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EP-FXT in-orbit Calibration status

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On behalf of EP-FXT Calibration team

IHEP

2024.05.13



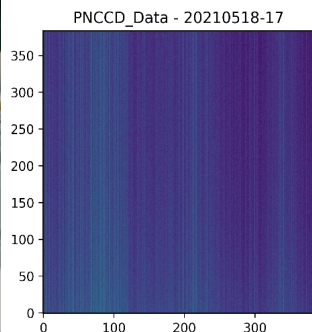
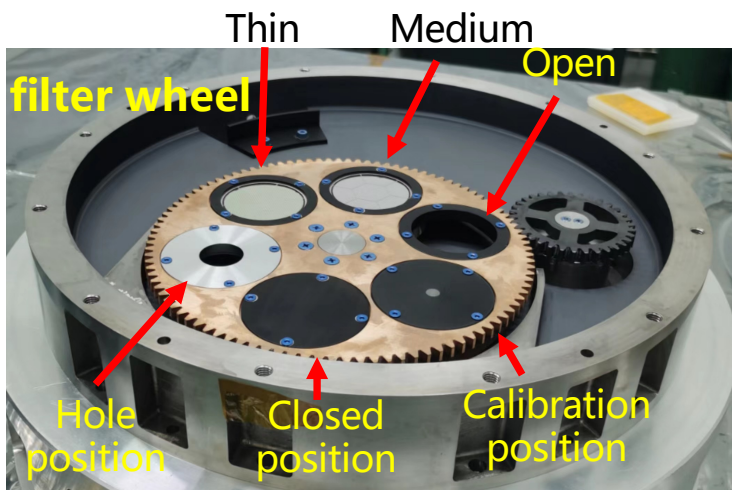
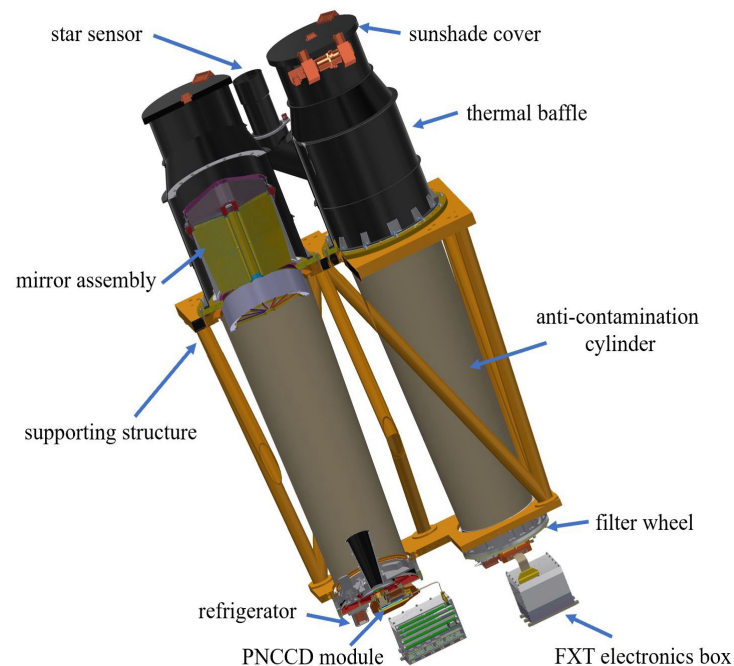
- Introduction of EP-FXT
- Subjects of FXT in-orbit calibration
- Completed Calibration Observations and preliminary verifying of initial CALDB
- Upcoming Plans

Introduction of EP-FXT

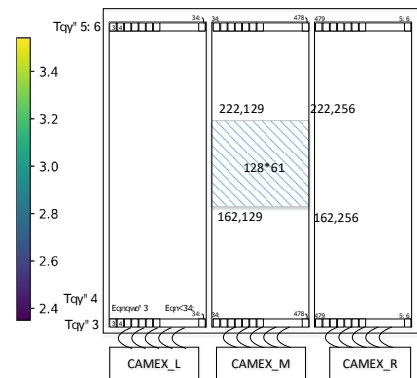


Designed characteristics of FXT

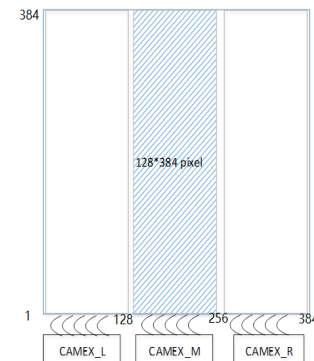
	goal
FOV	$1^\circ \times 1^\circ$
EA	$\geq 600\text{cm}^2$ @1.25 keV, on axis
angular resolution	$\leq 30''$; HPD
Energy resolution	FWHM ≤ 120 eV@1.25 keV (Mg-K)
Energy range	0.3-10.0 keV
Source location error	$< 4''$ (1σ ; detector coordinate)



FF 50ms



PW 2.2ms



TM ~50 us

FXT In-orbit cal subjects and objects



- Background (Closed, blank sky, Lockman Hole)
- Plate scale and boresight (global/open cluster)
- Filter integrity (global/open cluster)
- Soft X-ray response and contamination monitoring(RXJ 1856)
- Gain and CTI (Puppis A, CasA, 1E0102)
- PSF(on/off axis) (PG 1634, 3c273, RXJ 1856)
- Effective area ,QE, flat-fielding, and vignetting(galaxy cluster, SNR)
- Optical loading (stars)
- Timing (Crab, other Pulsars)
- Power-law type spectrum (3c273, Coordinated obs)
- Cluster of galaxies (A1795, A3571)
- Coordinated observations (3c273)

FXT in-orbit calibration objects



1RXS J072025.1-312554	INS	110.1	-31.43	1024-0419	Contamination	1	50ks (ff/02)	
1RXS J185635.1-375433				0402-1004				
1RXS J170849.0-400910 (P=11 s)	Pulsar	162.54	-59.89	0115-0715	Timing	1	60ks (ff/02)	
PSR B1509-58 (p=150 ms)		228.48	-59.14	1213-0611		1	30ks (pw/02)	
Puppis A	SNR	126.03	-43	1121-0519		2	80ks (ff/01)	
						2	80ks (pw/01)	
M87	AGN	187.71	12.39	1225-0624	Gain, CTI, RMF, ARF	6	20ks*7 (ff/01) *2 (a/b)	
						2	20ks*3 (pw/01) *2 (a/b)	
						6	20ks*7 (tm/01) *2 (a/b)	
GX 301-2	HMXB/NS	186.66	-62.77	0201-0804				
Vela SNR	SNR	128.5	-45.83	1127-0524				
B Fe55								
SN 1006	SNR	225.59	-42.1	0215-0818		2	80ks (ff/01)	
PG 1634+706	Quasar	248.62	70.53	1118-0508	PSF	8	40ks*8 (ff/02)	5',0',-5',-10',-15',-20',25',-30'
Lockman hole	Blank sky	161.25		581109-0506	background	2	80ks (ff/01)	
PSR J1231-1411 (p=3.68 ms)	Pulsar	187.8	-14.2	0104-0705	Timing	3	100ks (tm/01)	
						2	100ks (tm/03)	
1RXS J072025.1-312554	INS	110.1	-31.43	1024-0419	Contamination	1	50ks (ff/02)	
1RXS J185635.1-375433		284.15	-37.91	0402-1004		1	50ks (ff/02)	
Mkn 421 (Power law)	BL Lac	166.11	38.21	1125-0522	ARF/RMF/EC	1	50ks (ff/01)	
PSR J1838-0655 (pl,)						1	50ks (ff/02)	
						1	50ks (pw/01)	
						1	50ks (pw/02)	
						1	50ks (ff/01)	
						1	50ks (ff/02)	
						1	50ks (pw/01)	
PKS 0745-191/Ophiuchus	Cluster	207.25	26.59	0105-0706		1	50ks (ff/02)	
						1	50ks (pw/01)	
						1	50ks (pw/02)	
Sco X-1	LMXB/NS	244.98	-15.64	0226-0829	X-ray baffle	2	10ks*9 (ff/02)	30',50',70',90',110',130',150',170',190'
						1	10ks*2 (tm/02)	0', 5'
PSR B1937+21 (p=1.558ms)	Pulsar	294.92	21.62	0423-1025	Timing	2	100ks (tm/01)	
1E0102.2-7219	SNR	16	-72.03	0506-1107	Gain, CTI, RMF, ARF	6	20ks*7 (ff/01) *2 (a/b)	
						2	20ks*3 (pw/01) *2 (a/b)	
						6	20ks*7 (tm/01) *2 (a/b)	
						1	20ks*2 (ff/00)	
						1	20ks*2 (ff/02)	
						1	20ks*2 (ff/03)	



