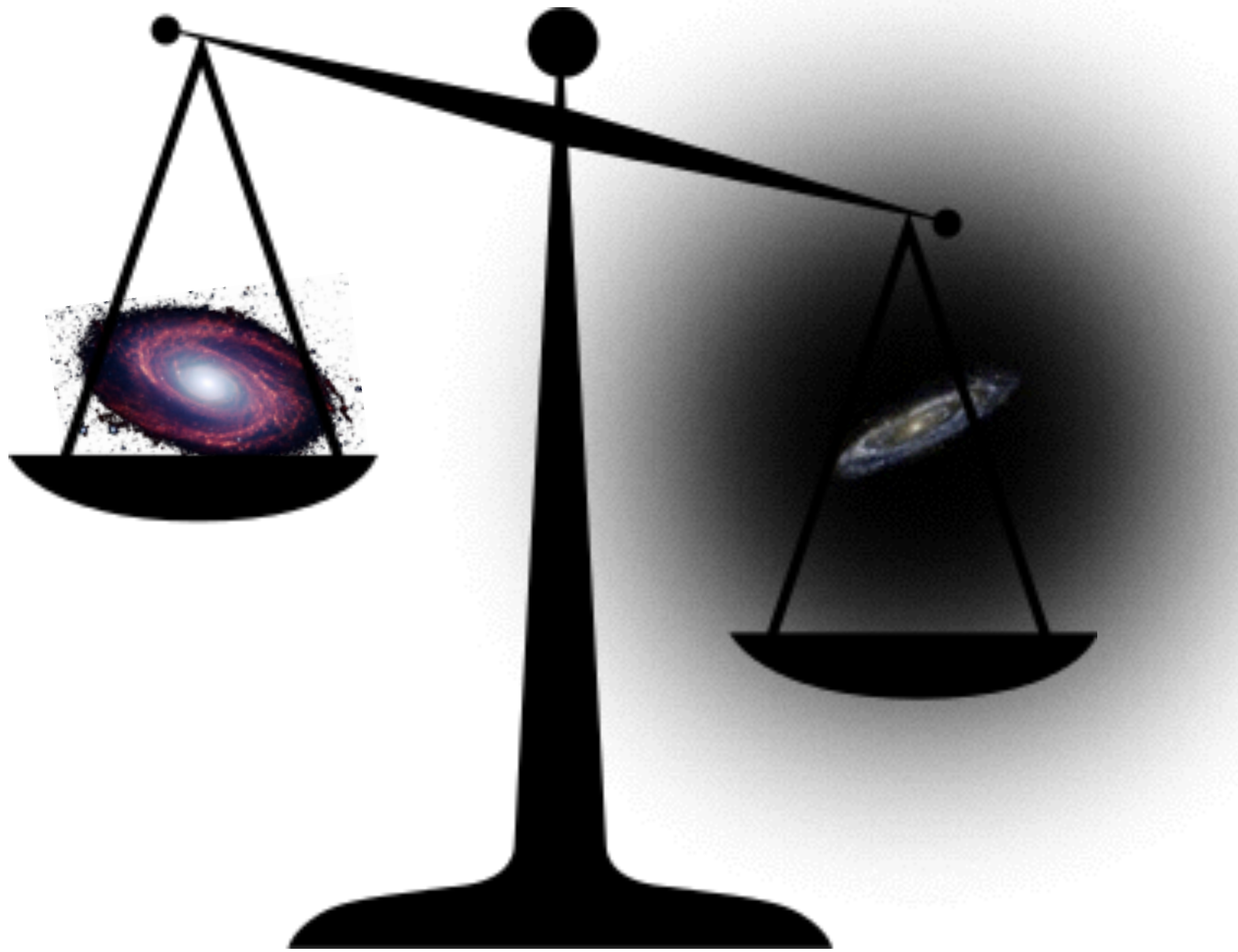
GALAXY-HALO CONNECTION FOR MASSIVE GALAXIES FROM BOSS

or… the curse of ridiculously small error bars …



Alexie Leauthaud - Kavli IPMU - U.Tokyo

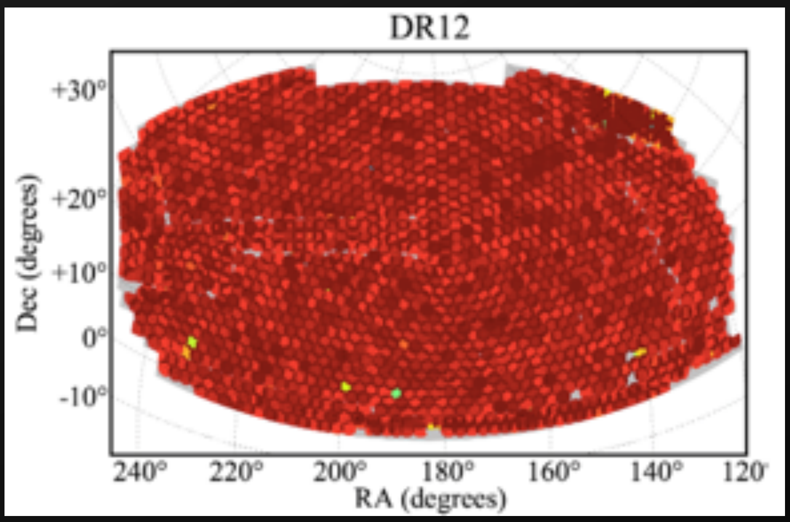
With Shun Saito (talk at 15:50) and the BOSS collaboration

Goals and Data

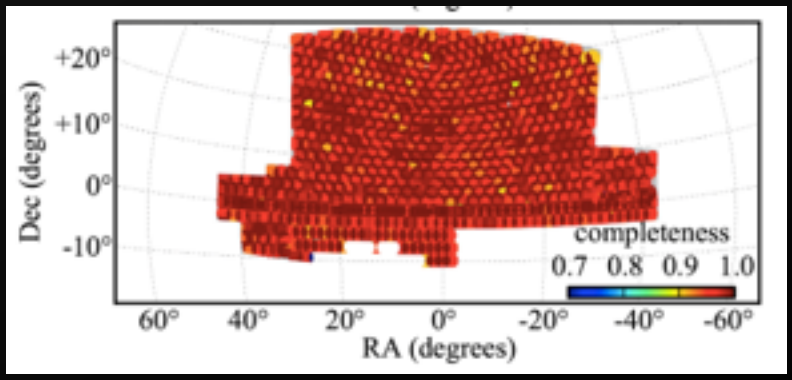
- Probe 2d redshift space clustering deep into the non linear regime. Few studies on these scales!
- Information on scales R=0.8 to 32 h^{-1} Mpc?
- Galaxy-halo connection for massive galaxies at z=0.57
- Velocity dispersions of satellites relative to their parent halos. Check assumptions on σ_{FOG}
- Growth rate of cosmic structure, $f\sigma_8$
- Constraints on these scales are particularly interesting for constraining modified gravity models

BOSS: Baryon Oscillation Spectroscopic Survey
1.5 million galaxies

"CMASS" z=[0.43,0.7]

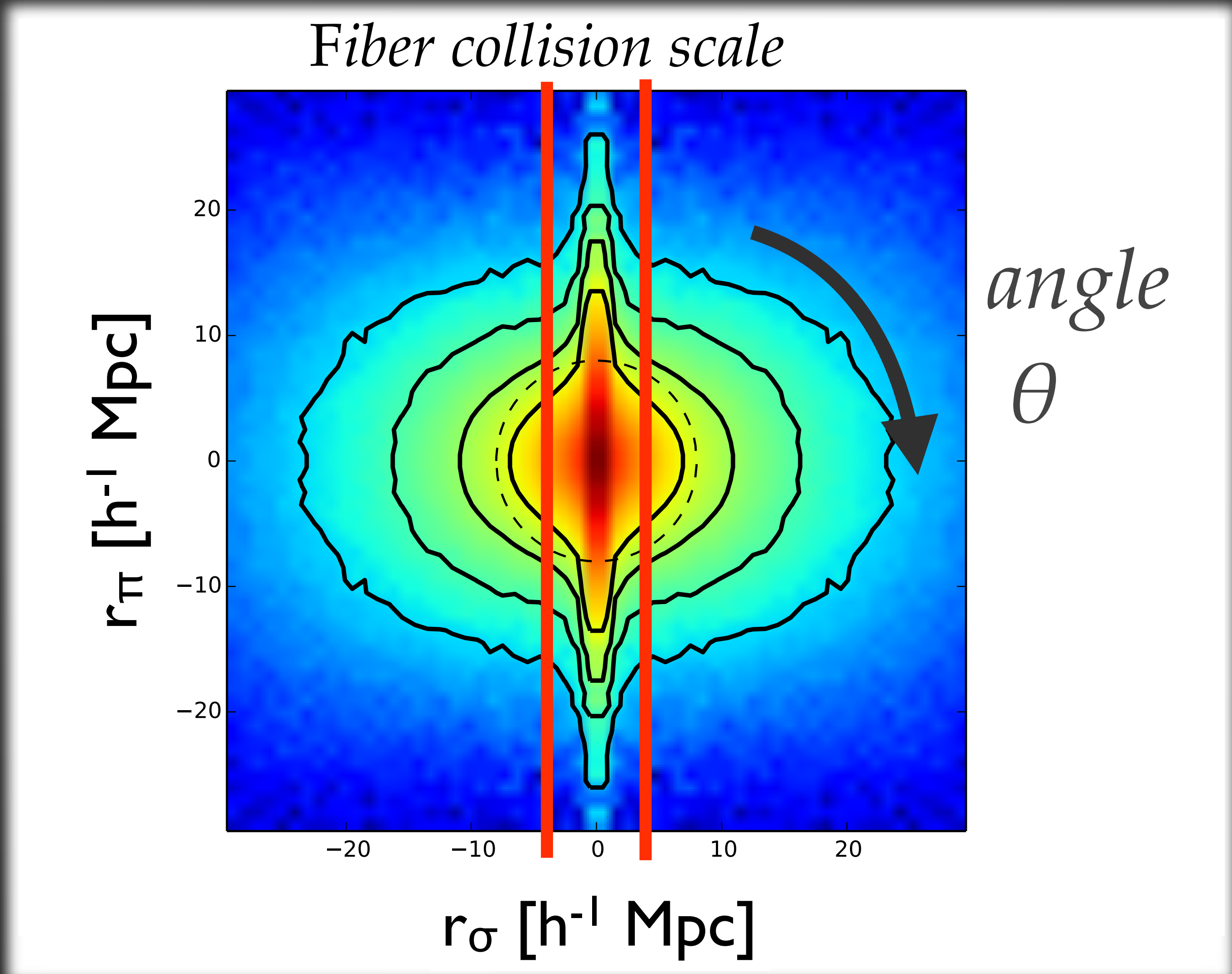


15.3 Gpc^3   *9376 deg^2*



2D Redshift Space Correlation Function

$\xi(s) \quad (s^2 = r_\sigma^2 + r_\pi^2)$



Reid, Seo, Leauthaud et al. 2014

- Multipoles

$L_0(\mu)=1$

$L_2(\mu)=1.5\,\mu^2-0.5$

$$\xi_\ell(s_i) = \frac{2\ell+1}{2}\int d\mu_s\, \xi(s_i,\mu_s)L_\ell(\mu_s),$$

~ *angle* θ

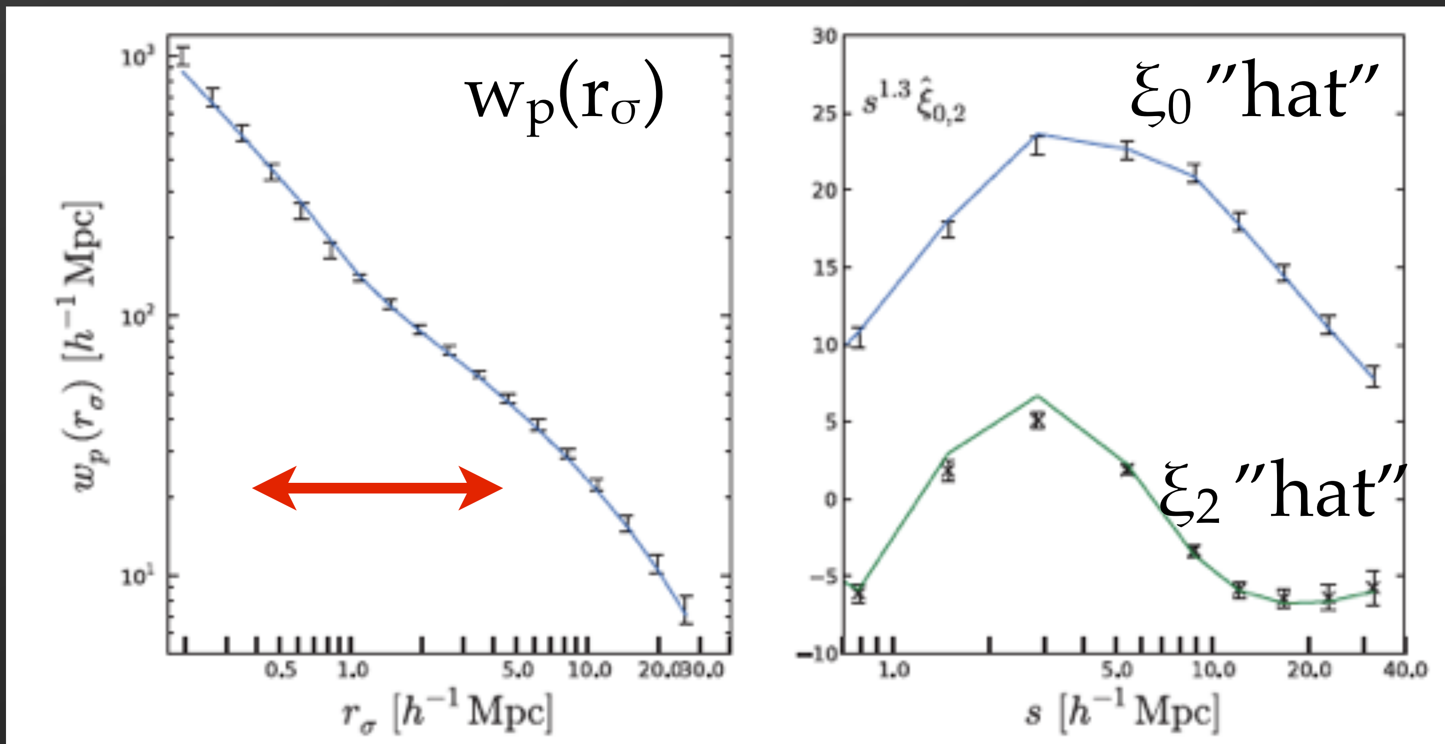
Spherical average $\xi_0(s)$.
Anisotropy $\xi_2(s)$.

