

# Workshop summary

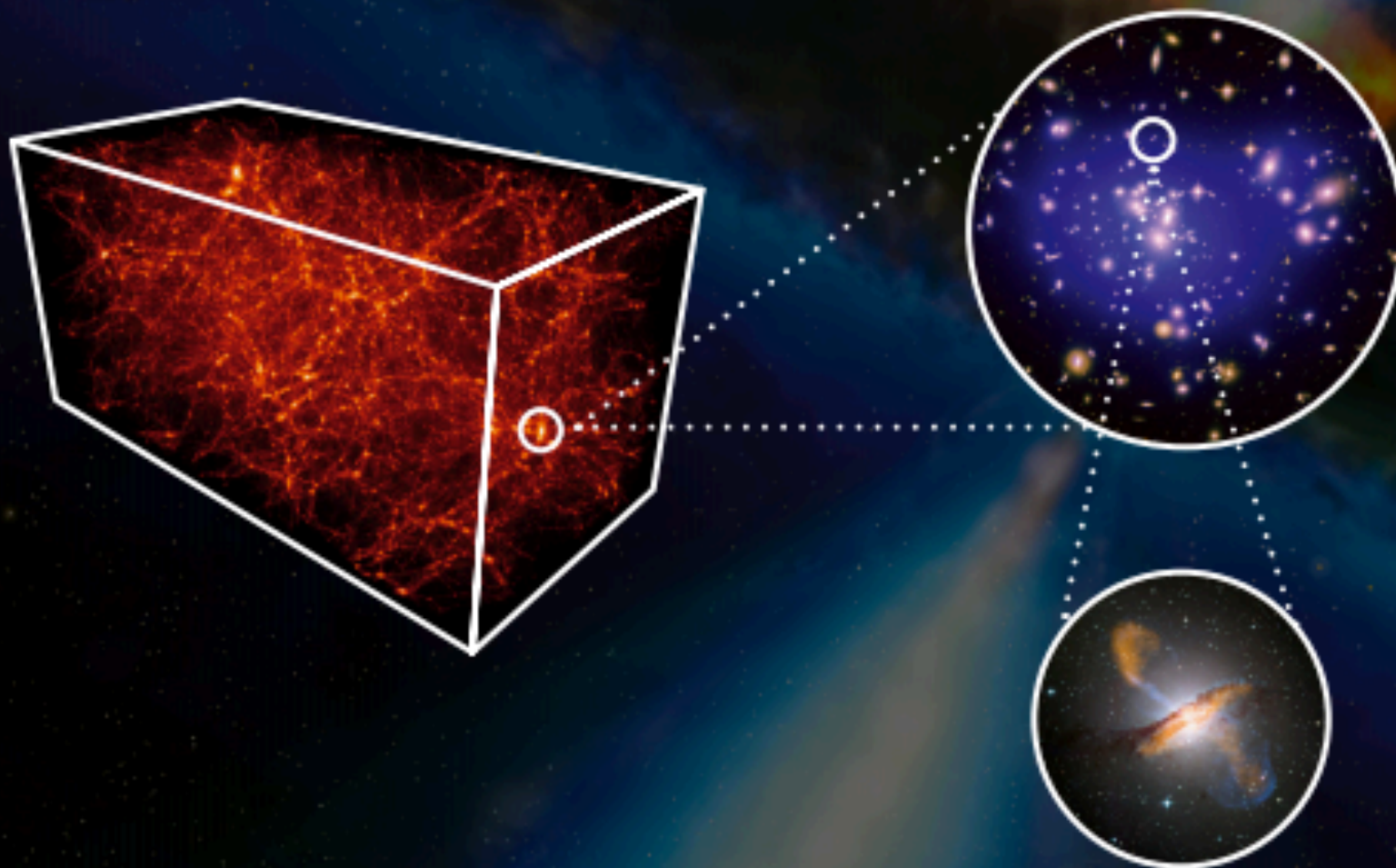
Ryan C. Hickox



*First ever workshop dedicated to:*

## Clustering Measurements of Active Galactic Nuclei

ESO Garching, 14–18 July 2014



# Motivation

BLACK  
HOLE

HOST  
GALAXY



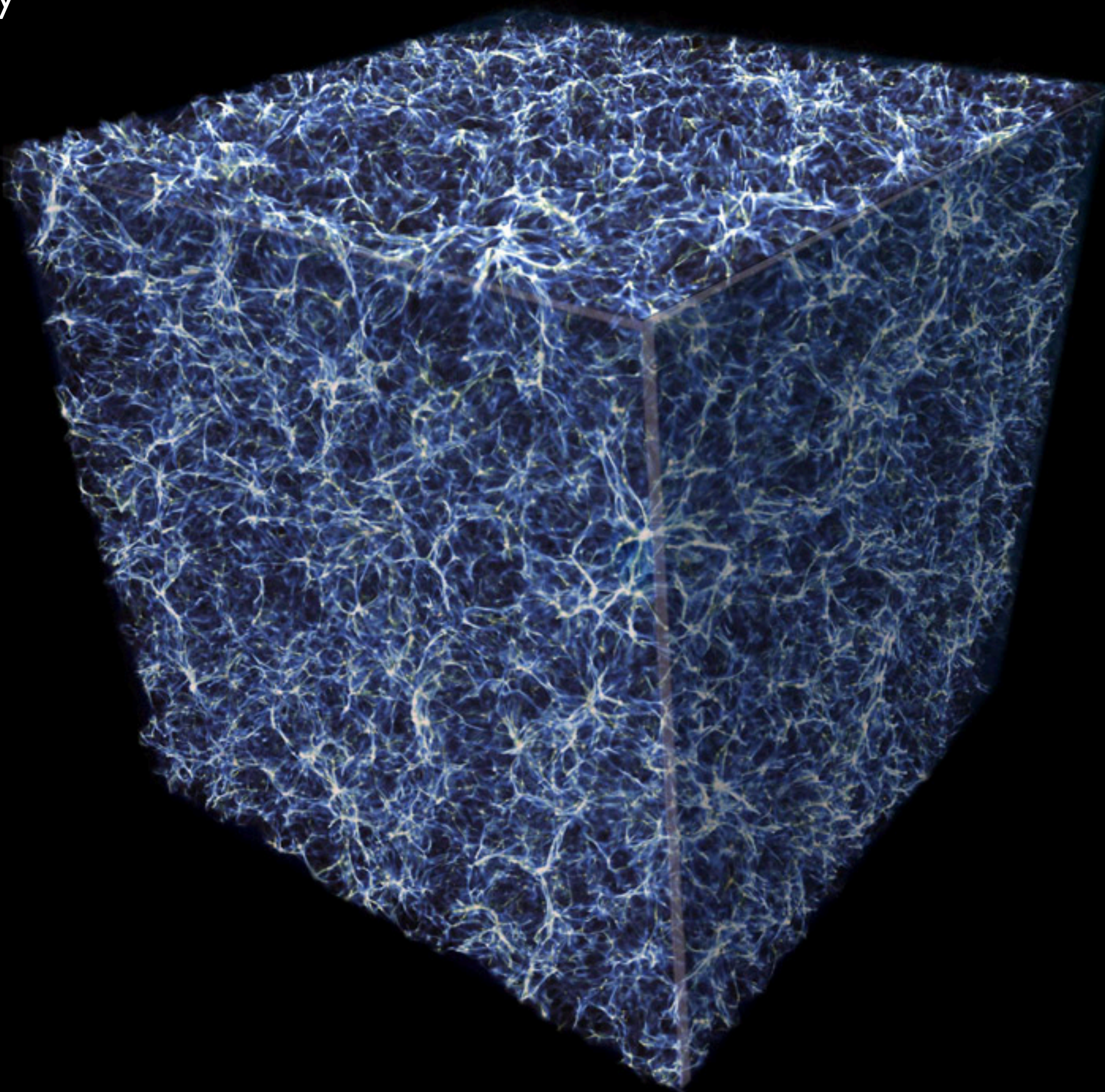
"You are doing the right thing here:  
Clustering is a powerful theoretical  
constraint" - V. Springel

