Subhalo abundance matching to model galaxy-halo connection in the Baryon Oscillation Spectroscopic Survey

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(→ Max Planck Institut für Astrophysik from April 2016)

SS, Leauthaud, Hearin, Bundy, Zentner, Behroozi, Reid et al.
& the BOSS collaboration, will appear on arXiv soon

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Importance of Galaxy-Halo connection

✦ BOSS provides the tightest cosmological constraints to date.

✦ Need to be checked against ***realistic mock*** catalogs
where *a galaxy-halo model (e.g. HOD parameters) is assumed*.

✦ A brief summary of Alexie's talk

-S82MGC shows ***BOSS CMASS*** is **NOT** a 'Constant Stellar Mass' sample

-Complicated selection effect in a **redshift-dependent** way

color-cut at low z

luminosity-cut at high z

✦ Galaxy Formation: BOSS galaxies firmly above $10^{12}\,M_{sun}$

-'Hot' halo mode: what determines color of massive galaxies?

-not all dead and red: ~25% SF disk Masters et al. (2011)

~37% blue cloud Montero-Dorta et al. (2014)

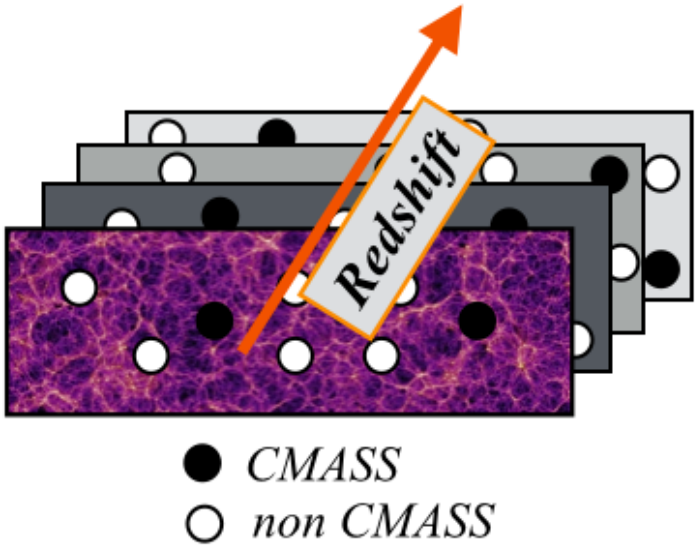
Modeling CMASS via SHAM

✦ Based on ***Subhalo Abundance Matching (SHAM)*** e.g., Kravstov et al. (2004)

- include the stellar mass incompleteness and reproduce dn/dz by design
- fit to total SMF and CMASS $w_p(r_p)$ at small scales [0.2-30 Mpc/h]

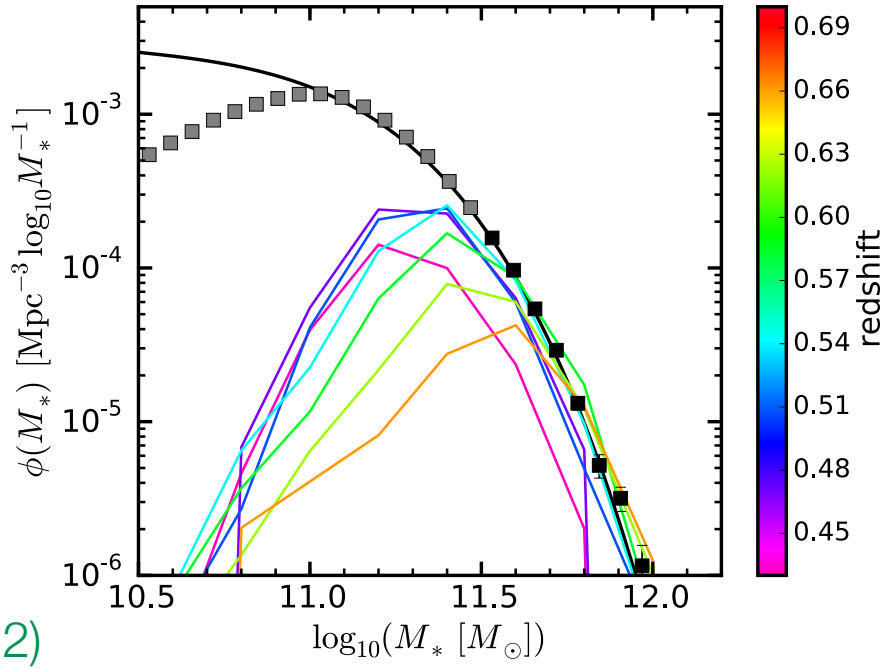
✦ First try "***Stochastic Color***" model

- once M* is specified, no correlated b/w color & other halo properties
- only need to account for stellar mass completeness of CMASS