- The EP satellite was launched at 15:03 on **January 9, 2024**, from the Xichang Satellite Launch Center.
- January 19: WXT was powered on, beginning in-orbit calibration observations.
- **January 25-26: FXTA was powered on.**
- February 6: FXTA & FXTB were powered on.
- February 22: FXTA cover opened—FXTA observation.
- February 28: FXTB cover opened—FXTA & FXTB observation.
- March 4: WXT completed calibration observations.
- **March 5-19: FXT in-orbit testing.**
- March 20-23: WXT sky survey observations.
- **Mar 24 - Apr 5: EP-PV observations.**
- **April 5-22: FXT in-orbit calibration observations.**
- **April 22-28: GW-ToO, WXT Supplementary calibration obs.**
- **May 4 to June: EP in-orbit calibration observations.**

FXT In-orbit calibration observations



Part 1: FXT In-Orbit Testing (March 5-19, 2024)

Ensure FXT performs as designed in space conditions.

Validate operational procedures and environmental adaptability.

System Performance: Imaging capabilities, detection sensitivity, data efficiency.

Adjusting mirror temperature, adjusting CCD temperature, adjusting operational parameters for PW and TM modes, etc.

Target	Date	Filter	Notes
NGC 2516	05/03-08/03	Medium	Center pixel, Matrix
Crab	08/03-09/03	Medium	FF/TM/PW Timing
Omega Cen	09/03-11/03	Thin	Center pixel, filter integrity
3c 273	11/03-13/03	Medium	PSF, Power-law spec
Vela SNR	15/03-17/03	Thin	EC, ARF
M87	17/03-19/03	Thin	EC, ARF

FXT In-orbit calibration observations



Part 2: FXT In-Orbit Calibration Obs (From April 5, 2024)

Target	Date	Filter	Notes
M87 /Fe55	05/04-06/04	Medium	EC, ARF
RXS J 170849	06/04-07/04	Thin	Timing/FF mode
Puppis A	07/04-08/04	Thin	8000s GTI,EC, image/ interrupted by too
Puppis A E Knot	08/04-09/04	Thin	EC
RXJ 1856	09/04-11/04	Thin	Low-E resp, contamination
3C 273	11/04-15/04	Medium	PSF off-axis/ interrupted by too
M87	15/04-16/04	Medium	EC, ARF/ interrupted by too
Puppis A	16/04-18/04	Thin Filter	EC, image,ARF/ interrupted by too
A1795	18/04-22/04	Thin/Medium	ARF
3C 273	04/05-07/05	Medium	Center pixel, vignetting
PSR B1509	07/05-08/05	Thin	Timing/PW mode
PSR B1821-24	08/05-10/05	Thin	Timing/TM mode

Preliminary verifying of initial CALDB



- **Centre Pixel and Coordinate Transformation Matrix**
NGC 2516, Omega Cen, other bright sources.
- **EC Relationship**
Fe55, Puppis A
- **ARF Verification**
Galaxy Clusters and SNRs: A1795, M87, A3571
- **PSF Verification**
3C 273
- **Time System Verification**
PSRs: Crab, B1509 B1821 RXJ1708
- **Background level Verification**
Closed filter, blank sky

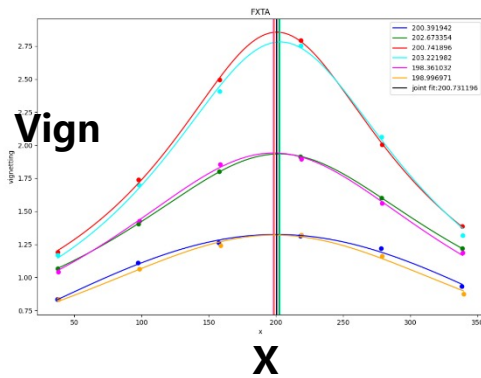
Preliminary verifying of Trans MTX



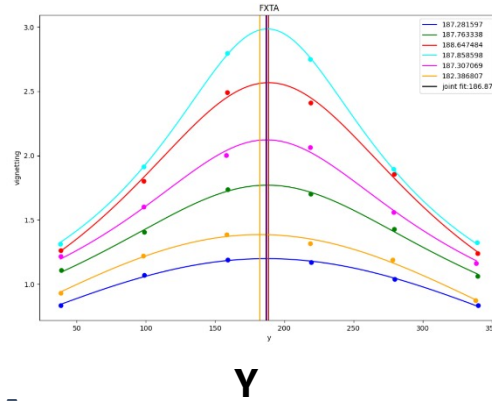
First Light: a positioning deviation of $\sim 2'$

Center Pixel:

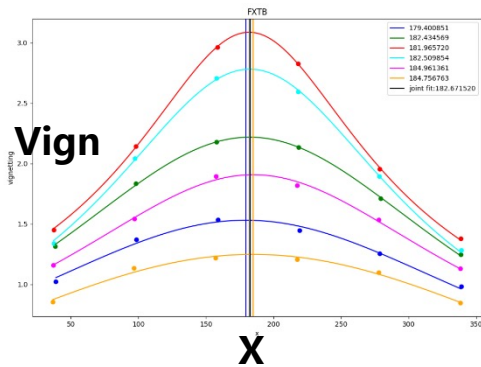
an initial update was made (A: March 2nd; B: March 8th), with a deviation of $\sim 10''$ (on-axis).



