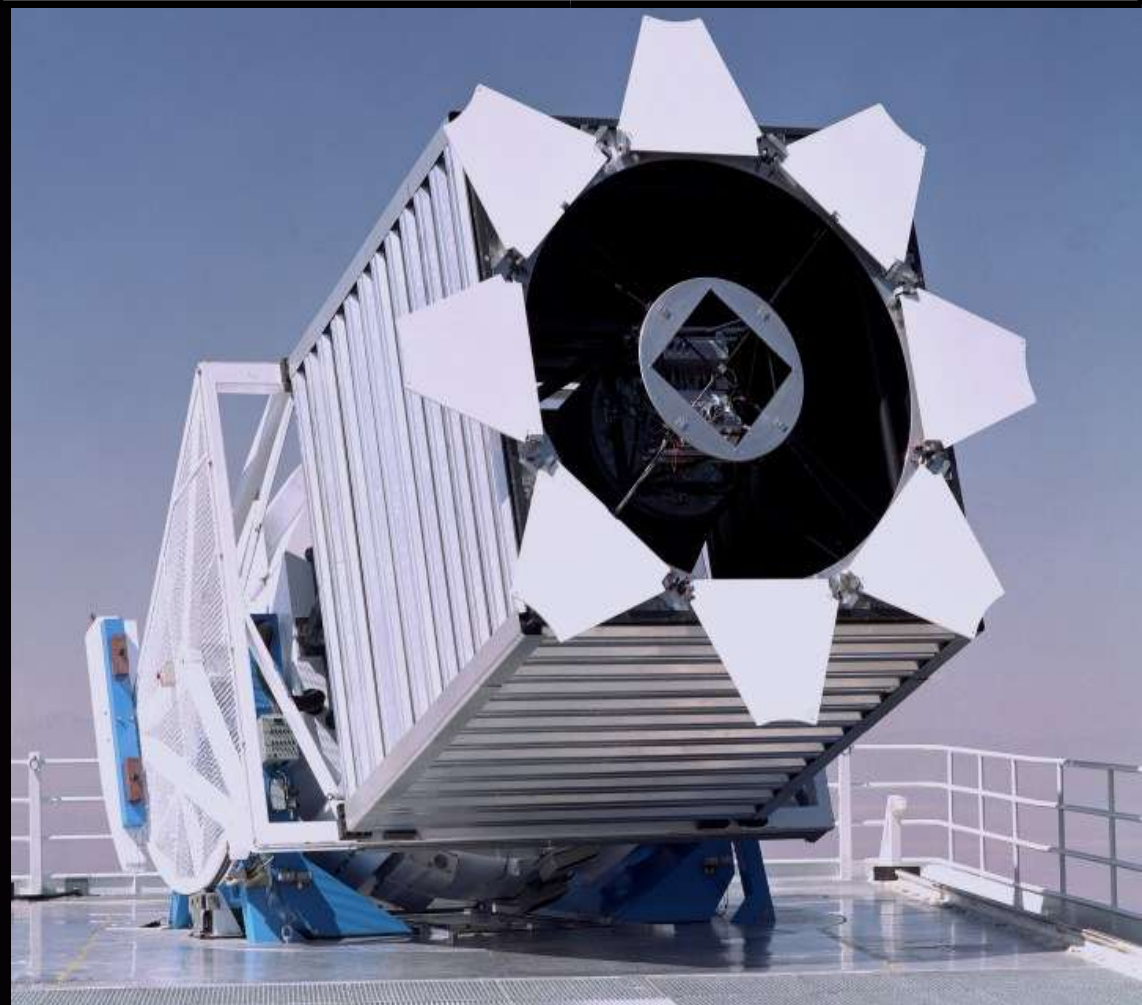
Sloan Digital Sky Survey

Towards an understanding of the co-evolution of bulges and black holes.



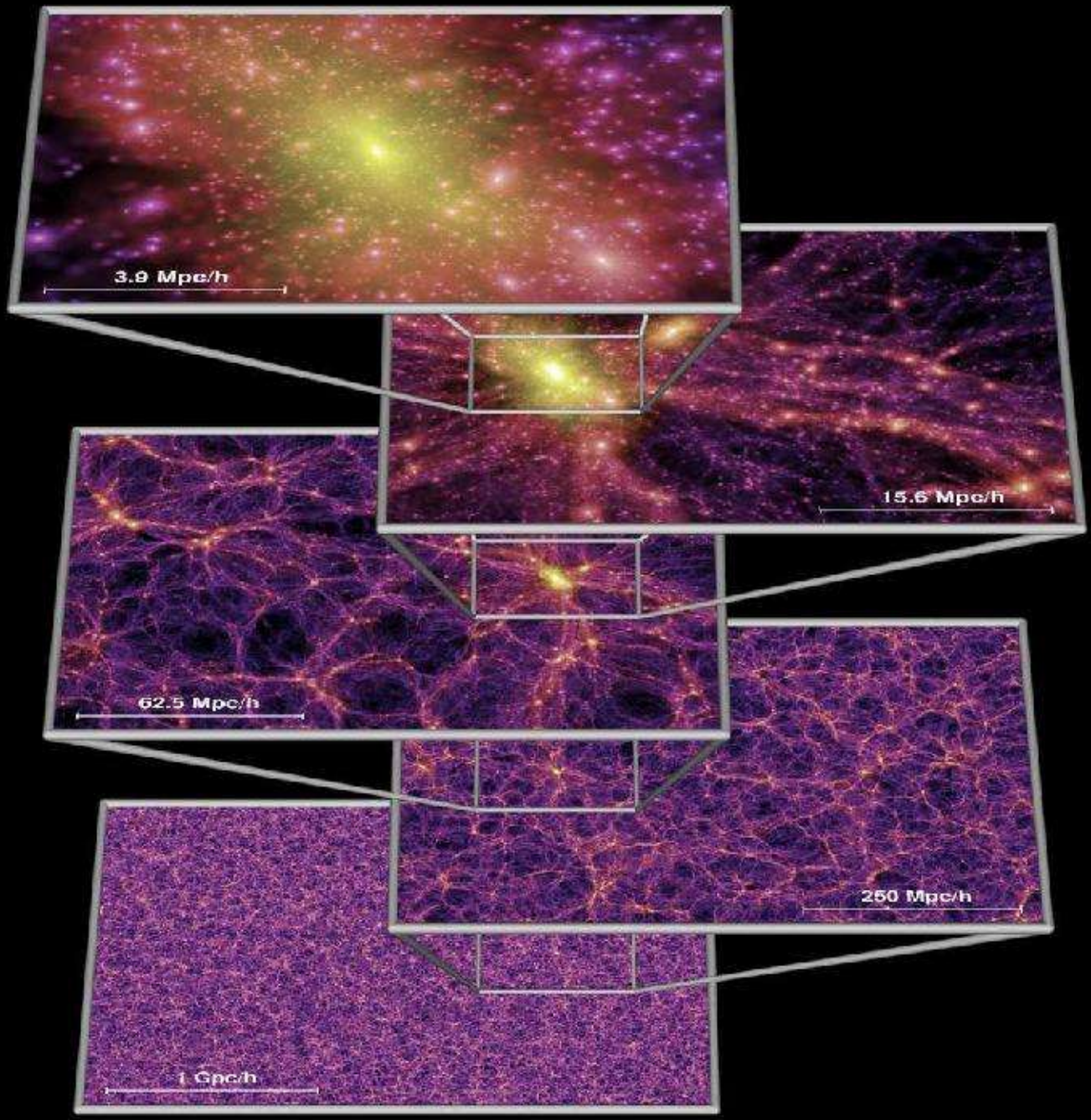
NEW INSIGHT INTO SOME UNANSWERED QUESTIONS:

1) What are the necessary conditions for bulge and black hole growth in galaxies?

2) What triggers episodes of significant growth of the black hole?

