HSCデータによる AGNと周辺銀河の相関解析
AGNs and galaxies cross-correlation using HSC data

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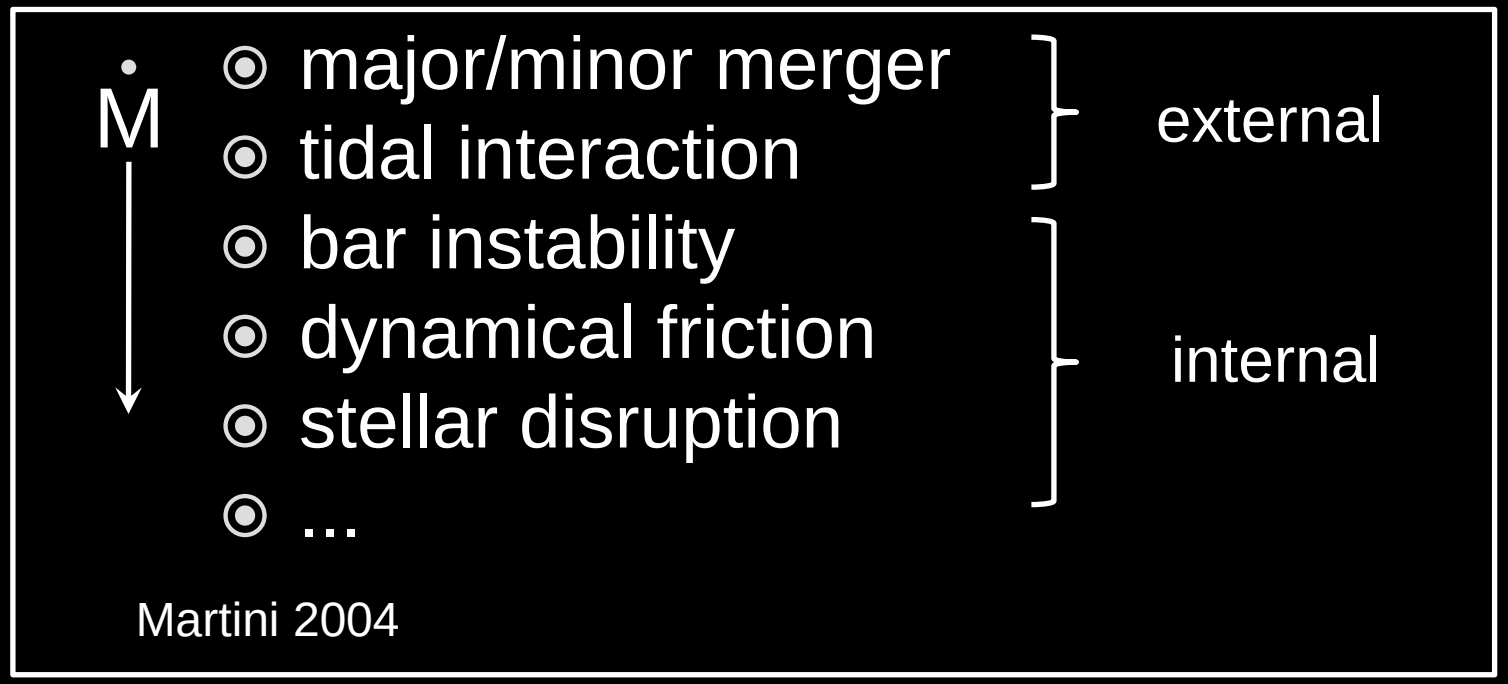
Unresolved problem in AGN research

- ✓ Fueling mechanisms of AGN

  How is the AGN fueling transferred to the SMBH ?

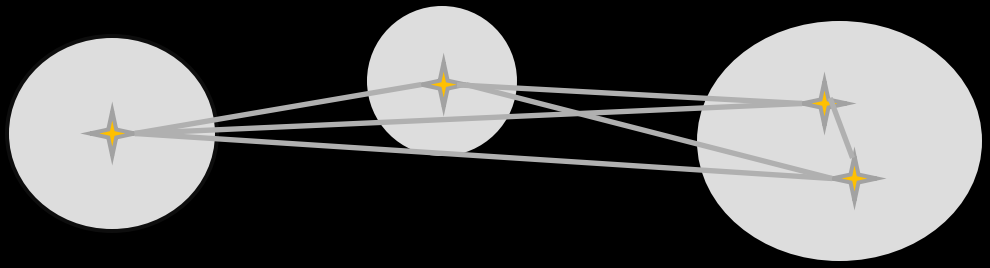


From recent observations :

- low/intermediate luminous AGN → internal
- most luminous AGN (QSO) → external

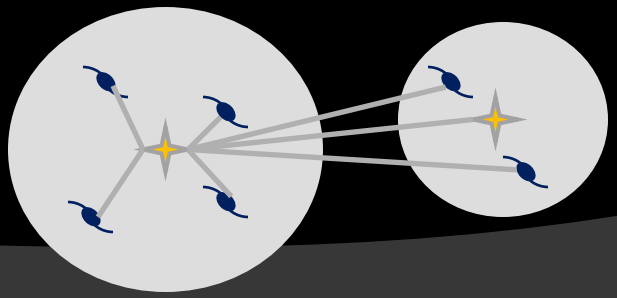
What does AGN environment tell us ?

