Test of gravity on cosmological scales in eBOSS

LAM
LABORATOIRE D'ASTROPHYSIQUE DE MARSEILLE

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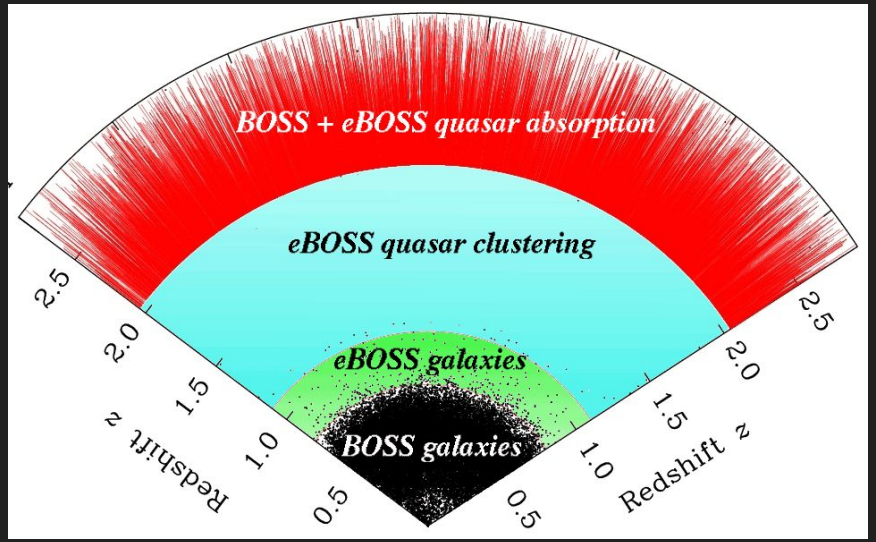
Outlines

- The eBOSS survey
- BAO and RSD
- Observationals Systematics
- Mocks used in eBOSS
- Final constraint on the LRG sample

The eBOSS survey

BOSS legacy (Baryon Oscillation Spectroscopics Surveys)



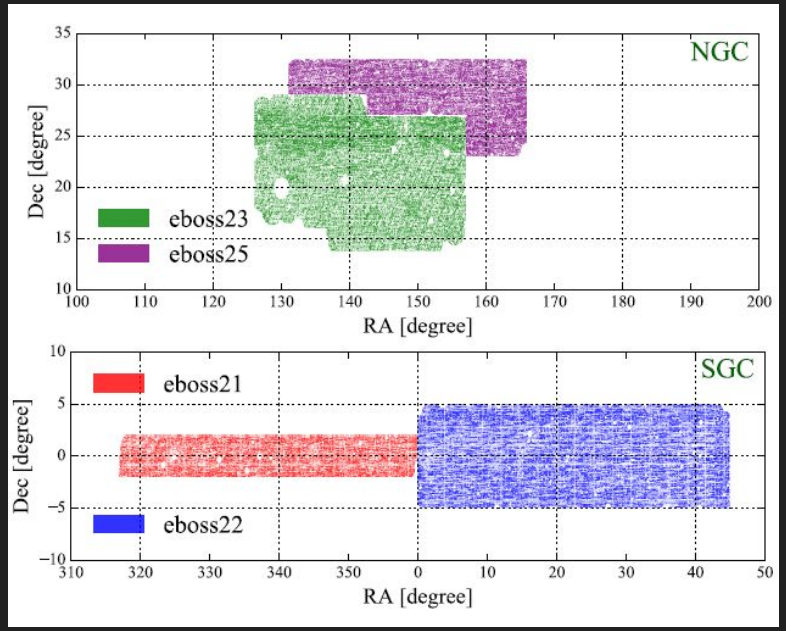
Observed galaxies of BOSS and eBOSS

eBOSS goal : extend study of galaxy clustering to higher redshifts, also a prequel of DESI.

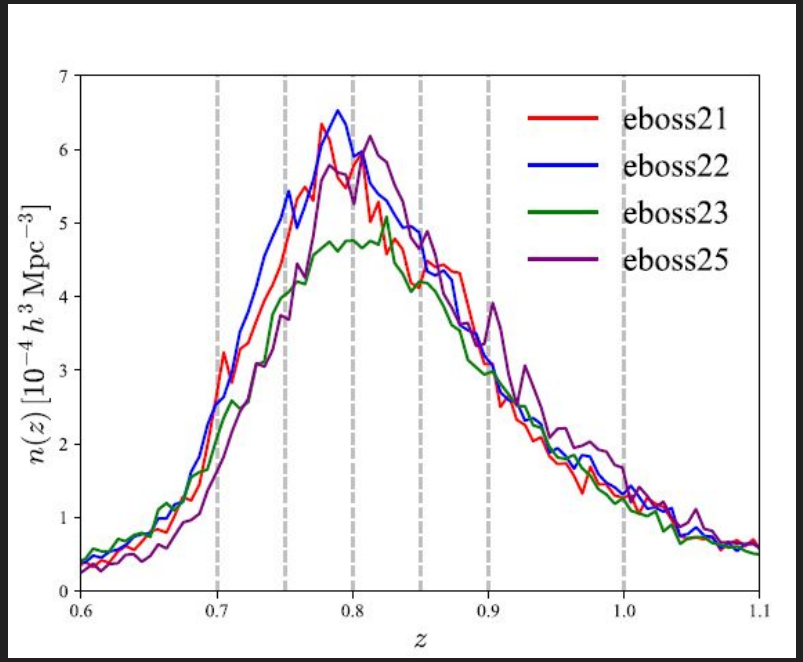
eBOSS in number :

