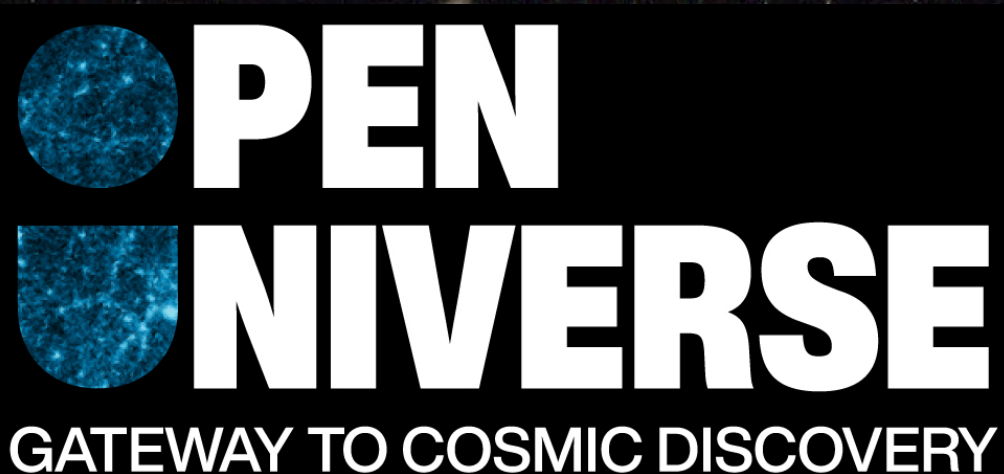


A Decade of Weak Lensing in DES: From Promise to Precision Science

Michael Troxel
Duke University
June 11, 2026
(CCAPP Fellow 2016-2018)

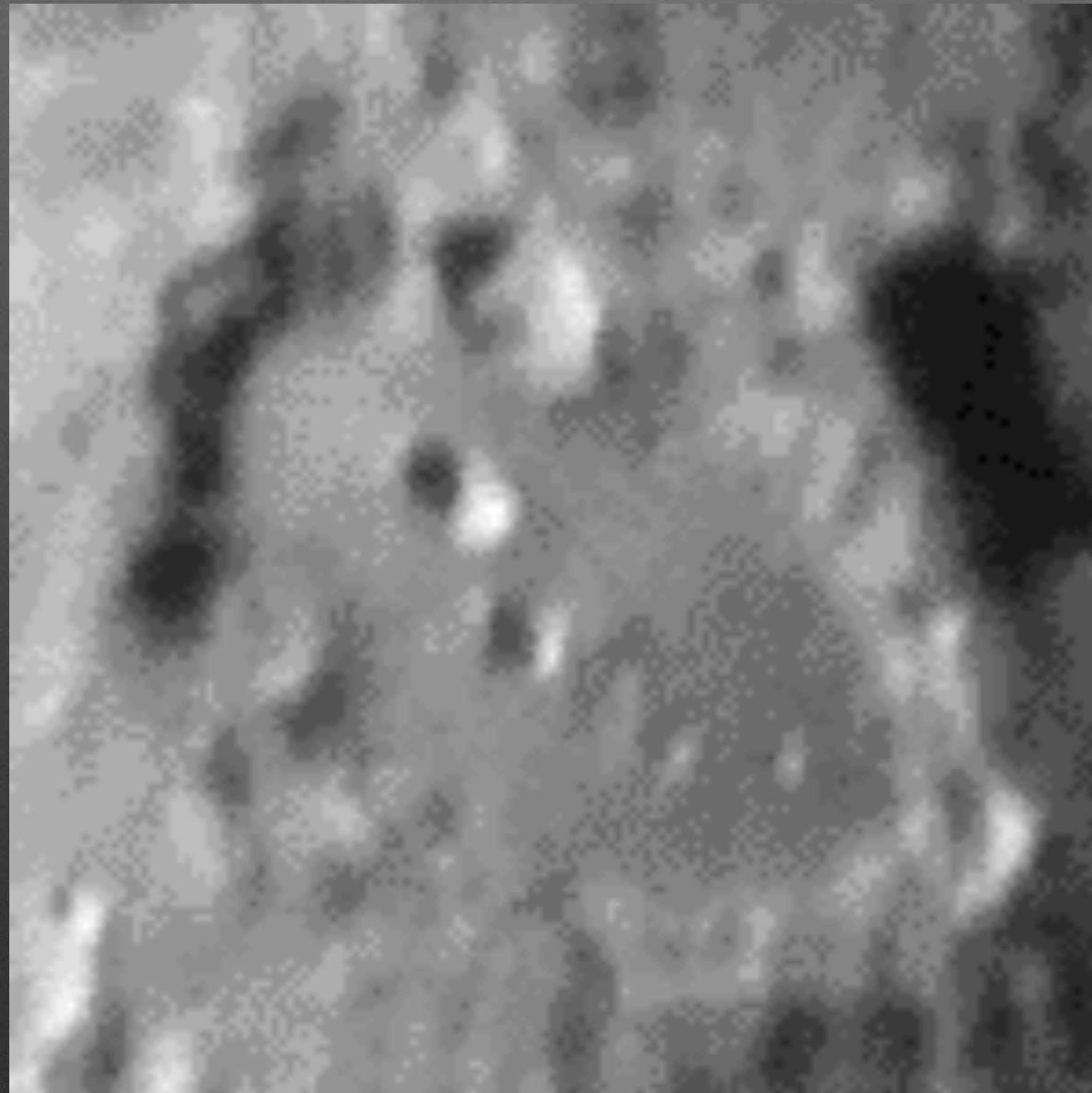


Favourite quote of the meeting

We should have listened to the lensers all along. - Annika

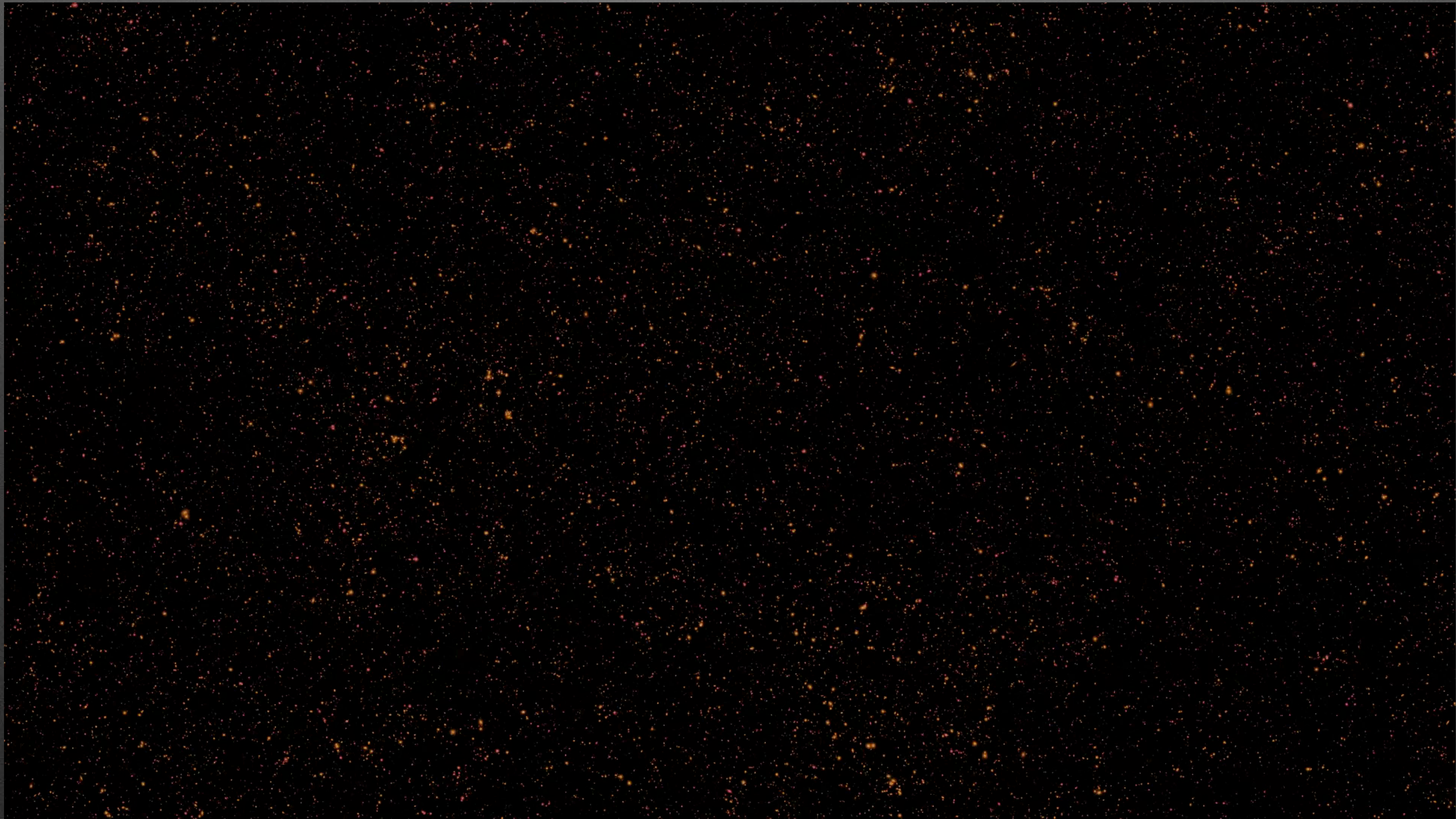
Weak lensing - cosmic shear

Nothing you see is actually what it looks like to you - this is even more true when we look out into the Universe.



