

**A Direct Measurement of the Quasar Mean
Occupation Function ;
Breaking Degeneracies between Halo Occupation
Distribution Models**

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Collaborators



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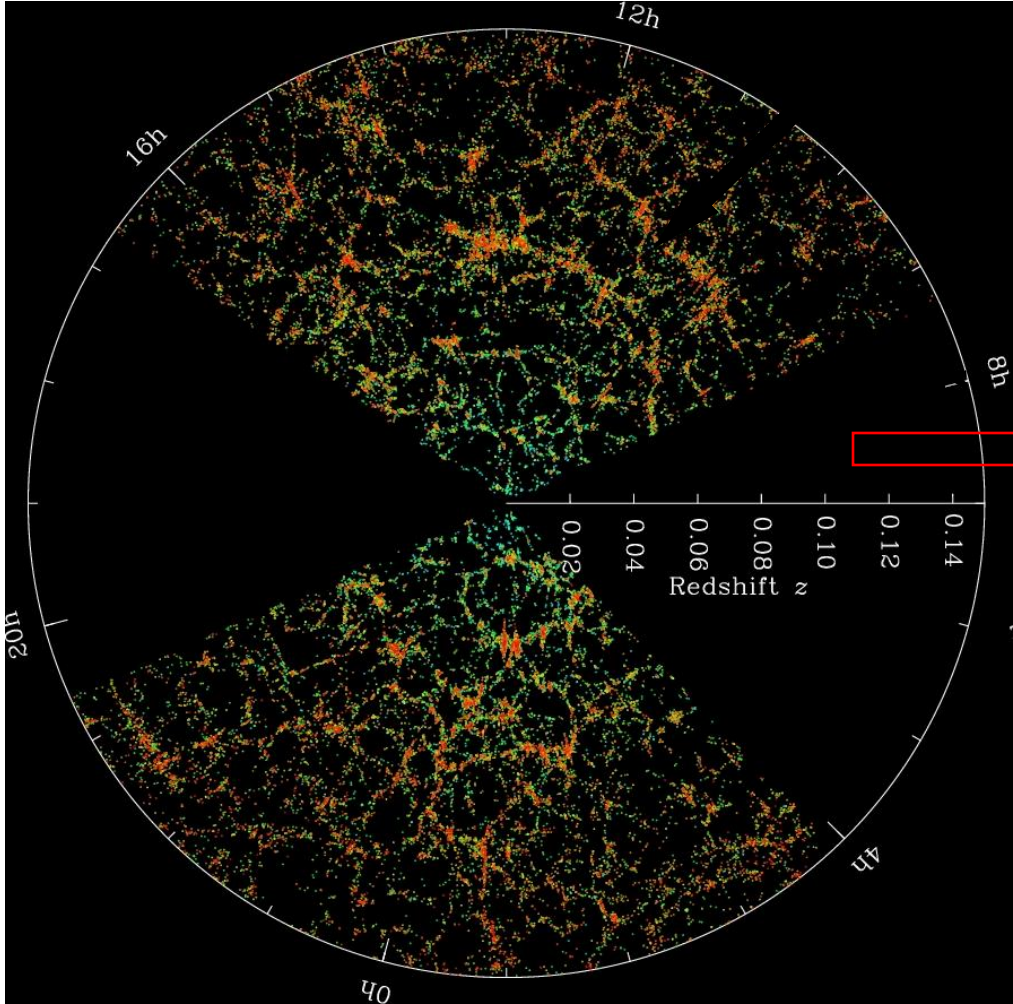