- 210 000 Luminous red galaxies $0.6 < z < 1.0$
- 230 000 emission line galaxies $0.6 < z < 1.1$
- 300 000 clustering quasars $0.8 < z < 2.2$

the eBOSS survey : Emission line galaxies

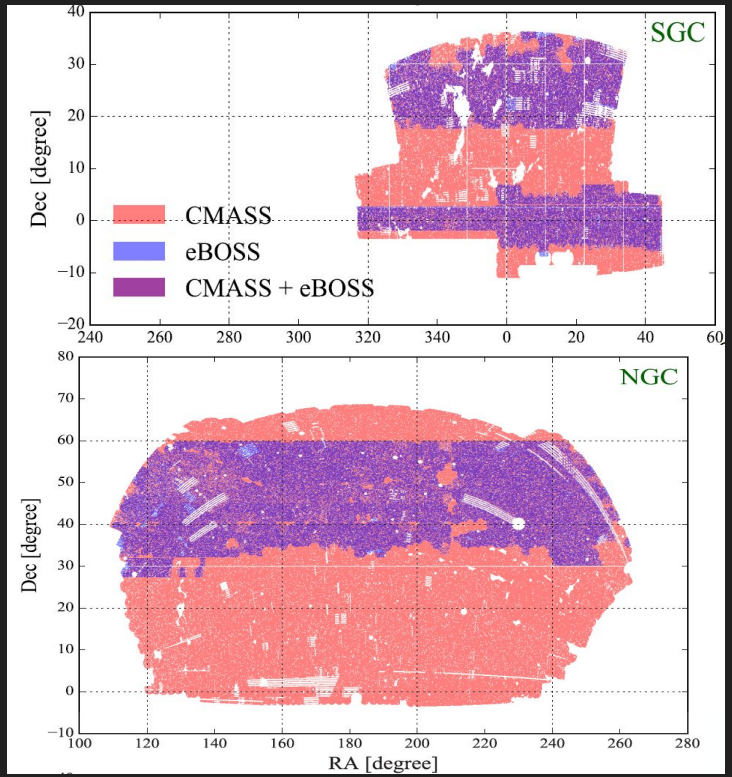


ELG footprint

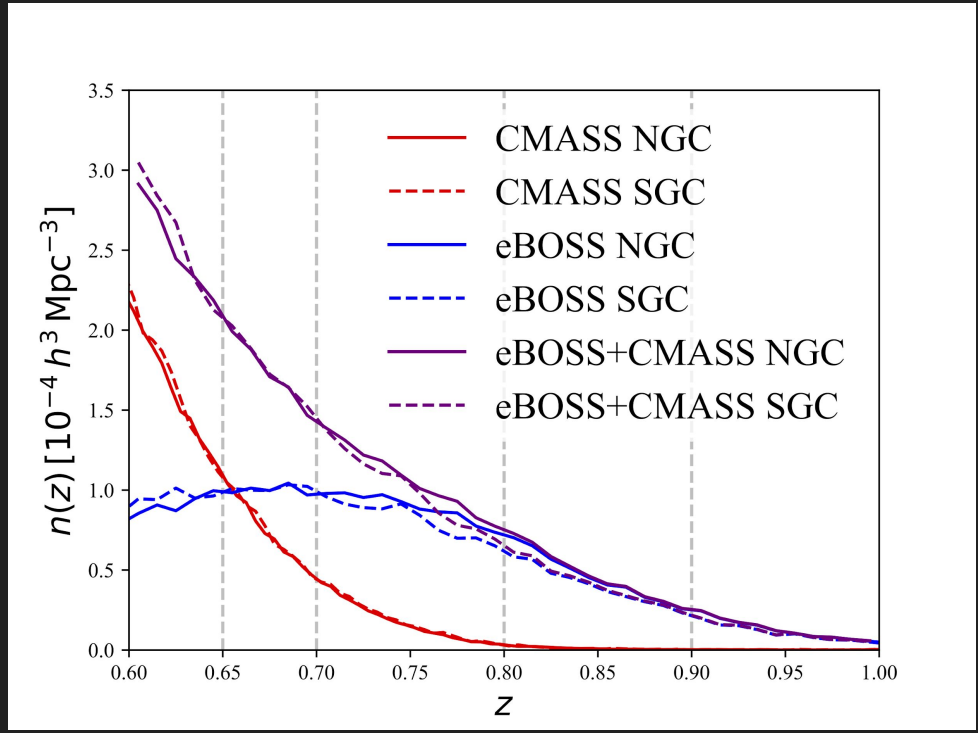


ELG selection function

the eBOSS survey : Luminous red galaxies

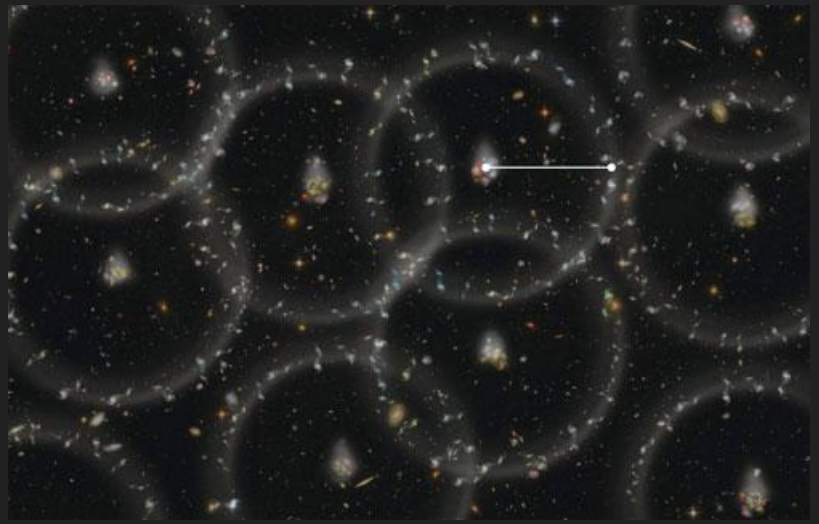


LRG footprint

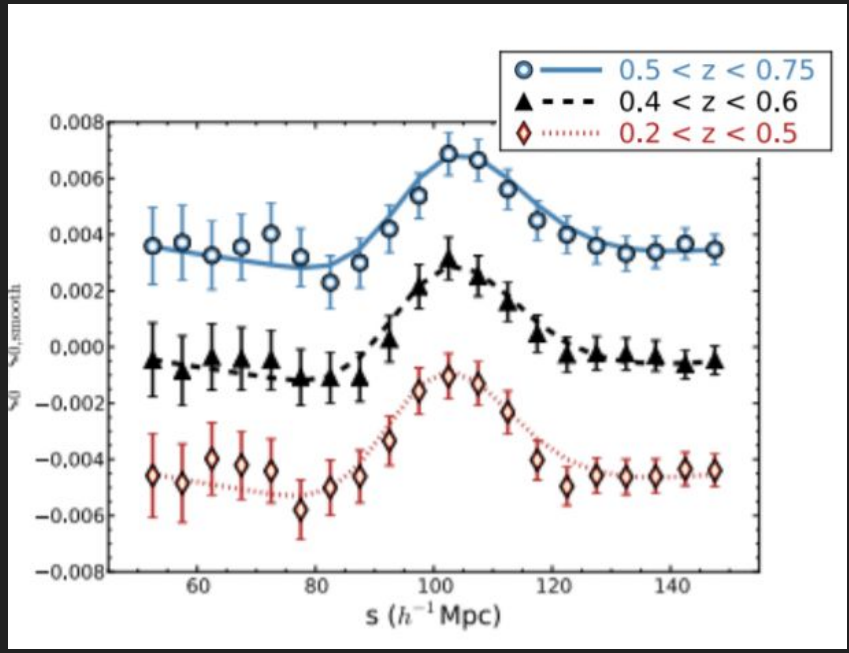


LRG selection function

Clustering of galaxies : Baryon acoustic oscillations



