HXMT/ME development and calibration status

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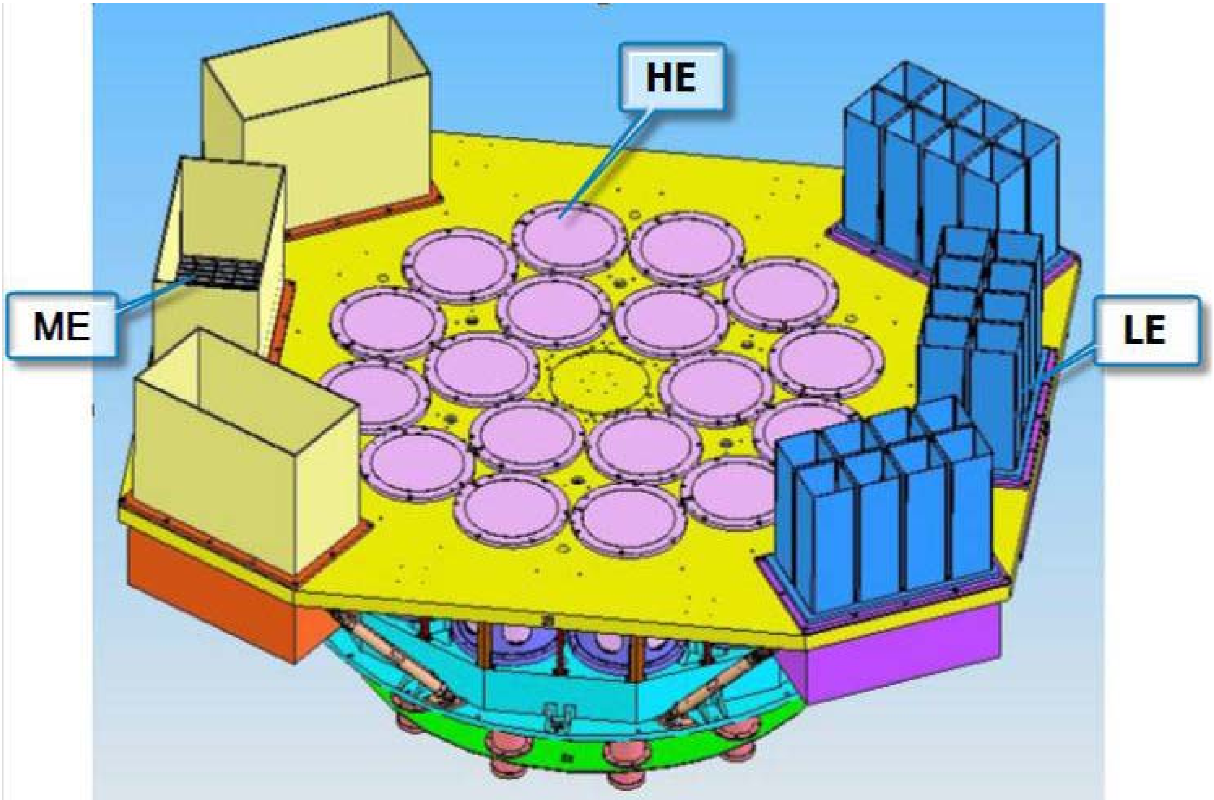
Outline

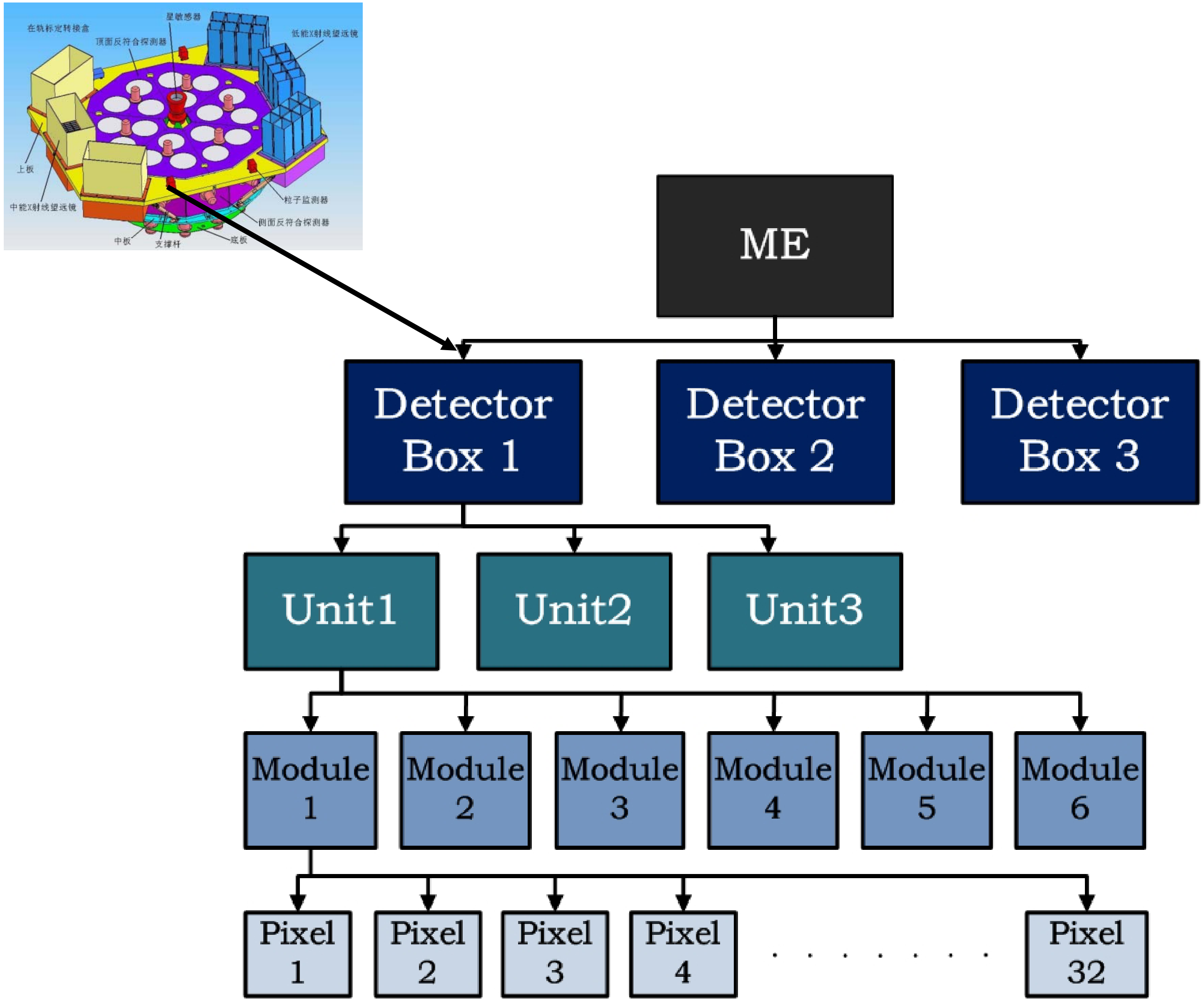
- ➢ **Introduction to the ME Telescope**
  - ✓ **Architecture**
  - ✓ **Characteristics**
  - ✓ **Detector**
  - ✓ **Collimator**
  - ✓ **Electronics**
- ➢ **Calibration status**
  - **Arrangement for the calibration**
  - **Calibration Experiments**
  - **Experiment procedure**
  - **In-flight calibration**

