DES Year 3 cosmological constraints from galaxy clustering and galaxy-galaxy lensing using an optimized lens sample

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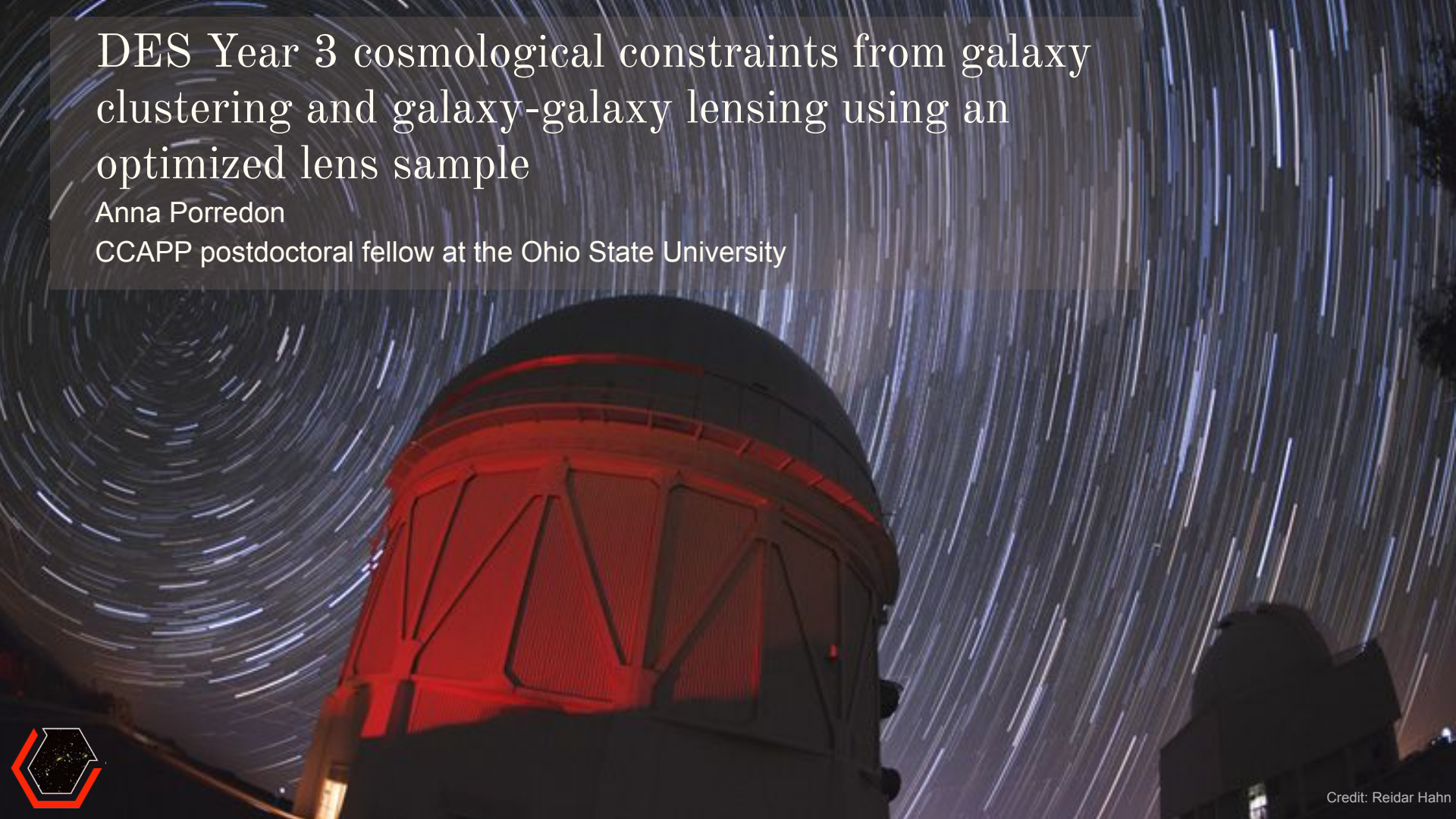
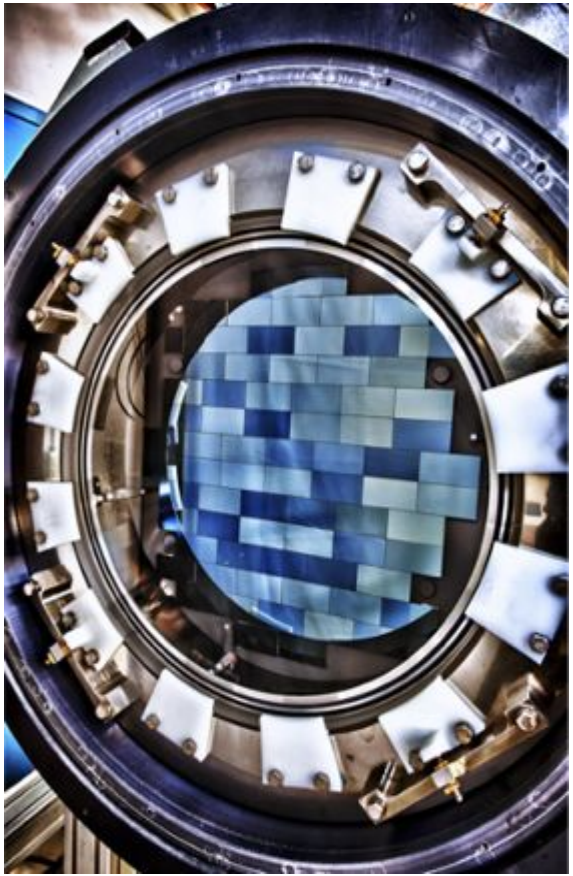
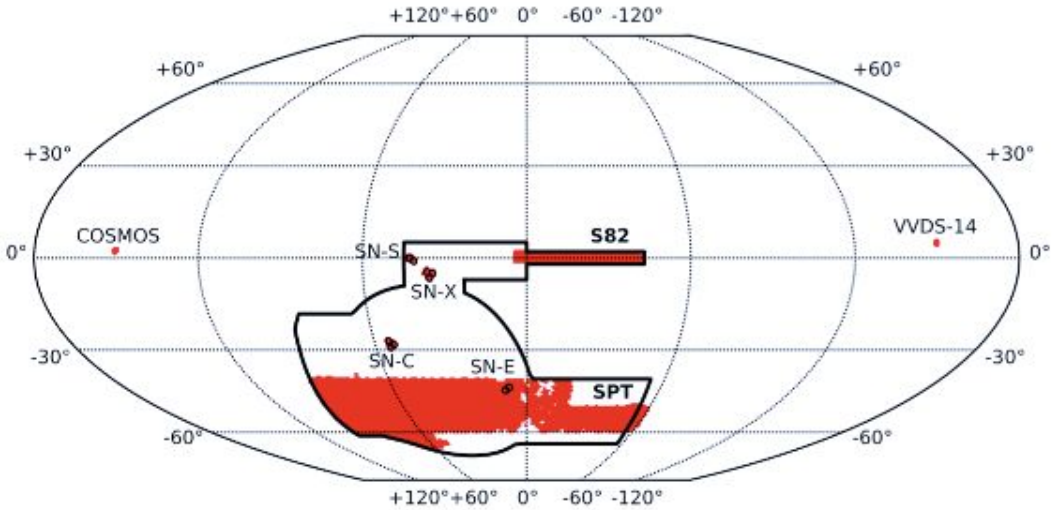


