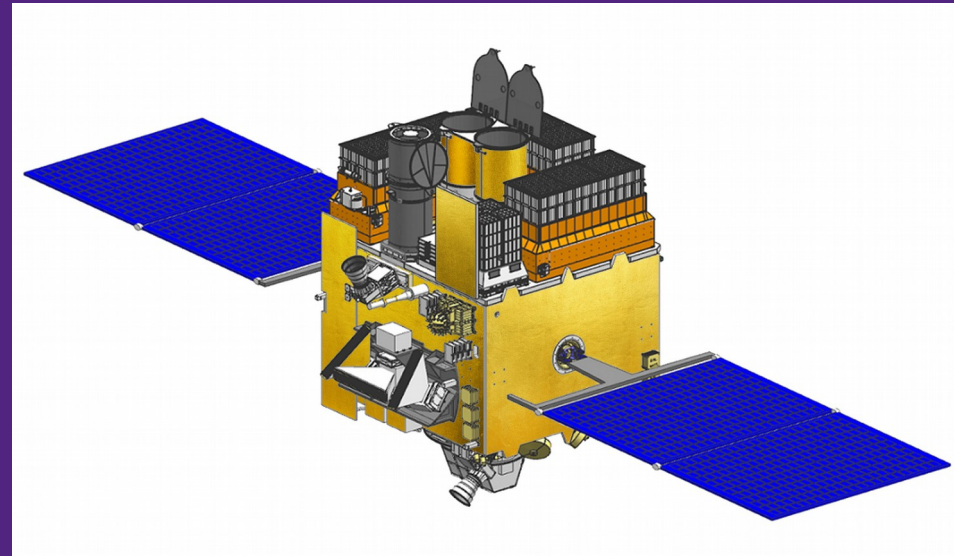# CZTI Data Analysis

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Overview:

- CZTI data reduction (formation of level2 products):

  File structure of level1 data

  Level1 to level2 conversion

  Cleaning: charged particle, bad pixels, earth occultation, etc

  Formation of image

  Formation of lightcurve, spectra and response files

- Work with level2 products:

  Apply barycentre correction using the code as1bary

  Formation of power spectrum using ftool powspec and finding signal at ~ 30 Hz

  Finding best best spin period value using ftool efsearch

  Formation of folded lightcurve using ftool efold

  Estimation of spin loss rate

Data with reduced exposure for the hands-on session (Obsid 9000000406)

Reduced exposure: ~400 sec
Full exposure: 251639 sec ~ 70 hours
Time required for the data reduction for full exposure: ~ 2 hours
Size of level1 and level2 data: 5 GB and 50 GB

File structure
Level1 data contents

- **Read software user guide and AstroSat HANDBOOK for more detail**
- Data folder 20160331_T01_112T01_9000000406_level1 after uncompress
- Level1 folder 20160331_T01_112T01_9000000406_level1/czti may contain following files and folders
- file: AS1T01_112T01_9000000406czt_level1_mcap.xml (text file)

    AS1T01_112T01_9000000406czt_level2.mkf
- Aux (directory)
- LEVL1AS1CZT20160331T01_112T01_9000000406_dqr_V1.2.xml(text file)
- ModeM0 (directory)
- ModeSS (directory)

Modes of data:
ModeM0: default mode: science data
ModeM9: during SAA region
ModeSS

.tct file

.att file

Aux1 folder

.orb file

aux

Aux2 folder

.lbt file

Aux3 folder

.orb file
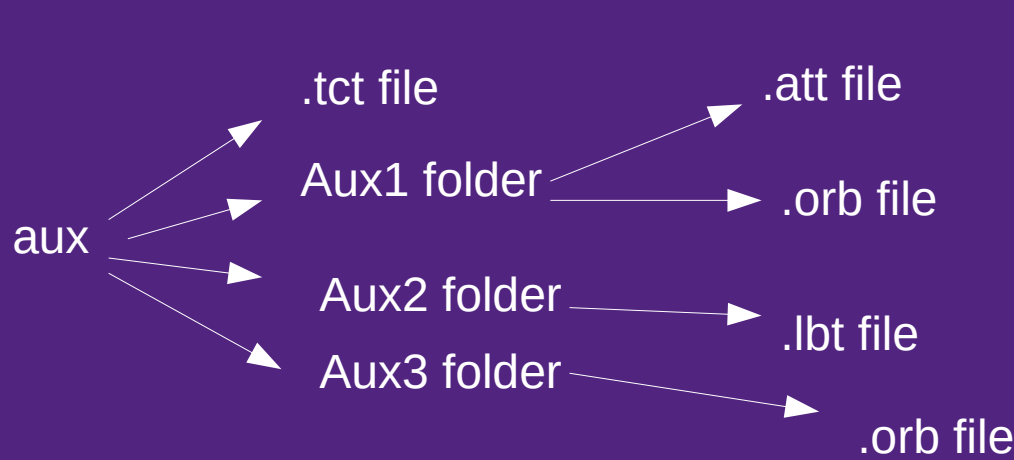
modeM0 → Science data, fits file

modeSS → Temperature information every 100 sec

.tct file

fv: Binary Table of AS1G02_016T01_9000000258czt_level1...

