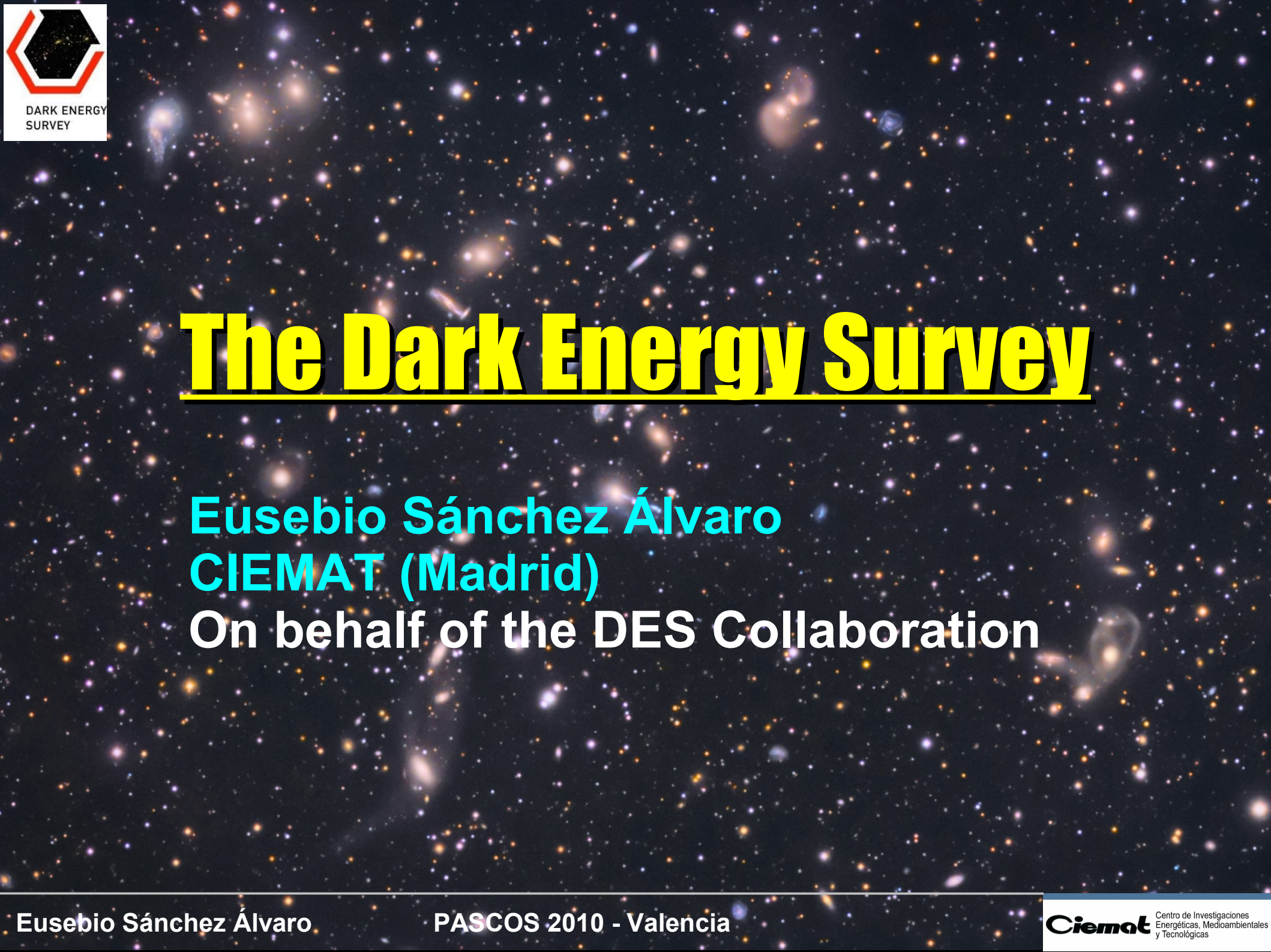


The Dark Energy Survey

Eusebio Sánchez Álvaro
CIEMAT (Madrid)
On behalf of the DES Collaboration

OUTLINE

- Motivation :Probes of Dark Energy
- The Dark energy Survey
- The Collaboration
- The Instrument: DECam
- Data Management
- DES Forecast: Figure of Merit
- Timescale
- Conclusions

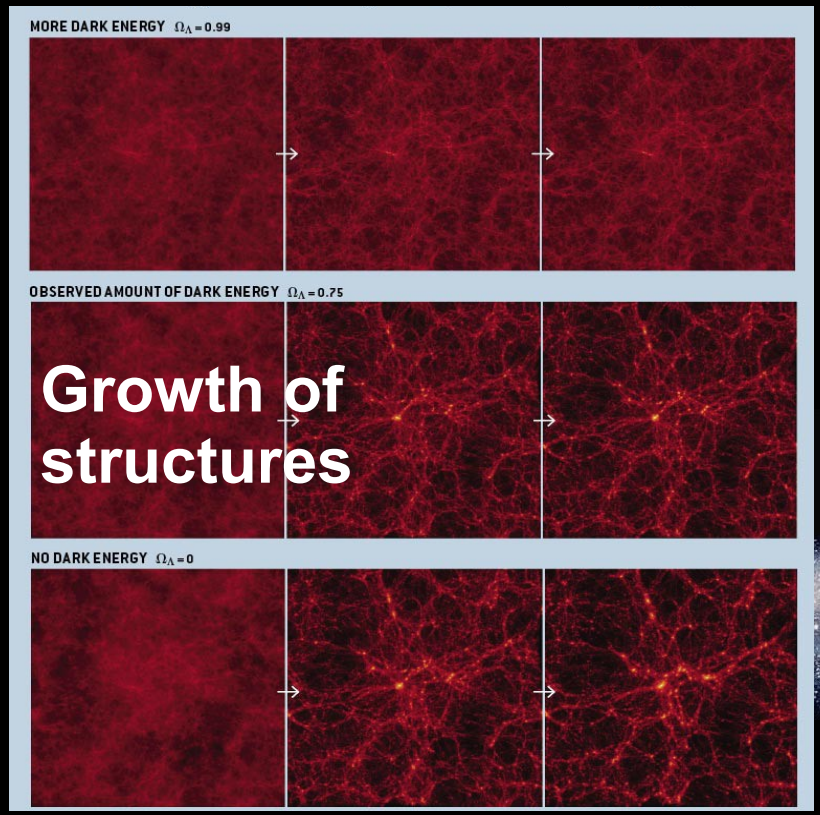
Motivation

Main (and ambitious) goal: Identify the nature of the Dark Energy

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

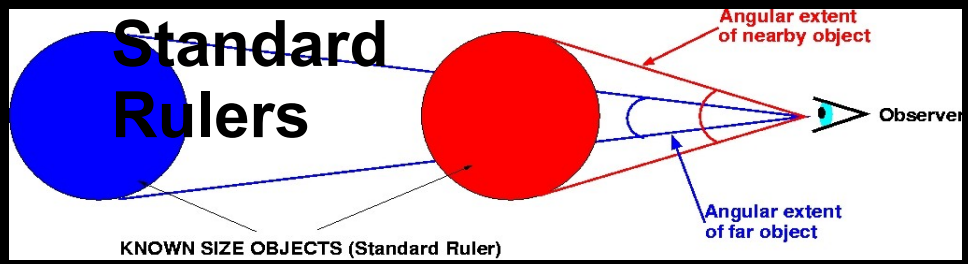
It is necessary to measure with precision, since the differences among different models are small.

Control systematic errors!!!!

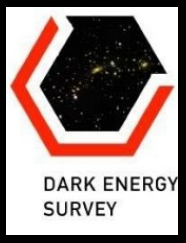


Growth of structures

Standard Candles



Standard Rulers



Observational Probes of Dark energy

Distance probes: CMB acoustic peaks, SNIa, BAO, SZ+X-ray+Optical clusters, strong lensing statistics, Ly-alpha forest correlations, Alcock-Pazynski test, galaxy counts…

Growth of structure probes: CMB, weak lensing, galaxy clusters, Ly-alpha forest, ISW effect, …

Many tests to attack the problem of dark energy, with different sensitivities, different systematics and different levels of practical difficulty.

A full study of all the methods was done by the DETF in 2006. The main conclusion is that the study of dark energy must be done using multiple techniques.

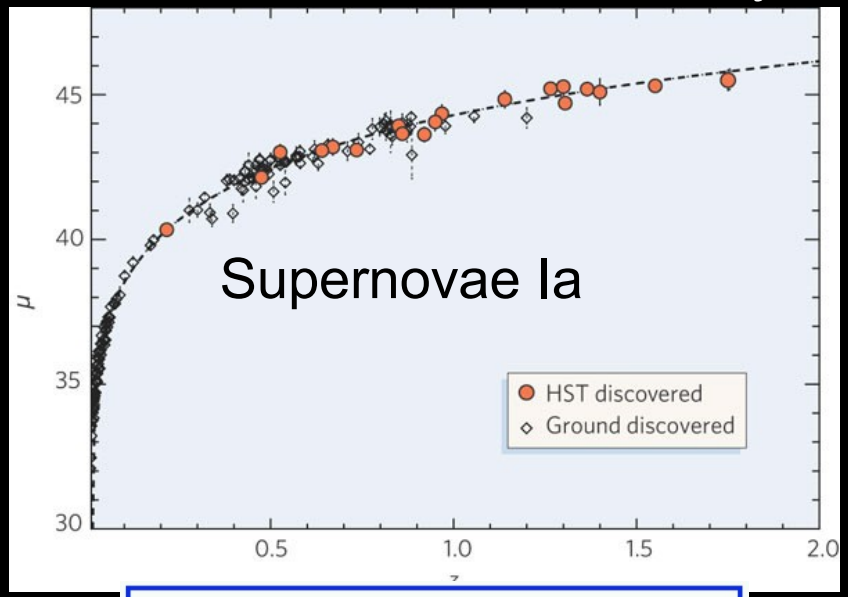
No single technique is powerful enough to improve the knowledge of dark energy at the level of one order of magnitude.

