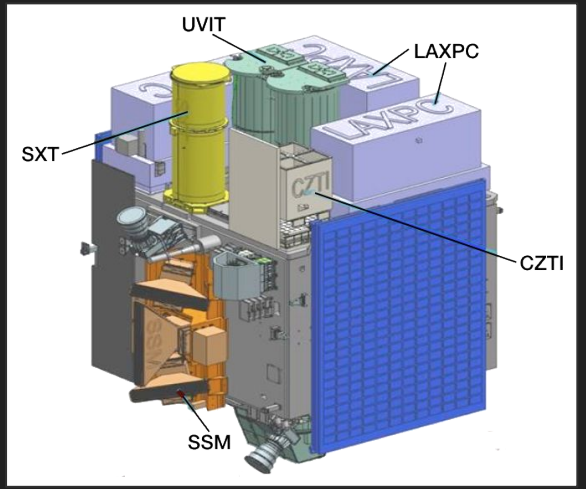
AstroSat/CZTI mass model

Sujay Mate
TIFR Mumbai

1st National Workshop on GEANT4 and its Application to High-Energy Physics and Astrophysics

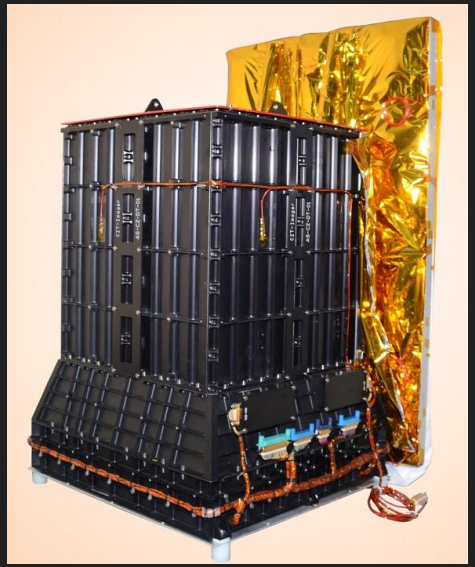
The AstroSat

- First multi-wavelength space observatory launched by India.
- Four co-pointing telescopes and one sky monitor.
- Broadband coverage from UV to hard X-rays.
- Spectral and temporal studies of astrophysical sources.



The Cadmium Zinc Telluride Imager

- Overview:
  - Imaging and spectroscopy in 20 - 200 keV (and polarimetry!)
  - Effective area: 488 cm^2 at E <90 keV
  - Energy resolution: 9 % at 60 keV
  - Angular resolution: 8 arc min
- Scientific goals
  - Spectral and temporal studies of galactic X-ray binaries and pulsars
  - Polarimetry of bright sources
- Additional advantage:
  - Open sky detector > 100 keV → Excellent for detecting bright high-energy transients such as Gamma-ray bursts and Soft gamma repeaters (SGRs)