File   Edit   Tools   Help

Select	■ SPS_TIME	■ SPS_OBT	■ INSTRUMENT_TIME
■ All	D	D	D
	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...

File   Edit   Tools   Help

Select	■ TIME	■ Q_SAT	■ Roll_RA	■ Roll_DEC	■ Roll_ROT	■ ATD_STATUS
■ All	D	4D	D	D	D	8X
	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

Modules/tasks for data analysis

1) cztscience2event
2) cztbunchclean
3) cztpha2energy
4) cztgtigen
5) cztgaas
6) cztdatasel
7) cztpixclean
8) cztflagbadpix
9) cztevtclean
10) cztdpigen
11) cztimage
12) cztbindata
13) cztrspgen

Single task for whole data analysis
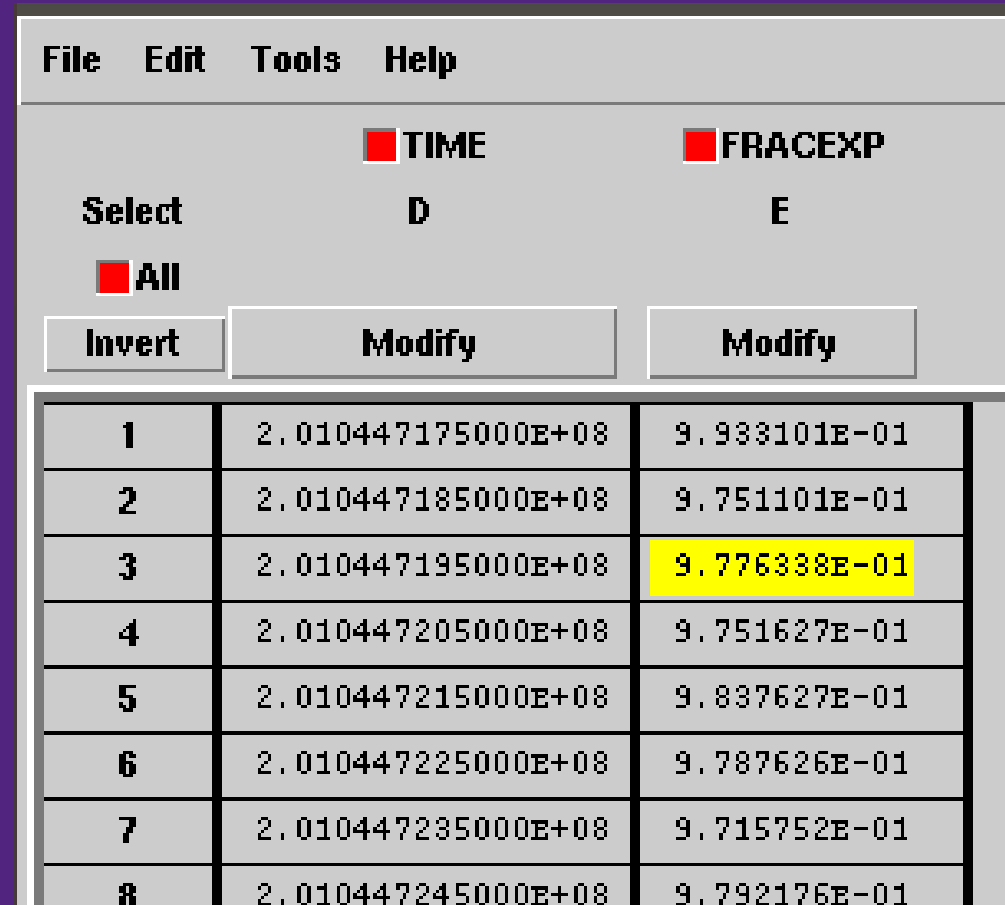cztpipeline

Task1: **cztscience2event**
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

- Input:1. level1 event file

  2. tct file

- Output: 1. header file

  2. bunch file

  3. level2 science data file

Task2: **cztbunchclean**
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

Task3: **cztpha2energy**

- It estimates the nominal energy of the incident photon

- It reads PHA, detid and pixid of each event

- It takes the temperature information using modsSS data.