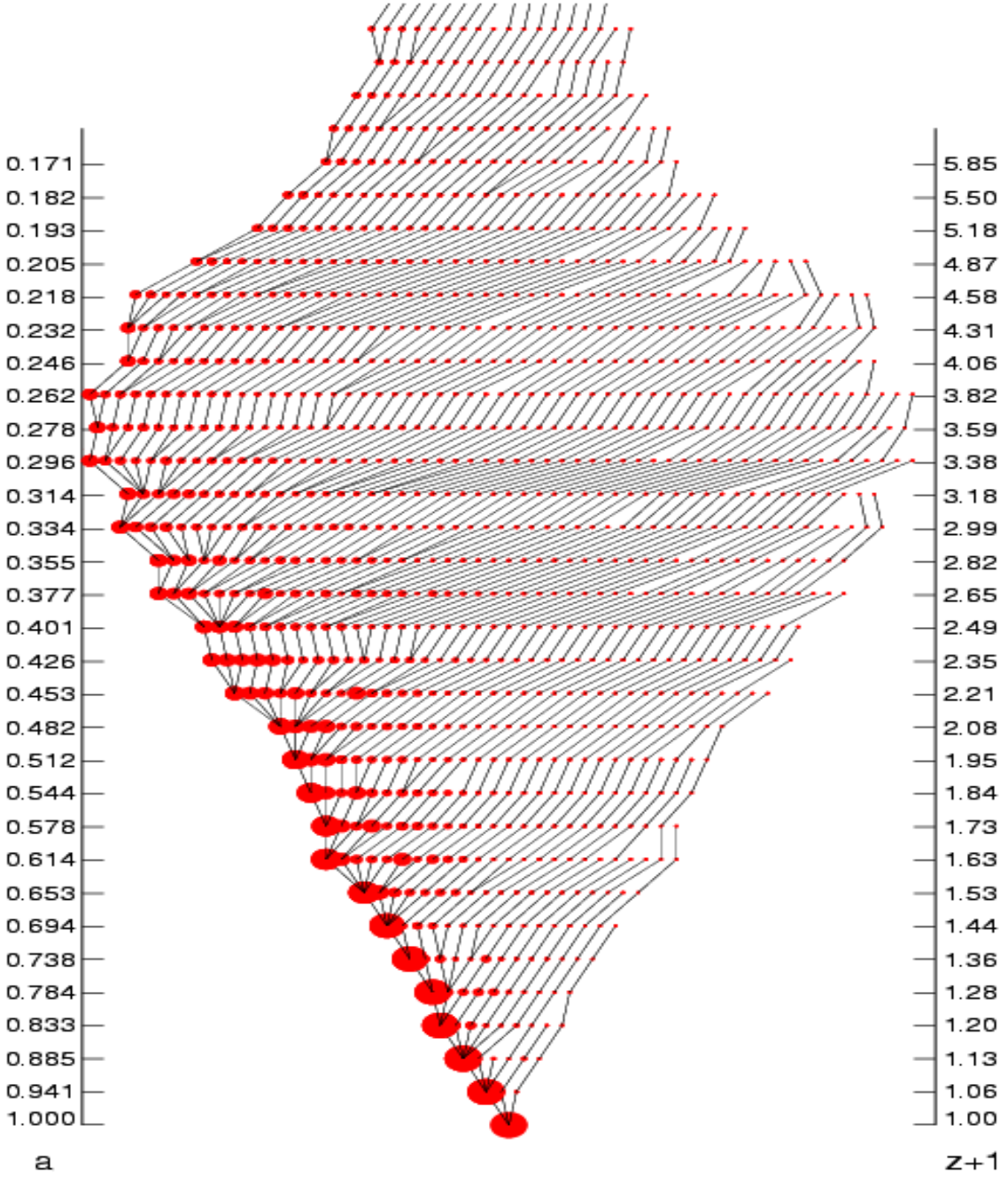
Analysis techniques:
UV studies of AGN from GALEX data

AGN/galaxy cross-correlation function
Collaborators: Cheng Li, Lan Wang, Tim H., Simon White

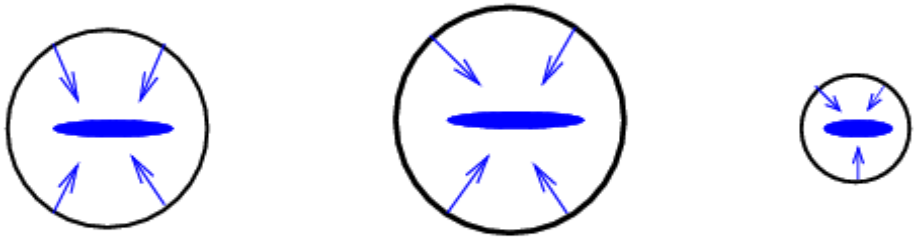


A new generation of simulation: Springel et al 2005

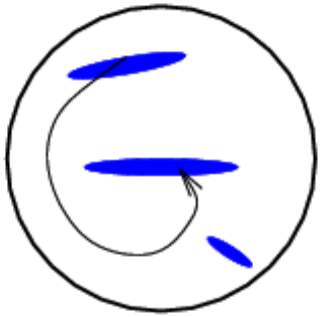
THE MERGING TREE



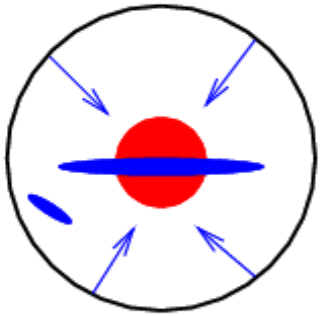
Formation of Different Hubble Types in Semi–Analytic Models



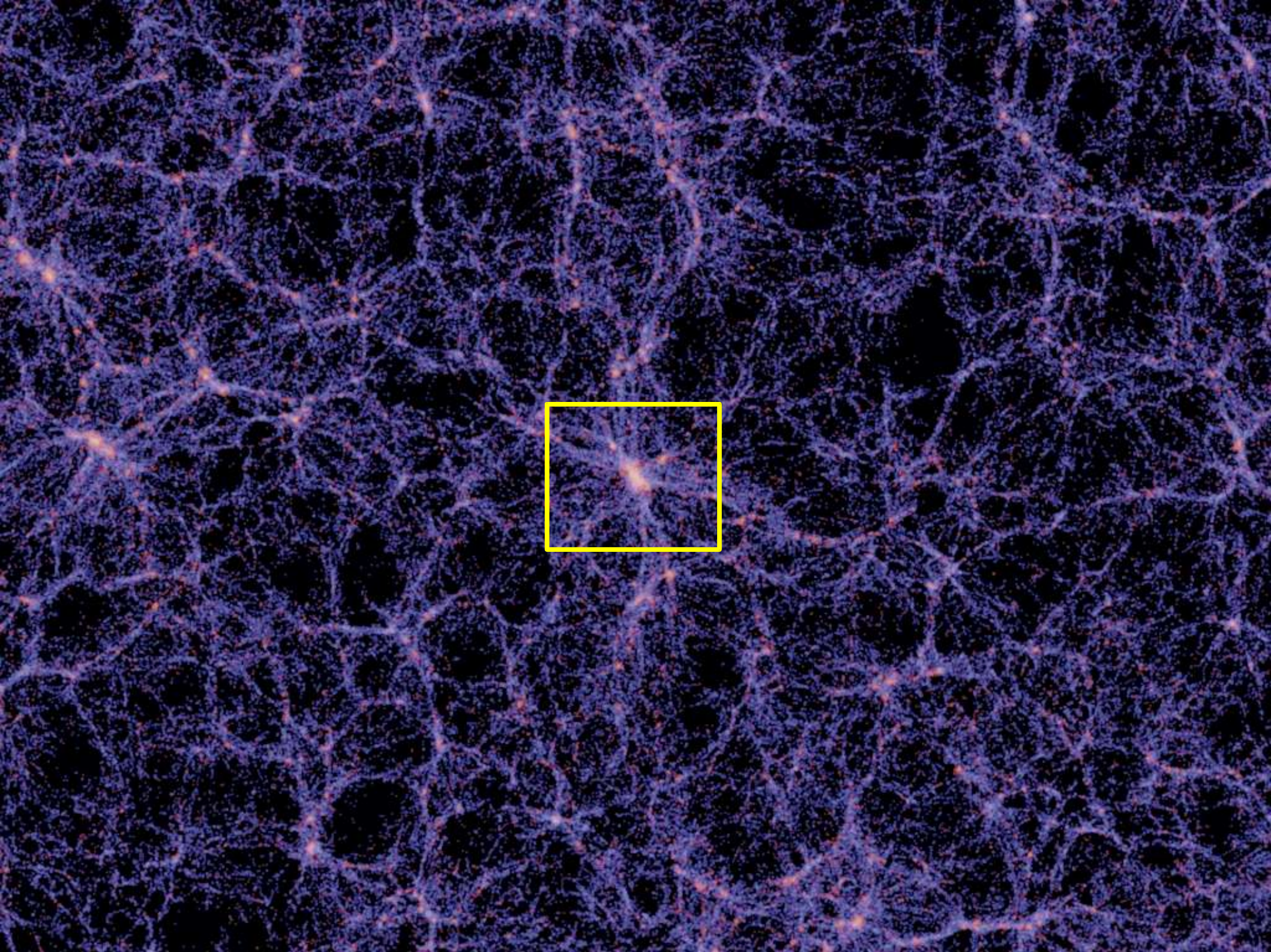
Gas cools and forms a rotationally–supported disk