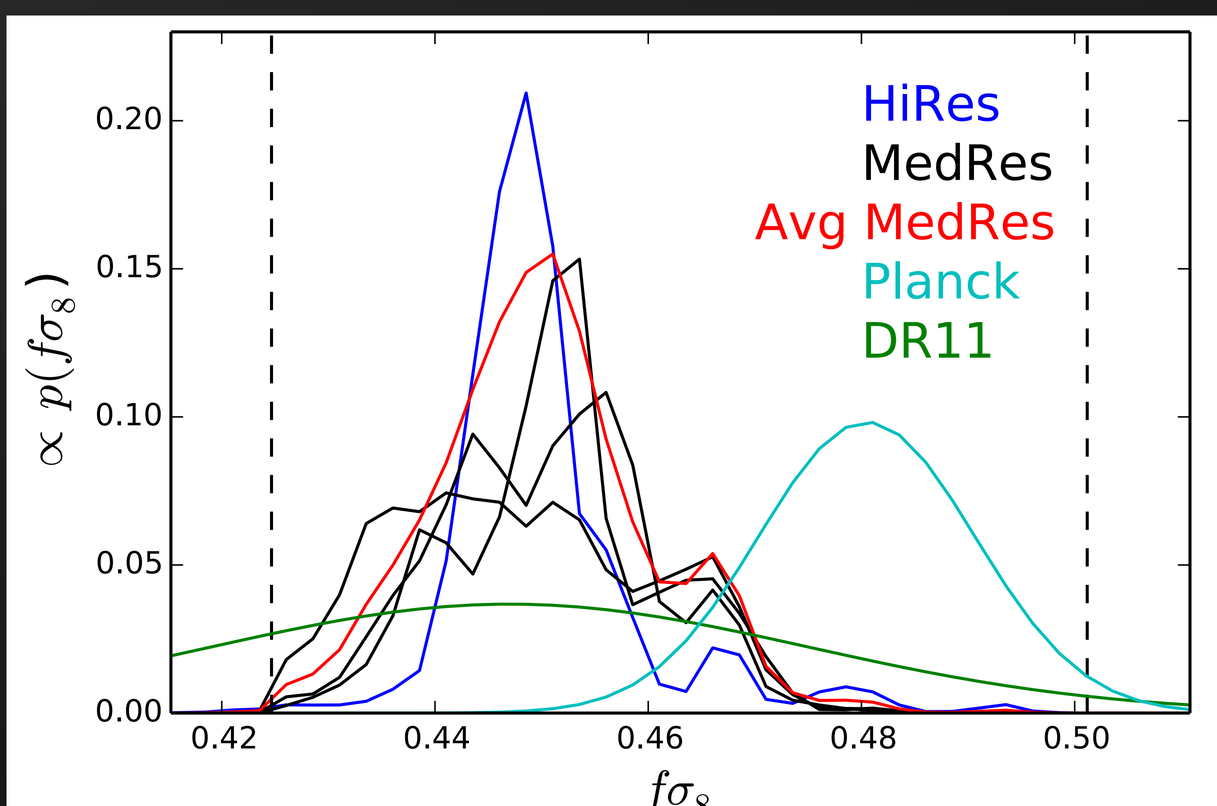
- "xi-hat" statistic

$$\hat{\xi}_\ell(s_i) = \frac{2\ell+1}{2}\int_0^{\mu_{\max}(s_i)} d\mu_s \xi(s,\mu_s)L_\ell(\mu_s).$$

no pairs with $r_\sigma < 0.534\,h^{-1}$ Mpc.

A 2.5% Measurement of the Growth Rate from BOSS





- Model: 5 standard HOD parameters + velocity parameters
  - γ_{HV} ($\propto f\sigma_8$)
  - γ_{IHV} (satellites)
  - γ_{cenv} (centrals)
- Joint fit to w_p and "xi-hat"
- Growth of structure $f \times \sigma_8 = 0.450 \pm 0.011$
  2.5 x improvement over DR11 large scale analysis

but no systematic error!

Reid, Seo, Leauthaud et al. 2014

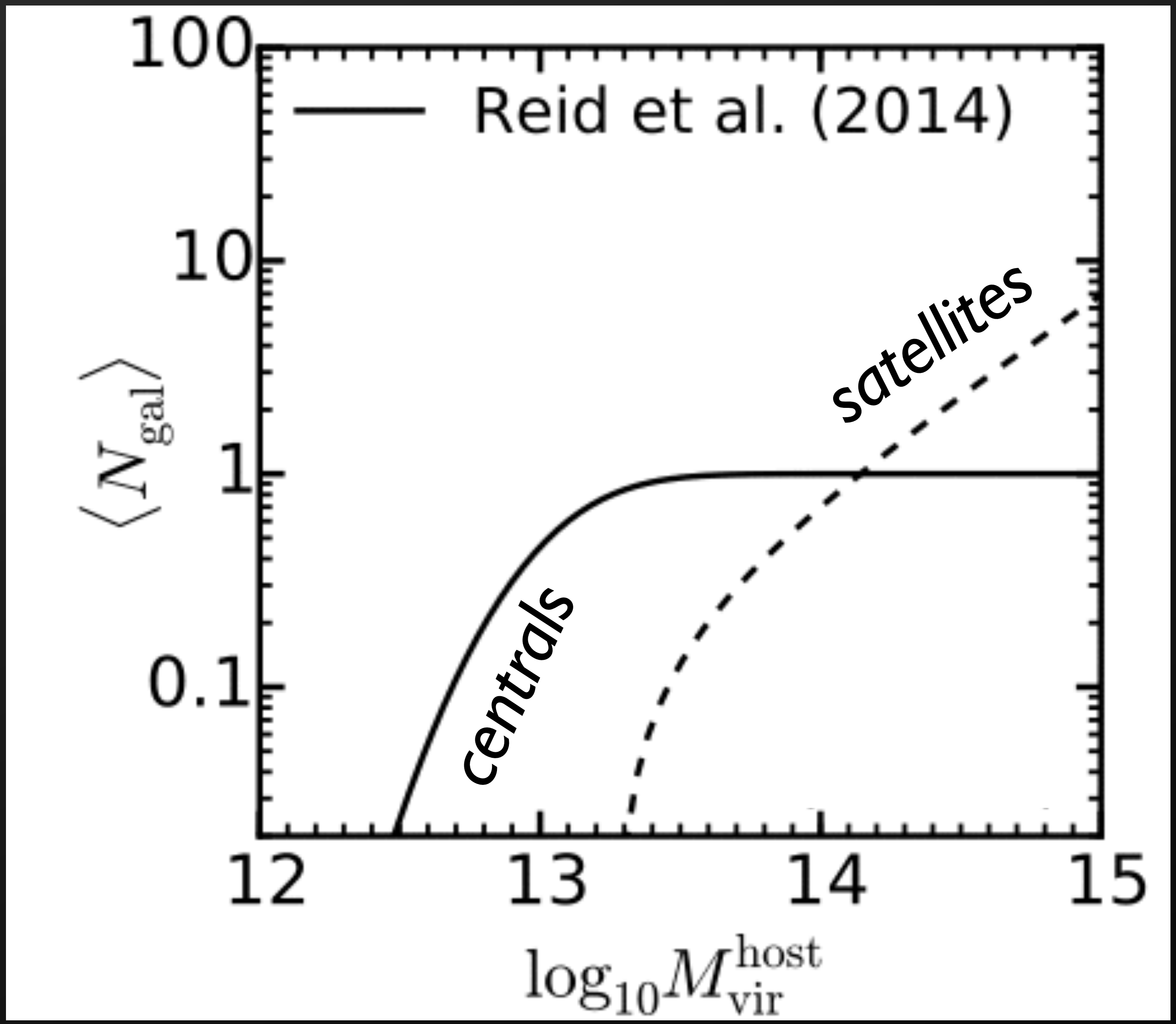
But .....

Because observed clustering of CMASS does not appear to vary with redshift :

