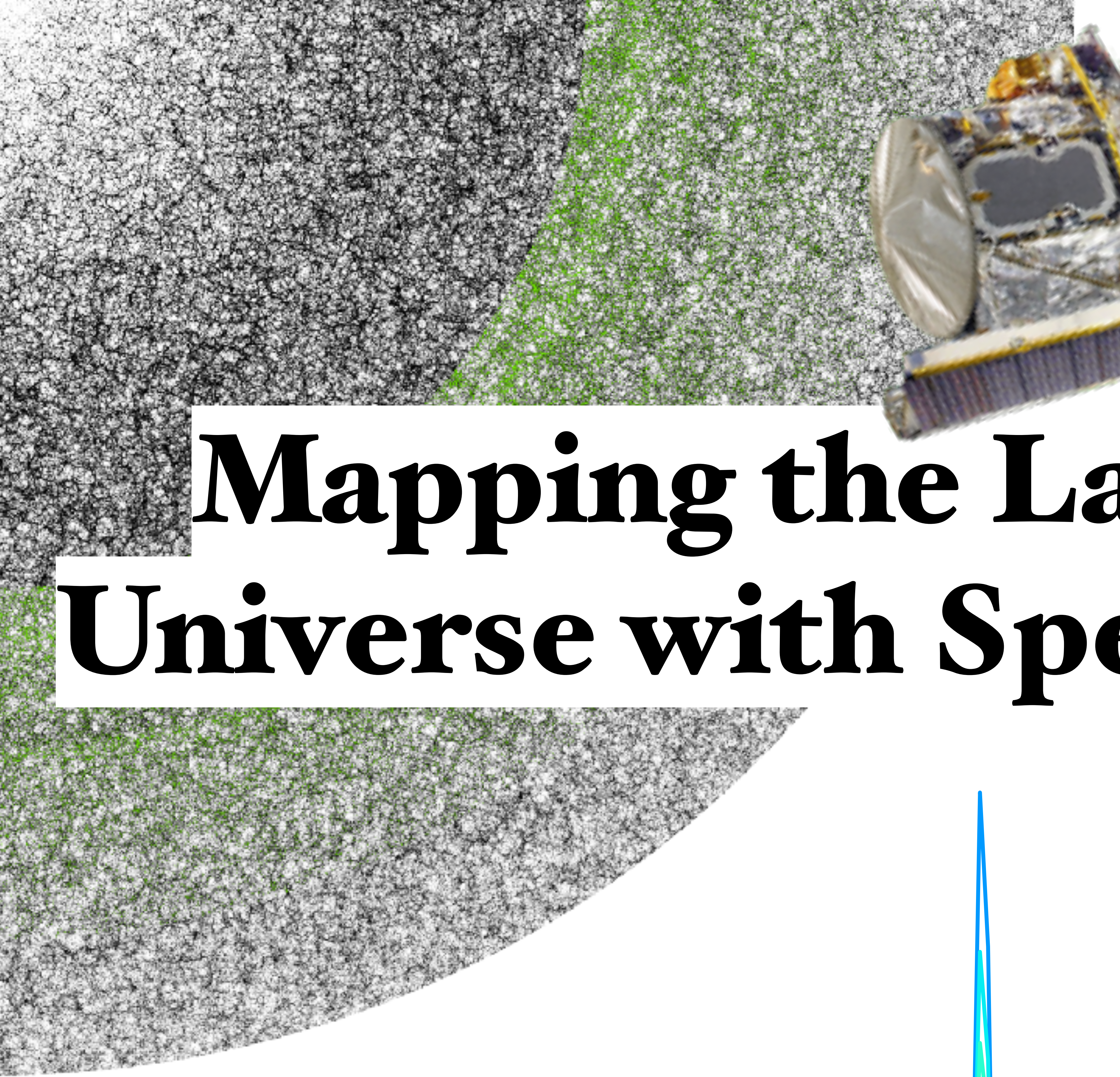

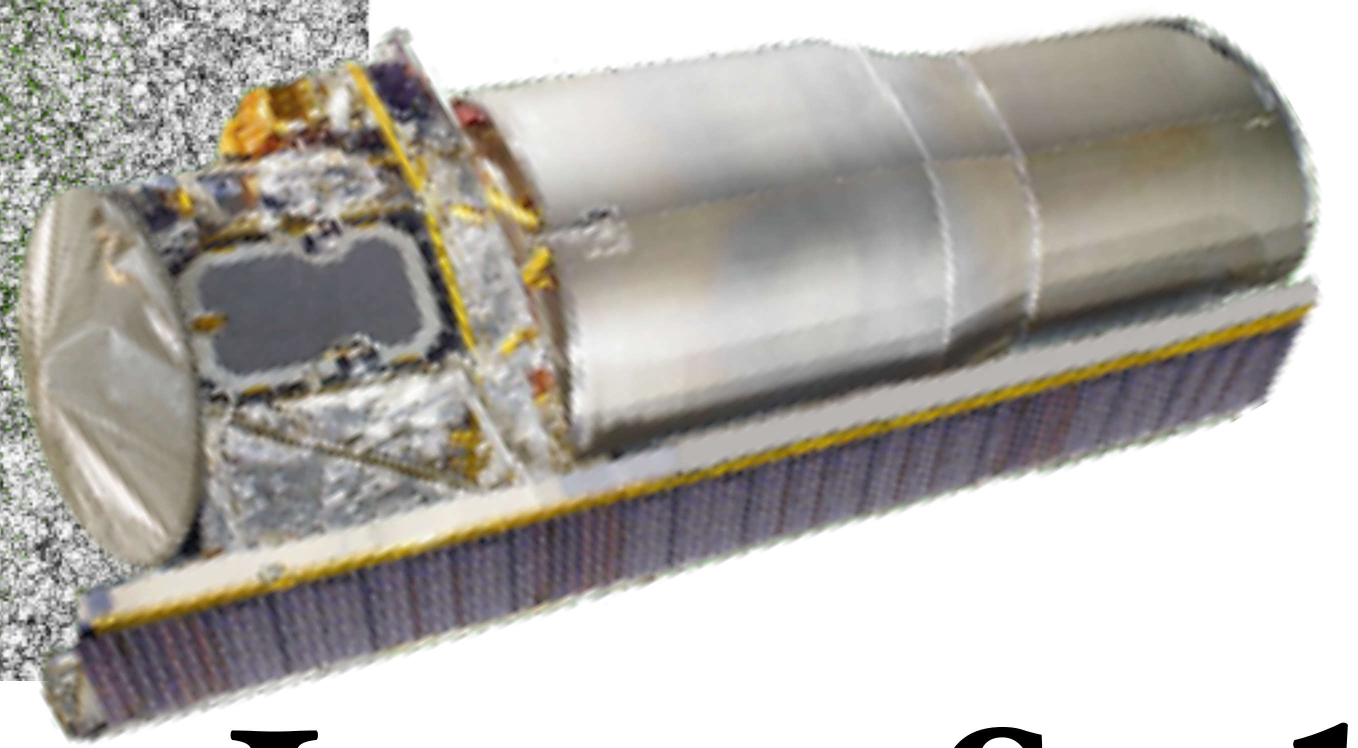

Mapping the Large-Scale Structure of the Universe with Spectroscopic Redshift Surveys