DM HALO

Measure **halo mass** via clustering  
Learn about **cosmological evolution**

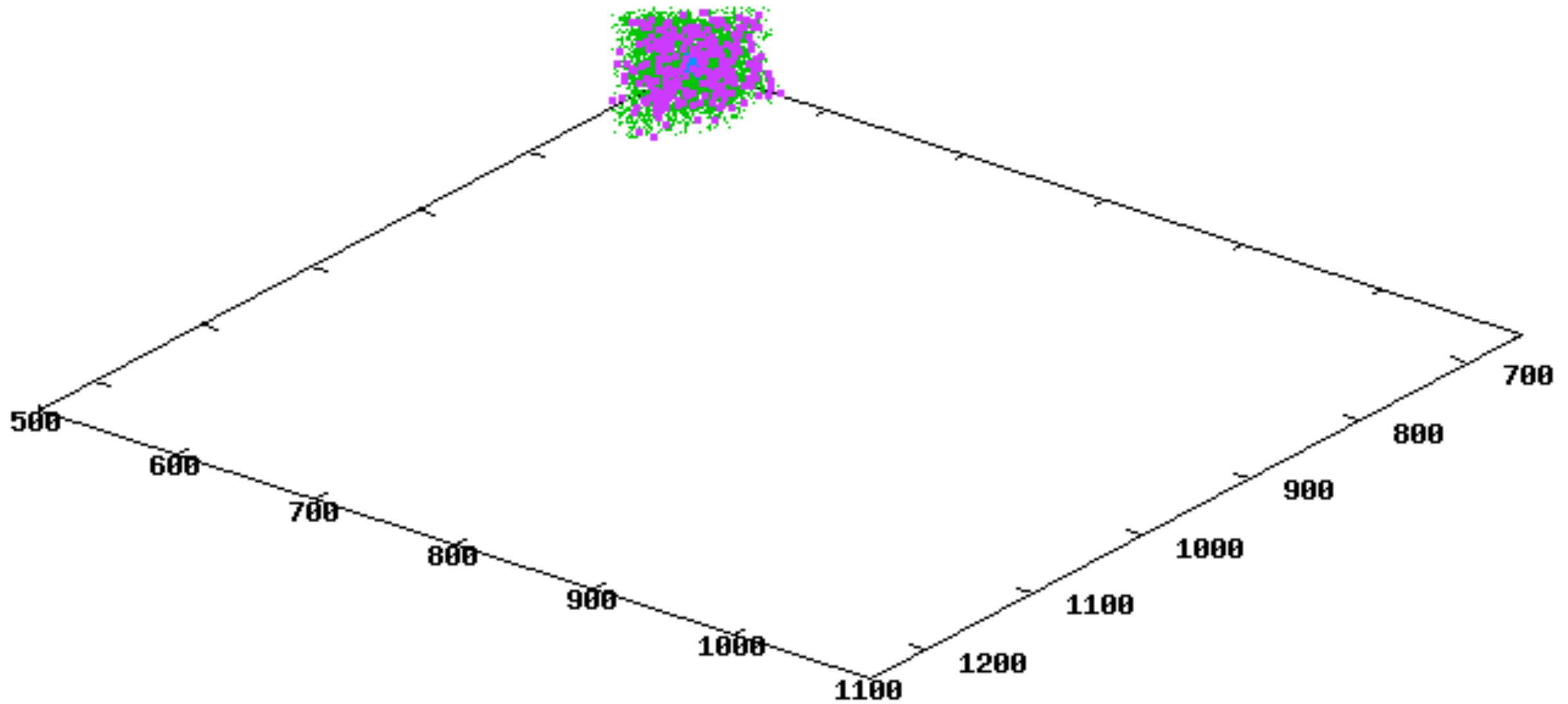


Theory



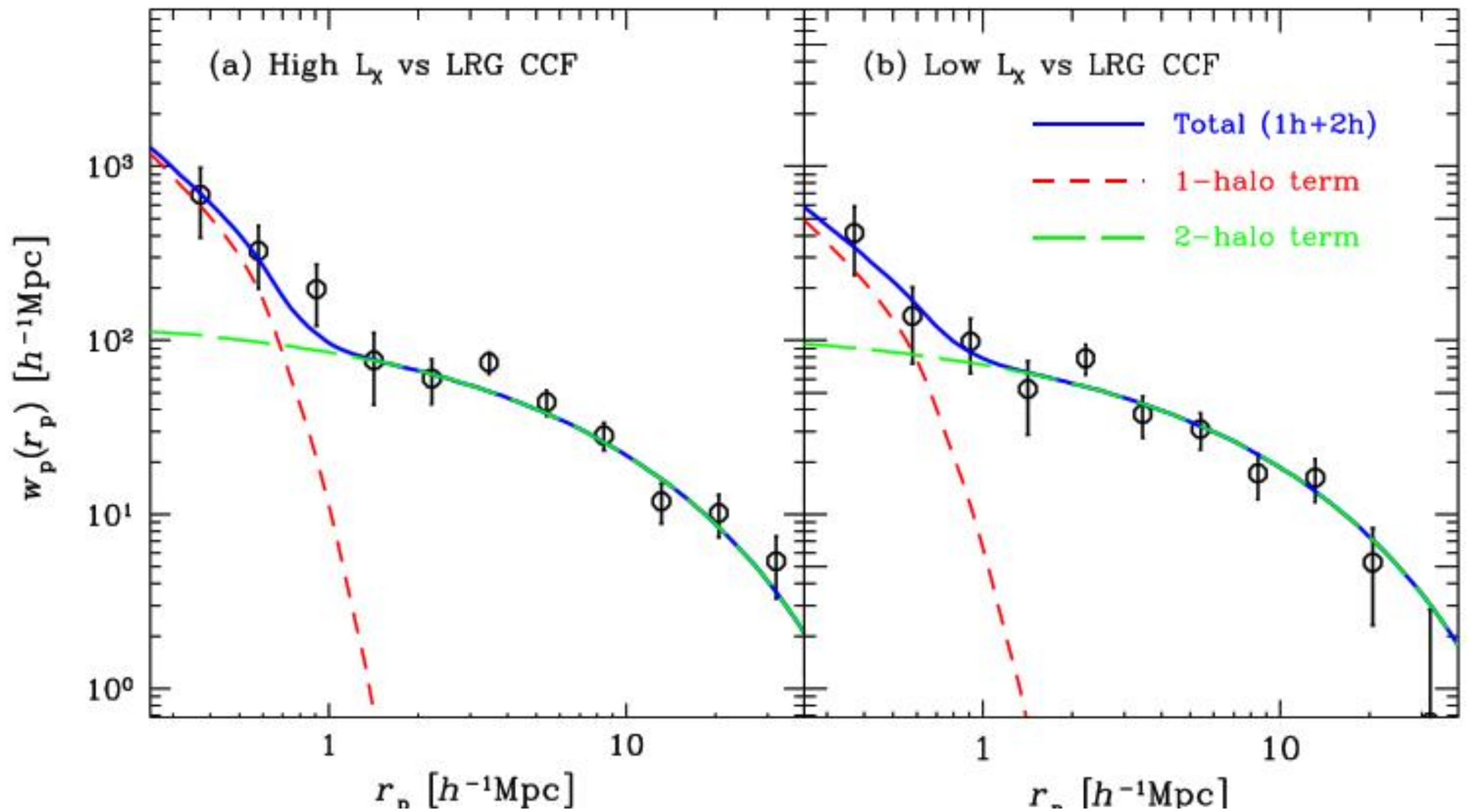
# Observation

- galaxies
- X-ray AGN

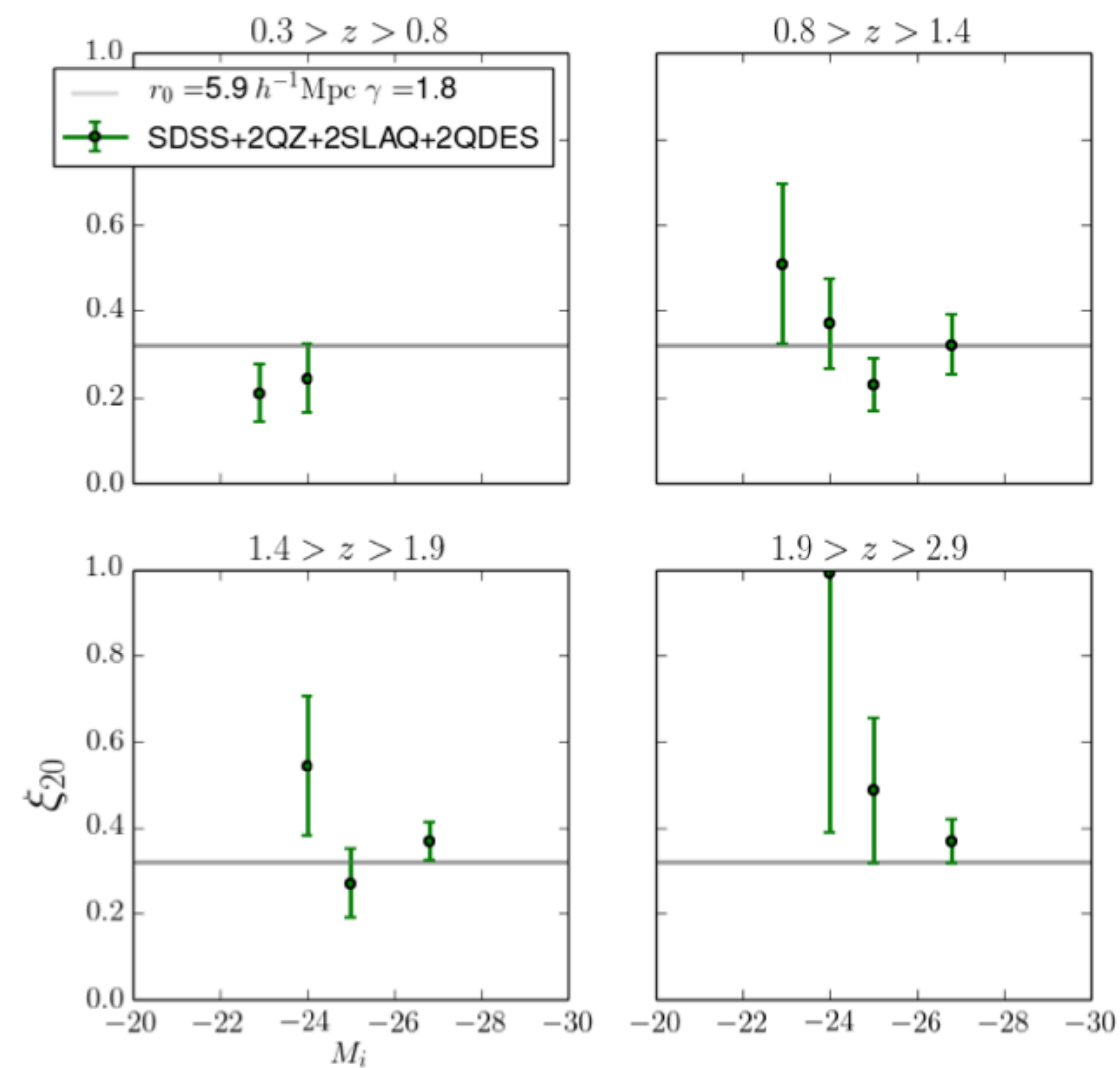
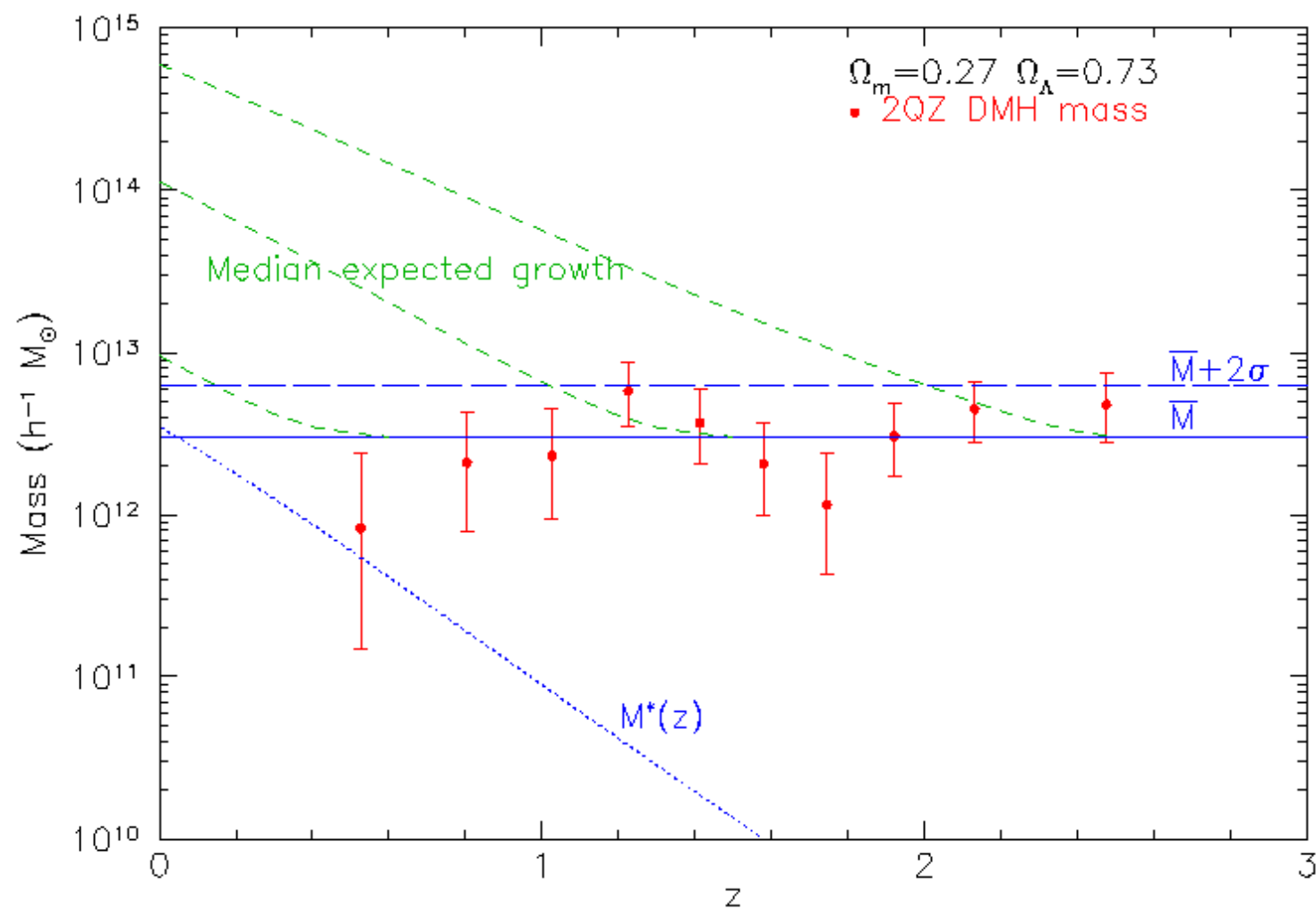




This is **amazing**



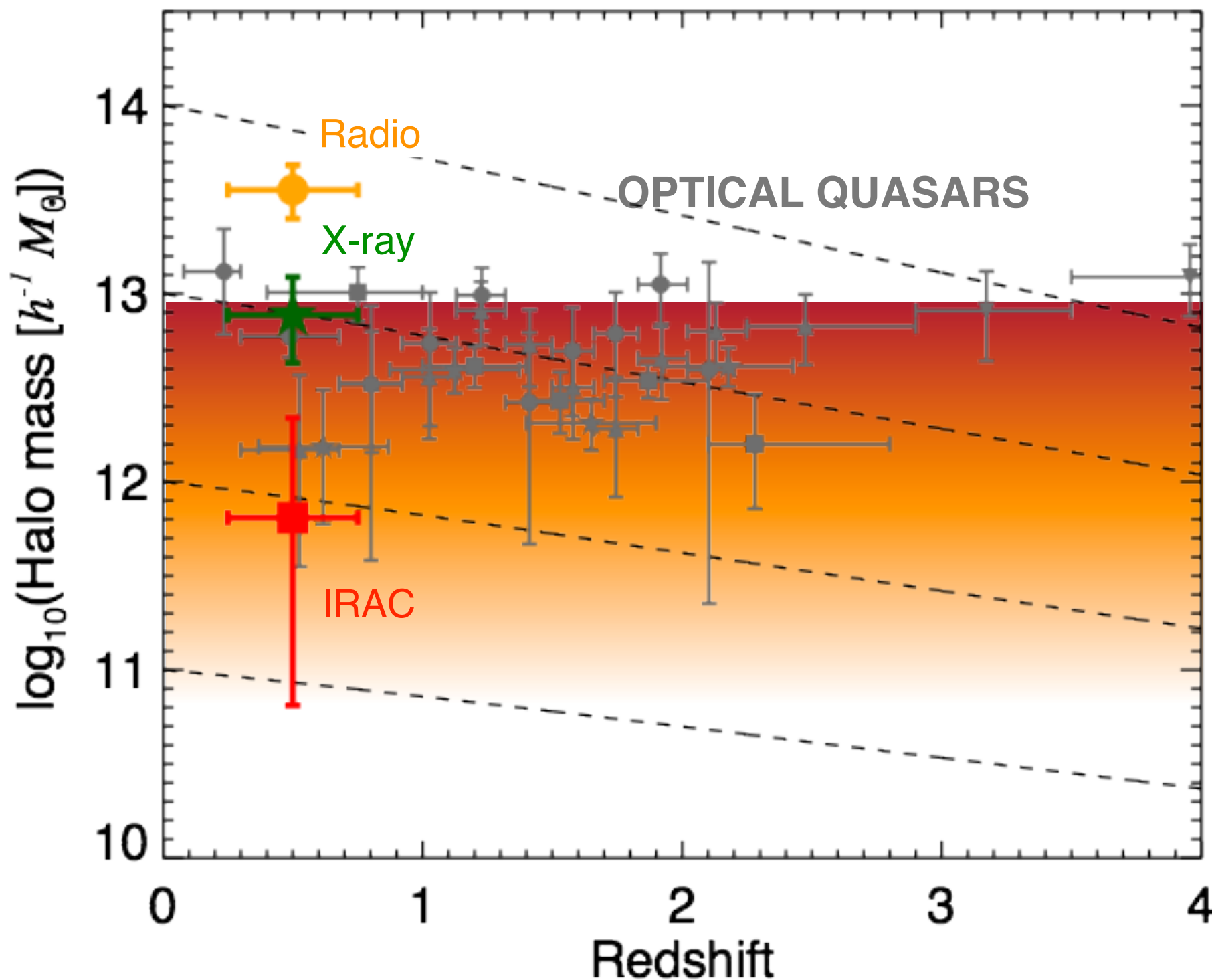
# Optical quasars reside in halos of **~constant mass** with luminosity and redshift



[Croom, Chehade, Rentana-Montenegro]

