

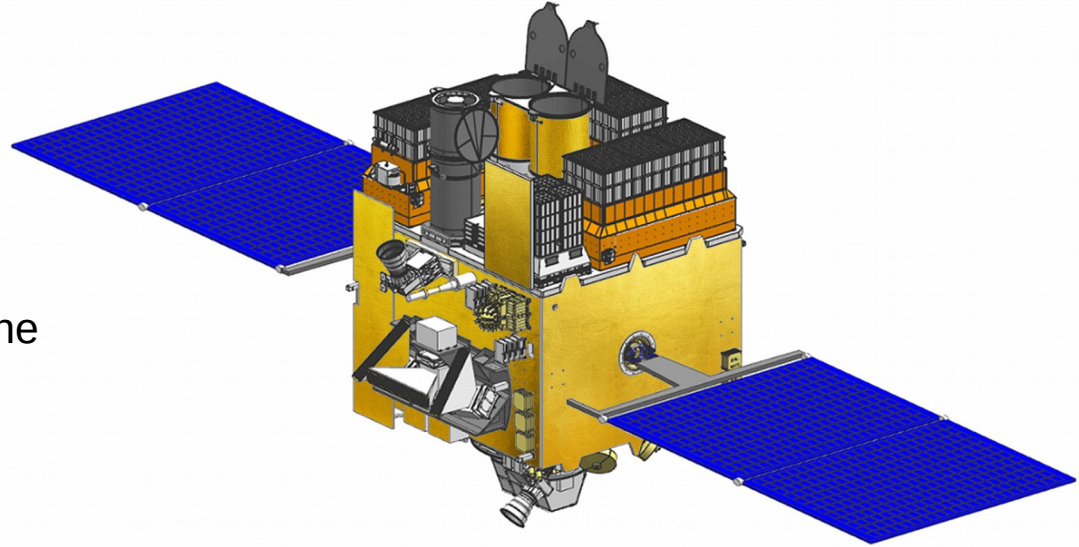
CZTI Data Analysis

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On behalf of CZTI team, IUCAA, Pune



Overview

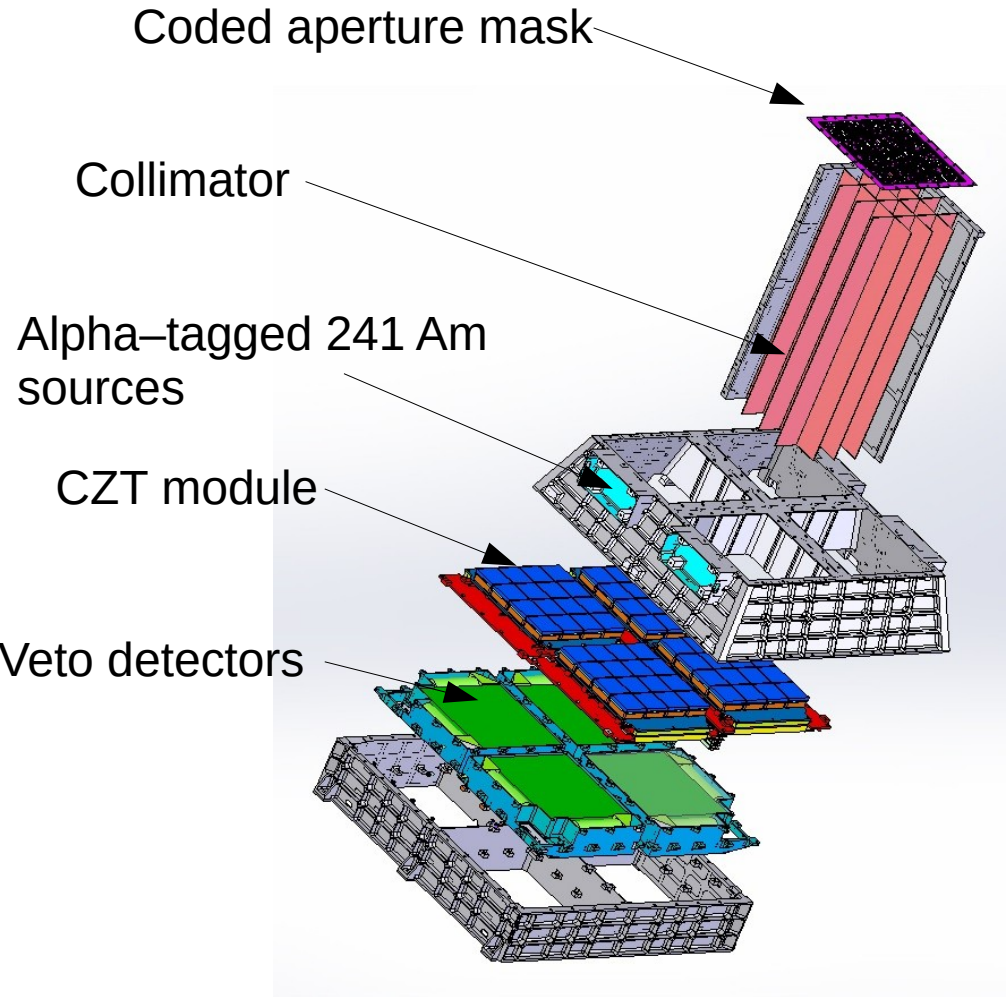
- Basic features
 - 1) coded aperture mask
 - 2) Collimator
 - 3) CZT Detector
 - 4) Alpha and veto detector
- Data reduction process
 1. file structure
 2. level1 to level2
 3. cleaning of data
 4. formation of products: image, lightcurve, spectrum, response files.
 5. Data quality check
 6. GRB 160325A detection



CZTI (AstroSat)

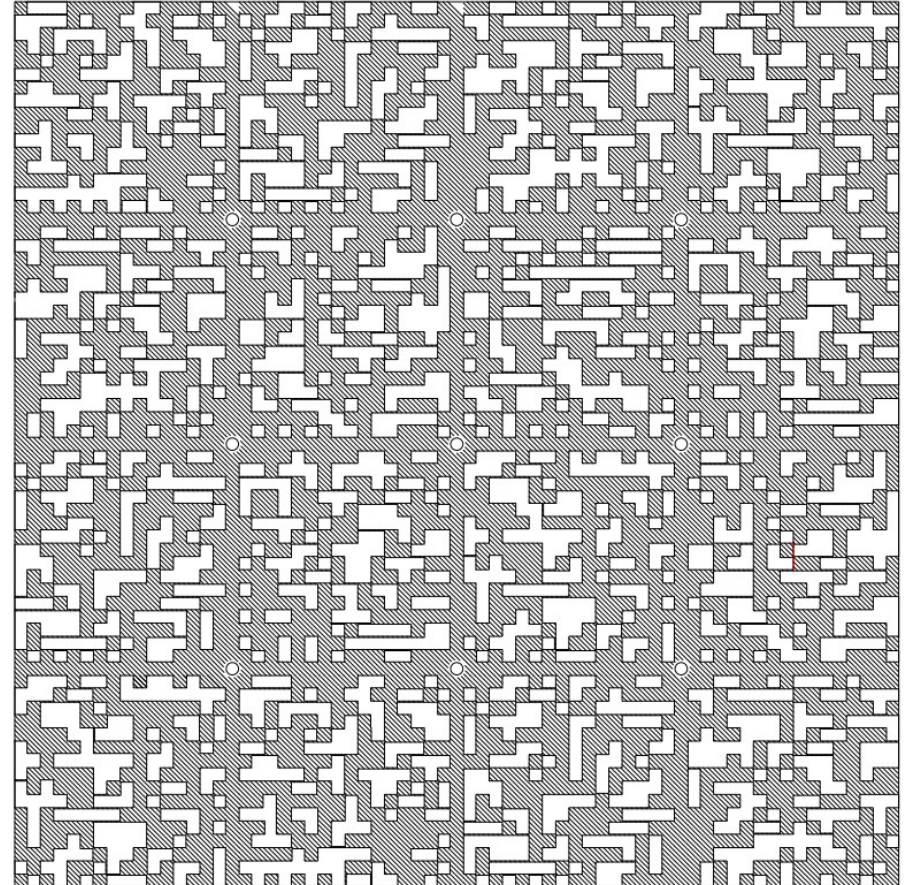
<http://astrosat.iucaa.in/czti/?q=home>

- CZTI is a hard X-ray imaging telescope
- Divided into four independent quadrants
- Can observe the source with veto detectors with 20 micro-sec time resolution
- Good energy resolution



