SHAMe in Cylinders

Constraining Galaxies to Constrain Cosmology

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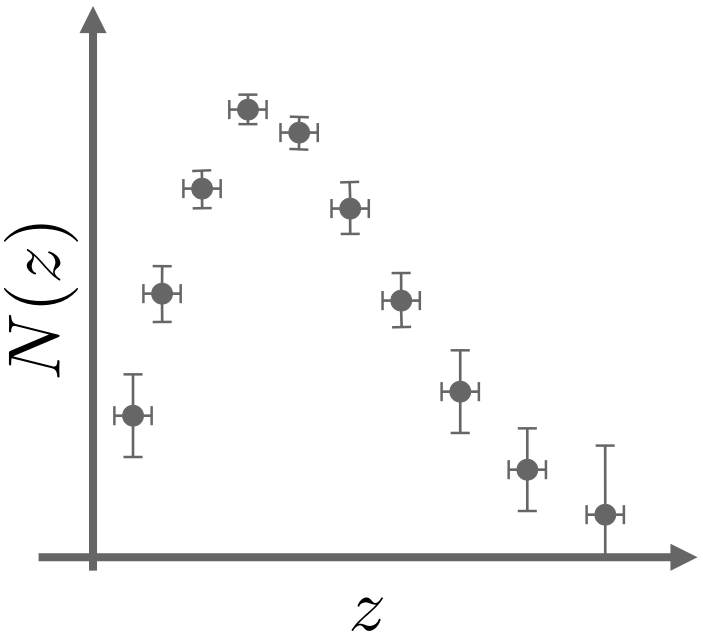
AGENCIA ESTATAL DE INVESTIGACIÓN

Cluster Number Counts



Disclaimer: This is not real data

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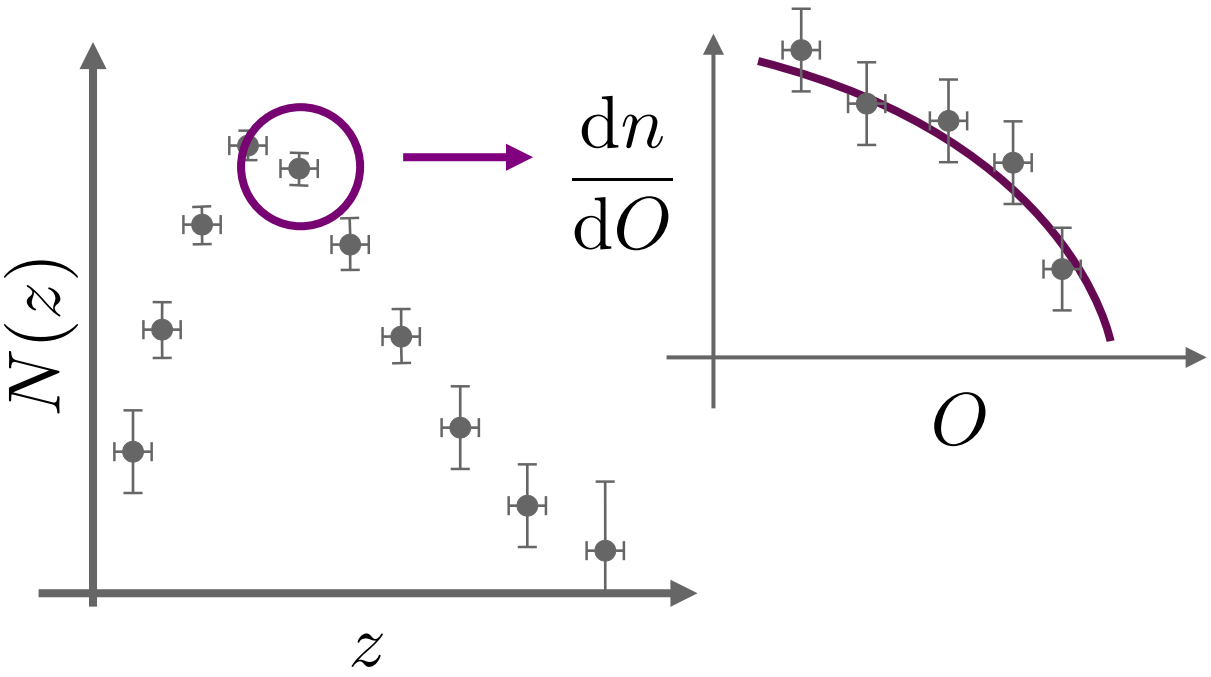

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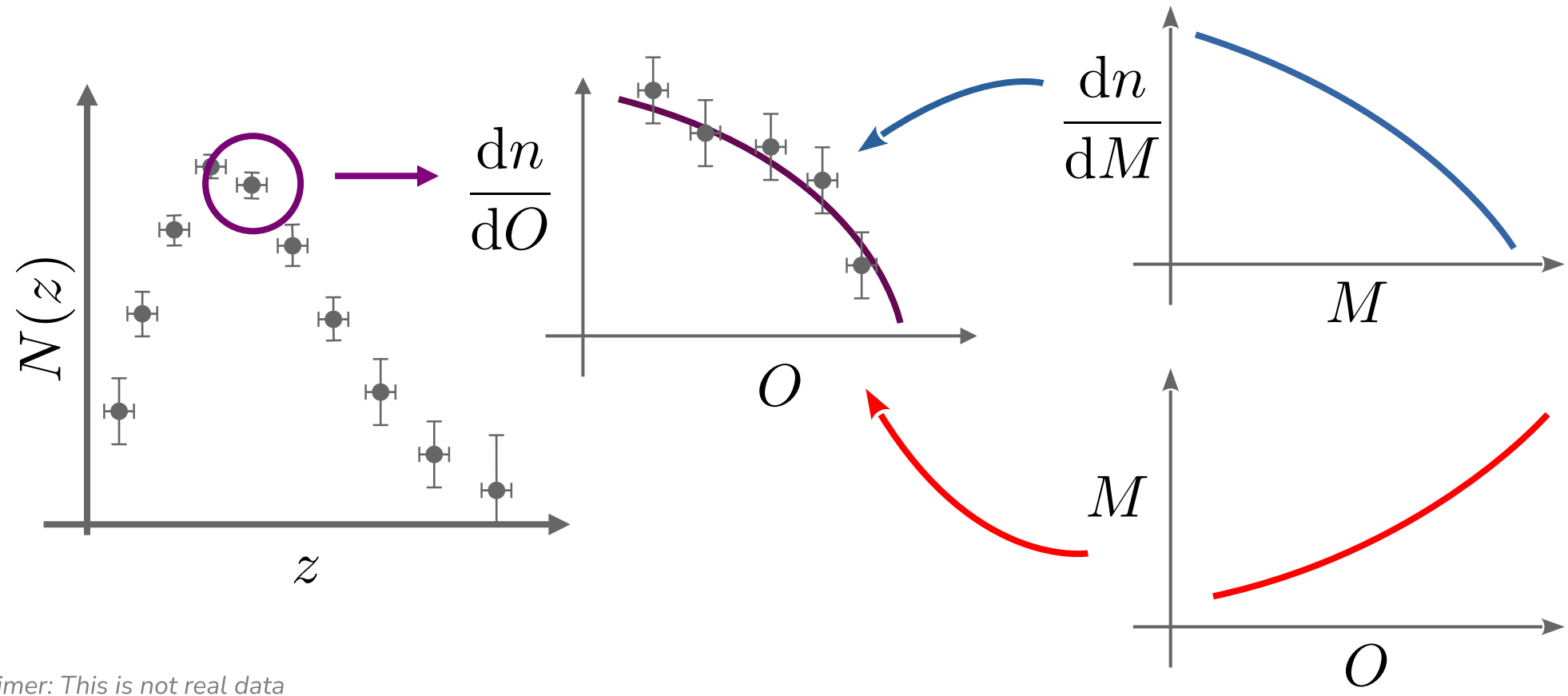

