Model the missing fraction of galaxies using Incomplete Conditional Stellar Mass functions

Xiaohu Yang

Collaborators: Guo Hong, Anand Raichoor, Zheng Zheng, Johan Comparat, V. Gonzalez-Perez, & SDSS-IV eBOSS Team.

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Tsung-Dao Lee Institute, Shanghai Jiao Tong University

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Submission Information

Publish Date: Wednesday, October 24, 2018
Archive Date: Wednesday, November 21, 2018
To event remaining 13 days

Job Summary

Job Category: Faculty Positions (tenure and tenure-track)
Institution Classification/Type: Large Academic
Institution/Company: Shanghai Jiao Tong University
City: Shanghai
State/Province: Shanghai
Country: China

Announcement

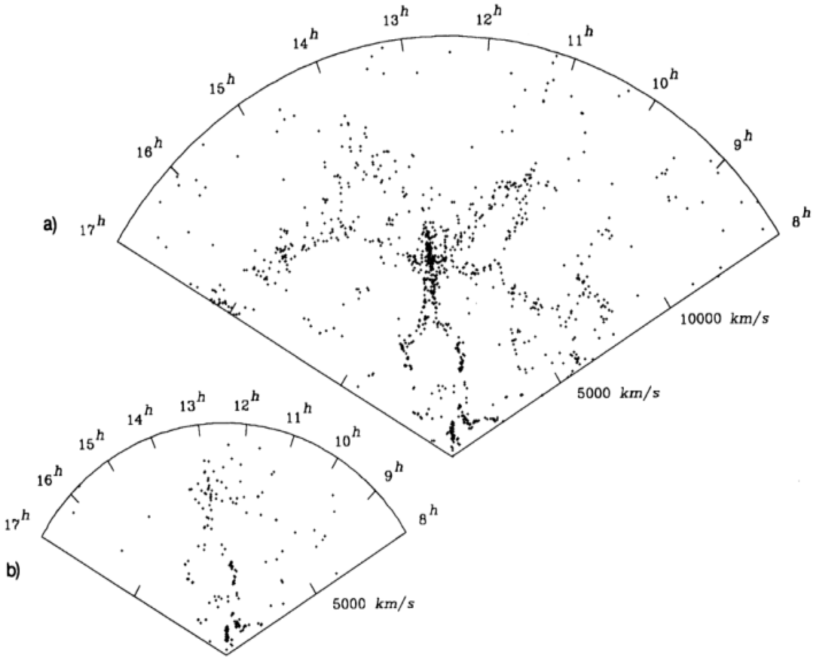
Job Announcement Text:

The department of astronomy (DoA) at Shanghai Jiao Tong University (SJTU) invites applications for tenure-track positions in all frontiers of astronomy and astrophysics, from exoplanets to cosmology, and from theoretical astrophysics to observational astronomy. DoA has about 11 faculty members and a fast growing group of postdocs and students. The research team is very diverse and international, spanning across theoretical, numerical, and observational frontiers of galaxy formation and cosmology. DoA is also eager to expand into other frontiers of astronomy and will provide ample research funds to support such efforts. More information can be found at http://astro.sjtu.edu.cn/.

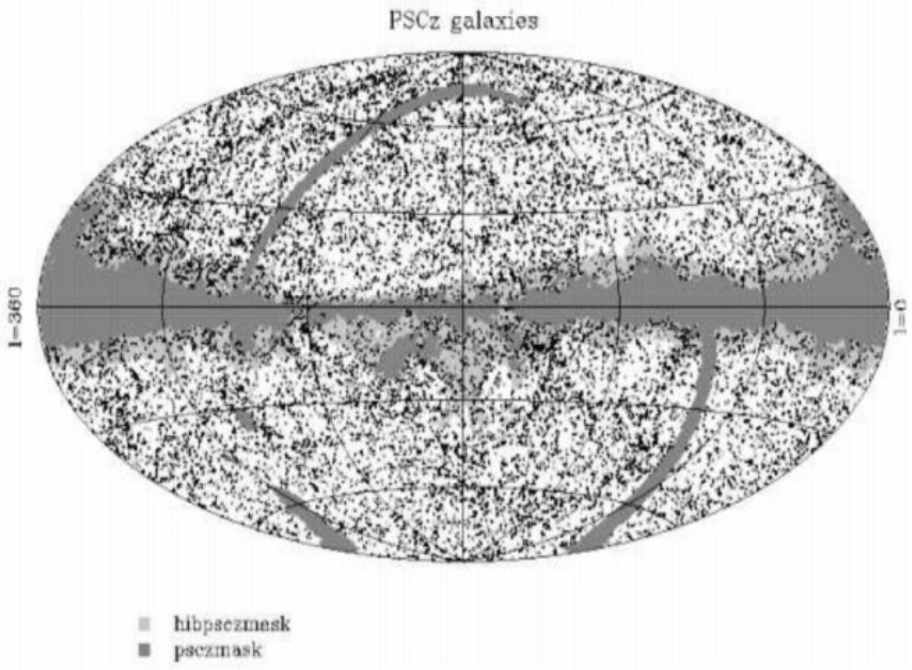
Constrain cosmology using `Large' redshift surveys

1990s

CFA



PSCz



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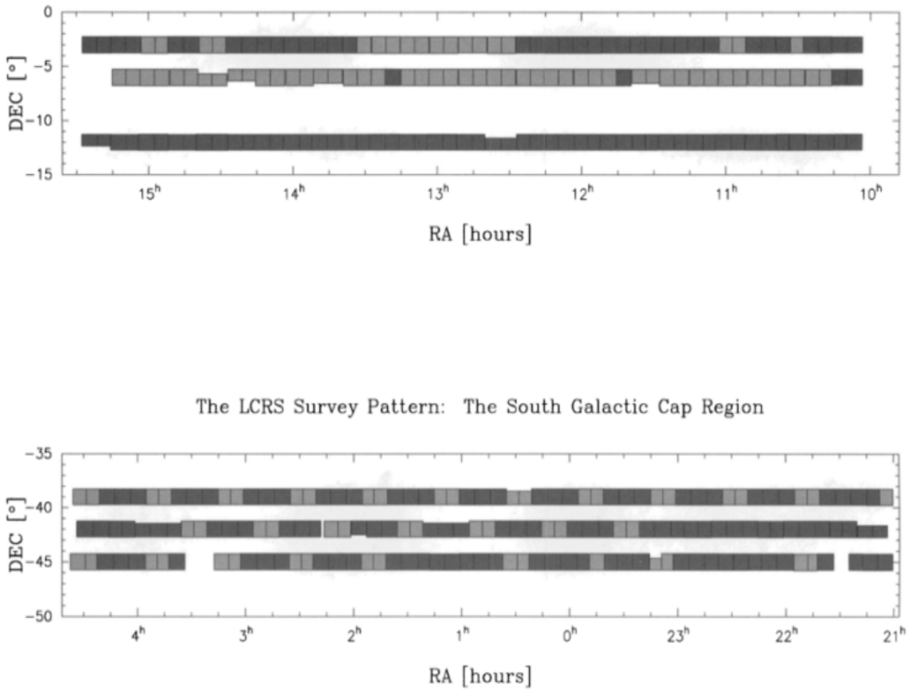

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1994ApJ...431.

THE ASTROPHYSICAL JOURNAL, 431:569–585, 1994 August 20
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POWER SPECTRUM, CORRELATION FUNCTION, AND TESTS FOR LUMINOSITY BIAS IN THE CfA REDSHIFT SURVEY[1]

CHANGBOM PARK,[2] MICHAEL S. VOGELEY,[3,4] MARGARET J. GELLER,[3] AND JOHN P. HUCHRA[3]
Received 1993 August 31; accepted 1994 February 16

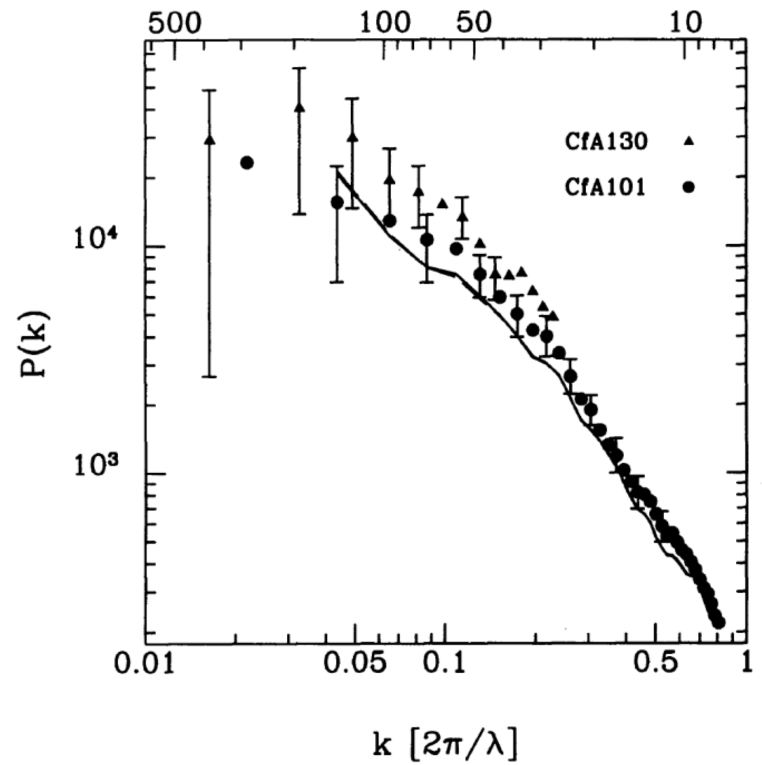

FIG. 5.—PS for volume-limited samples of CfA2 with depth 101 h^{-1} Mpc (CfA101; *circles*) and 130 h^{-1} Mpc (CfA130; *triangles*). We also plot the PS for a magnitude-limited sample with depth 101 h^{-1} Mpc (CfA101m; solid line for ϕ_1, dashed line for ϕ_2). The slope of the PS is $n \approx -2.1$ for $\lambda < 25\ h^{-1}$ Mpc and $n \sim -1.1$ for $30 < \lambda < 120\ h^{-1}$ Mpc.

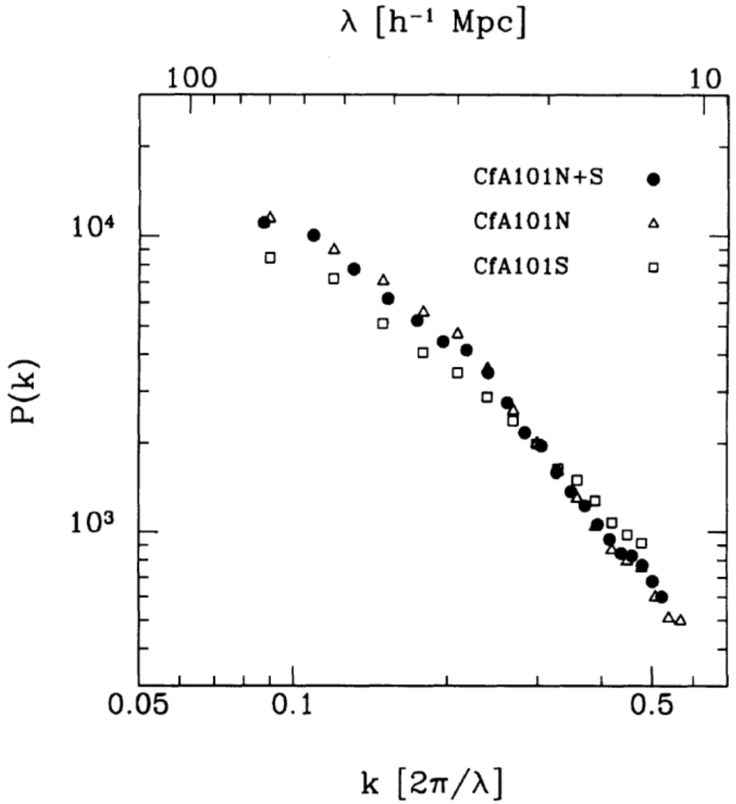

FIG. 8.—PS of the CfA101 sample. We separately plot the PS of CfA2 North (*open triangles*) and CfA2 South (*open squares*) along with the full CfA101 sample (*filled circles*). The southern sample has slightly less power on large scales and a slightly shallower PS, but the PS for the two regions are consistent within the finite sample errors.

THE ASTROPHYSICAL JOURNAL, 553:1–13, 2001 May 20
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MEASURING THE GALAXY POWER SPECTRUM WITH MULTIRESOLUTION DECOMPOSITION. II. DIAGONAL AND OFF-DIAGONAL POWER SPECTRA OF THE LAS CAMPANAS REDSHIFT SURVEY GALAXIES

XIAOHU YANG,[1,2] LONG-LONG FENG,[1,2,3] YAOQUAN CHU,[1,2] AND LI-ZHI FANG[4]

Received 2000 October 30; accepted 2001 January 18

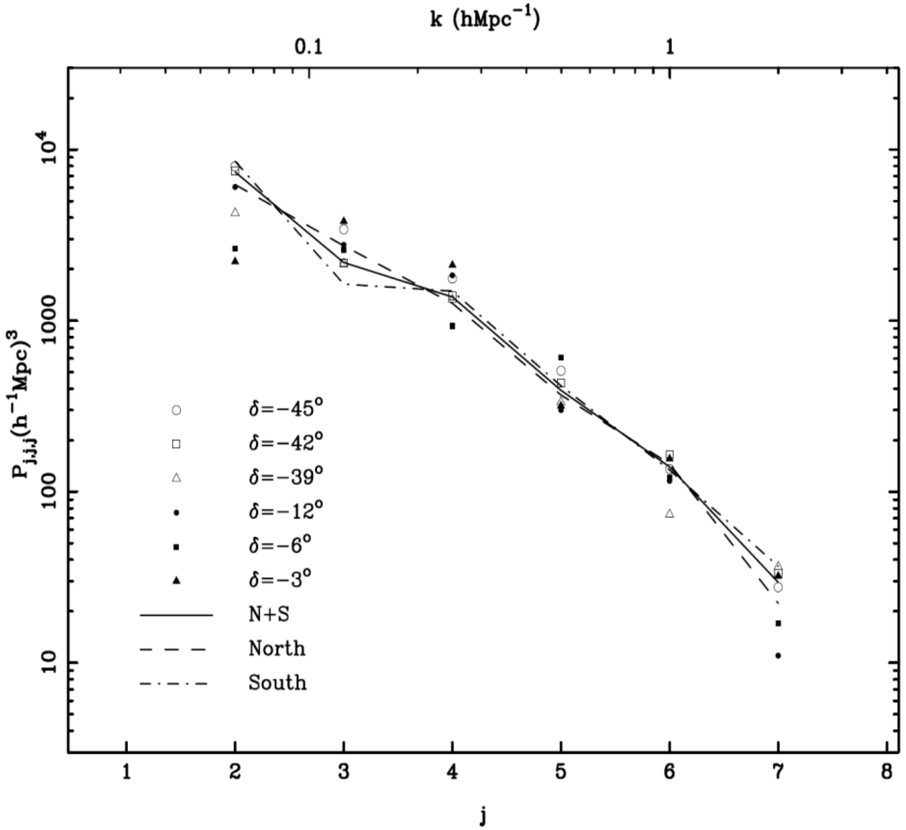

FIG. 8.—DWT power spectrum measured in the flux-limited LCRS samples. The scatter symbols represent the DWT power spectrum measured in the six slices, as indicated on the legend. The solid line shows the mean power averaged over these six slices. The dashed and dot-dashed lines are for the DWT power spectra calculated from the three north and south slices enclosed in one box, respectively.

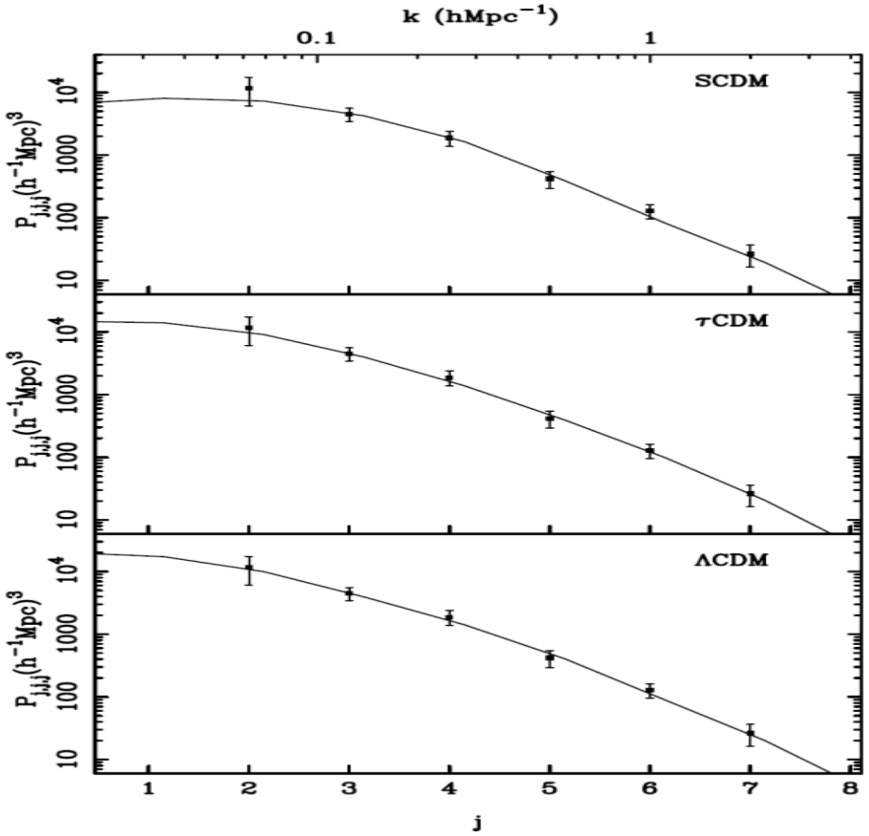

FIG. 9.—Best fit (*solid line*) of the LCRS diagonal DWT power spectrum for models SCDM (*top*), τCDM (*middle*), and ΛCDM (*bottom*) with parameters listed in Table. 1. The observed values (*filled square*) have been corrected for the slicelike geometry effect using the mock samples. The error bars are given by 1 σ variance obtained from the observed six slices.

