The background image shows a large, industrial X-ray testing facility. A prominent feature is a large, cylindrical, polished metal component, likely a detector or part of a beamline, mounted on a complex metal frame. The facility is dimly lit, with the primary light source being the X-ray beam, which creates a bright, yellowish glow inside the cylindrical component. The overall environment is clean and technical, typical of a high-energy physics laboratory.

The 14th IACHEC Workshop, 2019, Japan

X-ray testing facility at IHEP and Calibration Plans for EP&eXTP

YuSa Wang

2019-5-22



Outline

- 1 X-ray testing facility at IHEP
- 2 X-ray testing of single Wolter I mirror
- 3 FXT ground calibration plan
- 4 eXTP ground calibration plan



Outline

1

X-ray testing facility at IHEP

2

X-ray testing of single Wolter I mirror

3

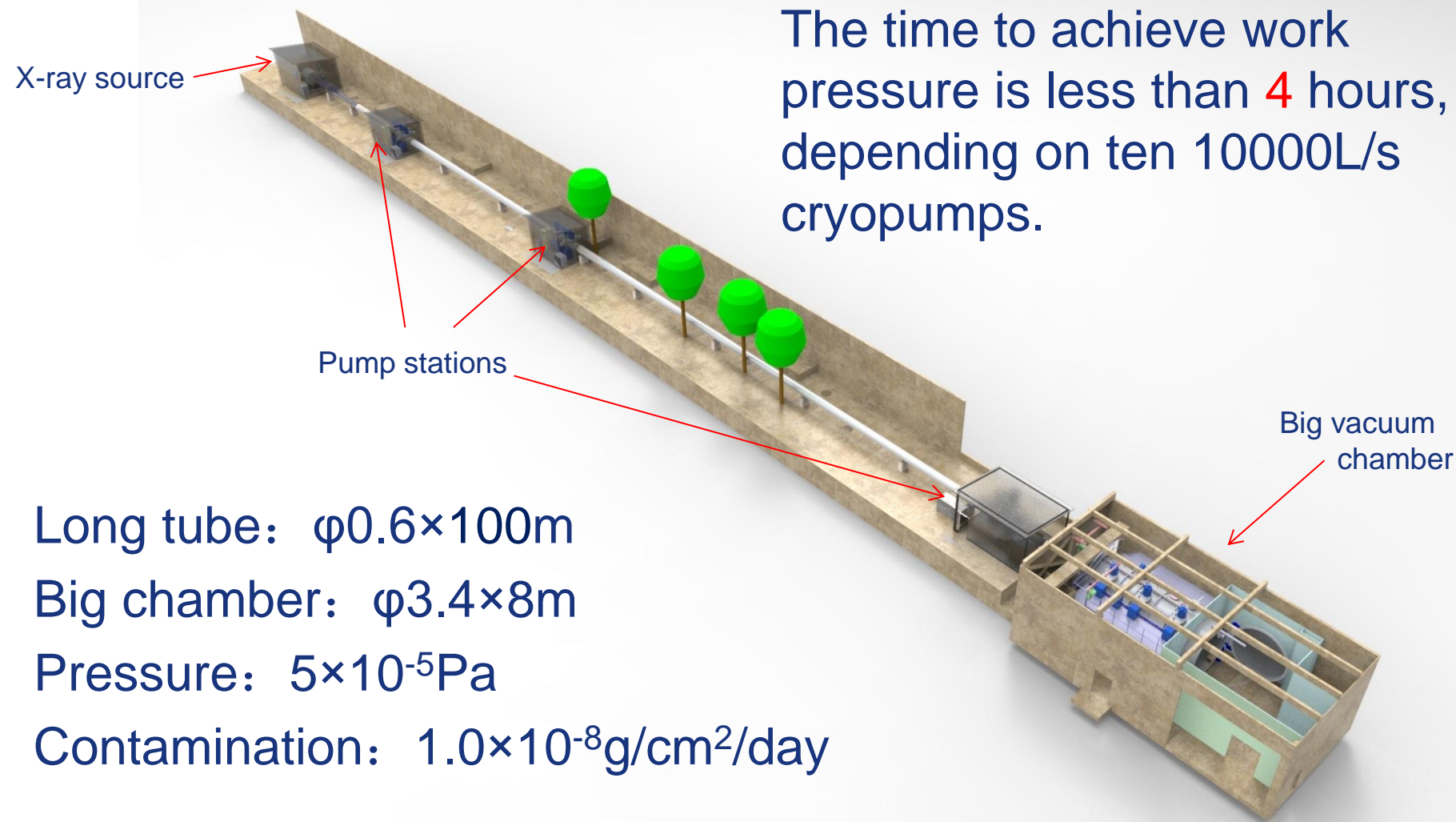
FXT ground calibration plan

4

eXTP ground calibration plan



X-ray testing facility at IHEP: 100m X-ray facility





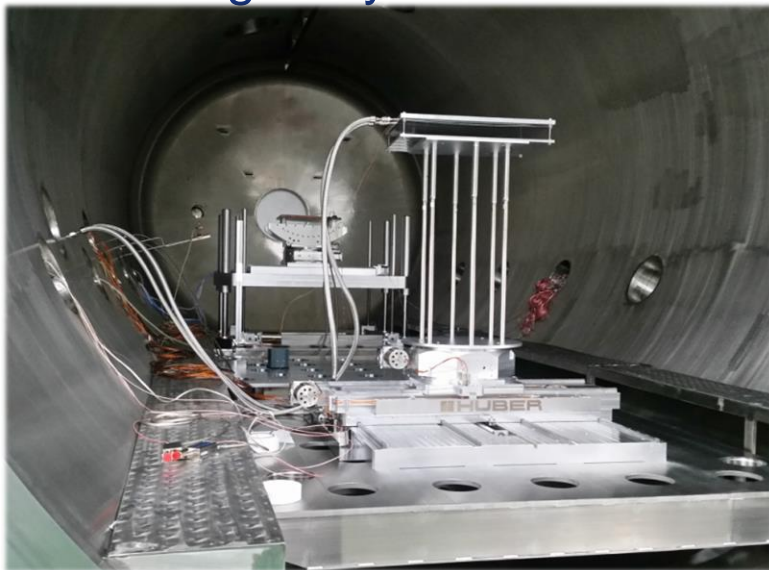
X-ray testing facility at IHEP: 100m X-ray facility



100m long x-ray tube



Big vacuum chamber



Inside big vacuum chamber



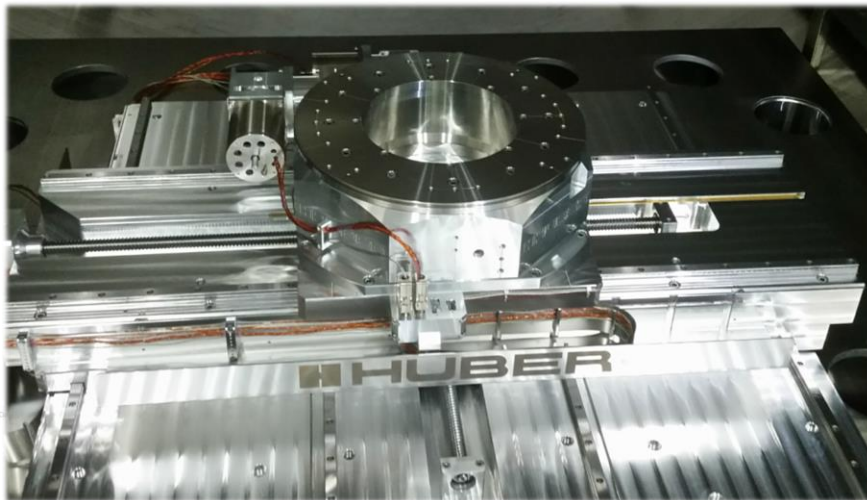
X-ray testing facility at IHEP: 100m X-ray facility

