



HoDpipe

recreating a realistic Universe

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Why do we even need galaxy mocks?

Goals?

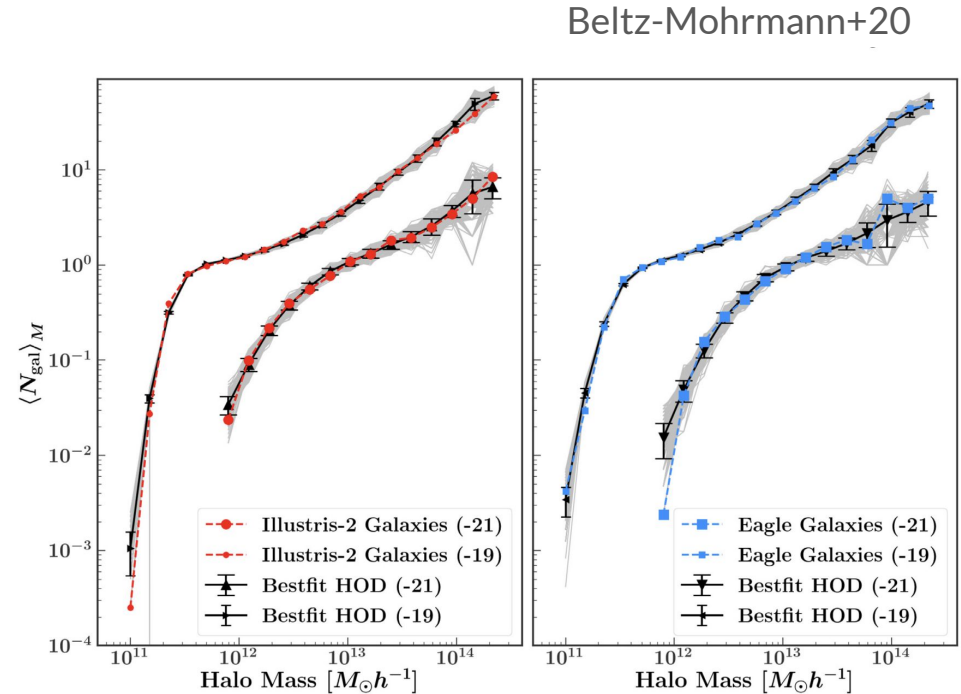
- Model testing
- Covariance matrix measurements (+ validations)
- Calibration of galaxy surveys

How to produce them?

- N-body simulation → matter field
- Halo finder → halo field
- HOD → galaxy field

Halo Occupation Distribution

- Central galaxies:
 - Either 0 or 1
 - Positioned at halo center
 - Same velocity of halo
- Satellite galaxies:
 - From 0 to infinity
 - Responsible for fingers-of-God



