Constructing the connection between dark matter halos and emission line galaxies (ELGs)

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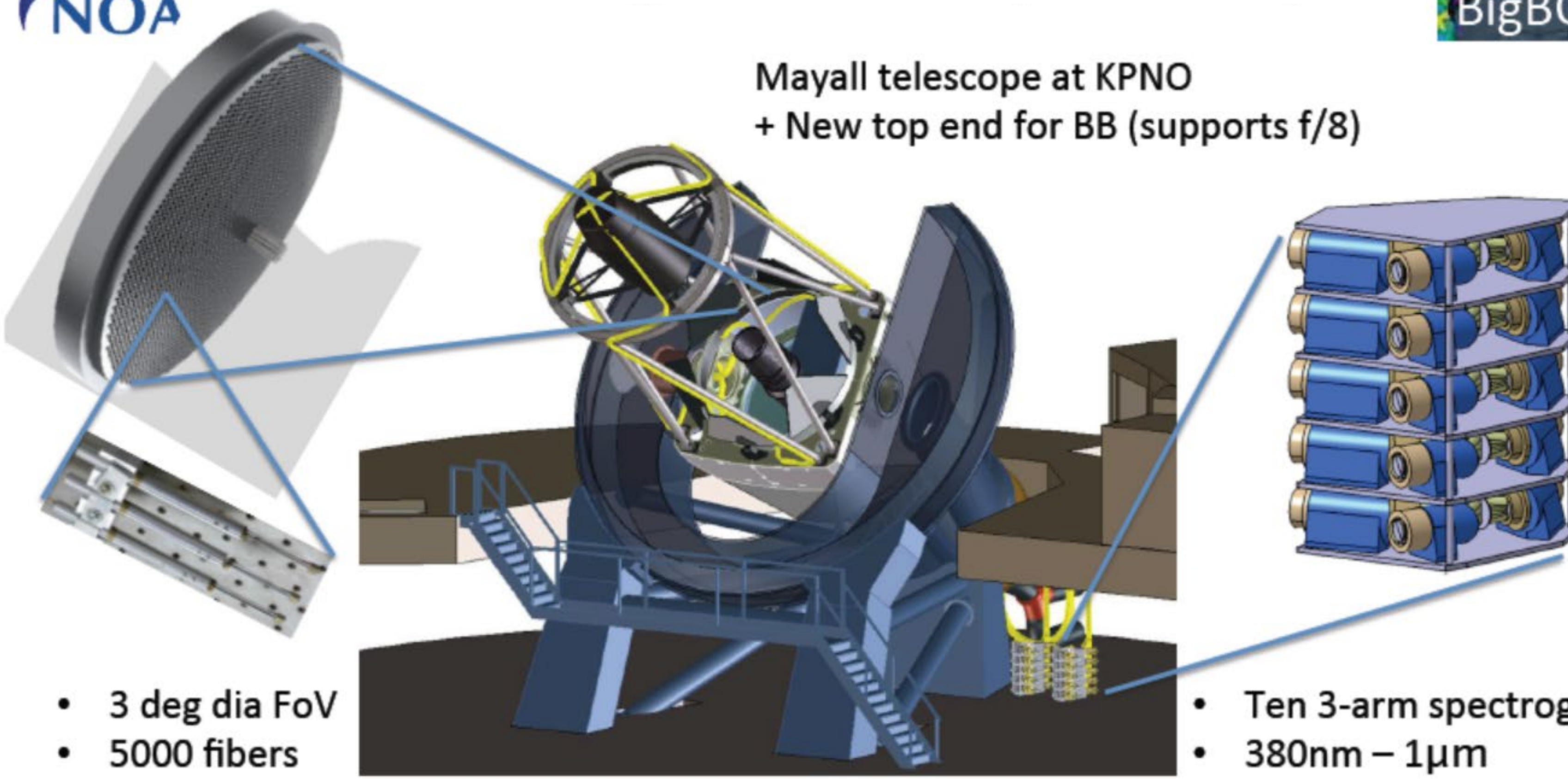
DESI--Dark Energy Spectroscopic Instrument

DESI Capability



- 3 deg dia FoV
- 5000 fibers

- Ten 3-arm spectrographs
- 380nm – 1μm

Nearly 40,000 spectra per night!!

See Natalie Roe's talk!

DESI 光谱观测样本

Summary: A new baseline

SV3 LRG	0.3–1.0	g,r,z,$W1$	600	565	500	7.0 M
SV3 ELG	0.6–1.6	g,r,z	1950	1420	910	12.7 M
SV3 QSO (tracers)	< 2.1	g,r,z,$W1$,$W2$	210	210	140	1.96 M
SV3 QSO (Ly-α)	> 2.1	g,r,z,$W1$,$W2$	100	295	60	0.84 M
Total in dark time			**2860**	**2490**	**1619**	**22.5 M**
SV3 BGS	0.05–0.4	r (Gaia G)	860	688	678	9.5 M
SV3 BGS–Faint	0.05–0.4	r (Gaia G)	540	324	317	4.4 M
SV3 MWS	0.0	g,r (Gaia μ)	800+	720	720	10.1 M
Total in bright time			**2200+**	**1732**	**1715**	**24.0 M**

观测样本巨大：3000万+ 河外天体

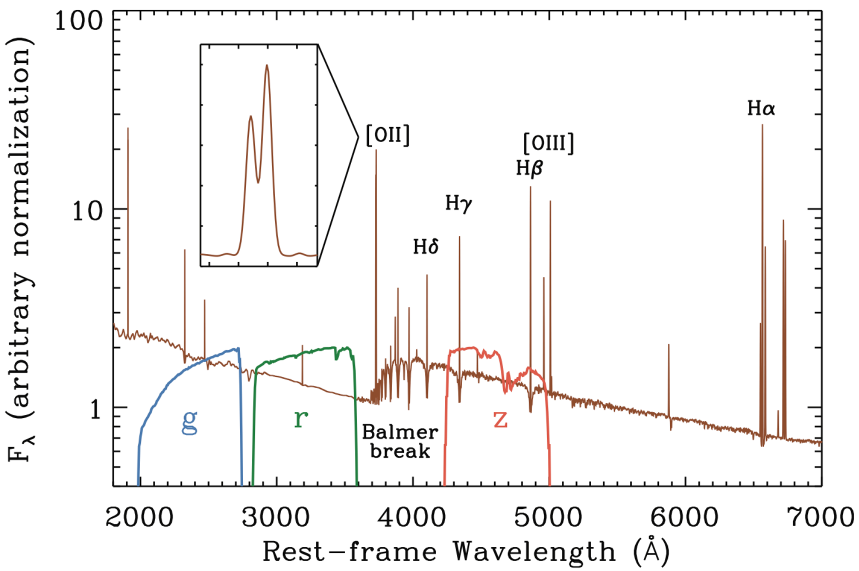
但是 LRG、ELG、QSO都是选择性很强的样本

它们与暗物质分布之间的关系？

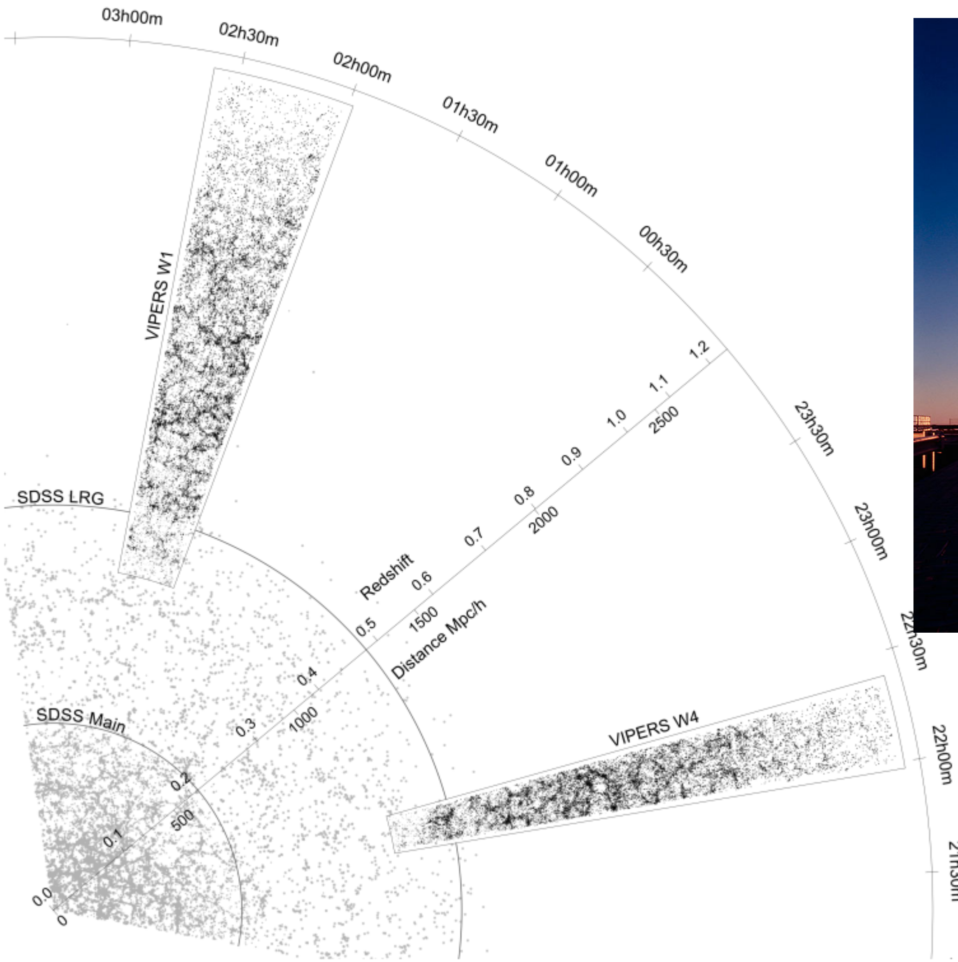
Emission line galaxies (ELGs) vs host DM halos

- *ELGs are the main target of DESI, PFS,Euclid,Roman*
- *They have strong OII lines that can be detected with a resolution 3000-5000*
- *The relation important for cosmology and galaxy formation*

