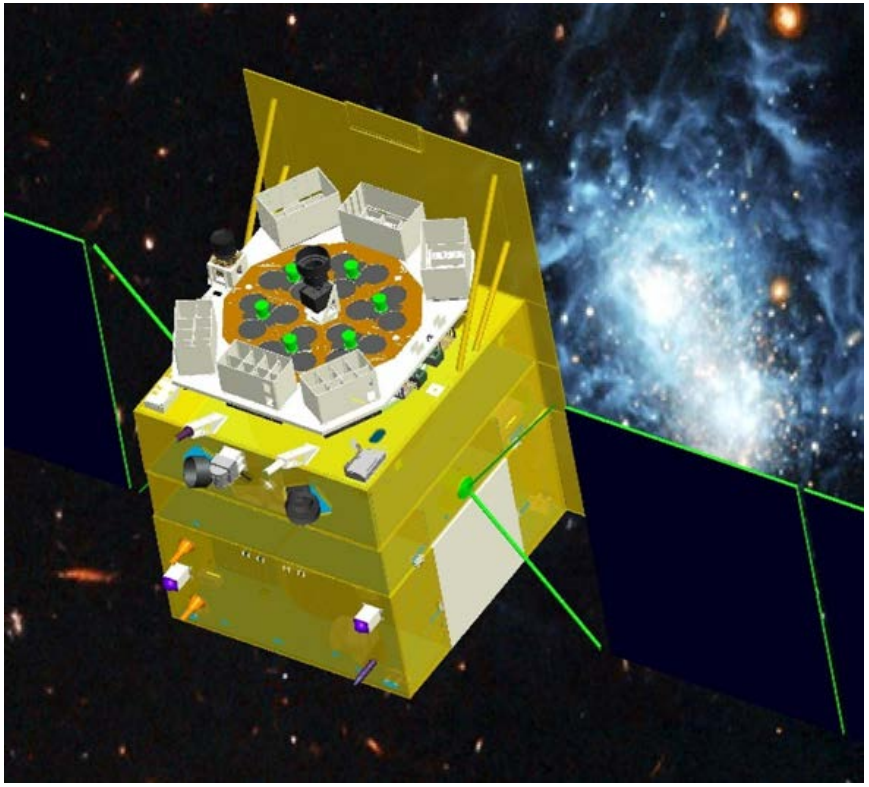


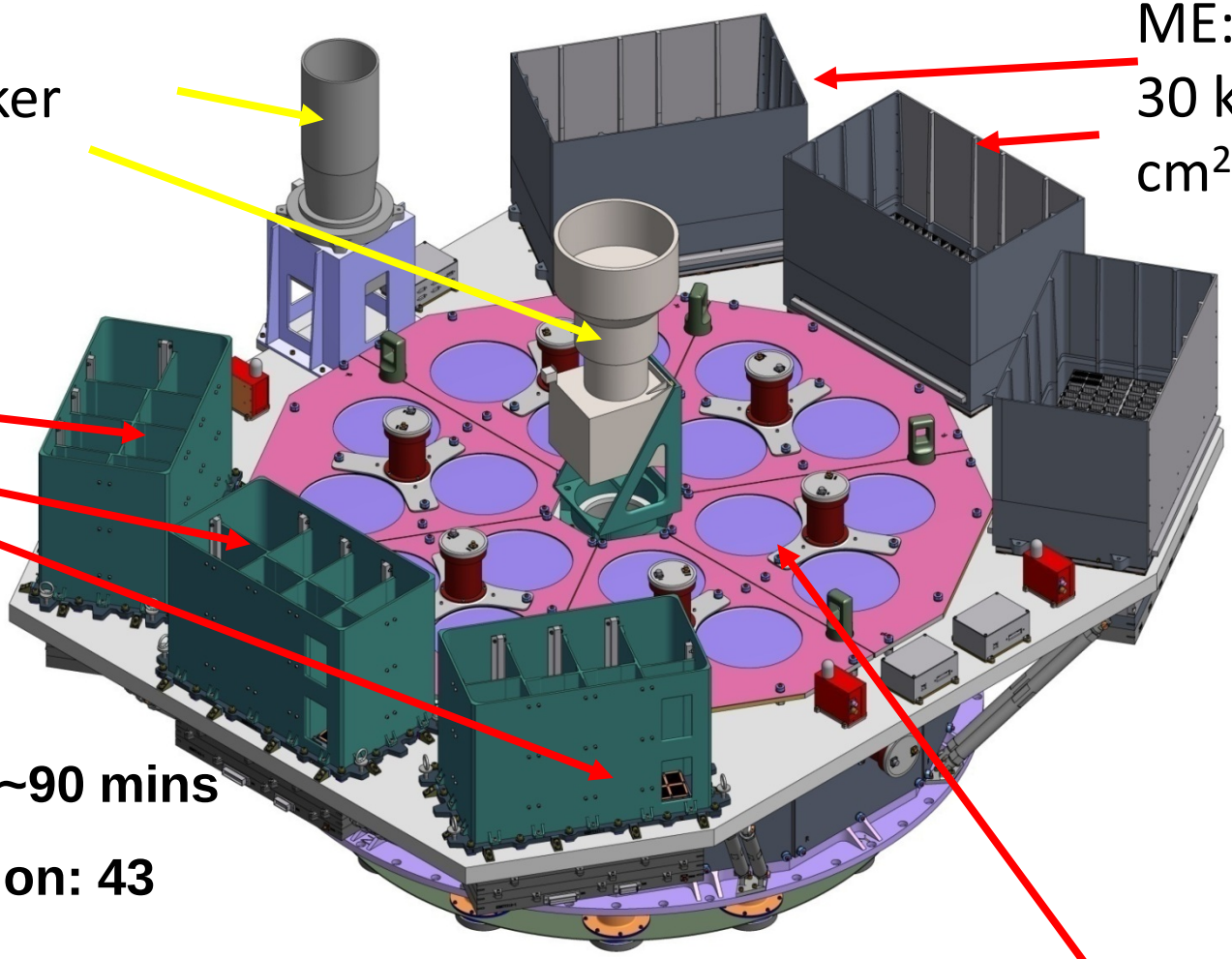
Current Status of the Hard X-ray Modulation Telescope

Yuan Liu (on behalf of the HXMT team)
Institute of High Energy Physics, CAS
12th IACHEC @ Lake Arrowhead

Outline:

1. Introduction to the payloads
2. Progress of HXMT payloads in 2016
3. Ground calibration of instruments
4. In-orbit calibration plan
5. Data processing of HXMT
6. Summary

1.Science payloads

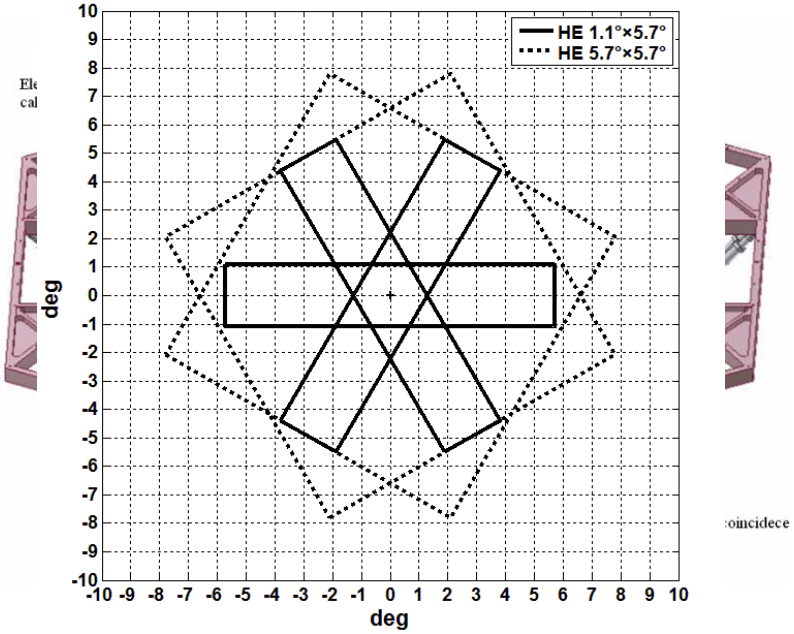


Orbital period: ~90 mins

Orbital inclination: 43 degrees

Launch time：2017 June

The High Energy X-ray Telescope (HE)



