Introduction on HXMT Project, Ground Segment, Calibration and Ground Facility

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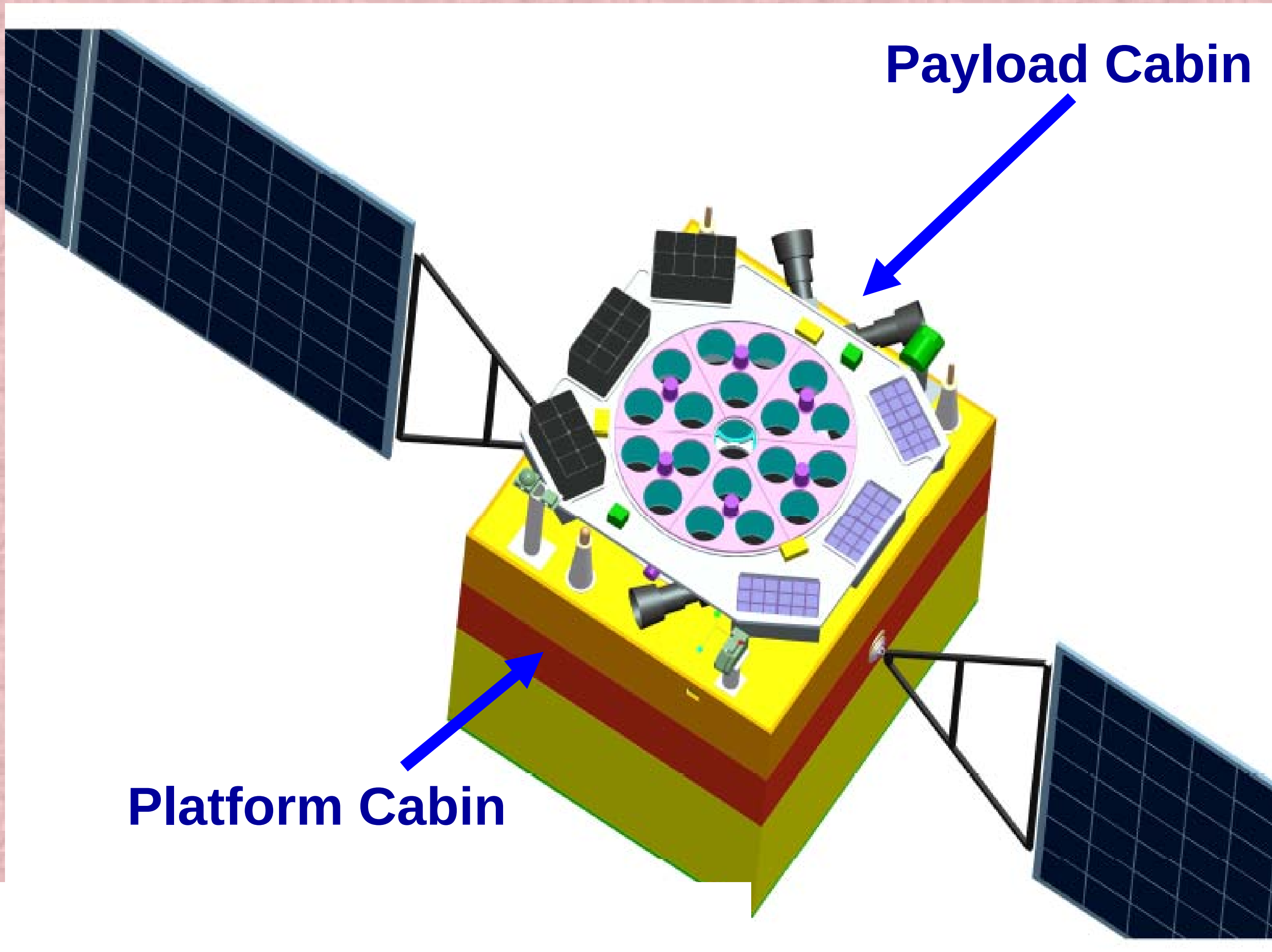
Outline

- Overview on HXMT
- Collaborations with ESA
- HXMT ground segment
- HXMT Calibration

  data flow ; organization

  implementation ; milestones; status
- Ground facility

Overview on HXMT

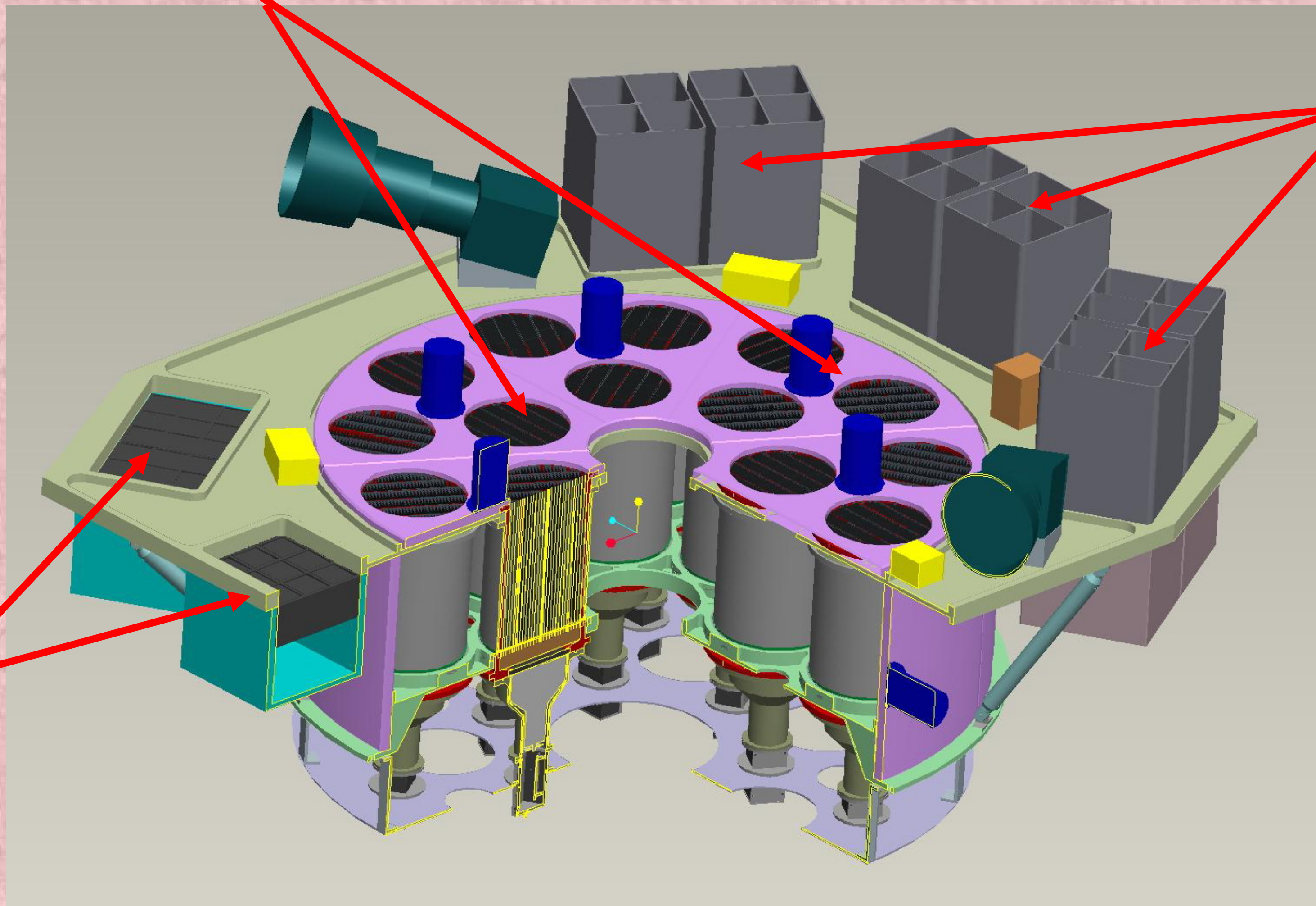


Chinese Academy of Sciences, Tsinghua University
Chinese Academy of Space Technology

