The Dark Energy Survey: WL Status and Plans

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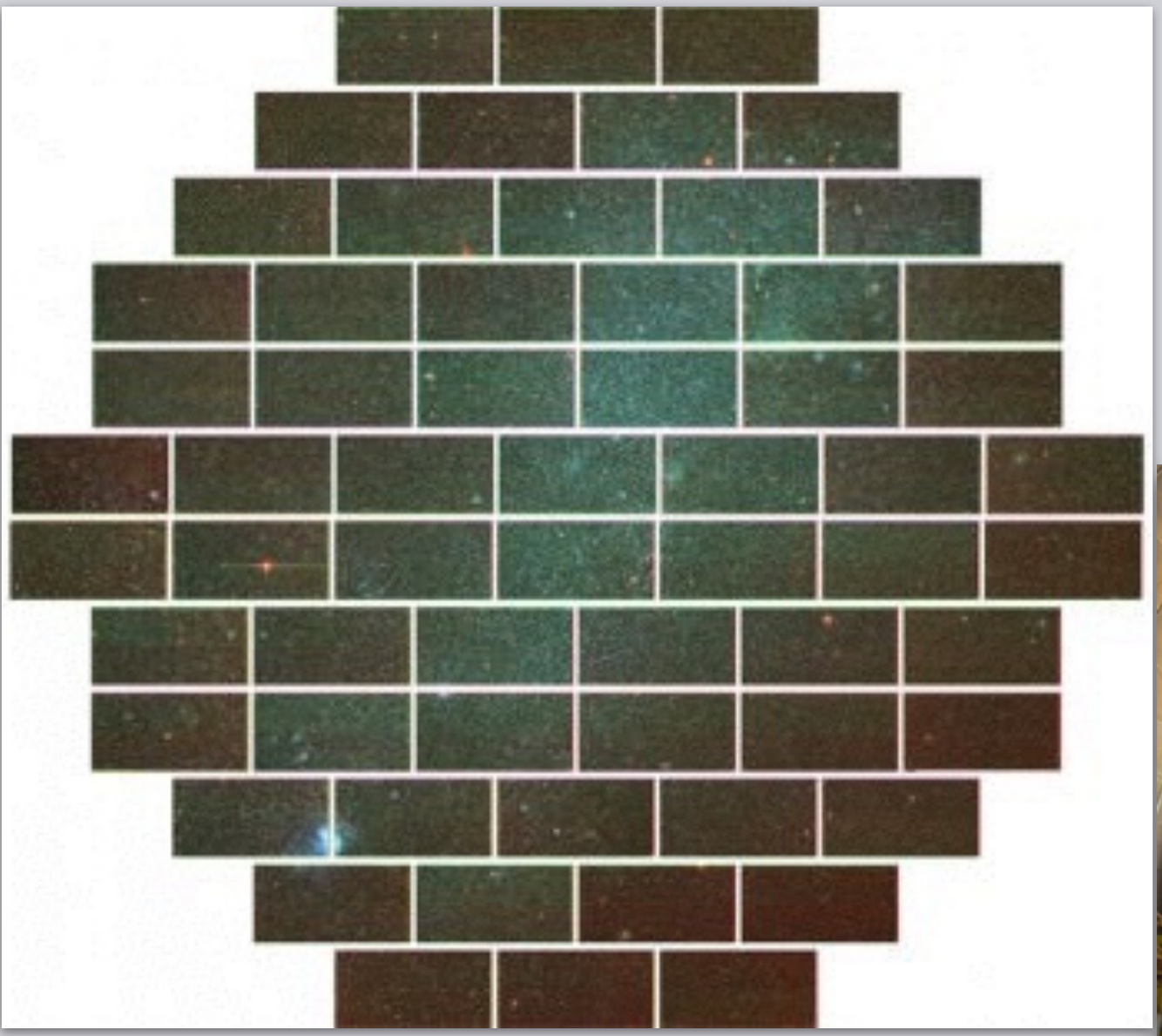
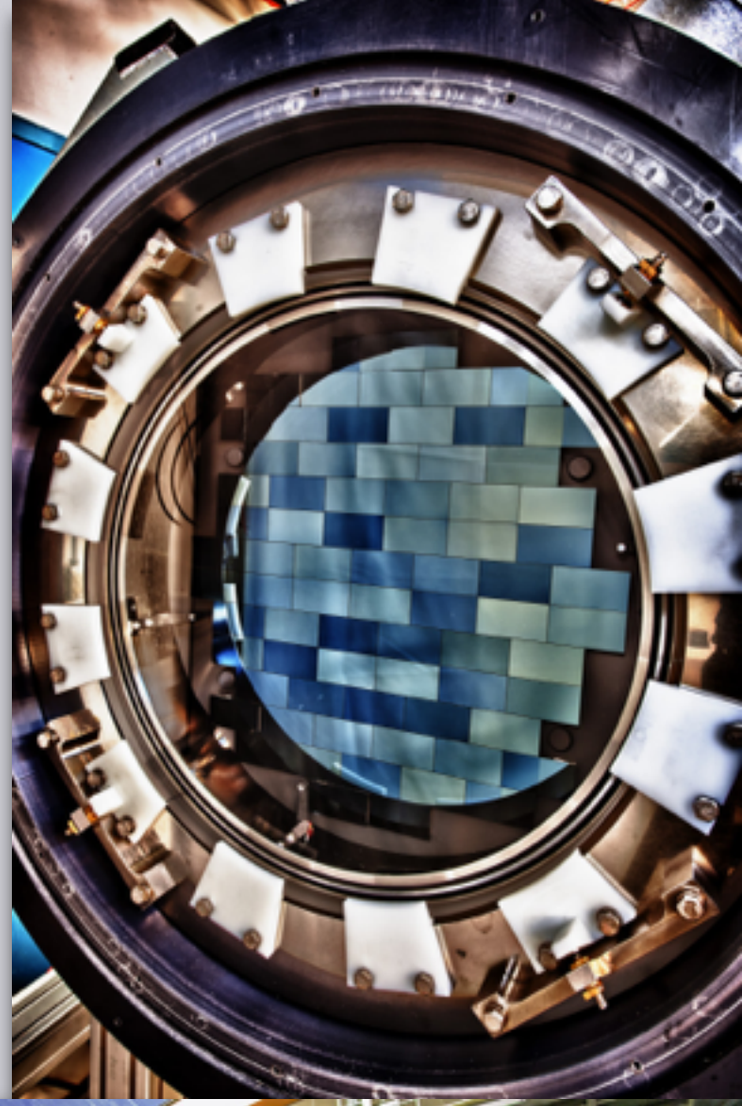
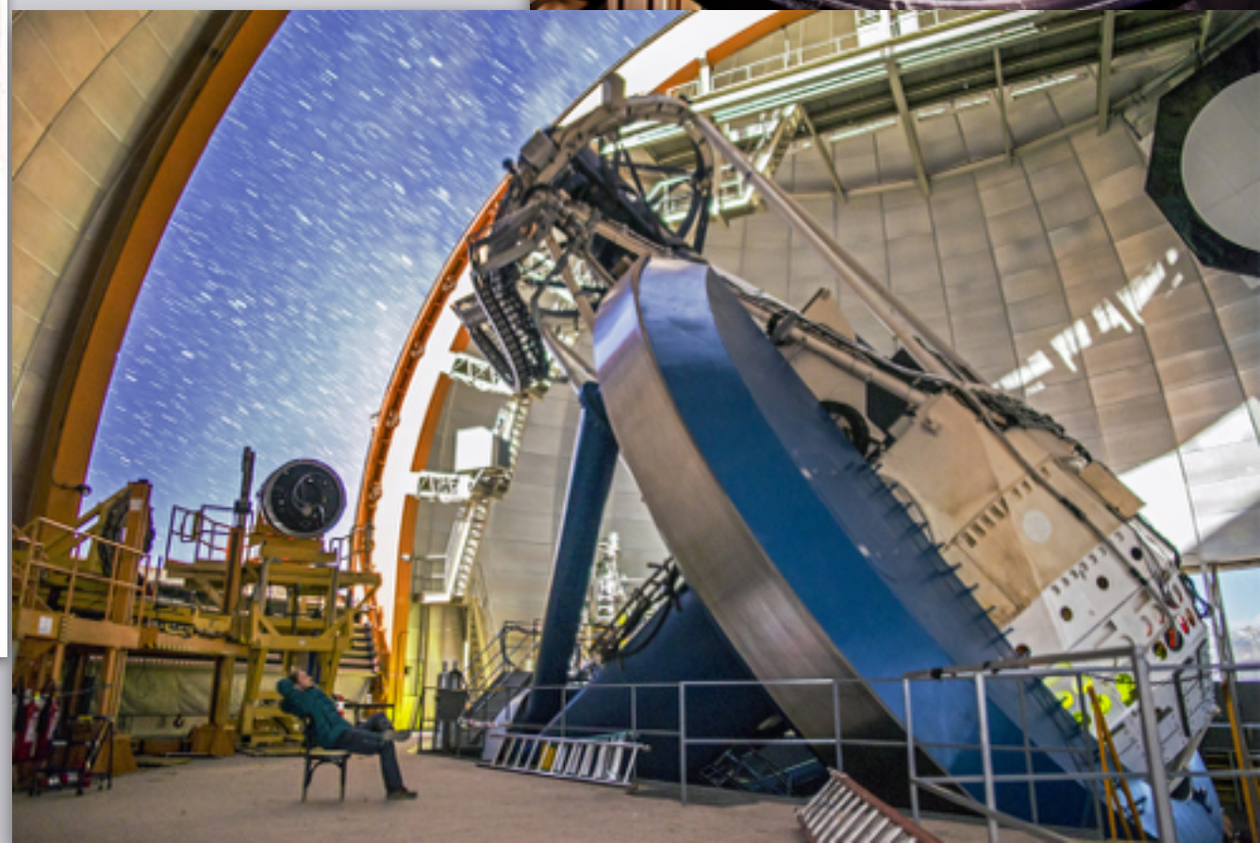
The Dark Energy Survey