Weak lensing - cosmic shear

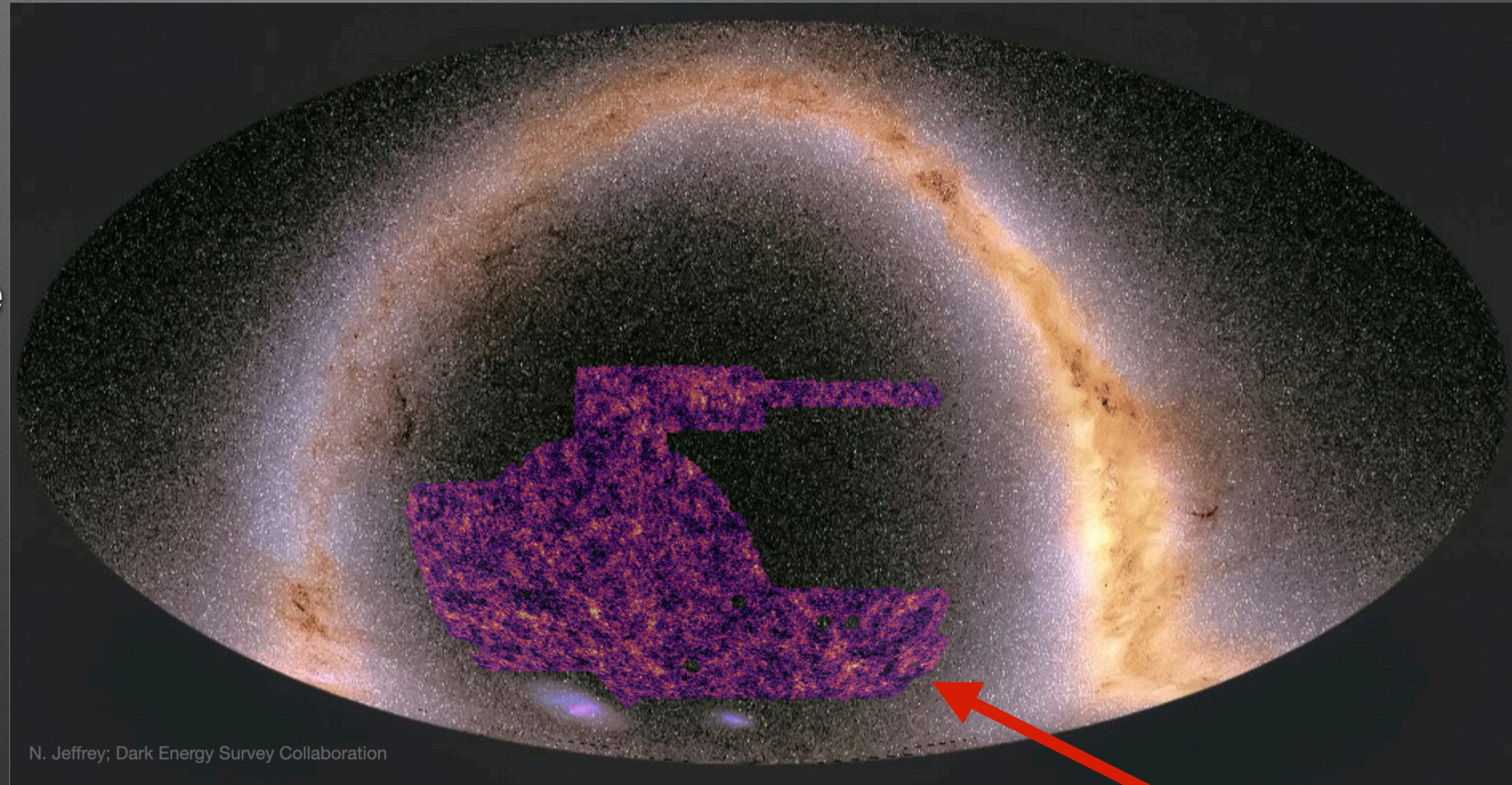
Nothing you see is actually what it looks like to you - this is even more true when we look out into the Universe.



Weak lensing - cosmic shear

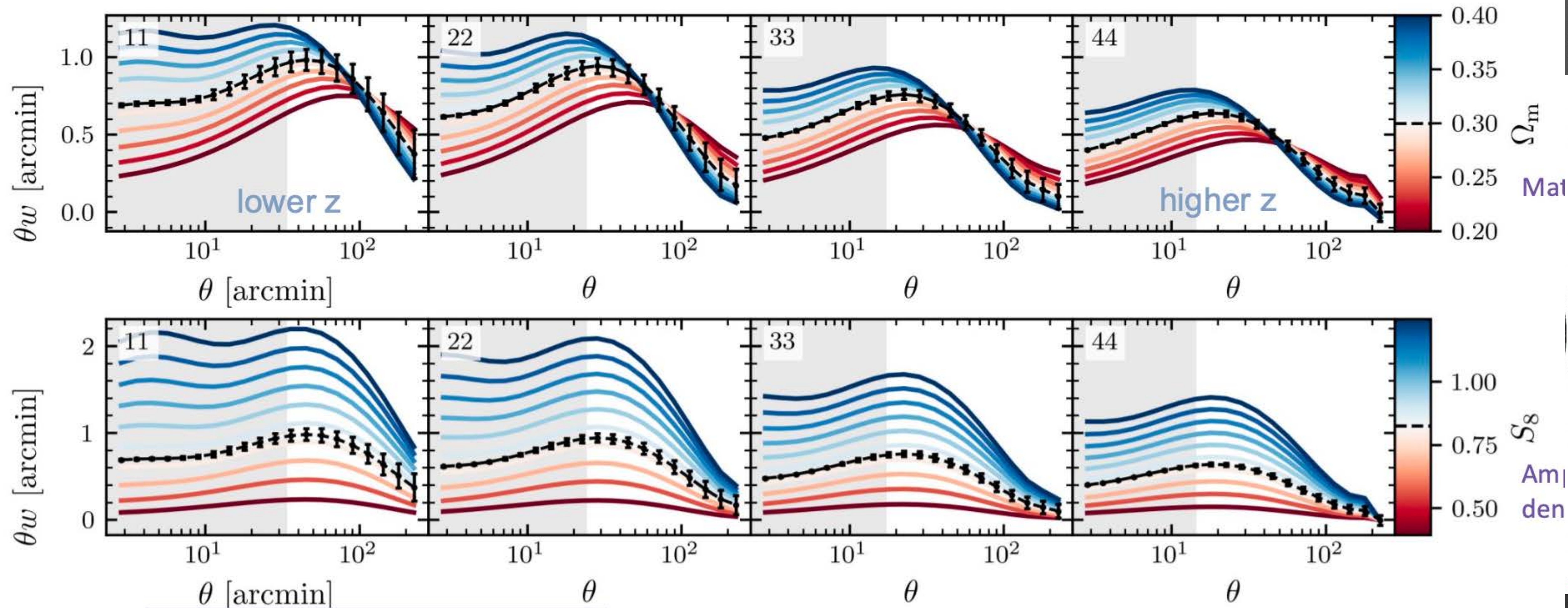
Growth of large-scale structure in the Universe:

1. Slowed down by accelerated expansion due to overall geometry & dark energy.
2. Accelerated by additional gravitational mass (or curvature) due to dark matter.



