THE DARK ENERGY SURVEY (DES)

http://www.darkenergysurvey.org

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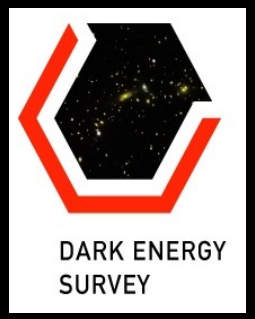
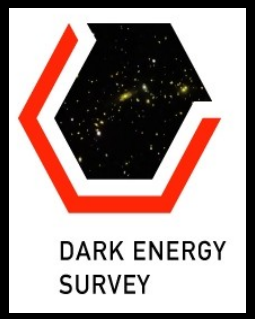
CIEMAT
On behalf of the DES Collaboration

Deep Galaxy Surveys, LSS and Dark Energy
Valencia, 29-30 March 2012



Overview

Motivation: Dark Energy Probes
The Dark Energy Survey
The Collaboration
The Instrument: DECam (Dark Energy Camera)
Data Management
DES Forecast: Figure of Merit
Spain Contributions
Timescale



Motivation

The main (and ambitious) goal of the project is to discover the nature of the dark energy

Try to identify the nature of the dark energy **measuring the parameter w of the EOS** as a function of the redshift

It is necessary to measure with high precision, since differences among models are small.

Control systematic errors!!!!

In order to achieve precision and control of systematic errors, *several measurement techniques must be combined*. There is no single technique sensitive enough to give a competitive measurement alone.

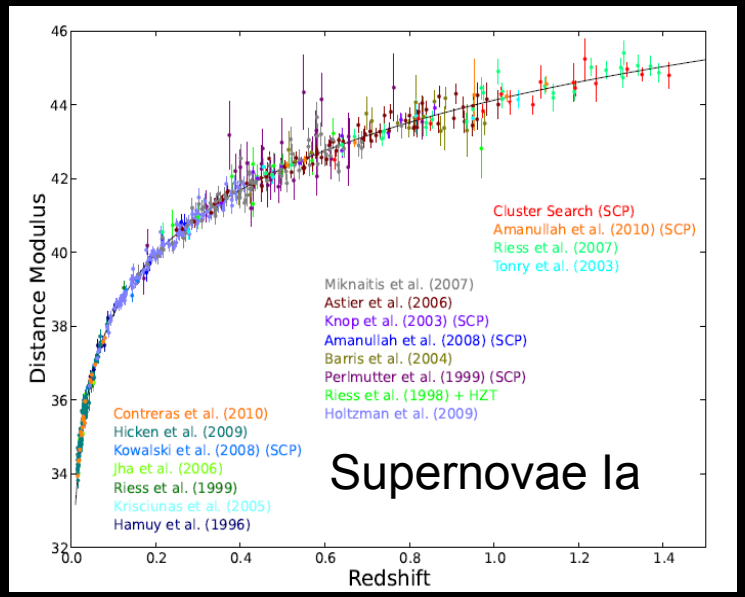
Observational Probes of Dark Energy

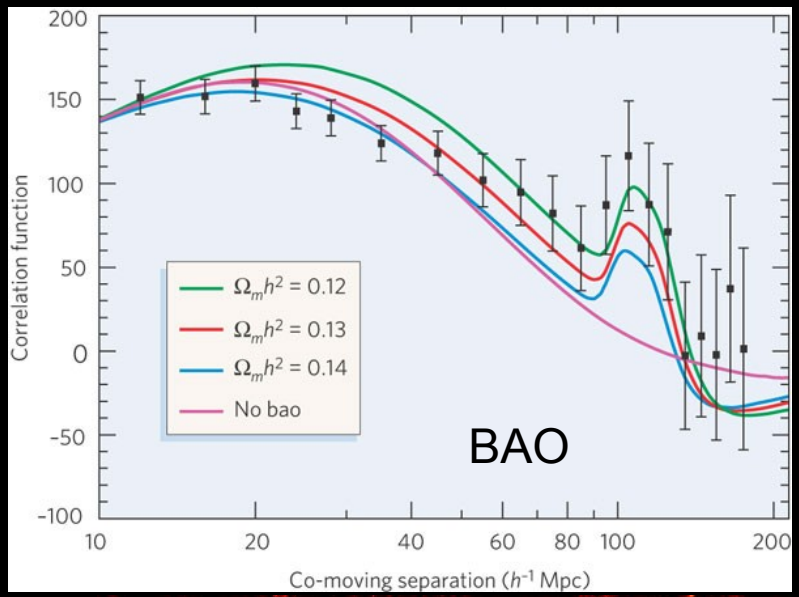
DARK ENERGY SURVEY

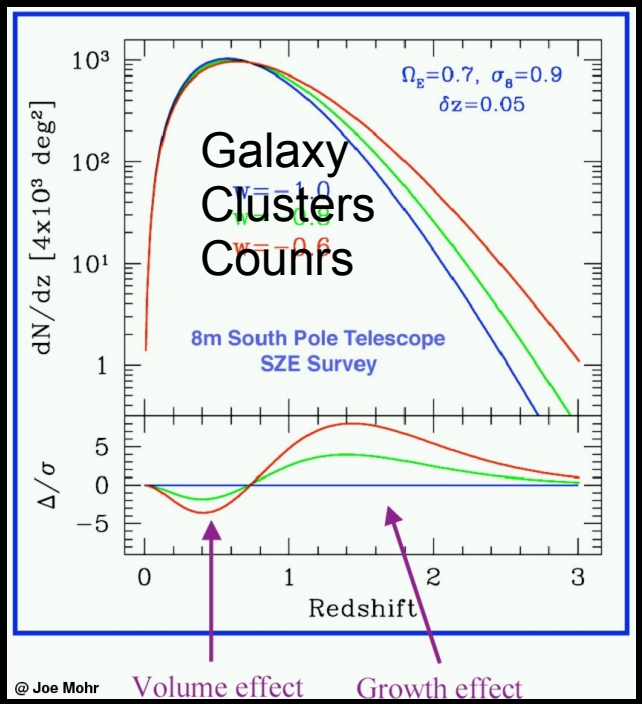
Four methods were identified by the DETF as the most promising

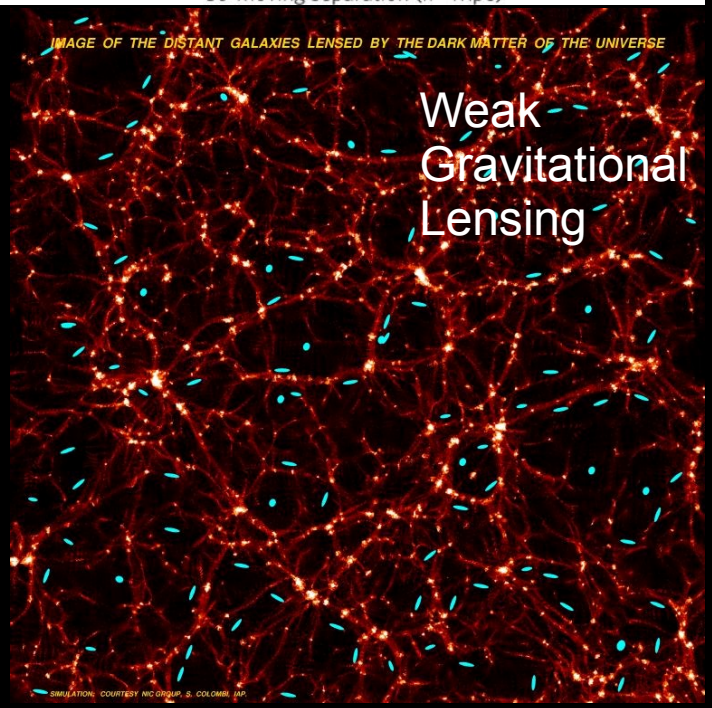
Distance and growth of structure measurements

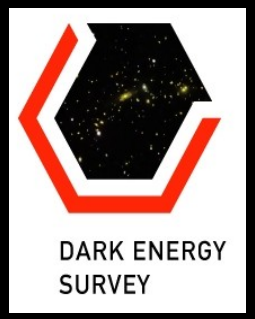
Different sensitivities and different systematic errors











The Dark Energy Survey (DES)

Next generation sky survey aimed directly at understanding the mistery of dark energy

4 main science goals:

Galaxy Clusters counting and spatial distribution at $0.1<z<1.5$

BAO and LSS at $0.1<z<1.5$

Weak Lensing on redshift shells up to $z\sim1$

4000 snIa $0.1<z<1.2$

Impact (20000 clusters, 300 Million Galaxies, 4000 snIa):

5% measurement of w

20% measurement of dw/dz

Combined, they will provide stronger constraints and check on systematic errors

DES: Galaxy Clusters Counts

DARK ENERGY SURVEY

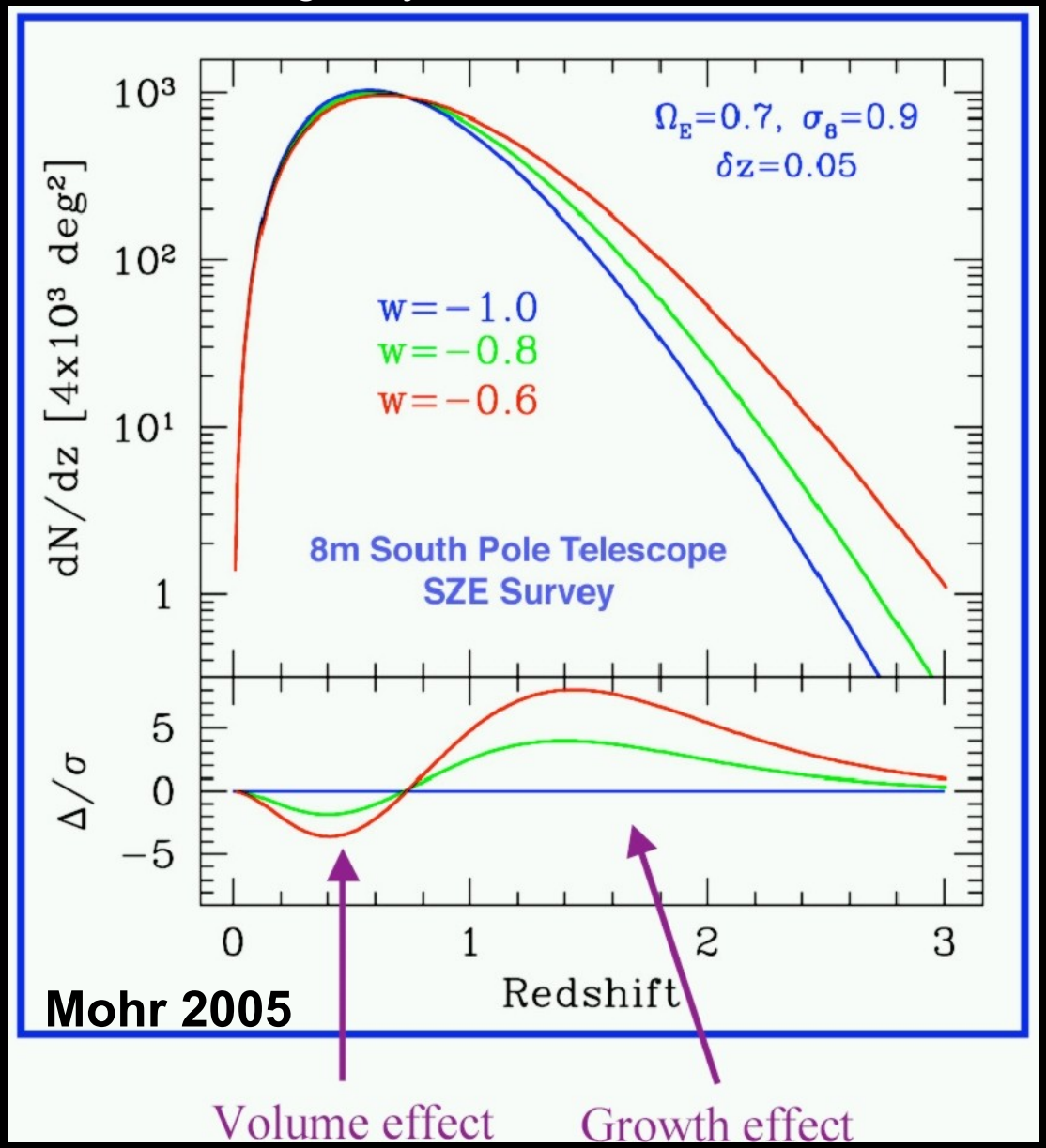
Abundance, mass function and correlations sensitive to cosmology via volume and perturbations growth

