CZT Imager of *ASTROSAT*

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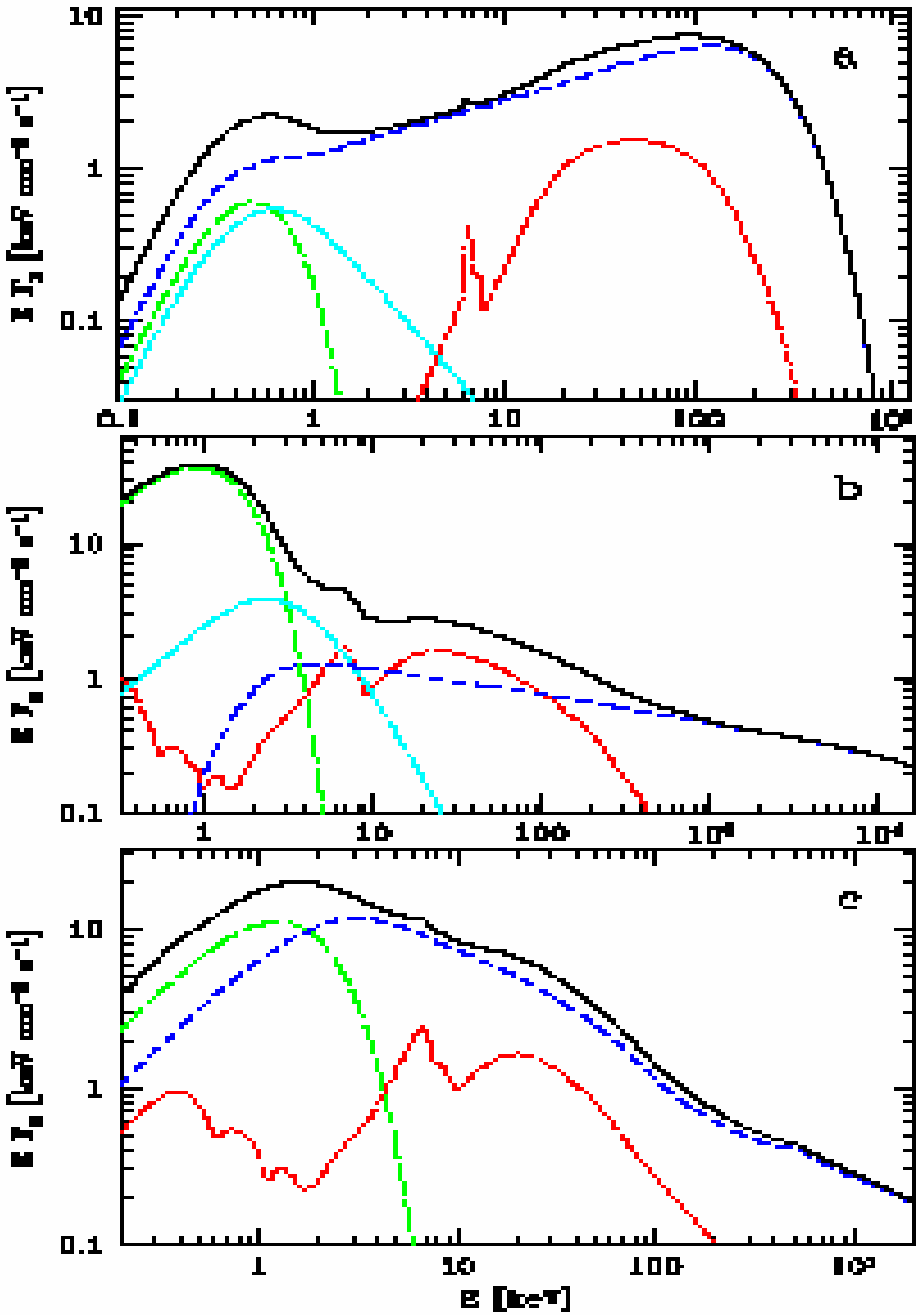
टाटा मूलभूत अनुसंधान संस्थान
TATA INSTITUTE OF FUNDAMENTAL RESEARCH

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

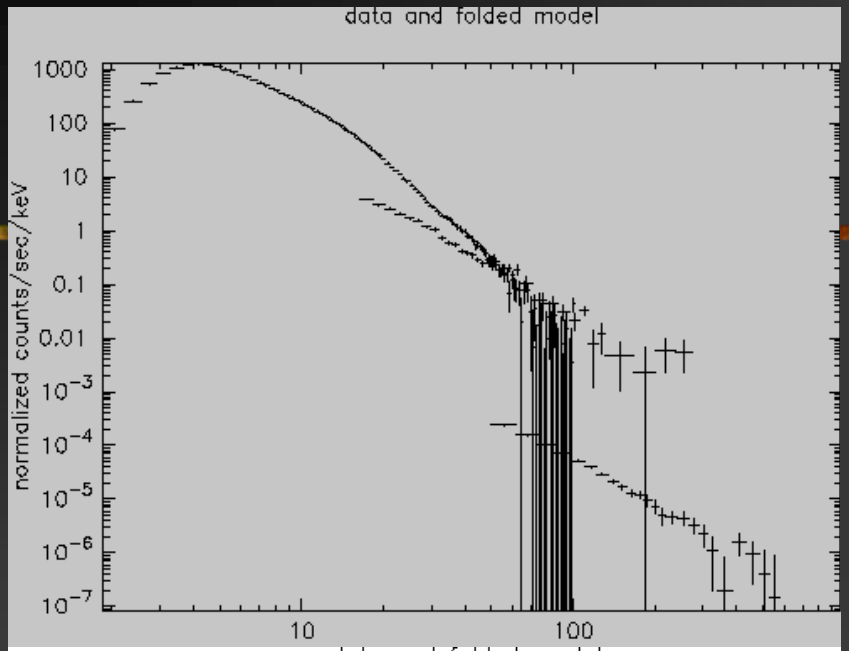
Astrosat Science Objectives

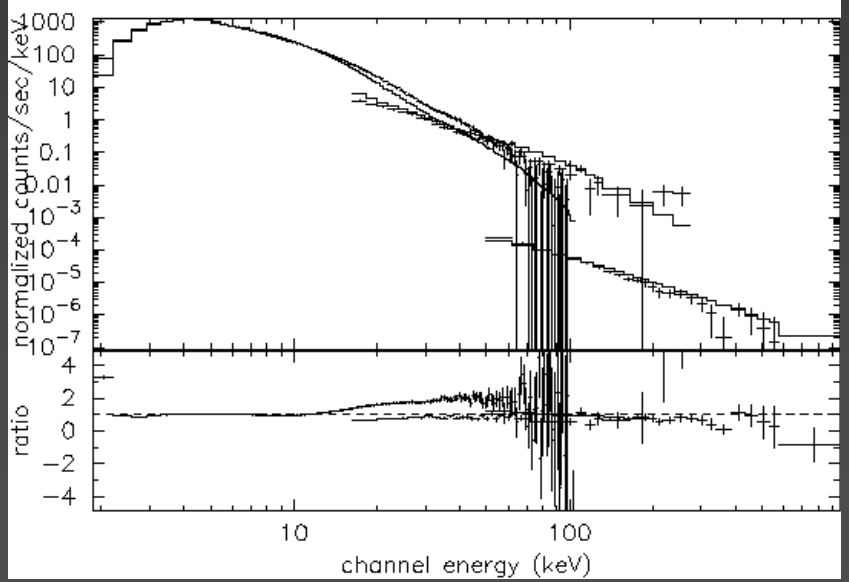
- Multi-wavelength studies (UV to X-rays)
  spectra, variability
- Periodic and aperiodic variability
- *Broad band X-ray spectroscopy*
  non-thermal components,
  cyclotron lines
- Surveys
  All-sky, Galactic plane, deep