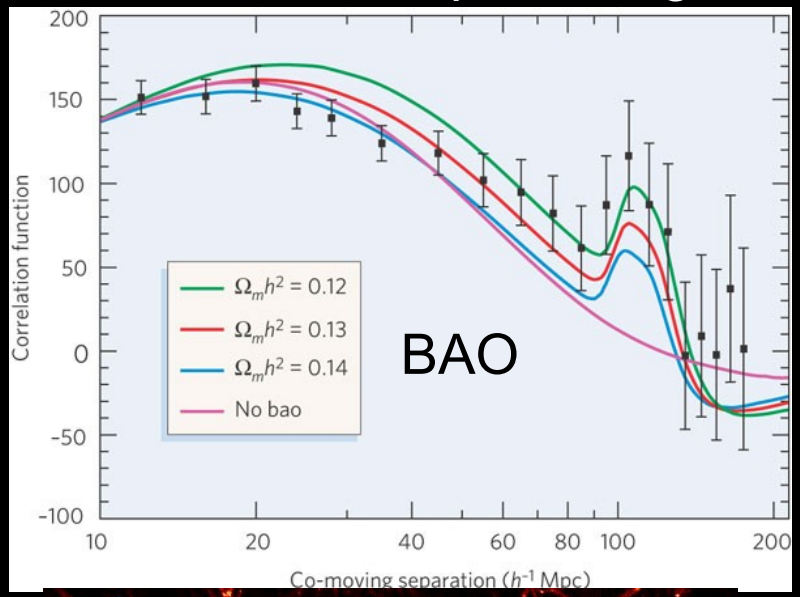
Combinations of techniques: substantially more statistical power, much more ability to discriminate among dark energy models, and more robustness to systematic errors than any single technique.

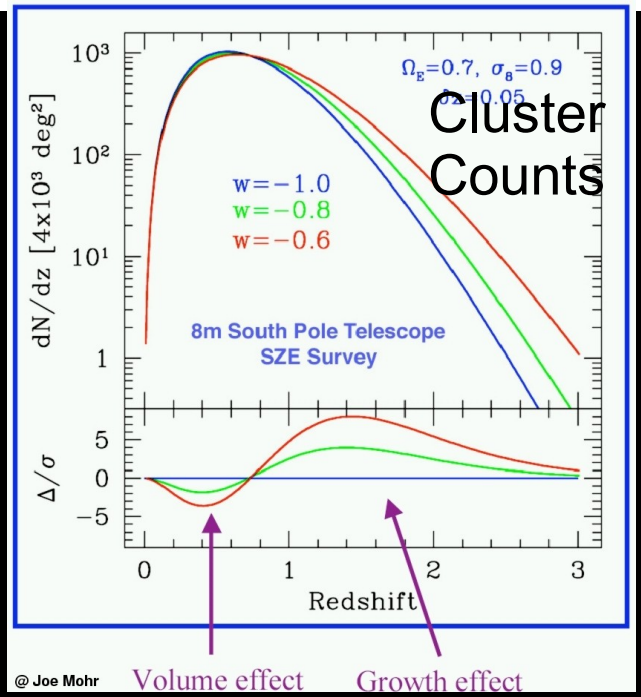
Also, the confirmation of results from any single method

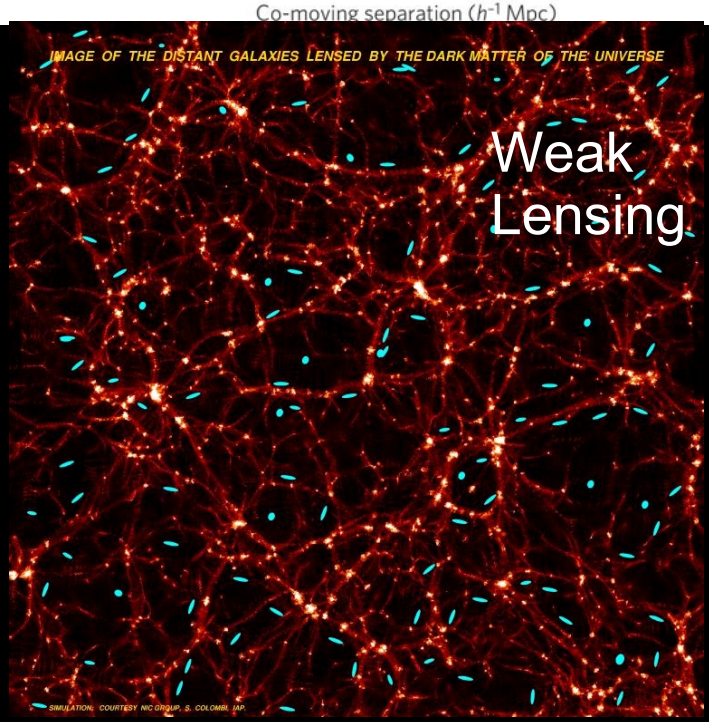
Observational Probes of Dark energy

Four methods are identified by the DETF as the most promising:









The Dark Energy Survey (DES)

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

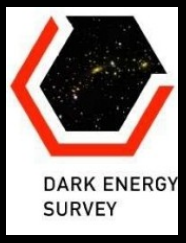
4 Main Science Goals:

- *Galaxy Clusters counting and spatial distribution at 0.1<z<1.5*
- *BAO and galaxy distribution at 0.1<z<1.4*
- *Weak Lensing on several redshift shells up to z~1*
- *2000 snIa at 0.3<z<0.8*

Impact (20000 clusters, 300 million galaxies, 2000 snIa):

- **5-15% measurement of w in each technique**
- **~30% measurement of dw/dz in each technique**

Combined, they will provide STRONGER CONSTRAINTS and CHECK ON SYSTEMATIC ERRORS



Galaxy Clusters

SZ measurements from SPT

Sensitive to growth of structure and geometry

Systematics: Mass calibration, photo-z

Weak Lensing

Shape measurements of 300 million galaxies

Sensitive to growth of structure and geometry

Systematics: Calibrations, PSF, intrinsic alignments, photo-z

Large Scale Structure

Position in the sky and photo-z of 300 million galaxies

Sensitive to geometry

Systematics: Non-linear galaxy bias, photo-z

Supernovae

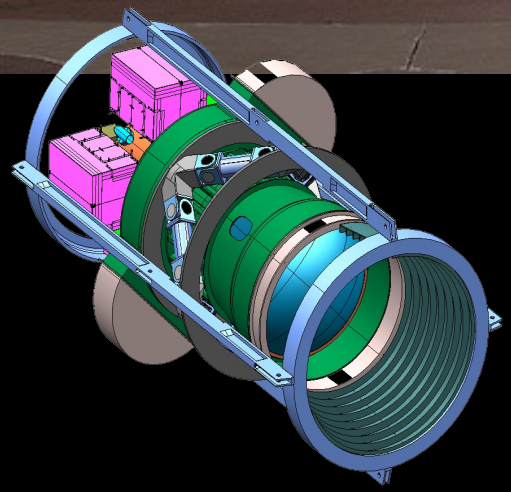
15 sq deg time-domain survey, ~2000 Snela to z ~1

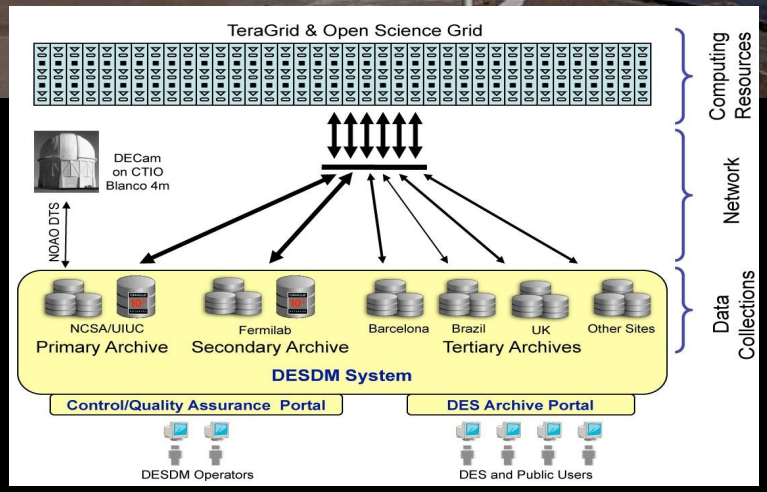
Sensitive to geometry

Systematics: SN evolution, extinction, photometric errors

Implementation of these measurements

DARK ENERGY SURVEY





Galaxy survey of 5000 square degrees in the South Galactic Cap. 3 ELEMENTS: Telescope, Camera and Data Management

Using the 4m Blanco Telescope at CTIO (Chile); an existing and working telescope *(30% DES, 70% of public use)*


