Dark Energy Science with DES and SDSS

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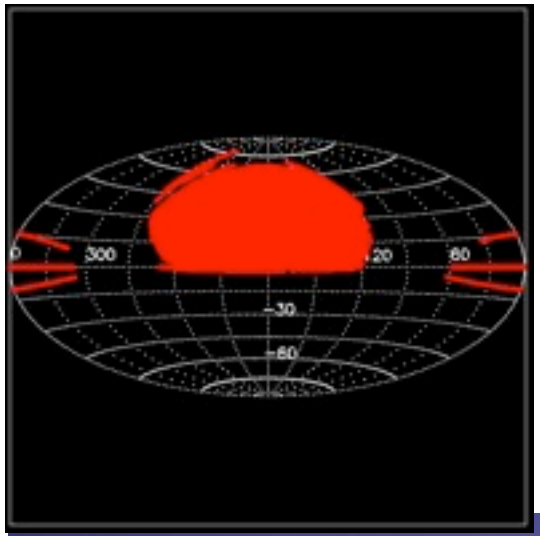
4/23/2010

Fermilab

Sloan Digital Sky Survey

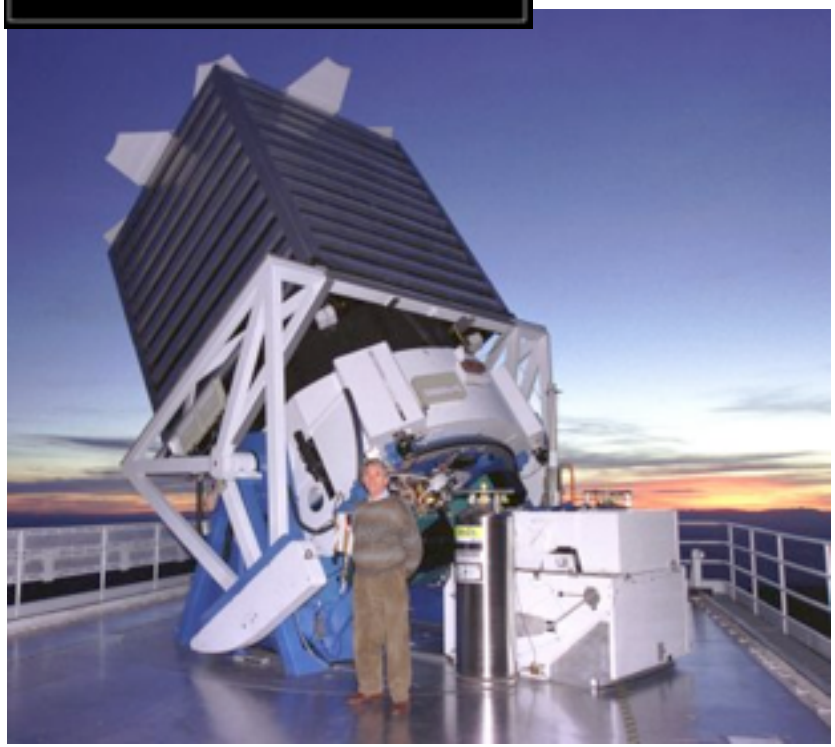


SDSS-I 2000-2005

SDSS-II 2005-2008

SDSS-III 2008-2014 BOSS without FNAL

- 8,400 square degrees multi-color images
- 930,000 galaxies
- 120,000 quasars
- 14,000 clusters of galaxies.



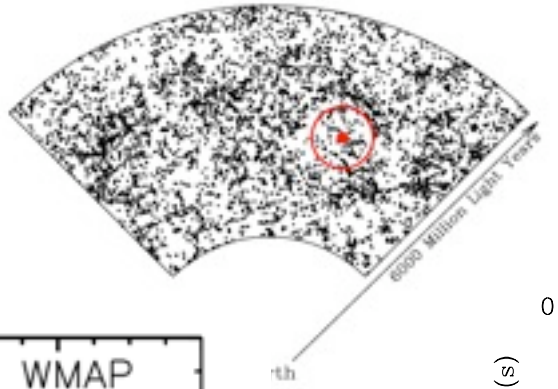
Dedicated 2.5-meter telescope at APO, New Mexico,