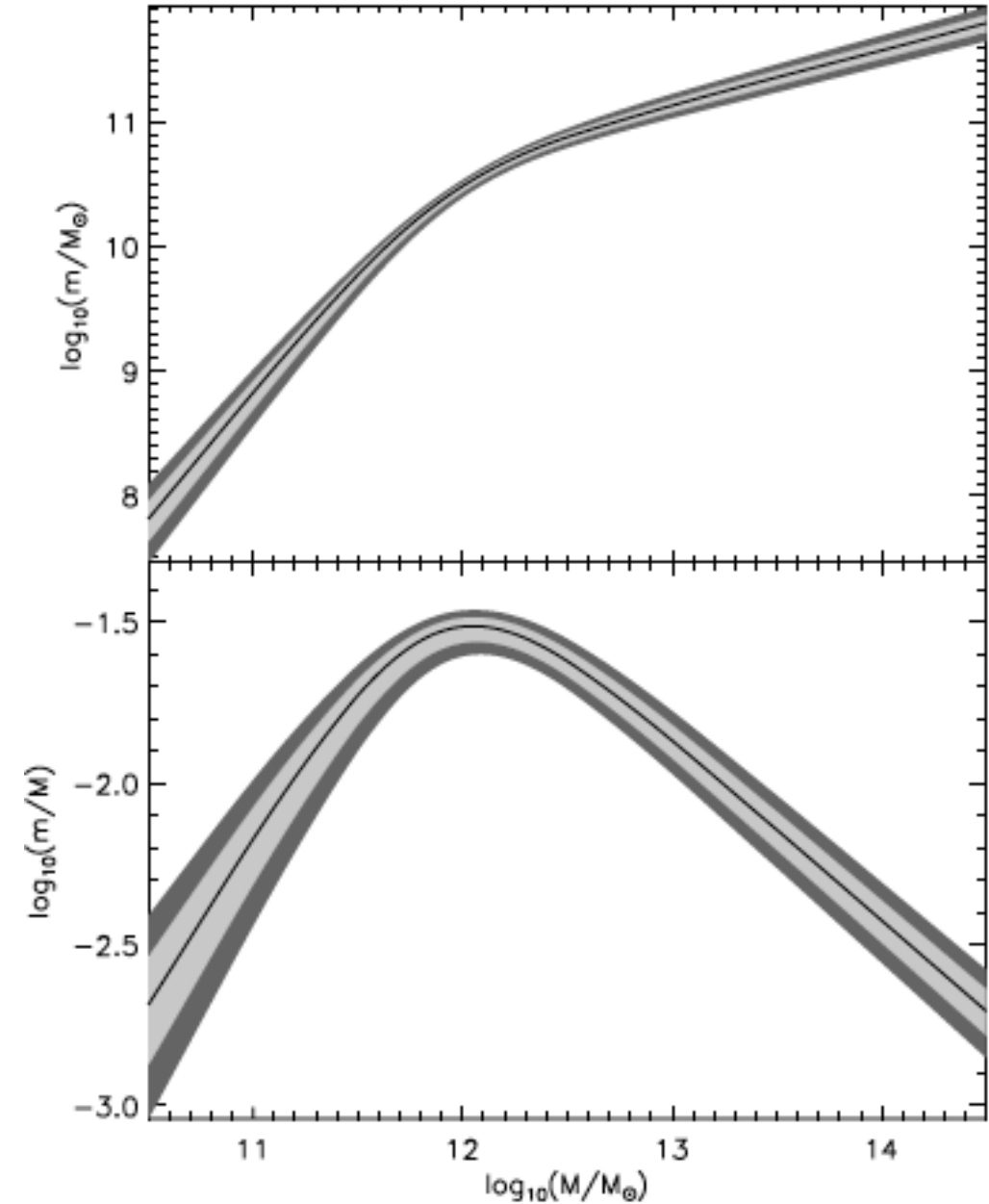
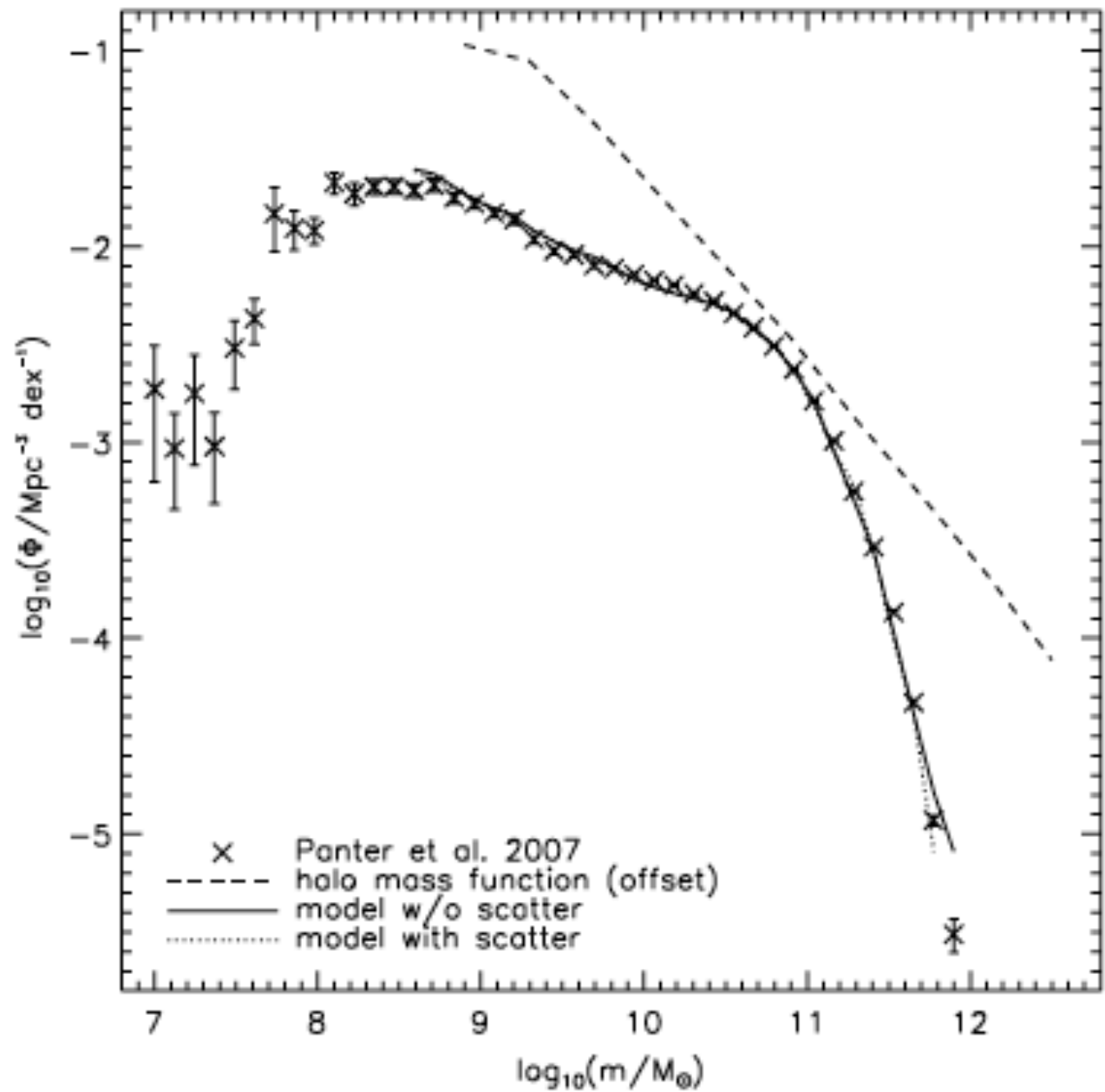


# Importance of **AGN selection methods**



[Hickox, Chehade, Mendez, Myers, Willett]

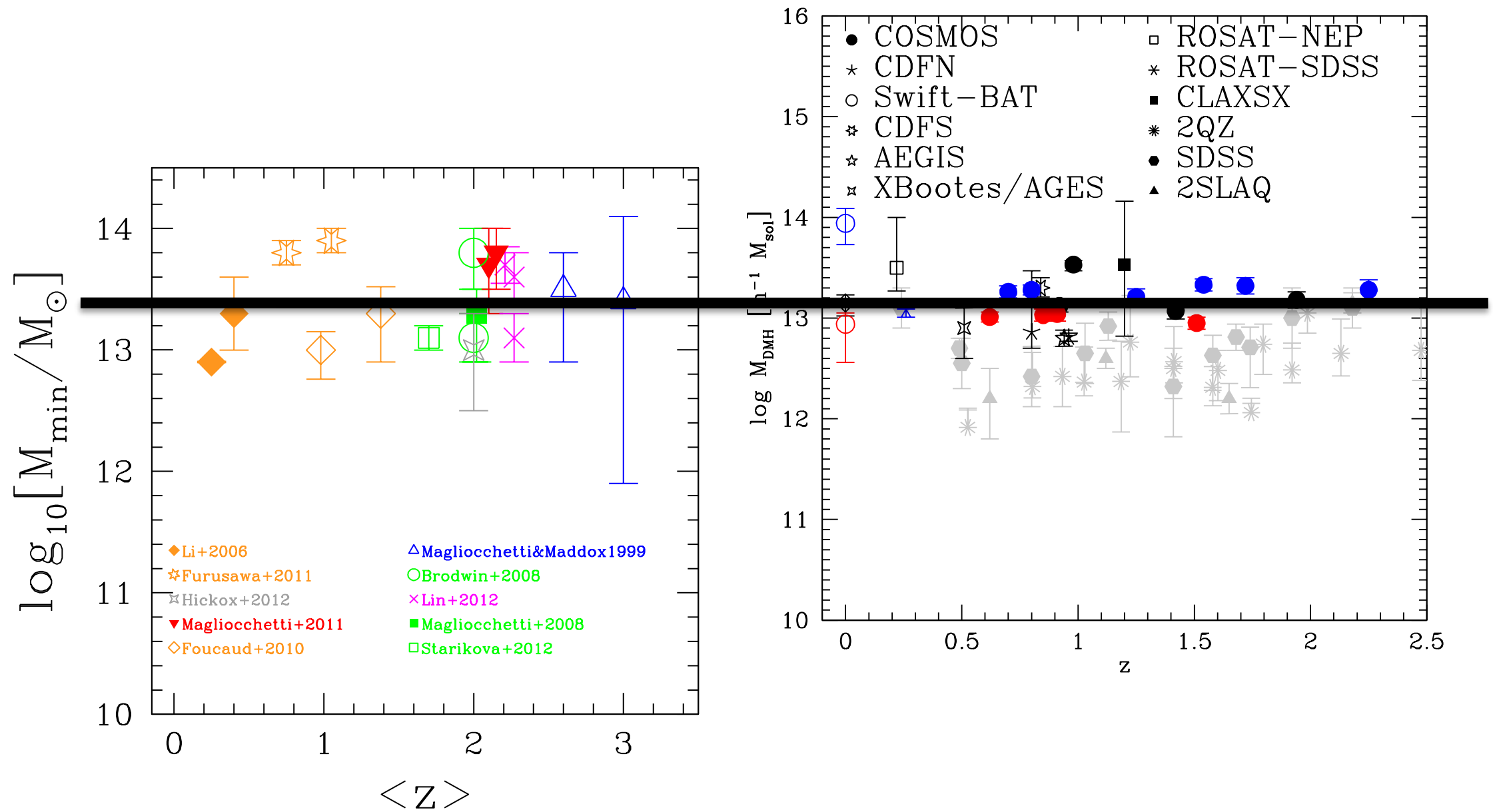
Halo mass is **very important** for galaxy formation; galaxy clustering **well understood**



[Coil, Cole, Springel, Fanidakis]

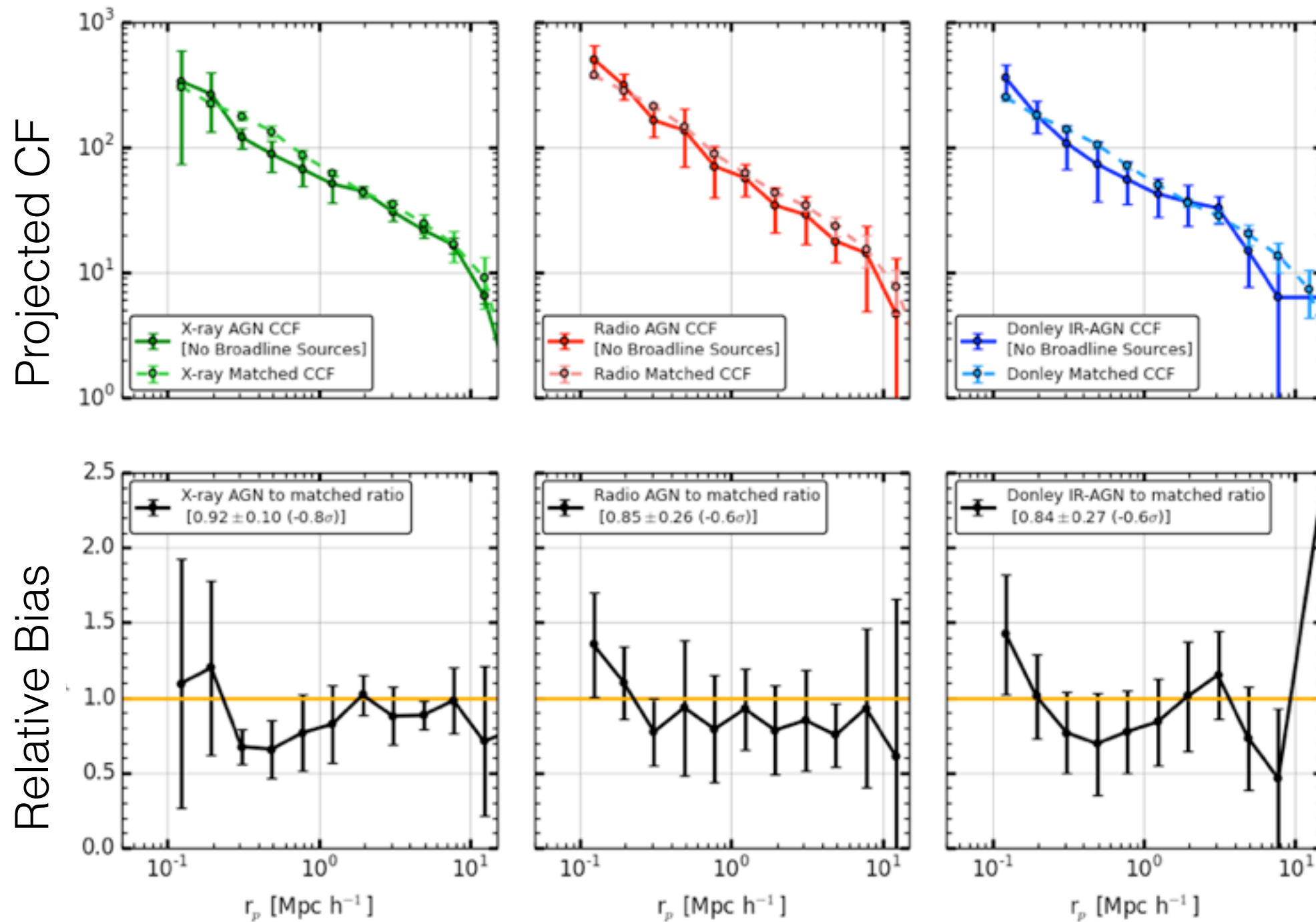


# Does AGN activity **follow** star formation in galaxies?



[Hickox, Wang, Coil, Magliocchetti]