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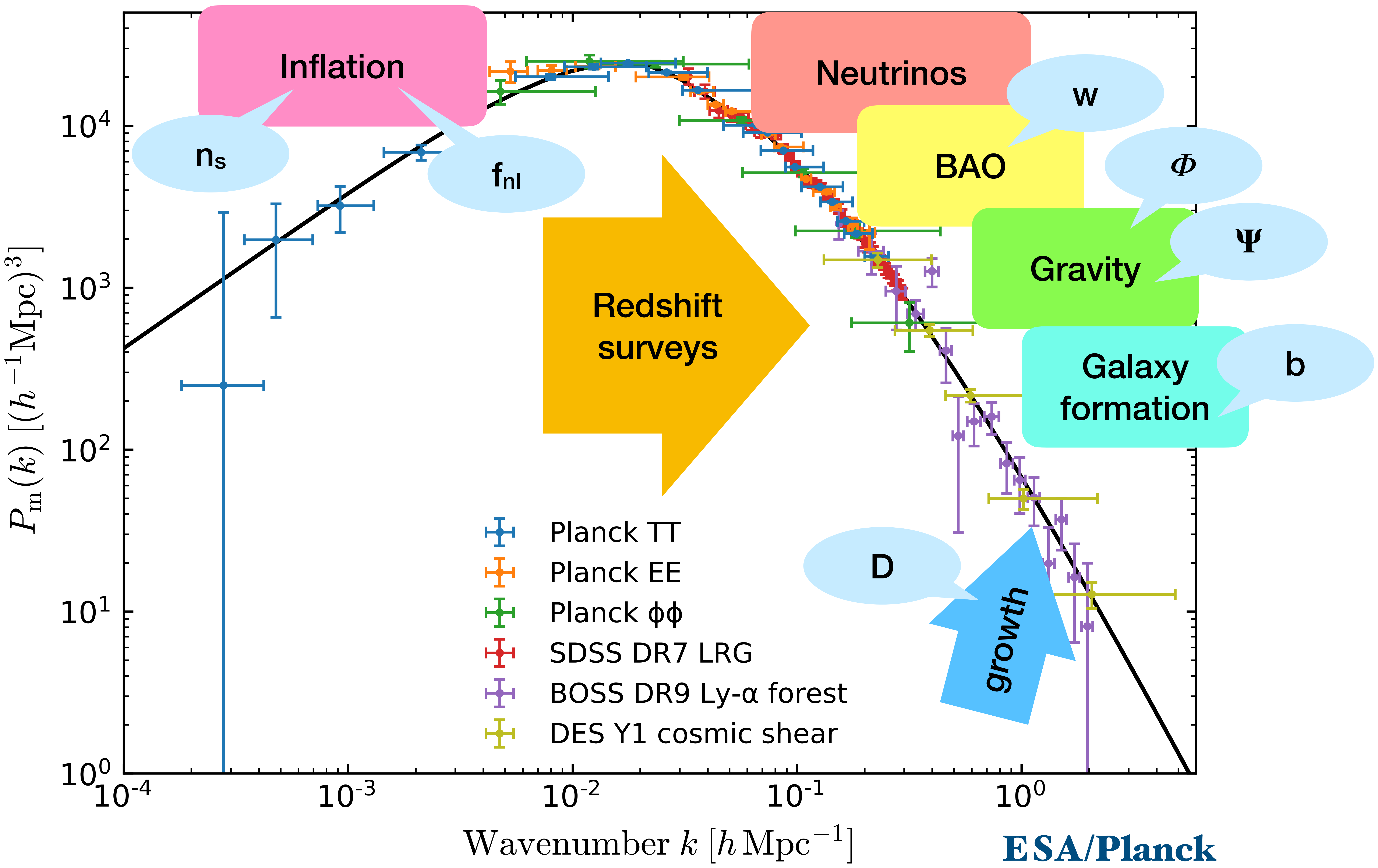
22 June 2021

VIPERS galaxy spectra

ATLAS21

Massively Parallel Large Area Spectroscopy from Space

What Do We Learn From Galaxy Clustering?



ESA/Planck

★ **Complications & opportunities: non-linear growth, galaxy bias, baryons, redshift-space distortions, observational systematics…**

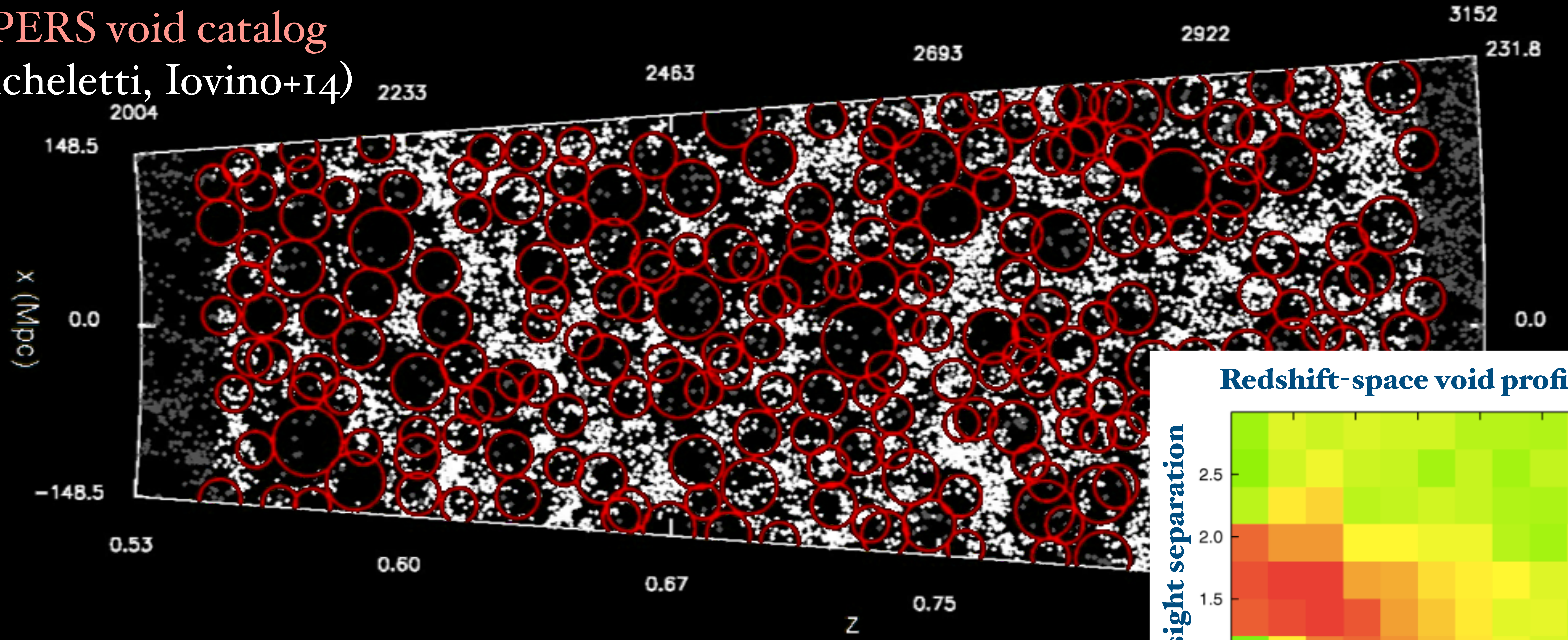
Cosmic Cartography

VIPERS (Guzzo+2014, Scodeggio+2018)