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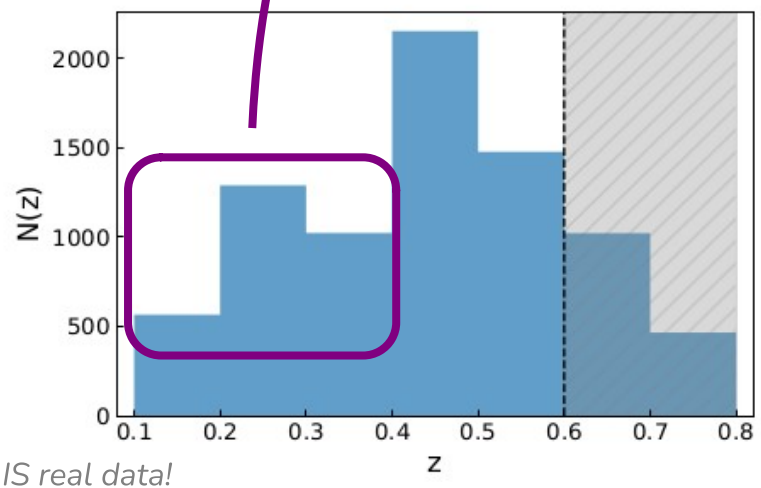
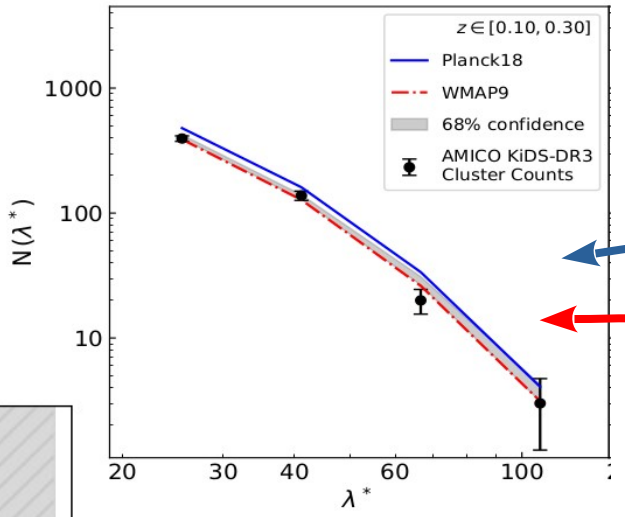
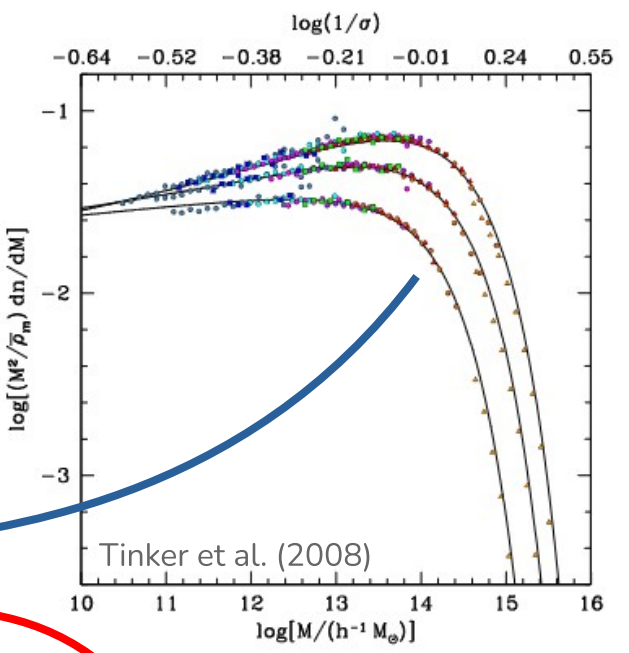
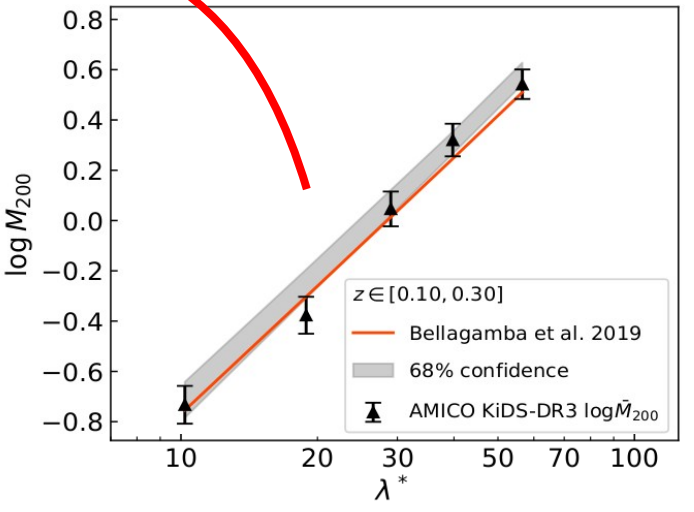
Example: KiDS-DR3

Lesci et al. (2022)



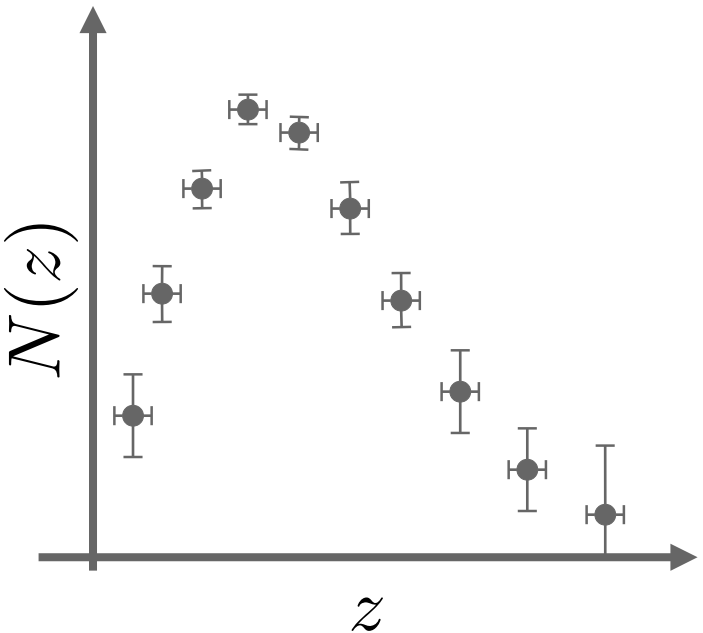






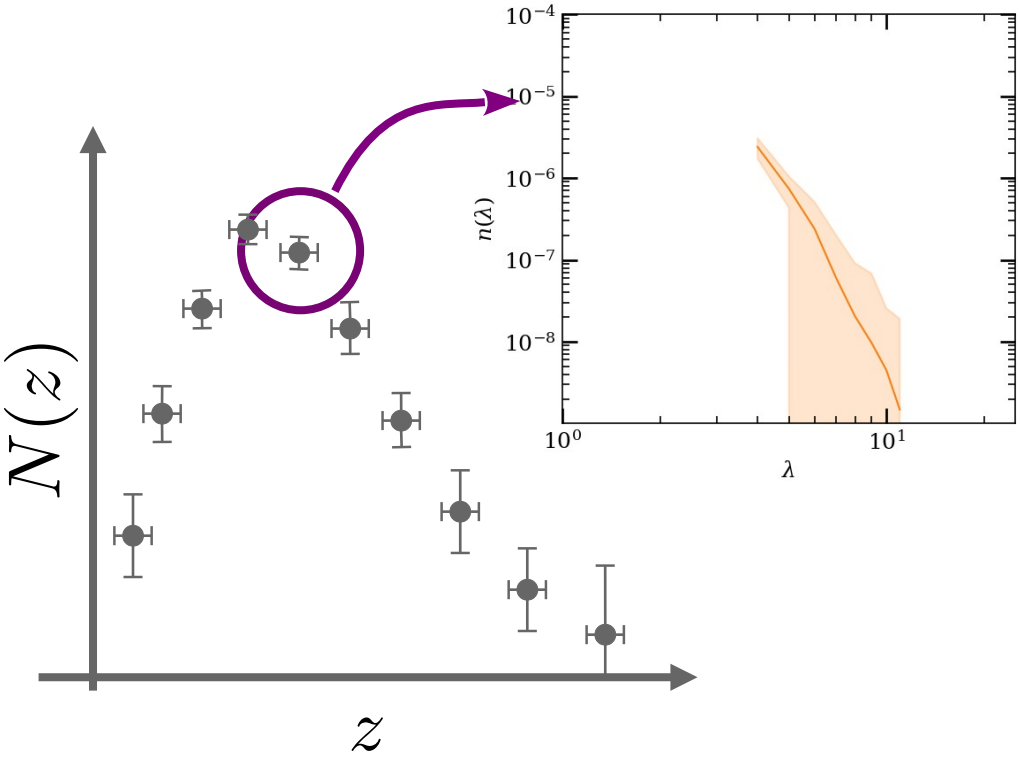
This IS real data!

Number counts x Clustering



This still is not real data

Number counts x Clustering



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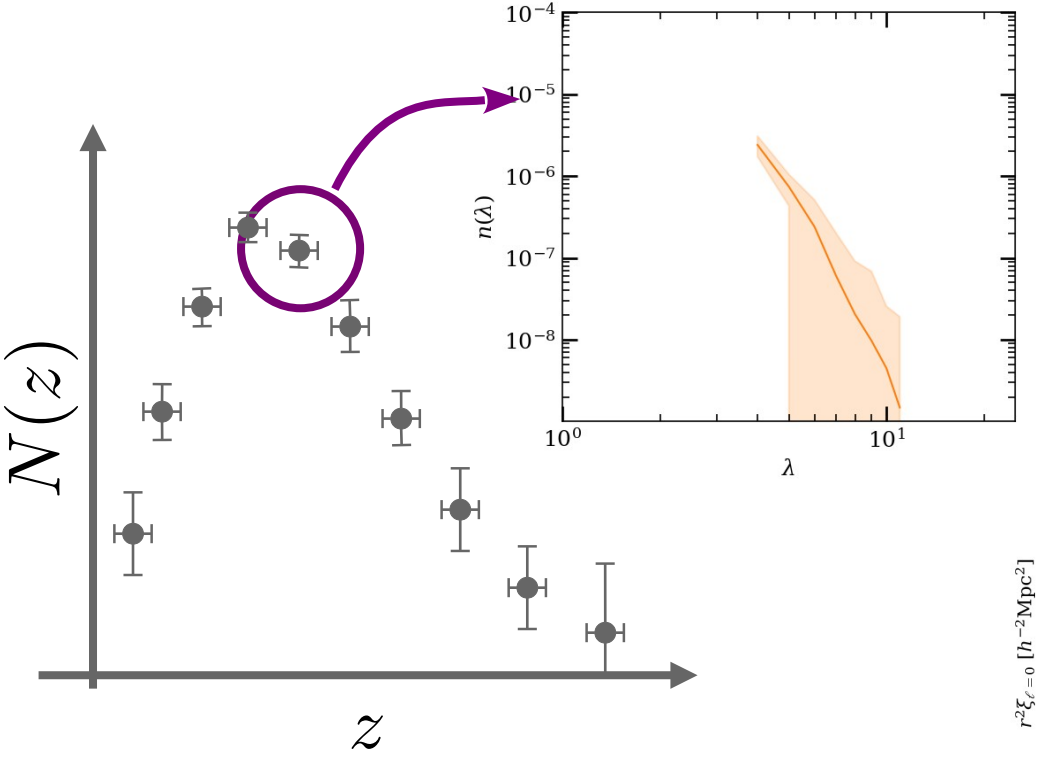
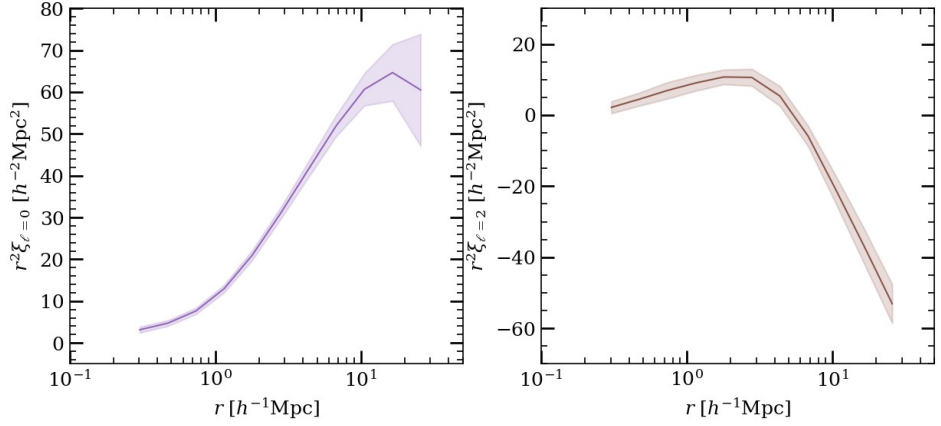
Number counts x Clustering





