ASTROSAT CALIBRATION

Dipankar Bhattacharya, IUCAA, Pune
on behalf of the Astrosat collaboration

ASTROSAT

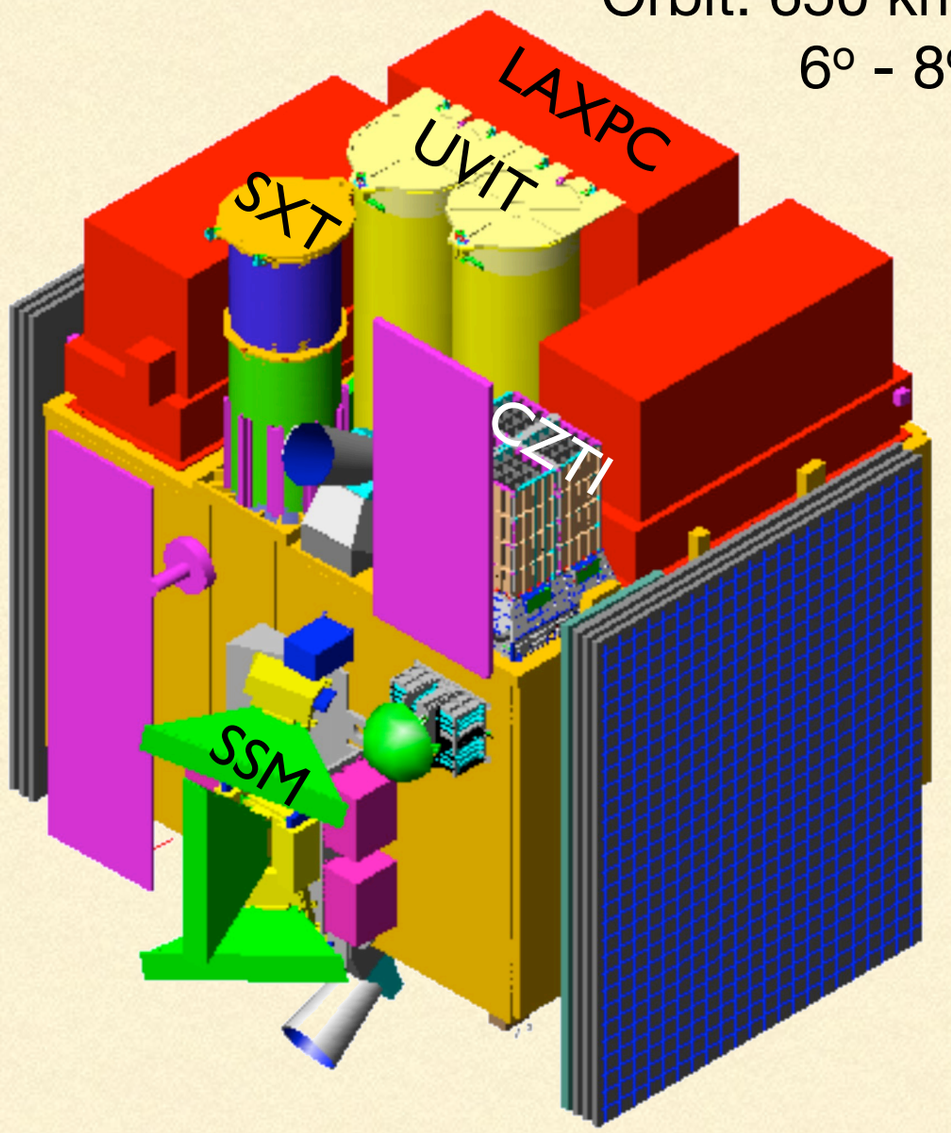
A Satellite Mission for Multi-wavelength Astronomy

Indian Space Research Organisation

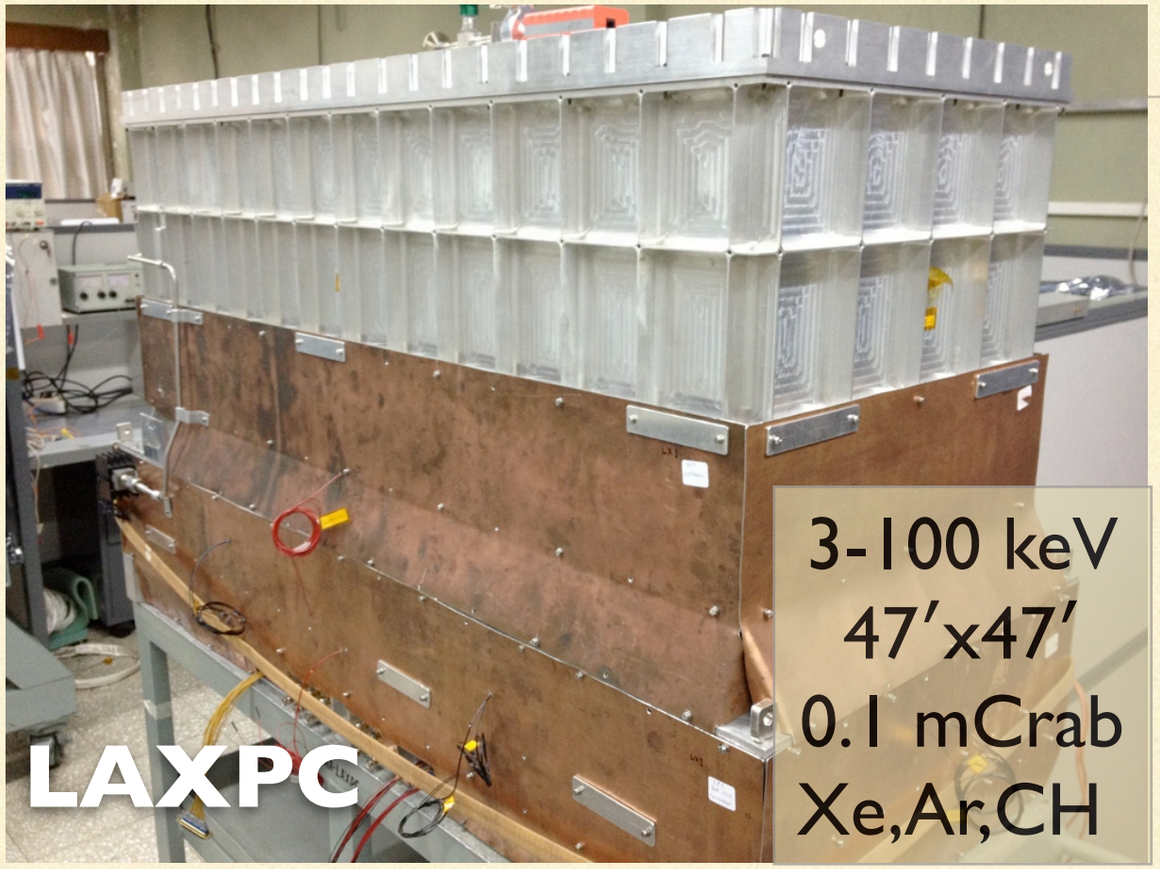
http://astrosat.iucaa.in/

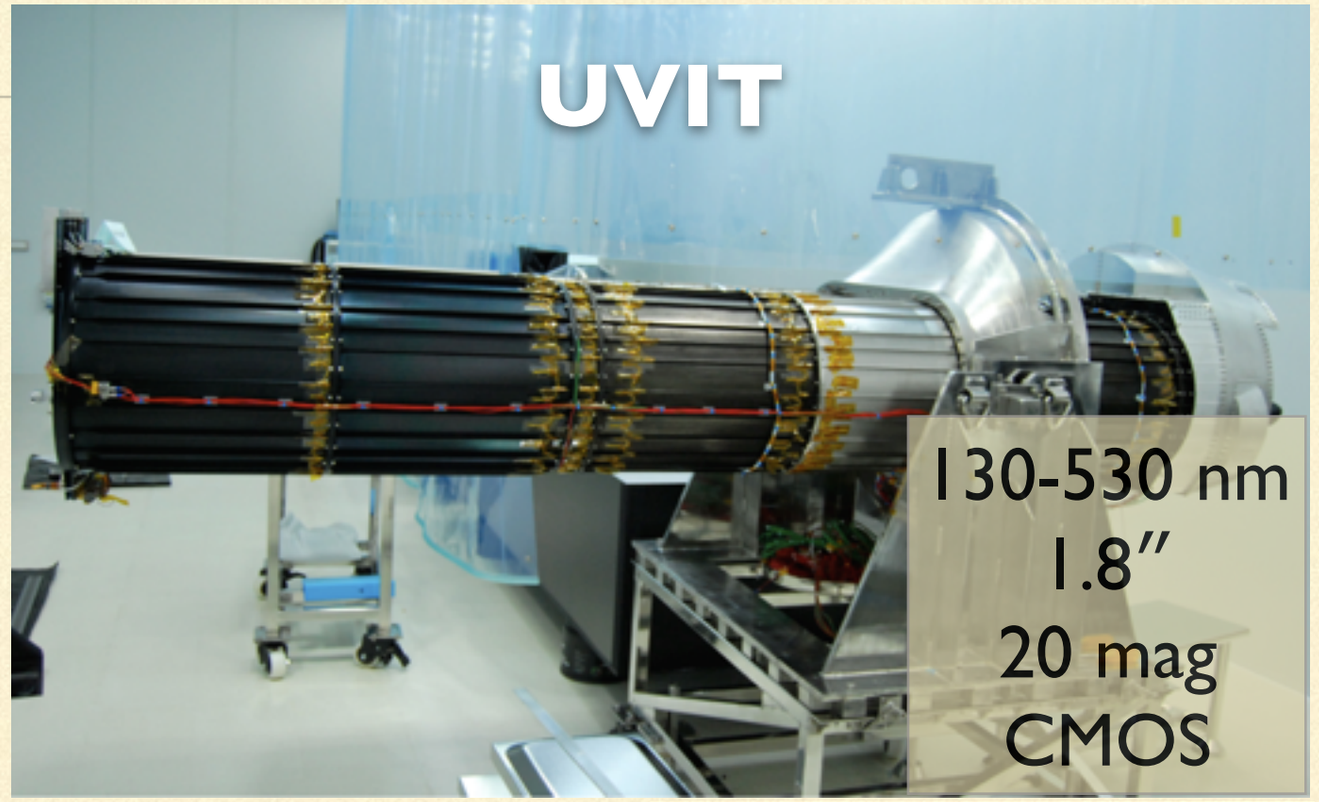
India's first dedicated astronomical observatory in space

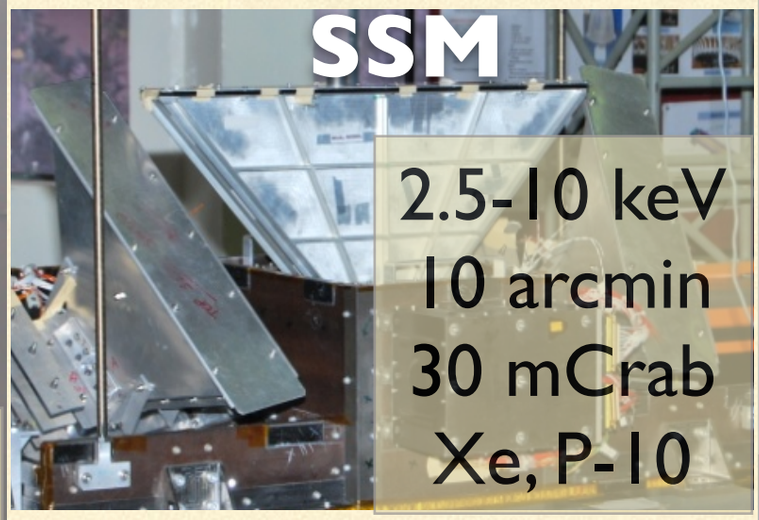
- Five science payloads covering Opt/UV to hard X-ray bands for simultaneous multi-wavelength timing and spectroscopy
- *All science payloads delivered*
- *Final integration ongoing*
- **Being readied for Oct 2015 launch**



