University of BRISTOL

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# The X-ray Properties of Optically Selected Galaxy Groups

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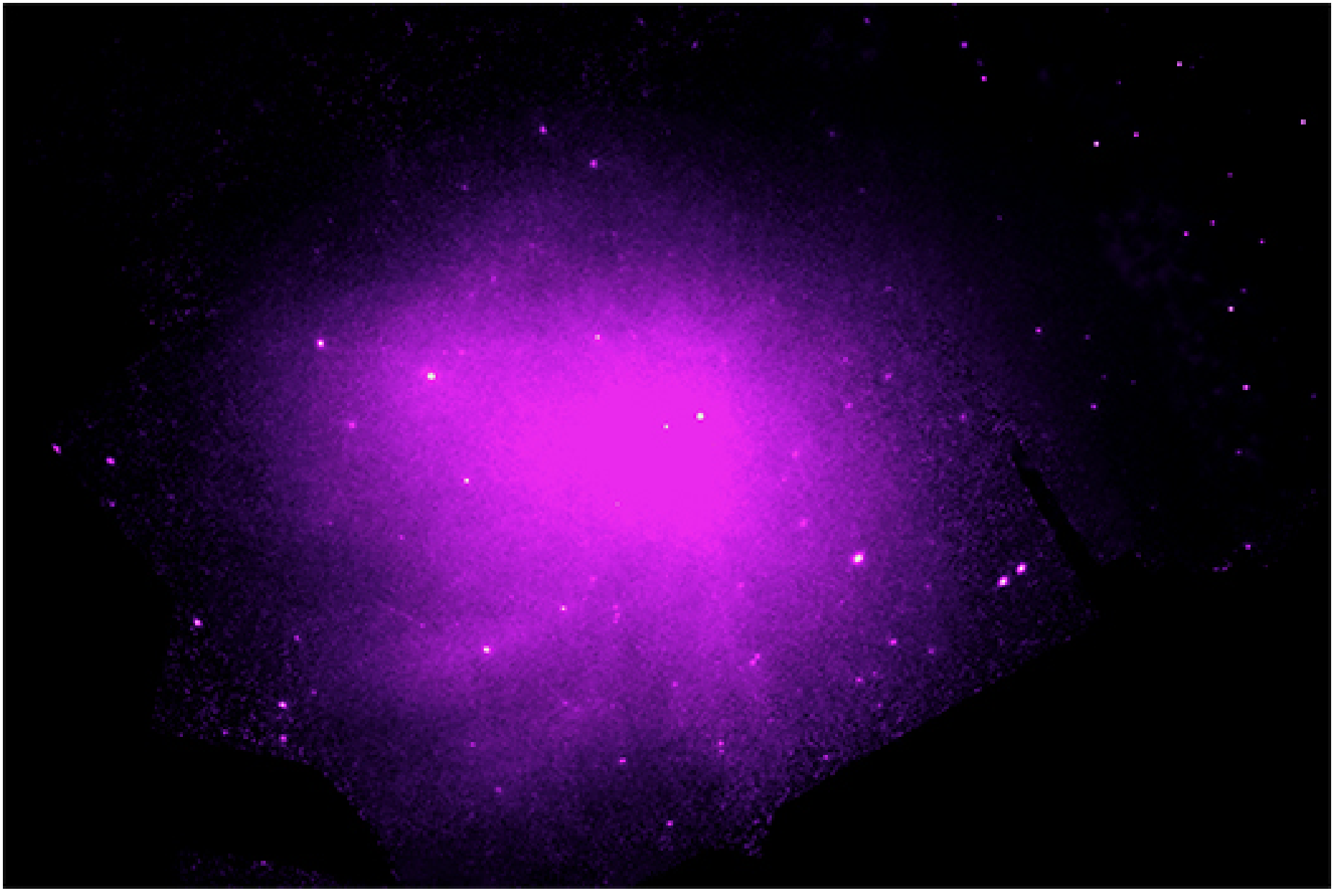
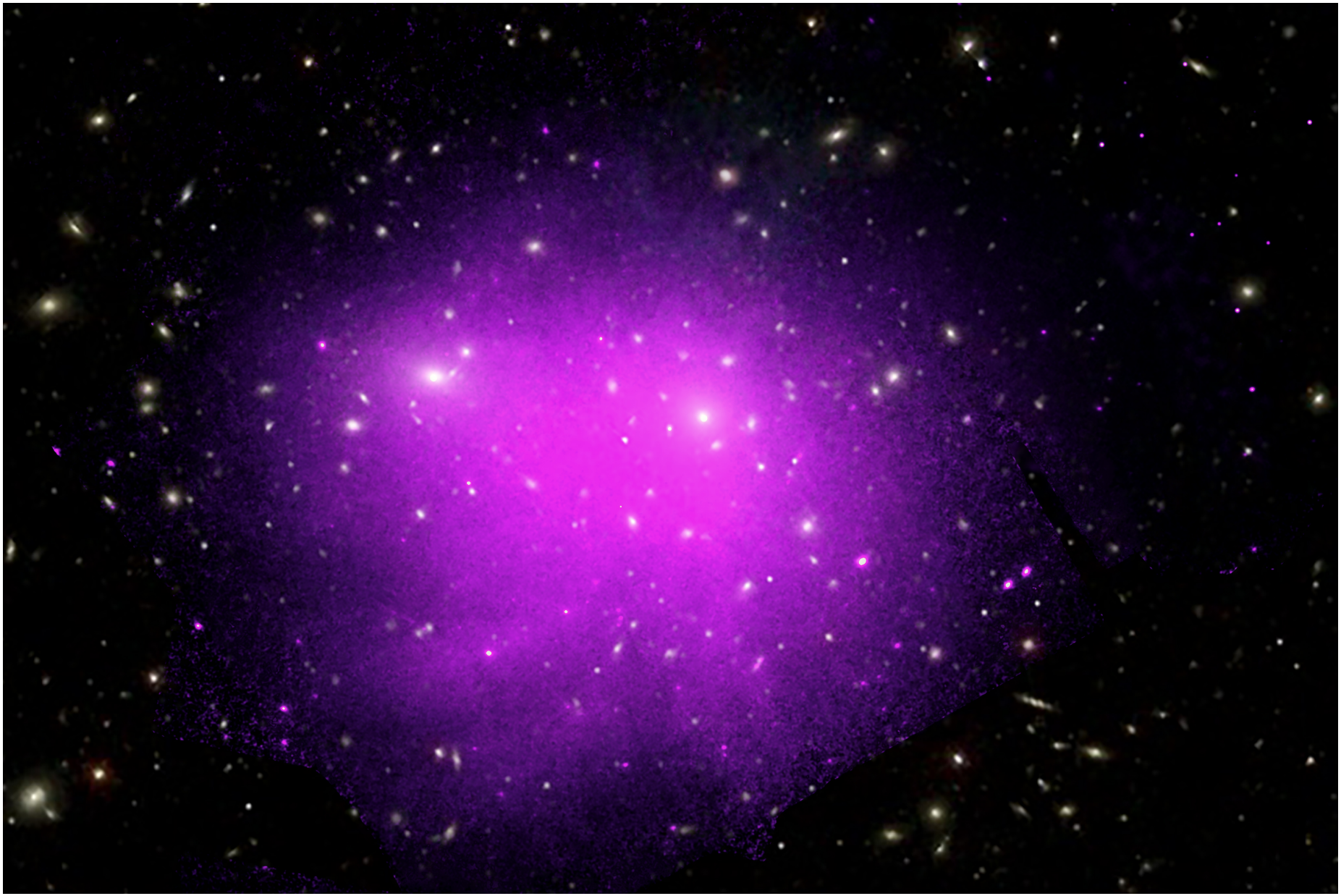
# Introduction

- What are Galaxy Groups?
- Self-similarity
- GAMA & XXL surveys
- Measure X-ray Luminosity of Optically Selected Galaxy Groups
- Luminosity - Mass Relation
- The Future: Euclid, eROSITA & Fornax