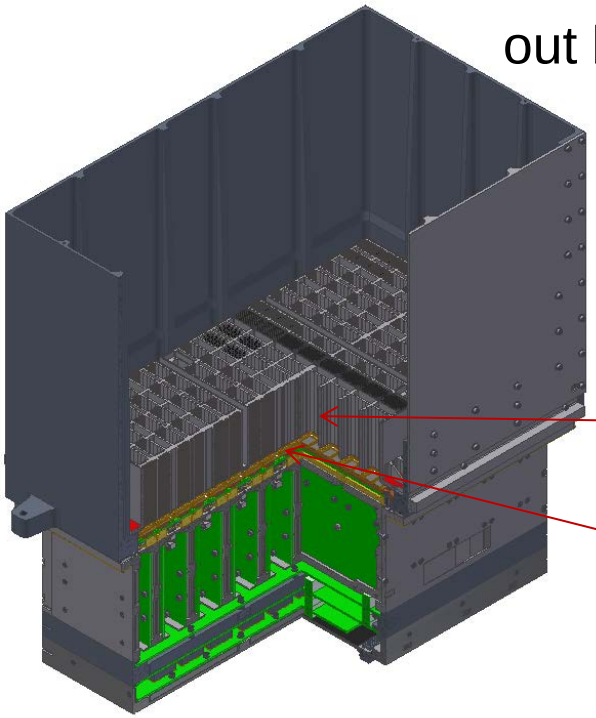
- **18 main collimated phoswich detectors (NaI/CsI)**
- **18 anticoincidence plates (6 top +12 lateral side)**
- **3 particle monitors**
- **Different FOV (15 small: 1.1° ×5.7° ; 2 large: 5.7° ×5.7° 1 blind)**

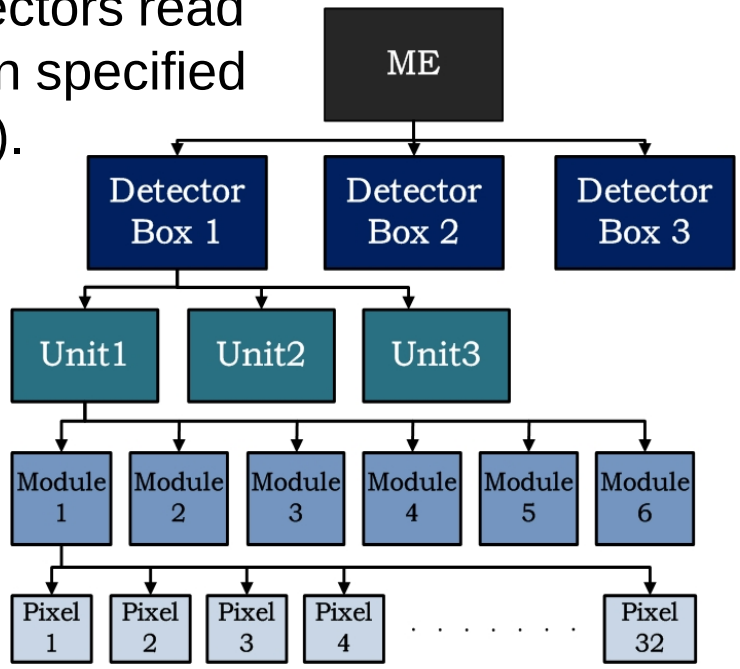
Table 1 Main features of HE

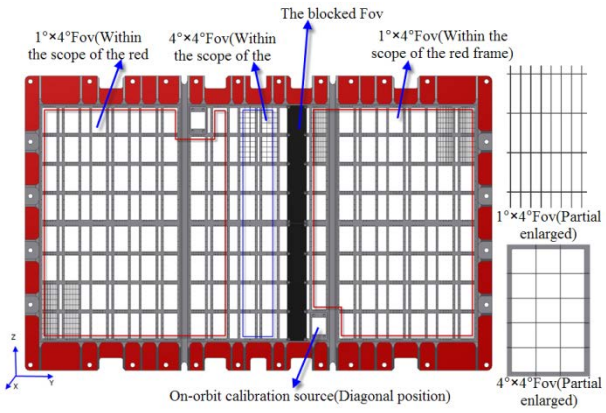
Parameter	Result
Energy band	20-350 keV
Geometric area	5096 cm^2
Main detector	NaI(Tl)/CsI(Na) ~ 3.5 mm/40 mm
Dead-time	8 μs
FOV (FWHM)	5.2° x 5.2°
Energy resolution	~(14%-16%)@60 keV
Maximum count rate	>30,000 cnts/sec

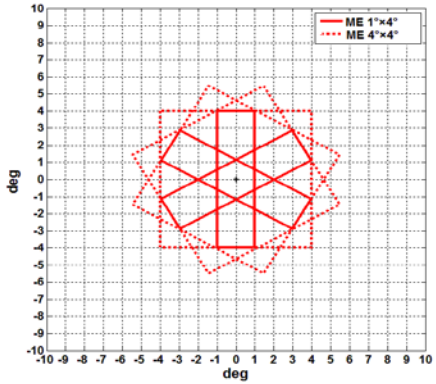
The Medium Energy X-ray Telescope (ME)

ME uses 1728 Si-PIN detectors read out by 54 ASIC (application specified integrated circuit).