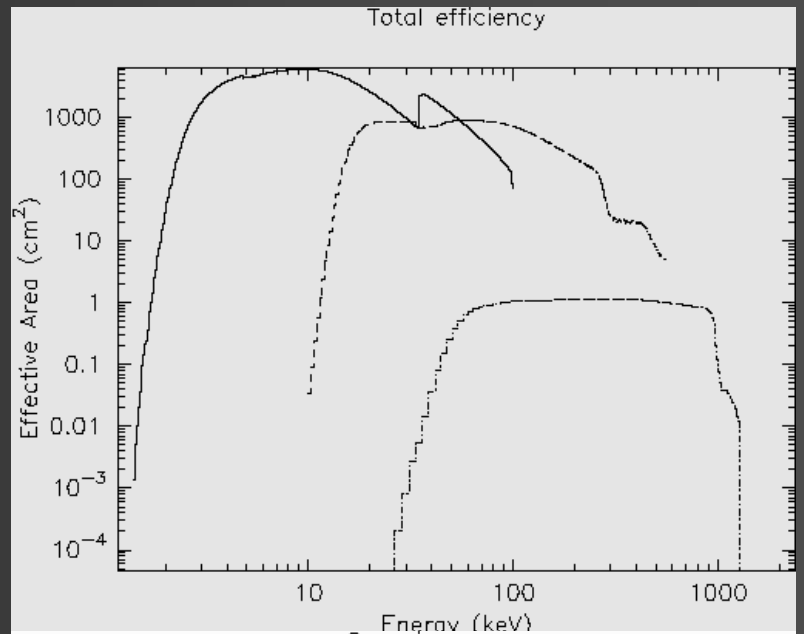
Cygnus X-1: Spectral components

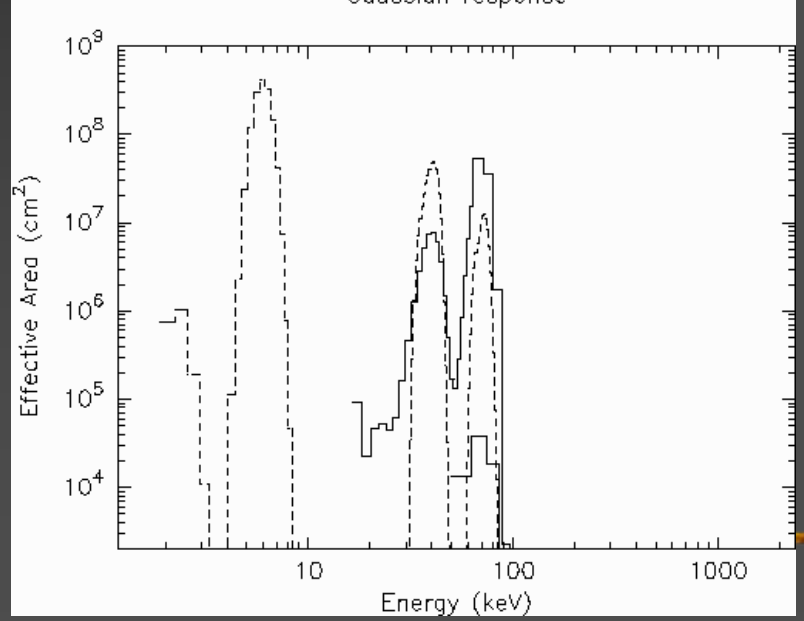


Wide band spectrum of a black hole candidate





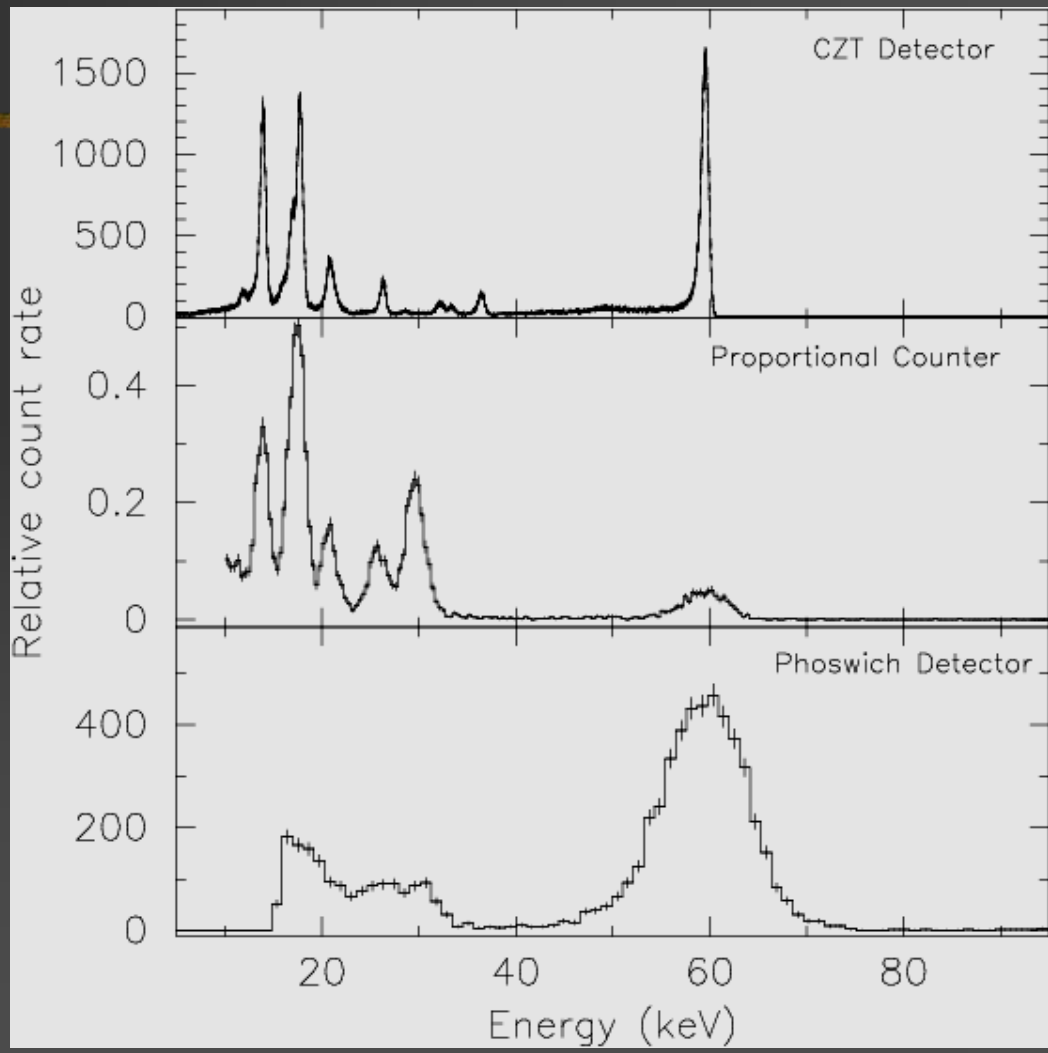




CZT: Hard X-ray detector of the future …..

