“AGN Environments to z~1.5 in the UKIDSS Ultra-Deep Survey”

Emma Bradshaw

Introduction

- AGN and their environments
- UKIDSS and the Ultra-Deep Survey
- Cross-correlation techniques
- Results
  - -X-ray and radio AGN correlations
  - -hard-soft AGN
  - -optical-X-ray dominated AGN
  - -low redshift comparison
  - -local environments
- Analysis

AGN Environments

- Many galaxy properties are dependent on the environment within which they reside (e.g. Kauffmann et al. 2004, Best et al. 2007)

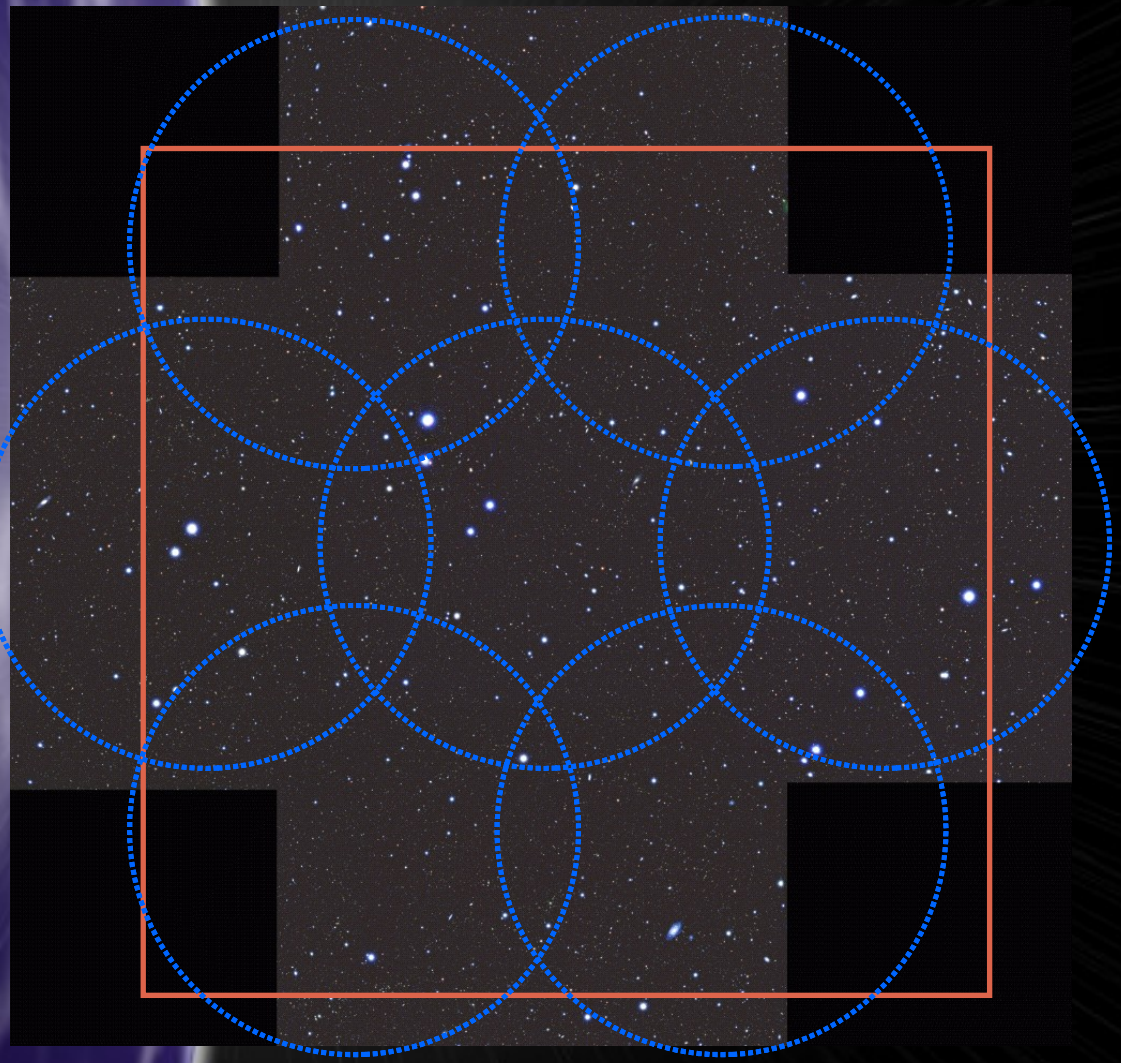
- In general, it seems that radio AGN are associated with massive red galaxies at the centre of galaxy clusters (Best et al. 2002, Johnson et al. 2003)