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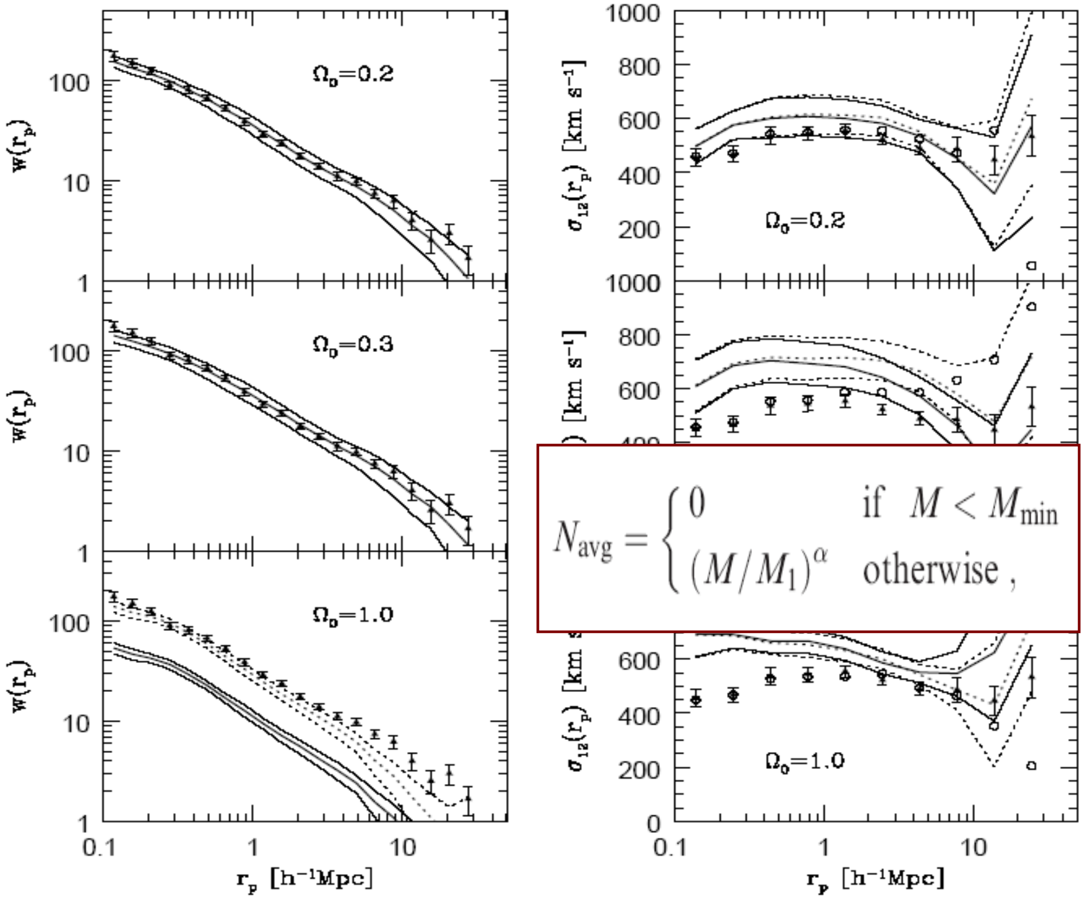
SPATIAL CORRELATION FUNCTION AND PAIRWISE VELOCITY DISPERSION OF GALAXIES: COLD DARK MATTER MODELS VERSUS THE LAS CAMPANAS SURVEY

Y. P. JING,[1,2] H. J. MO,[2] AND G. BÖRNER[2]
Received 1997 July 11; accepted 1997 September 19



$$N_{\rm avg} = \begin{cases} 0 & \text{if } M < M_{\rm min} \\ (M/M_1)^{\alpha} & \text{otherwise}, \end{cases}$$

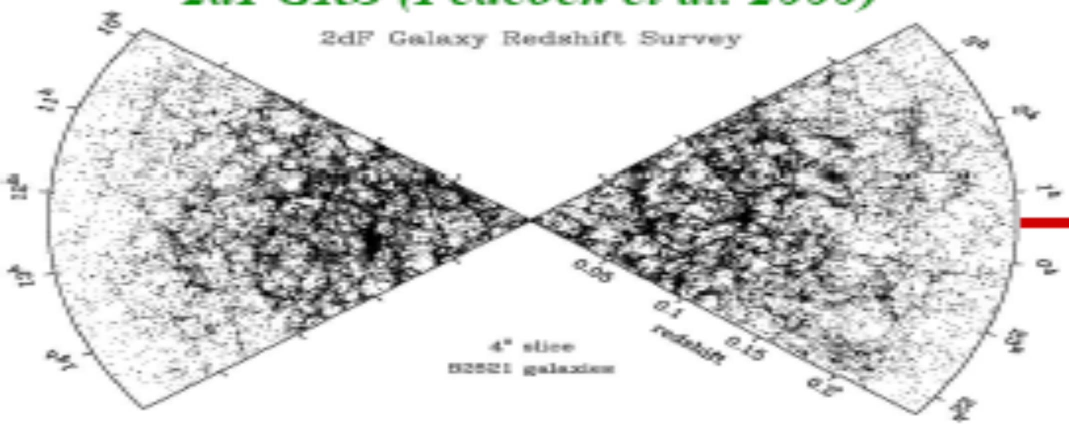
The HON (HOD) was initially introduced to understand the clustering of galaxies, the large scale structure.

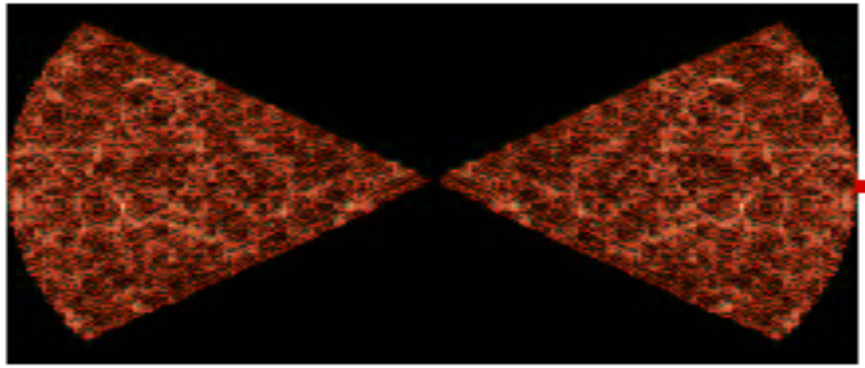
Since this quantity itself contains the information regarding the galaxy formation efficient in halos of different masses.

It gradually turns into a powerful tool to probe the galaxy formation processes.

Linking galaxies with dark matter halos with HOD models

2dFGRS (Peacock et al. 2000)





CDM simulation (Virgo consortium)

Halo Occupation Distribution (HOD)

P(N|M)

Seljak 2000

Scoccimarro et al. 2001

Scranton 2002

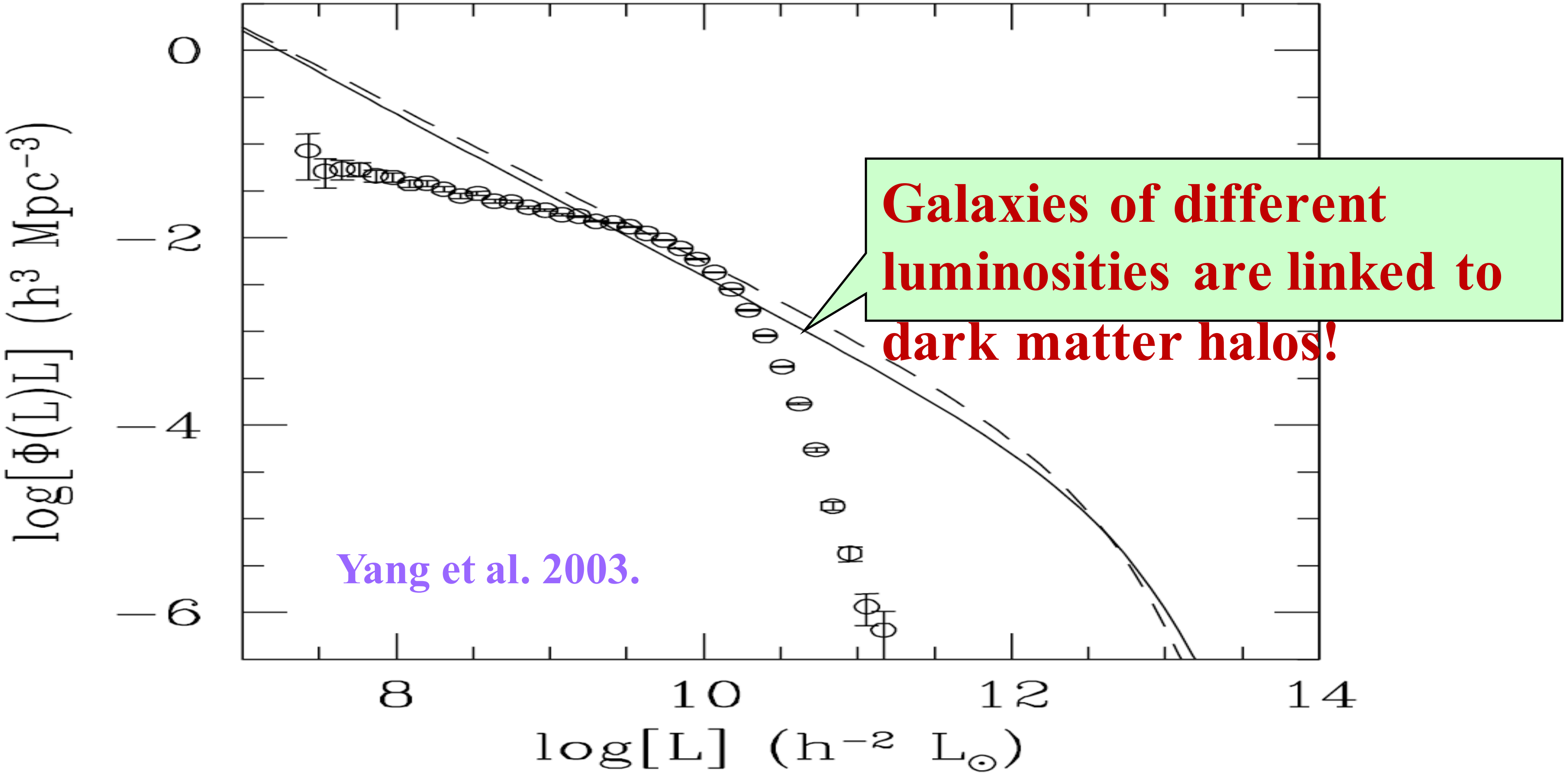
Berlind & Weinberg 2002

Magliochetti & Porciani 2003

The Halo Occupation Number method specifies $P(N|M)$, the probability that a halo of mass M contains N galaxies. HONs can address galaxy clustering by linking $\xi_{\rm gg}(r)$ to $\xi_{\rm hh}(r)$

Linking galaxies with dark matter halos with CLF models

- CLF (CSMF) (use both the galaxy luminosity/stellar mass function and clustering to constrain the galaxy distribution in dark matter halos)
  - Yang et al. 2003; van den Bosch et al. 2003; 2007; Cooray 2006; Yang et al. 2012…



Linking galaxies with dark matter halos with CLF models

The luminosity function:

$$\Phi(L) = \int_0^\infty \Phi(L|M)\, n(M)\, \mathrm{d}M$$

The average luminosity in a halo of mass M:

$$\langle L\rangle(M) = \int_0^\infty \Phi(L|M)\, L\, \mathrm{d}L$$

The average number of galaxies in a halo of mass M with $L > L_1$:

$$N_M(L > L_1) = \int_{L_1}^\infty \Phi(L|M)\, \mathrm{d}L$$

Clustering properties of galaxies as function of luminosity:

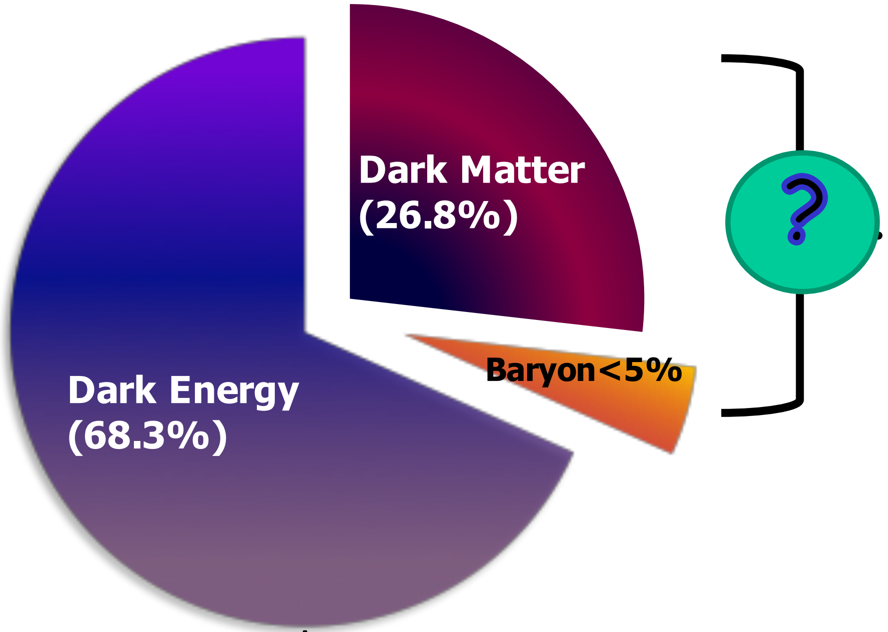
$$\xi_{\rm gg}(r|L) = b^2(L)\, \xi_{\rm dm}(r)$$

$$\bar{b}(L) = \frac{1}{\Phi(L)} \int_0^\infty \Phi(L|M)\, b(M)\, n(M)\, \mathrm{d}M$$

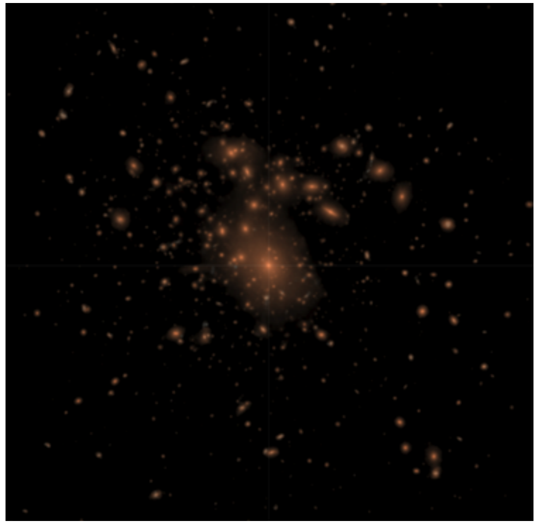
The conditional LF is the ideal statistical 'tool' to link the distributions of dark matter haloes and galaxies.

Yang et al. 2003, van den Bosch et al. 2003

Linking galaxies with dark matter halos：3 methods



Cosmology

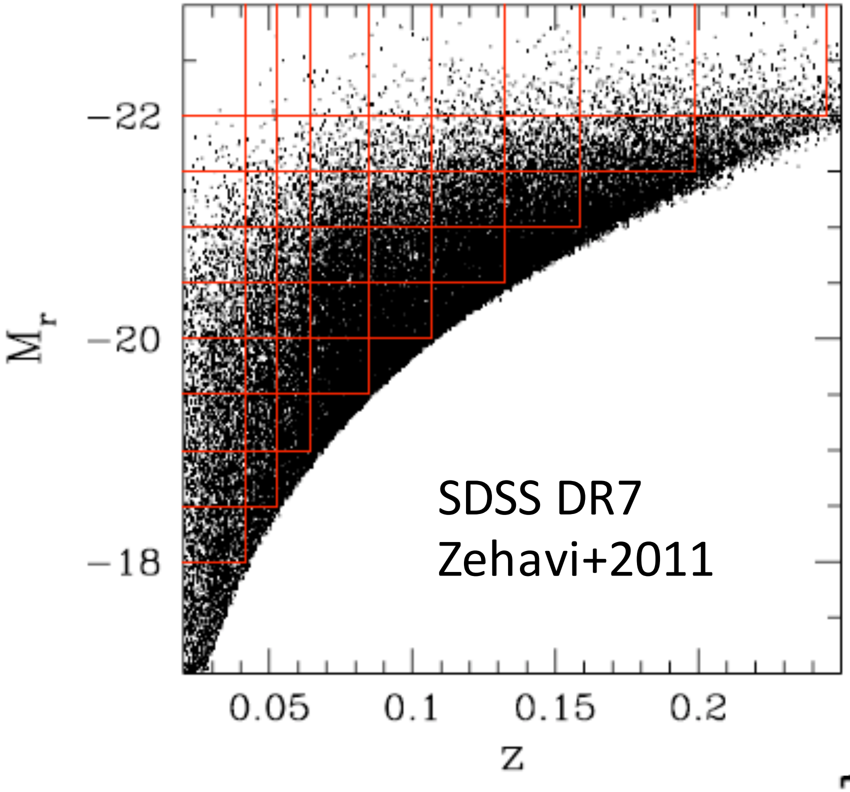


Galaxy Distribution

Dark Matter Distribution

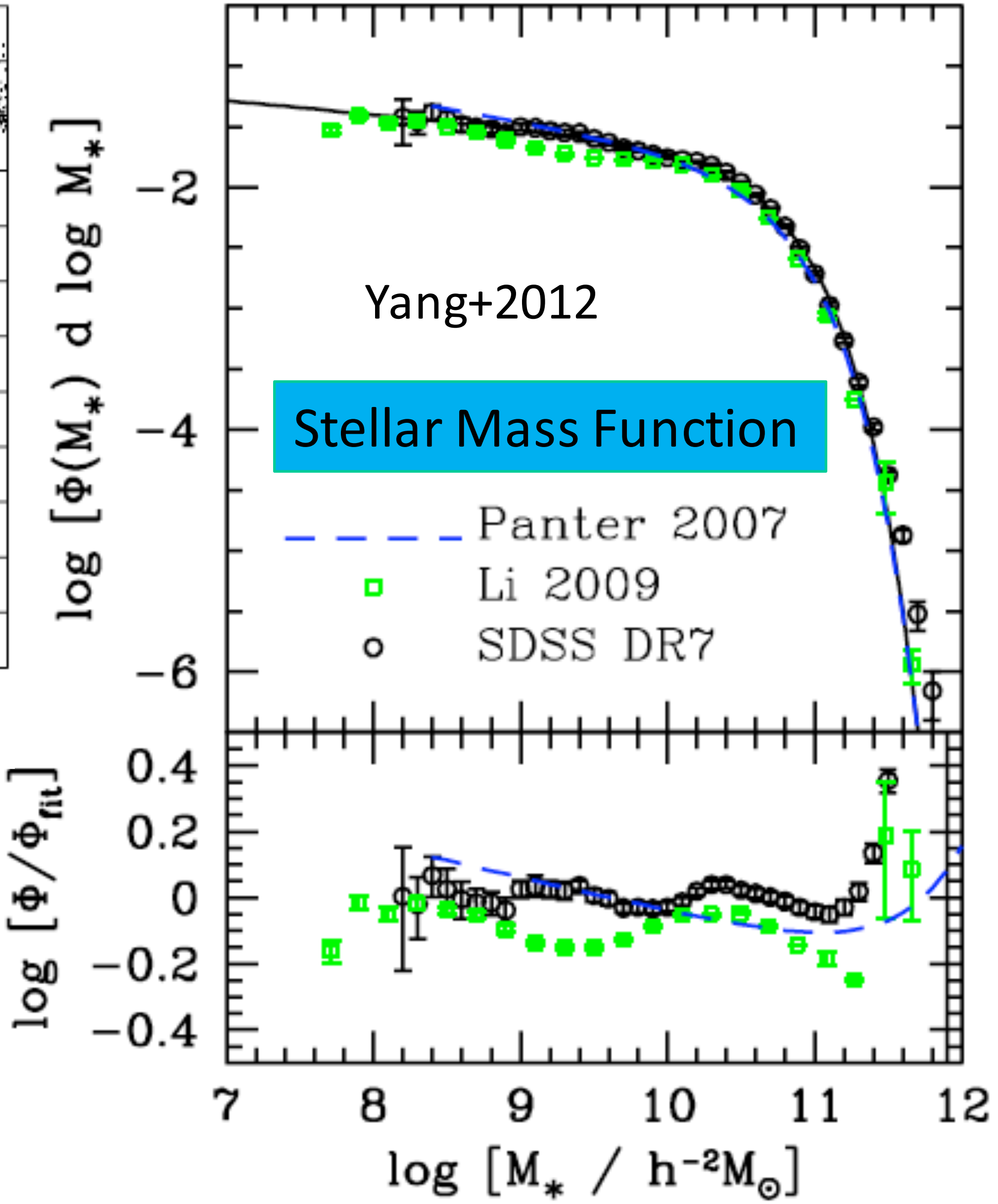
- **HOD: halo occupation distribution models**
- **CLF/CSMF: conditional luminosity (stellar mass) functions**
- **SHAM: subhalo abundance matching methods**

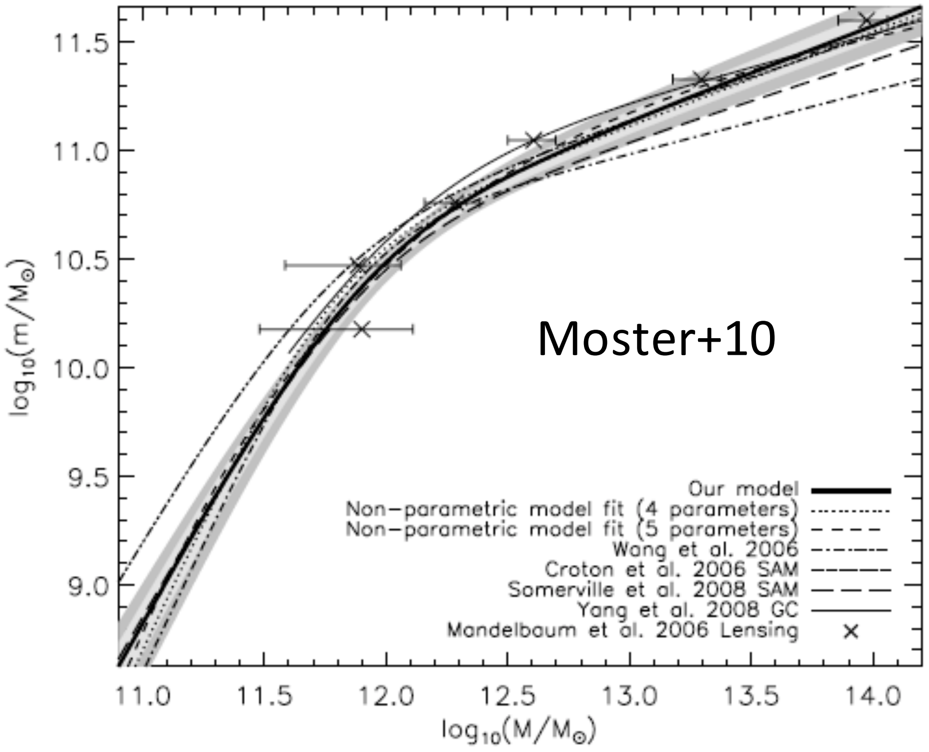
Many applications: stellar-halo mass relations



SDSS DR7 sample selection:

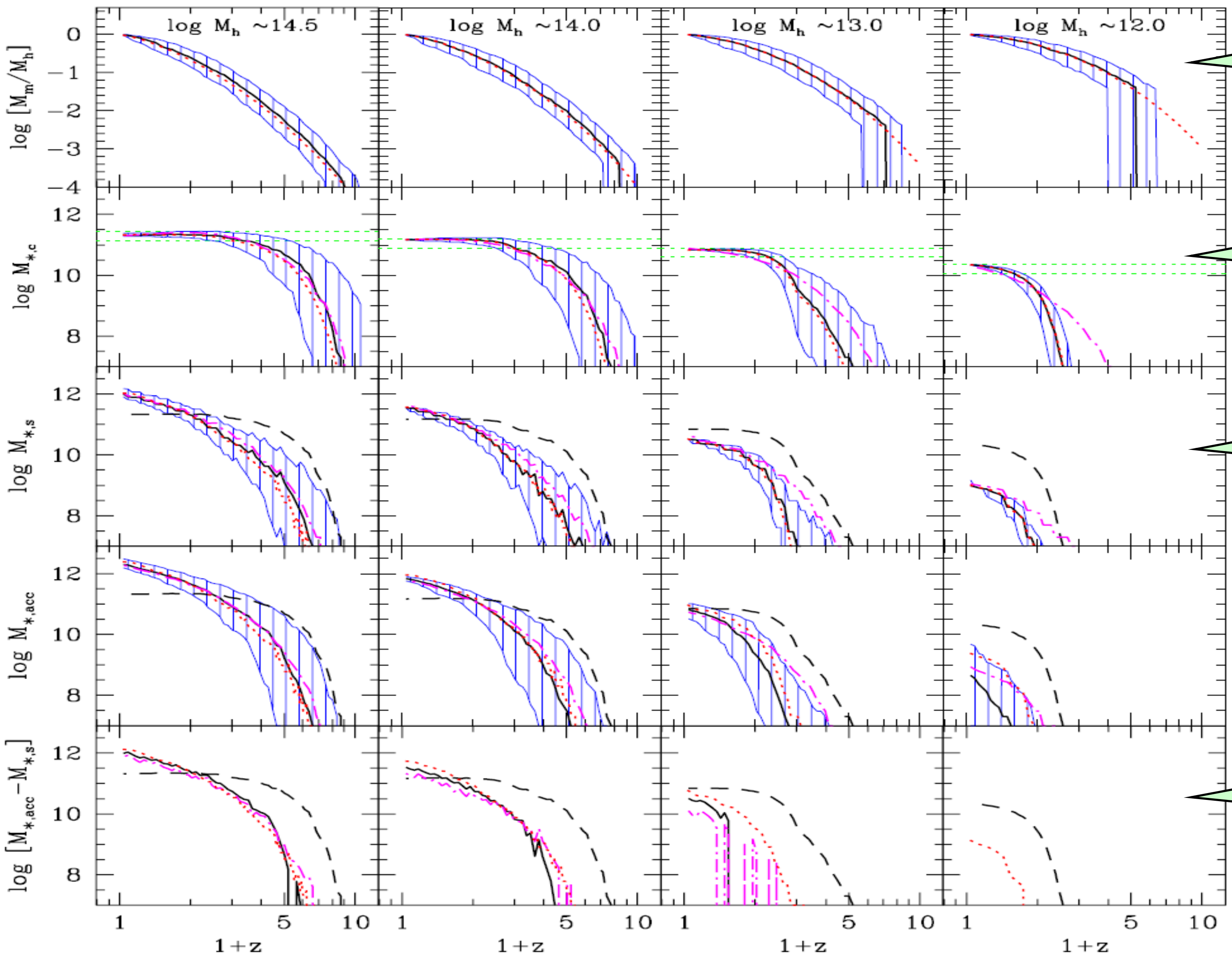
r-band flux limit, r<17.75





Stellar-Halo Mass Relation

Many applications: growth of galaxies



Growth of dark matter halos

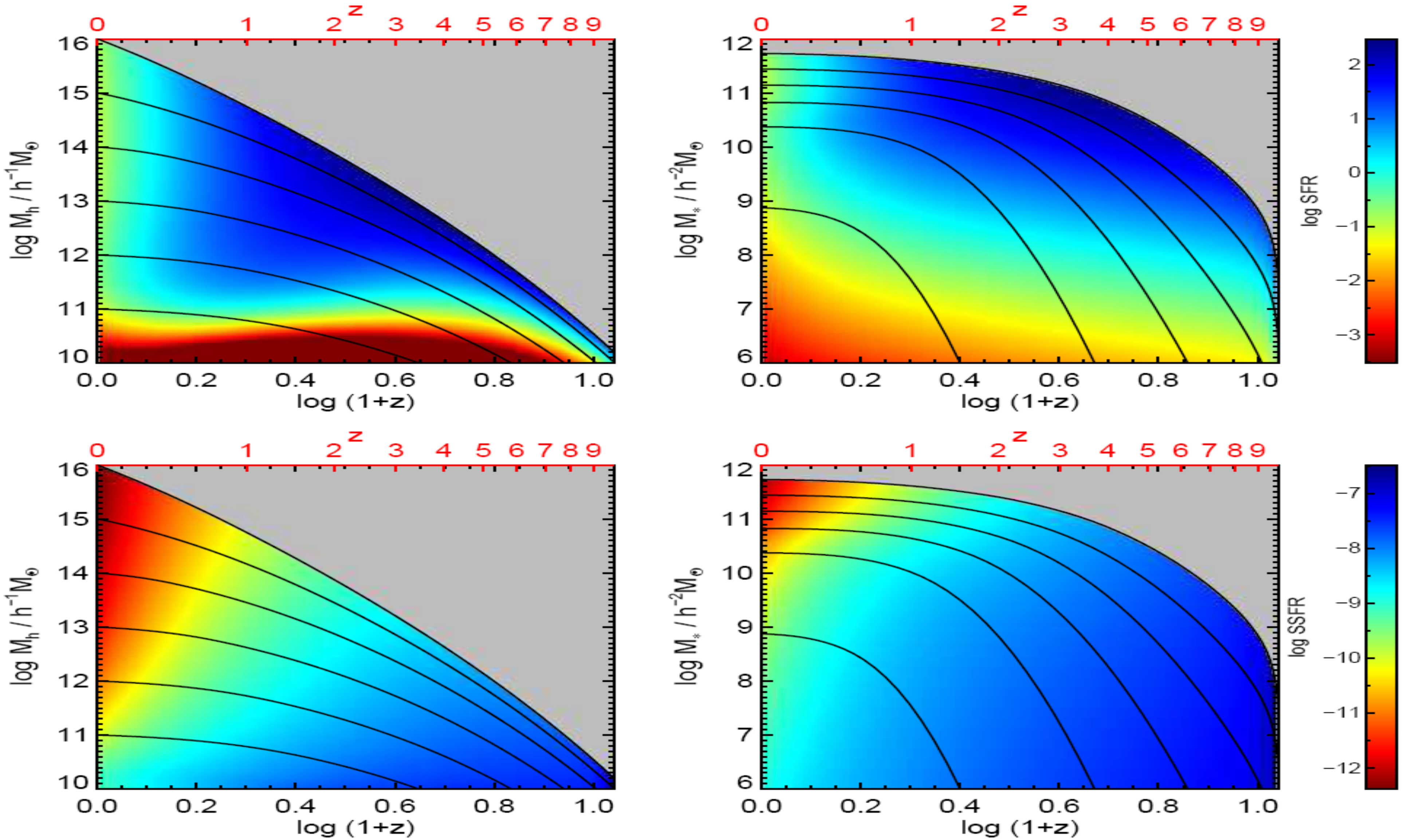
Growth of central galaxies

Growth of satellite galaxies

Growth of intra-cluster stars

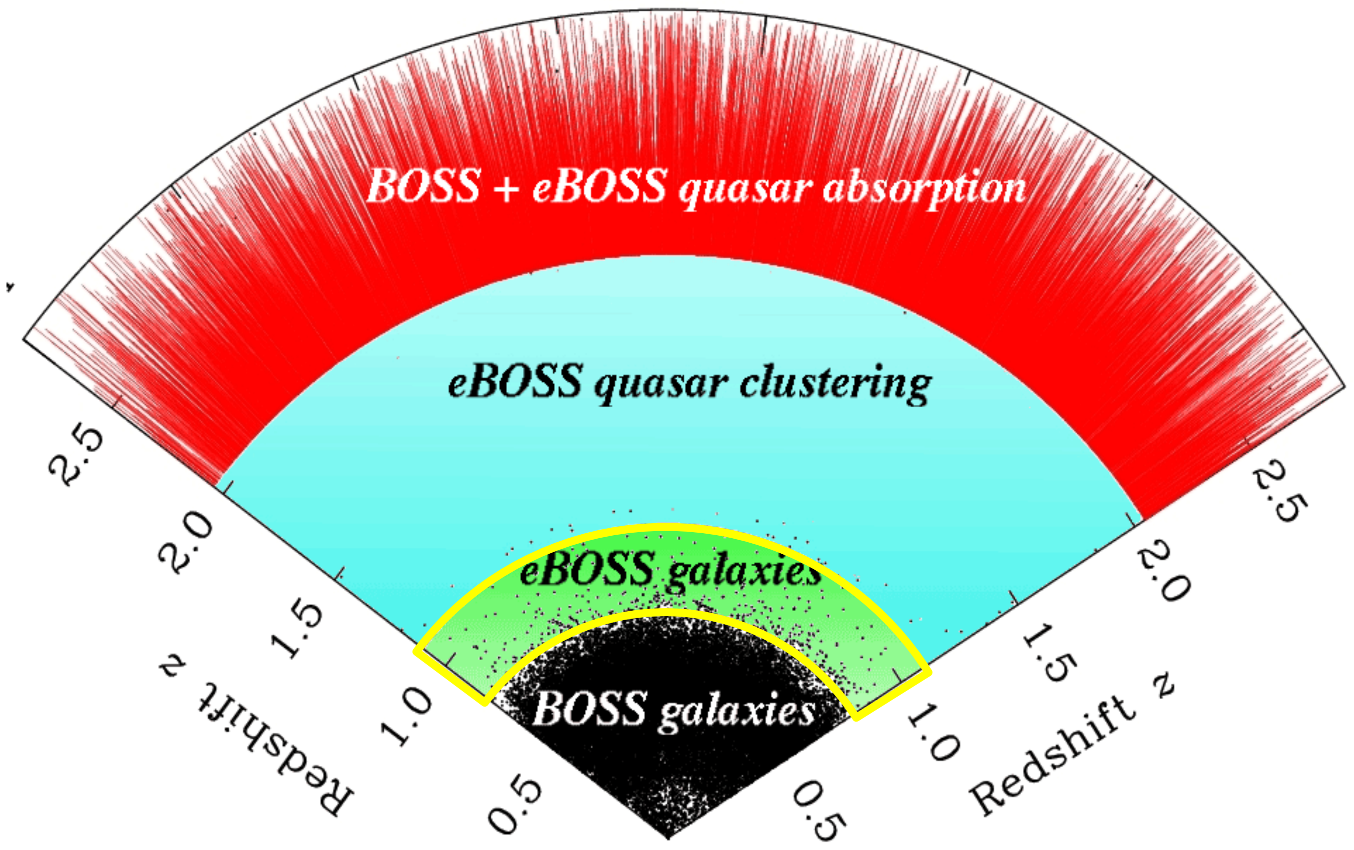
Yang et al. 2012

Many applications: SFH map of galaxies



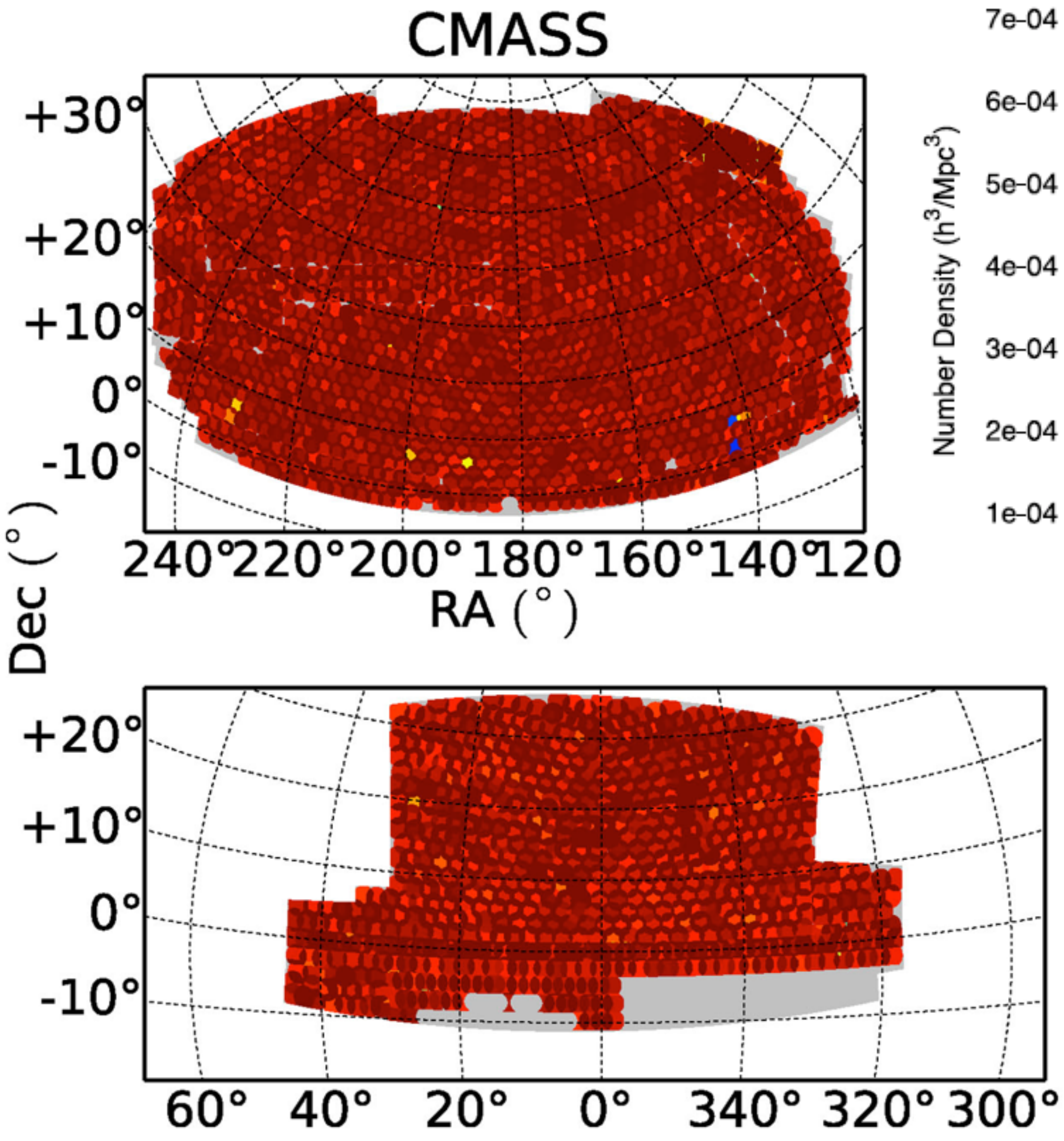
Yang et al. 2013; see also: Moster et al. 2013; Behroozi et al. 2013

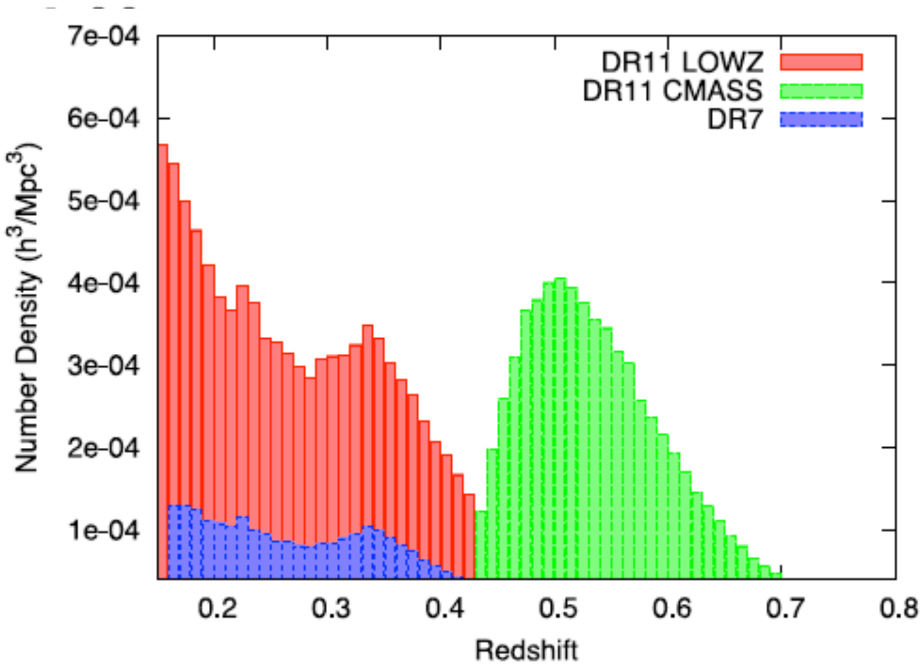
Why should we introduce the incomplete CSMF?