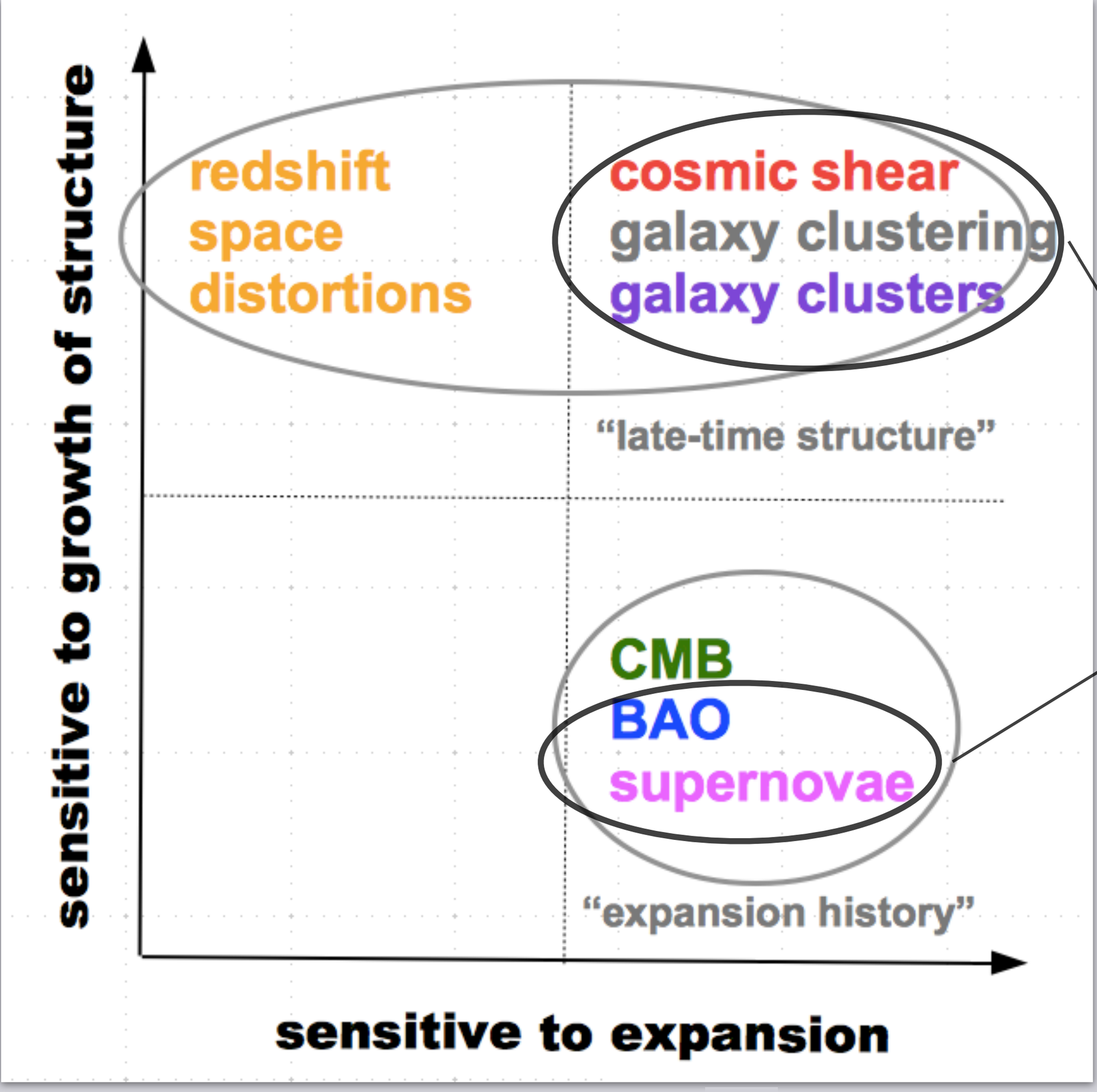
- Complete six year, 5000 sq. deg survey to 24th mag (10 tilings)
- DECam: a 570 Mpix camera on the 4m Blanco Telescope
- Approx. 3 sq. deg field of view
- Observing in (u)*grizY* filters
- Ongoing analysis of Y3/Y5 data - WL+LSS+Clusters+BAO+SNe



Small Magellanic Cloud







Dark Energy Survey

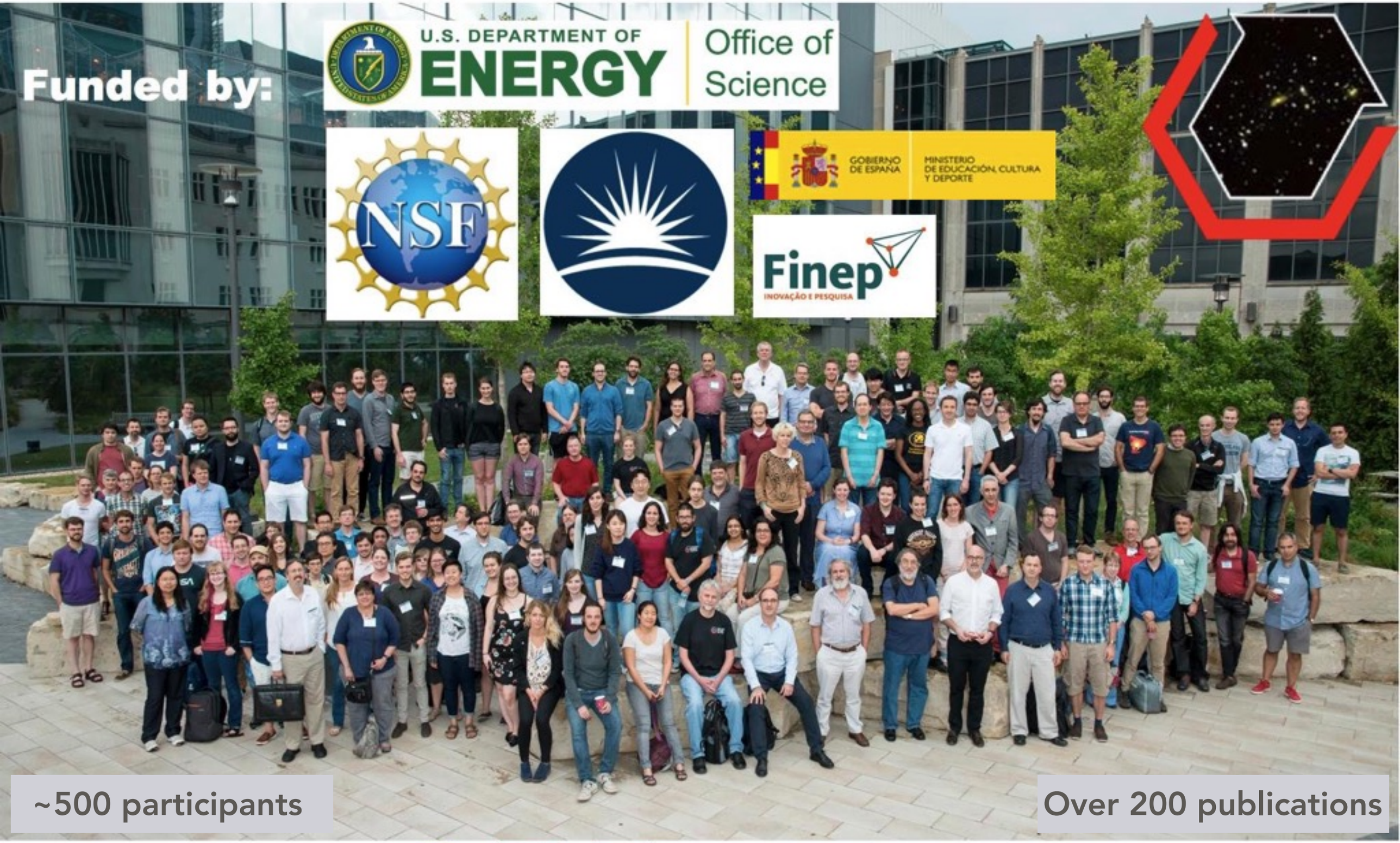
Funded by:

U.S. DEPARTMENT OF ENERGY | Office of Science

NSF

GOBIERNO DE ESPAÑA · MINISTERIO DE EDUCACIÓN, CULTURA Y DEPORTE

Finep
INOVAÇÃO E PESQUISA



~500 participants

Over 200 publications

Collaborating institutions:

NCSA · OHIO STATE UNIVERSITY · TM · LMU · SLAC · ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

#DESendofnights

A Brief History of DES WL

Science Verification catalogs - 139 sq. deg

- ngmix - 3.4M galaxies
  - Multi-band (riz)
  - No a posteriori calibration
- im3shape - 2.1M galaxies
  - Single-band (r)
  - Simulation calibration

