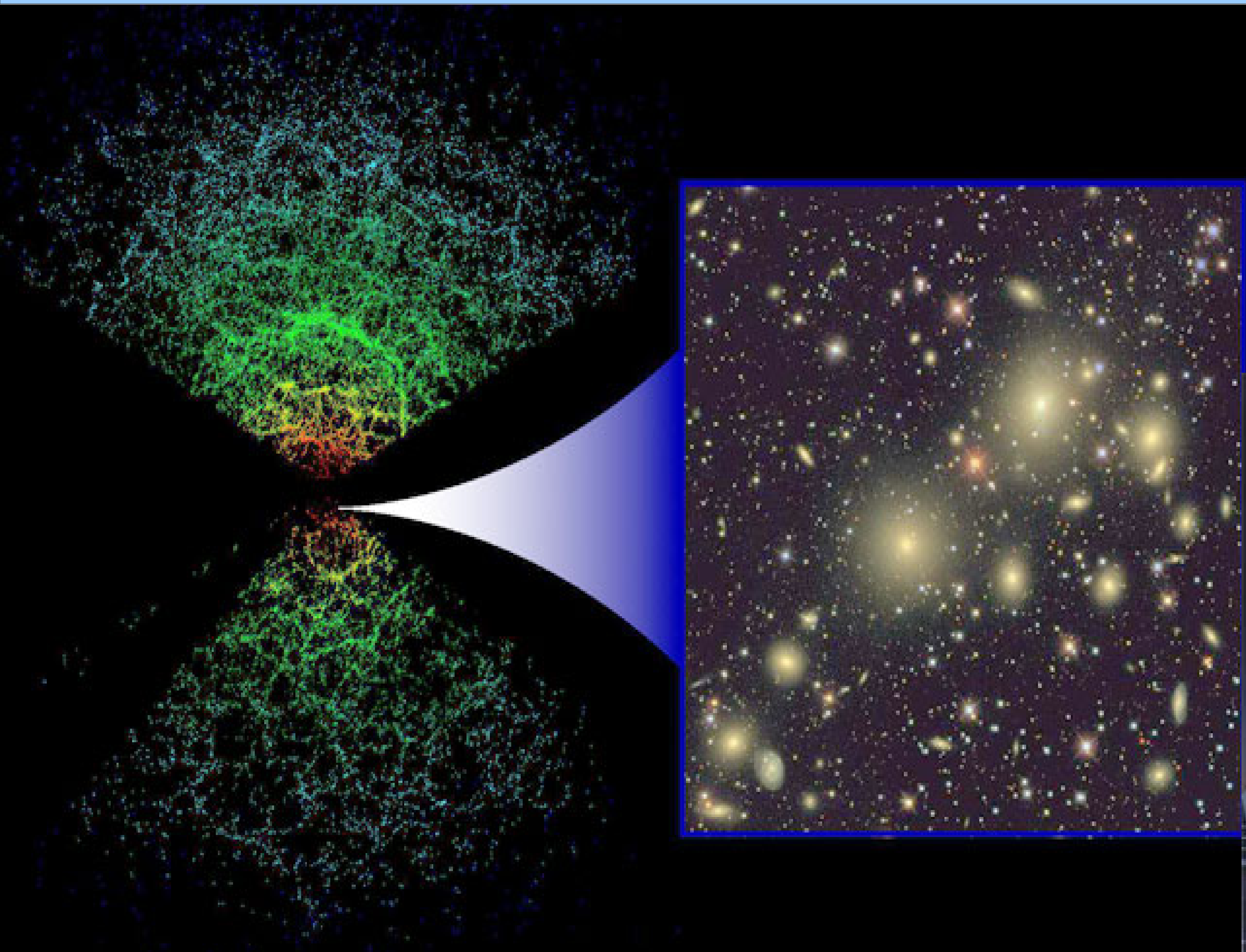
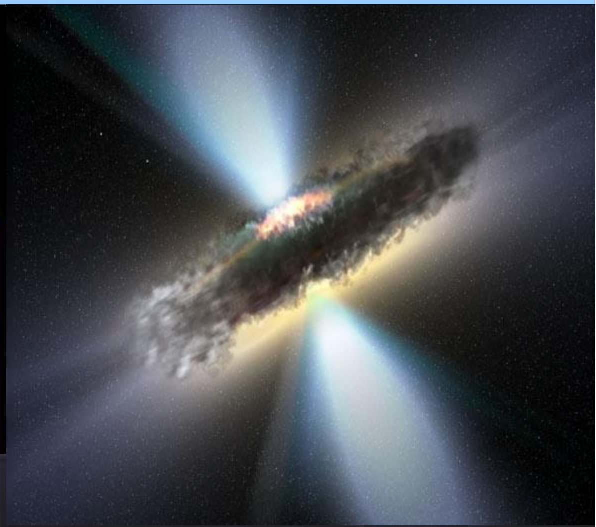
Radio-Loud versus Radio-Quiet AGN: a view from SDSS





Philip Best
IfA, Edinburgh

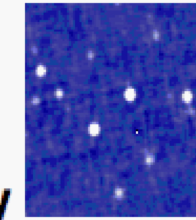
Emilio Donoso
MPA, Garching (PhD 2009)

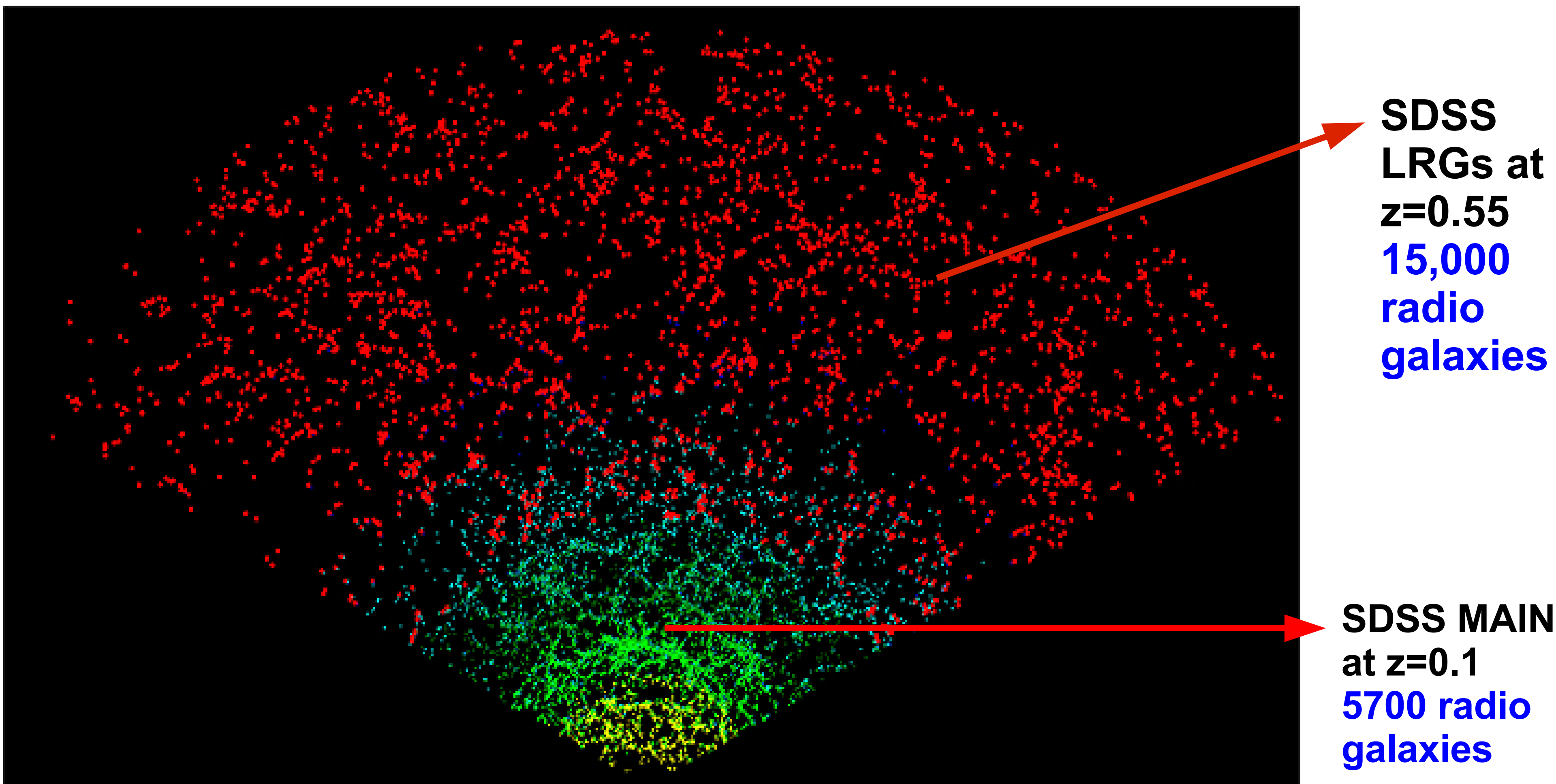
Rachel Mandelbaum (IAS), Cheng Li (MPA), Timothy Heckman (JHU)

FIRST

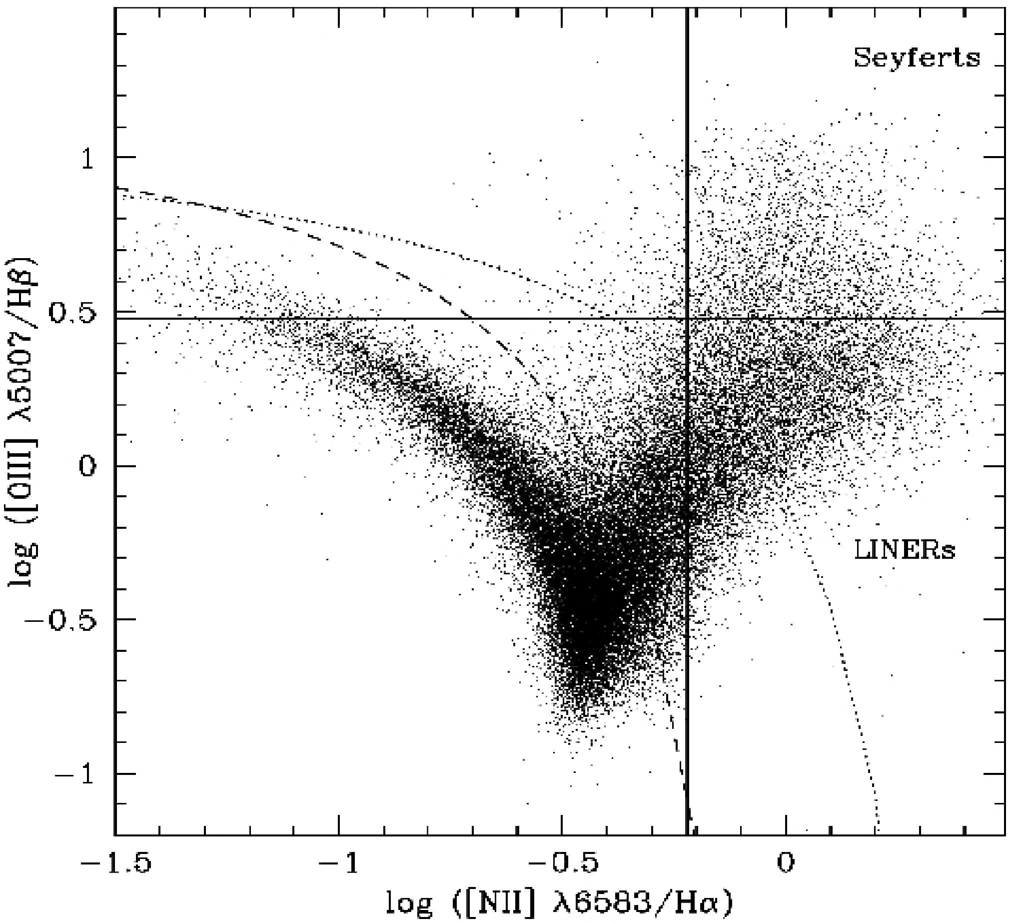
NVSS

The NRAO VLA Sky Survey





Surveys of Type II AGN at Low Redshifts from SDSS

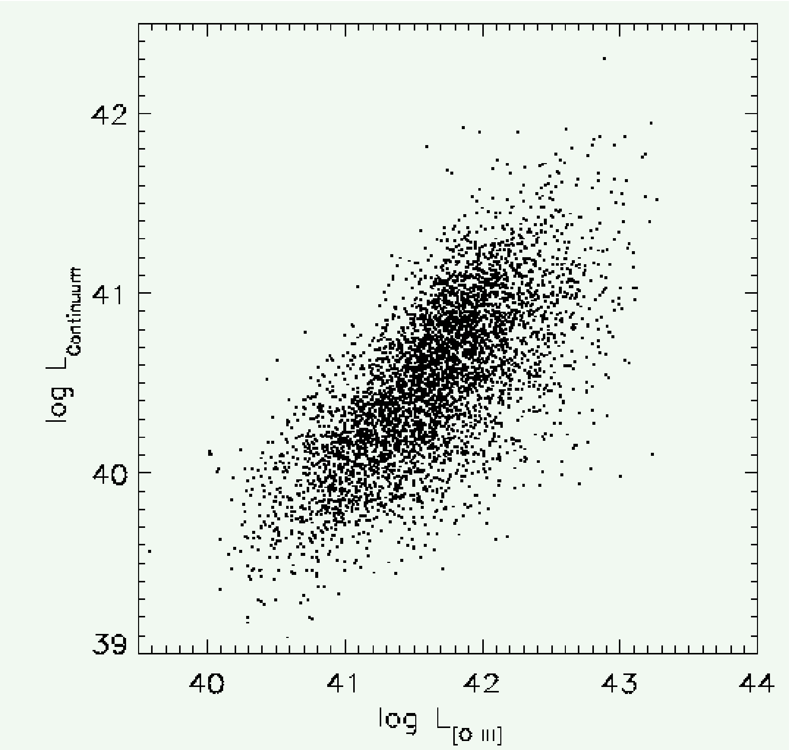


Kauffmann et al 2003

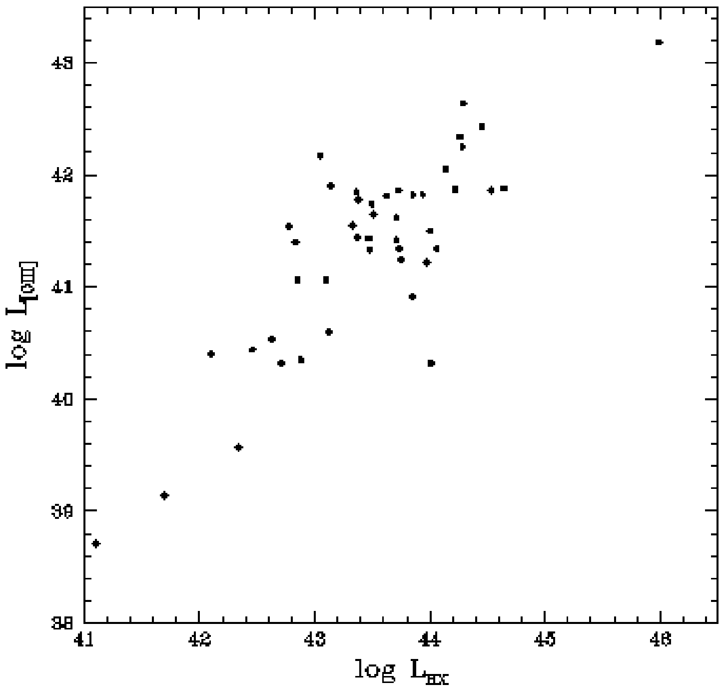
80,000 out of 400,000 galaxies are classified as AGN

