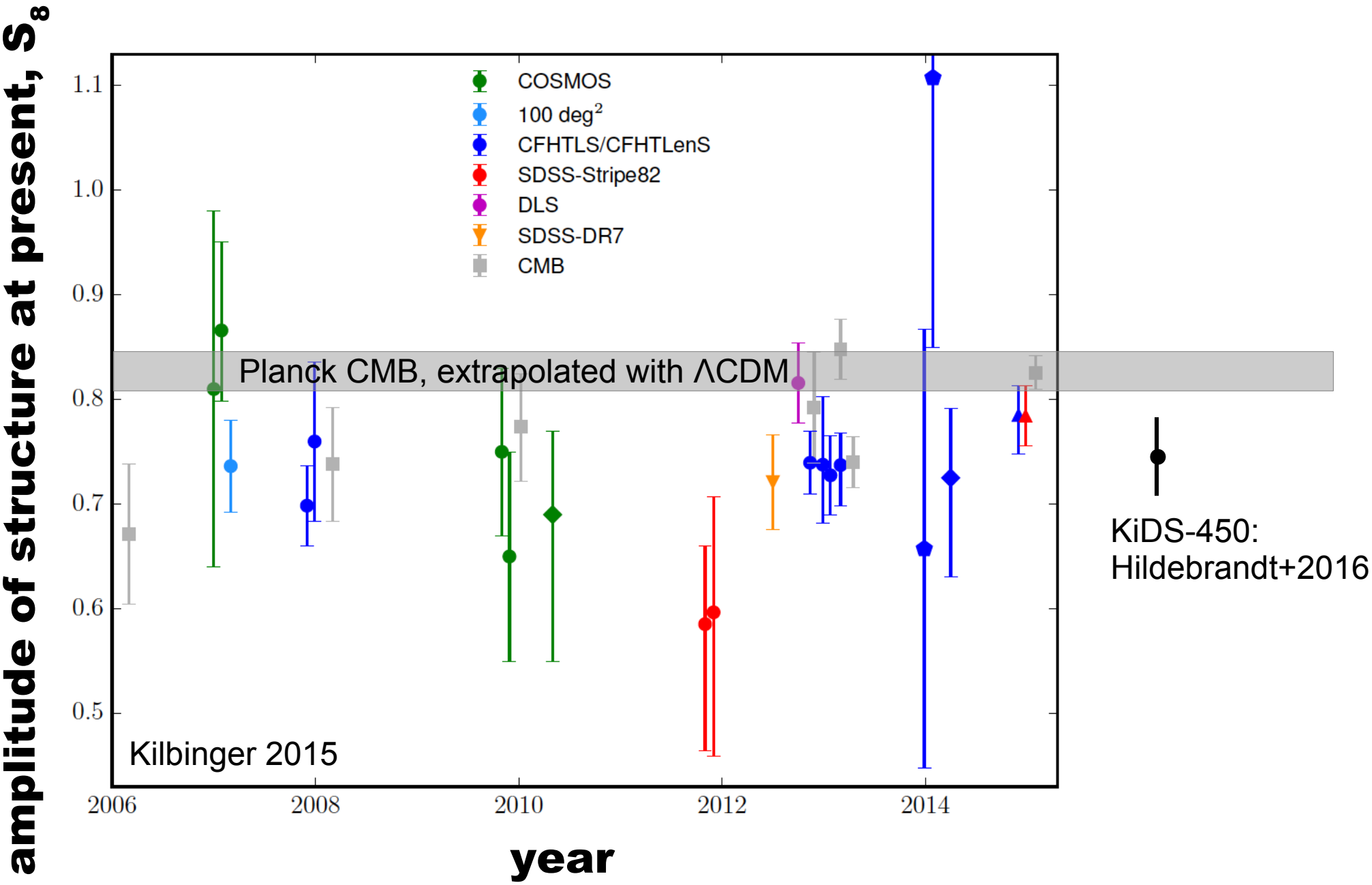
THE DARK ENERGY SURVEY

Cosmology results from weak gravitational lensing in the Dark Energy Survey

Daniel Gruen, Einstein Fellow at SLAC/KIPAC

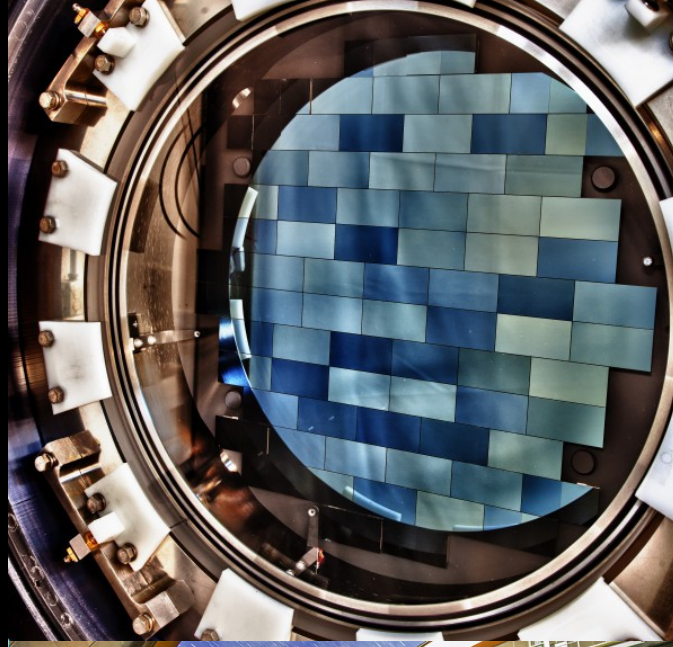
and about 400 collaborators

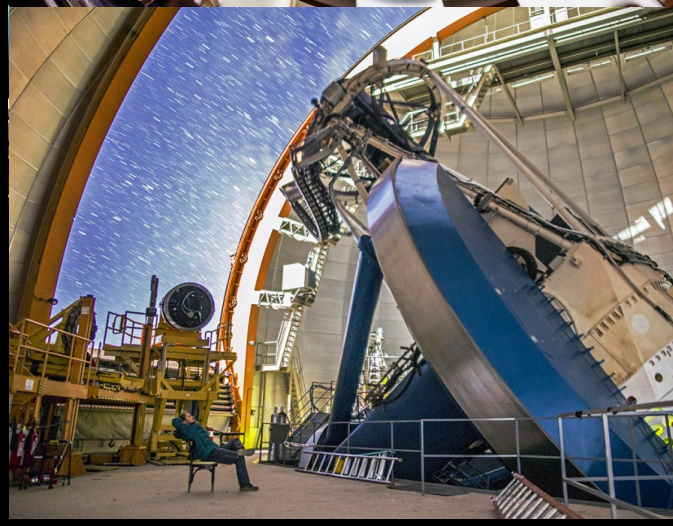
Einstein Fellows Symposium, Oct 13, 2017


amplitude of structure at present, S_8
1.1
1.0
0.9
0.8
0.7
0.6
0.5
2006
2008
2010
2012
2014
year
COSMOS
100 deg^2
CFHTLS/CFHTLenS