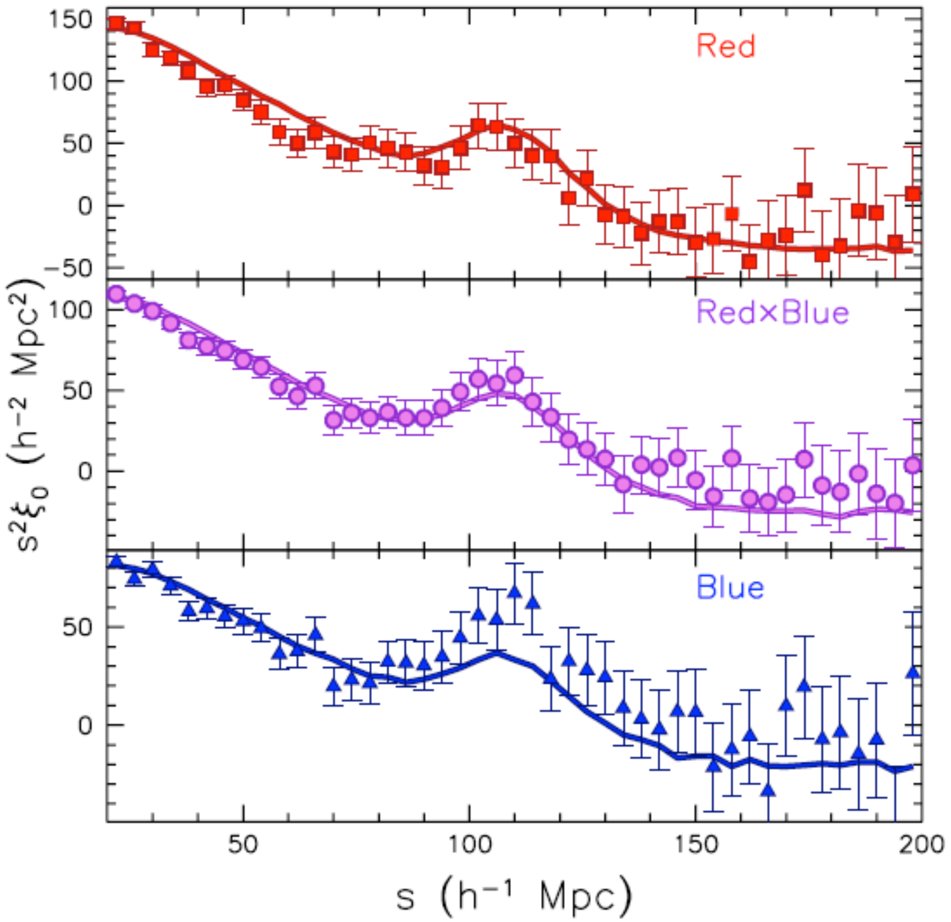


Guo et al., 2018, arXiv: 1804.01993
Guo et al., 2018, arXiv: 1810.05318

Motivation： From Simple To Complex Survey Target Selections



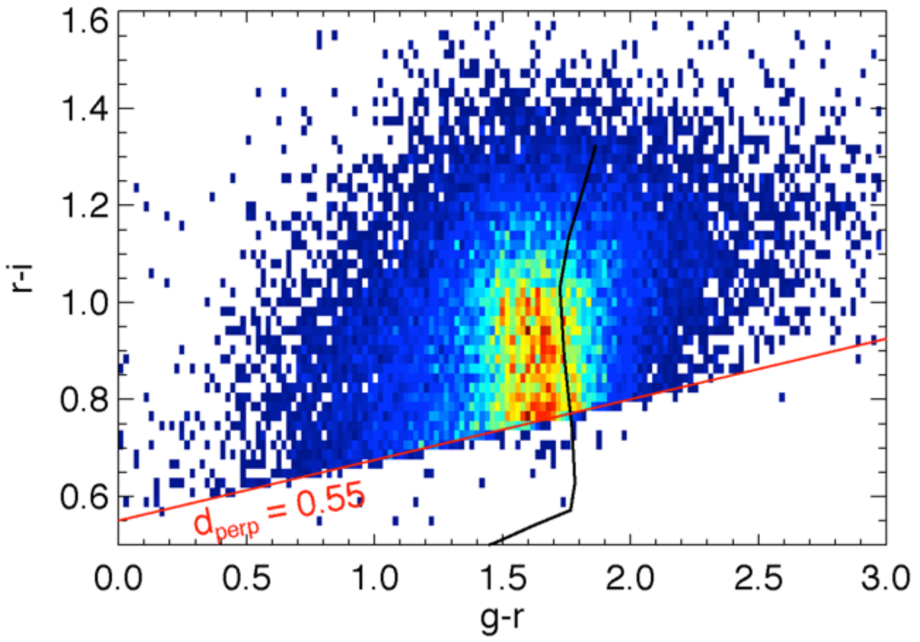


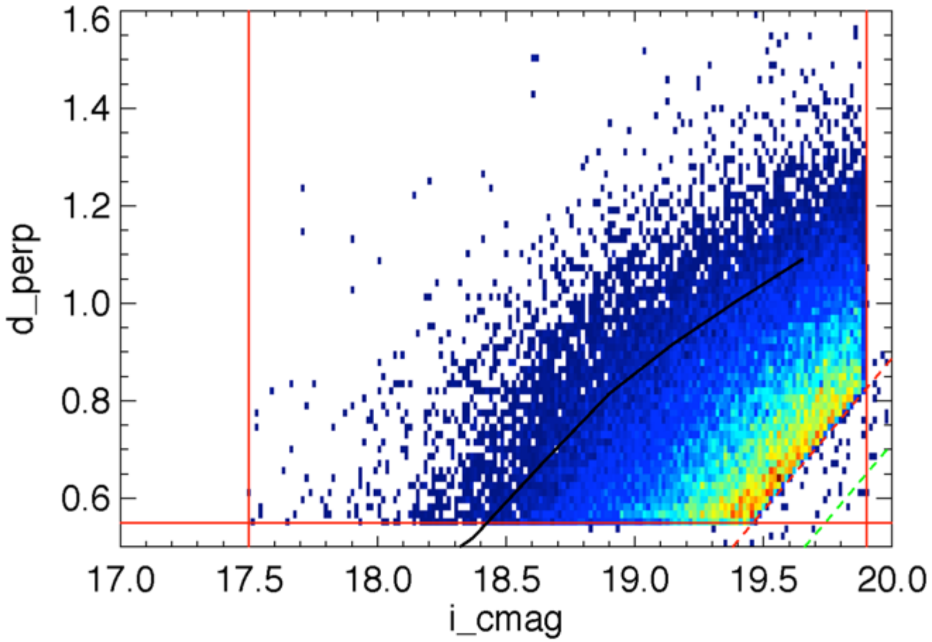


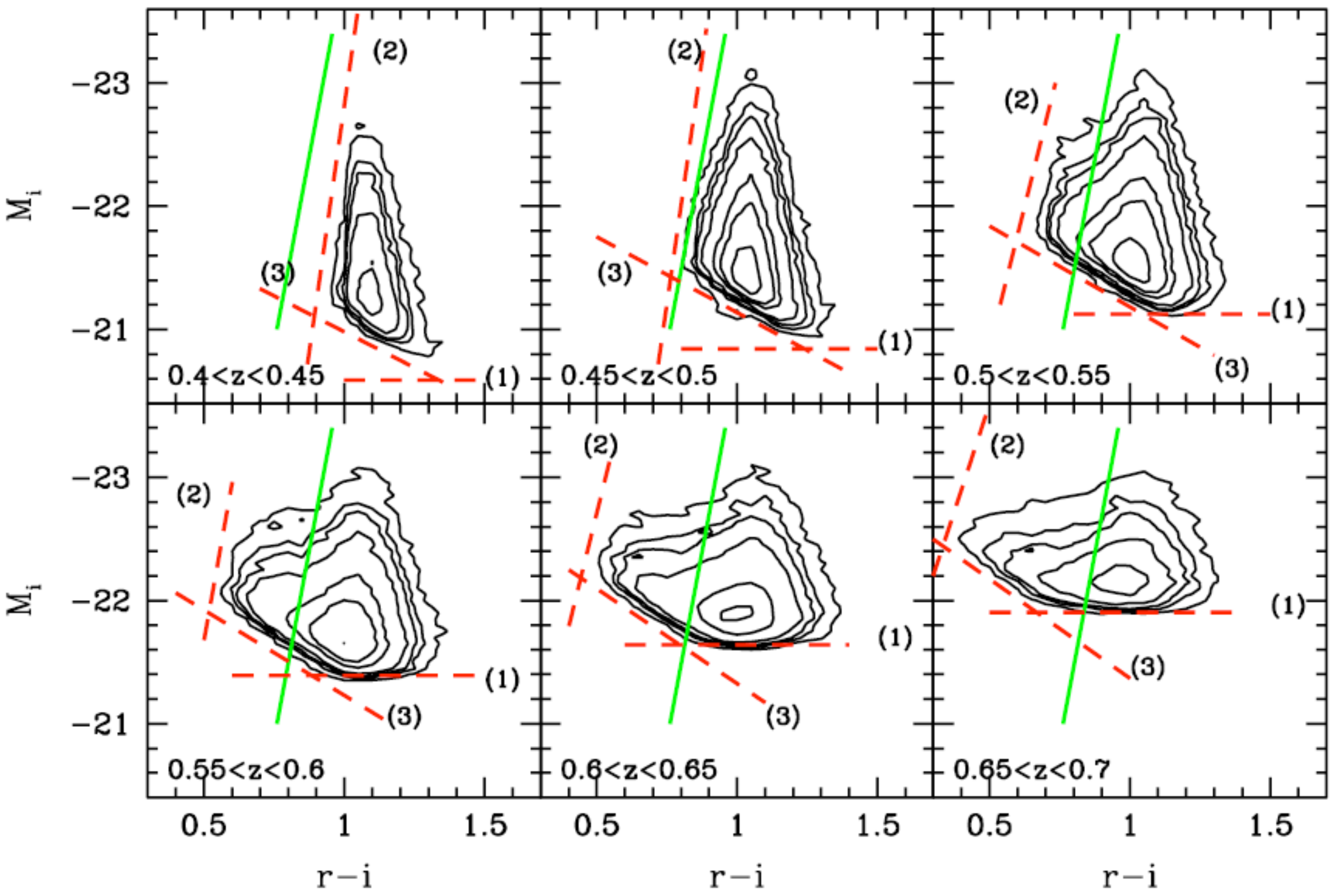
Reid et al. (2016): SDSS-III BOSS CMASS galaxies at 0.4<z<0.7

Ross et al. (2014)

Motivation： From Simple To Complex Survey Target Selections







Guo et al. (2013)

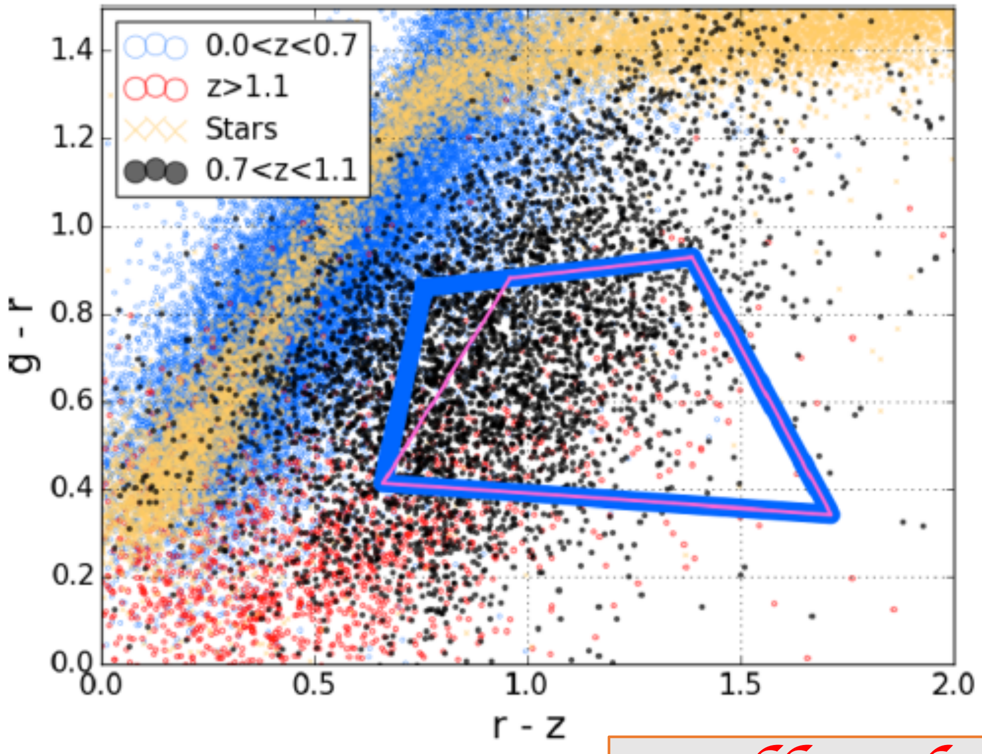
Difficulty: Level 1

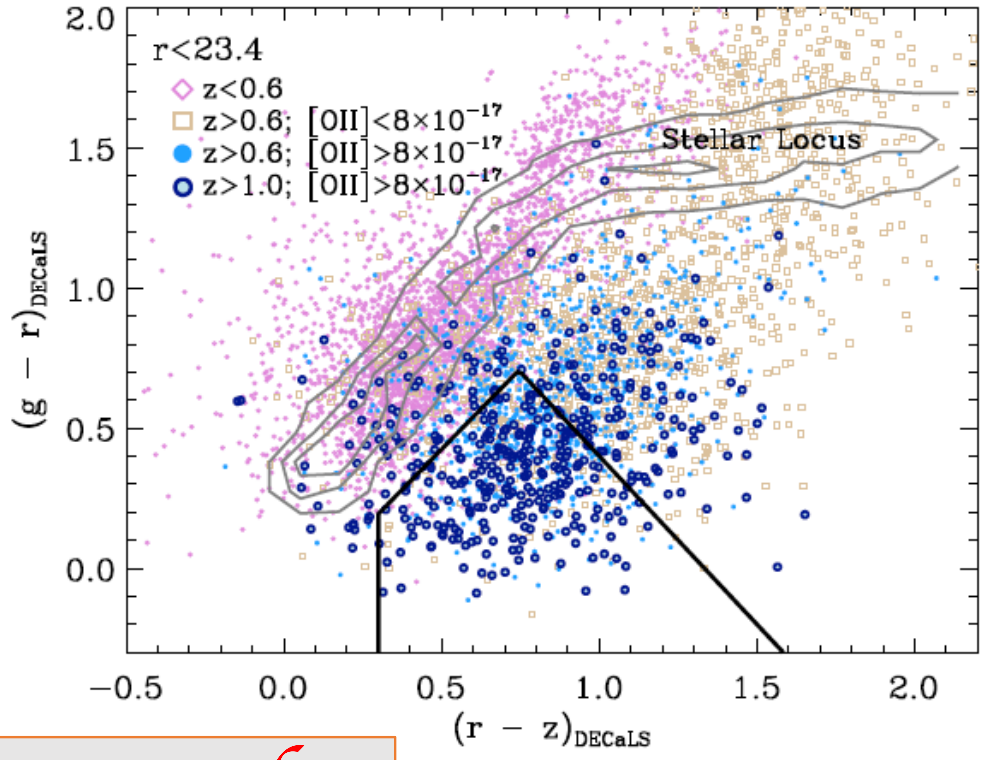
The ELG as cosmological tracers of high-redshift galaxy surveys

SDSS-IV eBOSS: 0.7<z<1.1

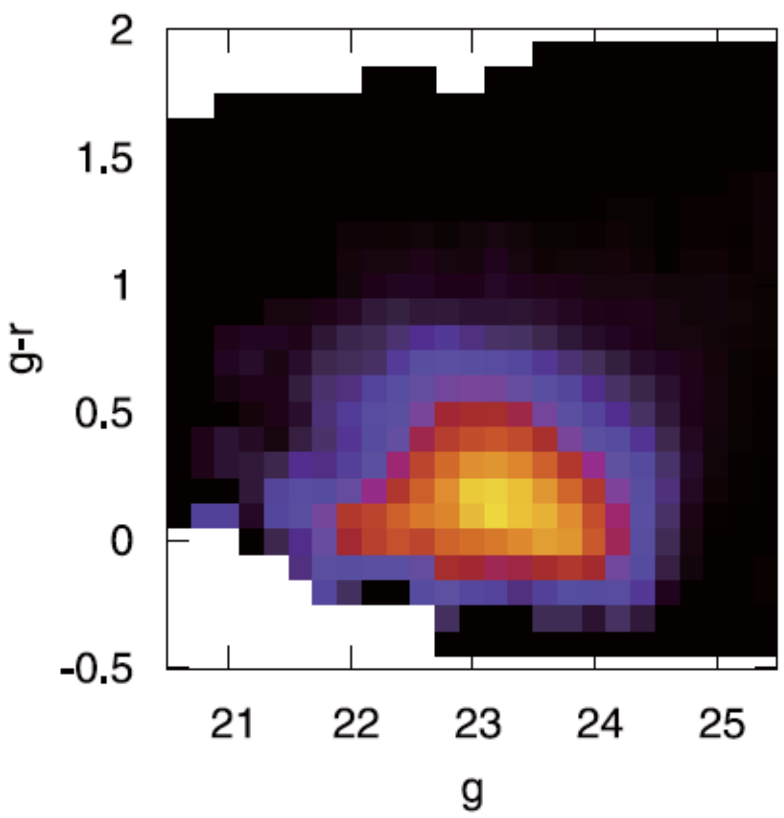
DESI: 0.6<z<1.6

PFS: 0.8<z<2.4





z>0.7 ELG efficiency, f_{hiz}



Difficulty: Level 2

How to make use of such selected galaxies?

All about Dark Energy?

– I still want to link these galaxies with halos to constrain galaxy formation processes.

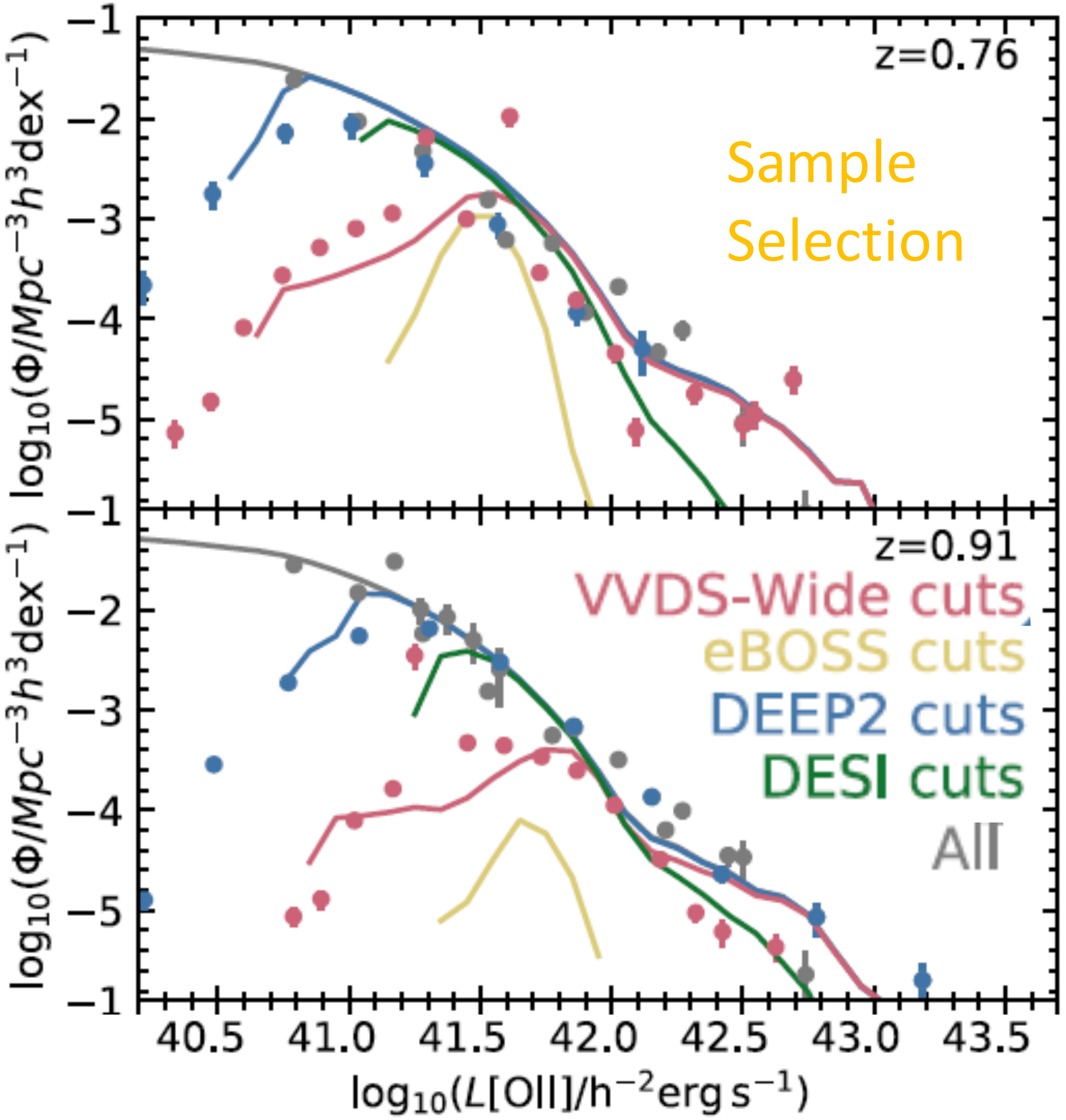
Key Questions

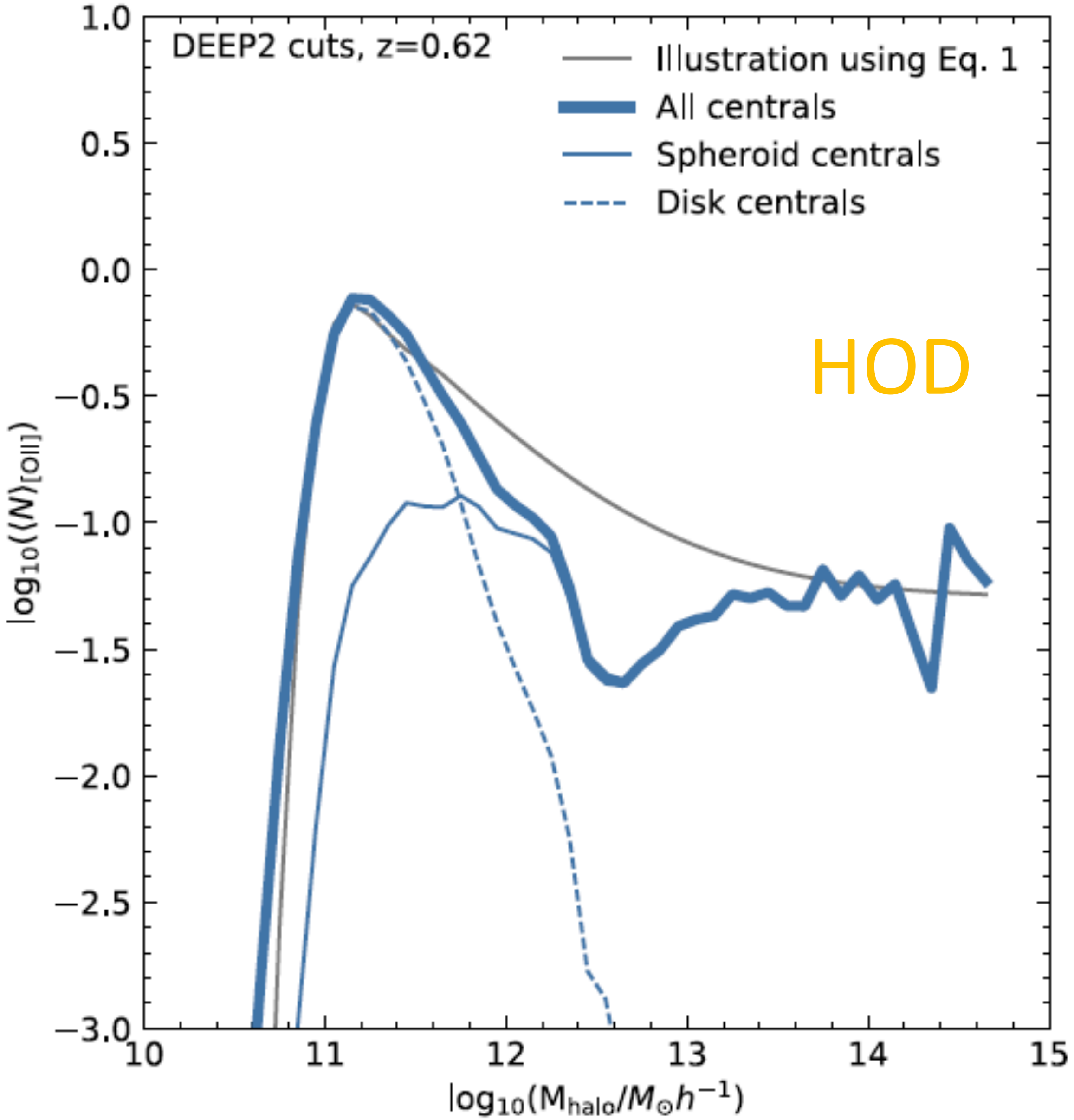
1 Sample completeness — quantify target selection effects

