Review of likelihood frameworks: DESC

Andrina Nicola, JBCA Manchester - CosmoForward meeting, February 11th 2026

Disclaimer

LSST in a nutshell
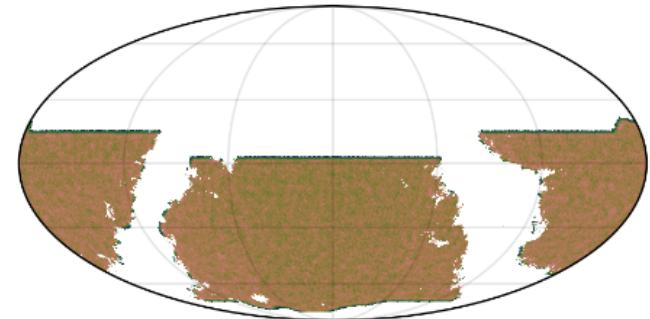
10-year survey, operations started in 2025

Image southern hemisphere in ugrizy

Cosmology analysis in Y1, Y4, Y7, Y10.

Depth builds up over time, full area starting Y1:
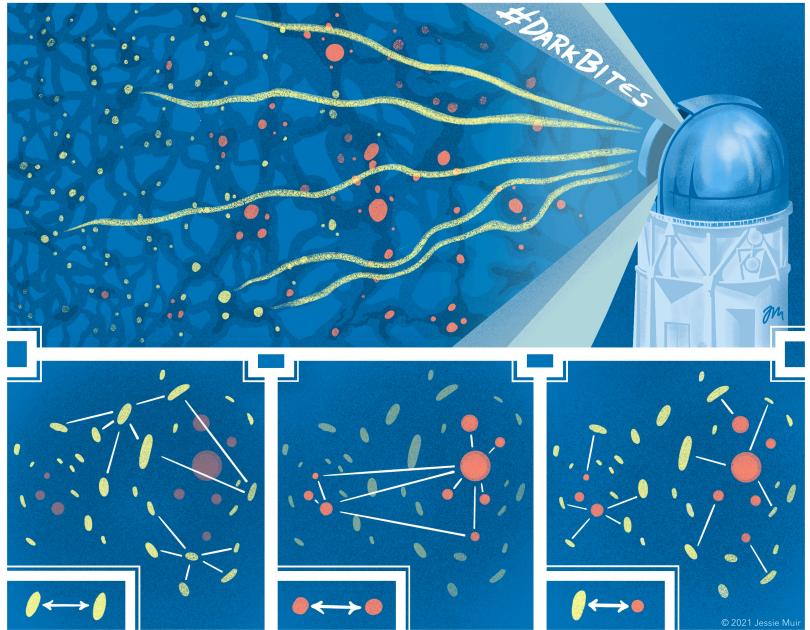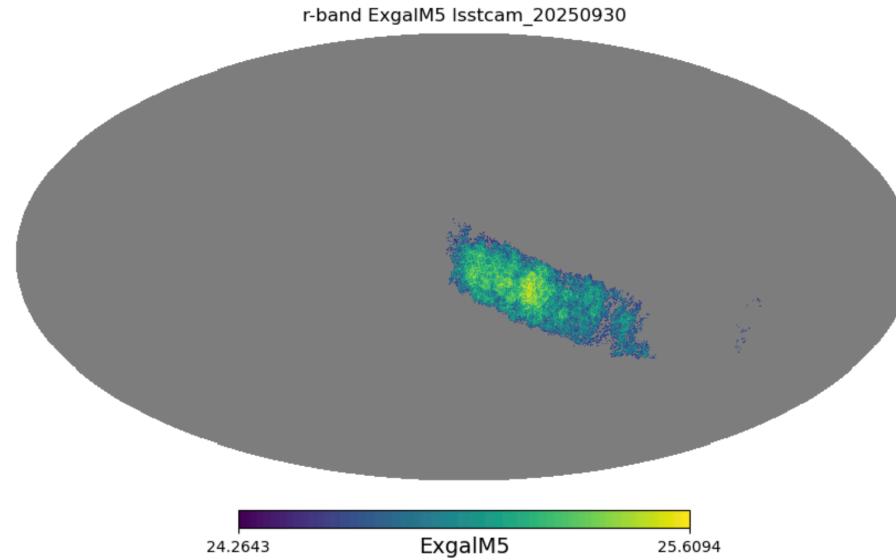
   Y1: rlim~26.25

