FARO:
The Fisher gAlaxy suRvey cOde

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https://arxiv.org/abs/2007.05360

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Outline

- Introduction.
- FARO features.
- Main observables of FARO.
- Code structure.
- Results of FARO.
- Conclusions.

Introduction

- In next years, new galaxy surveys will put powerful constraints to cosmology.
- The main observables are galaxy clustering and the weak lensing effect.
- It is interesting to test how these future surveys could constraint the cosmology and how should be designed to maximize that constraints.
- Codes of galaxy survey forecast are the main tool for this purpose.

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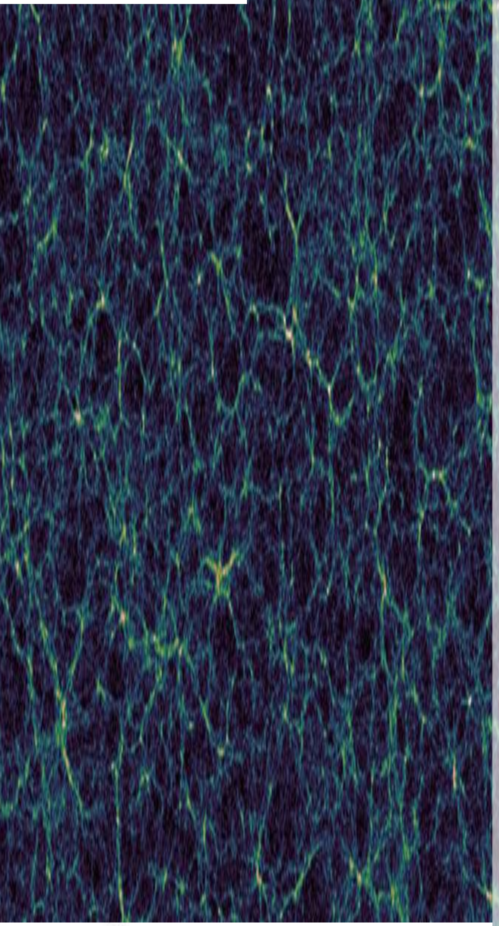
Introduction

- Fisher matrix forecast is the fastest method to estimate future constraints.

- There are several Fisher forecast codes like: BFF, CarFisher, FisherMathica, etc. These codes computes clustering, lensing and the cross correlation.

- FARO is a new Fisher code which is totally public, fast and easy to use and modify.



FARO features

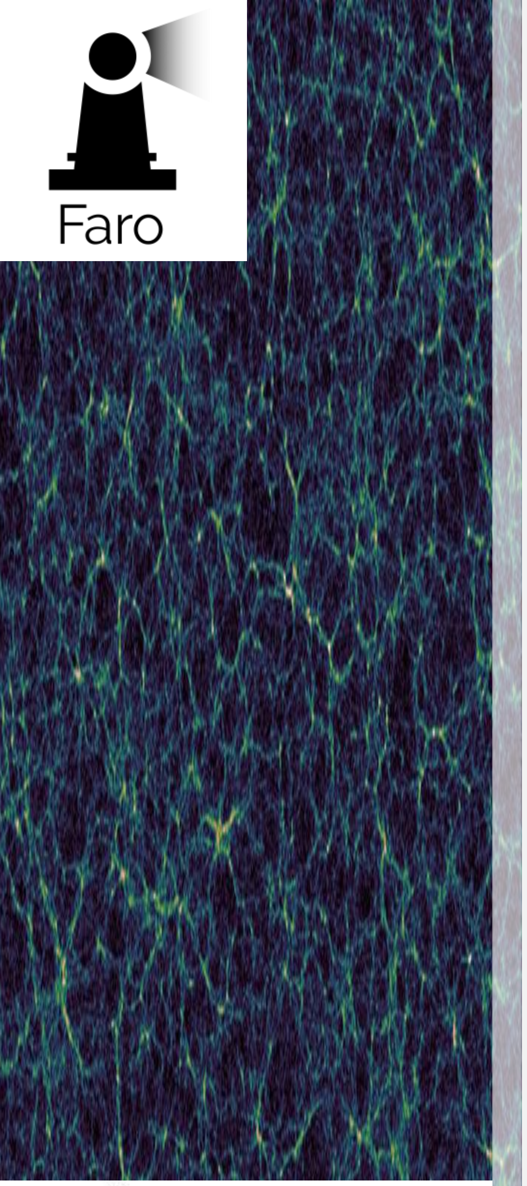
- The main features of FARO are:

- **Python code:** it uses CLASS to compute the matter power spectrum.

- **Observables:** 3D galaxy power spectrum, convergence power spectrum and the cross correlation.

- **Multitracer:** any number of tracers can be computed with the galaxy-lensing cross correlation.

- **Redshift and scale binning:** arbitrary bins of z and k can be chosen.



