



愛因斯坦探針  
einstein probe

## EP Performance Verification (PV) Targets Recommendation Form

**Submission Due Date: 15<sup>th</sup> October 2023**

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

## 1. TITLE

Galaxy cluster pair A3407+A3408 and AGN 1H0707-495

## 2. ABSTRACT (< 250 words)

(summarize the target properties, the EP capabilities to be verified, and justify why the proposed observations and targets should be considered for the PV phase)

Thanks to the large FOV of FXT, we propose one FXT pointing that covers three interesting targets, Abell 3407, Abell 3408, and 1H0707-495. A3407 and A3408 are a pair of galaxy clusters that are likely interacting. ROSAT observation shows that they have complex substructures and possibly a weak bridge connecting them. By now, deep X-ray observation of this region is not yet available. We propose deep FXT exposure to detect the bridge between them. Such a bridge, if detected, is not only a significant finding but also the best indicator of FXT's imaging performance. We will perform spatial-resolved spectral analysis of this cluster pair in order to reveal its dynamical nature. 1H0707-495 is one of the most famous AGN in the universe. Because it has drastic variability in X-ray flux and spectrum, observations of it have triggered a lot of progress in AGN model development but leaving more open questions. It is always a promising AGN target for more follow-up.

## 3. RECOMMENDERS' INFORMATION

Principal Recommender	
*Recommender' Name	Jun-Xian Wang
*Recommender' Email Address	jxw@ustc.edu.cn
*Recommender' Expertise	Jun-Xian Wang is an expert in AGN and X-ray astronomy
*Recommender' STP(s)	STP1

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Co-Recommendors	
<b>*Recommendors' Names</b>	Teng Liu
<b>*Recommendors' Email Addresses</b>	liuteng@ustc.du.cn
<b>*Recommendors' Expertise</b>	Teng Liu is an expert in X-ray observations of AGN and clusters
<b>*Recommendors' STP(s)</b>	STP1

#### 4. TARGET FORM

- TARGET 1 (mandatory)**

<b>*Target Name</b>	Abell 3407, Abell 3408, and 1H 0707-495			
<b>*Target Type</b>	Galaxy cluster pair, AGN			
<b>*Target Coordinates</b>	<b>*RA:</b>	106.7	<b>*DEC:</b>	-49.25
<b>*Expected Flux in 0.3-10 keV</b>	AGN: $5\text{e-}13 \sim 1\text{e-}12 \text{ erg/cm}^2/\text{s}$ Clusters: $3\text{e-}12 \sim 7\text{e-}12 \text{ erg/cm}^2/\text{s}$			
<b>*Primary Instrument</b>	FXT			
<b>FXT Configuration</b> <i>(mandatory if the primary instrument is FXT, optional if the primary instrument is WXT)</i>	<b>FXT-A</b>	Full-frame Thin filter	<b>FXT-B</b>	Full-frame Thin filter
<b>*Exposure Time</b>	5 cycles per day x 7 days, in total $3.6\text{ks} \times 5 \times 7 = 126 \text{ ks}$			

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<b>Suggest Joint Observation with Other X-ray Telescopes</b>	
<b>Other remarks</b>	(any other remarks)
<i>Note: * mandatory items</i>	

- **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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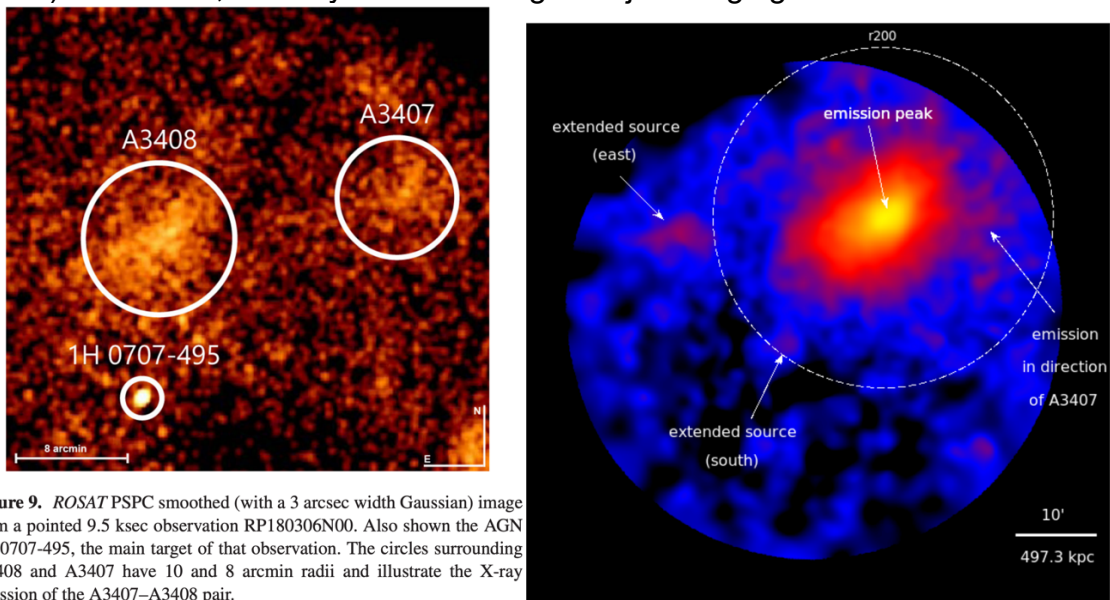
## 5. SCIENTIFIC AND TECHNICAL JUSTIFICATION

