BARYON ACOUSTIC OSCILLATIONS IN DES-Y3 DATA

DARK ENERGY SURVEY
On behalf of the DES collaboration

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

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INTRODUCTION

In this work we explain a method to obtain the Baryon Acoustic Oscillation (BAO) scale from the Angular Correlation Function (ACF). This method is tested with the ACFs of 1000 lognormal mocks (simulated galaxy catalogs). The cosmology of the simulations is recovered with a precision of a few percent on the distance measurement. The final goal of the analysis is to measure the evolution of the angular diameter distance from the DES-Y3 data from redshift 0.6 to redshift 1.1.

THE DES-Y3 BAO SAMPLE

The DES-Y3 BAO sample is a photometric red galaxy sample selected using the $griz$ bands and a photometric redshift estimate. It is built looking for a good compromise between **photo-z accuracy and number density**. It is selected with the cuts

$$\begin{aligned} &1.7 < i - z + 2(r - i) && \text{(color selection)}, \\ &17.5 < i < 19 + 3z_{ph} && \text{(flux selection)}, \\ &0.6 < z_{ph} < 1.1 && \text{(photo-z range)}. \end{aligned} \tag{1}$$

This BAO sample is divided in **5 redshift bins** with bounds [0.6, 0.7, 0.8, 0.9, 1.0, 1.1]. In this work, we will focus on how the BAO is measured in the **2-point ACF**. Since **the ACF of the DES-Y3 data is still blinded**, we will measure the BAO in a set of **1000 lognormal mocks** (simulated galaxy catalogs) instead. This will be useful to validate the methods and to obtain an estimation of the error in the BAO from the 1000 mocks.

METHODOLOGY

The methodology followed in this work is the following:

1. Generate the lognormal mocks (**1000** in total). Firstly, we have to **fix an input cosmology** (in this case, we will use the **MICE cosmology**) and a **redshift distribution of the galaxies** for each redshift bin (we will use the ones of the DES-Y3 BAO sample).
2. Calculate the ACFs of each mock. Also, calculate the **full covariance matrix** of the ACFs, $(\mathrm{cov})^{z_{bin_1}, z_{bin_2}}_{\theta_i, \theta_j}$.
3. **Obtain the BAO scale of each mock** by fitting its ACFs using the full covariance matrix. The χ^2 of the fit is

$$\chi^2_{mock}(\vec{p}) = \sum_{z_{bin_{1,2}}} \sum_{i,j} \left[\omega^{z_{bin_1}}_{mock}(\theta_i) - \omega^{z_{bin_1}}_{model}(\theta_i; \vec{p}^{\,z_{bin_1}})\right] (\mathrm{cov}^{-1})^{z_{bin_1}, z_{bin_2}}_{\theta_i, \theta_j} \left[\omega^{z_{bin_2}}_{mock}(\theta_j) - \omega^{z_{bin_2}}_{model}(\theta_j; \vec{p}^{\,z_{bin_2}})\right]. \tag{2}$$