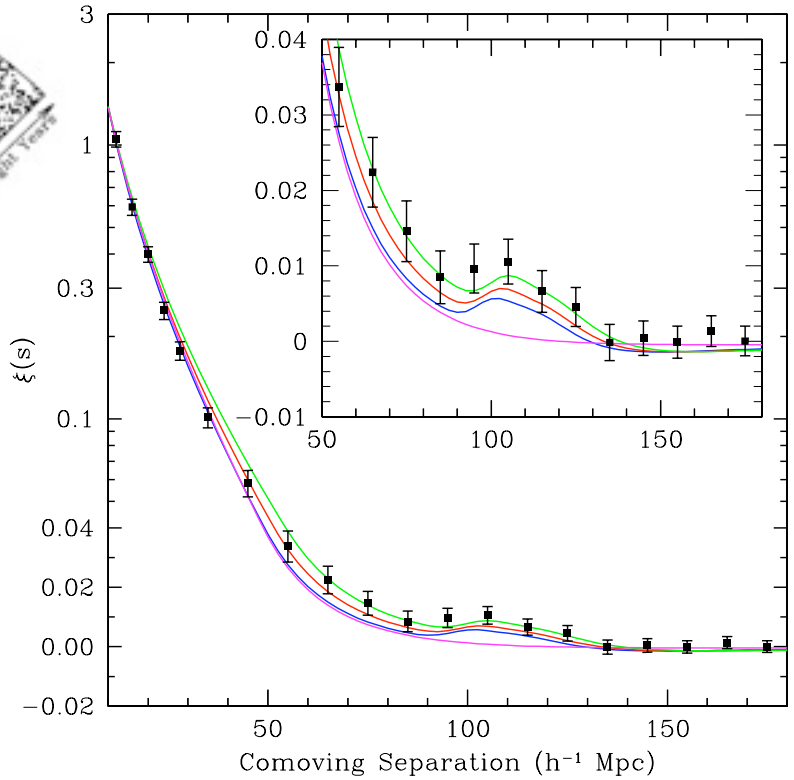
- 120-megapixel camera, 1.5 square degrees of sky at a time
- A pair of spectrographs fed by optical fibers measured spectra of more than 600 objects
- custom software pipelines kept pace with the enormous data flow from the telescope.

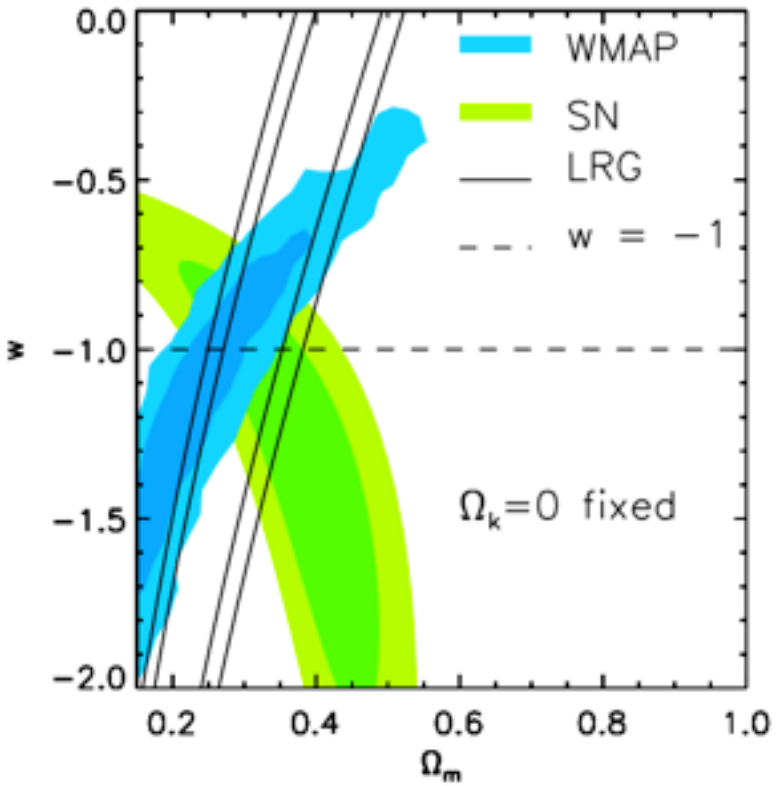
- The SDSS-II Supernovae Survey of 300 square degree southern equatorial stripe to discover
- discovered nearly 500 spectroscopically confirmed Type Ia supernovae

SDSS DE science - BAO

Measurements of Baryon Acoustic Oscillation (standard ruler)







Ried et at 2009

Eisenstein et al 2005 produced the first measurements (w/FNAL authors)

Now BOSS (SDSSIII) is going to get a much better measurement of the standard ruler.

SDSS DE science - Galaxy Clusters

- maxBCG galaxy cluster sample (Koester et al 2007 w/FNAL authors) with ~14000 clusters.
- Cosmology produced with this catalog (Rozo et al 2010 w/ FNAL authors).

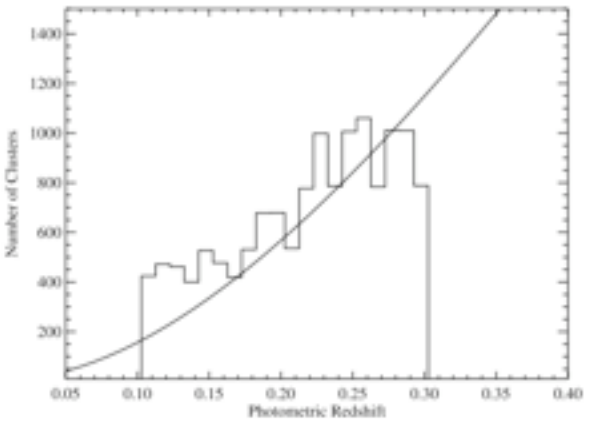


FIG. 4.—Number of clusters as a function of redshift for the maxBCG cluster catalog. The solid line shows the expectation for a volume-limited sample with a density of 2.3×10^{-5} clusters h^3 Mpc^{-3} in a standard ΛCDM cosmology.