3-D manipulators

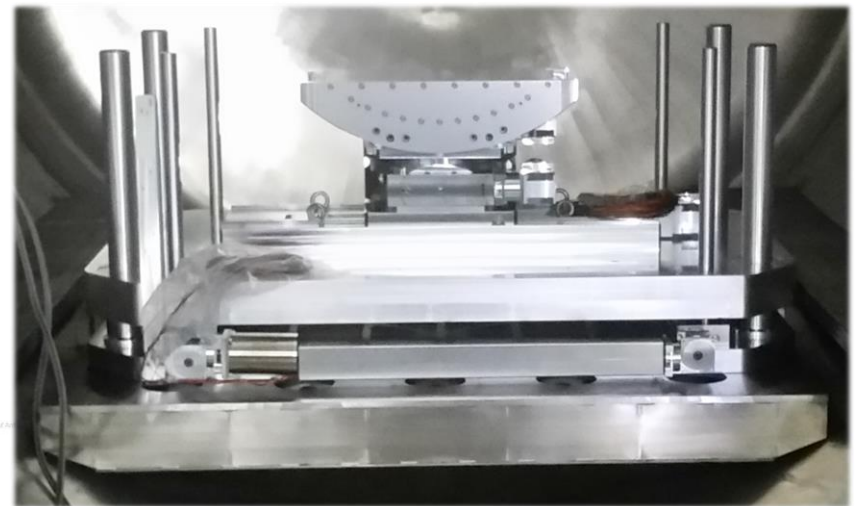
XY travel range[mm]: 800
Travel repeatability: $\pm 5\mu\text{m}$
Travel range[$^{\circ}$]: 360°
Repeatability: $\pm 10''$
Load: 300kg

4-D manipulators

XY travel range[mm]: 800
Travel repeatability: $\pm 5\mu\text{m}$
Travel range[$^{\circ}$]: 360°
Repeatability: $\pm 5''$
Pitch travel range[$^{\circ}$]: $\pm 20^{\circ}$
Repeatability: $\pm 10''$ Load: 200kg



3-D



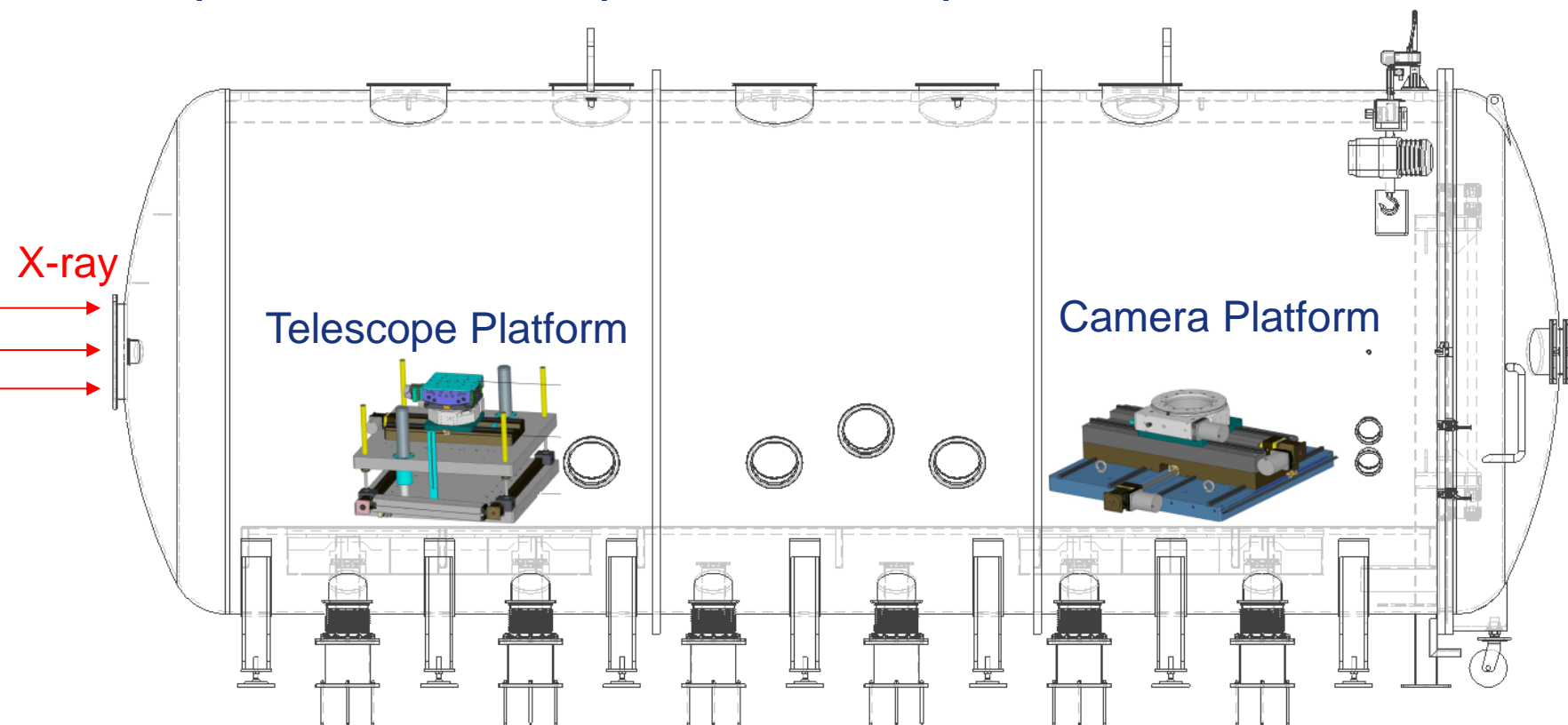
4-D



X-ray testing facility at IHEP: 100m X-ray facility

The SDD, CdTe, X-ray camera and thermal control unit will be placed on the top of 3-D manipulators.

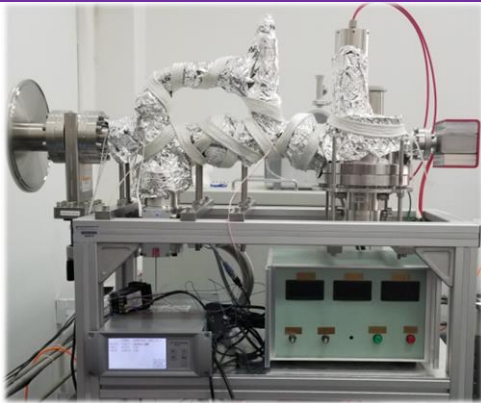
The X-ray optics, electric box and thermal control unit will be placed on the top of 4-D manipulators.