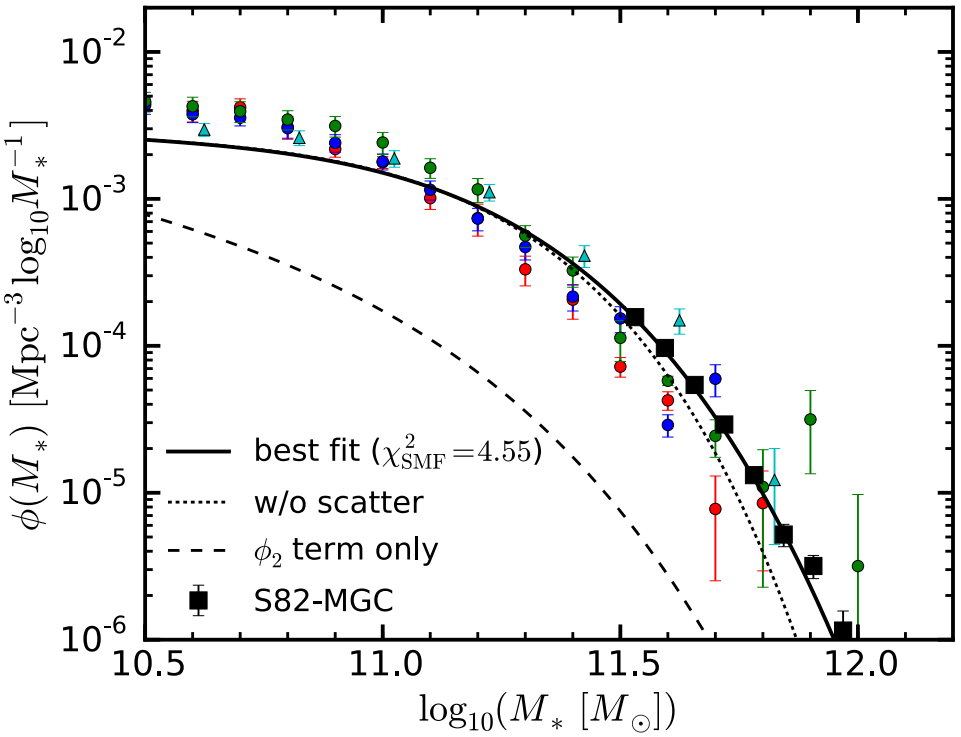


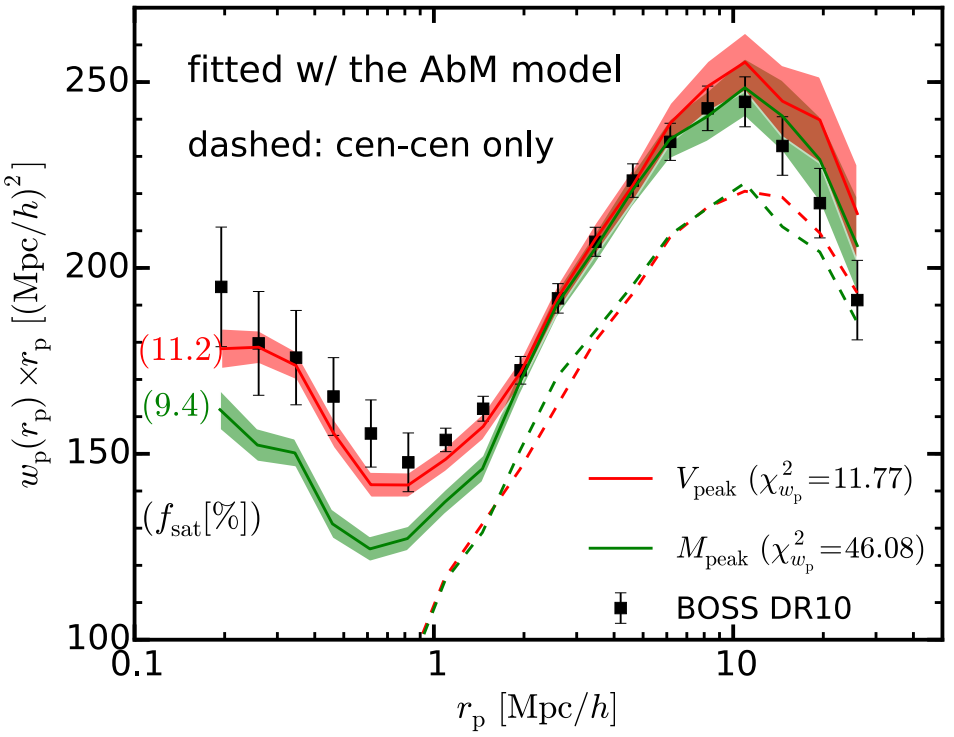
Multidark 1Gpc/h simulation

Prada et al. (2012)



Results of the Stochastic Color model





- ✦ Our mock well fits to S82-MGC SMF & BOSS CMASS w_p.
- ✦ SHAM w/ V_{peak} fits better than M_{peak}. Reddick et al. (2013) Chaves-Montero et al. (2015)
- ✦ small scatter, $\sigma_{P(M^*|Vpeak)}$ = 0.1 Shanker et al. (2015)

