The Current Status and Calibration Plan of the Hard X-ray Modulation Telescope Project

Fangjun LU

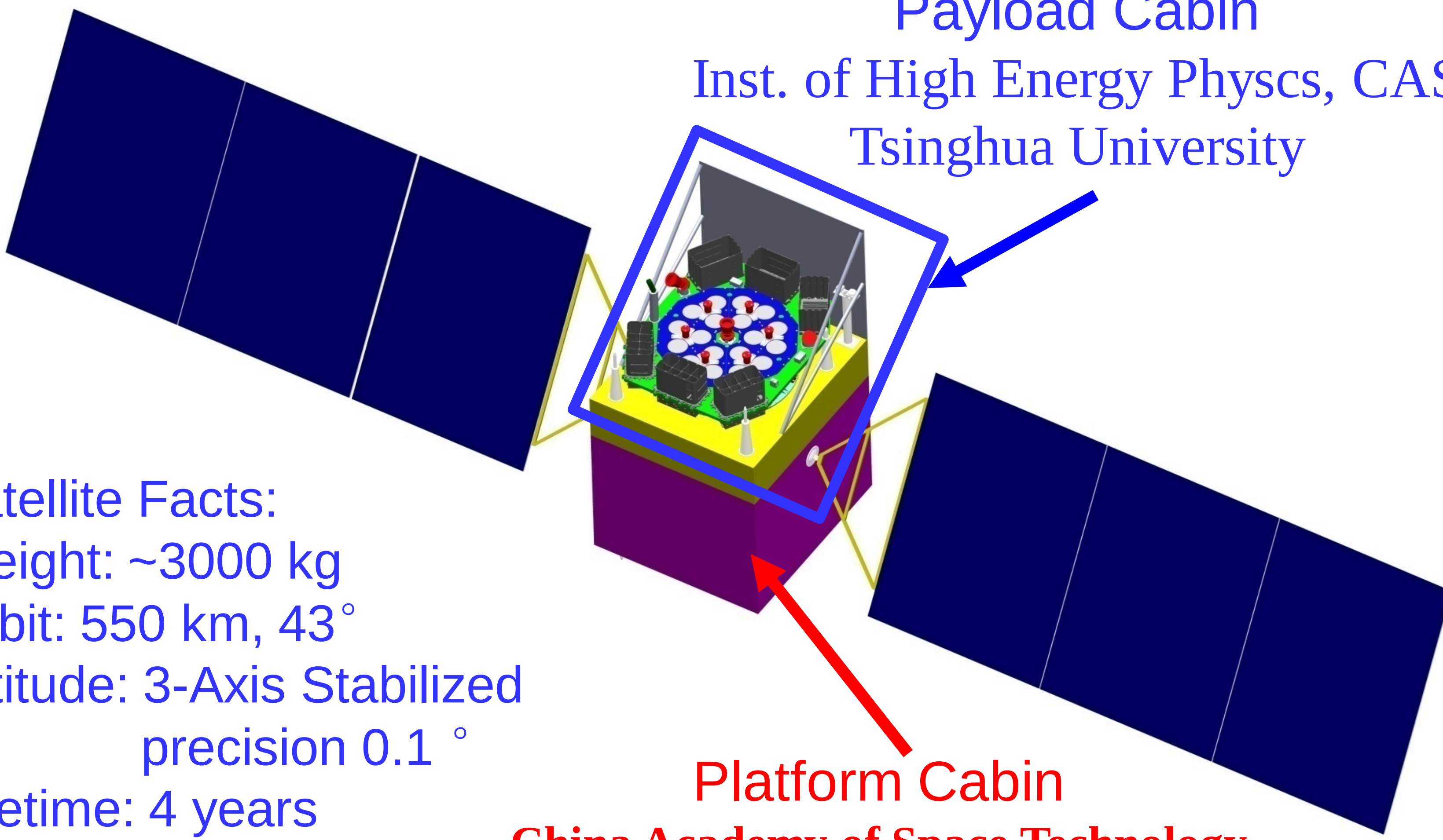
(On Behalf of the HXMT team)

Institute of High Energy Physics
Chinese Academy of Sciences

Outline

- Overview of the HXMT project
- Status of the hardware development
- Calibration plan and progress

Hard X-ray Modulation Telescope (HXMT)
—— China's first astronomical satellite



Satellite Facts:

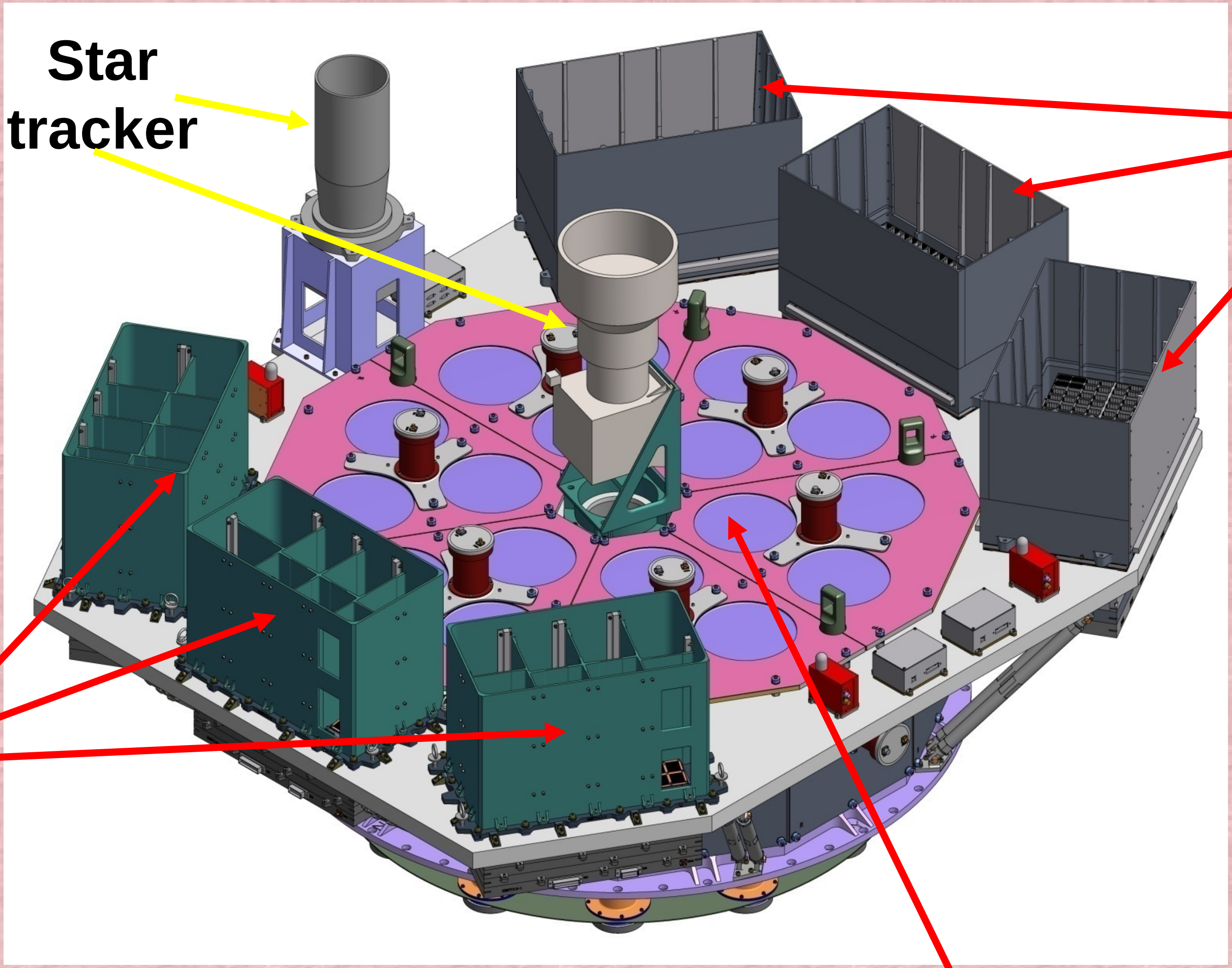
Weight: ~3000 kg

Orbit: 550 km, 43°

Attitude: 3-Axis Stabilized
precision 0.1 °

Lifetime: 4 years

Payloads onboard HXMT

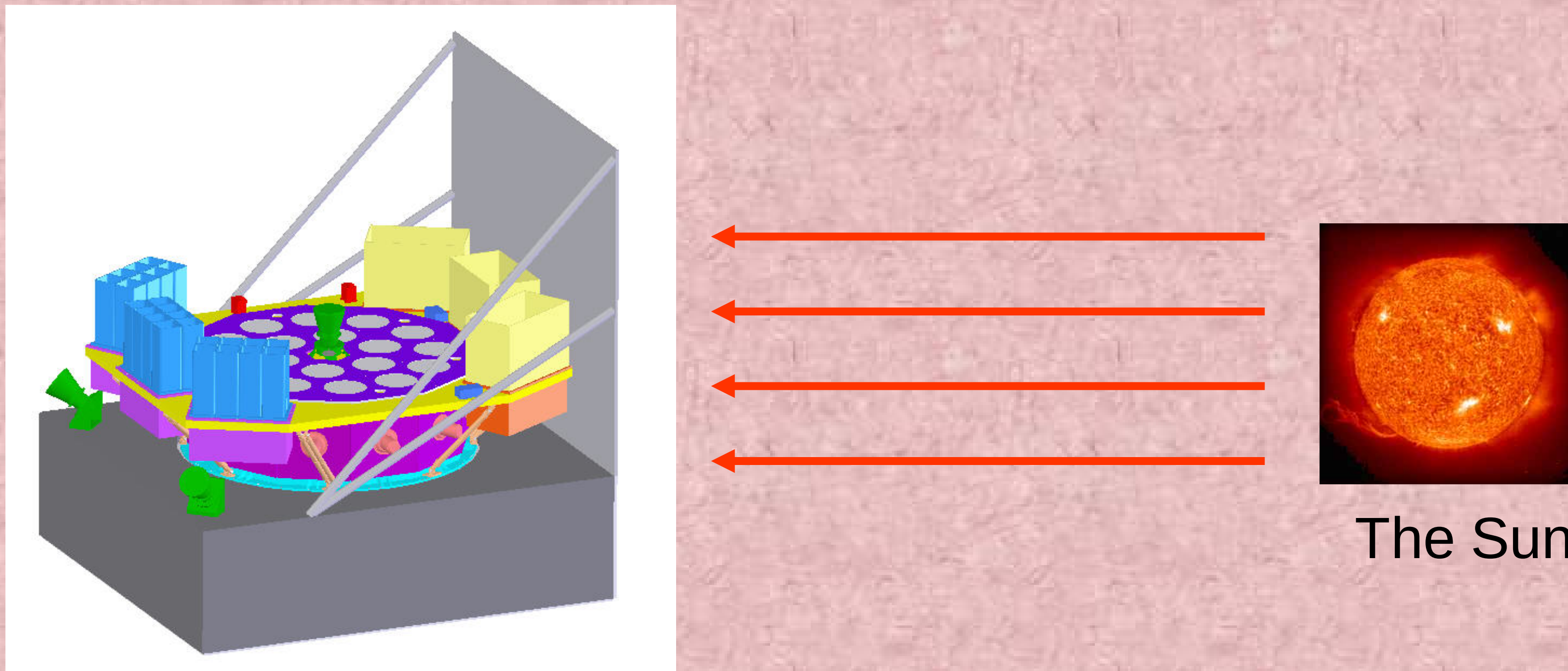


LE:SCD,1-15 keV, 384 cm^2

ME:Si-PIN,3-30 keV, 952 cm^2

Size： 1900×1650×1000 mm

HE: NaI/CsI, 20-250 keV, 5000 cm^2



A sunshading board will be set so that the LE and ME telescopes can work at low temperatures

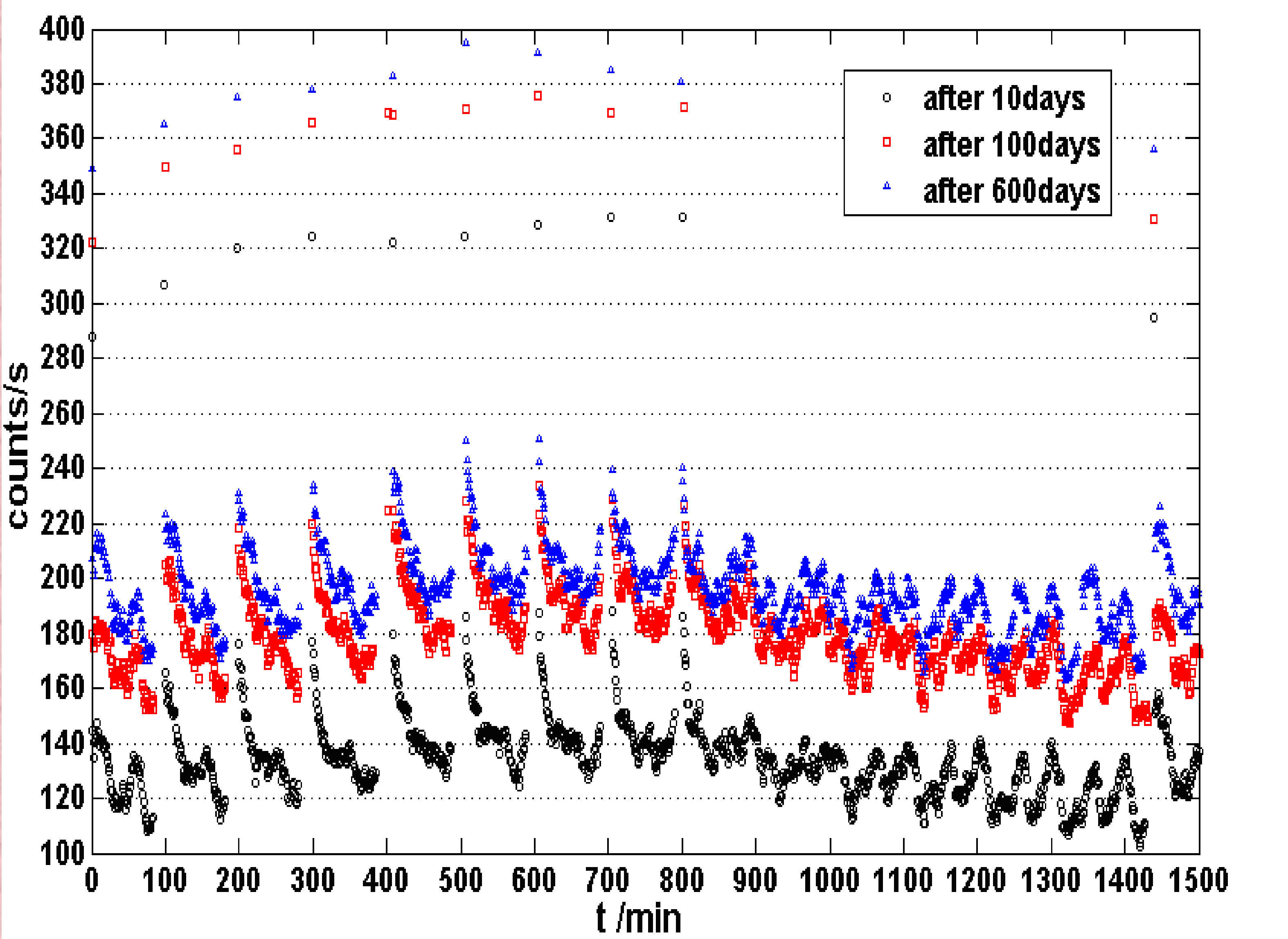
Working temperatures of the detectors

- HE (NaI/CsI): 18 ± 1℃
- ME(Si-PIN): -40 ~ -20℃
- LE (SCD): -80 ~ -45℃

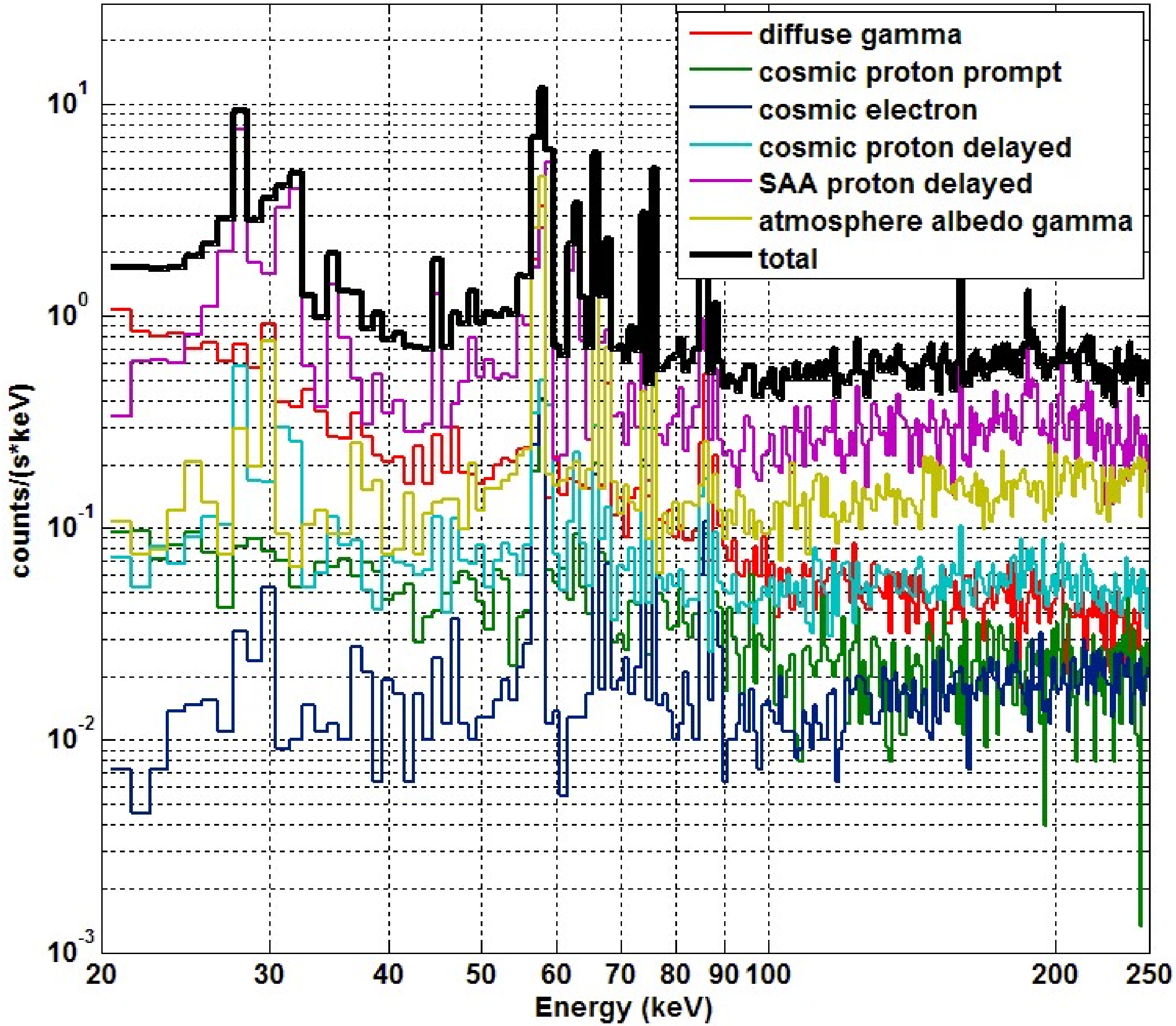
Characteristics of the HXMT Mission

Detectors	LE: SCD, 384 cm^2;ME : Si-PIN, 950 cm^2 HE : NaI/CsI, 5000 cm^2
Energy Range	LE: 1-15 keV;ME: 5-30 keV;HE: 20-250 keV
Time Resolution	HE: 25μs; ME: 180μs;LE: 1ms
Working Temperature	HE: 20±3℃; ME: -40~-20℃; LE: -80-45℃
Energy Resolution	LE: 2.5% @ 6 keV ME: 10% @ 17.8 keV HE: 19% @ 60 keV
Field of View of one module	LE: 6° ×1.6° ; 6° ×4° ; 60° ×3° ; blind; ME: 4° ×1° ; 4° ×4° ; blind; HE: 5.7° ×1.1° ; 5.7° ×5.7° ； blind
Source Location	<1' (20σ source)