Good energy resolution
Good efficiency
Pixelated :
- **Moderate imaging**
- **Background estimation**
- **Avoids source confusion**

Background reduction
Good spectroscopic detector

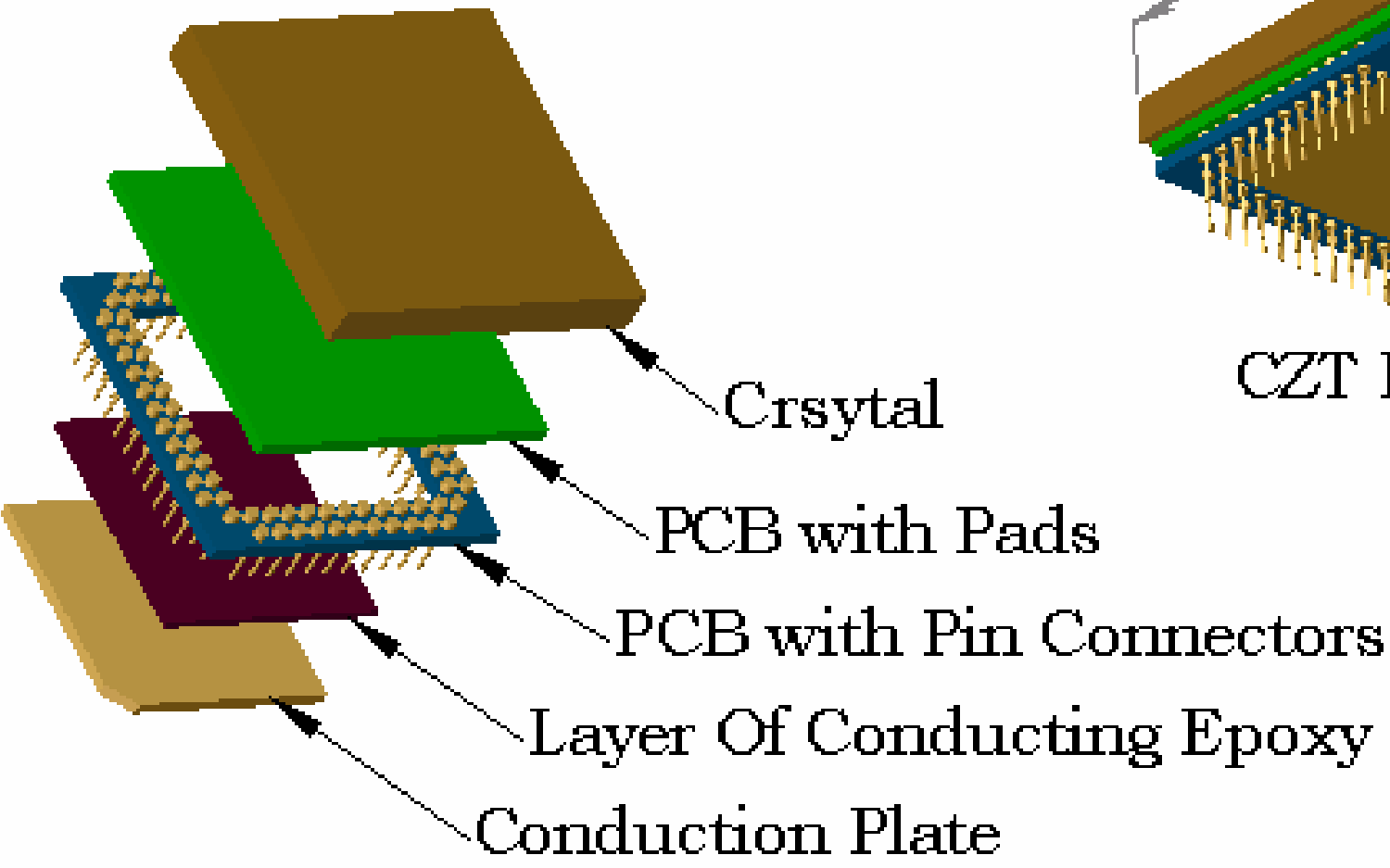


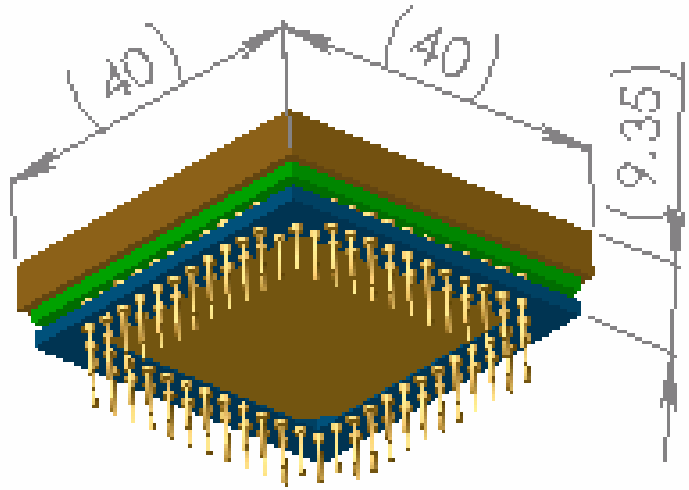
Note: Used up to now only as a gamma-ray imager