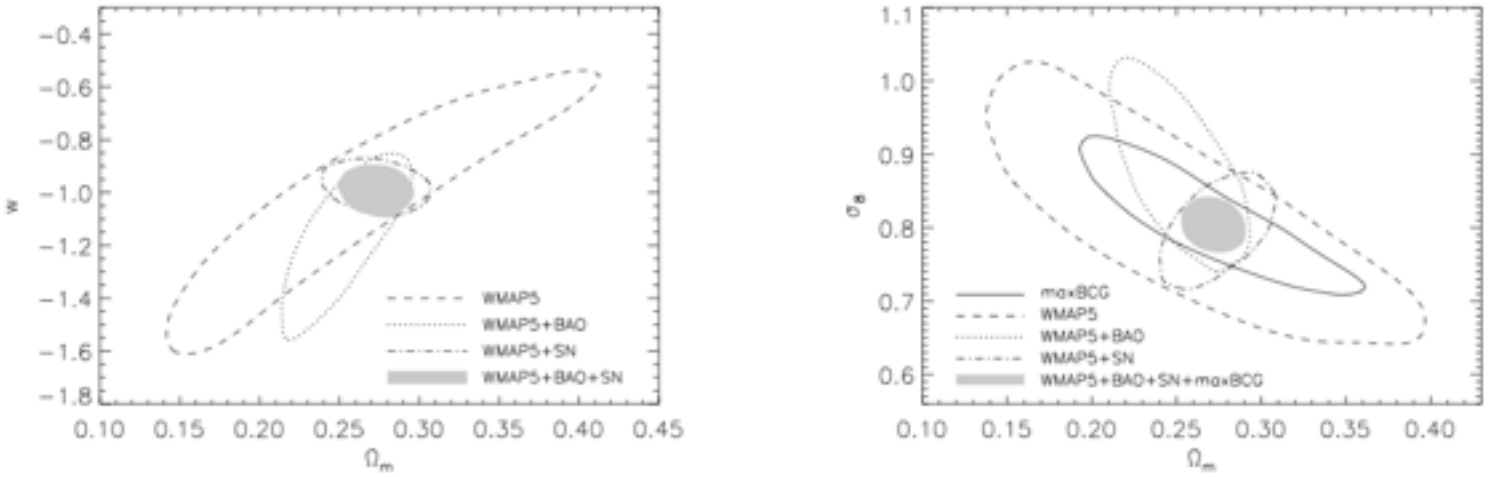
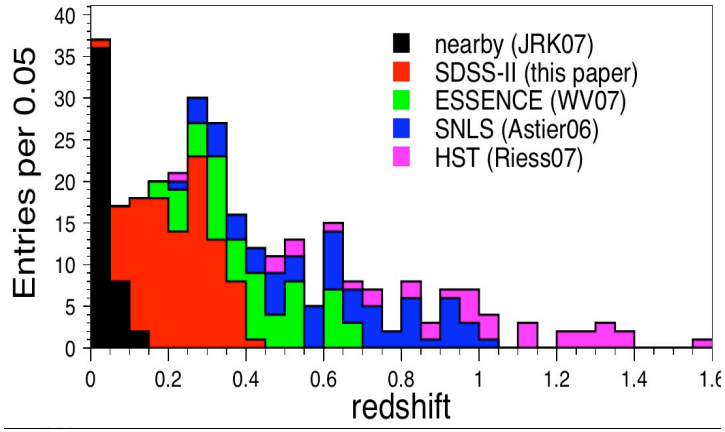


FIG. 14.— Parameter constraints on the $w - \Omega_m$ plane (left) and $\sigma_8 - \Omega_m$ plane (right) in a flat wCDM cosmology, for various data combinations. All contours shown are 68% confidence, and are obtained using the MCMC chain outputs downloaded from the LAMBDA website (http://lambda.gsfc.nasa.gov/). Despite the fact that the WMAP5 data constrain the amplitude of the primordial power spectrum with comparable accuracy in both a ΛCDM and wCDM cosmology, allowing w to vary introduces a large degeneracy between w and Ω_m. This degeneracy severely degrades the WMAP constraints in the $\sigma_8 - \Omega_m$ plane, as seen in the right panel. Adding new observables that break the $w - \Omega_m$ degeneracy restores the complementarity between WMAP5 and clusters in the $\sigma_8 - \Omega_m$ plane, which helps improve dark energy constraints through the growth of structure.

SDSS DE - SNIa

covered a region of redshift not well populated before.



