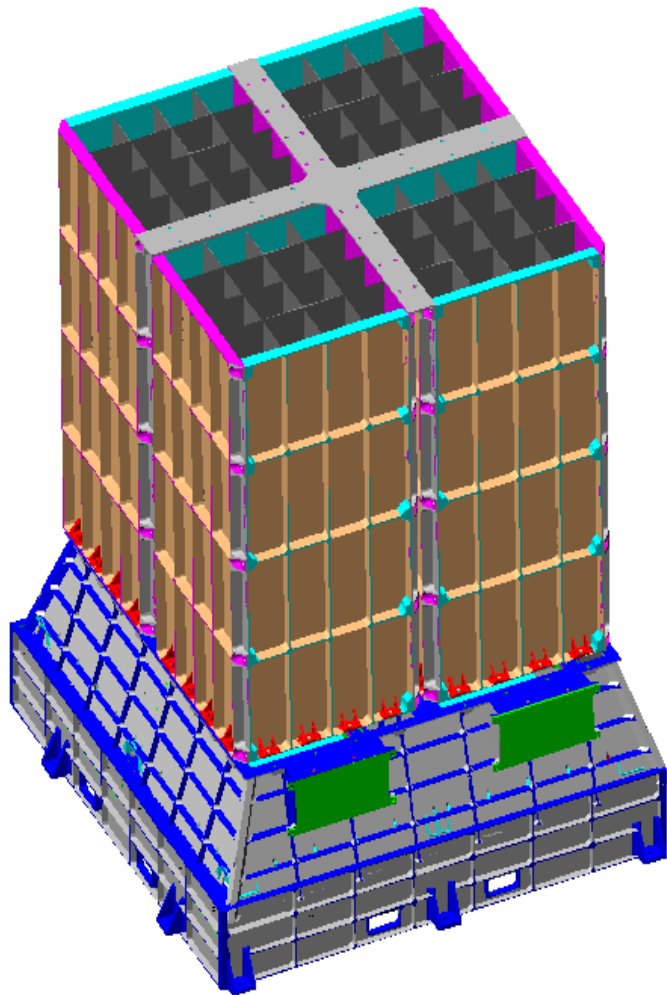
## **Four Independent Quadrants of Detector**

Size - 484 x 484 x 600 mm

**CsI Veto detector below CZT Plane**

Onboard calibration with Alpha tagged Am-241 source

## Details of a Quadrant



## **Four Independent Quadrants of Detector**

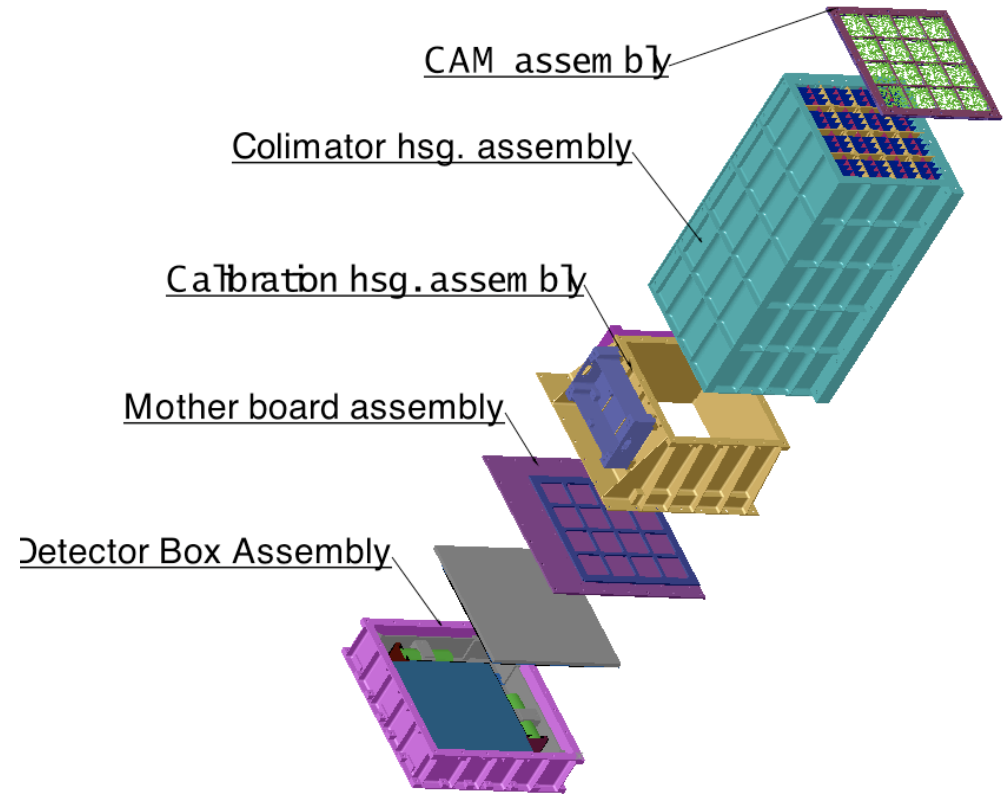
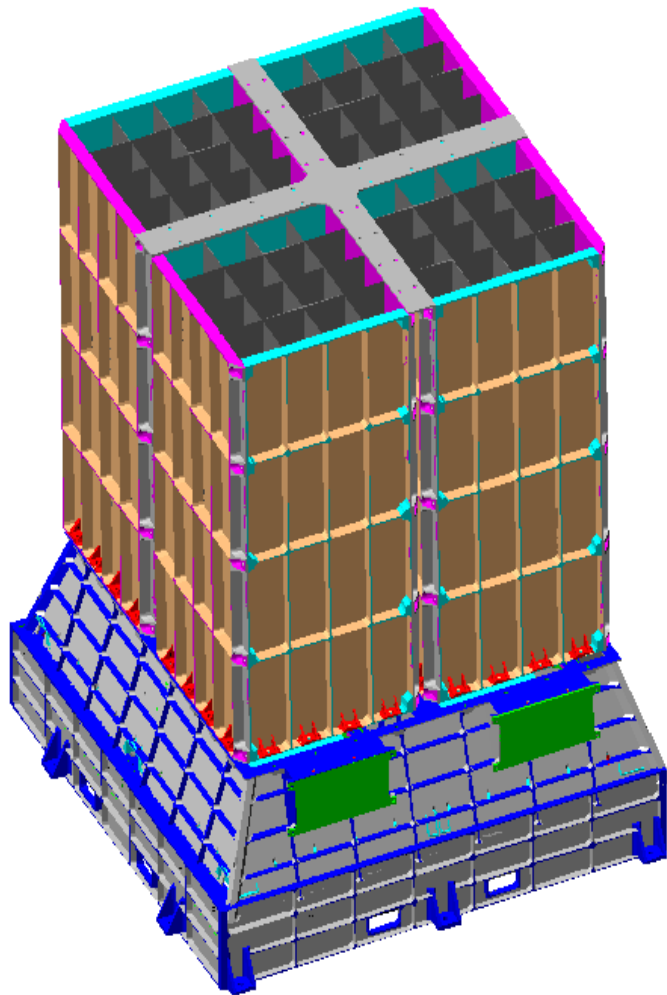
Size - 484 x 484 x 600 mm