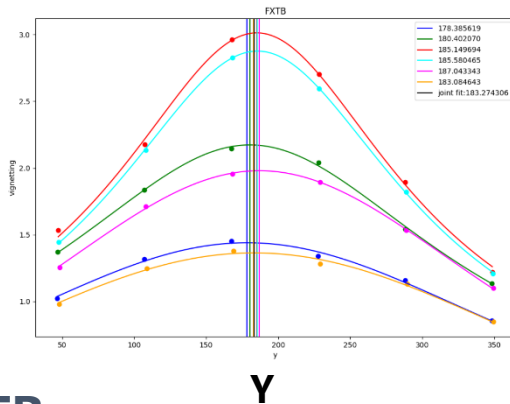
FXTA



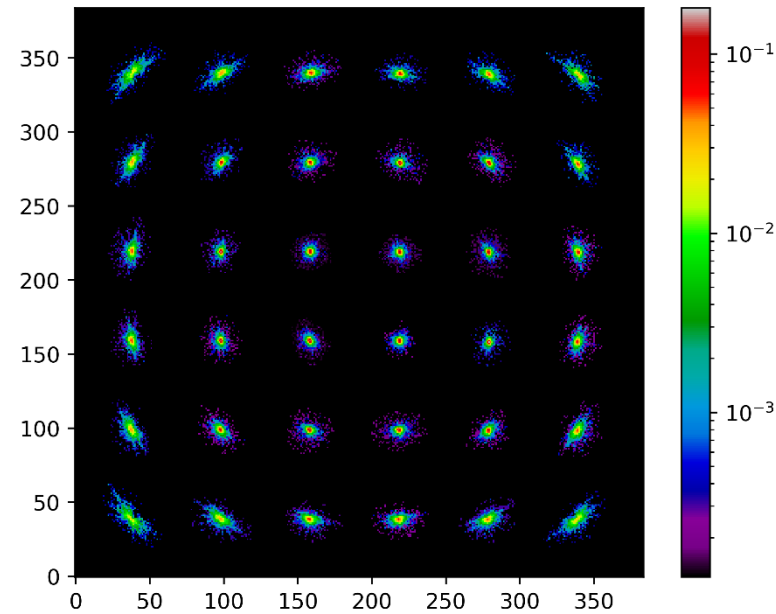
Y



FXTB



Y



3C 273 Obs

See xiaofan Talk

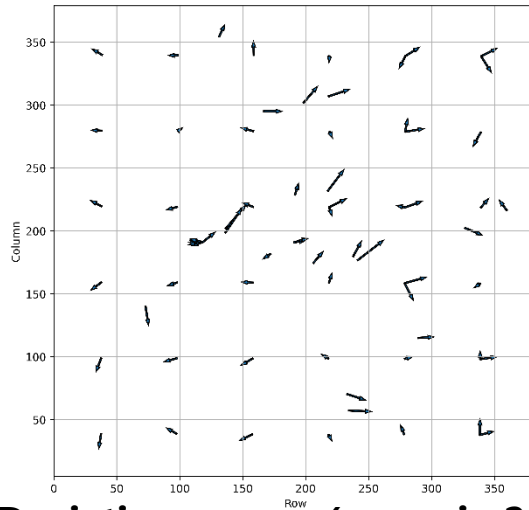
Preliminary verifying of Trans MTX



Plate Scale and Matrix:

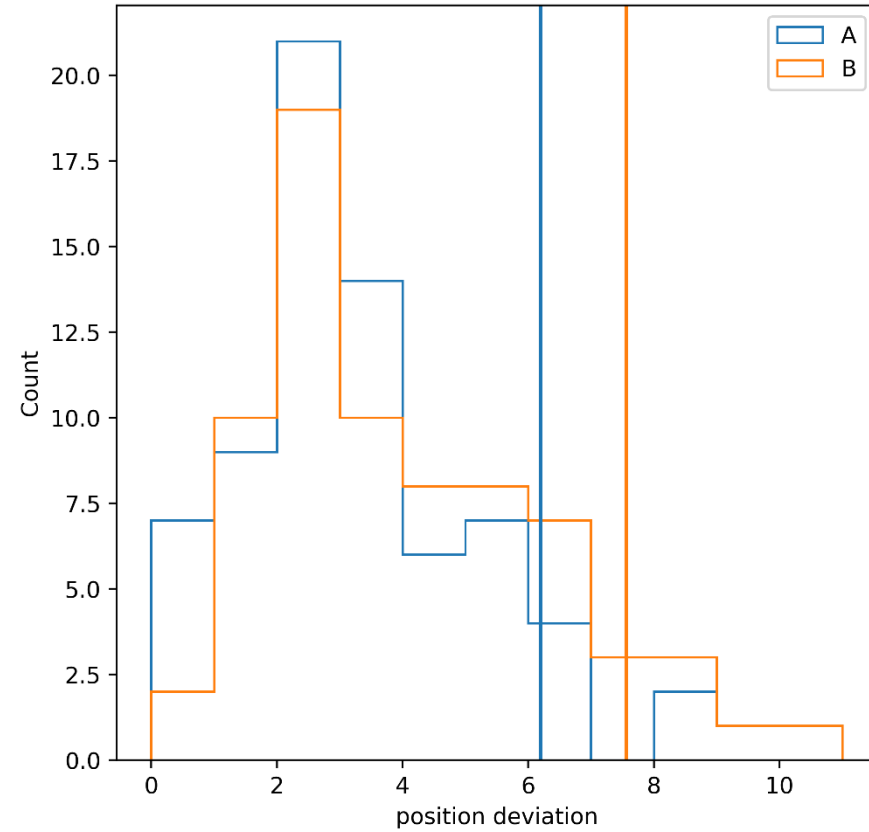
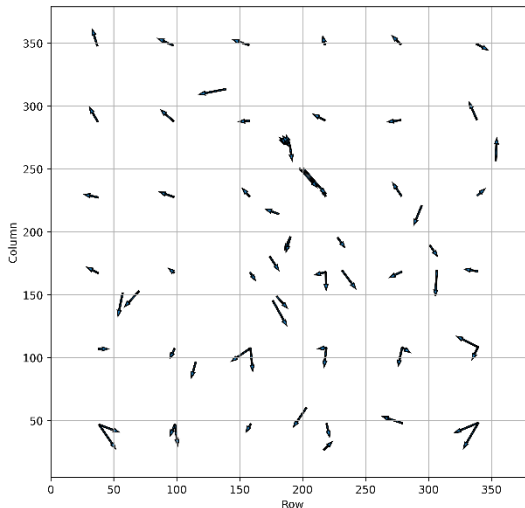
Focal length: FXTA 1604mm, FXTB 1606mm, with a deviation of $\sim 7''$ (on-axis).

FXTA



Deviation arrows (zoom in 20x)