Accretion

The [OIII] Line Luminosity as a Black Hole Accretion rate Indicator

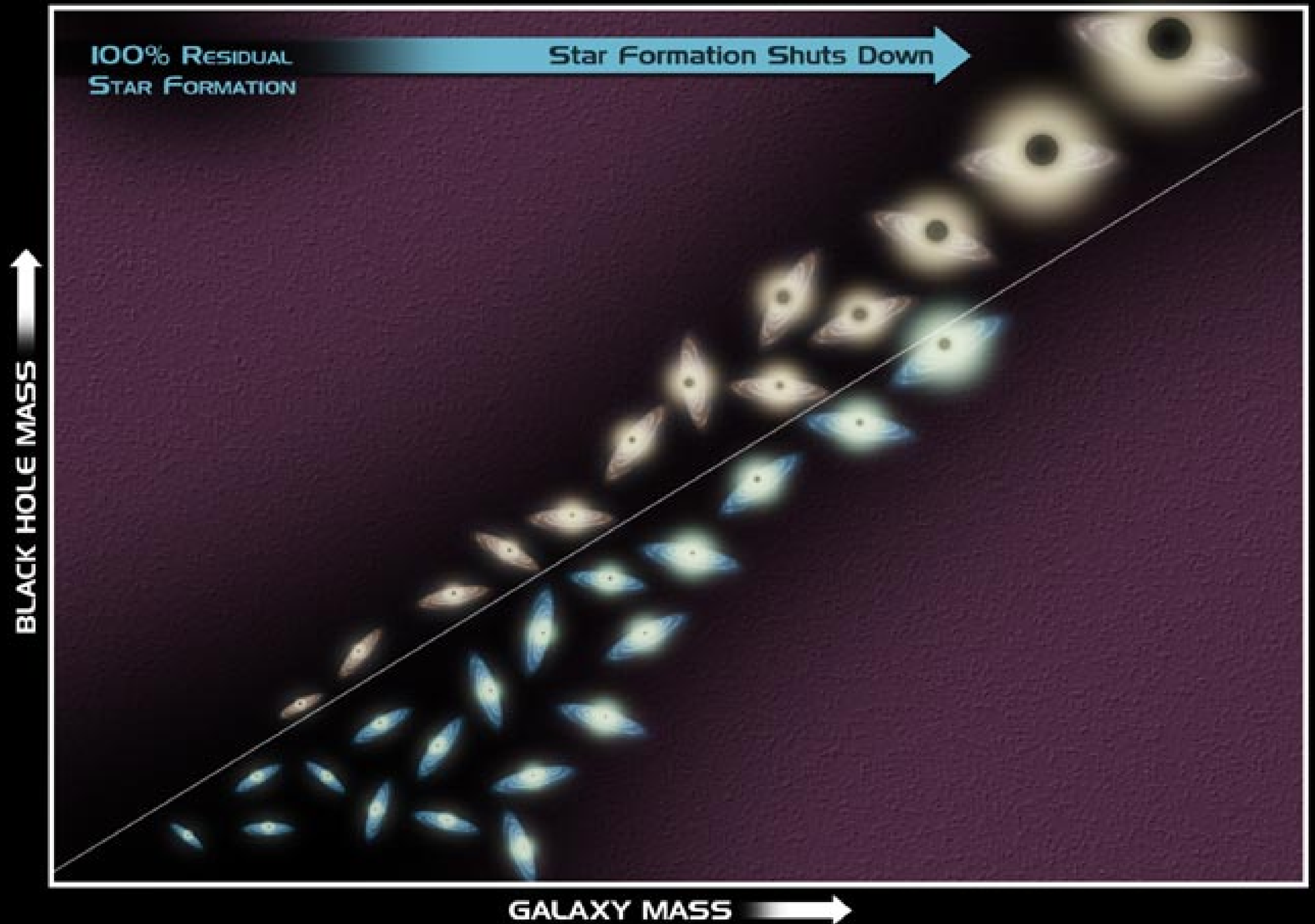


Correlation of [OIII] luminosity with continuum luminosity for Type 1 AGN (Zakamska et al 2003)

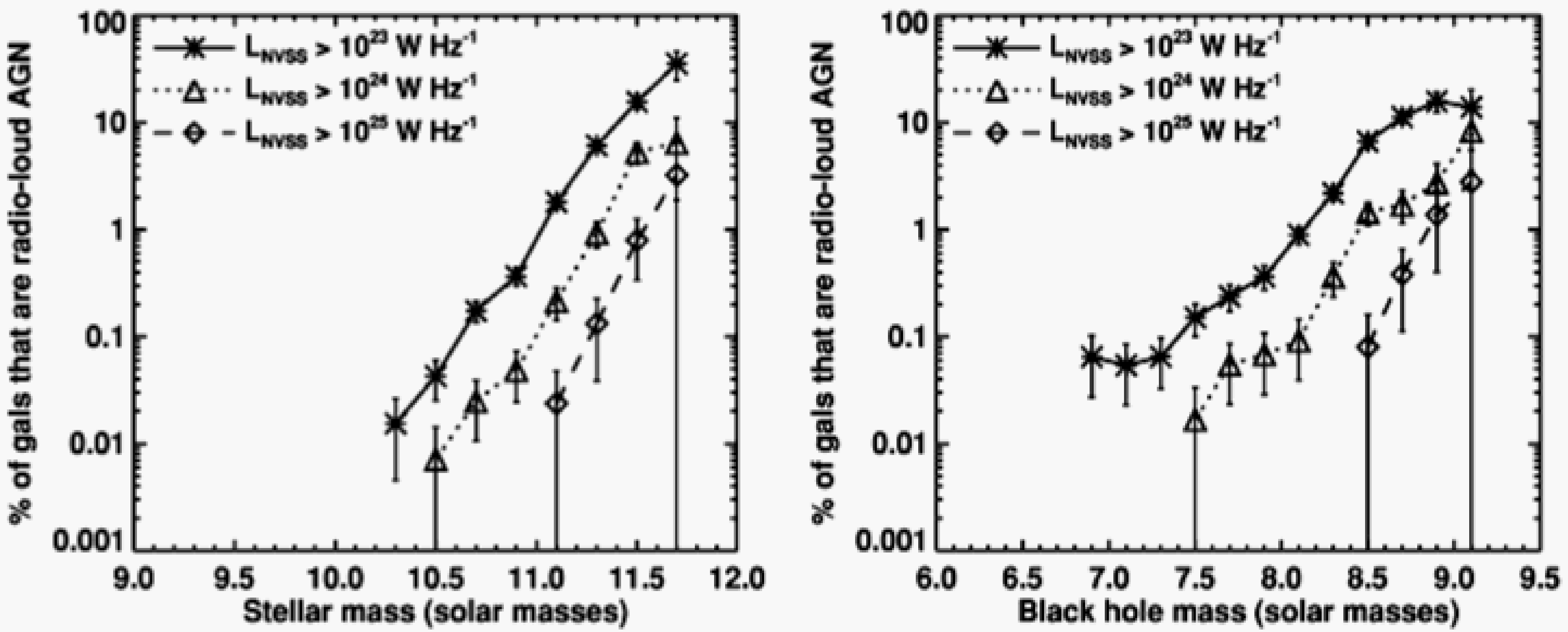


Correlation of [OIII] luminosity with hard x-ray luminosity (Heckman et al 2005)

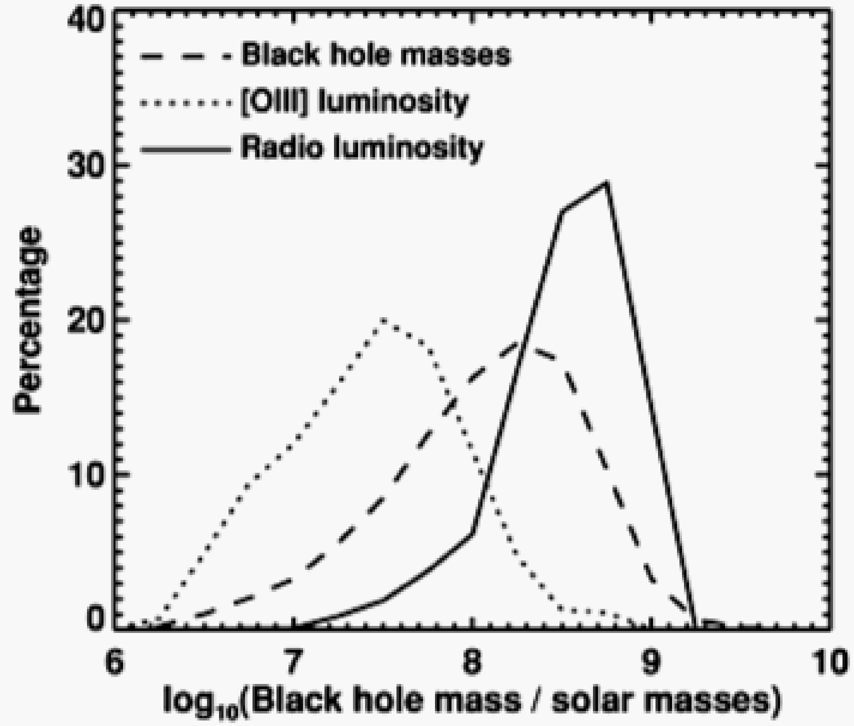
Host galaxies and black hole masses



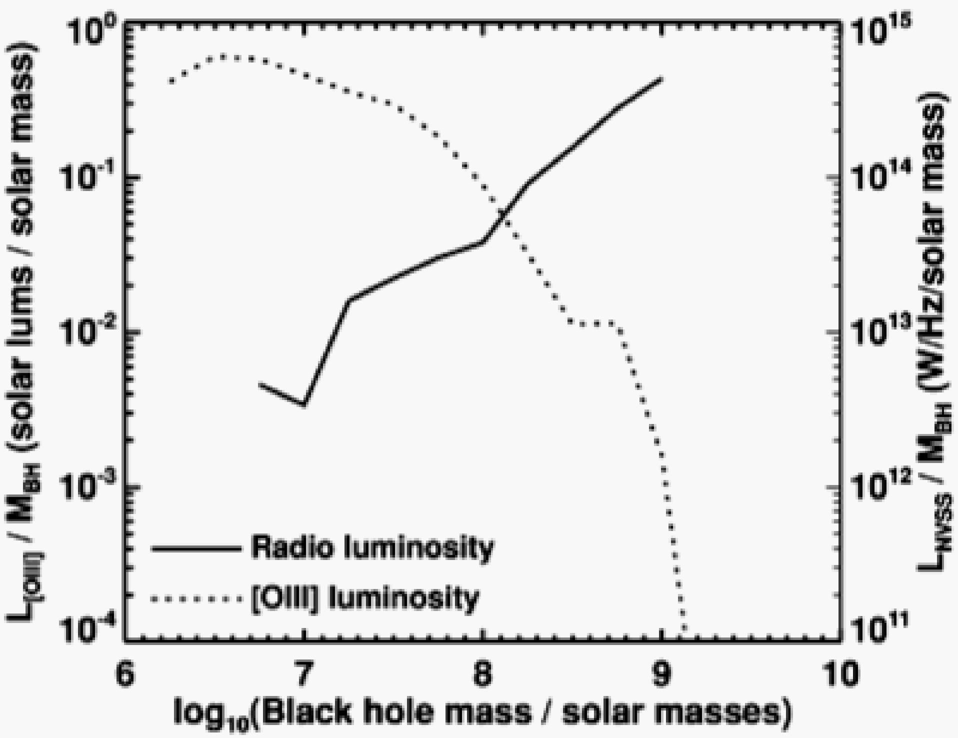
Radio AGN occur most frequently in the most massive galaxies with the most massive black holes



