University of BRISTOL

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The X-ray Properties of Optically Selected Galaxy Groups

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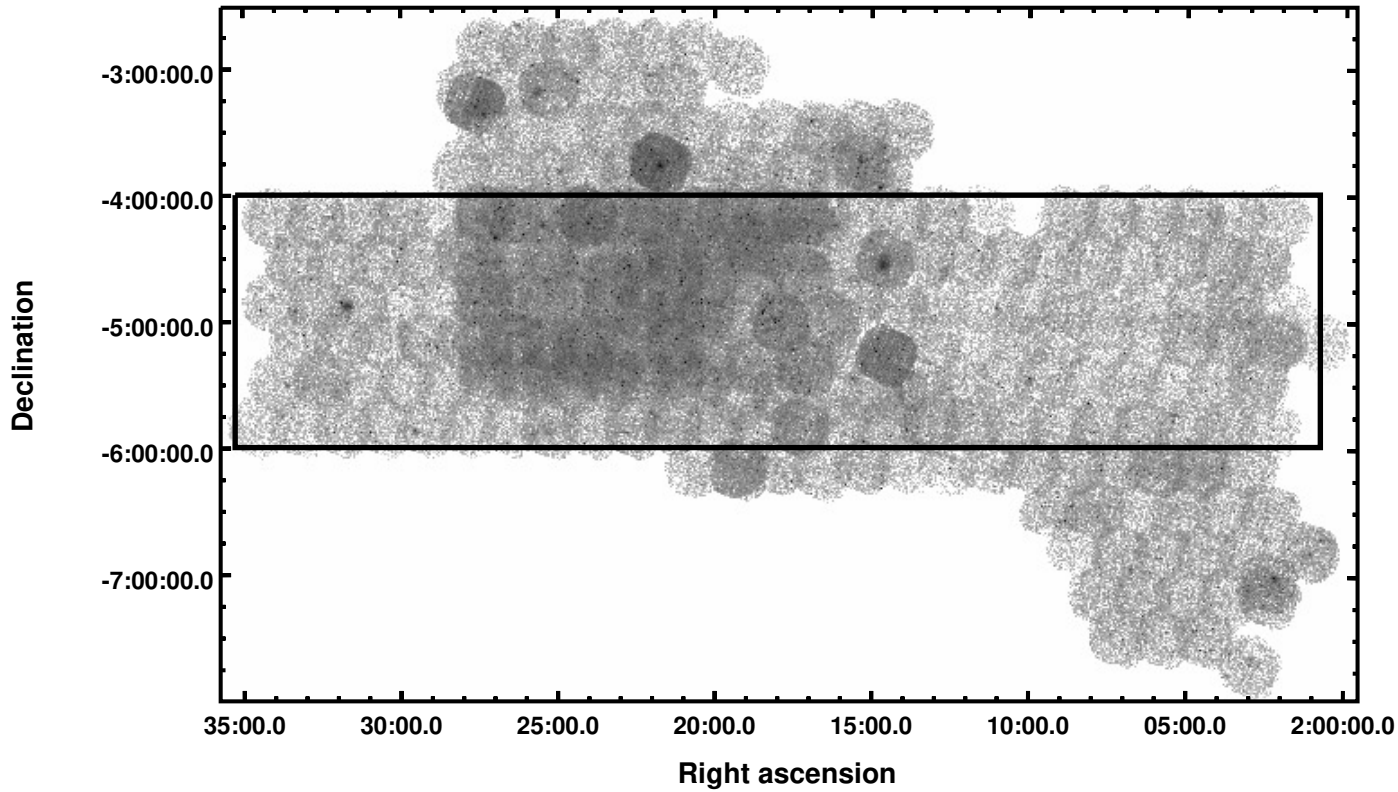
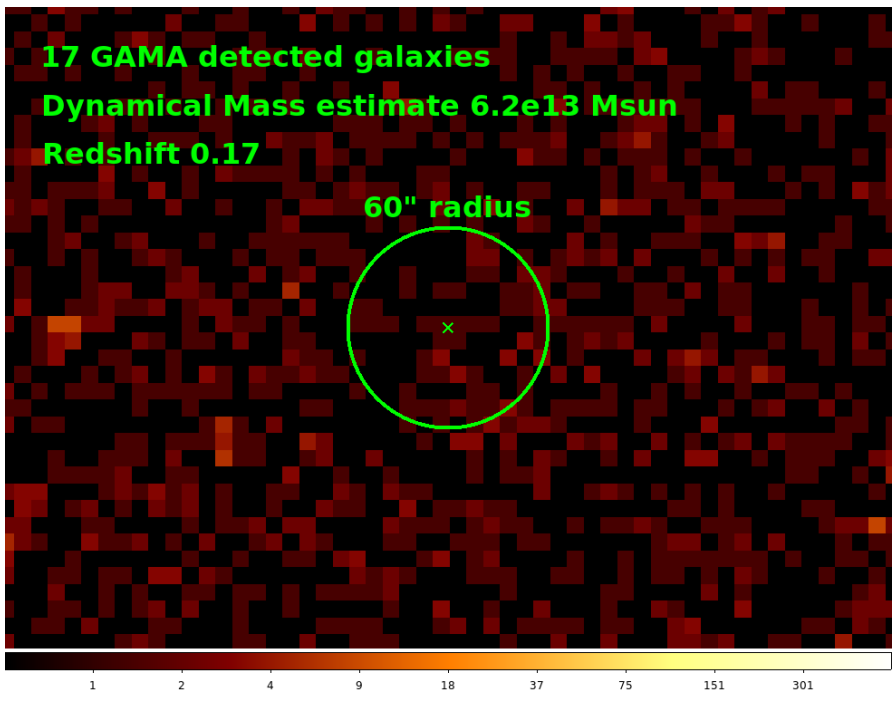