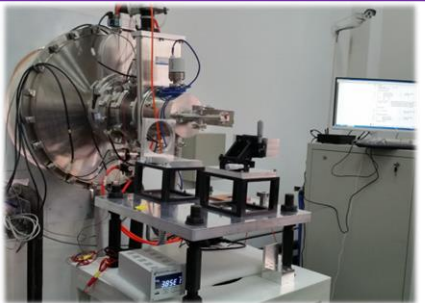
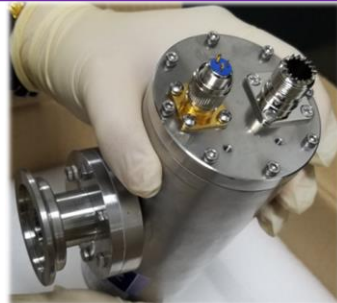
X-ray testing facility at IHEP: 100m X-ray facility

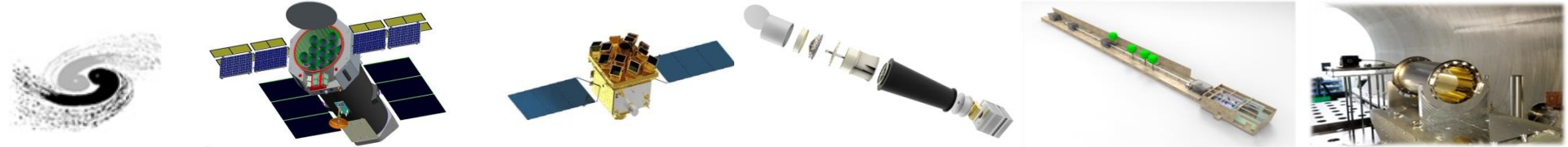
X-ray source: Rigaku 9kW Copper target electron impact source, 1-60keV
Double Crystal Monochromator: 1-40keV, 1% resolution, with Si111, Si100, KAP100.



Multi-target x-ray source with Ag, Mo, Cu, Fe, Cr, Ti, Al, Mg, SiO₂, C, covering the energy from 0.2-20keV.

A modulated x-ray source is available, which can generate a pulsed x-ray for checking the timing performance of detectors. About 0.5us accuracy!





X-ray testing facility at IHEP: 100m X-ray facility

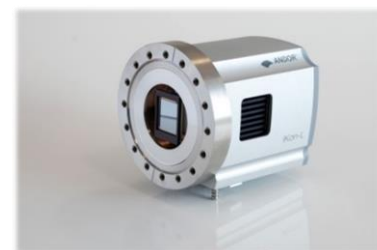
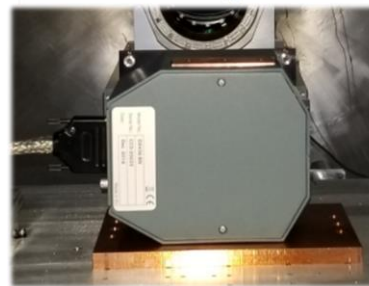
SDD、FastSDD (Be,C1,C2) : 0.2-15keV
Amptek and ketek



CdTe (Cadmium Telluride): 3-250keV,
1.5keV@122keV
Amptek



X-ray camera DX436: 1-15keV; 2048×2048
X-ray camera DX440: 1-15keV; 2048×512



HPGe (Germanium): 3-200keV,
140eV@5.9keV, 550eV@122keV, for QE
calibration(3-60keV).

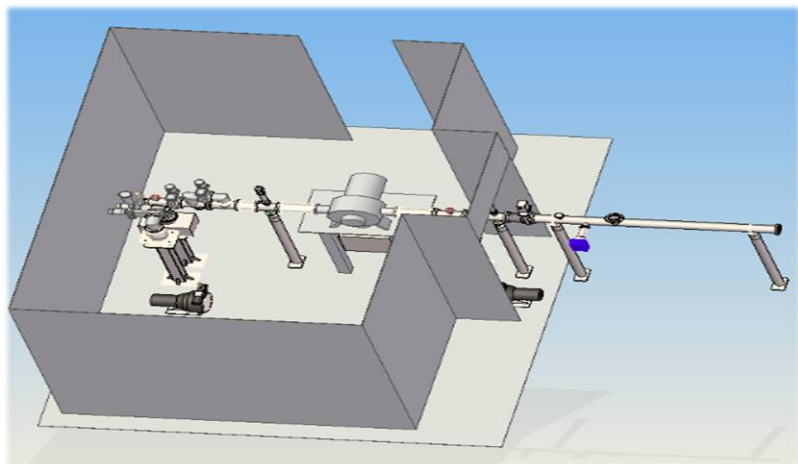




- ✓ This 100m X-ray facility is for the calibration of X-ray optics, including Optics and telescopes of EP&eXTP.
- ✓ There is another 8m x-ray test facility in IHEP, which can meet the testing requirements of x-ray detectors, electronic boxes.

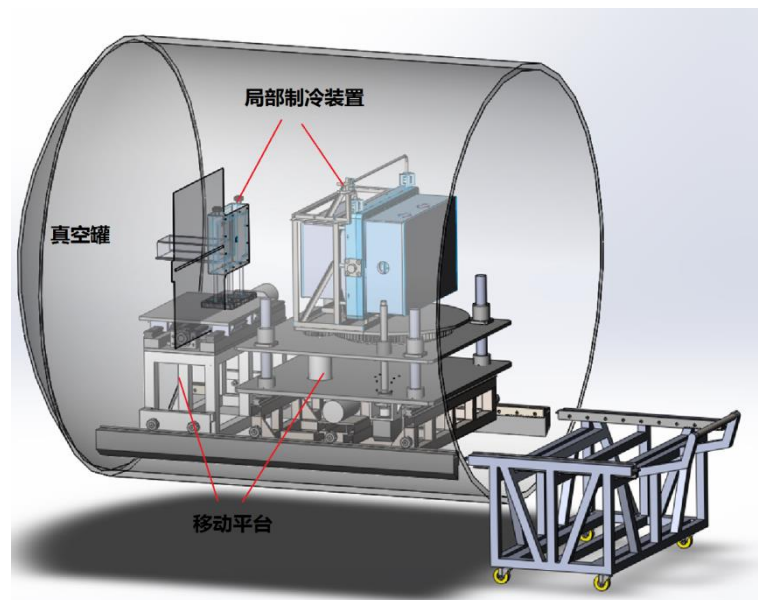


X-ray testing facility at IHEP: 8m X-ray facility



Long tube: $\phi 0.1 \times 8\text{m}$
Vacuum chamber: $\phi 2 \times 2\text{m}$
Pressure: $5 \times 10^{-5}\text{Pa}$
Contamination: $1.0 \times 10^{-8}\text{g/cm}^2/\text{day}$

X-ray energy: 1-30keV
Area: $\phi 0.1\text{m}$
Count: $\sim 100\text{mm}^2/\text{s}$