Measure ~20000 clusters
Combine with SZ from SPT and Weak Lensing

Systematics: Mass-Observable calibration, photo-z, cluster selection effects

Very sensitive, systematics, Untested

Number of galaxy clusters above threshold



DES: Weak Lensing

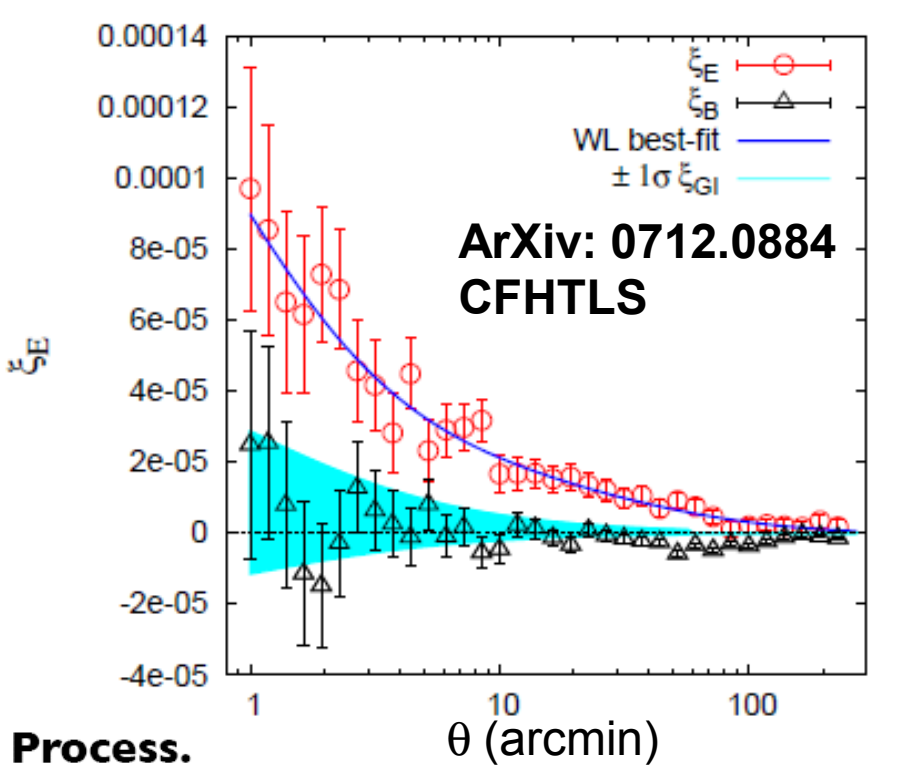
Shape measurements of 300 million galaxies
PSF<0.9” FWHM

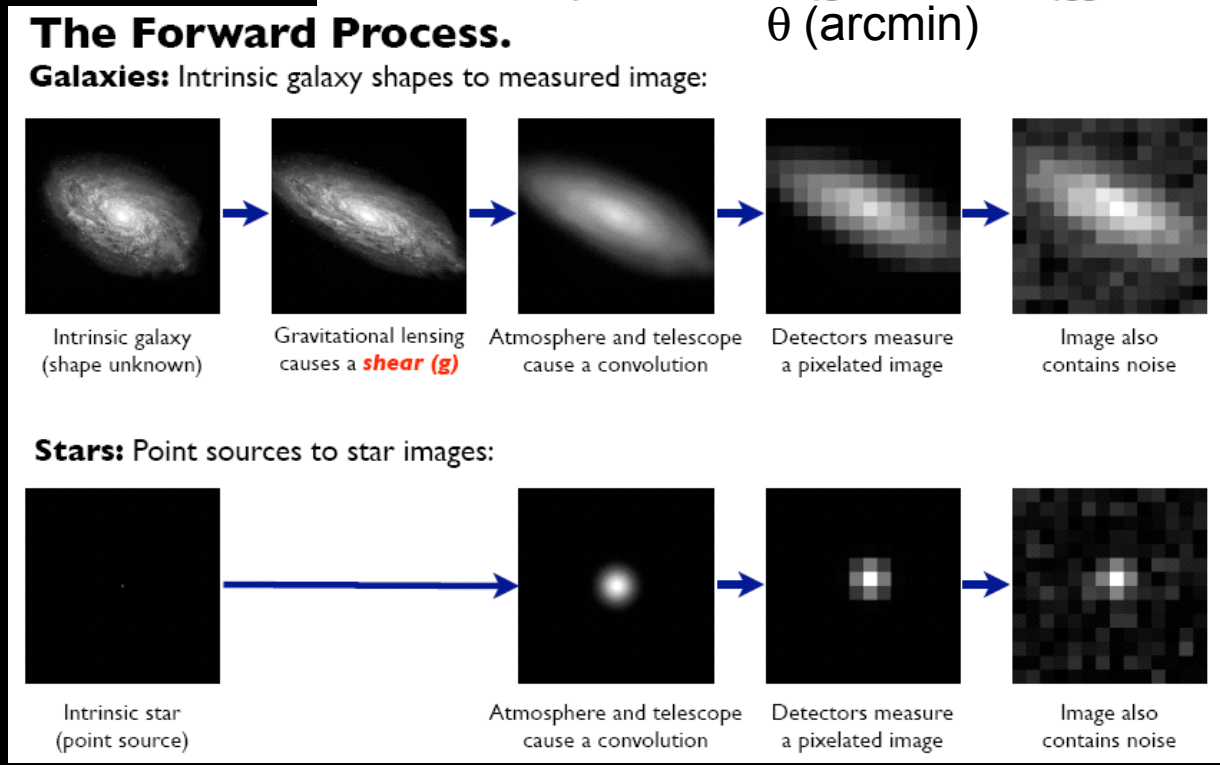
Statistical measurement of distortions of background objects by intervening matter

