AGN clustering using photometric redshifts

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The correlation function

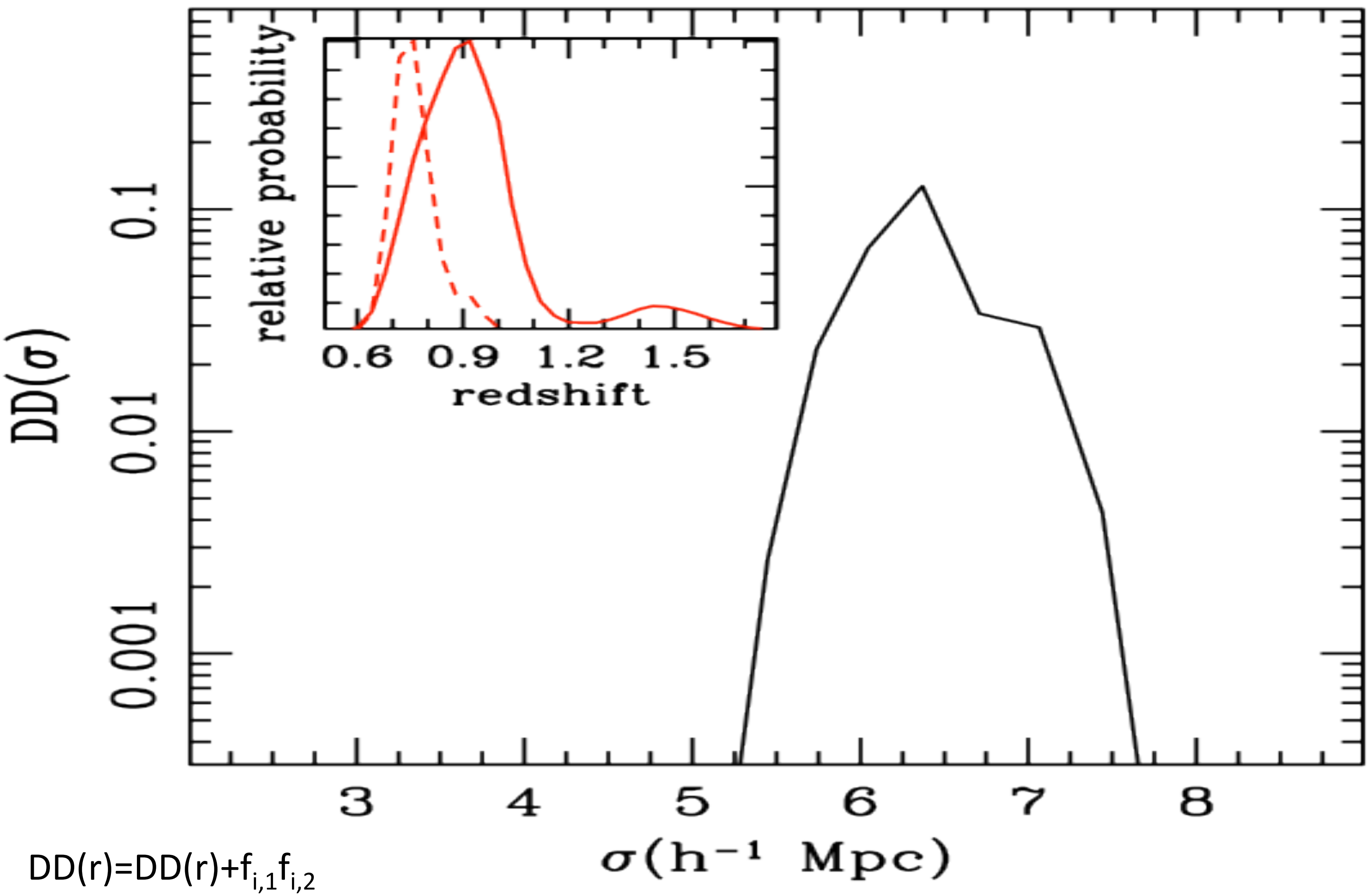
auto-correlation function (e.g. Gilli et al. 2009, Starikova et al. 2011, Allevato et al. 2011, Koutoulidis et al. 2013)

cross-correlation function (e.g. Coil et al. 2009, Mountrichas & Georgakakis 2012, Krumpe et al. 2012, 2013)

A new method that uses photometric redshift Probability Distribution Functions (PDFs; Myers et al. 2009, Hickox et al. 2011, 2012) for AGN and galaxies to estimate the real-space cross-correlation function (Mountrichas, Georgakakis, et al. 2013, Georgakakis, Mountrichas, et al., 2014).

