

Investigation of Hard X-ray Polarization Properties of Galactic Black-hole Binaries with Astrosat-CZTI

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On behalf of Astrosat CZTI team

Astrosat is first Indian astronomical satellite. CZTI, one of the five instruments onboard Astrosat, is a hard X-ray imaging spectrometer. It employs coded mask imaging and large detector plane of pixilated CZT detectors. Because of its significant Compton scattering probability at energies beyond 100 keV and pixelation nature, it's possible to attempt Compton polarimetry with CZTI. Here we present the simulation and experimental results in support of CZTI polarization measurement capability and discuss the astrophysical significance of CZTI polarimetry.

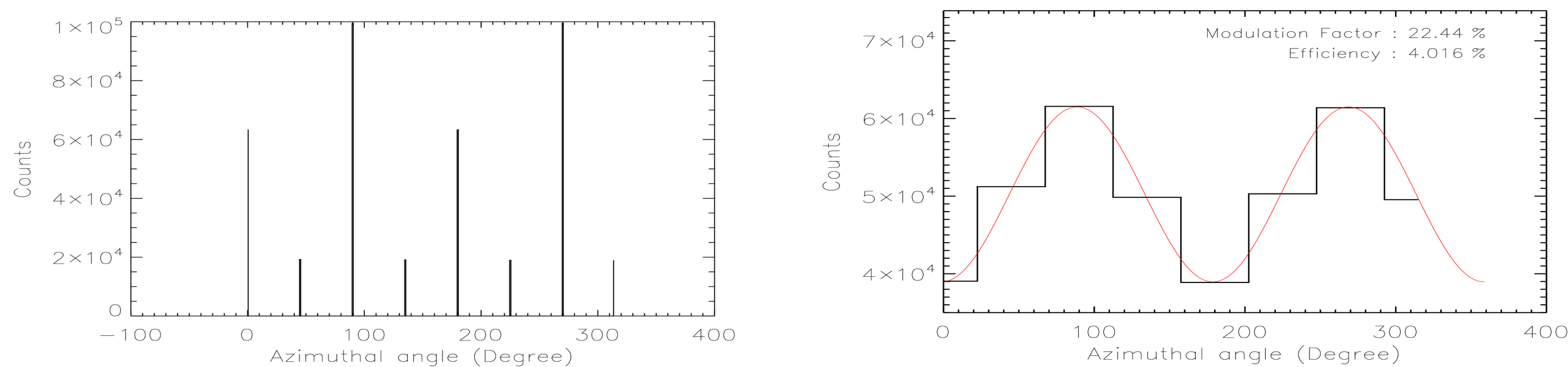
CZTI-Imager



- CZTI consists of 64 CZT modules
- CZT dimensions: 4cm X 4cm X 5mm
- Total 256 pixels in 16 X 16 array
- Pixel dimension: 2.5mm X 2.5mm