Flagship 2 galaxy mock

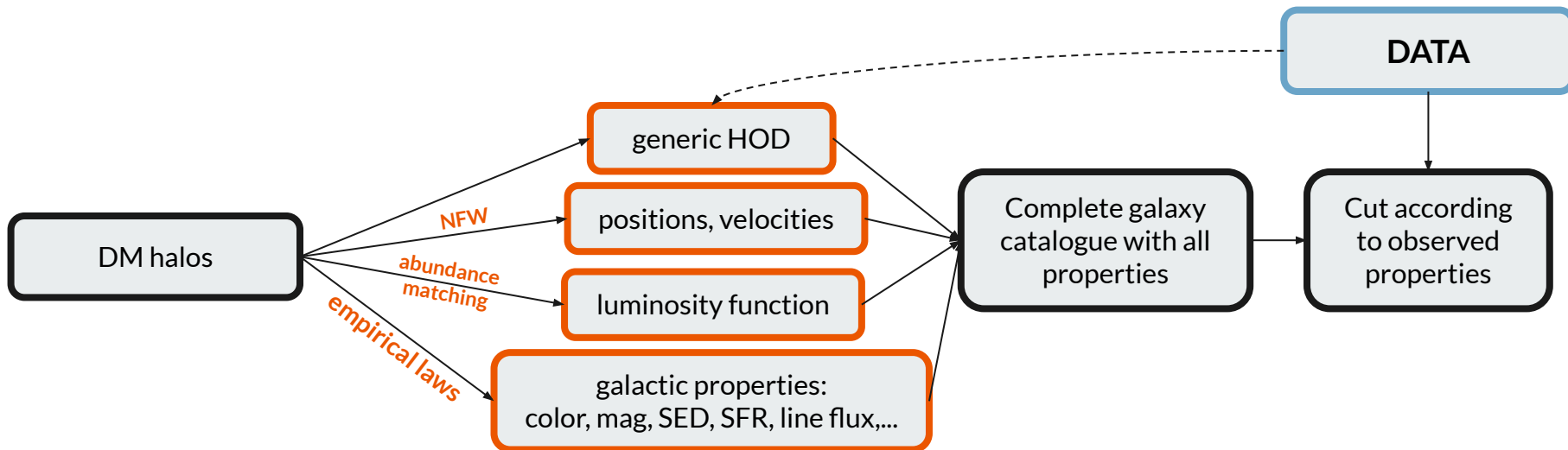
- Support to the *Euclid* spectroscopic survey
- Galaxy mocks generated from Flagship simulation (Castander+24)

But we only have one! We need more!

We consider:

$$f_{\text{H}\alpha} \geq 2 \times 10^{-16} \text{ erg s}^{-1} \text{ cm}^{-2}$$
$$0.7 \leq z \leq 2.1^*$$