- *An optical spectrum of a typical Emission Line Galaxy (ELG)*

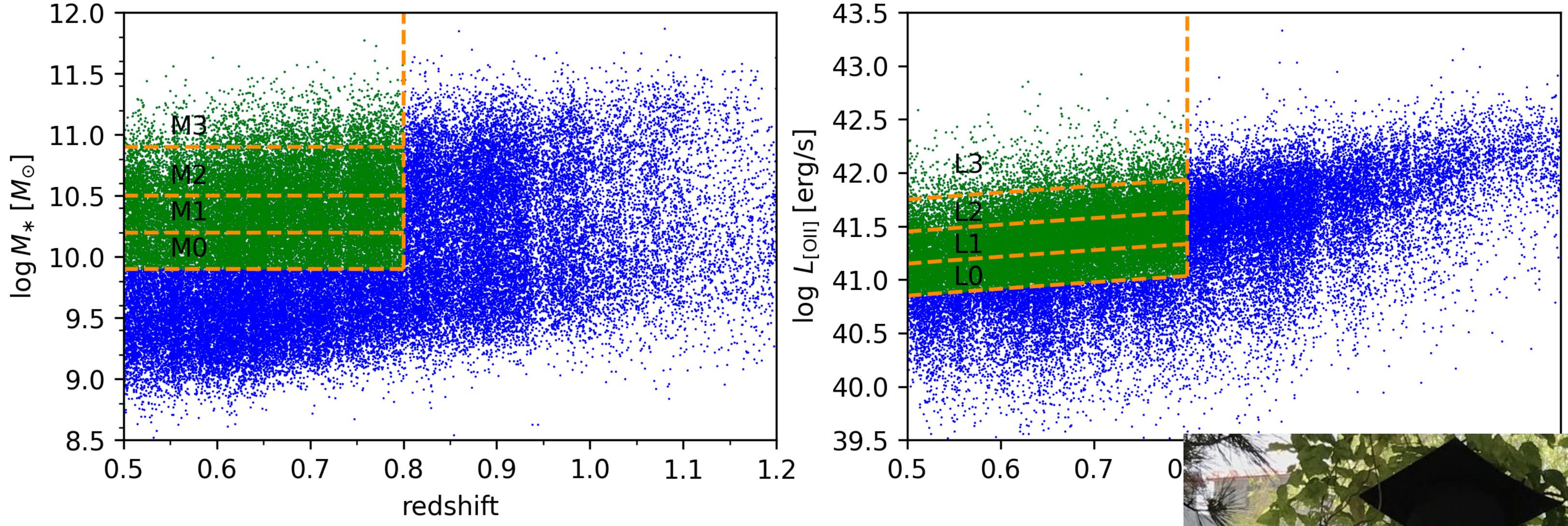


VIMOS Public Extragalactic Redshift Survey(VIPERS)at VLTs



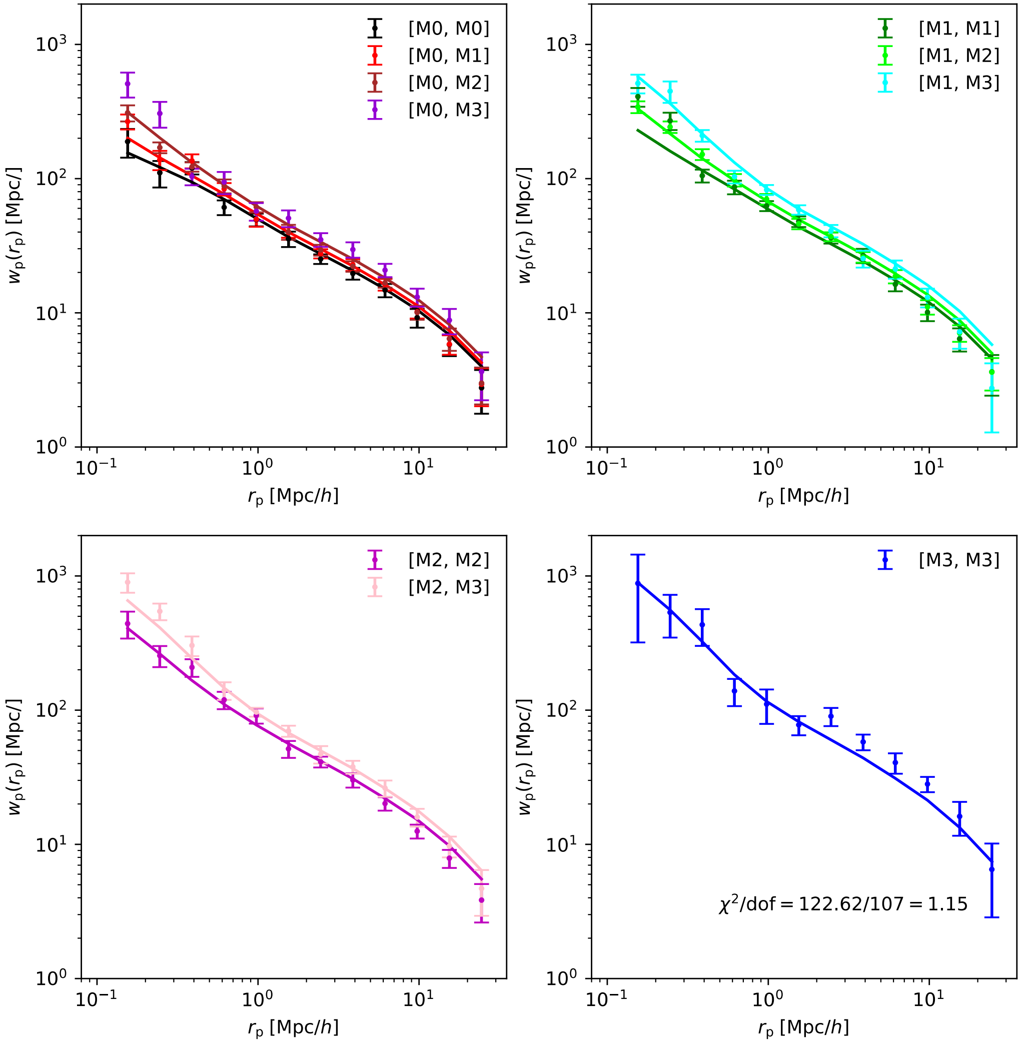
Subsamples used

- *4 samples divided by stellar mass (normal galaxies)*
- *4 samples divided by OII luminosity (ELGs)*

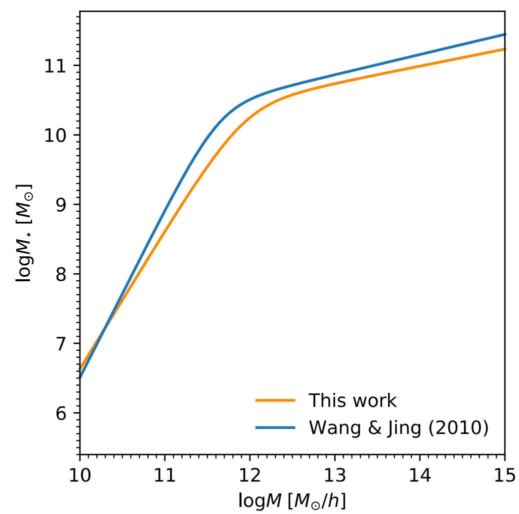


Hongyu Gao (高鸿宇）,YPJ, Yun Zheng, Kun Xu, ApJ (2022)

Normal galaxies

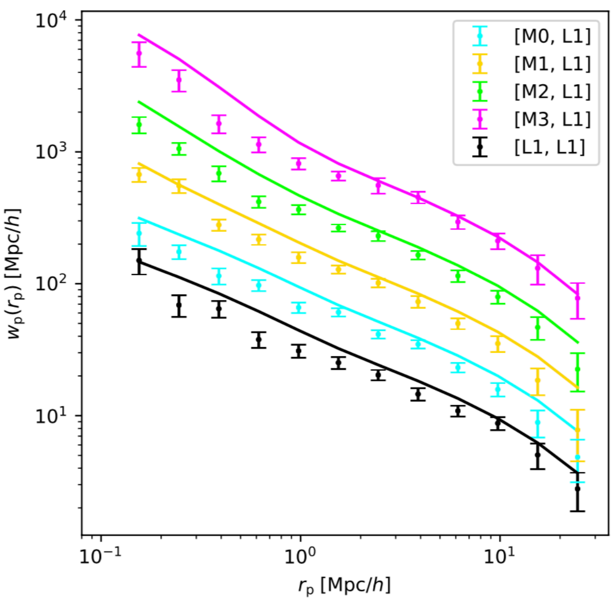


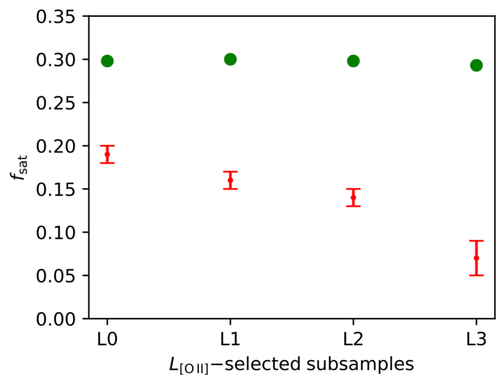
Stellar mass halo mass relation

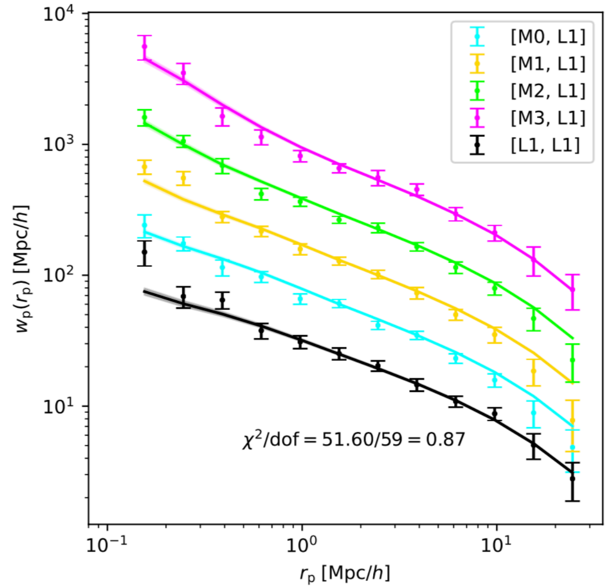


The relation of ELGs with Dark Matter halos

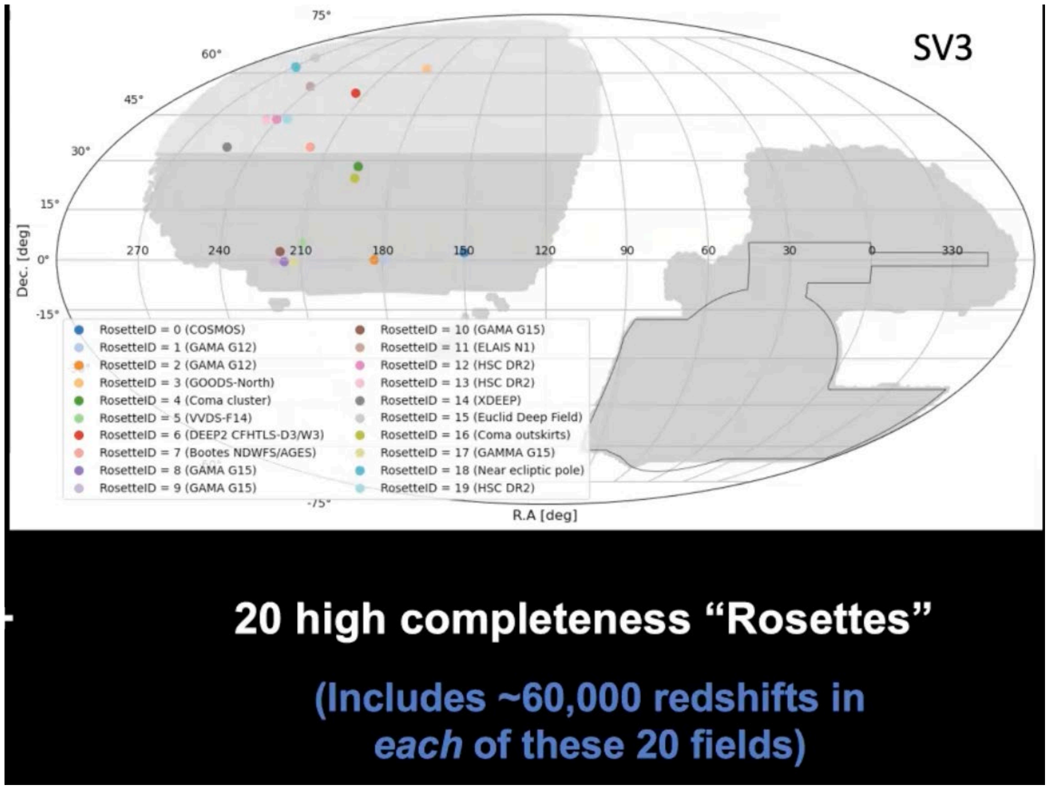
***Main conclusion:** The stellar mass-(sub)halo mass relation (SHMR) of normal galaxies is valid for ELGs, once the satellite fraction is properly reduced*







Using SV3 fields

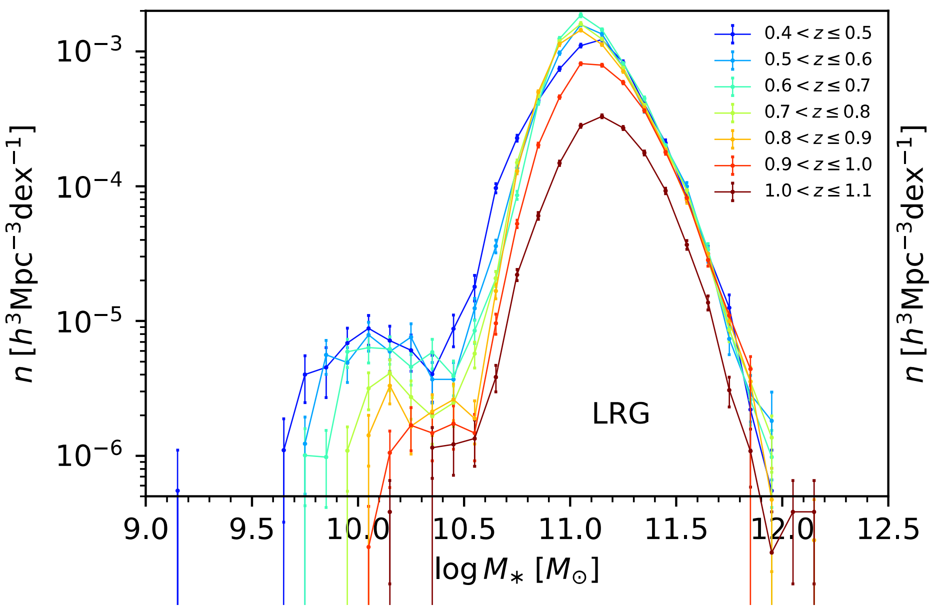


Gao,H, YPJ, et al. 2023, arXiv:2306.06317

Measuring Physical Properties

- BC03 Stellar Population Synthesis (SPS) library (Bruzual & Charlot 2003)
- Chabrier (2003) IMF
- Metallicities Z /Z_sun= 0.4, 1 or 2.5
- SFH -Delayed $\psi(t) = 1\mathrm{M}_\odot \; \tau^{-2} \, t \, \exp(-t/\tau)$
- With 32 τ=0.01 to 12.6 Gyr with Δlogτ=0.1
- Extinction Law: Calzetti Law
- EBV range: 0.0-0.50
- Using Le Phare code to fit the photometric data with the templates