CZTI as a Compton Polarimeter

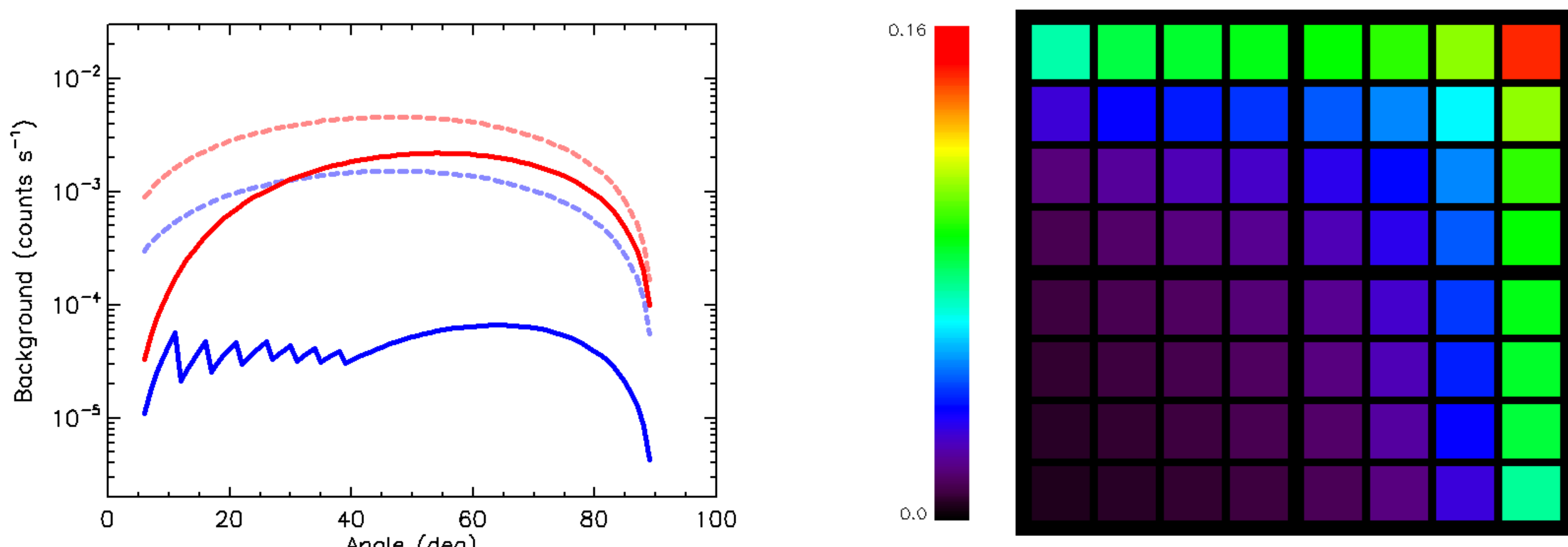
- Simulation of X-ray interaction in CZT - investigation of the double pixel events. Simulation in 100 - 300 keV for unpolarized and polarized beam at various polarization angle.
- Double pixel events consist of escape events; Compton events and bremsstrahlung events



- Intrinsic modulation pattern even for unpolarized beam due to unequal bin size.
- Used for geometric correction the modulation pattern for polarized beam
- Modulation factor depends on the polarization angle.
- Highest modulation for 45 degree polarization angle and lowest for 0 degree.
- Polarimetric efficiency is ~ 4 %.

