Evolution of AGN bias in the COSMOS field

Subdominant role of mergers in triggering moderate luminosity X-ray AGN

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- Max Planck IPP -

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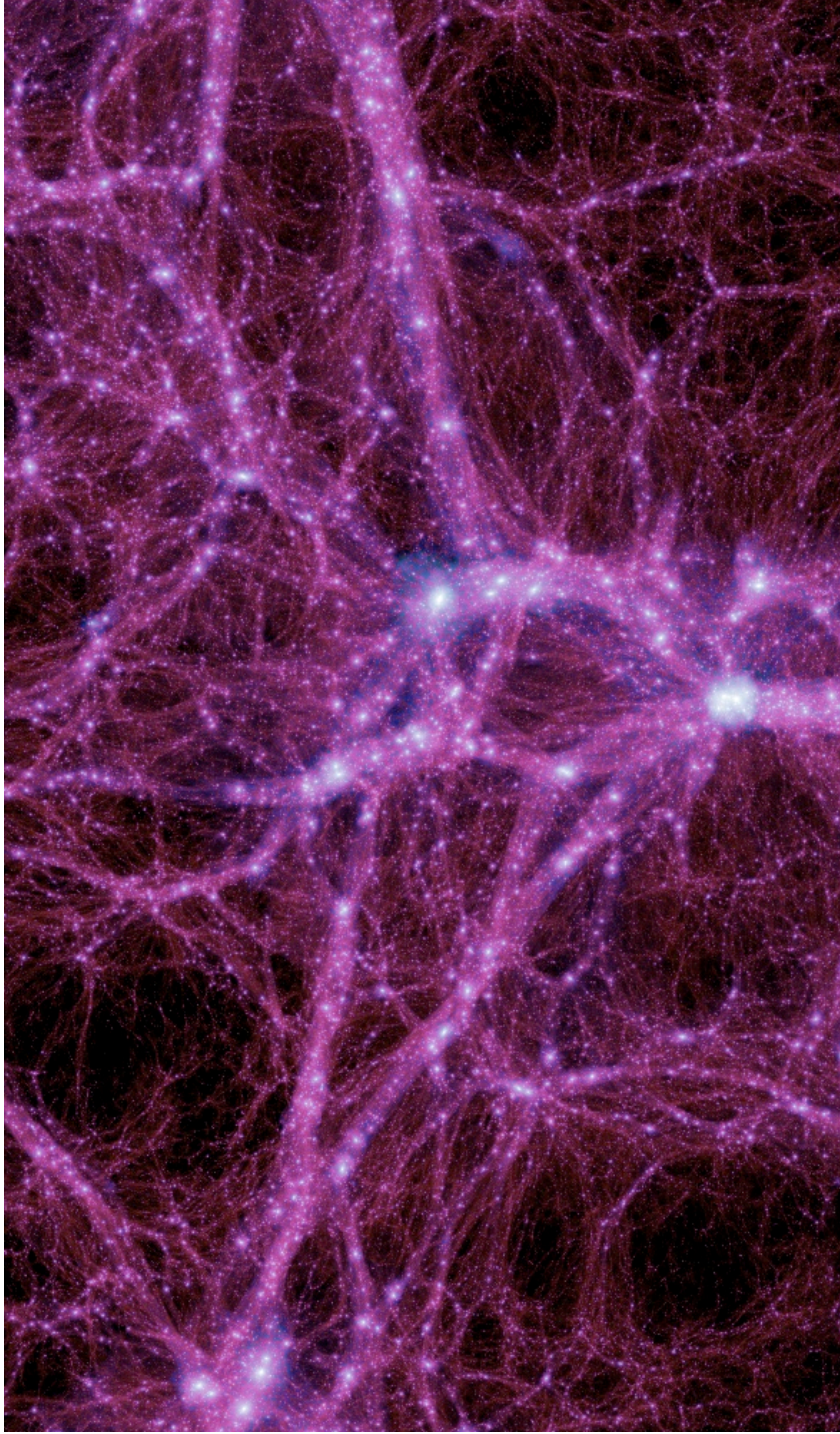
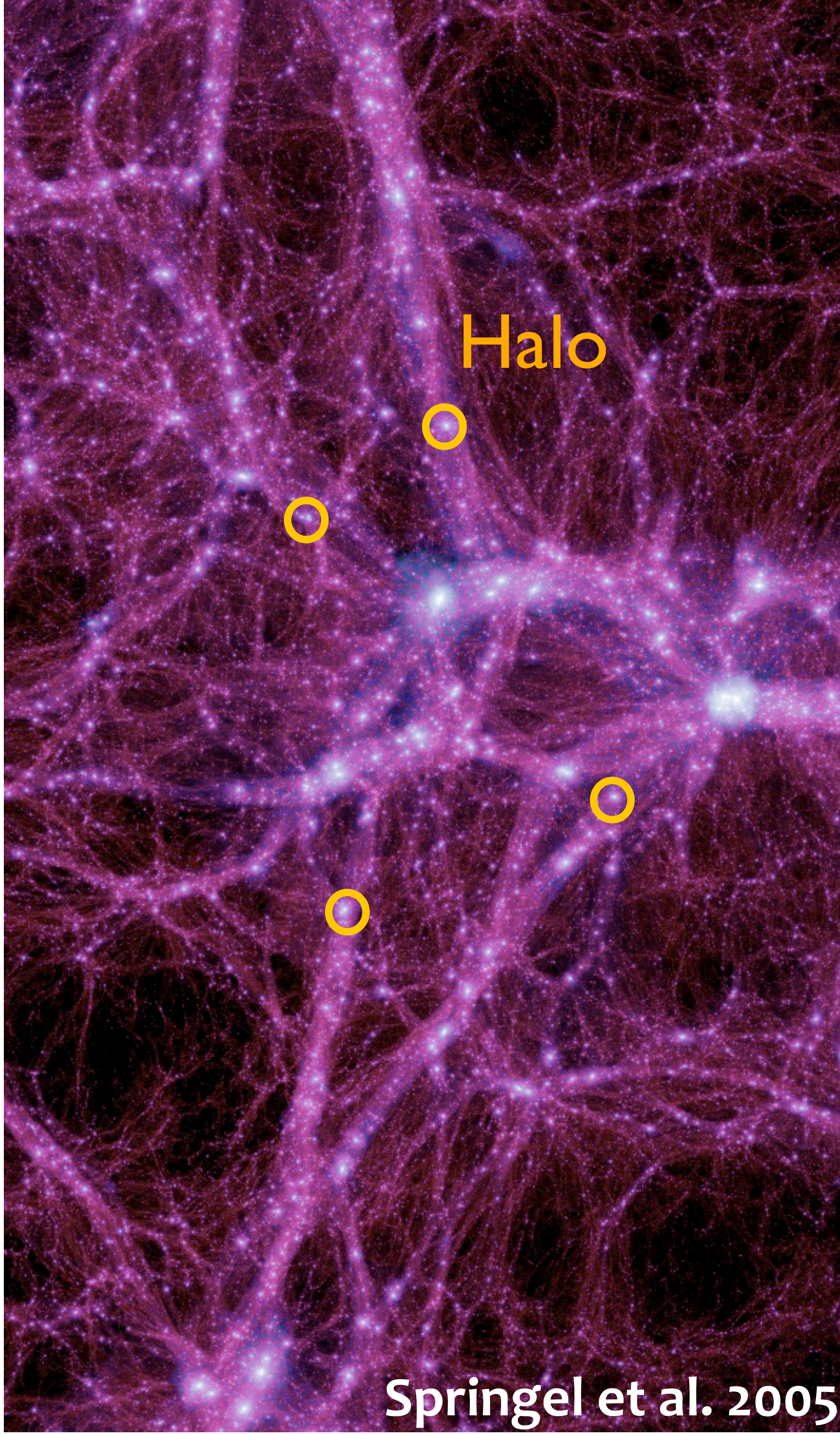
M. Salvato, M. Brusa & COSMOS Team

X-ray Universe 2011,
Berlin June 30



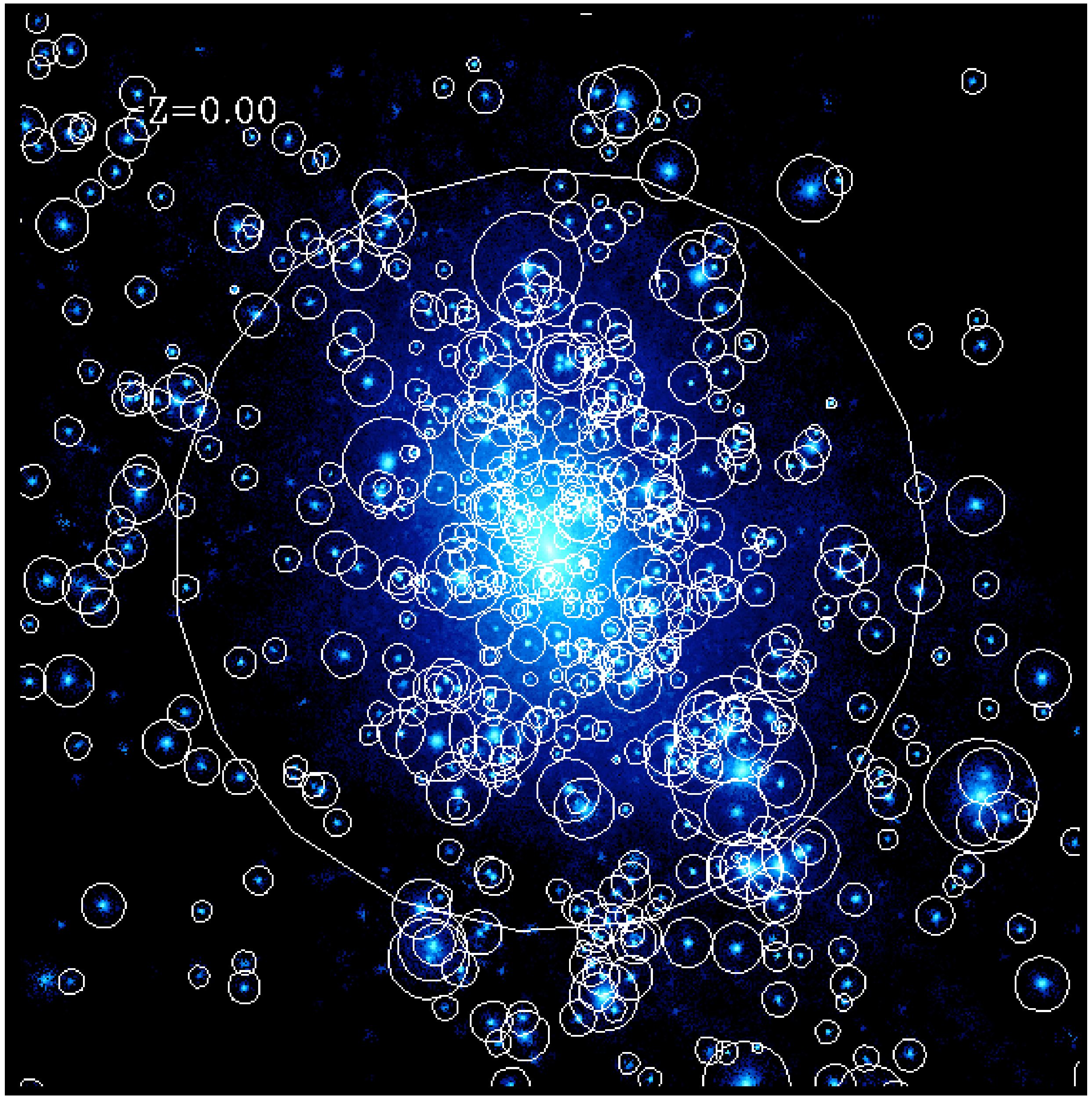
Biased Galaxy Formation

- **Galaxies form** from the same **primordial density fluctuations**
- **Dark matter collapses in halos** which are sites of high peaks in the initial density field
- **Galaxies only reside** in dark matter **halos**
- **Galaxies are biased tracers** of the overall matter distribution

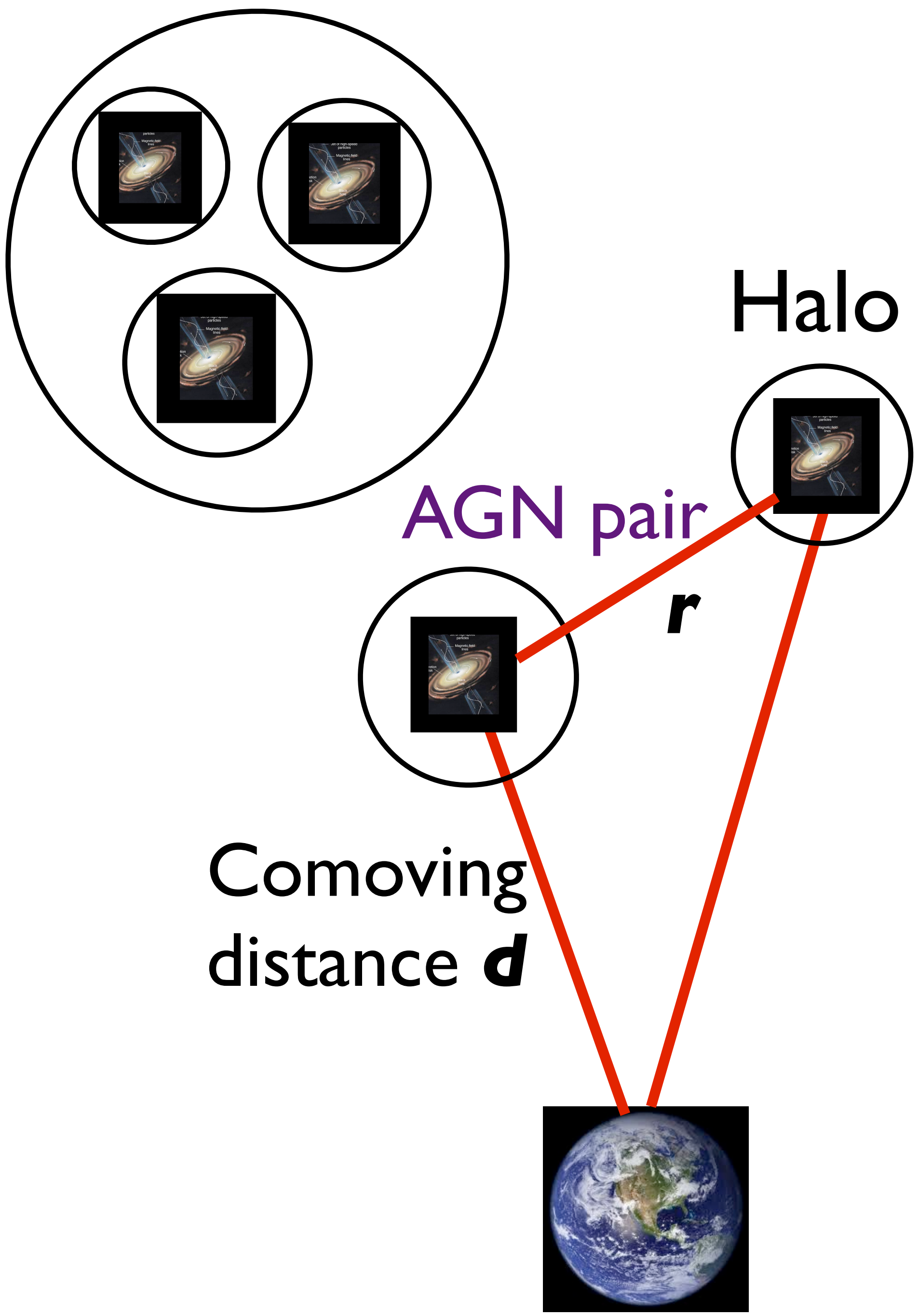


Halo Model

- **AGN reside in DM halos**
- The **halo mass** is the only thing that **impacts the clustering of objects**
- **Ingredients**:
  - Density profile of halos $\rho(M_h)$
    Navarro et al. 1997, Cooray & Sheth 2002; Knollmann et al. 2008; Stadel et al. 2009
  - Halo mass function $n(M_h)$
  - Halo bias factor $b(M_h)$
    Sheth & Tormen 1999, Sheth et al. 2001, Tinker et al. 2005, Tinker et al. 2010
  - **AGN H**alo **O**ccupation **D**istribution $N(M_h)$