Best et al 2005



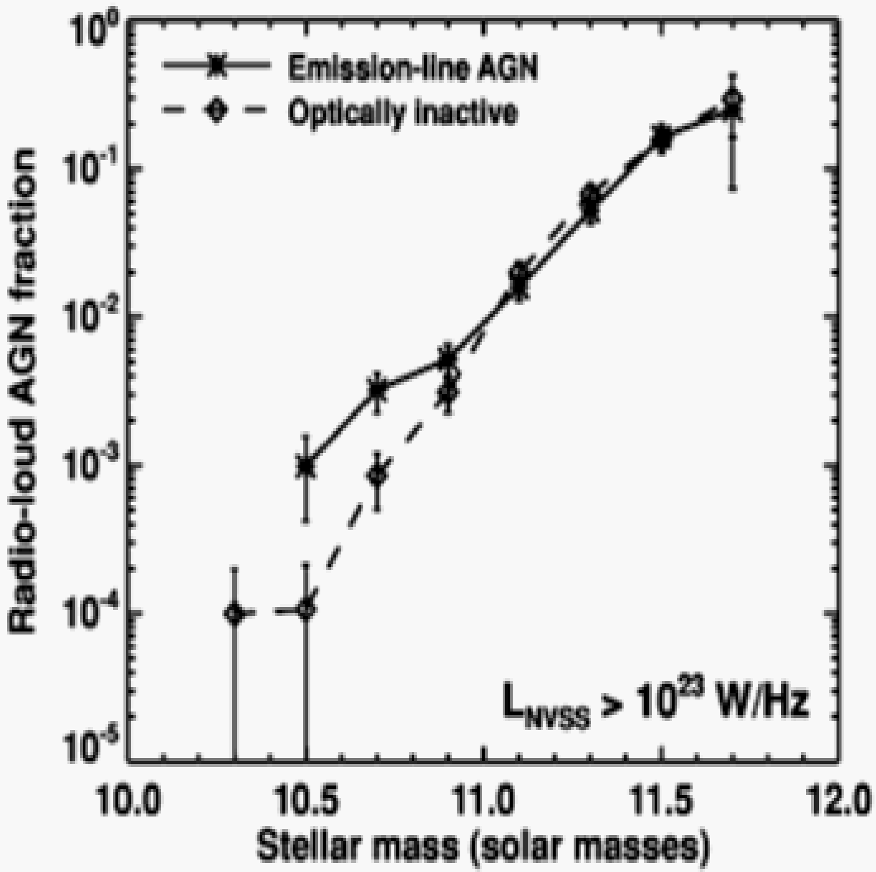
Partition function of integrated radio luminosity from radio AGN compared to integrated [OIII] luminosity from type II AGN

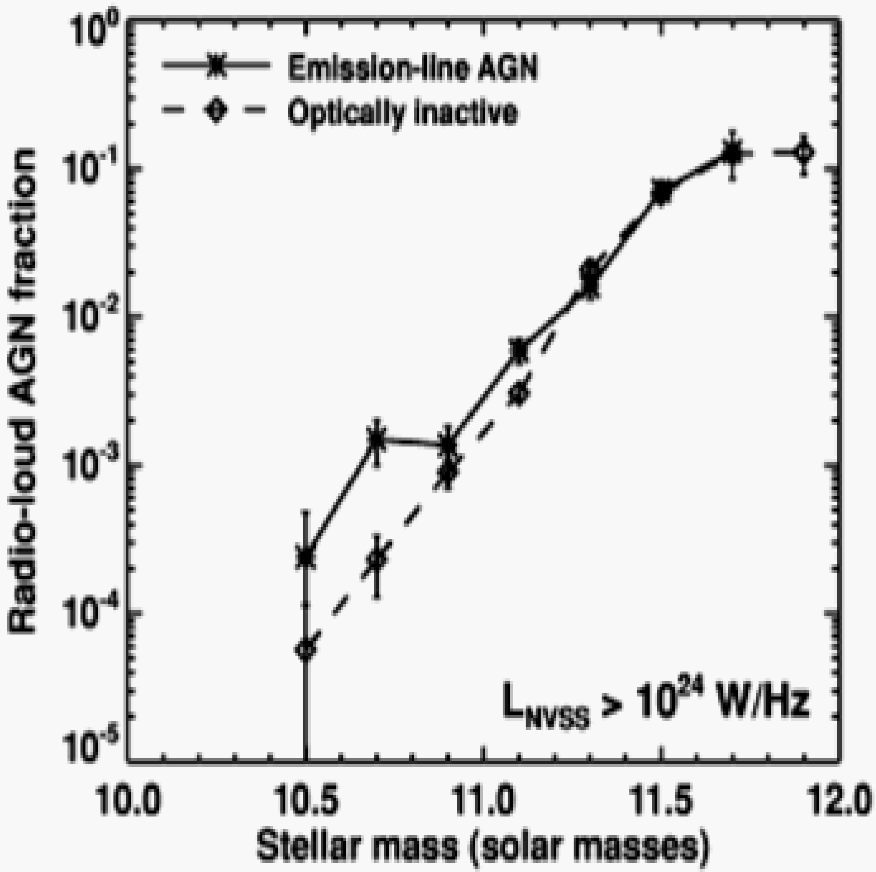


Average radio luminosity per unit black hole mass compared to average [OIII] luminosity per unit black hole mass.

INDEPENDENCE OF RADIO AND OPTICAL AGN ACTIVITY , 1

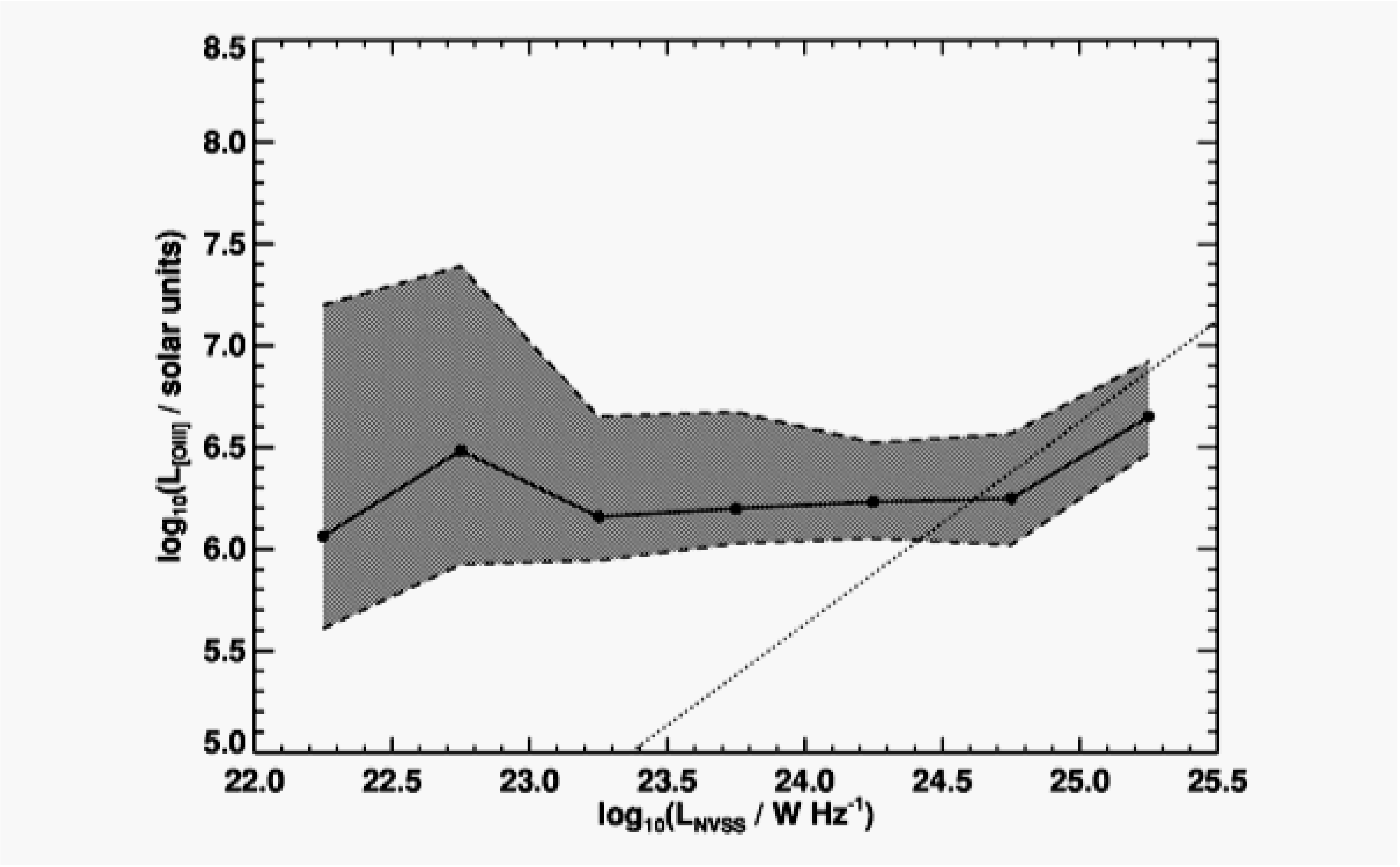
The probability that a galaxy is a radio-loud AGN is independent of whether it is an optical AGN.