Weight - 50 K gm

**CsI Veto detector below CZT Plane**

Onboard calibration with Alpha tagged Am-241 source

## Details of a Quadrant



## **Four Independent Quadrants of Detector**

Size - 484 x 484 x 600 mm

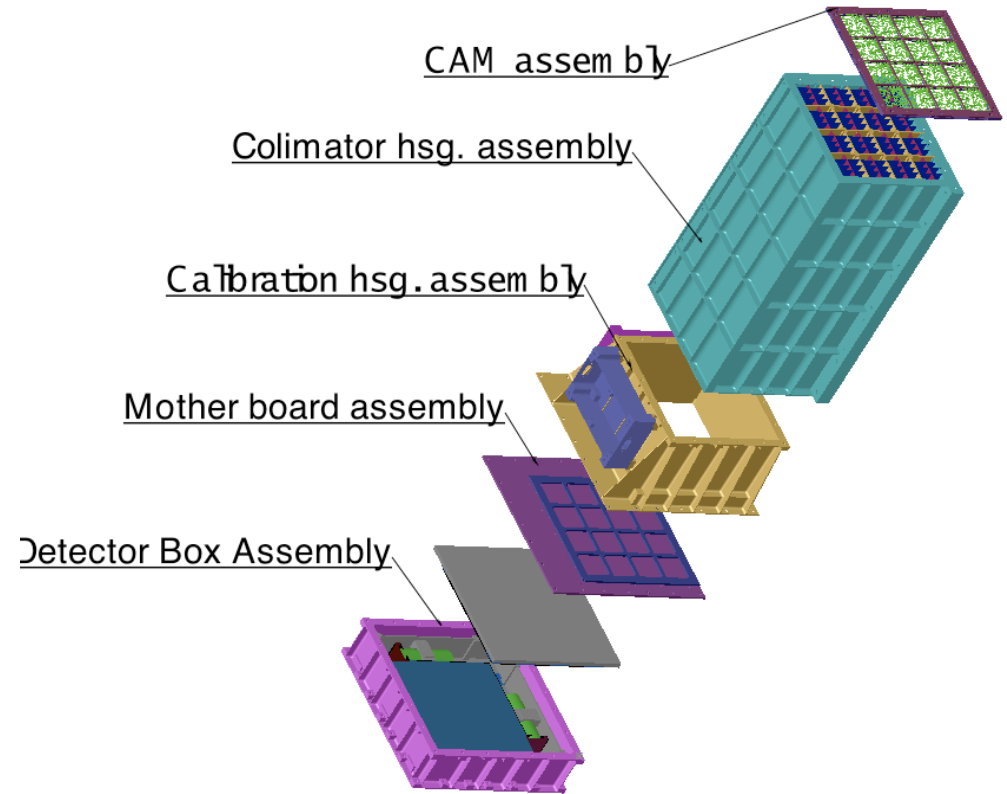
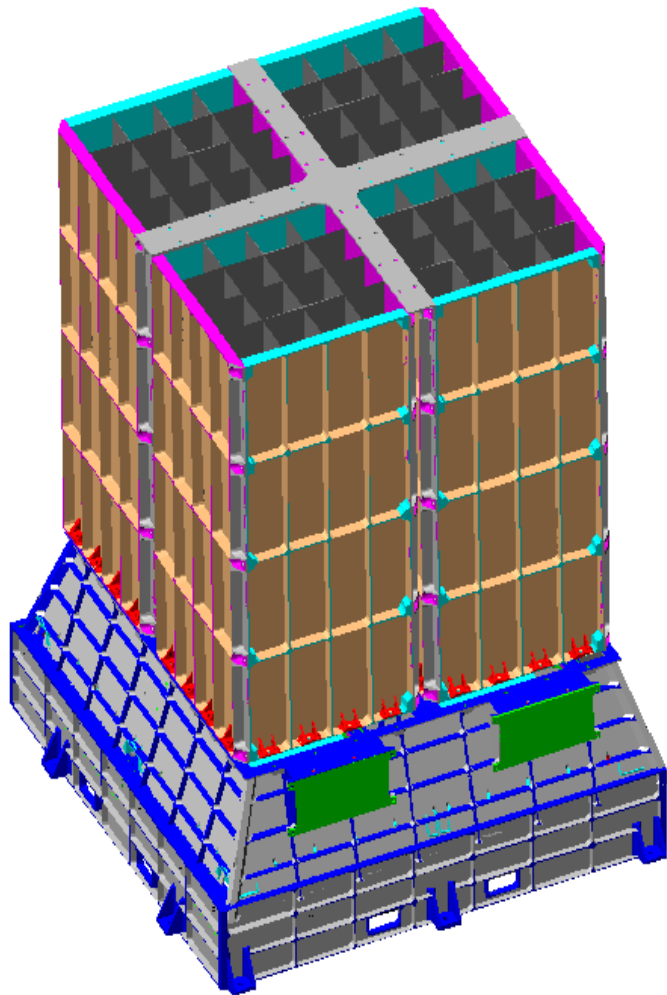
Weight - 50 K gm

Collimators - 6 x 6 Degree, 17 x 17 Degree

**CsI Veto detector below CZT Plane**

Onboard calibration with Alpha tagged Am-241 source

## Details of a Quadrant



## **Four Independent Quadrants of Detector**

Size - 484 x 484 x 600 mm

Weight - 50 K gm

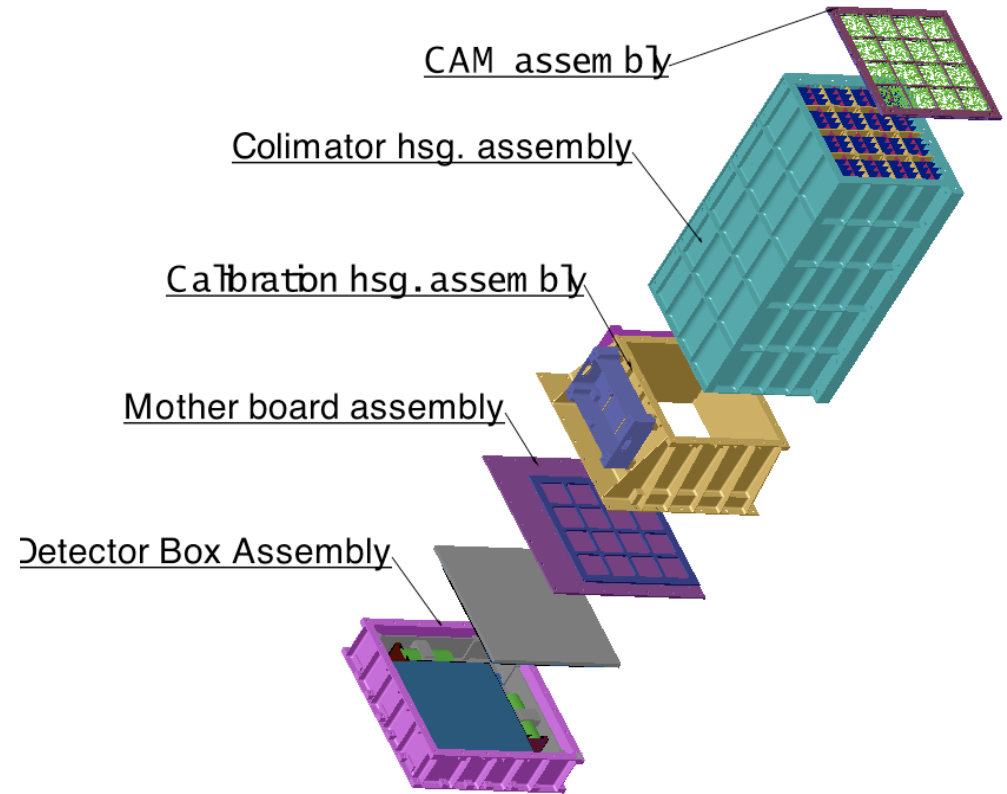
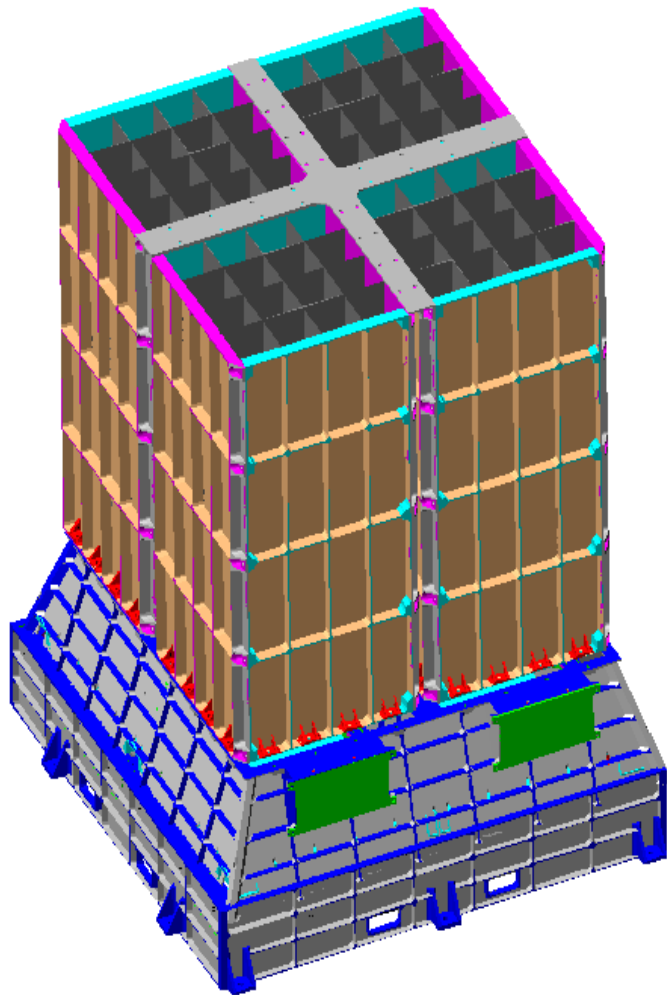
Collimators - 6 x 6 Degree, 17 x 17 Degree