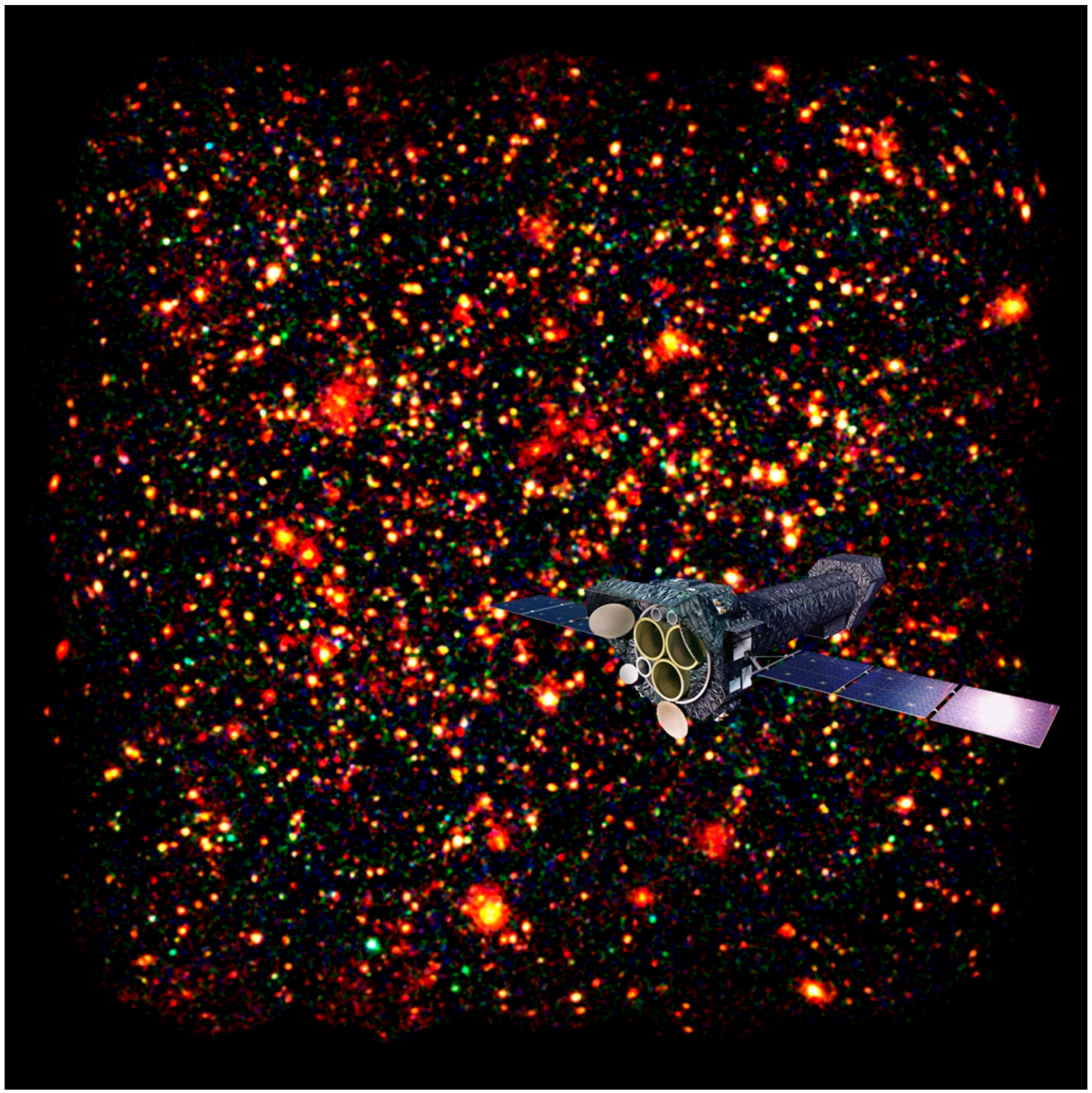


Correlation Function



- Correlation function tells **how strongly are AGN clustered**
- Projected ACF $\mathbf{w_p(r_p)}$:
  $w_p(r_p) \propto N_{pair}$ separated by r_p
  $\mathbf{r_p}$: projected separation between AGN pairs
- $\mathbf{w_p(r_p) = 0}$
  AGN are randomly distributed
- **Estimators:**
  Landy & Szalay 1993

XMM-COSMOS AGN



XMM-COSMOS survey

XMM-Newton selected sources

Hasinger et al. 2007, Cappelluti et al. 2007, Cappelluti et al 2009

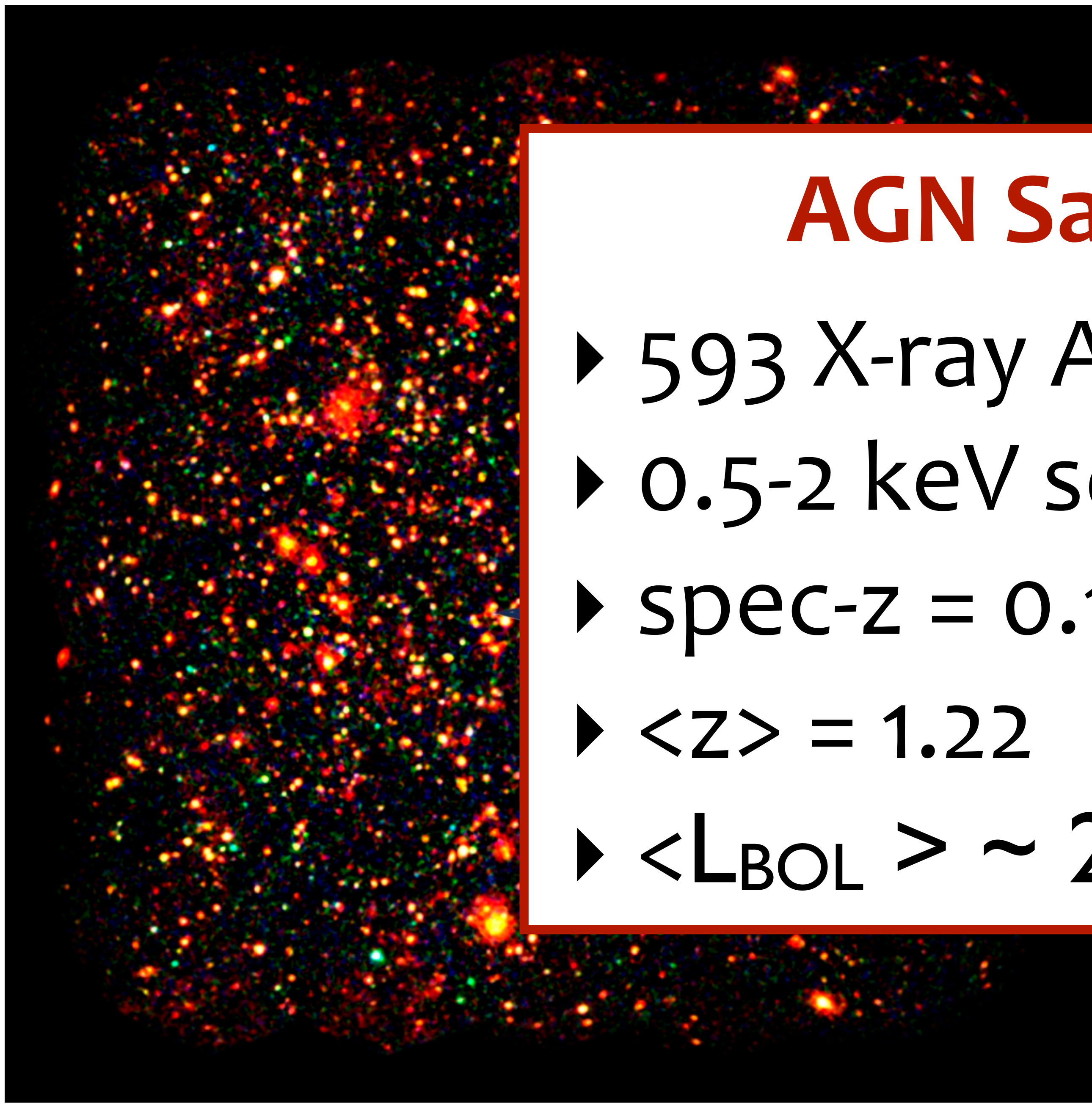
- 2.13 deg^2
- 0.5-10 keV energy band
- 1822 X-ray sources

Multiwavelenght Catalog

Brusa et al. 2010

- 1797 sources
- optical identification
- multiwavelength properties
- z information

XMM-COSMOS AGN



XMM-COSMOS survey

AGN Sample:

- 593 X-ray AGN
- 0.5-2 keV soft band
- spec-z = 0.1 - 4
- $\langle z \rangle = 1.22$
- $\langle L_{BOL} \rangle \sim 2 \times 10^{45}$ erg s^{-1}

XMM-Newton selected sources

...ppelluti et al. 2007,

...rgy band

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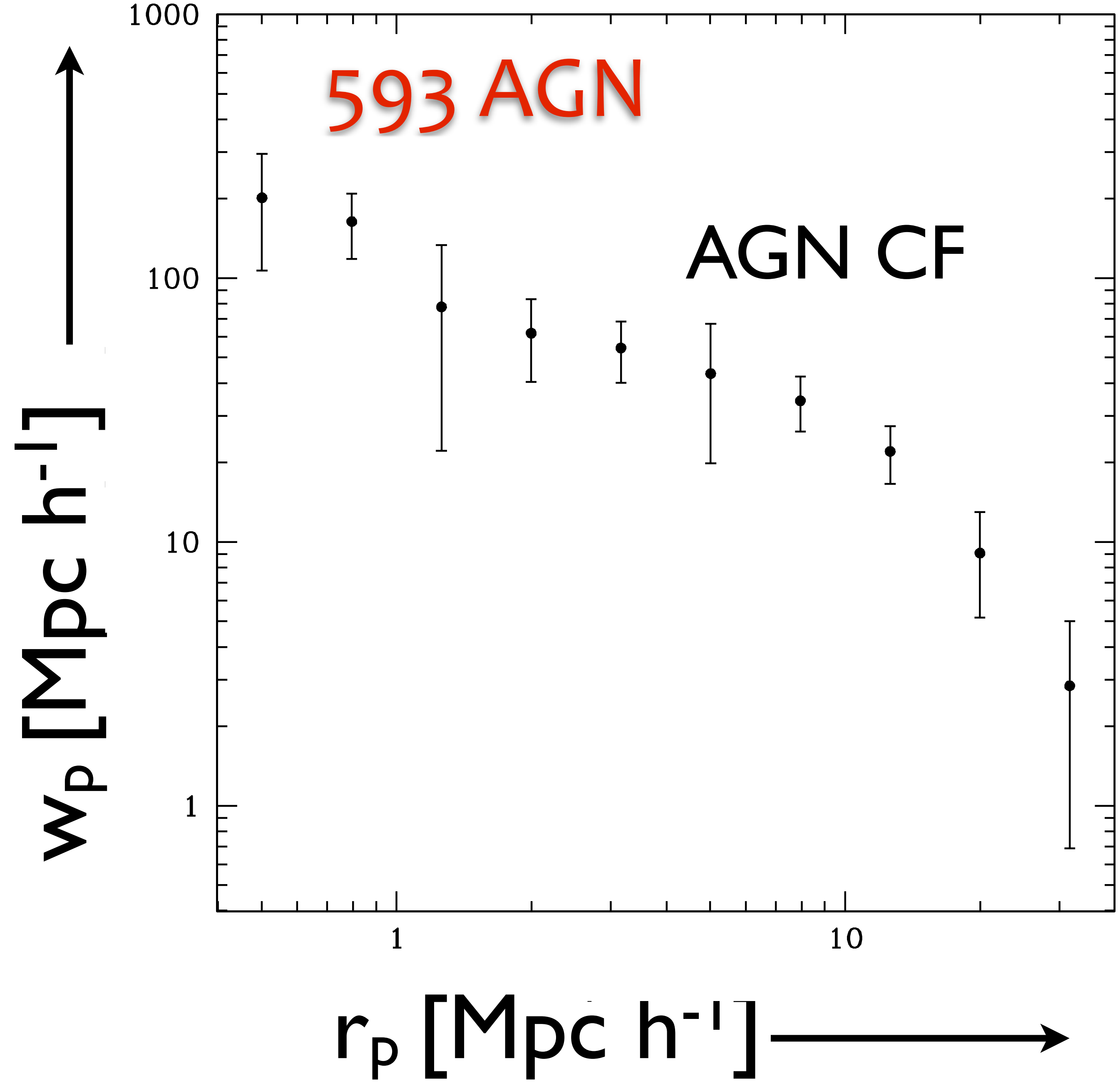
AGN projected CF