ME Telescope Si-PIN ~950cm^2

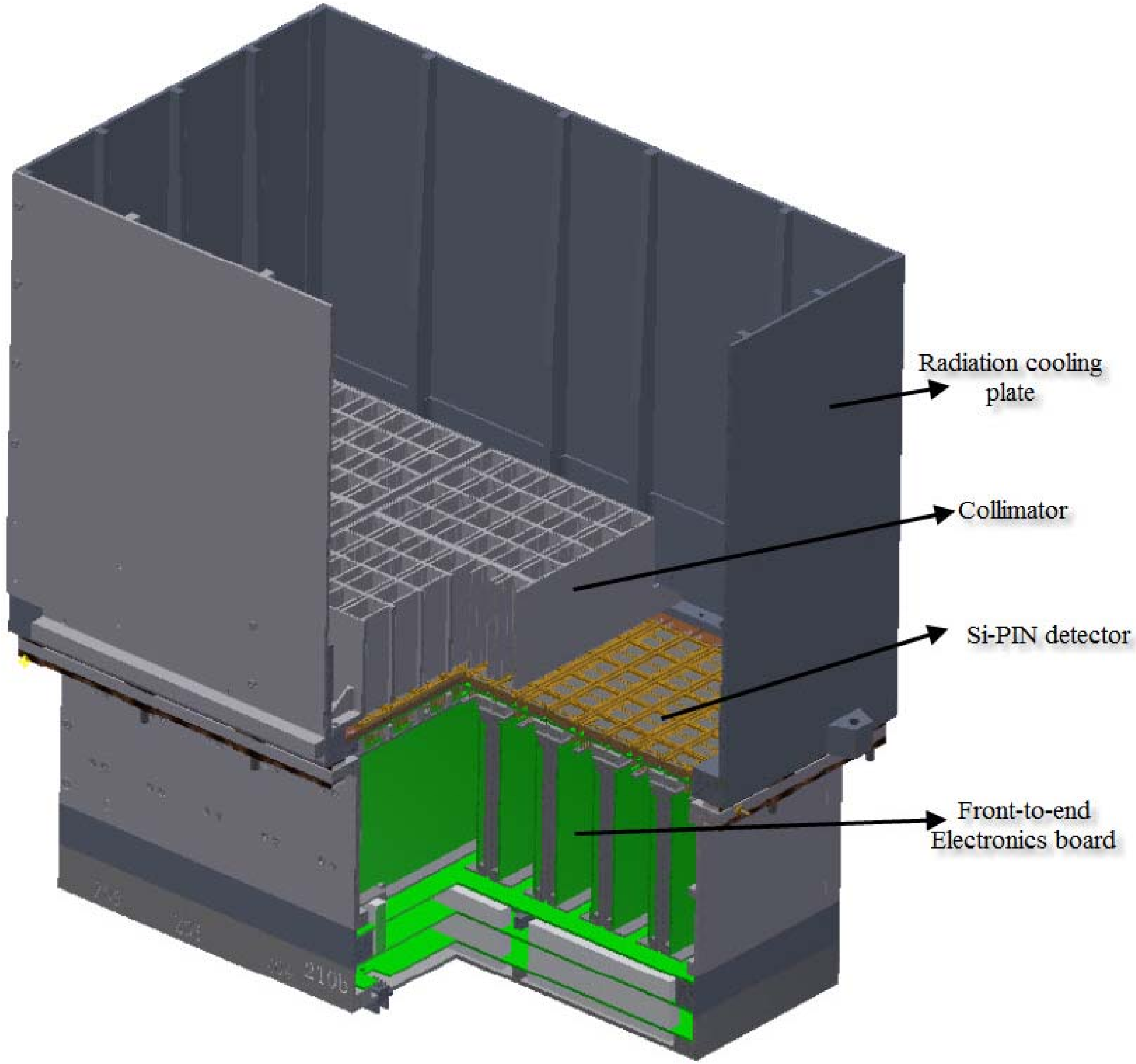


The Main Payload of Hard X-ray Module Telescope (HXMT)