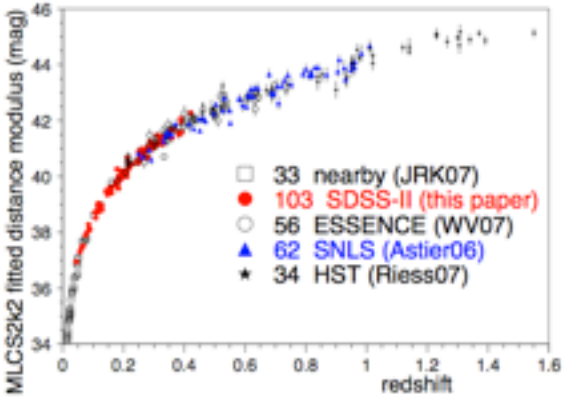
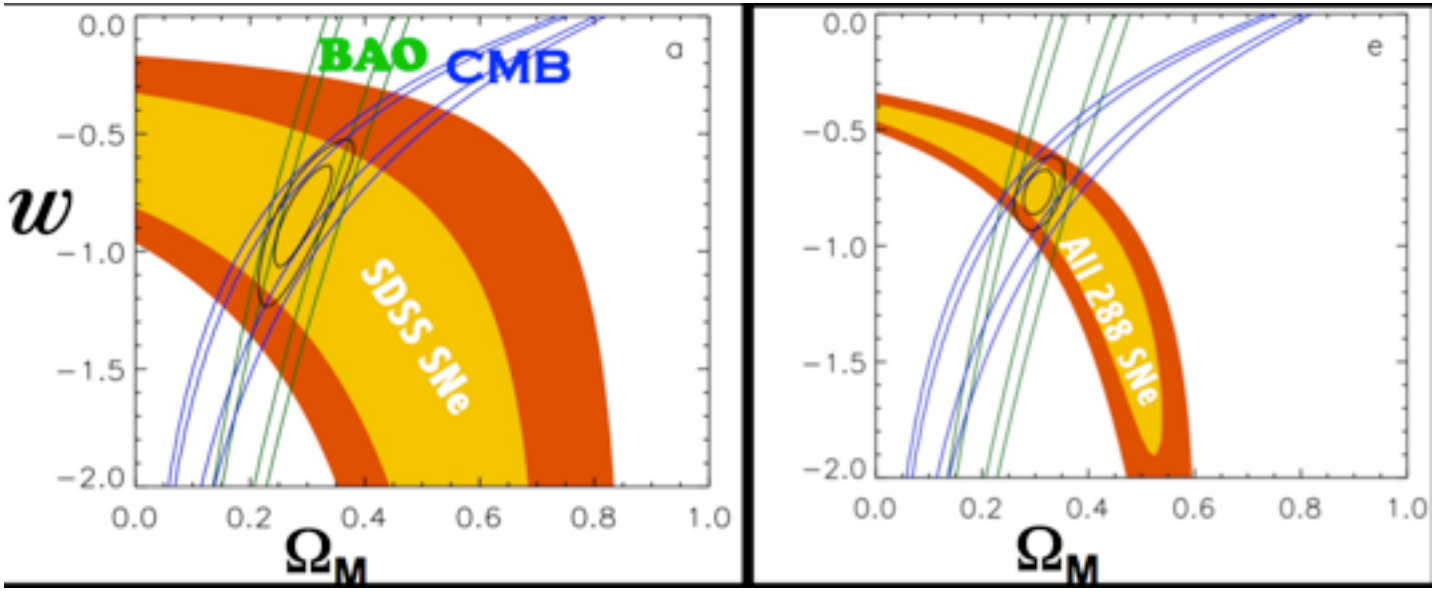


FIG. 23.— Fitted distance modulus (from MLCS2k2) versus redshift for the 288 SNe Ia from the five samples indicated on the plot.

the rigor of experimental HEP analysis in SNIa cosmology.

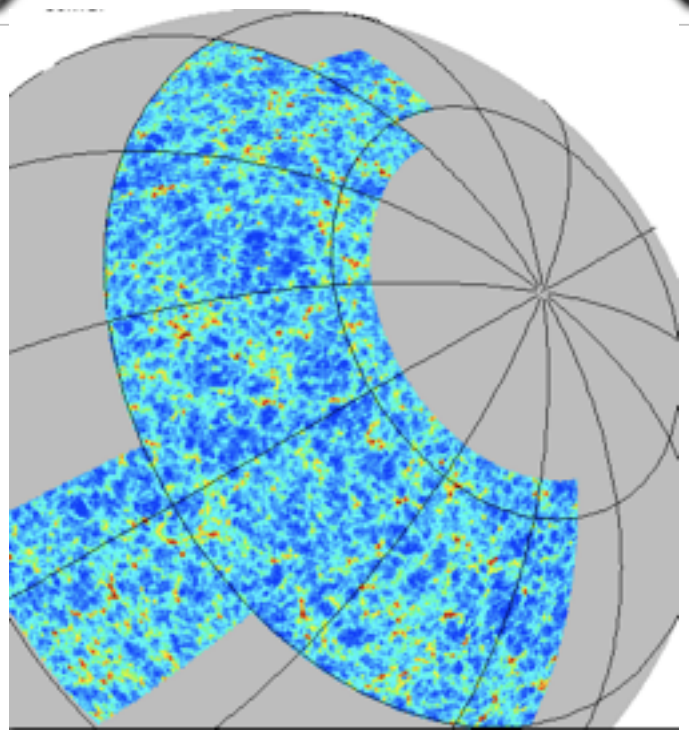


Kessler et al 2009 - w/FNAL authors

The Dark Energy Survey

A survey of the southern galactic cap (z~1) to characterize Dark Energy with 4 complementary techniques. Start of data collection in last quarter 2011!