SDSS-Stripe82
DLS
SDSS-DR7
CMB
Planck CMB, extrapolated with ΛCDM
Kilbinger 2015
KiDS-450:
Hildebrandt+2016

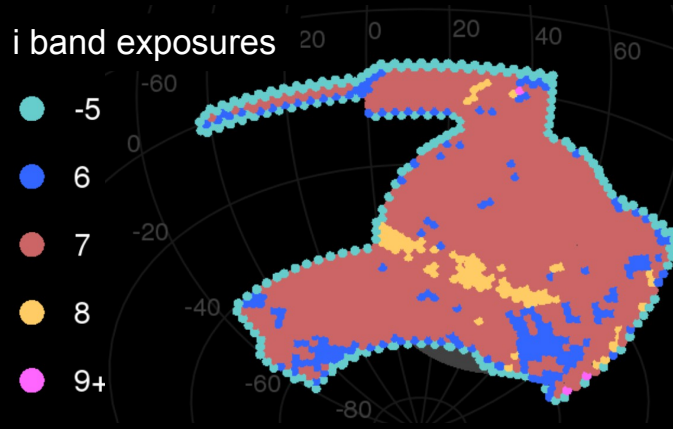
The Dark Energy Survey

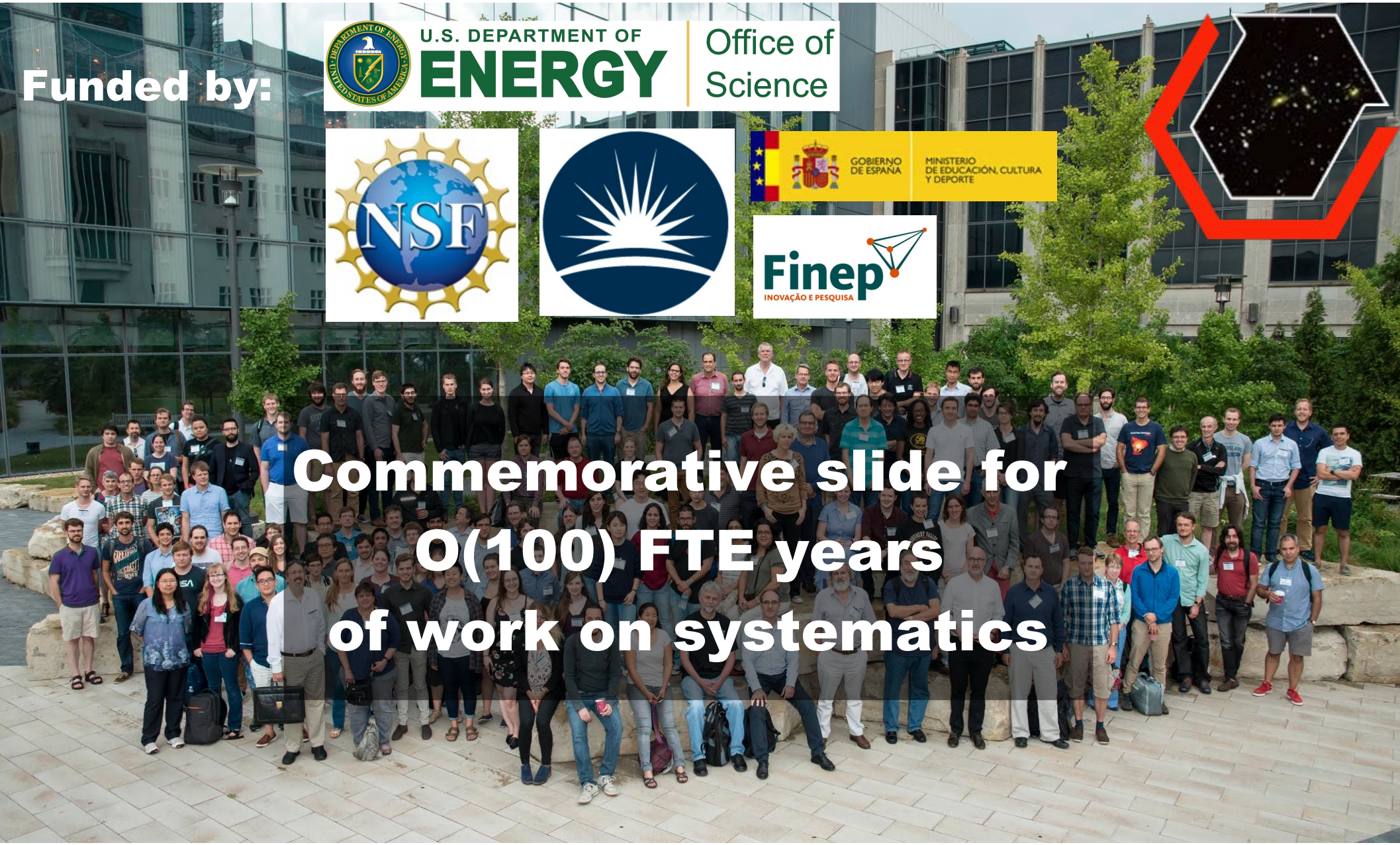
- 5000 sq. deg. survey in grizY from Blanco @ CTIO, 10 exposures, 5 years
- Primary goal: dark energy equation of state





- Status:
  - Y1 (1500 sq. deg, 40% depth):
    data processed, results on cosmology today
  - Y5 already in progress and going well!