ME: 5-30 keV sky survey and pointed observations, 950 cm^2 ,Si-PIN, 1728 channel

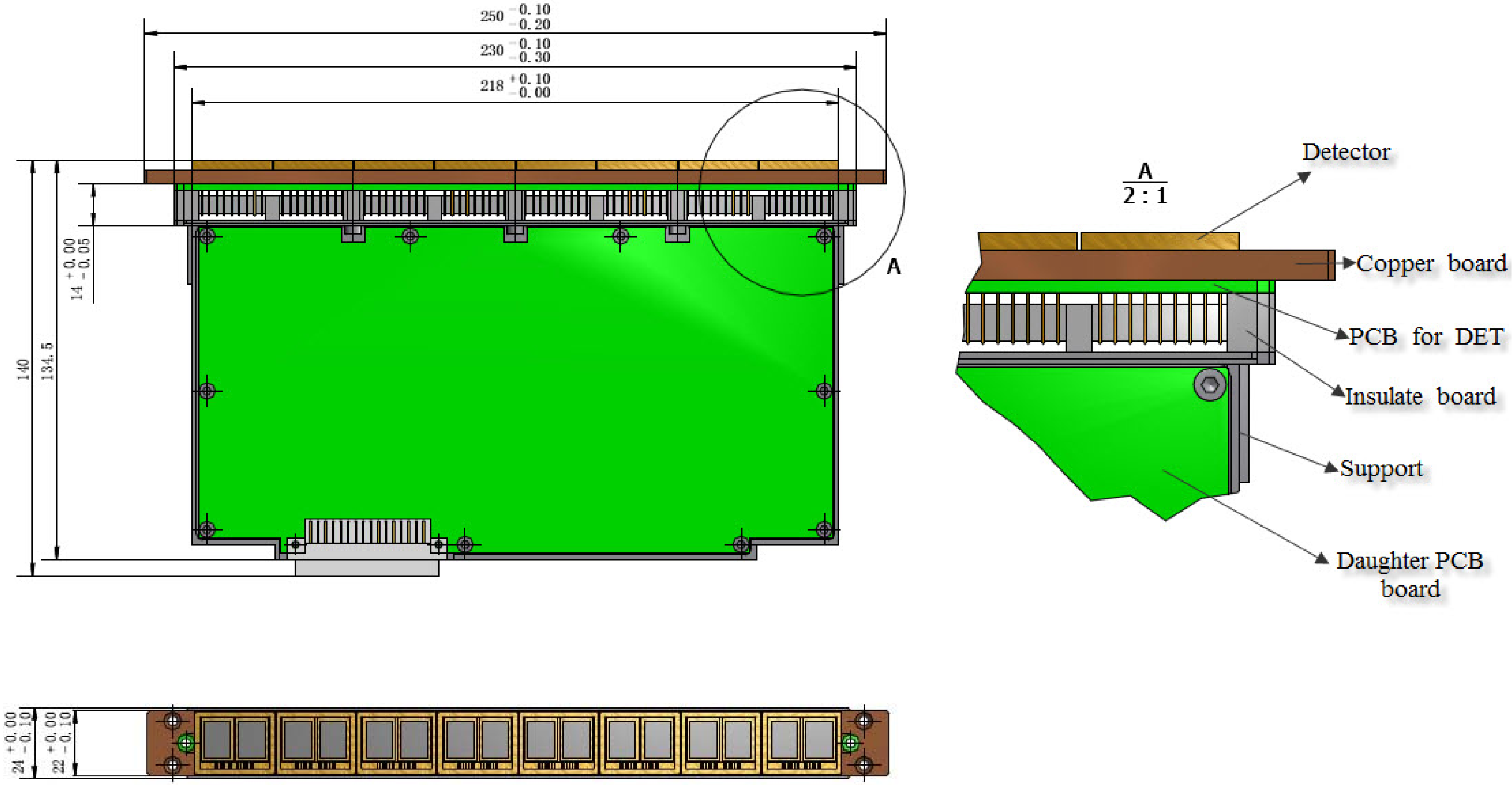


Architecture of HXMT/ME



One detector Box:

3 units, 18 modules

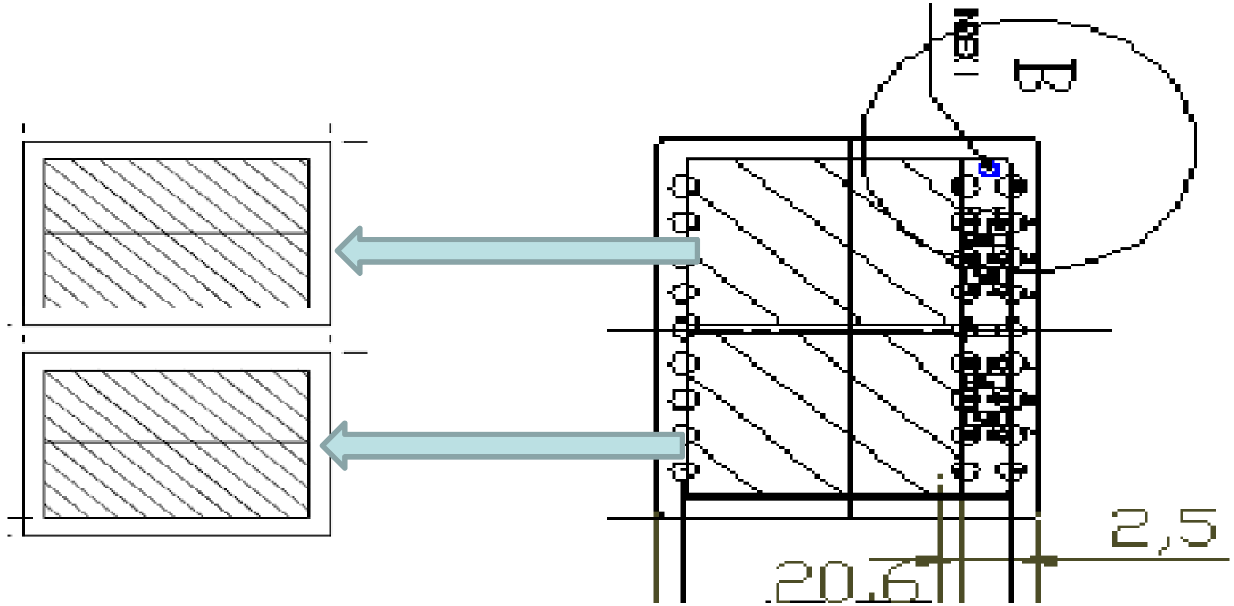

250 −0.10 −0.20
230 −0.10 −0.30
218 +0.10 −0.00
140
134.5
14 +0.00 −0.05
A
A
2 : 1
Detector
Copper board
PCB for DET
Insulate board
Support
Daughter PCB board
24 +0.00 −0.10
22 +0.00 −0.10

One module

Characteristics

Detector:	Si-PIN
Energy coverage:	5-30 keV
Detection area:	~950 cm^2 (1728 pixels)
Field of view:	1° ×4° ,4 ° ×4° , blind field
Energy resolution:	FWHM ~2 keV@20keV
Work temperature:	-10~-55℃ for Si-PIN
Time resolution:	180 μs
Mass:	120kg
Power dissipation:	~135 W