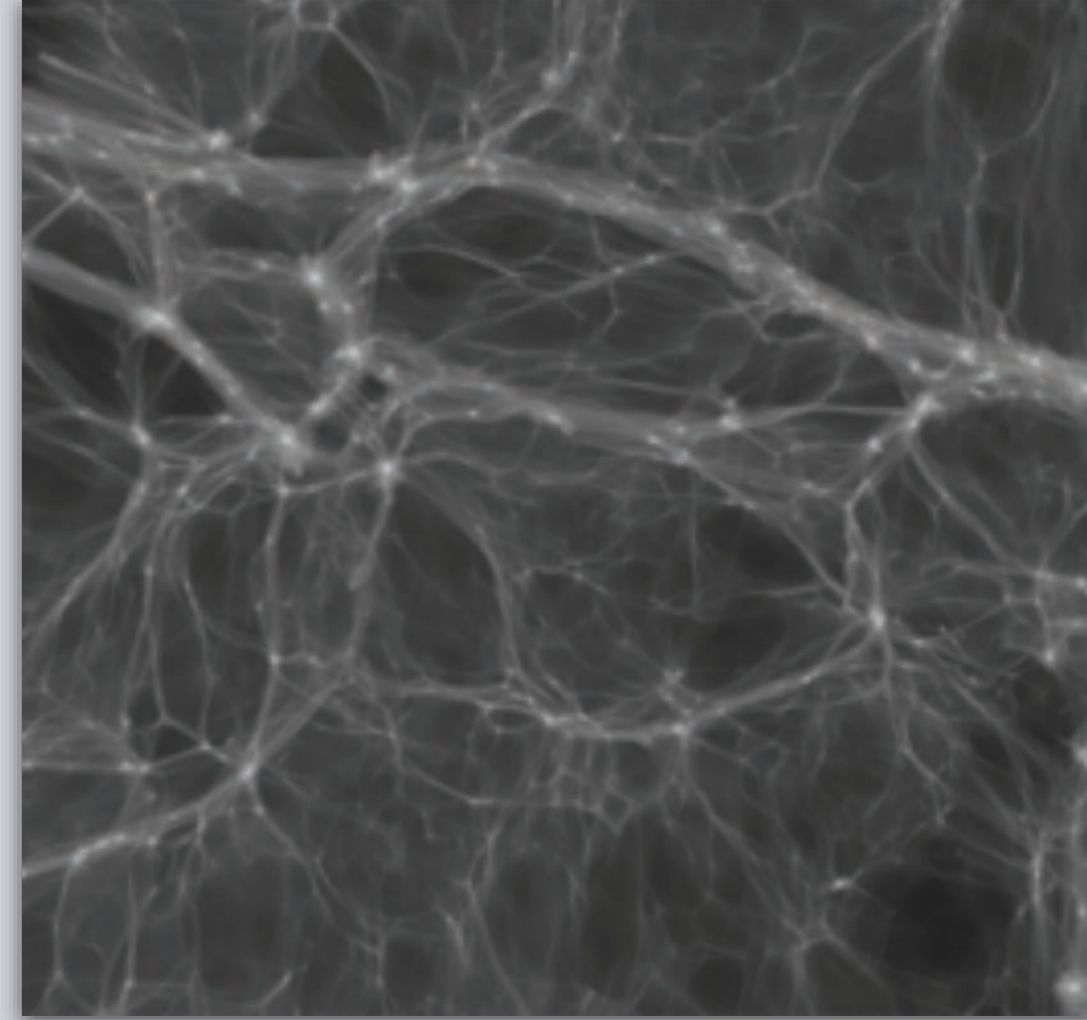
DES dark matter map

Weak lensing - cosmic shear

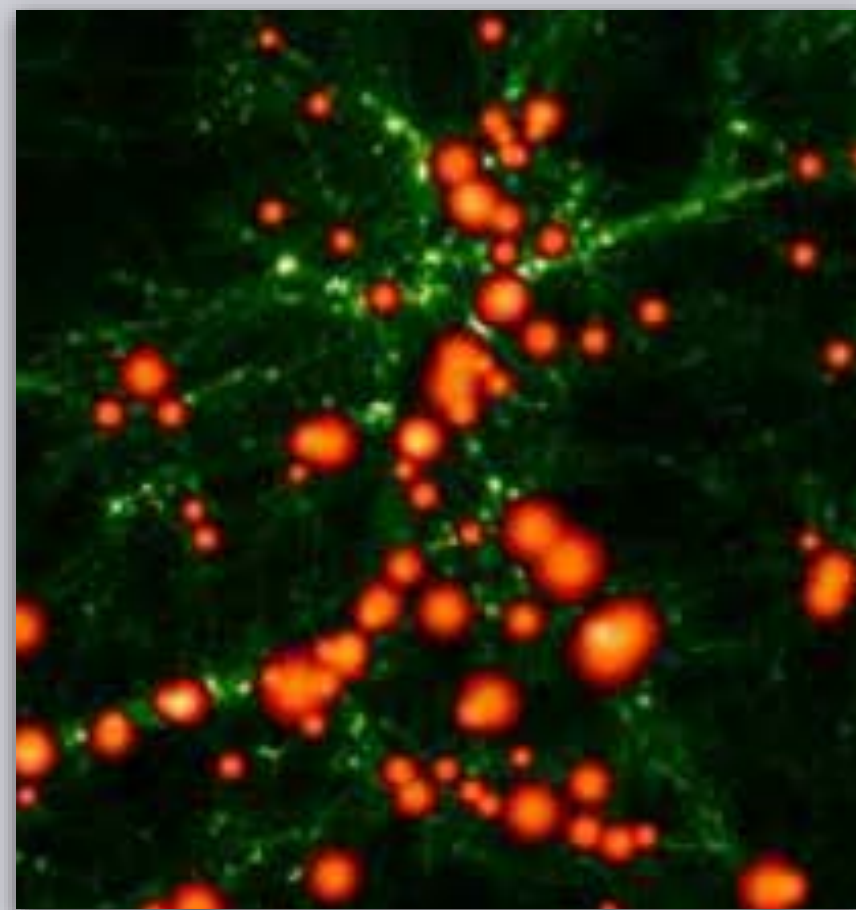


Credit: Jessie Muir

**Pioneered and
refined by CCAPP
Fellows in DES**

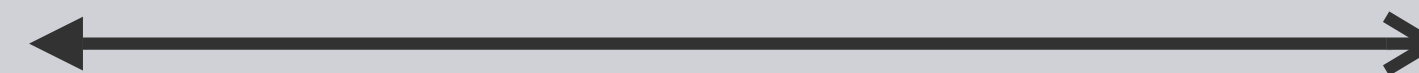


Dark Matter

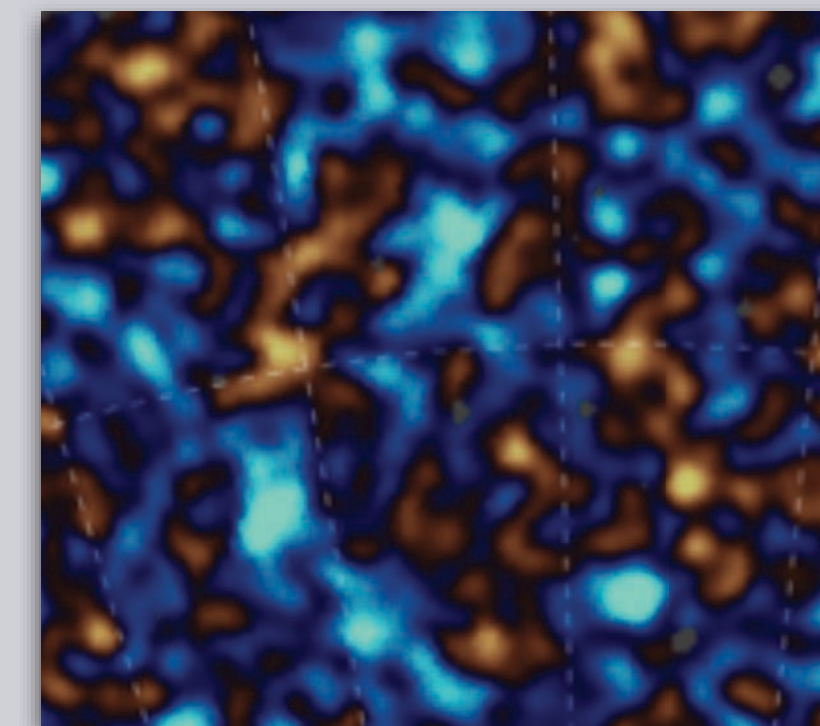


1) Galaxy clustering

"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

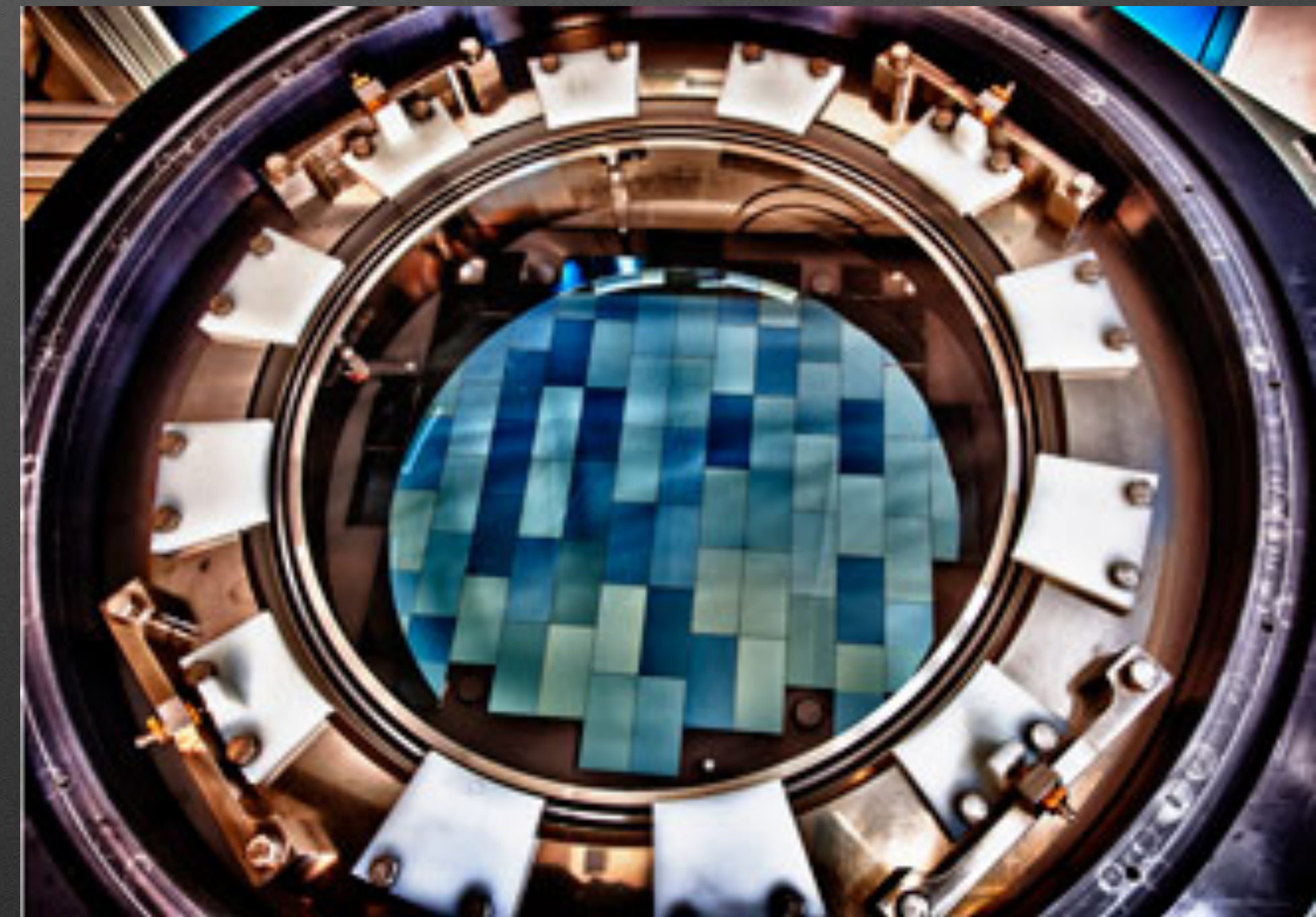
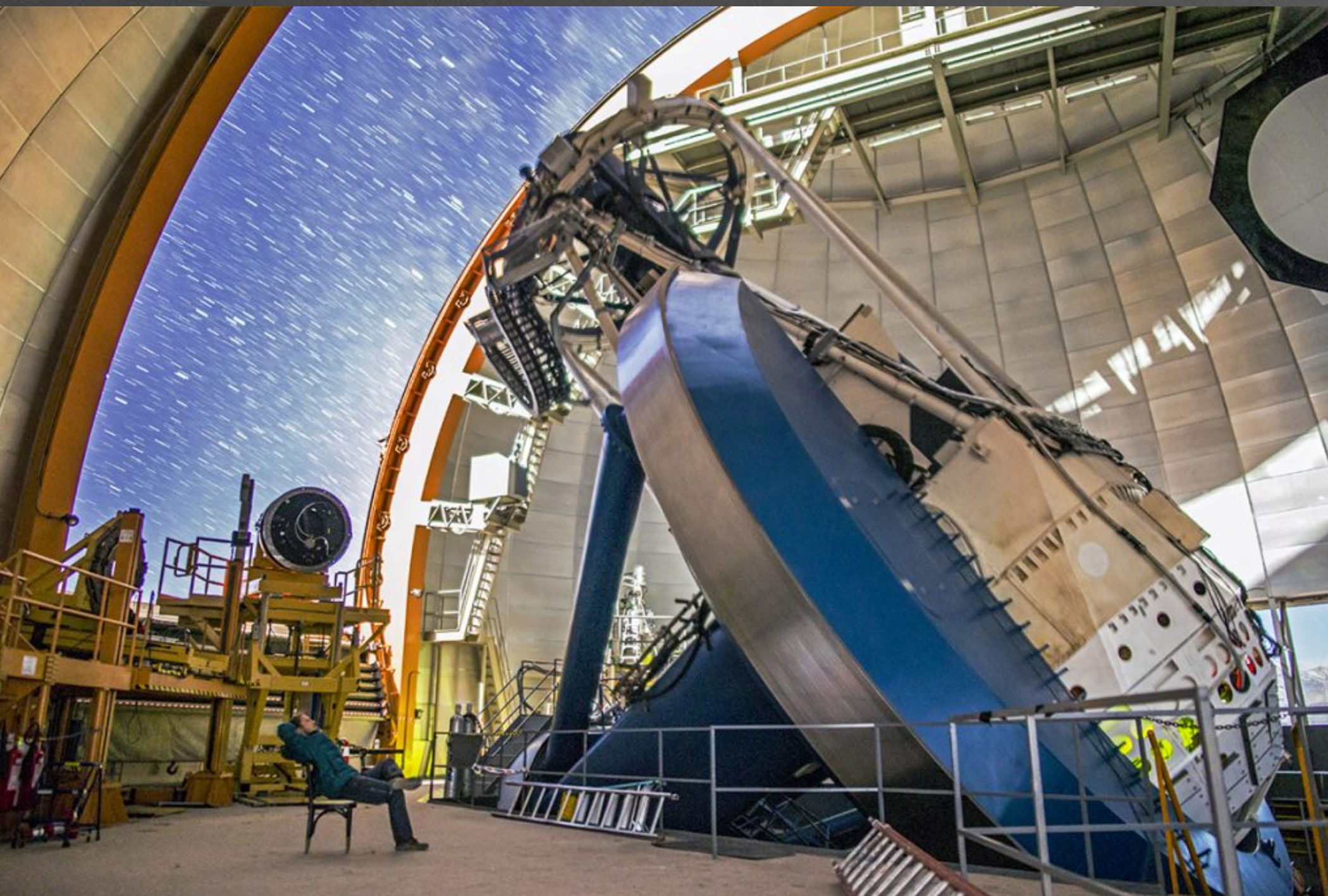
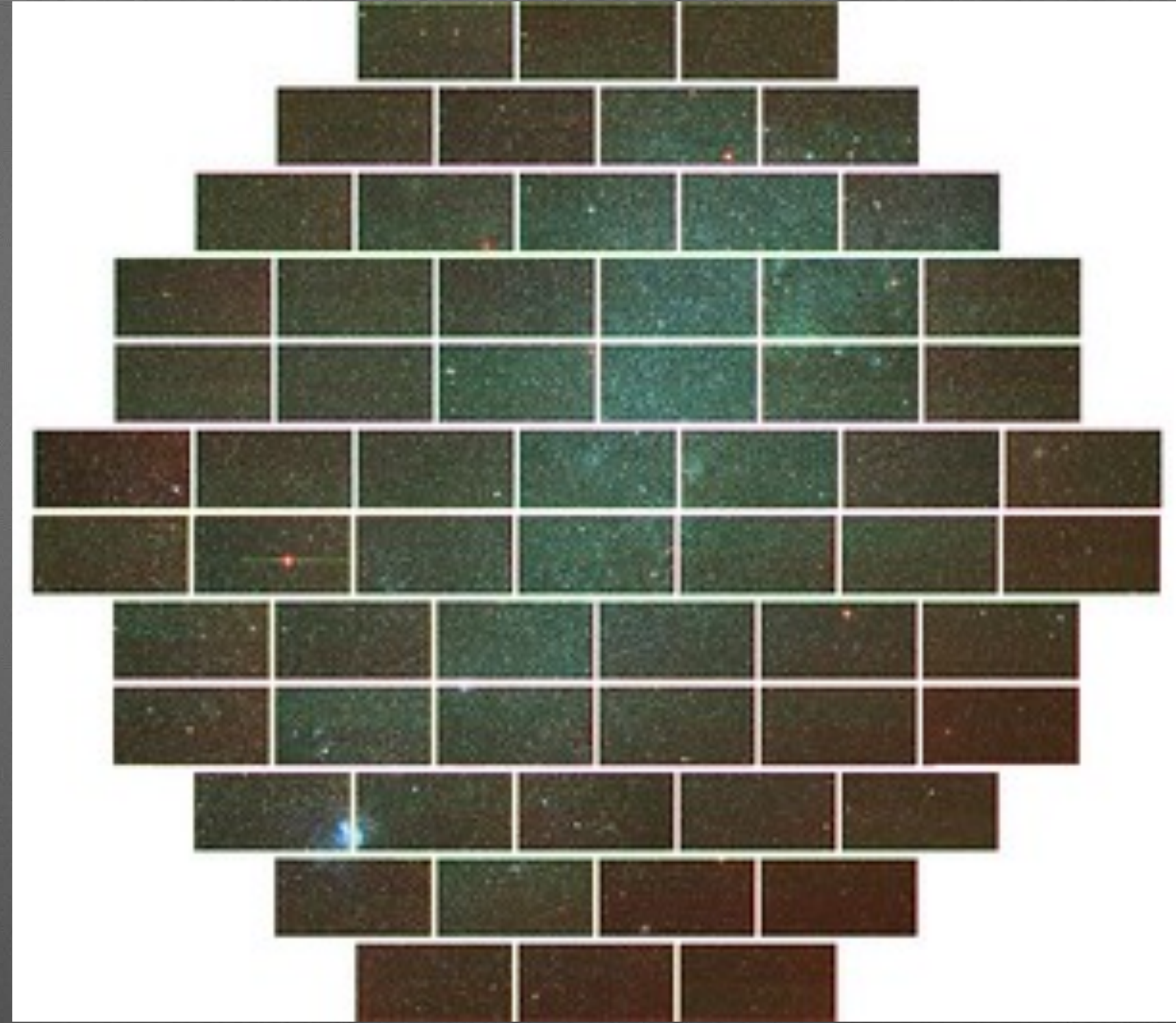
The Dark Energy Survey

