The Dark Energy Survey

Status and First Results

E. Sánchez (CIEMAT)

On behalf of the DES Collaboration

ICHEP 2014 VALENCIA

37th INTERNATIONAL CONFERENCE ON HIGH ENERGY PHYSICS

2-9-JULY-2014-VALENCIA

DARK ENERGY SURVEY

Outline

1. Dark Energy
2. The DES Project
3. Current Status
4. First Scientific Results
5. Conclusions

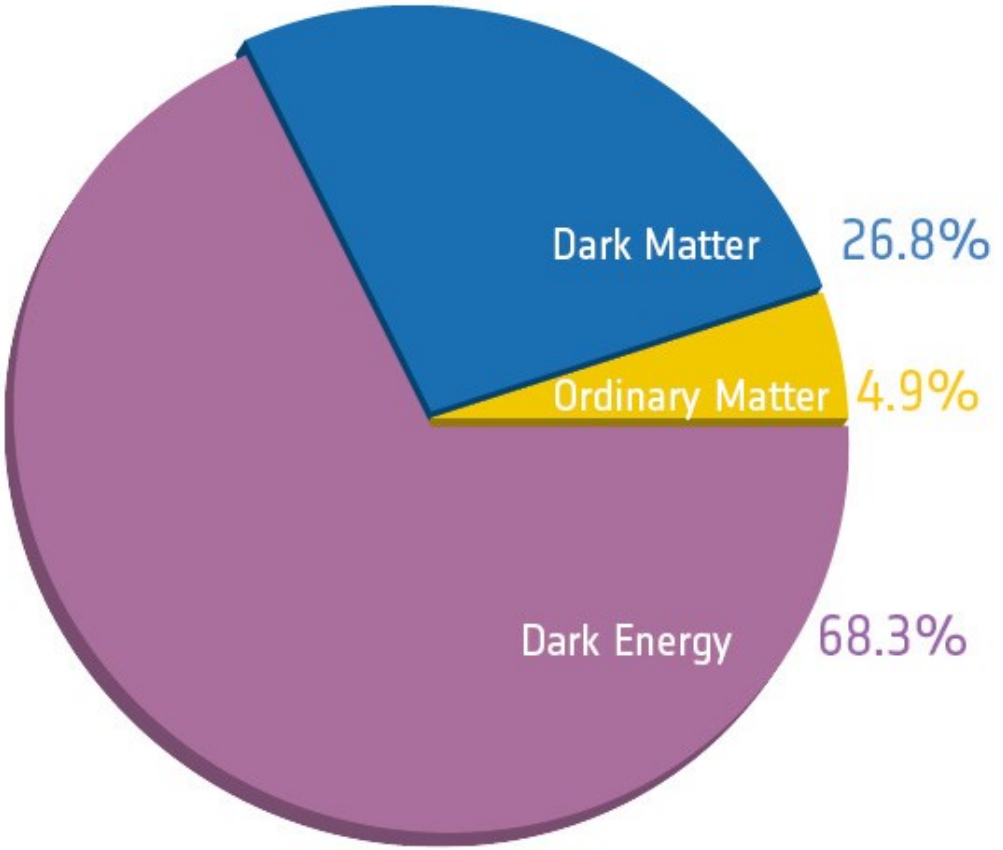
The Dark Energy

DARK ENERGY SURVEY

What is the physics behind the acceleration of the expansion of the Universe?
Cosmological constant ?
Any new dynamical field?
Modifications to General Relativity?

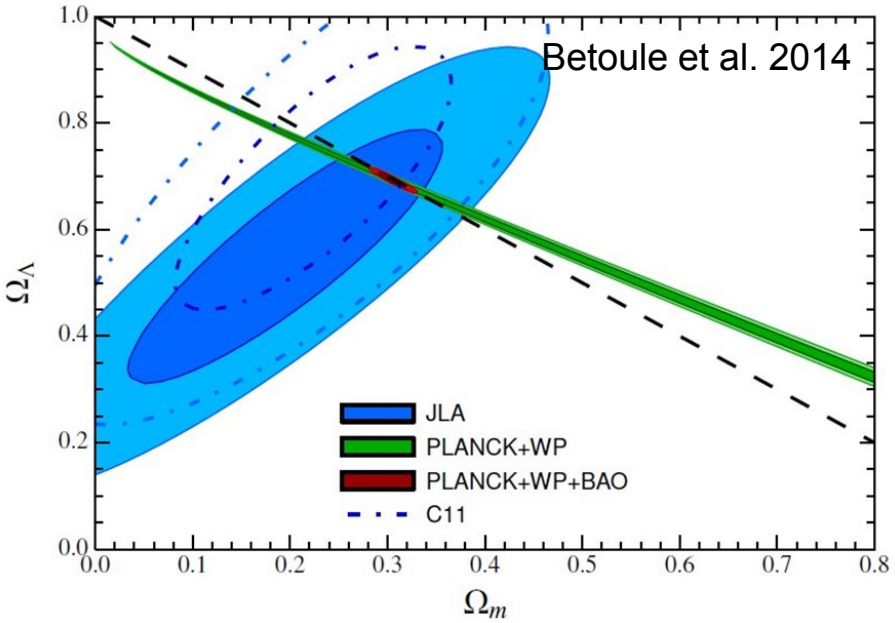
Studies of dark energy from:
Expansion rate of the Universe
Growth of structure

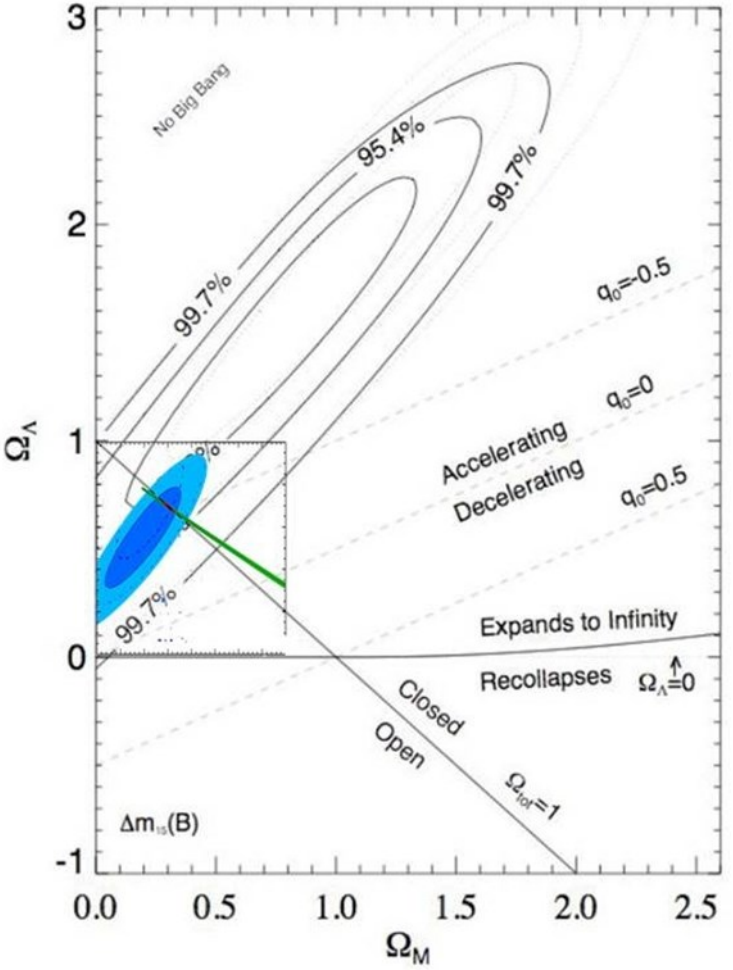
Can be measured from **Galaxy Surveys**



The Dark Energy

DARK ENERGY SURVEY





Huge progress over the last 15 years

However, there is still a very large room for improvement.

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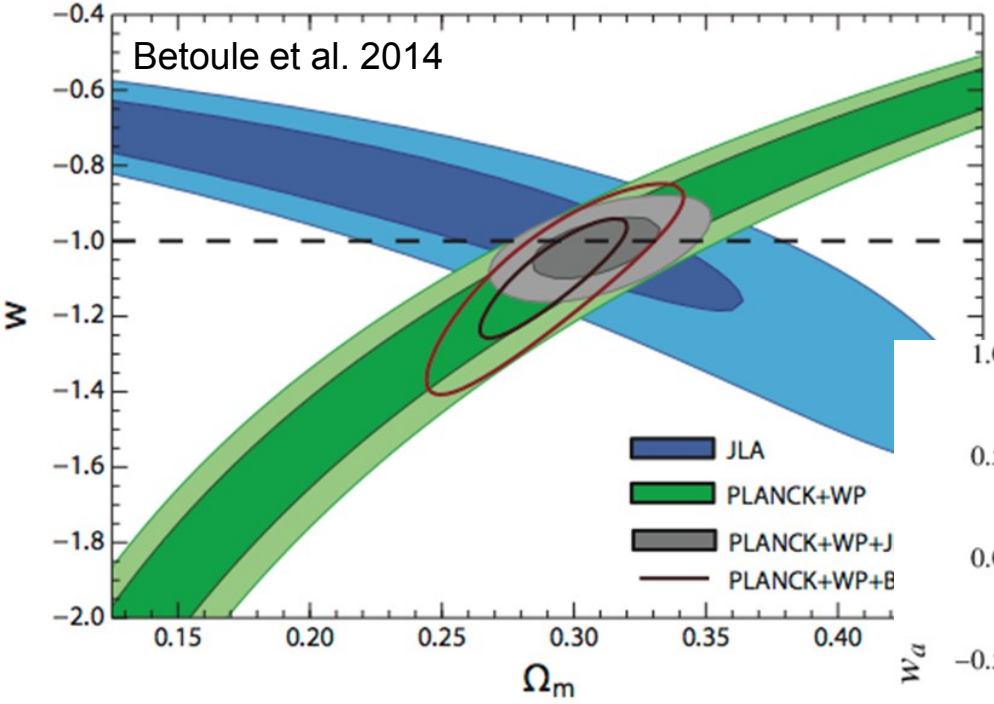
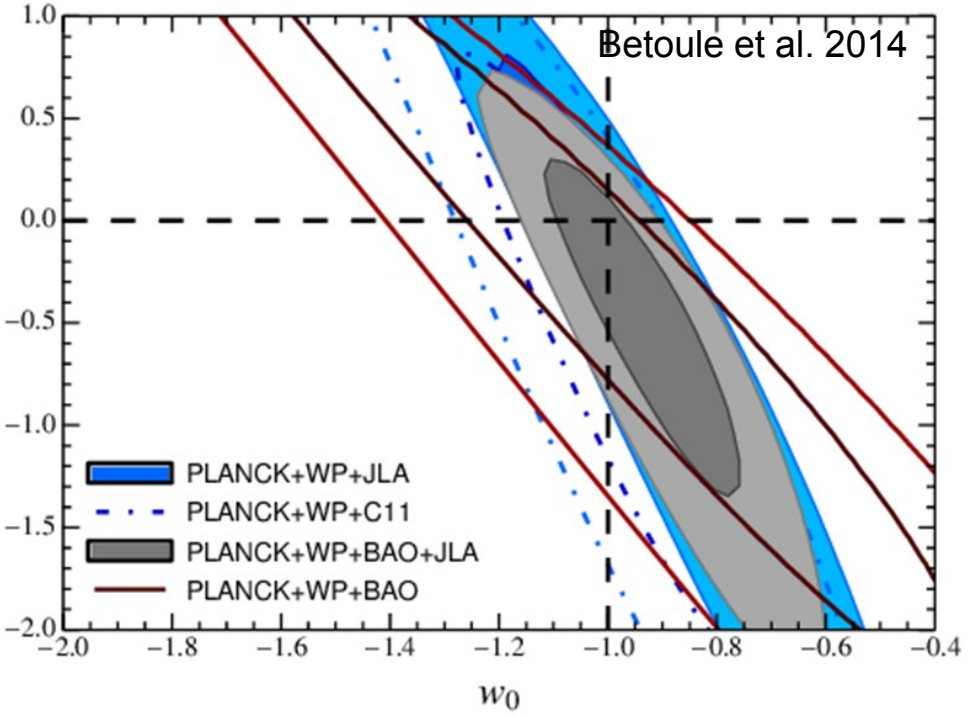
The Dark Energy

DARK ENERGY SURVEY



Current measurement compatible with dark energy being the cosmological constant



But not very sensitive yet to the time variation of the equation of state

The Dark Energy Survey

DARK ENERGY SURVEY

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

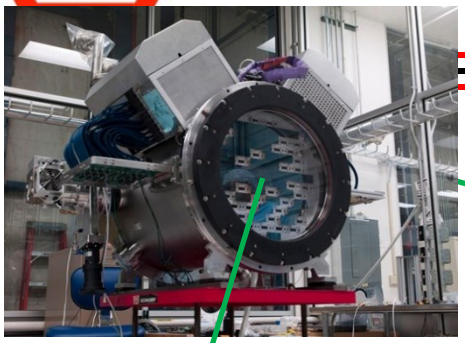
5000 sq-deg (1/8 of the sky) in grizY bands (2500 sq-deg overlapping with SPT survey) + 30 sq-deg time-domain griz (SNe)

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

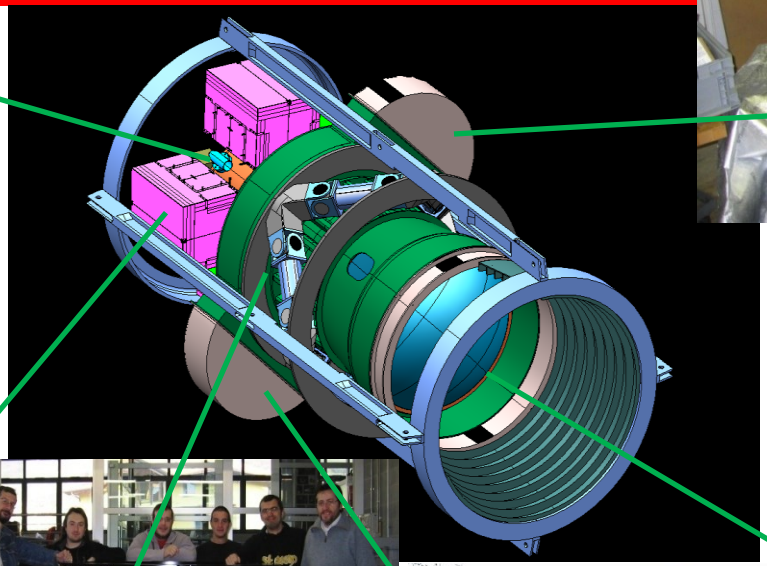
Up to 24th magnitude (z~1.5)