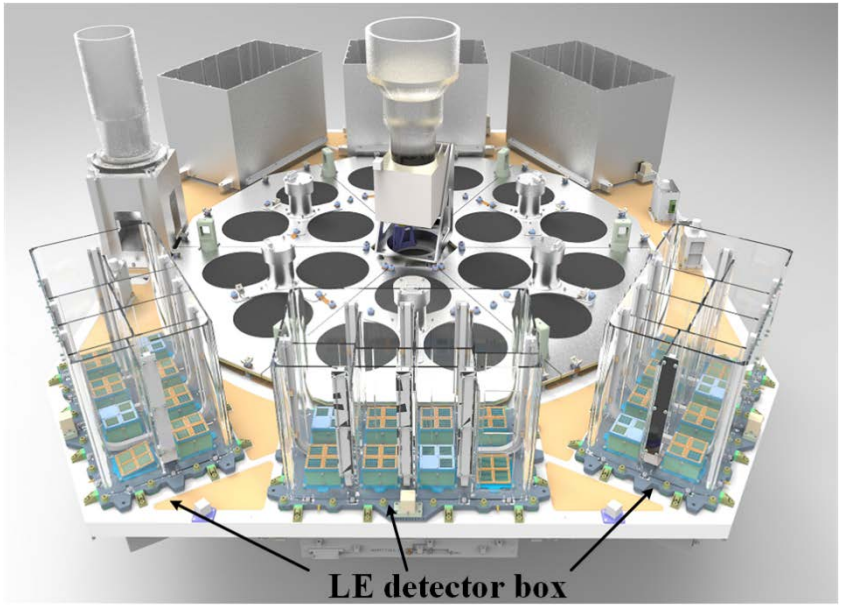


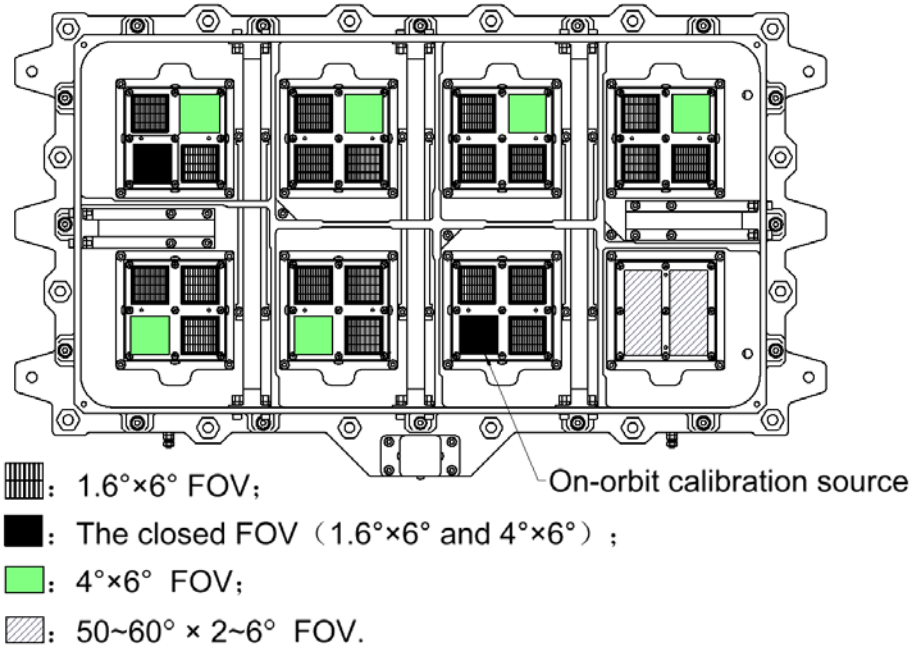


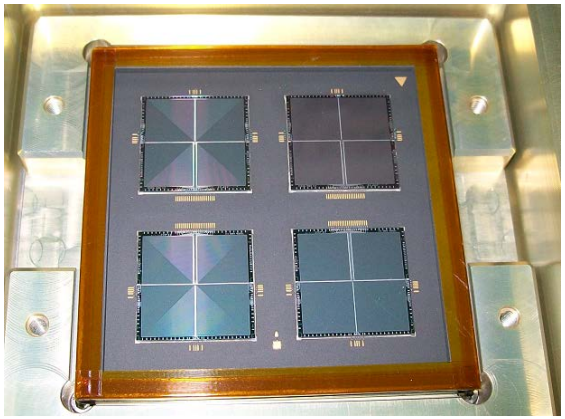


Parameter	Technical specifications
Energy range of detection	5-30keV
Detector type	Si-PIN
Detection area	952cm^2
Energy resolution (FWHM)	~3keV@20 keV
Time resolution	255μs
Detector working temperature	-50℃~-5℃
Maximum count rate allowed	2.2×10^4 cts/s
Power	155W

The Low Energy X-ray Telescope (LE)







LE consists of 3 detector boxes, and each boxes contains 32 CCD236.

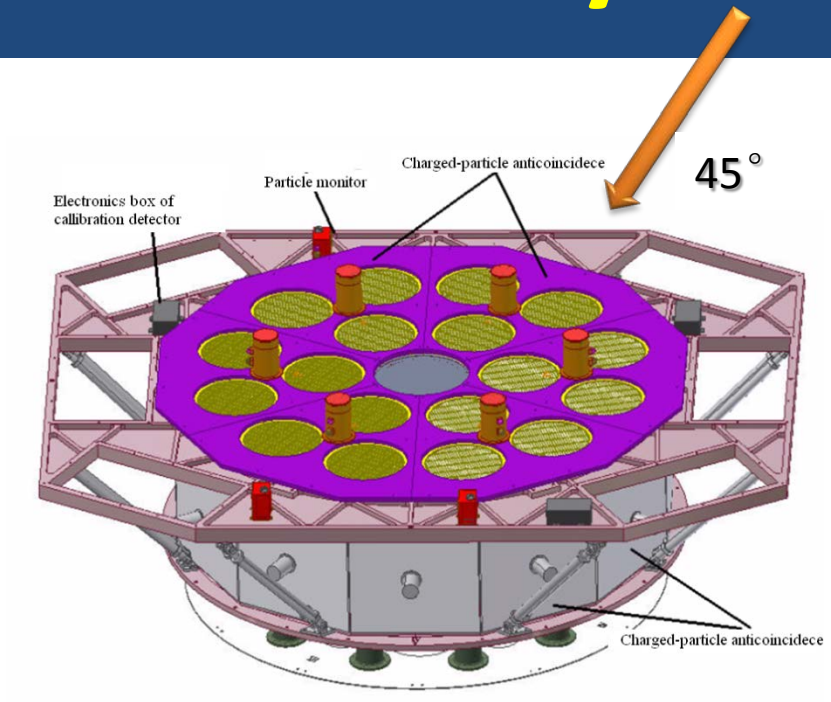
Comparison between HXMT and other major hard X-ray telescopes

HXMT		RXTE	INTEGRAL/IBIS	SWIFT	NuSTAR
Energy Band (keV)	LE: 1-15 ME: 5-30 HE: 20-250	PCA: 2-60 HEXTE: 15-250	15-10000	XRT: 0.5-10 BAT: 10-150	3-79
Detection Area (cm^2)	LE: 384 ME: 950 HE: 5000	PCA: 6000 HEXTE: 1600	2600	XRT: 110 BAT: 5200	847 @ 9 keV 60 @ 78 keV
Energy Resolution (eV)	150@ 6 keV 2500@20 keV 10000@60 keV	1200@6keV 10000@60 keV	8000@ 100 keV	150 @ 6 keV 3300 @ 60 keV	900 @ 60 keV
Time Resolution (ms)	LE: 1 ME: 0.18 HE: 0.012	PCA: 0.001 HEXTE: 0.006	0.06	XRT: 0.14, 2.2,2500 BAT: 0.1	0.1
Sensitivity (@100keV, 3σ, 10^5s, mCrab)	0.5	1.5	3.8	9	0.03 @ 20 keV

Scientific objectives

- Scan the Galactic Plane to find new transient sources and to monitor the known variable sources
- Observe X-ray binaries to study the dynamics and emission mechanism in strong gravitational or magnetic fields
- Find and study GRB by CsI anticoincident detectors.

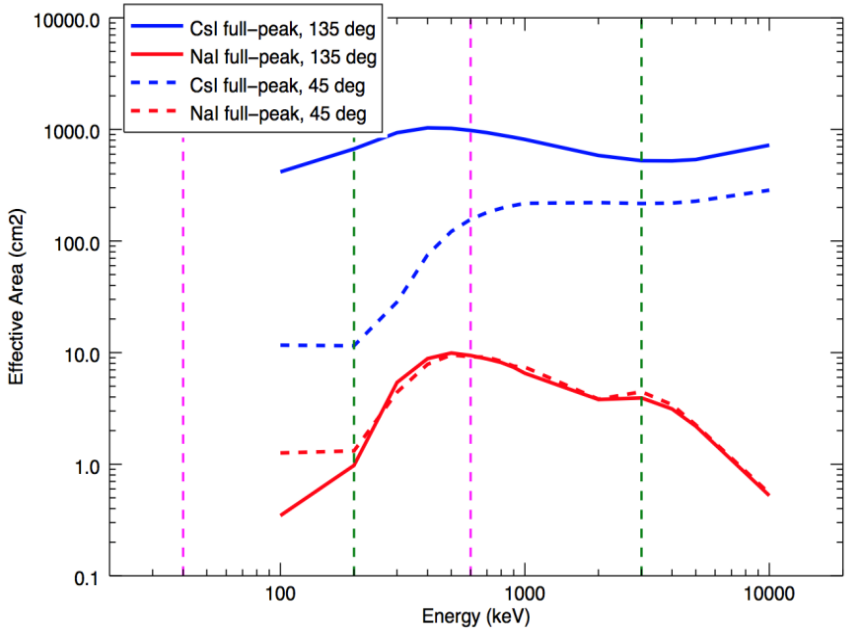
Gamma Ray Burst mode for HE



- The structure is transparent for high energy photons (>300 keV)
- CsI: large thickness; high density; 4π FOV
- Decrease the voltage of PMT in the earth shadow