DARK ENERGY
SURVEY


Telescope Wed - 2009 Dec 09 08:58:27
re: 4400
DARK ENERGY
SURVEY

The Collaboration

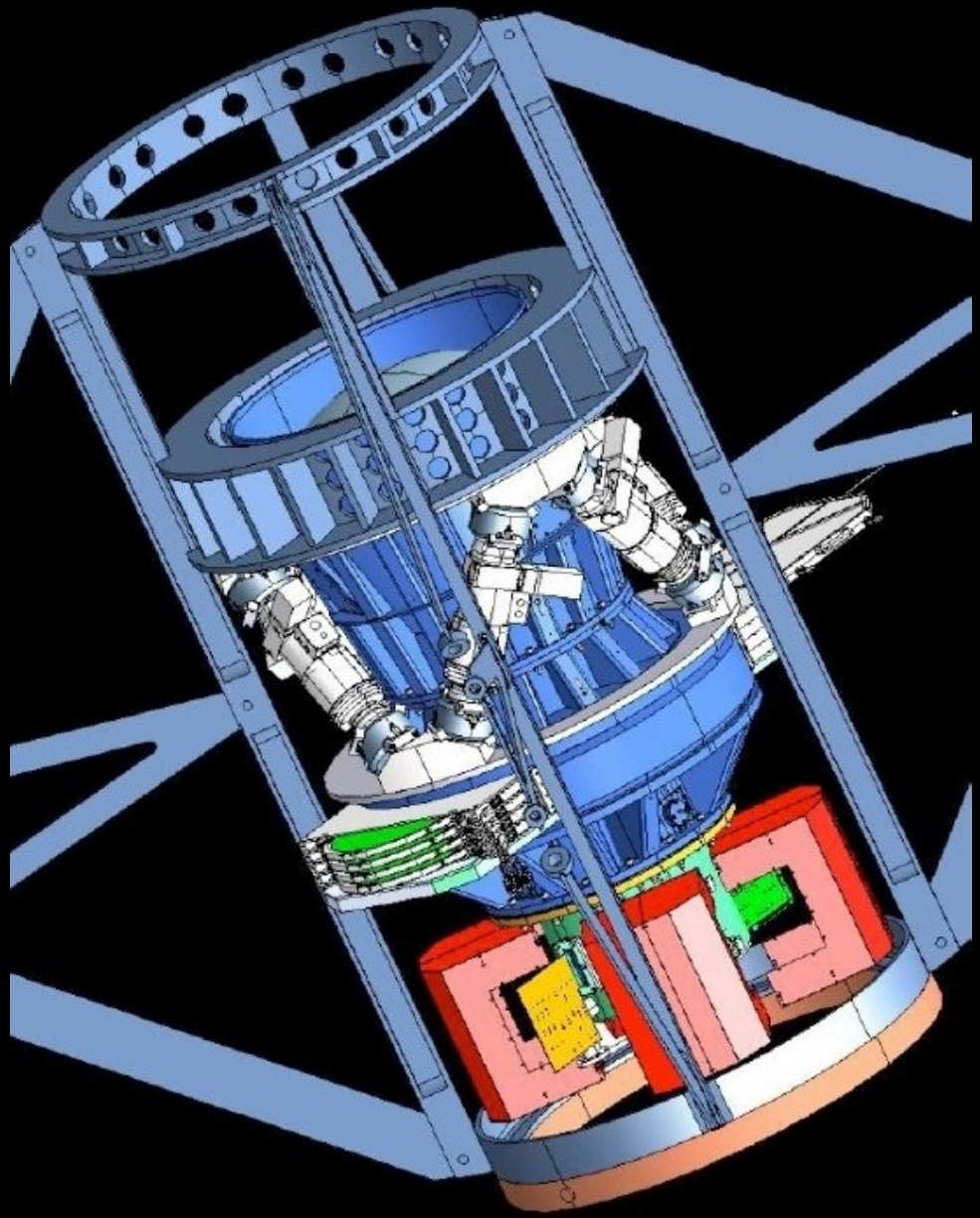
an international collaboration of ~100 scientists from ~20 institutions

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

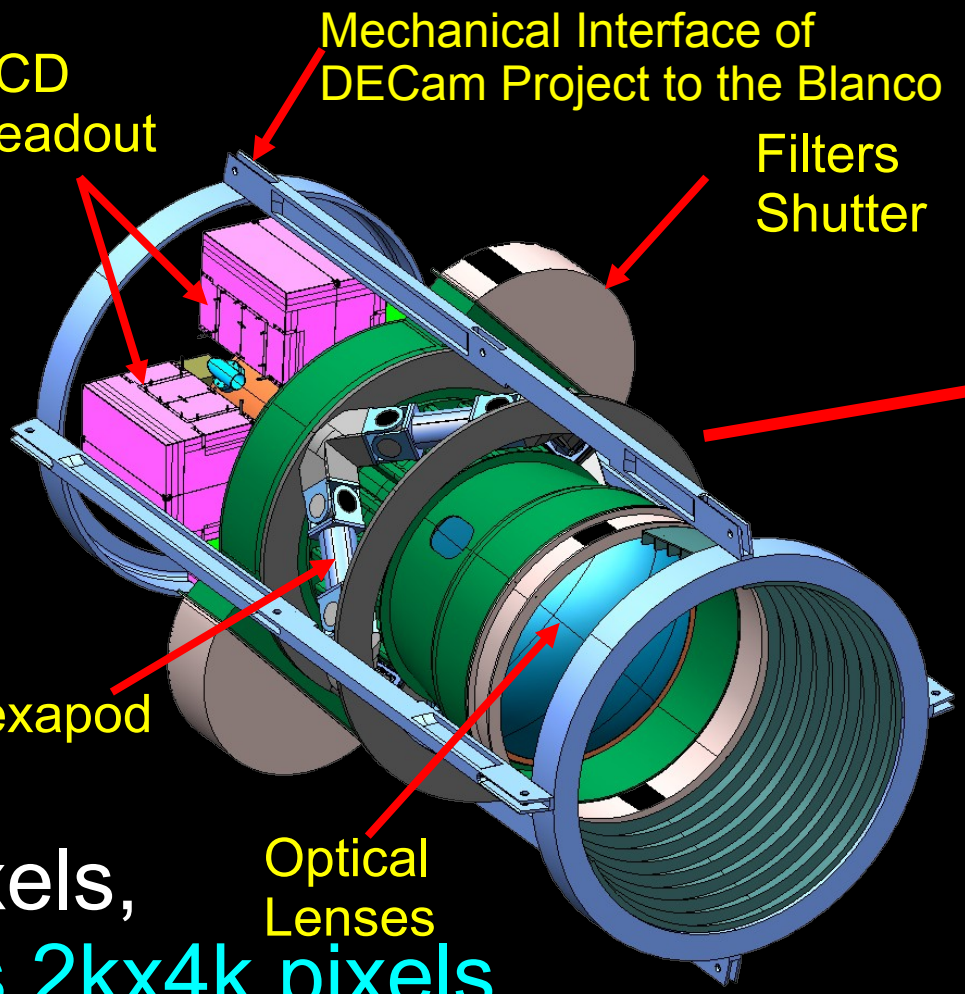
Spokesperson: Josh Frieman (Fermilab)

The DES Camera: DECAm

DES will replace the entire cage at the prime focus.
Install a **NEW CAMERA** and **NEW OPTICAL CORRECTOR**
Use g,r,i,z,Y filters covering visible and NIR wavelengths (correlate with VHS to go further in IR)
Each image will cover 3 sq-deg (~20 clusters and ~20000 galaxies)
~300 GB image data/night

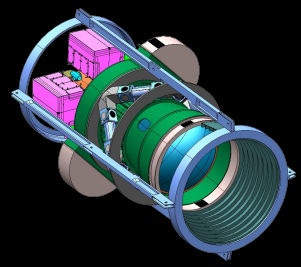


The DES Camera: DECam



520 Mpixels,
62 CCDs 2kx4k pixels
0.27´´/pixel
Shutter: <3s open-close
<10 s for filter exchange, Readout time: 17 s

DECam Overview



CCD focal plane is housed in a vacuum vessel (the imager) which is supported by the barrel

LN2 is pumped from the telescope floor to a heat exchanger in the imager: cools the CCDs to -100 C

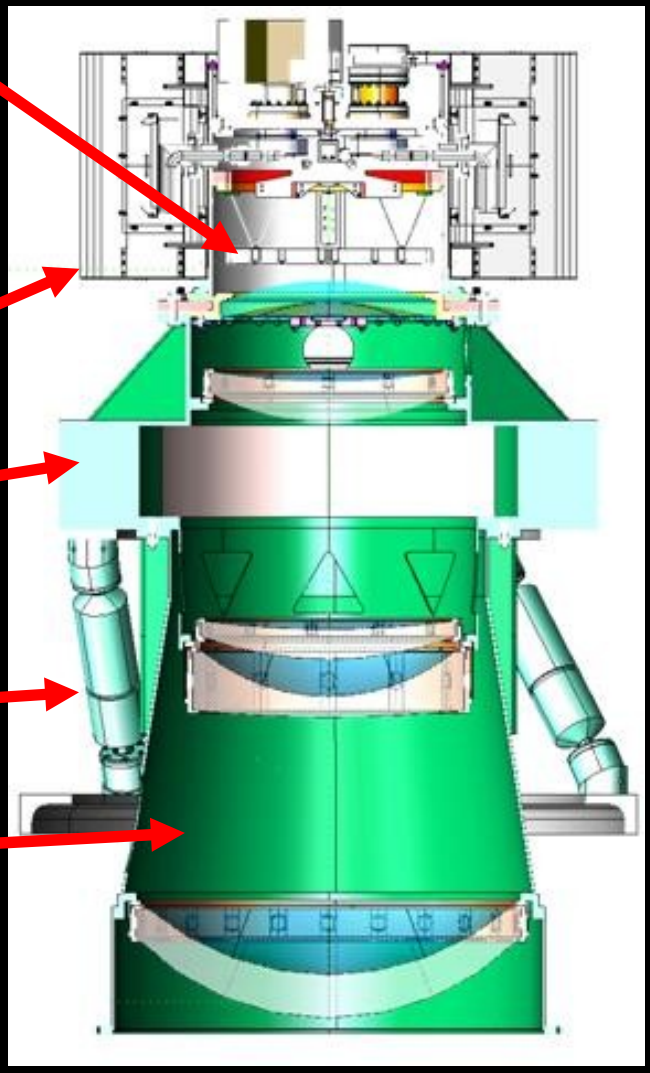
CCD readout electronic crates are mounted to the outside of the Imager and are actively cooled.

Filter changer (8 filter capacity) and shutter form one mechanical unit.