Number distribution vs stellar mass $M_\star$



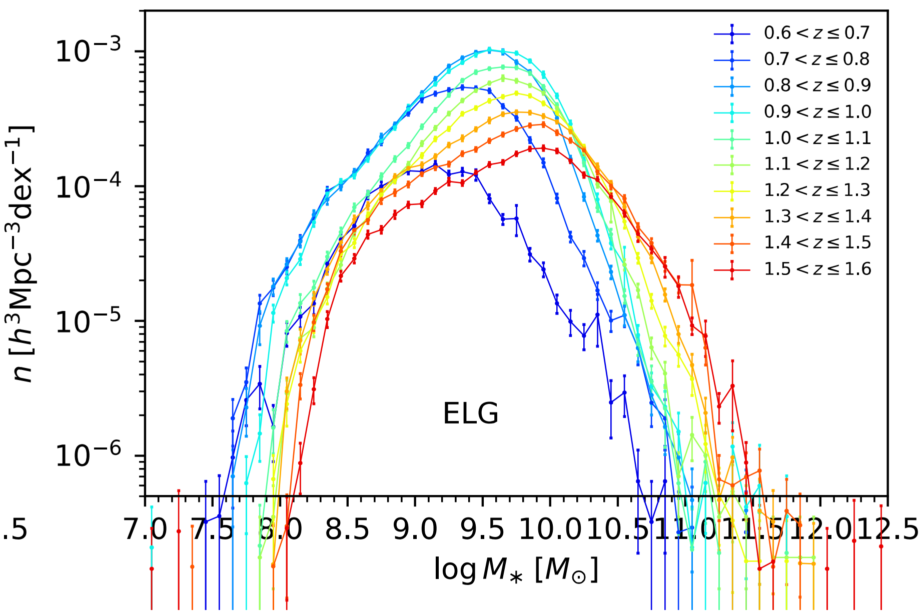


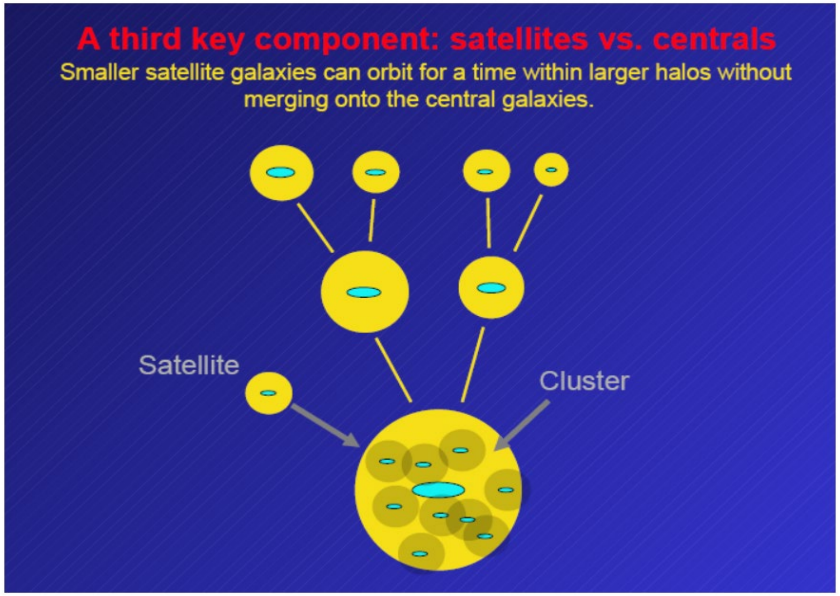
Table 1. Details of four LRG subsamples.

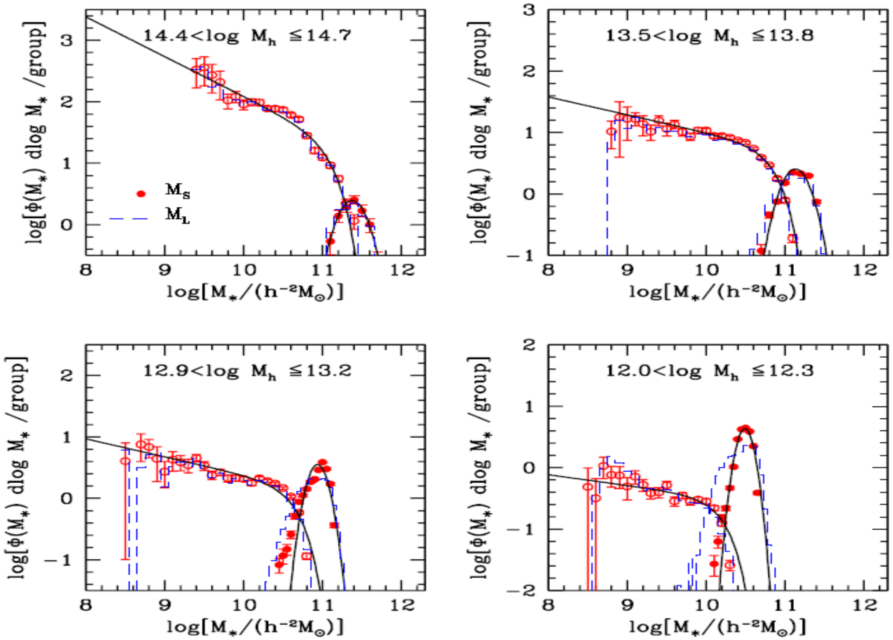
Name	Redshift Range	$\log M_*\,[M_\odot]$	N_g
LRG0	$0.8 < z \leq 1.0$	$[11.1, 11.3]$	13906
LRG1	$0.8 < z \leq 1.0$	$[11.3, 11.5]$	4834
LRG2	$0.8 < z \leq 1.0$	$[11.5, 11.7]$	957
LRG3	$0.8 < z \leq 1.0$	$[11.7, 11.9]$	124

Table 2. Details of four ELG subsamples.

Name	Redshift Range	$\log M_*\,[M_\odot]$	N_g
ELG0	$0.8 < z \leq 1.0$	$[8.5, 9.0]$	9481
ELG1	$0.8 < z \leq 1.0$	$[9.0, 9.5]$	29764
ELG2	$0.8 < z \leq 1.0$	$[9.5, 10.0]$	34155
ELG3	$0.8 < z \leq 1.0$	$[10.0, 10.5]$	6583

Empirical approach: Galaxies in halos





Have determined galaxies in halos using

1、 Halo Occupation Distribution (Jing et al. 1998;Zheng et al. 2005)

2、 Conditional Luminosity Function (Yang X.H. et al. 2003; 2006)

3、 Group catalogs (Yang et al. 2004,2007,2008-2009)

4、 Abundance Matching Method (L. Wang et al. 2006; Wecshler et al.2006)

5、 reconstruction simulation (H.Y. Wang et al. 2016)

Modeling ELGs

- *ELGs subject to complicated target selections (color and mag.cuts)*
- *Incomplete and changes rapidly with redshift*
- *Although HOD are being attempted by people in the collaboration, I believe Abundance Matching better suits for the complicated TS*

Abundance Matching

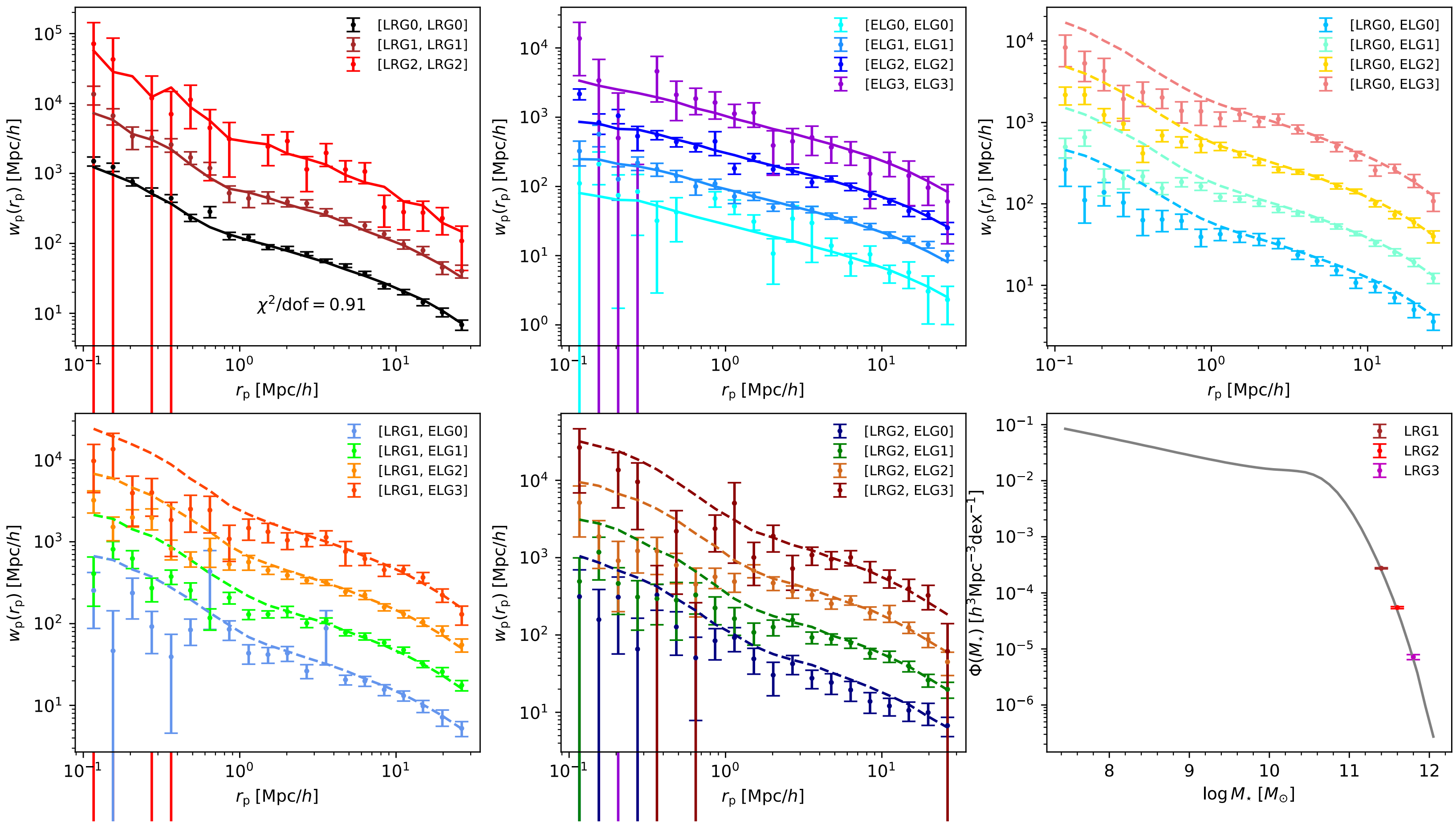
- *Use high resolution simulation CosmicGrowth (Jing 2019) to model the observed $w_{xy}(r_p)$*
- *Halos and subhalos identified with HBT(Han et al 2012)*
- *Assuming a lognormal distribution for M_* of scatter σ, use Abundance Matching (AM) method with two forms,*
  - *Double Power law (DP):*
    - *five parameters*

$$M_* = \left[\frac{2k}{(M_{acc}/M_0)^{-\alpha} + (M_{acc}/M_0)^{-\beta}} \right]$$

The same clustering and density

- *Step1: Following Gao et al 2022,we assume that central ELGs follows the same SMHR as the whole population, but the satellites are reduced to the fraction $0 < P_{sat} < 1$ in a halo of mass M_{acc} (the same clustering)*
- *Step2: assuming we get the number density $n_{can}(M_\star)$ from Step 1, we normalize the density to the observed one $n_{obs}(M_\star)$ by randomly selecting with the probability $F^{ELG} \equiv \frac{n_{obs}(M_\star)}{n_{can}(M_\star)}$ (the same density)*

