X-ray burst science with Astrosat

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40 years of X-ray bursts: Extreme explosions in dense environments

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Astrosat

1. LAXPC: Large Area X-ray Proportional Counters;
$A_{eff} \approx 6000$ cm^2; FOV $=1^0$ X 1^0; 3-80 keV;

2. CZTI: Cadmium-Zinc-Telluride Imager with Coded Aperture Mask (CAM);
$A_{eff} = 500$ cm^2; FOV $= 6^0$ X 6^0;10 – 100 keV; E/ΔE $\approx$ 20 to 30.

3. SSM : Scanning Sky Monitor with 3 PSPCs and CAM;
$A_{eff} \approx 30$ cm^2 (each); 2-20 keV.

4. SXT : Soft X-ray Telescope using conical-foil mirrors
$A_{eff} \approx 200$ cm^2 ; FOV $= 0.5^0$; (~3$'$ res); 0.3-8 keV; E/ΔE $\approx$ 30

5. UVIT : Ultraviolet Imaging Telescope; two telescopes each with 38 cm aperture; near-uv , far-uv and visible bands.

Singh et al. 2014

PI: S. Seetha (ISRO); LAXPC: J S Yadav (TIFR); SXT: K P Singh (TIFR); UVIT: S N Tandon (IIA); CZTI: A R Rao (TIFR); SSM: M.C. Ramadevi (ISRO)

Participating Institutes…

- ISRO Centers

  Satellite, rocket, T&E, Launch, Orbit, SSM,

  Level 1&2 software + overall management

- Research Institutes

  Tata Institute of Fundamental Research

  LAXPC, CZTI, SXT

  Indian Institute of Astrophysics UVIT

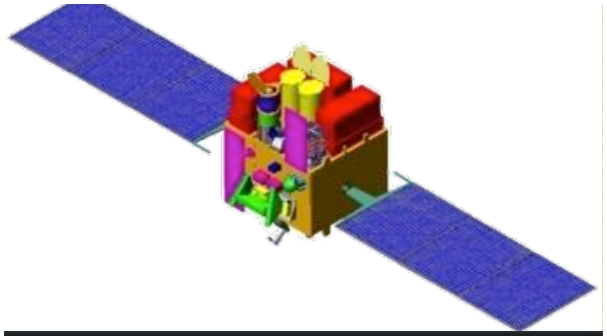
  IUCAA SSM, CZTI

  RRI LAXPC

  PRL, Universities,

- Leicester Uty (SXT), Canadian Space Agency (UVIT)

ASTROSAT



- **IRS (Indian Remote Sensing) Class**
- **Launch PSLV C30** from SHAR
- Altitude : 650 km; **Inclination : 6 deg.**
- Mass 1550 kg. (780 kg. Payloads)
- Power : 2200 watts
- **200 Gb (210 Mb/sec)**
- Satellite Positioning System for orbit and time data
- **Payload pointing (3σ): 0.05 degree**
- **Slew rate : 0.6 deg/sec**
- **Launch: 3rd quarter of 2015**
- Operational life > 5 years

Slide courtesy: K S Sarma

LAXPC:

Large area Xenon-filled Proportional Counters

Energy range : 3 – 80 keV

Time Resolution: 10 μsec

Dead time : 50 μsec

Area : 6000 cm^2

E /ΔE ~ 3 - 7

Event Analysis Mode : *Time Tagged events (*10 μsec), *pulse height and layer ID.*

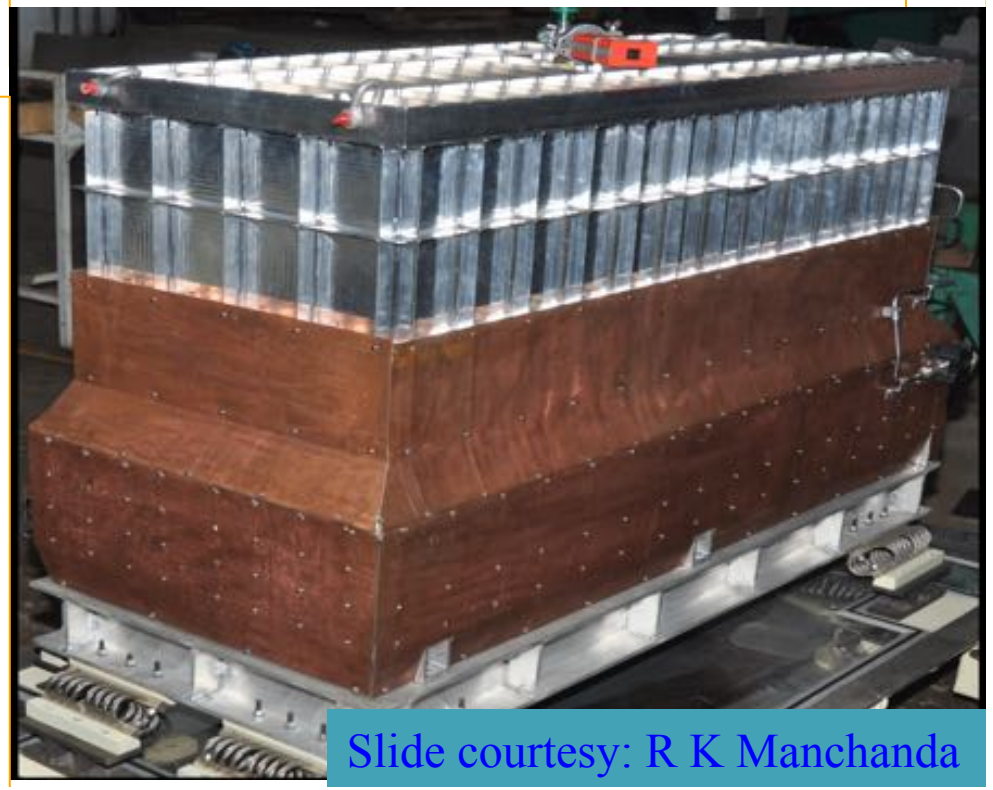
Broad Band Counting Mode: *Rate in various energy bands with selectable periods (8 ms to 1024 ms)*

