A NEW APPROACH TO MEASURE THE EVOLUTION STRUCTURE GROWTH

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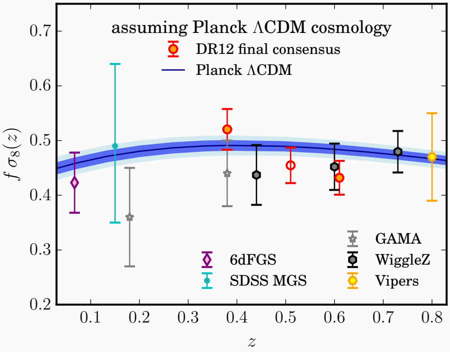
Clustering analysis goals

- Improve the methodology used to analyse data (BAO)
- Development of fast method to measure anisotropic signal (P, ξ)
- **How to combine data from different volumes within the surveys.**

How to combine data from wide redshift ranges



(S. Alam et al. 2016)

How to combine data from wide redshift ranges

Redshift-bins splitting with traditional clustering analysis,

- loss of signal across bin boundaries
- computational expensive
- Window function effects

Optimal redshift weights as smoother windows on data,

- compression of the information in the redshift direction
- sensitivity to evolution with redshift
- decrease computational effort for large data sets

Accounting for evolution,

- $\xi(r,z) \rightarrow b(z), f\sigma_8(z), \alpha_{||}(z), \alpha_{\perp}(z)..\,.$
- $\xi(r) = \int dz\, \xi(r,z)$

Accounting for evolution in an optimal way

- $\xi_w(r) = \int dz\, \xi(r,z) w(z)$
- w(z) for different parameters, based on a fiducial model

Linear compression of a data-set $\mathbf{x}$, Gaussian distributed, with mean μ and covariance C,

$$y = \mathbf{w}^T\mathbf{x}. \tag{1}$$

For a single parameter θ_i,

$$F_{ii} = \frac{1}{2}\left(\frac{\mathbf{w}^T C_{,i}\mathbf{w}}{\mathbf{w}^T C\mathbf{w}}\right)^2 + \frac{\left(\mathbf{w}^T\mu_{,i}\right)^2}{\mathbf{w}^T C\mathbf{w}}, \tag{2}$$

We maximise F_{ii} w.r.t $\mathbf{w}$ assuming C a priori, $C_{,i} = 0$ and the only non-trivial eigenvector is

$$\mathbf{w}^T = C^{-1}\mu_{,i}, \tag{3}$$

Modelling $\xi(r, z)$, $P(k, z)$

$$\xi(r) = \int dz\, \xi(r, z) w(z)$$

Modeling $\xi(r, z)$ evolution by allowing free functions (i.e. Taylor expanding cosmological quantities) and making sure there is enough freedom in other parameters. E.g. for the linear bias, $b(z) = A + Bz^2$.

- derive a set of weights for each of the parameters of interest, (A, B)
- apply weights to the data computing the weighted multipoles $P_{0,A}, P_{2,A}, P_{0,B}, P_{2,B}$...
- include weights in the model $\rightarrow$ **window function**
- joint fit of all the multipoles w.r.t the different weights.

Modelling the evolution about ΛCDM: $\Omega_m(z, q_0, q_1)$, $f\sigma_8(z, p_0, p_1)$

$$\frac{\Omega_m(z)}{\Omega_{m,\mathrm{fid}}(z)} = q_0\left[1 + q_1 y(z) + \frac{1}{2} q_2 y(z)^2\right], \tag{4}$$
$$y(z) + 1 \equiv \Omega_{m,\mathrm{fid}}(z)/\Omega_{m,\mathrm{fid}}(z_p);$$

A common framework to test for deviations both in terms of geometry and growth rate, $f[\Omega_m(q_i, z)]$, $[H, D_A][\Omega_m(q_i, z)]$

$$\frac{\Omega_m(z)}{\Omega_{m,\mathrm{fid}}(z)} = q_0\left[1 + q_1 y(z) + \frac{1}{2} q_2 y(z)^2\right], \tag{4}$$
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A common framework to test for deviations both in terms of geometry and growth rate, $f[\Omega_m(q_i, z)]$, $[H, D_A][\Omega_m(q_i, z)]$

$$\frac{f\sigma_8(z)}{f\sigma_{8,\mathrm{fid}}(z)} = p_0\left[1 + p_1 x(z) + \frac{1}{2} p_2 x(z)^2\right], \tag{5}$$

It allows a wider range of deviations from the ΛCDM scenario, as it does not assume any particular form or relation for f and σ_8