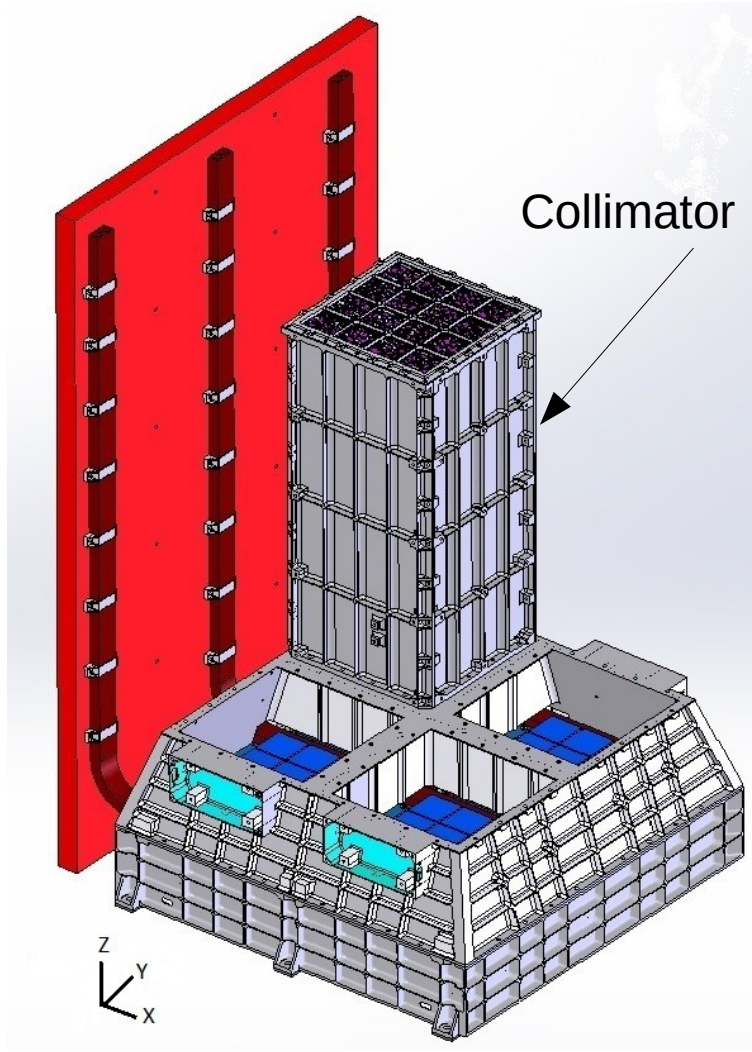
Coded aperture mask

- It is at the top of the detector
- Incident X-ray photons reach the detector through this and collimator
- It consists of a structure of holes of square and rectangular shape
- Its shadow on the detector is used to find the location of the source
- It is used for imaging purpose
- It is made of Tantalum
- At higher energy, photons can pass through all direction and CZTI becomes open sky detector



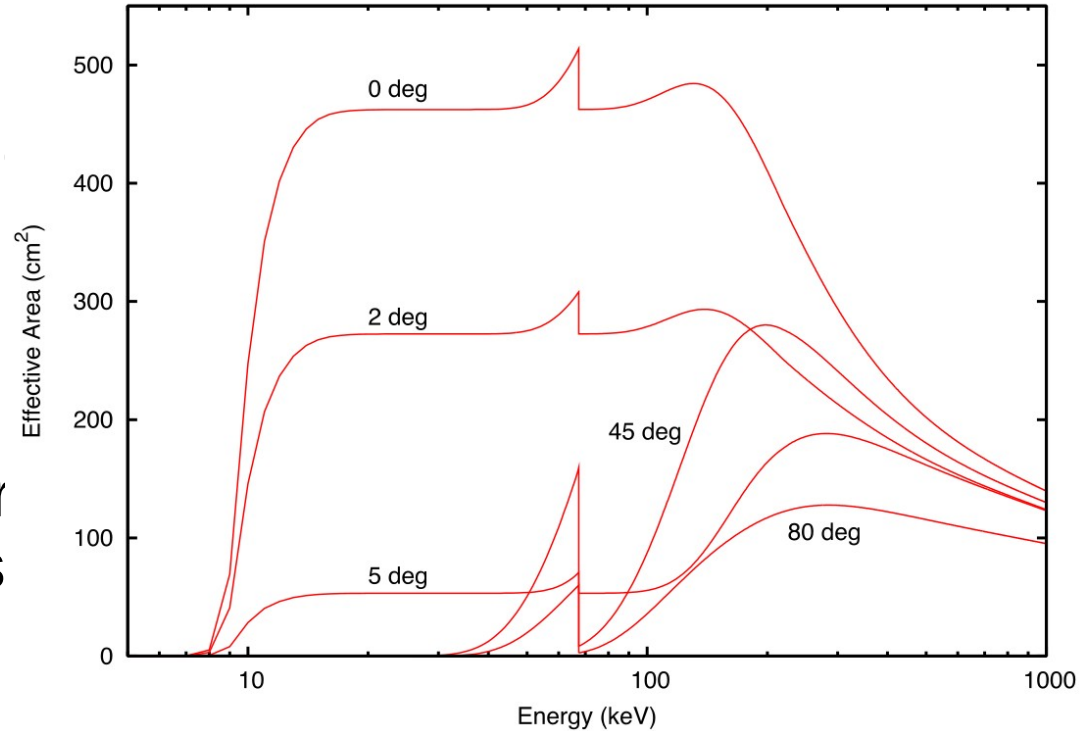
Collimator

- X-ray photon reach on the CZT detector through collimator: made of tantalum and aluminum
- It restricts the field of view by 4.6×4.6 degree.



Effective area of CZTI

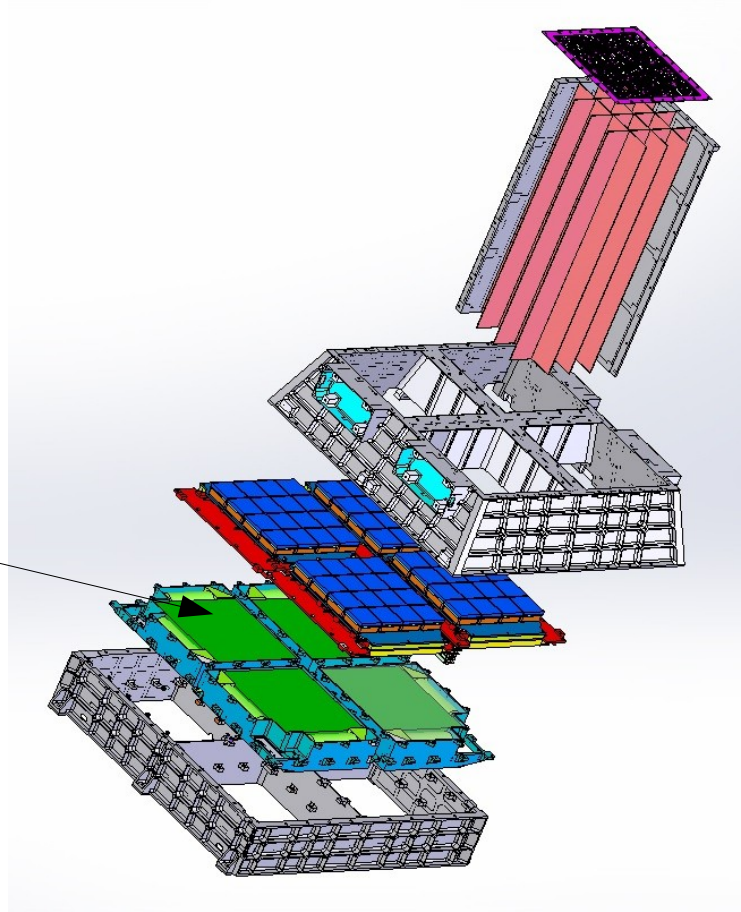
- The effective area of CZTI depends on energy range and direction of incident photons
- Large decrease at energy ~ 60 keV is due to Tantalum
- Effective area increases after 100 keV because it becomes open detector at high energy



Veto detector

- It is used for background reduction
- It is a 20 mm thick CsI(Tl) scintillator
- Signals are amplified by a photomultiplier tube
- When high energy charged particle or photon hit the detector
- It generates light emission
- PMT amplifies the signal
- Time of incidence is noted
- Any event reach on the detector at that instance is removed

Veto detector



alpha-tagged radioactive sources

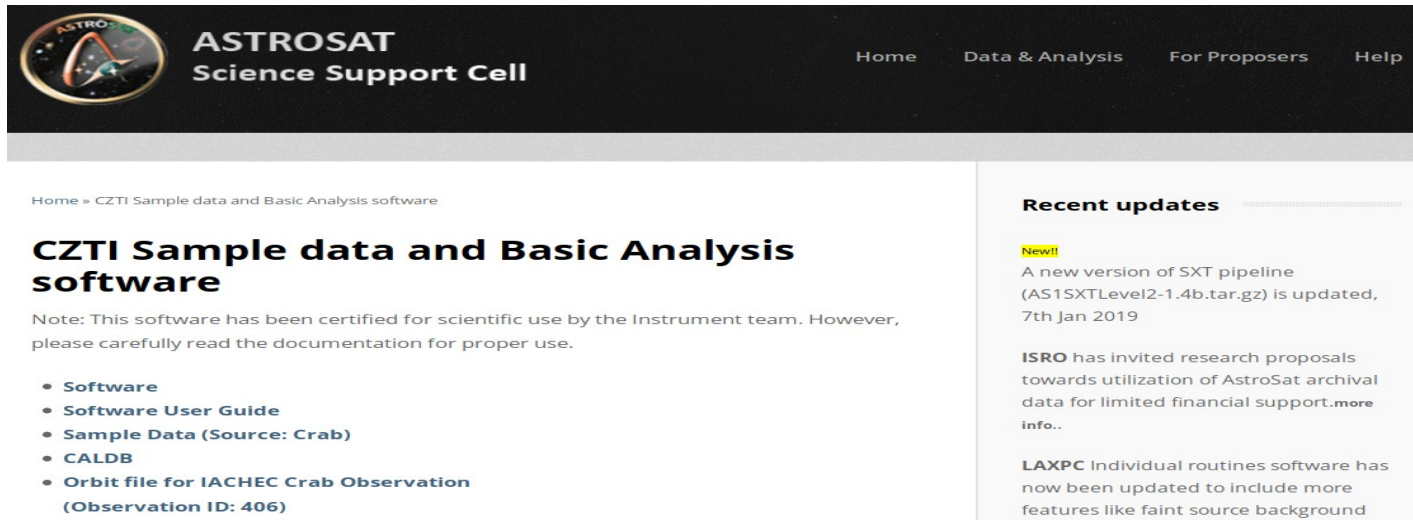
- It is used for calibration purpose
- Radioactive source Am 241 is embedded with scintillator CsI (TI) crystal
- Alpha particle emission is detected in the scintillator which was modified by amplifier
- 59.5 keV X-ray photons emitted during the disintegration of radioactive material pass through Scintillator and reach on the detector
- Pulse created by the alpha particle is time tagged so we can find the 59.5 keV photons.
- We already studied 59.5 keV line at different conditions (like temperature, pixels behaviour, voltages) when it was on the ground
- We use this information for the purpose of calibration