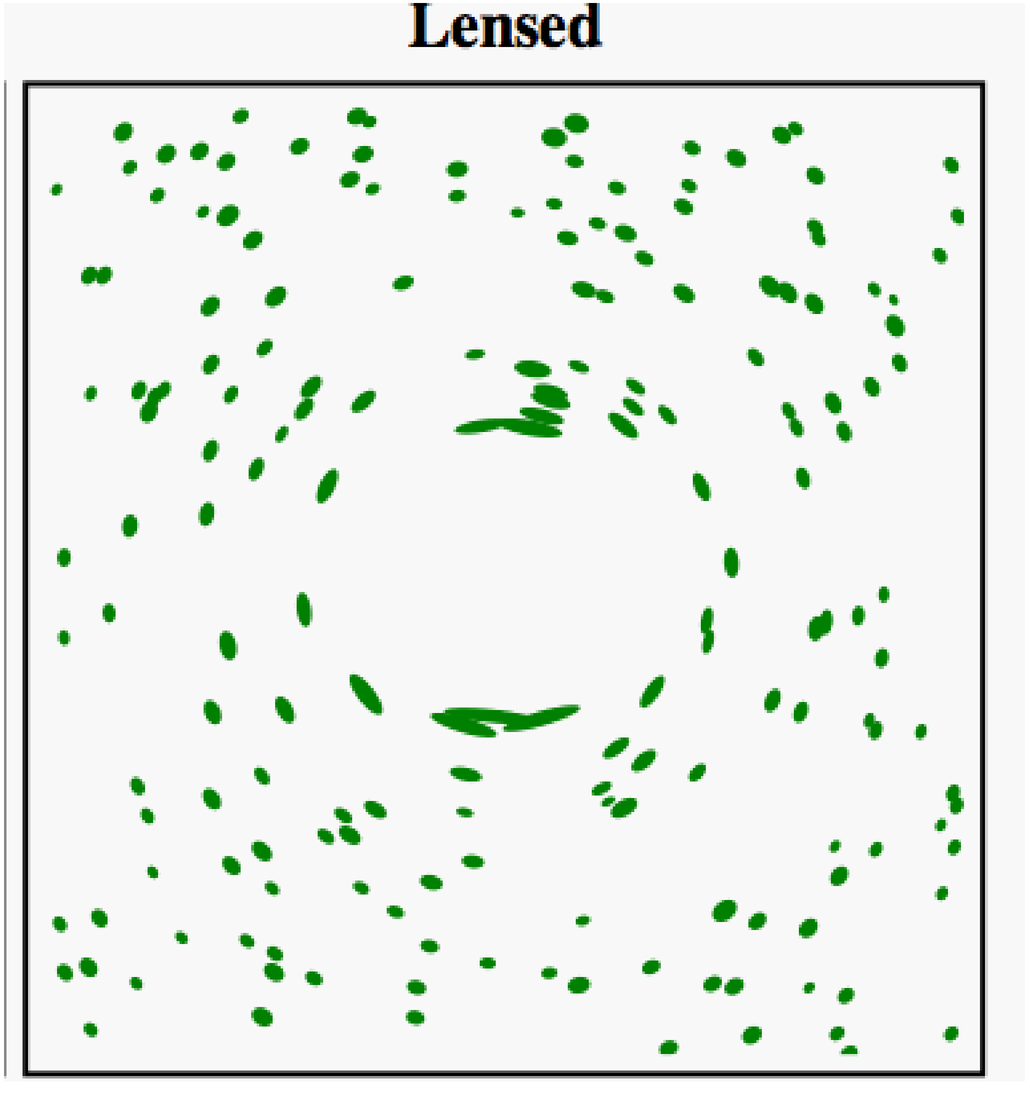


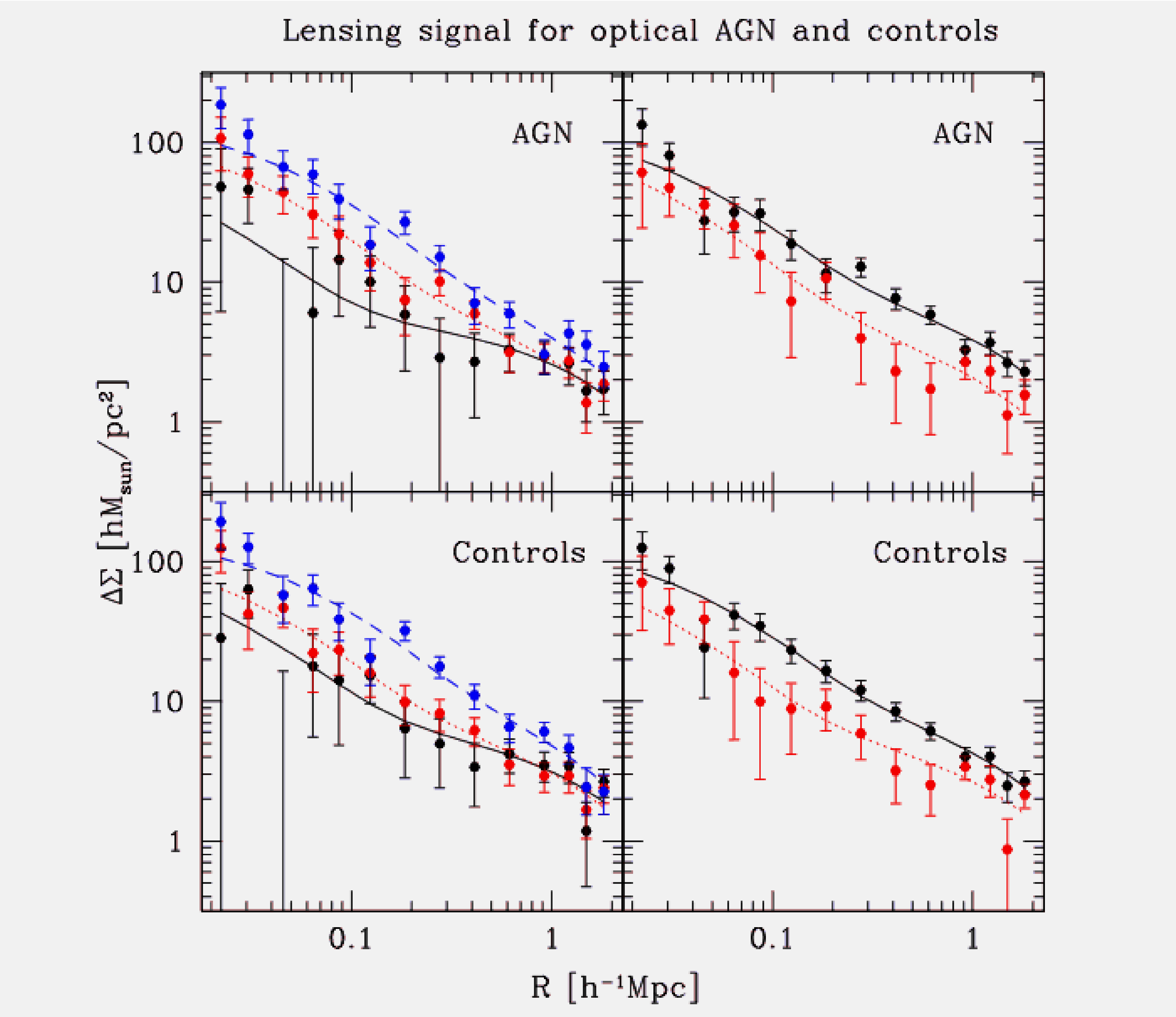
INDEPENDENCE OF RADIO AND OPTICAL AGN ACTIVITY , 2

[OIII] emission line luminosity and radio luminosity are uncorrelated

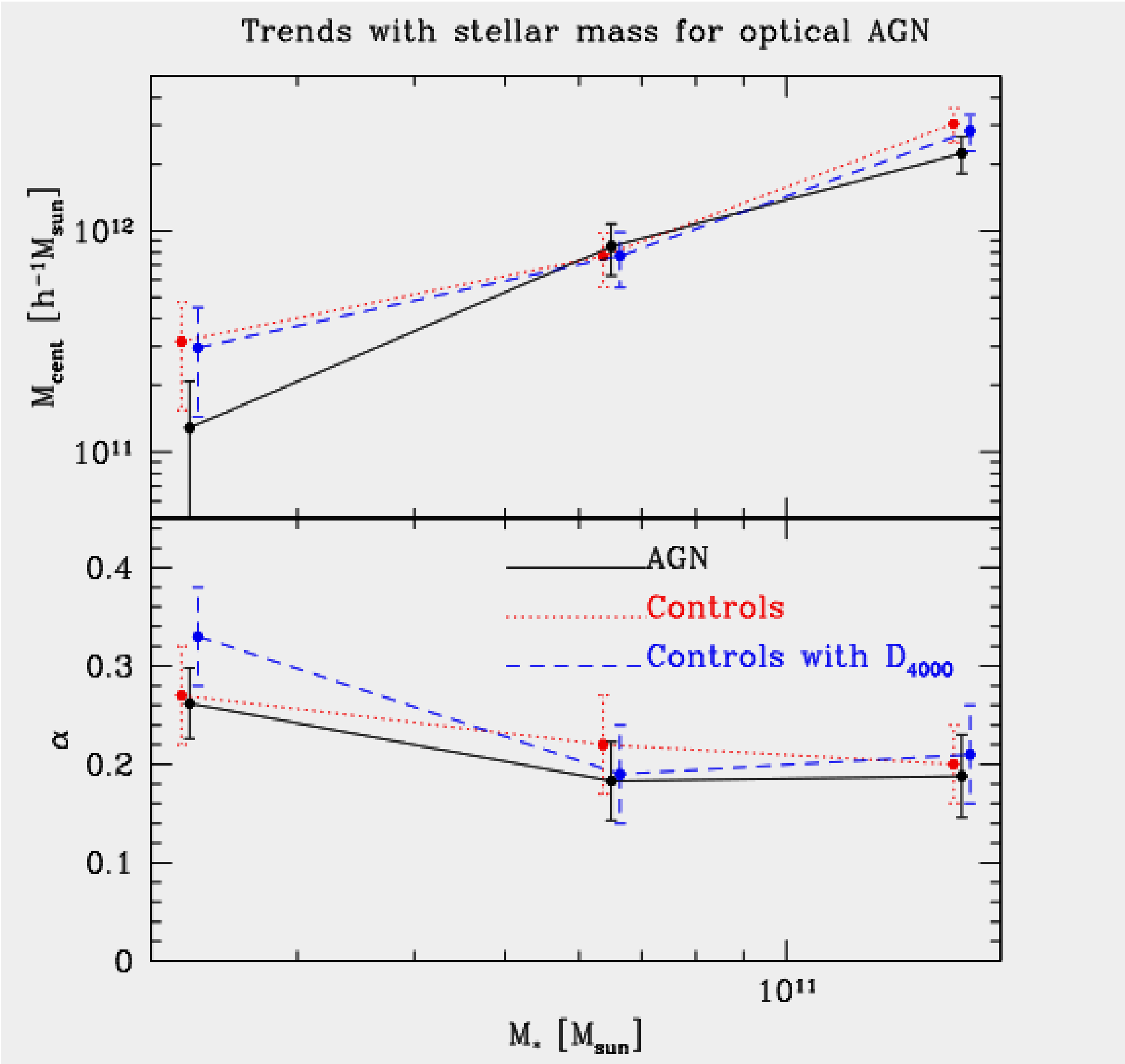


Dark Matter Halo Masses using Clustering and Galaxy-Galaxy Lensing Measurements
(Rachel Mandelbaum and Cheng Li)

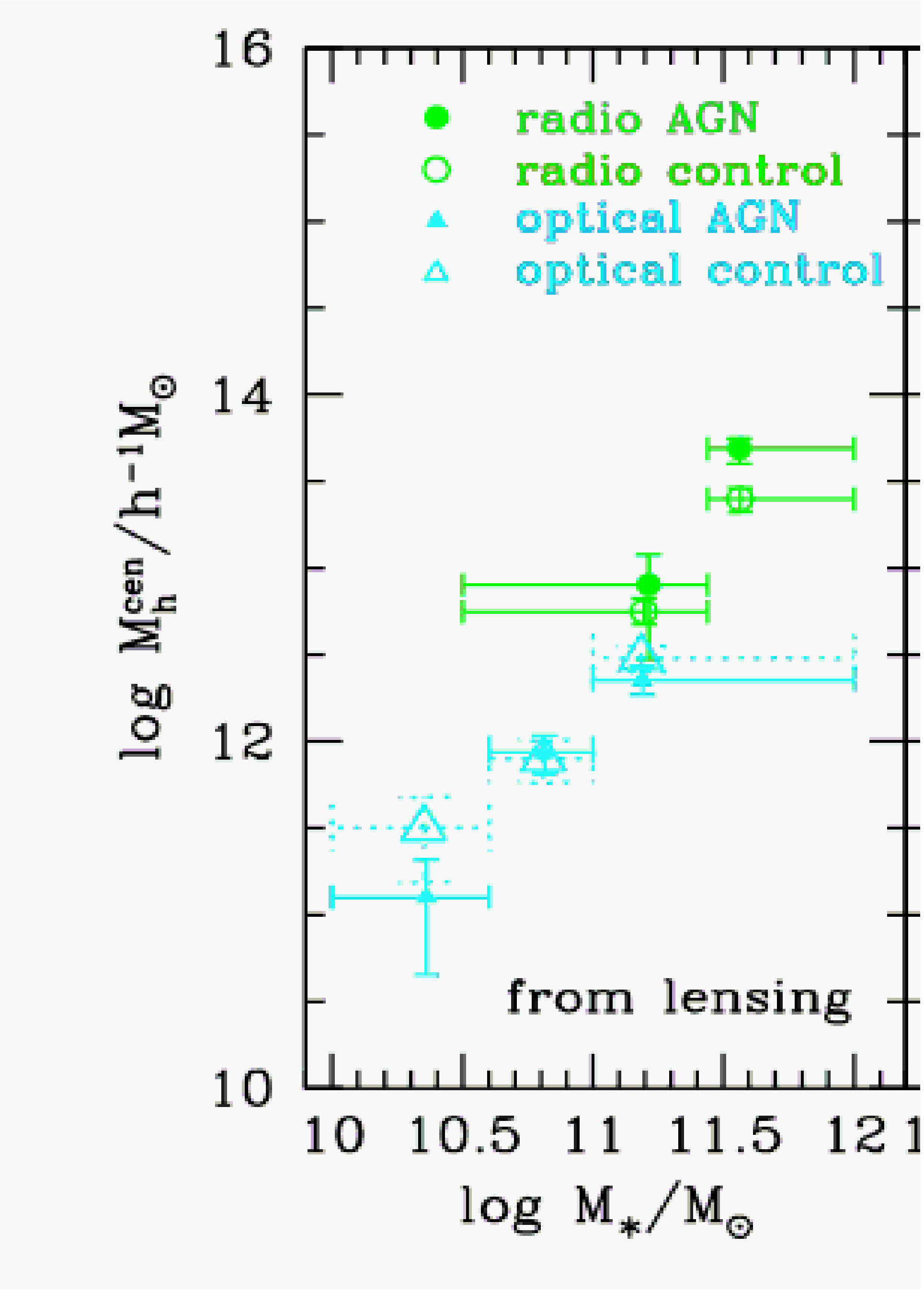




Lensing signal for optical AGN and controls
AGN
AGN
Controls
Controls
ΔΣ [hM_sun/pc²]
R [h⁻¹Mpc]
100
10
1
0.1



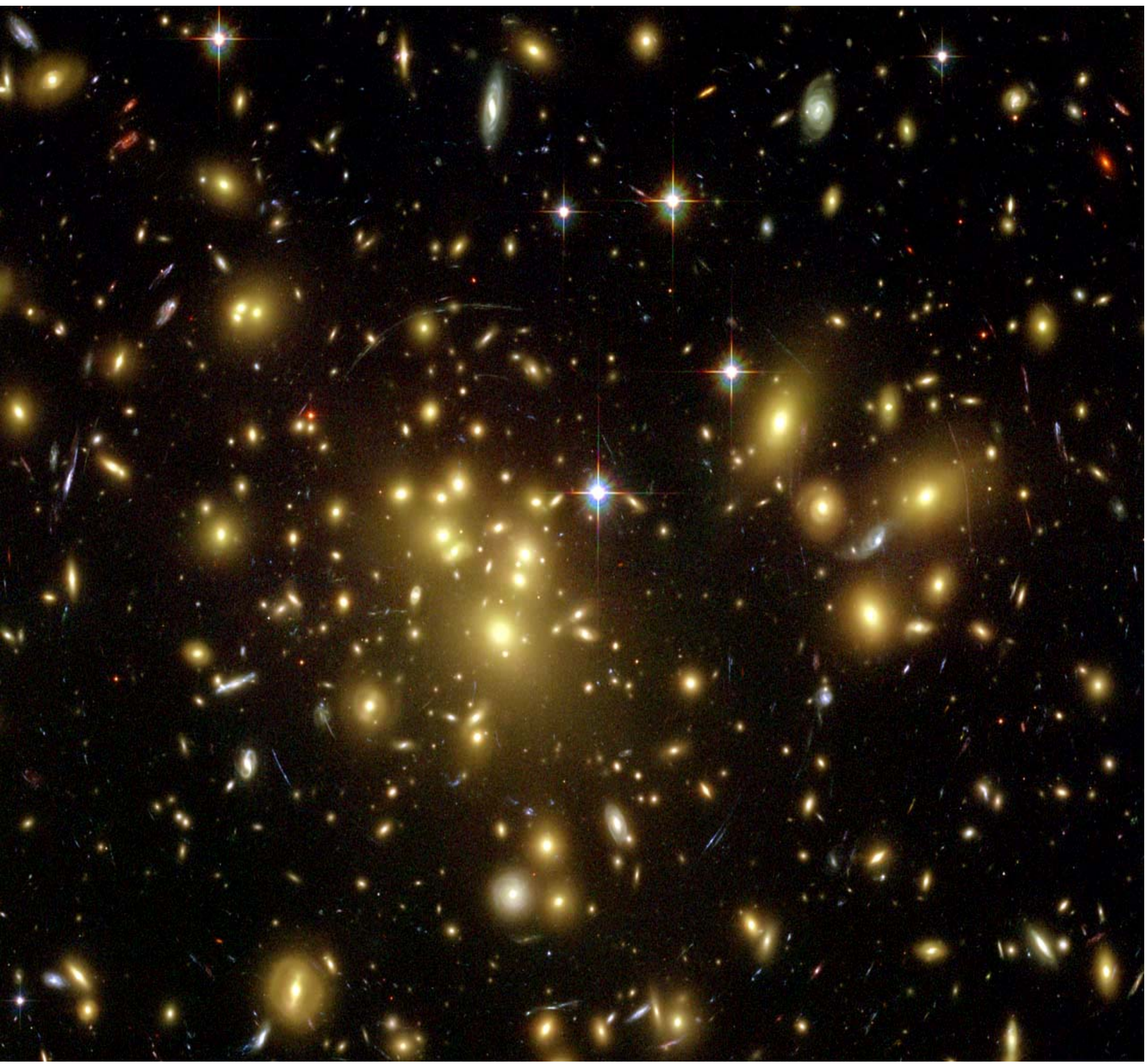
Halo masses for optical AGN range from 10^{11} to a few x 10^{12} solar masses