Slide credits: Mithun NPS

The Cadmium Zinc Telluride Imager

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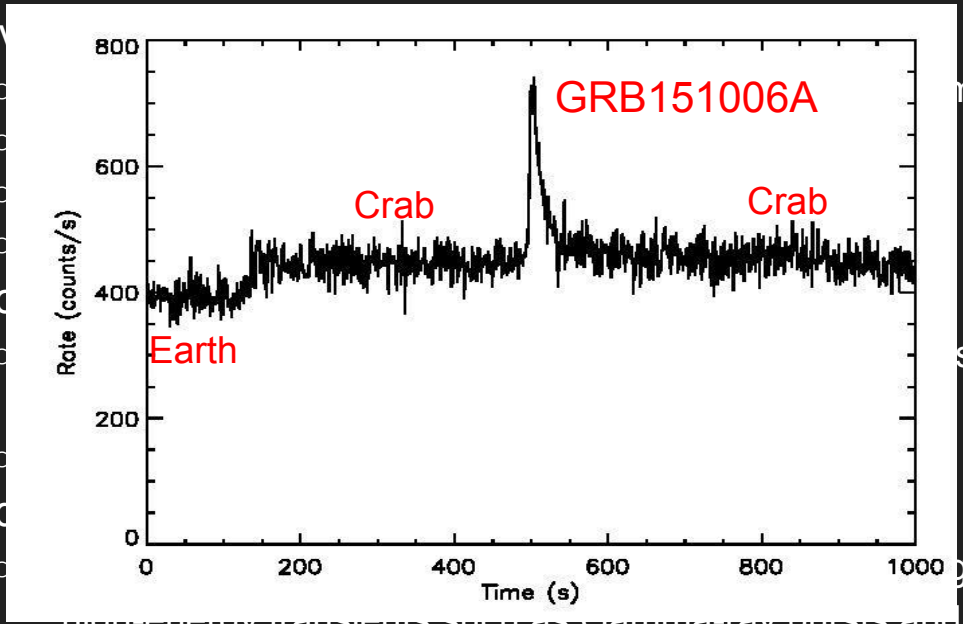

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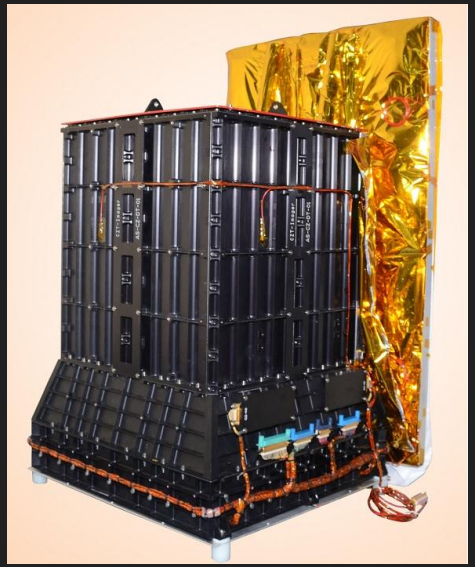

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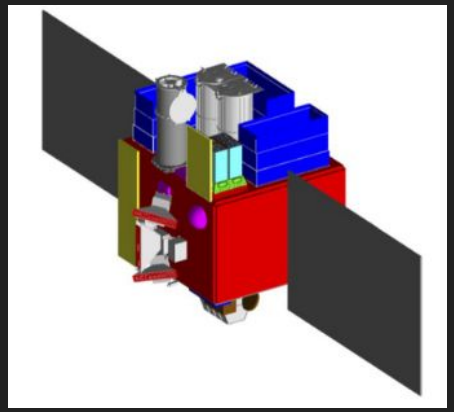
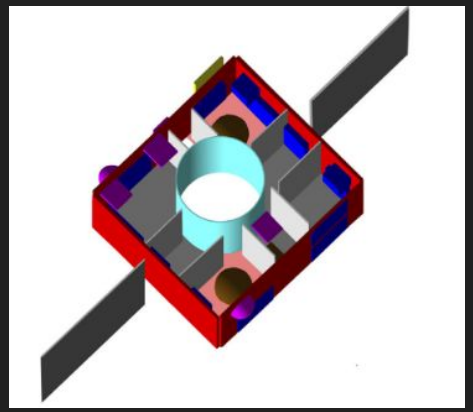
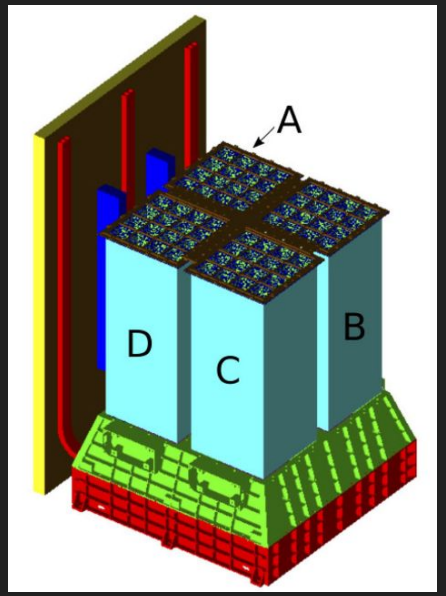
The AstroSat/CZTI mass model

- Full GEANT4 simulation of the AstroSat satellite with CZTI detectors as active volume.
- Simulate off-axis spectral and polarimetric response of CZTI for Gamma-ray Bursts and/or other bright hard X-ray transients.







