

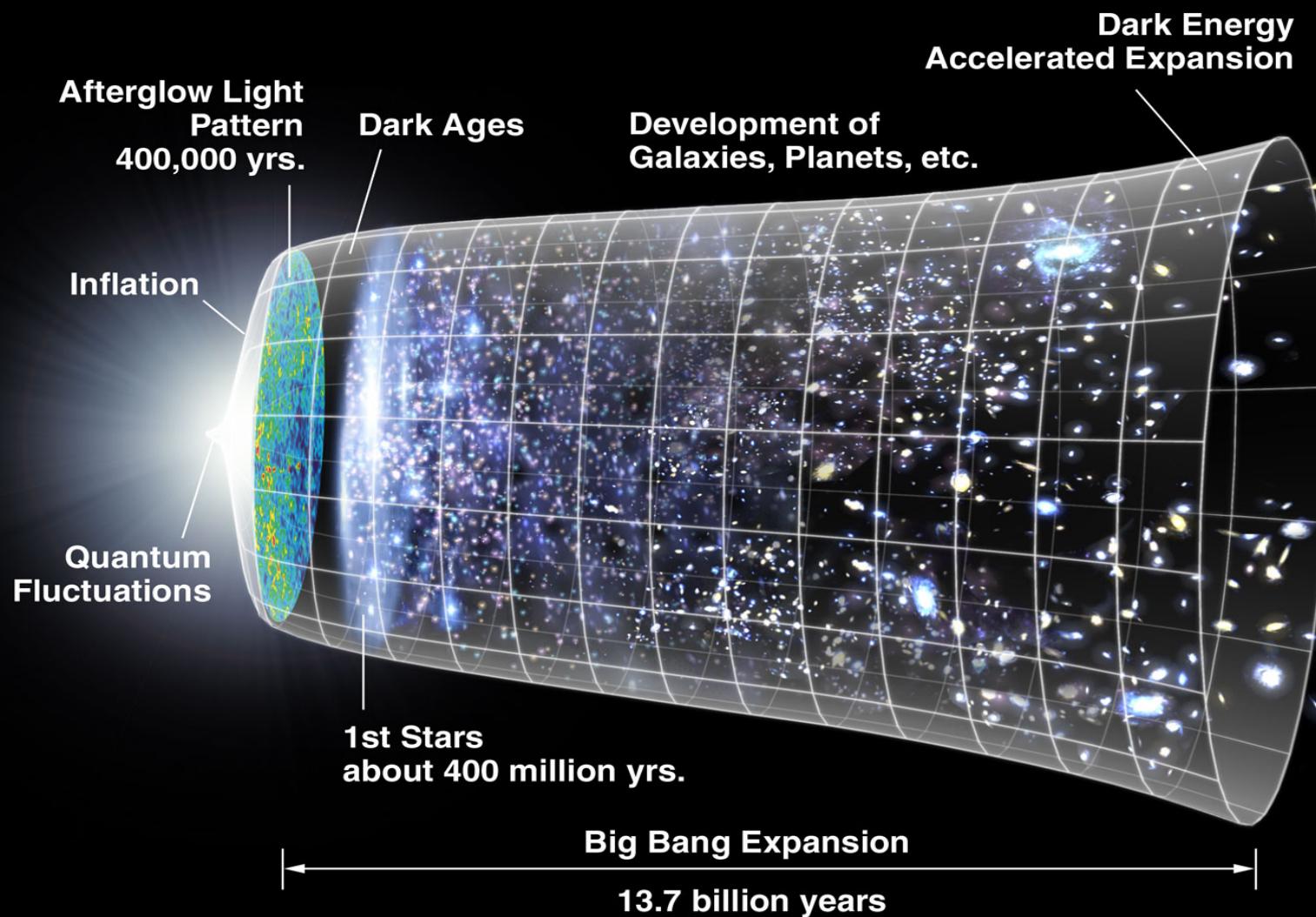
The Dark Energy Survey

Matías Carrasco Kind
University of Illinois

on behalf of the Dark Energy Survey Collaboration

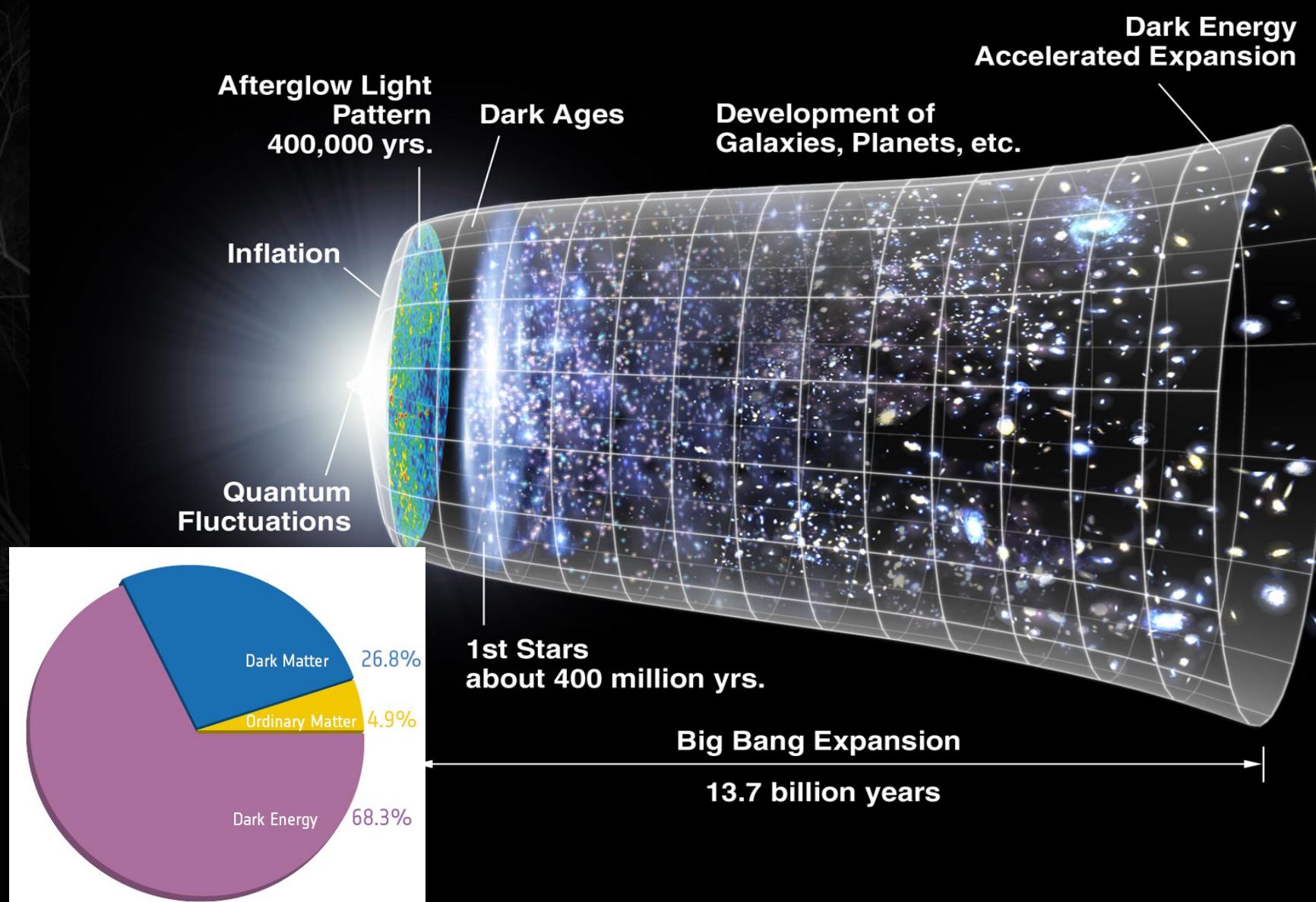


Current picture of the Universe



NASA/WMAP Science Team

Current picture of the Universe

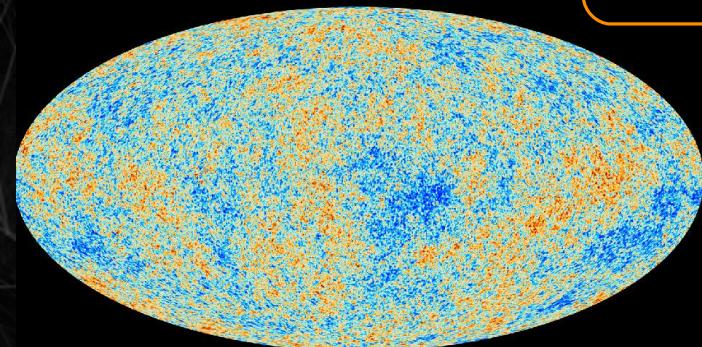




Cosmological Observables

VERY large-scale, VERY early Universe

Credit: Planck Satellite, 2013



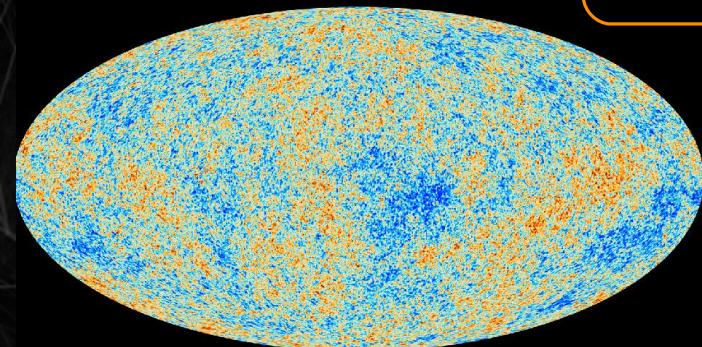
Cosmic Microwave Background (CMB)



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Baryonic Imprints on the CMB
Constrains cosmological models
Microwave spectral range