* slightly larger than *Euclid* redshift range



How to “more Flagships” Part I

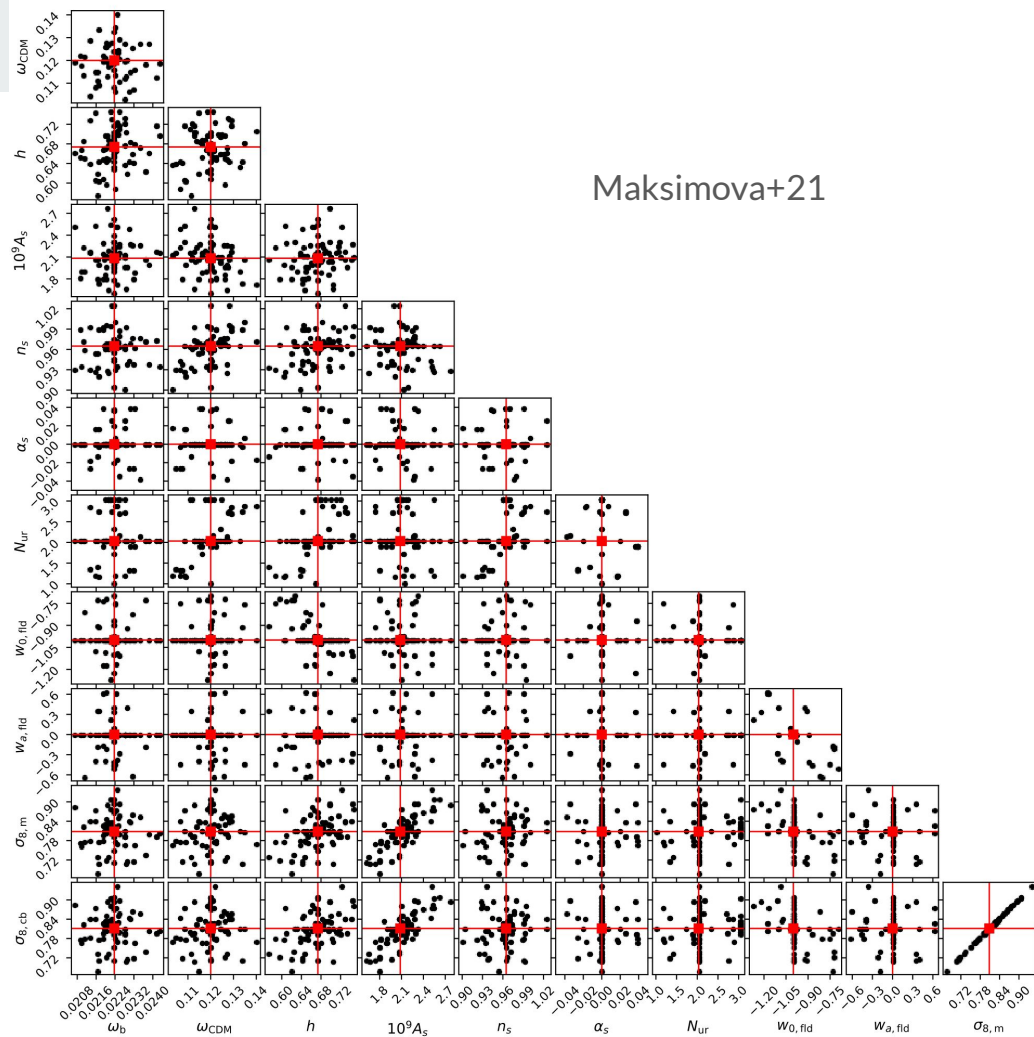
- Input: Flagship2

- galaxies with $f_{\text{H}\alpha} > 2 \times 10^{-16}$ erg/s/cm²
- patch of area ~ 1500 deg²
- redshift slices of $\Delta z = 0.2$



- Output: AbacusSummit_base

- 25 realizations with Planck cosmology (+98 more simulations)
- $L=2$ Gpc/h, $N=6912^3$ particles
- $\sim 4x$ Euclid DR3 volume
- $z=0.8, 1.1, 1.4, 1.7, 2.0$



*based on Scipic (J. Carretero + Flagship team)

HoDpipe*

- Data-driven
- Focused on clustering properties
- Goal is to generate a galaxy population that mimics these properties

- **Survey geometry**

- Comoving boxes
- Lightcones

- **HOD**

- Customizable functional forms
- Satellite conformity
- Non-Poisson satellite distribution
- Assembly bias
- Realistic models for redshift evolution

- **Positions and velocities**

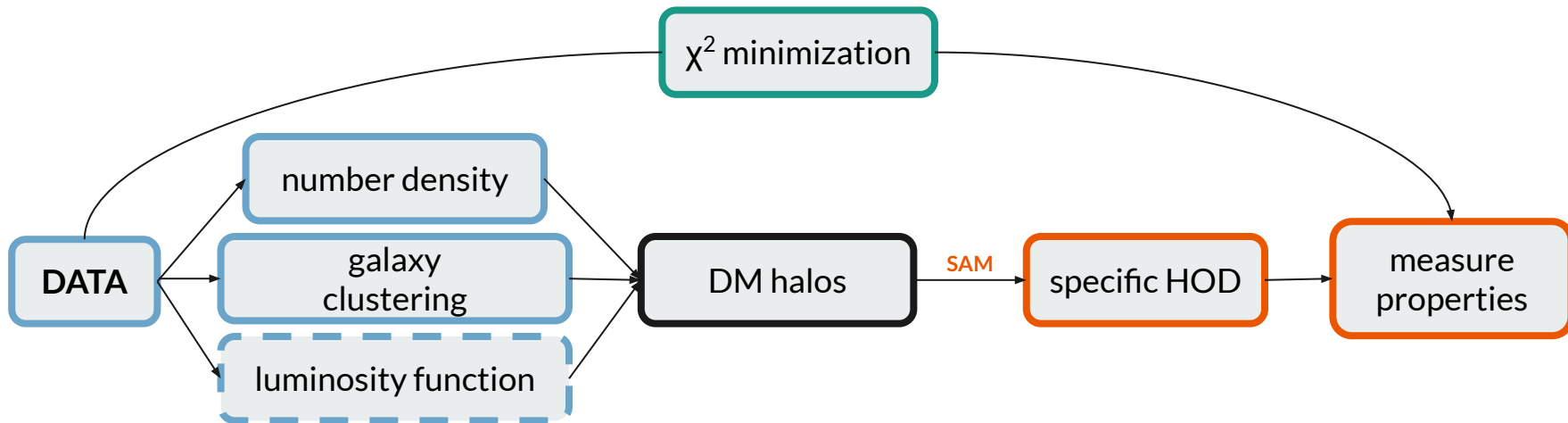
- Triaxiality
- Different profiles: generalized NFW (α, β, γ), Einasto
- Tired anisotropy profile for velocities
- Velocity bias