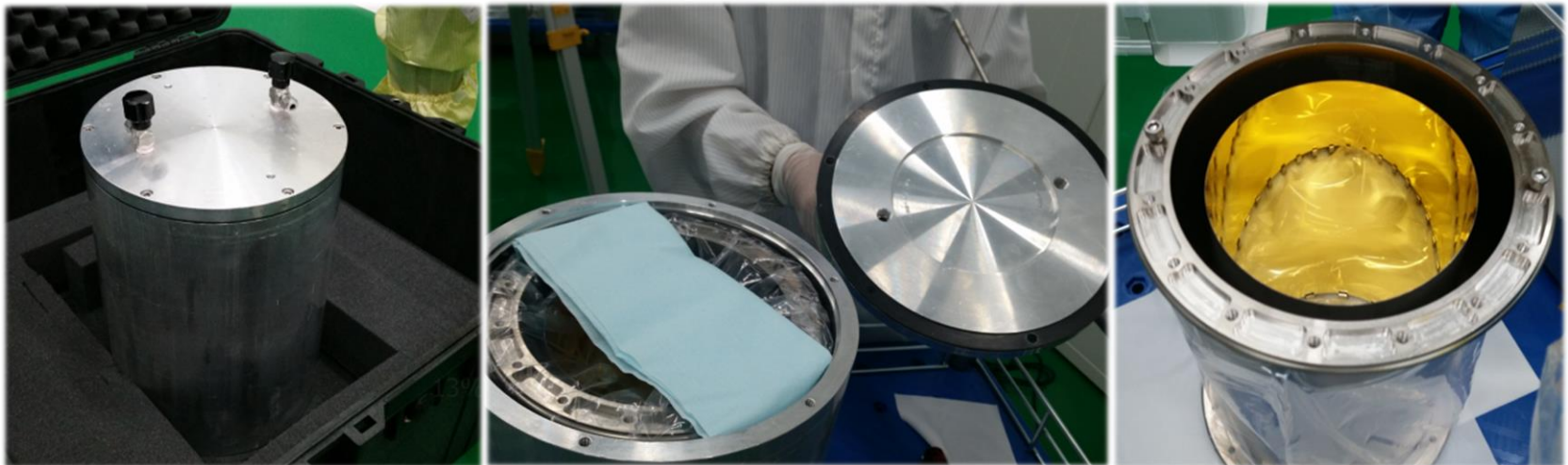
Outline

- 1 X-ray testing facility at IHEP
- 2 X-ray testing of single Wolter I mirror
- 3 FXT ground calibration plan
- 4 eXTP ground calibration plan



Introduction to single shell Wolter-I mirror

A single shell Wolter I mirror was bought from Italy for checking the x-ray beam, also learning the testing method of x-ray mirror.

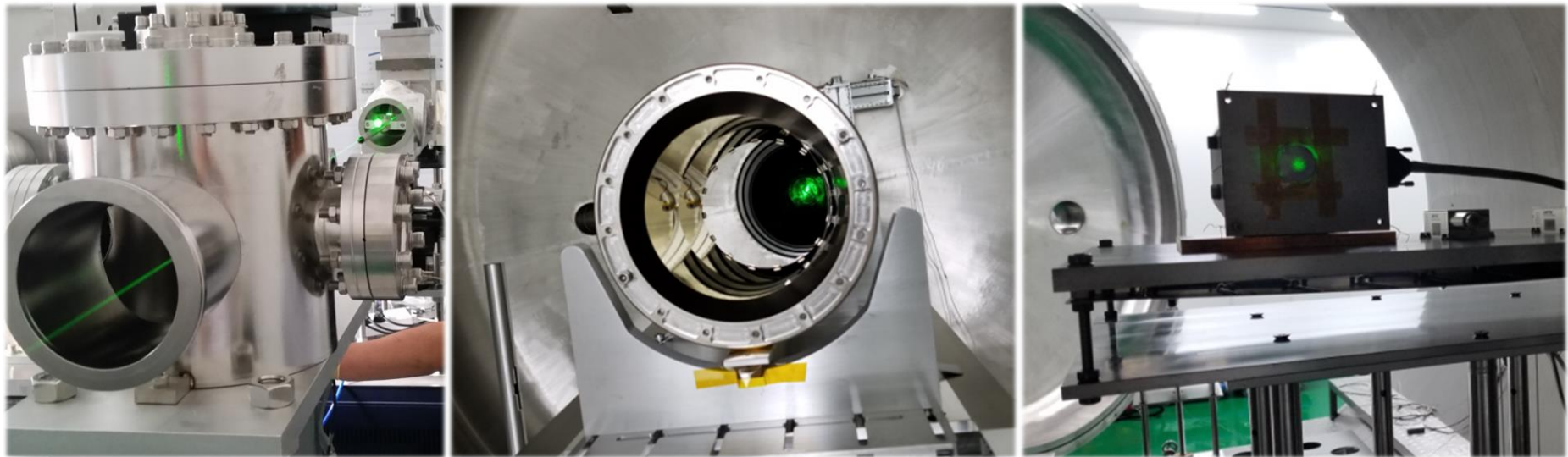


Parameter	Specification
Focal length	1600 mm
Mirror Thickness	0.23 mm
Mirror min diameter	148.01 mm
Mirror middle diameter	159.25 mm
Mirror max diameter	162.94 mm
Mirror leght:	300 mm total, 150 mm parabola and 150 mm hyperbola
Optical coating	Au
PSF (HEW) :	< 15 arcsec at 1.5 keV
Mass of the single shell:	0.303 kg
Total mass of the MM:	3.5 kg



Alignment and focusing with green laser

A green laser with beam expander was used to align mirror and x-ray camera, through the adjustment of 3-D and 4-D manipulators.