Credit: Reidar Hahn

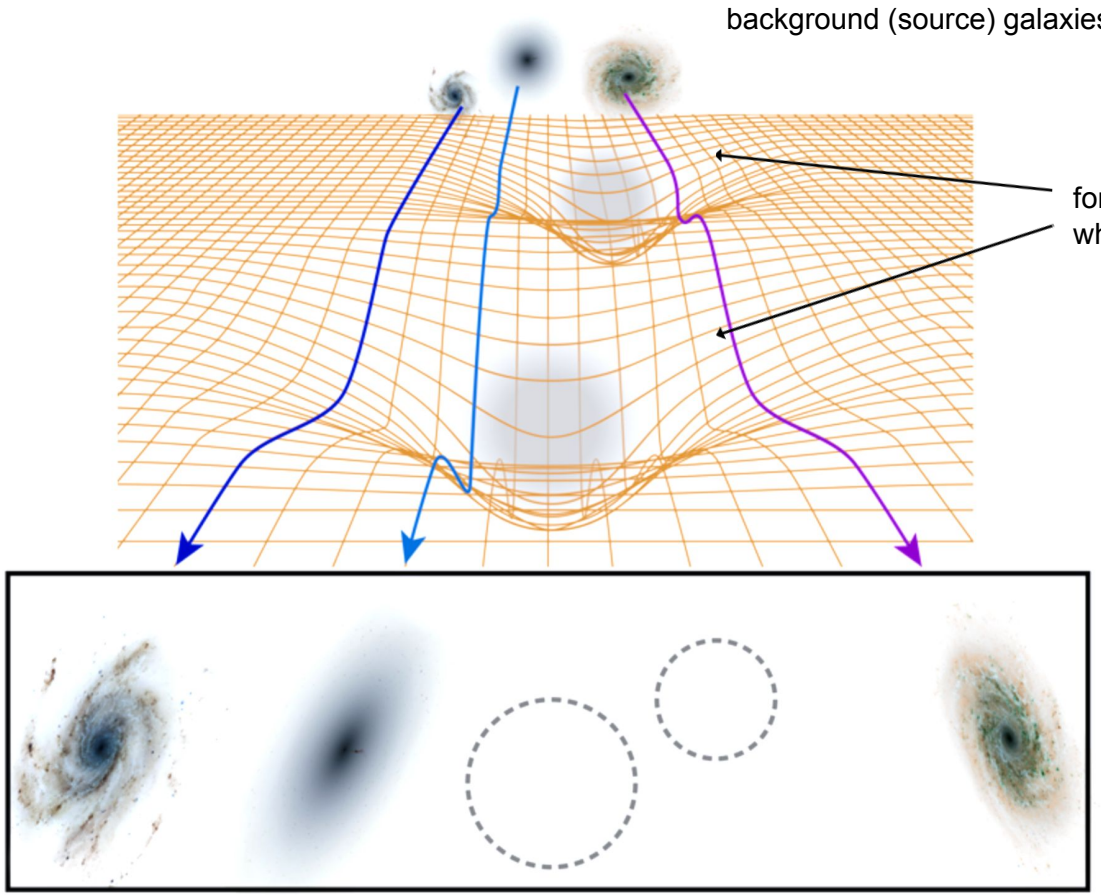
The Dark Energy Survey

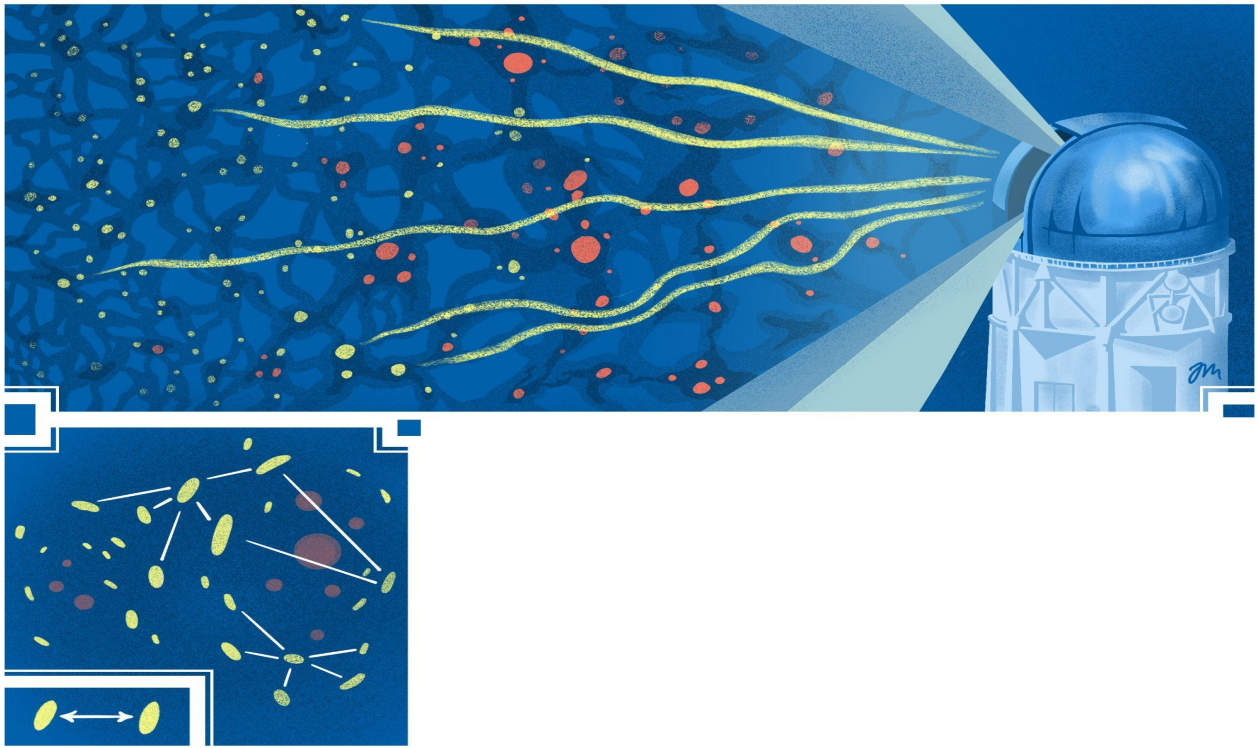


- 570 Megapixel camera for the Blanco 4m telescope in Chile.
- Full survey 2013-2019 (Y3 2013-16).
- **Wide field:** 5000 sq. deg. in 5 bands. ~23 magnitude.
- DES Y3: Positions and shapes of > 100M galaxies.



