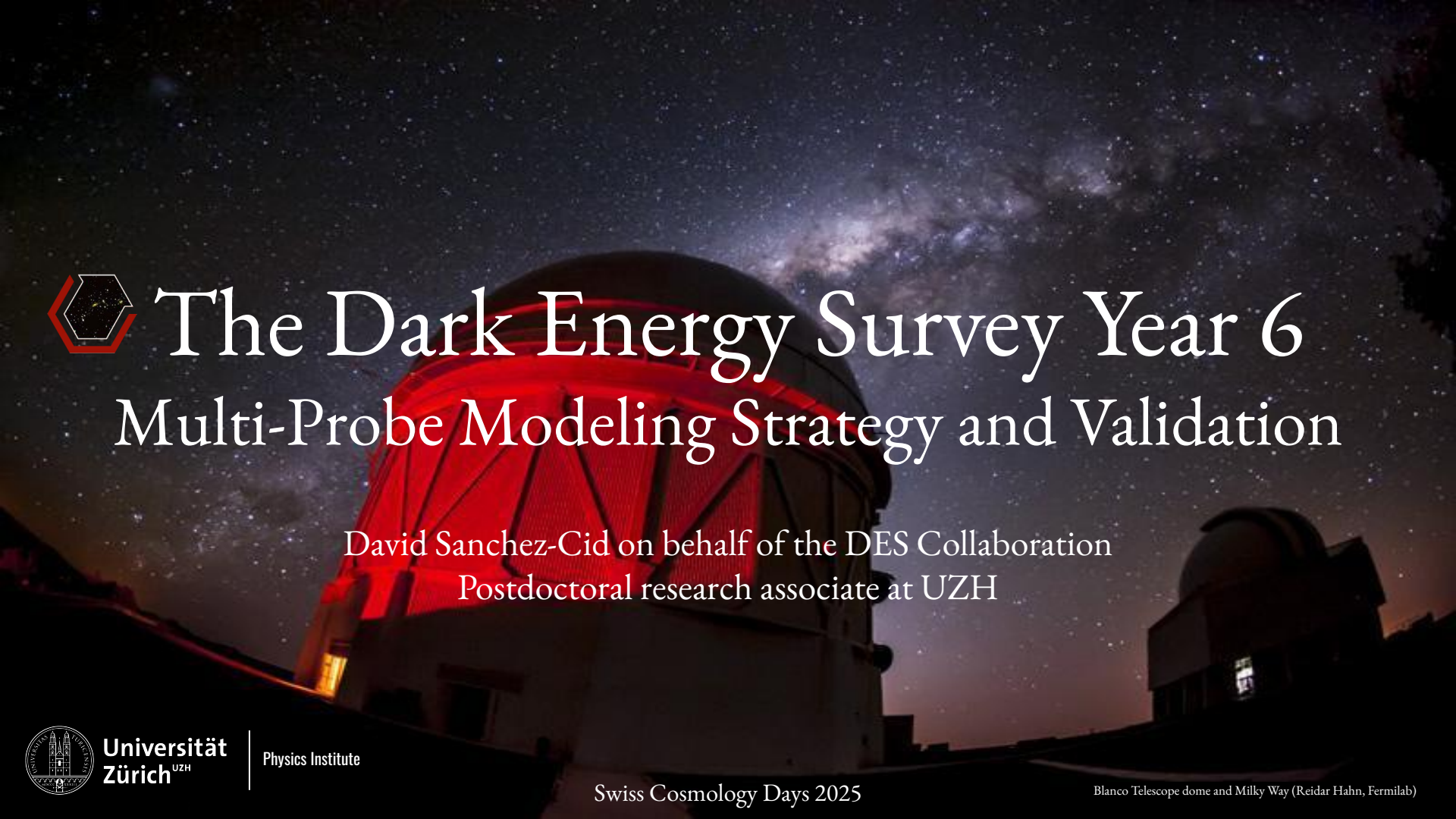


The Dark Energy Survey Year 6

Multi-Probe Modeling Strategy and Validation

David Sanchez-Cid on behalf of the DES Collaboration
Postdoctoral research associate at UZH