- AGN auto-correlation
  - correlation between different DMHs
  - large scale structure



Mass of the DMH

- AGN-galaxy cross-correlation
  - correlation within the same DMH
  - small (+intermediate) scale structure



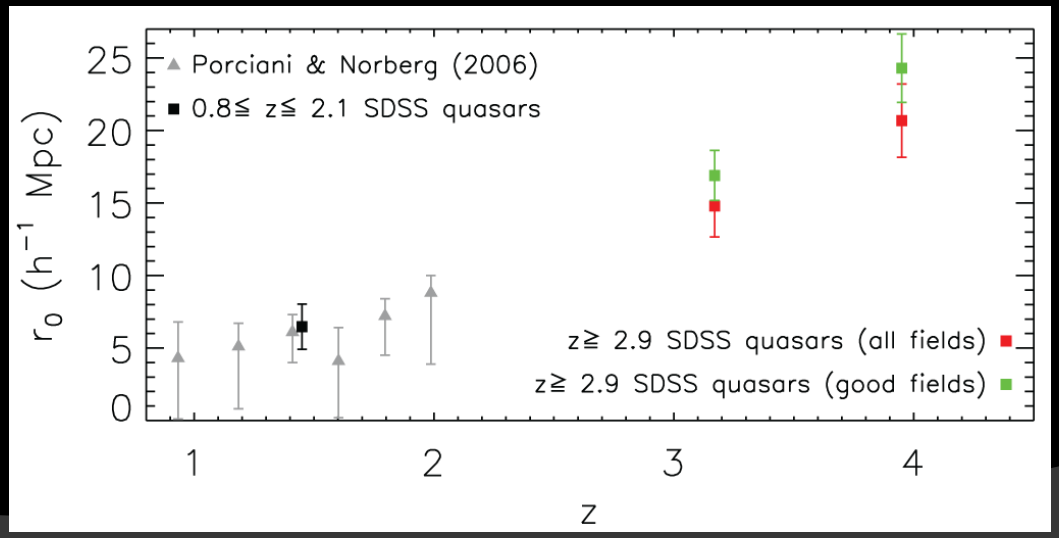
Mass of the DMH
+ Distribution in the DMH

AGN auto-correlation

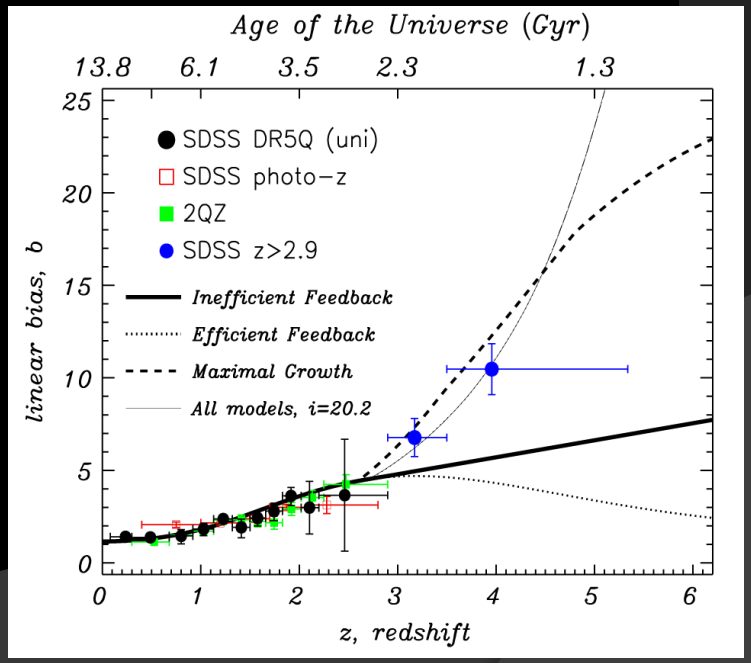
- Require uniform large area survey
  - 2dF Survey
  - SDSS Survey
- Constant M_{DMH} below z = 3.0
- Larger M_{DMH} at higher redshift (or luminosity ?)