Distances depend on geometry, foreground mass depends on structure growth

Systematics: shear calibration, PSF, intrinsic alignments, photo-z

Theoretically well founded, galaxy shapes are difficult





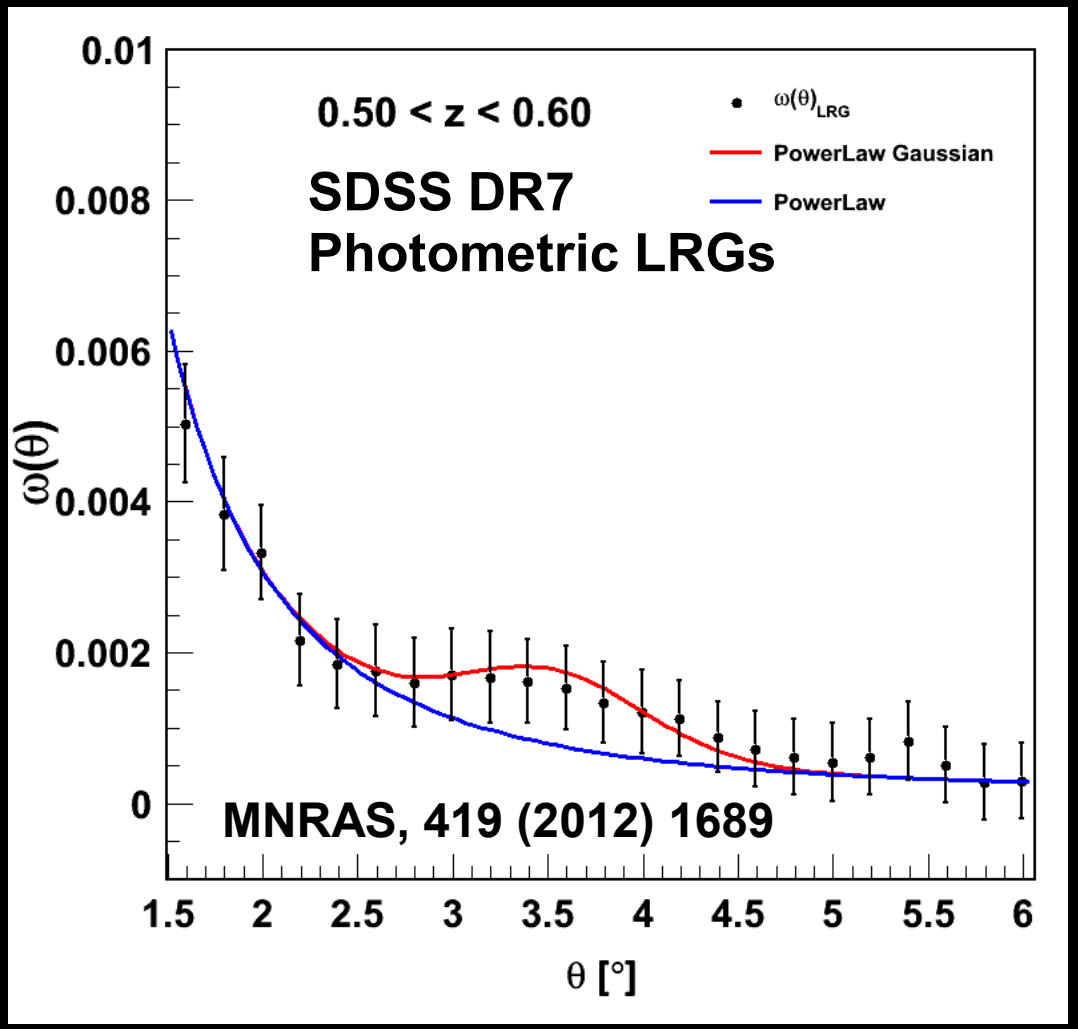
DES: LSS and BAO

Position in the sky and photo-z of 300 million galaxies up to z~1.5

Look for BAO peak in the angular 2pt correlation function in photo-z shells

Systematics: Non-linearities, bias, photo-z

Doable (SDSS), robust, sensitivity



DES:Supernovae Ia

4000 Supernovae Ia in 30 sq-deg up to z~1.2

Large sample with improved z-band response

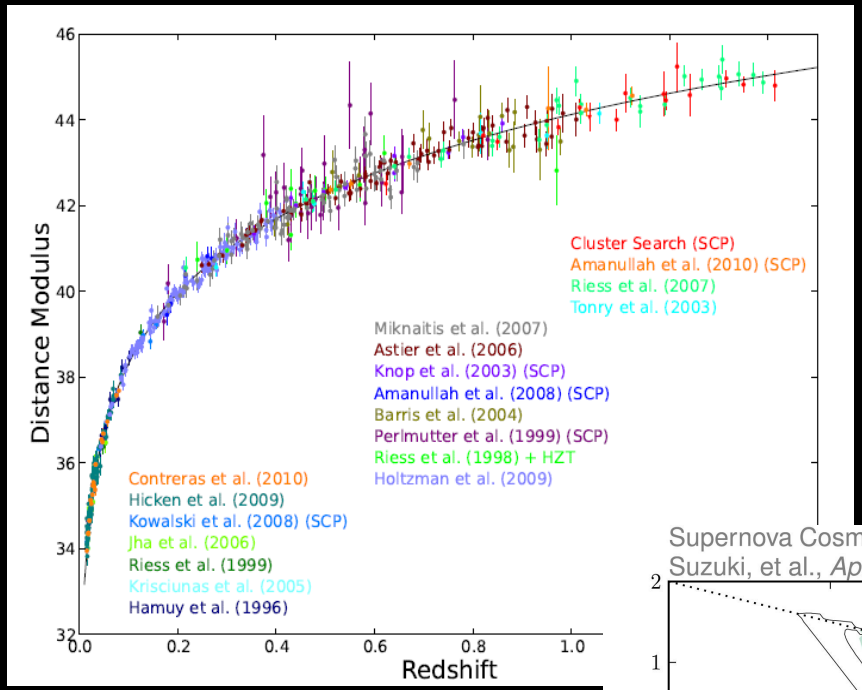
Largest consistent sample

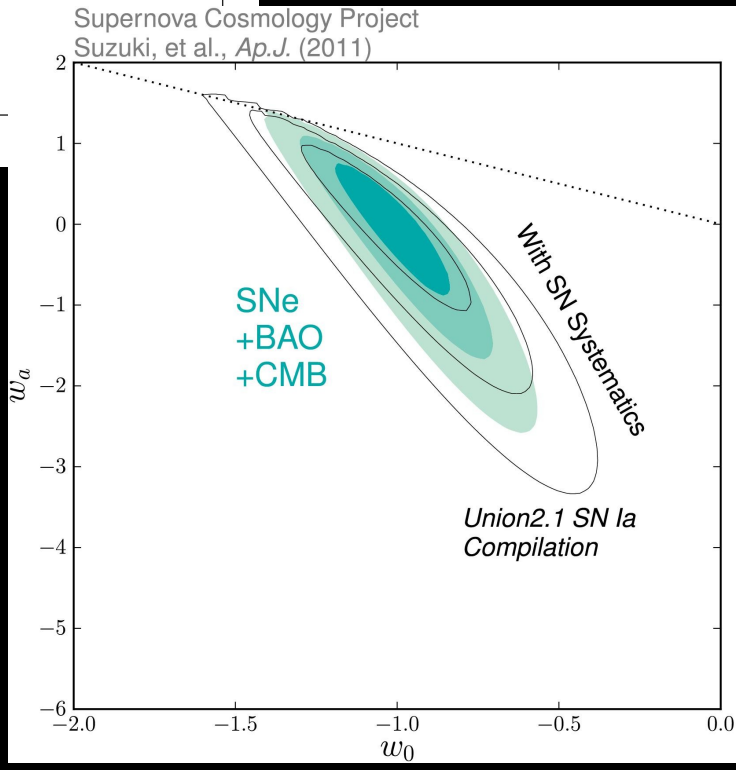
Obtain light curves+calibrate

Test luminosity distance

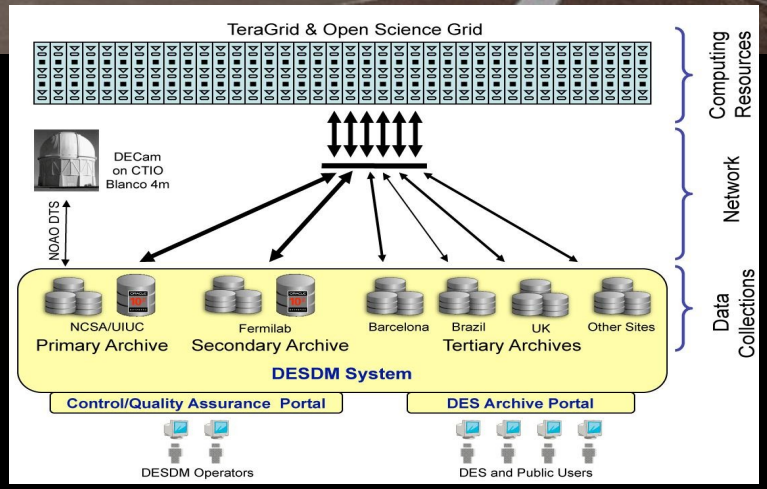
Systematics: Dust, evolution, calibration, photo-z

Mature technique, spectra





Implementation of these measurements



Galaxy survey of 5000 square degrees in the South Galactic Cap to 24th mag in g,r, i, z ,Y filters + 30 square degrees repeat for supernovae.

3 Projects: Build a new 3 sq-deg camera, telescope improvements and Data Management system

The Collaboration

DARK ENERGY SURVEY

International Collaboration of more than 120 scientists from 23 institutions

US: 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

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

Spain Consortium:
CIEMAT, IEEC, IFAE

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

Spokesperson: Josh Frieman (Fermilab)

DES: The Telescope

TELESCOPE: V. M. Blanco at CTIO (Chile), 4m
Existing, well-known and working telescope
Some improvements and upgrades for DES project

DES: Telescope upgrades

DARK ENERGY SURVEY

Succesfully upgraded the primary mirror radial support

New telescope control system

New clean room installed

DES: Telescope upgrades

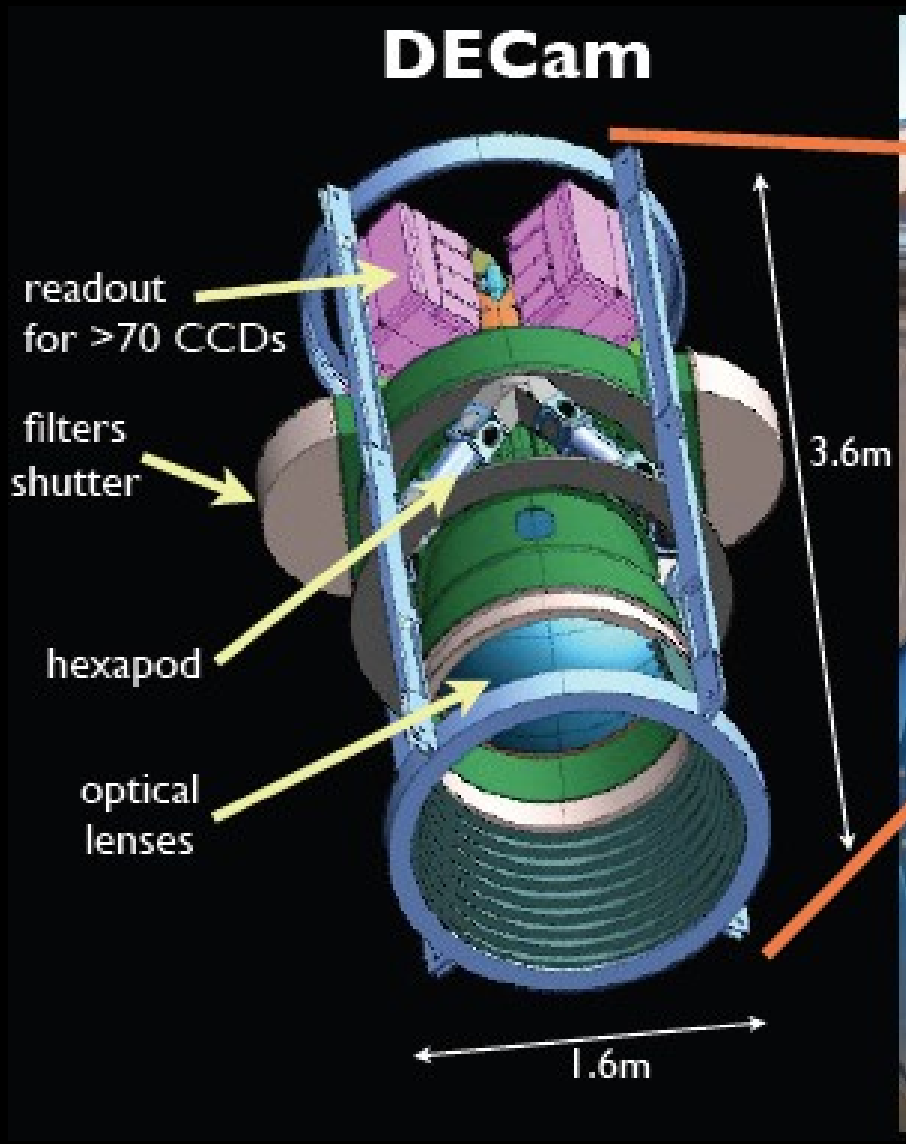
Other improvements:

Environmental control system
Upgrades on the glycol system
Better control & computer rooms
Installation of cryogenic lines
Enhanced bandwidth to USA
Data transport system

DES: The Camera (DECam)