Credit: SDSS

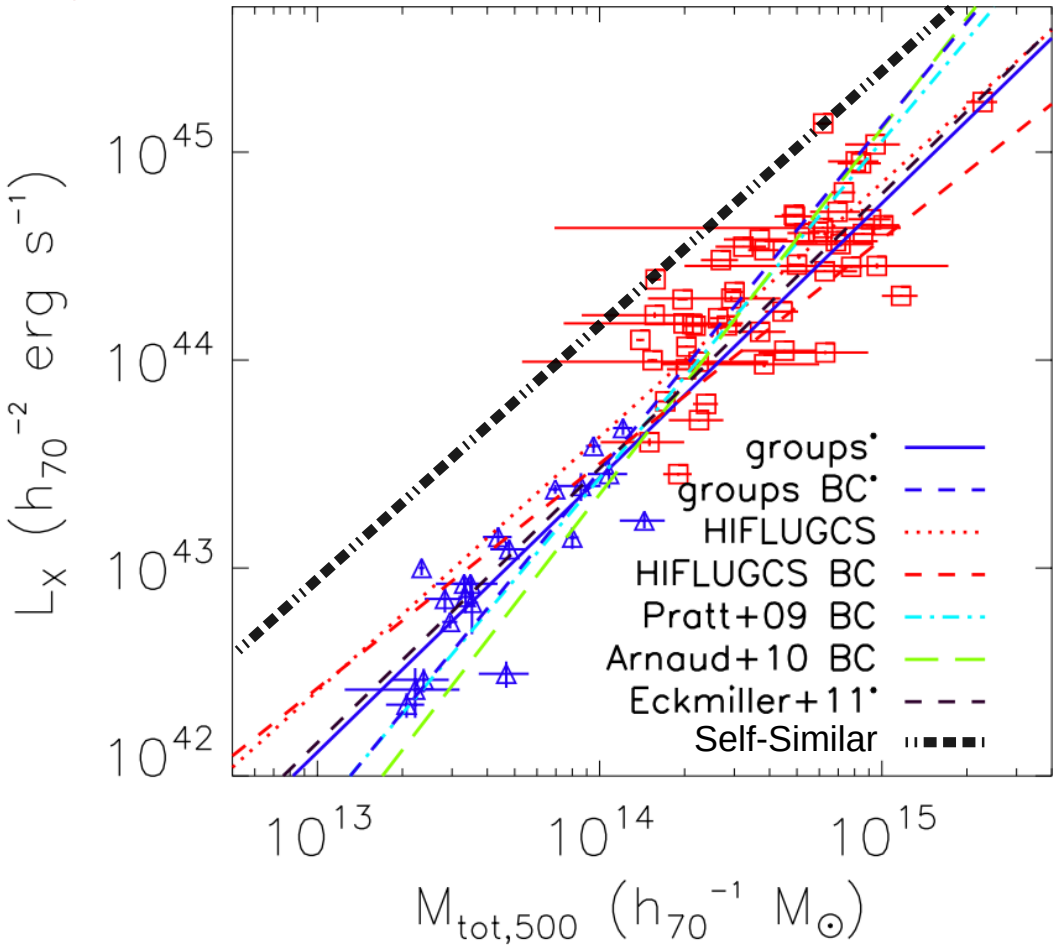


Credit: NASA/CXC/Univ. of Chicago, I. Zhuravleva et al



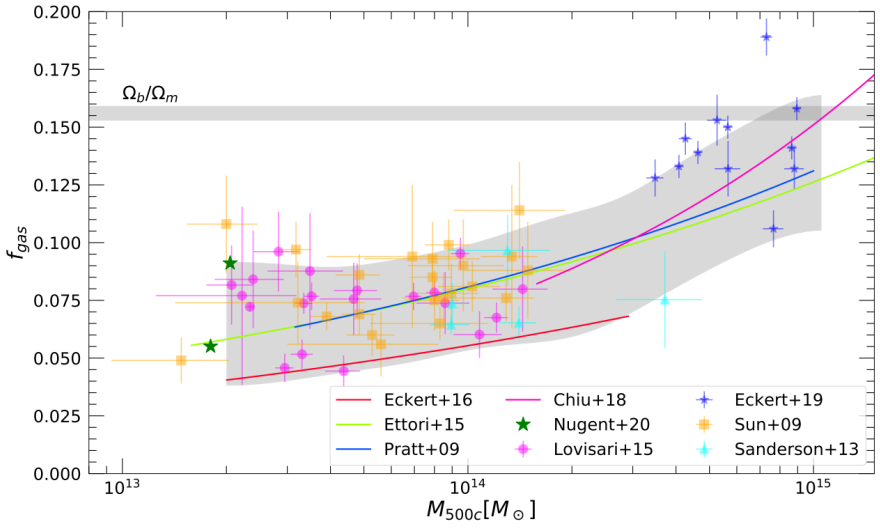
Credit: X-ray: NASA/CXC/Univ. of Chicago, I. Zhuravleva et al, Optical: SDSS

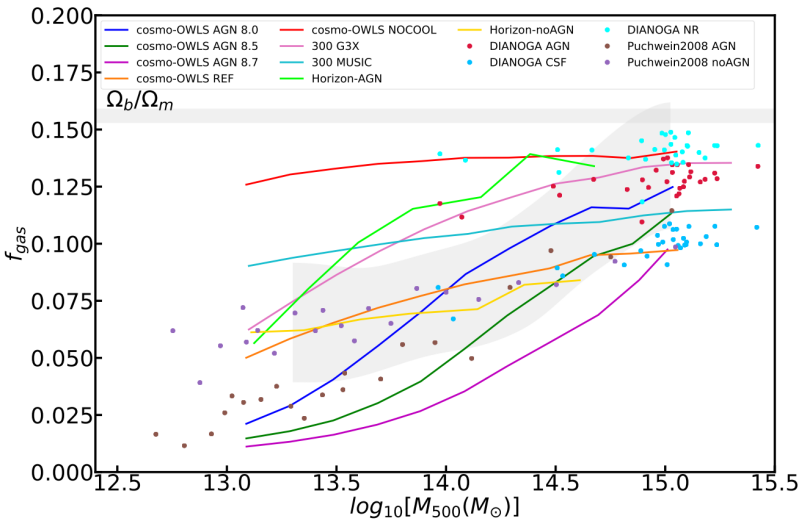
# Self-Similarity




From: Lovisari et al. (2015)

# Feedback

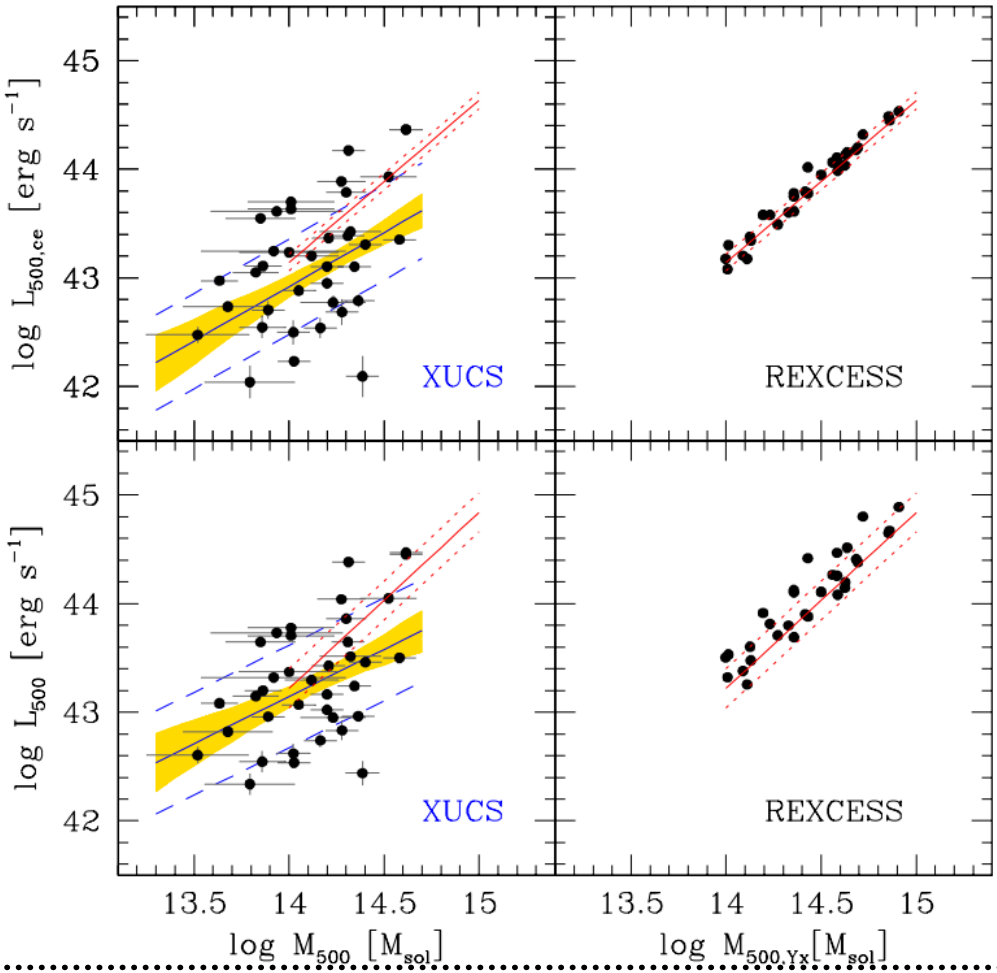



Selection effects...

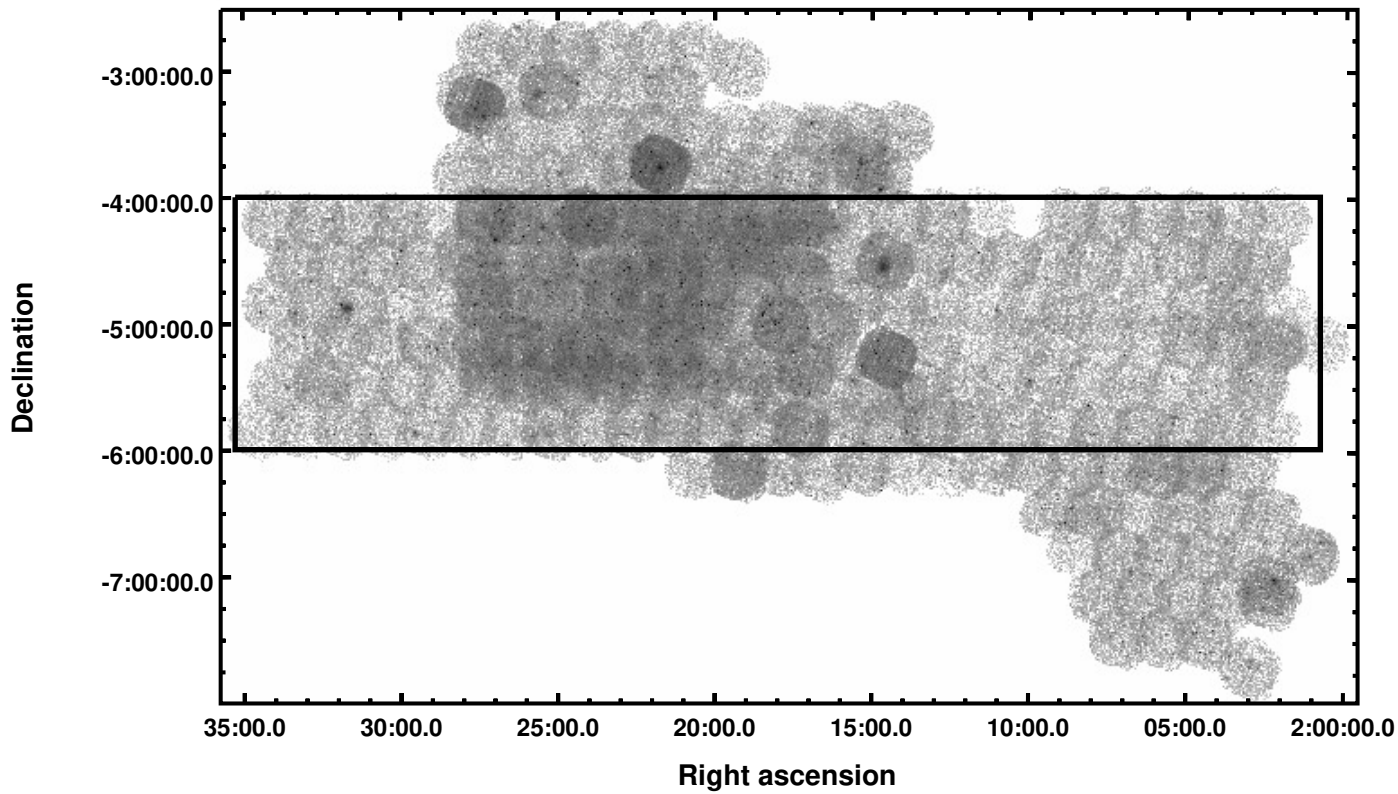
From: Eckert et al. (2021)

