Probing clustering of X-ray AGN using Chandra COSMOS Legacy

Viola Allevato

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SCUOLA
NORMALE
SUPERIORE

AGN13, Milano 9-12 Ottobre

Clustering Analysis

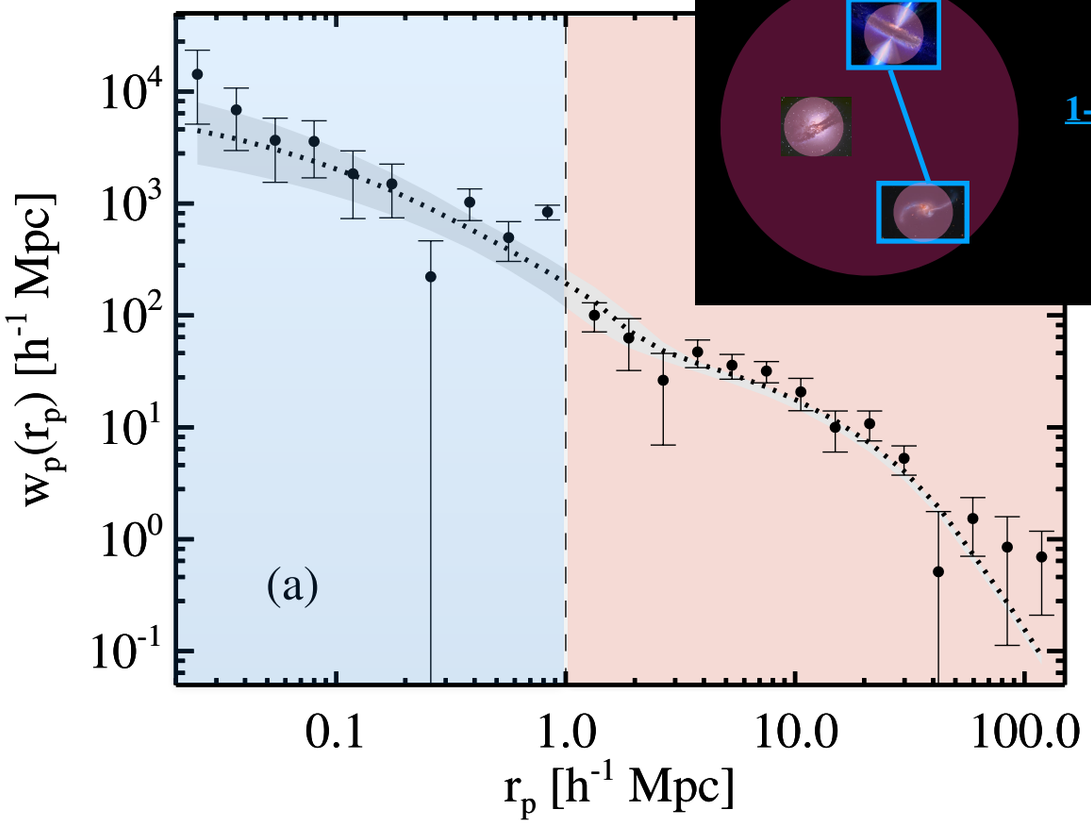
Clustering provides a unique way to study:

- **How AGN populate DMHs;**
(Relative fraction of AGN in **satellite** and **central** halos)

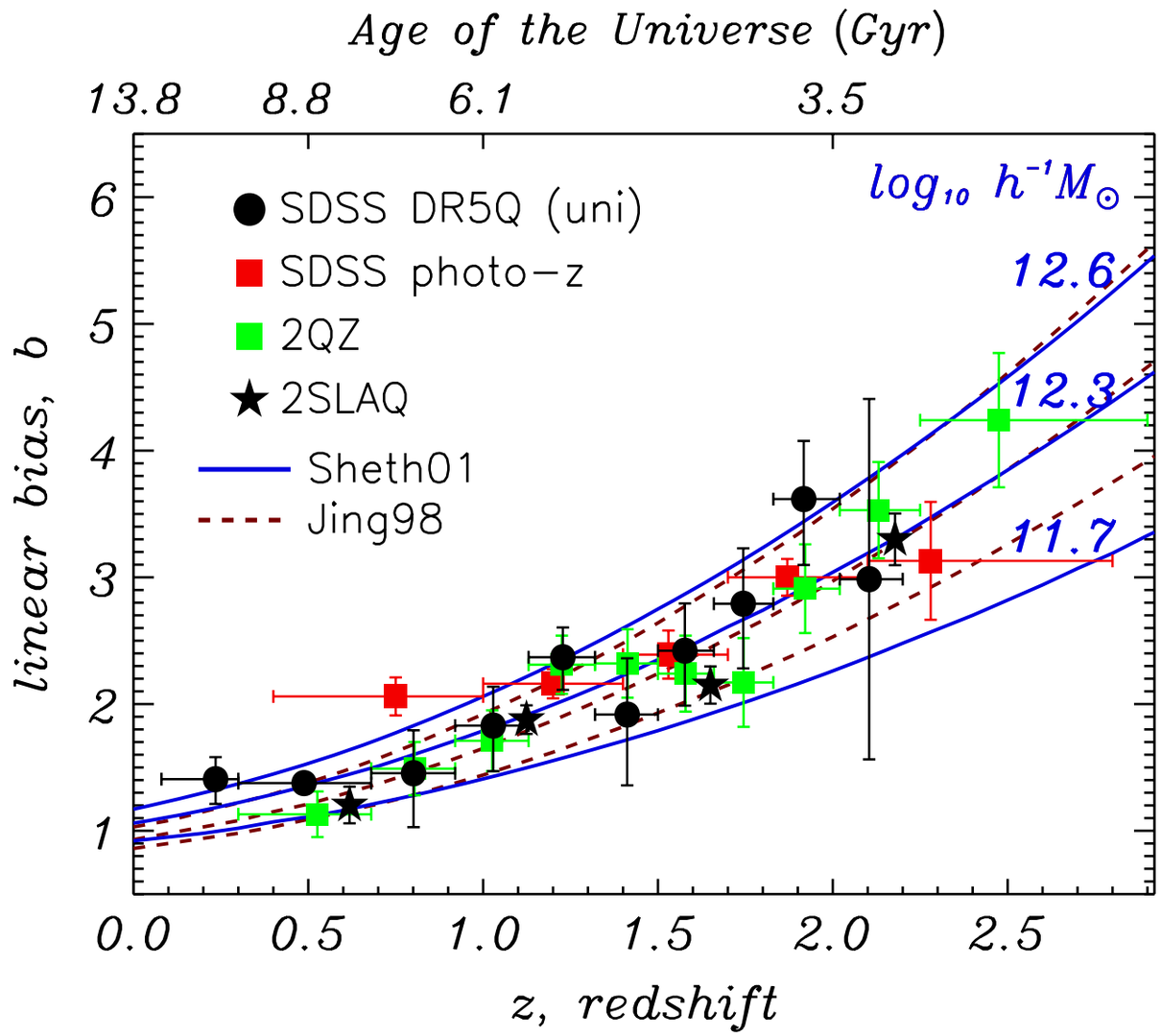
- **Typical AGN environment;**
(**Bias** and DMH mass)

- AGN Evolutionary Models;

- AGN **triggering** mechanisms;



