X-ray Properties of Galaxy Clusters with *eROSITA*

Joseph Hall

New Results in X-Ray Astronomy 2025

4 September 2025

BACKGROUND

A New Era

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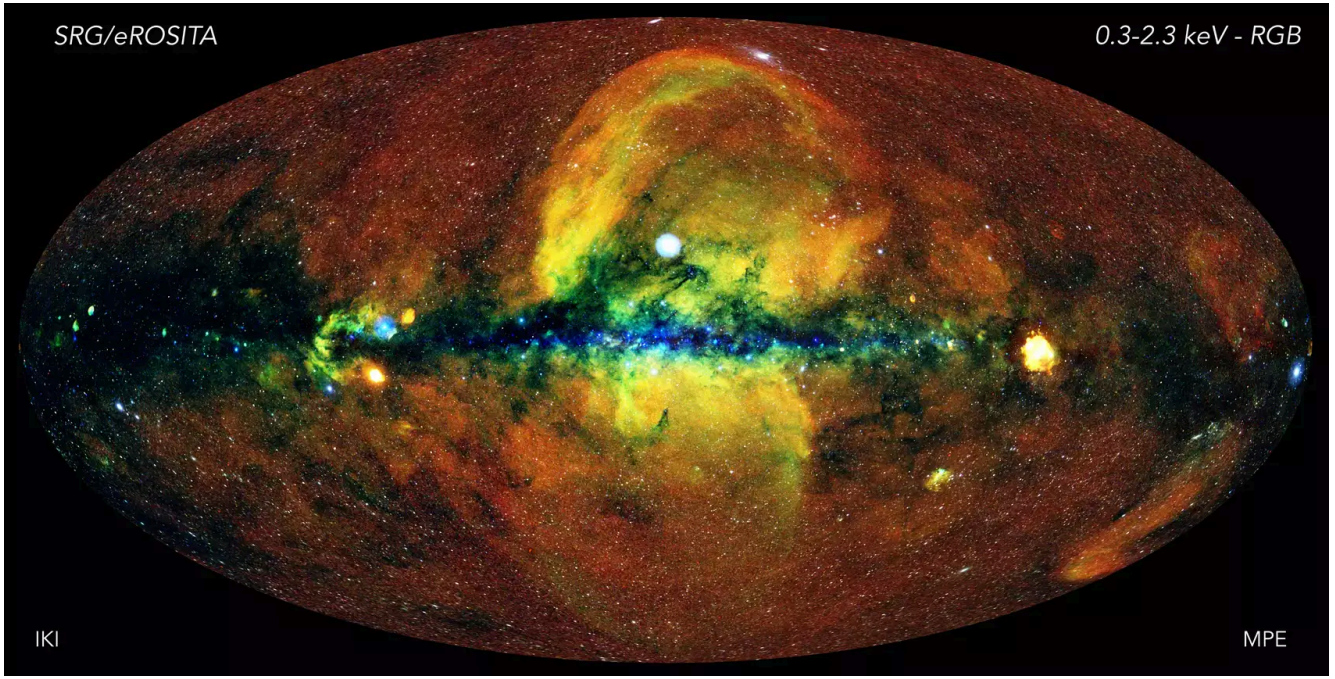

For 2.5 years from 2019 **eROSITA** mapped the X-ray sky, so far providing 2 data releases

Brunner et al. 2022, Merloni et al. 2024

Image Credit: Jeremy Sanders, Hermann Brunner and the eSASS team (MPE); Eugene Churazov, Marat Gilfanov (on behalf of IKI)

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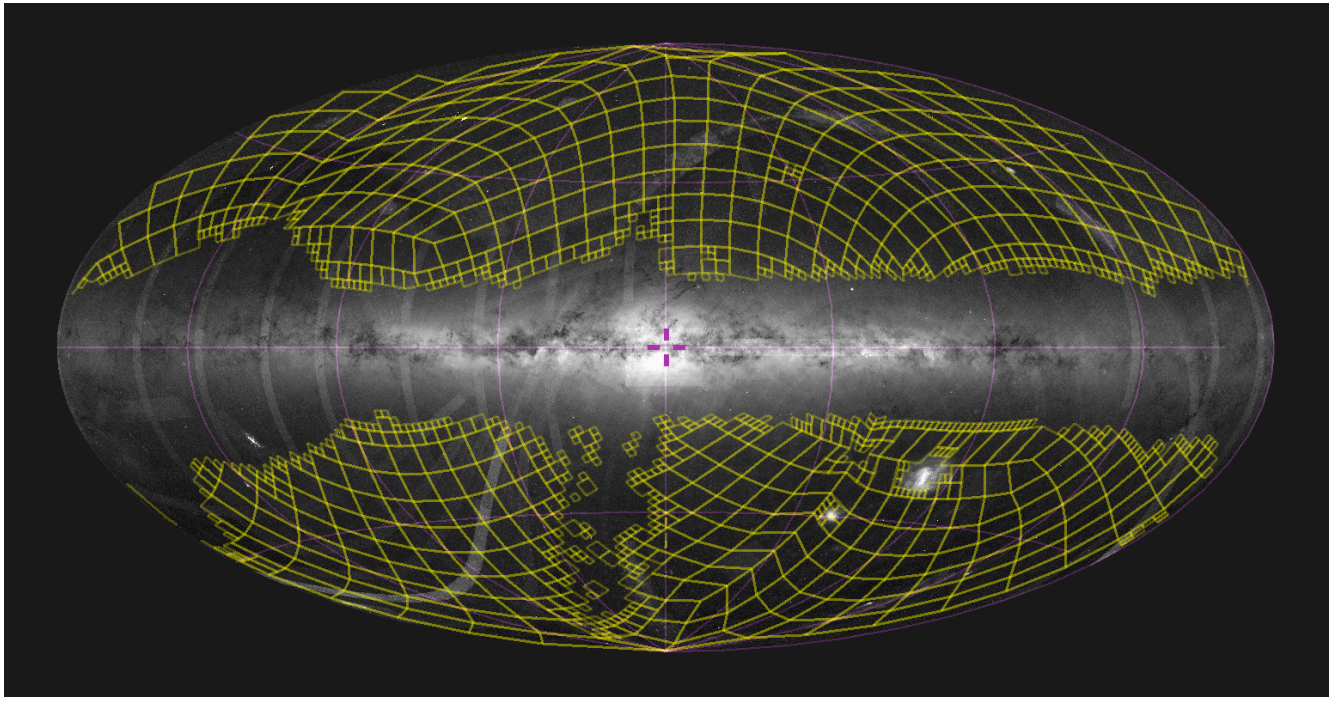

The optical sky has been well-mapped by **DES** and **DESI**, with **Euclid** Q1 data providing a preview of the full data coming next year

DES Collaboration 2021, *Dey et al. 2022*, *Euclid Collaboration 2025*
Image credit: Wen & Han 2024 via VizieR

Galaxy Clusters: They're Like Dragons.

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They're the *largest gravitationally bound objects*, only 20% of their baryons are in stars, the rest is in the X-ray emitting **ICM**.