- X-ray AGN in the local Universe generally seem to be associated with a range of environments (Gilmour et al. 2007, Silverman et al. 2009)

UKIDSS and the Ultra-Deep Survey

- The UDS is one of five surveys which makes up UKIDSS (The UK Infrared Deep Sky Survey)
- 0.77 square degrees centred on SXDS
- Deepest near-infrared survey of this size to date
- 9896 galaxies in the redshift range z=1-1.5 using the DR3
- The UDS is an ongoing survey aiming to reach depths of K=25.0, H=25.0, J=25.5

UKIDSS and the Ultra-Deep Survey



RA = 02 18 00, Dec = -05 00 00

Optical:
B=28.2, V=27.6, R=27.5,
i'=27.2, z'=27

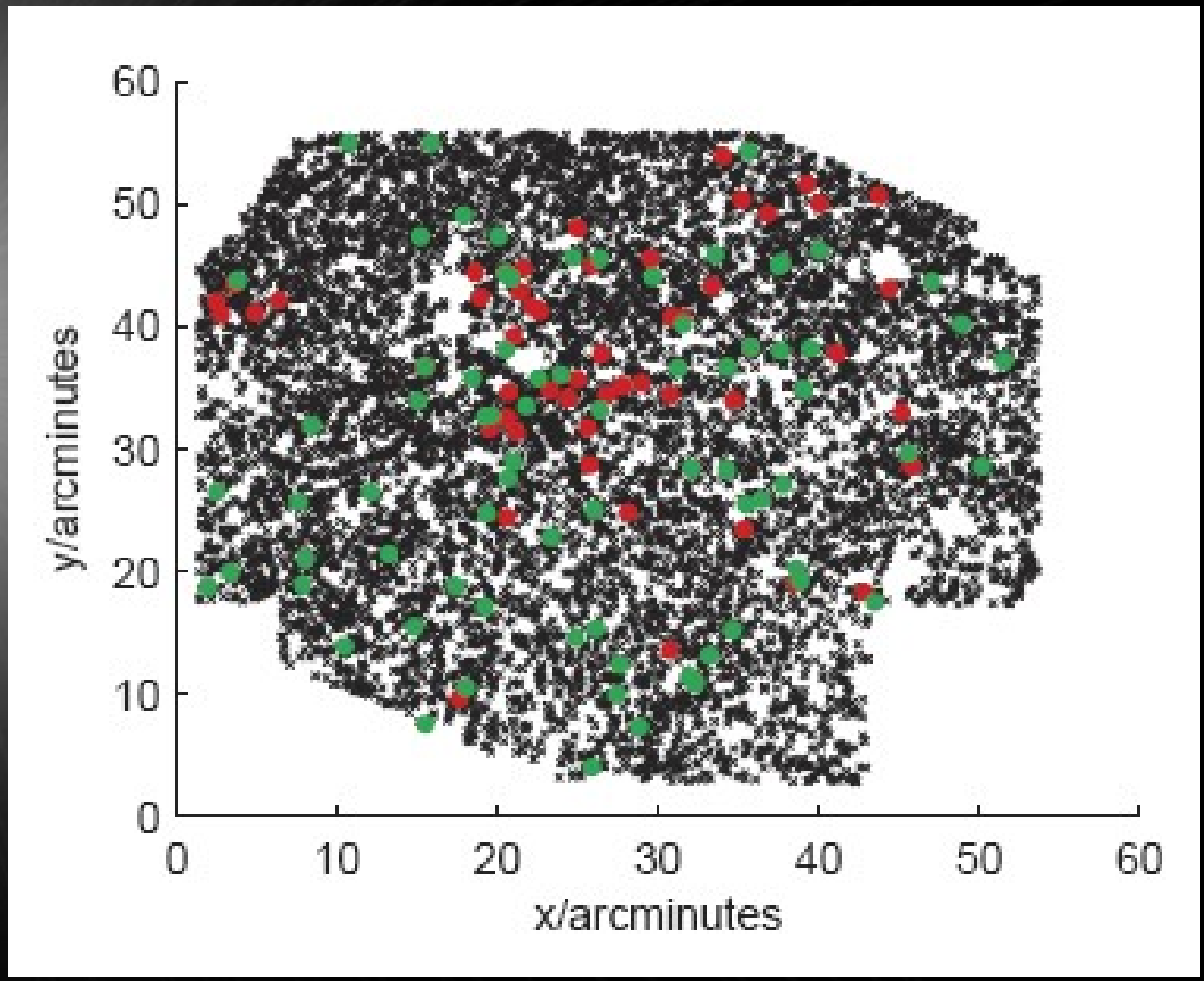
X-ray:
XMM-Newton 100ks + 6x50ks

Radio:
VLA 12 μ Jy rms 1.4Ghz

Spitzer:
Spitzer SWIRE 3.6-160μ m
(*NEW*: Legacy survey to
~24 AB at 3.6, 4.5μ m)

Submm:
SHADES 8mJy (**850**μ m)