Clustering of QSO



Shen et al. 2009

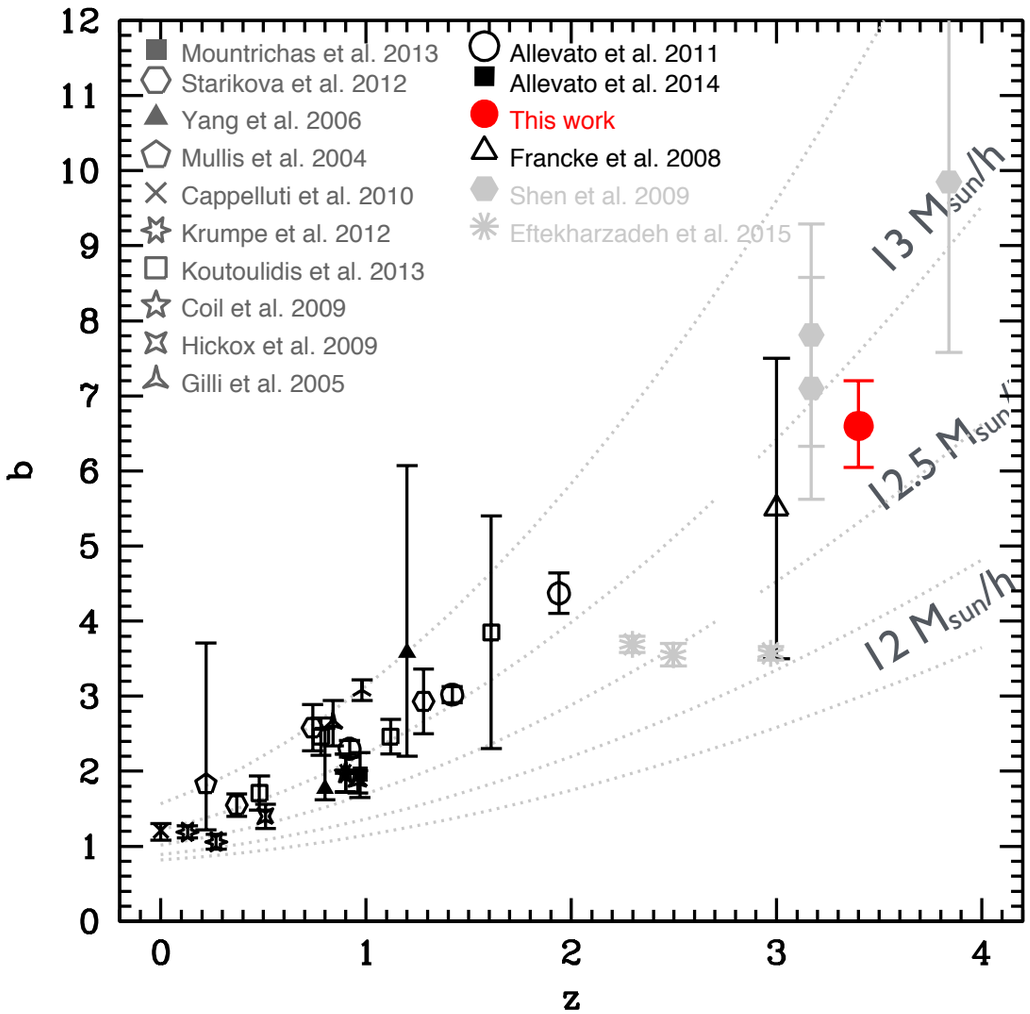
- **Luminous quasars** $\log L_{bol}$ >46 erg/s reside in DMHs with typical mass of **~ 3 x $10^{12} M_{sun}/h$ up to z = 2-3**

  e.g. Croom et al. 2005, 2009, Da Angela et al. 2005, 2008, Shen et al. 2008, Ross et al. 2009

- **Major merger** models reproduce the observed quasar clustering and **bias as a function of L and z**;

  Hopking et al. 2007, 2008, Shen 2009, Shankar et al. 2009, 2010, Bonoli et al. 2009

Clustering of X-ray AGN



Allevato et al. 2016

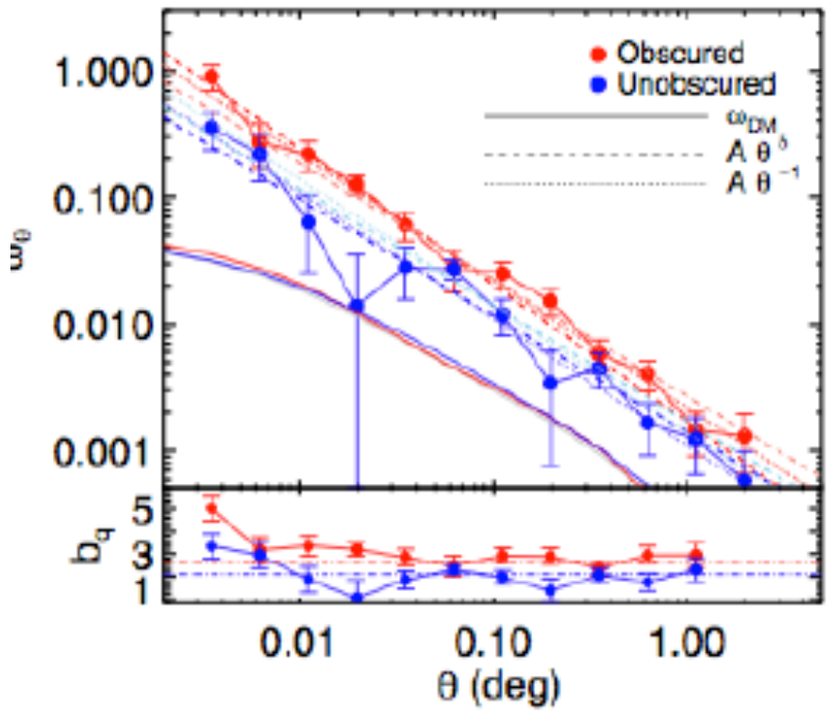
- Moderate luminosity AGN reside in DMHs with **typical mass of ~ 10^{13} M_{sun}/h up to z~2-3**

e.g. Hickox et al. 2009, **Allevato et al. 2011,2012, 2014, 2016**, Starikova et al. 2012, Krumpe et al. 2012, Koutoulidis et al. 2013

This difference in halo mass is interpreted as evidence **against cold gas accretion via major mergers** in X-ray AGNs and/or as support for multiple modes of BH accretions.

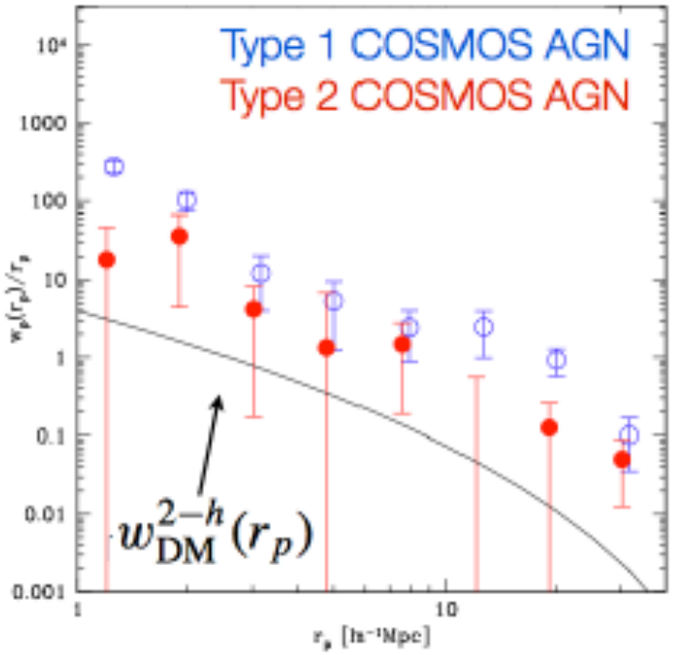
Allevato et al. 2011, Fanidakis et al. 2013, Mountrichas & Georgakakis 2012

Type 1 & 2 AGN



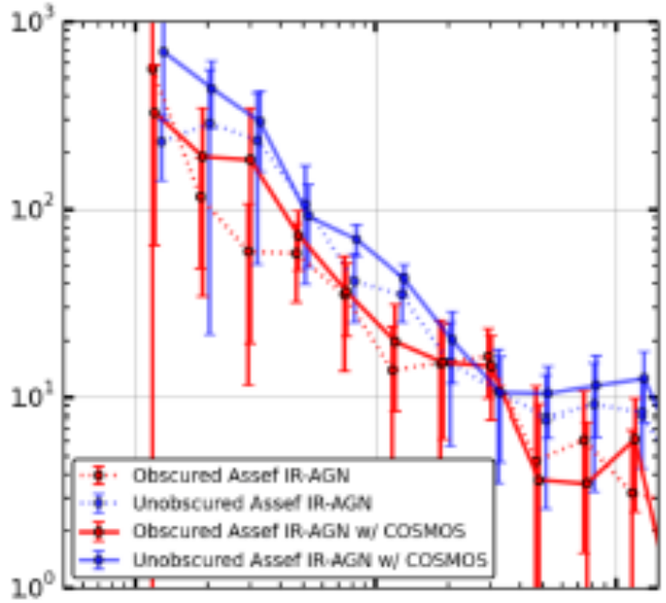
Obscured AGN clustered more strongly

Hickox et al. 2011,
Donoso et al. 2014
DiPompeo et al. 2014,
2015, 2016



Unobscured AGN clustered more strongly

Allevato et al. 2011, 2014,
Cappelluti et al. 2010
Krumpe et al. 2018
Powell et al. 2018