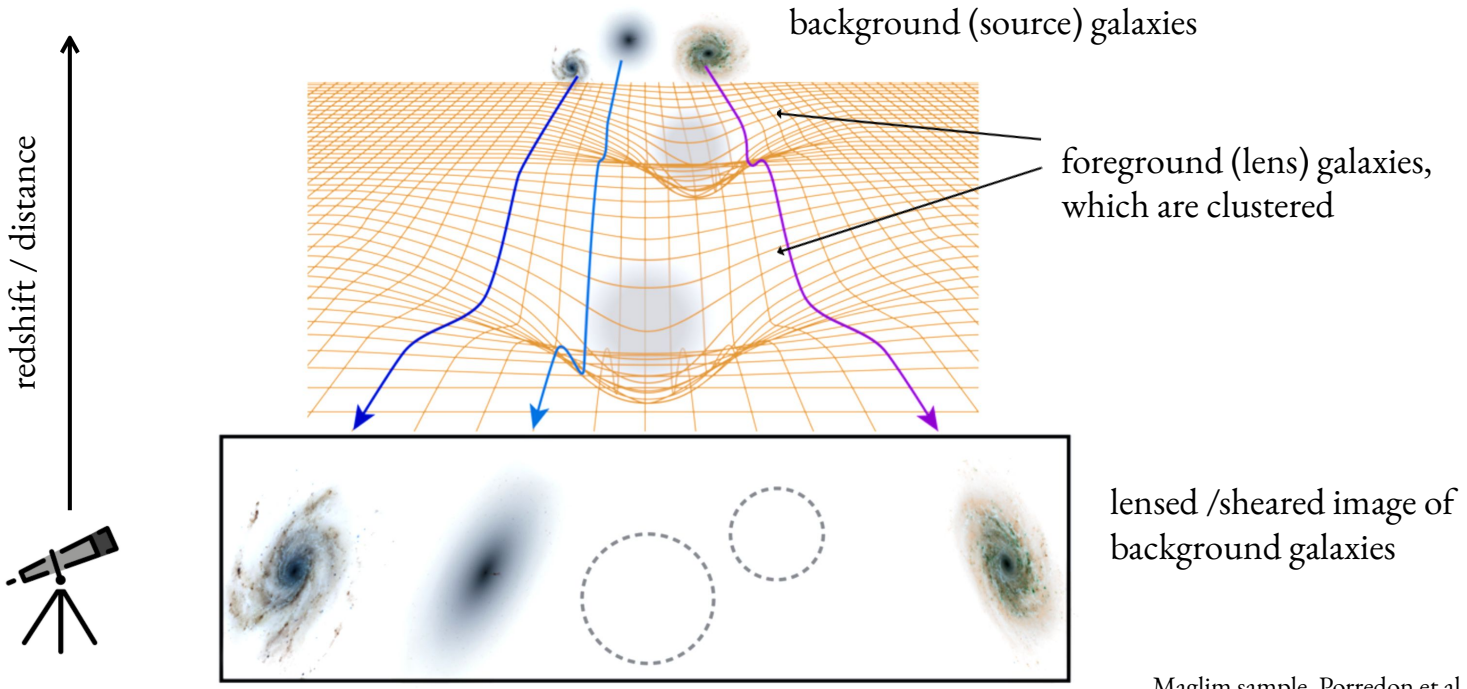
Universität Zürich[UZH] | Physics Institute

Swiss Cosmology Days 2025

Blanco Telescope dome and Milky Way (Reidar Hahn, Fermilab)

Cosmology from Weak Lensing and Galaxy Clustering

Combined analysis to learn about the nature of the dark energy



Maglim sample, Porredon et al. 2105.13546
Metadetect sample, Yamamoto et al. 2501.05665