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GOBIERNO DE ESPAÑA | MINISTERIO DE EDUCACIÓN, CULTURA Y DEPORTE

Finep INOVAÇÃO E PESQUISA

Commemorative slide for O(100) FTE years of work on systematics

Collaborating institutions:

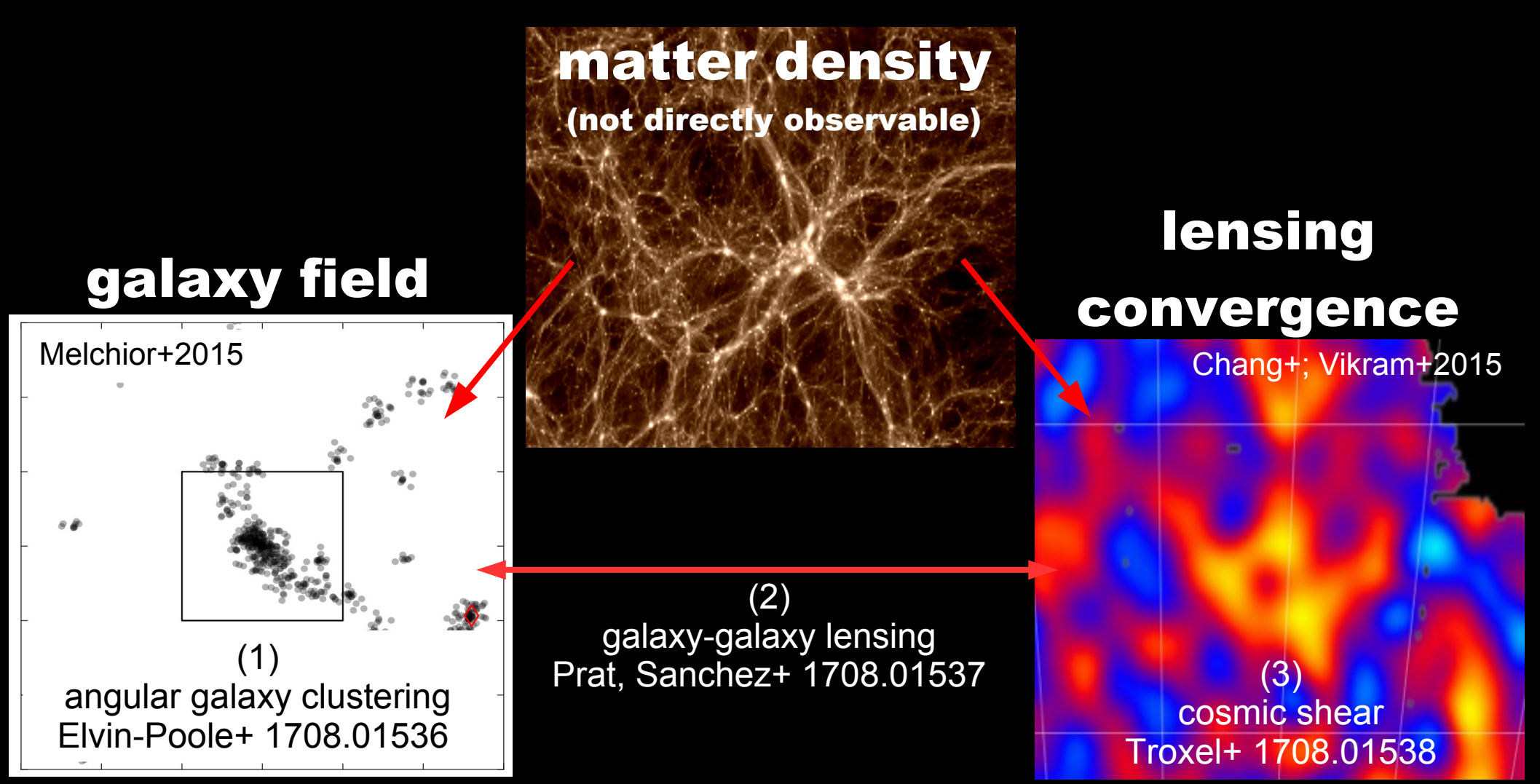
NCSA

THE OHIO STATE UNIVERSITY

LMU

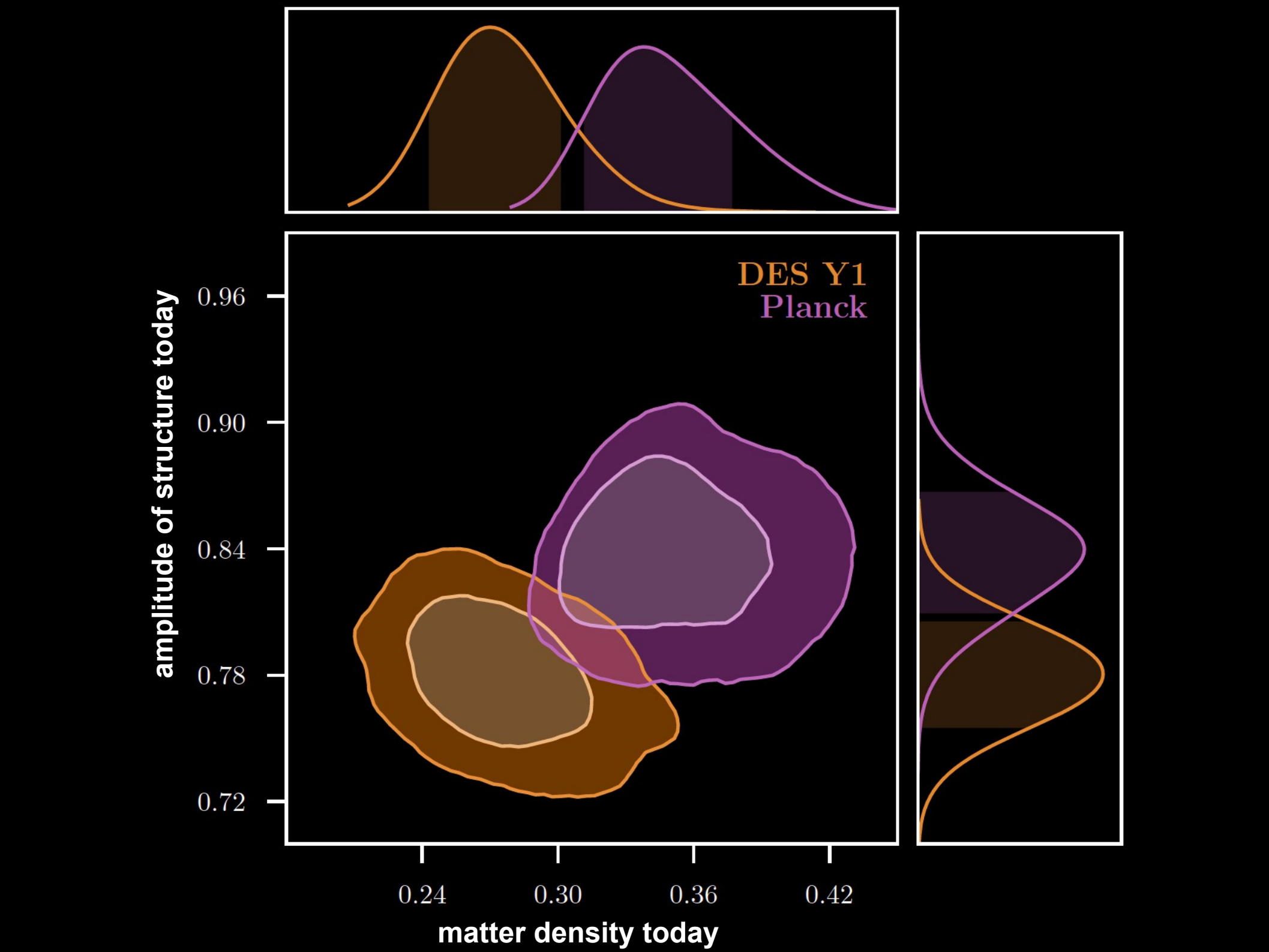
SLAC

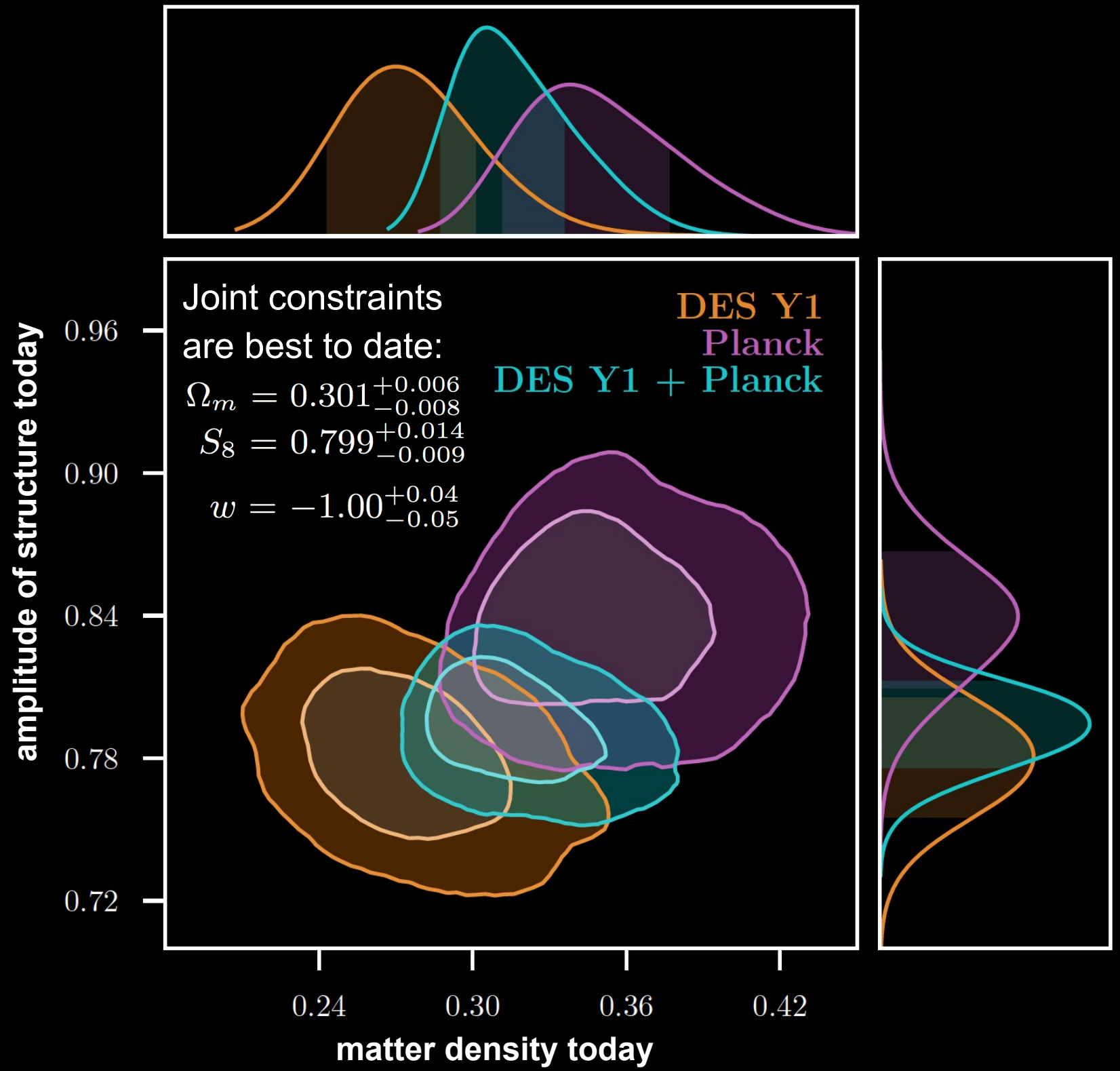
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