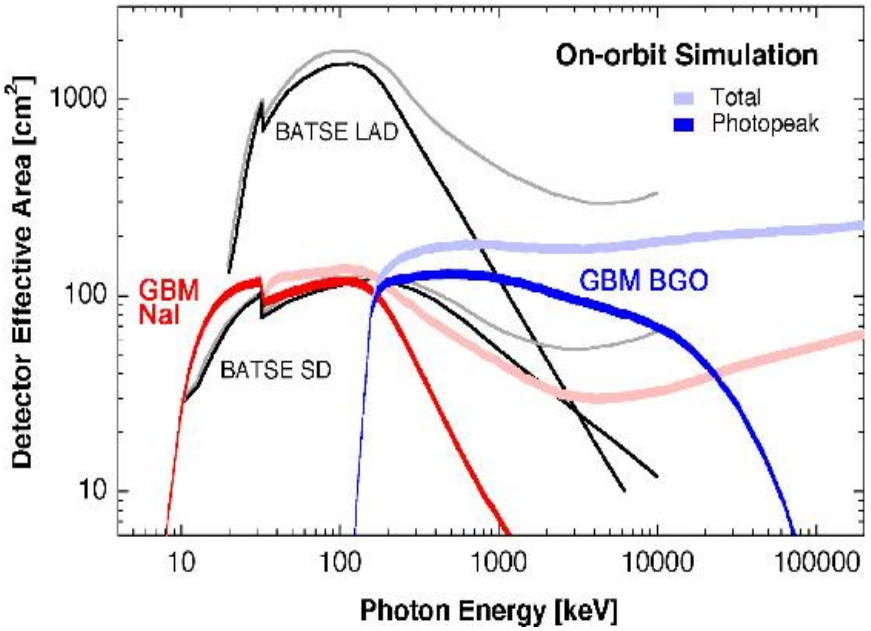
	NaI (keV)	CsI (keV)
Normal mode	20 – 250	40 – 600
GRB mode	100 – 1250	200 – 3000

Gamma Ray Burst mode for HE



- CsI: large effective area 800 cm^2@1 MeV
- ~100 GRBs/yr
- Constrain Epeak of GRB

- EM counterpart of GW
- Localization (degrees)

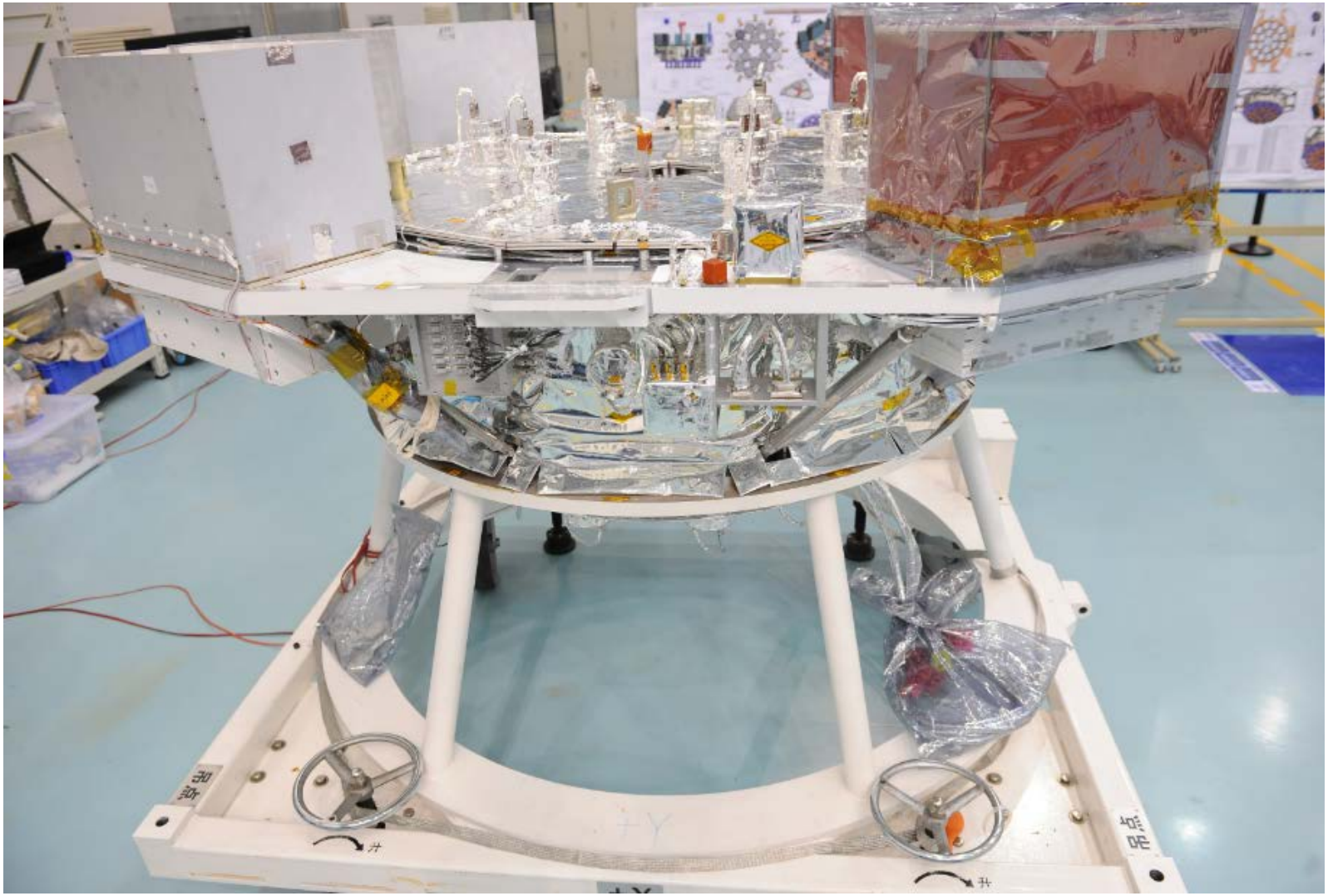


2. Progress of HXMT in 2016

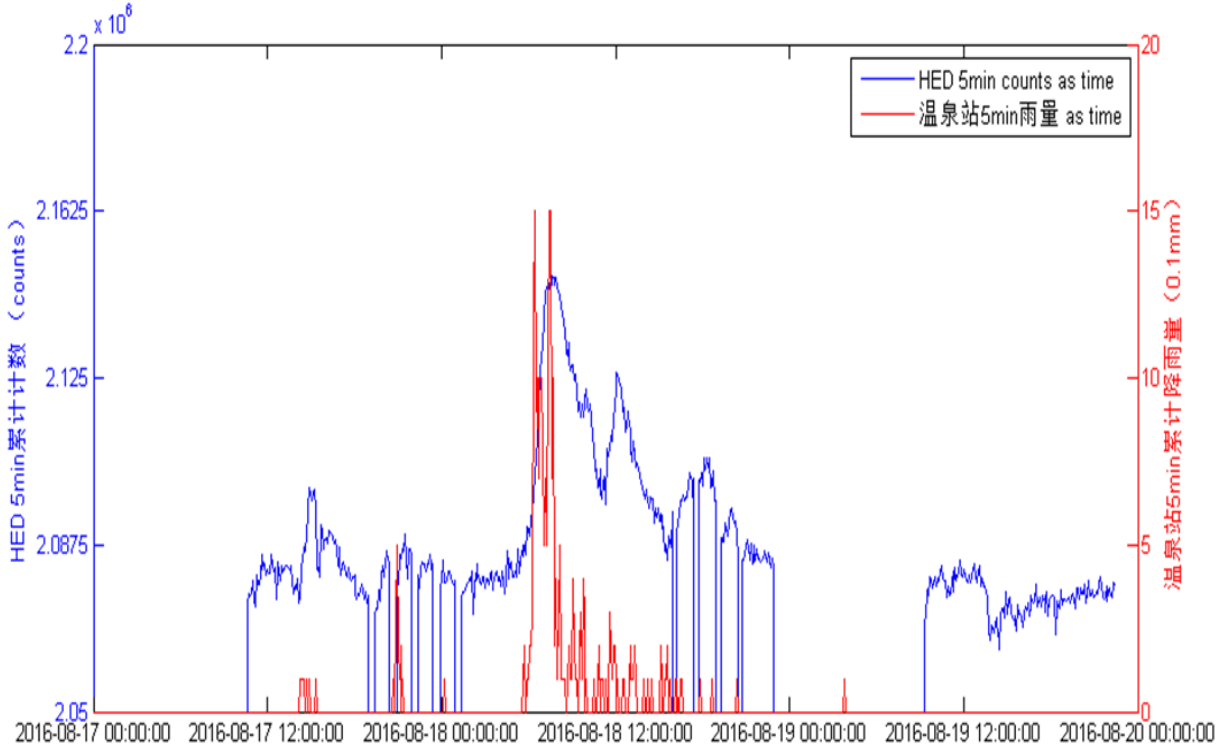
- All detectors of HXMT have completed the ground calibration in 2016
- In the early May of 2016, all the products have been delivered to the satellite.
- The detectors show a normal and stable performance in environmental tests
- Finished the satellite-system-level integration tests.