- 5000 sq.deg
- 100,000 clusters with M > 0.5E14 M_{sun}
- 300 million galaxies to z ~ 1
- 1000 SNe Ia, to z = 1
- building on SDSS calibration



Survey:

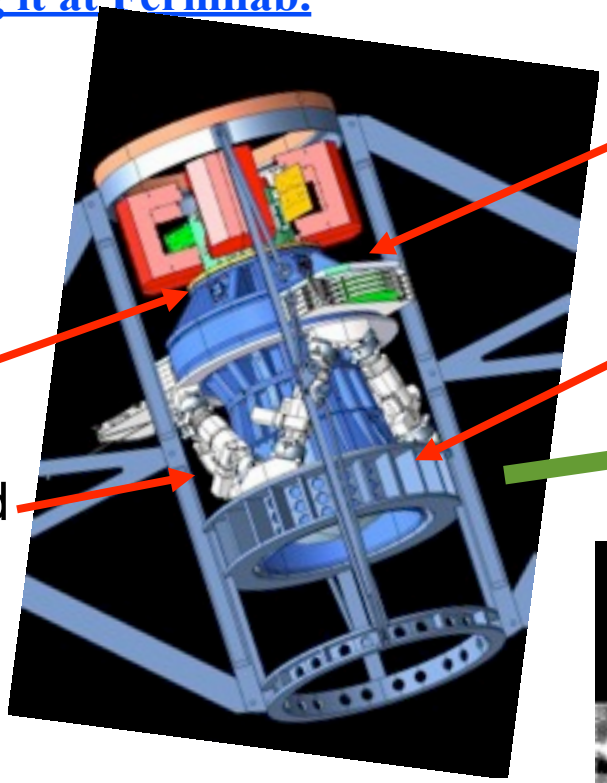
- Survey Area 5000 sq. deg. in Southern Galactic Cap
- SDSS g,r,i,z filters 10 σ Limiting mag: 24.6, 24.2, 24.0, 23.9
- Connection to SDSS stripe 82 for photo-z calibration

10 US Institutions/Consortia plus 3 International Consortia > 100 scientists

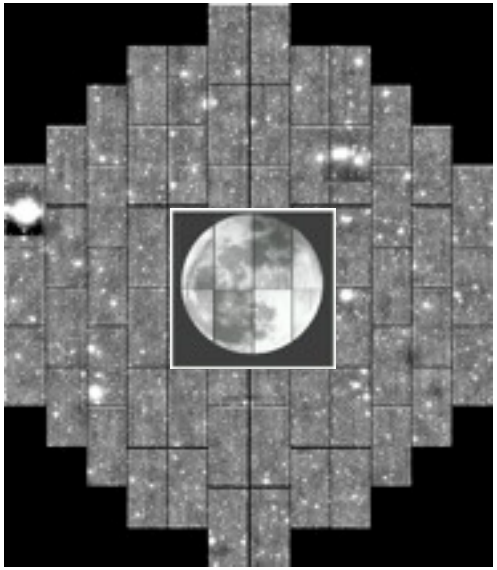
DECam : new instrument for DES

DARK ENERGY SURVEY

Replace the PF cage on the CTIO Blanco 4m telescope with a new optical imager. We are building it at Fermilab.



diameter = 48 cm

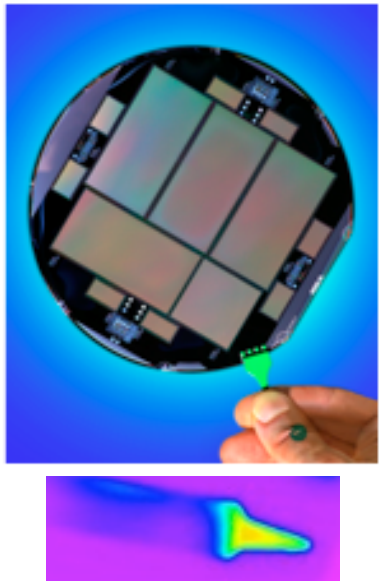


3 sq-deg imager:
62 2kx4k Image CCDs: 520 MPix

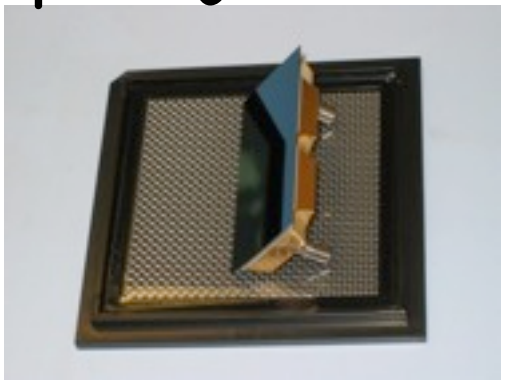
Imager to be delivered at **early 2011**, start taking last quarter on 2011. In exchange we get 30% of telescope time for DES during 5 years. Facility instrument available the rest of the time.