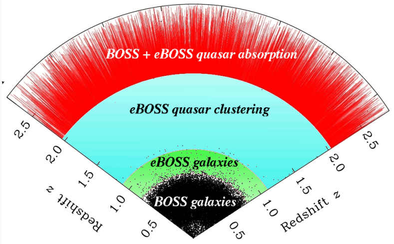
Fitting models to the data

- Linear compression of a data-set $y = \mathbf{w}^T\mathbf{x}$.
- search for **optimal** weights $\rightarrow$ fisher matrix (RSD: Ruggeri et al 2017; Mueller et al 2017; Zhu et al 2015;)

- derive a set of weights for each of the parameters of interest (e.g. q_i, p_i)
- apply weights to the data; compute weighted multipoles: $P_{0,q_0}, P_{2,q_0} \ldots \ldots$
- include weights in the model $\rightarrow$ (TNS 1-loop)
- joint fit of all the multipoles w.r.t the different weights.

eBOSS in a nutshell

- Part of SDSS-IV collaboration
- Spectroscopic survey: $\sigma_z \sim 0.001$
- Apache Point Telescope 2.5m
- 2014 - 2019 observing LRGs, ELGs, quasars, Lyα
- 1000 fibres per plate ($\sim 7deg^2$)



DR14Q data. RSD & iso-BAO analyses completed. Measurements on D_A, H and $f\sigma_8$ at $z = 1.52$ for the first time. (Ata et al 2017);

eBOSS in a nutshell

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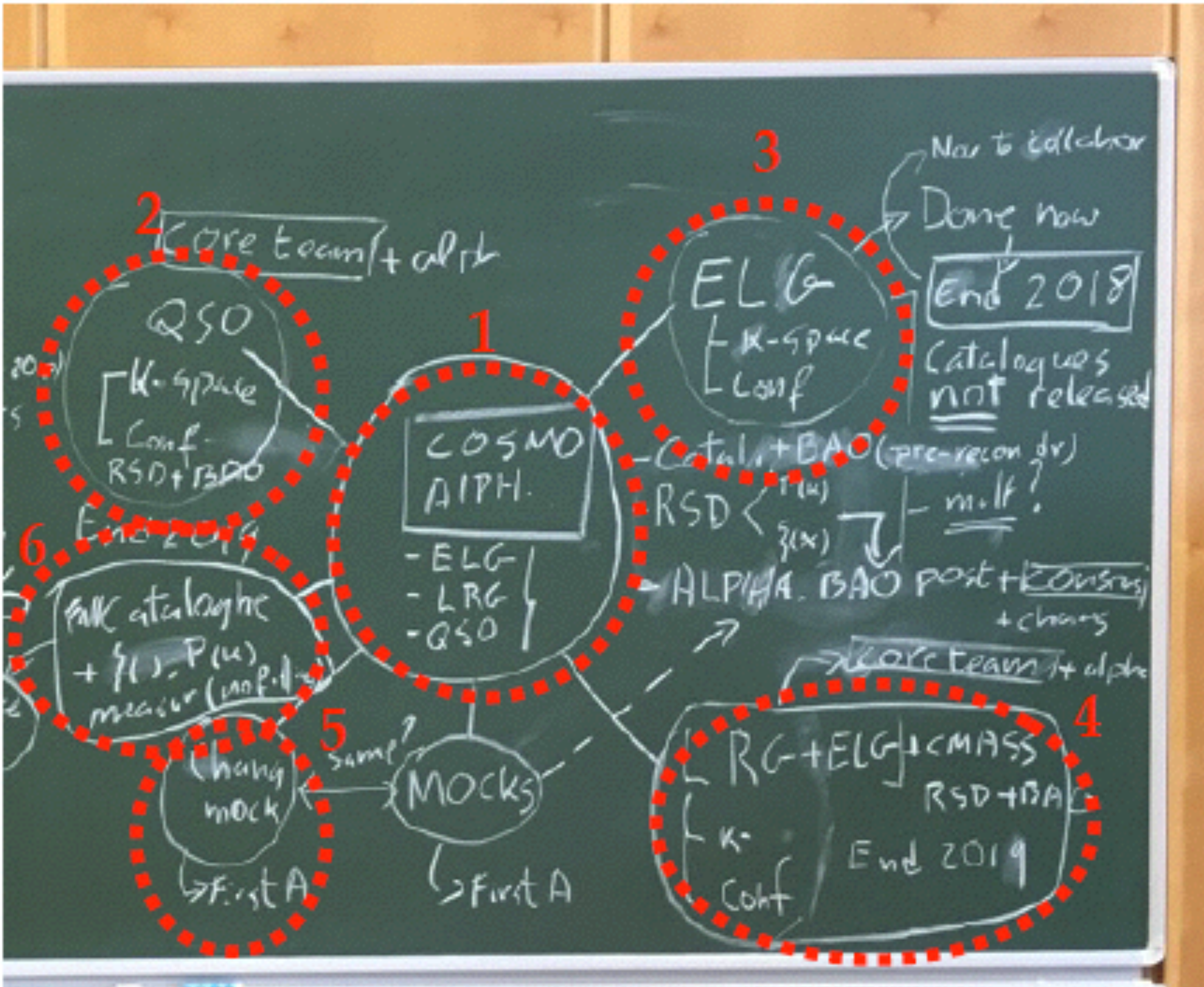
==List of first author papers based on DR14 QSO data==