   The model is given by

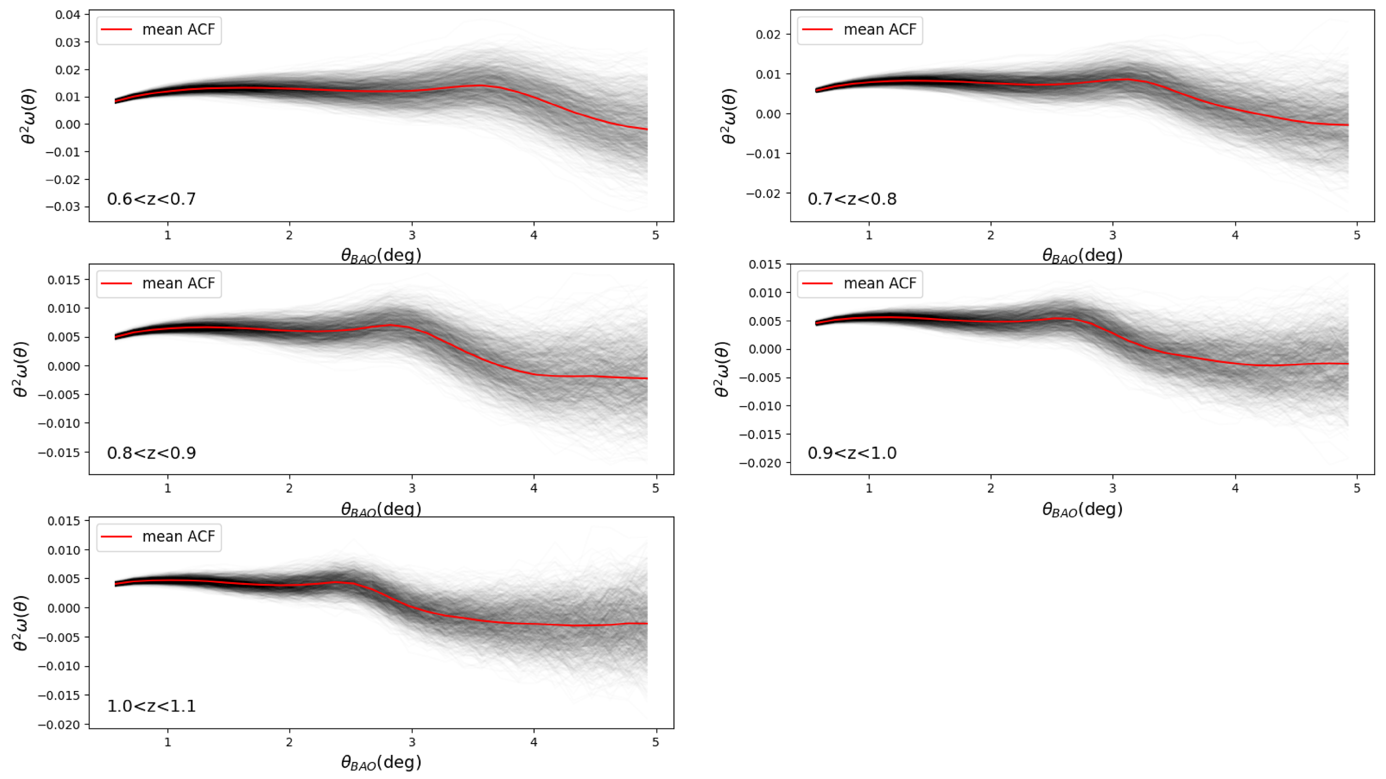
$$\omega^{z_{bin}}_{model}(\theta, \vec{p}^{\,z_{bin}}) = A^{z_{bin}} \omega^{z_{bin}}_{template}(\alpha \cdot \theta) + B^{z_{bin}} + \frac{C^{z_{bin}}}{\theta} + \frac{D^{z_{bin}}}{\theta^2}, \tag{3}$$

   where $\boldsymbol{\omega^{z_{bin}}_{template}(\theta)}$ **is the theoretical ACF computed for a given cosmology**. The BAO scale is given in terms of the **shift** $\boldsymbol{\alpha}$ with respect to the template cosmology, $\alpha = \theta^{template}_{BAO} / \theta^{mock}_{BAO}$.
4. Calculate the **mean** and the **standard deviation** of the 1000 α values. We will use **two different template cosmologies** in order to compare the results.