Image Credit: ESA/XMM-Newton/DSS-II/J. Sanders et al. 2019

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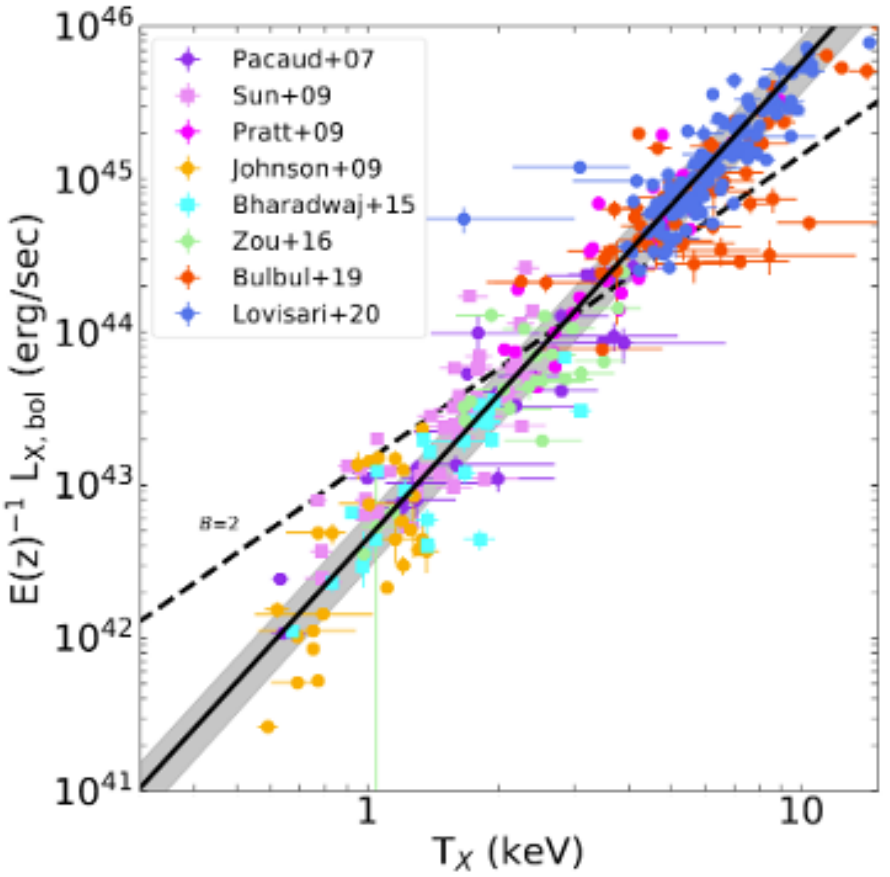

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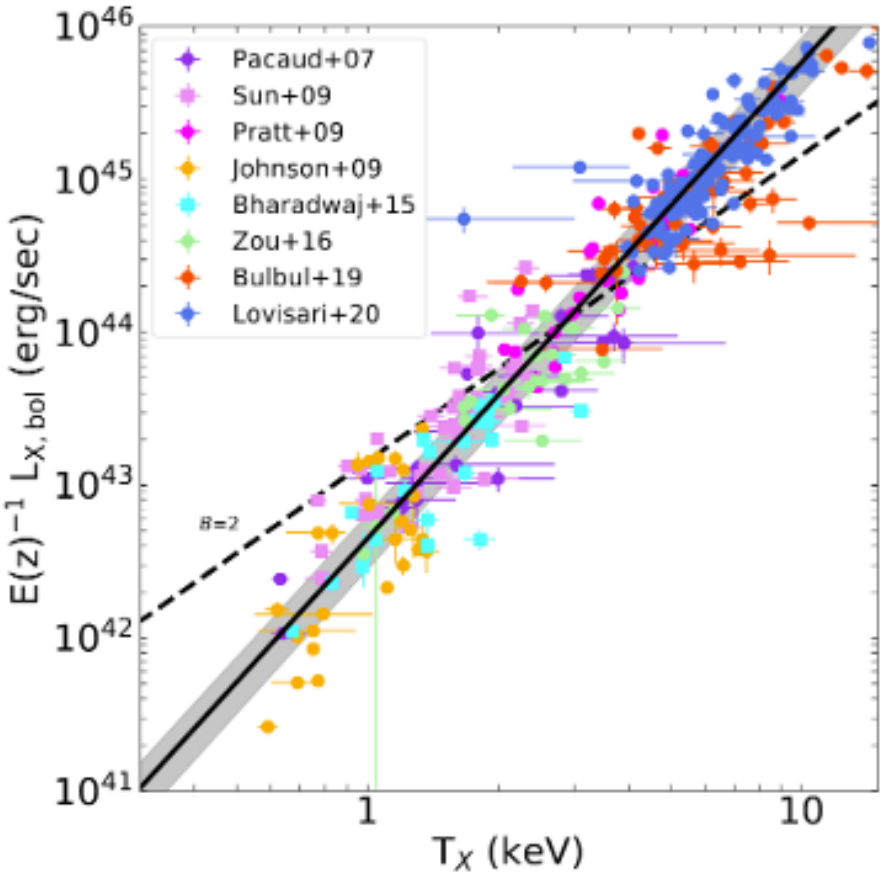
Deviations from the model are the result of extra astrophysics.



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Cluster Cosmology

Counting the number of clusters in the universe can help to constrain cosmological parameters, particulary σ_8 and Ω_M