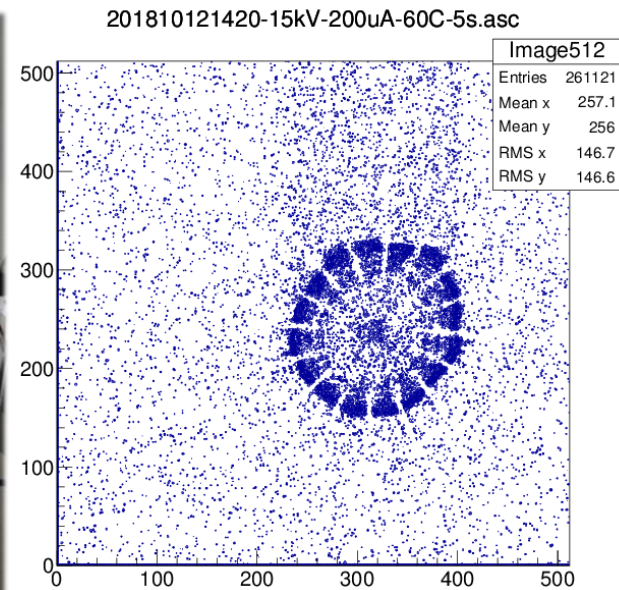
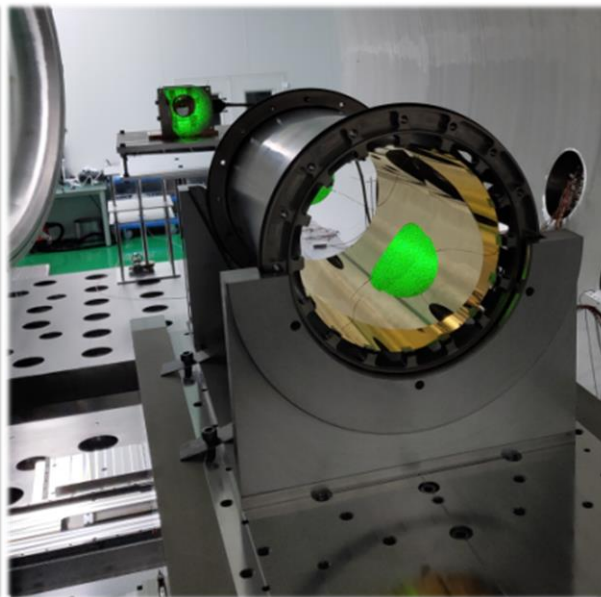
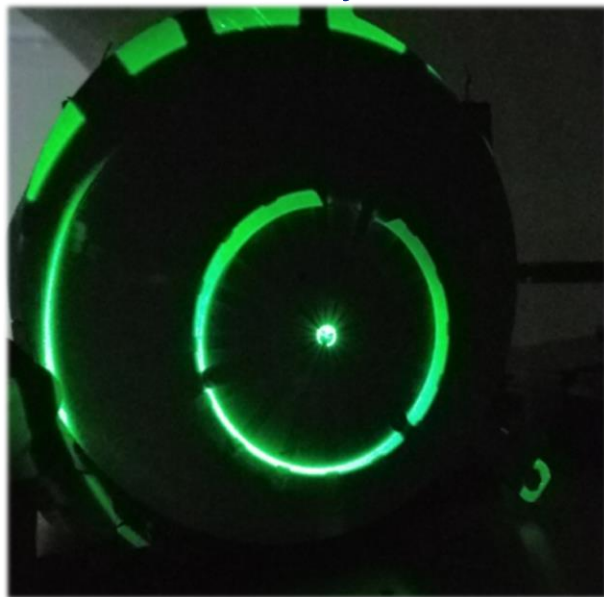


This the first step of alignment.



Alignment and focusing with green laser

Then green laser was also used to focus mirror and x-ray camera, through the adjustment of 3-D and 4-D manipulators. The double reflection focus could be seen on “board”. Then the laser was replaced with a x-ray source.



The expectant x-ray focus(2.9keV) was obtained, without any adjustment of 3-D and 4-D manipulators. This is the first x-ray focus in our 100m x-ray testing facility.



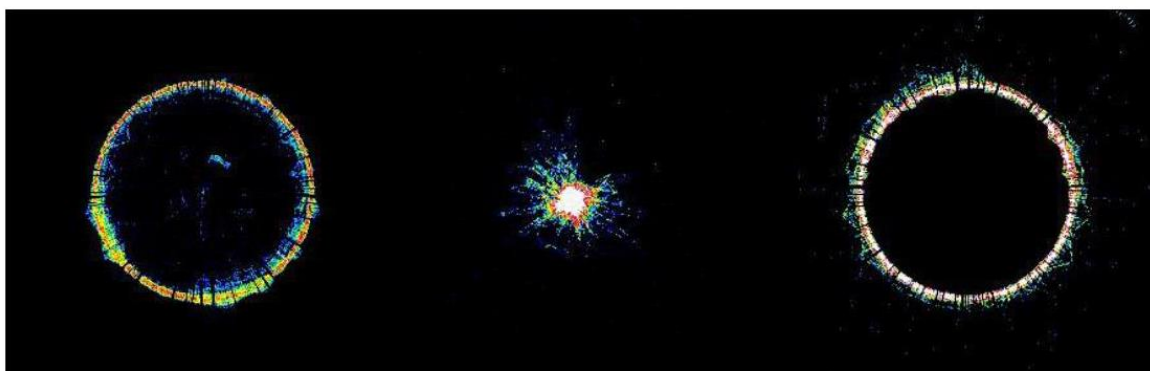
Extra focal/focal/Intra focal images

The focusing result at 100m x-ray testing facility is same to that of MPE PANTER. The best focus profiles at two facilities are not ideal gaus profile.