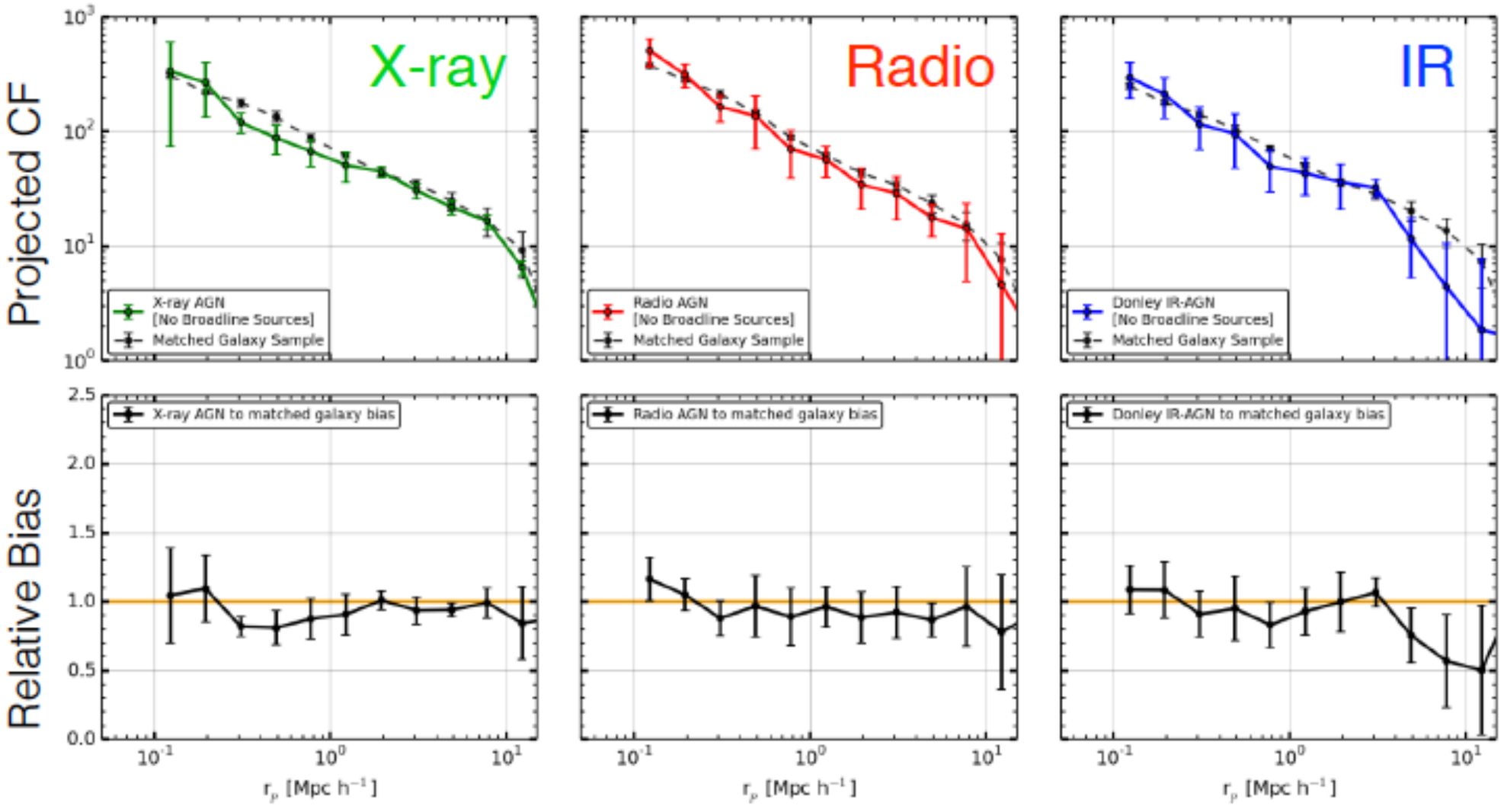


No significant difference

Krumpe et al. 2012,
Mendez et al. 2015
Krumpe et al. 2015

AGN Host Galaxies

Can AGN clustering be entirely understood in terms of galaxy clustering and AGN selection effect?



Mendez et al. 2016

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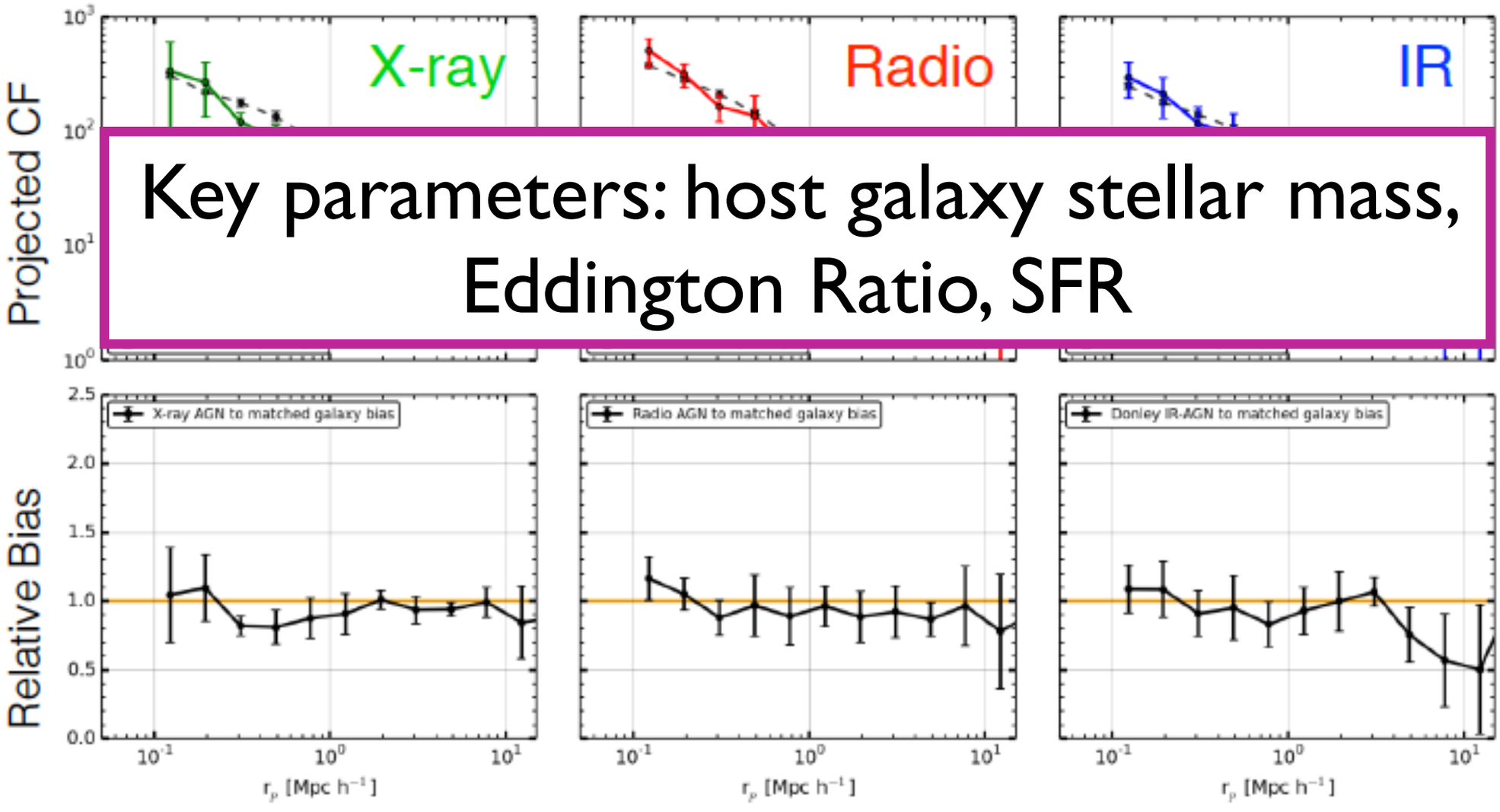
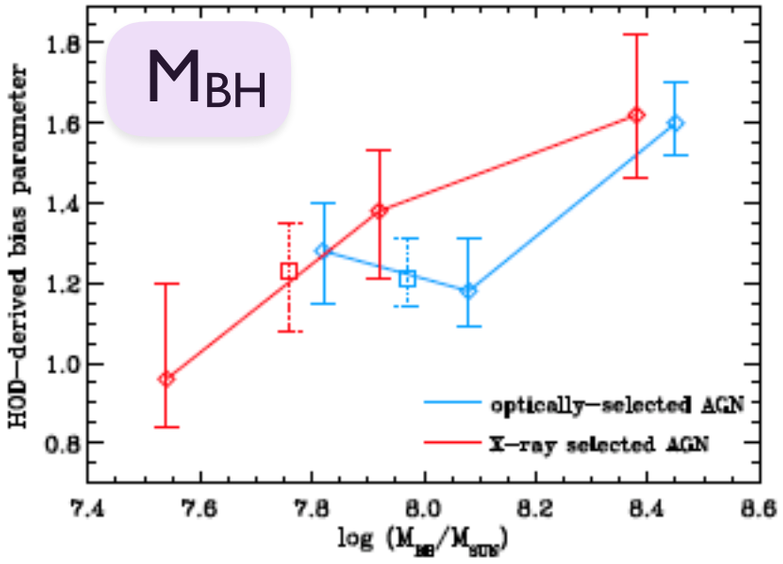