Polarimetric Background estimation

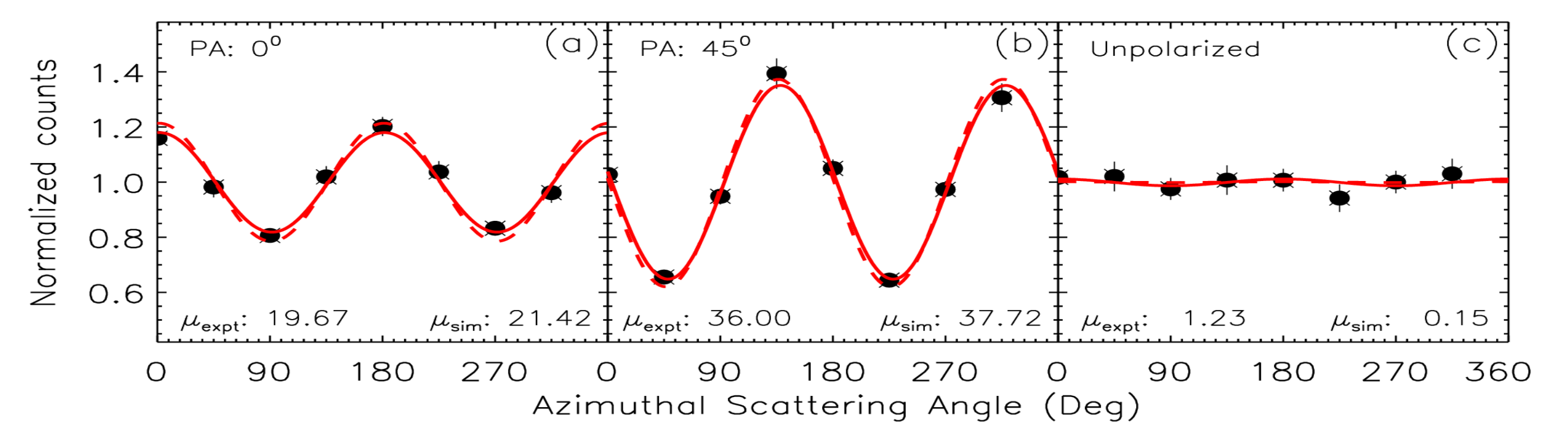
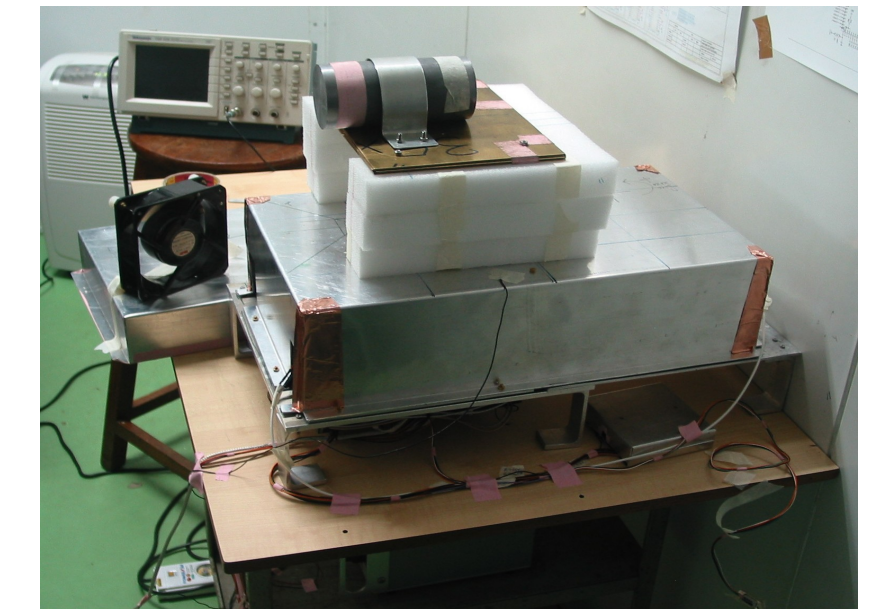
- Require background estimation accurately. CZTI support structure becomes increasingly transparent > 100 keV.
- Spurious background events: 1. chance coincidence events between CXB/ALBEDO, source events and instrumental background events. 2. Compton scattering of CXB and ALBEDO photons.



- Numerical modeling including collimators, support structure along with detailed simulation for offaxis photons.
- Background different from module to module - overall background ~ 1 Crab - degradation in modulation- degradation depend on source intensity
- Polarimetric sensitivity dependent on source intensity and choice of modules.