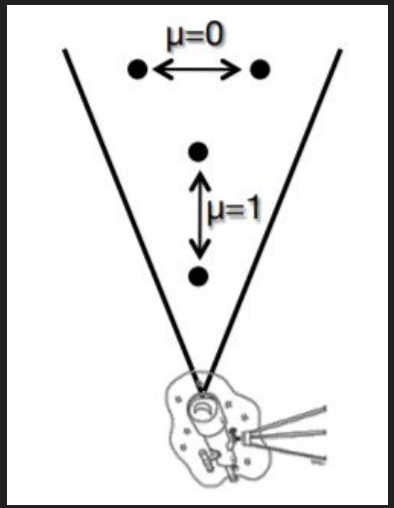
Credit : BOSS



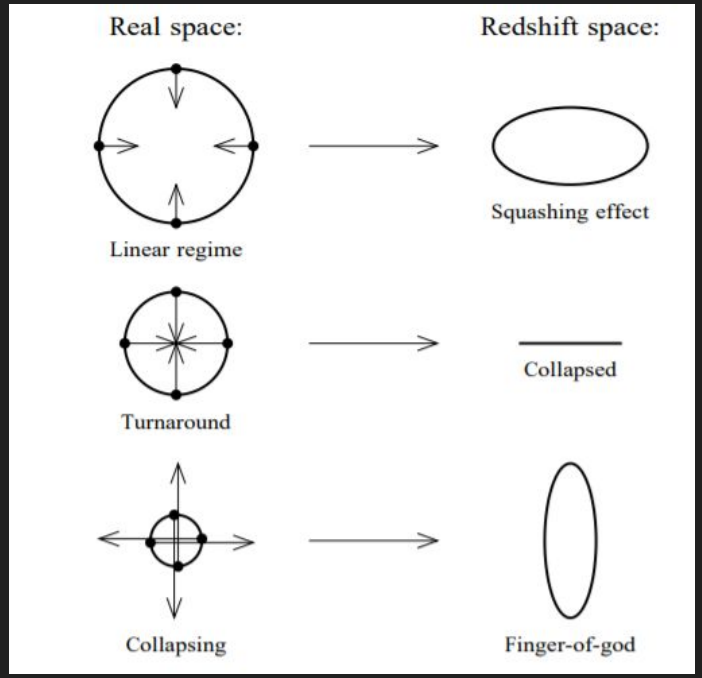
Credit : BOSS

Clustering of galaxies : Redshift space distortion

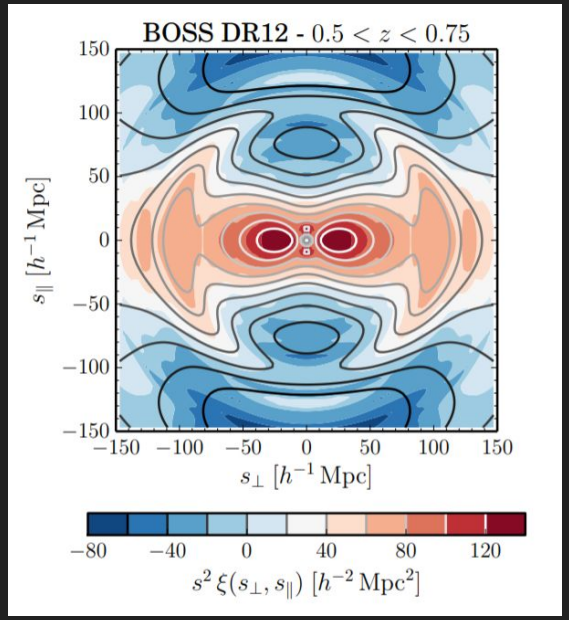
$$\mathbf{s} = \mathbf{r} + \mathbf{v} \cdot \hat{\mathbf{r}}$$



Credit : Percival



Credit : Hamilton



Credit : Alam et al.

Amount of 2d anisotropy due to peculiar velocity is related to the rate of growth of structure.

Clustering of galaxies

2 point statistics description of the density field

$$\xi(\mathbf{r}) = < \delta(\mathbf{r})\delta^*(\mathbf{r}) > \quad \delta(\mathbf{r}) = \frac{\rho(\mathbf{r}) - \bar{\rho(\mathbf{r})}}{\rho(\mathbf{r})}$$

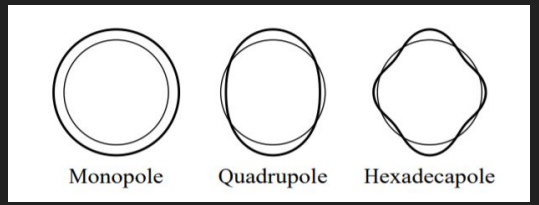
Estimator based on pairs counts

$$\xi(s,\mu) = \frac{DD(s,\mu) - 2DR(s,\mu) + RR(s,\mu)}{RR(s,\mu)} \qquad \mu = cos(\theta)$$

where the randoms galaxy catalog has the same angular and radial selection function than the data.

Legendre polynomials to compress the 2D information

$$\xi^l(s) = \frac{2l+1}{2} \int \xi(s,\mu) \mathrm{L}(\mu) d\mu$$



Shape of l = 0,2,4 harmonics
Credit : Hamilton et al.

