The FMOS-COSMOS Survey: Properties of dark matter halos of main-sequence star-forming galaxies at z~1.6

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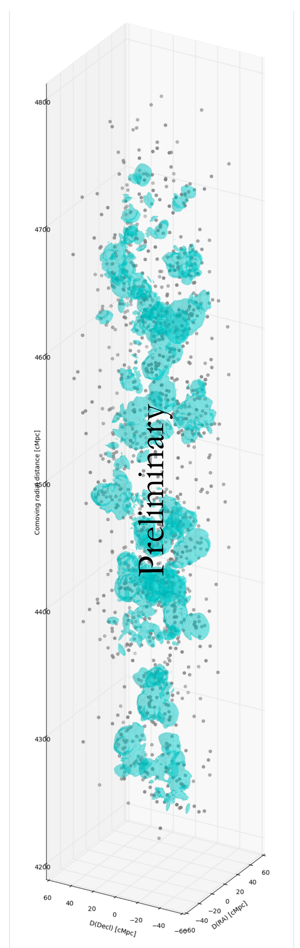
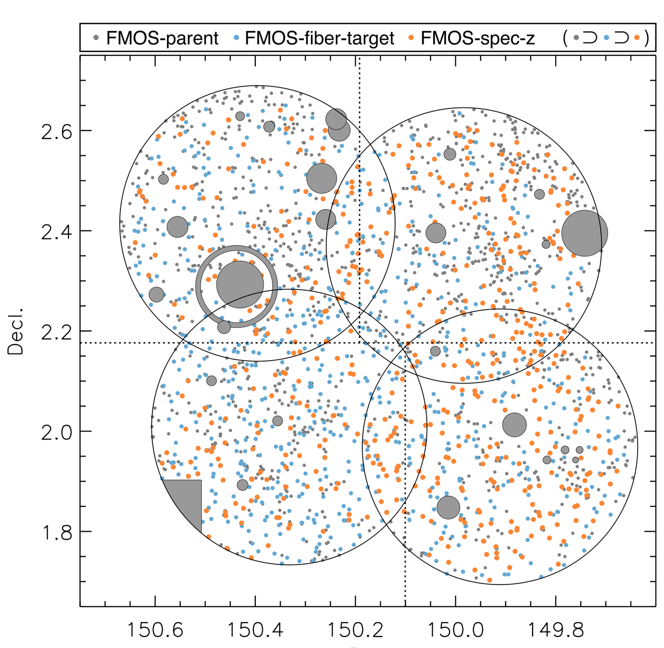
Overview