Science requirements

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

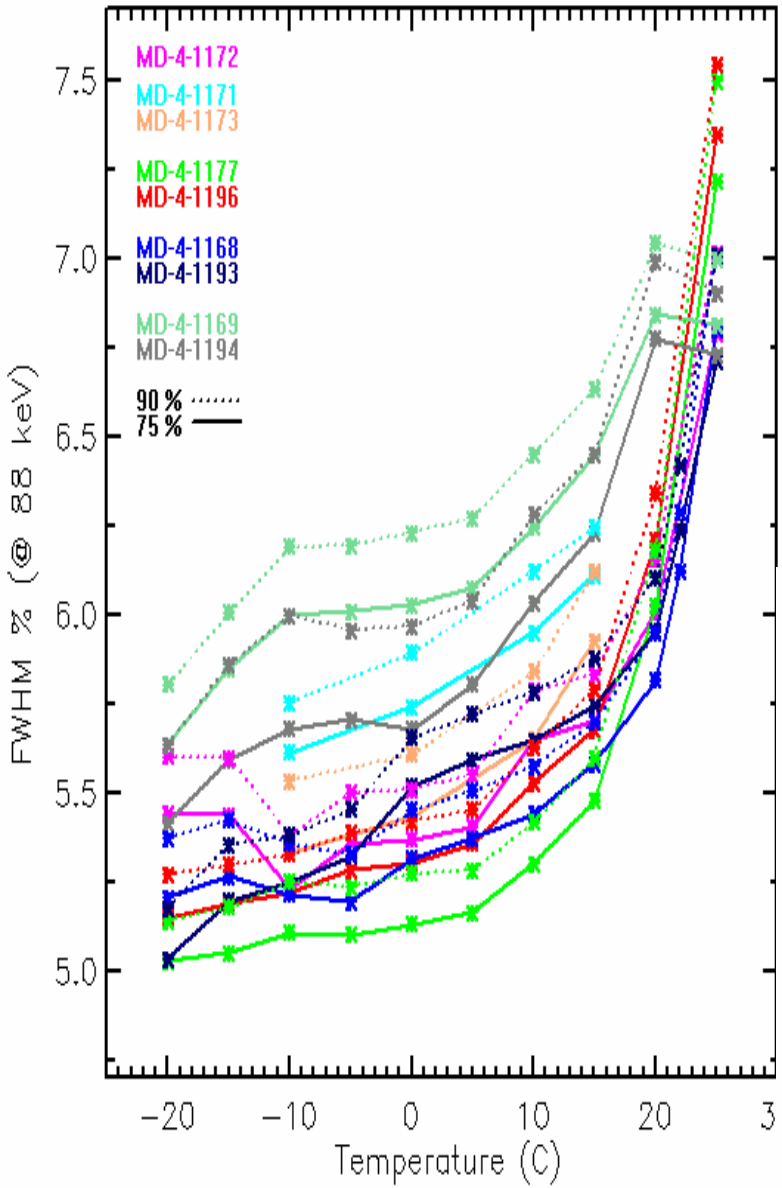
CZT Module

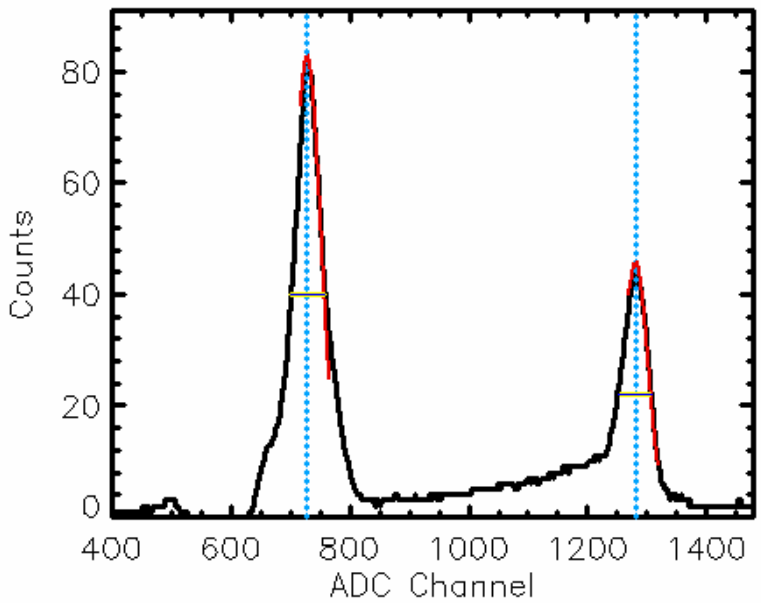




CZT Module

CZT Module characterization





Specifications…

Area	1024 cm^2 (+/- 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^2 (CAM) - *> 100 keV* 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; 10^4 s)

Design considerations

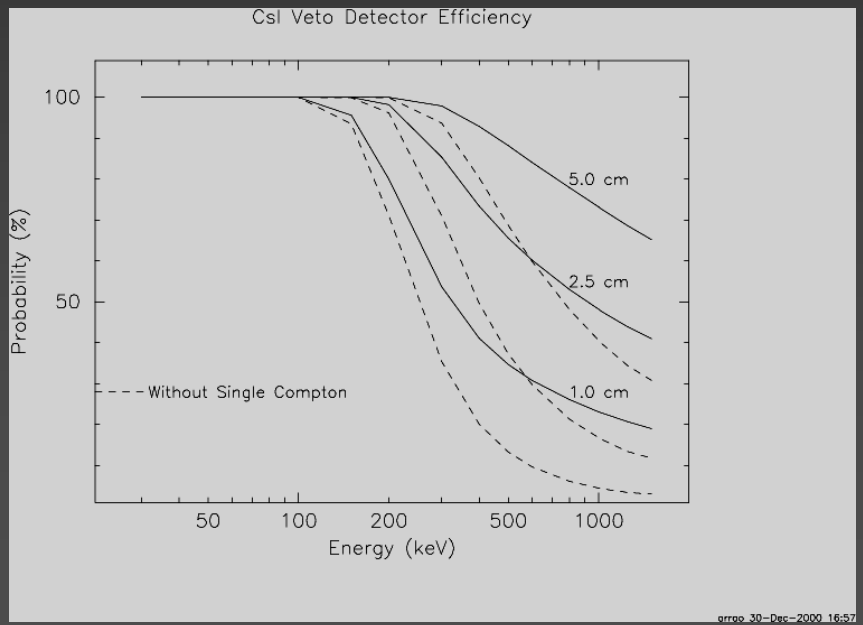
- Active Compton Background rejection
- Simple shield – minimize mass
- Collimator to reduce DCXRB
- Quadrant-wise
- Cooling requirements