Adam Myers
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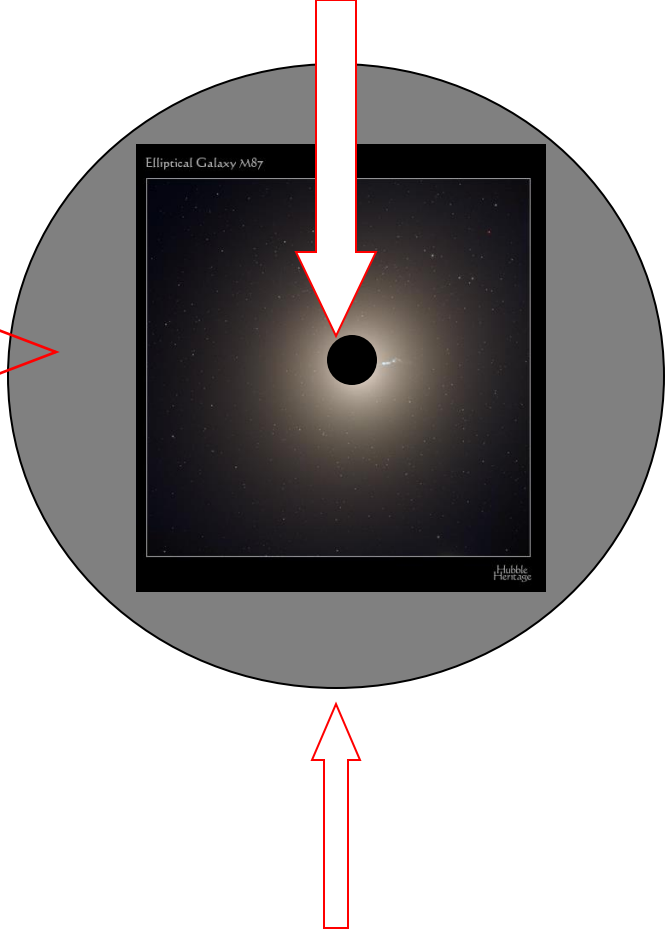
Zheng Zheng
University of Utah

Large Scale Structure in the Universe



Distribution of galaxies (SDSS)