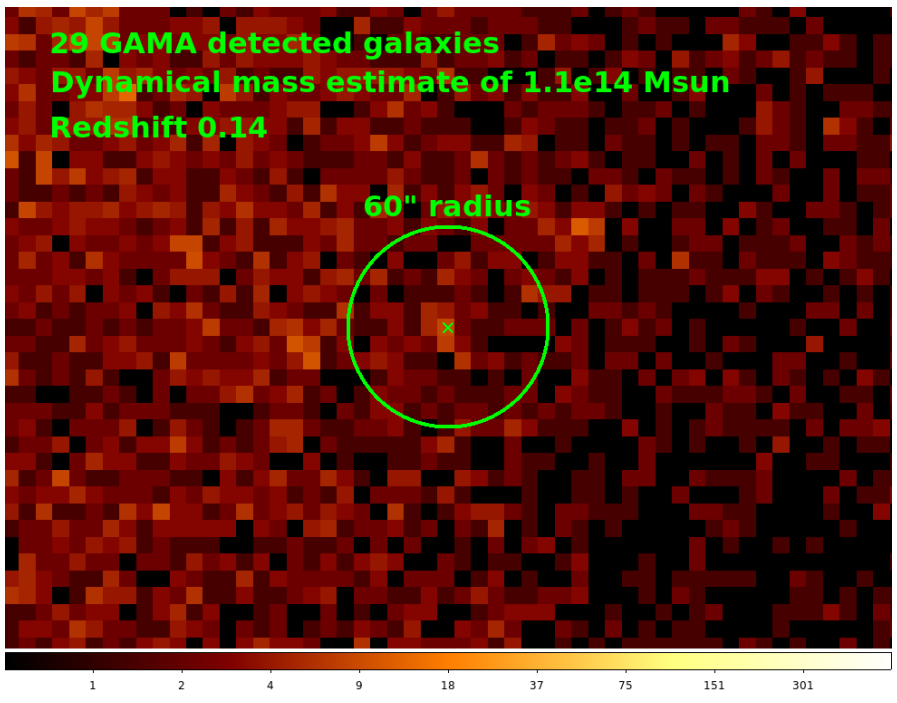
234 GAMA (Driver et al. 2011) galaxy groups with 5 or more members in 16.6 deg^2 overlap region, see Robotham et al (2011) for details on group detection method and FoF algorithm, RA range 30.2 to 38.8 and DEC range -4 to -6