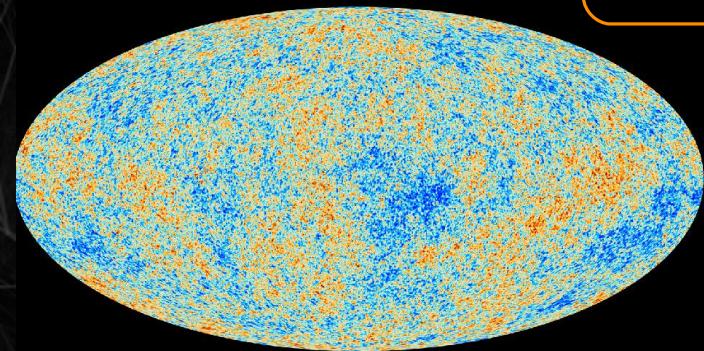
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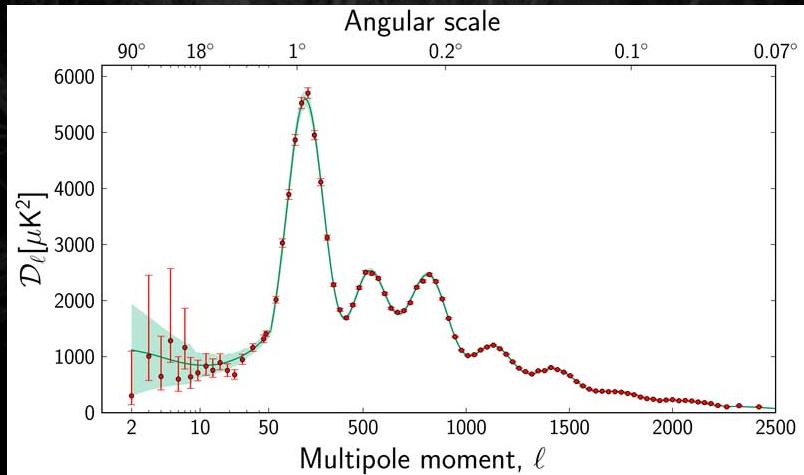
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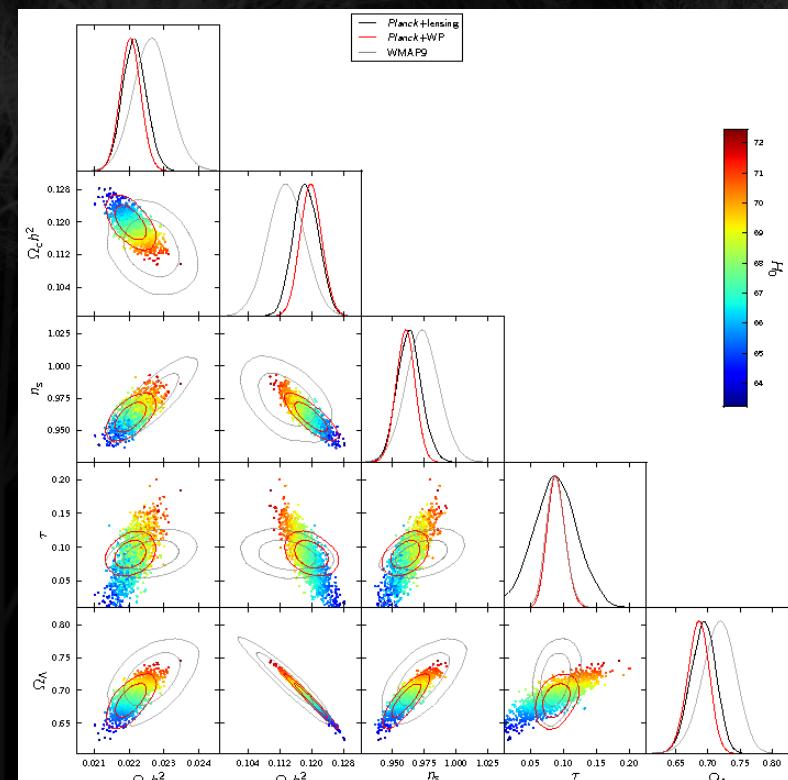


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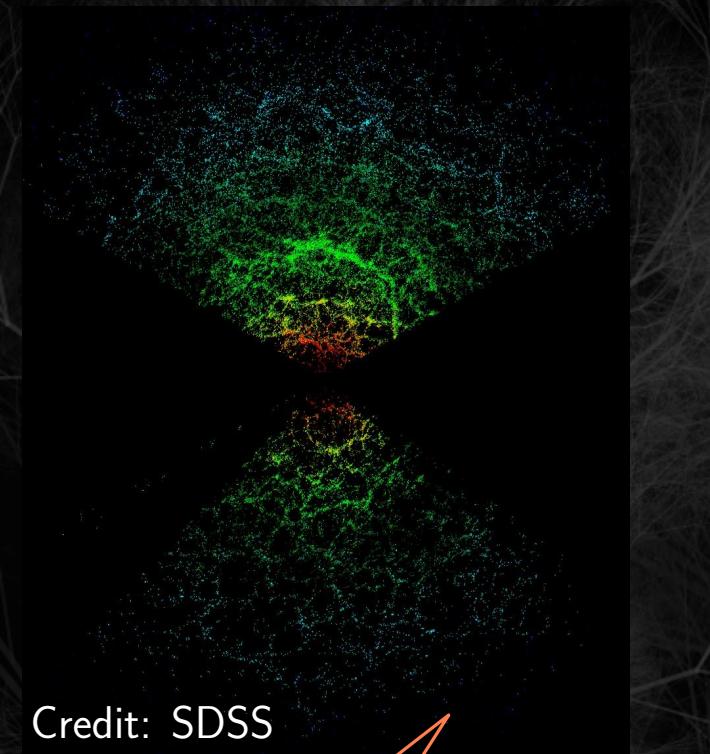
Angular power spectrum of fluctuations





Cosmological Observables

Large-scale structure, "Recent" Universe



Credit: SDSS

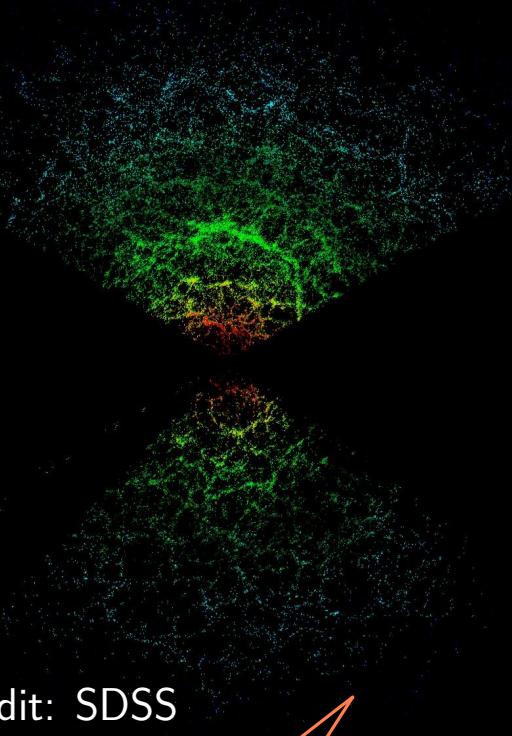
Distribution of
galaxies shows
clustering and
cosmic web





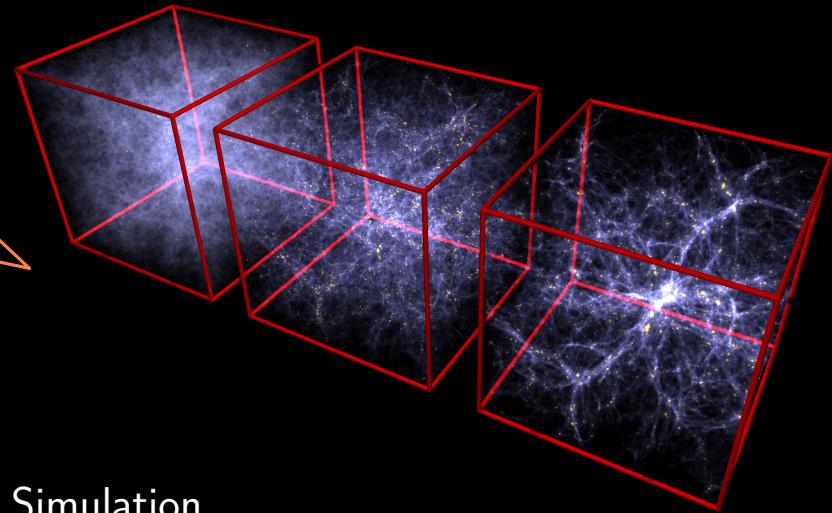
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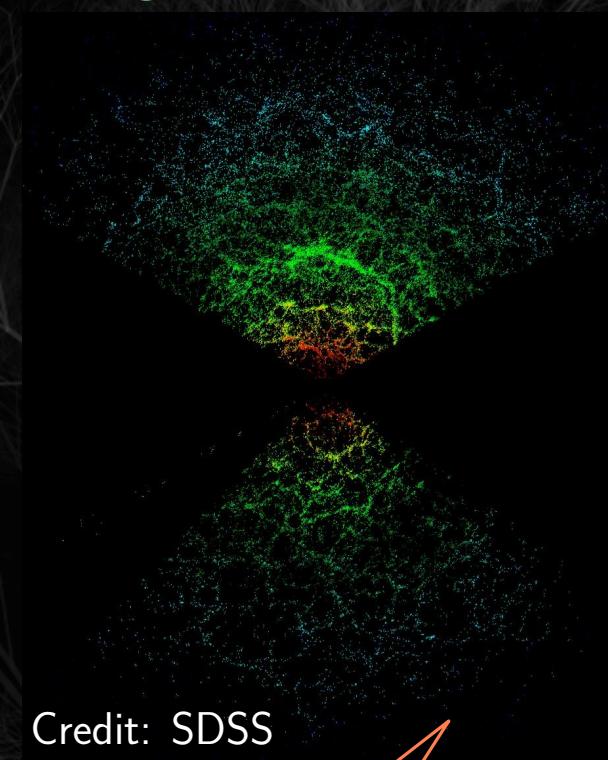
Clustering evolution with cosmic time





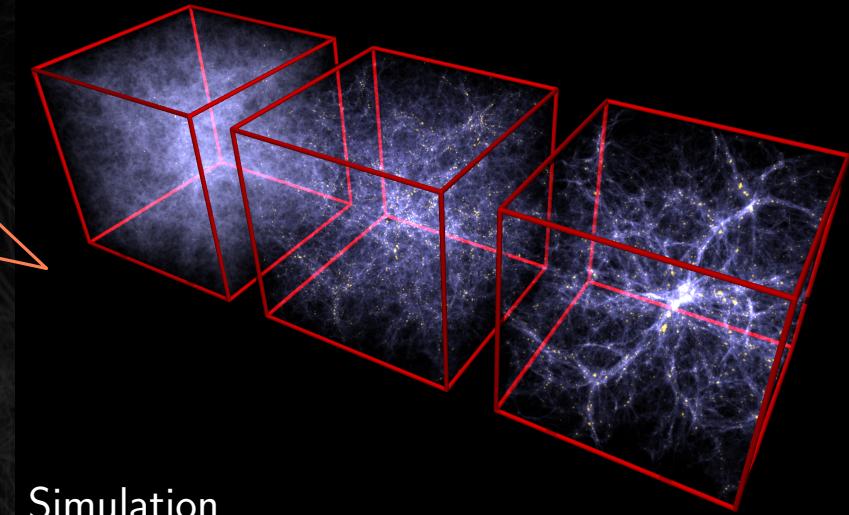
Cosmological Observables

Large-scale structure, "Recent" Universe



Distribution of galaxies shows clustering and cosmic web

Clustering evolution with cosmic time



Simulation

Gravitational effects deflect light given a mass distribution



Cosmological Observables

Cluster-scale structure, "Recent" Universe

Cluster of galaxies,
gravitationally bounded
structures

Cluster members,
alignments, mass, etc...