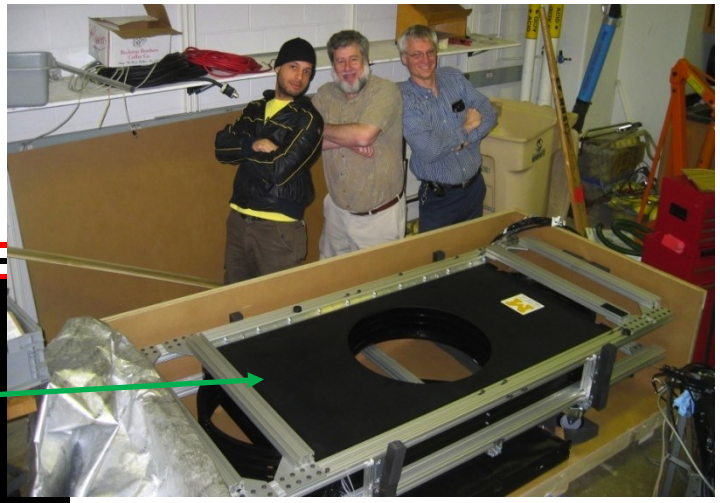
DECam

The Dark Energy Camera

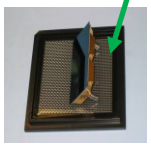


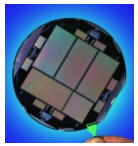
Imager, FNAL





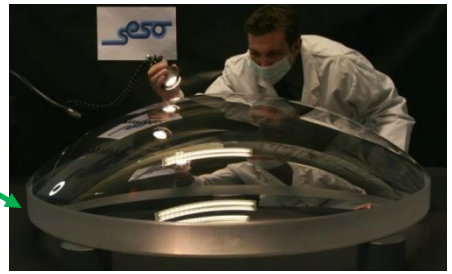
Filter changer, Univ. of Michigan



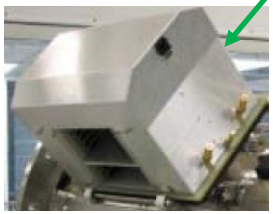


CCDs, wafer from LBNL, packaged at FNAL

Optics , UK



Hexapod, Italy



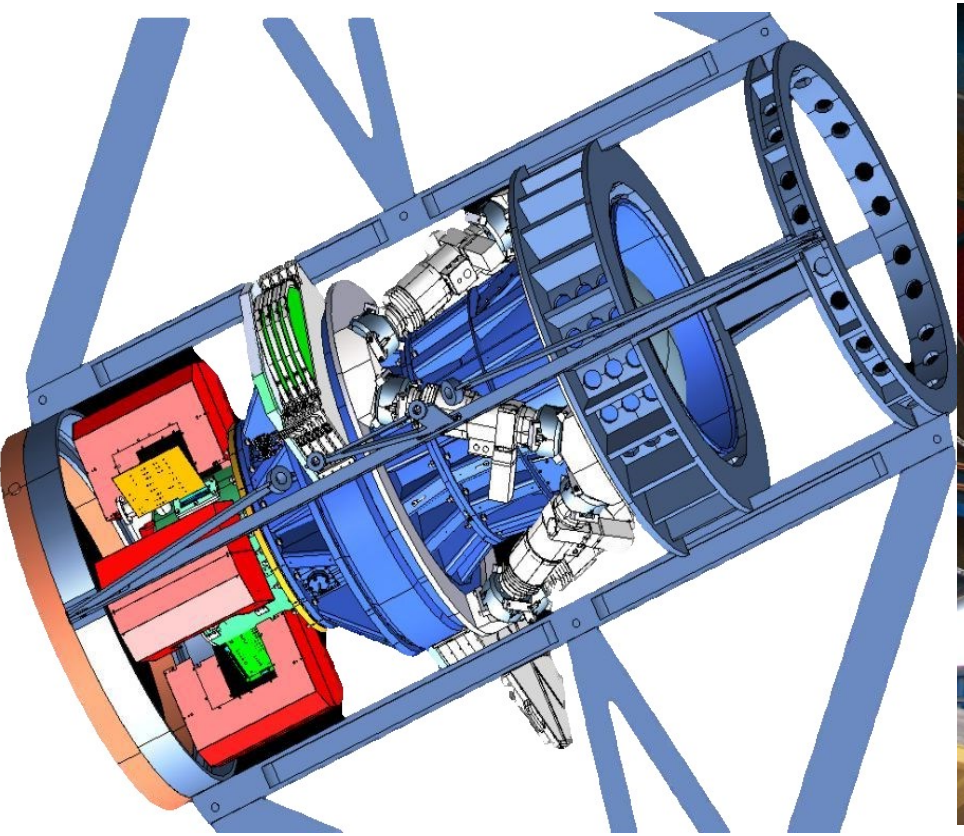
Electronics, Spain and FNAL

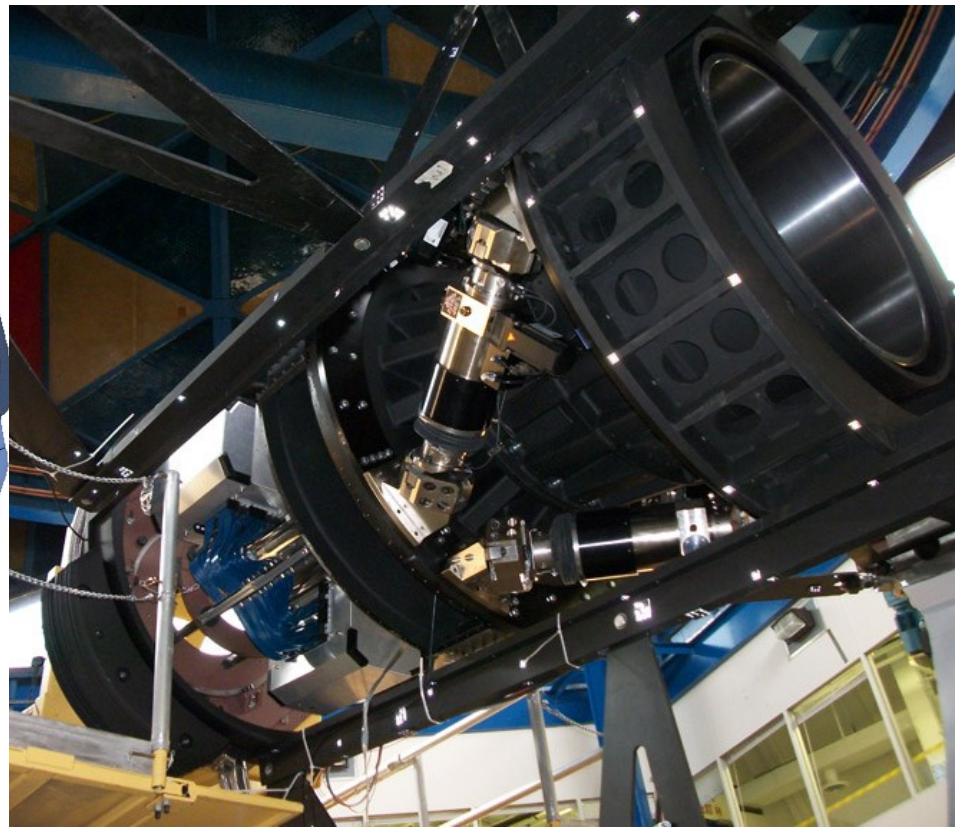
Shutter, Germany

Optomechanics, FNAL

DECam: 570 Mpixel camera

DARK ENERGY SURVEY





Installed on Blanco since august 2012

DARK ENERGY SURVEY

DECam

DARK ENERGY SURVEY

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

u,g,r,i,z,Y filters for photoz

Low noise electronics (<15 e @ 250 kpx/s)

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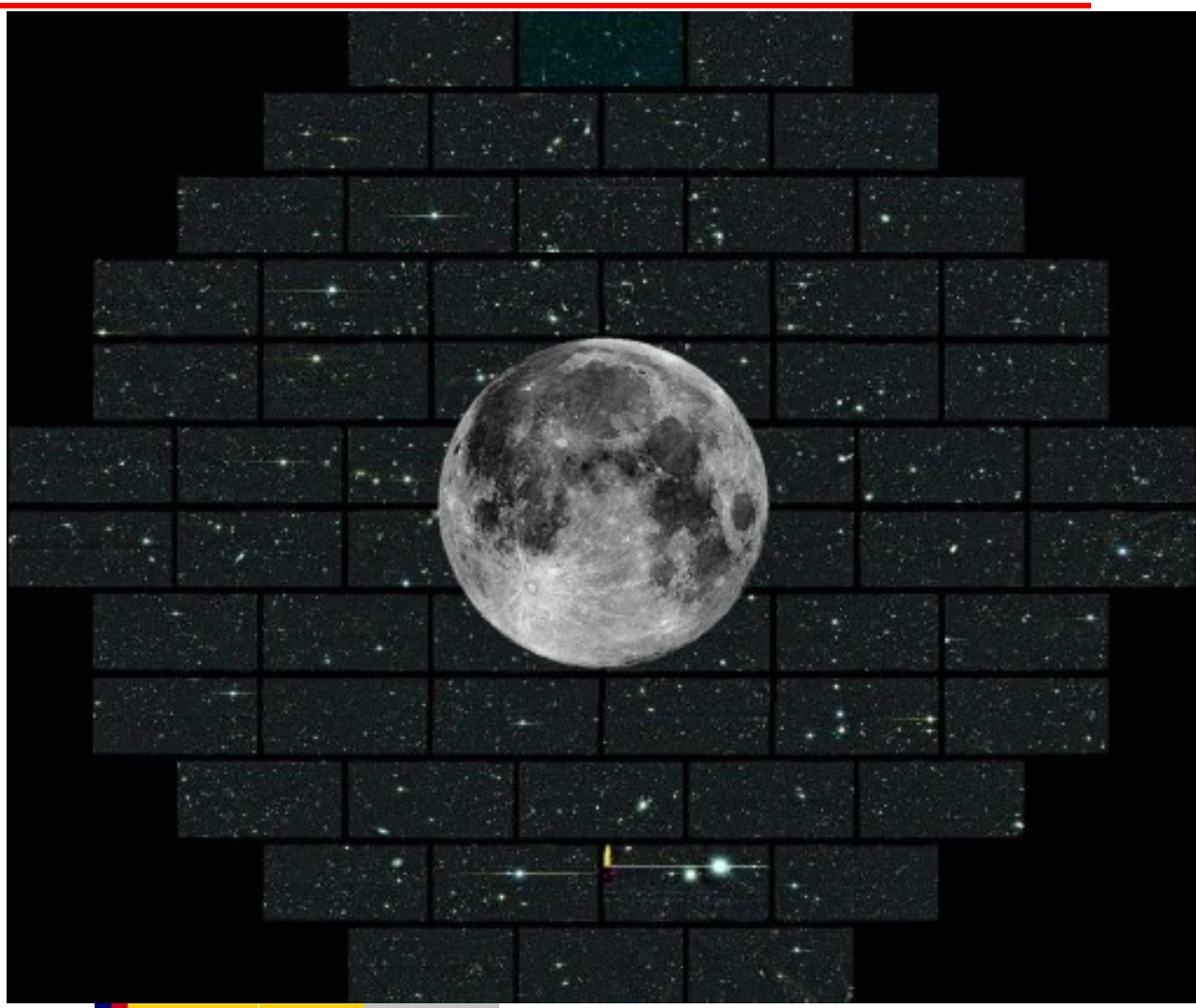


Photometric Redshift

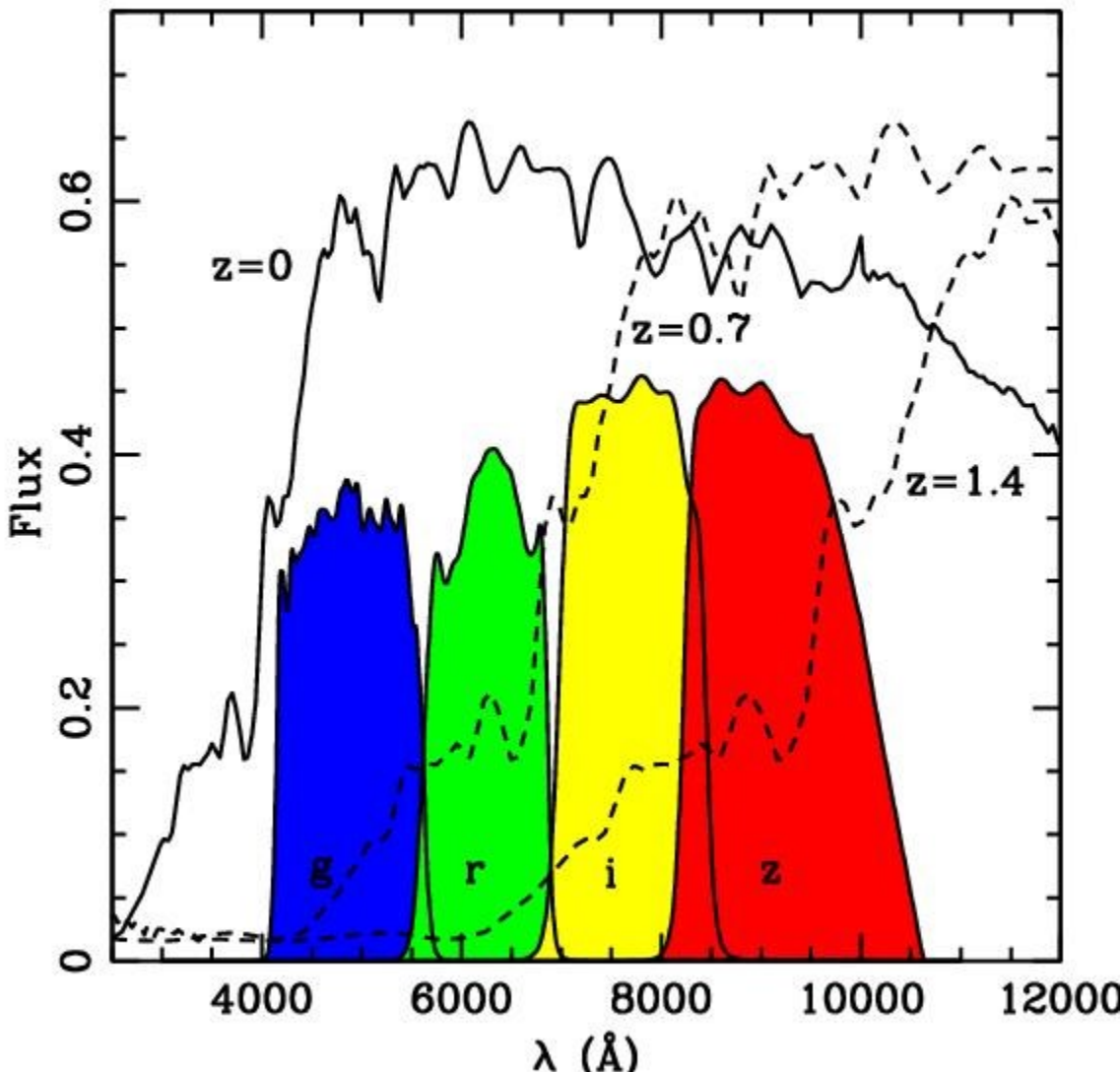
DARK ENERGY SURVEY

Collect light from galaxies in several broad-band filters in optical and NIR

grizY (DES) + JK (VHS)

Use the flux in each filter to determine:
Type (Star/galaxy/QSO…)
Galaxy Type (spiral, elliptical…)
Photometric Redshift

Also position on the sky and shape information



DES Science summary

DARK ENERGY SURVEY

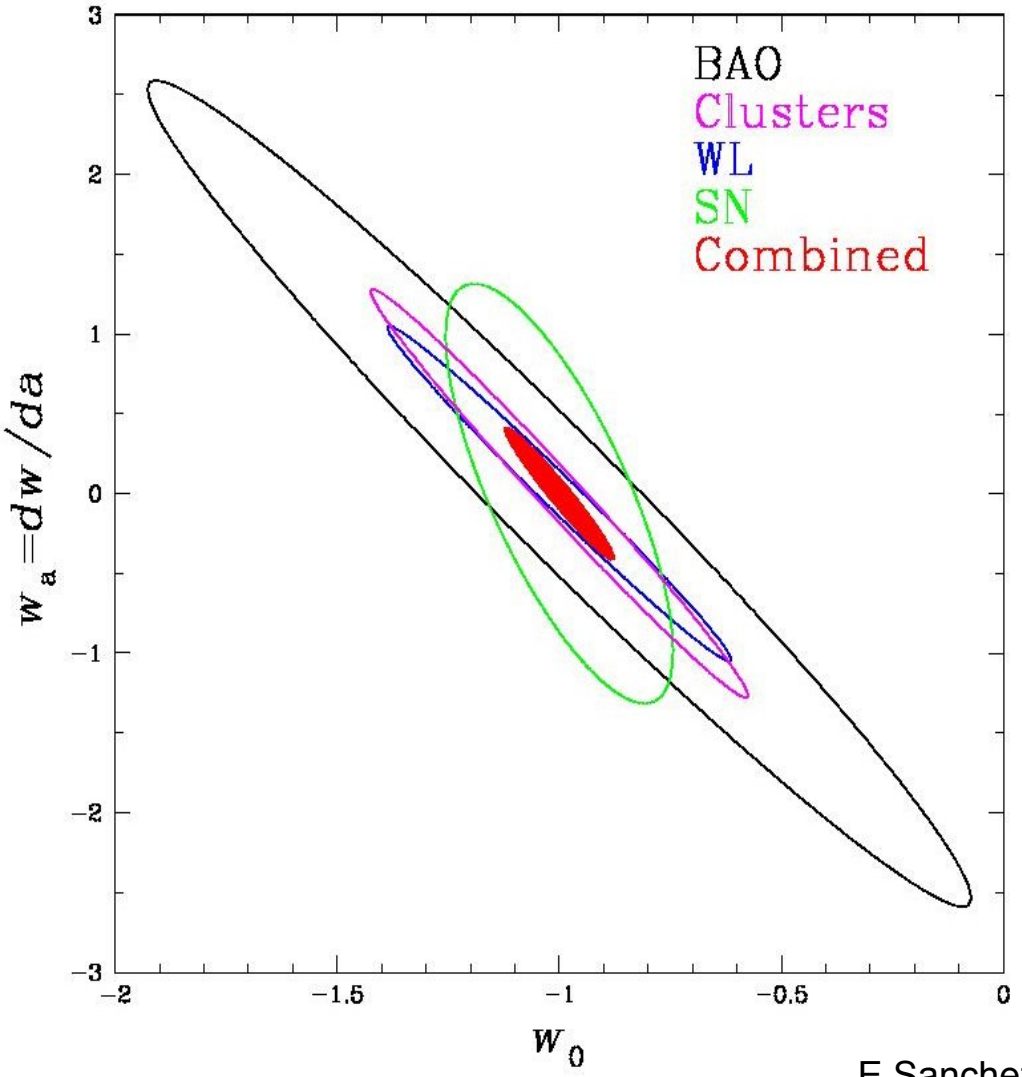
4 Probes of Dark Energy

Galaxy Clusters (dist & struct)
Tens of thousands of clusters to z~1
Synergy with SPT, VHS