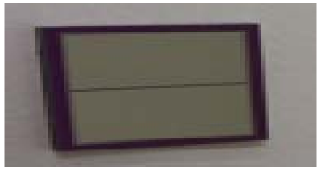
Si-PIN Detector



pixel detector **4 pixel Si-PIN detector**

Si-PIN Detector

1



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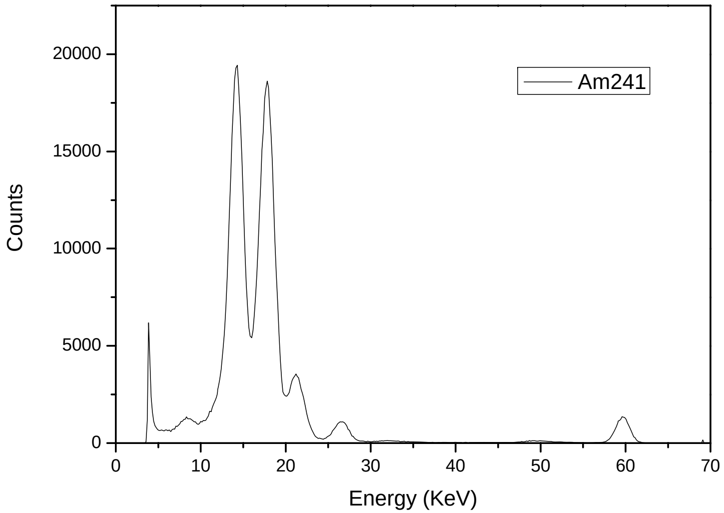


4

Fig.1 the 2-pixel Si-PIN detectors

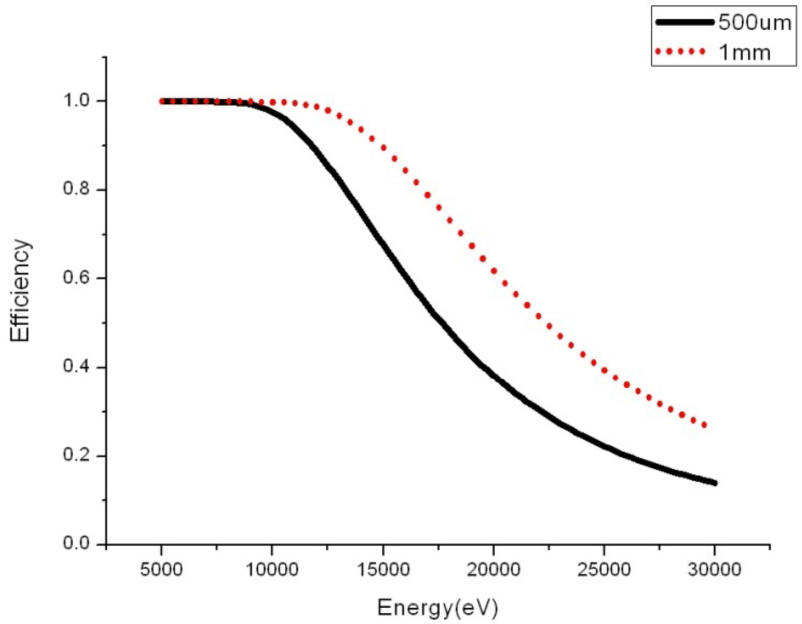
Fig.2 the ceramic package

Fig.3 the 4-pixel in one ceramic package

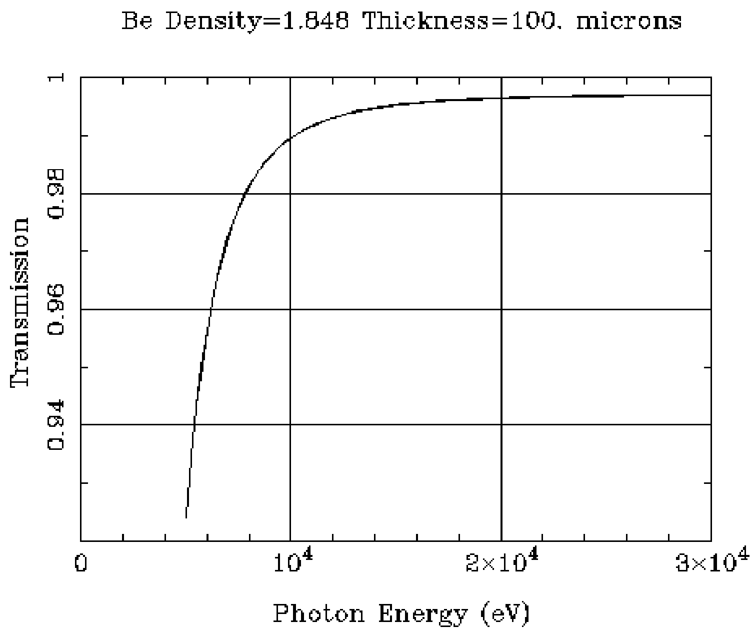
Fig.4 Coupled with the ASIC, the Am-241 spectrum by the 4-pixels detectors in -30℃. Energy resolution FWHM 1.8keV@59.5keV.

Detector Characteristics

- **Pixel Size:** **4.1mm*13.8mm**
- **Thickness:** **1mm**
- **Leakage current:** **~1nA@20 ℃**
- **Number of pixels:** **1728**
- **Entrance Window:** **100µm Beryllium**