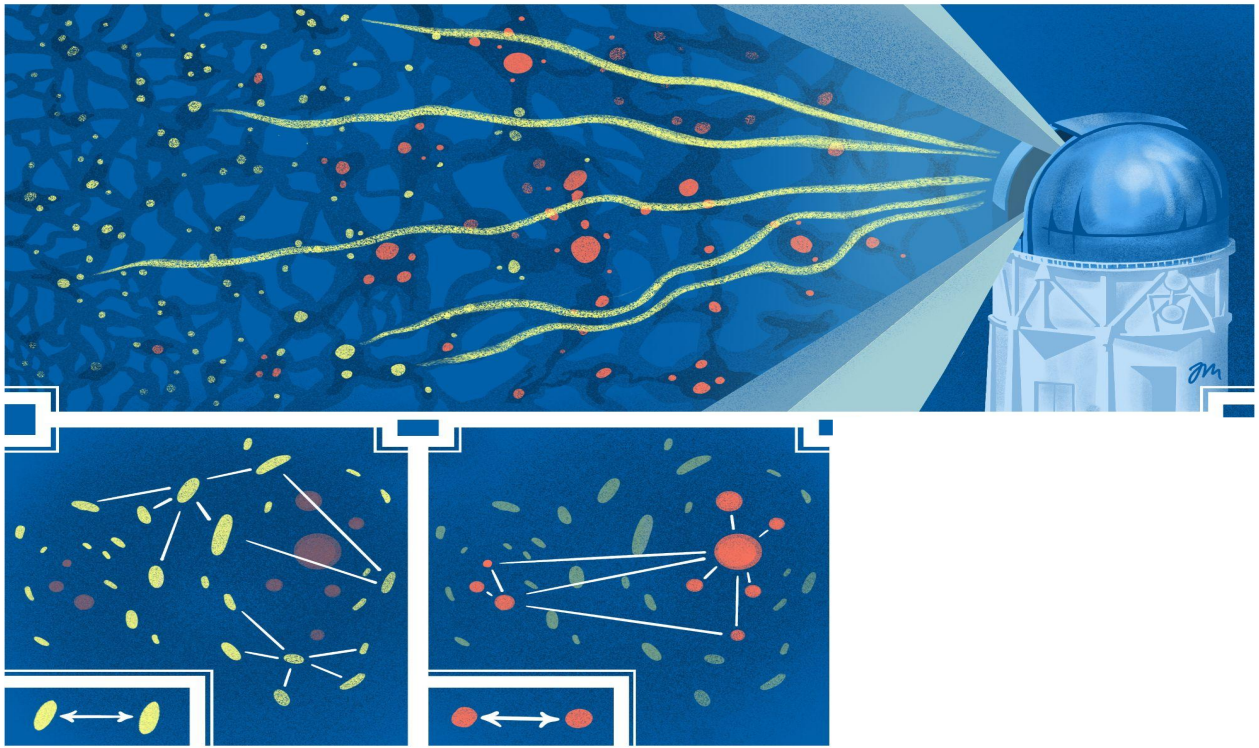
Weak gravitational lensing





cosmic shear

correlation in the shapes of (source) galaxies

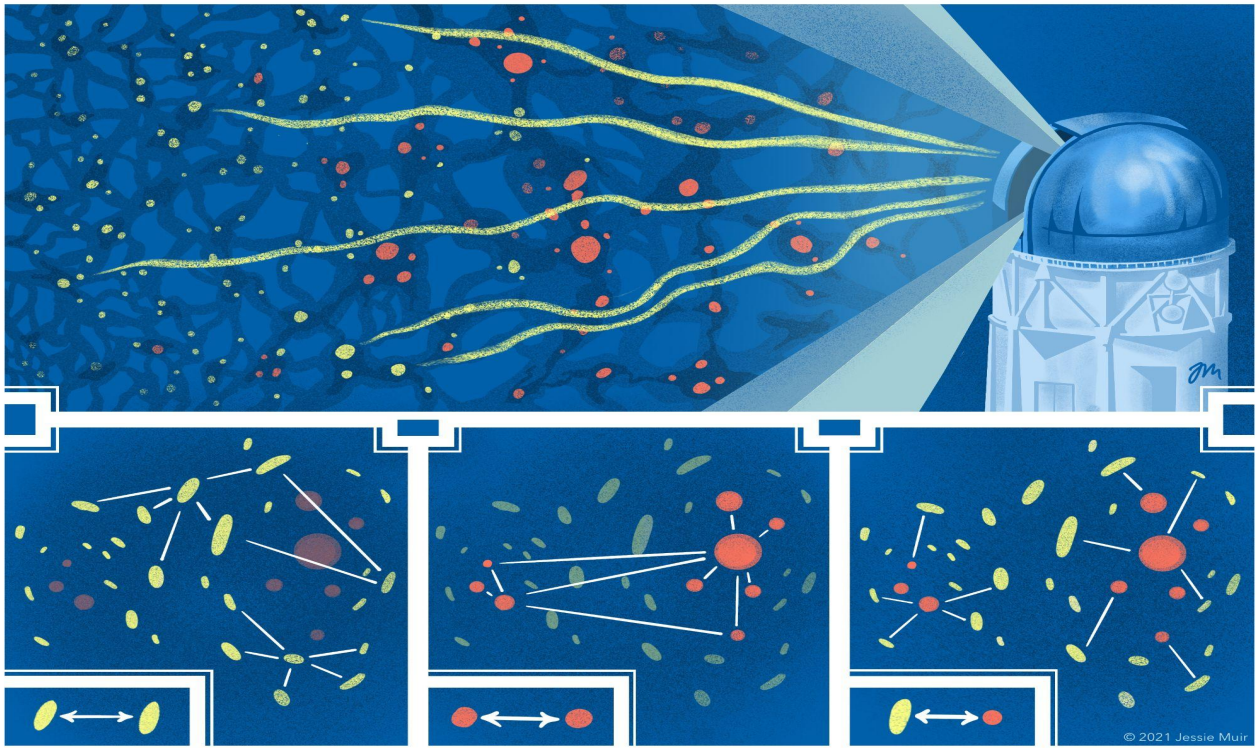


cosmic shear

correlation in the shapes of (source) galaxies

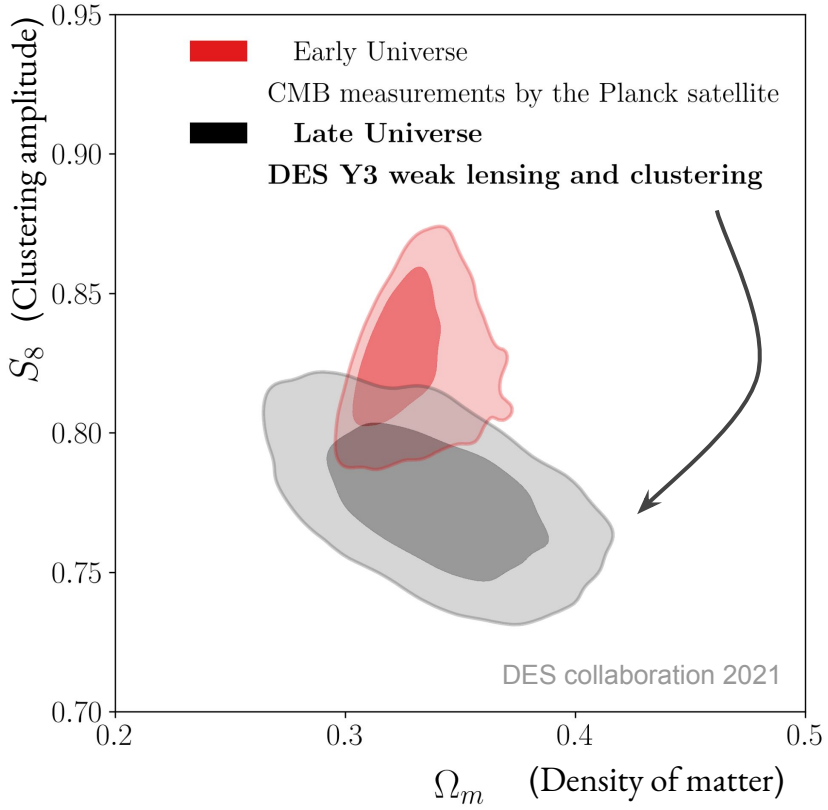
galaxy clustering

correlation in the positions of (lens) galaxies

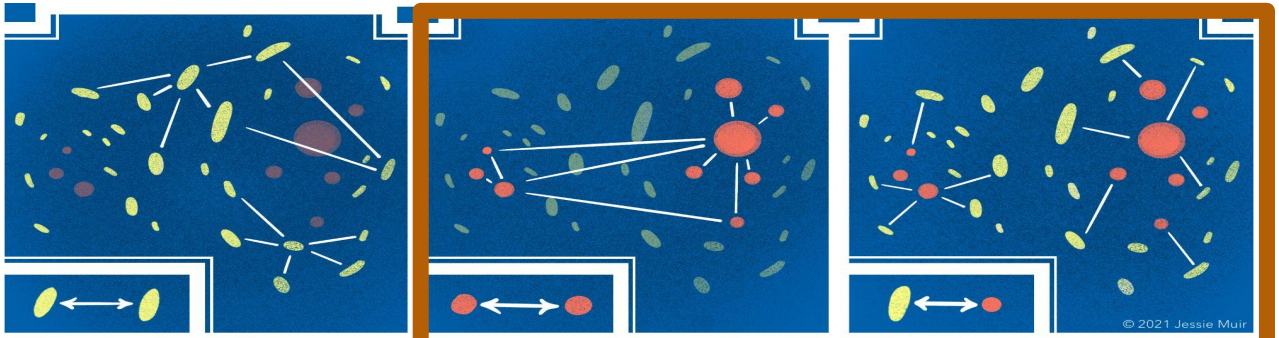


cosmic shear	galaxy clustering	galaxy-galaxy lensing