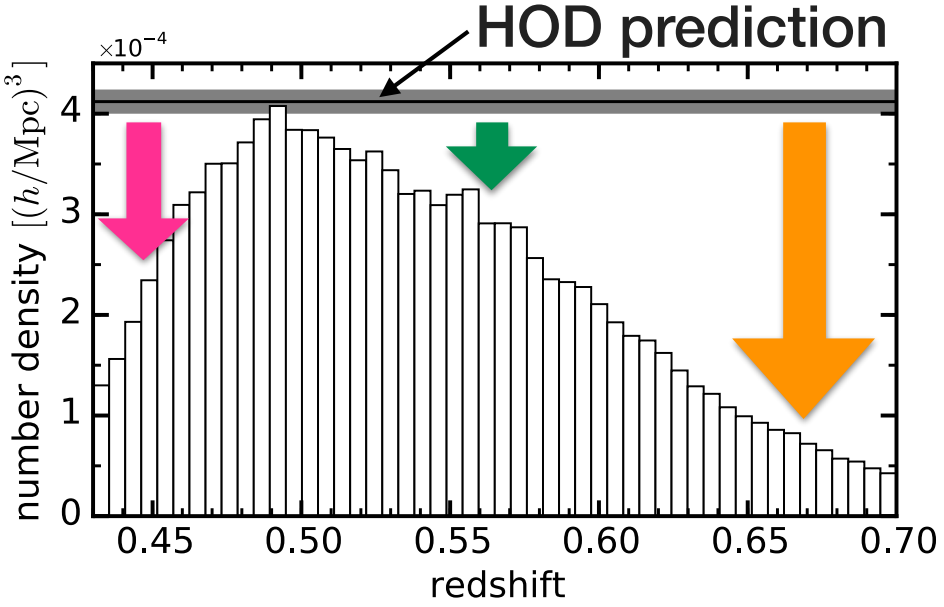
Results of the Stochastic Color model

✦ constant HOD

White et al. (2011) & Reid et al. (2014)