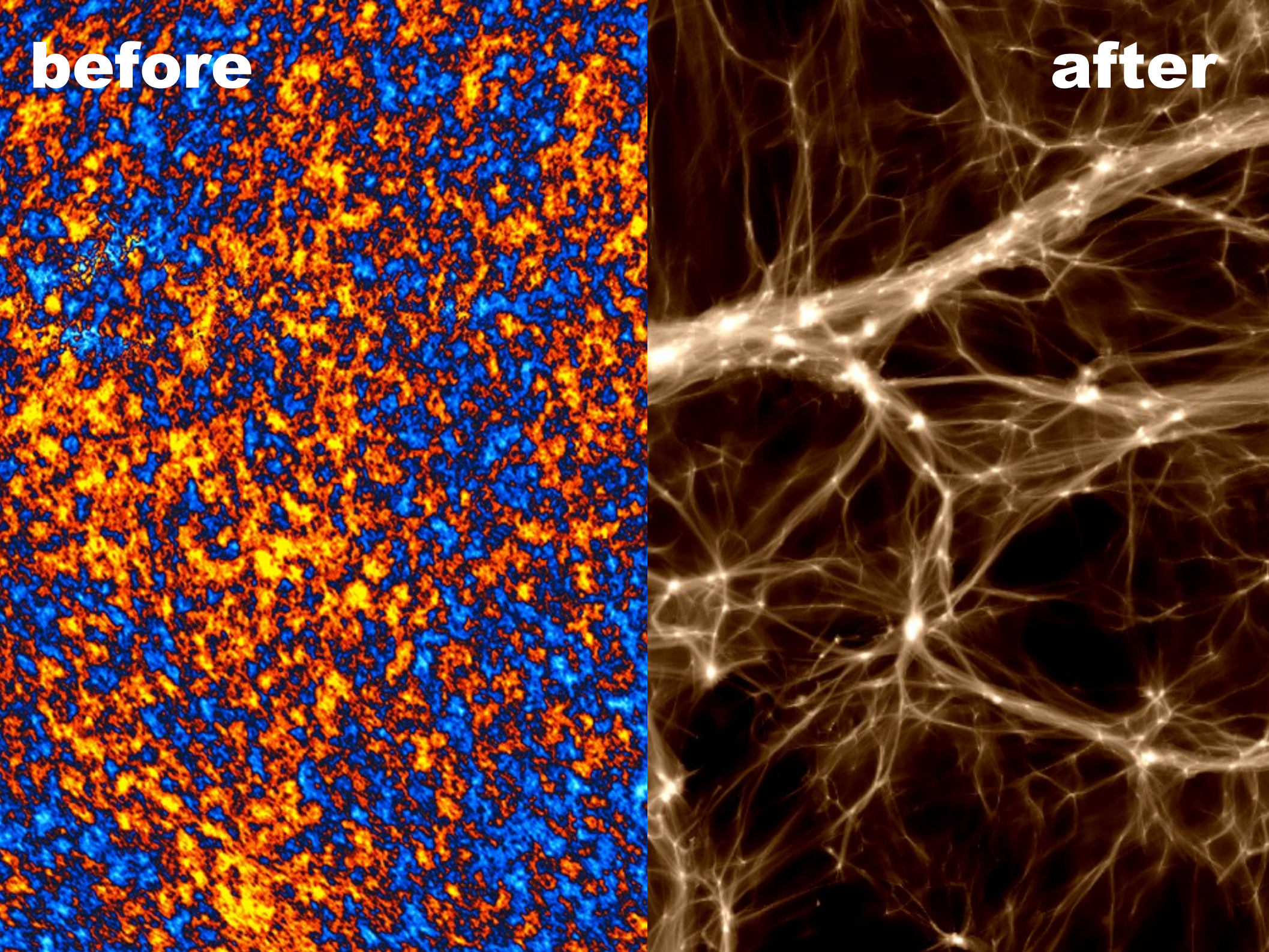


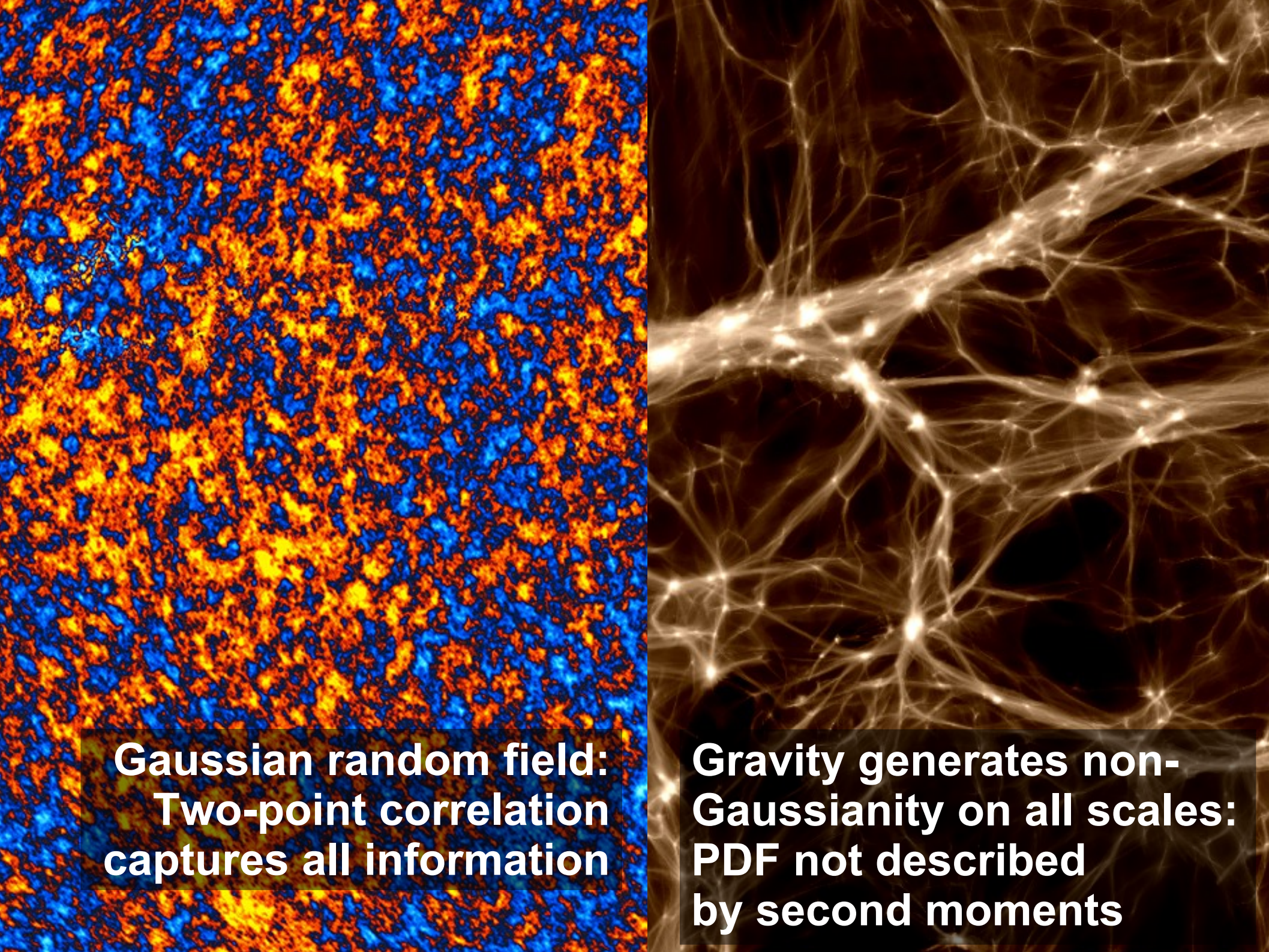
combination of these three two-point functions
jointly and robustly constrains cosmology and nuisance parameters
[Hu&Jain 2004, Huterer+2006, Bernstein+2009, Joachimi&Bridle 2010, van Uitert+2017, Joudaki+2017]

joint constraints from these three probes in a photometric survey for the first time:
DES Collaboration+ 1708.01530