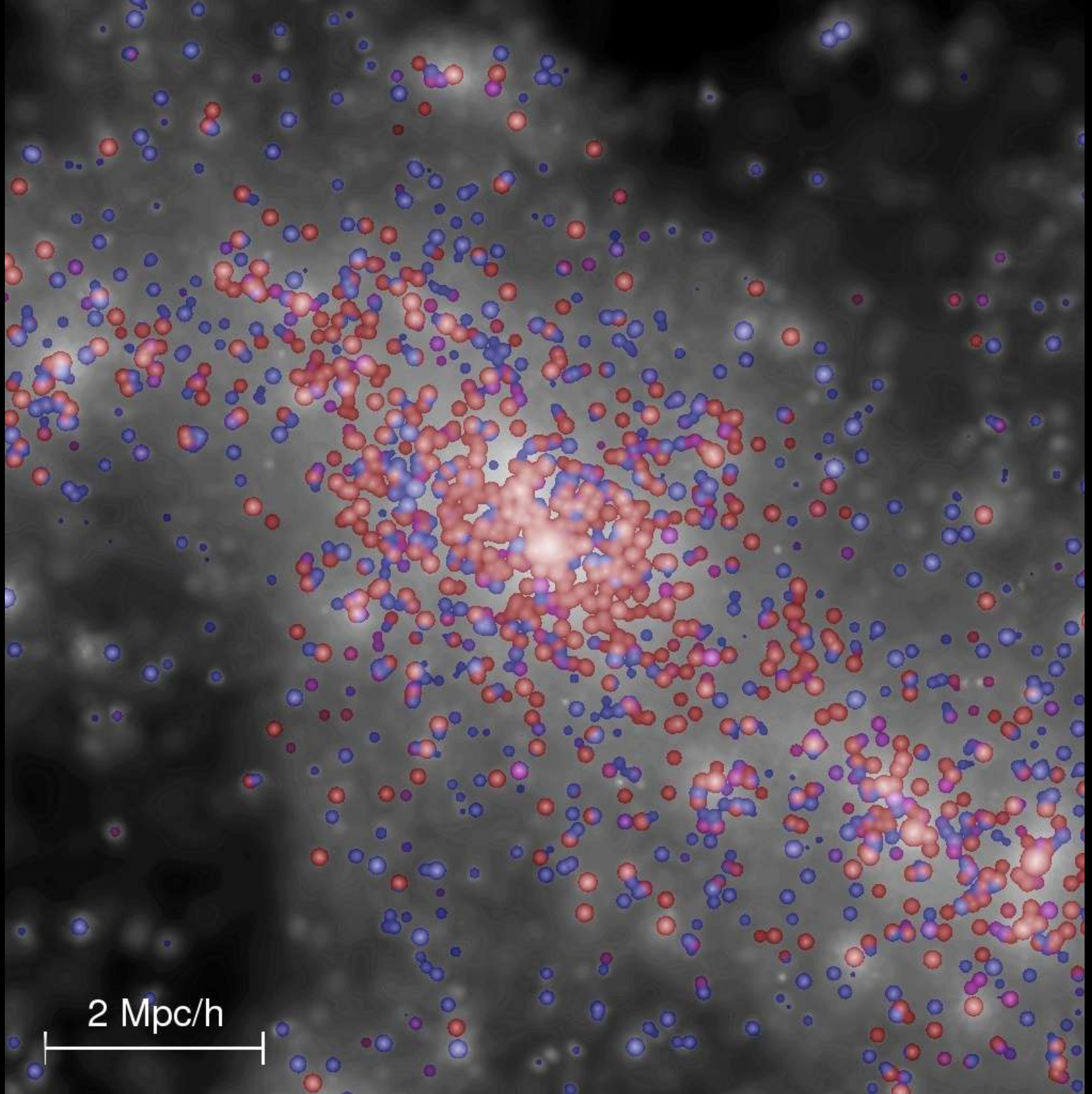


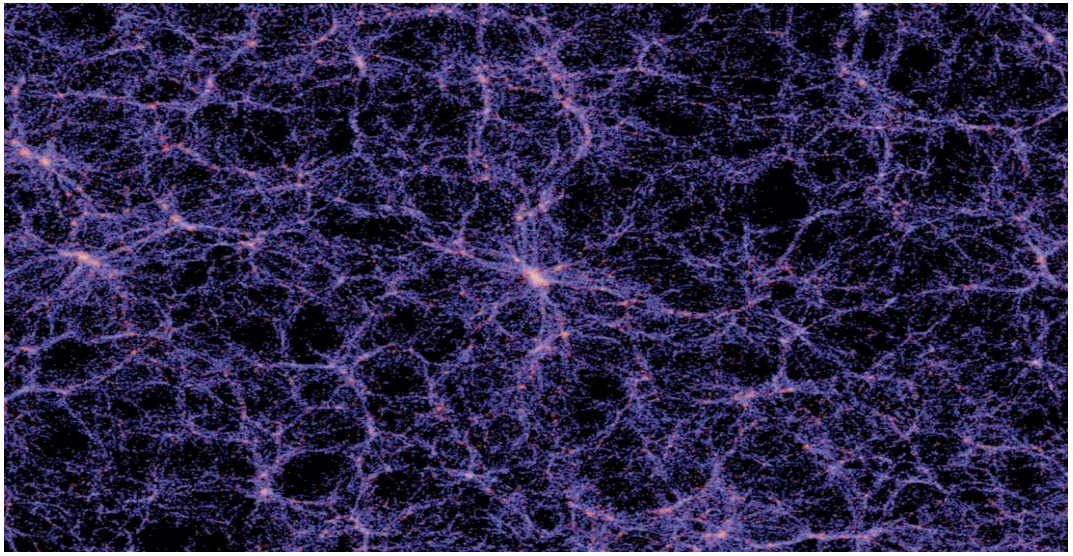
Galaxies merge on a dynamical friction time–scale