   Y10: rlim~27.5

Leistedt et al., 2025

LSST and its cosmological probes

Weak & strong gravitational lensing

Galaxy clustering

Optical galaxy clusters

Supernovae

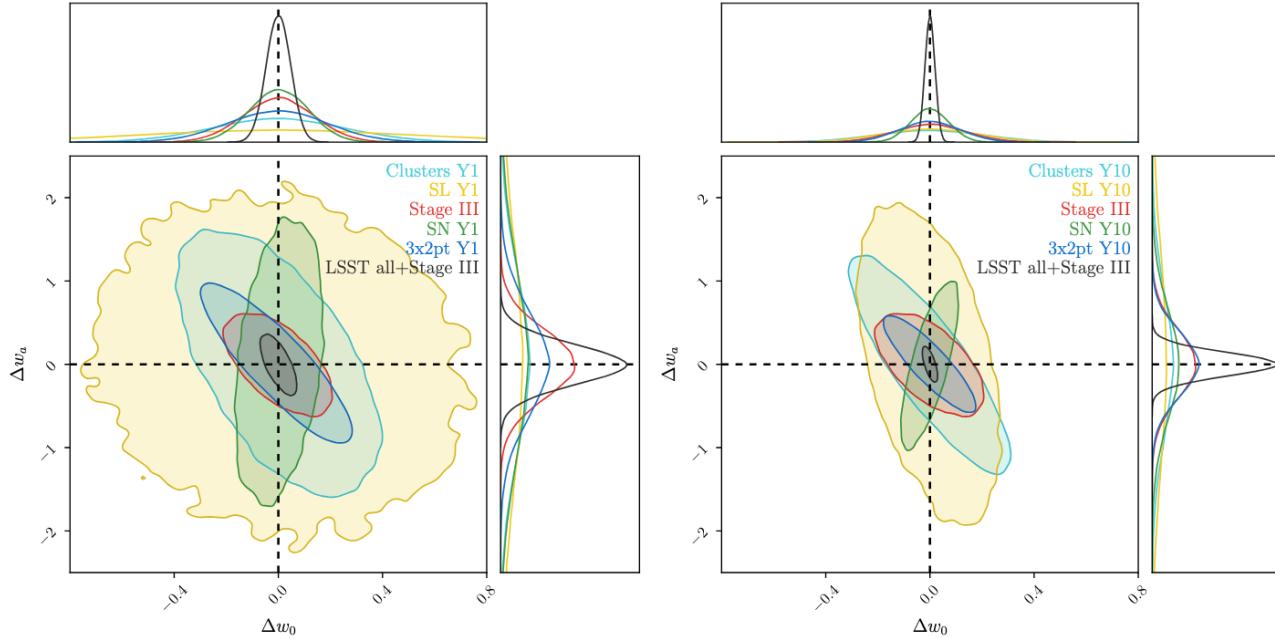© 2021 Jessie Muir

LSST timeline

mid-2026: Release of DP2, ~1500 sq.deg, overlaps with ACT/DESI

late 2027-early 2028: DR1, first cosmology release

r-band ExgalM5 lsstcam_20250930

The goal

LSST cosmological inference framework

Cobaya/CosmoSIS:
likelihood sampling

Firecrown: likelihood evaluation
by calling CCL

$$-2\log\mathscr{L} = (\mathbf{D} - \mathbf{M}(\boldsymbol{\theta}))^{\mathrm{T}} C^{-1} (\mathbf{D} - \mathbf{M}(\boldsymbol{\theta}))$$

TXPipe: data vector
measurement

TJPCov: analytic
covariance matrix

Augur: Fisher forecasting tool
Smokescreen: Data vector blinding

The Core Cosmology Library (CCL)

Limber/non-Limber Cls for weak lensing, galaxy clustering, CMB lensing, tSZ, CIB, ISW

Halo-model with NFW, generalized NFW, HOD, and CIB profiles

Nonlinear galaxy bias models: LPT, EPT, HEFT (BACCO, aemulus_heft in prep.)