We plan a combined submission of first-author papers (most of them based on BAO/RSD/mocks).

Please, write down the status of your project, so we can coordinate the dates for the join submission.

First-author	**Potential Title**	**Expected date for submitting to the collaboration**
Hector Gil-Marin	Growth rate measurement from the quasar power spectrum in the redshift range 0.8<z<2.2	Beginning of July
Rossana Ruggeri	The extended Baryon Oscillation Spectroscopic Survey (eBOSS): testing a new approach to measure the evolution of the structure growth	Beginning of July
Rossana Ruggeri	The extended Baryon Oscillation Spectroscopic Survey (eBOSS): Measuing redshift space distortions at z ~ 1.55 on the QSO optimally weighted multipoles.	Beginning/Mid? of July
Fangzhou Zhu	Analysis of the eBOSS DR 14 Quasar Sample: Measuring the Baryon Acoustic Oscillations with Redshift Weights	Beginning of July
Pauline Zarrouk	Growth rate measurement from the quasar correlation function in the redshift range 0.8<z<2.2	Beginning of July
Dandan Wang	Analysis of the eBOSS DR 14 Quasar Sample: Measuring the Baryon Acoustic Oscillations with Redshift Weights in Fourier space	Beginning of July
Gongbo Zhao	Analysis of the eBOSS DR 14 Quasar Sample: Measuring the expansion history and growth rate with redshift weights in Fourier space and cosmological implications	Beginning of July
Jiamin Hou	Analysis of the eBOSS DR 14 Quasar Sample: cosmological implications of the configuration-space clustering wedges	Mid of July



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2
3
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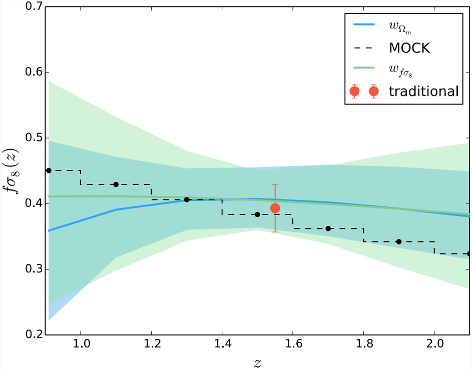
COSMO ALPH.
- ELG
- LRG
- QSO
QSO
Core team + alpha
ELG
k-space
Conf
Done now
End 2018
Catalogues not released
RSD
BAO
MOCKS
same?
First A
LRG + ELG + CMASS
RSD + BAO
End 2019
Conf
Core team + alpha

The extended Baryon Oscillation Spectroscopic Survey (eBOSS): testing a new approach to measure the evolution of the structure growth

arXiv:1712.03997

Rossana Ruggeri[1*], Will J. Percival [1], Eva-Maria Mueller [1], Héctor Gil-Marín [2,3], Fangzhou Zhu [4], Nikhil Padmanabhan[4], Gong-Bo Zhao [5,1]



The quasar sample represents an important sample-test to investigate the improvements possible through the optimal weights. Characterized by a wide redshift range, (0.8 – 2.2), and lower density 82.6/deg2;

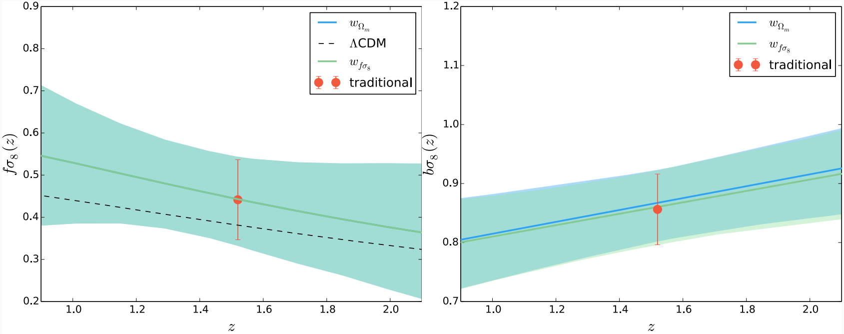
The extended Baryon Oscillation Spectroscopic Survey (eBOSS): Measuring the evolution of the growth rate using redshift space distortions between redshift 0.8 and 2.2