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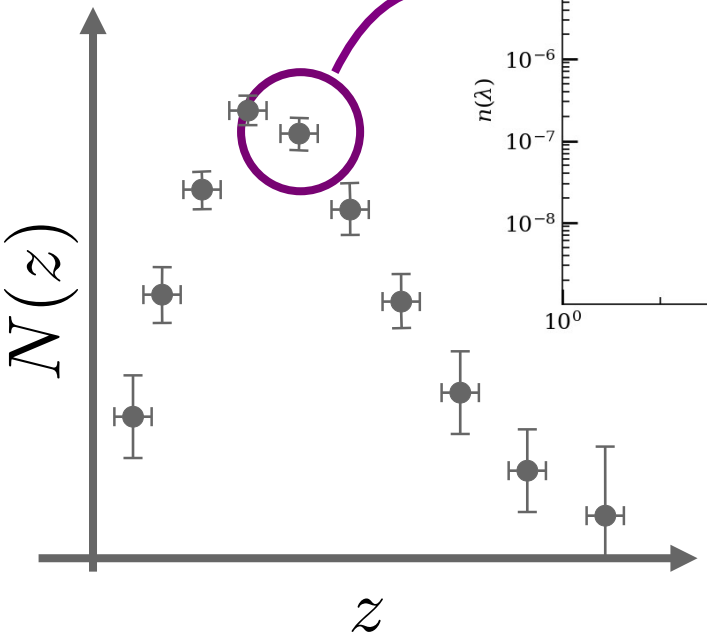

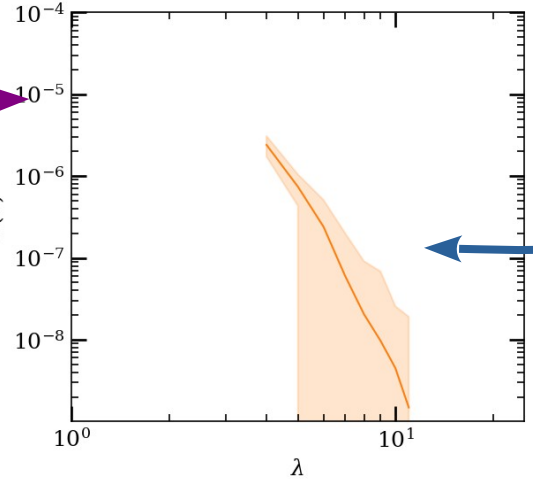

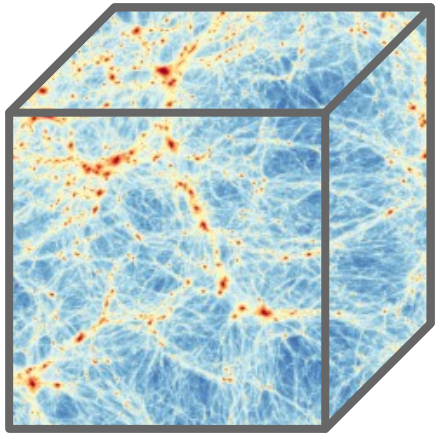

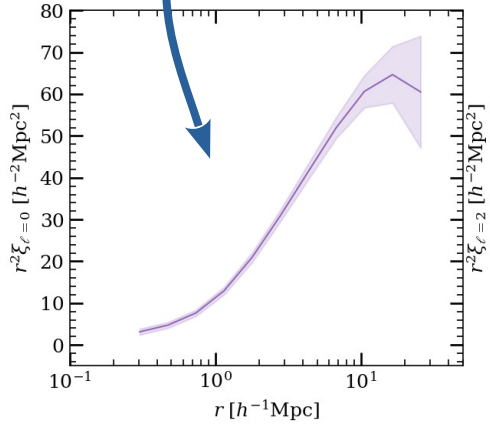

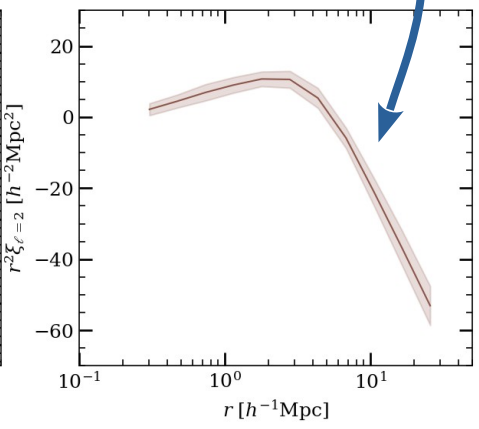

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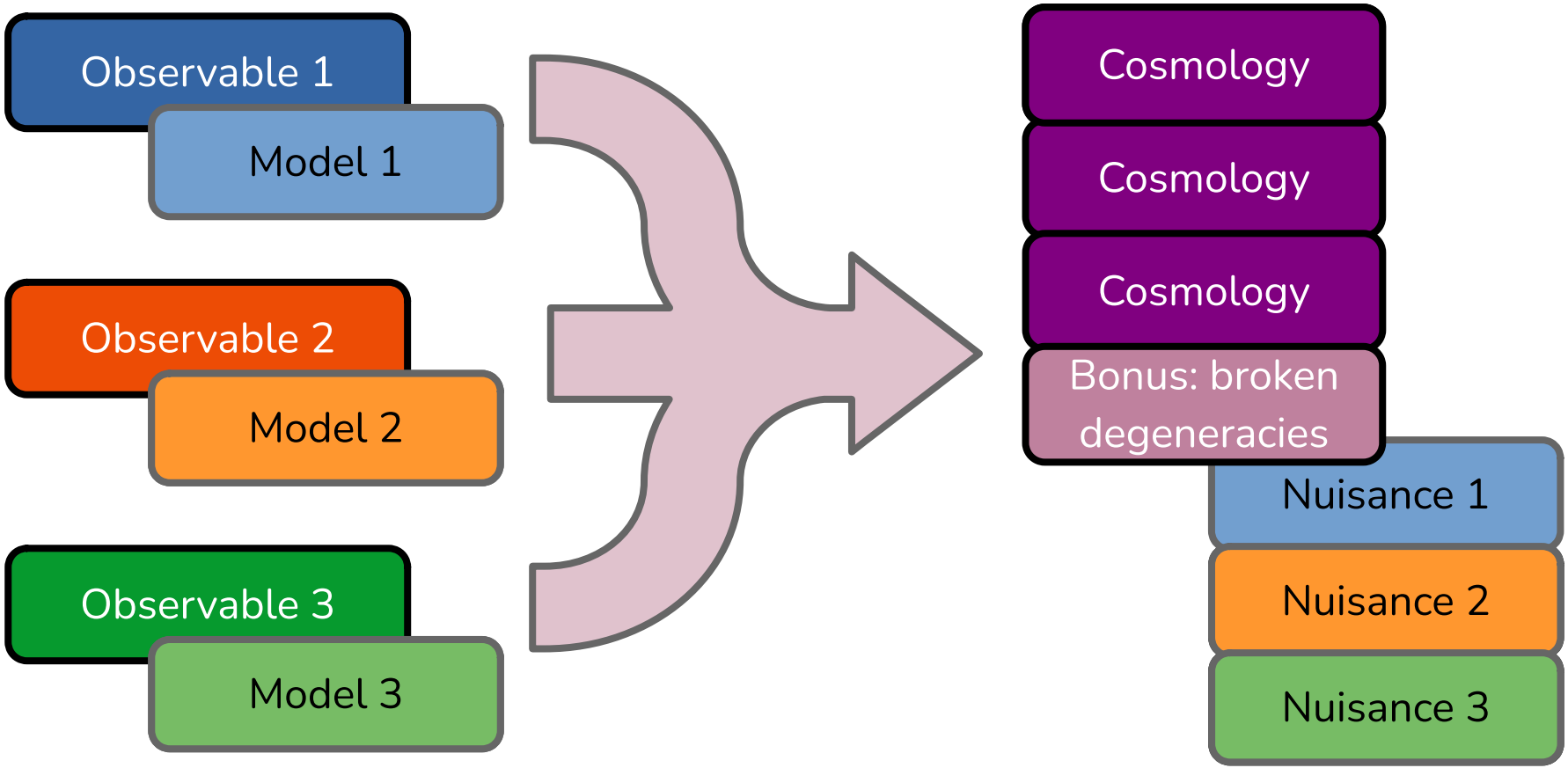
The case for joint modelling

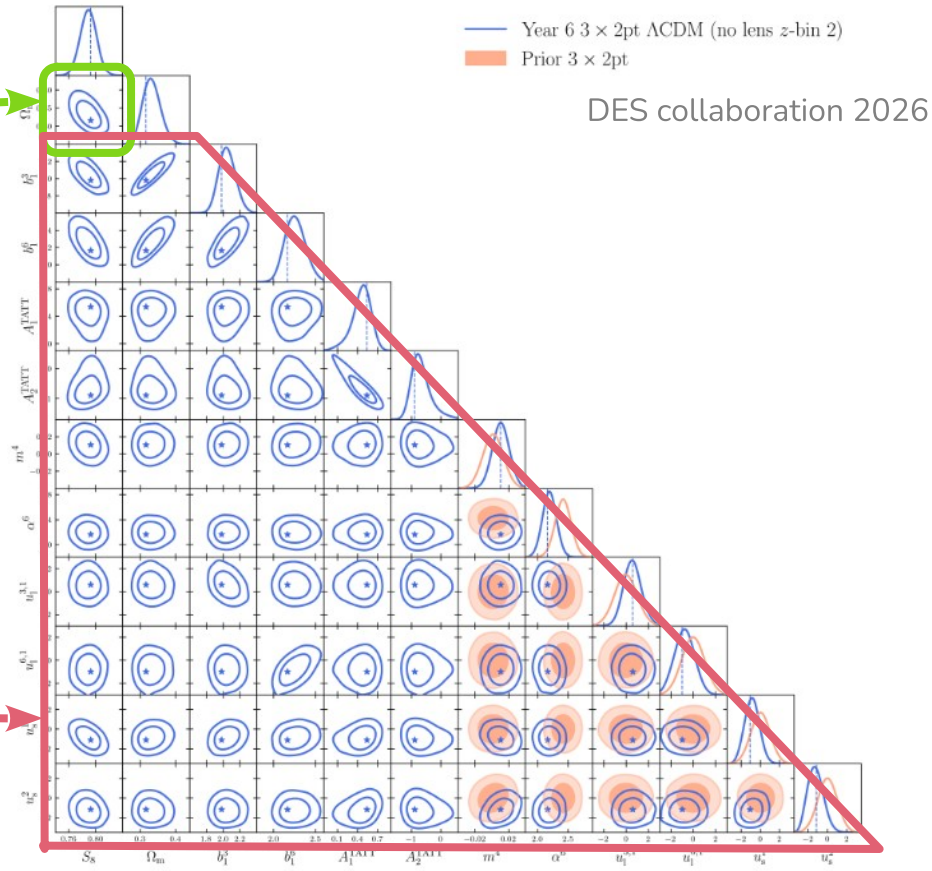
Simplified view (reality is a lot more complicated)