# AGN are in general clustered **consistently to matched host galaxies**

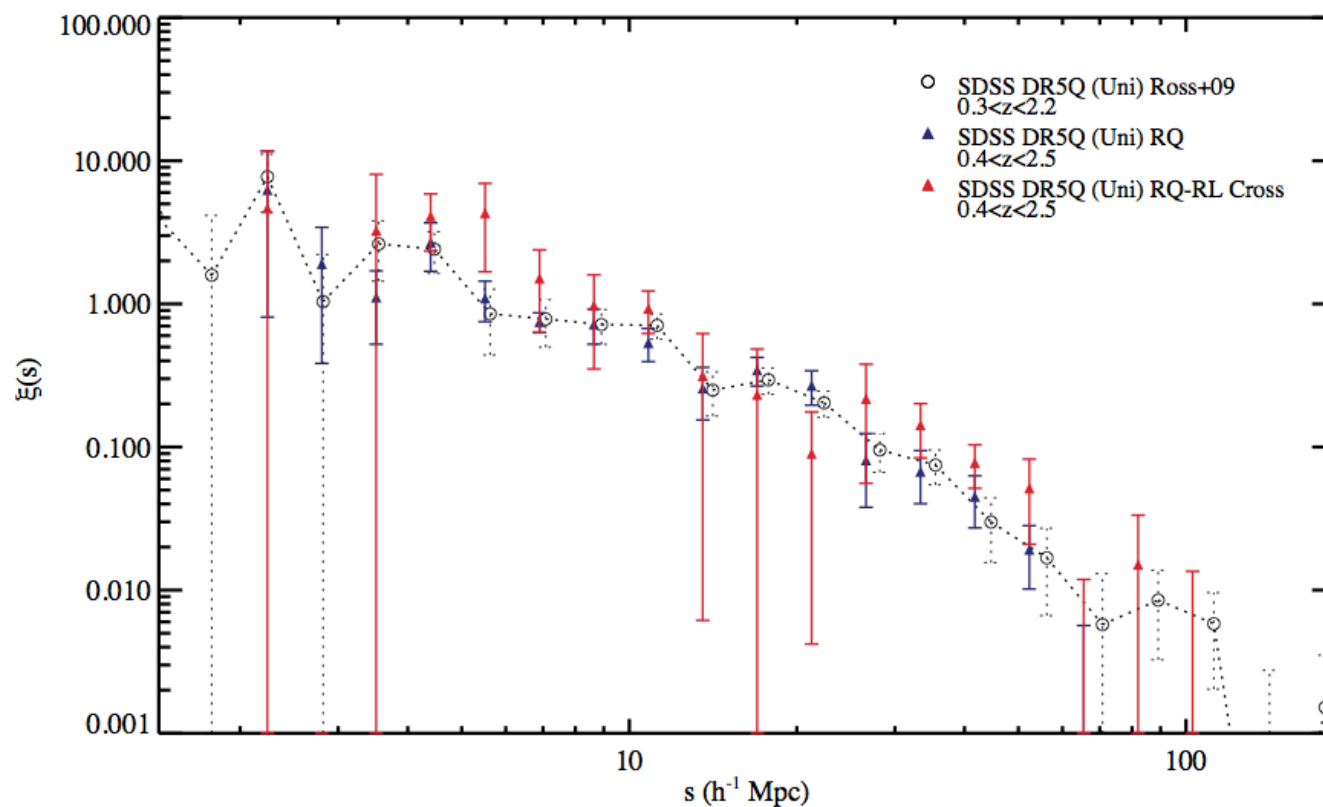
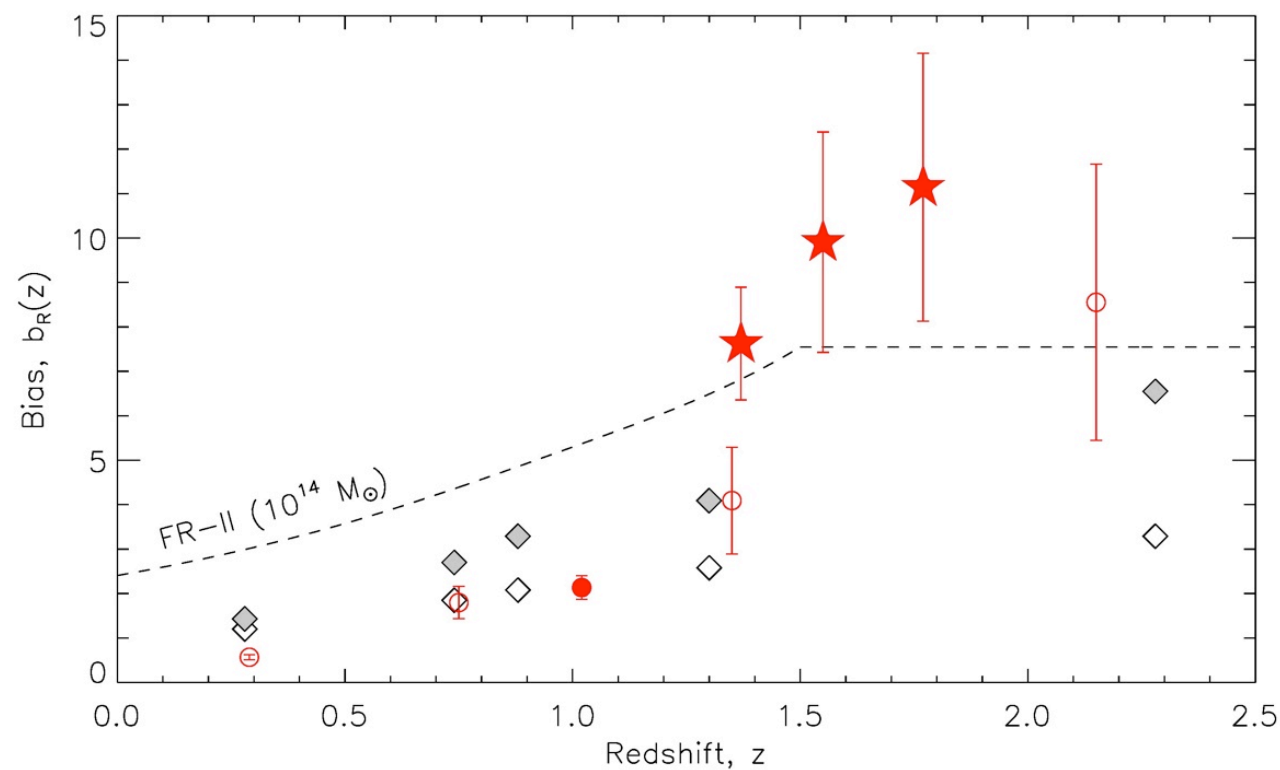


X-ray  
Radio  
IR:Donley

[Georgakakis, Coil,  
Mendez, Karhunen]



# “Radio-mode” AGN are very **strongly clustered** and in **massive halos**

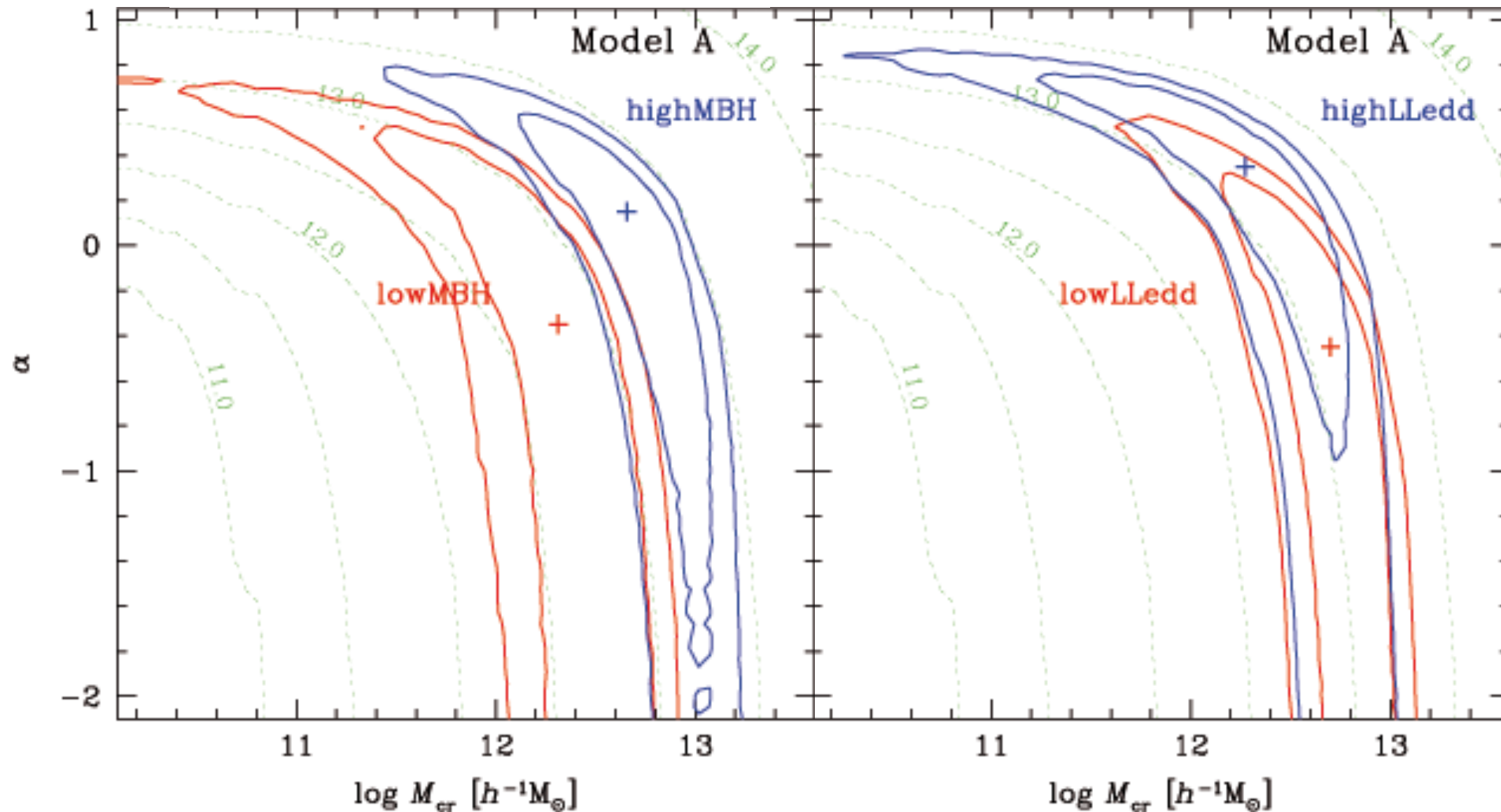


[Rentana-Montenegro, Mendez, Ramos-Almeida, Lindsay, Willett, Hickox]