Fast Counter Mode: *Event rate in top layer of detector in 4 different energy bands in* 160 μsec *(3.0-6.0 keV, 6.0-8.0 keV, 8.0-12.0 keV, 12.0-20.0 keV)*

Three identical xenon filled proportional counters. Multi layer and multi cell geometry with 60 anode cells and 28 anti cells

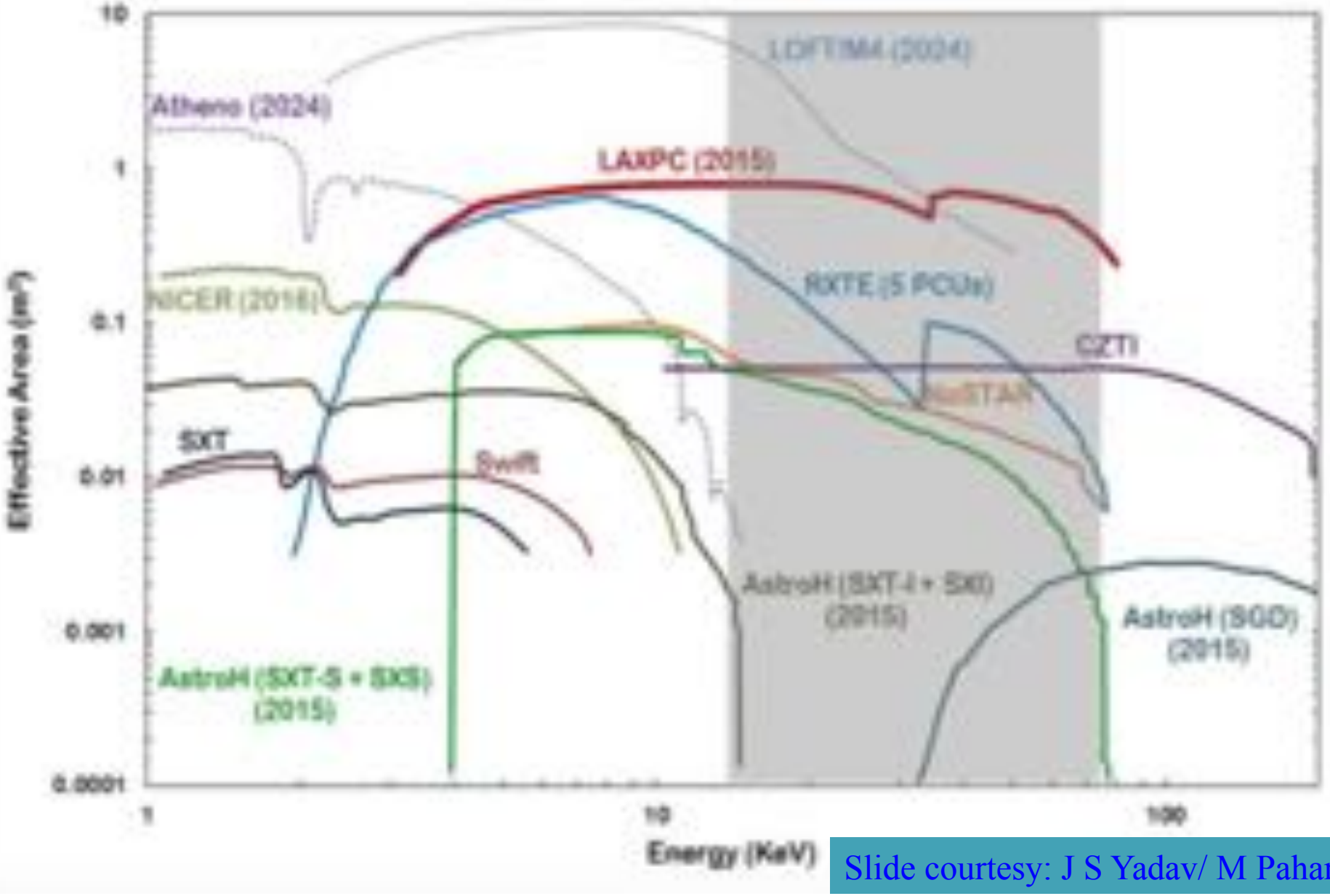
Xenon + methane mixture at a pressure 1500 mm of Hg.

