



# CZT Imager of *ASTROSAT*

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टाटा मूलभूत अनुसंधान संस्थान  
TATA INSTITUTE OF FUNDAMENTAL RESEARCH

UV AND MULTIWAVELENGTH ASTRONOMY  
WITH ASTROSAT. 2006 Sep 27 – 29, IIA, Bangalore



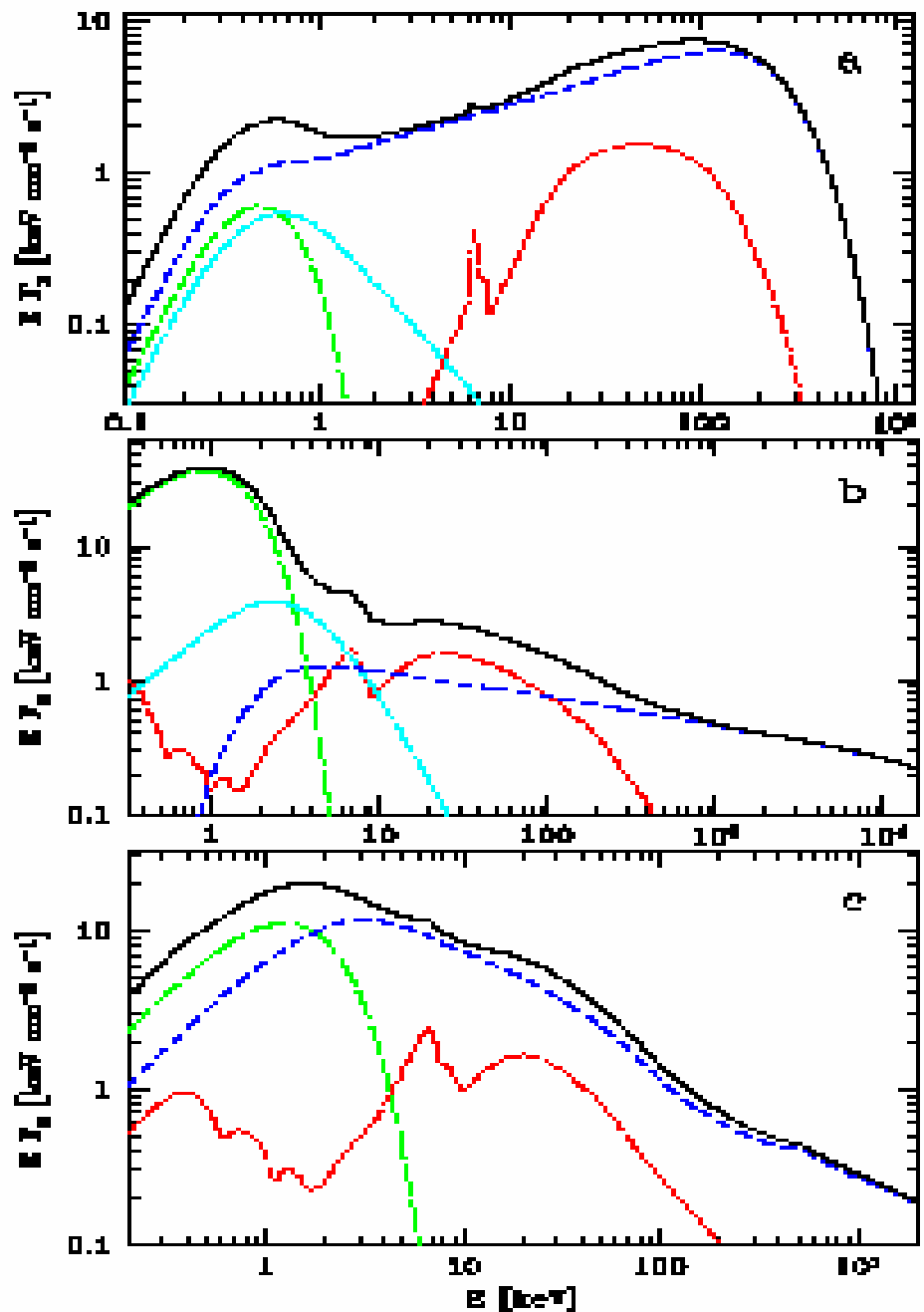
TIFR

# Astrosat Science Objectives

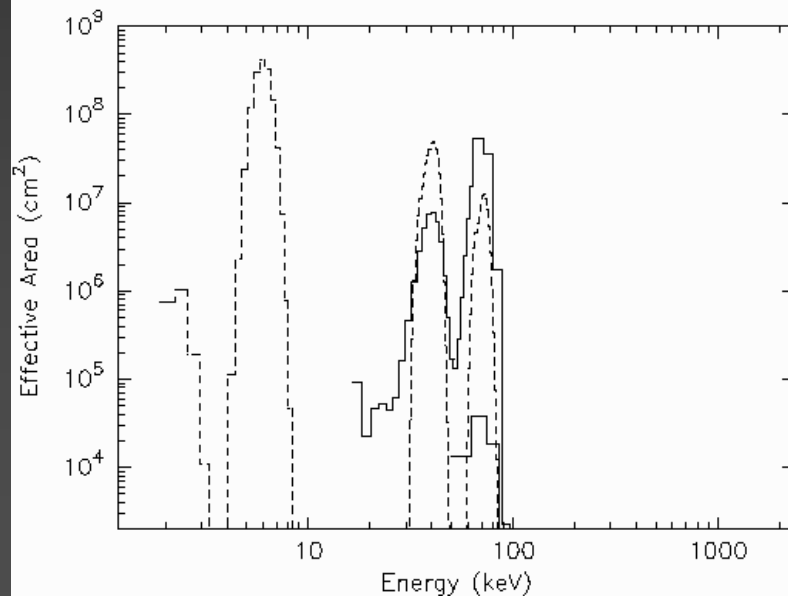
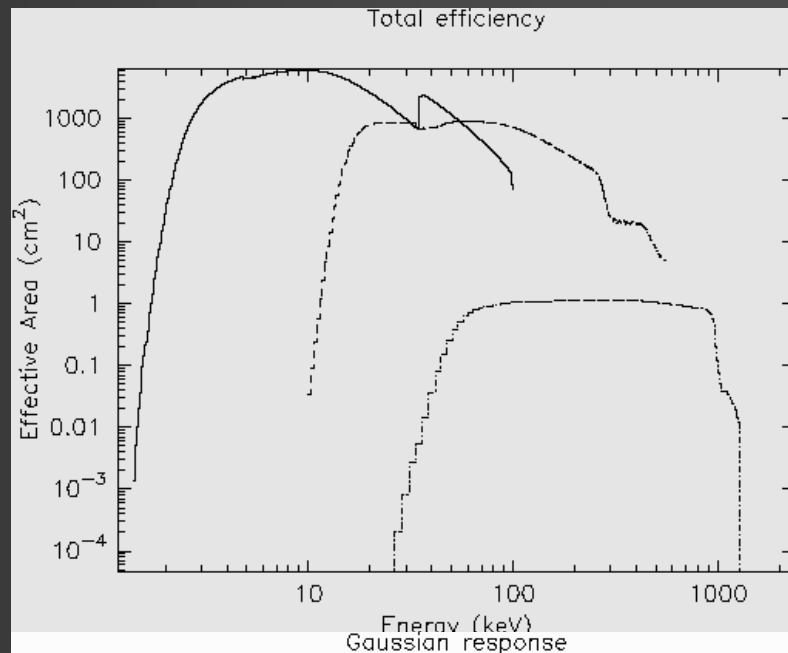
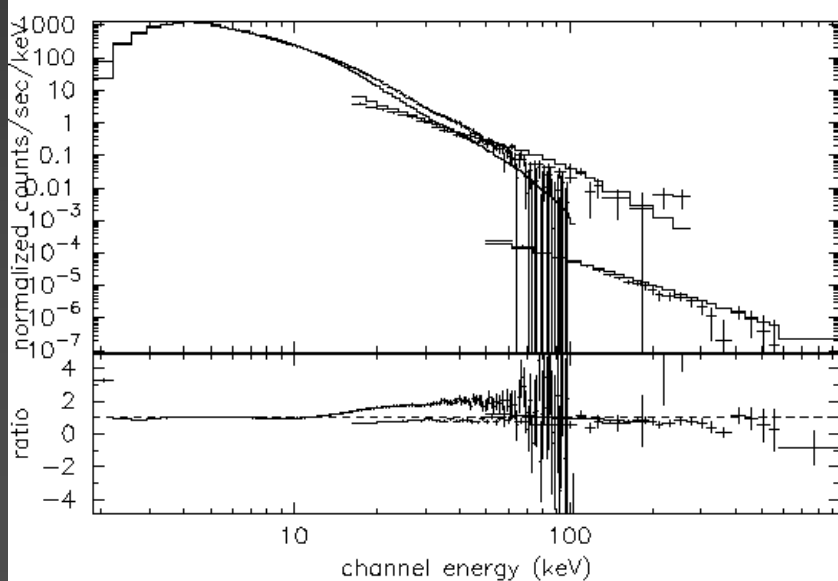
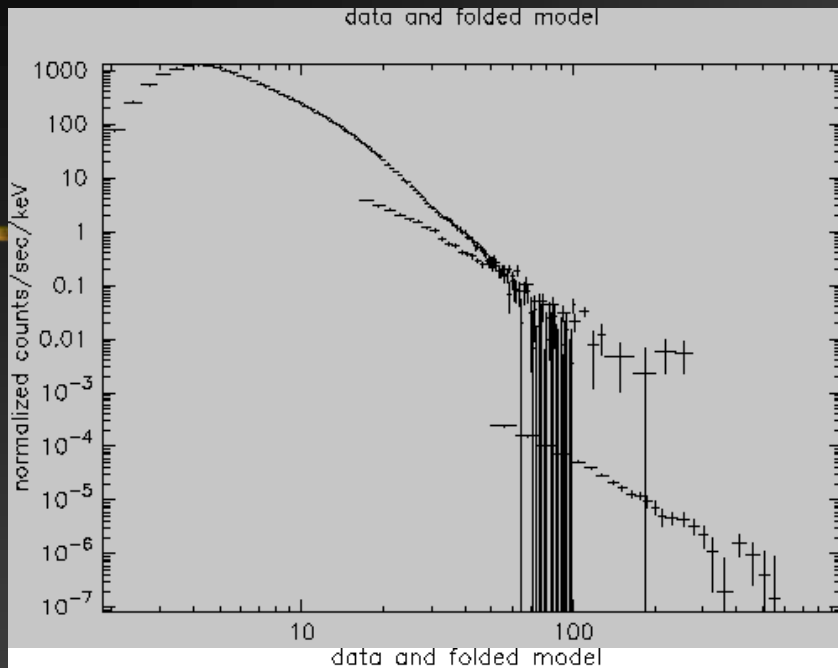
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- Multi-wavelength studies (UV to X-rays)  
spectra, variability
  - Periodic and aperiodic variability
  - *Broad band X-ray spectroscopy*  
*non-thermal components,*  
*cyclotron lines*
  - Surveys  
All-sky, Galactic plane, deep
-