$M_{DMH} = 2 \times 10^{12}\ h^{-1} M_{\odot}$ (z < 3)

$$\xi(r)_{\text{quasar}} = b_Q^2\ \xi(r)_{\text{matter}},$$



Shen et al. (2007)



Ross et al. (2009)

AGN-galaxy cross correlation (1)

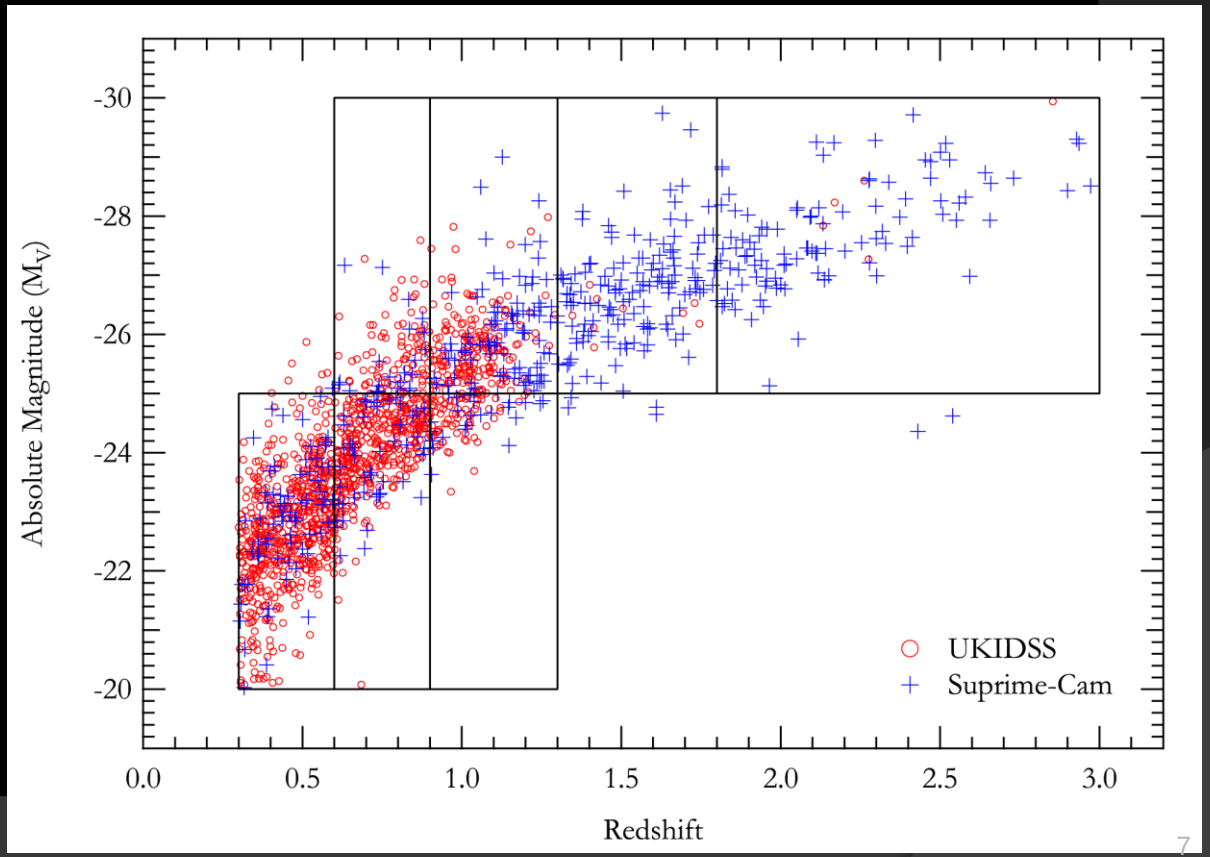
- Low redshift ($z < 0.6$)
  - SDSS, 2dF Survey
  - Low luminosity AGN
  - $r \sim 6\ h^{-1}$Mpc
  - similar to typical local galaxy
- Intermediate redshift ($z = 0.6 \sim 3.0$)
  - Deep survey / IR observation
  - Low/intermediate luminosity AGN
  - small sample (a few tens or less)
  - $r = 3.7 \sim 6.3\ h^{-1}$Mpc
    - radio AGN > X-ray AGN > IR AGN (Hickox et al. 2009)

AGN-galaxy cross correlation (2)

- Subaru Suprime-Cam archive + UKIDSS
- z = 0.3 ~ 3.0
- wide luminosity range (M_V = -30 ~ -20)
- 1,809 AGNs

Largest samples ever achieved (at z > 0.6)