- needs to be randomly down-sampled

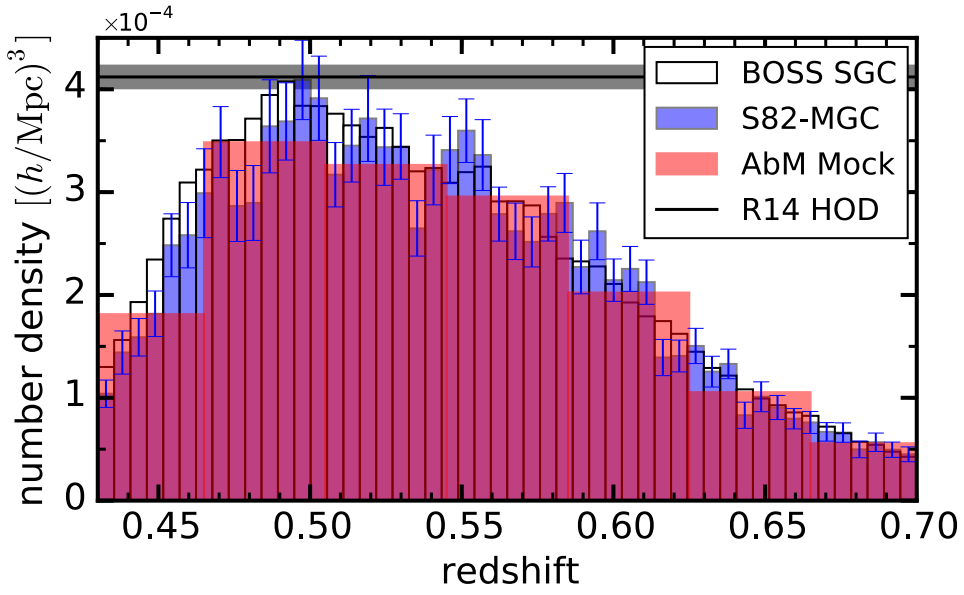
- clustering **does NOT** evolve



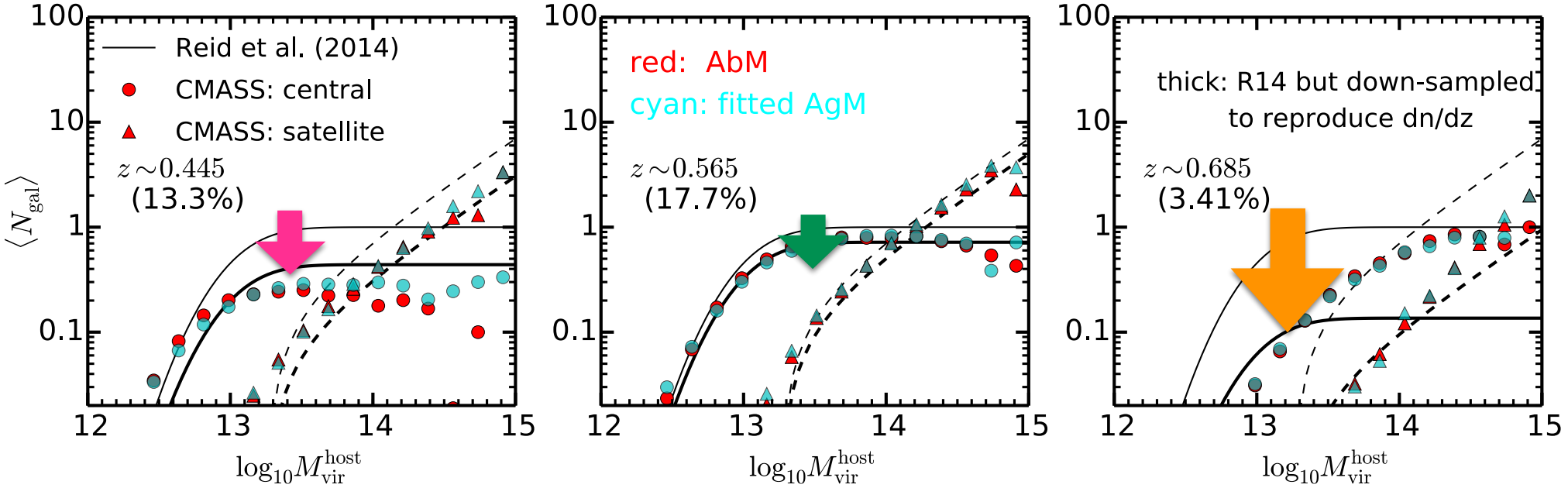
✦ Our SHAM model

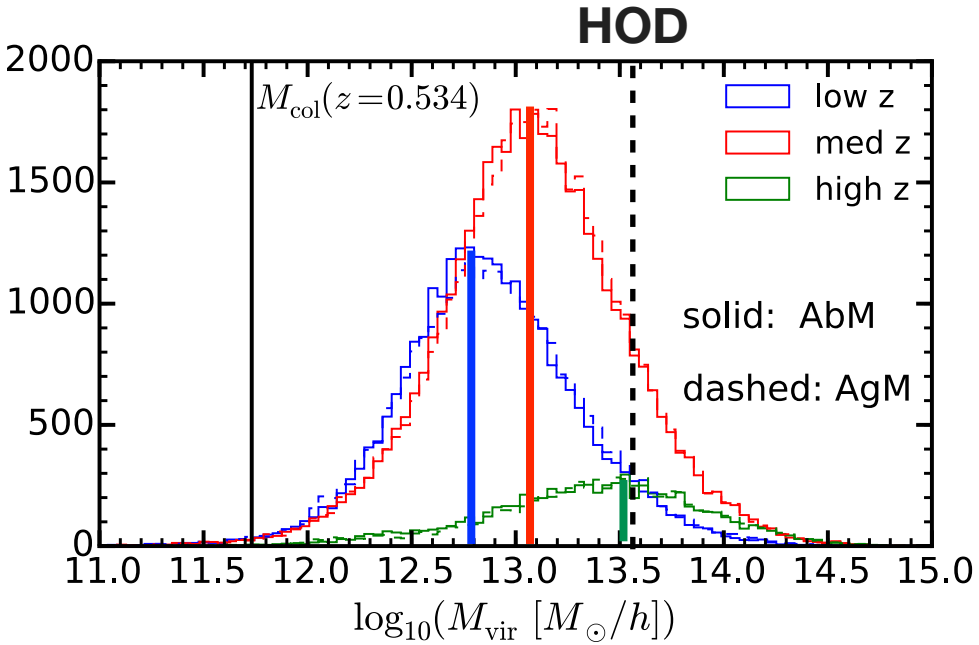
- reproduce dn/dz by construction as a consequence of CMASS incompleteness

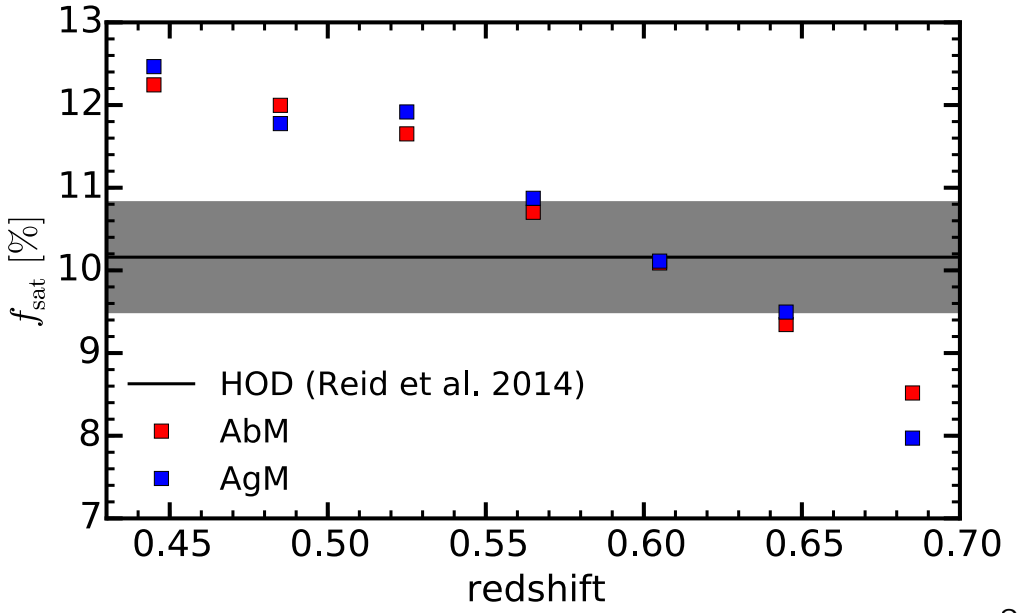
- clustering DOES evolve (see next)