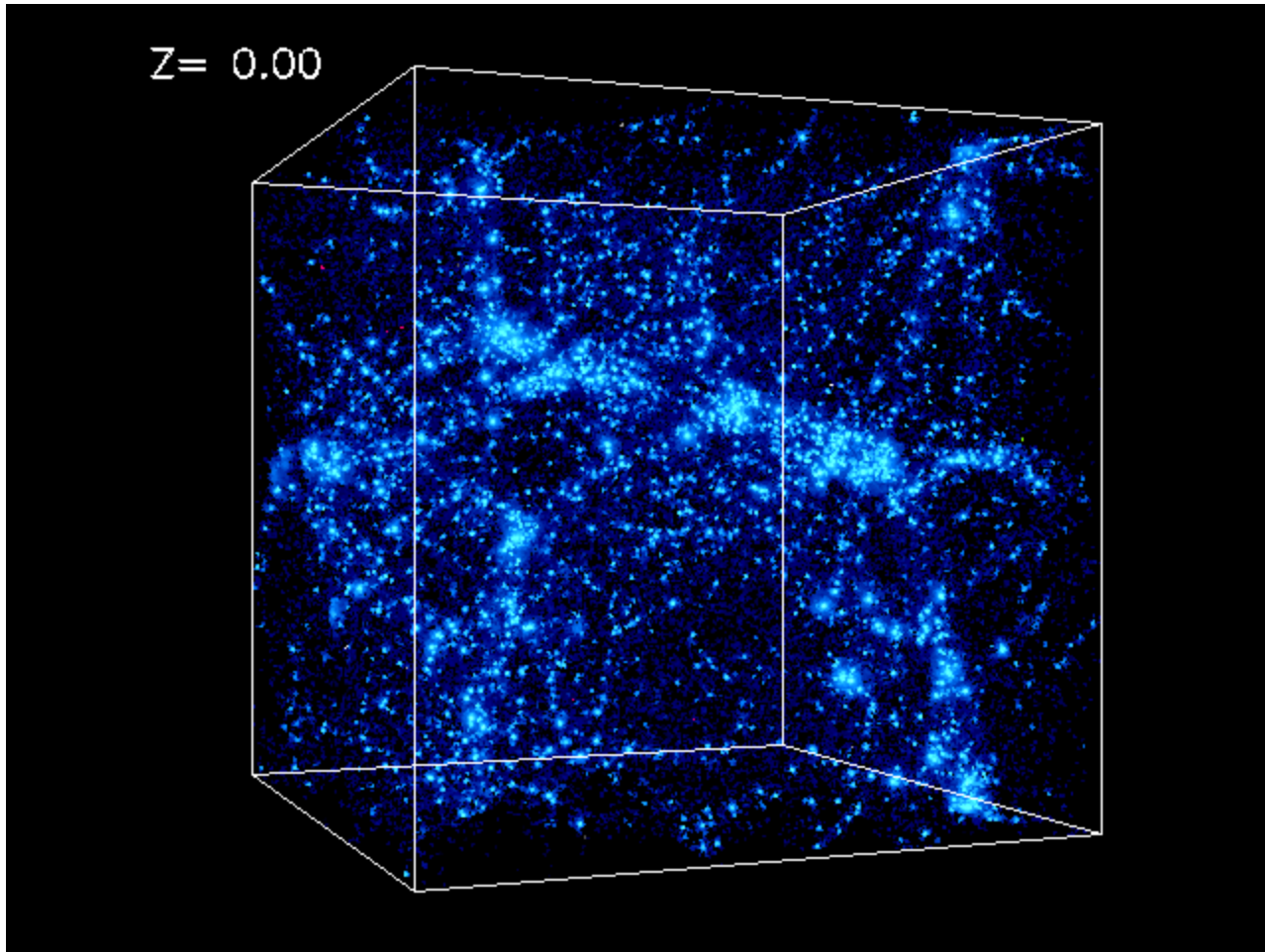
Supermassive black holes



Dark Matter Halos

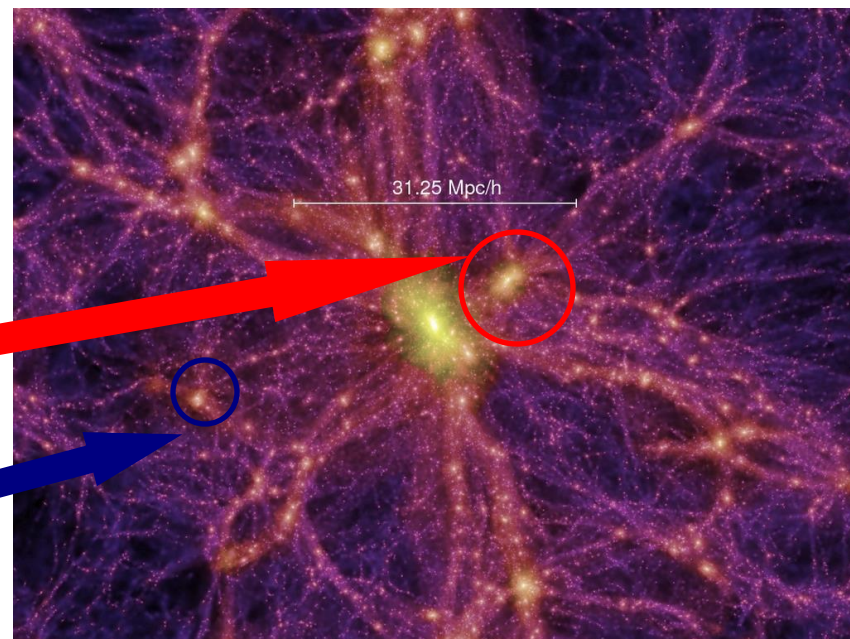
