Subaru user meeting FY2017, Jan. 17-19, 2018 Mitaka JP

Clustering of quasars in a wide luminosity range at z~4 with HSC wide field imaging

https://arxiv.org/abs/1704.08461

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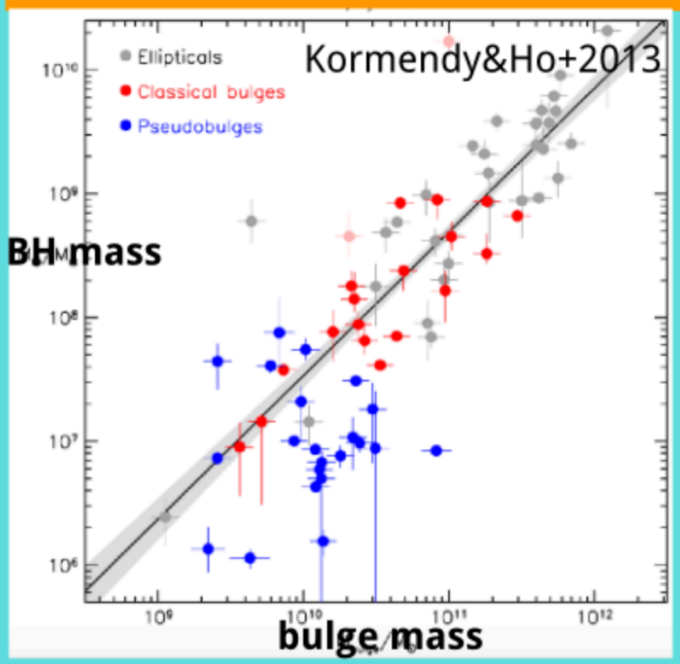
Introduction



- supermassive black holes are ubiquitous in massive galaxies
- BH mass is correlated with properties of host galaxy

? How is black hole growth associated with galaxy evolution?

quasar is triggered by accretion towards BH

One good tool: clustering analysis of quasars and galaxies

quasar/galaxy

underlying DM

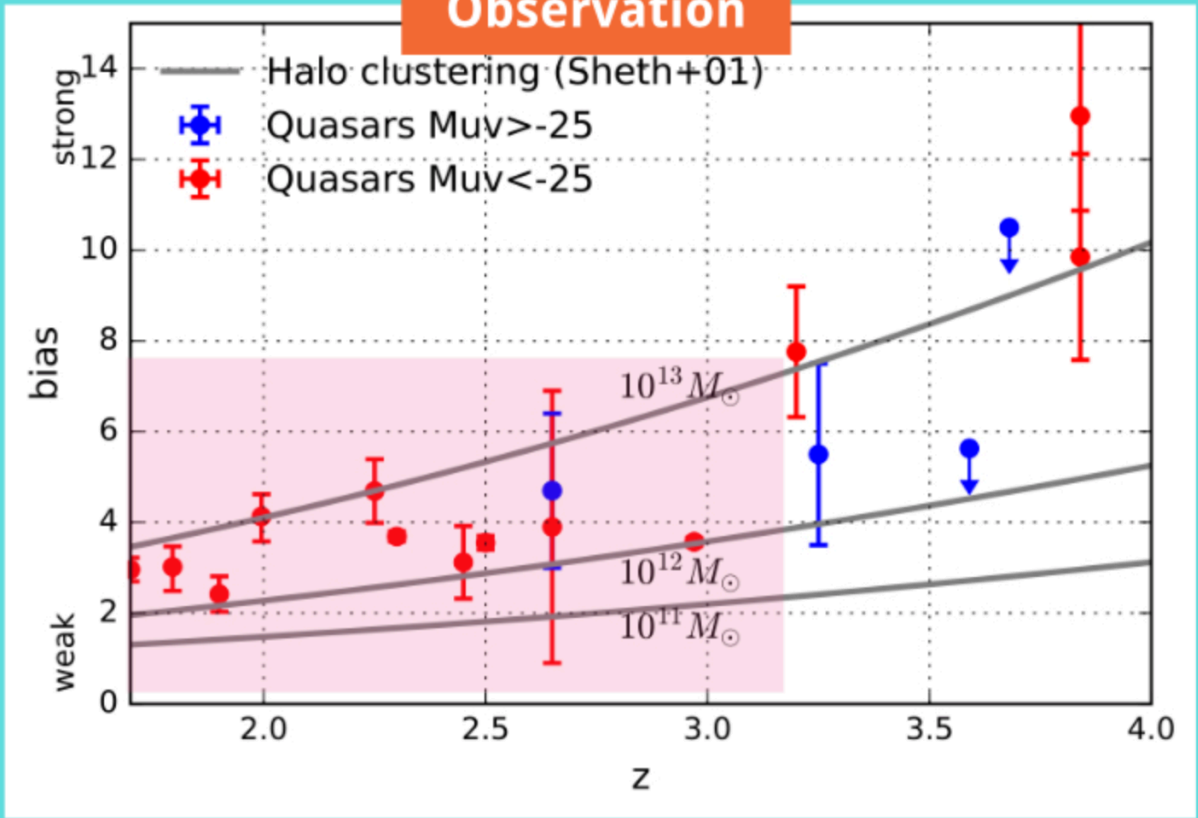
bias(z)

halo bias(M,z)

host halo mass & duty cycle

Previous studies

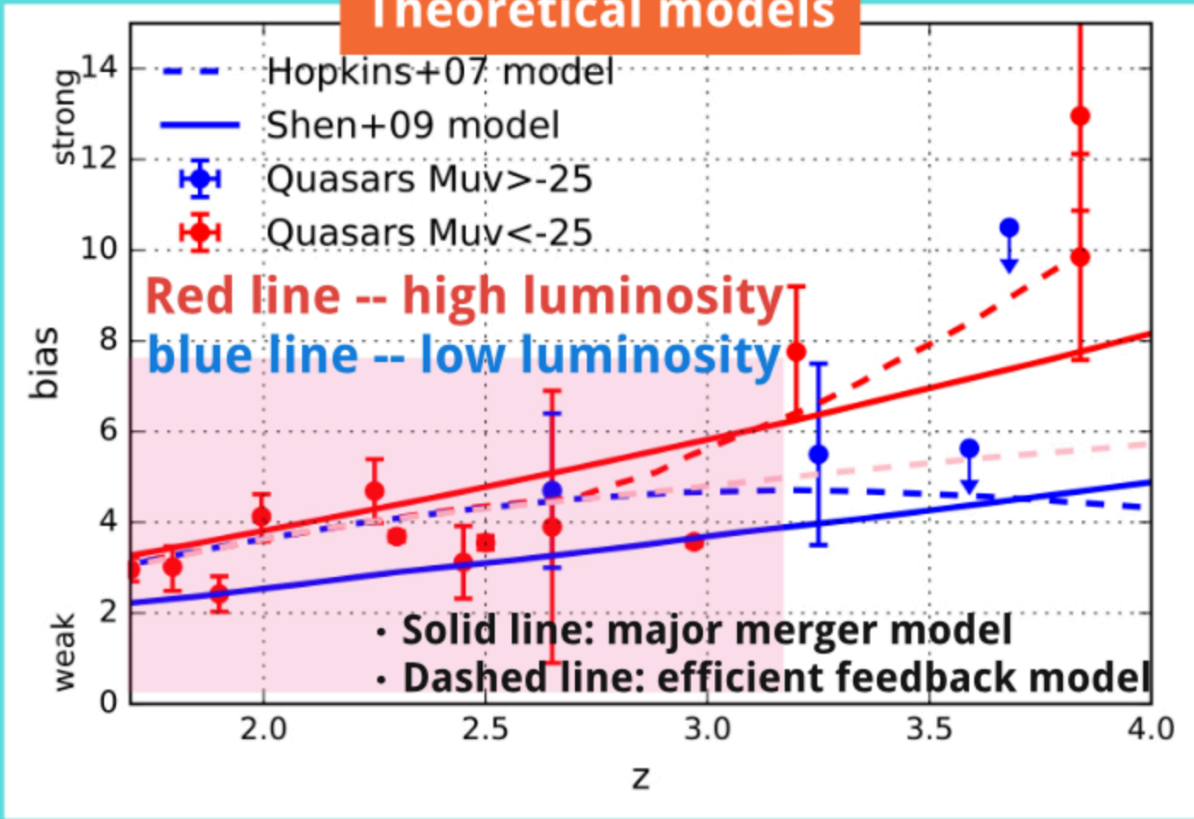
Observation



No matter being luminous or faint, quasars prefer residing in massive halos (10^12-10^13) at z<3 (Shen+09; Ikeda+15...).

Previous studies

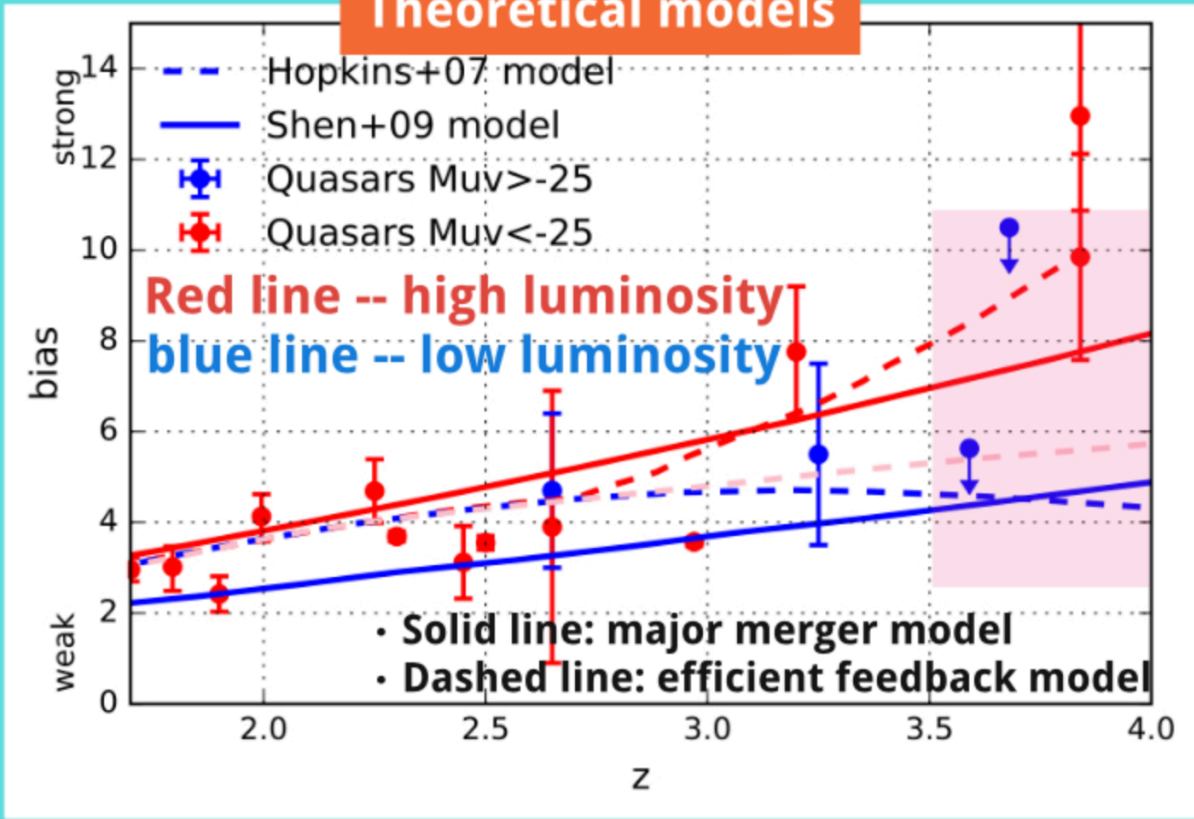
Theoretical models



Models can explain weak luminosity dependence at z<3.