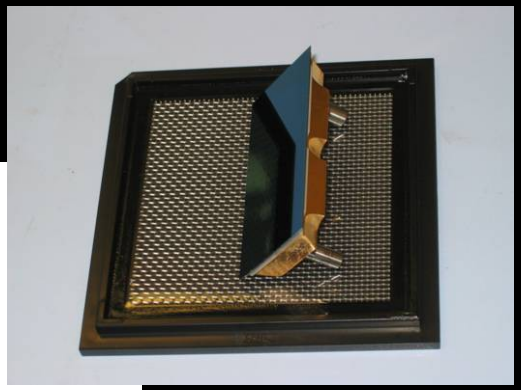
Hexapod provides focus and lateral alignment capability for the corrector-imager system

Barrel supports the lenses and imager

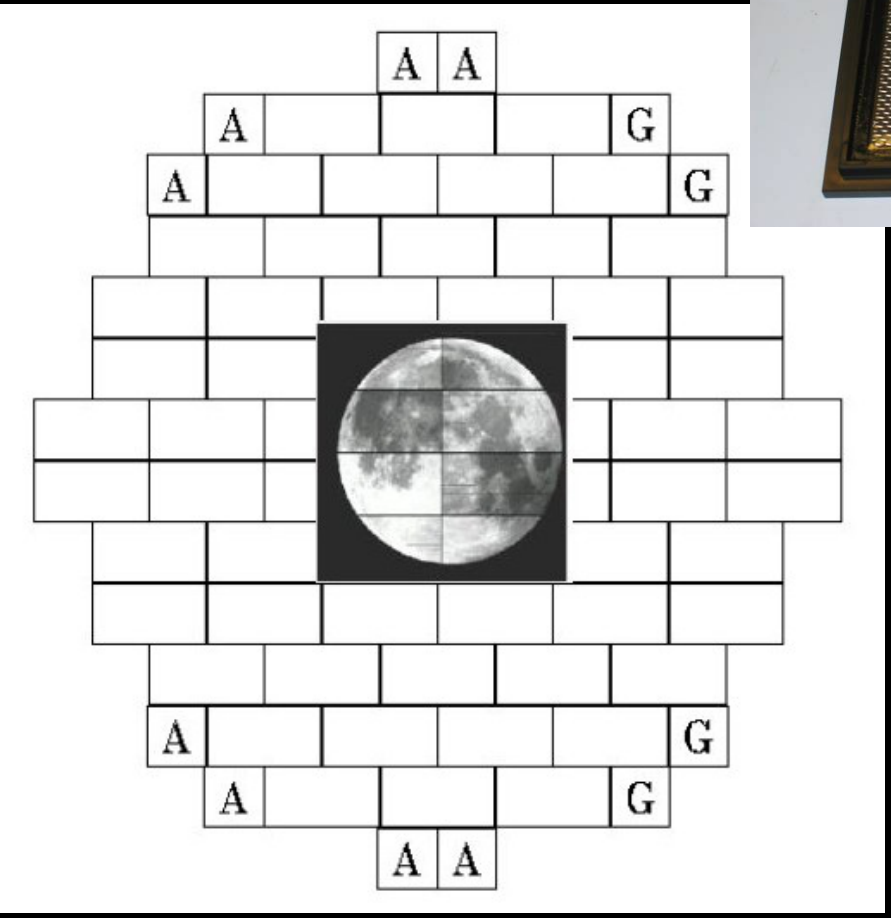
DECam weighs about 4 tons (load limit is ~ 6 tons)



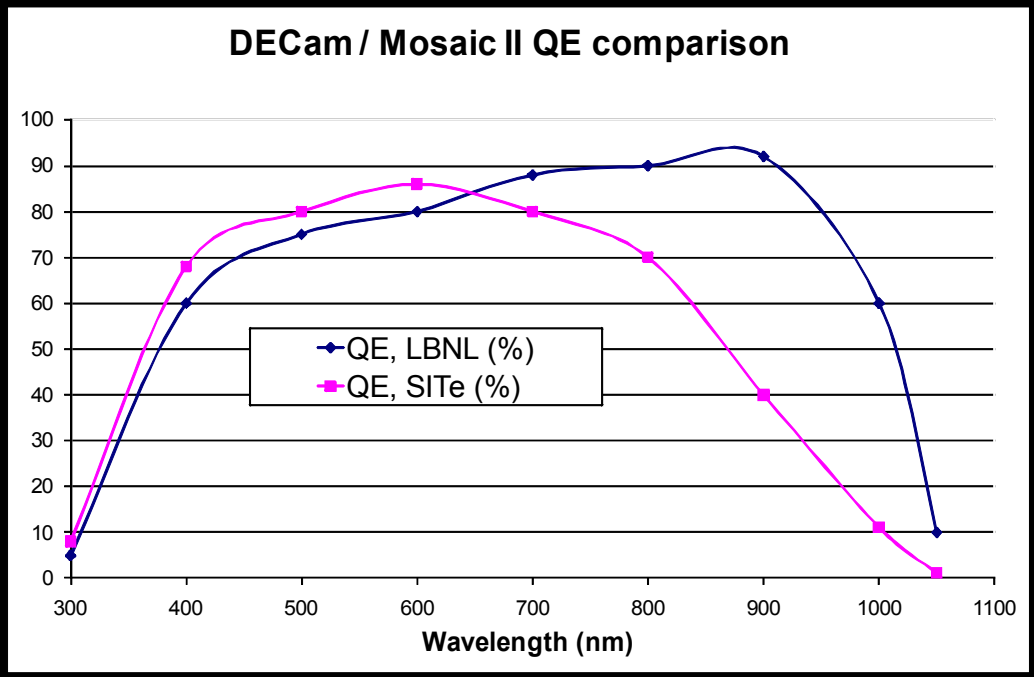
DECam: CCDs



Pixel size: 15x15 microns
Noise: 5e at 250 kpix/s
QE > 50% at 1000 nm
250 microns thick
2 readout channels device
Developed by LBNL for SNAP
Already produced and tested.

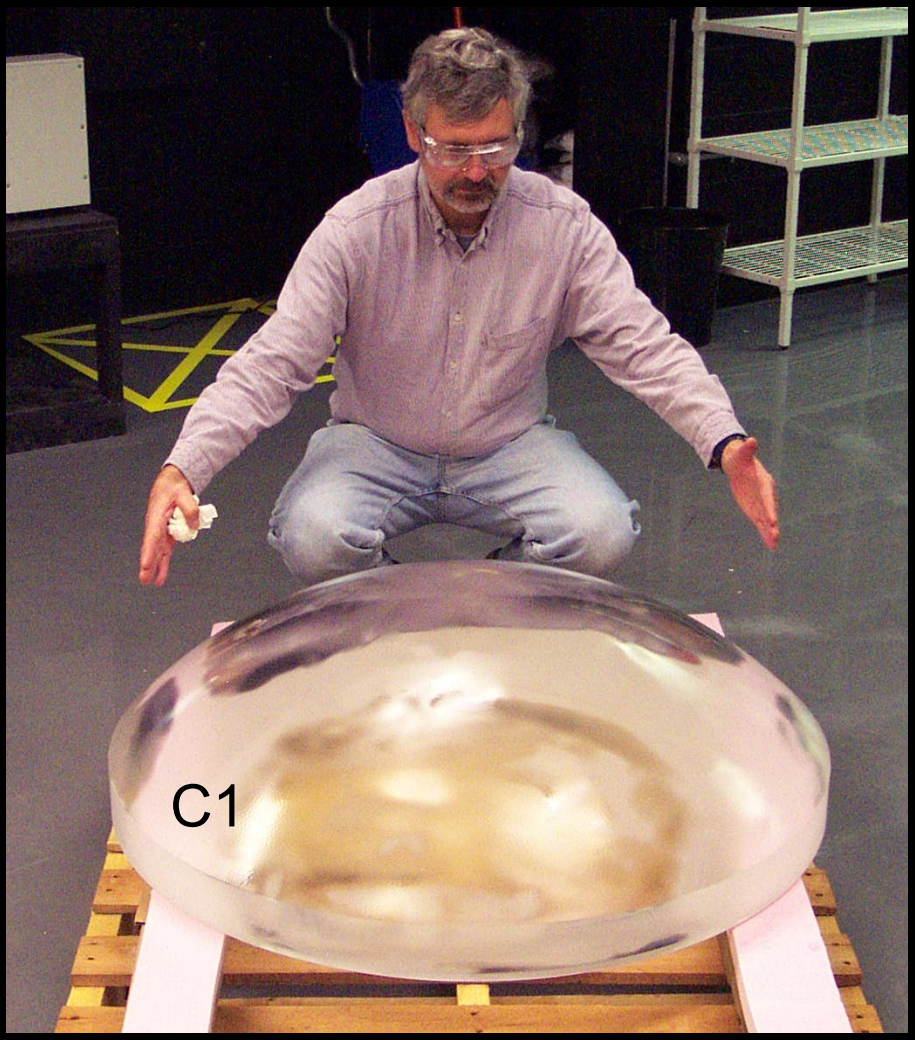


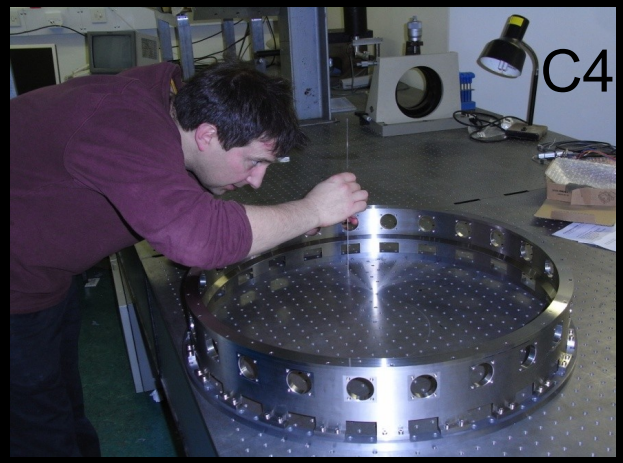
Hexagonal focal plane for tiling, 2 degrees diameter

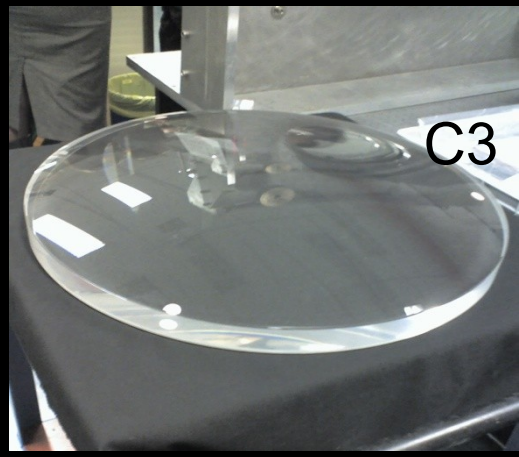


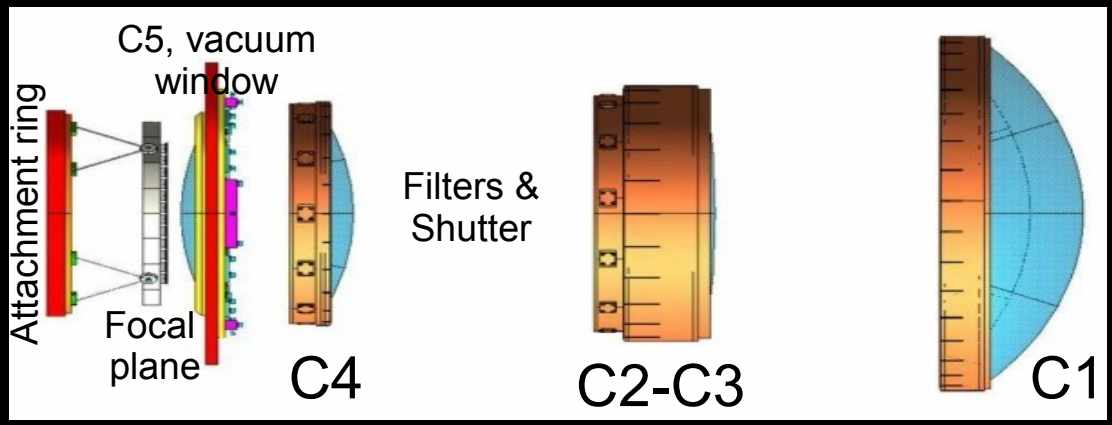
DECam: Optics

Blanks completed in 2008
Grinding and polishing in progress. Huge lenses!!