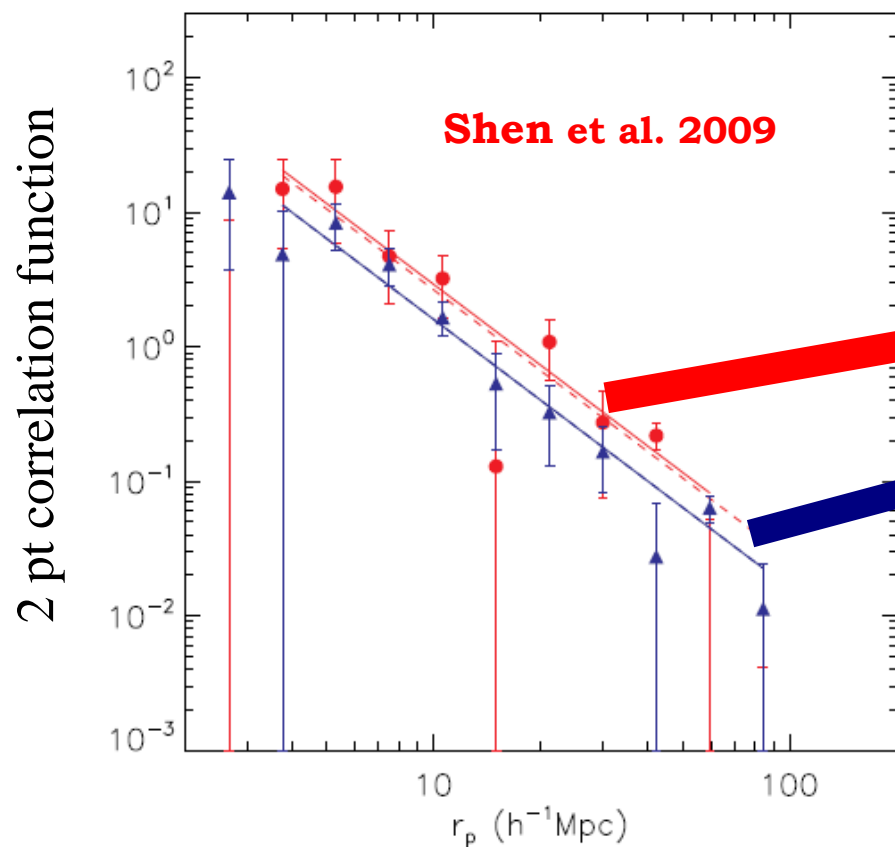
Large scale distribution of supermassive black holes.

