Using the Mark Weighted Correlation Functions to Improve the Constraints on Cosmological Parameters

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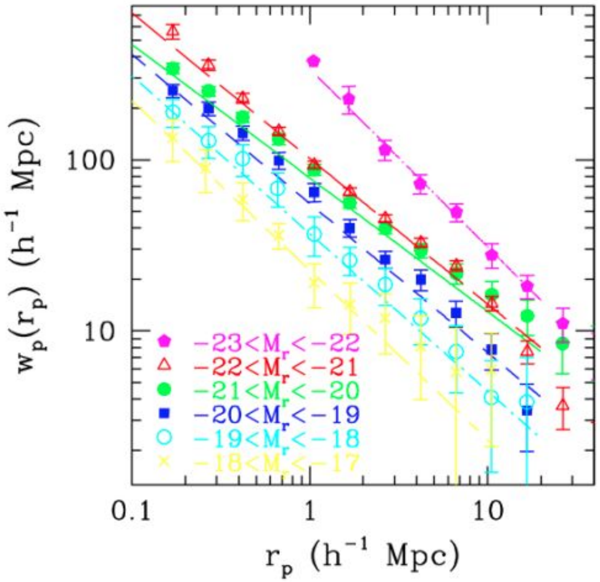
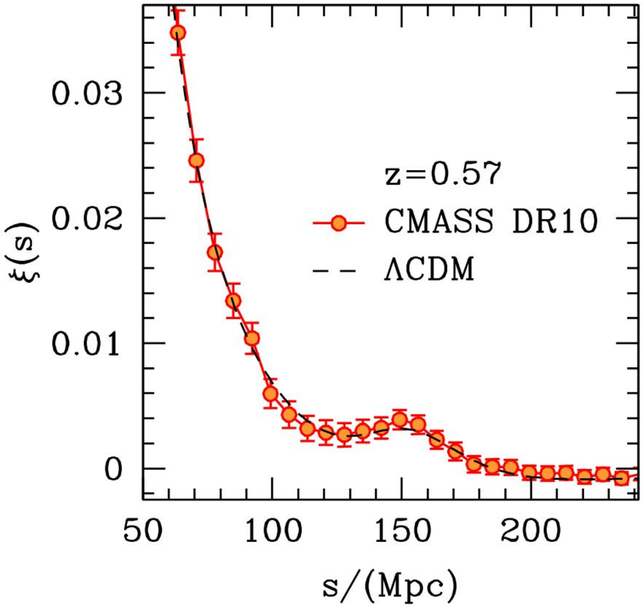
The two-point correlation function is a workhorse in observational cosmology



Zehavi+, ApJ, 630,1 (2005)



Chiang+, JCAP, 09,028 (2015)

The Marked Correlation Function (MCF) gives different weights to each galaxy

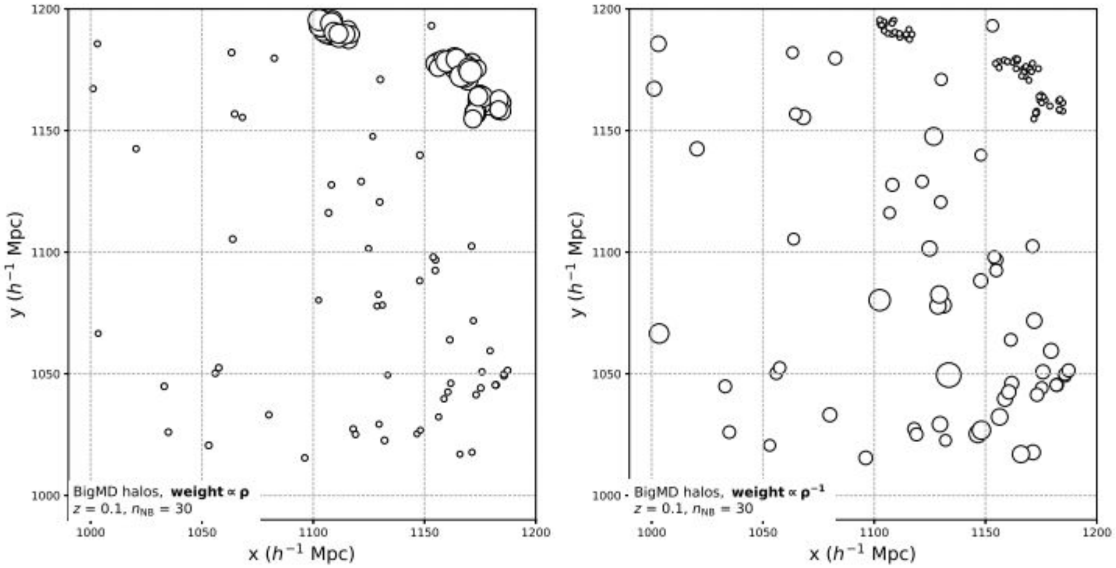


Figure 2. Halos selected from a $200 \times 200 \times 20(h^{-}1\mathrm{Mpc})^3$ slice in the BigMD sample. Their weights, as represented by the circle size, are determined by ρ^{α}, where $\alpha = 1, -1$. The $\alpha = 1$ scheme puts significantly more emphasis on the objects in dense environment, while the other scheme does the opposite.