2 Stellar-Halo Mass Relation — estimate the halo mass

3 Fraction of Star-forming galaxies — estimate the abundance

Sample Completeness from the SAM



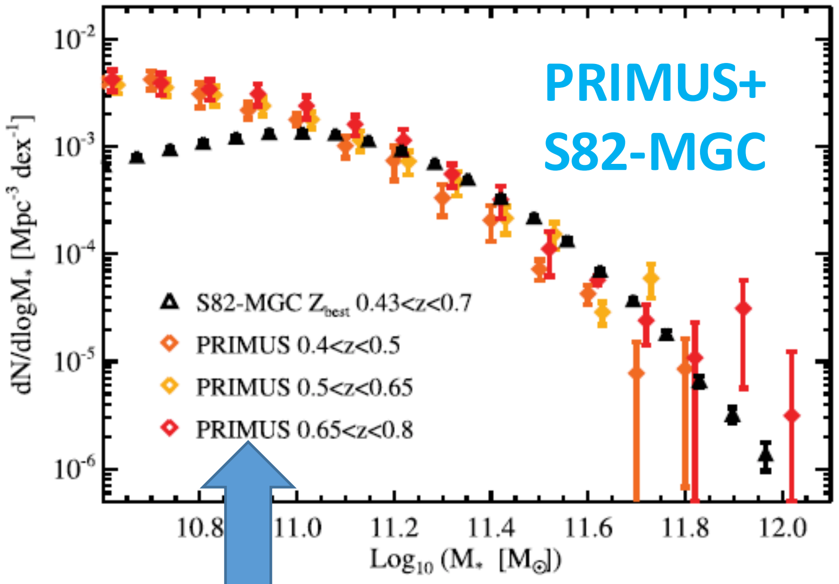


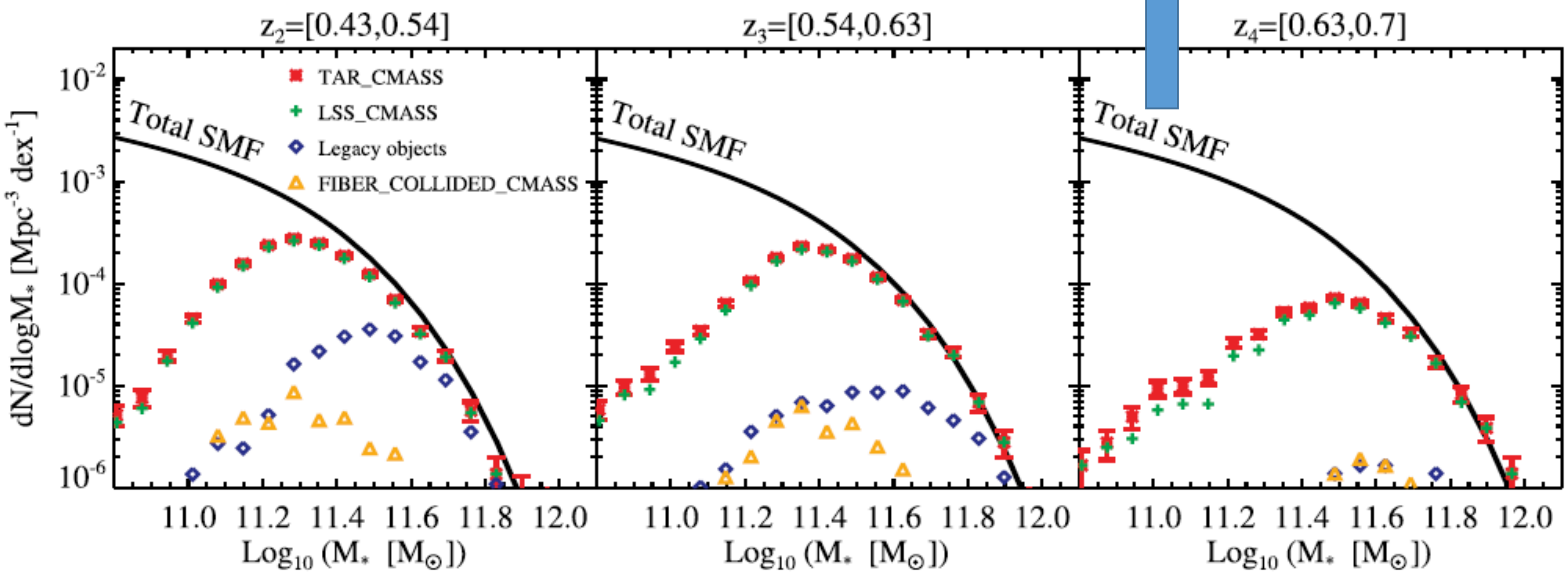
Gonzalez-Perez et al. 2018, using SAM of GALFORM

Sample Completeness

With the help of external Deeper Surveys

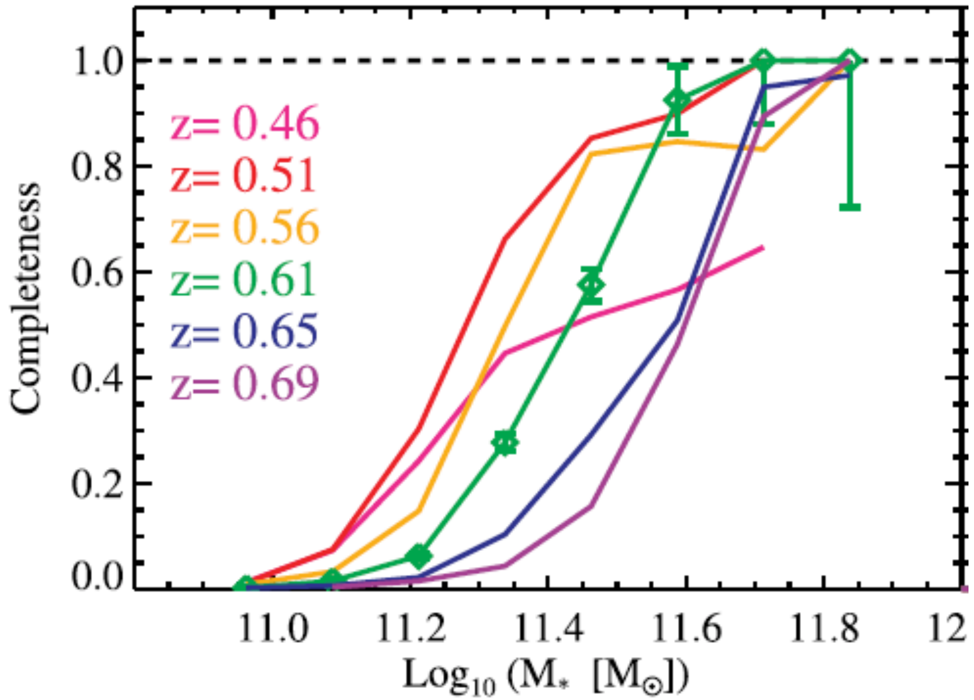
The accuracy depends on a small-area survey

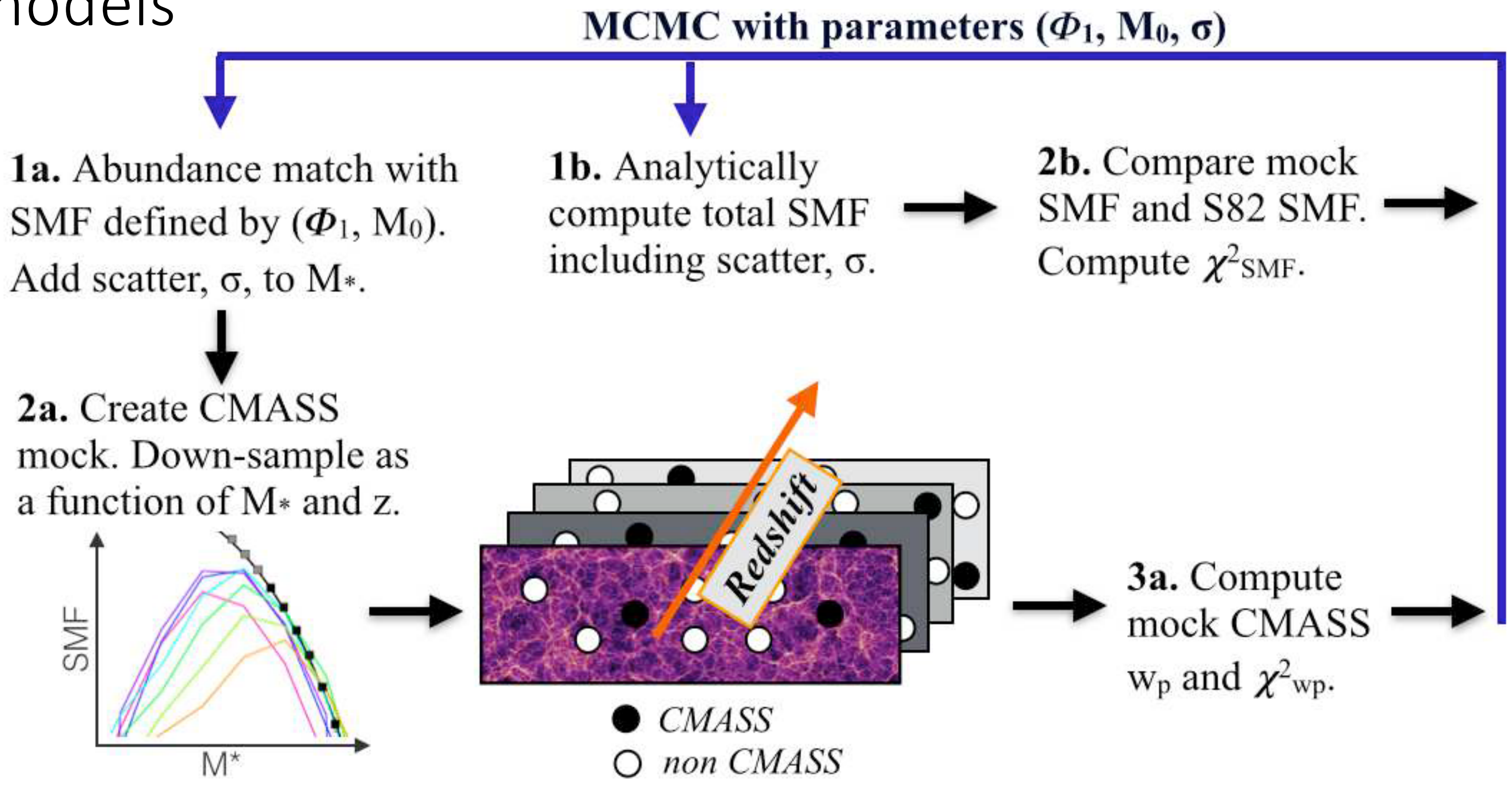




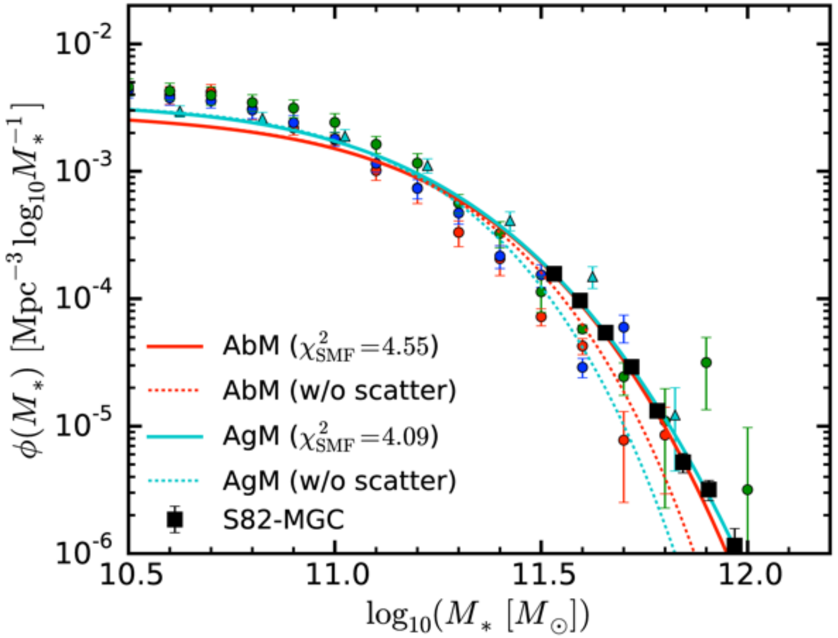
Leauthaud+16

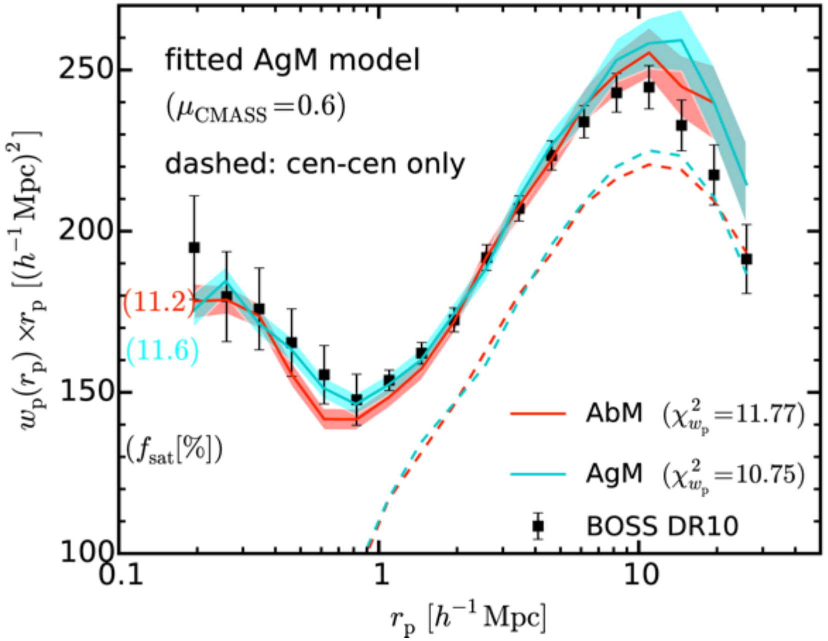
Using Galaxy clustering to constrain the models





Leauthaud et al. (2016)





Saito et al. (2016)

Can we estimate the completeness from the data itself?

Yes!

Conditional Stellar Mass Function

Conditional Stellar Mass Function

$$\Phi_c(M_*|M)$$

Satellite-subhalo Mass Relation

Halo Mass Function

$$n_h(M)$$

Observables

Two-point Correlation Functions

Stellar Mass Functions

Yang+2012
Leauthaud+2012
Behroozi+2013
Moster+2013
Reddick+2013
Rodriguez-Puebla+2017
……

Incomplete Conditional Stellar Mass Function

Conditional Stellar Mass Function

$$\Phi_{\rm c}(M_*|M)$$

Satellite-subhalo Mass Relation

Halo Mass Function

$$n_{\rm h}(M)$$

Stellar Mass Completeness

$$c(M_*)$$

$$c(M_*) = \frac{f}{2}\left[1 + {\rm erf}\left(\frac{\log M_* - \log M_{\rm min}}{\sigma}\right)\right]$$