# Selection bias




From: Andreon et al. (2016)

- XXL X-ray survey
- GAMA spectroscopic survey
- 235 GAMA groups (with 5+ members) in overlapping region

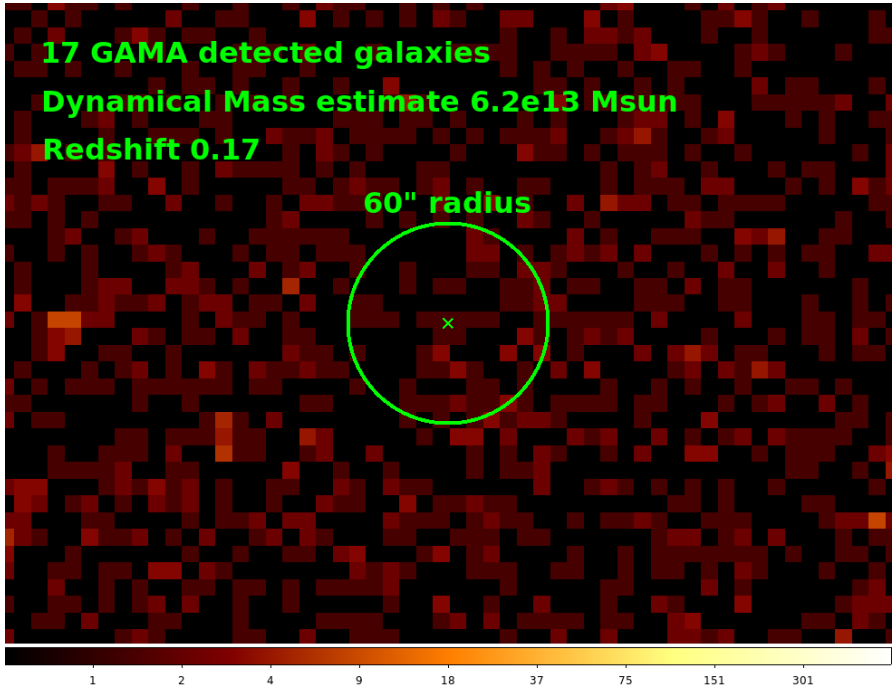


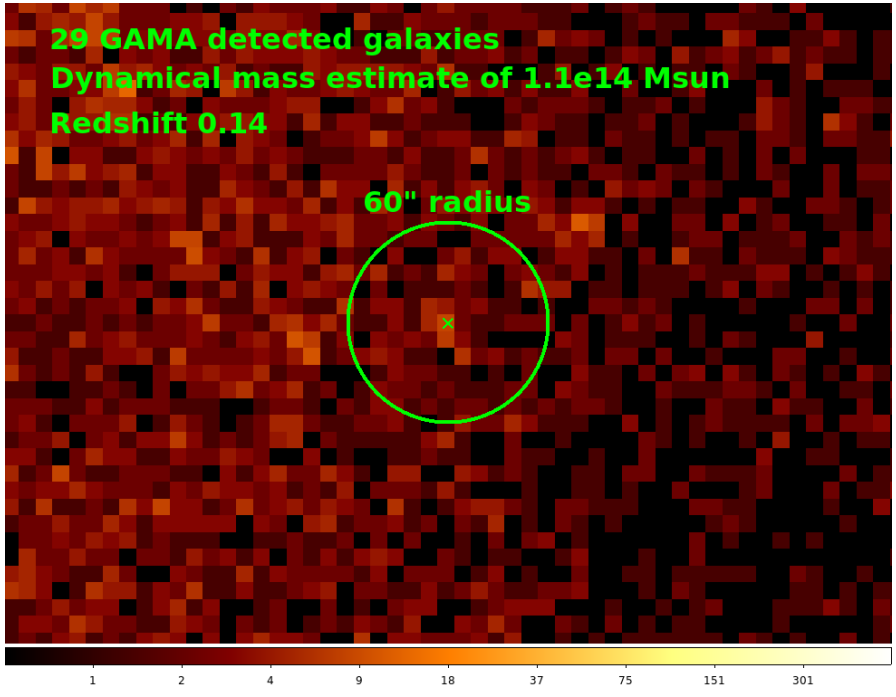

GAMA: Driver et. al (2011), XXL: Pierre et al. (2016)

FoF Algorithm: Robotham et al. (2011)

