COSMOLOGICAL LARGE SCALE STRUCTURE AT IAC

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DESI, EUCLID, PFS

UNDARK meeting IAC 10/10/24

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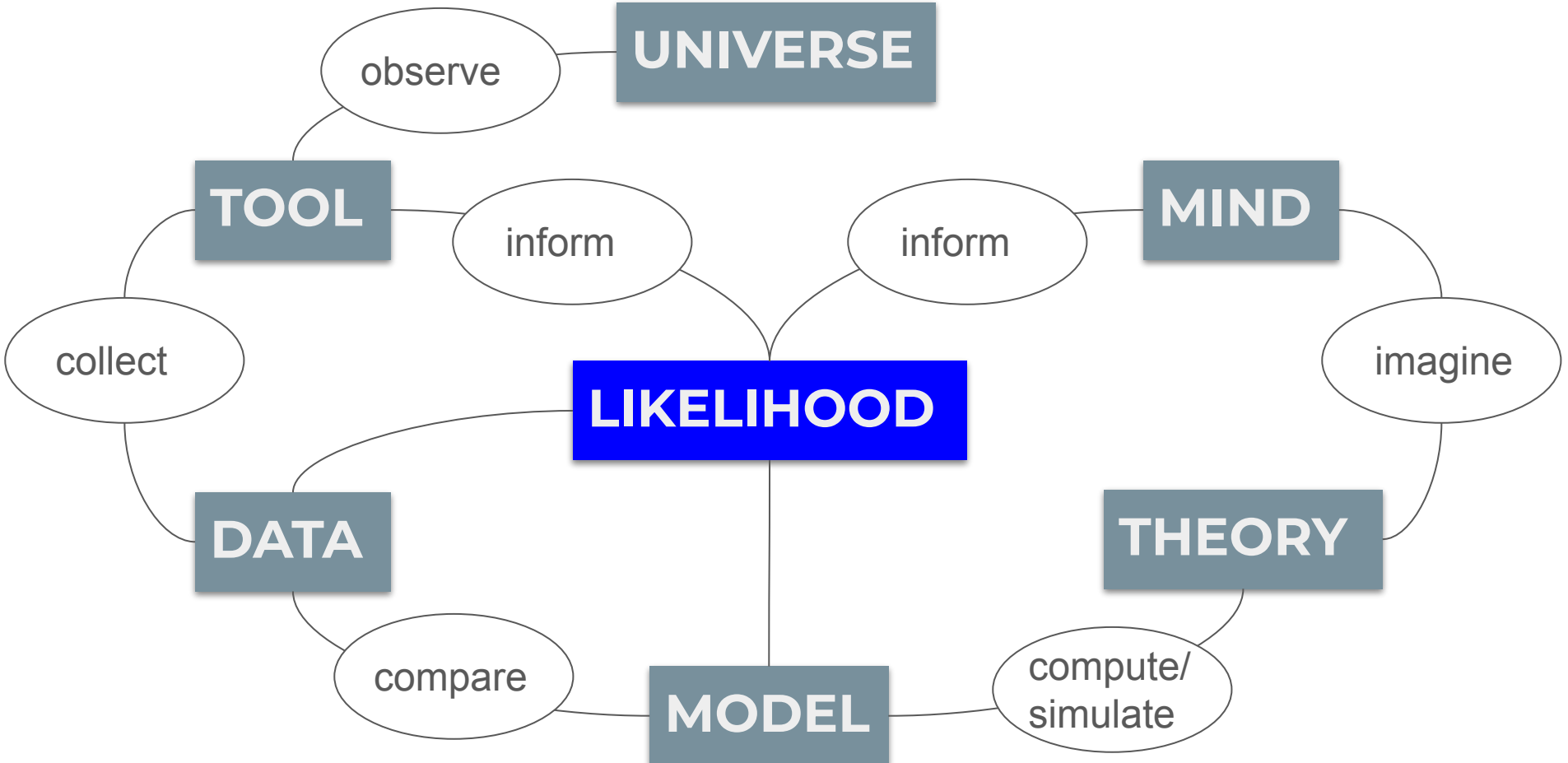
GOAL: UNDERSTAND THE COSMOS



Observe/measure with tool (telescope): rely on luminous tracers (galaxies)