**CsI Veto detector below CZT Plane**

Onboard calibration with Alpha tagged Am-241 source

**Power- 50 Watts**

## Details of a Quadrant



## **Four Independent Quadrants of Detector**

Size - 484 x 484 x 600 mm

Weight - 50 K gm

Collimators - 6 x 6 Degree, 17 x 17 Degree

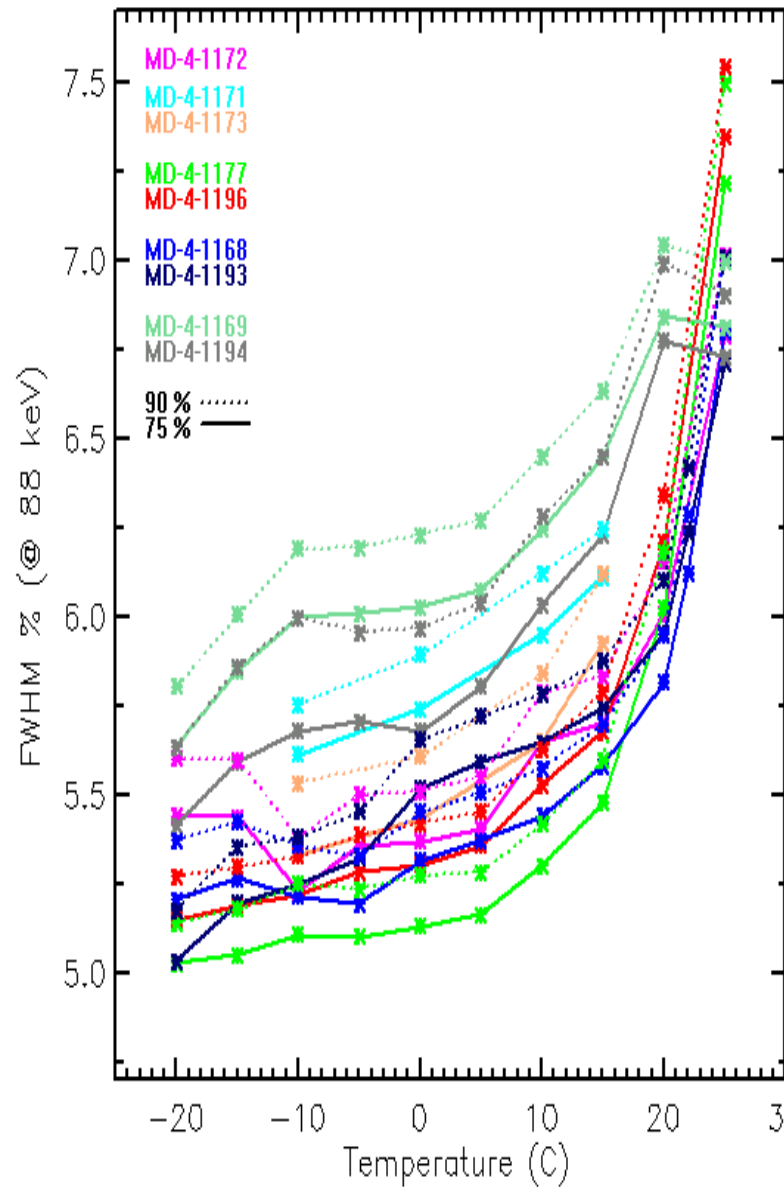
Graded Shield Material – **Tantalum + Aluminum** (For Passive shielding)

**CsI Veto detector below CZT Plane**

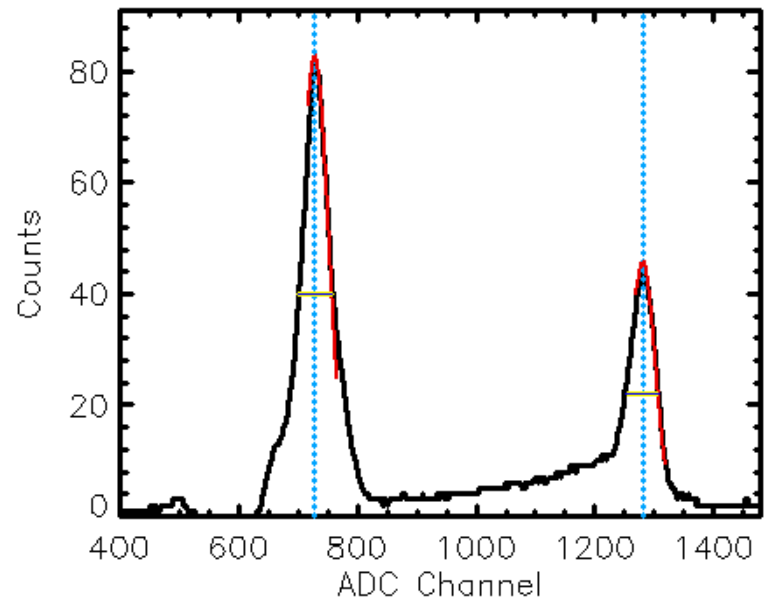
Onboard calibration with Alpha tagged Am-241 source

**Power- 50 Watts**

# CZT Module characterization



Vadawale et al. 2006





**CZTI Qualification Model with one Quadrant of CZT detectors mounted , being made ready for the Vibration and Shock Tests.**

# Status

- CZT modules qualified.
- Qualification model (QM) assembled, tested.
- Space qualification tests for QM
  - vibration tests, completed
  - thermovac test : Completed
- All parts for Flight Model (FM) fabricated.
- Flight electronics in final stage of fabrication