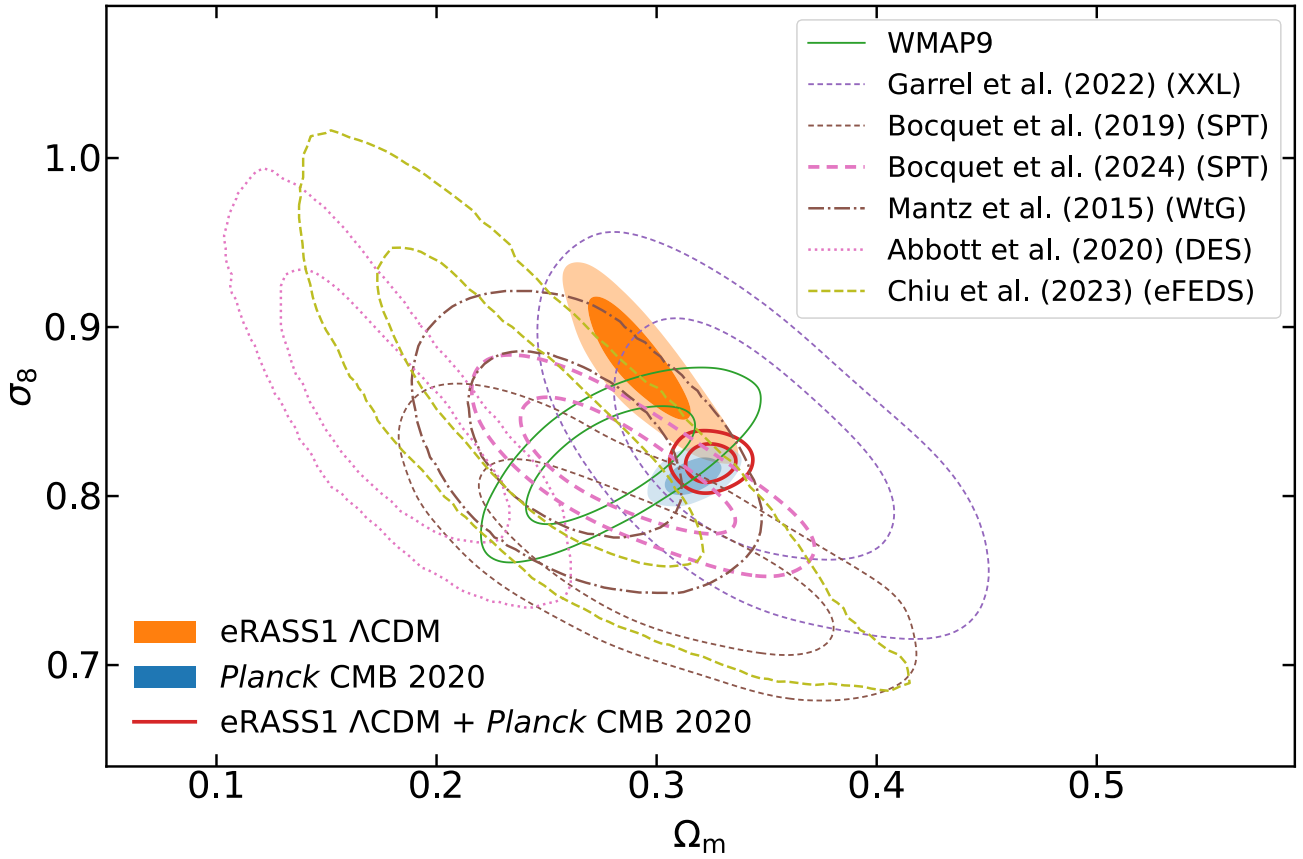

Image Credit: Ghirardini et al. 2024

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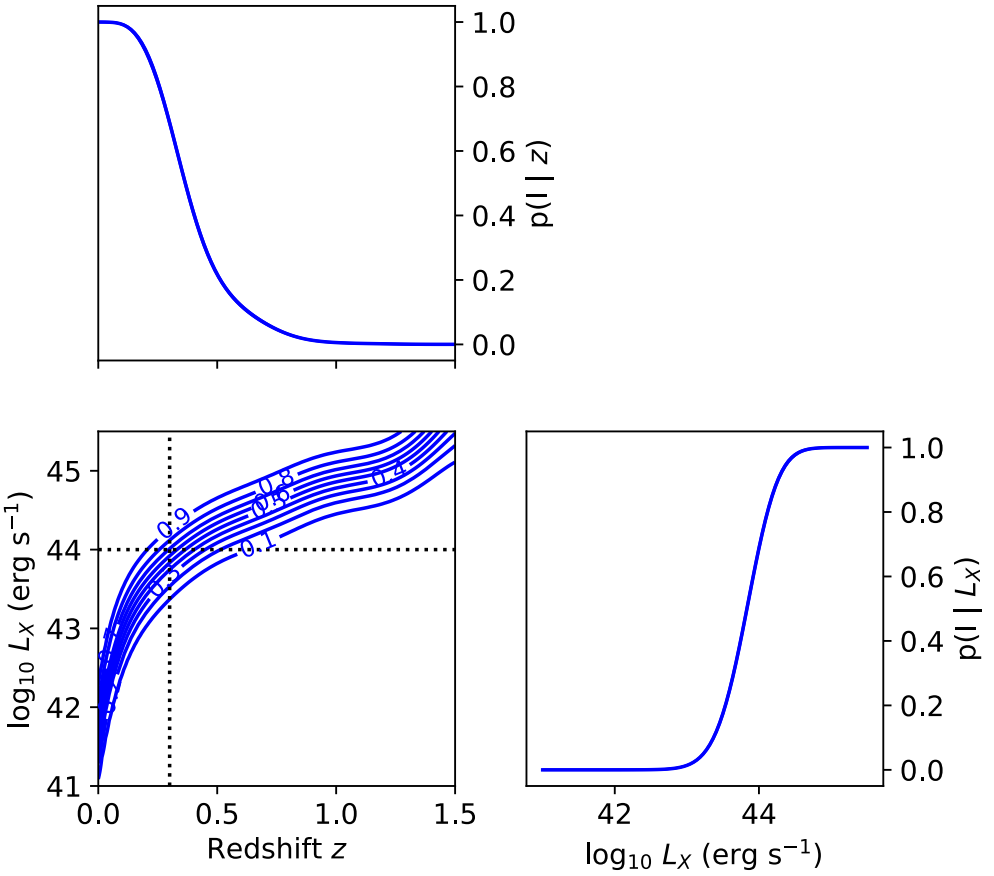

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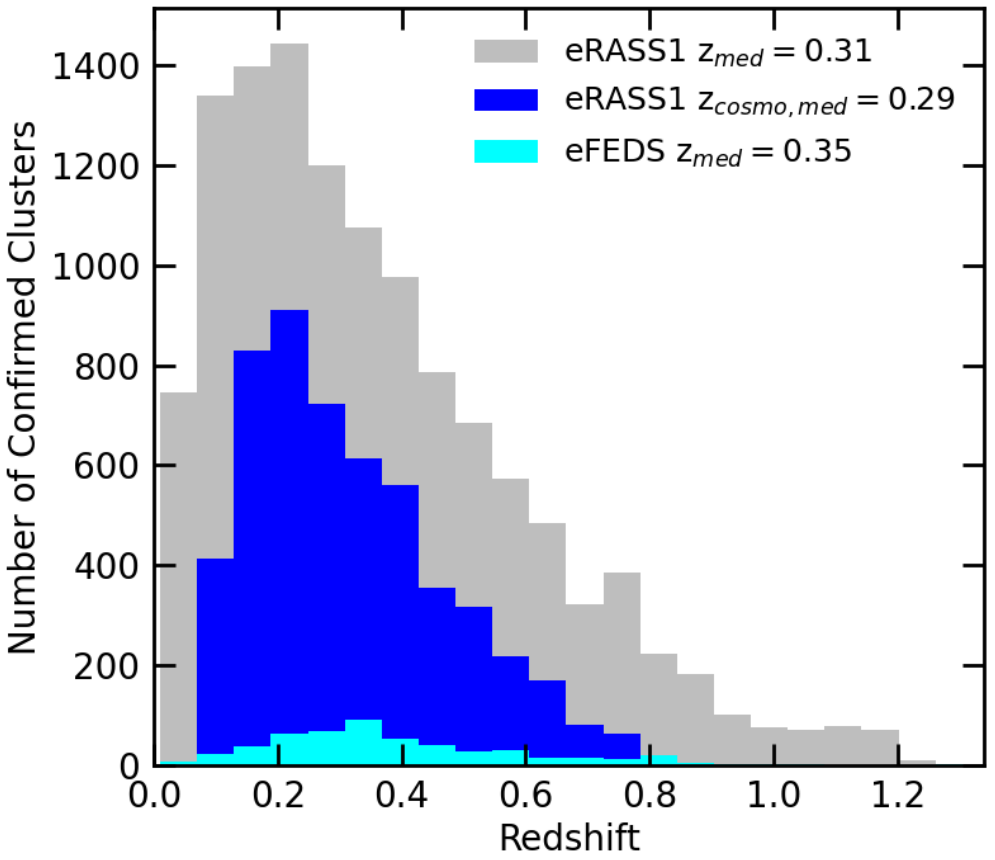

Image Credit: Bulbul et al. 2024

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Andreon et al. (2016) found diffs in scaling rels for **optical and X-ray clusters**

