

WXT developments and status of commissioning



SITP



NAOC



NNVT



- 1 Development of WXT
- 2 Ground tests of WXT
- 3 In-orbit tests of WXT

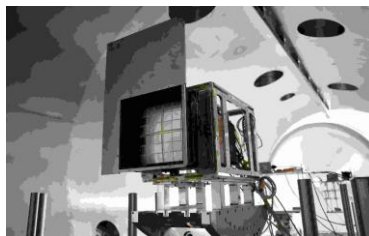
1.

Developments of flight modules

Milestones



2021/11/8~2022/10/19
CMOS ready



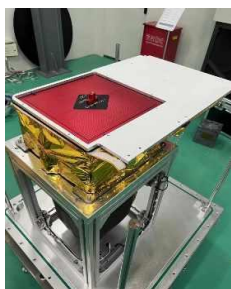
2022/8/19~2022/8/25
FM1 E2E calibration

2022/7/27
LEIA with SY-01
Launched



2022/3/11
Passed WXT FM
design review

2022/4/30~2023/3/28
MPO optics assemblies ready



2022/12/8 FM1, 2, 3,4
2023/2/15 FM6, 7, 8, 9
2023/4/23 FM5, 10,11,12
Modules thermal tests



2023/6/12
Completed 12 sets of module
integration tests and delivered

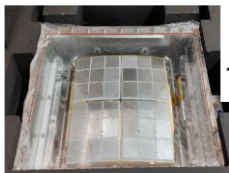
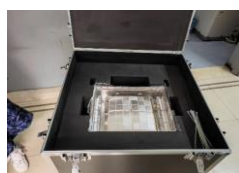


2022/4/30~2023/4/11
12 sets of modules ready



2023/5/11~2023/5/22
FM5 E2E calibration
2023/5/22~2023/5/29
FM11 E2E calibration

2023/6/24
Completed WXT satellite AIT



1. Development of WXT

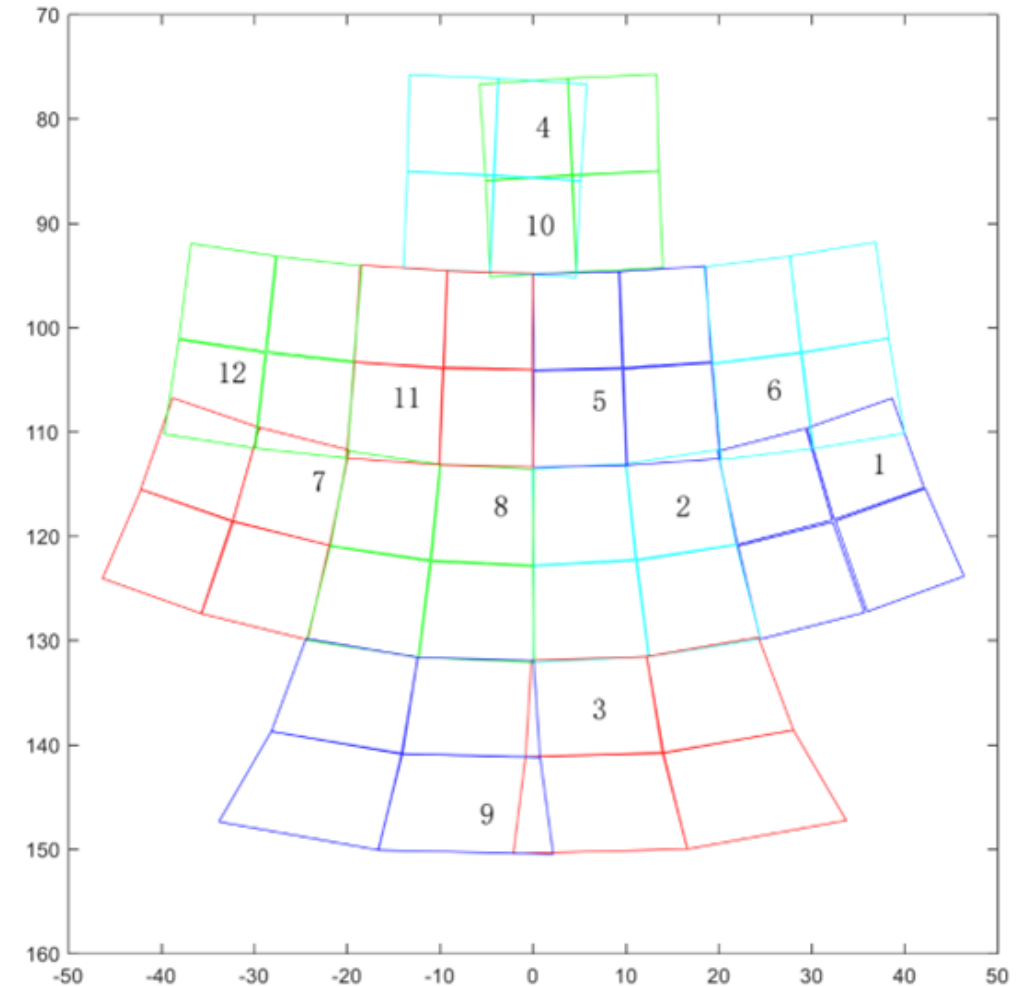
Payload Performance (ground test)

No.	Item	Specifications	Performances
1	Total FOV	> 3600 square degree	3850 square degree
2	Focal Length	375 mm \pm 2%	373.9~382.25 mm
3	Angular Resolution	\leq 5 arcmin @ 1keV	<5 arcmin @ 1 keV
4	Position Accuracy	\leq 1 arcmin (Detector coordinate system)	58 arcsec
5	Energy Range	0.5~4 keV	0.5~4 KeV
6	Time Resolution	\leq 0.05 s	0.04991~0.04995 s
7	Energy Resolution	\leq 170 eV @ 1.25 keV	< 150 eV @ 1.25 keV
8	Digitalizing bit	12 bit	12 bit
9	Trigger Threshold	10 mCrab (10 minute integration)	2.8 mCrab (10 minute integration)
10	Total Mass	\leq 294 Kg	283.86 Kg
11	Total Power	\leq 479 W (Average) \leq 637 W (Peak)	469 W (Average) 627 W (Peak)

1. Development of WXT

Optical Subsystem

12 optics assemblies
(FM5 calibrated at MPE)