- **Systematics**

- Redshift errors

- **Estimators**

- Mass functions
- Correlation functions
- Window functions



How to “more Flagships”

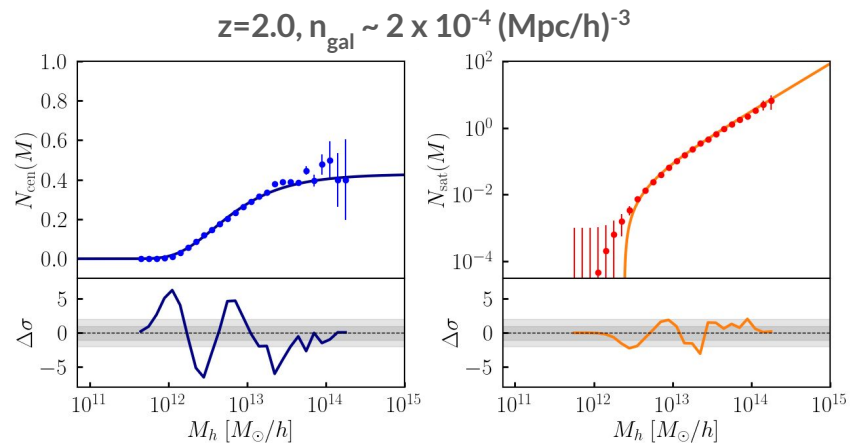
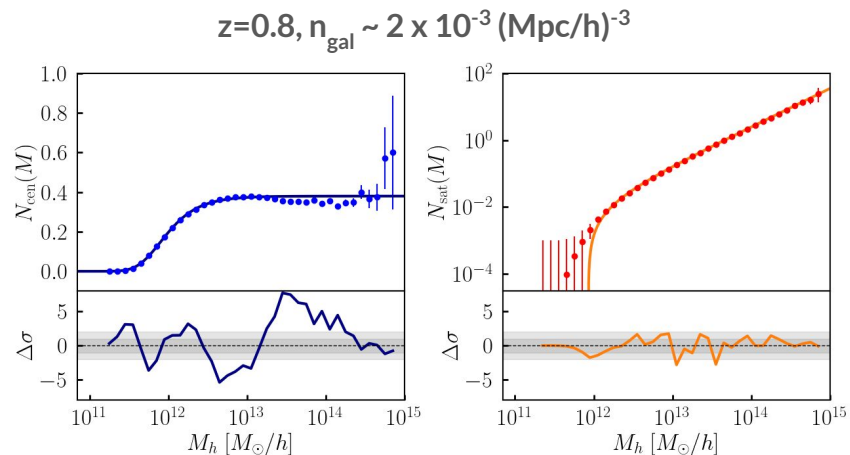
Part II

1. Select H_α galaxies from Flagship
2. Measure HOD
3. Fit it with parametric function at each redshift

$$\langle N_{\text{cen}}(M) \rangle = \frac{f_{\text{max}}}{\left\{ 1 + \left[\mathcal{C}(a, b) \frac{\log M_{\text{min}}}{\log M} \right]^{1/a} \right\}^{1/b}}$$