HE: NaI/CsI 5000 cm^2

LE:SCD,384 cm^2

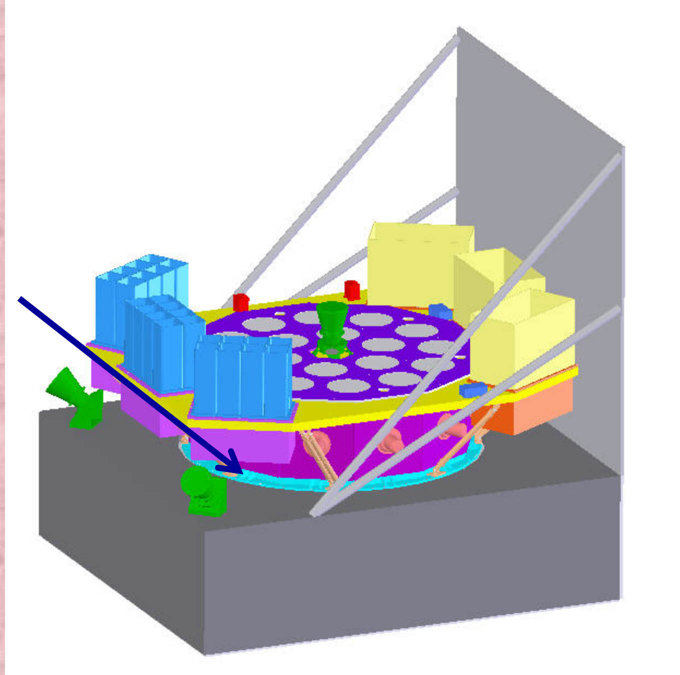
ME:Si-PIN,952 cm^2

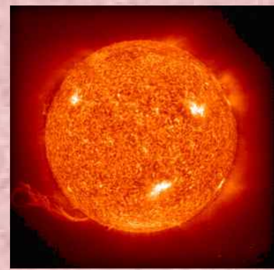


Payloads onboard HXMT

Size： 1900×1600×1000 mm

LE





The Sun

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

Characteristics of the HXMT Mission

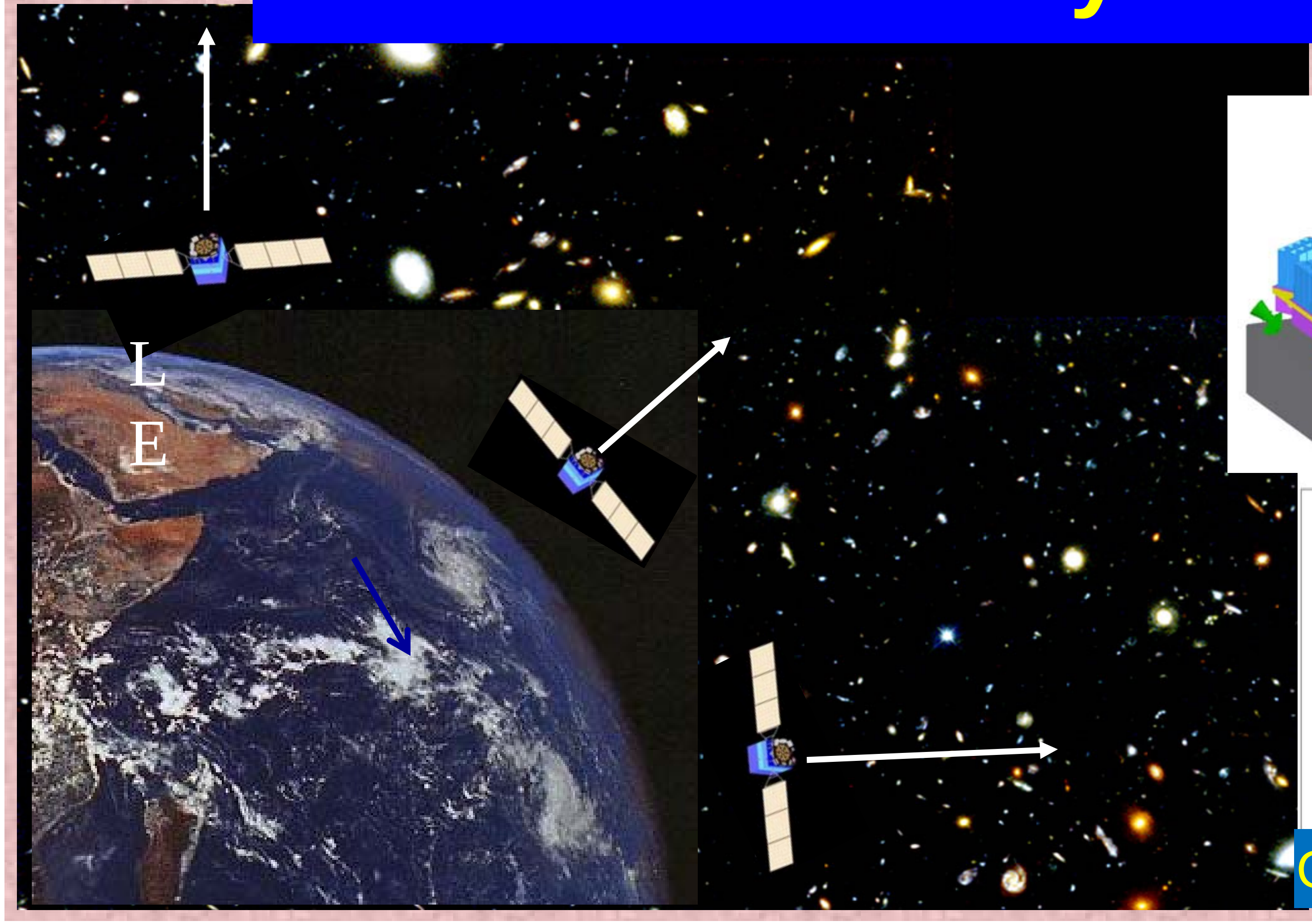
Detectors	LE: SCD, 384 cm^2;ME : Si-PIN, 950 cm^2 HE : NaI/CsI, 5000 cm^2
Energy Range	LE: 1-15 keV;ME: 5-30 keV;HE: 20-250 keV
Time Resolution	HE: 25 μ s; ME: 180 μ s;LE: 1ms
Energy Resolution	LE: 2.5% @ 6 keV ME: 8% @ 17.8 keV HE: 19% @ 60 keV
Field of View of one module	LE: 6° ×1.6° ; 6° ×4° ; 60° ×3° ; blind; ME: 4° ×1° ; 4° ×4° ; blind; HE: 5.7° ×1.1° ; 5.7° ×5.7° ； blind
Source Location	<1' (20 σ source)

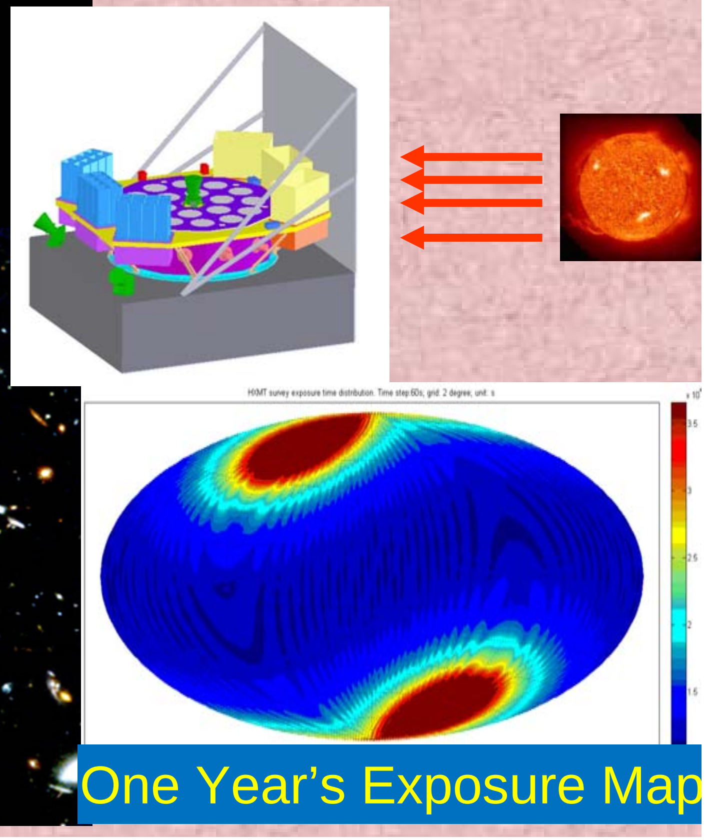
Orbit	Altitude: ~550 km ; Inclination: ~43°
Attitude	Three-axis stabilized Control precision: ±0.1° Measurement accuracy: ±0.01°
Data Rate	LE: 3 Mbps; ME: 3 Mbps; HE: 300 kbps
Payload Mass	~1000 kg
Nominal Lifetime	4 years
Working Mode	Scan survey, pointed observation

Observation modes

- All-sky Survey mode
- Deep imaging observation of selected sky regions (such as the Galactic center region)
- Pointed observations

HXMT in all-sky survey





During this phase, the satellite attitude is in the three-axis stabilized state with the telescopes pointed in the plane perpendicular to the Sun. The common optical axis of the telescopes scans a great circle of constant ecliptic longitude in one orbital period. (Similar to ROSAT all-sky survey)

Main advantages and key sciences of HXMT

Hard X-ray sky survey with highest sensitivity

- High precision hard X-ray full sky map: diffuse background and cosmic variance
- Discover highly obscured supermassive BHs: galaxy formation and evolution
- Discover new types of high energy objects: usual surprises of new surveys

High precision pointed observations of high energy objects

- Space-time in strong gravitational field: dynamics and radiation near BH horizons of stellar mass and supermassive BHs
- Equation of state in strong magnetic field: neutron star and its surface properties
- High energy particle acceleration: AGN, SNR, shock and relativistic jets
- Large scale structure: through hard X-ray detection of galaxy clusters

Status on the overall project

- Officially approved by CNSA in March 2011
- Entered Phase-B in the end of 2011

Milestones

Phase-B (qualification module):	finishing at the end of 2012
Phase-C (flight module):	from 2013 until mid 2014
Launch:	late 2014 to early 2015

Schedule of HXMT

Operation plan:

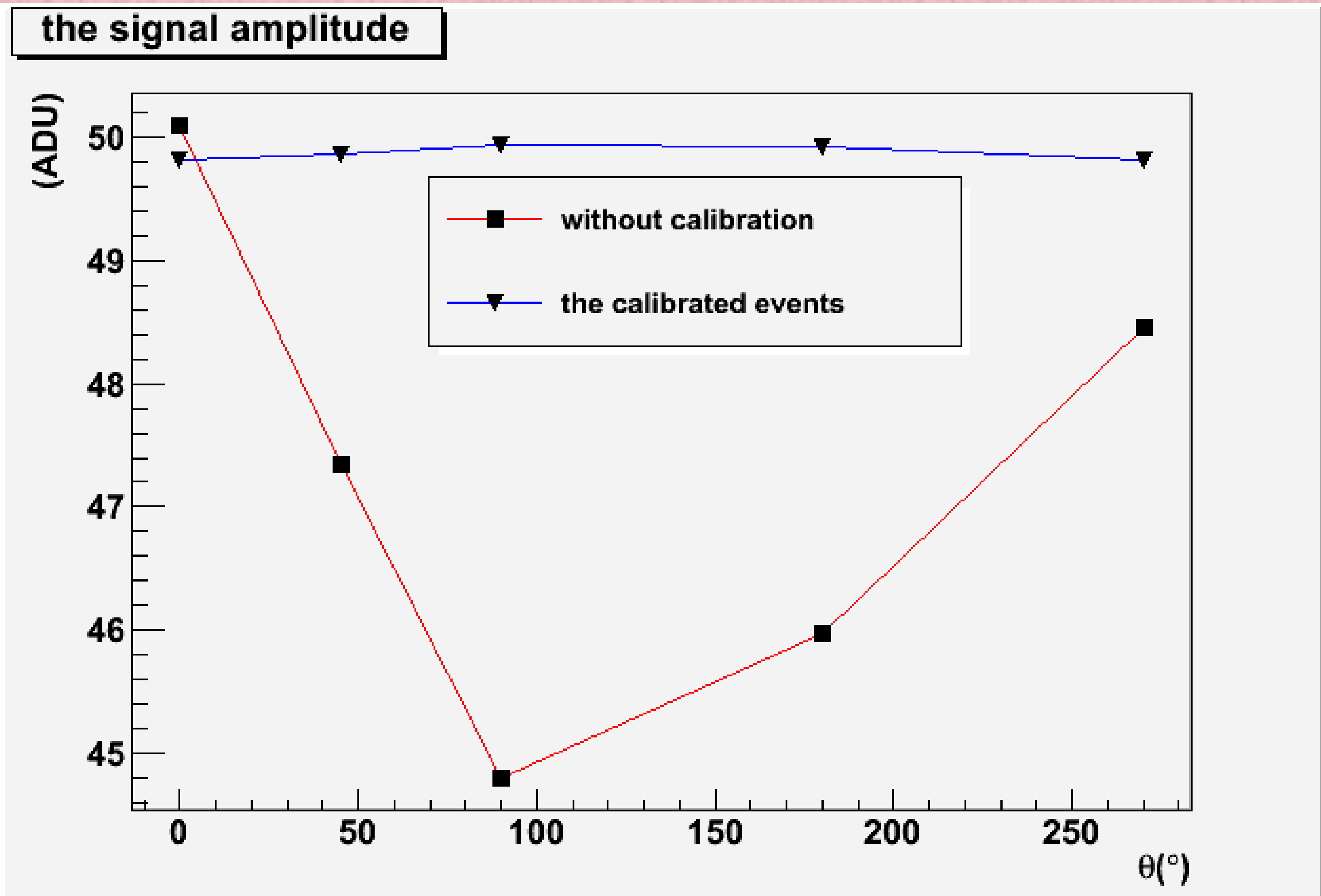
- Year I: All-sky survey (No AO time)
- Year II: Pointed Observations and small region imaging.
- Year III: Pointed Observations and imaging
- Year IV: Pointed Observations
- ⩾Year V: Pointed Observations

Status on the overall project

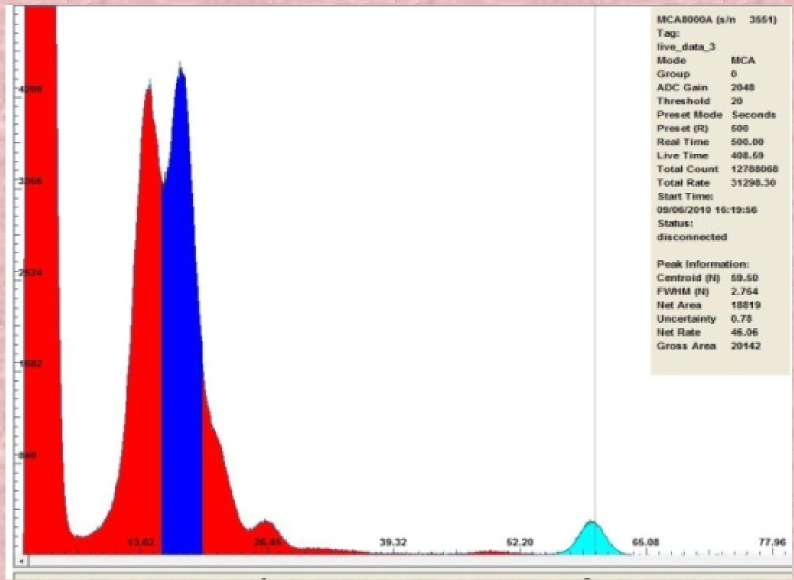
HXMT mission will be dominated :

By building the hardware (in Phases B and C) :

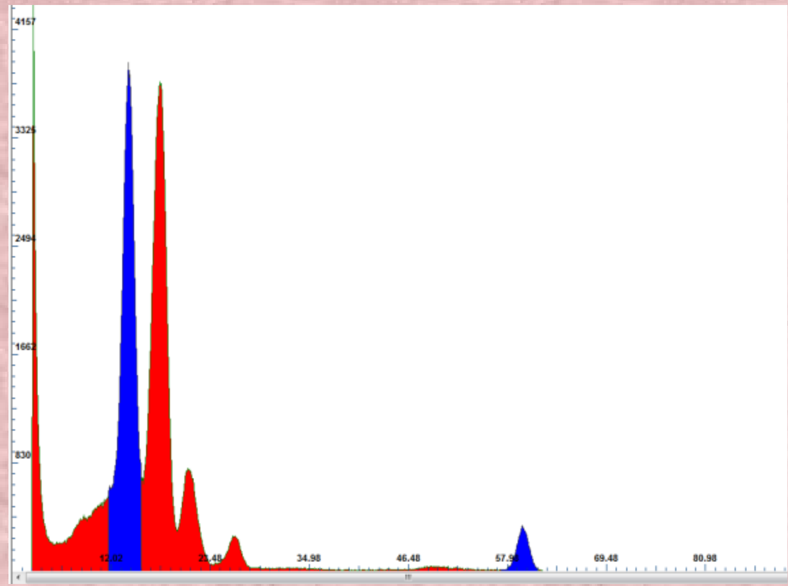
By ground segment after launch :



The automatic gain control of HE works very well

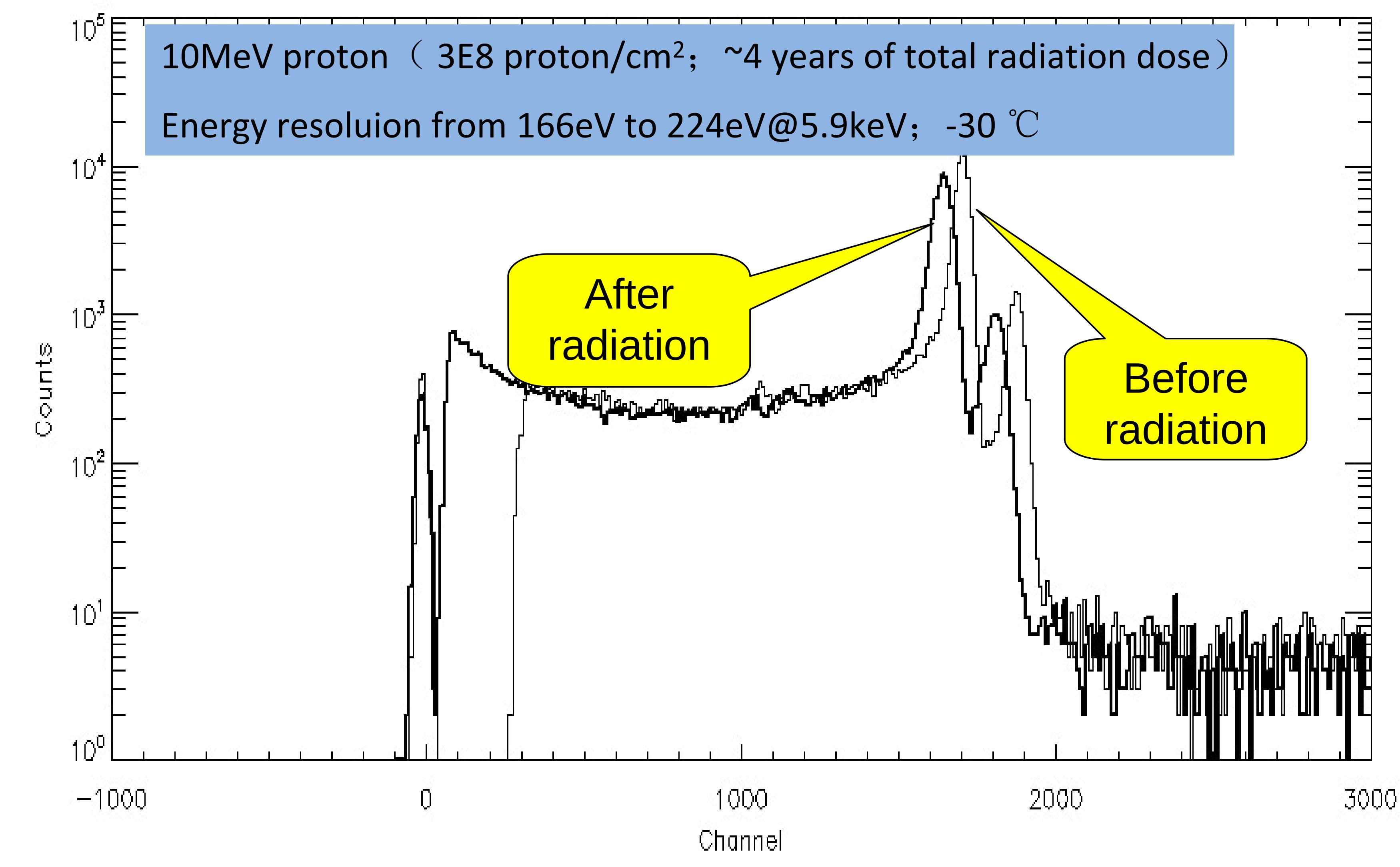


2.8keV @60keV, room temperature



1.7keV @60 keV, -28℃

Energy resolution of ME



Radiation damage experiment of the LE detector

Collaborations with ESA

ESA Assistances and helps upon:

HXMT ground segment;
HXMT calibration;

(documentation, software, experienced consultant etc.)