Sketch of WXT FOV
configuration

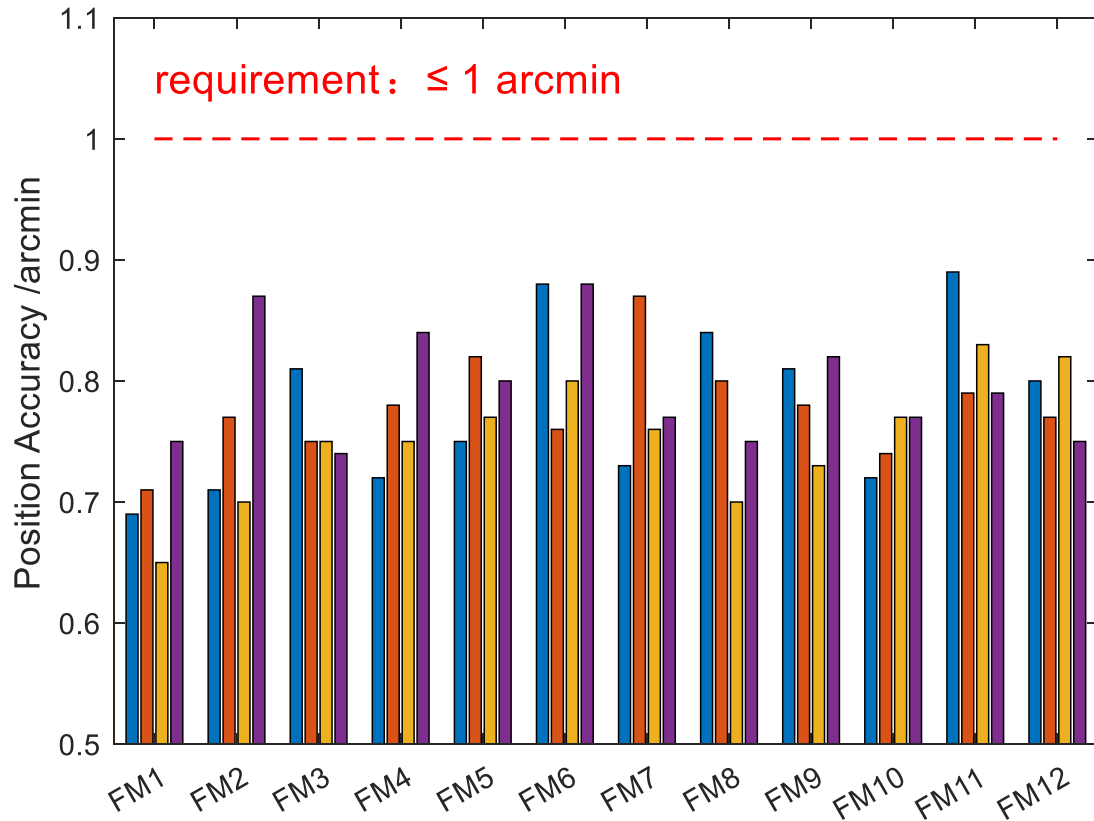
1. Development of WXT

Optical Subsystem

■ Performance of optics Assemblies on ground *Achieve the requirements*

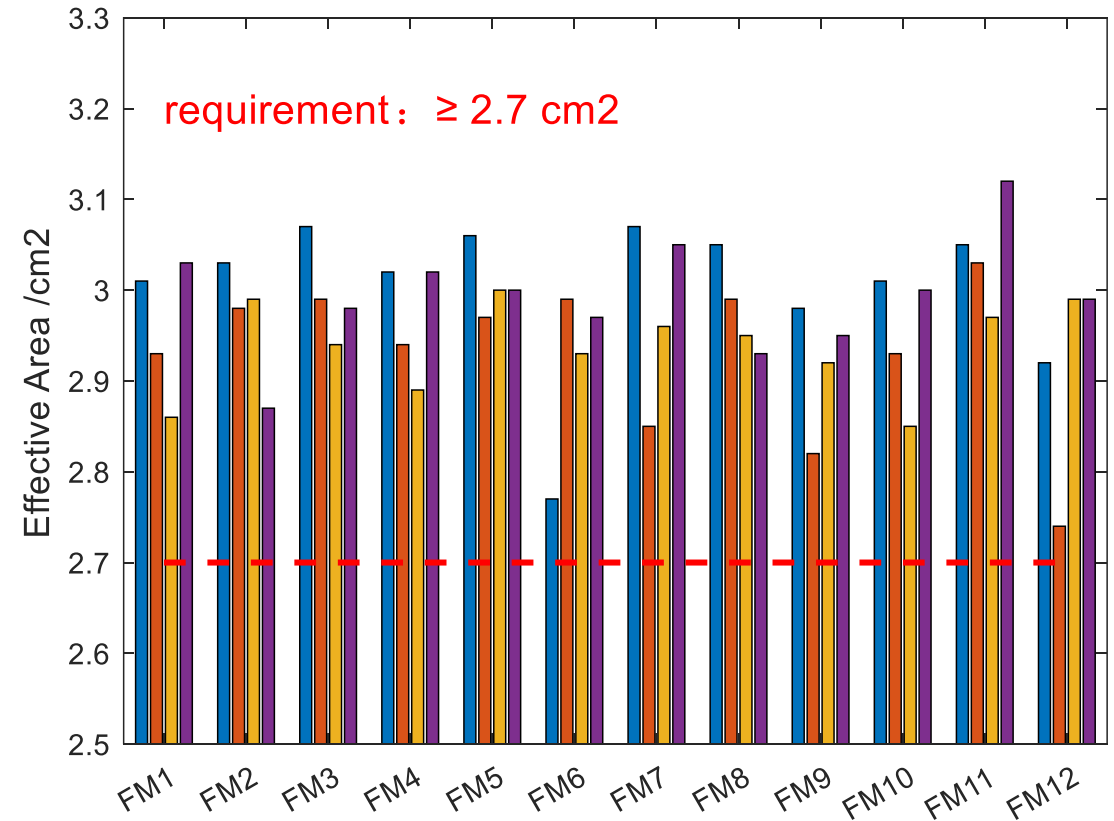
Pointing Accuracy ≤ 1 arcmin

Position Accuracy of 4 sections
for 12 sets of MPO assemblies



Effective Area ≥ 2.7 cm² @ 1 keV

Effective Area of 4 sections
for 12 sets of MPO assemblies

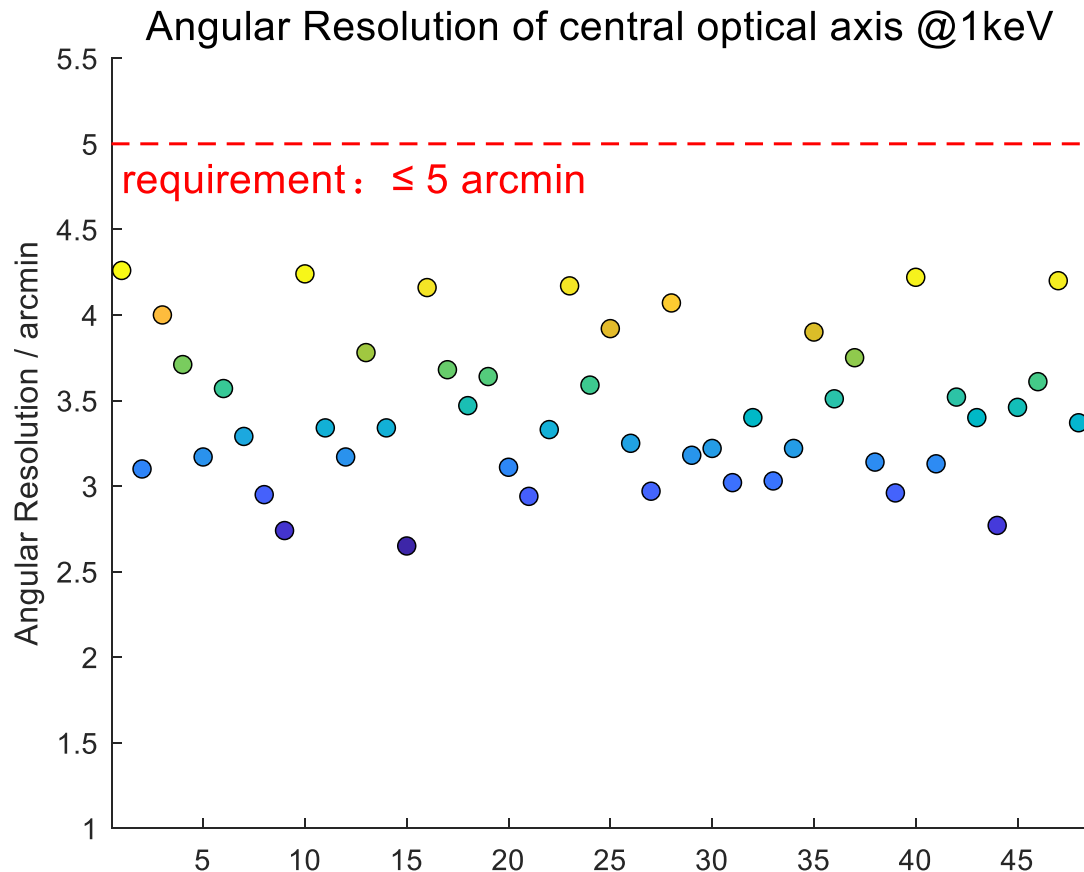


1. Development of WXT

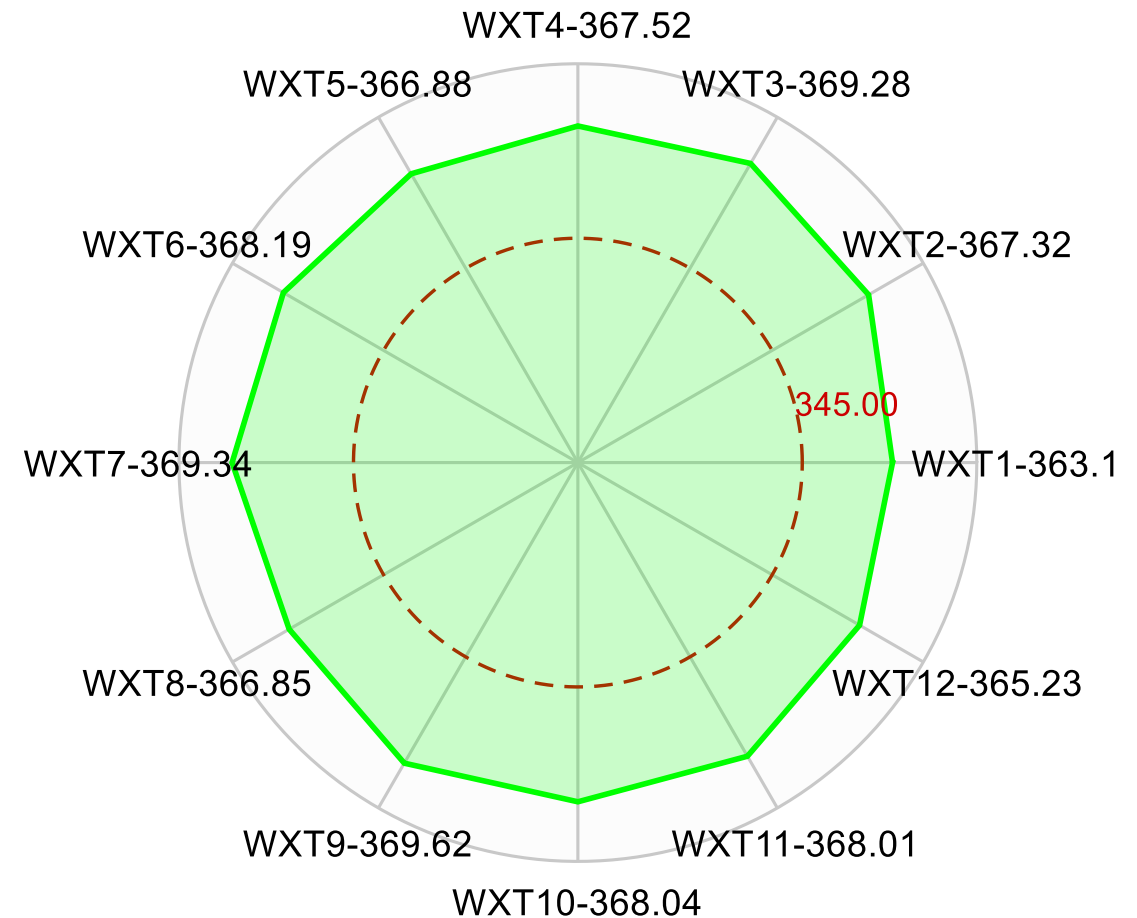
Optical Subsystem ground test

Meet the requirements

Central optical axis for each section



FOV for each module



2. Ground tests of WXT

Thermal tests

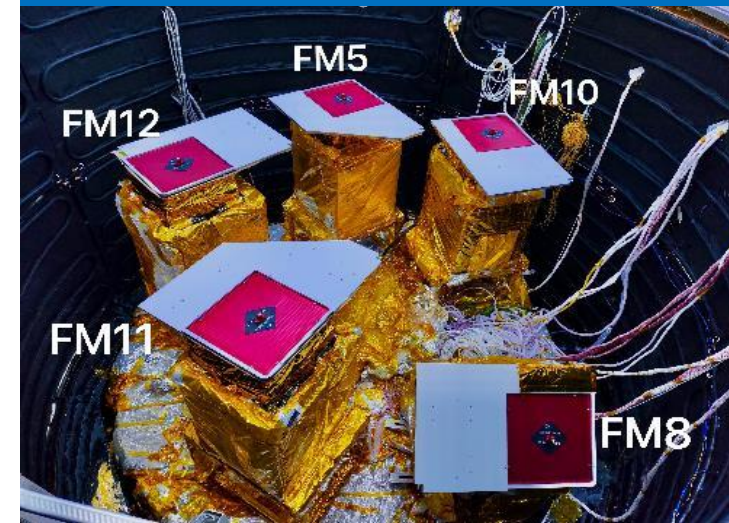
2022.11.30-2022.12.08



2023.02.15-2023.02.28



2023.04.2-2023.04.23



Total power of Thermal system

Mode	Average		Peak	