Focal Plane detectors + electronics + mechanics

DECam wafer

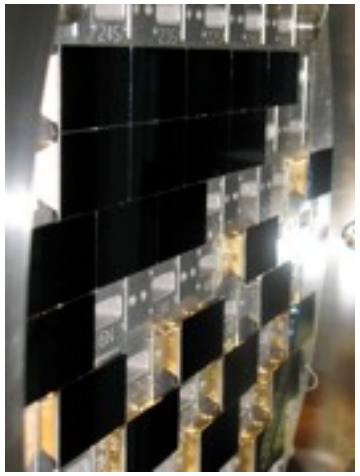


DECam science package



CCD readout electronics

prototype focal plane



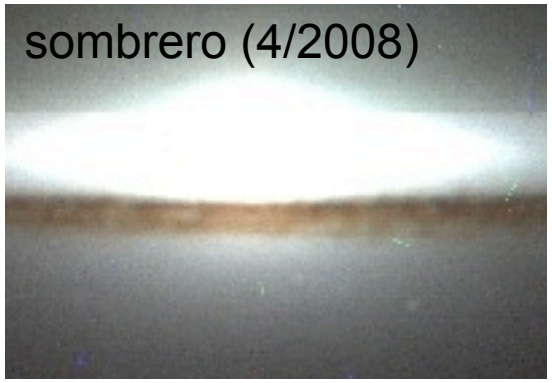
We built a CCD lab to certify the new type of detectors + production testing.
Packaged and tested **200+ detectors** .
Prototype focal plane operated with 224 Mpix built meets all requirements

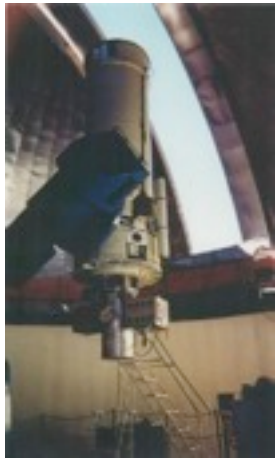
(...all this at FNAL, now we know how)

This worked incredible well, like **a factory,** for about 1.5 years. **Fermilab is an excellent place to do this kind of work. Thanks to dedicated infrastructure, technicians and engineers (previously experts in Silicon trackers).**

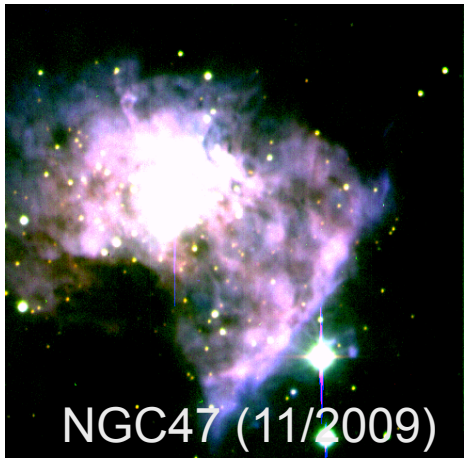
Observing with DECam CCDs

New type of detector **not been use extensively in astronomy**. We **studied them on the sky**. These are also **tests of the readout electronics** developed for DECam.





1m telescope at CTIO

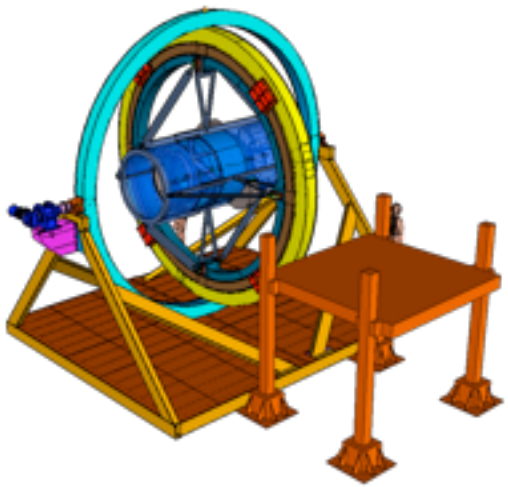


last February completed a new engineering run to understand grounding and filtering at CTIO. **Demonstrated that the DECam production electronics meets requirements when used on the mountain.**

A lot of FNAL engineers/technicians now starting to understand operations in the telescope. New area of expertise here.

