

# Status and Recent Results of the Dark Energy Survey

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DARK ENERGY  
SURVEY

# Outline

1. The DES Project
2. Current Status
3. A few selected Scientific Results
4. Conclusions



# The Dark Energy Survey

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Optical/IR imaging survey with the Blanco 4m telescope at Cerro Tololo Inter-American Observatory(CTIO) in Chile

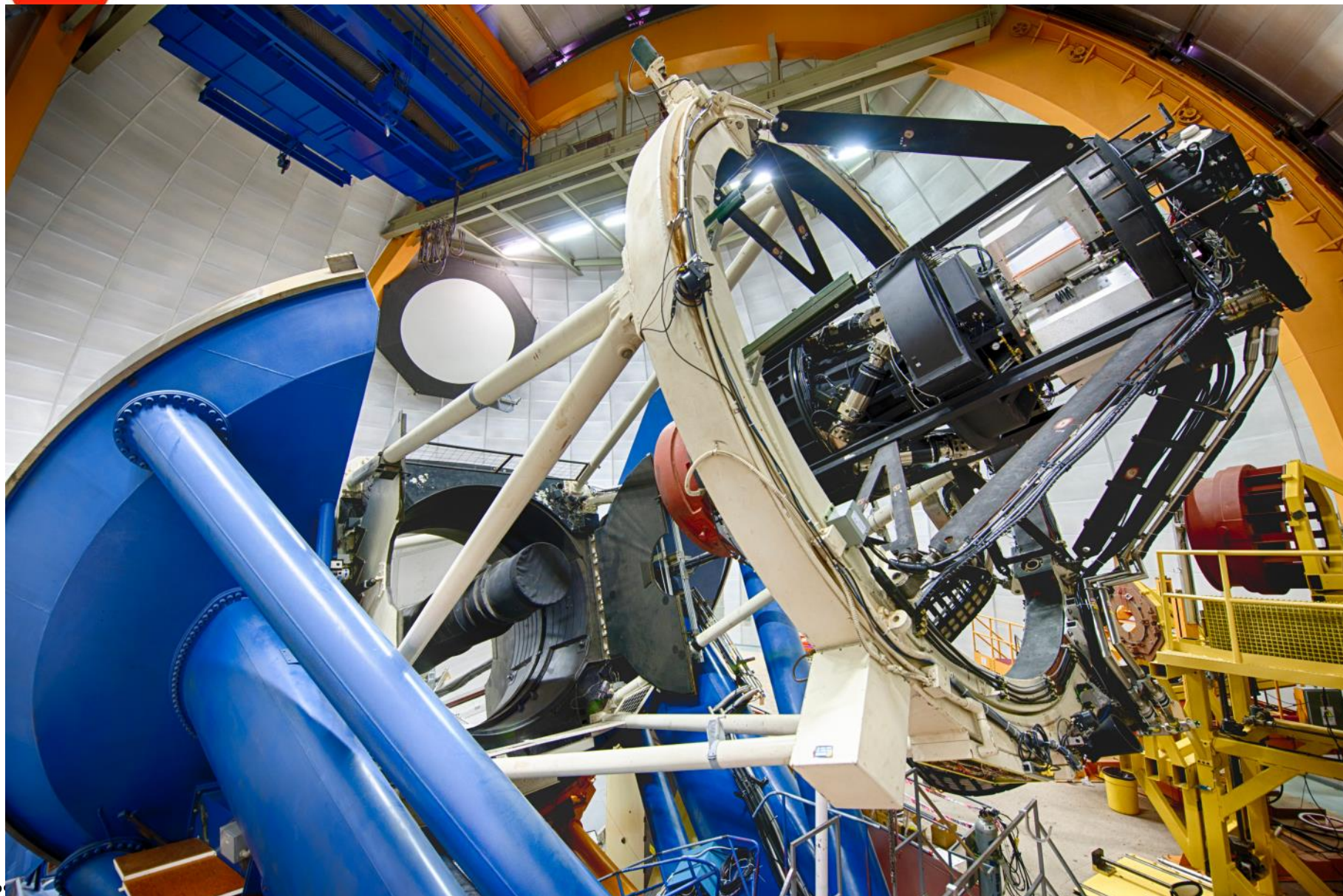
5000 sq-deg (1/8 of the sky) in grizY bands (2500 sq-deg overlapping with SPT survey)  
+ 30 sq-deg time-domain griz (SNe)

Up to  $i_{AB} \sim 24$ th magnitude at  $10 \sigma$  ( $z \sim 1.5$ )

New 570 Mpx camera with 3 sq-deg FoV, DECam



**Installed on Blanco since august 2012**





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# NGC 1365

NGC 1365 (the Great Barred Spiral Galaxy) is a barred spiral galaxy about 56 million light-years away in the constellation Fornax.



*(Credit: DECam, DES Collaboration)*



# DECam

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74 CCD chips (570  
Mpx/image) (62 2kx4k  
image, 8 2kx2k  
alignment/focus, 4 2kx2k  
guiding)