FARO features

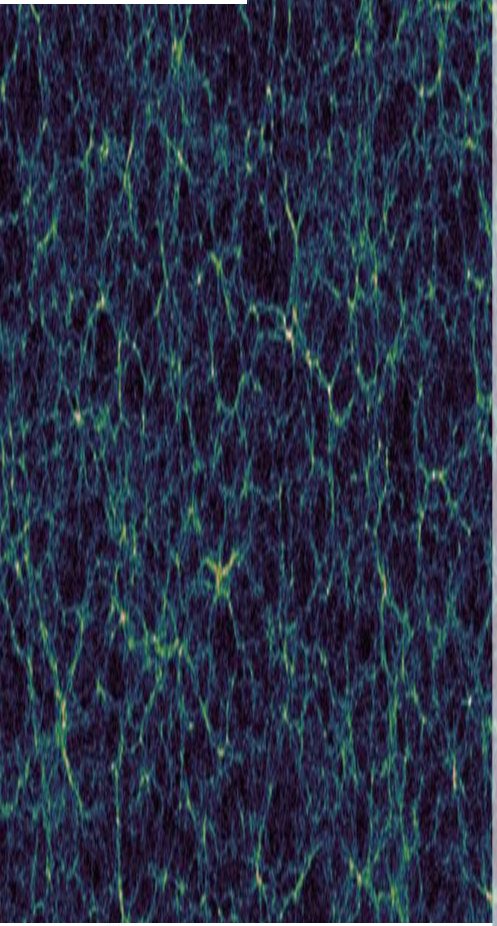
➢ The main features of FARO are:

- **Model independent:** a model independent set of parameters are considered, this allows to make all the derivatives analytic making the code faster.

- **Tomographic errors:** for each parameter in each z and k.

- **Flexible and user friendly:** the code is easy to use and to obtain the results. Also it is easy to be modified.

https://www.ucm.es/iparcos/faro



FARO features

- The main assumptions of FARO are:

- **Flat FRW background:** this approximation simplifies the code making it faster.

- **Scale-independent growth:** thanks to consider this, we can factorize the scale and redshift dependent parameters.

FARO features

- The parameters that FARO considers are:

$$A_a(z) = \sigma_8(z)\, b_a(z) \qquad L(z) = \Omega_m\, \sigma_8(z)\, \Sigma(z)$$

$$R(z) = \sigma_8(z)\, f(z) \qquad E(z) = \frac{H(z)}{H_0}$$

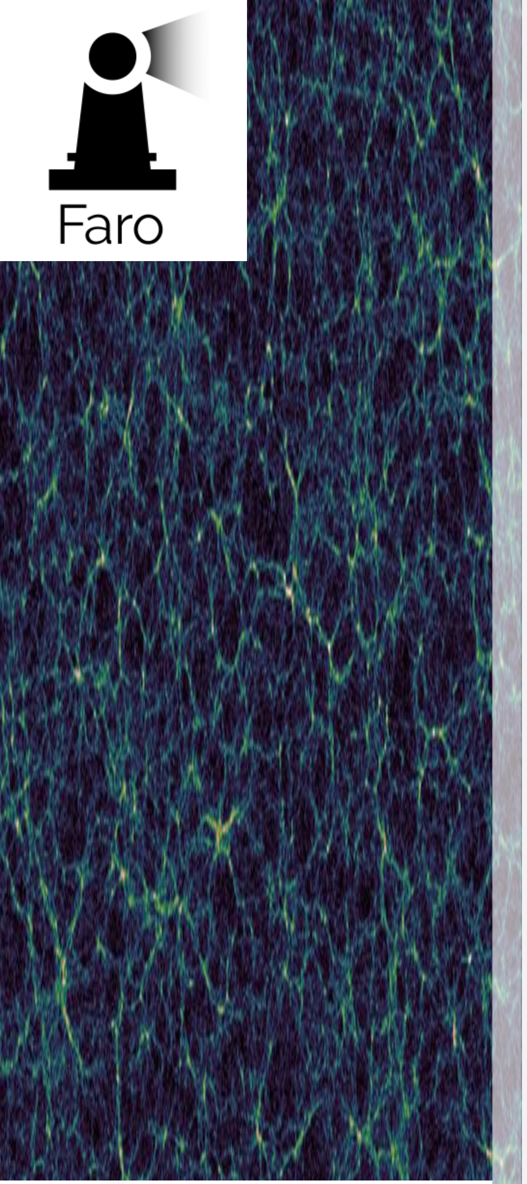
- We also consider as independent parameter in each scale bin:

$$\hat{P}(k) = \frac{P(k)}{{\sigma_8}^2}$$

FARO features

- We have no considered $D_A(z)$ as independent parameter because we asume a flat FRW background.

- We have no considered a non-Gaussian shot noise parameter $P_s(z)$ because we are not interested on constraint it, and it is not too much correlated with other parameters.



FARO features

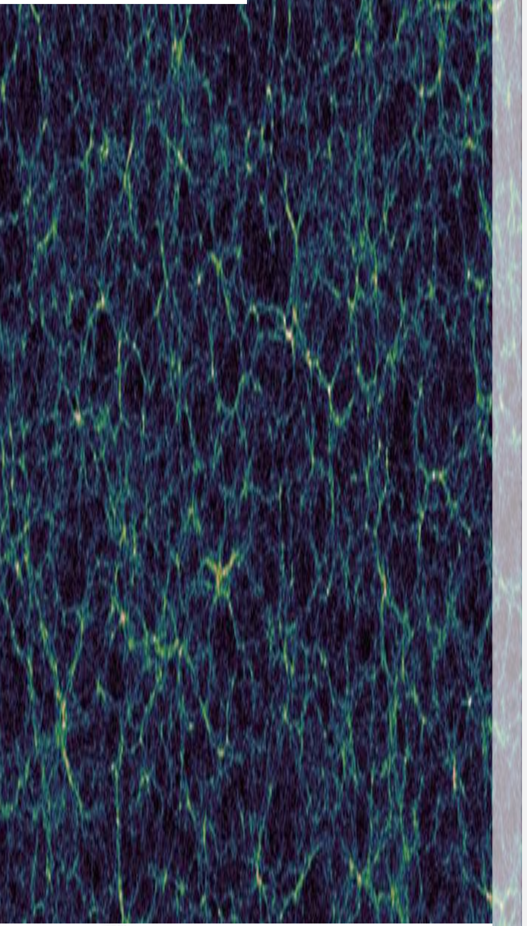
- The main differences of FARO respect to other codes are:

- Totally public, easy to use and install.