→ problem: observing strategy, systematics

→ problem: bias

First strategy

- model as precisely as possible what has the least uncertainty, leave the rest free within a model description

- use metrics which can be corrected for systematics, but are very informative

→ can only be done on small effective volumes

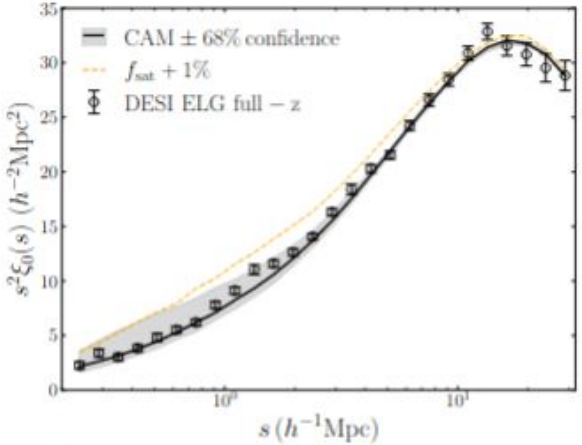
Halo to galaxy connection based on detailed N-body simulations

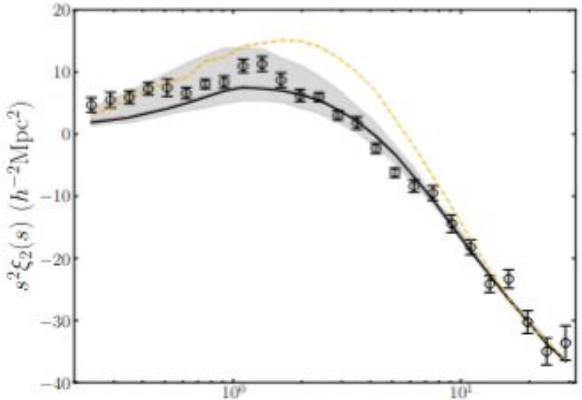
imagine → simulate

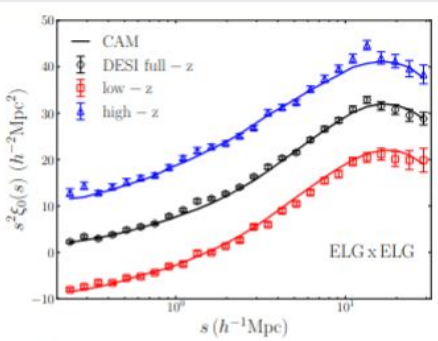
model → compare

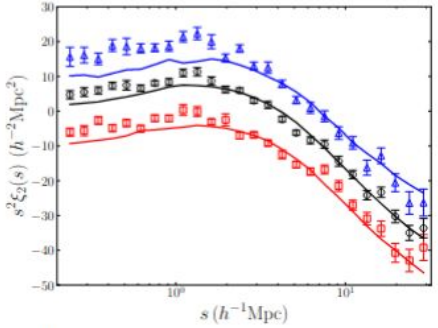
Ginevra Favole, FSK+ in prep

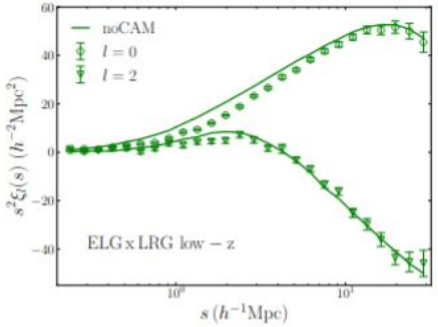
Highly sensitive
precise and accurate
models!











Second strategy

- develop fast gravity solvers on coarse resolutions
- develop effective field level bias models
- develop sub-field-level models
- compute systematics
- learn from reference simulations to constrain the parameters

→ can be done massively

→ covariance matrices, control over systematics

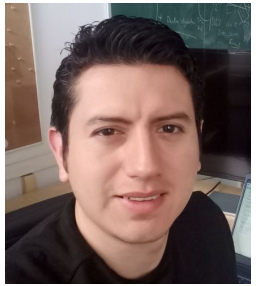
GOAL:
MODEL ALL TRACERS AT ONCE

BGs
LRGs
eLGs
QSOs
Lyman-alpha
Weak-lensing
Alternative gravity models
Survey systematics