Evolution of HOD with Redshift

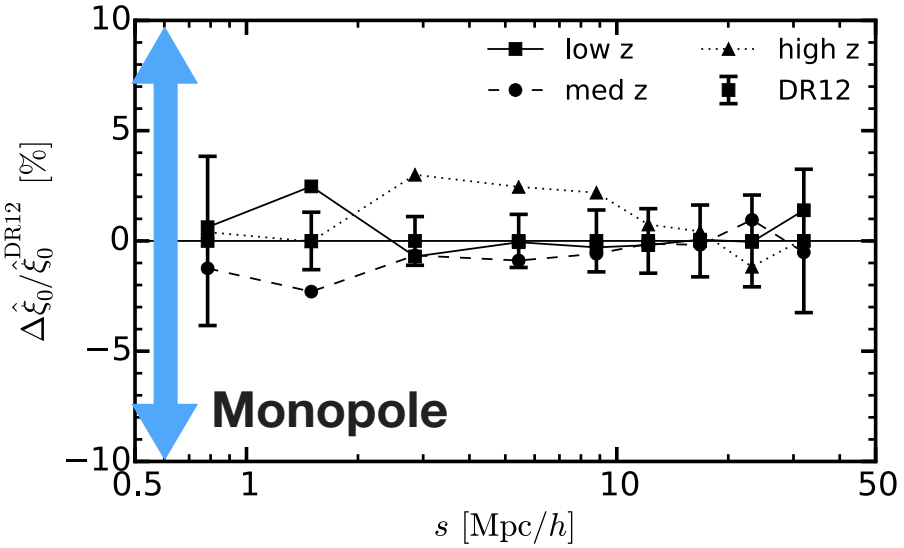


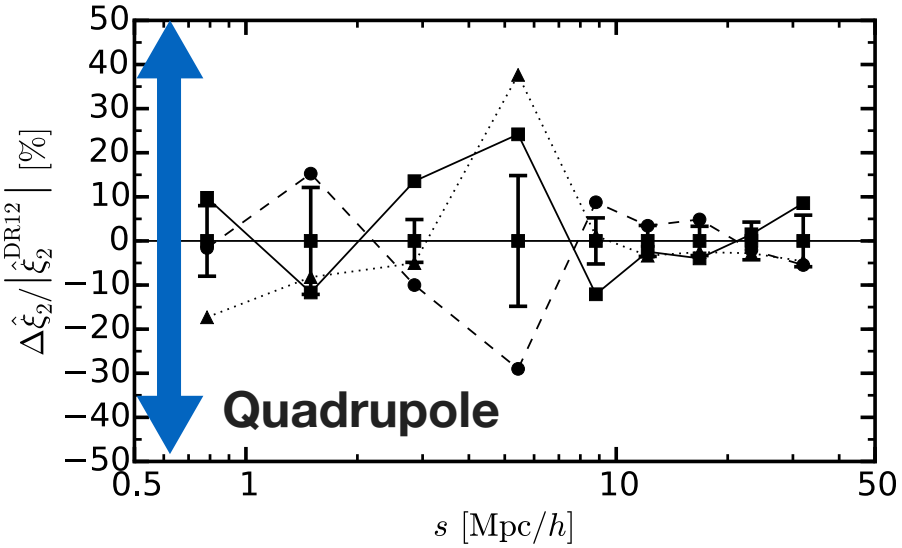




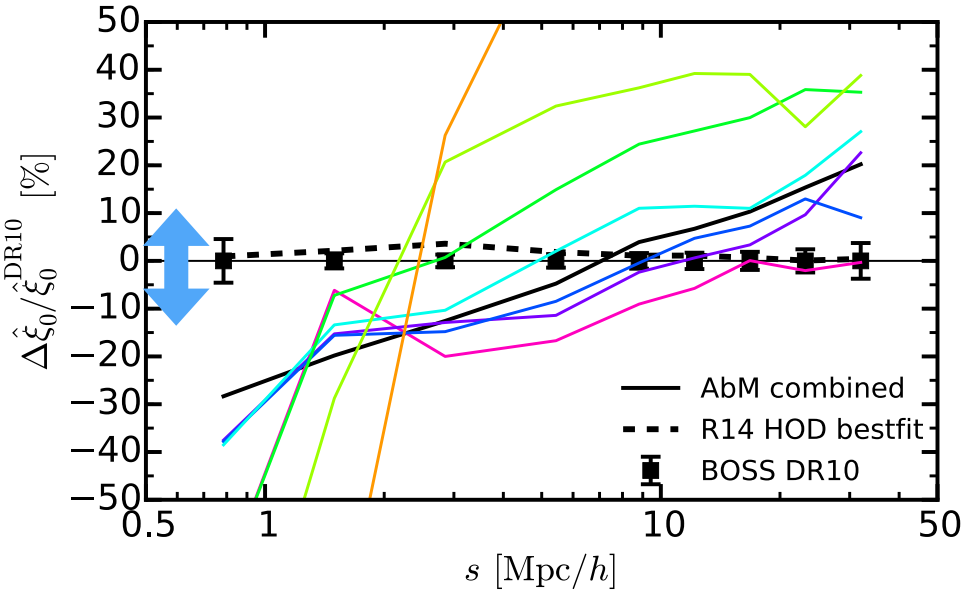
But …fails for 3D Clustering Signal

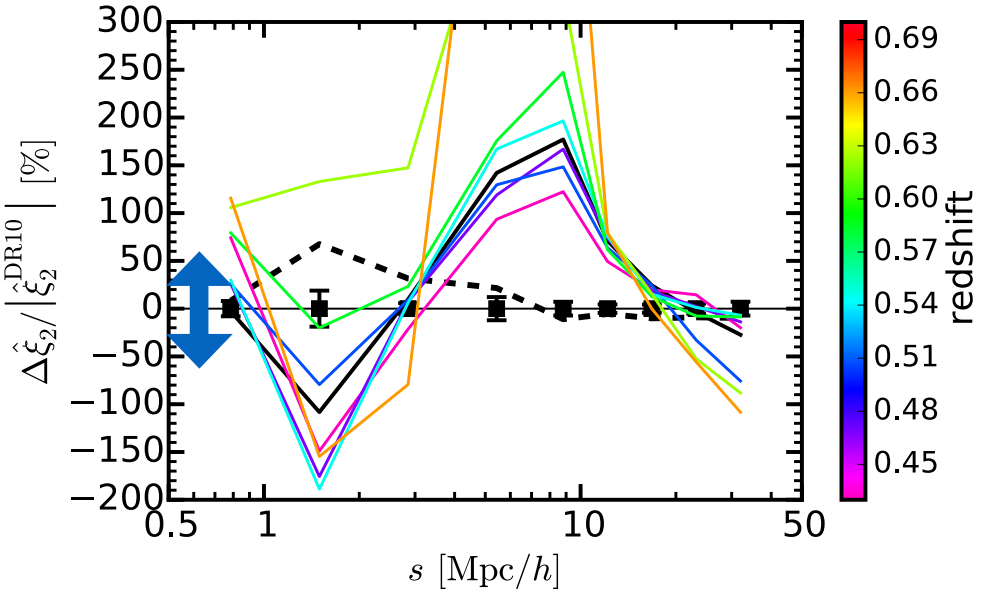
✦ The measurements show **NO** redshift evolution





✦ Our “Stochastic Color” model





Failure of "Stochastic Color" model

- "Stochastic Color" model is highly ruled out by the data
  - CMASS SMFs show a higher $\overline{M}_*$ at higher redshift
  - therefore, $\overline{M}_{\rm halo}$ also evolves with time