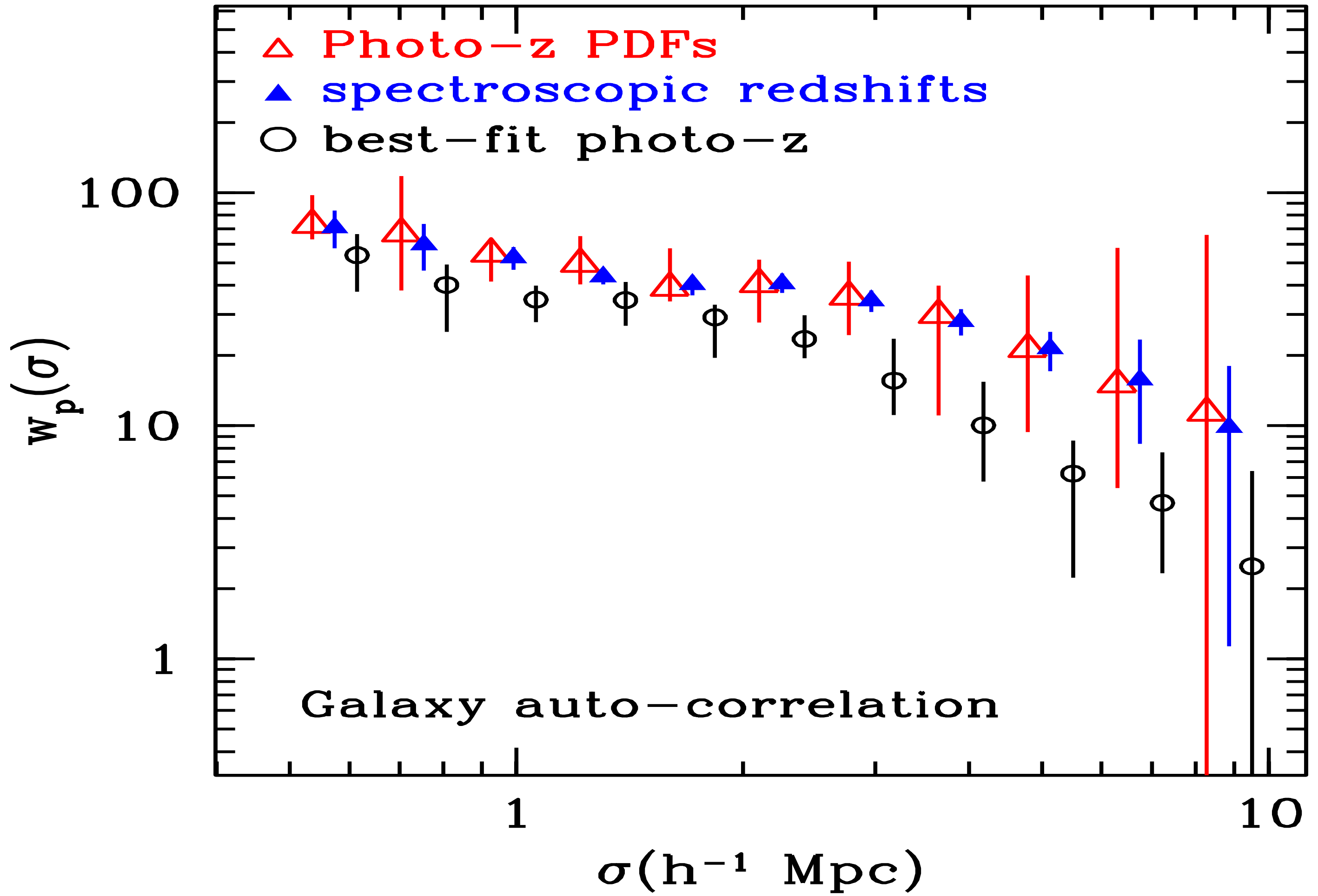
$\xi(r)=DD(r)/DR(r) - 1$ (Davis & Peebles 1983)