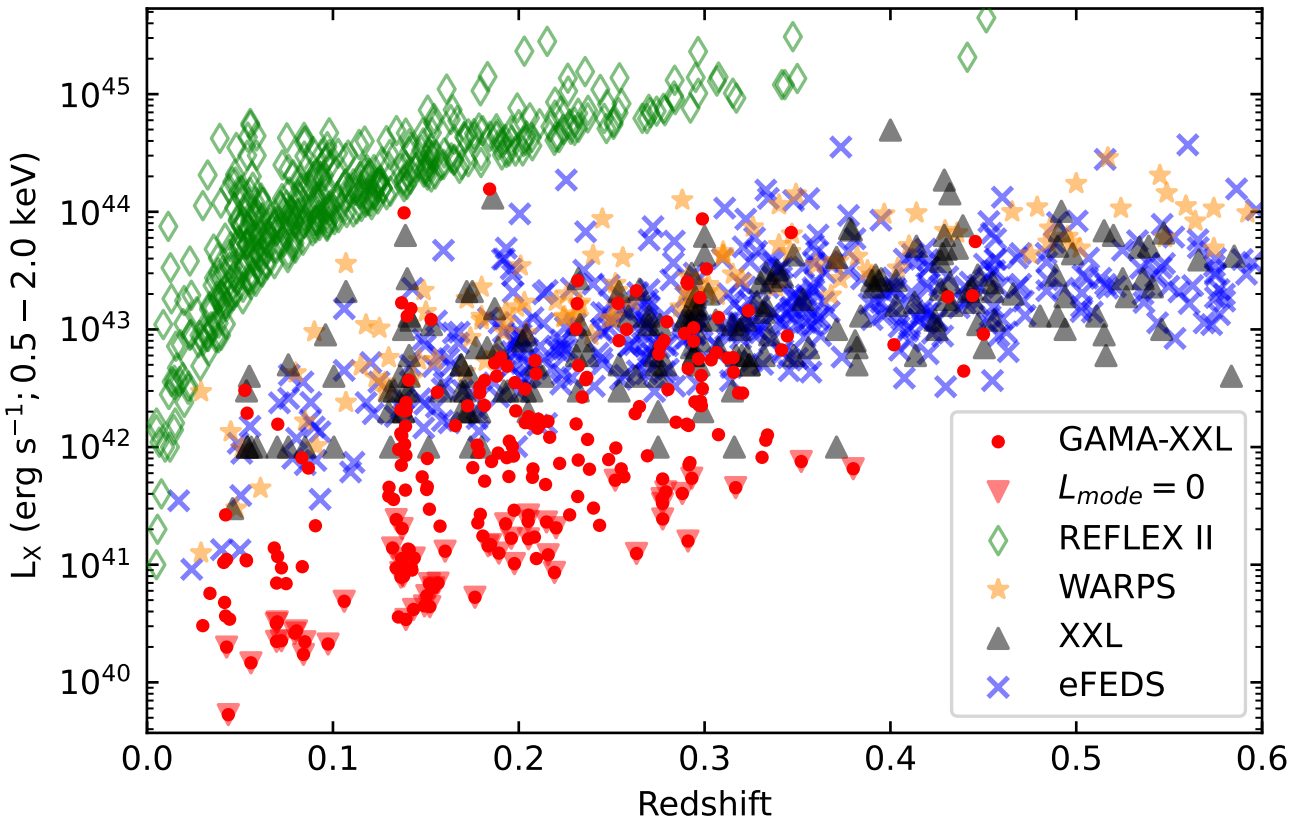
# X-ray Undetected Groups

- 77% are not detected as clusters by XXL
- Use luminosity posterior



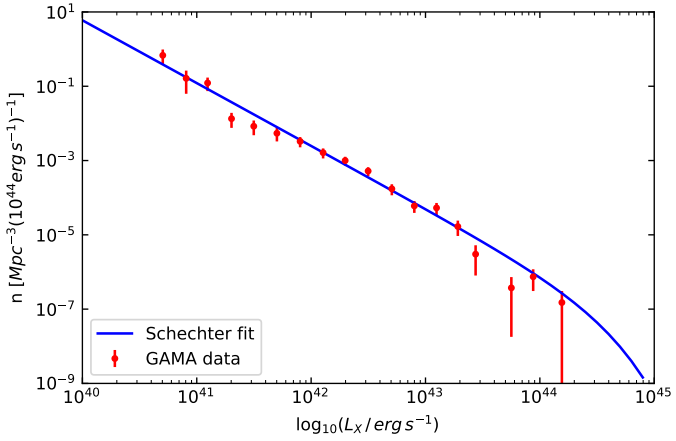



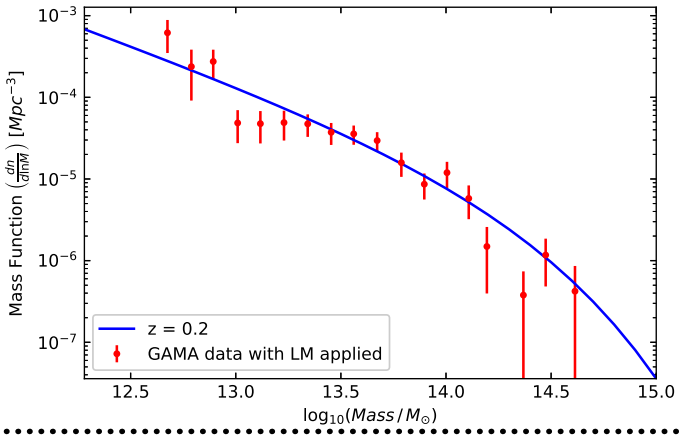
# Luminosity - Redshift Space



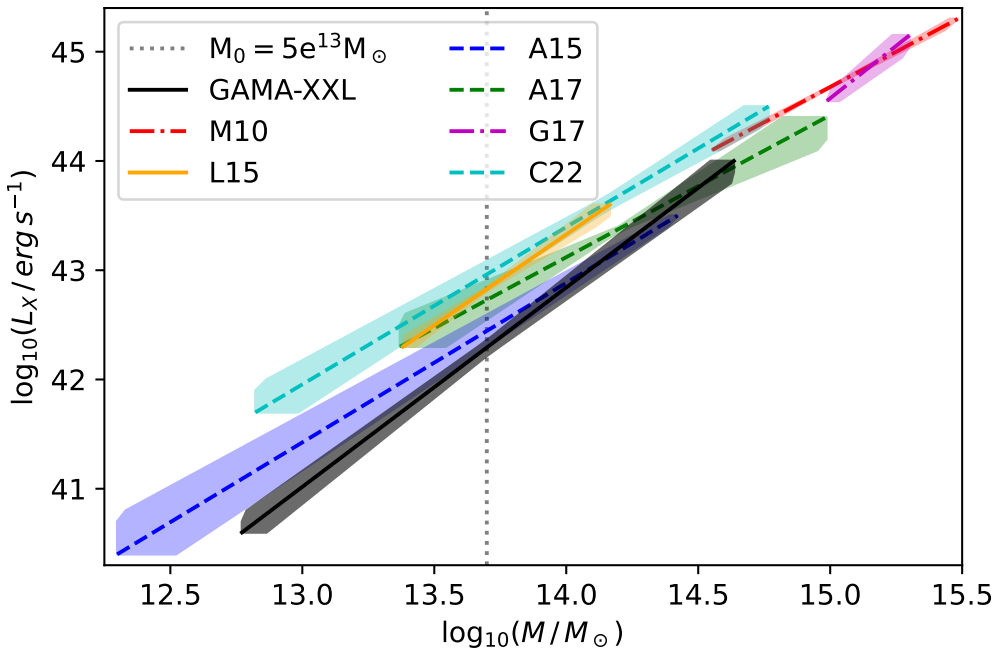

REFLEX II: Böhringer et al. (2014), WARPS: Koens et al. (2013), XXL: Pacaud et al. (2016), eFEDS: Liu et al. (2021)

# Luminosity - Mass Relation

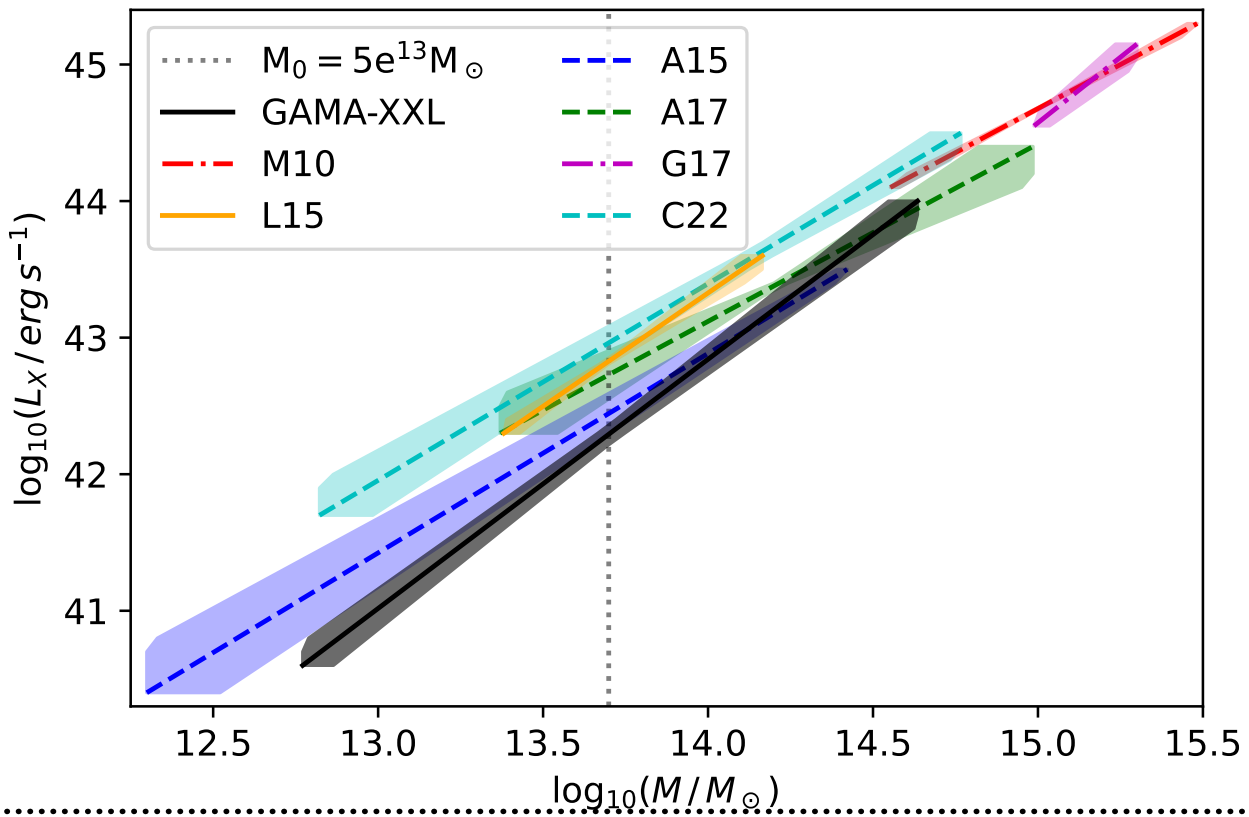



(without Mass measurements)



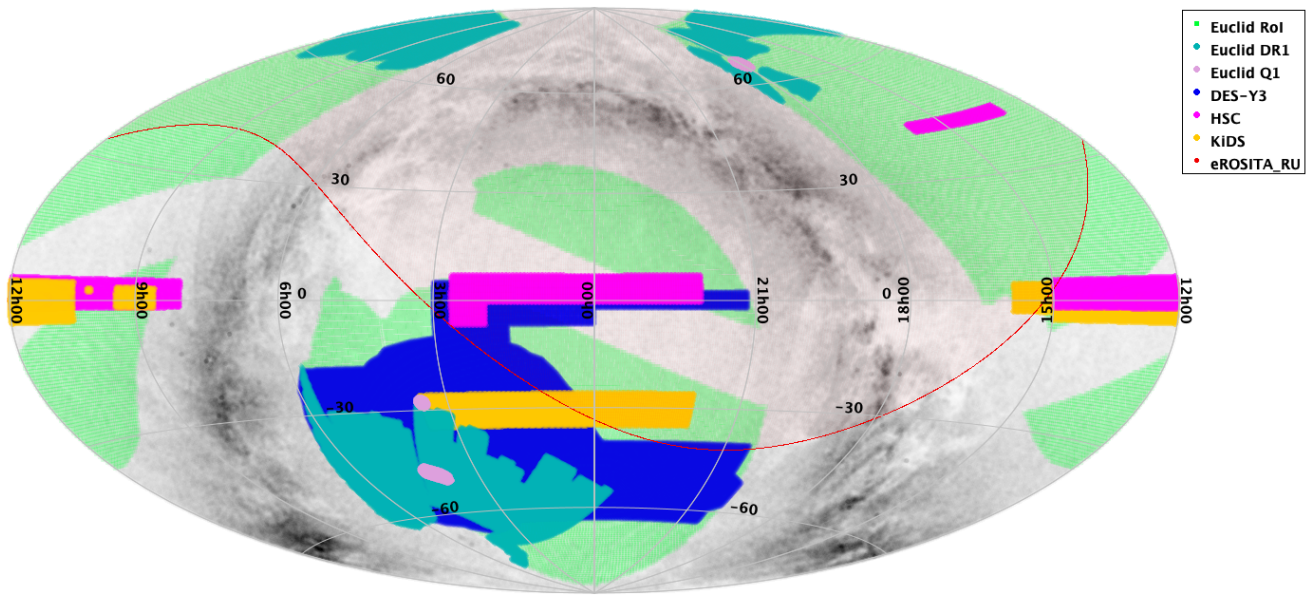
# Luminosity - Mass Relation




Mantz et al. (2010b, M10), Lovisari et al. (2015, L15), Anderson et al. (2015, A15)†, Andreon et al. (2017, A17)†, Giles et al. (2017, G17), and Chiu et al. (2022, C22) († optically selected).