Credit: DES



Cosmological Observables

Cluster-scale structure, "Recent" Universe

Cluster of galaxies,
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Cluster members,
alignments, mass, etc...

Credit: DES



Strong lensing from
cluster of galaxies.
GR effects, total mass
of lens cluster, very
far lensed galaxies



Cosmological Observables

Galaxy-scale, "Recent" Universe: Supernovae Ia



- Supernovae Ia as standard candles
- Transient and short events
- Have standard luminosity
- Distance-redshift relationship



Dark energy model

From Einstein's field equations we can derive Friedmann's-Lemaître's equations:

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}(\rho + 3p) + \frac{\Lambda}{3}$$

and from the conservation of energy to:

$$\dot{\rho} = -3\frac{\dot{a}}{a}(p + \rho)$$



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geometry

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growth of
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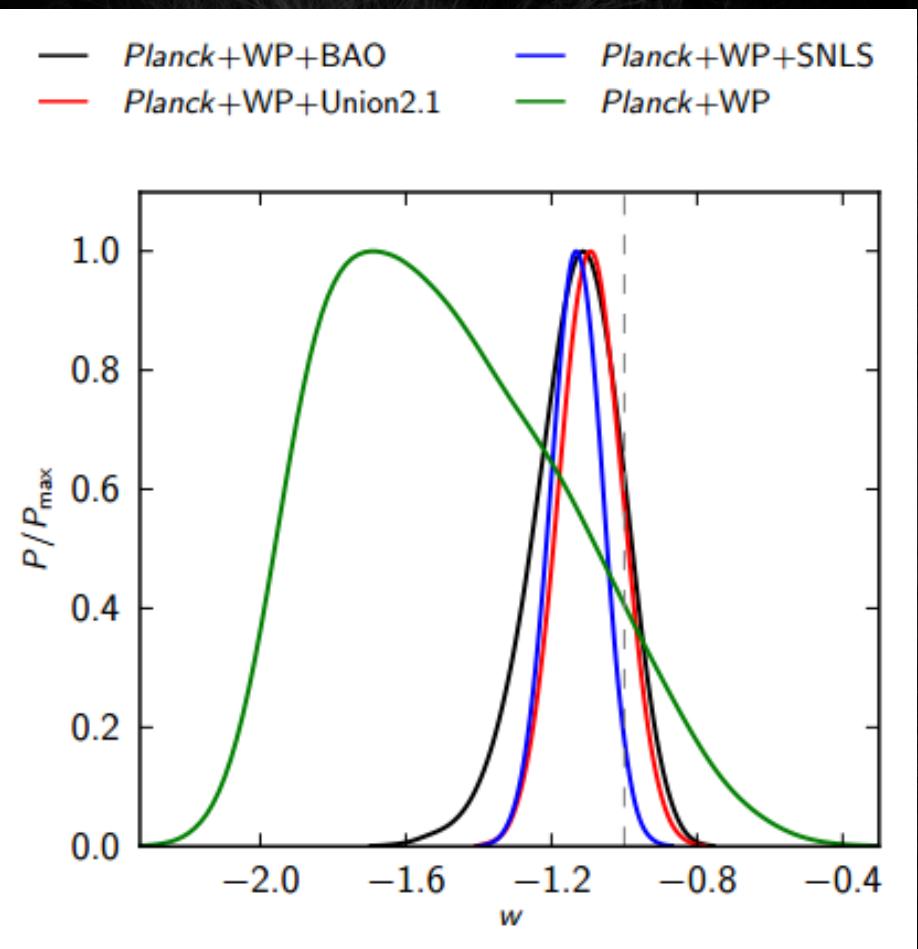
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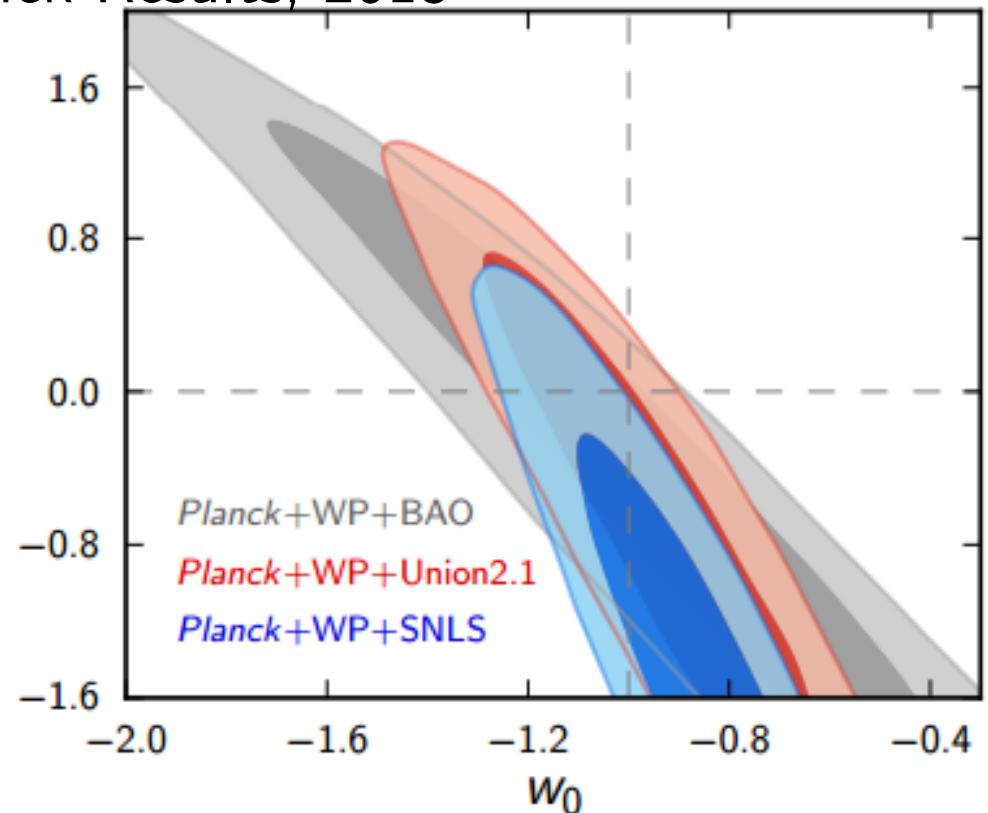
There are alternative
models than can be
tested/ruled out

Equation of state

$$\omega(a) = \omega_0 + \omega_a(1 - a)$$



Planck Results, 2013



Planck does not give very tight constraints on ω and ω_a ,
need complementary approach. A big survey!



The Dark Energy Survey



CTIO 4m Blanco

- 5000 sq. deg. (1/8 sky) Southern Hemisphere
- 5 bands (g, r, i, z, Y) to 24th mag.
- DECam: 570 Mpx, most powerful camera
- First light: Sept., 2012
- DES Survey, Sept., 2013, 525 nights
- SN fields revisited several times
- 300 million galaxies up to $z \sim 1.5$, 4000 SNe