$DD(r)=DD(r) + 1$ (classical approach)



$DD(r)=DD(r)+f_{i,1}f_{i,2}$

Tests and limitations of the photo-z method



Specz: $b = 1.63^{+0.07}_{-0.05}$ (6,500 galaxies)

Photo-z: $b = 1.72^{+0.24}_{-0.15}$ (23,000 galaxies)

- Using the photo-z best-fit solution, underestimates the signal
- The photo-z method is geared toward large sample sizes

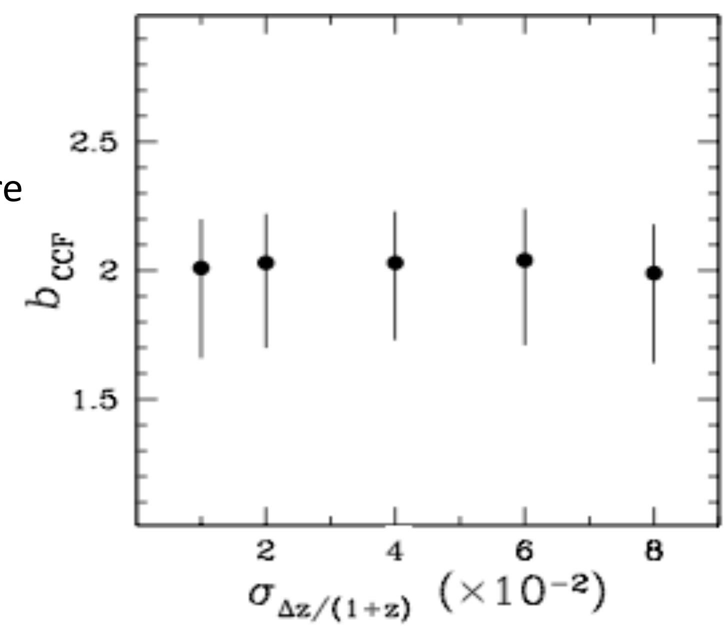
Required accuracy of photo-z estimations

X-Ray photoz errors:
C-COSMOS: $\sigma_{\Delta z/(1+z)} \approx 0.016$
AEGIS-XD: $\sigma_{\Delta z/(1+z)} \approx 0.04$

Using AEGIS specz X-ray AGN, convolve them with a Gaussian filter with $\sigma_{\Delta z/(1+z)}$ in the range 0.01-0.08 and cross-correlate them with photoz galaxies (CFHTLS-D3).
The photo-z method breaks down for $\sigma_{\Delta z/(1+z)} > 0.04$ (π_{max} is not stable)**.**
This accuracy for AGN photoz estimations is challenging, particularly for bright AGN samples.

Galaxies in C-COSMOS: $\sigma_{\Delta z/(1+z)}=0.01$ (0.03 for CFHTLS in the AEGIS-XD).
In this case the photo-z method recovers the clustering signal even when AGN photoz uncertainties are up to $\sigma_{\Delta z/(1+z)}=0.08$.

The uncertainties of the inferred bias are nearly independent of the AGN $\sigma_{\Delta z/(1+z)}$.



A galaxy sample with accurate photo-z can compensate for larger photo-z uncertainties of the AGN sample.