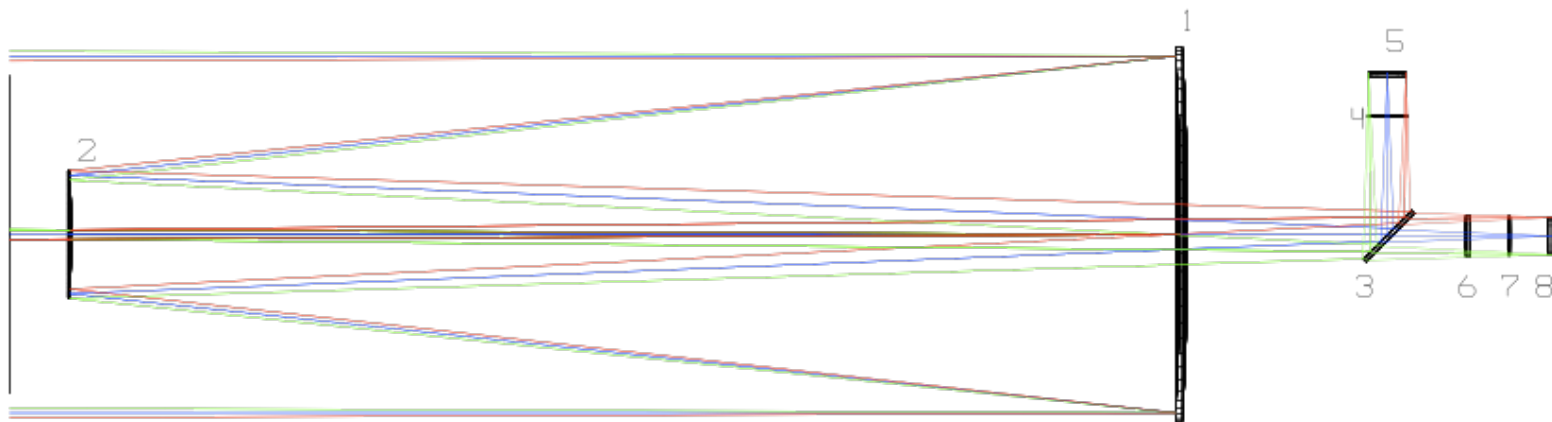
# ULTRA VIOLET IMAGING TELESCOPE (UVIT)

## Science drivers

- Simultaneous X-ray and UV emission studies
- Imaging the emission nebulae and supernova remnants
- Hot stars in nearby galaxies (LMC, SMC, M31, ...)
- UV Morphology of galaxies (blue dwarf galaxies,  $z > 0.5$ , ...)
- Quasars and active galactic nuclei (deep survey : discover faint QSOs)
- Lyman  $\alpha$  surveys (stripped gas in galaxy clusters, ...)
- Deep surveys and rate of star formation ( $1.3 < z < 2$ )
- Monitoring of X-ray Sources (& GRB afterglows, )
- UV Sky Survey in selected regions (20- 21 magnitude)

# OPTICAL LAYOUT – NUV & VIS

## f/12 Cassegrain, ~ 380 mm aperture



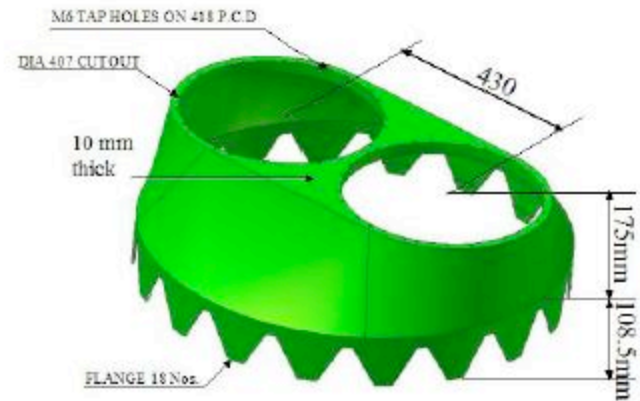
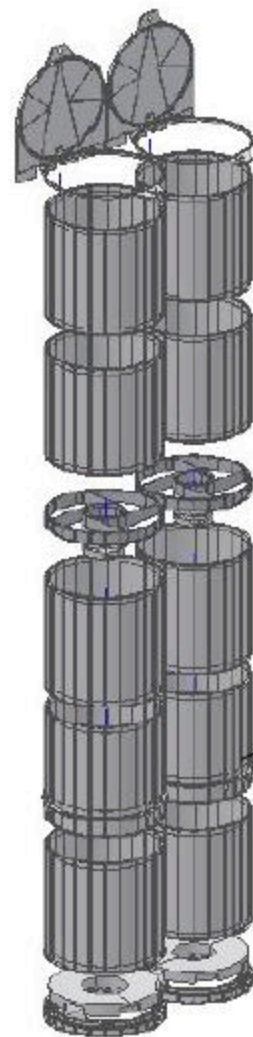
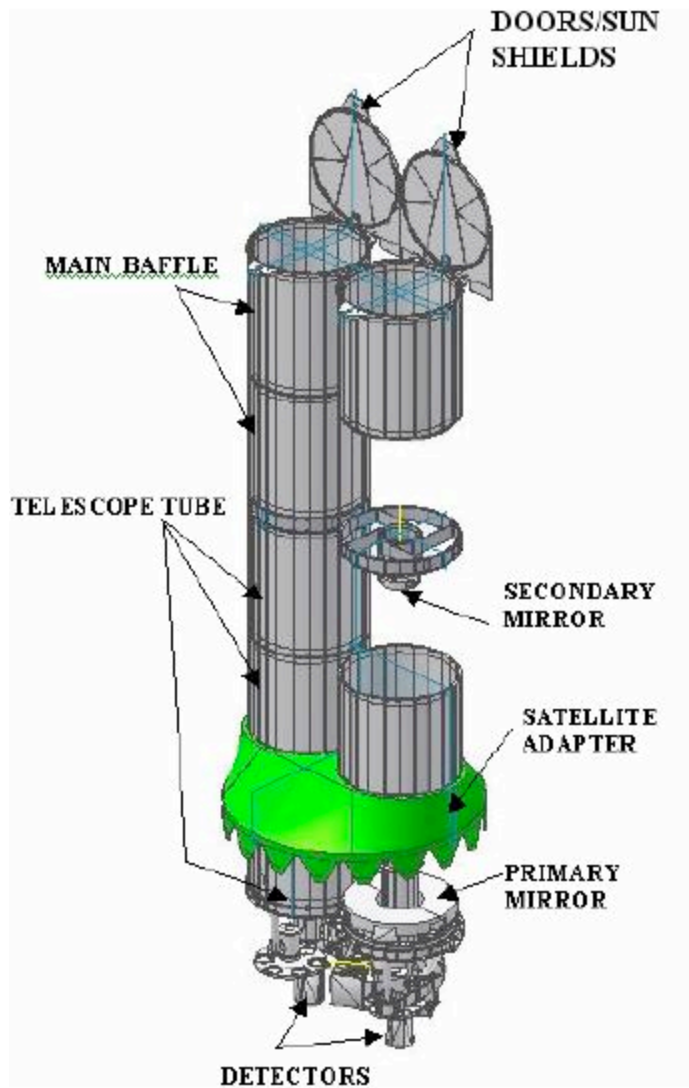
- 1- PRIMARY MIRROR
- 2- SECONDARY MIRROR
- 3- BEAM SPLITTER
- 4- NUV FILTER
- 5- NUV DETECTOR WINDOW
- 6- VIS CORRECTOR
- 7- VIS FILTER/GRATING
- 8- VIS DETECTOR WINDOW