FXTB



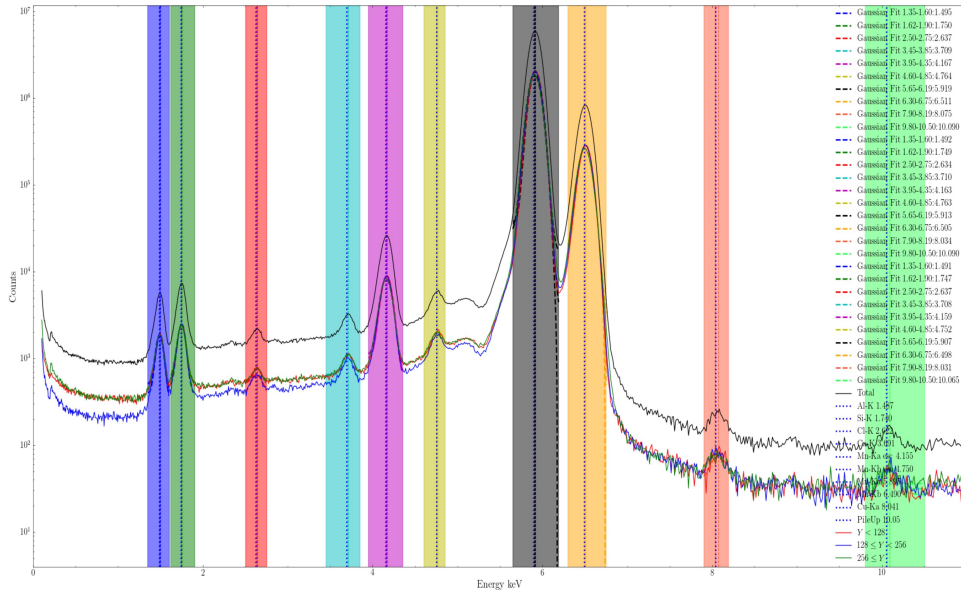
See xiaofan Talk

Preliminary verifying of E-C

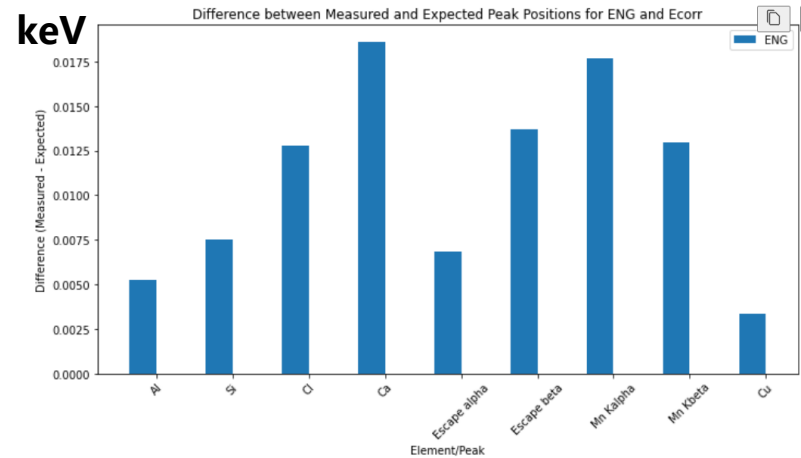


Fe55: ~10-15 eV

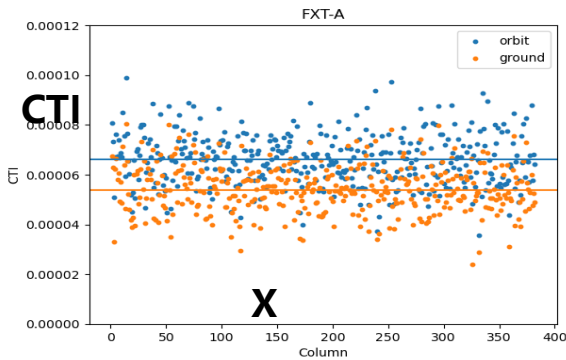
Temperature FXTA: -95° FXTB: -90°



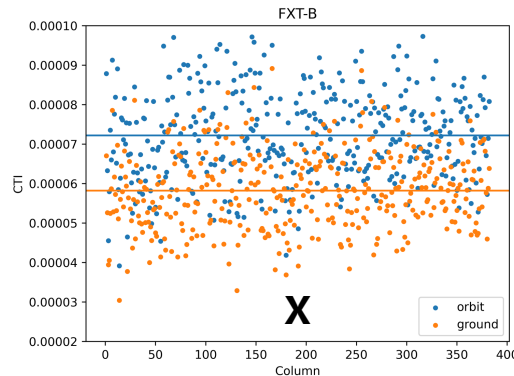
FXTA Fe55 spectrum



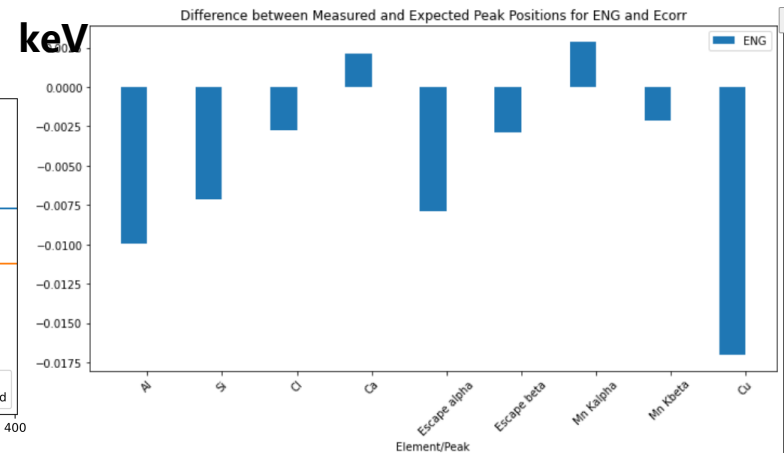
FXTA PI shift



FXTA CTI @5.9 keV

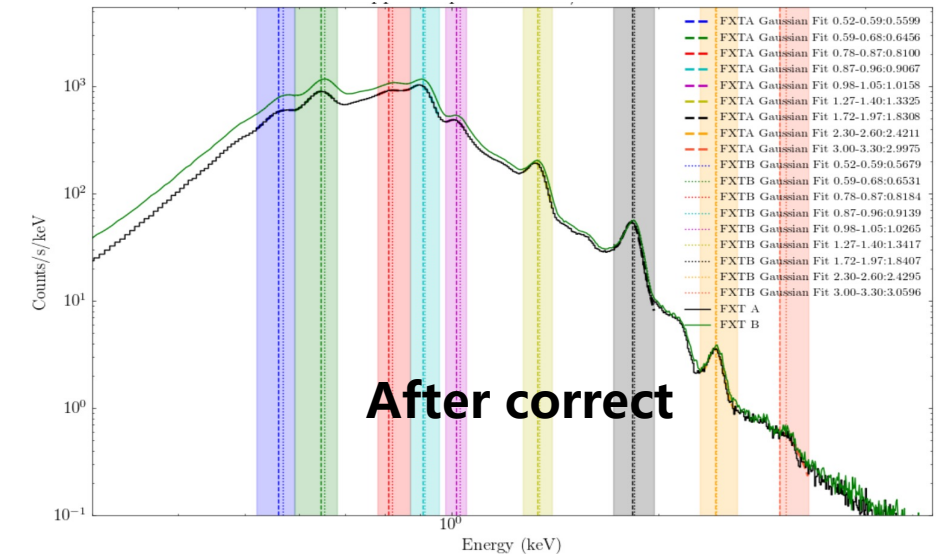
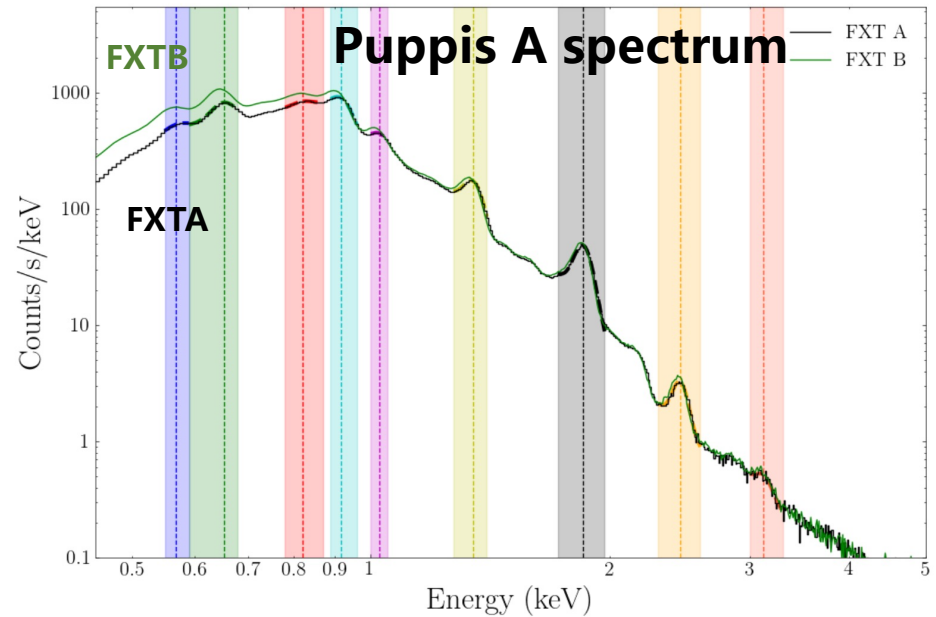
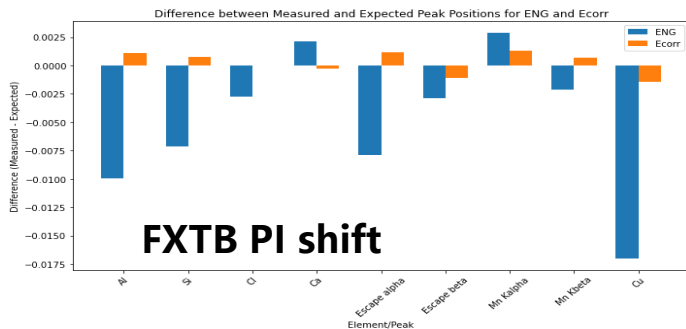
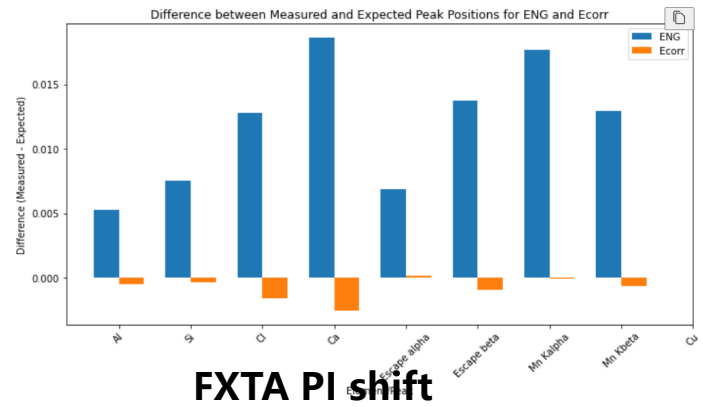
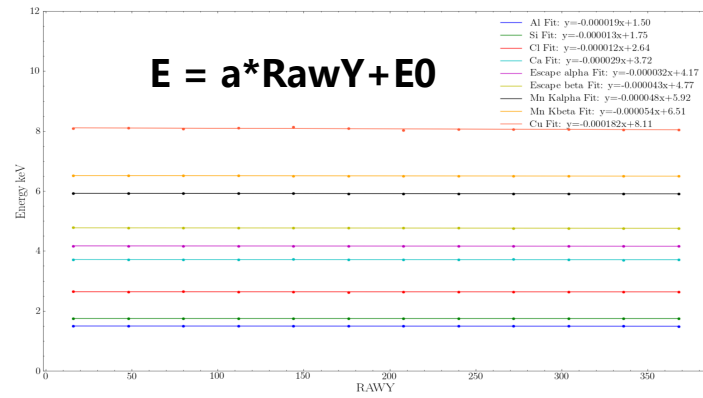