Weak Lensing (dist & struct)
Shape and magnification measurements of 200 million galaxies

Baryon Acoustic Oscillations (dist)
300 million galaxies to z~1.4

Supernovae (dist)
3500 well-sampled Sne Ia to z~1



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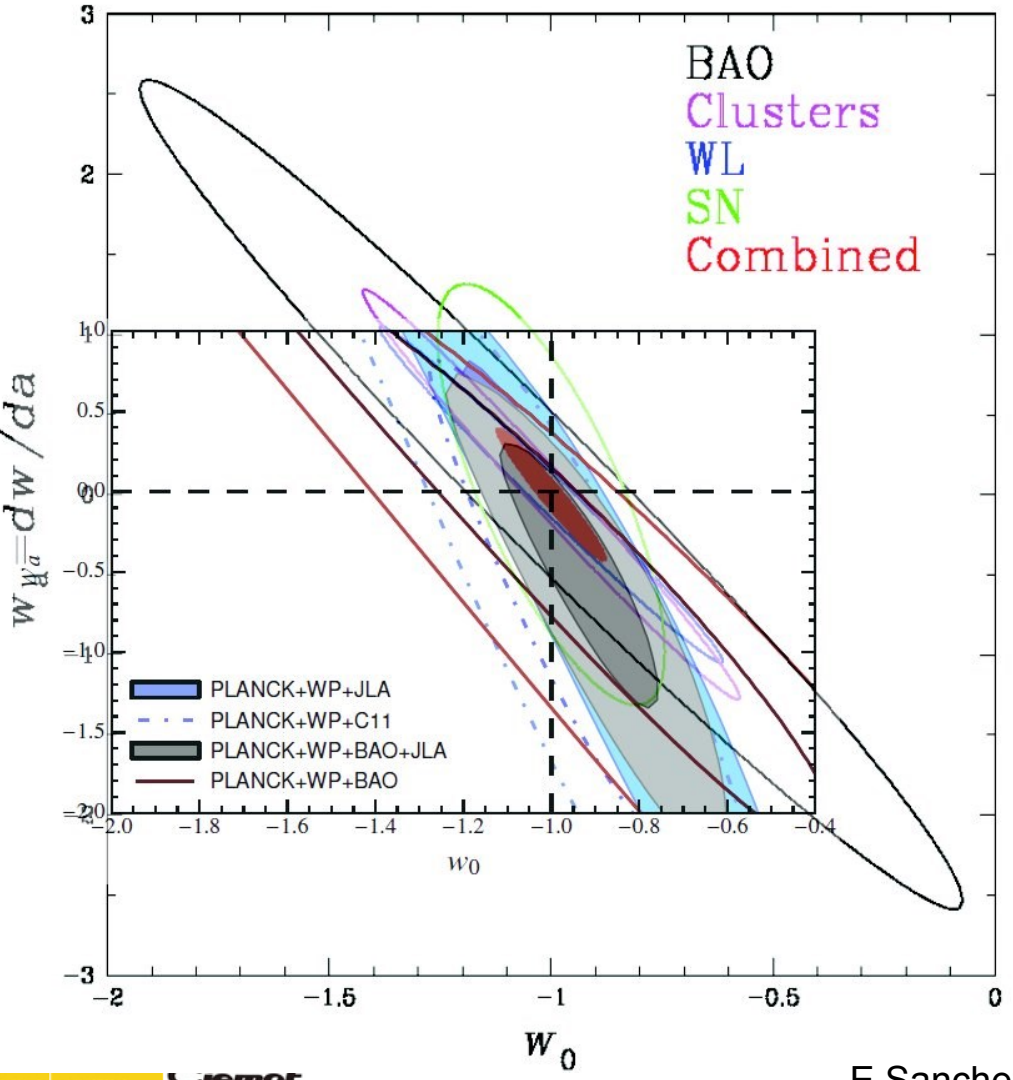

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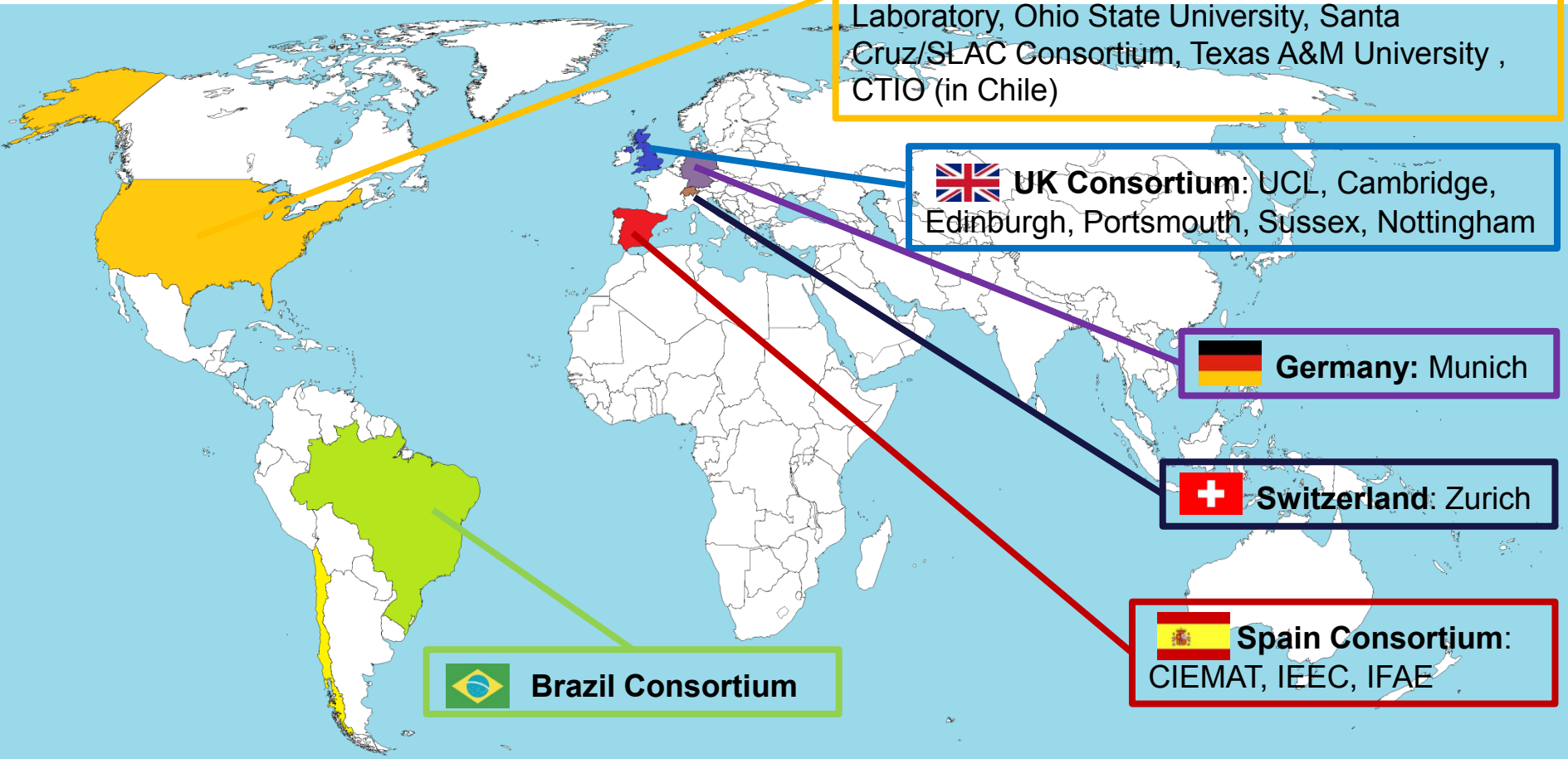
DES Collaboration:

~300 scientists from 28 institutions from around the world

DARK ENERGY SURVEY

facebook.com/darkenergysurvey
http://darkenergysurvey.org



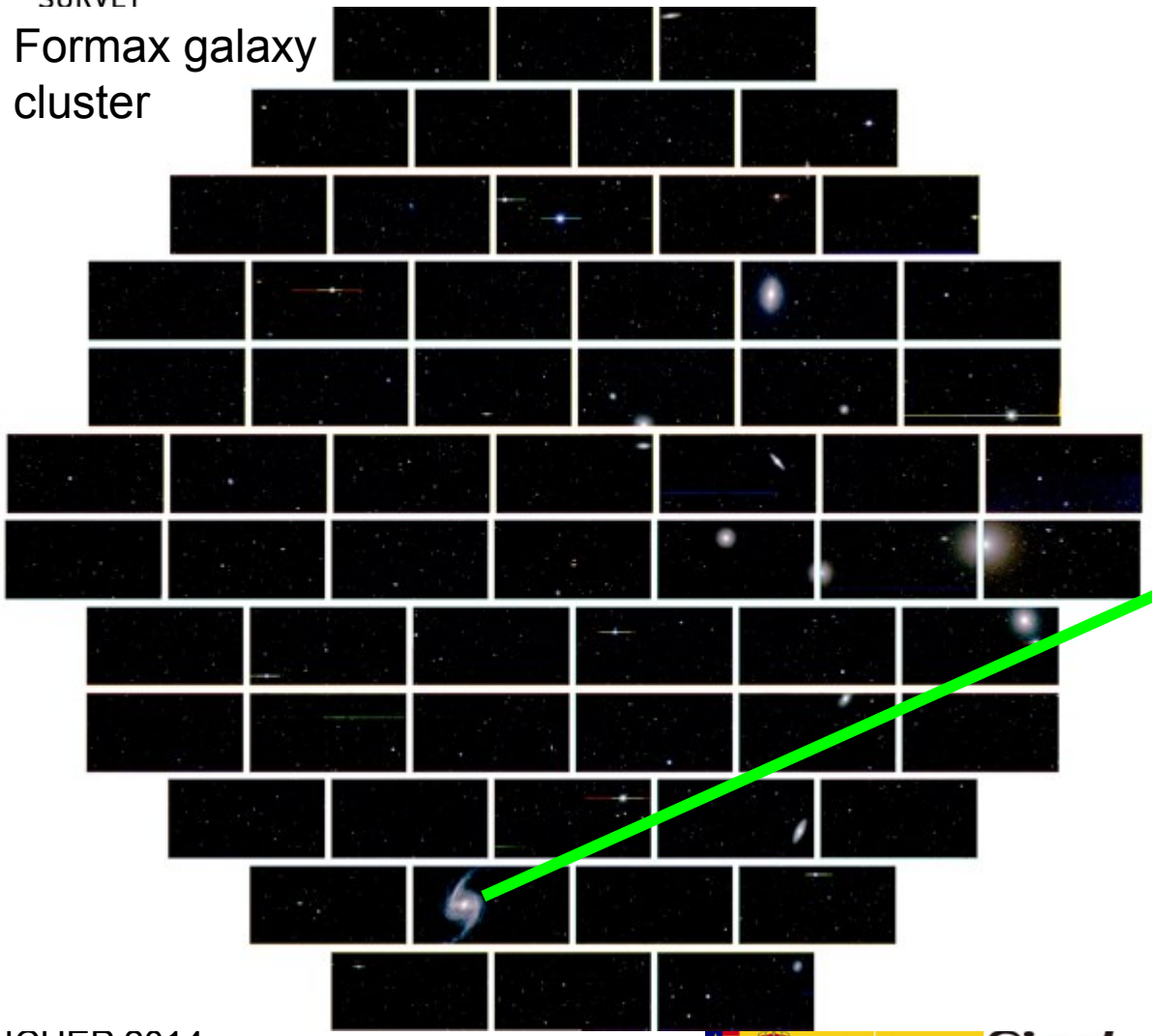
DES Timeline

2003	Project start
2004-8	R&D
2008-11	DECam construction
2012 [Sept]	Installation and first light
2012 [Sept-Oct]	Commissioning
Nov 2012- Feb 2013	**Science Verification**
Aug 31 2013 -9 Feb 2014	**First Season (Year 1)**
2014-2018	Second-Fifth Seasons