DES Y1
Planck
amplitude of structure today
0.96
0.90
0.84
0.78
0.72
0.24
0.30
0.36
0.42
matter density today

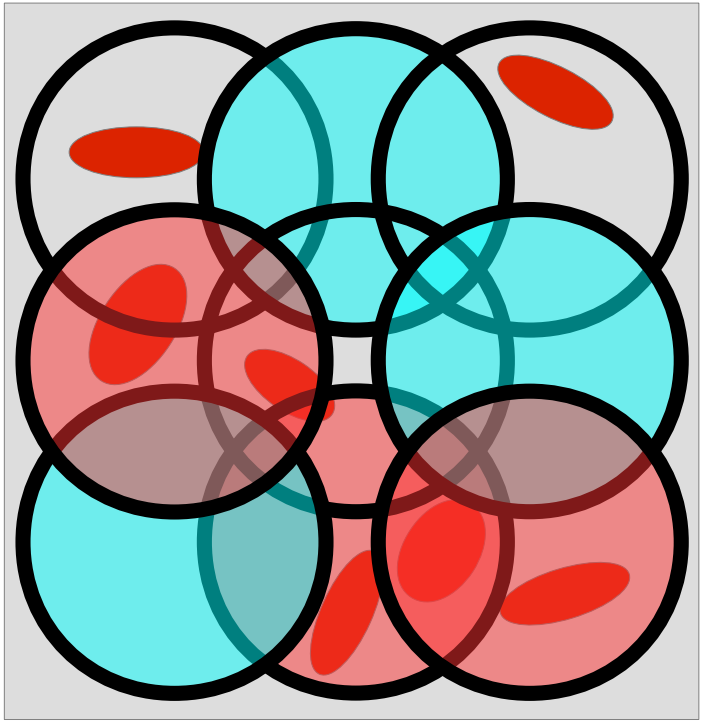

Joint constraints
are best to date:
$\Omega_m = 0.301^{+0.006}_{-0.008}$
$S_8 = 0.799^{+0.014}_{-0.009}$
$w = -1.00^{+0.04}_{-0.05}$
DES Y1
Planck
DES Y1 + Planck
amplitude of structure today
0.96
0.90
0.84
0.78
0.72
0.24
0.30
0.36
0.42
matter density today