- Perform multitracer in a simple way for clustering and the cross correlation with lensing.

- The model independent approach allows a fully analytical compute that make it faster.

Main observables of FARO



- Multitracer galaxy power spectrum:

$$P_{ab}^{\delta\delta}(z,\hat{\mu}_r,k_r) = \frac{D_{A\,r}^2\,E}{D_A^2\,E_r}\,(A_a + R\,\hat{\mu}^2)\,(A_b + R\,\hat{\mu}^2)\,\hat{P}(k)\,e^{\frac{-k_r^2\,\hat{\mu}_r^2\,\sigma_a^2}{2}}\,e^{\frac{-k_r^2\,\hat{\mu}_r^2\,\sigma_b^2}{2}}$$

- Convergence power spectrum:

$$P_{ij}^{\kappa\kappa}(\ell) = \frac{9\,H_0^3}{4}\int_0^{\infty}\frac{(1+z)^2}{E(z)}\,g_i(z)\,g_j(z)\,L^2(z)\,\hat{P}\left(\frac{\ell}{\chi(z)}\right)dz$$

- Cross-correlation power spectrum:

$$P_{ij\;a}^{\kappa\delta_2}(\ell) = \frac{3\,H_0^2}{2}\,\frac{(1+z_j)}{\chi(z_j)}\,g_i(z_j)\,A_a(z_j)\,L(z_j)\,\hat{P}\left(\frac{\ell}{\chi(z_j)}\right)$$

Code structure

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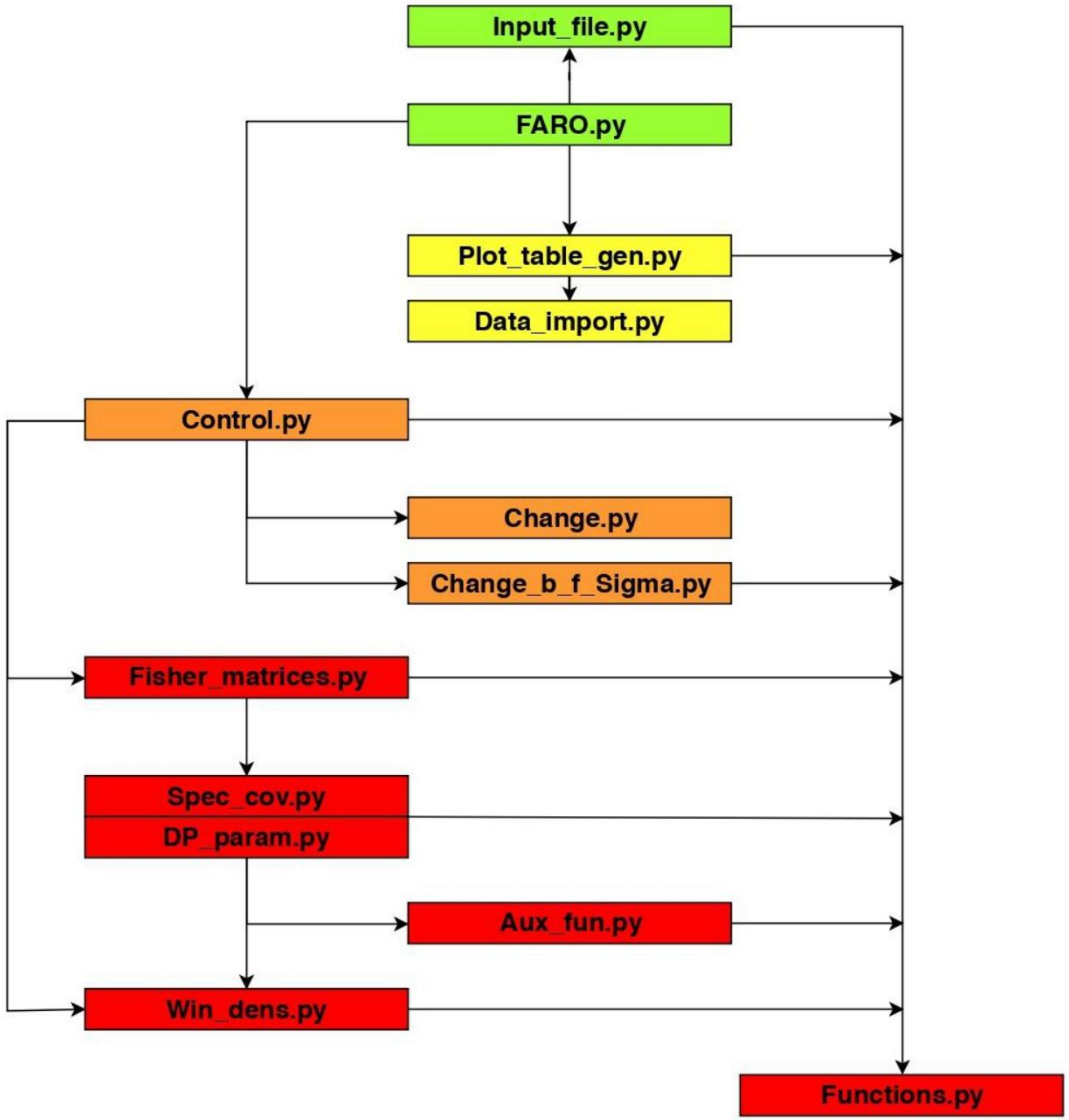
Easy use of FARO

Data management, plot and tables

Compute and combine Fisher matrices

Basic FARO modules



Code structure

- The basic approach of the code is to define each quantity as a multidimensional matrix and we operate them with the function np.einsum.