First Light: 12 september 2012

DARK ENERGY SURVEY

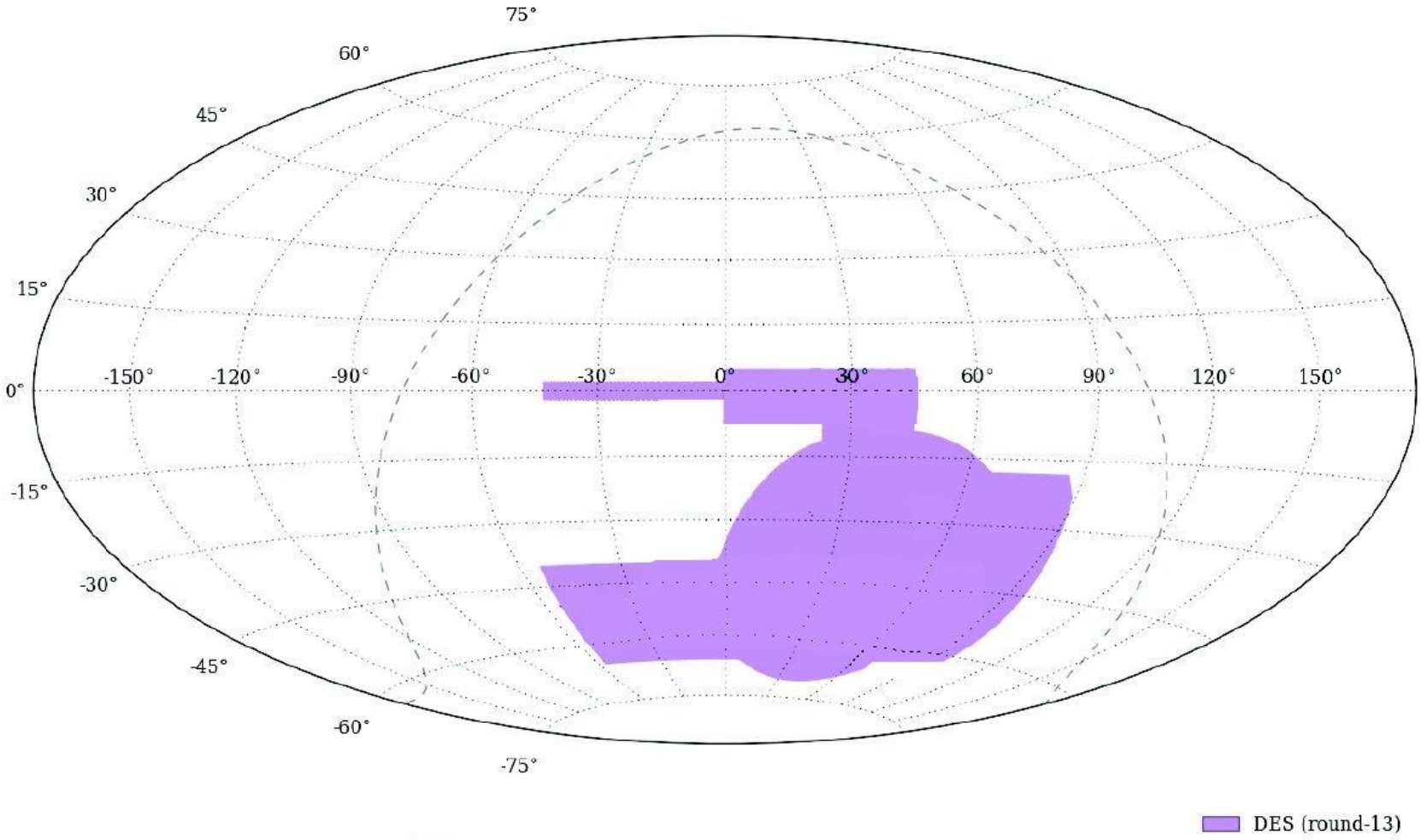
Formax galaxy cluster



NGC 1365

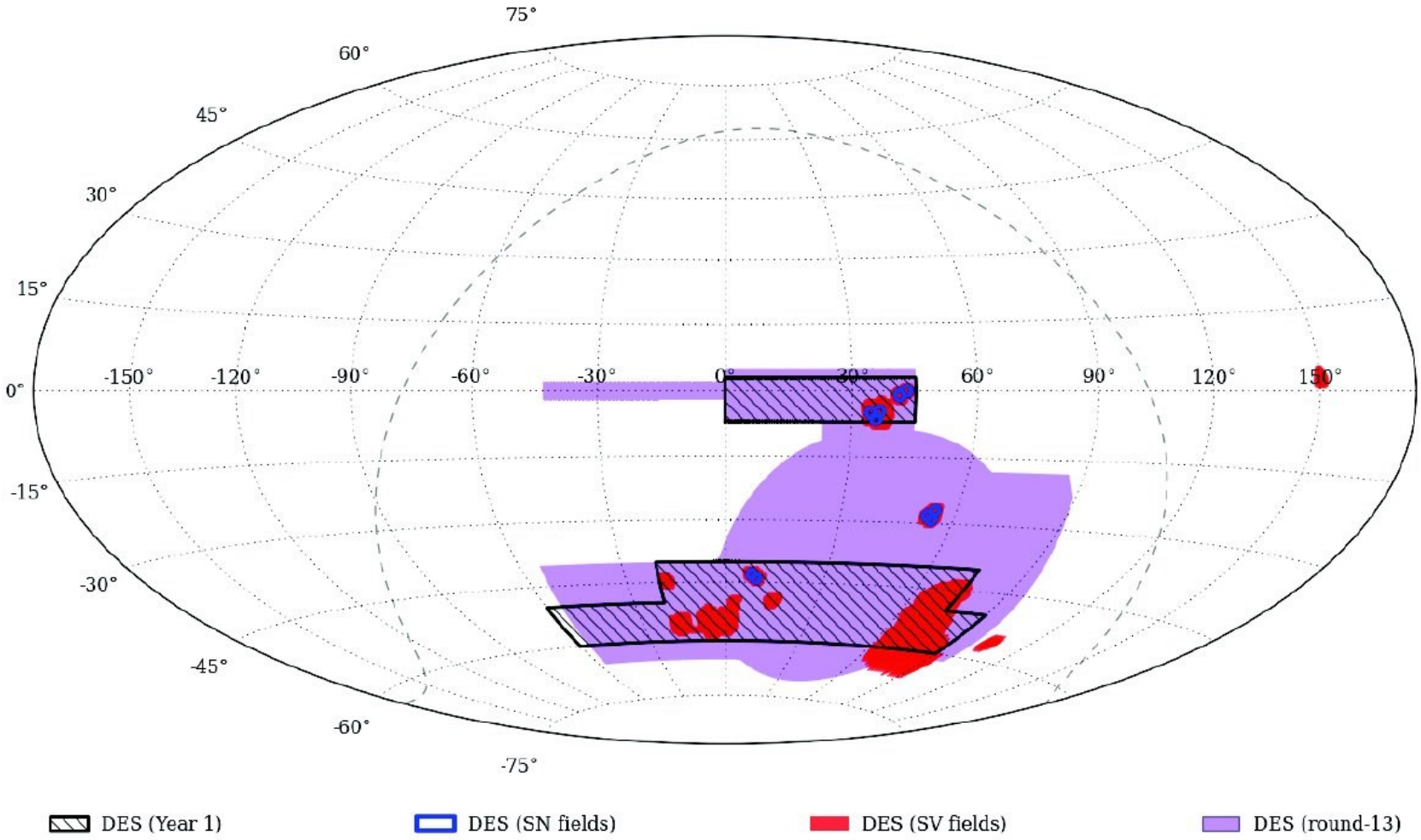
DES Footprint

DARK ENERGY SURVEY



DES Current Status

DARK ENERGY SURVEY



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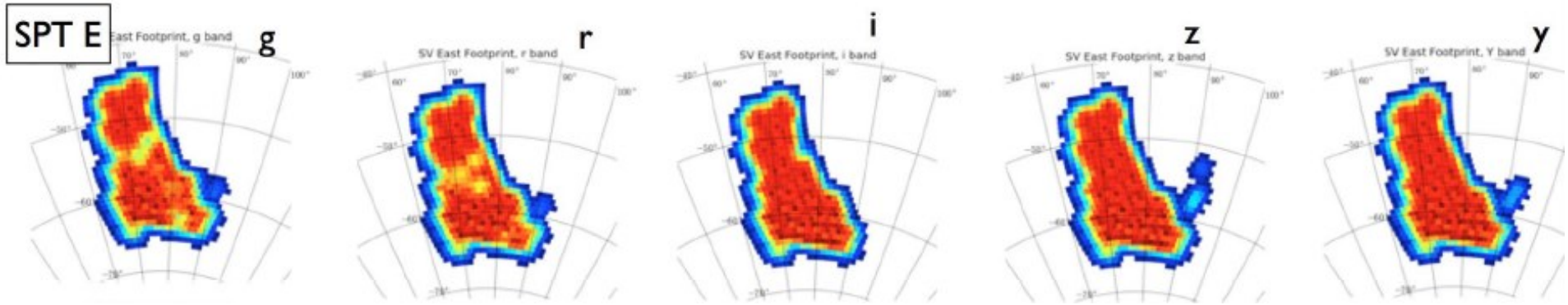
First Results: DECam performance has been extremely good

DARK ENERGY SURVEY



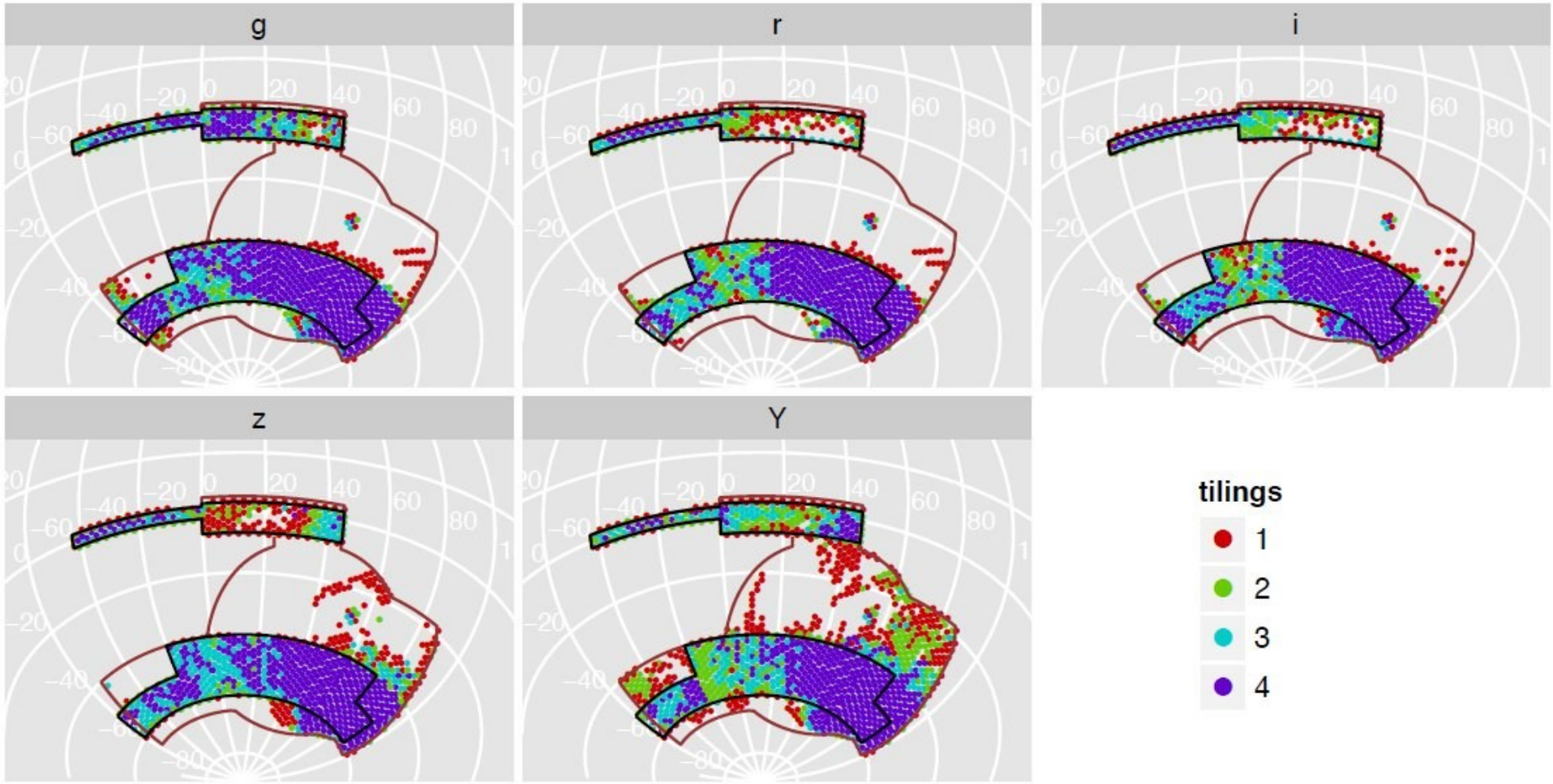
The next scientific results are based on these data (~157 sq-deg)

Main Goals: Exercise downstream analyses (DESDM) and determine whether quantites derived from image data are meeting DES requirements

Year 1 wide survey progress

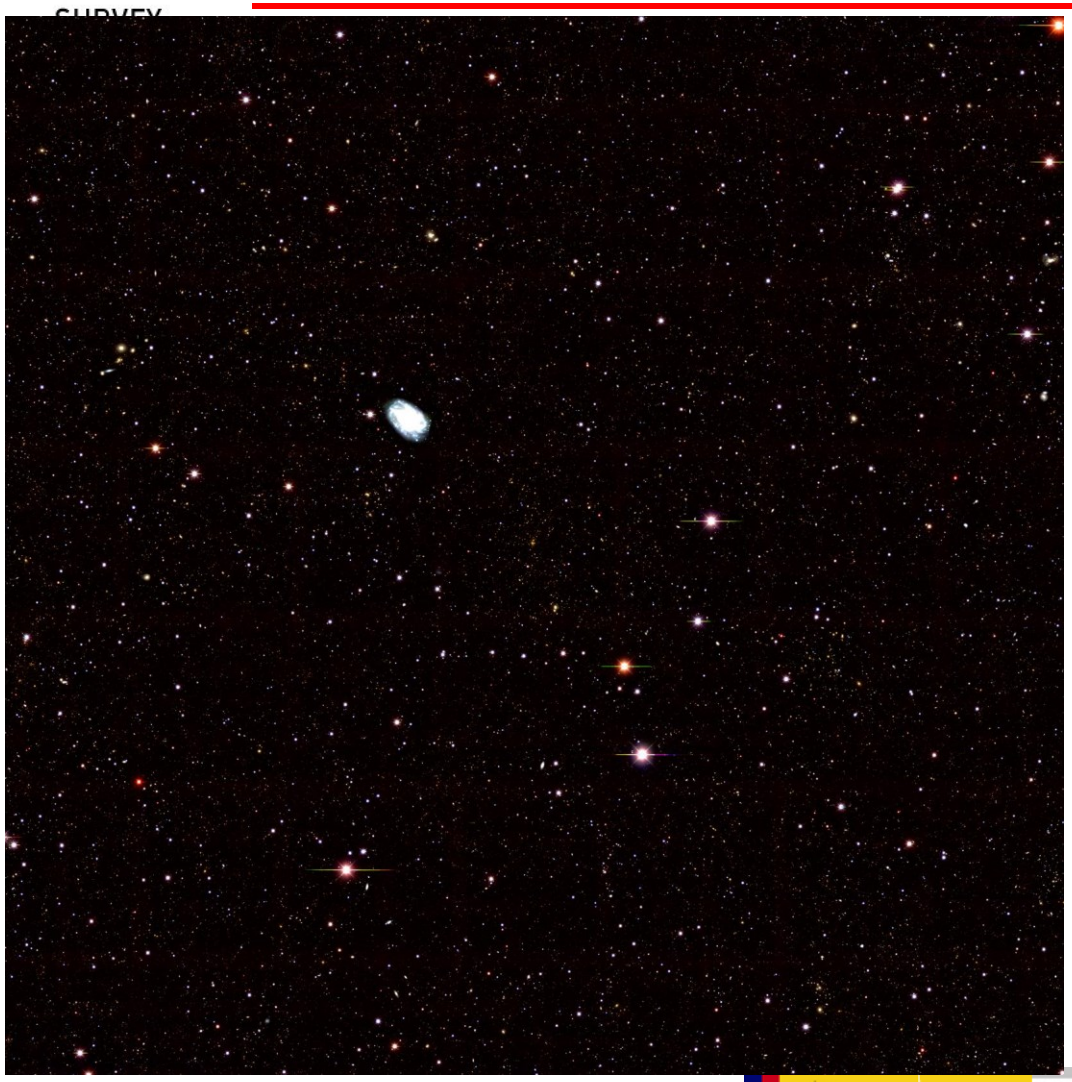
2000 sq-deg in 4 tilings (2/5 of the final depth)

DARK ENERGY SURVEY



DES SV DATA

DARK ENERGY SURVEY



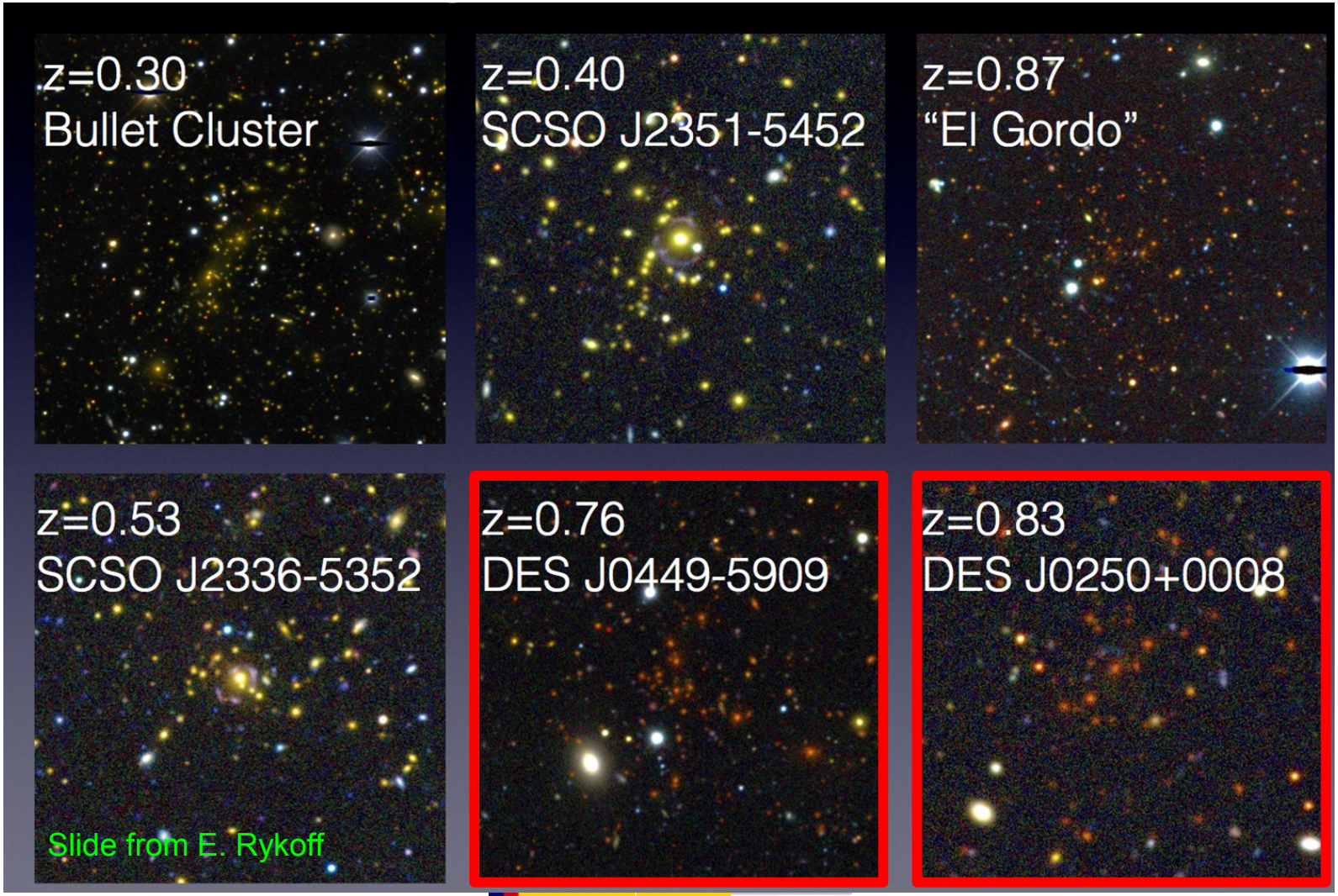
DECam 1x1 deg (1/3 of DECam FoV) grizY co-add image of SPT cluster at z=0.32

Around 50000 galaxies in this image

DES will be an unprecedented sample of galaxies going out to high redshifts

Galaxy clusters from DES: New clusters at high redshift (z>0.7!)