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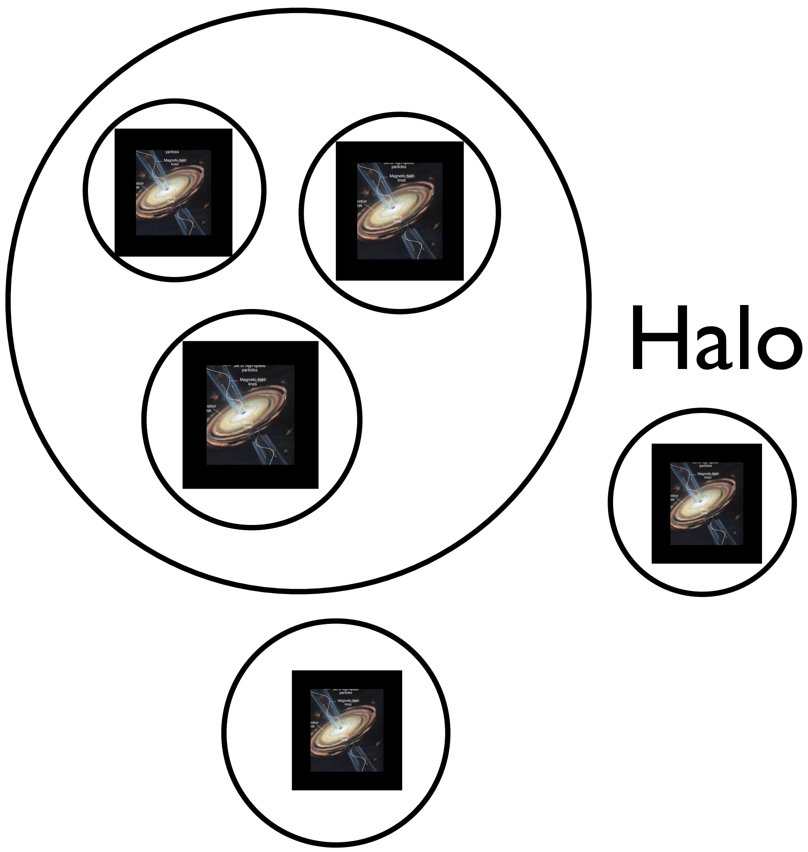
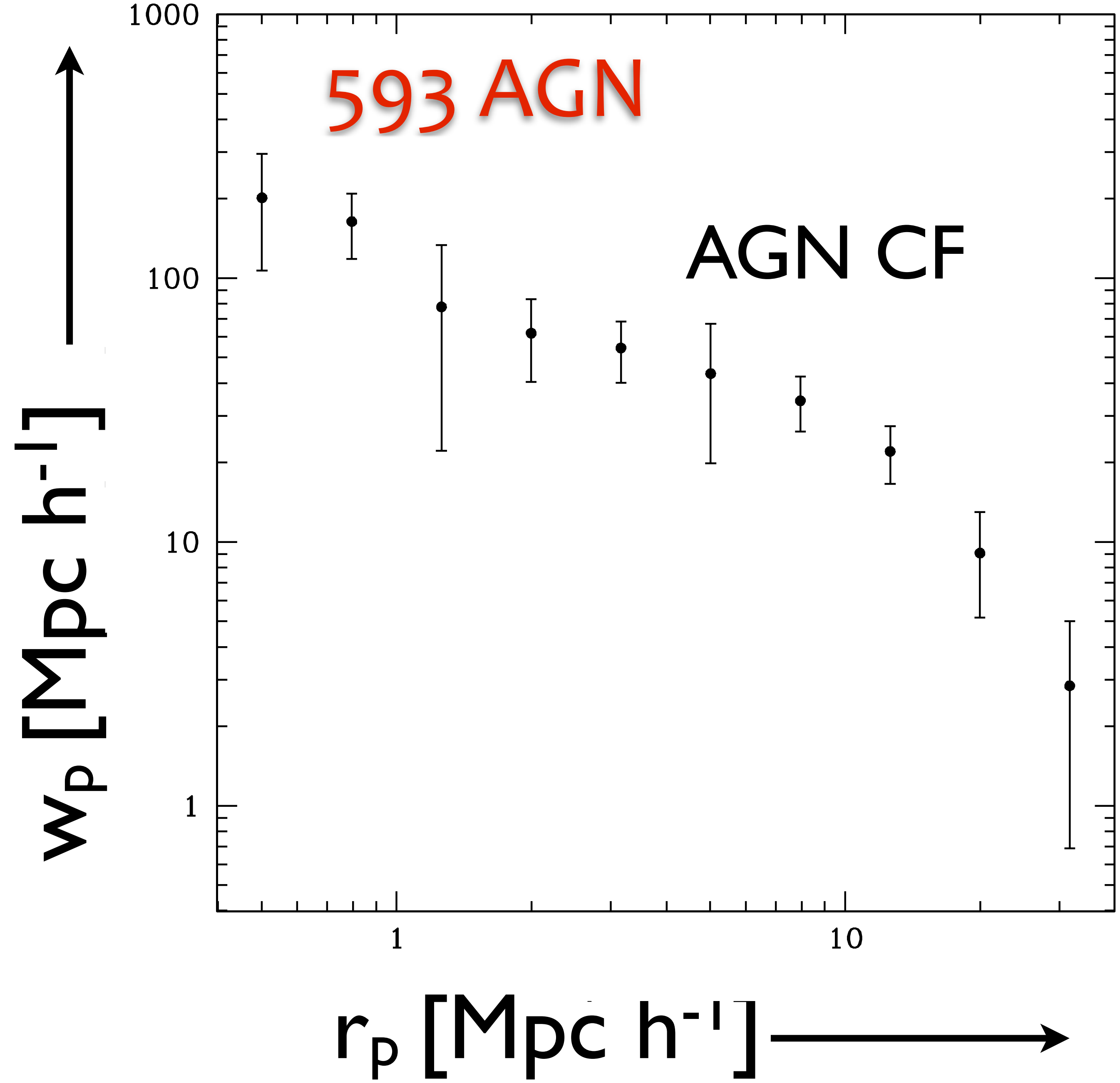
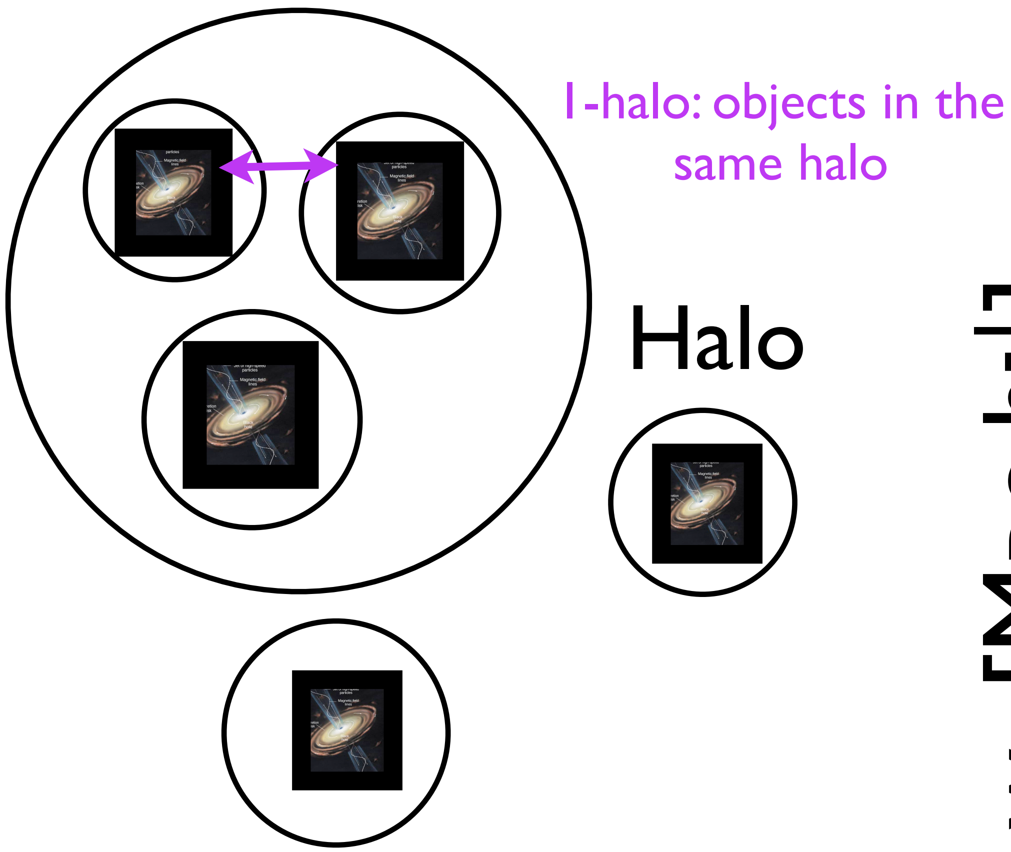
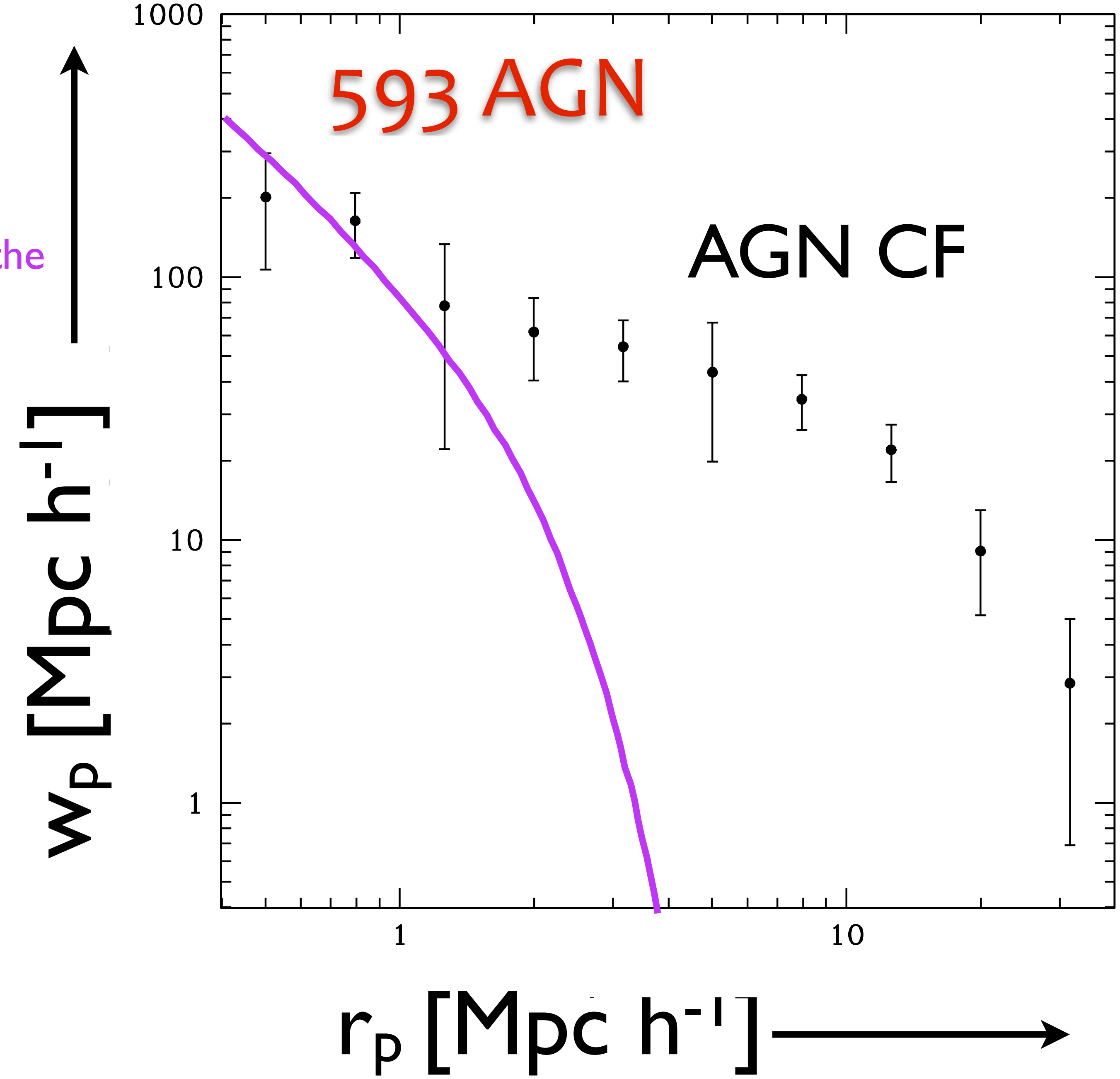




$$w_{AGN}(r_p) = w_{AGN}^{1-h}(r_p) + w_{AGN}^{2-h}(r_p)$$

AGN projected CF





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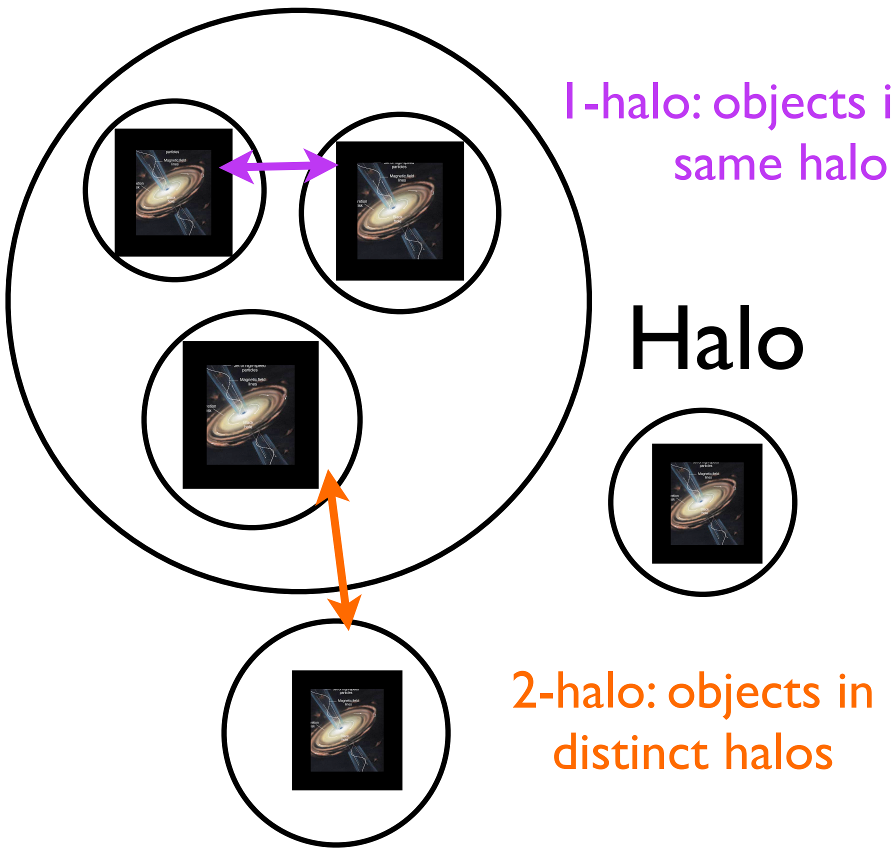

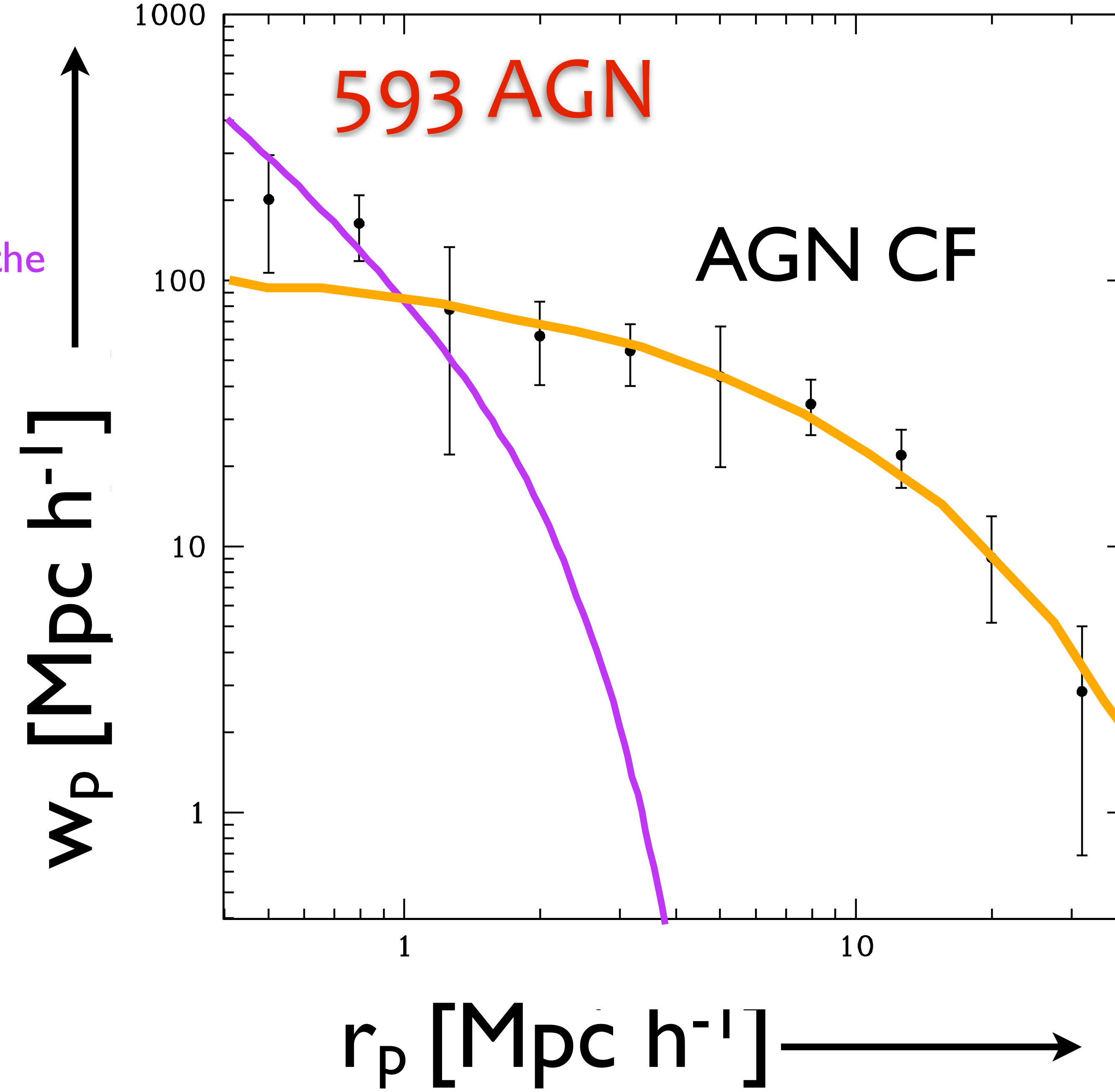

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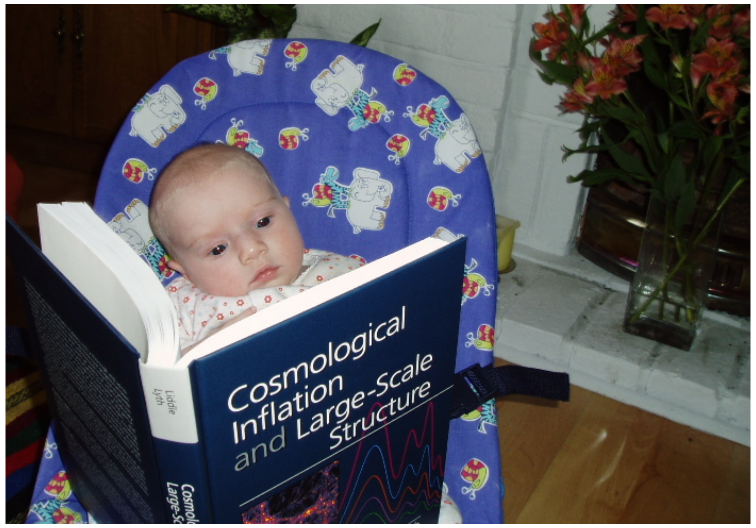
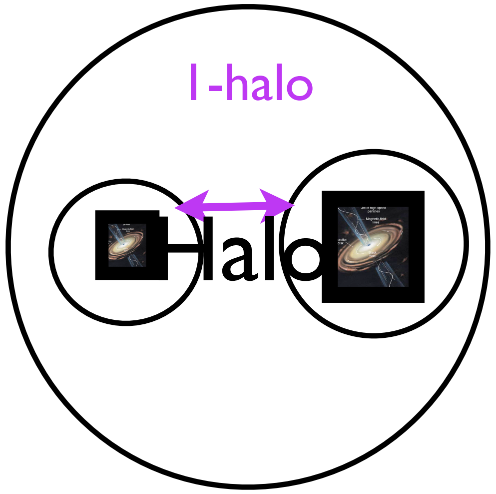
What can we learn from clustering?