WIREFRAME

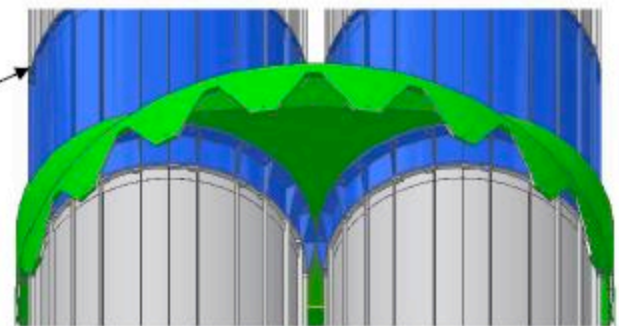
IVIT  
UE FEB 28 2006

S. SRIRAM  
IIAP

# UVIT CONFIGURATION



Cone Adapter  
(Material Ti)



Interface with cone adapter

# UVIT CONFIGURATION

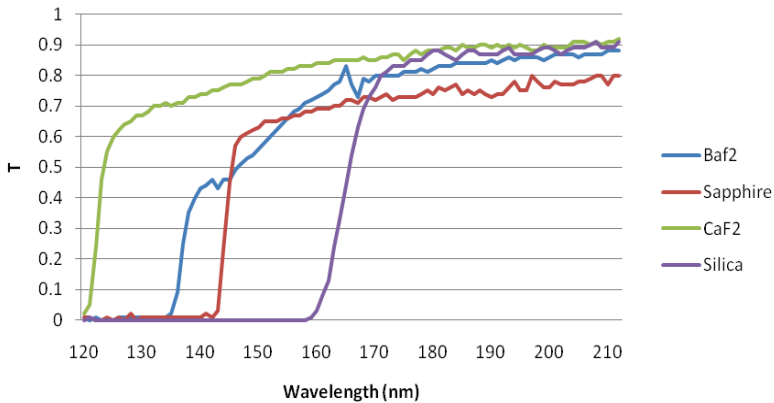
- Imaging in 29' field with  $< 1.8''$  resolution, in 2 UV bands
- Two 380 mm aperture Cassegrain telescopes used: one for Far UV (130-180 nm) and the other for Near UV (200-300 nm) and Visible (320-550 nm)
- For each channel a band is selected by a filter on wheel
- Intensified CMOS detectors are used for imaging in photon counting mode

# FUV filter specification

| Slo t.N o. | Filter Type     | Filter Thickn ess Mm | Pass Band Nm |
|------------|-----------------|----------------------|--------------|
| 0          | Block           |                      |              |
| 1          | CaF2            | 2.50                 | > 125        |
| 2          | Barium Fluoride | 2.40                 | > 135        |
| 3          | Sapphire        | 2.00                 | > 142        |
| 4          | Grating - 1     | 4.52                 | > 125        |
| 5          | Silica          | 2.70                 | > 160        |
| 6          | Grating - 2     | 4.52                 | > 125        |
| 7          | CaF2            | 2.50                 | > 125        |

NUV filter specification

FUV Filter Transmission



# Near UV Filter Specification

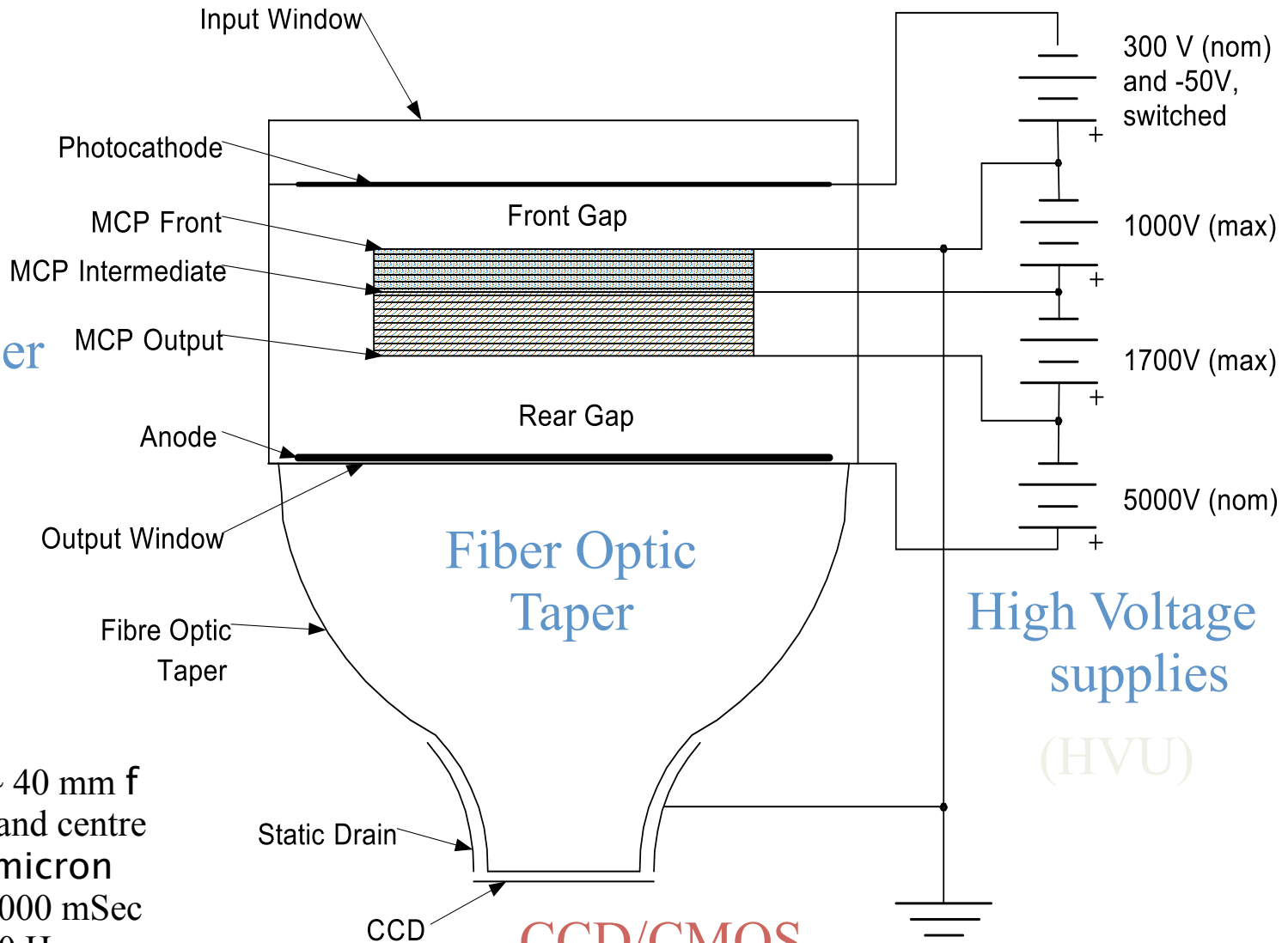
| Sl ot. No | Filter Type | Filter Thickn ess Mm | Pass Band Nm |
|-----------|-------------|----------------------|--------------|
| 0         | Block       |                      |              |
| 1         | Silica      | 3.00                 | > 200        |
| 2         | NUV15       | 2.97                 | 200 - 230    |
| 3         | NUV13       | 3.15                 | 230 - 260    |
| 4         | Grating     | 4.52                 | > 200        |
| 5         | NUVB4       | 3.33                 | 250 - 280    |
| 6         | NUVN2       | 3.38                 | 275 - 285    |
| 7         | Silica      | 3.30                 | > 200        |

# Measured transmissions of FUV Filters

# Components in each Detector

## Intensifier

(DM)