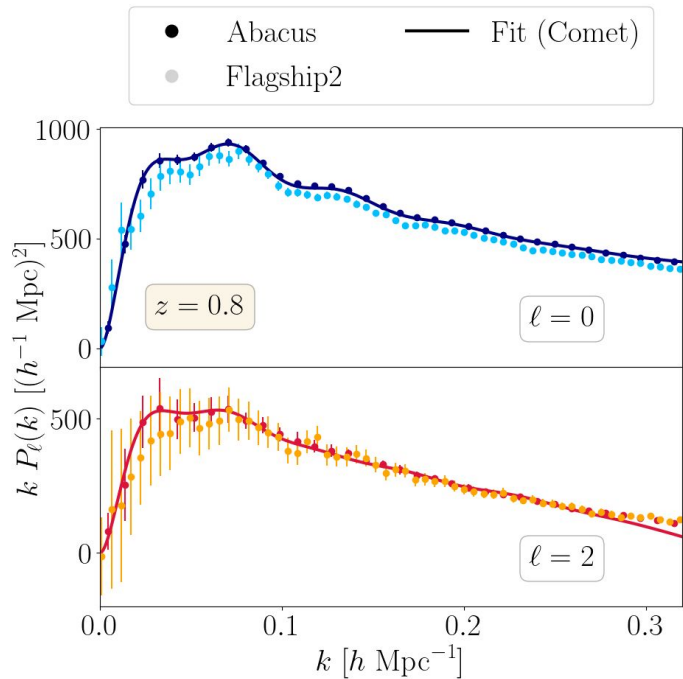
$$\langle N_{\text{sat}}(M) \rangle = \left(\frac{M - M_{\text{cut}}}{M_1} \right)^\alpha \quad [M \geq M_{\text{cut}}]$$

4. Implement that HOD in N-body halo catalogue at fix redshifts

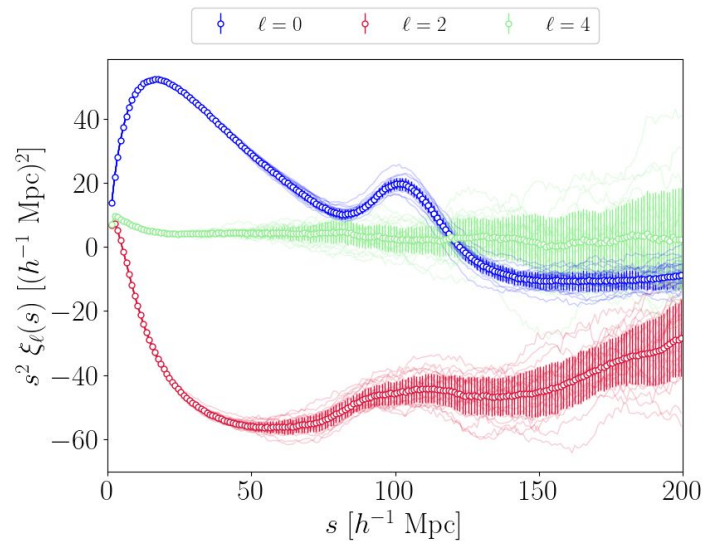
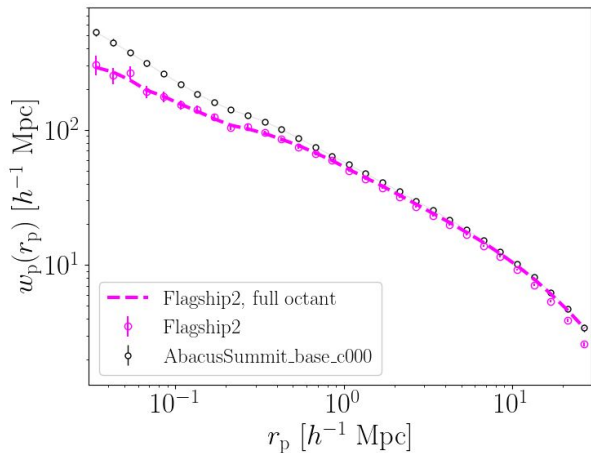


And so...

