Calibration for Follow-up X-ray Telescope on Einstein Probe

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2019-05-22

Overview

- FXT introduction
- Simulation
- Ground calibration
- Calibration plan

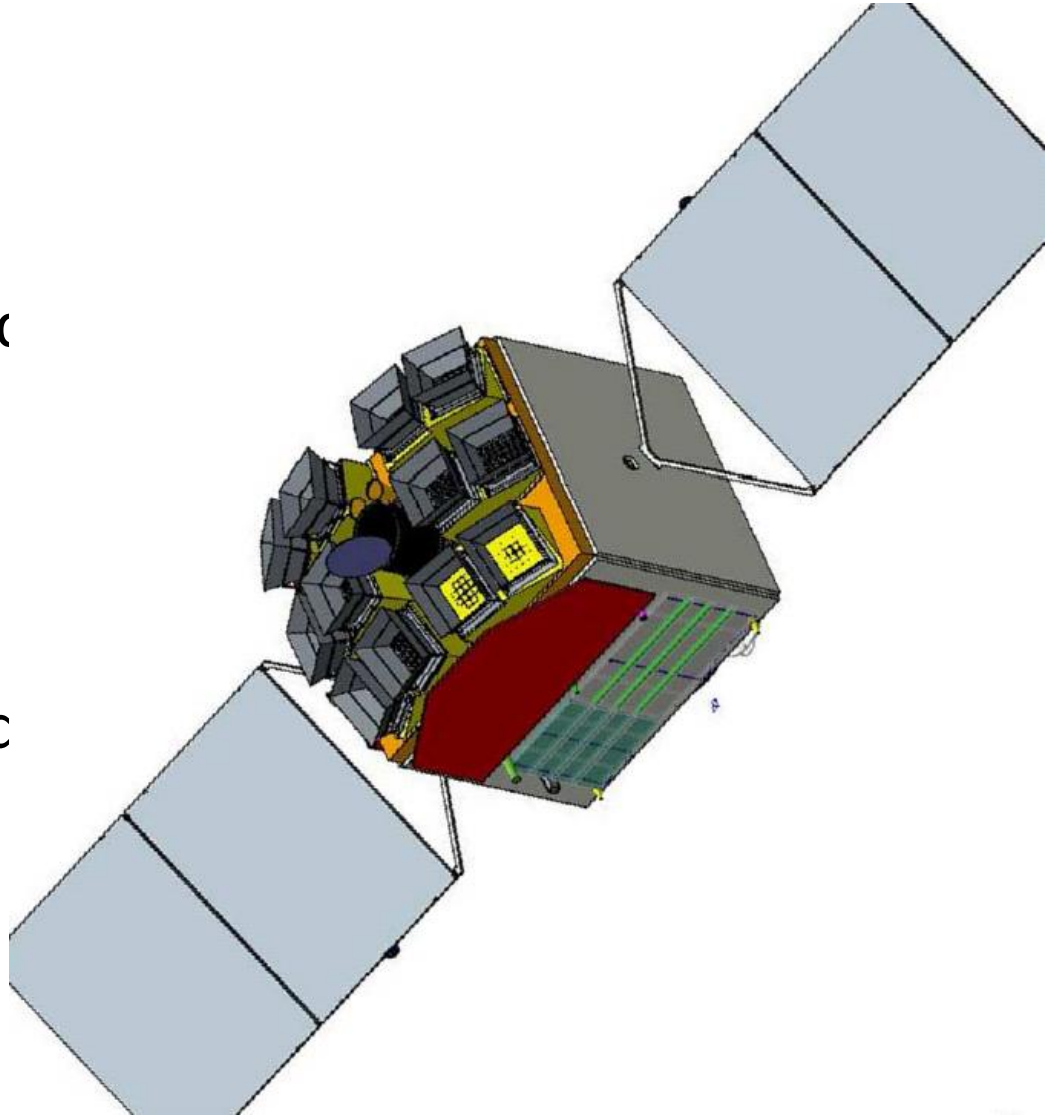
Aim for EP/FXT

- EP:

  A mission for all-sky monitoring to discover and study high
energy transients and variability in the soft X-ray band

- FXT: responsible for the quick follow-up observation of the triggered sources by WXT and pointed observations of other targets.

More accurate positioning, better spectrum and lightcurve with wider energy band than WXT.