Data reduction process

- Download: software, CALDB, and data
- File structure
- Level1 to level2
- cleaning
- Formation of image
- Formation of lightcurve, spectra and response files

Software and CALDB: download

- Download software and CALDB from AstroSat Science Support Cell
- <http://astrosat-ssc.iucaa.in/?q=cztiData>
- Follow the instructions given in pipeline user guide

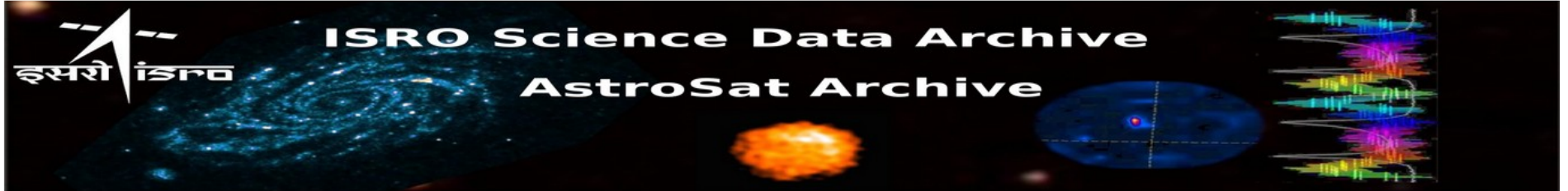


The screenshot shows the website header for the AstroSat Science Support Cell. The header includes the AstroSat logo, the text "ASTROSAT Science Support Cell", and navigation links for "Home", "Data & Analysis", "For Proposers", and "Help".

The main content area displays the breadcrumb "Home » CZTI Sample data and Basic Analysis software" and the title "CZTI Sample data and Basic Analysis software". A note states: "Note: This software has been certified for scientific use by the Instrument team. However, please carefully read the documentation for proper use." Below the note is a list of links: "Software", "Software User Guide", "Sample Data (Source: Crab)", "CALDB", and "Orbit file for IACHEC Crab Observation (Observation ID: 406)".

On the right side, there is a "Recent updates" section. It features a "New!" tag and a notification: "A new version of SXT pipeline (AS1SXTLevel2-1.4b.tar.gz) is updated, 7th Jan 2019". Below this, it mentions "ISRO has invited research proposals towards utilization of AstroSat archival data for limited financial support.more info.." and "LAXPC Individual routines software has now been updated to include more features like faint source background".

Data download



LOGIN

Username

Password

Enter the code

Submit

Reset

[Register/Password Reset](#)

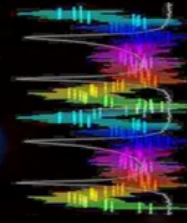
Welcome to ISRO Science Data Archive for AstroSat Mission

Utilization of Astrosat Archival Data (with limited financial assistance) [click here](#) for more details

The science data from observations made by the instruments on board the spacecraft are available for download after the [proprietary perio](#) from this portal.



ISRO Science Data Archive AstroSat Archive



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Object Name e.g. M31 or sirius

RA

DEC

OR

Coordinate System

Search Radius

Default radius is 1.0

Search Results Formats Formatted Text VOTable

Released Data

Instrument/Mode Selection

ALL

SXT
Photon Counting Mode
FW

UVIT
Photon Counting Mode
Integration Mode

LAXPC
Broad Band Counting Mode
Event Mode
Fast Counter Mode

CZTI
Normal Mode



WELCOME : alam



Search results for :- INSTRUMENT : CZT and RA : 299.59031 and DEC : 35.202

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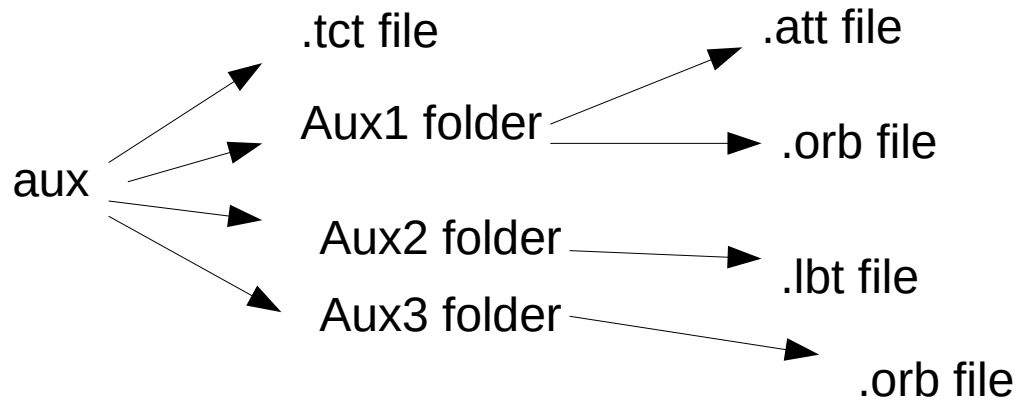
1- 25 OBSERVATIONS out of 30 rows

Download Dataset	Product Details	Sky Map	Proposal Id	Target Id	Observation Id	PI Name	Orbit	Version	Source Name	RA	DEC	Instrument	Date Of Observation	Release Date	Modes
Q ↓ L1 ↓ L2 ↓			G05_237	T03	G05_237T03_9000000426	santoshv	3076	1.2	Cyg X-1	299.59	35.202	CZT	22-Apr-2016	02-Nov-2018	M0,SS
Q ↓ L1 ↓ L2 ↓			G05_191	T01	G05_191T01_9000000524	dedhia	4099	1.2	Cyg X-1	299.5903	35.20161	CZT	01-Jul-2016	02-Nov-2018	M0,SS
Q ↓ L1 ↓ L2 ↓			G07_027	T01	G07_027T01_9000001358	santoshv	9570	1.2	Cygnus X-1	299.5903	35.20161	CZT	05-Jul-2017	25-Sep-2018	M0,SS
Q ↓ L1 ↓ L2 ↓			G06_034	T01	G06_034T01_9000000722	jsyadav	5589	1.2	Cyg X-1	299.5903	35.20161	CZT	09-Oct-2016	25-Sep-2018	M0,SS
Q ↓ L1 ↓ L2 ↓			G05_127	T01	G05_127T01_9000000436	dedhia	3179	1.2	Cyg X-1	299.5903	35.20161	CZT	29-Apr-2016	02-Nov-2018	M0,SS

File structure

Level1 data contents

- AS1G05_167T01_9000000456czt_level1_mcap.xml (text file)
- AS1G05_167T01_9000000456czt_level2.mkf
- Aux (directory)
- LEVL1AS1CZT20160515G05_167T01_9000000456_dqr_V1.2.xml (text file)
 - Modes of data: —
 - ModeM0: default mode: science data
 - ModeM9: during SAA region
 - ModeSS
- ModeM0 (directory)
- ModeSS (directory)



modeM0 → Science data, fits file
 modeSS → Temperature information every 100 sec

.tct file

fv: Binary Table of AS1G02_016T01_9000000258czt_level1...

	SPS_TIME	SPS_OBT	INSTRUMENT_TIME
Select	D	D	D
All	s	s	s
Invert	Modify	Modify	Modify
1	1.899789820000E+08	1.614382106797E+06	1.221207821530E+05
2	1.899789980000E+08	1.614398106707E+06	1.221367821330E+05
3	1.899790140000E+08	1.614414106742E+06	1.221527821130E+05
4	1.899790300000E+08	1.614430106781E+06	1.221687820920E+05
5	1.899790460000E+08	1.614446106691E+06	1.221847820720E+05
6	1.899790620000E+08	1.614462106727E+06	1.222007820520E+05
7	1.899790780000E+08	1.614478106641E+06	1.222167820320E+05

.att file

fv: Binary Table of AS1G02_016T01_9000000258czt_level1.att[1] in /home/md/Documents/cospar_19/cygnu...

	TIME	Q_SAT	Roll_RA	Roll_DEC	Roll_ROT	ATD_STATUS
Select	D	4D	D	D	D	8X
All	s		deg	deg	deg	
Invert	Modify	Modify	Modify	Modify	Modify	Modify
1	1.899790290000E+08	Plot	2.995589892396E+02	3.519531359183E+01	-1.022624768484E+02	0
2	1.899790300000E+08	Plot	2.995586118158E+02	3.519604084049E+01	-1.022620727791E+02	0
3	1.899790310000E+08	Plot	2.995582712953E+02	3.519673486623E+01	-1.022616833267E+02	0
4	1.899790320000E+08	Plot	2.995579234554E+02	3.519744524026E+01	-1.022612920903E+02	0
5	1.899790330000E+08	Plot	2.995575672444E+02	3.519810702667E+01	-1.022609074115E+02	0

Level1 to Level2 event file

- Level1 data: packets of 2048 bytes
- Extract information and write into level2 event file
- Level2 event file: contain information about time, position and energy of each event in tabular format

- Level1 to level2 is done by the task **cztsience2evt**
- Input:
 1. level1 event file
 2. tct file
- Output:
 1. header file
 2. bunch file
 3. level2 science data file

Cleaning

- Charged particle background
- Hot and noisy pixels
- SAA region
- Earth occultation