Ginevra Favole


Francesco Sinigaglia


Aurelio Carnero Rosell


Jorge García Farieta


José María Coloma-Nadal

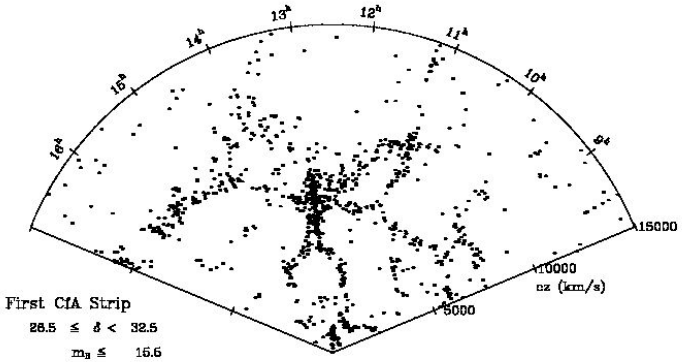

Daniel Forero Sánchez


Natalia Villa Nova Rodrigues

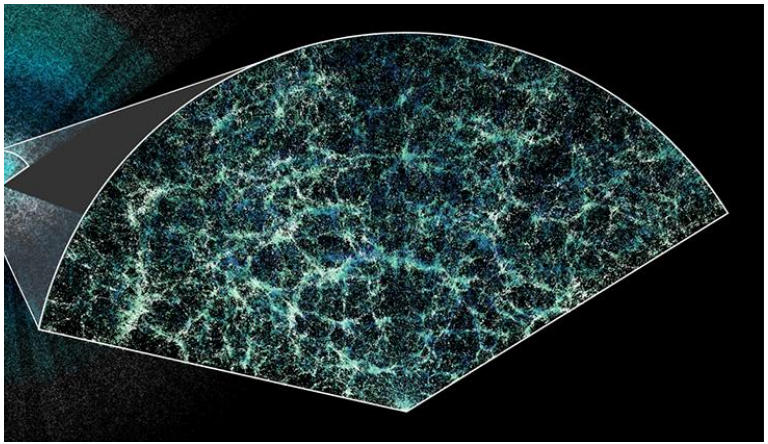

Pere Roselló

The Data for Large Scale Structure

CfA Redshift Survey (1982)



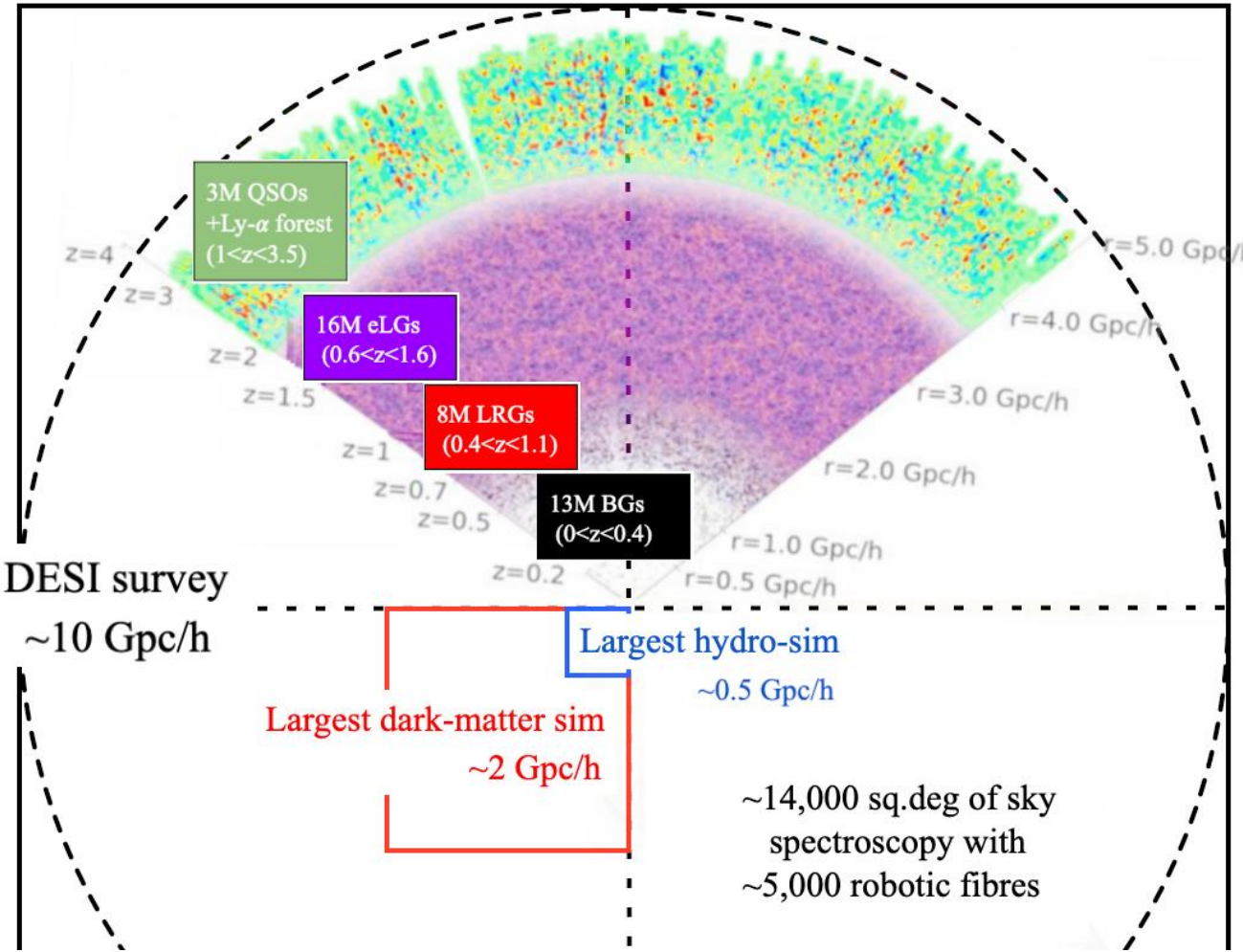
DESI Redshift Survey (2024)