DARK ENERGY SURVEY

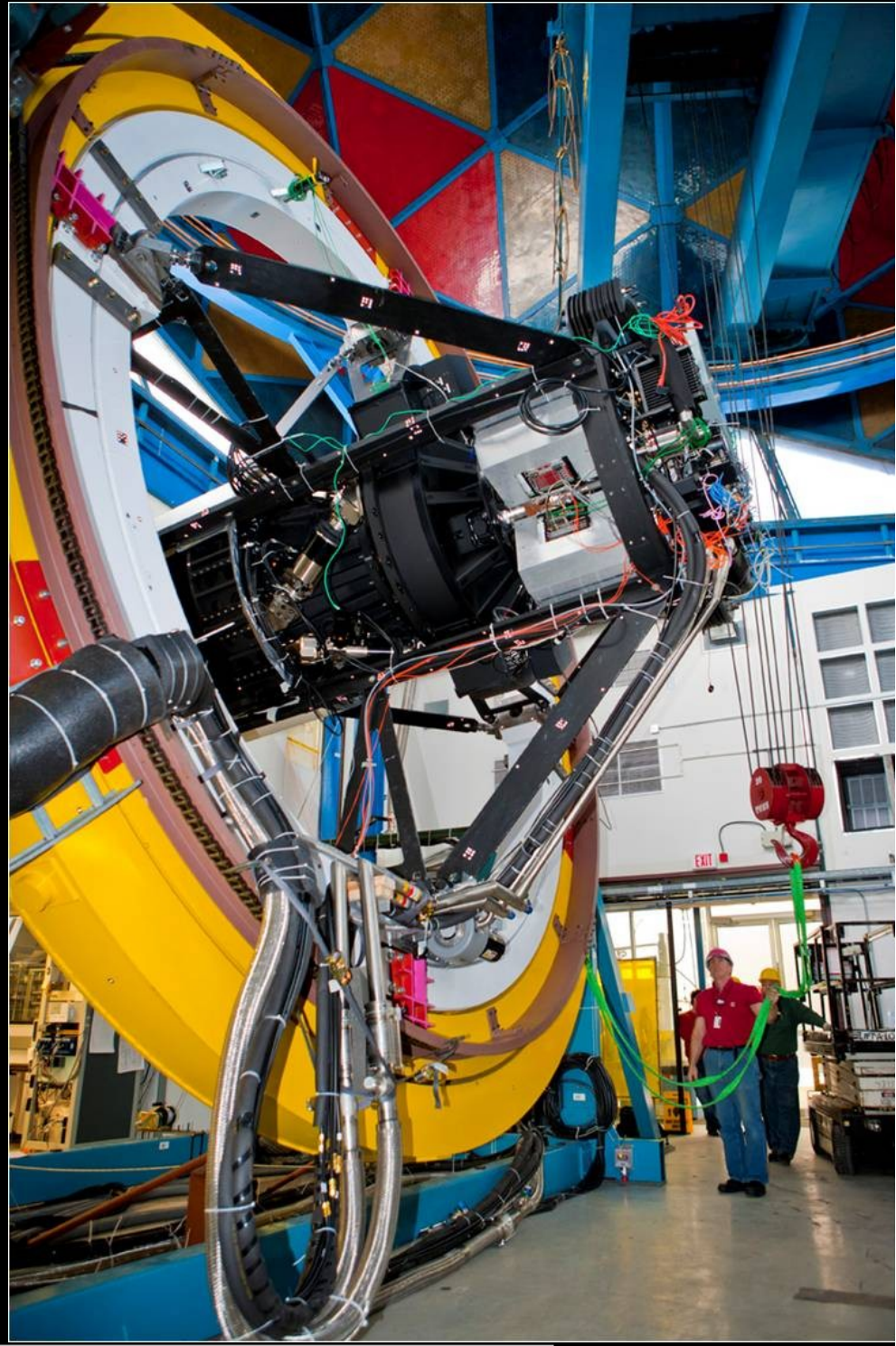
New prime focus instrument at Blanco



To meet the scientific requirements of DES: 3 sq-deg FoV
Red sensitive CCDs (from LBNL), g, r, i, z, Y filters
Low noise electronics (readout with <10 e noise!), Cryogenic cooling system

DES: DECam

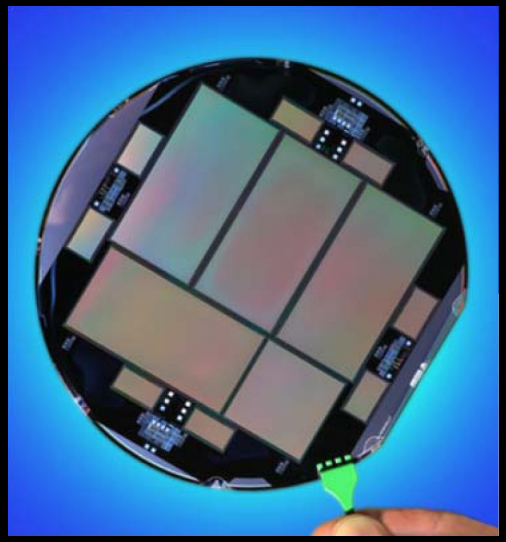
It has been extensively tested in a full size telescope simulator in Fermilab during 2011

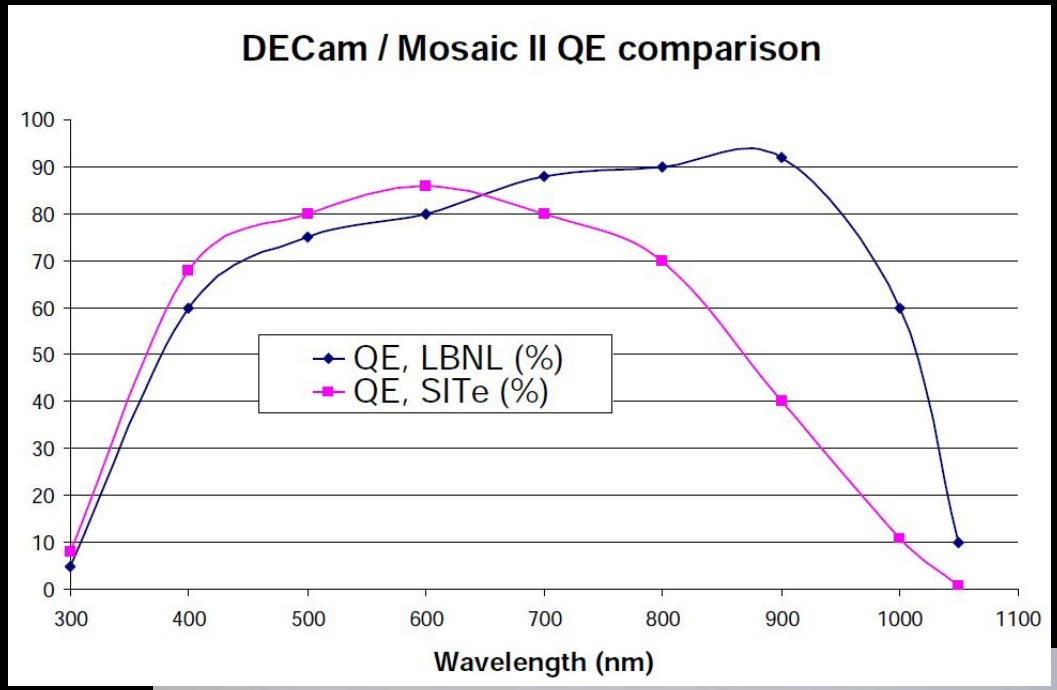


DES: DECam

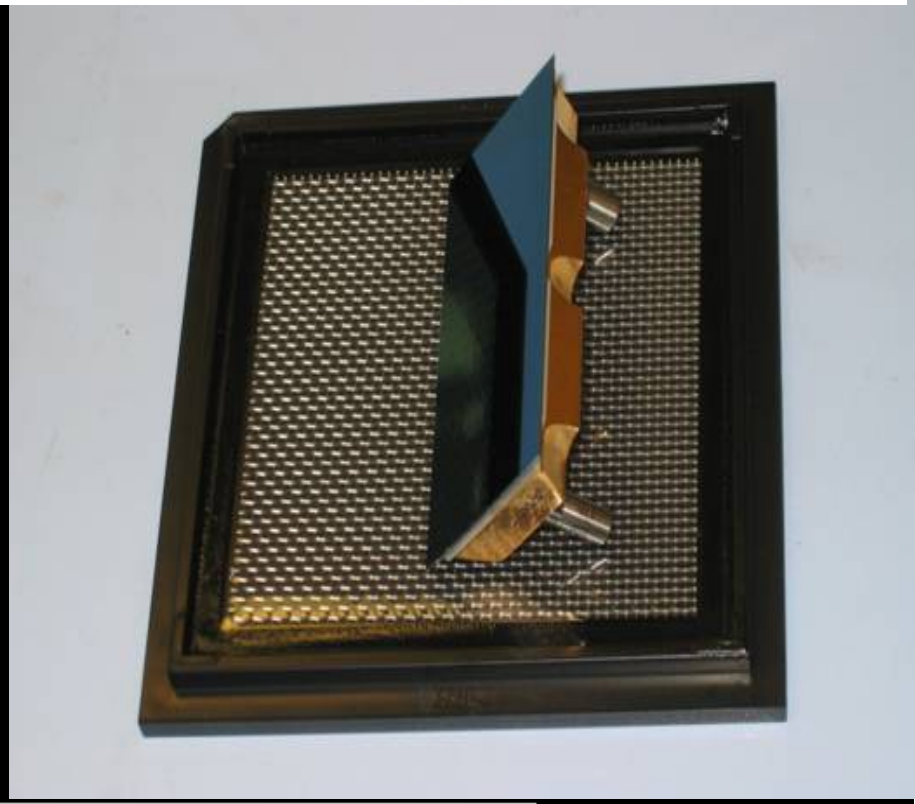
All the components are in Chile. The camera is currently being mounted on the telescope

DECam:CCDs





Red sensitive CCDs, designed by LBNL:
QE>50% at 1000nm
250 microns thick
Readout 250 kpx/s
2 RO channels/device
17 s readout time



DECam:Electronics

Monsoon readout system (NOAO) was redesigned to be able to read the large number of CCDs of DECam

Readout very fast and with very low noise

Readout 250 kpx/s
17 s readout time

Noise < 10 e

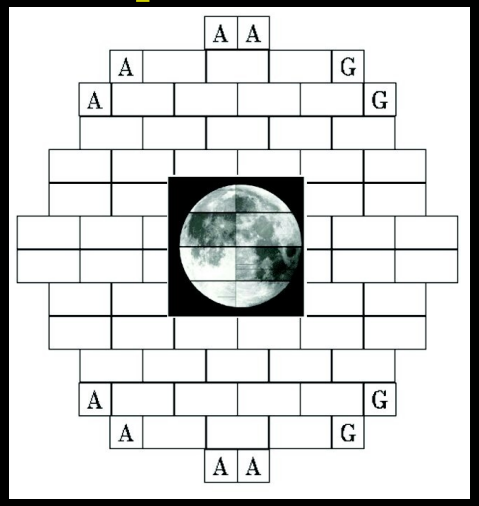
DECam:Imager

DARK ENERGY SURVEY

62 2kx4k CCDs: 520 Mpx

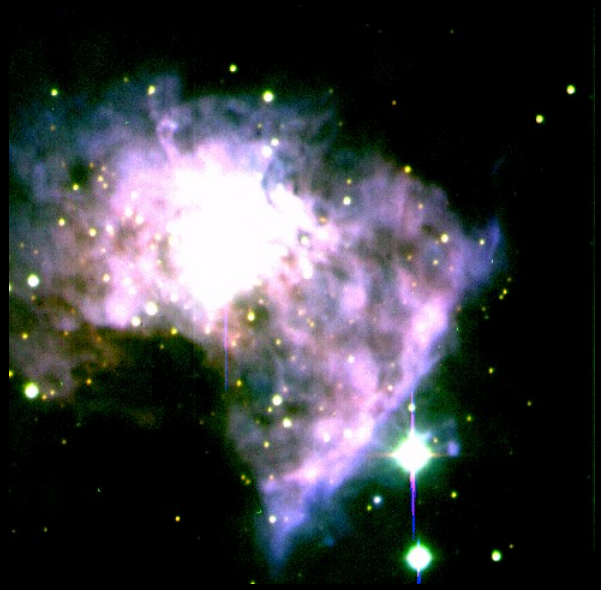
12 2kx2k CCDs guide & focus

0.5 m diameter focal plane



Imager at CTIO clean room

DECam:Test Images



CCDs and electronics tested in realistic conditions

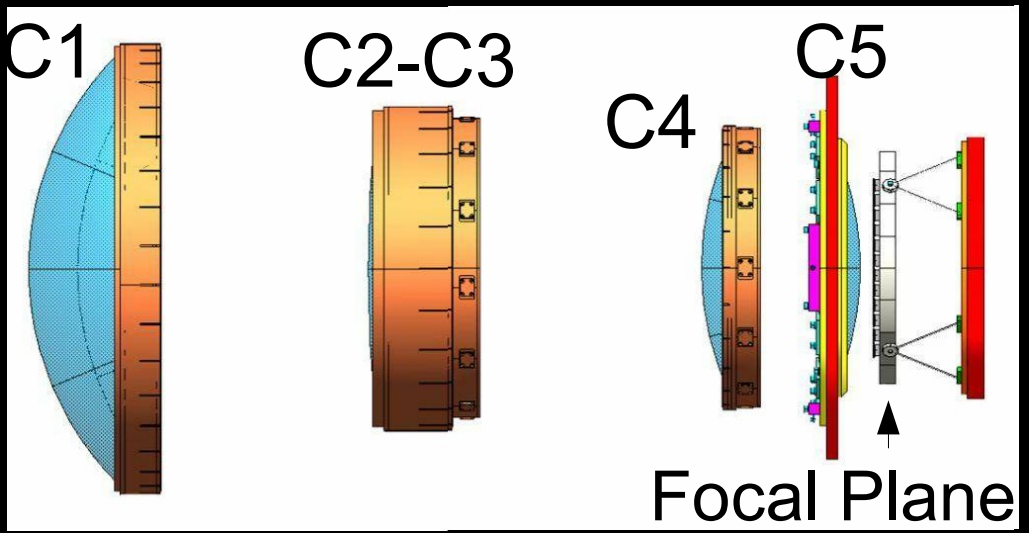
November 2009:
- 1 DECam CCD
- with DECam electronics
- On the CTIO 1m (next to the Blanco)
- VRI filters