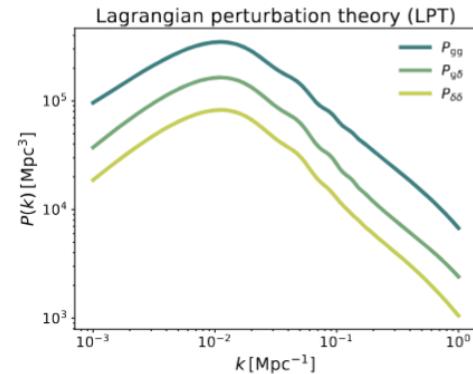CCL tutorial notebooks

Stay tuned for CCLv3 paper

Image credit: Niko Šarčević

TJPCov

Covariances for projected probes and clusters:

Gaussian covariance matrix from namaster

Non-Gaussian covariance from halo model

Galaxy cluster (cross-)covariances in prep.
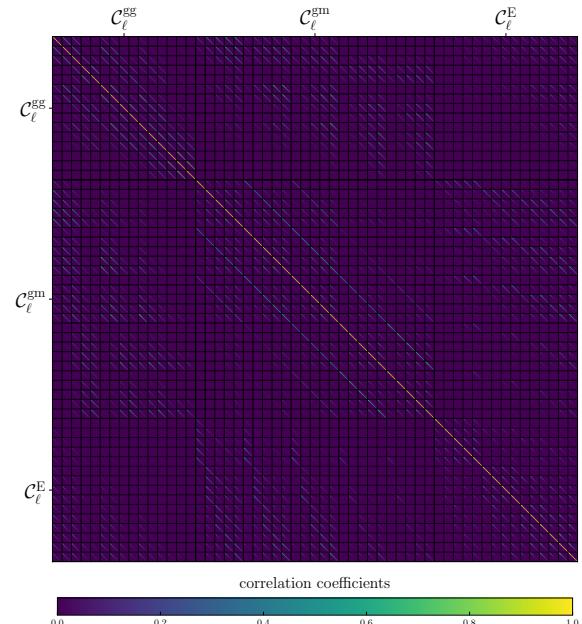
Tangential shear/Delta sigma in prep.

Image credit: Robert Reischke

Firecrown

Framework to write likelihoods

Theory backend: CCL

Includes models of systematics, e.g. redshift distribution uncertainties

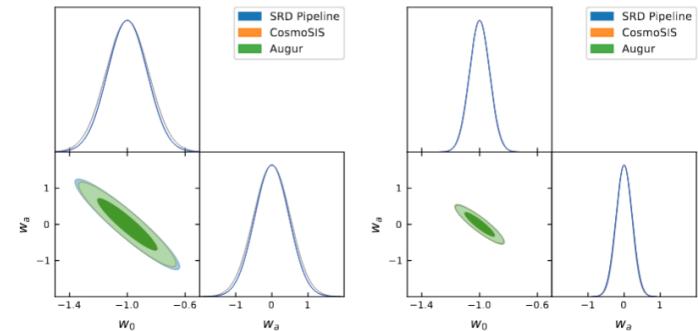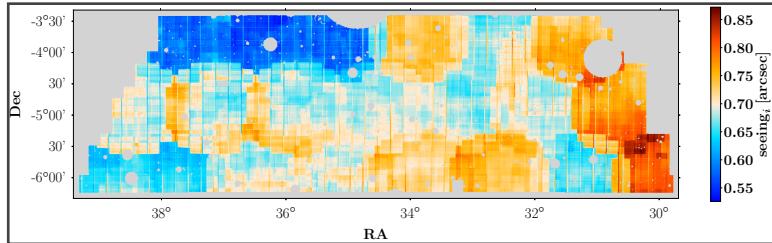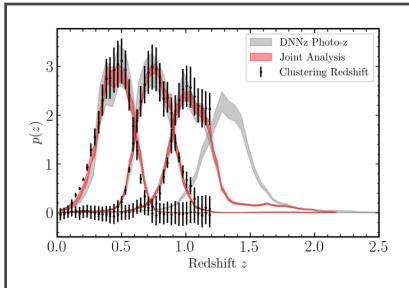Sampling through **cobaya/CosmoSIS/NumCosmo**
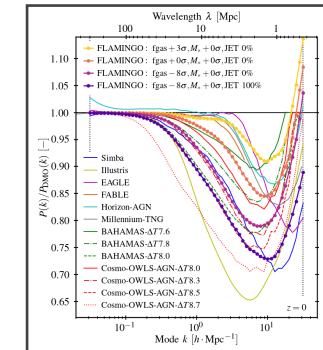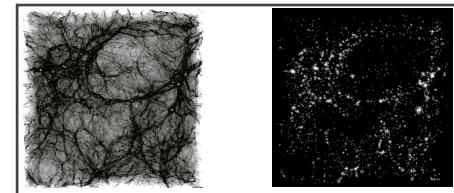
Data format: sacc