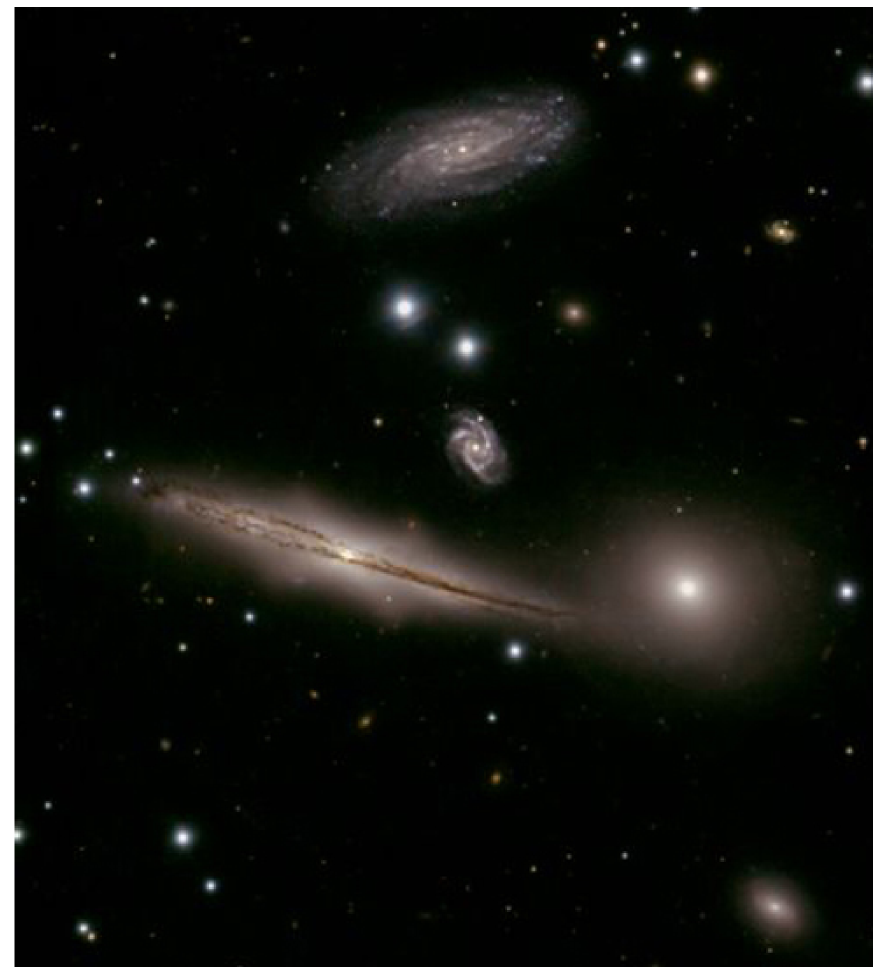


Halo masses for radio AGN range from a few x10^{12} solar masses up to 10^{14} solar mases.

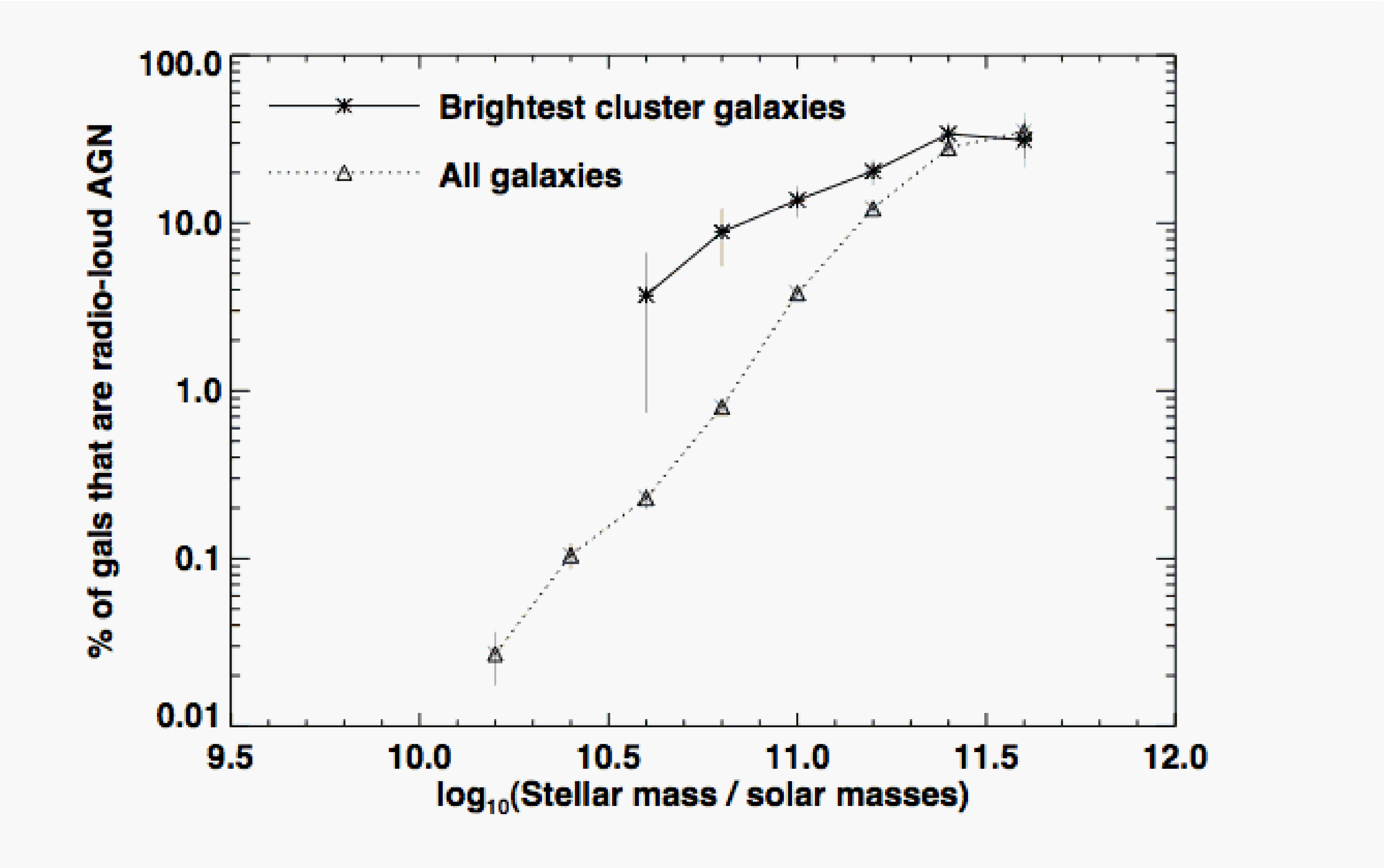
At fixed stellar mass, the radio AGN occur in **more massive** halos.

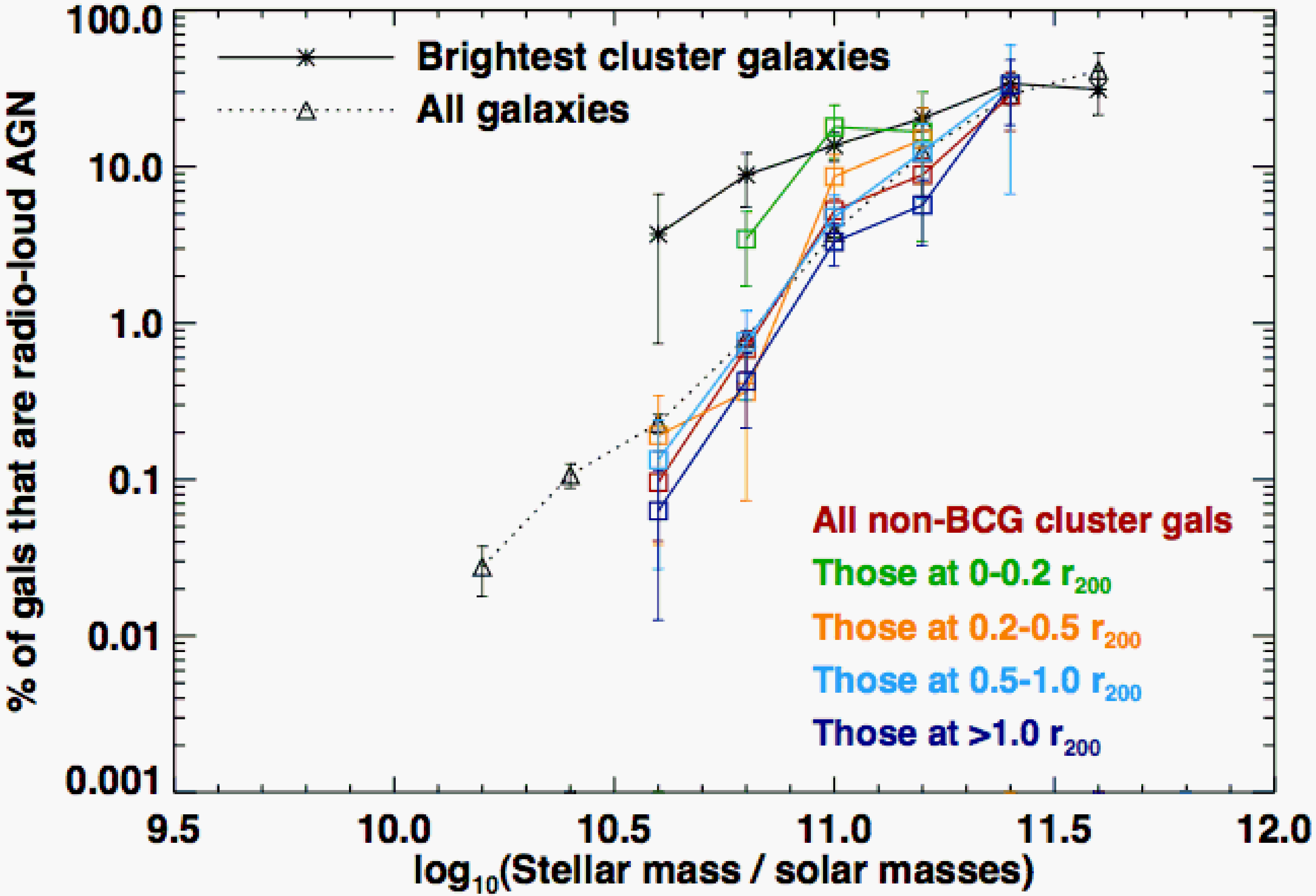
LOCATION OF THE RADIO AGN IN GROUPS AND CLUSTERS





Radio AGN activity is boosted in the galaxy at the centers of groups and clusters (Best et al 2007)





Brightest cluster galaxies
All galaxies
All non-BCG cluster gals
Those at 0-0.2 r200
Those at 0.2-0.5 r200
Those at 0.5-1.0 r200
Those at >1.0 r200
100.0
10.0
1.0
0.1
0.01
0.001
% of gals that are radio-loud AGN
9.5
10.0
10.5
11.0
11.5
12.0
log10(Stellar mass / solar masses)

SUMMARY OF RADIO AGN PROPERTIES AT Z=0.1

1) The probability that a galaxy hosts a radio loud AGN increases strongly as a function of host galaxy mass and black hole mass

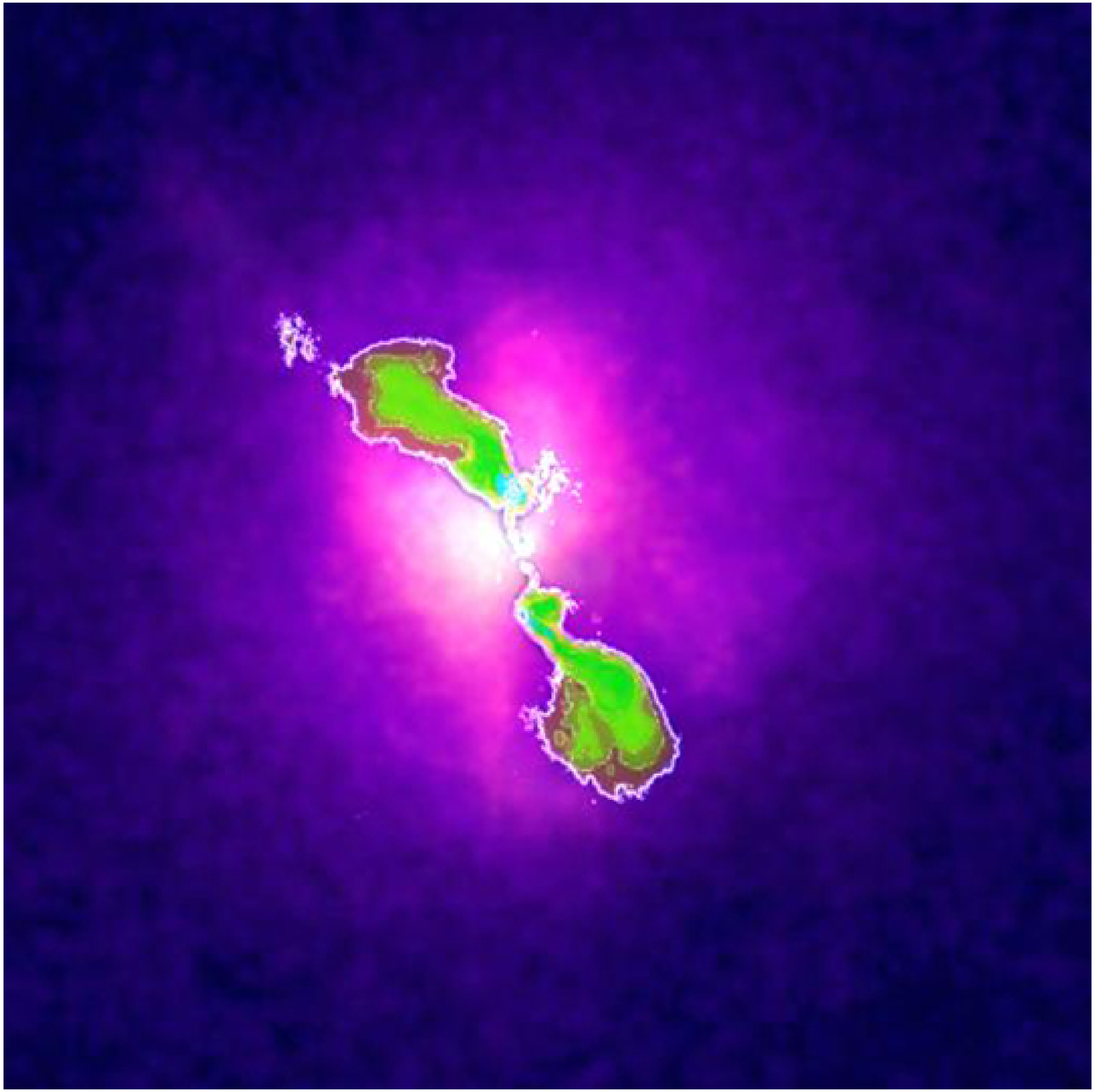
2) The integrated radio lumnosity mainly comes from black holes of 10^9 solar masses (as compared to 10^7 solar masses for the optical line luminosity)

3) The probability that a galaxy hosts a radio loud AGN is independent of whether or not it hosts an optical AGN

4) Radio AGN are found in dark matter halos with masses greater than $3X\ 10^{12}$ solar masses.