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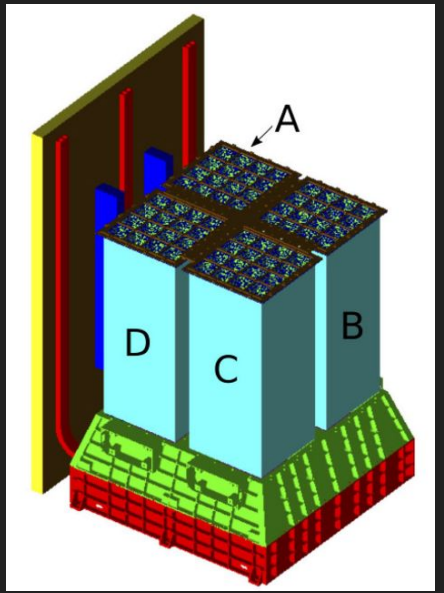
Instrument	Simulated mass (kg)	Actual mass (kg)
CZTI	41.87	50.29
SXT	44.03	57.64
UVIT	212.58	202.06
LAXPC	350.87	389.10
SSM	71.53	71.53
Satellite bus and electronics	657.22	668.47
Total	1378.10	1439.09



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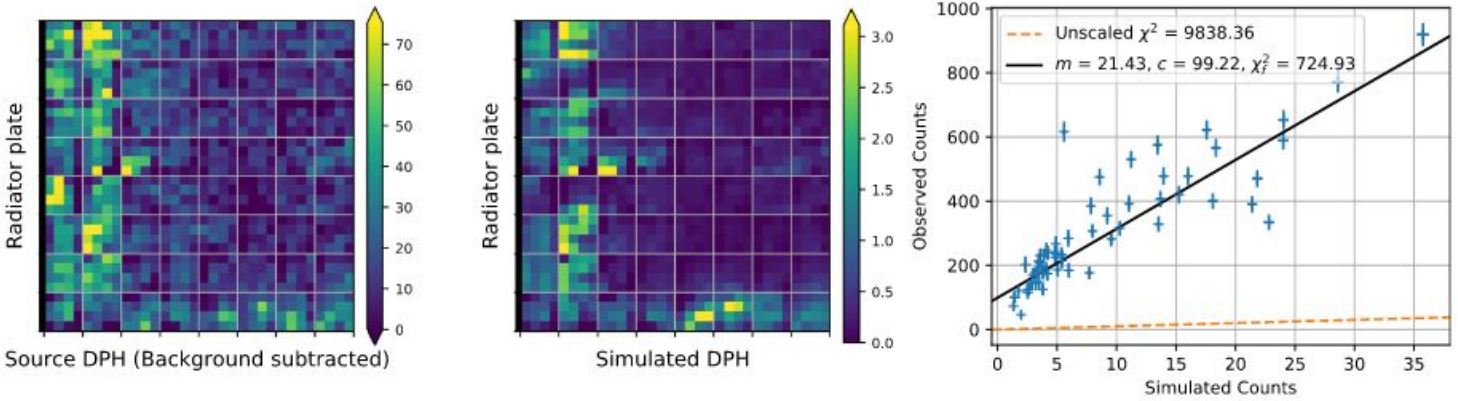
The AstroSat/CZTI mass model: Comparison with data

