爱因斯坦探针
einstein probe

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

Studying the baryons in the outskirts of the elliptical galaxy NGC 5044 to demonstrate the FXT background

2. ABSTRACT *(< 250 words)*

NGC 5044 is the X-ray brightest galaxy group in the sky. One of the most pressing questions in astrophysics is how feedback affects baryons in the outskirts of groups and galaxies. Here we suggest using EP-FXT to trace the evidence for feedback in the intragroup medium, to measure the gas density in the outskirts and to infer the baryon fraction. The target is an excellent opportunity to demonstrate the low background of EP and demonstrate its imaging and spectroscopic capabilities. This observation will be a demonstrator of the ability of EP to probe the outskirts of clusters and groups.

3. RECOMMENDERS' INFORMATION

Principal Recommender	
***Recommender' Name**	Jeremy Sanders
***Recommender' Email Address**	jsanders@mpe.mpg.de
***Recommender' Expertise**	J. Sanders is an expert in studying the physics of nearby clusters and groups. He is the chair of STP5.

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***Recommender' STP(s)**	STP5
Co-Recommenders	
***Recommenders' Names**	
***Recommenders' Email Addresses**	
***Recommenders' Expertise**	
***Recommenders' STP(s)**	

4. TARGET FORM

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

***Target Name**	NGC 5044			
***Target Type**	Galaxy group (4 offset pointings)			
***Target Coordinates**	***RA:**	13:16:42 (pointing 1) 13:14:04 (pointing 2) 13:16:42 (pointing 3) 13:14:04 (pointing 4)	***DEC:**	-16:05:16 (1) -16:05:16 (2) -16:43:50 (3) -16:43:50 (4)
***Expected Flux in 0.3-10 keV**	5.5×10^{-11} erg cm^{-2} s^{-1}			
***Primary Instrument**	FXT			
FXT Configuration ***(mandatory if the primary instrument***	**FXT-A**	*full-frame* *medium*	**FXT-B**	*full-frame* *medium*

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is FXT, optional if the primary instrument is WXT)				
***Exposure Time**	4 x 10 ks = 40 ks			
Suggest Joint Observation with Other X-ray Telescopes	No			
Other remarks	Note this is four exposures. Could be replaced by a scan for more uniform PSF, if that is possible.			
*Note: * mandatory items*				

- **TARGET 2 and more…**
  (optional, if there are more than one target in this recommendation, copy the entire target form above to the empty space below; note that this is only for the case that one observing proposal includes multiple targets; for targets of a different proposal with distinct technical and scientific goals, please submit them in separate proposals.)

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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**

  How feedback affects baryons in lower mass systems, such as elliptical galaxies and groups is an important topic currently (e.g. Eckert et al. 2021). X-ray observations have been used successfully to target the outskirts of galaxy clusters to detect the low density material to R_{200}. Much less is known about lower mass systems such as galaxy groups. Here we suggest to make an observation of NGC 5044, a very bright X-ray elliptical galaxy to trace the low surface brightness gas in the outskirts of the system.

  NGC 5044 is the X-ray brightest galaxy group in the HIFLUGS cluster and group sample and lies at a redshift of 0.009. It is a very well-known galaxy group with detailed multiwavelength coverage. The group is relaxed with a cool core. There are cavities and a small jets in the core, indicating the presence of AGN feedback (Schellenberger et al. 2020). The proposed observations would map the gas out to 500-700 kpc radius, which is close to the virial radius of 870 kpc (Buote et al. 2004). The object has temperature components spanning 1.4 keV down to 0.7 keV in the centre.

  The main aim of the proposal is to trace the surface brightness profile of the cluster, and the temperature and metallicity where possible. We will also fit a hydrostatic model to the object and make other measurements of cluster mass. We will measure the baryon fraction of the gas (f_{gas}) in the group as far as possible. This will be compared to predictions of feedback in groups.

  This should be considered for a PV program, to verify the stability of the background over time. It will also demonstrate the spectral resolution in the centre, and PSF over the field. The image will show the power of the EP-FXT to image low surface brightness structures.

- **EP Capabilities to be Verified**

  Stability of background, large region imaging, spectral resolution in centre, PSF over field.