- On small scales **r_p≤1-2 Mpc h^{-1}** the 1-halo term infers how AGN populate the halo:
AGN Halo Occupation Distribution

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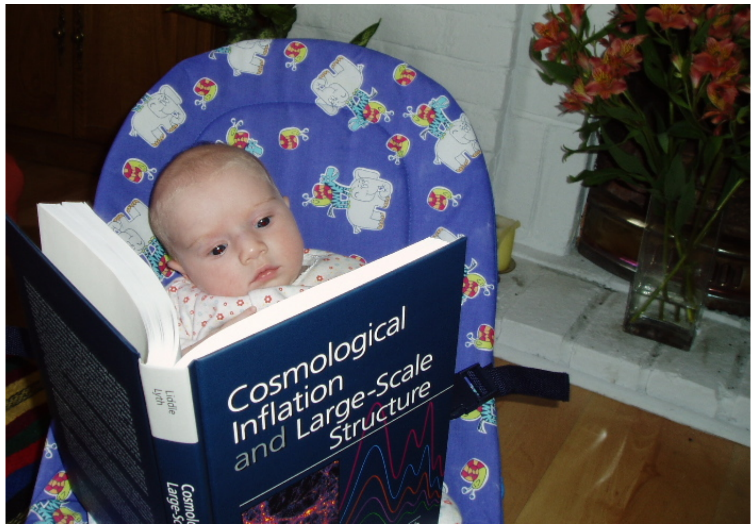
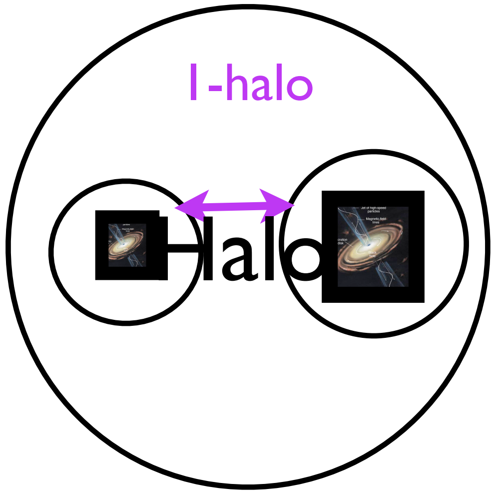
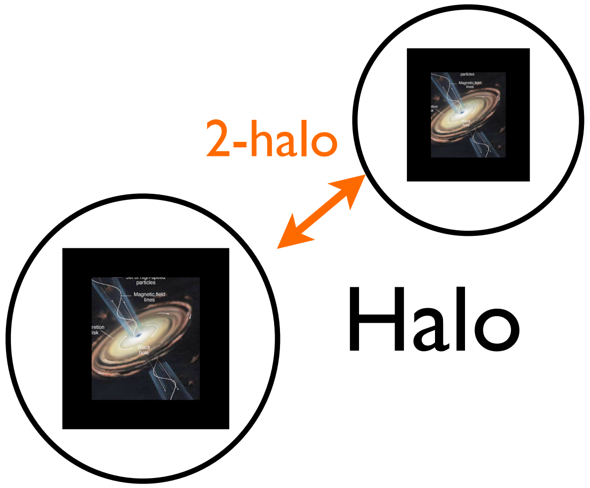




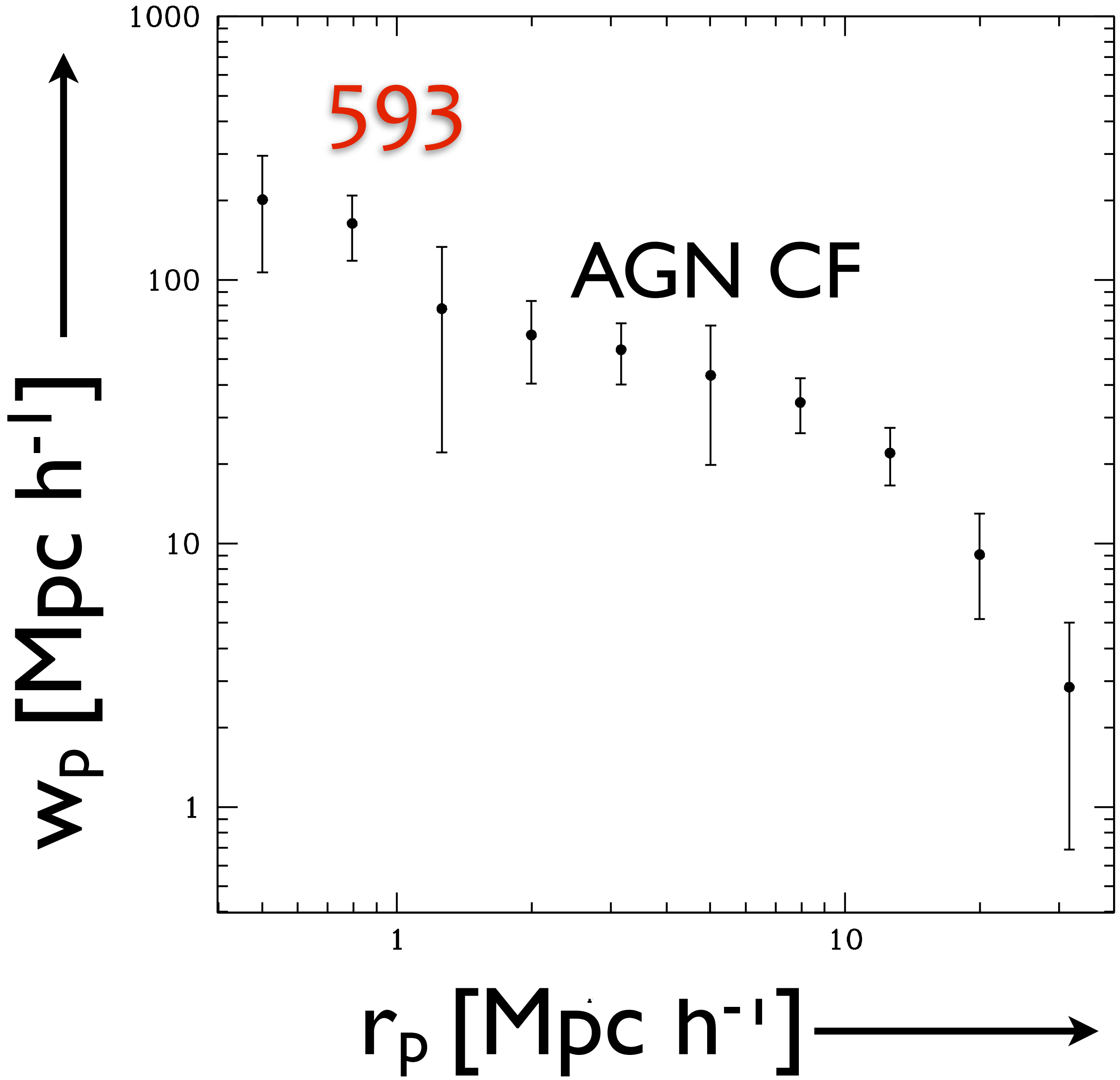
- On small scales $r_p \leq 1$-2 **Mpc h^{-1}** the 1-halo term infers how AGN populate the halo:
  AGN Halo Occupation Distribution



- On large scales $r_p > 1$-2 **Mpc h^{-1}** the 2-halo term infers:
  AGN Bias Factor
  Typical DM Halo Mass

2-halo term

- We are interested in the AGN **bias** which is an indicator of the **mass of the DM halos** they live in



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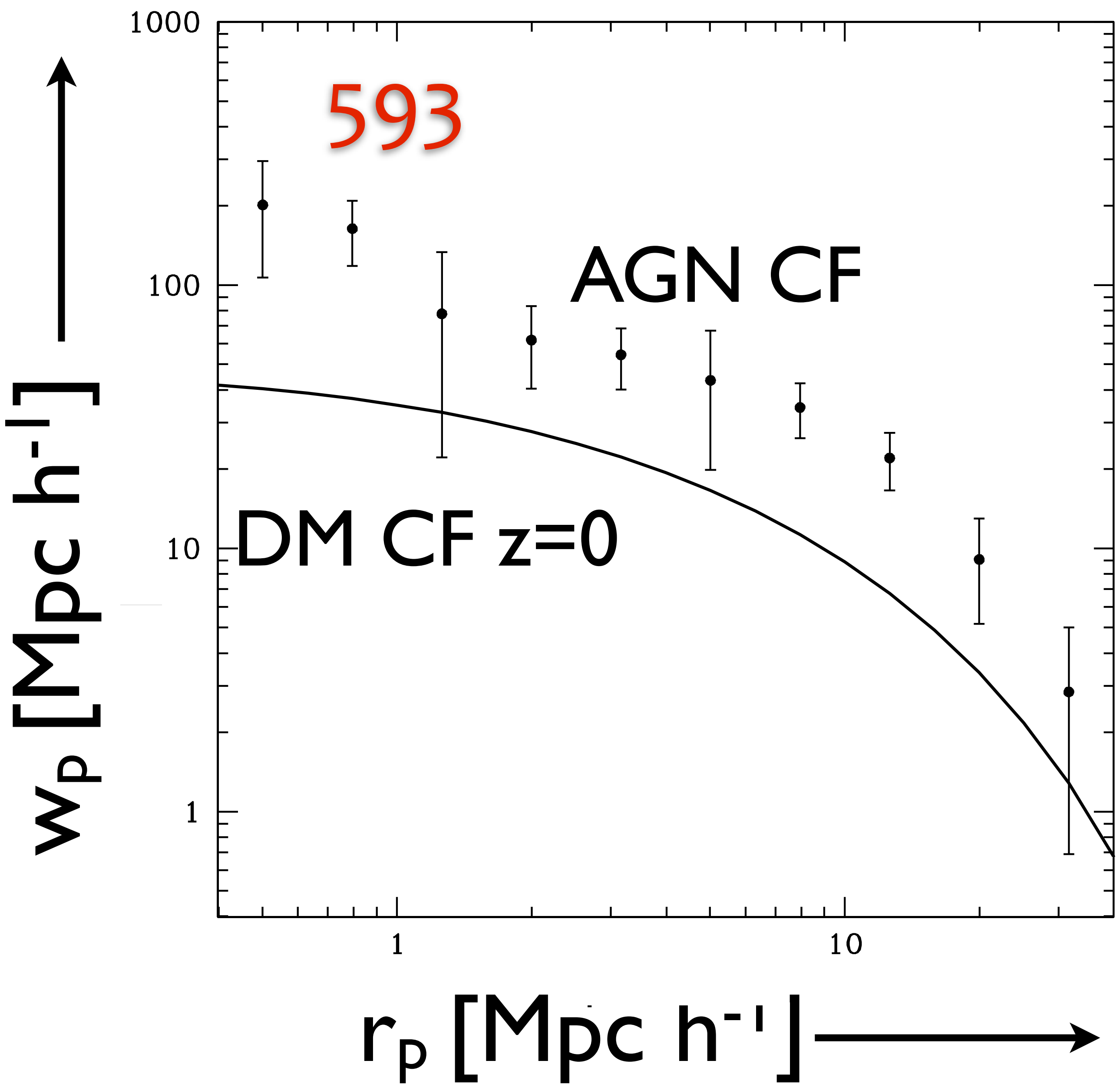

- In linear regime:

$$w^{2-h}_{AGN}(r_p) = b^2_{AGN} w^{2-h}_{DM}(r_p)$$

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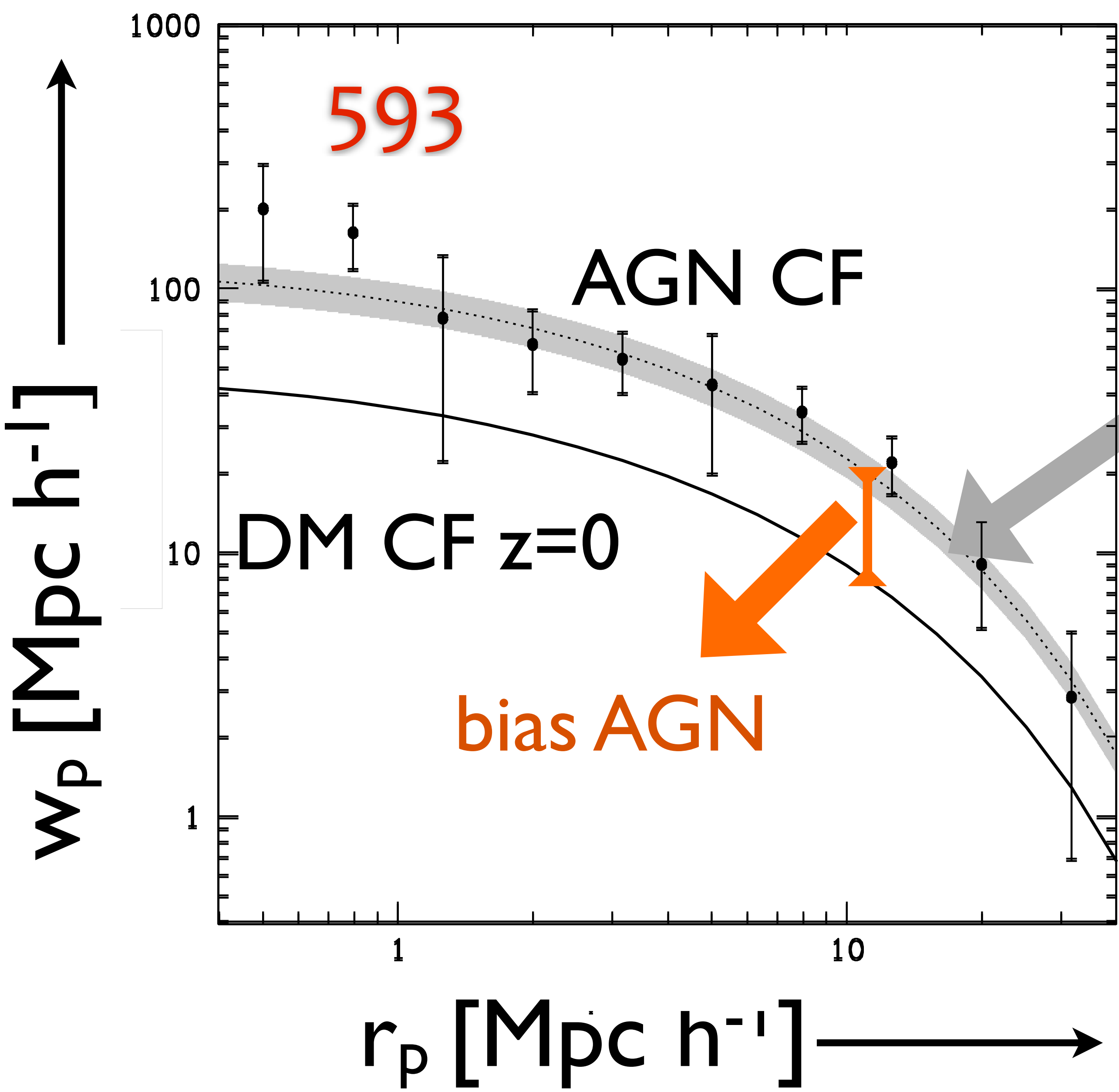
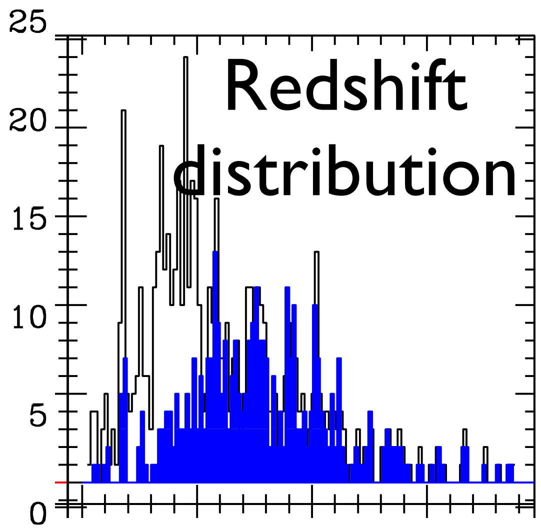