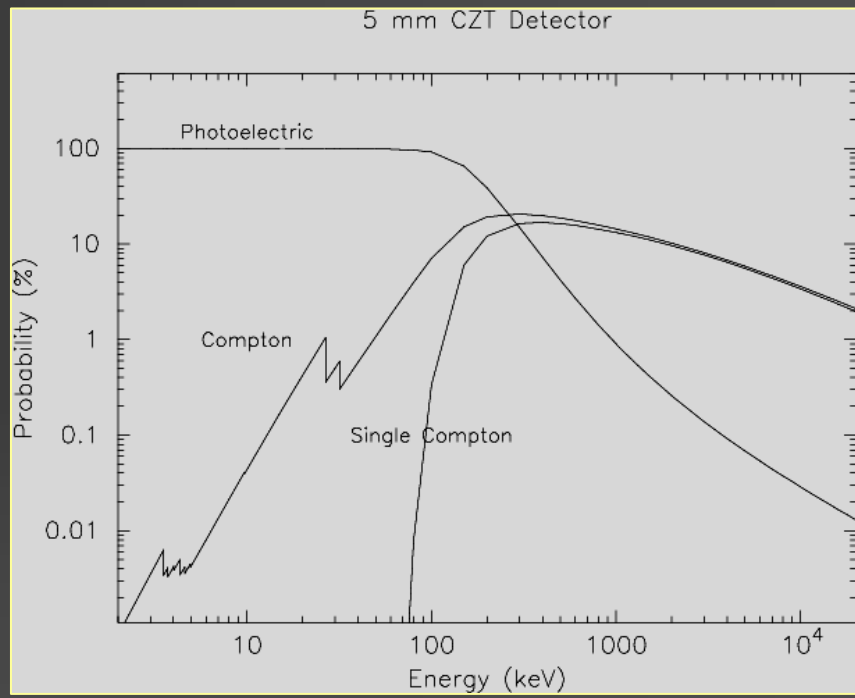
Major components

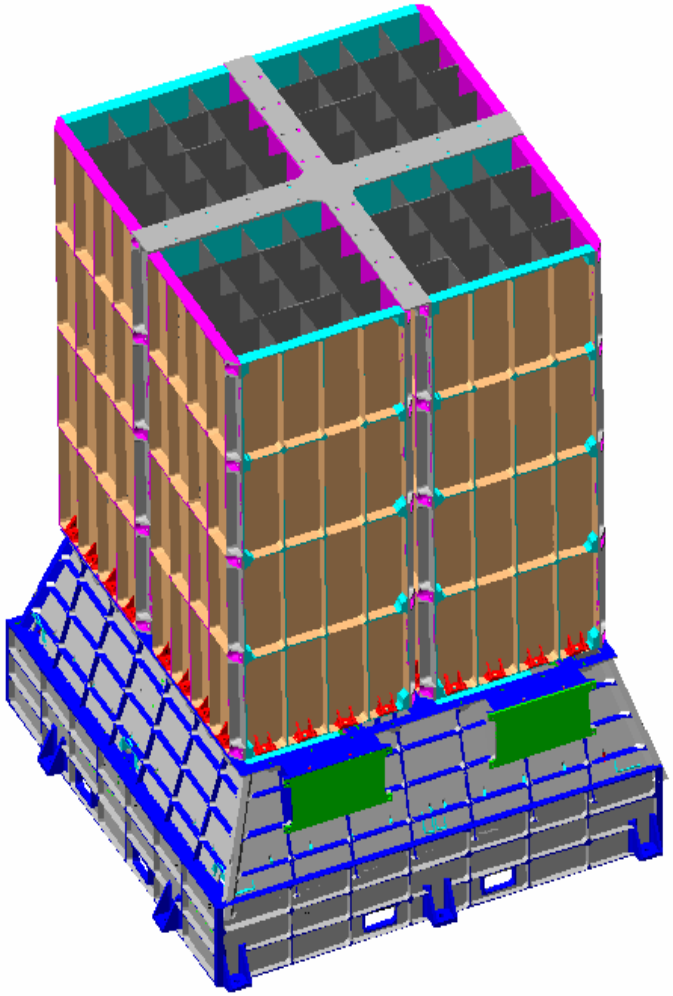
- CZT detectors
- CsI(Tl) – anticoincidence
- Collimator/ Coded Aperture Mask
- Alha-tagged source
- Data handling system

Background Reduction

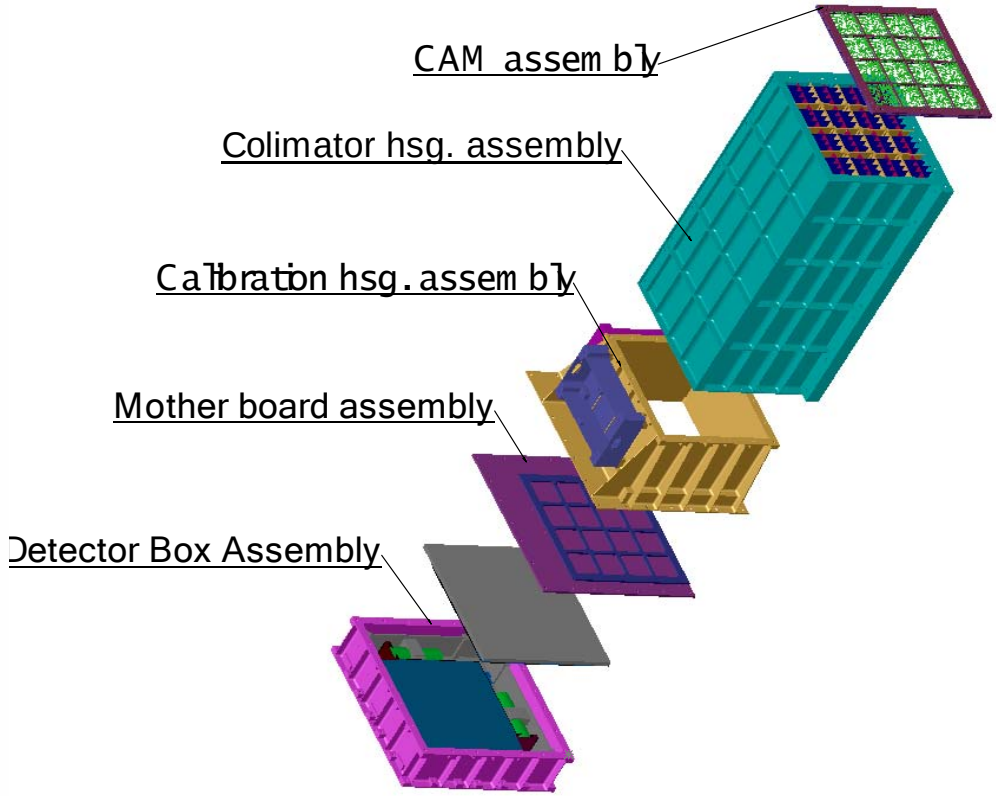
New "Phoswich" combination ….







Details of a Quadrant



Four Independent Quadrants

Size - 484 x 484 x 600 mm

Power- 50 Watts

Weight - 50 K gm

Collimators - 6 x 6 Degree, 17 x 17 Degree

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


Pattern 1
Pattern 2
Pattern 3
Pattern 4
Pattern 5
Pattern 6
Pattern 7
Pattern 8
Pattern 9
Pattern 10
Pattern 11
Pattern 12
Pattern 13
Pattern 14
Pattern 15
Pattern 16