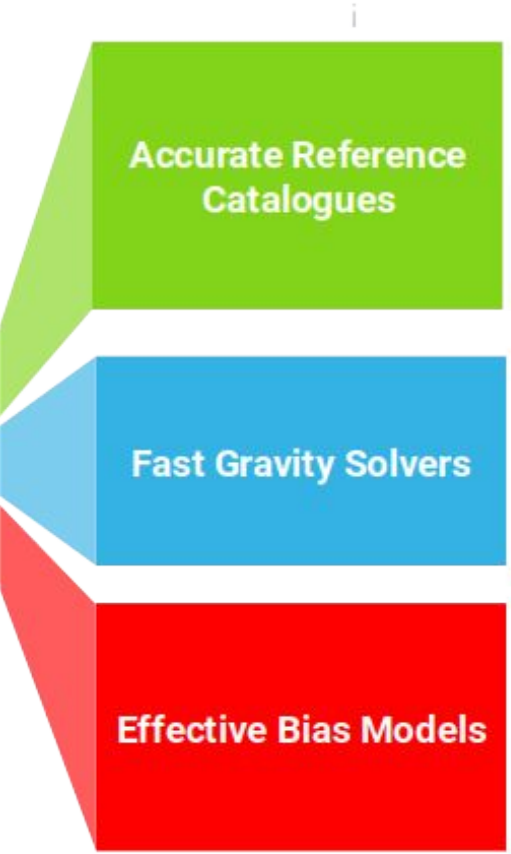
Bigger Volume & Number Density!

~15 Gpc side cubical volumes

What is the IAC Cosmology LSS group doing?



Is this feasible?



Goal: resolve halo dynamics and internal structure
Halo-galaxy connection
Accurate peculiar velocities
Accurate higher order statistics