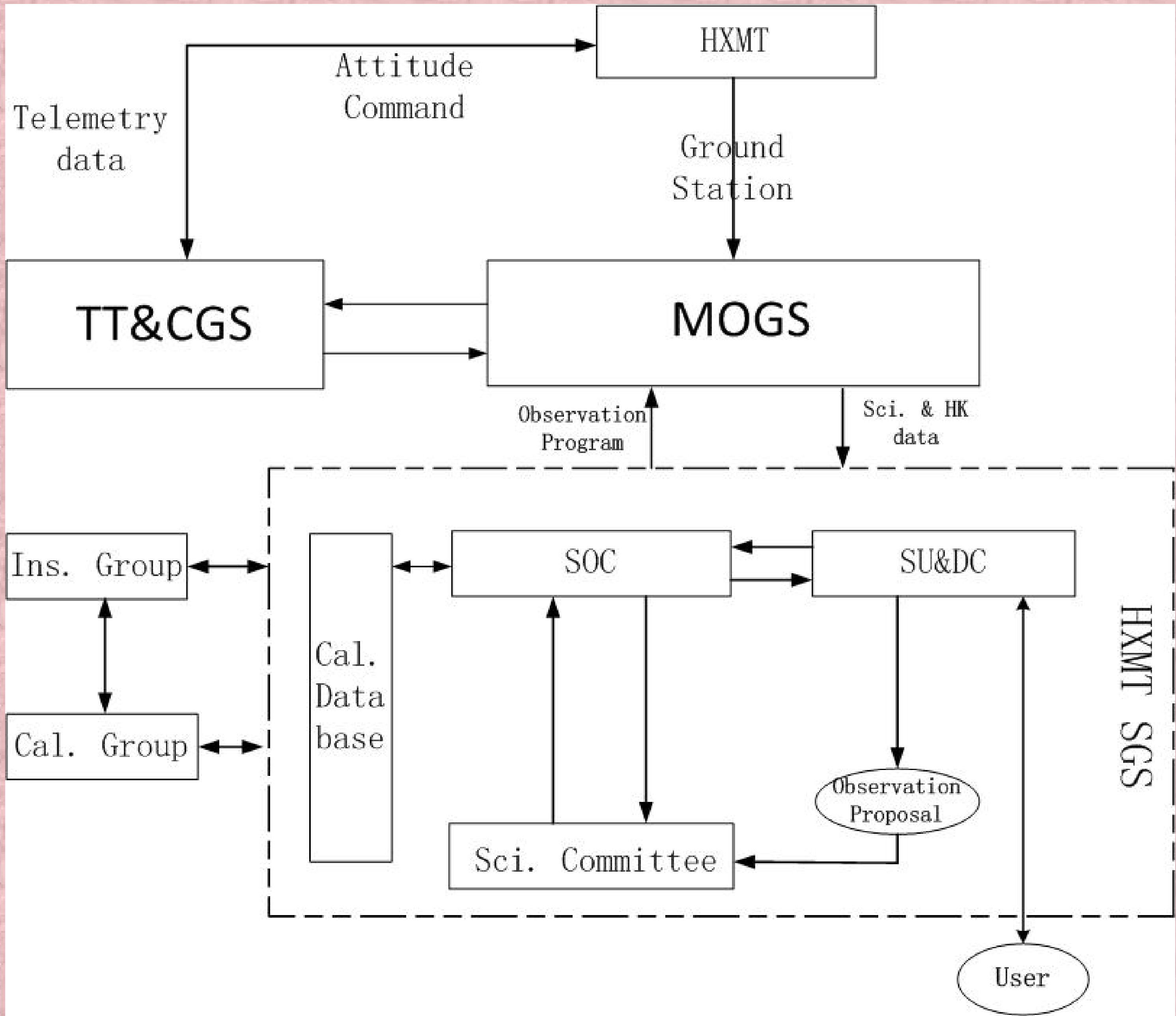
HXMT ground segment

Configuration for HXMT Ground Segment

The HXMT Ground Segment is composed of three parts：

(1) Track , Telemetry and Control Ground Segment (TT&CGS)
(2) Mission Operation Ground Segment (MOGS)
(3) Science Ground Segment (SGS)

In China, the functions of Mission Operation Center (MOC) is divided into two parts, TT&CS and MOGS.


HXMT
Attitude
Command
Telemetry
data
Ground
Station
TT&CGS
MOGS
Observation
Program
Sci. & HK
data
Ins. Group
Cal. Group
Cal.
Data
base
SOC
SU&DC
Observation
Proposal
Sci. Committee
HXMT SGS
User

The responsibilities of TT&CGS

The responsibilities of TT&CGS are to exchange between platform and ground for those:

(1) telemetry data
(2) uploading commands
(3) payload data

The responsibilities of HXMT SGS

(1) Observational plan and, accordingly, platform attitude and payload condition be figured out
(2) Contemporary payload health and performance
(3) Inflight calibration and calibration database
(4) Scientific and auxiliary data productions
(5) Software maintenance/assistance to both on-board and user
(6) ToO and multi-wavelength campaign

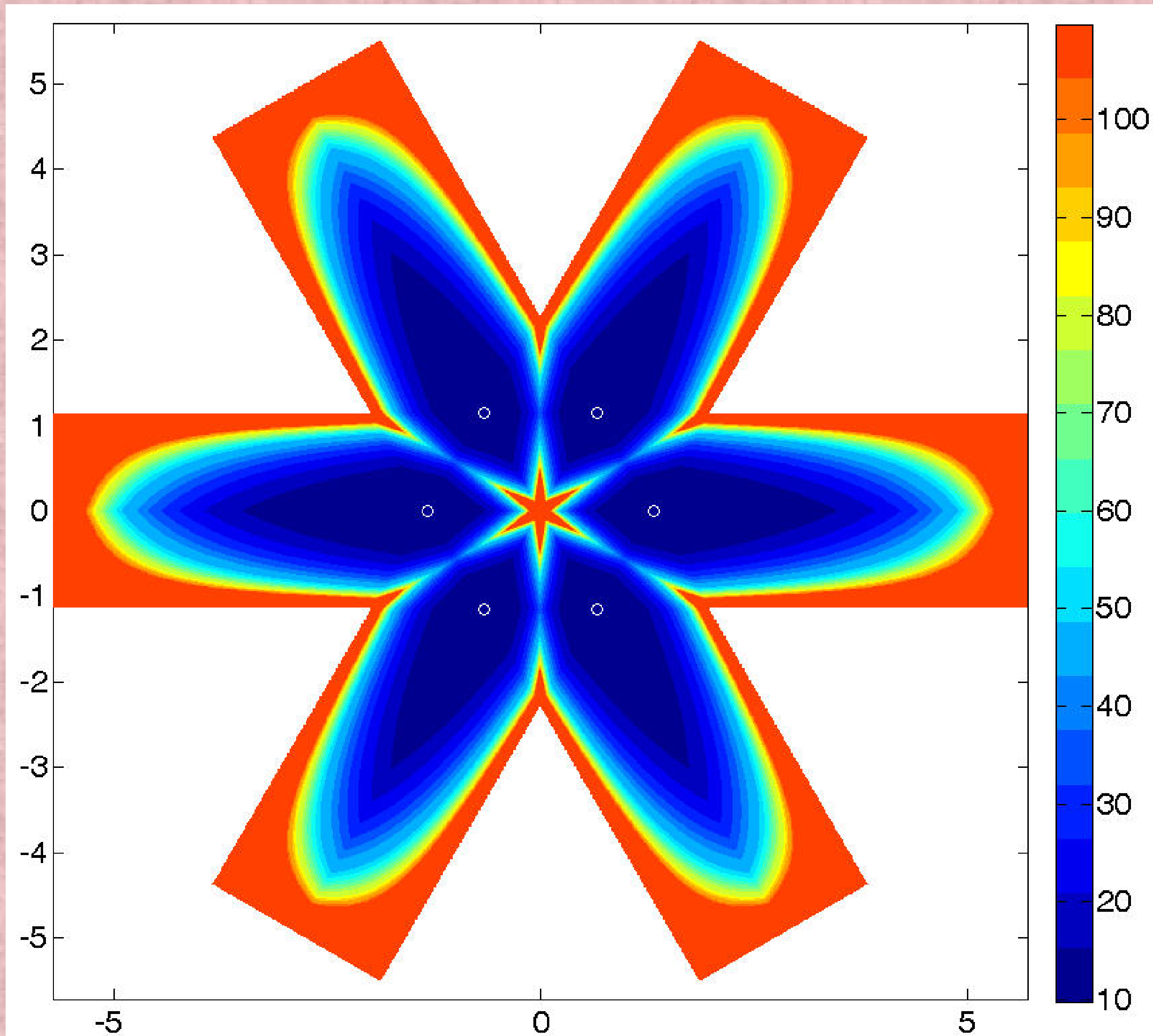
The Progress of SGS

1、Generator to produce data analogue to inflight one: under test and mostly ready for HE.