Cosmology from Weak Lensing and Galaxy Clustering

Combined analysis to learn about the nature of the dark energy

3x2pt

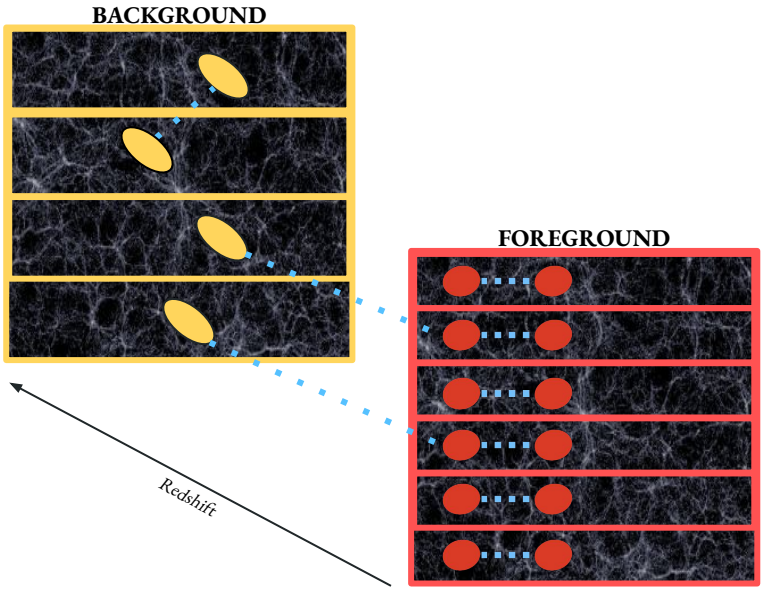
2x2pt

Cosmic Shear : shape-shape

Galaxy Clustering : position-position

Galaxy-Galaxy Lensing : position-shape

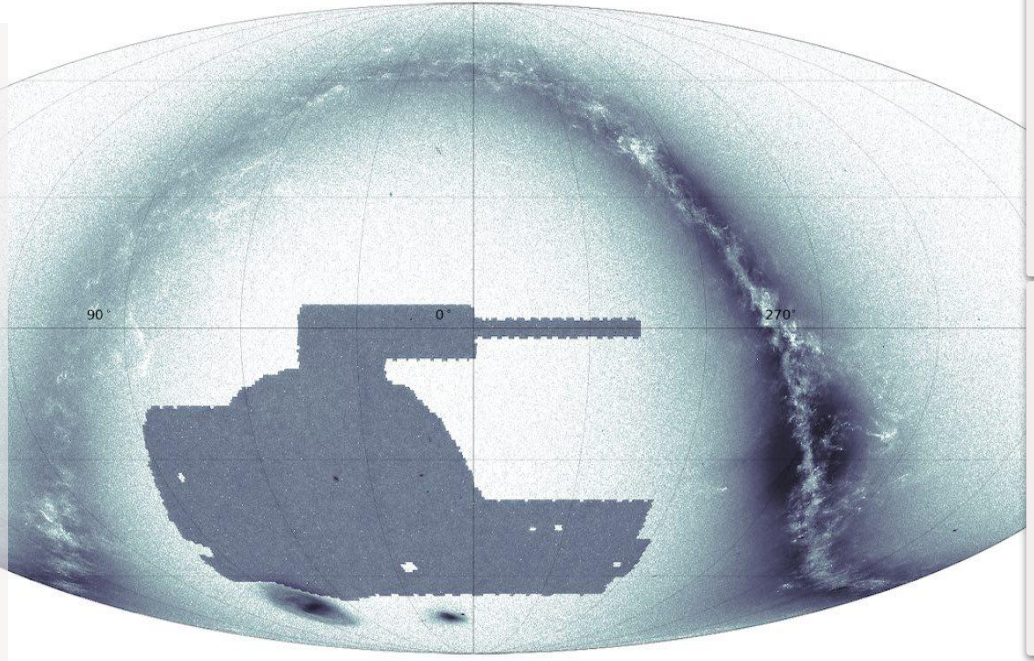
Novel method! A joint analysis maximises the cosmological information and robustly constrains astrophysical & observational priors in the analysis!