## Fiber Optic Taper

## High Voltage supplies

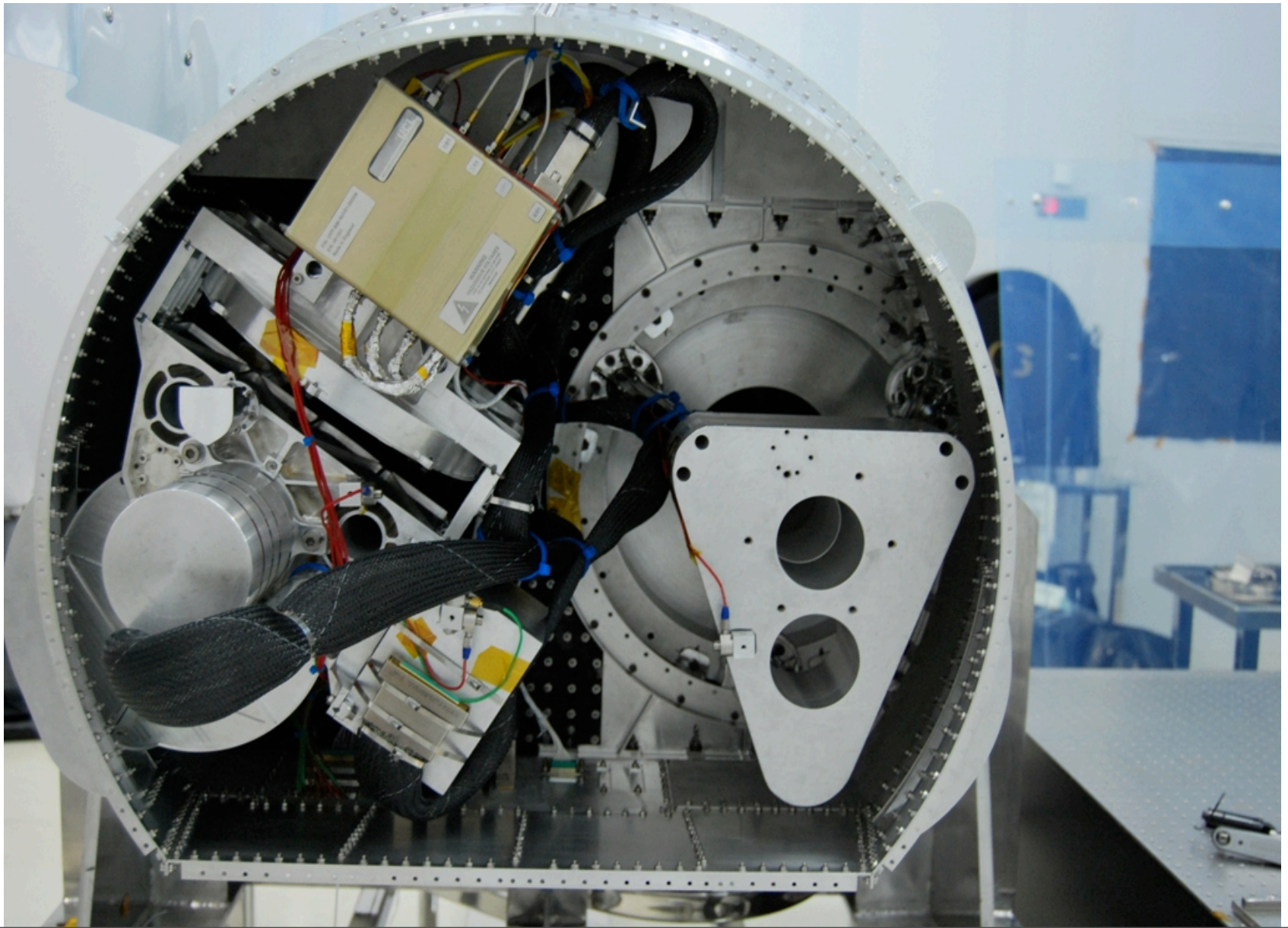
(HVU)

## CCD/CMOS

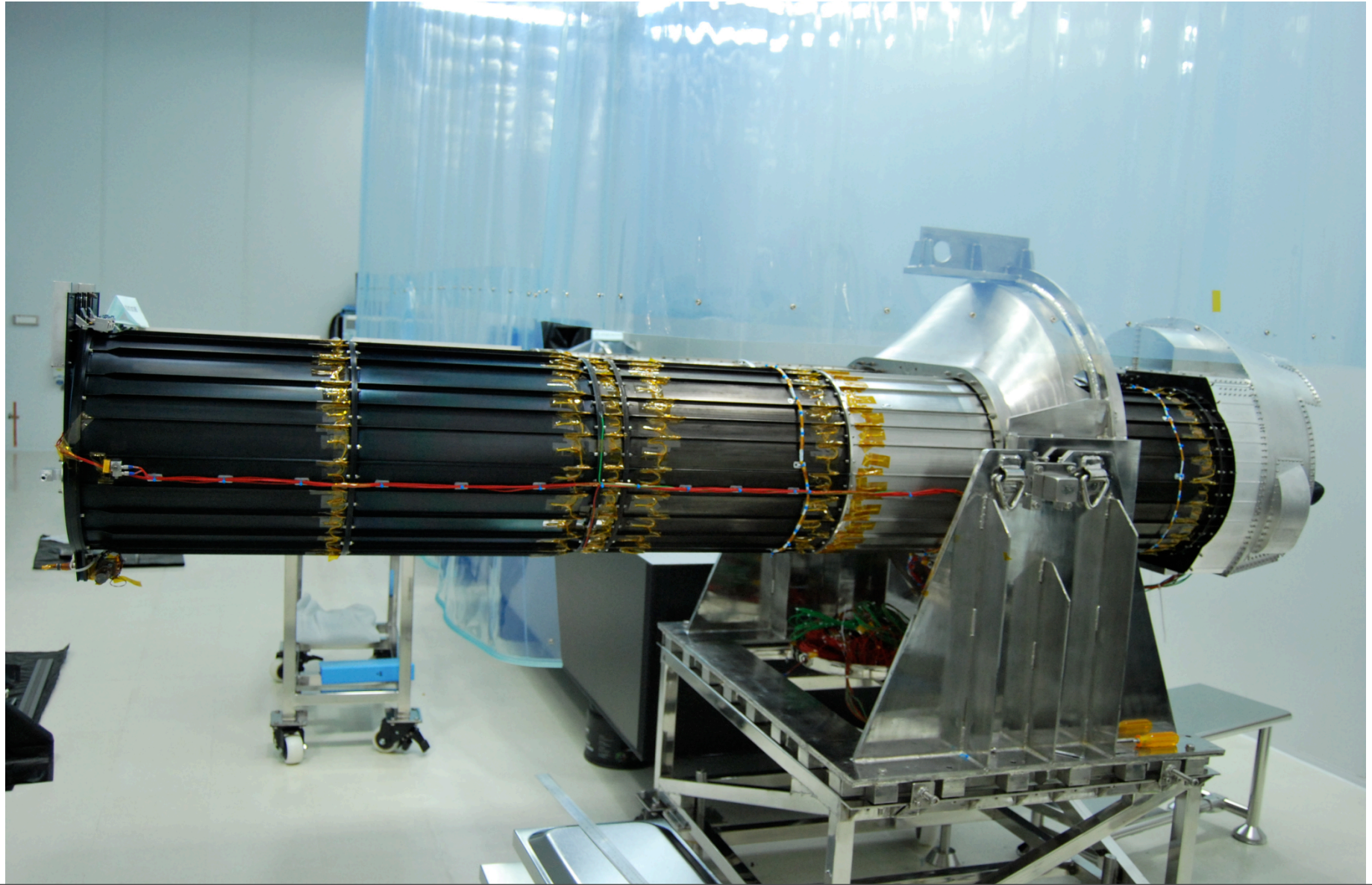
Imaging area : ~ 40 mm f  
QE :> ~5% in band centre  
Pos. res. < 100 micron  
Exposure : 10-1000 mSec  
Frame rate : > 20 Hz  
Gain : 2000 – 20,000 e-/g  
Safety : electronic gating