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

- **Scientific Motivations and Values**

Most of the “missing baryons” are expected to reside in the cosmic filaments that connect the highest density peaks of the Universe (galaxy clusters) in the form of the warm-hot intergalactic medium (WHIM) in a low-density, low temperature ( $10^5$ - $10^7$ K) phase. However, WHIM remains elusive in spatially resolved X-ray emission, because of the lack of facilities that have both a high sensitivity and a good spatial resolution. eROSITA has met these requirements, and during its PV phase, eROSITA detected the filament along the clusters A3391 and A3395 and the bridge connecting them (Reiprich et al. 2021). Until now, eROSITA has not yet any opportunity to follow up more cluster pairs to detect such cases of intercluster medium. Between interacting cluster pairs, it is one of the most promising positions to detect the X-ray emissions of WHIM. Meanwhile, analysis of the connecting bridge between cluster pairs, if exists, provides essential information to the dynamical nature of the cluster pair and the model of large-scale structure growing.

X-ray bridge were claimed to be detected in only a few cluster pairs, e.g., A222+A223, A339+A401, A2029+A2033. Thanks to the capability of eROSITA, A3391+A3395 was the only case in which a hint of WHIM (colder than cluster ICM) was found. Unluckily, the bridge between them is contaminated by a much-brighter galaxy group, which hampered the analysis. We propose a deep follow-up of the cluster pair A3407+A3408 with FXT, which has similar characteristics to eROSITA. Nascimento et al. (2016) performed spectroscopic survey to probe the galaxy dynamics in this field. They found that likely the pair is gravitationally bound and rotating globally. They note in the ROSAT image a weak bridge leaving A3407 and going towards A3408 (left figure). If it is true, we may be witnessing a major merging event.



**Figure 9.** ROSAT PSPC smoothed (with a 3 arcsec width Gaussian) image from a pointed 9.5 ksec observation RP180306N00. Also shown the AGN 1H 0707-495, the main target of that observation. The circles surrounding A3408 and A3407 have 10 and 8 arcmin radii and illustrate the X-ray emission of the A3407–A3408 pair.

Before the eROSITA all-sky survey (eRASS), this region was only observed by ROSAT. Even with eRASS, the data is far from sensitive enough to detect the

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connecting bridge because of limited depth. During the eROSITA PV phase, A3408 was serendipitously covered during the observation of the AGN 1H 0707-495 in deep pointing mode. From this data, Iljenkarevic et al. 2022 found that in the direction from A3408 to A3407, the emission and temperature of A3408 are enhanced (right figure), suggesting that the ICM of A3408 is affected by interaction. Therefore, this cluster pair is a very promising case for detection of a connecting bridge and detailed dynamical analysis.

- **EP Capabilities to be Verified**

1. Detecting a bridge is the best indicator of FXT's imaging performance
2. Demonstrate FXT calibration by comparing the cluster spectra (non-variable and high S/N) with that obtained by eROSITA (A3408)
3. Capability of FXT in studying both spectrum and variability of AGN

- **Immediate Objectives**

1. Detect the bridge between the two interacting clusters
2. Constrain the dynamical model of cluster pair
3. Check the state of 1H0707-495 by comparing it with history data
4. Test AGN spectra models with 1H0707-495

- **Technical Justification (e.g. target visibility during the PV phase)**

This region is visible in March 2024

The eROSITA image (Figure above on the right, Iljenkarevic+2022) was obtained using 3 cameras (out of 7) of eROSITA during a 50ks observation. There is likely an arm of emission extending from A3408 to A3407. We expect that the brightness of the bridge, if exists, would be similar to this arm. To reach the quality of this image, we need FXT exposure of at least 130ks, assuming that the FXT effective area is 1/6 of that of eROSITA.

- **References**

Nascimento et al. 2016, "[Dynamical analysis of the cluster pair: A3407 + A3408](#)", MNRAS 460,2193

Iljenkarevic et al. 2022 "[eROSITA spectro-imaging analysis of the Abell 3408 galaxy cluster](#)" A&A 661, 261

Liu et al. 2022 "[The eROSITA extragalactic CalPV serendipitous catalog](#)", A&A 664,A126

Boller et al. 2021 "[Extreme ultra-soft X-ray variability in an eROSITA observation of the narrow-line Seyfert 1 galaxy 1H 0707-495](#)" A&A 647A,6B

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