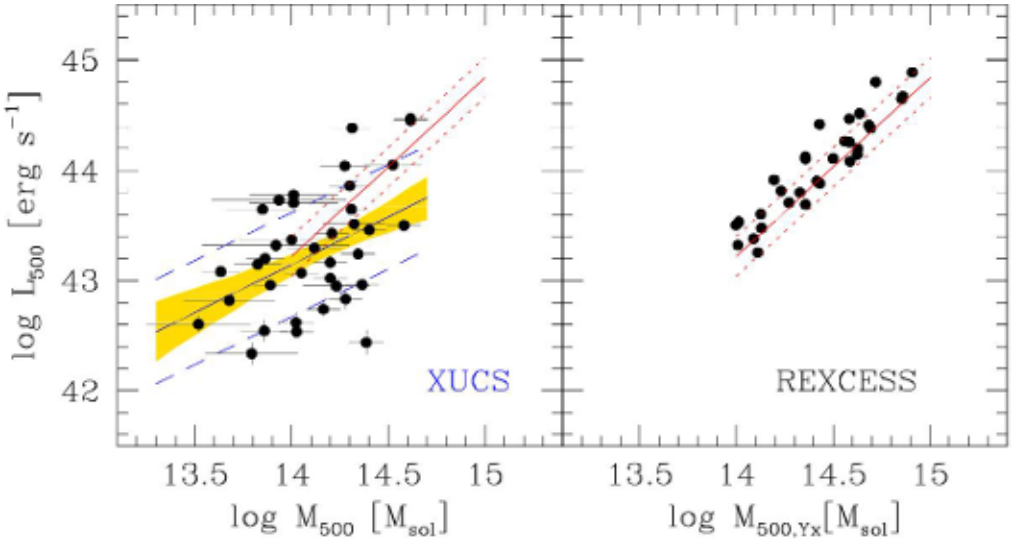

Image Credit: Andreon et al. 2016

Combining eROSITA data with clusters found in wide optical surveys gives the ideal platform to test these biases

SAMPLE SELECTION

Choosing a Catalogue – X-rays

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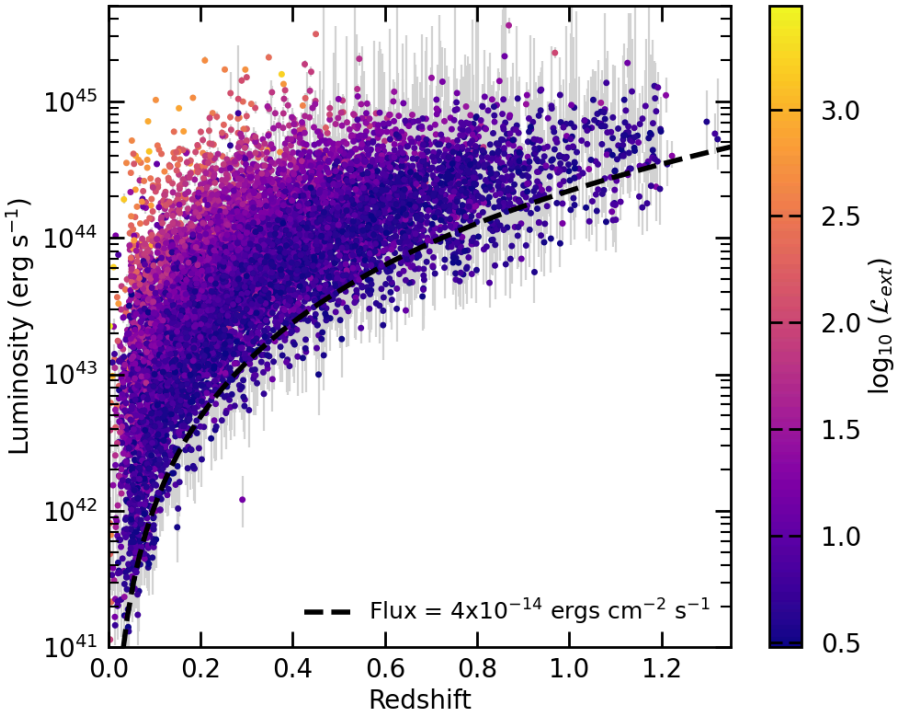

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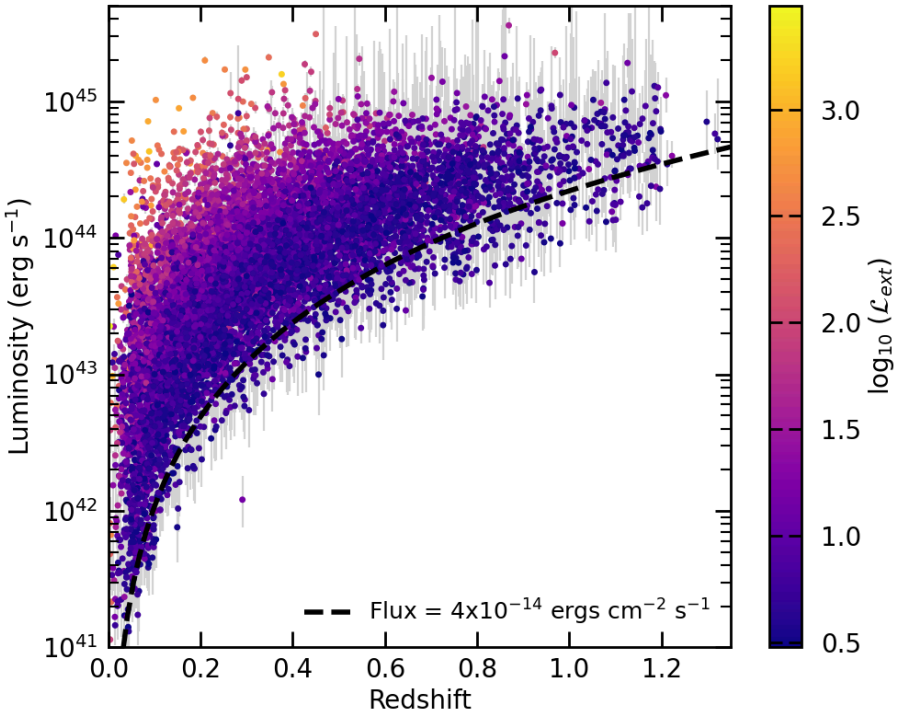