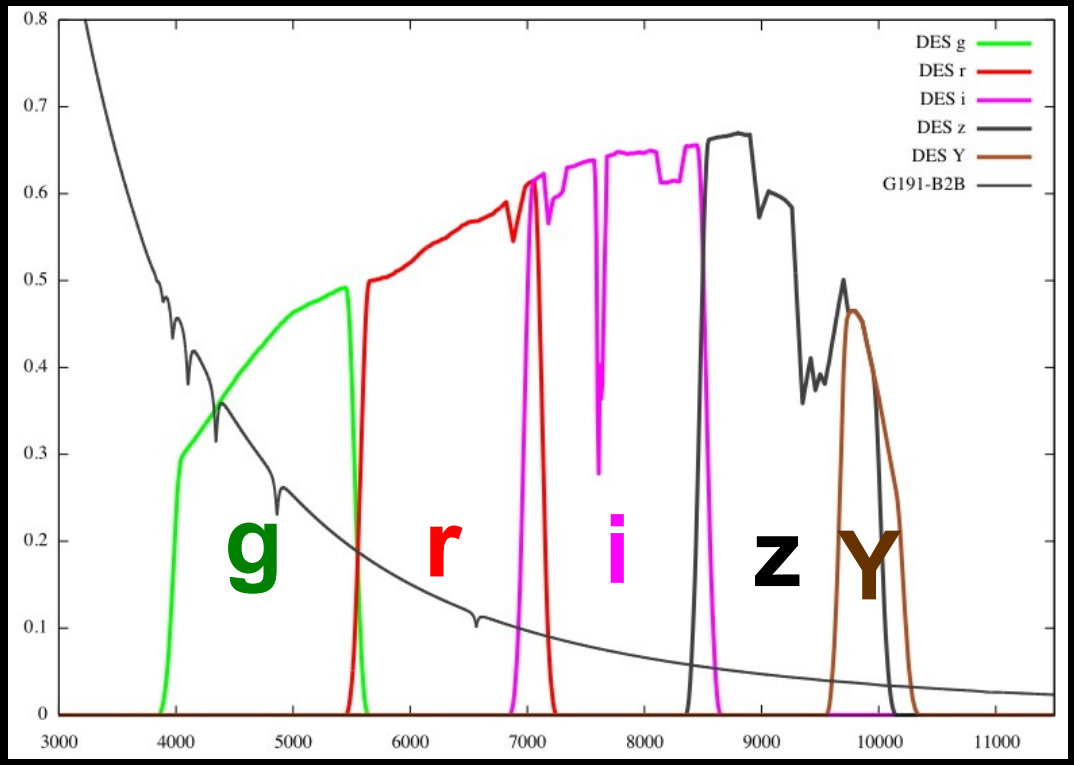


DECam: Filters

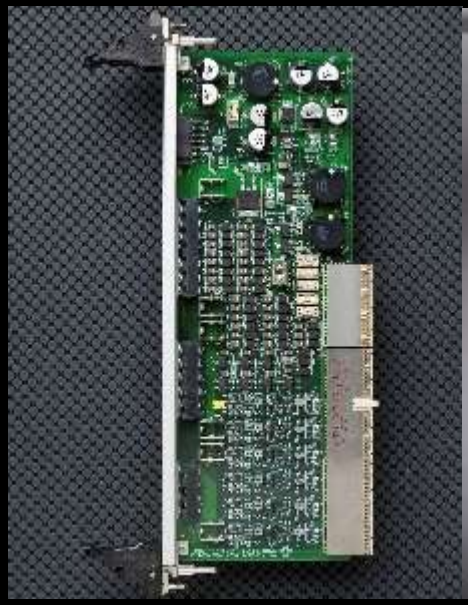
Filters are being manufactured, and are expected for september 2011

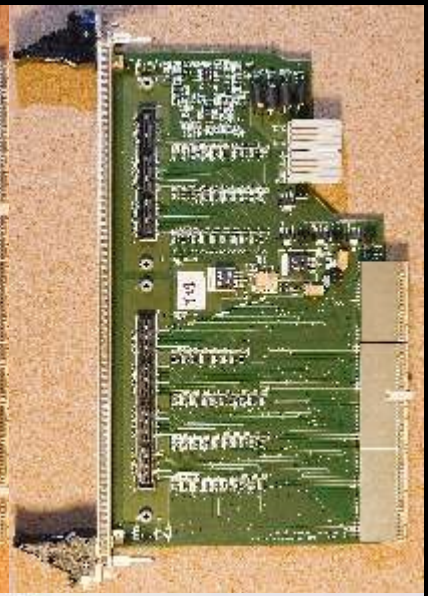
Very large, 620 mm diameter

Strong requirements on spatial uniformity of transmission, in order to reach a 2% photometric calibration in the survey



DECam: Electronics

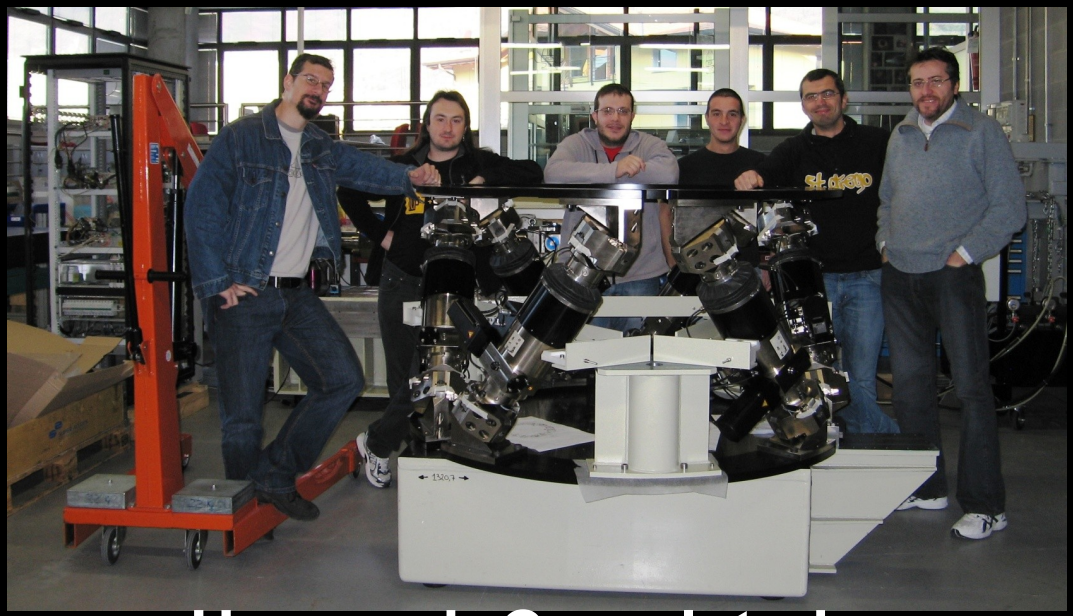


Electronics is almost completed . Remaining work is testing and integration (in progress)