# Cygnus X-1: Spectral components



# Wide band spectrum of a black hole candidate



# CZT: Hard X-ray detector of the future .....

**Good energy resolution**

**Good efficiency**

**Pixelated :**

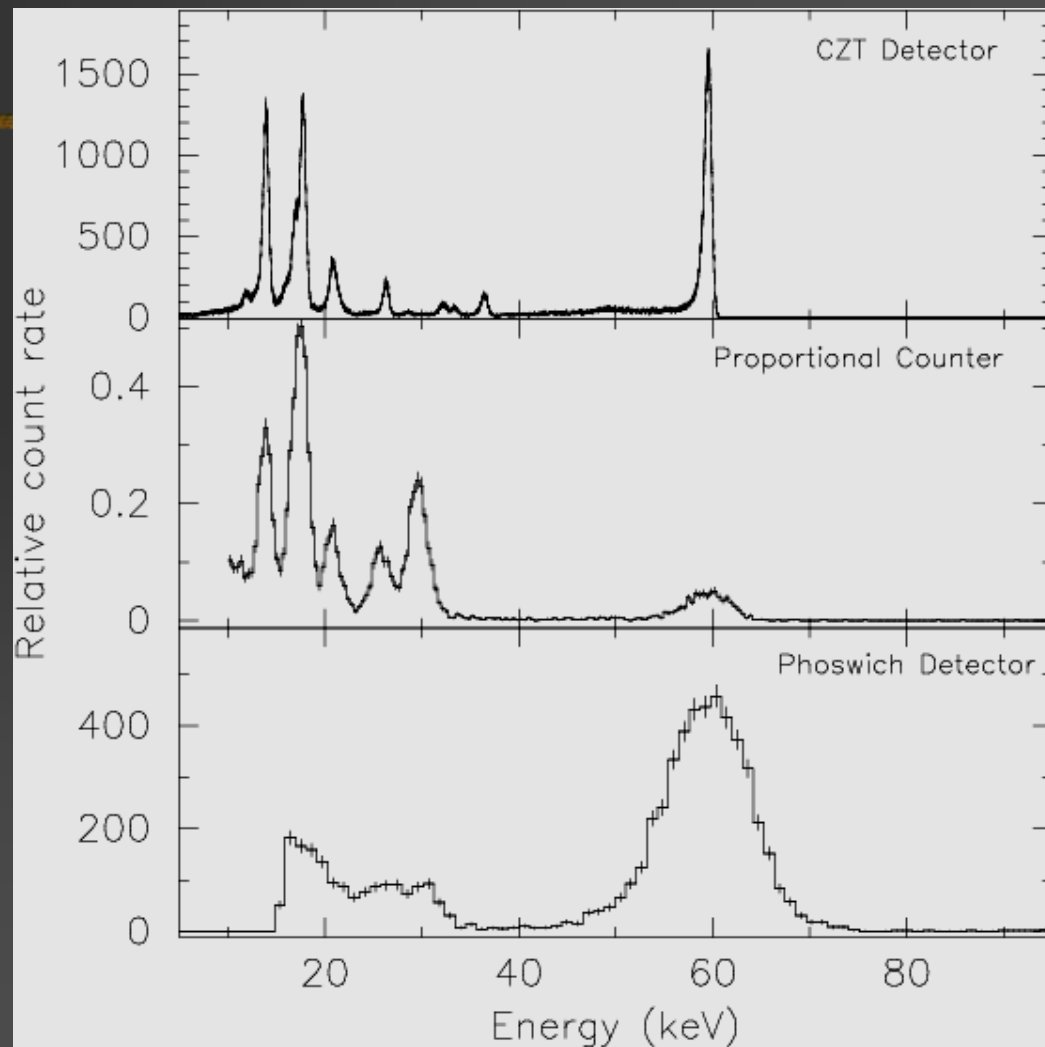
**Moderate imaging**

**Background estimation**

**Avoids source confusion**

**Background reduction**

**Good spectroscopic detector**



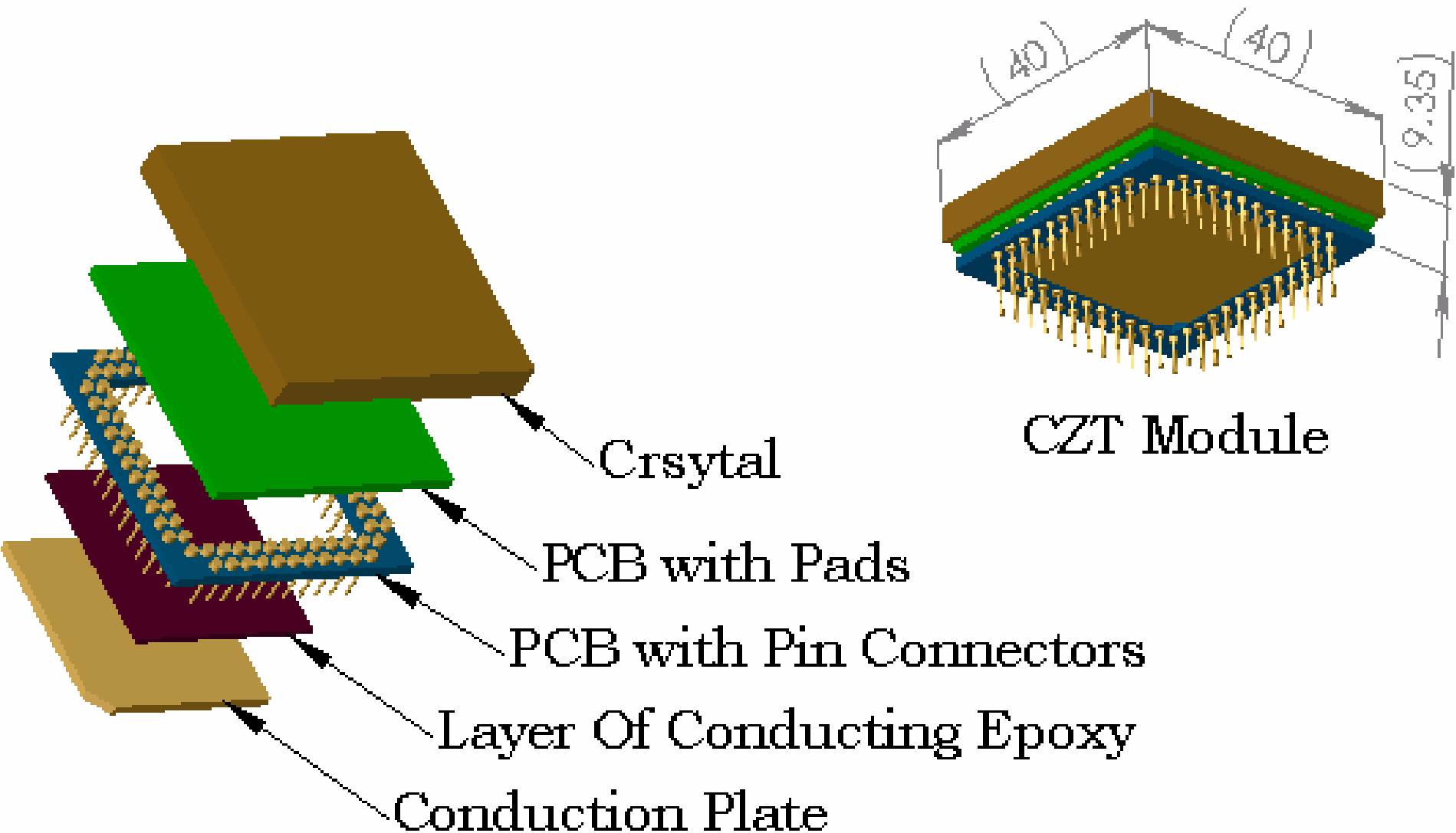
***Note: Used up to now only as a gamma-ray imager***

# Science requirements

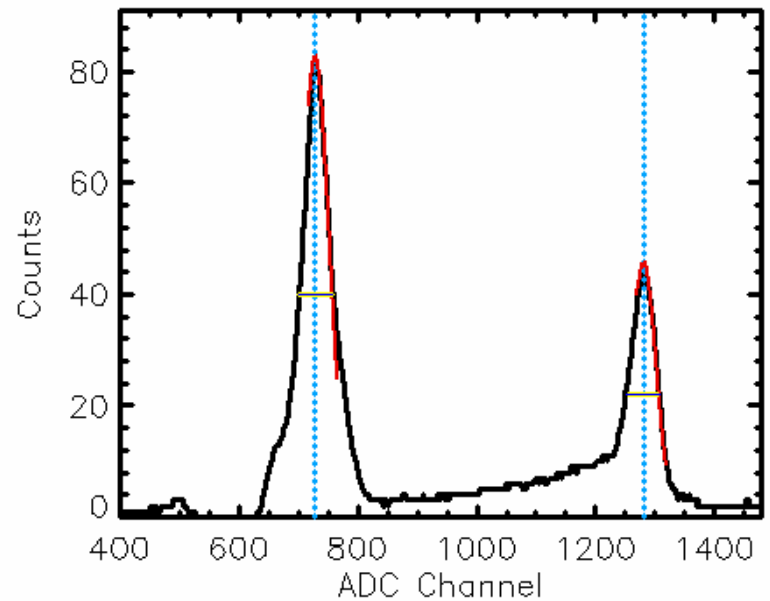
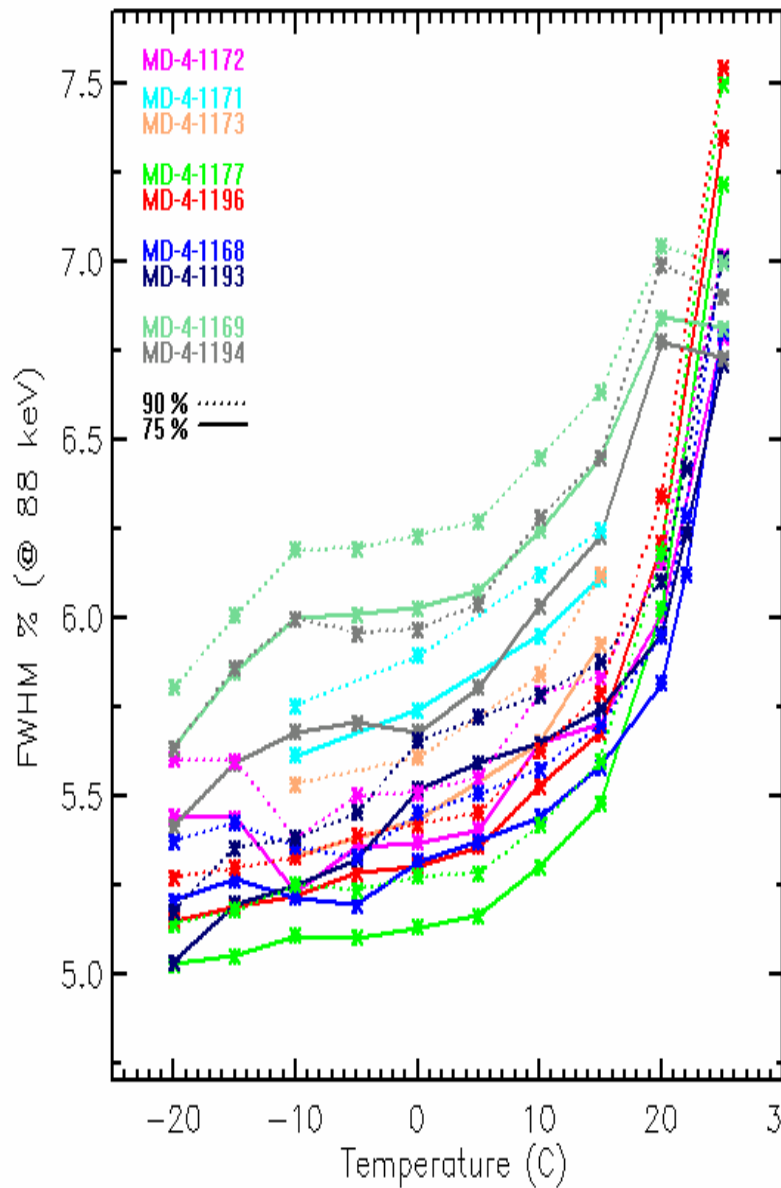
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- Area comparable to recent high energy spectroscopic detectors (HEXTE; PDS : 800 cm<sup>2</sup>).
  - Emphasis on spectroscopy
  - Energy resolution < 5 % @ 60 keV
  - Individual pixel handling/ calibration
  - Background reduction
  - Use the pixel for bgd. estimation etc.
  - Minimum mass
-

# CZT Module



# CZT Module characterization



# Specifications...

Area	1024 cm <sup>2</sup> (+/- 20%)
Pixels	16384
Pixel size	2.5 mm X 2.5 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> (CAM) - <u>&gt; 100 keV</u> 5 X 5 (25 – 100 keV) 1 X 1 (5 – 25 keV)
Angular resolution	8 arcmin (21 arcmin geometric)
Energy resolution	5% @ 100 keV
Energy range	5 – 100 keV Up to 1 MeV (Photometric)
Sensitivity	0.5 mCrab (5 sig; 10 <sup>4</sup> s)