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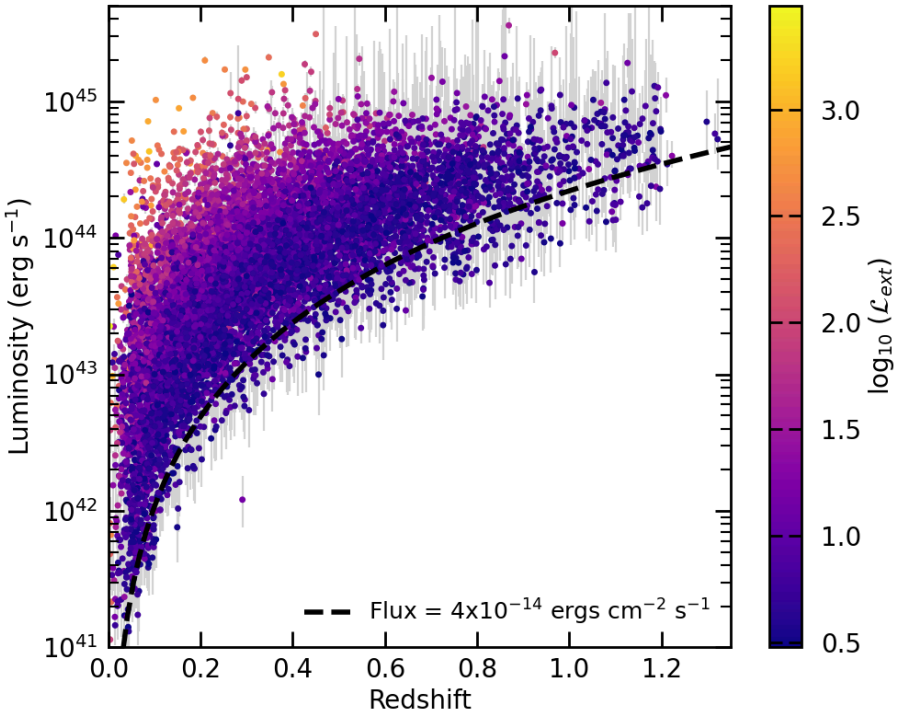

Recent work in Balzer et al. (2025) has identified **1,000s** more clusters in the eRASS1 data

Image Credit: Bulbul et al. 2024

Choosing a Catalogue – Optical

Wen & Han (2024) is the best optical catalogue for the work I want to do.

Final Samples

Redid the cross-matching but changed the search area to be where the eRASS1 exposure > 170 s & where the **eRASS sky** intersects with the **Wen & Han field** for $0.1 < z < 0.2$.

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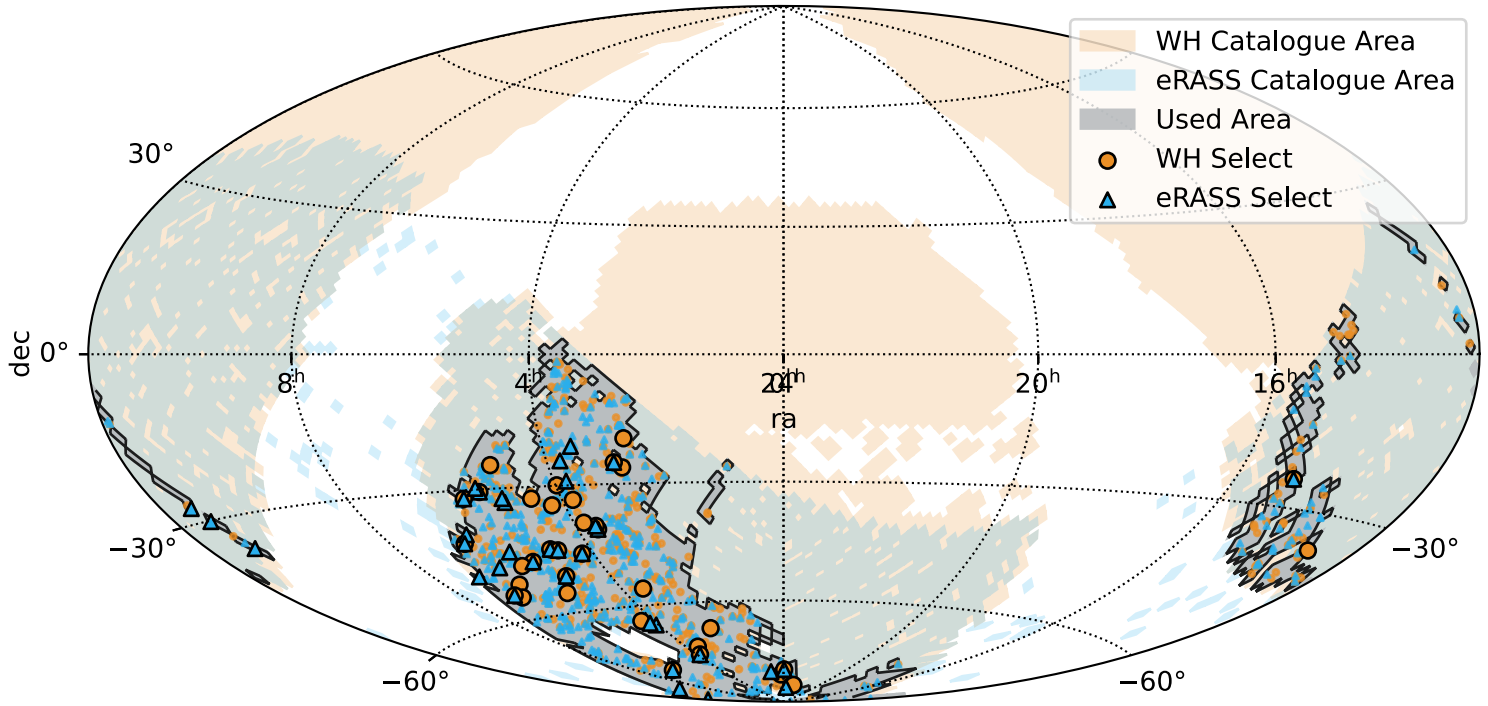

DATA ANALYSIS

X-rays Generate and Analyse

A mission agnostic platform for processing and analysing X-ray data.

Turner et al. 2022, 2024a, 2024b

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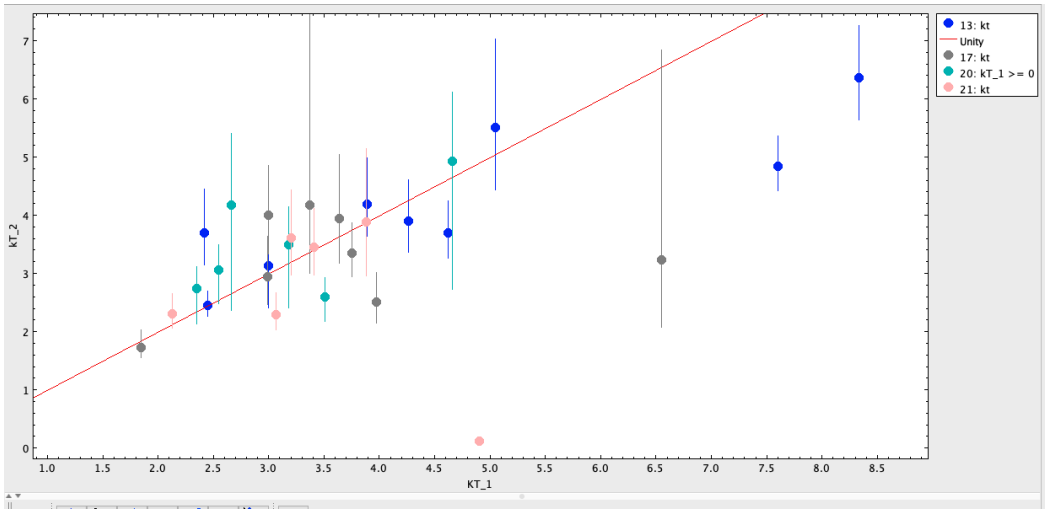

Validated XGA results by comparing its cluster temperatures and luminosities with those from the eRASS catalogue.