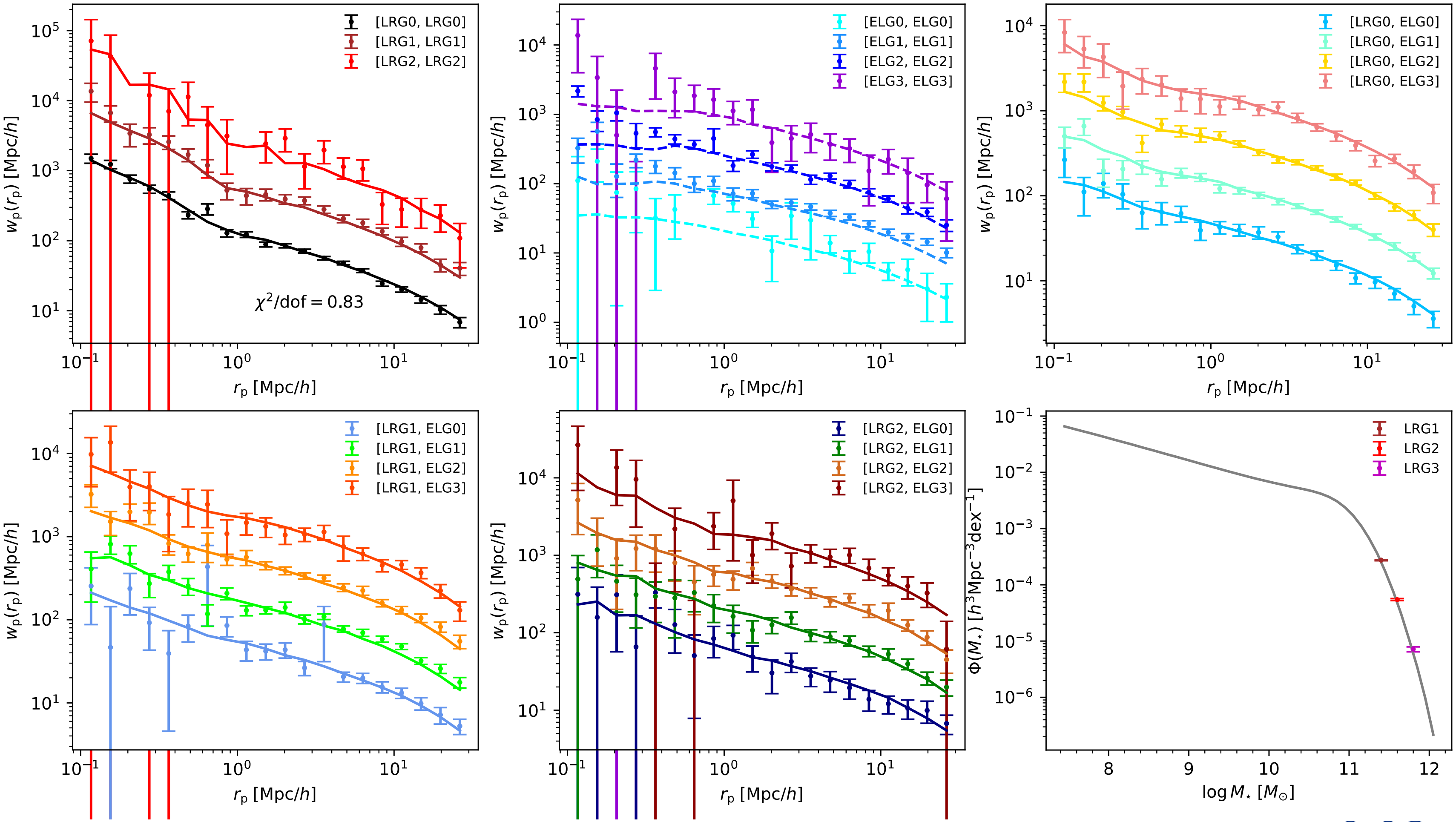
Modeling auto CFs with $P_{sat} = const$



Auto CFs reproduced with $P_{sat} = 0.89^{+0.07}_{-0.11}$

But cross CF between LRG and ELGs too high

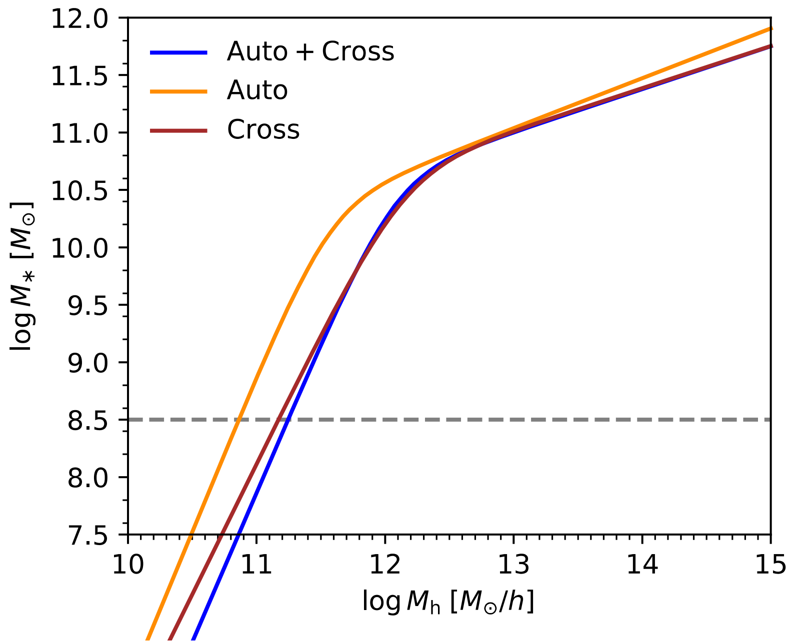
Modeling without ELG auto CFs with P_{sat} = const

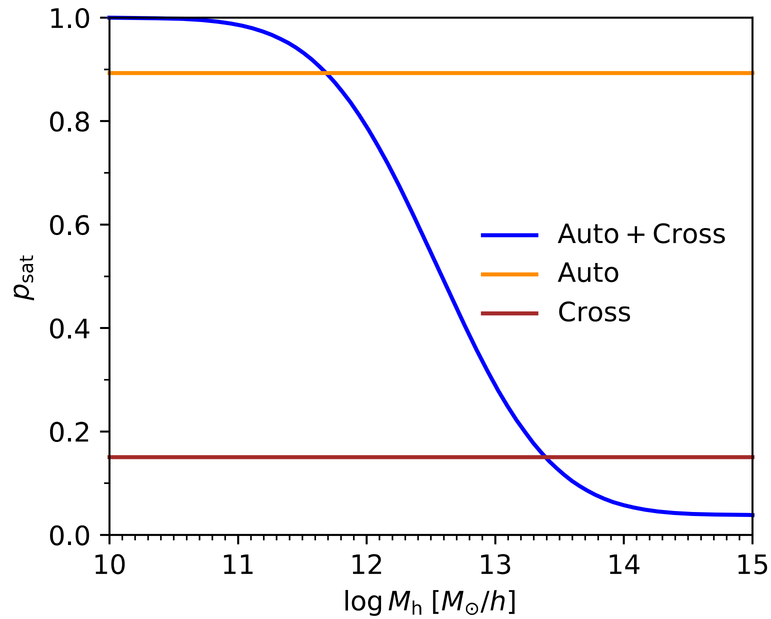


LRG and cross CFs reproduced with $P_{sat} = 0.15^{+0.02}_{-0.01}$

But auto CFs of ELGs too low in model

Fitting results



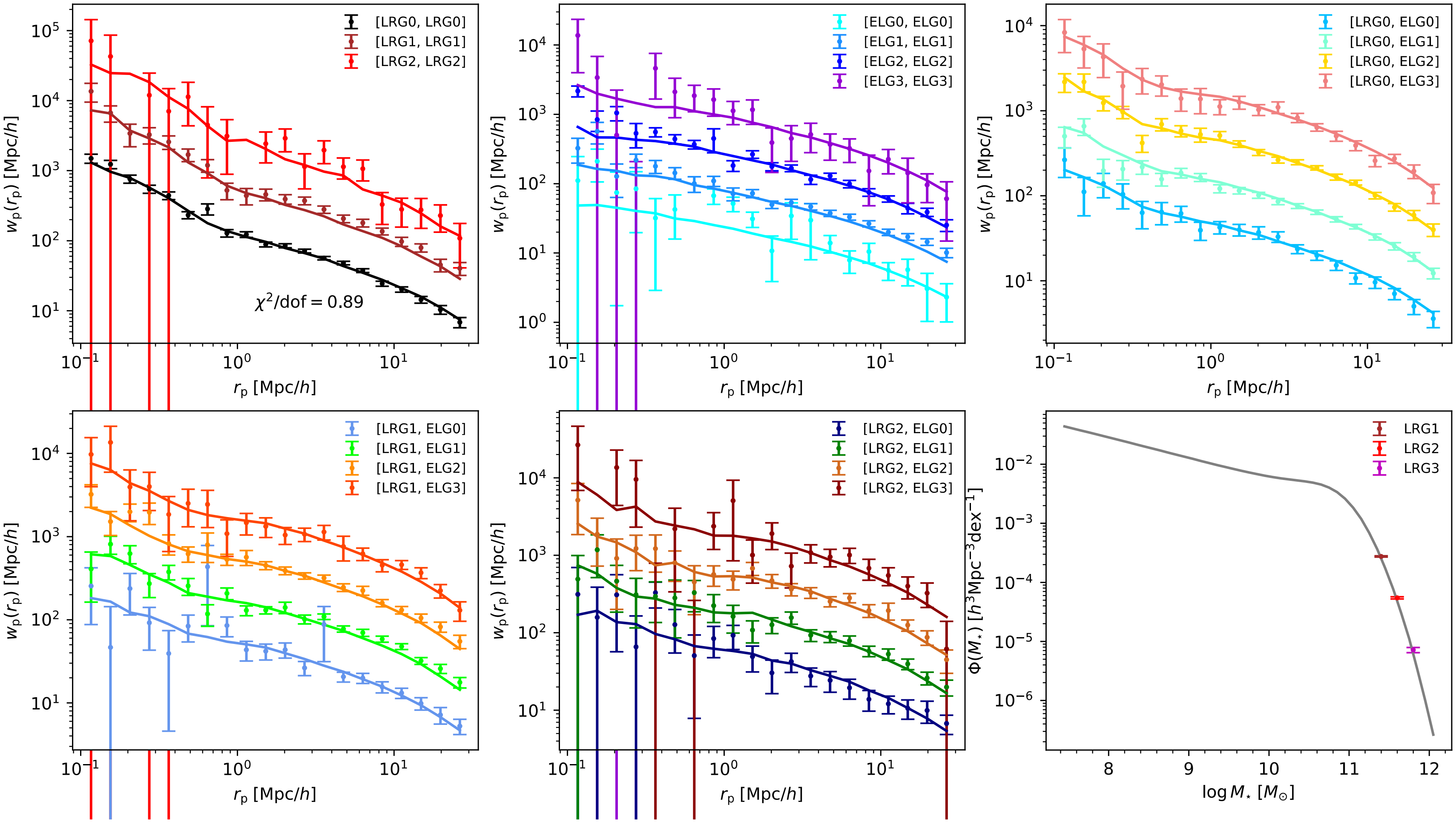


$$P_{sat}(M_{acc}) = \frac{1}{2}[1 - erf(lg\, M_{acc} - b)] + \frac{c}{2}[1 - erf(b - lg\, M_{acc})]$$