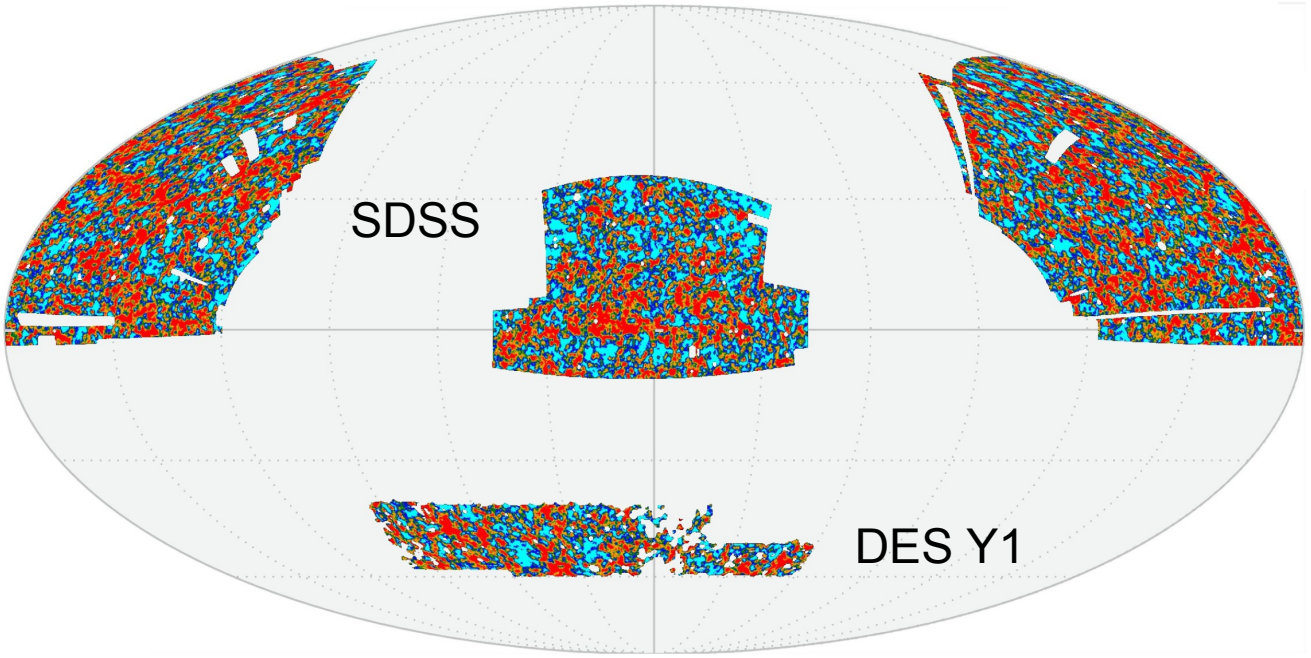

before
after


Gaussian random field:
Two-point correlation
captures all information
Gravity generates non-
Gaussianity on all scales:
PDF not described
by second moments

Cosmology from matter/galaxy PDF with counts and lensing in cells

- Step 1: split lines of sight into quintiles of redMaGiC galaxy count – underdense to overdense

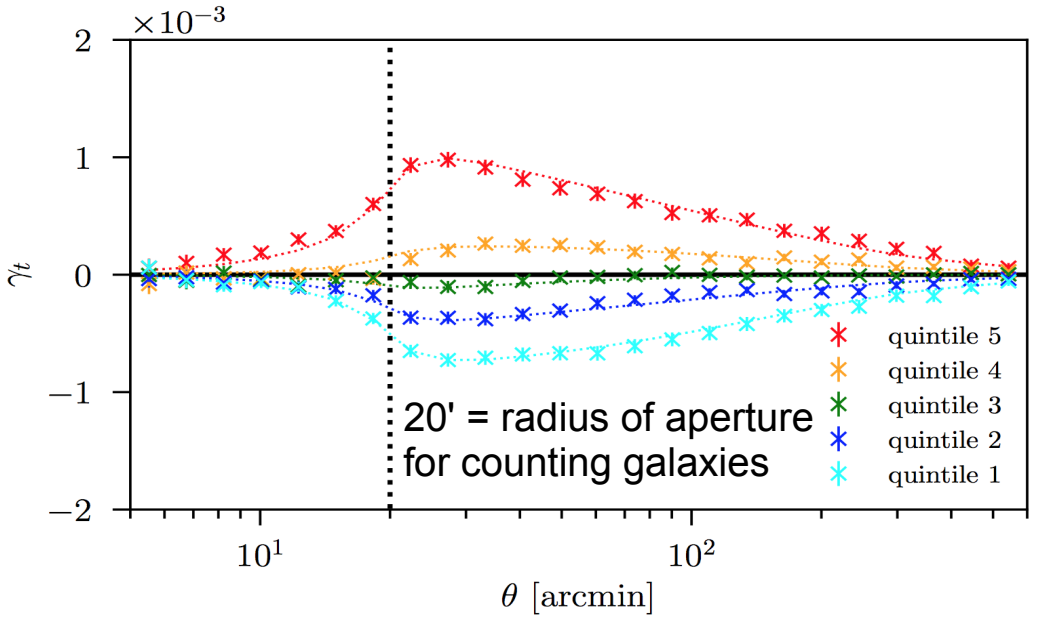


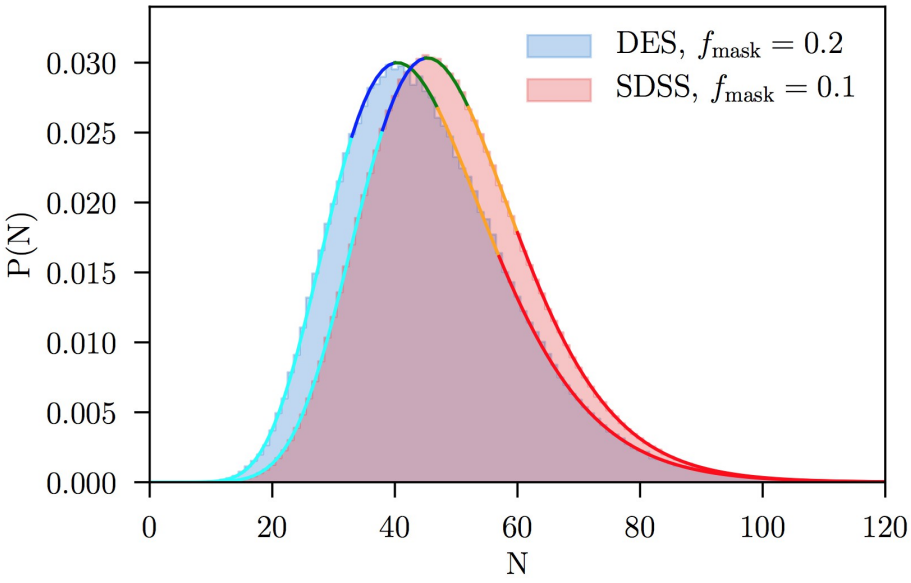


DG+ in prep.
cf. DG+ arXiv:1507.05090

Cosmology from matter/galaxy PDF with counts and lensing in cells

- Step 1: split lines of sight into quintiles of redMaGiC galaxy count
- Step 2: measure shear around and mean counts in quintiles – there is an asymmetry / skewness!