Red Sensitive CCDs  
QE>50% @ 1000 nm  
250 microns thick

3 sq-deg FoV  
Excellent image quality  
0.27"/pixel

Low noise electronics (<15 e  
@ 250 kpx/s) done by DES-  
Spain group





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# DES Science Summary

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## 4 Probes of Dark Energy

### Galaxy Clusters (dist & struct)

Tens of thousands of clusters to  $z \sim 1$

Synergy with SPT, ACT, VHS

### Weak Lensing (dist & struct)

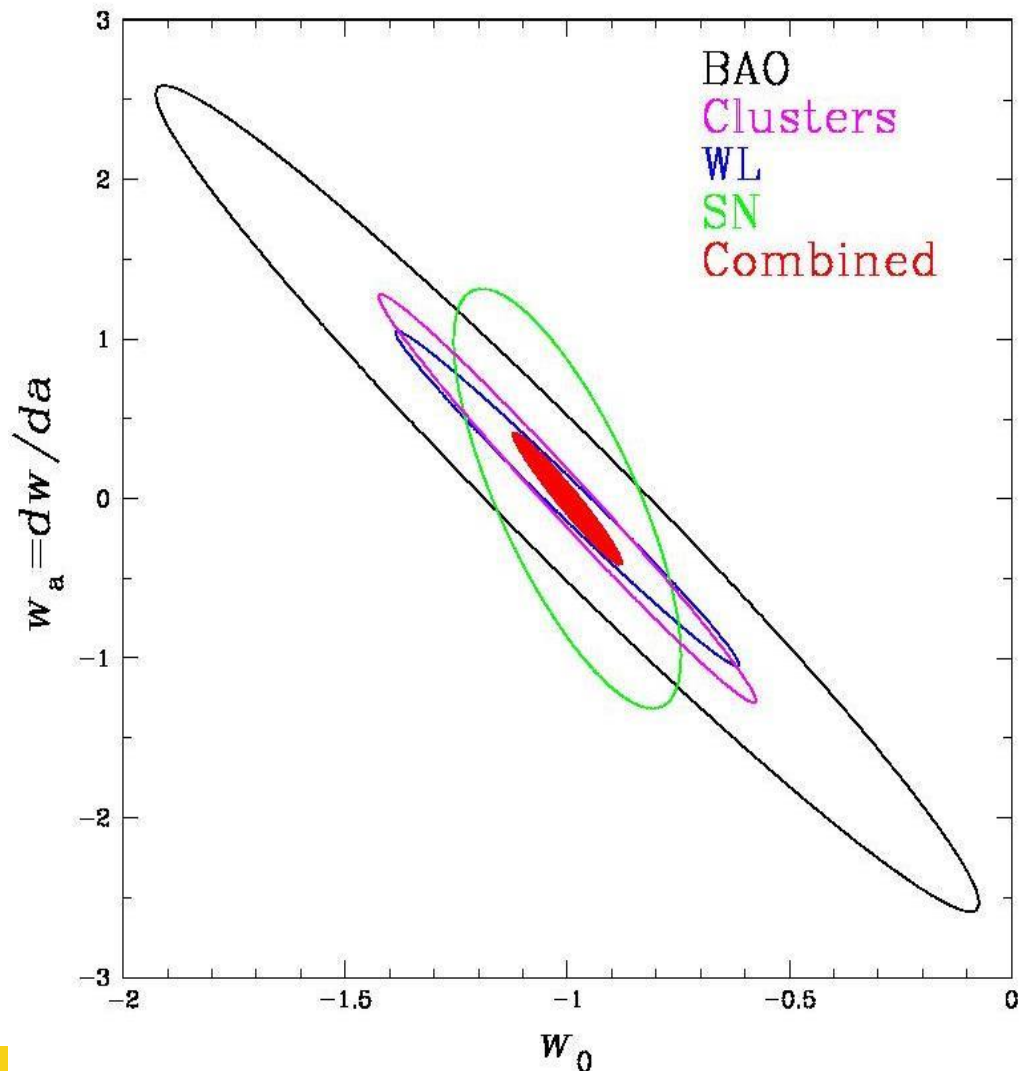
Shape and magnification measurements  
of 200 million galaxies

### Baryon Acoustic Oscillations (dist)

300 million galaxies to  $z \sim 1.4$

### Supernovae (dist)

>3500 well-sampled SNe Ia to  $z \sim 1$



Y COMPETITIVIDAD

Centro de Investigaciones  
Energéticas, Medioambientales  
y Tecnológicas





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DARK ENERGY  
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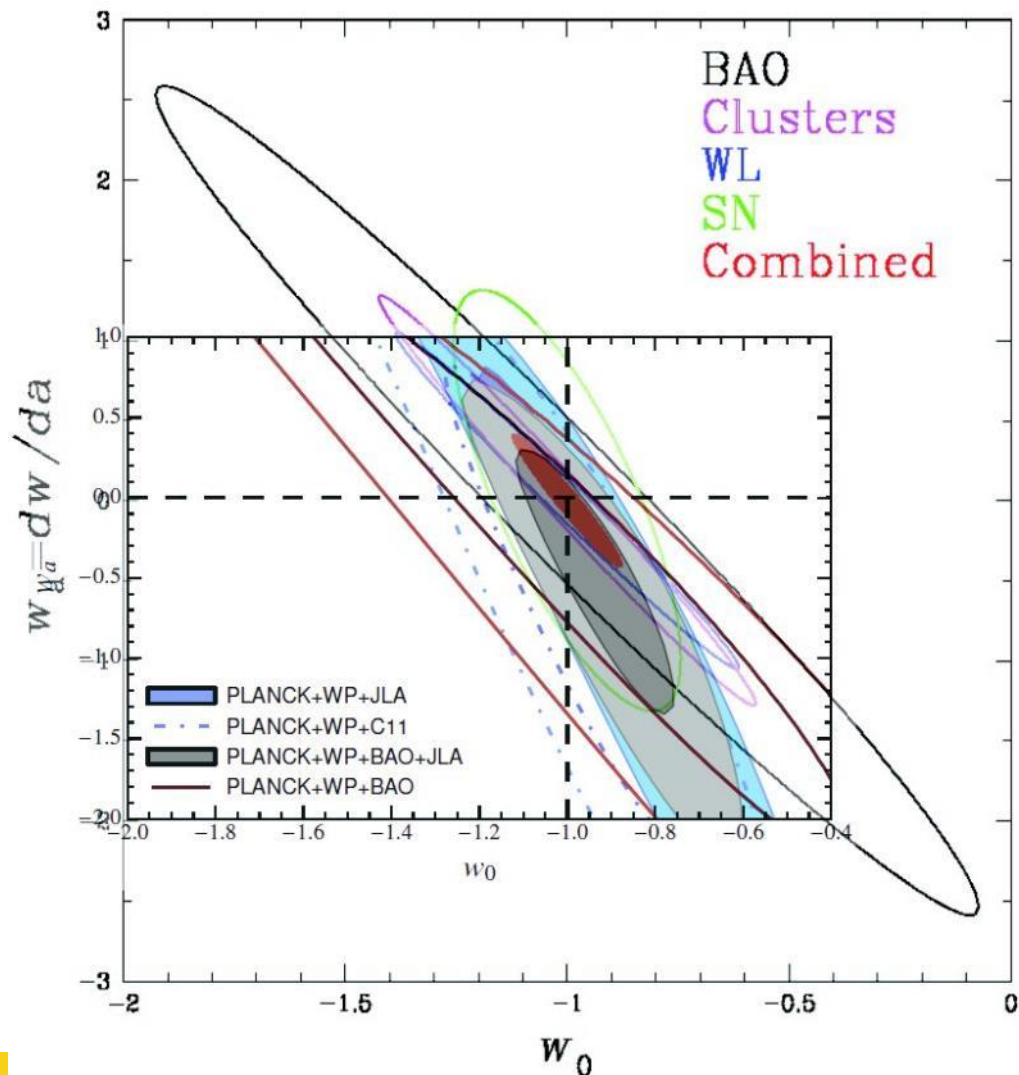
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MINISTERIO  
DE ECONOMÍA  
Y COMPETITIVIDAD