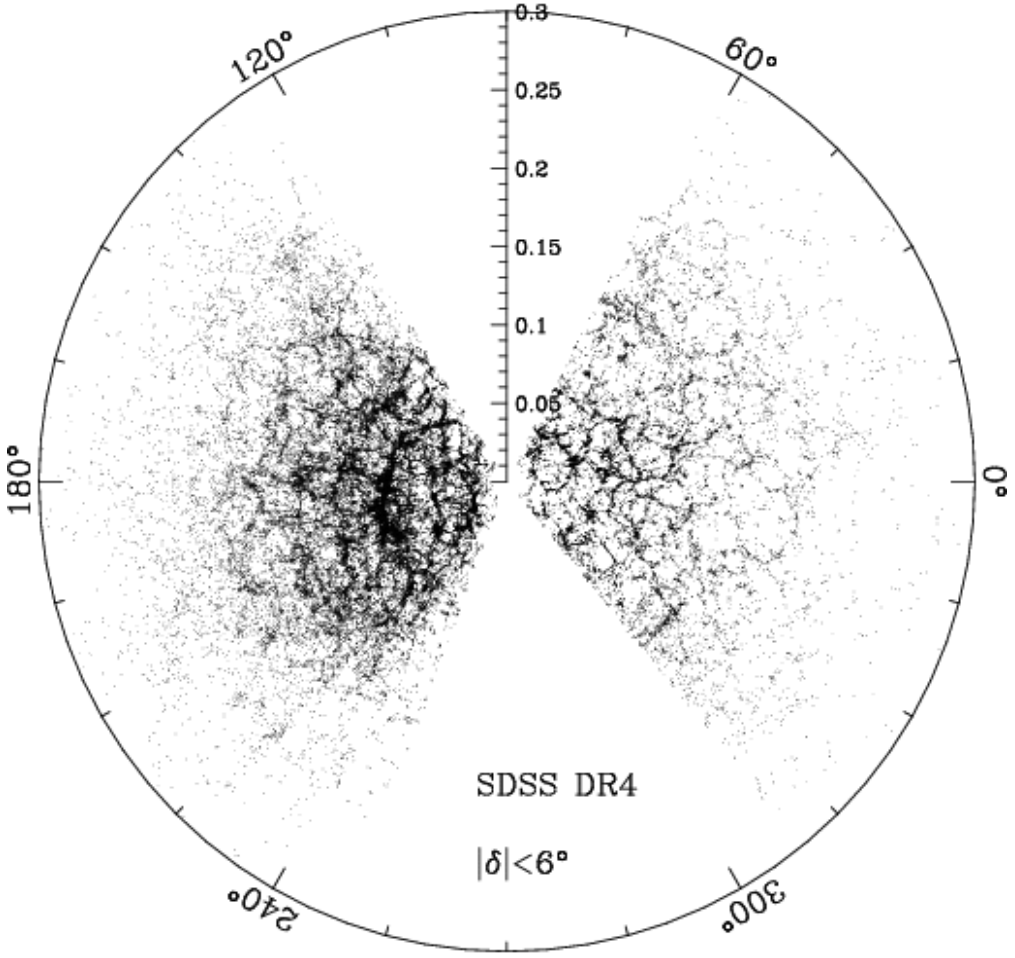


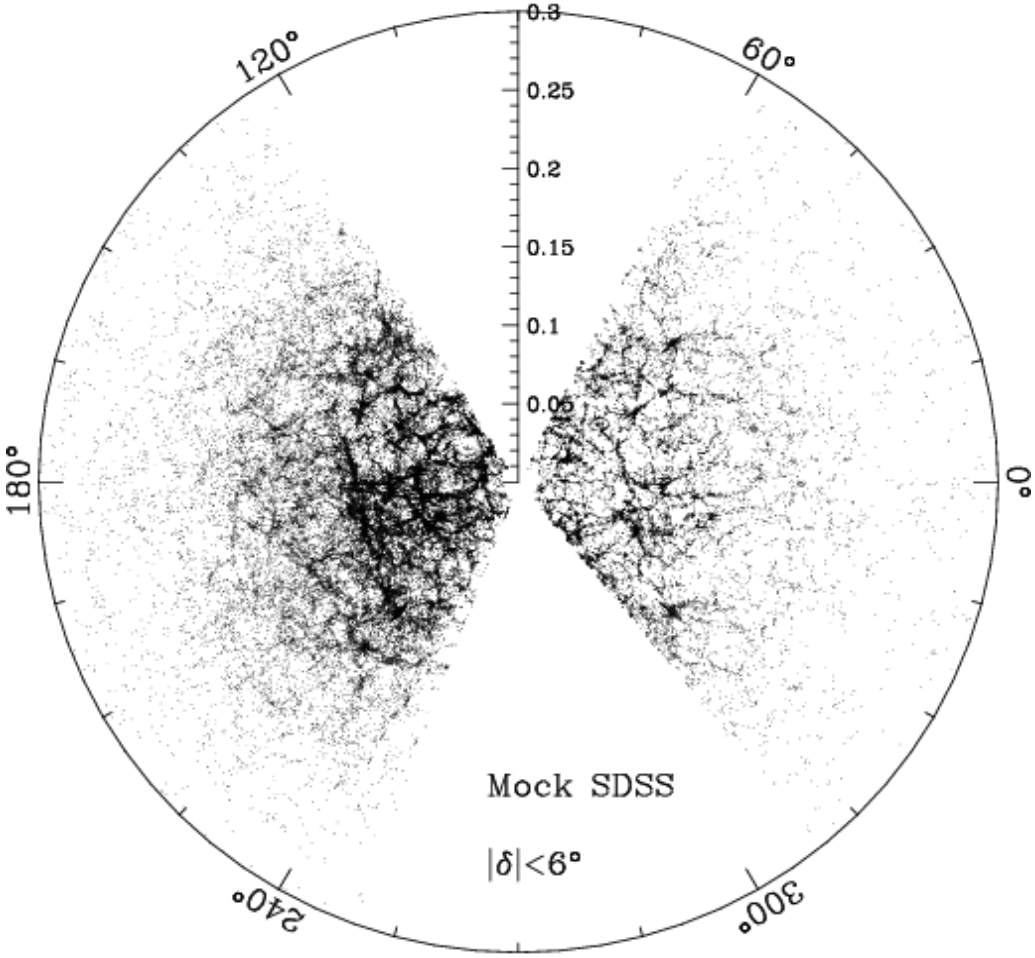
Major merger leads to formation of bulge; new disk forms when gas cools again



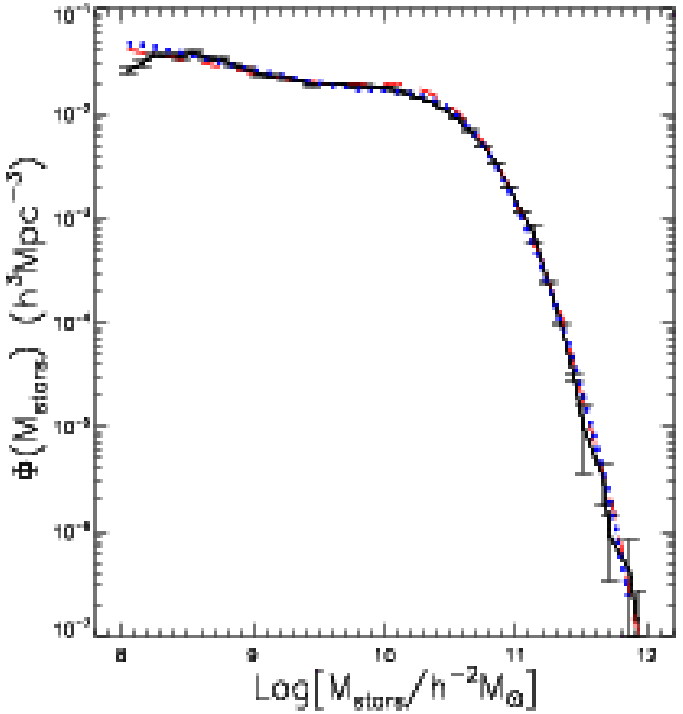

2 Mpc/h

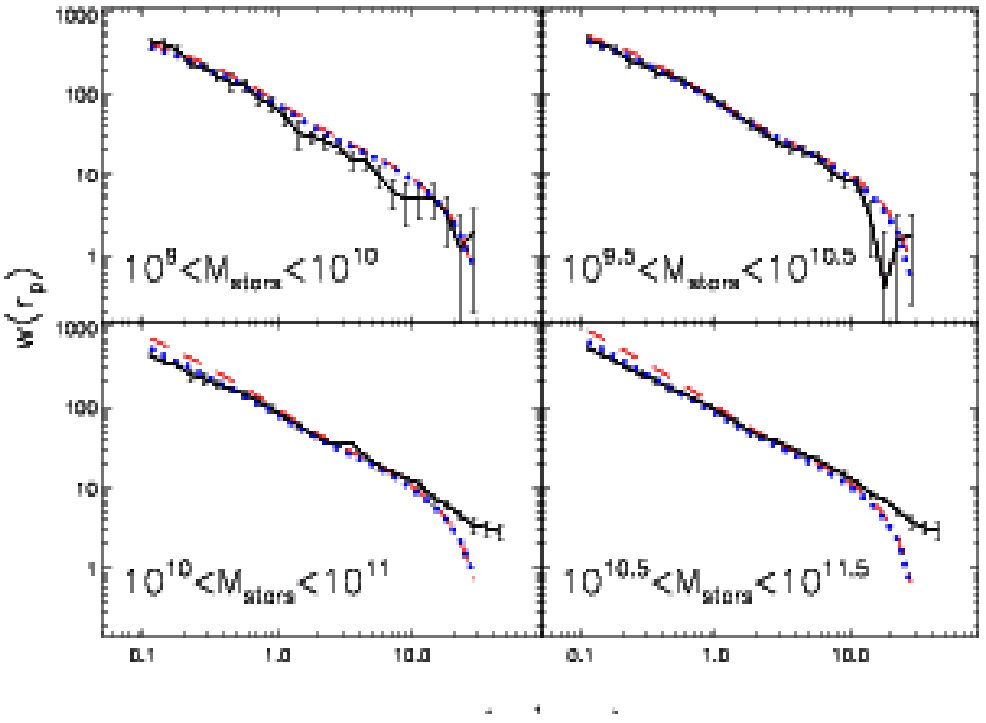



120°
60°
180°
0°
240°
300°
0.3
0.25
0.2
0.15
0.1
0.05
SDSS DR4
|δ|<6°


120°
60°
180°
0°
240°
300°
0.3
0.25
0.2
0.15
0.1
0.05
Mock SDSS
|δ|<6°

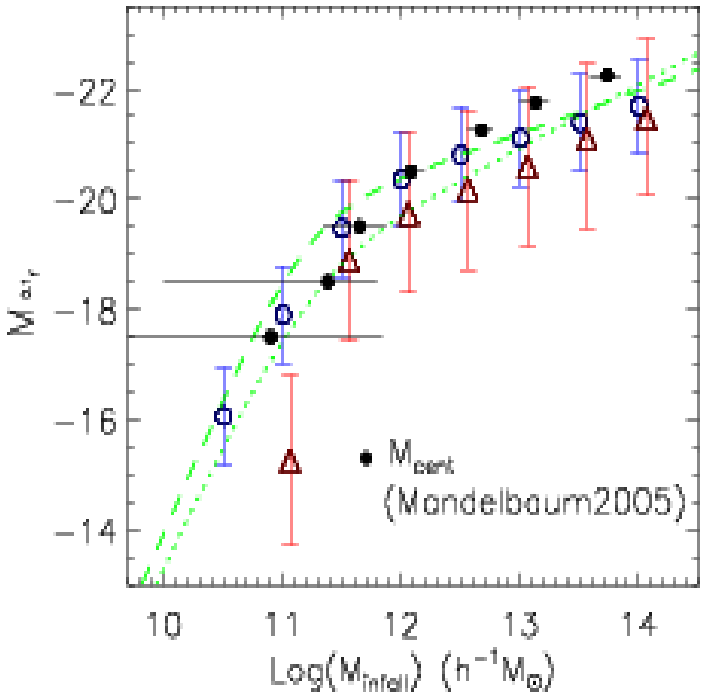
Our mock catalogues are constructed so that they EXACTLY reproduce the observed stellar mass function and the two point correlation function as a function of mass from SDSS.