	requirement	measurement	requirement	measurement
Low temperature	≤ 130 W	122.28 W	≤ 288 W	240 W
High temperature	≤ 130 W	43.32 W	≤ 288 W	120 W
Safety (Simulation)	≤ 148 W	107.4 W	\	\
Bake (Simulation) (2 bake+10 safety)	≤ 450 W	368.2 W	≤ 450 W	444 W

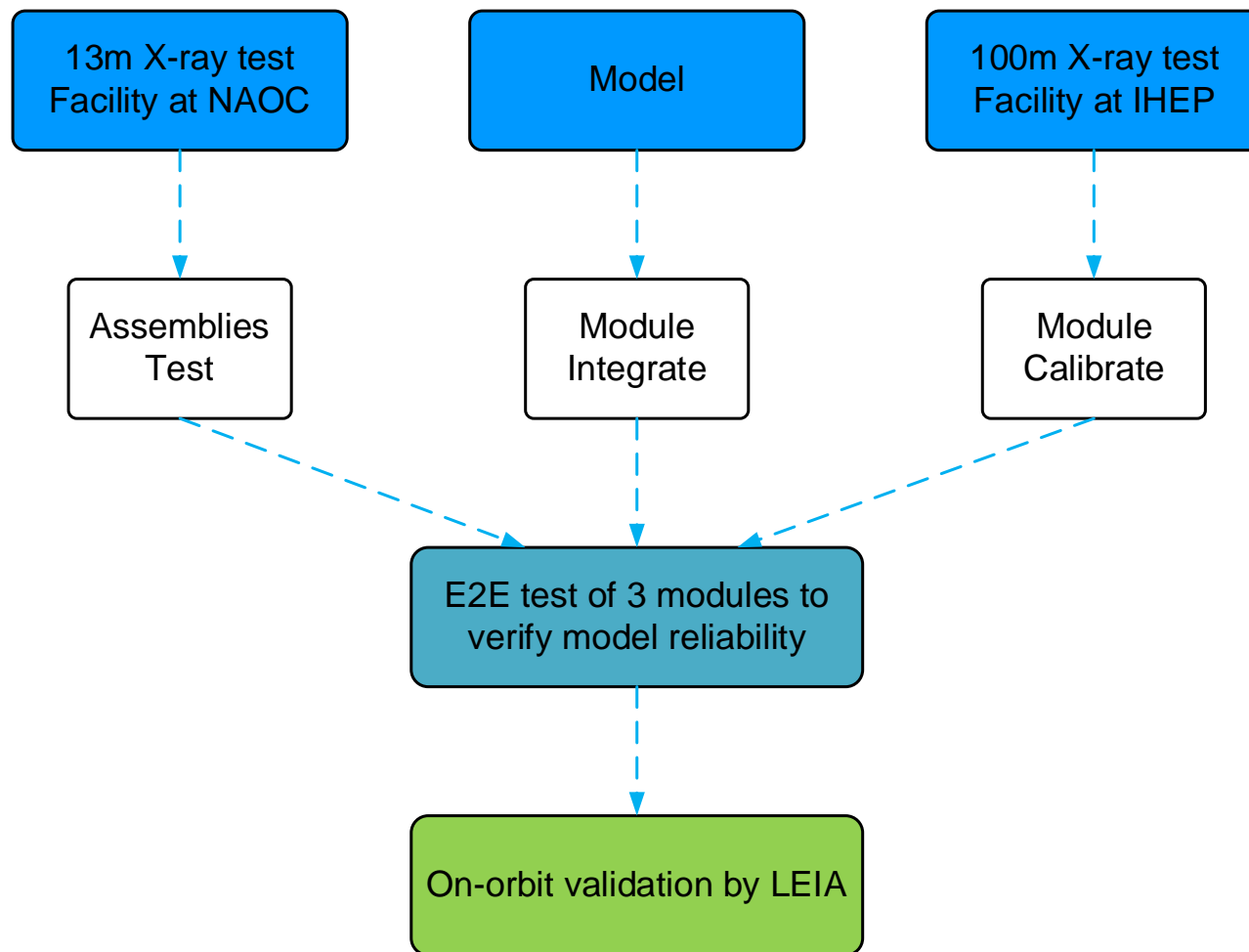
Temperature of each component in thermal tests

Component	Baking Mode		Safety Mode (120min)		Working Mode	
	requirement	measurement	requirement	measurement	requirement	measurement
Optics	15~20 °C	15.11~15.52 °C	0~30 °C	1.81~5.65 °C	6±2 °C	4.1~7.8 °C
Detector	-5~10 °C	-4.92~-4.78 °C	-40~25 °C	-39.15~-34.52 °C	Low: -33°C±2°C High: -27±3°C	Low: -34.96~-31.1 High: -29.56~-24.14
Front electronics	-30~45 °C	11.5~11.52 °C	-30~45 °C	5.52~22.29 °C	-15~30 °C	18~26 °C
Main structure	5~25 °C	13.66~13.7 °C	-30~30 °C	3.52~16.38 °C	5~30 °C	12~20.72 °C