DARK ENERGY SURVEY



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DES clusters correlate with X-ray data

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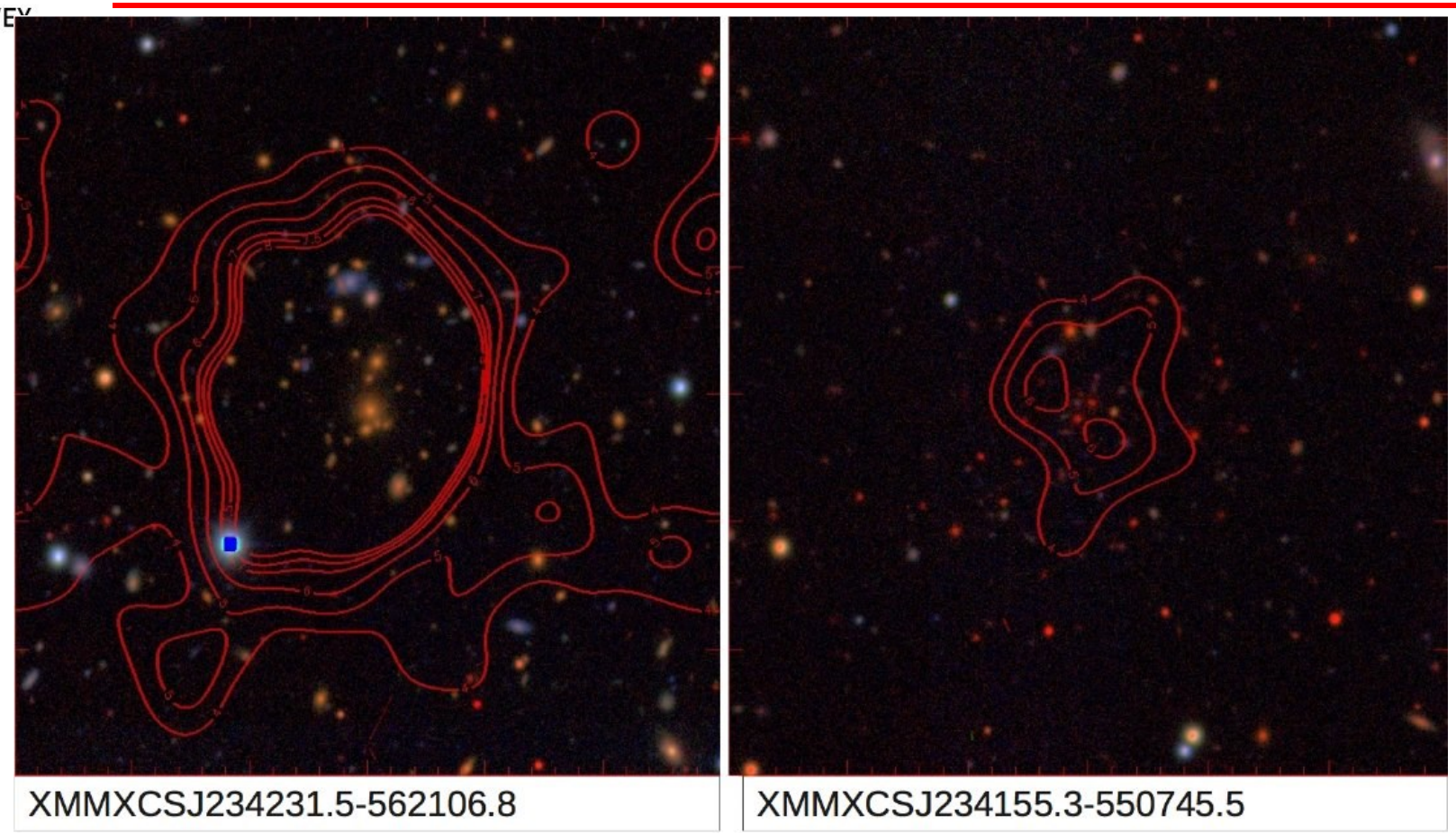


XMMXCSJ234231.5-562106.8

z=0.43

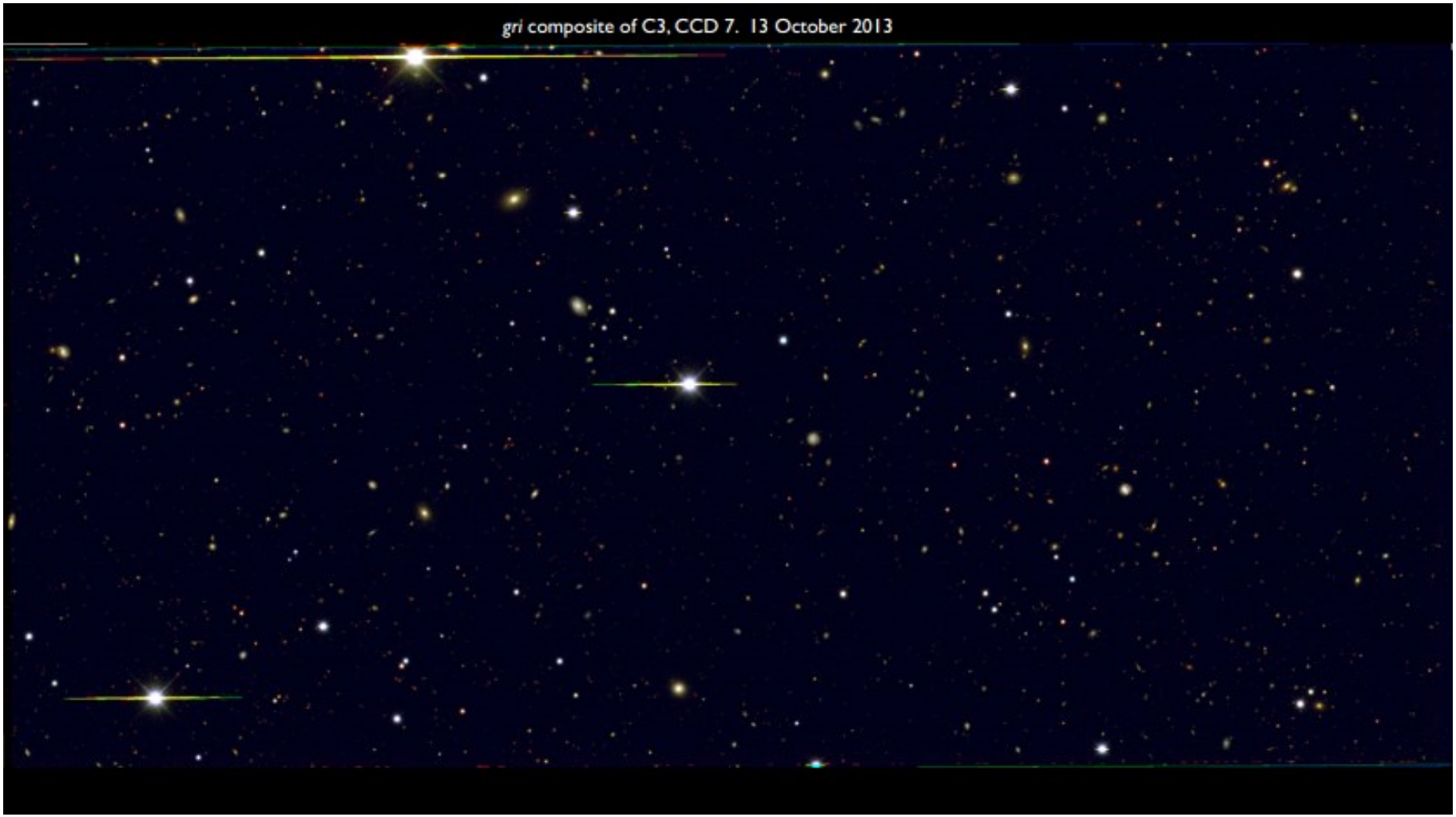
XMMXCSJ234155.3-550745.5

z=0.47

Courtesy Phil Rooney and Eli Rykoff

Supernova DES13C3hwb, SN-Ia at z=0.606

DARK ENERGY SURVEY



Supernova DES13C3hwb, SN-Ia at z=0.606

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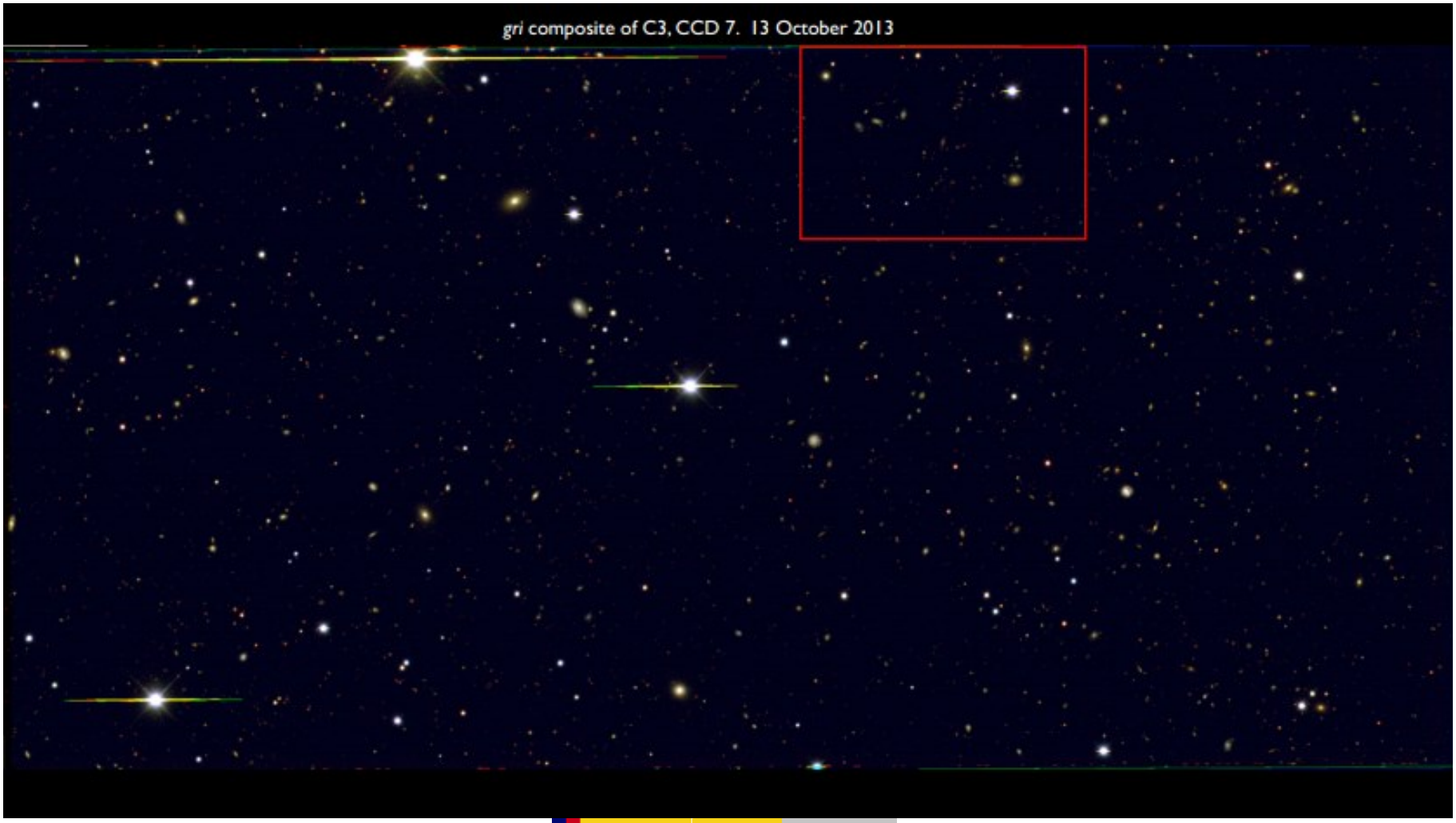

Supernova DES13C3hwb, SN-Ia at z=0.606

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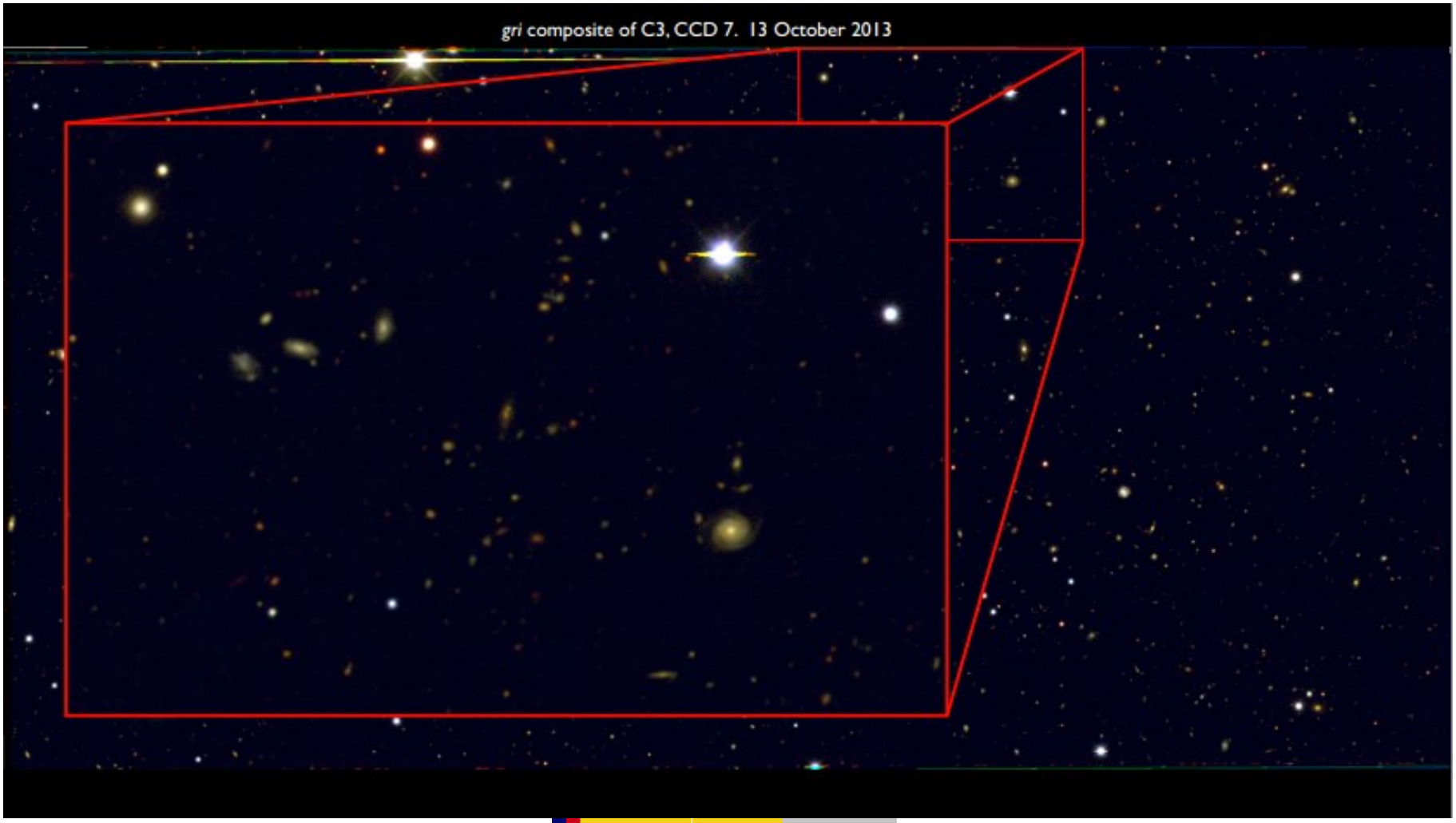