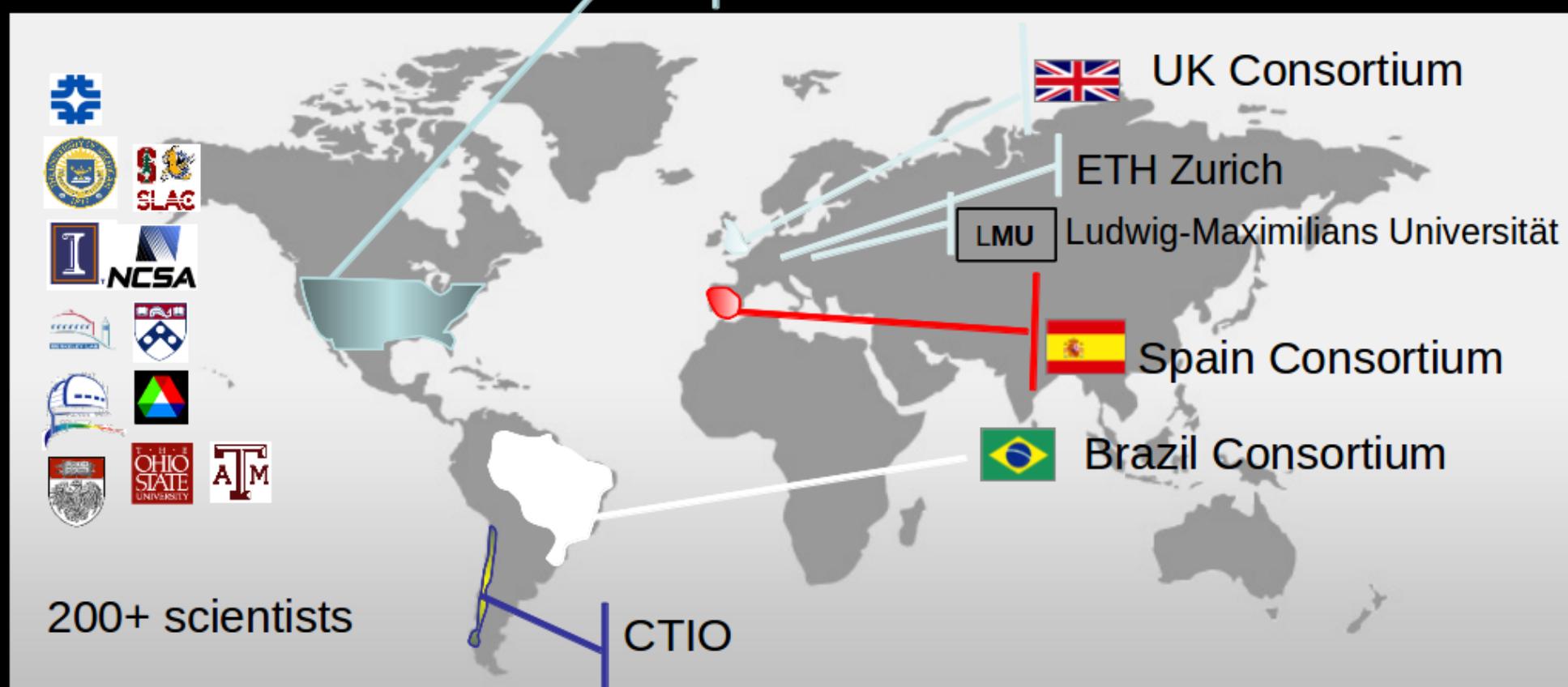


DES Collaboration

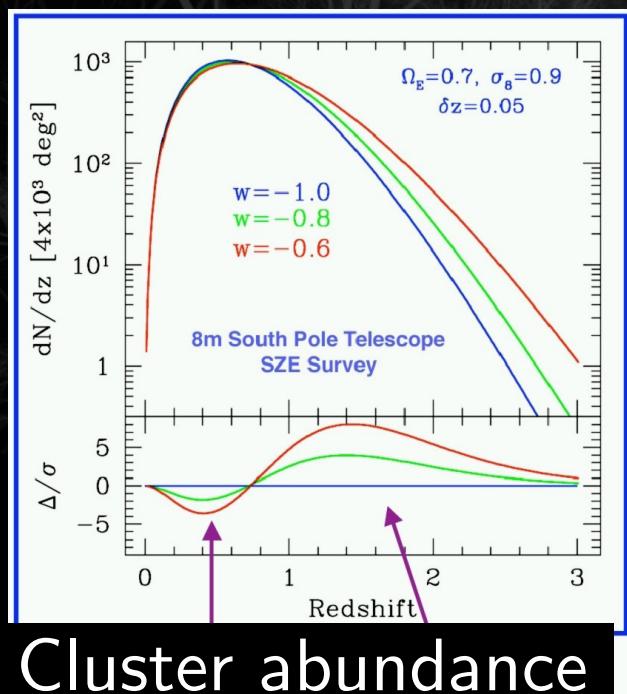
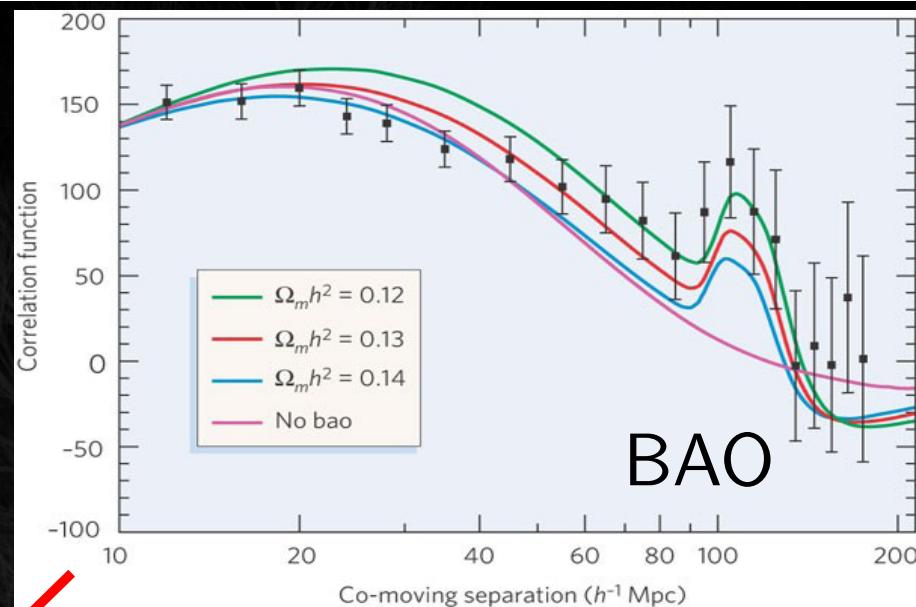
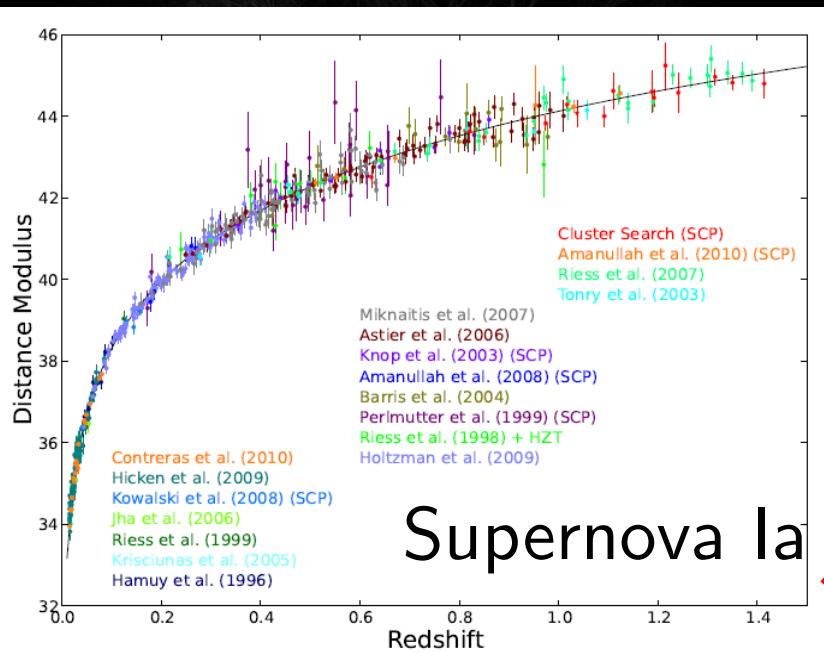


Funding from DOE, NSF, foreign funding agencies, and DES institutions

Fermilab, UIUC/NCSA, University of Chicago, LBNL, NOAO, University of Michigan, University of Pennsylvania, Argonne National Laboratory, Ohio State University, Santa-Cruz/SLAC/Stanford Consortium, Texas A&M