X-ray Undetected Groups

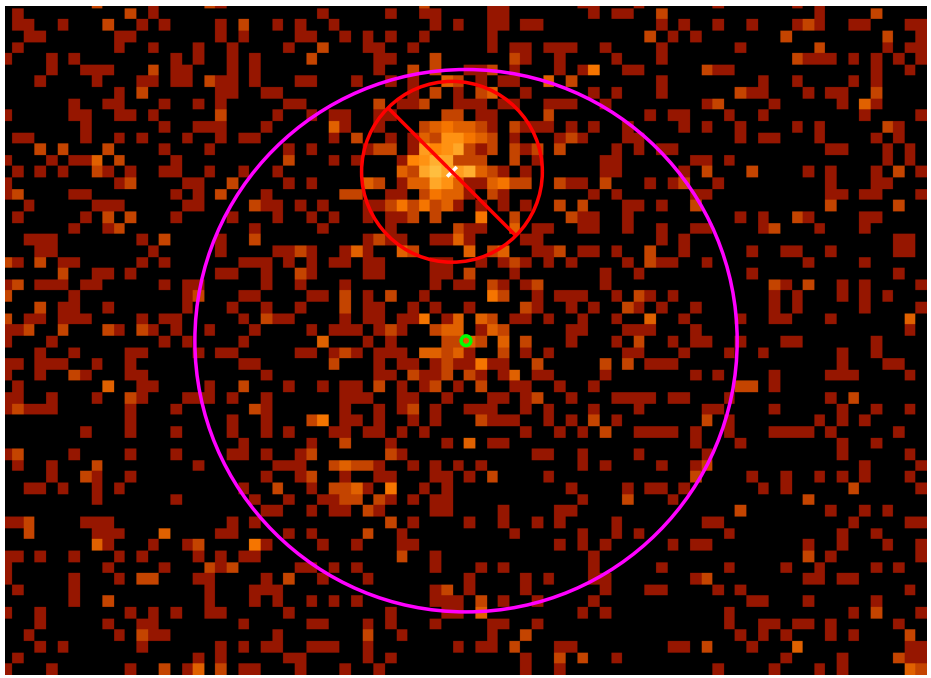
Example XXL mosaic images with GAMA group location marked, along with number of galaxies, dynamical mass and redshift data from GAMA.