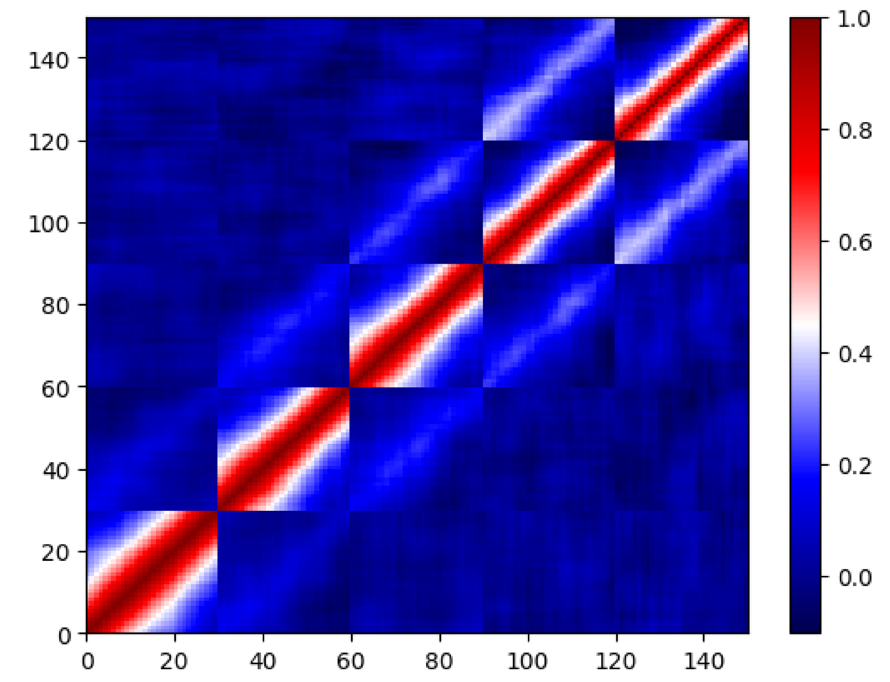
RESULTS

Correlation functions calculated from the mocks

ACFs of the 1000 mocks



Full correlation matrix



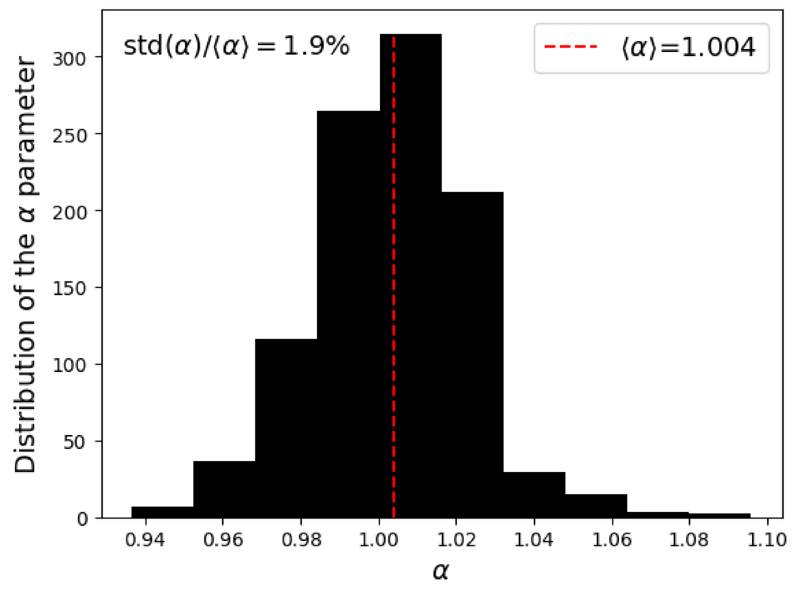
Template ACFs: two different cosmologies

	Ω_b	Ω_c	h	A_s or σ_8	n_s
MICE cosm.	0.044	0.206	0.7	$\sigma_8 = 0.8$	0.95
Planck cosm.	0.0494	0.2656	0.6727	$A_s = 2.101 \cdot 10^{-9}$	0.9649

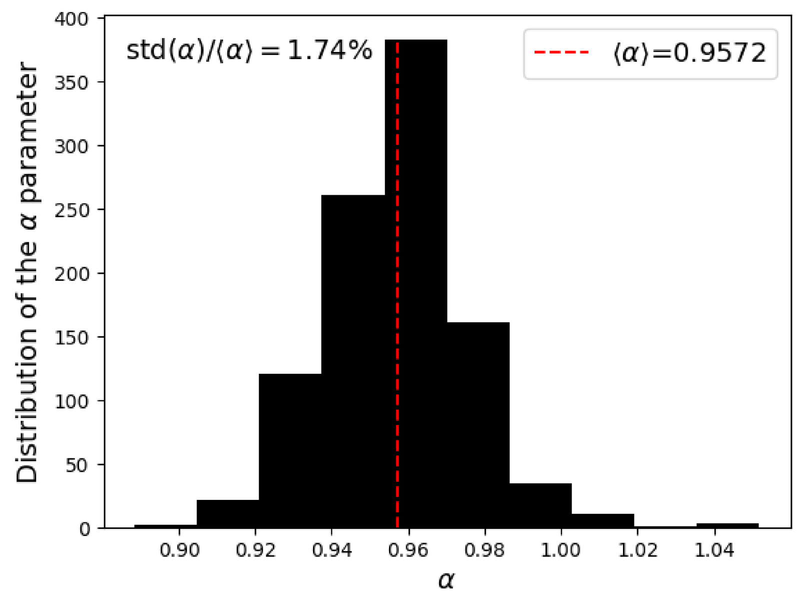
We compute the ACF, $\omega^{z_{bin}}_{template}(\theta)$, for both cosmologies in order to do the BAO fits, eqs. (2) and (3).

Fit results

1) Using the MICE template



2) Using the Planck template



Summary of the results

	MICE t.	Planck t.
$\langle\alpha\rangle$	1.0040	0.9572
$std(\alpha)/\langle\alpha\rangle$	1.9 %	1.74 %
$\alpha_{th}(z_{eff})$	1	0.9528

Conclusions

- We have obtained a **standard deviation** of the 1000 α values **of** $\boldsymbol{\sim 2\,\%}$ **with respect to the mean** $\boldsymbol{\alpha}$. As expected, using the MICE template gives $\langle\alpha\rangle \approx 1$, while using the Planck template gives a slightly different $\langle\alpha\rangle$. For both templates, $\boldsymbol{\langle\alpha\rangle}$ **corresponds to the theoretical value of each cosmology**, since $\langle\alpha\rangle/\alpha_{th} \approx 1.004$.
- The standard deviation over the mean **does not depend on the cosmology of the template** used to do the fits. This allows us to use this method with real data (for which we don't know the exact cosmology).

REFERENCES

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