Complete six-year, 5000 sq. deg survey to 24th mag (10 tilings)

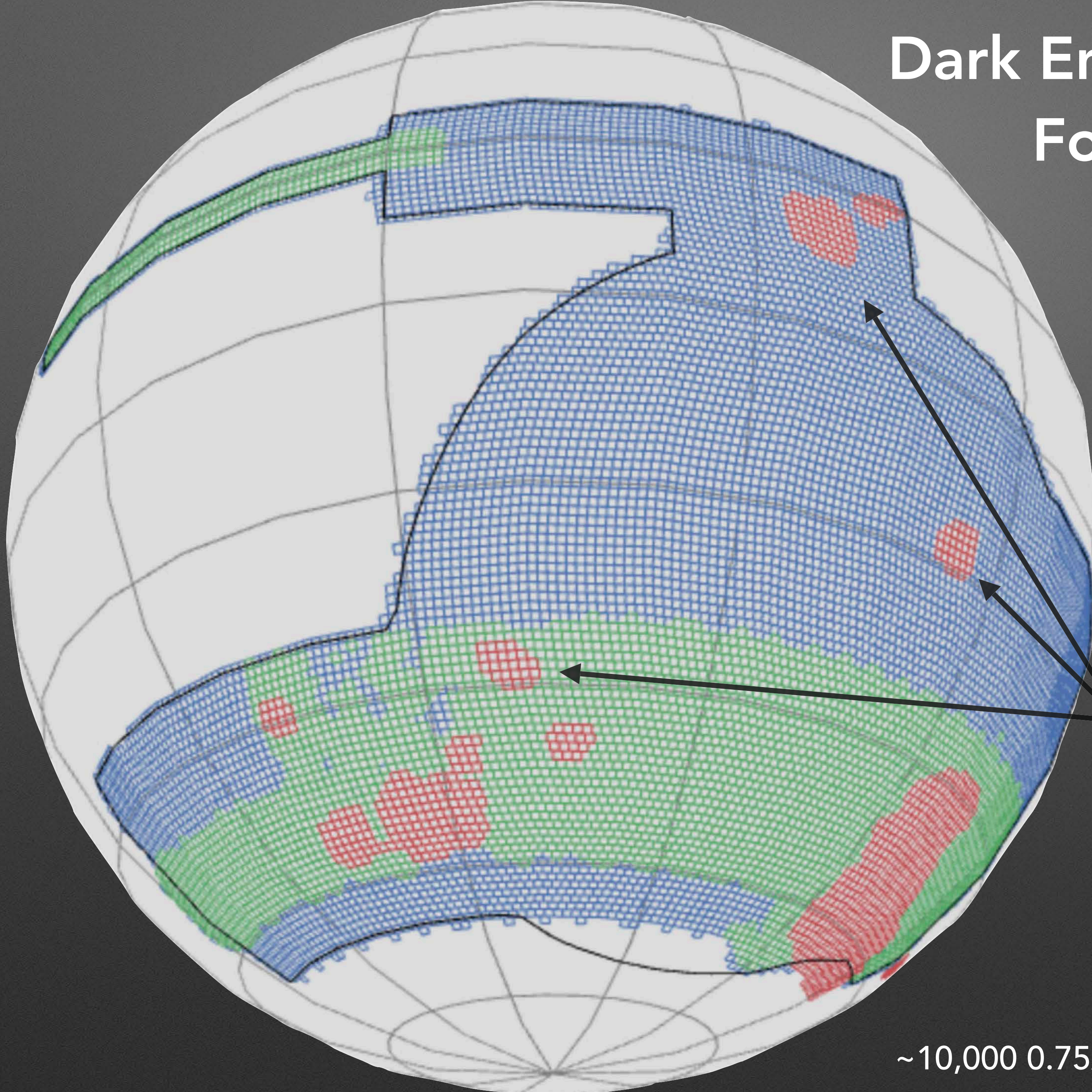
DECam: a 570 Mpix camera on the 4m Blanco Telescope