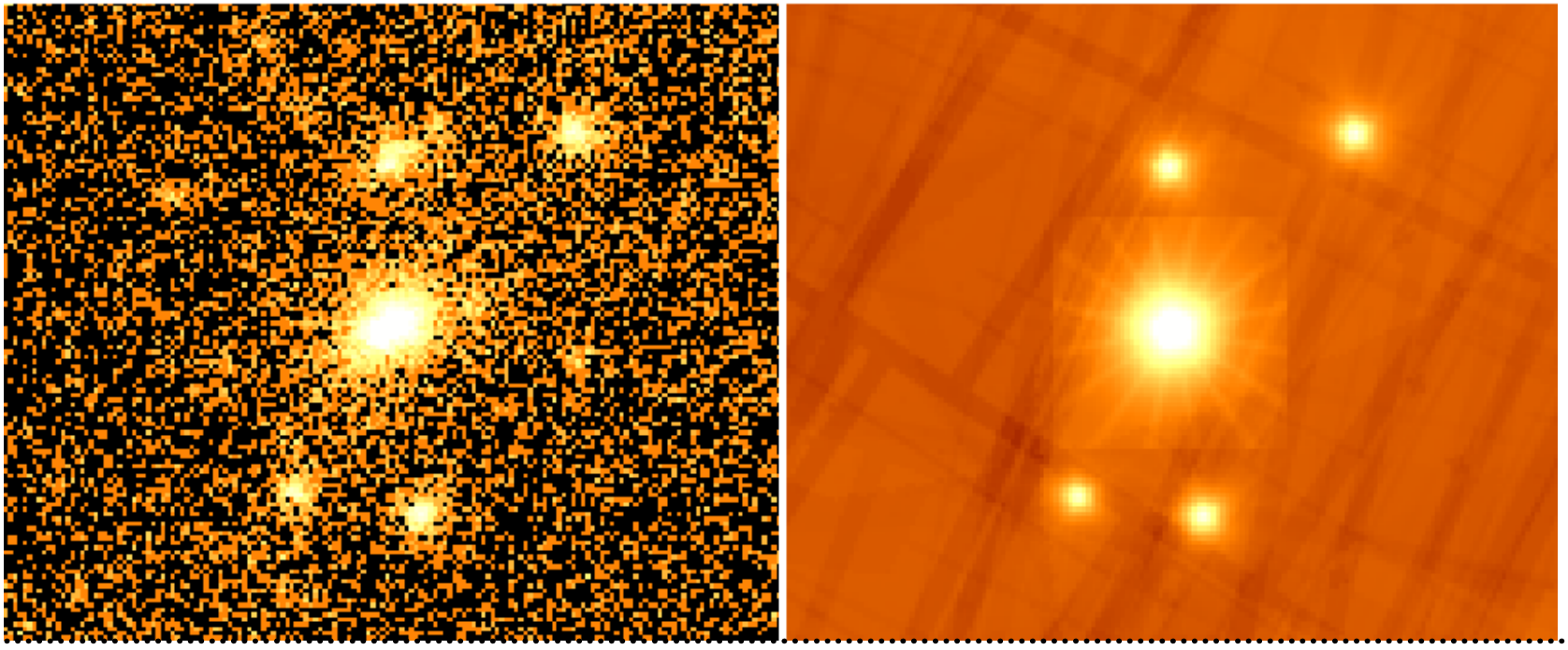
Excluding Non-Central Point Sources

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.

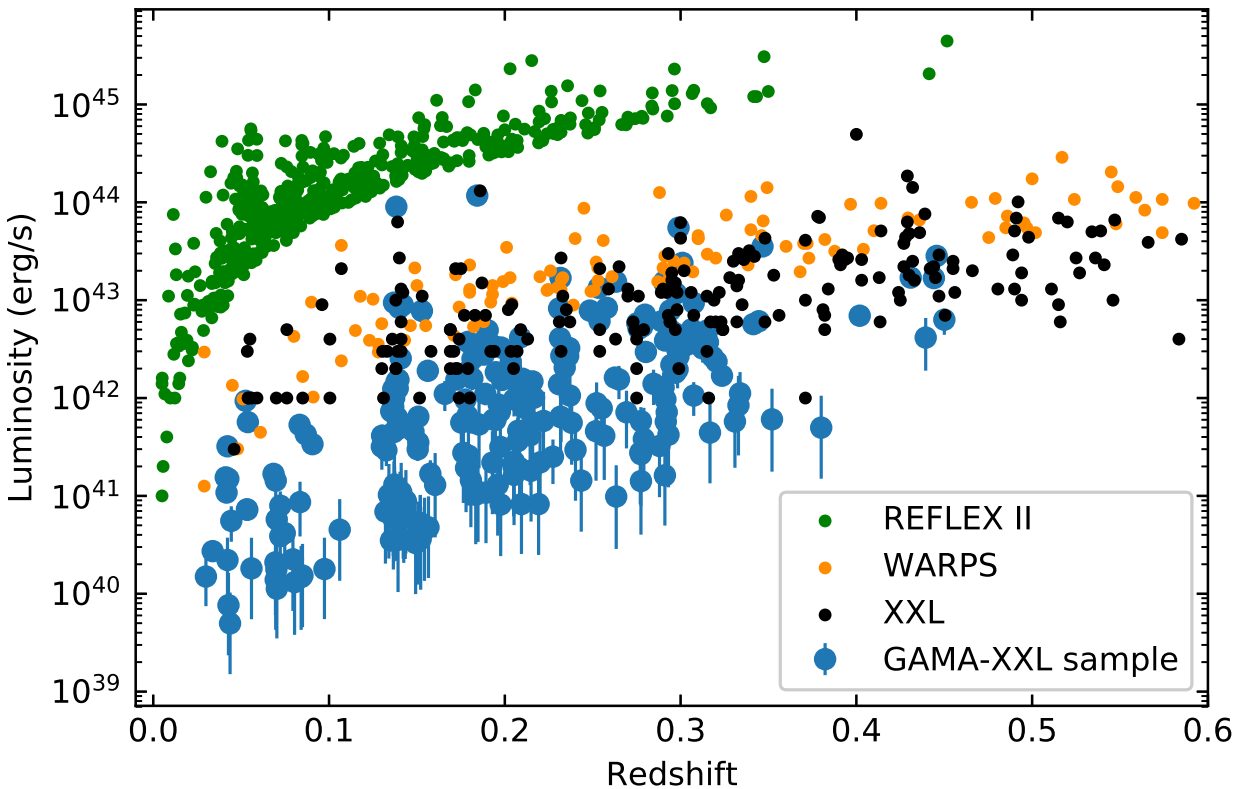


Modelling Central Point Sources

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.