5) Radio AGN are found in more massive halos than optical AGN. This is true even if one compares at **fixed stellar mass**.

6) Radio AGN activity is enhanced in the galaxies found at the centers of groups and clusters.



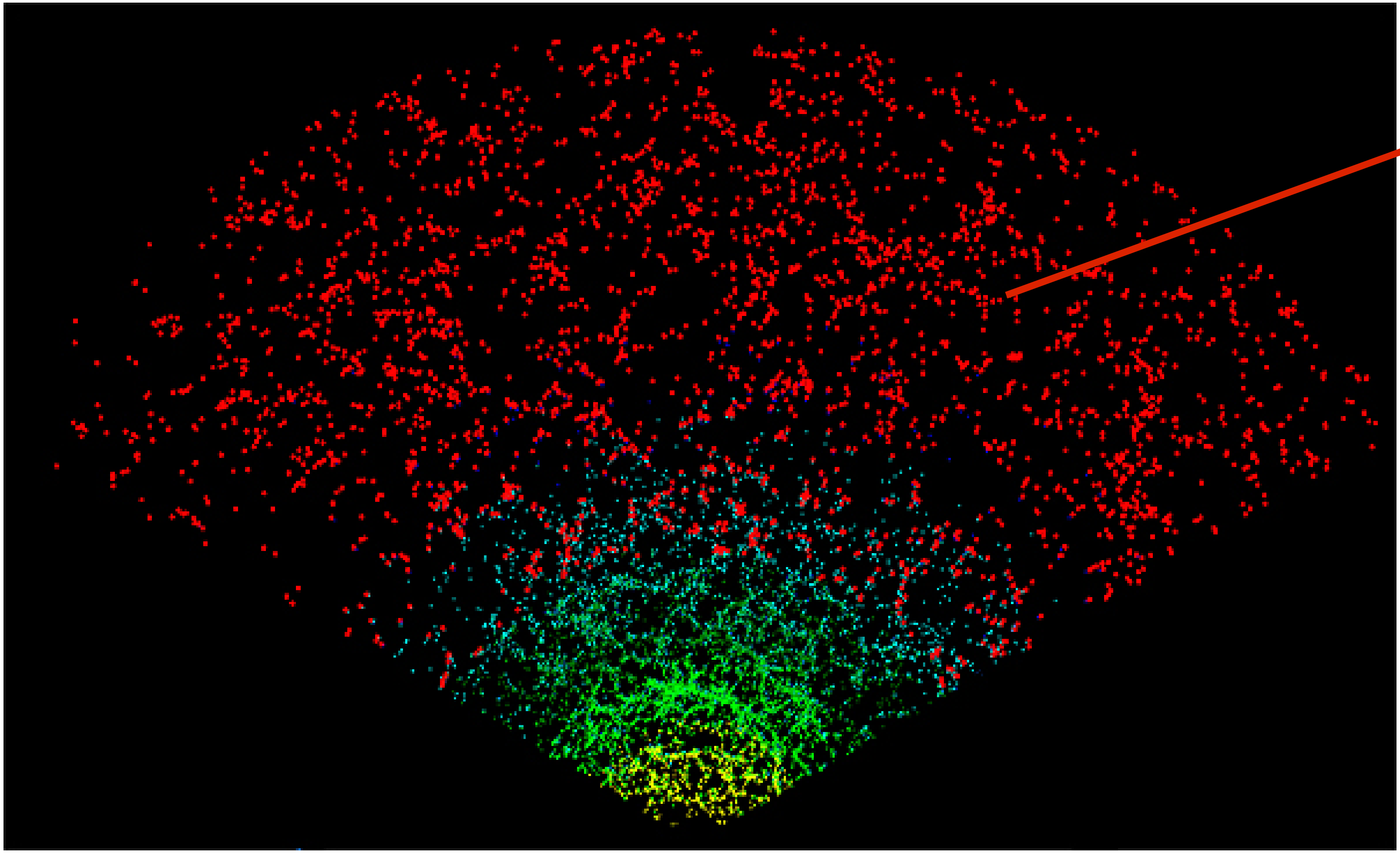
These results are fully consistent with a picture in which the low redshift radio galaxy population consists of FRI type radio galaxies fuelled by (Bondi?) accretion from the hot gas in massive dark matter halos.

These radio galaxies are likely to be responsible for the so called "radio mode" feedback that prevents gas from cooling and forming stars at high rates in massive elliptical galaxies in groups and clusters.

"Back of the envelope" calculation by Best et al (2007) demonstrate that heating can balance cooling globally for these massive halos.

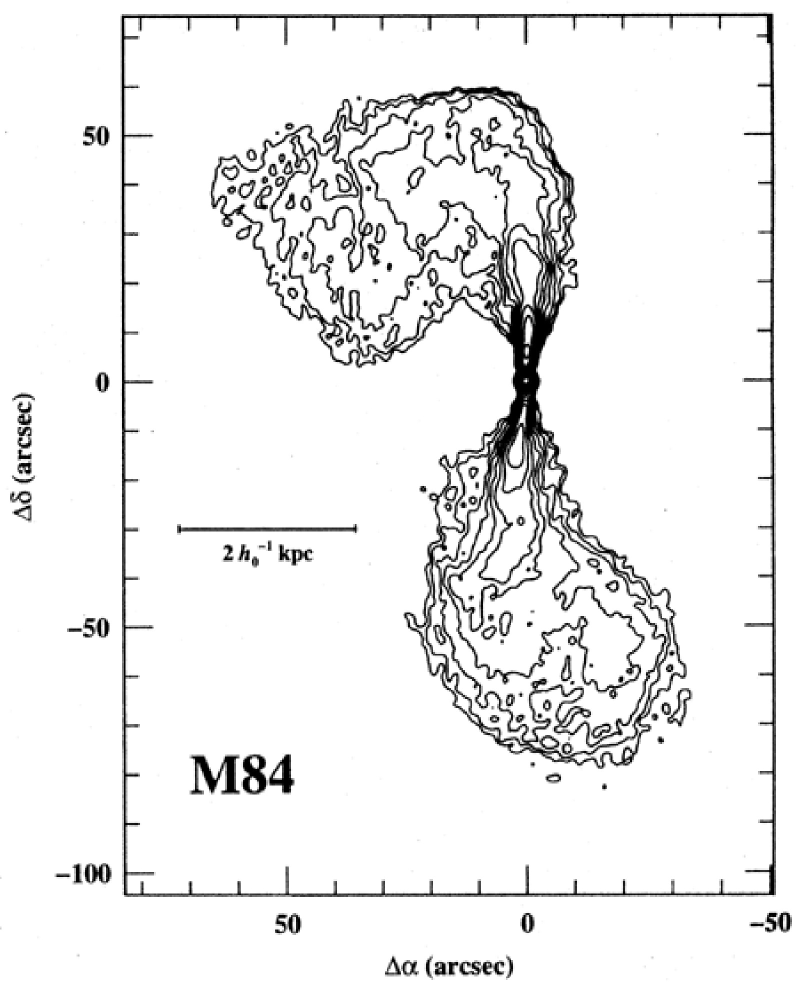
Now let us examine how things evolve with lookback time....

PhD work of E. Donoso



SDSS LRGs at z=0.55
15,000 radio galaxies

Does the low-redshift, sub-Eddington population of FRI- type radio galaxies give way to a more powerful radio galaxy population that may be more closely related to the QSOs?



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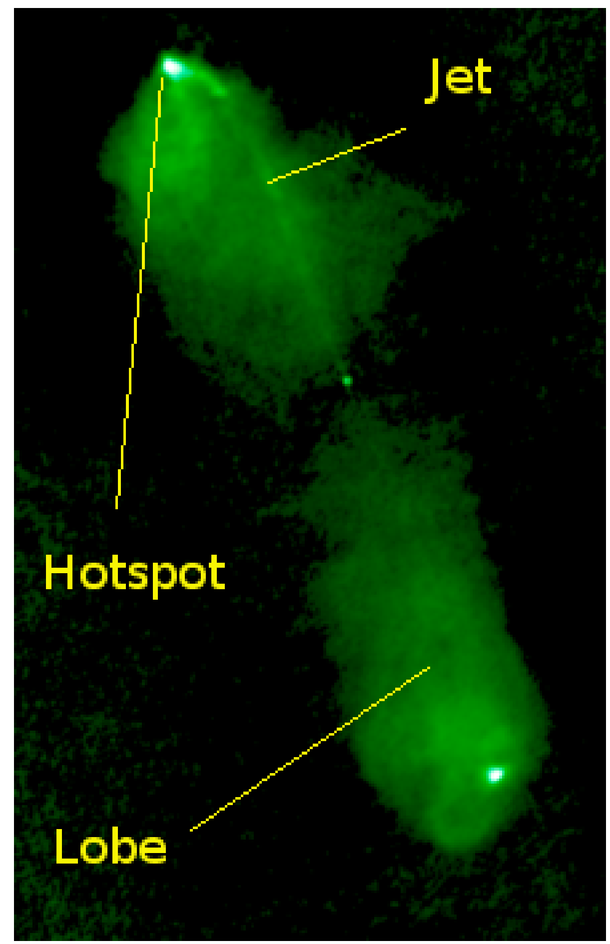
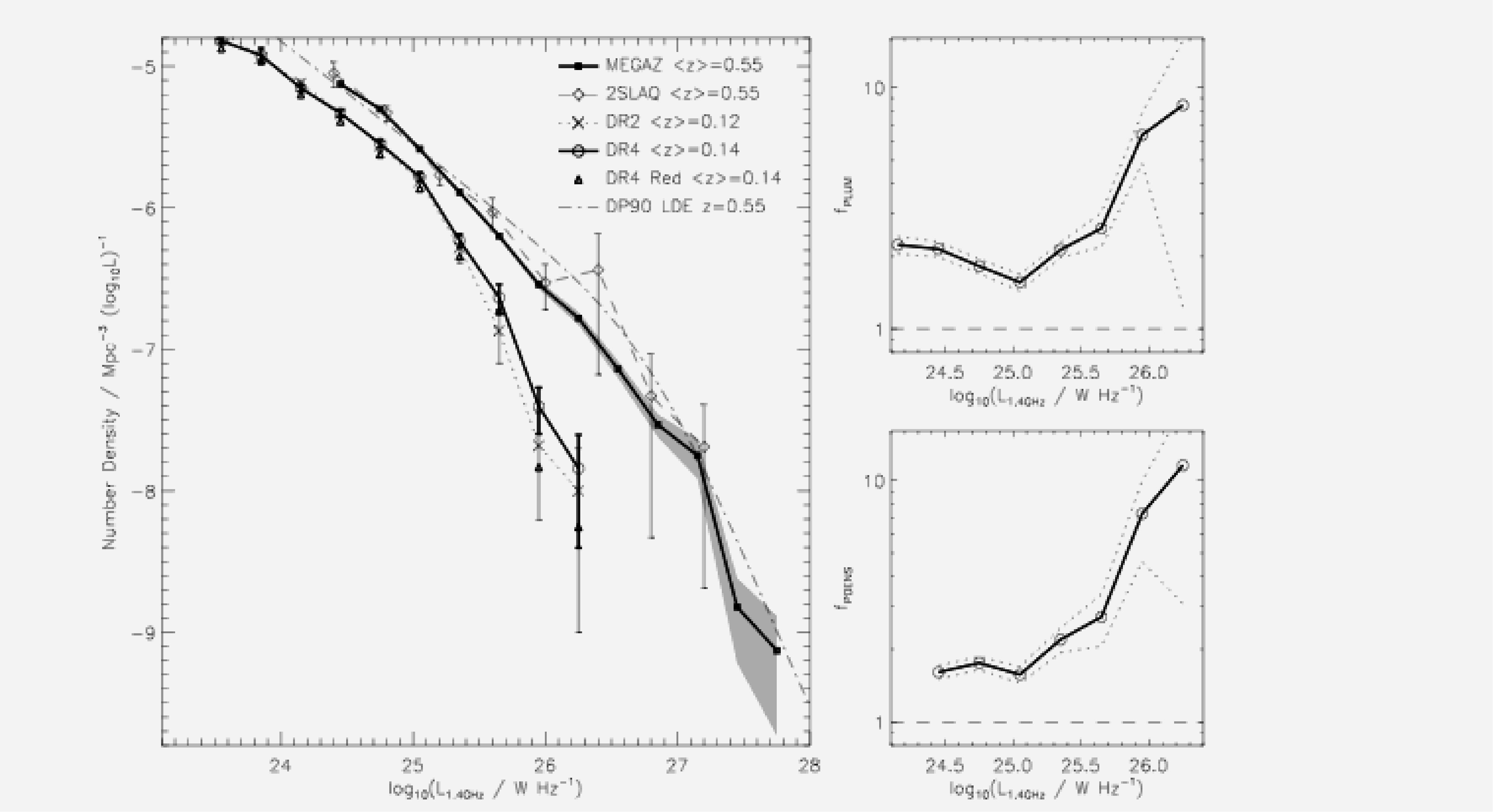
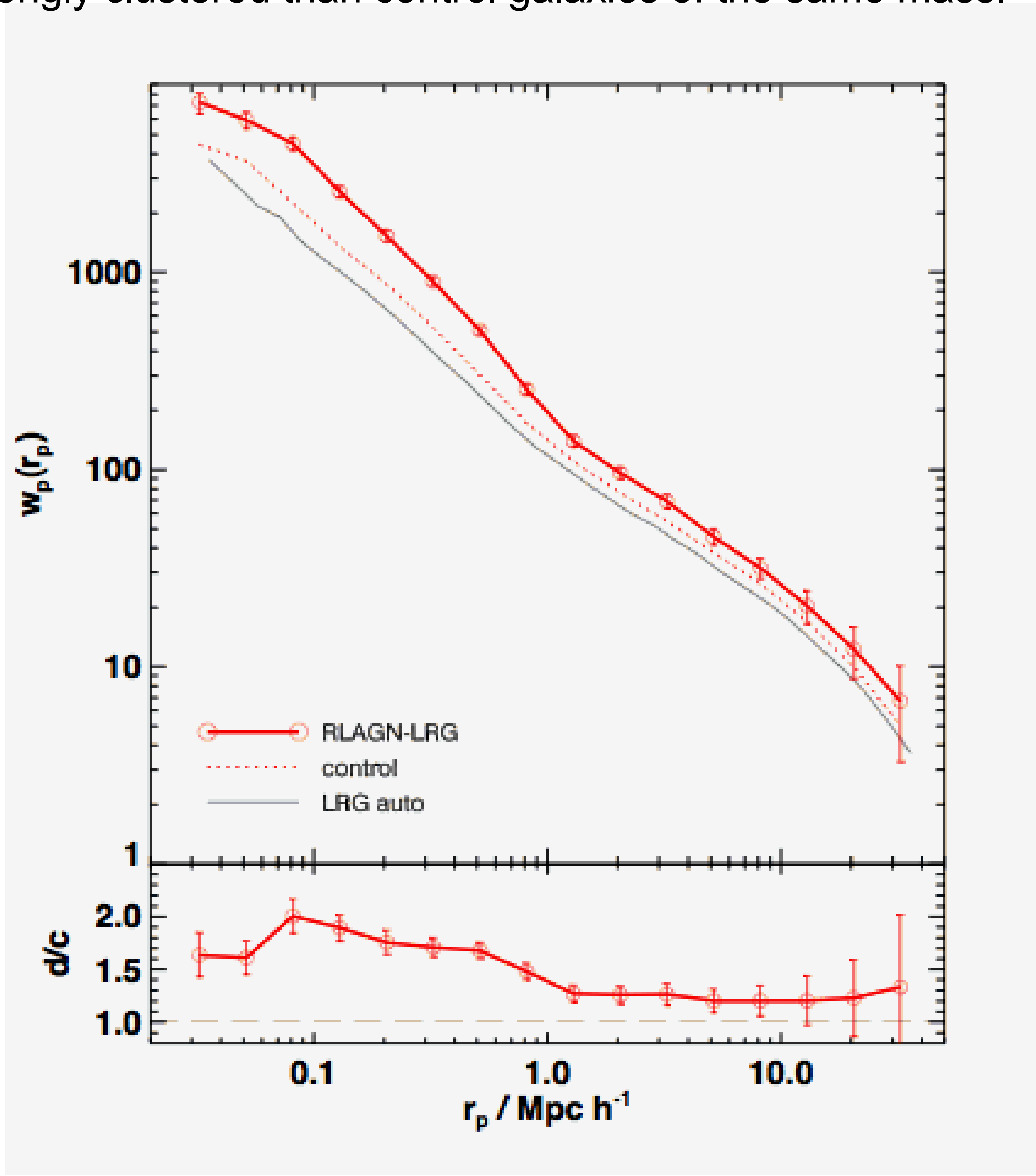