Single constant HOD with redshift

"CMASS" : ~~Constant Mass~~

~~Simple selection function~~

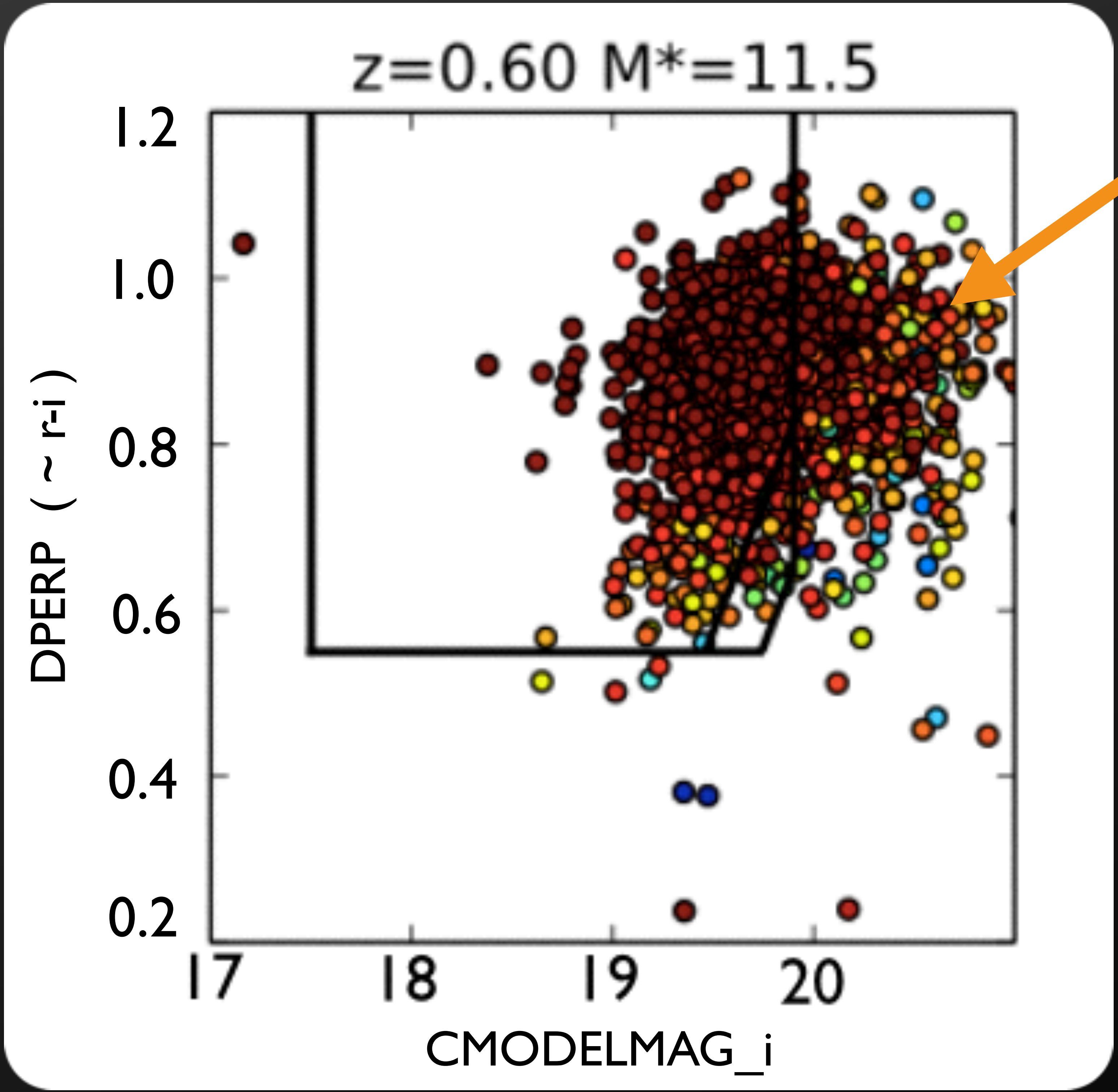


Stellar Mass Completeness of the BOSS CMASS and LOWZ samples

Leauthaud et al. 2015

arXiv:1507.04752

BOSS Selection Function



Bluer colors indicate more recent star formation

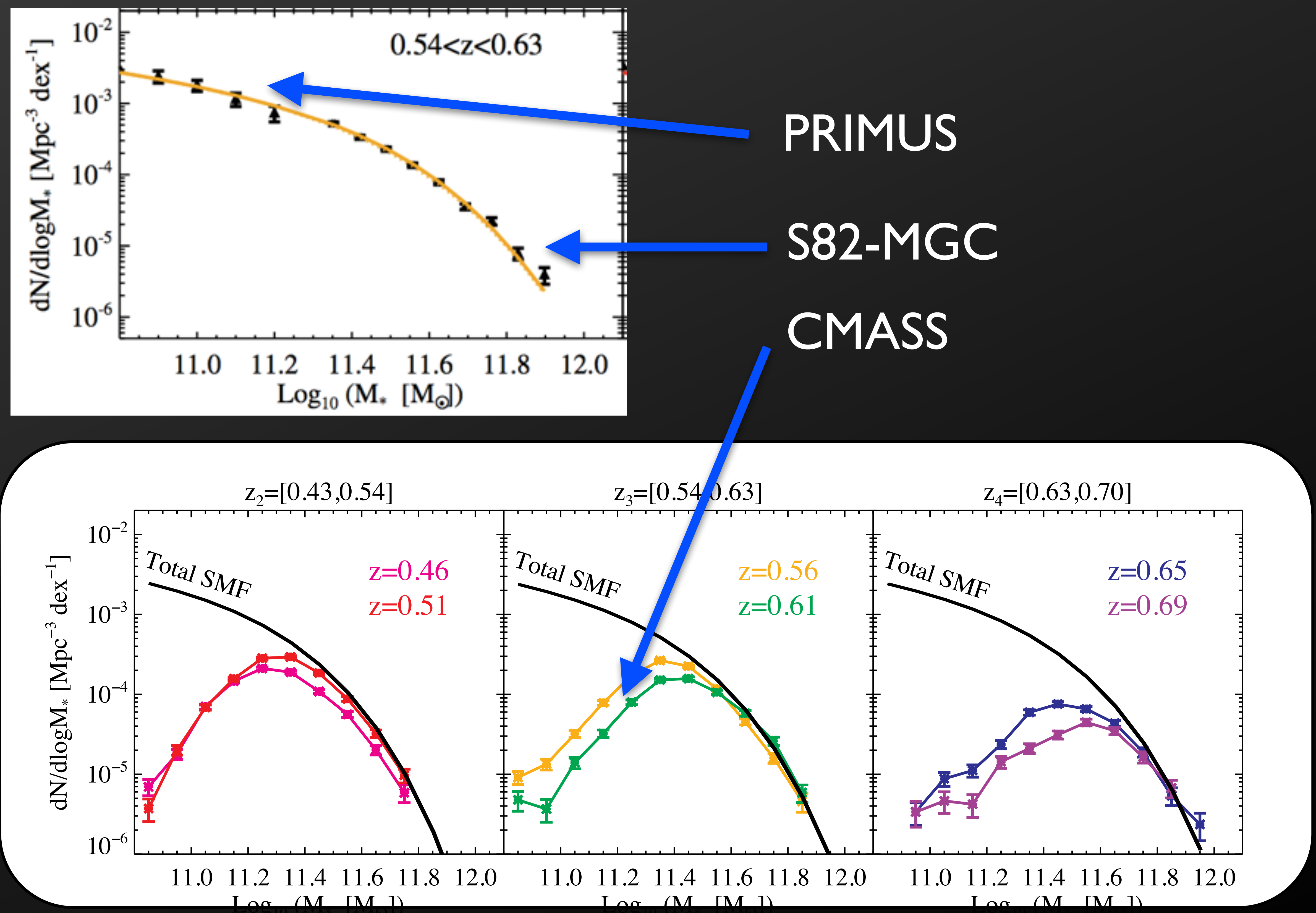
Stripe 82 Massive Galaxy Catalog (S82-MGC)

Bundy et al. in prep

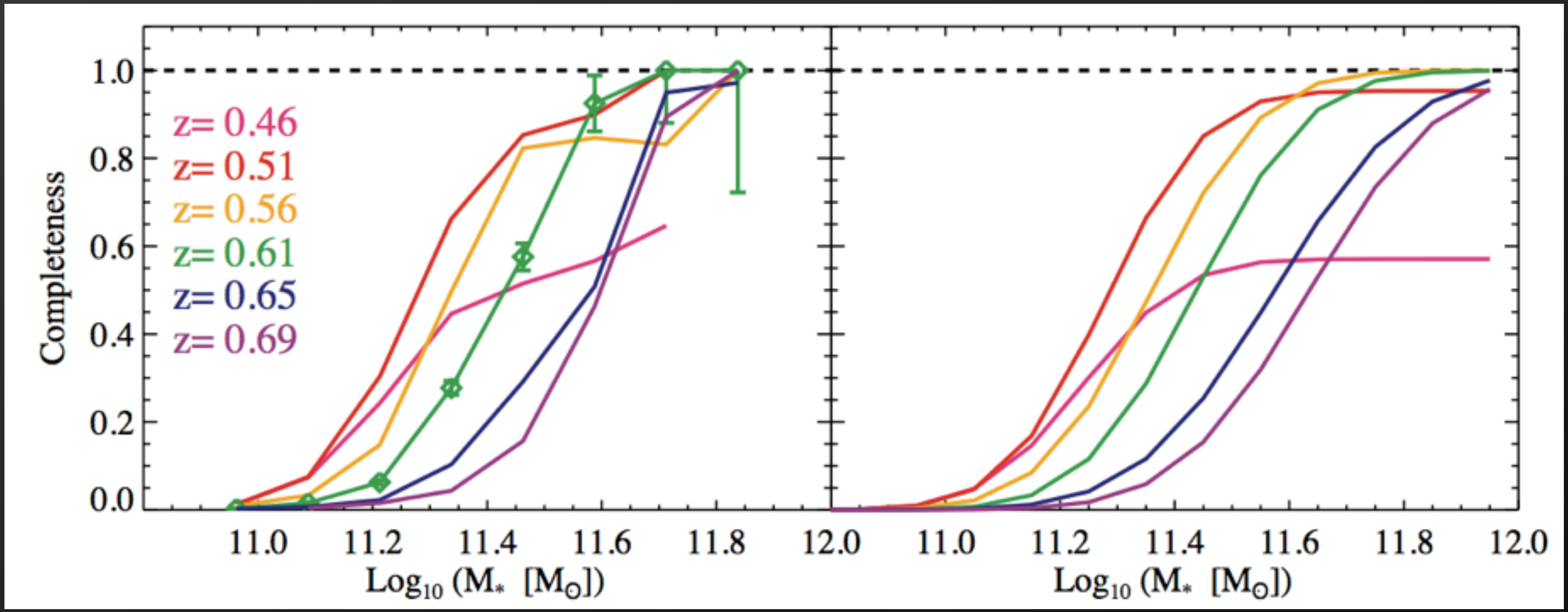
Stripe 82 co-adds + Matched NIR photometry

Leauthaud et al. 2015

Stellar Mass Function at Redshifts 0.43 - 0.7



Mass Completeness of CMASS Sample



- ★ Completeness depends on M* and redshift
- ★ Notice that mean M* increases with redshift

also for the LOWZ sample at 0.15<z<0.43

Leauthaud et al. 2015

A Redshift Dependent Model for CMASS

Saito et al. in prep

A Redshift Dependent Model for CMASS

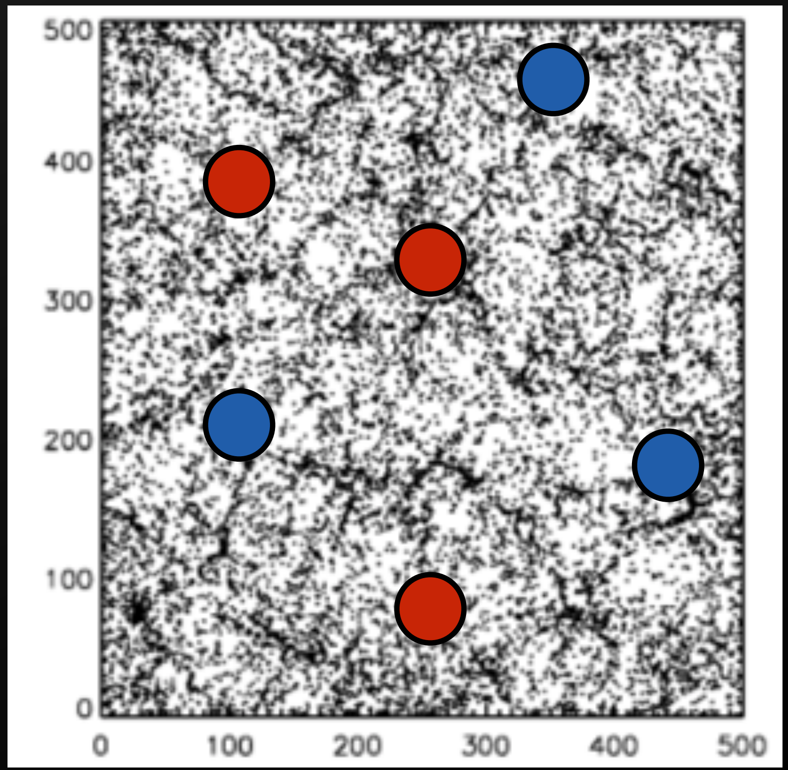
In collaboration with __Shun Saito__, Andrew Hearin, Jeremy Tinker, Martin White, Beth Reid

- ★ Account for BOSS selection function (stellar mass, color)
- ★ Model built from N-body simulations directly via abundance matching
- ★ Model : for simplicity, begin with assumption that galaxy color in high mass halos is a stochastic process

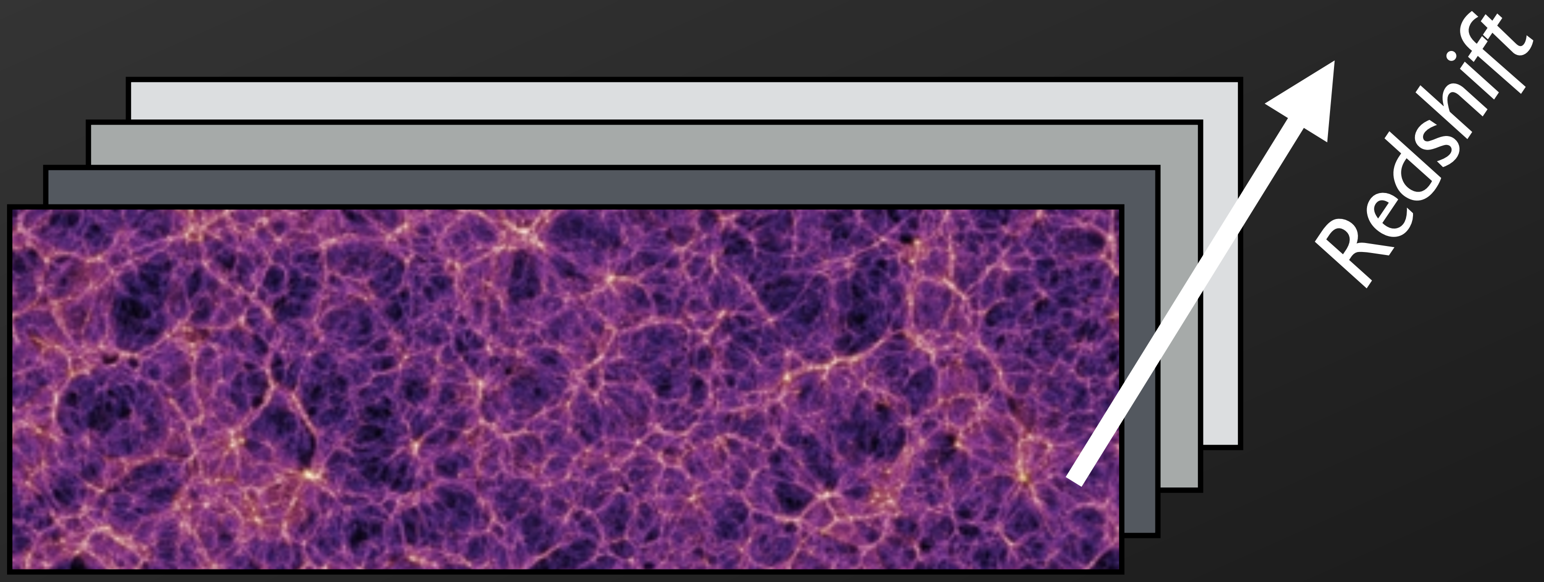
(More sophisticated model = see Shun's talk this afternoon)