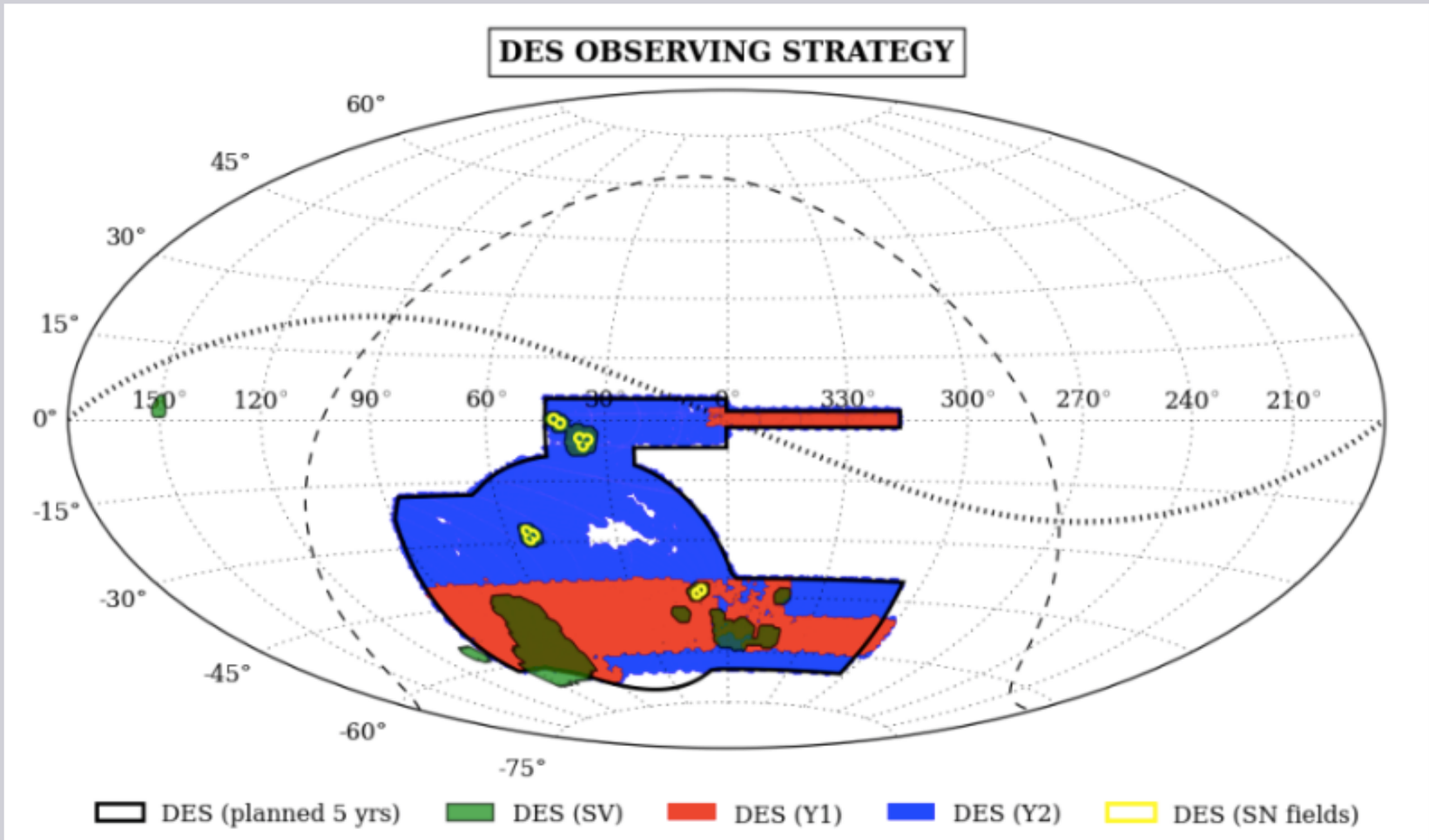
Year 1 catalogs - 1321 sq. deg

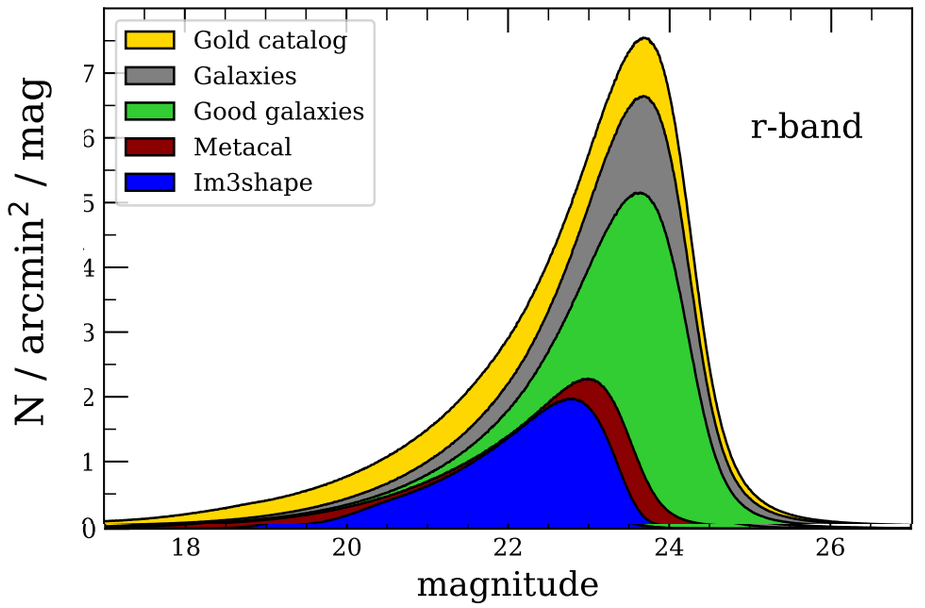
- metacal - 34.8M galaxies
  - Multi-band (riz)
  - Metacalibration
- im3shape - 21.9M galaxies
  - New: Updated, more realistic calibration simulations

Year 3 catalogs - 4160 sq. deg

(Preliminary - still subject to change!)

- metacal - 93.6M galaxies
  - New: neighbor subtraction from
    MOF multi-object fitting; PIFF PSF modelling





A (partial) History of DES WL

Science Verification (2015-2016)

Mass map

Trough lensing

***Cosmic shear**

Galaxy-galaxy lensing

***Galaxy-galaxy lensing + galaxy clustering**

***Shear peaks**

Cluster lensing

All of these catalogs are public!
Add to the list…

Year 1 (2017-2018)