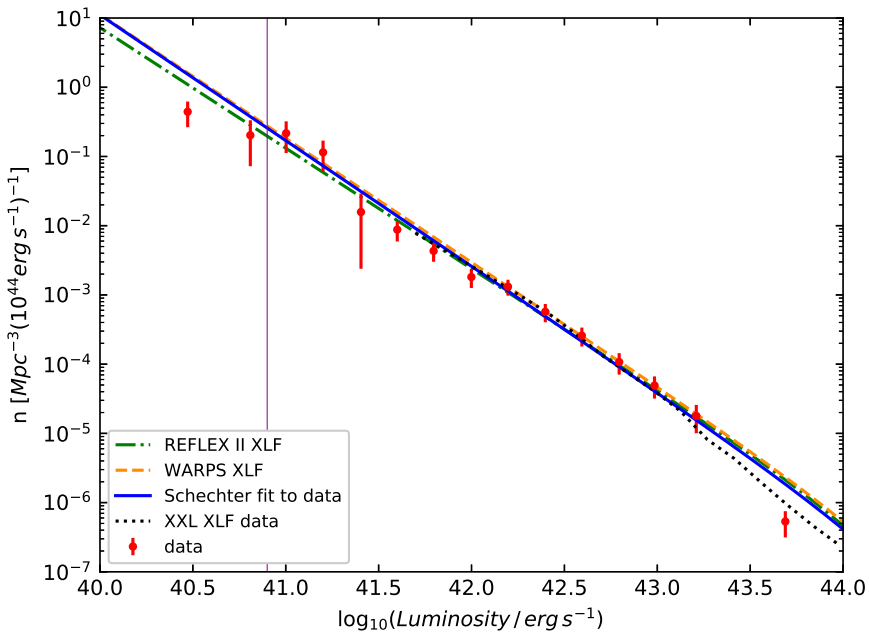
Luminosity - Redshift Space



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

X-ray Luminosity Function

The magenta line represents an estimation for the incompleteness of the GAMA sample, above that, the data and best fit agree well with other X-ray selected samples, whilst extending down an order of magnitude in luminosity.



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

Summary & Future

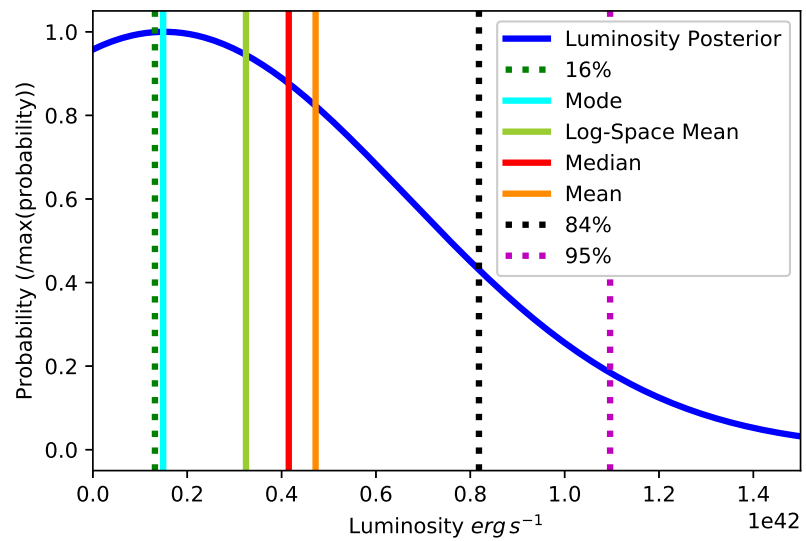
- Completed forced X-ray aperture photometry on optically selected group sample
- XLF found to be in good agreement for lower X-ray luminosities
- Next stage is to constrain Luminosity-Mass relation
  - Done by comparing X-ray Luminosity Function with the Halo Mass Function
  - Use Poisson likelihood of counts, Removing need for upper limits
  - Model Mass-Richness relation to handle GAMA selection function
- Following slides useful for reference, please ask for more detail

Likelihood Model: Luminosity Prior

$$\mathcal{L}(z, N|\theta, (\phi)) =$$

$$\frac{\int \boxed{P(L)} \int P(N|R,z) \int P(M|z)P(R|M,\phi)P(L|M,\theta)dMdRdL}{\sum_{N=5}^{\inf} \int P(L) \int P(N|R,z) \int P(M|z)P(R|M,\phi)P(L|M,\theta)dMdRdL}$$

A probability density function is calculated for each group using CIAO package Aprates (Primini & Kashyap, 2014), whereby the number of counts observed is considered a Poisson realisation of the true number of counts.