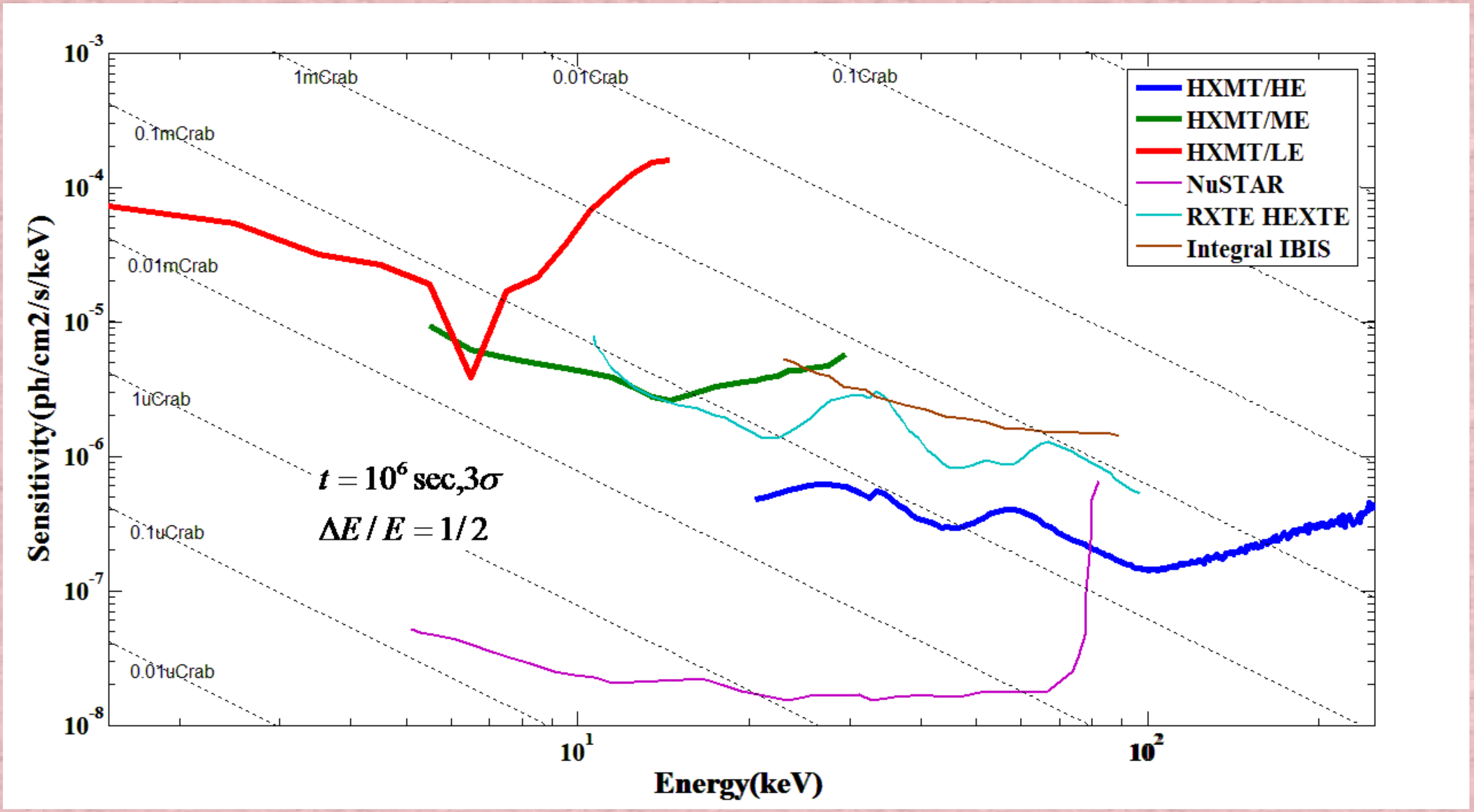
Orbit	Altitude: ~550 km ; Inclination: ~43°
Attitude	Three-axis stabilized Control precision: $\pm 0.1°$ Measurement accuracy: $\pm 0.01°$
Data Rate	LE: 3 Mbps; ME: 3 Mbps; HE: 300 kbps
Payload Mass	~1000 kg
Nominal Lifetime	4 years
Working Mode	Scan survey, small region scan, pointed observation



Simulated in-space background of HXMT/HE



100 days after launch, 30 minutes after passing SAA



The sensitivities of the three telescopes of HXMT. The sensitivities of NuSTAR, INTEGRAL/IBIS and RXTE/HEXTE were reprinted from Koglin et al. (2005)[3].

Sciences with HXMT

All-sky survey

- Diffuse X-ray emission: cosmic X-ray background; X-ray emission from the Galactic ridge and the Galactic center region
- Detection of new sources and constrain their broad band (1-250 keV) properties

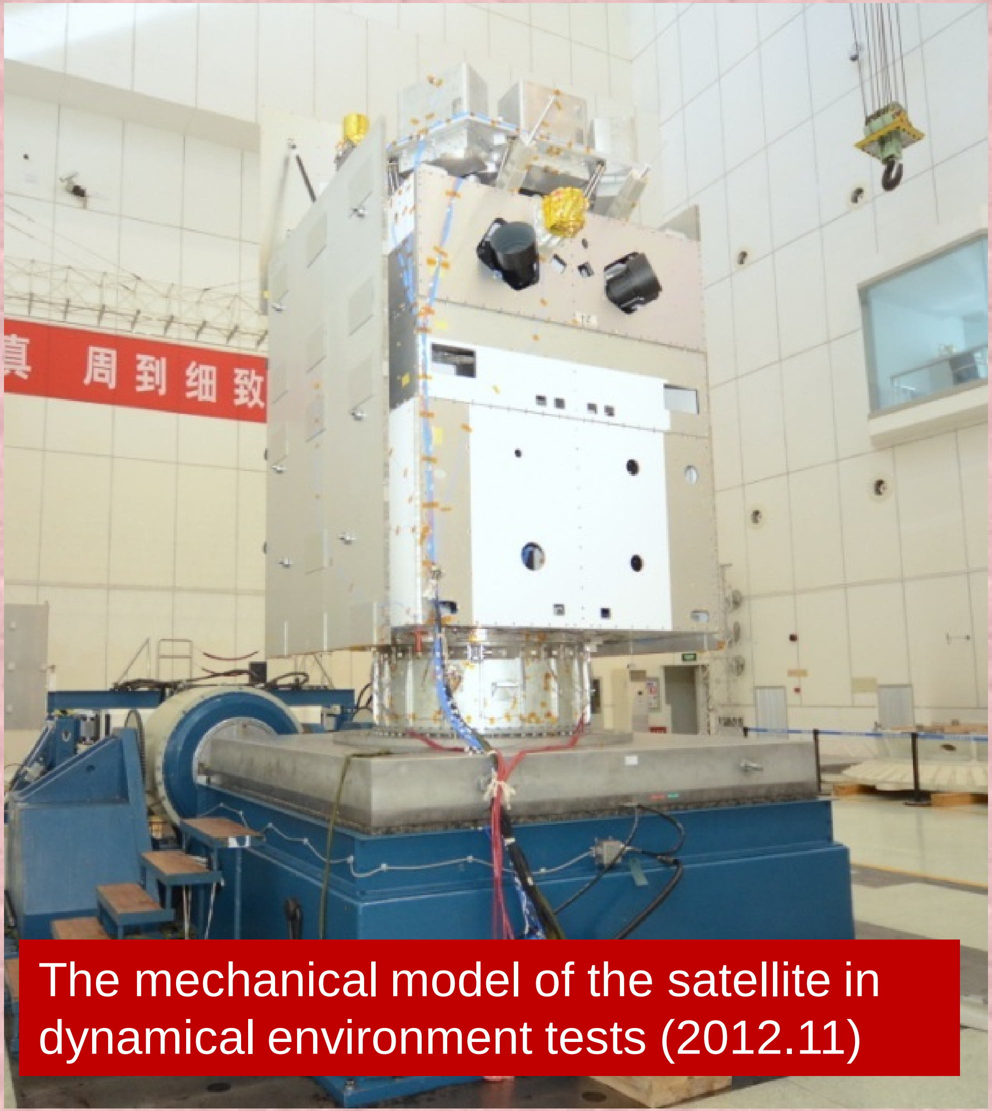
Pointed observations

- X-ray binaries: multiwavelength temporal behaviors, broad band spectra and Fe emission line
- Equation of state in strong magnetic field: AXP, X-ray Bursts
- Monitoring of Blazars and bright AGNs

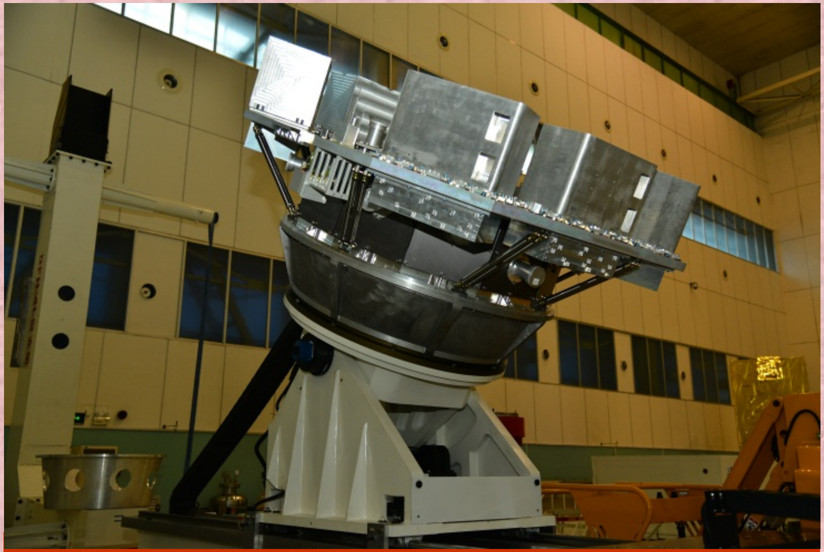
Frequent scan of the Galactic plane, LMC/SMC