Key parameters: host galaxy stellar mass, Eddington Ratio, SFR

Mendez et al. 2016

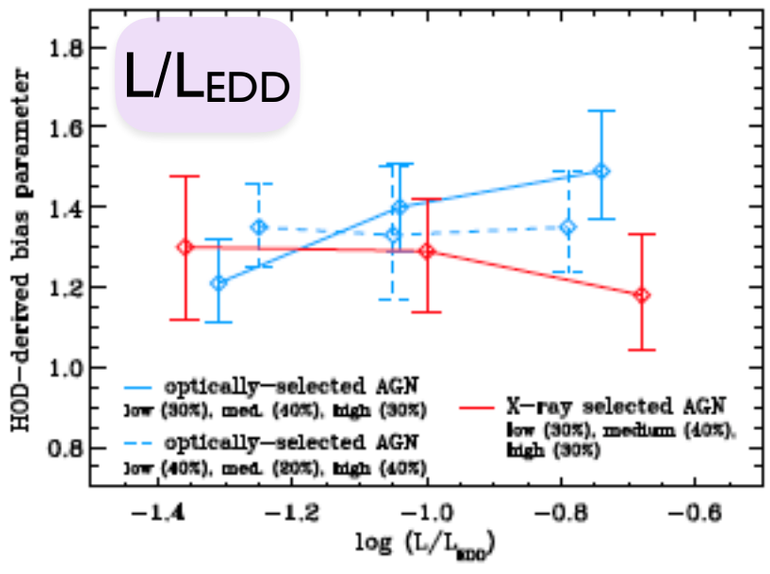
BH mass and Eddingtion Ratio

- Weak clustering dependence with M_{BH} and L/L_{EDD} in the locale Universe;

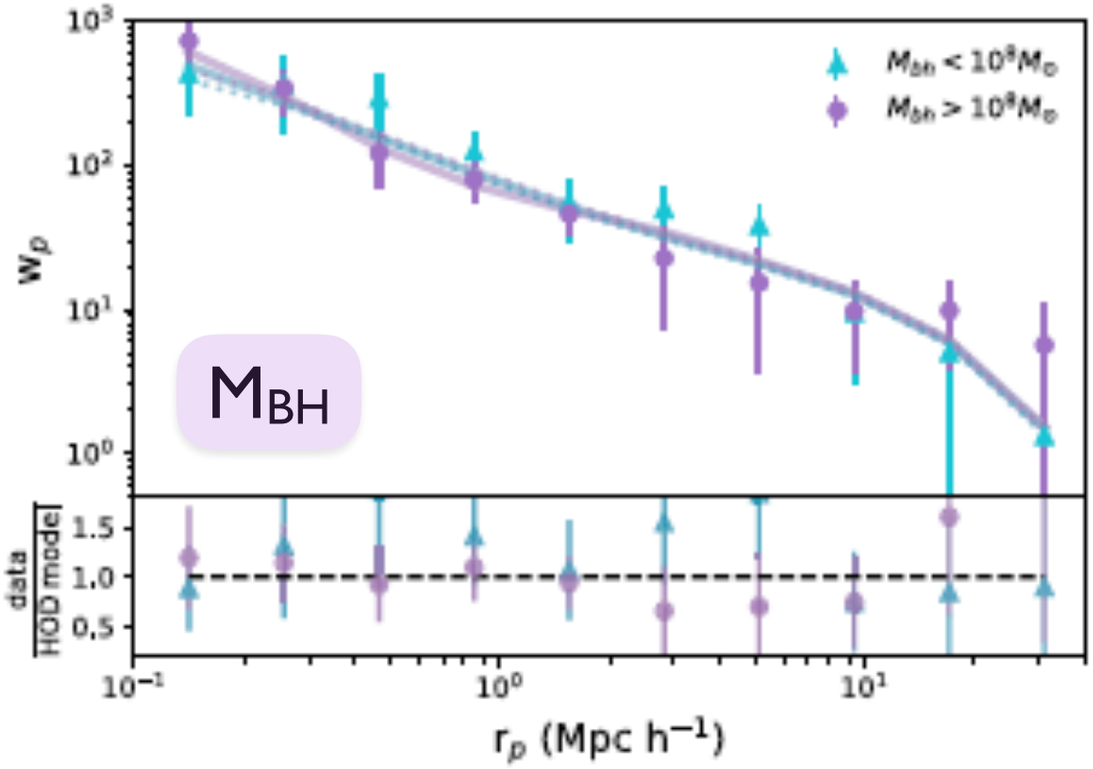


Krumpe et al. 2015

z < 0.35



z < 0.1



Powell et al. 2018

Chandra COSMOS Legacy

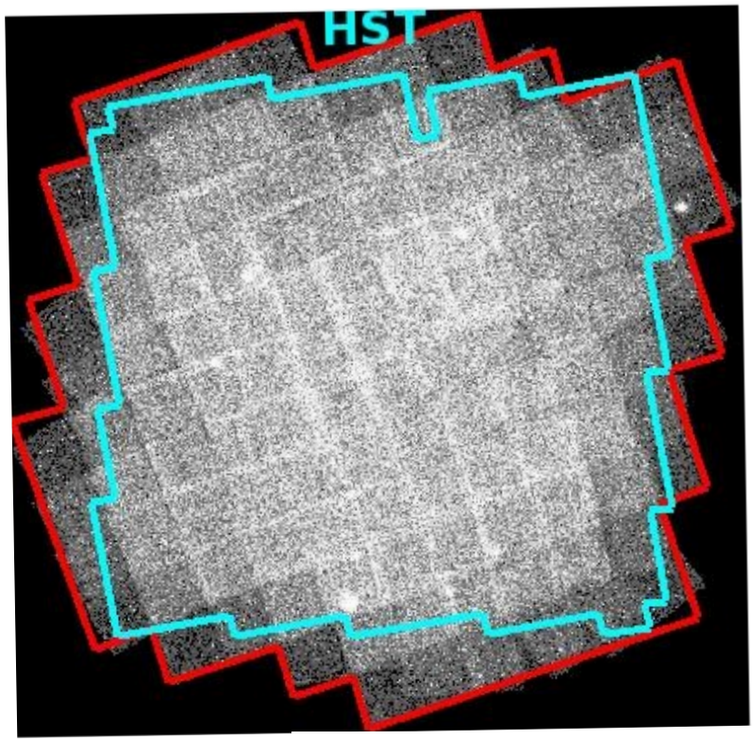
- CCL source catalog : 4016 sources
  (Civano et al. 2016)

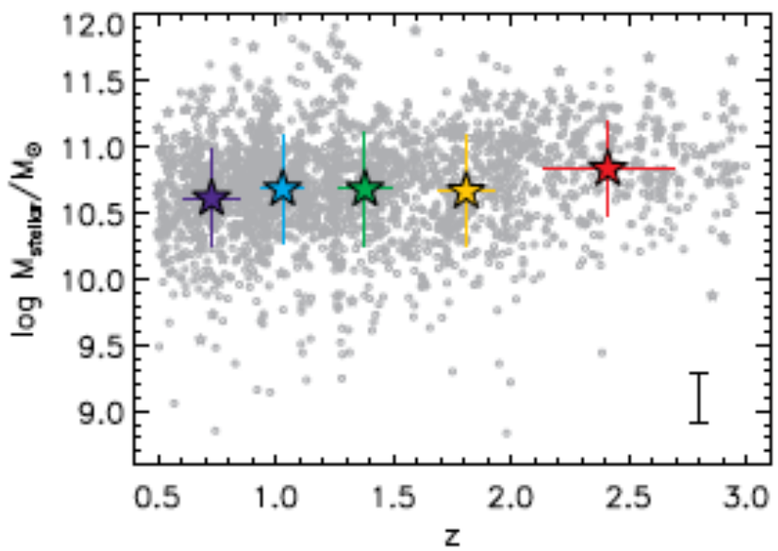
- 3886 CCL AGN with optical counterparts and photo-z
  (Marchesi et al. 2016a)