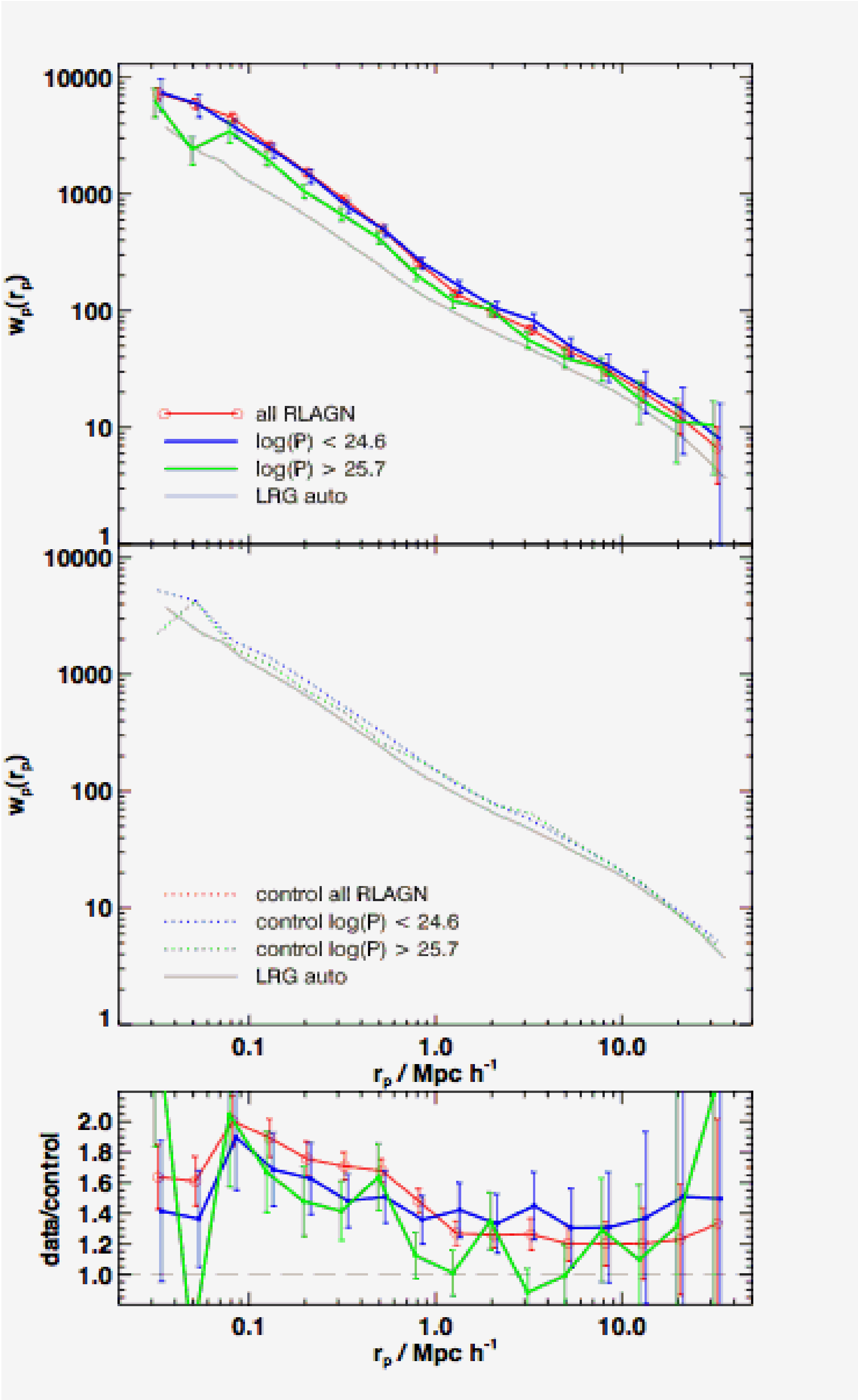
Evolution of the radio luminosity function out to z=0.6

There is a strongly evolving regime above $10^{25.5}$ W/Hz.

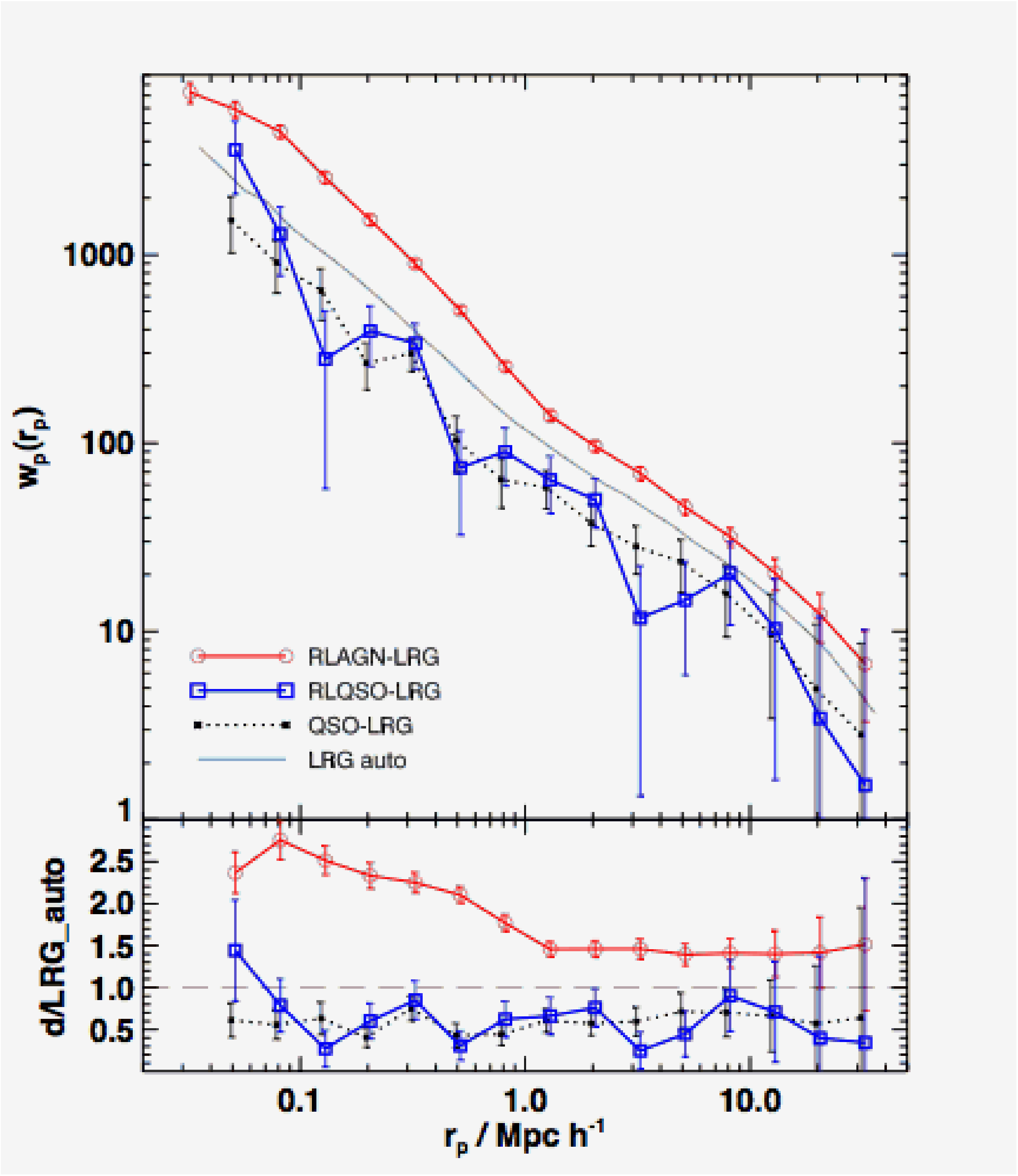


The two-point cross-correlation function between radio-loud AGN and galaxies measured at z=0.55. Once again we see that radio-loud AGN are more strongly clustered than control galaxies of the same mass.