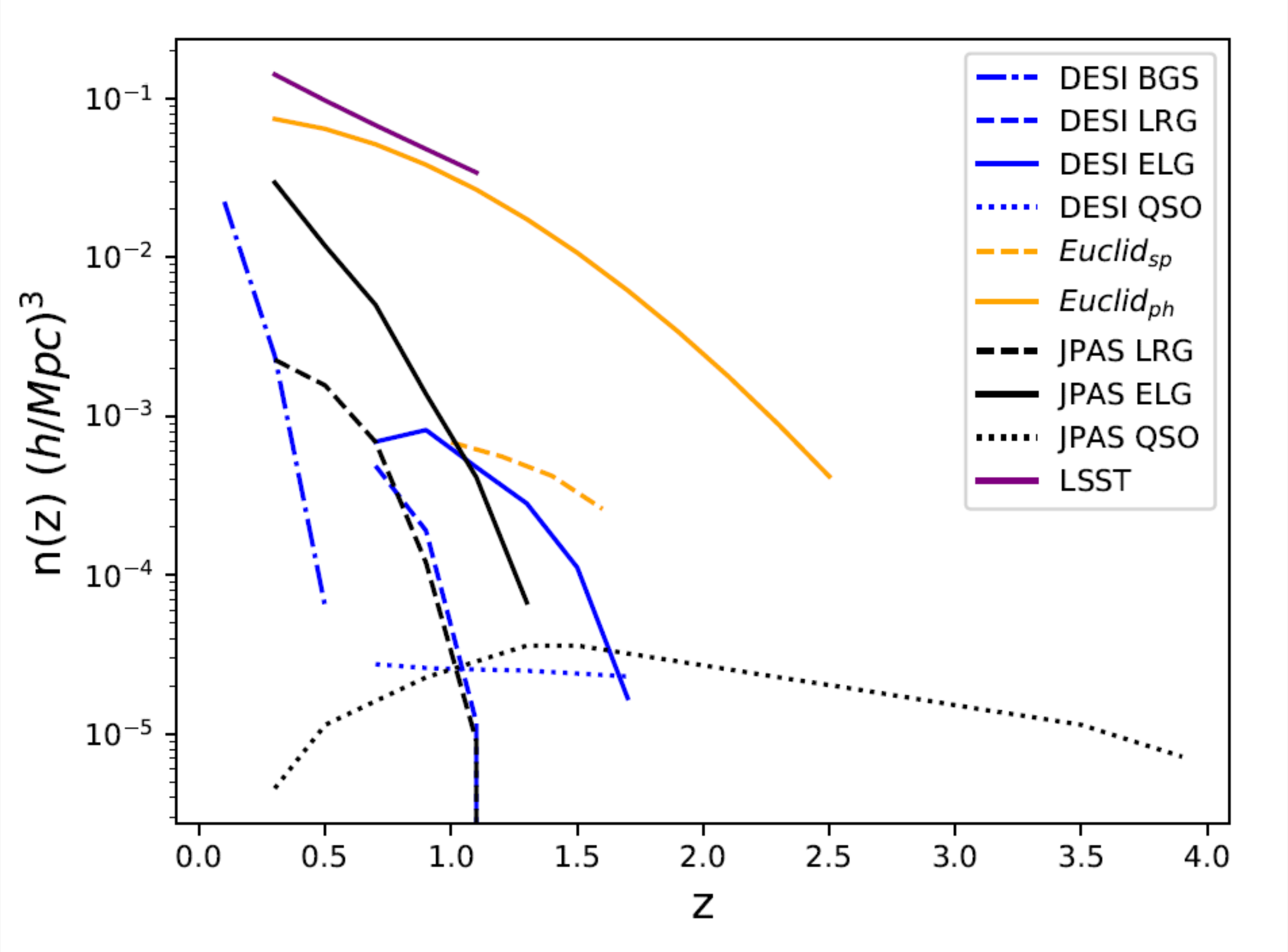
- Fisher matrices are then defined with finite sums and the observables are evaluated at discrete bins in $k, \hat{\mu}, \ell$ and z.

- Useful to modify a particular element without affect the rest of the code.