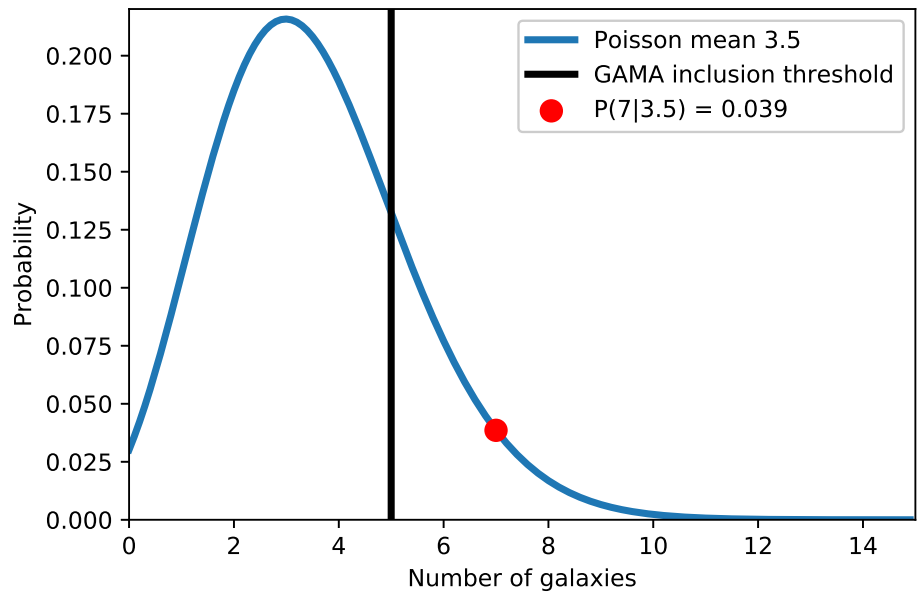


Likelihood Model: Probability of Galaxy Number

$$\mathcal{L}(z, N|\theta, (\phi)) =$$

$$\frac{\int P(L) \int \boxed{P(N|R,z)} \int P(M|z)P(R|M,\phi)P(L|M,\theta)dMdRdL}{\sum_{N=5}^{\inf} \int P(L) \int P(N|R,z) \int P(M|z)P(R|M,\phi)P(L|M,\theta)dMdRdL}$$

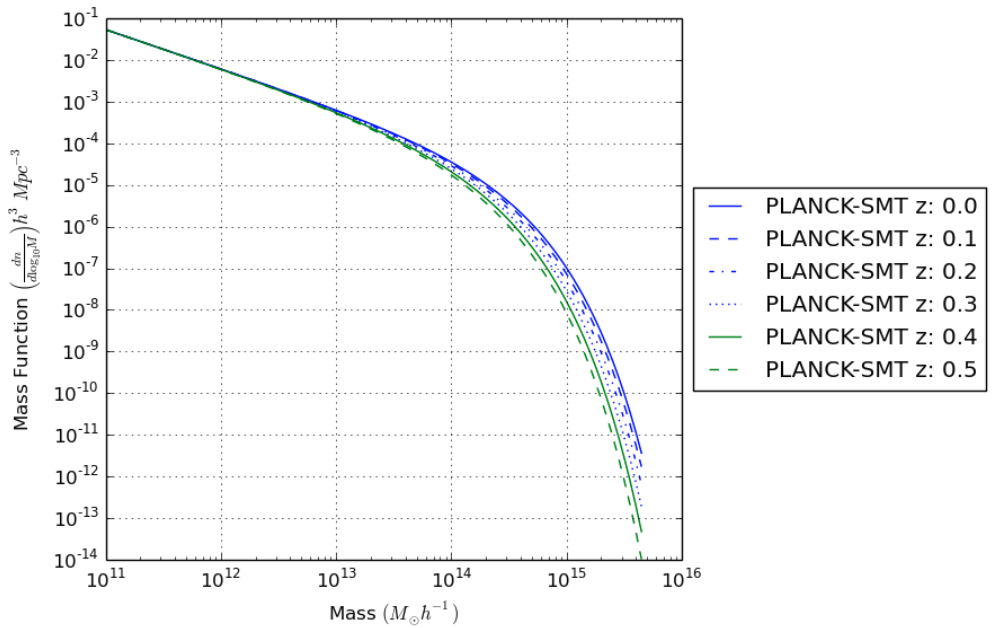
This is the Poisson probability of observing N galaxies in a group given a richness R at a redshift z.



