第2回銀河進化研究会 2015年6月4-6日 名古屋大学

Connection between dark matter and star-forming galaxies at z~1.6 in COSMOS

柏野 大地 | 名古屋大学

J. Silverman[IPMU]; S. More[IPMU]; COSMOS team

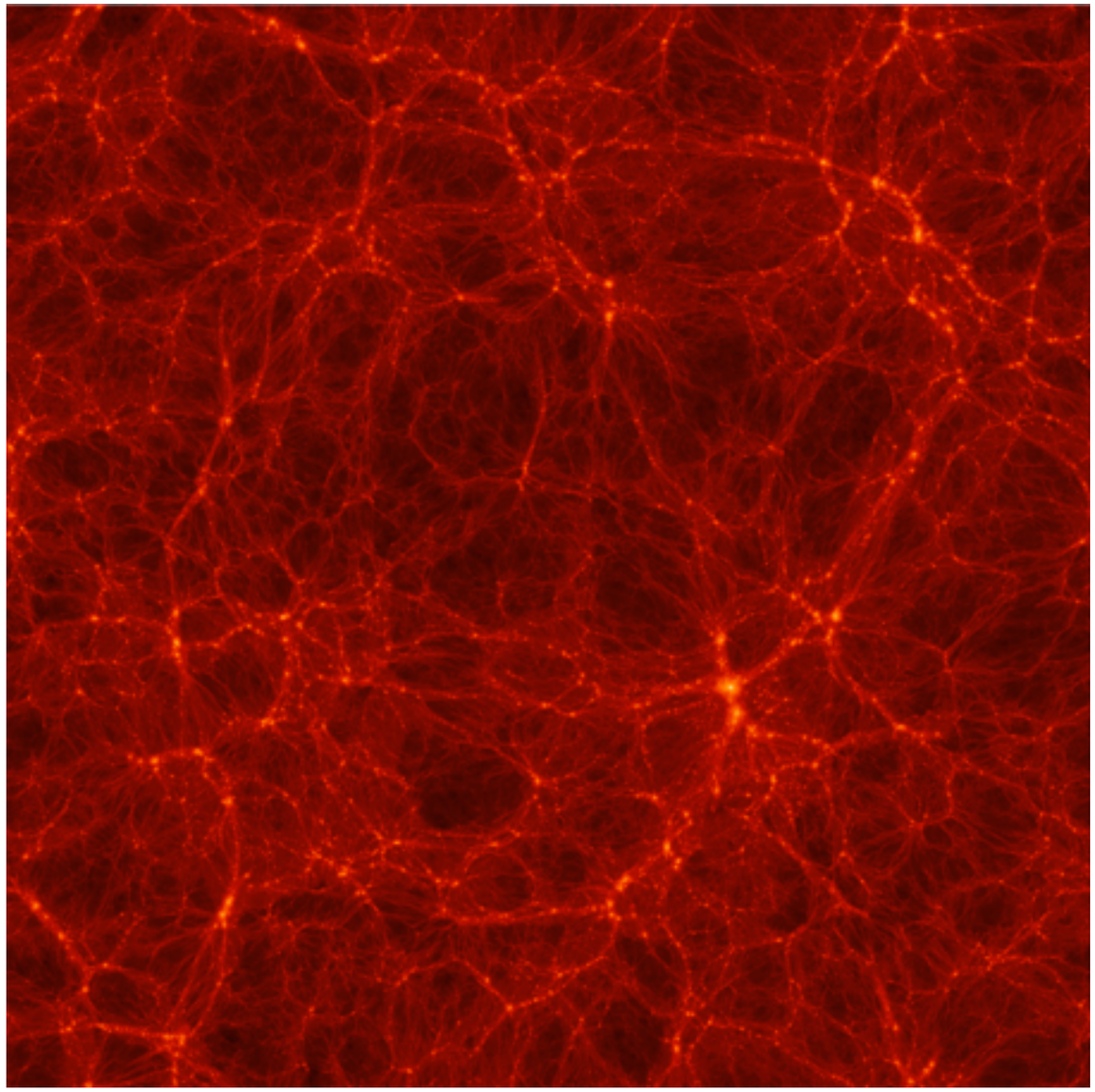
Motivation

In what environment were galaxies formed at the peak epoch?

What is their fate?

The epoch z=1-3 is a peak era of the cosmic star formation history, the bulk of galaxy's stellar mass were formed through active star formation.

Galaxy clustering:
A powerful method to study the connection between galaxies and their host dark matter halos.