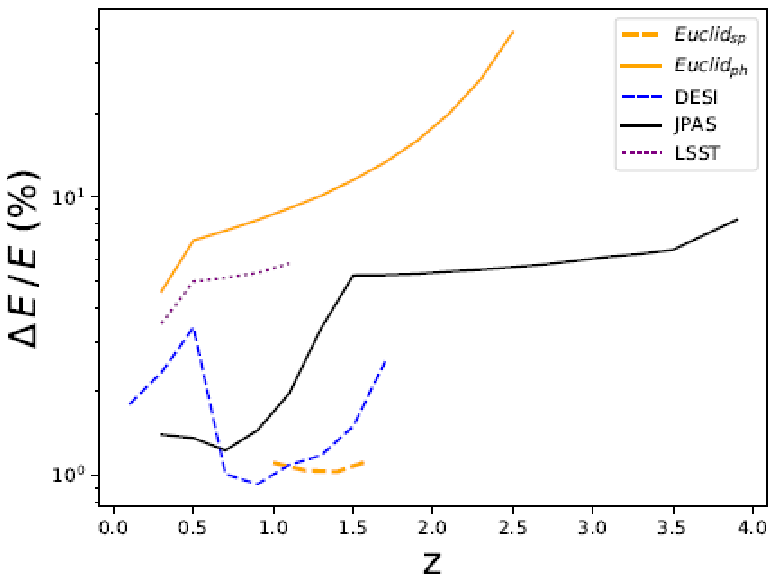
FARO results

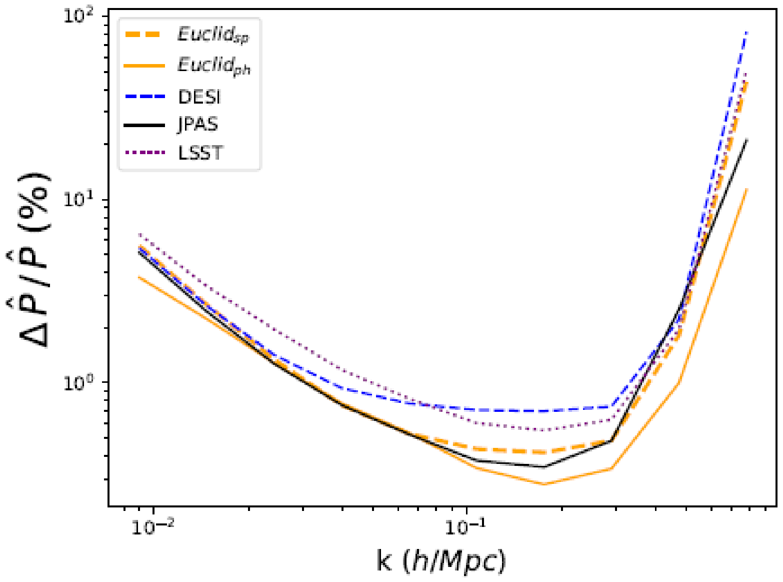
- Finally, we perform some results for the most important future surveys: spectroscopic Euclid, photometric Euclid, DESI, LSST and JPAS.

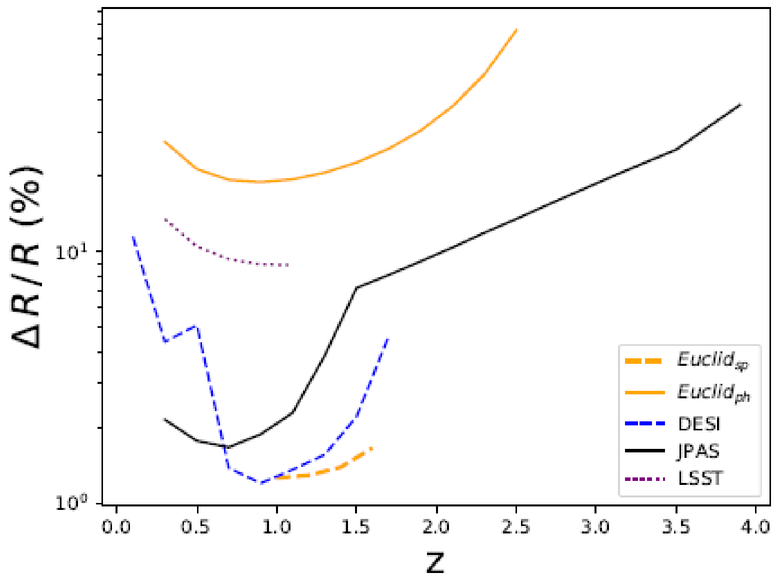
	sky area ($\deg^2$)	δz^C	δz^L	n_θ
J-PAS	8500	0.003	0.03	12
DESI	14000	0.0005	-	-
LSST	14300	0.03	0.05	27
$\mathrm{Euclid_{sp}}$	15000	0.001	-	-
$\mathrm{Euclid_{ph}}$	15000	0.05	0.05	30