FXTB CTI @5.9 keV



FXTB PI shift

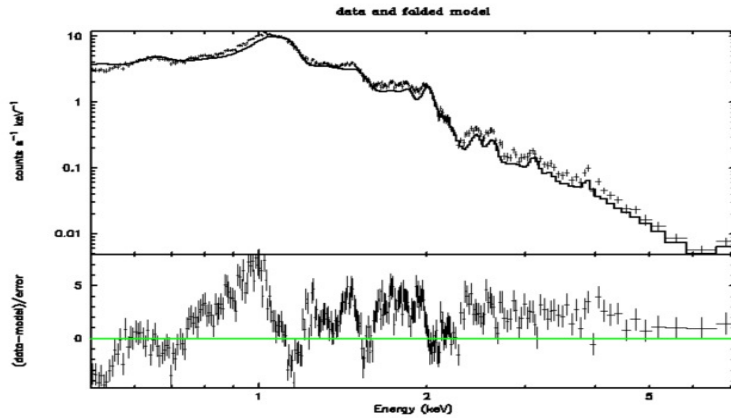
Preliminary verifying of E-C



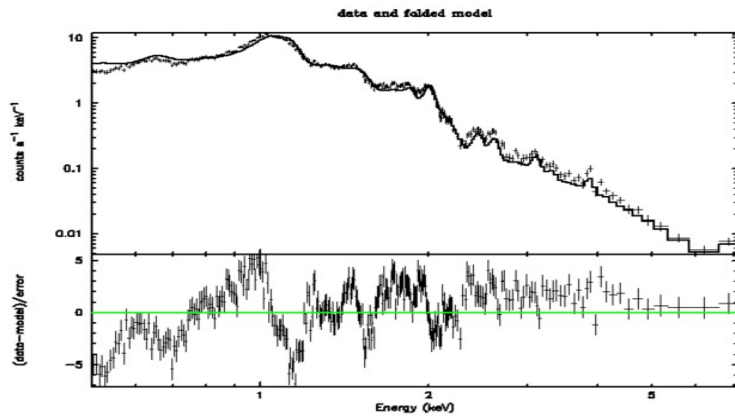
Preliminary verifying of ARF



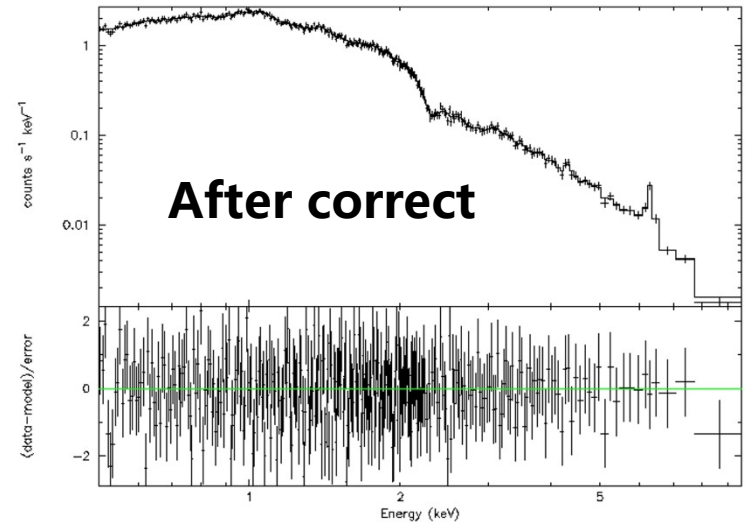
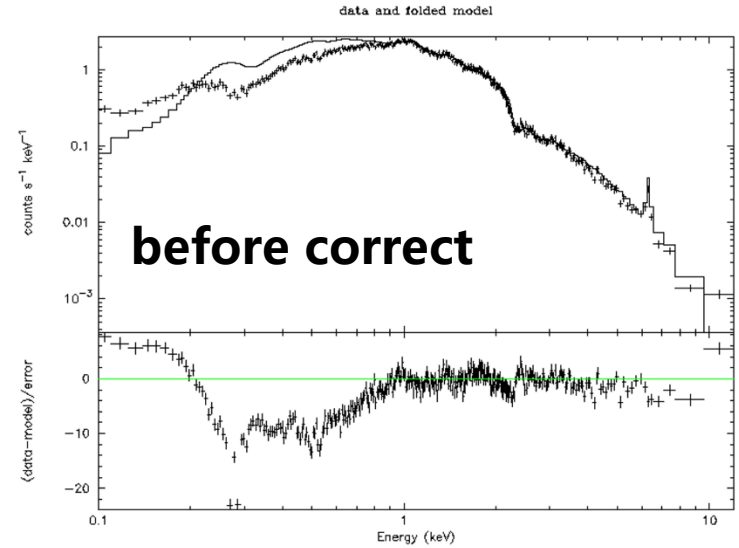
ARF verify: ~10%