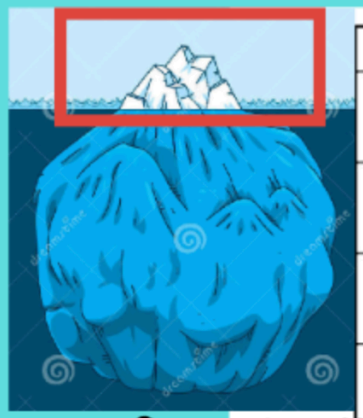
Previous studies

Theoretical models



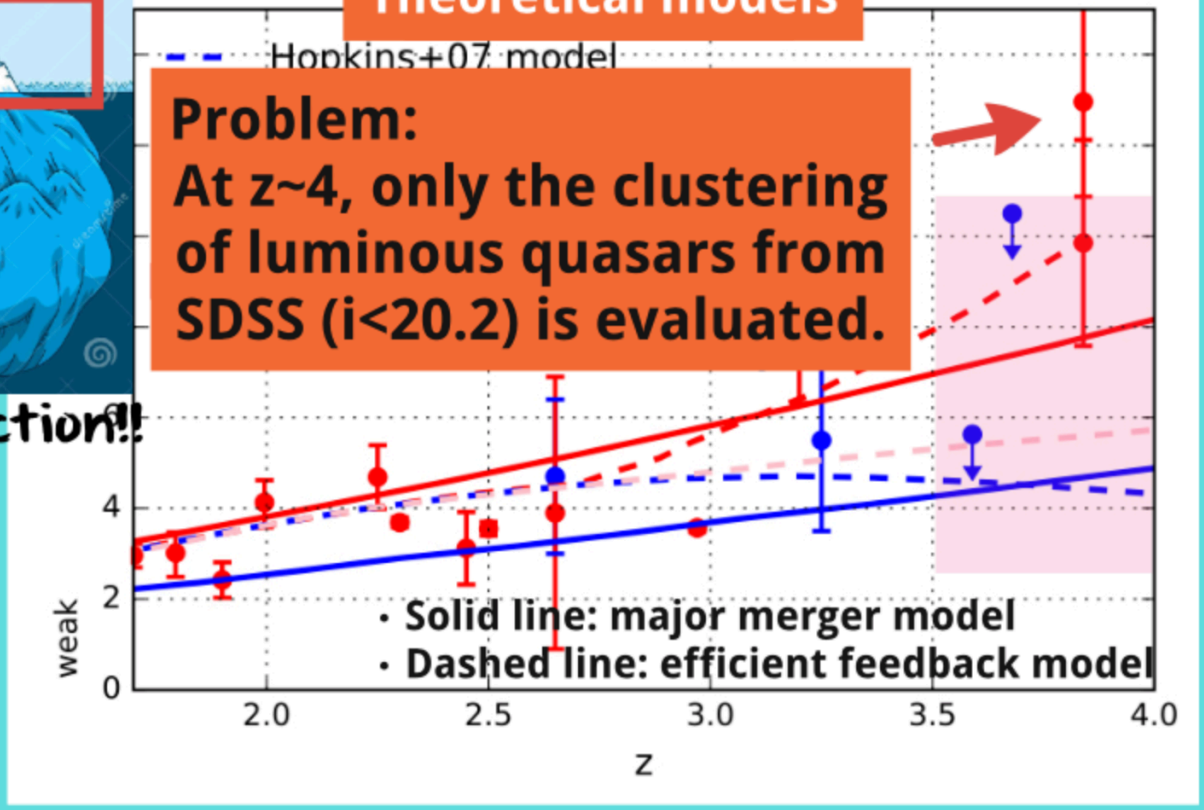
At z~4, SMBH growth models suggest weaker clustering, i.e. smaller host halo, for less-luminous quasars.

Previous studies



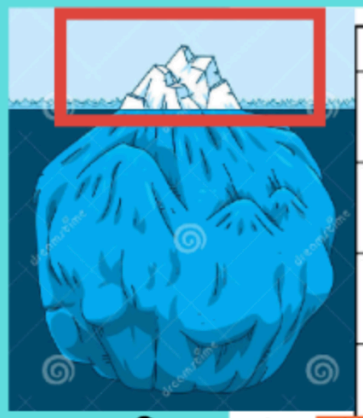
Small fraction!!

Theoretical models



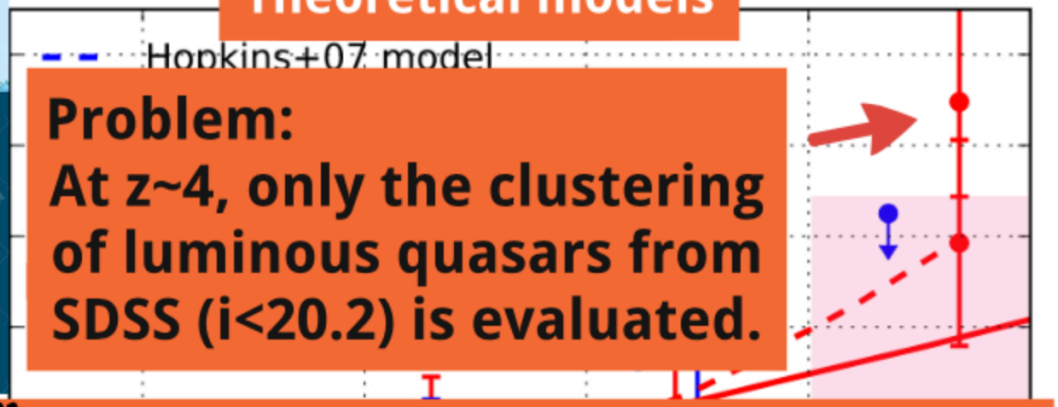
At z~4, SMBH growth models suggest weaker clustering, i.e. smaller host halo, for less-luminous quasars.

Previous studies



Small fraction!!

Theoretical models



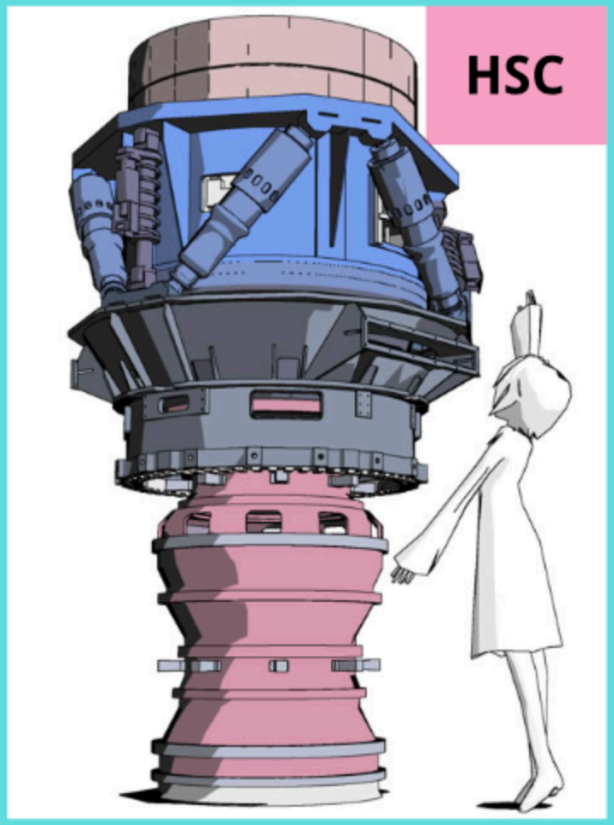
Problem:
At z~4, only the clustering of luminous quasars from SDSS (i<20.2) is evaluated.

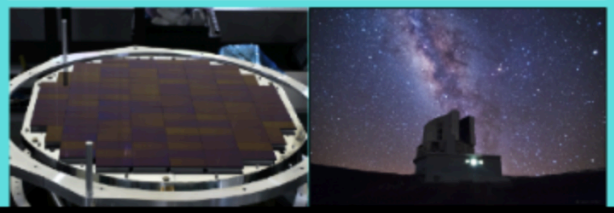
HSC-SSP wide and deep imaging can help examine the clustering of faint quasars at z~4!!
--> motivation

weak

At z~4, S ng, i.e. smaller host halo, for less-luminous quasars.

Data sample





- **Subaru Hyper Suprime-Cam (HSC) SSP**

1. 116 2K x 4K CCDs (104 CCDs for science)
2. 1.5 deg FoV
3. Wide: i < 25.9 over 1400 deg2
   Deep: i < 26.8 over 27 deg2
   UDeep: i < 27.4 over 3.5 deg2

--> a large sample of quasars with low luminosity at high redshifts (z>3) can be constructed for further statistics analysis

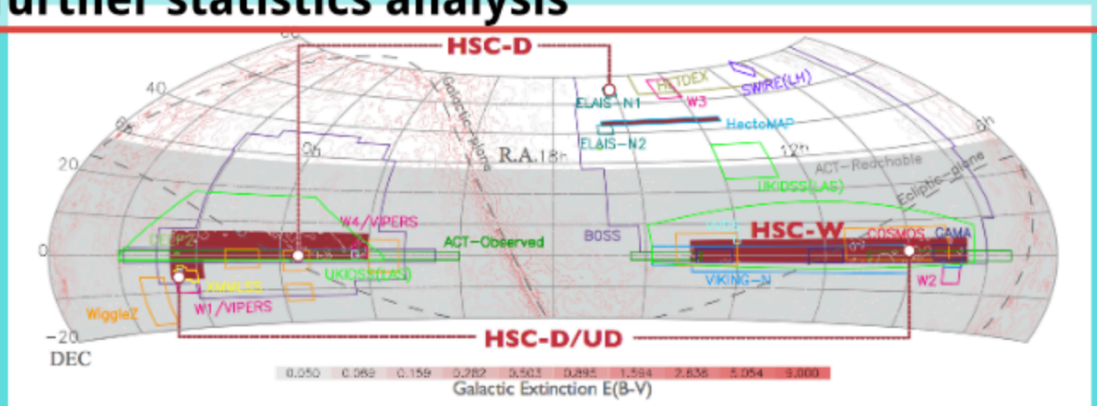
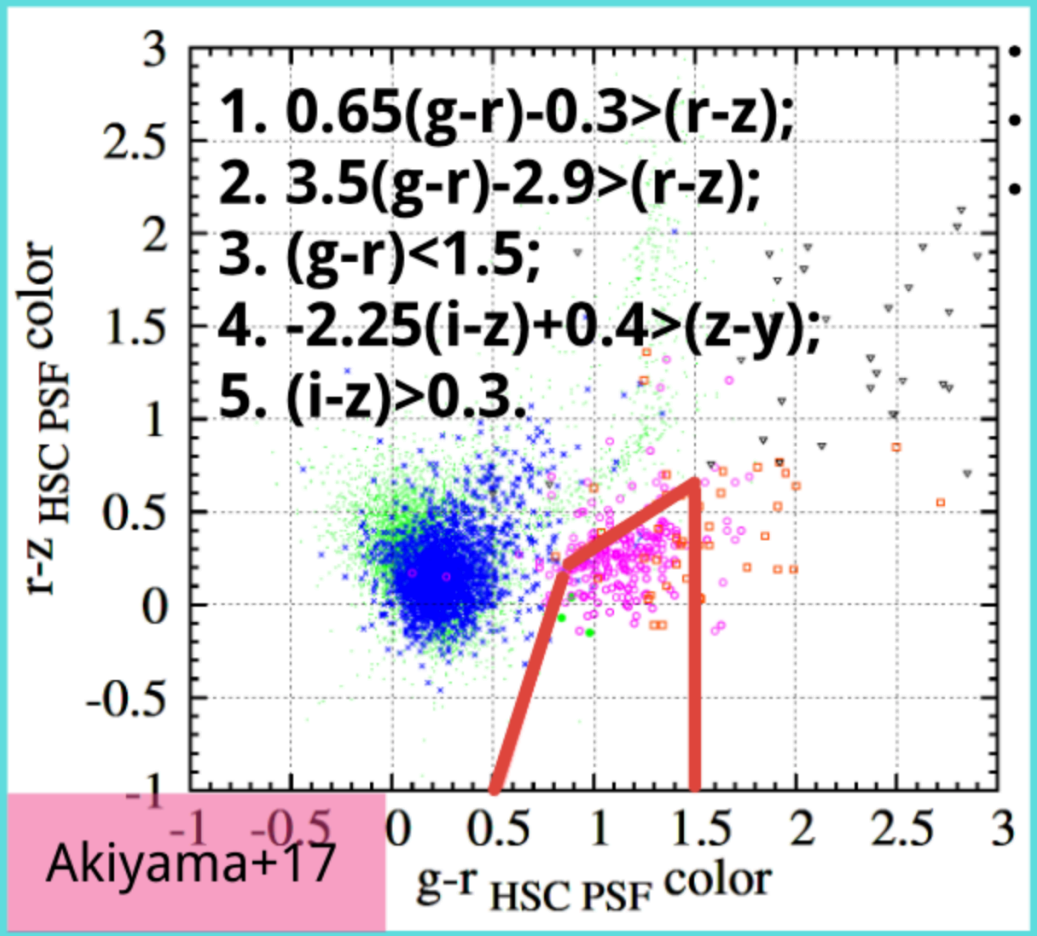