Bolshoi simulation

FMOS-COSMOS survey

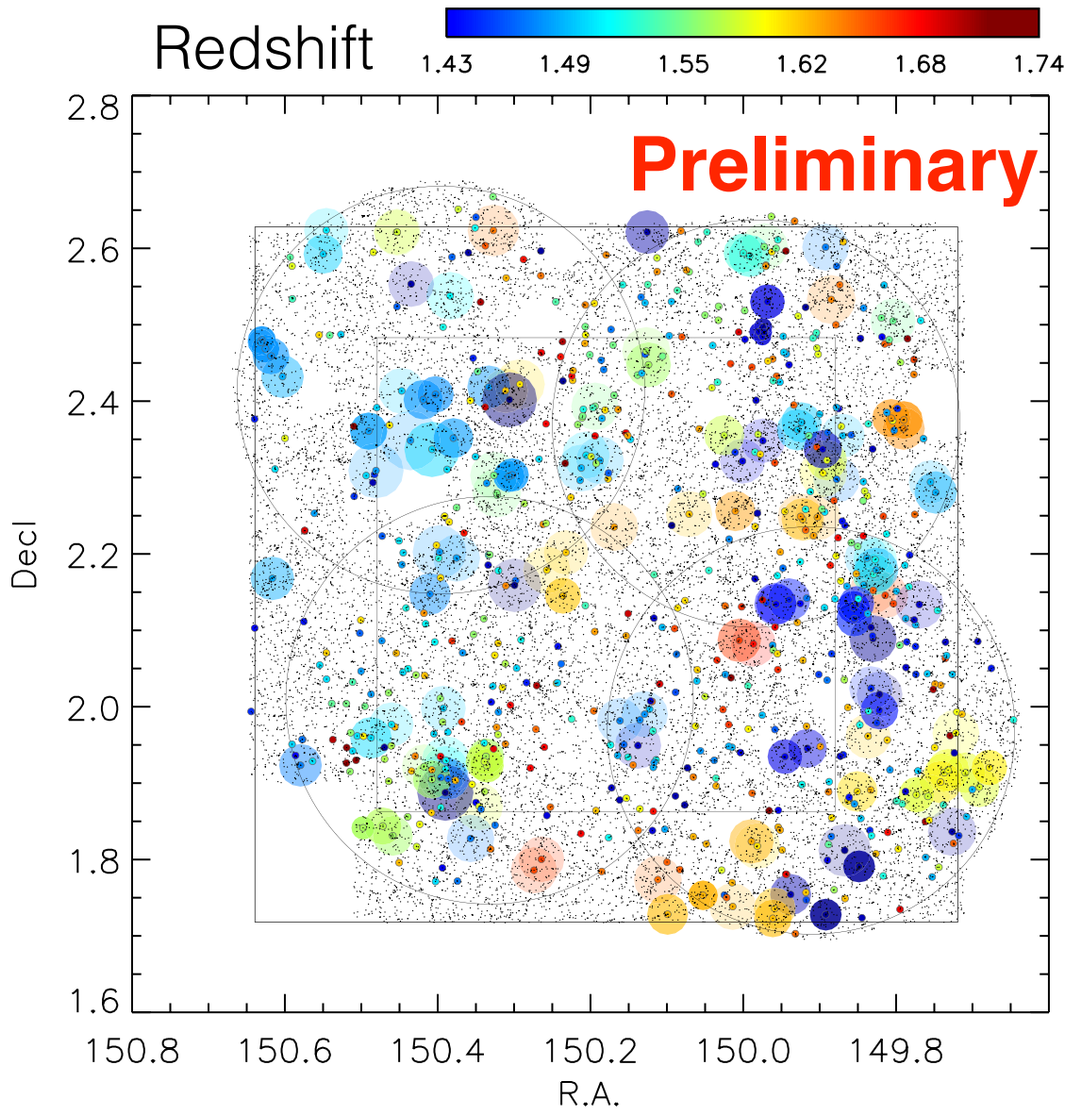
Near-IR spectroscopy at z~1.6

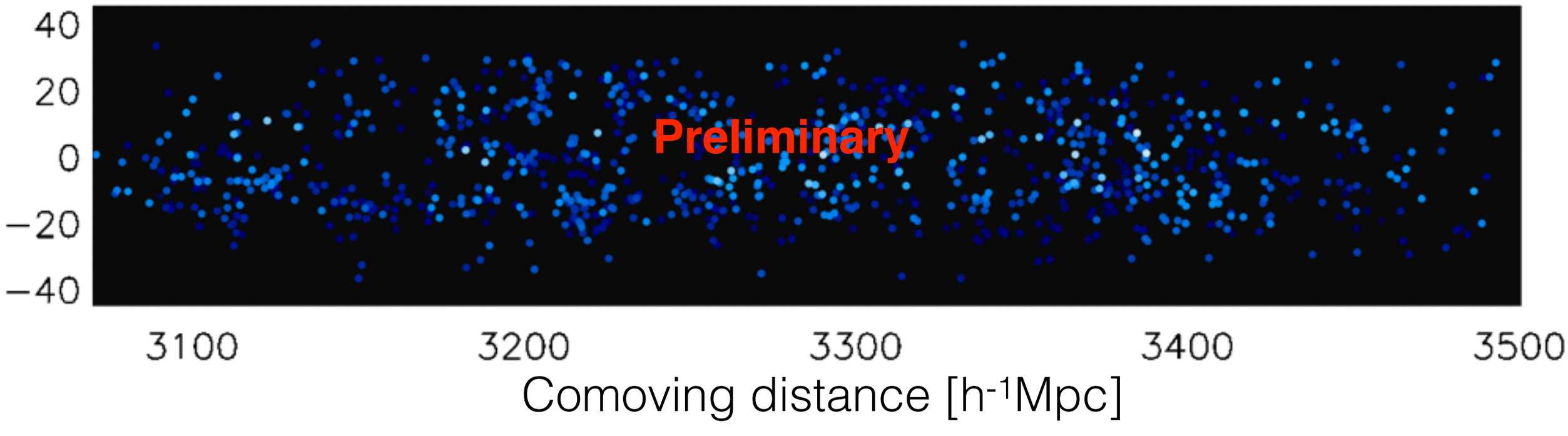
Mapping galaxy 3D distribution

More than 1100 spec-z beyond z>1

Small scales traced by multiple exp.

Wide range of the MS (SFR$\gtrsim$10M$_\odot$yr^{-1}) mapped by long exp. (~4-5hrs)

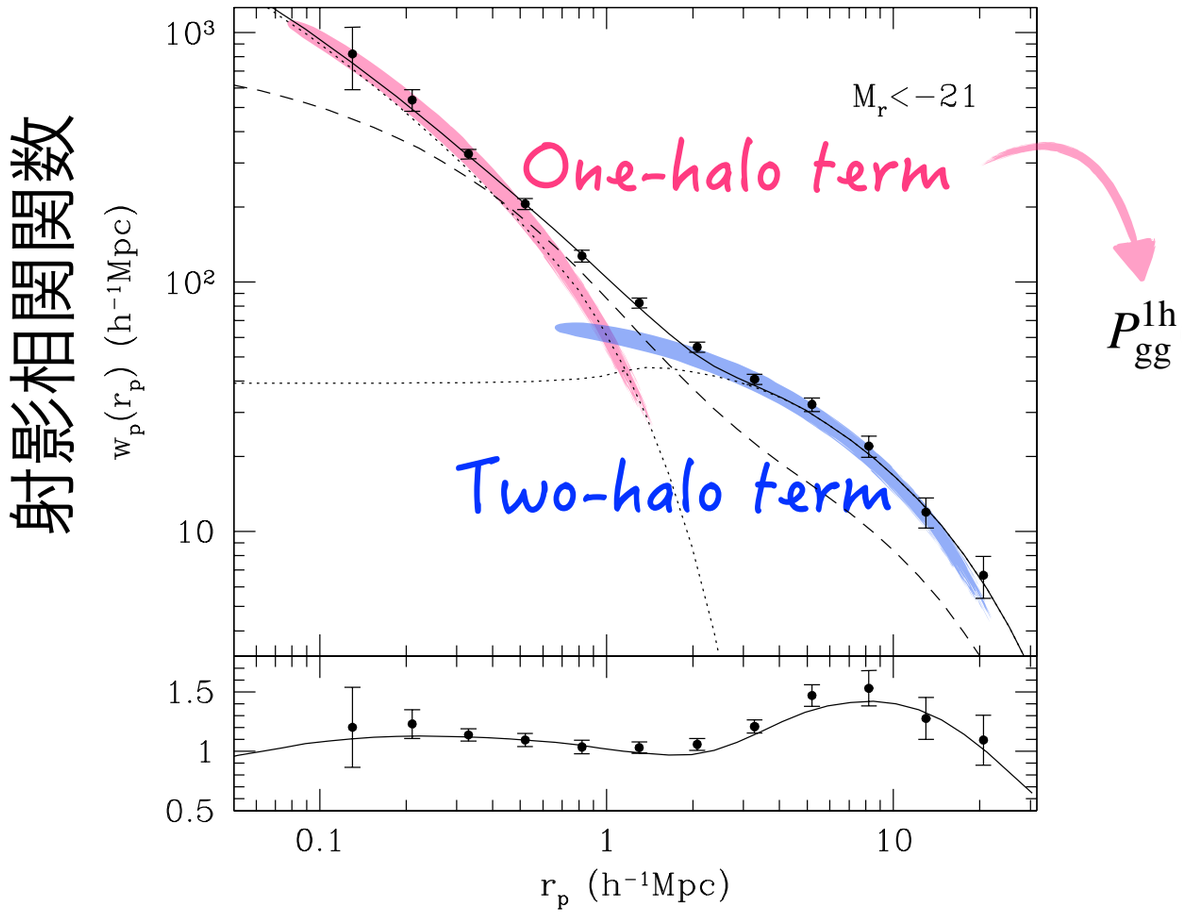




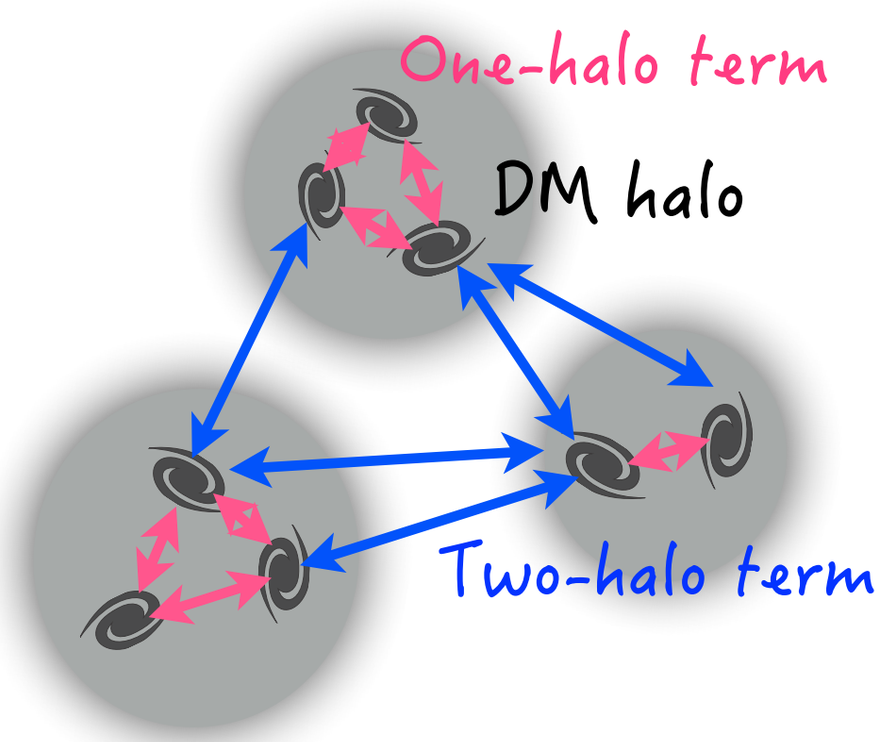
Galaxy clustering

ハローモデルは観測をよく記述する

$$P_{gg}(k) = P_{\rm gg}^{1h}(k) + P_{\rm gg}^{2h}(k)$$



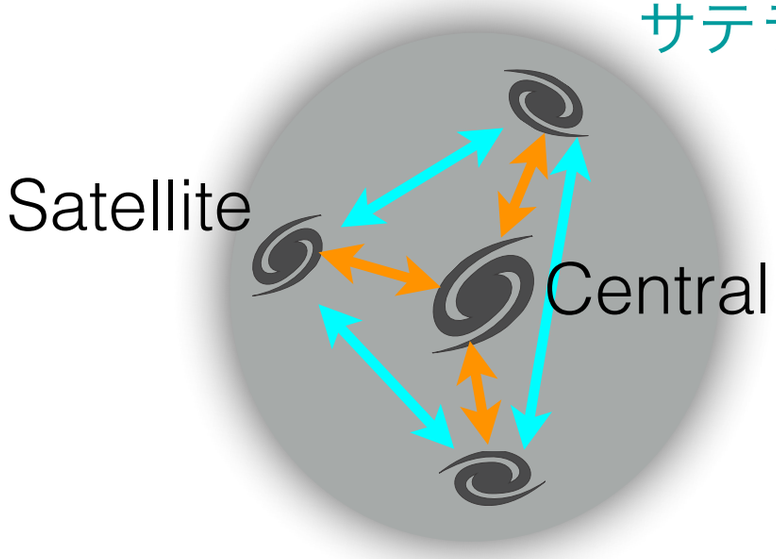
SDSS; et al. 2004



セントラル銀河とサテライト銀河

$$P_{\rm gg}^{\rm 1h}(k,z) = \frac{1}{\bar{n}_g^2}\int dM \frac{dn}{dM}(M,z)\Big[2\langle N_{\rm cen}|M\rangle\langle N_{\rm sat}|M\rangle u(k,M,z) + \langle N_{\rm sat}|M\rangle^2 u^2(k,M,z)\Big]$$