# AGN clustering depends strongly on **black hole mass**, not on **Eddington ratio**

low vs high  $M_{\text{BH}}$

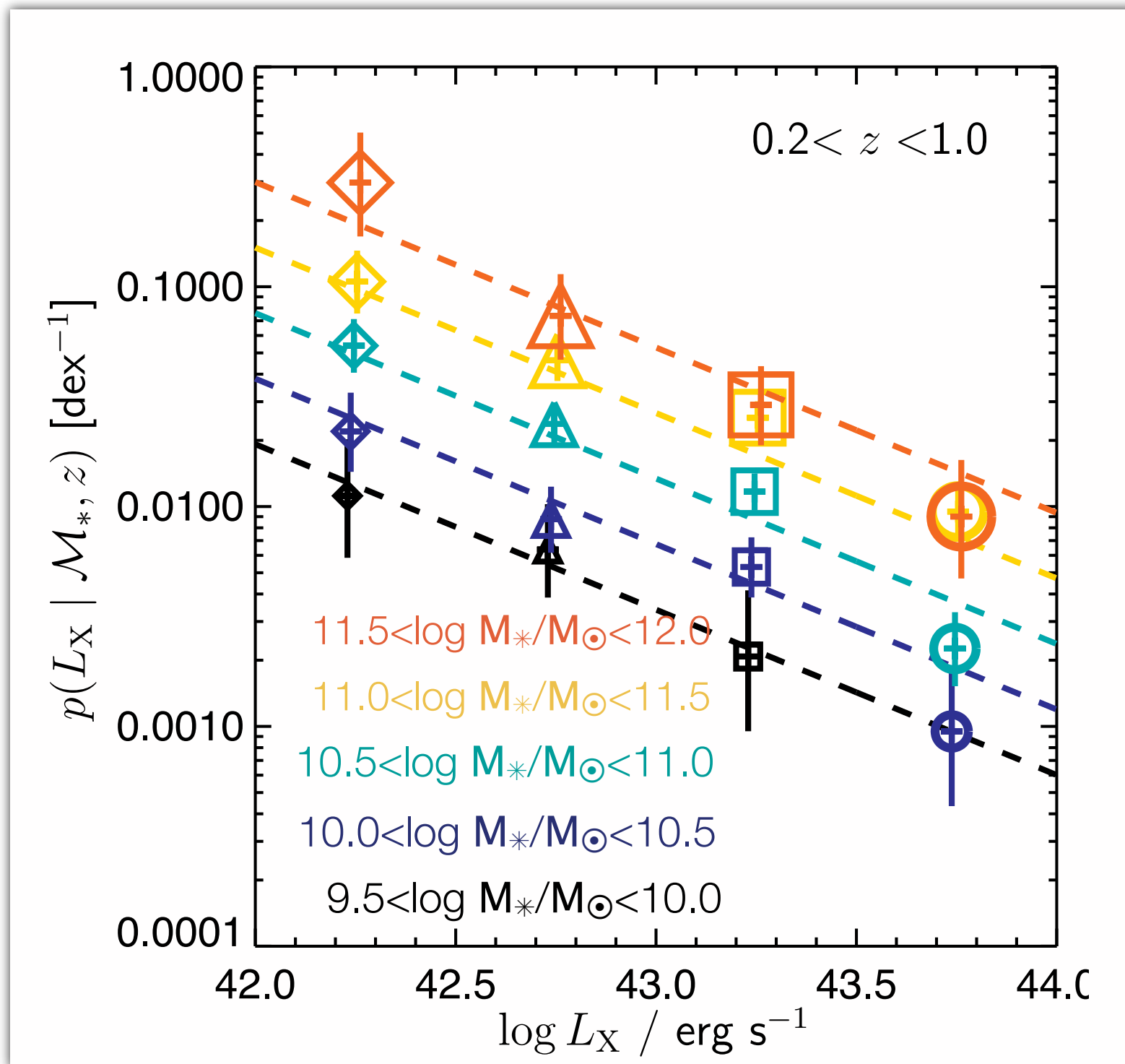
low vs high  $L/L_{\text{EDD}}$



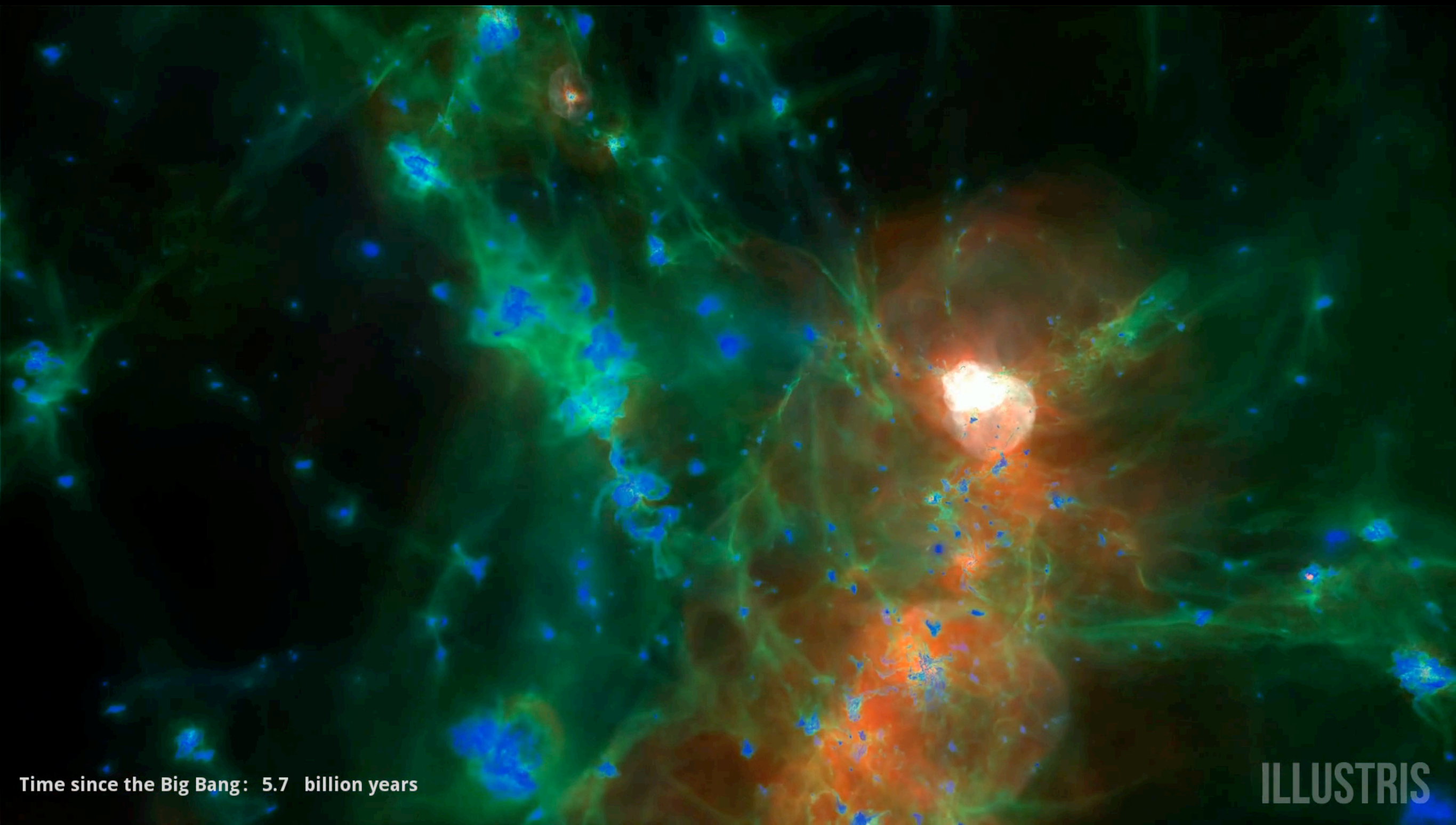
[Rentana-Montenegro,  
Krumpe, Shiarasaki]



# Importance of **stochasticity** in the AGN population



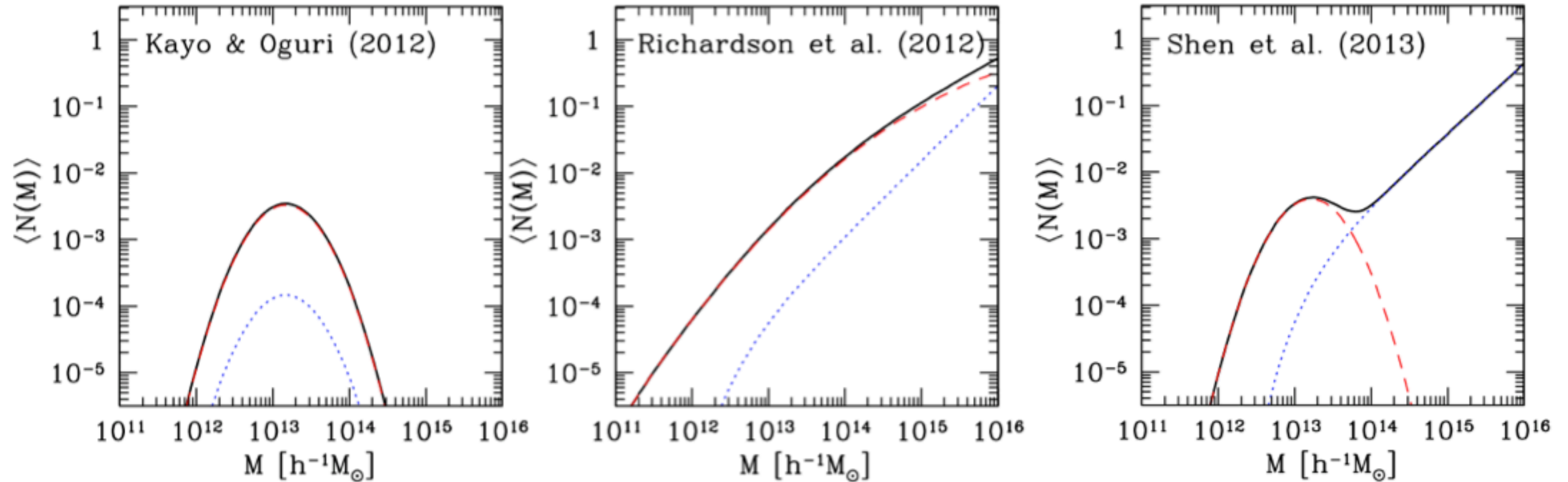
[Coil, Springel]



Time since the Big Bang: 5.7 billion years

ILLUSTRIS

# What is the AGN halo occupation distribution?

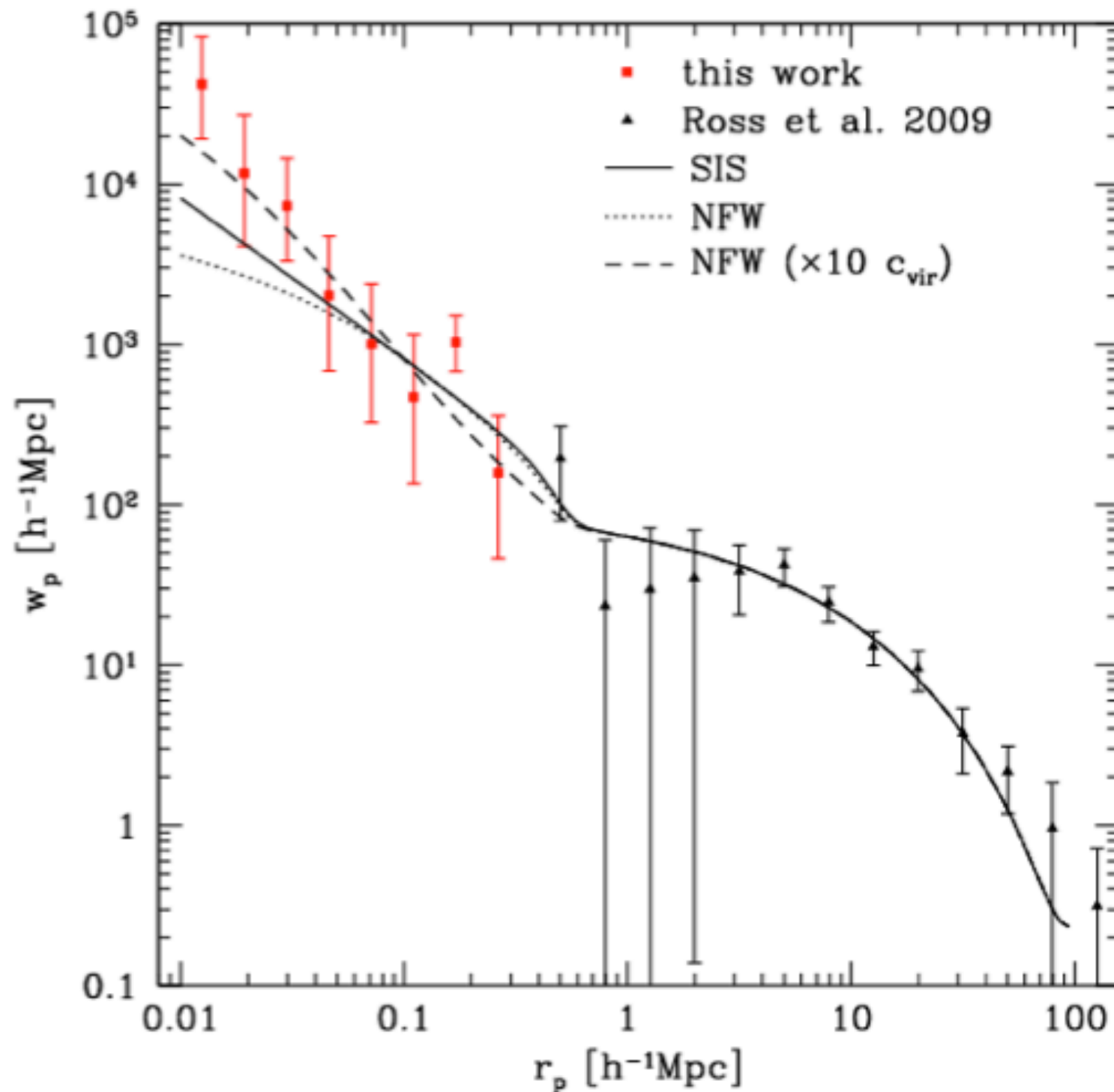


Difference between  
**average** and **median**  
halo mass

[Coil, Miyaji, Kayo,  
Finoguenov, Finoguenov,  
Nguyen, Altamirano-Divora]



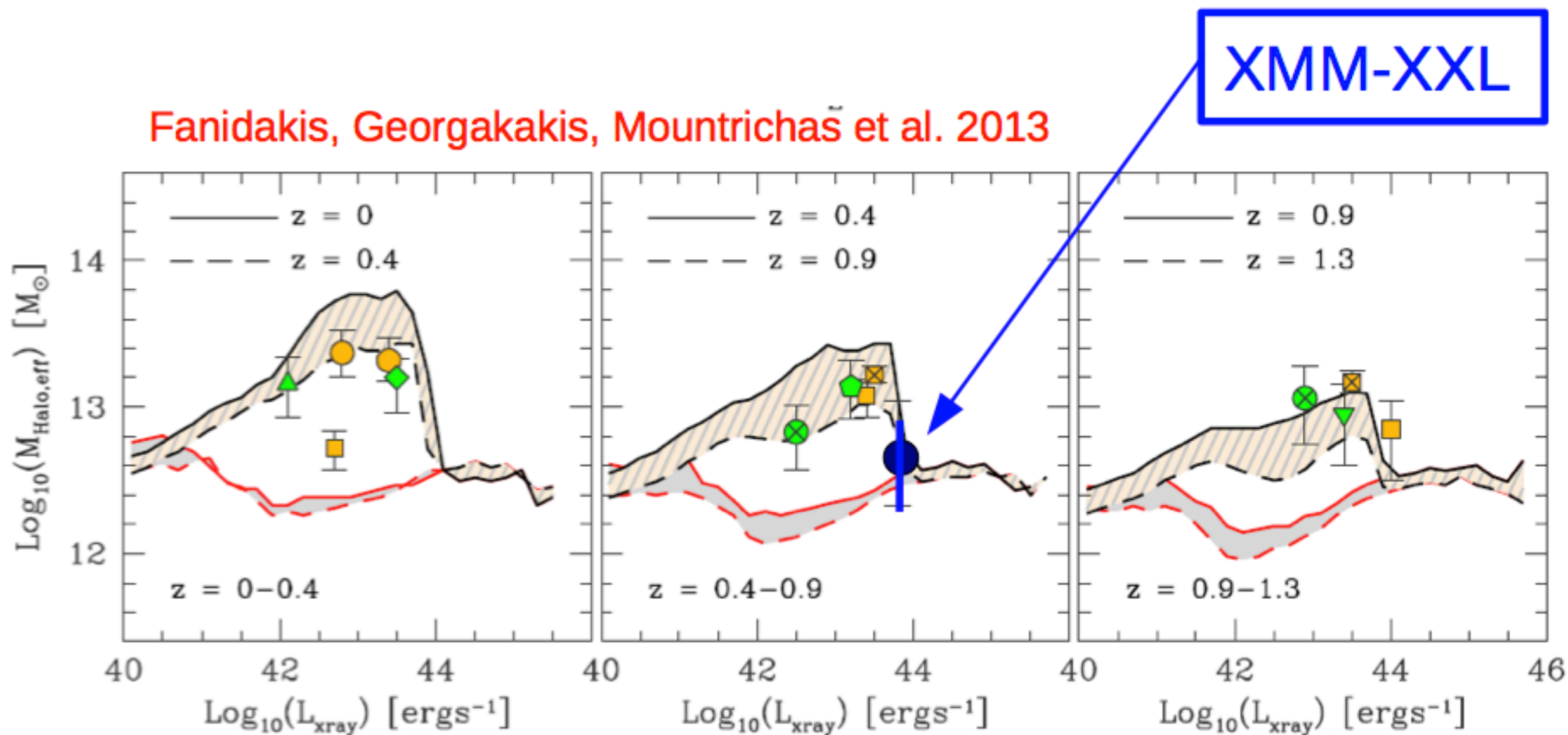
# Can clustering constrain the importance of mergers?