Image credit: Paul Rogozenski & Niko Šarčević

Systematics, systematics, systematics…

observational

theoretical

Galaxy density

CMB temperature & polarization

Line-intensity mapping

Weak lensing

X-rays

Galaxy clusters

FRBs

Cosmic Infrared Background

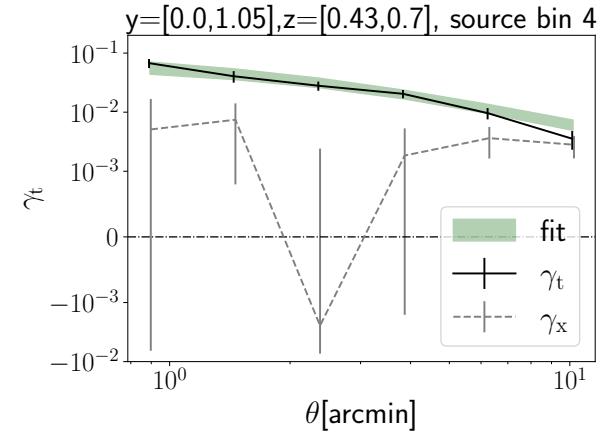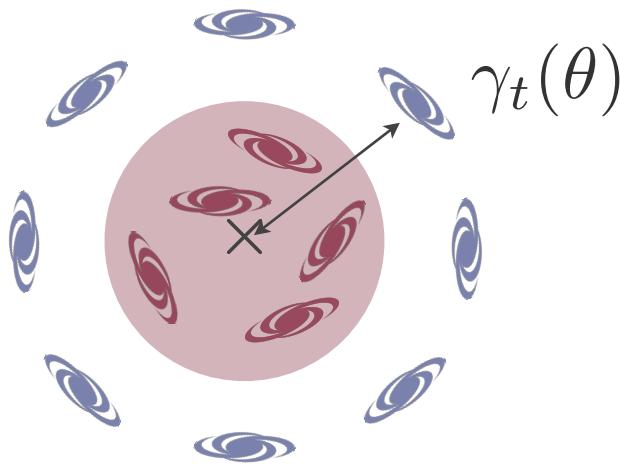thermal Sunyaev-Zel'dovich

kinematic Sunyaev-Zel'dovich

Constraining baryonic feedback with the CMB

Kovač et al., 2025, see also e.g.
McCarthy et al., 2025, Siegel et al., 2025

Optical cluster mass calibration

$$\gamma_t(\theta)$$

y=[0.0,1.05],z=[0.43,0.7], source bin 4

fit
$\gamma_{\rm t}$
$\gamma_{\rm x}$

$\gamma_{\rm t}$

$\theta[\rm arcmin]$

Shin et al., 2025

Beyond ΛCDM

Seraille et al., 2024

What do we need for joint analyses?