Supernova DES13C3hwb, SN-Ia at z=0.606

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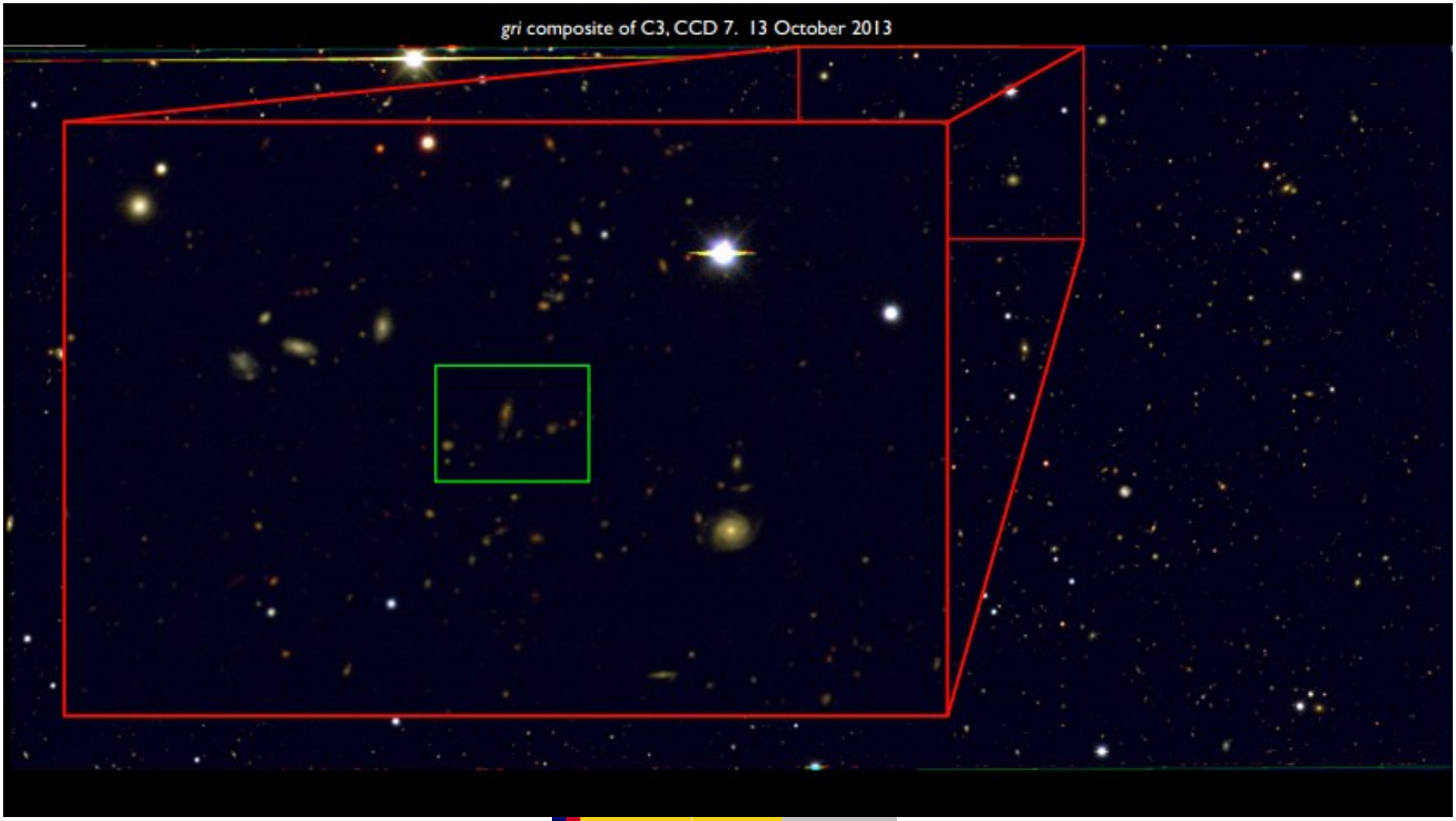

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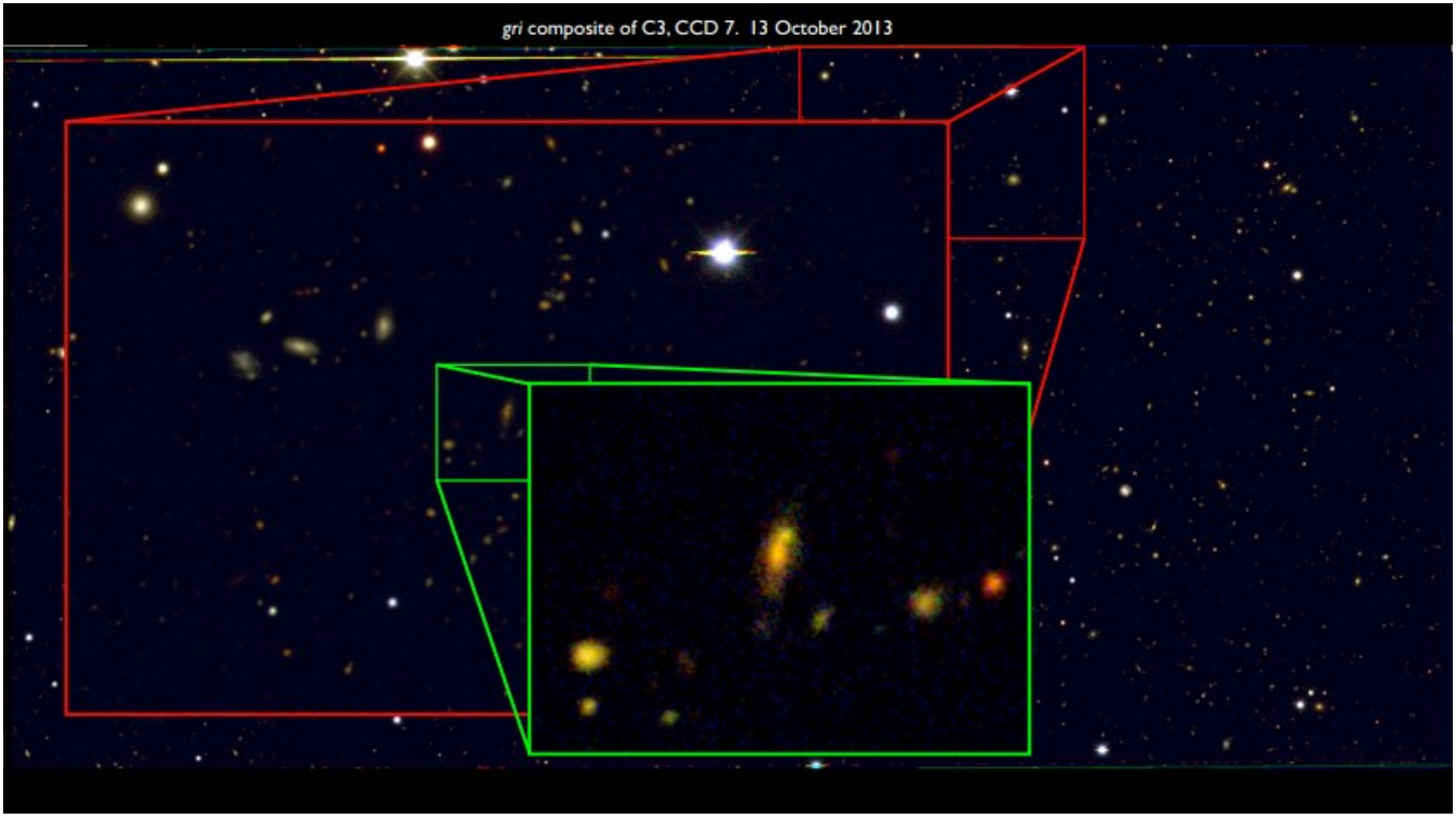

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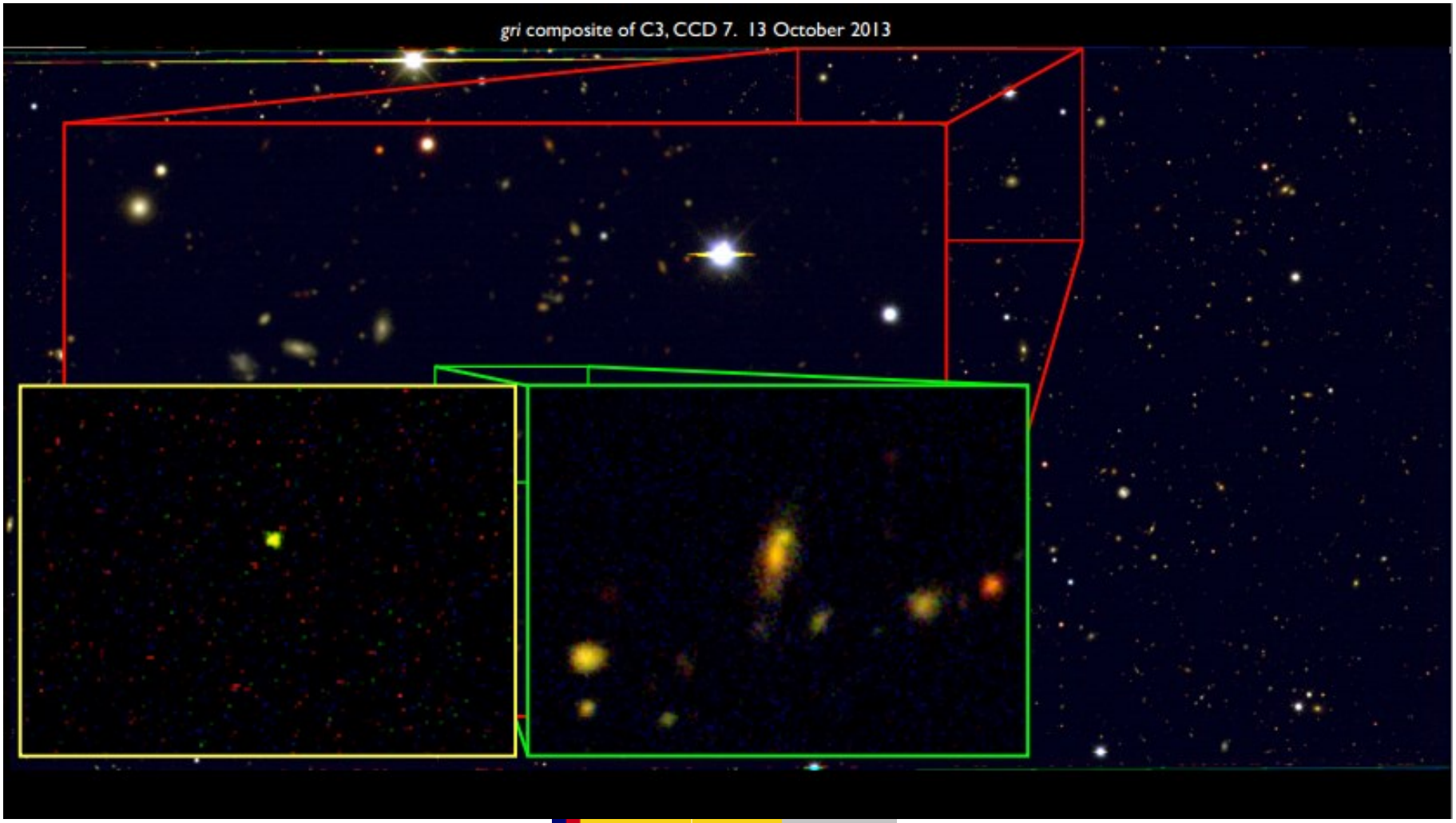
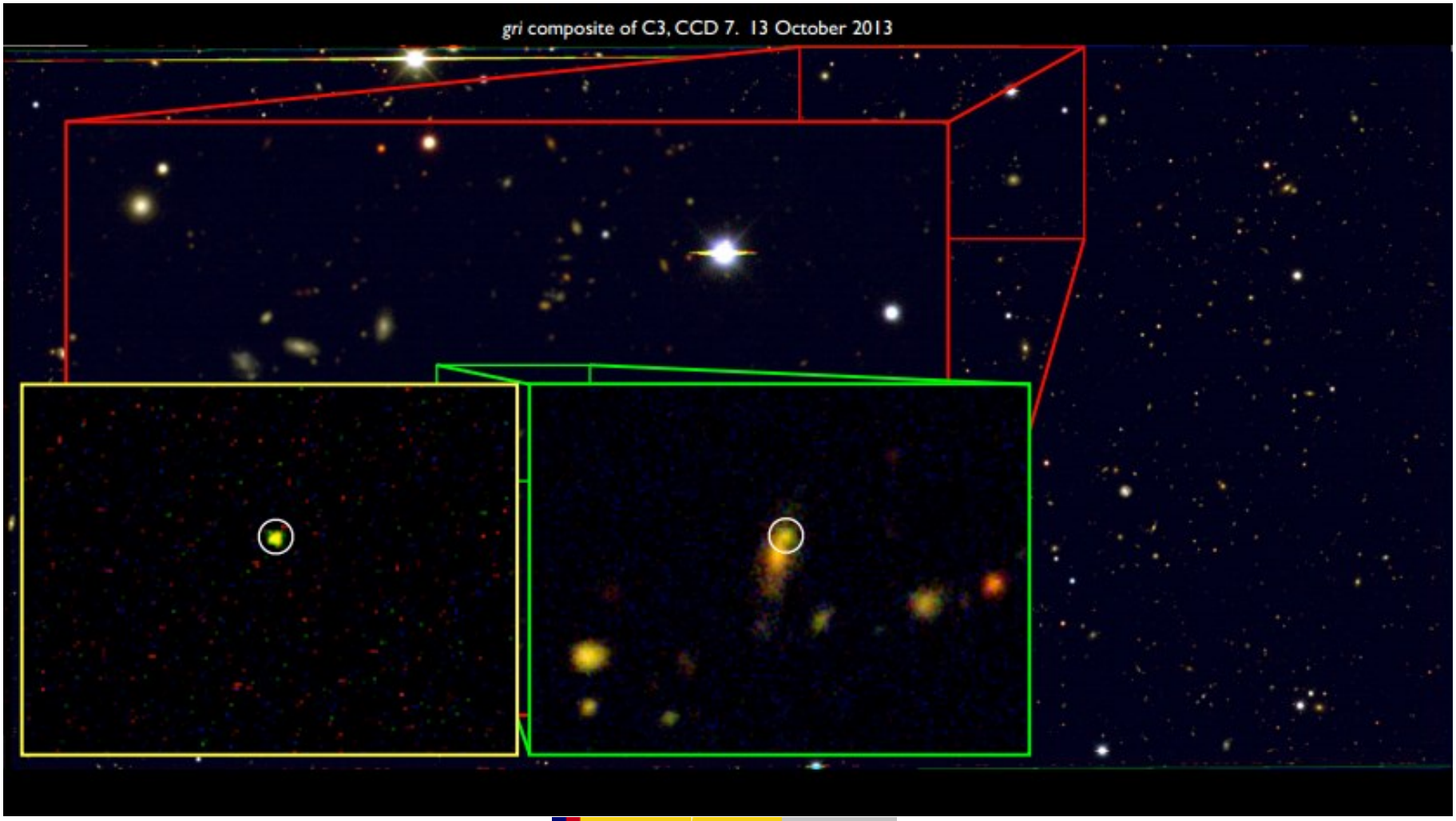