Georgakakis, Mountrichas, et al. 2014

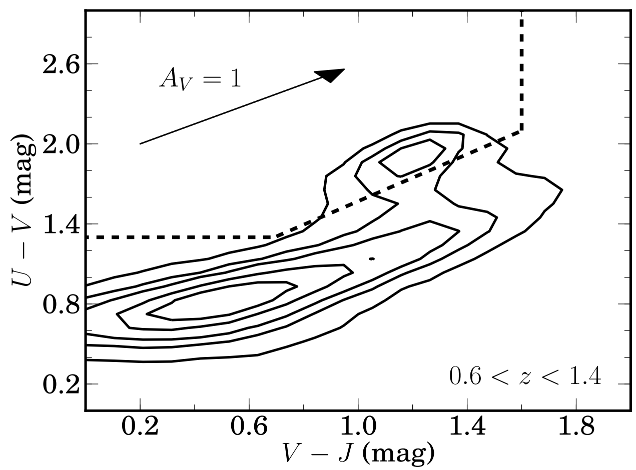
Compare the Dark Matter Halos of X-ray AGN, star-forming and passive galaxies at z≈1

DATA:

X-ray AGN: Chandra 800ks AEGIS-XD / C-COSMOS
Specz: DEEP2+DEEP3 / VIMOS-zCOSMOS + Magellan-IMACS
Photoz: Nandra et al. (in prep) / Salvato et al. (2009,2011)

Far-IR galaxies: PEP programme

Passive galaxies:

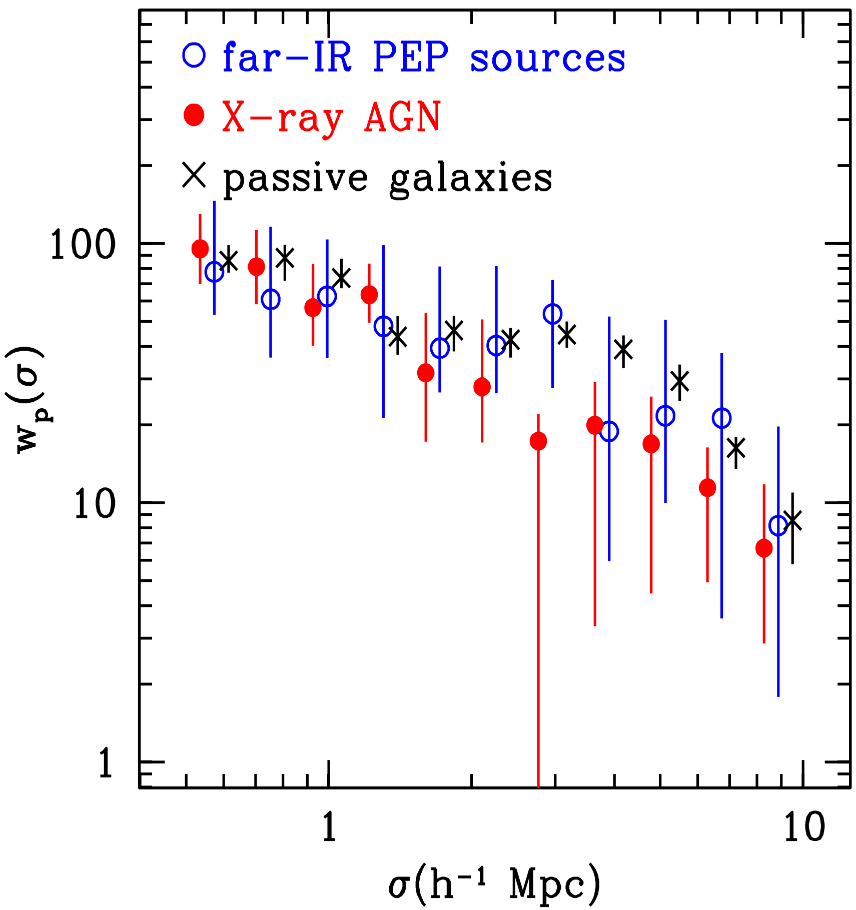


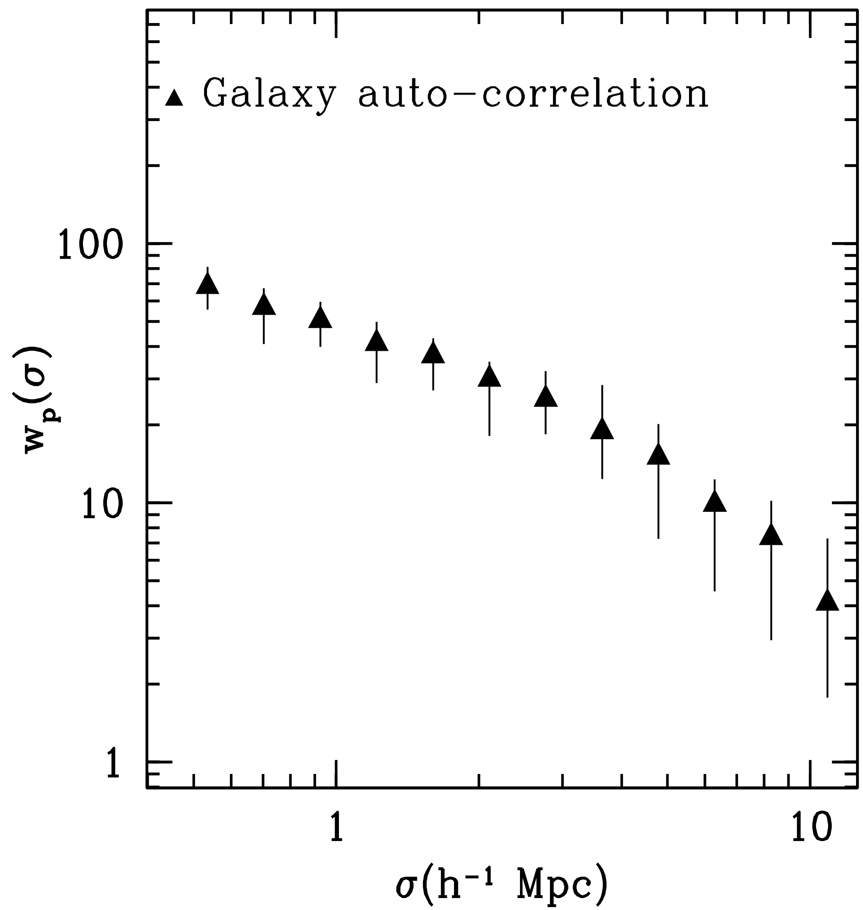
dashed line: U-V=0.88(V-J)+0.69, U-V>1.3, V-J<1.6 (Williams et al. 2009)
arrow: the reddening vector

Sample	Number of sources
X-ray AGN	1269 (430)
PEP far-IR galaxies	1032 (576)
UVJ passive galaxies	4883 (796)
galaxies	68,690

Tracer sample: CFHTLS-D3 / v1.8 of Ilbert et al. (2009)