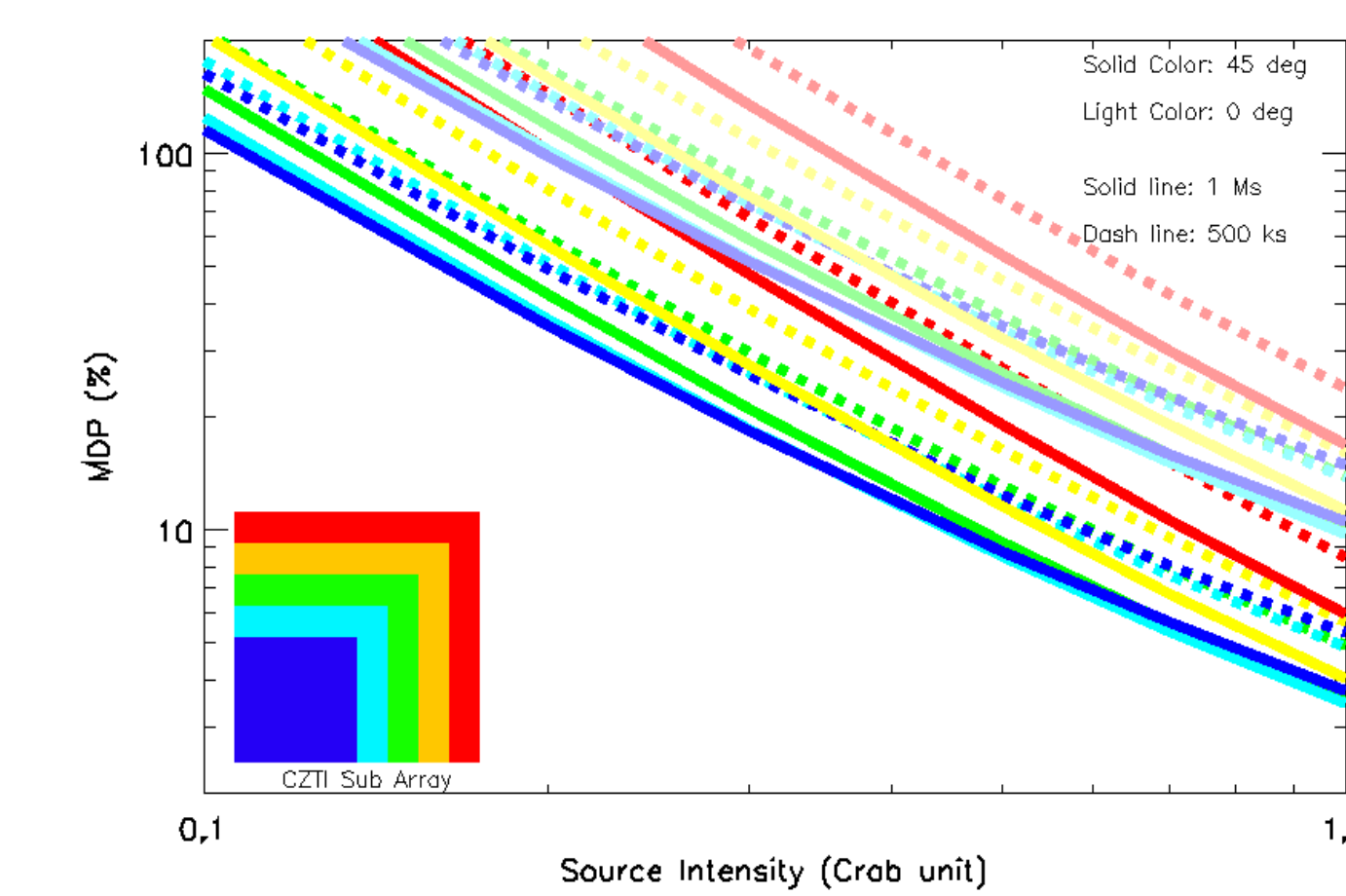
Experimental Confirmation

- Polarization experiment with CZTI including complete onboard processing electronics
- 90 degree Compton scattering of 356 keV from Ba133 - partial polarized beam in 190 - 240 keV at different polarization planes.