correlation in the shapes of (source) galaxies	correlation in the positions of (lens) galaxies	correlation between positions of the lenses and shapes of the sources

$$S_8 \equiv \sigma_8 \left(\frac{\Omega_m}{0.3} \right)^{0.5}$$



2x2pt

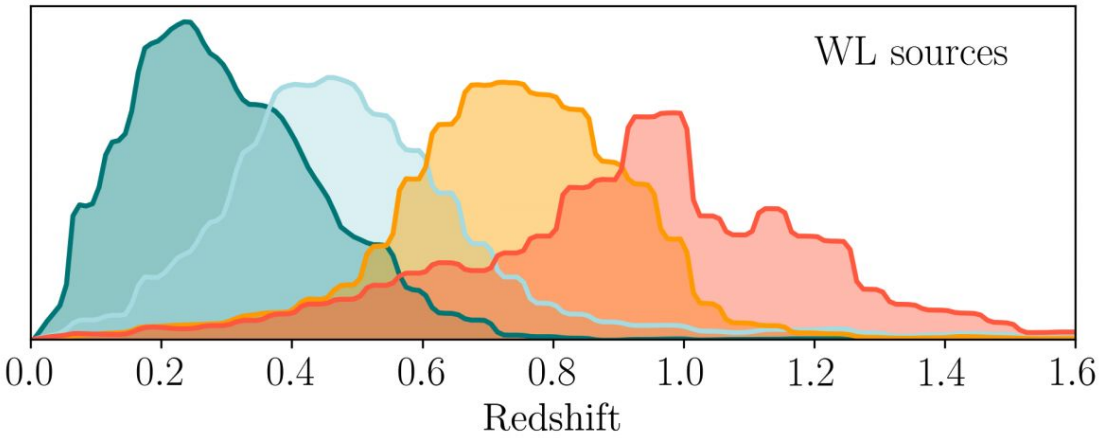


cosmic shear | galaxy clustering | galaxy-galaxy lensing

Source sample

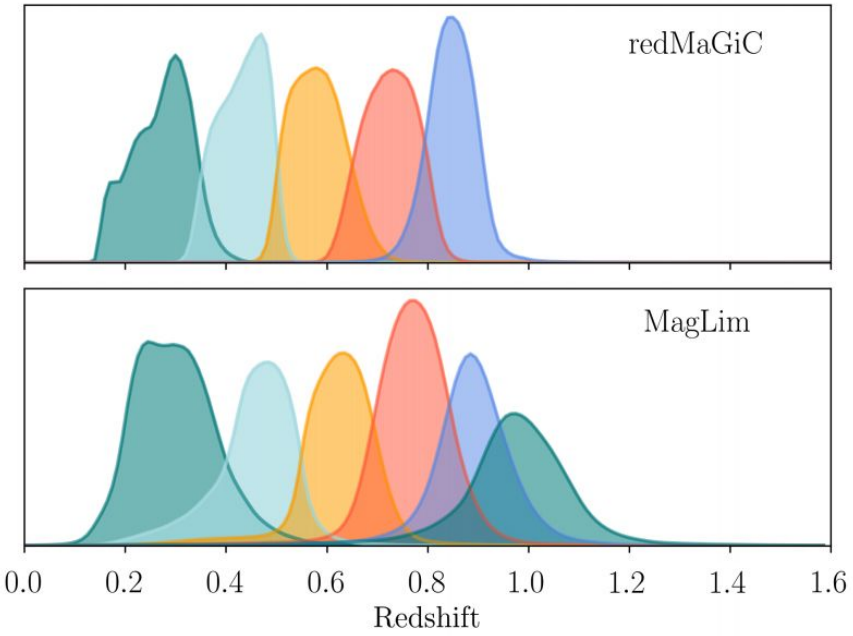
Gatti, Sheldon+ 2021

100 million galaxy shapes!