PRL RRI University of Leicester





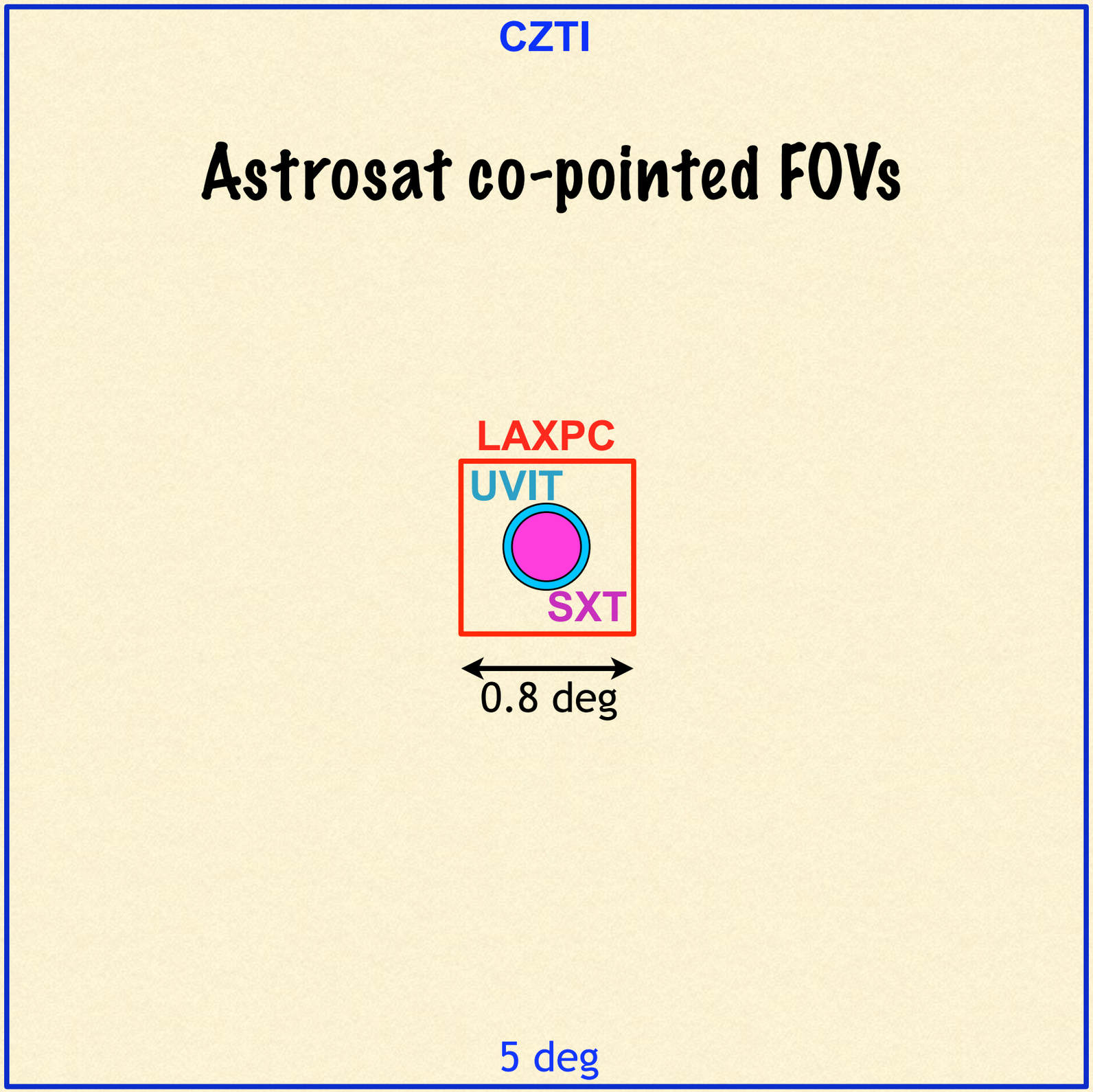


ASTROSAT SCIENCE PAYLOADS

Dipankar Bhattacharya

IACHEC 2015 Beijing

Astrosat co-pointed FOVs



CZTI:
128x128 array
+ Coded Mask

LAXPC:
Collimator

UVIT:
MCP+CMOS
512x512

SXT:
Foil Mirrors +
600x600 CCD

SSM 3
10’

LAXPC 47’

Astrosat angular resolutions

UVIT 1.8”

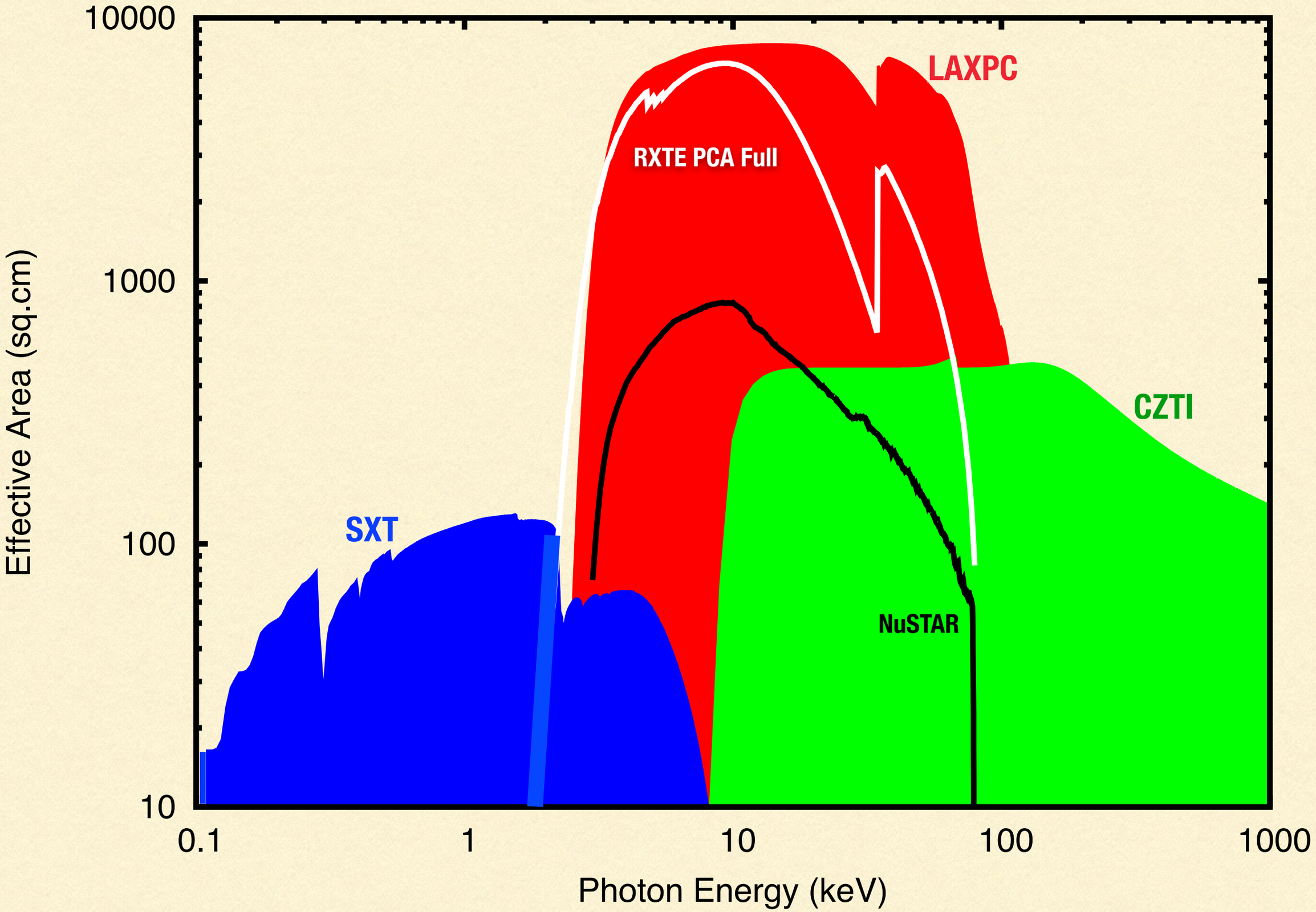
CZTI 8’

SXT 3’

SSM 2: 13’

SSM 1: 13’

Astrosat X-ray instrument effective areas



ASTROSAT will be a proposal-driven observatory-class mission

(*AO will be opened 1 year after launch; 1st 6m PV, followed by 6m of GT*)

Major interest areas of X-ray instruments will include

- Strongly Magnetic Neutron Stars: Cyclotron Spectra, HE continuum

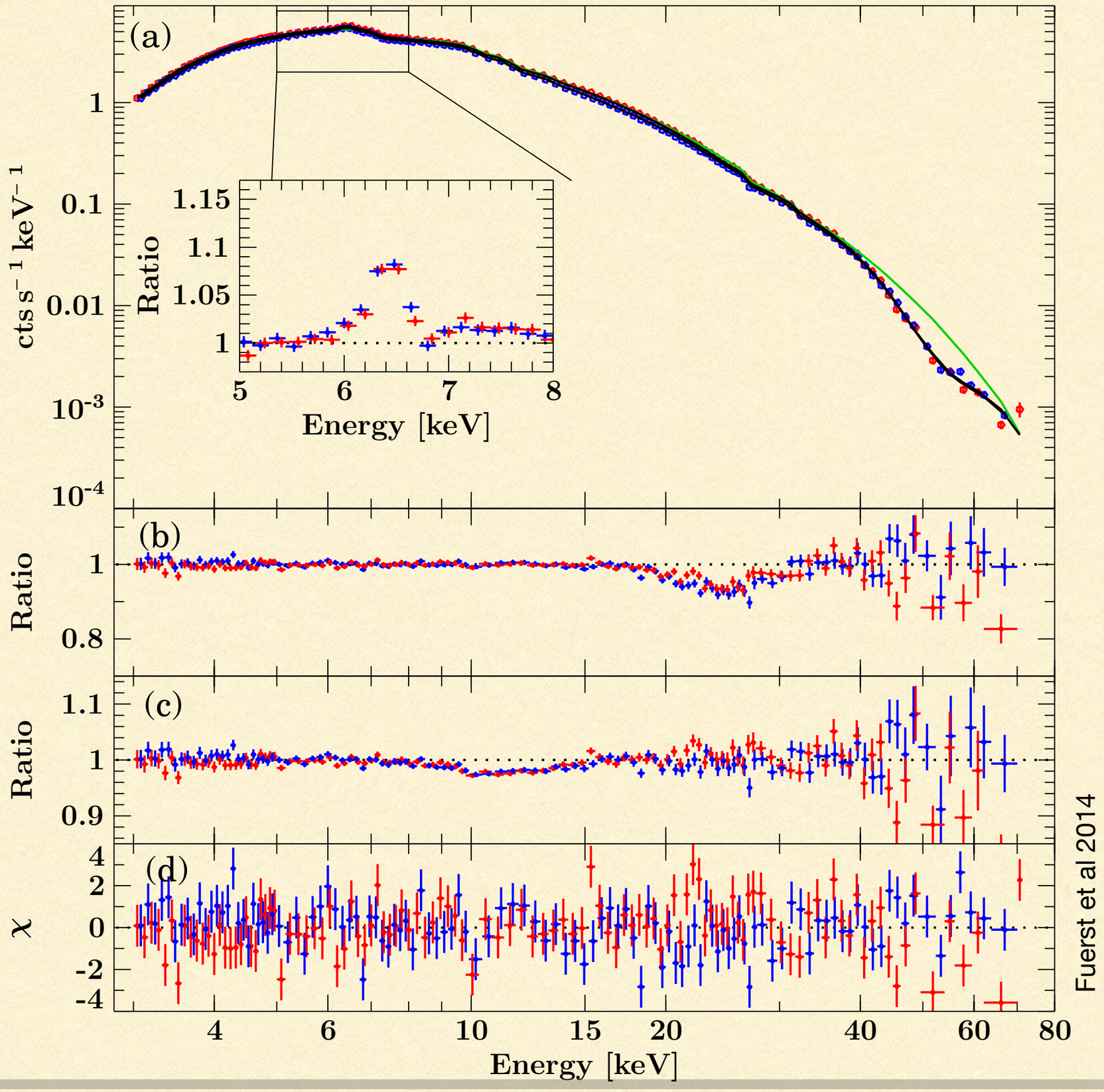
  (*structure and evolution of neutron star magnetic fields, radiation processes*)