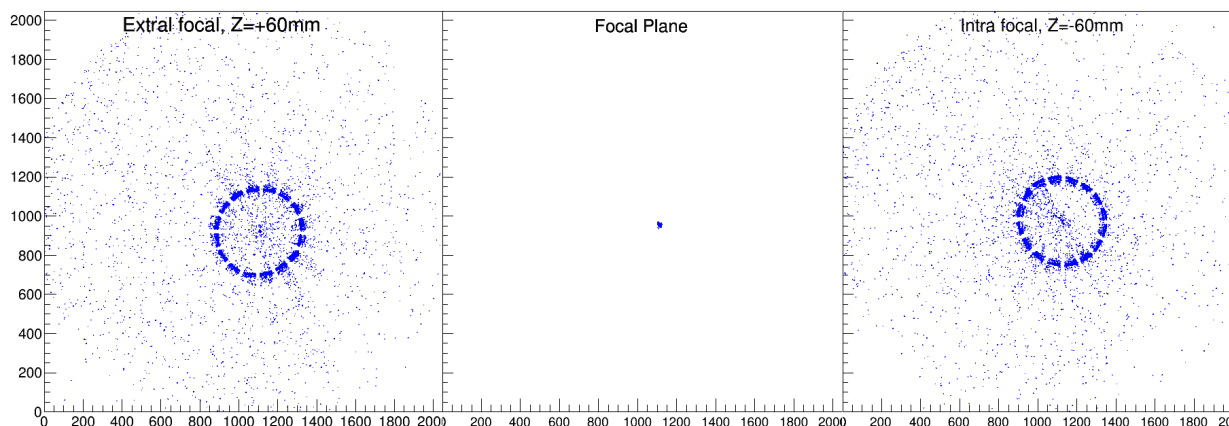
Extra focal, $Z = 60 \text{ mm}$

Focal plane

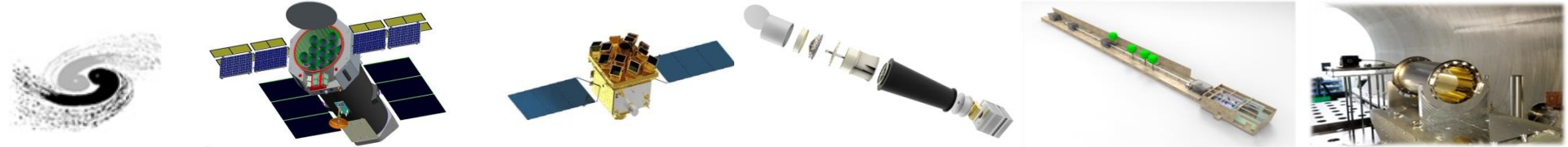
Intra focal, $Z = -60 \text{ mm}$



Results in
MPE PANTER

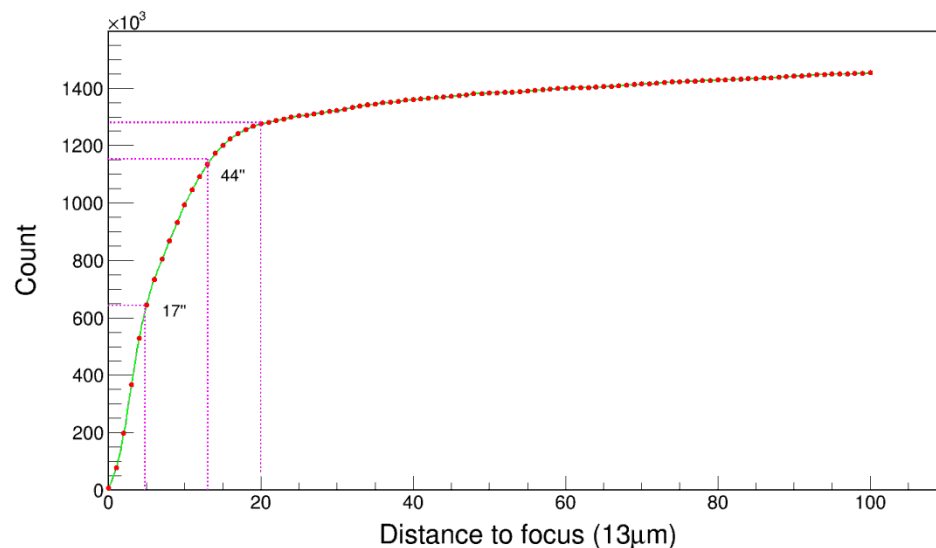
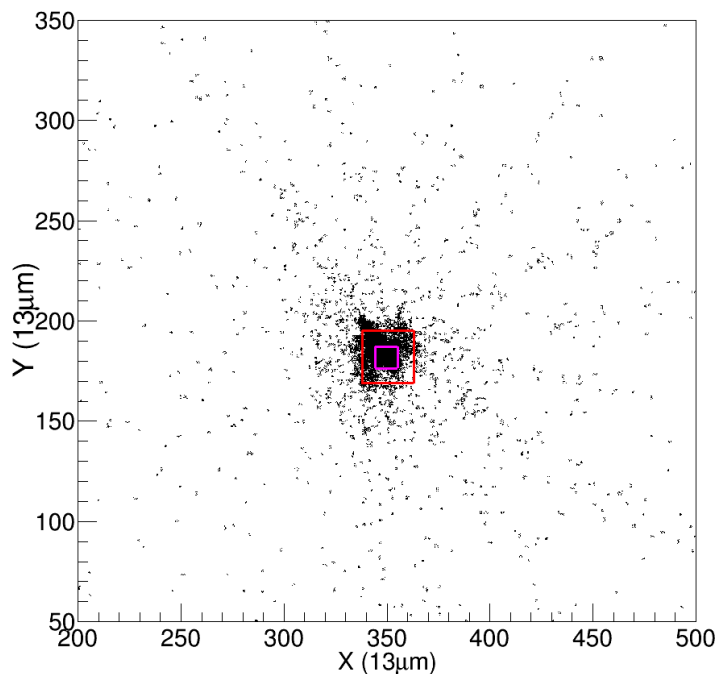


Results in
IHEP x-ray
testing facility



HPD and W90

Since the x-ray split events affect the spectrum and make the selection of needed events difficult. We only select the isolated x-ray events (2.9keV). And we acquired 60 frames for good significance.

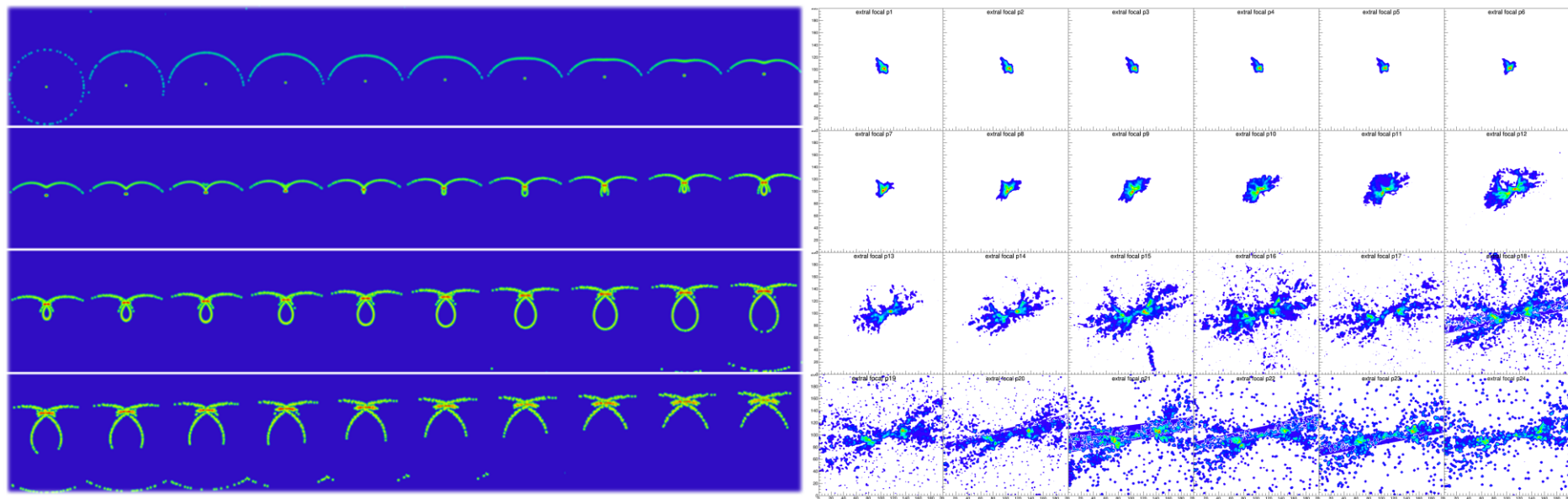


The HPD and W90 is calculated through the values of pixels, so it is the quadrate HPD and W90. The HPD from two facilities are same.



Off axis testing

We rotated the mirror for checking the performance of off-axis, without a whole rotation of mirror and camera.



The off-axis results from testing are similar to the simulated results from ray-tracing software. We are designing the big adjusted manipulator for future general off-axis test.



Outline

- 1 X-ray testing facility at IHEP
- 2 X-ray testing of single Wolter I mirror
- 3 **FXT ground calibration plan**
- 4 eXTP ground calibration plan



FXT ground calibration plan: Small team



Yusa WANG

STAFF,
responsible
for test and
calibration of
x-ray detector
and optics



Can CHEN

Student,
Timing and
polarization
test and
calibration



ZiJian ZHAO

Student,
Optical
simulation &
alignment of
telescope



DongJie HOU

New staff,
DCM,
absorption
edge and
absolute QE



XiongTao YANG

New staff,
Integration,
cleanness
control and
management

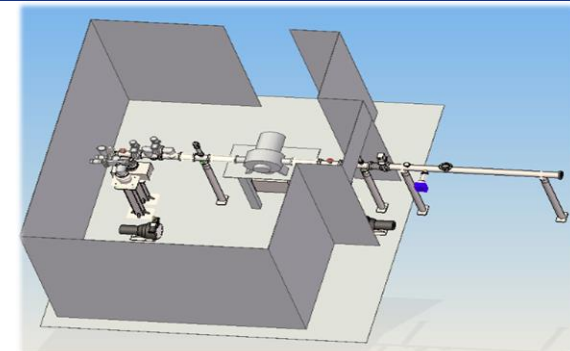
Small team for the Timing, Spectroscopy, QE, Polarization of
x-ray detectors and optics.