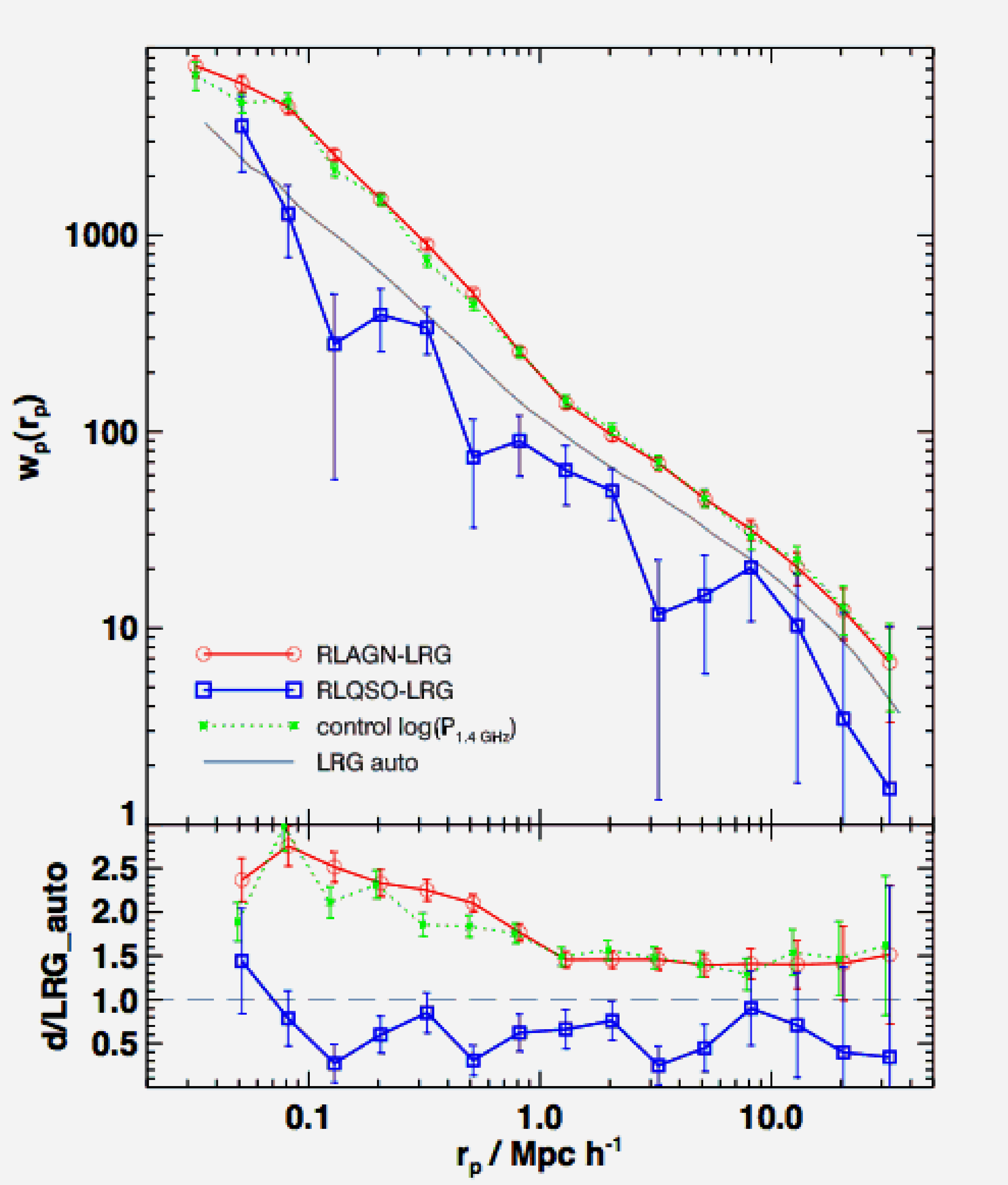


Trends in Clustering strength as a function of radio luminosity are very weak.

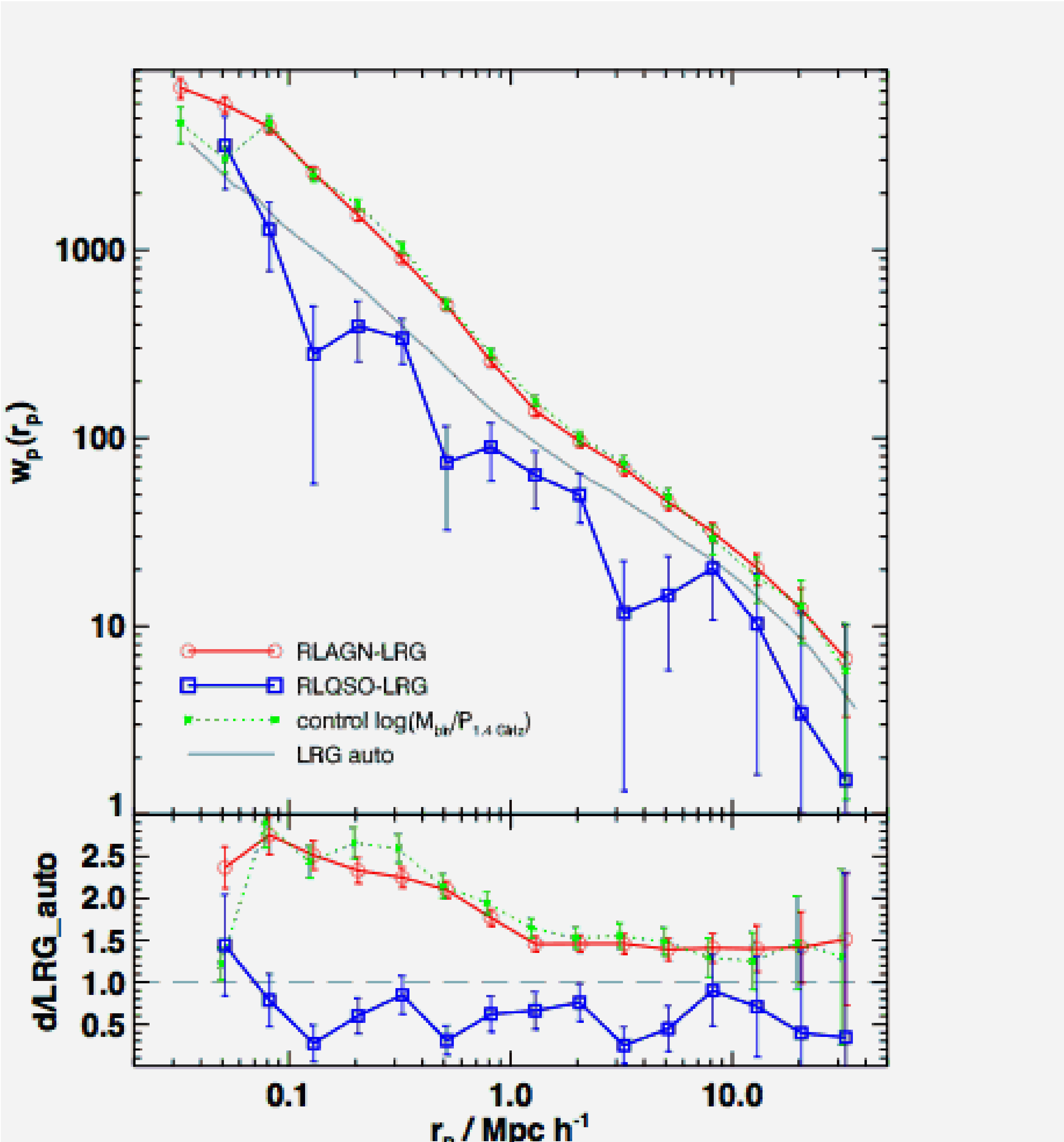


The radio loud AGN are clustered **much** more strongly than the quasars at the same redshift.

Radio-loud and radio-quiet quasars are clustered in the same way.

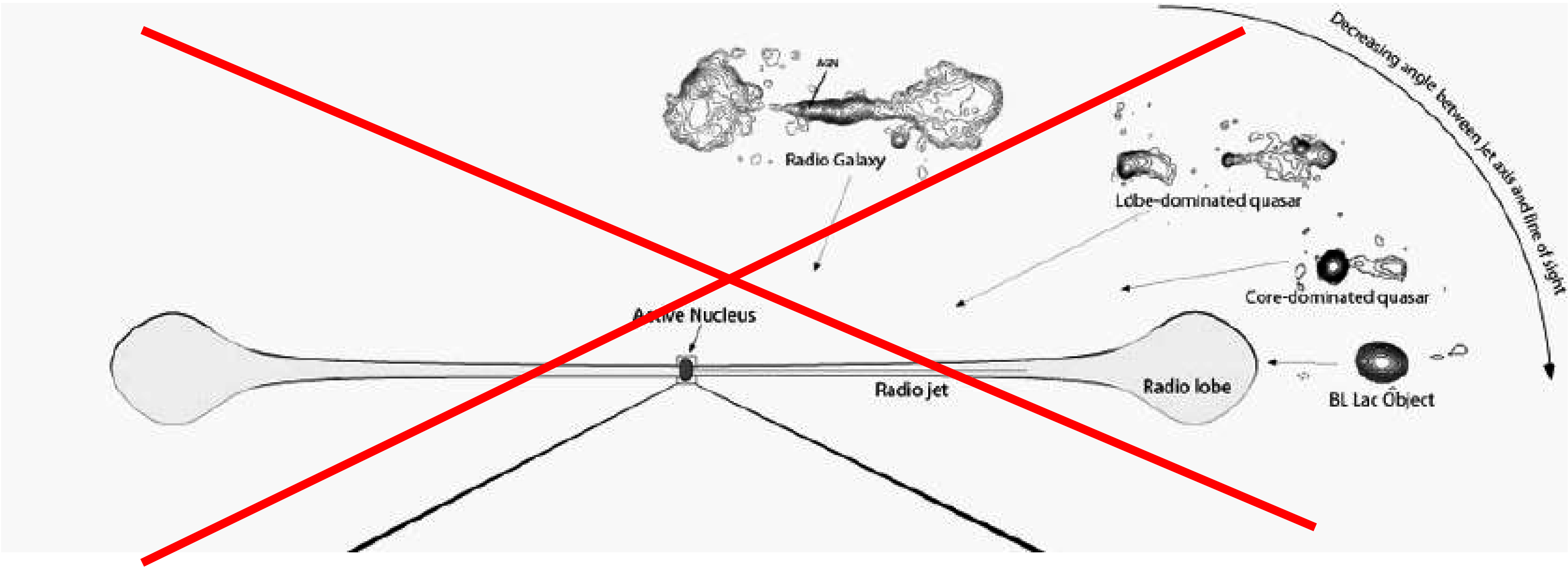


The clustering difference persists even if the quasars and radio AGN are matched in radio luminosity...



The clustering difference persists even if the quasars and radio AGN are matched in radio luminosity and black hole mass...

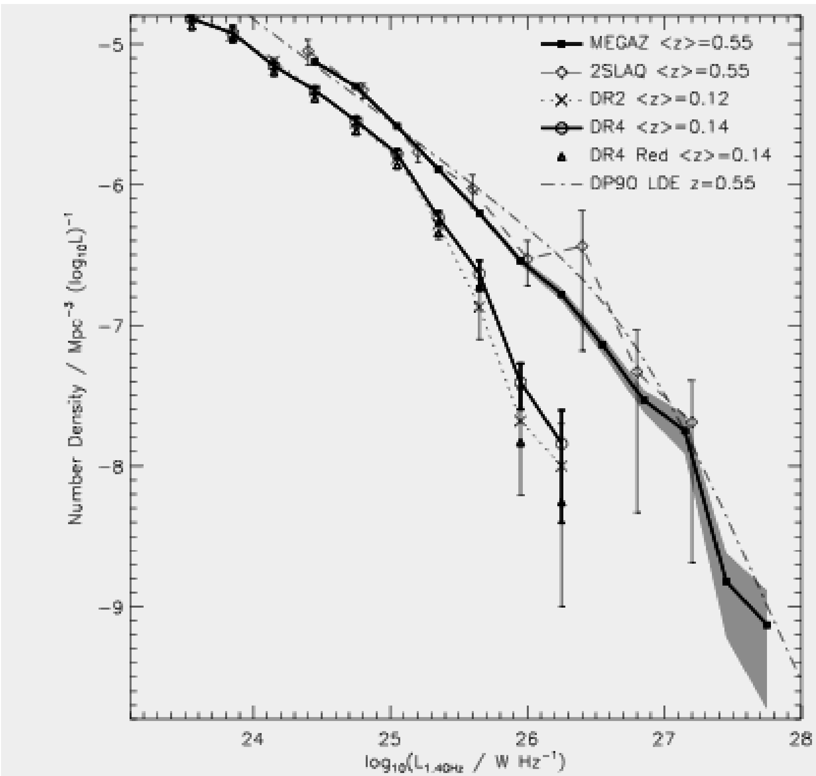
CONCLUSION I



This "unified" scenario linking radio AGN and quasars does not apply to the the **bulk** of the strongly evolving population seen at z=0.6.

Warning: We are not yet able to match the radio AGN and the quasars in terms of emission line luminosity....

CONCLUSION II



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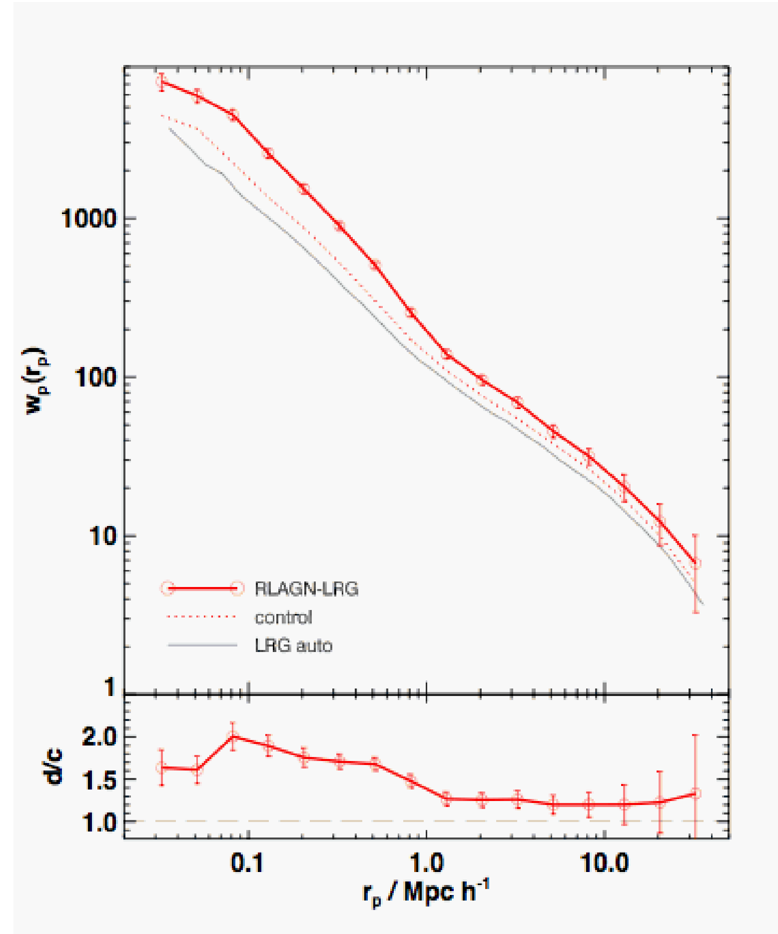

STRONG EVOLUTION

STRONG CLUSTERING

Together, this must imply that the total energetic input from radio AGN into the intra-cluster or intra-group medium is significantly larger at higher redshifts.

More detailed calculations currently under way ....