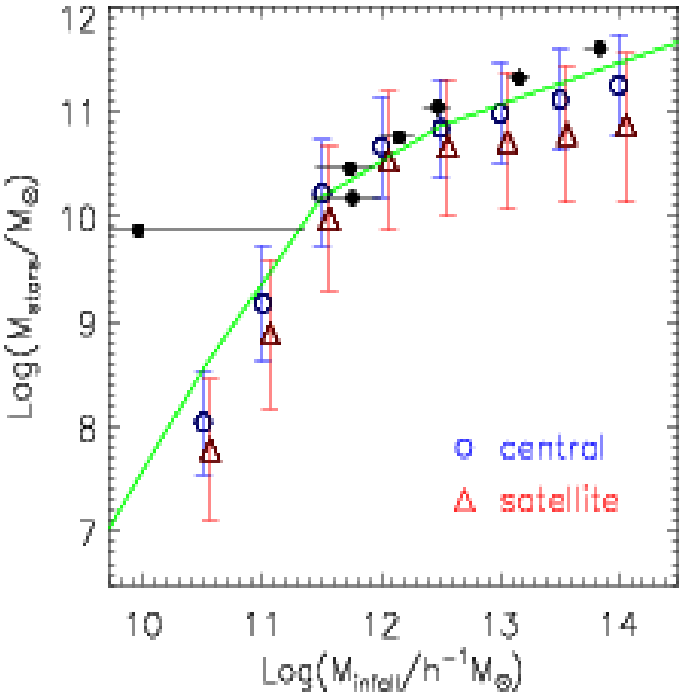




Lan Wang et al 2006

This is done by parameterizing the relation between M_*, L and the quantity M_infall, defined as the mass of the halo when the galaxy was last the central object in its own halo.





OBSERVATIONAL SAMPLES:

1) AGN sample (89,000 objects) : splits into bins of velocity dispersion (M_BH) and L[OIII]/M_BH (accretion rate relative to Eddington)

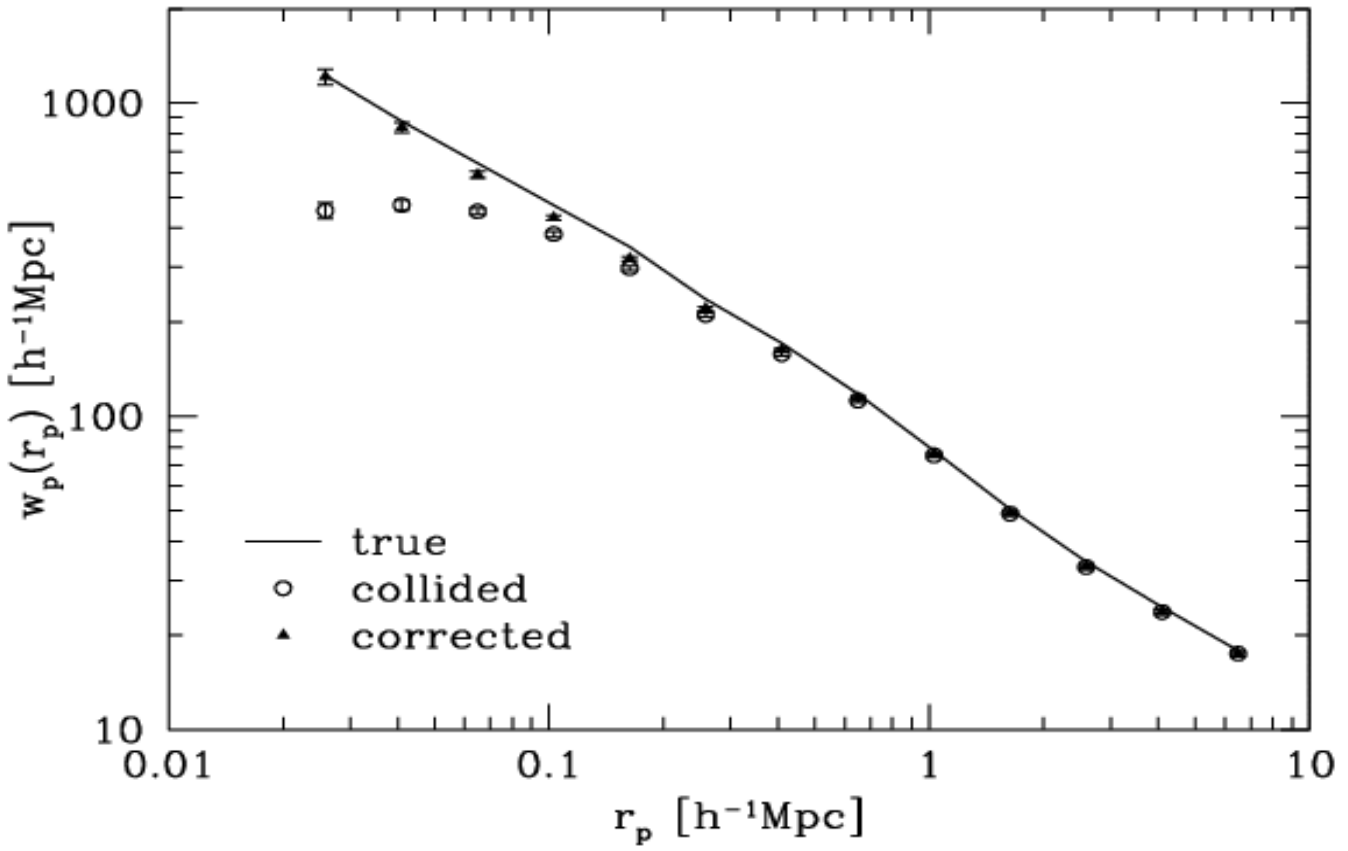
2) Multiple control samples of non-AGN:
matched in z, M*, velocity dispersion and concentration
matched in z, M*, velocity dispersion, cencentration and D4000

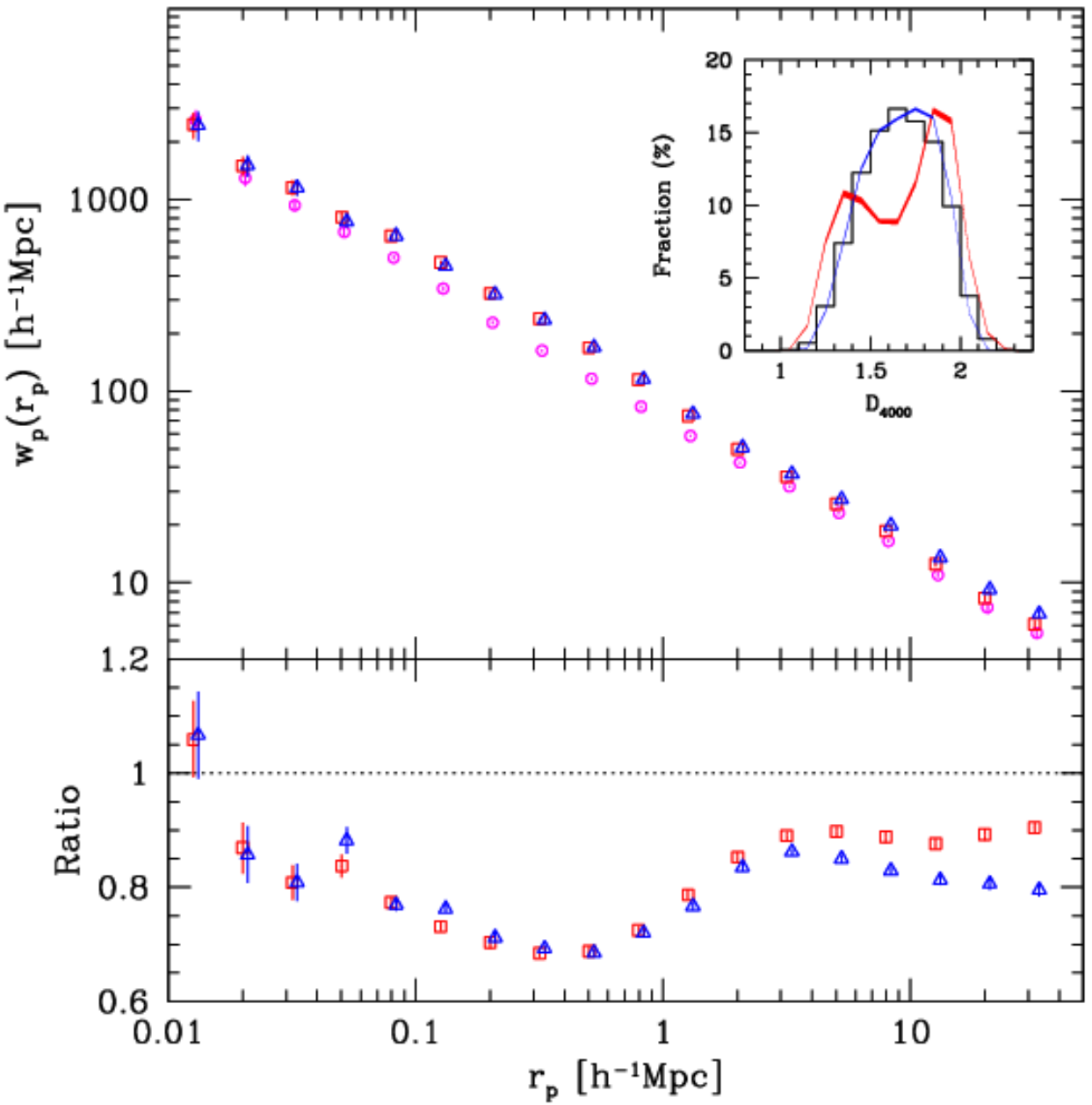
3) The "reference" sample of galaxies:
a) spectroscopic: r< 17.7
b) photometric: r < 19