Mass map

***Cosmic shear**

Galaxy-galaxy lensing

***3x2pt (cosmic shear + galaxy clustering + galaxy-galaxy lensing)**

***Galaxy lensing-CMB lensing**

***5x2pt (3x2pt + galaxy lensing-CMB lensing + galaxy-CMB lensing)**

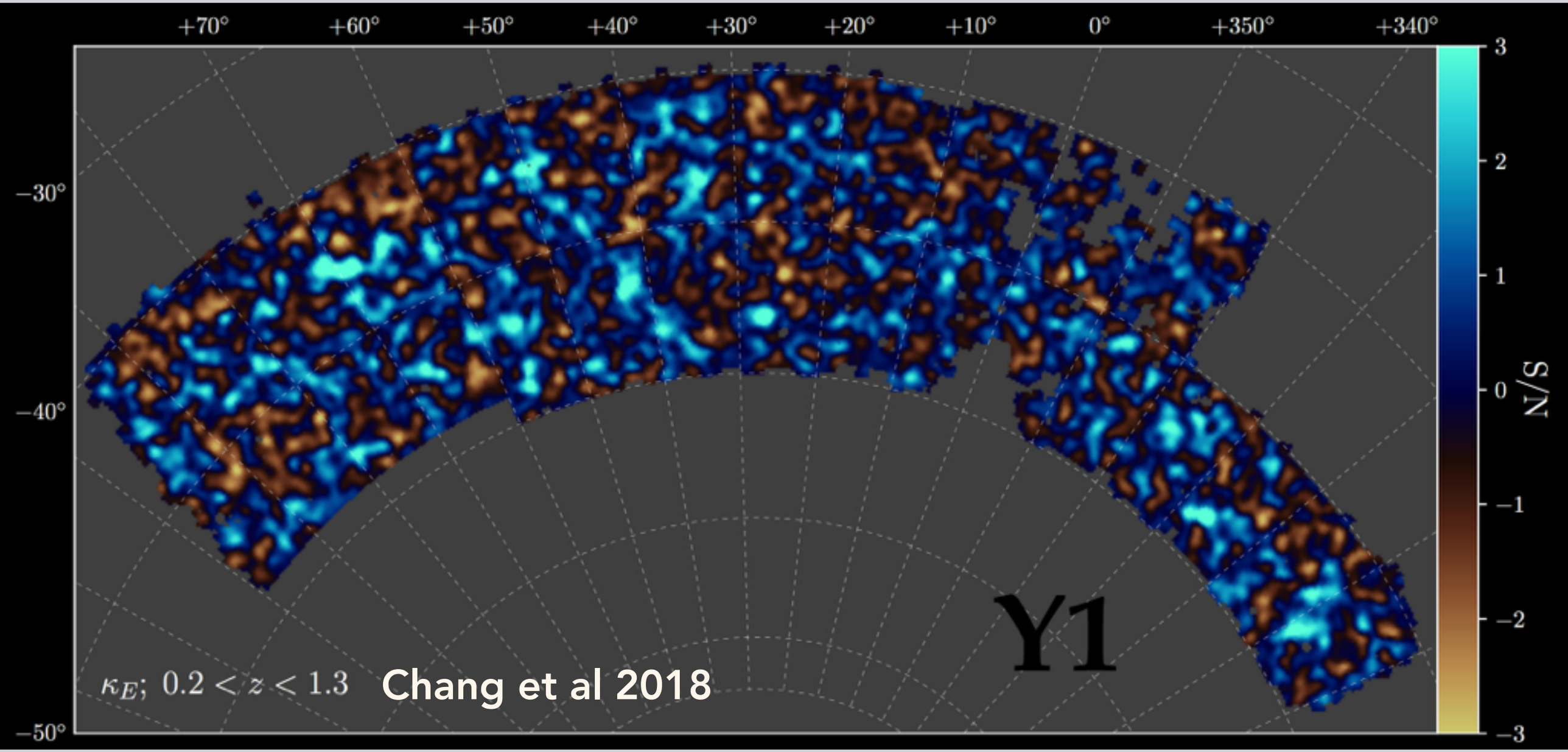
***Trough lensing**

Cluster lensing

***Combined probes (3x2pt + BAO + SNe Ia)**

Recent WL cosmology results

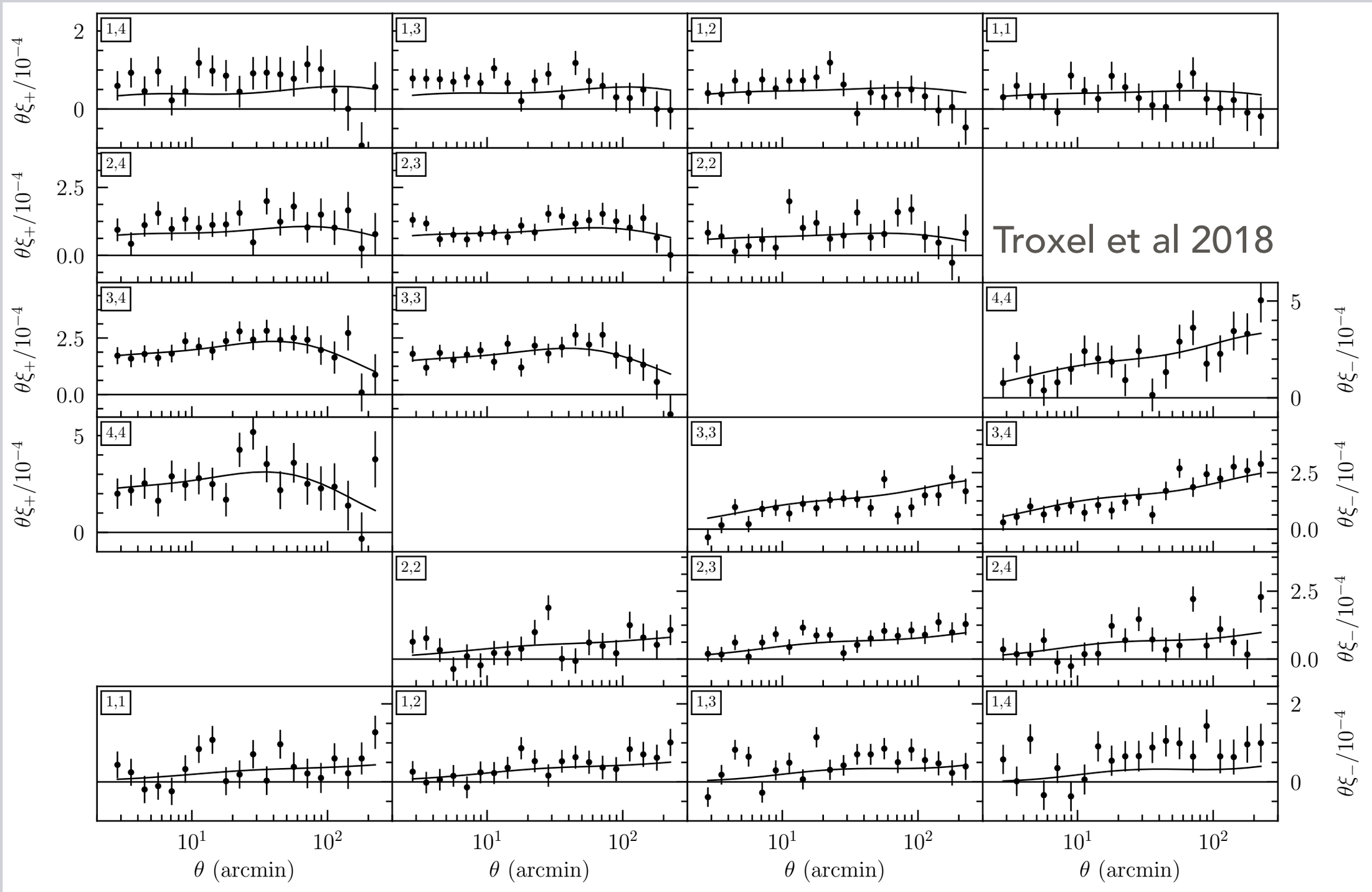
Mass mapping



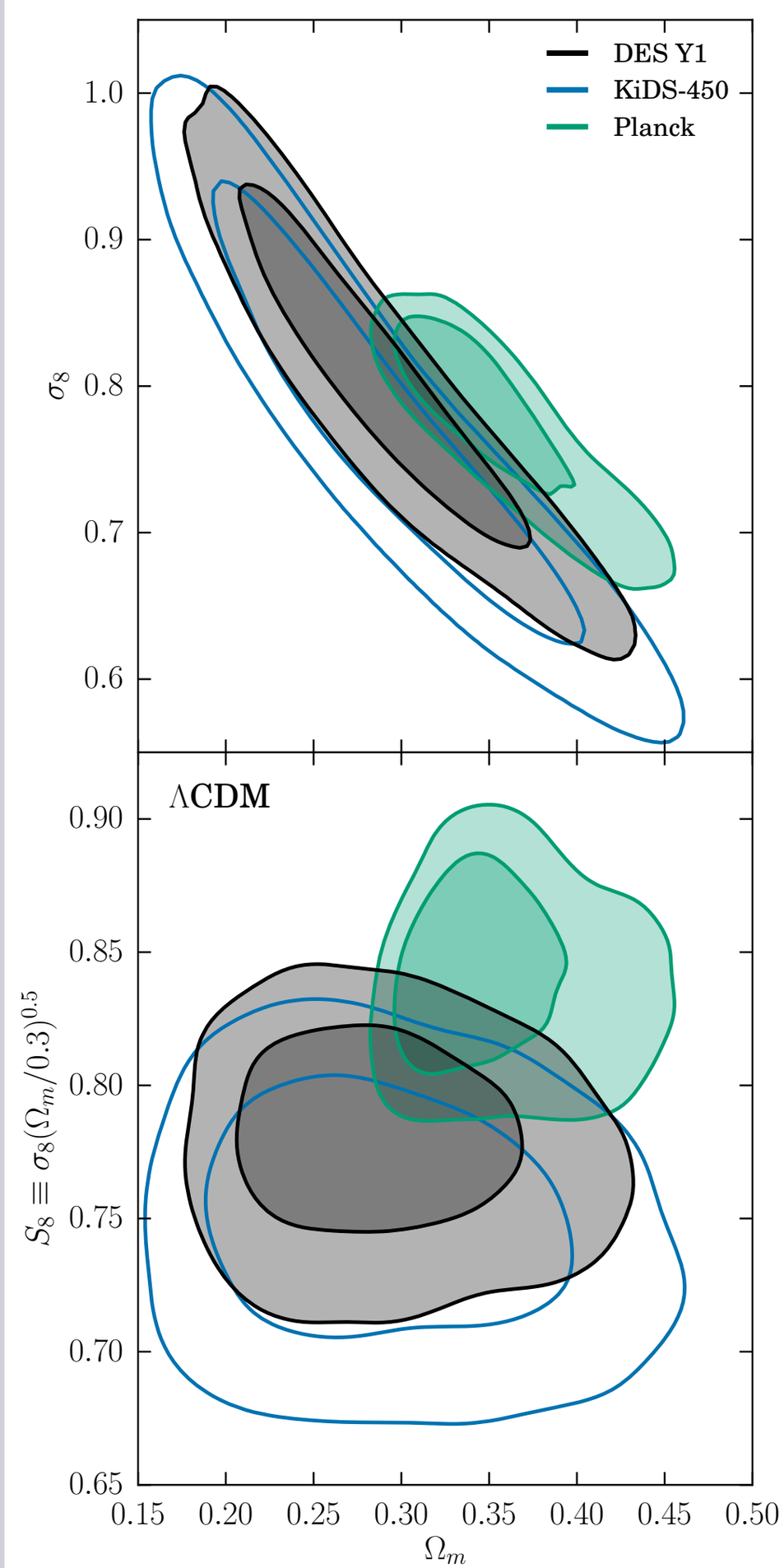
Chang et al 2018

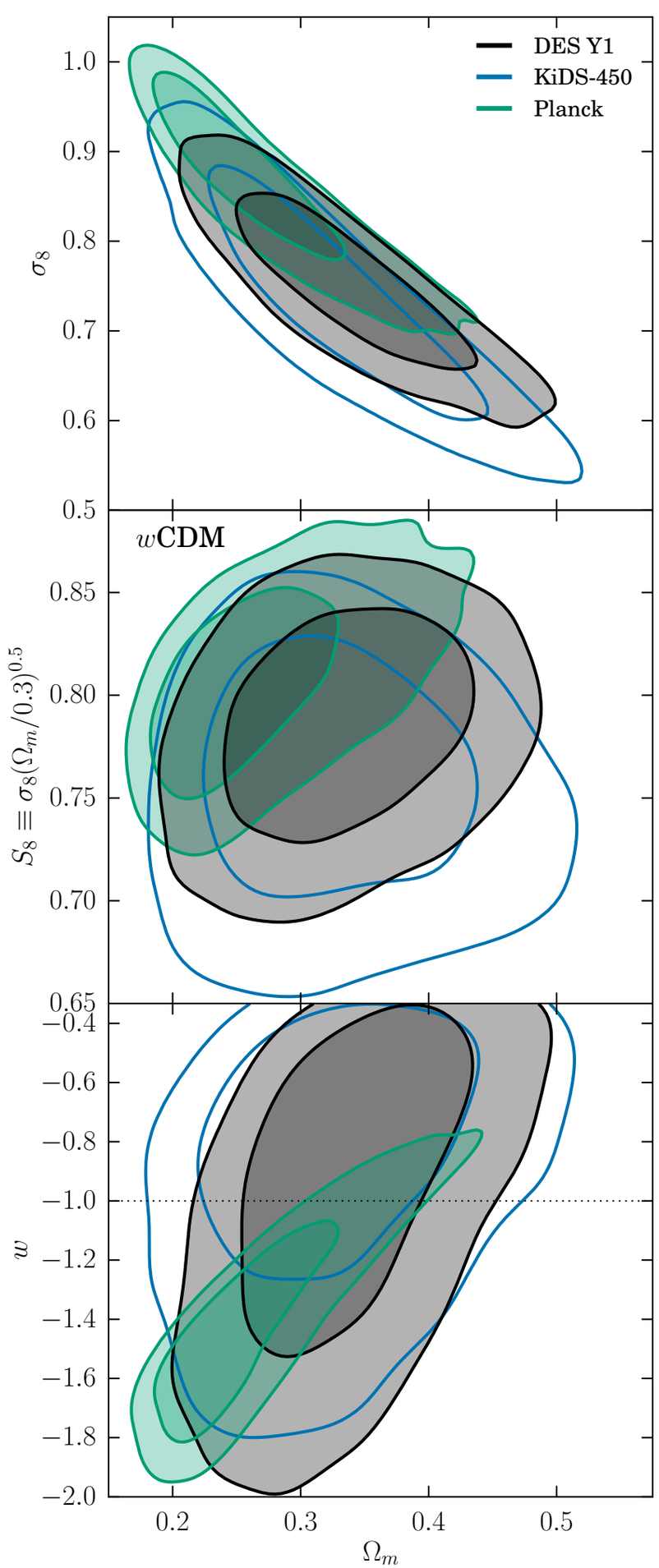
Recent WL cosmology results

Cosmic shear

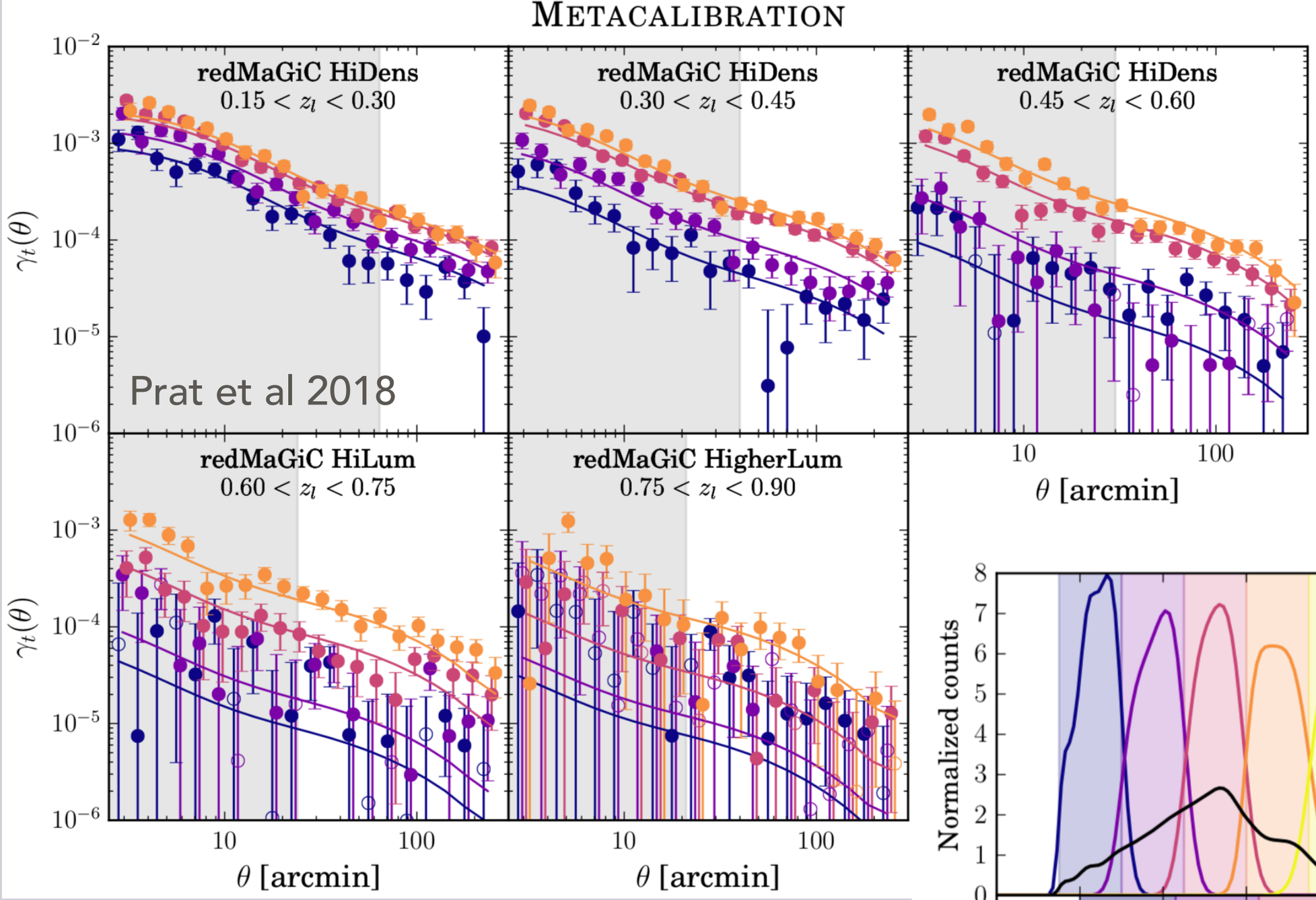


Cosmic shear



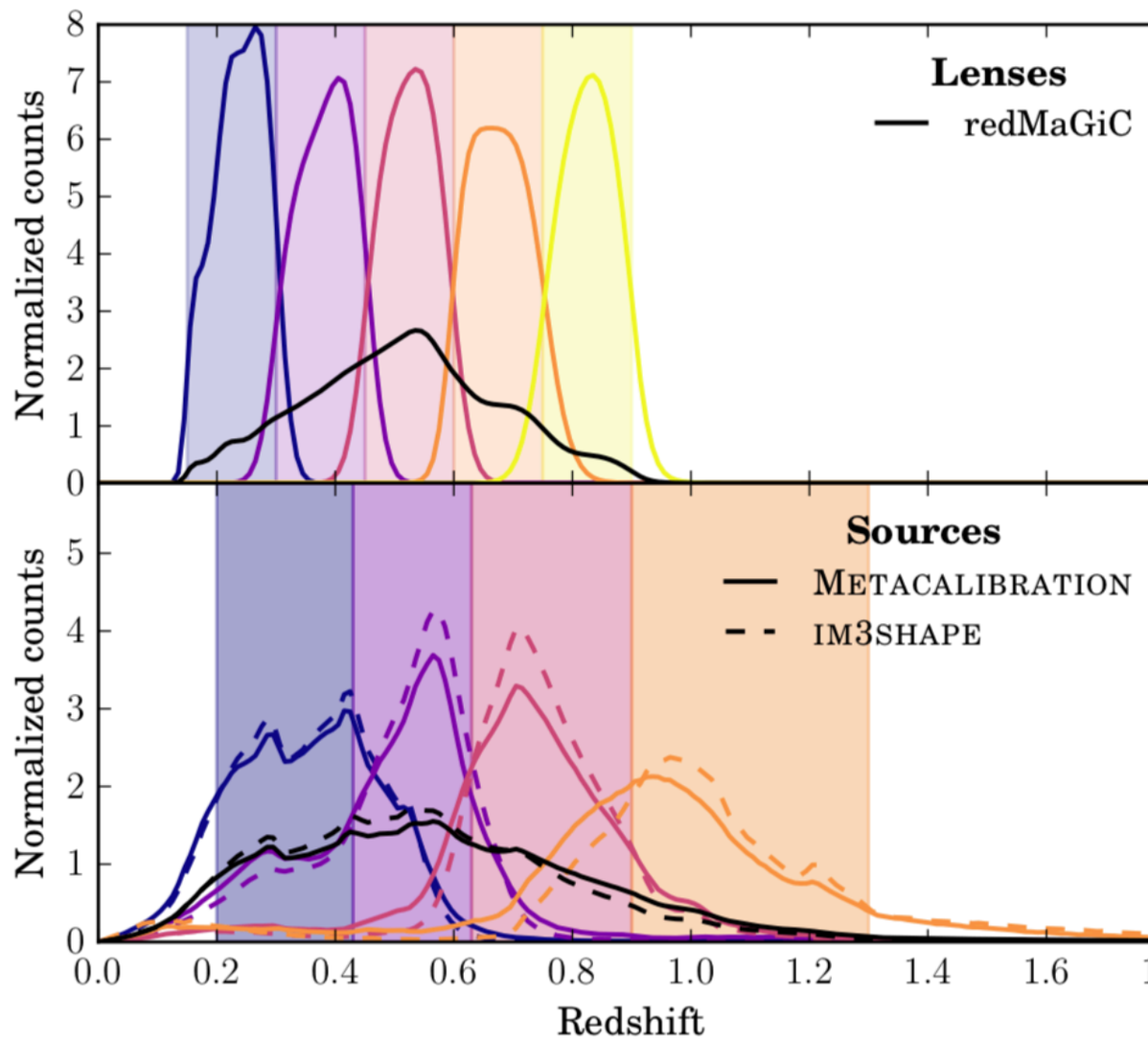


Galaxy-galaxy lensing

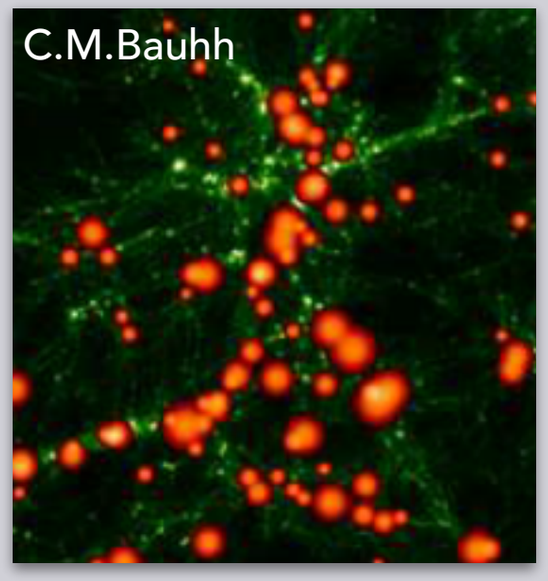


Prat et al 2018

- $0.20 < z_s < 0.43$
- $0.43 < z_s < 0.63$
- $0.63 < z_s < 0.90$
- $0.90 < z_s < 1.30$



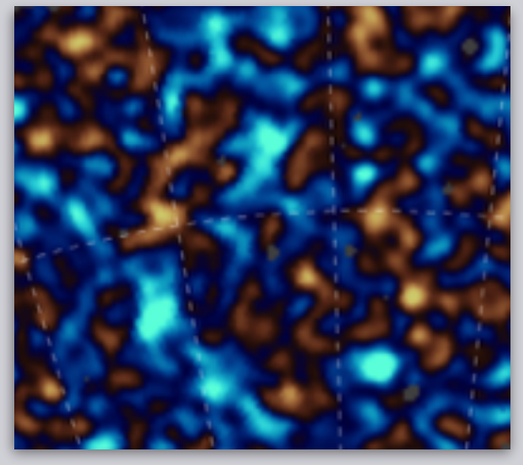
Dark Matter



1) Galaxy clustering

"3x2pt"

3) Galaxy-galaxy lensing



2) Cosmic shear

Combination of these three probes maximizes use of large-scale structure information and jointly and robustly constrains astrophysical and systematic parameters in the analysis