(Need High Voltage Power Supplies;  
up to 8000 V)

# EM: NUV/VIS Tel. Focal-plane



# EM: UVIT



# UVIT Status

- **Vibration tests of EM completed**
- **Mirrors fabricated , mounted and characterized**
- **Detectors with HV and signal processing electronics fully tested and characterized**
- **All the filters and grisms received and tested**
- **Fight unit structure fabrication nearing completion**
- **Calibration Facility for testing integrated UVIT in place at IIA and ready for use**

# Scanning Sky X-ray Monitor (SSM)

## Objectives

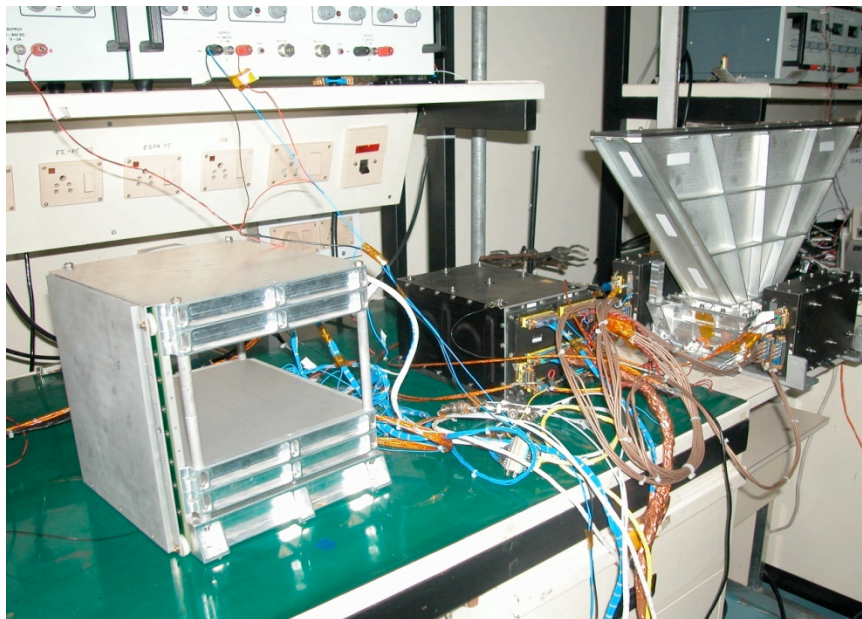
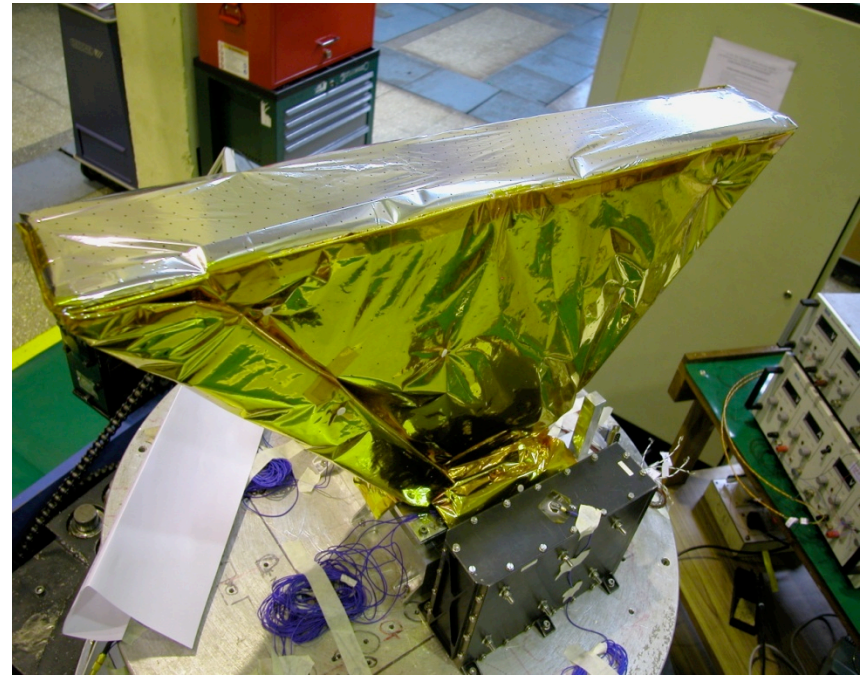
- To detect, locate and monitor x-ray transients.
  - **Nearly half of known x-ray binaries are transients**
- Monitor known bright sources
  - **several samples/day; monitor for many months.**
- To alert other instruments for detailed studies

# Scanning Sky X-ray Monitor

1-D coded mask position-sensitive detector very similar to ASM on RXTE.

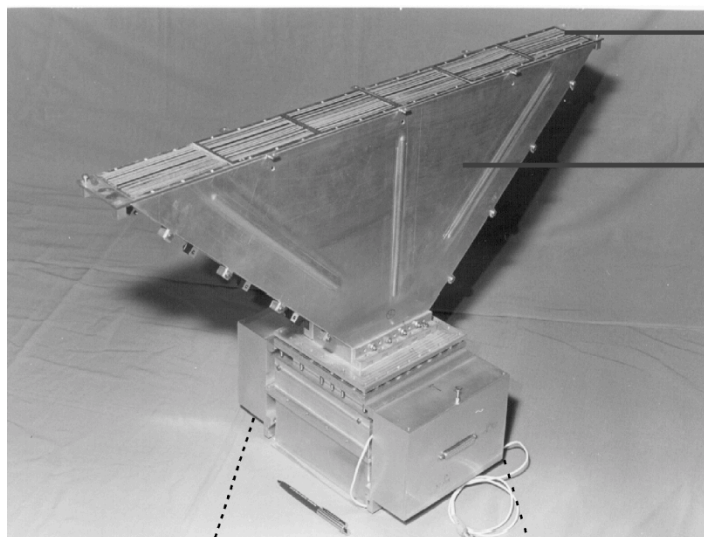
- **Detectors:** proportional counters with resistive anodes; Ratio of signals on either ends of anode gives position.

- Energy range 2-10 keV
- Position resolution ~ 1.5 mm(FWHM)
- Position determination ~ 0.5 mm
- Field of view ~ 10° X 90° (FWHM )
- Sensitivity ~30 mCrab (5 min. integ.)
- Best time resolution 1ms
- Nominal scan rate ~ 1 degree/minute
- Payload Weight - 48 kg, Power- 30W



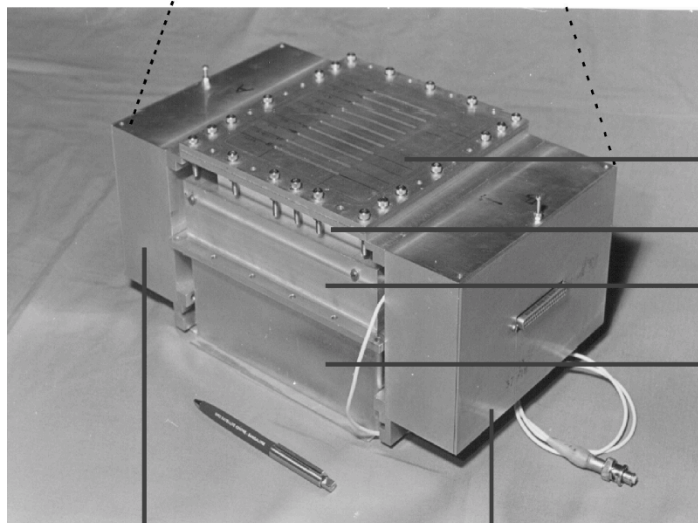
## Assembly of SSM Detector

# SCANNING SKY MONITOR (Engg. Model)



→ CODED MASK

→ CODED MASK HOUSING



→ COVER PLATE TO TEST WIRES (temp.)