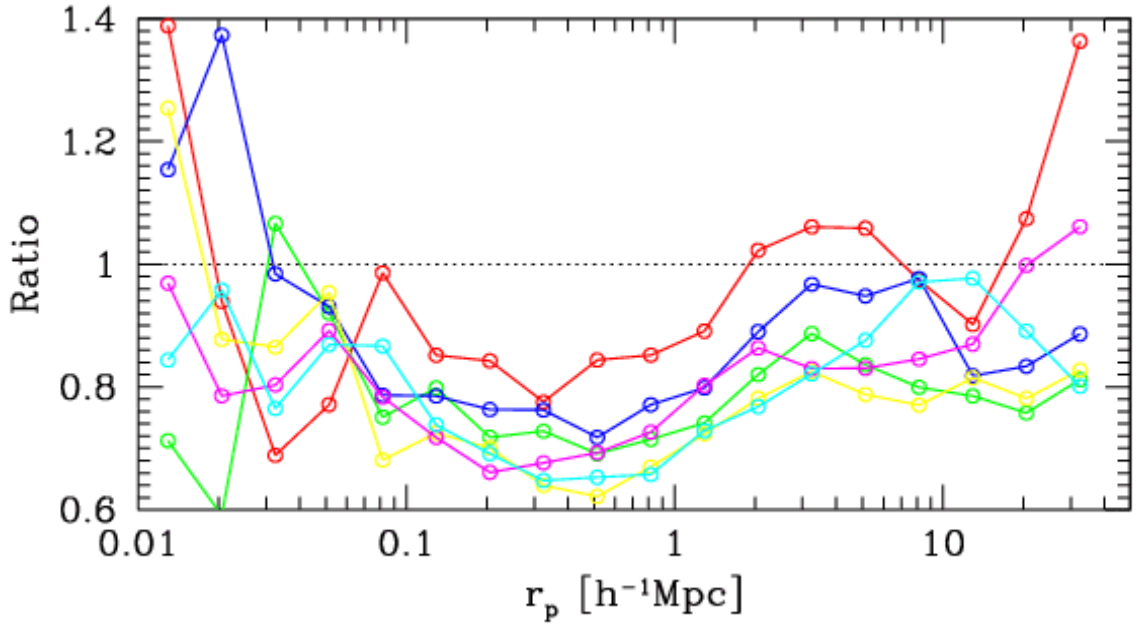
METHOD:

We compute the projected cross-correlation function between the AGN/control samples and the reference galaxies

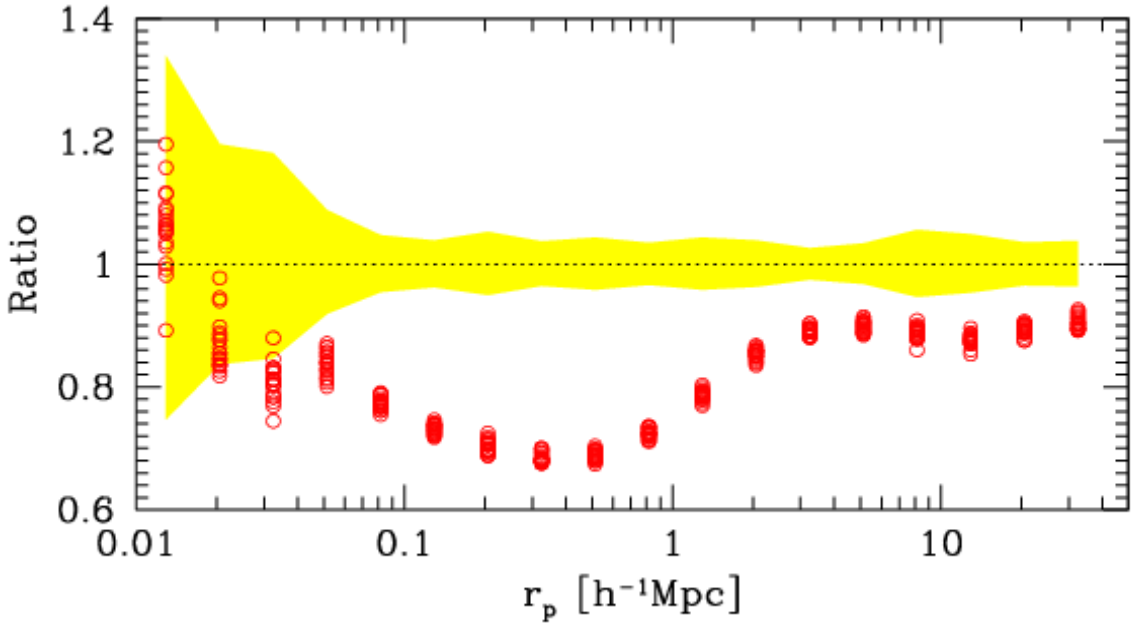
We can use the mock catalogues to test our procedure for correcting for fiber collsions in the SDSS