50 micron thick aluminized Mylar window with a FOV of 1°x1°



Slide courtesy: R K Manchanda

LAXPC Effective Area



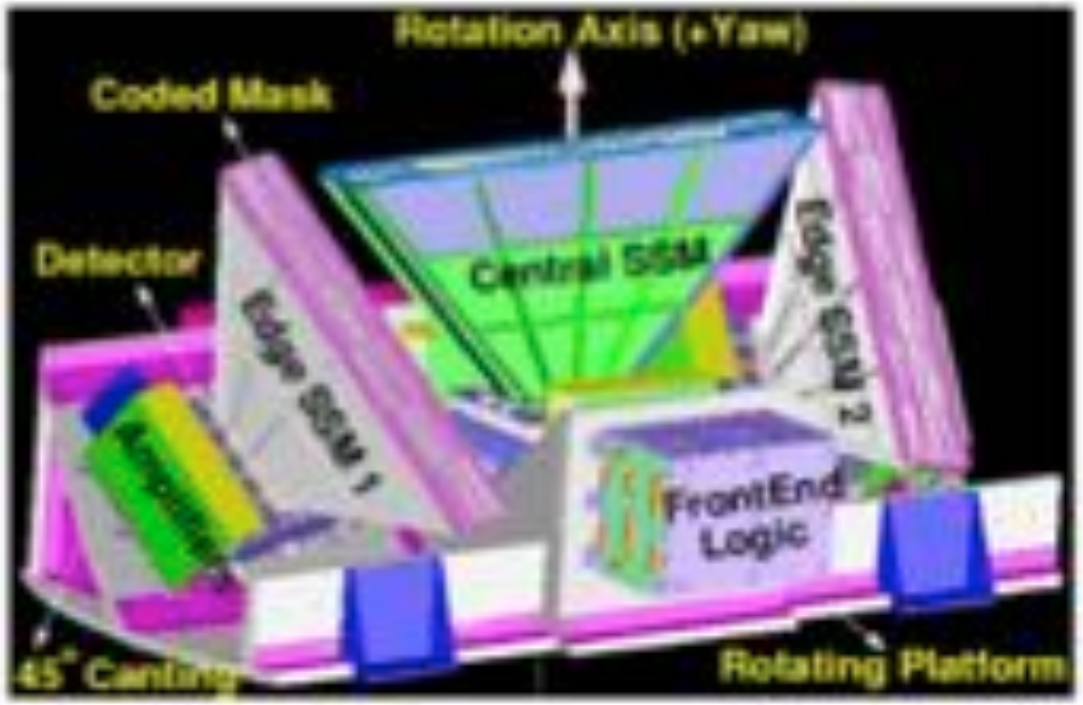
Slide courtesy: J S Yadav/ M Pahari

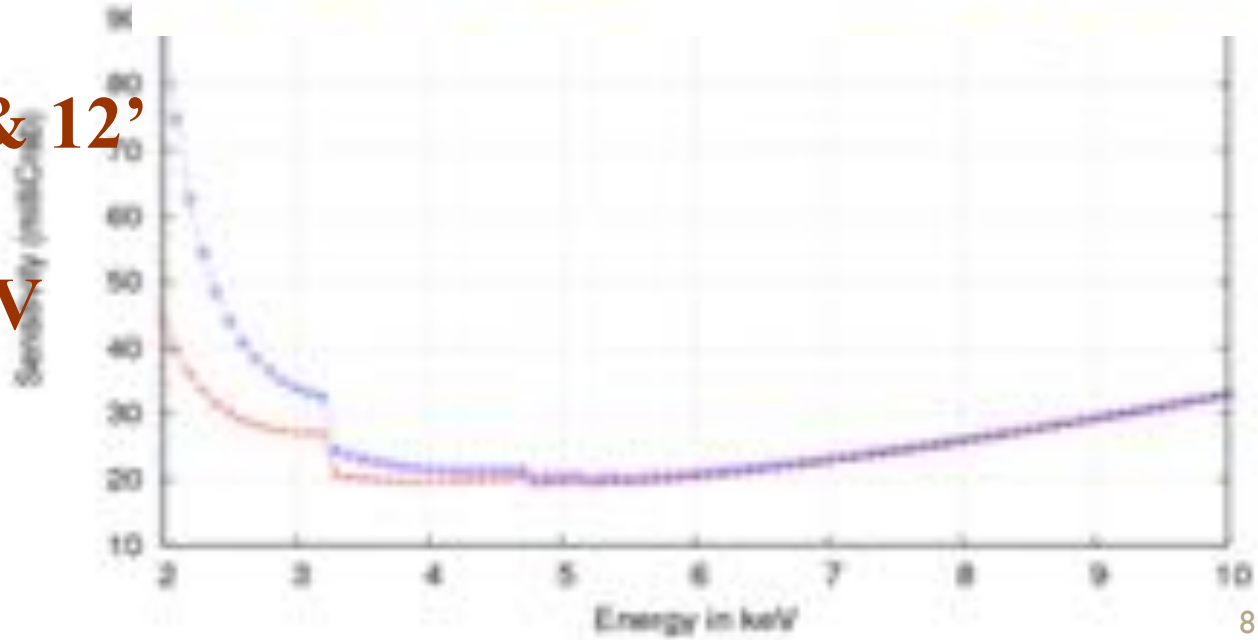
CZT-Imager

Area	1024 cm^2
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^2 (100 – 300 keV) Polarization measurement 6 X 6 (10 – 100 keV) – CAM
Angular resolution	8 arcmin
Energy resolution	5% @ 100 keV
Energy range	10 – 100 keV (100 – 300 keV; uncollimated)
Sensitivity	0.5 mCrab (5 sigma; 10^4 s)

Scanning Sky Monitor (SSM)

- 3 PSPC
- Area 60 cm^2 (5 keV)
- Ang res. : 2.5^o & 12’
- Res 20%@ 6 keV





Soft X-ray Telescope (SXT)