Combined "3x2pt" cosmological analysis

Krause et al 2018

Combination of:

1) Galaxy clustering
2) Cosmic shear
3) Galaxy-galaxy lensing

Marginalizing over:

- 6 (+w) cosmological parameters
  - including the neutrino mass density with prior from oscillation exps.
- 7 astrophysical parameters
- 13 systematic parameters

Data and analysis testing and validation extended over more than two years

Parameter	Prior
Cosmology	
Ω_m	flat (0.1, 0.9)
A_s	flat $(5 \times 10^{-10}, 5 \times 10^{-9})$
n_s	flat (0.87, 1.07)
Ω_b	flat (0.03, 0.07)
h	flat (0.55, 0.91)
$\Omega_\nu h^2$	flat$(5 \times 10^{-4}, 10^{-2})$
w	flat $(-2, -0.33)$
Lens Galaxy Bias	
$b_i (i = 1, 5)$	flat (0.8, 3.0)
Intrinsic Alignment	
$A_{\rm IA}(z) = A_{\rm IA}[(1+z)/1.62]^{\eta_{\rm IA}}$	
$A_{\rm IA}$	flat $(-5, 5)$
$\eta_{\rm IA}$	flat $(-5, 5)$
Lens photo-z shift (red sequence)	
$\Delta z_{\rm l}^1$	Gauss $(0.001, 0.008)$
$\Delta z_{\rm l}^2$	Gauss $(0.002, 0.007)$
$\Delta z_{\rm l}^3$	Gauss $(0.001, 0.007)$
$\Delta z_{\rm l}^4$	Gauss $(0.003, 0.01)$
$\Delta z_{\rm l}^5$	Gauss $(0.0, 0.01)$