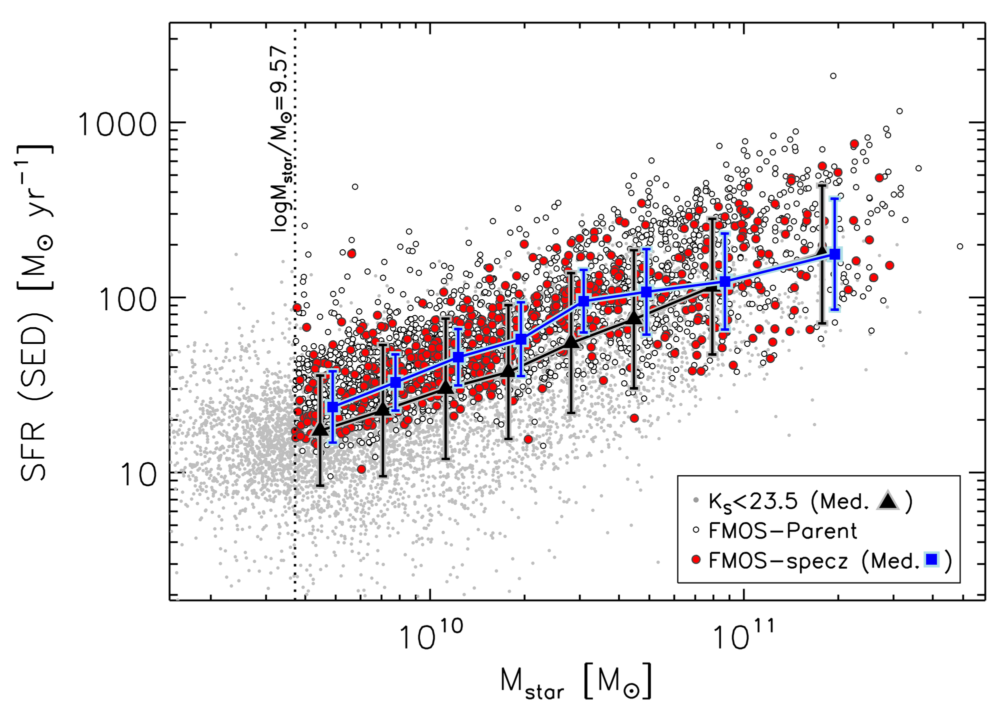
We investigate the properties of dark matter halos that contain "main-sequence" star-forming galaxies at 1.43<z<1.74 using the FMOS-COSMOS survey. The projected correlation function is measured for 516 galaxies down to stellar mass of $10^{9.57}$ $M_\odot$ and SFR~15 $M_\odot$ yr^{-1}, for which the Hα emission line is detected. We find that these galaxies live in halos of $M_h=5\times10^{12}$ $M_\odot$ on average, which will likely become present-day halos equivalent to the typical mass scale of galaxy groups. We then constrain the stellar-to-halo mass ratio at $M_h<10^{12}$ $M_\odot$, finding a systematically lower mass ratio than those measured at higher masses.