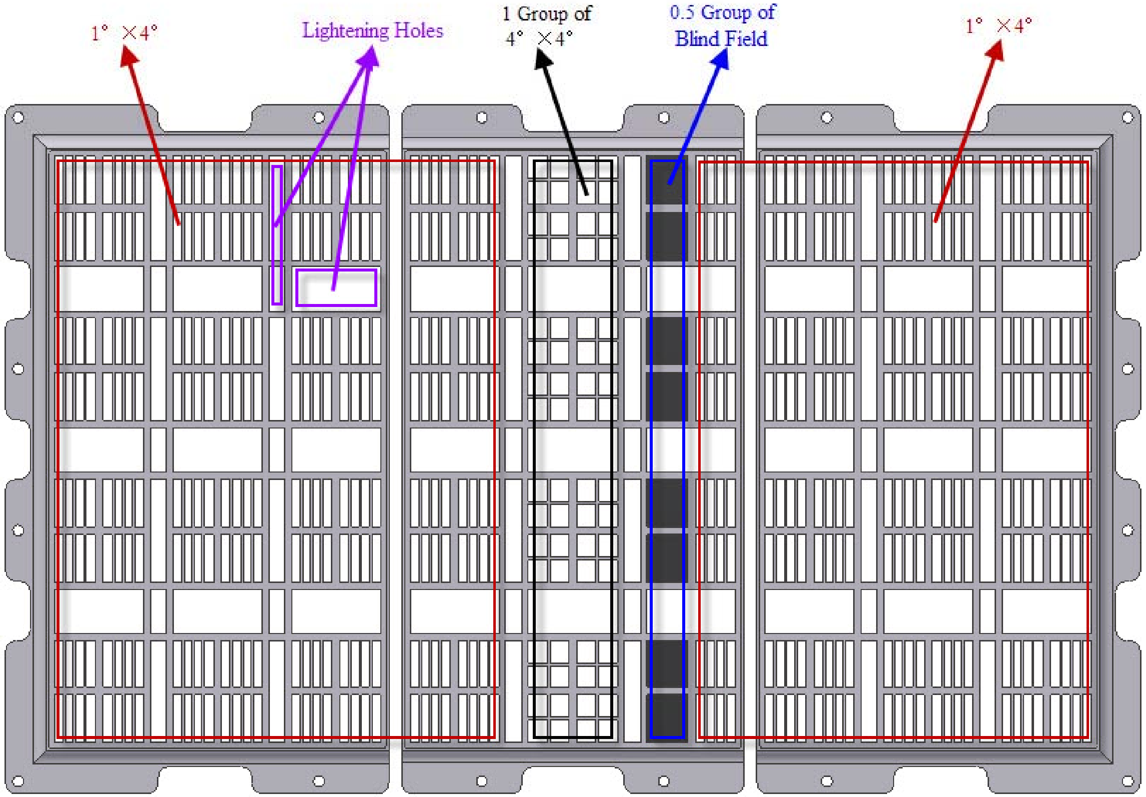


Simulated efficiency curve of Si-PIN detector with the thickness of 500μm (black curve) and 1mm (red dot) respectively



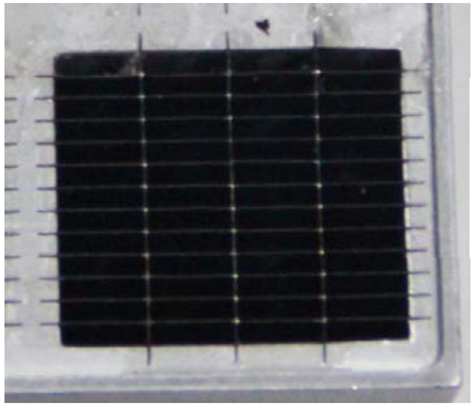
Transmission of 100 μ m Beryllium window

Collimator



Field of view arrangement

three types of FOVs, 1° x 4°, 4° x 4°, and the blind field.



A prototype collimator

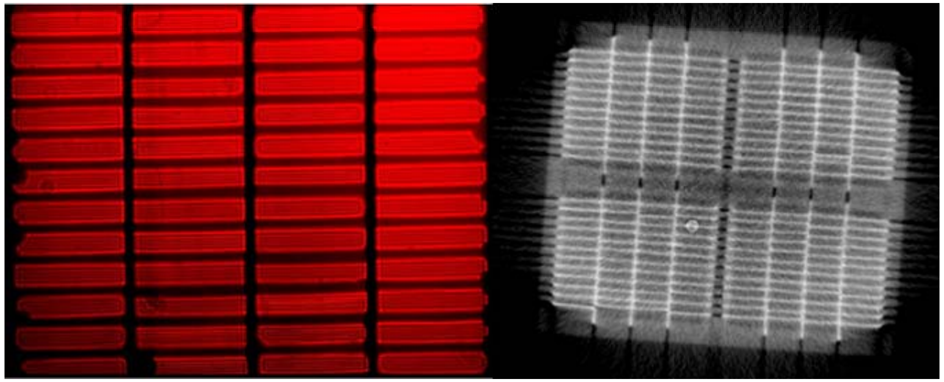


Image by a CCD

The FOVs are defined by the 50 um thickness Ta plates, the fraction of the detection area is high than 90%.

Electronics

ME electronics consist three parts：

data acquisition subsystem (DAQS)

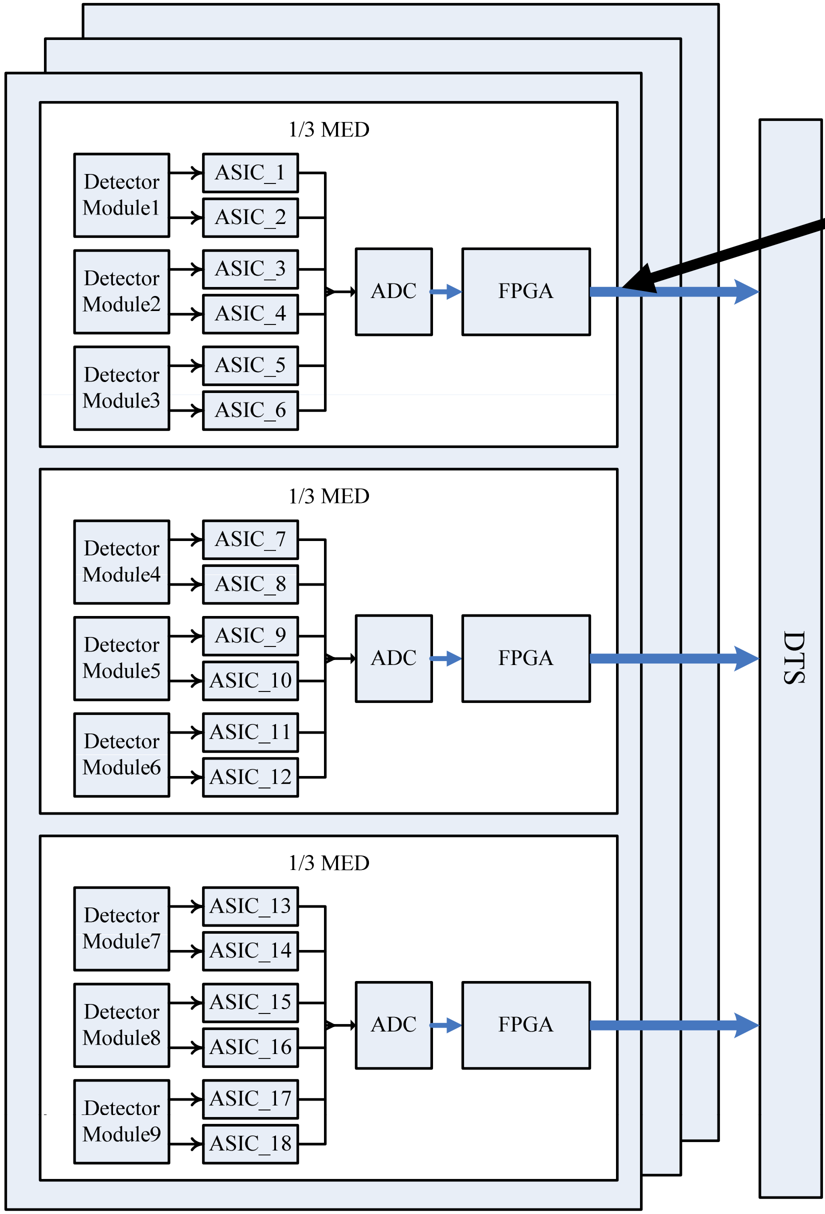
- The DAQS with the function of preamplifier, shaper, and digitizer.
- 36-channel ASIC (RENA-3) is used as the readout
- FPGA as an ASIC controller and data FIFO.