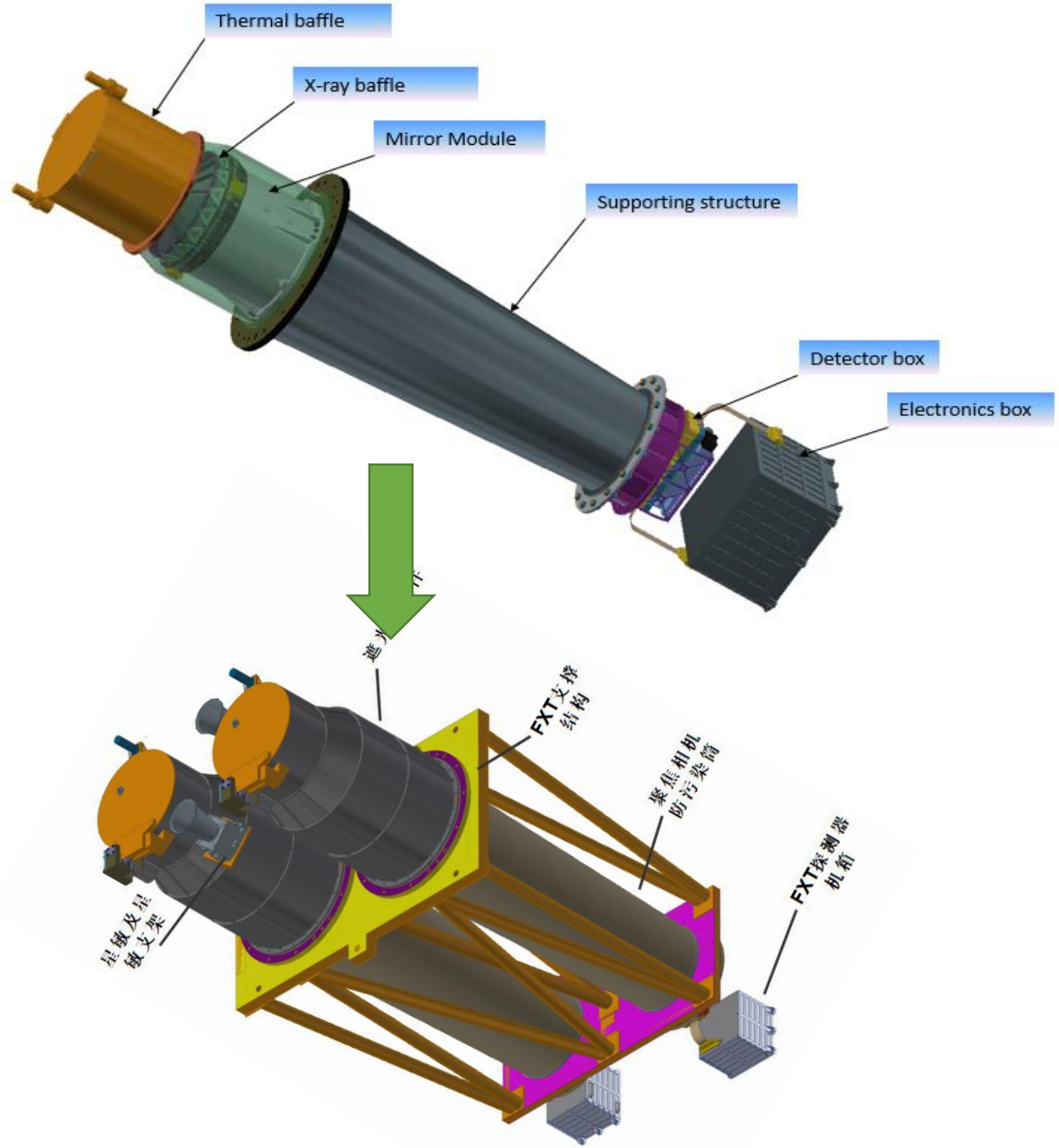
Performances and requirements of FXT

	Requirement	Goal
Field of View (FOV)	≥38′ in diameter	≥38′ in diameter
Effective Area	≥100cm^2@1.25keV， on axis	600 cm^2@1.25keV, on axis
Half Energy Width (HEW)	≤2′ HPD	30″ HPD on axis
Energy Resultion (FWHM)	≤170 eV@1.25keV(Mg Kα)	≤120 eV@1.25keV(Mg Kα)
Energy Range	0.5~8.0 keV	0.3~10.0 keV
Source Position Error	≤20″ in detector coordinate system 90% confidence, observation time more than 100 second and x-ray count more than 200	≤5″ in J2000 system 68% confidence
Frame Rate	1 Hz	≥20Hz
Mass (TBC)	150kg	150kg
Power Consumption (TBC)	200W	200W
Outer Envelope Size	Φ630mm×2700mm	Φ630mm×2700mm
Nominal Lifetime	3 years	5 years

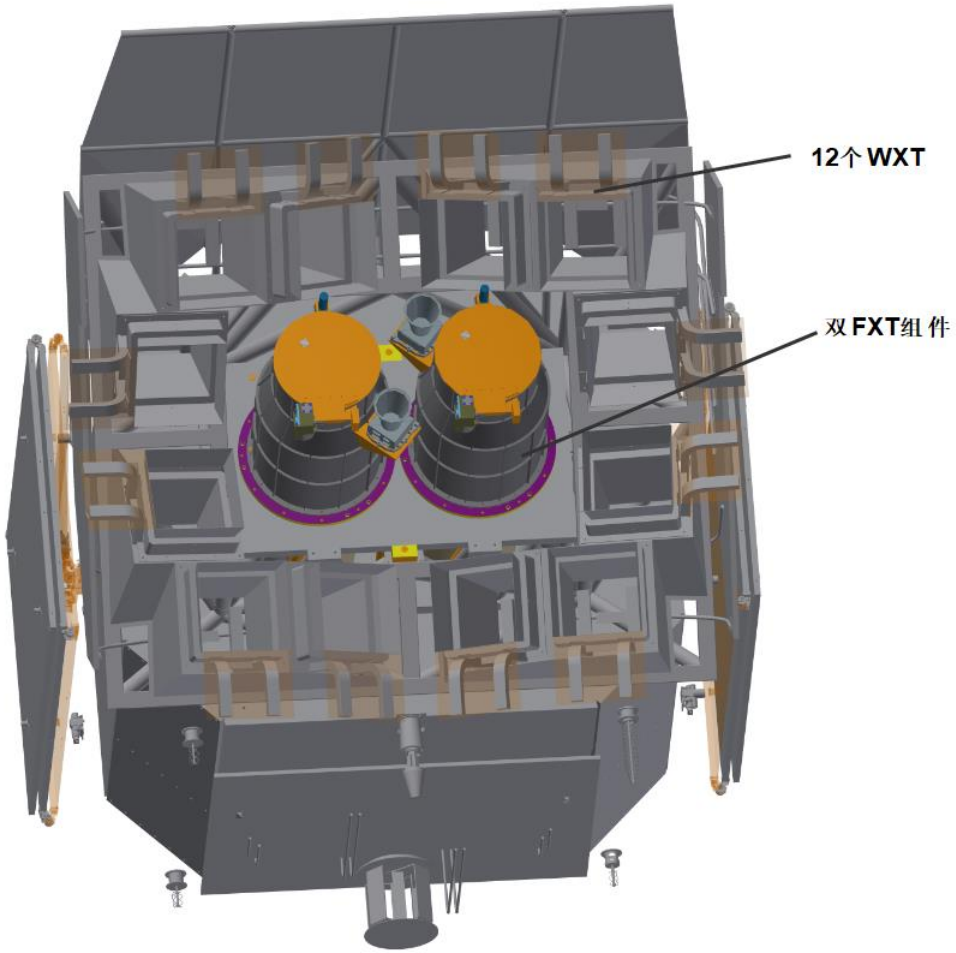
The model of EP-FXT

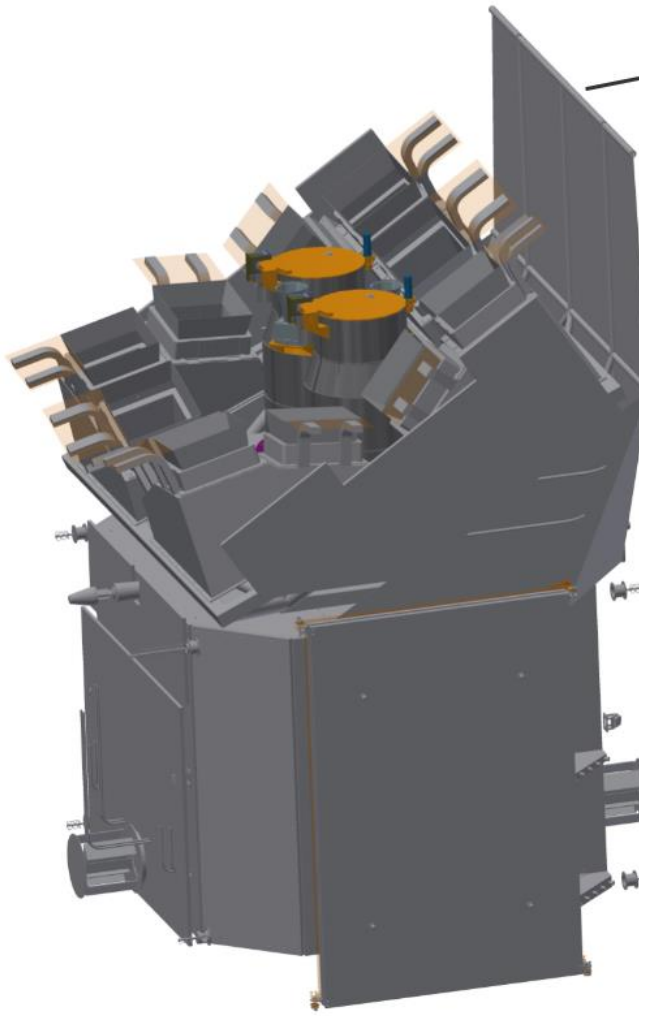
FXT is a Wolter-I type telescope operating in 0.5-8 keV. It has a narrow field of view and 20 arcsec source localization error in the detector coordinate system. The FXT detector system consists of two pnCCD modules (the size of the imaging area is 28.8mm×28.8mm, provided by MPE) and a shifter.