DECam: Opto-Mechanics

Filter changer: Completed



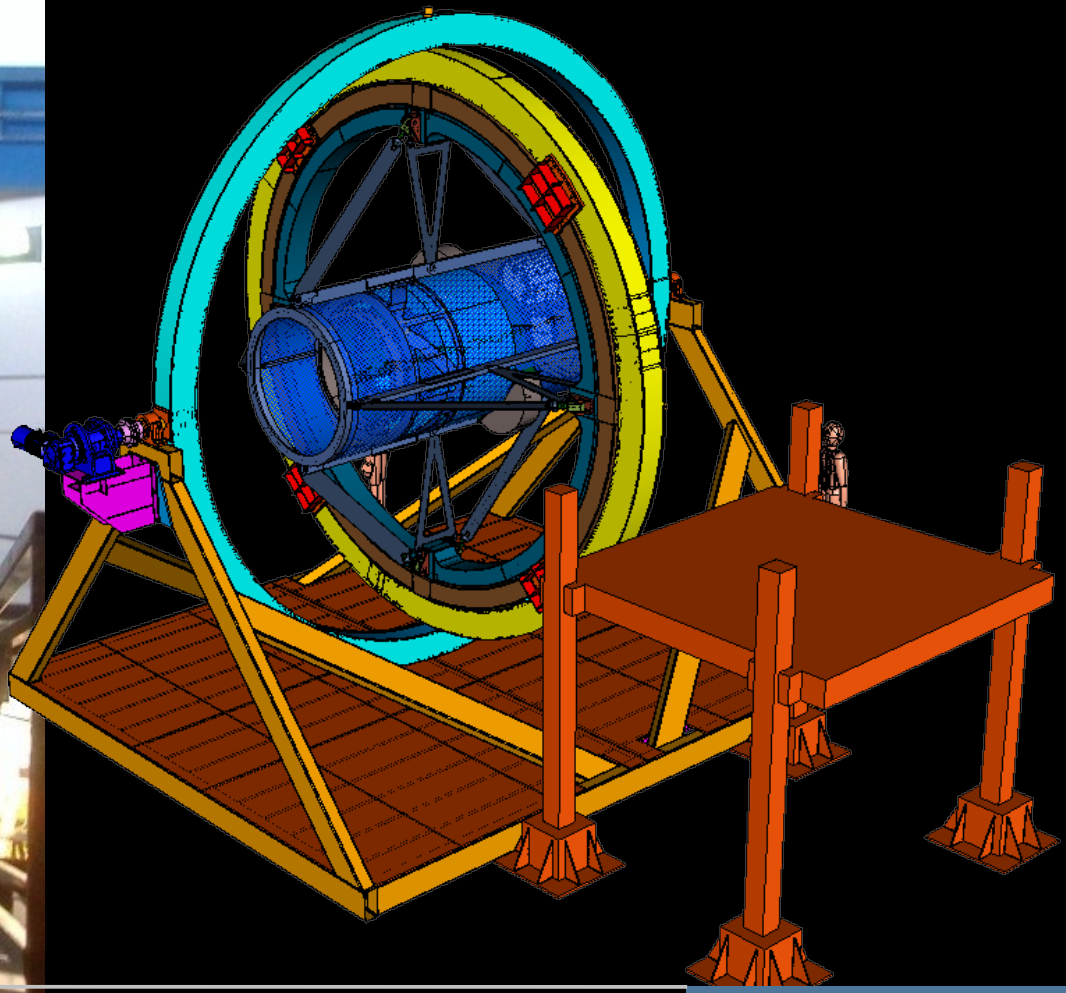
Hexapod: Completed

Filter changer: completed
Shutter: Completed
Barrel: Completed
Cooling system: Completed, in testing

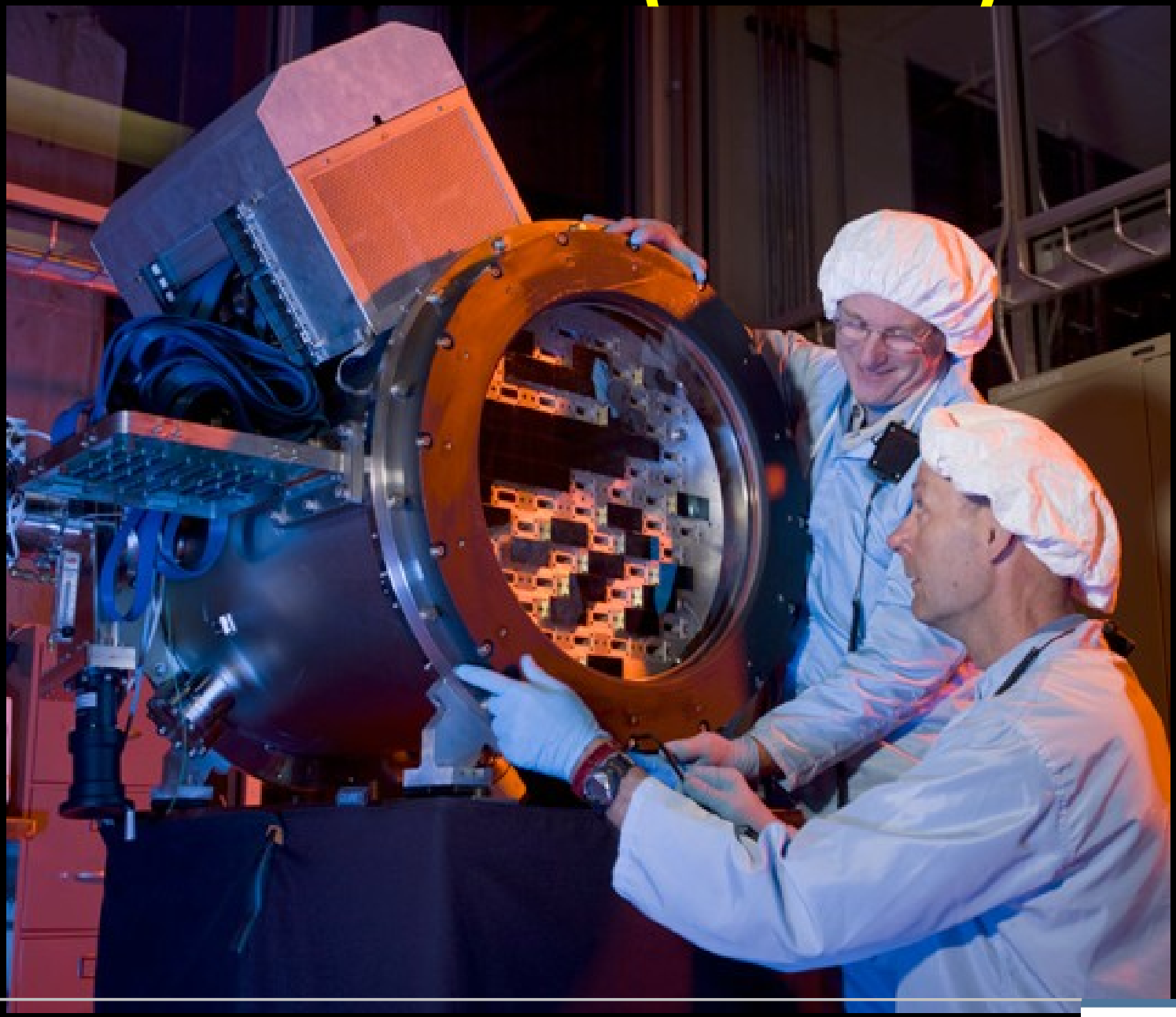
REMAINING WORK: INTEGRATION AND TESTING

DECam: Telescope Simulator (Fermilab)

Testing DECam in all the possible orientations it will have in the telescope. Cabling, cooling, liquid nitrogen circuit

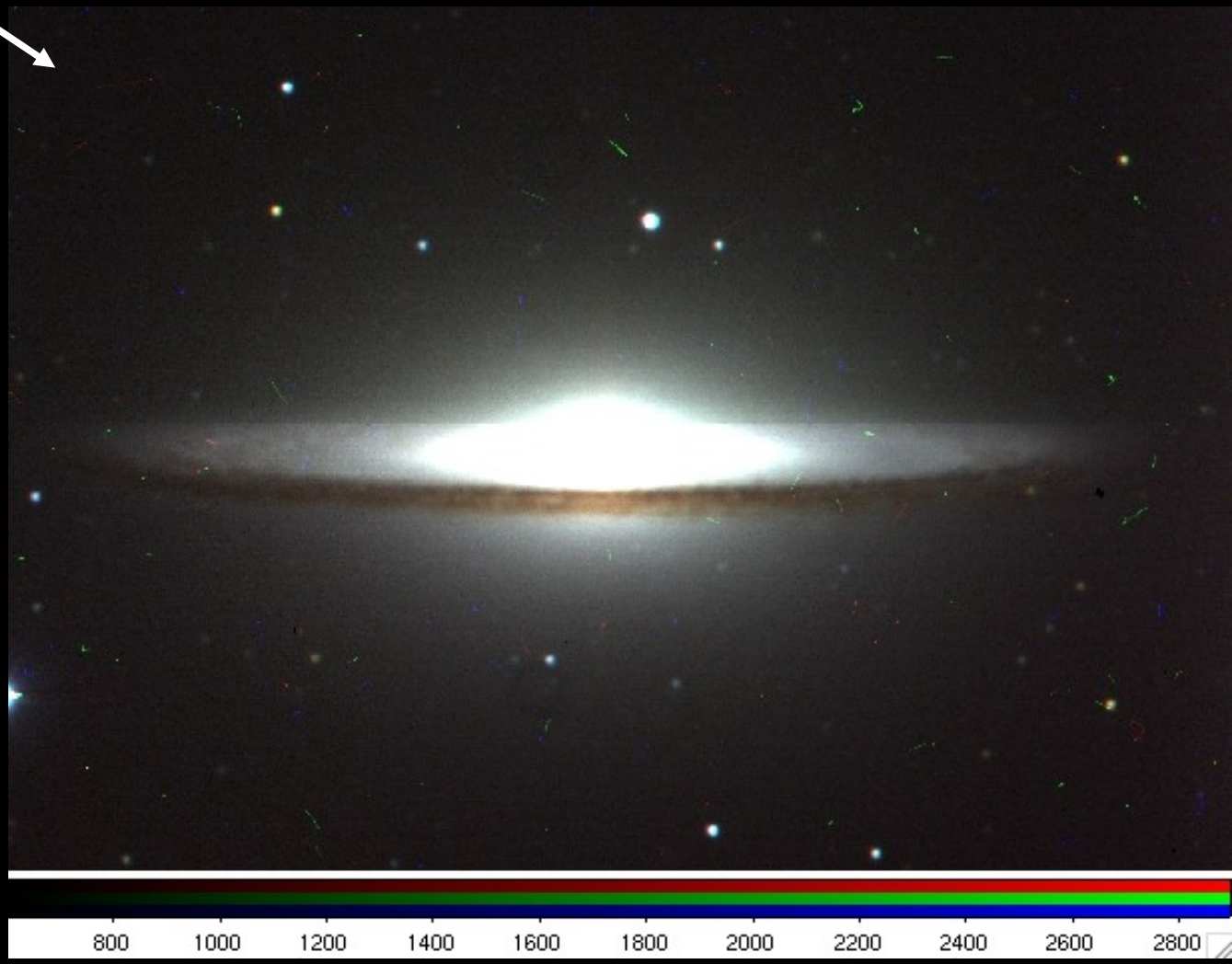


DECam: Focal Plane with CCDs and electronics (Fermilab)



DECam: Images with small prototype

April 2008



1 DECam CCD

with Monsoon electronics

in a small test dewar

on the CTIO 1m (next to the Blanco)