	Total ($P>2\times10^{-5}$)	Spec-z	Photo-z
Number	4016 (1887 in XMM)	2151 (53.6 %)	3872 (96%)

- CCL AGN host galaxies (2300 Type 2)
  (Suh et al. 2017)

- Properties of XMM AGN host galaxies;
  (Bongiorno et al. 2012)



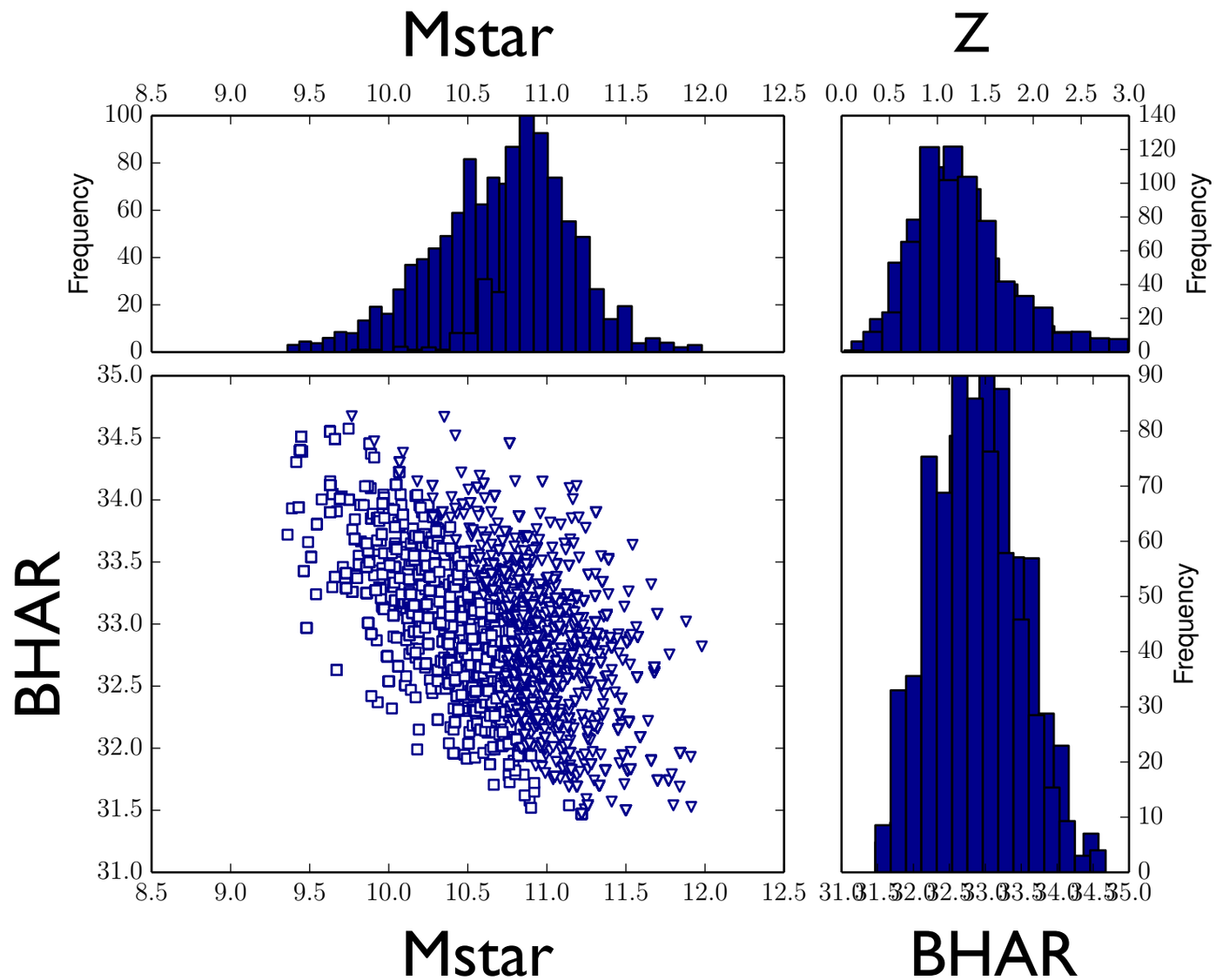


CCL + XMM AGN

CCL + XMM AGN

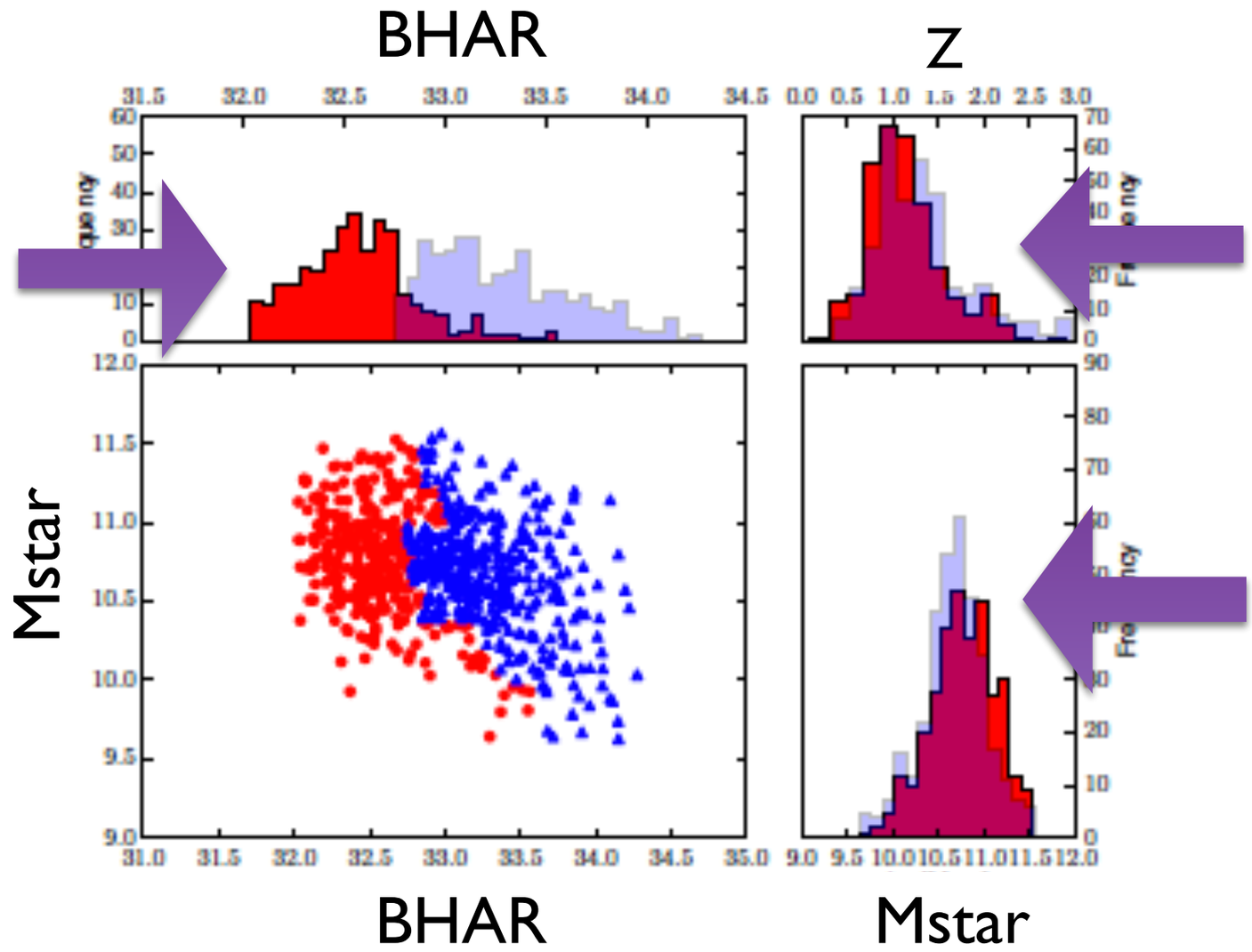
~ 1800 AGN Type 2
z = [0.5-3]
log(Lx/erg s^{-1}) = [42-45.5]
log(Mstar/Msun) = [9-12.5]
BHAR = [31-34.5]

$$BHAR = \frac{k_{bol} \cdot A}{1.3 \times 10^{38}} \times \frac{L_X}{M_{star}}$$