サテライト銀河同士



Our galaxy sample

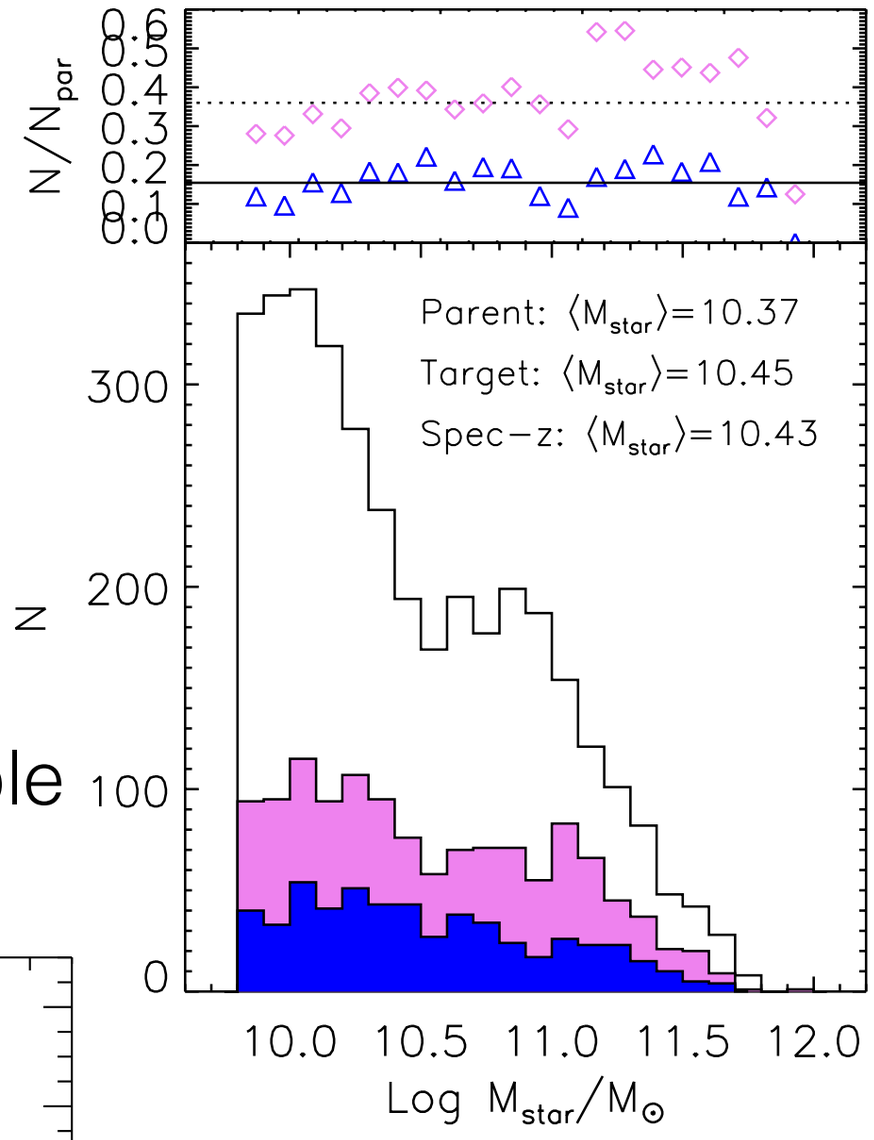
Parent sample (SED-selected): #3567

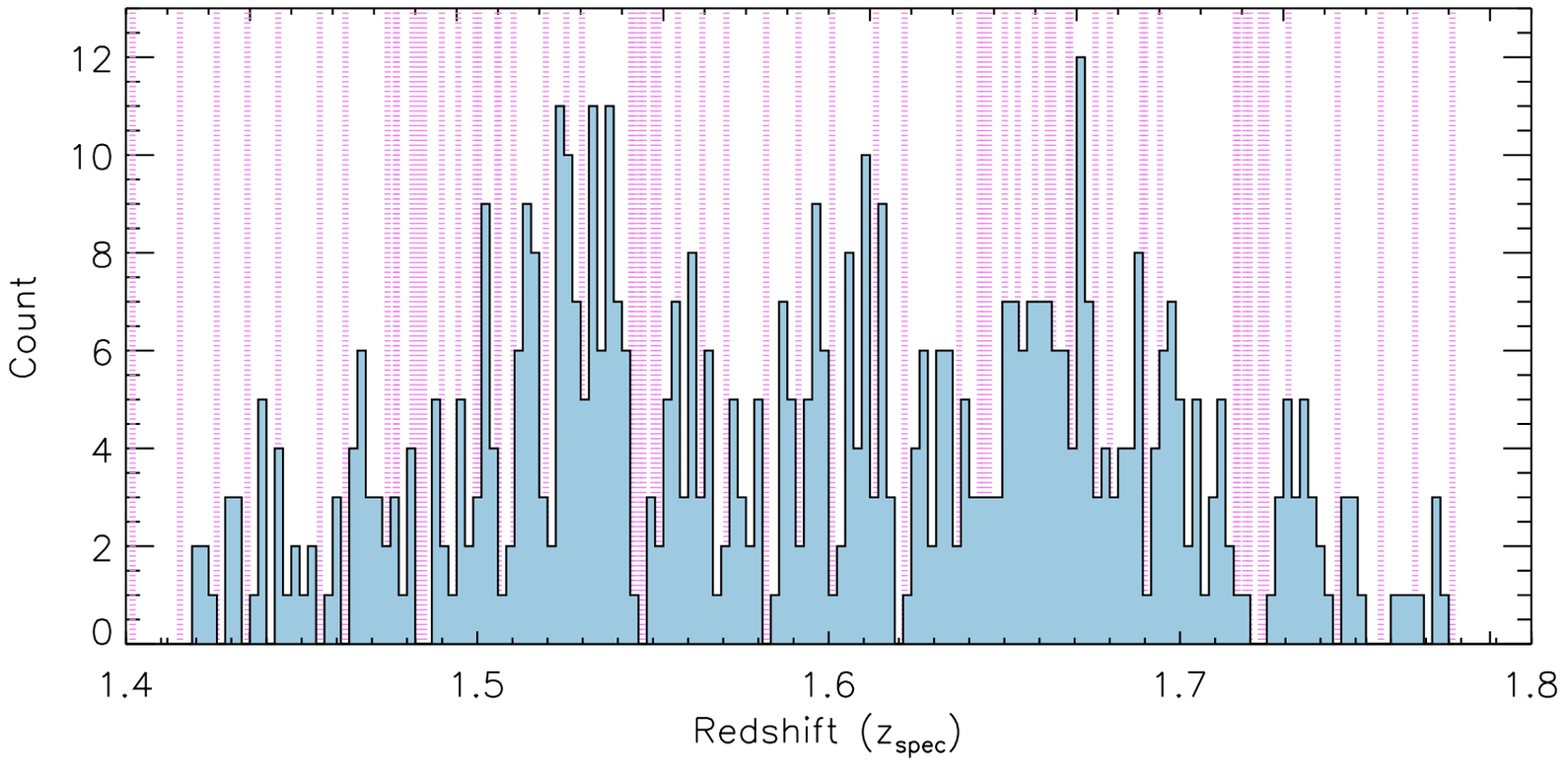
$K_{AB}<23.5$
$M_{star}>10^{9.8}M_{sun}$
Predicted f(Ha)>4e−17 erg/s/cm²