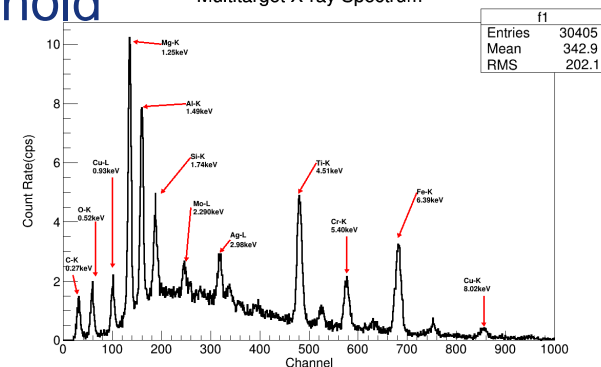
FXT ground calibration plan: focal plane camera

pnCCD test and calibration at 8m facility:

- Performance under higher temperature (-30~-80°C)
- Energy response (0.3-12keV) and low energy threshold
- Energy resolution and time resolution using multi-target source and grid electrode x-ray source
- Pile-up and split events between multi-pixels
- The program of calculating the center of focus

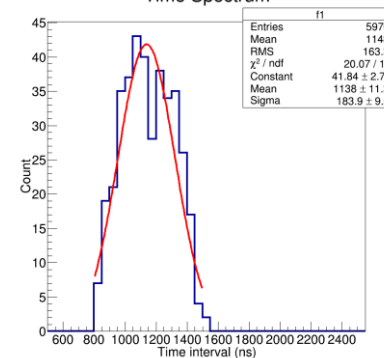


Multitarget X-ray Spectrum



f1	
Entries	30405
Mean	342.9
RMS	202.1

Time Spectrum

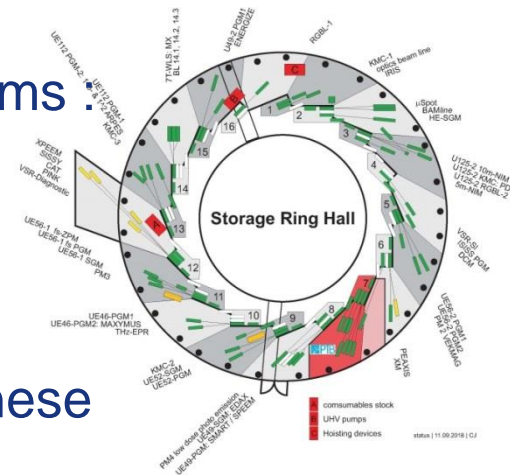




FXT ground calibration plan: focal plane camera

Test and calibration at Chinese synchrotron radiation beams

- The standard x-ray detector will be calibrated by PTB.
- pnCCD QE measurement could be completed on Chinese synchrotron radiation beams or DCM at IHEP.
- Transmission of kinds of filters.





FXT ground calibration plan: mirror modules

Under the cooperation agreement, the most FXT mirrors will be tested at MPE PANTER. Only the FM will be tested at IHEP

At that moment, we will repeat the testing at PANTER, and knowing well the performance of mirror assembly.

- Field view and PSF;
- HPD at Mg-K, Al-K, Cu-K, C-K;
- Effective area at Al-K;
- Focal length for integration;
- Off-axis performance;

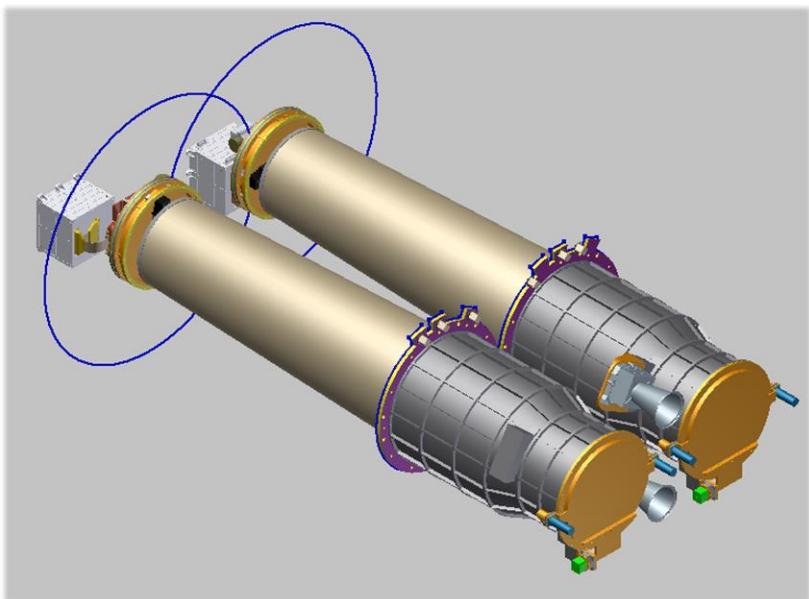


Figure from MPE



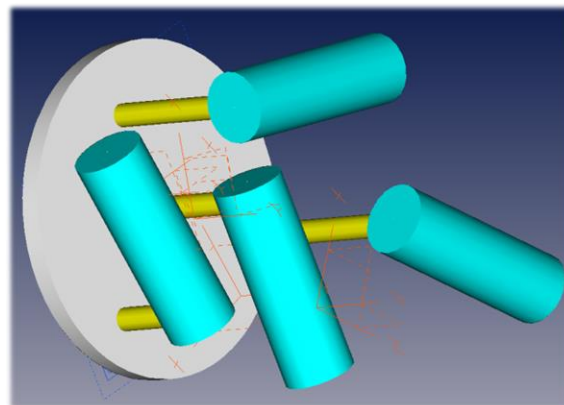
FXT ground calibration plan: telescopes

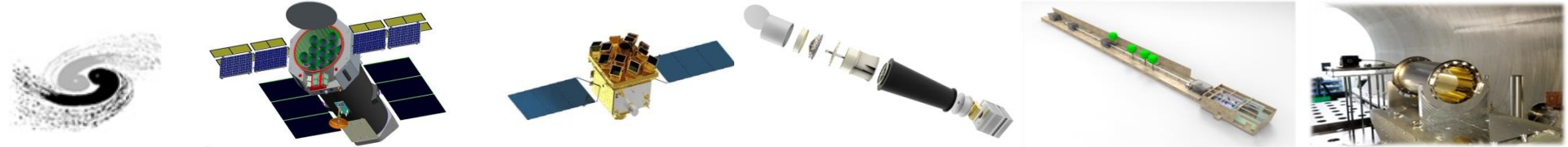
The whole FXT will do the end-to-end in our facility one by one, checking every function and performance for several times.



- Field of view and PSF;
- HPD at Mg-K, Al-K, Cu-K, C-K;
- Effective area at Al-K;
- Focal length confirmation;
- Off-axis performance;
- The program of calculating the center of focus, estimating the position accuracy;
- Estimation of visible light under different combination of filters.