**Cremac**  
Centro de Investigaciones  
Energéticas, Medioambientales  
y Tecnológicas



**USA:** Fermilab, UIUC/NCSA, University of Chicago, LBNL, NOAO, University of Michigan, University of Pennsylvania, Argonne National Laboratory, Ohio State University, Santa Cruz/SLAC Consortium, Texas A&M University, CTIO (in Chile)

# DES Collaboration

~450 scientists from 25 institutions in 7 countries

[darkenergysurvey.org](http://darkenergysurvey.org)

[Facebook.com/darkenergysurvey](https://Facebook.com/darkenergysurvey)



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**UK Consortium:** UCL, Cambridge, Edinburgh, Portsmouth, Sussex, Nottingham



**Germany:** Munich



**Switzerland:** Zurich



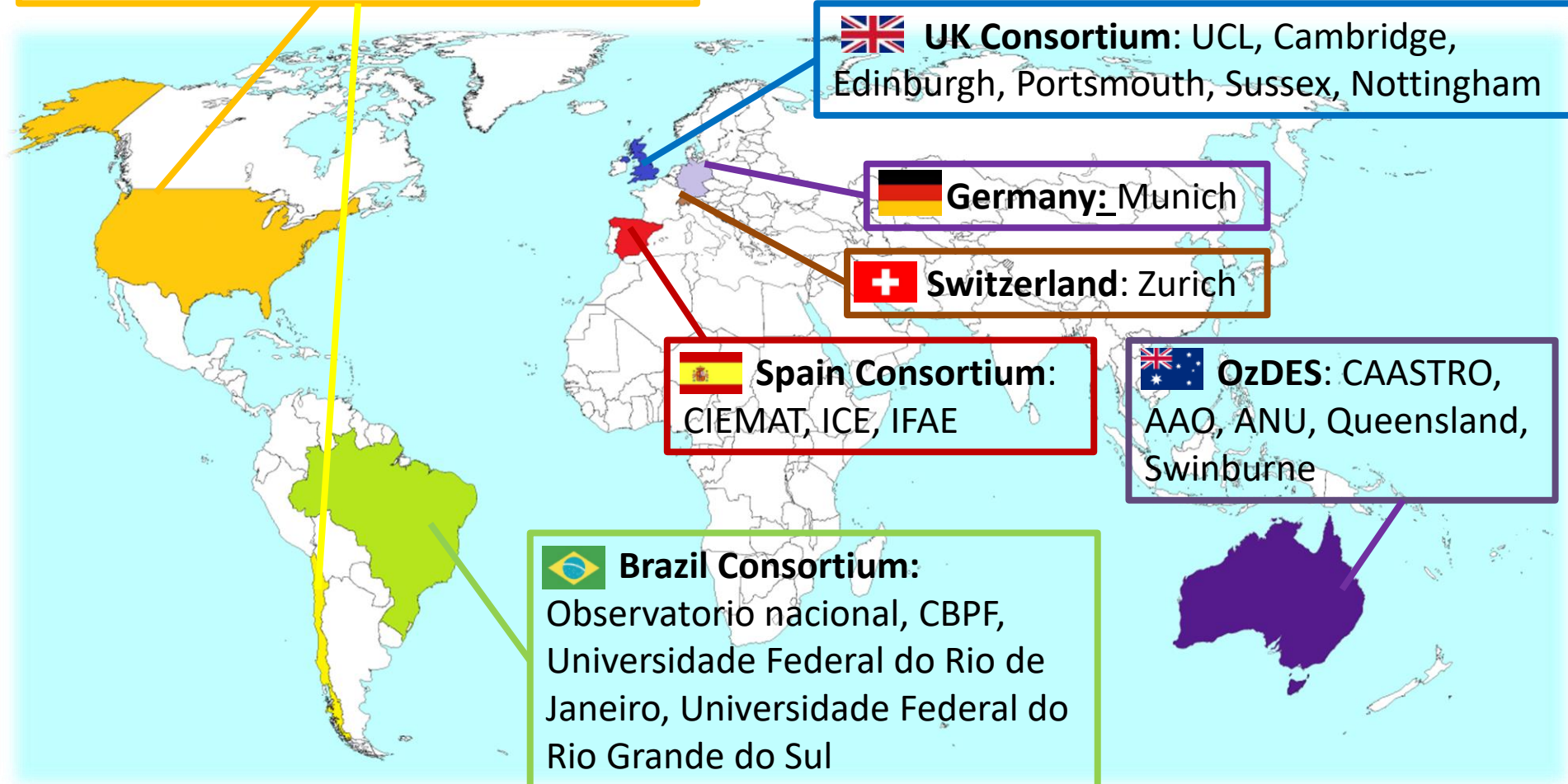
**Spain Consortium:** CIEMAT, ICE, IFAE



**OzDES:** CAASTRO, AAO, ANU, Queensland, Swinburne



**Brazil Consortium:** Observatorio nacional, CBPF, Universidade Federal do Rio de Janeiro, Universidade Federal do Rio Grande do Sul