Modelling RSD

Linear Kaiser model

$$P^s(k,\mu) = D_{FoG}[1 + f^2\mu]P_{lin}(k)$$

modified TNS model (de la Torre et al)

$$P^s(k,\mu) = D_{FoG}[P_{\delta\delta} + 2\mu f^2 P_{\delta\theta} + \mu^2 f^4 P_{\theta\theta} + C_a(k,\mu) + C_b(k,\mu)]$$

non linear matter power spectra

1 loop correction terms

Finger of god modeled as a Lorentzian

Cross spectrum matter velocity divergence

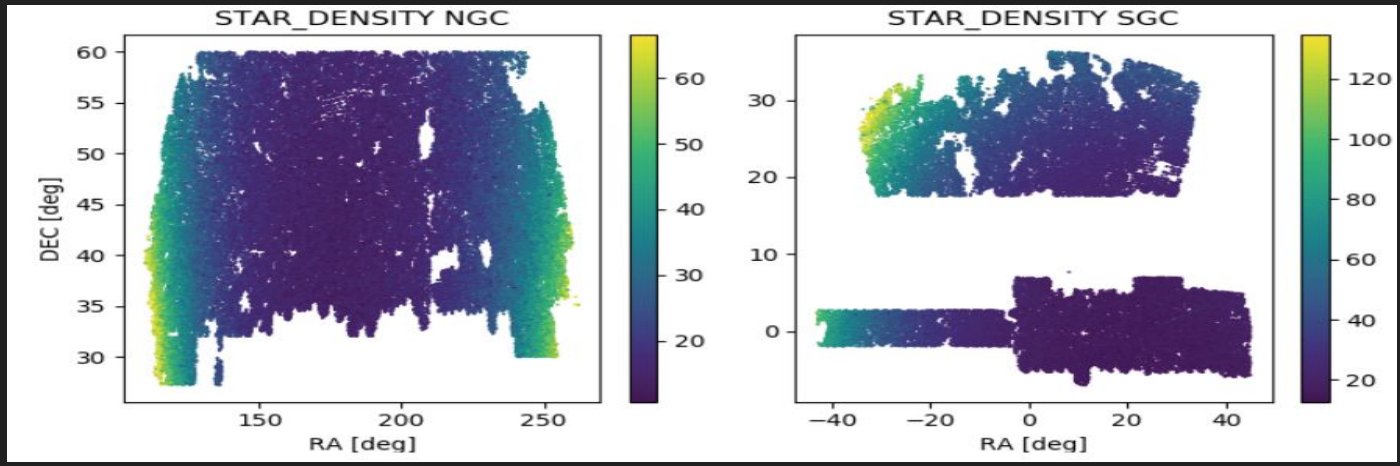
velocity divergence spectrum

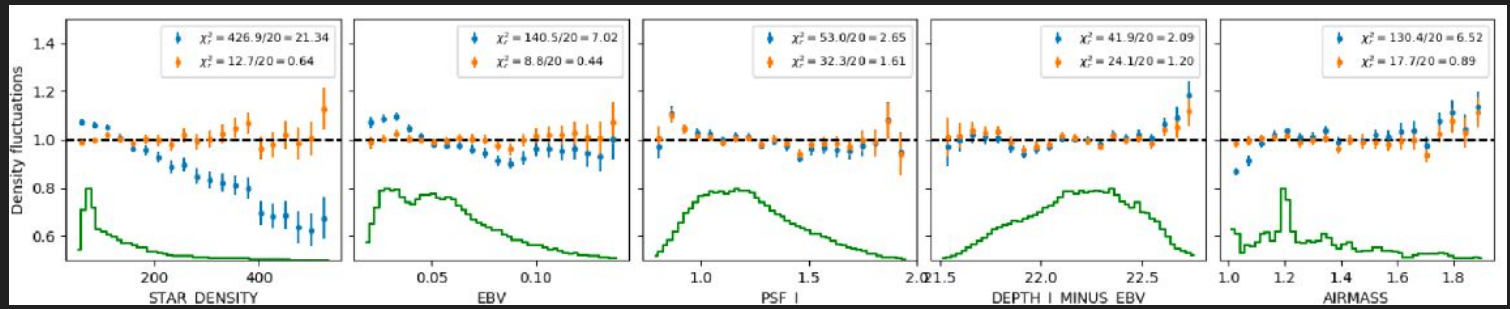
\+ bias model as galaxies are not a perfect tracer of the underlying density field

$$\delta_h = b_1\delta + \frac{b_2}{2}\delta^2 + b_{\mathcal{G}_2}\mathcal{G}_2 + \frac{b_3}{6}\delta^3 + b_{\mathcal{G}_3}\mathcal{G}_3 + b_{(\mathcal{G}_2\delta)}\mathcal{G}_2\delta + b_{\Gamma_3}\Gamma_3$$ (Assassi et al)