Quick example: DES Y6 3x2pt

What we're interested in

Model parameters we need to interpret the data



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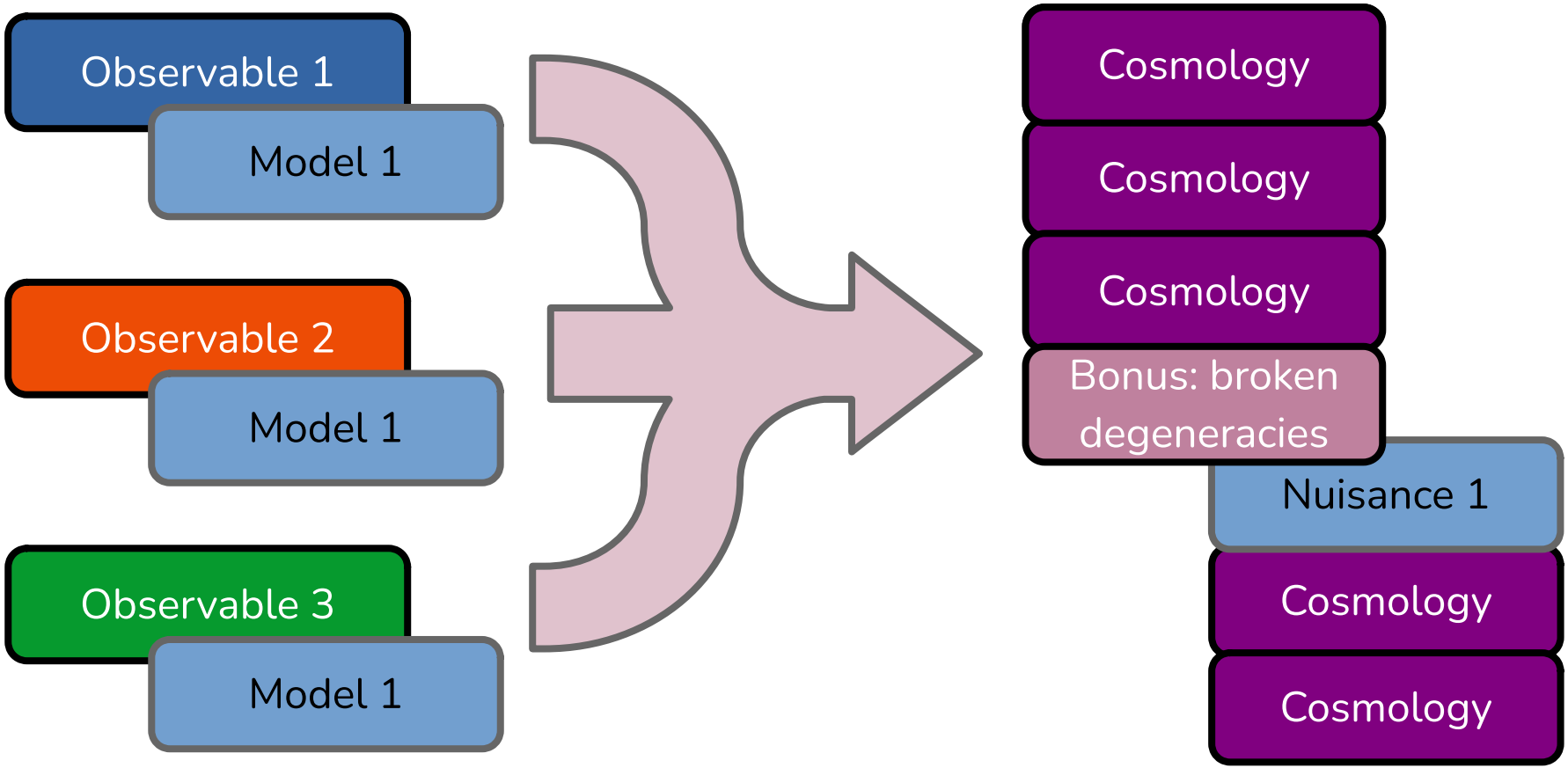
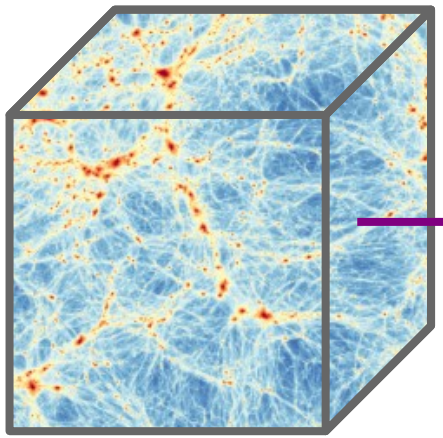
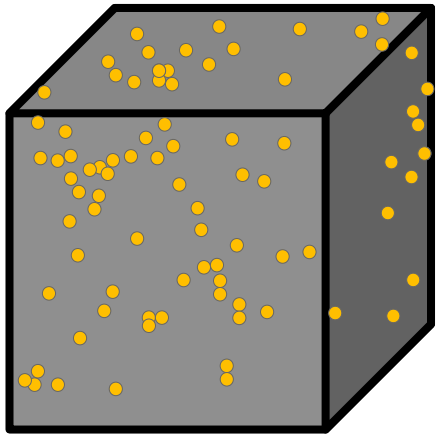


Joint Forward Modelling

DMO simulations





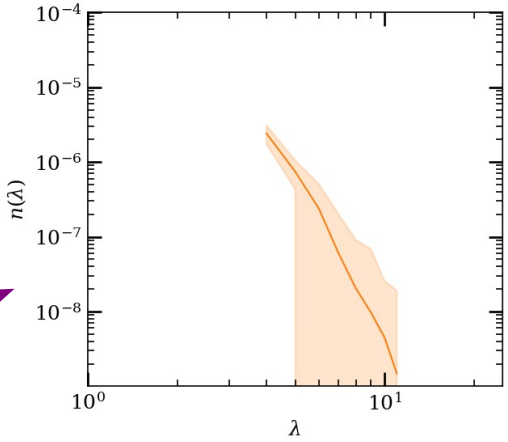
Populate with galaxies

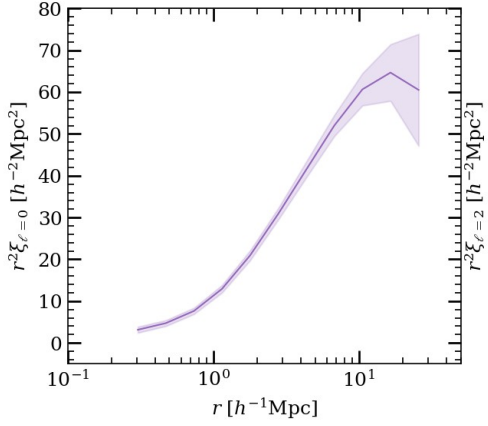
Galaxy sample:

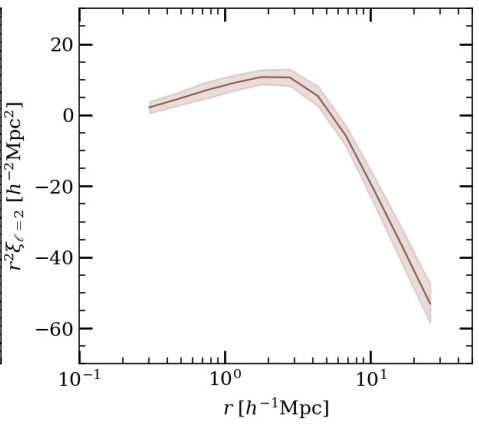
$n = 10^{-3}$ gals/h^{-3}Mpc^3

$M_\star \gtrsim 7 \cdot 10^{10}\ h^{-1}\mathrm{M}_\odot$

Measure Statistics







Cosmology Rescaling

Basic Idea:

Changes in cosmological parameters can be mapped to **changes in time and length**.