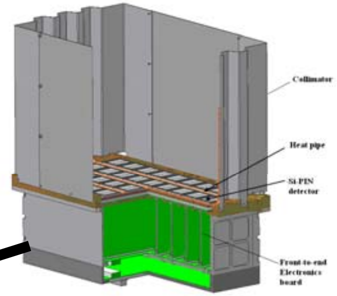
data transmission subsystem (DTS)

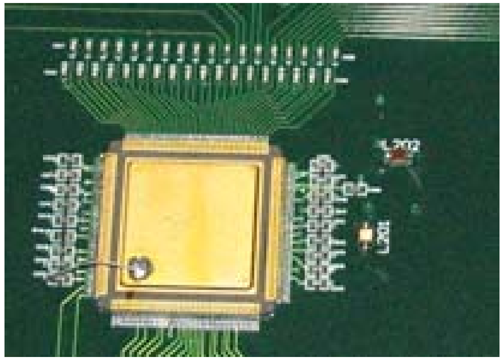
- The DTS transfers commands from the platform to the DAQS, buffers;
- Transfer scientific data and engineering parameters from DAQS to the platform.

power distribution subsystem (PDS)

Data Acquisition subsystem







- Function: Preamplifier， pole-zero cancel， differential amplifier， shaper， peak detector， and trigger circuit.
- Power consumption: 1mW.
- Input referred noise： 39 e rms

Data transmission subsystem (DTS)

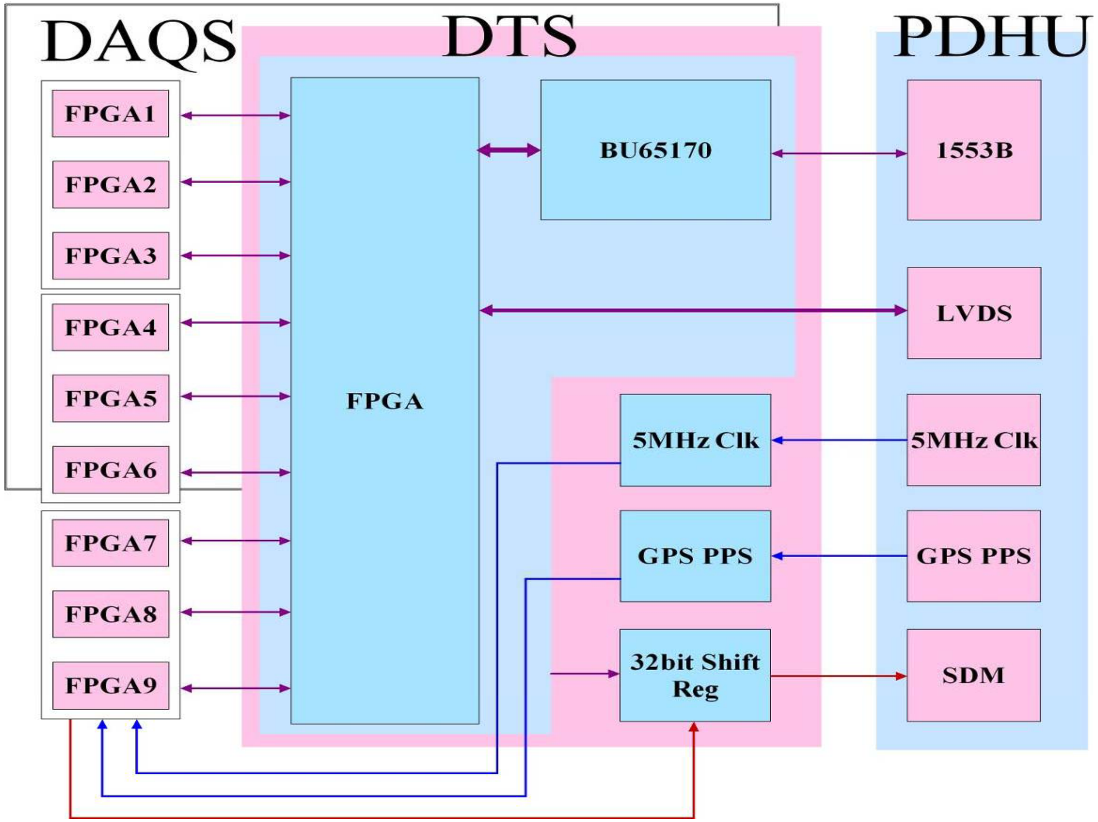
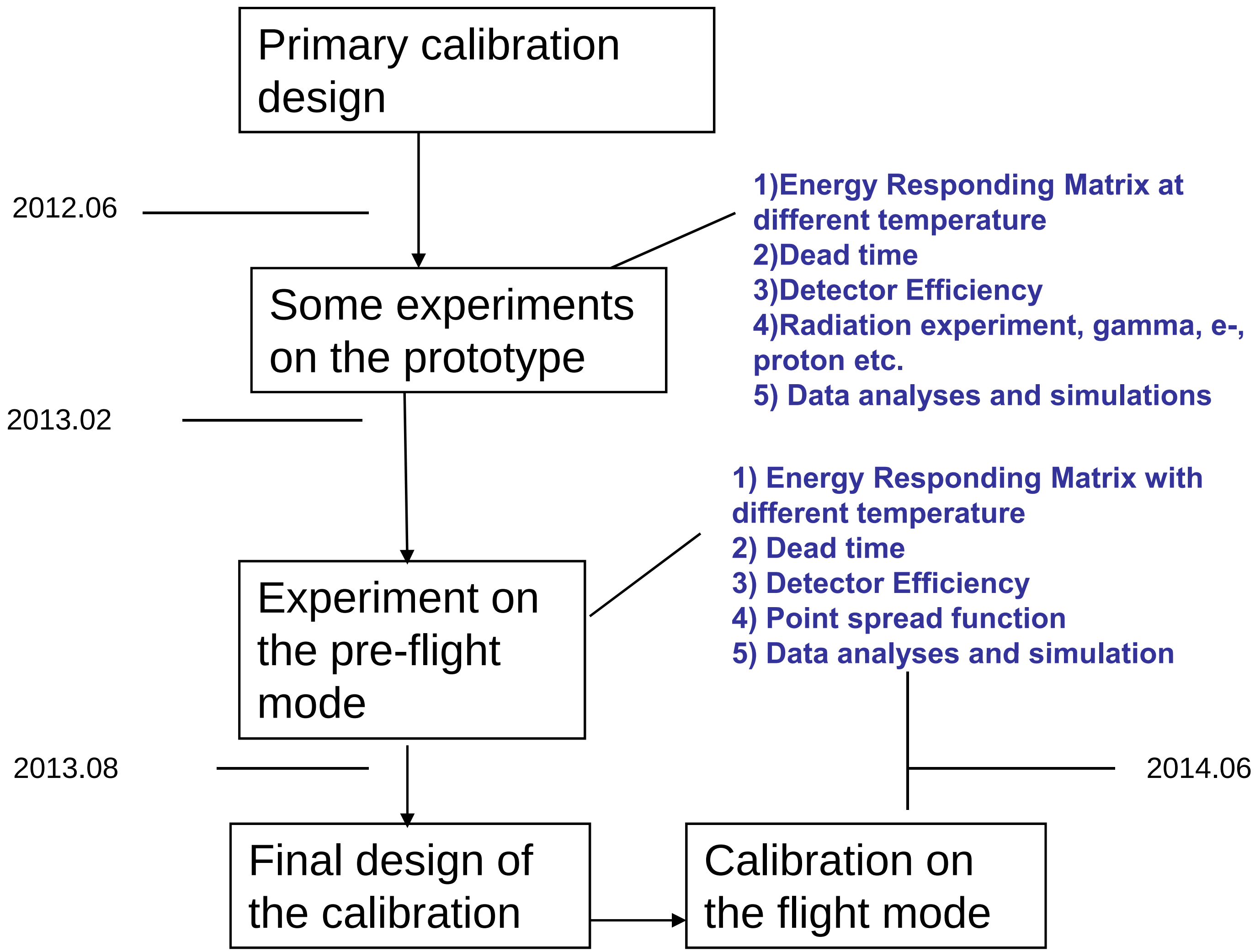