Turner et al. 2022, 2024a, 2024b

Scaling Relations – Set-up

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Accounted for cluster evolution by dividing L for each cluster by:

$$E(z)^{\gamma} = \left(\sqrt{\Omega_M(1+z)^3 + \Omega_k(1+z)^2 + \Omega_\lambda}\right)^{\gamma}.$$

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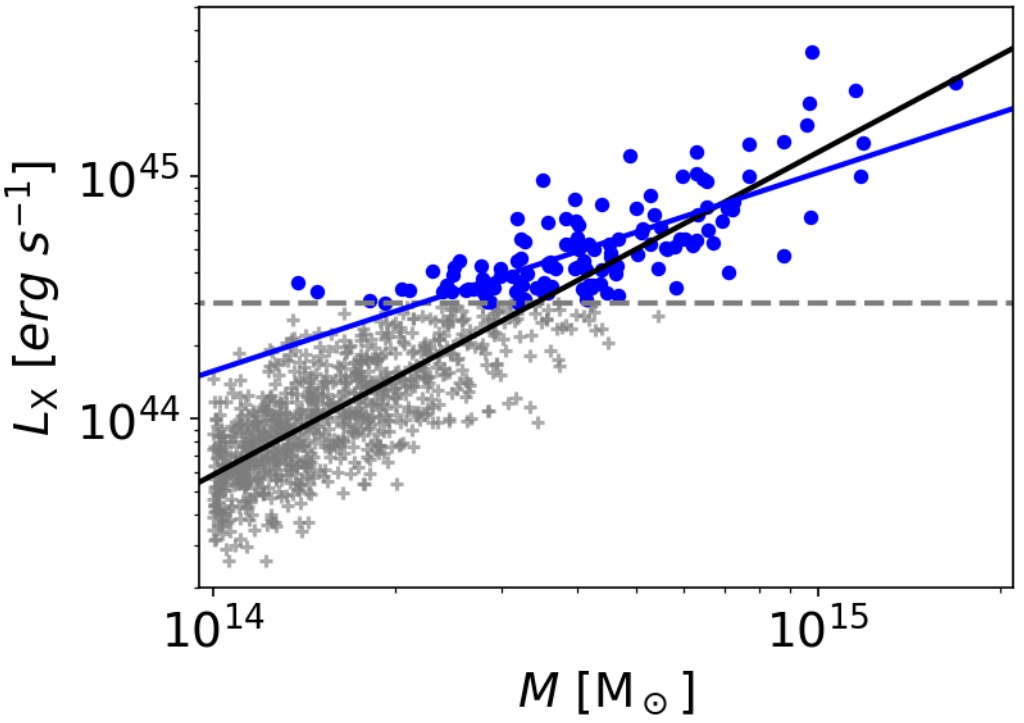
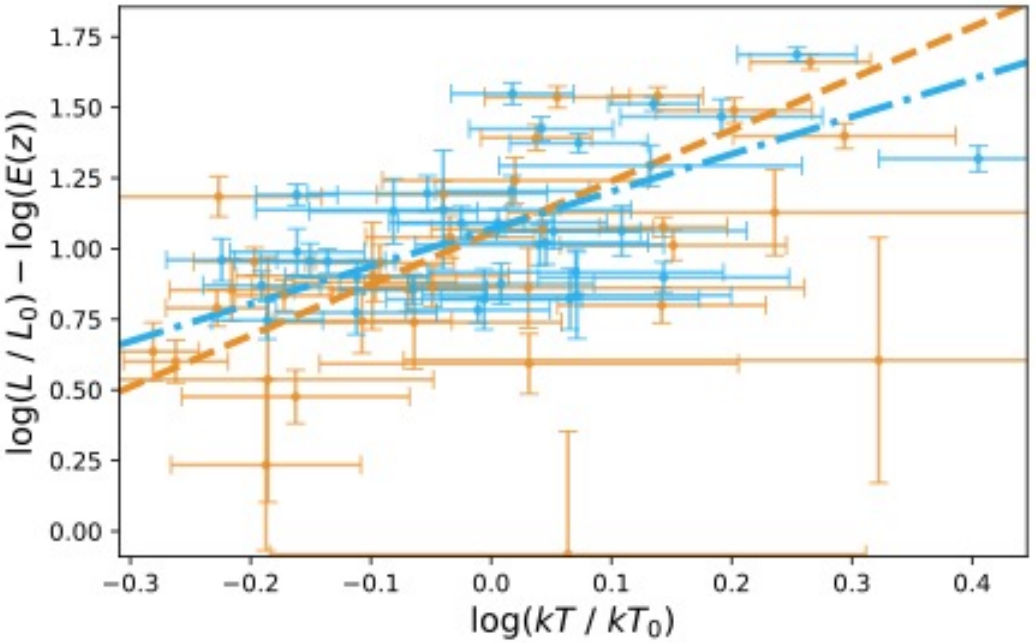
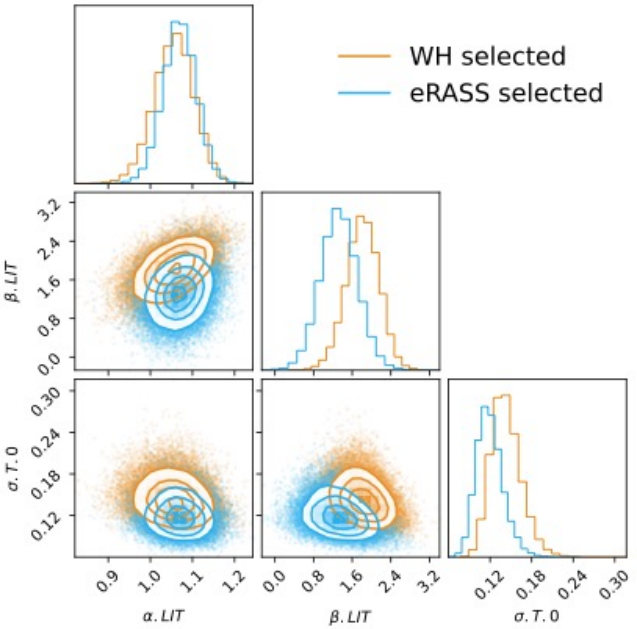
Improvement as it does **Bayesian** linear regression and can account for intrinsic scatters and biases from selection effects.