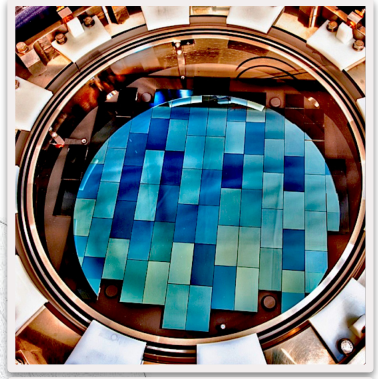


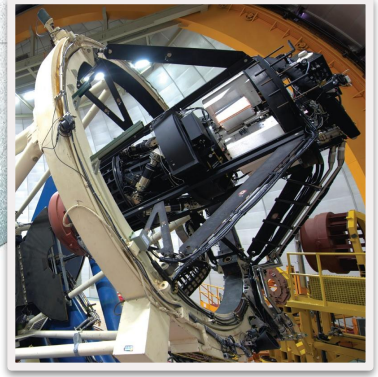
The Dark Energy Survey

A flagship photometric galaxy survey

- 570 Megapixel camera for the Blanco 4m telescope in Chile.
- Full survey 2013-2019
- **Wide field:** 5000 sq. deg. in 5 bands. i~24 magnitude.
- **Growth of structure** and **geometry** probes
- **DES Year 6 results analysing**: positions and shapes of > 140M galaxies.





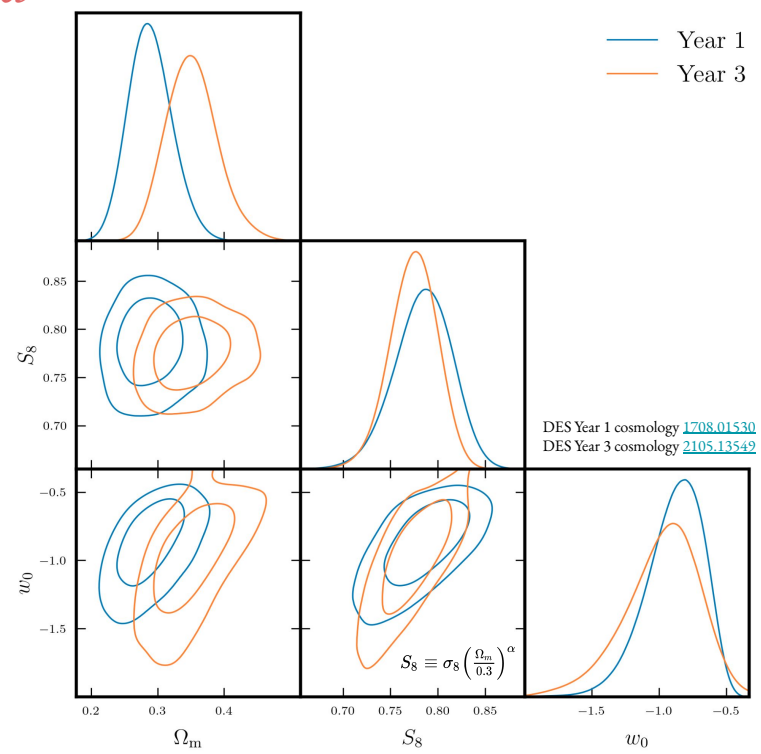


The DES Year 6 3x2pt

Setting the standard: how DES shaped the 3x2pt analyses

- **DES made a leap forward**: first to deploy the full 3×2pt framework on data, setting a new standard.
- The "**DES approach**" became the model: **LSST**, **Euclid**, and others are building on its expertise.
- **Staged data releases**: SV, Y1, Y3, Y6 (increasing area & depth).
- *This work*: adapt modeling to enhanced Y6 catalog.
- Led by the **Modeling & Validation Team** (D.S-C, A. Ferté, J. Blazek).
- Final pipelines for:
  - **cosmic shear** ($\xi_{+/-}$),
  - $\gamma_t + w(\theta)$ (**2x2pt**),
  - and **3x2pt** LCDM and *w*CDM.