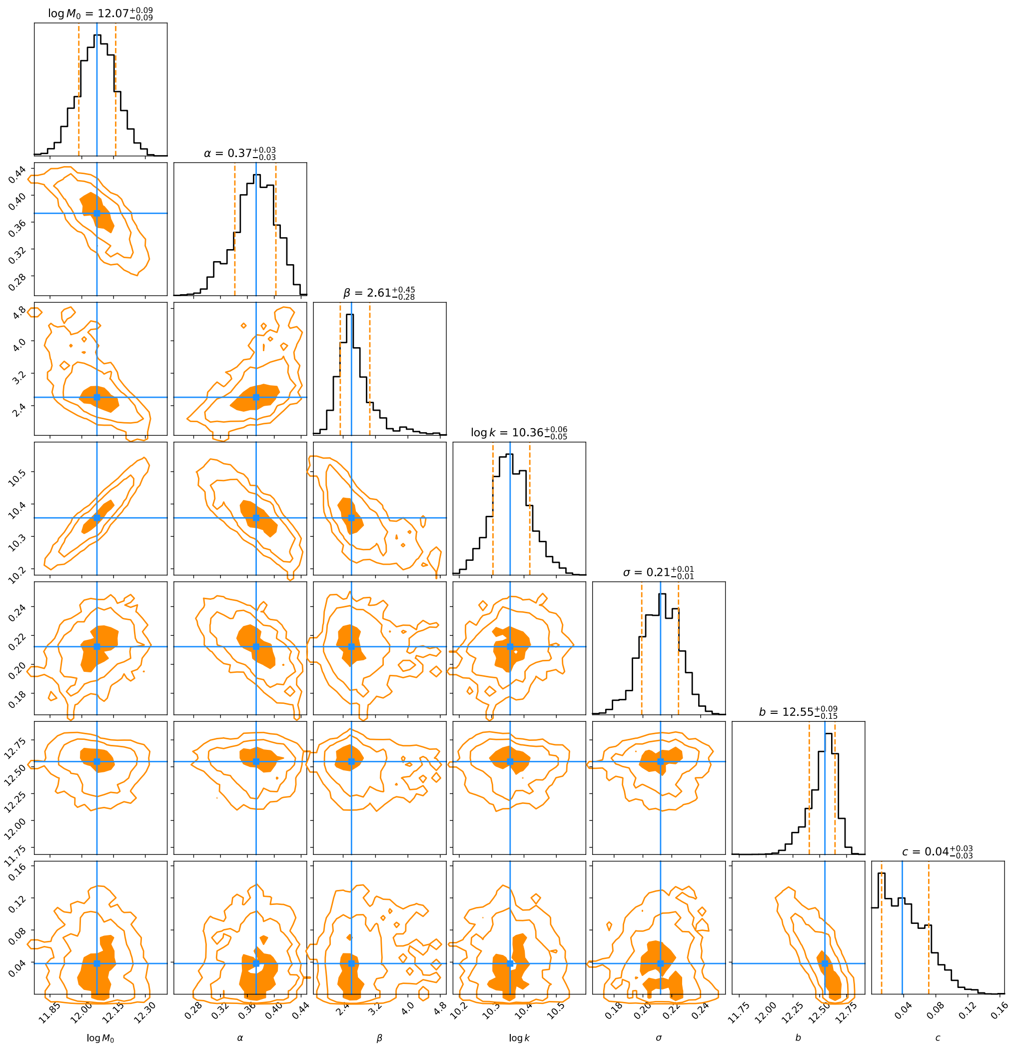
2 parameters b and c

7 parameters in total in the model

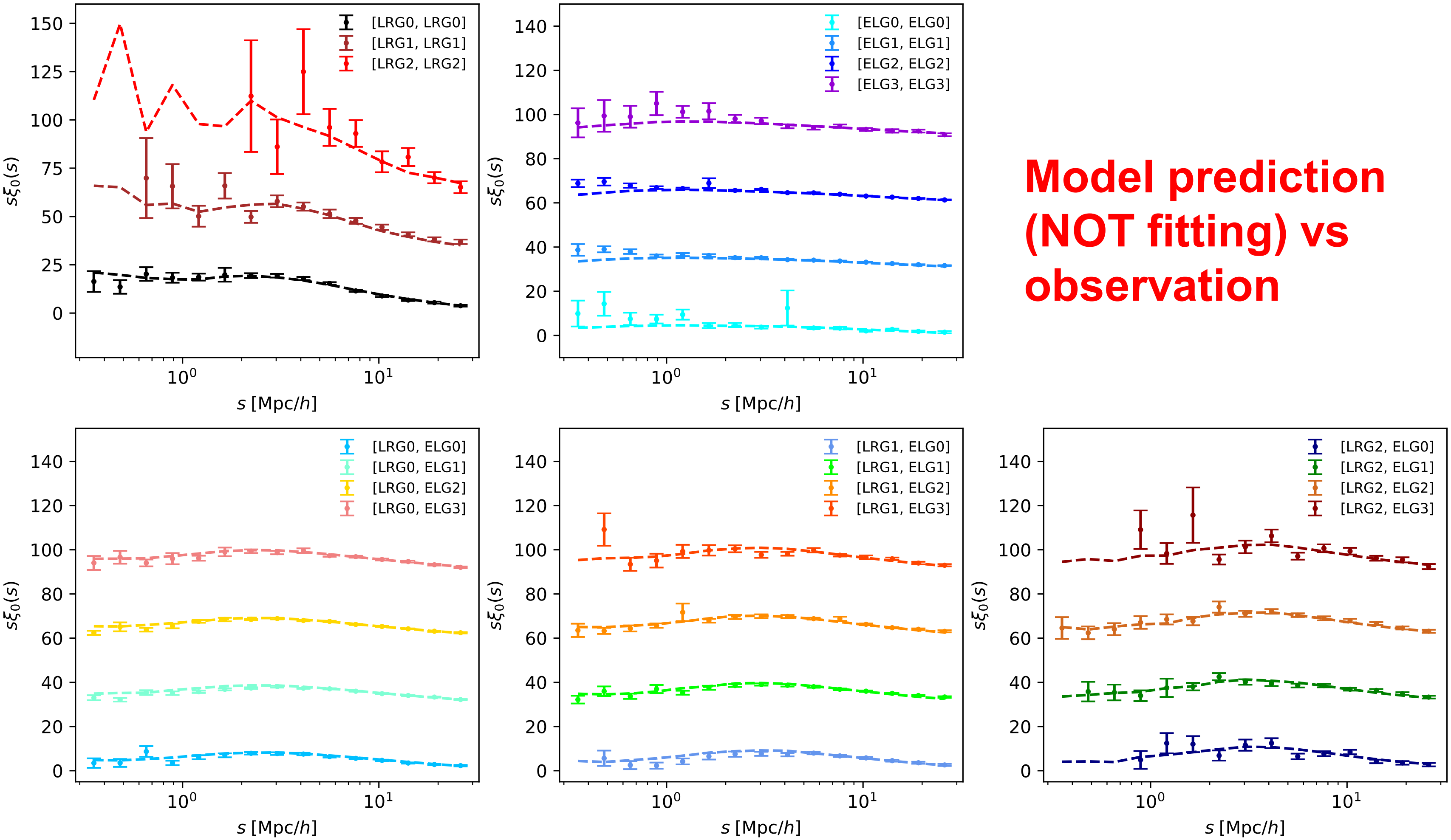
Modeling all CFs with $P_{sat}(M_{acc})$



7 parameters are well constrained



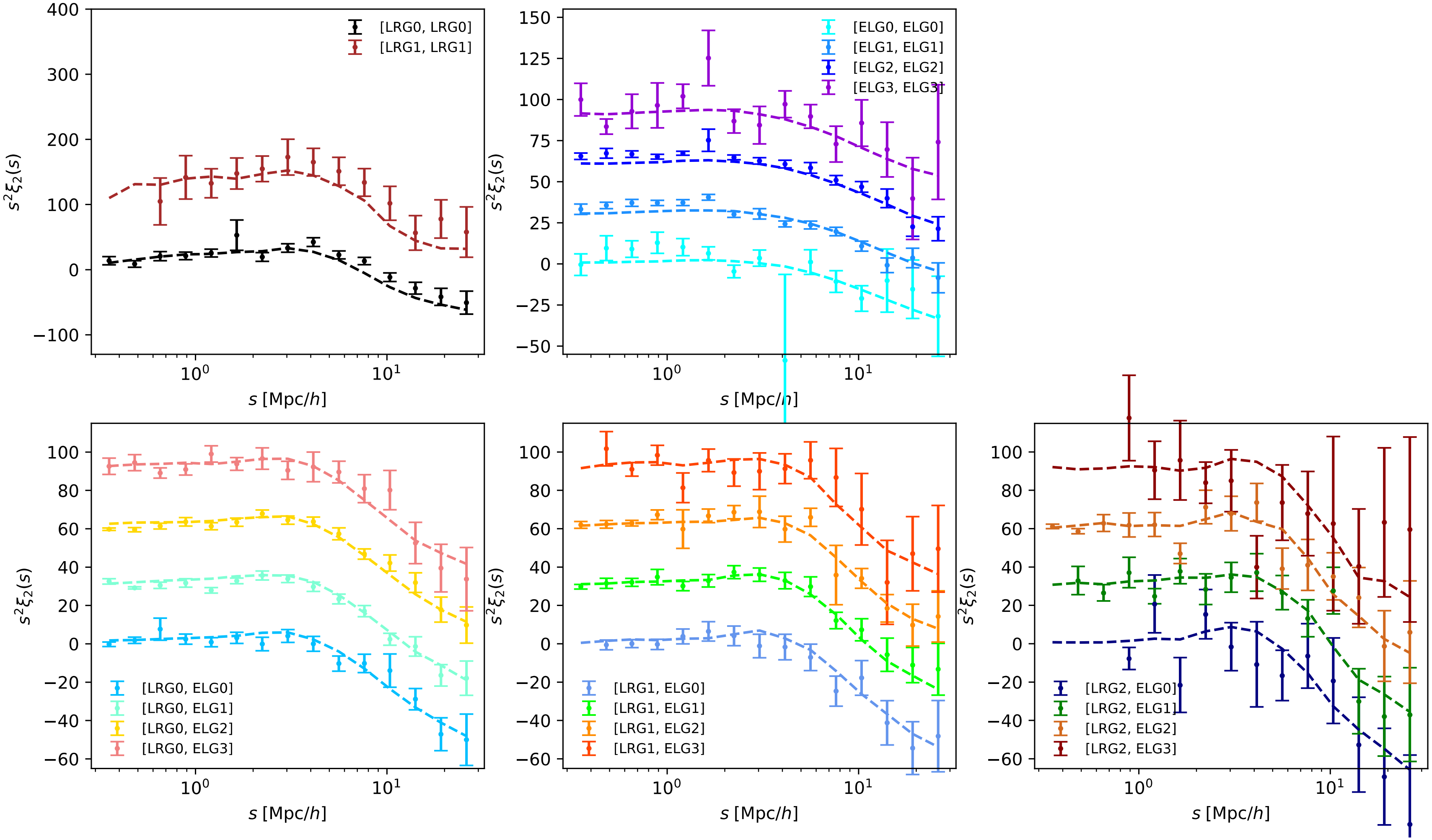
Monopole moments in redshift space



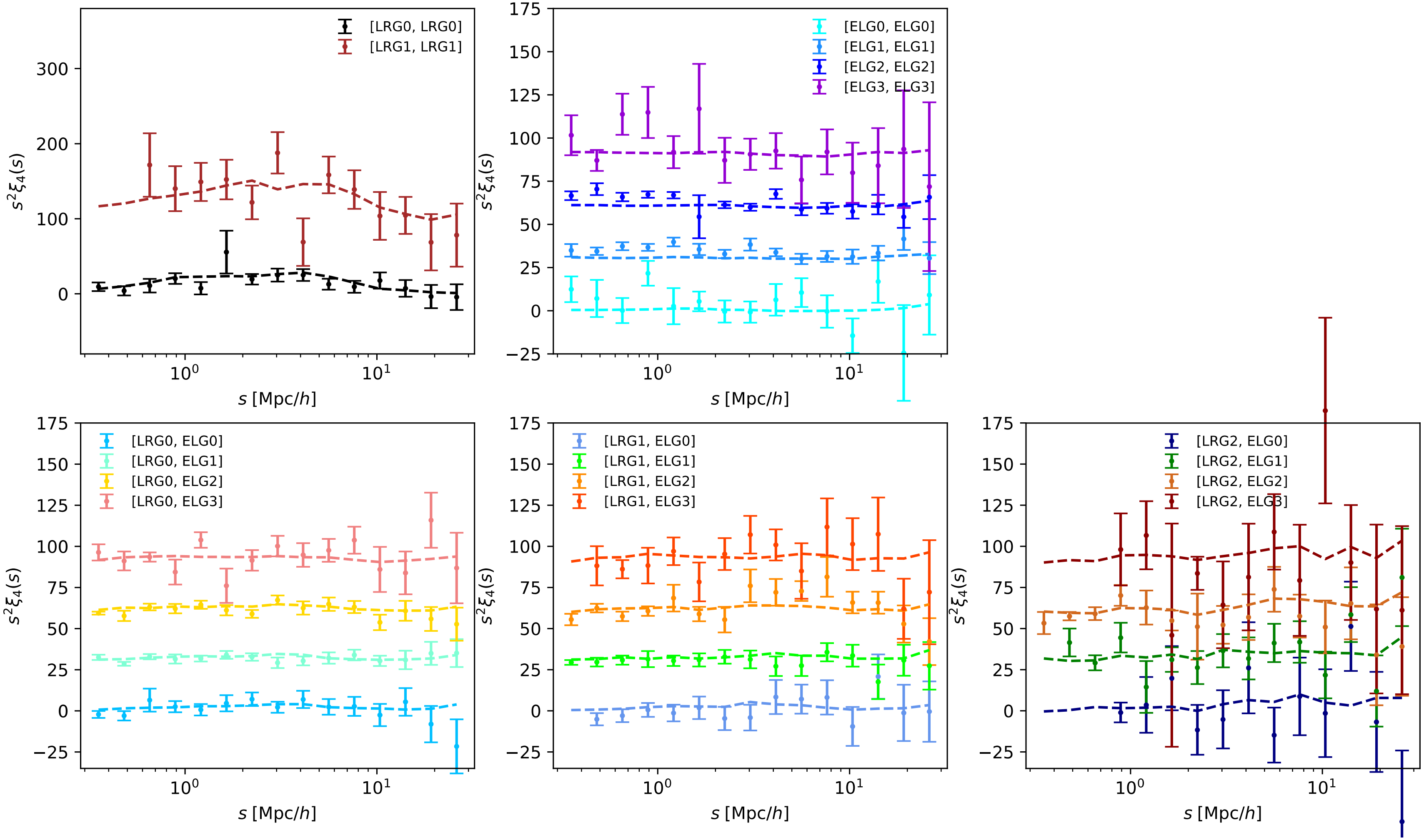
Model prediction (NOT fitting) vs observation