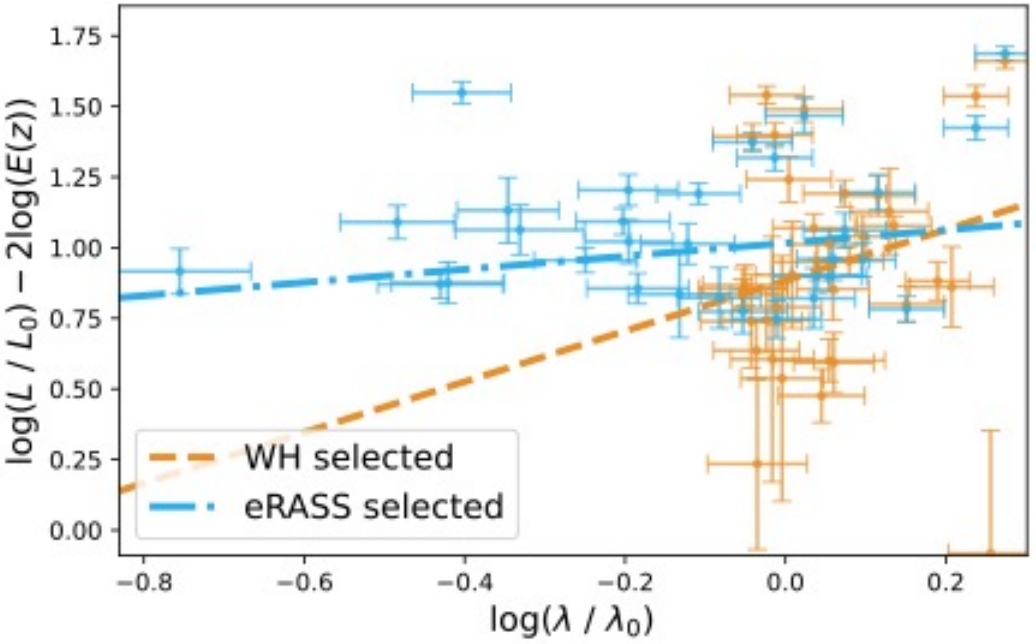


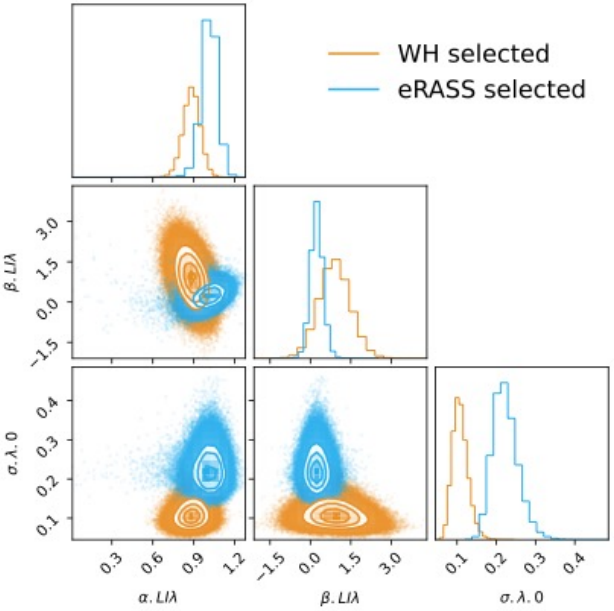
RESULTS

Results


log(L / L0) − log(E(z))
log(kT / kT0)


WH selected
eRASS selected
α. LIT
β. LIT
σ. T. 0


log(L / L0) − 2log(E(z))
log(λ / λ0)
WH selected
eRASS selected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Discussion

The optical sample has a **steeper slope (β)** for both relations.

Parameter	$L-T$		$L-\lambda$	
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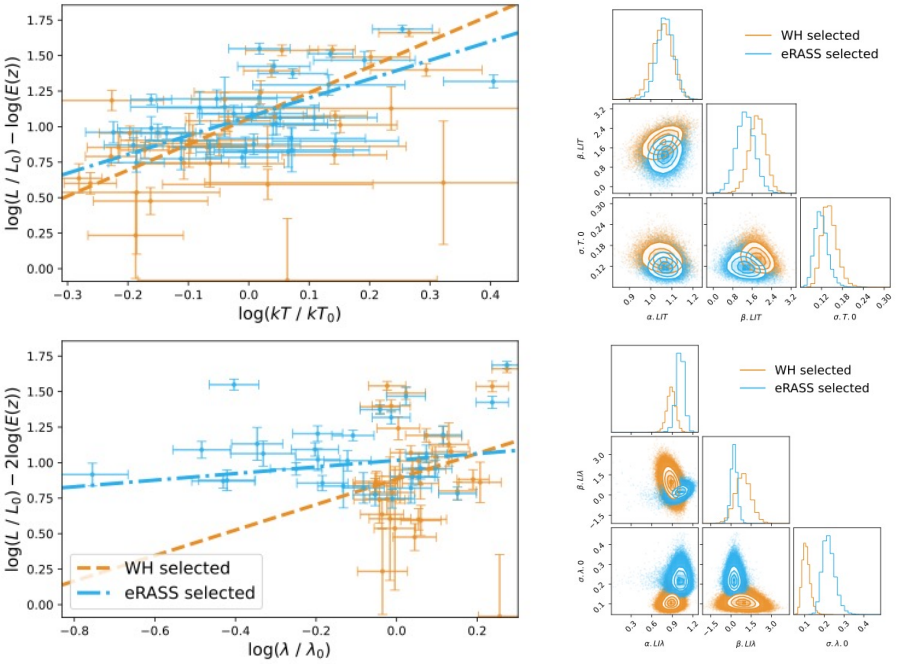
β	$1.819^{+0.336}_{-0.342}$	$1.325^{+0.384}_{-0.337}$	$0.897^{+0.584}_{-0.573}$	$0.233^{+0.227}_{-0.222}$
σ	$0.141^{+0.024}_{-0.019}$	$0.118^{+0.020}_{-0.017}$	$0.107^{+0.021}_{-0.017}$	$0.22^{+0.035}_{-0.028}$



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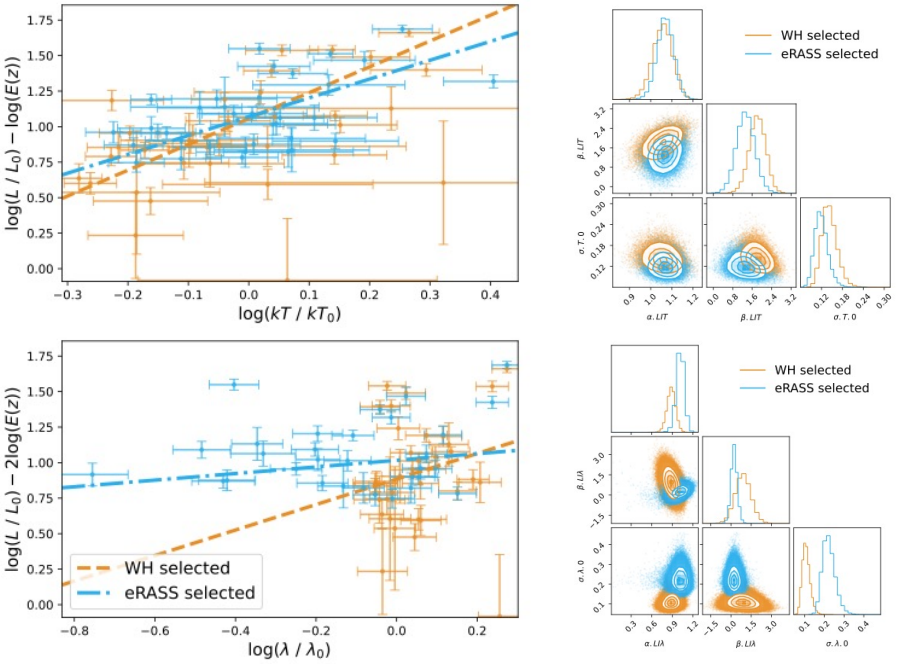

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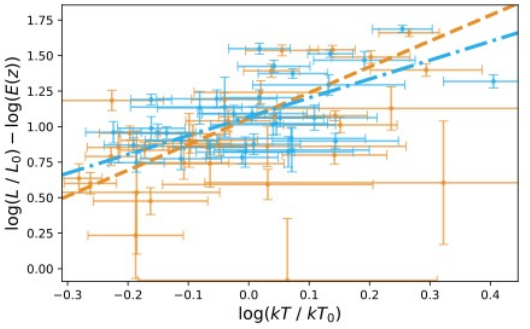