stellar mass ⇔ V_{peak}

*assume color is un-correlated with other halo properties at fixed M**



1 Gpc^3 N-body Simulation



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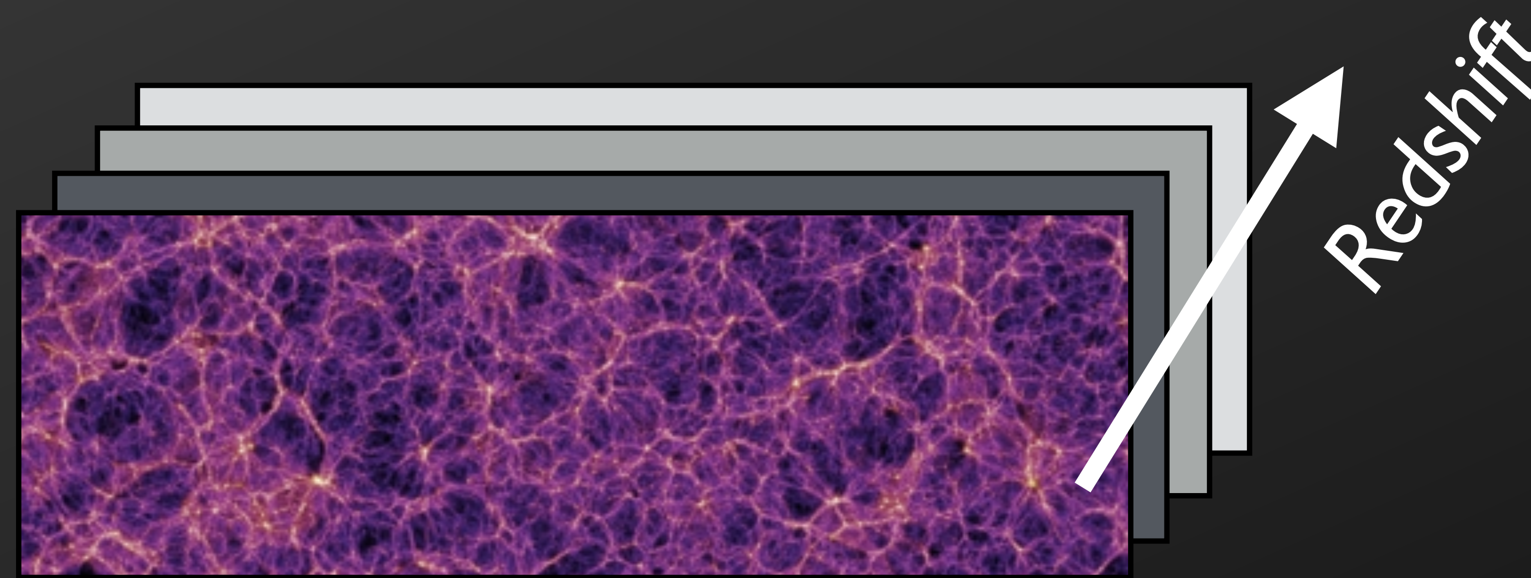
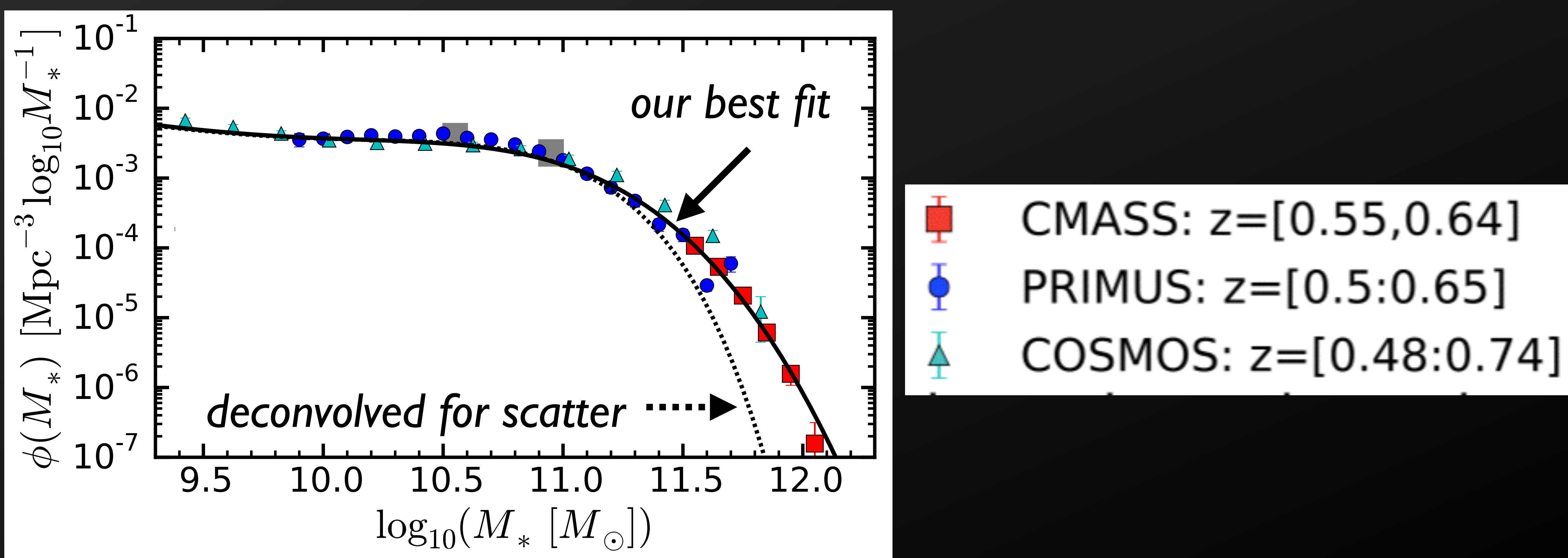


Step 1: Determine Mass Function and abundance match (V_{peak})



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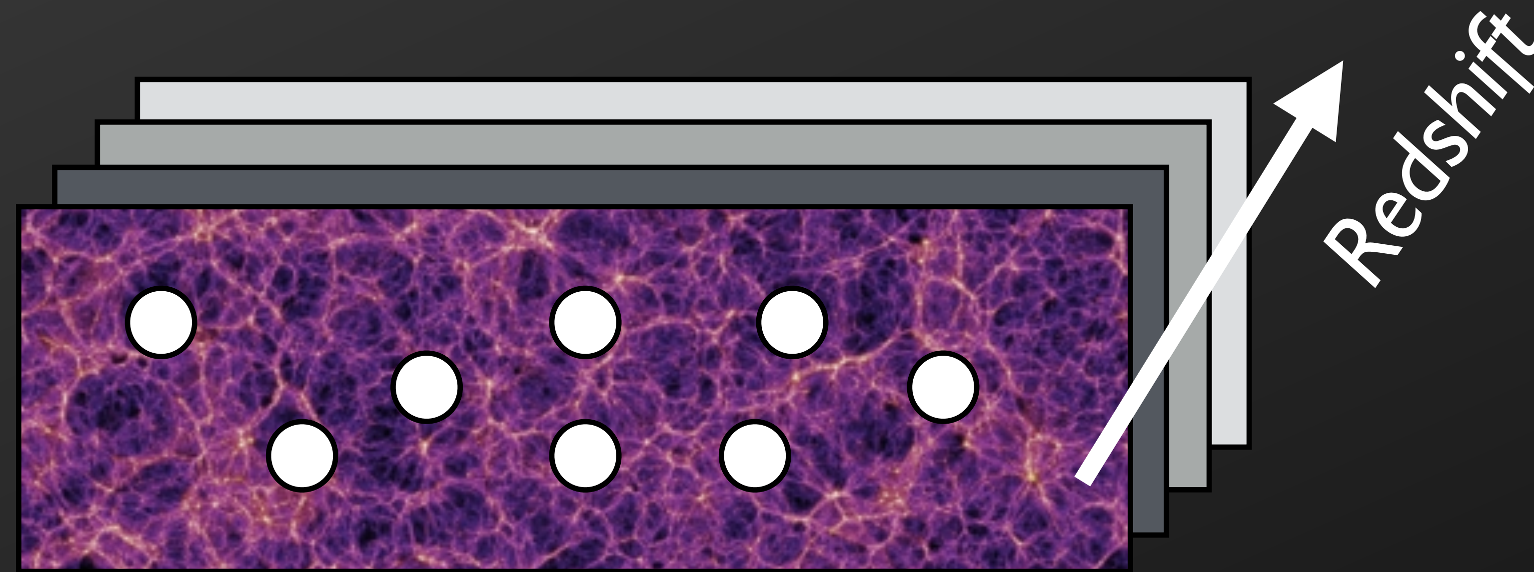

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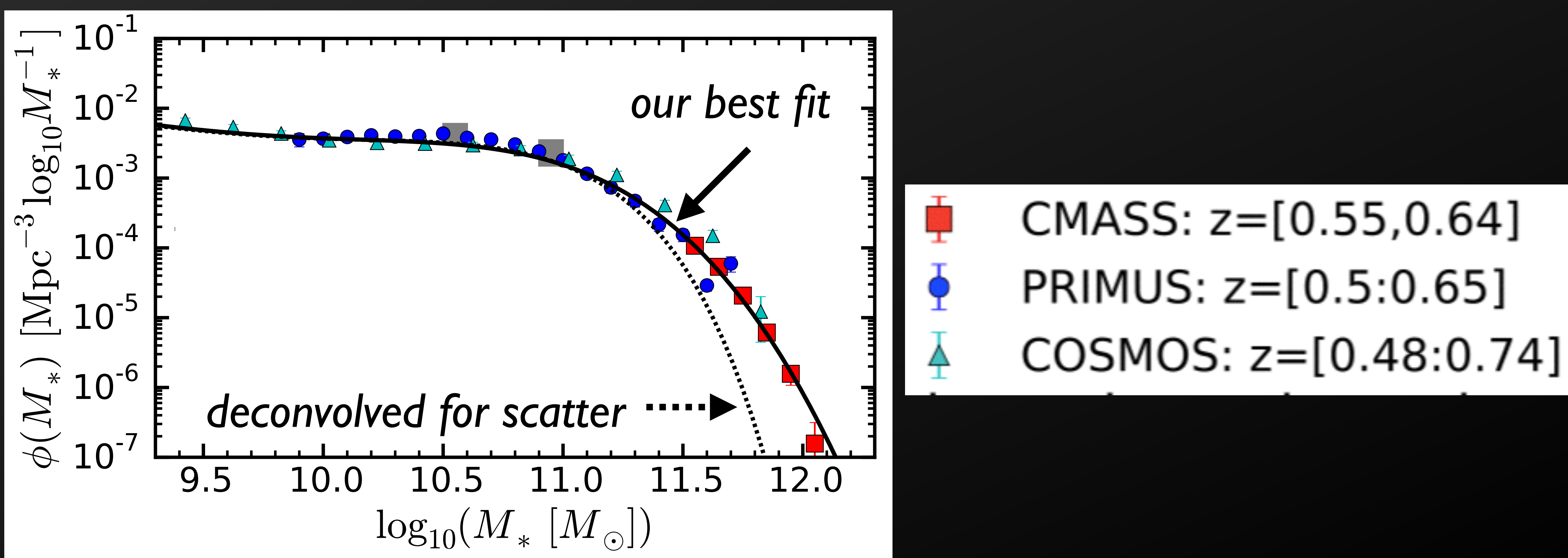
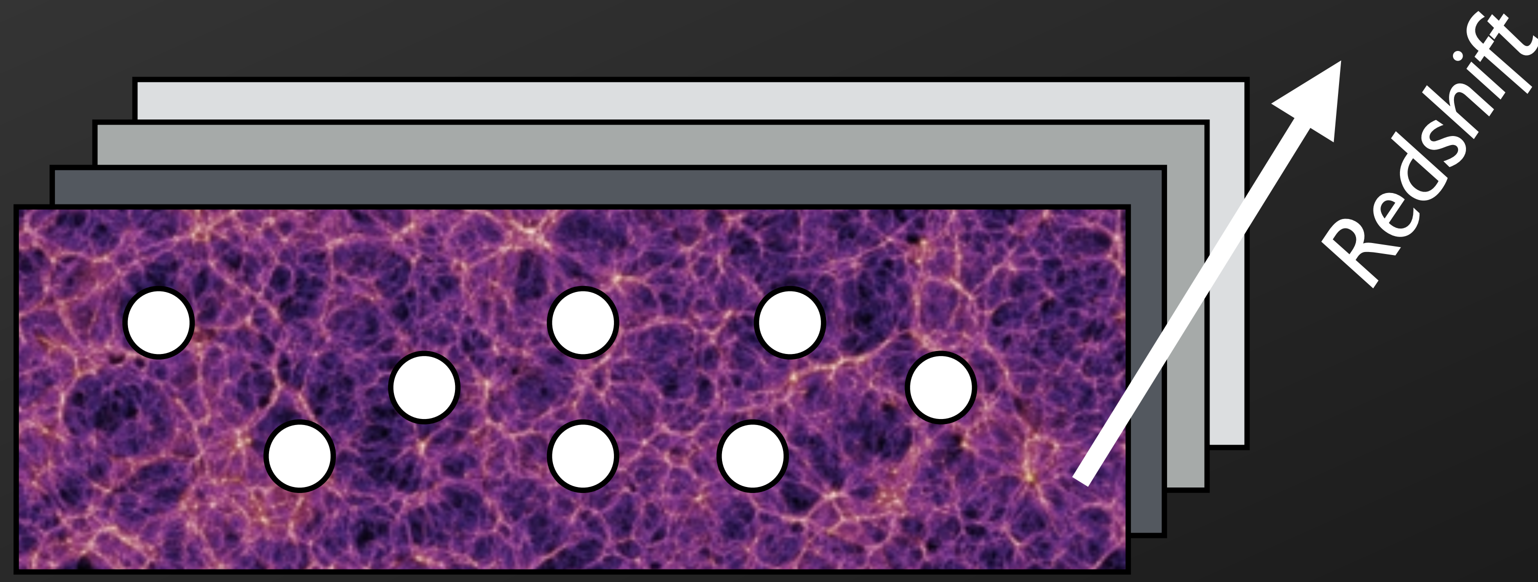
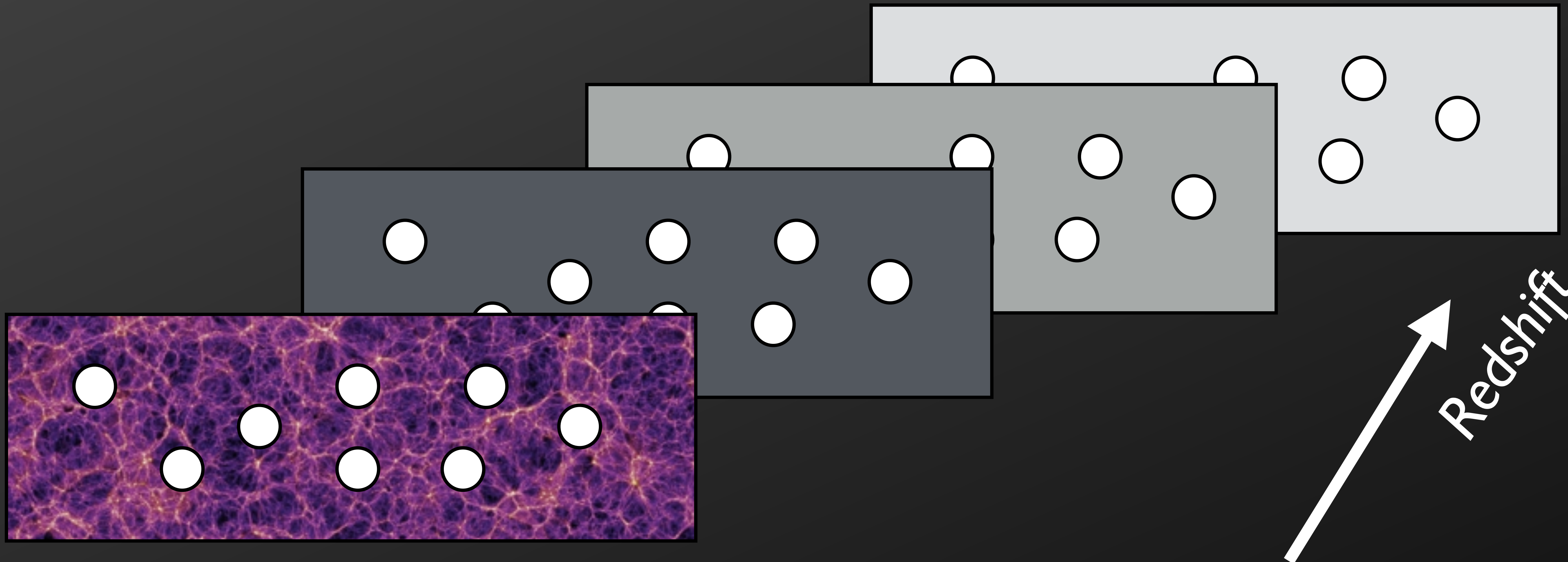