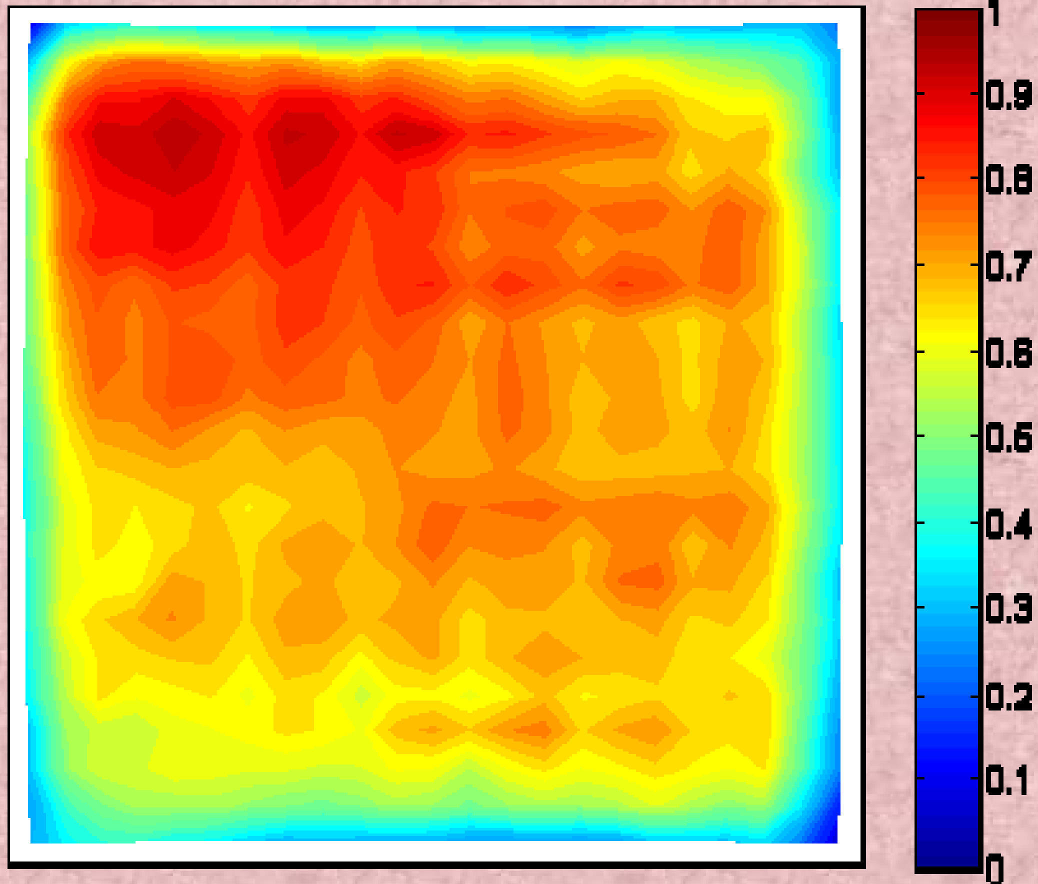
2、Optimize strategy upon source observation：have the source and background be derived contemporarily

3、Tool to estimate the sky coverage for survey under breaks of SAA and earth occultation.

4、Lessons for the inflight background modeling from the pioneer missions

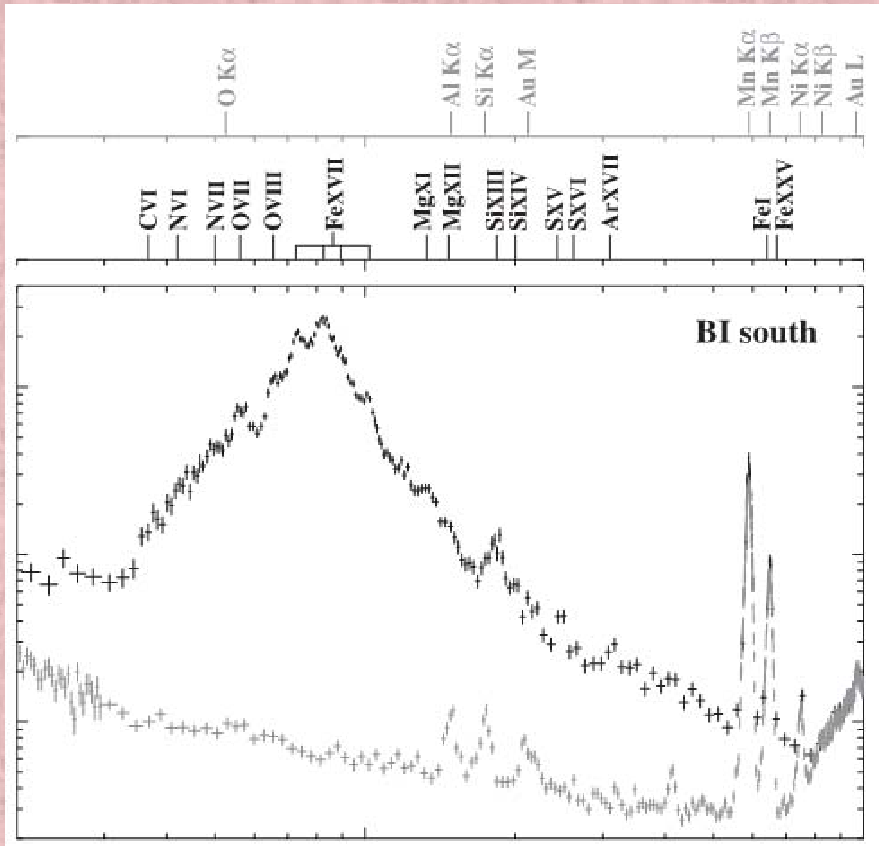


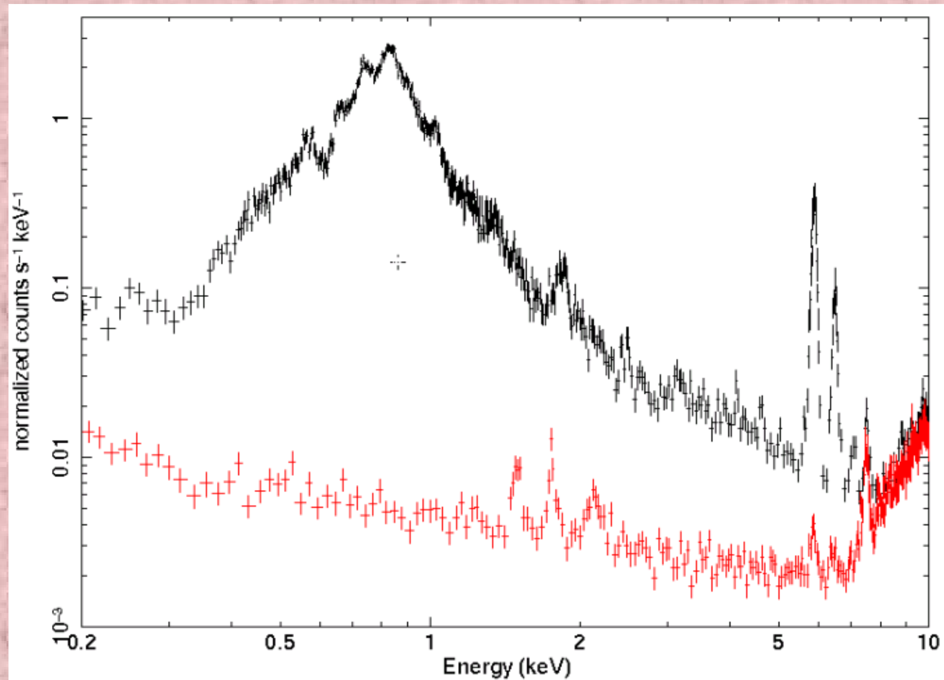
Optimized source (located at center) observations (pointing toward the write circles)