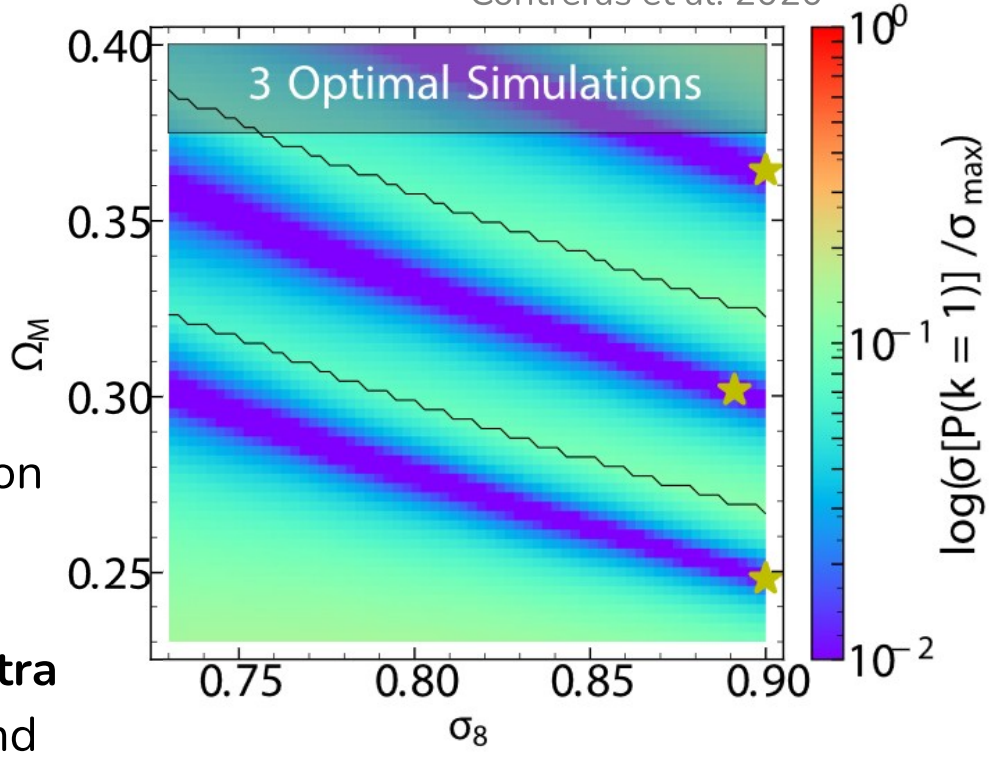
In practice a bit more complex:

Correct masses
Correct Large scale modes using LPT
Correct non-linear scales assuming c-M relation

Result:

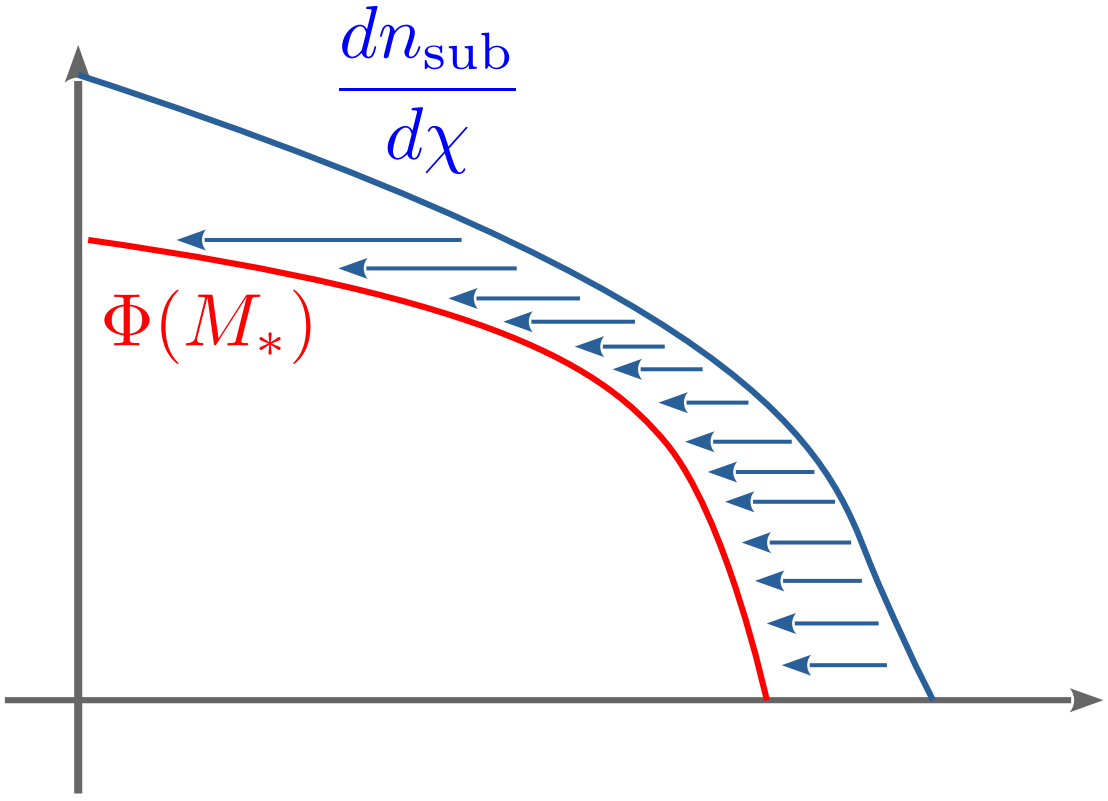
Matter, halo and sub-halo matter **power spectra accurate to within 3%** for Lbox 1.44h^{-1}Gpc and 4320^3 particles in a matter of minutes

Contreras et al. 2020



Angulo & White 2010, Angulo et al. 2020, Contreras et al. 2020

Sub-Halo Abundance Matching extended

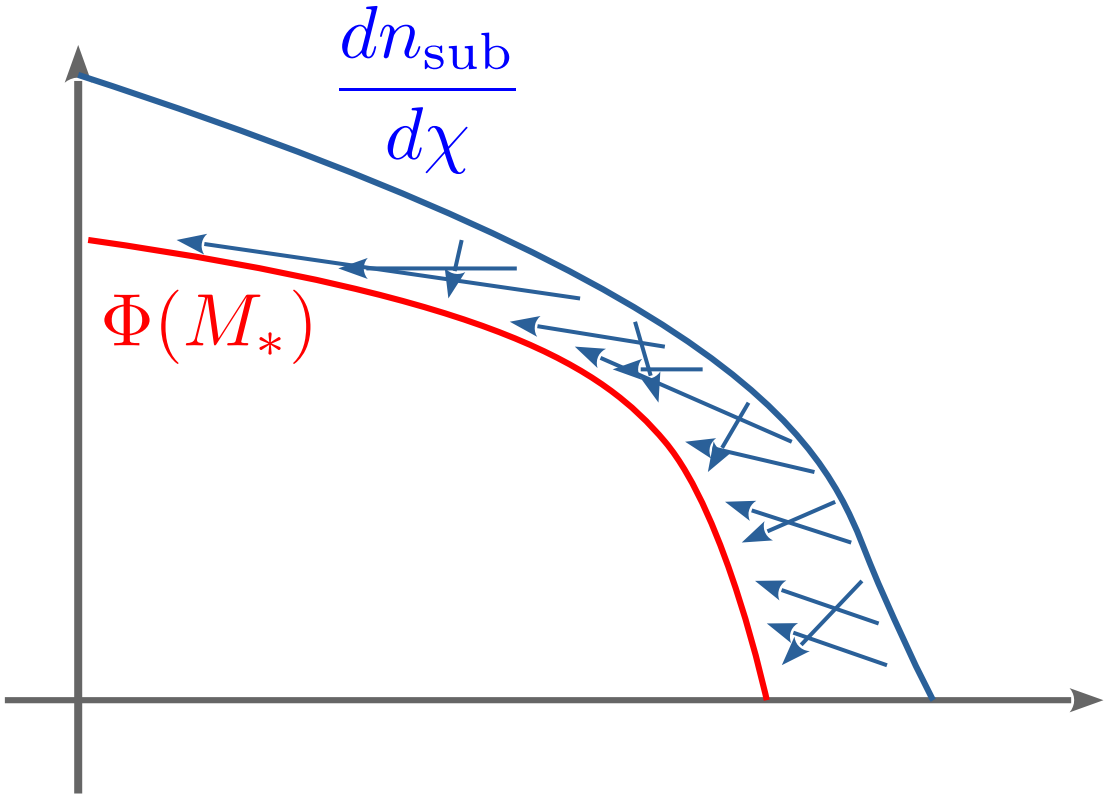


Contreras et al. 2020

Sub-Halo Abundance Matching

Match the abundance of sub-haloes as a function of a given property χ to the **abundance of galaxies**.

Sub-Halo Abundance Matching extended



Contreras et al. 2020

Sub-Halo Abundance Matching

Match the abundance of sub-haloes as a function of a given property χ to the **abundance of galaxies**.

Extended

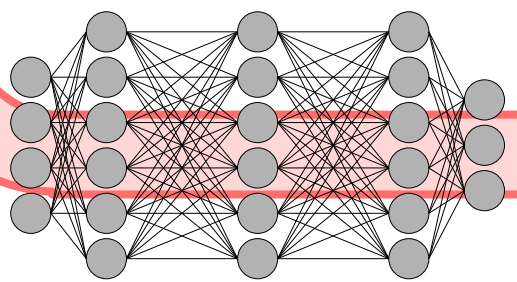
Orient stochasticity to mimic the effect of assembly bias.
Track orphan sub-haloes that are artificially destroyed