Distribution of Dark Matter in the Universe from Cosmological Simulations



Courtesy: Andrei Kravtsov

Spatial Clustering of AGN

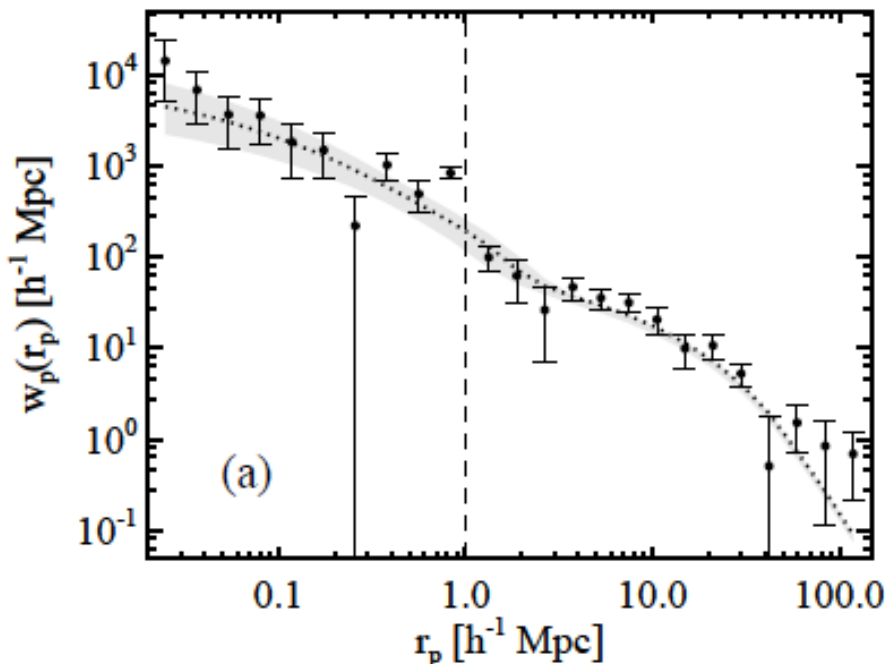


Springel et al. 2005

- ❖ Excess Probability of having number of black hole pairs at a given spatial scale over a random distribution
- ❖ Derive host dark matter halo properties from clustering

The Halo Occupation Distribution

- ❖ Probability distribution $P(N|M)$ that a halo of mass M contains N black holes
- ❖ Spatial distribution of black holes within halos
- ❖ Proposed model can be derived by fitting the correlation function.



Based on a 5 parameter model derived from cosmological simulation

$$\langle N_{\text{cen}} \rangle = \frac{1}{2} \left[1 + \text{erf} \left(\frac{\text{Log}M - \text{Log}M_{\text{min}}}{\sigma_{\text{Log}M}} \right) \right]$$

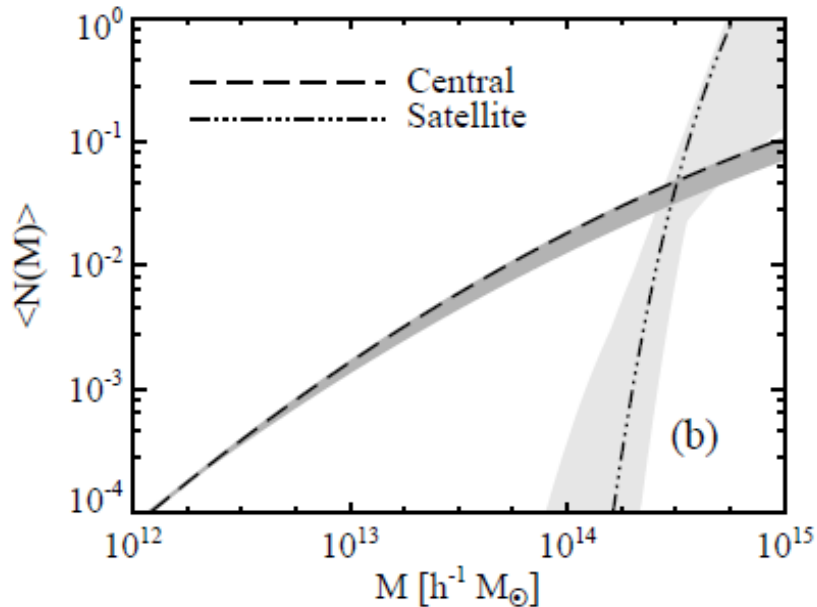
$$\langle N_{\text{sat}} \rangle = (M/M_1)^\alpha \exp(-M_{\text{cut}}/M)$$