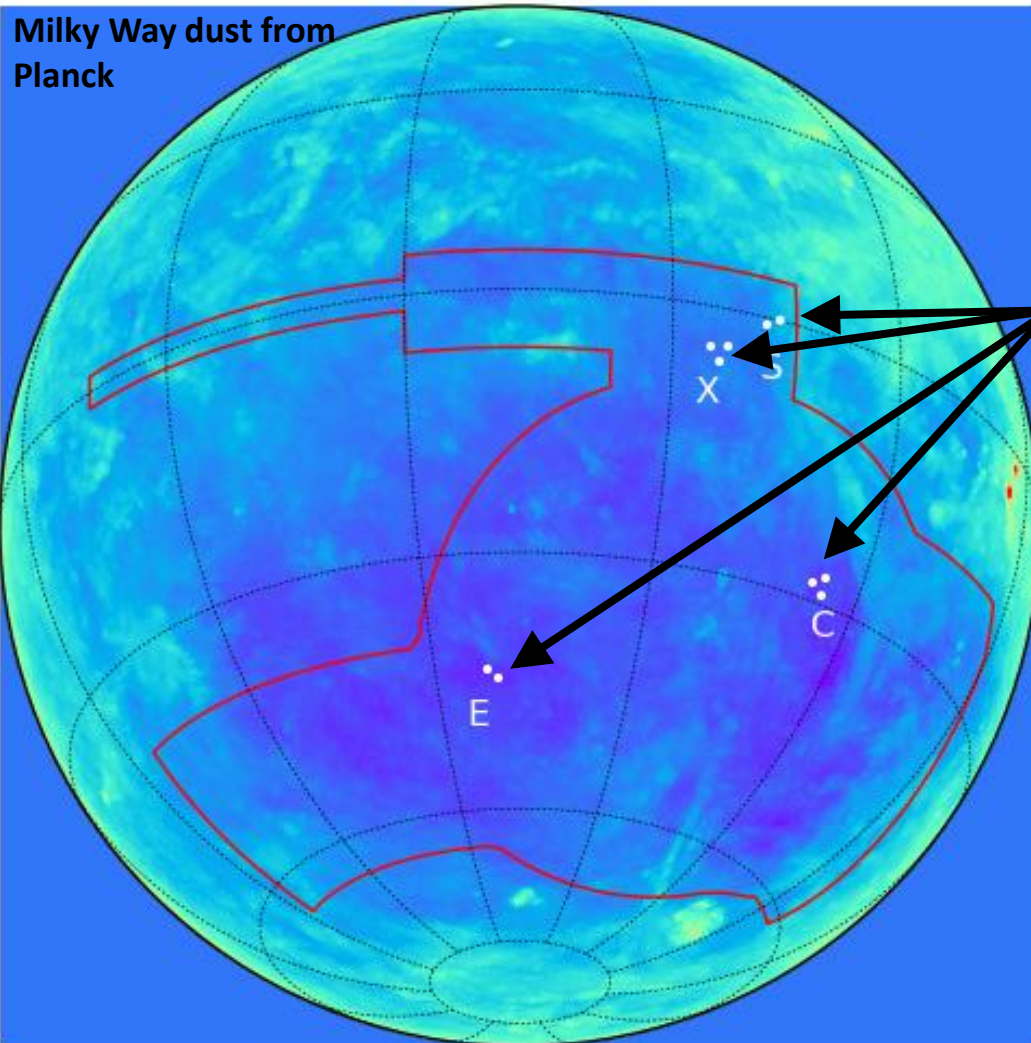
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# DES Survey Area

5000 square degrees, 1/8 of the sky

Footprint to be covered  
900 seconds  
in each filter  
(g,r,i,z; 450  
sec in Y) after  
5 seasons.

Build depth  
over time

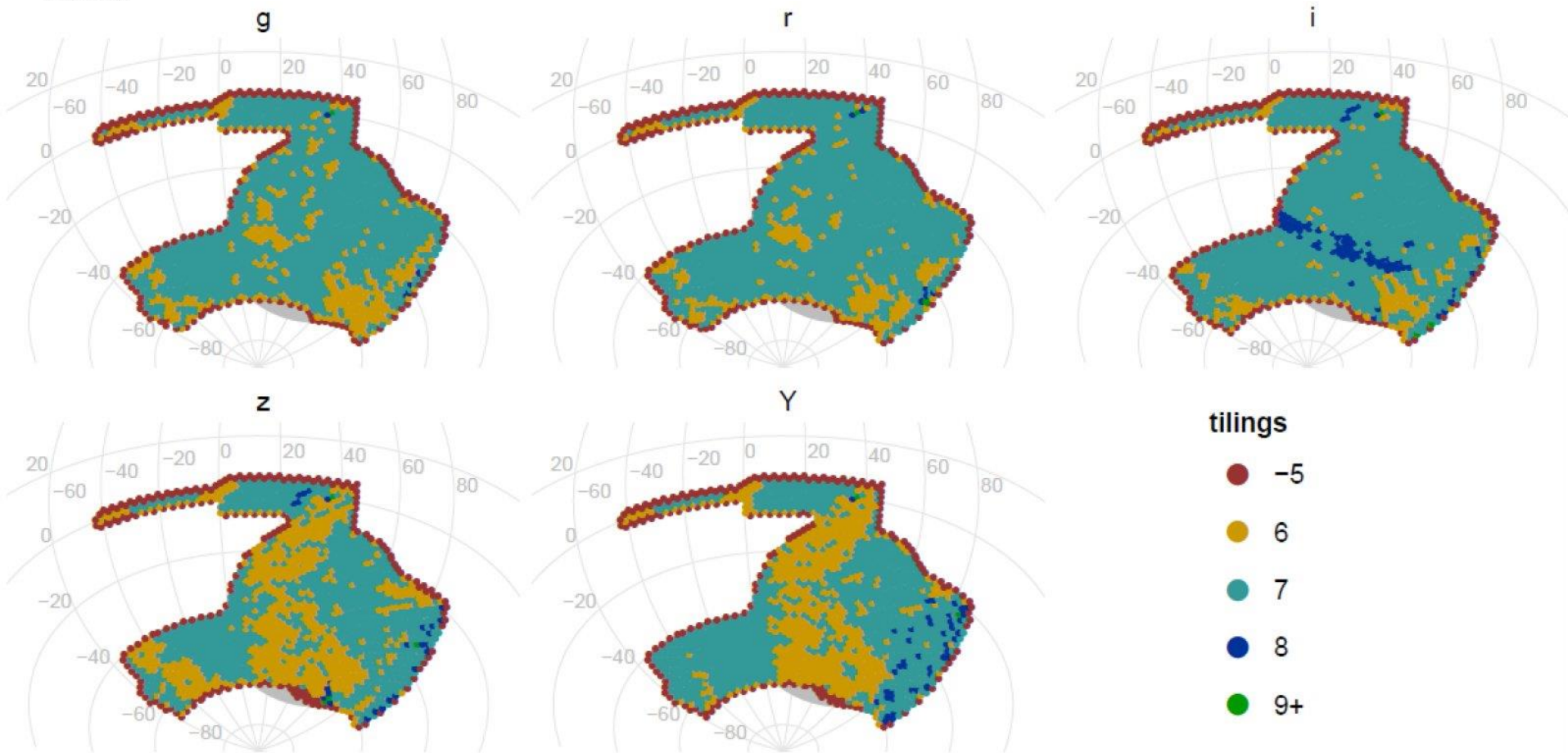




# DES Y4 ended on february 2017

DES is projected for 5 years , up to 2018

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Tiling = One 90 seconds exposure over entire footprint