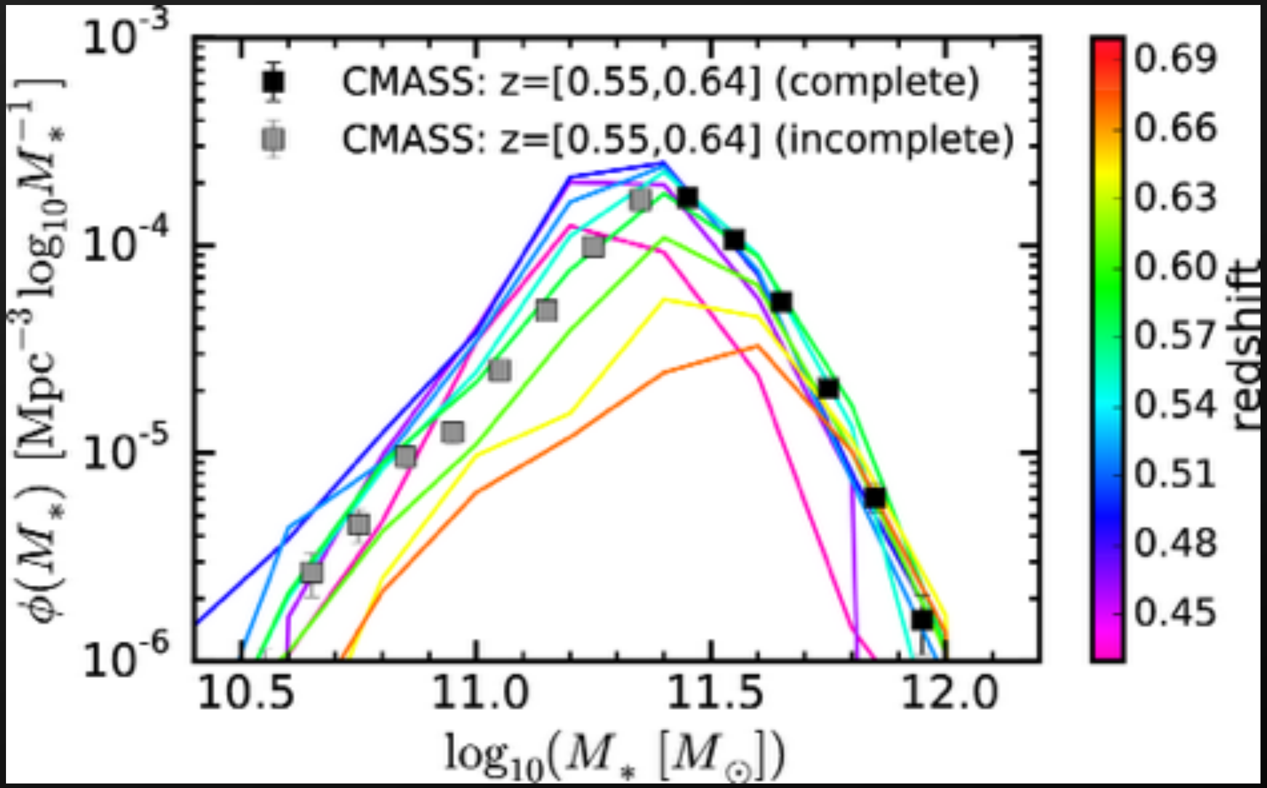
1 Gpc^3 N-body Simulation

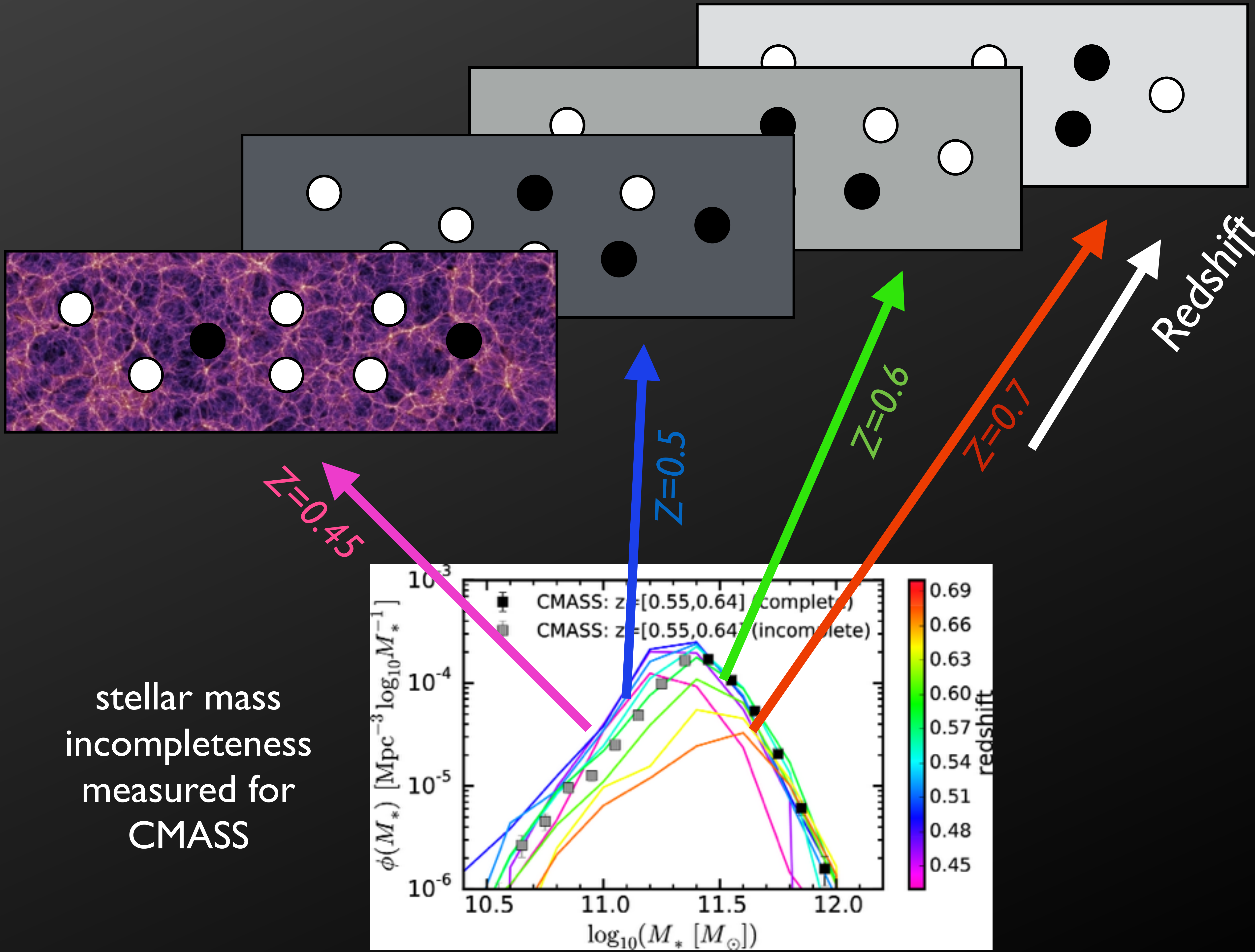


Step 2 : Redshift dependence of stellar-mass completeness

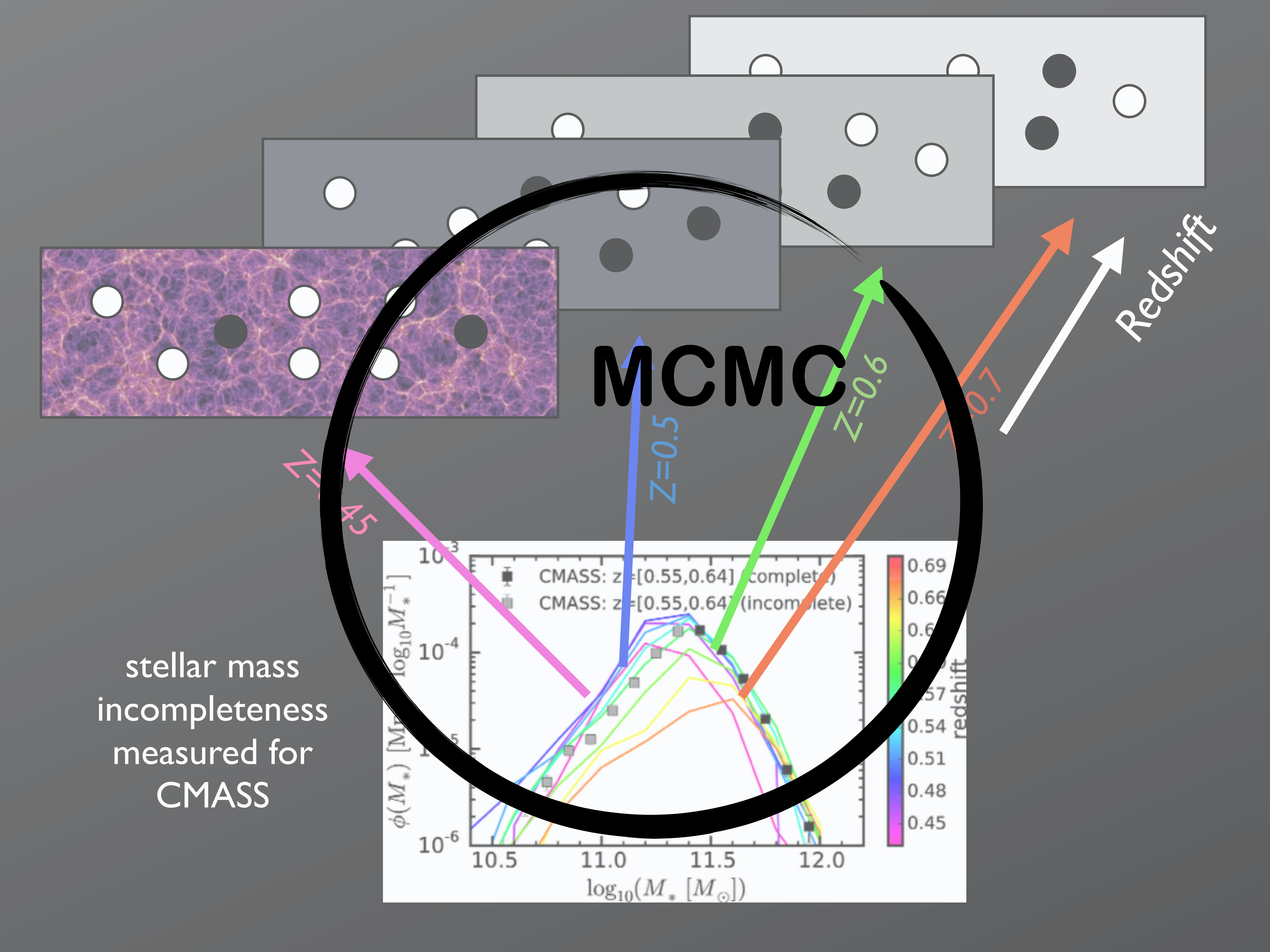


stellar mass completeness measured for CMASS

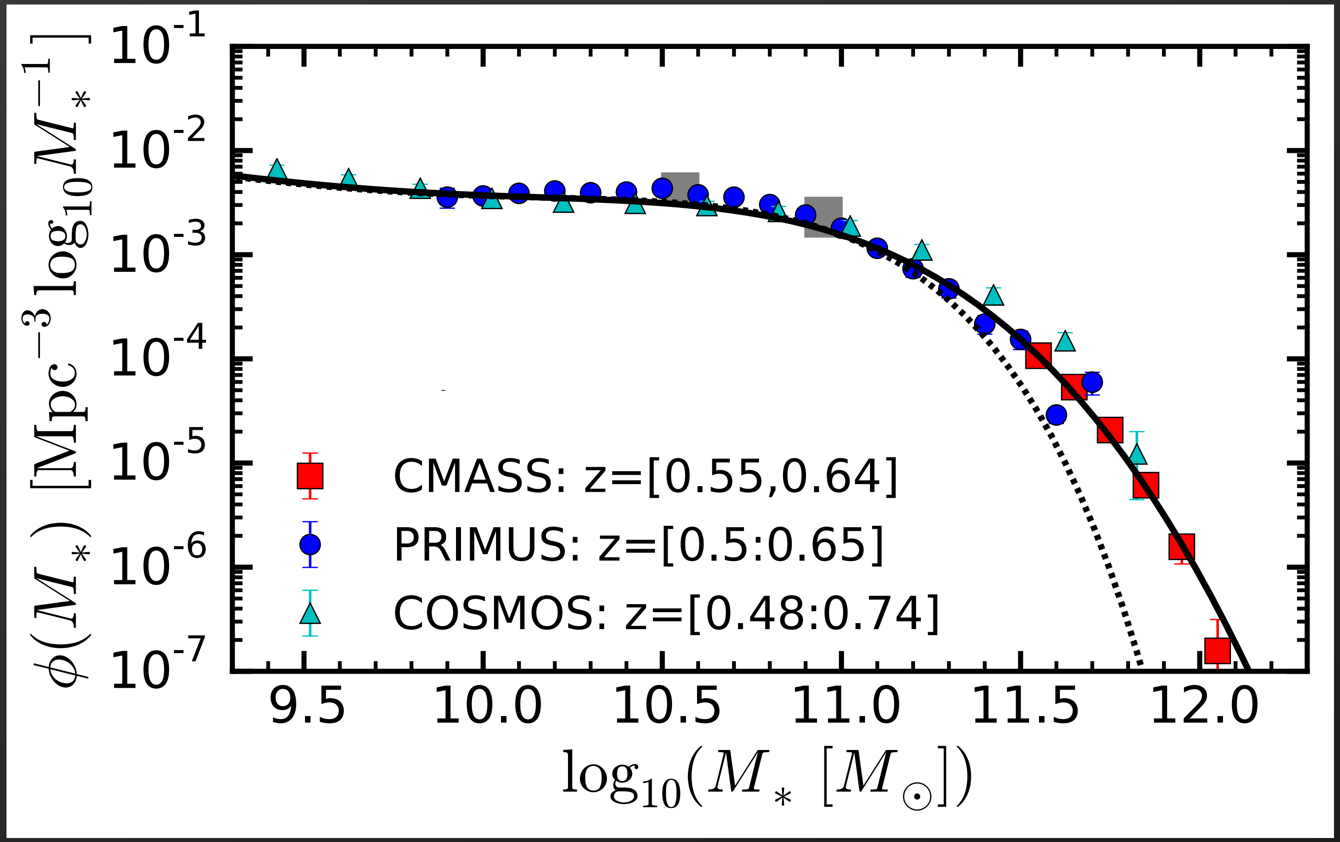




stellar mass incompleteness measured for CMASS

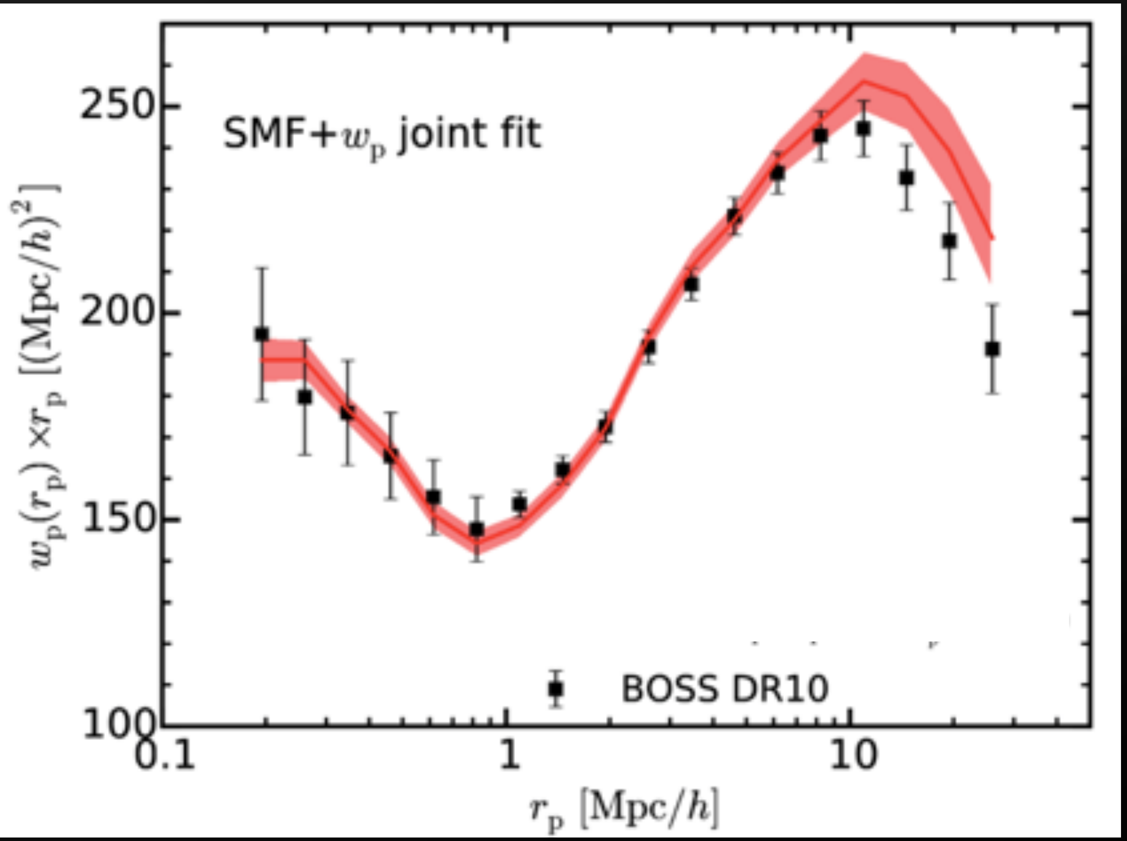

MCMC
Redshift
Z=0.5
Z=0.6
0.7
45
stellar mass
incompleteness
measured for
CMASS
CMASS: z=[0.55,0.64] (complete)
CMASS: z=[0.55,0.64] (incomplete)
$\log_{10}(M_* [M_\odot])$
10^{-3}
10^{-4}
10^{-6}
10.5
11.0
11.5
12.0
redshift
0.69
0.66
0.54
0.51
0.48
0.45