A. CLUSTERING INFORMATION:

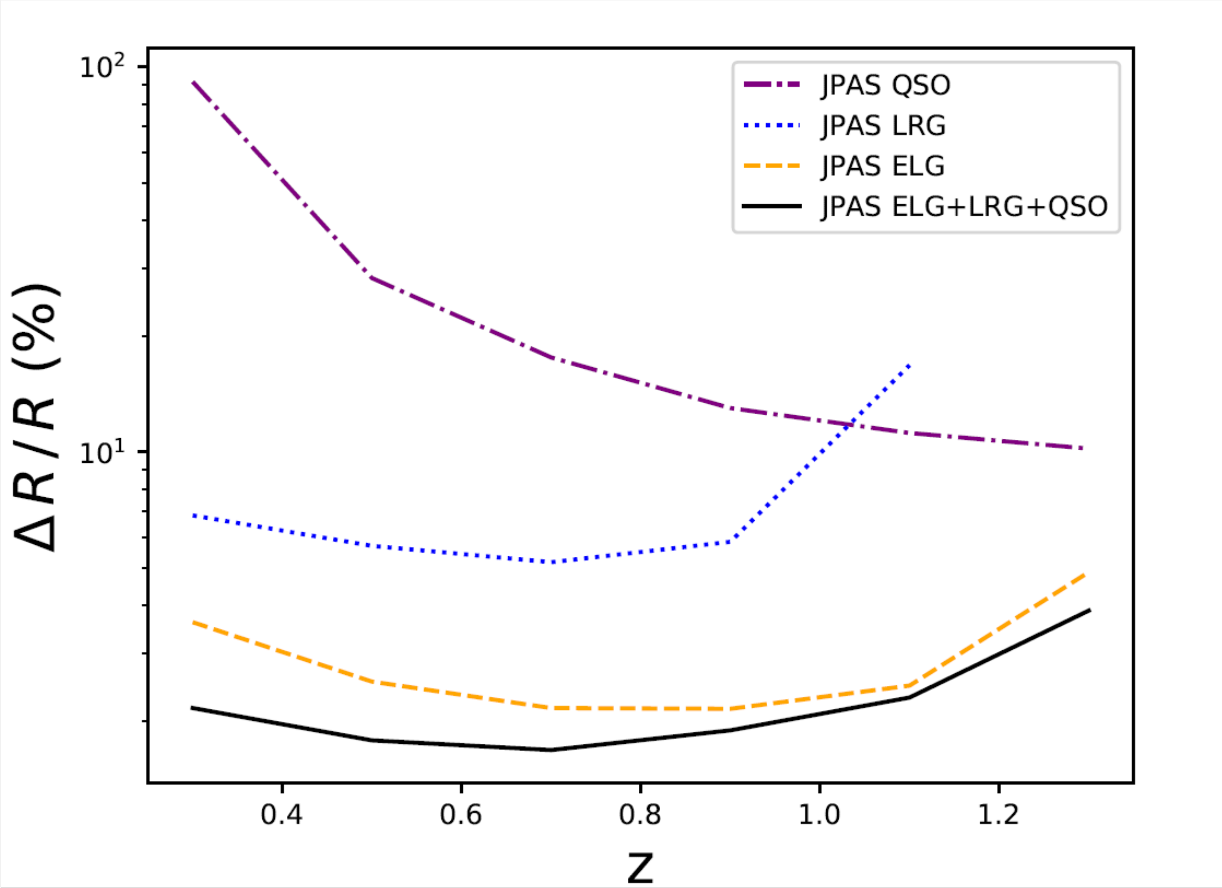




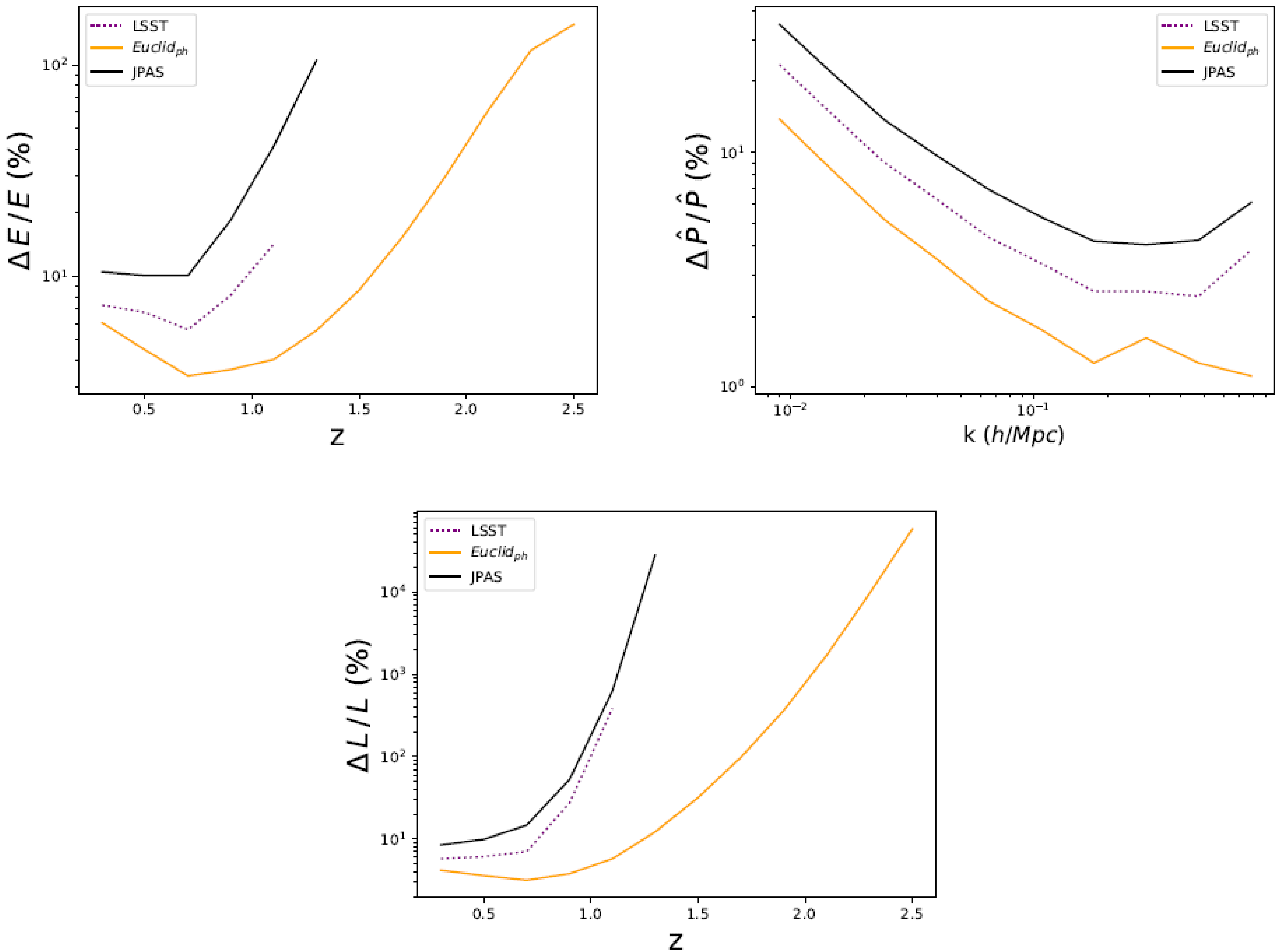


FARO results