# DES has produced many results already

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Over 100 papers published or submitted

Majority of early results based on Science Verification (SV) data (full depth mini-survey in 2012): less than 3% of full survey. An improvement of  $\sim 1$  order of magnitude is expected for the final data set.

Some selected results published from Y1 and Y2 as well. **Cosmology analysis of Y1 data underway. Results are expected in a few weeks.**

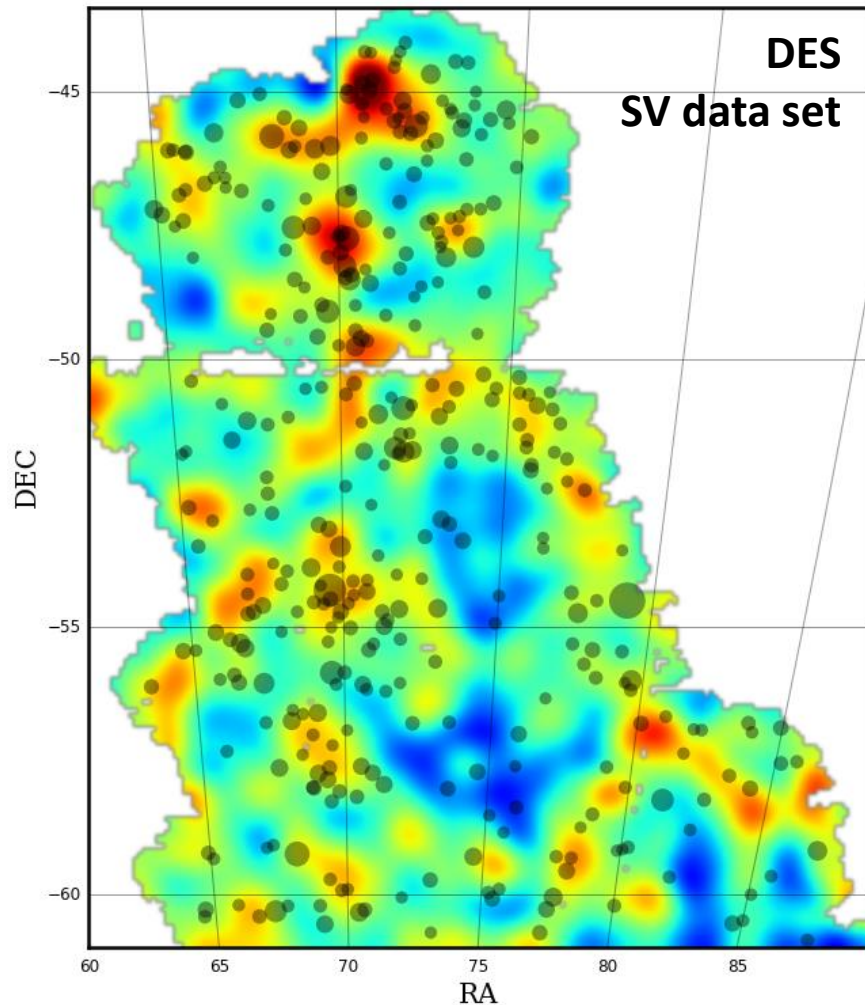
Emphasis of early cosmology analyses has been on understanding systematic errors, with an eye to analyzing larger data sets in the future. **DES Y1 is already the most powerful data set ever for many probes, and a careful study of systematic errors is mandatory**

I will flash a few selected results



# DES projected mass map from weak lensing

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## Dark Matter Mass Map

Based on measurements of shapes of background galaxies

Chang et al., PRL 115 (2015) 05301  
Vikram et al., PRD 92 (2015) 022006

Blue: under-dense regions

Red: over-dense regions

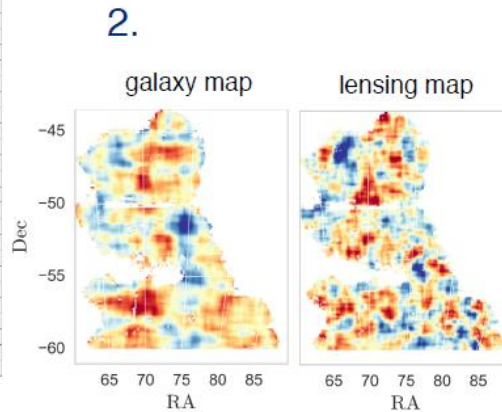
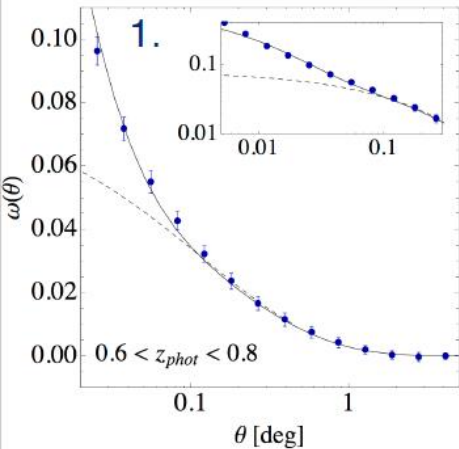
Circles: visible foreground galaxy clusters

Largest contiguous lensing mass map ever, yet only 3% of final DES area



# Galaxy bias: Multi-probe approach

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Galaxy bias: the relationship between the (dark) matter and galaxy distributions

$$\delta_g(\mathbf{z}, \theta) = b(\mathbf{z}, \theta) \delta_m(\mathbf{z}, \theta)$$