$$\xi_l(s) = \frac{2l+1}{2}\int_0^1 \xi(s,\mu) L_l(\mu) d\mu$$

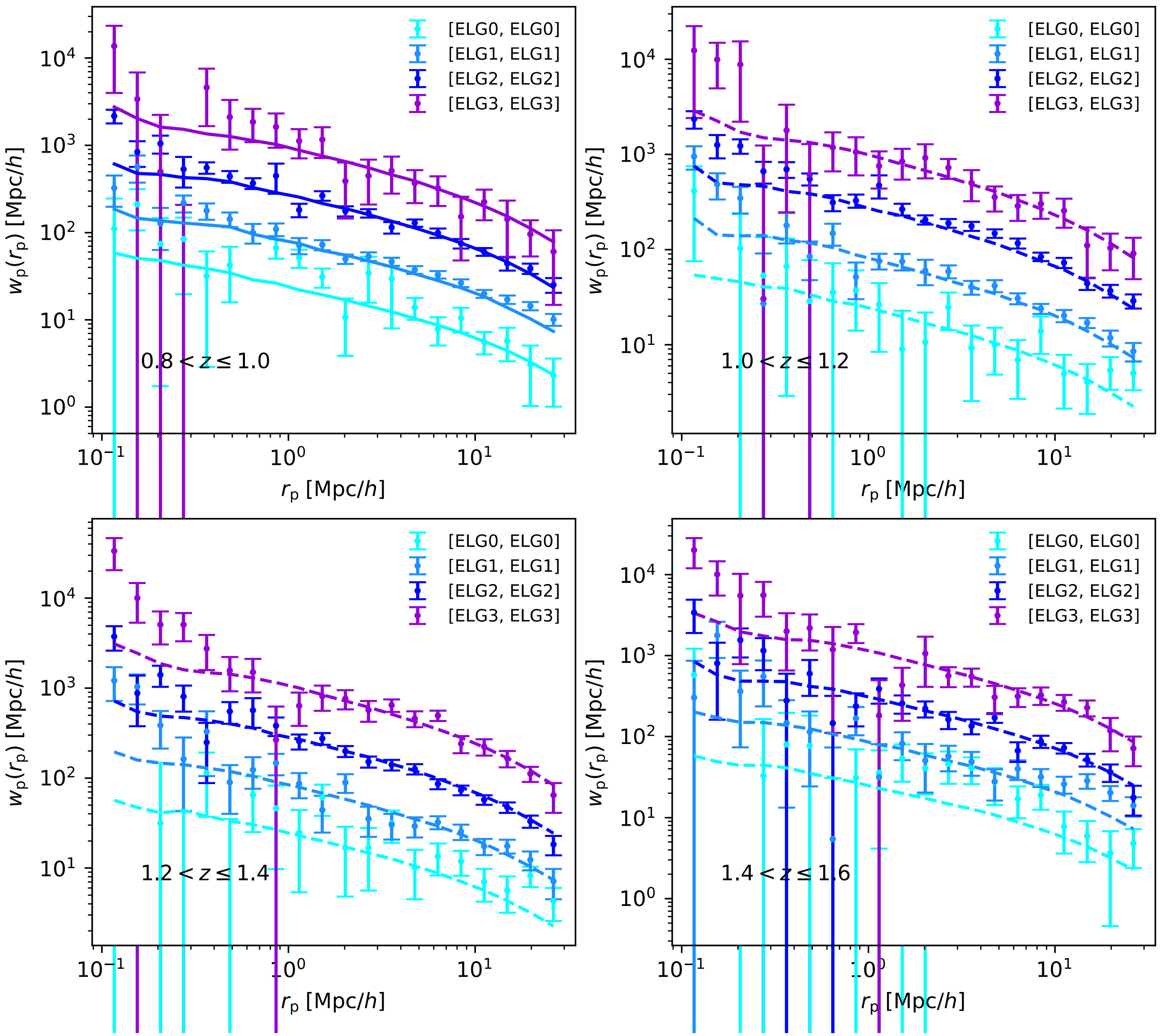
Quadrupole moments in redshift space



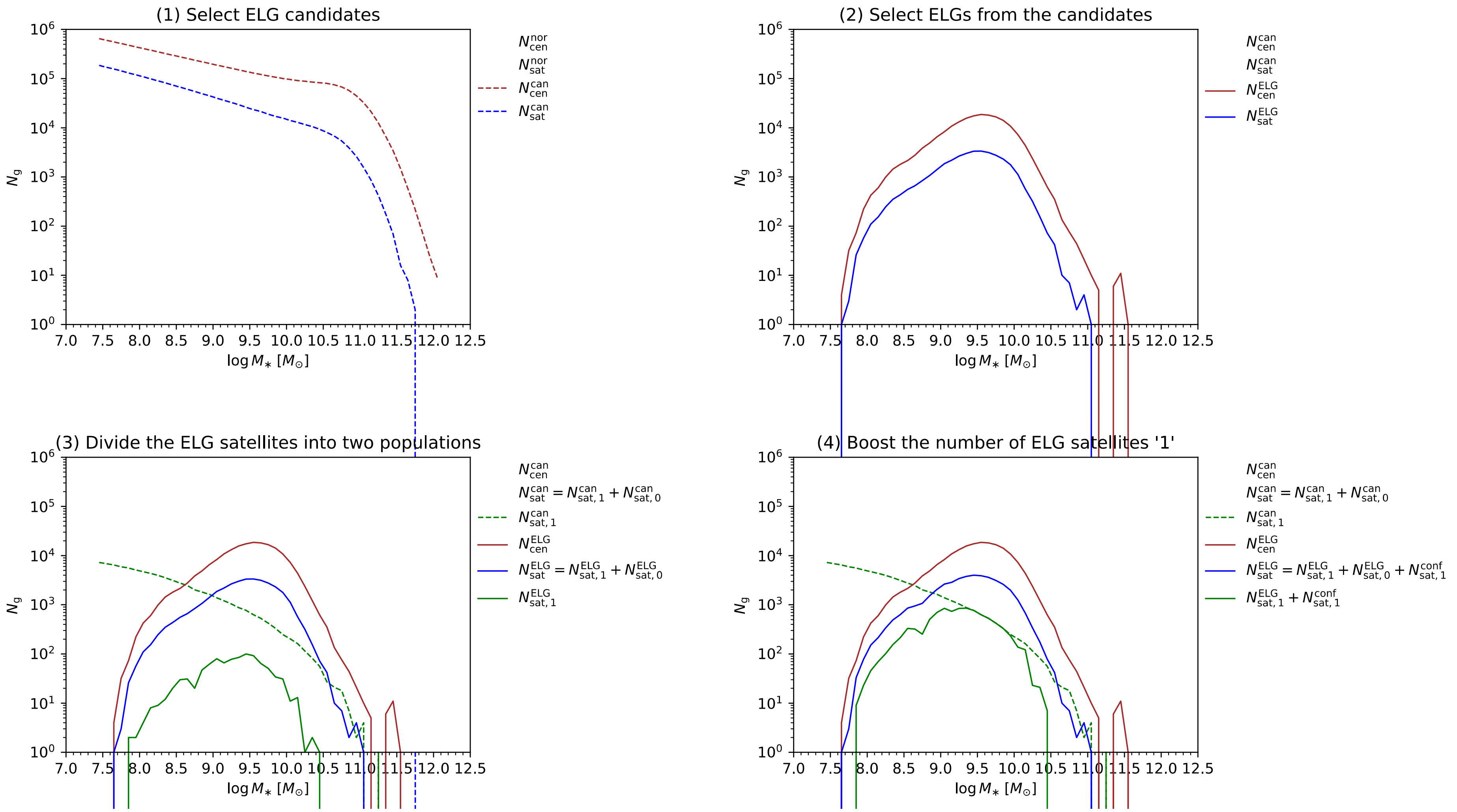
Hexadecapole moment in redshift space



Valid for higher redshift



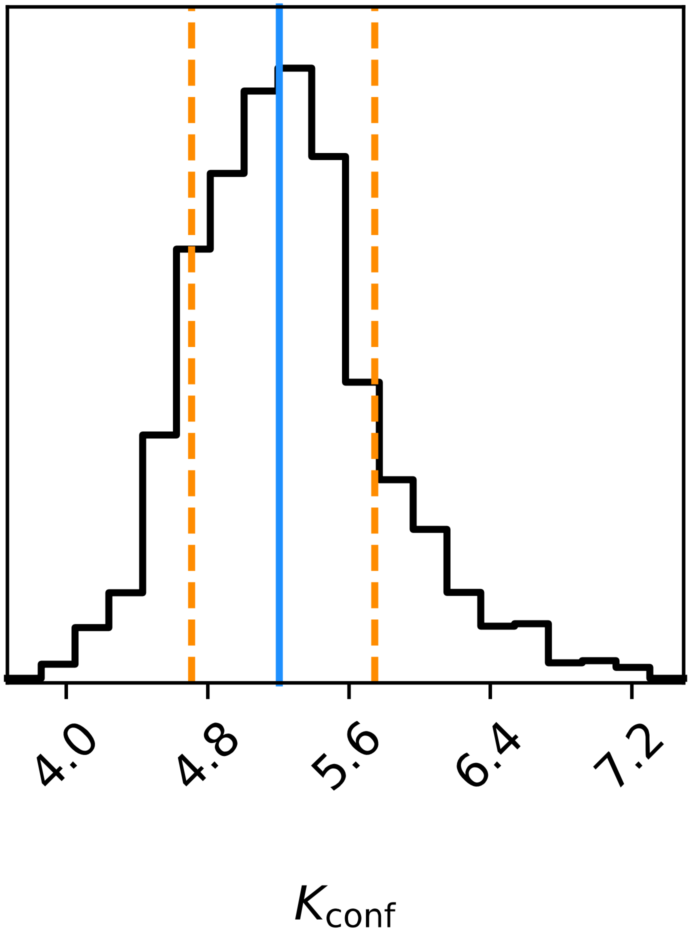
Galactic Conformity



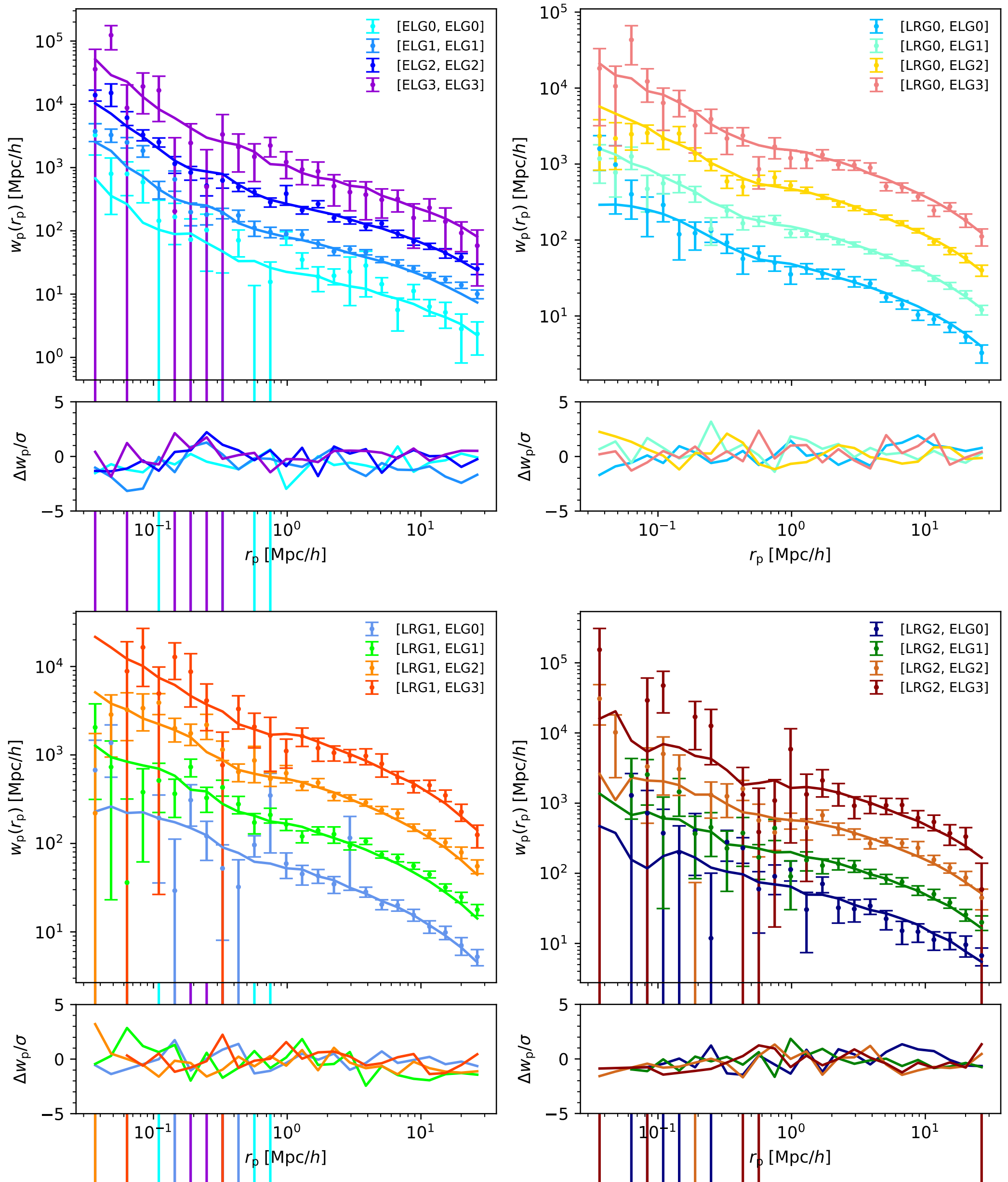
Gao,Hongyu,YPJ et al. under DESI internal review