Observationals systematics

Multilinear regression weight to account for inhomogeneity of observationals systematics



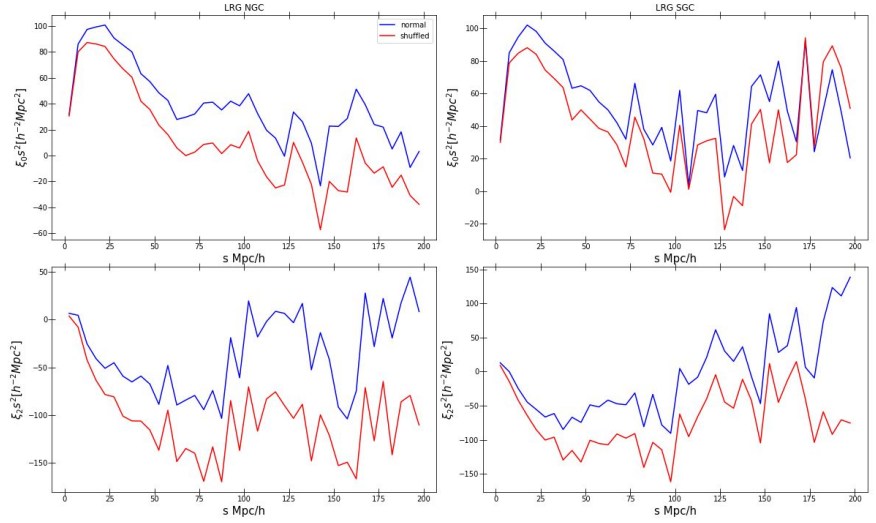


Credit : Bautista et al

Other way of dealing with systematics

The shuffling technics (Burden et al)

$$\tilde{\xi}(r_\perp, r_\parallel) = \frac{DD(r_\perp, r_\parallel) - 2DS(r_\perp, r_\parallel) + SS(r_\perp, r_\parallel)}{RR(r_\perp, r_\parallel)}$$



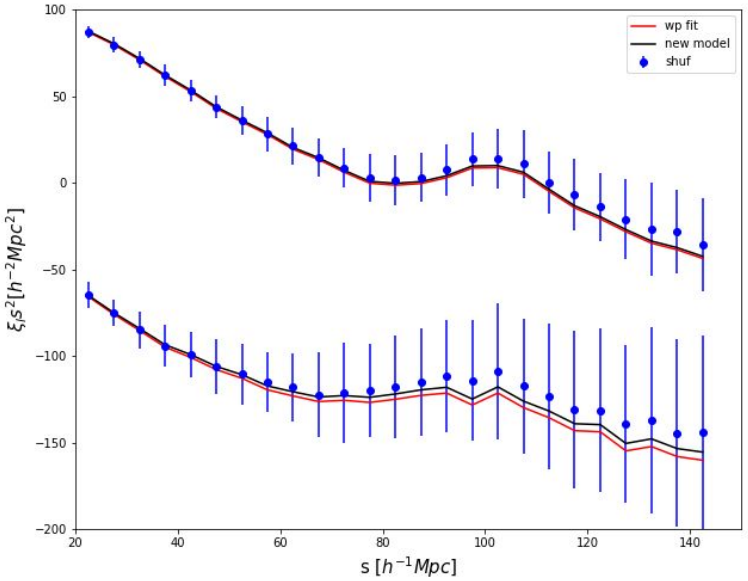
S : Shuffled RA,DEC random catalog. Instead of being uniform along the survey footprint, this random catalogs mimics exactly the angular distribution of the data → kills angular modes (which are the one affected by systematics.)

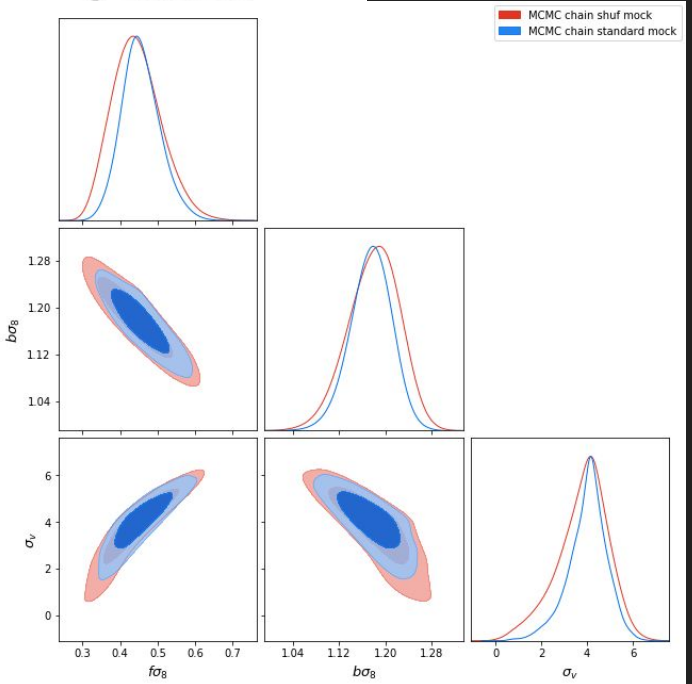
RA-DEC shuffling

Even if this method supress informations, it does not bias the recovery of cosmological parameter