Particle background issue

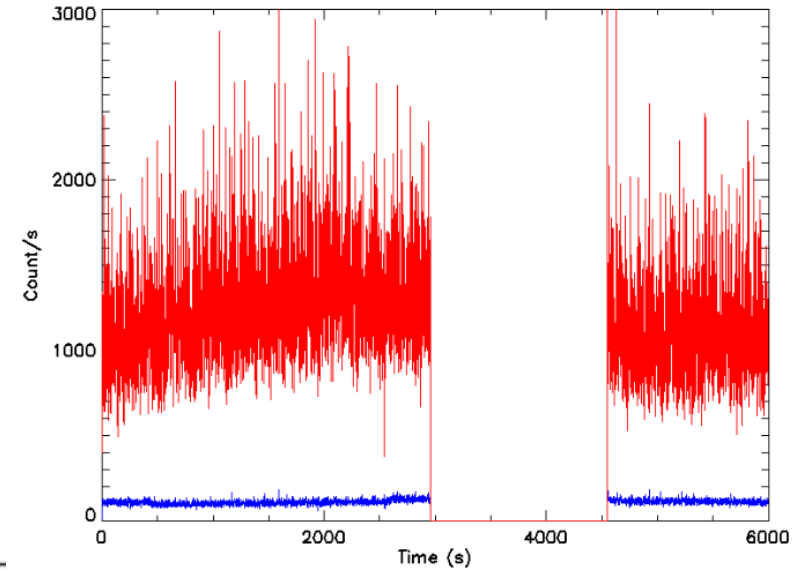
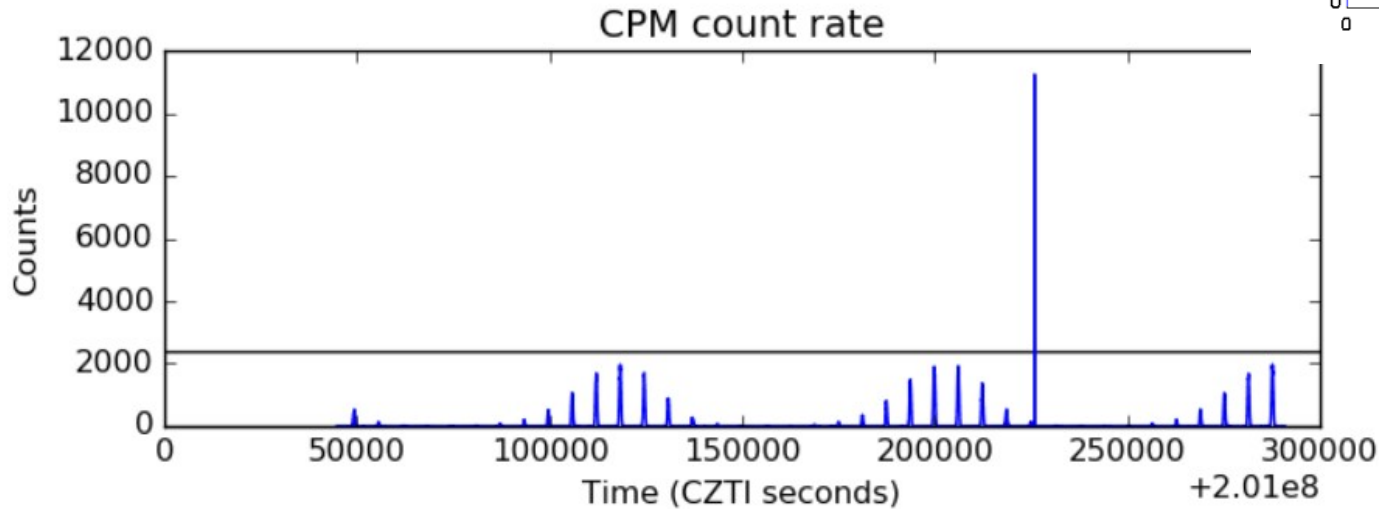
- Bunched event: multi-hit event: events occurred within 30 micro sec
- Identified and recorded onboard
- Only single and double event are recorded others are removed
- Remove all events occurred within 0s time difference
- For less than or equal to bunch length threshold (20), ignore 0.001 sec after the end of the bunch from module
- For greater than or equal to bunch length threshold (20), ignore 0.001 sec after the end of the bunch from all modules

- Events correspond to charged particle are removed by the task **cztbunchclean**
- Input file: 1. event file
2. bunch file
- Output file: 1. bunch cleaned event file
2. livetime file

File Edit Tools Help		
	<input checked="" type="checkbox"/> TIME	<input checked="" type="checkbox"/> FRACEXP
Select	D	E
<input checked="" type="checkbox"/> All		
Invert	Modify	Modify
1	2.010447175000E+08	9.933101E-01
2	2.010447185000E+08	9.751101E-01
3	2.010447195000E+08	9.776338E-01
4	2.010447205000E+08	9.751627E-01
5	2.010447215000E+08	9.837627E-01
6	2.010447225000E+08	9.787626E-01
7	2.010447235000E+08	9.715752E-01
8	2.010447245000E+08	9.792176E-01

We switch off detectors in SAA region

Veto detector is used to remove the events due to charged particle
CZTI communicates with CPM and switch off
the detector during SAA region



Typical lightcurve with/without
particle background correction

Pixel behaviour

- Dead pixel: no sensitivity to detect X-ray
- Noisy pixels: shows large fluctuation in counts
 - 1) Some pixels are noisy constantly
 - 2) Some pixels are noisy during the observation
 - 3) Some pixels are noisy for short duration
- Bad pixels: bad energy resolution
- 7.27 percent of the total pixels are disabled

	Quadrant 1	Quadrant 2	Quadrant 3	Quadrant 4
Ground	204	216	127	209
On-orbit	85	117	74	160
Total	289	333	201	369

Total no of pixels disabled upto 31/11/2017

- Detector lightcurve: remove data when the rate is 25 count /sec
- Pixel lightcurve: remove data when the rate is 2 counts/s
- This issue is solved by the task **cztpixclean**
- Input file: 1. event file,
2. livetime file
3. badpix file from CALDB
- Output file: 1. corrected event file
2. livetime file
3. badpix file
- We can provide external bad pixel file also: **cztflagbadpix**

fv: Binary Table of l2_badpix.fits[1] in ...

File Edit Tools Help

DETID PIXID PIX_FLAG

Select B B B

All

Invert Modify Modify Modify

1	0	0	4
2	0	1	4
3	0	2	1
4	0	3	1
5	0	4	4
6	0	5	1

SAA region, earth occultation

- SAA region, earth occultation or large angular offset, etc are considered using the task **cztgtigen**
- Input file: 1. event file
 2. mkf file
 3. mkfthreshold file
- Output: 1. gti file
 - (both quadrantwise and common)
- This gti is applied by the task **cztdataset**

Add PI and nominal energy column in the event file

- Use gain, offset, and ebounds from caldb
- Use SS mode event file: temperature of pixels
- $E = \text{gain} * \text{PHA} + \text{offset}$
- From Ebounds, find to which PI bin does the computed energy belong
- This task is done by the command **cztpha2energy**
- Input files: 1. event file
2. event file with SS mode data
- Output files 1. Event file with Energy and PI columns added

Remove events correspond to veto count and alpha particle

- Task: **cztevtclean**
- Input file: event file
- Output file: modified event file

```
evel2_456$ cztevtclean
Enter input event file: [l2_evt_bc_p2e_gti_pc.fits] :
Enter output event filename: [l2_evtclean.fits] :
Alpha values to be accepted(0;1;0,1): [1] : 0
Veto Range/Ranges to accept: [0-0] :
Write history keywords in fits file [YES] :
Overwrite Existing file? [YES] :
```

Image formation

- pointing direction of czti: cztgaas
- The pattern of total counts on each pixel: detector plane histogram (DPH) cztdpigen
- DPH corrected by the effective area of pixels: detector plane image (DPI) cztdpigen
- Cross-correlation of mask pattern with the DPI using Fourier technique produces a crude image of the field.
- Remove spurious noise

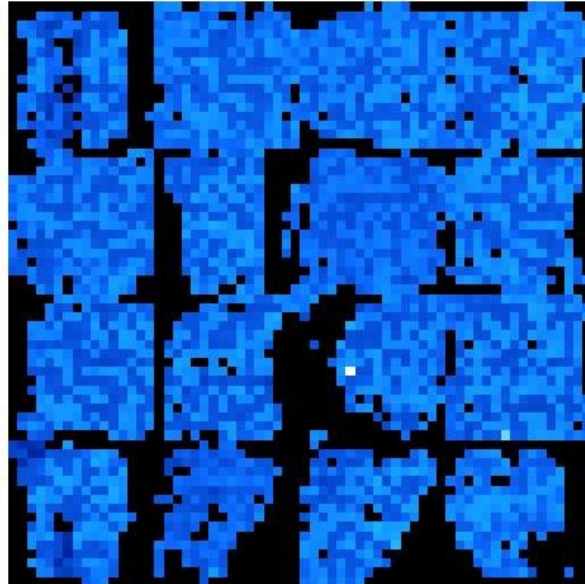
- Image formation is done using three tasks **cztgaas**, **cztdpigen**, and **cztimage**
- **Cztgaas**: input file:
 1. event file
 2. mkf file
 3. teldef file from CALDB
 4. gti file

output file: aspect file

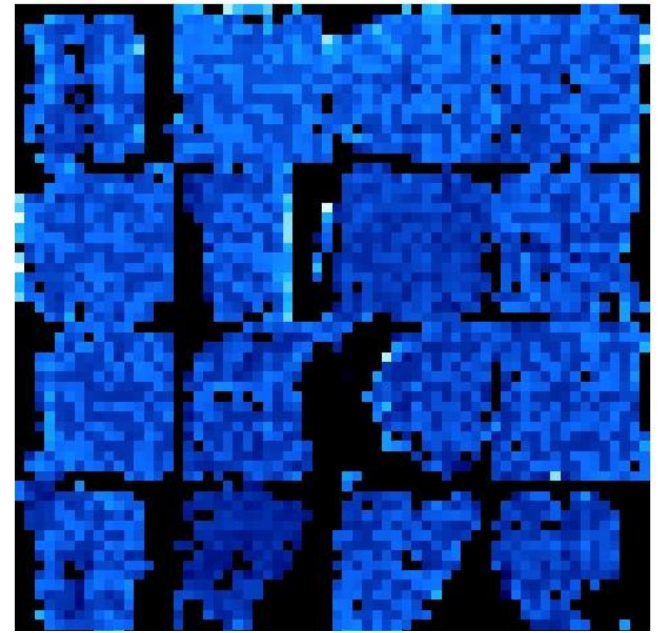
cztdpigen:

- Input file: 1. event file
 2. efective area file from CALDB
- Output file: 1. Detector plane histogram (dph)
 2. Detector plane image (dpi)

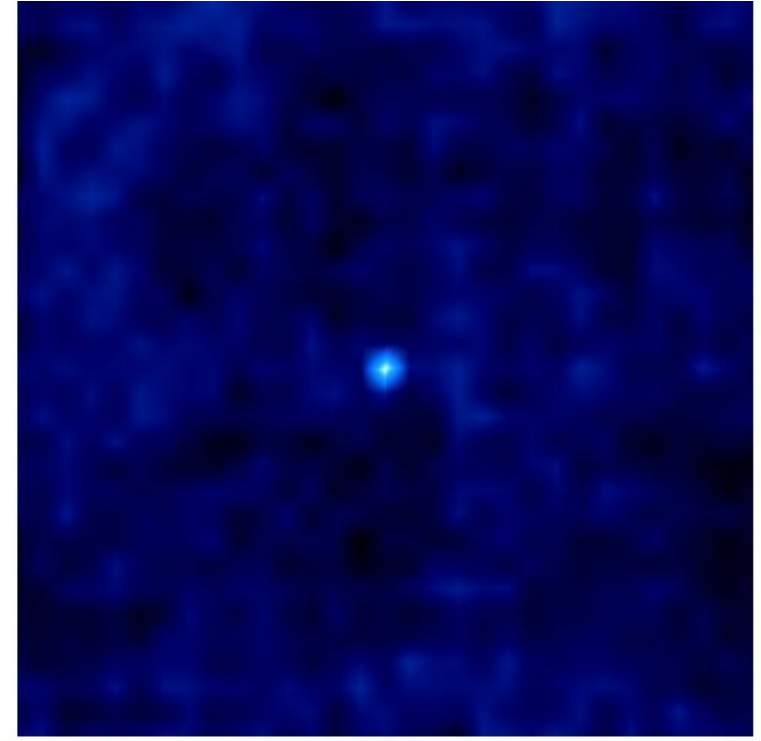
DPI



DPH



- **cztimeimage:**
- Input file: 1. dpi file
2. mask pattern
from CALDB
- Output file: Image



Lightcurve, energy spectrum, response files

- These files are generated by the task **cztbindata** and **cztrspgen**

Single command to do all the task

cztpipeline

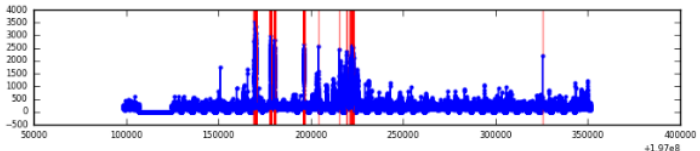
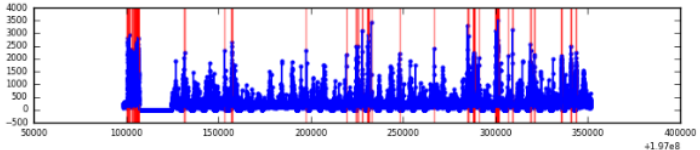
Data quality information

- Dqr webpage:

http://www.iucaa.in/~astrosat/czti_dqr/

Noise dominated fraction

Noise dominated data is calculated using 1-second bins in **cleaned** event files. If a bin has >2000 counts, and if more than 50% of those come from <1% of pixels, then it is considered to be noise-dominated and hence unusable.

Quadrant	# 1 sec bins	Bins with >0 counts	Bins with >2000 counts	High rate bins dominated by noise	Noise dominated (total time)	Noise dominated (detector-on time)	Marked lightcurve
A	252952	205196	317	317	0.13%	0.15%	
B	252952	205190	172	172	0.07%	0.08%	

- Detector plane histograms are available for all the four quadrants separately.
- It can give the idea of the distribution of noisy and dead pixels.

Detector plane histogram (DPH)

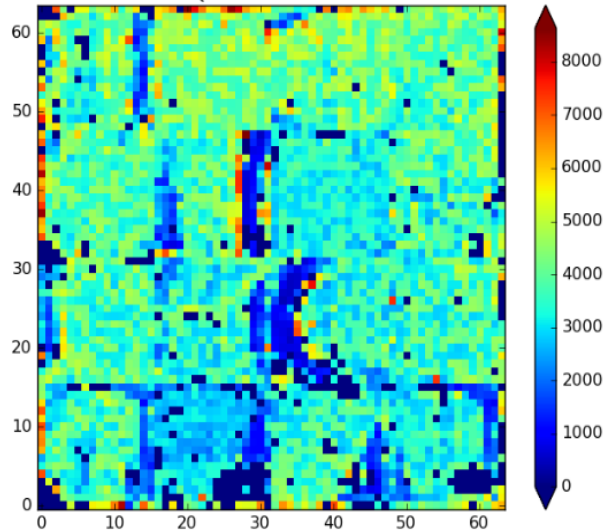
[^TOP](#)

Histogram calculated using DETX and DETY for each event in the final `_common_clean` file

Quadrant A

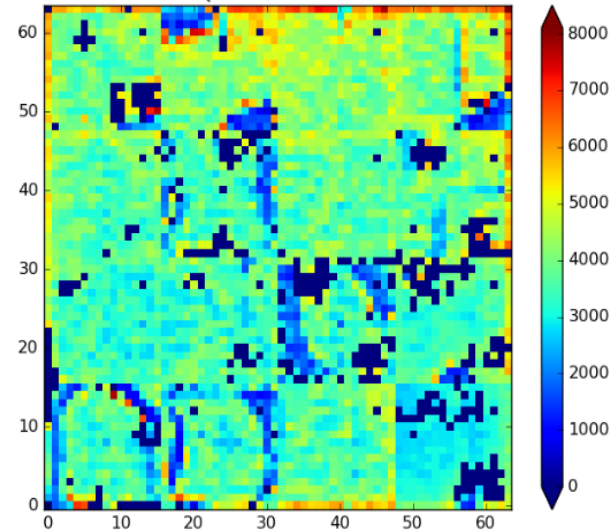
Data file: modeM0/AS1T01_112T01_9000000406cztM0_level2_quad_clean.evt

Quadrant 0 DPH



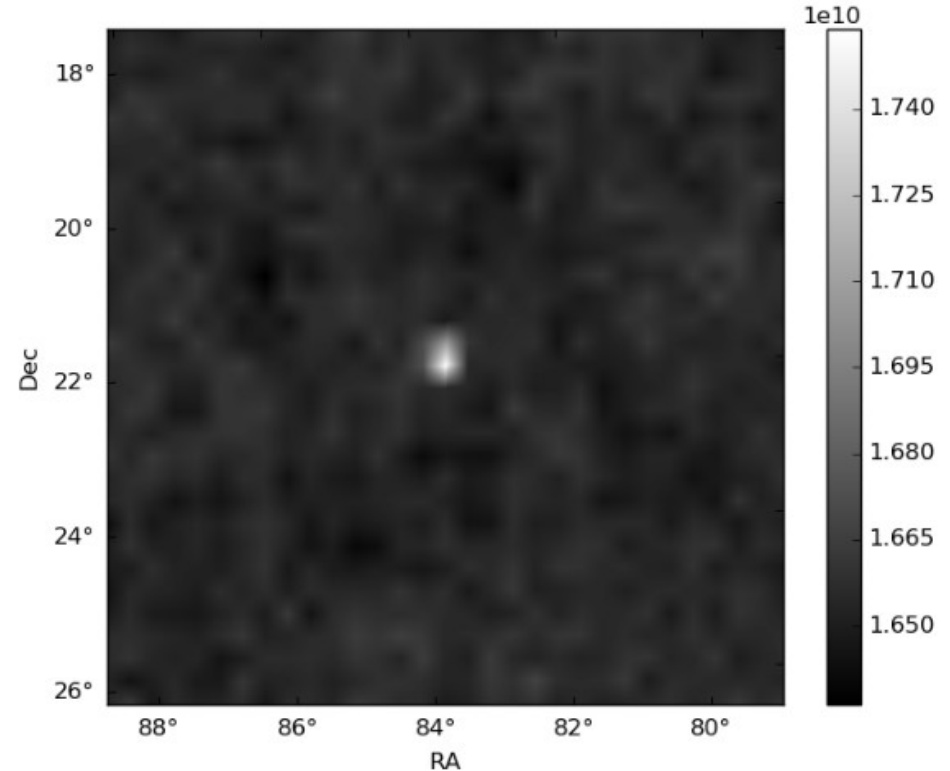
Data file: modeM0/AS1T01_112T01_9000000406cztM0_level2_quad_clean.evt