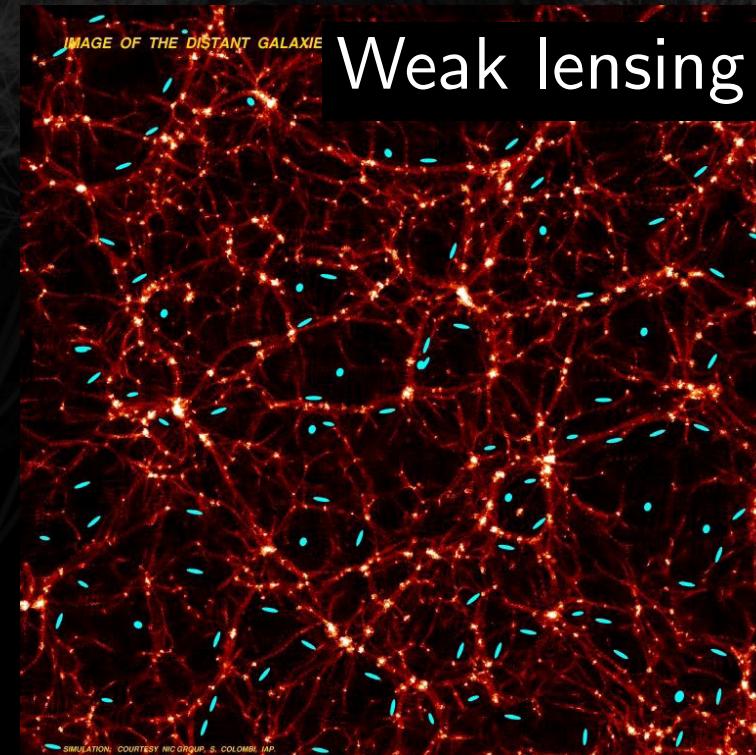


Observational Probes of Dark Energy



Geometry

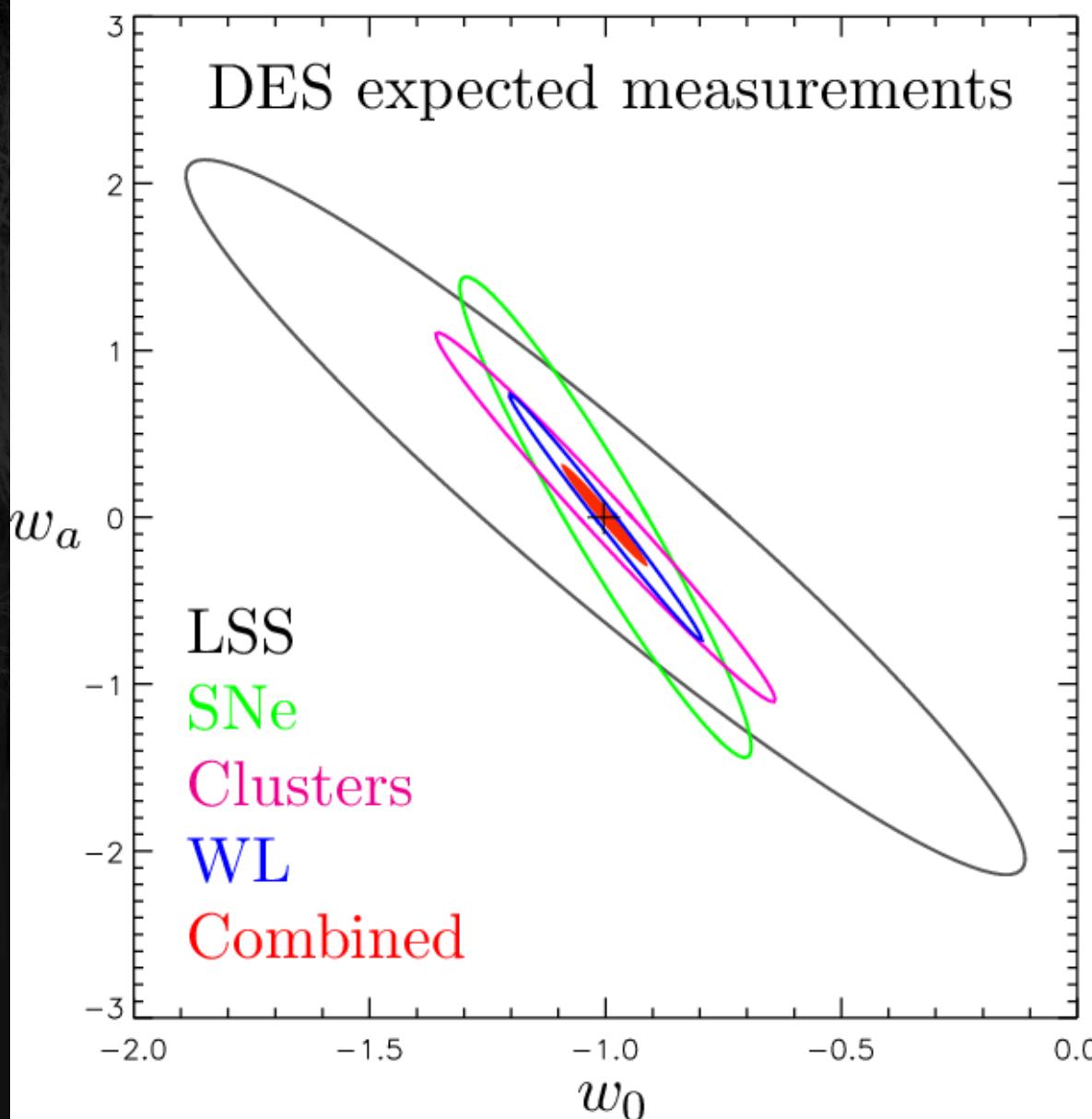
Growth of structure



Probes of Dark Energy : Combined

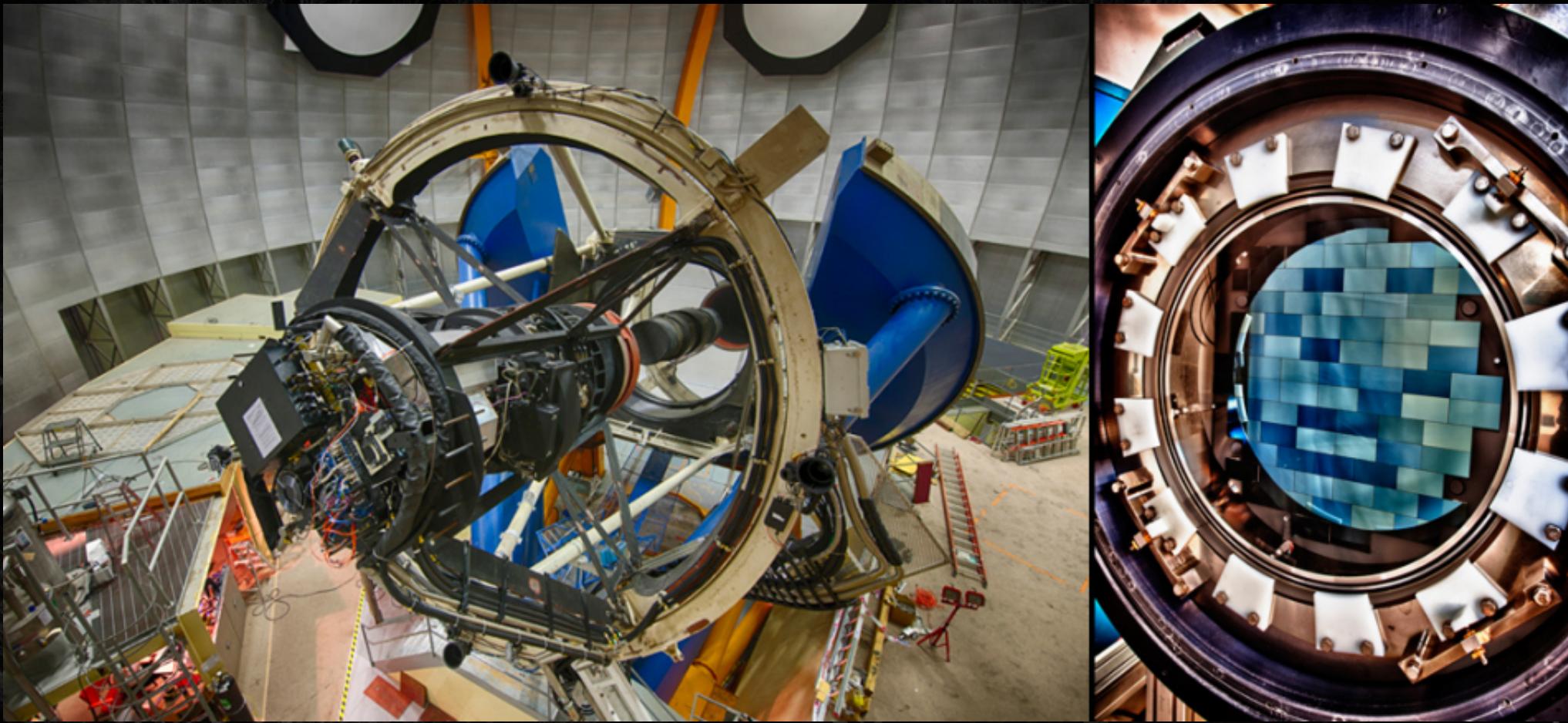
- DES first to combine 4 probes with one dataset
- Not only these probes
- Combined probes provide tighter constraints
- Cross-check for systematics

$$\omega(a) = \omega_0 + \omega_a(1 - a)$$





The Dark Energy Camera DECam



- * 62 2k x 4k CCDs for imaging and 12 2k x 2k for calibration
- * Each CCD is 62.94mm x 30.72 mm
- * Great effort to build and put camera together. Installation completed in August 2012



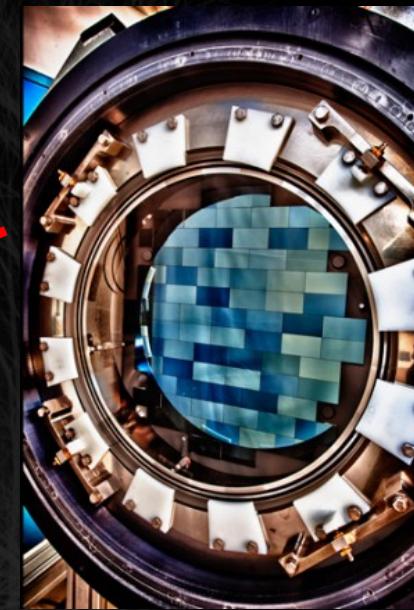
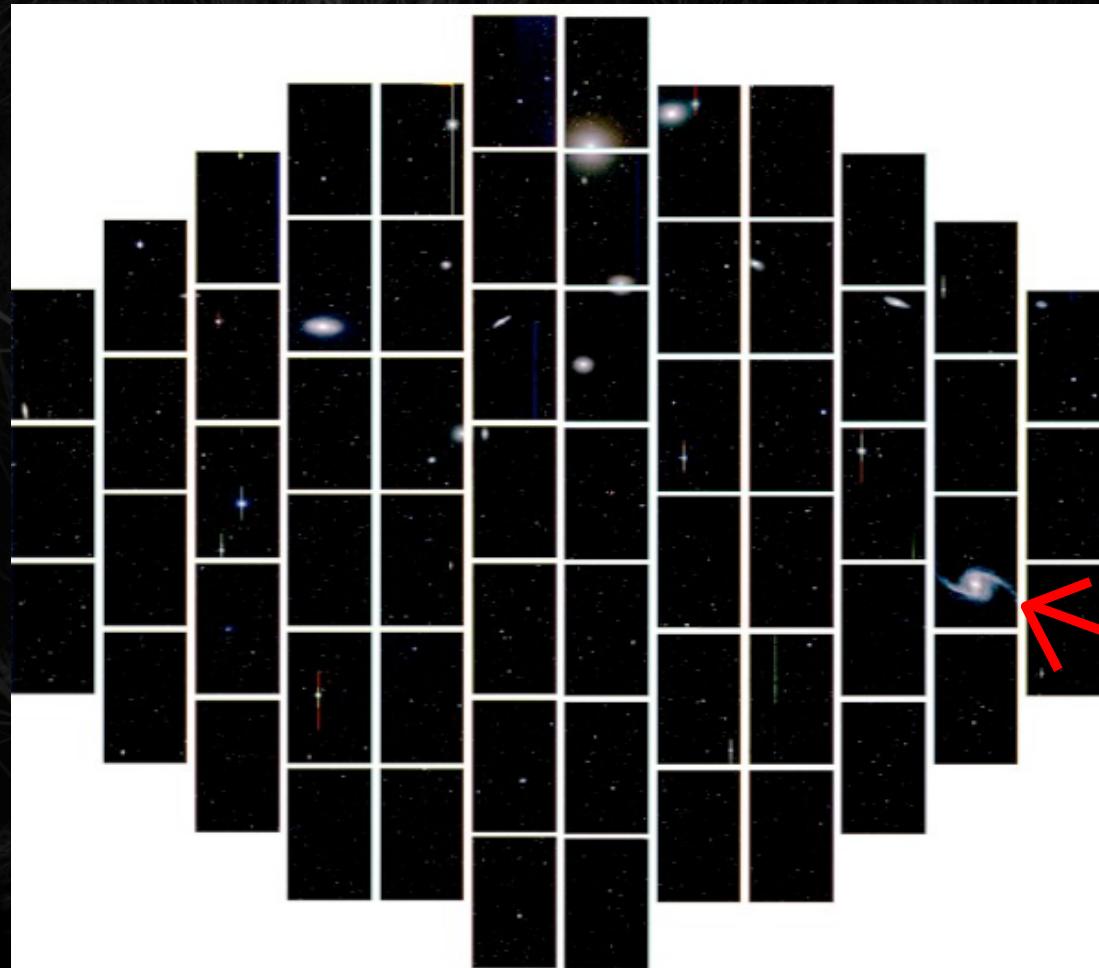
The Dark Energy Camera DECam