Sky coverage of survey under breaks of SAA and earth occultation

Inflight background: lessons from Suzaku/XIS





HXMT Calibration

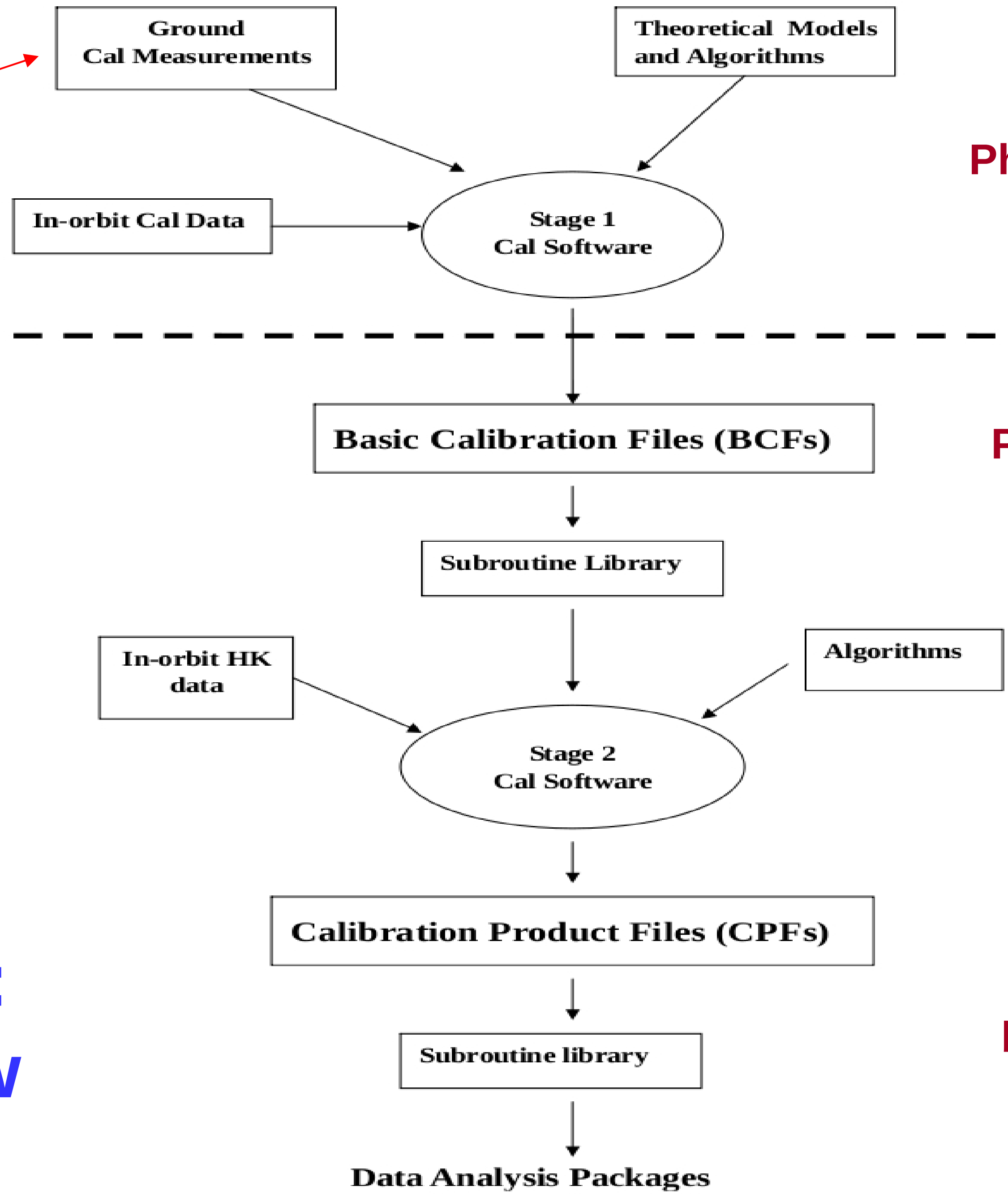
Calibration production (Concept)

- **PCF（primary calibration files）: raw ground and in-orbit calibration data set, most of which are of not direct interest to users in their scientific data analysis;**

- **BCF (basic calibration files): the lowest level calibration datasets potentially required by analysis software, can be considered as the atom units of the instrument calibration;**

- **CPF (calibration product files): the convolution of the information stored within BCFs customized for a specific analysis task or observations.**

We are currently at here



Phases B & C

Phase B & C

Phase C & beyond launch

Scheme: data flow

Organization

- **Instrument teams (The Core prior to launch):**

  LE, ME, HE

- **Science Ground Segment (The Core post launch) :**

  SOC, SU&DC

- **Project committee (The head of HXMT):**

  every aspect of the overall project

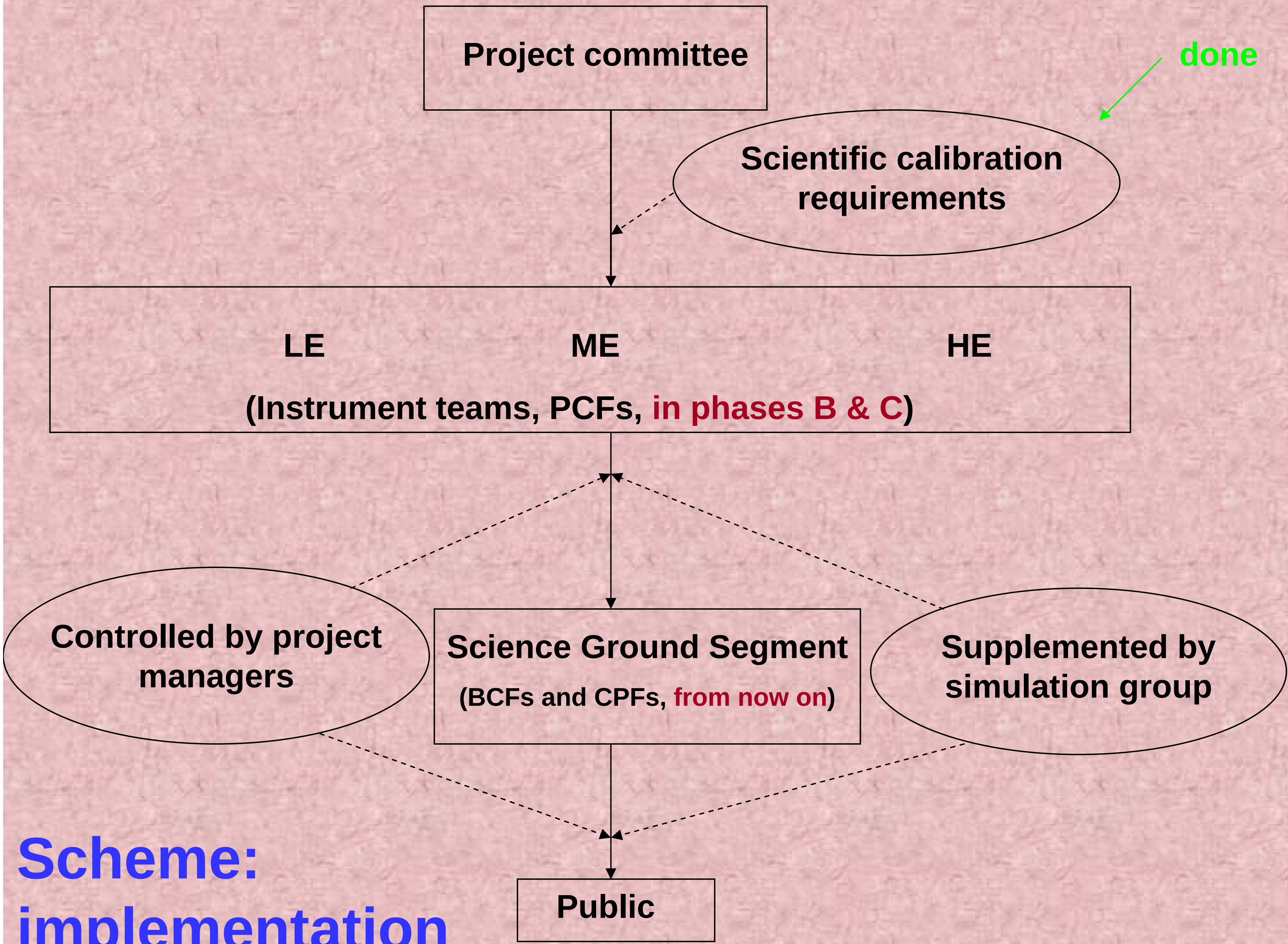
- **Project management (The officers):**

  coordinating the implementation;

- **Small technique groups (The working bees):**

  simulation, thermal control, structure etc.

Scheme: implementation



Calibration milestones

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 SU&DC);

Figure out interface between PCF and BCF (by SU&DC);

Tests for performance of instruments (by ins. team);

Calibration milestones

Phase C (2013-2014) (ground segment mostly involved):

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

Calibration plan for producing BCF (by SU&DC);

Calibration plan for producing CPF (by SU&DC);

Inferface between ground PCF and inflight PCF (by SU&DC);