Approx. 3 sq. deg field of view

Observing in (u)grizY filters



Dark Energy Survey Footprint



Year 1

Science
Verification

Supernovae
Fields

Complete

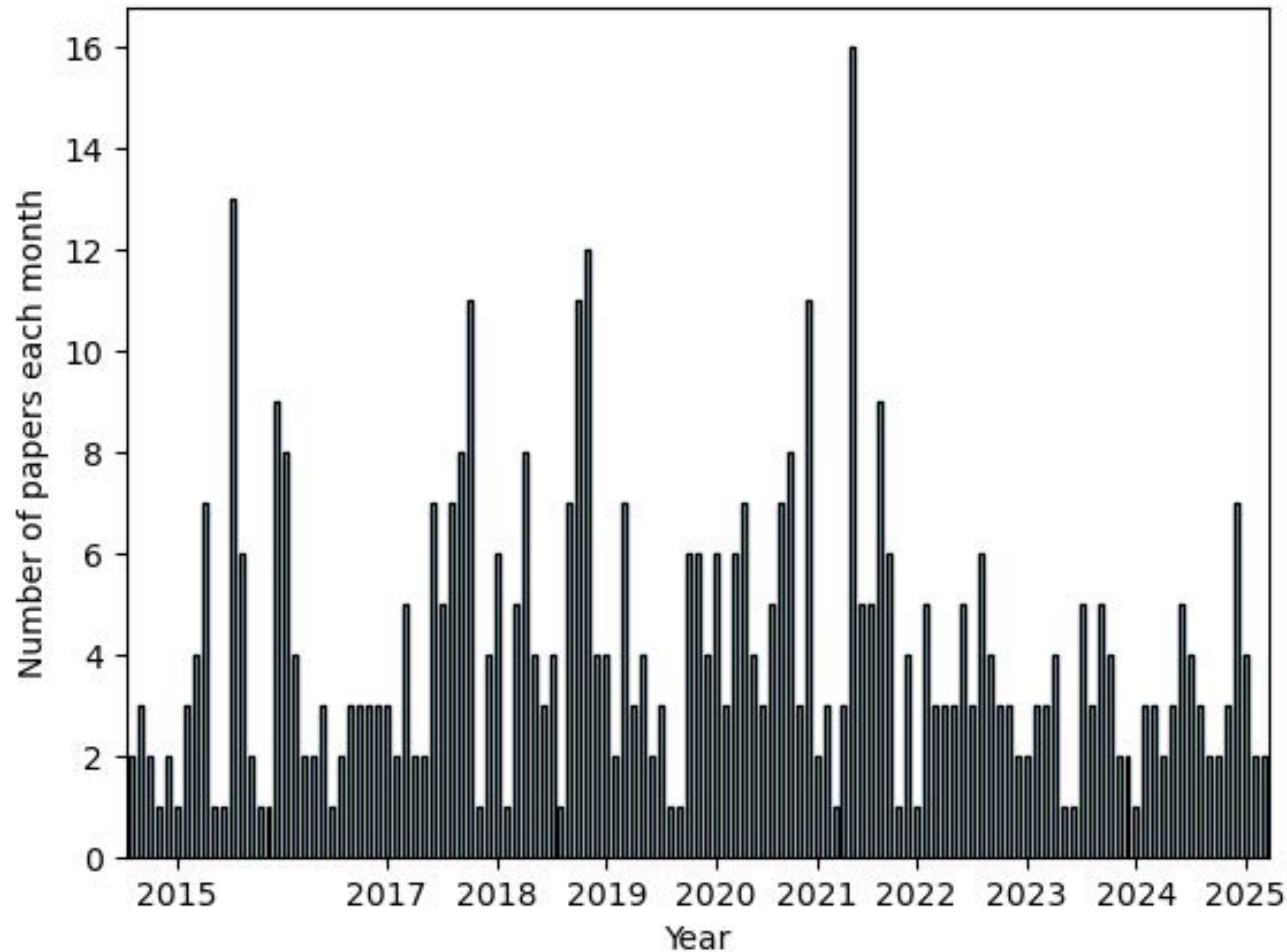
~10,000 0.75x0.75 deg coadd images







DES — not just weak lensing



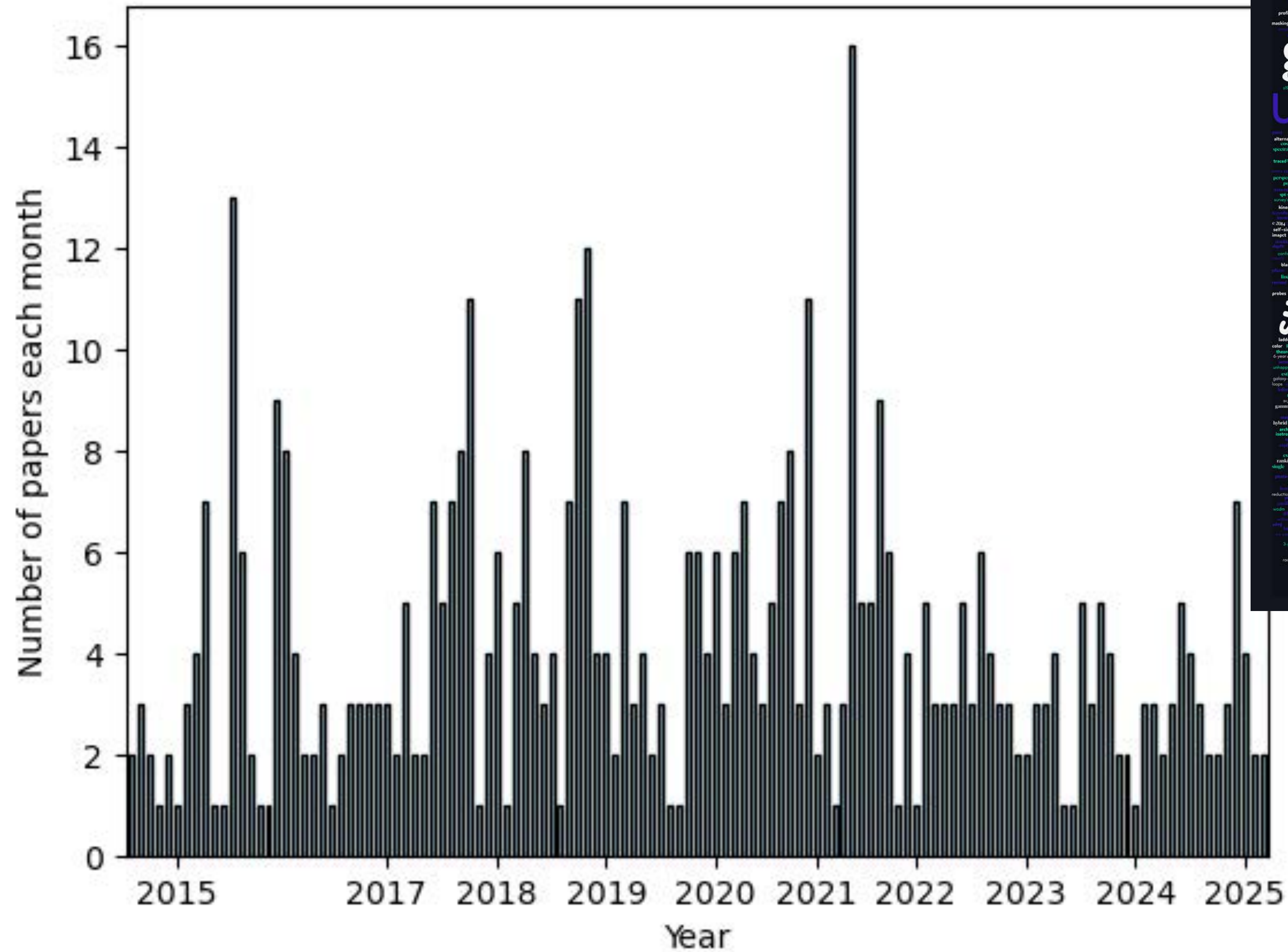
Four primary probes:

- 1) Weak lensing
- 2) Supernovae type Ia
- 3) Baryon Acoustic Oscillations
- 4) Galaxy clusters

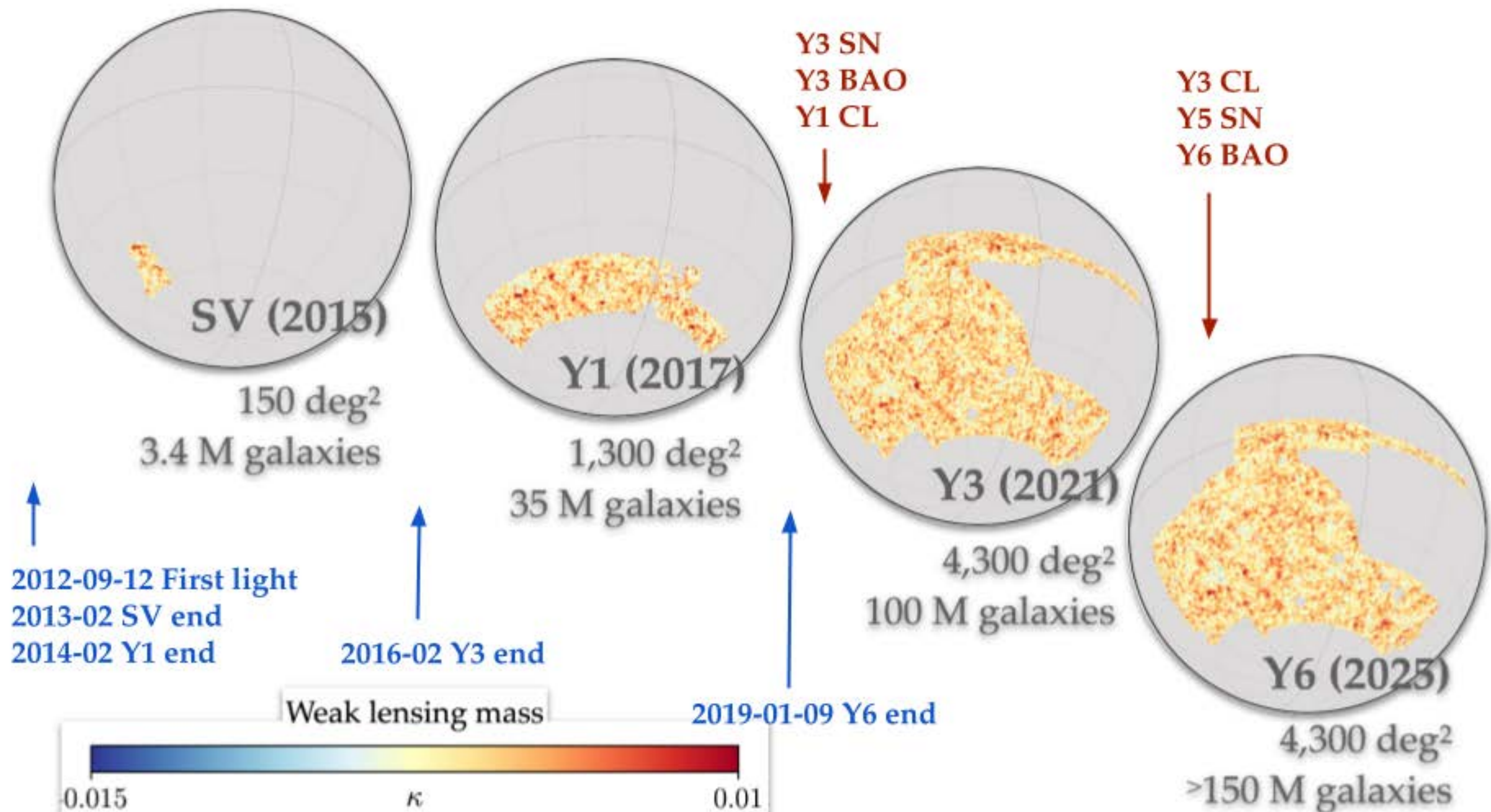
+ lots of astrophysics

Over 500 publications over the last ~decade!

DES — not just weak lensing



Over 500 publications
over the last ~decade!



DES Weak Lensing — how far have we come?

Science Verification

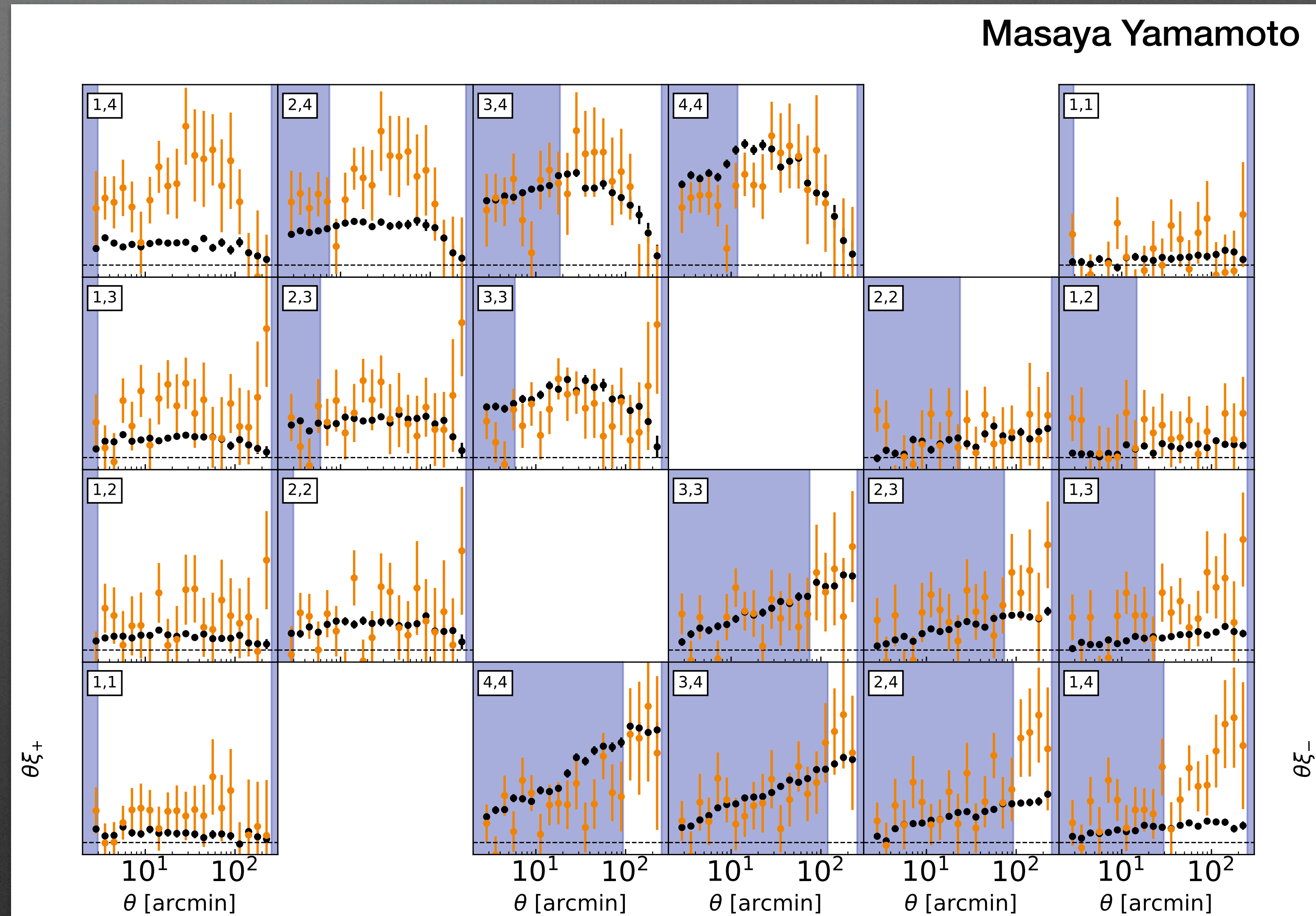
3M galaxies, S/N = 10

Full survey data (Year 6)