Meet the requirements

2. Ground tests of WXT

Calibration program

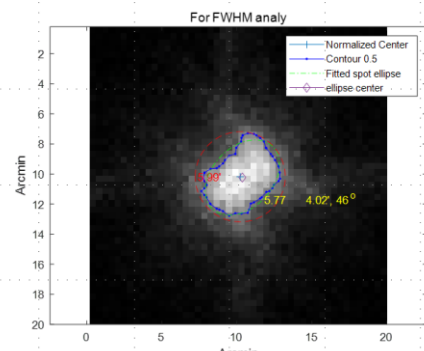
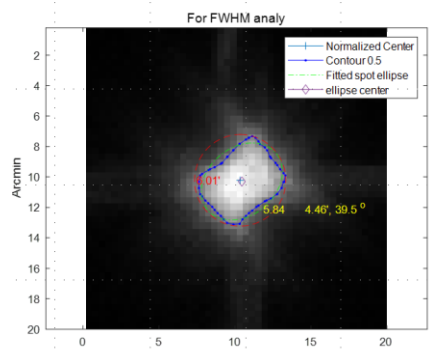
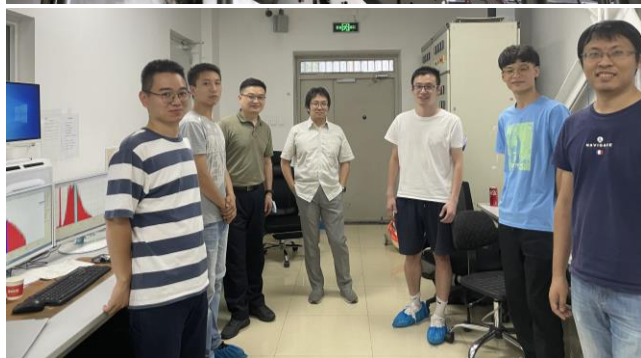
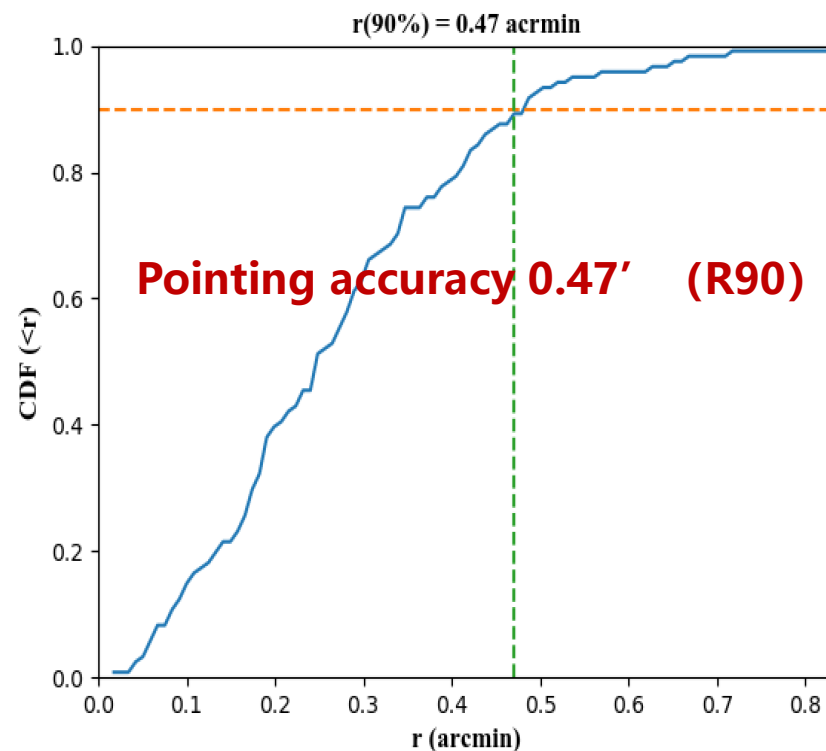
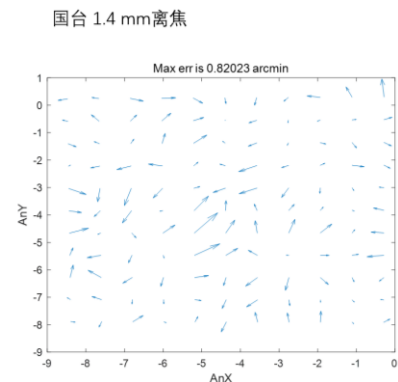
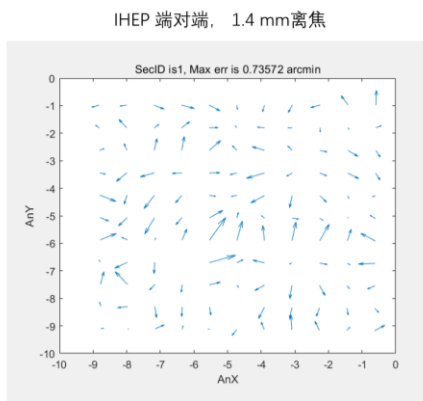
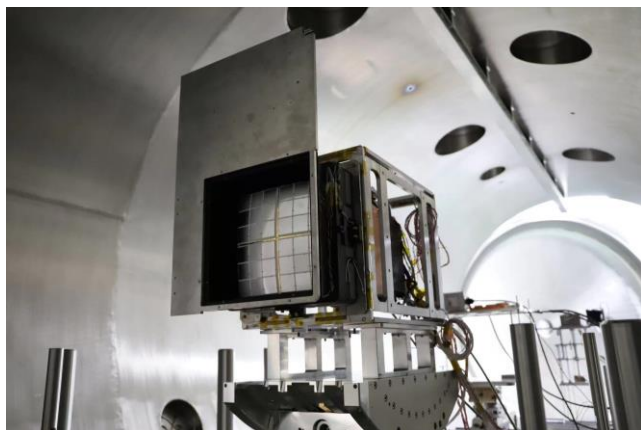


- Assembly and device calibration: 12 optics assemblies and 48 CMOS devices.
- Calibration database: established with integration and component-level calibration data.
- FM1, FM5, FM11: End-to-end calibration.

2. Ground tests of WXT

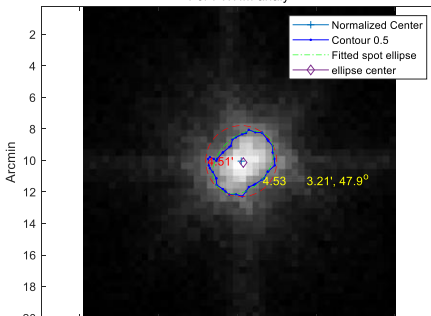
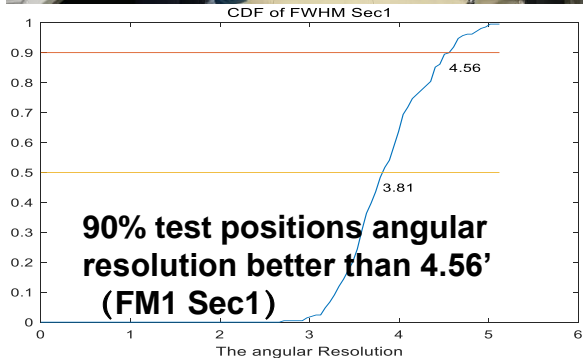
E2E alibration test

◆ FM1 E2E test (2022.8.19~8.25)



IHEP End2End, 1.4 mm off focus

NAOC, 1.4 mm Off focus

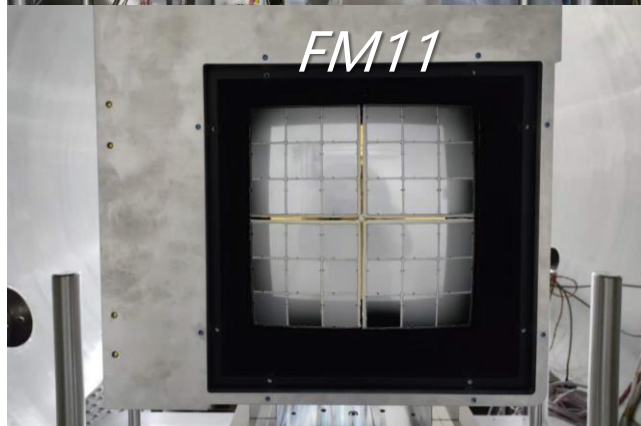


test performance are consistent with model simulation results

2. Ground tests of WXT

E2E alibration test

◆ FM5 E2E test (2023.5.10~5.22) FM11 E2E test (2023.5.22~5.29)



FM5 test items

Expld	Target	Scanning mode
2	Mg-K 1.25keV	Center Exposure
11	Mg-K 1.25keV	11×11 spatial response
31	Cu-L 0.93keV	3×3 effective area test
33	Ti-K 4.51keV	3×3 effective area test
34	Si-Ka 1.74keV	3×3 effective area test
35	Ag-L 2.98keV	3×3 effective area test
37	O-K 0.53keV	3×3 effective area test

FM11 test items

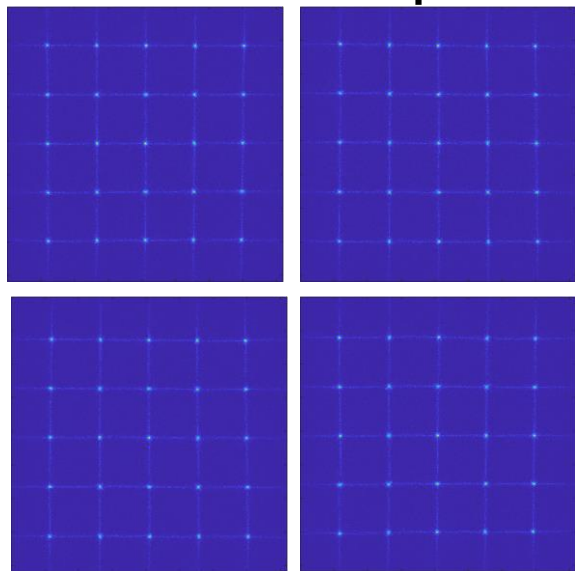
Expld	Target	Scanning mode
2	Mg-K 1.25keV	Center Exposure
11	Mg-K 1.25keV	11×11 spatial response