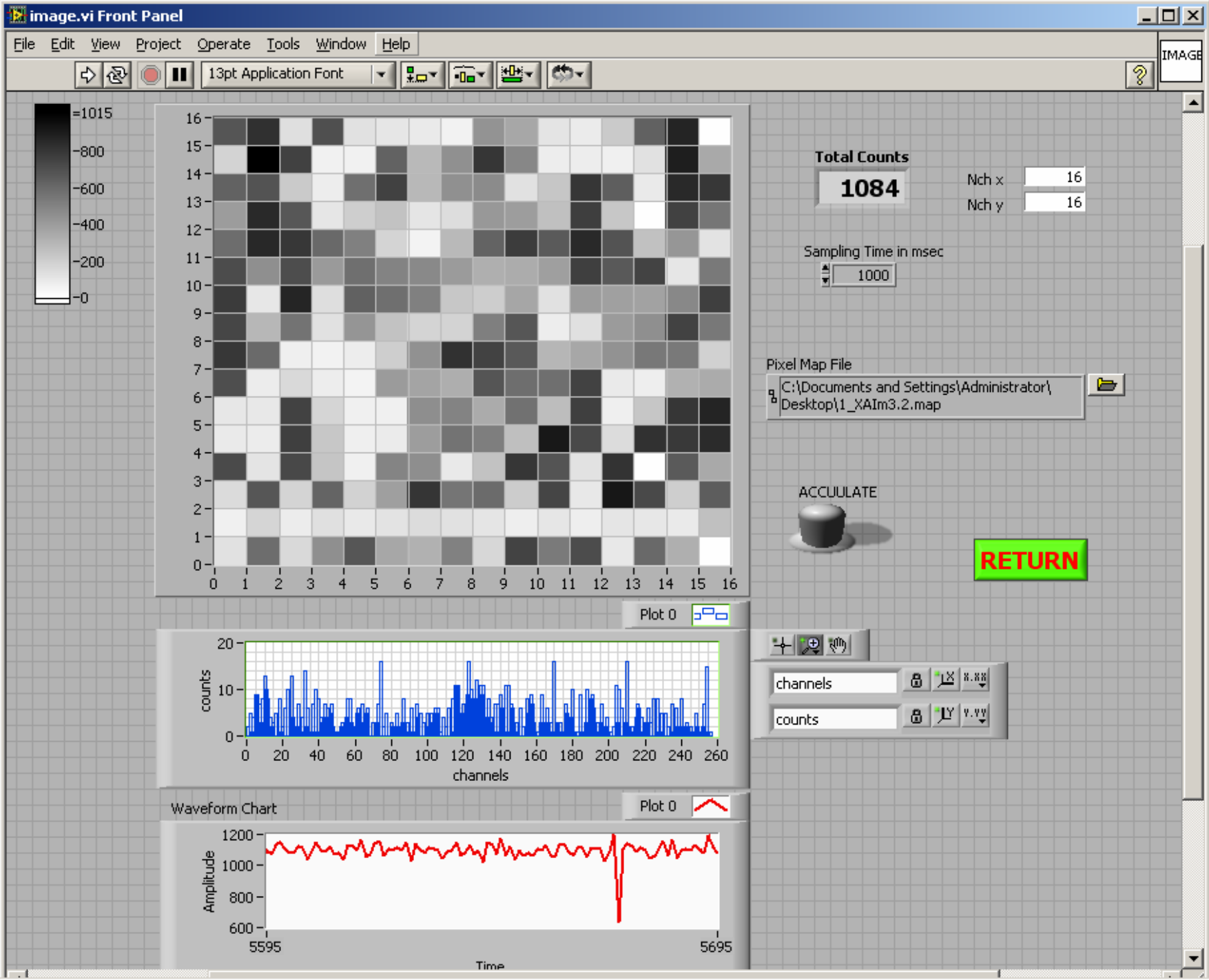
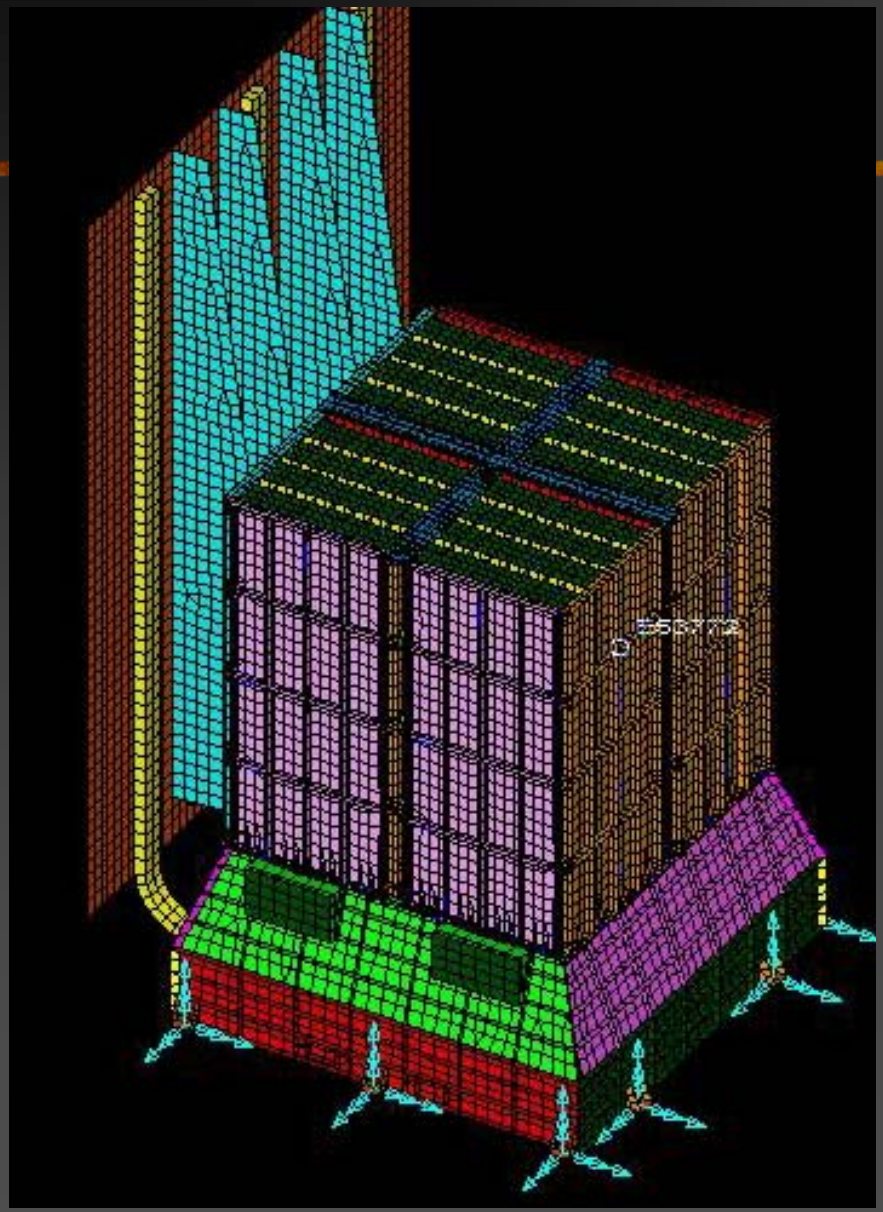