Myles, Alarcon+ (2021)
Gatti, Giannini+ (2021)

Lens samples



~ 3 million galaxies

Luminous red galaxies with high quality photometric redshift estimates

~ 11 million galaxies

Magnitude-limited sample with selection optimized in terms of its 2x2pt cosmological constraints

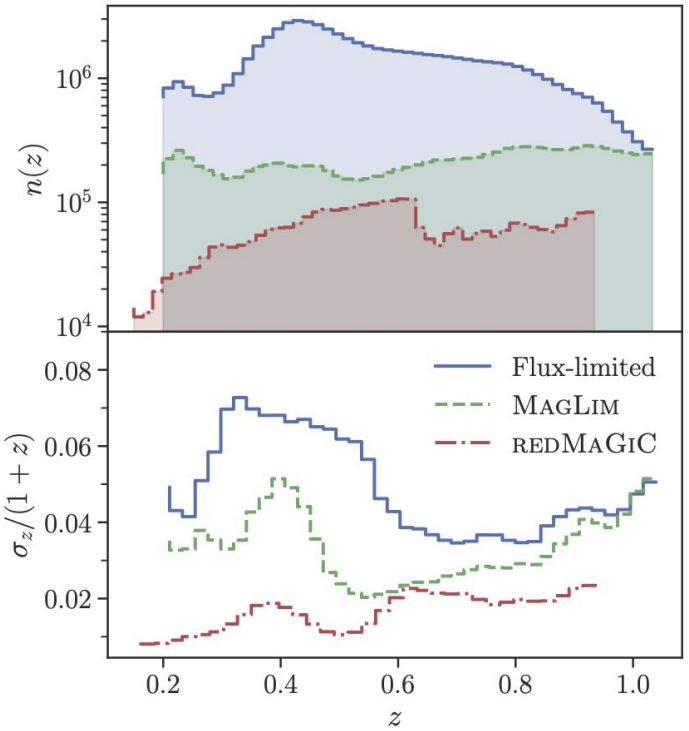
$$i < 4\, z_{phot} + 18$$

Lens sample optimization

A. Porredon et al. 2020 (arXiv:2011.03411)

Motivation

Explore the trade-off between number density and photo-z accuracy to define a lens sample that is optimal in terms of its 2x2pt cosmological constraints



Flux-limited `mag_i < a`

MagLim `mag_i < a* z_phot + b`

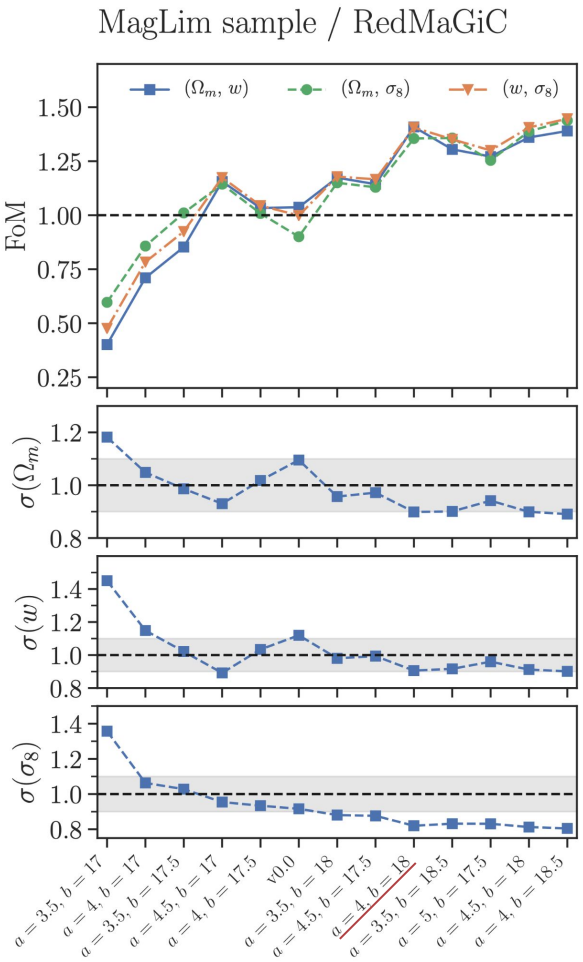
RedMaGiC

Lenses

Y3

Sample optimization

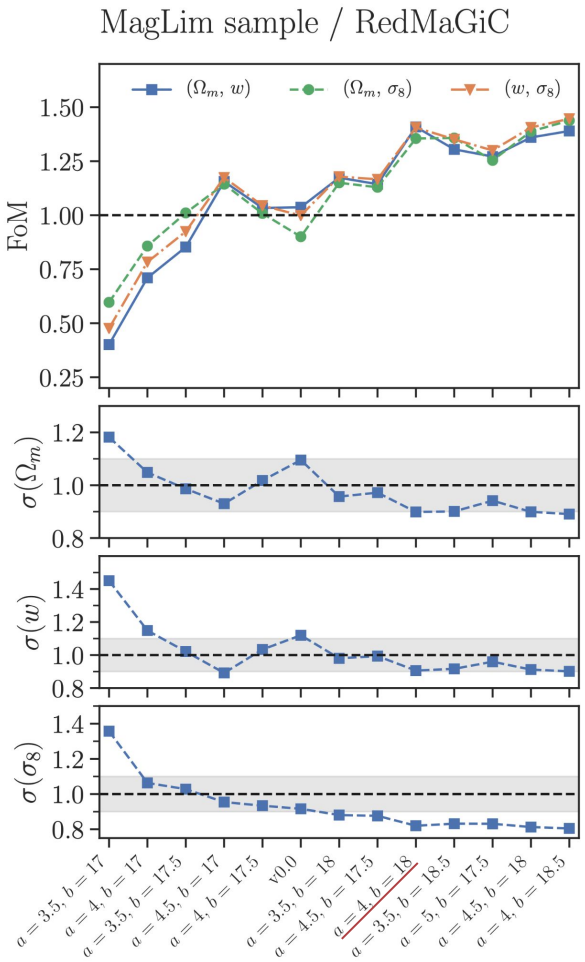
1. Consider a given value for *a* = [3.5, 4, 4.5, 5] and *b* = [17, 17.5, 18, 18.5]
2. Apply the selection to the DES Y3 data catalog
3. Extract the *n(z)* and number densities
4. Generate a covariance and a theory data vector
5. Run a 2x2pt Fisher forecast on wCDM marginalizing over a realistic list of systematics, including photo-z



Sample optimization

The optimal sample yields improvements of 10-15% in *w*CDM compared to redMaGiC

A flat flux limited sample (`mag_i < 22`) with about 70 million galaxies also improves upon redMaGiC but the photometric uncertainties degrade further



2x2pt cosmological constraints using the MagLim lens sample

A. Porredon et al. 2021 (arXiv:2105.13546)

Outline

- Photometric redshift calibration
- Model validation
- Measurements
- Cosmological constraints

MagLim photometric redshift calibration

DNF
neighborhood fitting using a reference sample
(De Vicente+ 2016)

Clustering Redshifts
cross-correlation with BOSS and eBOSS
(Cawthon+ 2020)

SOMPZ
classification of galaxies by photometric phenotypes
(Giannini+ in prep.)