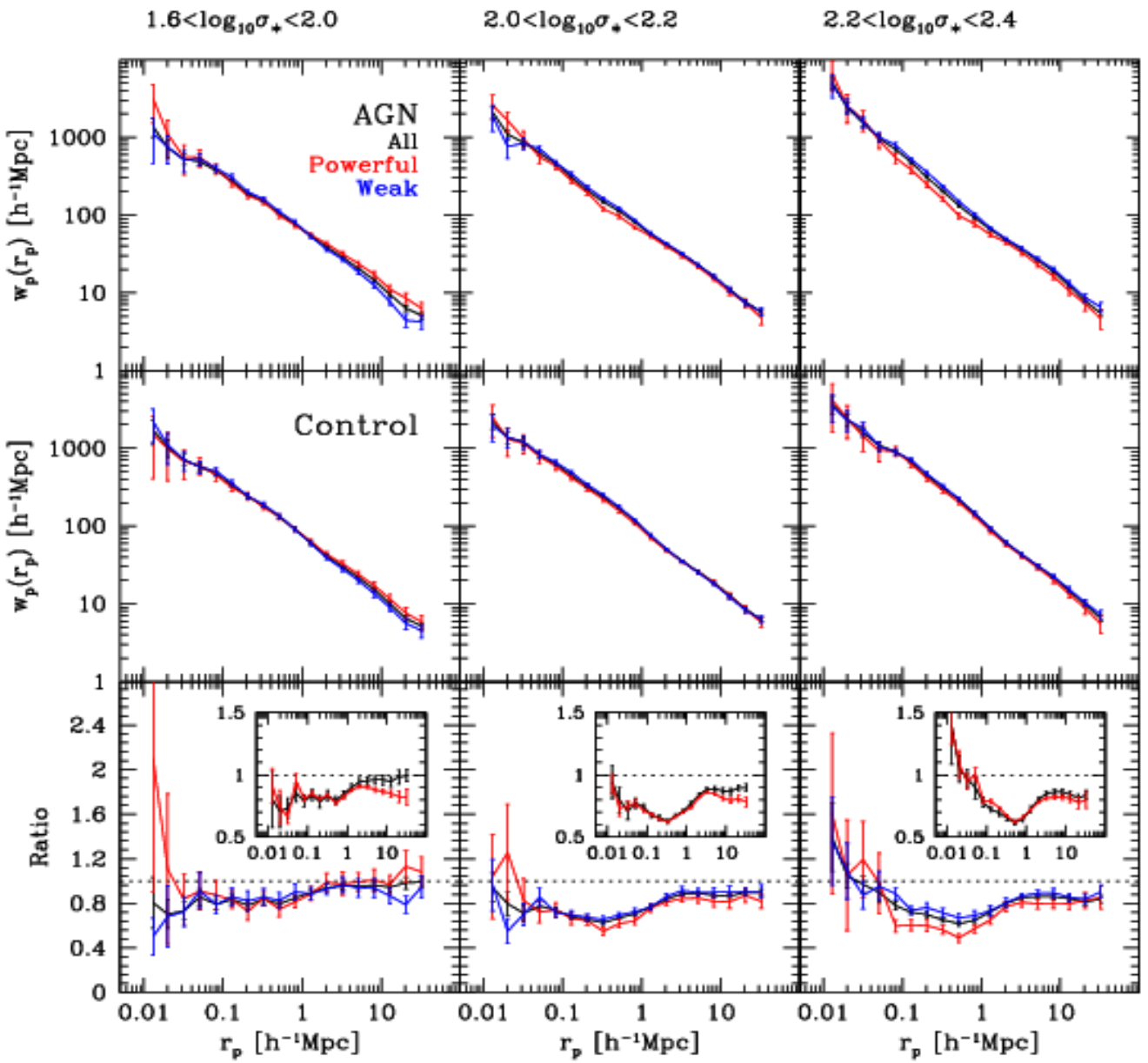

1000
100
10
1.2
1
0.8
0.6
Ratio
0.01
0.1
1
10
$w_p(r_p)$ [h^{-1}Mpc]
r_p [h^{-1}Mpc]
20
15
10
5
0
Fraction (%)
1
1.5
2
D_{4000}



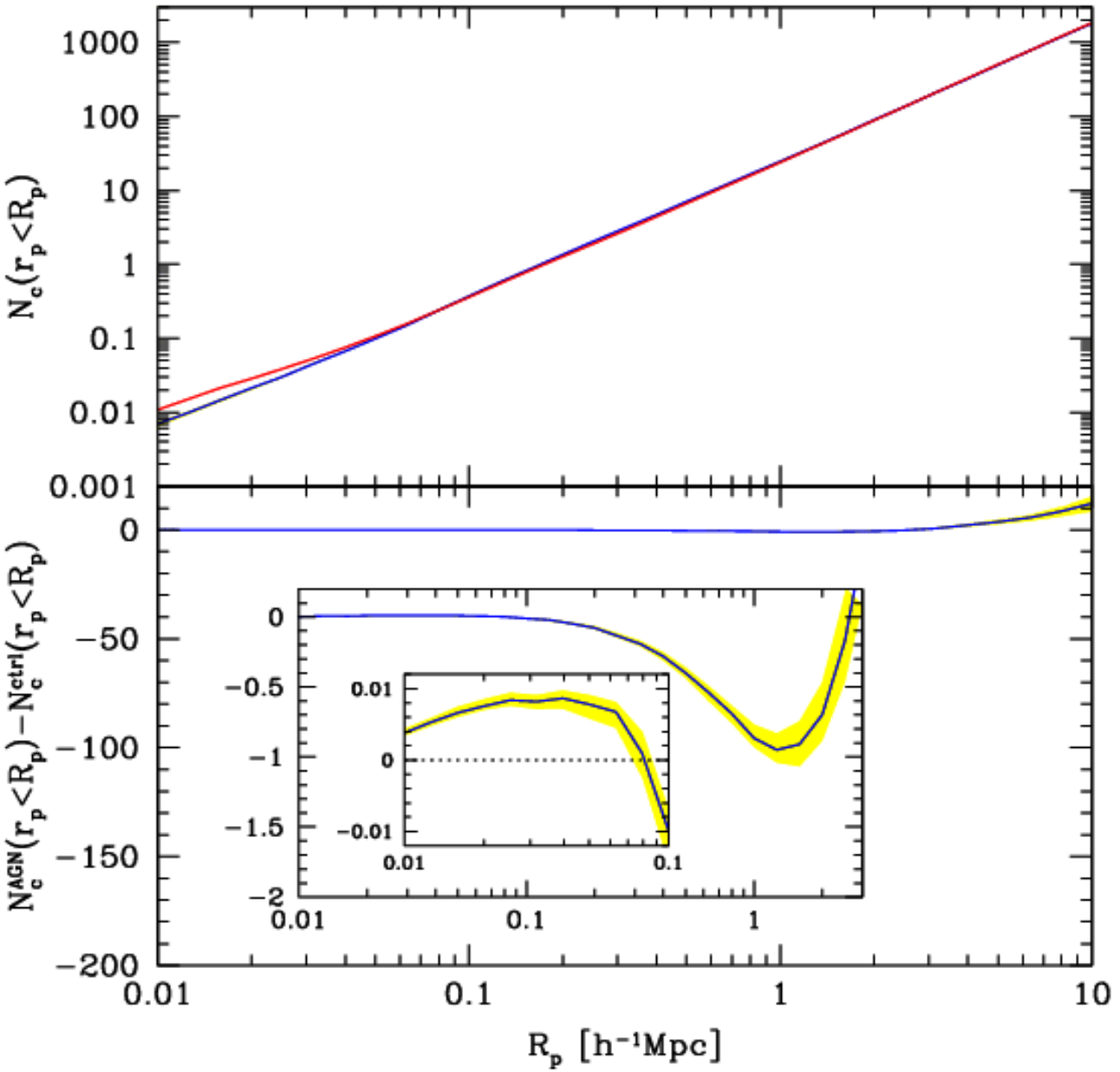
Scatter between different areas of the survey



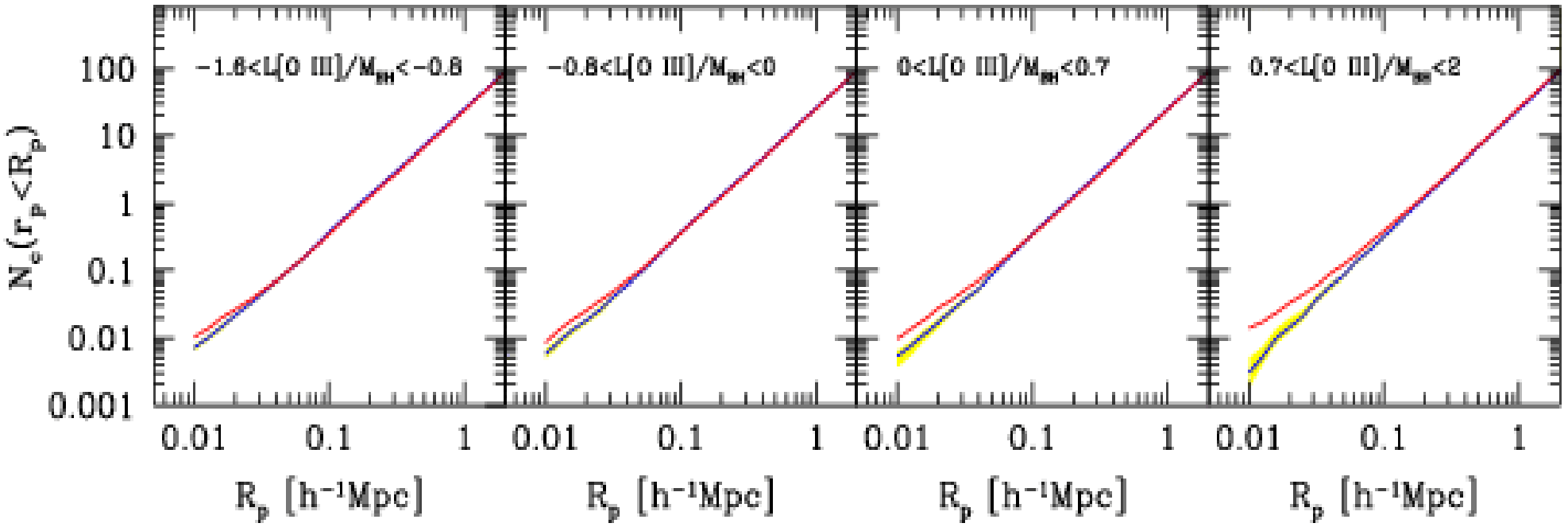
Scatter between different control samples