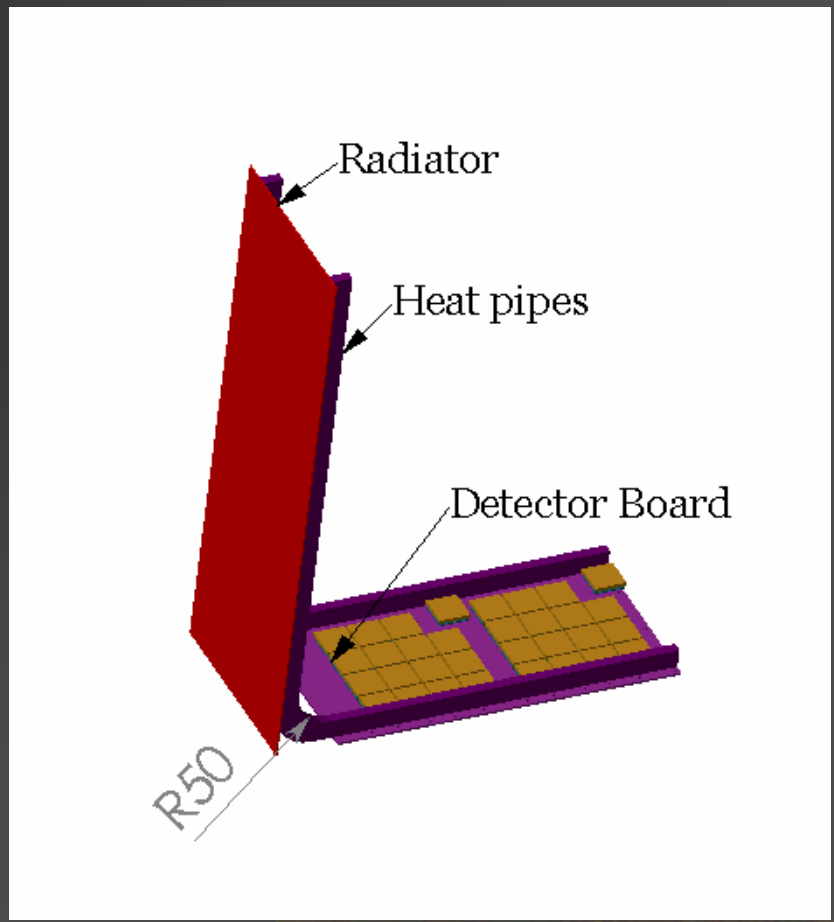
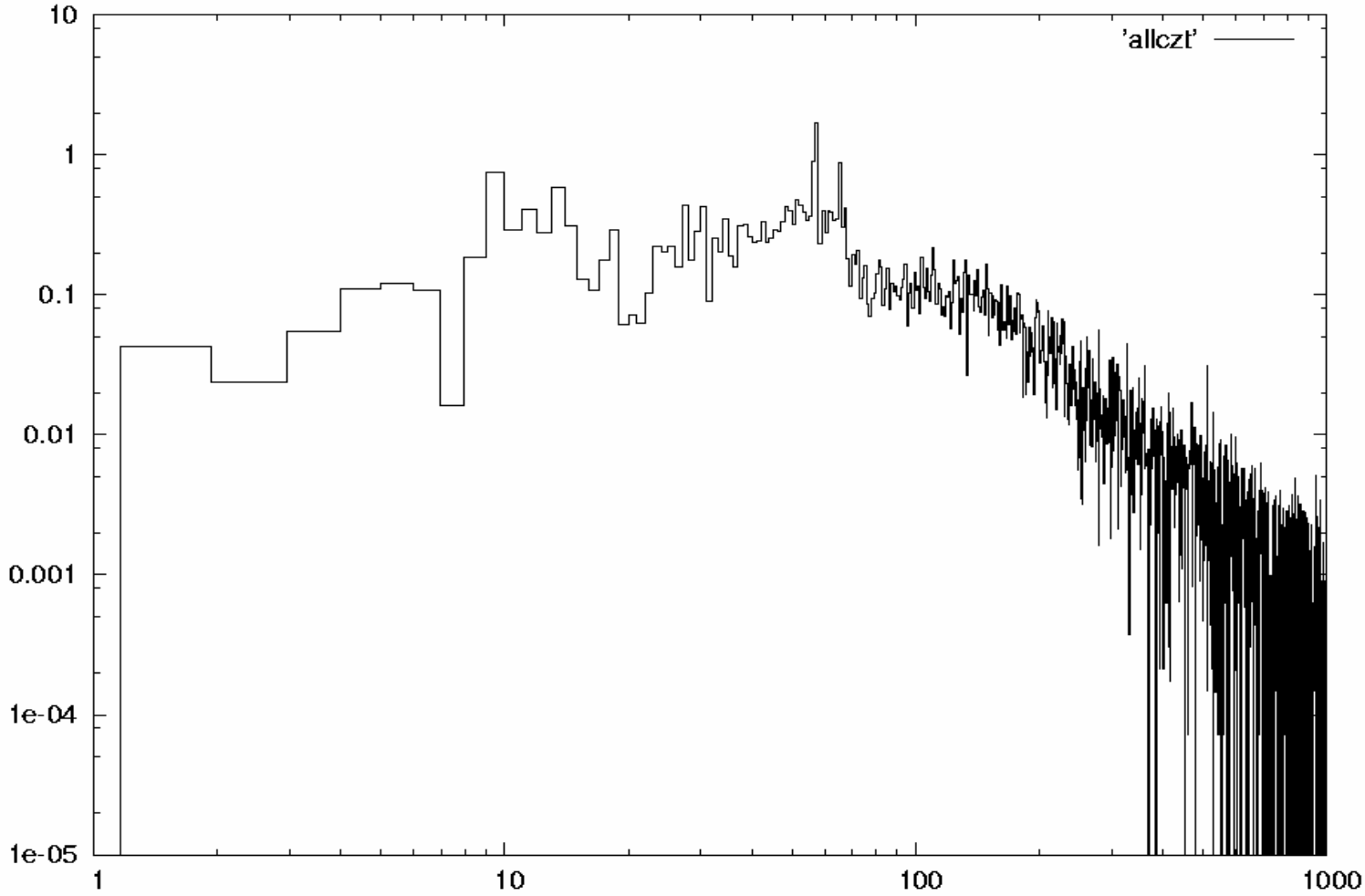