152M galaxies

S/N = 71

$n_{\text{eff}} = 8.22$

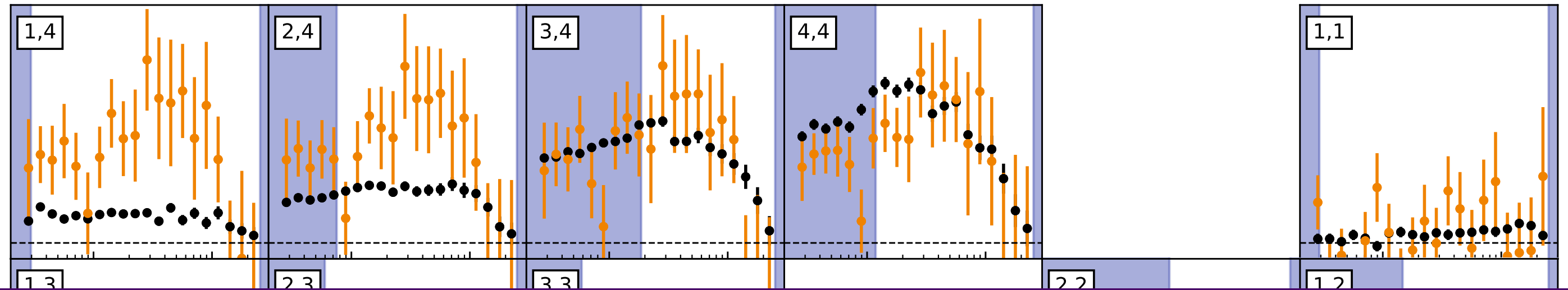


DES Weak Lensing — how far have we come?

Science Verification

3M galaxies, S/N = 10

Masaya Yamamoto



Physics

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Weak Lensing Becomes a High-Precision Survey Science

Anže Slosar

Physics Department, Brookhaven National Laboratory, Upton, NY 11973, USA

August 27, 2018 • *Physics* 11, 85

Dark Energy Survey Year 1 results:
Cosmological constraints from cosmic shear

M.A. Troxel *et al.* (Dark Energy Survey Collaboration)

Phys. Rev. D 98, 043528 (2018)

Published August 27, 2018

DES Weak Lensing — how far have we come?

Science Verification

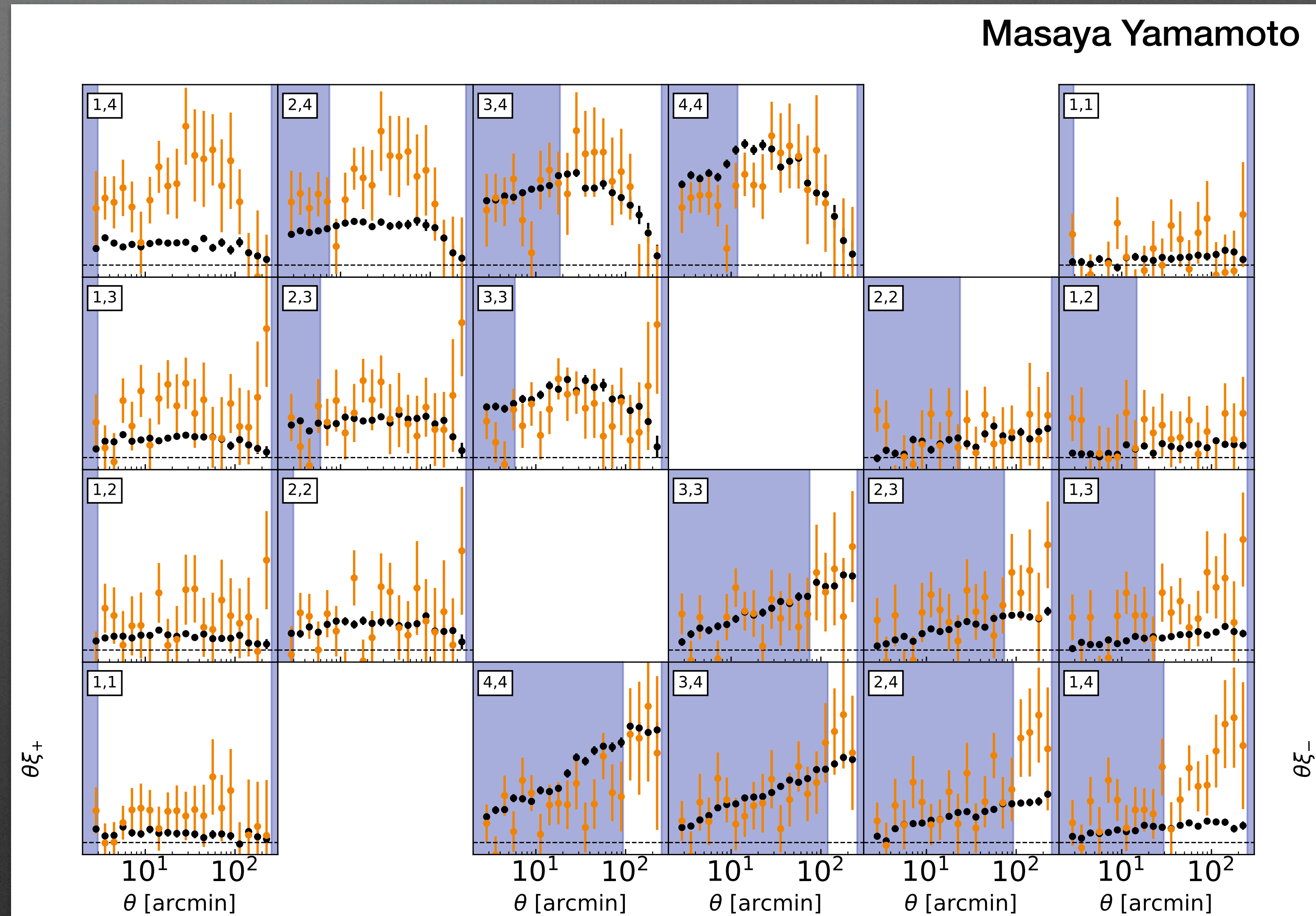
3M galaxies, $S/N = 10$

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$n_{\text{eff}} = 8.22$



DES + CCAPP from beginning to end

36 CCAPP DES participants just at this meeting

1st CCAPP Fellow — Eduardo Rozo

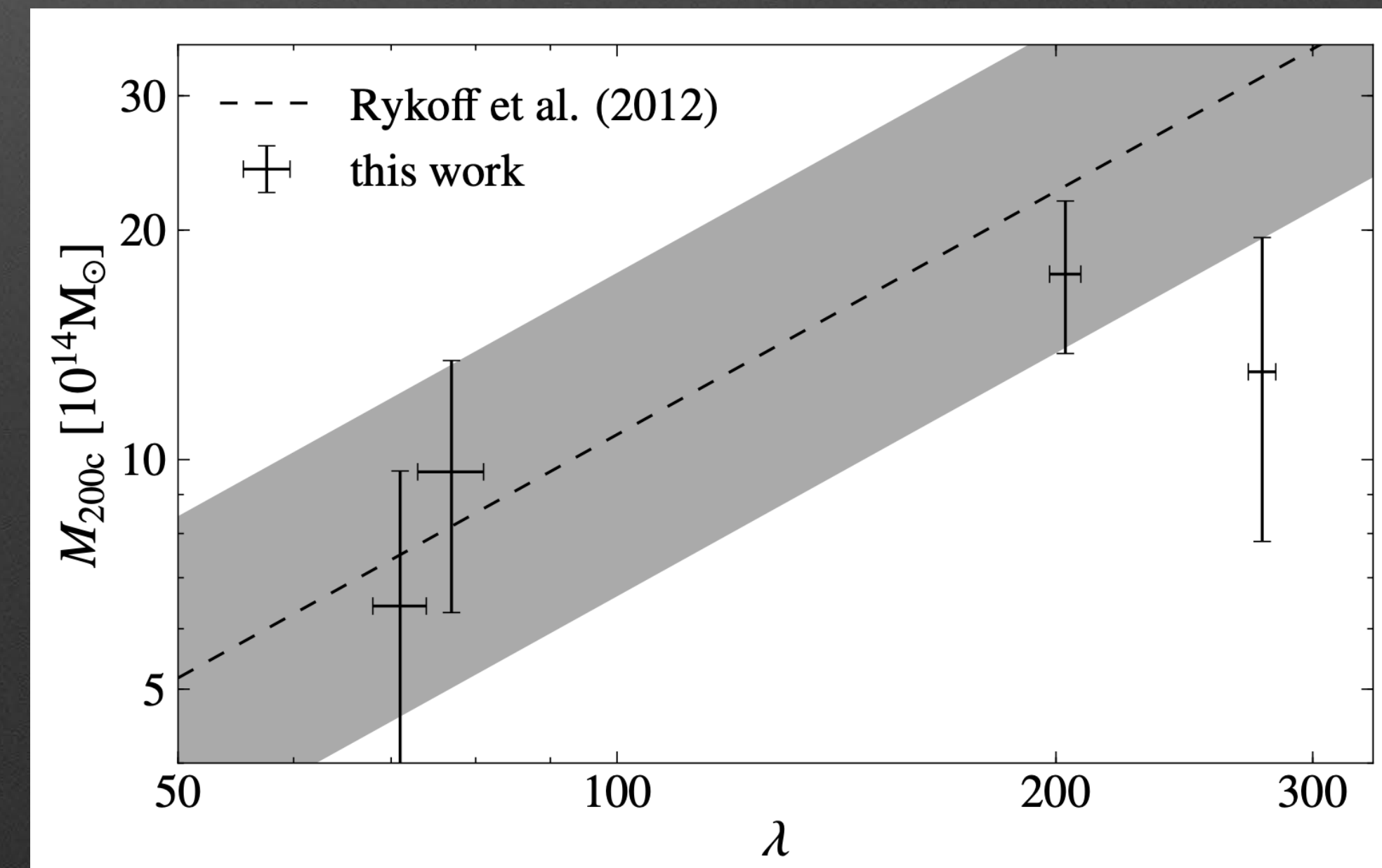
DES + CCAPP from beginning to end

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1st CCAPP Fellow — Eduardo Rozo