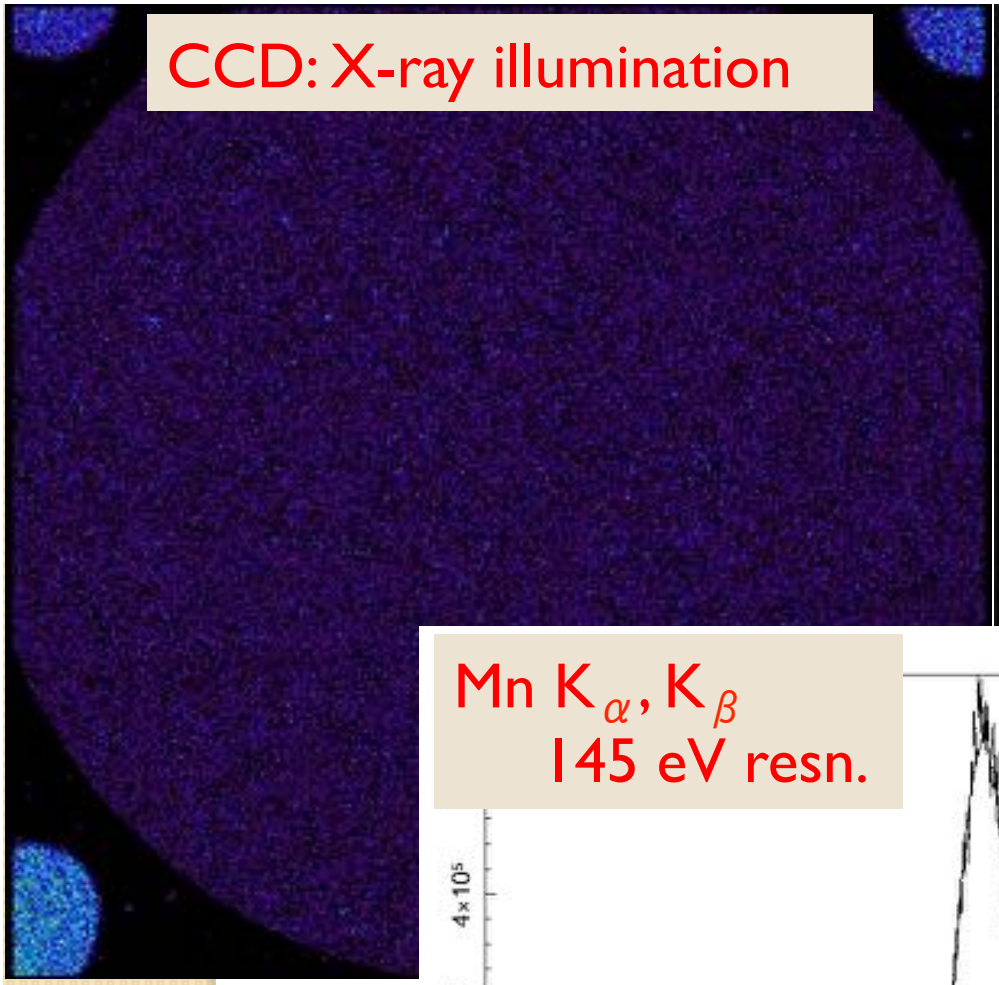
Telescope Length: 2465 mm (Telescope + camera + baffle + door)
Top Envelope Diameter: 386 mm
Focal Length: 2000 mm
Epoxy Replicated Gold Mirrors on Al substrates in conical Approximation to Wolter I geometry.
Radii of mirrors: 65 - 130 mm; Reflector Length: 100 mm
Reflector thickness: 0.2 mm (Al) + Epoxy (~50 microns) + gold (1400 Angstroms)
No. of nested shells : 40
No. of reflectors: 320 (40 per quadrant)
Detector : E2V CCD-22 (Frame-Store) 600 x 600

Field of view : 41.3 x 41.3 arcmin

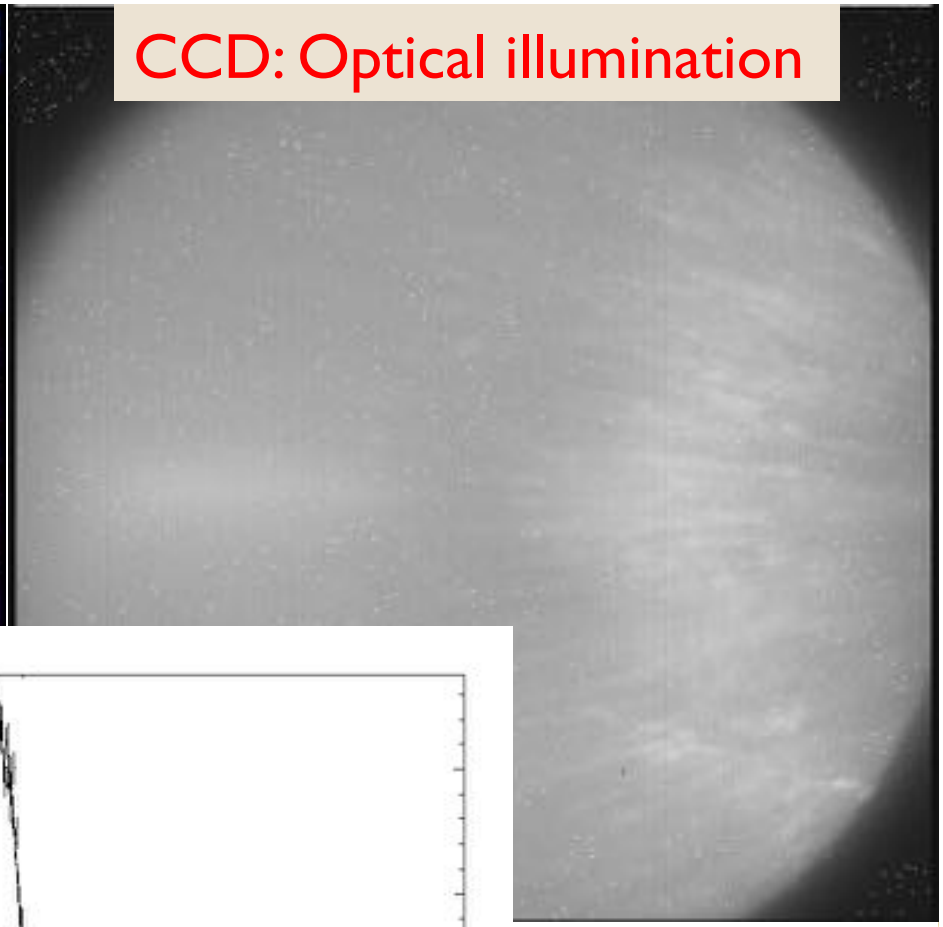
PSF: ~ 2 arcmins
Sensitivity (expected): 15 μCrab (0.5 cps/mCrab)

