EP Performance Verification (PV) Targets Recommendation Form

Submission Due Date: 15th October 2023

NOTE: Please do not change or delete the words marked in blue.

1. TITLE

EP's First Glimpse of the Galactic Centre Region with its Large Field-of-View and High Sensitivity

2. ABSTRACT *(< 250 words)*

The Galactic center (GC) region is one of the richest laboratories for astrophysics. Thousands of persistent and transient X-ray sources are embedded in it, such as X-ray binaries, magnetars, cataclysmic variables, active stars, as well as the holy source Sgr A* - the closest supermassive black hole in our backyard. During the past decades, various X-ray telescopes have conducted deep scans or monitoring of the GC region. For example, XMM-Newton and Chandra GC mosaic observations are too expensive to repeat for monitoring purpose. MAXI and INTEGRAL's routine GC monitoring programs are difficult to distinguish sources clustered near Sgr A*. Swift/XRT's daily monitoring of Sgr A* is constrained by its FoV and sensitivity, primarily detecting the brightest flares from Sgr A*. EP's FXT, with a sensitivity a few times higher than XRT, can simultaneously observe 1x1 deg^2 area around Sgr A*, including known sources and new transients. This allows for the study of their spectral variability and foreground dust scattering. FXT can also detect fainter flares from Sgr A*, thereby constraining the latest flaring rate. Additionally, WXT can observe bright sources (including Sco X-1) and transients over a wide northern region of GC. Therefore, this program can offer a wealth of scientific objectives, and set a good benchmark for EP's future GC monitoring. Being a PV program, it can also test various capabilities of EP, such as its large FoV and high sensitivity, PSF profile, effective area and vignetting, spectral response and pointing accuracy.

3. RECOMMENDERS' INFORMATION

Principal Recommender	
***Recommender' Name**	C. Jin
***Recommender' Email Address**	ccjin@bao.ac.cn
***Recommender' Expertise**	AGN, XRB, ISM
***Recommender' STP(s)**	STP1, STP4, STP6
Co-Recommenders	

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***Recommenders' Names**	W. Yuan, W. Zhang, J. Hu, H. Yang,
***Recommenders' Email Addresses**	wmy@nao.cas.cn, hujingwei@nao.cas.cn, hnyang@bao.ac.cn, wdzhang@nao.cas.cn
***Recommenders' Expertise**	AGN, XRBs, X-ray transients, etc.
***Recommenders' STP(s)**	STP1, STP4, STP5, STP6

4. TARGET FORM

- **TARGET 1** ***(mandatory)***

***Target Name**	Galactic centre (including Sgr A*)			
***Target Type**	Sky region (including SMBH Sgr A*, XRB, magnetar, ISM)			
***Target Coordinates**	***RA:**	17:45:40.03	***DEC:**	-29:00:28.2
***Expected Flux in 0.3-10 keV**	Sources with flux > 1.e-13 erg/cm^2/s			
***Primary Instrument**	FXT (and WXT)			
FXT Configuration ***(mandatory if the primary instrument is FXT, optional if the primary instrument is WXT)***	**FXT-A**	Full-frame, thin filter	**FXT-B**	Full-frame, thin filter
***Exposure Time**	30 ks			
Suggest Joint Observation with Other X-ray Telescopes	Swft/XRT			

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Other remarks	
*Note: * mandatory items*	

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5. SCIENTIFIC AND TECHNICAL JUSTIFICATION

(< 2 pages in total for this session, including figures, tables and references)

- **Scientific Motivations and Values**

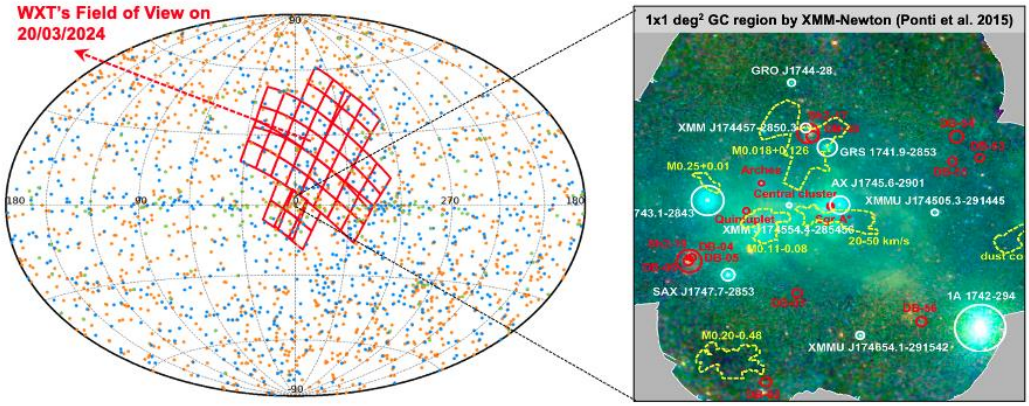

Fig. 1. The FoV of WXT (left panel) and FXT (right panel) for the proposed GC program pointing at Sgr A*. The existing XMM-Newton GC scan shows that many GC sources near Sgr A* can be covered by FXT, while WXT may detect ~200 bright X-ray sources, providing a wealth of scientific objectives.