Telescope simulator built at Fermilab to test DECam



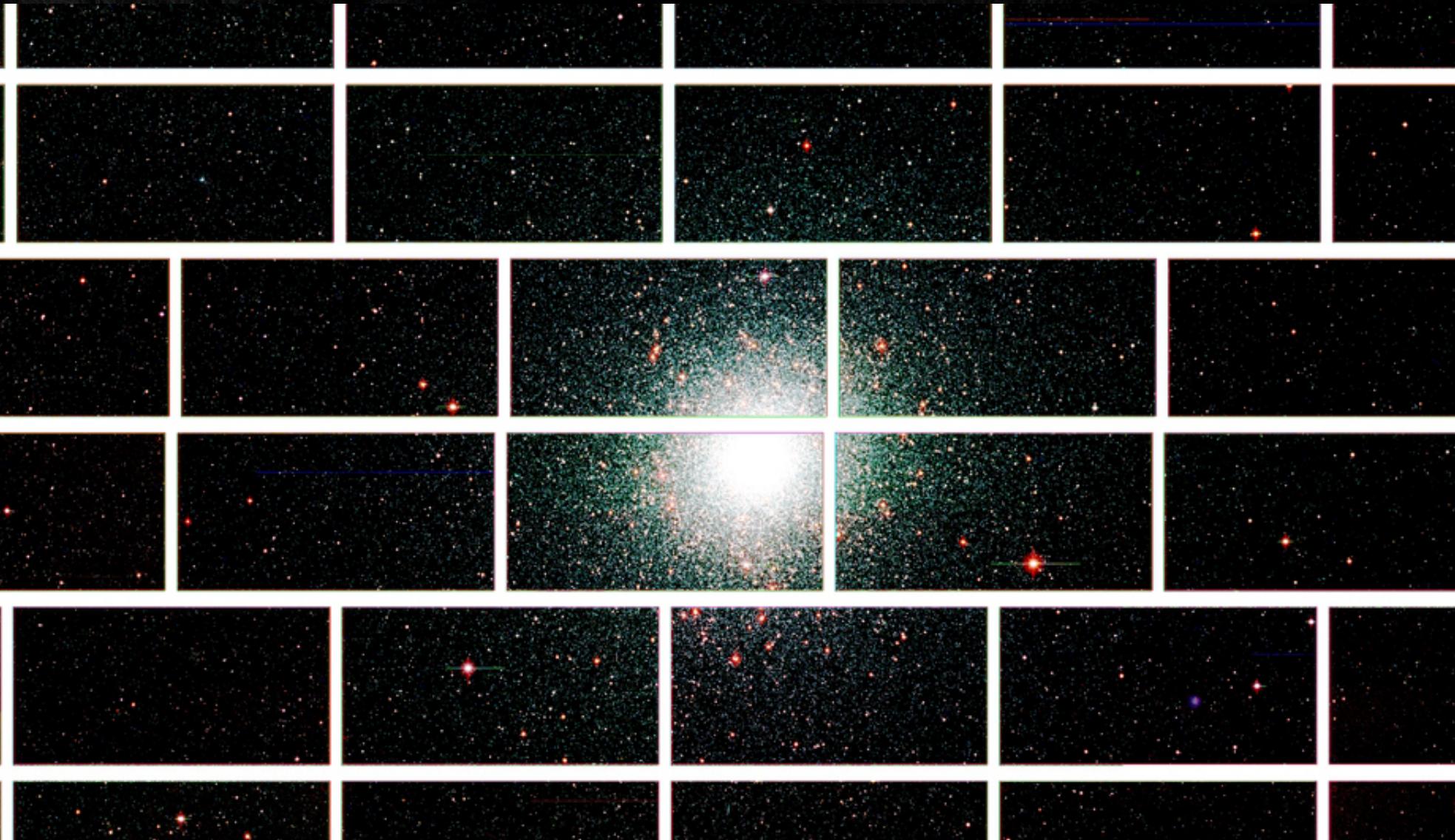
DECam first light on 12/Sept/2012



NGC 1365



DECam first images



Globular cluster 47 Tucanae

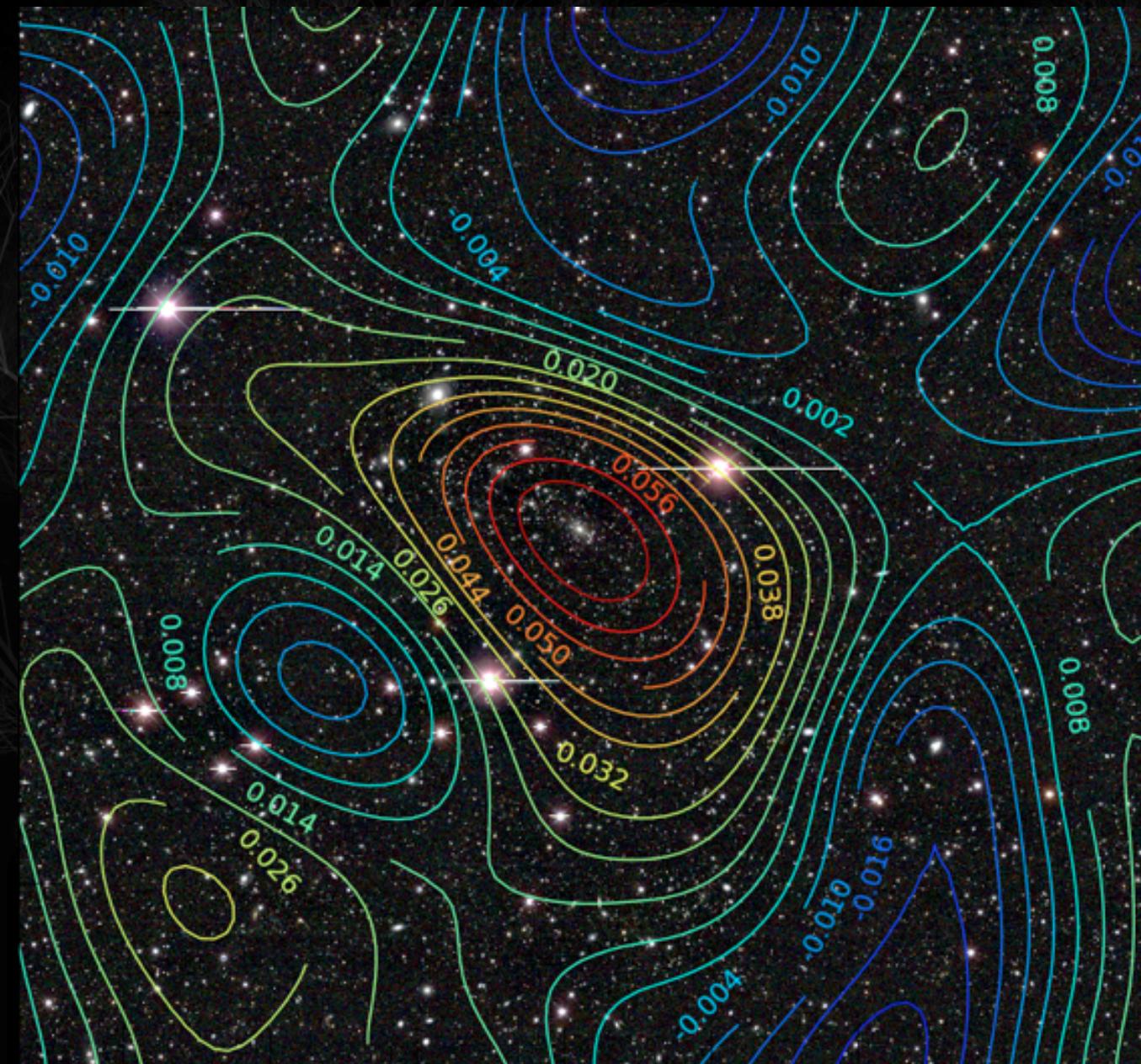


DES Time scale

- Review and design : 2003 – 2008
 - Construction : 2008 – 2011
 - Delivery to CTIO, Chile : 2011 – 2012
 - Installation of camera: January 2011 – August 2012
 - First Light : September 2012
 - Commissioning : Sep – Oct 2012
 - Sience Verification : Nov 2012 – Feb 2013
 - Early processing data release, ~ 100 sq. deg. fully through pipeline : April – May 2013
- DONE!
- DES Survey : Sep 2013 – Feb 2018. 105 night/year (525 nights) . Astronomy community tool from Feb to Sep each year