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The Marked Correlation Function (MCF) has been suggested to study modified gravity

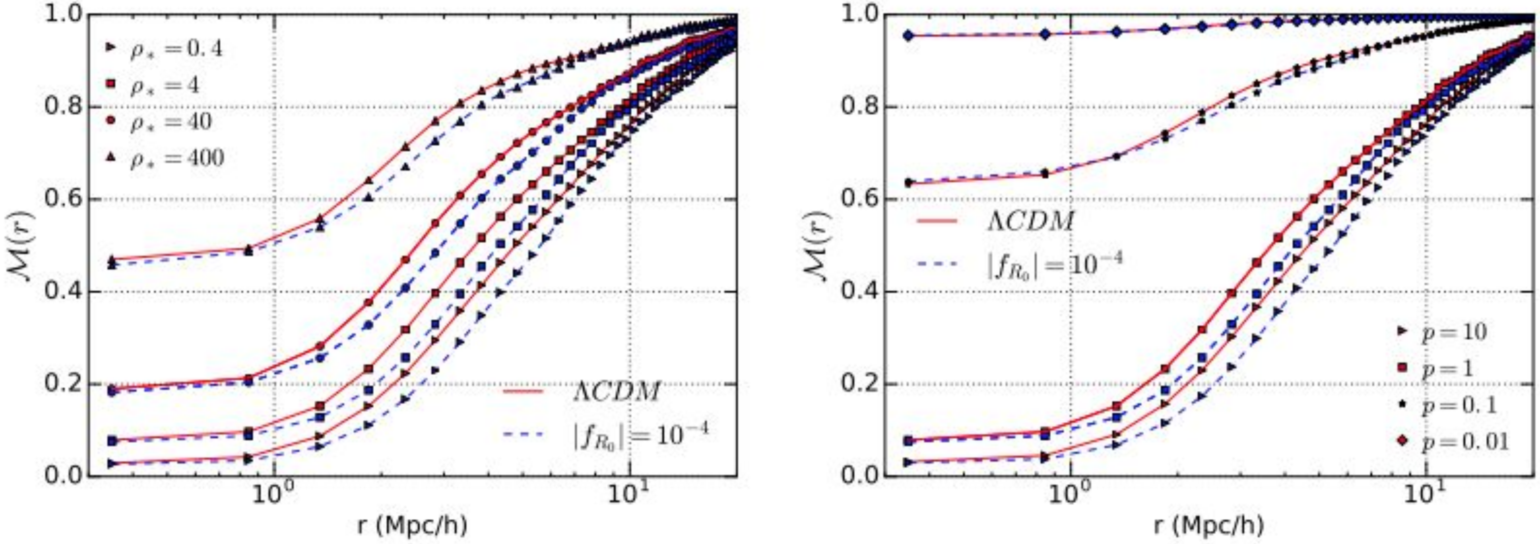
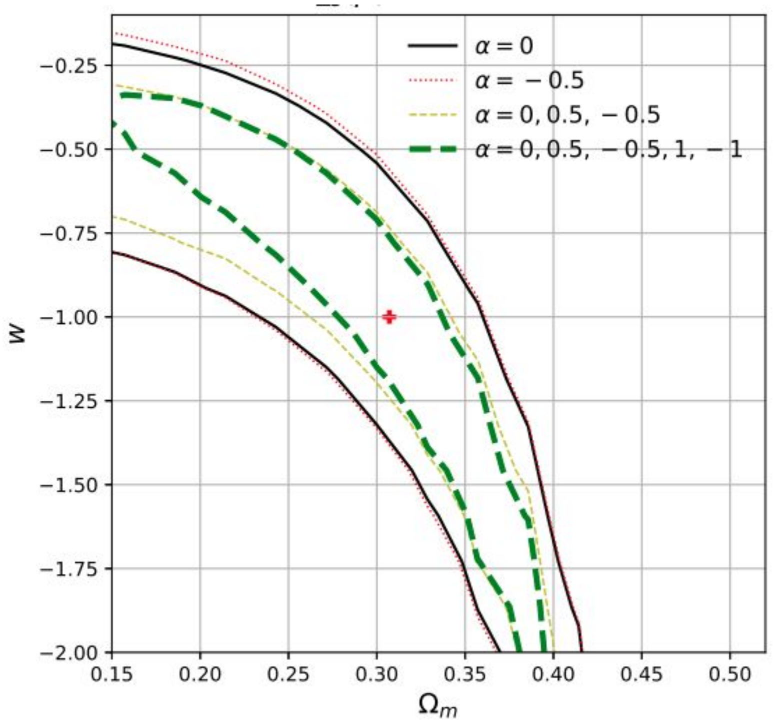


FIG. 6: The variation of the marked correlation function, $\mathcal{M}(r)$ for one realization, as a function of comoving length scale, r, for the ΛCDM [red, full line] and $|f_{R_0}| = 10^{-4}$ [blue, dashed line] scenario, as a function of [left] ρ_*, with fixed $p = 10$, and [right] p, with fixed $\rho_* = 0.4$.