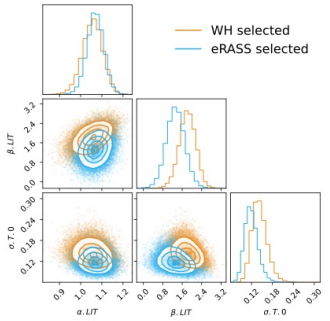

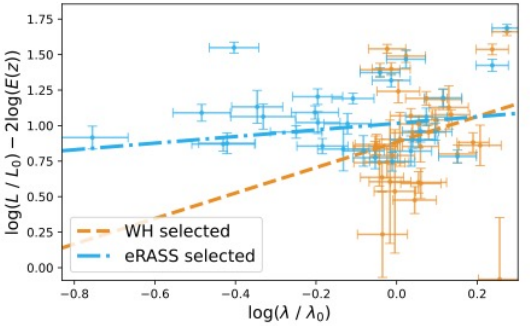

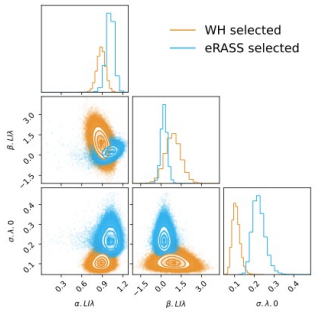

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Similar to Andreon et al. (2016), we see a lot of high λ, low L clusters in the optical sample missed by the X-ray

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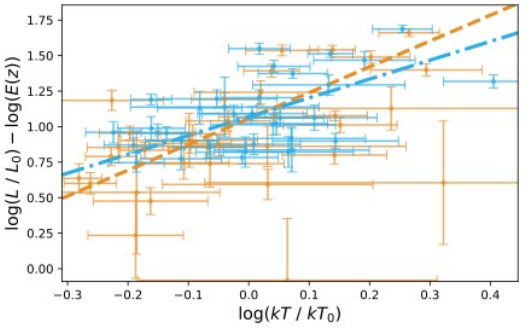
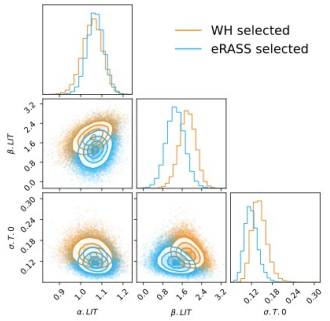
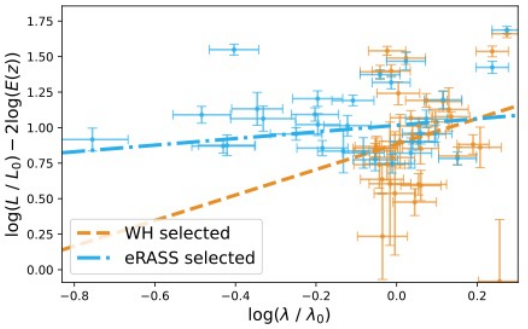
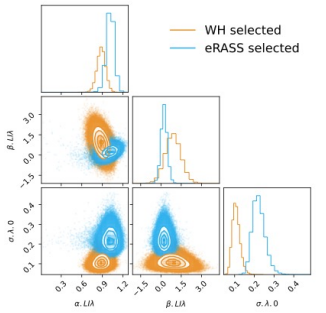


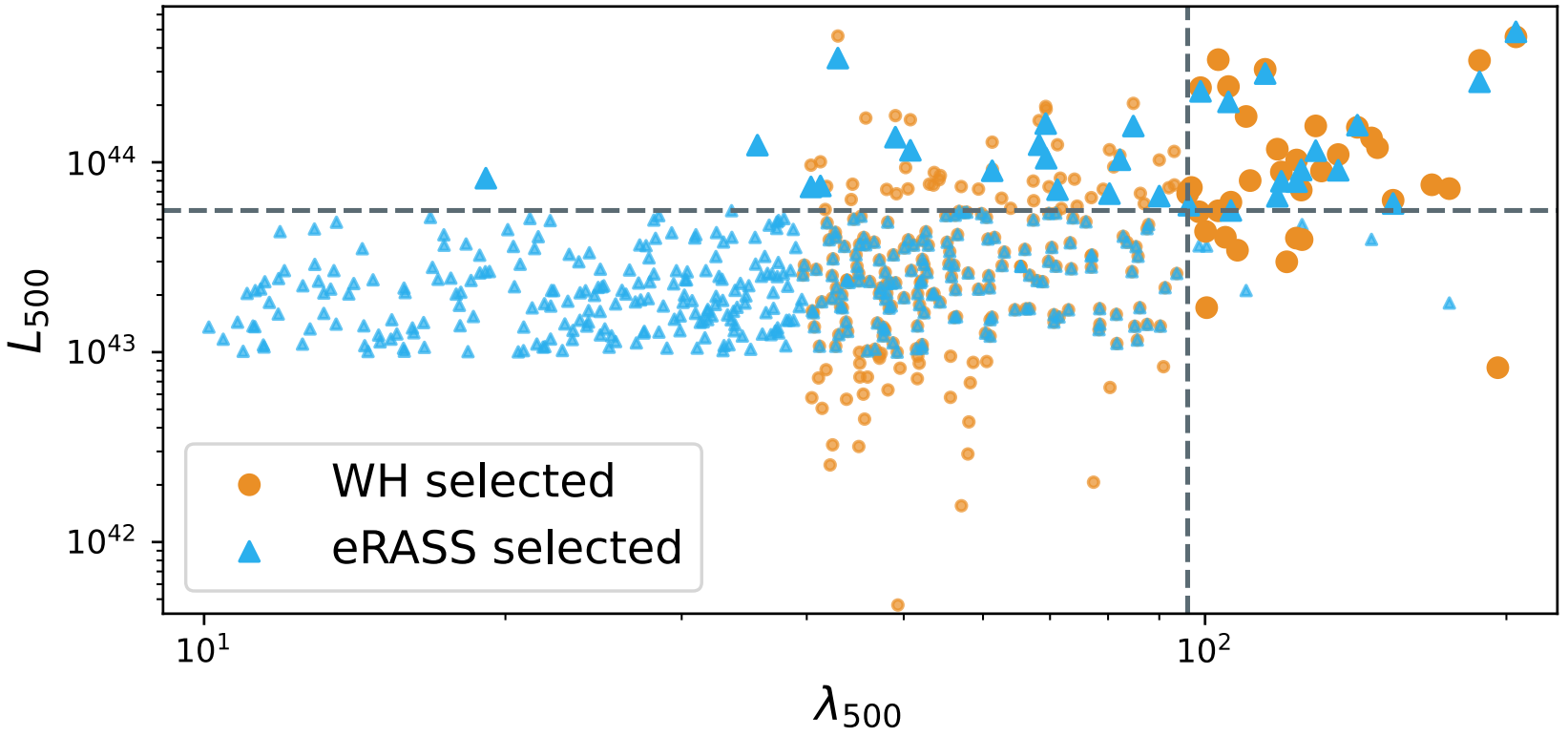






Future Work

My samples are currently very **incomplete**. I have used only 35 from each selection method of a possible 500 that I identified during sample selection:



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