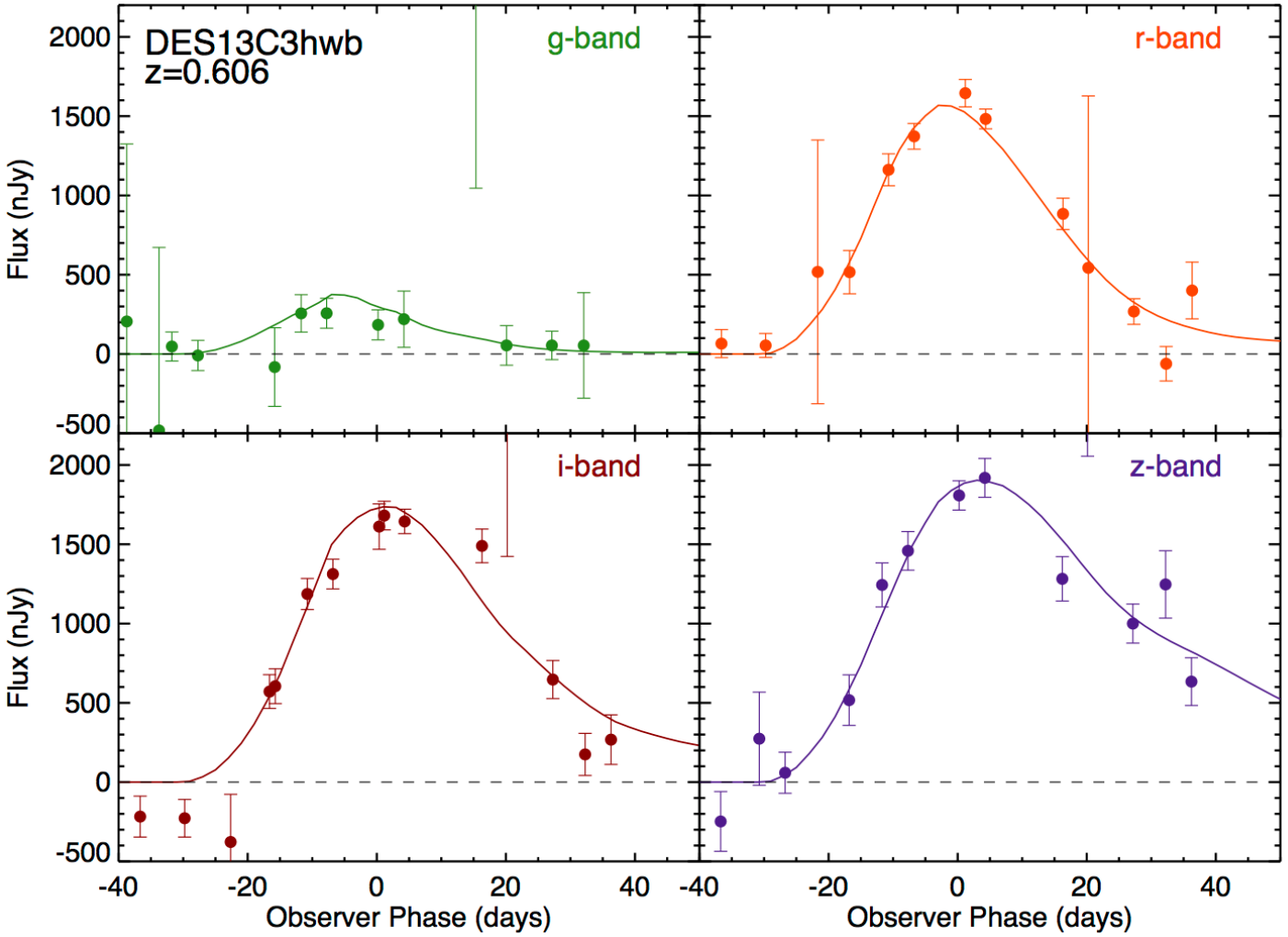
Supernova DES13C3hwb, SN-Ia at z=0.606

DARK ENERGY SURVEY

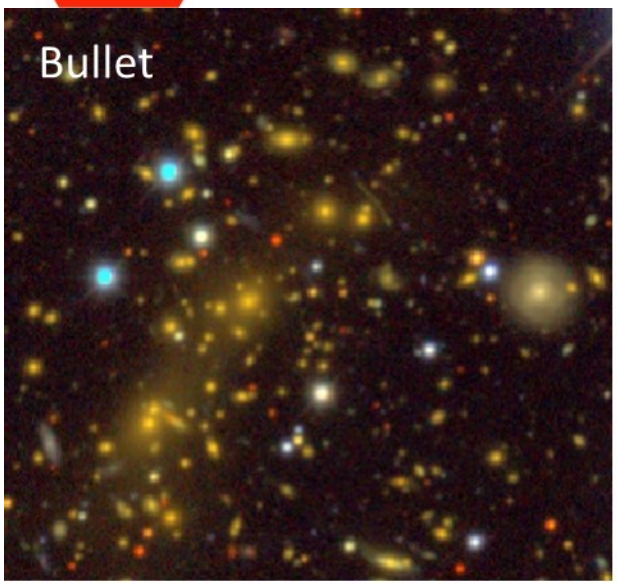


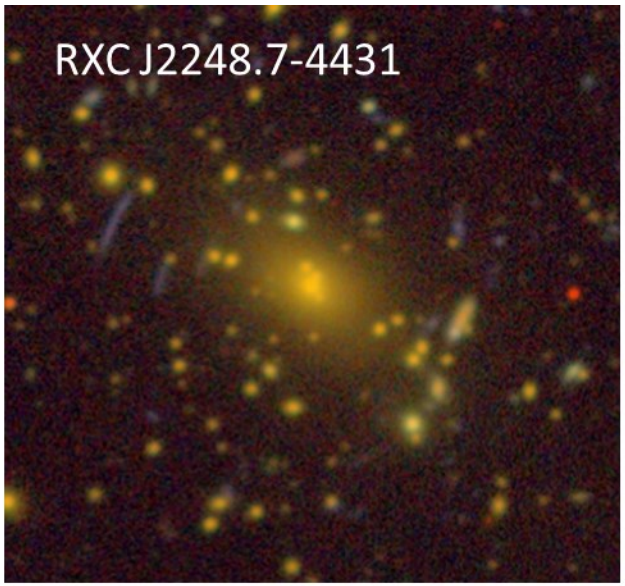
Supernova DES13C3hwb, SN-Ia at z=0.606 (Light Curves)

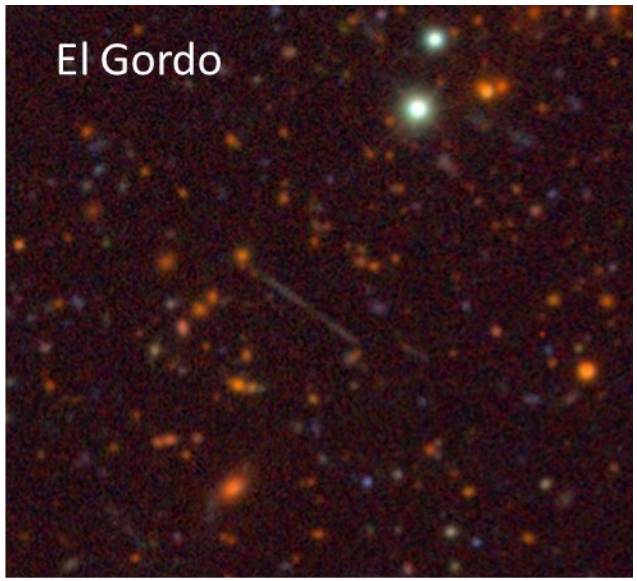
DARK ENERGY SURVEY

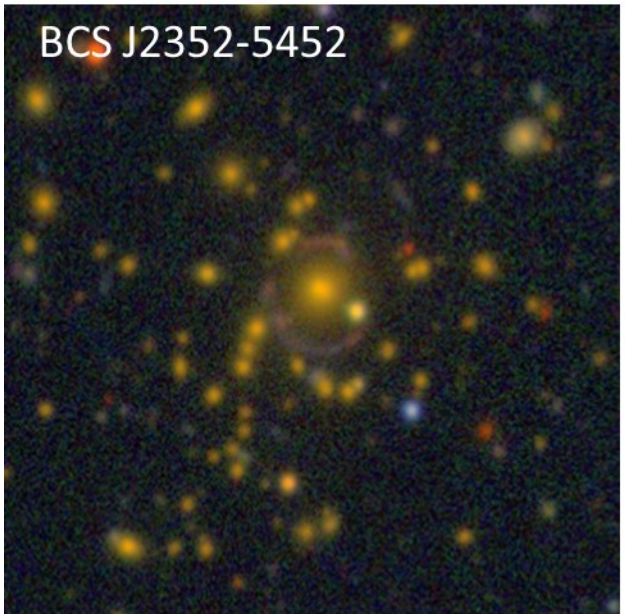


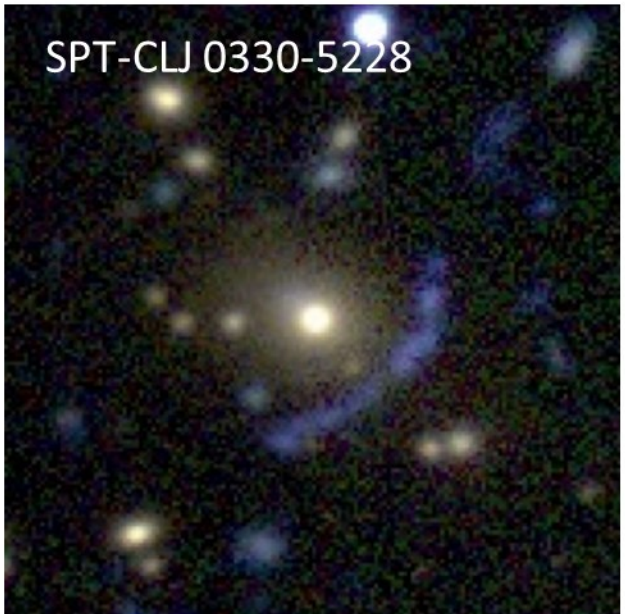
Strong Gravitational Lenses

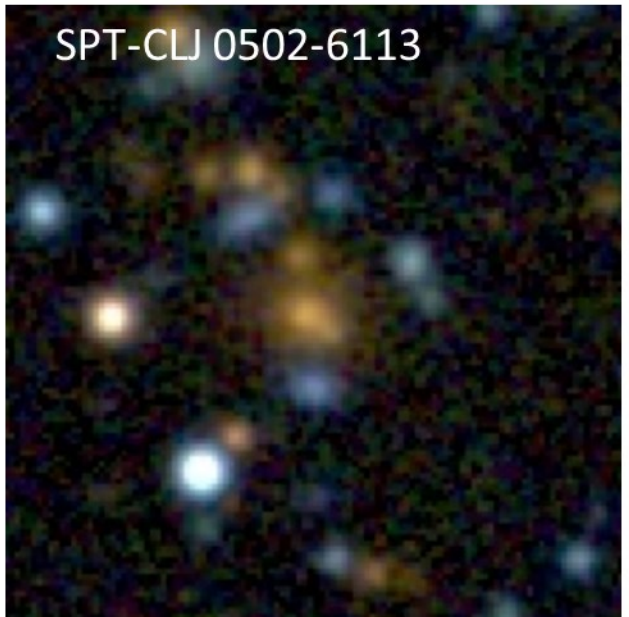












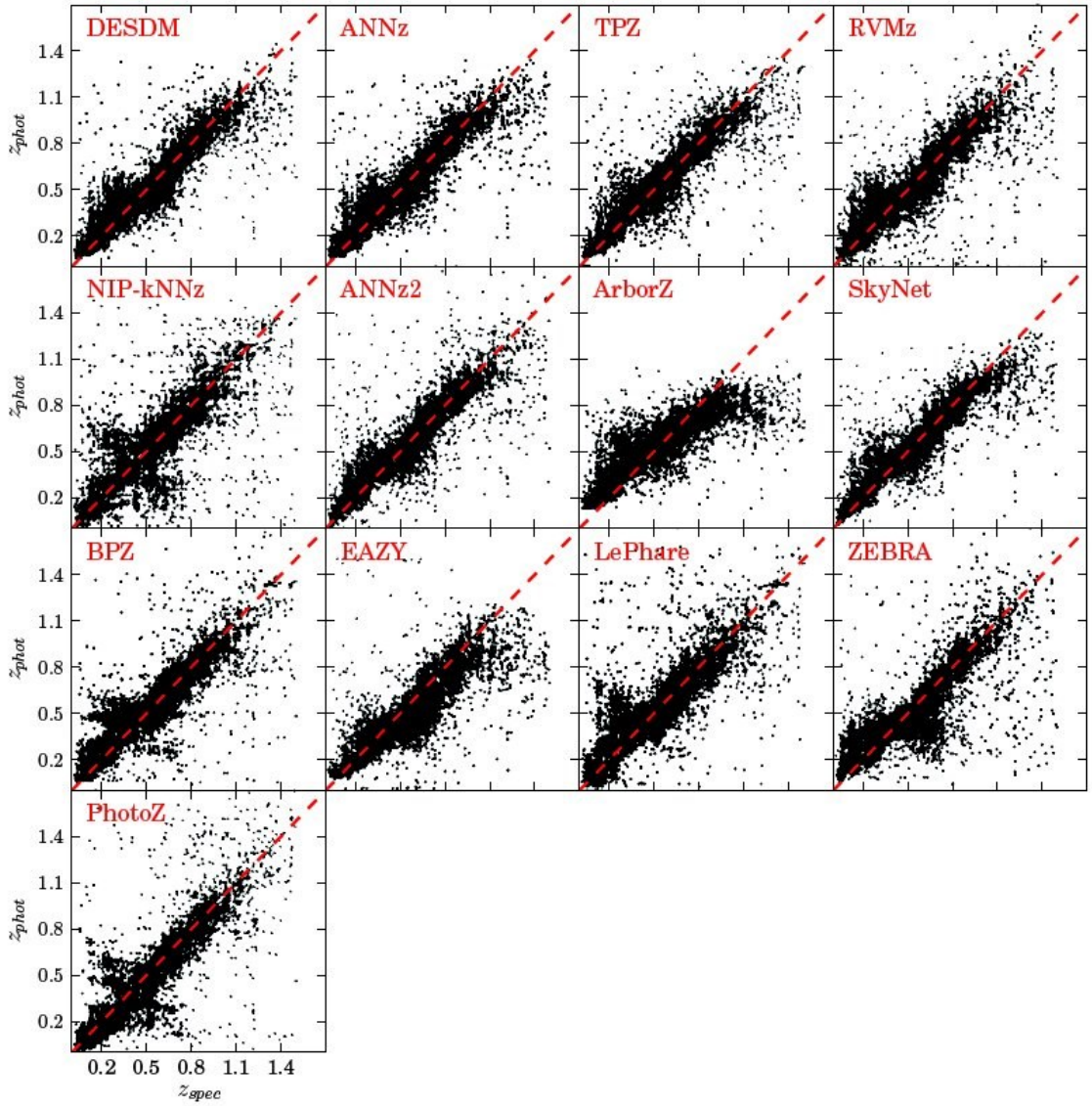
Photometric redshift performance (arXiv:1406.4407)

DARK ENERGY SURVEY

Use 15000 galaxies with spectroscopic determination of the redshift (from several previous surveys) for testing and calibrating photoz

Most of the codes meet the DES science requirements, already at this early stage

This paper proves that DES can measure photometric redshifts



ICHEP 2014

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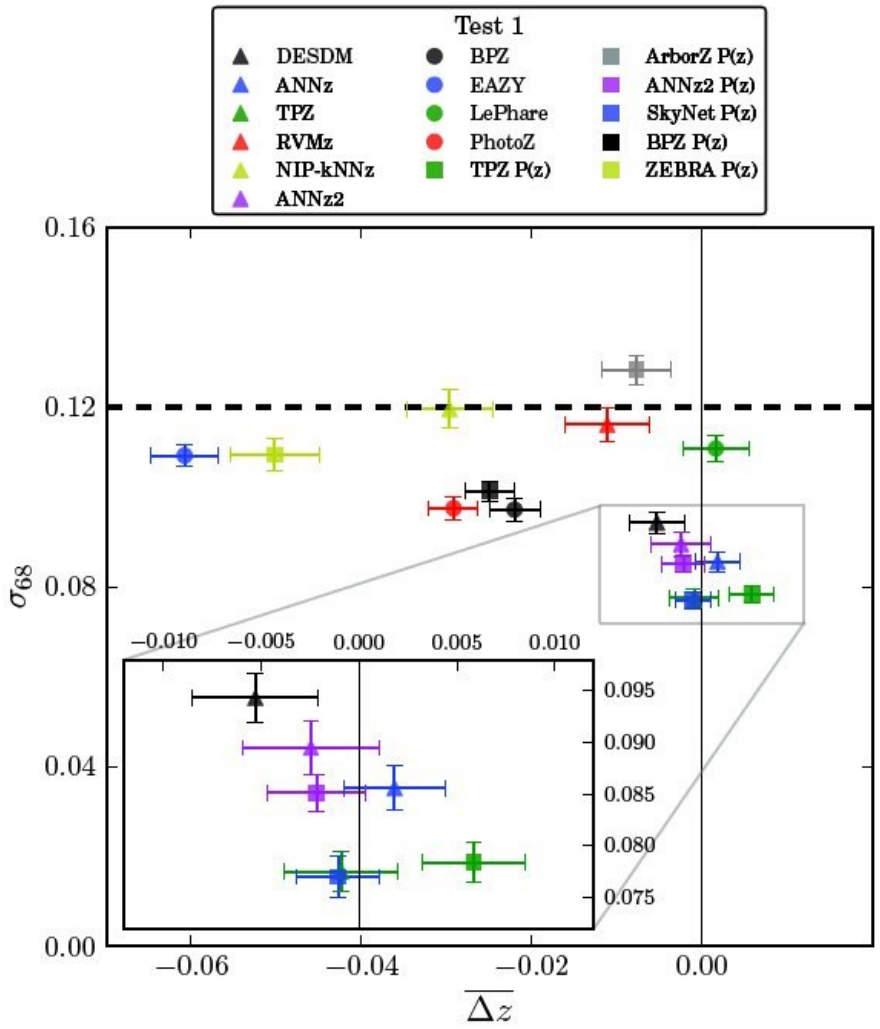