Electromagnetic compatibility test, thermal vacuum test, and mechanical test

HXMT is ready to launch

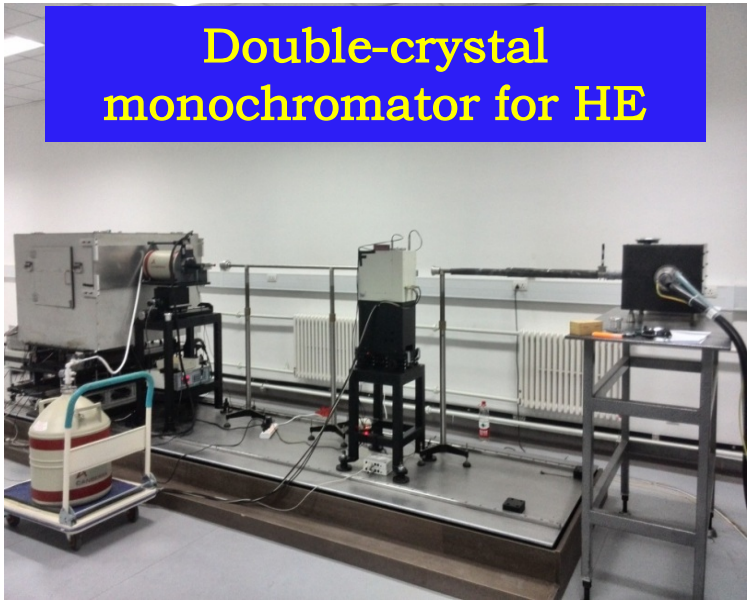


The positive correlation between the counting rate and the rainfall

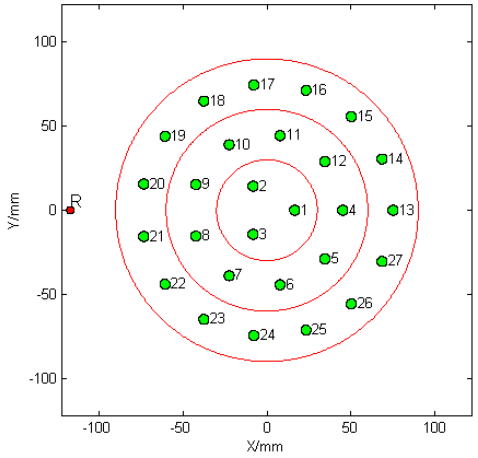


- Blue line: the count rate of HE; red line: the rainfall
- Caused by the increase of the radioactive background of ^{222}Rn decay chain

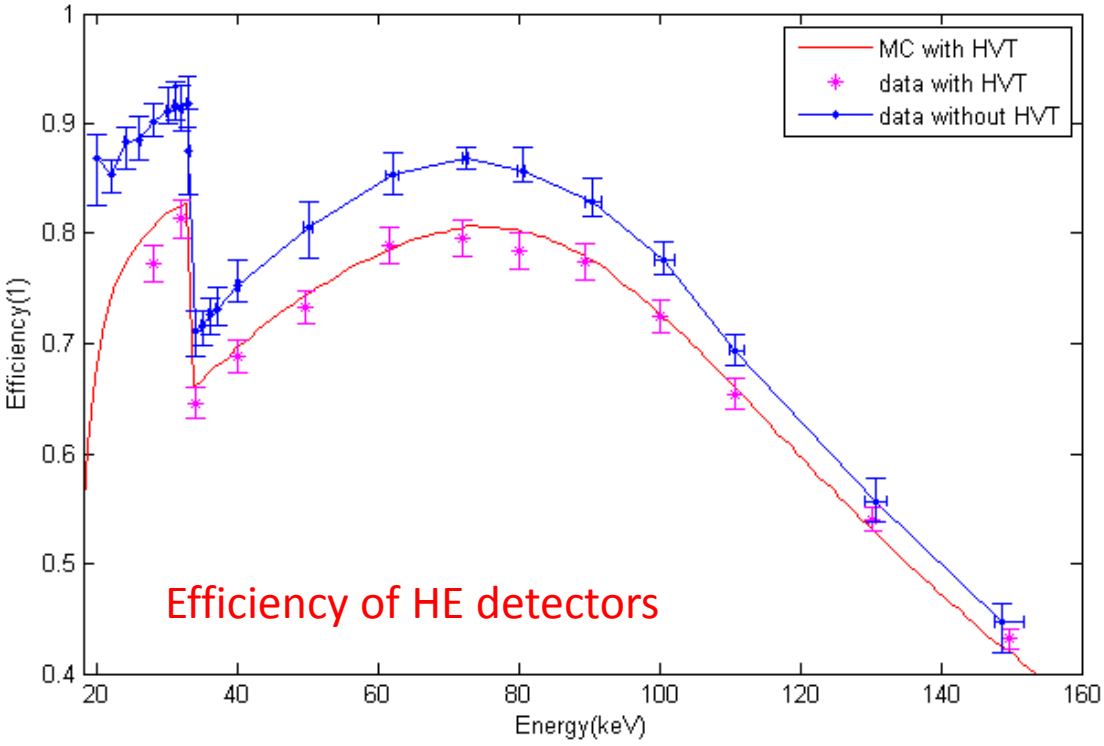
3.Ground Calibration of the HE



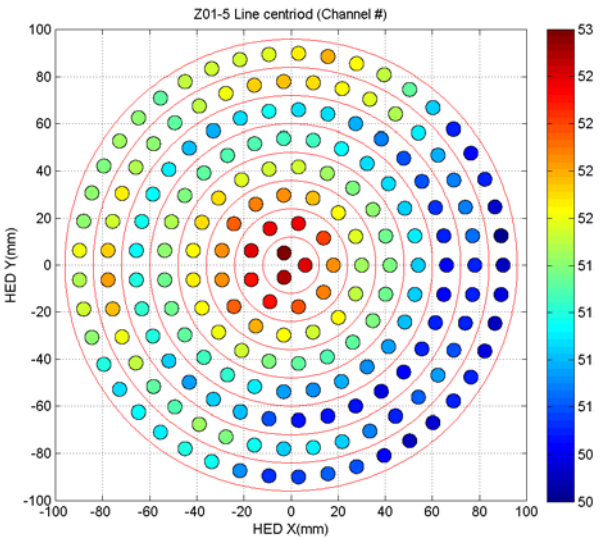
Position of incident X-ray:



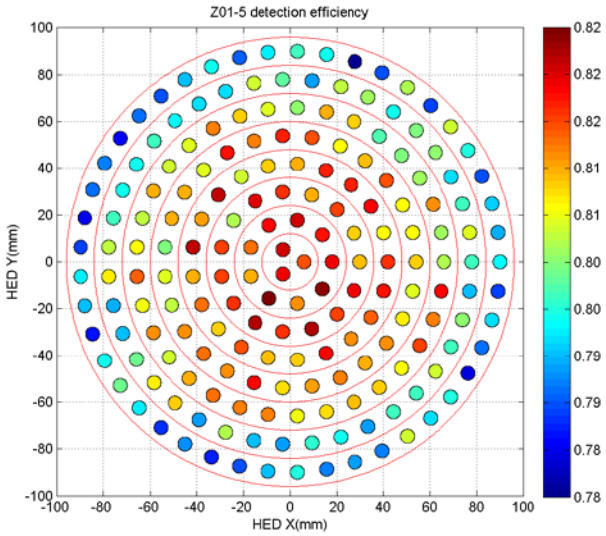
- Beam size is small
- The accumulated spectrum from 27 points across the detector
- Mimic a parallel X-ray beam uniformly illuminating the surface of HE.