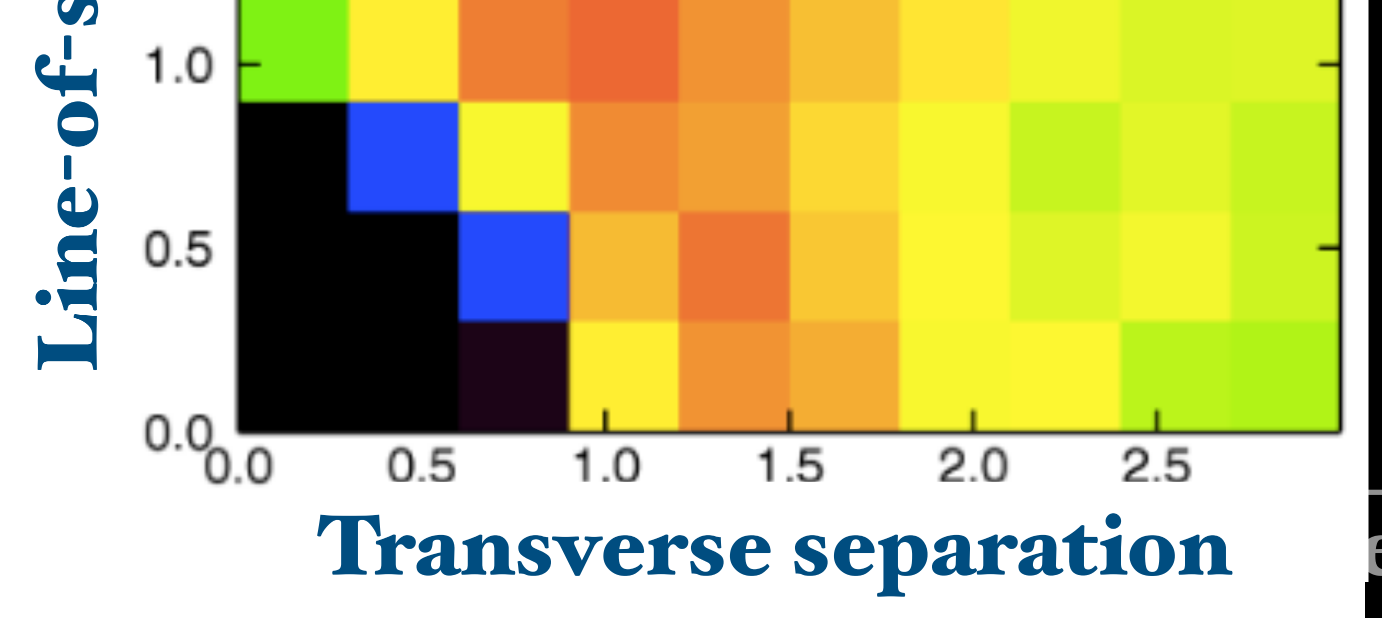
vipers.inaf.it

Cosmic Cartography

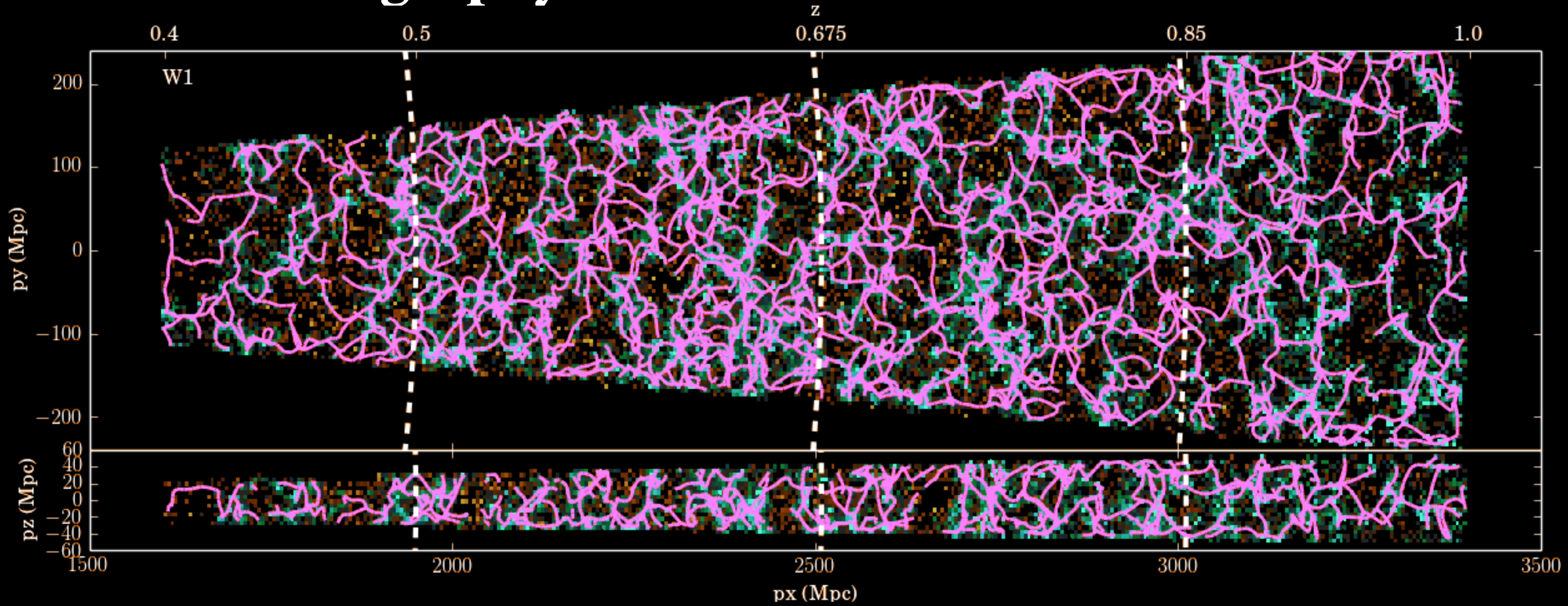
VIPERS void catalog
(Micheletti, Iovino+14)



★ The growth rate can be inferred from the 3D void profile in redshift-space (Hawken, BRG+17)



Cosmic Cartography

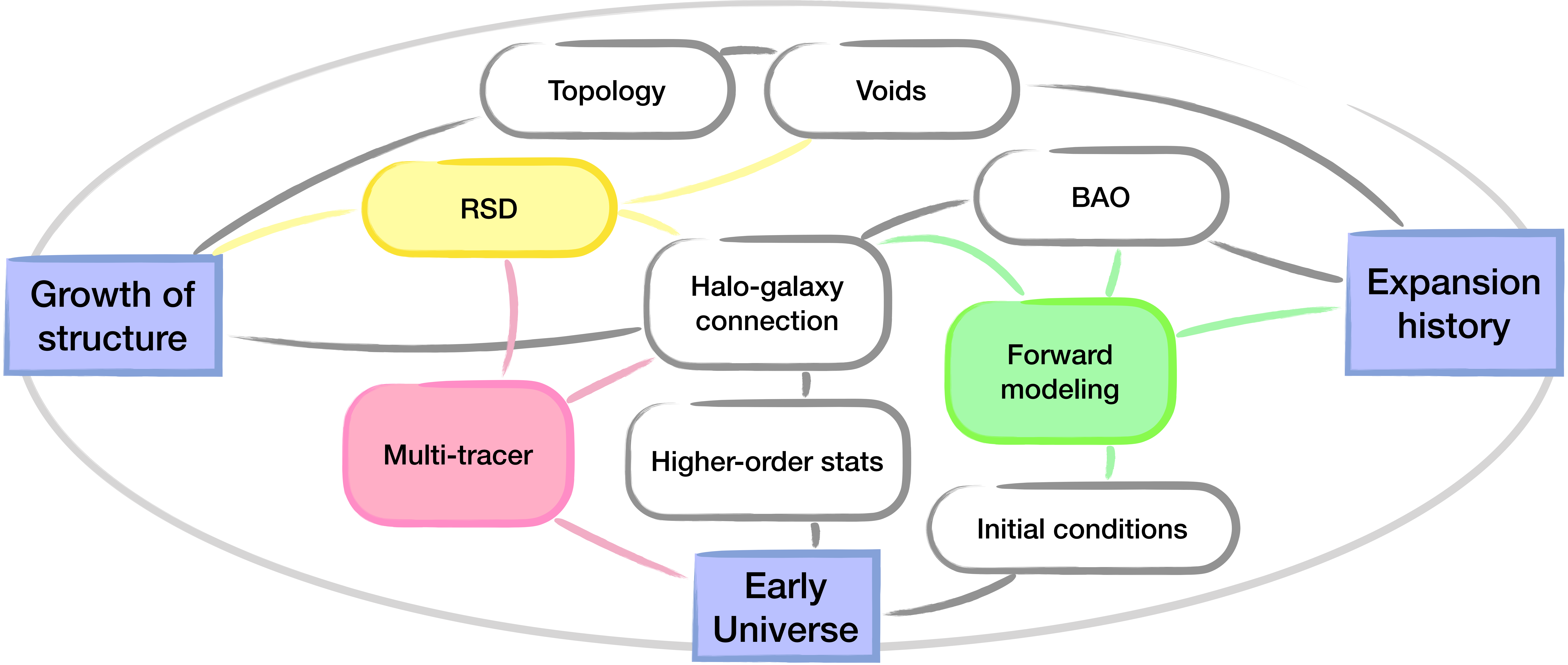


VIPERS filament catalog

- Star formation history is correlated with the position of the galaxy along the filament (Malavasi+2017)

Richness of 3D LSS Analyses

★ Deep and dense spectroscopic samples will enrich current cosmological probes and enable new analyses