Slide courtesy: K P Singh

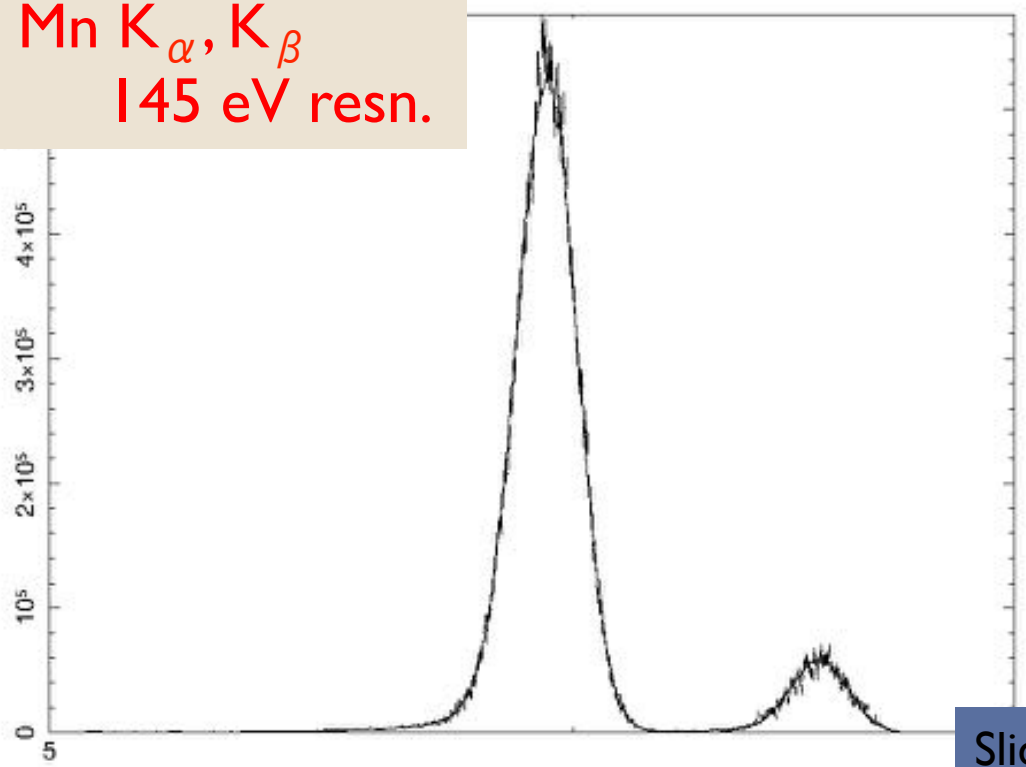
CCD: X-ray illumination



CCD: Optical illumination

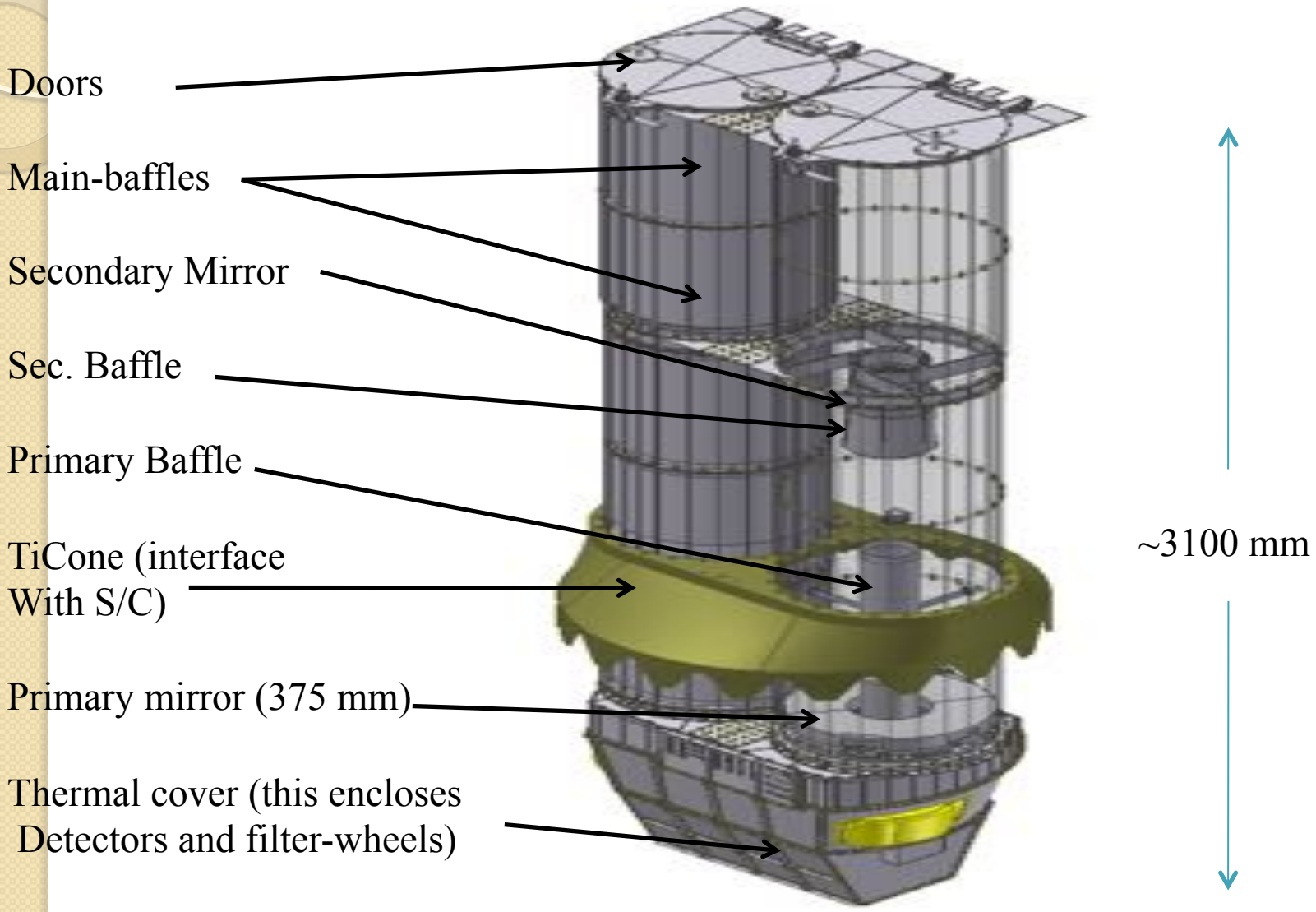


Mn K_α, K_β
145 eV resn.



Slide courtesy: K P Singh

Ultraviolet Imaging Telescope (UVIT)



Slide courtesy: Swarna Ghosh

Comparison of UVIT with GALEX (#1 of 2)

parameter	GALEX	UVIT
No. of telescopes	1	2
Telescope optics	RC, f/6	RC, f/12; RC, f/12
Primary Mirror size (dia)	50 cm	38 cm, 38 cm
FoV (Circular dia)	75 arc-min	28 arc-min
No. of bands	2 (Far-UV =FUV Near-UV=NUV)	3 channels FUV (125-180 nm) NUV (180-300 nm) Visible=VIS (320-550 nm)
Filters in FUV	1 fixed band	4 filters
Filters in NUV	1 fixed band	5 filters
Filters in VIS	-------	5 filters

Slide courtesy: Swarna Ghosh

Comparison of UVIT with GALEX (#2 of 2)

parameter	GALEX	UVIT
Slitless Spectroscopy with	Grism	Grating