x4 area and galaxies -> **10%** in $\sigma(S_8)$



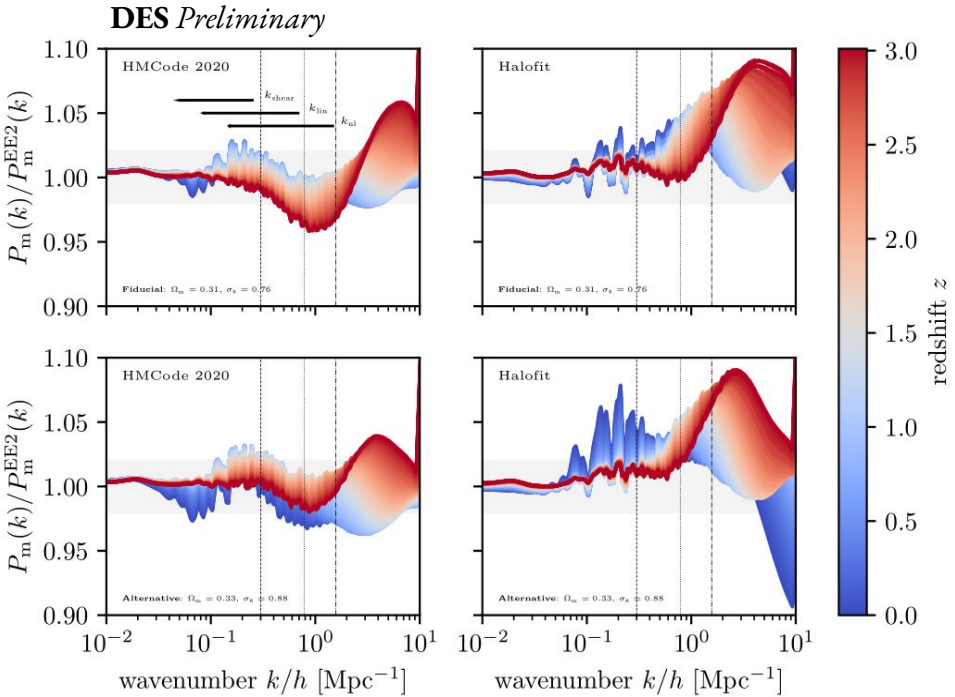
Analysis pipeline and theoretical systematics

New modeling ingredients and analysis variants

Alternative pipelines:

- Cosmic shear with alternative **intrinsic alignment** parameterizations.
- **Galaxy bias** down to i) linear (6 Mpc/h), and ii) non-linear regime (4 Mpc/h).

Non-linear matter power spectrum: HMCode 2020 + fixed baryon.

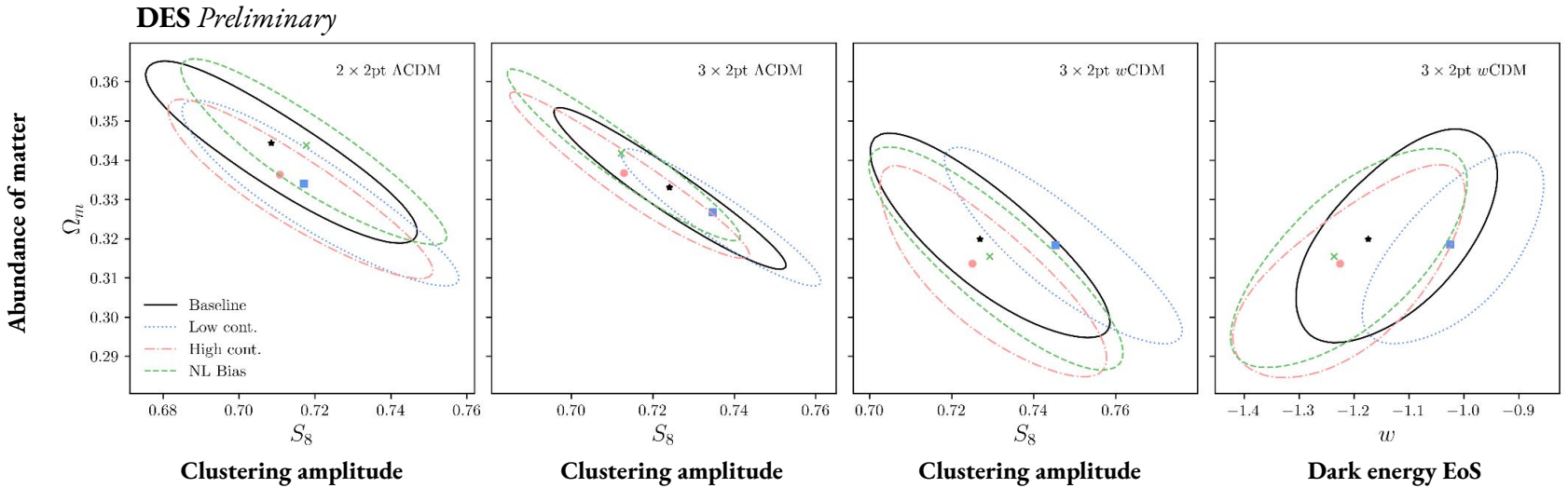


Mead et al. 2009.01858
Takahashi et al. 1208.2701
Knabenhans et al. 2010.11288

Robustness of the scale cuts

Calibrating the impact of theoretical systematics at the posterior level

Scale cuts for the linear galaxy bias analysis efficiently **mitigate unmodeled systematics**...