Chatterjee et al. 2012

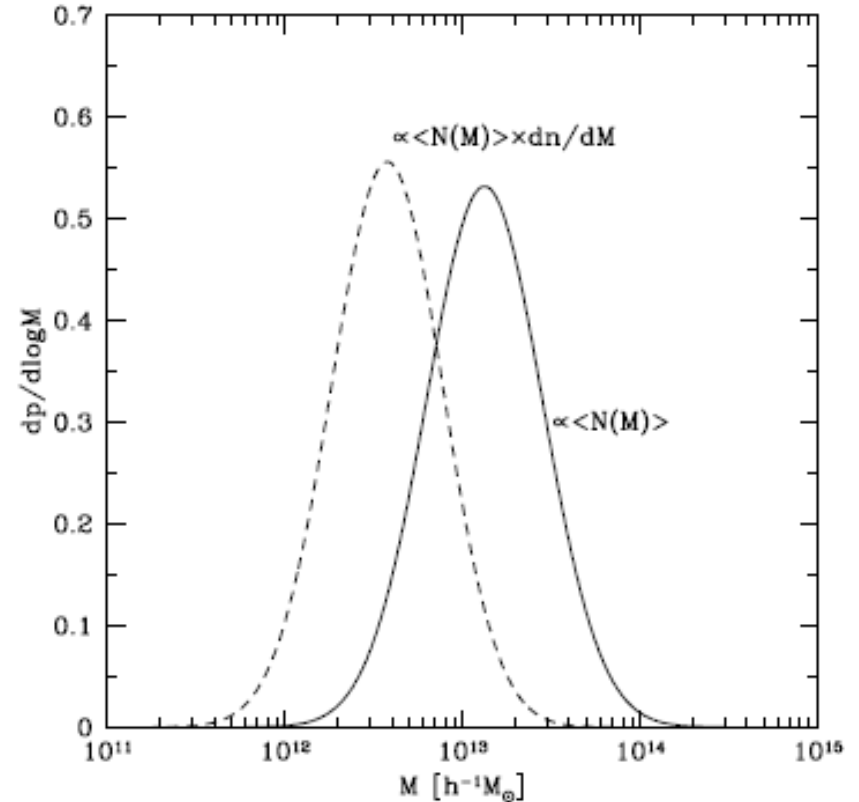
Richardson, ZZ, SC et al. 2012

Degeneracy Between Halo Occupation Distribution Models

Mean number of quasars per halo as a function of halo mass at $z \sim 1$



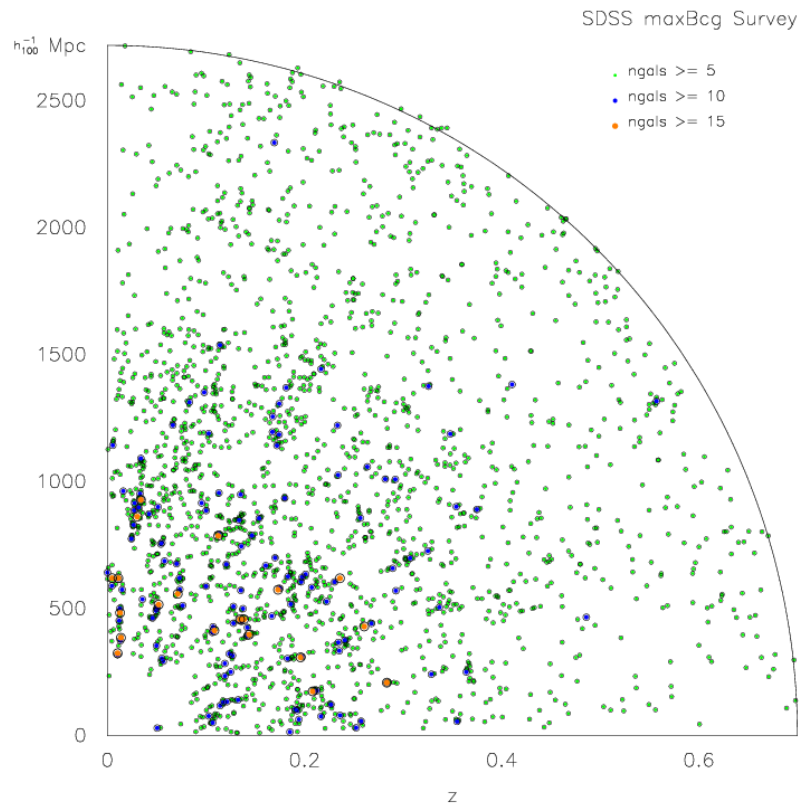
Richardson, ZZ, SC, et al. 2012



Kayo & Oguri 2012