Survey Strategy

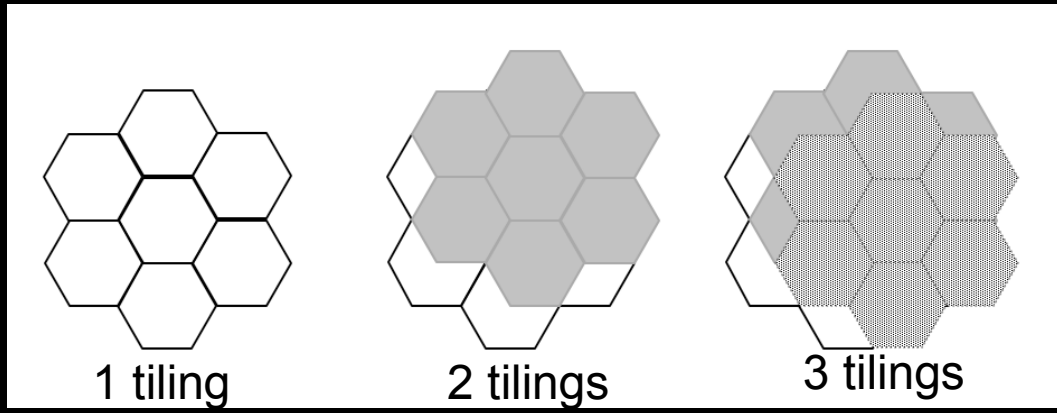
Sensitivity, 10σ *grizY* = 24.6, 24.2, 24.4, 23.8, 21.5 for galaxies

Area = 5000 deg^2
Repeated area of 15 deg^2 for SNe

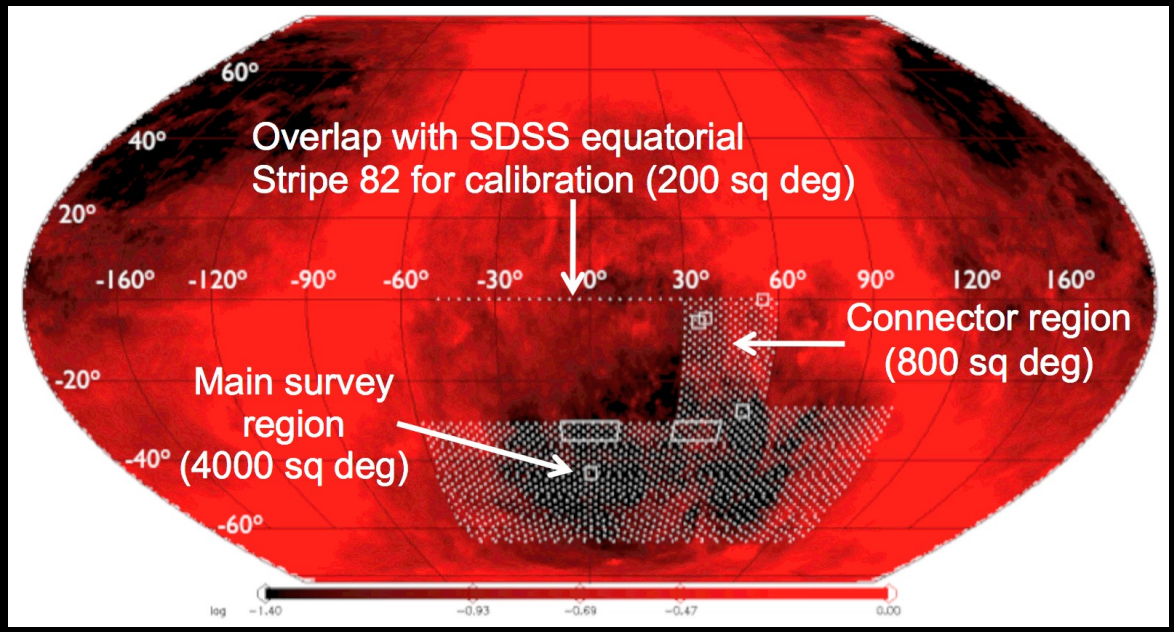
Nominal 100 sec exposures
gr in dark time, *izY* in bright time
Nominally 2 survey tilings/filter/year

Image quality <0.9 arcsec FWHM
Stable across full field-of-view

Photometric calibrations <2% absolute
Multiple tiling survey strategy



Survey Area



Total Area: 5000 sq deg

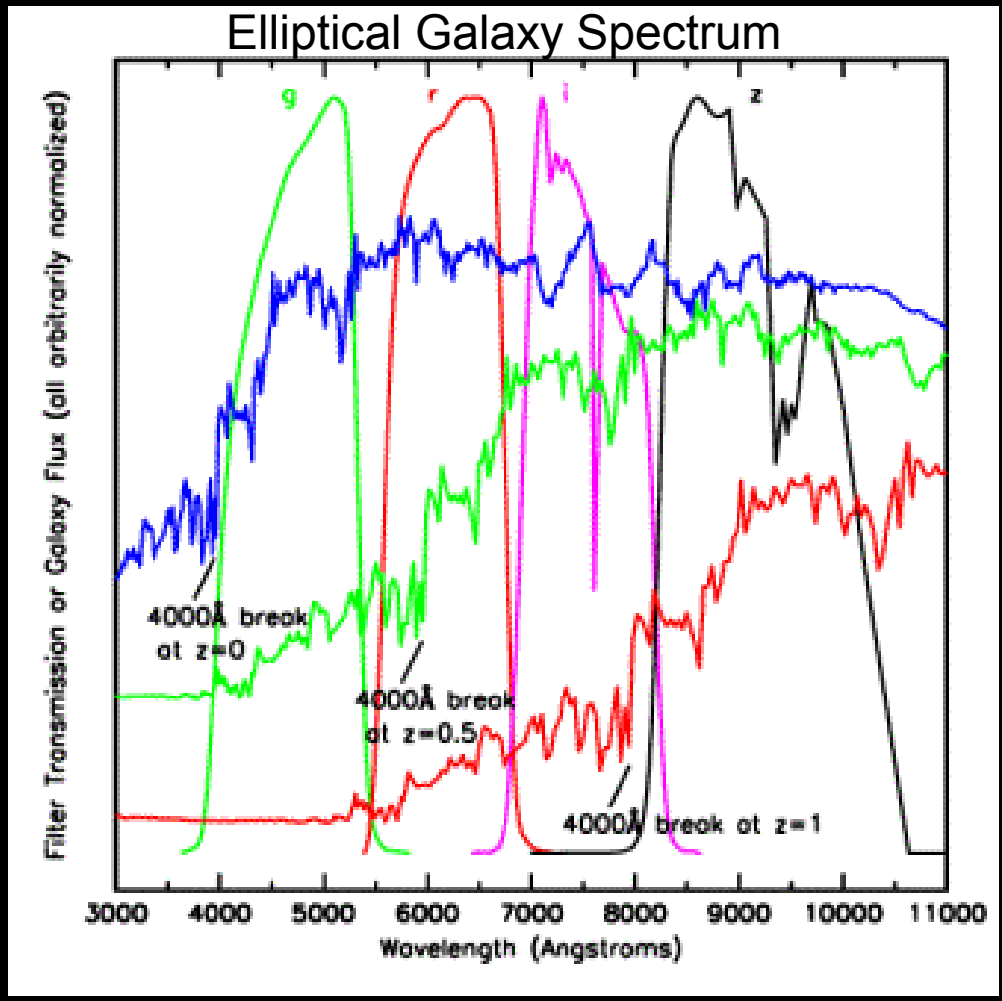
Photometric Redshifts

Measure relative flux in *grizY* filters and track the 4000 A break

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

Precision is sufficient for dark energy probes, provided error distributions are well measured

Good detector response in *z*-band filter needed to reach z~1.5

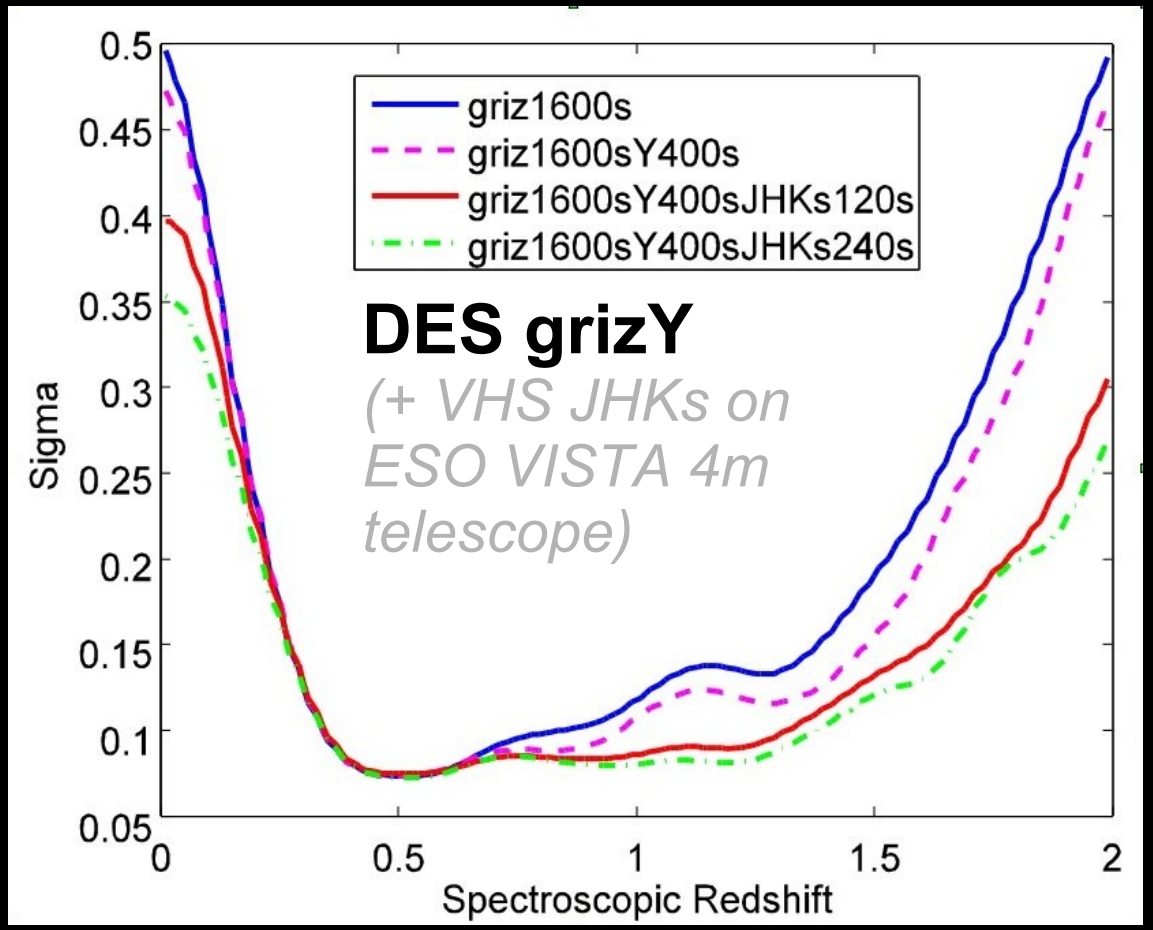


Photometric Redshifts Simulation

10σ Limiting Magnitudes
- g 24.6
- r 24.1
- i 24.0
- z 23.9

+2% photometric calibration error added in quadrature

Key: Photo-z systematic errors under control using *existing* spectroscopic training sets to DES photometric depth: low-risk