- It takes gain and offset at a temperature nearest to the actual detector temperatture for that pixel id from the CALDB

- Now it computes the nominal energy using the relation

- E = gain * PHA + offset

- Run **cztscience2evt** task again to generate level2 event file with modess data

- Input files: 1. event file

  2. event file with SS mode data

- Output files 1. Event file with Energy and PI columns added

- Task4: **cztgtigen**

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
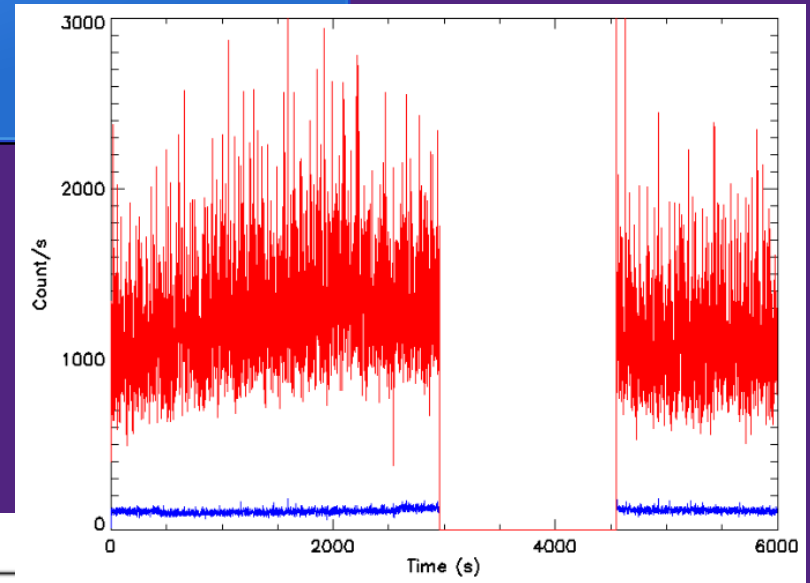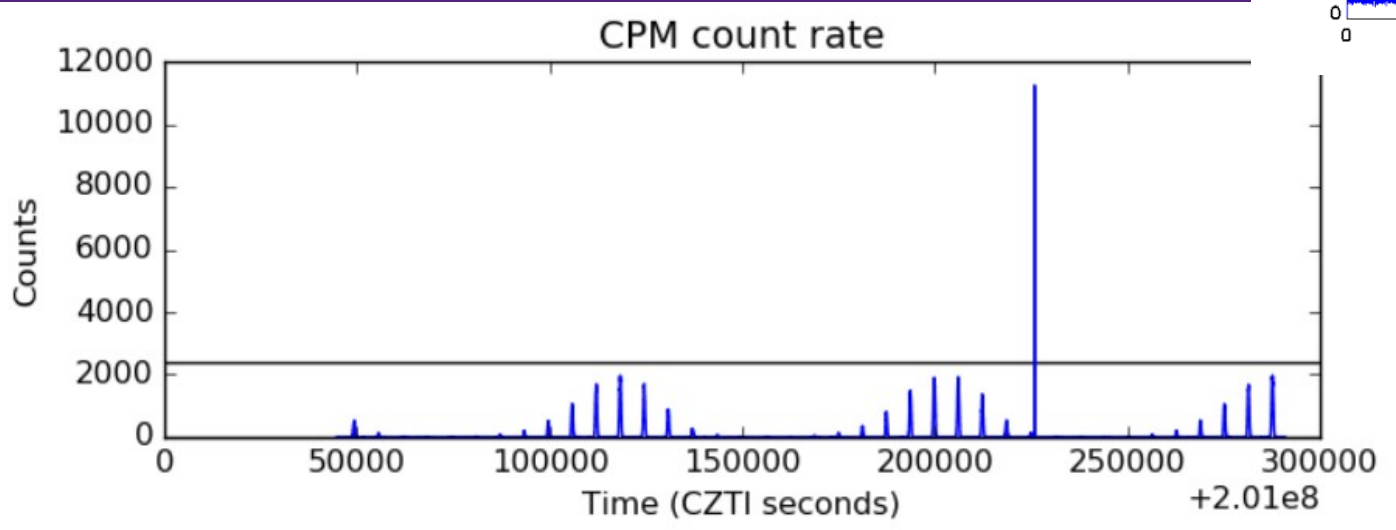
Typical lightcurve with/without particle background correction

- 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 **cztdatasel**

Task5: **cztgaas**

- pointing direction of czti: cztgaas
- input file: 1. event file

  2. mkf file

  3. teldef file from CALDB

  4. gti file

- output file: aspect file

Task6: **cztdatasel**

- This task filters the events in the input event file based on GTI file.