- Wideband Spectral Variability Monitoring

  (*accretion disk geometry, emission mechanism, QPO origin, disk-jet connection*)

- Transients

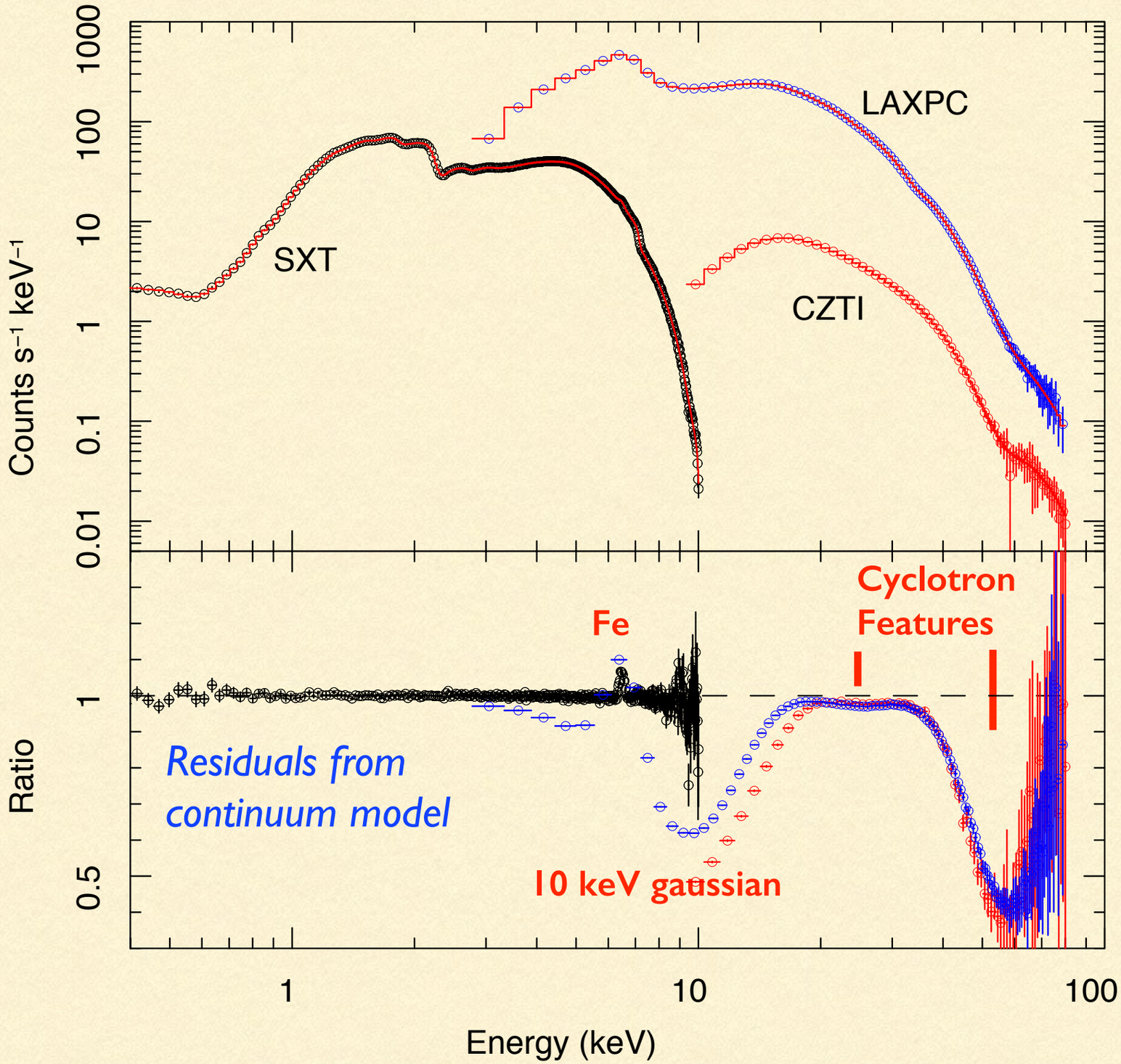
Vela X-1, NuSTAR, 42 ks



ASTROSAT Simulation

Target : Vela X–1

Model: (constant(1)*tbabs(1) + (1. – constant(1))*tbabs(2))* (fdcut(1) * gabs(1) * gabs(2) + gaussian(1) + gaussian(2) + gaussian(3))



Exposure: 50.0ks

Count Rates

SXT: 222.14 count/s

CZTI: 118.16 count/s

LAXPC: 5306.77 count/s

Flux (erg/cm^2/s):

SXT(0.5–2 keV): 1.7e–09

SXT(2–10 keV): 8.1e–08

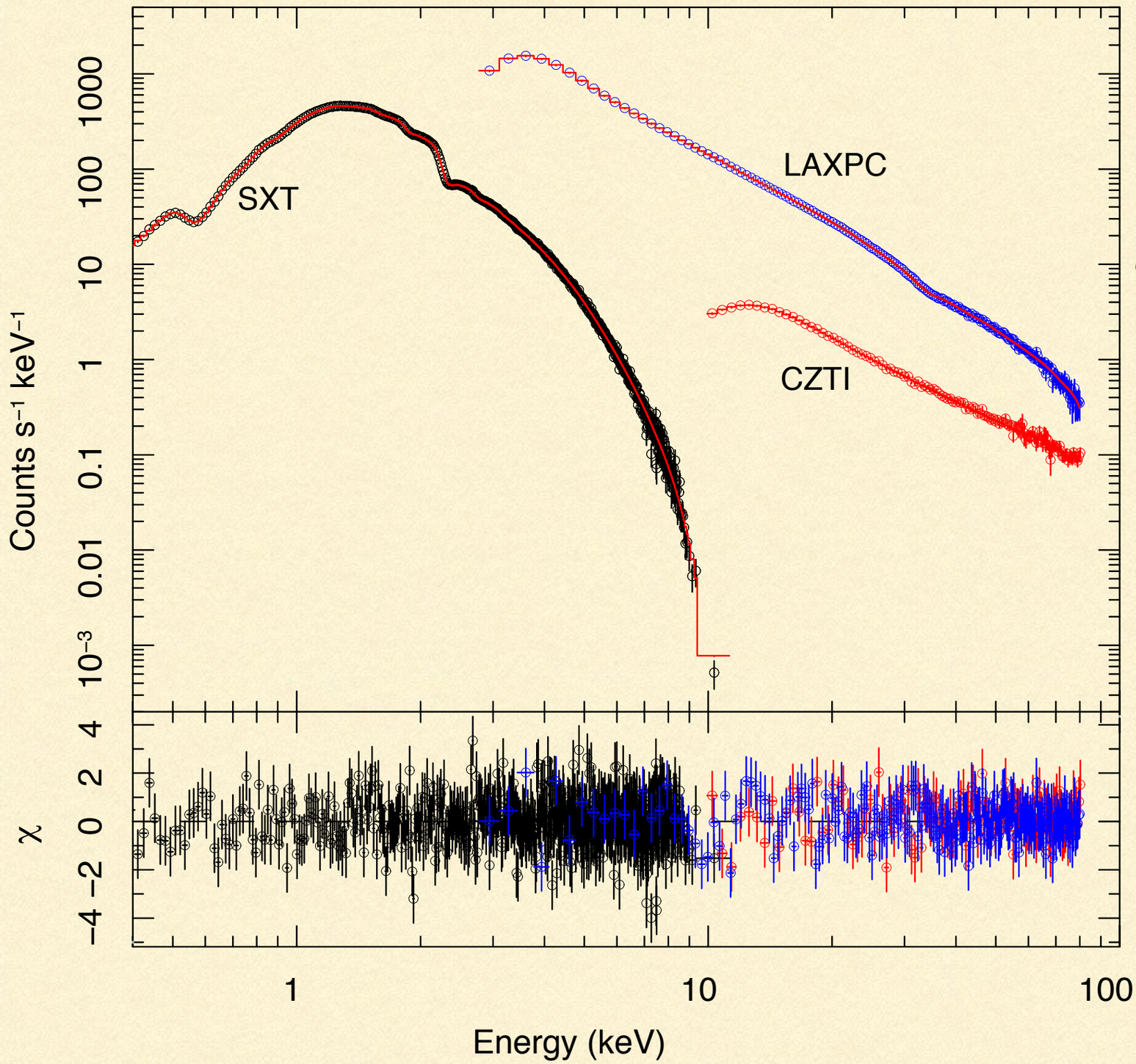
CZTI(10–100 keV): 9e–09

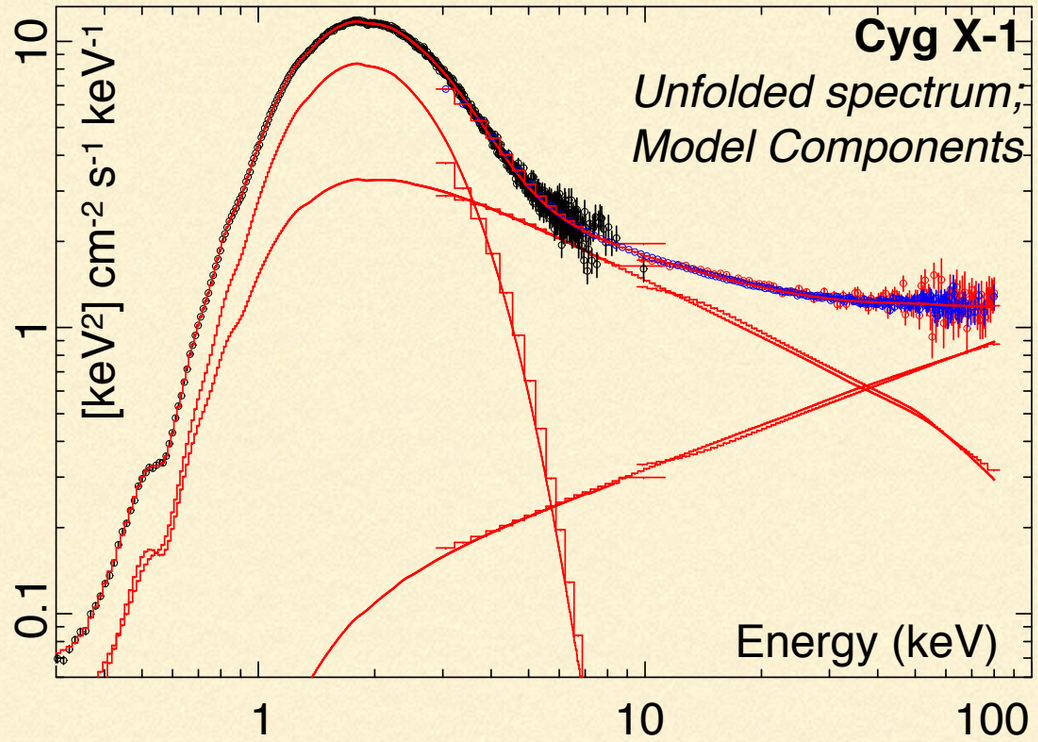
LAXPC(3–80 keV): 1.81e–08

ASTROSAT Simulation

Target : Cygnus X–1

TBabs*(diskbb + powerlaw*highecut + powerlaw(2)*highecut(2))