#1) First DES paper in 2014: Peter Melchior et al, Mass and galaxy distributions of four massive galaxy clusters from Dark Energy Survey Science

Verification Data



DES + CCAPP from beginning to end

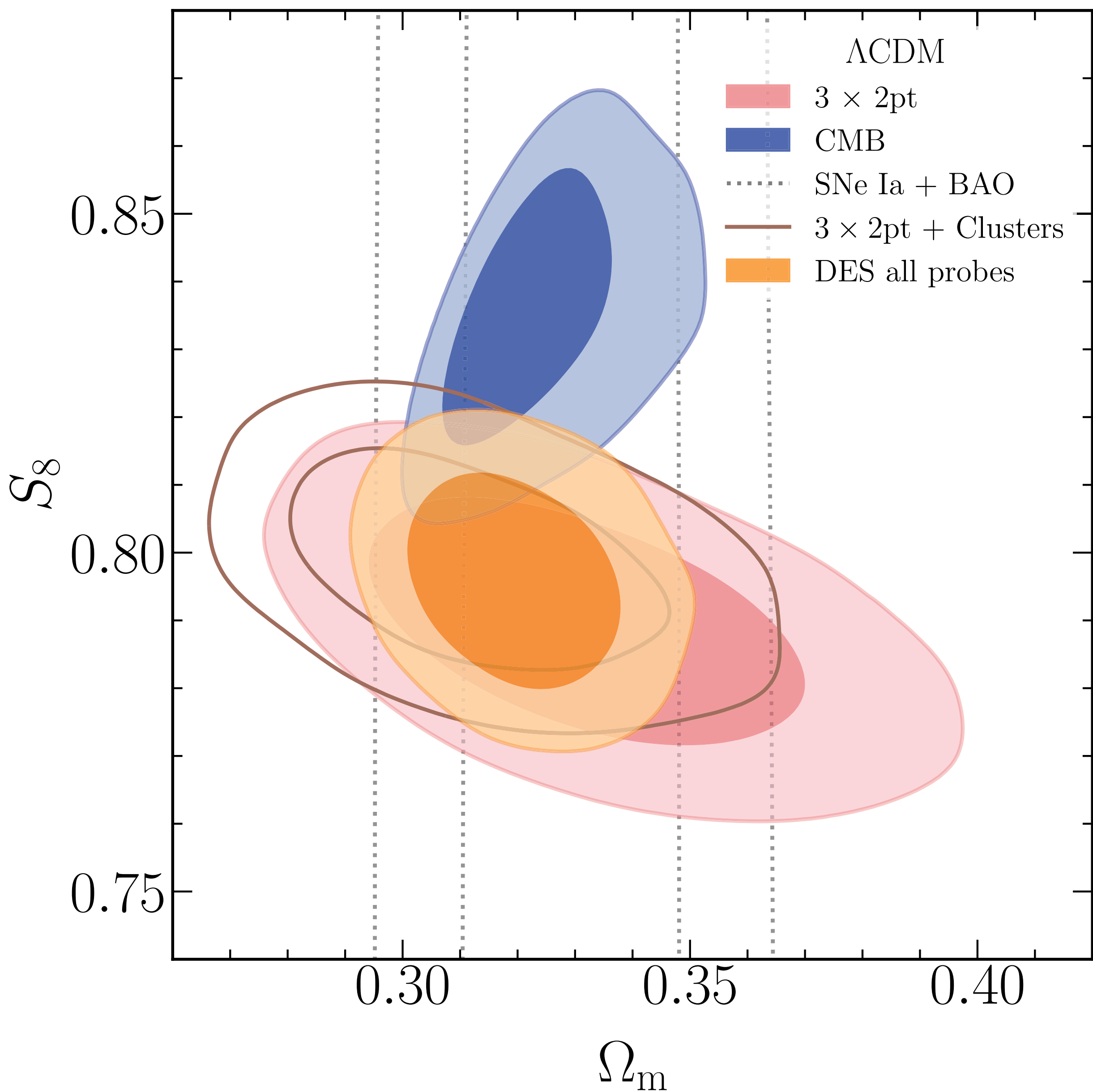
36 CCAPP DES participants just at this meeting

1st CCAPP Fellow — Eduardo Rozo

#1) First DES paper in 2014: Peter Melchior et al, Mass and galaxy distributions of four massive galaxy clusters from Dark Energy Survey Science Verification Data

#534-ish) 'Final' (?) DES key result led by Sujeong Lee et al (alphabetical), Constraints on Dynamical Dark Energy from Multiple Probes in the Full Dark Energy Survey

DES — The ‘final’ dark energy results

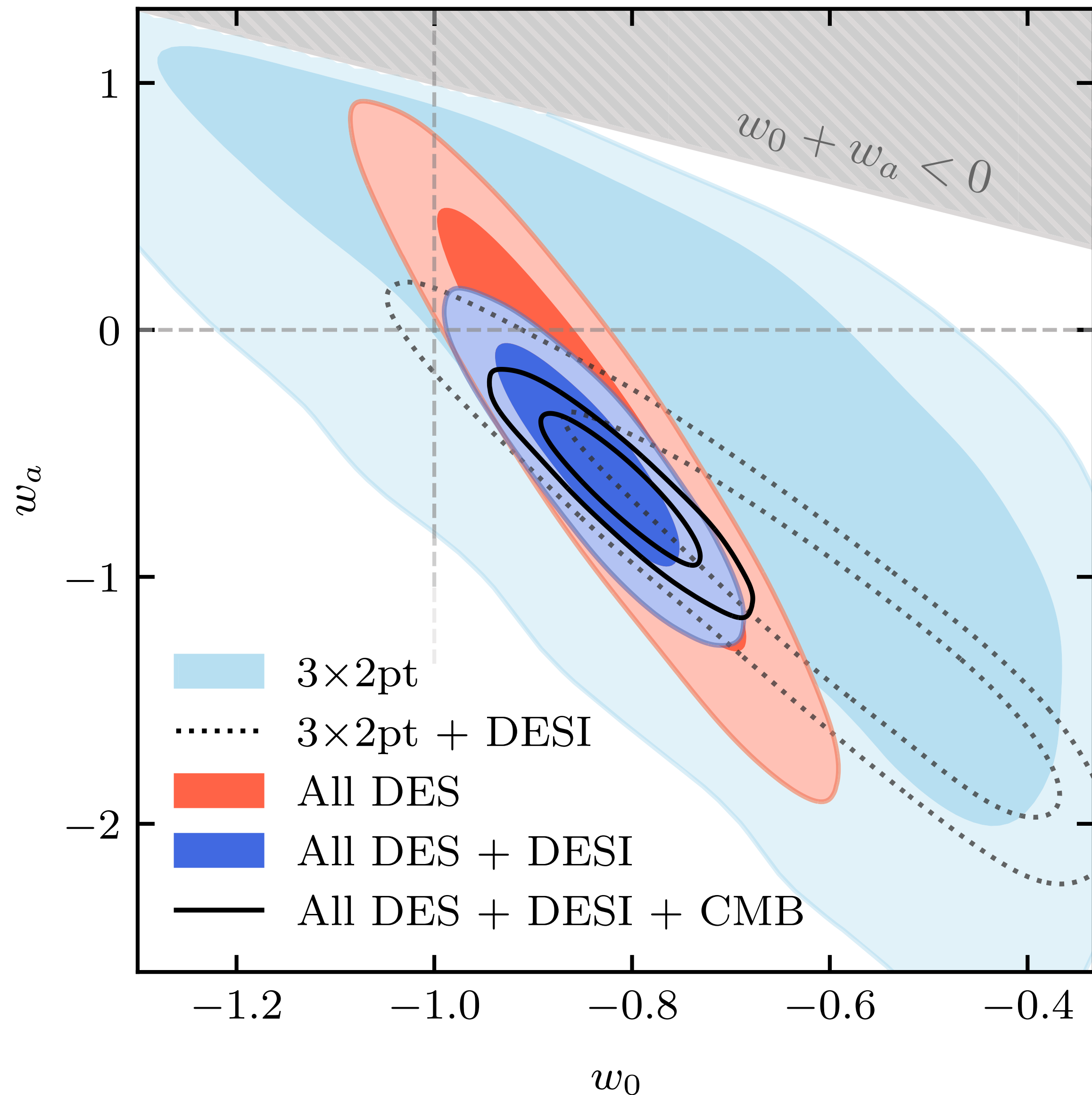


Test of standard model — CMB vs low-redshift:

DES constrains late-time structure as well as the CMB, despite only covering 1/8 of the sky.

General consistency, $\sim < 3$ sigma for all probes, even smaller for 3x2pt.