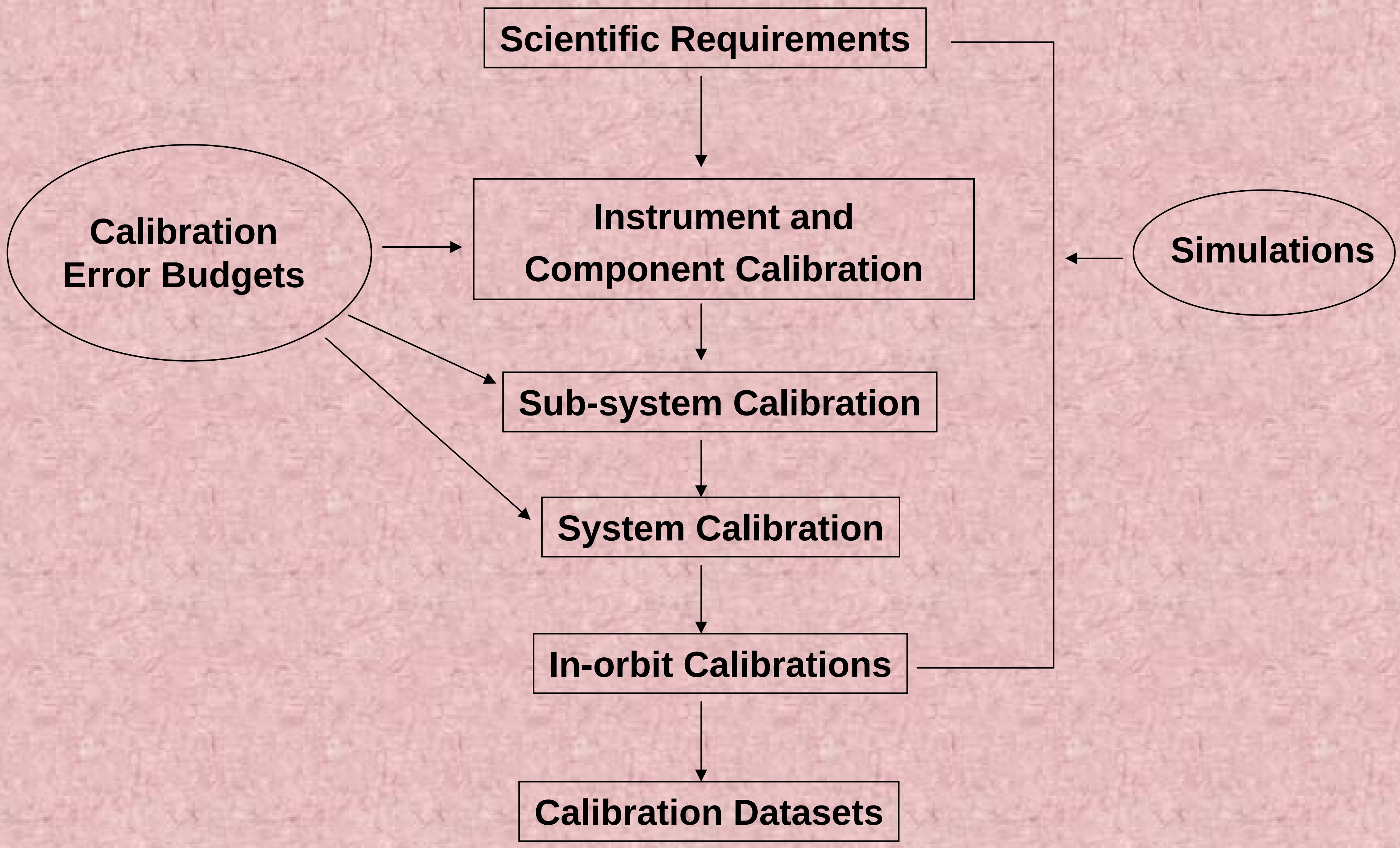
Carry out the ground calibration and produce PCF (by ins. team);

Calibration milestones

After launch (2015-) (ground segment dominated):

Implementation of inflight calibration and produce PCF;

Produce BCF and CPF datasets;



Scheme: Implementation

Instrument and Component Calibration
(Ongoing)

Collimator: **psf, parrellel, etc.**

PMT: **efficiency, degrading etc.**

CCD: **QE, CTI, energy response, etc.**

Crystal: **NaI/CsI, energy response, etc.**

Dependences on temperature, magnetic field, etc.

Sub-System and System Calibrations

(not yet done)

The performance of the integrated sub-system:

(LE, ME and HE) and system (the sum of all)

Calibration Error Budgets

(Not yet touched)

Scientific drivers for calibration -> the goals of the calibration accuracies of parameters.

To exam the component calibrations, make sure these goals are met and maintained by establishing error budget to work to.

In-Orbit Calibrations
(plan not yet available)

Standard candles:

Crab, and others see IACHEC

Embedded calibration sources:

Am-241, Fe-55

Environmental fluorescence lines :

Si, etc.

Operational conditions:

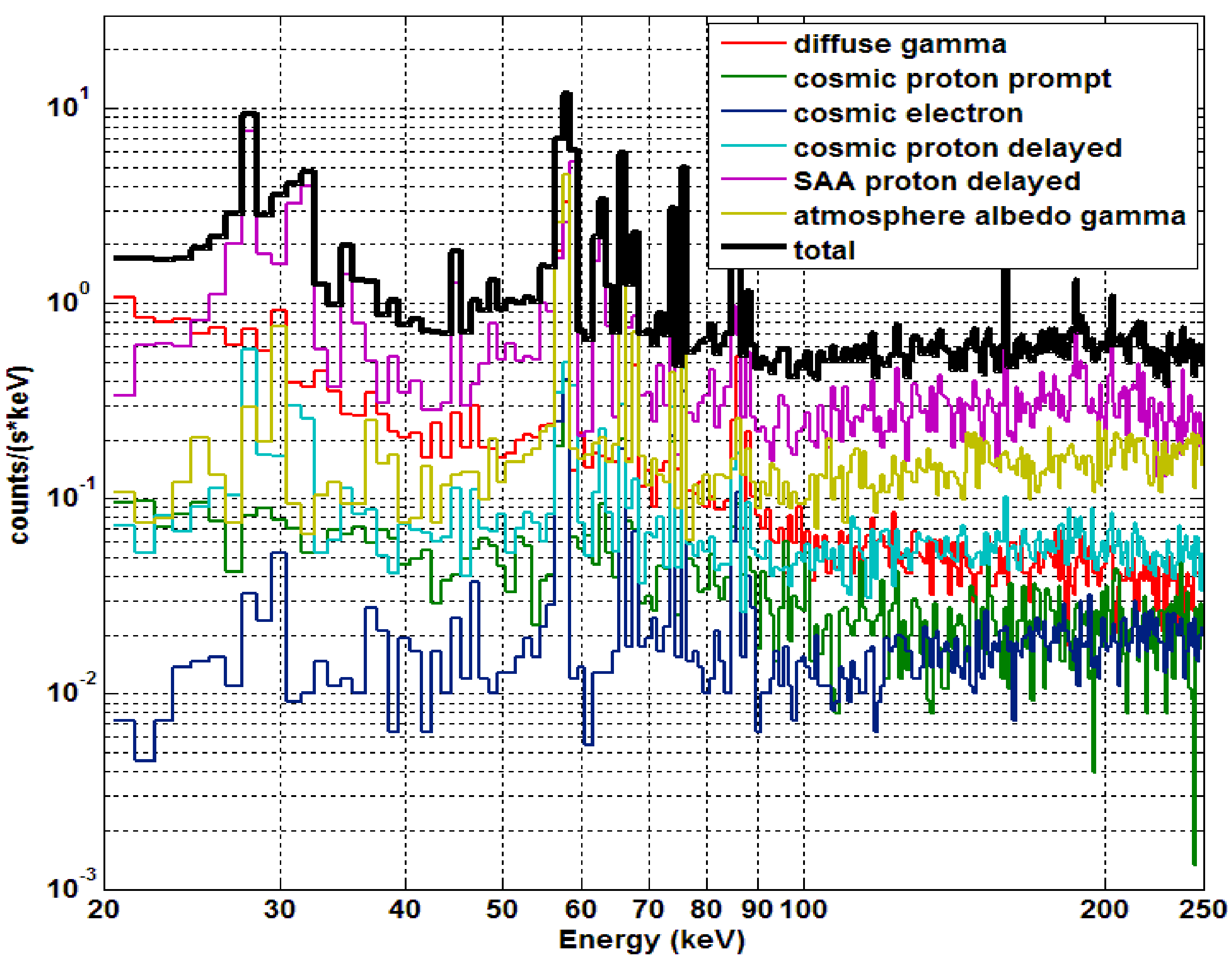
Gain, temperature etc.

Collimator PSF; energy response; effective area; timing etc.

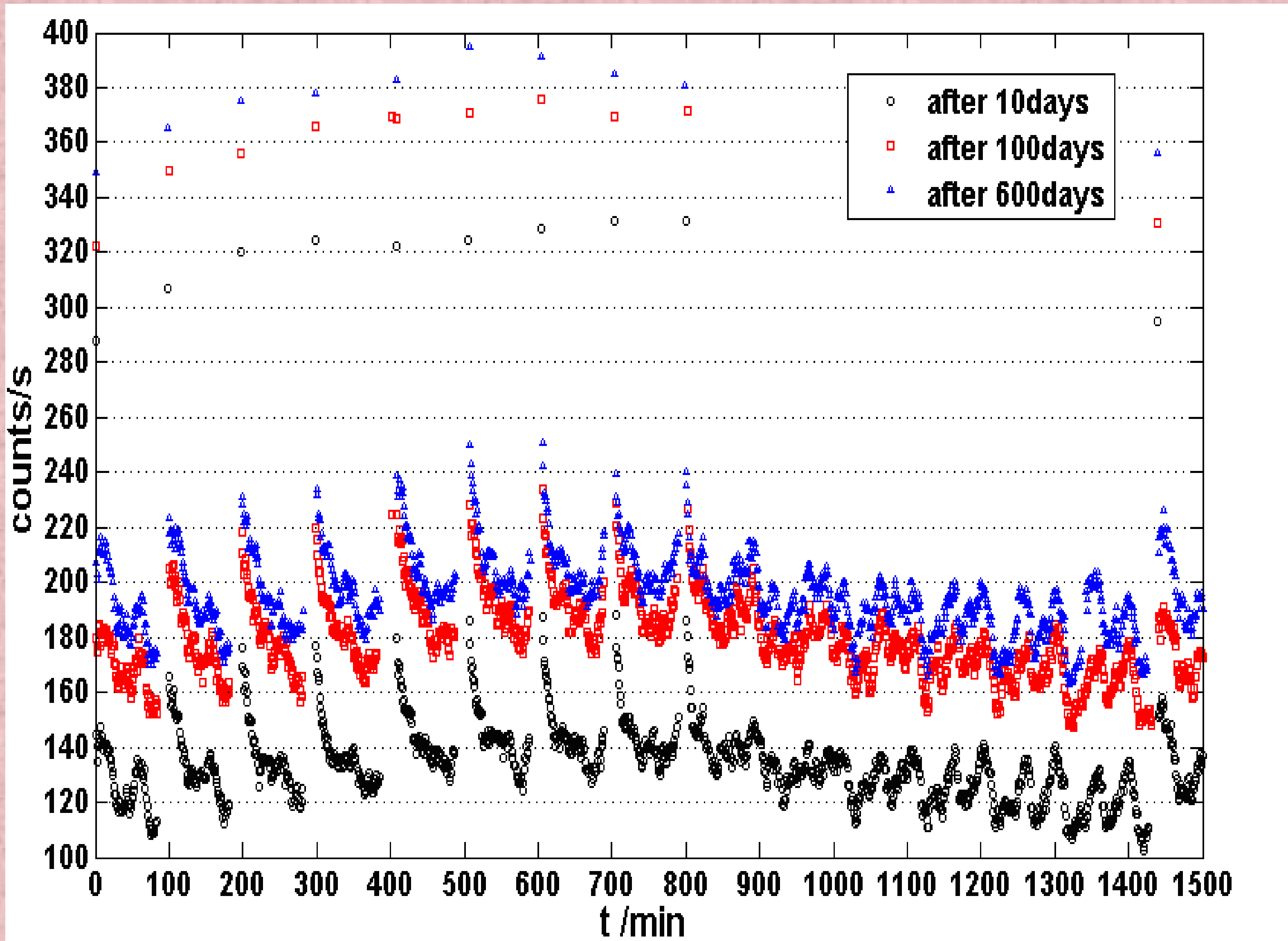
Simulations

(Working bees busy for years)