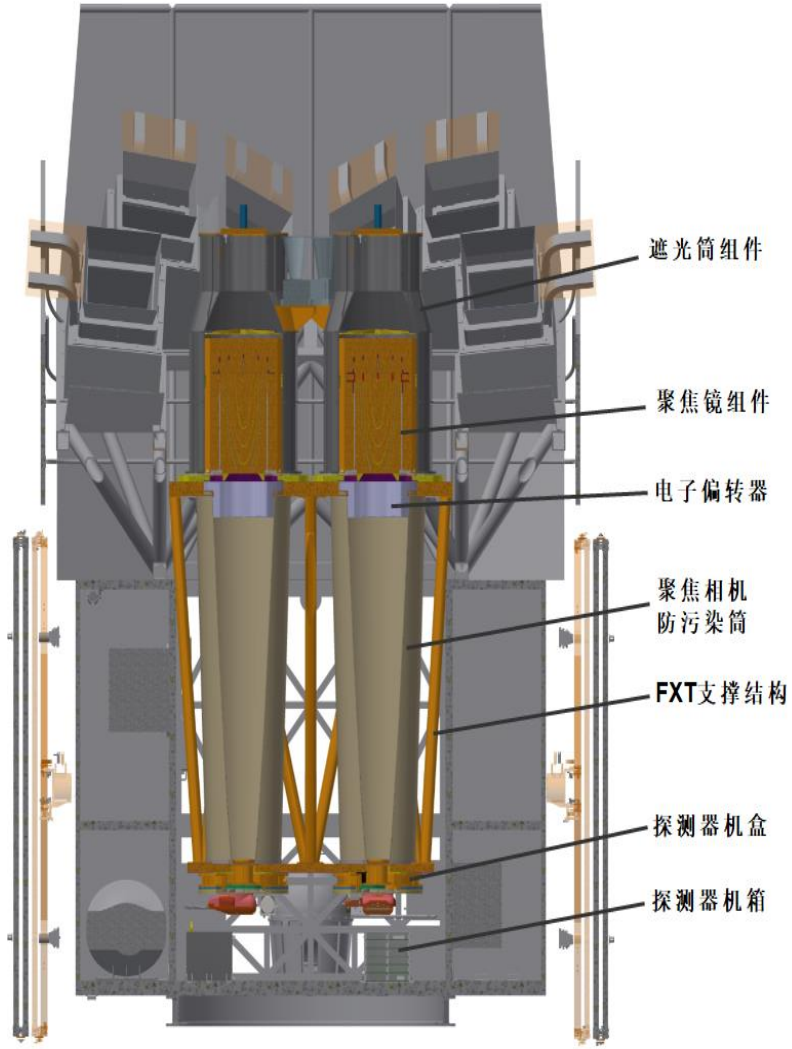
One pnCCD module serves as the backup of the other module, and the two pnCCD modules are both cooled (-110~-80℃) by helium pulse tube refrigerators, respectively.