Observables

Two-point Correlation Functions

Incomplete Stellar Mass Functions

Predictions

Halo Occupation Distribution

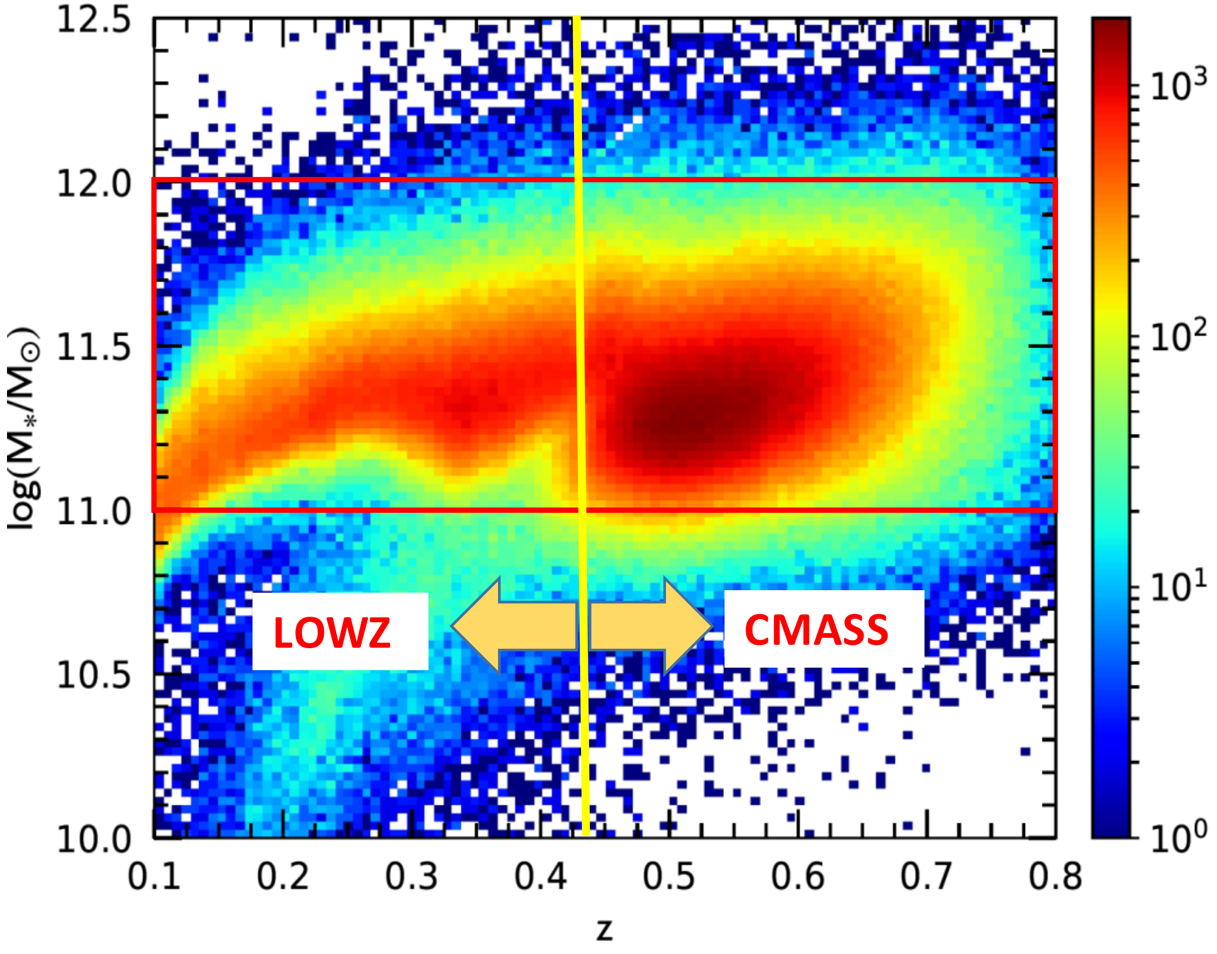
Satellite Galaxy Fraction

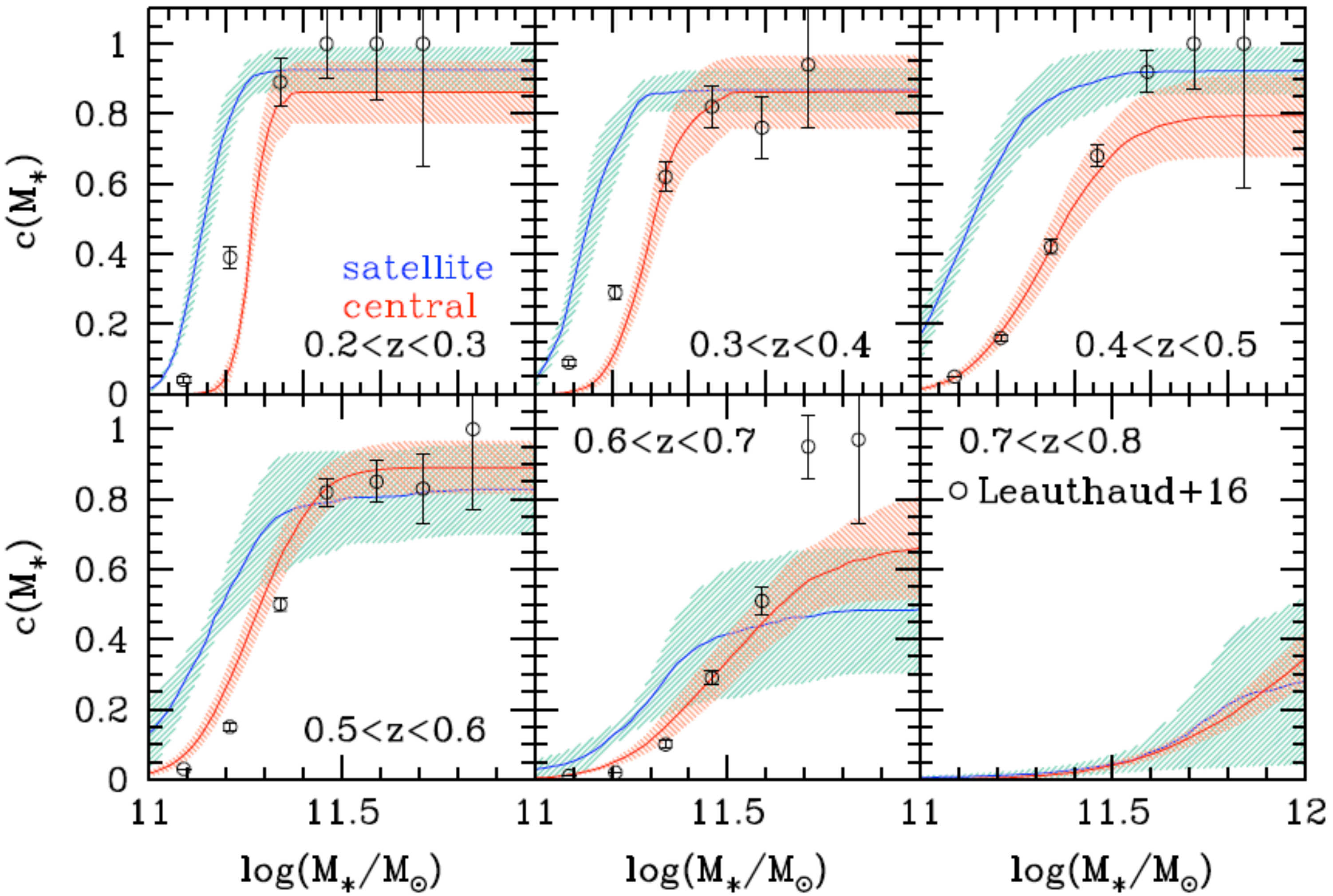
Galaxy Bias of galaxies

Intrinsic Stellar Mass Functions

Guo et al. (2018)

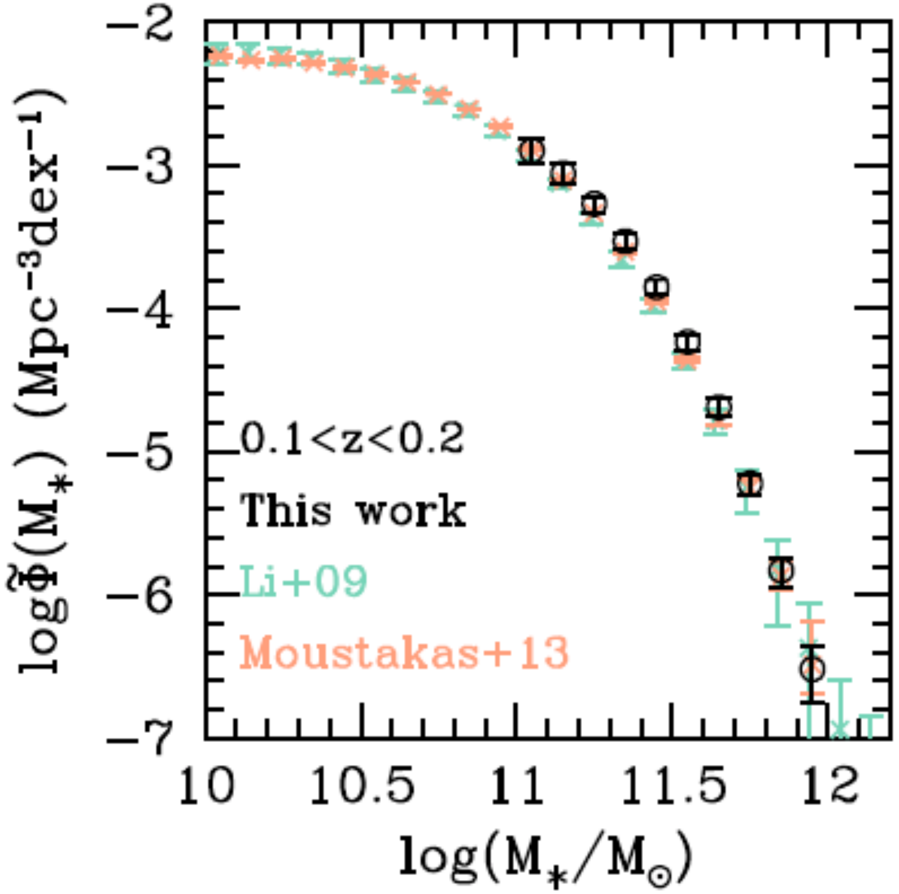
Application to BOSS massive galaxy sample