Galaxy density map reconstructed from the full FMOS-COSMOS dataset

Sample of star-forming galaxies at 1.43<z<1.74

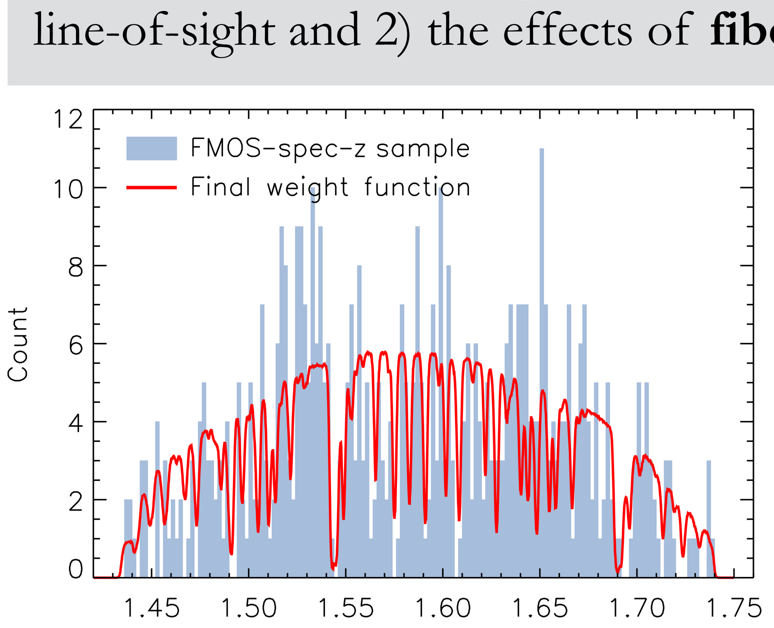


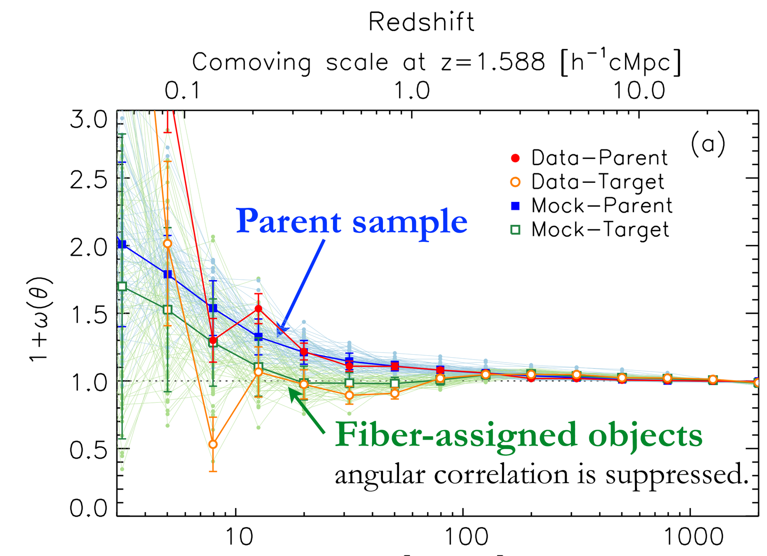


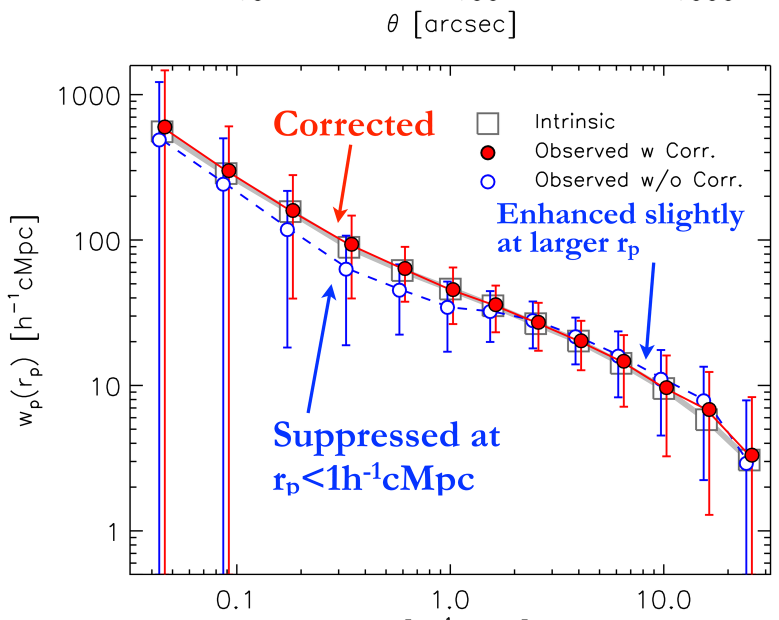
The parent galaxies are selected to have K_{AB}<23.5, $M_\star>10^{9.57}$ $M_\odot$, SED-based predicted f(Hα)>10^{-16} erg s^{-1} cm^{-2}, over the central 0.8 deg^2 of the COSMOS field, covered by four FMOS footprints (large circles). The FMOS-specz sample (used for clustering analysis) consists of 516 star-forming galaxies, along the epoch's "main sequence", which have a detection of Hα at 1.43<z<1.74, corresponding to the FMOS *H*-long grating range.

Method and Corrections for biases

Two-point projected *redshift-space* correlation function $w_p(r_p)$ is measured using the Landy & Szalay's estimator, while carefully taking into account significant observational biases, in particular, 1) **inhomogeneous detectability** along the line-of-sight and 2) the effects of **fiber allocation.**







1) Detection rate drops around strong OH lines, and decreases toward ends of the spectral coverage due to increasing instrumental noise, affecting the redshift distribution, and thus introducing spurious clustering. A weight function is defined by performing MC simulations of detecting artificial Hα lines with realistic noise, and applied (combined with a realistic PDF(z) of the sample) to mimic the features in the random sample.