DECam:Optical Corrector

FoV 3 sq-deg (2 deg diameter)

Large lenses, up to 1m diameter

Good image quality across FoV

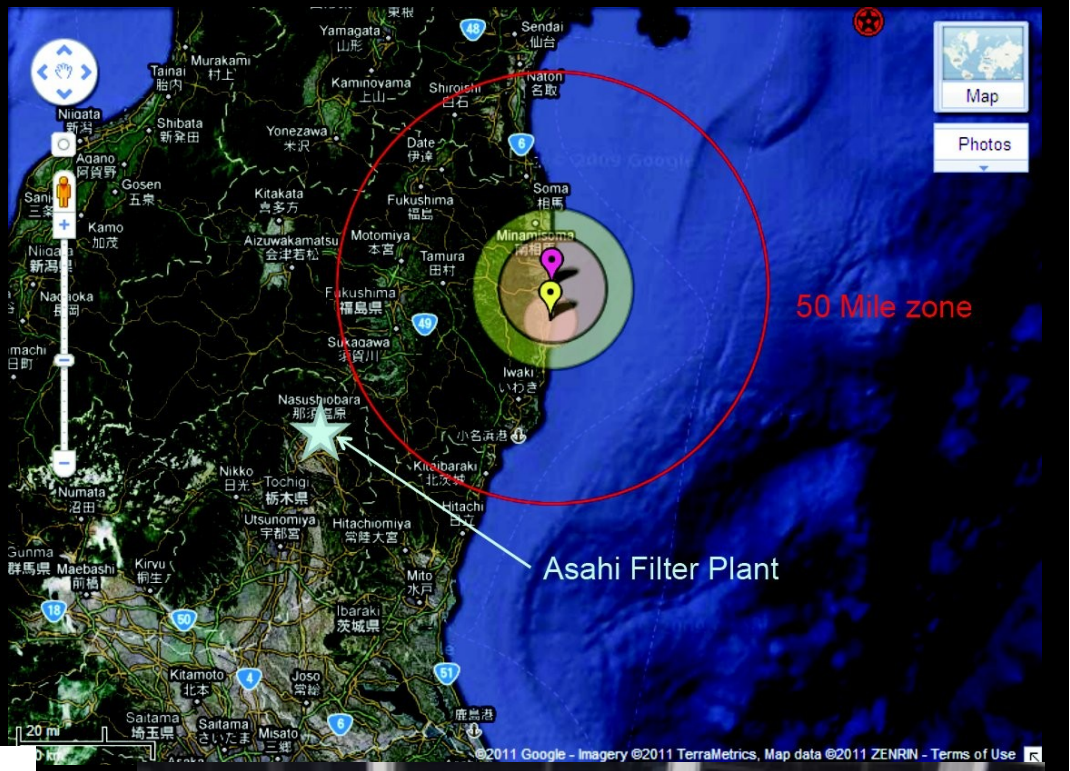


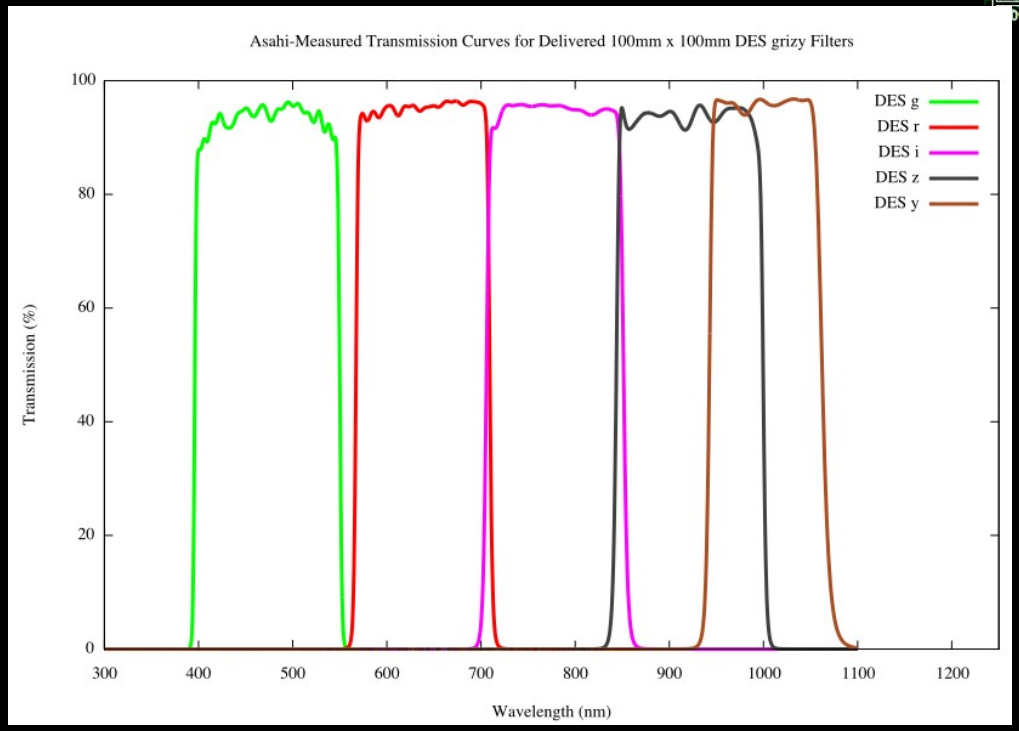
DECam: Filters

Largest filters to date, 60 cm diameter

Good homogeneity

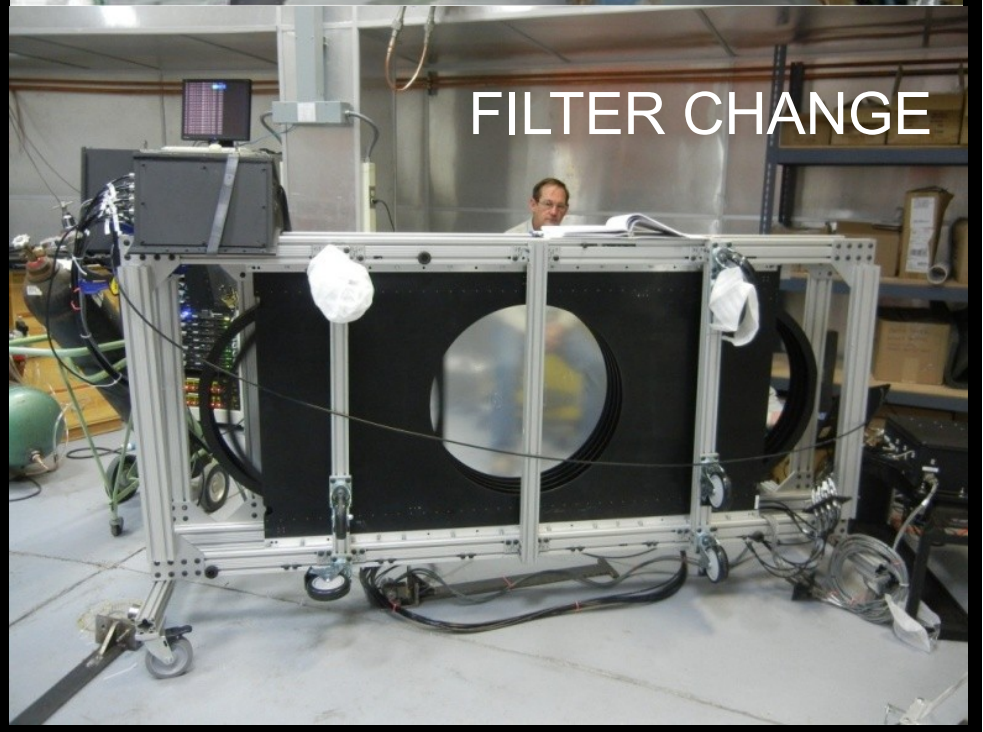
Special coating chamber





DECam: Opto-mechanics

DARK ENERGY SURVEY

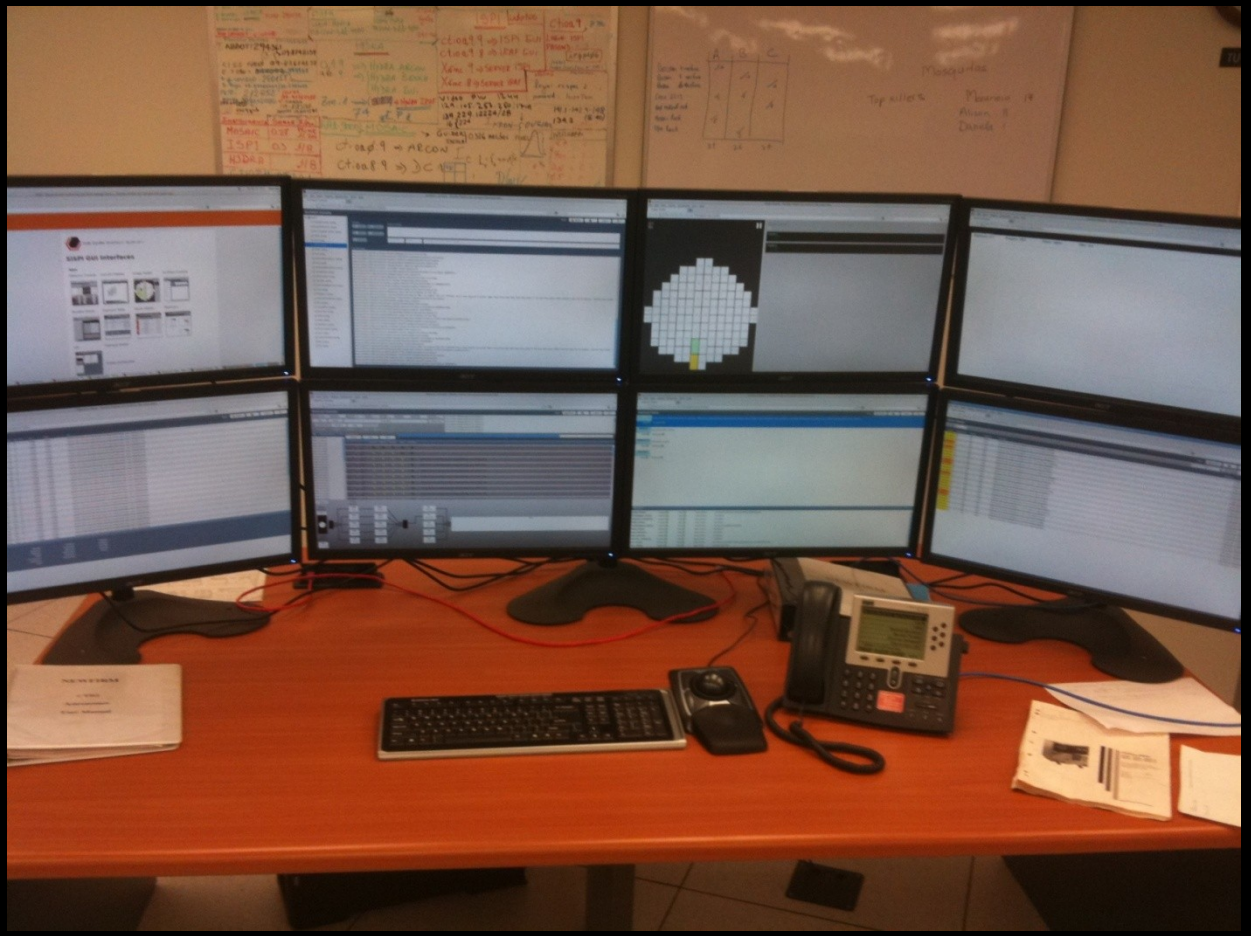


DECam: Data Acquisition

New control run for the telescope