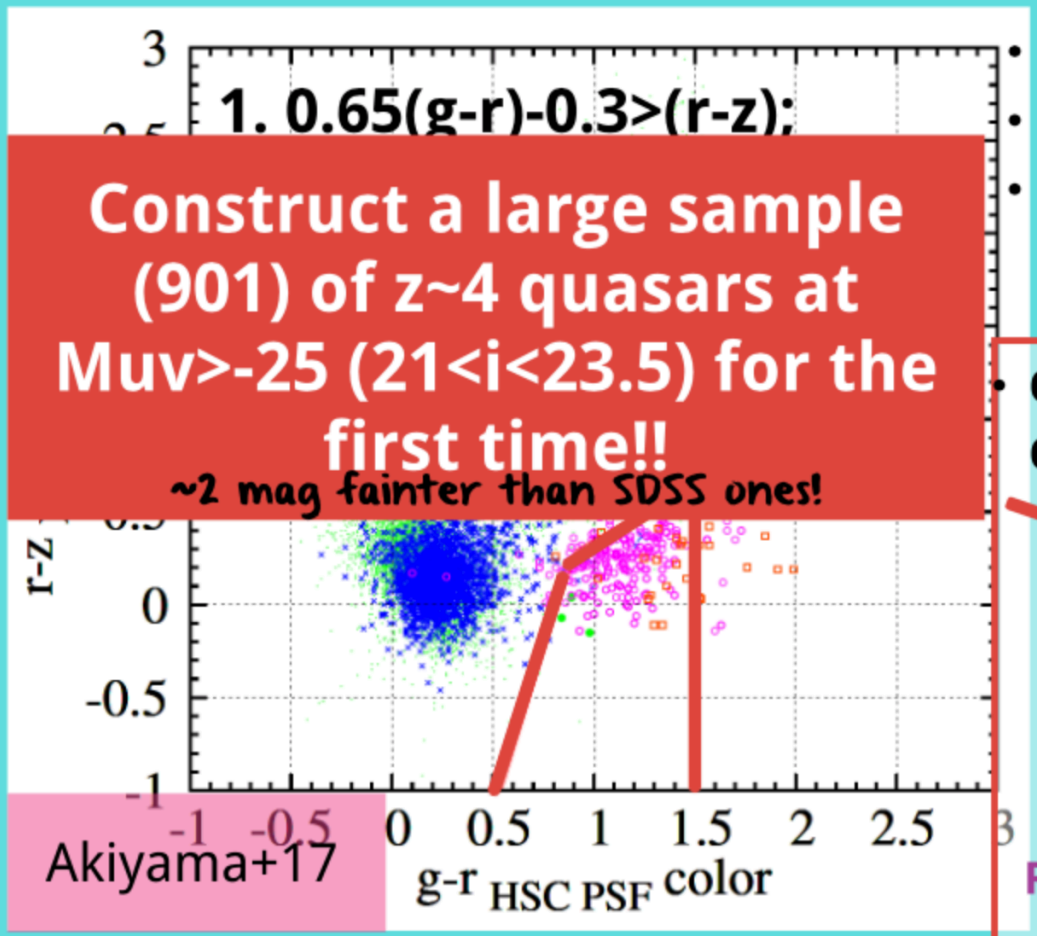
Figure 11: The location of the HSC-Wide, Deep (D) and Ultradeep (UD) fields on the sky in equatorial coordinates. A variety of external data sets and the Galactic dust extinction are also shown. The shaded region is the region accessible from the CMB polarization experiment, ACTPol, in Chile.

Data sample



- Data: HSC-SSP S16A
- Effective area: 172 deg^2
- Method: g-drop color selection

Data sample



Construct a large sample (901) of z~4 quasars at Muv>-25 (21<i<23.5) for the first time!!

~2 mag fainter than SDSS ones!

- Data: HSC-SSP S16A
- Effective area: 172 deg^2
- Method: g-drop color selection

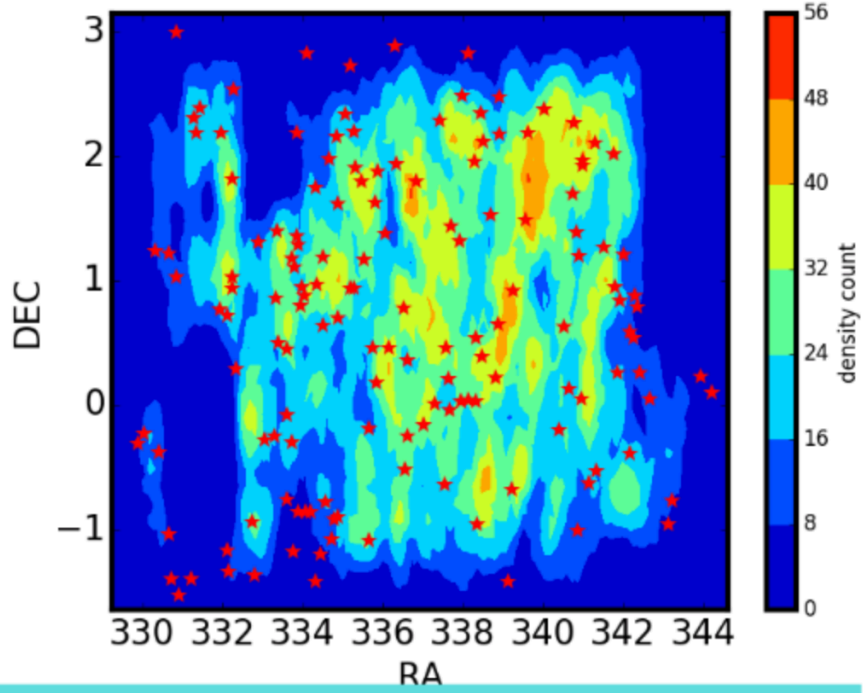
- clustering: angular cross-correlation function (CCF)

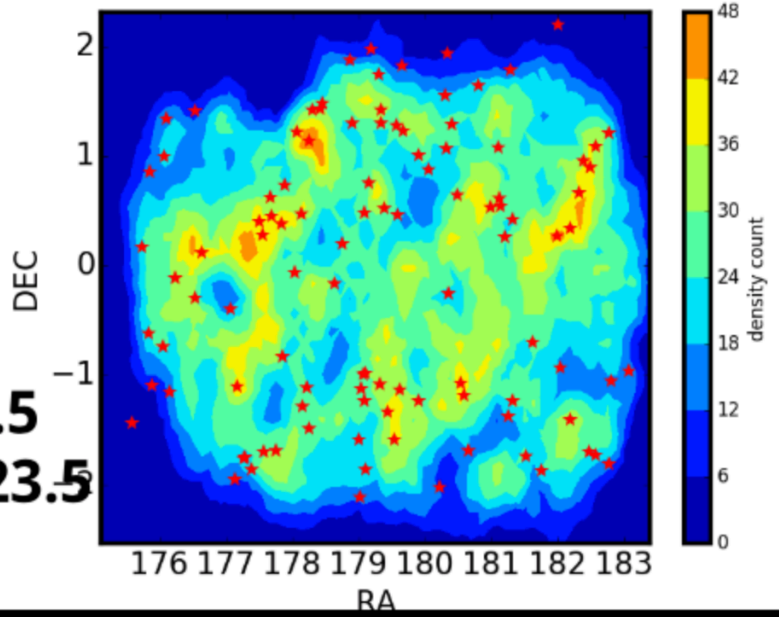
$$\omega(\theta) = \frac{DD(\theta)}{DR(\theta)} - 1$$