FXT structure

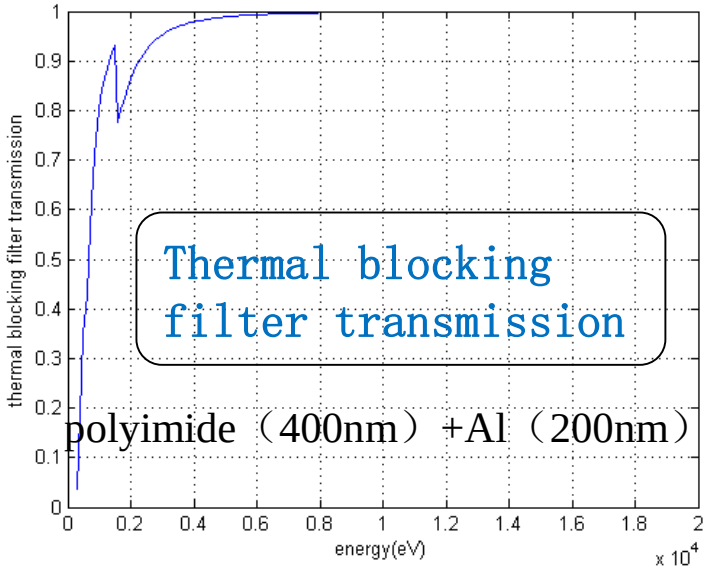


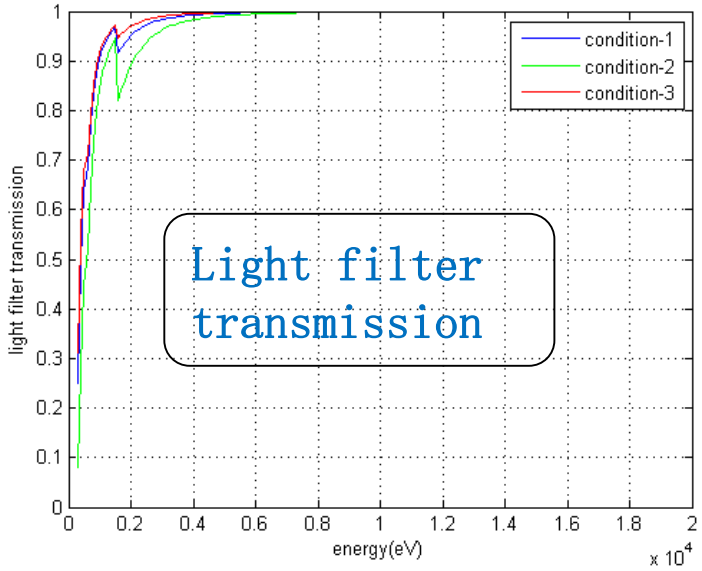


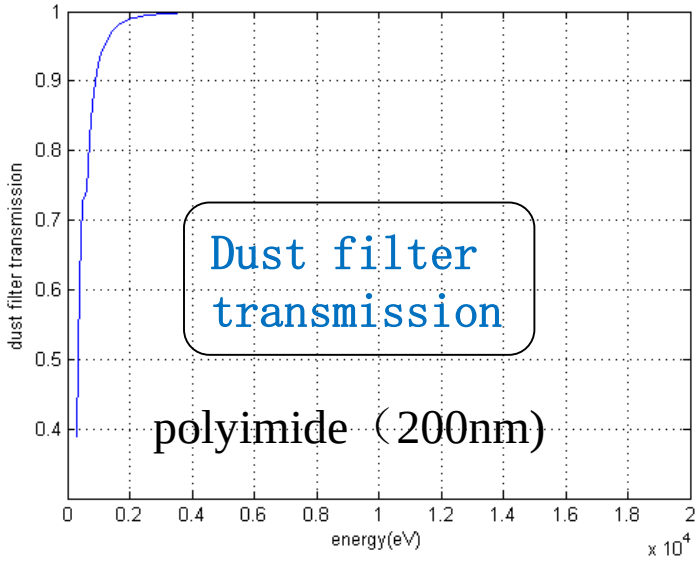


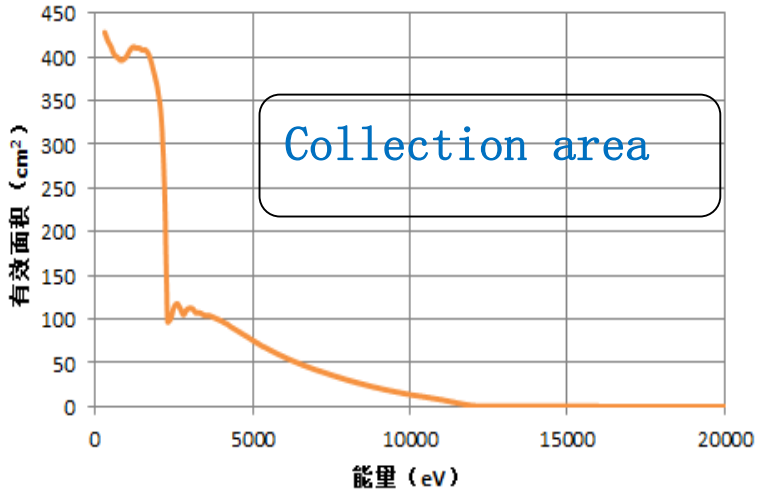
Simulation：Effective area

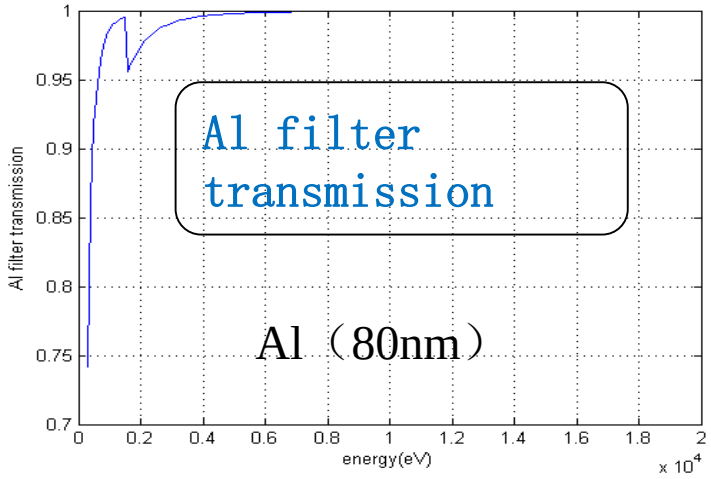
factors for effective area : filter, mirror, detector.