→ DETECTOR

→ HV DIST. GAS PORT etc.

→ FE LOGIC

→ CSPA HOUSINGS ←

# SCANNING SKY MONITOR (SSM)

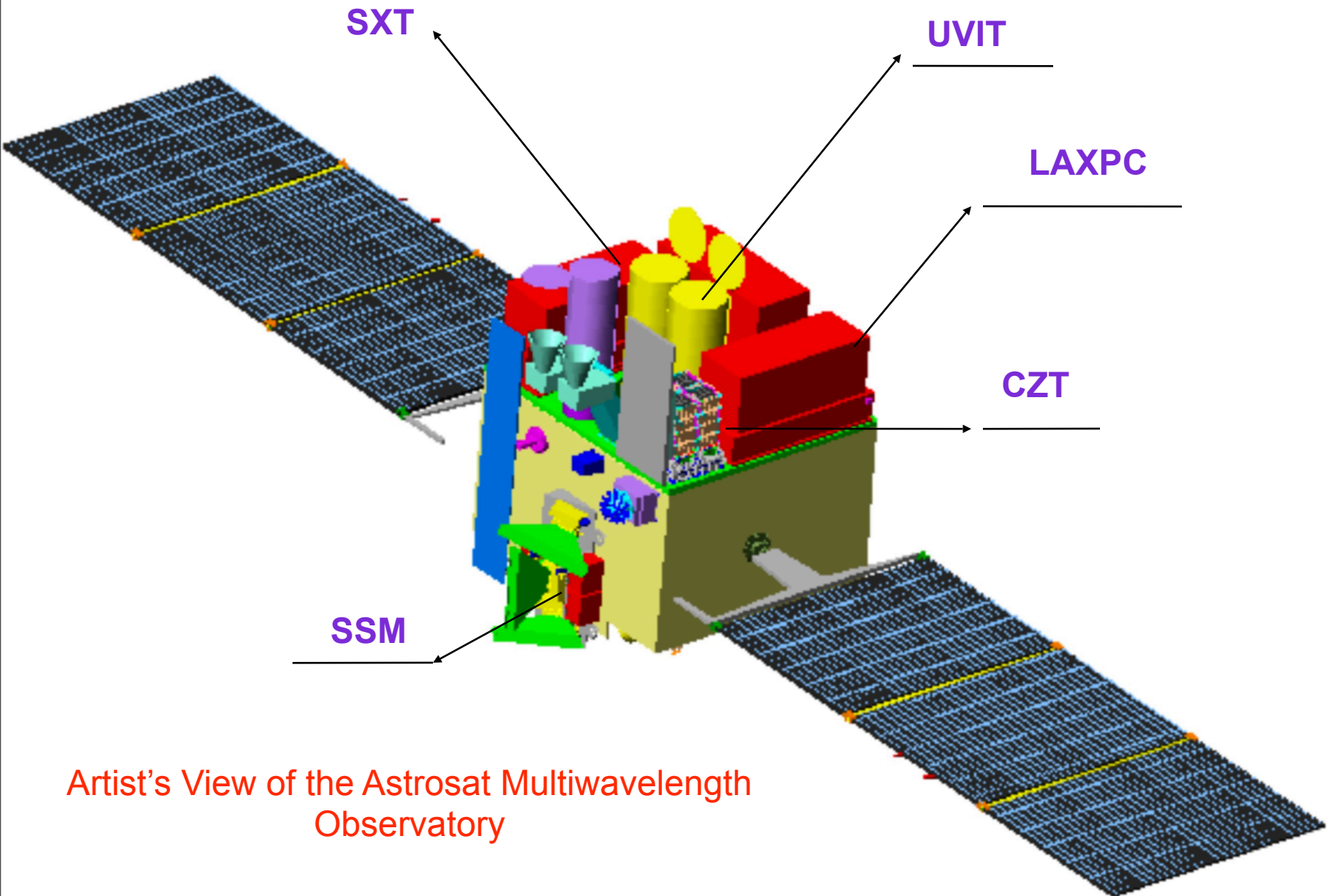
## QM model

- QM Detector and Electronics Thermovac tests and Vibration tests completed
- QM SSM steering mechanism is assembled demonstrated and Thermovac environmental tests are planned in July 2010. Full QM integrated assembly of platform ,cone and steering mechanism is planned in August 2010.

## FM model

- All mechanical components of FM detectors are ready.
- FM Mask also fabricated and ready
- Flight electronics under fabrication.

# ASTROSAT Top Deck Layout



Artist's View of the Astrosat Multiwavelength Observatory

|                          | UVIT                                       | LAXPC                               | SXT                     | CZTI                        | SSM             |
|--------------------------|--|-------------------------------------|-------------------------|-----------------------------|-----------------|
| Energy Resolution (FWHM) | < 100 nm<br>(depends on choice of filters) | 10% @ 22 keV                        | About 2% to 3% at 6 keV | 5% at 60 keV (aiming at 3%) | 19% @ 6 keV     |
| Angular Resolution       | 2 arcsec                                   | ~ 1 to 5 arcmin (in scan mode only) | 3-4 arcmin (HPD)        | 8 arcmin                    | ~ 5 – 10 arcmin |
| Time Resolution          | 1  | 10 microsec                         | 2.6 s, 0.3 s, 1         | 1 ms                        | 1 ms            |

# Astrosat Mission Characteristics

- Mission life of at least 5 years. Circular orbit of 650 km altitude and inclination of  $< 8^\circ$ . Orbital period of 100 minutes.
- Launch by well proven Indian Polar Satellite Launch Vehicle (PSLV) from Satish Dhawan Launch Center at Shriharikota (India).
- Mass of satellite 1608 kg including 868 kg mass of science payloads.
- Total Power generation = 1250 Watts , Payload Power needed is 488 Watts.
- Two 120 Gb Solid State Recorders for onboard data recording and read out with capability to record data for 4 orbits.
- Large number of On/Off, Data Commands and Time-tagged commands available for the control and operation of the Science Instruments .
- Data transmission by two X-band carriers at a rate of 105 Mbits per sec.
- A Charged Particle Monitor to control the operation of the instruments in zones of high fluxes of particles.

# Conclusions

- **Astrosat will enable timing observations with 10  $\mu$ s accuracy in a broad spectral band of 3-80 keV with LAXPCs of  $A \sim 6000 \text{ cm}^{-2}$  in 3-20 and  $\sim 5000 \text{ cm}^{-2}$  in 20-50 keV bands. Largest area ever used for hard X-ray studies.**
- **Medium energy resolution capability of CZT for accurate spectra and detection of cyclotron features.**
- **SXT for imaging and spectral studies for 0.3-8 keV band.**
- **Simultaneous observations with co-aligned 3 X-ray Instruments covering 0.3-100 keV region to construct spectra of sources.**

**Obtain multifrequency spectra covering Visible, UV , Soft X-ray and Hard X-ray regions for a variety of sources.**

**UV studies and deep UV survey of selected regions and sources with UVIT to a limit of  $m \sim 21$ st magnitude.**

**Detection and monitoring of transient and persistent X-ray sources with SSM.**