- Detect new transients
- Diffuse emission

Status of the Hardware Development (1)



The mechanical model of the satellite in dynamical environment tests (2012.11)



Measureing the weight center and rotation inertia of the telescope (2012.11)

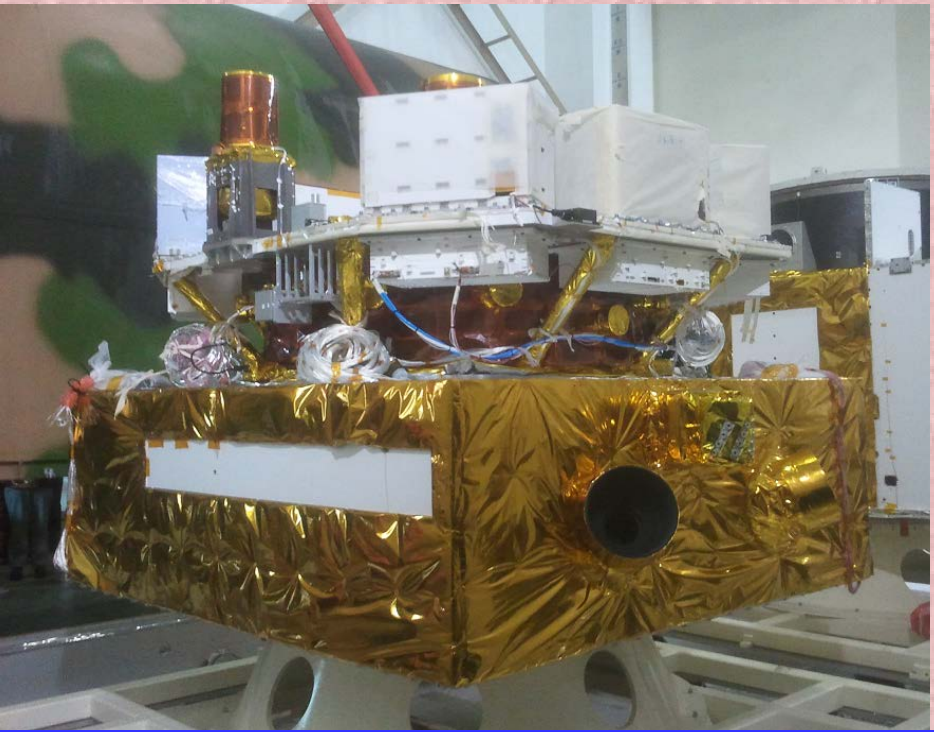
The Mechanical Model of the satellite was finished in 2012. The payloads and platform both passed the dynamical environment tests.

Status of the Hardware Development (2)

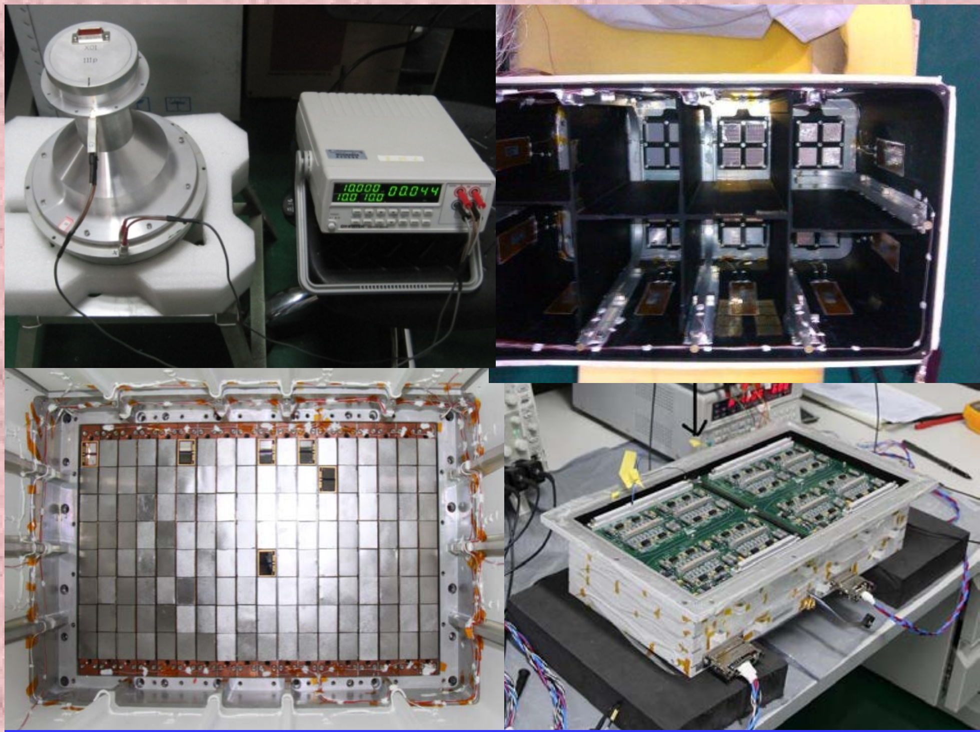
The electric model of HXMT's payloads in testing (2012.12).

The tests of the electric performance of the payloads were finished in Dec. 2012, and those of the whole satellite were finished in early March of 2013.

Status of the Hardware Development (3)



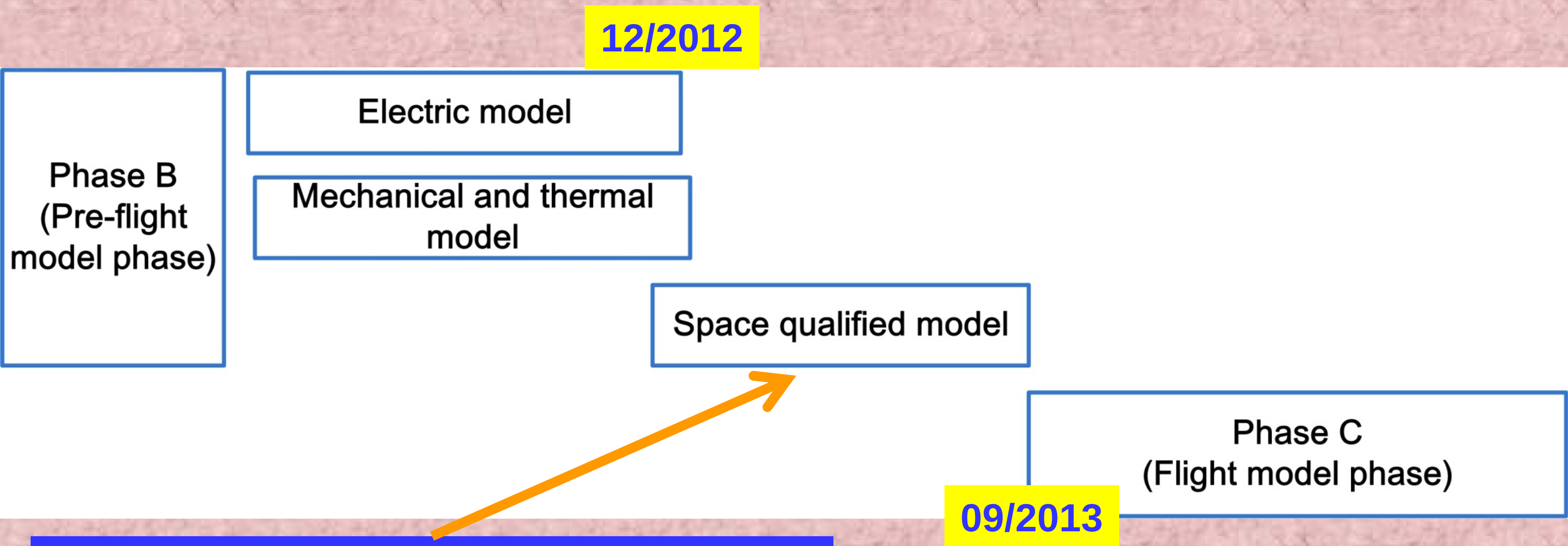
The payloads after thermal control coating



Some of the components jointed the vacuum tests

Vacuum thermal balance tests of the satellite were carried out in Dec. 21 to 29, 2012. The quasi-qualification models of all the detectors joined the tests. Those of HE and LE worked well during the tests, but that of ME had some problems with the FPGA, which was fixed and tested in a new experiment a few days ago.