New 2pt statistics can easily be modeled for.

$$\tilde{\xi}(r_p,\pi) = \xi(r_p,\pi) - 2\frac{\int_{-\pi_{max}}^{+\pi_{max}} \xi(r_p,\pi)\bar{n}(\chi_{eff}-\pi)d\pi}{\int \bar{n}(\chi')d\chi'} + \frac{\int \bar{n}^2(\chi')d\chi' \int \xi(r_p,\pi)d\pi}{(\int \bar{n}(\chi')d\chi')^2}$$





Method used for the ELG

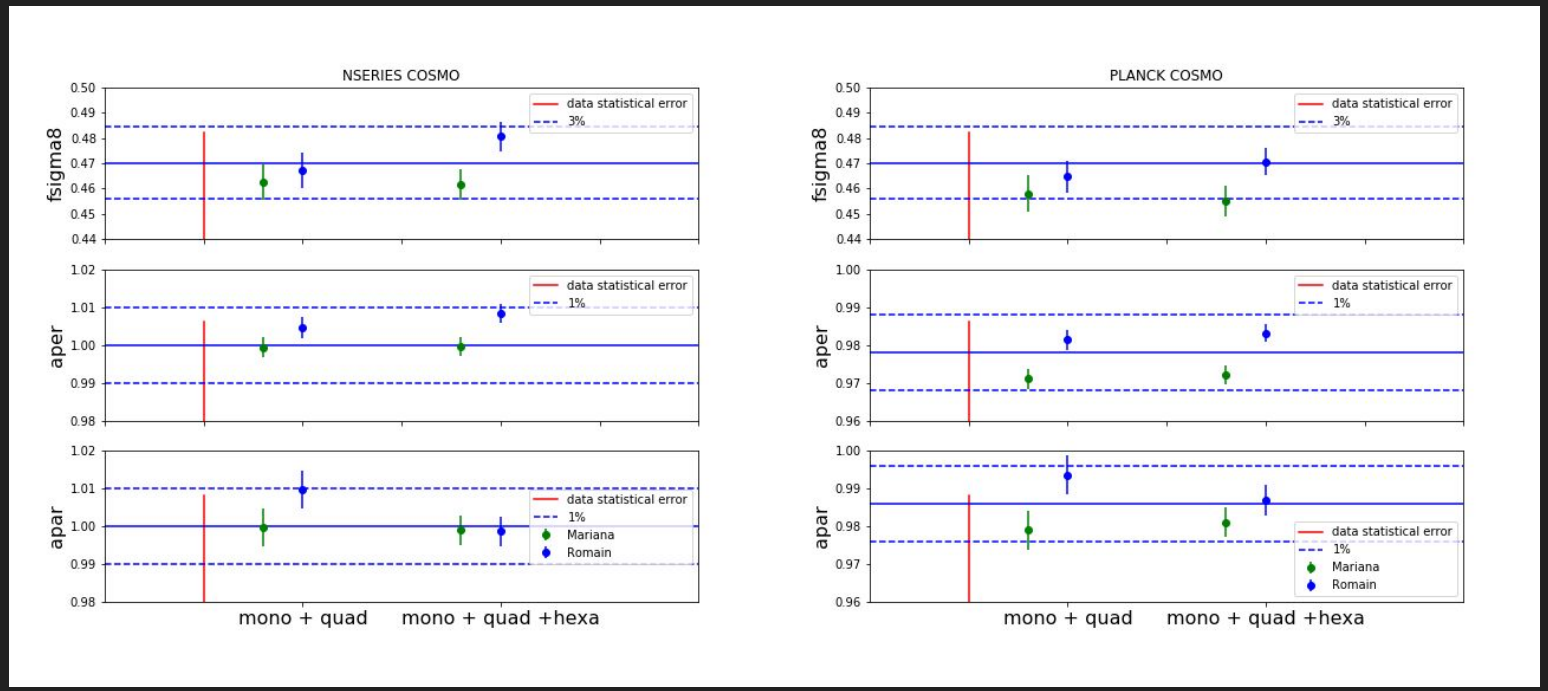
eBOSS mocks

Need mocks to evaluate theoretical systematics and covariance matrix
2 set of mocks in eBOSS :
- OuterRim : 1 realisation Nbody. Lbox = 2.6 Gpc/h, constrain theoretical systematics of the TNS model.
- EZmock (mocks based on the Zel'dovich approximation): 1000 set of independent realisation with the same footprint as the eBOSS sample, with observationals systematics included, for covariance matrix
1 mock of BOSS :
- NSERIES mocks : 7 independant realisation of CMASS galaxies. Gives better constraint on cosmic variance.