R: random LBGs

D_LBG: z~4 LBGs from HSC-SSP Wide imaging

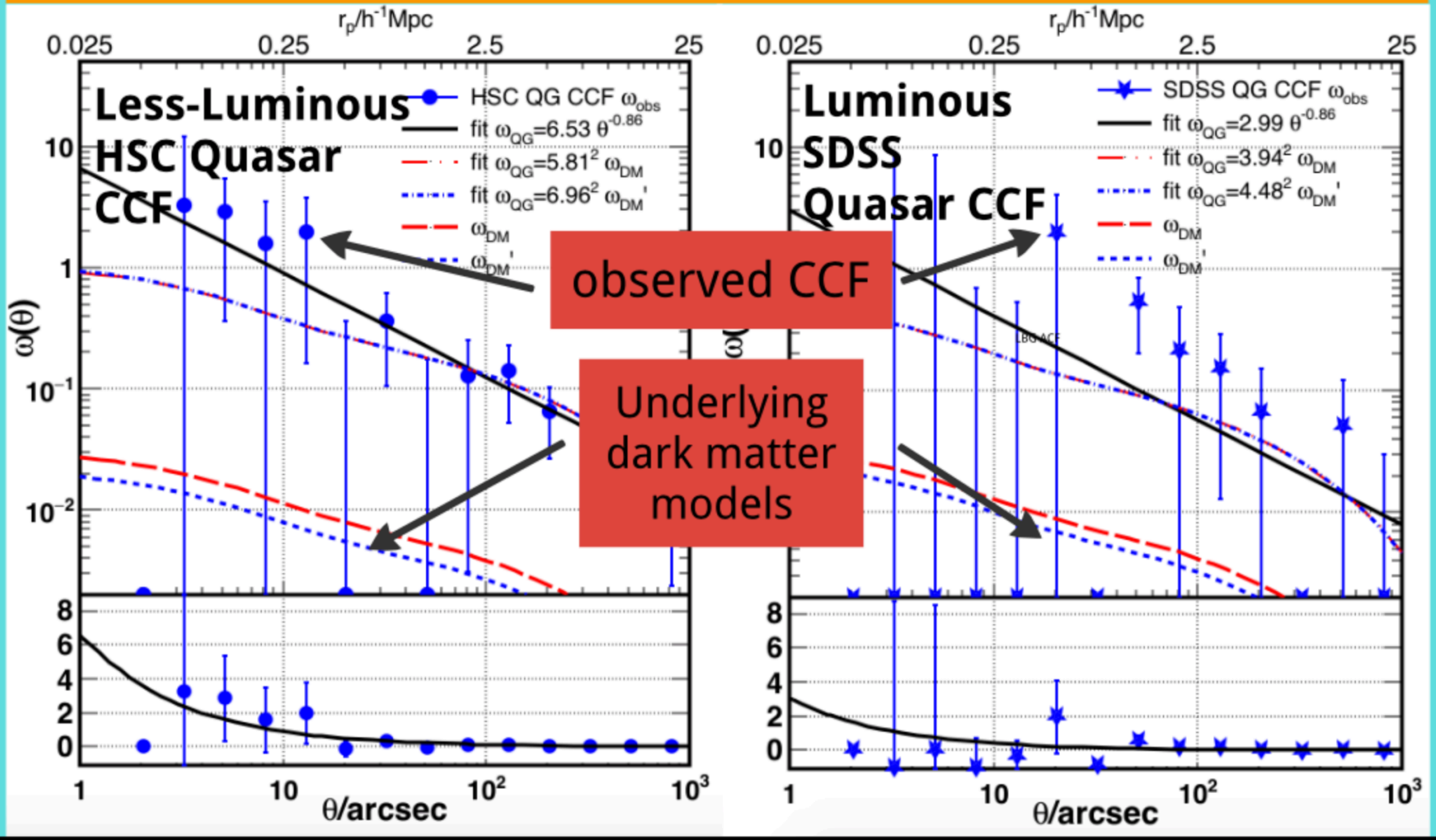
Two sub-regions





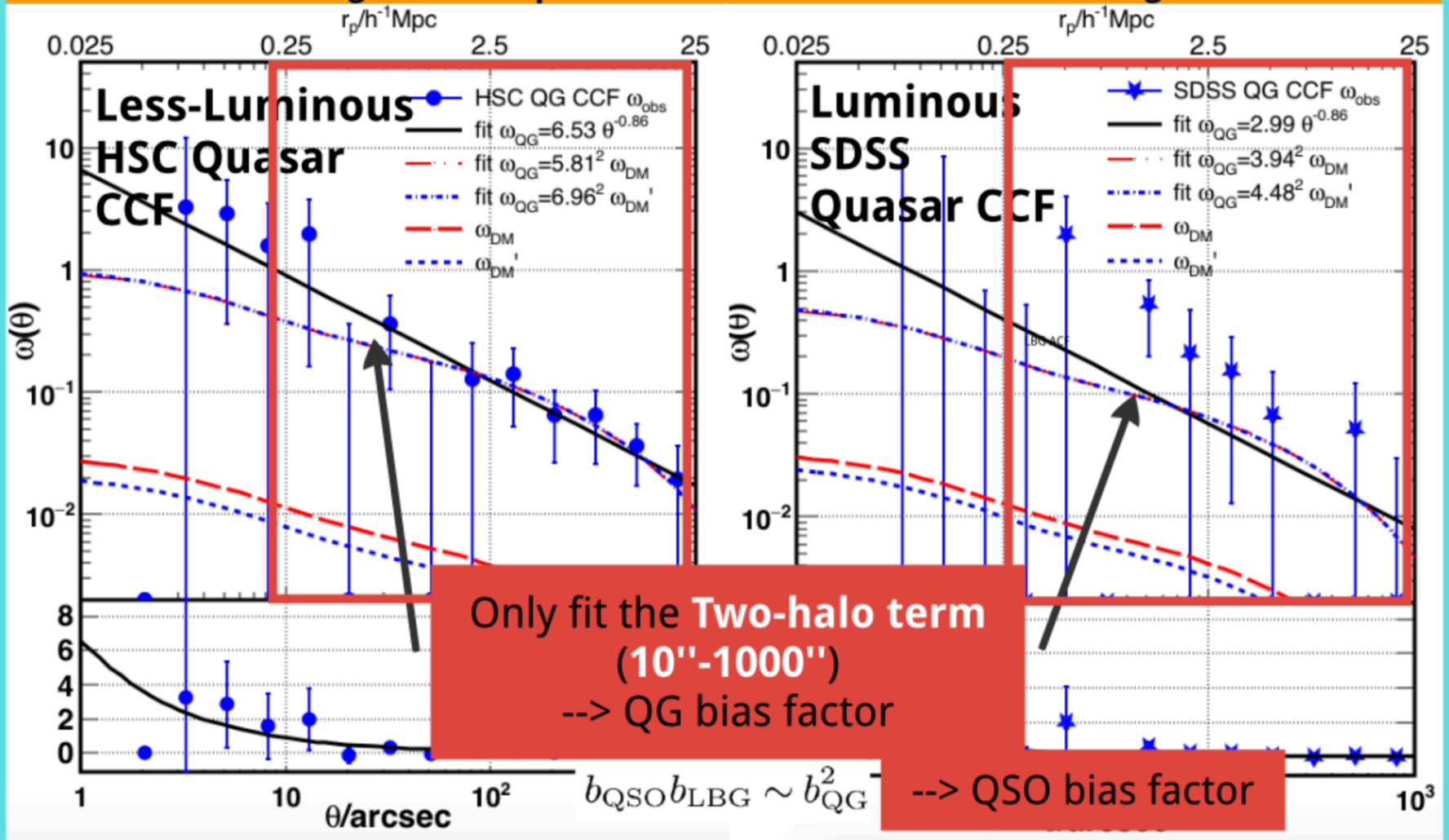
- density map: z~4 LBGs at i<24.5
- red star: z~4 quasars at 21<i<23.5