DECam Imager

Prototype imager operated for ~2 years.
Up to ~50% of detectors instrumented.
Meets the mechanical/electronic requirements.



Full integration in telescope simulator at a level that has never been done before with an instrument prior to taking it to the mountain.
Starting at SiDet this summer.

DES Science Goals

Measure w with 4 techniques with about 5% error

Galaxy Cluster counting
(collaboration with SPT, see next slides)
100,000 clusters with M > 0.5E14 M_{sun} to z~1
(10000 with mass from SPT)

Weak lensing
300 million galaxies with shape measurements over 5000 sq deg

Spatial clustering of galaxies (BAO)
300 million galaxies to z ~ 1

Supernovae type Ia (secondary survey)
~1000 SNe Ia, to z = 1

geometry +structure
(DE is damping term)

?

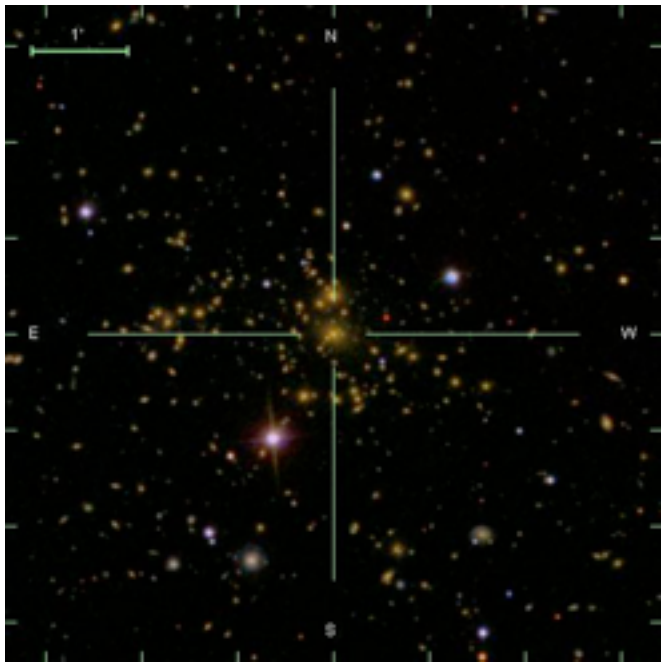
=

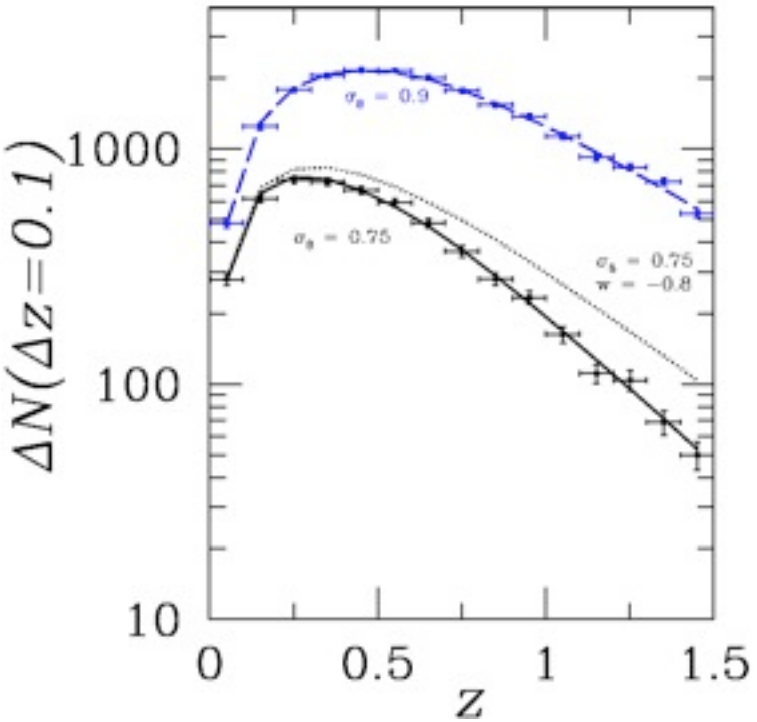
geometry only

One experiment covering the main probes for dark energy. This will facilitate study of systematic effects and correlations between techniques. FNAL is involved on all groups, maybe concentrating on SN and Clusters.