# Design considerations

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- Active Compton Background rejection
  - Simple shield – minimize mass
  - Collimator to reduce DCXRB
  - Quadrant-wise
  - Cooling requirements
-

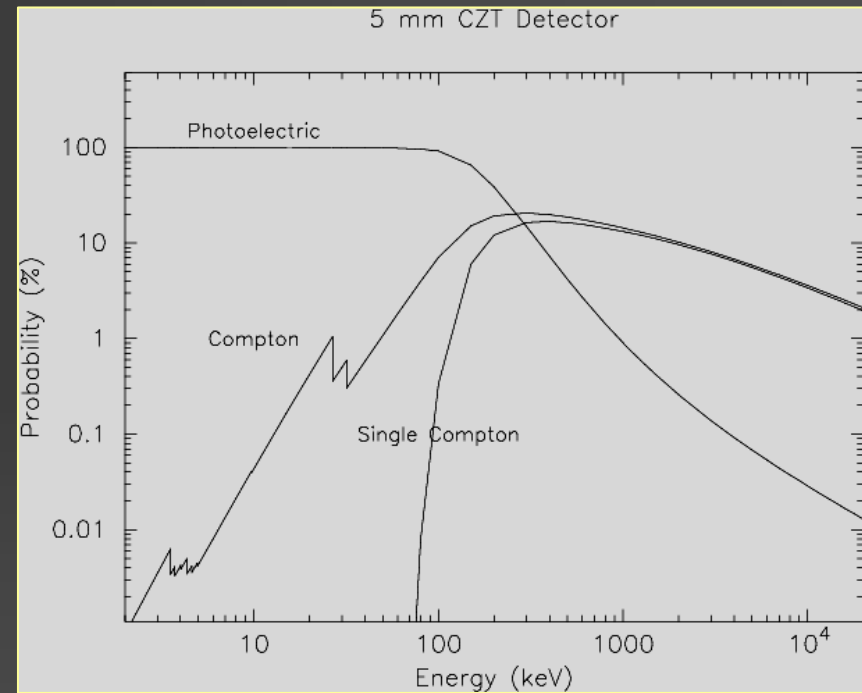
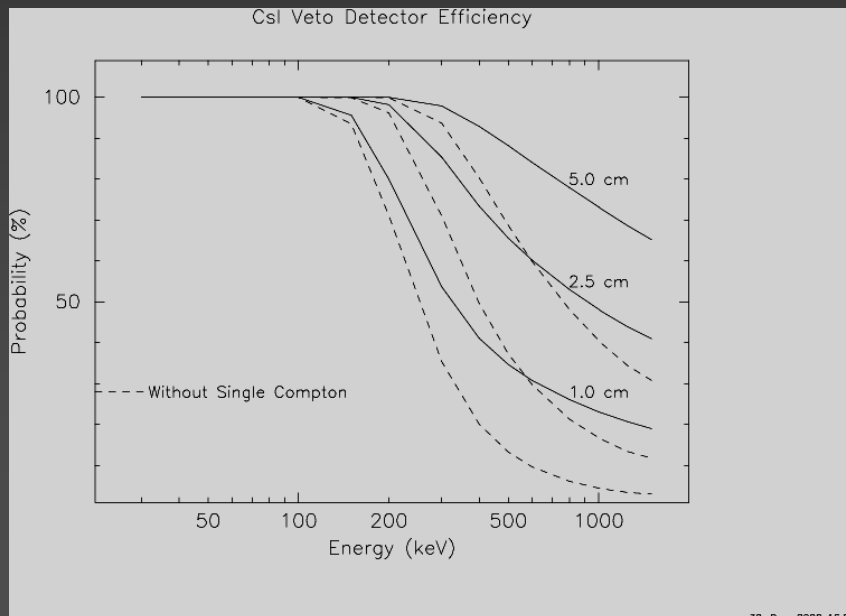
# Major components

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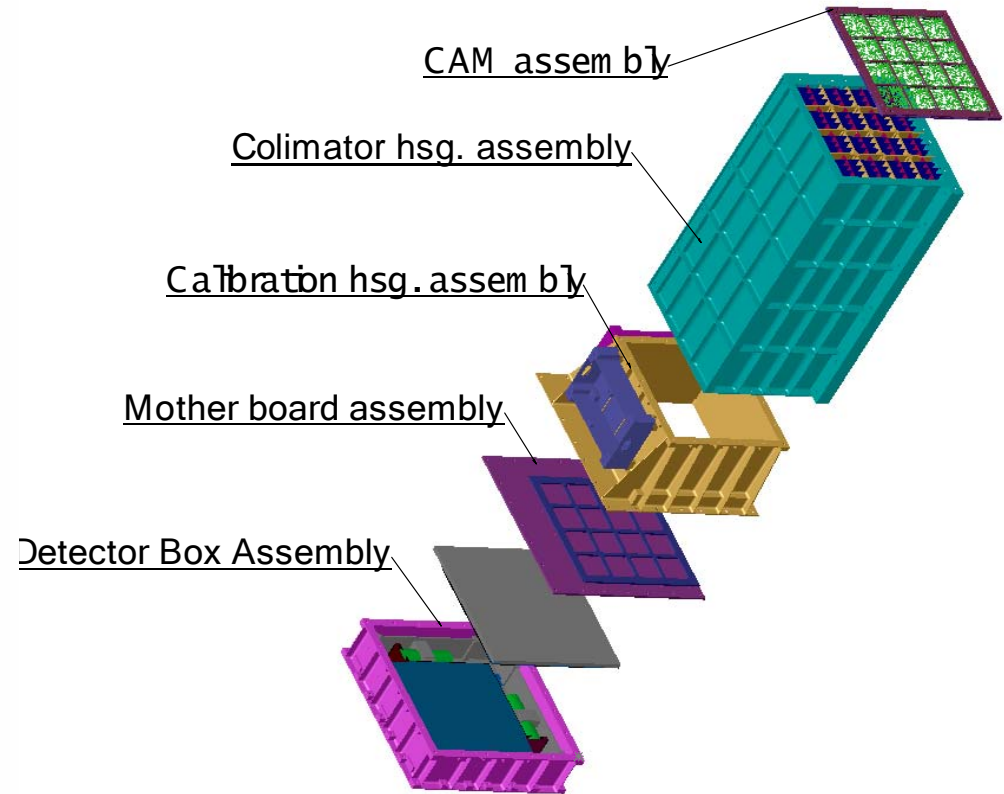
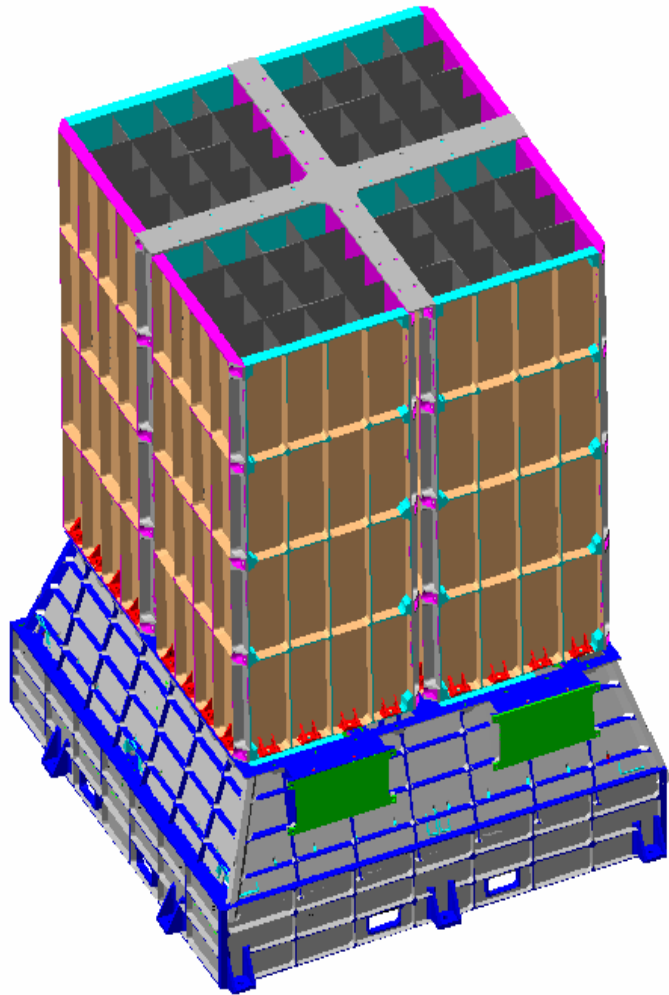
- CZT detectors
  - CsI(Tl) – anticoincidence
  - Collimator/ Coded Aperture Mask
  - Alpha-tagged source
  - Data handling system
-

# Background Reduction

New “Phoswich”  
combination ....