Results



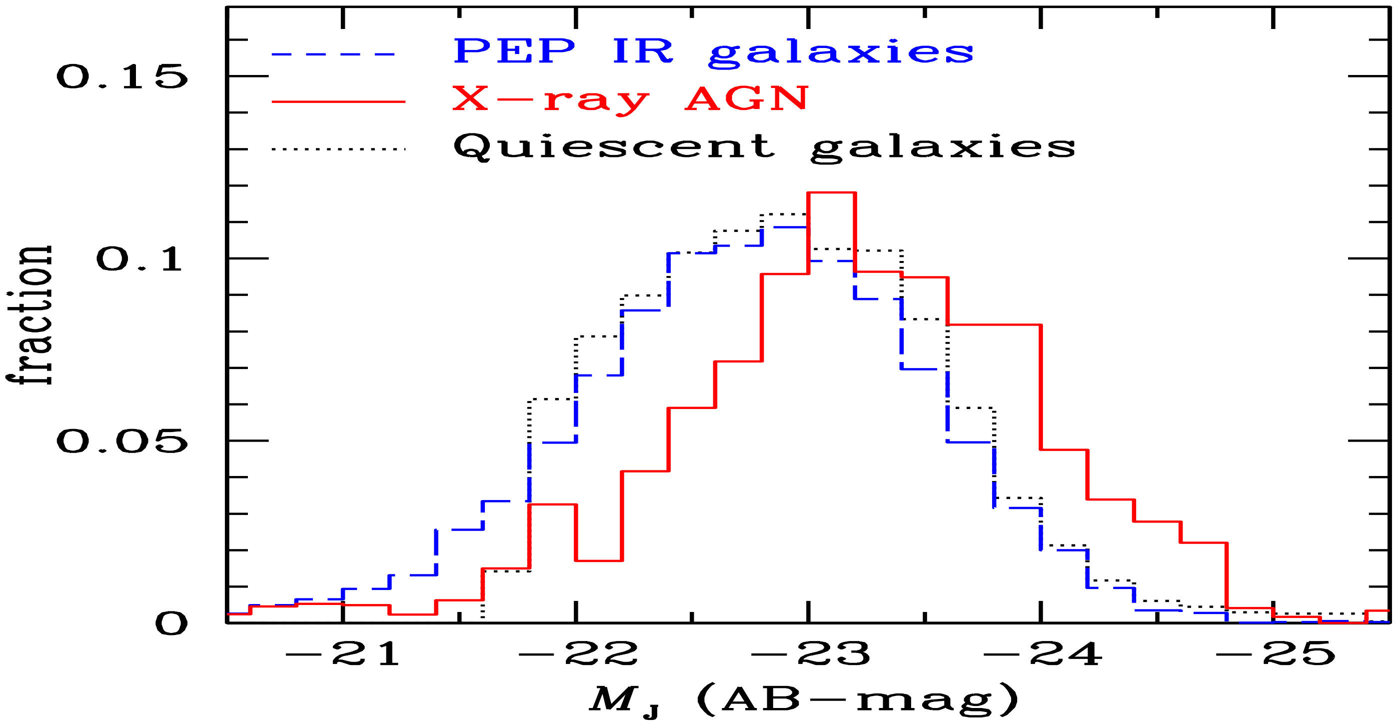


Sample	median redz	log DMHM ($h^{-1}M_\odot$)
X-ray AGN	0.95	$13.0^{+0.3}_{-0.4}$
PEP far-IR galaxies	0.90	$13.0^{+0.4}_{-0.5}$
UVJ passive	0.84	$13.1^{+0.4}_{-0.4}$

$b_{gal} = 1.6^{+0.1}_{-0.2}$

Recent studies have shown that the galaxy clustering is a function of both stellar mass and SFR (e.g. Meneux et al. 2008, Foucaud et al. 2010, Mostek et al. 2012, Bielby et al. 2013).

At high stellar masses ($\log(M_*/M_\odot > 10.5$), there is evidence that passive and SF galaxies, have similar DMHMs (Mostek et al. 2012).



All 3 samples have similar distributions in J-band luminosity (stellar mass).
X-ray AGN, far-IR and passive galaxies trace massive systems with $\log M_*/M_\odot > 10.5$(M_J=-21.5 mag, Bell & Jong 2001), which are expected to have similar clustering properties (Mostek et al. 2012).

Large-scale structure of X-ray AGN is closely related to the stellar mass of their hosts.

M_j<-23.25 mag, $b_{AGN} = 2.1^{+0.7}_{-0.9}$,DMHM=12.9 $h^{-1}M_{\odot}$

M_j>-23.25 mag, $b_{AGN} = 1.6^{+0.5}_{-1.0}$,DMHM=12.5 $h^{-1}M_{\odot}$

If this result is confirmed by larger samples, it may offer a straightforward interpretation to the clustering properties of AGN. As in the case for galaxies, the clustering properties of AGN may simply depend on the stellar mass of their hosts.

Claimed trends between AGN properties, such as accretion luminosity or level of obscuration, may be driven by differences in the stellar mass of AGN hosts.

Conclusions

- Photometric Probability Density Functions can effectively substitute specz to recover the clustering signal of extragalactic populations.

- The photo-z method is geared towards large samples and requires accurate photo-z estimations for the AGN and galaxies, $\sigma_{\Delta z/(1+z)} \approx 0.04$, or $\sigma_{\Delta z/(1+z)} \approx 0.08$ for AGN if $\sigma_{\Delta z/(1+z)} \approx 0.01$ for galaxies.

- X-ray AGN, star-forming galaxies and passive galaxies live in haloes with similar masses, because they have similar stellar mass distributions

- All galaxies that can potentially host X-ray AGN, because they have stellar masses in the appropriate range, live in similar haloes independent of their SFRs.