Galaxy power spectra



Projected and multipoles of correlation function



Bispectra

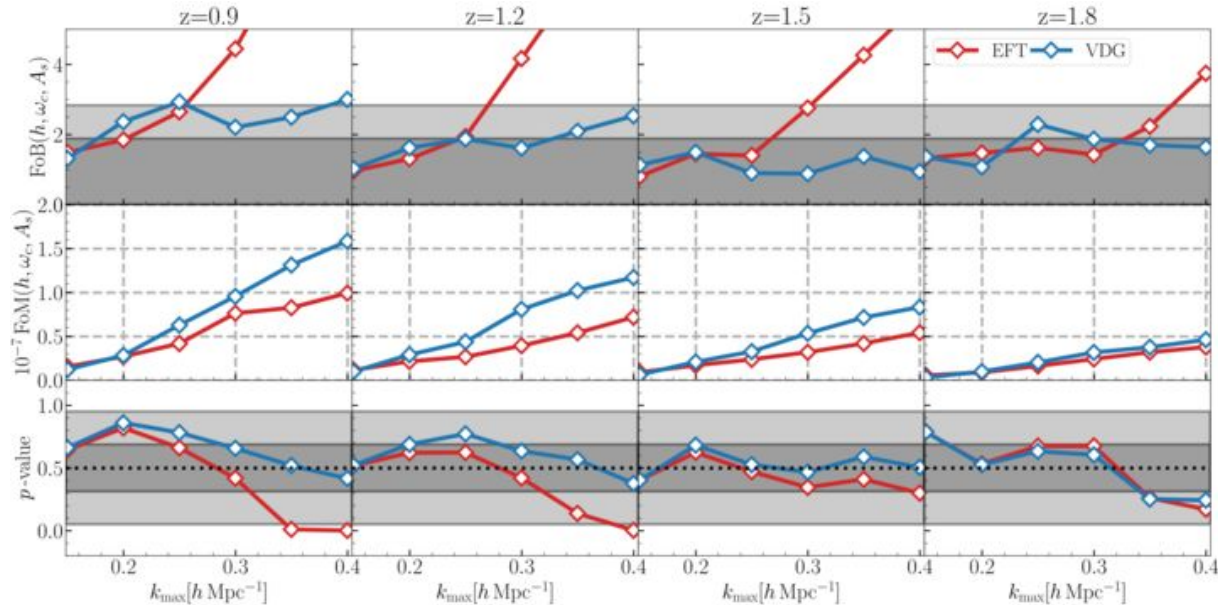


Comparing theories: EFT vs. VDG

EFTofLSS (e.g. Ivanov+22 for a detailed review)

VDG (Sanchez+17, Eggemeier+24)