... keeping potential biases on the best-constrained parameters **below the 0.5σ** threshold.

Forecasting DES Year 6 3x2pt *w*CDM

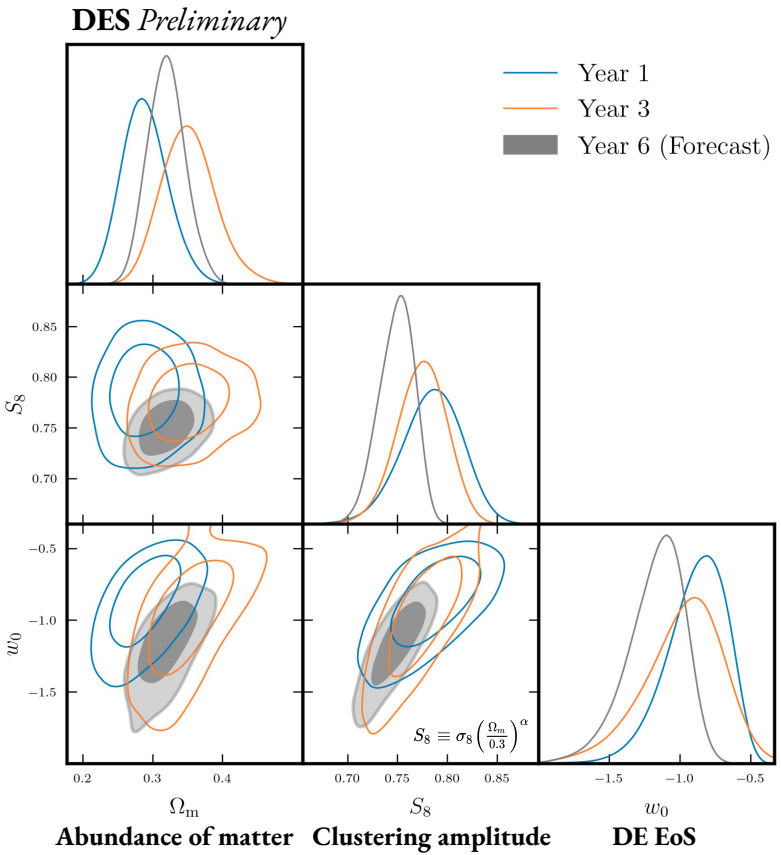
Constraining power on Ω_m, S_8 and w

Pushing to smaller scales:

- **660** data points (462 in Year 3),
- SNR of **116** (87 in Year 3).

Parameter space is getting more and more complex!
7 cosmological, 4 IA, 6 galaxy bias, and 35 for calibration.

Improvement of factor 2.1 in figure-of-merit in $\Omega_m - \sigma_8$



Conclusions and future prospects

Challenges for present and future galaxy surveys

- The DES opened the window to **precision cosmology** with weak lensing.
- This work builds on a decade of development in modeling and inference to fully exploit DES 3×2pt pushing to smaller scales.
- DES Y6:
  - First batch of papers already out!
  - Next batch will include this paper on **methodology** (Sánchez-Cid et al.)
  - Upcoming: **cosmology** from cosmic shear, 2×2pt, and 3×2pt, plus **extensions to LCDM** (e.g. w0wa)
- The 3×2pt framework presented here provides a robust, validated baseline for **future analyses** — including LSST, which will see first light on *June 23rd*!

LSST precursor project: HSC Y1 3x2pt re-analysis

with DESC pipelines

Sanchez-Cid + LSST-DESC Collab.

- Reproduce HSC public results with **DESC measurement** and **inference pipelines**.
- Extend to 3x2pt analysis in **harmonic** space.