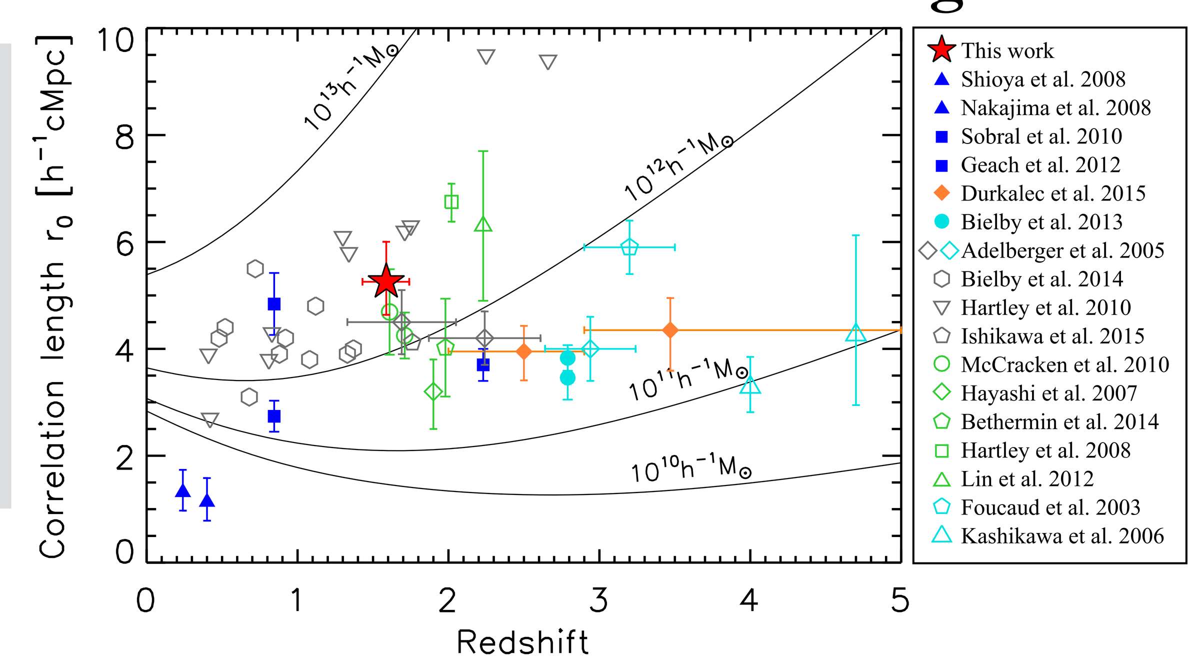
2) On-sky galaxy distribution is biased by fiber allocation. The sampling rate of galaxy pairs is suppressed at scales less/similar to the minimum fiber separation (~1.6'), while distant pairs are easy to sample. These effects, distorting the resulting $w_p(r_p)$, are corrected by weighting galaxy-pair counts depending on their angular separation. The weight is defined as a ratio of angular correlation function of the parent sample and fiber-assigned objects:

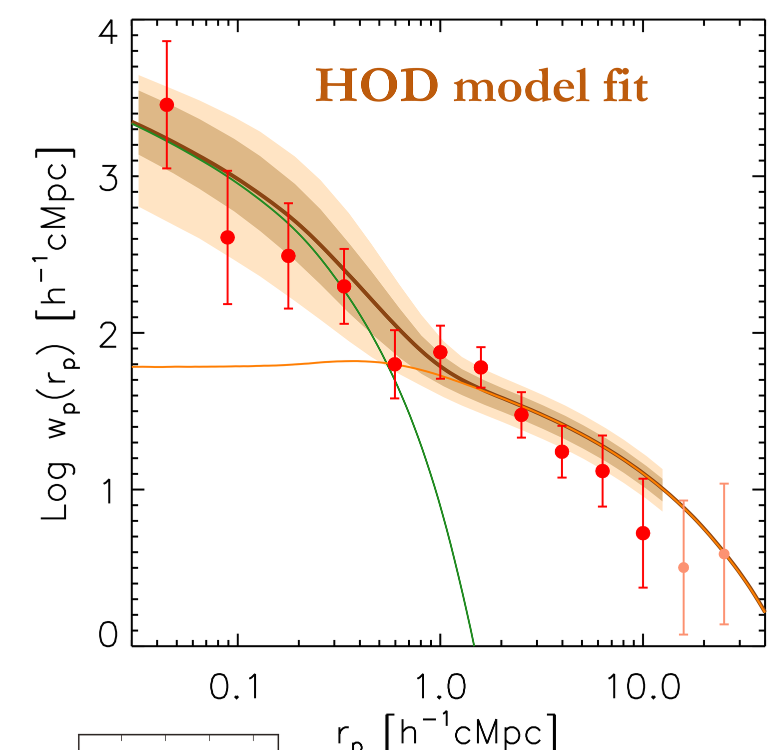
$$W(\theta)=\frac{1+w_{\rm parent}(\theta)}{1+w_{\rm fiber}(\theta)}$$

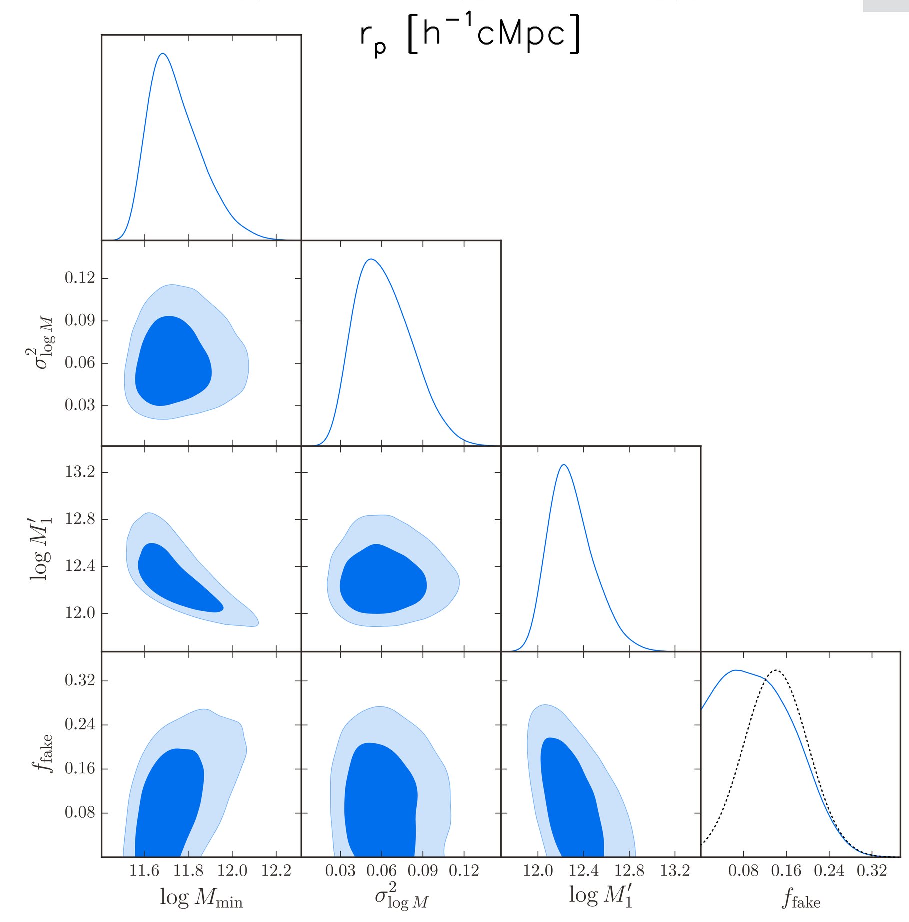
To avoid large statistical uncertainties, the weight function is defined using 64 mock samples.