Valogiannis+Bean, Physical Review D, Volume 97, Issue 2

We suggest the MCF to improve constraints on the cosmological parameters



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We start with a Landy-Szalay estimator

$$W(s,\mu) = \frac{WW - 2WR + RR}{RR}$$

$$\mu = \cos(\theta)$$

with θ being the angle between the line joining the pair and the line of sight (LOS) direction

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We weight the tracers using the density field

$$\text{weight} = \rho_{n_{\rm NB}}^{\alpha} \qquad \rho_{n_{\rm NB}}(\mathbf{r}) = \sum_{i=1}^{n_{\rm NB}} W_k(\mathbf{r} - \mathbf{r_i}, h_W)$$

$$\xi(\mathbf{r}) = \langle \delta(\mathbf{x}) \delta(\mathbf{x} + \mathbf{r}) \rangle$$

$$W(\mathbf{r}) = \langle \delta(\mathbf{x}) \rho_{n_{NB}}(\mathbf{x})^{\alpha} \delta(\mathbf{x} + \mathbf{r}) \rho_{n_{NB}}(\mathbf{x} + \mathbf{r})^{\alpha} \rangle$$

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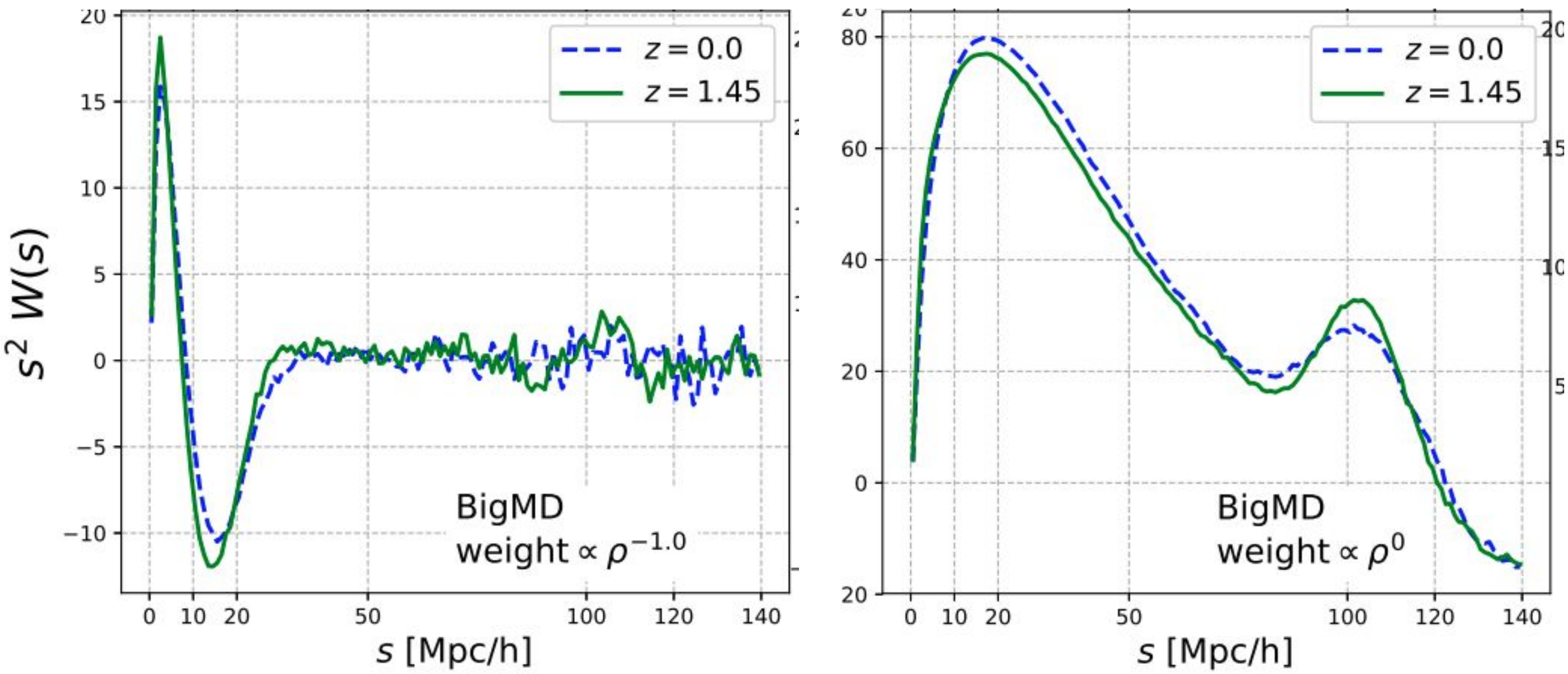
Compared to the standard 2pCF we find different features