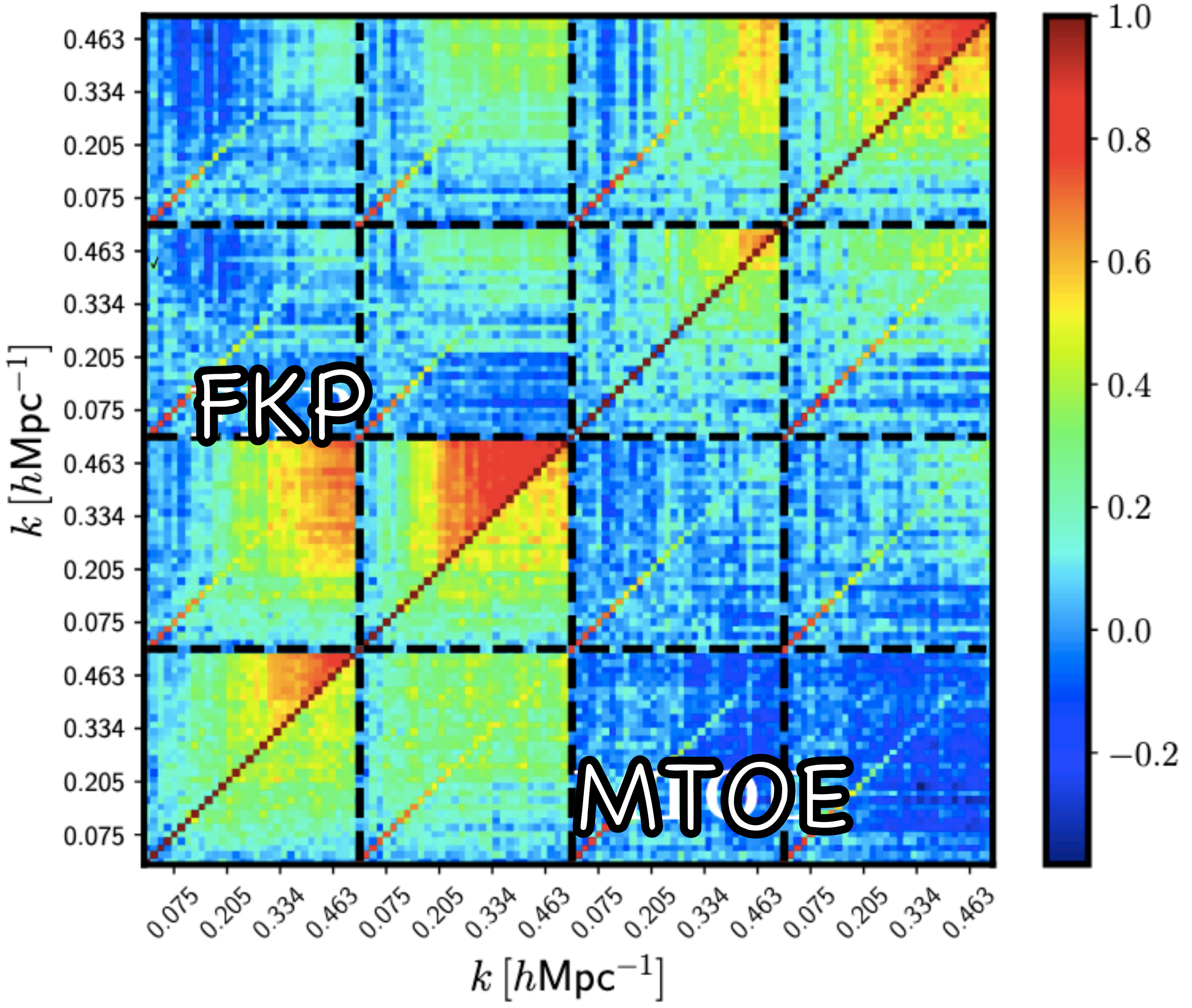
Multi-Tracer Analyses

Density field reconstructed in VIPERS 0.6<z<0.8 (Granett)

- The covariances between multiple tracers of the same volume gives a measure of relative bias without sample variance (McDonald & Seljak, 09). Gain depends on the spread in bias and number densities
- Applications: non-Gaussianity, growth-rate (20% improvement seen in GAMA, Blake+13)
- Enabled by dense galaxy sampling and broad selection functions

Multi-Tracer Analyses

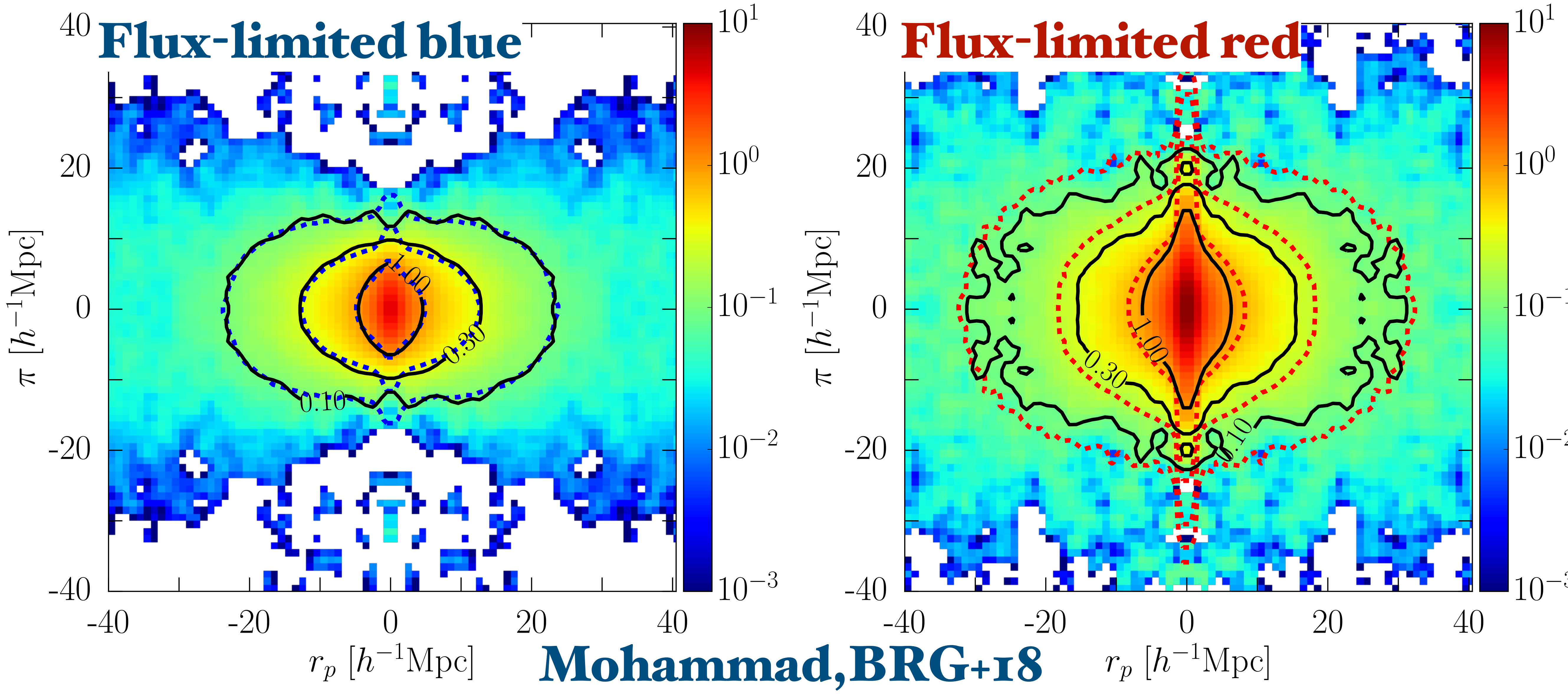
- The multi-tracer optimal estimator (MTOE, Abramo 16) was applied to VIPERS to measure the galaxy power spectrum of multiple samples (Montero-Dorta, Abramo, BRG+20)
- Accounting for correlations between samples suppresses shot noise and allows more information to be extracted from small scales that is lost by the standard FKP estimator