Fig. The block diagram of one TDS part

Function: to receive/send command and to transfer data.
Command transfer: 1553B;
Scientific data transfer: LVDS

Calibration status

- Arrangement for the calibration
- Calibration experiments
- Experiment procedure
- In-flight calibration


Primary calibration design
2012.06
1)Energy Responding Matrix at different temperature
2)Dead time
3)Detector Efficiency
4)Radiation experiment, gamma, e-, proton etc.
5) Data analyses and simulations
Some experiments on the prototype
2013.02
1) Energy Responding Matrix with different temperature
2) Dead time
3) Detector Efficiency
4) Point spread function
5) Data analyses and simulation
Experiment on the pre-flight mode
2013.08
2014.06
Final design of the calibration
Calibration on the flight mode

Calibration Experiments

- **Energy response calibration (@ different temperatures)**

  energy-channel relationship
  energy resolution characteristics
  energy redistribution matrix function
- **Effective area**
- **Point spread function**
- **Dead time**
- **Response to the high energy particles and the radiation damage**

  e-, gamma, proton, etc.
  the response in the Si-PIN
  the change of the energy resolution and the energy-channel relationship

Experiment procedure

Energy response calibration

List	Item	experimental procedure
Require-ments to the facility	X ray source	Fe-55、Am-241、I-125, Co-57, Cd-109, X ray tube+monochromator, Synchrotron Radiation
	pressure	~5×10^{-3}Pa
	Temperature control	-55℃～20℃ (For the detectors)
	Cleanliness	10000
	Platform	2-D moving
	Notice	To keep the temperature of electronics in -40℃ ~+25 ℃, while the detectors in -55℃～-10℃

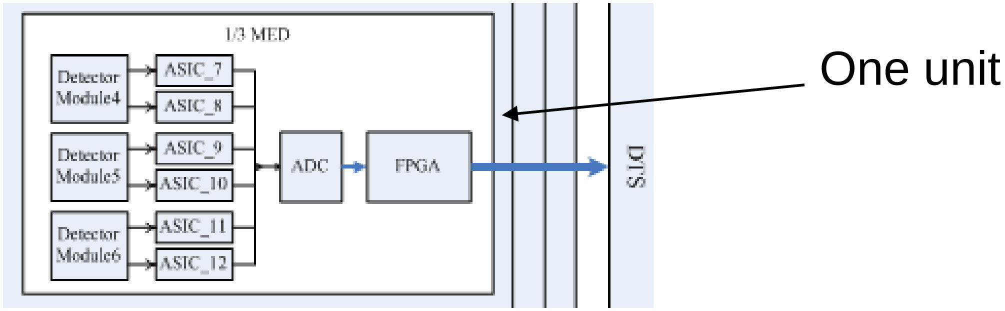
Energy response calibration

Test points	energy points	4.9keV（V-Kα）、5.9keV（Mn-Kα、Fe-55）、6.4 keV（Fe-Kα、Fe-55）、6.9 keV（Co-Kα）、8.0 keV（Cu-Kα）、13.9keV（Am-241）、14.4keV (Co-57)、17.8 keV（Am-241）、24.9 keV（Cd-109）、26.3 keV（Am-241）、35.5 keV（I-125）、 59.5 keV(Am-241)
	temperature points (℃)	-55、-50、-40、-35、-30、-25、-20、-15、-10、0、20
Statistics	event	>20000
Time		4 months
Simulation	Geant 4	Basing on the data from the experiments, we can get the energy response matrix by simulation.