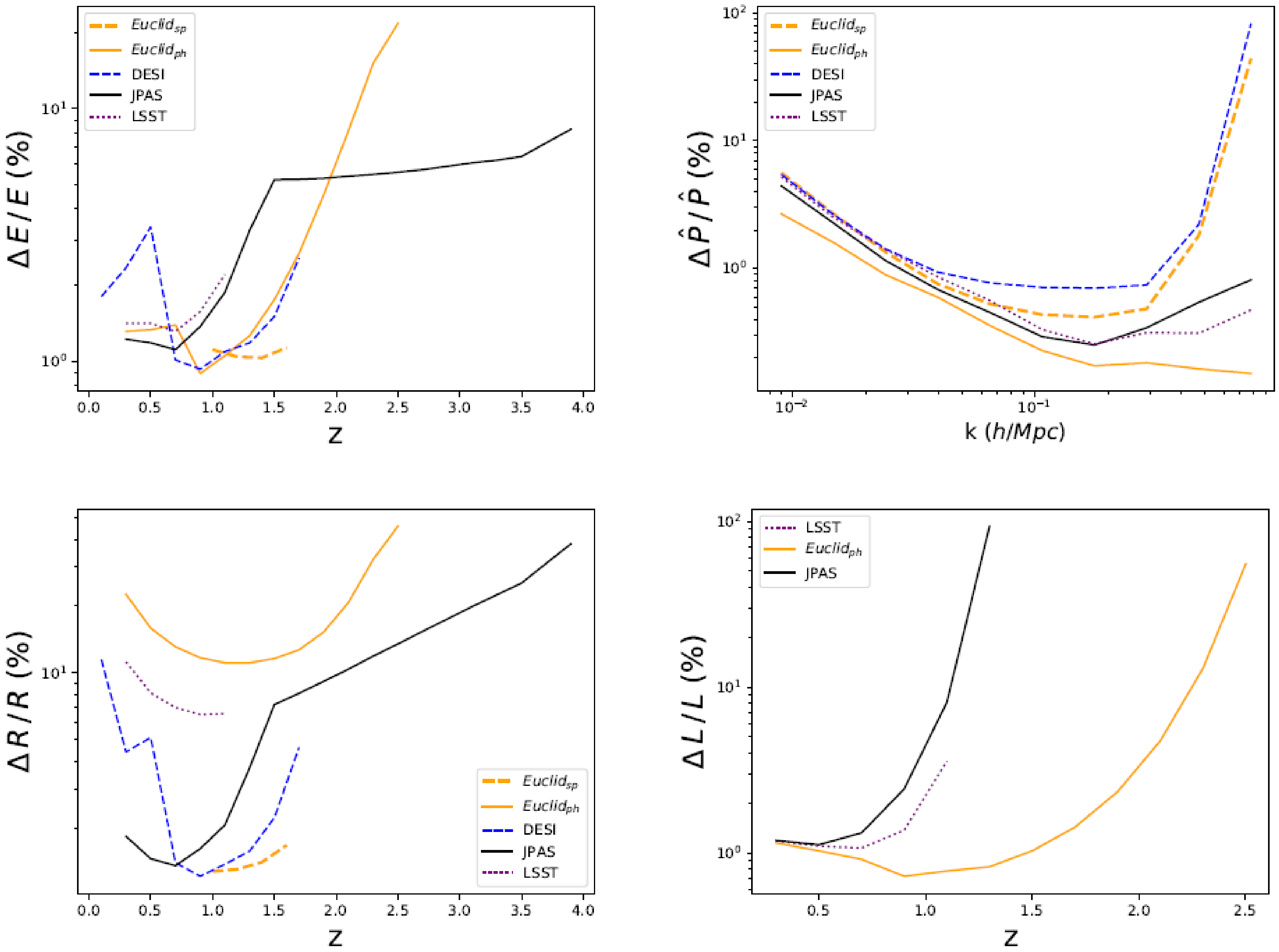
- The multitracer analysis improves the sensitivity obtained with the best tracer that, in this case, are the ELGs.