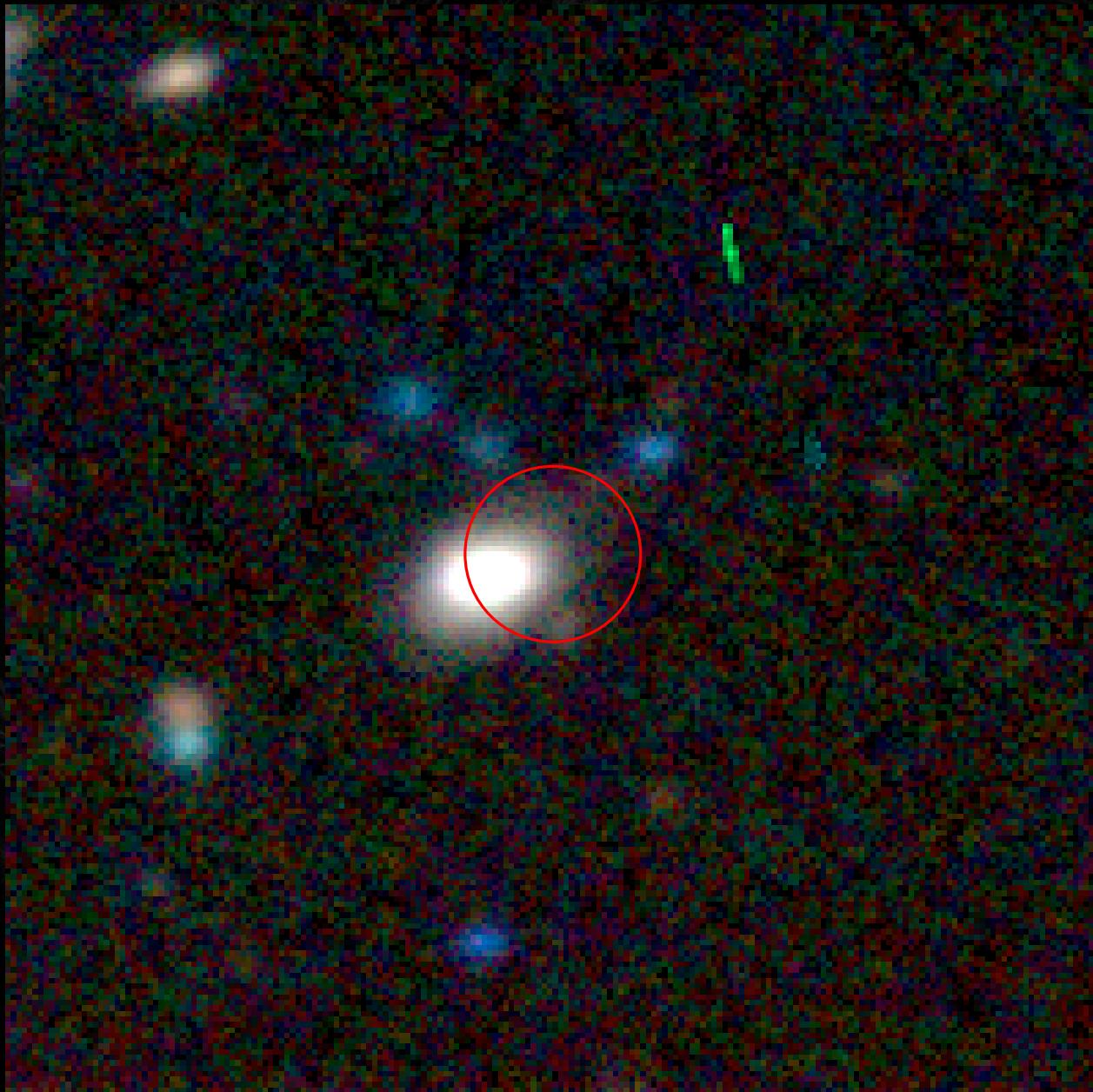
DES Science Verification data



- Mass reconstruction of cluster RXJ2238 at $z = 0.38$ from weak lensing



DES Science Verification data

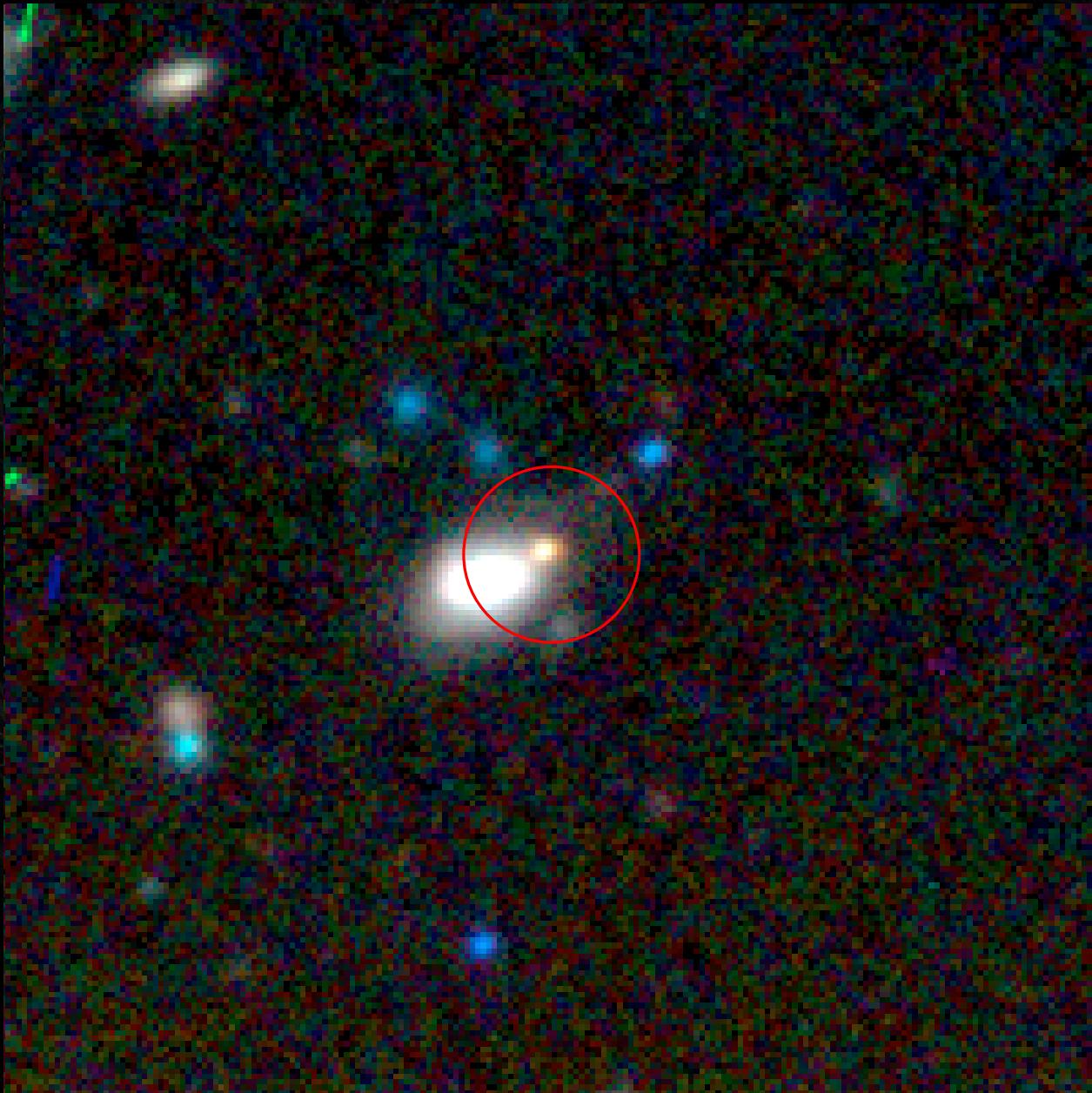


- Type Ia Supernova discovery at $z = 0.2$
- 7 confirmed SN, 5 of them SNIa

November 7



DES Science Verification data



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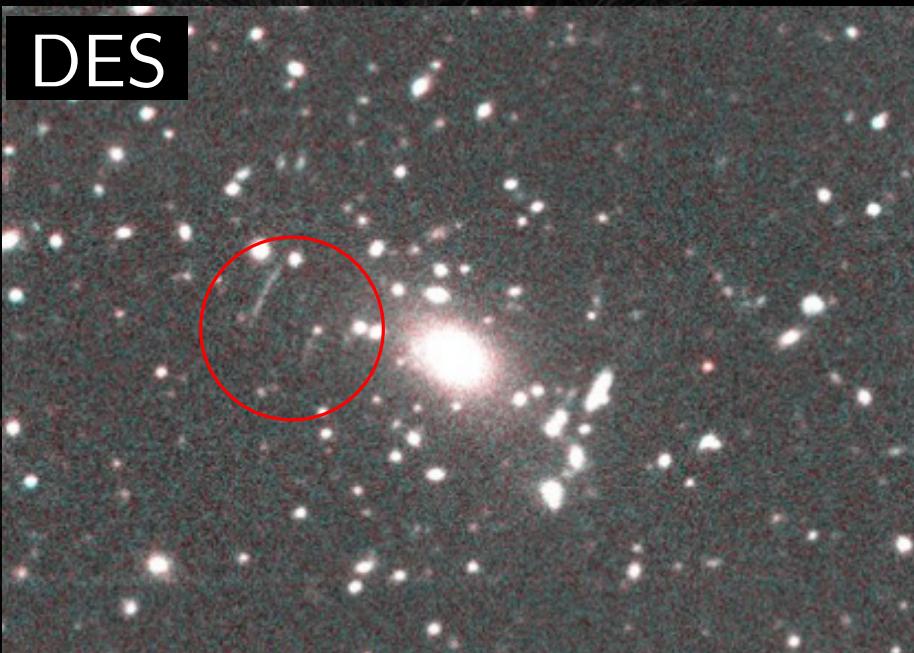
December 15