## Details of a Quadrant



## **Four Independent Quadrants**

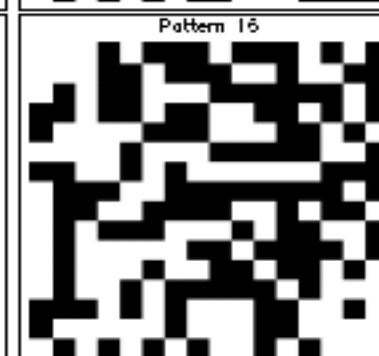
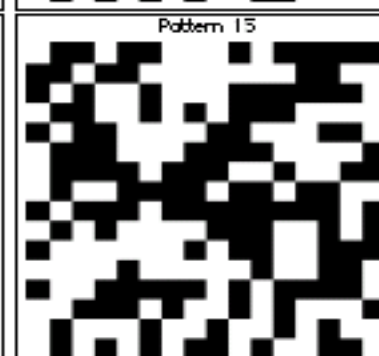
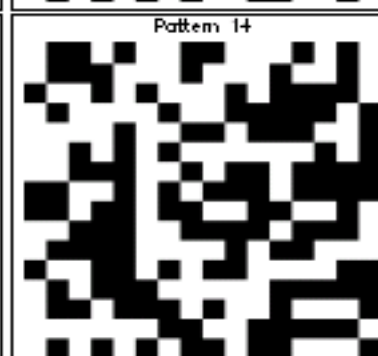
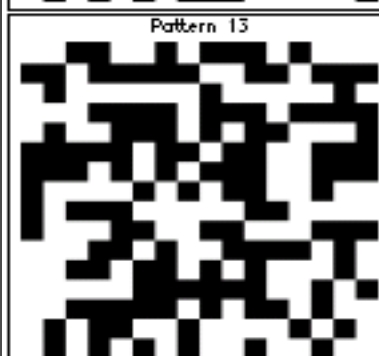
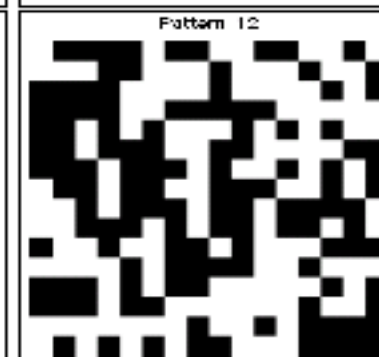
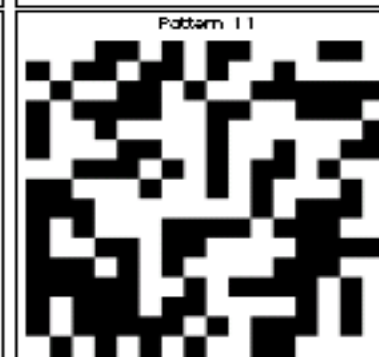
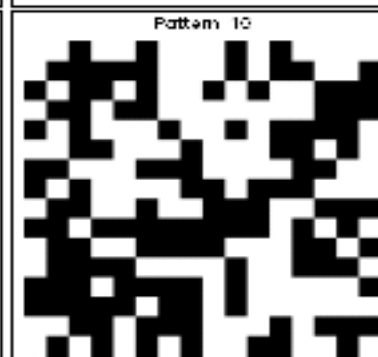
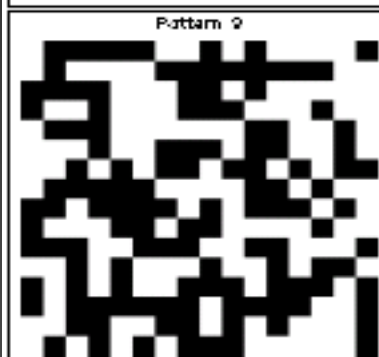
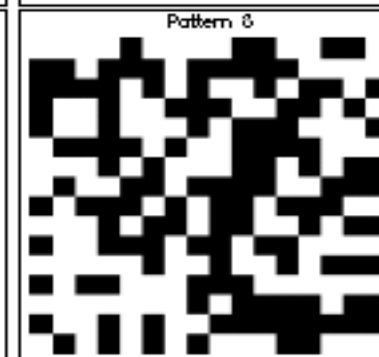
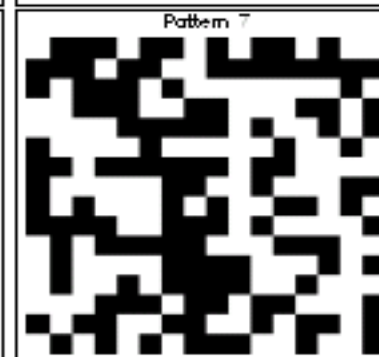
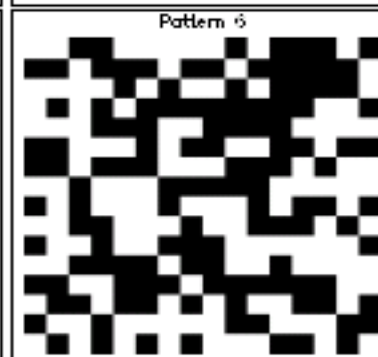
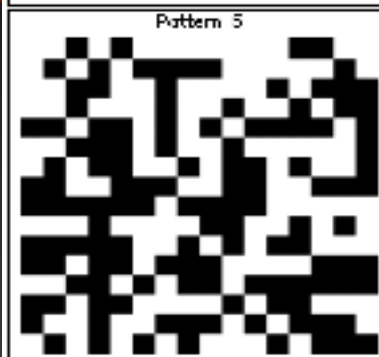
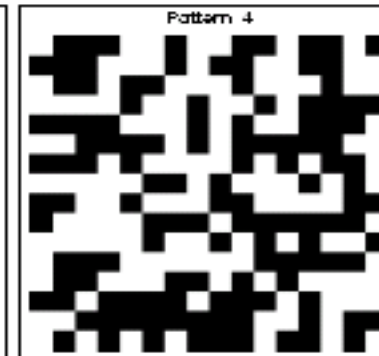
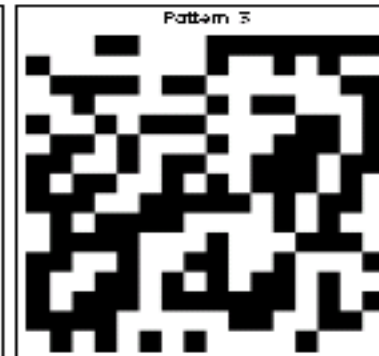
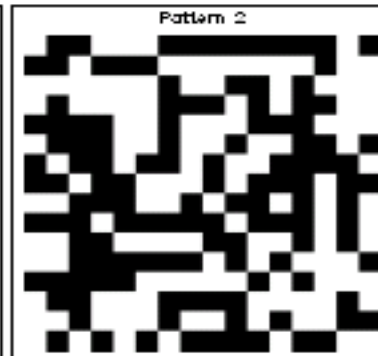
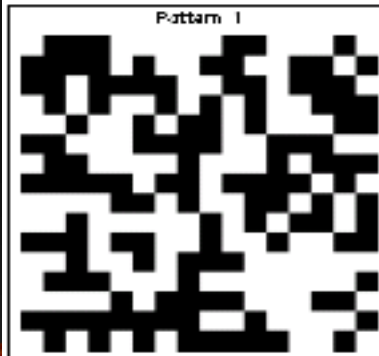
Size - 484 x 484 x 600 mm