Clustering analysis



Clustering analysis

***Negative data points are also considered in the fitting.**

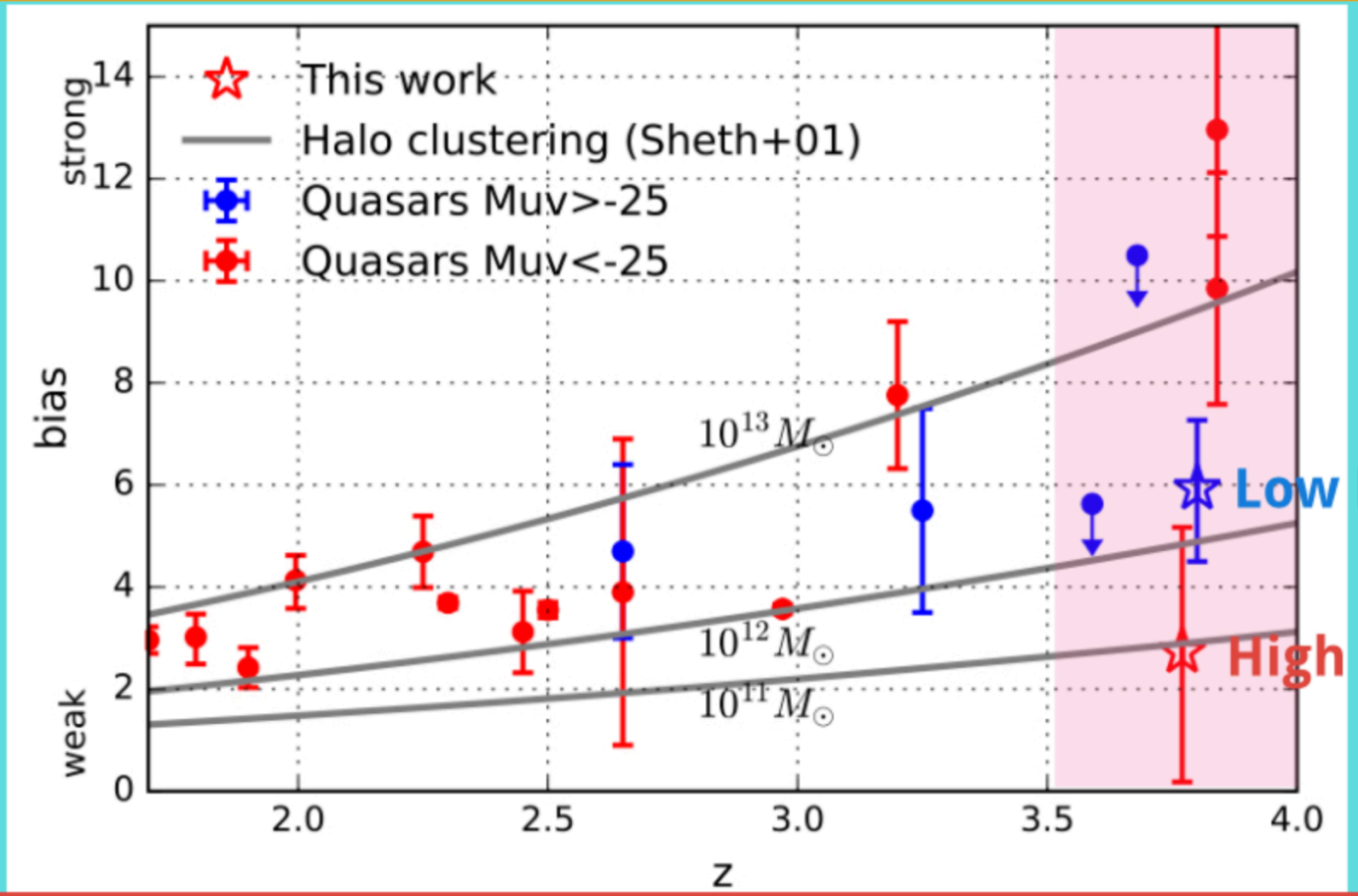


Only fit the **Two-halo term (10''-1000'')**
--> QG bias factor

$$b_{\mathrm{QSO}} b_{\mathrm{LBG}} \sim b_{\mathrm{QG}}^2$$

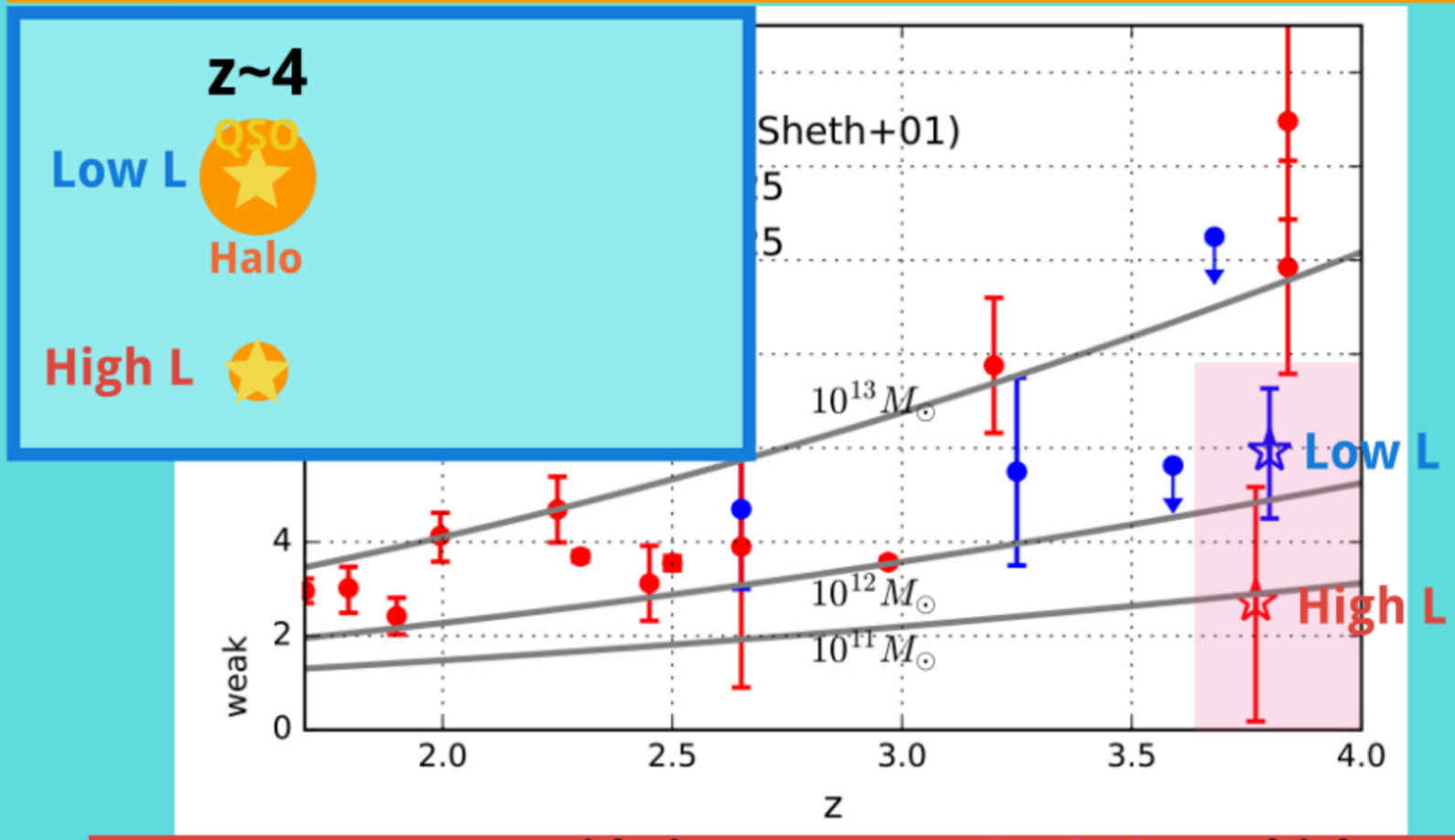
--> QSO bias factor

Discussion



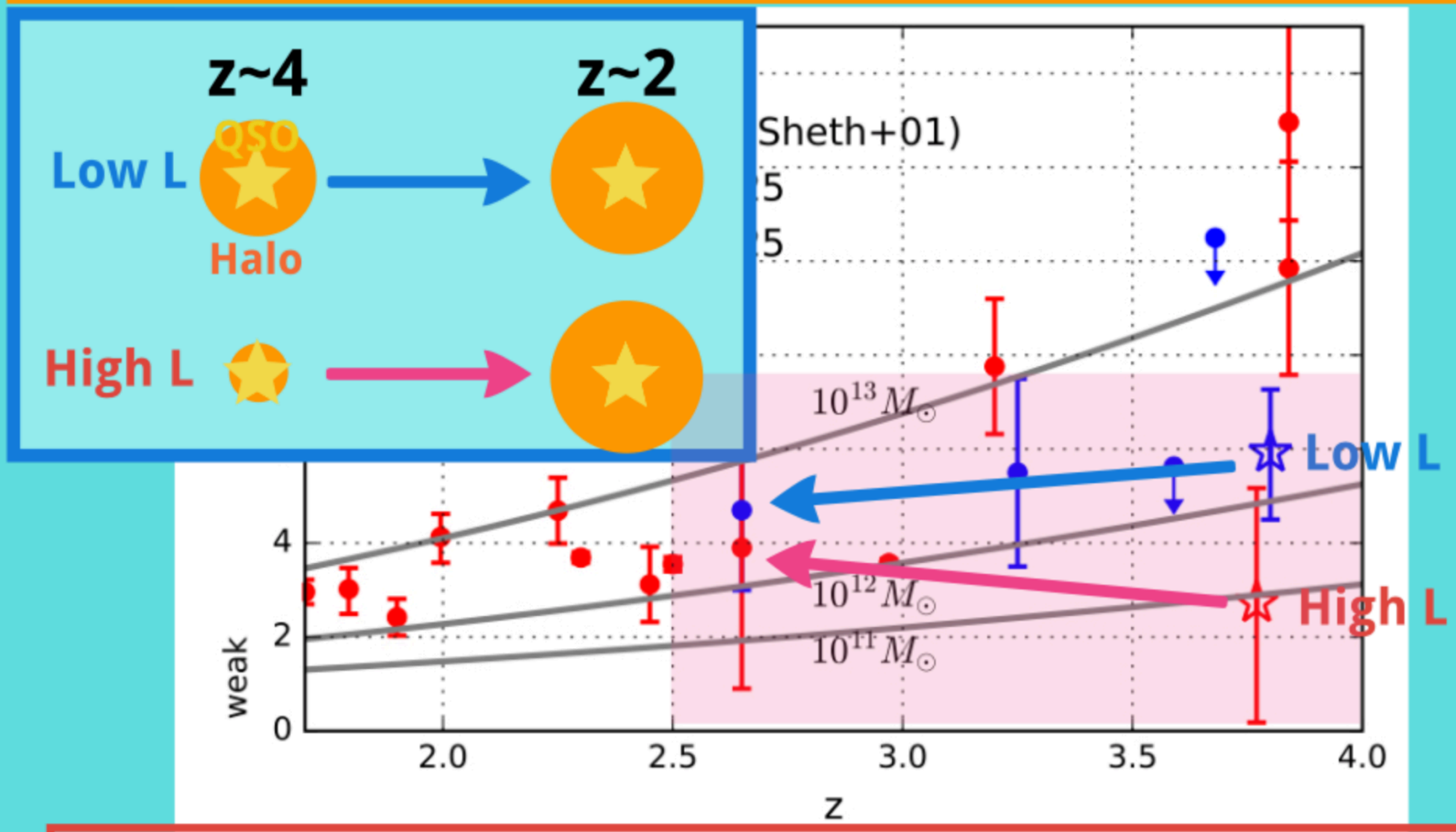
- We obtain the bias factor of both of high- and low-luminosity quasars at z~4 from their CCF with LBGs.

Discussion 1: one scenario



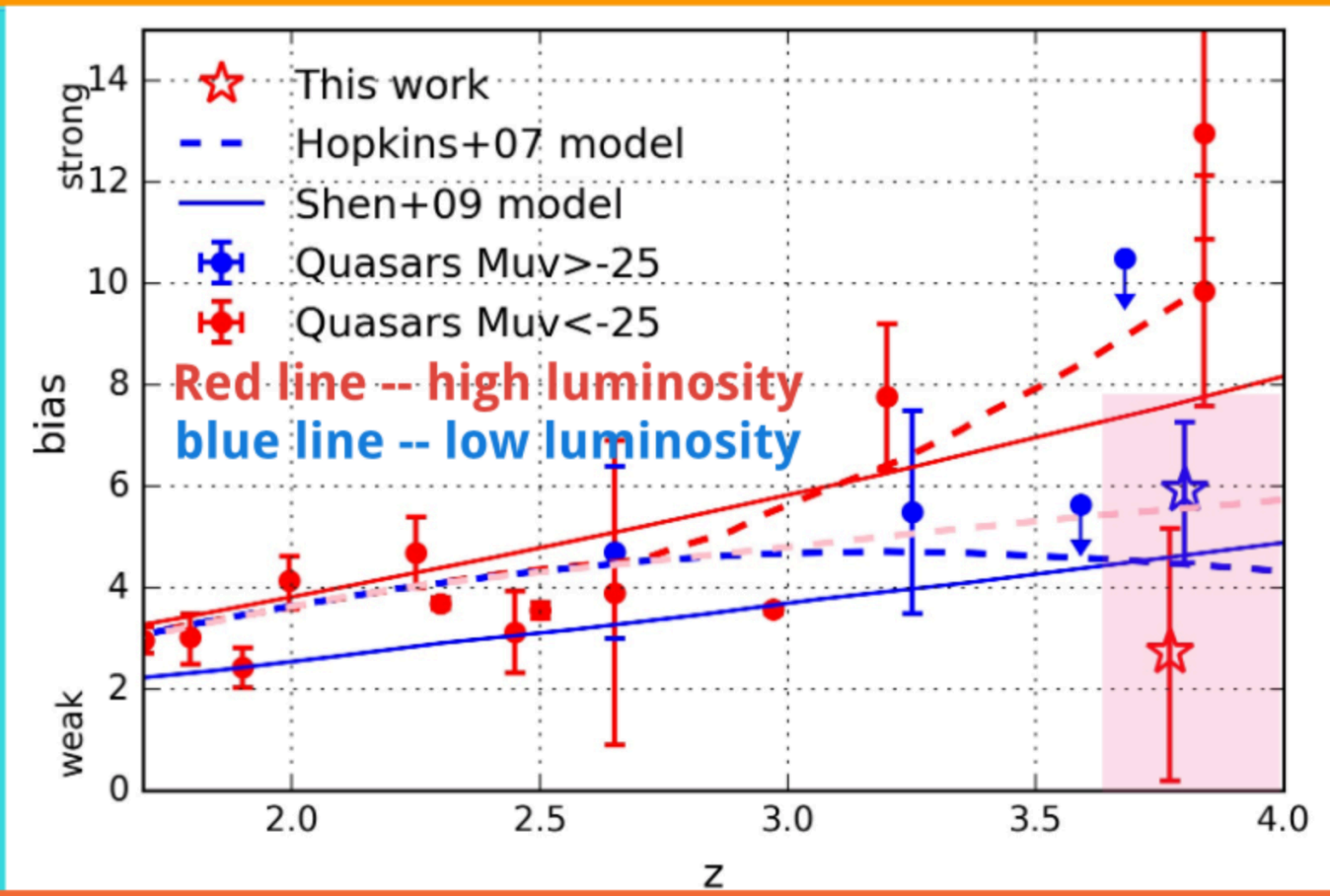
- Low-L quasars reside in more massive halos, which are formed at earlier epoch, than high-L ones at z~4.

Discussion 1: one scenario



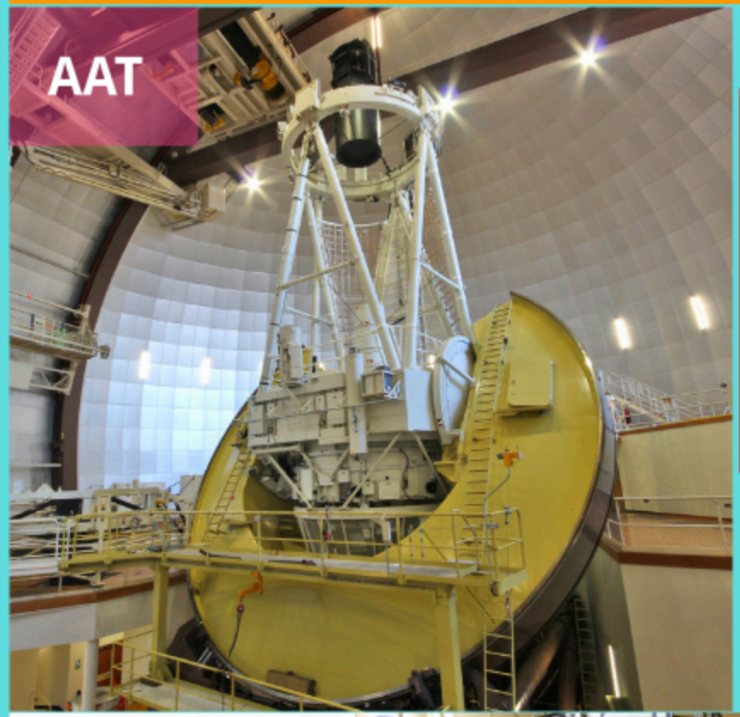
- Host halo of high-L quasars is quickly growing from z~4 to z~2, resulting in a similar host halo mass to that of low-L quasars at z~2.