# Euclid

- Near-infrared survey covering $\sim$ 15,000 deg$^2$ of extragalactic sky
- Estimate 2 $\times 10^6$ clusters with M $> 10^{14} M_\odot$ out to z $\sim 2$
- Selection function has weak redshift dependence
- Weak lensing mass measurements expected for clusters at z $\leq 0.6$

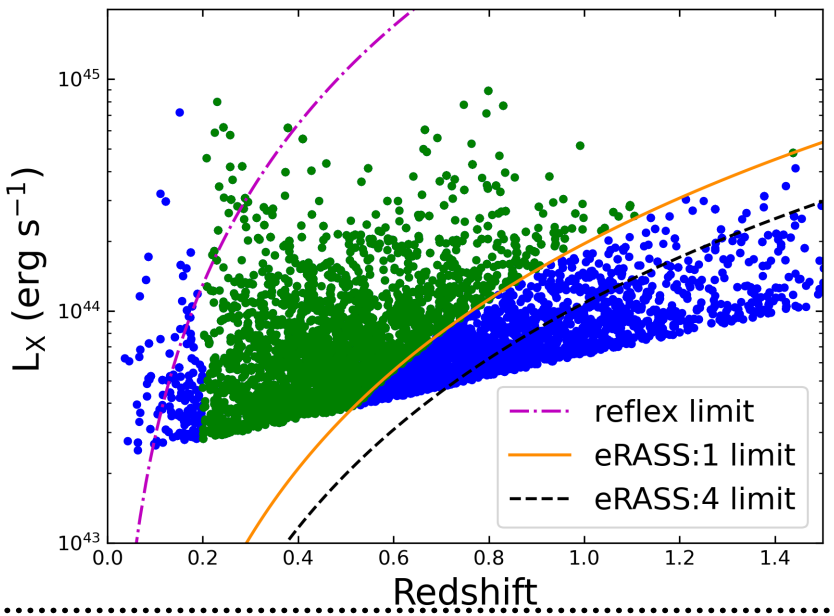



Forecast from Sartoris+ (2016)

Image credit: Florian Pacaud

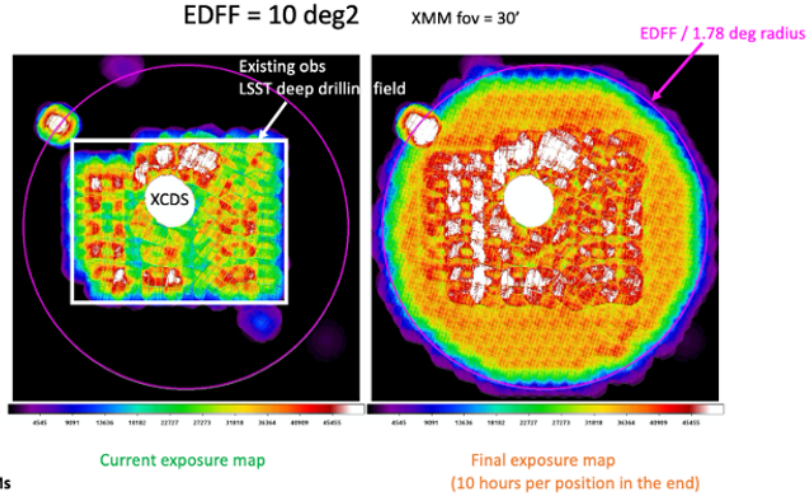
# Euclid & eROSITA

- DR1 / eRASS:1 overlap $\sim$ 1,250 deg$^2$
  - estimate 5,000 clusters
- DR3 / eRASS:4 overlap $\sim$ 7,500 deg$^2$
  - estimate 60,000 clusters




Forecast from Sartoris+ (2016)

# Euclid & XMM Fornax



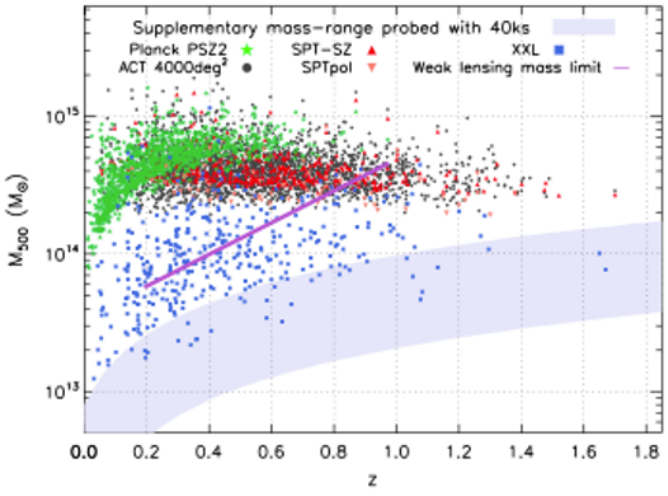
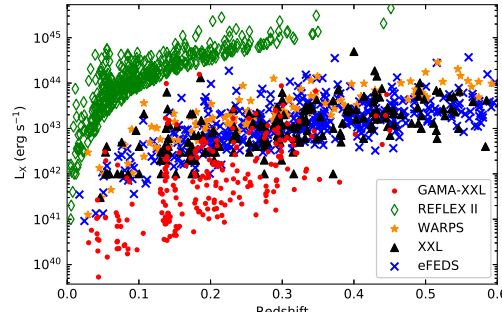
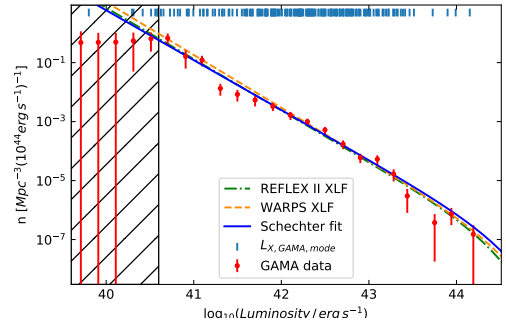



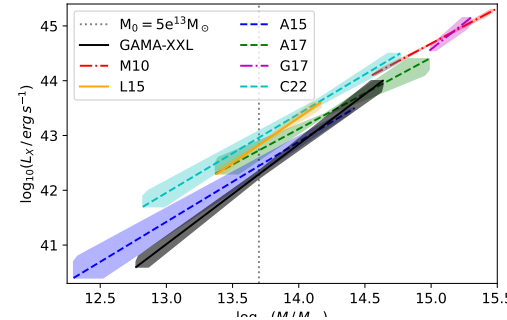

Image credit: Florian Pacaud

# Summary

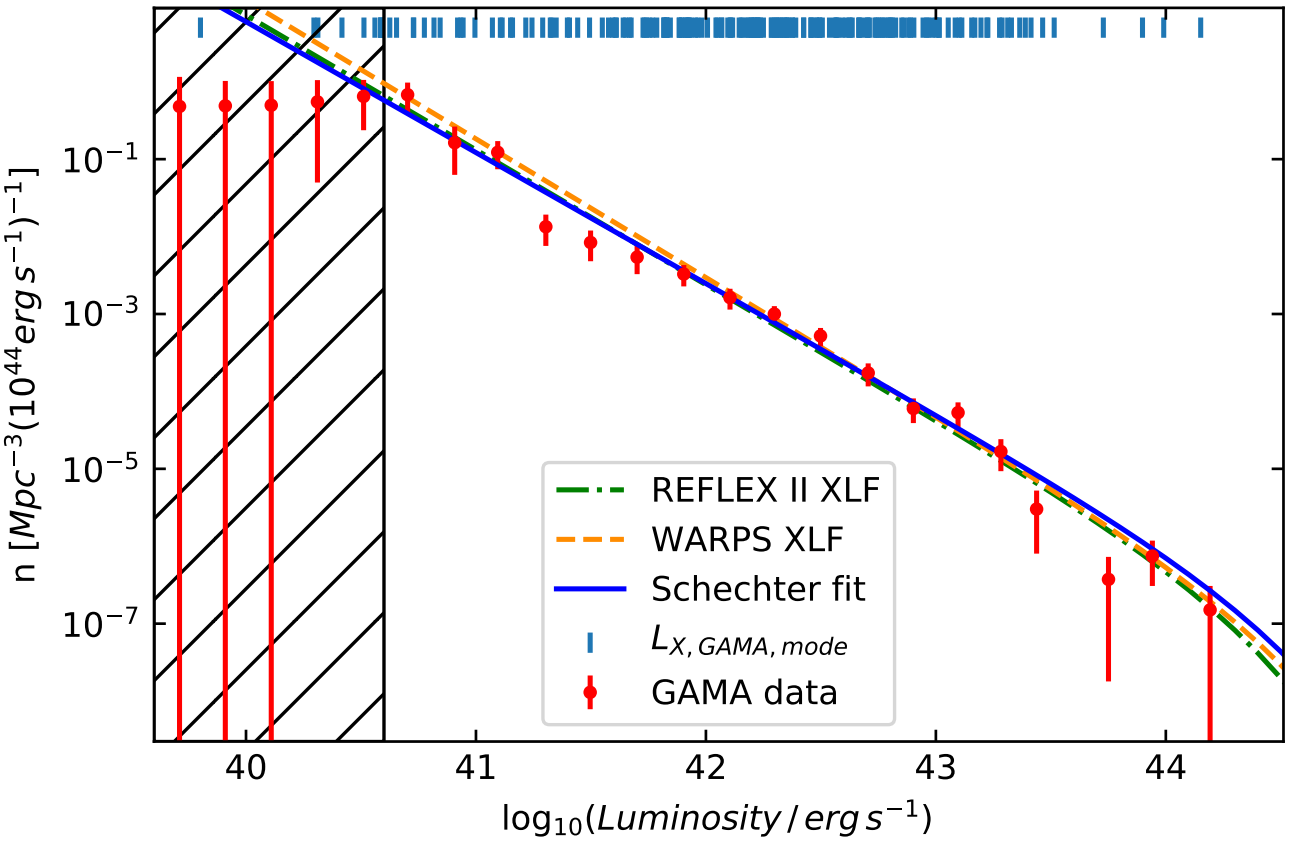
- Measured X-ray luminosities of optically selected galaxy group sample
- Observed X-ray luminosity function and inferred luminosity-mass relation shape
- Inclusion of non-detections allowed exploration of low luminosity regime
- Results suggest feedback and X-ray selection bias present
- Work to be continued using Euclid and eROSITA and XMM-Fornax data