arXiv:1801.02891

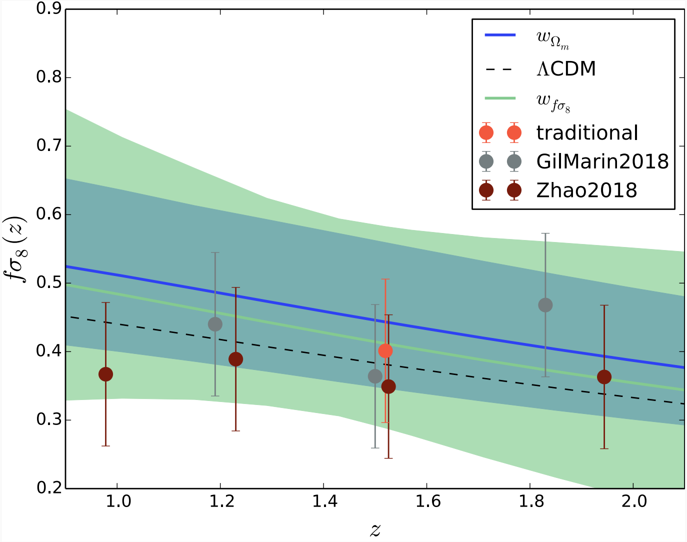
Rossana Ruggeri[1⋆], Will J. Percival [1], Héctor Gil-Marín, Florian Beutler[1], Eva-Maria Mueller[1], Fangzhou Zhu [4], Nikhil Padmanabhan[4], Gong-Bo Zhao [5,1] et eBOSS collaboration

eBOSS DR14: $f\sigma_8(p_i, z), f\sigma_8\left[\Omega_m(q_i, z)\right], b\sigma_8(z)$

$$z_{\mathrm{p}} = 1.52$$



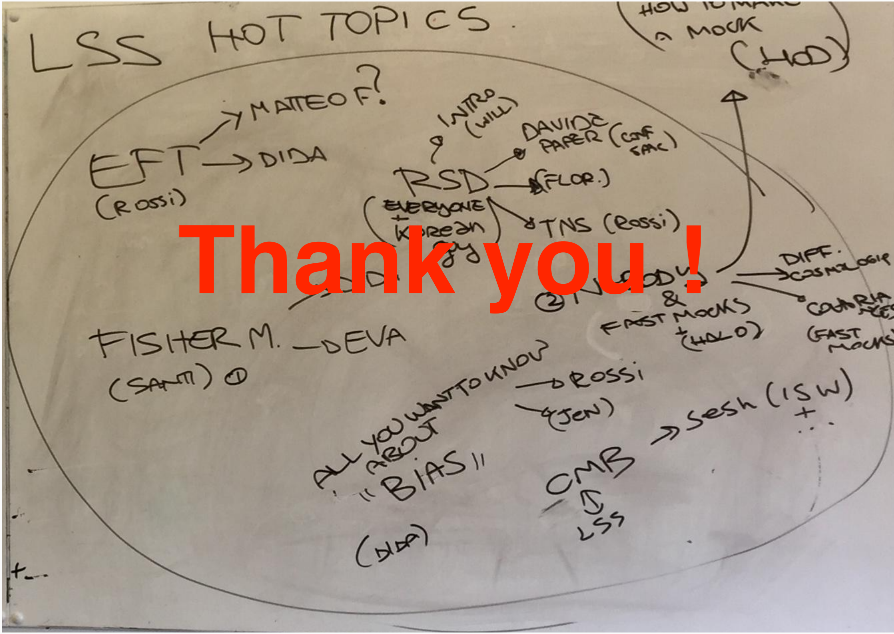
eBOSS DR14: $f\sigma_8(p_i, z), f\sigma_8\left[\Omega_m(q_i, z)\right], b\sigma_8(z)$



DR16 + FUTURE SURVEYS

- More signal $\rightarrow$ evolution to break degeneracy
- Optimal weights technique, as a more efficient and accurate alternative would enhance S/N, considering all galaxy pairs.
- Weighting scheme: the method is flexible and works for other sets of parameters;
- Future surveys: 20 - 30 million objects, $0.5 < z < 3.5$; 15-18,000 deg^2;
- Traditional analysis: e.g for DESI, to be repeated on 35 redshift bins, neglecting cross correlation between different volumes.

Thank you !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