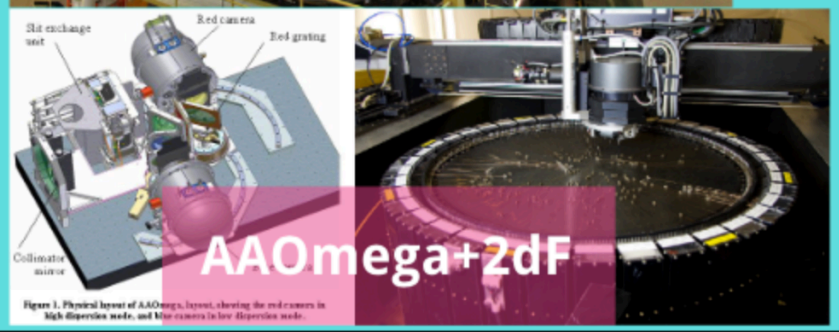
Discussion 1: one scenario



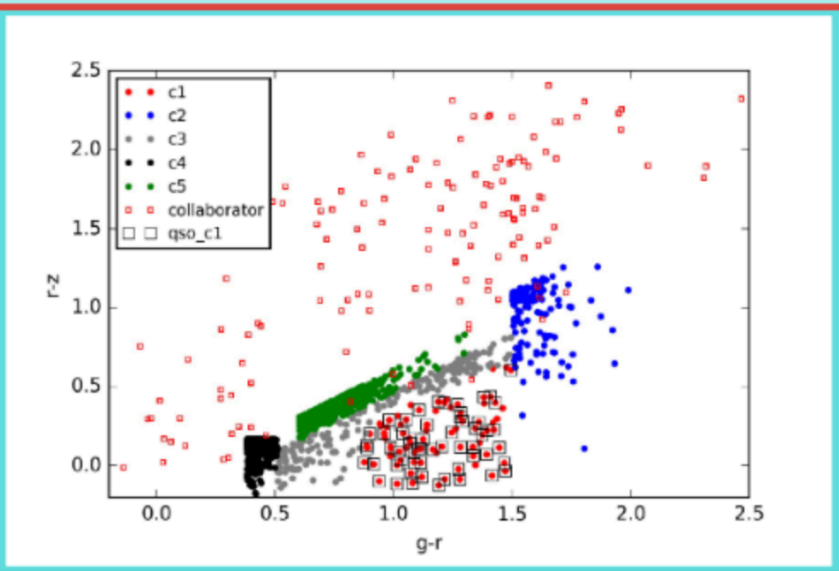
Conficting with major merger/efficient feedback model?

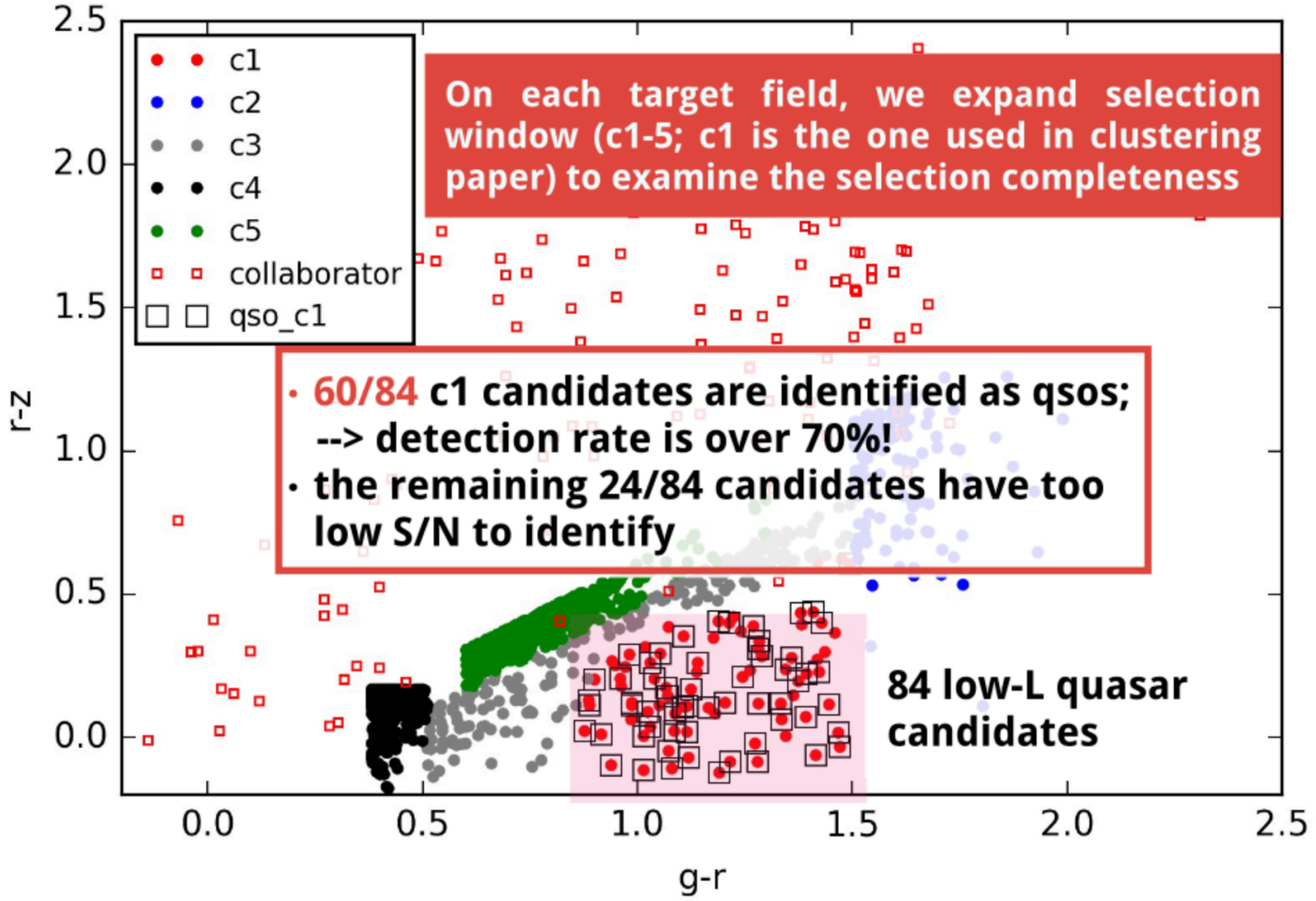
Discussion 1: one scenario



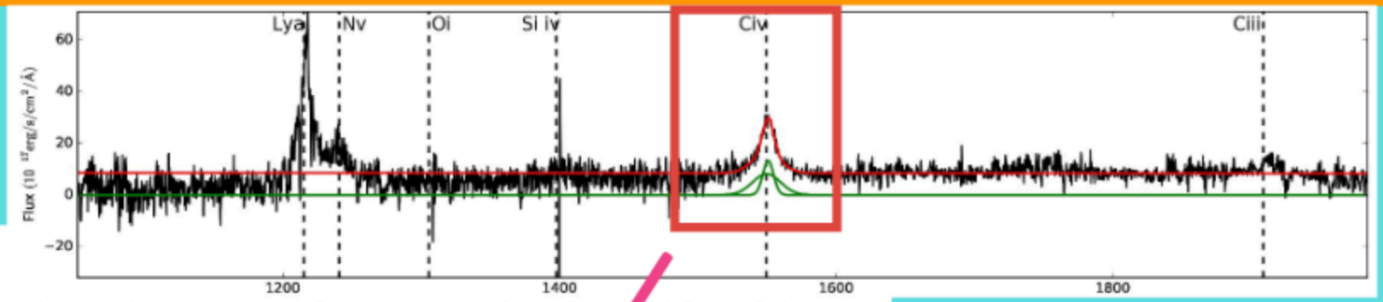


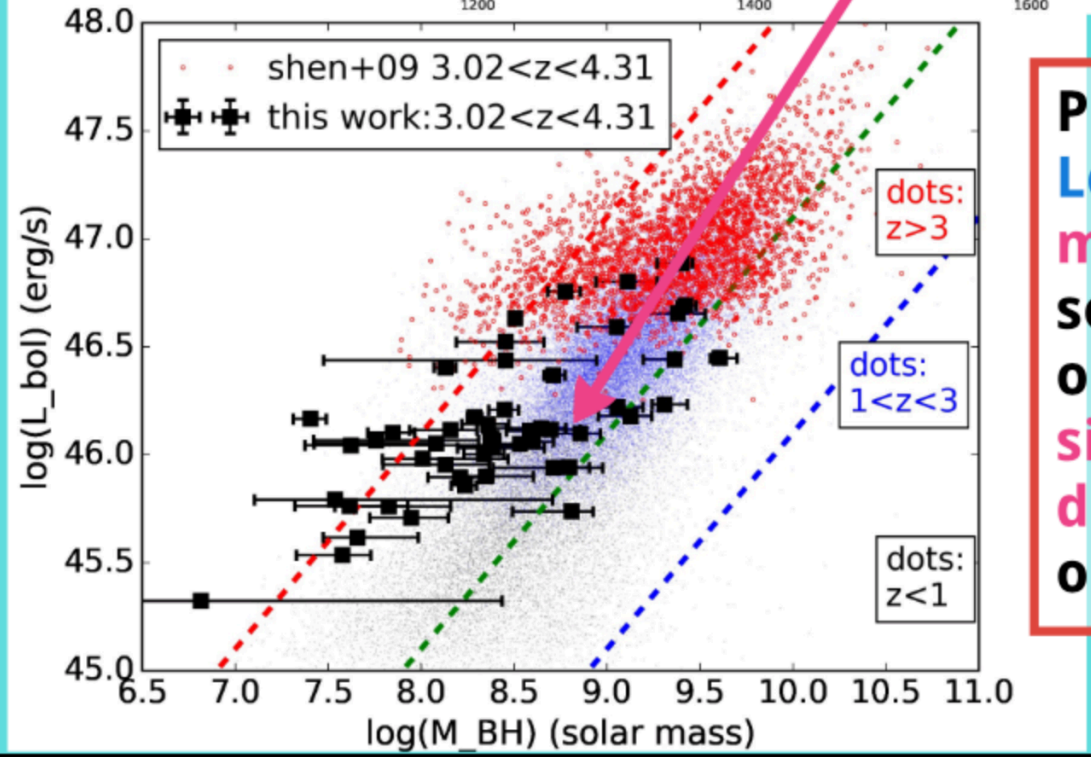
- **Spectroscopic follow-up:**
  - **5 nights with AAT/AAOmega+2dF (70% time is clear)**
  - **Grating: 580V+385R**
  - **84 z~4 HSC quasar candidates at 20<i<23 are allocated with fibres**
  - **~4h exposure time for each target field**




c1
c2
c3
c4
c5
collaborator
qso_c1
On each target field, we expand selection window (c1-5; c1 is the one used in clustering paper) to examine the selection completeness
• 60/84 c1 candidates are identified as qsos; --> detection rate is over 70%!
• the remaining 24/84 candidates have too low S/N to identify
84 low-L quasar candidates
r-z
g-r
0.0
0.5
1.0
1.5
2.0
2.5