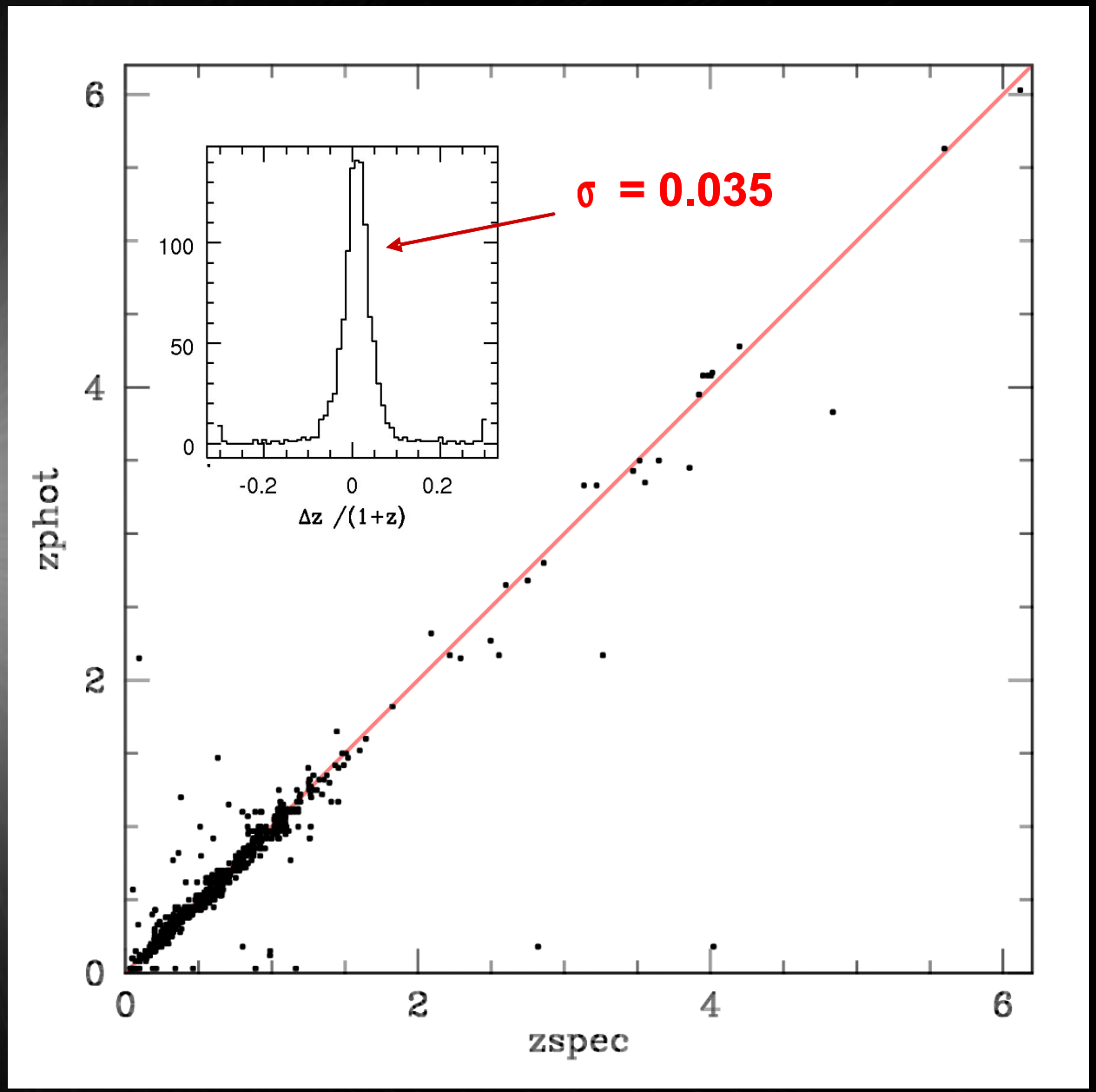
UKIDSS and the Ultra-Deep Survey



Cross Correlations

- 9896 galaxies between z=1-1.5
- 53 radio and 53 X-ray selected AGN (after masking and sensitivity mapping applied)
- 35 X-ray AGN have spectroscopic redshifts
- 11 radio AGN have spectroscopic redshifts
- Random galaxy catalogue of 500,000