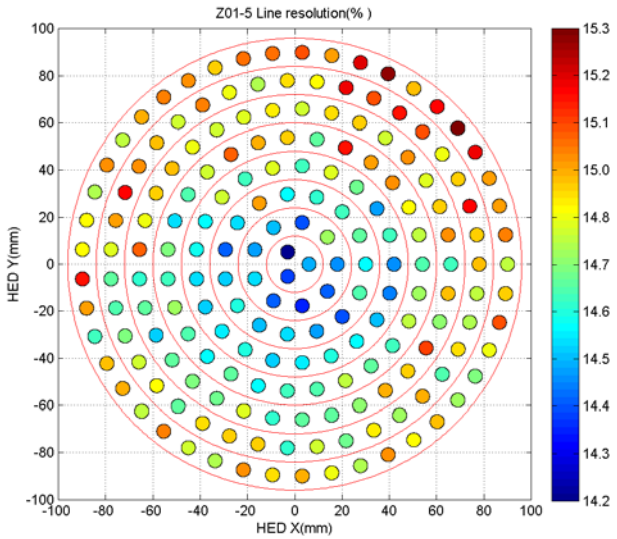
Response uniformity of HE



Peak mapping of 50 keV on 192 positions



Efficiency at 50 keV on 192 positions

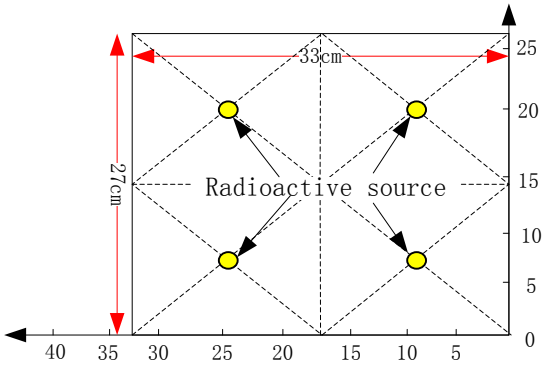


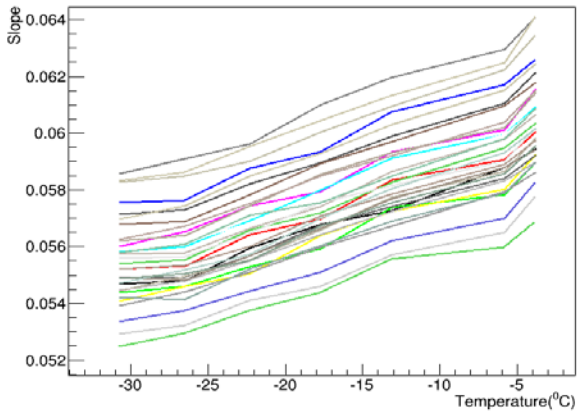
Energy resolution at 50 keV on 192 positions

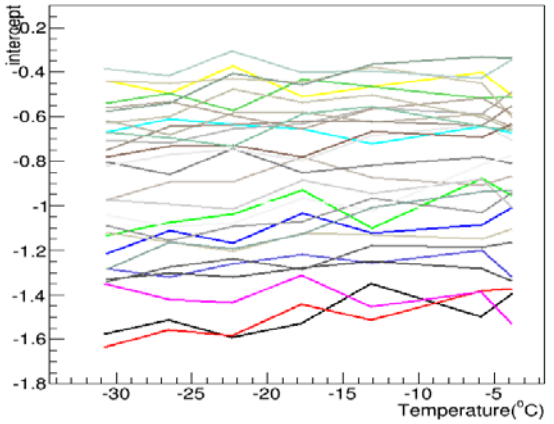
- The scintillation fluorescence is well collected
- No significant dead area

Ground Calibration of ME

4 same radioactive sources on one plate

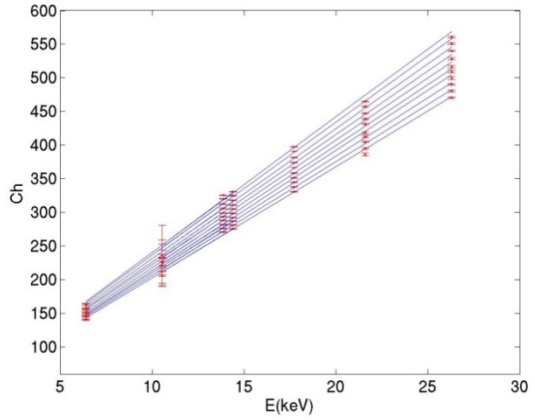


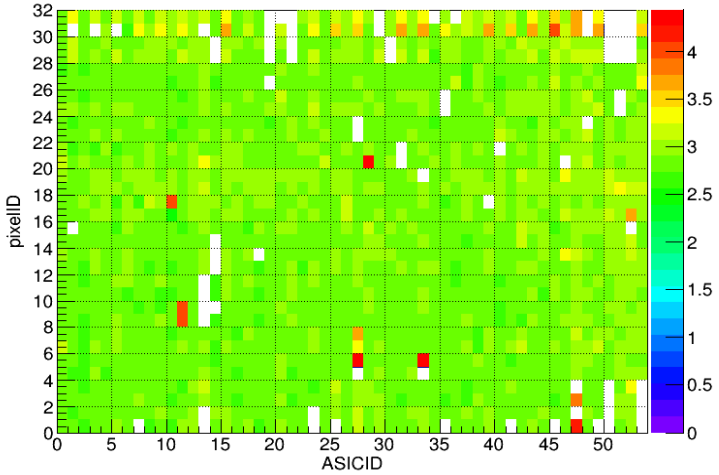




- A linear Energy-Channel relation
- Interpolate to get the slope and intercept at any T without calibration data

A typical energy spectrum of ^{241}Am:

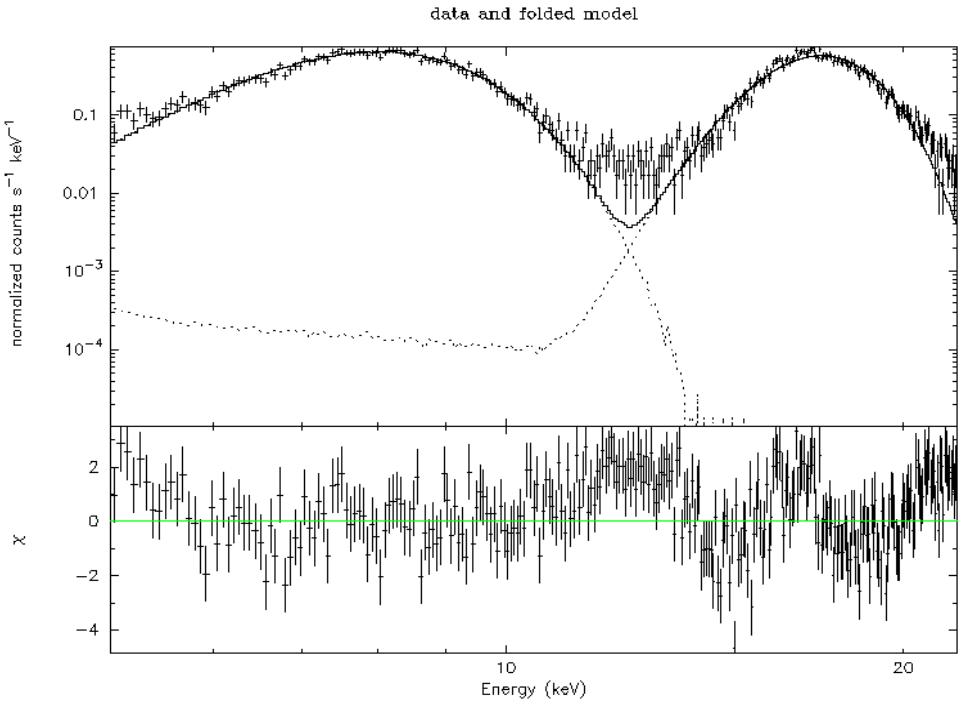




The FWHM of all the pixels of ME.