Source photo-z shift	
$\Delta z_{\rm s}^1$	Gauss $(-0.001, 0.016)$
$\Delta z_{\rm s}^2$	Gauss $(-0.019, 0.013)$
$\Delta z_{\rm s}^3$	Gauss $(+0.009, 0.011)$
$\Delta z_{\rm s}^4$	Gauss $(-0.018, 0.022)$
Shear calibration	
$m^i_{\rm METACALIBRATION} (i = 1, 4)$	Gauss $(0.012, 0.023)$
$m^i_{\rm IM3SHAPE} (i = 1, 4)$	Gauss $(0.0, 0.035)$

Combined "3x2pt" cosmological analysis

Krause et al 2018

Combination of:

1) Galaxy clustering
2) Cosmic shear
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Great way to study more than just cosmology!

See Simon's talk…

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Combined “3x2pt” cosmological analysis - components

Shear calibration

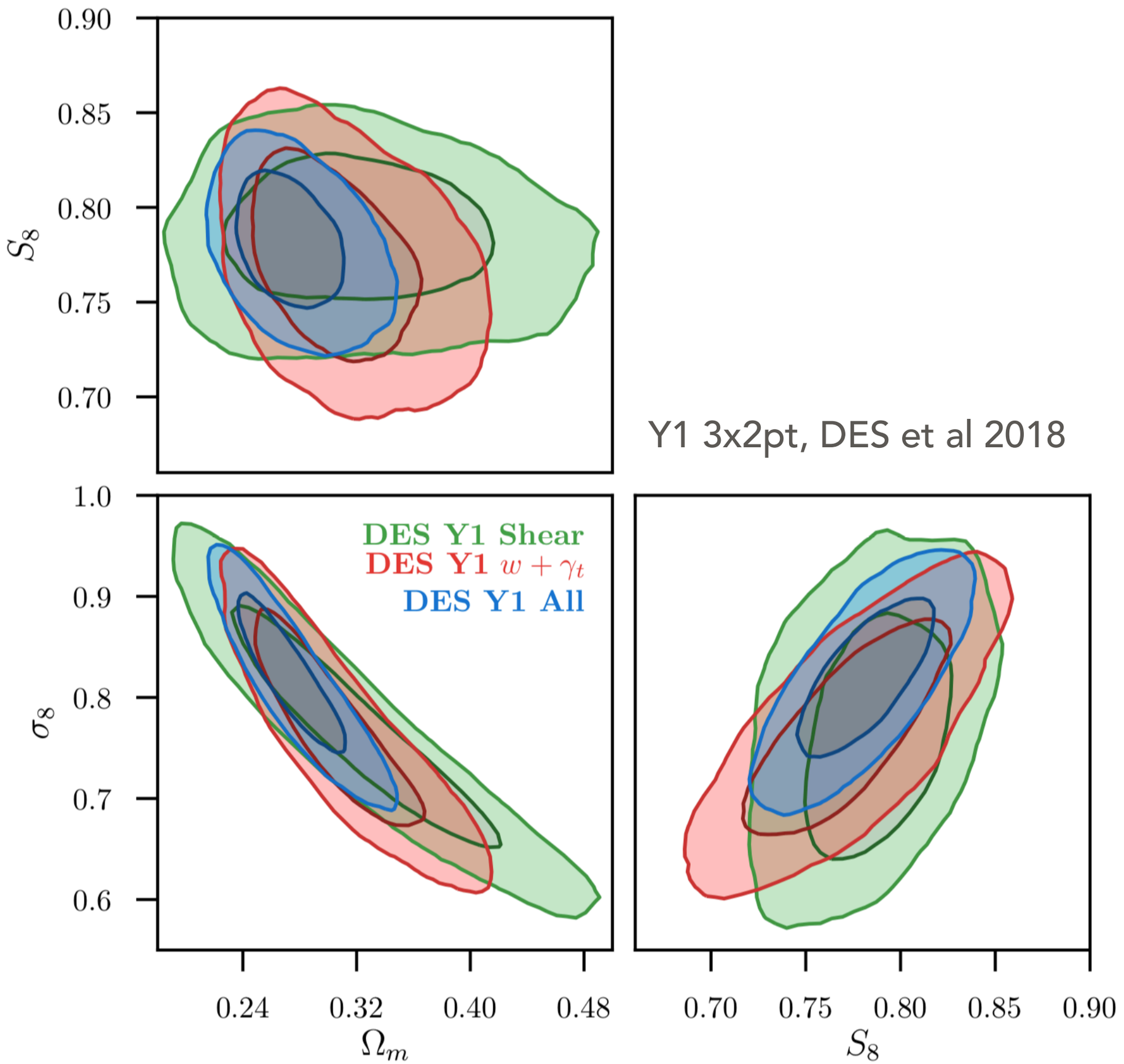
- Metacalibration - requires rerunning photo-zs five times to calibrate selection bias
- Accuracy of calibration confirmed in simulations, but not the hyper-realistic sims used to calibrate im3shape
- Marginalized over m per z-bin (correlation accounted for by widening per-bin priors); non-zero centered prior to account for estimated neighbor/blending bias
- Subtracted off residual mean shear