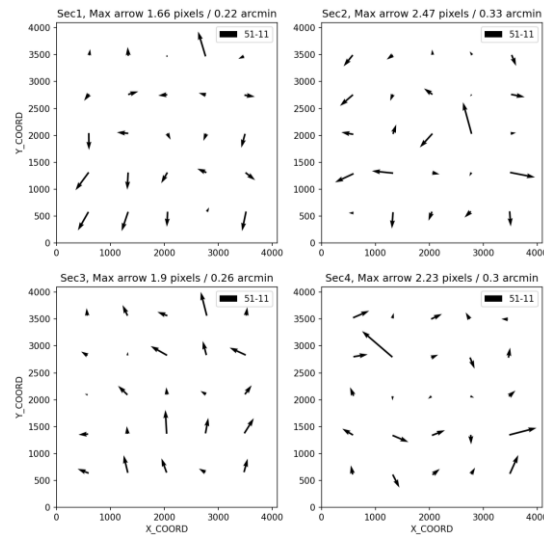
2. Ground tests of WXT

Thermal-optical test

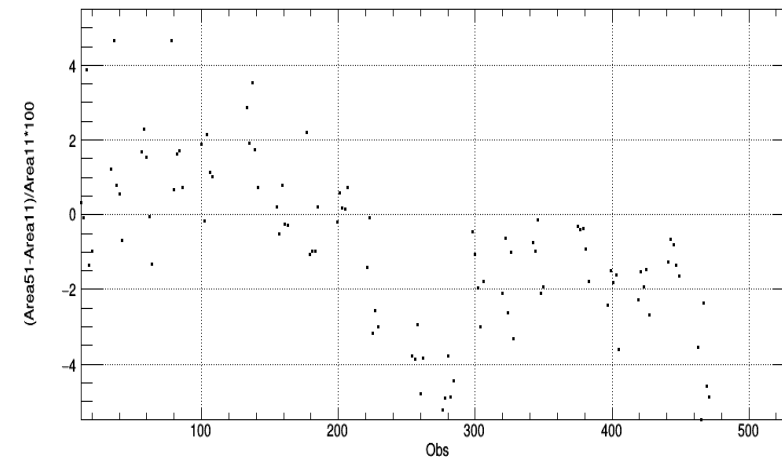
FM1 thermo-optical test 2022.8.26



No significant change in PSF shape



Maximum change of spot position 19.8 arcsec

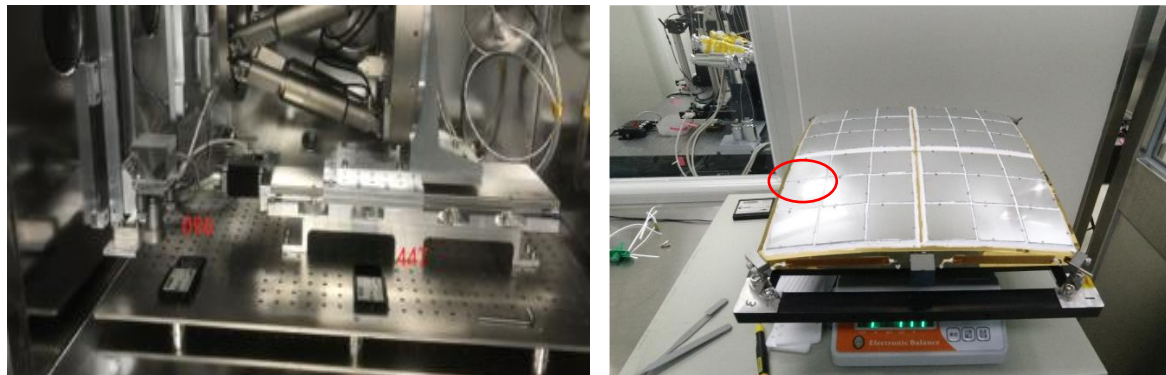


Effective spot area change <5%

- 1) At 9 °C uniform temperature bias of MPO assemblies (15 °C- \rightarrow 24 °C), PSF (FWHM) < 4.5'(R60);
- 2) At 9 °C uniform temperature bias of MPO lens, MPO assembly average pointing varied of about [3.8, 4.7] arcsec, maximum change of 19.8 arcsec;
- 3) MPO lens assembled at 15 °C, on-orbit operating at 6 °C, thermo-optical test at 24 °C, both with a temperature bias of 9 °C. Therefore, the MPO assembly is considered to function properly with a temperature bias of ± 9 °C

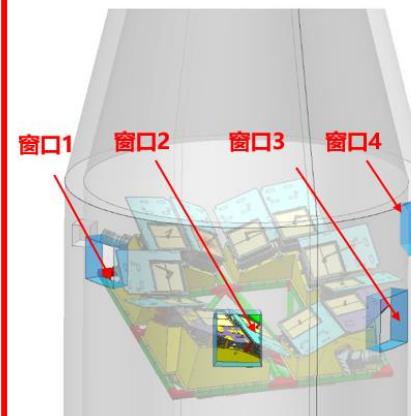
2. Ground tests of WXT

Contamination control

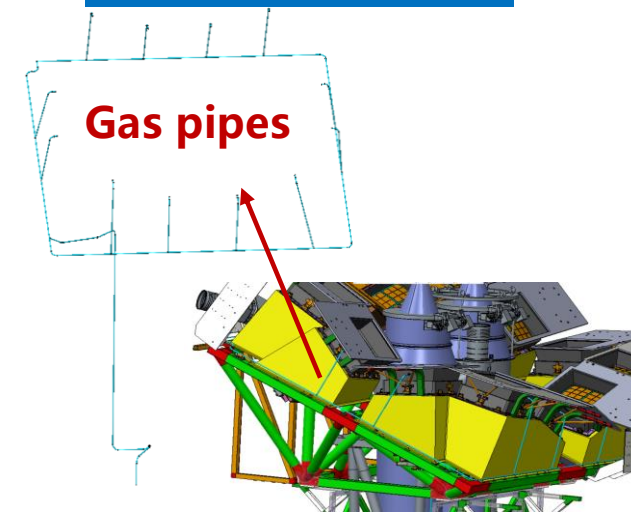
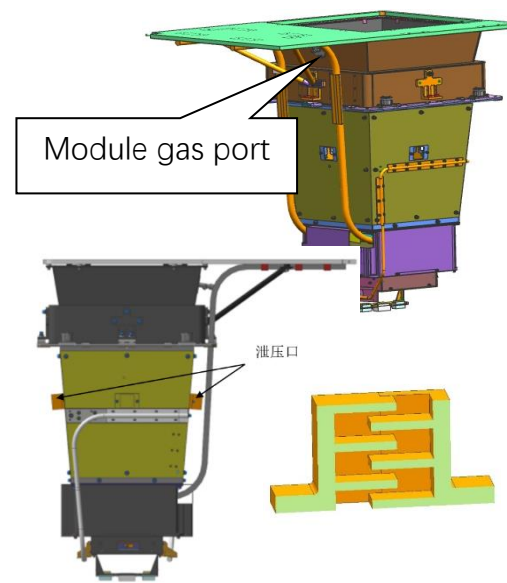


	MPO assemble (1:2)	Module integrate (1:2)	Vibration test(1:20)	Thermal test(1:1)	Calibrate (1:1)	Transport (1:20)	Store (1:20)	Total
FM1	289	55.5	10.3	589	16	32.05	191	1182
FM2	195	59.5	10.3	589	0	20.15	139	1013
FM3	147	156.5	10.3	589	0	12.4	121	1036
FM4	239	131	10.3	589	0	21.45	116	1106
FM5	334	98	10.3	219	8	10	47	726
FM6	257	14	10.3	580	0	5.55	113	980
FM7	352	28	10.3	580	0	2.3	93	1066
FM8	208	52	10.3	580	0	0.45	72	923
FM9	244	24	10.3	580	0	2.3	60	921
FM10	146	24.5	10.3	219	0	1.4	43	444
FM11	417	92.5	10.3	219	16	10.3	11	776
FM12	198	28.5	10.3	219	0	1.4	32	489

Camera cover removed before launch



Nitrogen protection

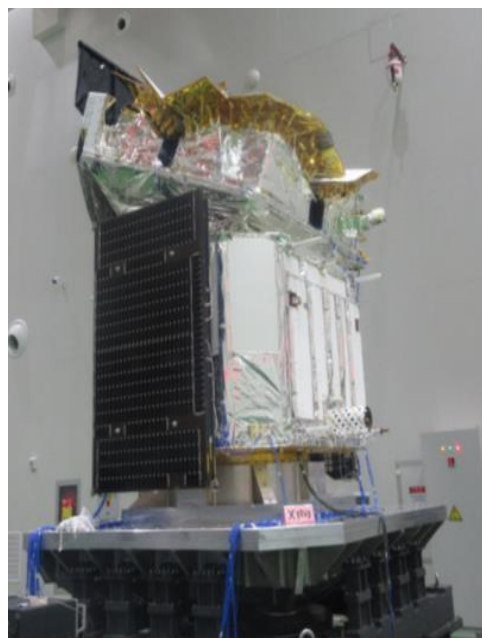


2. Ground tests of WXT

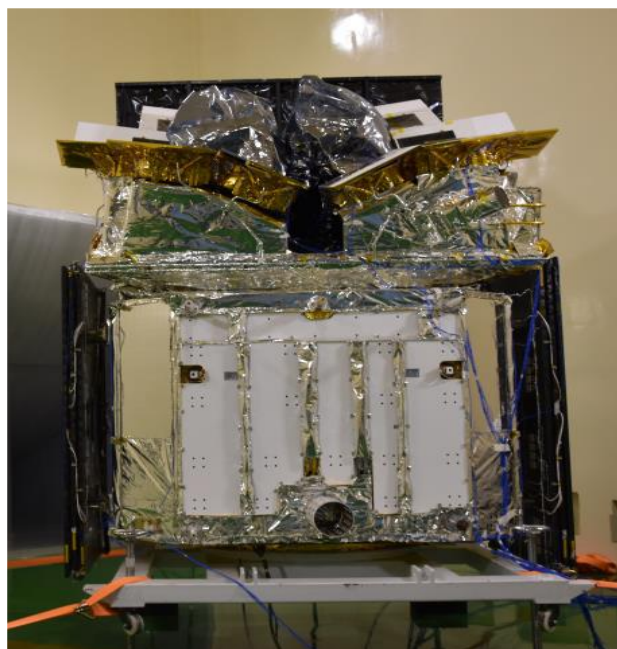
Test with satellite



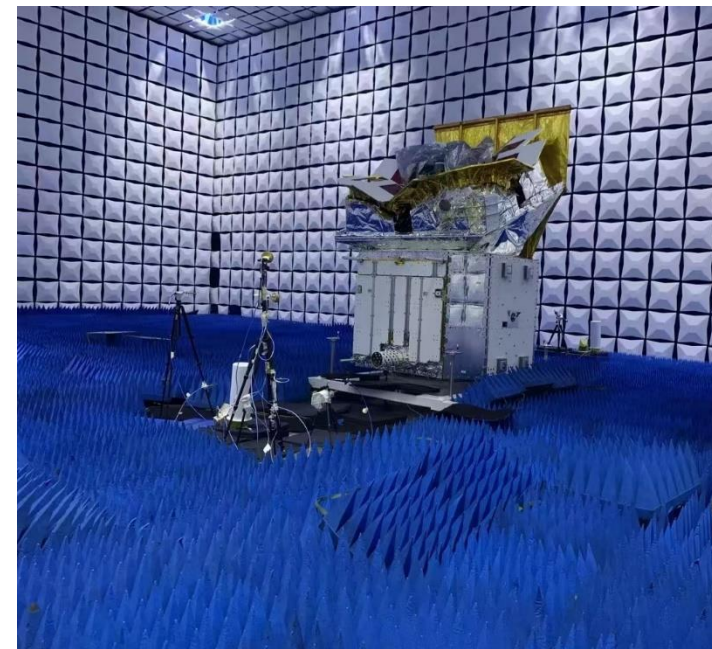
Thermal test
(8.3~8.23)