- **Immediate Objectives**

  Map the surface brightness out to large radius
  Measure gas mass fraction (f_{gas}) out to large radius

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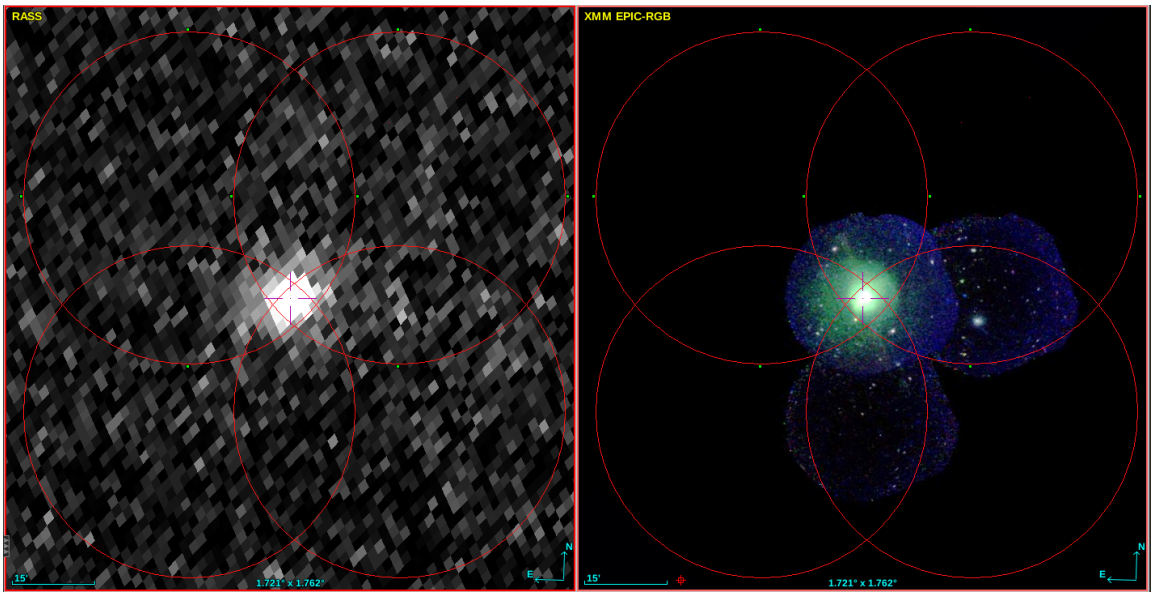
- **Technical Justification (e.g. target visibility during the PV phase)**
  eROSITA is able to detect the surface brightness out to at least 30 arcmin radius in the eRASS:4 survey (based on images without careful analysis). The eROSITA exposure is 480s, which is roughly equivalent to an EP-FXT exposure of 1.7 ks (on axis). To increase the signal to noise ratio at this ratio by a factor of 2, needs 4 times greater exposure. Due to FXT vignetting we estimate a total exposure of 40 ks for the field (4×10 ks).



ROSAT image and XMM image with the four overlayed pointings. The pointings cover 700kpc radius of the group. (note: we do not show eROSITA data here)

If we take the approximate eROSITA surface brightness at 30 arcmin radius, we should be able to measure around 400 counts above the background in a 1 arcmin wide aperture with 10ks pointings (ignoring the overlap regions between the pointings). This will allow the surface brightness profile to be measured on finer scales around this radius, and the spectrum to be determined on scales of a few arcmin. The group surface brightness declines by a factor of approximately 6 from 20 to 30 arcmin radius. With these deeper observations we hope to measure it to at least 45 arcmin radius (500 kpc), depending on the level of the background and the shape of the group profile, extrapolating from eROSITA. The exact radius we can reach will depend on how well we can mask background sources and structures and the EP-FXT background stability.

The target is visible for most of the PV phase period (March and April 2024).

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- ## References

Buote, D. A., Brighenti, F., & Mathews, W. G. 2004, ApJL, 607, L91.
Eckert, D., Gaspari, M., Gastaldello, F., et al. 2021, Universe, 7, 142.
Schellenberger, G., David, L.~P., Vrtilek, J., et al. 2020, ApJ, 894, 72.

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