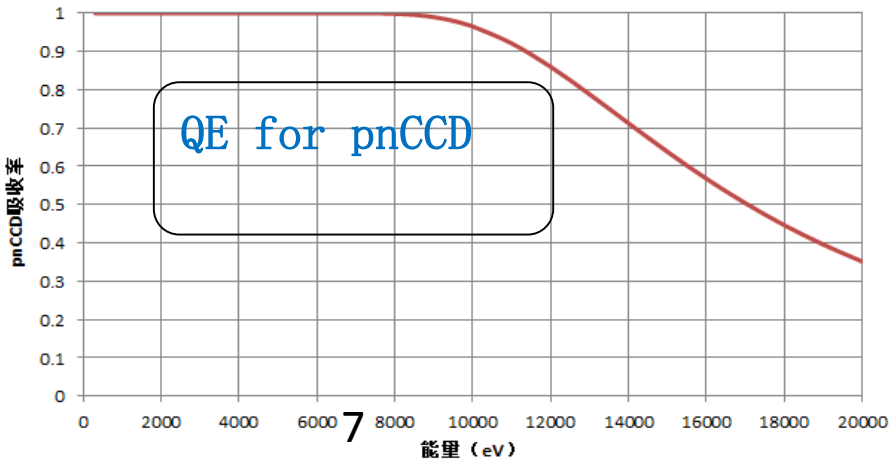




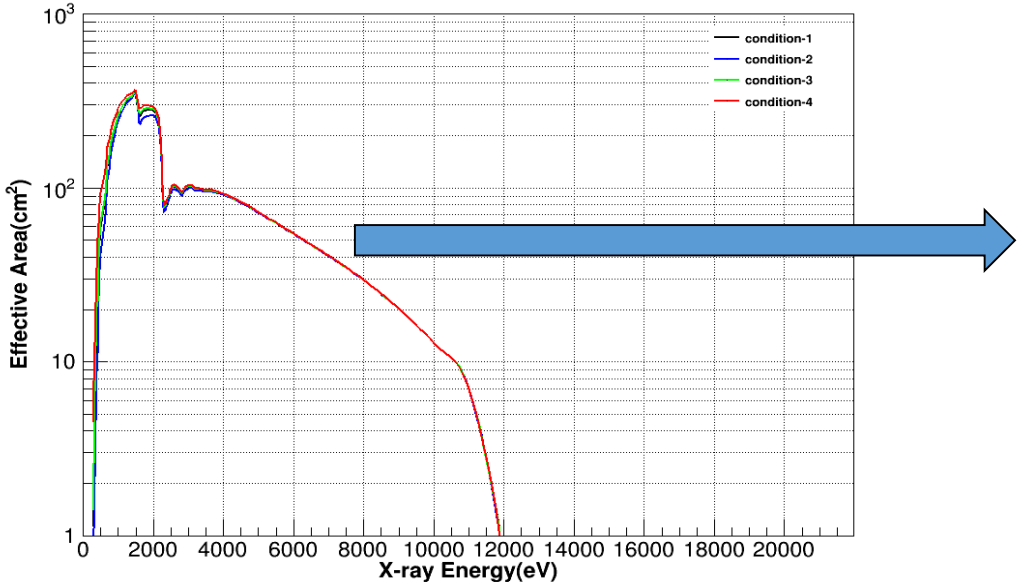


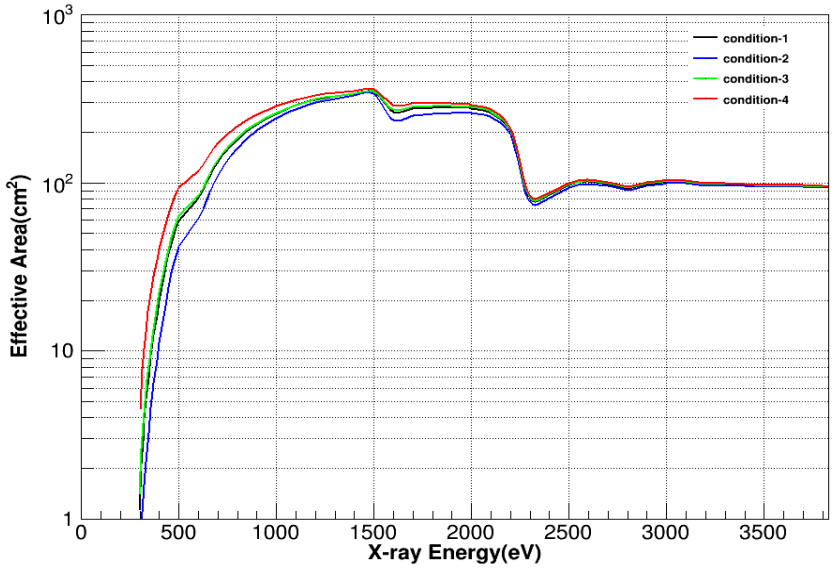




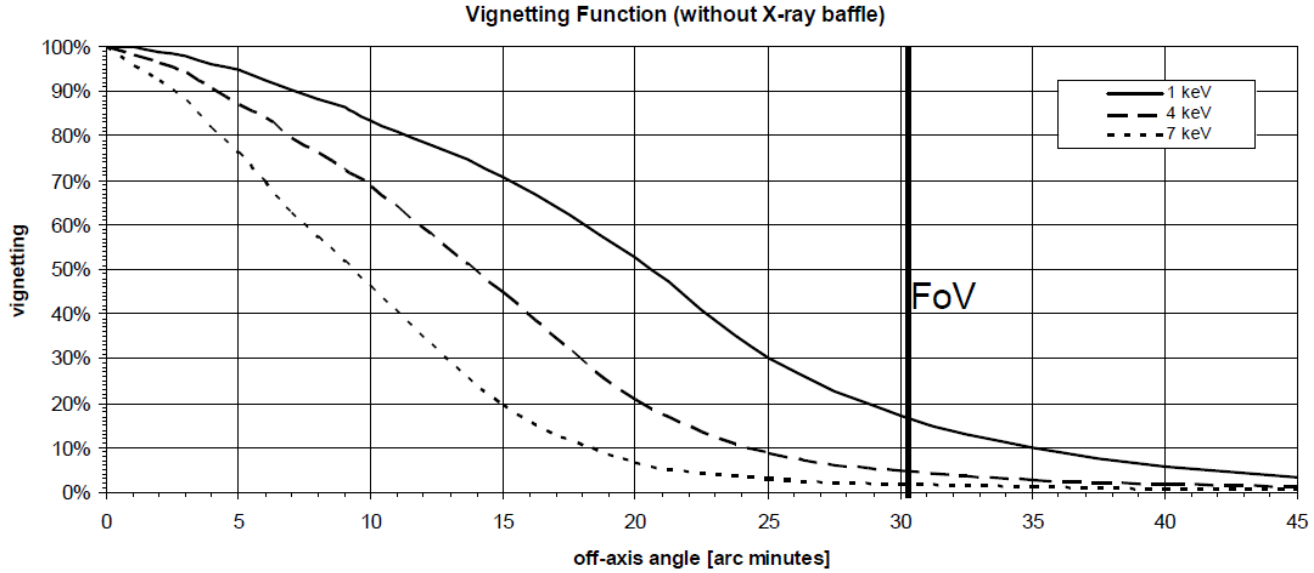


Simulation：Effective area





Condition-1 : polyimide (200nm) +Al (120nm) ;
Condition-2 : polyimide (300nm) +Al (300nm) ;
Condition-3 : polyimide (200nm) +Al (60nm) ;
Condition-4 : open。



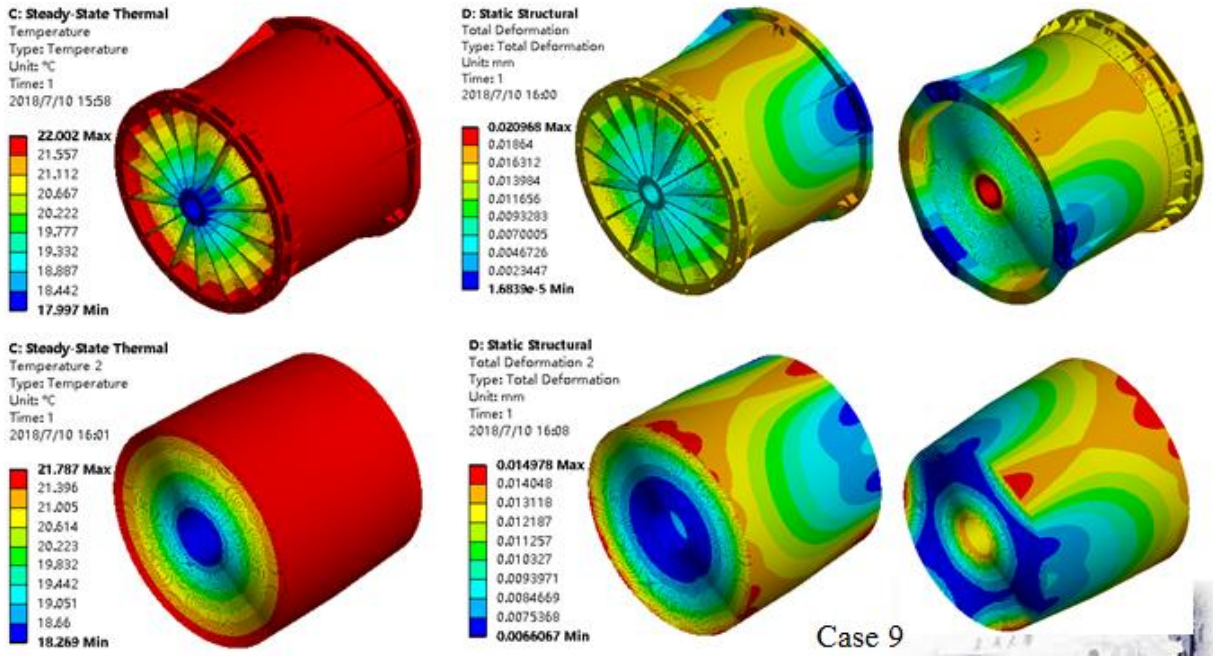
At the edge of FOV the lost of Aeff ＜50%, @1keV

simulation： thermal deformation

Thermal deformation is difficult to corrected in orbit. It is a import factor affecting the angular resolution and position accuracy.