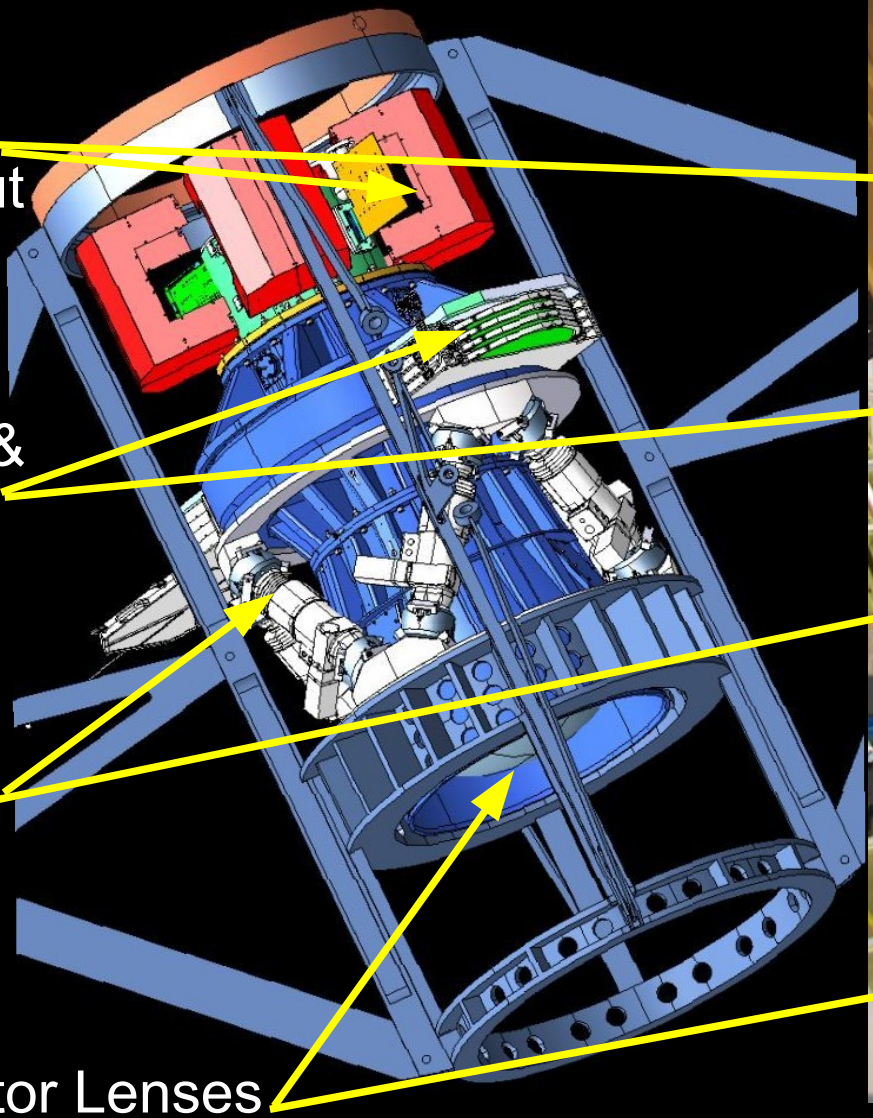
DECam data acquisition system working

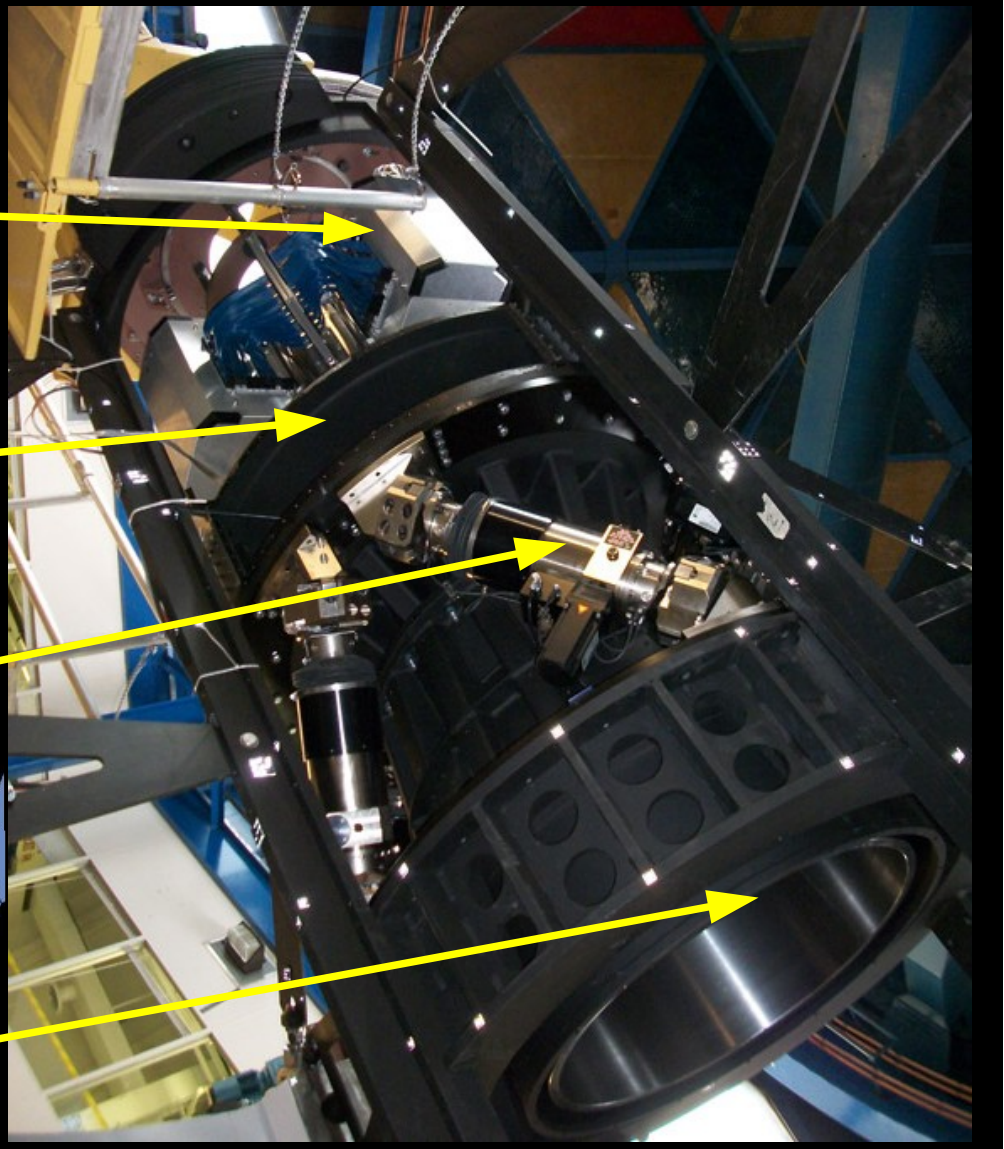
Tested at CTIO



DECam is being mounted on the Blanco Telescope

DARK ENERGY SURVEY





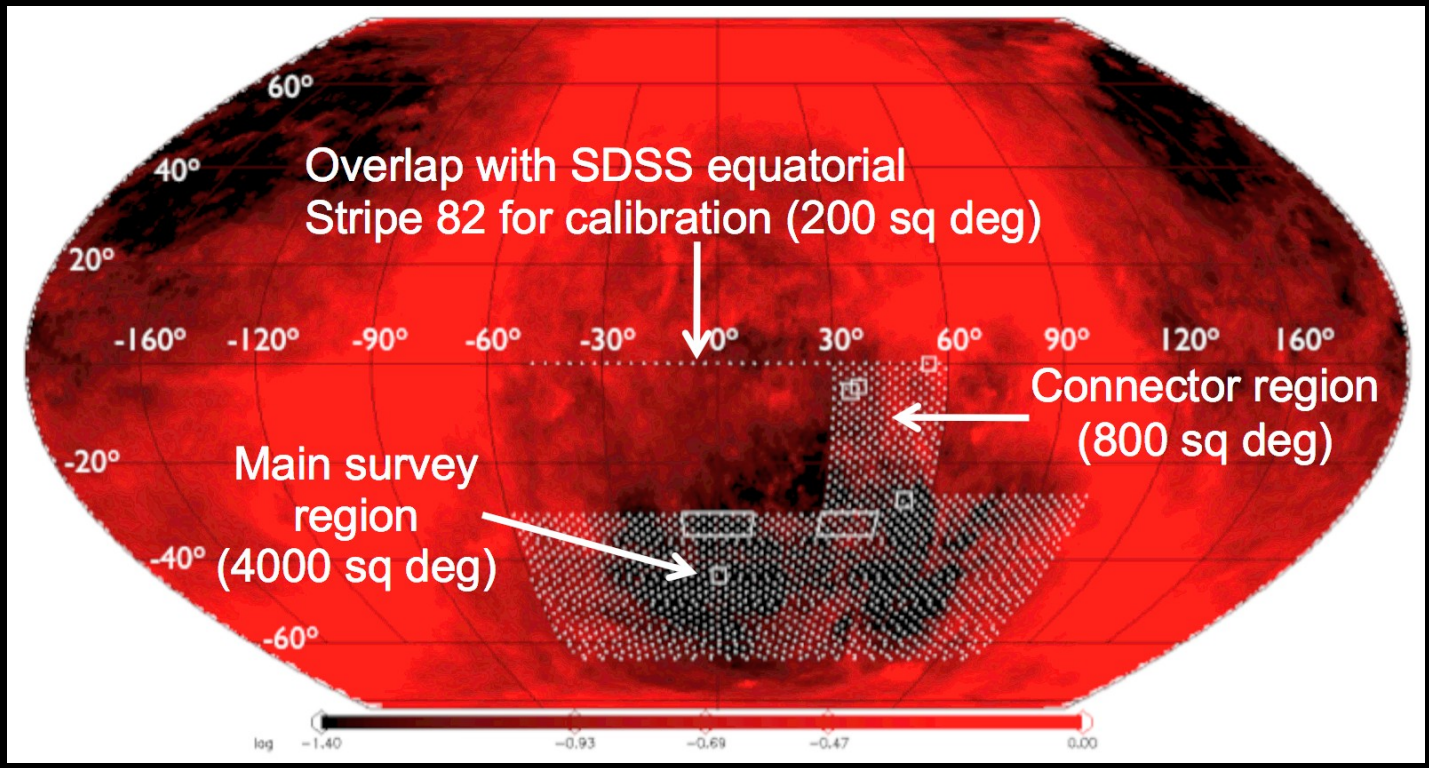
DES Survey Strategy

DARK ENERGY SURVEY

Sept-Feb observing sessions

80-100 s exposures

2 filters per pointing
gr in dark time
izy otherwise

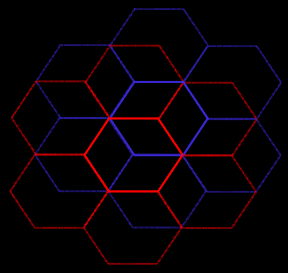


Photometric calibration: Overlap tilings, standard stars, spectrophotometric calibration