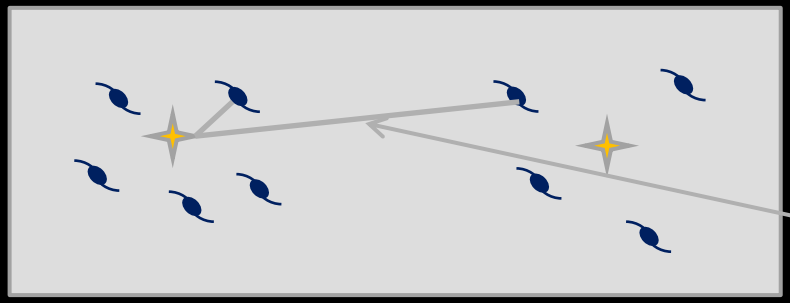
Shirasaki et al. (2011) PASJ 63 S469



Our method

- cross correlation function : $\xi(r)$

  probability of finding a galaxy at a given separation from an AGN compared to a random distribution ≈ $n(r) / n_0 - 1$



can be ignored if the two AGN are well separated

$$\omega(r_p) = \int_{-\infty}^{\infty} \xi(r_p, \pi) d\pi = \frac{1}{\rho_0} \int_{-\infty}^{\infty} (\rho(r) - \rho_0) d\pi \quad = \frac{n(r_p) - n_{\rm bg}}{\rho_0},$$

- Stack the number density $n(r_p)$ for all the AGNs and derive the average of $\omega(r_p)$

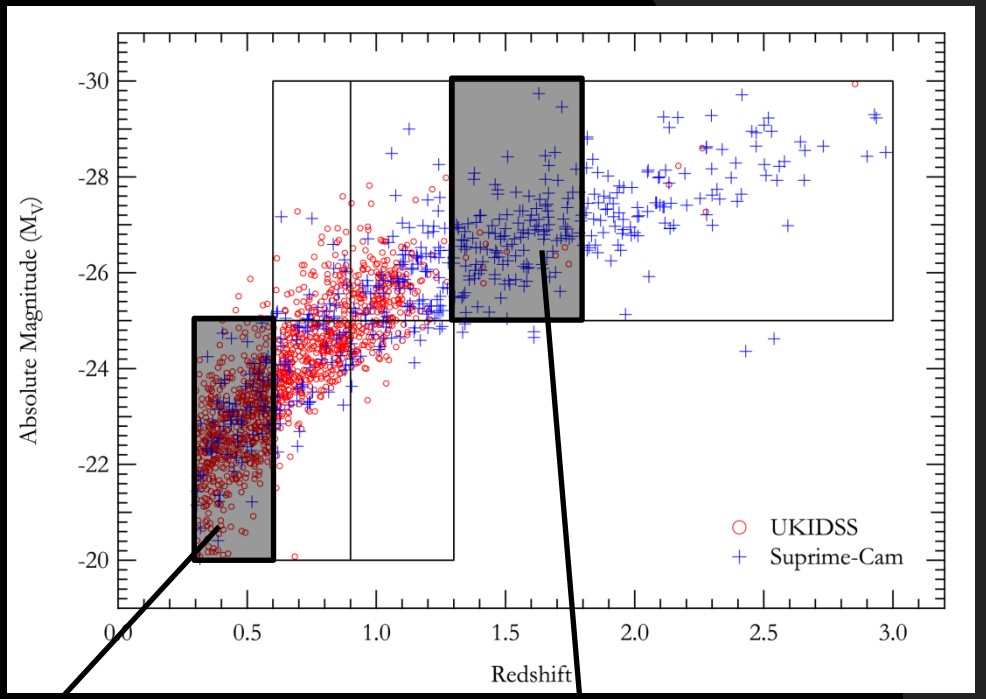
$$\omega(r_p) = \frac{< n(r_p) > - < n_{\rm bg} >}{< \rho_0 >},$$