Cunha et al. , Banerji et al. (2008)

Still in process of development and optimization

Data Management

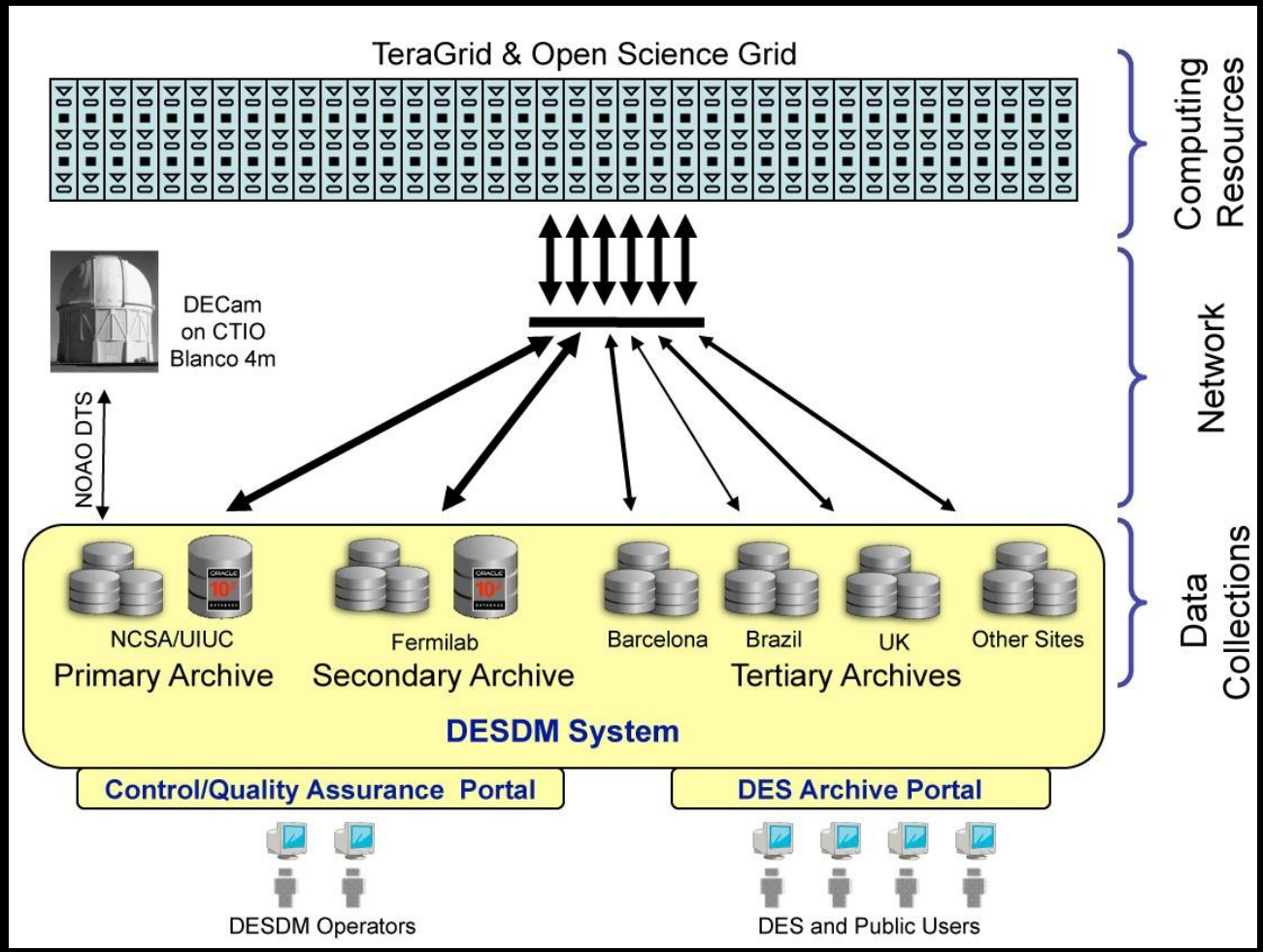
Transmission of images from CTIO to NCSA (Illinois), ~300 GB/night

Use GRID for nightly processing

Data Archive: Images and catalogs, total ~4 PB

Data Access Portal

Provide a Community Pipeline for the public use of DECam at CTIO



DES Forecast: DETF FoM

FoM=Figure of Merit (Inverse of the ellipse area)

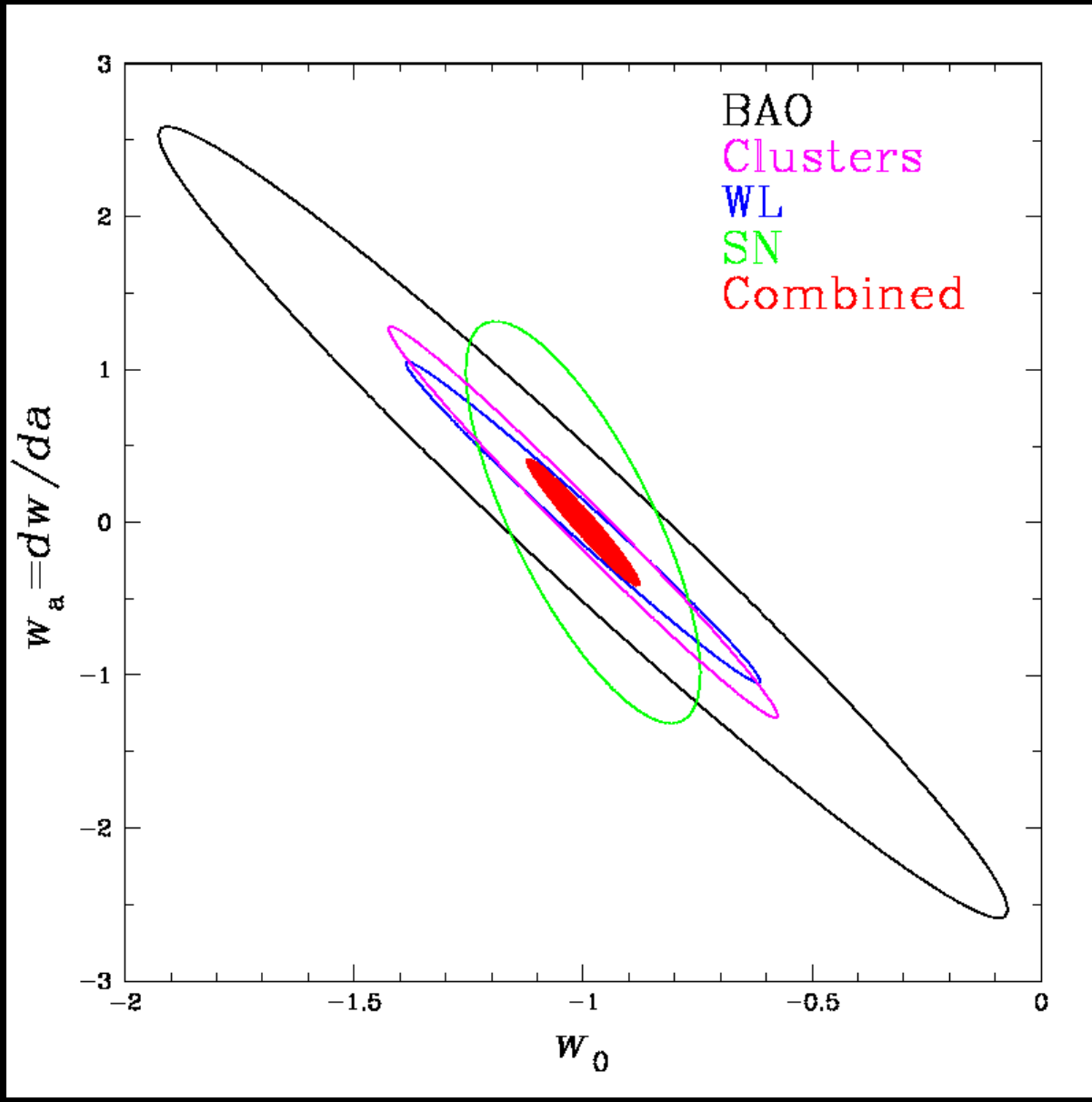
$w(z) = w_0 + w_a (1-a)$

Statistical + photo-z systematic error only

Spatial curvature, galaxy bias marginalized

Planck Priors

Factor 4.6 of improvement, relative to stage II (current constraints)



DES Timeline

During 2010: Integration of all the camera elements (except optics)
Test with the telescope simulator

First Half 2011: All Camera elements arrive to CTIO (including optics)

Summer 2011: Installation in the Blanco Telescope

Test of data management, software and scientific analyses on simulations (data challenges)

Fall 2011: Commisioning and on-sky validation
Survey begins: 525 nights in 5 years
(30% of telescope time for DES,
70% of telescope time for public use)

SCIENCE!!!

Conclusions

DES will measure the Dark Energy using 4 COMPLEMENTARY probes: Galaxy clusters, weak lensing, BAO and supernovae. Provide robust constraints and control of systematic errors

Instrument construction well in progress: Currently in the phase of integration and final testing. DECam, camera with 520 Mpixels for optical and NIR observations

Start observations in the fourth quarter of 2011 from the Blanco telescope at CTIO (Chile)

Survey of 525 nights in 5 years