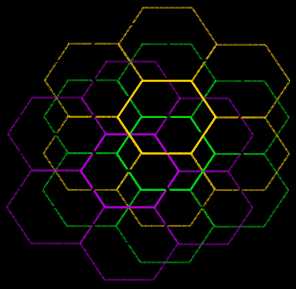
2 survey tilings/filter/year

Interleave 10 SN fields in griz if non-photometric or bad seeing or time gap (aim for ~5 day cadence)

2 tilings



3 tilings



DES Data Management

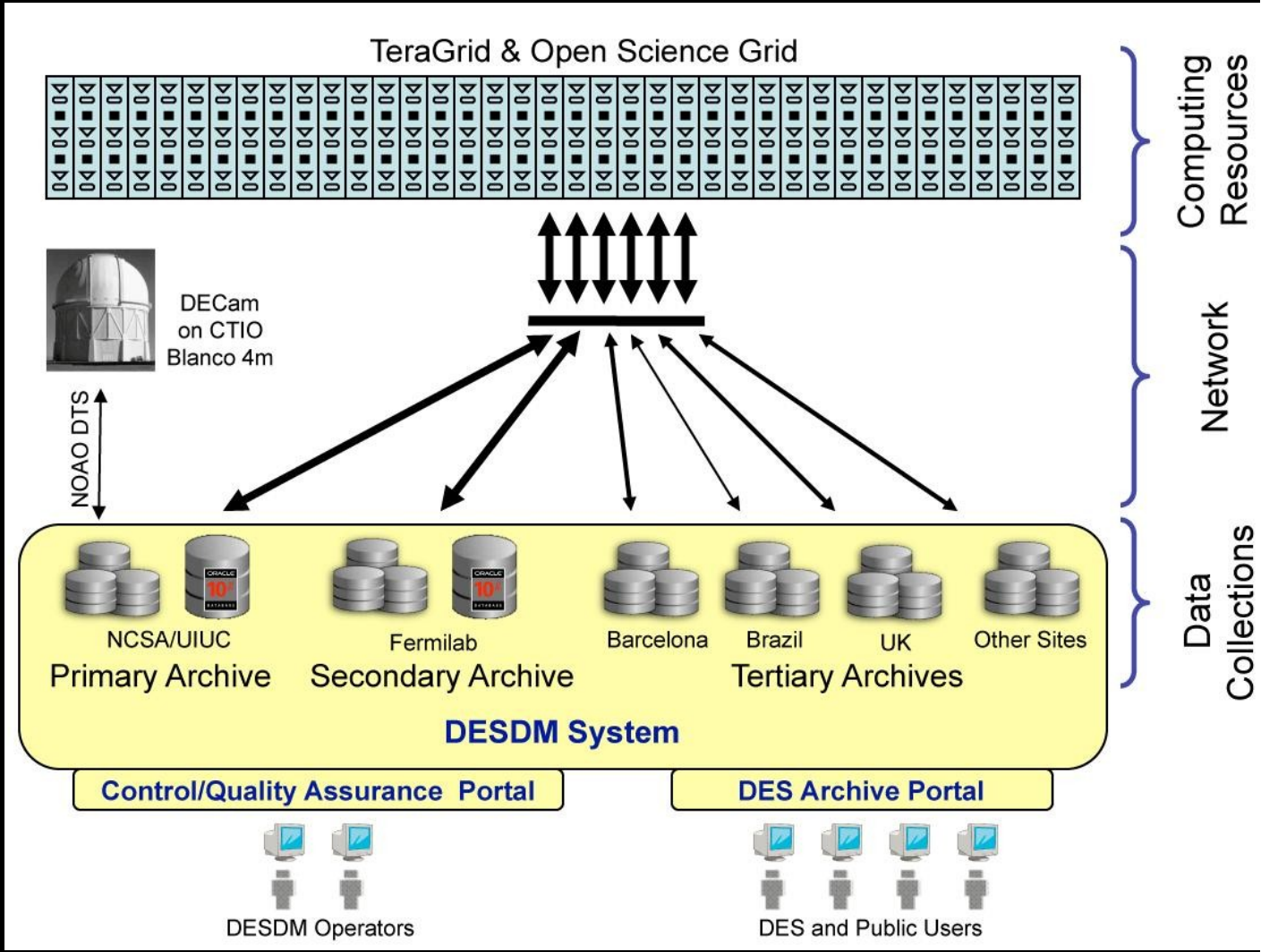
Transmission of imagesfrom CTIO to NCSA (Illinois), ~300 GB

Use GRID for nightly processing

Data archive: Images and catalogs, total ~4 PB

Distribute data to the collaboration

Distribute data to public Raw/reduced after 1 year Provide a community pipeline for public use