Observed galaxies: #1284

Spec-z sample: #551 15% of parent sample

for clustering analysis





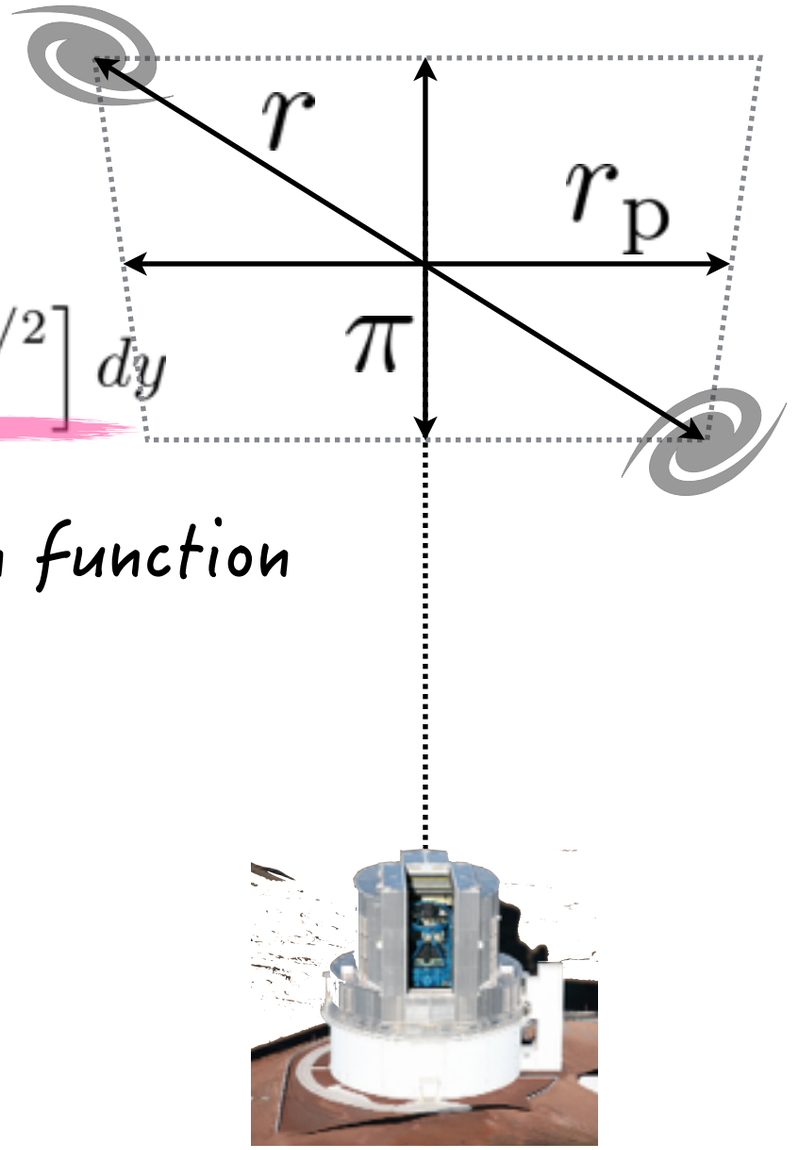
Measuring correlation function

Projected correlation function

銀河の固有速度の影響を最小化する。

$$w_{\rm p}\left(r_{\rm p}\right) = \int_{-\infty}^{+\infty} \xi\left(r_{\rm p}, \pi\right) d\pi = 2 \int_{0}^{\infty} \xi\left[\left(r_{\rm p}^2 + y^2\right)^{1/2}\right] dy$$

Real space correlation function



Landy & Szalay's (1983) estimator:

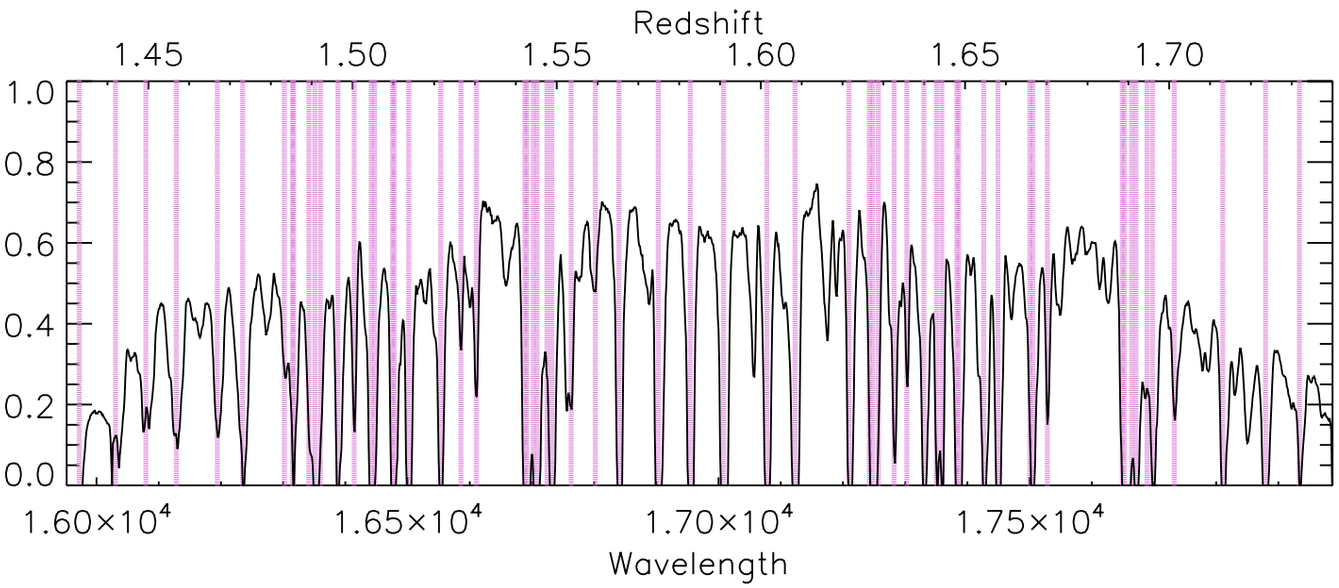
$$\xi\left(r\right) = \frac{DD\left(r\right) - 2DR\left(r\right) + RR\left(r\right)}{RR\left(r\right)}$$

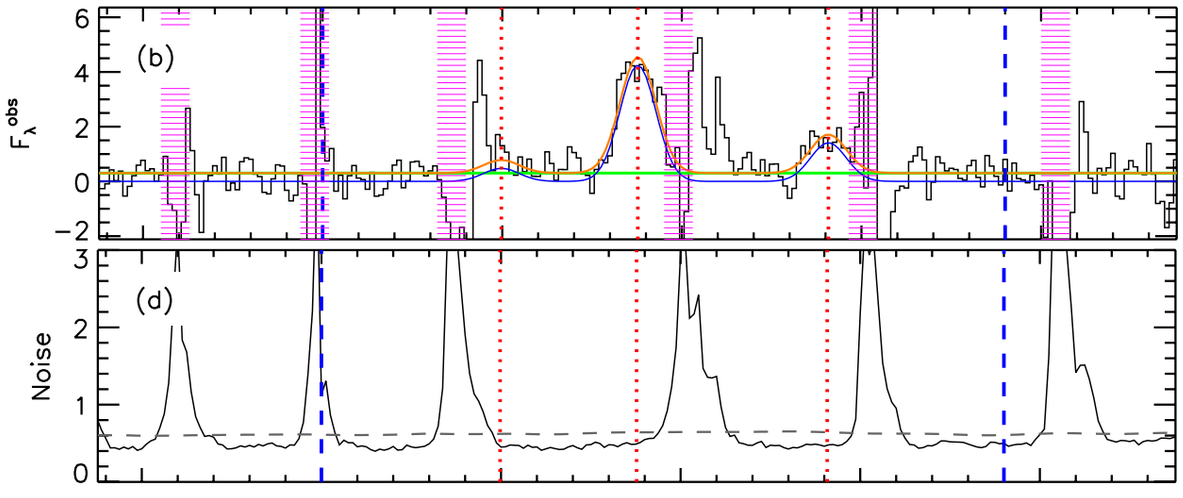
Two difficulties

- OH airglow and masks on radial selection
- The fiber-allocation system of FMOS

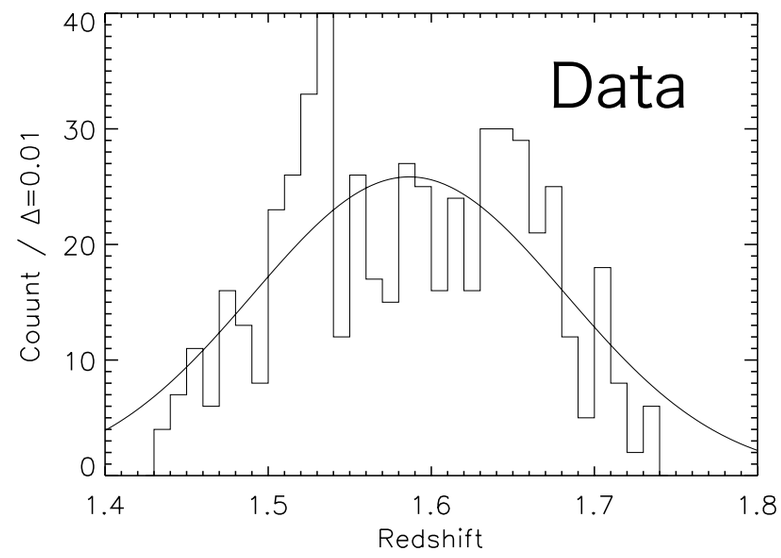
Effects of OH airglow and masks on radial selection:

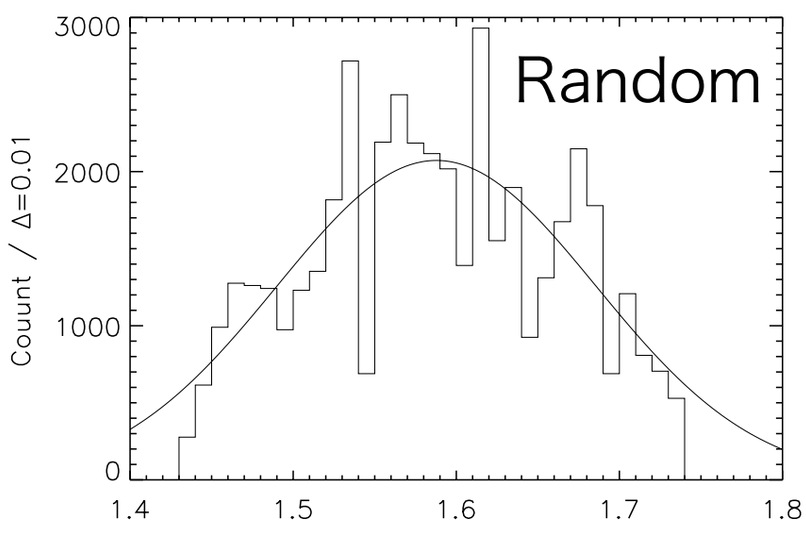
Weight function taking into account the OH line positions constructed by noise spectra



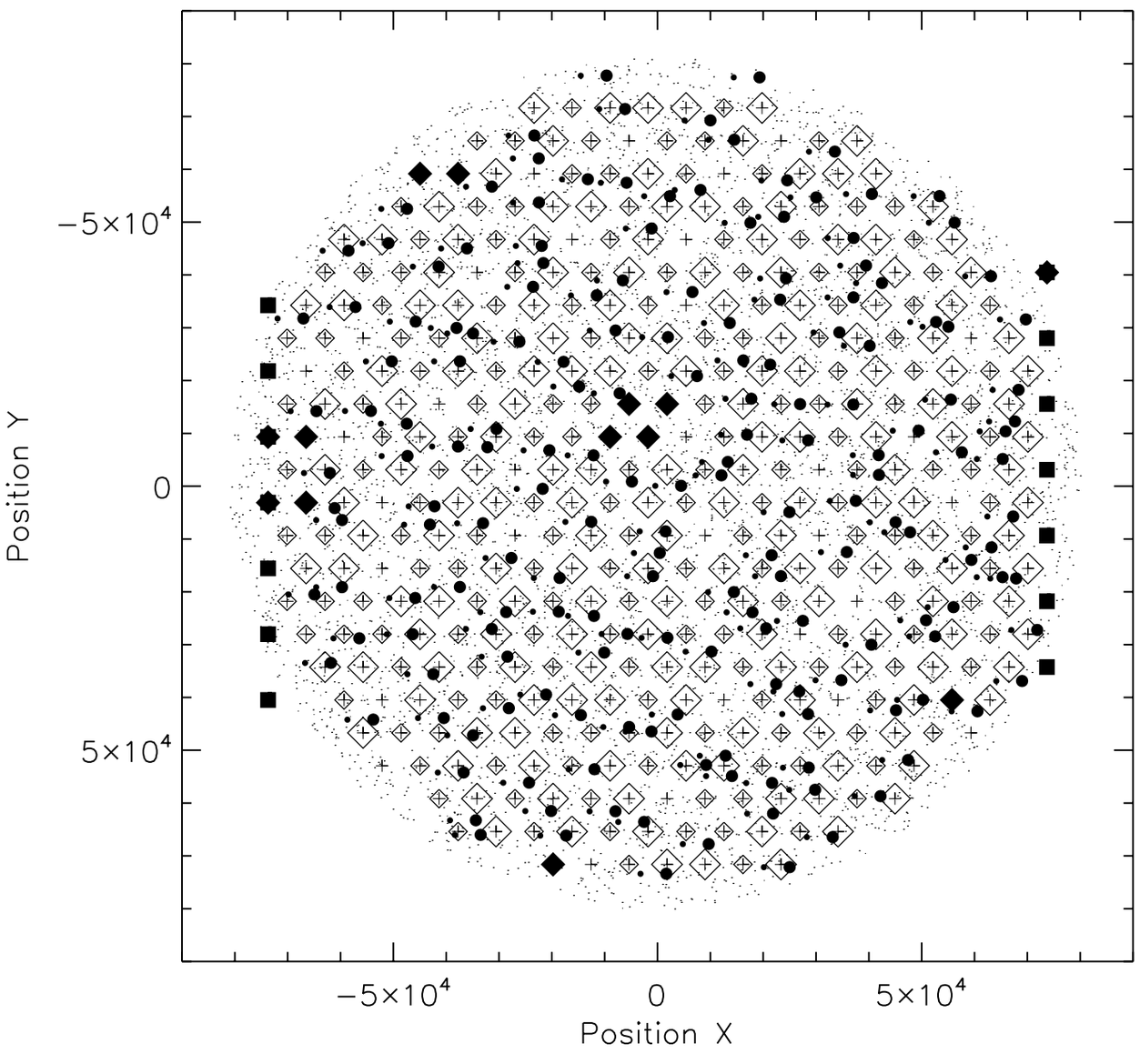


FMOS noise spectrum





Effects of the fiber-allocation system of FMOS
causing suppression of finding close pairs and
nasty clusterings on the 2D distribution



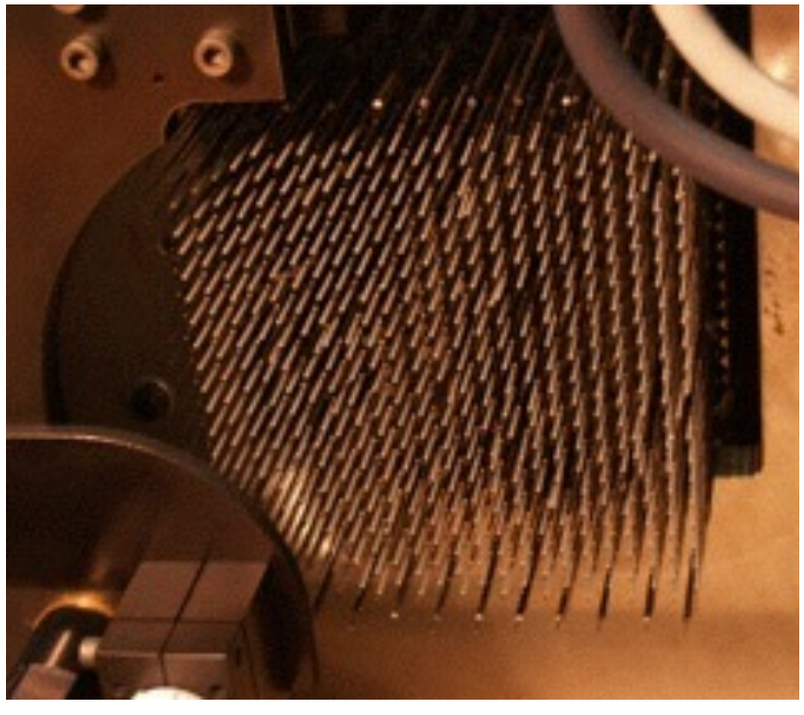
Fiber home positions

Allocated fibers (for dummy positions)

Observed galaxies (dummy positions)