Spectral Resolution	R ~ 100-200	R ~ 100-200
No. of grism/grating	1 per band	2 per band (orthogonal pair)
Angular resolution(FWHM)	4.5-6.0 arc-sec	< 1.8 arc-sec
Peak Effective area	FUV : 37 cm^2 NUV : 62 cm^2	FUV : ~15 cm^2 NUV : ~50 cm^2 VIS : 50 cm^2
Saturation (m_{AB})	< 10 mag	< 8.0 mag (with ND filter)
Time resolution	~ 10 milli-sec	< 5 milli-sec

Slide courtesy: Swarna Ghosh

X-ray burst science with Astrosat

- Low Inclination
- Continuous time-tagged individual photon data (LAXPC, CZTI & SSM) - micro-seconds accuracy
- Bright source observing capability of SXT
- Facility to adjust SSM observation time
- Hard X-ray (above ~ 80 keV) monitoring capability.
- Significant time devoted for `timing science'

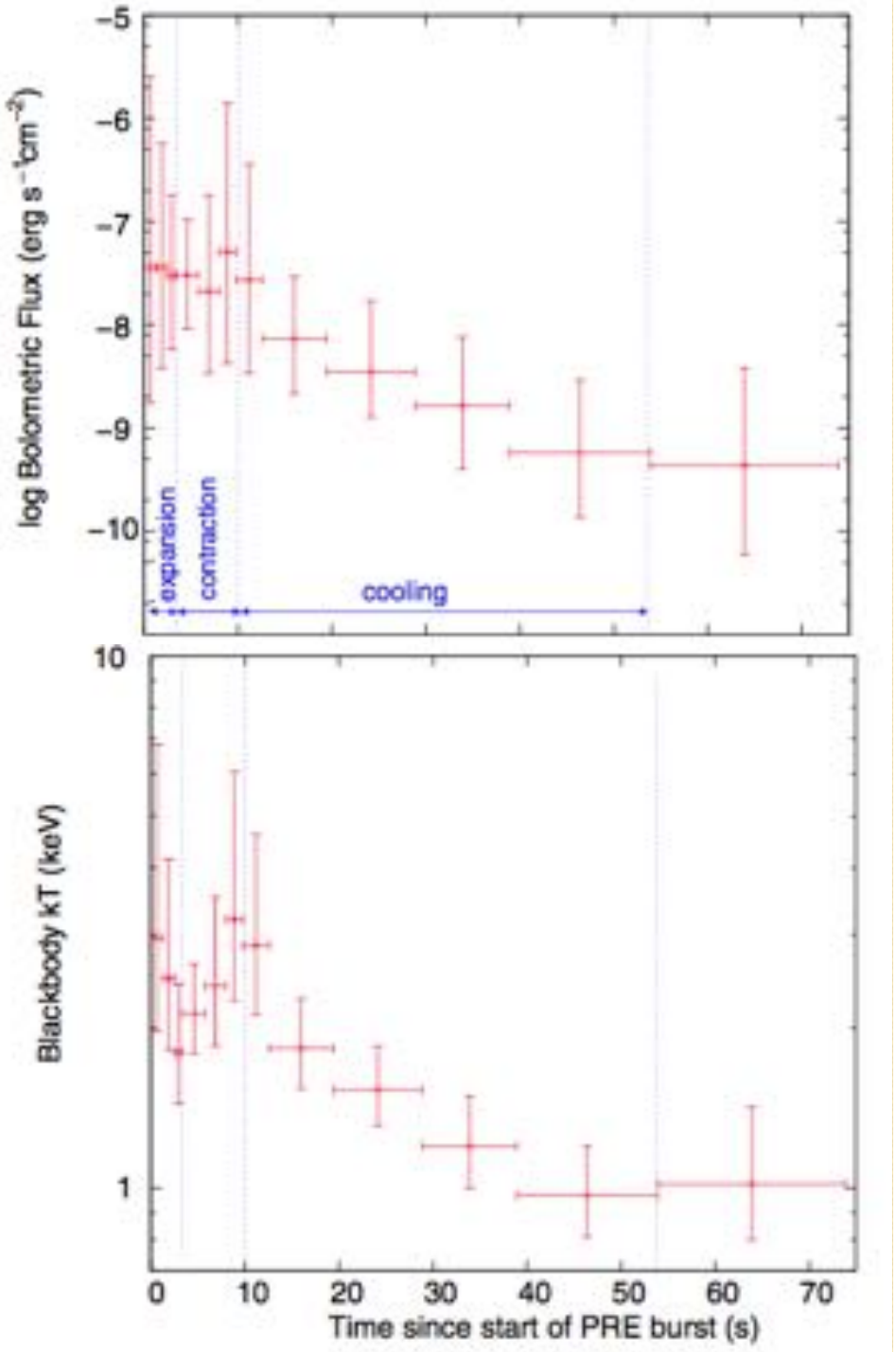
Spectral capability : *Wide band high resolution spectrum*