DES science : clusters of galaxies

the number of clusters as a function of z depends on DE





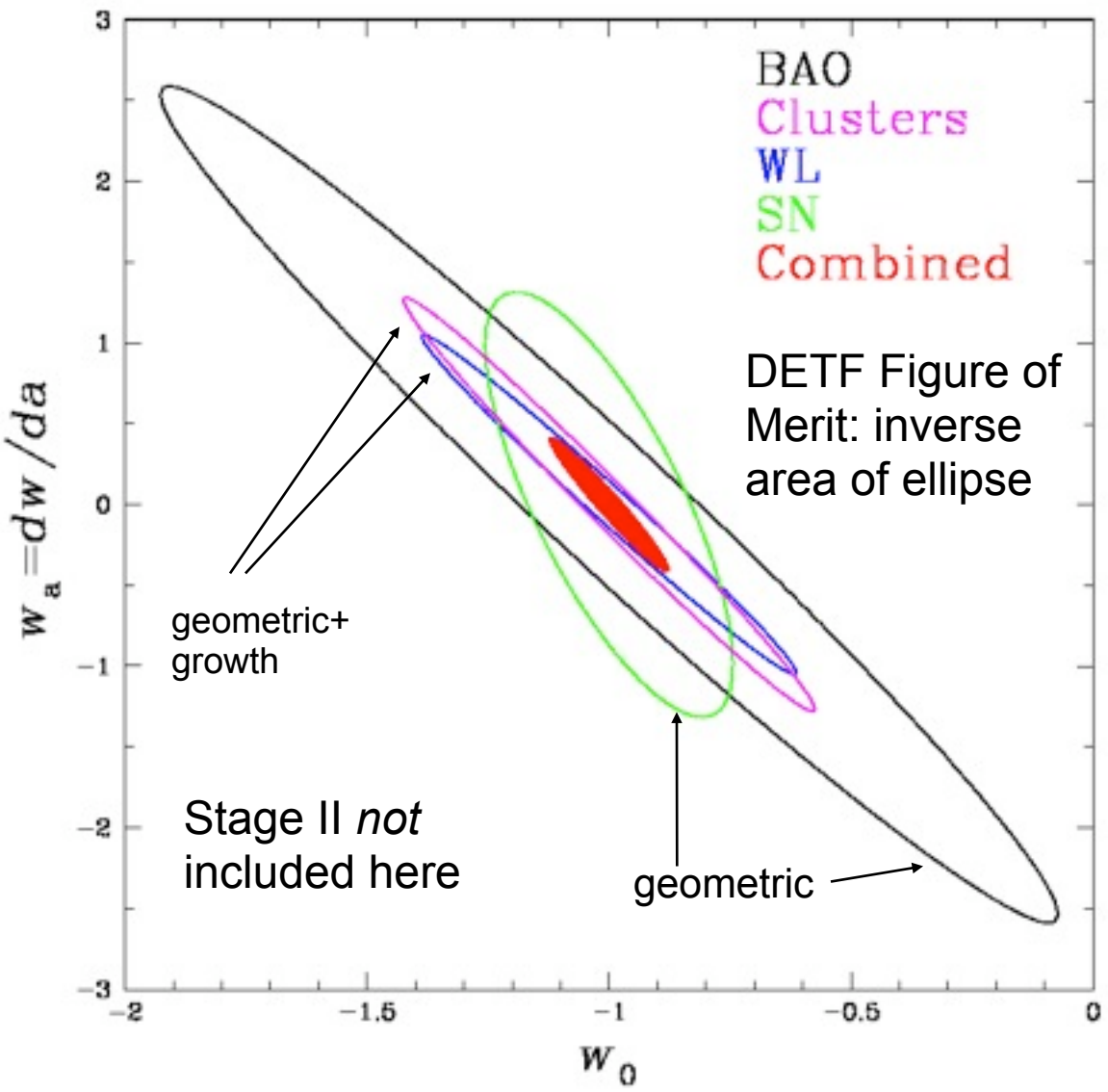
very promising data sample, the overlap with SPT should help us constrain the main source of uncertainty (mass estimation). Very active group at FNAL working on clusters for SDSS and DES.

Forecast

$w(z) = w_0 + w_a(1-a)$ 68% CL

Assumptions:
Clusters:
σ_8=0.75, z_{max}=1.5,
WL mass calibration
BAO: l_{max}=300
WL: l_{max}=1000
(no bispectrum)
Statistical+photo-z
systematic errors only

Spatial curvature, galaxy bias marginalized, Planck CMB prior
In terms of the DETF:
Factor 4.6 improvement over Stage II



DES/DECam

- DES is an outstanding example of the Laboratory taking leadership in an important field - proposing the experiment, building a collaboration, and moving the project forward toward completion.

- This project harnessed the cosmology expertise developed in SDSS and married it to the technical core competencies at the Lab in the fabrication and assembly of large silicon detector arrays.

- The project is proceeding well, and is on-track to provide world-leading constraints on DE parameters over the next few years. We were pleased to hear that Josh Frieman and Rich Kron have been selected as Director and Deputy Director, respectively.

slide from closeout report of the FRA Visiting Committee on 3/18/2010.

Dark Energy in DES and SDSS

With SDSS FNAL became involved in survey operations and science.

Using this expertise we built DES:

FNAL did a huge investment in DECam. We now have specialists with extremely valuable experience in building an instrument like this, we also have very nice infrastructure for this kind work.

Future:

FNAL is a leading the construction of DES and DECam. Now we have to make sure we also have an important participation in the production of science results. We are working on this.

At the same time, I hope we find the way to take advantage of our DECam experience building another large astronomical instrument. We have to make a plan for this.