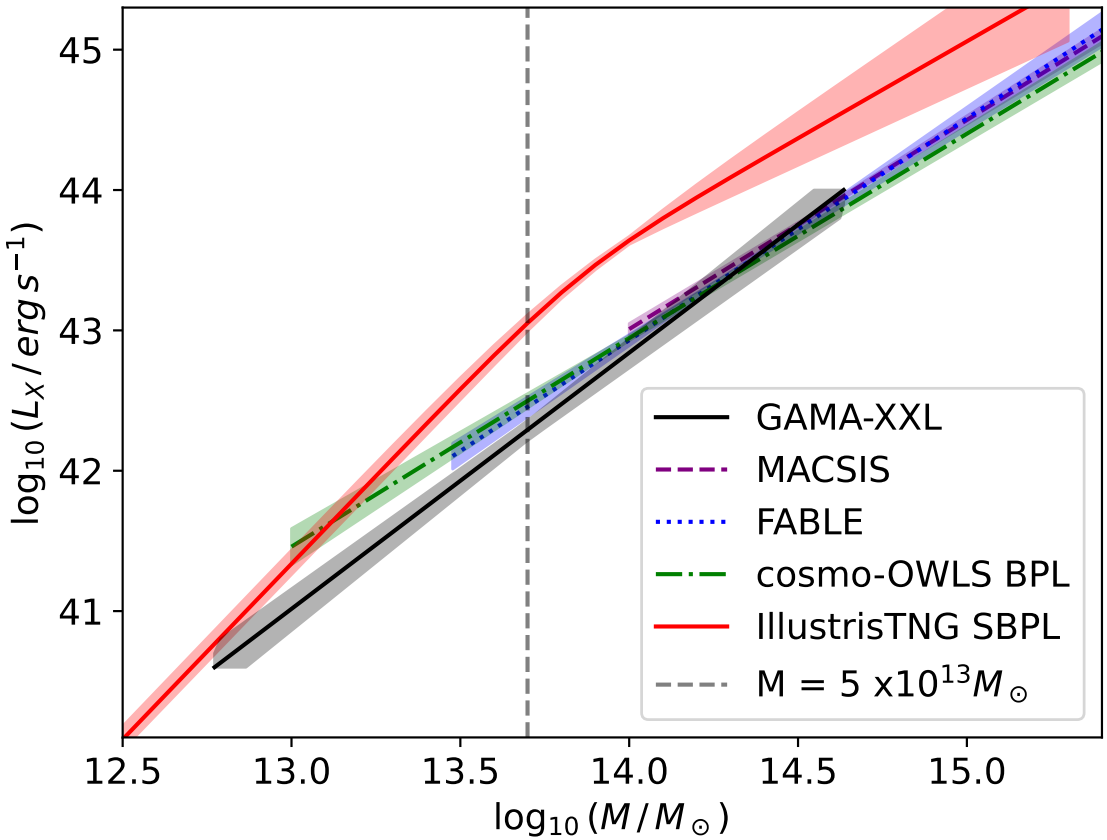



# X-ray Luminosity Function




REFLEX II: Böhringer et al. (2014), WARPS: Koens et al. (2013)

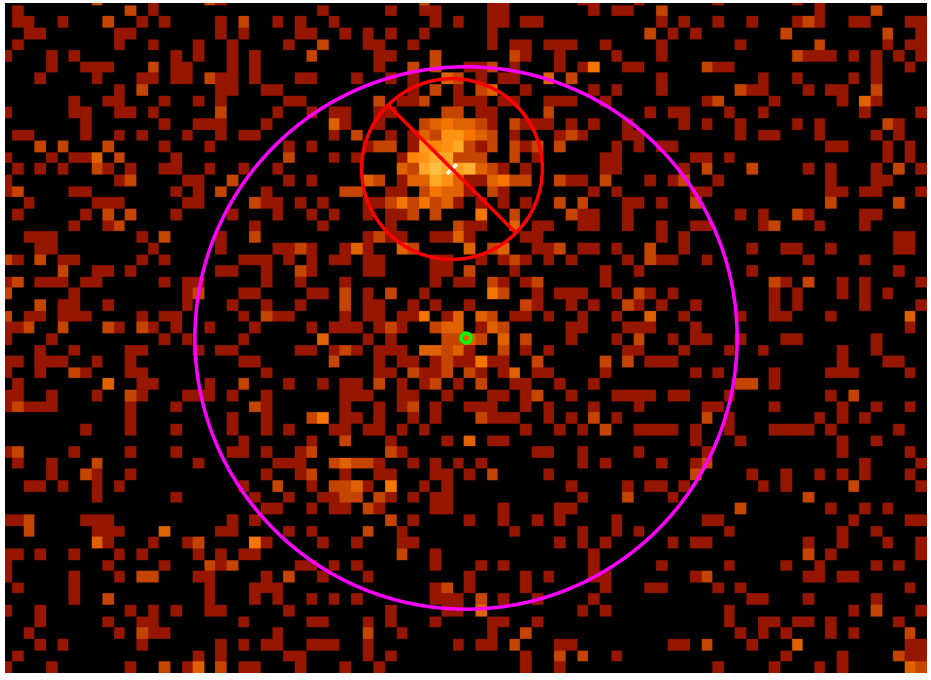
# Comparison with Simulations




MACSIS (Barnes et al. 2017), FABLE (Henden et al. 2019), cosmo-OWLS (Brun et al. 2017, broken power law), and IllustrisTNG (Pop et al. 2022, smoothly broken power law).

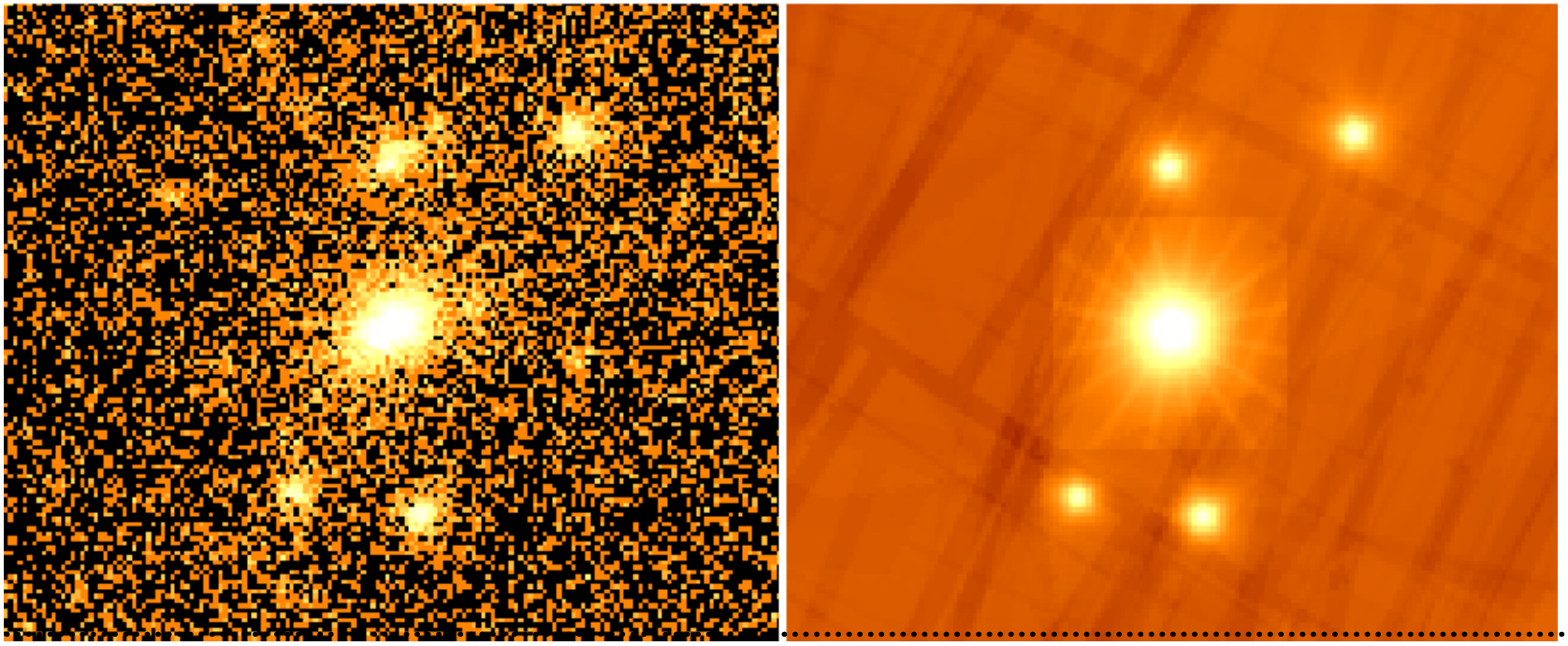
# Excluding Non-Central Point Sources

For point sources located between 30” and 110” away from the group location, the point source region was masked and remaining flux in the aperture modelled and subtracted.