  - However, data shows NO redshift evolution

- Next step:
  - There must be an effect which can compensate the evolution
  - At fixed stellar mass, introduce correlation galaxy color with
    - halo formation epoch (or age)
    - halo recent merger
    - local density (or environment)
  - Goal: explain DR12 $\hat{\xi}_\ell(s; color, z)$ & lensing (Alexie's talk)

Conditional SHAM: **Age Matching**

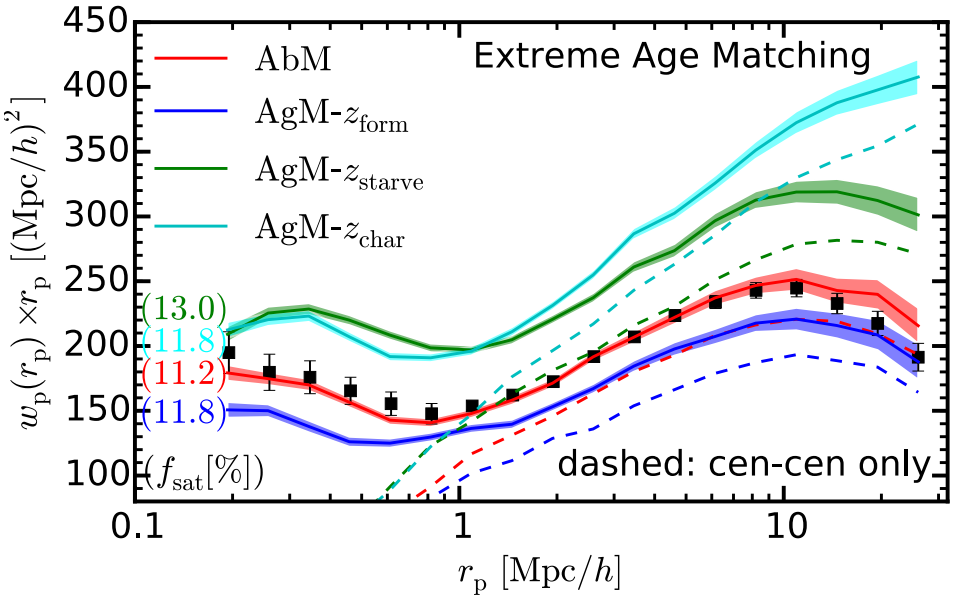
✦ At fixed stellar mass, "a ***redder*** galaxy tends to be hosted by an ***older*** halo"