The Galactic center (GC) region is one of the richest laboratories for astrophysics. Thousands of persistent and transient X-ray sources are embedded in it, such as X-ray binaries, magnetars, cataclysmic variables, active stars, as well as the holy source Sgr A* - the closest supermassive black hole in our backyard.

During the past decades, various X-ray telescopes have conducted deep scans or monitoring of the GC region (e.g. Degenaar et al. 2012; Ponti et al. 2015). For example, XMM-Newton and Chandra have conducted deep GC scans. Fig.1 right panel shows the 1x1 deg^2 region around Sgr A*, which includes many X-ray point-like sources (white), star clusters (red) and molecular clouds (yellow). However, due to their limited field-of-view (FoV), such mosaic observations are too expensive to repeat. On the other band, MAXI and INTEGRAL are conducting routine GC monitoring, but their angular resolution and sensitivity make it difficult to distinguish so many sources clustered near Sgr A*. Swift/XRT is also conducting daily monitoring of Sgr A*, but is constrained by its FoV and sensitivity, and so is primarily detecting the brightest flares from Sgr A*.

Here we propose a PV program to obtain the first glimpse of the GC region with EP at the beginning of its visibility window next year. This 30 ks exposure can offer a wealth of scientific objectives.

Firstly, EP's FXT, with a sensitivity a few times higher than XRT, can simultaneously observe 1x1 deg^2 area around Sgr A*, including known sources and new transients down to the flux limit of ~10^{-13} erg cm^{-2} s^{-1}. This allows for the study of their spectral variability (e.g. Mori et al. 2021) and foreground dust scattering (e.g. Jin et al. 2017). Additionally, Sgr A* was observed to produce X-ray flares regularly. A typical flaring rate of 0.5-1 per day was estimated for moderate and bright flares based on previous GC observations, and the rate shows significant interannual variation. FXT can detect fainter flares from Sgr A*, thereby constraining the latest flaring rate. Secondly, simultaneous WXT observation can detect ~200 bright X-ray sources and search for new transients over a

wide range on the northern side of GC down to the flux limit of ~5x10^{-12} erg cm^{-2} s^{-1} (Fig.1 left panel), including Sco X-1. Since the regular scientific observation will not start until at least 3 months after PV, and the regular GC monitoring of EP should be shallower, this PV program can set a good benchmark for EP's future GC monitoring.

Being a PV program, it can also test various capabilities of EP, such as its large FoV and high sensitivity, PSF profile, effective area and vignetting, spectral response and pointing accuracy.

- **EP Capabilities to be Verified**

1	Verify the large FoV of FXT and WXT
2	Verify the sensitivity of FXT and WXT
3	Verify the PSF profile of FXT, especially the PSF wing
4	Verify the effective area and energy response of FXT and WXT, especially the vignetting effect close to the FoV edge of FXT
5	With joint Swift/XRT obs, perform spectral cross-calibration with Swift/XRT for bright GC sources above 2 keV
6	Large number of sources within the FoV, verify EP's pointing accuracy

- **Immediate Objectives**

1	**GC images:** obtaining EP's first set of energy-resolved deep images of the GC region with both FXT for the 1º x 1º region around Sgr A* and WXT for the broader northern region of GC.
2	**GC point-like sources:** detecting various point-like sources, including known sources (e.g. XRBs, magnetar, pulsar) and new X-ray transients, studying their spectral-timing properties (e.g. Type-I burst). • FXT: within the 1º x 1º of Sgr A*, down to the flux limit of ~1.e-13 erg/cm2/s. • WXT: 3600 deg^2 northern of GC, down to the flux limit of ~5.e-12 erg/cm2/s.
3	**Sgr A* flares:** Searching for moderate and bright flares of Sgr A*, thereby constraining the latest flaring rate.
4	**Dust Scattering Halos:** Observing the dust scattering halos of bright GC sources with flux >1.e-11 erg/cm2/s, constraining GC foreground ISM
5	**Technical verification:** including FoV, sensitivity, PSF profile, effective area, vignetting, energy response, etc.

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- **Technical Justification (e.g. target visibility during the PV phase)**
  Sgr A* becomes visible to EP since 18th March 2024, so the proposed 30 ks exposure should be easy to schedule. Previous studies show that known sources in the GC region have maximal fluxes of less than a few times 1.e-10 erg cm^{-2} s^{-1}, but the nH of Sgr A*'s nearby region is as high as 10^{22}-10^{23} cm^{-2}, so even the brightest persistent source will only have < 2% pileup with the thin filter and full-frame mode.

- **References**

  - Mori K., et al., 2021, ApJ, 921, 148, The X-Ray Binary Population in the Galactic Center Revealed through Multi-decade Observations
  - Ponti G., et al., 2019, Nature, 567, 347, An X-ray chimney extending hundreds of parsecs above and below the Galactic Centre
  - Jin C., et al., 2017, MNRAS, 468, 2532: Probing the Interstellar Dust towards the Galactic Centre
  - Ponti G., et al., 2015a, MNRAS, 454,1525: Fifteen years of XMM-Newton and Chandra monitoring of Sgr A*
  - Ponti G., et al., 2015b, MNRAS, 453, 172: XMM-Newton view of the central degrees of the Milky Way