Sinusoidal vibration test
(9.8~9.11)



Noise test
(9.12~9.13)



EMC test
(9.30~10.1)

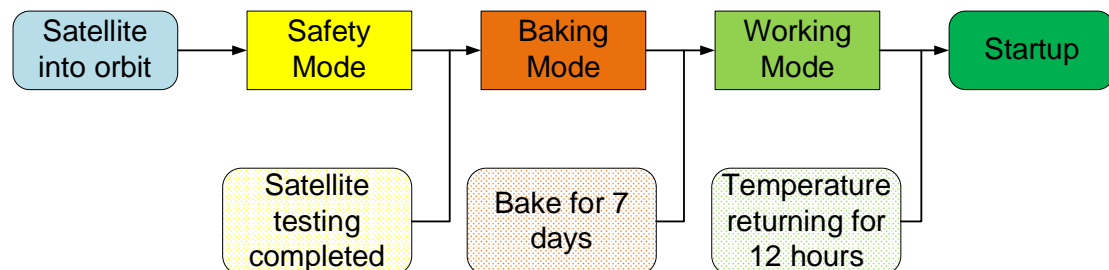
- **WXT flight-module completed mechanical, thermal and EMC tests with the satellite and function normally.**

- 1 Development of WXT
- 2 Ground tests of WXT
- 3 **In-orbit tests of WXT**

3. On-orbit tests of WXT

Baking and power up

Baking and startup process



Baking and power up sequence

No.	WXT	Bake time	Startup time
1	4、10	Jan. 11 ~ Jan. 18	Jan. 19
2	2、8	Jan. 18 ~ Jan. 25	Jan. 25
3	1、7	Jan. 25 ~ Feb. 2	Feb. 4
4	5、11	Feb. 2 ~ Feb. 13	Feb. 14
5	6、12	Feb. 13 ~ Feb. 20	Feb. 21
6	3、9	Feb. 20 ~ Feb. 27	Feb. 29

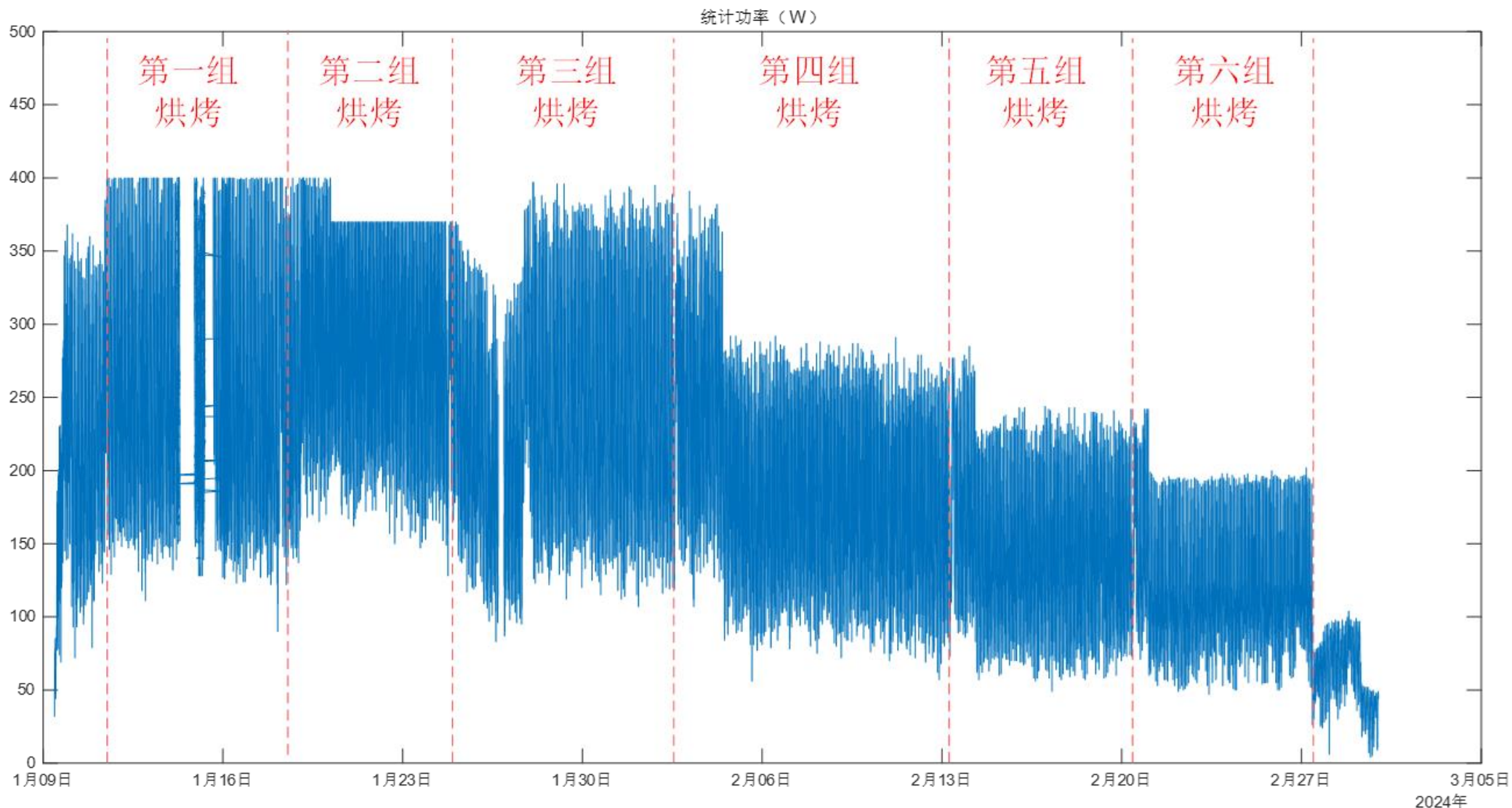
Key component temperature

WXT	Mirror Frame	Main Structure	Electronics	Detector
1	[24.5,24.9]	[14.9,15.9]	[14.2,14.5]	[-4.4,-1.7]
2	[24.2,25.0]	[15.0,16.0]	[14.9,15.2]	[-4.5,-1.2]
3	[24.3,24.9]	[15.1,16.1]	[14.3,14.7]	[-4.8,-2.1]
4	[24.6,24.7]	[15.1,16.1]	[14.2,14.6]	[-5.3,-3.2]
5	[24.3,25.0]	[14.9,16.2]	[11.0,11.7]	[-2.8,-1.4]
6	[24.3,25.0]	[15.2,16.2]	[12.0,12.3]	[-4.1,-2.0]
7	[24.5,24.8]	[15.1,16.1]	[13.9,13.9]	[-3.9,-2.6]
8	[24.5,24.9]	[14.9,16.2]	[14.6,15.0]	[-4.4,-1.6]
9	[24.4,24.8]	[15.1,16.1]	[14.3,14.7]	[-4.5,-1.8]
10	[24.4,25.0]	[15.0,16.1]	[14.1,14.4]	[-5.0,-3.0]
11	[24.3,24.8]	[14.9,15.9]	[14.5,14.9]	[-3.8,-1.8]
12	[24.6,25.0]	[15.1,16.1]	[14.4,14.8]	[-4.9,-2.2]

3.