Best value

$K_{\mathrm{conf}} = 5.21^{+0.54}_{-0.50}$

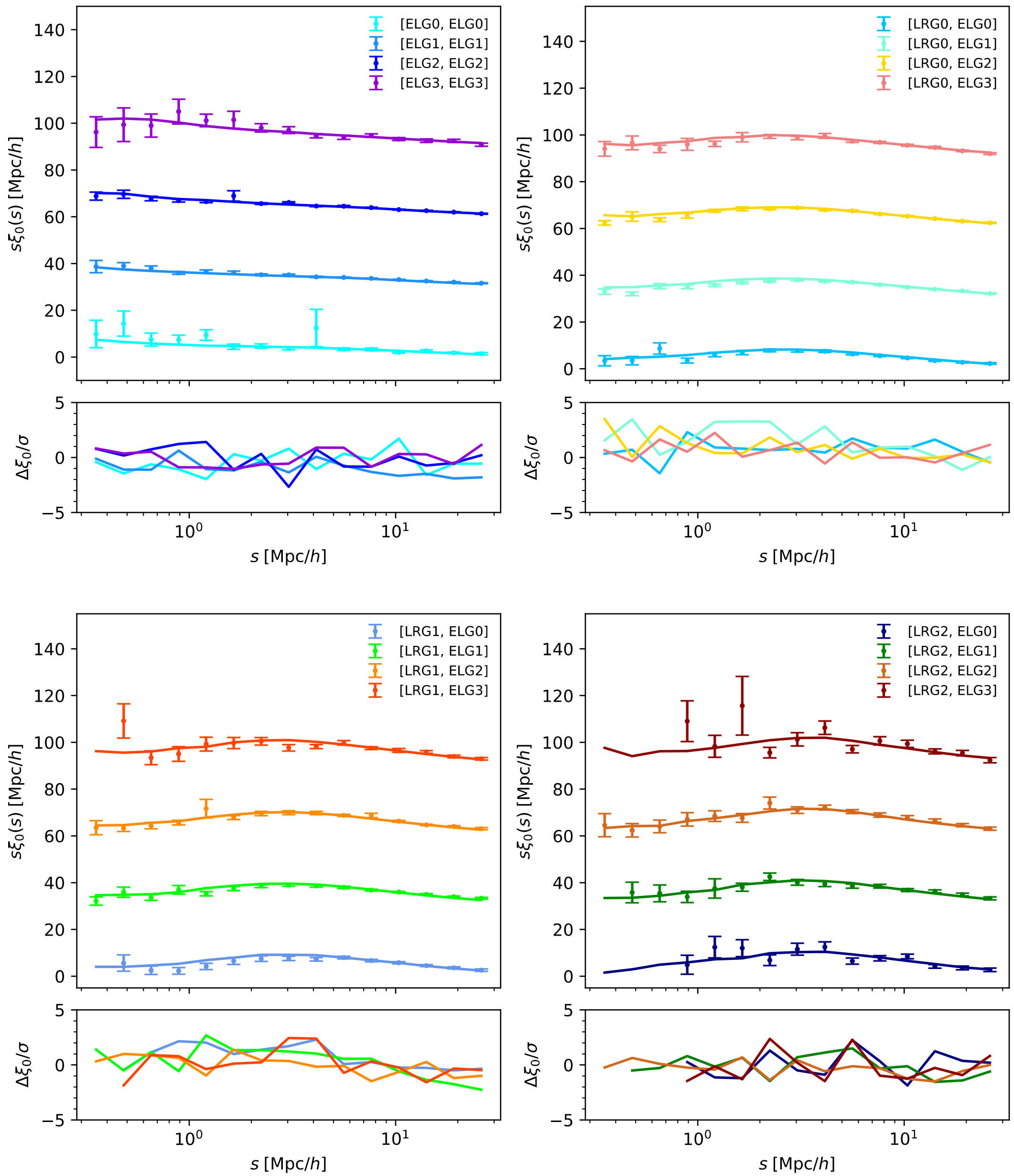


Project CF

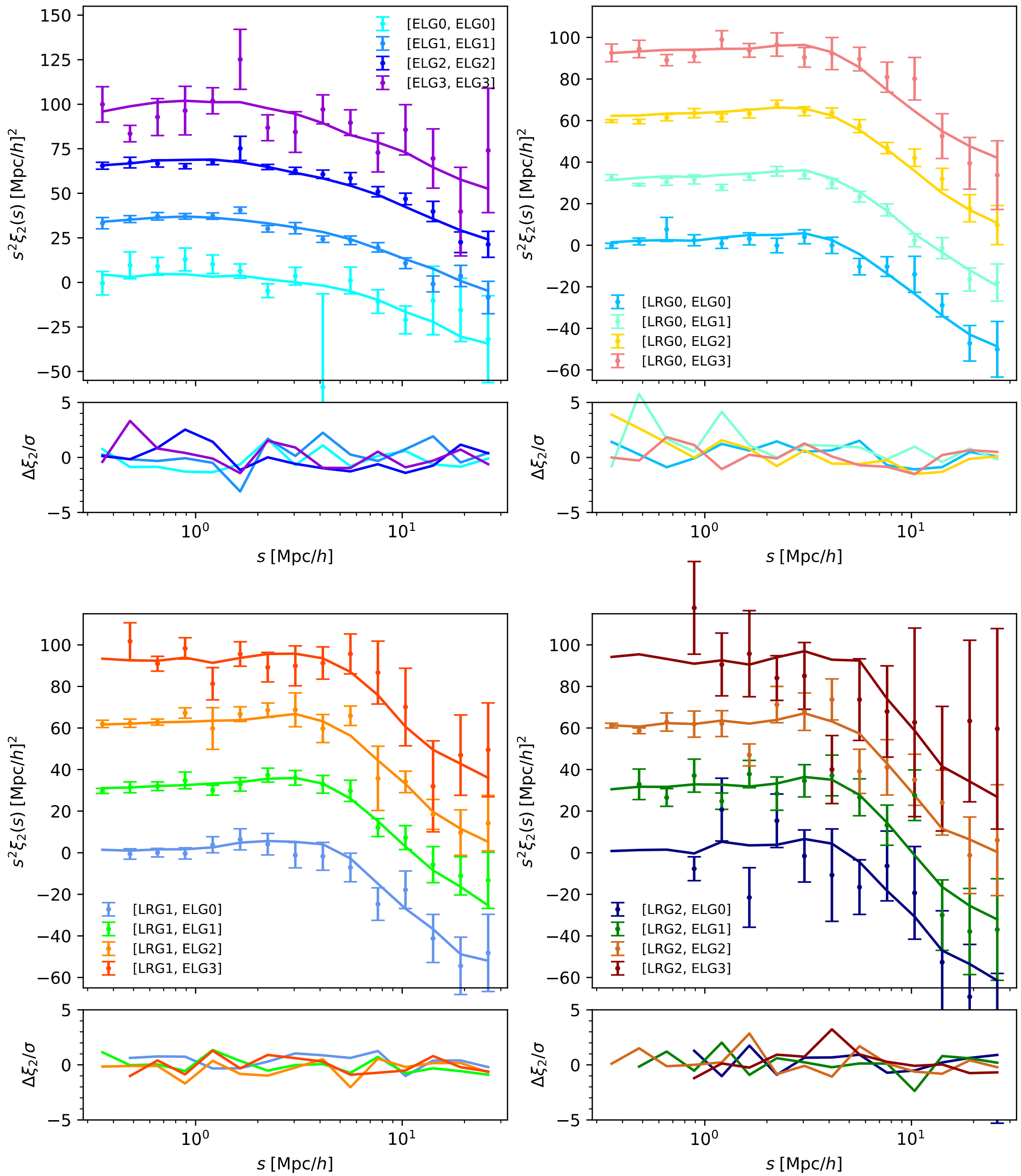


[ELG0, ELG0]
[ELG1, ELG1]
[ELG2, ELG2]
[ELG3, ELG3]
[LRG0, ELG0]
[LRG0, ELG1]
[LRG0, ELG2]
[LRG0, ELG3]
[LRG1, ELG0]
[LRG1, ELG1]
[LRG1, ELG2]
[LRG1, ELG3]
[LRG2, ELG0]
[LRG2, ELG1]
[LRG2, ELG2]
[LRG2, ELG3]
$w_p(r_p)$ [Mpc/h]
$\Delta w_p/\sigma$
r_p [Mpc/h]

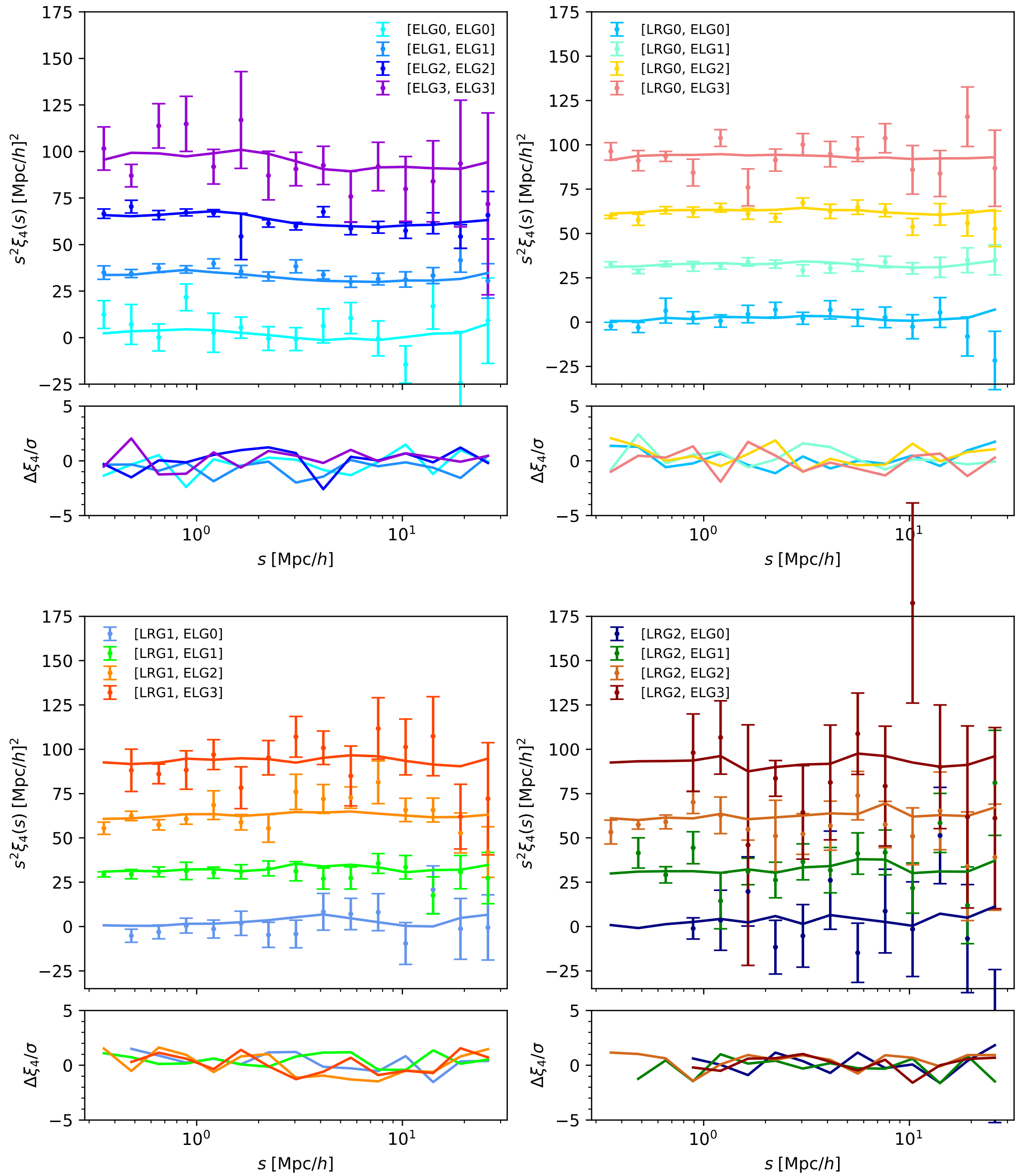
Monopoles (redshift space)