ME:

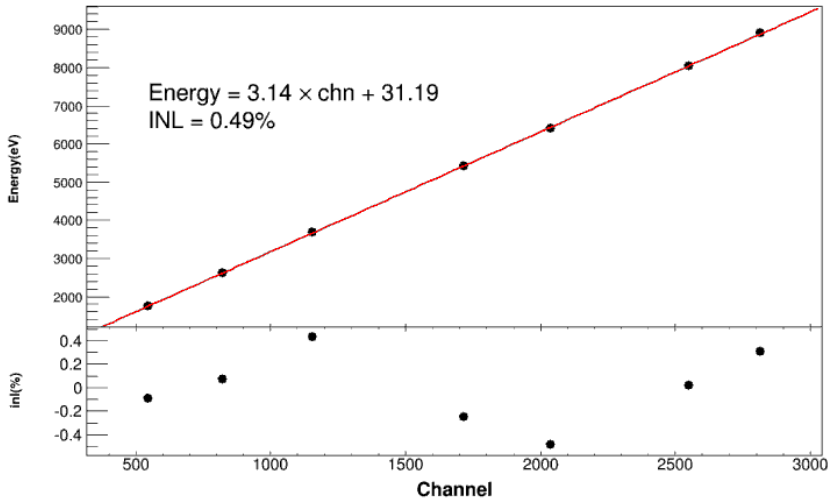
- The verification of RMF and E-C relationship of ME in thermal vacuum test with Cu and Mo target.

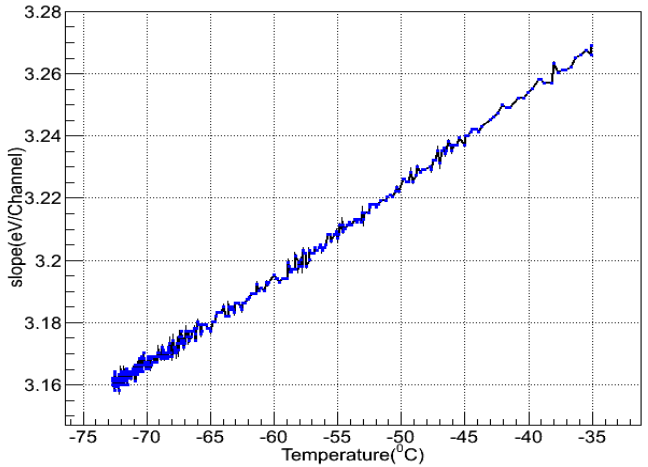


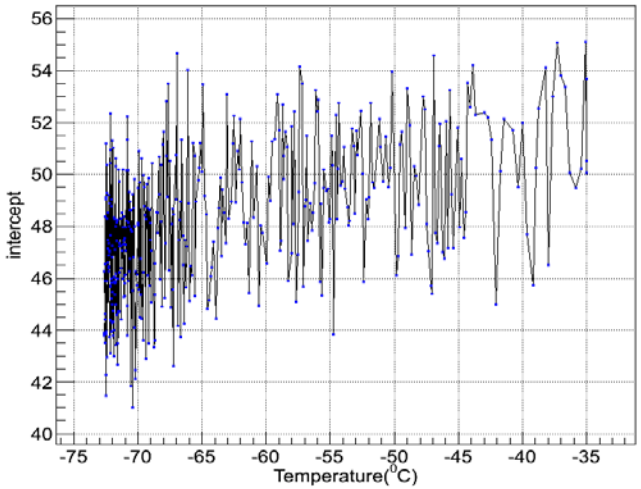
par	comp						
1	1	gaussian	LineE	keV	8.09877	+/-	2.44805E-02
2	1	gaussian	Sigma	keV	1.26775E-05	+/-	-1.00000
3	1	gaussian	norm		0.512805	+/-	5.69305E-03
4	2	gaussian	LineE	keV	17.3709	+/-	1.61902E-02
5	2	gaussian	Sigma	keV	0.711087	+/-	2.63752E-02
6	2	gaussian	norm		0.525225	+/-	5.74349E-03

Ground Calibration of LE

- Calibrate E-C relation and energy resolution using fluorescent lines, e.g., Cl-Ka, Fe-Ka, Cu-Ka, and Cu-Kb

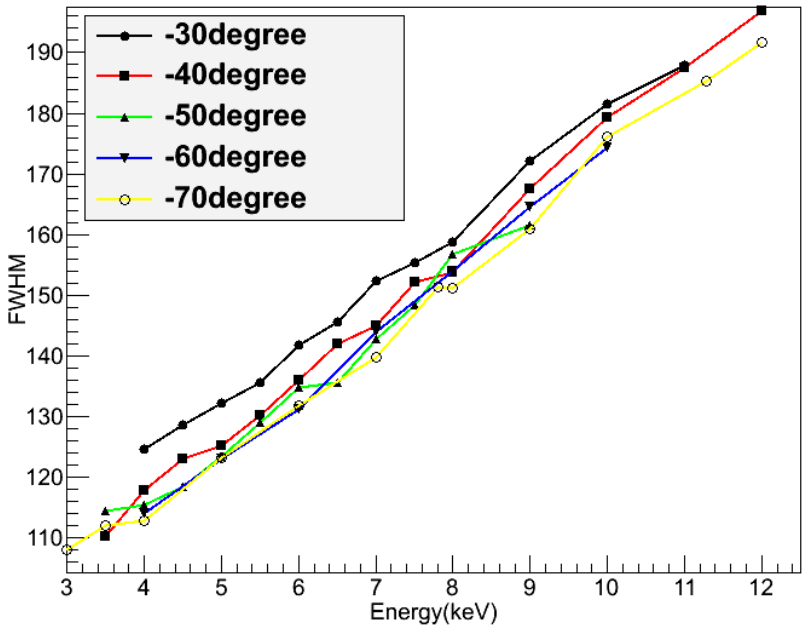


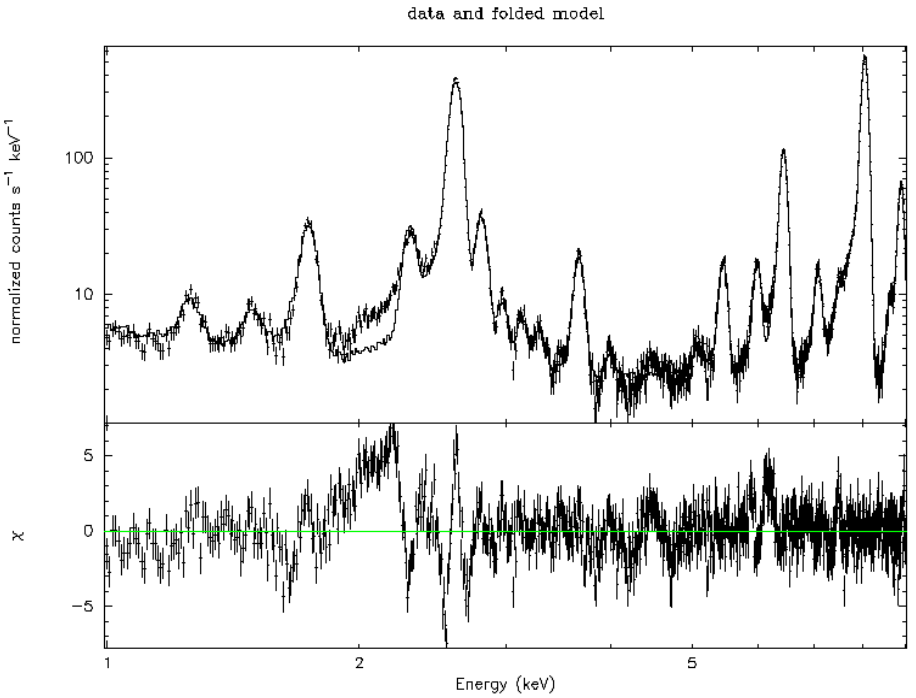




➢ Interpolate to get the slope and intercept at any T without Calibration data

Ground Calibration of LE





- FWHM vs Temperature
- Two RMFs for T=-75 ˚C ~ -40 ˚C and -40 ˚C ~ -30 ˚C

The verification of RMF and E-C relationship of LE in the thermal vacuum test

4. In-orbit Calibration plan

- The first 3 months after launch
- Verify/Optimize the performance of payloads
- Energy-Chan, Energy-FWHM, PSF, boresight, Eff. Area, RMF, Time accuracy, niformity between detectors, Background