DG+ in prep.

Cosmology from matter/galaxy PDF with counts and lensing in cells

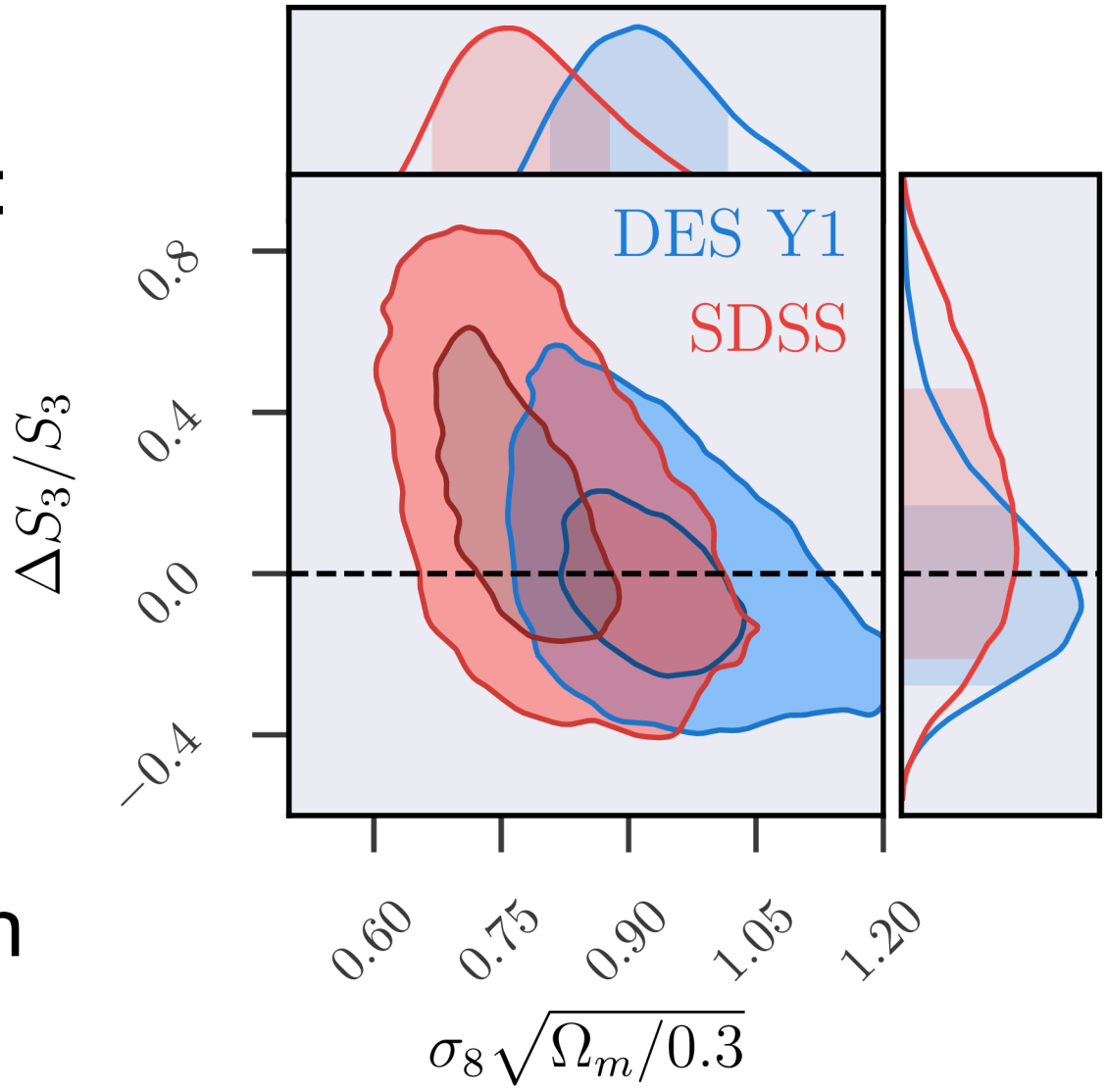
- Step 1: split lines of sight into quintiles of redMaGiC galaxy count N
- Step 2: measure shear around and mean counts in quintiles
- Step 3: model these signals via joint PDF of matter and galaxy density

$$\langle \gamma_t \rangle(N) = \int p(\delta_m|N) \langle \gamma_t \rangle(\delta_m)\, \mathrm{d}\delta_m$$

Perturbation theory model: Friedrich, DG+ (in prep.)

Cosmology from matter/galaxy PDF: skewness of matter density

- Counts + lensing in cells jointly constrain:
  - Cosmology
  - Bias + Stochasticity
  - Skewness of matter density: $S_3 \equiv \frac{\langle \delta^3 \rangle}{\langle \delta^2 \rangle^2}$
- Skewness agrees with ΛCDM prediction at ~20% uncertainty



DG+, which I really need to submit to arXiv right now, so please don't ask too many questions

Summary

- Wide range of probes from early & late Universe, geometry & structure, agree on fiducial ΛCDM cosmology
- DES has added the most precise measurement of structure in the evolved Universe
  - Control of systematics with improved, independent methods
  - Competitiveness and consistency with Planck CMB in ΛCDM, insignificant offset, but in the direction of other lensing studies
  - Precise joint measurements close to Ω_m=0.30, σ_8=0.80, w=-1.0
- First cosmological constraints from matter density PDF: complementary, consistent, and competitive
- Additional results + much more data (Y3) coming soon!