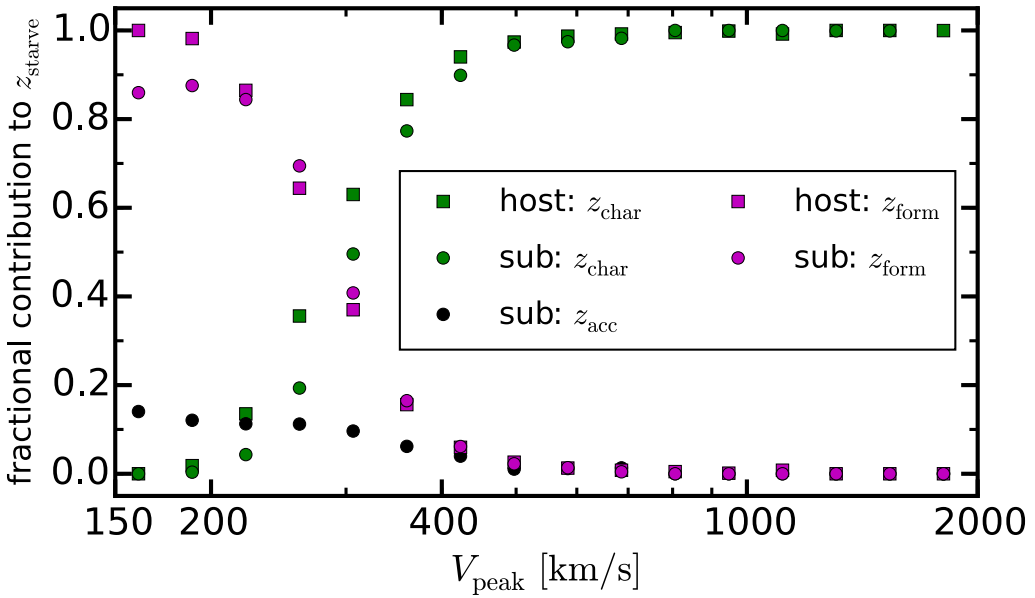
$$P(M_*|V_{\rm peak}) \rightarrow P(M_*, color|V_{\rm peak}, z_{\rm starve})$$ Hearin et al. (2013)

✦ 3 components in $z_{\rm starve}$

- $z_{\rm form}$: (sub)halo's concentration c.f., Miyatake et al. (2015)
- $z_{\rm char}$: when a (sub)halo get mass of 10^{12} $M_{\rm sun}$
- $z_{\rm acc}$: when a subhalo accreted onto its host halo

✦ The effect of **assembly bias** depends on definition of formation time





Velocity effect

✦ Should be careful on “velocity” to model redshift-space clustering

✦ Difference b/w **our SHAM model** & **HOD** (Reid et al. 2014)

1) velocity of central

Rockstar: core velocity defined within [0-0.1] r_{vir}

SO halos: core velocity defined within [0.06-0.33] r_{vir}

c.f.) Guo et al. (2014): defined within [0-0.25] r_{vir} + velocity bias

2) velocity of satellites

SHAM: the same as central

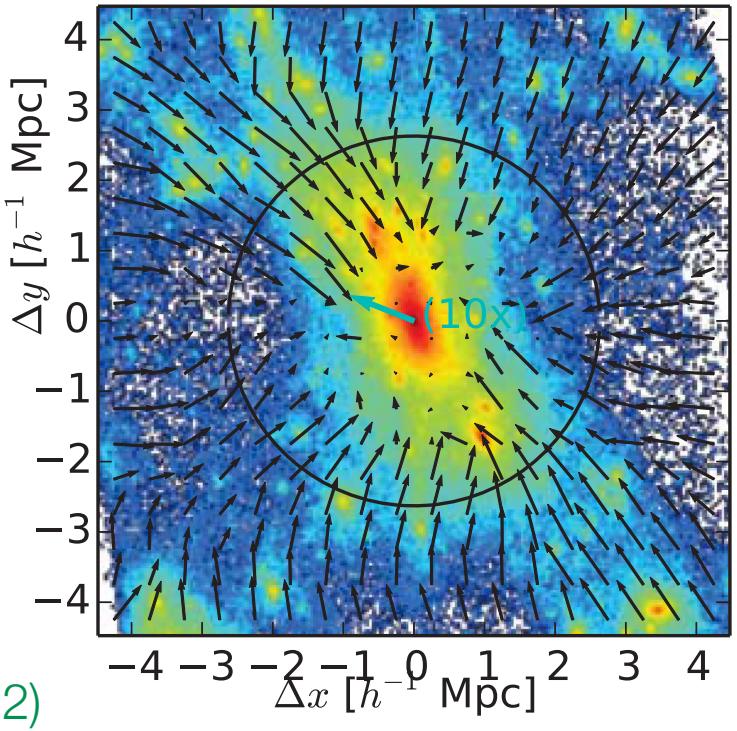
Reid et al. (2014): velocity of DM

✦ hydro simulation Wu et al. (2014)