On-orbit tests of WXT

Heating power



The whole process heating power ≤ 400 W, meet the requirements

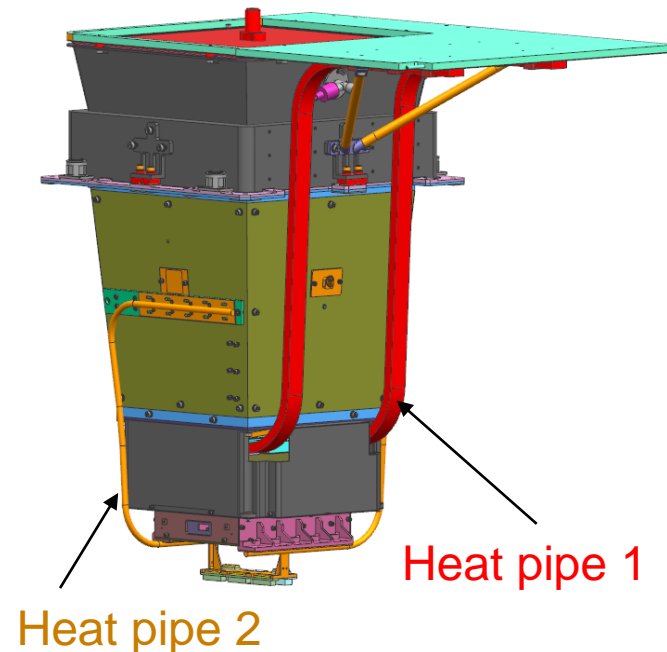
3. On-orbit tests of WXT

Heat pipes operation

◆ PV observation phase (2024-03-23)

Heat pipe 1 (Heat sink-Detector platform)			
WXT	Head sink	Platform	Detector
1	[-41.7,-34.3]	[-36.9,-31.8]	[-34.1,-28.9]
2	[-43.1,-36.2]	[-37.1,-33.7]	[-33.5,-29.8]
3	[-40.5,-33.2]	[-36.5,-30.5]	[-33.5,-27.3]
4	[-42.4,-38.3]	[-37.3,-35.0]	[-34.3,-31.9]
5	[-45.6,-39.6]	[-37.0,-34.5]	[-34.4,-31.6]
6	[-42.3,-36.3]	[-37.0,-33.3]	[-33.5,-29.7]
7	[-41.7,-34.7]	[-37.0,-32.3]	[-33.7,-28.9]
8	[-43.1,-36.6]	[-37.0,-33.6]	[-34.2,-30.4]
9	[-40.7,-33.3]	[-36.9,-30.6]	[-33.5,-27.7]
10	[-42.1,-38.0]	[-36.7,-34.6]	[-34.7,-32.3]
11	[-43.6,-38.5]	[-37.2,-34.5]	[-34.0,-31.7]
12	[-42.3,-36.8]	[-37.2,-34.4]	[-34.8,-31.9]

Heat pipe 2 (Main structure-Electronics)		
WXT	Main structure	Electronics
1	[20.0,21.1]	[26.3,27.5]
2	[18.0,19.0]	[24.2,24.9]
3	[19.4,20.5]	[25.8,26.9]
4	[18.1,18.8]	[23.5,24.2]
5	[16.9,17.3]	[25.5,25.9]
6	[16.5,17.2]	[26.6,27.4]
7	[18.1,19.2]	[24.6,25.4]
8	[16.9,17.9]	[23.2,24.3]
9	[18.9,19.9]	[25.5,26.6]
10	[16.4,17.4]	[25.6,26.4]
11	[18.3,19.0]	[23.5,24.2]
12	[17.4,18.1]	[25.2,26.0]

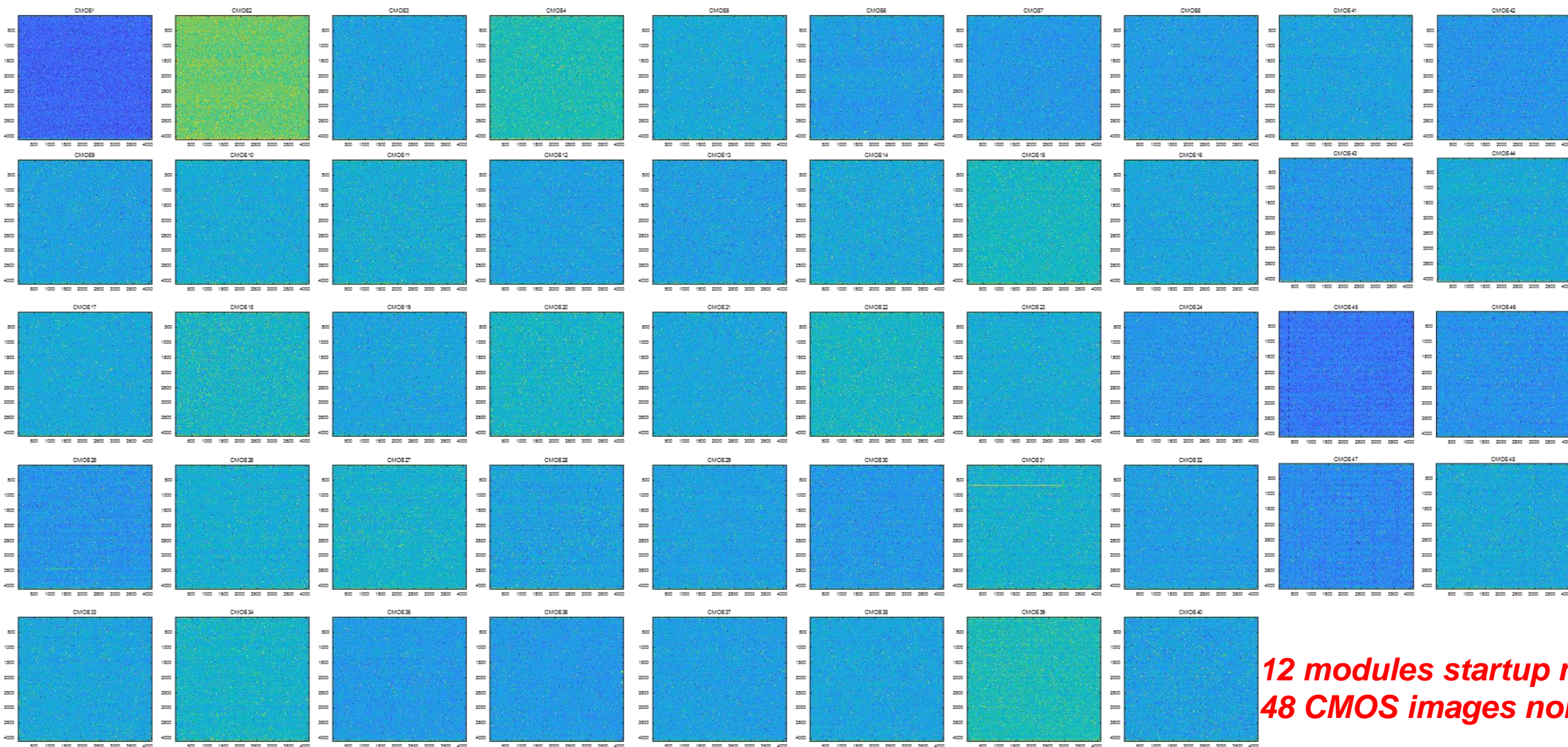


Heat pipes function normally

3.

On-orbit tests of WXT

Power up — CMOS raw image



12 modules startup normal
48 CMOS images normal

3. On-orbit tests of WXT

Power up — CMOS noise

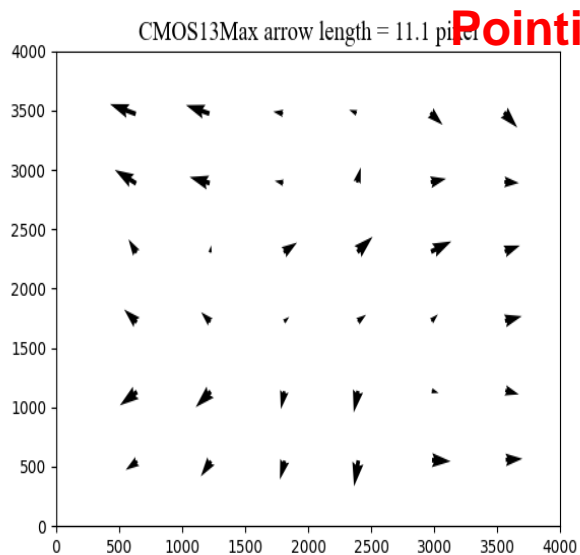
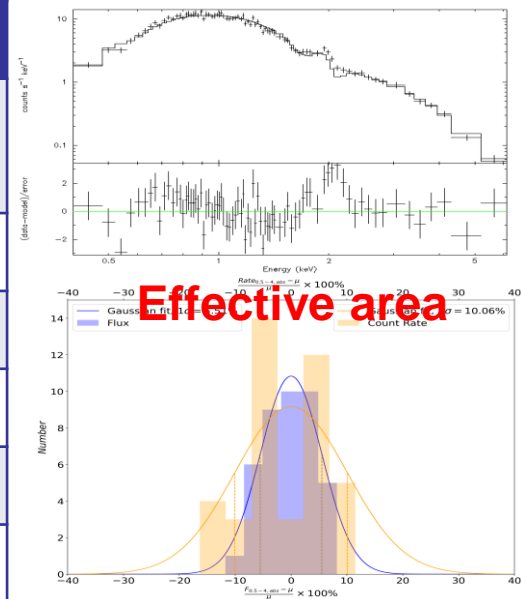
CMOS ID	In-orbit (DN)	Thermal test (DN)	CMOS ID	In-orbit (DN)	Thermal test (DN)	CMOS ID	In-orbit (DN)	Thermal test (DN)	CMOS ID	In-orbit (DN)	Thermal test (DN)
CMOS1	2.40	2.37	CMOS13	2.59	2.61	CMOS25	2.70	2.66	CMOS37	2.46	2.48
CMOS2	2.46	2.42	CMOS14	2.65	2.66	CMOS26	2.51	2.48	CMOS38	2.45	2.46
CMOS3	2.53	2.50	CMOS15	2.40	2.41	CMOS27	2.53	2.50	CMOS39	2.52	2.54
CMOS4	2.39	2.36	CMOS16	2.50	2.51	CMOS28	2.79	2.75	CMOS40	2.89	2.90
CMOS5	2.48	2.44	CMOS17	2.51	2.48	CMOS29	2.46	2.42	CMOS41	2.51	2.49
CMOS6	2.55	2.51	CMOS18	2.94	2.87	CMOS30	2.63	2.57	CMOS42	2.46	2.42
CMOS7	2.43	2.39	CMOS19	2.53	2.51	CMOS31	2.58	2.54	CMOS43	2.64	2.61
CMOS8	2.47	2.43	CMOS20	2.58	2.56	CMOS32	2.53	2.49	CMOS44	2.43	2.39
CMOS9	2.61	2.55	CMOS21	2.40	2.40	CMOS33	2.59	2.56	CMOS45	2.61	2.63
CMOS10	2.44	2.39	CMOS22	2.55	2.54	CMOS34	2.55	2.51	CMOS46	2.64	2.64
CMOS11	2.65	2.58	CMOS23	2.53	2.52	CMOS35	2.45	2.42	CMOS47	2.72	2.73
CMOS12	2.56	2.50	CMOS24	2.46	2.45	CMOS36	2.40	2.36	CMOS48	2.63	2.64