Exposure: 10.0ks

Count Rates

SXT: 565.4 count/s

CZTI: 62.97 count/s

LAXPC: 5647.23 count/s

Flux (erg/cm^2/s):

SXT(0.5–2 keV): 1.2e–08

SXT(2–10 keV): 1.4e–08

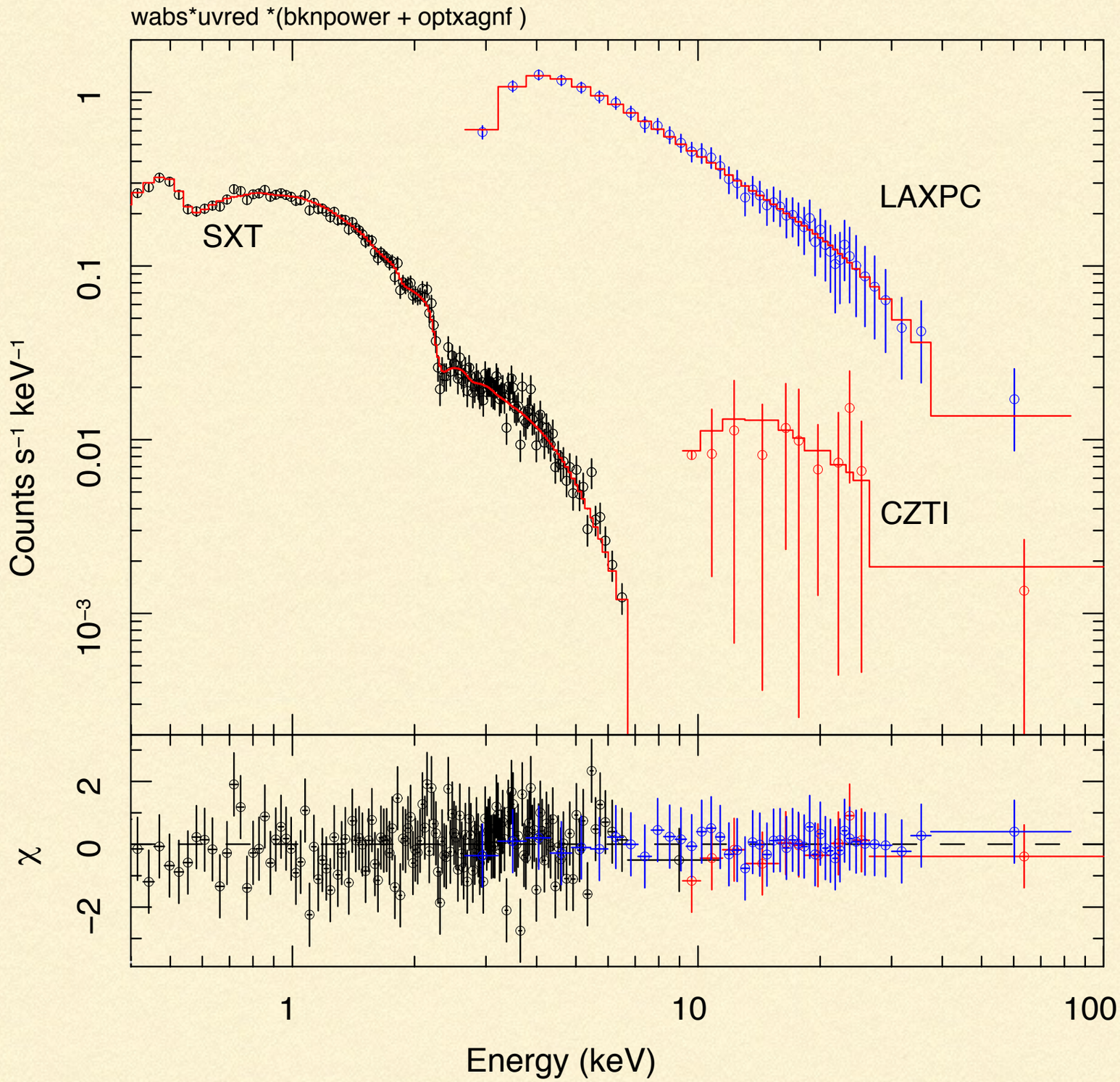
CZTI(10–100 keV): 4.8e–09

LAXPC(3–80 keV): 1.2e–08

ASTROSAT Simulation

O-UV-X Spectral Variability: disk-jet connection

Target : 1H0323+342, NLS1–Blazar



Exposure: 50.0ks

Count Rates

SXT: 0.39 count/s

CZTI: 0.31 count/s

LAXPC: 10.62 count/s

Flux (erg/cm^2/s):

SXT(0.5–2 keV): 7.4e–12

SXT(2–10 keV): 1.12e–11

CZTI(10–100 keV): 3.44e–11

LAXPC(3–80 keV): 3.79e–11

Ground Calibration of ASTROSAT X-ray Payloads

- Spectral channel to energy relation
- Spectral resolution
- Effective area
- Timing
- Imaging and FOV

Radioactive Sources

(simulations; need PV for final calibration)

Radioactive Sources,
X-ray gun, optical

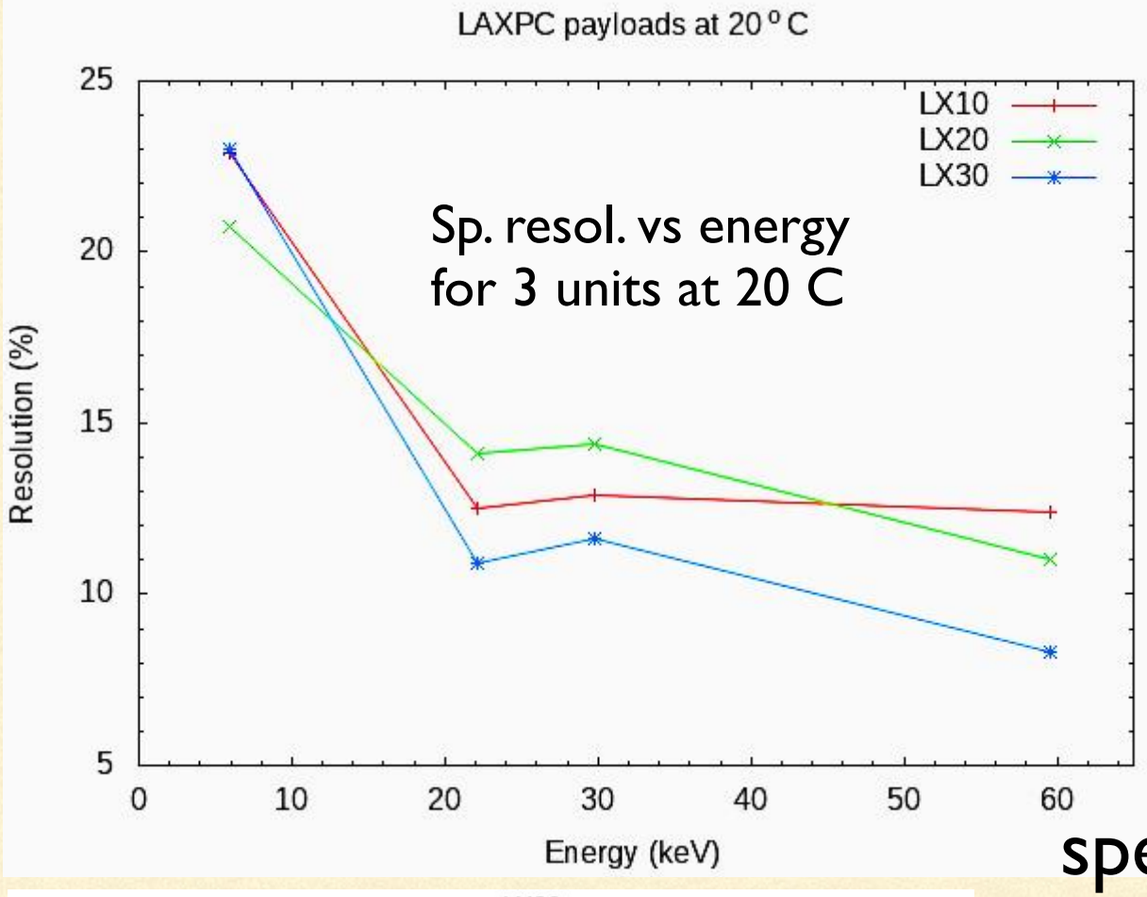
Supplemented by Geant4 simulations

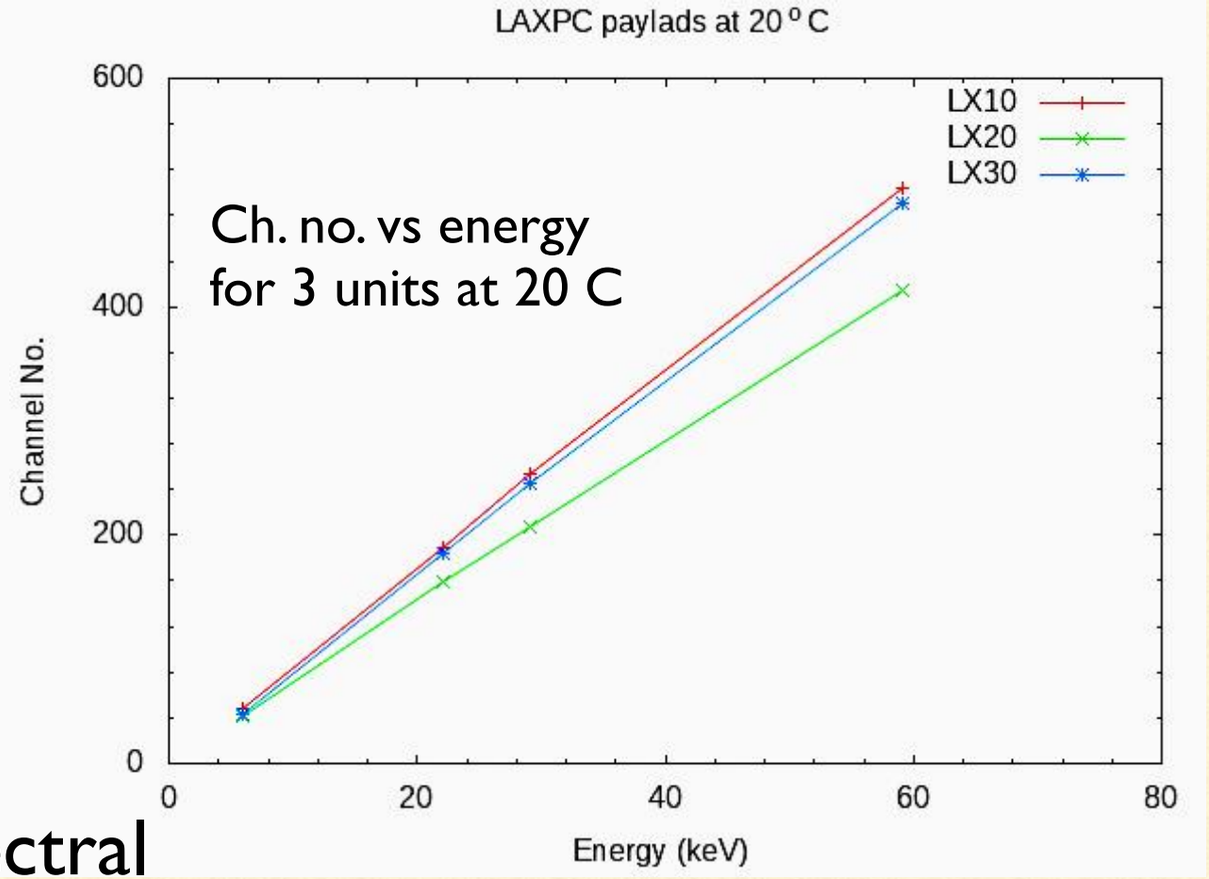
Products generated

Response of detector elements,
Individual and Collective
Dependence on instrument settings, temperature