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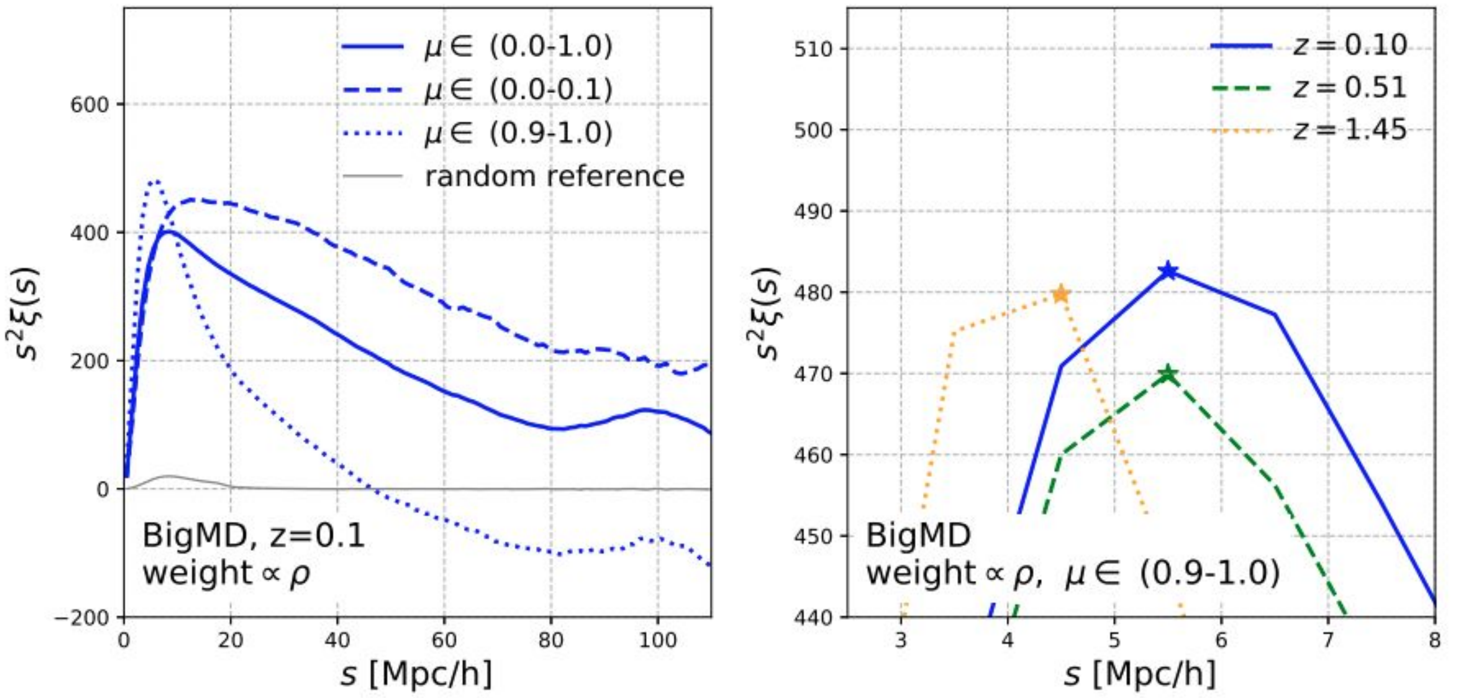
We find a sharp peak around 5 Mpc/h



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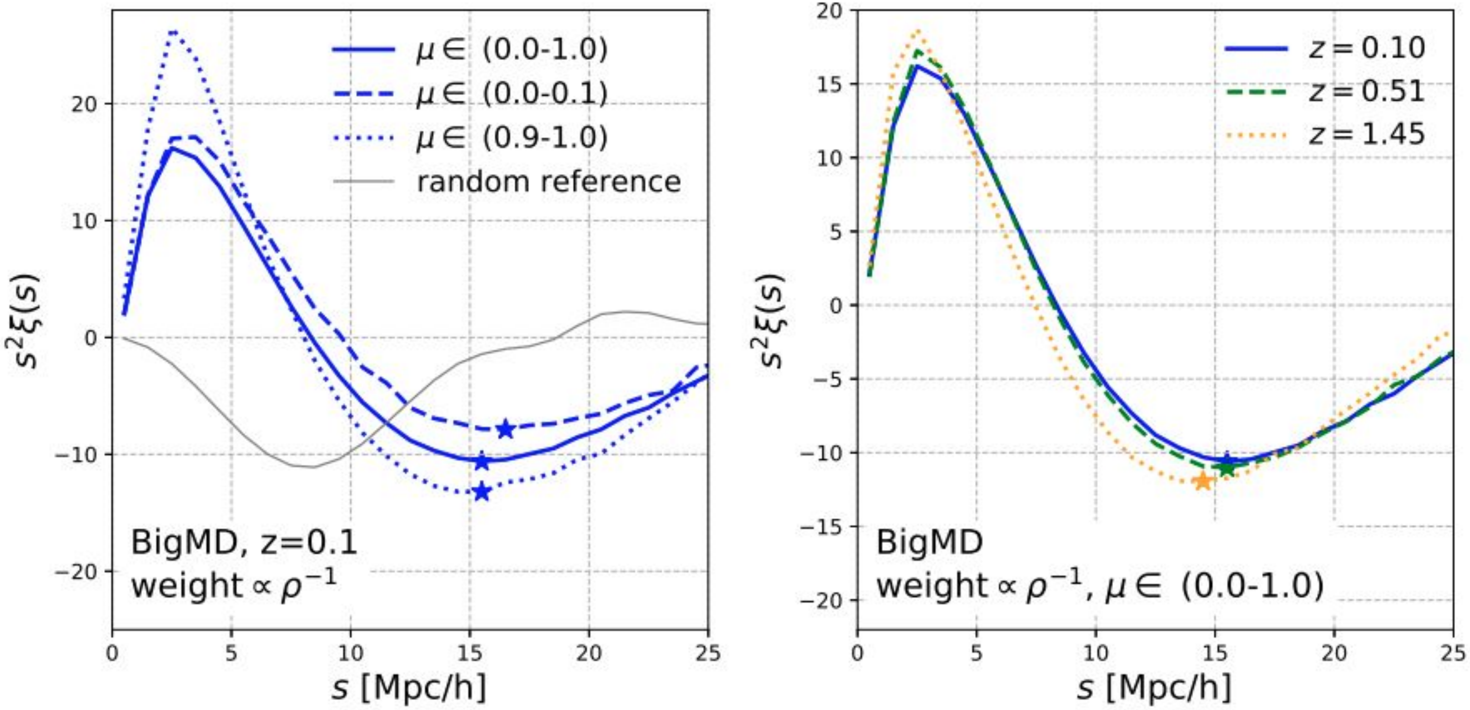
We find a valley around 15 Mpc/h