- Input: Event file

    gti file

- Output: GTI filtered event file

Task7: **cztpixclean**
Pixel behaviour

- Dead pixel: no sensitivity to detect X-ray

- Noisy pixels: shows large fluctuation in counts

- Bad pixels: bad energy resolution

1) Some pixels are noisy constantly

2) Some pixels are noisy during the observation
3) Some pixels are noisy for short duration

- 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

Task8: **cztflagbadpix**

- Input: Badpixel file 1, Badpixel file 2, etc
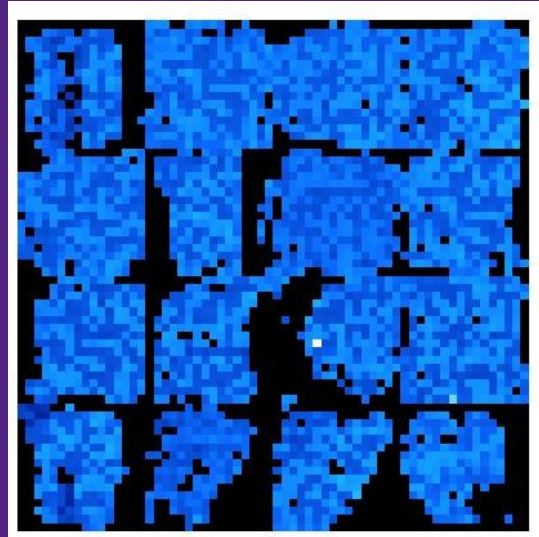- Output: Badpixel file

Task9: **cztevtclean**

- Remove events correspond to veto count and alpha particle

- Input file: event file

- Ouput file: modified event file

Task10: **cztdpigen**

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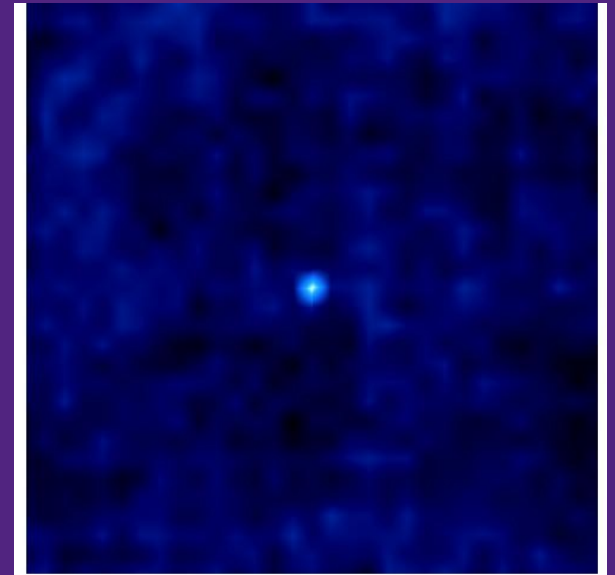   2. Detector plane image (dpi)
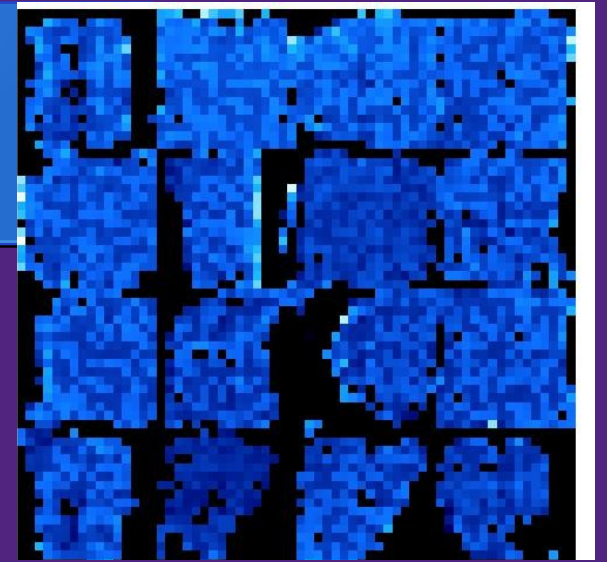
DPH

DPI

Task11: **cztimage**
Image formtion

- It generates image of the source

- pointing direction of czti: cztgaas

- Cross-correlation of mask pattern with the DPI using Fourier technique produces a crude image of the field.

- Remove spurious noise

- Input file: 1. dpi file

  2. mask pattern from CALDB

- Output file: Image

Task12: **cztbindata**
Formation of lightcurve and spectrum

- Input:

  Clean event file

  MKF file

  Live time file

  Badpixel file from pixclean

- Output:

  Spectrum

  Light curve

Task13: cztrspgen
Formation of response files

- Input

  Spectrum file

  Event file

- Output

  Response matrix (.rsp) file

Single command to do all the task

cztpipeline

Thank You