Multi-probe approach:

1. DES Galaxy clustering

*Crocce et al., MNRAS 455 (2016) 4301*

2. Ratio between DES Galaxy map and DES lensing mass map

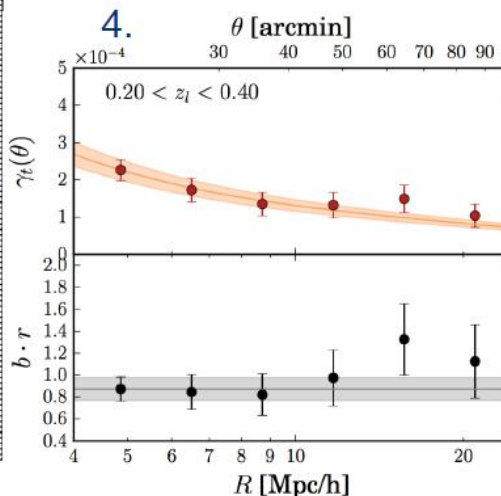
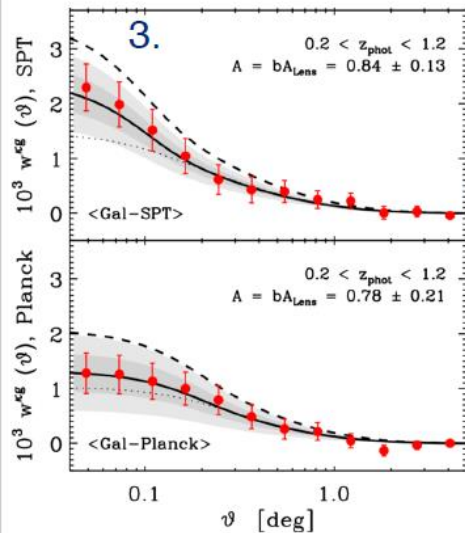
*Chang et al., MNRAS 459 (2016) 3203*

3. CMB lensing around DES galaxies

*Giannantonio et al., MNRAS 456 (2016) 3213*

4. DES background Galaxy lensing around DES foreground galaxies

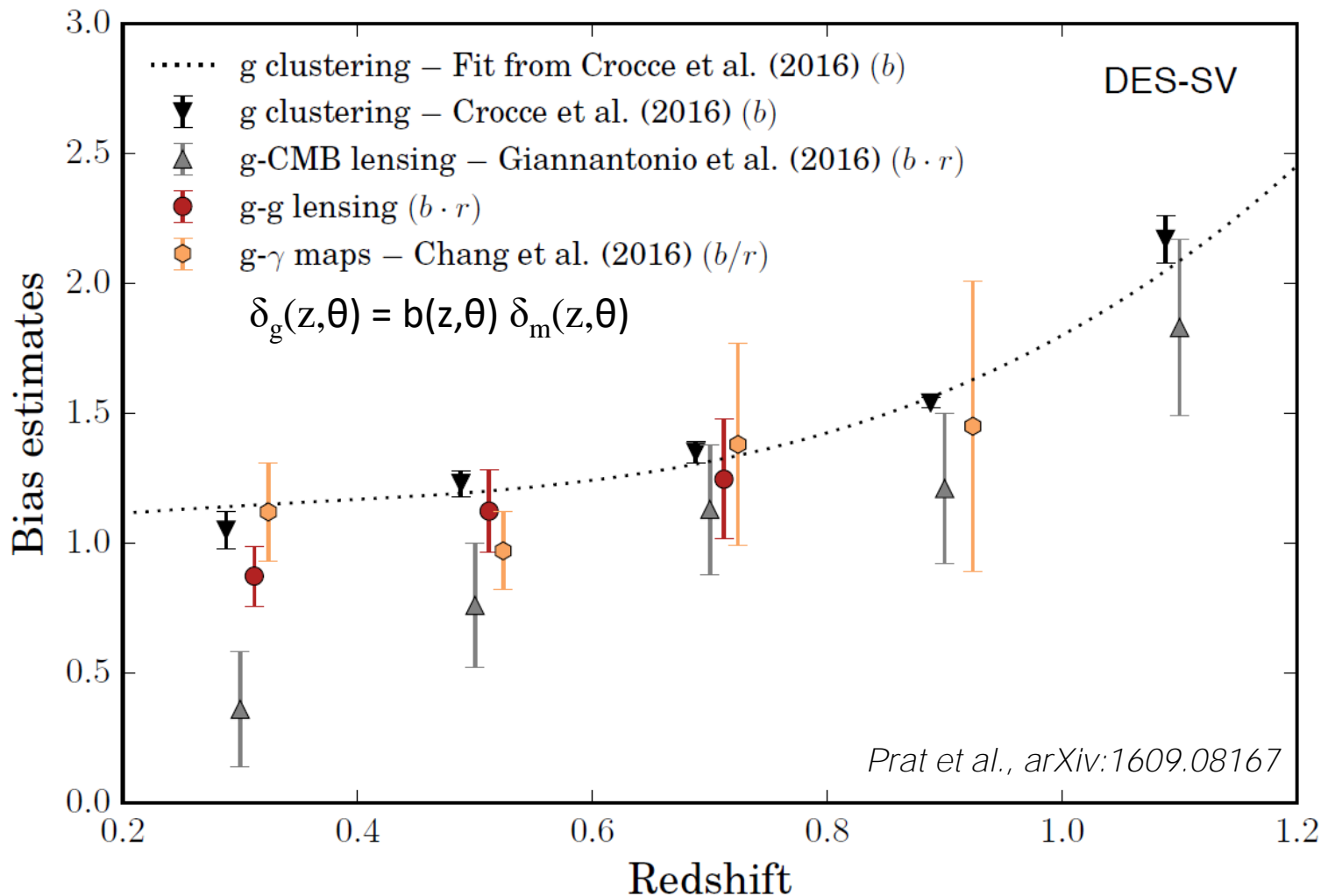
*Prat et al., arXiv:1609.08167 [astro-ph]*