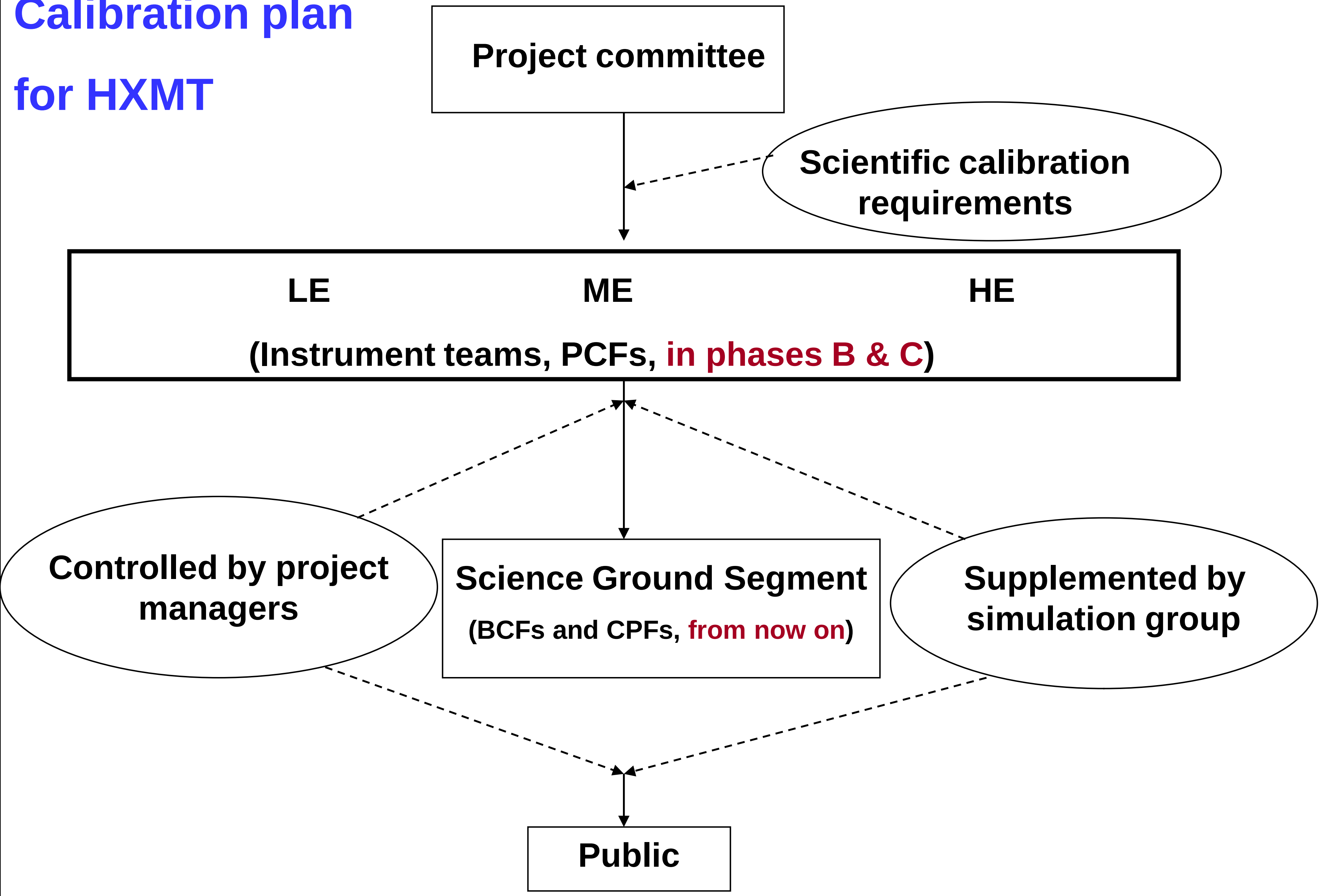
Status and schedule of the hardware development



We are now building the qualification model of the payloads: the mechanical structures close to finish, but the detailed designs of the electronics are still under inspections.

late 2014

Calibration plan for HXMT



PCF is now fully covered by the detector groups and BCF/CPF by SGS

Calibration milestones (1)

Phase B (2012-2013) (instrumental teams mostly involved):

- **Ground calibration plan (for PCF, by ins. team);**
- **Preliminary inflight calibration plan (for PCF, by ins. team);**
- **Preliminary calibration plan for producing BCF (by SGS);**
- **Figure out interface between PCF and BCF (by SGS);**

- **Tests for the ground calibration procedure using the qualification model (09-12, 2013, mainly by the ins. team);**

Calibration milestones (2)

Phase C (2014) (ground segment mostly involved):

Inflight calibration plan (for PCF, by ins. team);

Calibration plan for producing BCF (by SGS);

Calibration plan for producing CPF (by SGS);

Interface between ground PCF and inflight PCF (by SGS);

Carry out the ground calibration and produce PCF (by ins. team);

European Assistances

Documentation, software, experienced consultant etc. An agreement is expected to be sign later this year by ESA and the Chinese Academy of Sciences.

The HXMT group visited Panter in 2012. Calibration of a module for ME and a module for LE will probably be calibrated at Panter later this year, so as to check the calibration results in Beijing.
One HE main detector unit will be possibly calibrated at Ferrara University for the same purpose.

Ground facilities

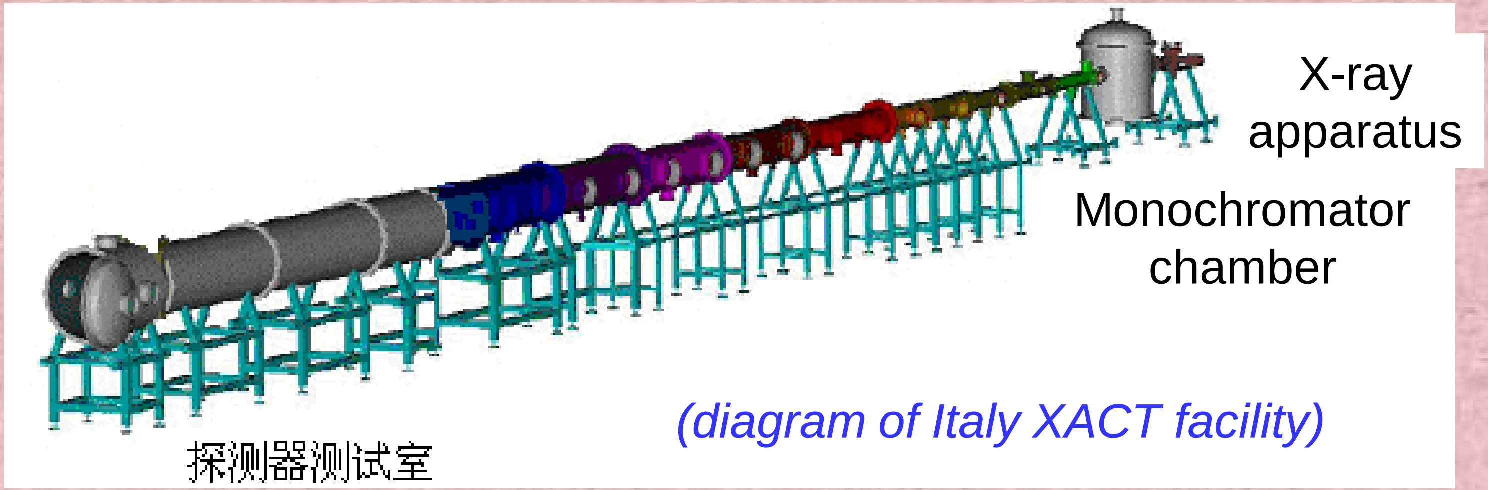
Radioactive sources.

Synchrotron radiation facility (for LE and ME) of Beijing Electron-Positron Collider.

Currently three facilities are in building in Beijing: Two at IHEP and another at the National Institute for Metrology.

Ground facilities

- **Facility being designed on IHEP campus**



X-ray apparatus: voltage ~100 kV

Beam line 100m: better parallelism

Designed for future mission like XTP (cal. Optics)

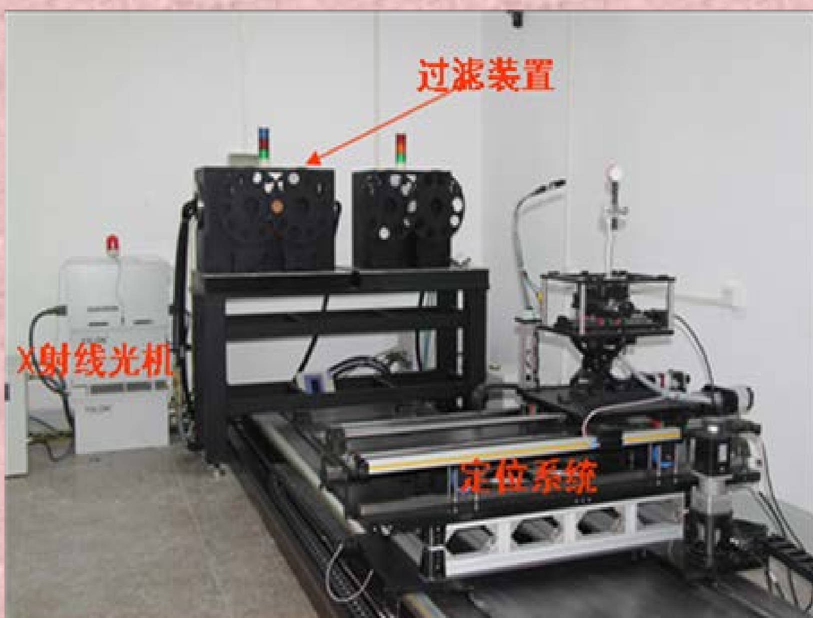
- **Facility in-build at IHEP**

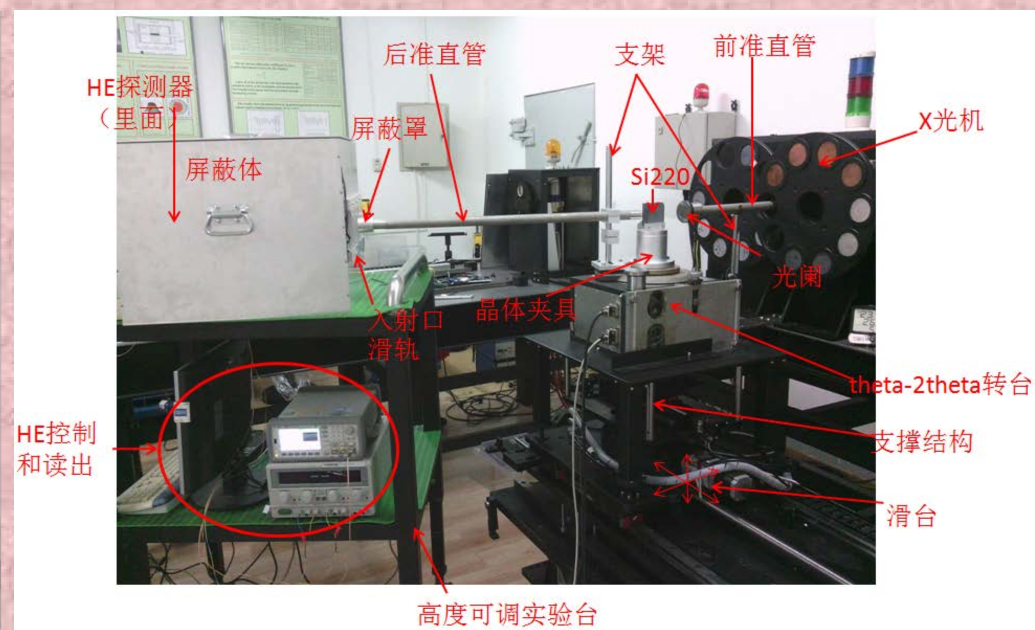
1-30 keV, for energy response calibration of LE and ME (Dr. Chen's talk)

Ground facilities

X-ray apparatus in upgrading at National Institute of Metrology.