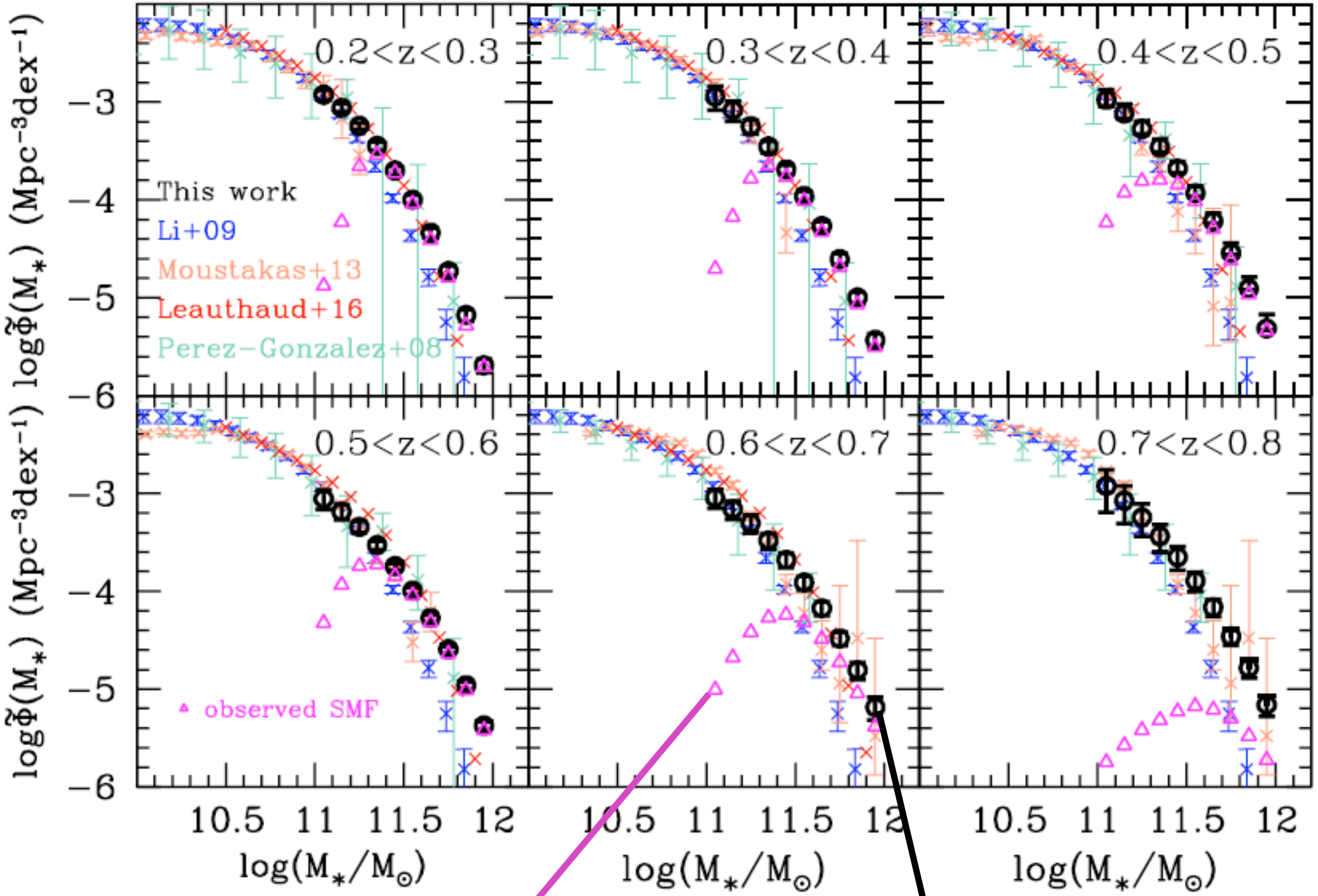




Guo et al., 2018, ApJ, arXiv:1804.01993

Recovering the intrinsic stellar mass function

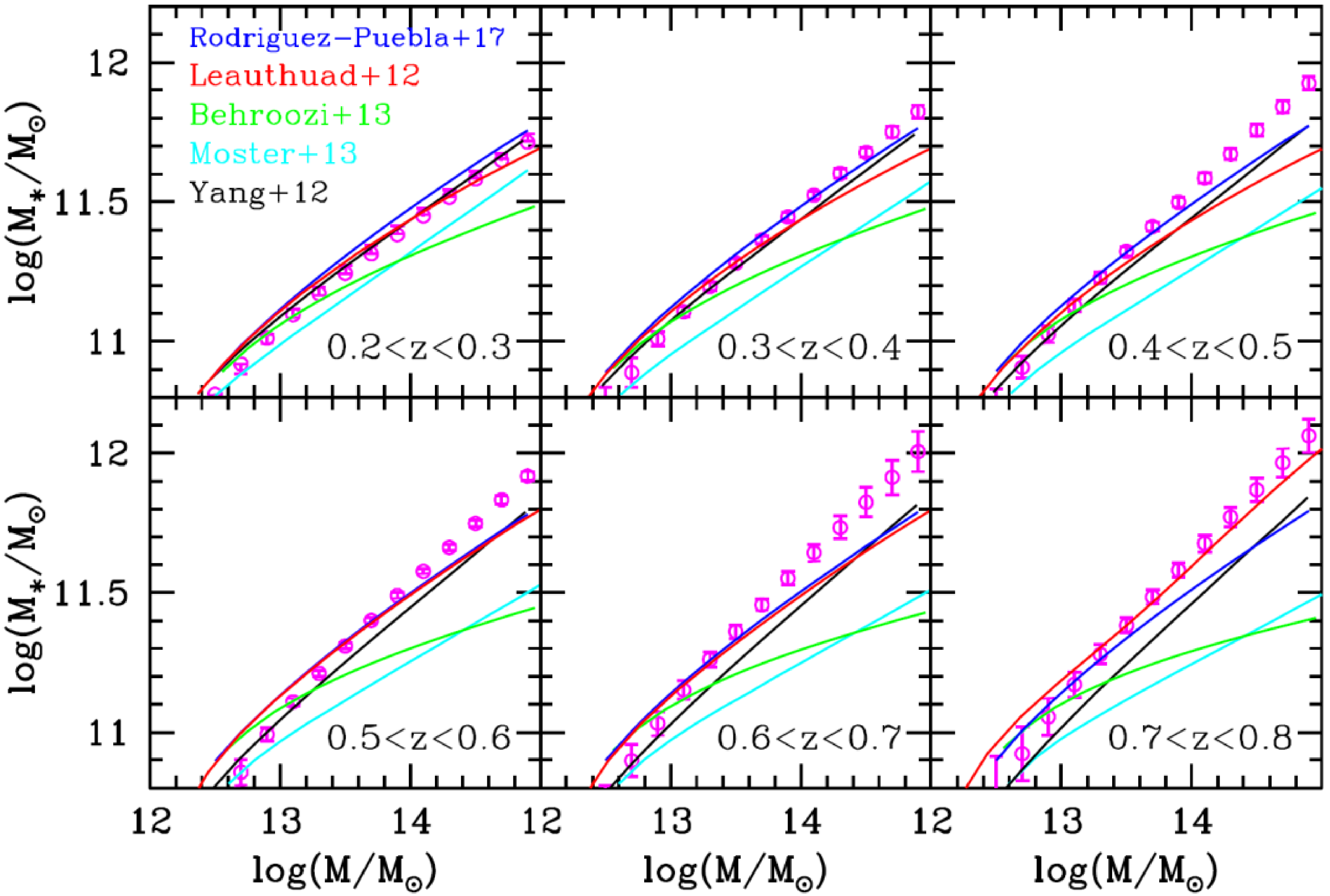




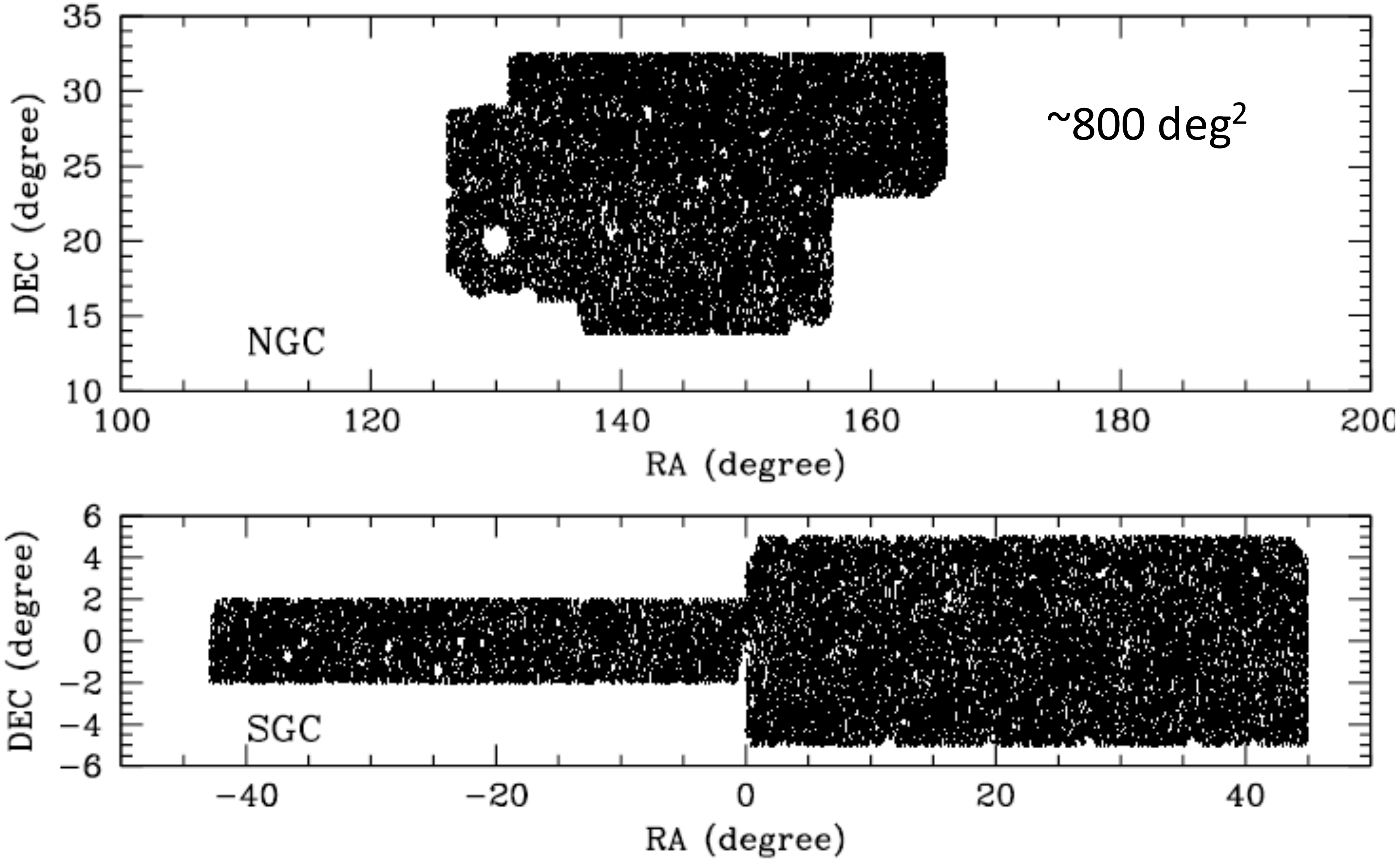
Observed SMF

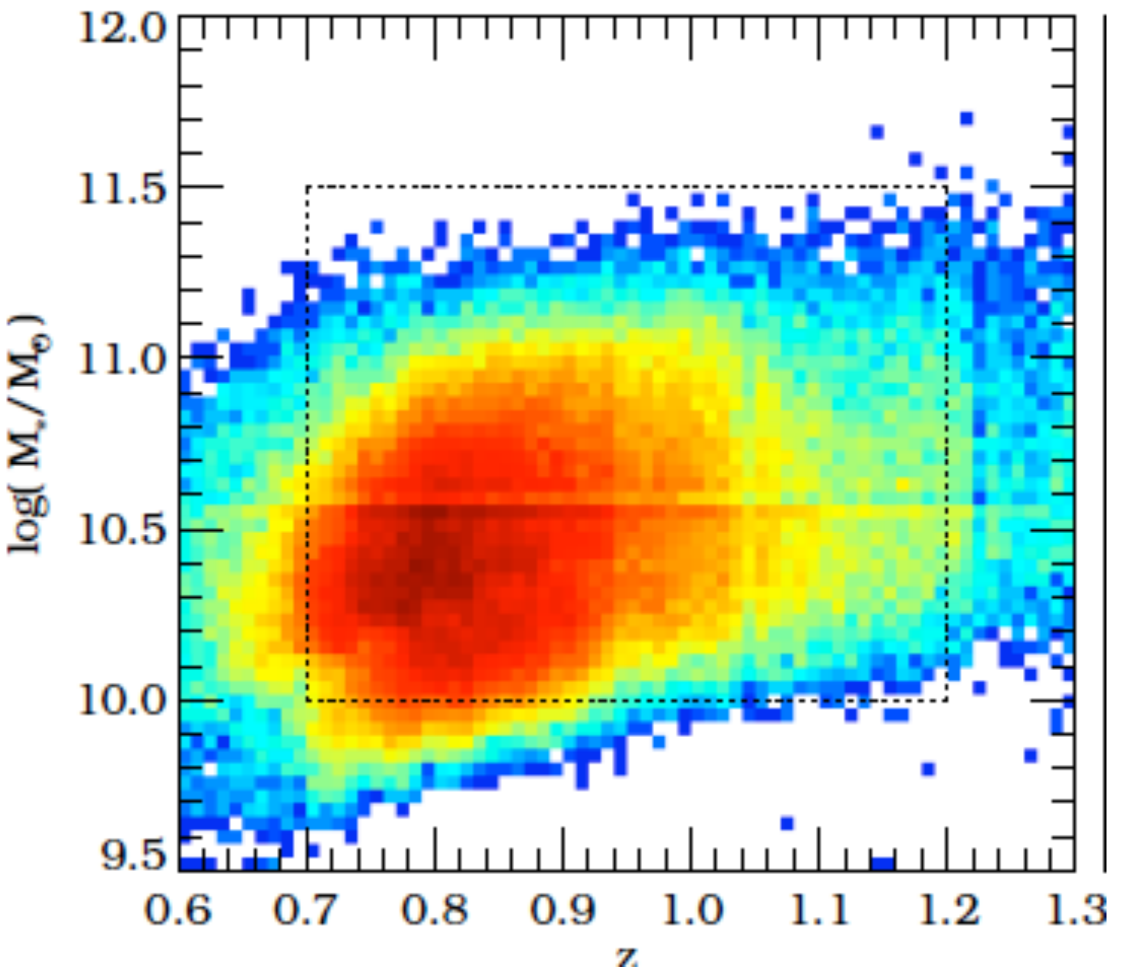
Recovered intrinsic SMF

Model prediction: the stellar-halo mass relation



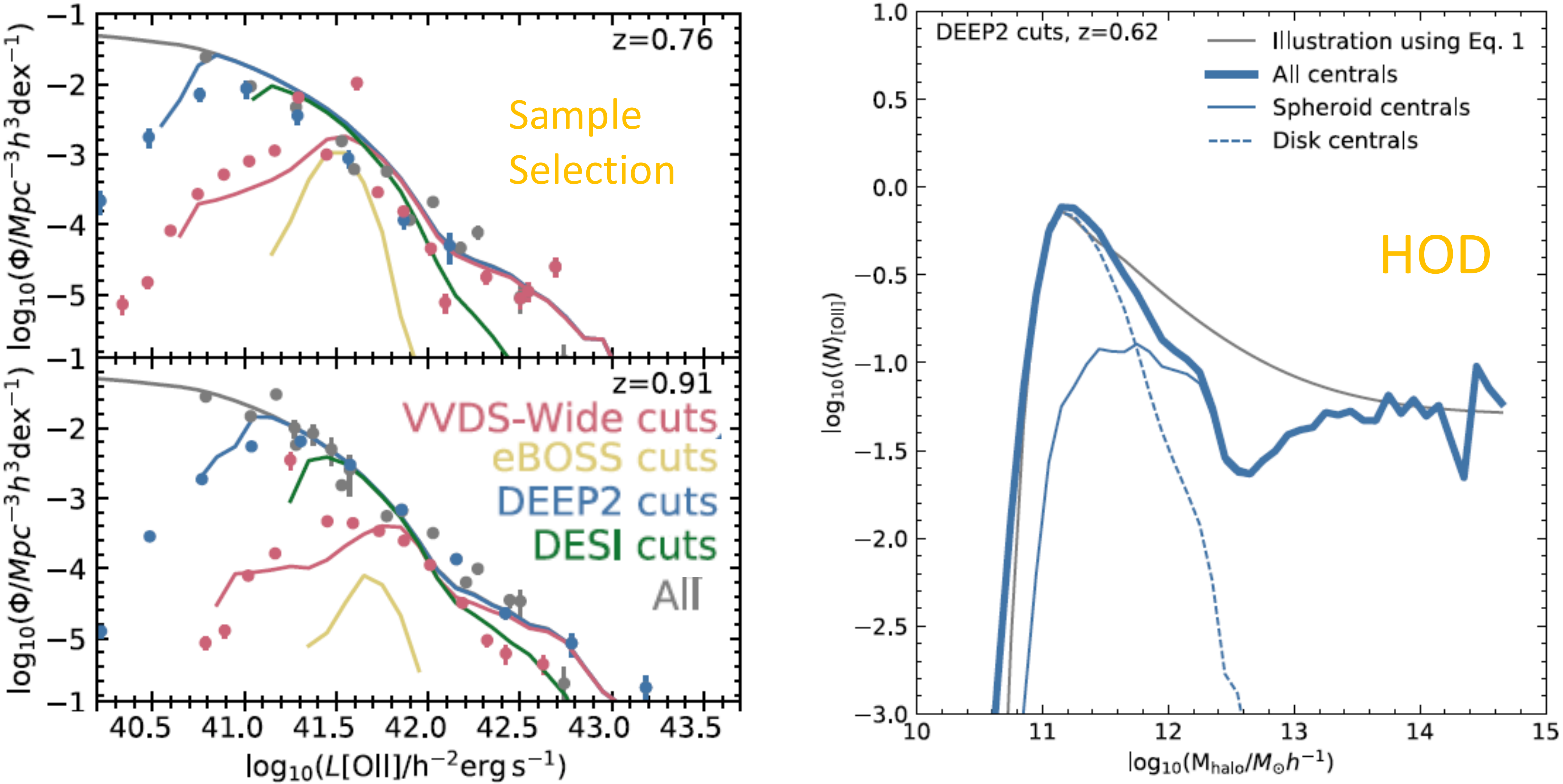
eBOSS ELG final data





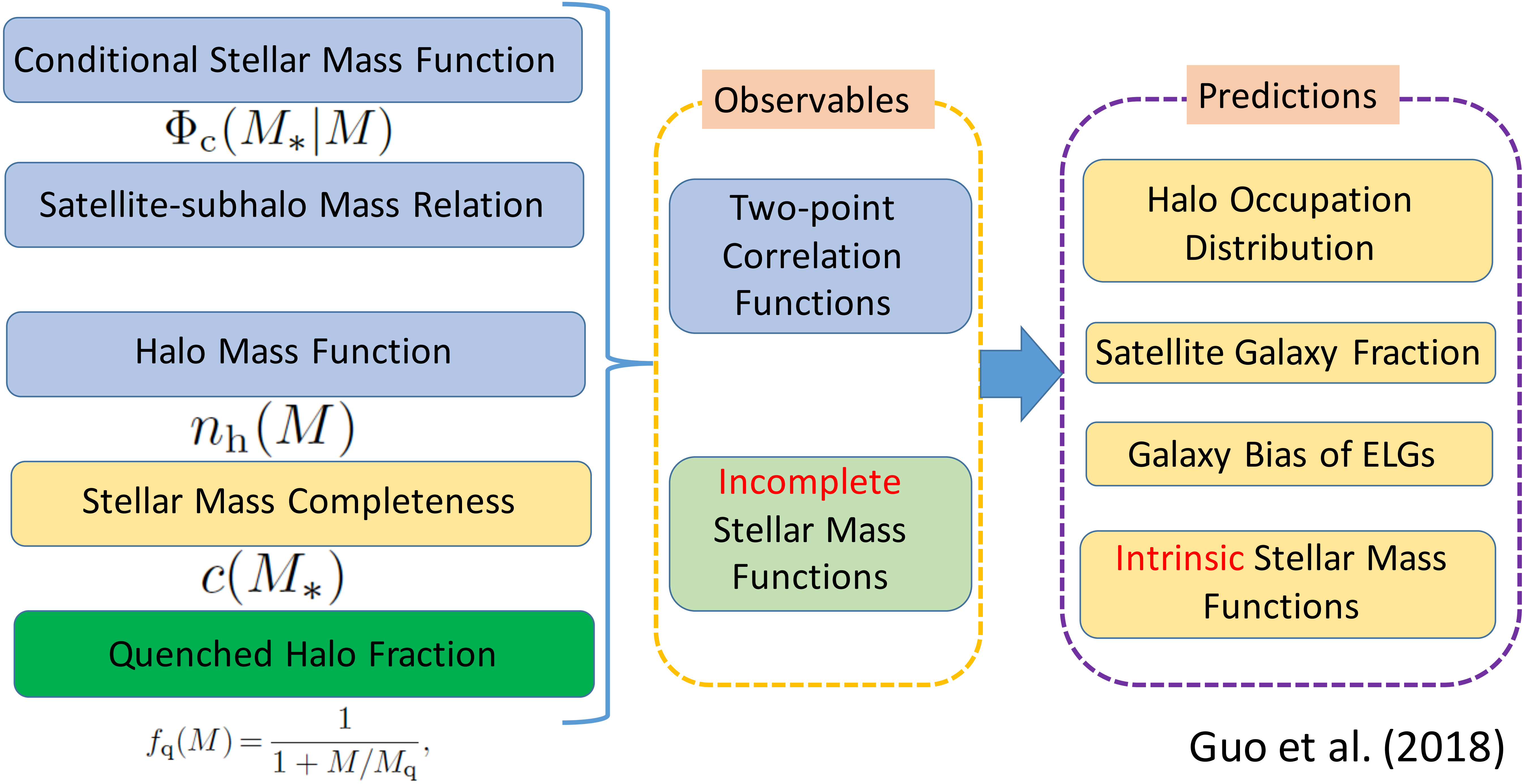
The largest Emission Line Galaxy Sample at 0.7<z<1.2 with spectroscopic redshifts

Sample Completeness from the SAM



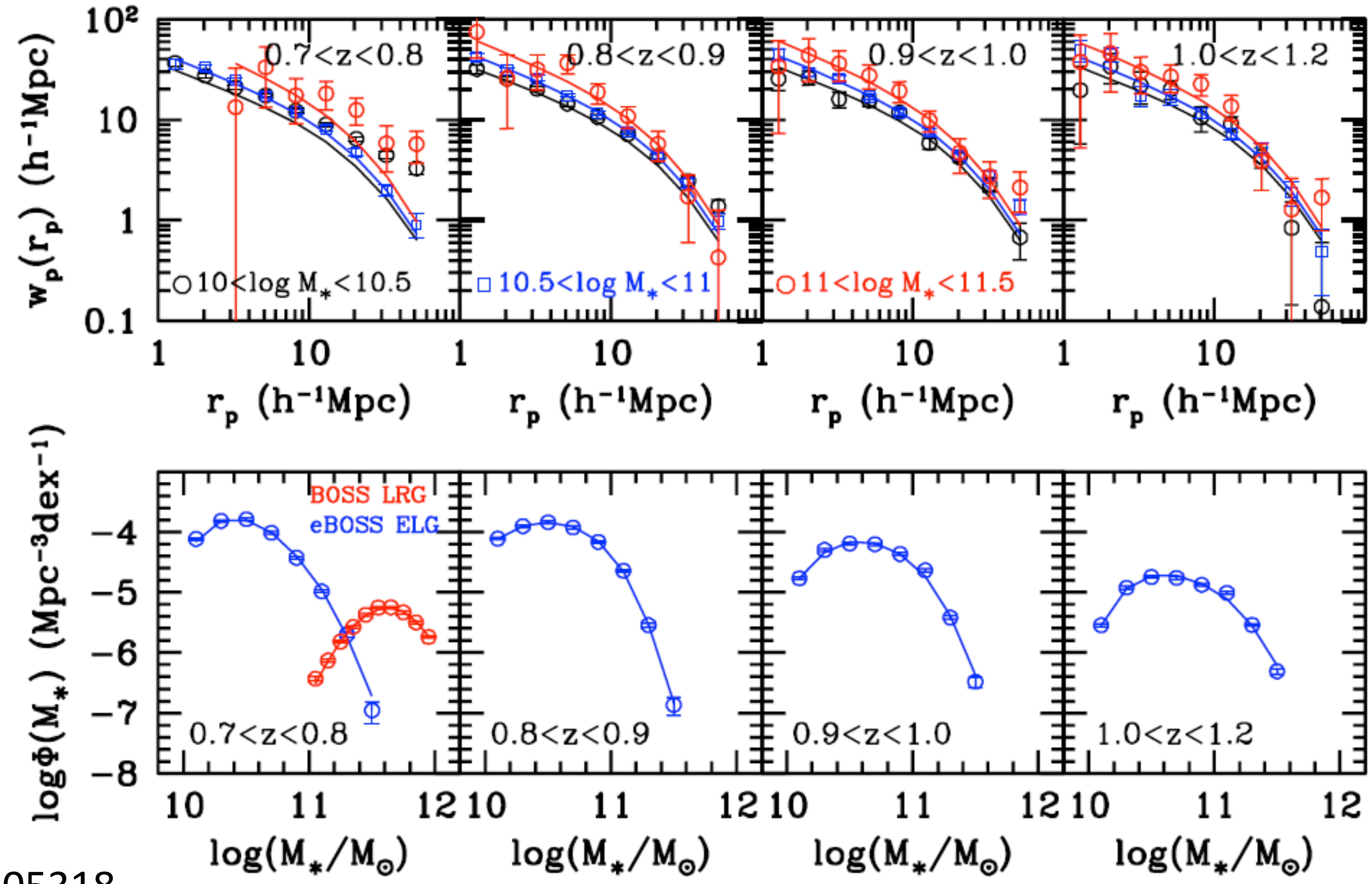
Gonzalez-Perez et al. 2018, using SAM of GALFORM

Incomplete Conditional Stellar Mass Function



Guo et al. (2018)

Fitting the Observables



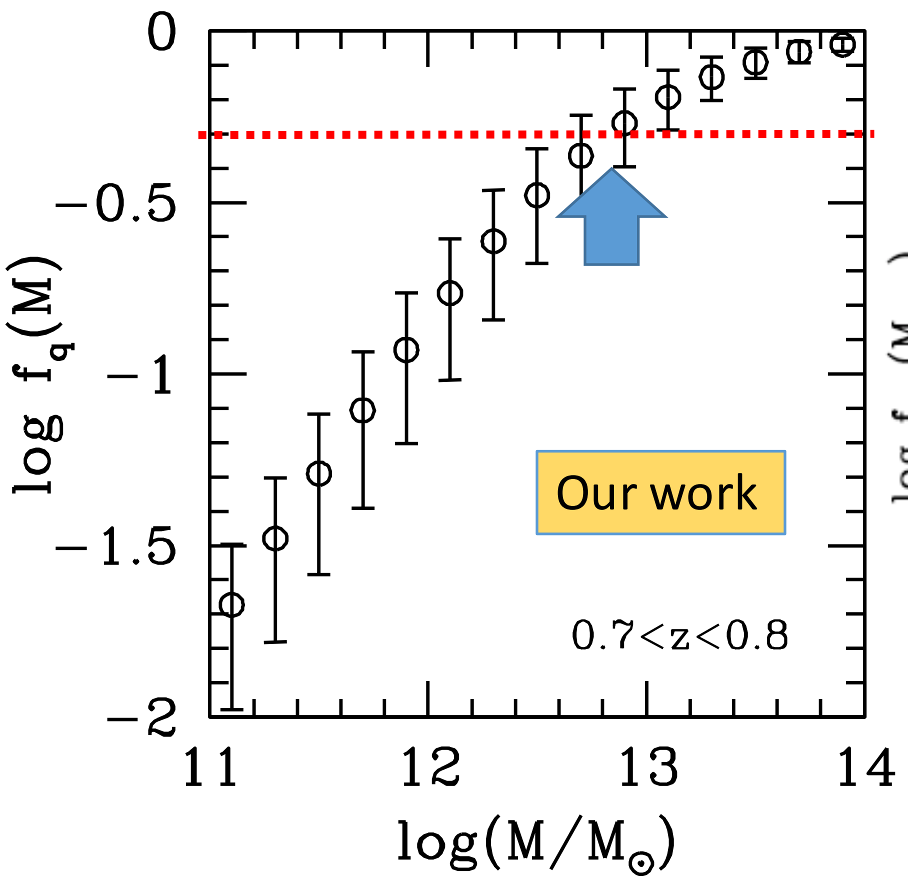
Guo et al.,
arXiv:1810.05318

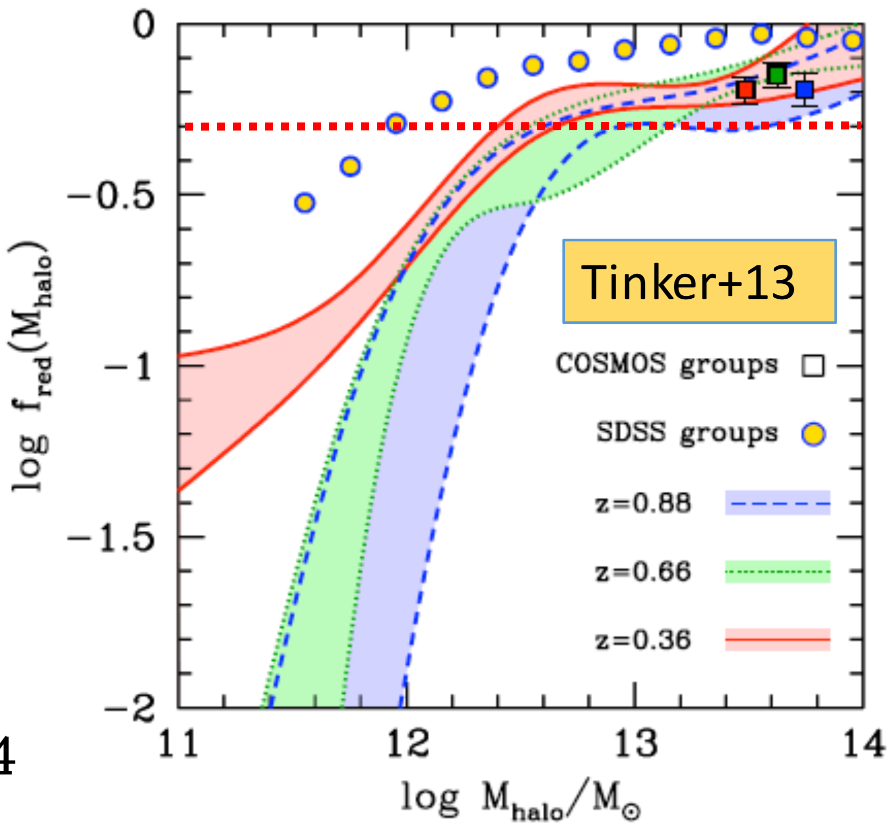
1 Quenched Galaxy Fraction

Model Constraints

Using both quiescent and star-forming galaxies to constrain the quenched halo fraction:

BOSS LRG and eBOSS ELG at 0.7<z<0.8

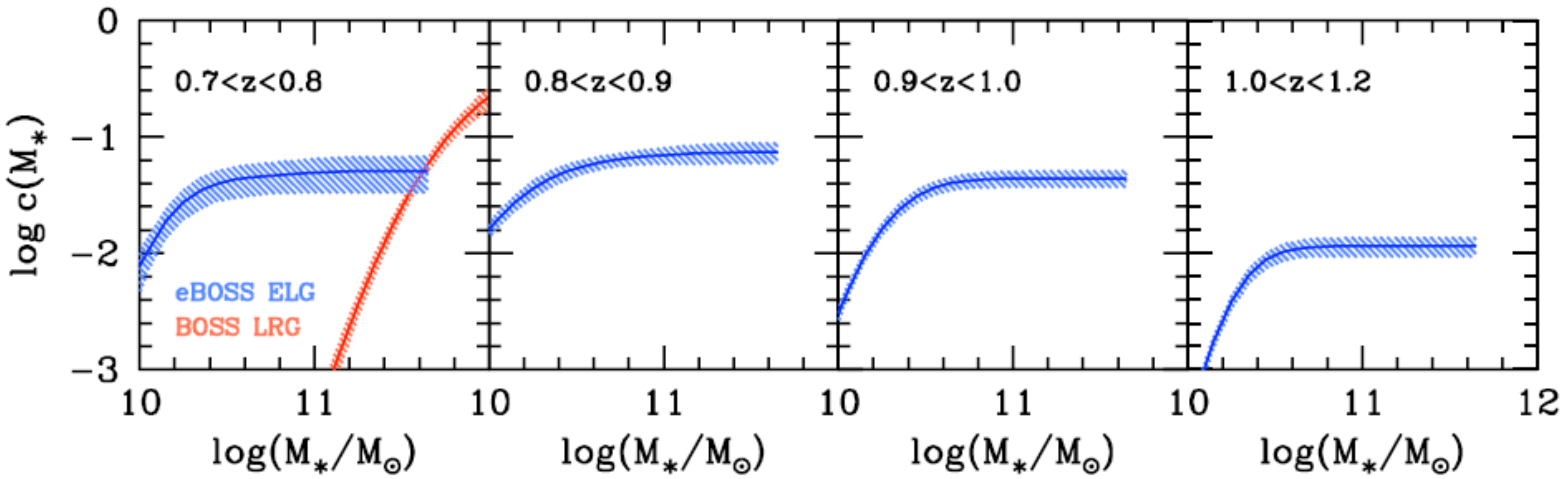




f_q(M): fraction of halos with quenched centrals

2 Stellar Mass Completeness

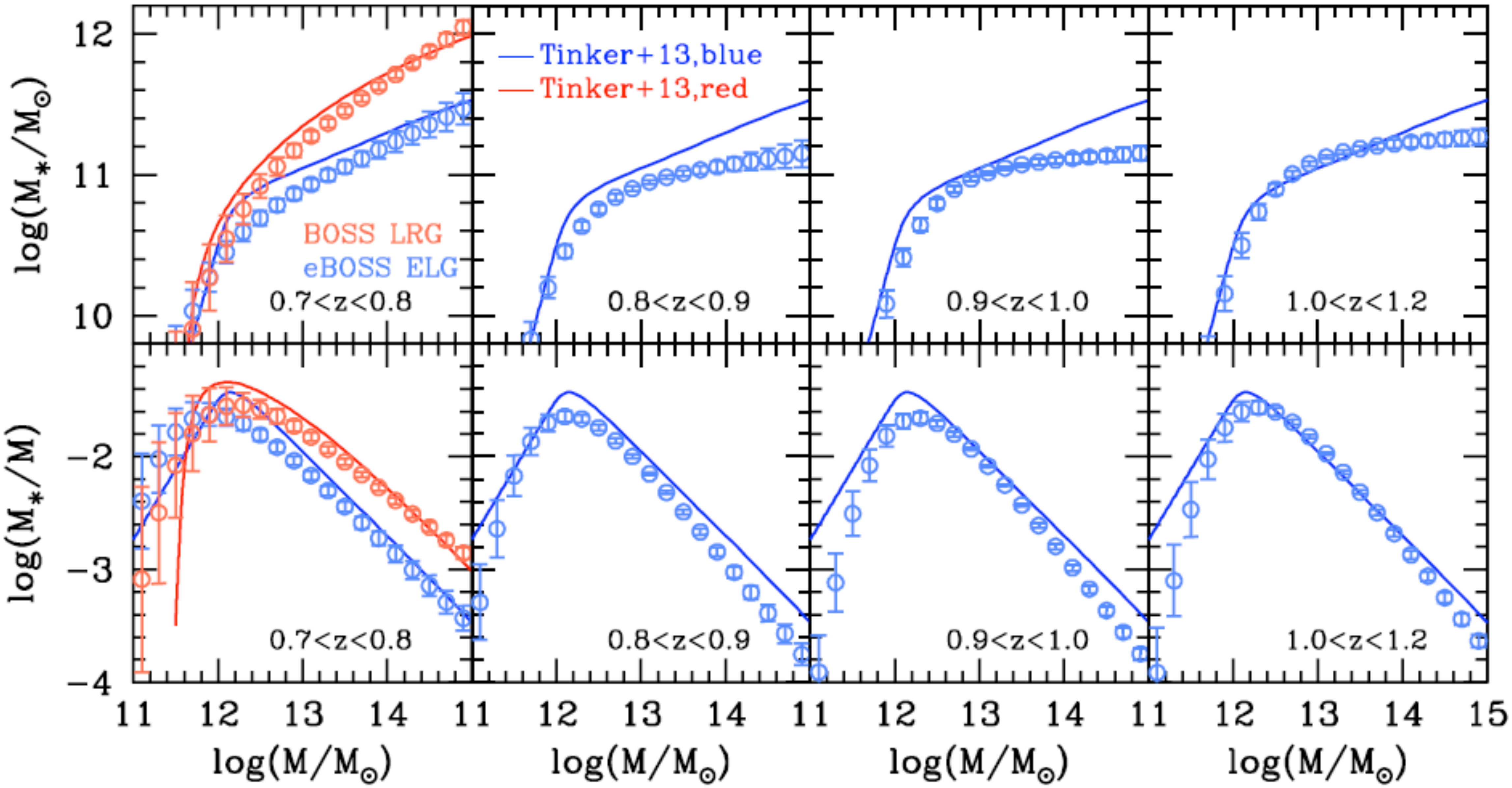
Model Constraints



The eBOSS ELG sample selection is very incomplete!