# Galaxy bias: Multi-probe approach

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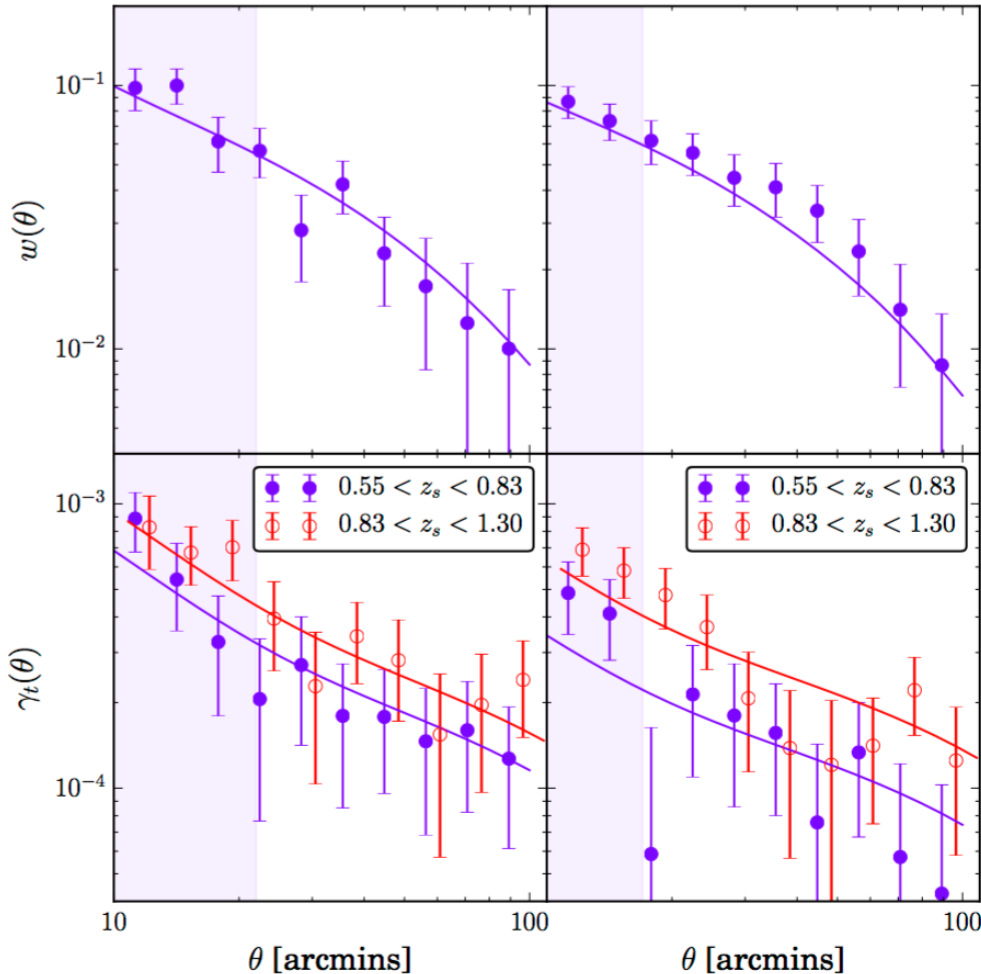
# galaxy clustering + weak lensing

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Kwan et al., MNRAS 464 (2017) 4045

$0.20 < z_l < 0.35$

$0.35 < z_l < 0.50$



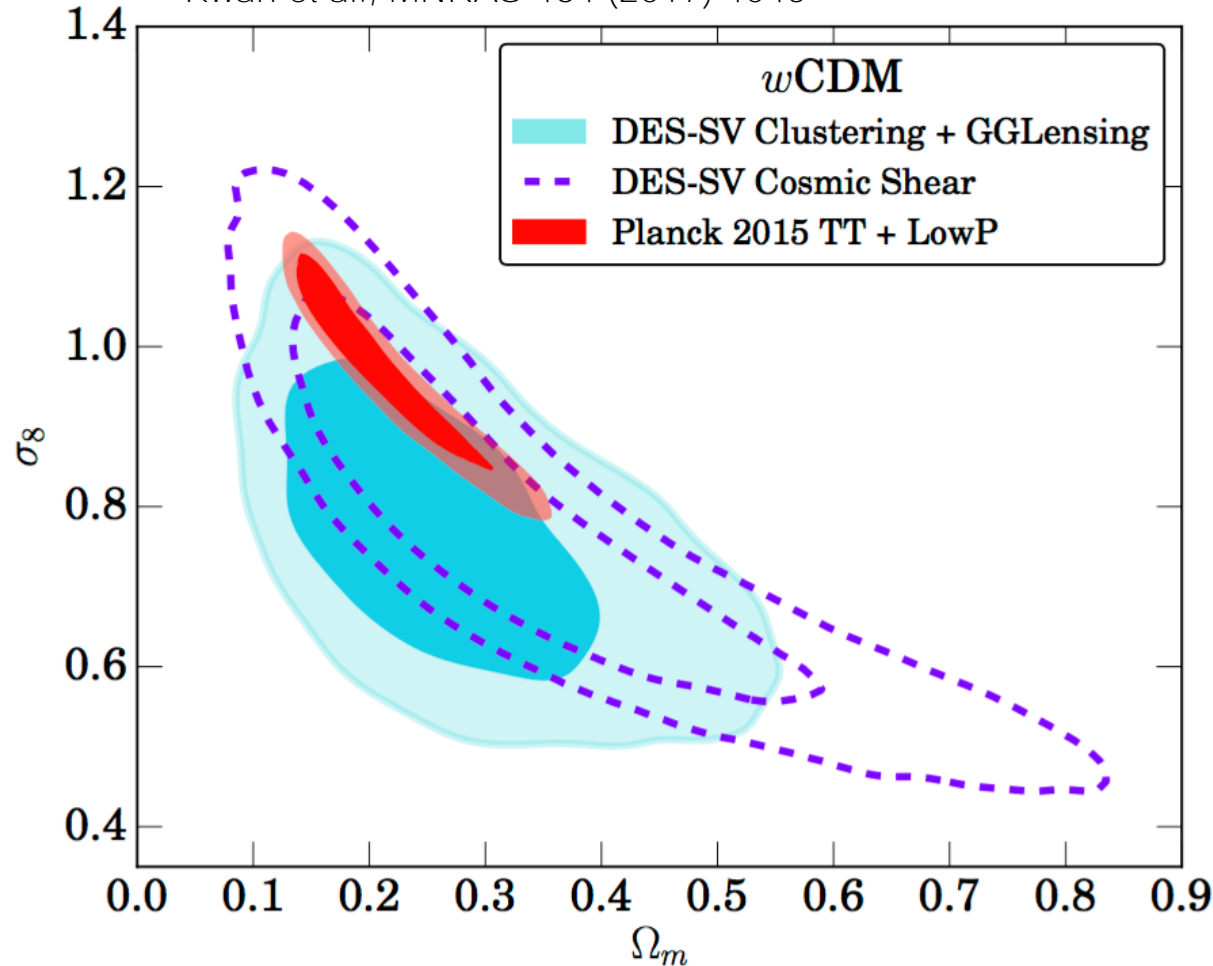
- Use a galaxy background galaxy sample to measure shapes (sources)
- Use DES sample of Luminous Red Galaxies (LRG) as lenses: excellent photo-z
- $w(\theta)$ : correlation function of density of lenses
- $\gamma_t(\theta)$ : tangential shear of sources around lenses
- Combination is sensitive to cosmological parameters and relatively insensitive to galaxy bias.