5-150 keV, beam line <5m, double crystal monochromater, designed for the calibration of HE

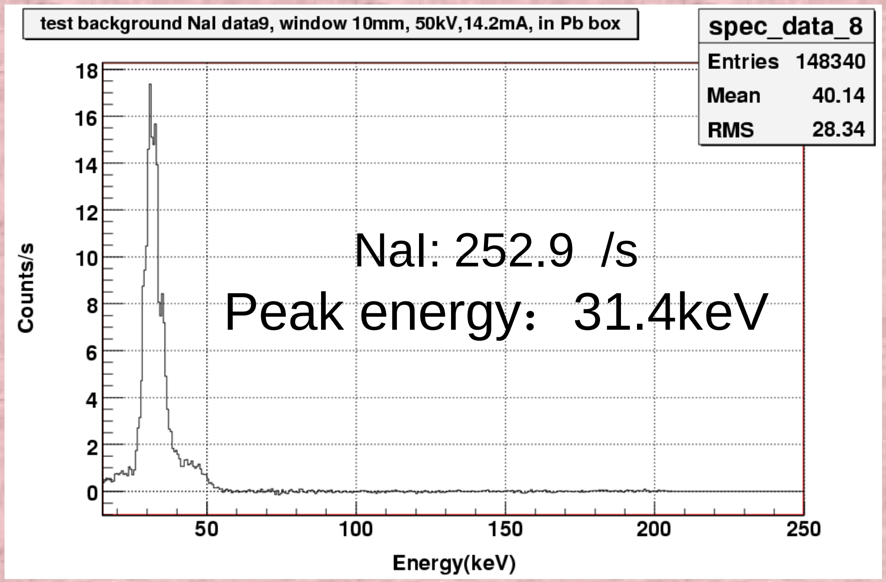


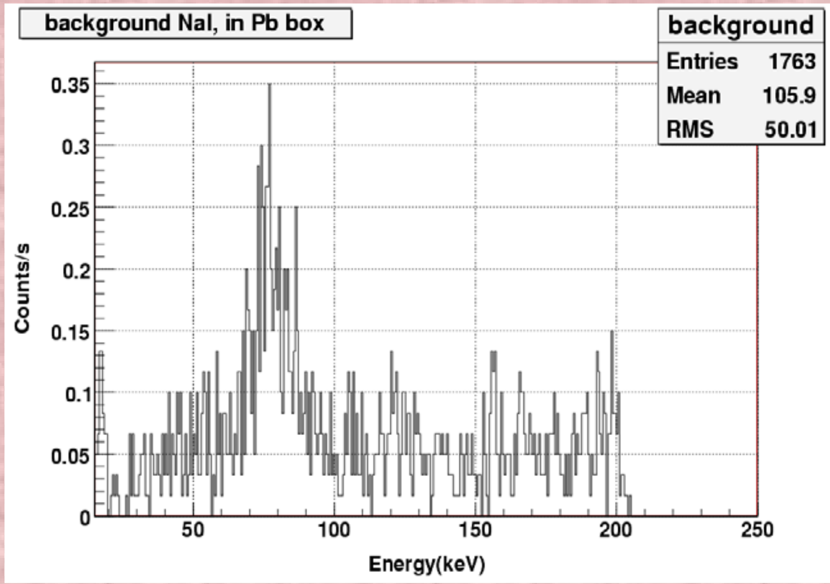


Before upgrading

After some upgrading

X-ray facilities at National Institute of Metrology





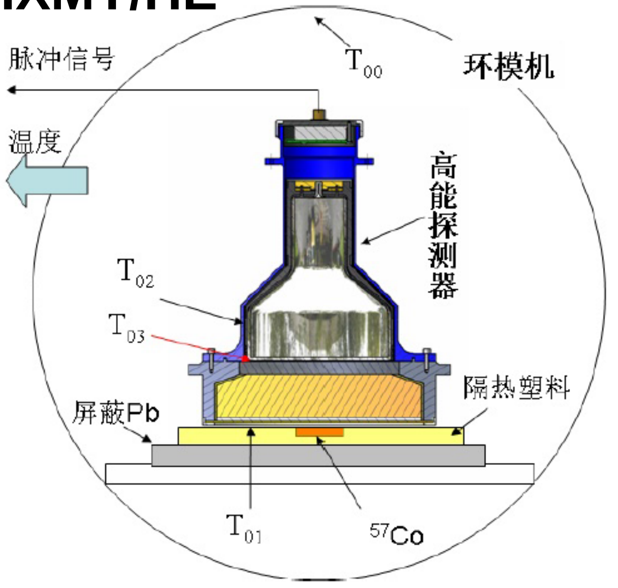
Mono-energy peak by a single crystal, the S/(S+N) is better than 90%

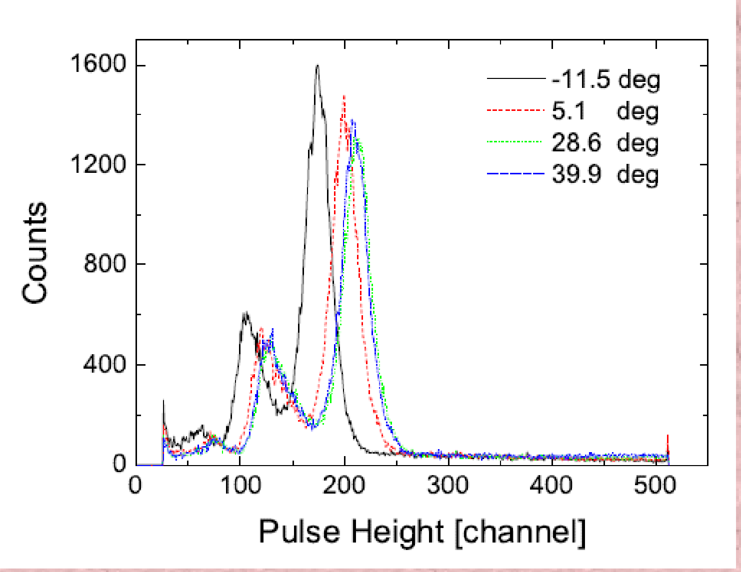
Residual background after shielding：21 counts/s

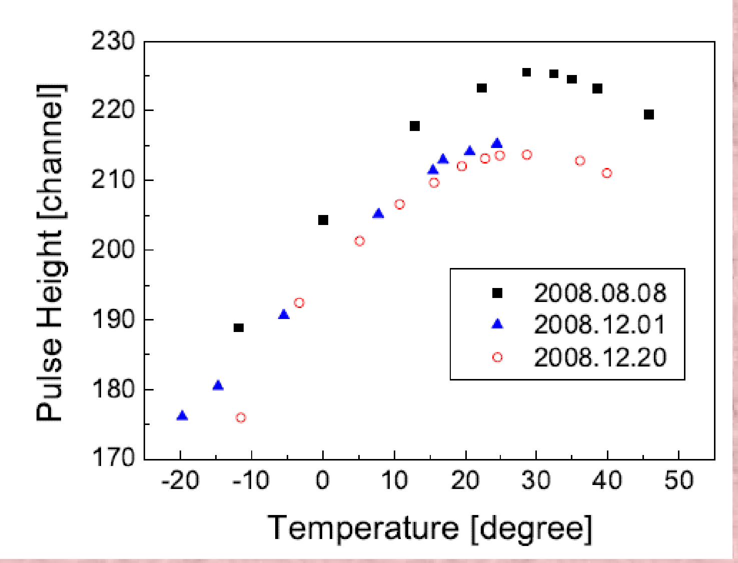
A double crystal monochrometer will be installed in April. After that we can start the calibration of the HE main detectors.