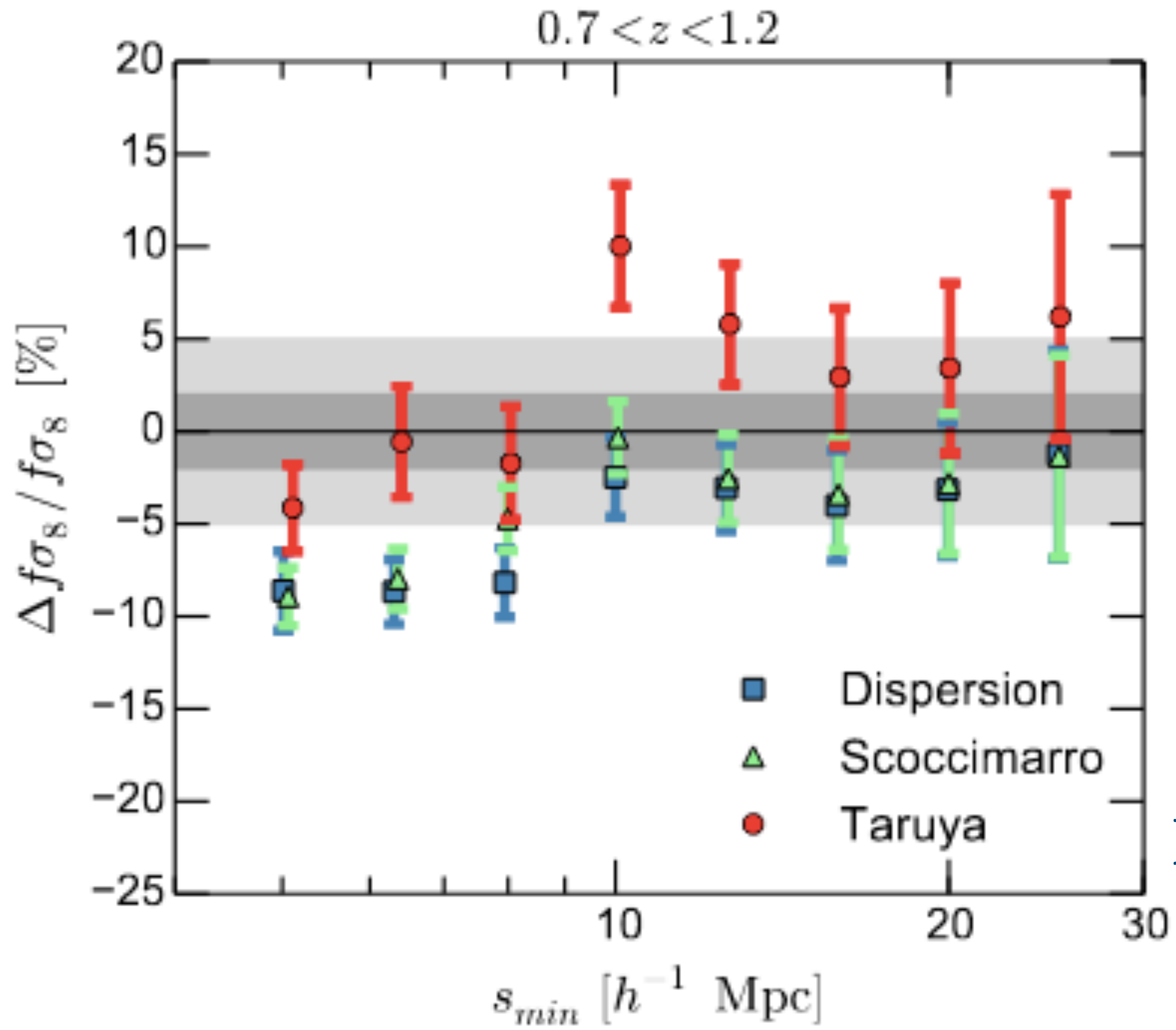
Correlation coefficients of P(k) for 4 luminosity-color selected samples from VIPERS mock catalogs (0.6<z<0.75)

Redshift-Space Distortions

- ★ RSD signal-to-noise is greatest on small scales, but it is contaminated by virialized velocities
- ★ Modeling RSD on small scales is a challenge for next-generation surveys
  - ➡ Forward modeling with N-body mocks and halo and SHAM galaxy occupation models