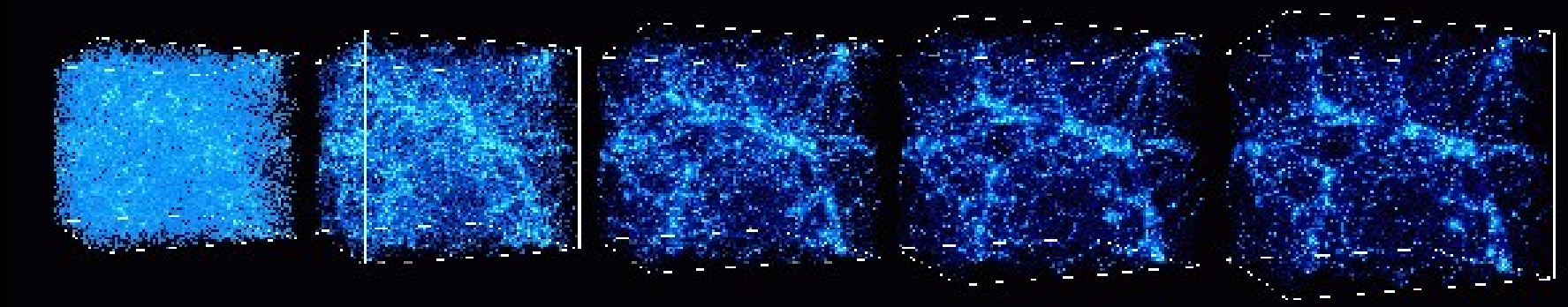


DES Data analysis

DARK ENERGY SURVEY

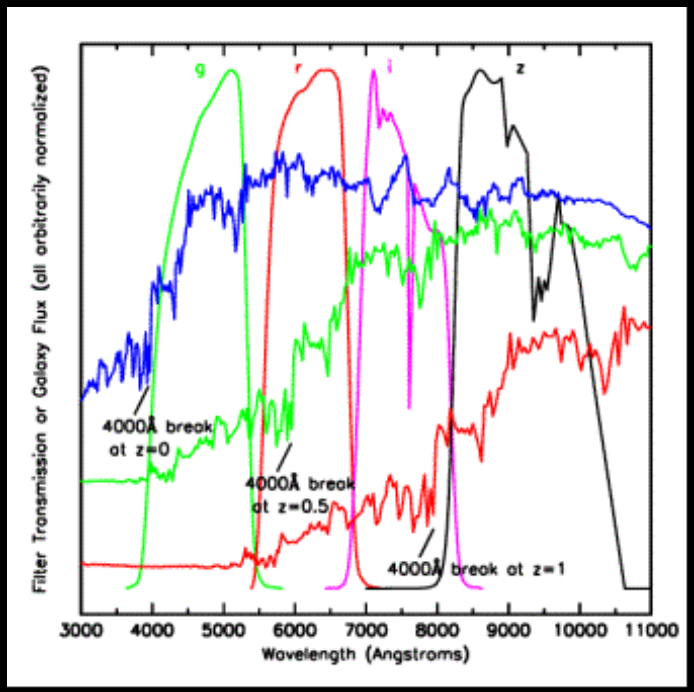
Map the universe

z=10 **z=0**

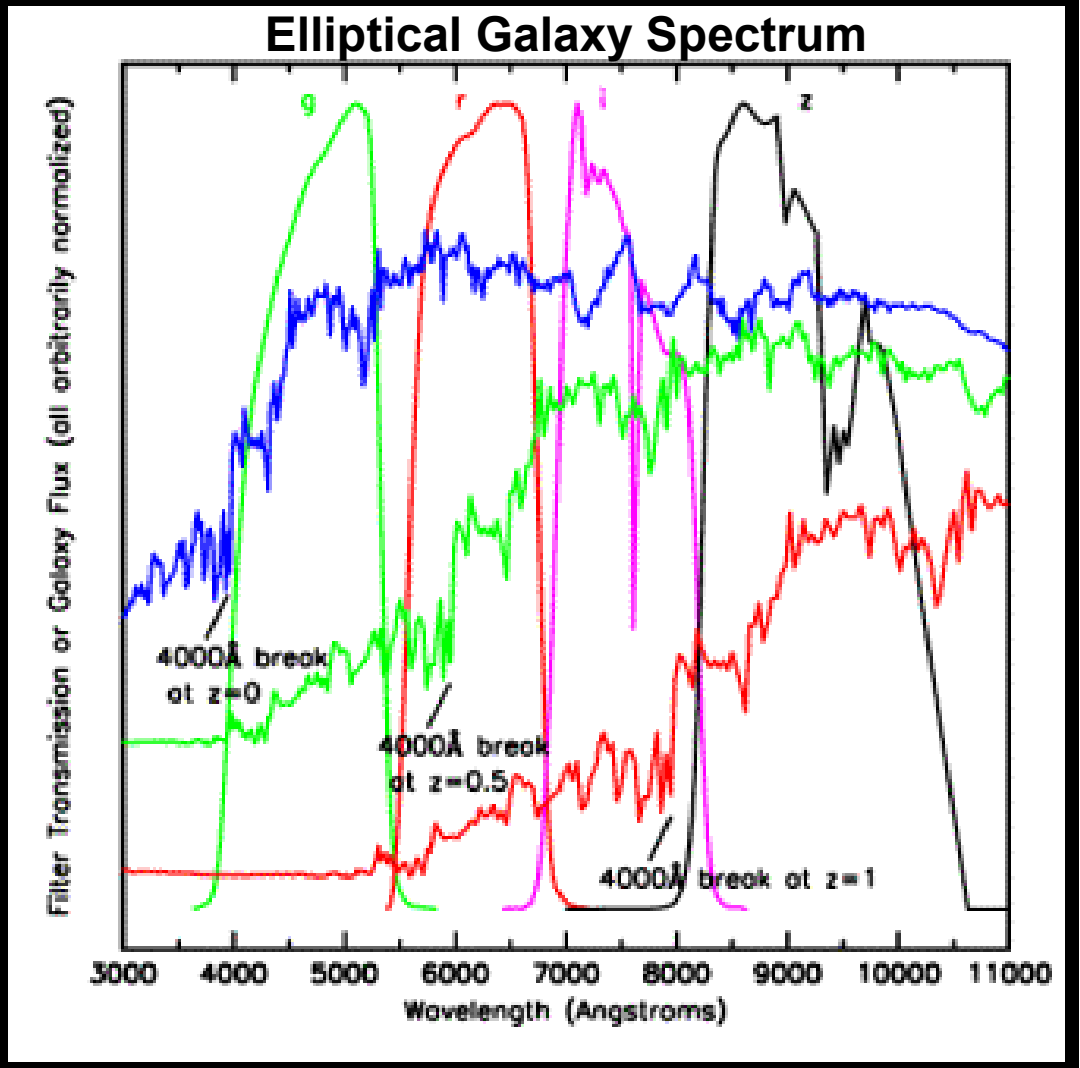


ϕ, θ from DECam images

Distance from Photo-z



DES Photometric Redshift



Measure the relative flux in grizY filters

Measure individual galaxy redshifts with precision $\Delta z<0.1$ (~0.02 for clusters)

Precision is enough for dark energy probes.

Control the photoz error

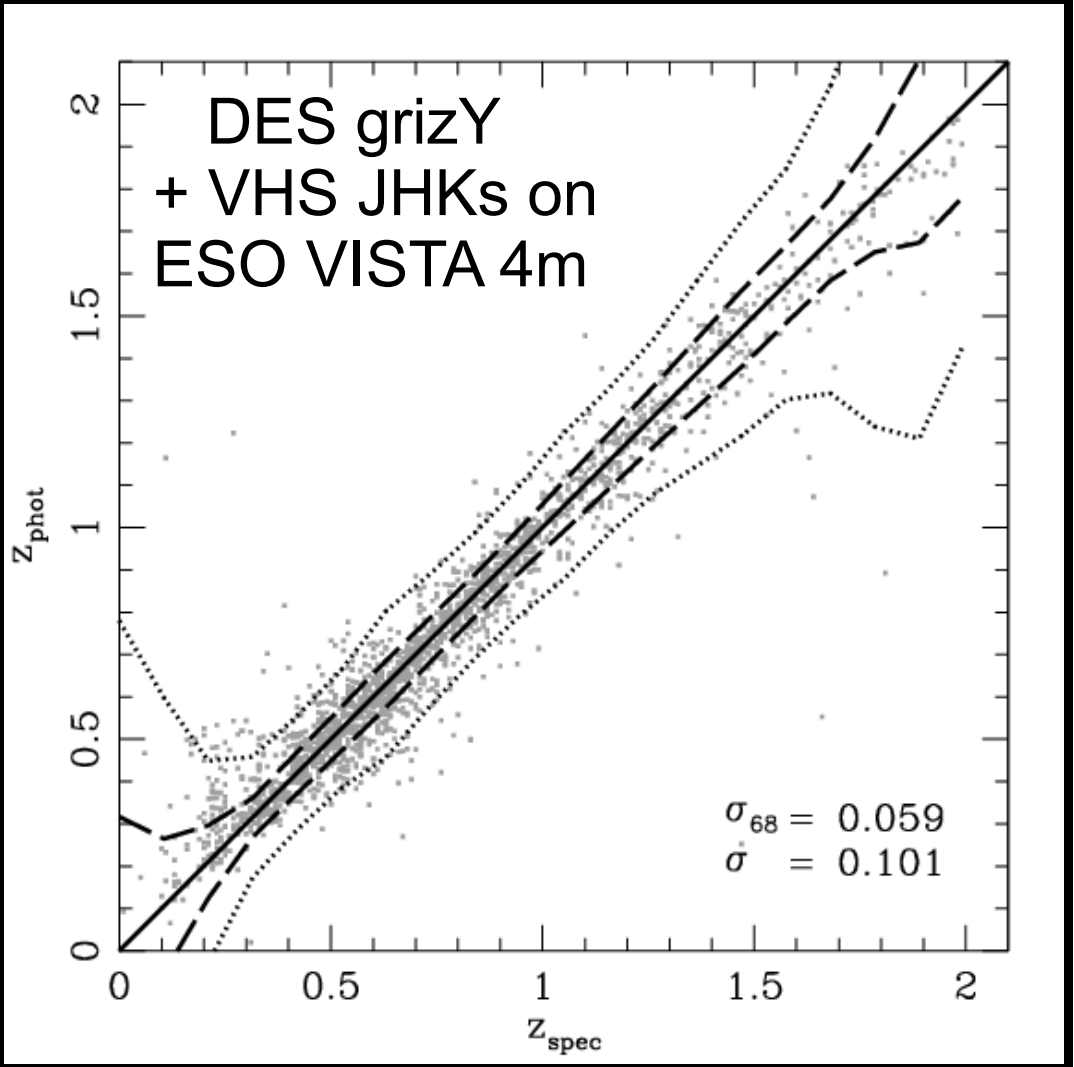
A good z-band response is needed to reach z~1.5

DES Photometric Redshift

Agreement DES with VHS (VISTA Hemisphere Survey)

Get J,H,Ks bands from the ESO VISTA telescope (4m), DES gives the Y band

This improves the photoz precision, specially at high z, enhancing the science capabilities



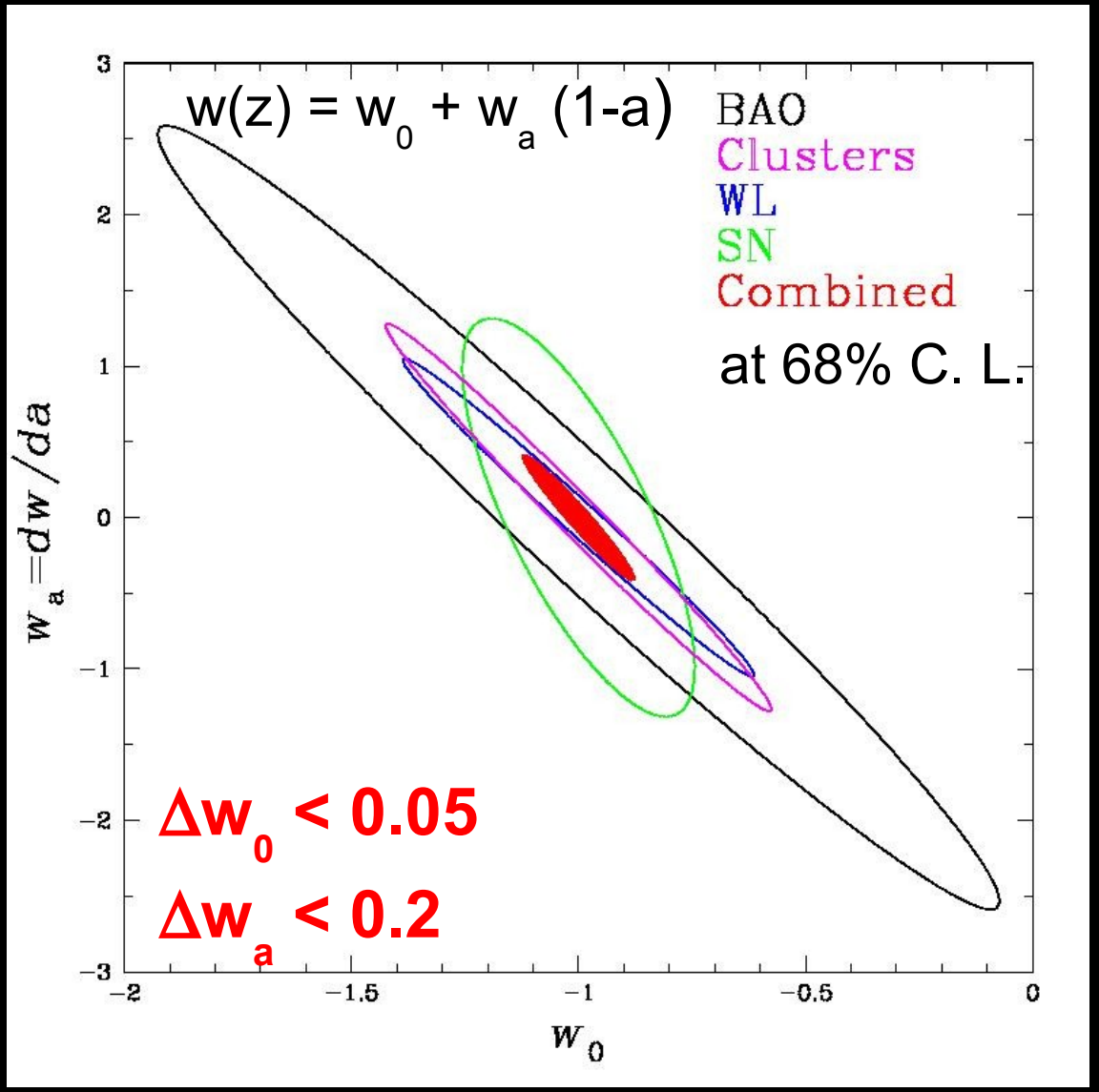
DES Summary and Forecast

DES will explore the nature of the Dark Energy

Using 4 complementary probes
Supernovae Ia
Galaxy Clusters Counting
Weak Lensing Tomography
Baryon Acoustic oscillations

To do this:
New wide field camera built
Upgraded Blanco telescope 4m
High performance data management system

Control of systematic errors
Improvement of a factor ~5 over current constraints



Spain contribution to DES

DES-Spain Collaboration: **CIEMAT (Madrid), ICE/CSIC and IFAE (Barcelona) + collaborators at PIC and UAM/IFT**

Summary of contributions:

DECam:

Design, production, testing and maintenance of the FEE (Front End Electronics)

Also used for guiding (fast readout and very low noise)

Design and implementation of Guiding software

DES Collaboration:

2 representatives in the Management and Science Comm.

1 representative in the Membership and the Publications Comm

Chair of the speakers boureau

Coordination of the LSS and Photoz Science Working Group

Spain contribution to DES

DES-Spain Collaboration: **CIEMAT (Madrid), ICE/CSIC and IFAE (Barcelona) + collaborators at PIC and UAM/IFT**

Summary of contributions:

Data management

Tertiary Archive at PIC (IFAE/CIEMAT)

Design and implementation of software for Data Quality Control (LSS)

Science

Many people active in very different science cases: BAO, LSS, Weak Lensing, Theory, Photoz...

DES Timeline

Project started 2003
DECam R&D 2004-2008
Camera construction 2008-2011
Ship to Chile : late 2011

Installation: Ongoing
First Light: Summer 2012
Commissioning : Summer 2012
Science Verification: Autum 2012

Survey: 2012-2017