# galaxy clustering + weak lensing

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Kwan et al., MNRAS 464 (2017) 4045



$\sigma_8$ : amplitude of power spectrum of matter density fluctuations (on scales of 8 Mpc/h)

Sensitivity similar to cosmic shear

Results compatible with cosmic shear

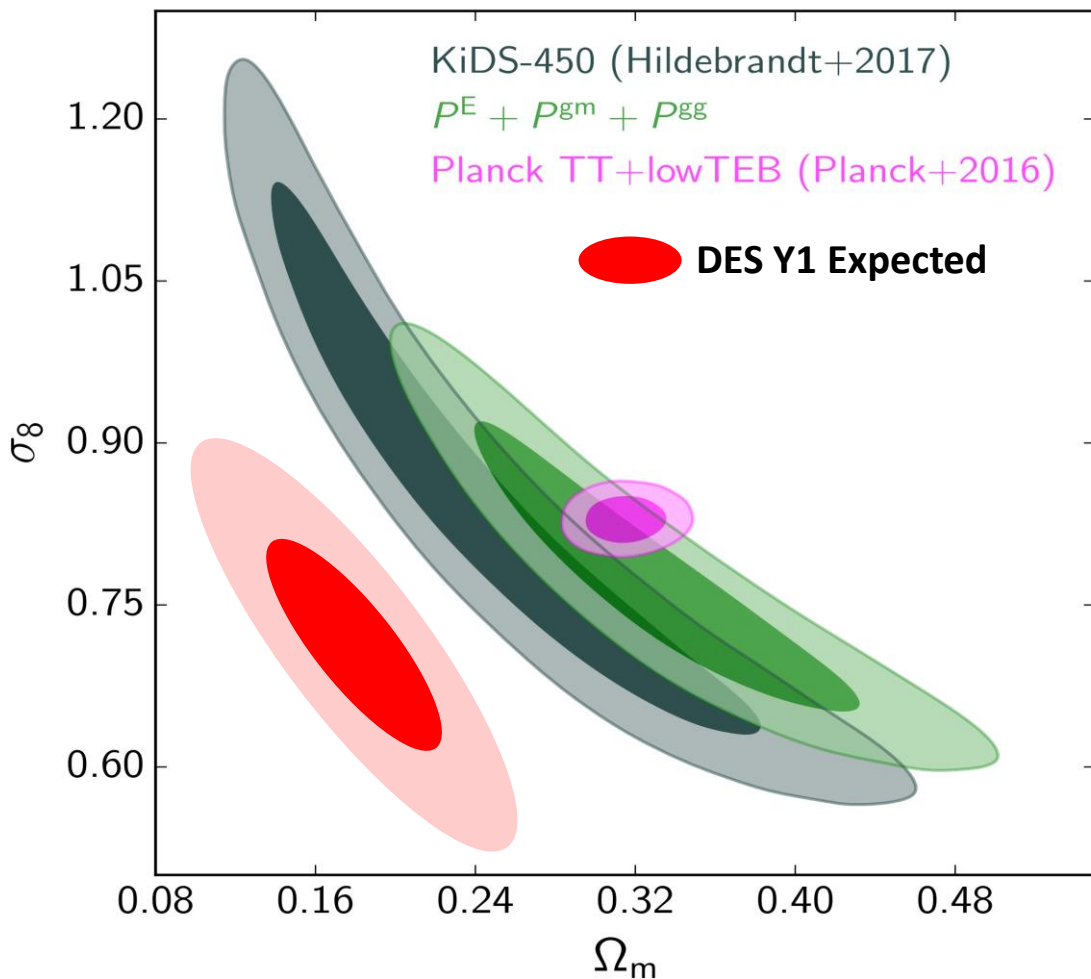


# galaxy clustering + weak lensing

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KIDS+GAMA: arXiv:1706.05004

DES Expected: arXiv:1706.09359



DES Y1 Will combine cosmic shear, Galaxy-Galaxy lensing and Galaxy clustering to measure cosmological parameters

The DES Y1 data are very powerful:

- $\sim 4x$  the area of the KiDS catalog and  $\sim 10x$  the area of DES SV & HSC release.
- $\sim 2.5x$  the number of objects as the KiDS catalog,  $\sim 3x$  as HSC release, and  $\sim 10x$  as DES SV.

Results will be published in a few weeks



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# Conclusions

**Science Verification** data provided a wealth of exciting science, e.g.  
*Galaxy clustering + weak lensing measurements.*  
*Cross-correlations with CMB + new probes.*

**Year 1** data, covering 1600 deg<sup>2</sup>, are being analyzed now. Expect results in a few weeks

*Cosmological results using combined probes (lensing+clustering).*  
*Many other new and interesting results. Stay tuned!!!*

**Years 2-4** data are recorded. Y1-Y3 dataset covers 5000 deg<sup>2</sup> to  $i_{AB} \sim 23.2$  mag: unique data set, extremely powerful for cosmology.

*Results from Y1-Y3 expected to be out in 2018.*