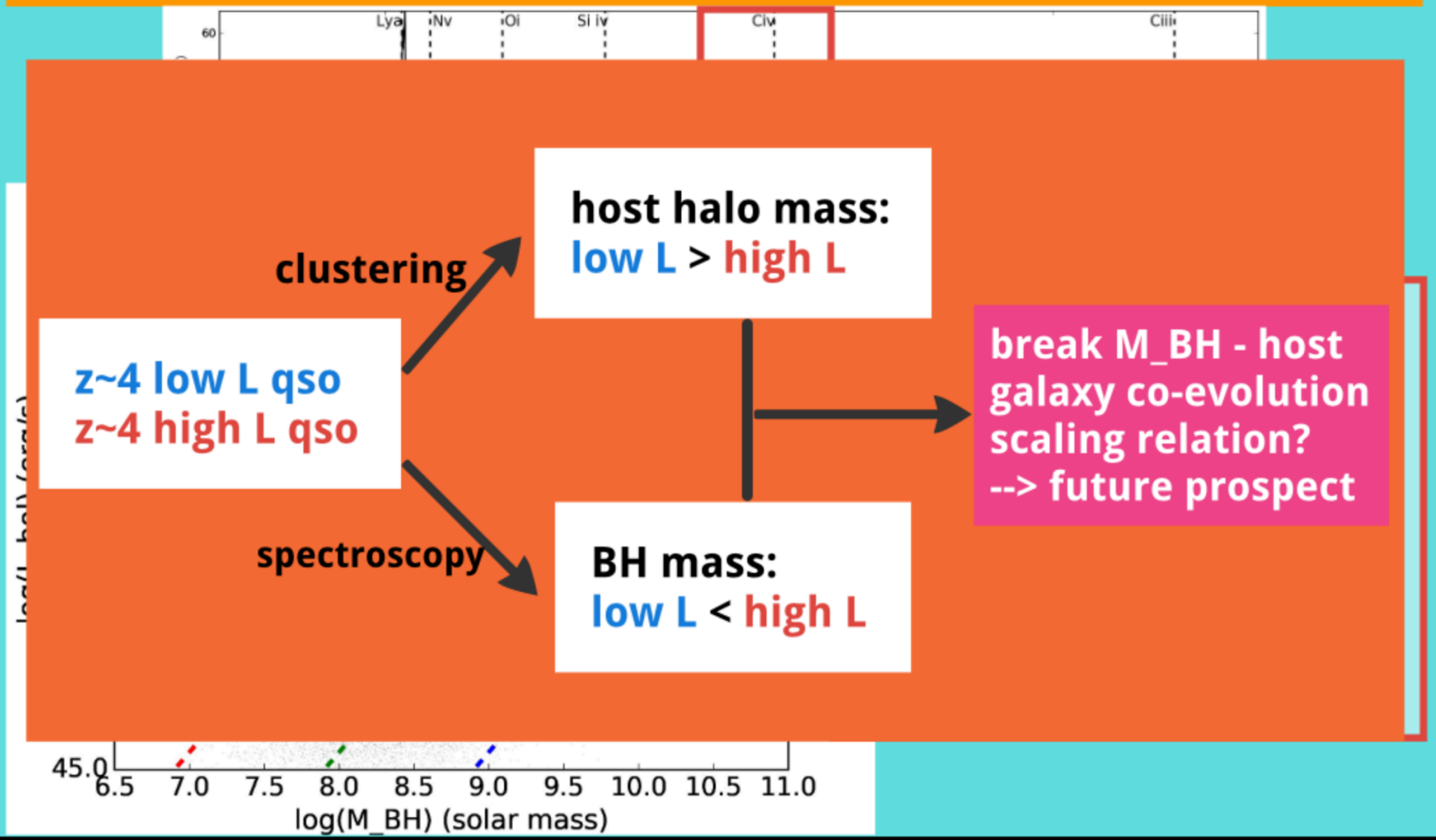
Discussion 1: one scenario



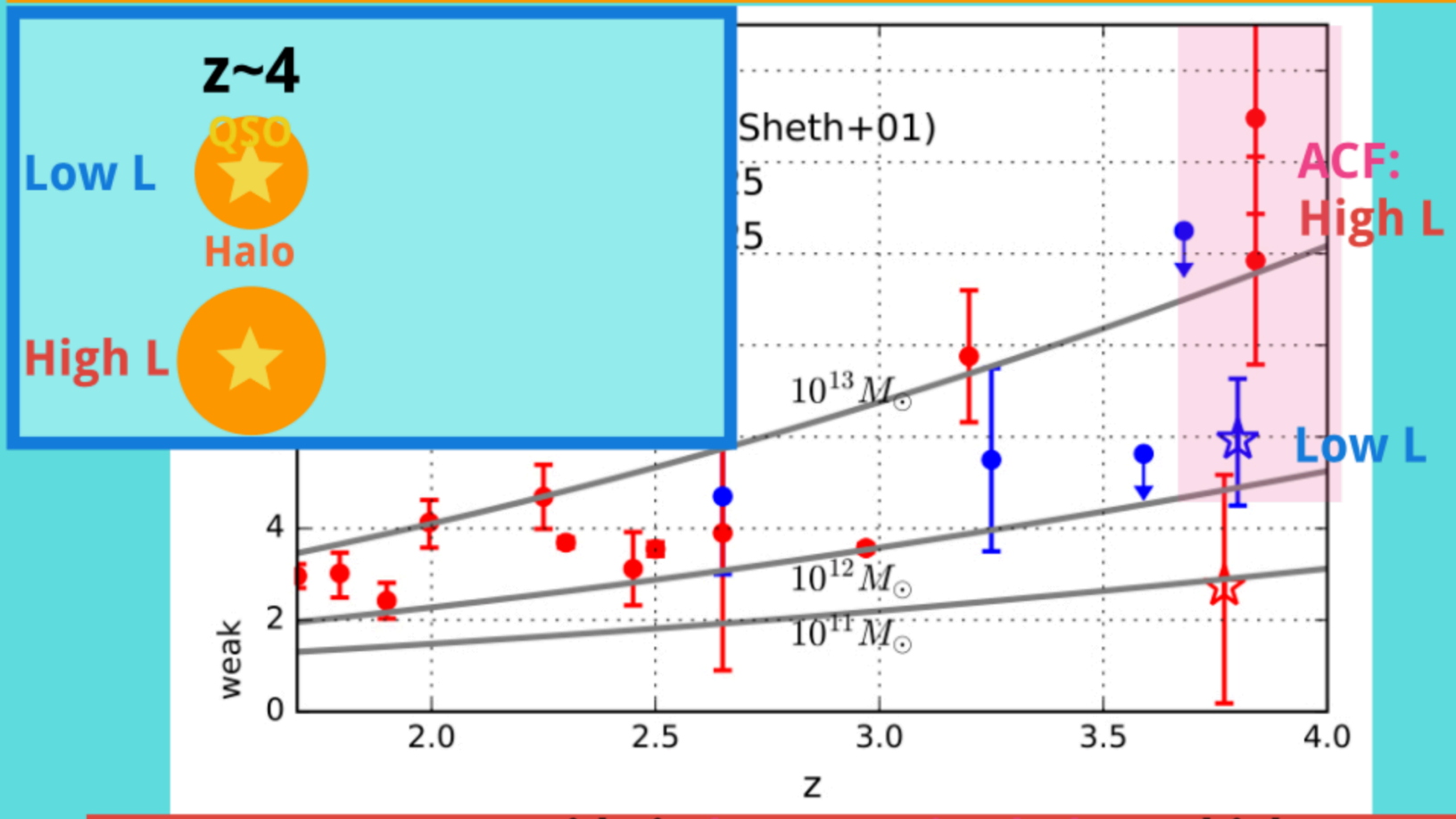


Preliminary results:
Low-L quasars are less-massive (peak at 10^8.5 solar mass) than high-L ones, and they have a similar Eddington ratio distribution to high-L ones.