Results: fits to $\Phi(M_*)$ and $w_p(r)$

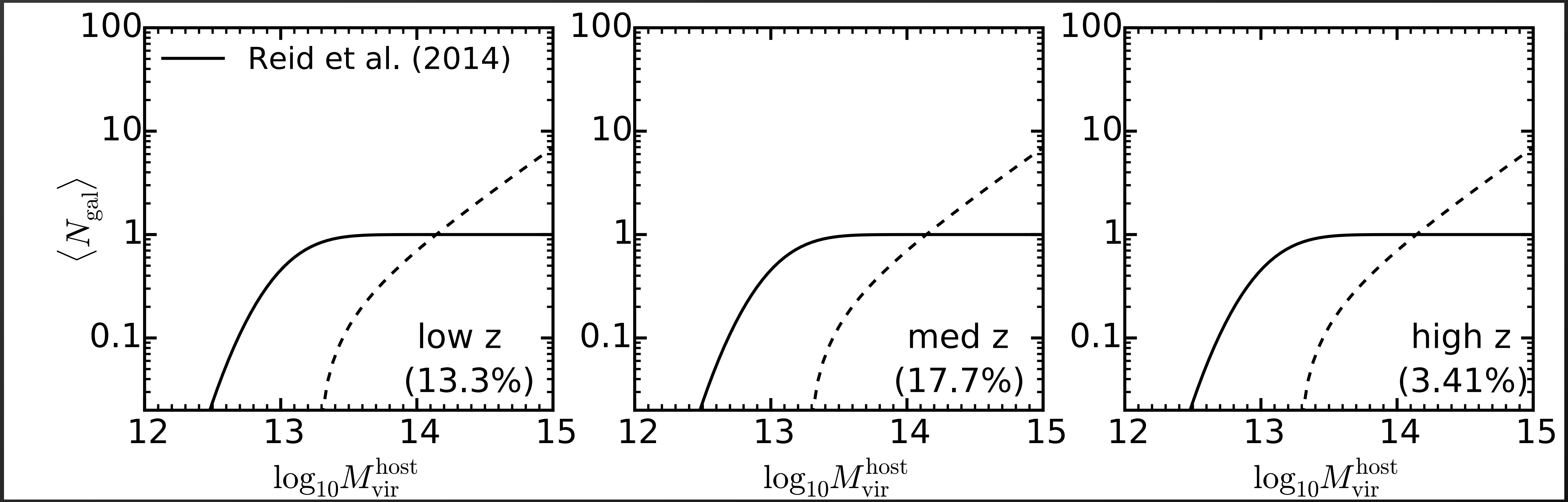


Galaxy Number Density
$\Phi(M_*)$

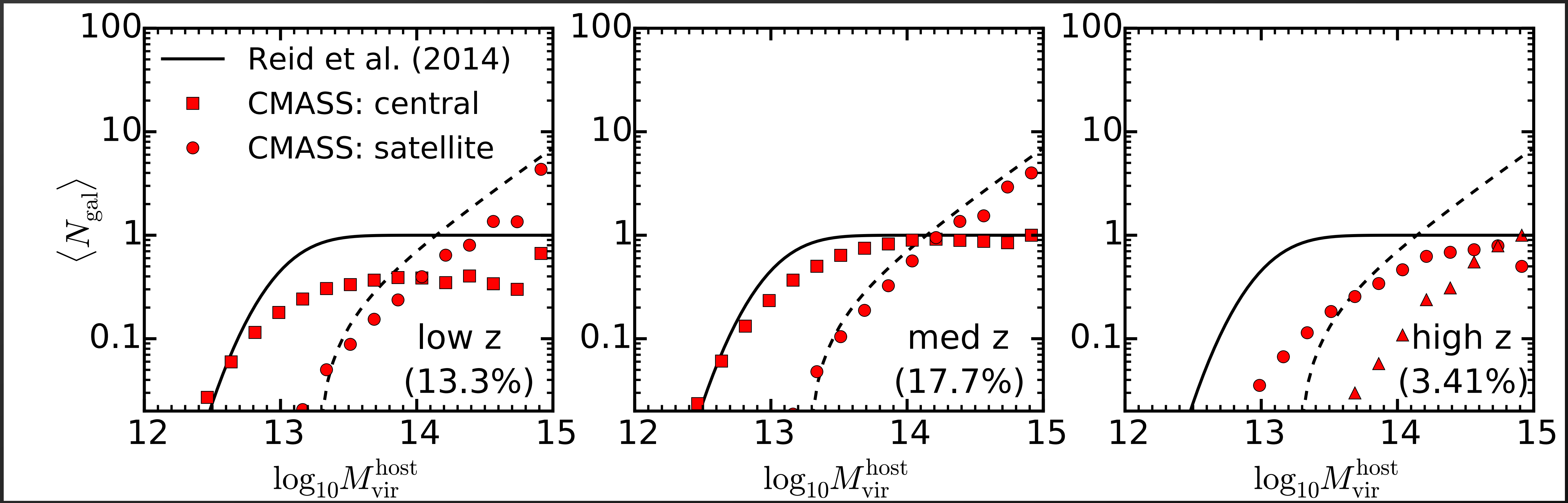
Projected Correlation Function
$w_p(r)$



Results: Halo Occupation



Results: Halo Occupation



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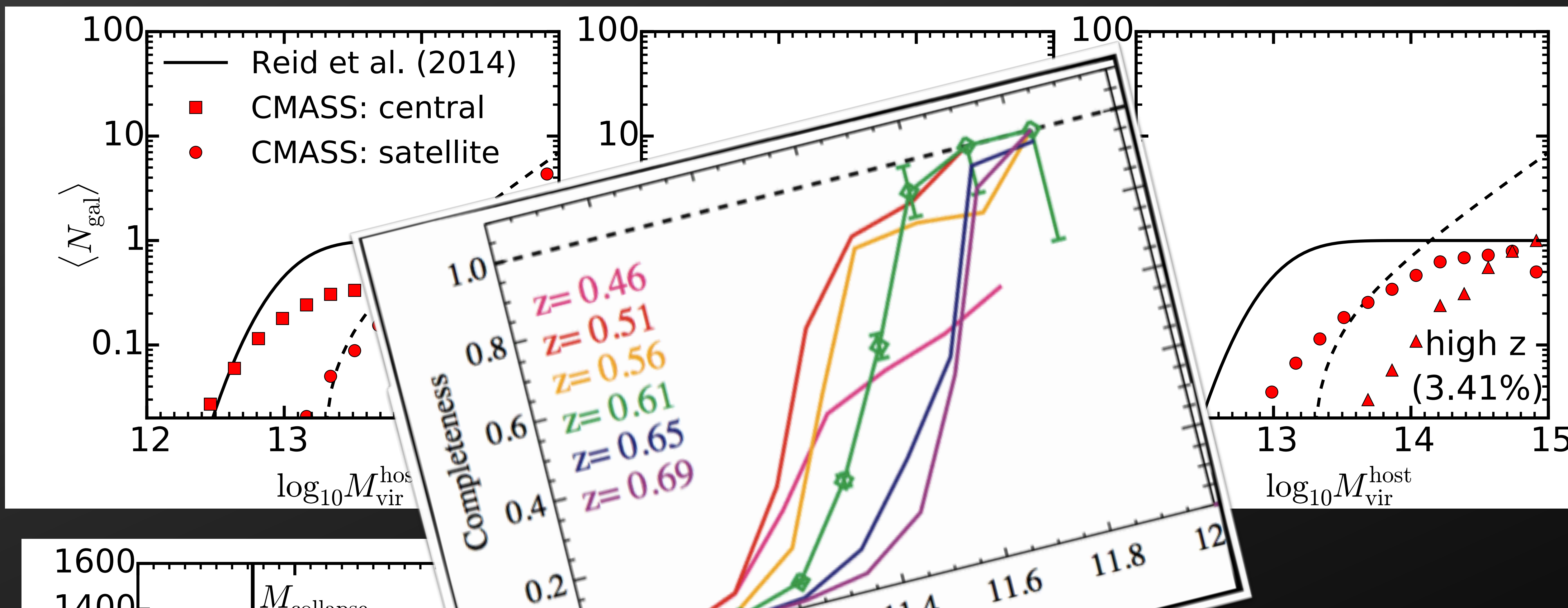