Observed two-point correlation function and HOD modeling

The observed $w_p(r_p)$ is well fit with a power-law model with a correlation length r_0=5.3±0.7cMpc (γ=2.0±0.2), which is broadly consistent with others at similar redshifts using samples of SF galaxies with a similar mass range.







The result is also fit with an HOD model, resulting in successful constraint of the model while confirming the one-halo term at r_p<0.6 h^{-1}cMpc.

HOD model (3 parameters):

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

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

$$\log M_{\rm cut}/(h^{-1}M_\odot)=0.76\log M_1'/(h^{-1}M_\odot)+2.3$$

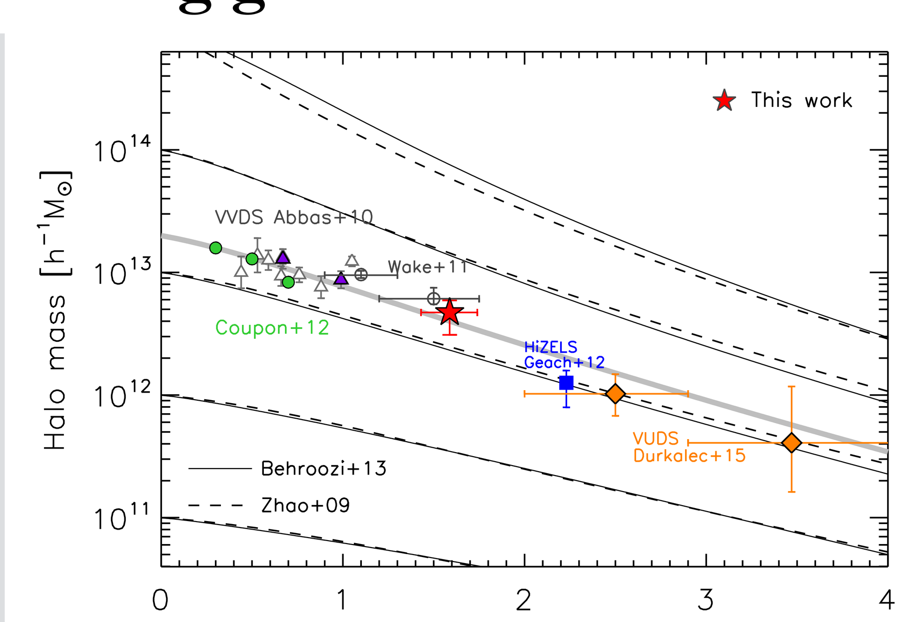
Parameters	Prior[a]	Best-fit
$\log M_{\rm min}/(h^{-1}M_\odot)$	$U(9,15)$	$11.72^{+0.11}_{-0.12}$
$\sigma^2_{\log M}$	$\geq 0, G(0.24,0.03)$ for $\sigma_{\log M}$	$0.057^{+0.021}_{-0.020}$
$\log M_1'/(h^{-1}M_\odot)$	$U(9,15)$	$12.27^{+0.17}_{-0.21}$
$f_{\rm fake}$	$\geq 0, G(0.14,0.06)$	$0.098^{+0.050}_{-0.091}$
χ^2/ν[b]	–	1.45 ($\nu=8$)