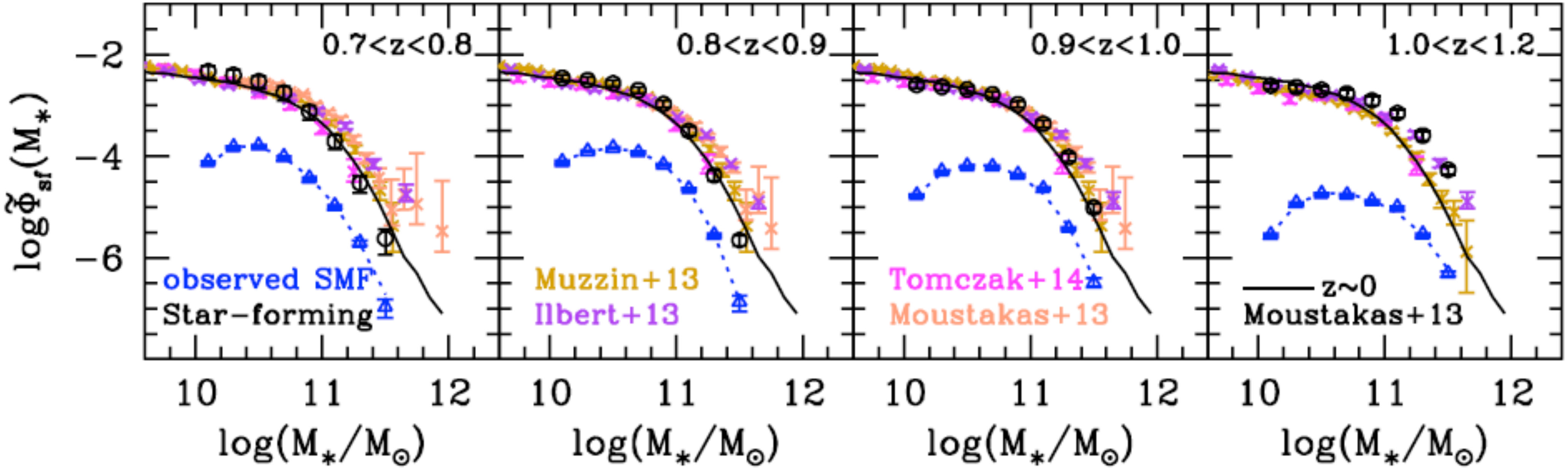
3 Stellar-Halo Mass Relation

Model Constraints

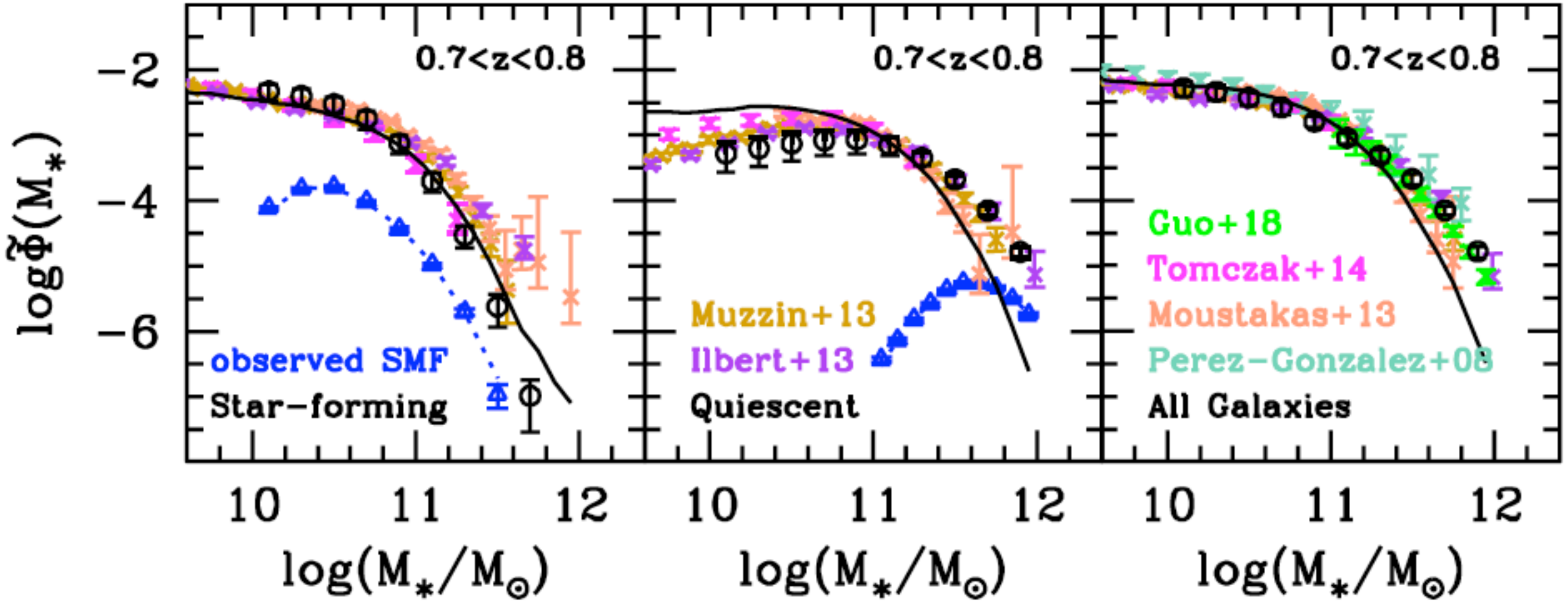


4 Intrinsic Stellar Mass Functions

Model Predictions



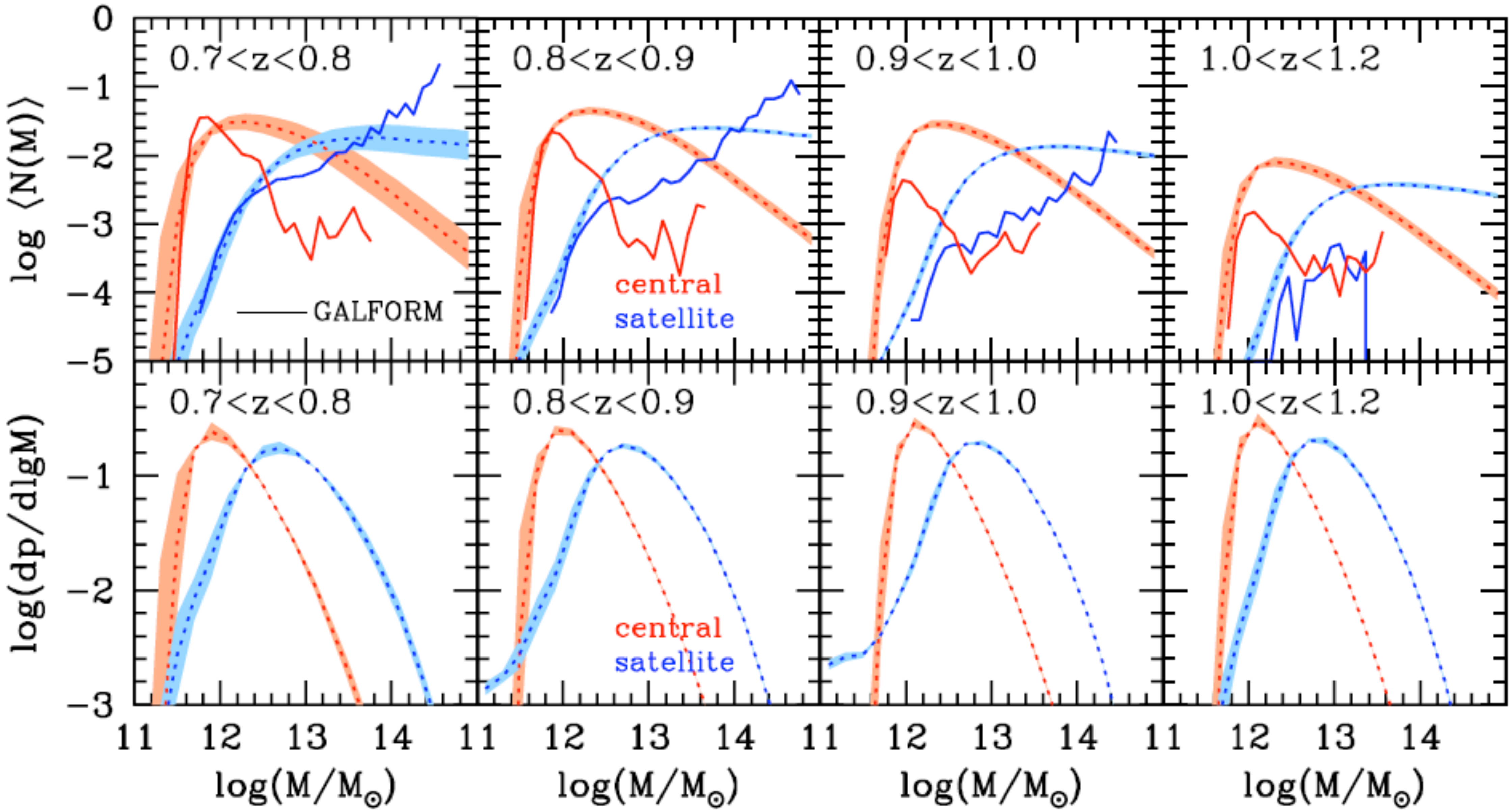
Redshift Evolution



SMFs of quiescent and star-forming populations

5 Halo Occupation Distribution

Model Predictions

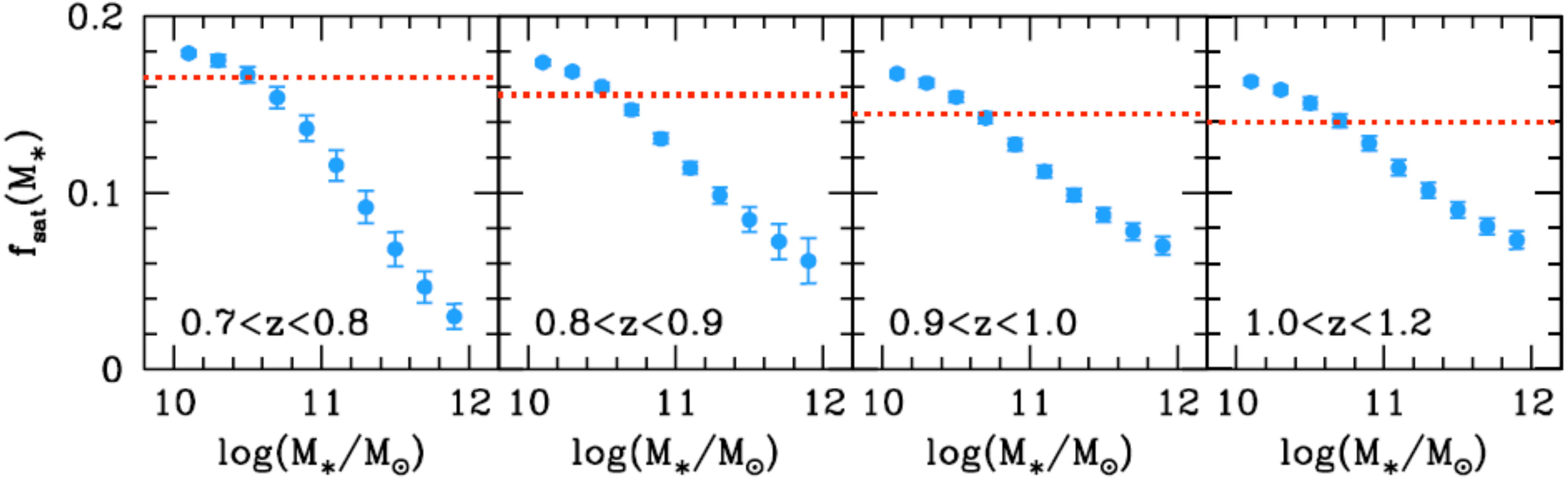


Solid Lines for the SAMs of Gonzalez-Perez et al. (2018)

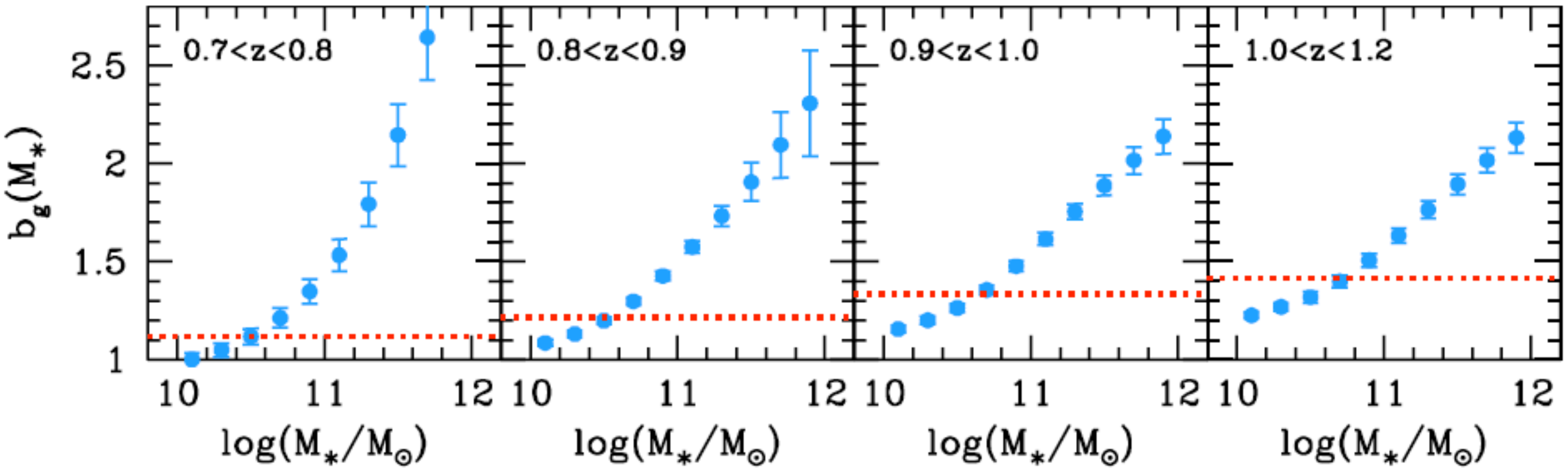
6 Sample Satellite Fraction

Model Predictions

Satellite Fraction



Galaxy bias



Summary

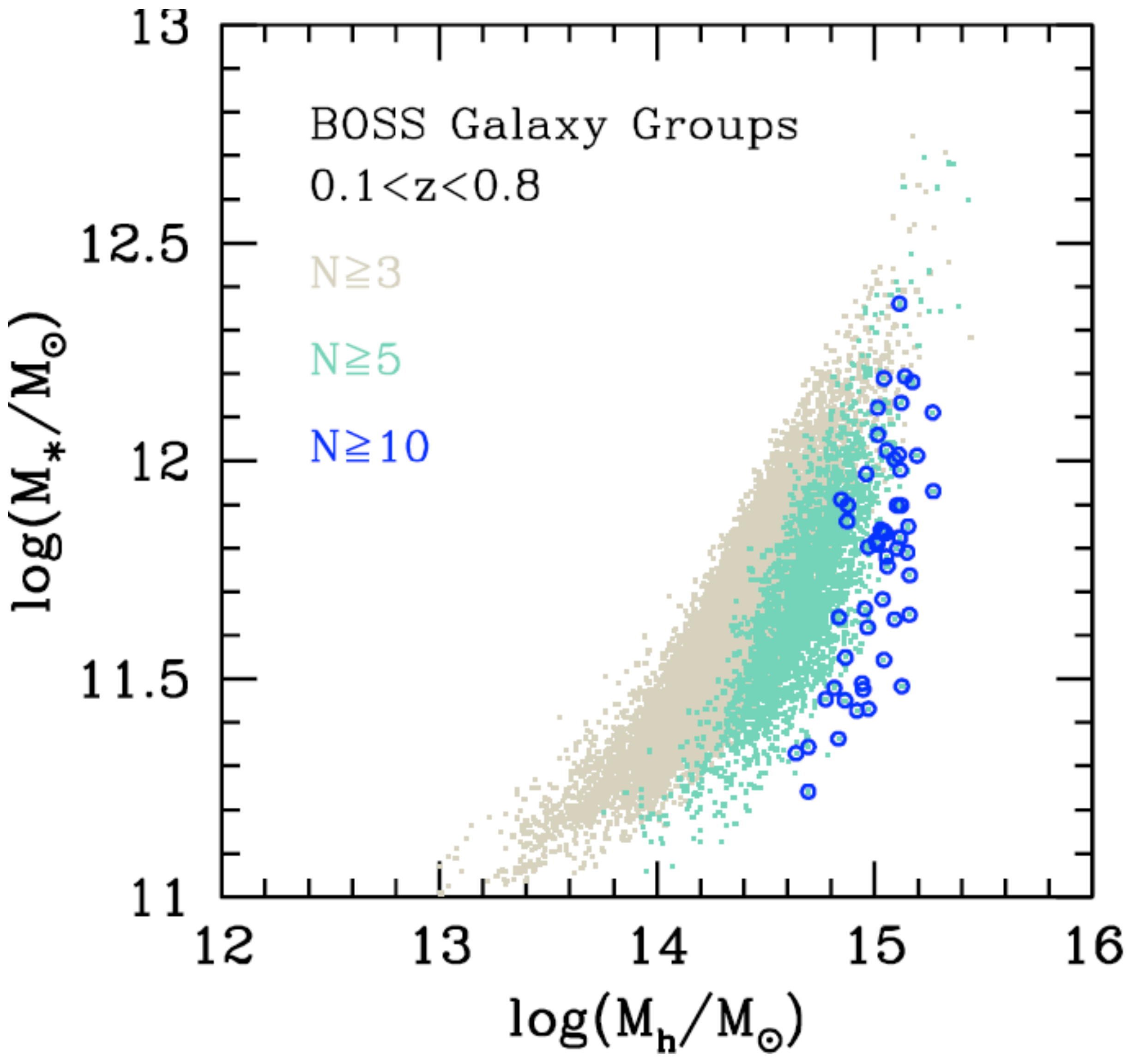
Incomplete Conditional Stellar Mass Function

- Sample completeness
- Stellar-Halo Mass Relation
- Quenched Halo Fraction

Predictions

- Halo Occupation Distribution
- Satellite Galaxy Fraction
- Galaxy Bias of ELGs
- Intrinsic Stellar Mass Function

Application: BOSS Galaxy Group Catalog



Guo et al., in prep.