Likelihood Model: Halo Mass Function

$$\mathcal{L}(z, N|\theta, (\phi)) =$$

$$\frac{\int P(L) \int P(N|R,z) \int P(M|z) P(R|M,\phi) P(L|M,\theta) dM dR dL}{\sum_{N=5}^{\inf} \int P(L) \int P(N|R,z) \int P(M|z) P(R|M,\phi) P(L|M,\theta) dM dR dL}$$



HMFcalc: Murray et al. (2013)

Model: Tinker et al. (2008)

Likelihood Model: Mass-Richness Relation

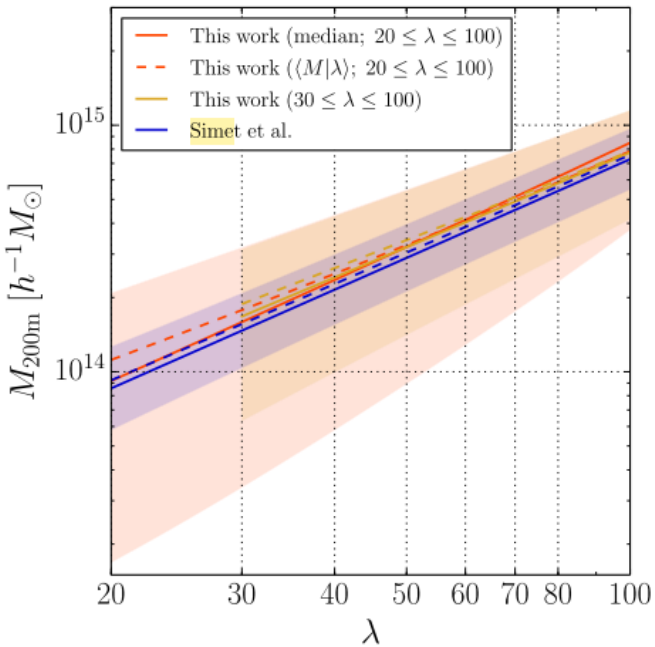
$$\mathcal{L}(z, N|\theta, (\phi)) =$$

$$\frac{\int P(L) \int P(N|R,z) \int P(M|z) \boxed{P(R|M,\phi)} P(L|M,\theta) dM dR dL}{\sum_{N=5}^{\inf} \int P(L) \int P(N|R,z) \int P(M|z) P(R|M,\phi) P(L|M,\theta) dM dR dL}$$

The MR relation used was that by Murata et al. (2018):

$$\ln(R) = A + B \ln\left(\frac{M}{M_{pivot}}\right) \quad (1)$$

where A is the normalisation, B the slope and M_{pivot} the pivot mass scale.