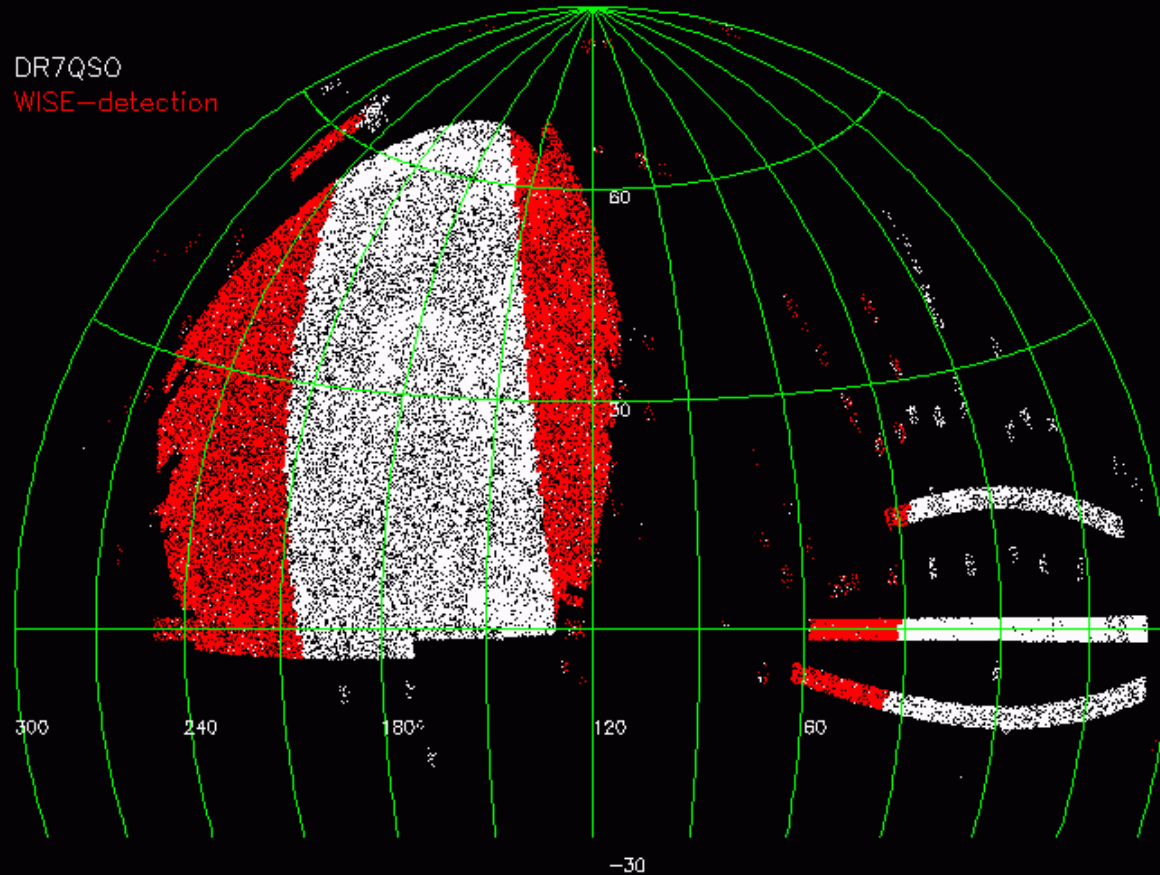
MaxBCG Clusters

Koster et al. 2007

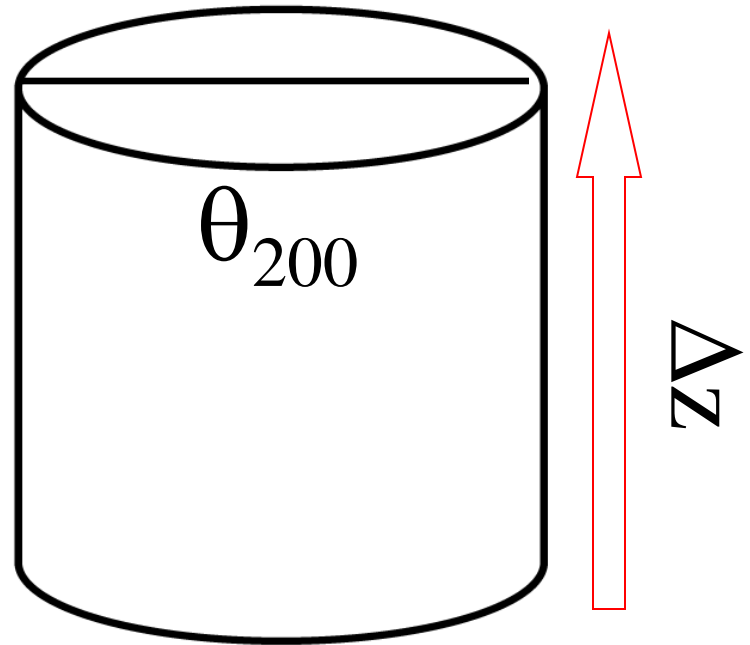
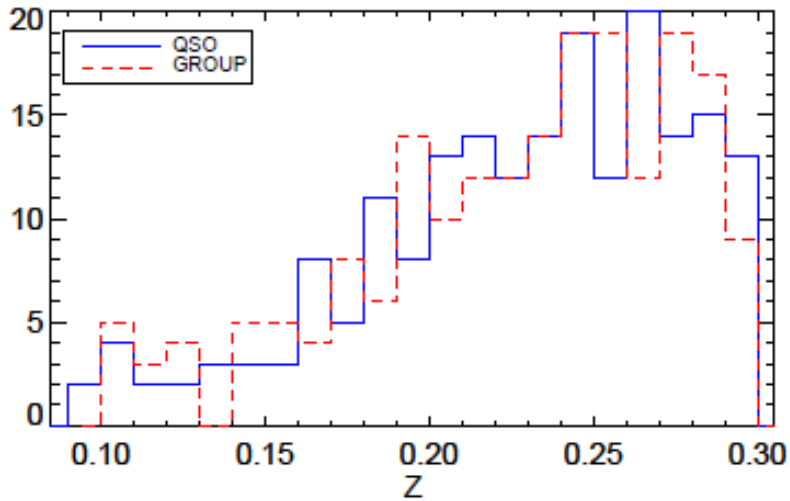
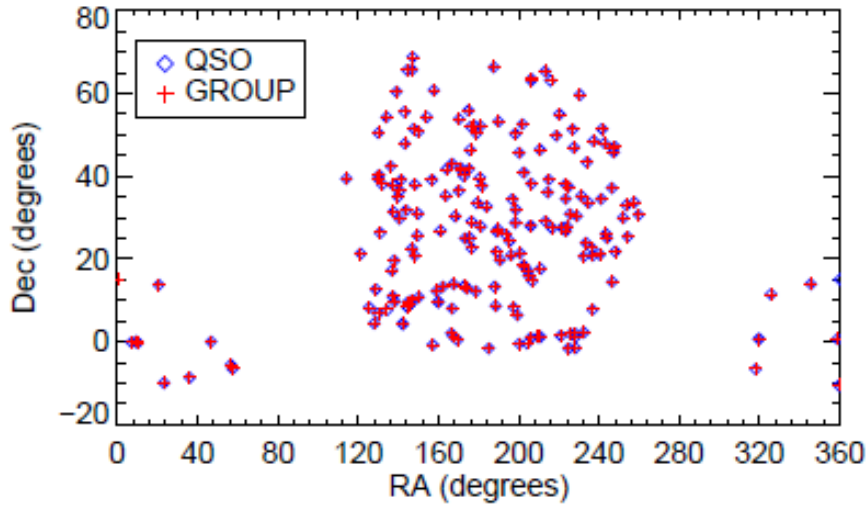


A Direct Approach

Cross-match between DR7 quasars and MaxBCG clusters
Mass of halos are obtained from cluster scaling relations.