Cover almost whole procedure of the calibration



Contributions of various components to the total background (HXMT/HE)



Simulated in-space background of HXMT/HE

Ground facilities

Ground facilities

Radioactive sources:

Advantages: known energy and flux: energy linearity and resolution

Disadvantages: mostly constrained by weak flux and short life time; and less available at hard X-rays

Radioactive Sources (HE)

Nuclide	Half-life	Line Energies/keV
^{241}Am	433y	26.3 59.54
^{57}Co	271d	122 136.5
^{109}Cd	453d	88 24.9 22
^{137}Cs	30y	32 36.6
^{203}Hg	46.6d	279.2
^{125}I	59d	27.3 35.5

Ground facilities

Synchrotron radiation facility:

Perfect for calibration:

good energy resolution, high flux level, good parallelism, energy continuity

Constraints:

available time very limited,

small beam dispersion -> long calibrations

Facility in China	Energy band	Light spot size	**Availability**
Shanghai synchrotron radiation facility	< 73 keV	~ 0.3 (H) mm X 0.3 (V) mm	very low
Beijing synchrotron radiation facility	< 25 keV	~ 25 (H) mm X15 (V) mm	low
Hefei synchrotron radiation facility	< 12 keV	~ 15 (H) mm X 1 (V) mm	ok

Ground facilities

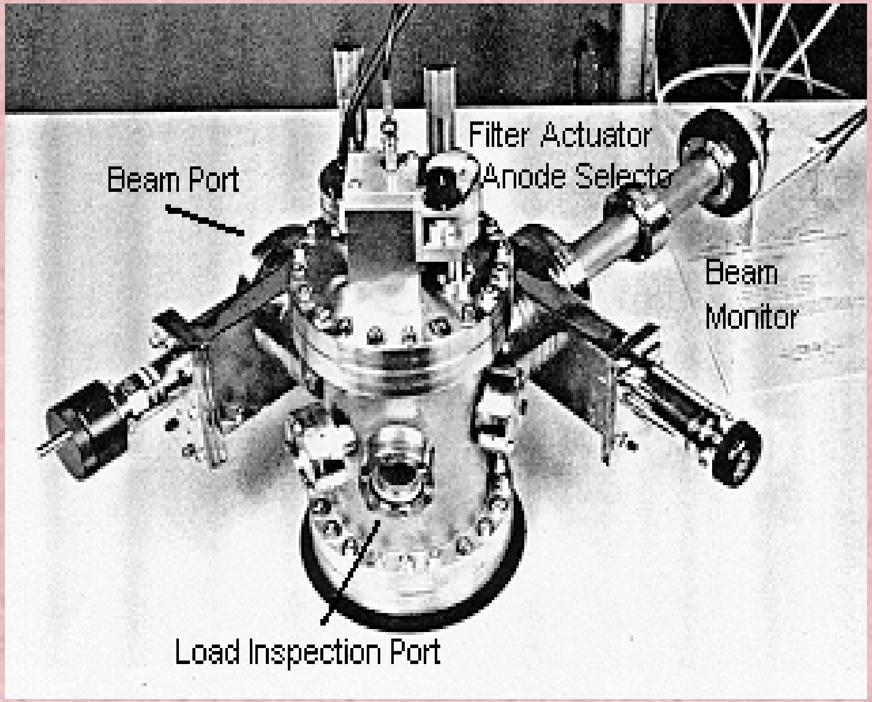
X-ray apparatus under construction at IHEP:

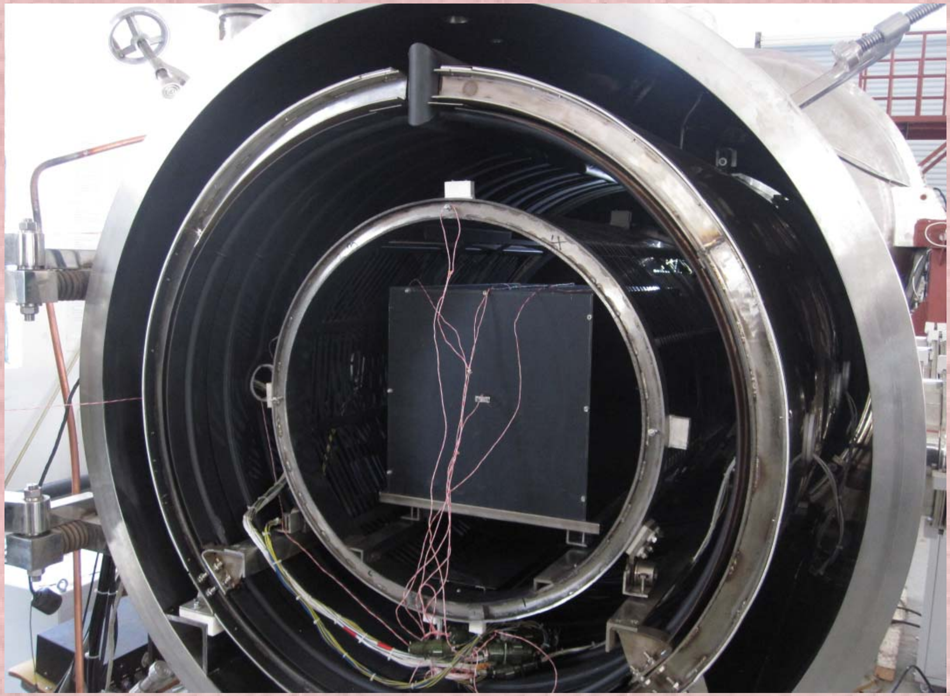
0.5-10 keV (multi-anode, fluorescence lines + filters for monochromatic light)

Beam line 3 m (relatively poor parallel of the produced X-rays)

Standard detector (monitor beam intensity)

Vacuum detector chamber (10^{-3}pa)





X-ray apparatus

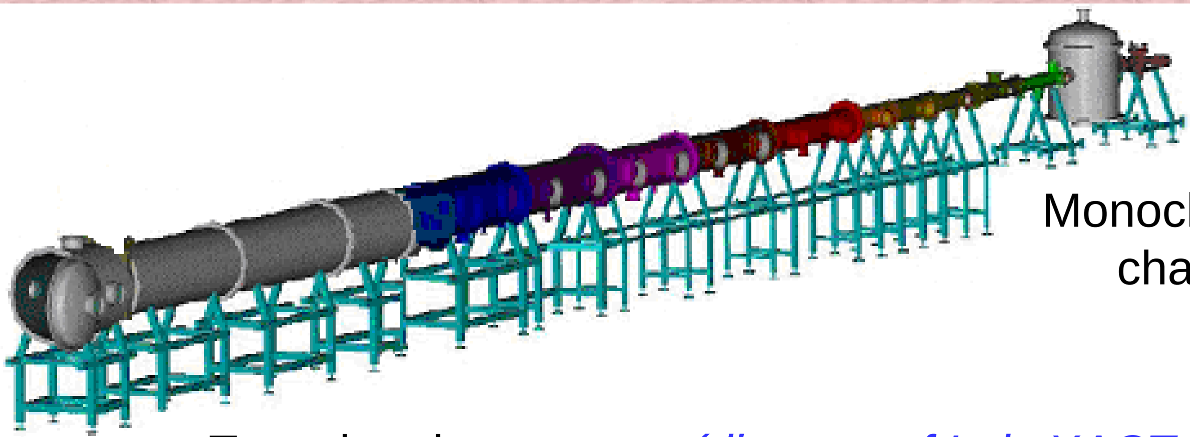
(Manson Model 05 from McPherson company)

Vacuum detector chamber

(diagram from Shanghai Shuguang company)

Ground facilities

Designed for upgrade in future:



(diagram of Italy XACT facility)

X-ray apparatus: voltage >60 kV, power >10 kw, X-rays up to 60 keV: cover hard X-rays

Double crystal monochromator : more energy points

Beam line extended to > 30m: better parallelity

Utility of the ground facilities: the perspectives

Radioactive sources: supplementary to all, HE in special

Synchrotron radiation facility: apply time to cover LE , ME, and partially HE

The X-ray apparatus: takes care of the LE and partially ME

Relatively safe for LE but still largely open for HE and ME

THANK YOU !