Quadrant 1 DPH



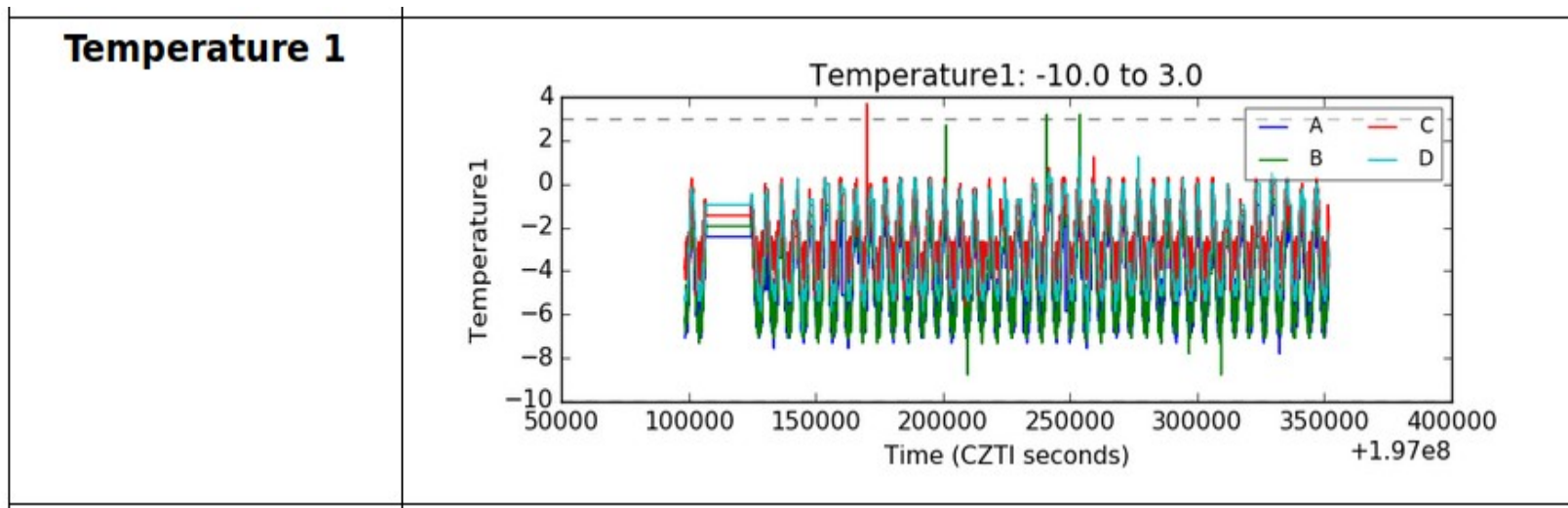
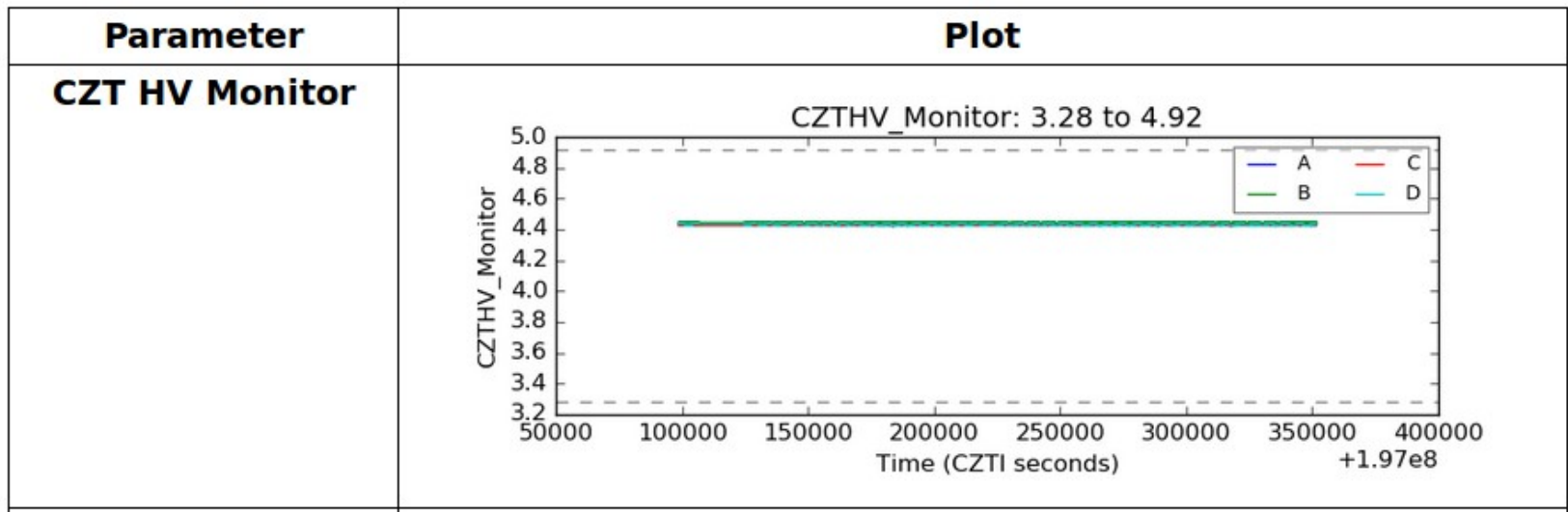
Quadrant B

- Images of all the quadrants are given on DQR page.
- Before analysis, we should check whether source is visible or not.
- In the cases of faint sources we do not see such image



Housekeeping plots

- Variation of large no of house keeping plots are given
- It also indicates acceptable range
- We can find out the time when detector shows abnormal behaviour



An example

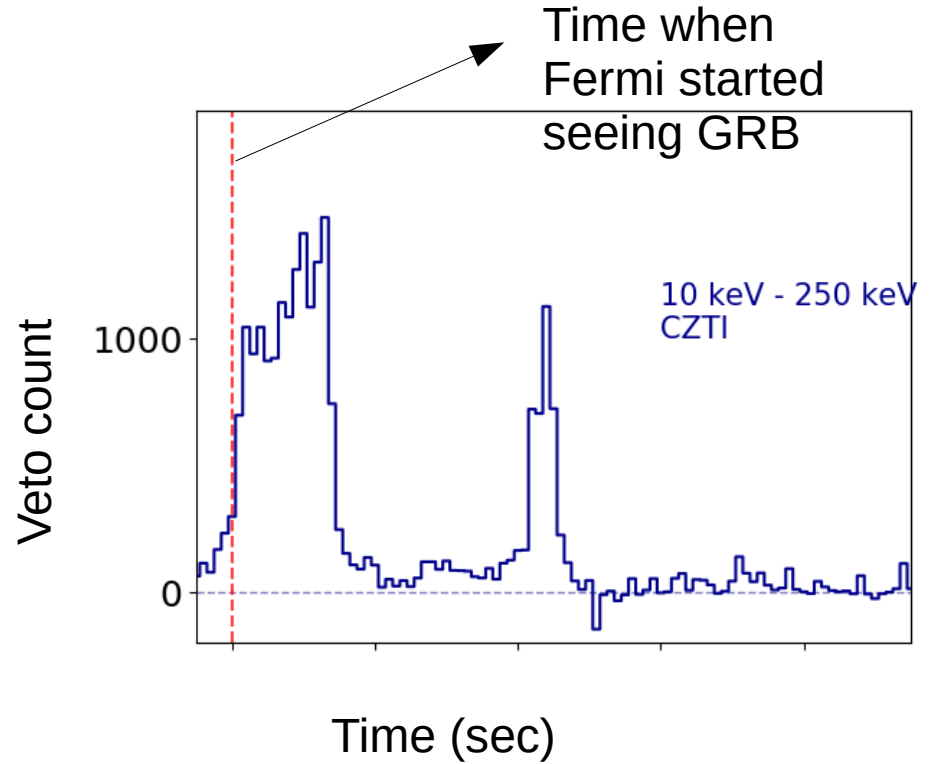
GRB 160325A detection

"At 06:59:21.51 UT on the 25th of March 2016, the Fermi Gamma-Ray Burst Monitor triggered and located GRB 160325A (trigger 480581965 / 160325291), which was also detected by Swift (Sonbas et al. 2008, GCN 19222). The GBM on-ground location is consistent with the Swift position. (gcn circular 19224)

- Ra= 15.697 (01:02:47.3)
- Dec= -72.702 (-72:42:07.2) (SWIFT/BAT)

- CZTI was observing a source 2E 0102-7217
- Luckily, it was pointing almost towards the GRB
- We took this data and applied a time filter
- It is not necessary that CZTI should point toward GRB for detection
- At higher energy, it becomes an open detector
- GRB photon can be incident not only from collimator but from other directions also

20160325_P01_010T01_9000000398_level2_02657	P01_010 T01_900 0000398	KPSingh 19	2E 0102-72 17 ON- AXIS	16.01	-72.0333 3	29039.1 173386	2016-03- 25 03:35:52	2016-03- 25 15:57:56
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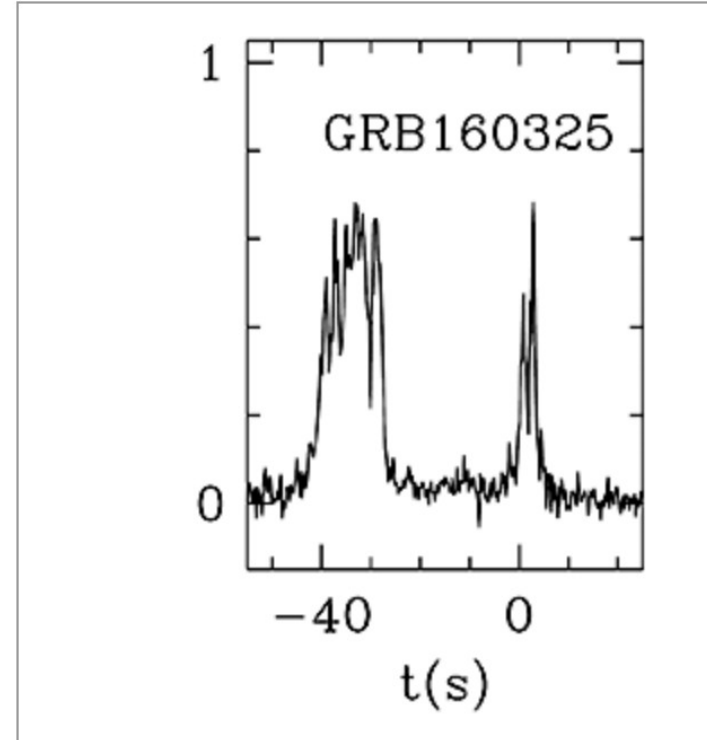


GRB lightcurve for 100 sec time interval from triggering time

SWIFT/BAT

BAT also observed this GRB.
GRB profile detected by AstroSat is
consistent with BAT

BAT Light Curve:

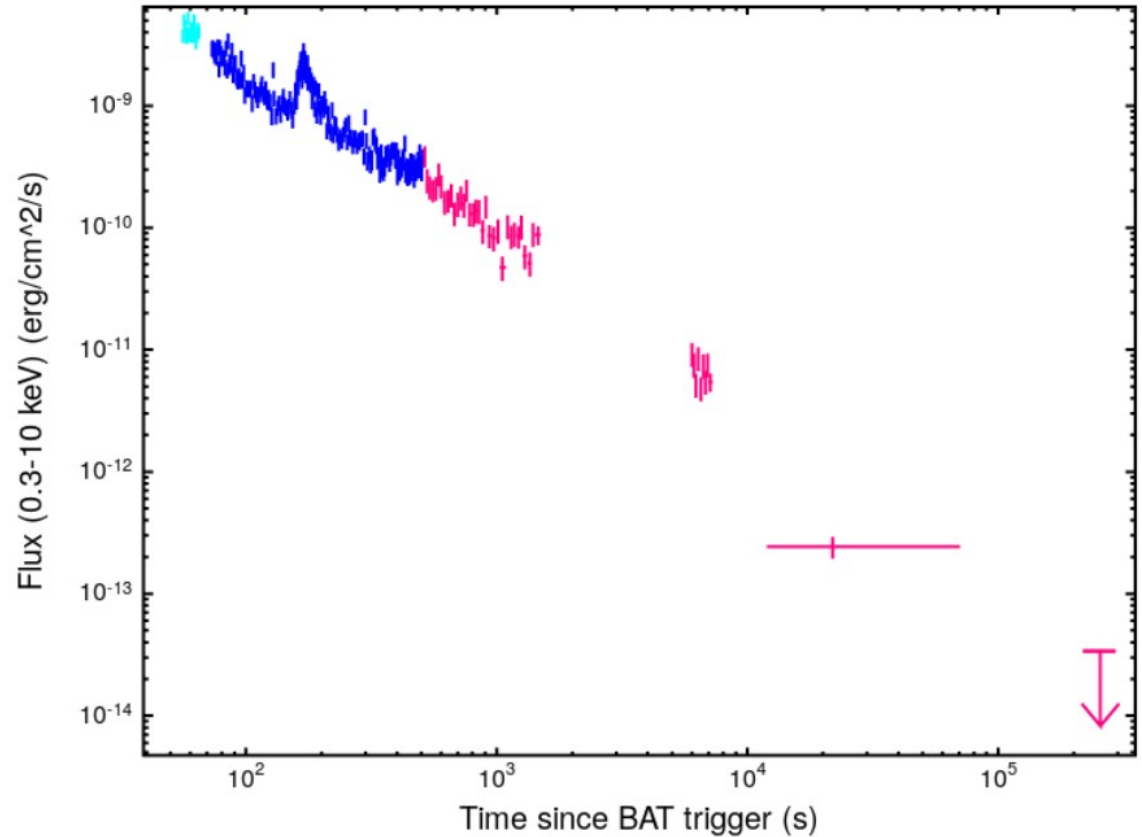


Ref:

https://swift.gsfc.nasa.gov/archive/grb_table/fullview/160325A/

SWIFT/XRT

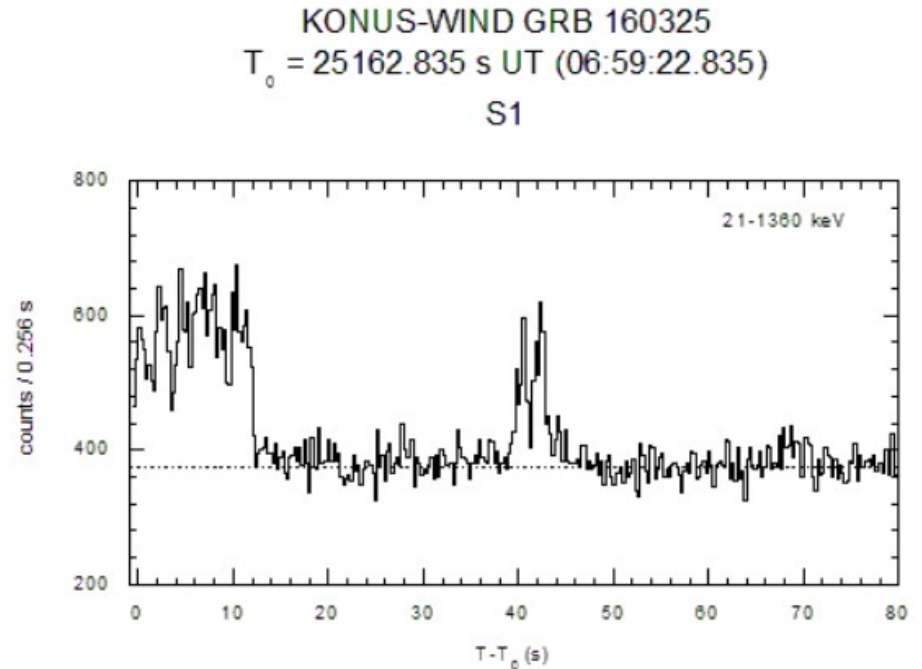
Swift/XRT data of GRB 160325A



Afterglow ~120 sec
It started looking after 66
sec from the trigger time

Konus: Gamma-Ray Burst Monitor

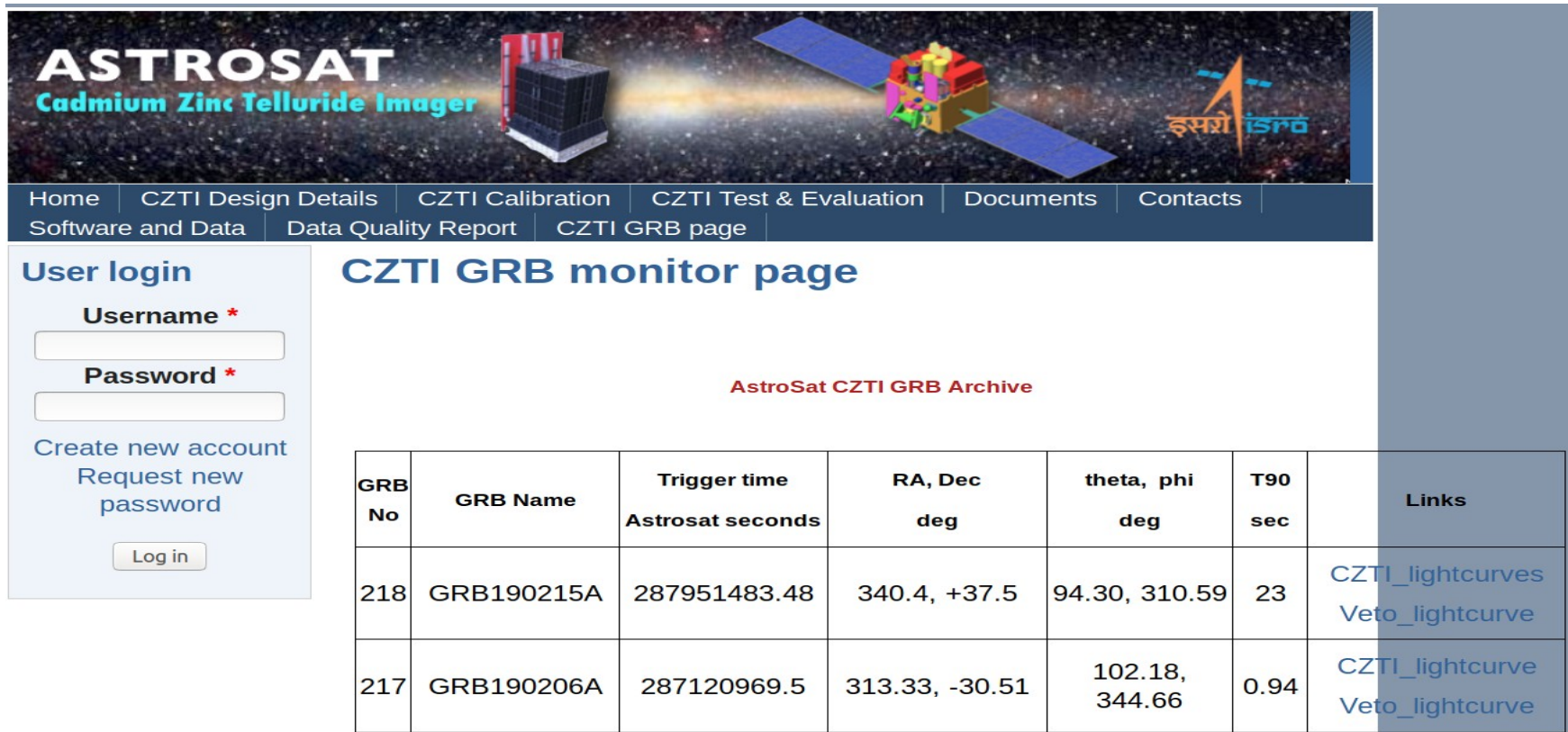
It is a GRB monitor
It is launched on the spacecraft “GGs-wind spacecraft”
It also observed double peak profile in 44 sec.