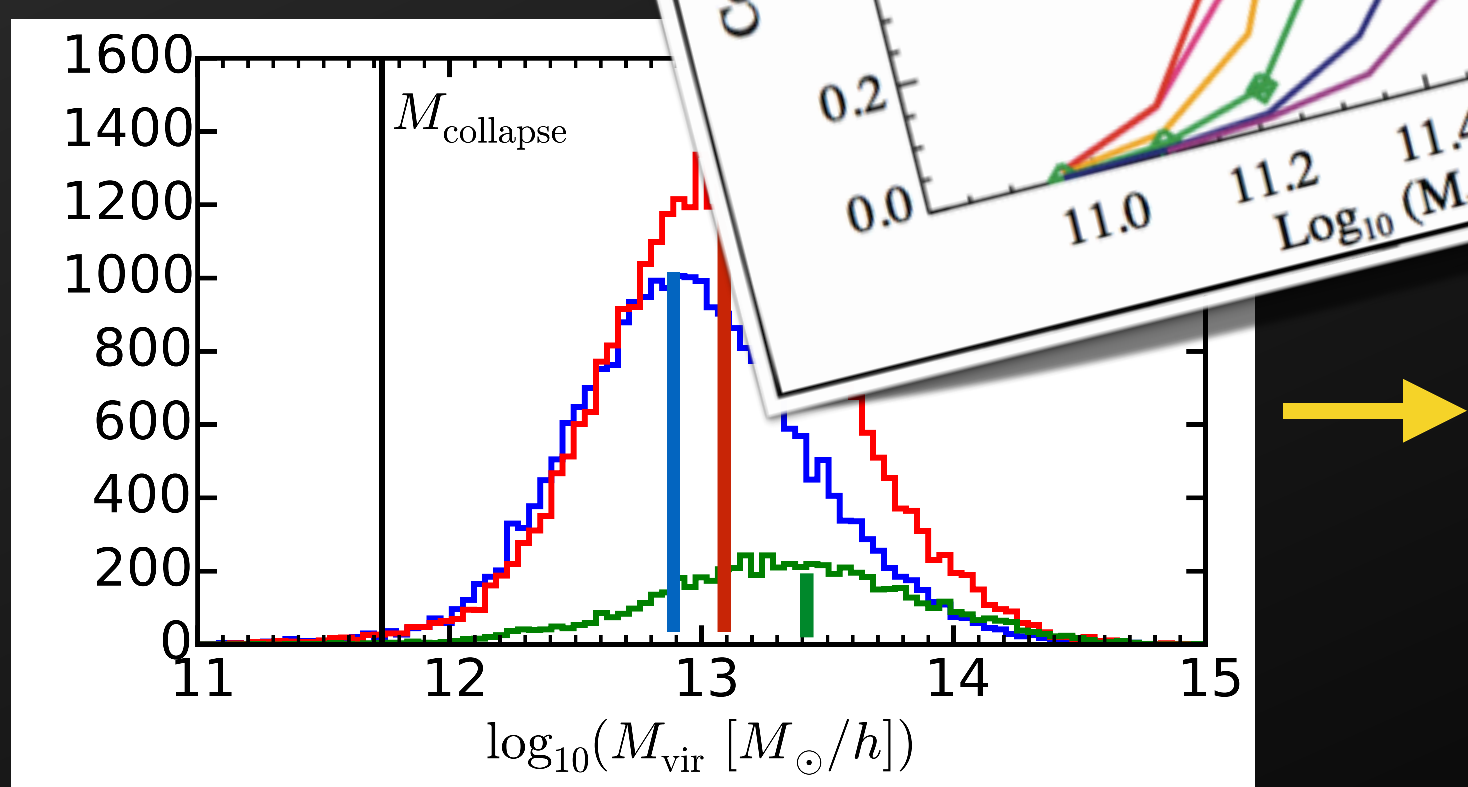
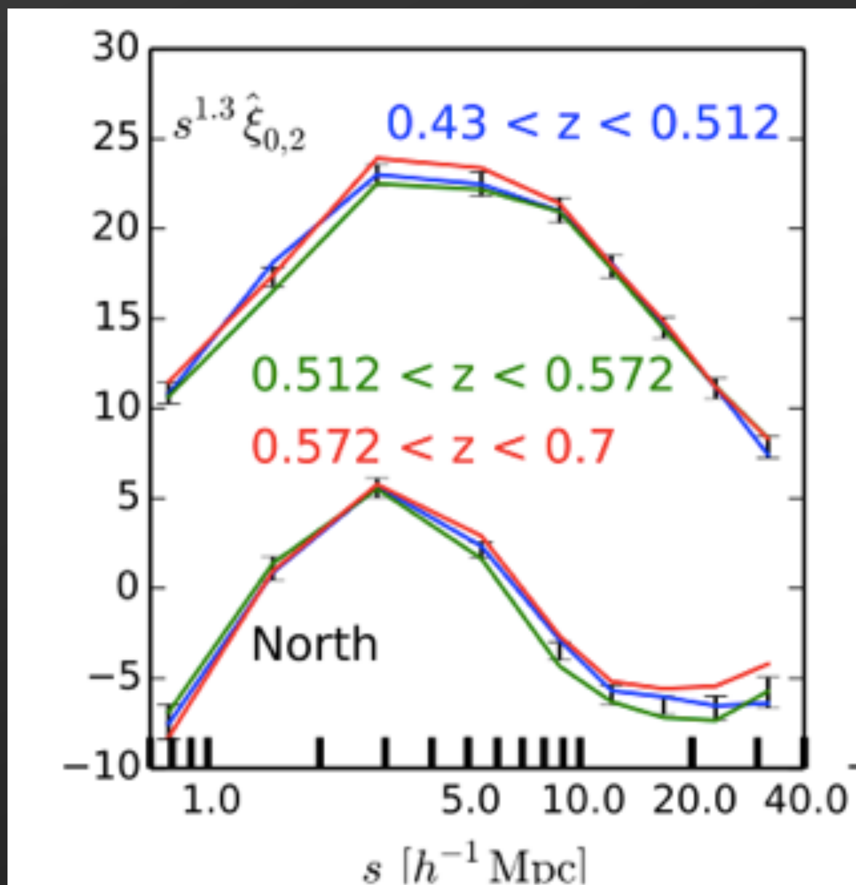


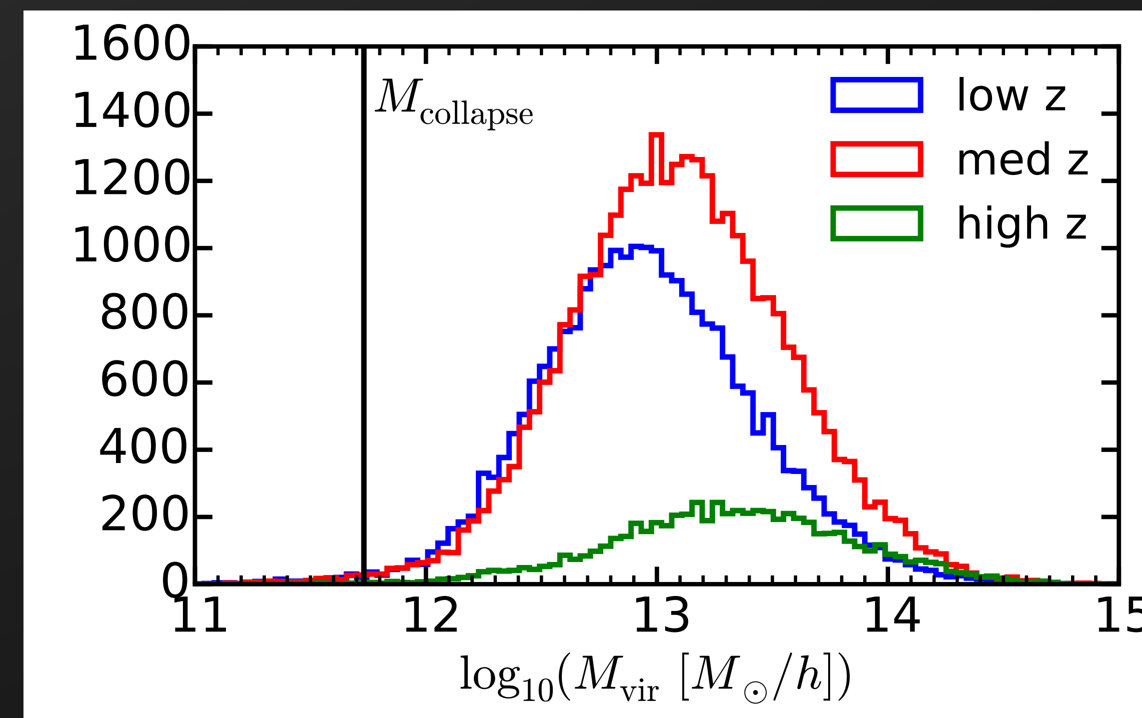


Mean halo mass (stellar mass) for the CMASS sample increases with z (factor of 3.5 for M_{halo})

BUT ...

A Fundamental Discrepancy





?

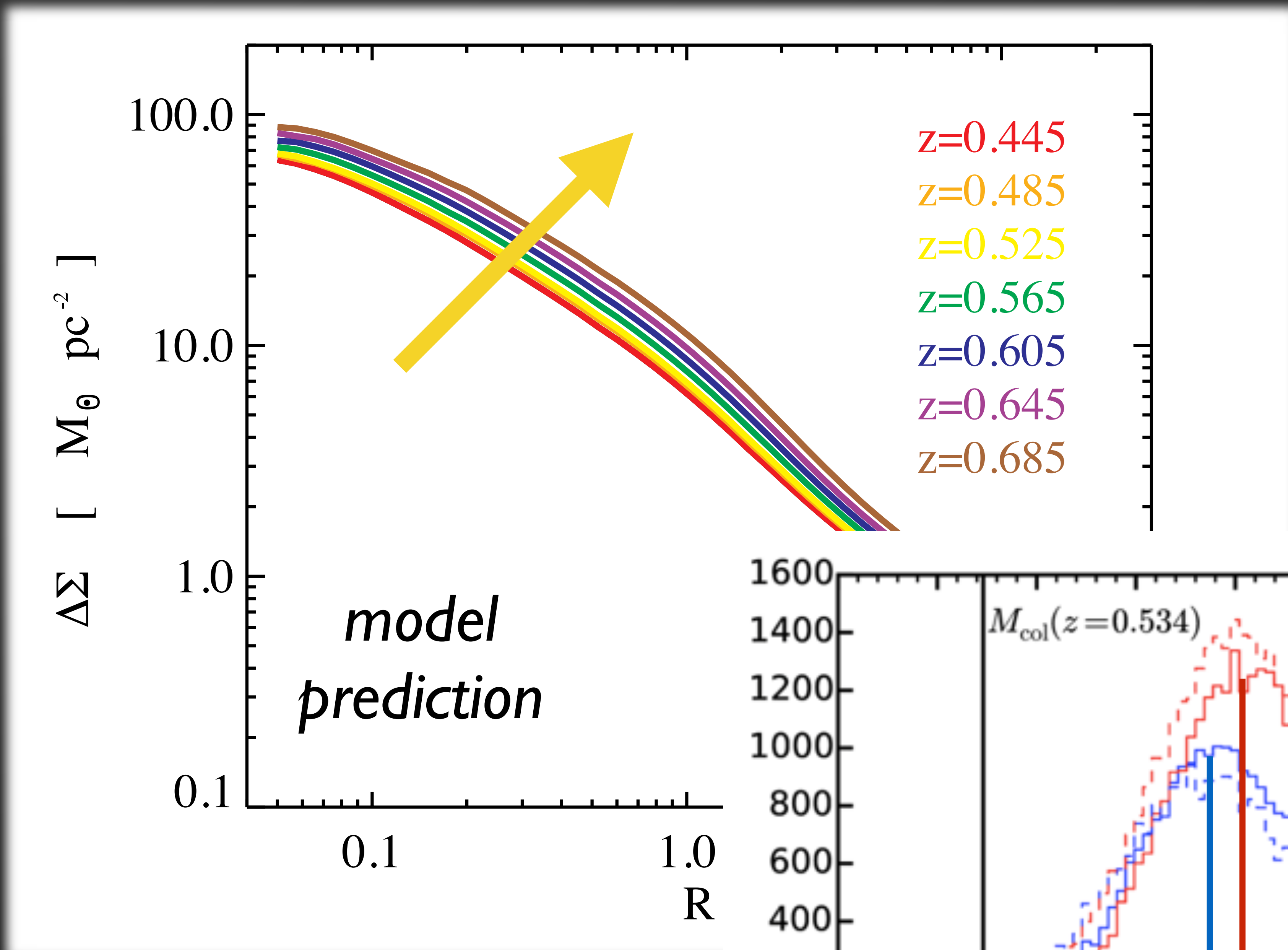
Redshift dependance of multipoles is constant with redshift (Reid et al. 2014)