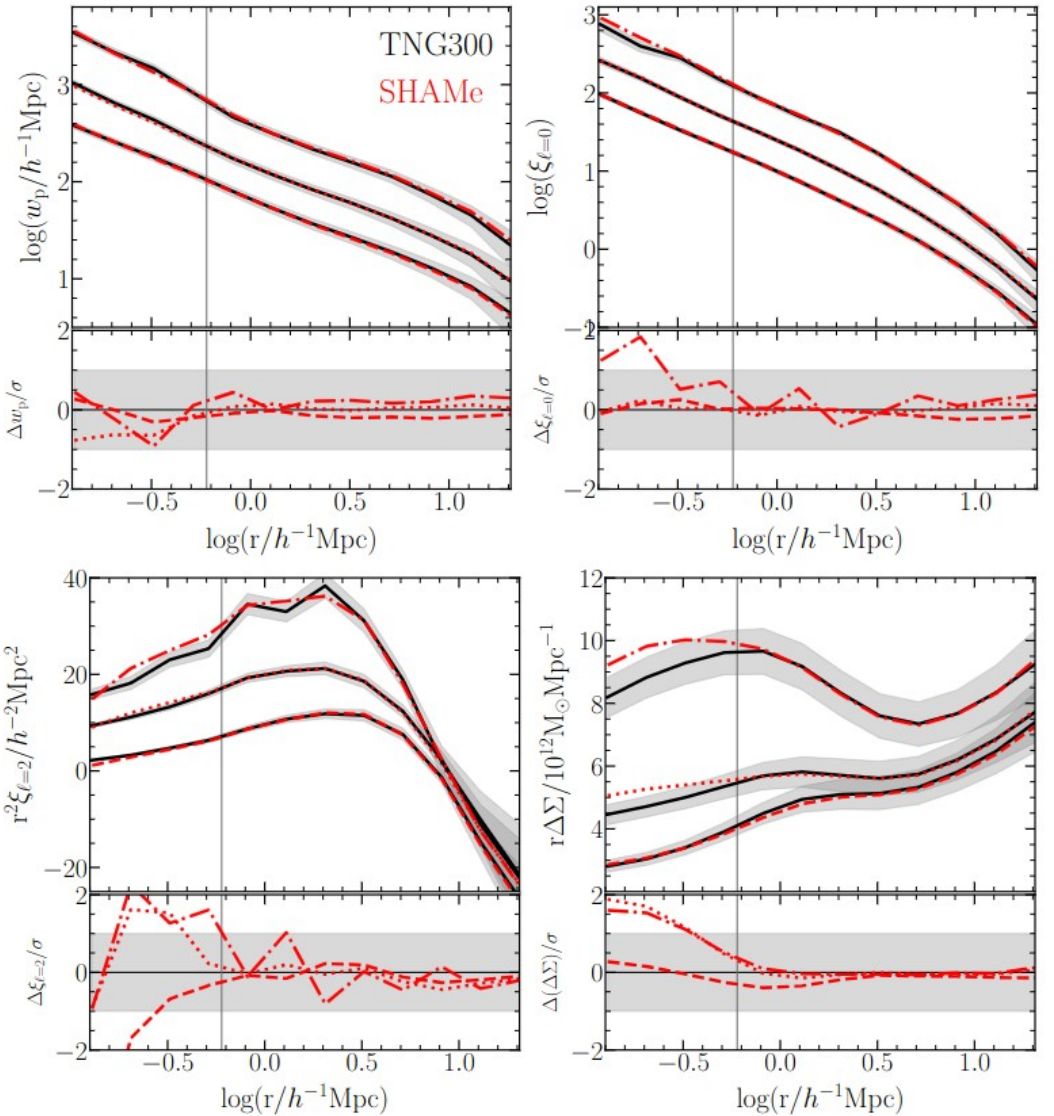
BACCO x SHAMe

BACCO
Cosmology

SHAMe
Galaxies

10,000 Cosmologies,
x 8 Snapshots,
x 2 SHAMe mocks,
= 160,000 simulations





Contreras et al. 2020

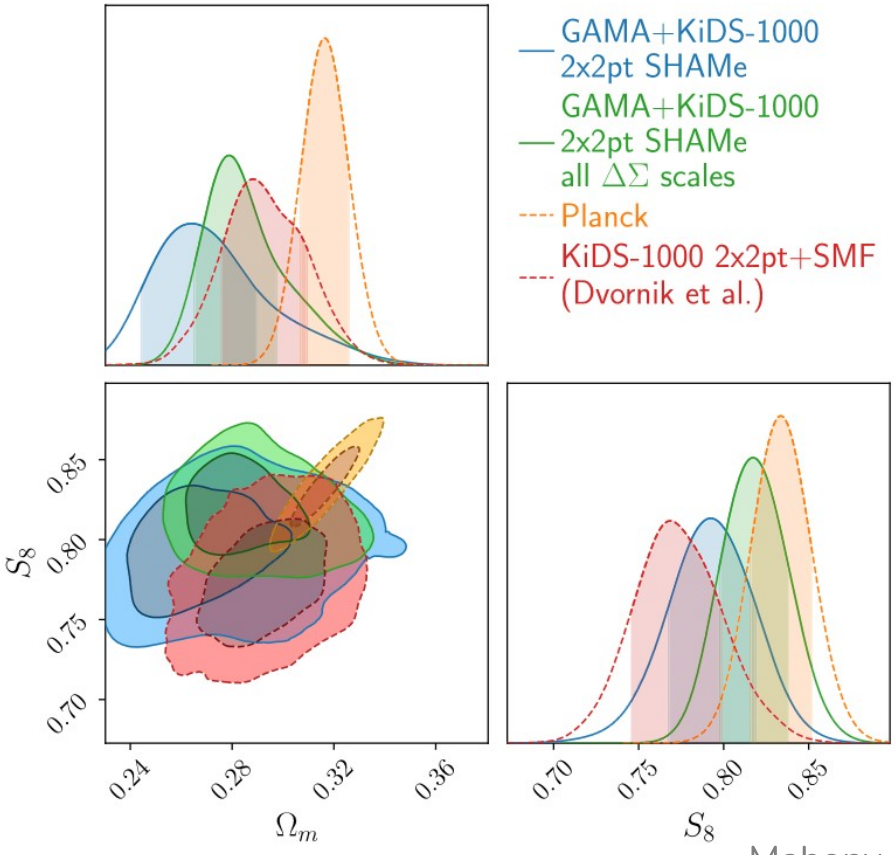
Combined analysis in KiDS and GAMA

First application to observational data (Mahony et al. 2026)

Joint modelling of $w_{\rm p} \times \Delta\Sigma$
Using data from the GAMA and KiDS surveys to constrain the model.

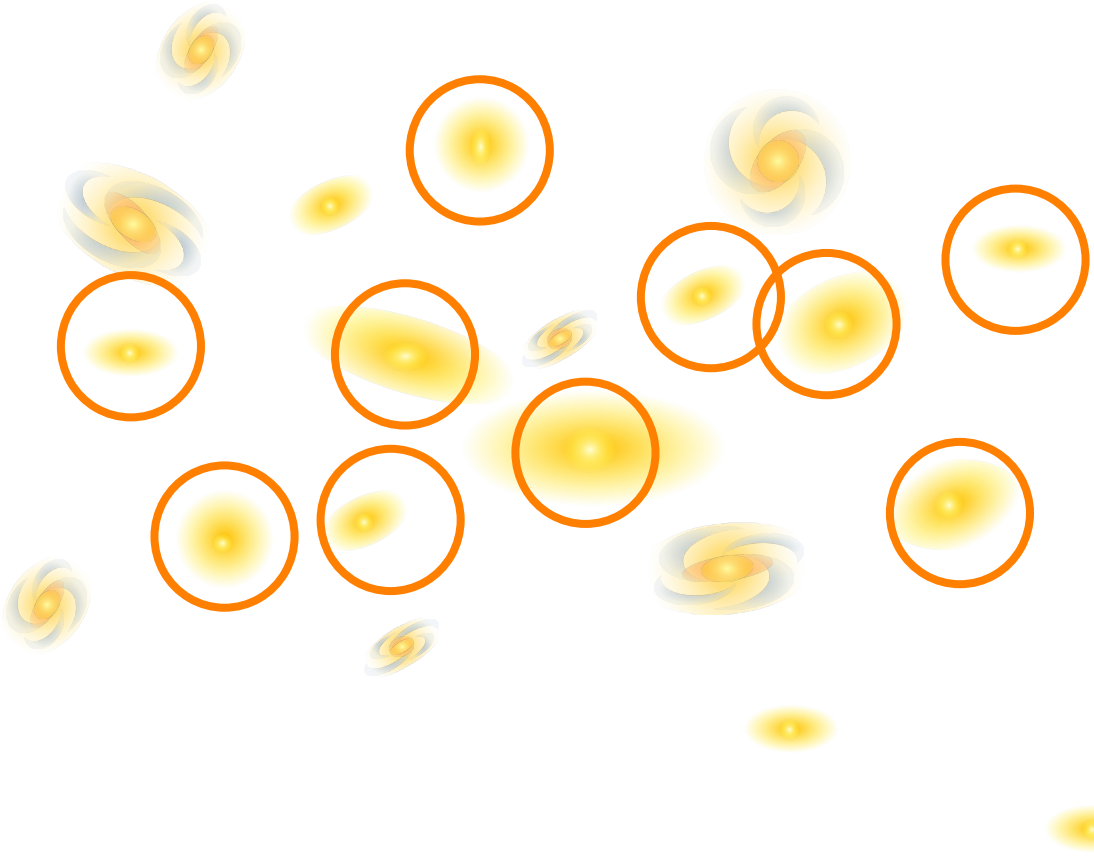
$$S_8 = 0.793^{+0.025}_{-0.024}\ \Omega_{\rm m} = 0.260^{+0.027}_{-0.015}$$

Competitive with equivalent HOD based approach (Dvornik et al. 2023)



Mahony et al. 2026

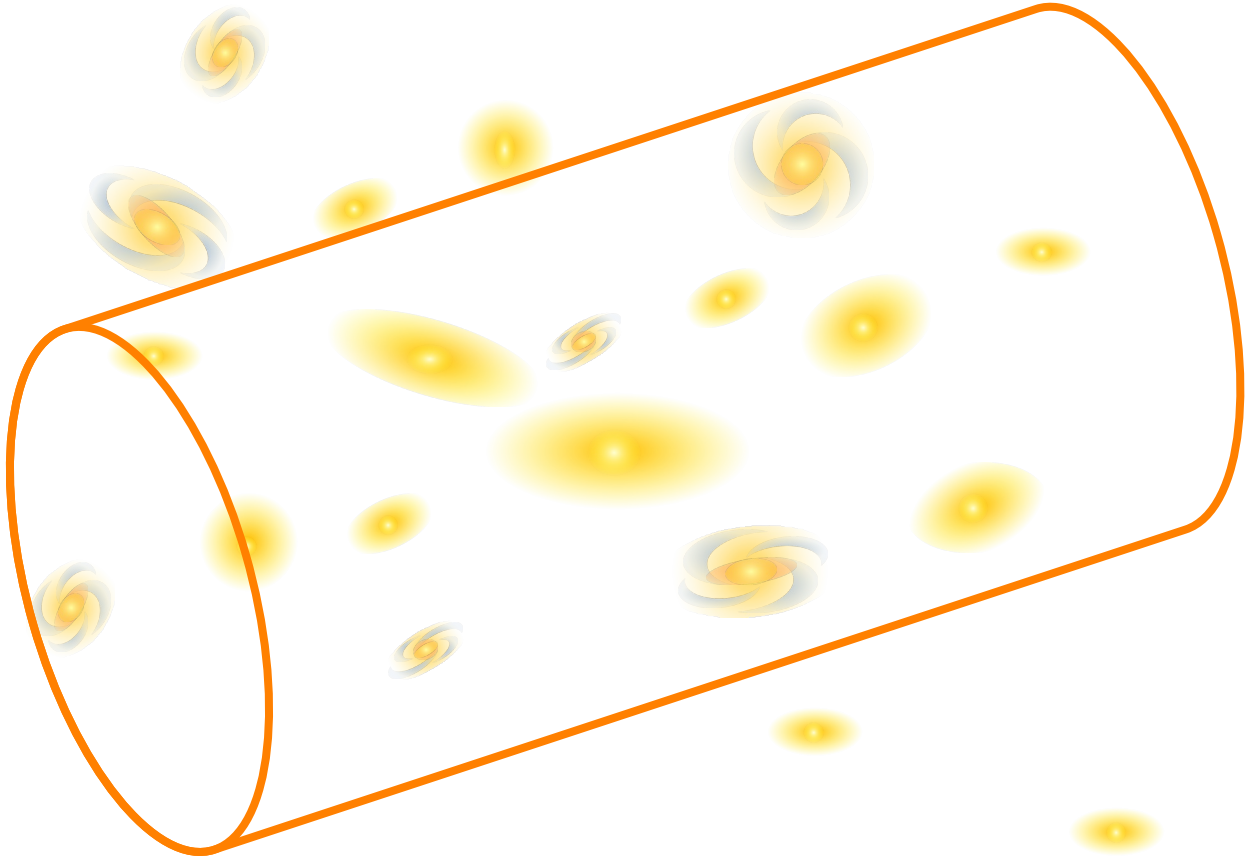
Clusters are hard :(



Galaxy Clusters:

Complex selections
> Colour cuts
> Magnitude cuts
> Member assignment
~~Systematics modelling~~

Proof of Concept: Counts in Cylinders



First glance, intuitive

Place **cylinder on bright galaxy and counts galaxies** within it.