Ginevra Favole, FSK in prep
GF 22,21,20,18,17,16b,16a

Goal: Fast and accurate calculations of the cosmic web on the lightcone

FSK & Hess 13
FSK, Sinigaglia+24
FSK+ in prep

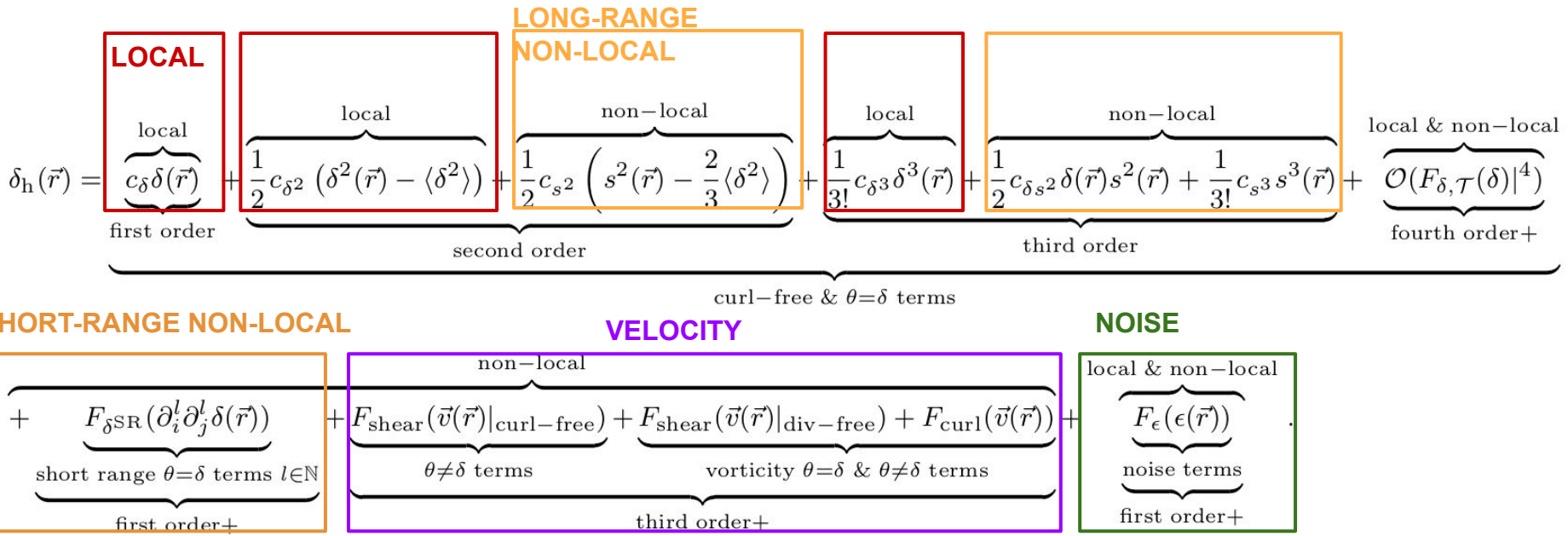
Goal 1: Accurate number counts: Nonlinear, nonlocal and stochastic field level bias
Goal 2: Positions and velocities: Subgrid modelling

FSK+22, 16, 15, 14
Vakili, FSK+17
Balaguera, FSK+23,20,19
Sinigaglia, FSK+24b,24, 22, 21
Coloma-Nadal, FSK+24
Forero-Sánchez, FSK+24
Villa-Nova, FSK+ in prep

Include now nonlocal nonlinear hierarchical bias developed in

Coloma, FSK+24

full description based on $T_{ij} \equiv \partial_i \partial_j \phi$ and $\nabla_i v_j$

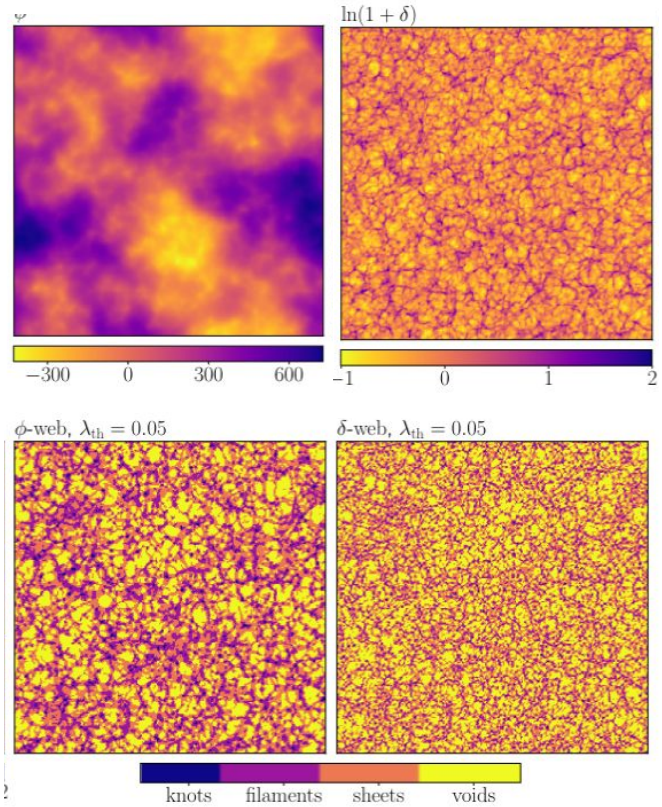


- s^2, s^3: scalars from the tidal field tensor related to its invariants (defined by its eigenvalues)