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Can we use these features to probe cosmology?

In galaxy surveys, the angular positions and redshifts of each galaxy is converted to 3D positions using the redshift-distance relation $r(z)$ adopted in an assumed cosmology. So wrongly adopted cosmology parameters lead to the following distortions of length in the directions parallel and perpendicular to the LOS,

$$\alpha_{||}(z) = \frac{H_{\rm true}(z)}{H_{\rm wrong}(z)},$$
$$\alpha_{\perp}(z) = \frac{D_{A,\rm wrong}(z)}{D_{A,\rm true}(z)}, \tag{7}$$

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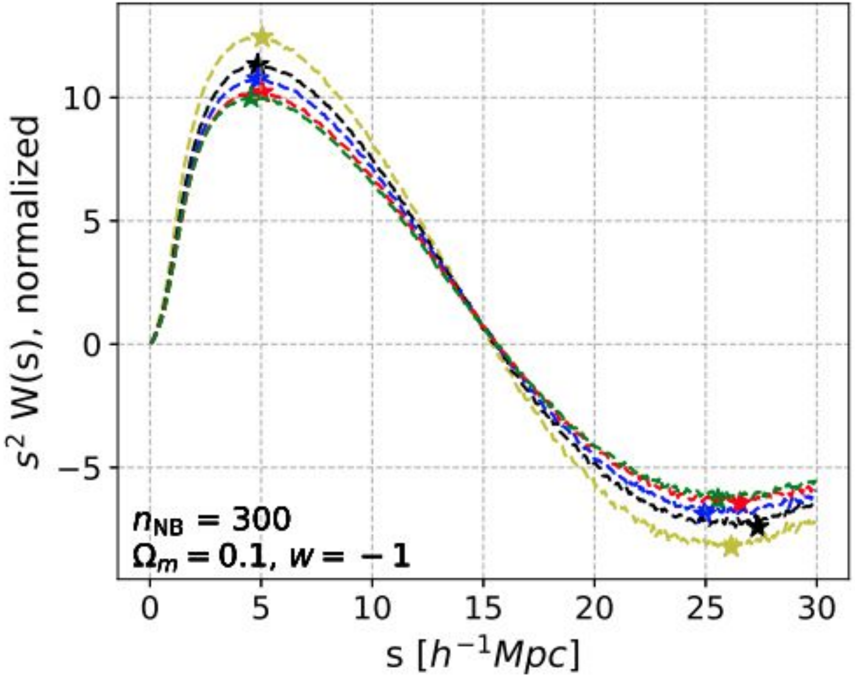
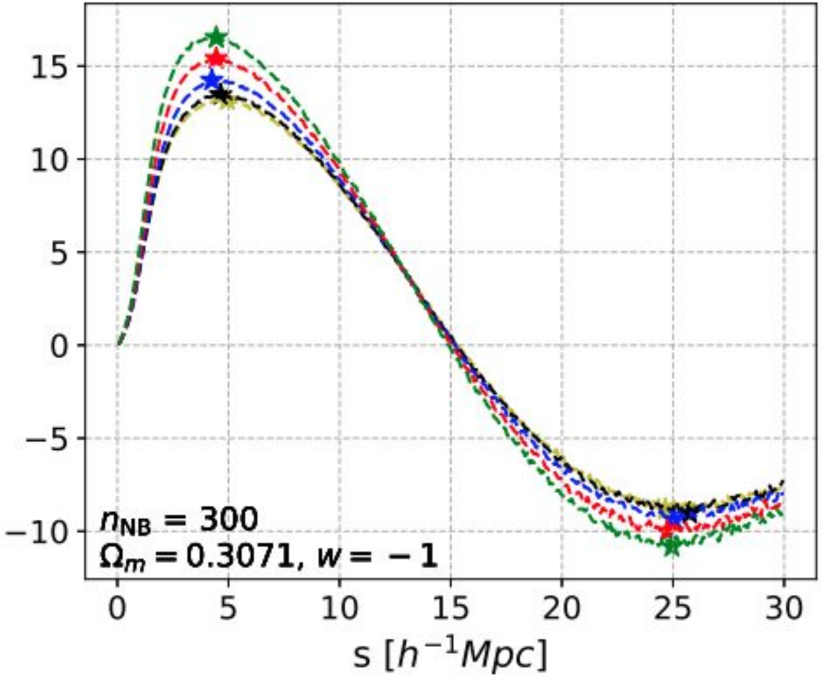
No. Peak and valley are largely insensitive to cosmology