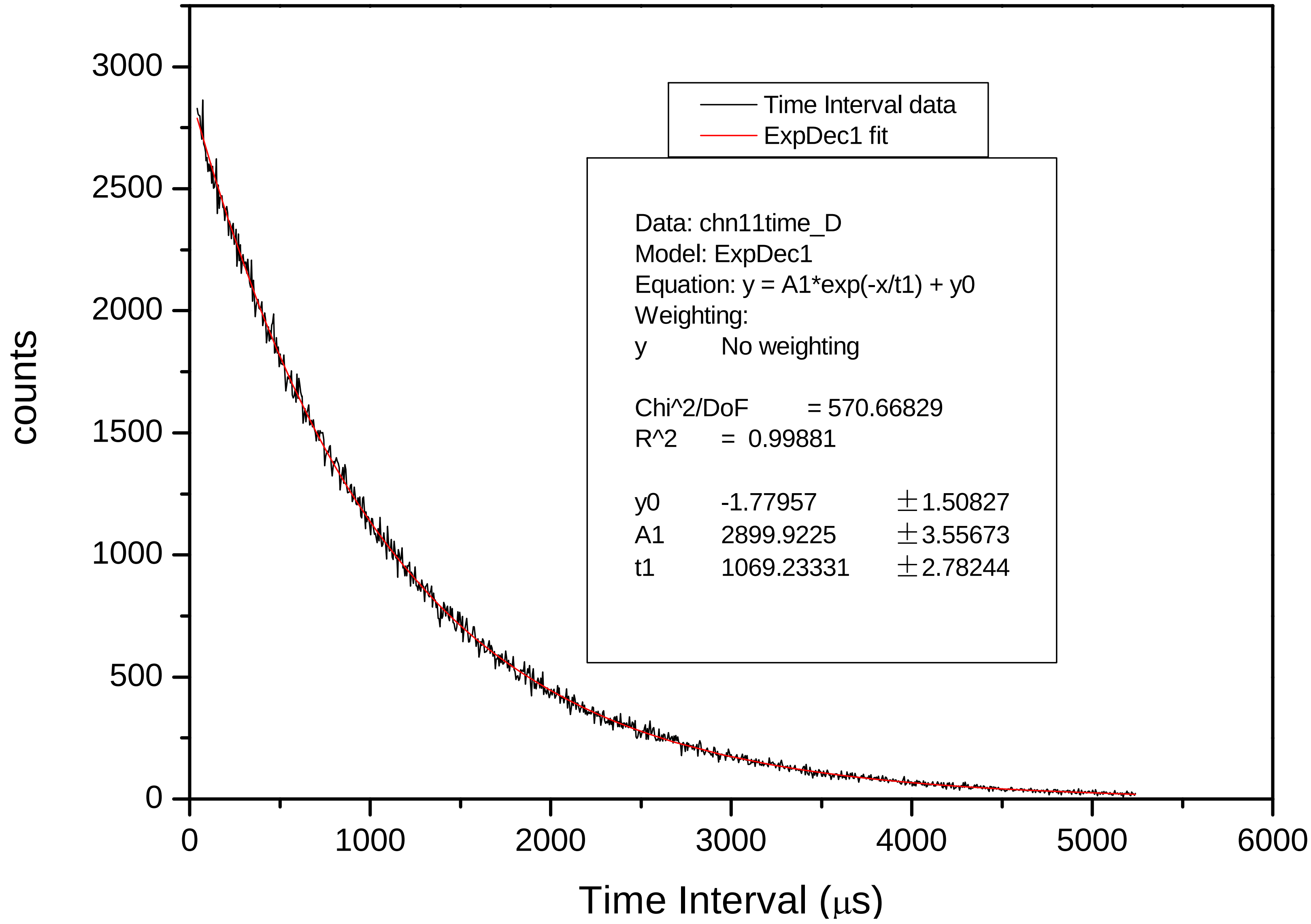
Effective area calibration

List	Item	experimental procedure
Condition	X ray source	Fe-55、Am-241、X ray tube + monochromator Synchrotron Radiation + monochromator
	pressure	>5×10^{-3}Pa
	temperature	-20℃
	cleanliness	10000
	notice	The distance between the X ray source and detector need to be measured precisely.
Time		2 weeks
Statistics	event	>20000
Simulation	Geant4	Relatively effective area by simulation

Dead time



List	Item	experimental procedure
Condition	X ray source	Am-241
	temperature	20℃
	air cleanliness	10000
	others	the X ray source can cover the 1/3 detector box (one unit) at least
Time		2 days
Experiment content		Measure the arrival time intervals between two neibouring events, then plot the time interval distribution, and find the cutoff point of the curve, which represents the dead time.
statistics	event	200000



The arrival time interval curve of the ME prototype

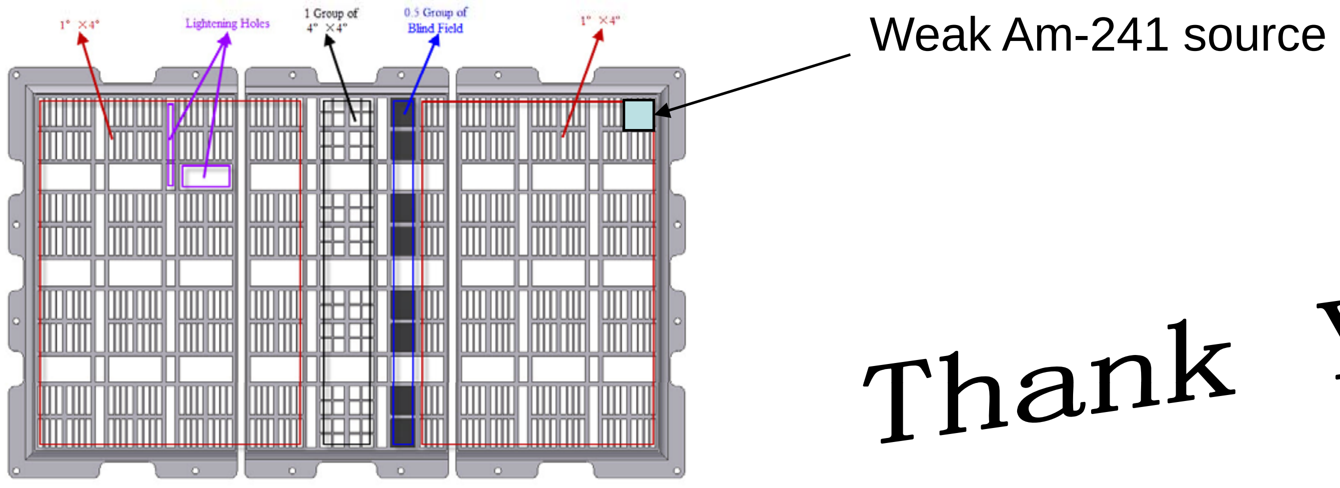
The particle radiation calibration

- **Particle type: e-, proton, gamma, neutron, etc.**
- **Measure the response of the detector to the particles.**

  and the irradiation damage of the Si-PIN detectors.
- **this experiment should be done only on the calibration-unit**
- **problem: The experiment is restricted by the particle lines.**

In-flight calibration

- **3 weak Am-241 source will be equipped in the collimator monitoring the performance of some detectors.**
- **For the in-flight PSF verification we can use strong X-ray sources such as the Crab and X-ray binaries.**
- **The energy response matrix could be also corrected by using the observations of Crab.**



Thank You!