×1.08



FXTA-M87 spectrum

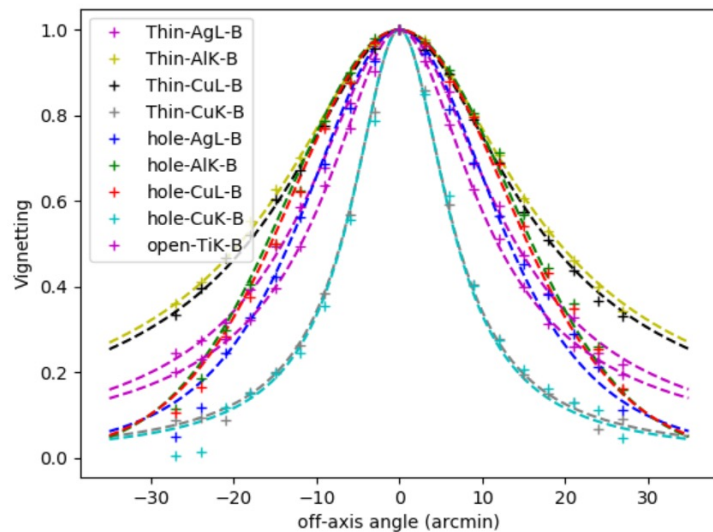
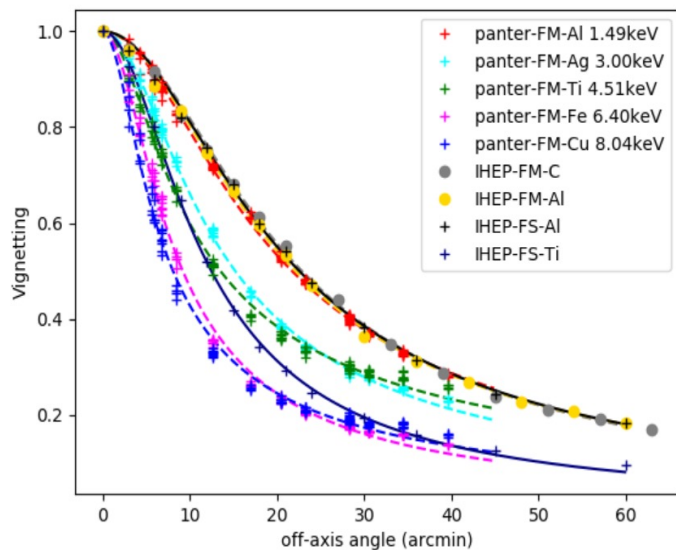


A1795 spectrum

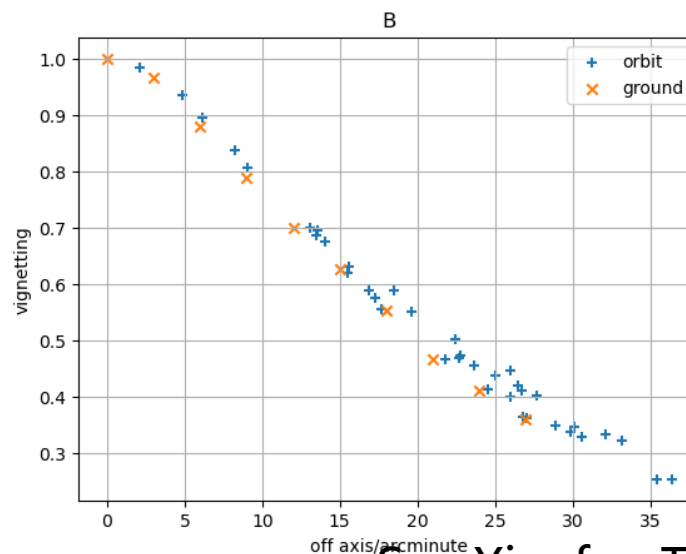
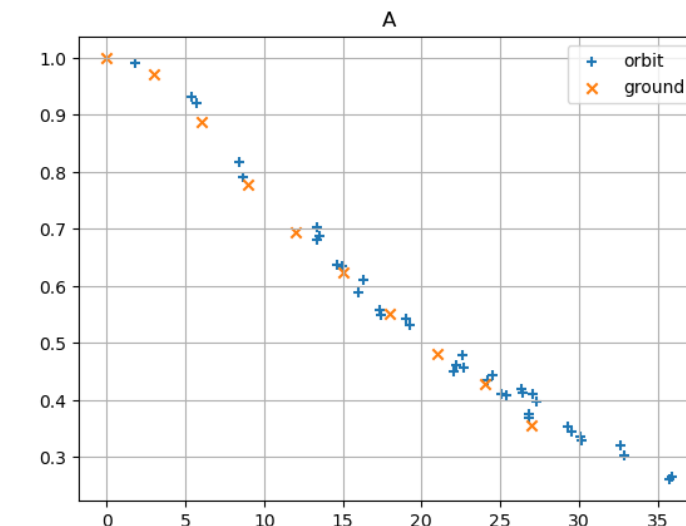
Preliminary verifying of vignetting



On-Ground

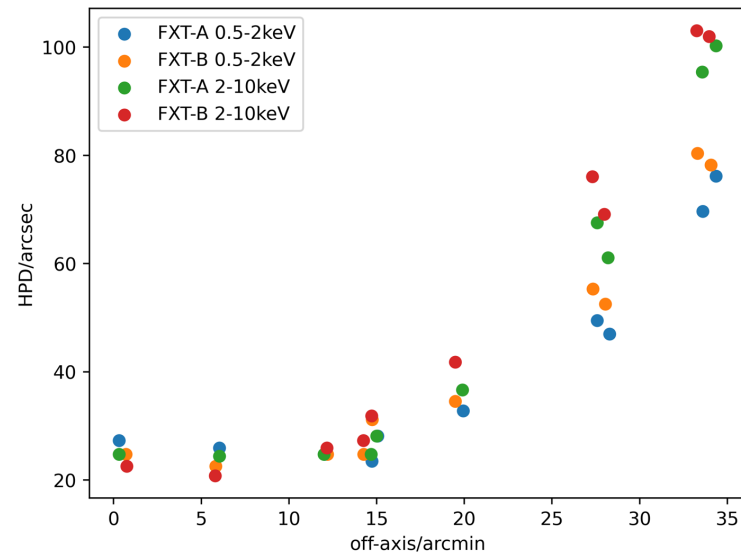
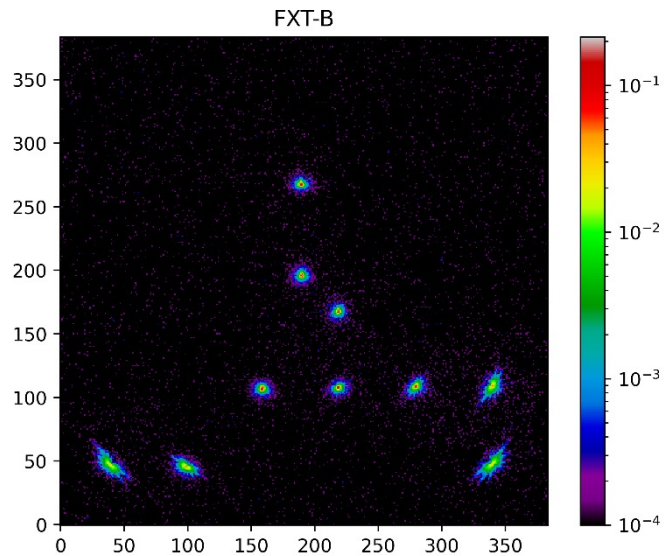
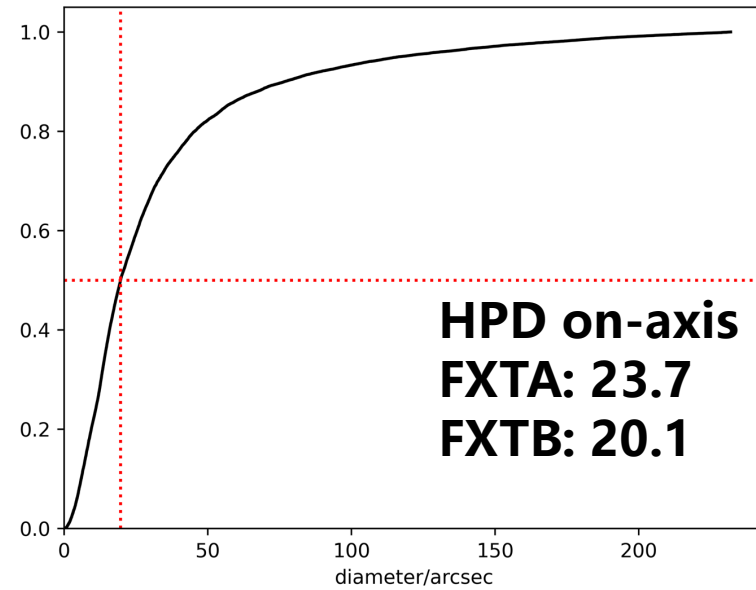
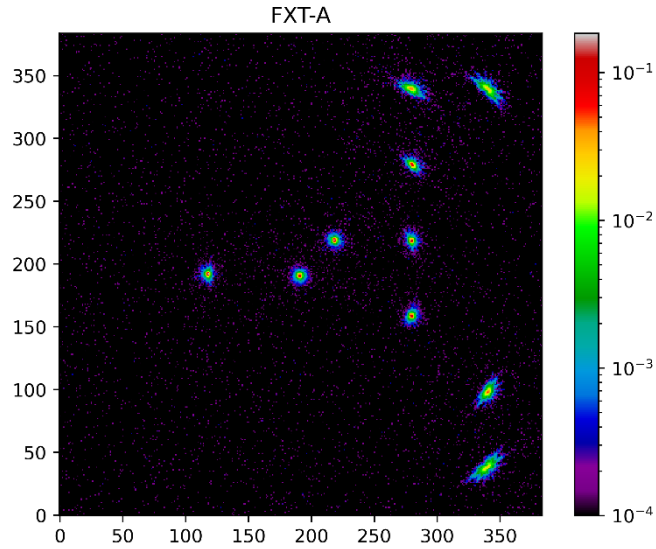