BH Accretion Rate

- We split the CCLXMM AGN sample based on:
  - Host galaxy stellar mass
  - Specific BH Accretion rate



Galaxy stellar Mass

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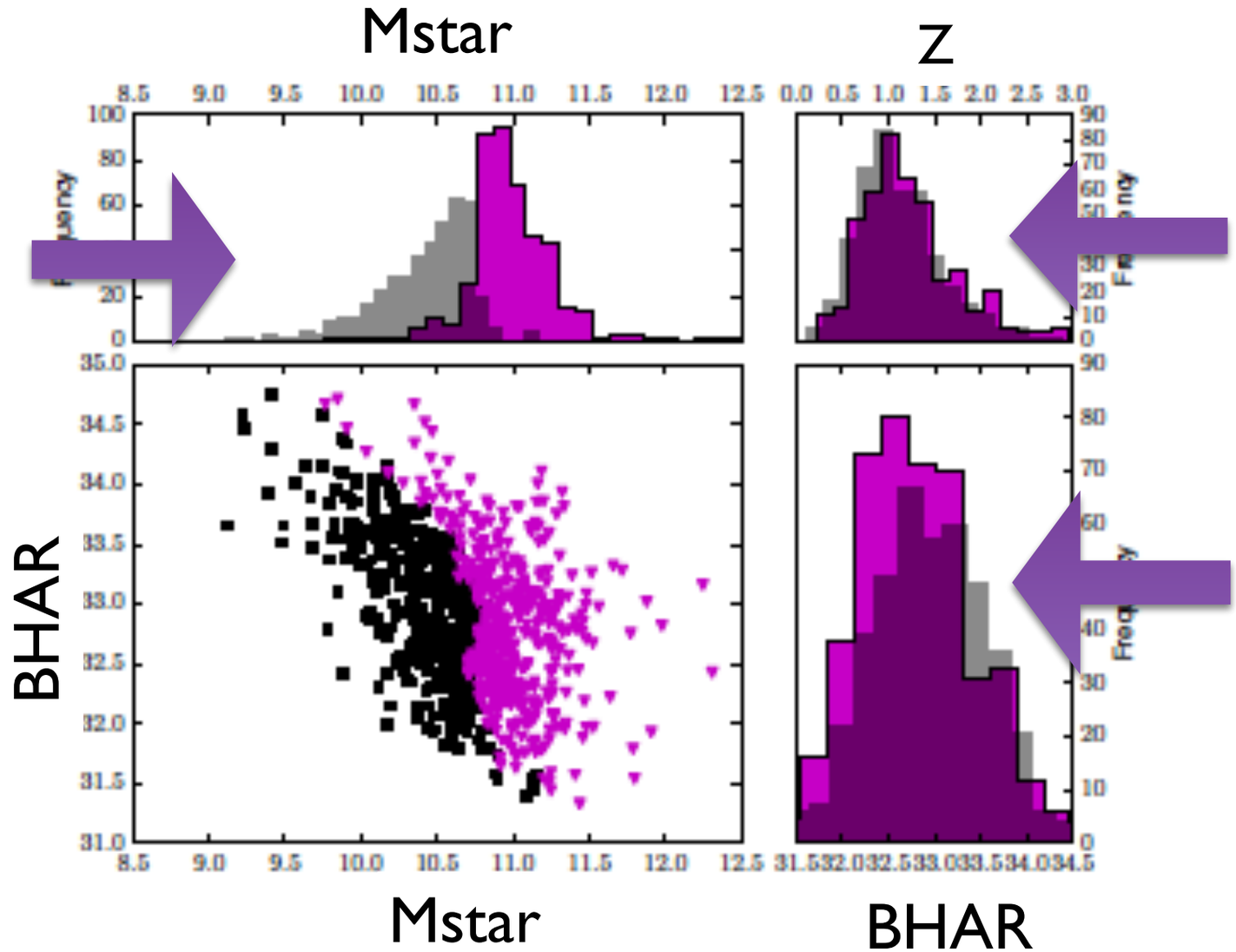
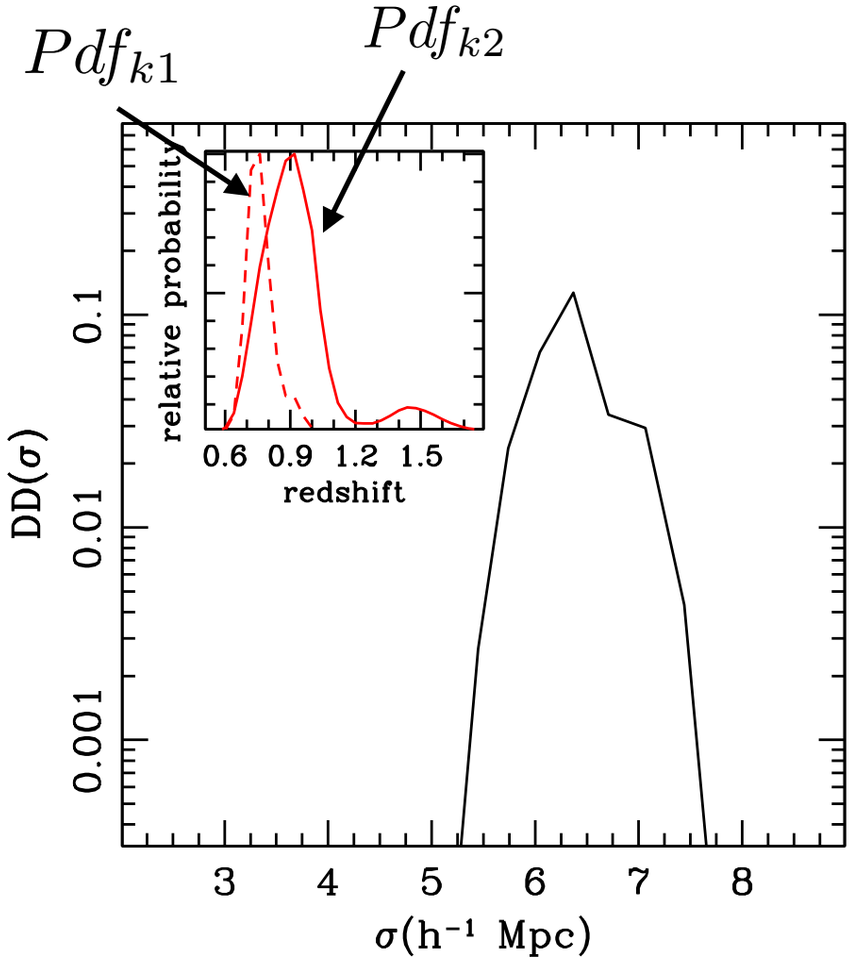