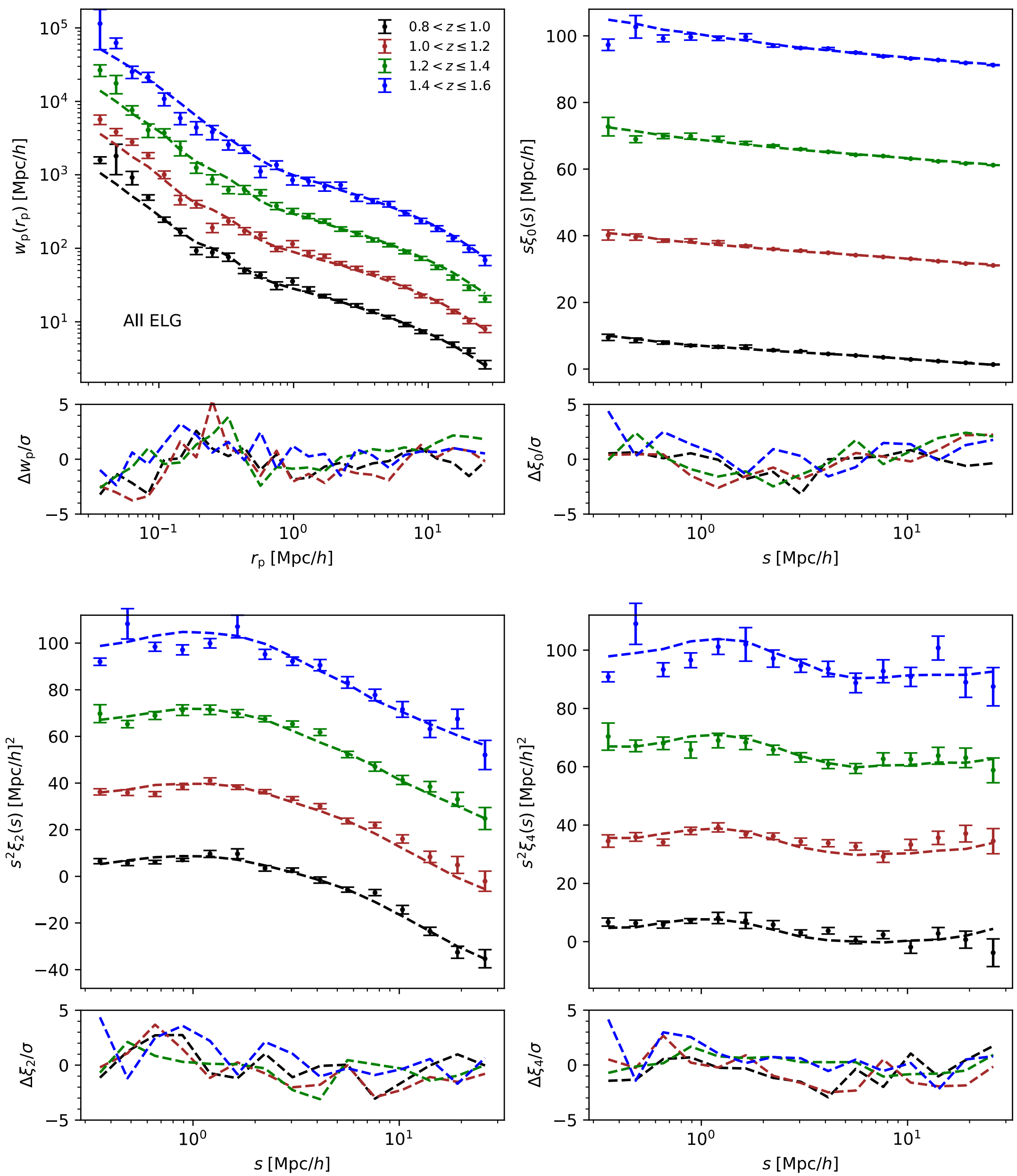
Quadropoles



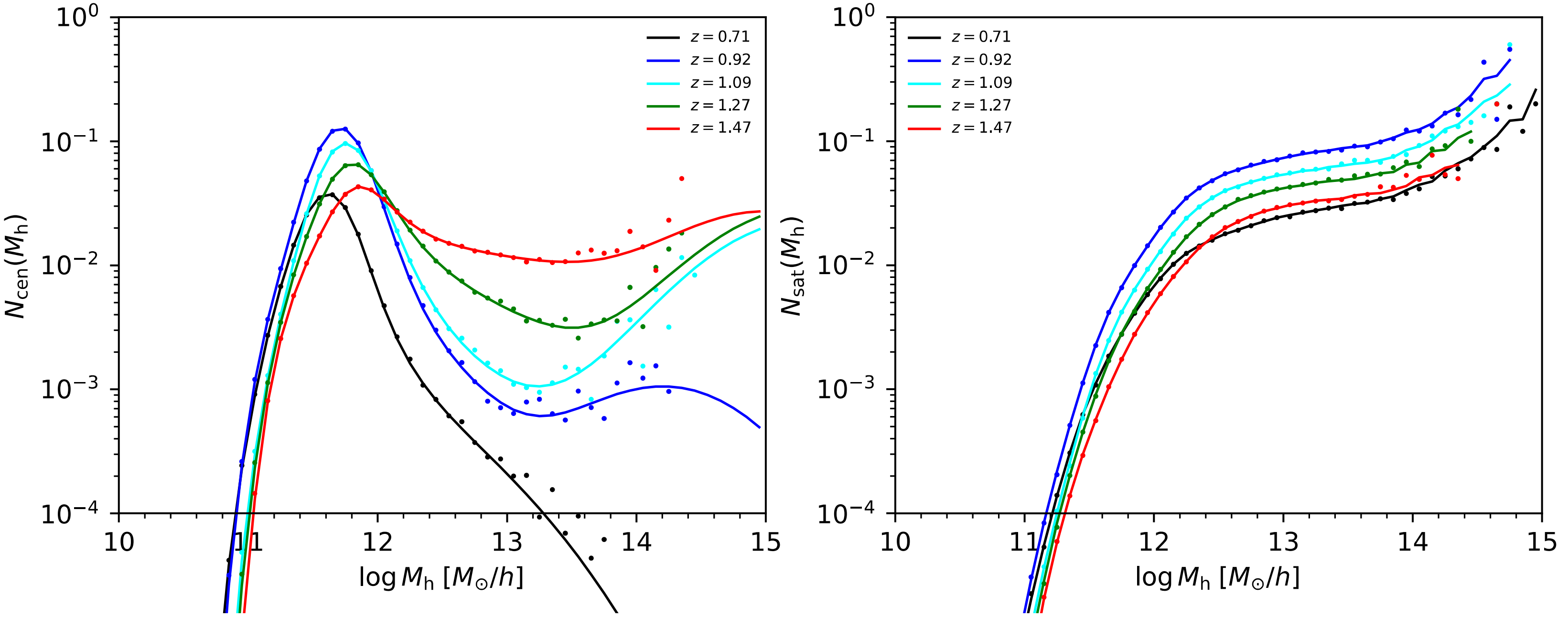
Hexadecapoles



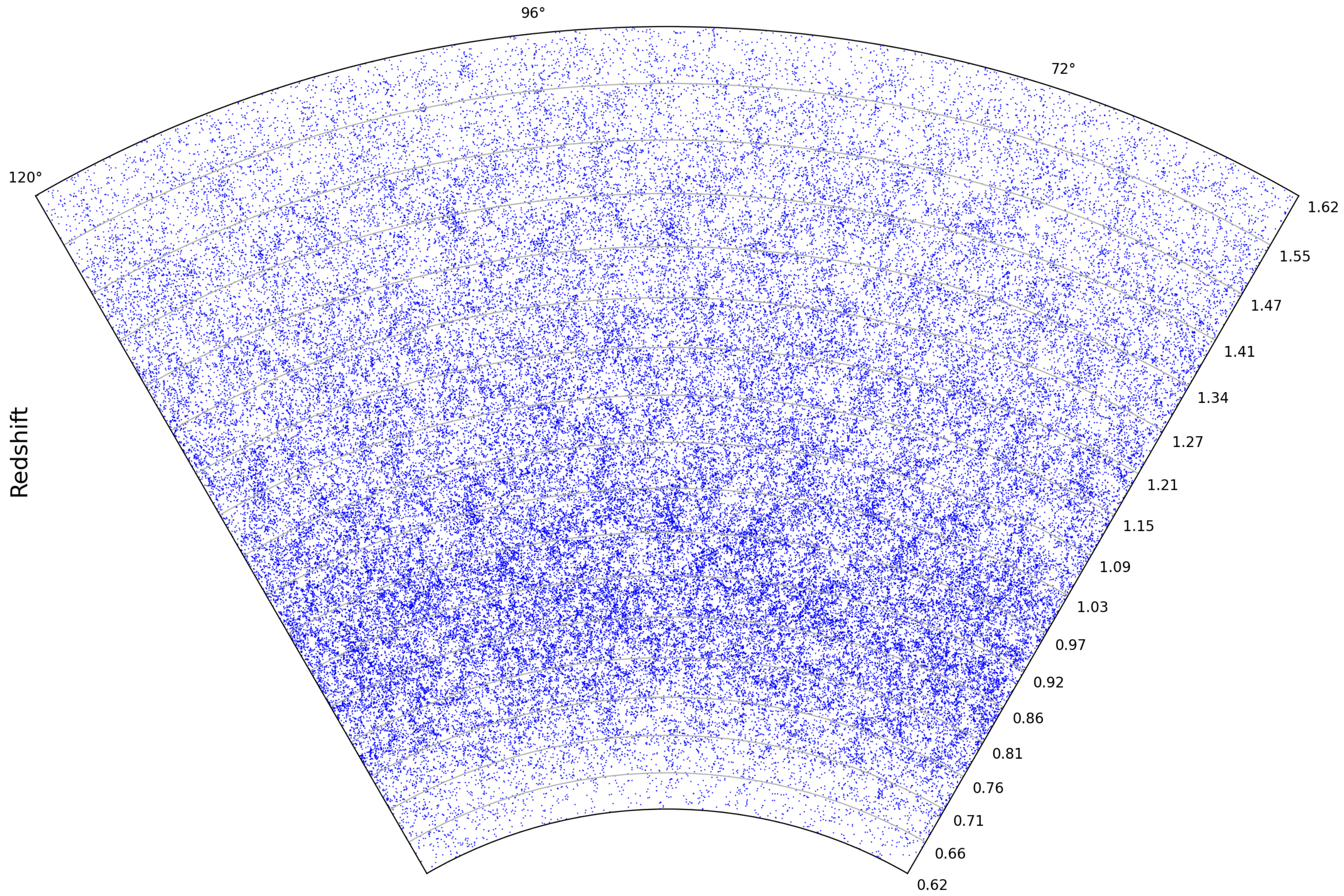
Evolution of whole ELGs



Complicated HODs at different redshift



ELG mock (赤道附件1度）



Conclusions

- *With just 7 parameters that are well determined by the observations, we are able to model the relation between ELGs and dark matter halos in DESI SV3;*
- *We find that galactic conformity is a must for explaining the strong clustering of ELGs*
- *With our framework, it is easy to include the galactic conformity with only 1 additional parameter;*
- *With much larger 1 Year sample, we are able to improve accuracy of the model, by introducing dependances on OII luminosity, redshift etc*