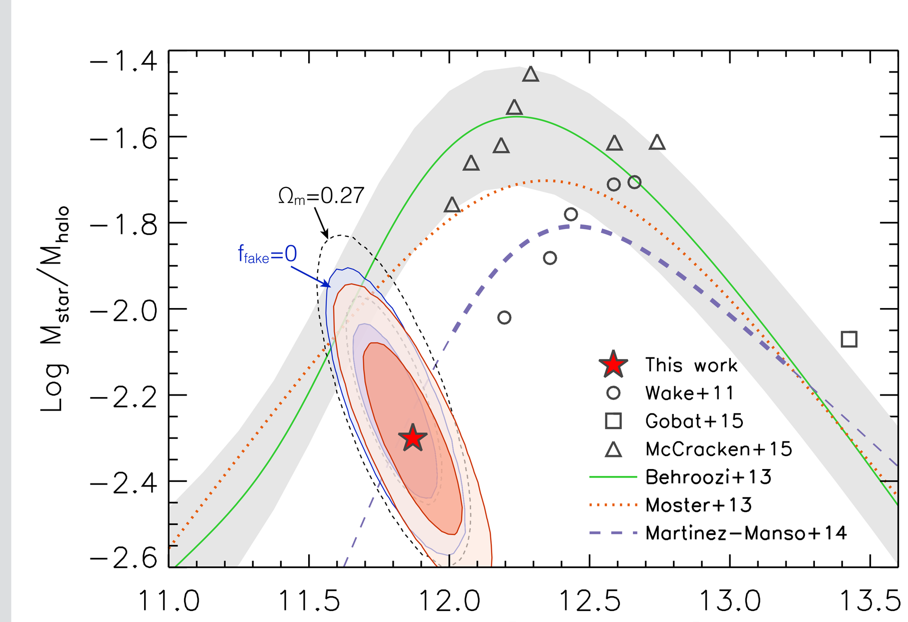
Inferred quantities	Constraint	Best-fit
$n_{\rm tot}/(h^{-1}{\rm cMpc})^3$[c]	$>0, G(9.29\,0.93)$	$9.22^{+1.33}_{-1.32}\times10^{-3}$
$n_{\rm cen}/(h^{-1}{\rm cMpc})^3$	–	$5.61^{+1.52}_{-1.73}\times10^{-3}$
$n_{\rm sat}/(h^{-1}{\rm cMpc})^3$	–	$3.61^{+1.39}_{-2.13}\times10^{-3}$
$f_{\rm sat}$	–	$0.39^{+0.15}_{-0.20}$
$M_{\rm eff}/(h^{-1}M_\odot)$	–	$4.71^{+1.19}_{-1.62}\times10^{12}$
$b_{\rm eff}$	–	$2.18^{+0.18}_{-0.24}$
$\log M_1/M_{\rm min}$	–	$0.64^{+0.30}_{-0.28}$

Discussions and Summary: properties of dark halos hosting star-forming galaxies at z~1.6

The result of the HOD modeling tells us,

1) These star-forming galaxies are biases with respect to dark matter with a large-scale bias factor b_{eff}=2.2±0.2, and live in halos of mass above M_{min}~7×10^{11} $M_\odot$, typically M_h~ 7×10^{12} $M_\odot$ on average, which will likely to grow up present-day halos of M_h~7×10^{13} $M_\odot$, equivalent to the typical mass scale of galaxy groups today.
2) The stellar-to-halo mass ratio (SHMR) is found to be lower ($M_\star/M_h$~0.0005) at M_{min}~ 7×10^{11} $M_\odot$ compared to others measured at higher masses (>10^{12} $M_\odot$), indicating a rapid drop of SHMR towards lower masses, as well-confirmed in present-day universe.
3) Relatively small "hosting gap" (M_1/M_{min}~4.4) and large satellite fraction (f_{sat}=0.4) are found (but with large uncertainties), which are broadly consistent with other studies at z>1 and indicates that galaxy pairs in the same, relatively low-mass halos significantly contribute to the one-halo term of the correlation function.





Next-generation NIR-MOS: Subaru/Prime Focus Spectrograph survey

Future PFS survey will provide Opt-NIR spectra of half a million galaxies at 0.7<z<2 over 15 deg^2, promising a dramatic step forward in our ability to study galaxy clustering and its link to galactic properties. Here we demonstrate the power of PFS on measuring galaxy correlation functions for subsets of galaxies.