Weight - 50 K gm

Collimators - 6 x 6 Degree, 17 x 17 Degree

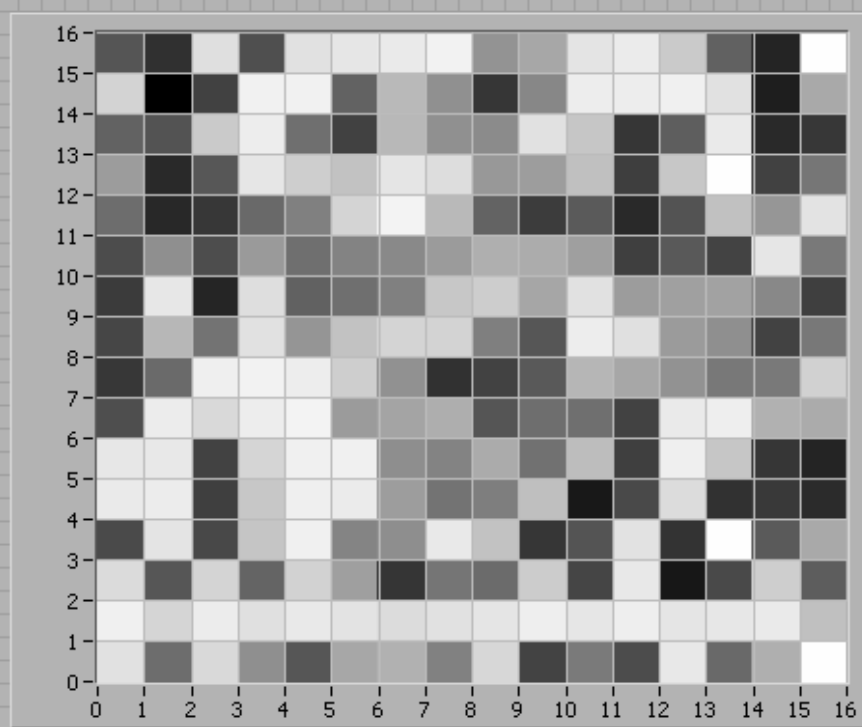
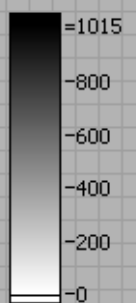
Graded Shield Material – **Tantalum + Aluminum** (For Passive shielding)

**Power- 50 Watts**





IMAGE



Total Counts

1084

Nch x 16  
Nch y 16

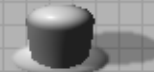
Sampling Time in msec

1000

Pixel Map File

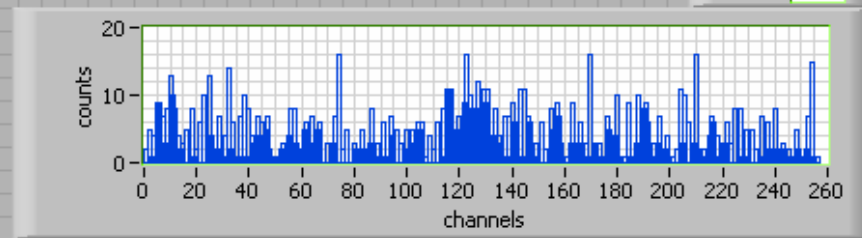
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ACCUULATE



RETURN

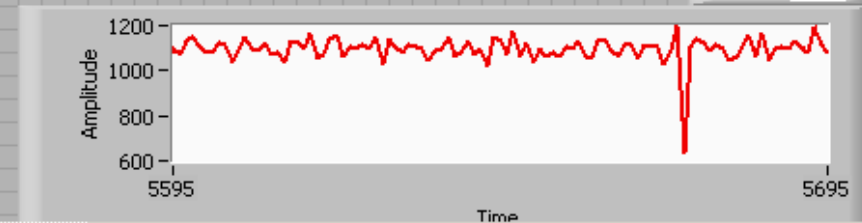
Plot 0

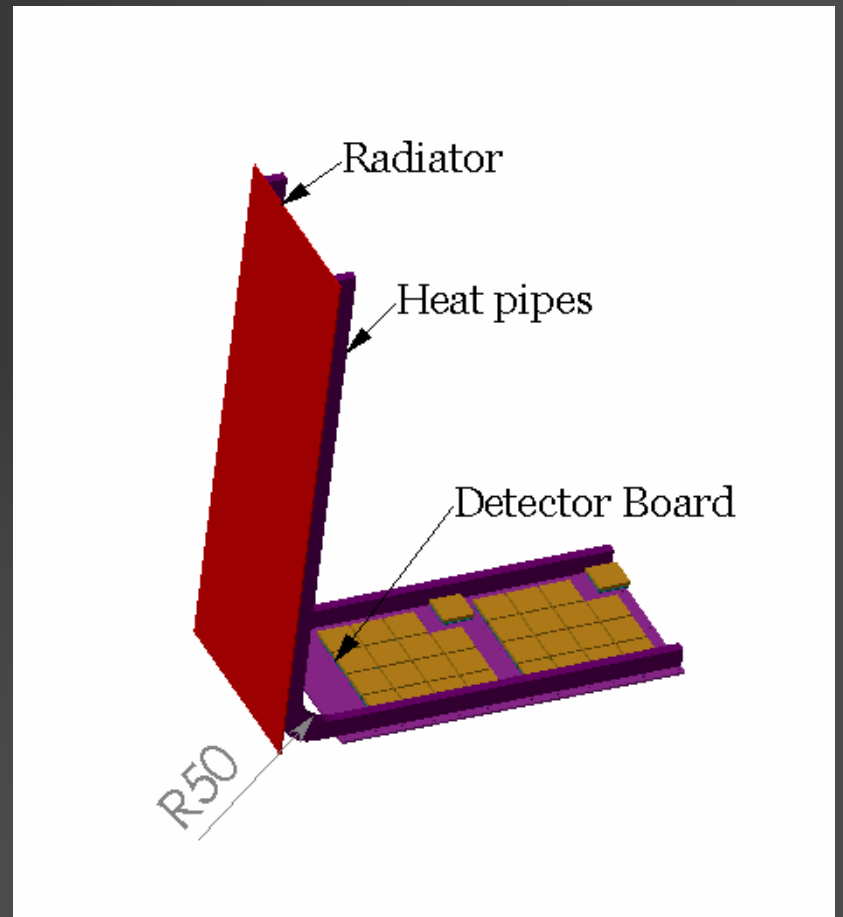
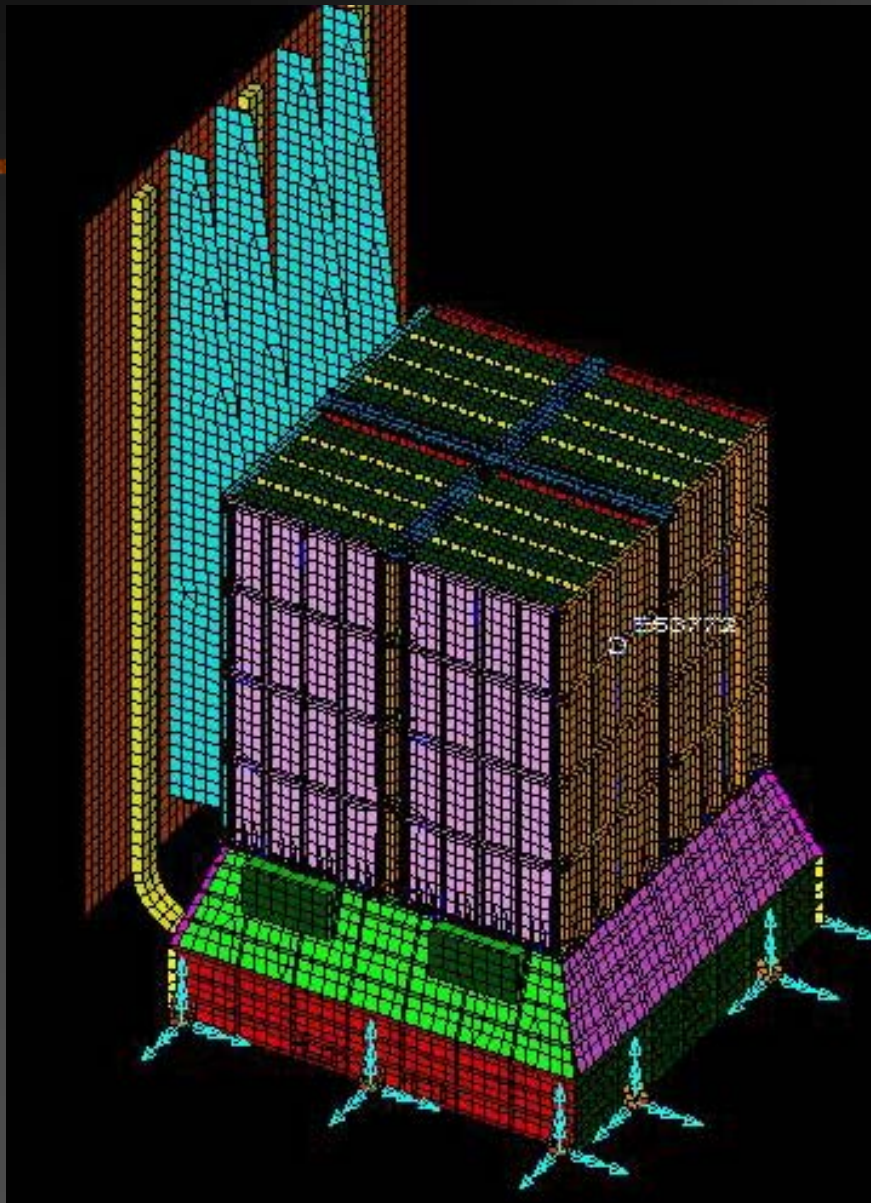