[Ramos-Almeida,  
Altamirano-Divora,  
Kayo, Oogi]

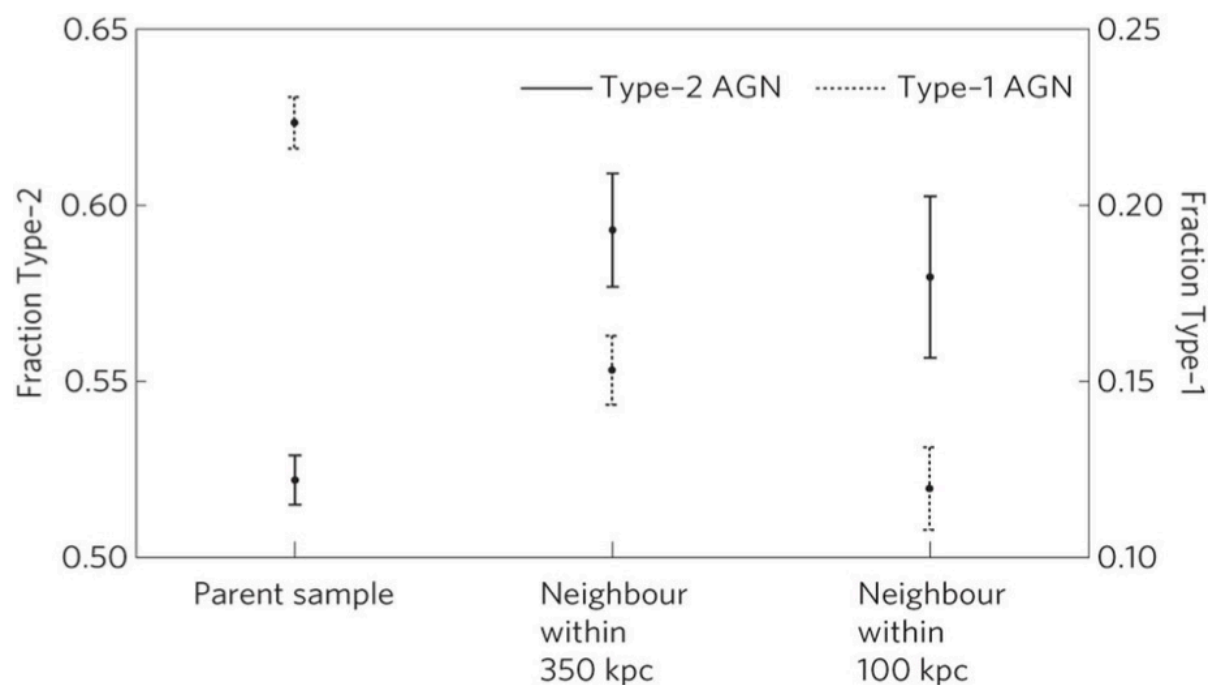
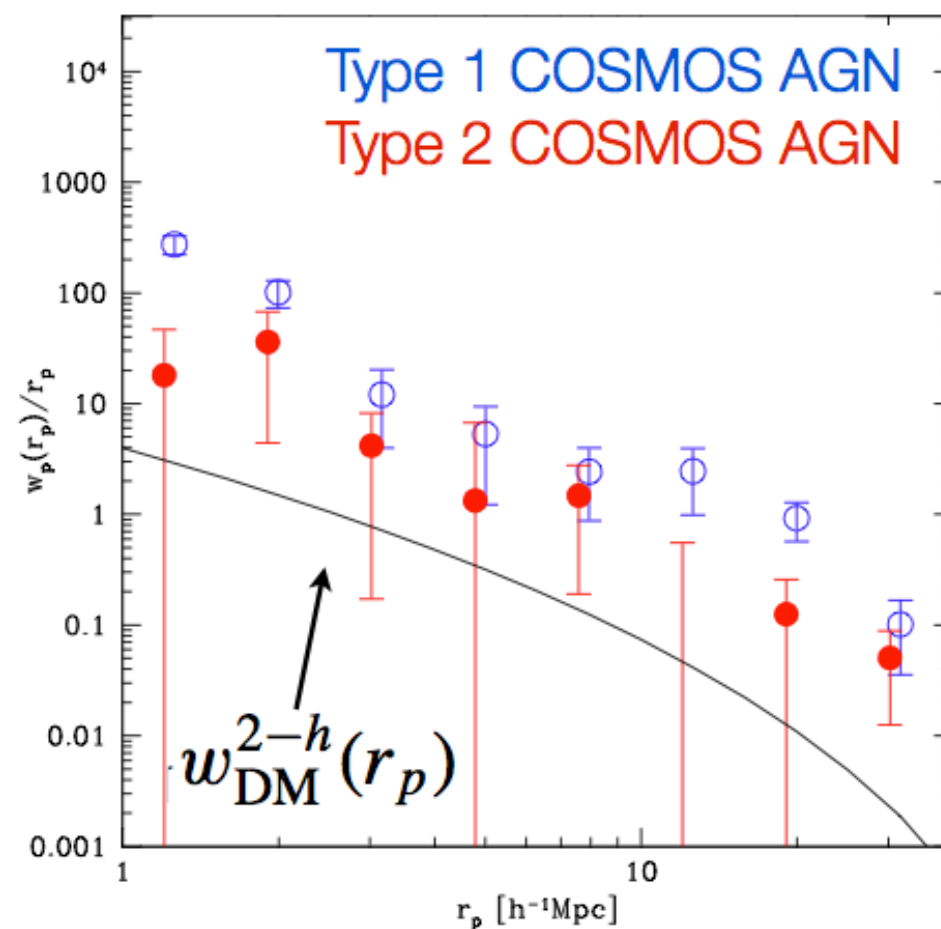
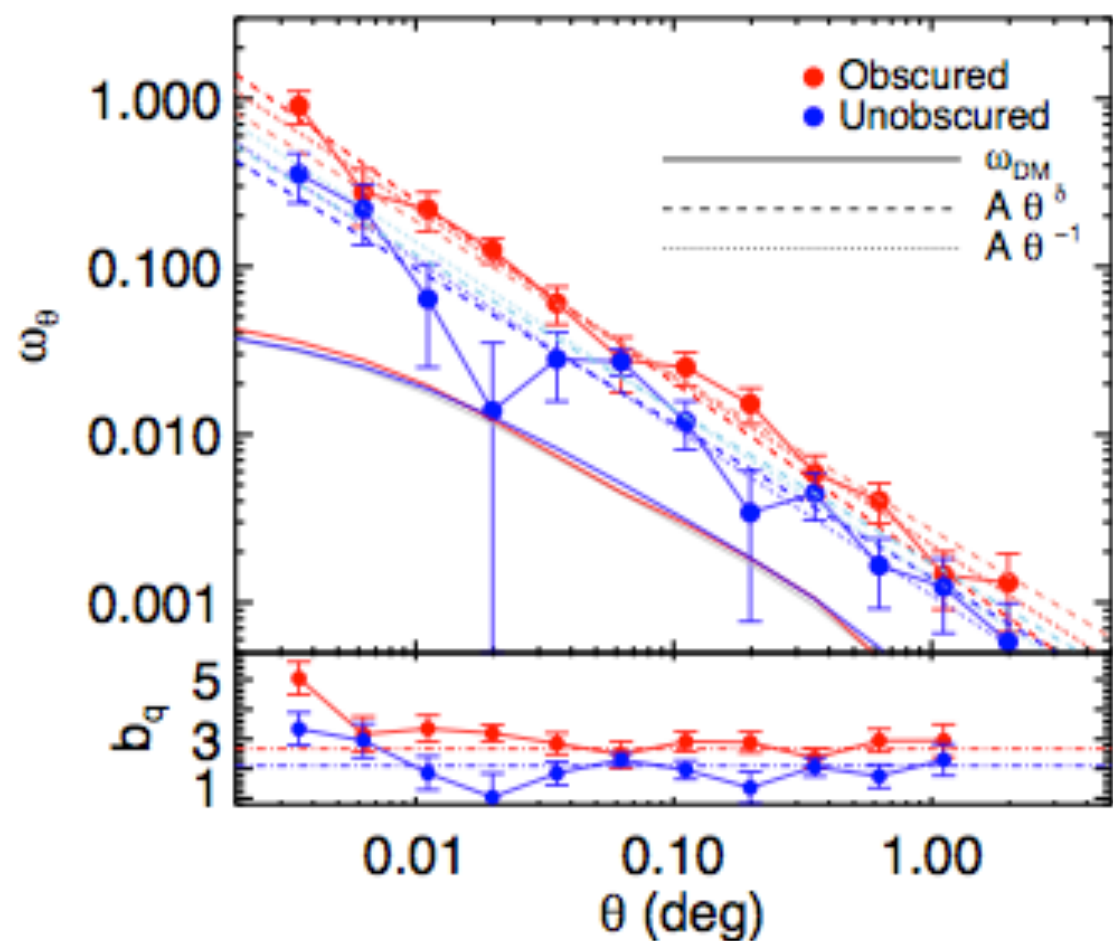
# Importance of different **modes of accretion** and **feedback**

Fanidakis, Georgakakis, Mountrichaš et al. 2013



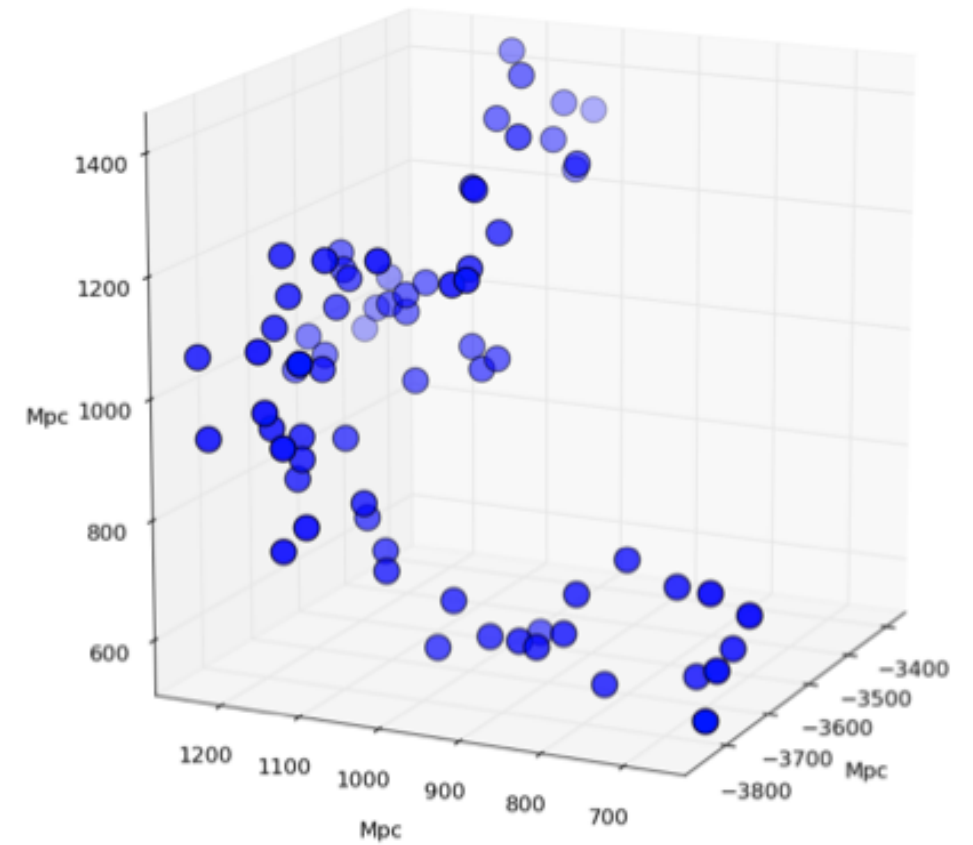
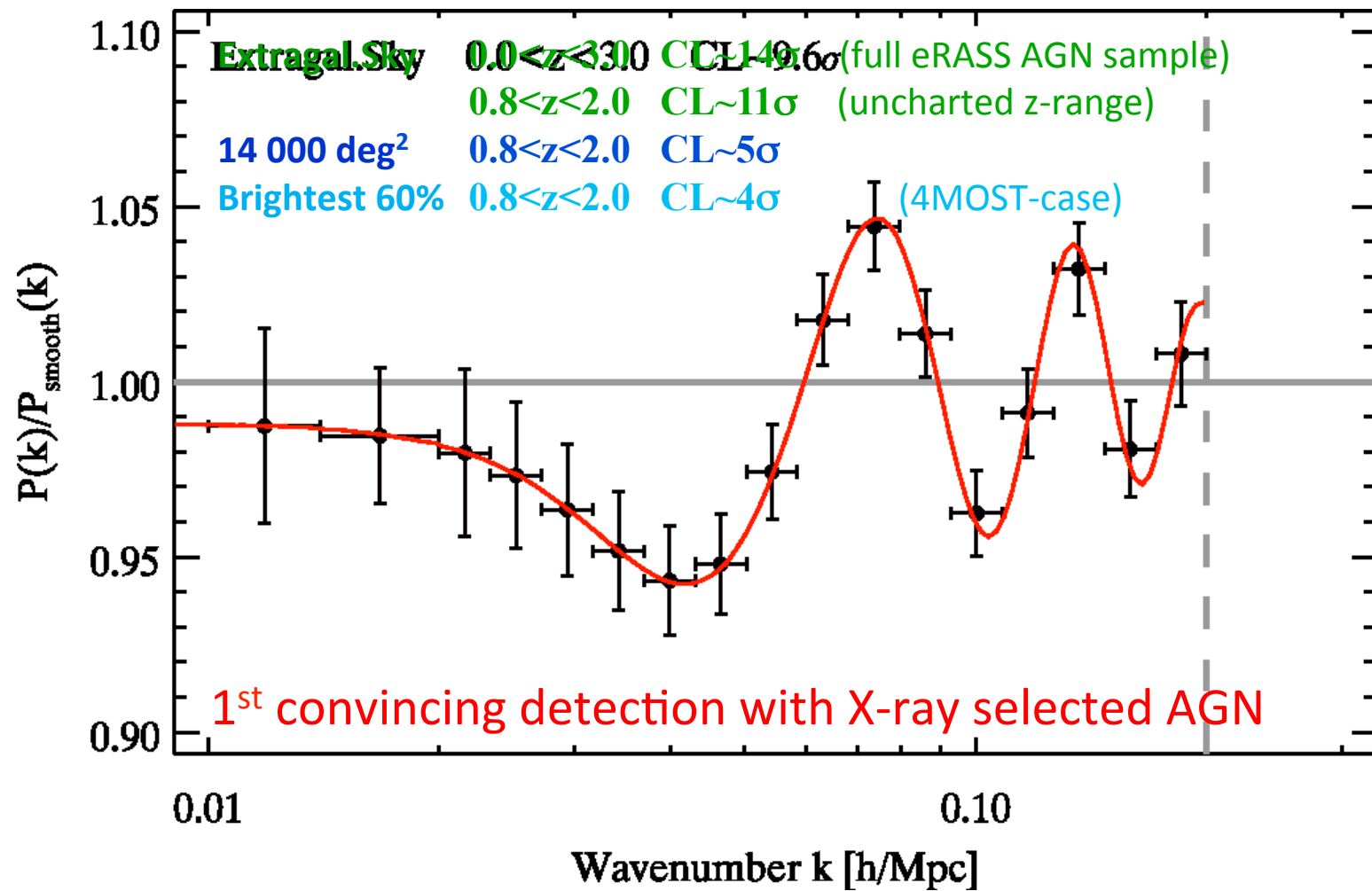
[Georgakakis, Springel, Fanidakis]