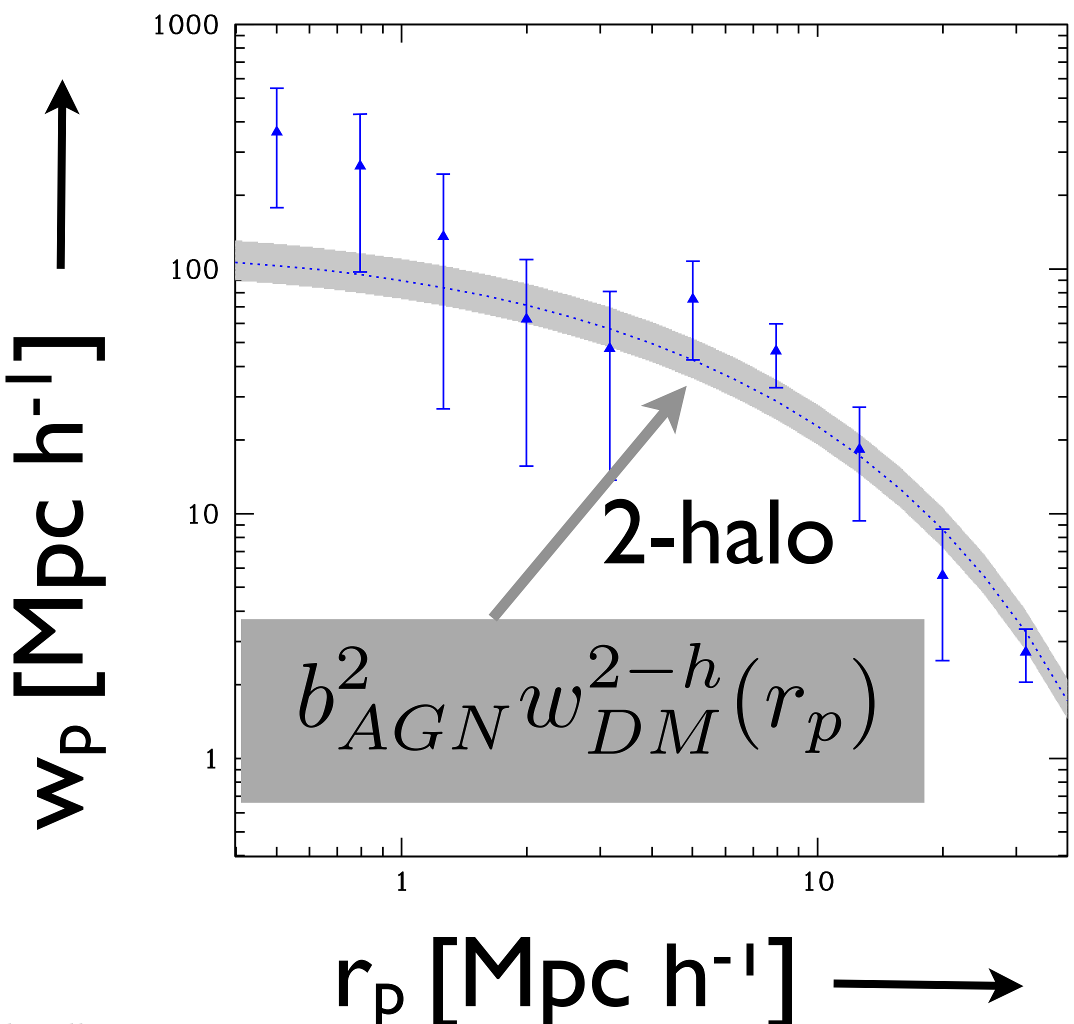
- In linear regime:

$$w^{2-h}_{AGN}(r_p) = b^2_{AGN} w^{2-h}_{DM}(r_p)$$

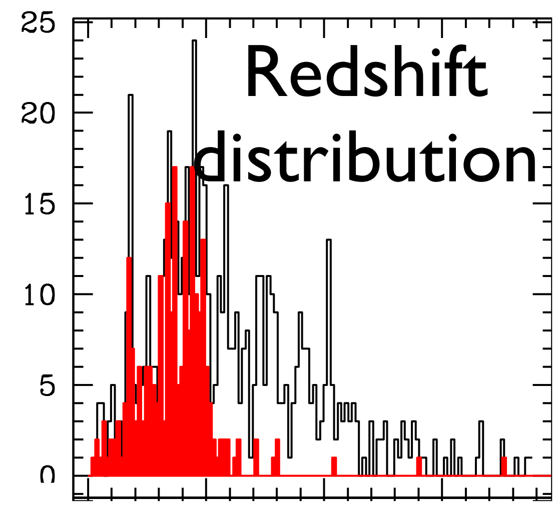
Ty 1 AGN



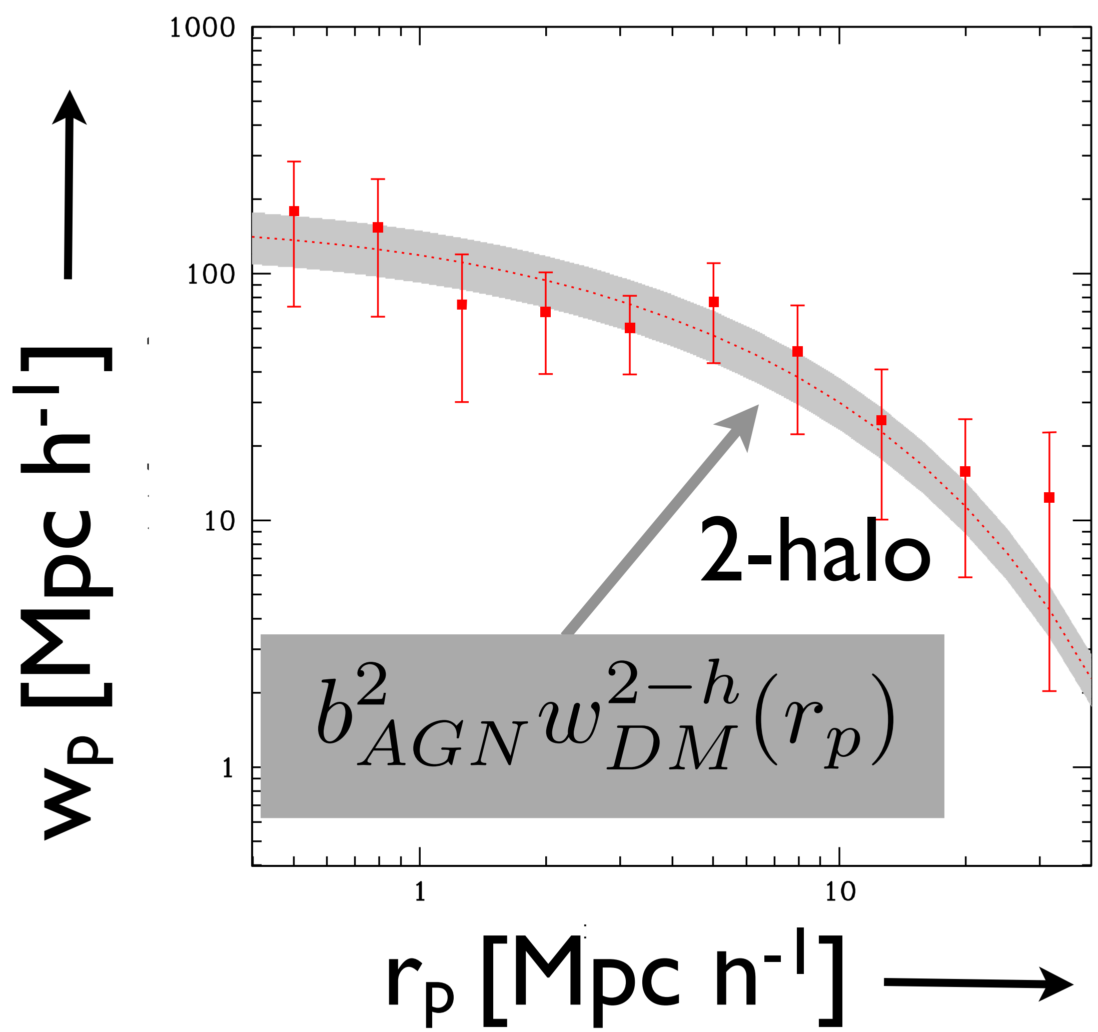
N = 354
z ~ 1.55



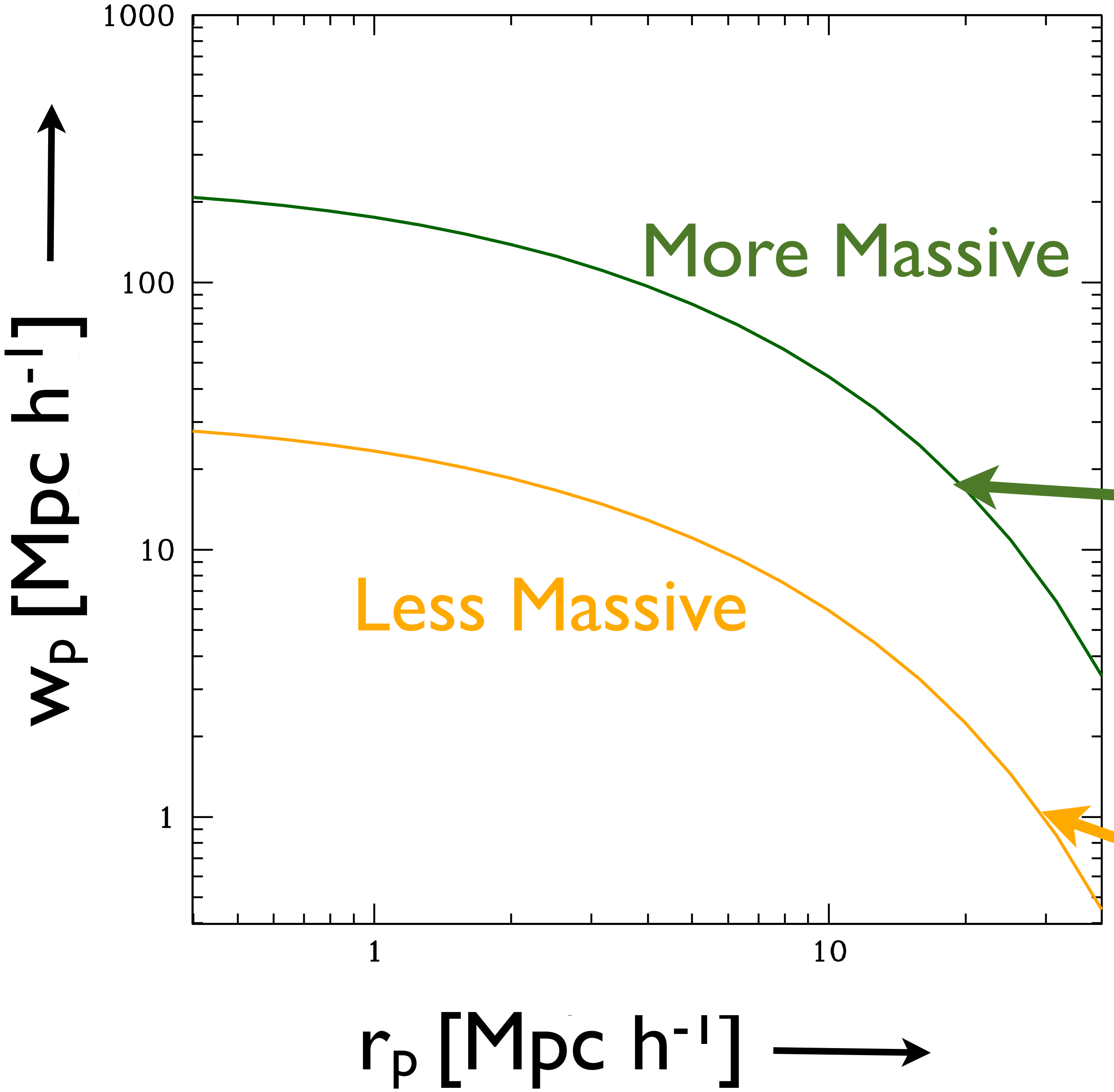
Ty 2 AGN

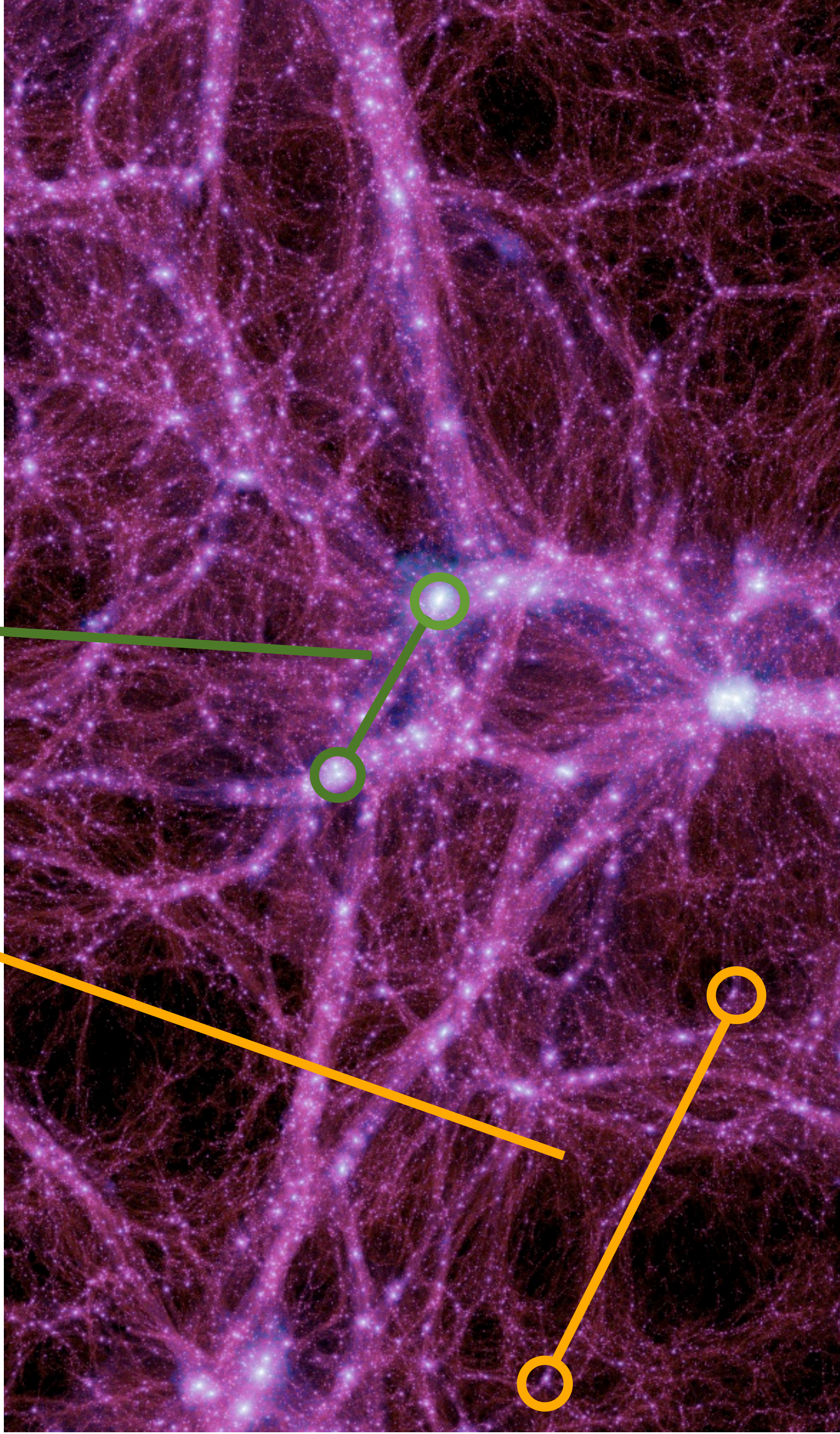


N = 239
z ~ 0.7



DM Halo Mass





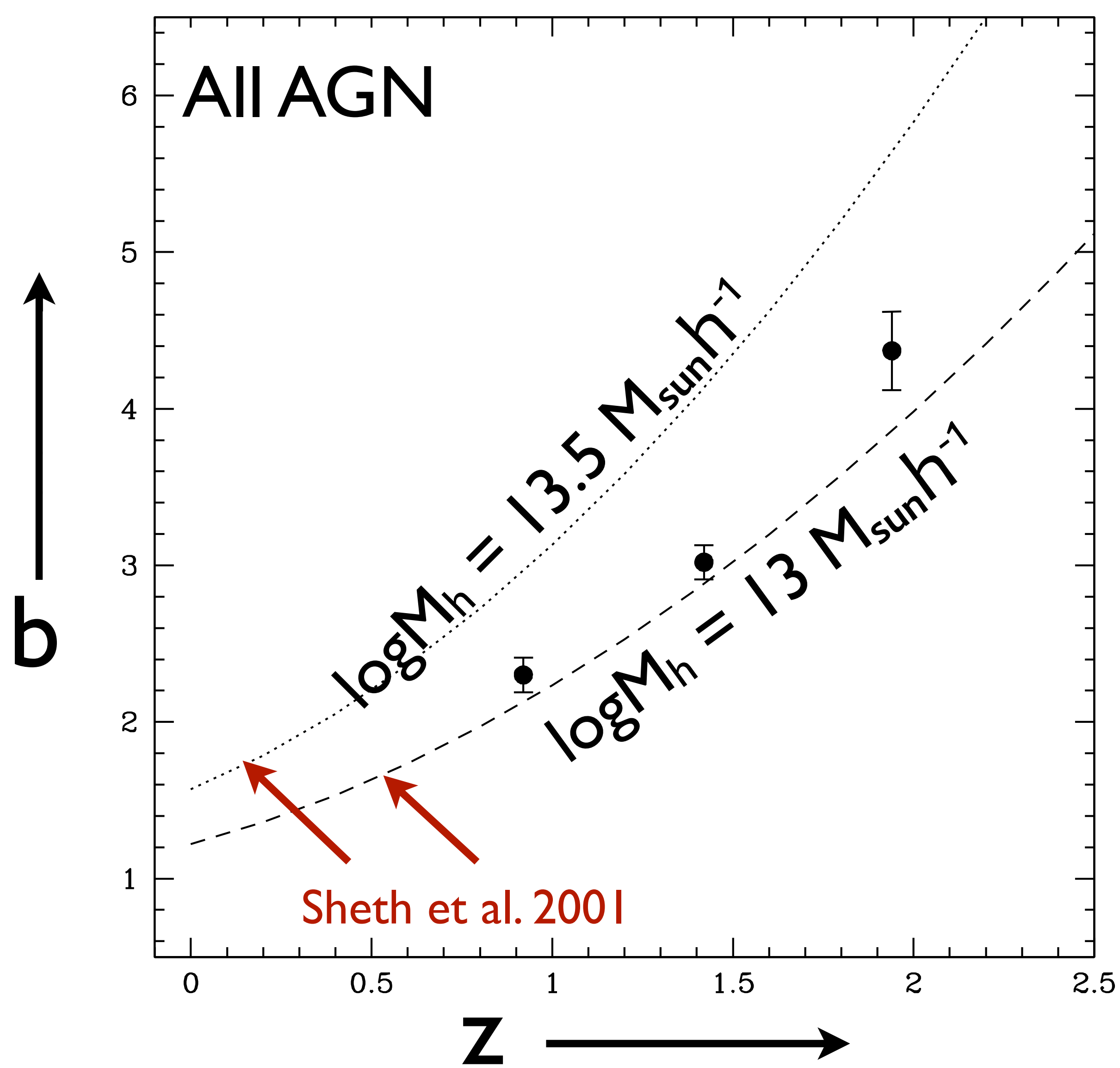
bias AGN ⇔ M_h

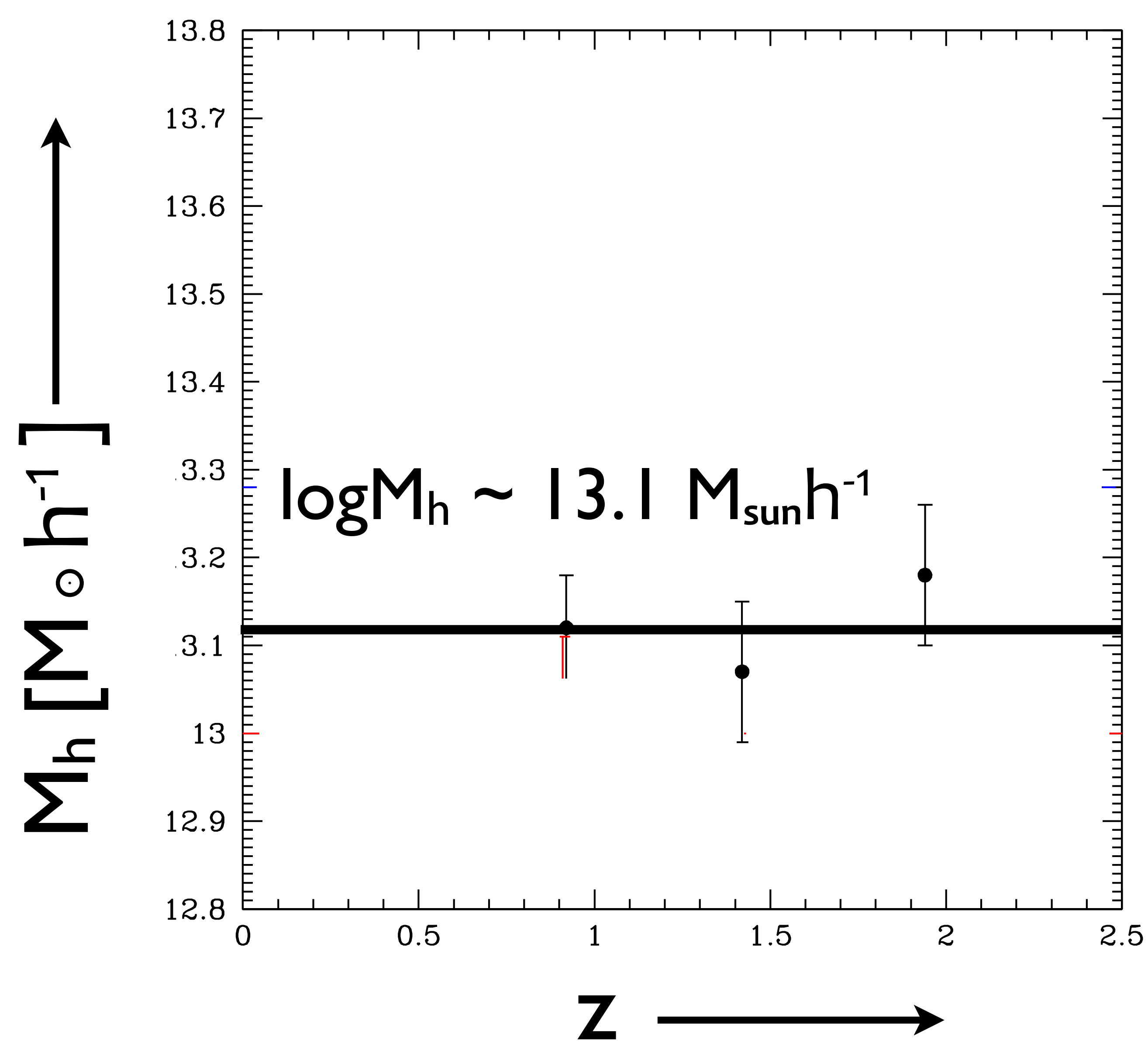
Sheth & Tormen 1999, Sheth et al. 2001,

Tinker et al. 2005, Tinker et al. 2010

Results - bias evolution

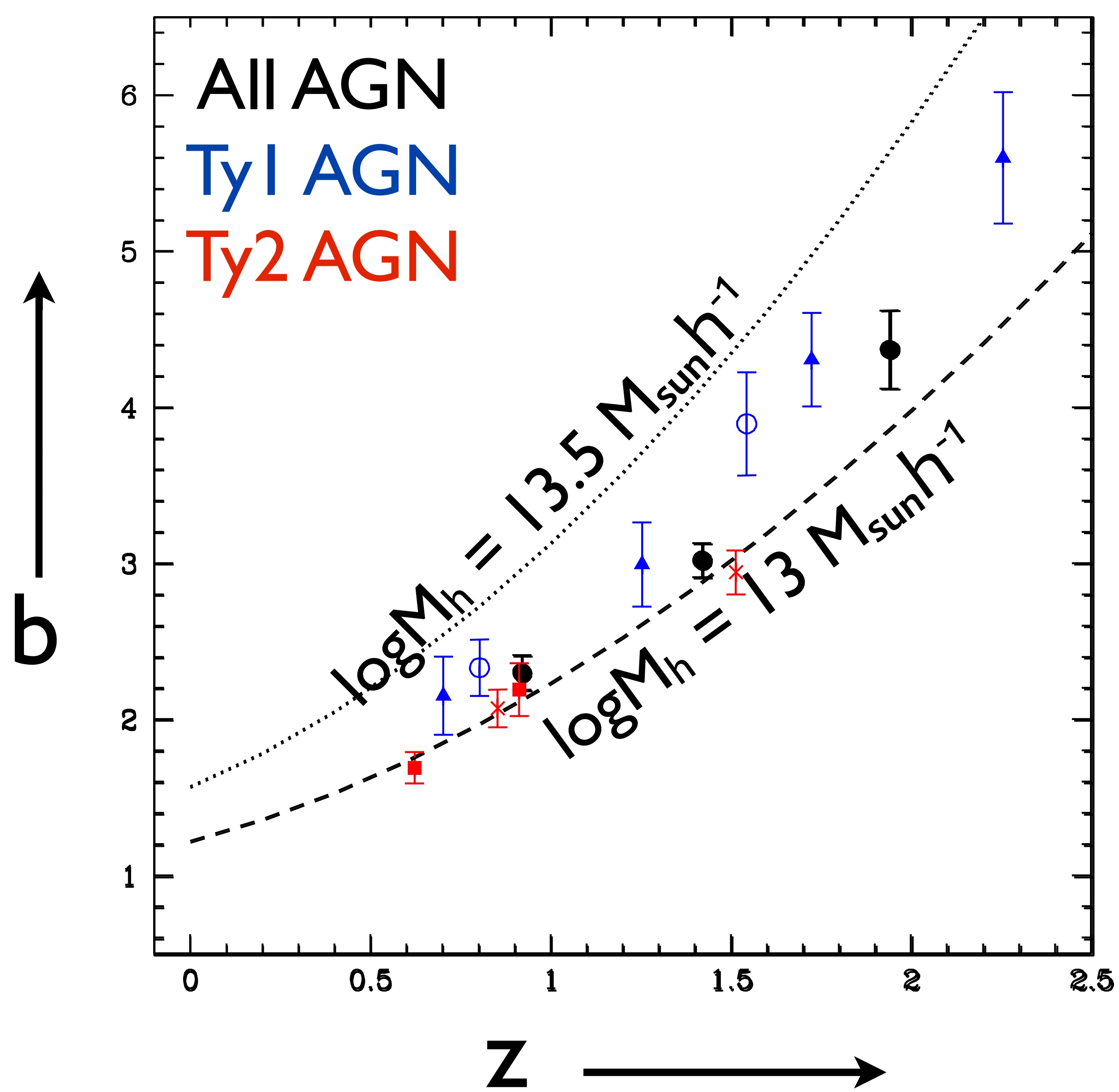
- AGN **bias increases** with redshift with **constant DM halo mass;**