channels  
counts

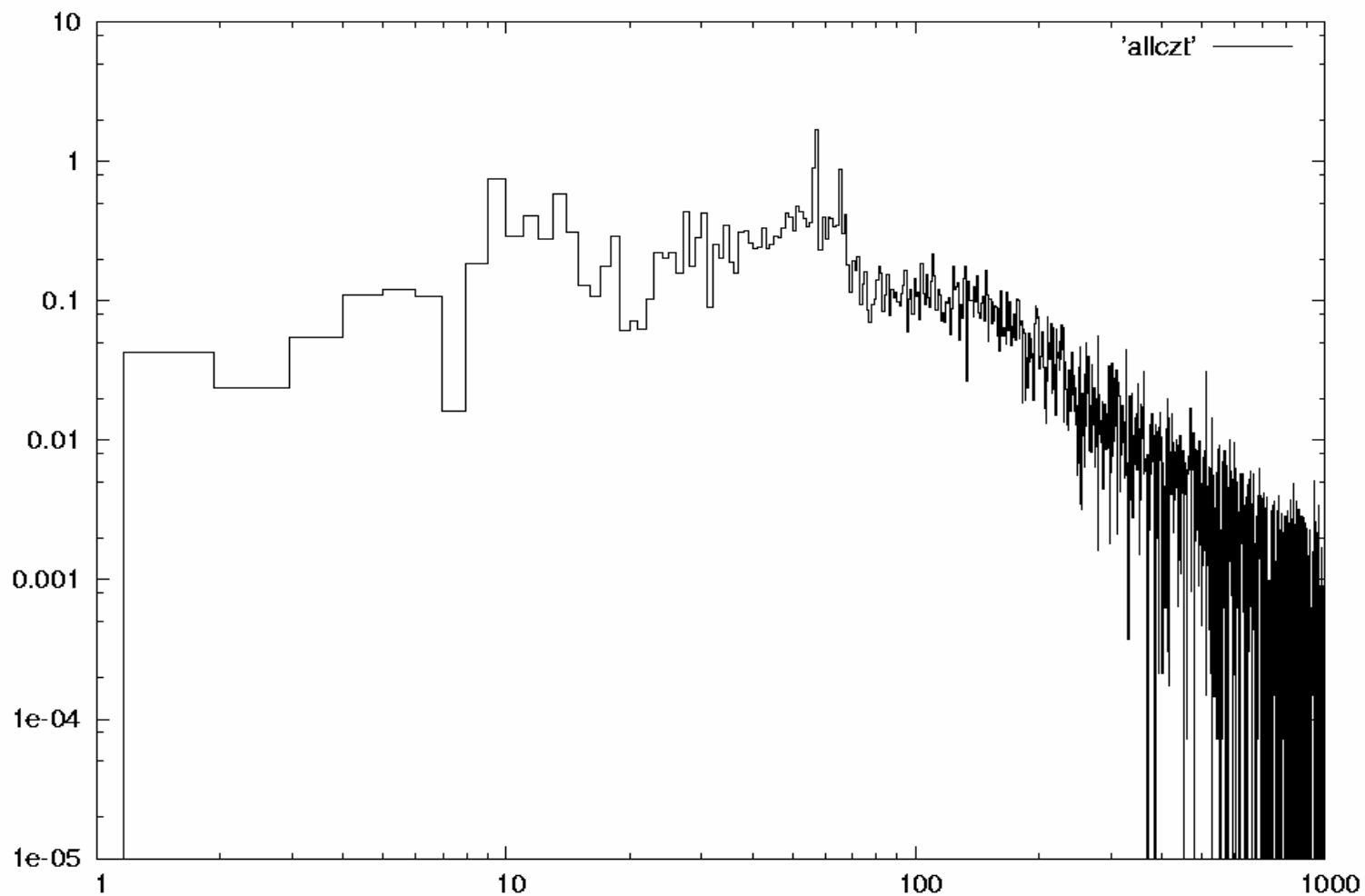
Waveform Chart

Plot 0

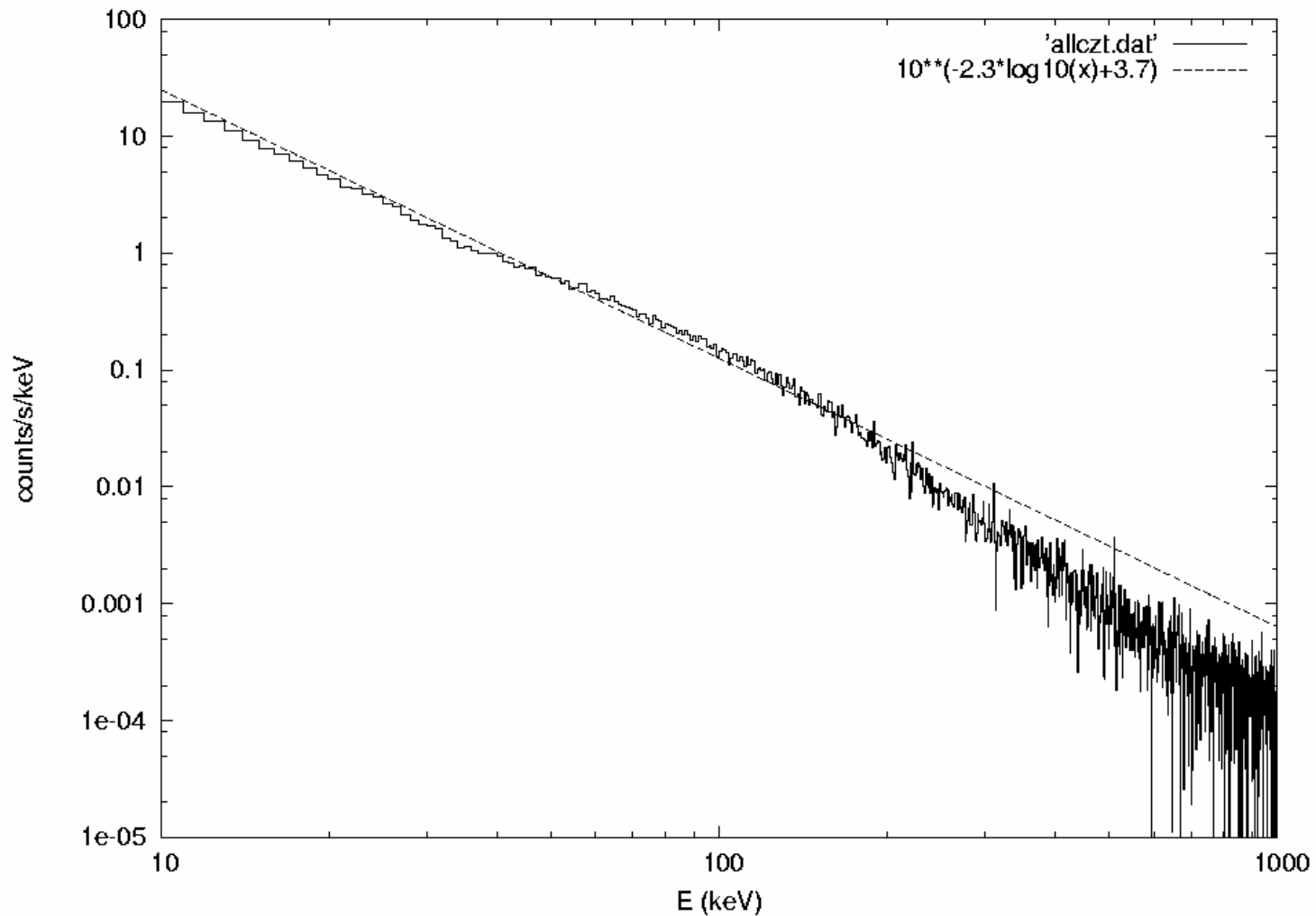




# CZT Background



# Response to a point source



## Expected Count rates (per second; per quadrant)

Diffuse Cosmic background	10
Calibration source	100
Crab Nebula (5 keV threshold)	200
Crab Nebula (10 keV threshold)	100
Veto triggered events	250
Maximum expected event rate	1000

## Output for each X-ray event

Trigger	1 bit
Pixel Address	16 bits
ADC output	12 bits
Multi-hit	1 bit
Veto trigger	1 bit
Veto ADC output	8 bits
ALPHA trigger	1 bit
<b>Total</b>	<b>39 bits + trigger</b>

## House keeping data

+5 V ; +10 V;

Veto HV ; Alpha voltage