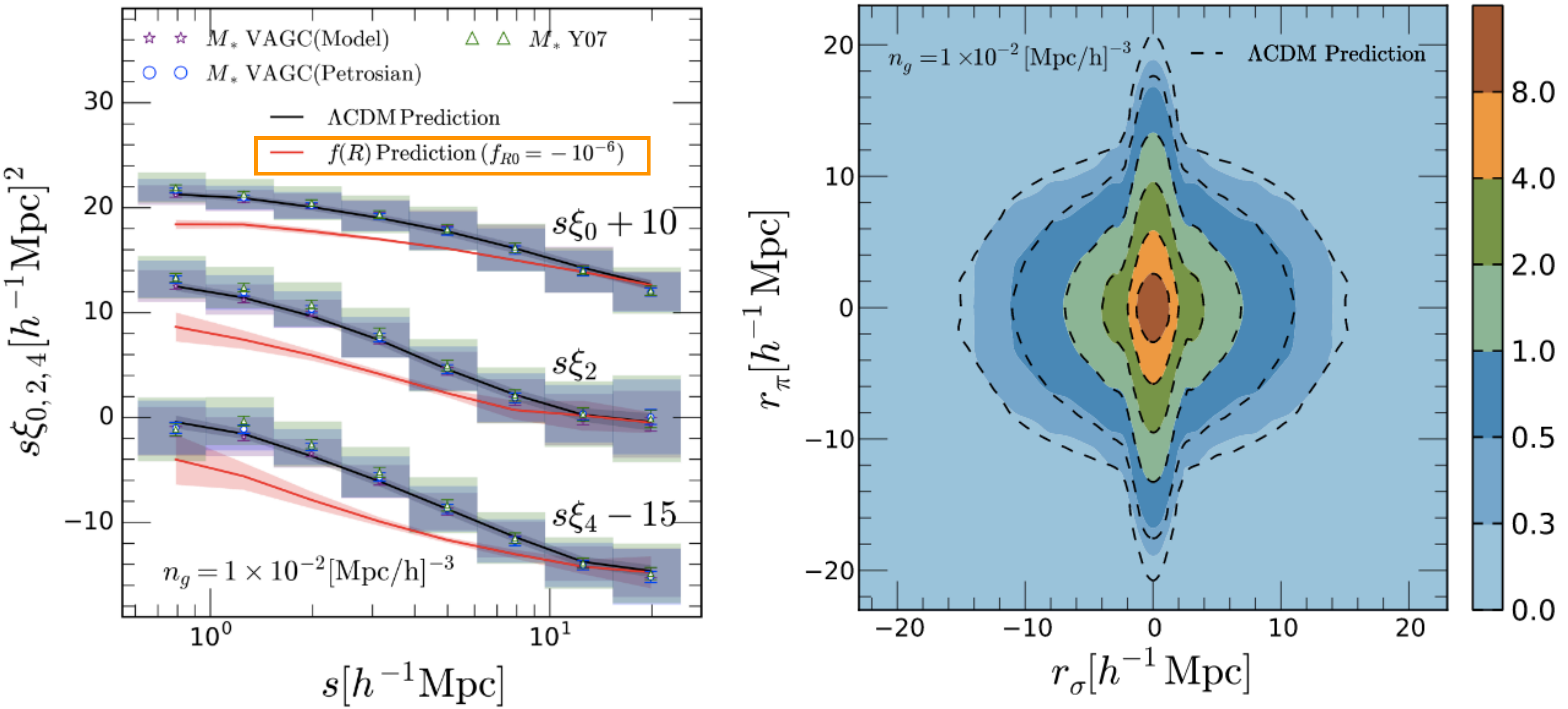


Mohammad,BRG+18



Pezzotta+17

SHAM Success at z=0 and Cosmological Implications

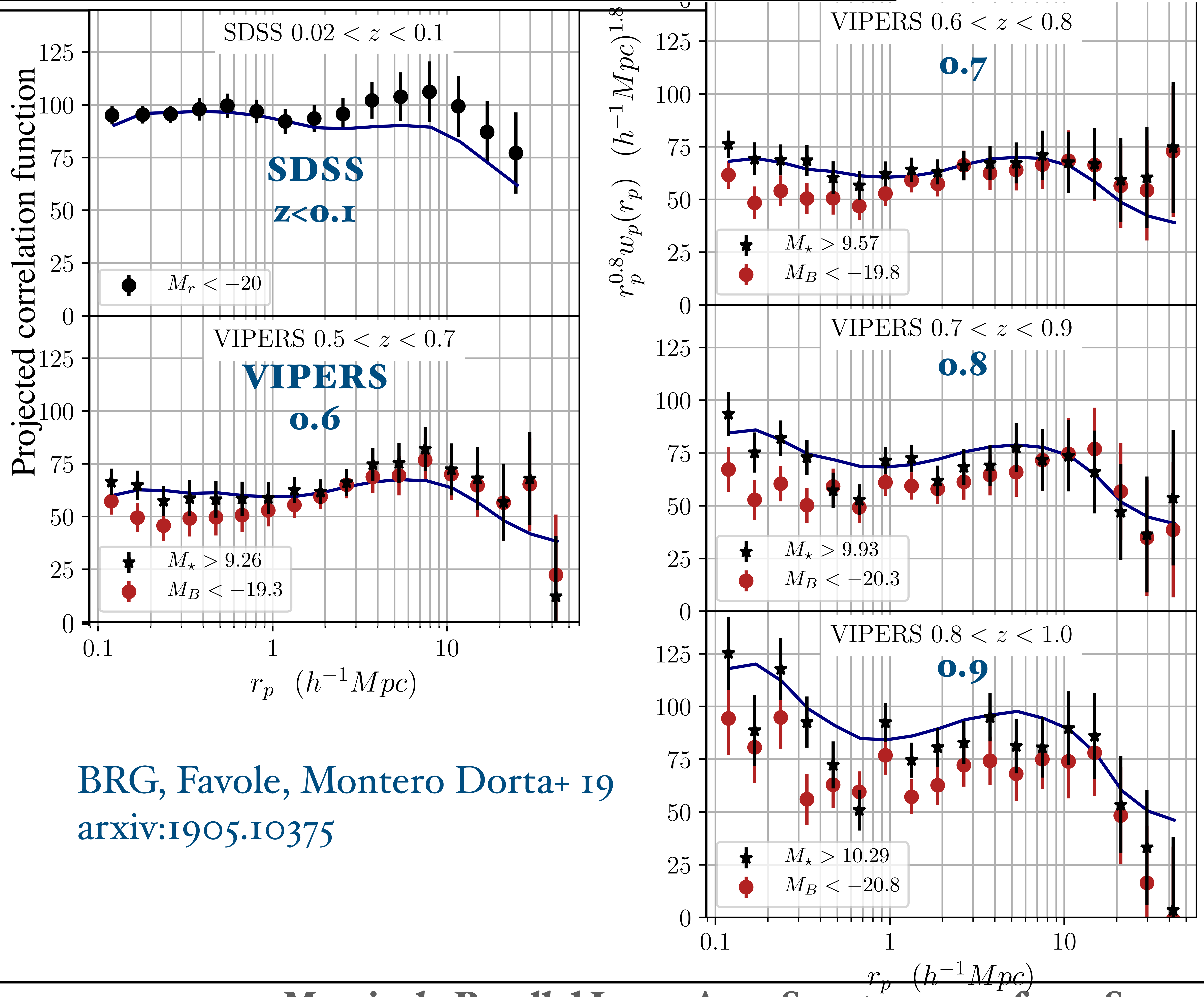


No evidence for modifications of gravity from galaxy motions on cosmological scales (He, Guzzo, Li, Baugh, 2018 Nature Astronomy, Volume 2, p. 967)

SHAMM Model for VIPERS

- MultiDark SHAM predictions match the projected correlation function in VIPERS 0.5<z<1
- Application of SHAM requires a proxy for halo mass and highly complete galaxy samples

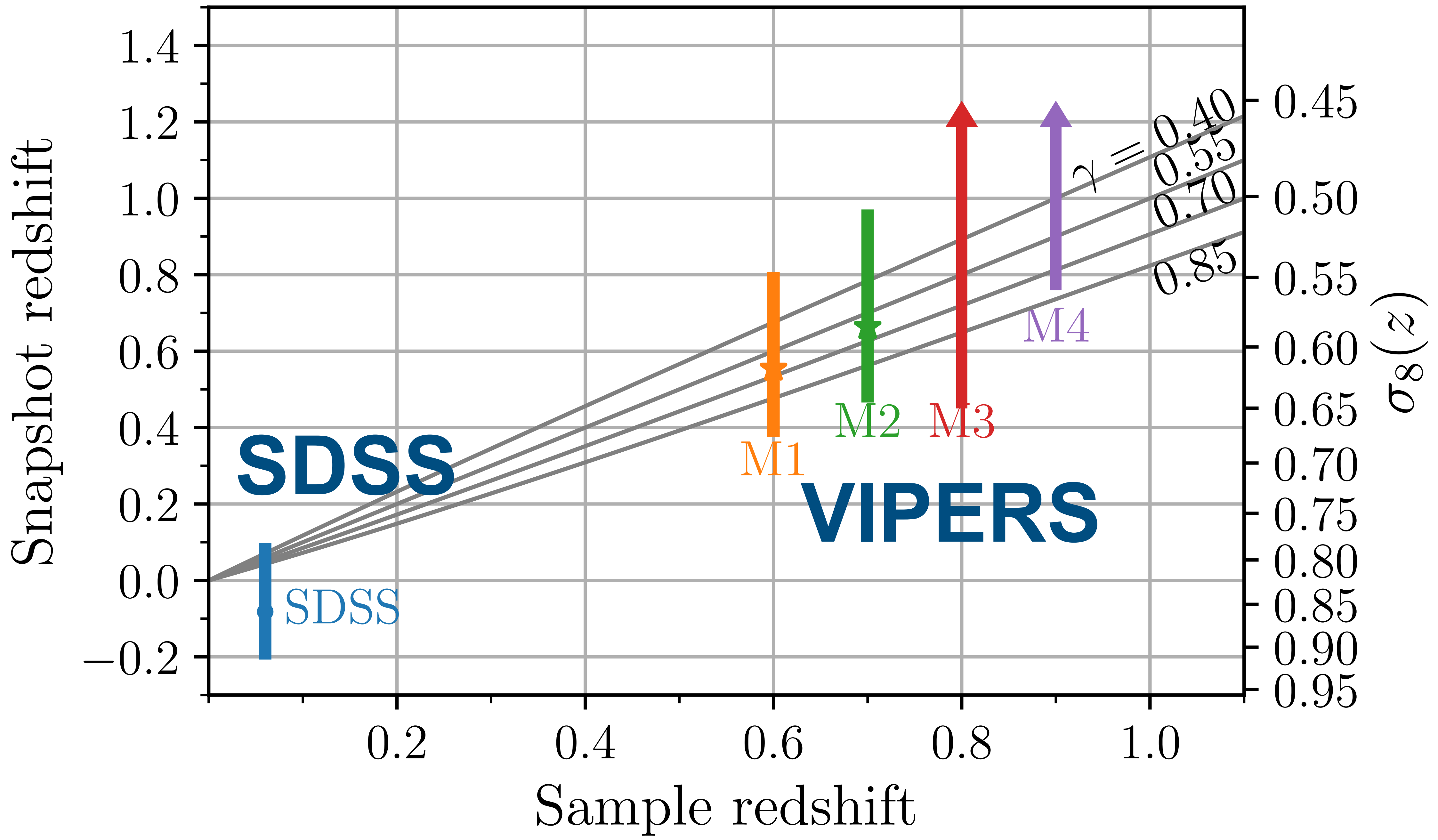
➡ Best choice for VIPERS: galaxy stellar mass



BRG, Favole, Montero Dorta+ 19
arxiv:1905.10375

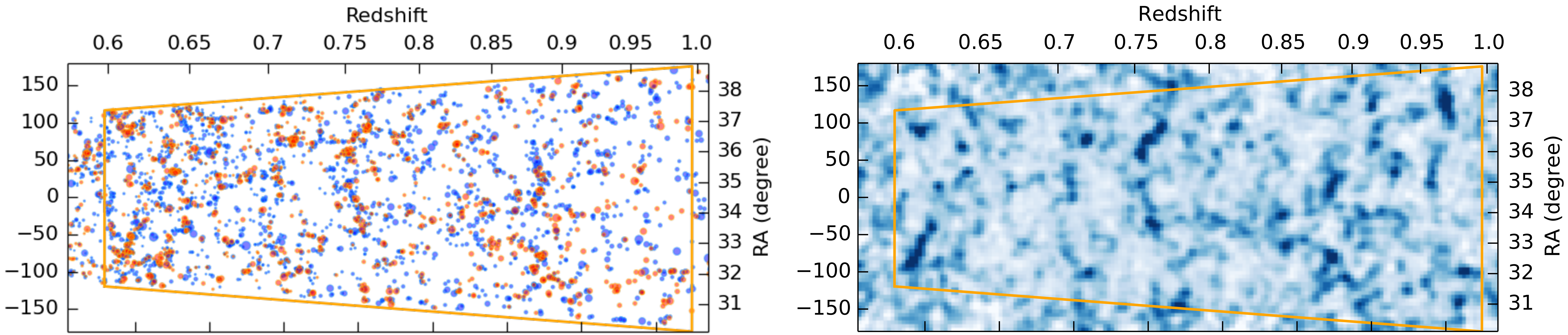
Forward Modeling the Growth of Structure