In-orbit



See Xiaofan Talk

Preliminary verifying of PSF

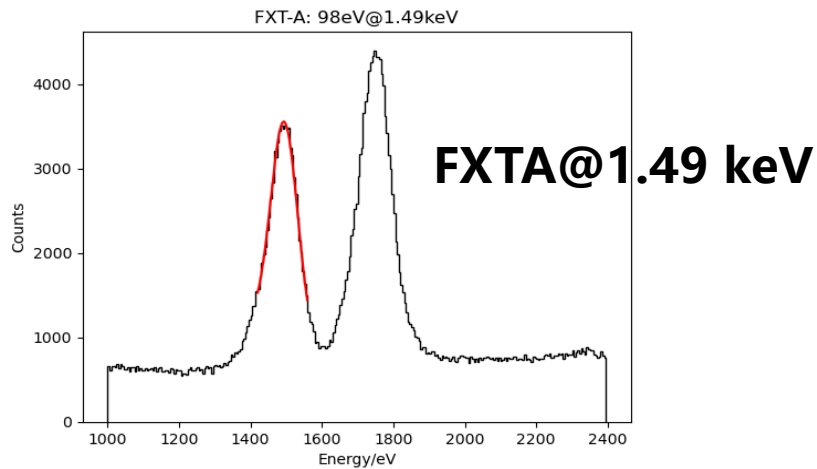


Preliminary verifying of RMF

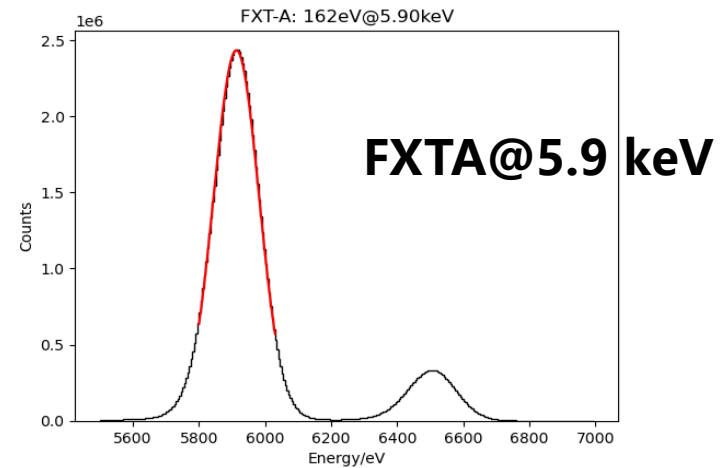


Energy resolution:

	FXT-A (ground)	FXT-A (orbit)	FXT-B (ground)	FXT-B (orbit)
Al-K(1.49keV)	96eV	98eV	94eV	95eV
Fe-K(5.90keV)	157eV	162eV	154eV	157eV



96eV (on ground)
98 eV (in orbit)

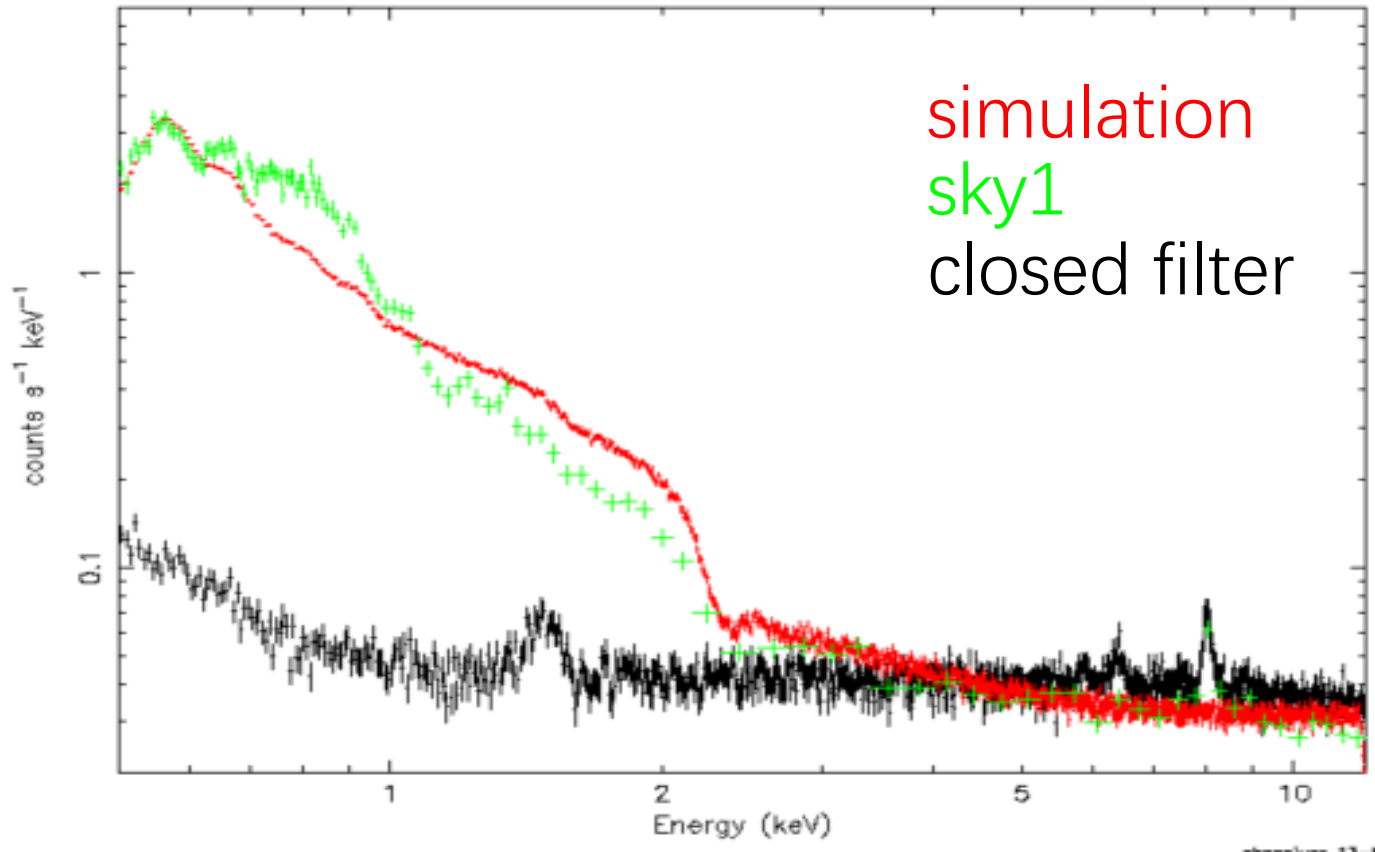


157 eV (on ground)
162 eV (in orbit)