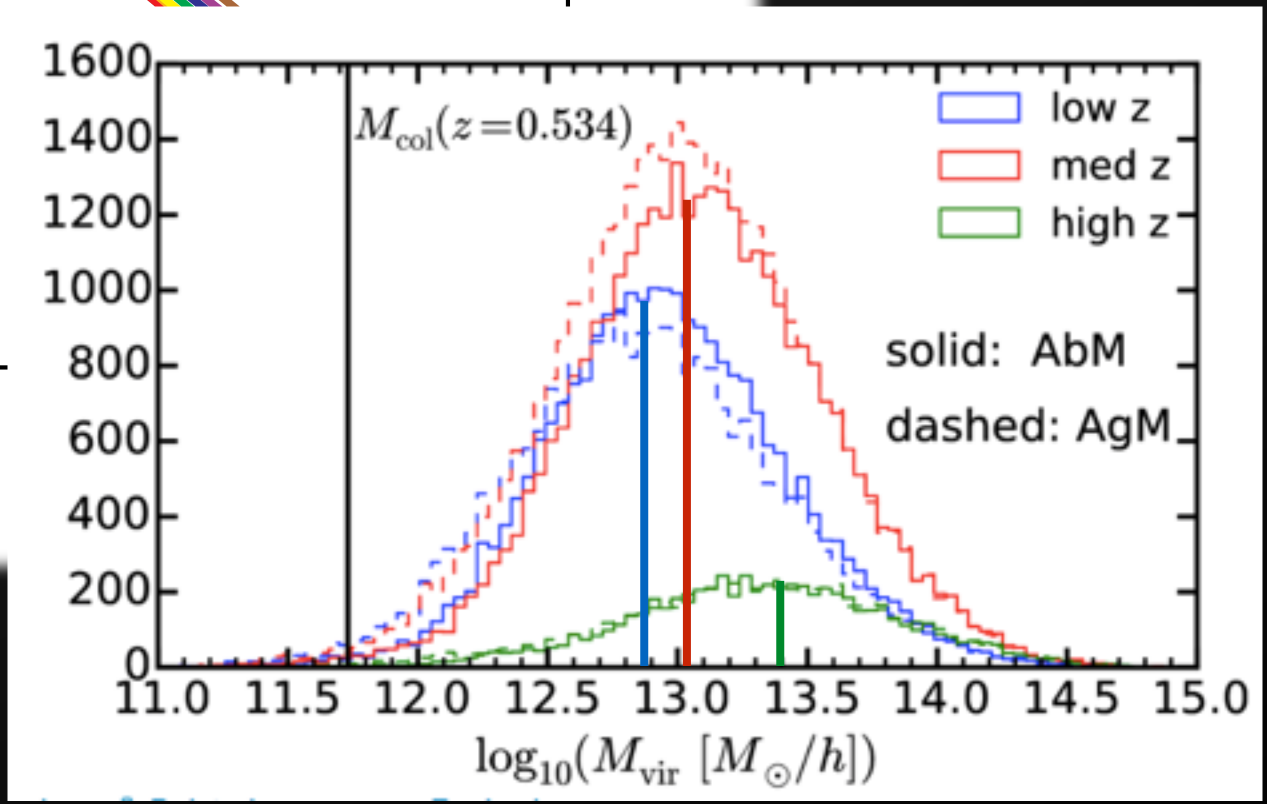
Mean halo mass (stellar mass) for the CMASS sample increases with z

Observable consequences for both clustering and lensing

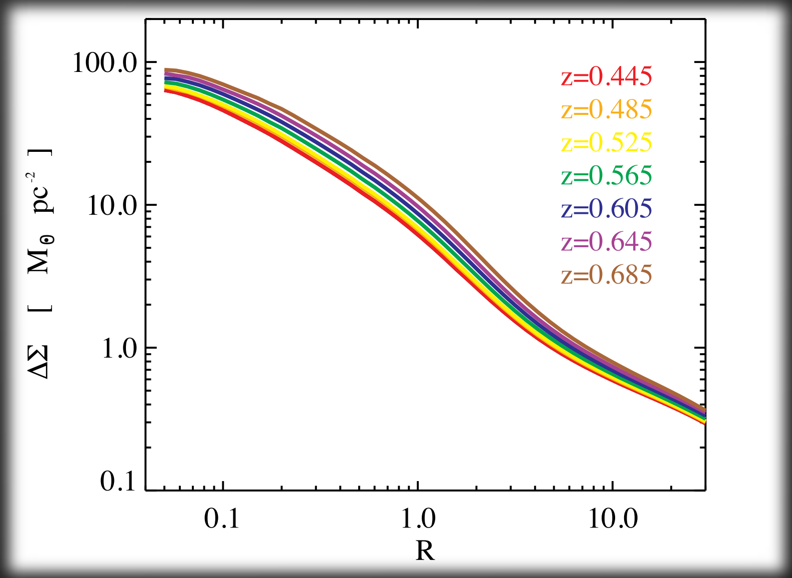
Evidence from Weak Lensing

Mean halo mass increases with z.

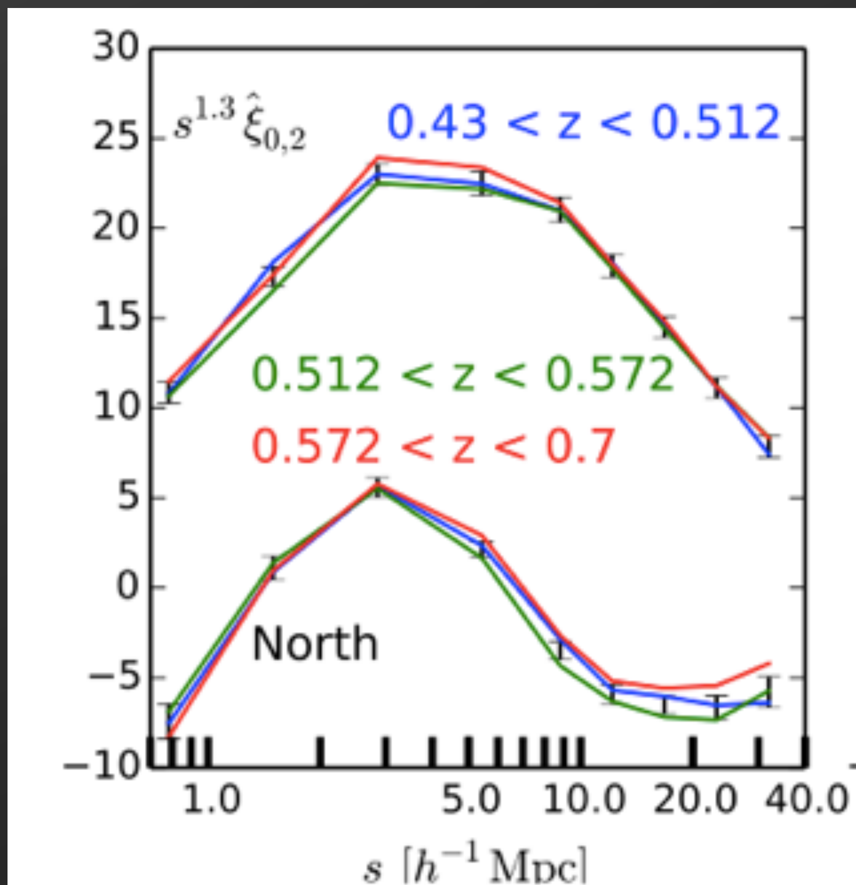




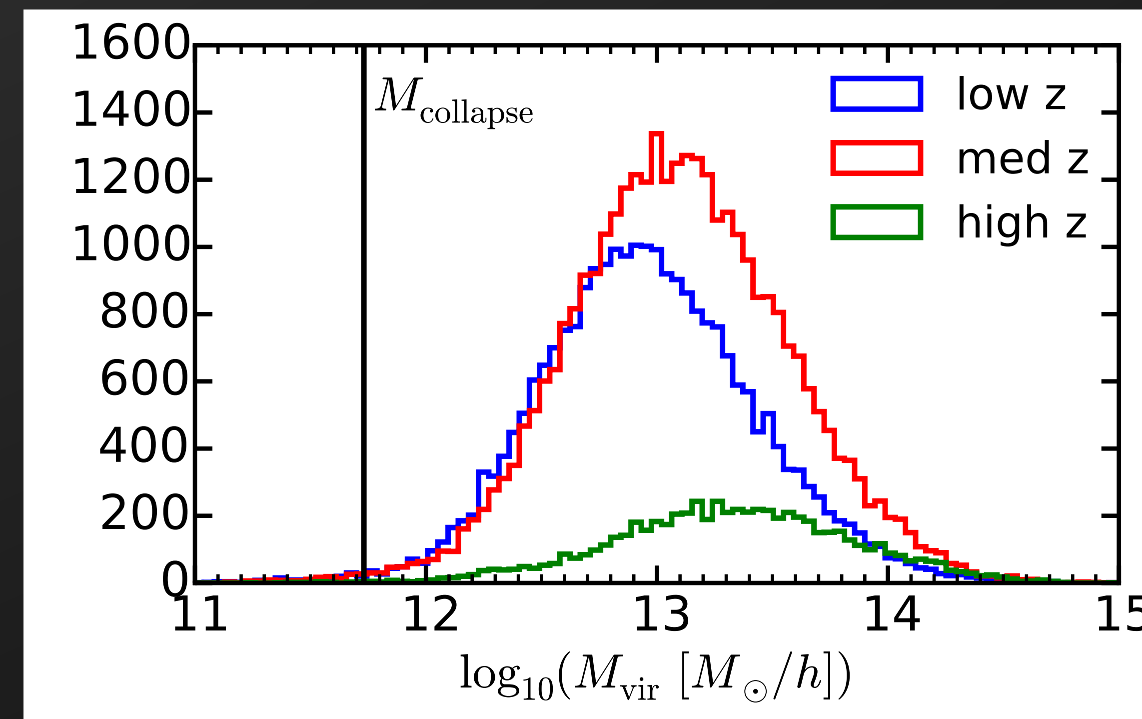
Evidence from Weak Lensing



Conclusion



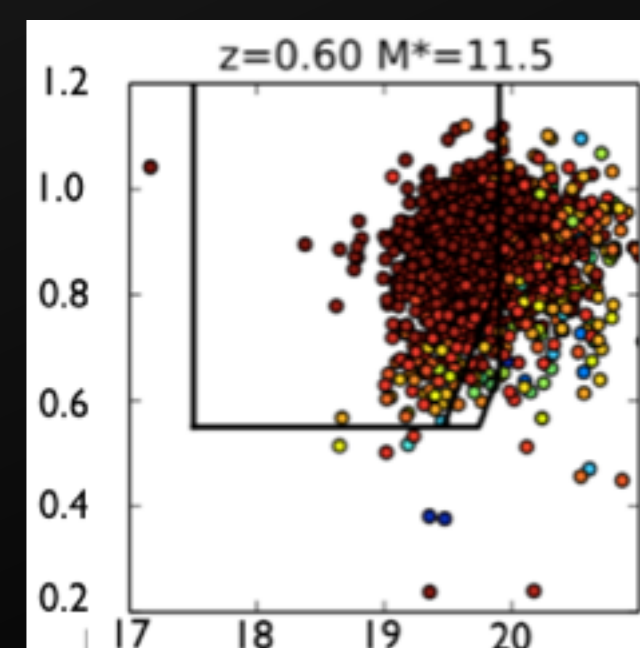
?



★ ~~Model: galaxy color in high mass halos is a stochastic process~~

stellar mass ⇔ V_{peak}

~~*assume color is un-correlated with other halo properties at fixed M**~~



Summary and Conclusions

- 2d redshift space clustering from BOSS and lensing from surveys such as HSC and DES = **tiny error bars!**
- Semi-linear scales, R=0.8 to 32 h^{-1} Mpc: **galaxy formation + cosmology**
- Stellar mass completeness for BOSS (Leauthaud et al. 2015)
- Galaxy-halo connection for massive galaxies at z=0.57?
  color in high mass halos is not a stochastic process at fixed stellar mass
- Velocity dispersions of satellites - check assumptions in previous papers on σ_{FOG}
- How robust are constraints on $f\sigma_8$?