- ★ We match MultiDark SHAM models with SDSS and VIPERS correlation functions from redshift 0<z<1
- ★ Remapping simulation snapshots (Angulo & White 2010) allows us to probe the dark matter clustering amplitude $\sigma_8(z)$



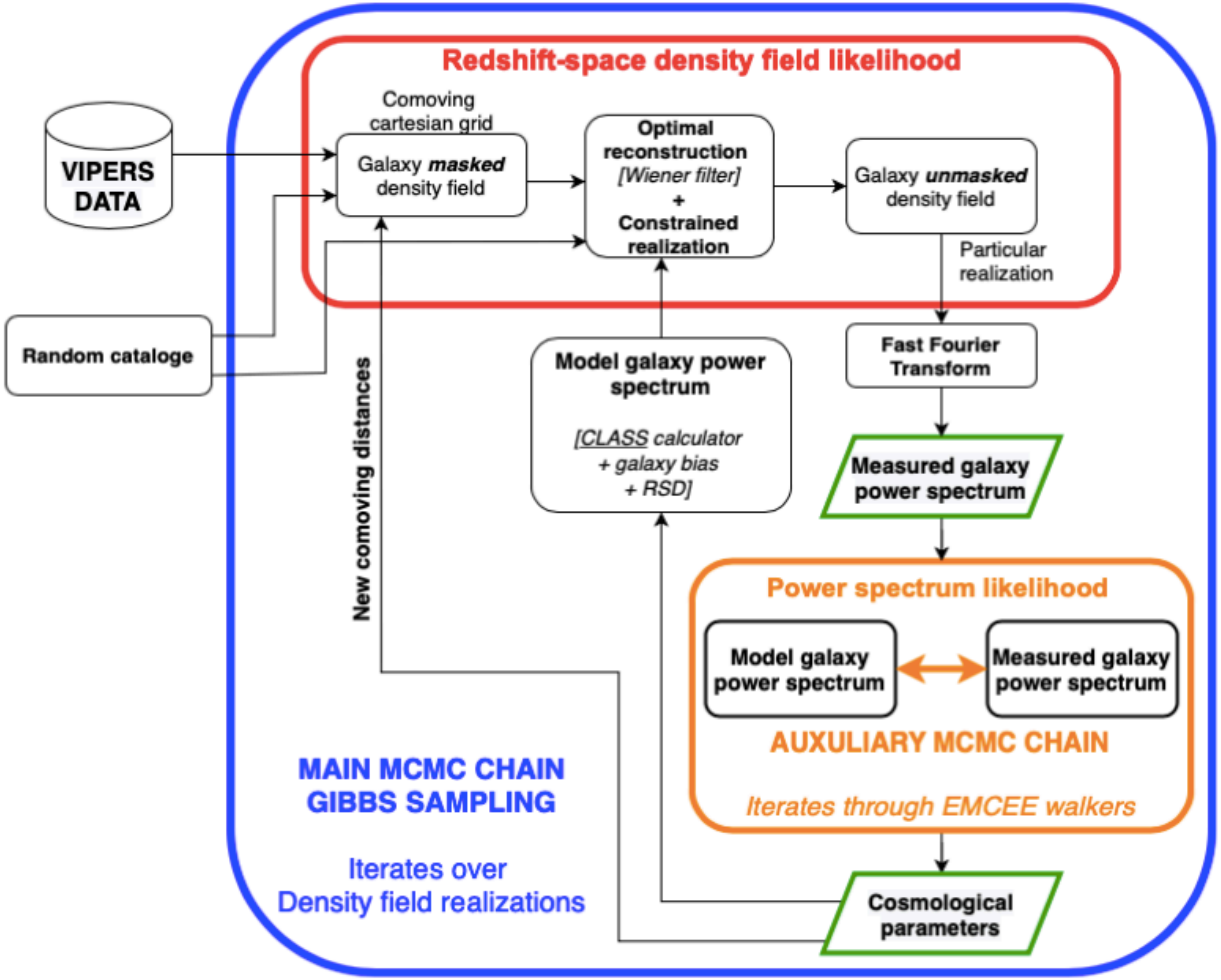
BRG, Favole, Montero Dorta+ 19
arxiv:1905.10375

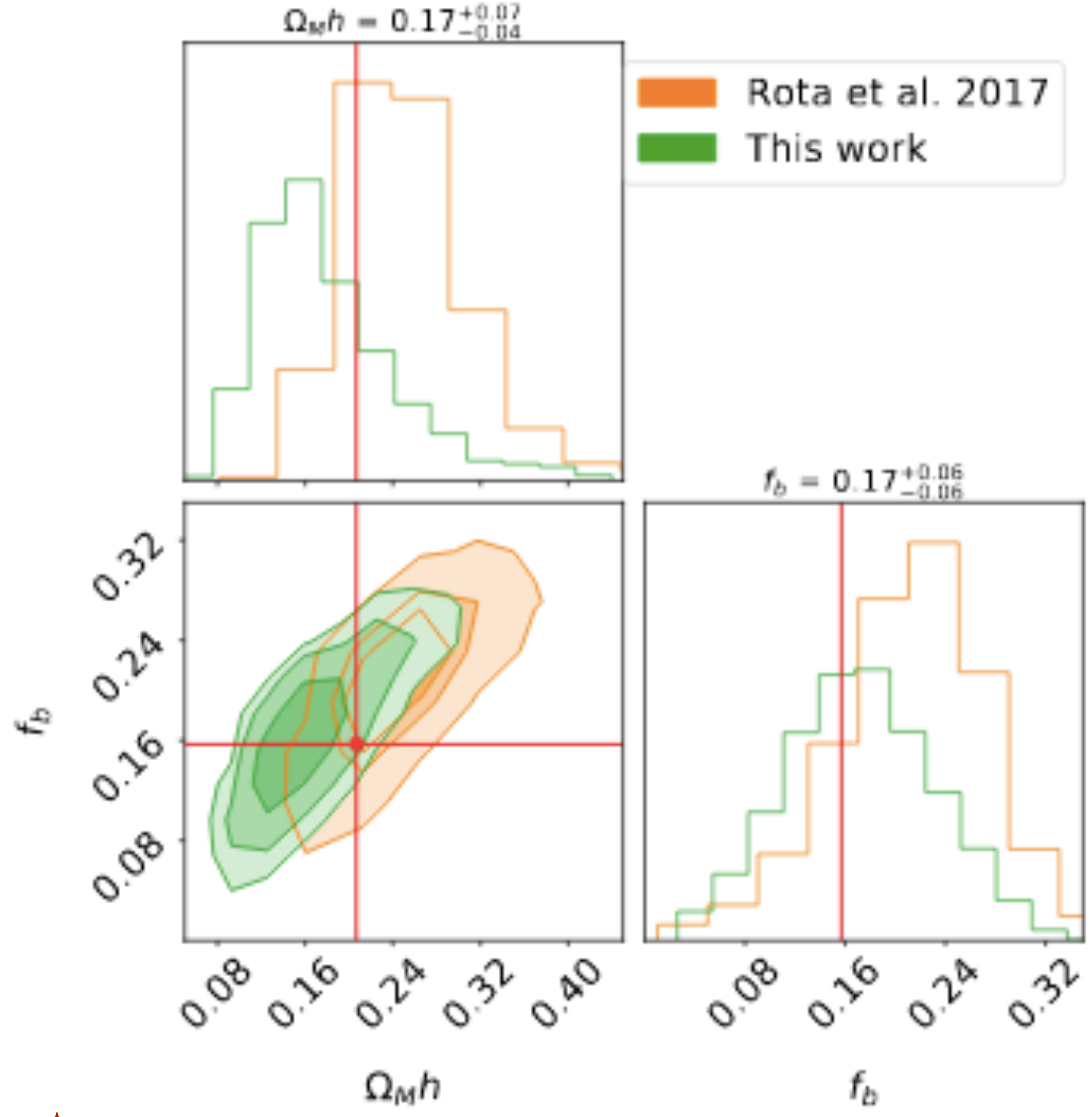
Extracting the Most from Spectroscopic Surveys



- Bayesian LSS inference promises to optimally mine the information from the rich galaxy field
  - ➡ Joint constraints on cosmological parameters, density field, galaxy bias & luminosity function with Gibbs sampling (Estrada & BRG+prep, BRG+15)
- Inference can be made on the Gaussian initial conditions by including structure formation models (Lavaux & Jasche 18, Kitaura 13)