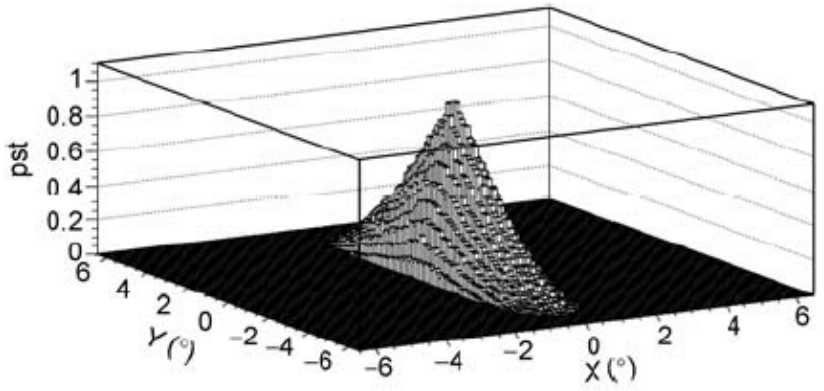
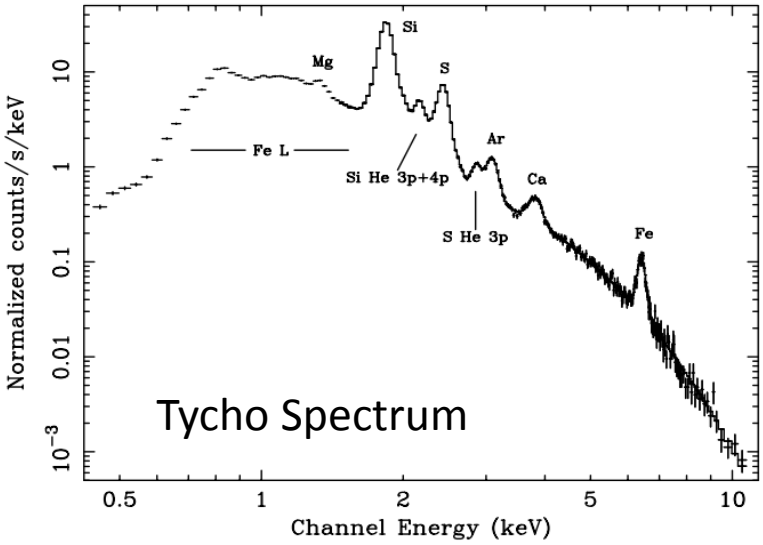


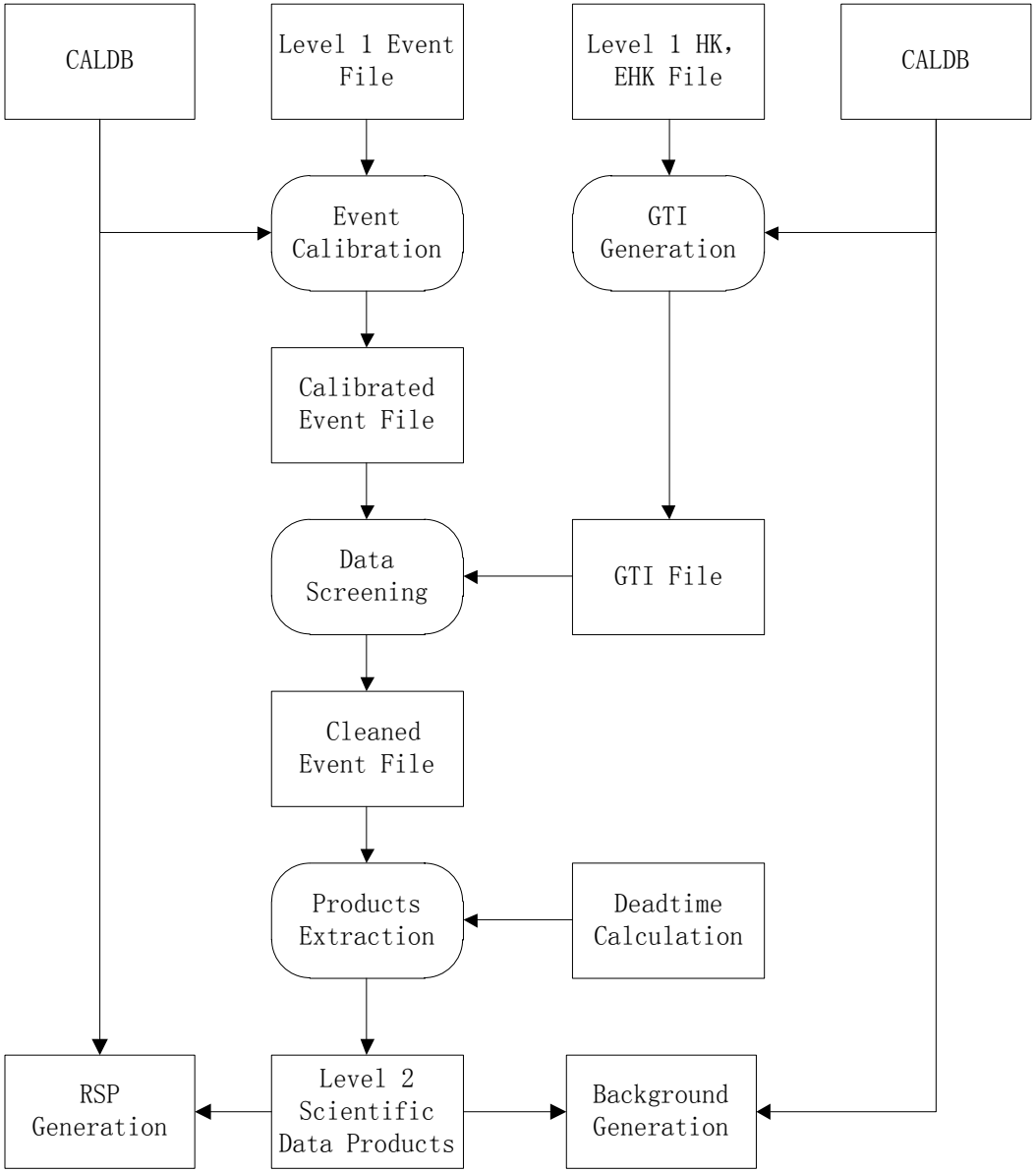
Figure 3 The normalized simulation data of a one-day observation of the Crab by Geant4.



List of In-orbit Calibration Sources

Source Name	RA	DEC	Usage
Crab	83.63	22.01	RMF, ARF, Timing, PSF, boresight, etc.
PSR B1509-58	228.48	-59.14	
Cas A	350.846	58.813	Data analysis, LE temperature drift
Tycho	6.334	64.150	
Cyg X-1	299.59	35.20	Data analysis, quick-look
Sco X-1	244.98	-15.64	
Blank Sky #1	145.9975	4.3899	Background (include: Night Earth)
Blank Sky #2	176.4366	-20.6326	
Blank Sky #3	232.5356	8.8014	
Blank Sky #4	251.8799	55.7135	
Blank Sky #5	322.4055	-24.2587	
Blank Sky #6	52.6687	-59.8347	
Blank Sky #7	312.2388	-11.8415	
Blank Sky #8	22.5767	-76.1370	

5. Data Processing of HXMT



Calibration files are generated and saved in HEASARC CALDB format.

6. Summary

- The whole satellite is well tested and ready to launch; HXMT will be launched in June 2017
- Galactic plane scanning will discover tens of new X-ray transient sources
- GRB mode will significantly increase the scientific output of HXMT
- Possible collaboration on cross calibration and follow-up observations (counterpart in soft X-ray and optical)

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