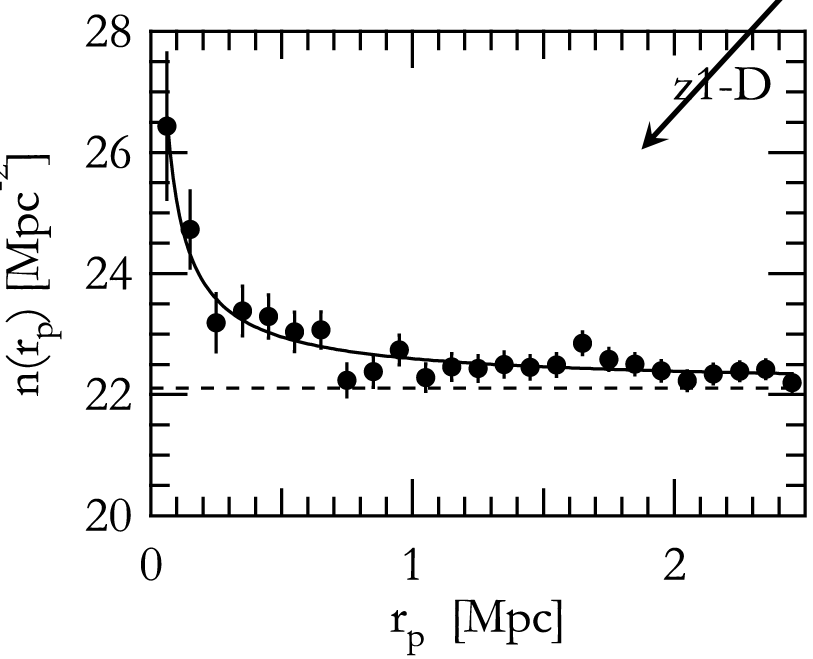
Merit of this method

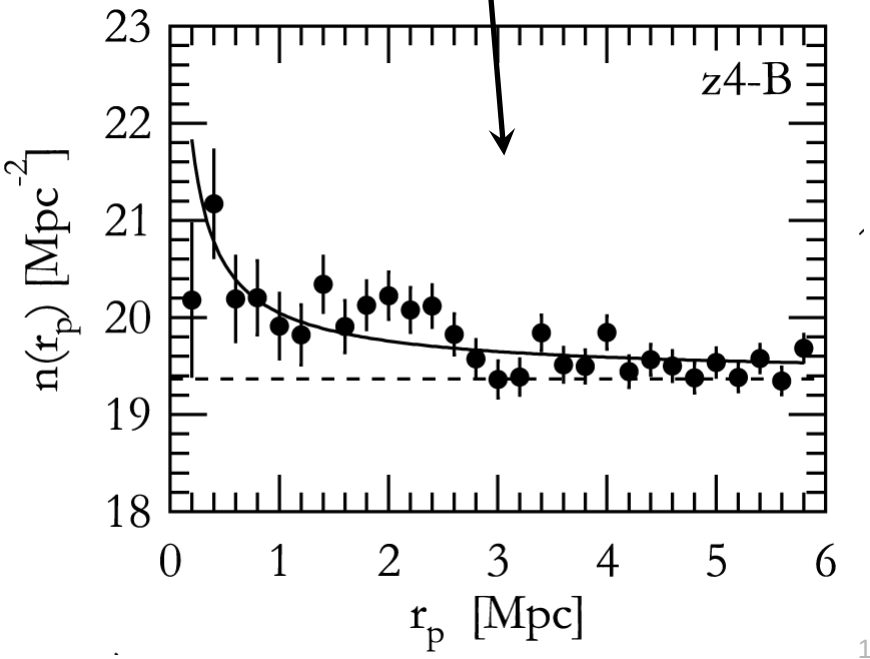
- Doesn’t require redshift measurement for galaxies
  - single band image
  - Easy to obtain a large statistical sample
- Precise measurement at small scale (average)
  - Distribution of AGN in a DMH
- Free from selection bias for galaxy sample
  - all objects detected in the image can be considered

Our result (1)

- Clustering detected up to z = 1.8
- Less luminous low-z AGN → power law
- Luminous high-z AGN → flat distribution < 3Mpc