- No lab calibration with full or partial mass model.
- “Bright” GRBs chosen to verify the “imaging” response.
- Due to many approximation, spectral response depends on direction and energy band.
- In general, good agreement with data for directions above the detector plane

The AstroSat/CZTI mass model: Imaging



(a) GRB180809B: $\theta = 26.46°$, $\phi = 198.83°$

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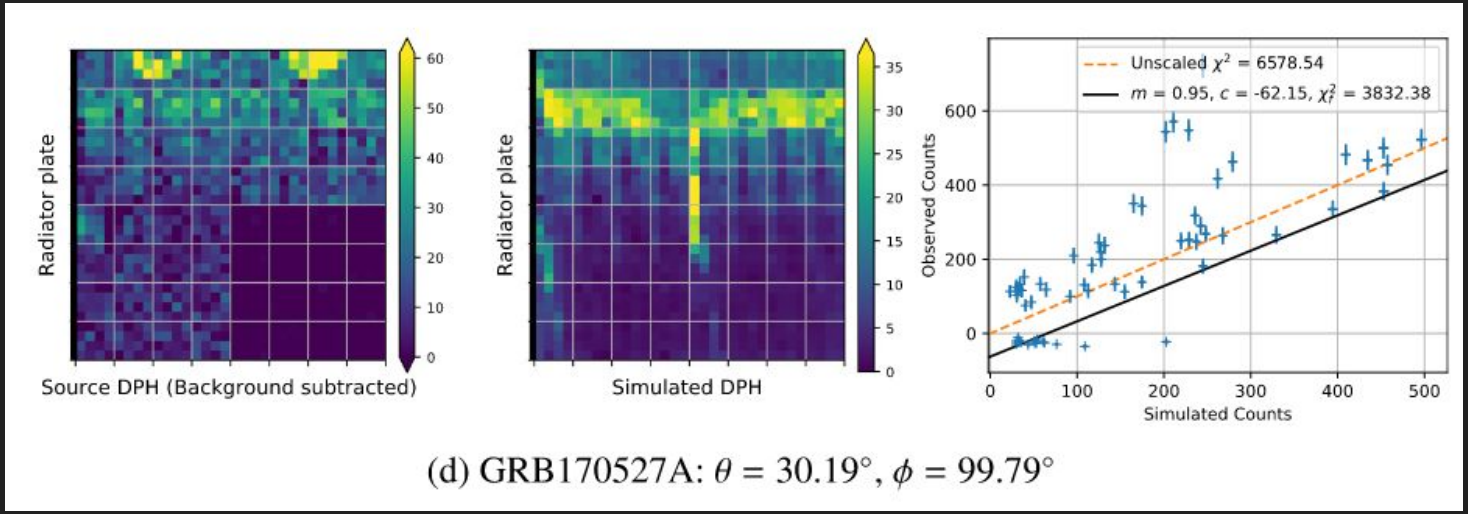
The AstroSat/CZTI mass model: Imaging