Some preliminary calibration tests

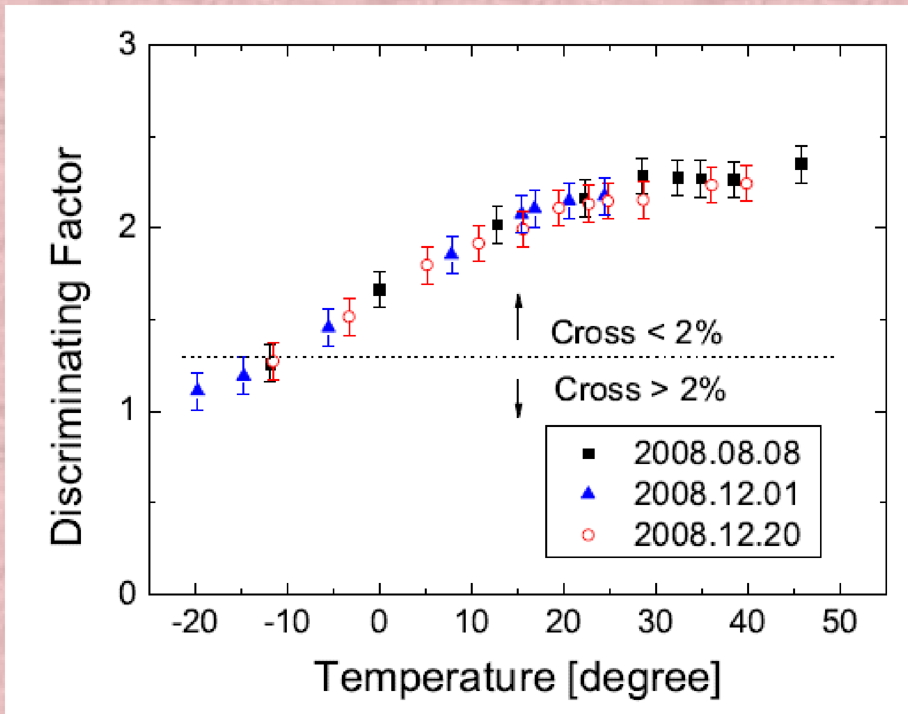
HXMT/HE

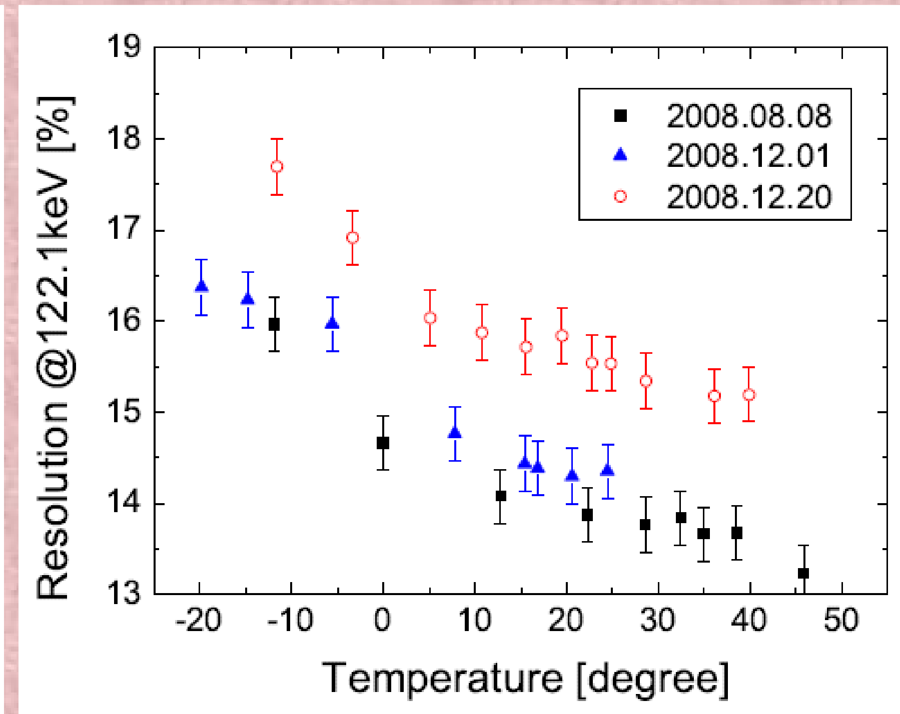






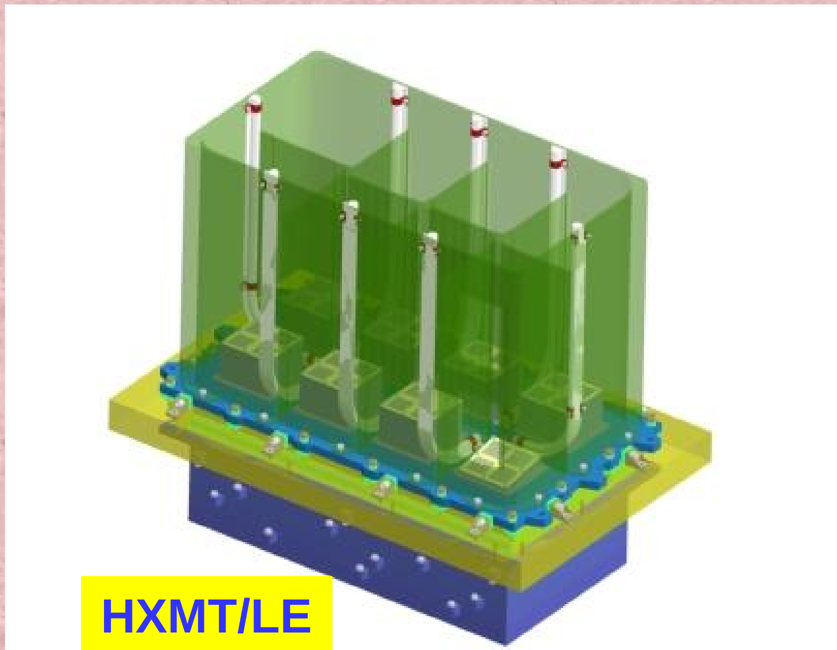
Tests to measure the properties changes with temperature



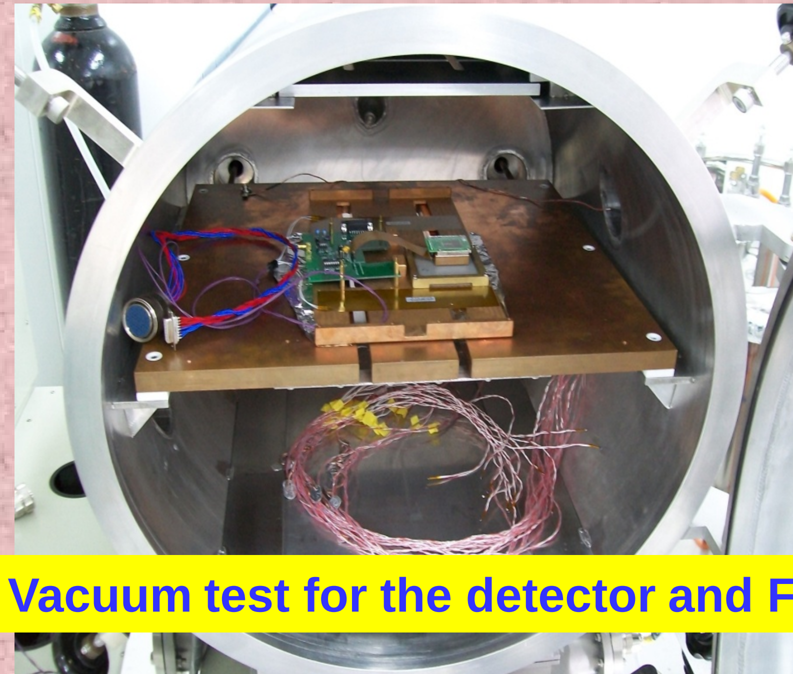


The performance of of the (NaI/CsI + PMT) detectors is also sensitive to temperatures. Onboard HXMT we have active temperature control to keep the scintilator working at 18±1℃, but the temperatures of the PMTs may change by a few degrees.

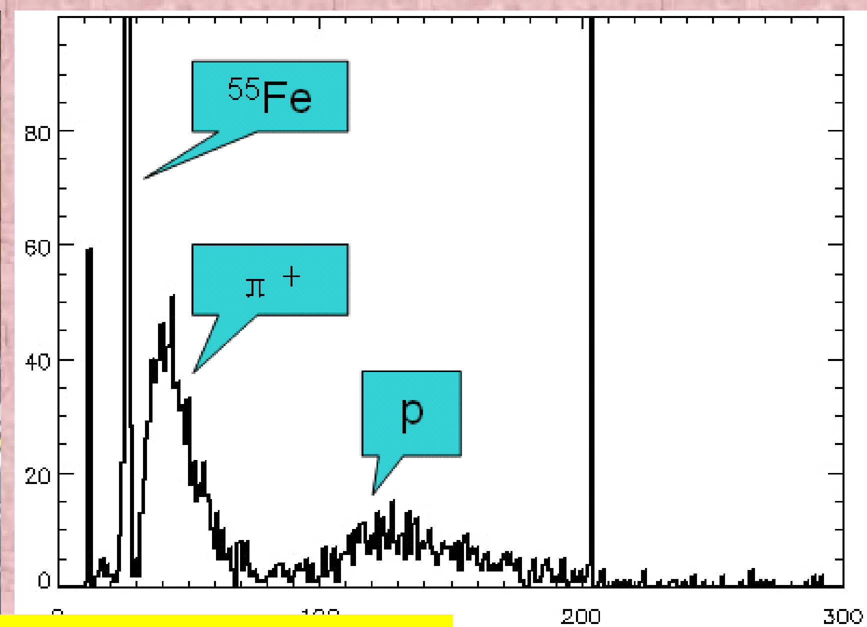
We therefore put an automatic gain control onboard, which works well on ground.