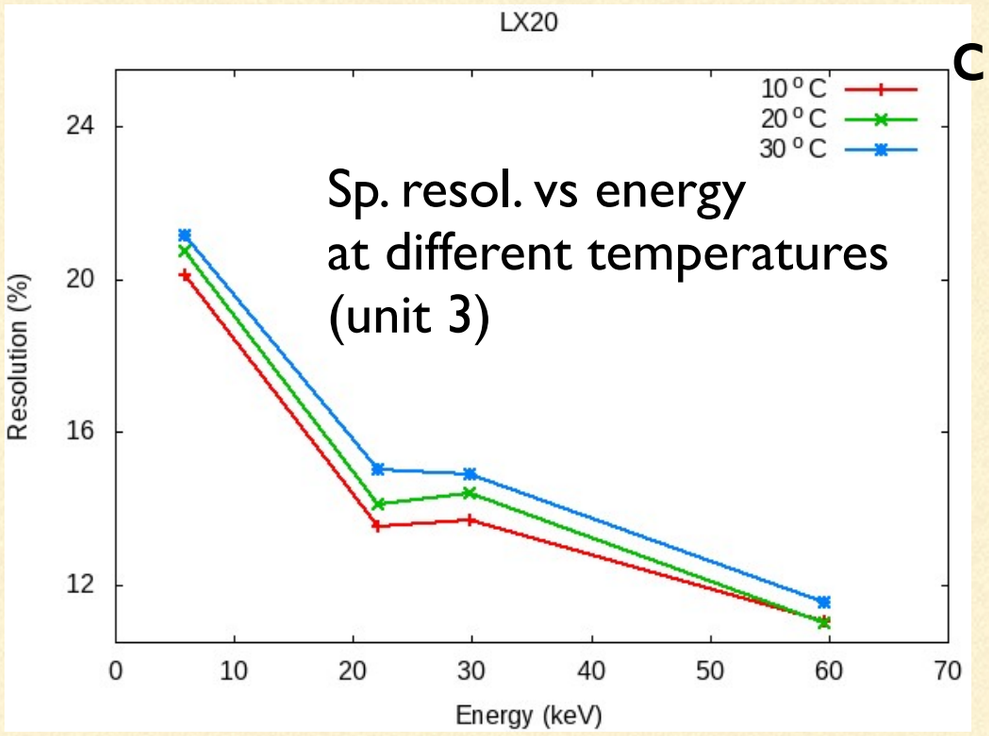
HEASARC CALDB format

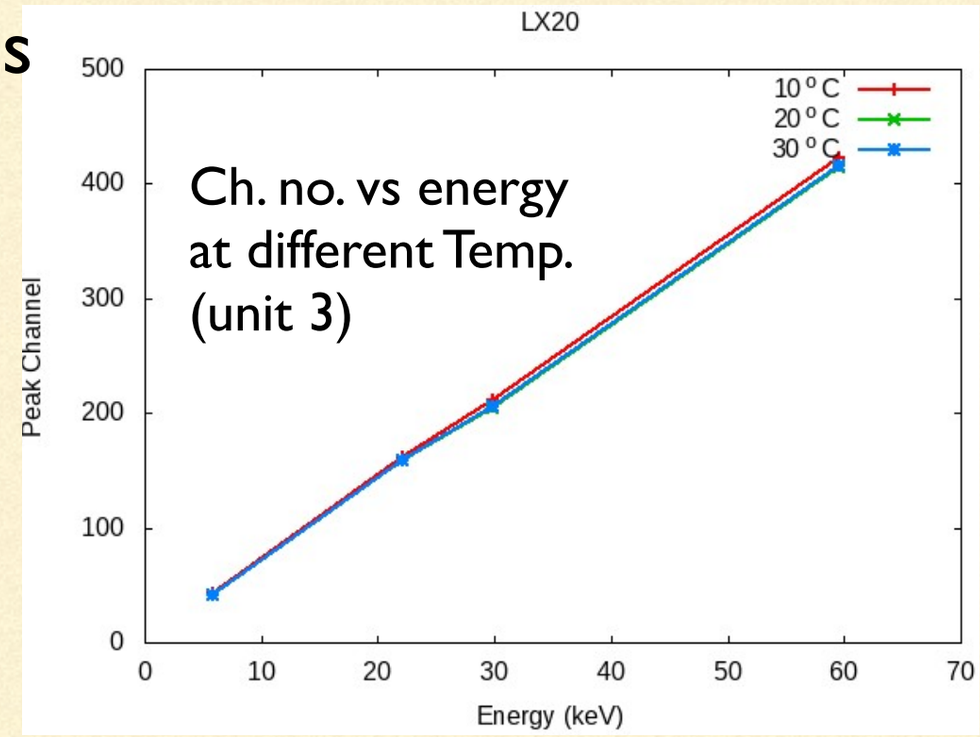
LAXPC: proportional counters (3 units)