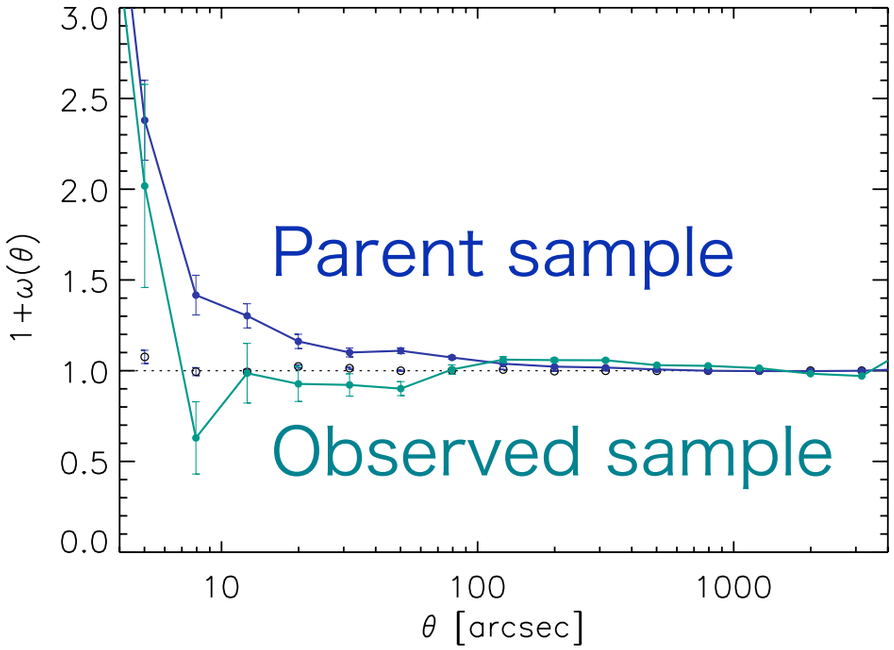
Out-of-order

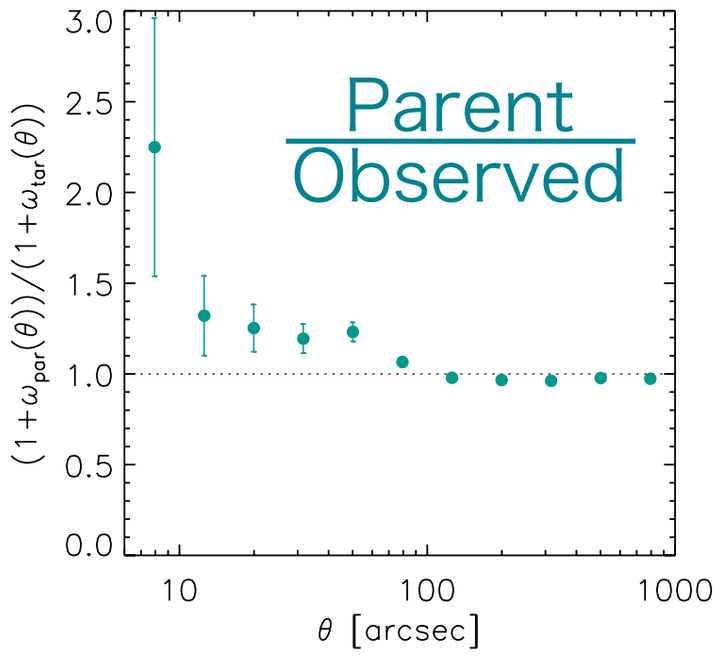
Fibers for guide stars



Correction with angular correlation

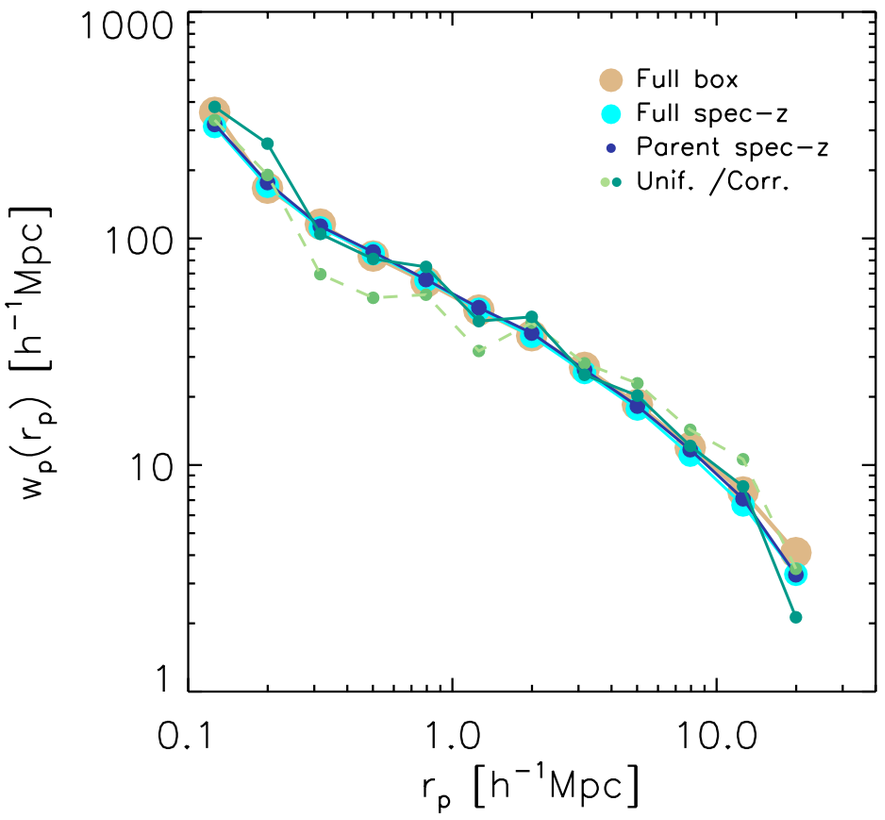
— weighting “DD” terms

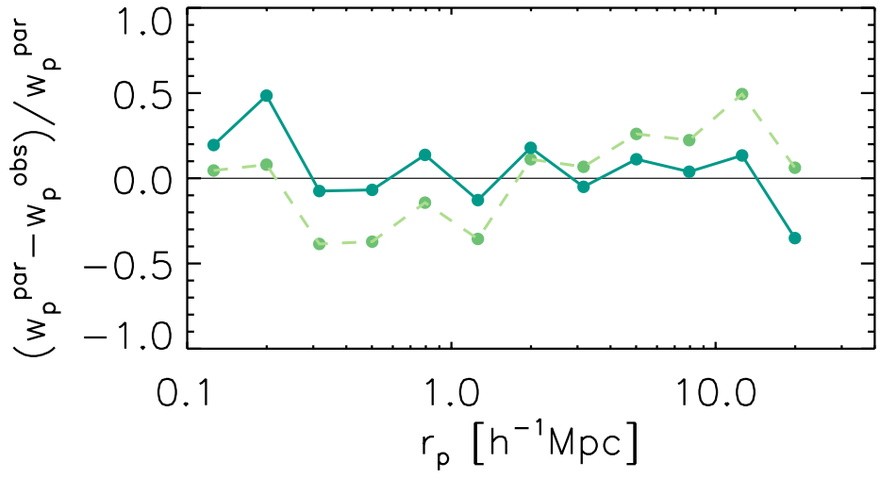




Validity check by mocks

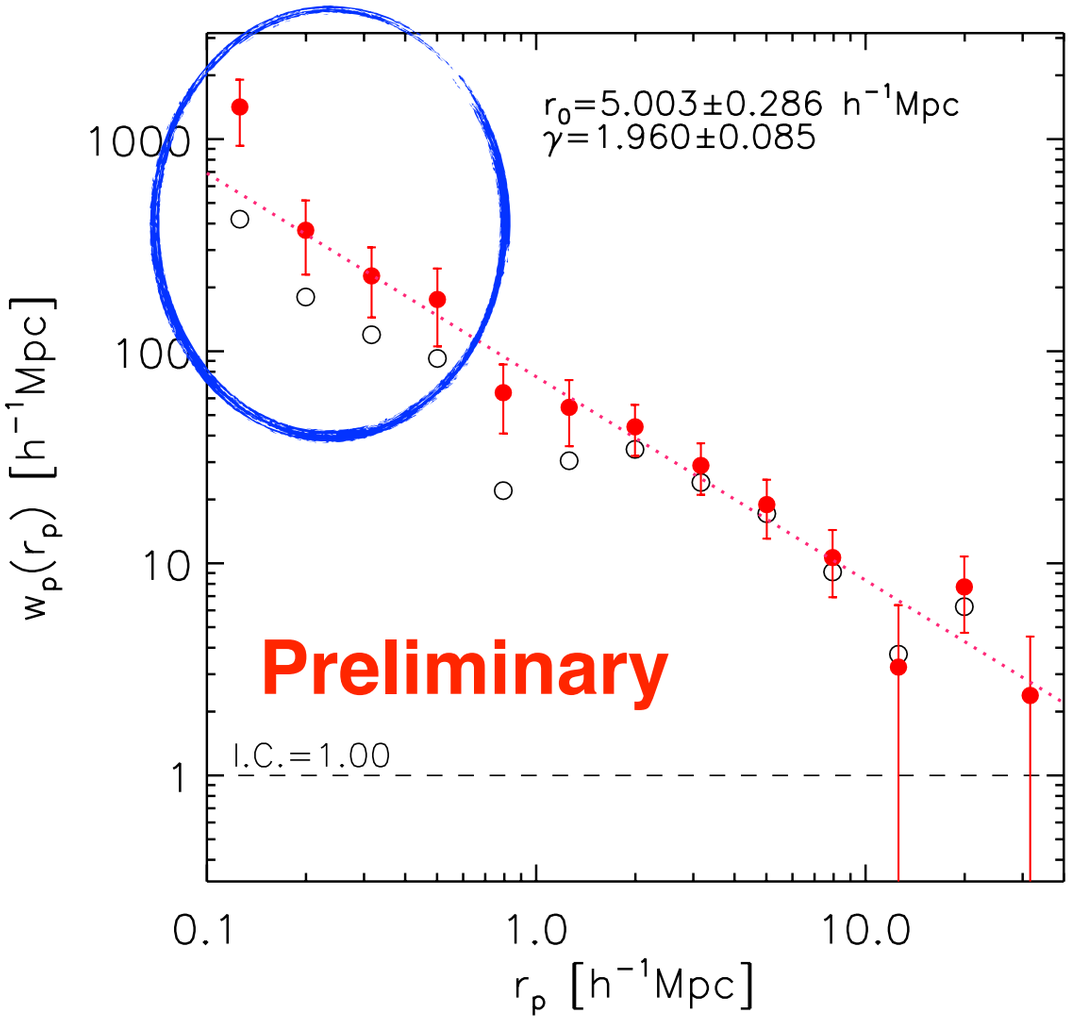
from Bolshoi simulation
sub-halo catalog