Generalised Estimator

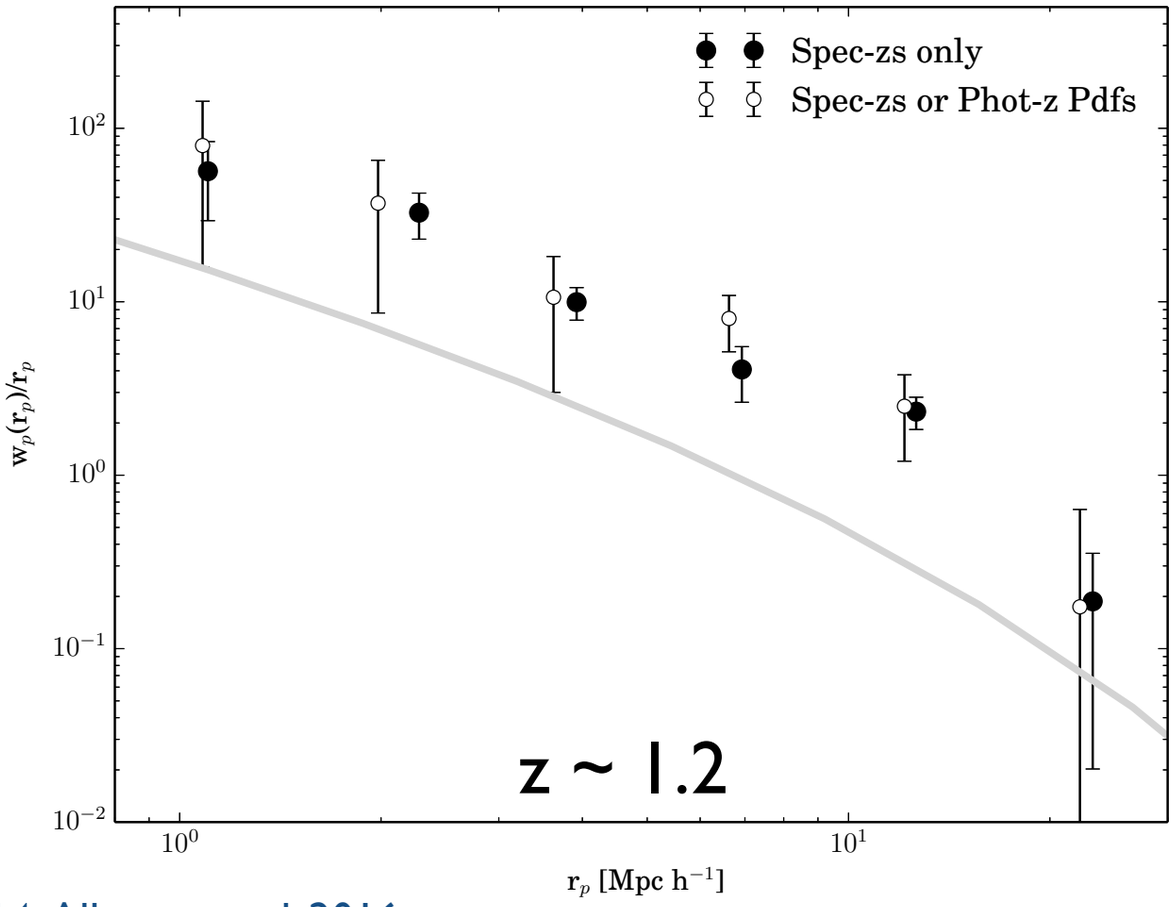
Classic LS estimator

$$DD(\sigma,\pi)_k \;=\; DD(\sigma,\pi)_{k-1} \,+\, 1$$



Generalised LS estimator

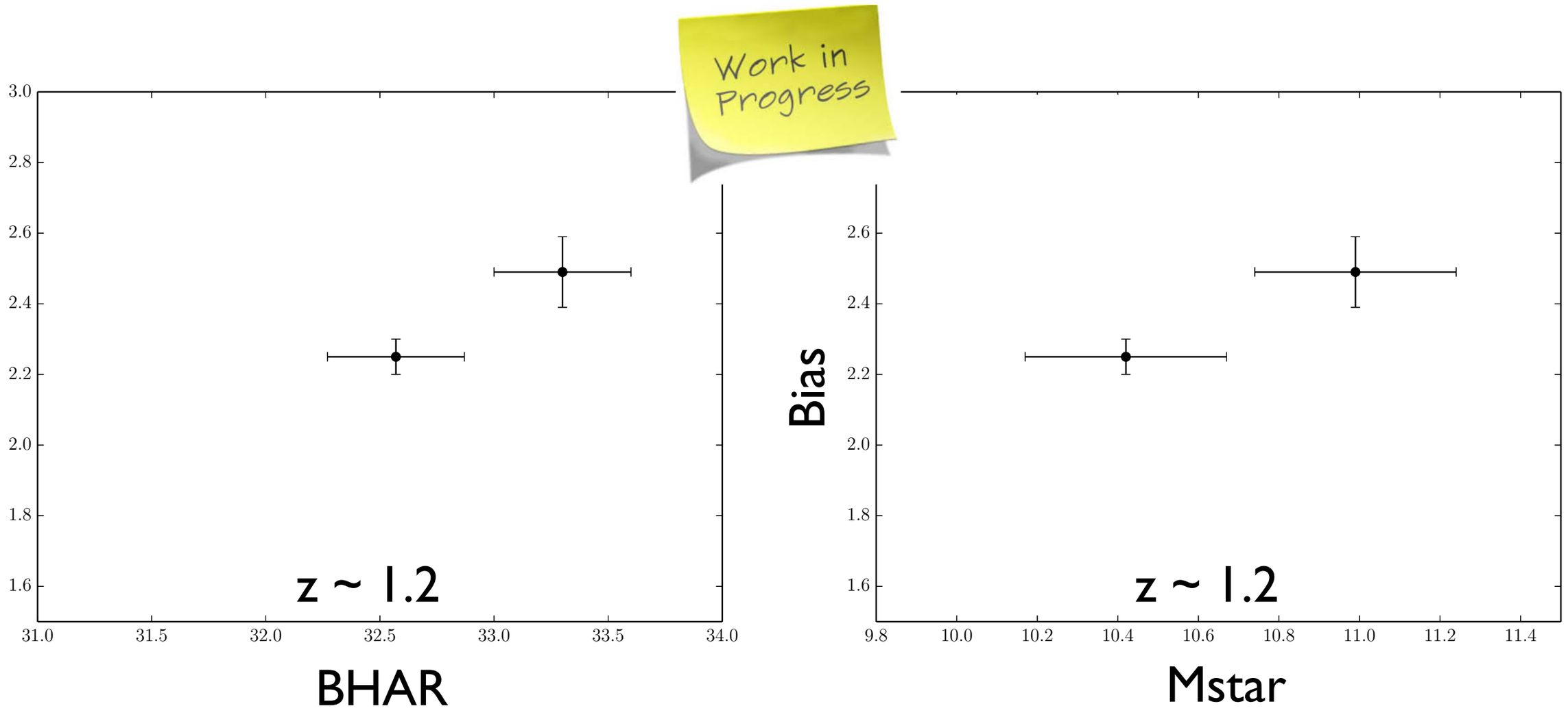
$$DD(\sigma,\pi) = DD(\sigma,\pi) + Pdf_{k1}(z=z_i)\,Pdf_{k2}(z=z_j)$$



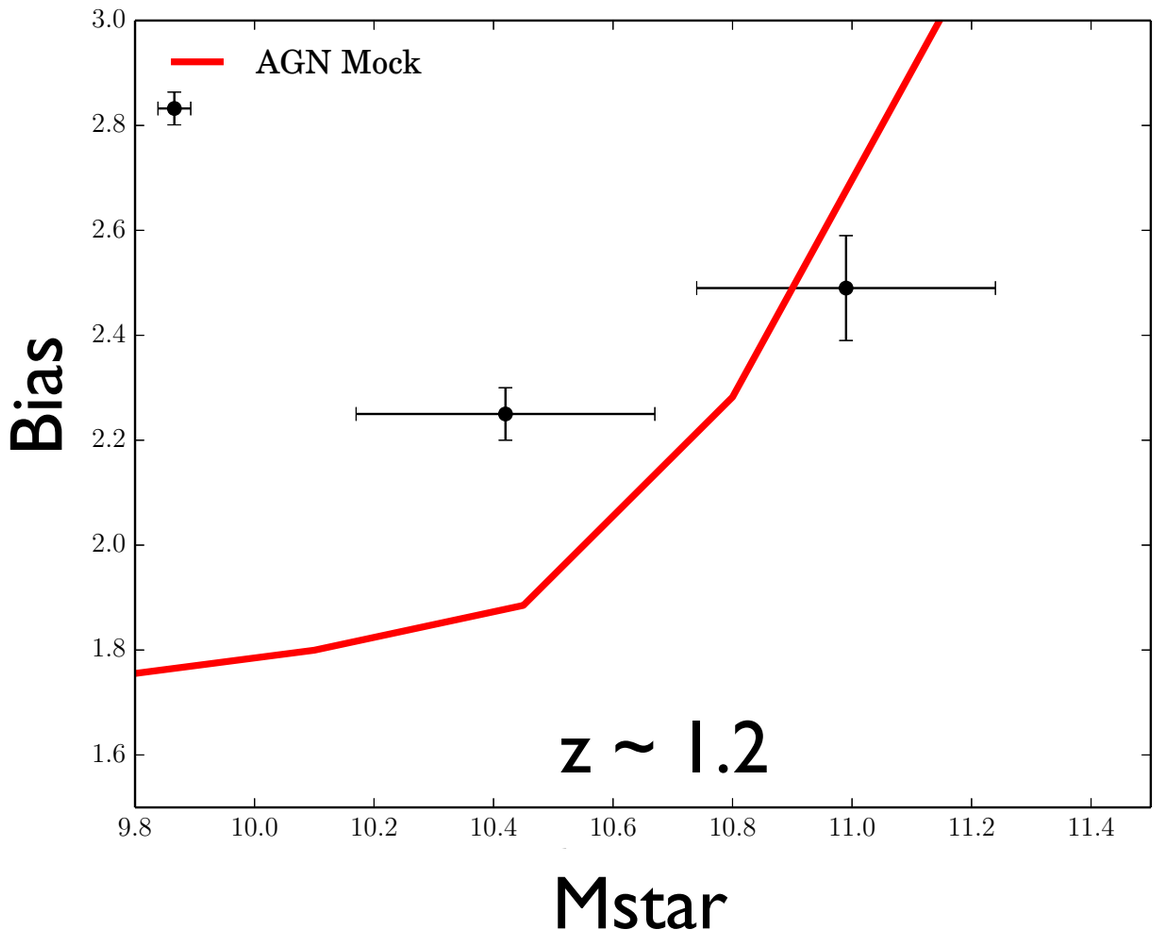
Georgakakis et al. 2014, **Allevato et al. 2016**