λ = Richness

Chosen dimensions:

$L = 24h^{-1}Mpc$

$c\Delta z \sim 1000km/s$

$R = 1\ h^{-1}Mpc$

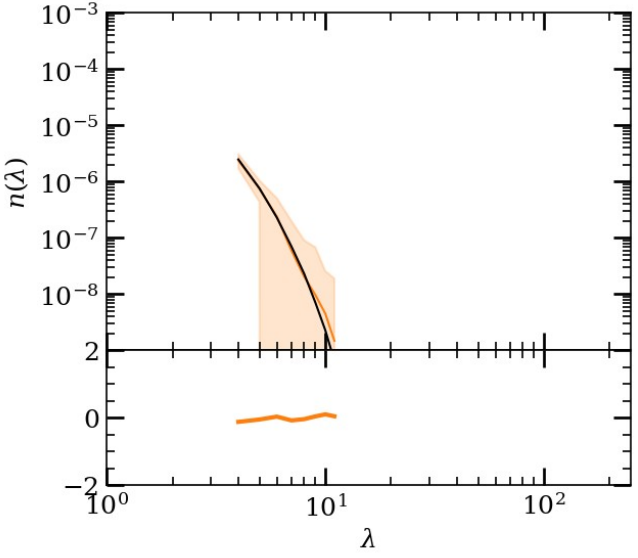
Berrier et al. (2010) SDSS
Pearl et al. (2023) DESI