Forward Modeling the Density Field



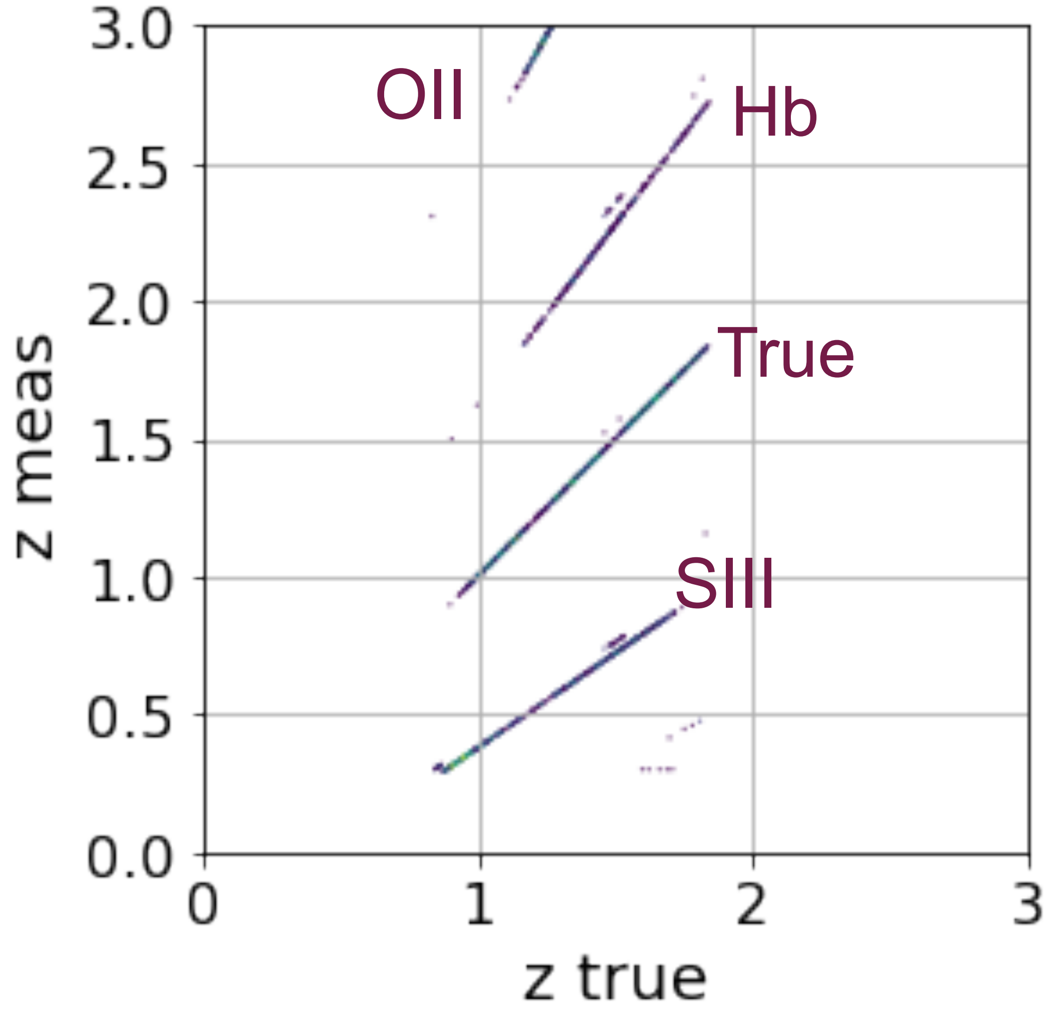


★ Gibbs sampler with more degrees of freedom outperforms FKP estimator (Estrada & BRG, in prep)

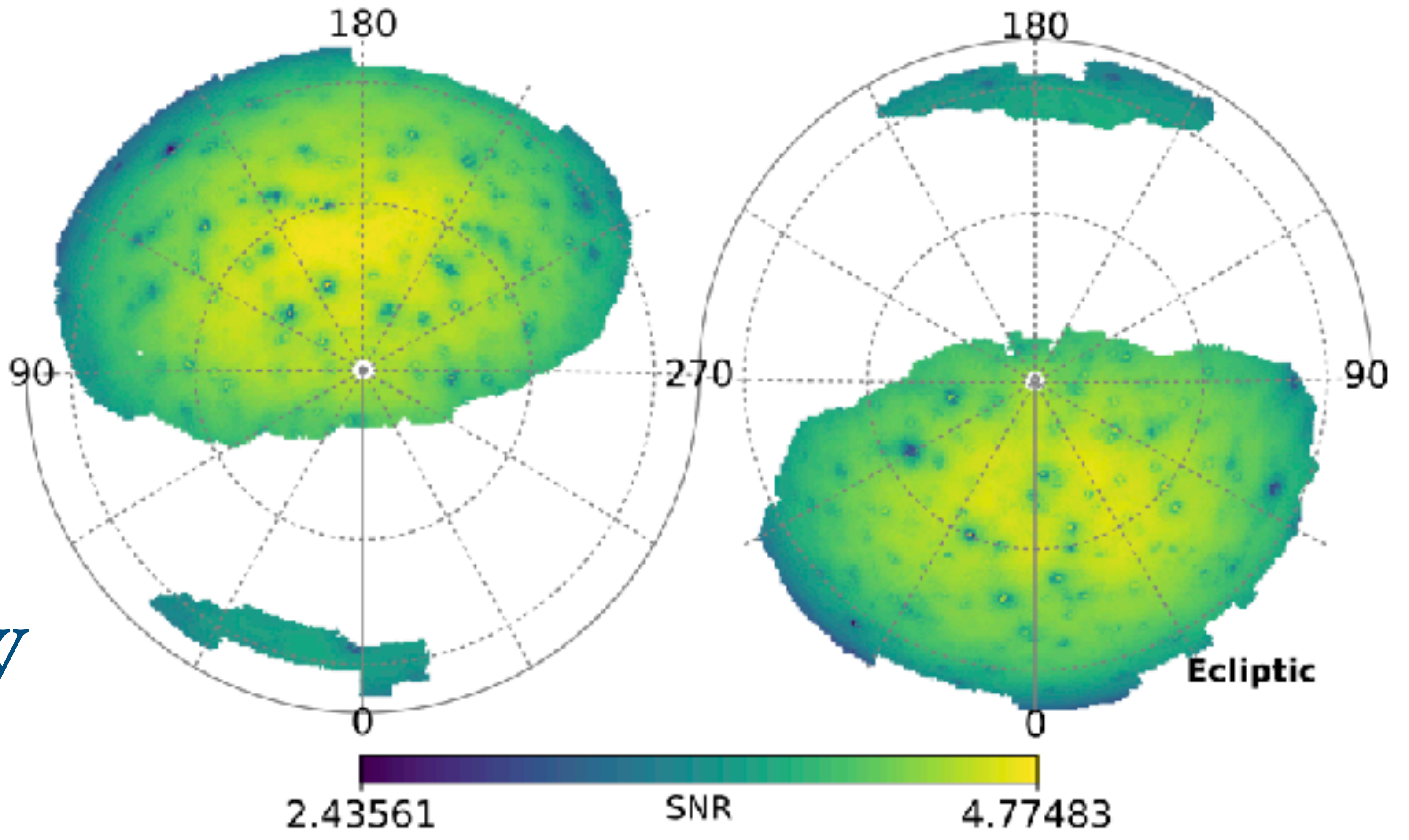
Systematics: the Next Frontier

- ★ Unless great care is taken, the high statistical precision of upcoming surveys will be spoiled by systematic uncertainties
- ★ Selection biases depend on underlying density field (eg slit assignment, slitless confusion, luminosity-dependent bias)
- ★ End-to-end simulations are essential to characterize the selection function and propagate errors

Potential Hα line misidentification in Euclid slitless spectroscopy. (Bruton, Scarlata, BRG+)



Euclid: variations in emission line SNR due to zodi, straylight and MW extinction. (BRG+)



Conclusions

- ★ Upcoming spectroscopic redshift surveys will uniquely constrain the cosmological model
- ★ Bright emission line galaxy samples are the tip of the LF
  - ➡ Rich massively parallel spectroscopic samples will enable new techniques: multi-tracer analyses, forward modeling small-scale RSD and Bayesian inference of the density field
- ★ Control of systematic errors will be paramount for success