AGN bias

Weak clustering dependence with M_{star} and BH SAR at z~1.2



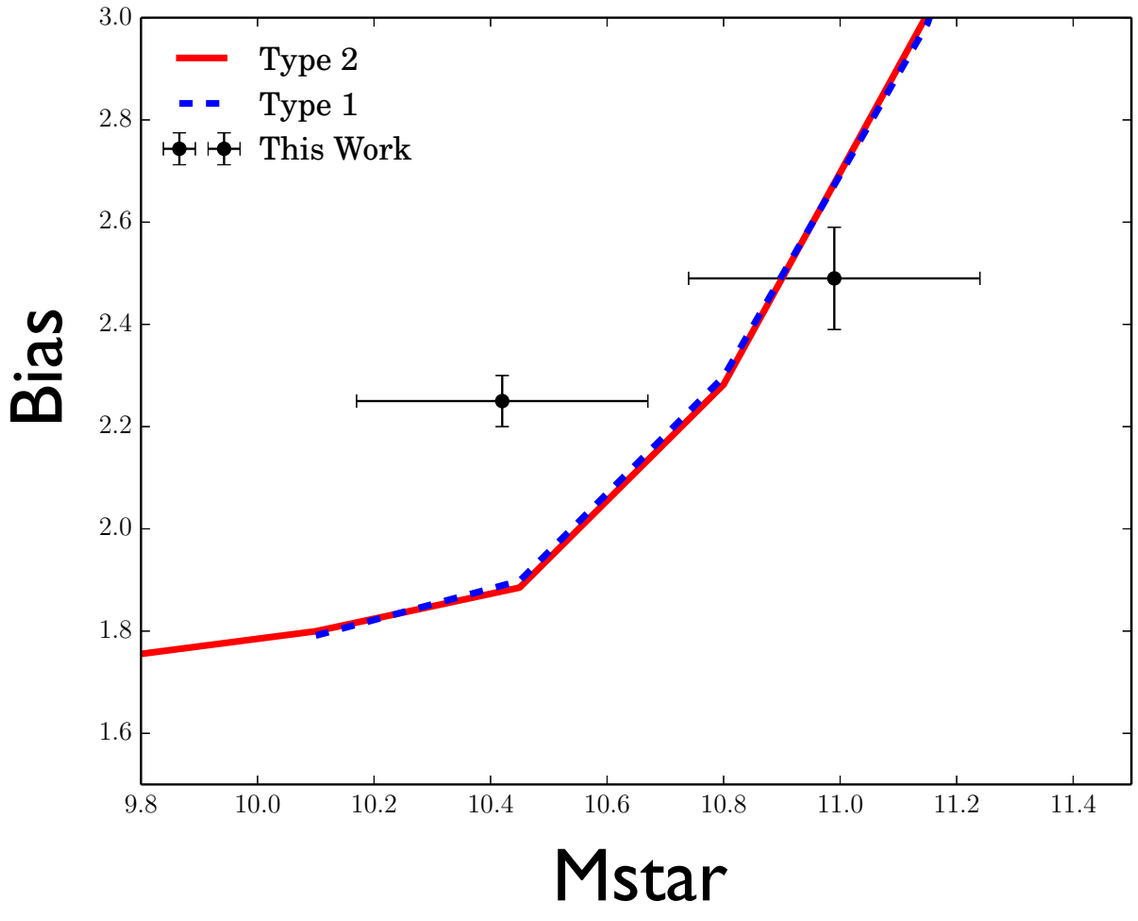
Bias vs Mstar - I



- Positive clustering dependence with M_{star} at z~1.2

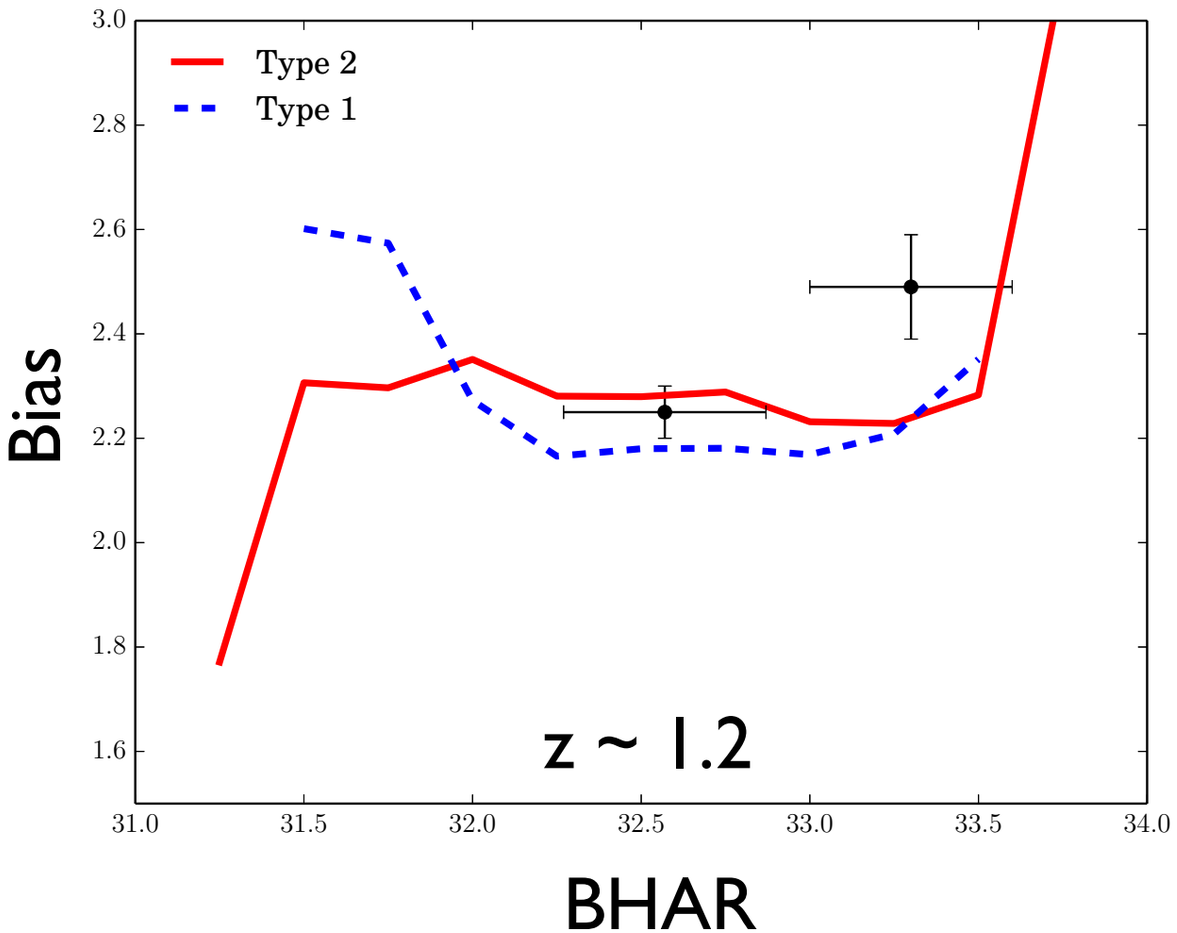
- Typical halo mass expected for these hosting galaxy mass M_{star}
(Moster et al. 2013, Berhoozi et al. 2013)

Bias vs Mstar - I



- Positive clustering dependence with M_{star} at z~1.2
- Typical halo mass expected for these hosting galaxy mass M_{star} (Moster et al. 2013, Berhoozi et al. 2013)
- Same evolution for Type 1 and Type 2 at z~1.2

Bias vs BHAR



- Mock predicts no clustering dependence with BHAR in this range at z~1.2

- Same dependence for Type 1 and Type 2

Conclusions

- First clustering measurements as a function of BH Specific Accretion Rate and host stellar mass at z=1.2;
- Weak clustering dependence with M_{star} and BH Specific Accretion Rate for Type 2 AGN;
- Similar clustering dependence for Type 1 and Type 2 AGN;

Future Plan

- Clustering measurements as a function of obscuration;
- 1-halo term;