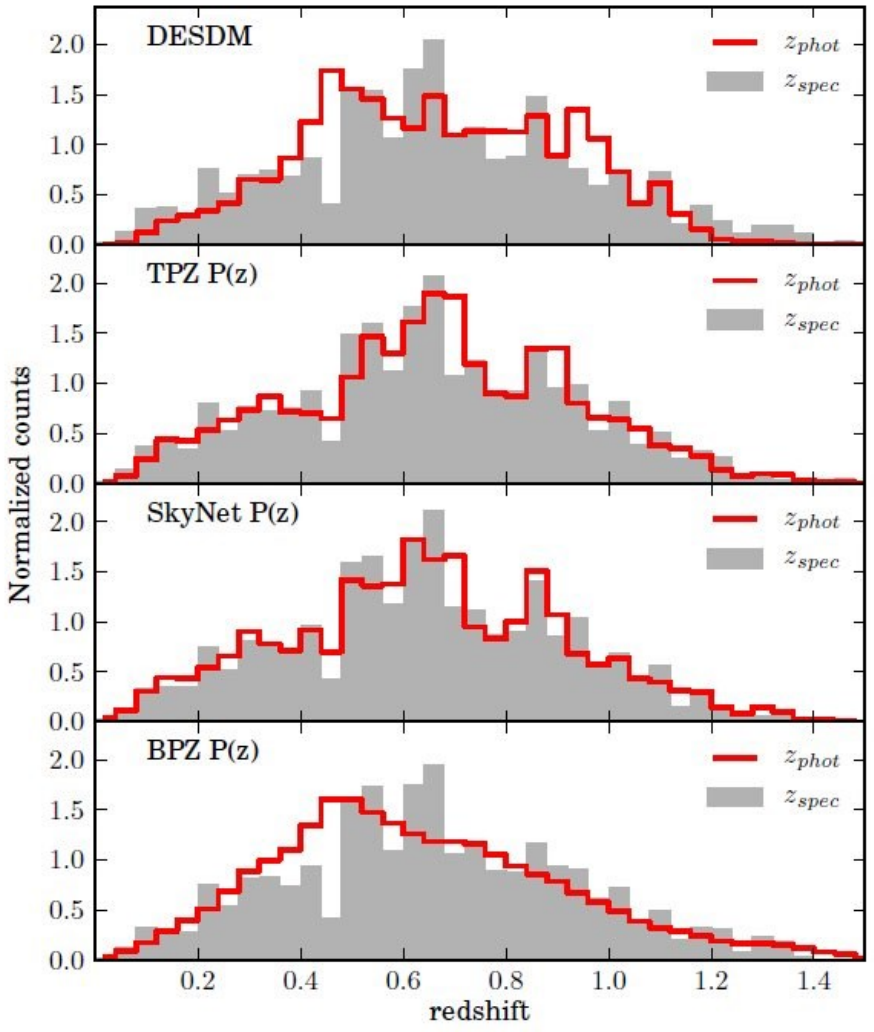

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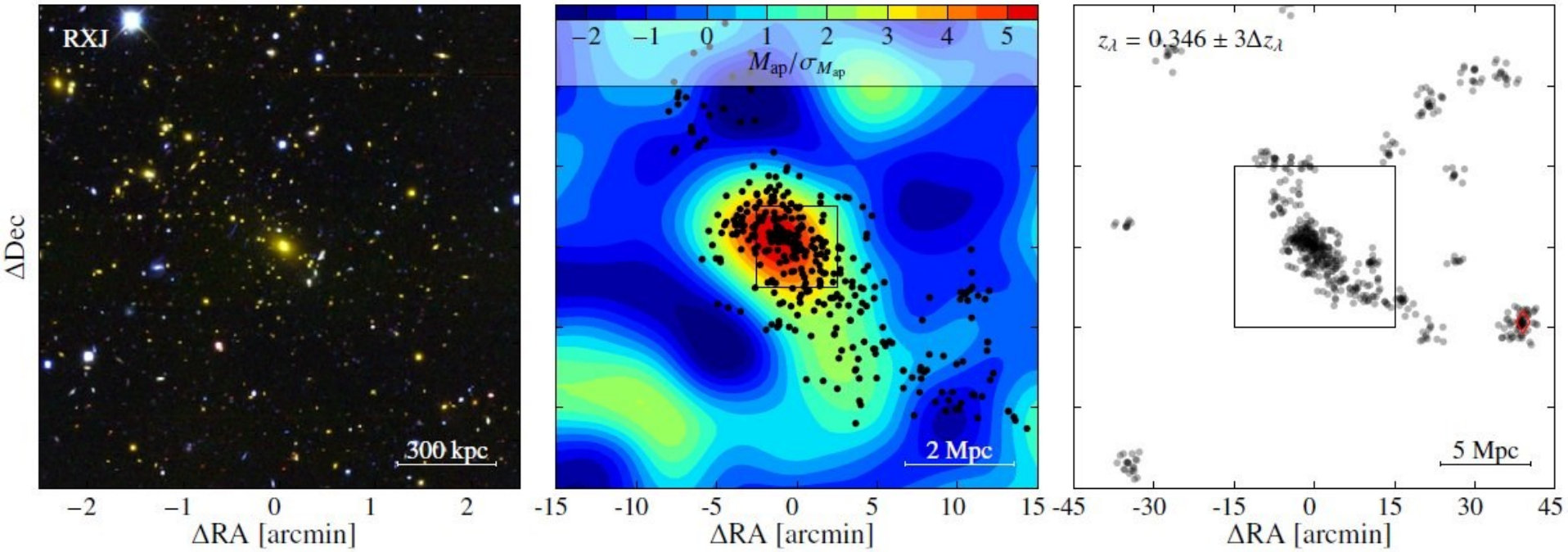
Testing Weak Lensing: Masses of 4 galaxy clusters (arXiv:1405.4285)

DARK ENERGY SURVEY



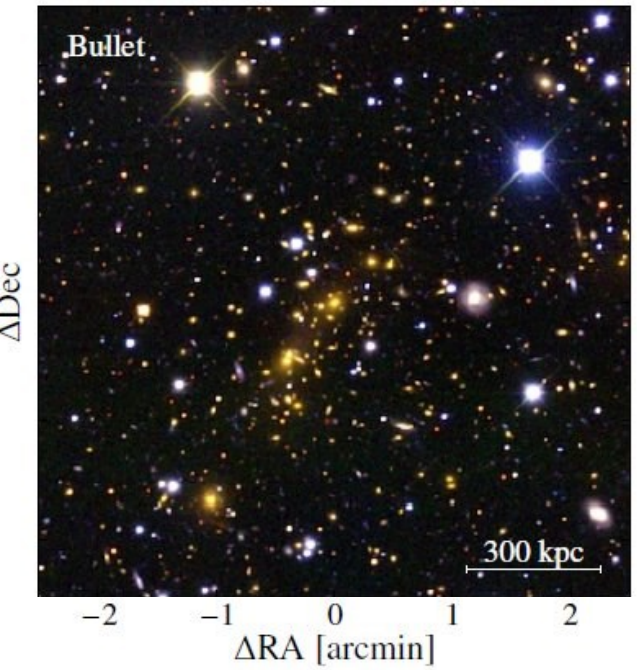
Multi-color image of the inner 5 arcmin

Weak lensing aperture mass significance map of the innr 30 arcmin, overlaid with galaxies

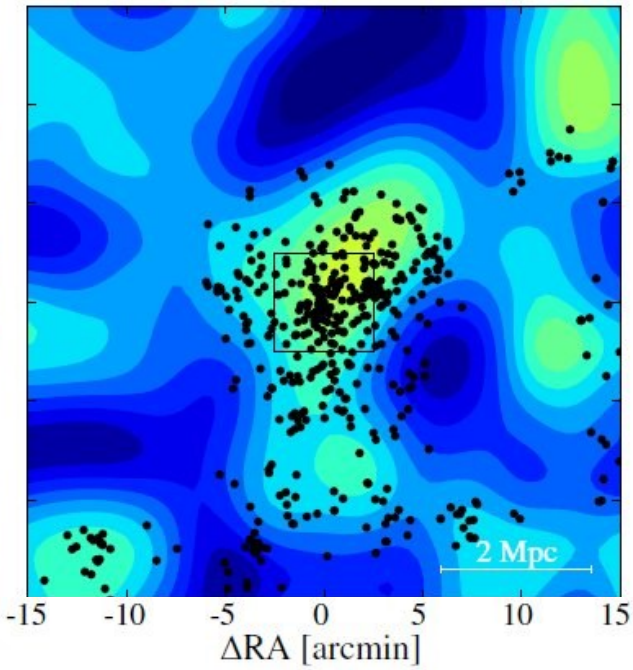
The same galaxies, but for the entire useable field of view of 90 arcmin

Testing Weak Lensing: Masses of 4 galaxy clusters

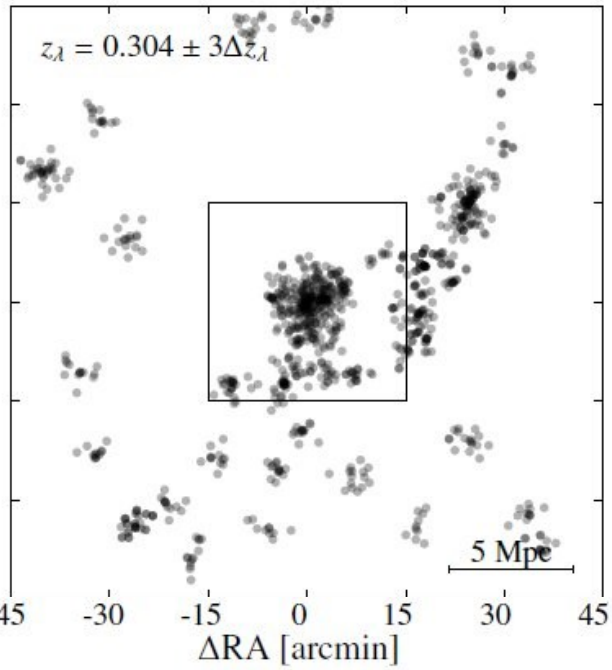
DARK ENERGY SURVEY



Multi-color image of the inner 5 arcmin



Weak lensing aperture mass significance map of the innr 30 arcmin, overlaid with galaxies



The same galaxies, but for the entire useable field of view of 90 arcmin

GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

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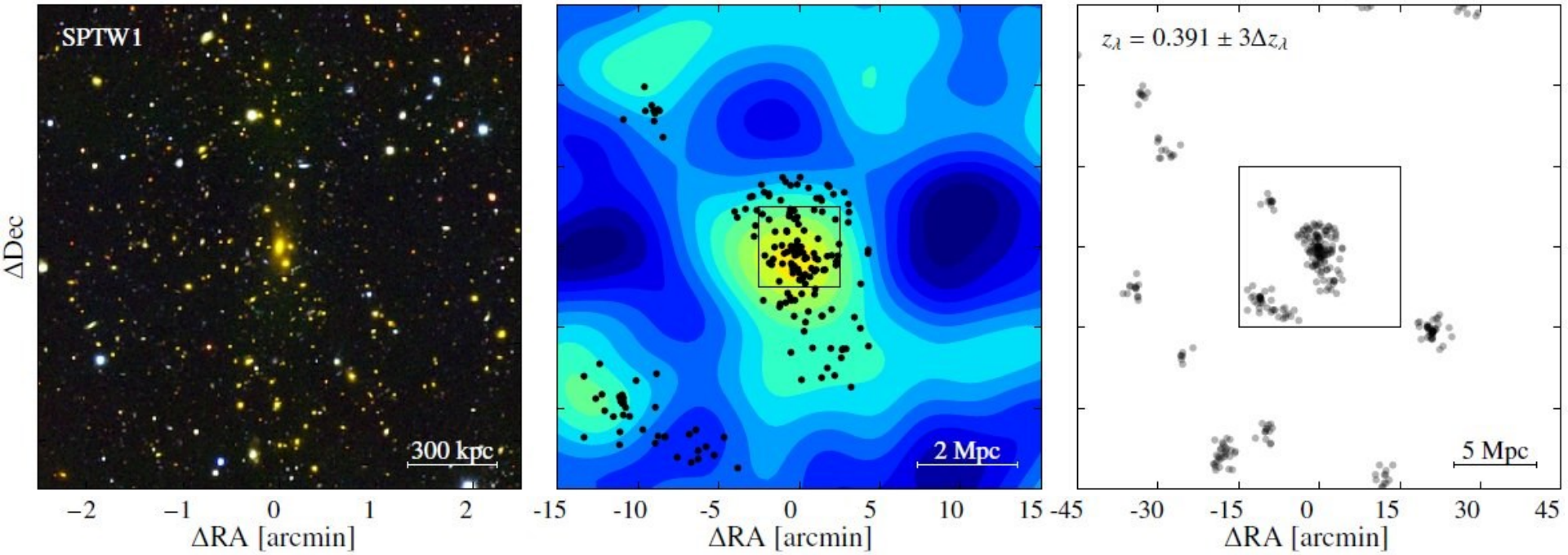

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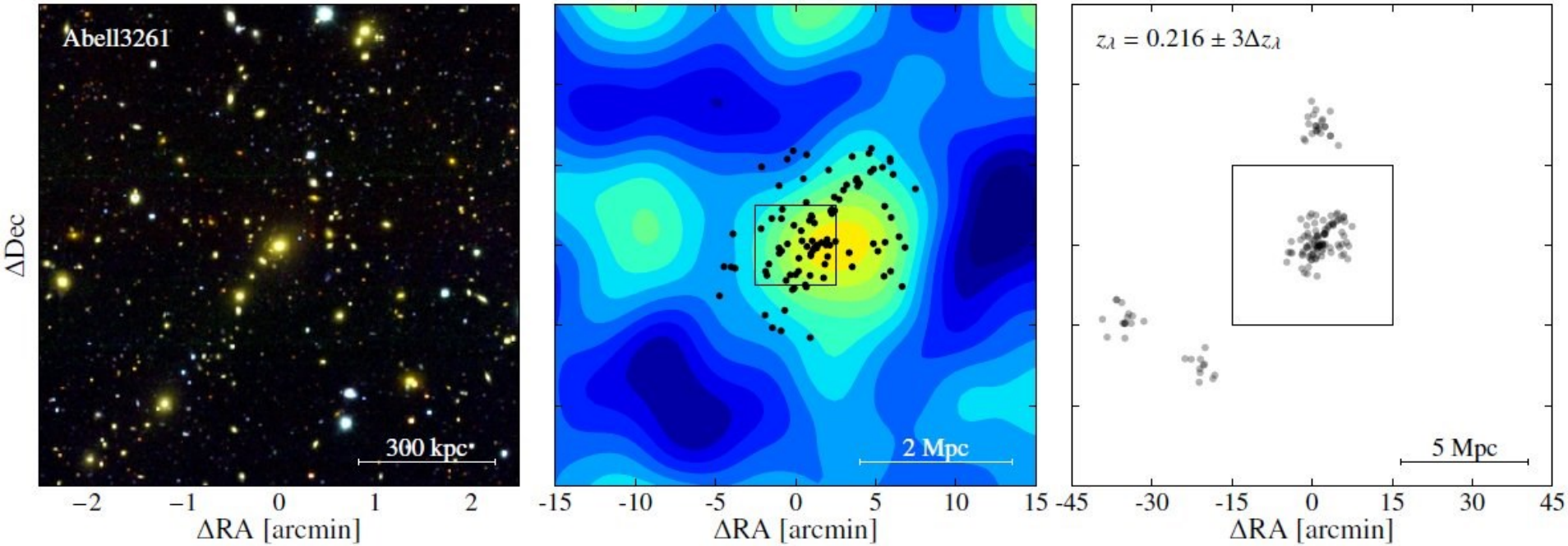

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The same galaxies, but for the entire useable field of view of 90 arcmin

Testing Weak Lensing: Masses of 4 galaxy clusters (arXiv:1405.4285)

DARK ENERGY SURVEY

Measure the masses and redshifts of four known massive galaxy clusters
Background galaxies identified using photo-z
Cluster member galaxies identified using photo-z and RedMaPPer
Weak lensing analysis using im3shape code

Results in very good agreement with previously known measurements

Table 4. Weak lensing masses M_{200c} in units of $10^{14}M_{\odot}$ (with a flat prior on c_{200c}), redMaPPer richness λ and redshift estimate z_λ, and their statistical errors (see Section 3.2 and Section 5.1 for details). The literature mass estimates are derived from weak lensing, galaxy dynamics (D) or optical richness (R).

Cluster name	M_{200c}	λ	z_λ	Literature value M_{200c}
RXC J2248.7-4431	$17.6^{+4.5}_{-4.0}$	203 ± 5	0.346 ± 0.004	$22.8^{+6.6}_{-4.7}$ (Gruen et al. 2013b), 20.3 ± 6.7 (Umetsu et al. 2014), 16.6 ± 1.7 (Merten et al. 2014)
1E 0657-56	$14.2^{+10.0}_{-6.1}$	277 ± 6	0.304 ± 0.004	17.5 (Clowe et al. 2004)[i], 12.4 (Barrena et al. 2002, D)
SCSO J233227-535827	$10.0^{+3.7}_{-3.4}$	77 ± 4	0.391 ± 0.008	$11.2^{+3.0}_{-2.7}$ (Gruen et al. 2013a), $4.9 \pm 3.3 \pm 1.4$ (High et al. 2010, R)
Abell 3261	$8.6^{+8.6}_{-3.9}$	71 ± 3	0.216 ± 0.003	—

[i] We converted the measured r_{200c} from Clowe et al. (2004), which lacks an error estimate, to M_{200c} using the critical density in our adopted cosmology.

This paper proves that DES can measure galaxy shapes, even in the Science Verification preliminary data set

Many other interesting results in the pipeline, that will be published soon

DARK ENERGY SURVEY

Galaxy clustering and validation against CFHTLS

DES SV galaxies cross-correlated with CMB lensing

SPT-SZE signatures of DES SV RedMaPPer clusters

Joint Optical and near infrared photometry from DES and VHS

Galaxy populations within SPT selected clusters

DES/XCS: X-ray properties of galaxy clusters in DES SV

The DES SV shear catalogue: Pipeline and tests

Calibrated ultra fast image simulations for DES

DES13S2cmm: The first super-luminous supernova from DES

The DES supernova survey: Search strategy and algorithm

Wide-field mass mapping with the DES SV data

DARK ENERGY SURVEY

Summary

DES started survey operations in august 2013

SV data are of high quality, are currently being analyzed, and first papers have been already submitted

Photoz required precision reached

DES is able to measure galaxy shapes

Many results in the pipeline…

The data quality and quantity for DES as a whole will be a major step beyond this

First season data are being processed.

First Dark energy results expected from 2 first seasons of data. STAY TUNED!!!