- Typical X-ray AGN luminosity = 2×10^{44} ergs sec^{-1}
- Radio AGN > 100-μJy


σ = 0.035
zphot
zspec
Δz /(1+z)
0
2
4
6
100
50
-0.2
0.2

Cross Correlations

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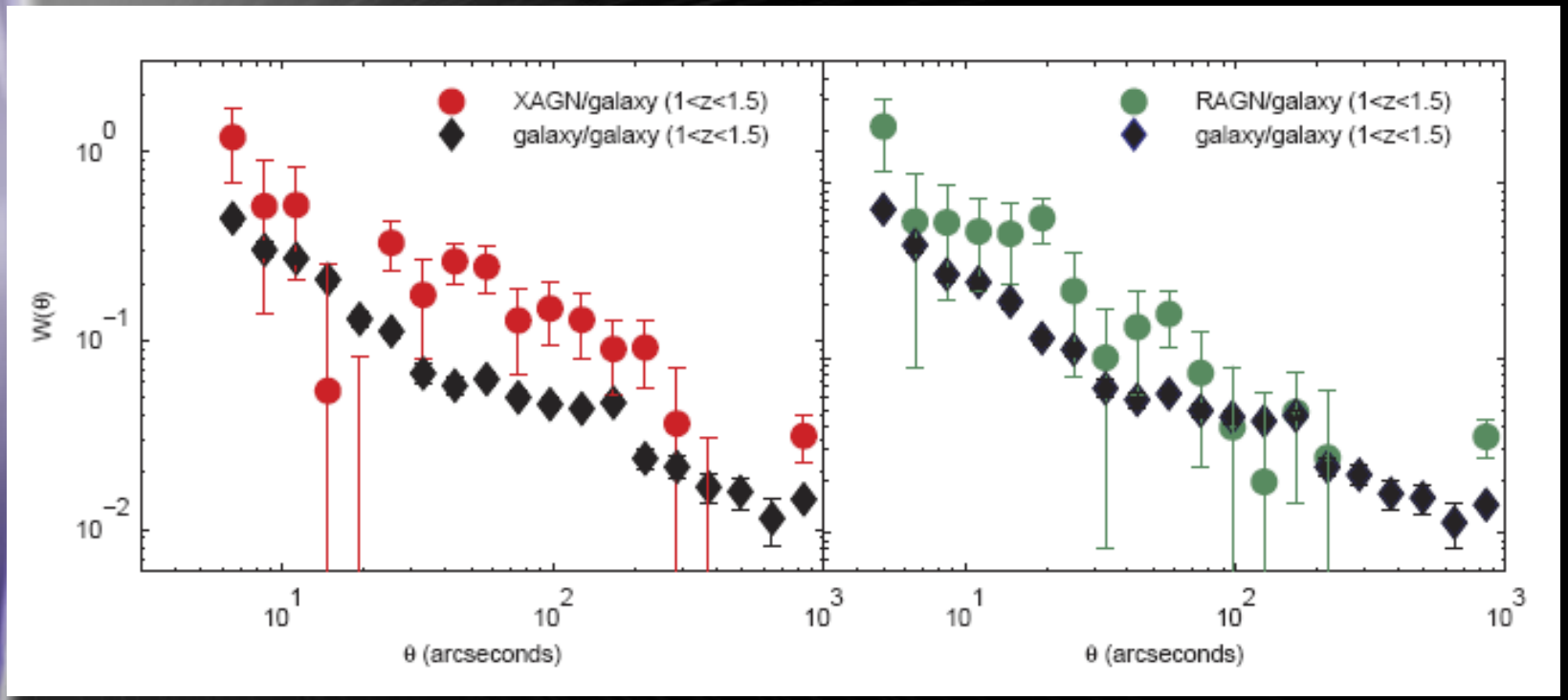
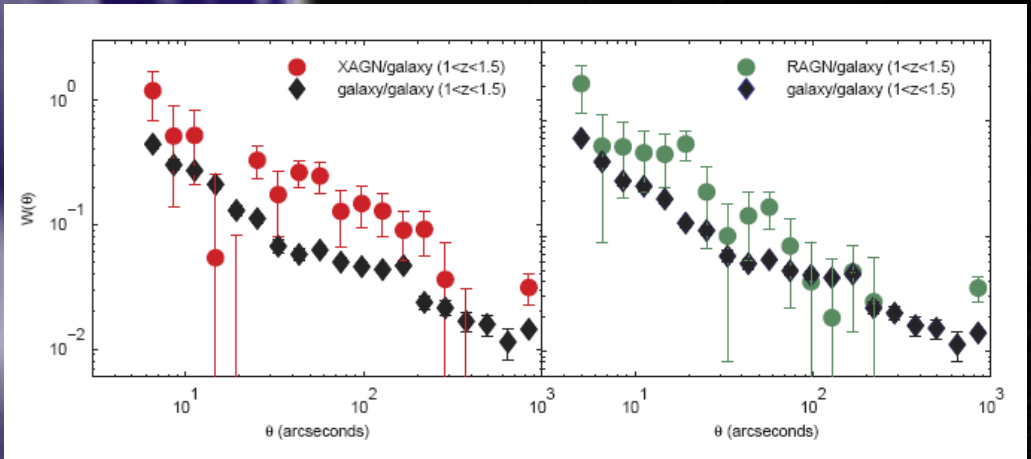
$$w(\theta) = \frac{N_{DD} - 2N_{DR} + N_{RR}}{N_{RR}}$$

Results


XAGN/galaxy (1<z<1.5)
galaxy/galaxy (1<z<1.5)
RAGN/galaxy (1<z<1.5)
galaxy/galaxy (1<z<1.5)
W(θ)
θ (arcseconds)
θ (arcseconds)



Results

This analysis was repeated with different X-ray AGN samples to confirm this result:

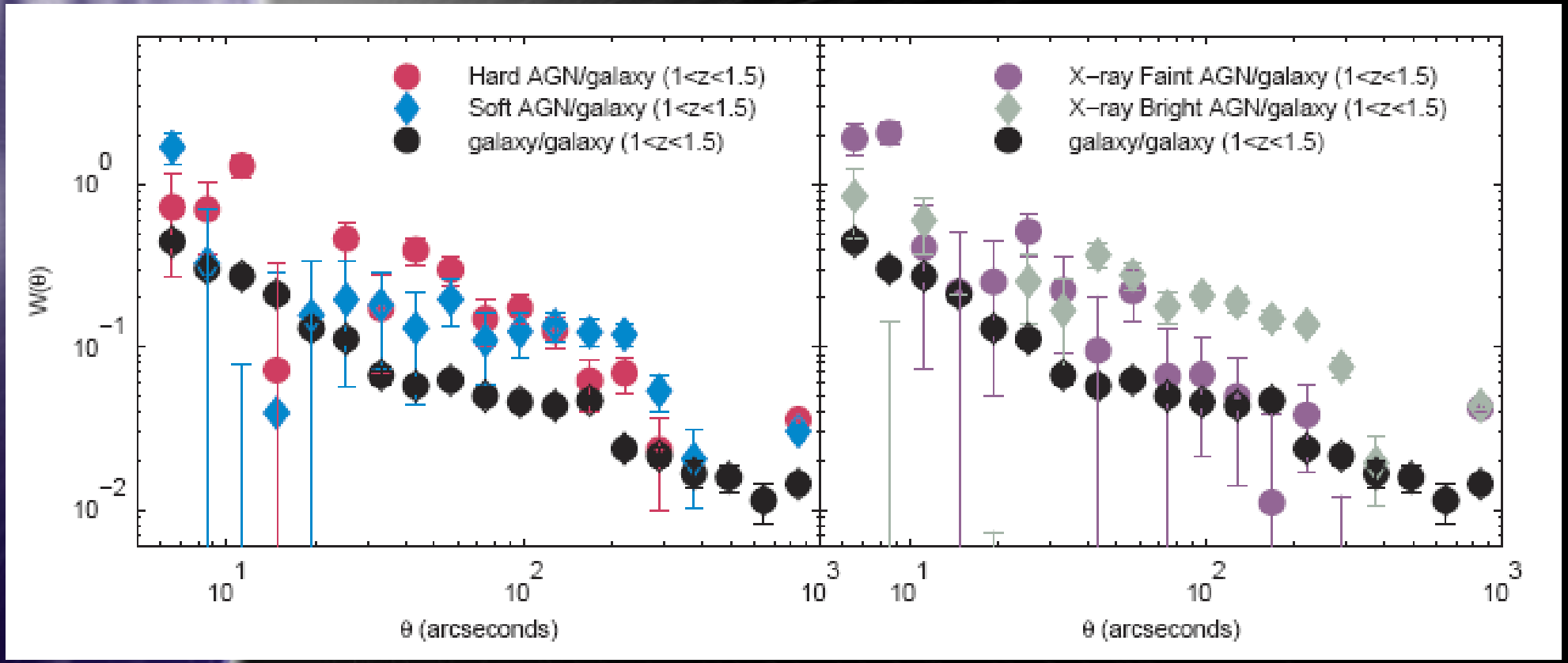
- Only those with spectroscopic redshifts
- Only those in the central pointing of the SXDS

No difference was found in the cross-correlations, the only difference was in the magnitude of the errors