Discussion 1: one scenario

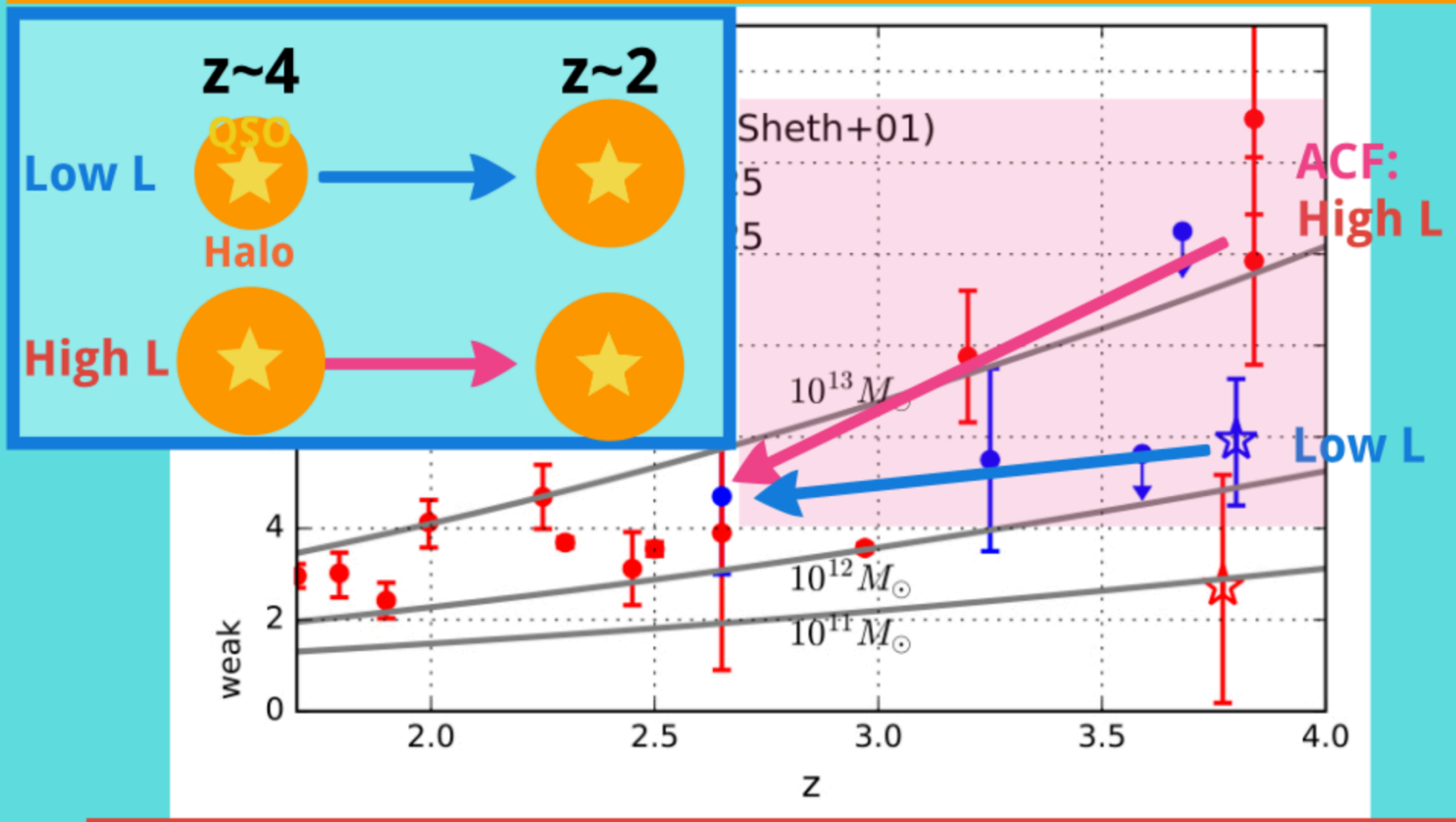


Discussion 2: another scenario



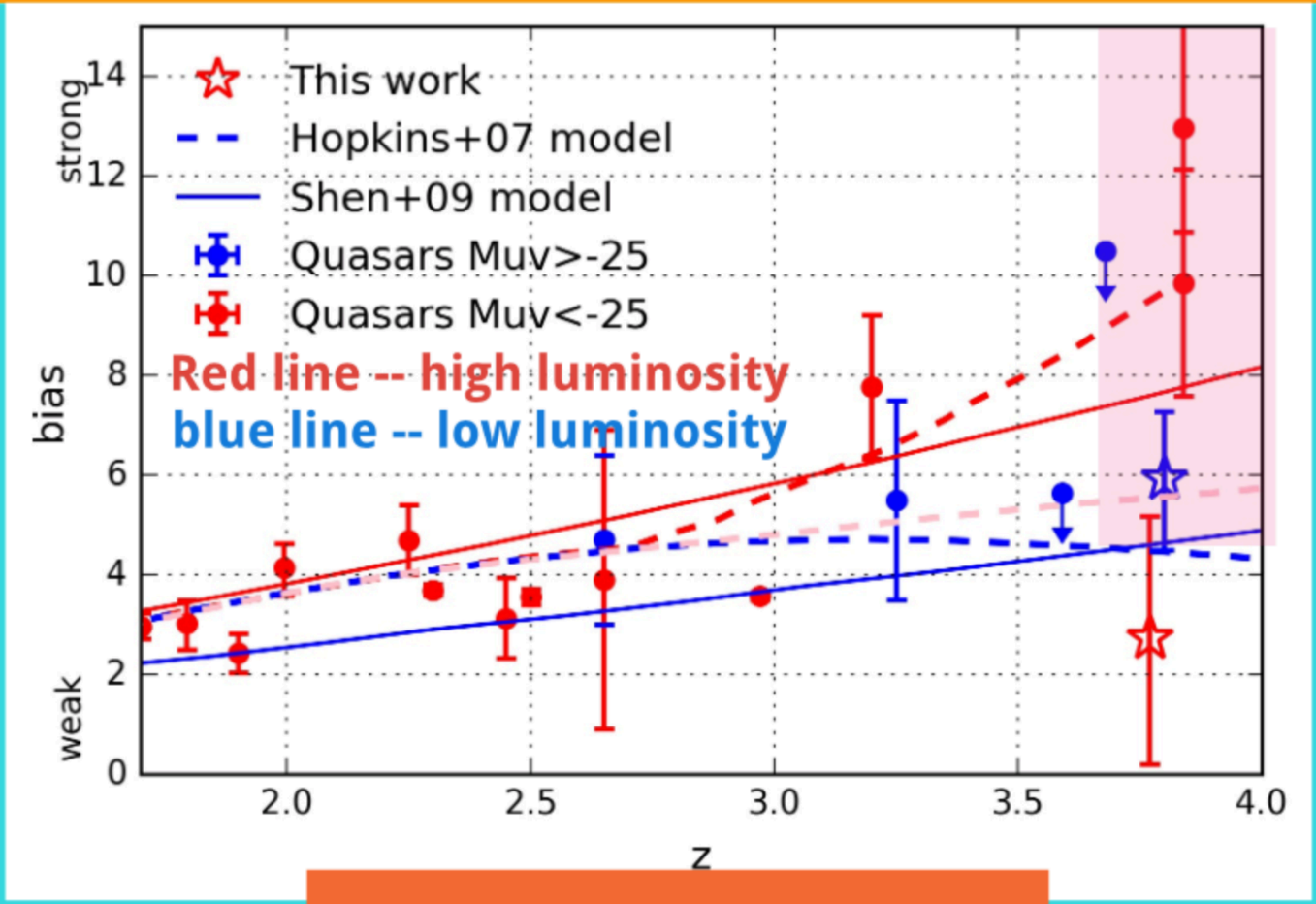
- Low-L quasars reside in less massive halos, which are formed at later epoch, than high-L ones at z~4.

Discussion 2: another scenario



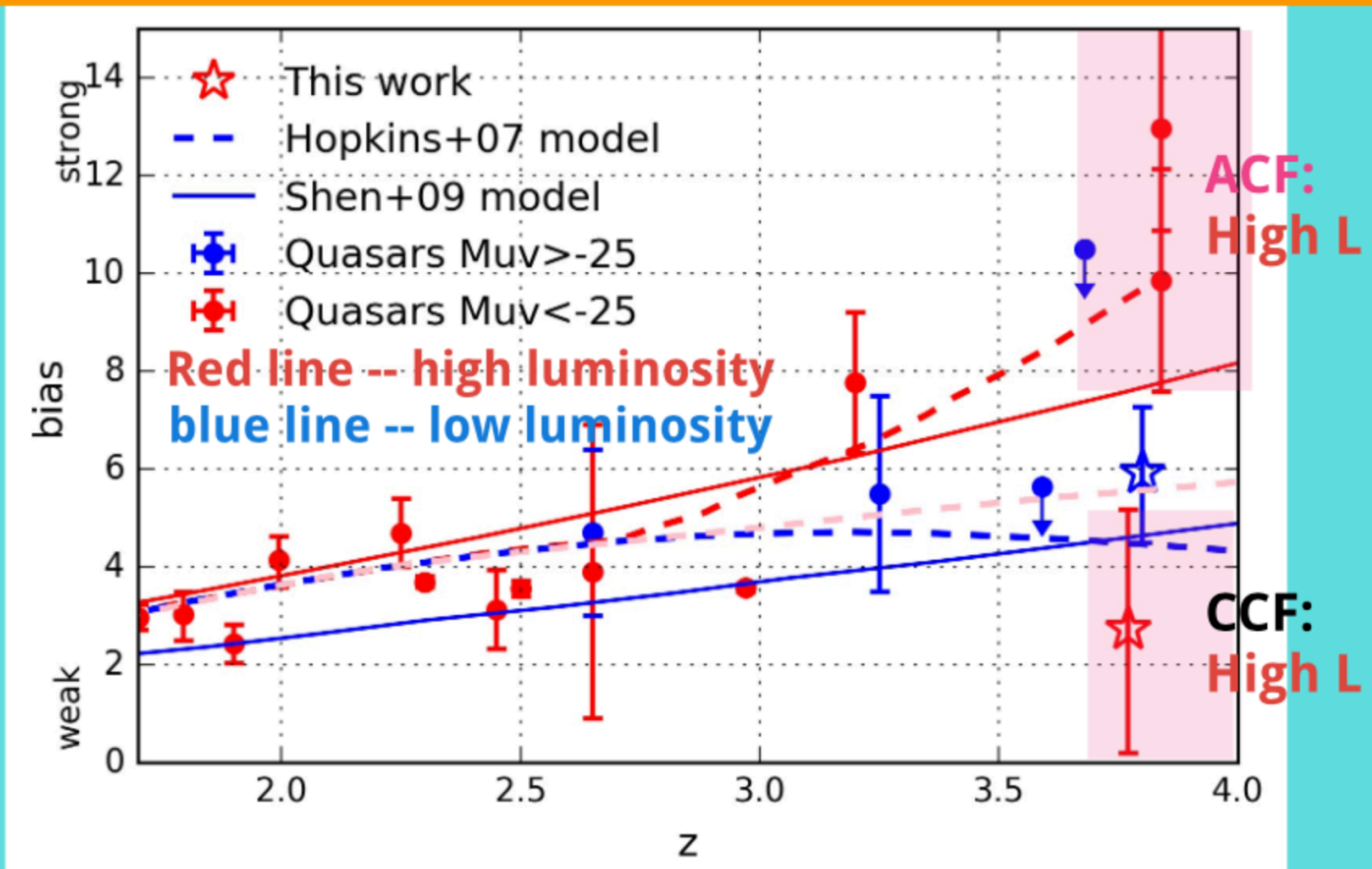
- High-L quasars keep residing in most massive halos from z~4 to z~2.

Discussion 2: another scenario



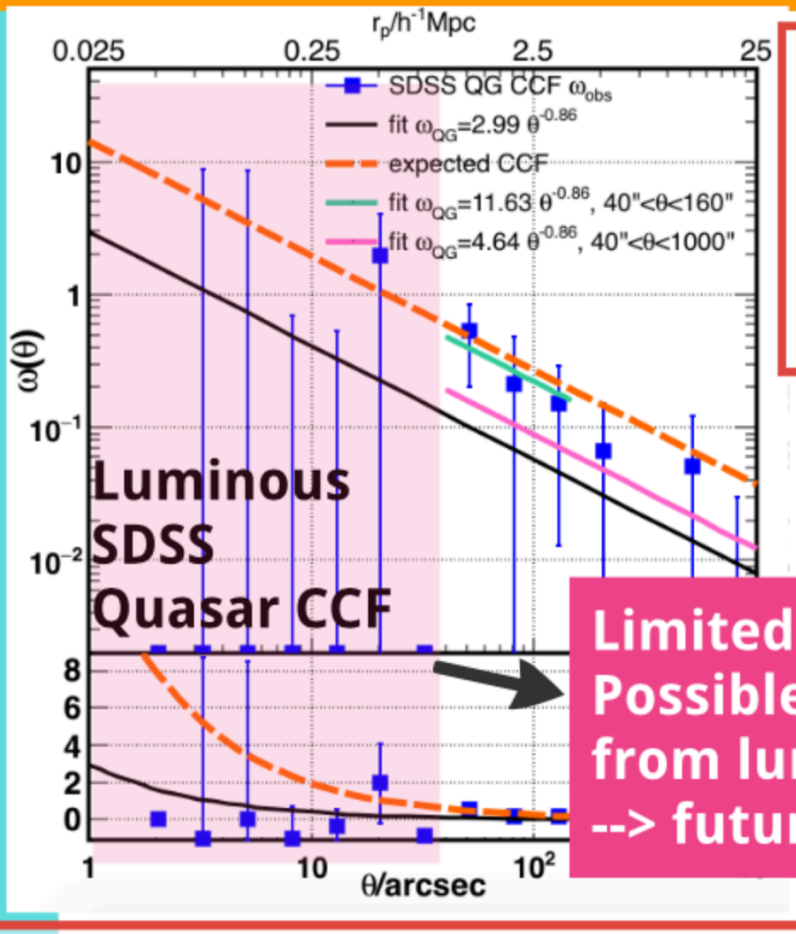
In consistent with models?

Discussion 2: another scenario

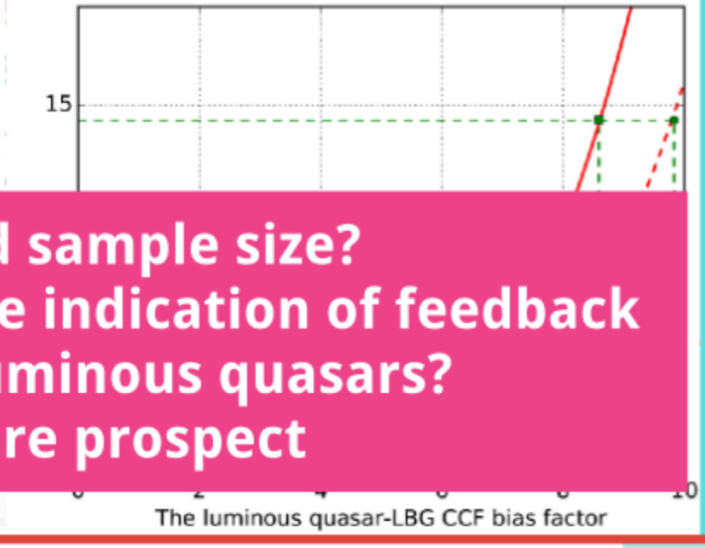


- The discrepancy between the ACf and CCF of luminous quasars makes conclusion complicated.

Discussion 2: another scenario



- Fitting strongly depends on scale
- There is a deficit of LBGs around luminous quasars within 40''



Limited sample size?
Possible indication of feedback from luminous quasars?
--> future prospect

- The discrepancy between the ACf and CCF of luminous quasars makes conclusion complicated.

Summary

- We find no significant luminosity dependence of quasar clustering at z~4, that both of high- and low-luminosity quasars reside in halos with ~10^12 solar mass;
- We find a discrepancy between the ACF and CCF of luminous quasars, which may be an indication of feedback from luminous quasars.

- 60/84 HSC z~4 quasar candidates at 20<i<23 are identified;
- Low-L quasars are less massive than high-L ones, and they have a similar Eddington ratio distribution.

--> the scaling relation between SMBHs and their host galaxies may be broken at early epoch.

- Final HSC-SSP data release / future follow-up with PFS...

Thank you for your attention!