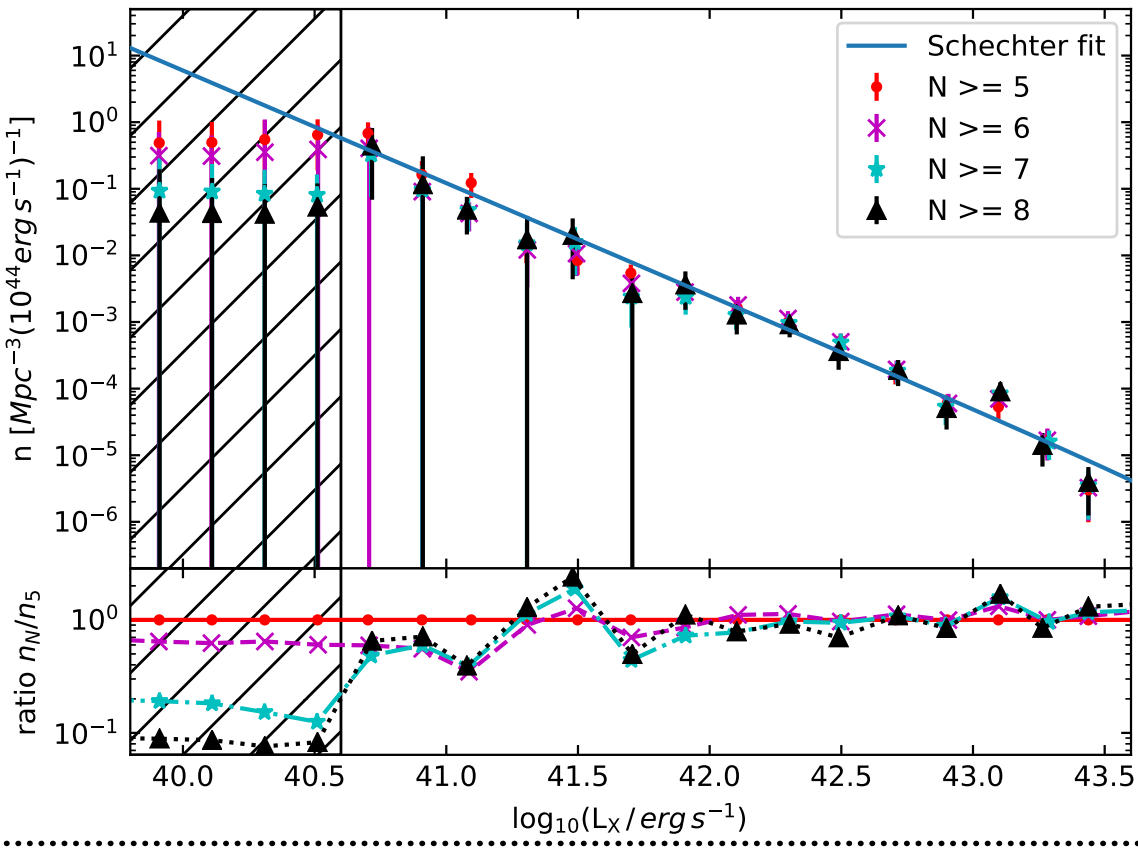


# Modelling Central Point Sources

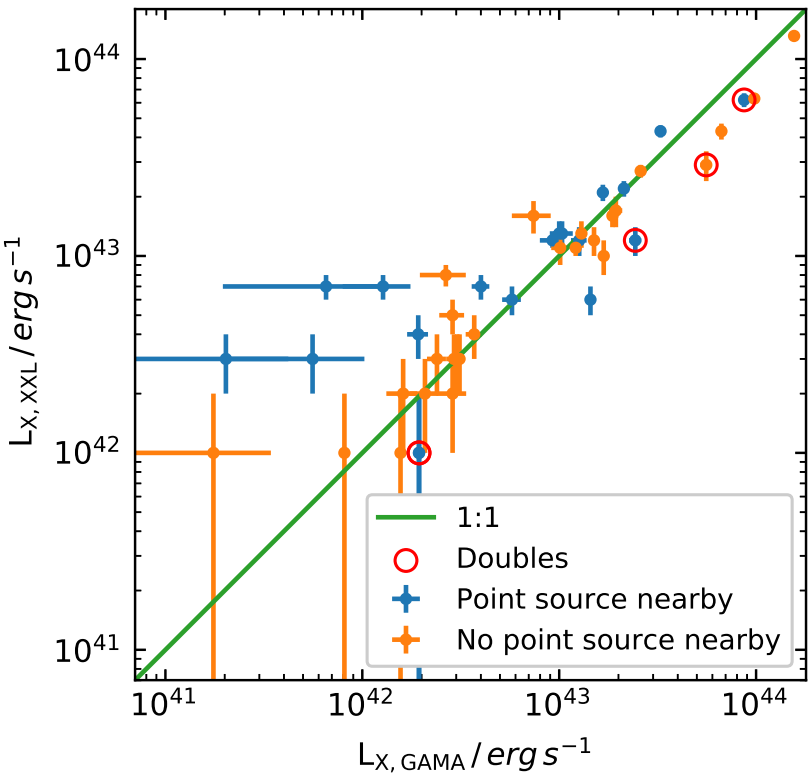
In cases where the point source was closer, the point source and group emission were modelled using the PSF and a beta model, and the proportion of emission expected from the group found.

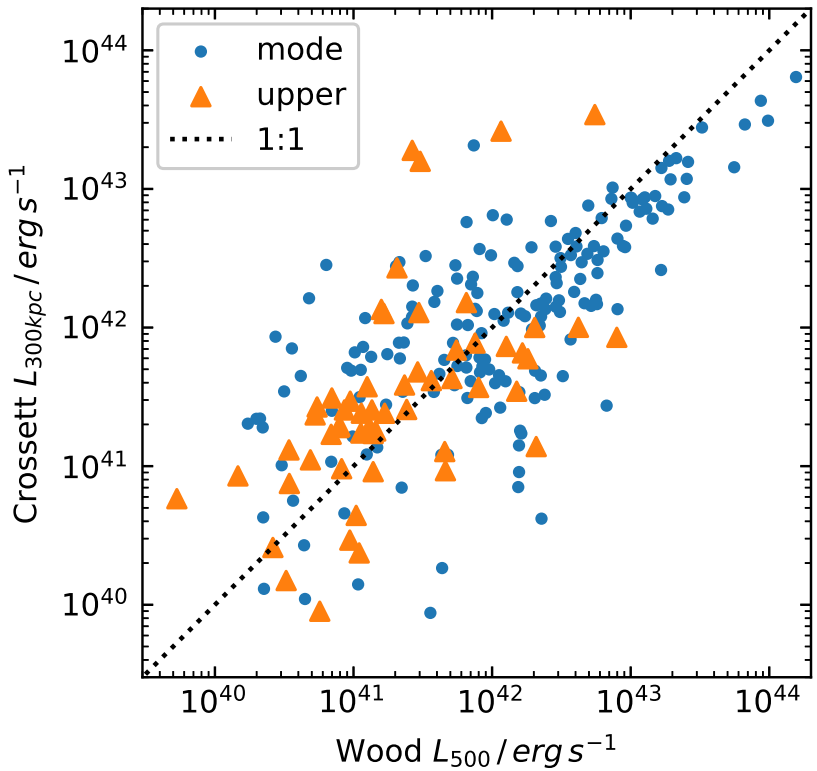


# Testing N $\geq$ 5 cut-off



# Comparing Luminosities

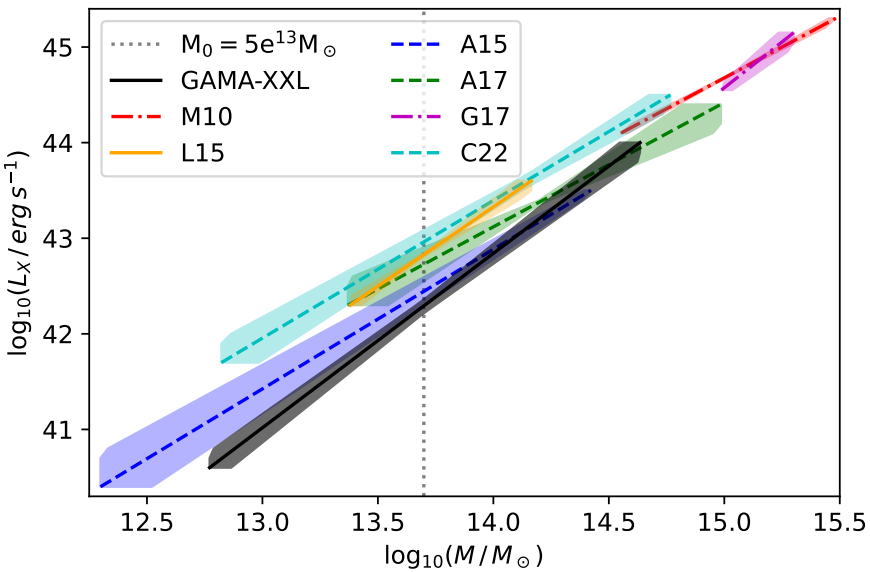


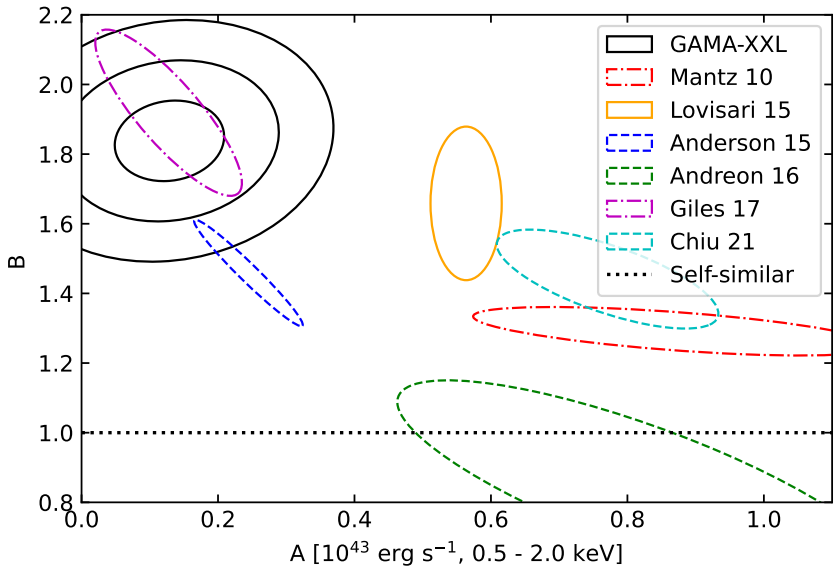




XXL: Pacaud et al. (2016)

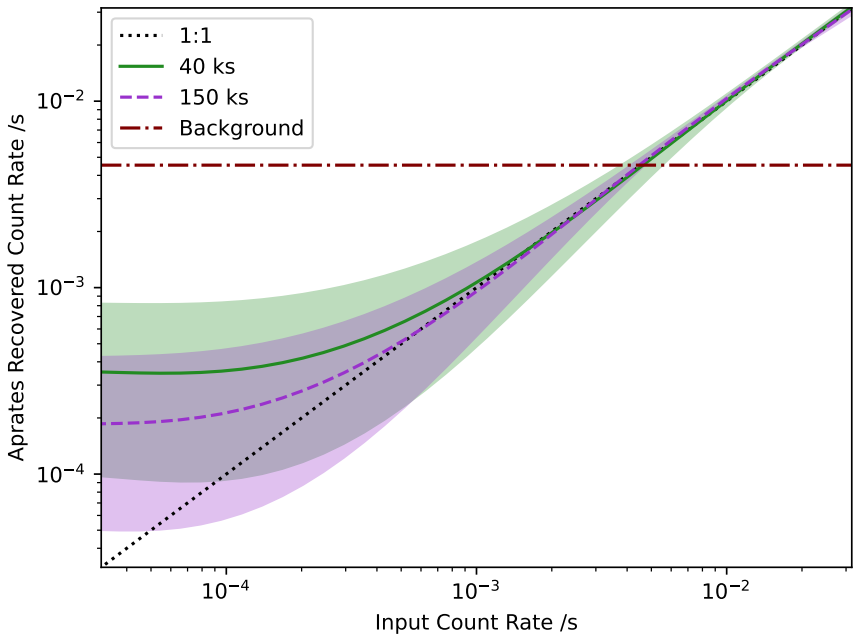
Crossett et al. (2022)