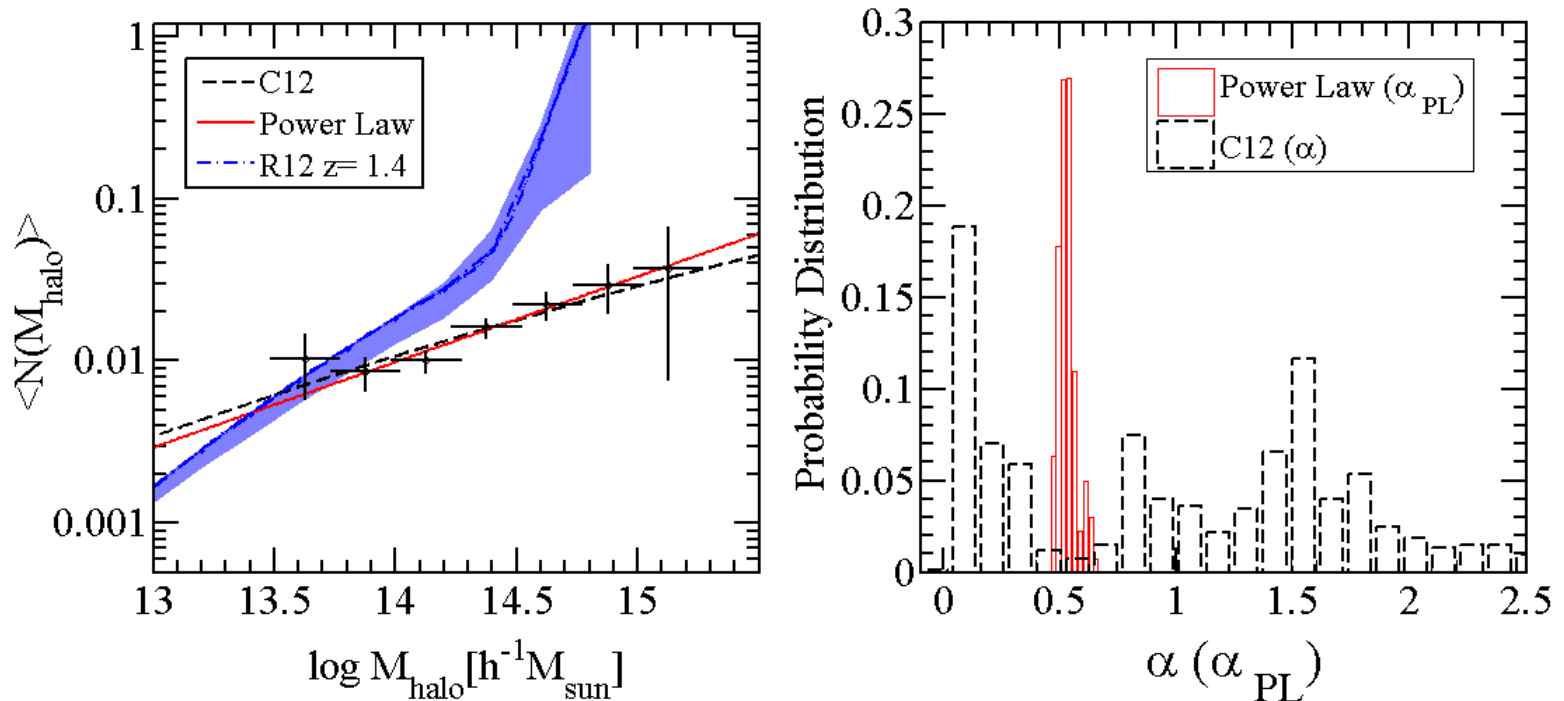
Spatially matching clusters with quasars



Chatterjee, Nguyen et al. 2013

The Mean Occupation Function of Quasars at $z \sim 0.25$

Chatterjee, Nguyen et al. 2013



The Low redshift mean occupation function favors a monotonically increasing slope

0.53 ± 0.04 (power law model)
C12 (R12) model unconstrained

Using the RedMapper catalog (Rykoff et al. 2014)

SDSS DR8 Cluster Catalog; 25,000 clusters, redshift ~ 0.6