radial direction : 20±0.5℃
Axial direction: 20±1℃

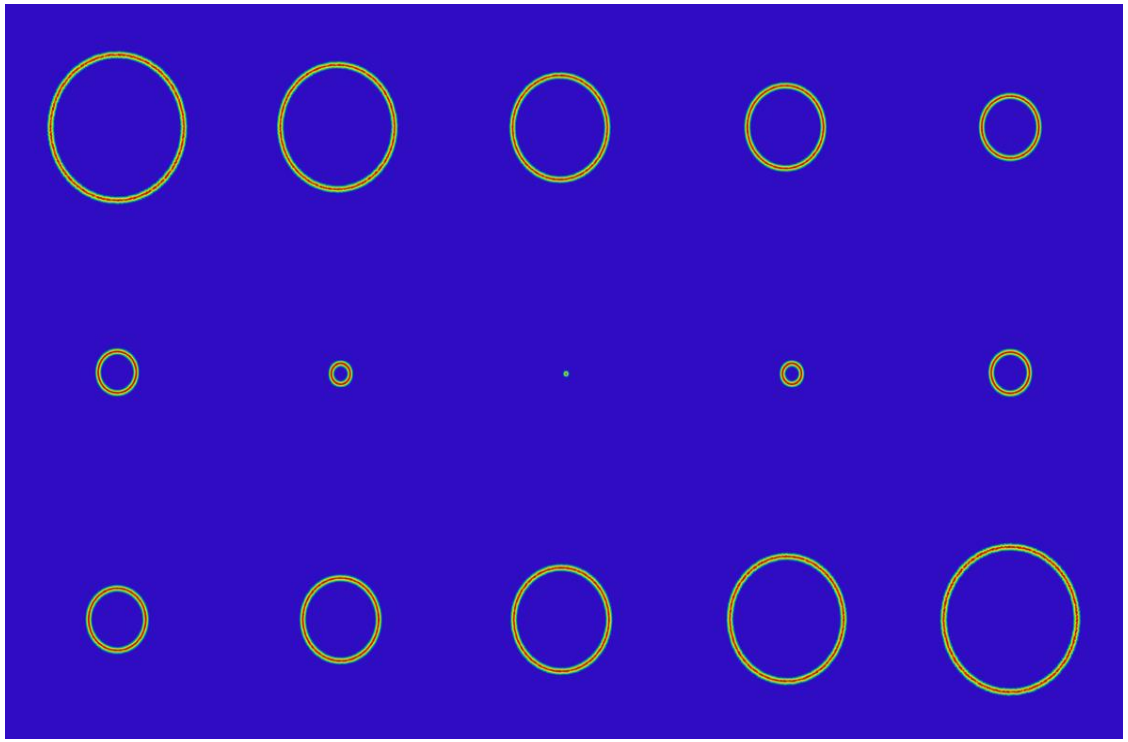
angular resolution : 18 ”
position accuracy: 4 ”



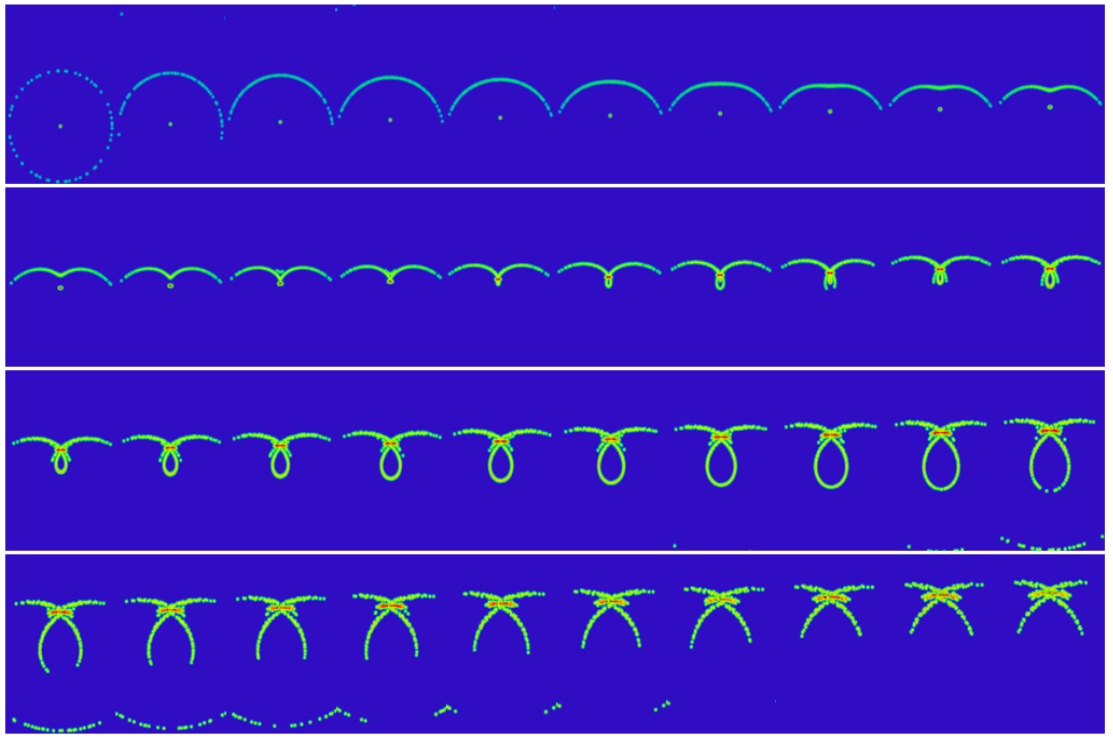
MM

Mirror No.	Max deformation (μm)	Spot shift (μm)	Angular resolution (”)
L1	3.5	100	12.5
L7	3.8	100	12.5
L15	4.3	100	12.5
L25	5.2	120	15
L35	6.5	140	17.5
L45	8	150	18.75