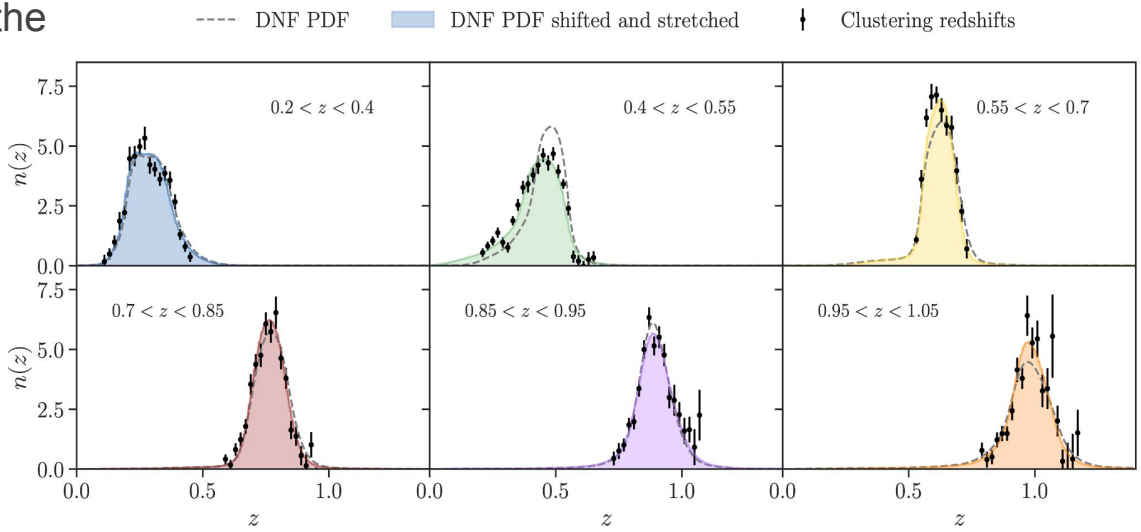
See Giulia Giannini's talk!

Maglim photometric redshift parameterization

In order to avoid biases in the cosmological constraints, we apply to the DNF n(z) either

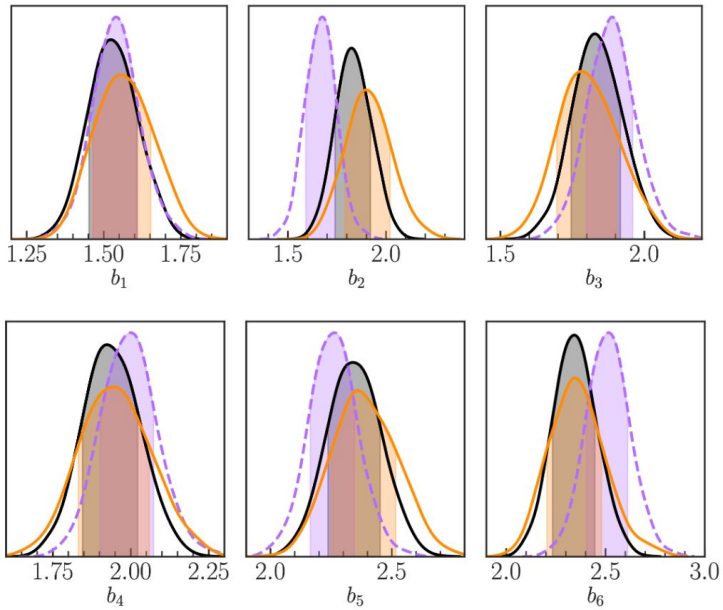
1. shifts: to match the **mean** of clustering-z estimates

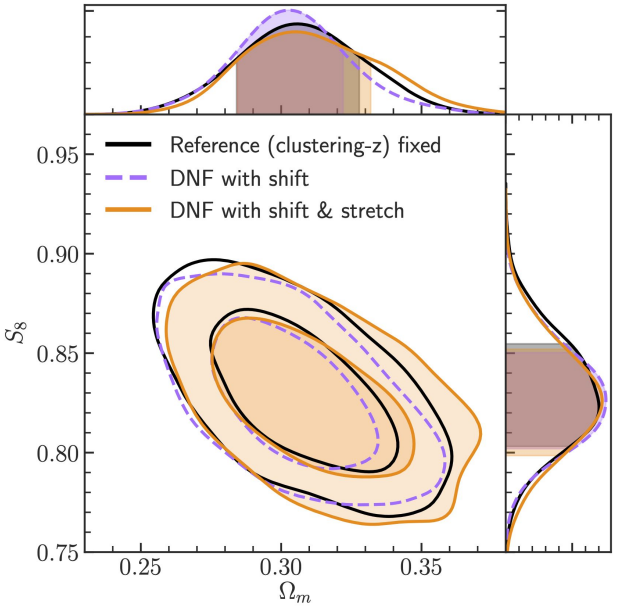
2. shifts & stretches: to match the **mean** and **width** of clustering-z estimates



Maglim photometric redshift parameterization

Applying both shift and stretch parameters allows to recover the cosmology and galaxy bias values