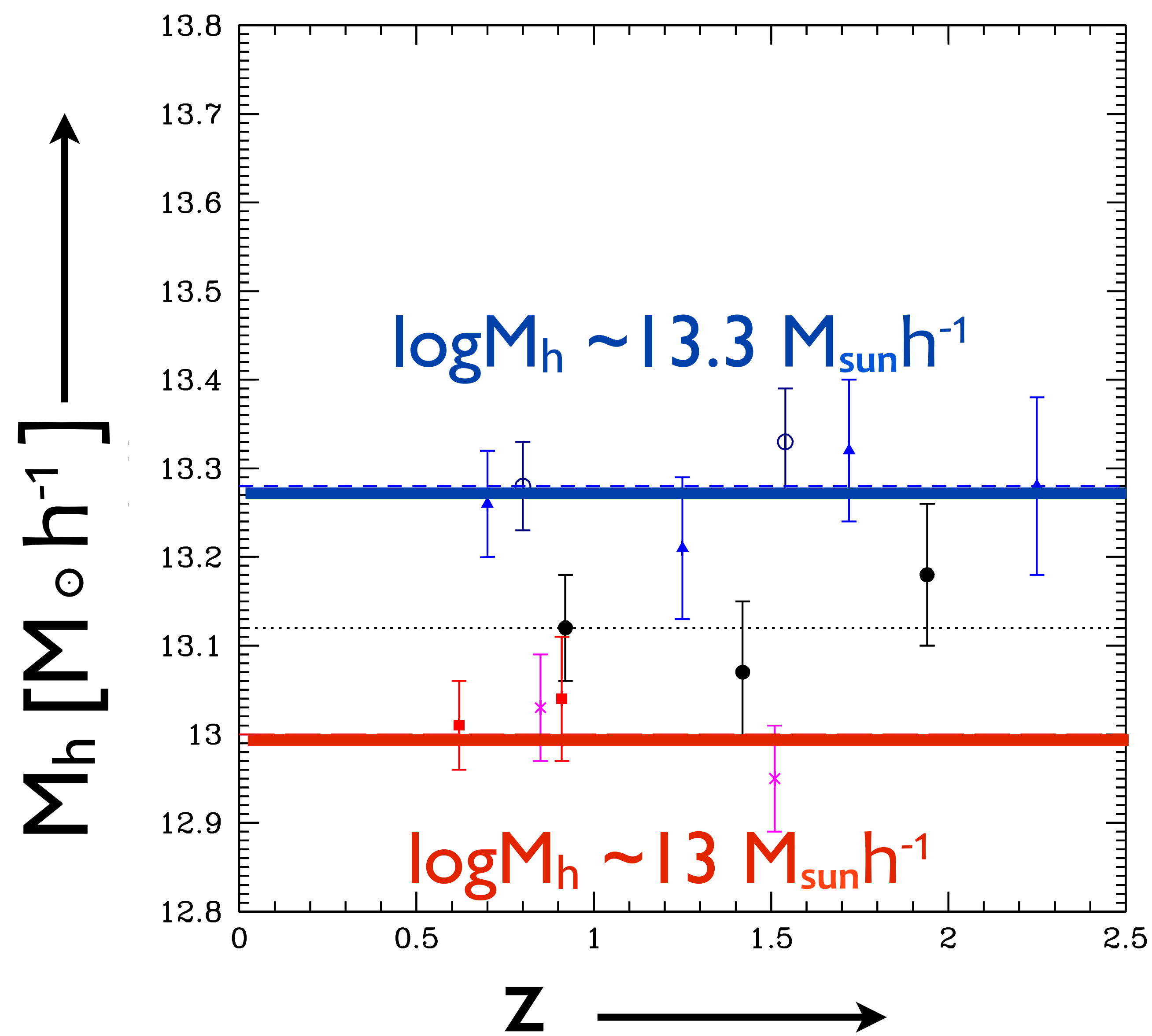




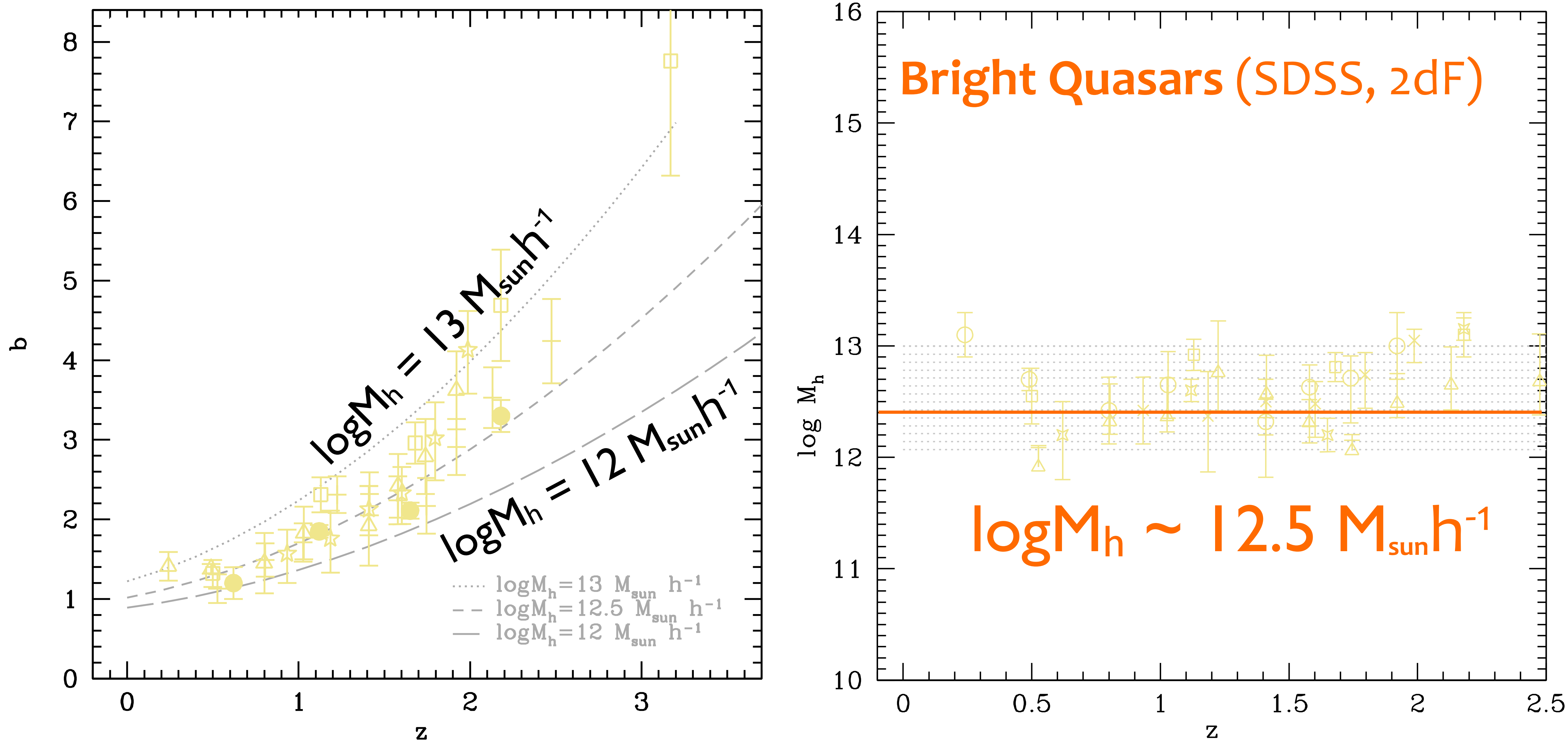
Results - bias evolution

- AGN **bias increases** with redshift with **constant DM halo mass;**
- Ty1 AGN **reside in more massive halos** compared to Ty2 AGN at ~ 2σ level;





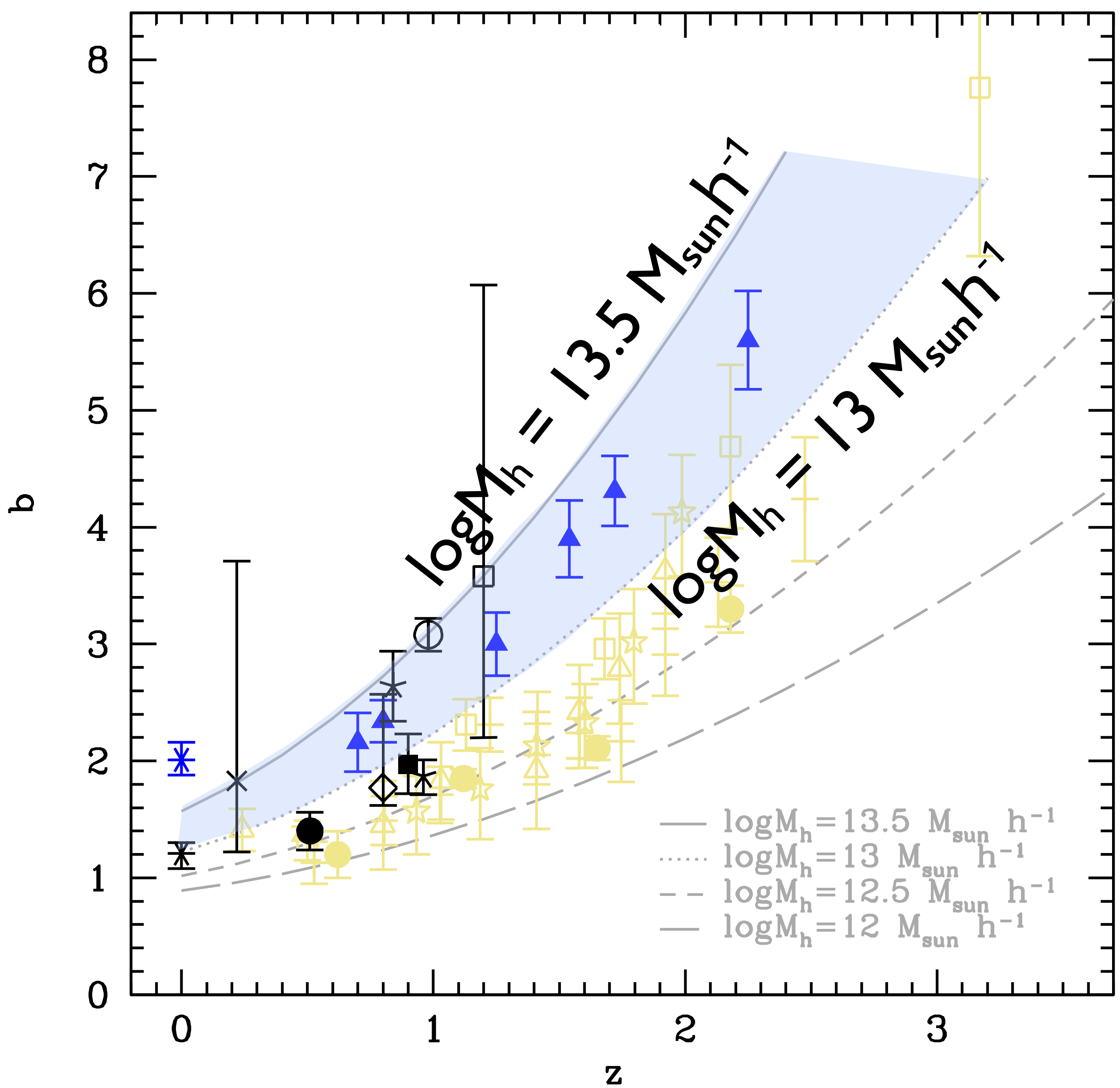
Optically Selected Bright Quasars

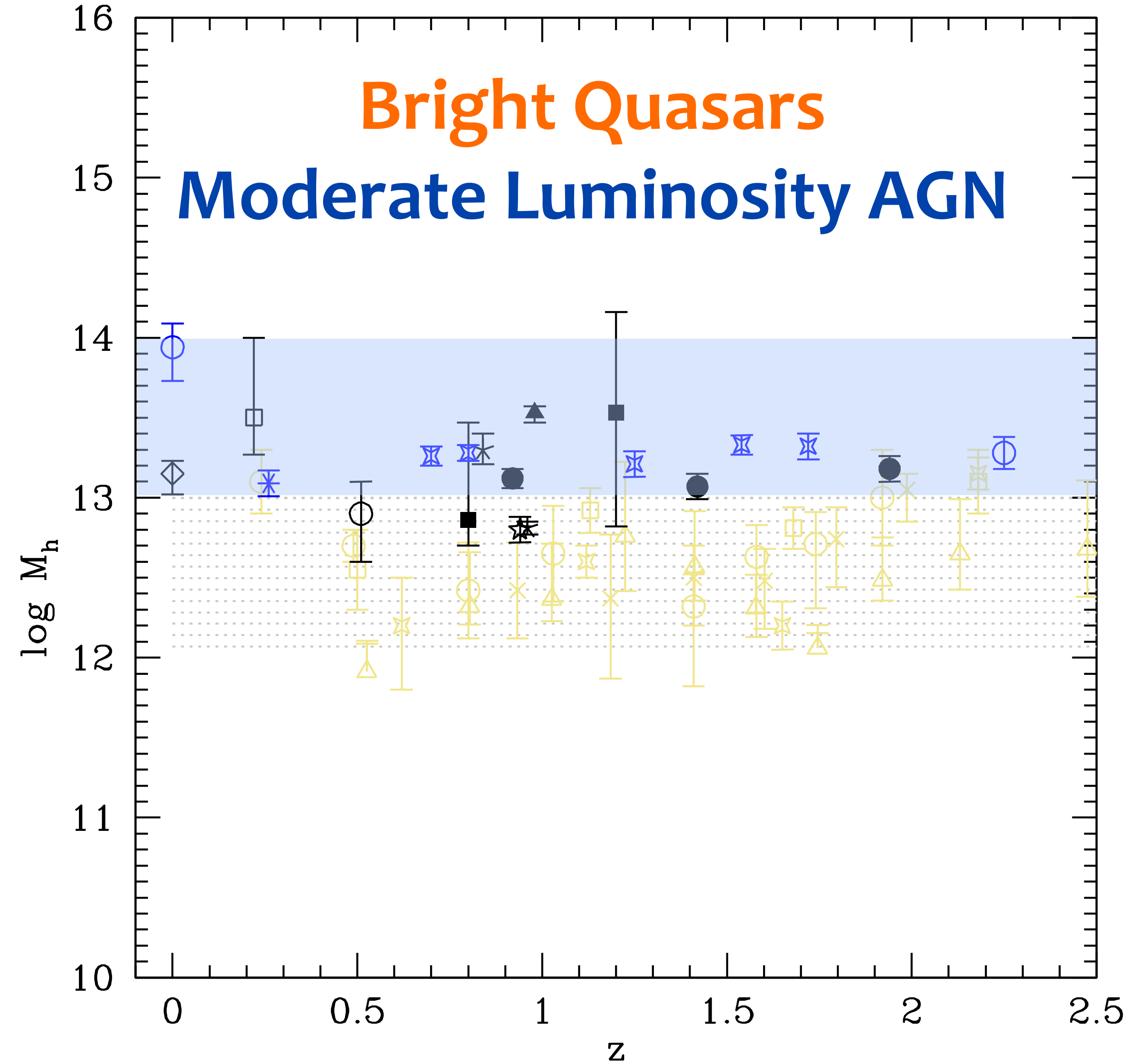


Ty 1 bright quasars reside in DM halos of constant mass up to z ~ 3

(Croom et al. 2005, Porciani & Norberg 2006, Coil et al. 2007, Myers et al. 2007, da Ângela et al. 2008, Shen et al. 2009, Ross et al. 2009)

Moderate luminosity AGN

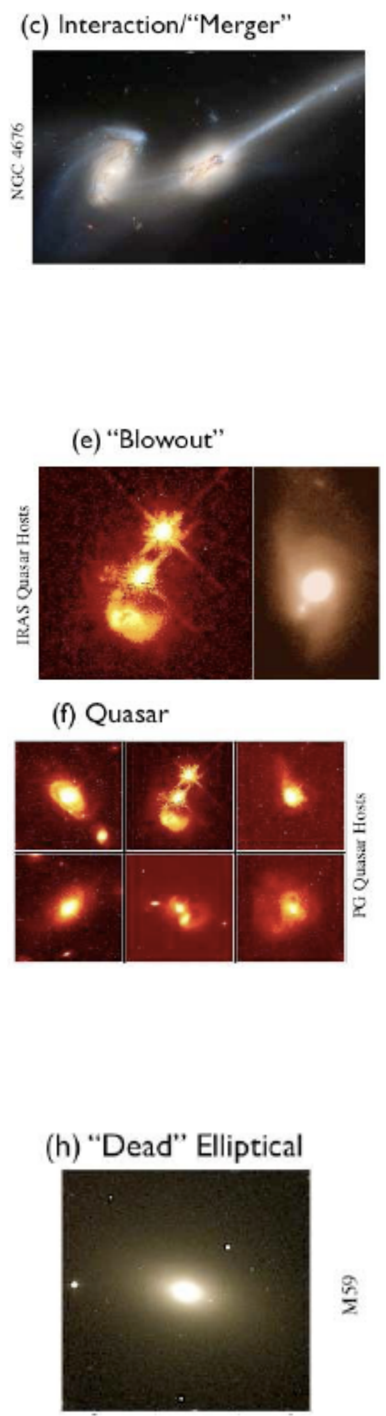




Moderate luminosity AGN reside in more massive DM halos than bright quasars up to z ~ 2.2

(Mullis et al. 2004, Yang et al. 2006, Gilli et al. 2005, Hickox et al. 2009, Gilli et al. 2009, Coil et al. 2009, Krumpe et al. 2010)