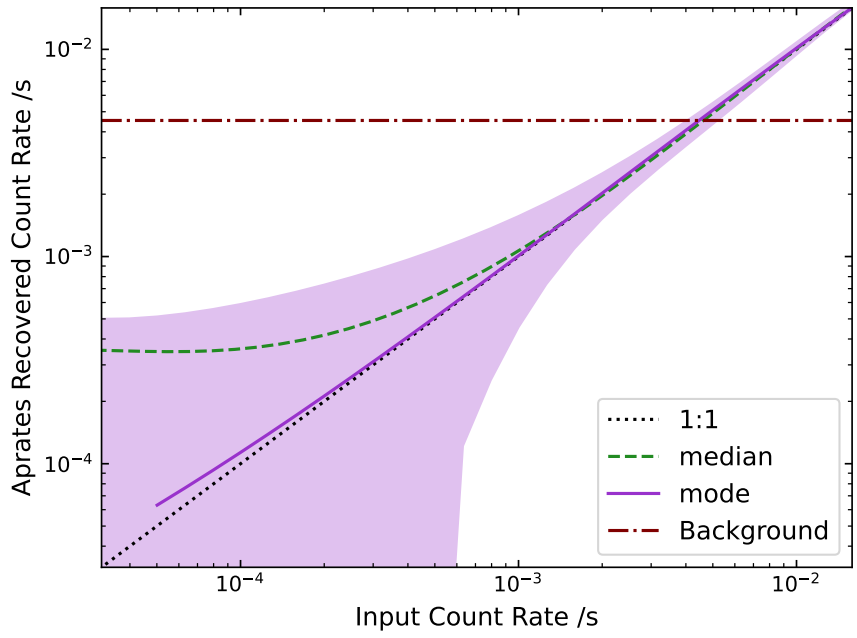
# Luminosity - Mass Relation



# Recovering Low Count Rates



# Euclid Q1 & DR1

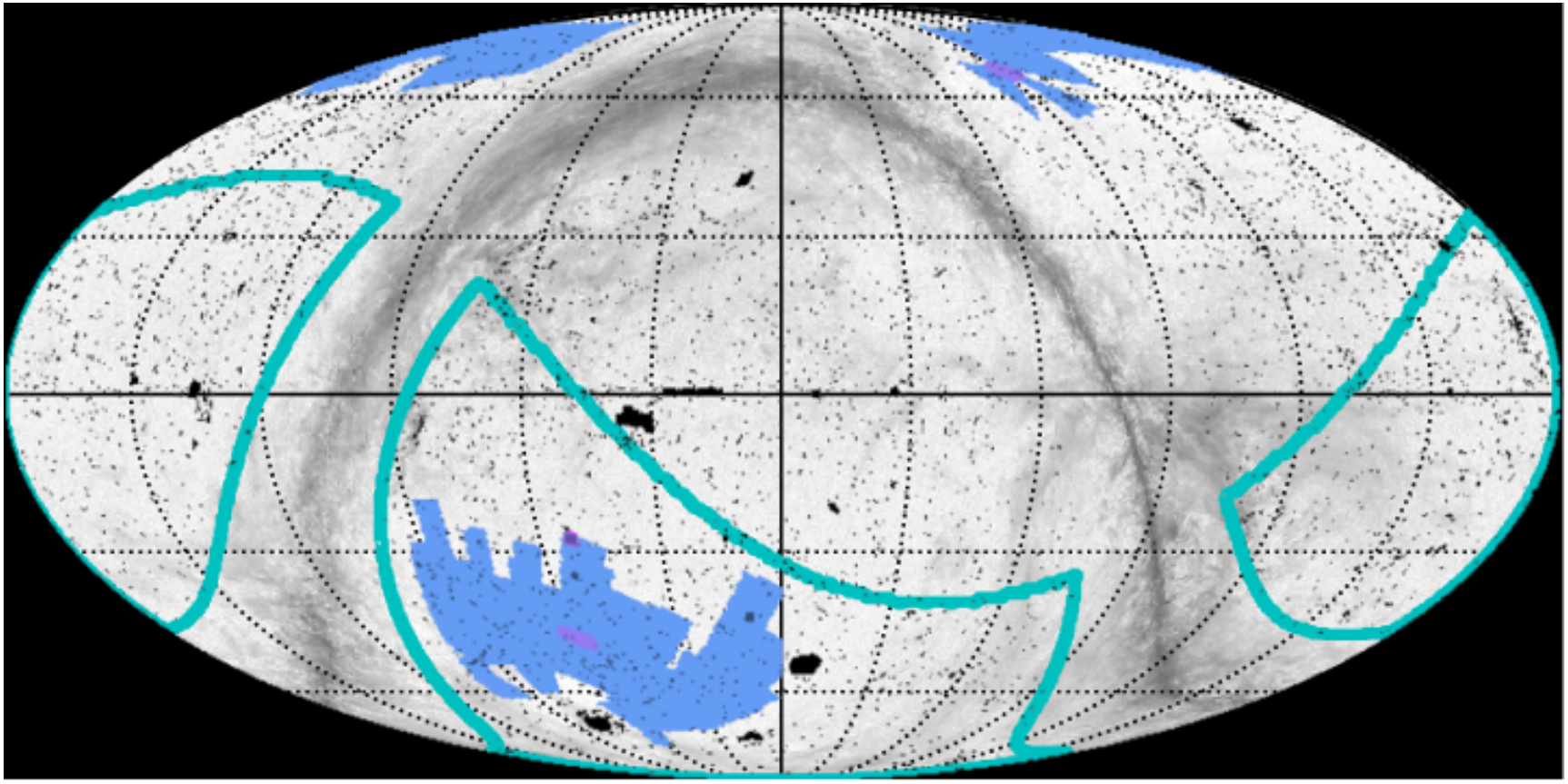


Image credit: Florian Pacaud

# eRASS:1 vs XMM Fornax

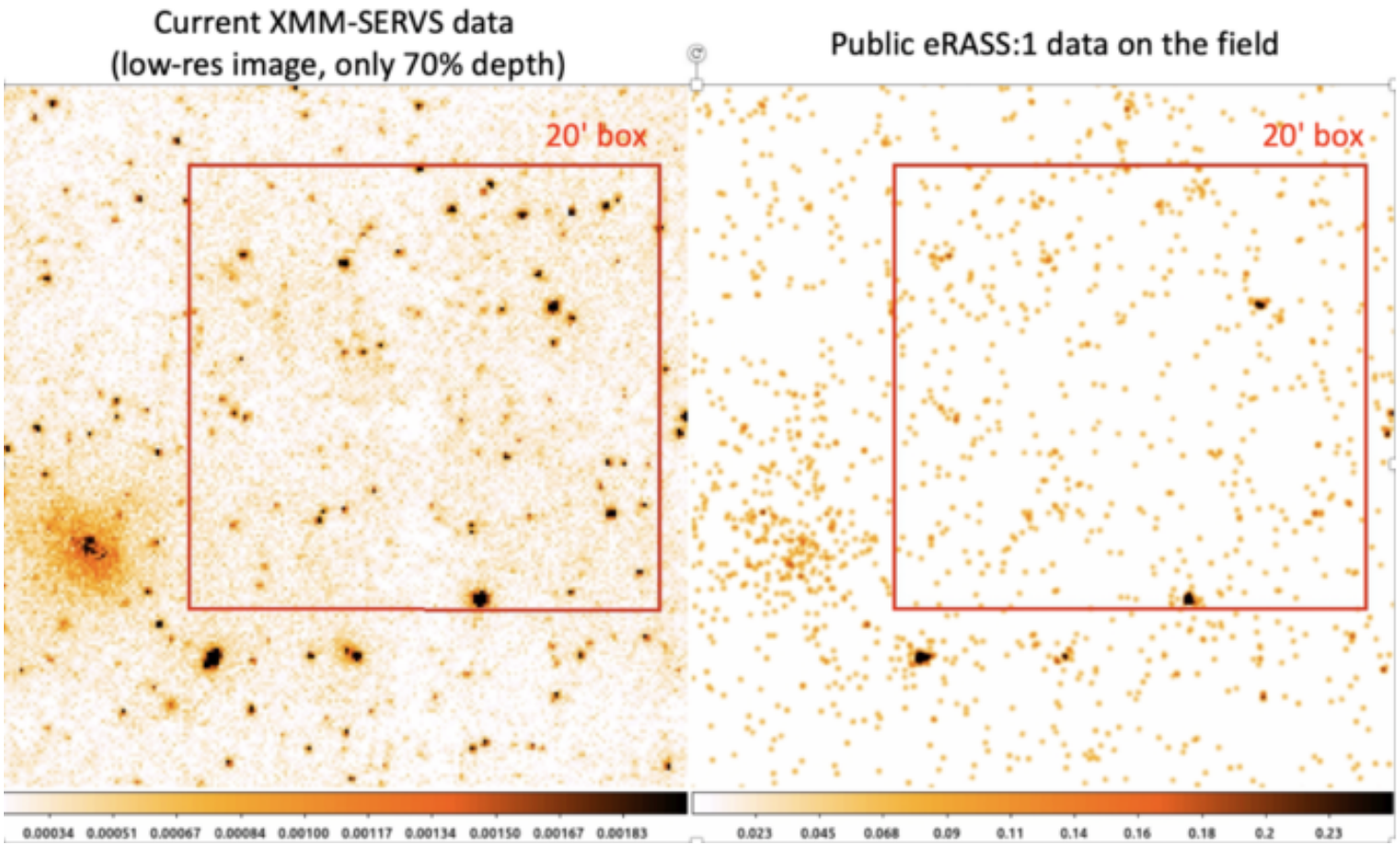



Image credit: Florian Pacaud