Simulation ： off focal plane & off axis

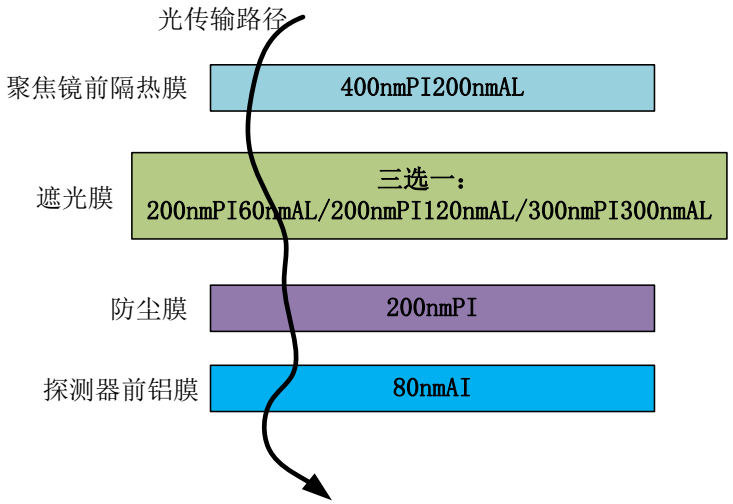


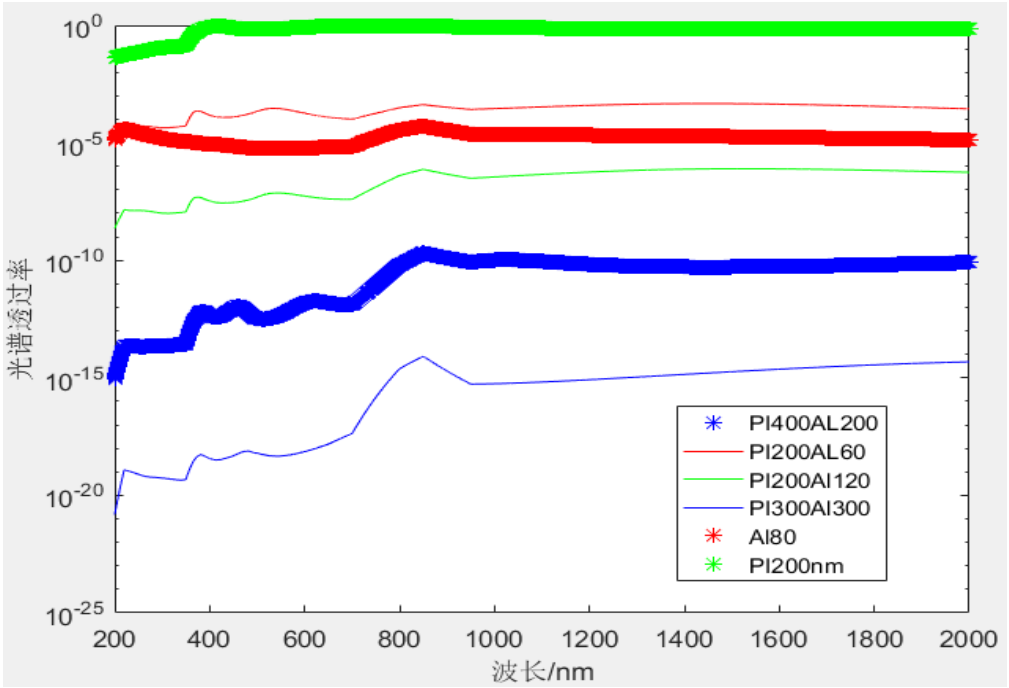
Off focal plane:
Z=±70mm ，step : 10mm



Off axis:2 degree
step:0.05 degree

Simulation: stray light





Visible light transmission

$$N_1 = \int_{200nm}^{2000nm} \tau_1 Q_{in1} d\lambda = 0.043 个 / 秒$$

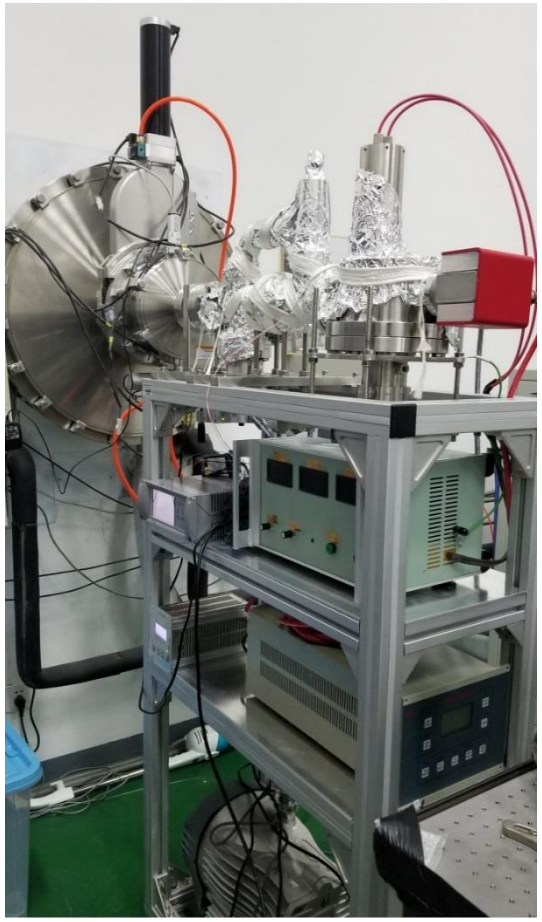
$$N_2 = \int_{200nm}^{2000nm} \tau_2 Q_{in1} d\lambda = 2.3\times10^{-10} 个 / 秒$$

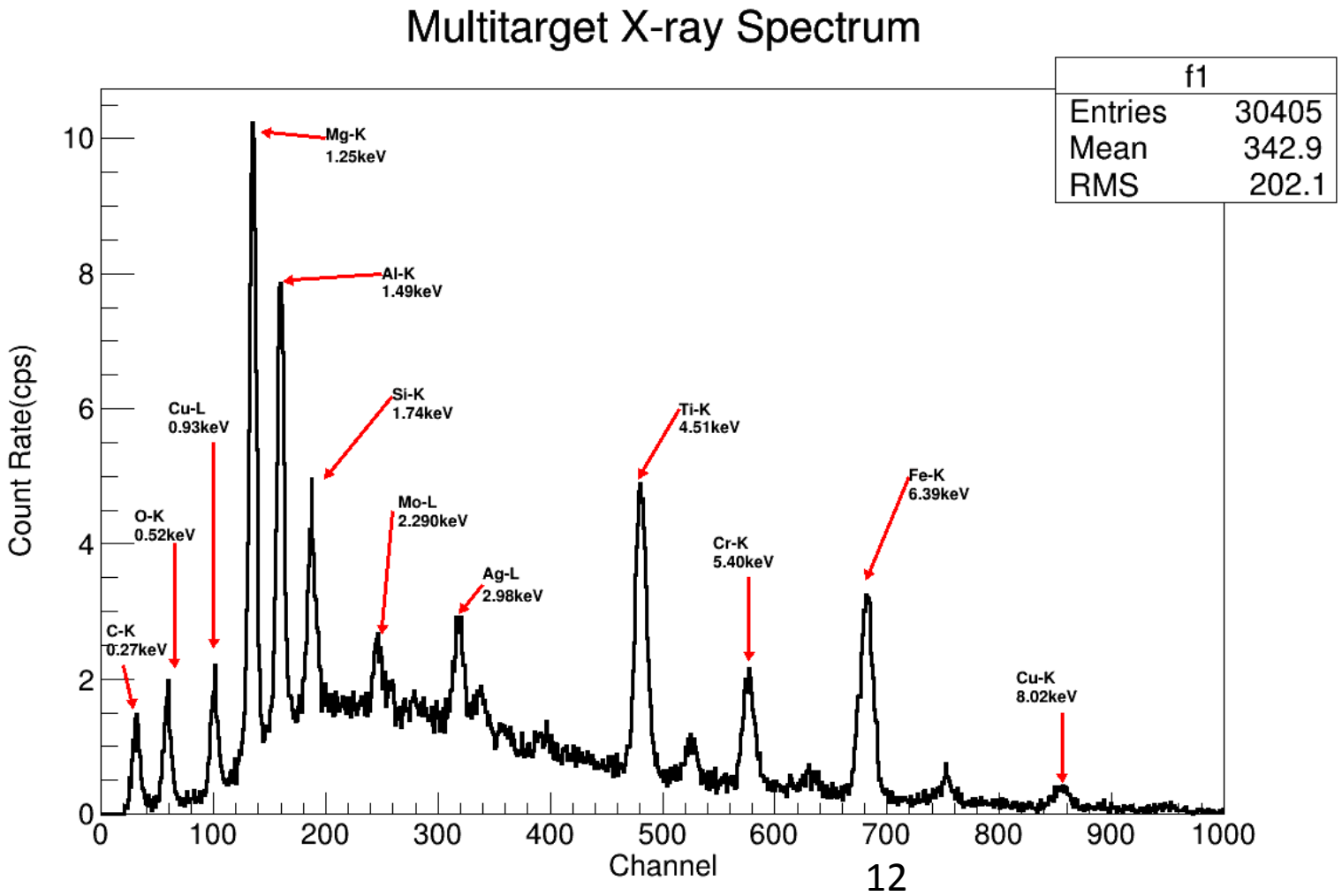
$$N_3 = \int_{200nm}^{2000nm} \tau_3 Q_{in1} d\lambda = 27 个 / 秒$$

In condition 1&2, the reflected light from earth can be blocked by filter totally.