Preliminary verifying of background



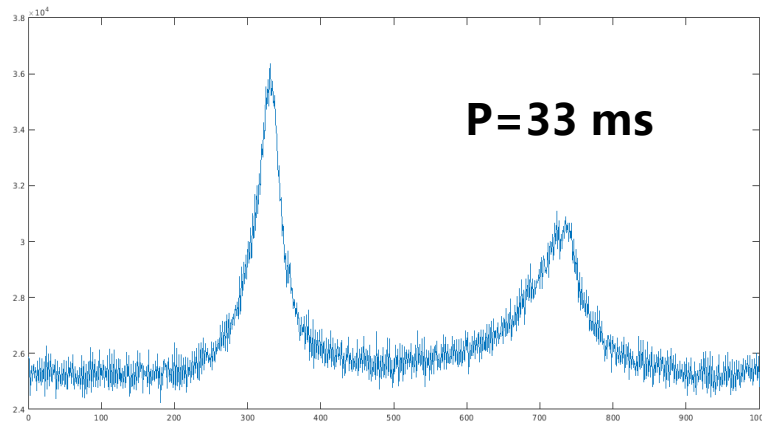
Similar to simulation



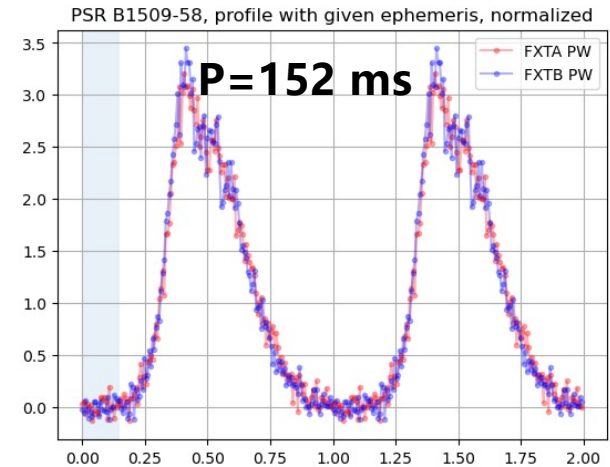
Blank sky and Closed position spectrum

See Juan Talk

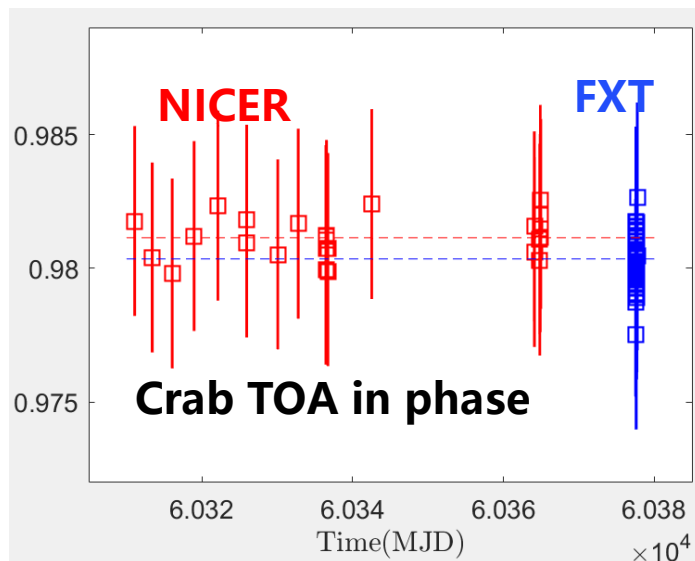
Preliminary verifying of Timing



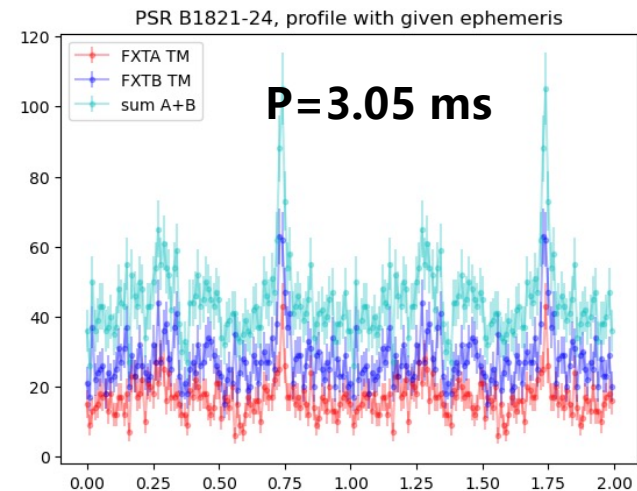
profile of Crab in timing mode



profile of B1509 in PW mode



Temporal stability $\sim 30\mu\text{s}$
Absolute timing $< 30\mu\text{s}$



profile of PSR B1821-24 in timing mode

In-orbit calibration subjects and objects



- Background (Closed, blank sky, Lockman Hole)
- Plate scale and boresight (global/open cluster)
- Filter integrity (global/open cluster)
- Soft X-ray response and contamination monitoring(RXJ 1856)
- Gain and CTI (Puppis A, CasA, 1E0102)
- PSF(on/off axis) (PG 1634, 3c273, RXJ 1856)
- Effective area ,QE, flat-fielding, and vignetting(galaxy cluster, SNR)
- Optical loading (stars)
- Timing (Crab, other Pulsars)
- Power-law type spectrum (3c273)
- Cluster of galaxies (A1795, A3571)
- Coordinated observations (3c273)

FXT In-orbit Calibration Work Plan



- Background (more blank sky observations)
- ~~Plate scale and boresight (NGC2516, Omega Cen, **already observed**)~~
- ~~Filter integrity and optical loading (global/open cluster, stars)~~
- Soft X-ray response and contamination monitoring (RXJ 1856)
- Gain and CTI (low energy band are needed. 1E0102?)
- PSF(off axis) (3c273?, RXJ 1856)
- Effective area ,QE, flat-fielding, and vignetting (galaxy cluster, SNR, low energy band: RXJ 1856 N132D? for Thin and Medium filters)
- Vignetting (G21.5?)
- ~~Timing (Pulsars: Crab, millisecond and other Pulsars)~~
- Coordinated observations (3c 273)
- Monitoring every 6 month: RXJ1856, 1E0102, Fe55

summary



- **The performance of EP-FXT is good in FF/TM/PW mode, and different filters.**
- **The in-orbit calibration observations have started for more than one month, and there are still over 30 days of calibration plan. But many of our calibration observation was interrupted by ToO obs.**
- **Coordinated Observation are needed.**
- **Currently, the results have only been preliminarily verified, and the calibration database will need to be modified subsequently.**

Thank you