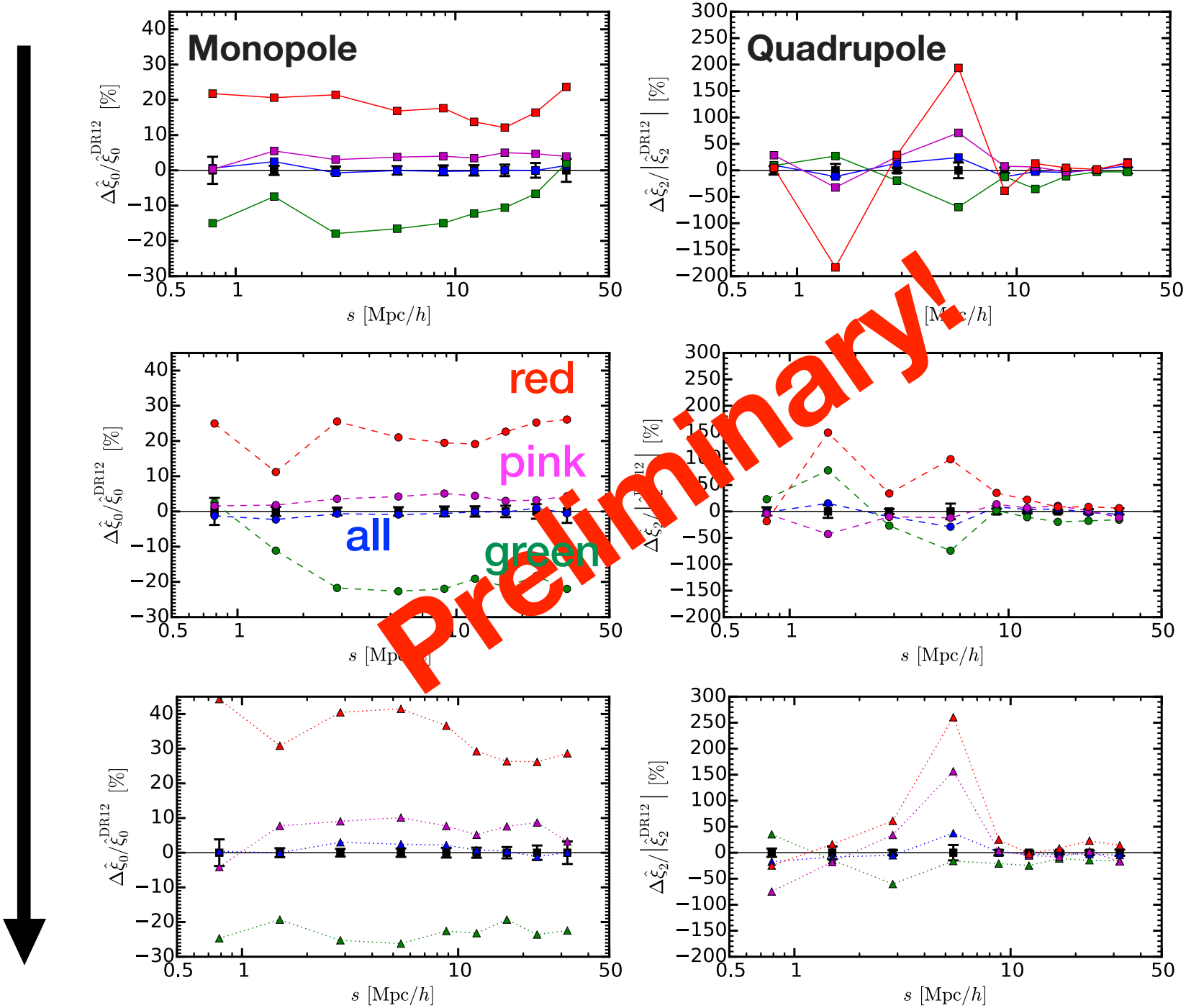
But I suggest to look at pairwise velocity

$$1+\xi(r_{\rm p},\pi)=\int dy[1+\xi(r)]\mathcal{P}(v_{12},\mathbf{r})$$

Scoccimarro (2004), Reid & White (2012)



Color and Redshift-dependent 3D clustering



Summary

- A realistic model of the CMASS-Halo connection is essential

- The CMASS SMFs in S82MGC varies as a function of z, therefore a simple SHAM ('Stochastic Color') model is ruled out

- Hope is a conditional SHAM such as *age matching* by introducing correlation b/w galaxy color & halo formation epoch

- However, there are caveats at massive end:
  - no unique definition of "halo age"
  - ambiguity to define "velocity" of subhalo (or galaxy)

Stay Tuned!