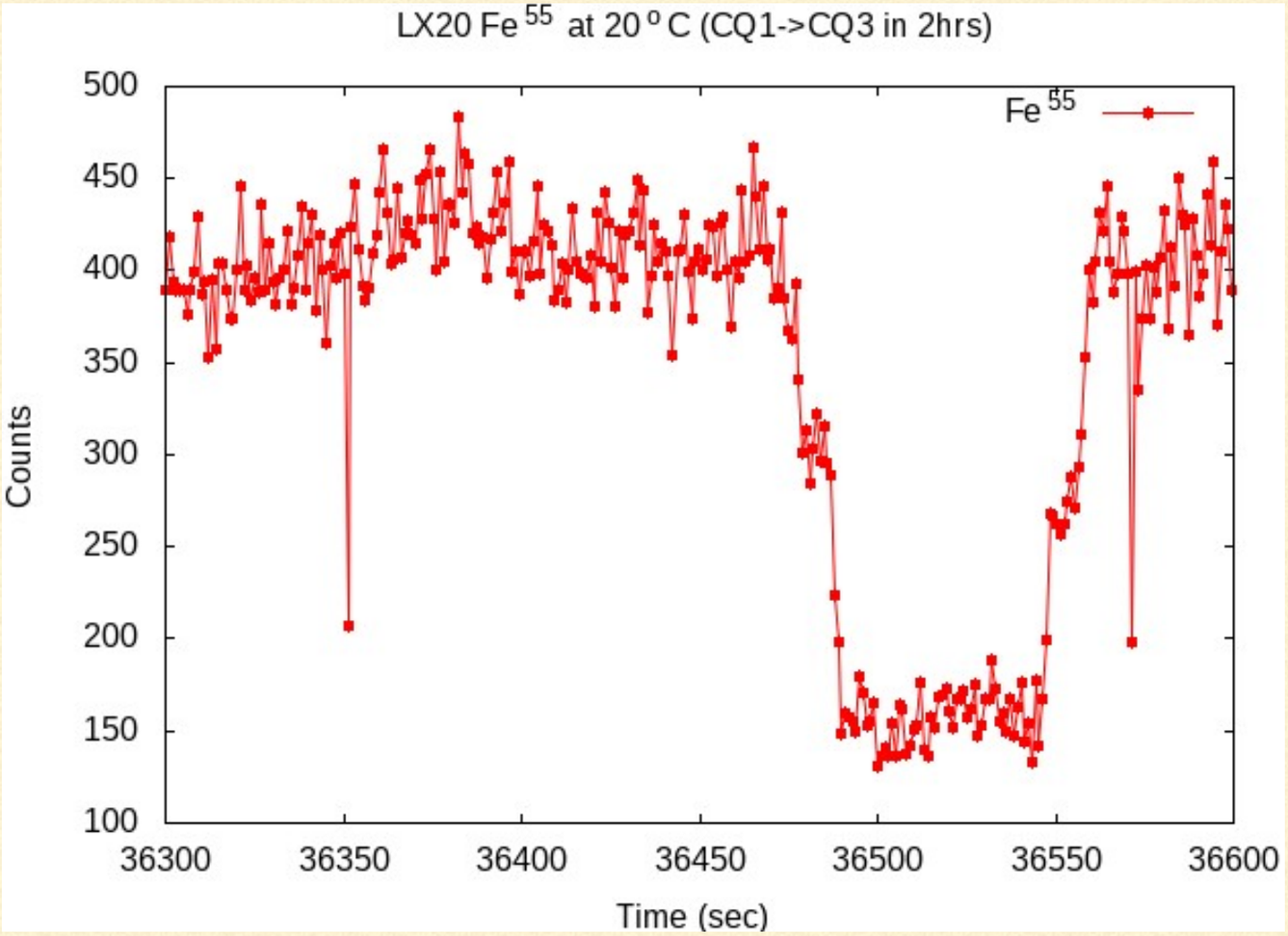


spectral characteristics

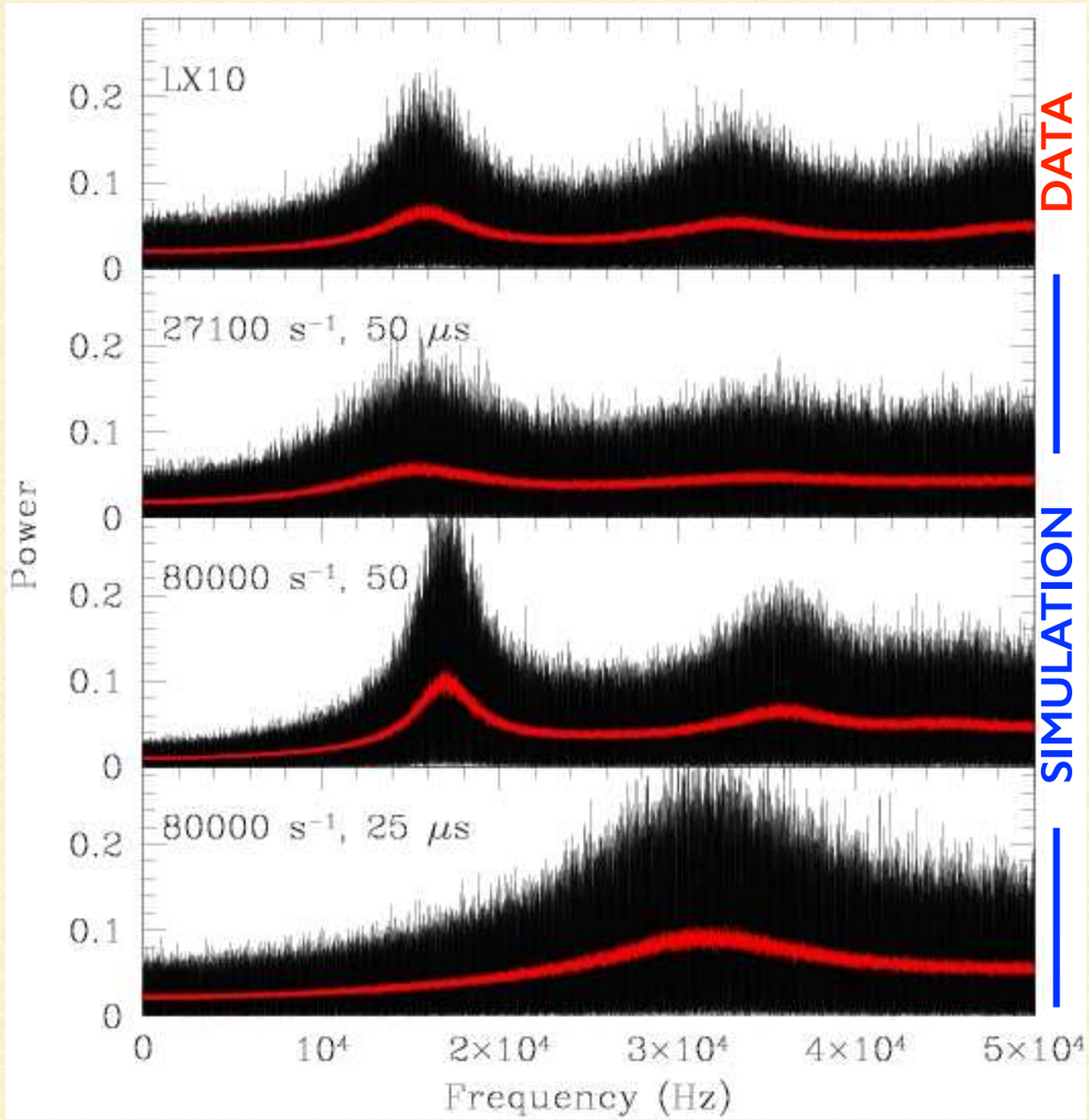




LAXPC



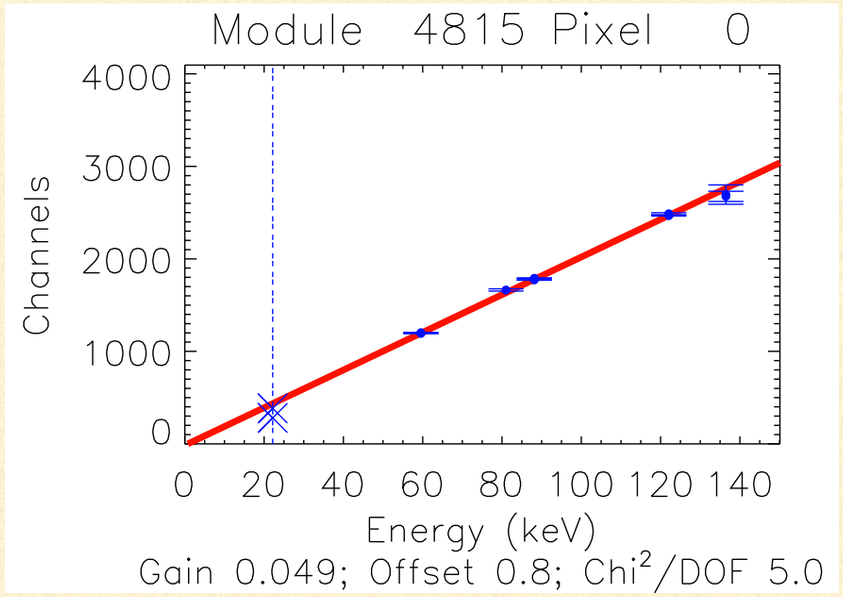
Collimator Profile
from source scan across the detector

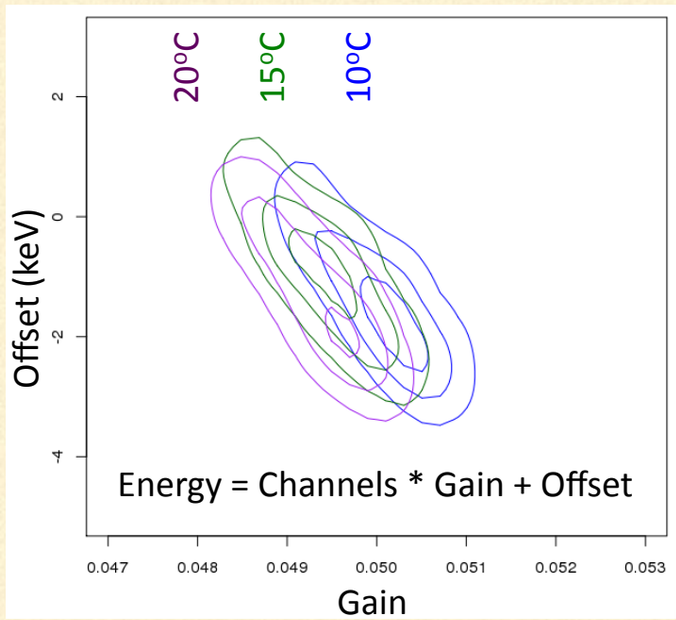


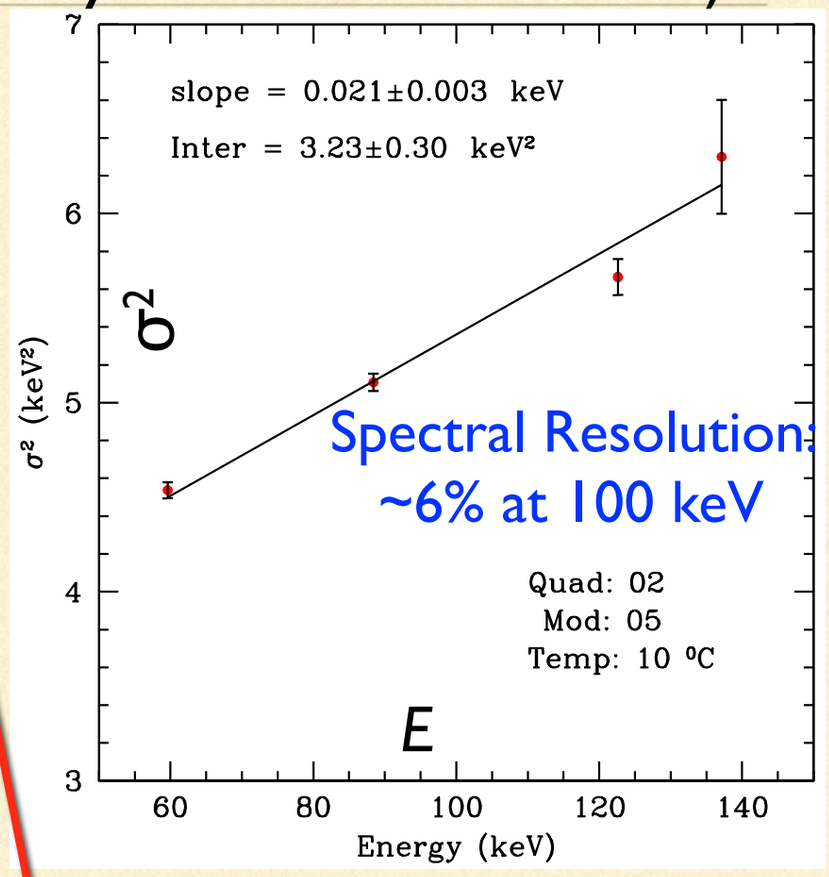
Timing properties:
power spectrum

CZTI: (Cadmium Zinc Telluride pixellated detector array behind Coded Mask)

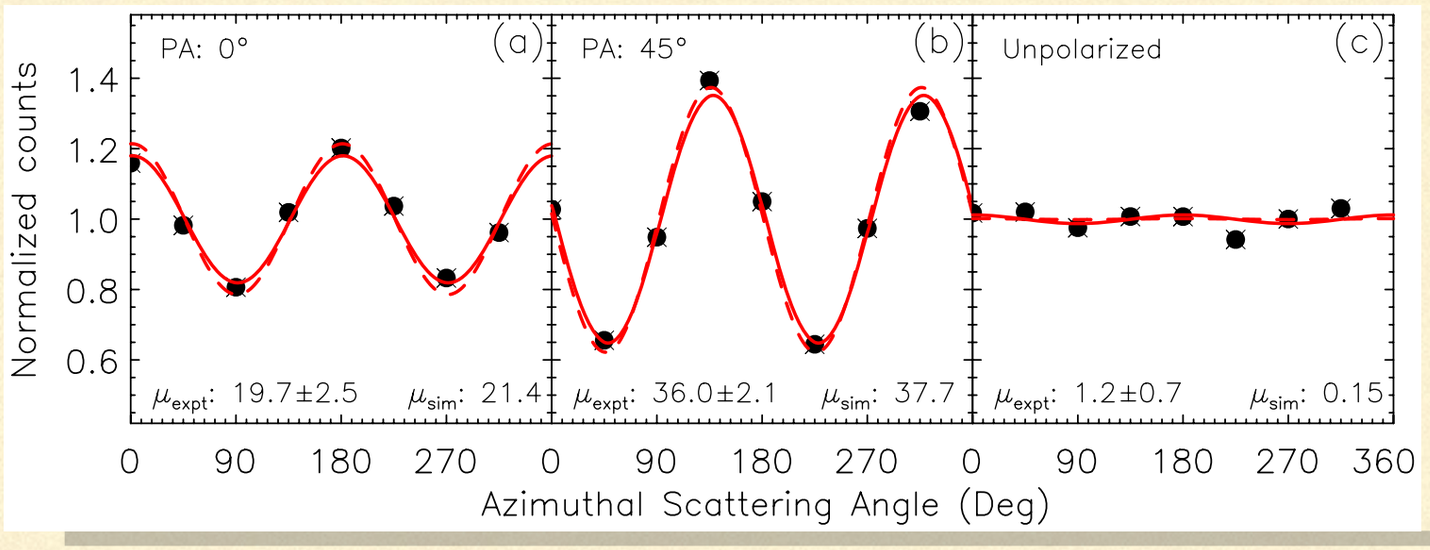
Spectral calibration of individual pixels (Am, Co, Cd)