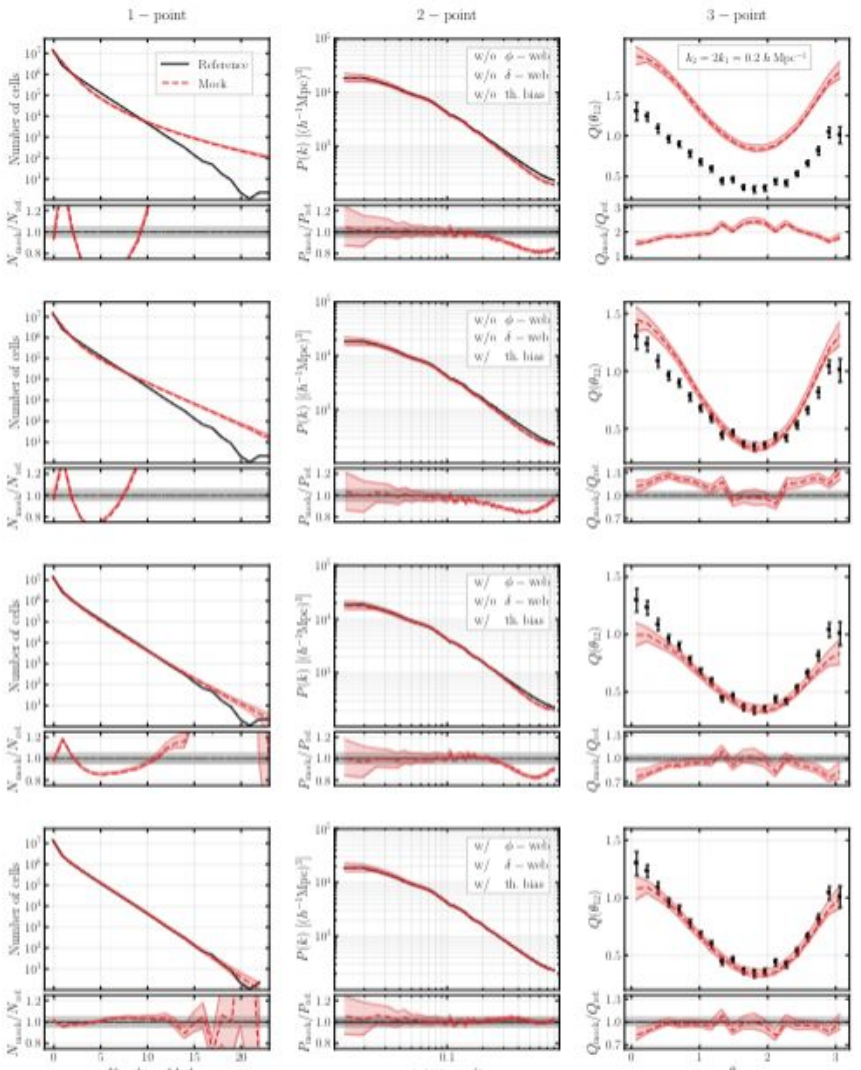
Cosmic web-halo distribution connection

FSK, Balaguera, Sinigaglia, Pellejero-Ibanez+22

J. M. Coloma-Nadal, FSK, J. E. García-Farieta, F. Sinigaglia, G. Favole & D. Forero Sánchez
JCAP 2024



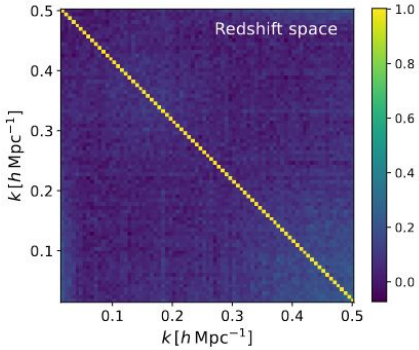
Within 2% accuracy k~0.8 ↦

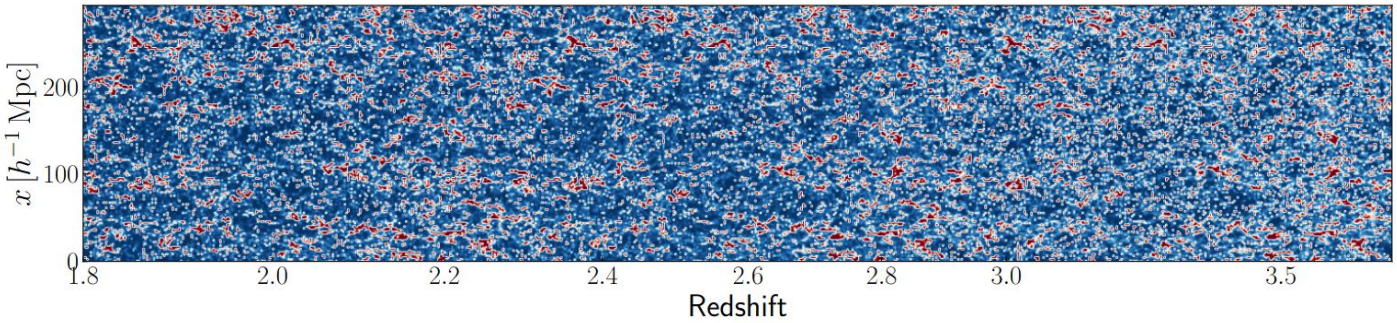


Augmented non-local FGPA Lyman-alpha forest

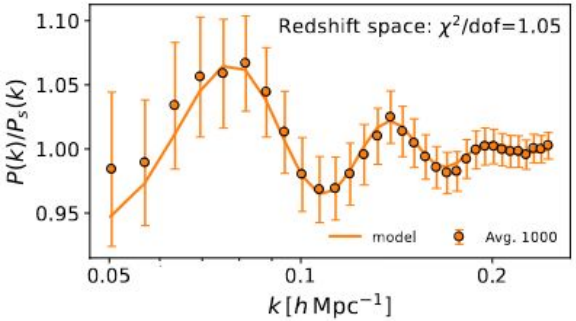
Francesco Sinigaglia, FSK+24a, 22, 21

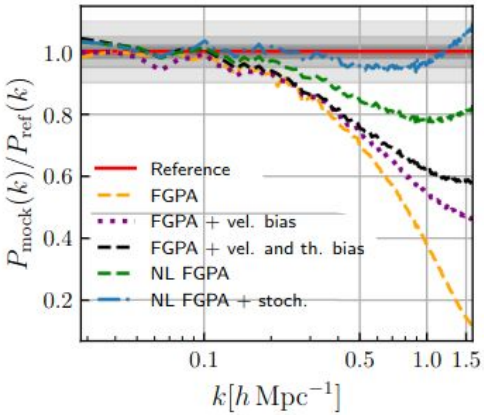
200 x 10 Gpc/h diameter lightcone mocks