Porredon+ 2021

Model validation on simulations

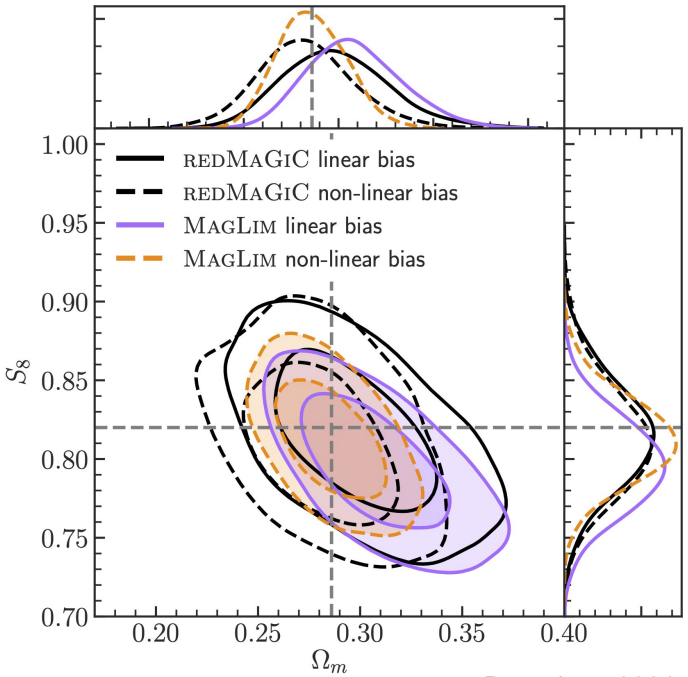
DeRose+ 2021

Validation of the analysis pipeline with the Buzzard suite of N-body simulations

1. Linear galaxy bias model
2. Non-linear galaxy bias model

Pandey+ 2020, Pandey+ 2021

This allows us to include smaller angular scales without biasing our cosmology



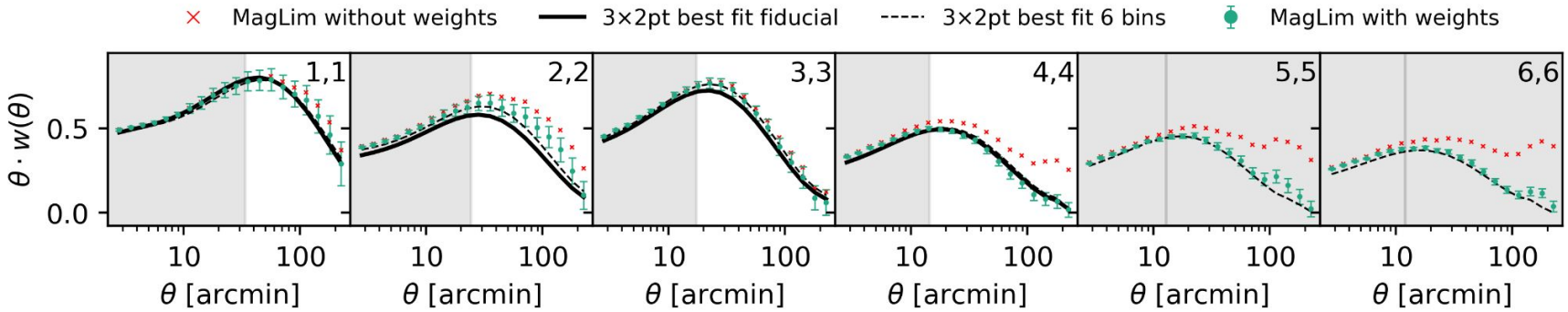
Porredon+ 2021

Galaxy clustering

position-position

Rodriguez-Monroy+ 2021

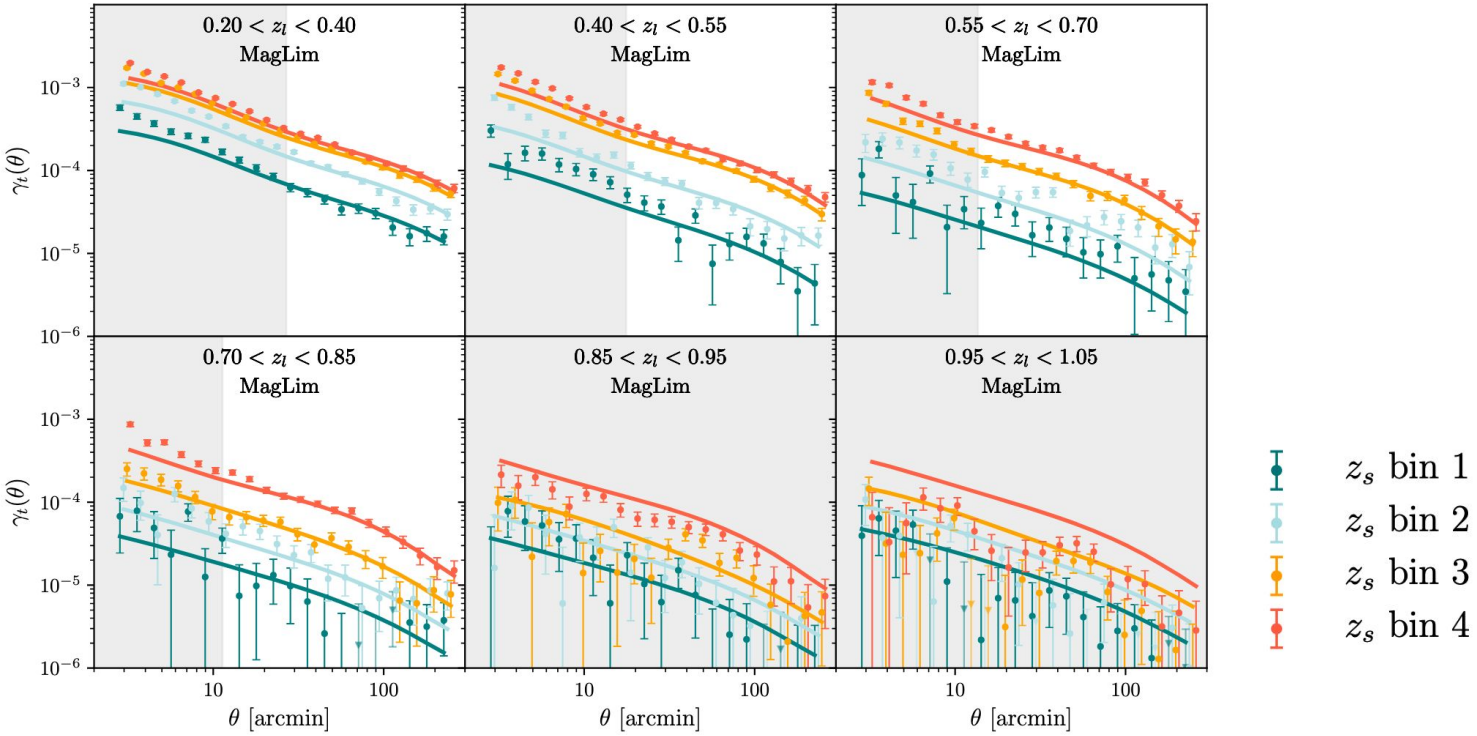
See Martin Rodriguez Monroy's talk!