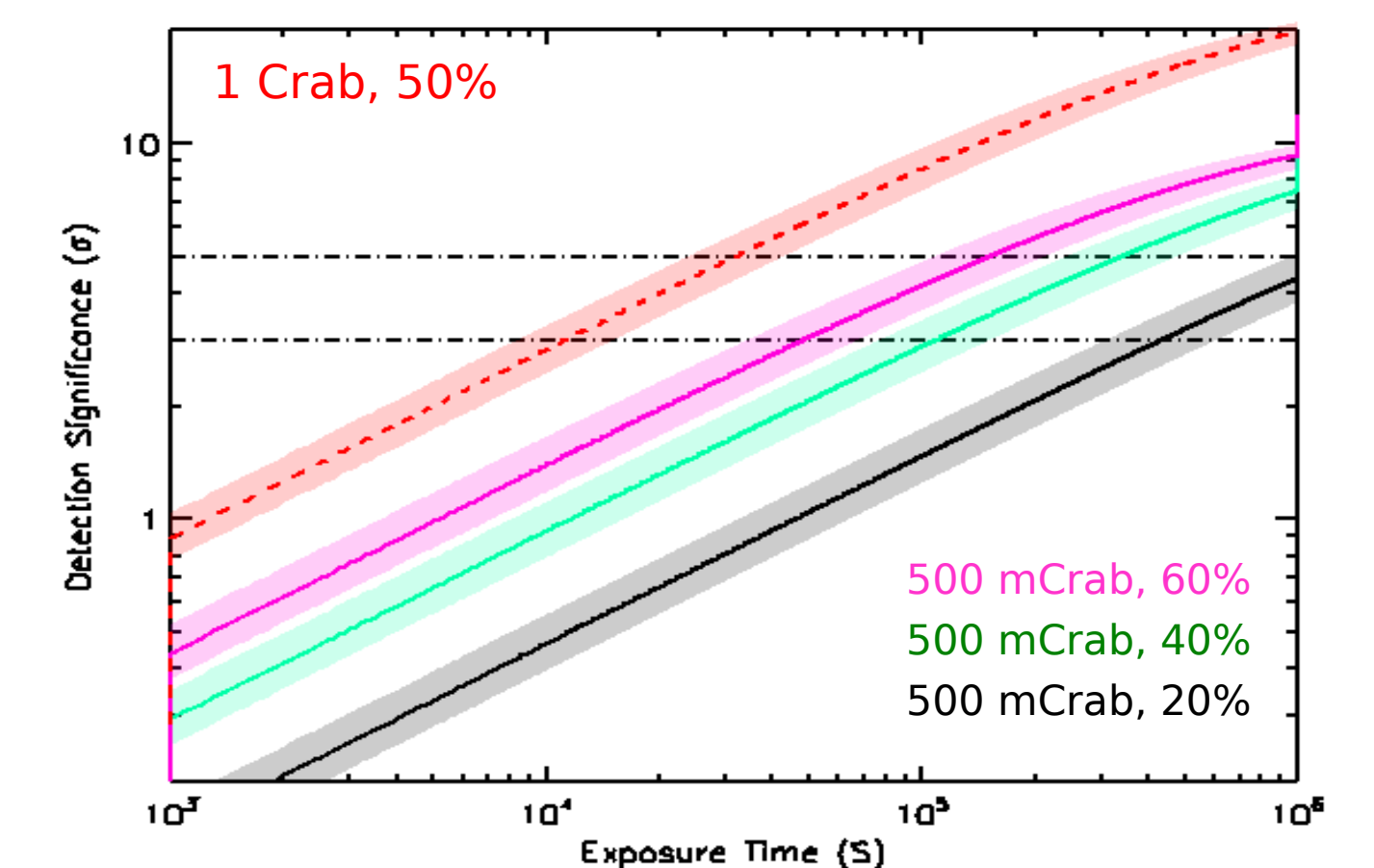


- Final CZTI configuration onboard Astrosat will have polarization measurement capability without any change in hardware configuration.