(d) GRB170527A: $\theta = 30.19°$, $\phi = 99.79°$

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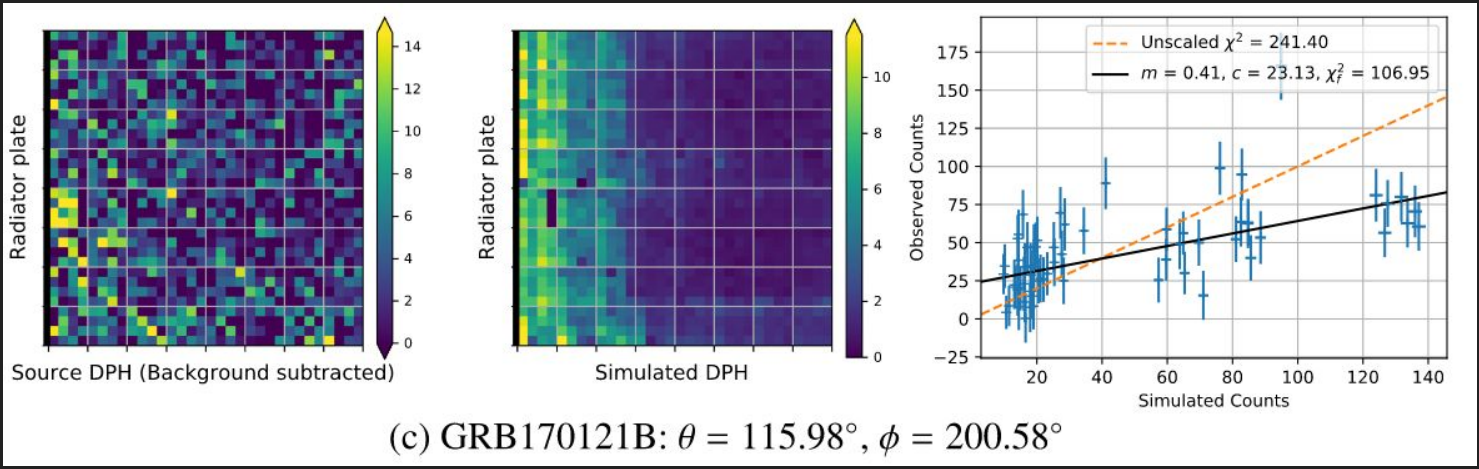
The AstroSat/CZTI mass model: Imaging



(c) GRB170121B: $\theta = 115.98°$, $\phi = 200.58°$

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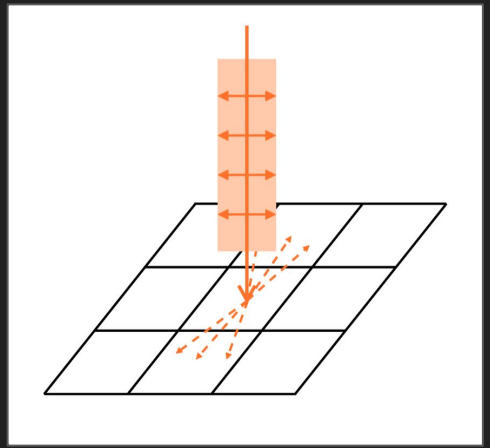
The AstroSat/CZTI mass model: Polarimetry

- Pixelated detector → 8 azimuthal pixel bins surrounding centre scattering pixel.
- Compton scattering dominate in 100 - 400 keV range.
- Polarisation measurement possible by selecting neighboring pixel “Compton” events and fitting the resulting modulation



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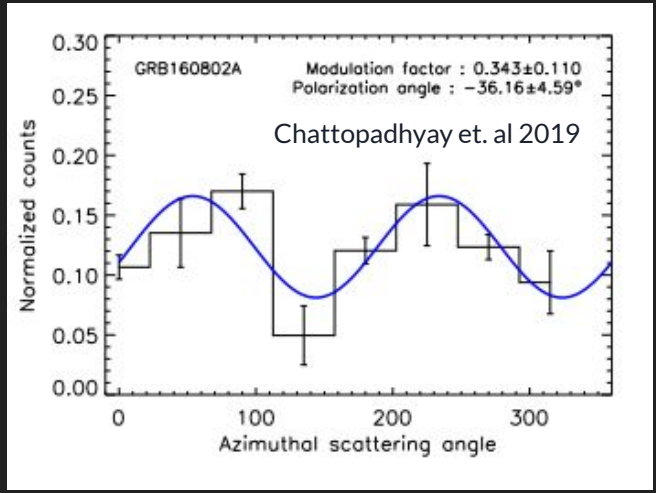

The AstroSat/CZTI mass model: Lessons learnt

- Start the modelling at before the launch, most information available easily.

- More systematic approach to writing the GEANT4 code.

- Lab calibrations at different level must for out of FoV angles:
  - Individual detector level
  - Individual instrument level

Thank you