image.vi Front Panel
File Edit View Project Operate Tools Window Help
13pt Application Font
IMAGE
=1015
-800
-600
-400
-200
-0
Total Counts
1084
Nch x
16
Nch y
16
Sampling Time in msec
1000
Pixel Map File
C:\Documents and Settings\Administrator\Desktop\1_XAIm3.2.map
ACCUULATE
RETURN
Plot 0
counts
channels
Waveform Chart
Plot 0
Amplitude
Time
5595
5695

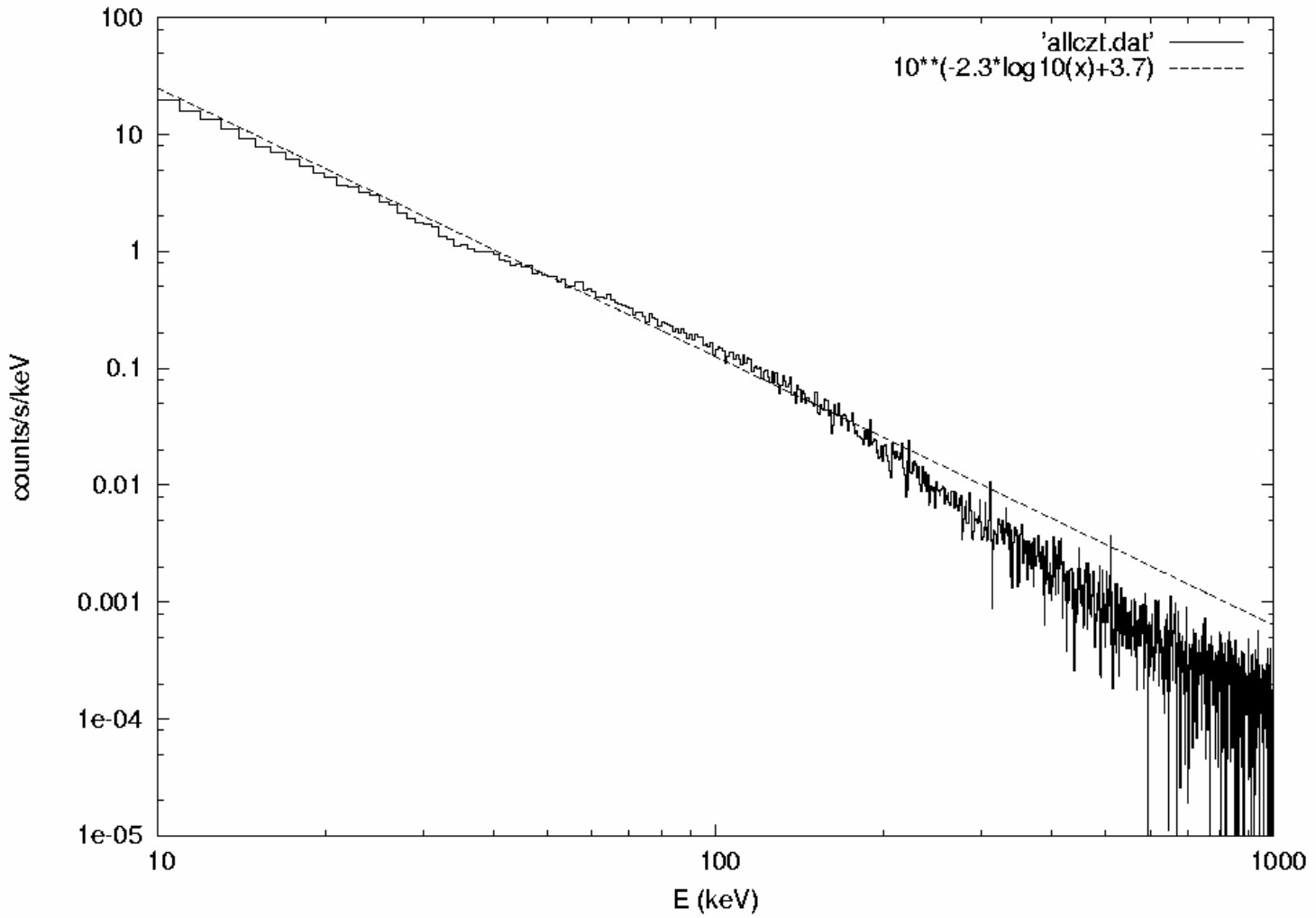



Radiator
Heat pipes
Detector Board
R50

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
Total	**39 bits + trigger**

House keeping data

+5 V ; +10 V;

Veto HV ;Alpha voltage

Temperature 1,2,3,4

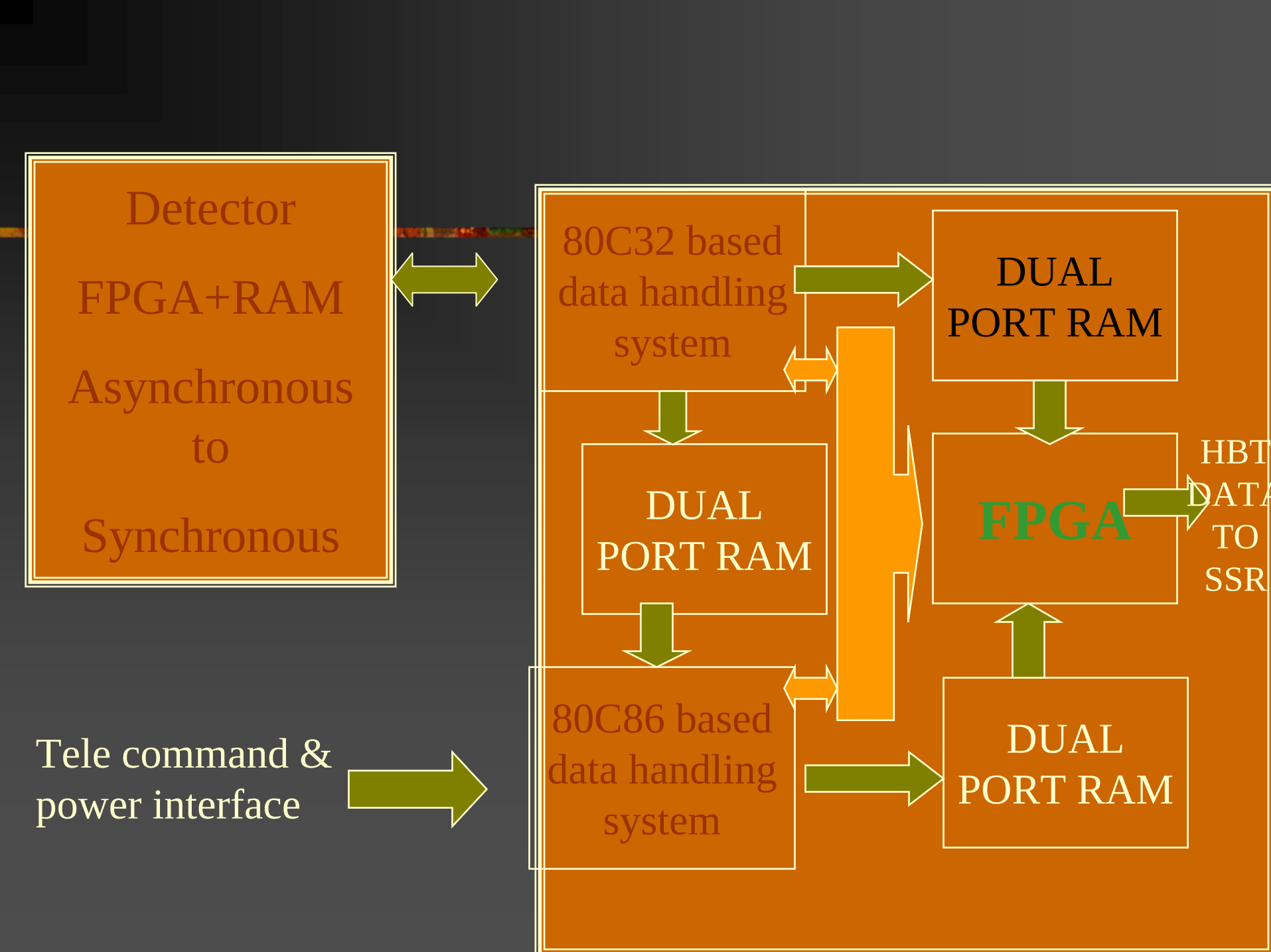
Counter data:

< E1; E1 – E2; > E2

Alpha, Veto

Two Software Counters (< E1; E1-E2)

LLD = 5 KeV; E1 = 40 keV; E2 = 100 keV


Detector
FPGA+RAM
Asynchronous
to
Synchronous
80C32 based
data handling
system
DUAL
PORT RAM
DUAL
PORT RAM
FPGA
HBT
DATA
TO
SSR
80C86 based
data handling
system
DUAL
PORT RAM
Tele command &
power interface

Conclusions ….

- 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 ….