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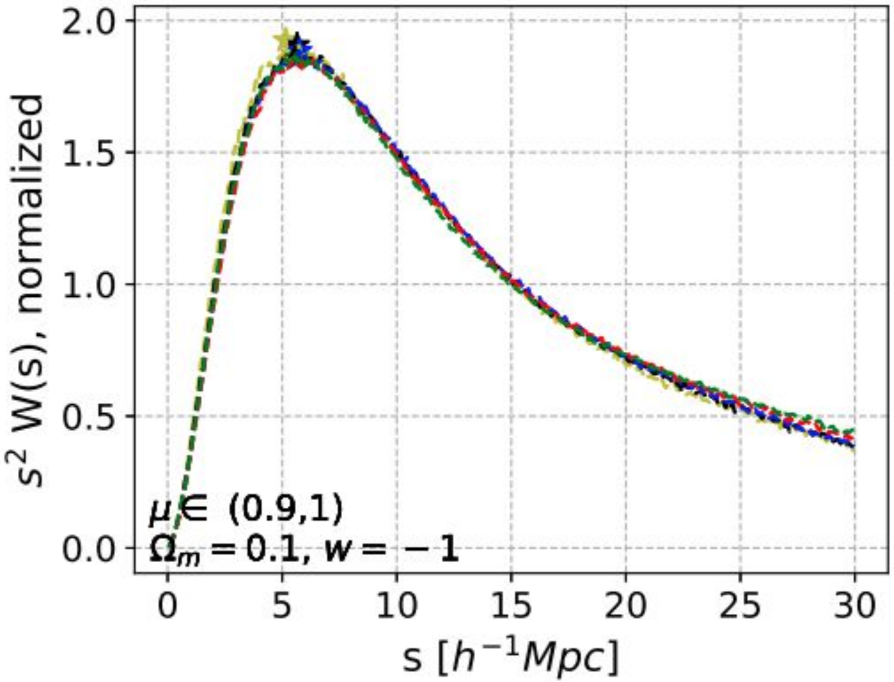
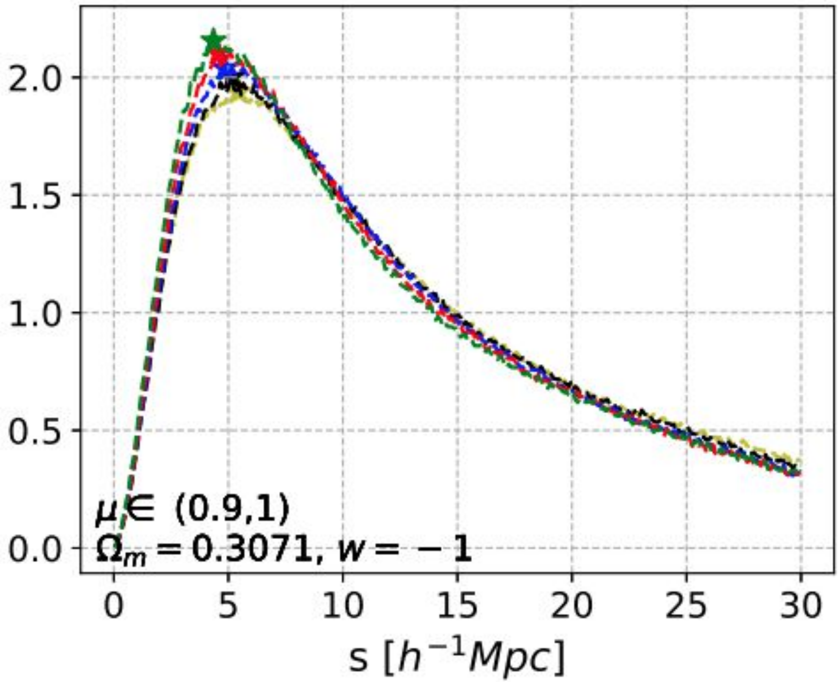
The peak is largely insensitive to cosmology