Photo-z calibration

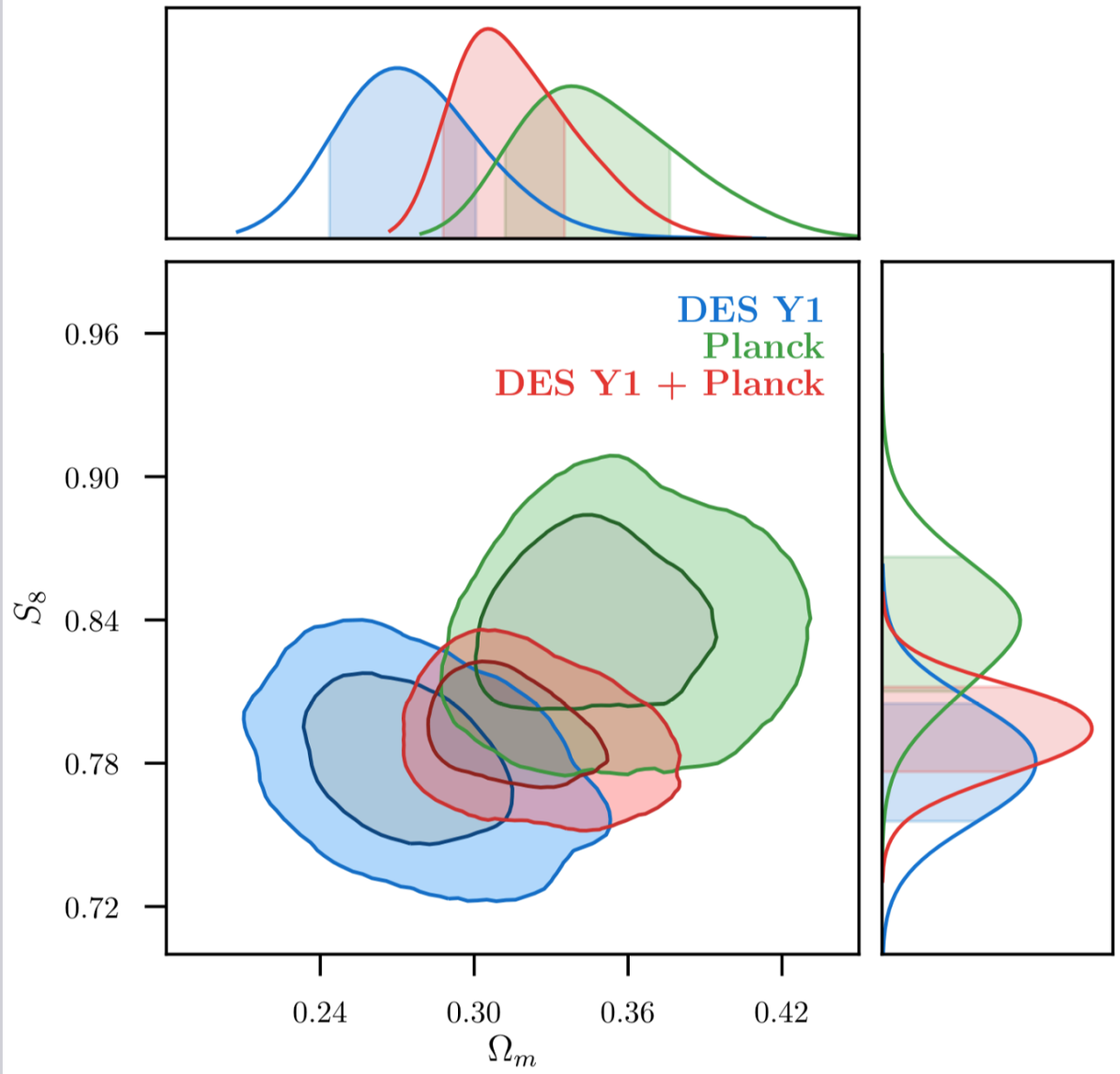
- BPZ with mean z per z-bin calibrated from COSMOS redshifts
- Calibration implemented as non-zero centered prior, with width derived jointly from COSMOS and cross-clustering correlation w/ RedMaGiC galaxies
- Systematic biases and uncertainties (i.e., cosmic variance) in methods constrained from simulations
- Marginalized over Delta-z per z-bin (correlation accounted for by widening per-bin priors)
- Tomographic selection done using metacal-measured fluxes; n(z) reconstruction from MOF fluxes
- Lenses: RedMaGiC photo-zs with calibration from cross-correlation with SDSS

Combined “3x2pt” cosmological analysis

Is DES internally consistent?

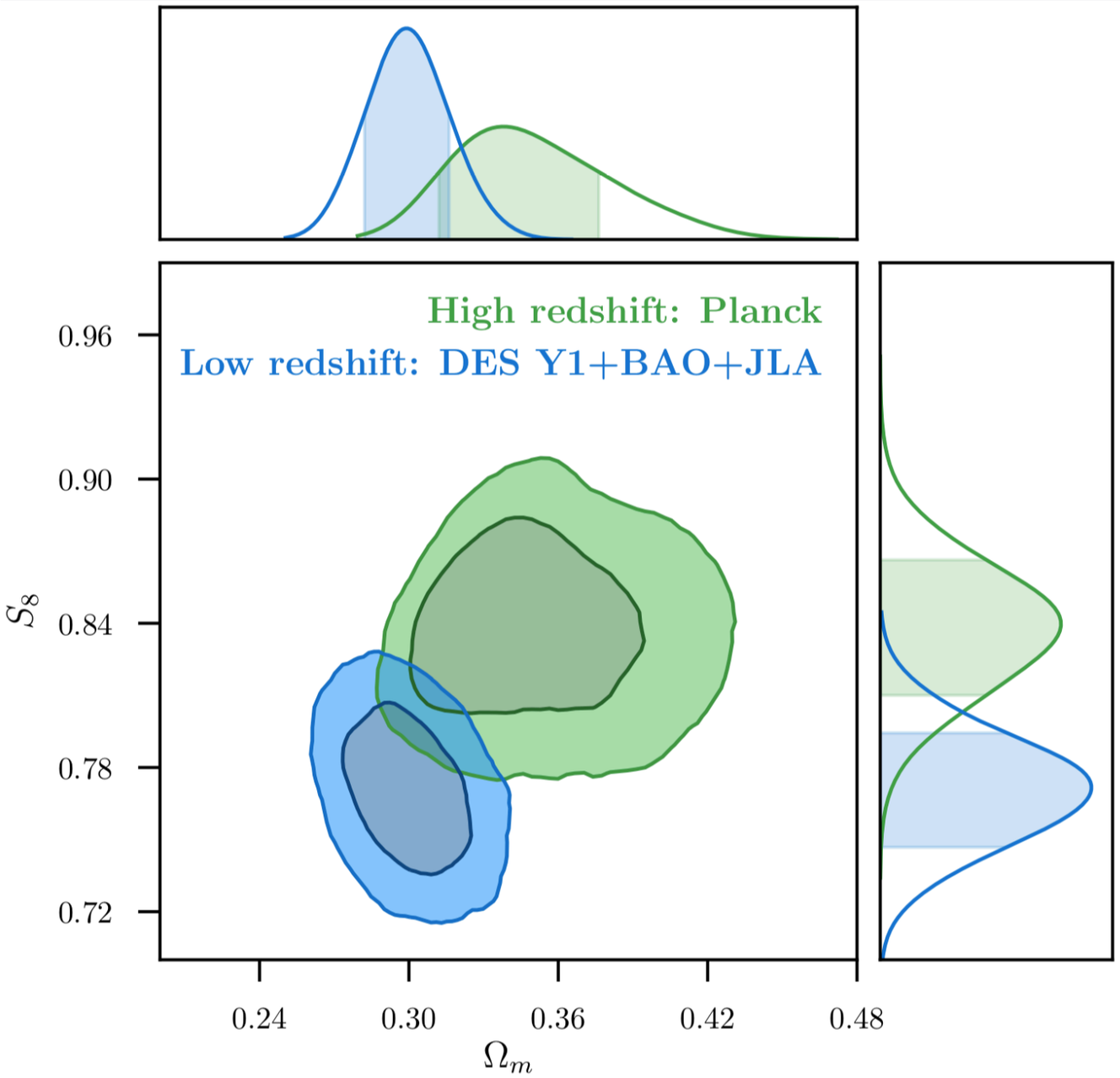


Y1 3x2pt, DES et al 2018



Y1 3x2pt, DES et al 2018

Is DES/late Universe
consistent with early Universe?