ASM capability: *Burst statistics*

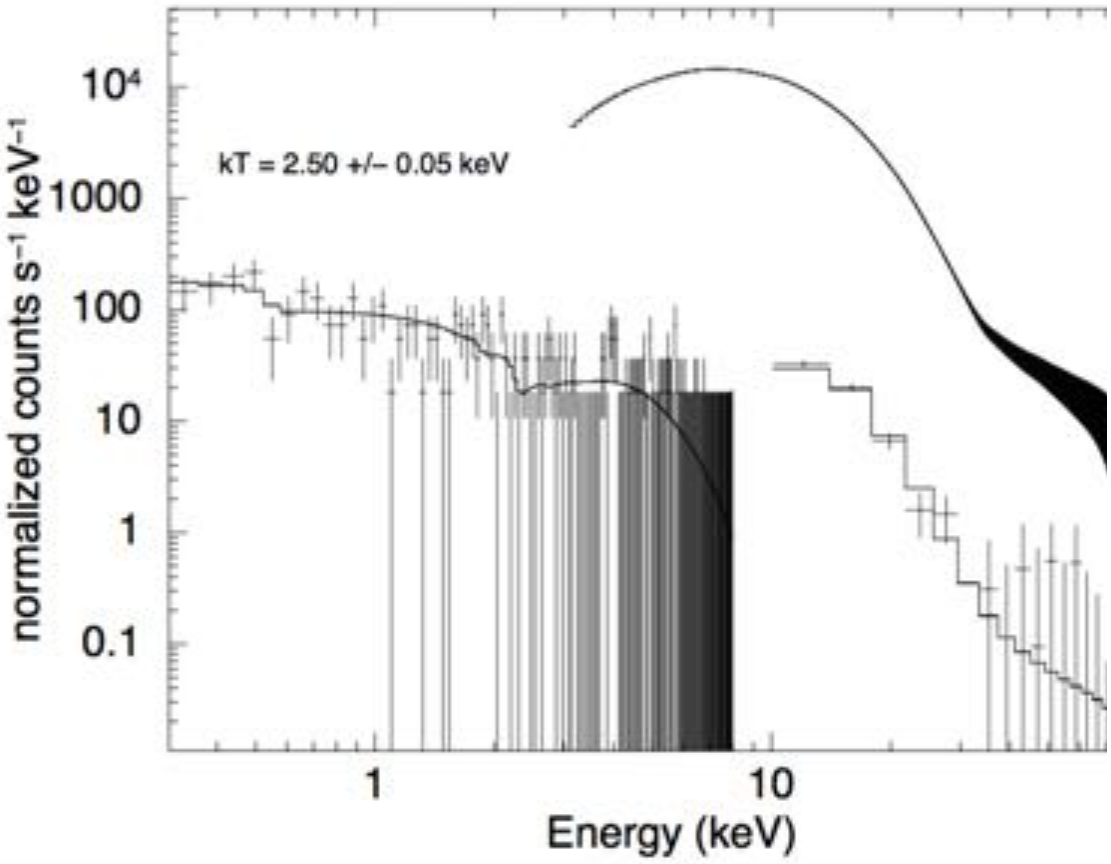
X-ray/ UV-optical association: *Simultaneous multi-filter UV/ optical observations simultaneously with X-ray spectroscopy.*

Rapid burster: XRT (Sala+2012)