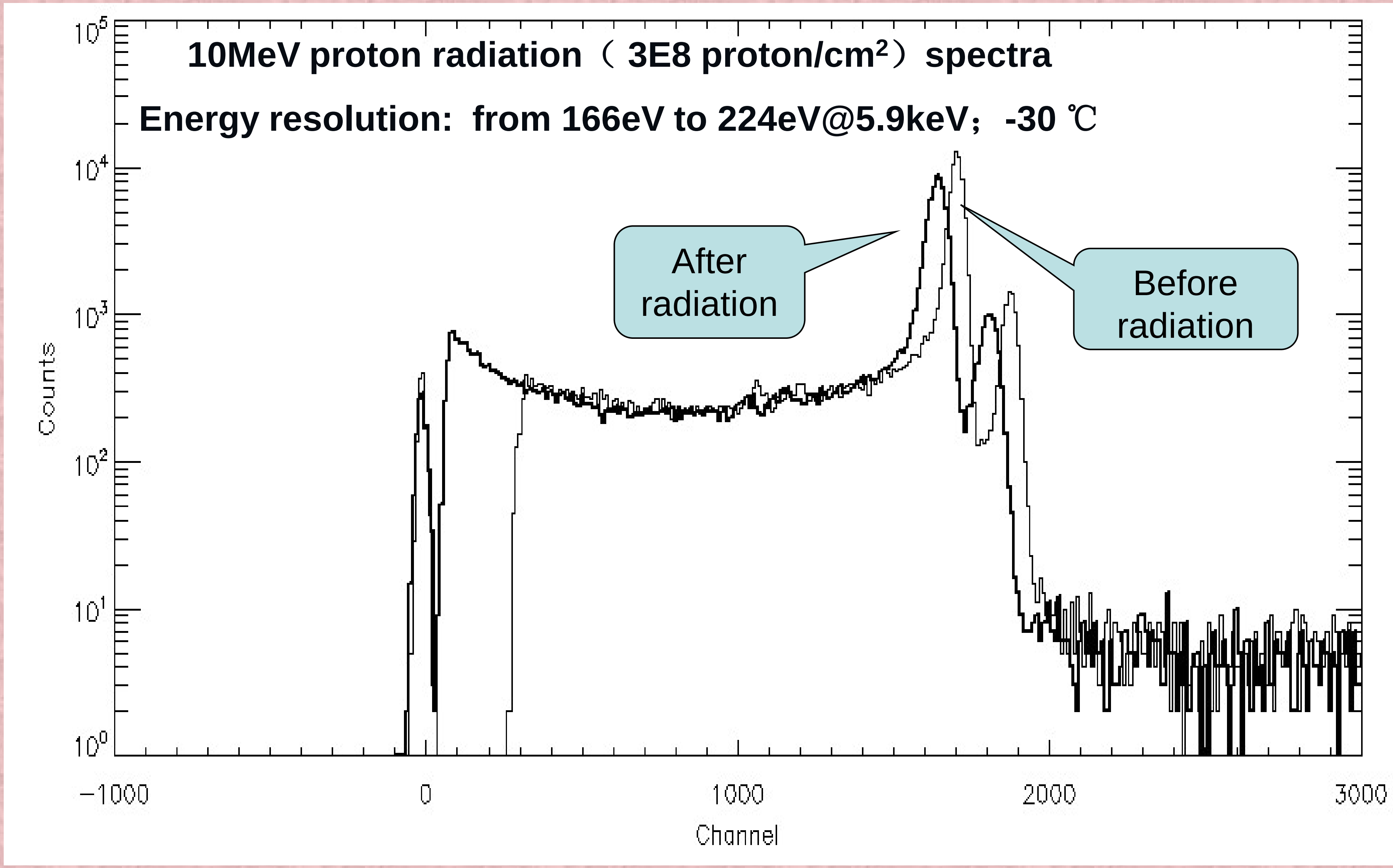
HXMT/LE



Vacuum test for the detector and FEE

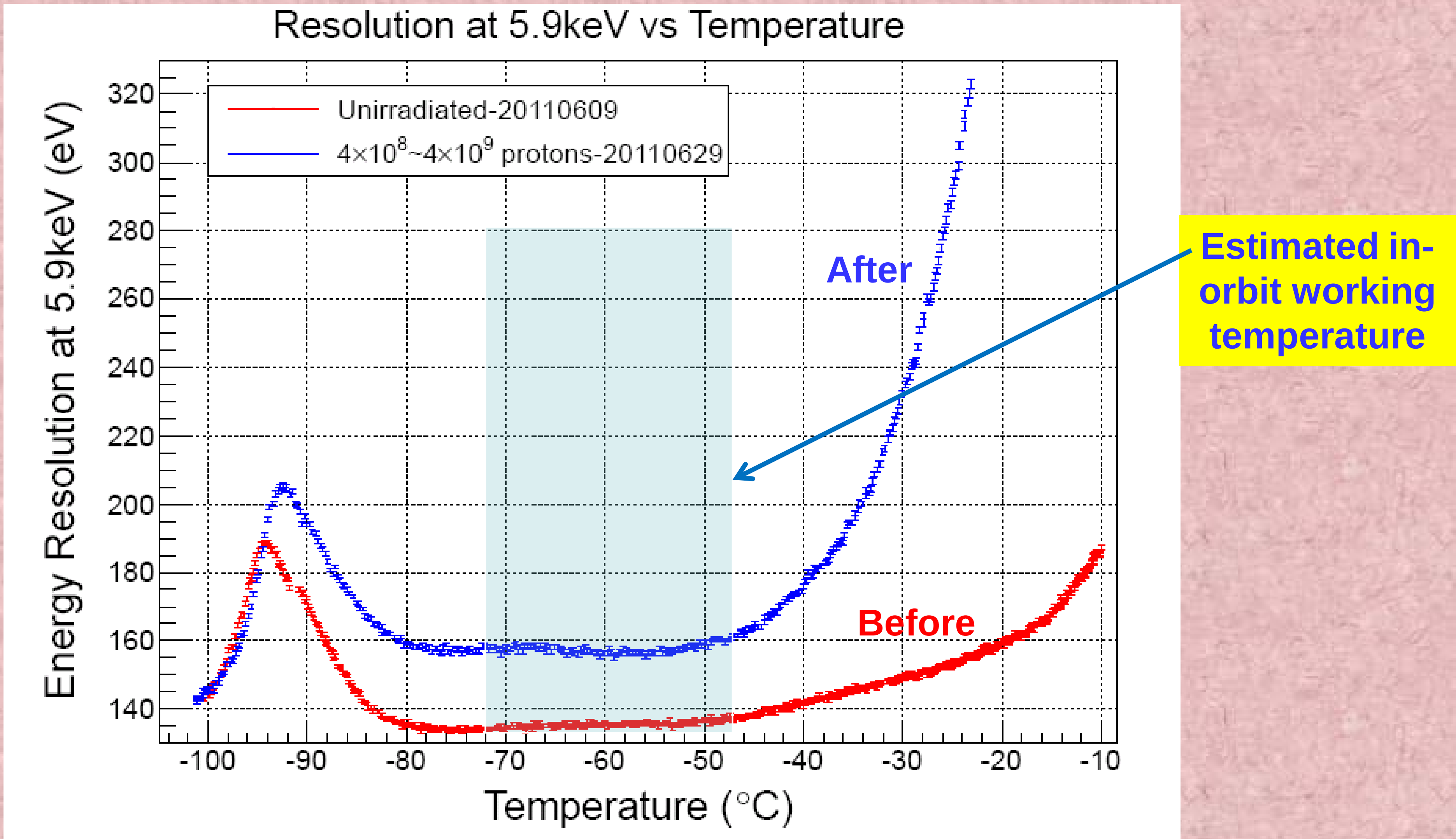


Charged Particle response experiment and results

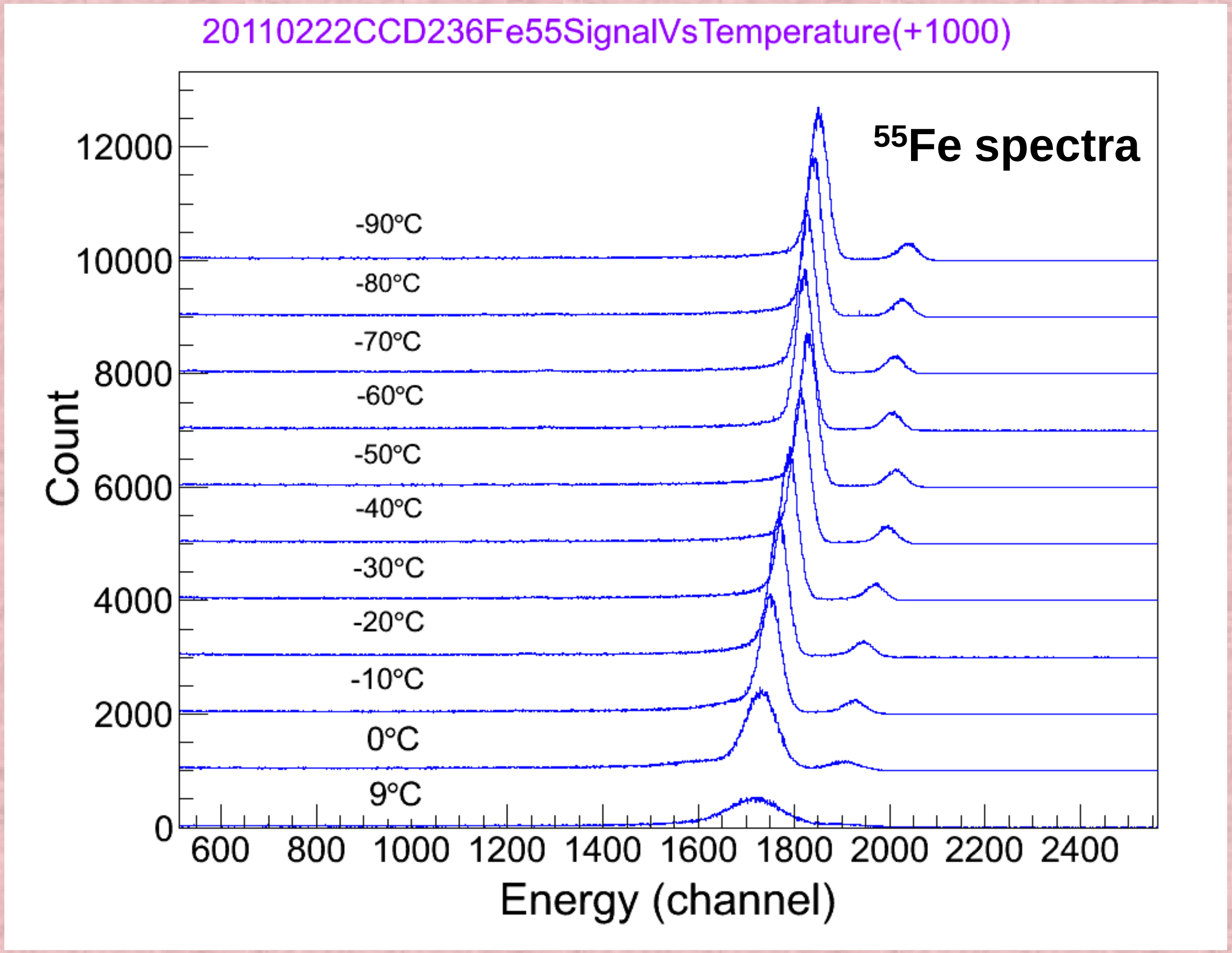


Performed on the 6MV EN tandem accelerator in Peking University

Proton radiation degradation



The energy resolution is acceptable after several years of operation in space.



LE has a temperature drift of about 0.1%/degree. ME once had a temperature drift of 2%/degree, and was lowered to 0.2%/degree.

Does the temperature drift vary in orbit compared to the ground calibration? Any change after radiation damage?

Summary

- HXMT is now in late Phase B and will enter Phase C in the end of August.
- We are building ground calibration facilities and the real ground calibration will begin in early September.
- Many thanks to our international colleagues for your great help.
- Open questions:
  - In orbit background estimates: for the NaI/CsI, Si-PIN, and SCDs, with available informations of different FOVs, particle flux and direction from the veto, particle spectrum and direction from a space environment monitor, signals from the detectors and so on.
  - Effect of the fluorecent lines and radiactive lines on the spectrum.
  - Monitoring of the detector degradation in space.
  - Others

Welcome to China

Hongkong

Beijing

Shanghai

Lijiang

Guilin

Zhangjiajie

2015?