[http://www.ioffe.ru/LEA/GRBs/
GRB160325_T25162/](http://www.ioffe.ru/LEA/GRBs/GRB160325_T25162/)

AstroSat GRB archive

- <http://astrosat.iucaa.in/czti/?q=grb>



ASTROSAT
Cadmium Zinc Telluride Imager

Home | CZTI Design Details | CZTI Calibration | CZTI Test & Evaluation | Documents | Contacts
Software and Data | Data Quality Report | CZTI GRB page

User login

Username *

Password *

Create new account
Request new password

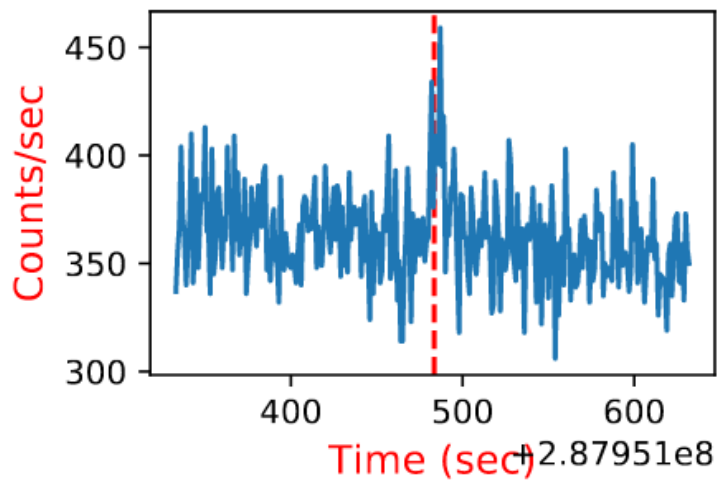
Log in

CZTI GRB monitor page

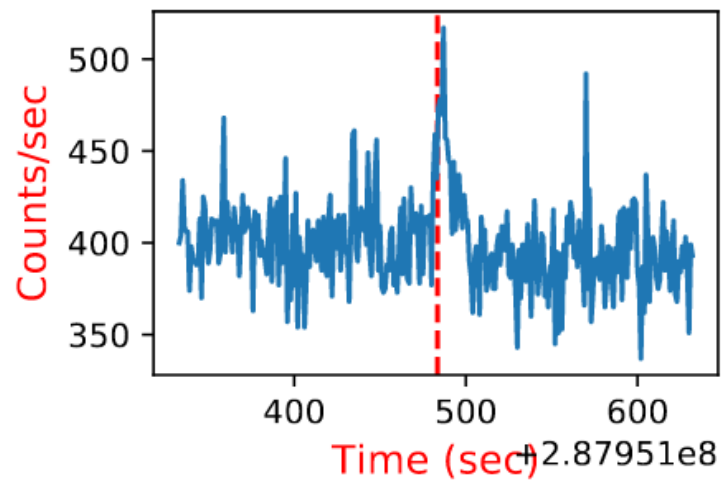
AstroSat CZTI GRB Archive

GRB No	GRB Name	Trigger time Astrosat seconds	RA, Dec deg	theta, phi deg	T90 sec	Links
218	GRB190215A	287951483.48	340.4, +37.5	94.30, 310.59	23	CZTI_lightcurves Veto_lightcurve
217	GRB190206A	287120969.5	313.33, -30.51	102.18, 344.66	0.94	CZTI_lightcurve Veto_lightcurve

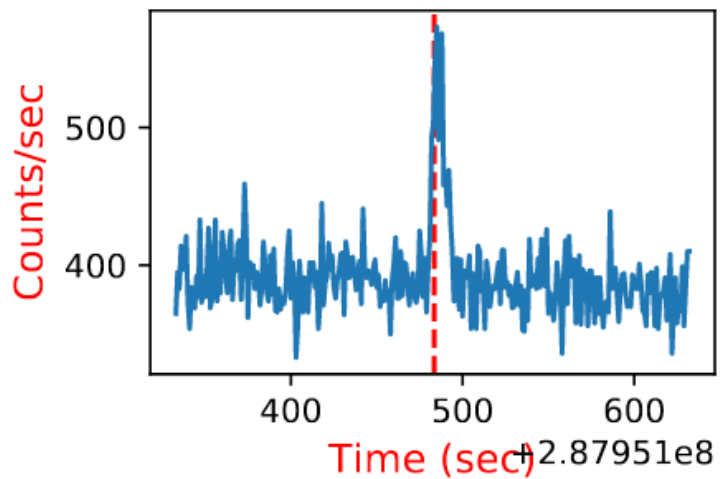
Quad A **Veto Light Curve**



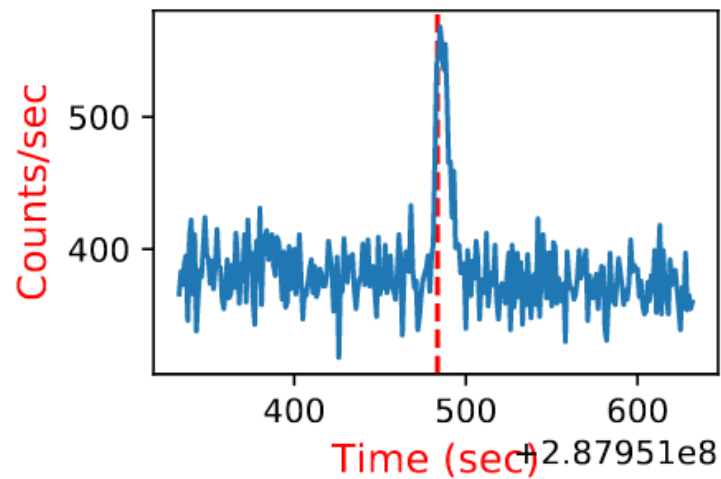
Quad B



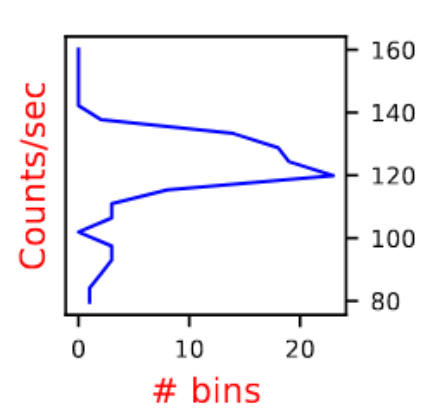
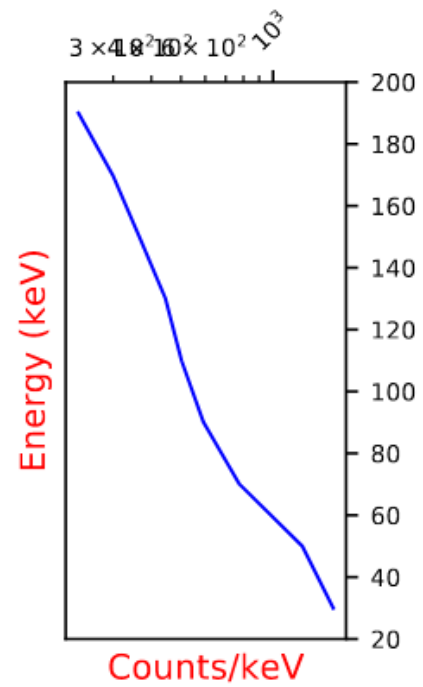
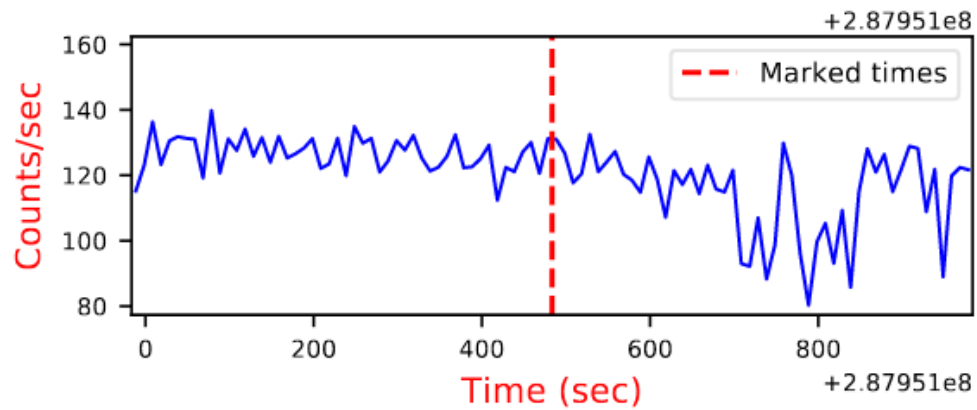
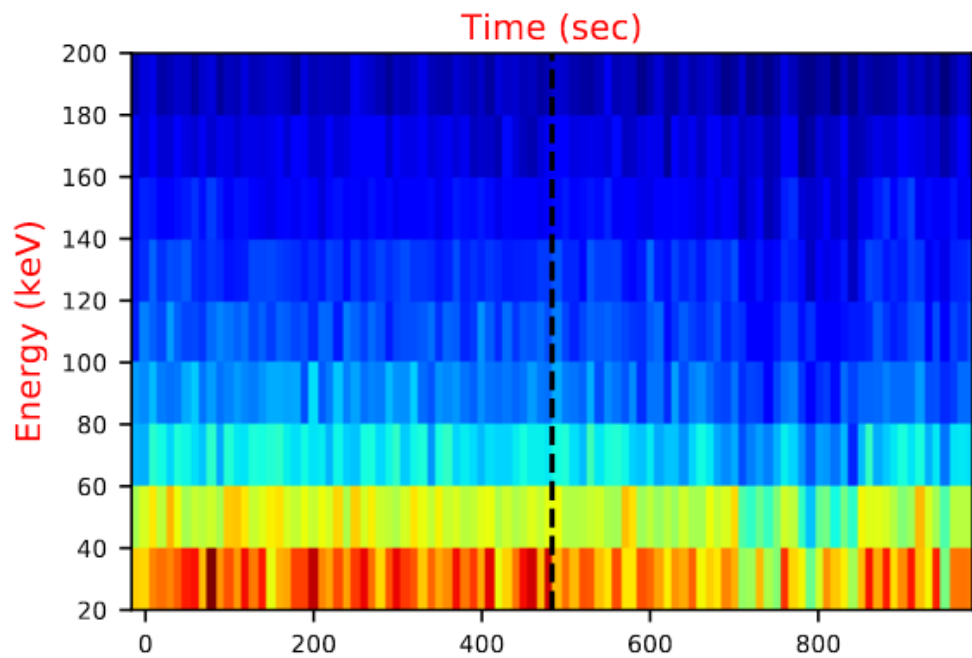
Quad C



Quad D



Quadrant A



Thank You