Polarimetric Sensitivity of CZTI

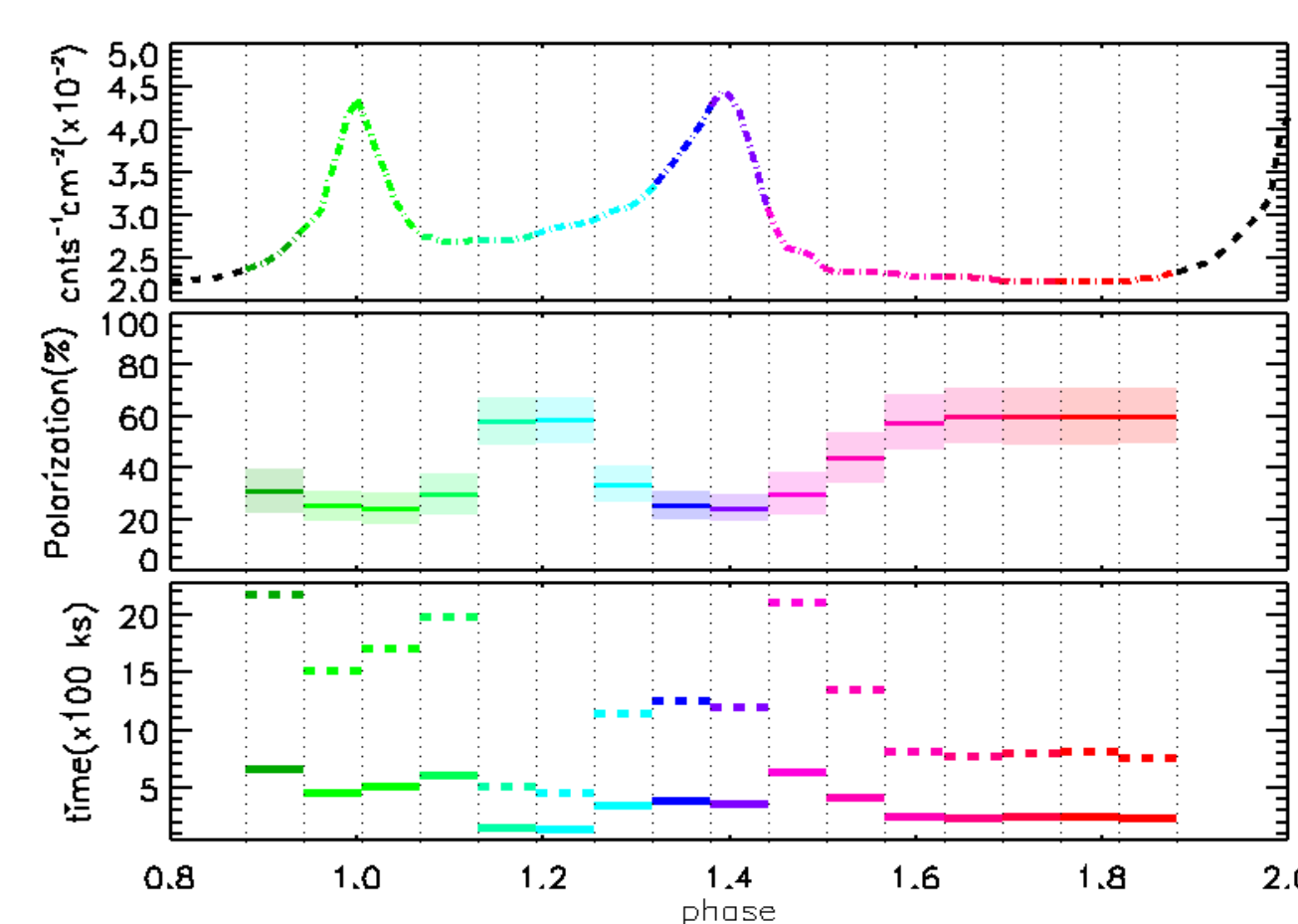


Polarimetric sensitivity of CZTI in terms of MDP as a function of source intensity.



Detection Significance vs. exposure time for polarization measurement of highly polarized bright sources.