On-orbit test VS satellite thermal test, CMOS noise is basically the same (max change 0.7 DN)

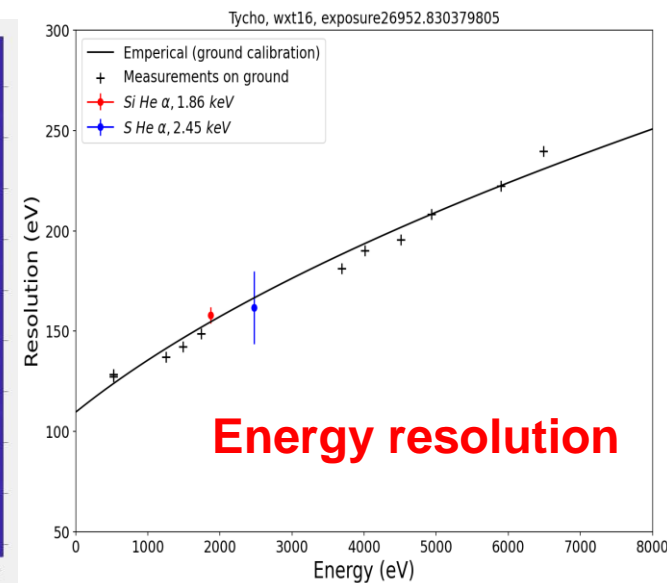
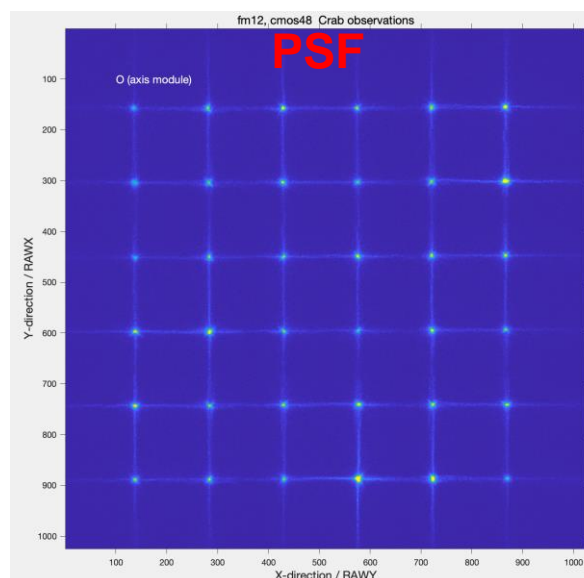
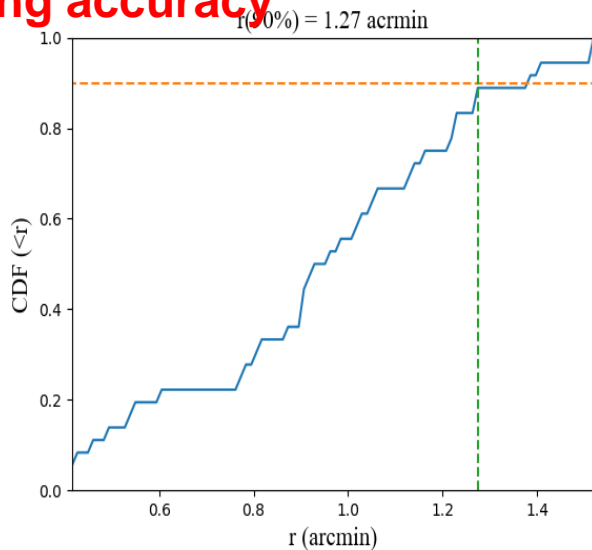
3. On-orbit tests of WXT

In-orbit calibration

No.	Item	Specifications	Performance
1	Pointing accuracy	≤ 1 arcmin (90% Confidence interval)	0.7 arcmin
2	Total FOV	≥ 3600 sq. deg.	3850 sq. deg. (calculated result)
3	Band range	0.5 keV~4 keV	0.4 keV~6 keV
4	Effective area	≥ 2 cm ² @ 1 keV	~3 cm ² @ 1 keV
5	Angular resolution	≤ 5 arcmin@ 1 keV	3.3~4.4 arcmin (R60)
6	Energy resolution	≤ 170 eV @ 1.25 keV	120~140 eV @ 1.25 keV



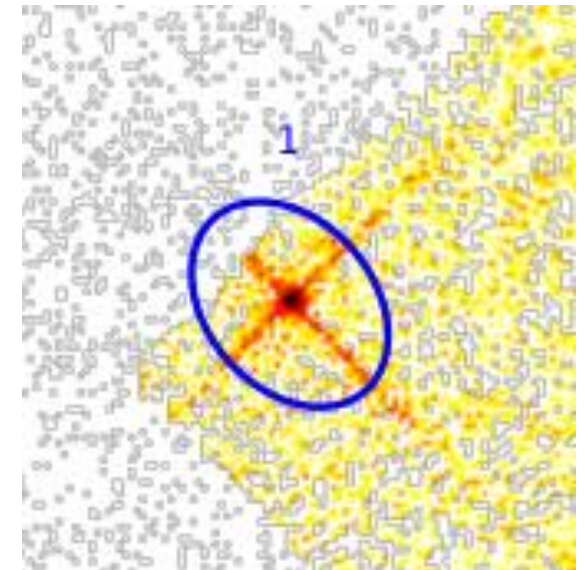
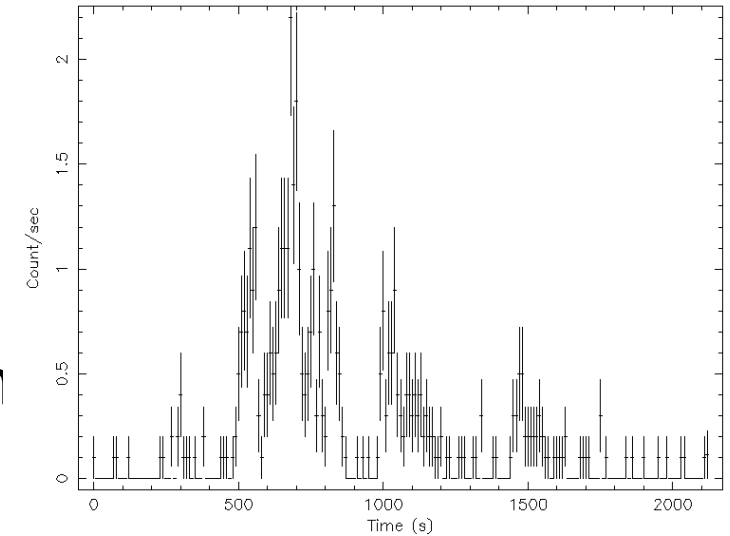
Pointing accuracy



- Trigger test: HD 22468 (ToO-MM 0x6600040F)
- Trigger number: 0x11810008
- Trigger time: 2024-02-21B17:53:55.350
- Integration 336 s, flux 15 mCrab
- Calculated source celestial position deviates 0.7 arcmin from true position
- Beidou message sent to EPSC
- VHF alerts sent but lost due no ground station insight

- Trigger test: 3C 84 (ToO-EX 0x5500000A)
- Trigger number: 0x1181004A
- Trigger time: 2024-02-21B20:42:03.100
- Integration 245 s, flux 10 mCrab
- Calculated source celestial position deviates 2.1 arcmin from true position
- Beidou message sent to EPSC
- EPSC receive all VHF messages: 1 Class A packet, 21 Class B packets)

- 2024-03-15T20:15:19 Onboard trigger time
- 20:15:30 Received Beidou alert
- 20:25:29 Received photon sequence information from VHF link
- 03-16T15:49:37 a CGN posted
- 03-17T01:02:52 VLT certifies the redshift of 4.9 GRB
- 03-17T14:10:00 EP-FXT ToO follow-up observation, detected the afterglow



- ❑ 12 WXT modules have been successfully powered on and work properly;
- ❑ 10 WXT modules have completed in-orbit calibration;
- ❑ Several transients have been detected;
- ❑ Calibration will be performed on the remaining 2 WXT modules;
- ❑ 48 CMOS detectors will be continuously monitored