For the check of the calculation of the x-ray source and the mode exchange under different observations. We are designing a **simulator** with four x-ray sources: the point strong source, timing point source, movable point source and diffused source.





Outline

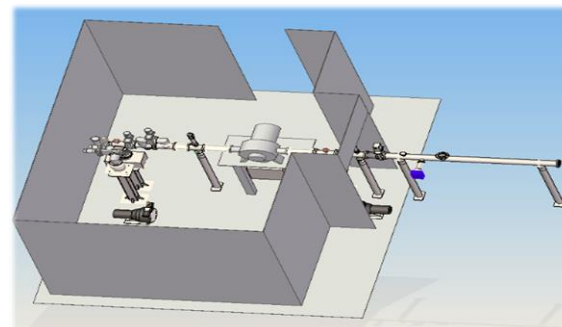
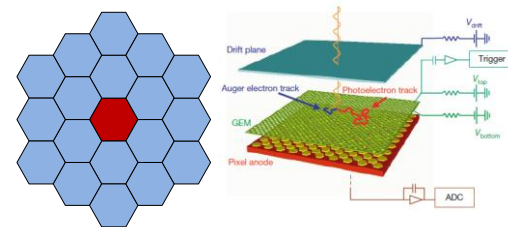
- 1 X-ray testing facility at IHEP
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- 4 eXTP ground calibration plan



Consideration of eXTP calibration-SFA&PFA FPD

SFA&PFA FPD at 8m facility

- Performance under low temperature
- Energy response (0.3-12keV) and low energy threshold
- Energy resolution
- Time accuracy and time resolution
- Split events between cells and optimization
- The effect of electron on SDD&GPD
- Checking the polarization performance
- Performance of background rejection with multi-cells



SFA&PFA FPD at Chinese synchrotron light source

- SDD&GPD QE measurement
- Transmission of kinds of filters

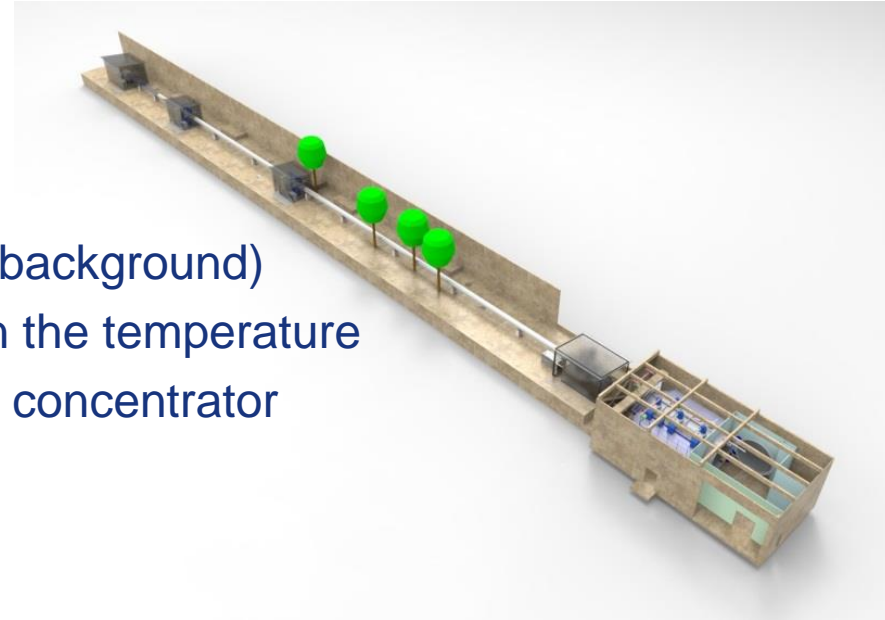
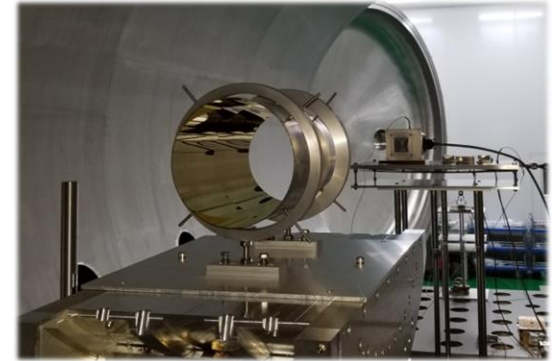




Consideration of eXTP calibration-SFA&PFA optics

SFA&PFA optics at 100m facility

- Field of view and PSF
- HPD at Mg-K, Al-K, Cu-K, C-K
- Effective area at Al-K, Cu-K
- Measurement of focal length
- Off-axis performance
- Optical axis alignment
- Checking the performance of stray light(background)
- The performance of mirror depending on the temperature
- W90 for checking the performance, as a concentrator



SFA&PFA optics at other facilities

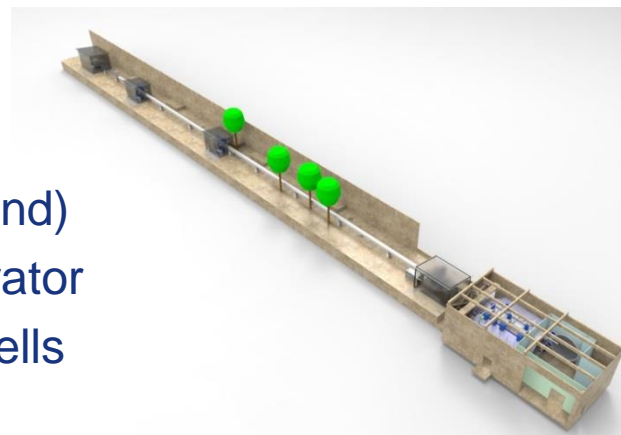
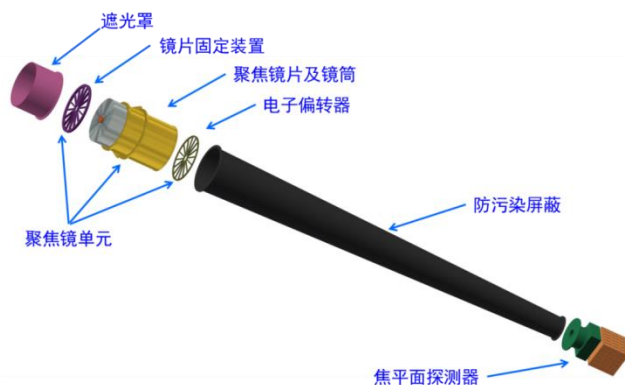
- Proton irradiation



Consideration of eXTP calibration-SFA&PFA telescope

SFA&PFA at 100m facility

- Field of view and PSF
- HPD at Mg-K, Al-K, Cu-K, C-K
- Effective area at Al-K, Cu-K
- Measurement of focal length
- Off-axis performance
- Optical axis alignment
- Time accuracy and time resolution
- The performance of electron deflector
- Checking the performance of stray light(background)
- W90 for checking the performance, as a concentrator
- Performance of background rejection with multi-cells
- Checking the polarization performance



The SFA&PFA will do the end-to-end at 100m facility, checking every function and performance one by one.



Thank you! ■