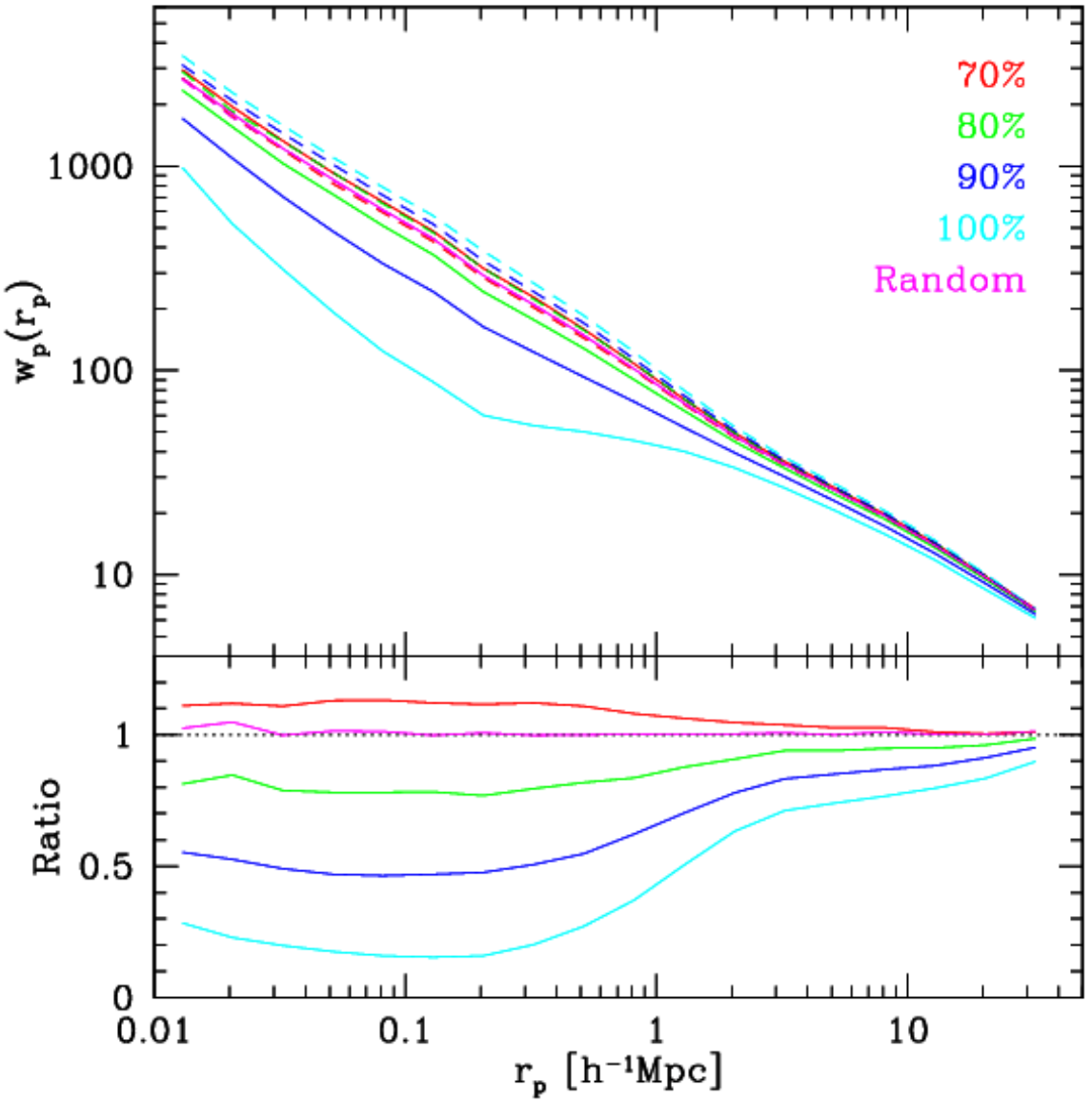

1.6<log10σ*<2.0
2.0<log10σ*<2.2
2.2<log10σ*<2.4
AGN
All
Powerful
Weak
Control
wp(rp) [h-1Mpc]
Ratio
rp [h-1Mpc]
0.01
0.1
1
10
100
1000
0.5
1.5
2
2.4
1.6
1.2
0.8
0.4
0

Counts around the AGN and the control galaxies



Counts around AGN in bins of accretion rate

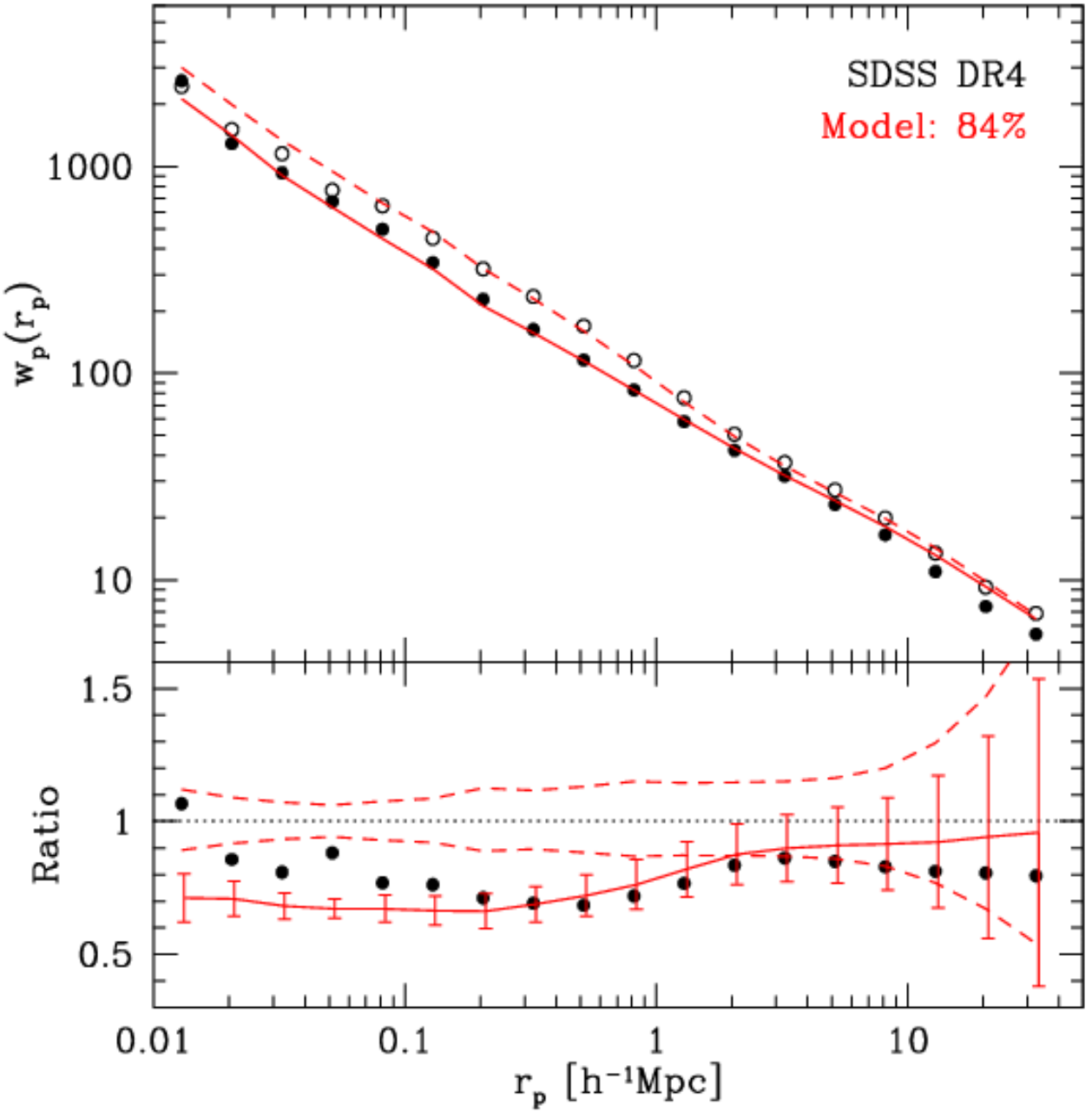




The Model:

For every AGN in our sample, we select a galaxy in the mock catalogue with the same stellar mass and redshift, but the probability of the galaxy to be an AGN will depend on whether it is a "central" or "satellite" galaxy in the halo.

Best-fit Model



CONCLUSIONS

Questions addressed:

a) How do the locations of galaxies within the large-scale distribution of dark matter influence ongoing accretion onto their central black holes?

b) Is AGN activity triggered by interactions or mergers.

Answers:

a) AGN are preferentially located at the centers of their dark matter halos. This is where gas would be expected to cool – connection with UV-bright disks?

b) Galaxy-galaxy interactions are not the primary triggering mechanism in nearby AGN. (What about quasars?)