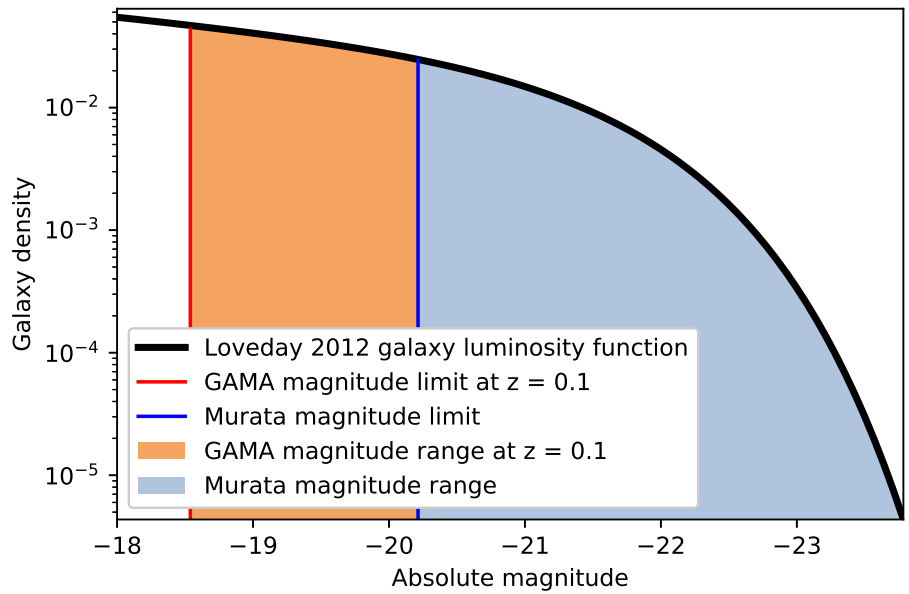


Likelihood Model: Observable Richness

$$\mathcal{L}(z, N|\theta, (\phi)) =$$

$$\frac{\int P(L) \int \boxed{P(N|R,z)} \int P(M|z) \boxed{P(R|M,\phi)} P(L|M,\theta) dM dR dL}{\sum_{N=5}^{\inf} \int P(L) \int P(N|R,z) \int P(M|z) P(R|M,\phi) P(L|M,\theta) dM dR dL}$$

Integrate galaxy luminosity function over GAMA and Murata et al. (2018) absolute magnitude ranges to convert richness to GAMA observable richness.



Likelihood Model: Luminosity-Mass Relation

$$\mathcal{L}(z, N|\theta, (\phi)) =$$

$$\frac{\int P(L) \int P(N|R,z) \int P(M|z) P(R|M,\phi) \boxed{P(L|M,\theta)} dM dR dL}{\sum_{N=5}^{\inf} \int P(L) \int P(N|R,z) \int P(M|z) P(R|M,\phi) P(L|M,\theta) dM dR dL}$$

The traditional LM relation is defined as:

$$\frac{L}{L_0} = A_{LM} E(z)^{\gamma_{LM}} \frac{M}{M_0}^{B_{LM}}$$

where A_{LM}, B_{LM} and γ_{LM} are the amplitude, mass slope and redshift evolution slope respectively.

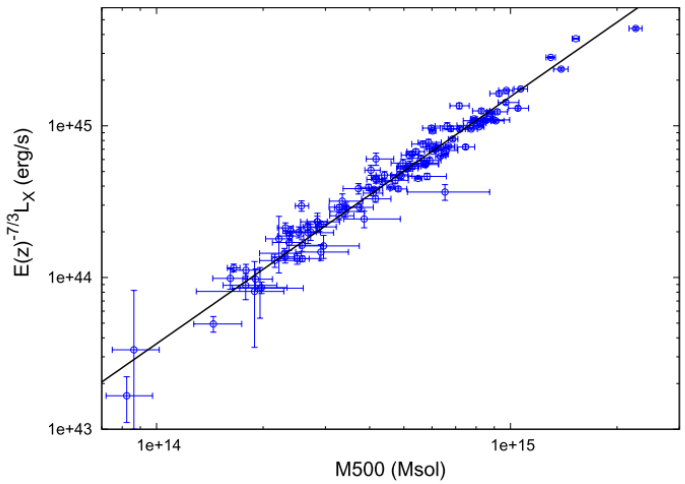


FIG. 7.— $L_X - M_{500}$ relation for the clusters with masses estimated from the $Y_X - M_{500}$ relation and bolometric luminosities measured from spectral fits in the $(0.15 < r < 1)R_{500}$ aperture, and scaled by the predicted self-similar evolution.

Maughan B. J., 2007, The Astrophysical Journal, 668, 772

Likelihood Model: Sample Incompleteness

$$\mathcal{L}(z, N|\theta, (\phi)) = \frac{\int P(L) \int P(N|R,z) \int P(M|z)P(R|M,\phi)P(L|M,\theta)dMdRdL}{\sum_{N=5}^{\inf} \int P(L) \int P(N|R,z) \int P(M|z)P(R|M,\phi)P(L|M,\theta)dMdRdL}$$

This normalises the likelihood model to account for the truncation of the data due to only including groups with 5 or more members.