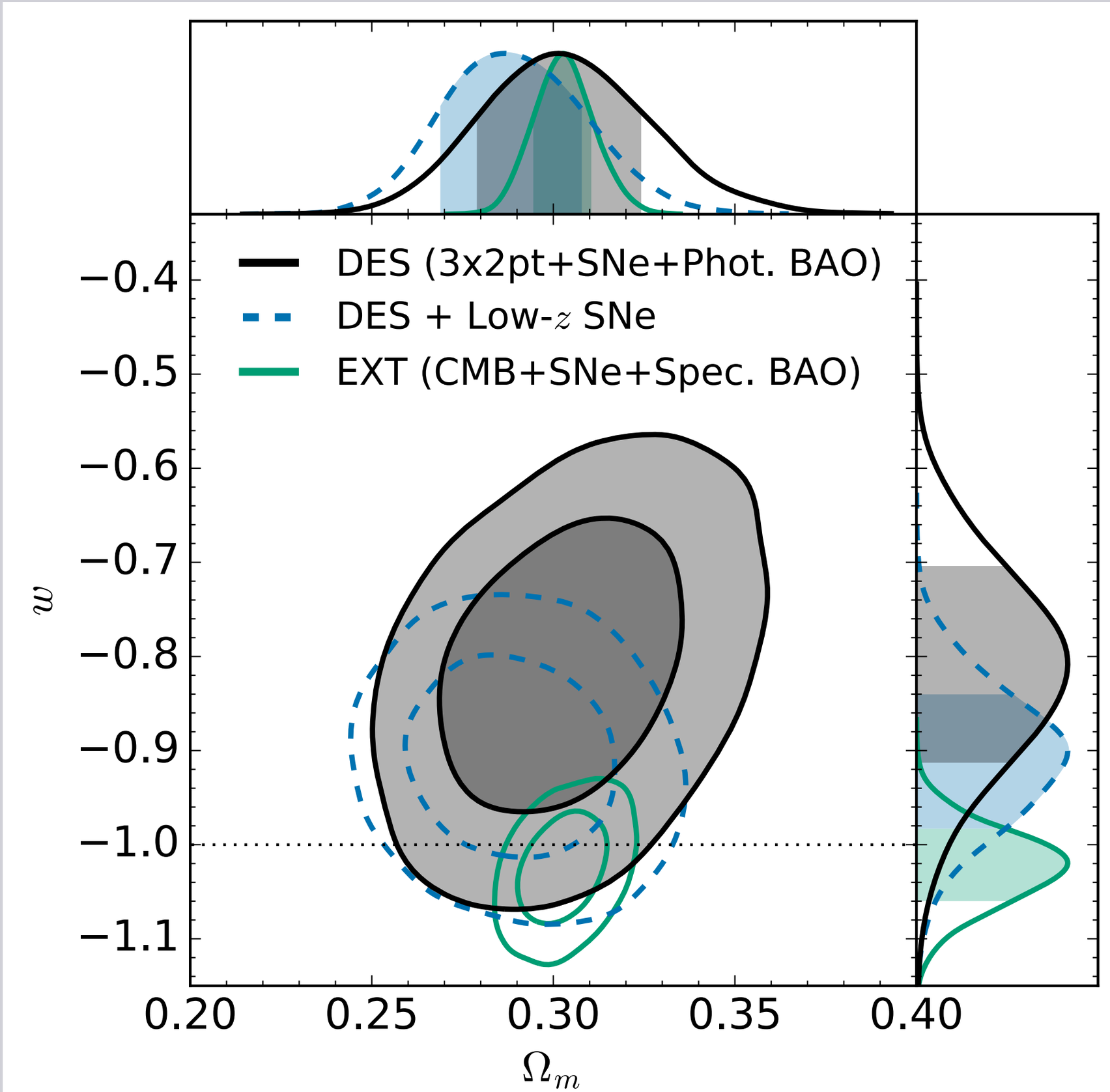
DES does a lot more than WL!

Expansion probes

- *SNe Ia*
- *BAO*

Growth probes

- *Galaxy clustering*
- *Weak lensing*
- Cluster lensing/counts



Where does DES Y3/Y5 stand?

Almost 100M shapes across 4160 sq. deg!

Primarily real-space analysis (harmonic effort)
Improvements in shear methodology (neighbor/blending effects in earlier slide)
New photo-z methodology (*see Daniel's talk*)
Attempting to push to smaller scales and improve modeling

- Nonlocal effects in galaxy-galaxy lensing
- Nonlinear bias
- Baryonic effects
- Nonlinear IA (*see Simon's talk*)

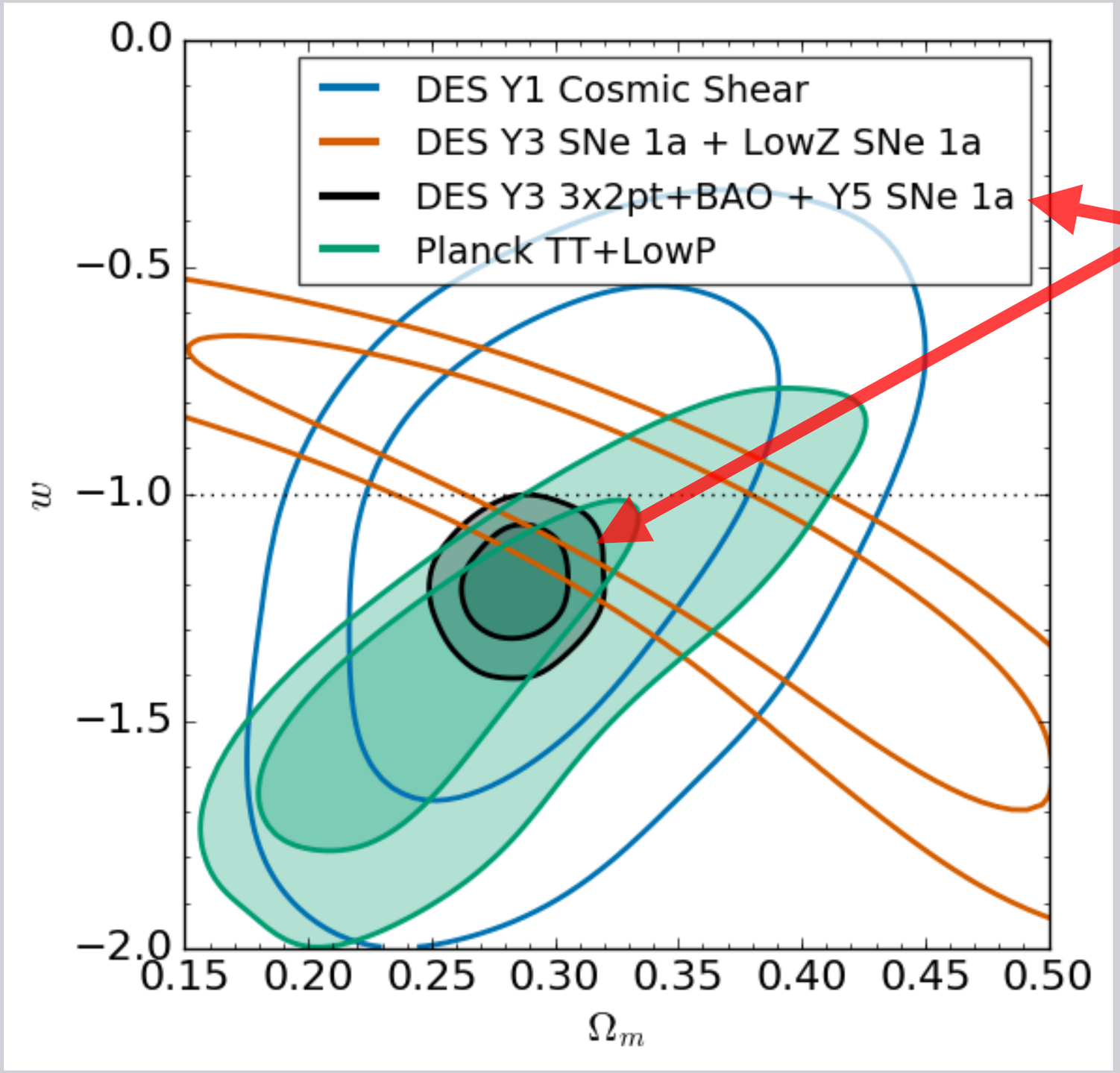
Talk to Bhuv/Joe

New blinding methodology - consistently shifting multi-probe data vector in wCDM-space
Exciting potential in internal combined probe comparisons beyond 3x2pt

Plan to finish 3x2pt this year and move on to final Y6 analysis.

- Also expect factor of ten more SNe Ia in ongoing Y5 photometric analysis

Where does DES Y3/Y5 stand?



Projection based on expected statistical and analysis improvements - not data!