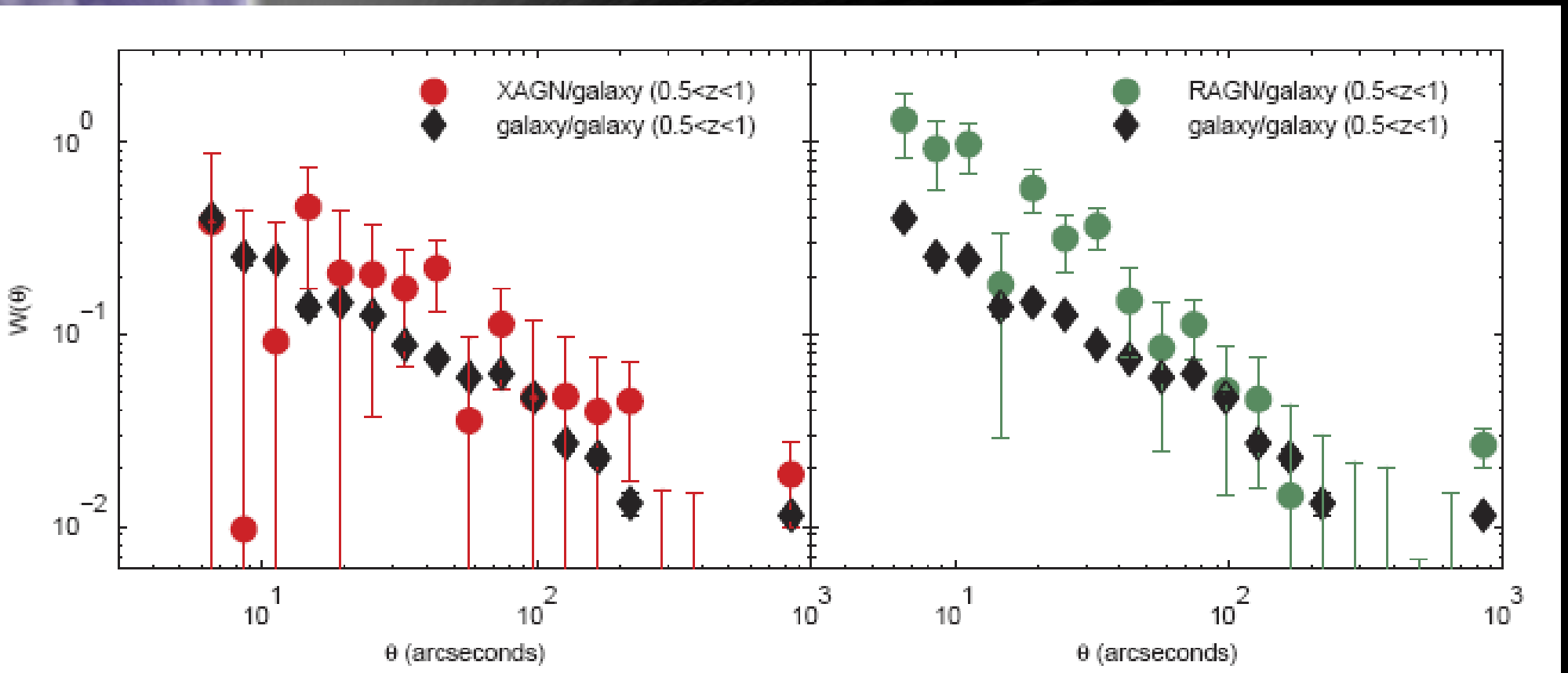
Hard vs Soft, X-ray Faint vs X-ray Bright

- Soft AGN HR < -0.4 (corresponding to an AGN at z=1 with a moderate intrinsic absorbing column of $N_H = 1x10^{22}$ atoms cm^{-2} and an unobscured power law spectrum of $\gamma=2$)
- 27 hard, 26 soft.
- K-band to X-ray flux ratio used to define those galaxies dominated by light from the AGN or the galaxy.
- 18 dominated by optical light, 35 by X-ray light.

Hard vs Soft, X-ray Faint vs X-ray Bright



Low Redshift Comparison (z=0.5-1)



Halo Masses

- Assuming galaxies and AGN trace the same underlying dark matter distribution, we can infer the AGN/AGN autocorrelation.

$$w_{AA} = w_{AG}^2 / w_{GG}.$$

- From the main result of this talk, we infer that the autocorrelation is similar to that of the passive galaxy autocorrelation at this redshift (see Hartley et al. 2010)