Result on mocks

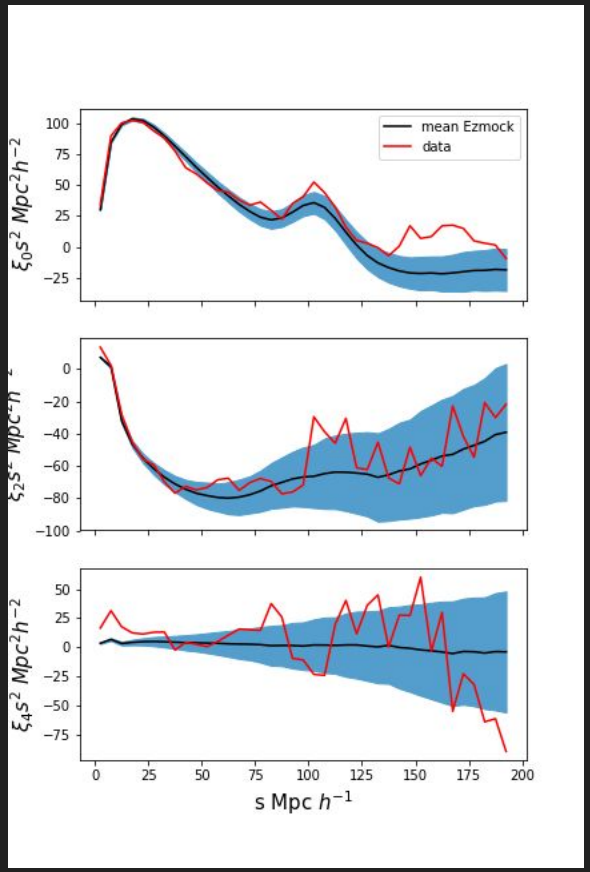
The use of a wrong cosmology to convert redshift into distance create distortion independent of RSD

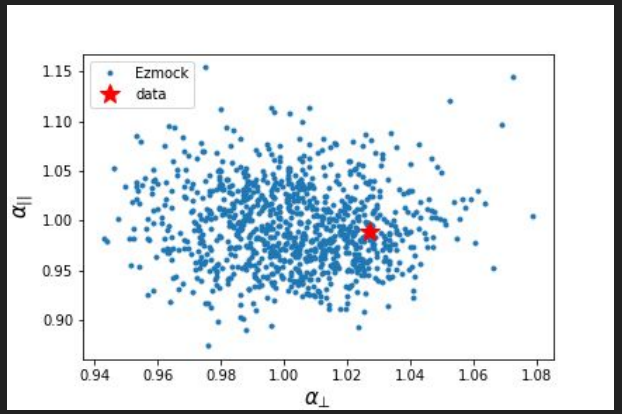
$$\alpha_\perp = \frac{D_M(z) r_{d,\mathrm{fid}}}{D_M^{\mathrm{fid}}(z) r_d}, \qquad \alpha_\parallel = \frac{H^{\mathrm{fid}}(z) r_{d,\mathrm{fid}}}{H(z) r_d}$$

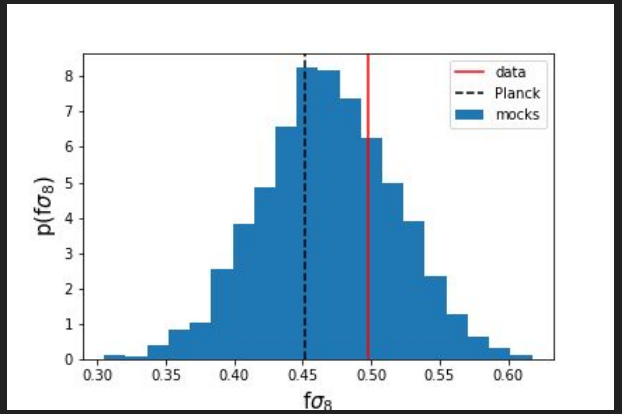


Analysis of the NSERIES mocks

Latest results on final version







Latest results on final version

Perspective ：
Knowledge of ξ_{gm} though galaxy-galaxy lensing break degeneracy between bias parameter, and break the degenerancy between f and σ_8.