B. LENSING INFORMATION:

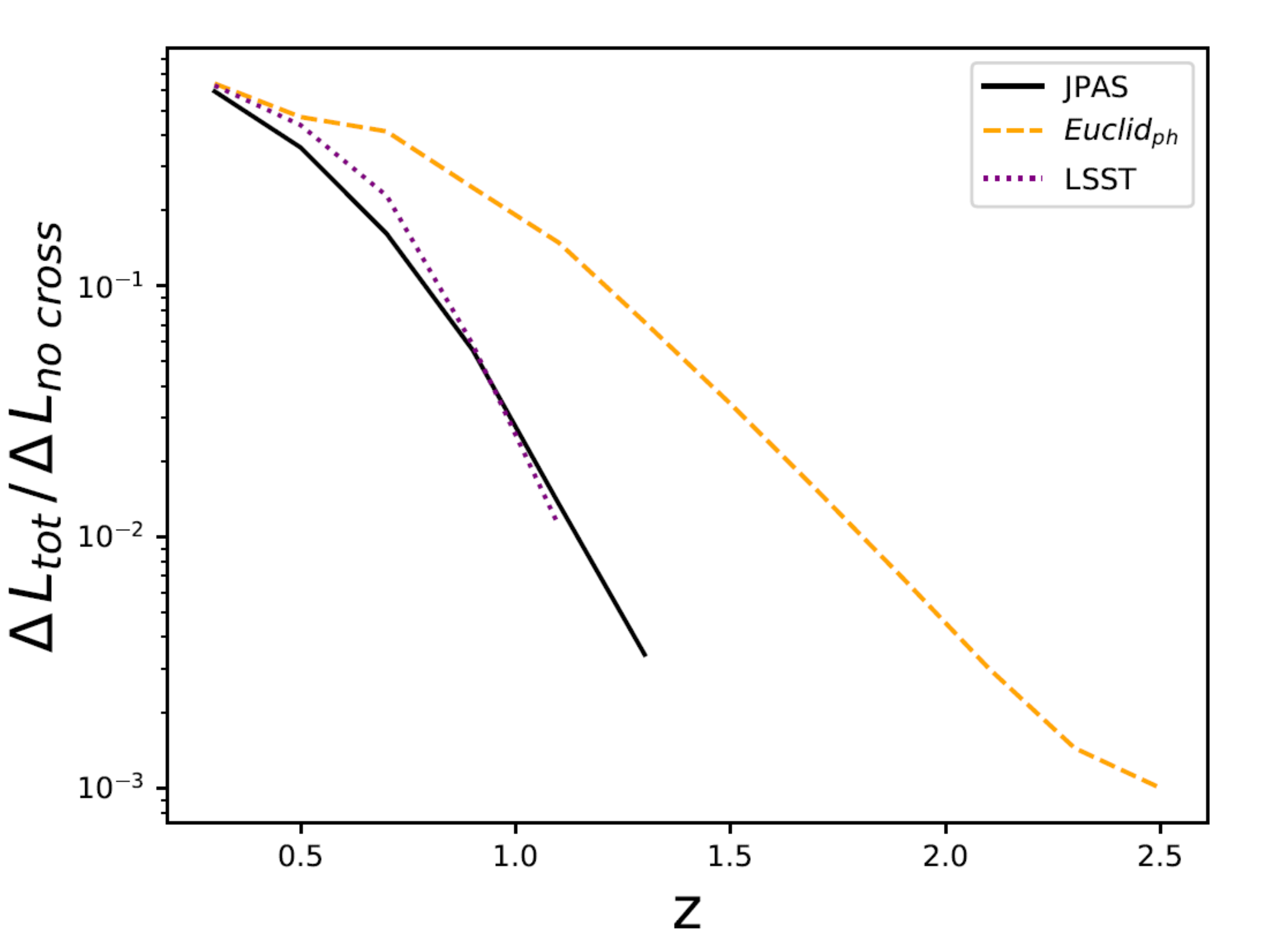


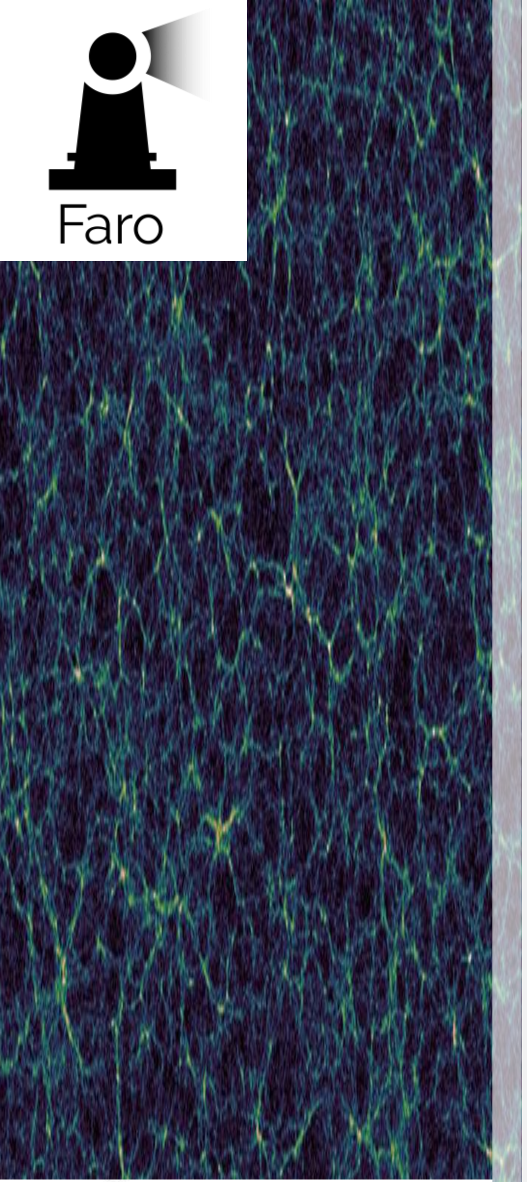
C. CLUSTERING + LENSING INFORMATION:



FARO results

- The cross-correlation information improves $L(z)$ constraints from one to three orders of magnitude.





Conclusions

- FARO is a new code for galaxy survey forecast that is totally public, model independent and easy to use.

- The code is made in Python and compute the multitracer power spectrum, convergence power spectrum and the cross correlation.

- The model independent set of parameters are: $\left[A_a(z), R(z), L(z), E(z), \hat{P}(k)\right]$

- The combination of clustering and lensing, with the cross correlation, improves significantly the constraints.