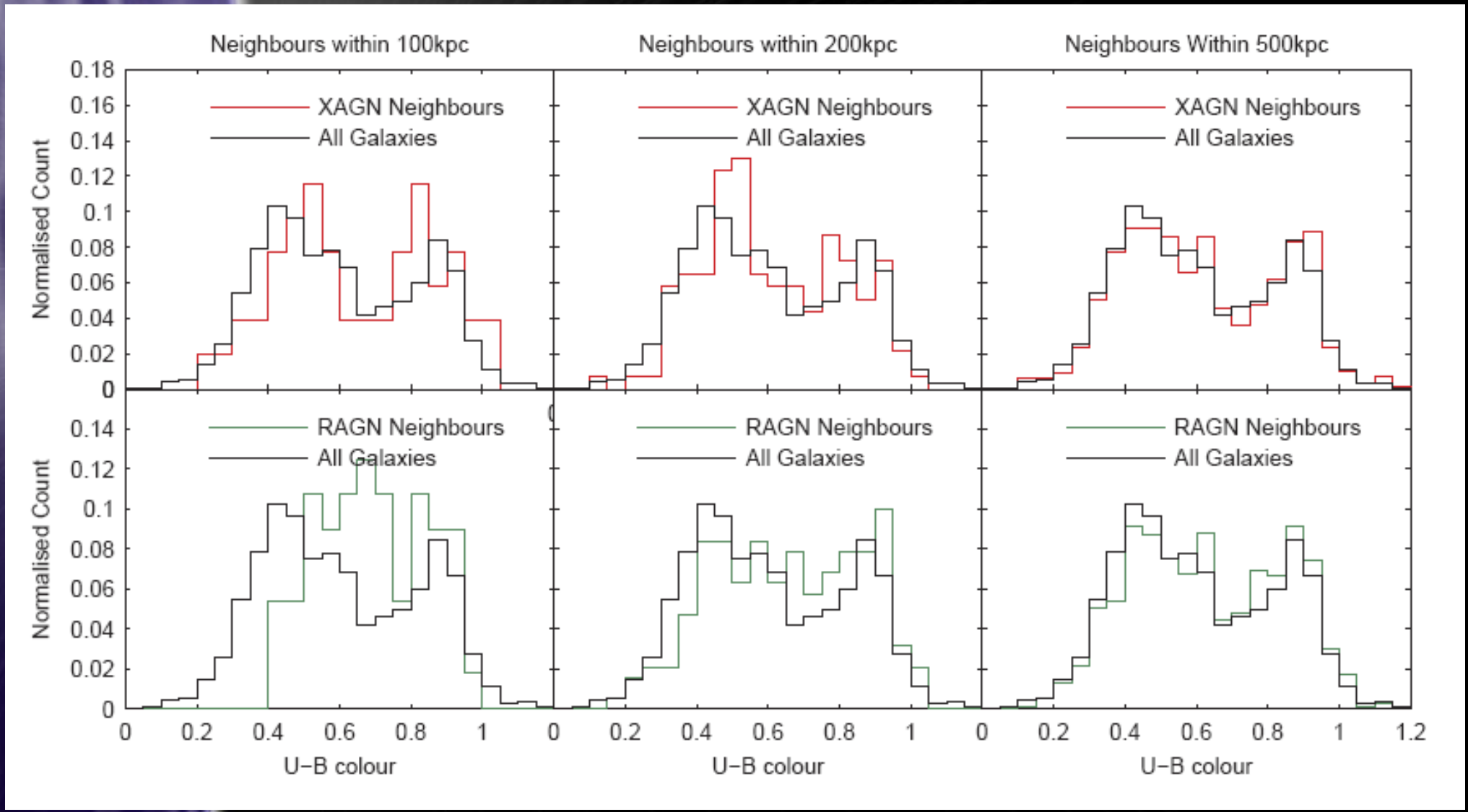
- $M > 5 \times 10^{12} M_{sun}$

- This can be done more quantitatively... work in progress...

Small-Scale Environments

- Take a closer look at galaxies within 100, 200 and 500kpc of AGN
- Look at K-band magnitudes and U-B colour
- KS-test performed between these populations and the overall general galaxy population.

Small-Scale Environments



Interpretation

- Radio AGN live in galaxy clusters at this redshift like in the local Universe
- The red/green colour of neighbouring galaxies suggests so.
- X-ray galaxies still associated with the outskirts of galaxy clusters as suggested by the colour of their neighbours (more like the generic population)
- Could X-ray AGN at this redshift therefore be associated with more massive halos?

Conclusions

- X-ray AGN live in equally dense environments as radio AGN in the redshift range z=1-1.5
- No difference between hard/soft, tentative differences between X-ray bright and faint AGN – needs more data
- Neighbours of radio AGN are mainly red/green galaxies, which would be expected if they lie in the centre of galaxy clusters
- Neighbours of X-ray AGN are more representative of the general galaxy population