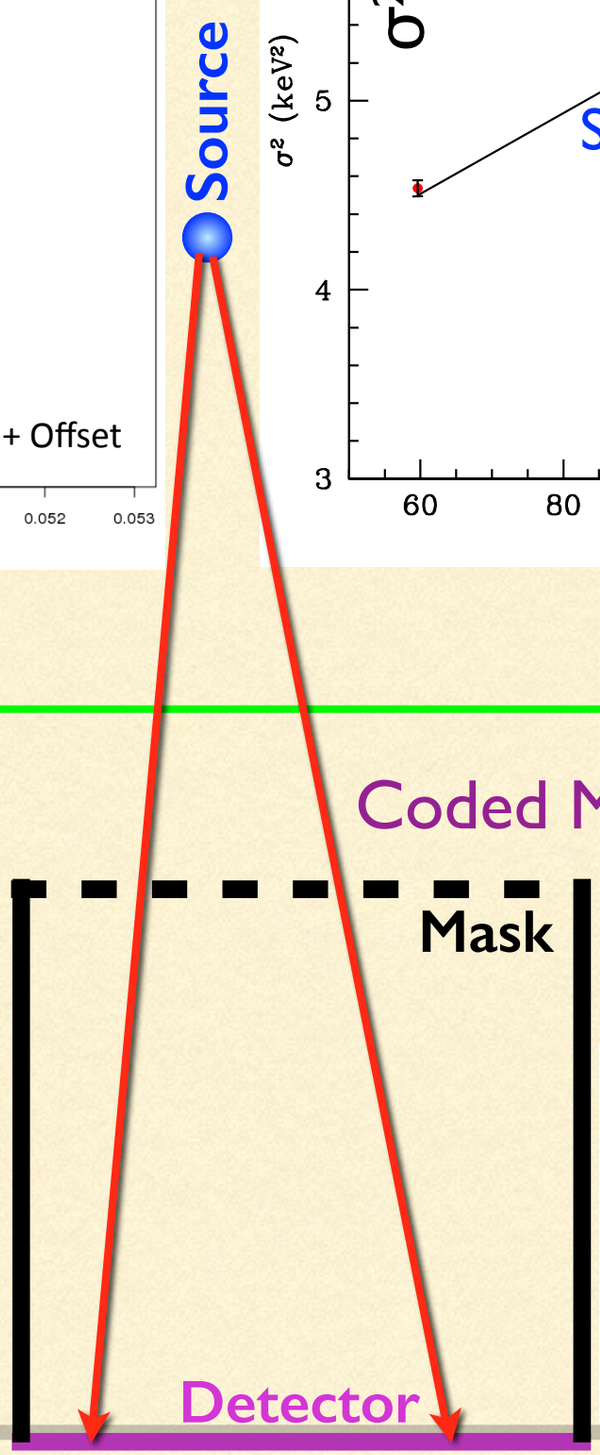






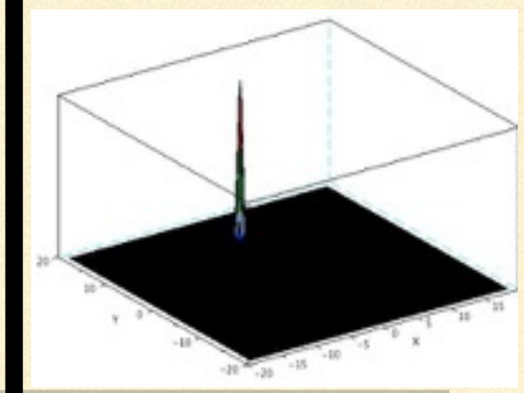
Polarimetry test, Ba^{133}, 356 keV



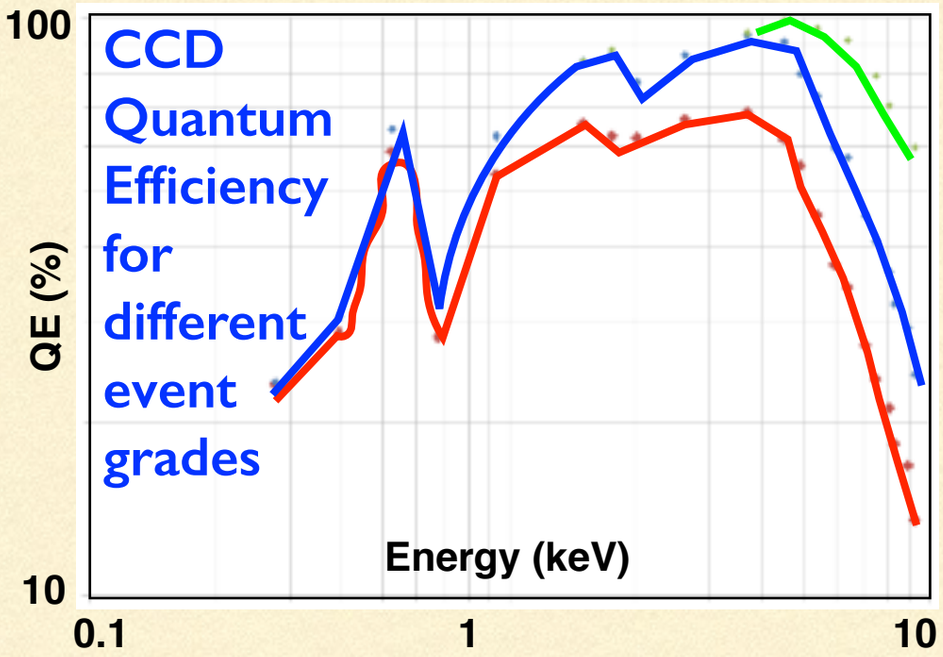


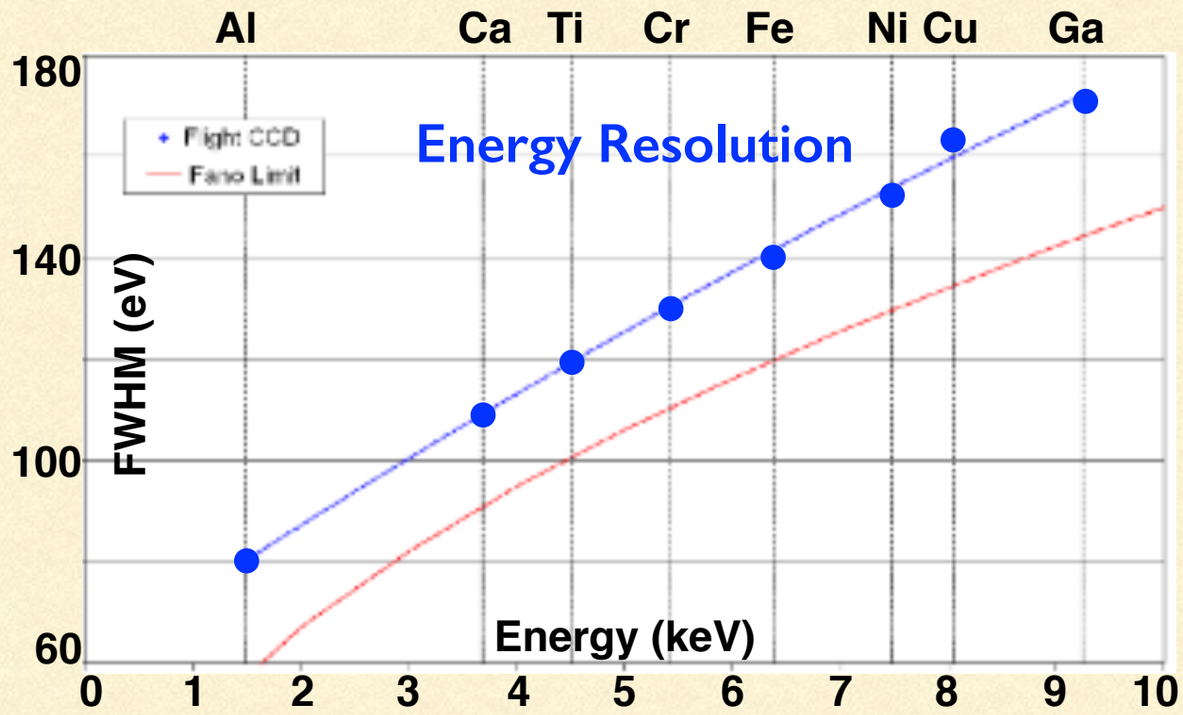
Coded Mask Imaging Test

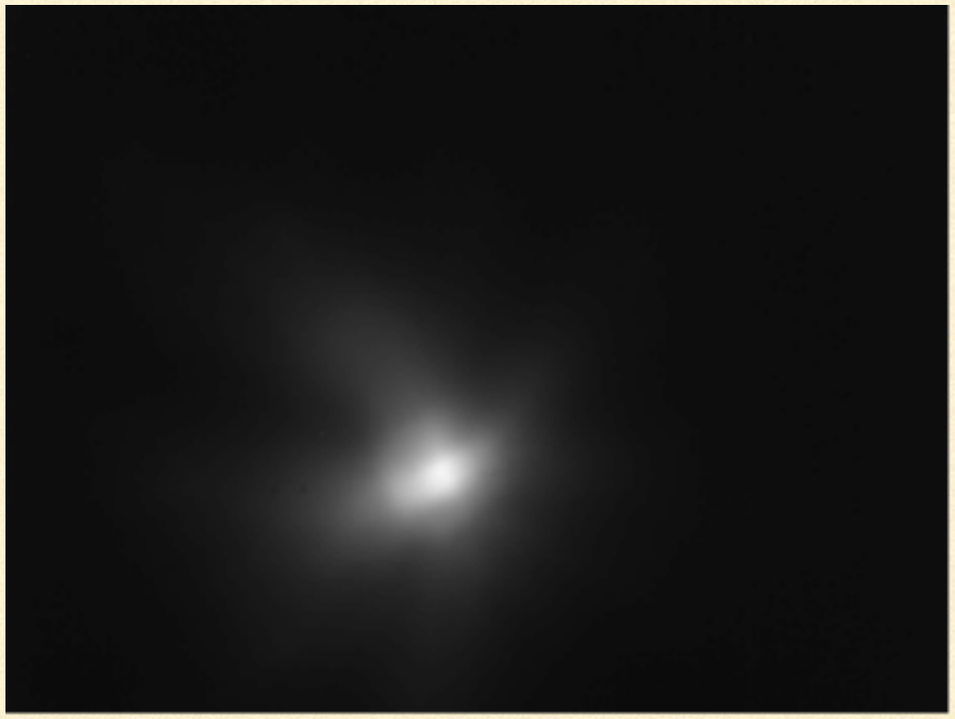
Reconstructed Image



SXT: (CCD at the focus of foil mirror optics)