Early coordination and collaboration between surveys
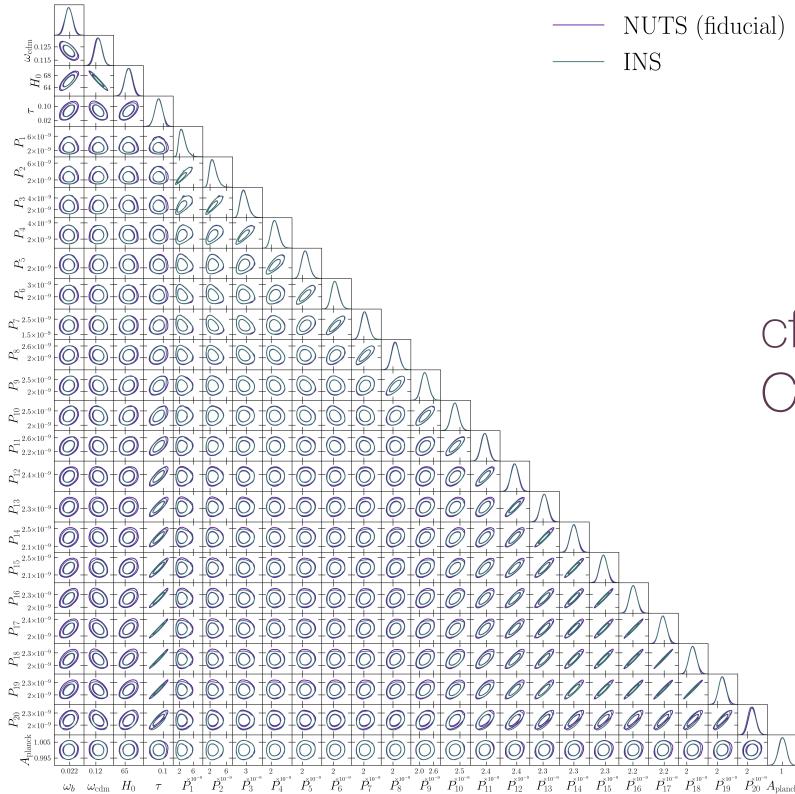
Compatible likelihood frameworks and analysis tools

Development of joint analysis tools/likelihood where needed

Rigorous testing of different frameworks against each other
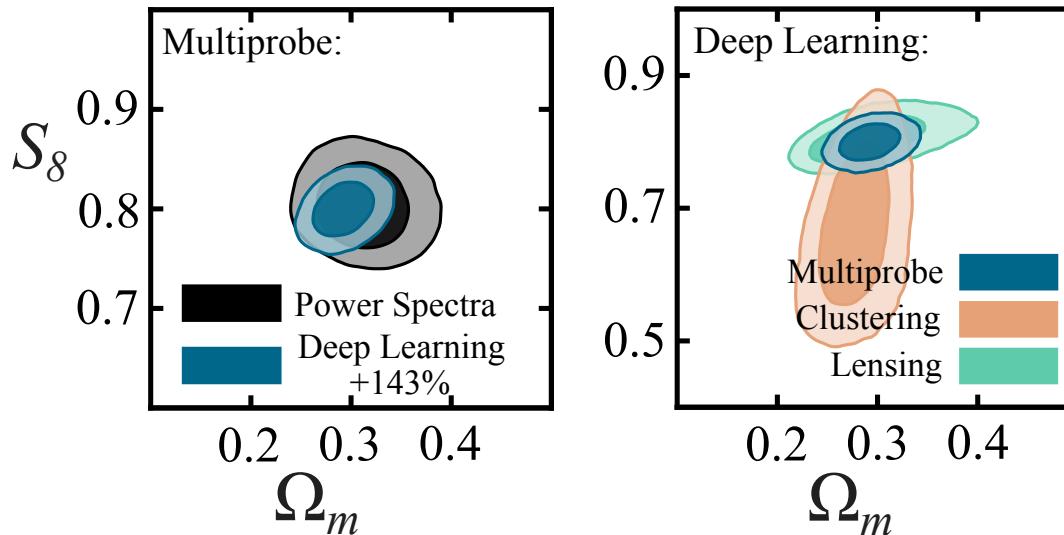
Consistent modeling choices

Challenges - parameter space dimensionality

cf. current efforts to rewrite CCL in jax

Chaki et al., 2025, see also e.g. Ruiz-Zapatero, 2023

Challenges - better data, worse constraints?

Conclusions

LSST DP2 is around the corner…

We are working in a systematics-limited regime

Probe/survey combination is crucial:
> Demonstrate consistent constraints
> Constraints on astrophysical systematics
> Mitigation & identification of (observational) systematics
> Self-calibration

Early coordination and collaboration between surveys

Let's work on these challenges together! NOW!