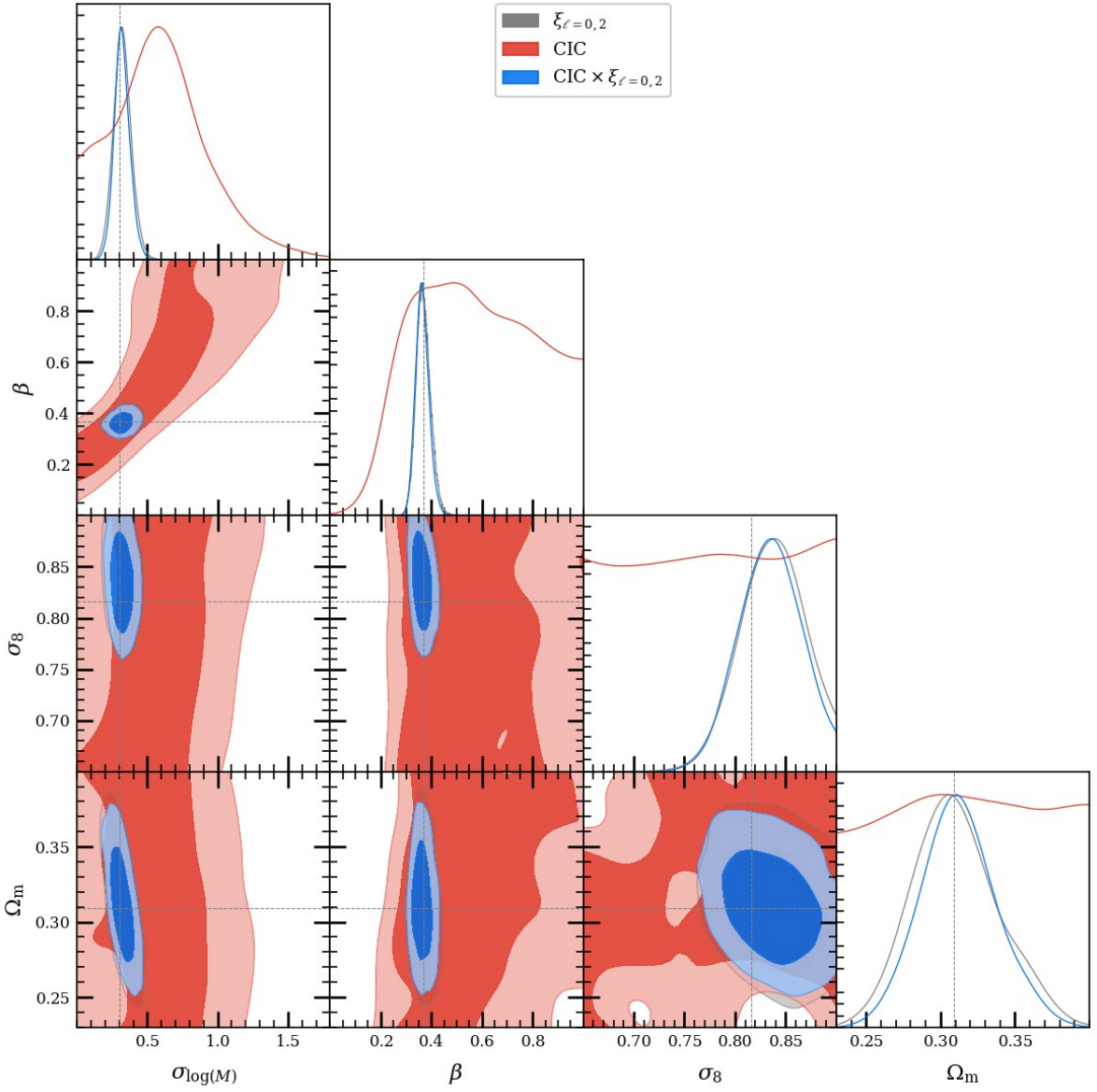
1 Aperture

Combining **1** aperture with $\xi_{\ell=0,2}$

Not much is gained

$$\frac{\Delta \mathrm{FoM}}{\mathrm{FoM}_{\xi}} \sim 0.25$$



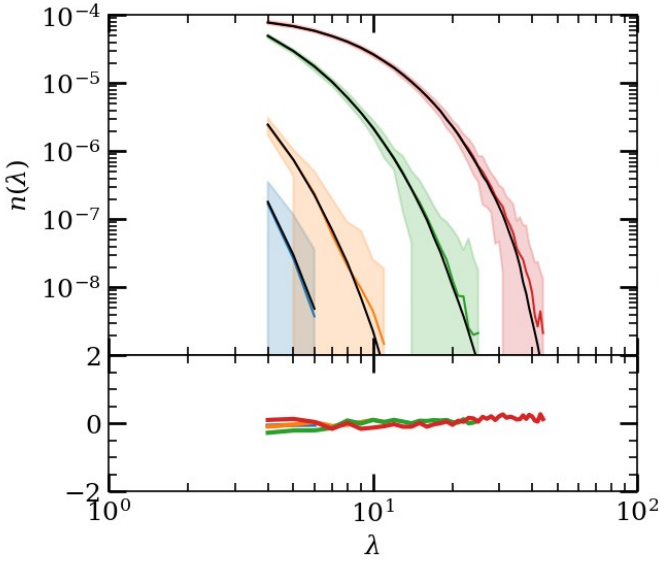


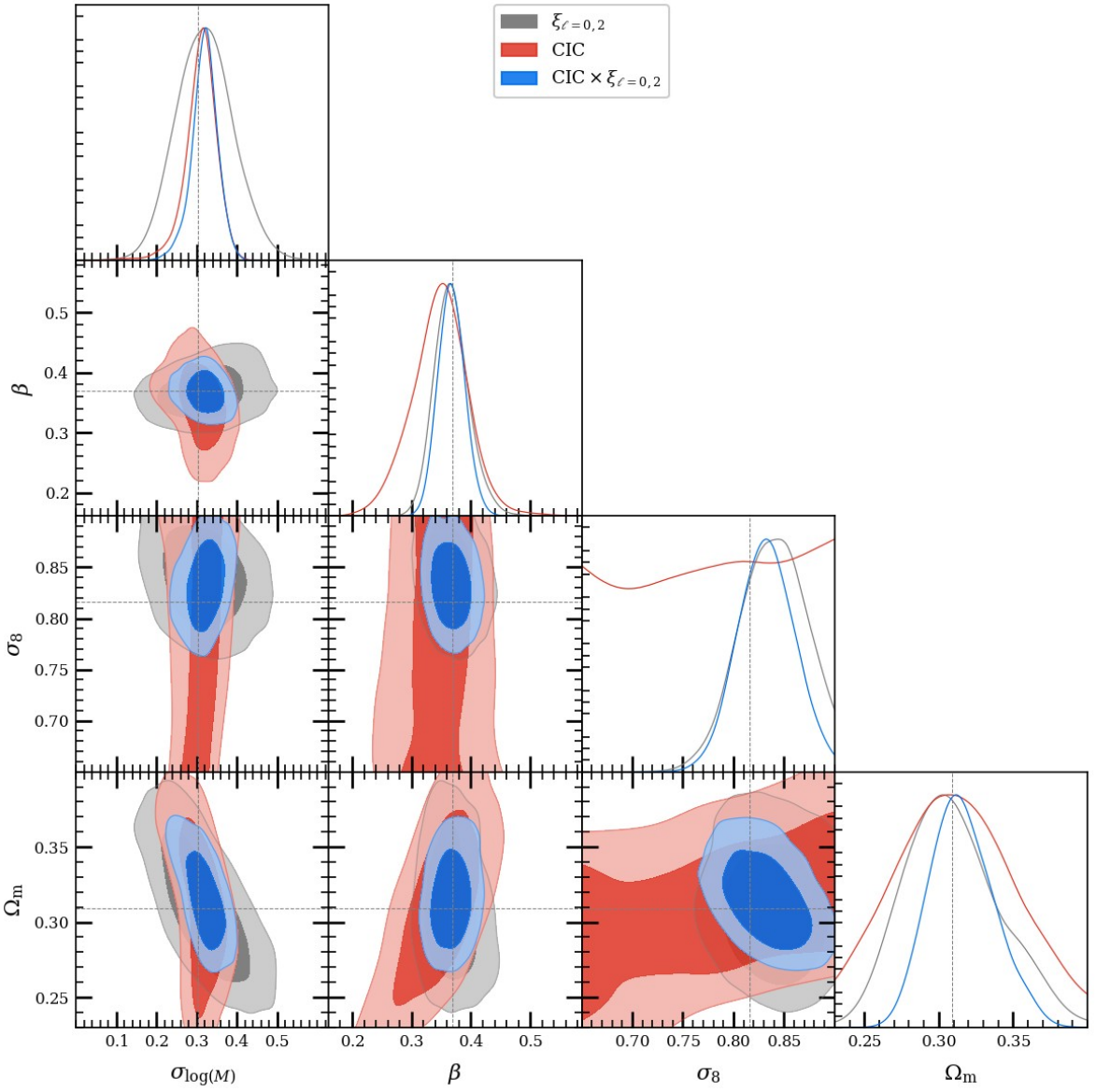
4 Apertures

Combining **4** apertures with $\xi_{\ell=0,2}$

Significant gains

$$\frac{\Delta \mathrm{FoM}}{\mathrm{FoM}_{\xi}} \sim 2.0$$

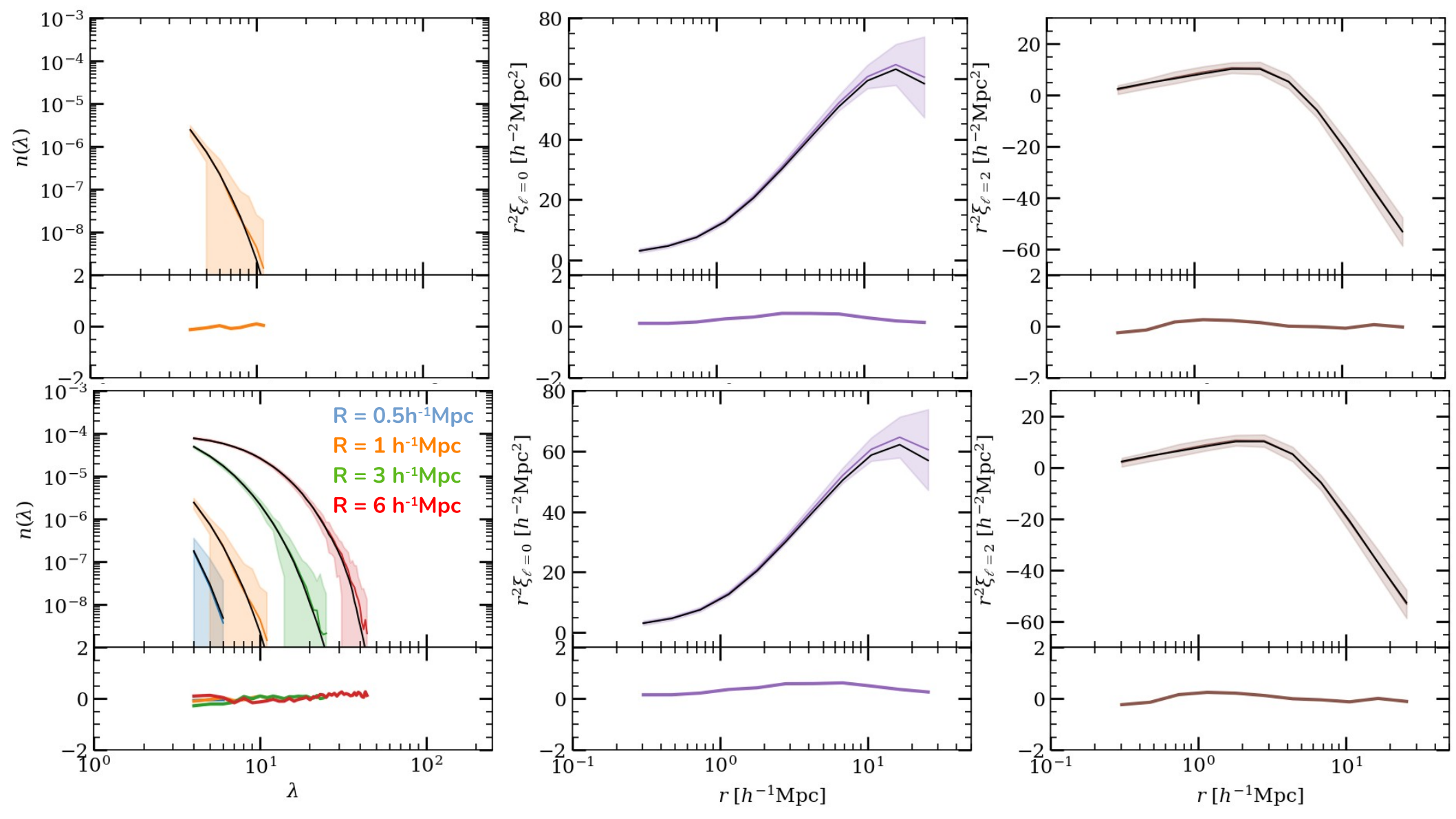




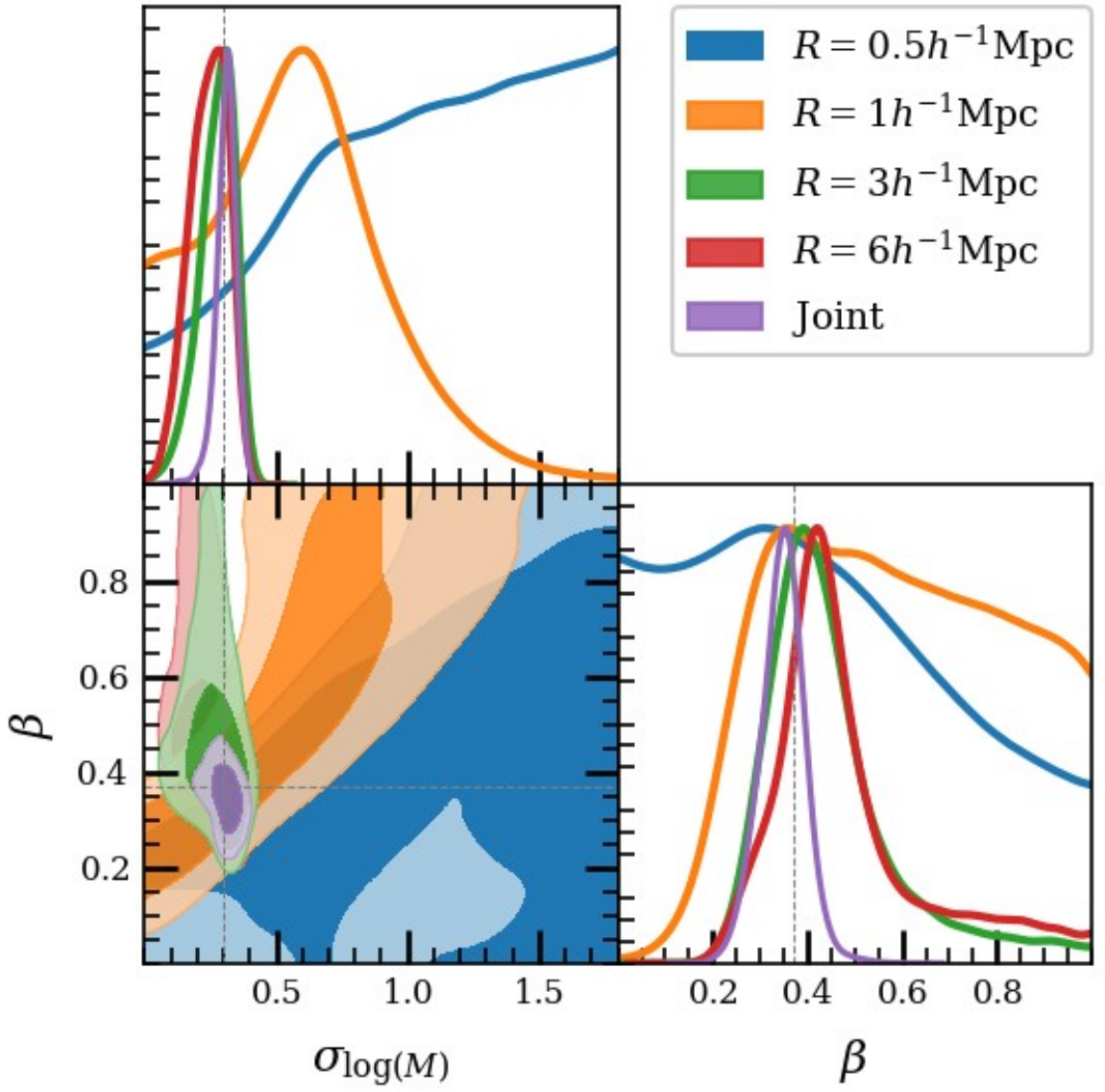
Moving Forward

- We are **able to jointly forward model, galaxy counts in cylinders and galaxy clustering**.
- We are also **able to jointly analyse** these measurements to extract **constraints on the cosmology and galaxy model** parameters
- Cluster number counts still lack major requirements: Joint redshift analysis, realistic clusters, and realistic systematics.
  We're working on it

Eskerik Asko!


$n(\lambda)$
$r^2\xi_{\ell=0}$ [h^{-2}Mpc^2]
$r^2\xi_{\ell=2}$ [h^{-2}Mpc^2]
R = 0.5h^{-1}Mpc
R = 1 h^{-1}Mpc
R = 3 h^{-1}Mpc
R = 6 h^{-1}Mpc
λ
r [h^{-1}Mpc]
r [h^{-1}Mpc]

Joint posterior



Covariance matrices