PRELIMINARY

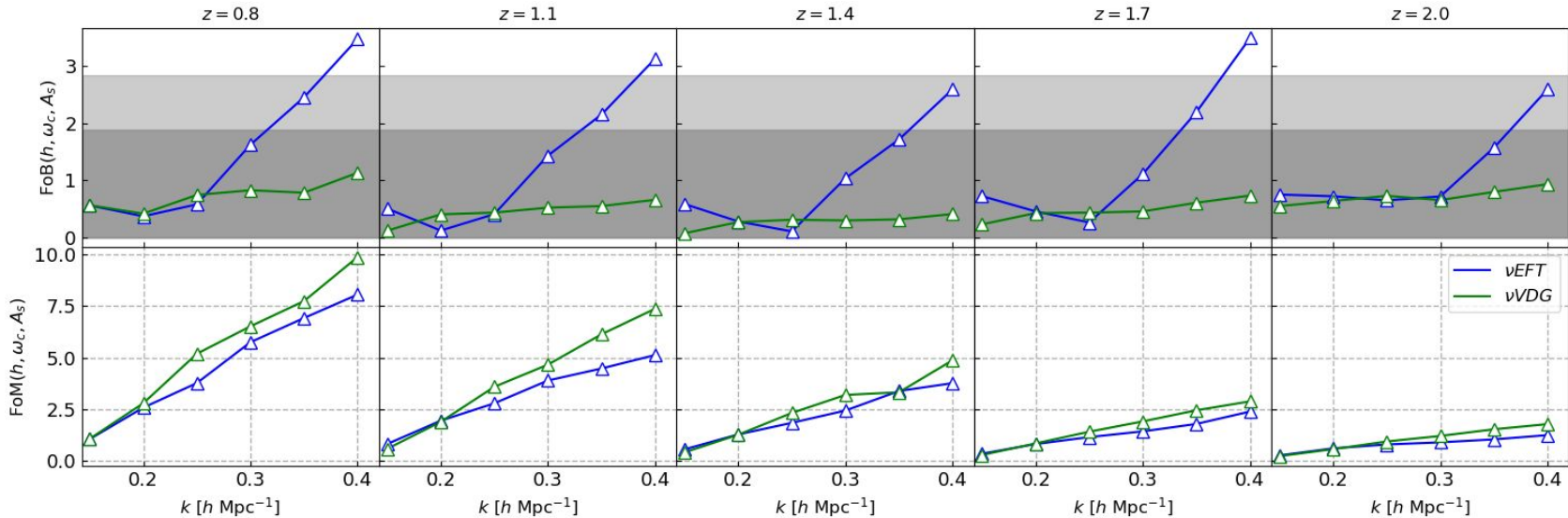


Credits: B. Camacho

Comparing theories: EFT vs. VDG

EFTofLSS (e.g. Ivanov+22 for a detailed review)

VDG (Sanchez+17, Eggemeier+24)



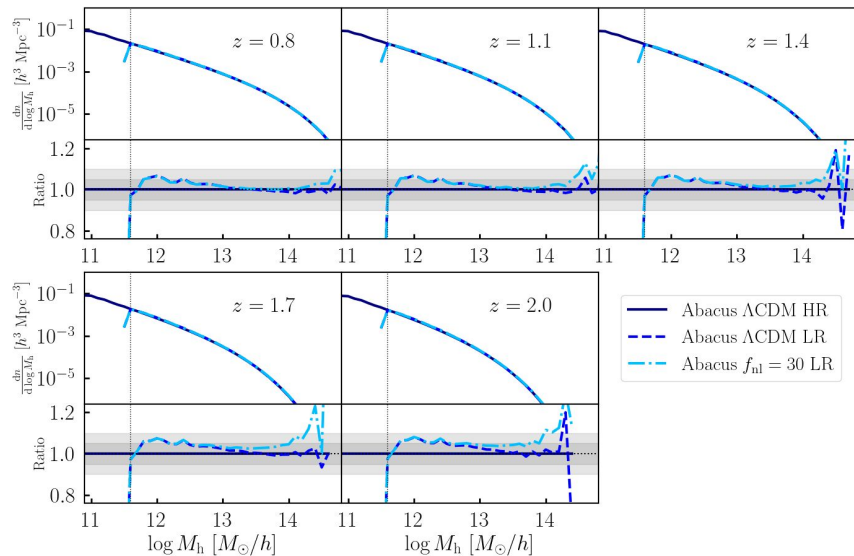
Credits: G. Gambardella

Primordial non-Gaussianities

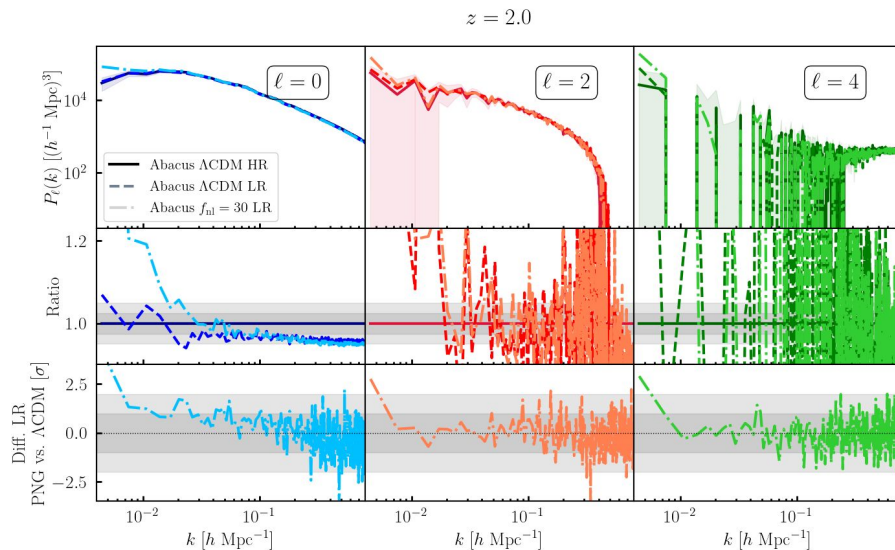
+ E. Sefusatti, A. Moradinezhad

Abacus_png simulations:

- **ΛCDM** lower resolution
- $f_{\text{nl}} = +30, +100, -30, -100$



Bispectrum measurements coming soon...



What's coming next

Things to play with

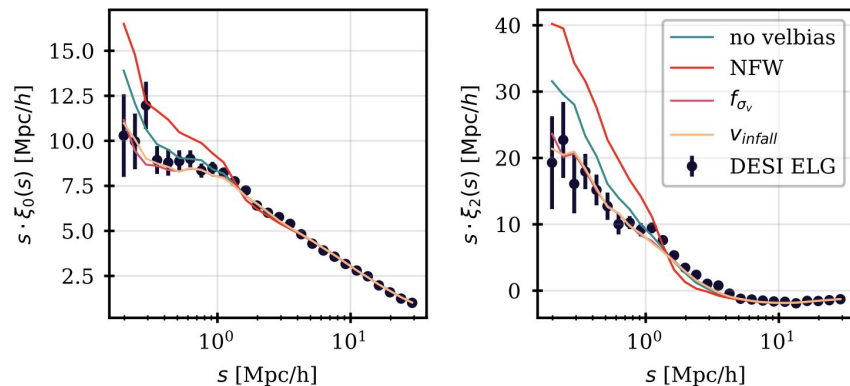
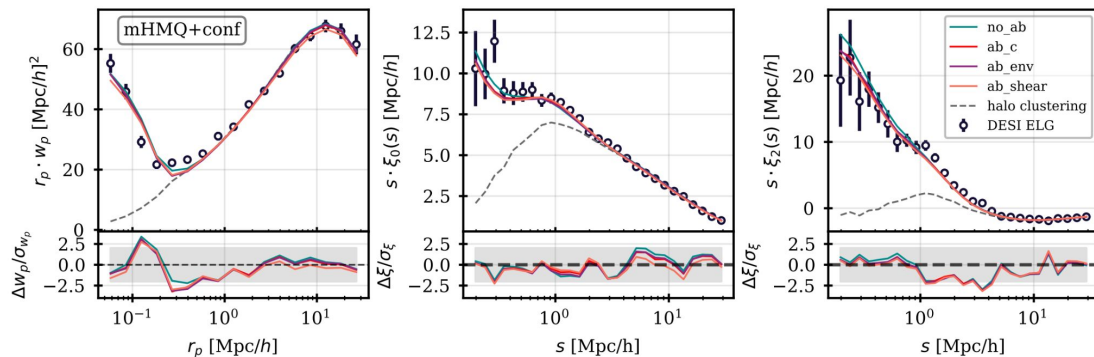
- assembly bias
- velocity bias
- other HODs
- central/satellite conformity
- halo profiles
- BAO reconstruction
- ...



Things to play with in the future

- purity/incompleteness
- interlopers (!!!)
- ...

DESI ELGs, Rocher+23





Conclusions

- N-body based mocks essential to validate several pieces of the GC pipeline (model choices, treatment of systematics, projection effects, covariance ...)
- We have one Universe (or one Flagship) -> **Abacus** suite
- **25 realisations of mock galaxy catalogs matching Flagship at $z = 0.8$ to 2.0**
- Build a **data-driven** mock-generating pipeline
- HoDpipe can recreate Flagship clustering with a simple HOD
 - confirmation of clustering model testing on Flagship
- Next steps
 - systematics
 - more HOD for same cosmologies
 - more cosmologies
 - application to real data

THANKS