Astrophysical significance of CZTI polarimetry



Hard X-ray polarimetry of CygX1

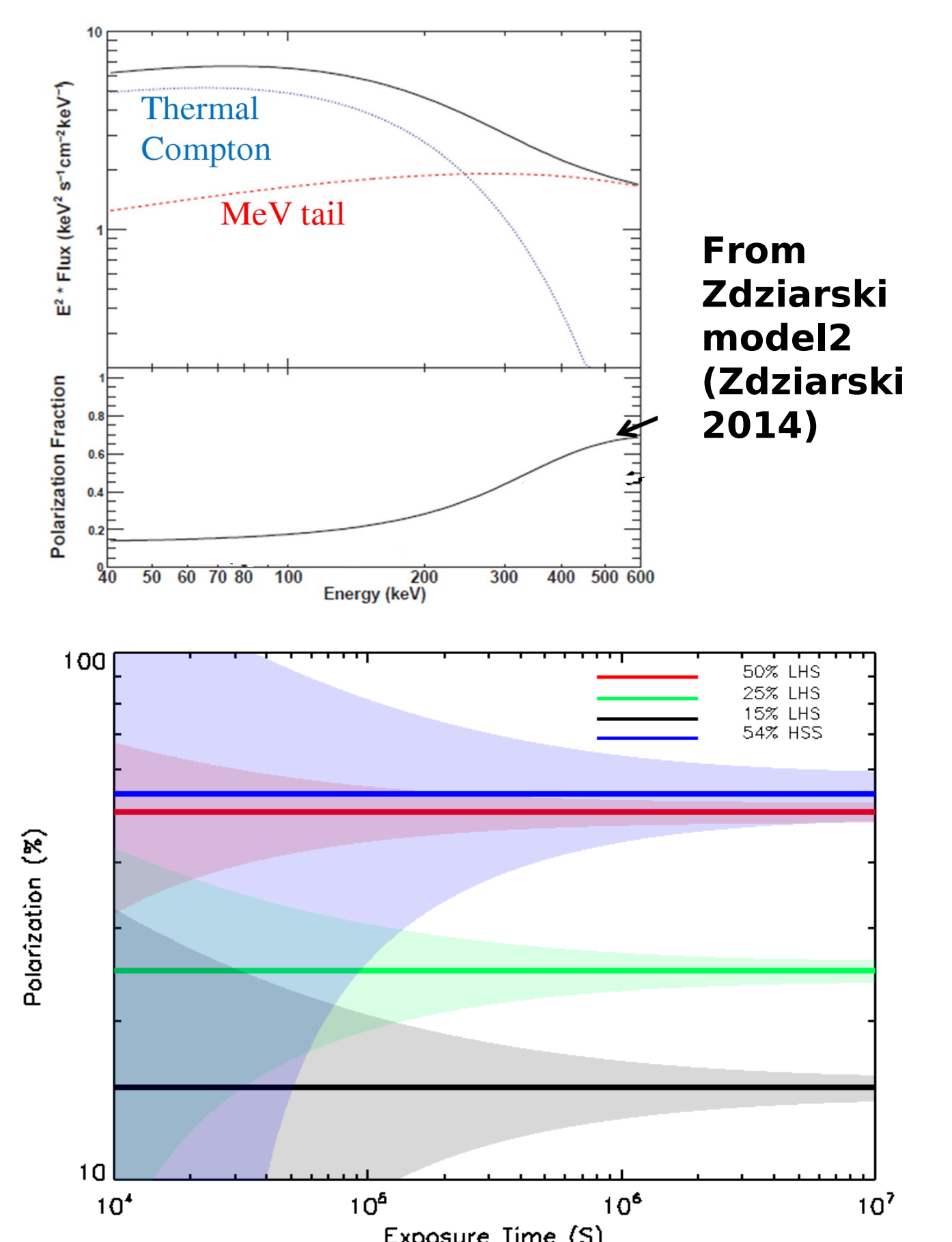
Hard X-ray origin for CygX1 at energies > 100 keV :

- Significant jet contribution? Recent Integral results show high polarization; (Laurent 2011, Jourdain 2012, zdziarski 2014 [model2])
 - Significant coronal emission? No jet contribution from jet, polarization from coronal emission (Zdziarski 2014 [model1], Schnittman 2010)
 - Synchrotron radiation from corona? Synchrotron radiation from leptohadronic corona (Romero 2014)
- Possible to distinguish all these processes with CZTI within 300 ks.

Phase-resolved polarimetry of Crab

may constrain the geometry and emission mechanism.

Assuming 16 uniform phase bins, phase resolved polarimetry with CZTI in 2Ms with 5 sigma detection significance.



From Zdziarski model2 (Zdziarski 2014)

Swift catalog indicates 3 more black-hole sources as possible candidates - GX339-4, XTEJ1752-223, SWIFTJ1753.5-0130