# Clustering of **obscured and unobscured** (or Type 1/Type 2) AGN and the unified model



[Hickox, Koutoulidis, Alleinato, Mendez, Villaruel]

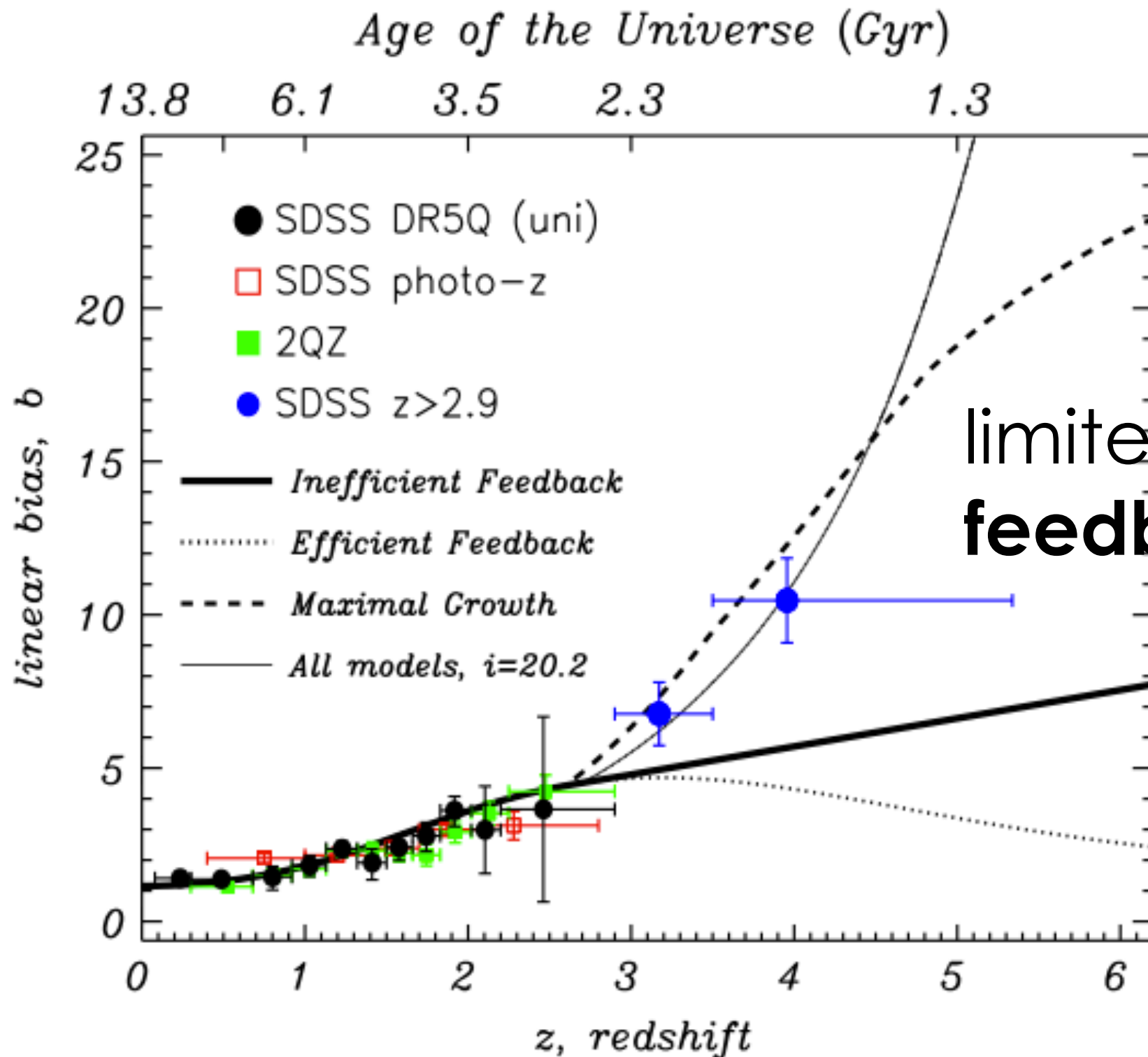
# AGN clustering and cosmology



[Cole, Marinello,  
Campusano, Kolodzig,  
Norris]



# Importance of clustering at **high redshift**

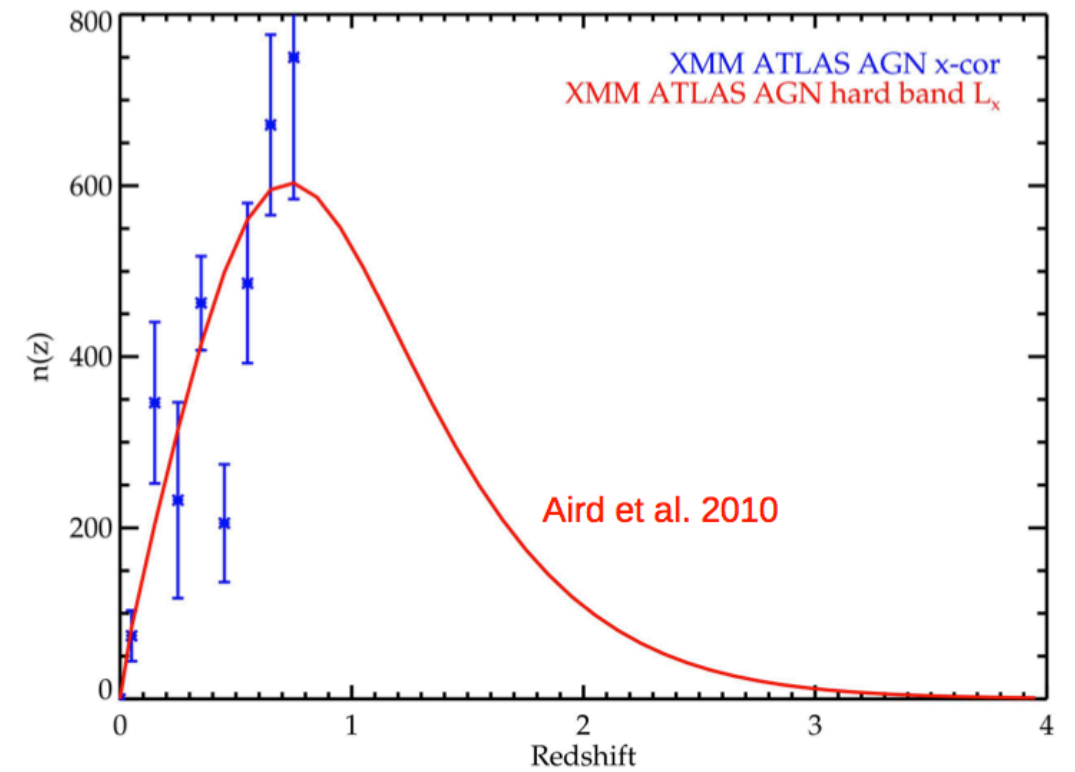
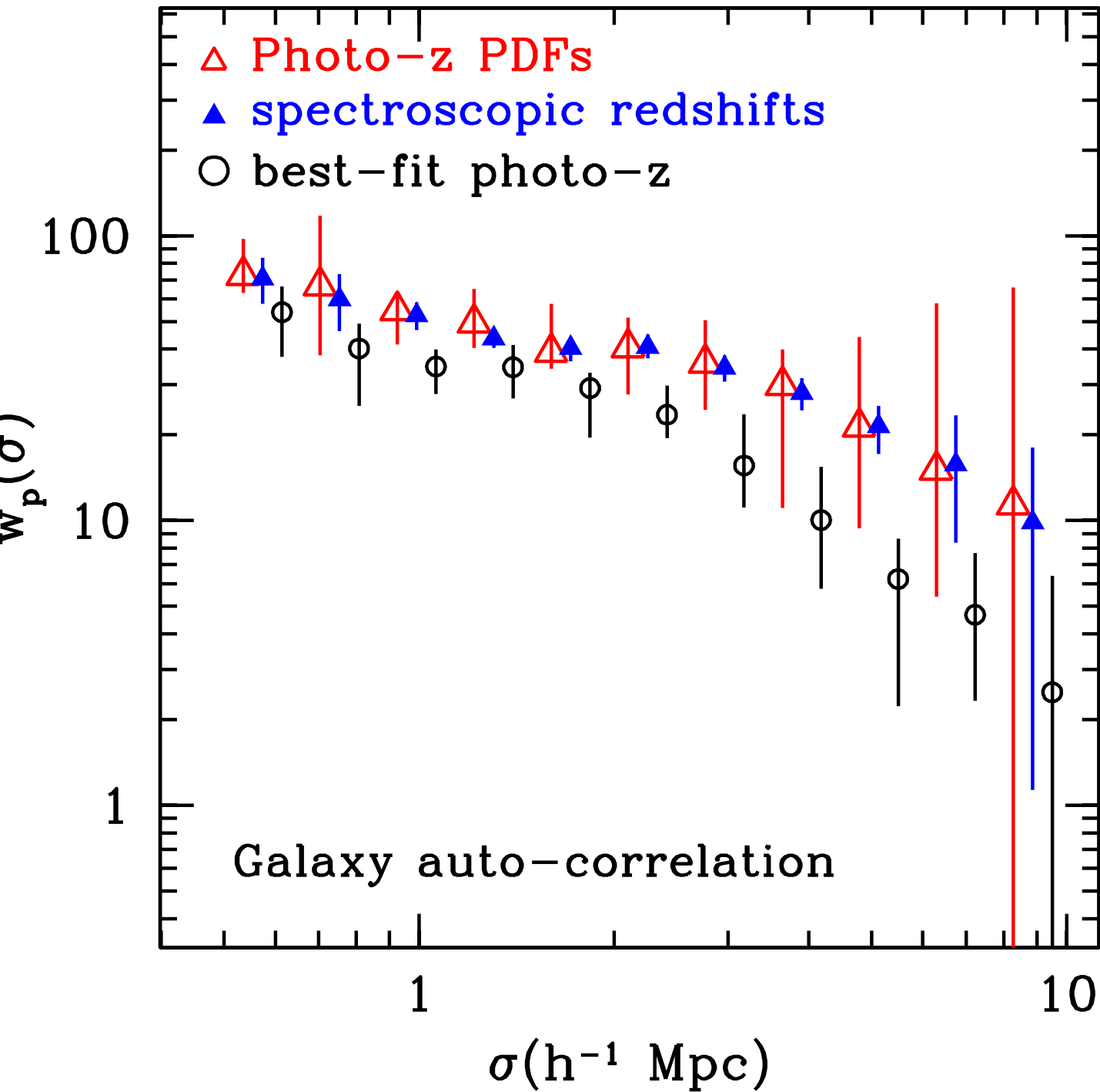


limited by **feedback**

limited by **gas supply**

[Croom, Allevato, Garcia Vergara, Schulze]