DES — The ‘final’ dark energy results

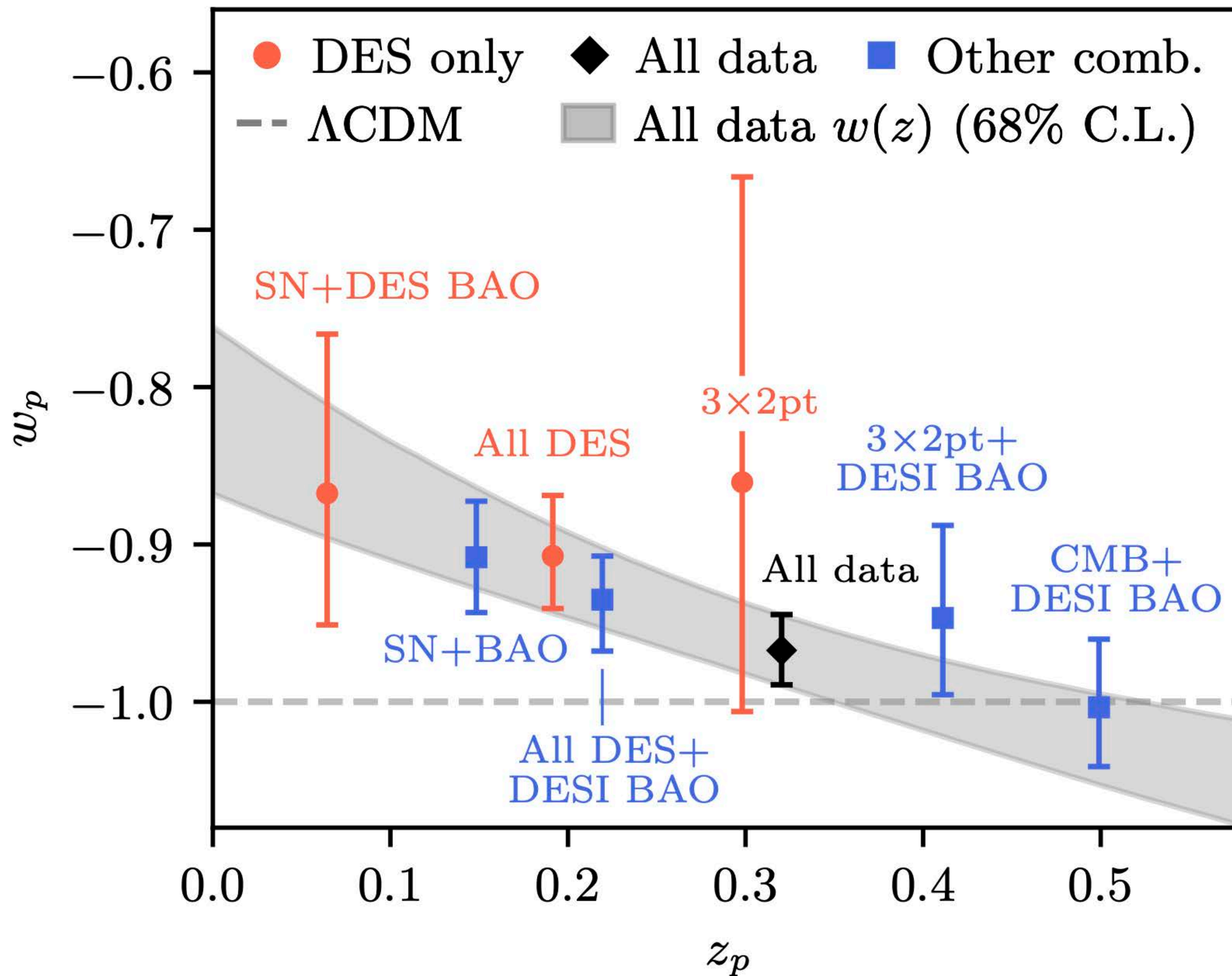
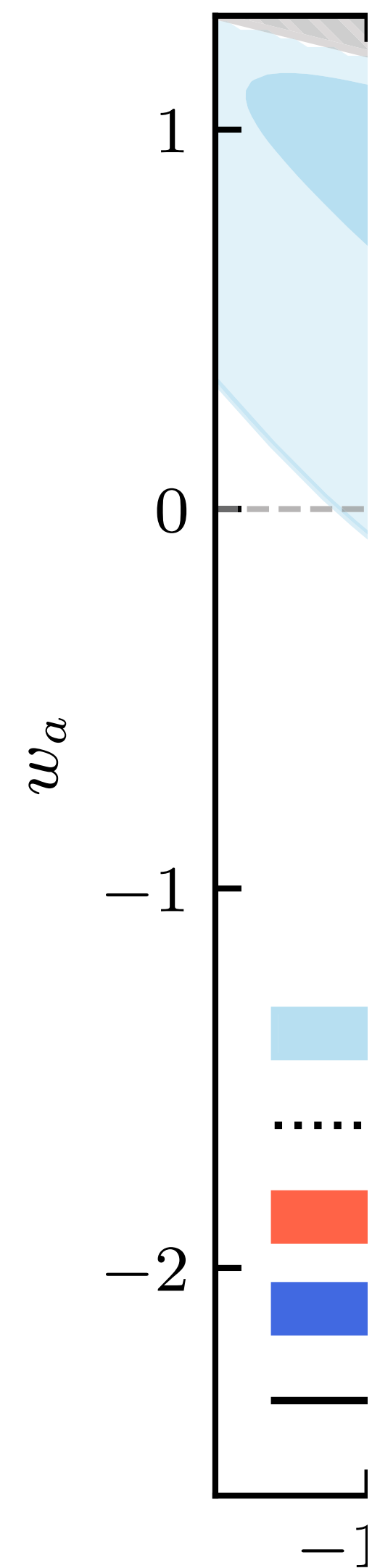


Is dark energy evolving? Inconclusive, but interesting.

Most recent constraints rely on geometry probes (SN, BAO, CMB).

Within DES, lensing adds 4X to evolving DE constraints over geometry alone!

Overall 2-3 sigma from LCDM, depending on which probe combination.



Results

conclusive,

the news on
(, CMB).

to
er geometry

DM,

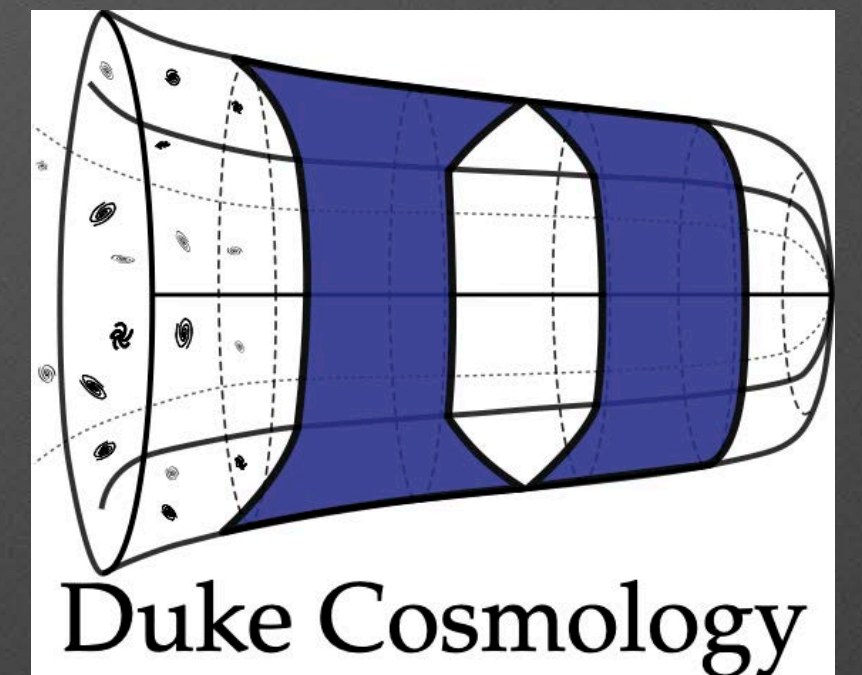
Post-CCAPP

When I left CCAPP, I had the goal to build my own center for cosmology based on lessons from DES and CCAPP.

Started a new cosmology group at Duke (expanding work on Roman and OpenUniverse) starting in 2019: now five faculty, 10 postdocs+, and ~ a dozen PhD students.

Started the Duke SPACE Initiative in Sep 2025, a center for space science & policy research.

spaceinitiative.duke.edu



Outer Space

Duke scholars are focused on the greatest of the universe's unknowns, from hibernation in space, to law and policy regulating space activity.

THE COSMOS

Cutting-Edge Space Exploration

A new Duke initiative will harness brainpower from across the university in an examination of the cosmos.



LOOK INTO THE UNKNOWN



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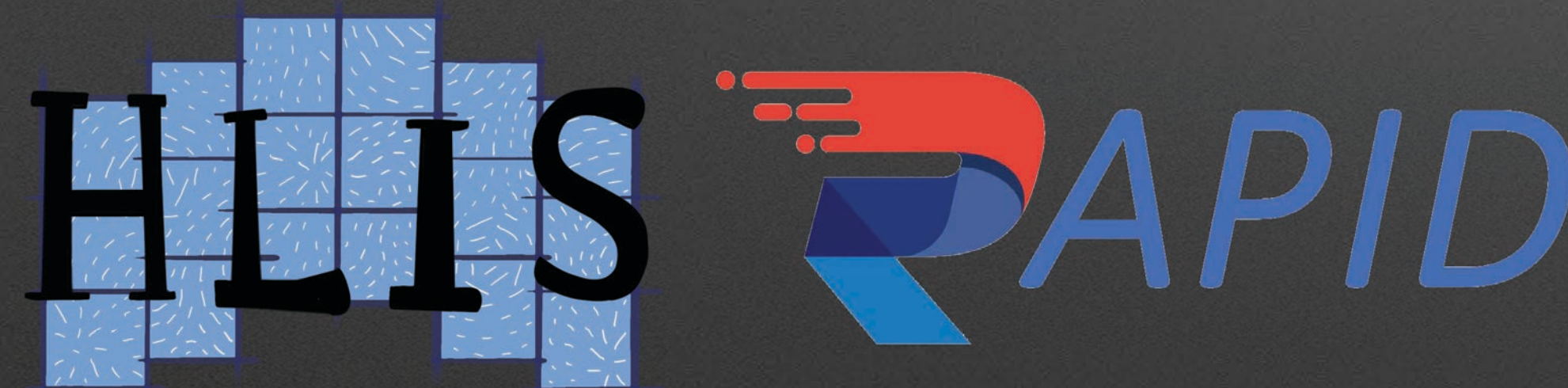
*Professor of the
Practice in the
Social Science
Research Institute*

OpenUniverse2024: A shared, simulated view of the sky for the next generation of cosmological surveys

OpenUniverse, The LSST Dark Energy Science Collaboration, The Roman HLIS Project Infrastructure Team, The Roman RAPID Project Infrastructure Team, The Roman Supernova Cosmology Project Infrastructure Team, A. Alarcon,¹ L. Aldoroty,² G. Beltz-Mohrmann,³ A. Bera,⁴ J. Blazek,⁵ J. Bogart,⁶ G. Braeunlich,⁷ A. Broughton,⁶ K. Cao,⁸ J. Chiang,⁶ N. E. Chisari,⁹ V. Desai,¹⁰ Y. Fang,² L. Galbany,^{1,11} A. Hearin,³ K. Heitmann,³ C. Hirata,⁸ R. Hounsell,^{12,13} B. Jain,¹⁴ M. Jarvis,¹⁴ J. Jencson,¹⁰ A. Kannawadi,² M. K. Kasliwal,¹⁵ R. Kessler,^{16,17} A. Kiessling,¹⁸ R. Knop,¹⁹ E. Kovacs,³ R. Laher,¹⁰ K. Laliotis,⁸ C. Lin,² I. Lopes,²⁰ A. Mahabal,¹⁵ R. Mandelbaum,²¹ J. Masiero,¹⁰ S. Mau,²² C. Meehan,² J. Meyers,⁶ B. Moraes,²⁰ R. Paladini,¹⁰ A. Pearl,²³ A. Plazas Malagon,⁶ B. Rose,²⁴ D. Rubin,²⁵ B. Rusholme,¹⁰ A. Santos,²⁶ N. Šarčević,²⁷ D. Scolnic,² M. A. Troxel,^{2*} N. Van Alfen,⁵ S. Van Dyke,¹⁰ C. W. Walter,² T. Wu,² M. Yamamoto,² Y. Yan,²⁸ and T. Zhang²³

<https://arxiv.org/abs/2501.05632>

<https://www.nasa.gov/universe/new-simulated-universe-previews-panoramas-from-nasas-roman-telescope/>



December 1, 2028



5"

One year later...
December 1, 2029

Get the simulations at:
<https://irsa.ipac.caltech.edu/data/theory/openuniverse2024/>



Roman Space Telescope

1 sq deg to
~0.5 sq arcmin



Simulated Image