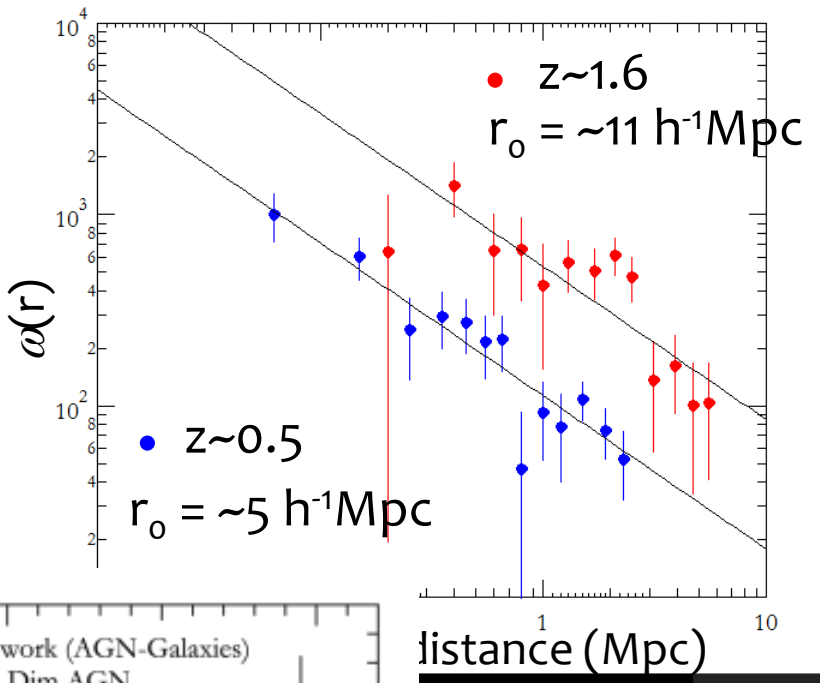


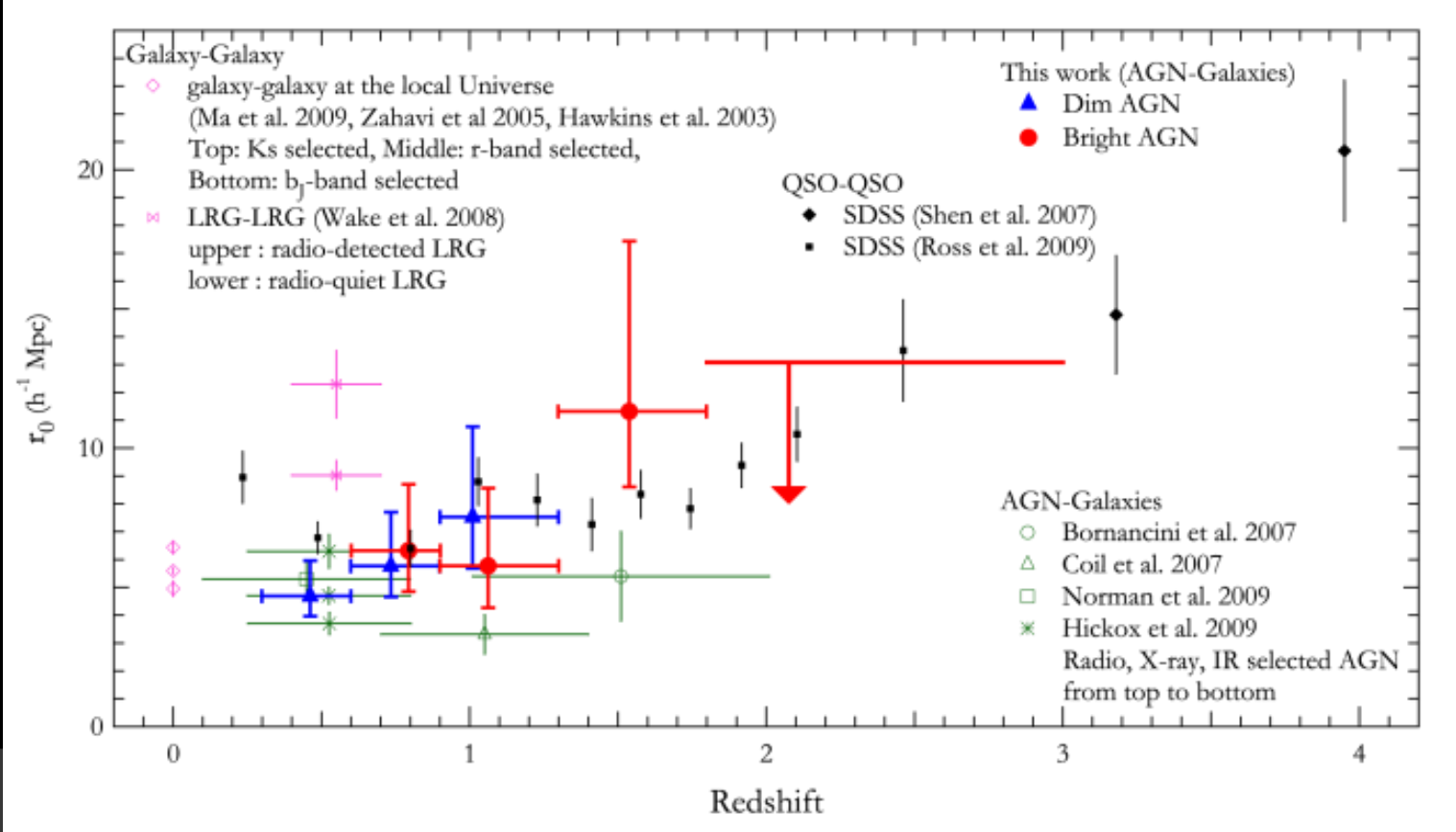


Our result (2)

Our z ~ 1.6 sample shows larger correlation length than that of the existing measurements

→ Difference of the galaxy samples ?