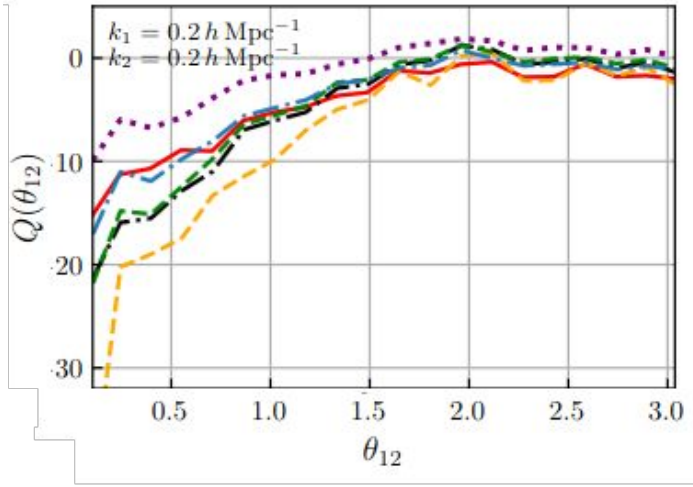




1000 x 1 Gpc/h cubical mocks





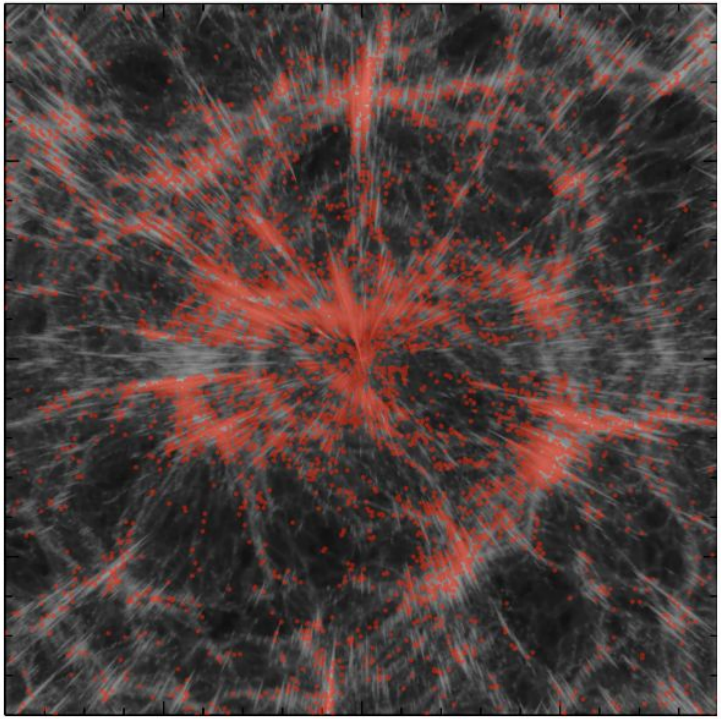


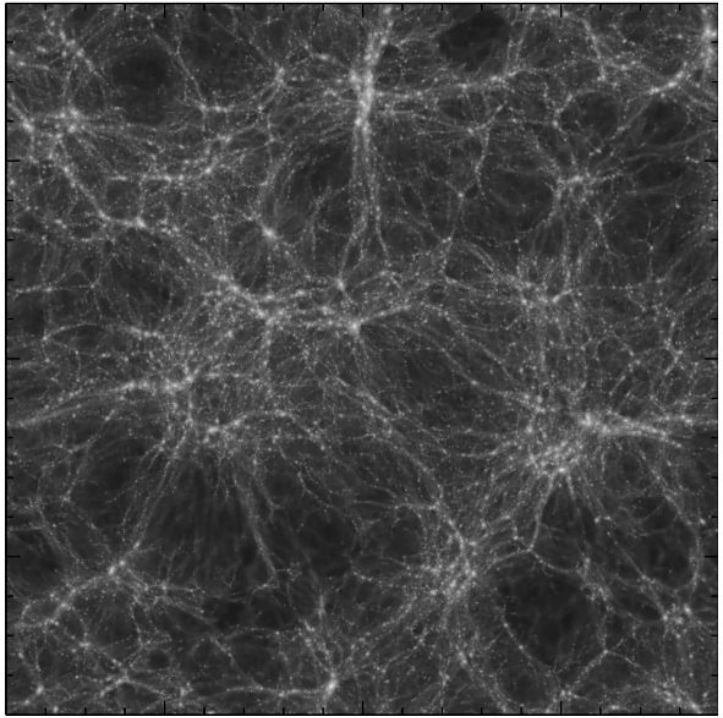
BAO shift in Lyman alpha forest from simulations!

Francesco Sinigaglia, FSK, Nagamine, Oku 24b

Third strategy

- exploit the analytic gravity solvers and the field level bias models to write a fully differentiable forward model for the large-scale structure
- implement this within a Bayesian inference model
- make a direct comparison between data and observations





1st forward modelling reconstruction ever:

[FSK+12 MNRASL]

fogs+coherent -> real-space

[Heß, FSK+13 MNRAS]

[FSK 13 MNRASL]

Conclusions

- We have developed accurate, fast, and differentiable analytic gravity solvers
- We have developed accurate and differentiable field-level bias models
- We have developed differentiable sub-level models
- We have written a full forward modelling connecting the primordial density fluctuations to the large-scale tracer distribution
- We are working on a Bayesian inference framework