# New AGN clustering techniques

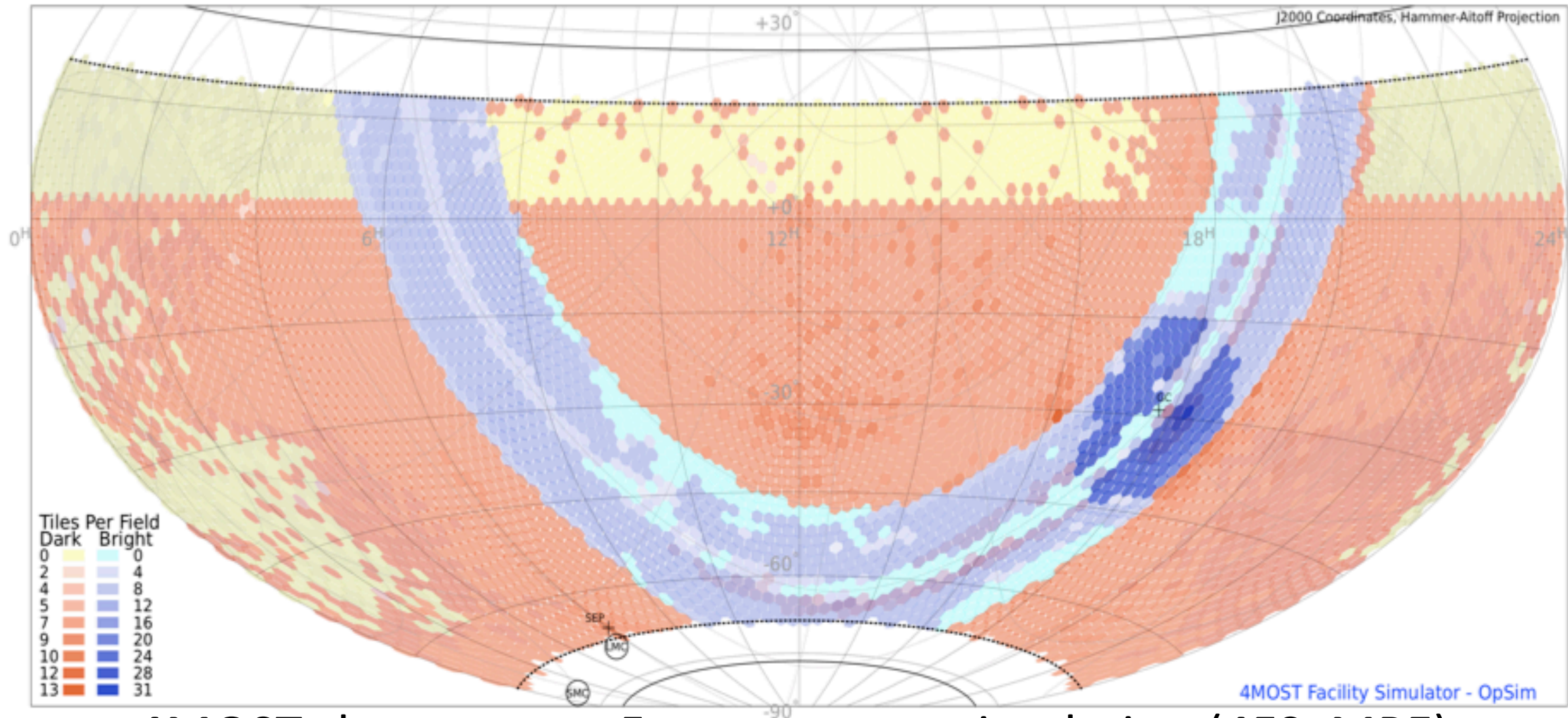


[Nikoloudakis,  
Mountrichas, Norris,  
Schulze]

# The future and large surveys

4MOST Sky Tiling layout

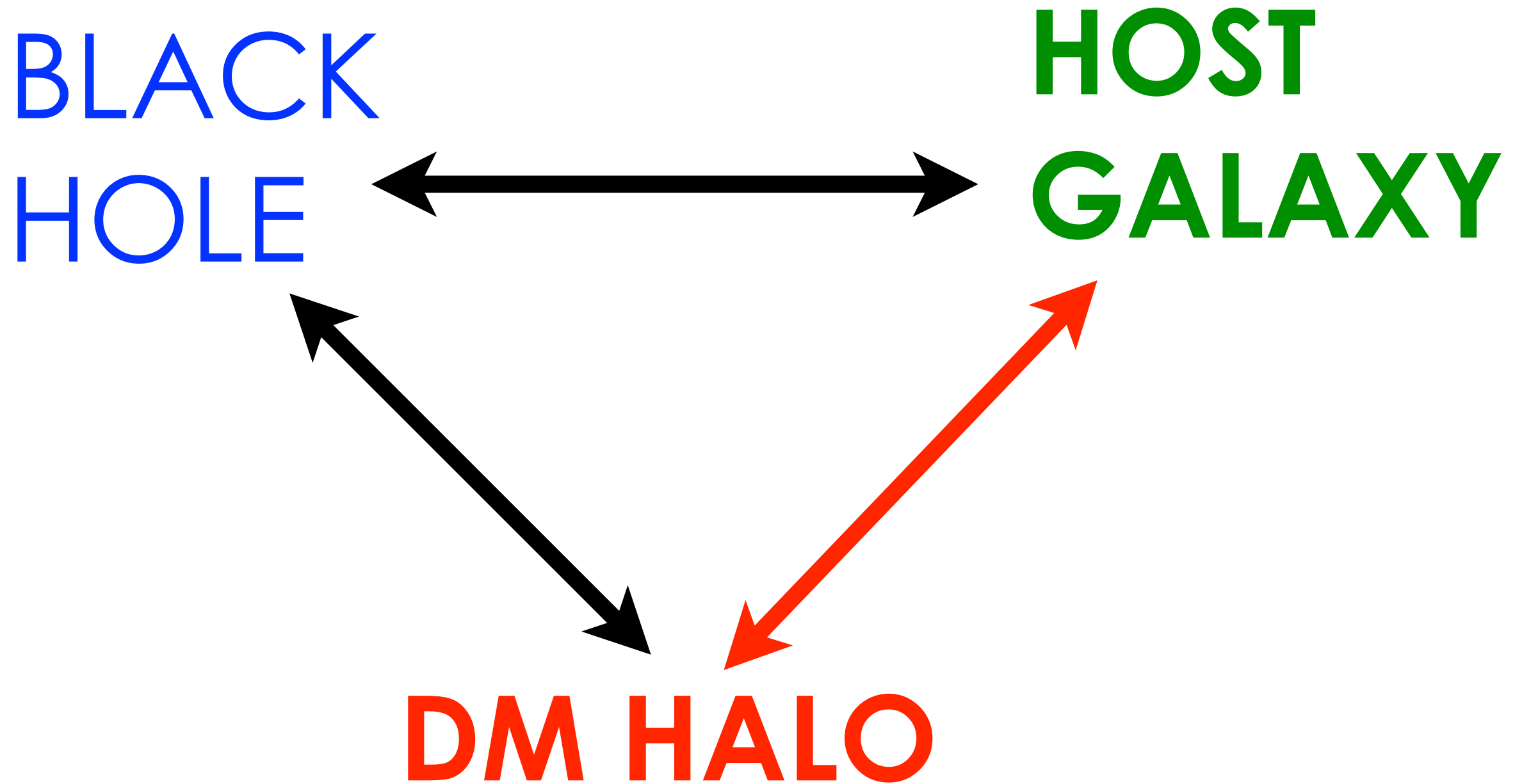
Tele=VISTA Positioner='Echidna-like' Geodesic- $N_{\text{pnts}}=10242$ , FOV=4.059deg<sup>2</sup>, 5 year survey



4MOST sky coverage 5 years survey simulation (4FS, MPE)

[Merloni, Kolodzig,  
Myers, Schulze,  
Geisbuech]

# Motivation



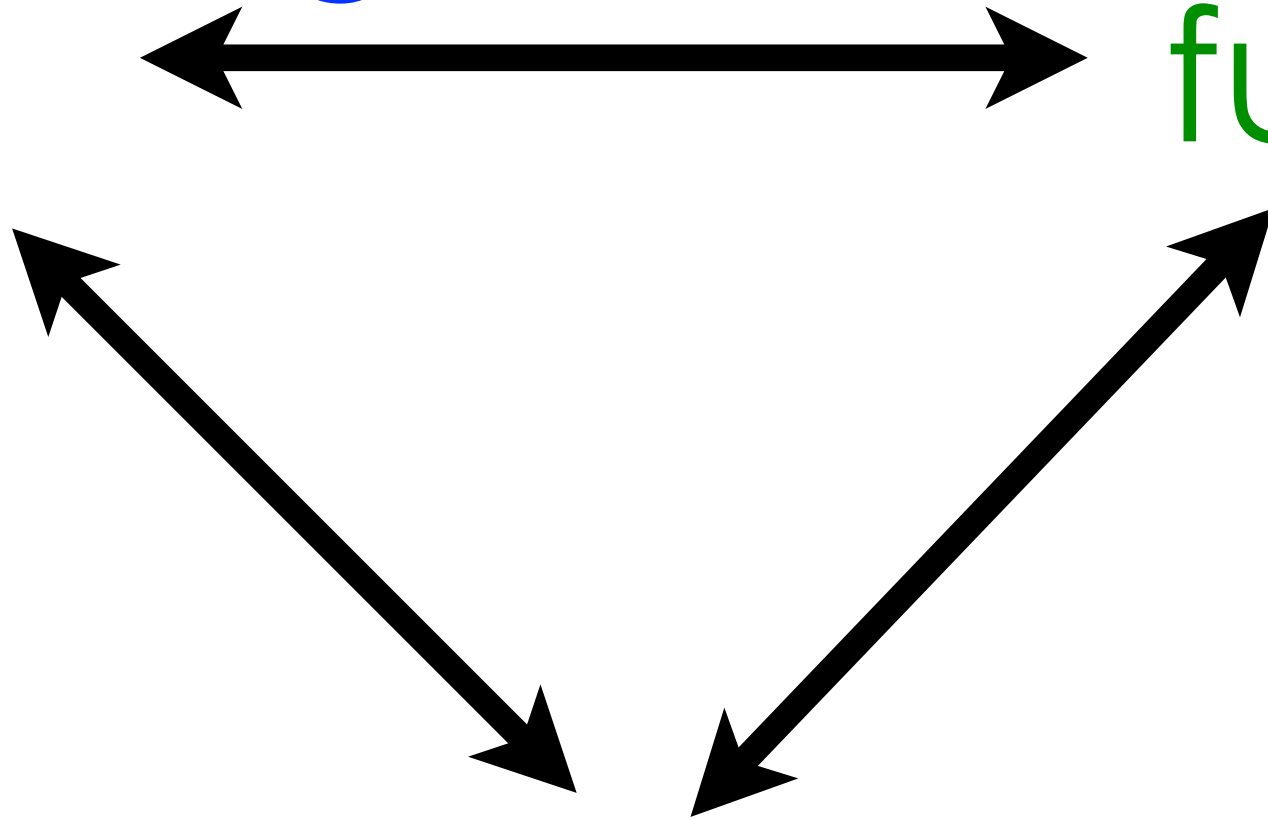
Measure **halo mass** via clustering  
Learn about **cosmological evolution**



The way forward

Clustering

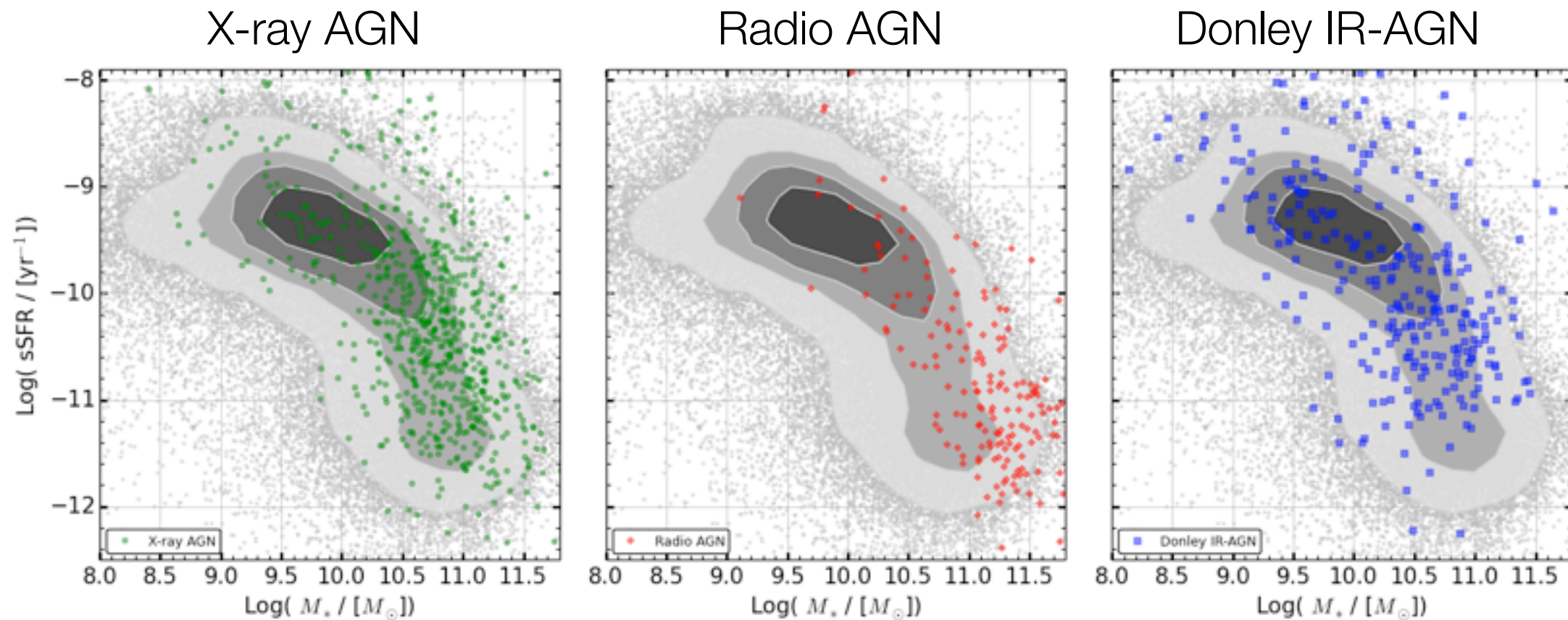
Luminosity  
function



Host galaxies

# The way forward

Understand **selection effects!!**



X-ray Radio IR:Donley





















**Thanks to Mirko and all the organizers  
for a fantastic week!**