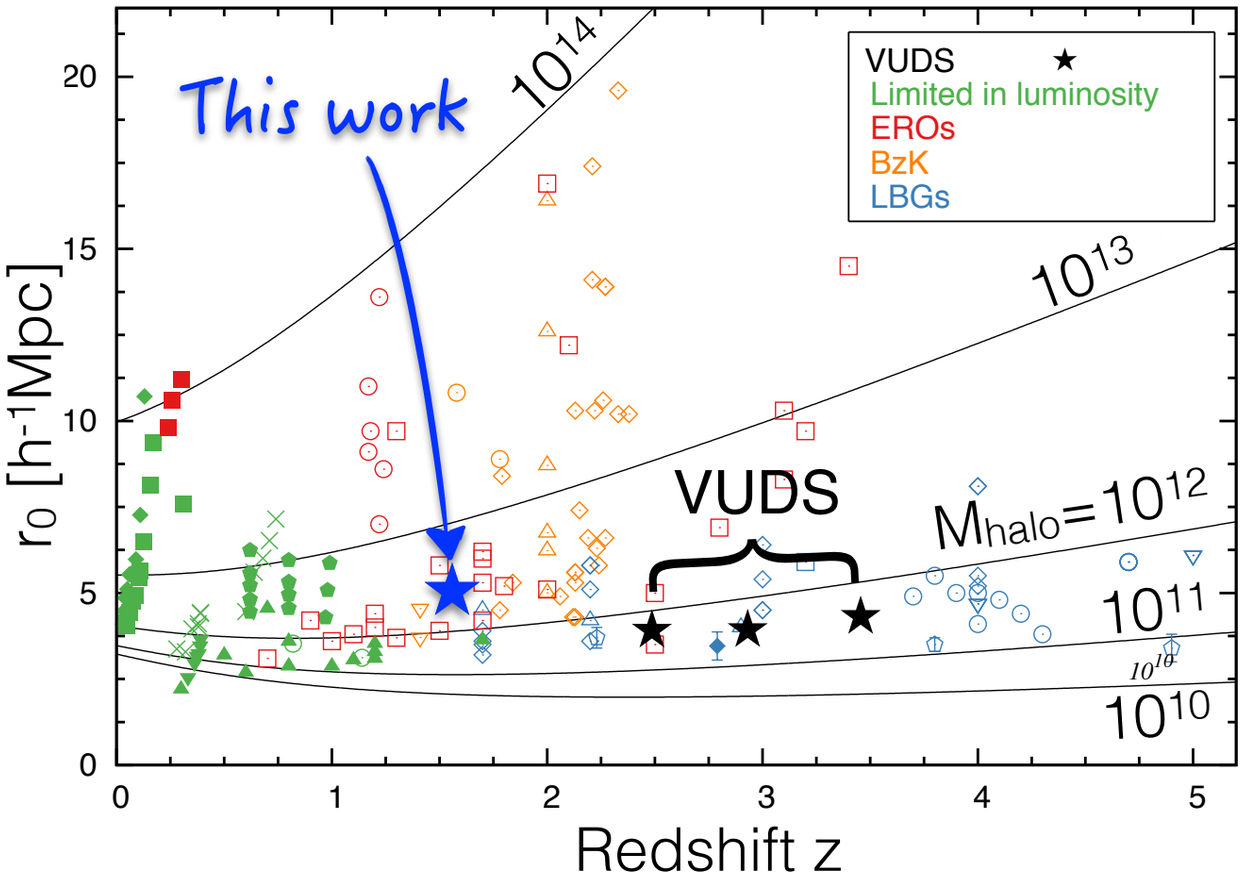
Results

Significant 1-halo clustering



Error estimate from Jackknife

Evolution of correlation length



Durkalec et al. 2014

HOD modeling

Halo occupation distribution

$$\langle N_{\rm cen}|M\rangle = F_g(1-F_s)\exp\left[-\frac{\log(M/M_{\rm min})^2}{2\sigma^2_{\log M}}\right] + F_s\frac{1}{2}\left[1+{\rm erf}\left(\frac{\log(M/M_{\rm min})}{\sigma_{\log M}}\right)\right]$$

Gaussian comp.

High mass comp.
(smoothed step function)

$$\langle N_{\rm sat}|M\rangle = \frac{1}{2}\left[1+{\rm erf}\left(\frac{\log(M/M_{\rm min})}{\sigma_{\log M}}\right)\right]\left(\frac{M}{M_1}\right)^{\alpha}$$

MCMC fitting

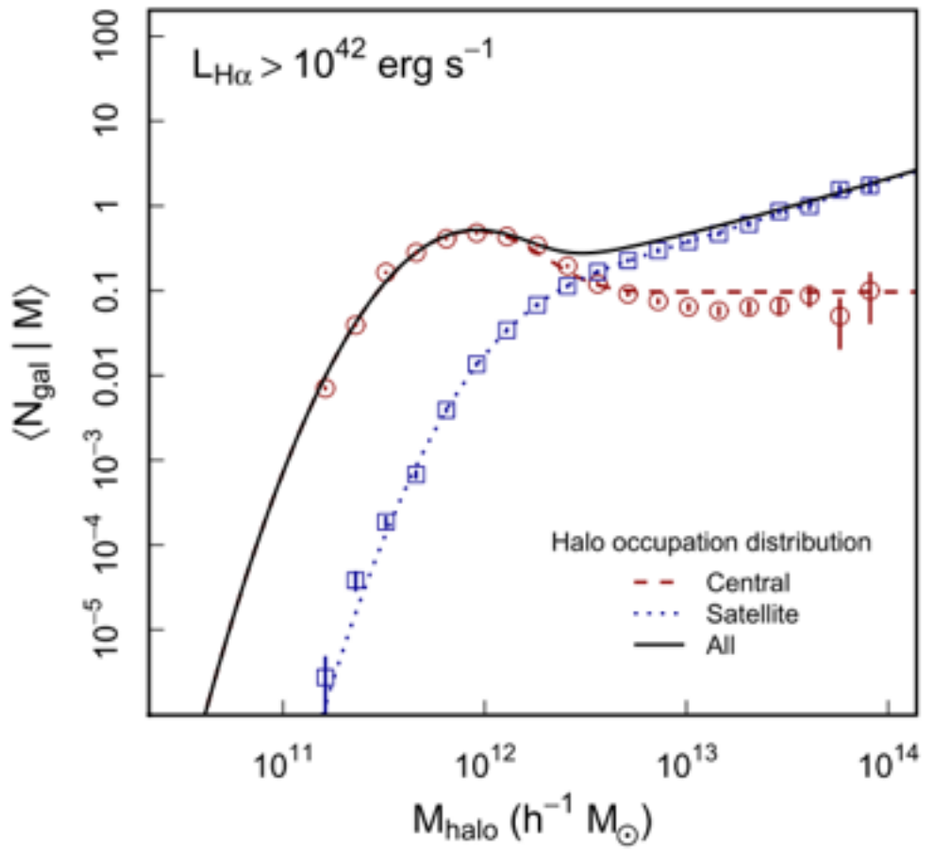
To avoid overfitting, some parameters are fixed:

Fg=0.6, Fs=0.1, $\sigma_{\rm logM}$=0.6, α=1

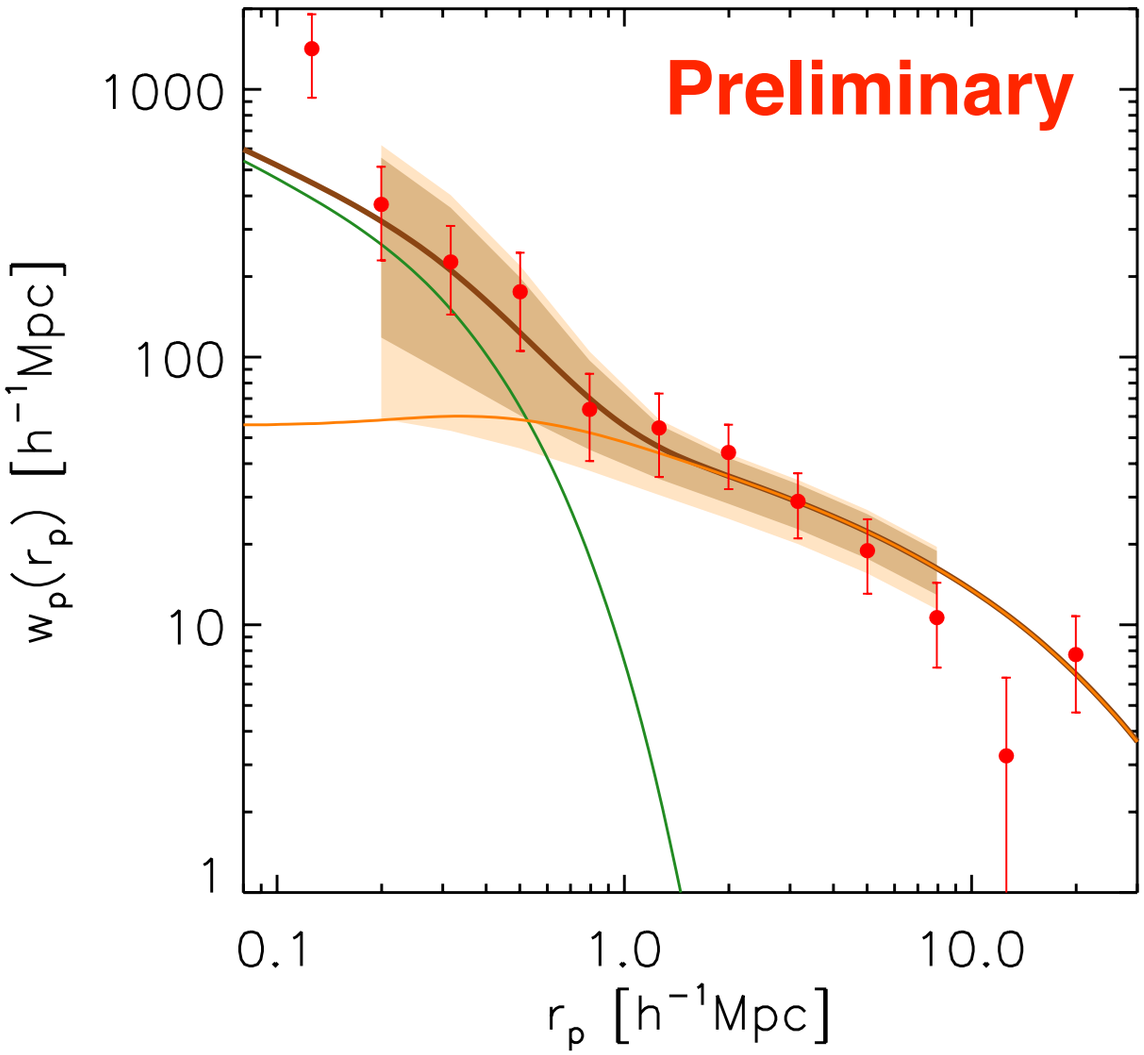
Only two free parameters: $M_{\rm min}$, M_1

$$\log M_{\rm min}=12.50^{+0.2}_{-0.15} \quad \log M_1=12.50^{+0.47}_{-0.24}$$

Geach+12; GALFORM

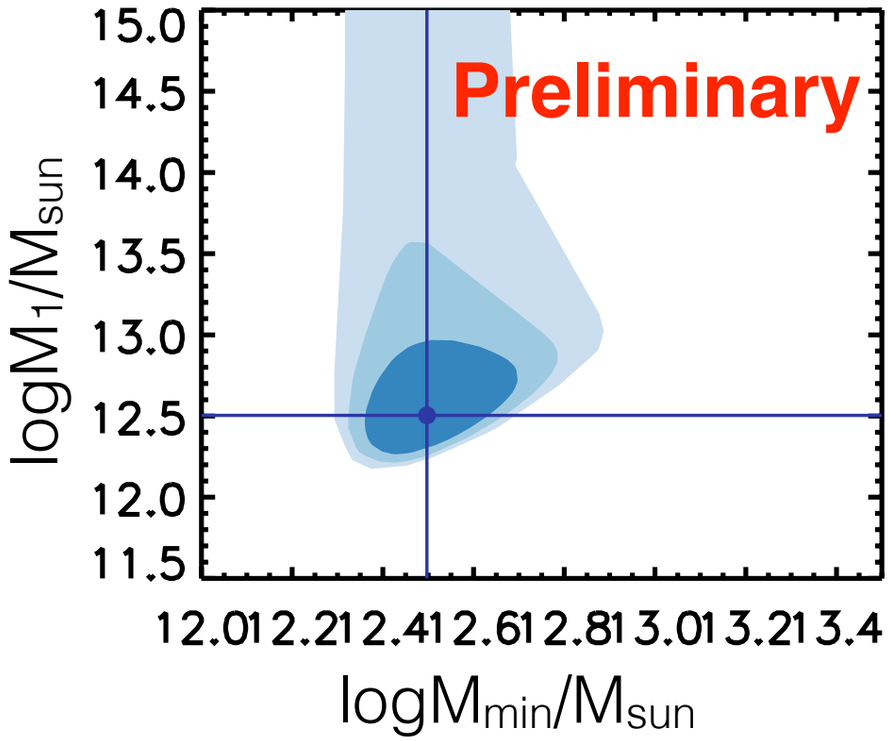


HOD modeling

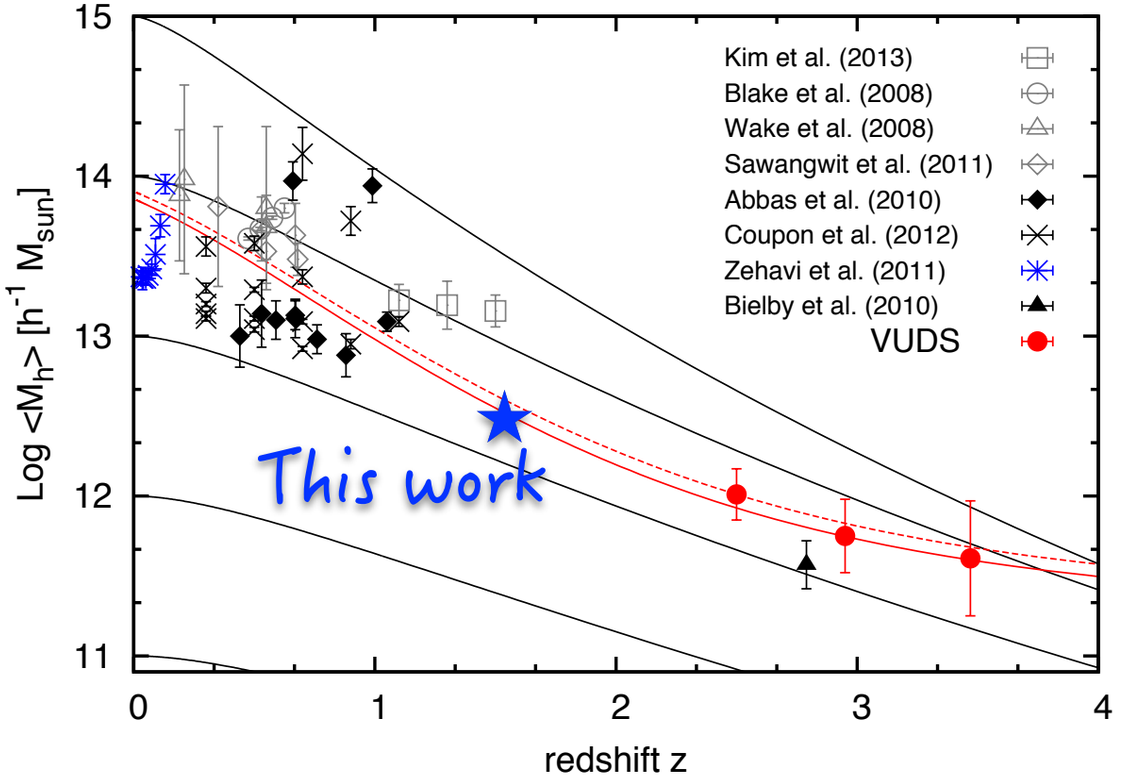


$\langle M_h \rangle = (3.2 \pm 1.5) \times 10^{12}\, h^{-1} M_{sun}$

Galaxy bias: $b_{eff} = 2.1 \pm 0.2$



Fate of z~1.6 star-forming galaxies



Durkalec et al. 2014

Summary

551個のFMOS spec-z 星形成銀河の射影相関関数を測定した

✓ ファイバー観測による影響を補正

✓ N-bodyモックカタログにより妥当性を検証

r_p~0.2-1 h^{-1}Mpc に優位な1-halo termを検出

相関長 r_0=5 h^{-1}Mpc ▶ M_{halo}~$10^{12.5}$ $h^{-1}M_{sun}$ at z~1.6

HODモデルでフィットし、average halo mass (=3.2x10^{12} $h^{-1}M_{sun}$), effective galaxy bias (b=2.1) を推定

✓ ハロー質量進化トラックに載せると、z=0で

$LogM_{halo}/h^{-1}M_{sun}$~13.5-14

✓ HODモデルの検証の必要あり