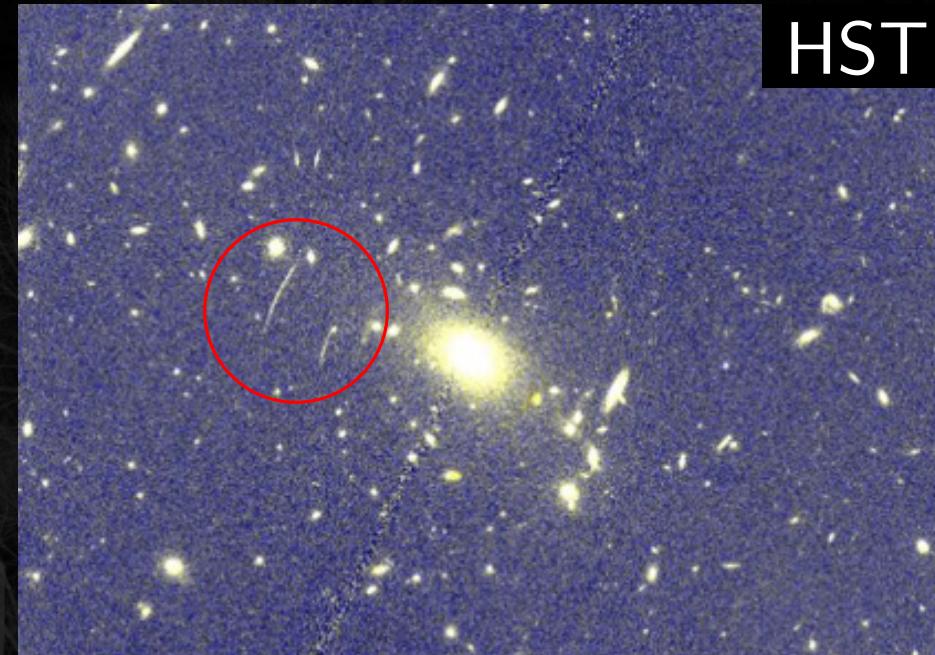
DES Science Verification data

RXJ 2248

DES

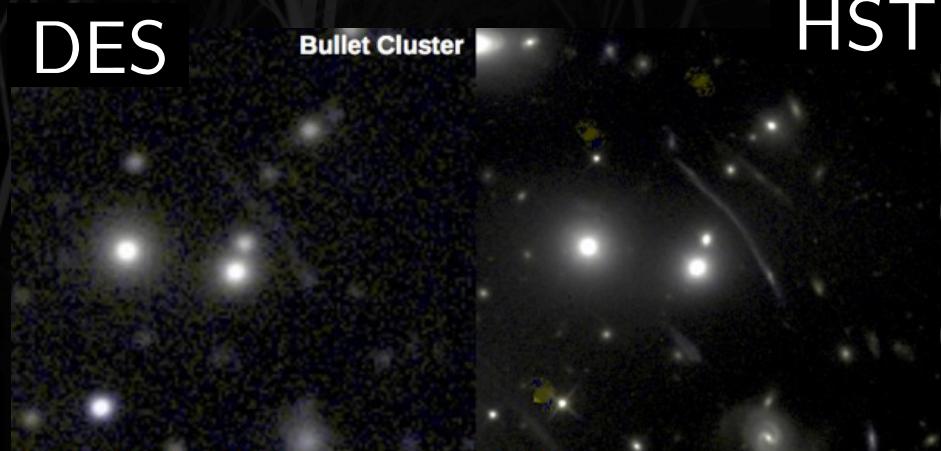


HST



- Strong lensing arcs in SV
- Previously observed by HST

DES

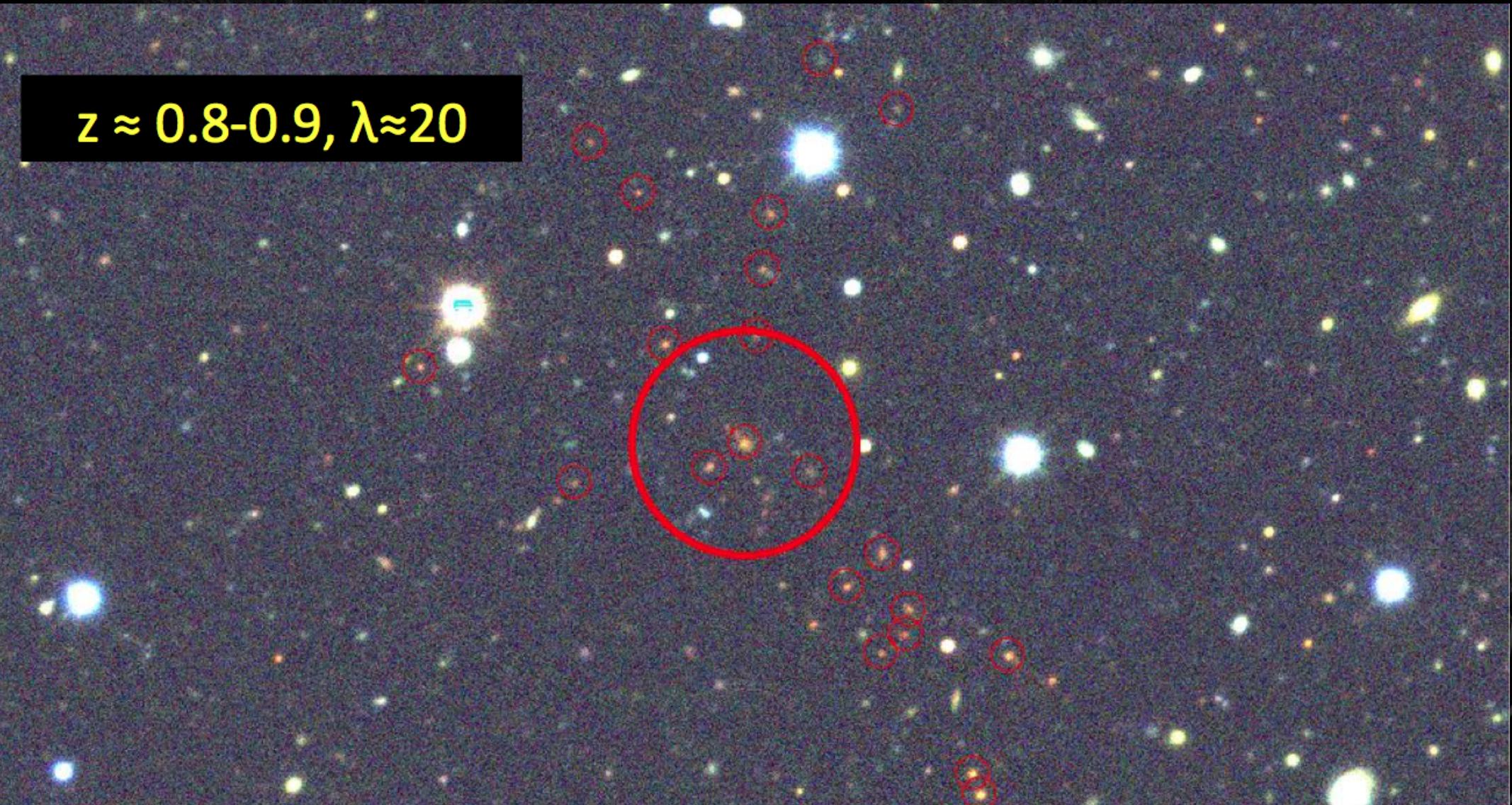


HST



DES Science Verification data

$z \approx 0.8-0.9, \lambda \approx 20$



New high redshift cluster



Summary

- * DES will study the nature of Dark Energy by using 4 complementary probes
- * New powerful camera DECam built and installed at a 4m meter telescope in Chile
- * Survey will start **this Fall**, will enable tight cosmological constrains



Thanks!

<http://www.darkenergysurvey.org/>

facebook

www.facebook.com/darkenergysurvey

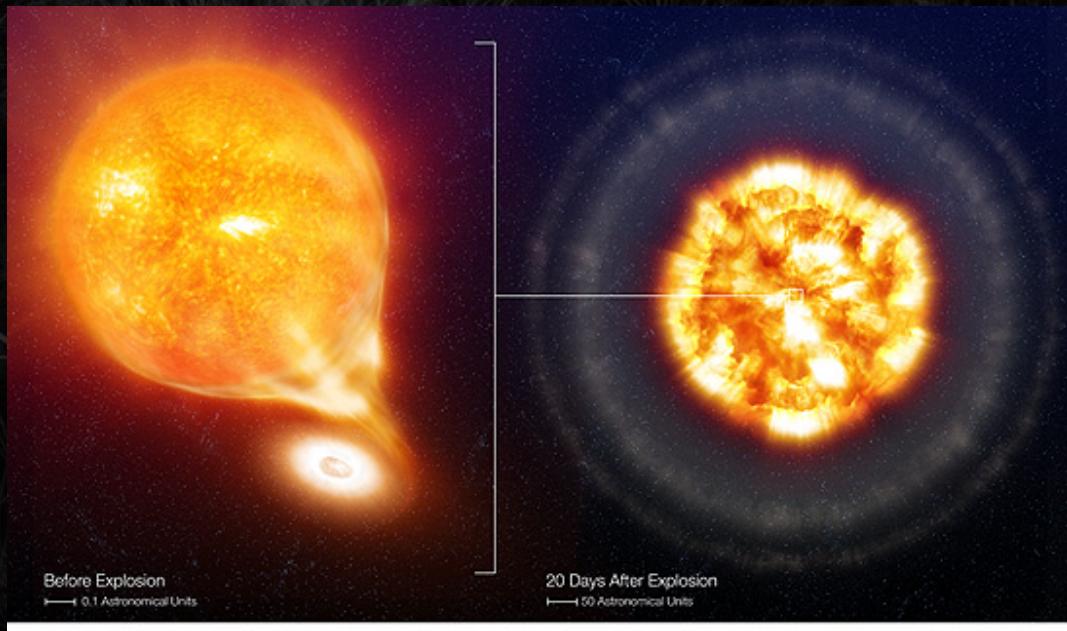
<http://darkenergydetectives.org/>



Extra Slides



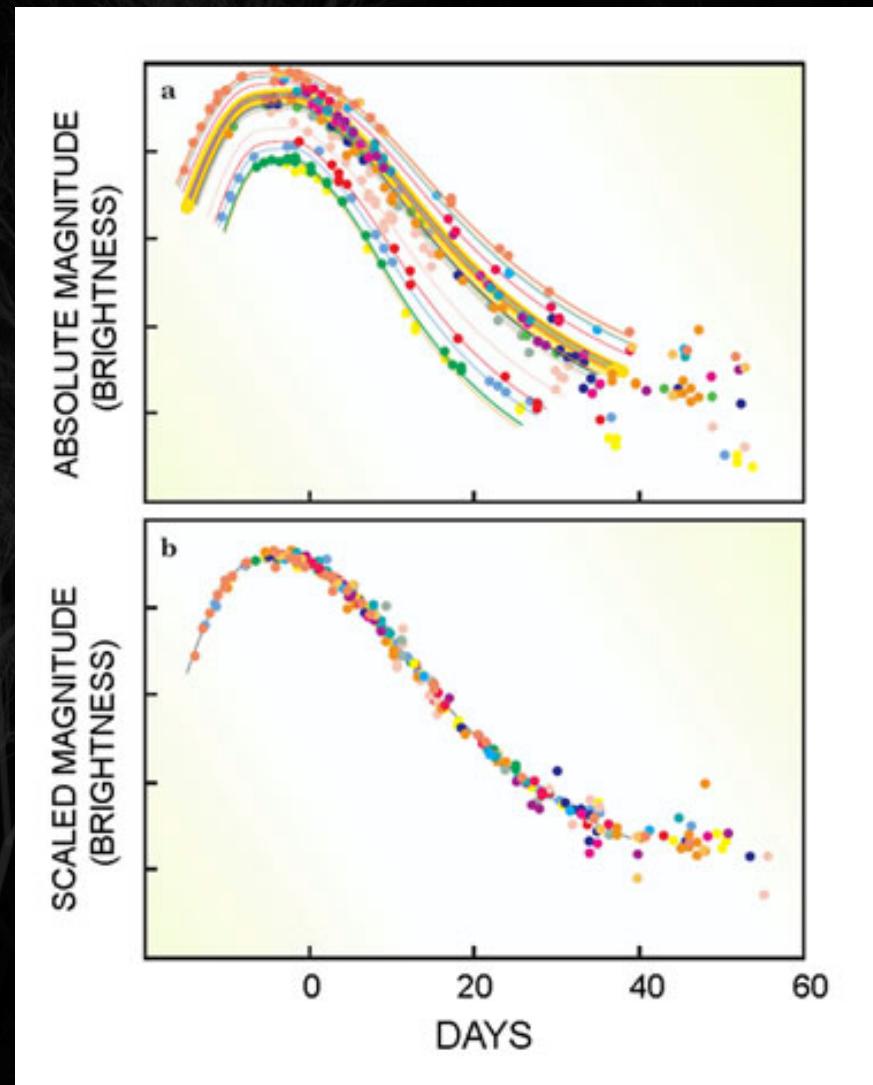
Supernova Ia as standard candle



SN 2006X, before and after the Type Ia Supernova Explosion
(Artist Impression)

ESO Press Photo 31b/07 (12 July 2007)

This image is copyright © ESO. It is released in connection with an ESO press release and may be used by the press on the condition that the source is cited, indicated in the caption.





Dark energy model

Starting with Einstein's field equations : $G_{\mu\nu} + \Lambda g_{\mu\nu} = 8\pi G T_{\mu\nu}$

Matter in universe as a fluid : $T_{\mu\nu} = -pg_{\mu\nu} + (p + \rho)u_\mu u_\nu$

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There are alternative models than can be tested, MOND, $f(R)$, TeVeS, etc...

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Equation of state