Galaxy-galaxy lensing

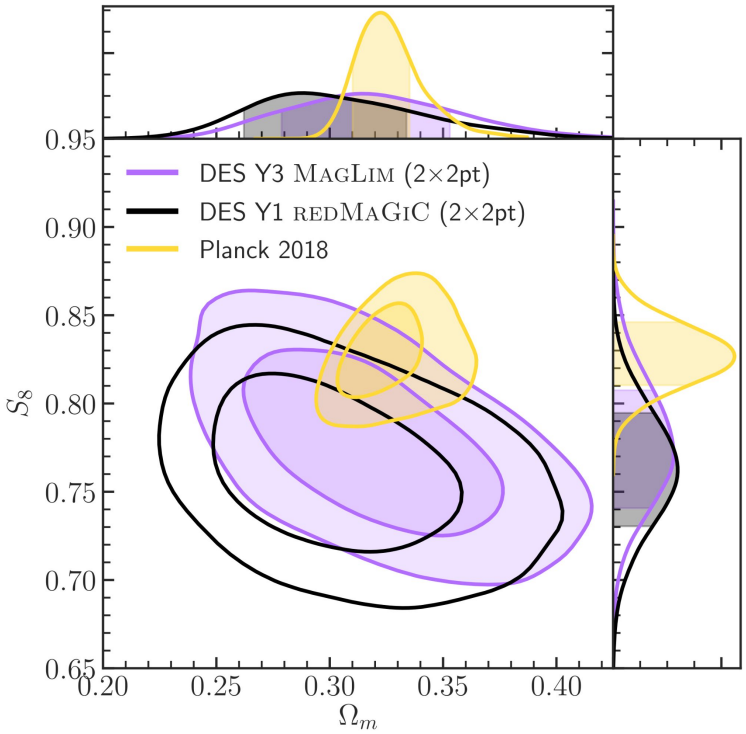
Prat+ 2021

position-shape



MagLim: cosmology from 2x2pt

Porredon+ 2021



1σ lower than *Planck* (TT+EE+TE) in the $S_8 - \Omega_m$ plane

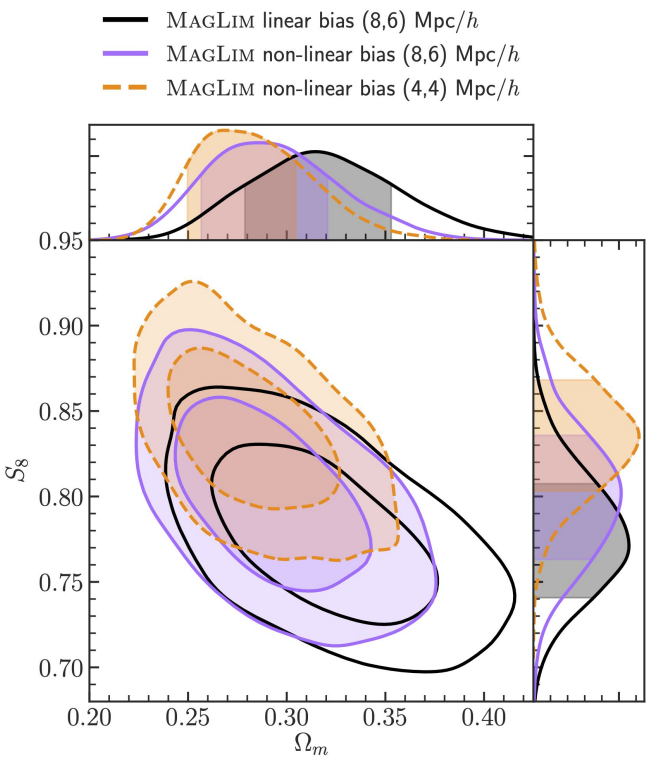
15% improvement when including galaxy clustering cross-correlations between bins

MagLim: cosmology from 2x2pt

Porredon+ 2021

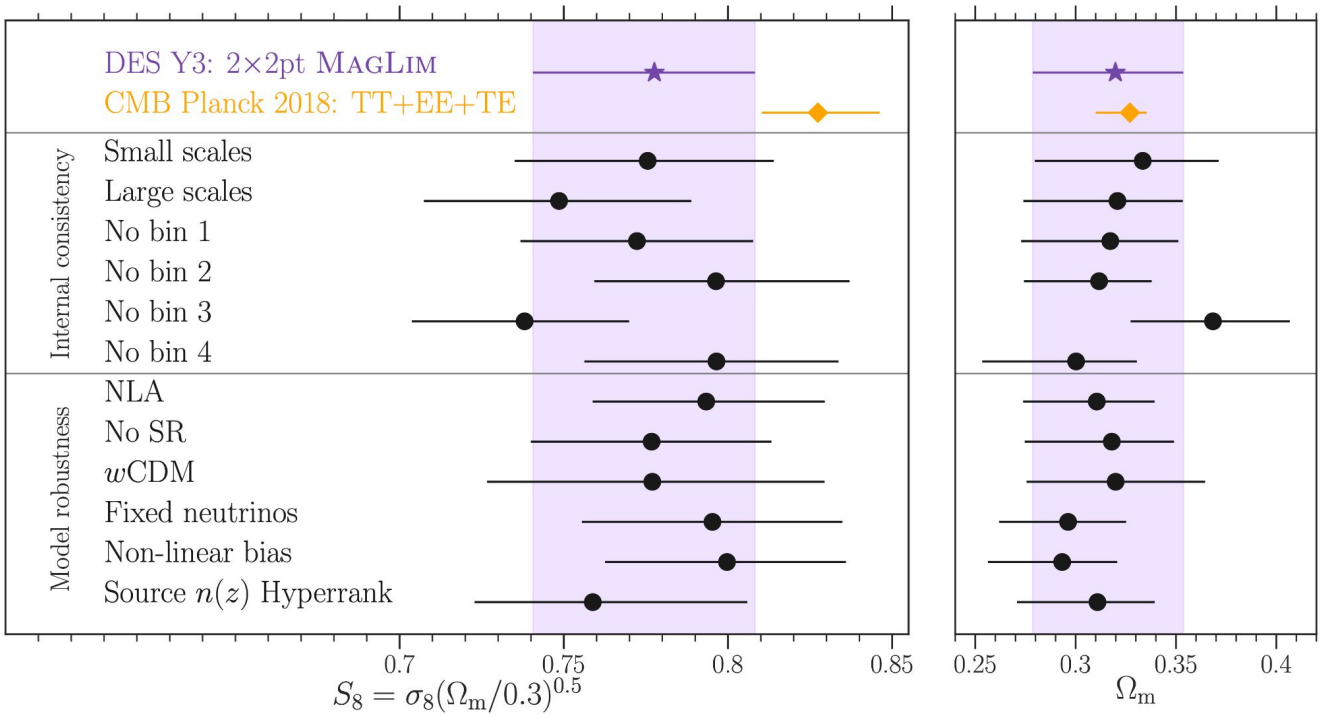
~30% improvement when including smaller angular scales with non-linear galaxy bias modeling

~40% improvement in wCDM ($w - \Omega_m$ plane)



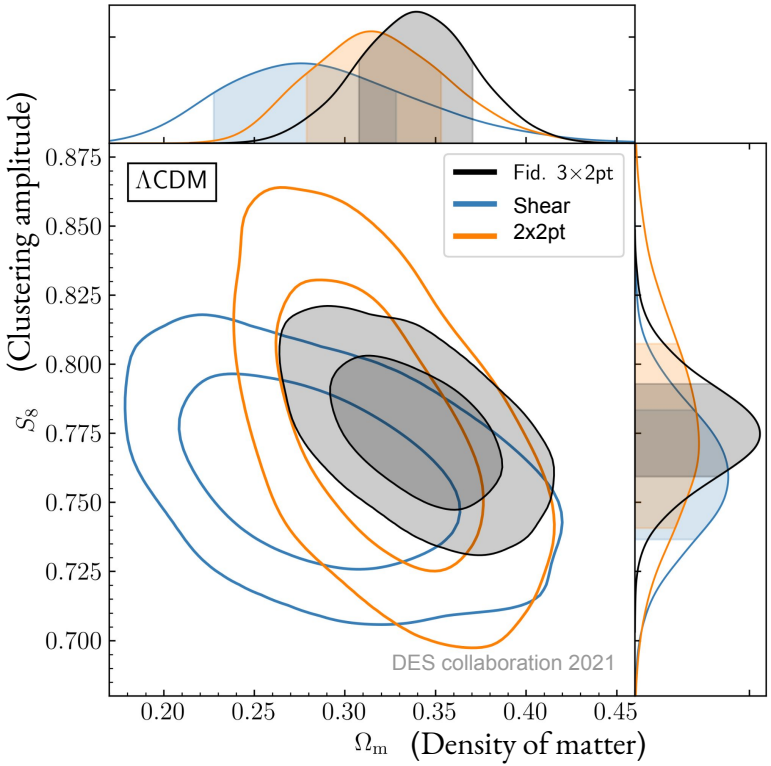
MagLim: 2x2pt robustness

Porredon+ 2021



MagLim 2x2pt + Cosmic Shear

Shear results in: Amon+ 2021, Secco, Samuroff+ 2021



The 2x2pt results are complementary to cosmic shear and, when combined, provide much tighter cosmological constraints

The results are consistent with the standard ΛCDM model

Conclusions

- We **optimize lens samples** in terms of their cosmological constraints. This has a lot of potential for future analyses.

- Several methods for **photo-z calibration** are being used for DES Y3. It's important to characterize the full shape of the redshift distribution to avoid biased cosmological results.

- **Including smaller scales** greatly improves the cosmological constraints. Non-linear modeling will be critical for future analyses, such as Euclid and LSST.