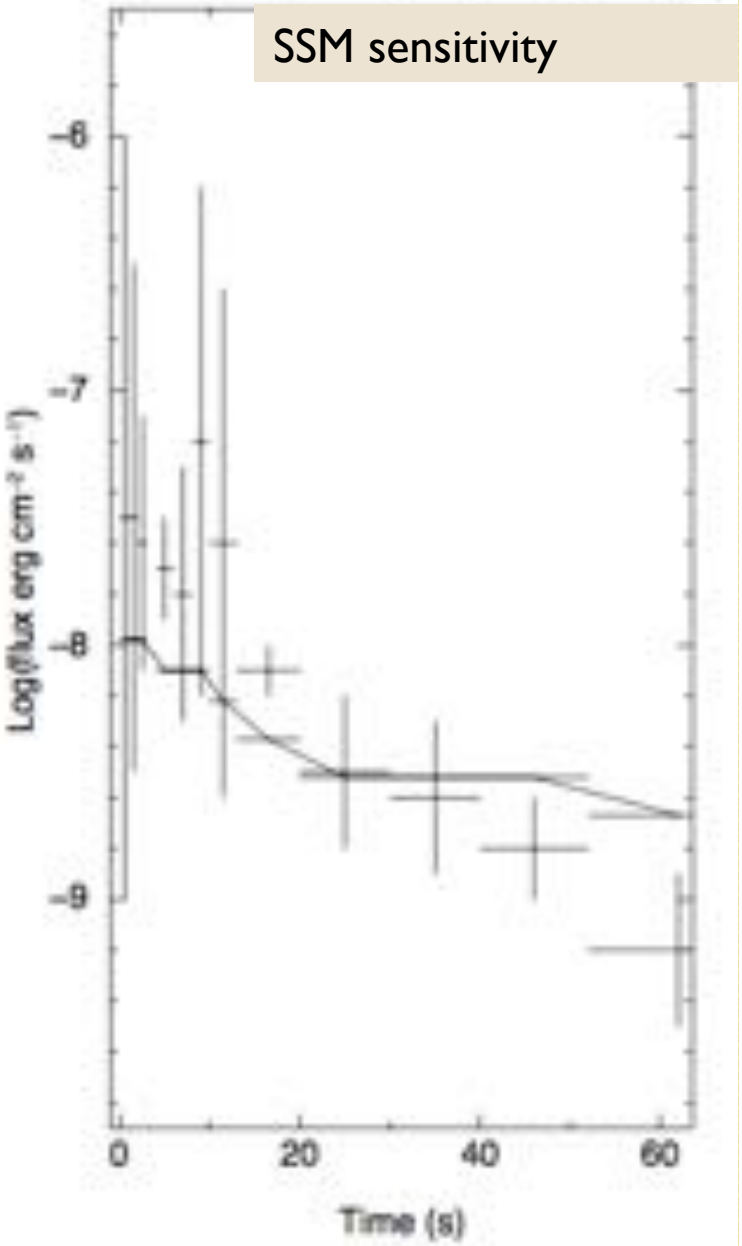
- M = 1.1 ± 0.3 $M_\odot$
- *R* = 9.6 ± 1.5 km



Astrosat spectra (1 s)



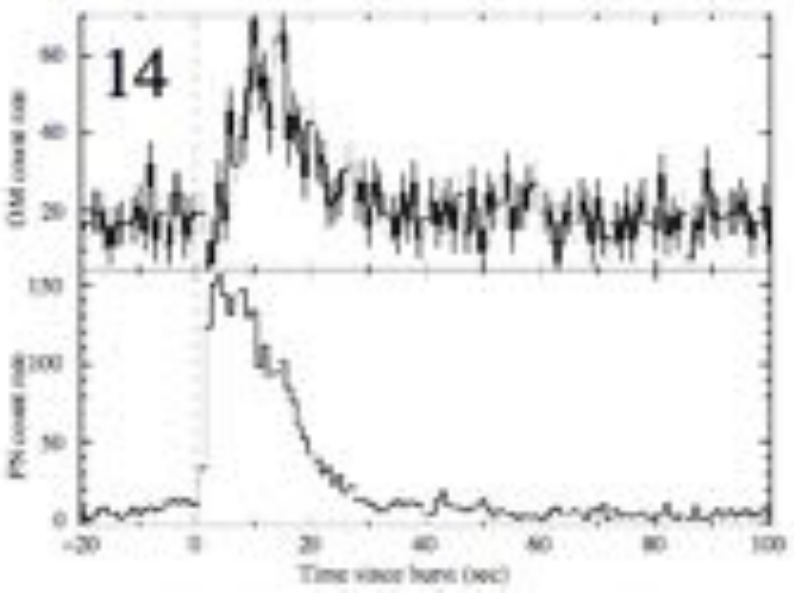
SSM sensitivity

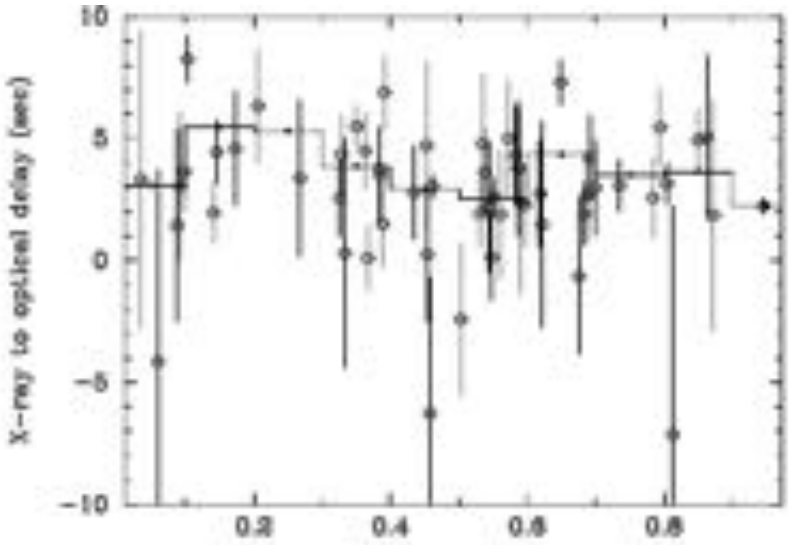


- Accurate temperature
- Dead time/ pile-up correction
- Other spectral components (in ‘t Zand+ 2013)

X-ray/ UV-optical association

- EXO 0748-676 (Paul+2012)
- A few seconds delay, no association with binary orbit:
  - accretion disk, companion ?
- X-ray spectroscopy along with simultaneous 3-band (FUV, NUV, opt) observations can be used to measure precise transfer function and binary parameters.





Conclusions

- Astrosat is an observatory class satellite, scheduled to be launched this year.
- X-ray timing measurement is the major thrust of the satellite.
- It will continue the legacy of RXTE for X-ray burst observations.
- Wide band X-ray spectroscopy and multi-wavelength observations from a single platform will add to our understanding of X-ray bursts.