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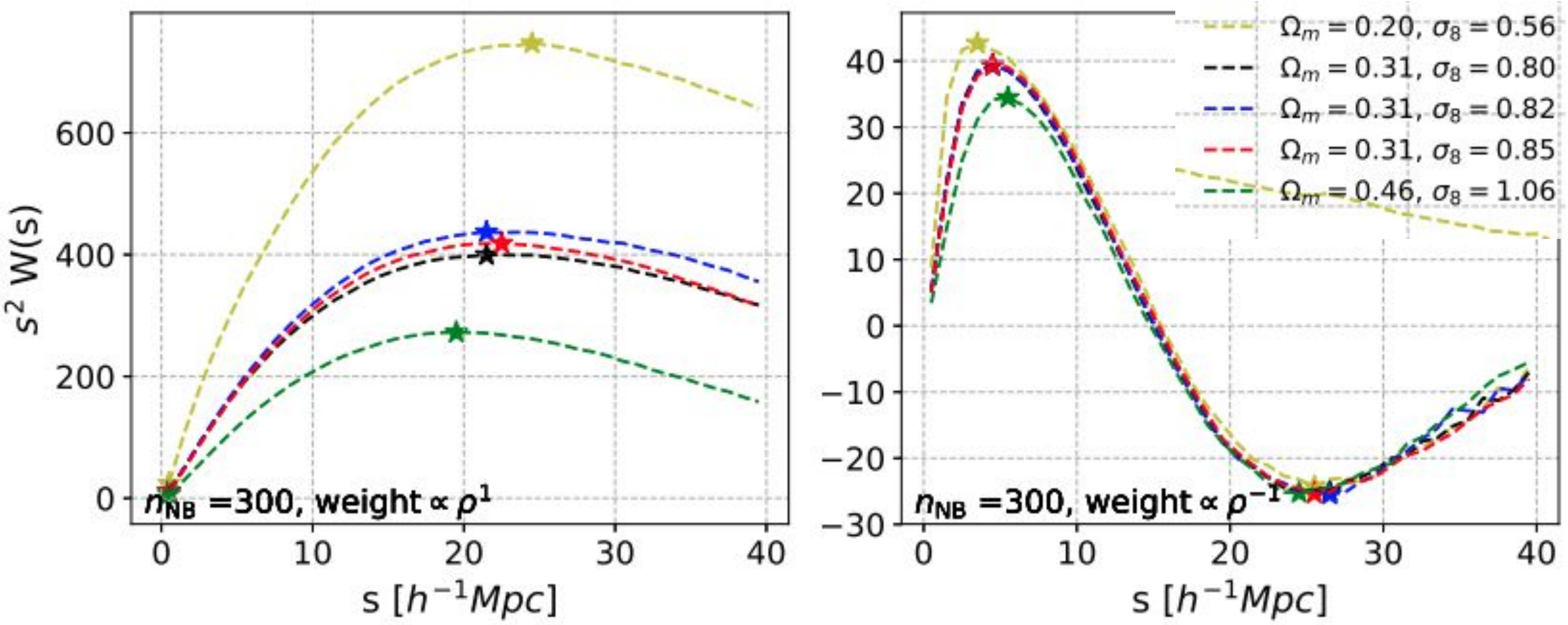
However, the peak is affected by sigma_8



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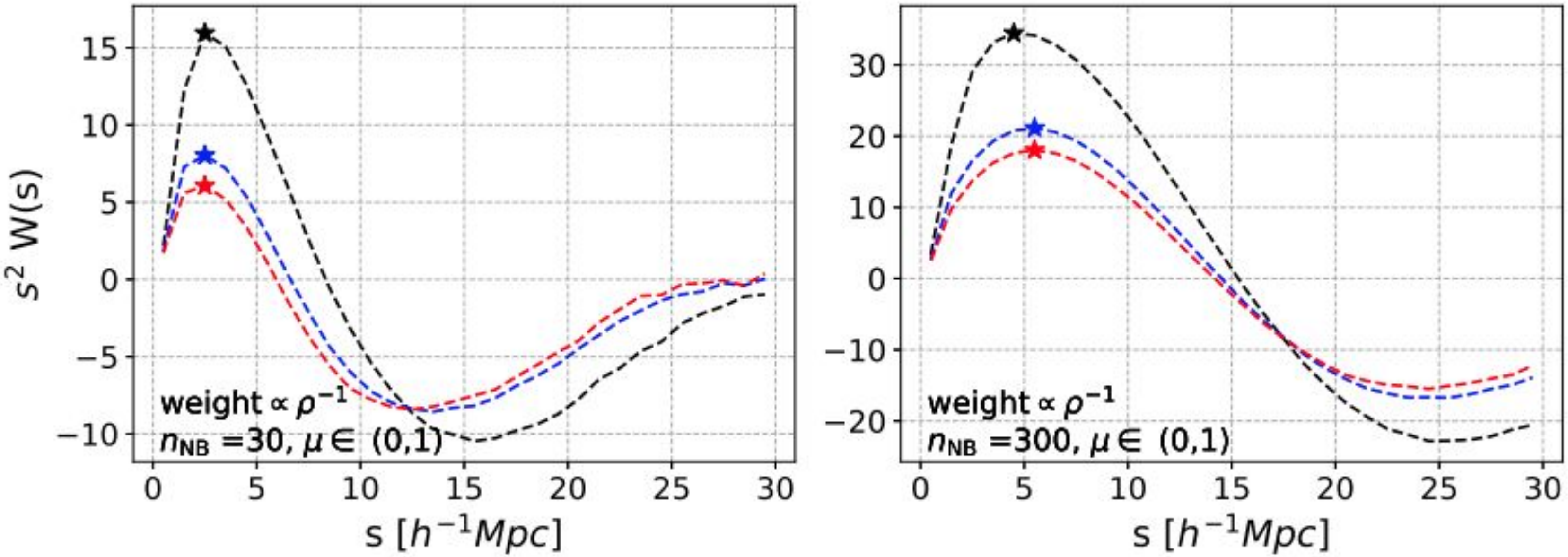
The valley is influenced by the bias