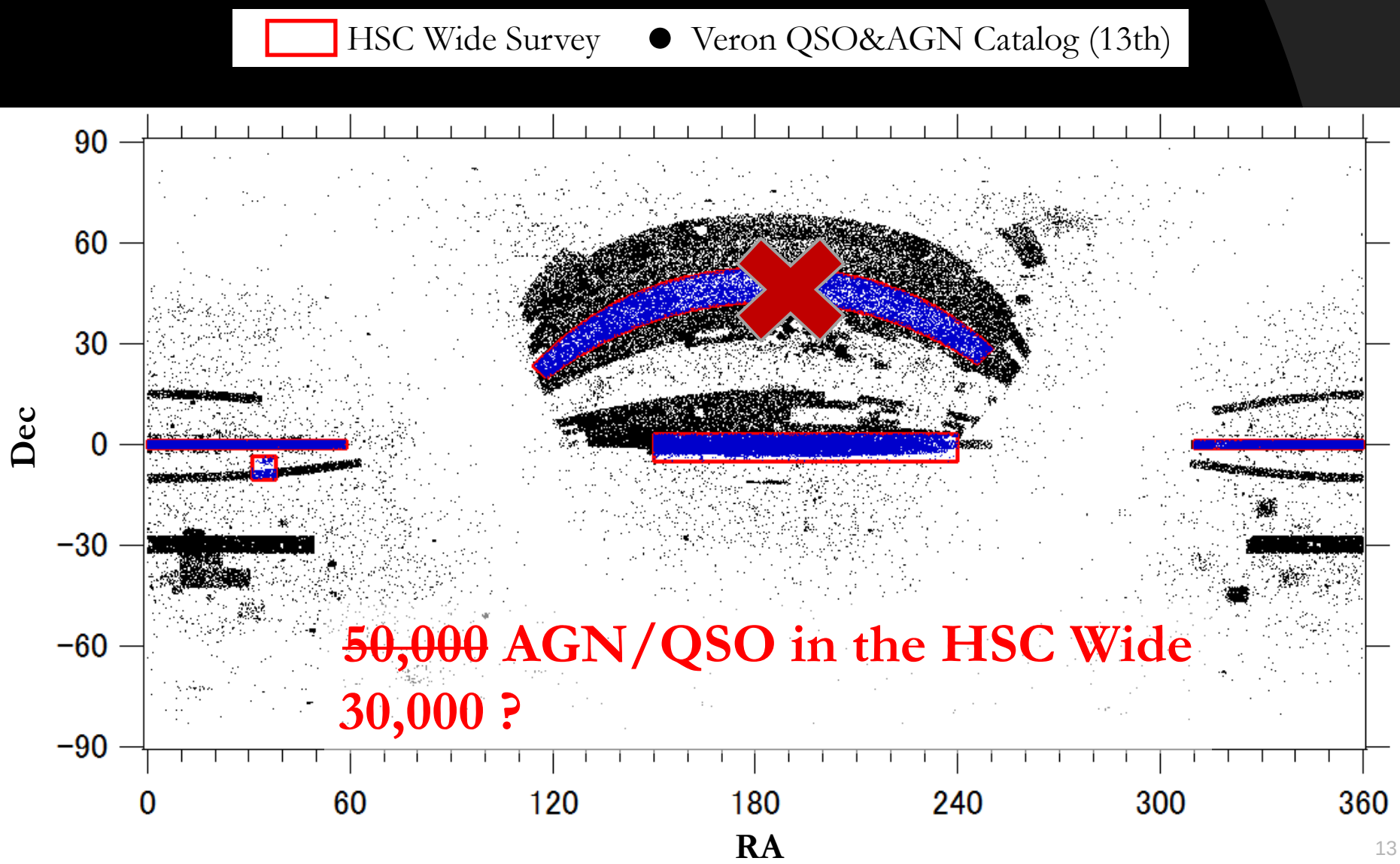




Summary of our result

- relatively large cross-correlation length was detected at z ~ 1.6
- no luminosity dependence was found between the two luminosity groups
- flat distribution at < 3 Mpc for the bright group indicates that the AGNs are distributed uniformly in their DMH
- open question:
  - nature of the large clustering found at z ~ 1.6
    - redshift, luminosity, galaxy type ?
  - the small scale structure should be confirmed with higher statistic