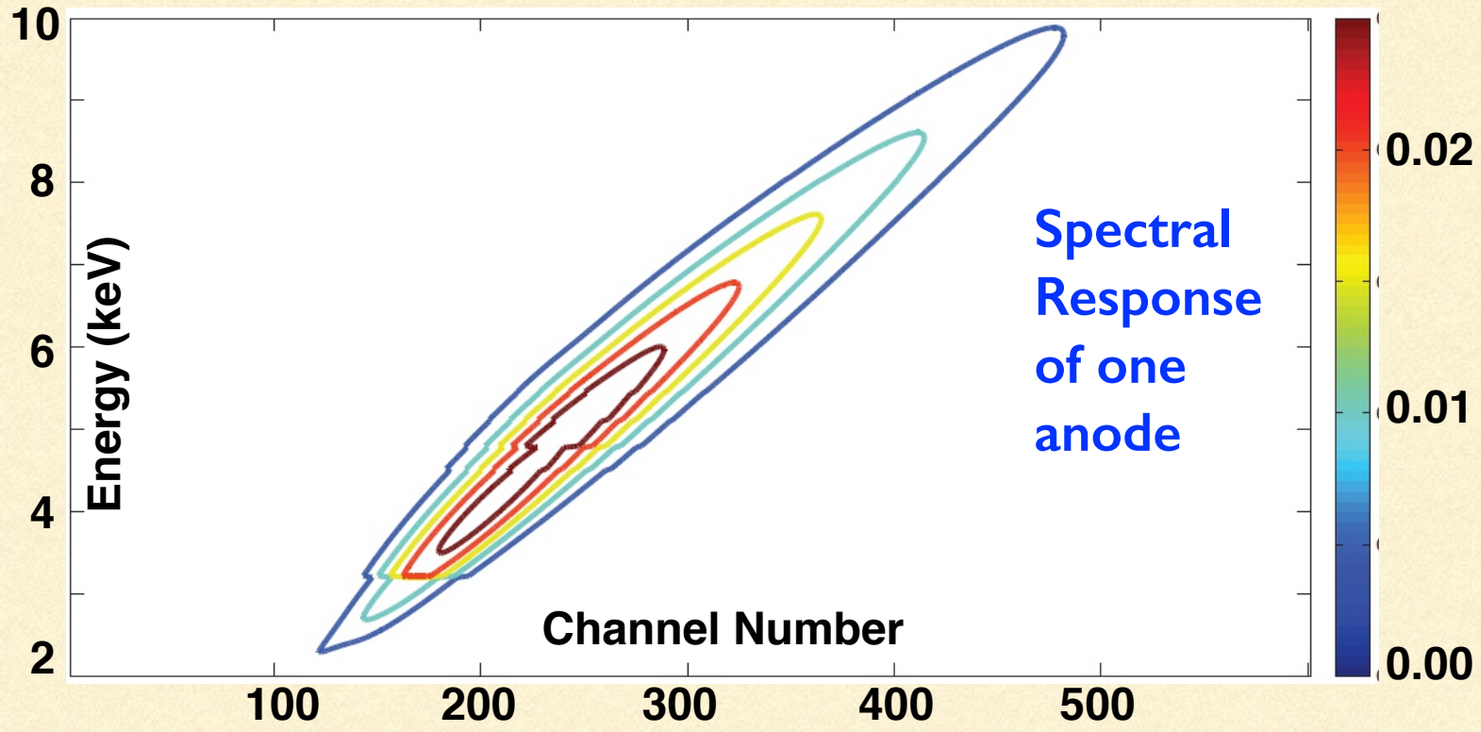




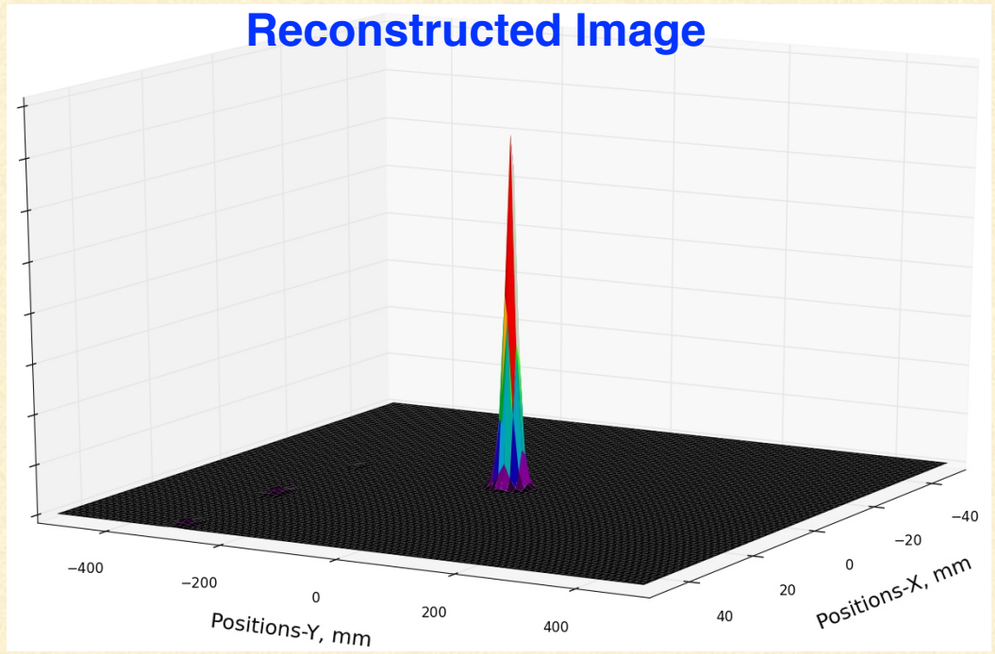


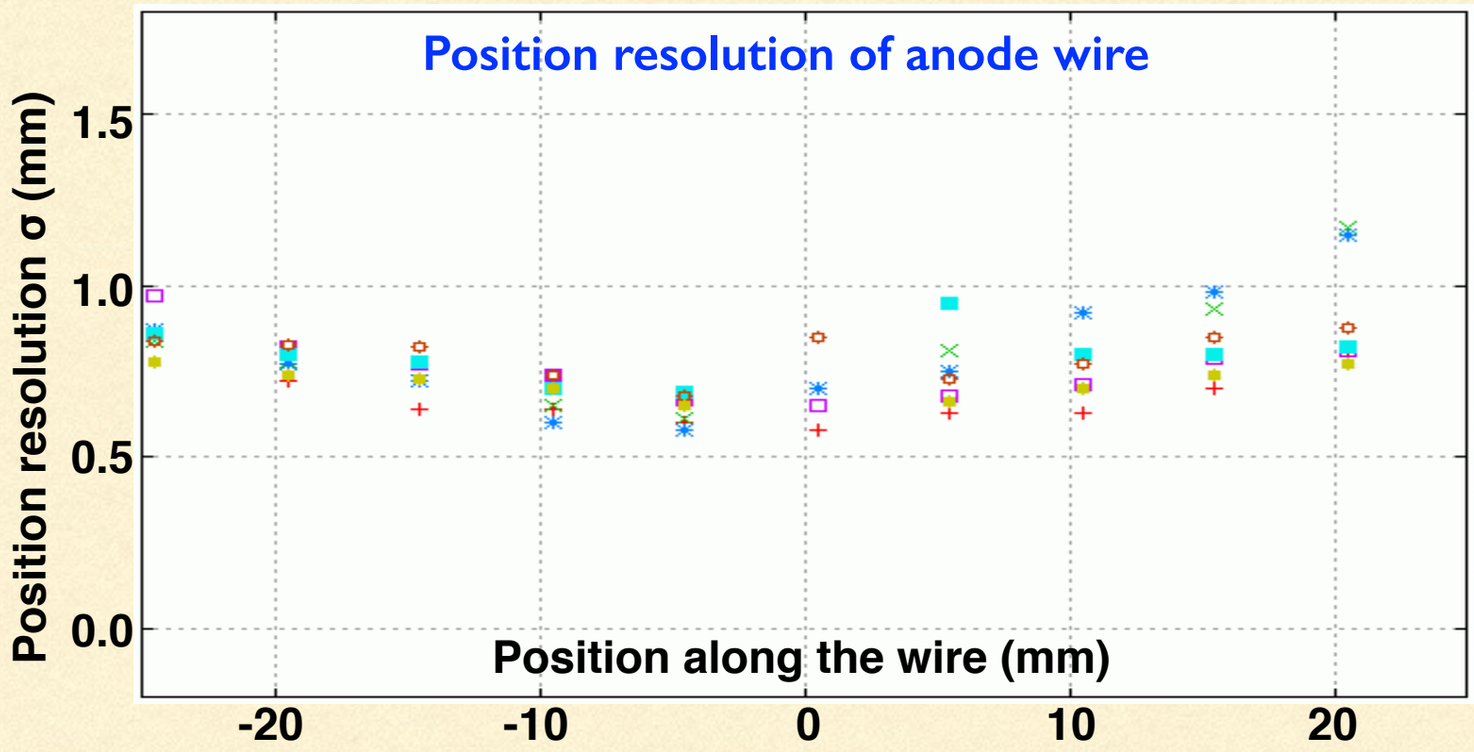
Optical
PSF

SSM: (prop. counter with position sensitive anodes behind Coded Mask)



- *Spectral response*
- *Position resolution*
- *Electrical to Physical position map*





In-flight Calibration

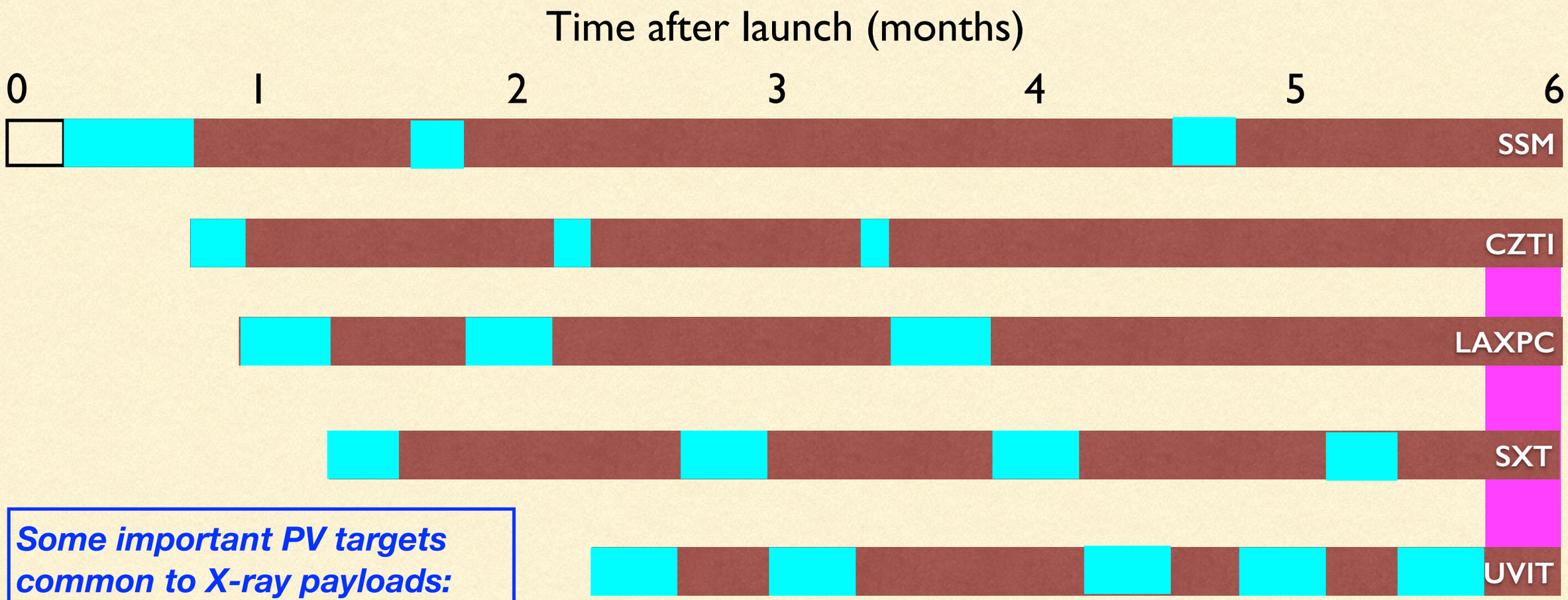
- Initial calibration during Performance Verification (PV) phase: 6 months
- Periodic calibration later in flight (2% of mission time reserved)

Calibration objectives during PV

SXT	LAXPC	CZTI	SSM
- Alignment - PSF - Effective Area - Spectral Response - Background - Timing - Contamination - CTI	- Alignment - FOV - Effective Area - Spectral Response - Background - Timing	- Alignment - FOV - Effective Area - Spectral Response - Background - Timing - CAM Response	- Alignment - FOV - Effective Area - Spectral Response - Background - Timing - CAM and Wire - Platform Rotation

- Target classes: *Stars, Isolated WD & NS, CVs, XRBs, SNRs, AGNs, Clusters*
- Several bright, hard sources will be used during these calibration runs
- Many are variable - essential to establish source characteristics via simultaneous observations with other missions, e.g. *SWIFT, NuSTAR*

ASTROSAT PV phase schedule



Some important PV targets common to X-ray payloads:
Crab, Cas A, Cyg X-1, Cyg X-2, Vela X-1, 3C273, Mrk421..

- *Request short (~1ks), simultaneous SWIFT observations of selected bright targets from ASTROSAT PV phase list*
- *Will plan ASTROSAT observations concurrent with scheduled NuSTAR targets - request collaboration for calibration*
- *Post-PV, will participate in periodic multi-mission calibration campaigns*

Thank you