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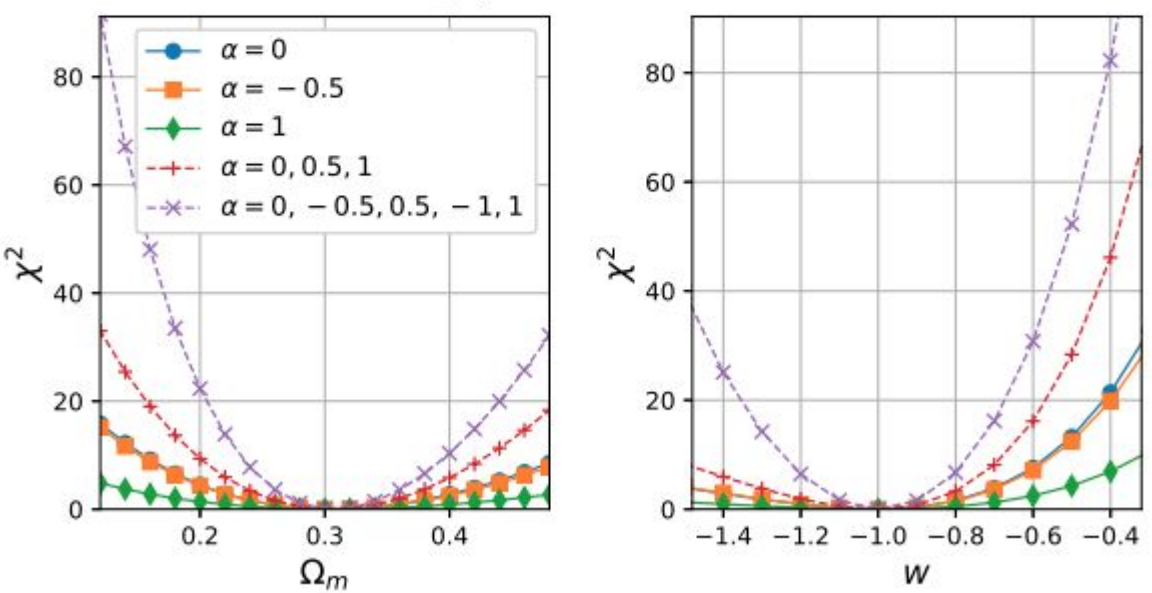
Using the full shape of the MCF we can constrain cosmological parameters



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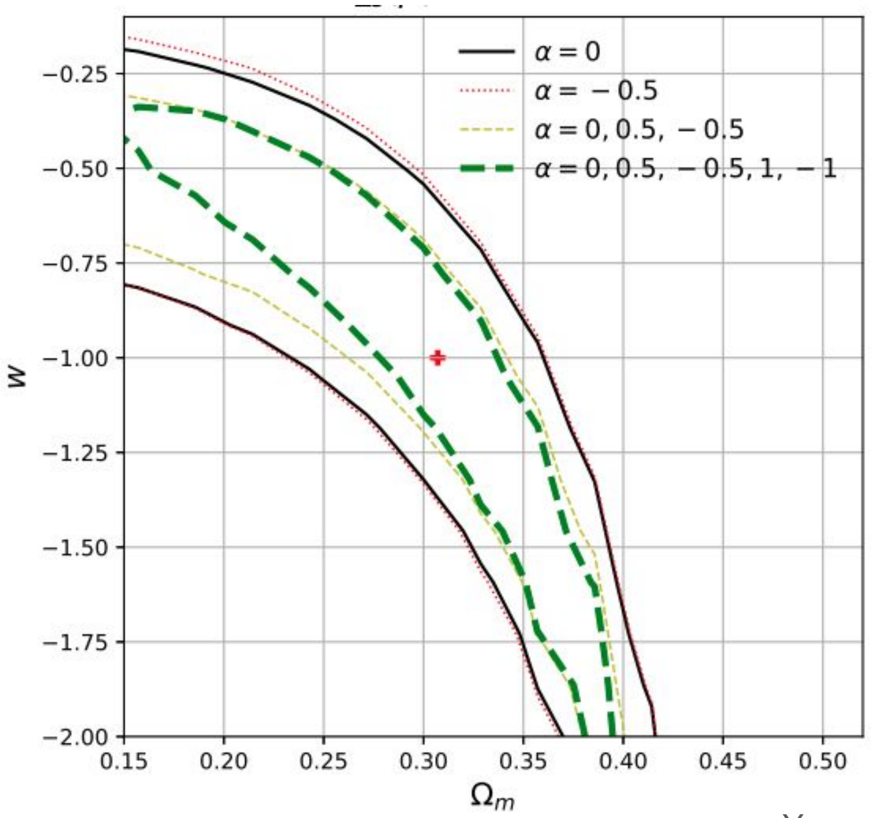
Joint distributions can be narrowed down with the MCF



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Conclusions

- We used density weights to explore the marked 2pCF.
- We find a distinctive location for a peak (5 Mpc/h) and a valley (15 Mpc/h).
- These locations turn out to be robust to changes in omega_m and w, however they are influenced by sigma_8 and the halo bias.
- For an improved constraint on the cosmological parameters we use the full shape of the weighted 2pCF.
- This methodology improves the constraints on omega_m and w by 30% and 50% respectively.

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