Temperature 1,2,3,4

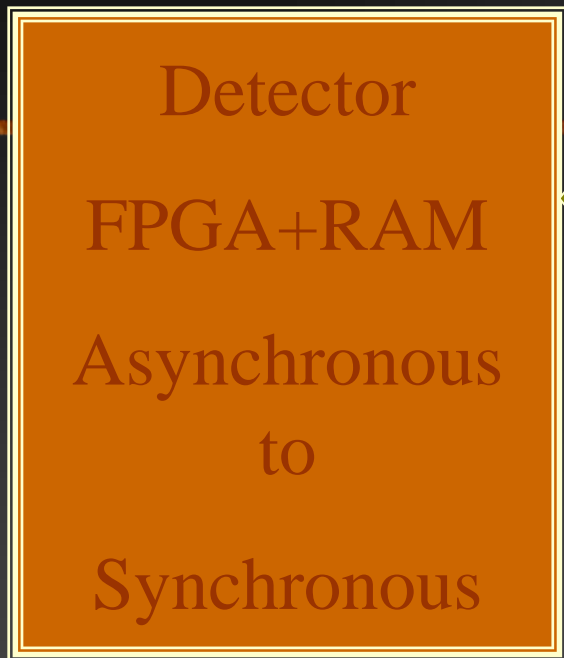
## Counter data:

$\langle E1; E1 - E2; \rangle E2$

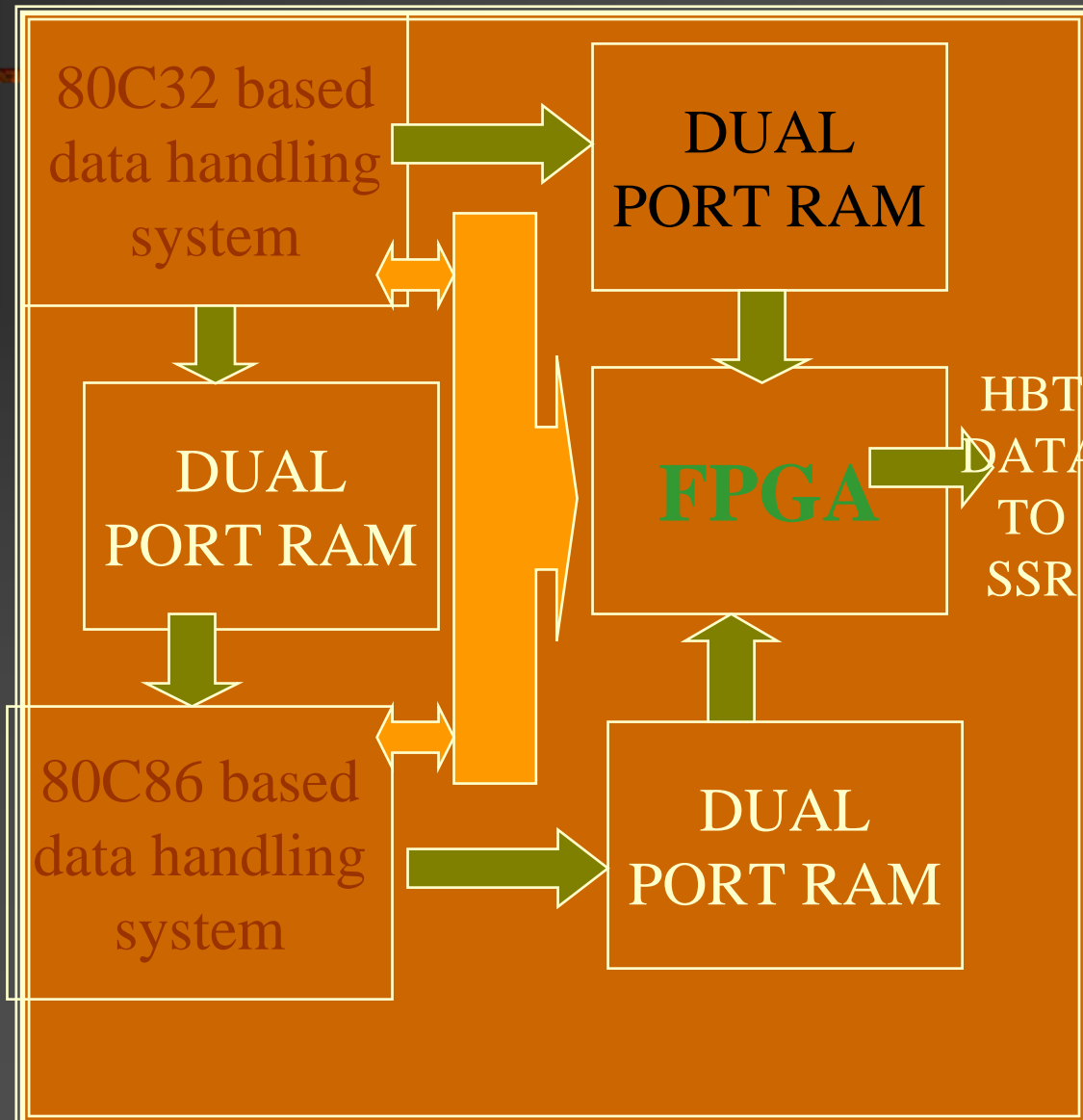
Alpha, Veto

Two Software Counters ( $\langle E1; E1-E2 \rangle$ )

$LLD = 5 \text{ KeV}; E1 = 40 \text{ keV}; E2 = 100 \text{ keV}$



Tele command & power interface



# Conclusions ....

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- Individual event transfer (50 Mbytes per orbit)
  - Continuous calibration
  - Active and passive shielding
  - Good energy spectrum of sources  
> 1 mCrab (about 1000 sources)
  - Galactic X-ray binaries, transients, GRBs, Seyfert galaxies, blazars ....
-