Ground calibration facility：test result of X-ray source

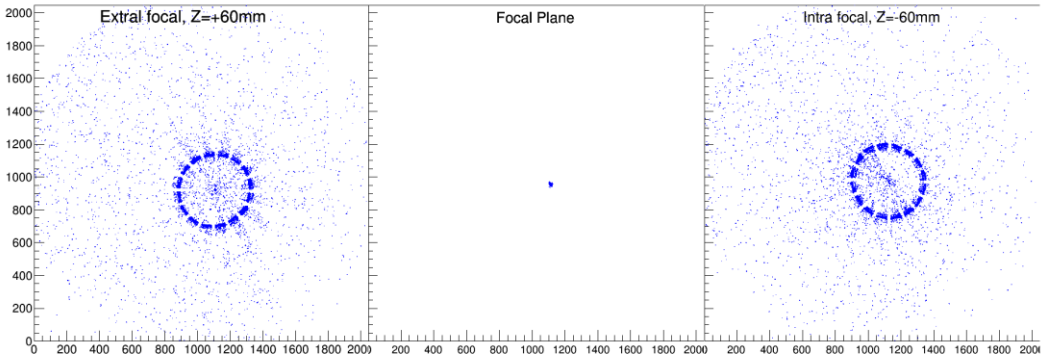
Ag、Mo、Cu、Fe、Cr、Ti、Al、Mg、SiO_2、C，0.3-22keV。



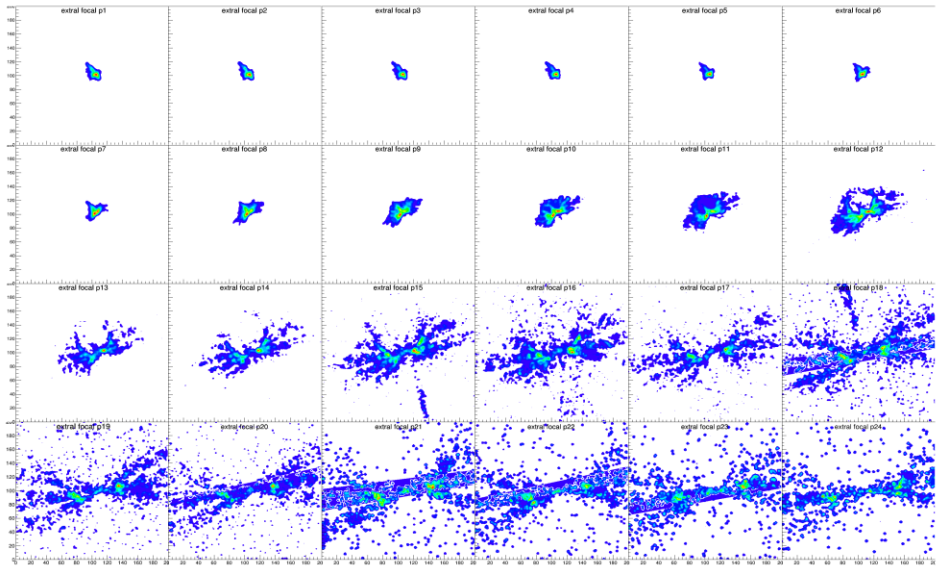


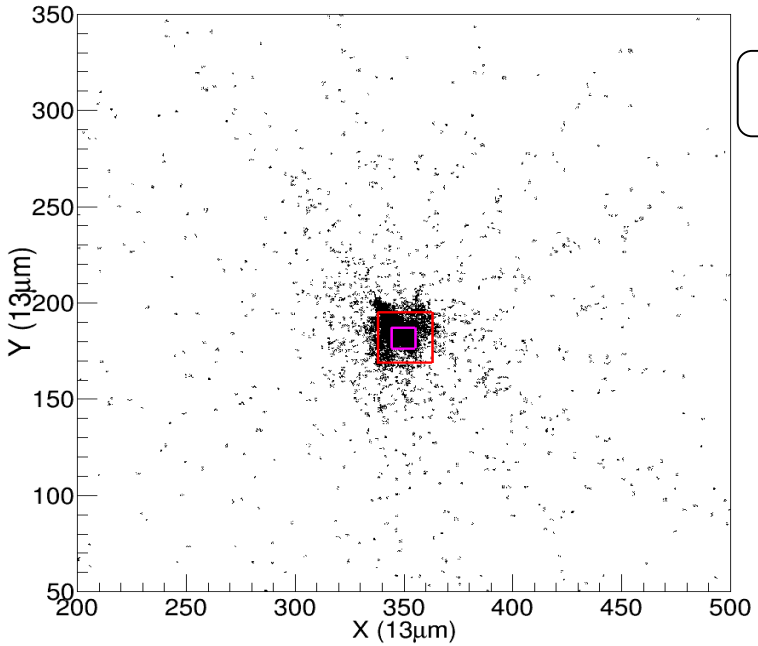
Ground calibration：test result for mirror

X-ray off focus plane

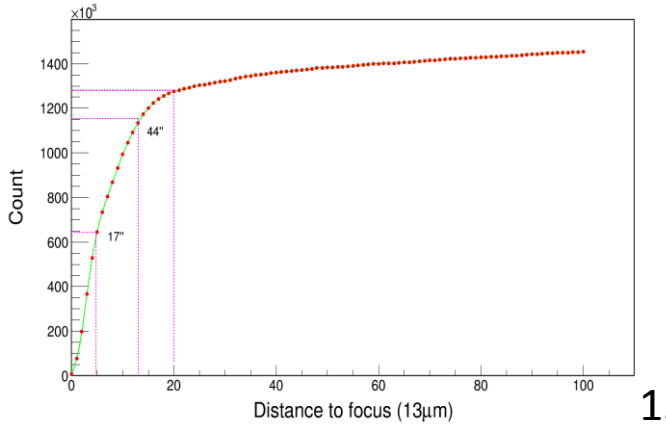


Off axis





Spot image



HPD W90

Calibration plan

- For the Mirrors:

  the on-axis and off-axis PSF shapes and effective areas will be determined at energies ranging from 0.5 keV up to 10 keV.

- For pn CCD:

a) Determine polynomial function relating channel to photon energy.

   determine event grade dependence

   ~10 reference points along the energy axis

a) The energy resolution in the range 0.5 keV to 10 keV will be determined.

b) The pile up effect.

c) Split case.

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  the on-axis and off-axis PSF shapes and effective areas will be determined at energies ranging from 0.5 keV up to 10 keV.

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Thank you