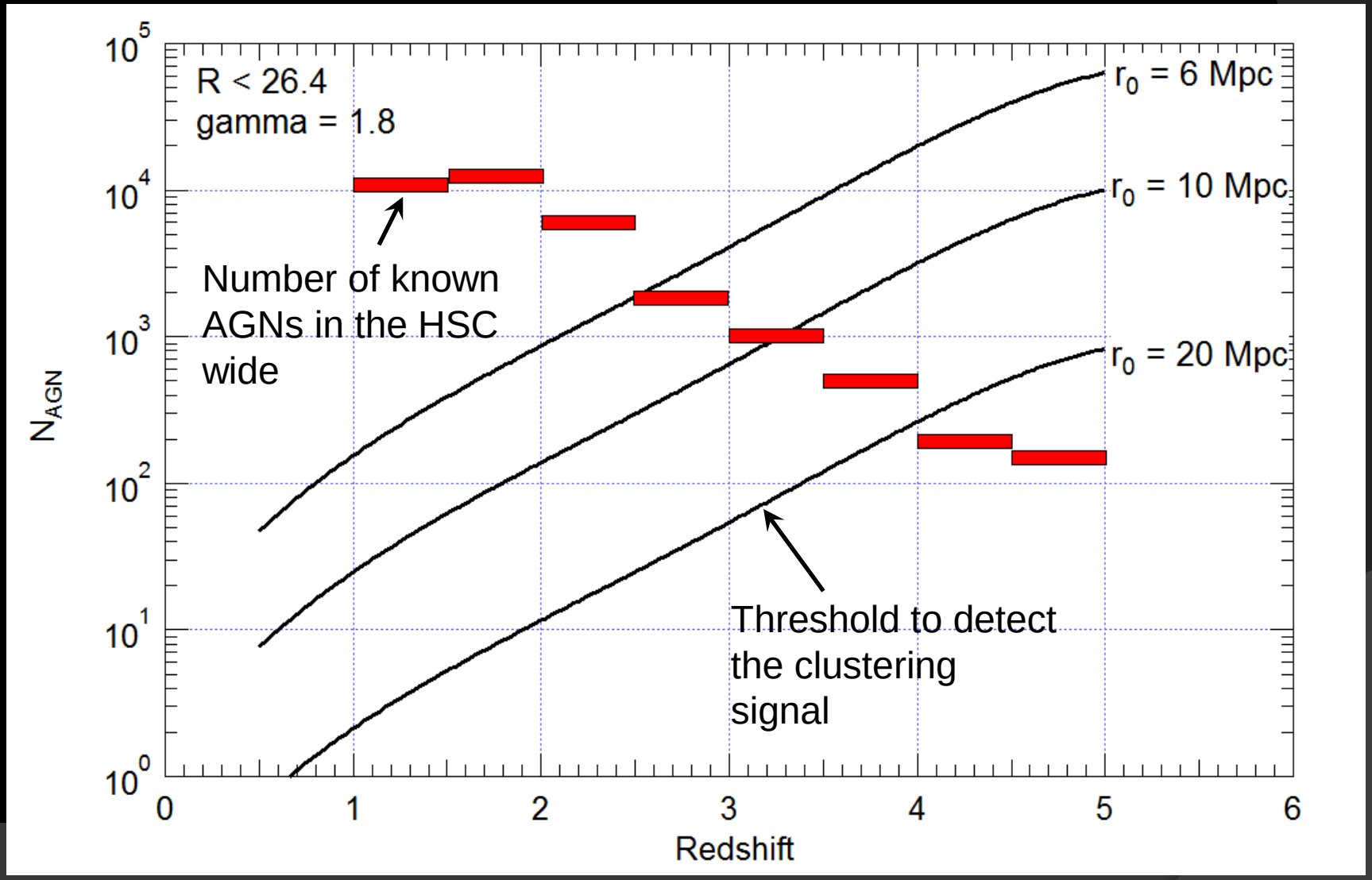
HSC Wide Survey + QSO/AGN



Expectations for HSC

- extends redshift range beyond 2
  - but may be difficult for z > 3. IR can do a better job...
  - increase S/N by incorporating photo-z of galaxies
- more precise study on luminosity dependence of clustering
  - known luminous AGNs + HSC low luminosity AGNs around z ~ 2
  - find a threshold where clustering becomes large
- precise measurement of cross correlation at a small scale → distribution of AGN in a DMH
- dependence on the galaxy type
  - needs help of IR data (UKIDSS, VISTA)

Detection threshold for single band analysis



Three steps strategy for writing a paper

1. Cross correlation study using single band data
   - simple extension of our study using the Suprime-Cam data with higher statistic.
   - This can be done quickly.
2. Galaxy selection/rejection by photometric redshift
   - need photo-z code and multi-band catalog
3. Dependence on galaxy type with the help from IR data
   - UKIDSS already there, VISTA will provides deeper catalog
   - MOIRCS archive data might also be useful.