Evolutionary Sequence

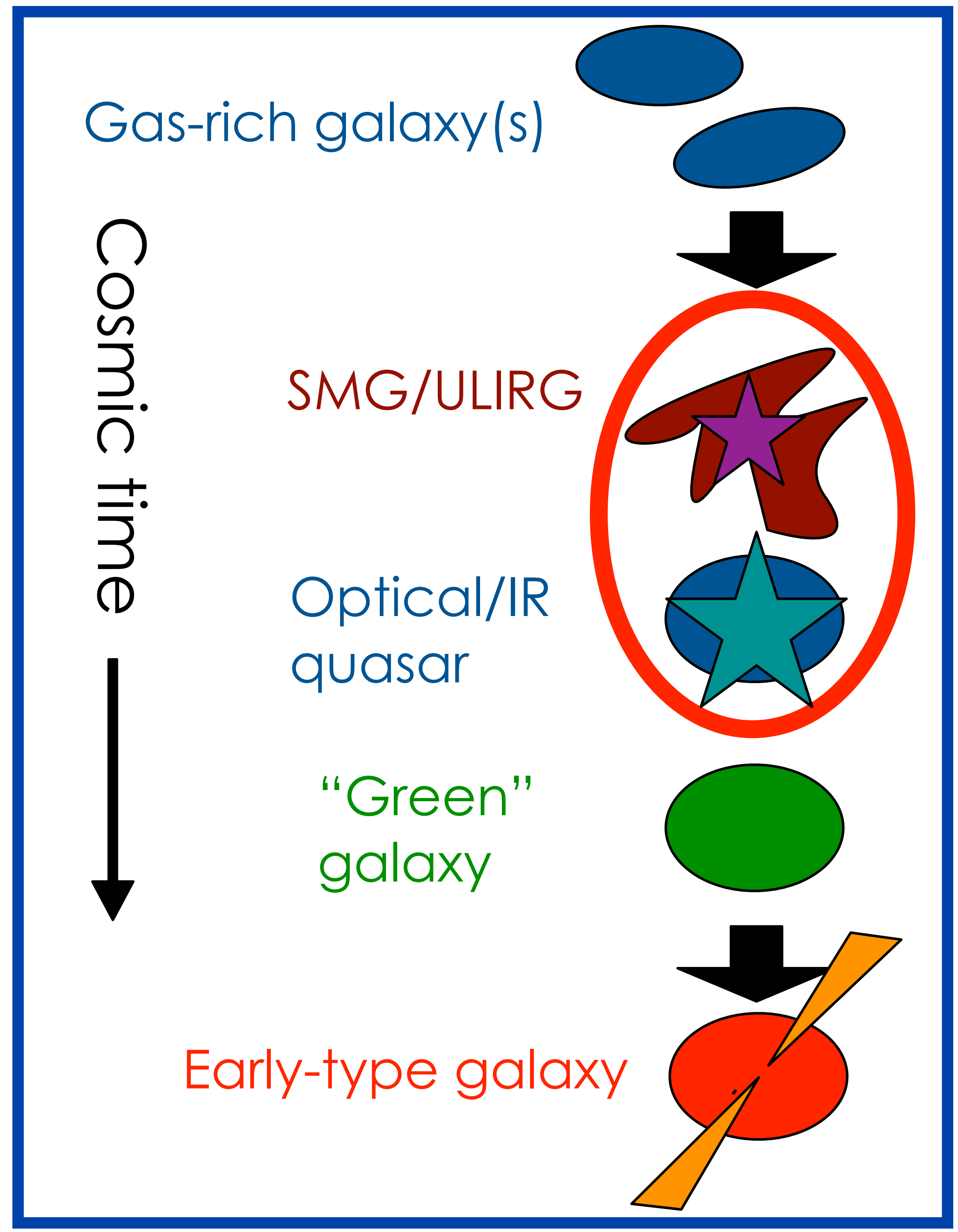


Galaxy Merger

Starburst galaxy
Obscured quasar

Active Quasar

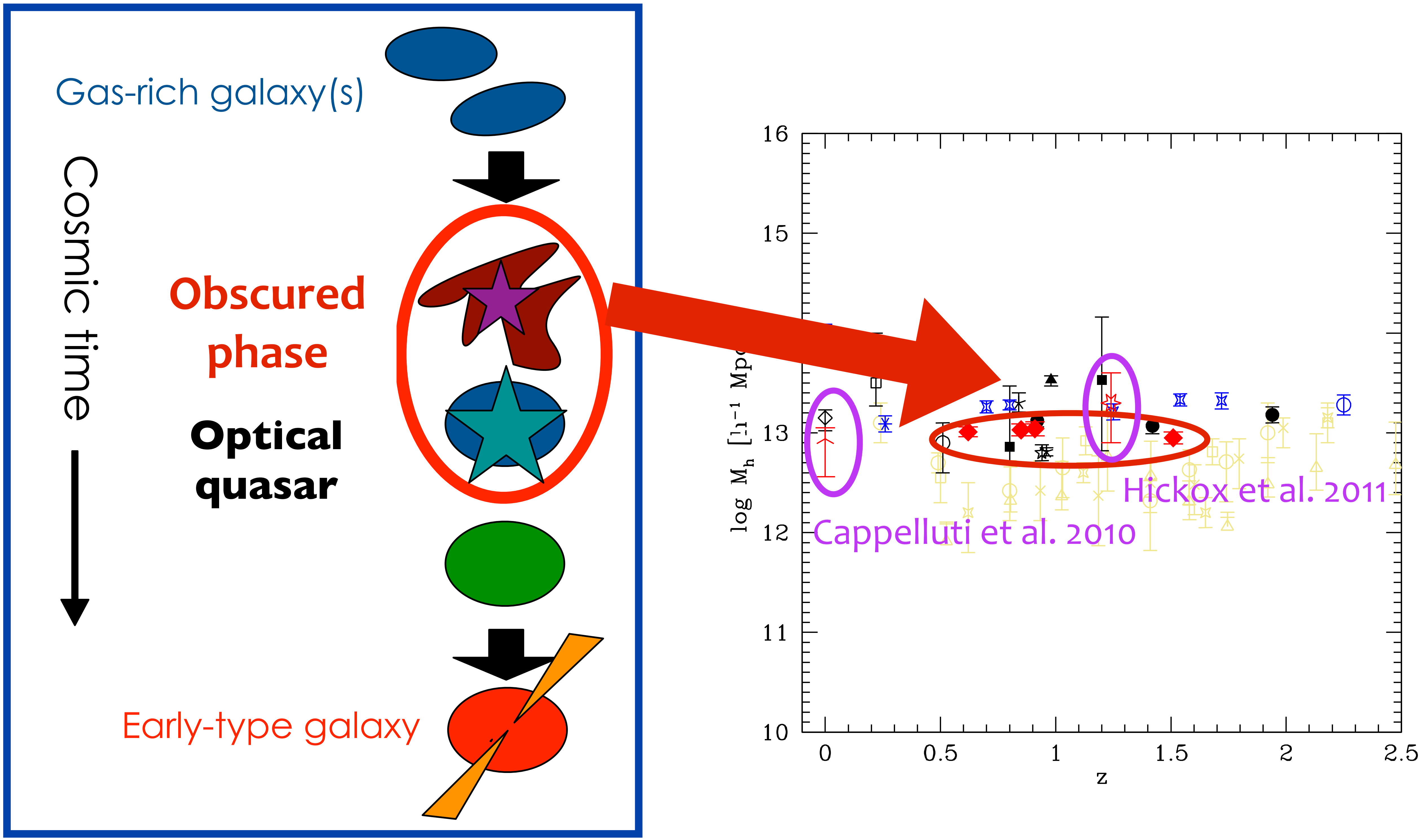
Dead Elliptical



adapted from Hopkins et al. 2008

adapted from Hickox et al. 2009

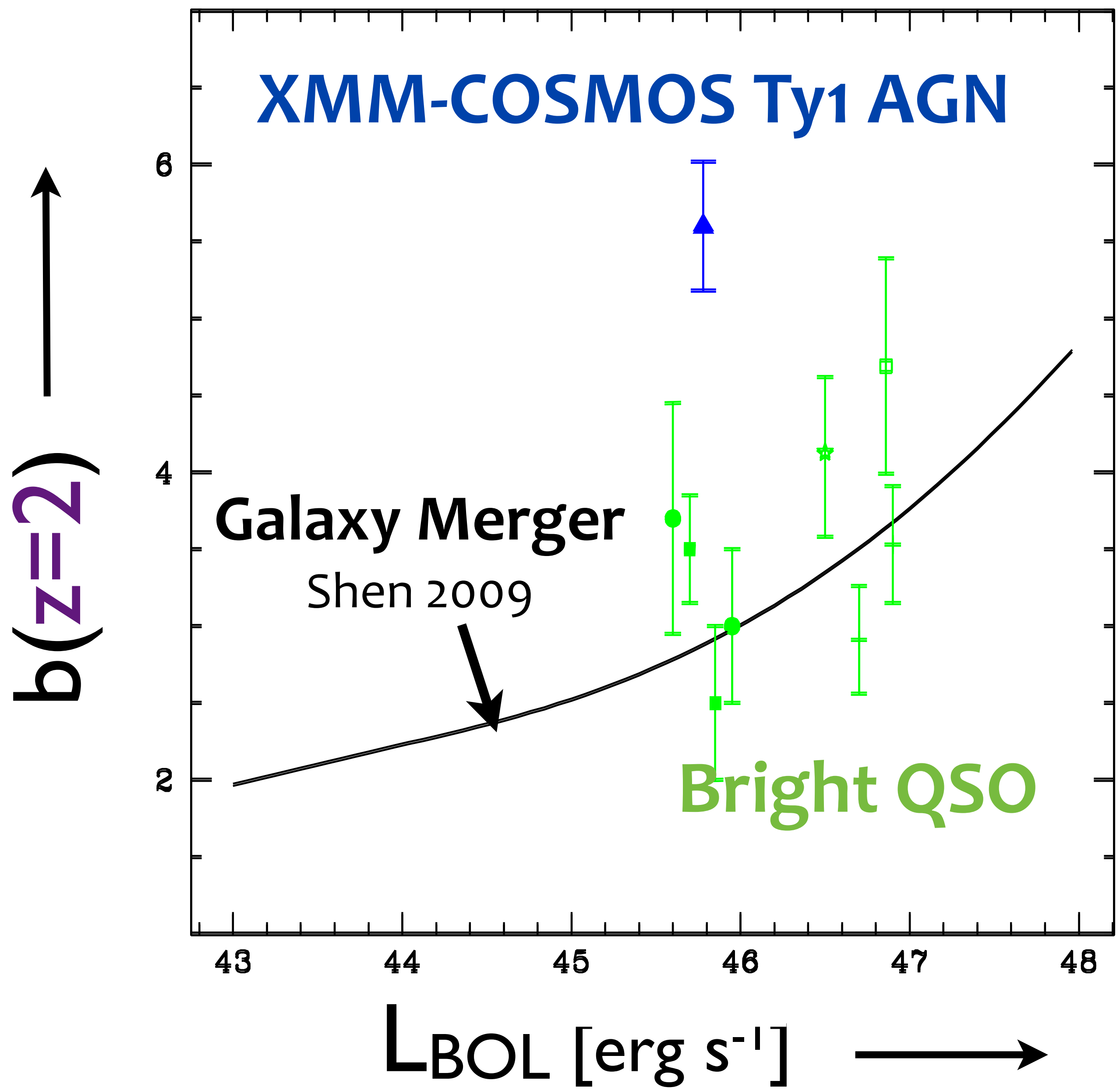
Evolutionary Sequence



Galaxy merger?

- Models of **major merger** appear to produce many observed properties of quasars (Hopkins et al. 2008; Shen 2009; Shankar et al. 2009,2010; Bonoli et al.2009)

Allevato et al. 2011



Secular processes?

- High luminosity **quasars are triggered by major mergers**
- For **moderate luminosity AGN, secular processes** in massive galaxies might play a dominant role

(see Georgakakis et al. 2009; Cisternas et al. 2011 for similar results)

Internal vs External Processes

AGN Host Galaxies

- With a proper selection, using the **luminosity or the mass of the host galaxies,** we can constrain the mechanism for the AGN triggering

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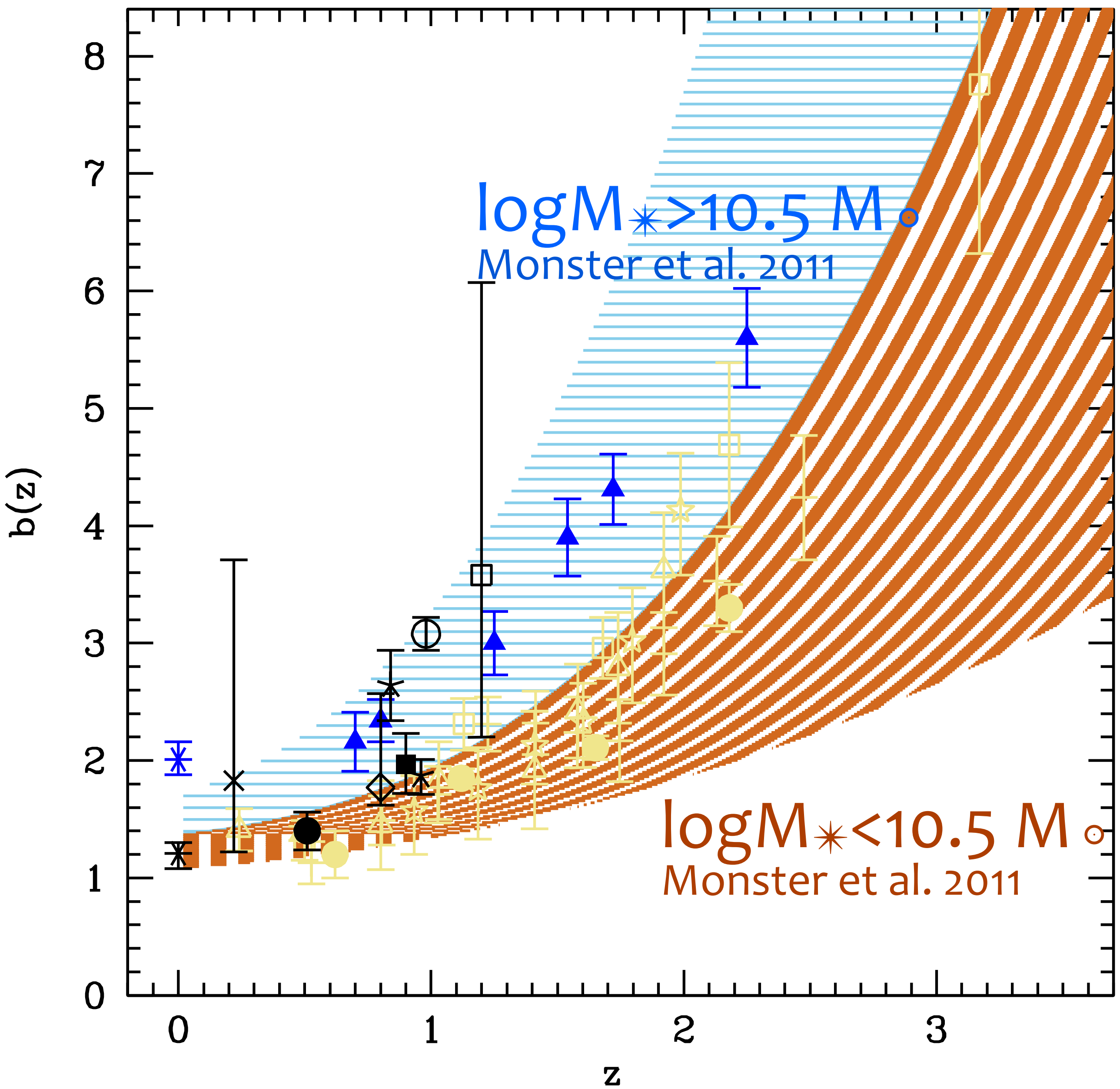

Conclusions

- We found evidence of a **redshift evolution of the bias** for the different AGN subsets, corresponding to a **constant DM halo mass** which differs for each sample;
- XMM-COSMOS **Ty1 AGN inhabit more massive halos compared to** XMM-COSMOS **Ty2 AGN at all z<2.2**, suggesting that the **AGN activity is a mass triggered phenomenon;**
- **Moderate luminosity X-ray AGN and bright optical quasars do not reside in DM halos with same mass;**
- For moderate luminosity X-ray Ty 1 AGN **secular processes might play a much larger role than major mergers up to z~2.2;**