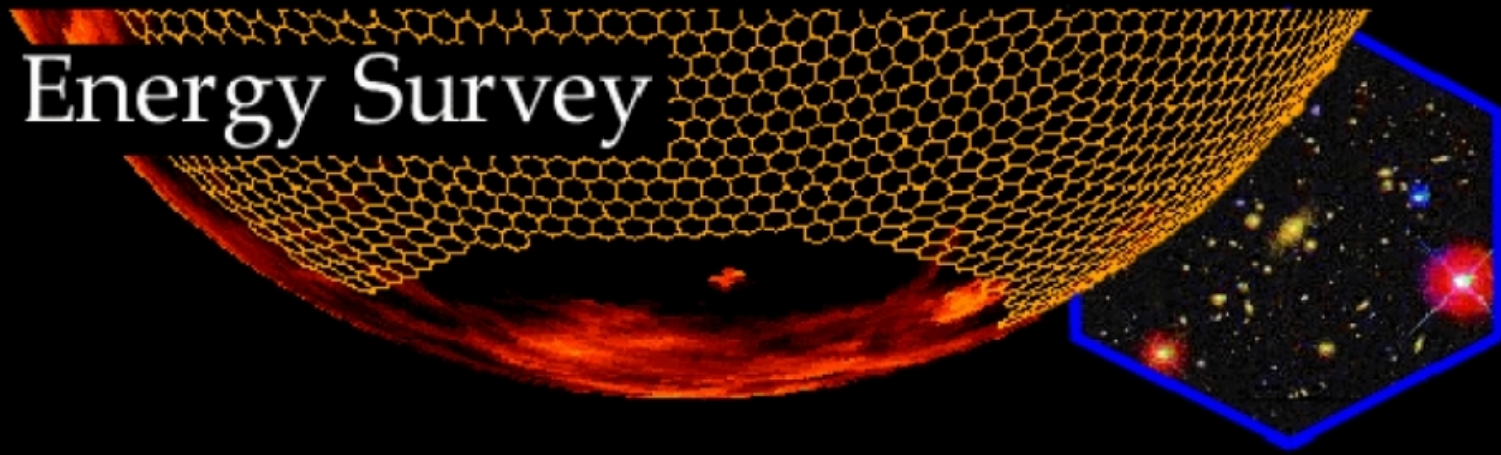


# The Dark Energy Survey



**E. Sánchez**  
**CIEMAT (Madrid)**

on behalf of the DES Collaboration



# Motivation and Probes of Dark Energy

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

### Probes of Dark Energy:

- **Luminosity Distance .vs. z:** SnIa
- **Angular Diameter Distance .vs. z:** BAO, Alcock-Paczynski
- **Comoving Volume\*Number Density .vs. z:** Galaxy Cluster counts, SZ, X-rays
- **Shear Convergence:** Weak Lensing
- **Other Tests:** CMB

### Cosmological observations can address:

- *Measure if  $w=-1$  or not*
- *$dw/dz$  non-zero would indicate the presence of something new*
- *Understand systematics!!!!*
- *Precise measurements (it's hard to distinguish among different models)*

### Several Observations with

- ◆ **Different systematics**
- ◆ **Different cosmological parameters degeneracies**
- ◆ **Different redshift sensitivities**



# The Dark Energy Survey

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

## 4 Science Goals

- ◆ *Cluster counting and spatial distribution of clusters at  $0.1 < z < 1.5$*
- ◆ *Distribution of galaxies and BAO*
- ◆ *Weak lensing measurement on several redshift shells to  $z \sim 1$*
- ◆ *2000 snla at  $0.3 < z < 0.8$*

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

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

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



# The Dark Energy Survey: Cluster Counting

**Measure:** Clusters redshift distribution, cluster observable distribution at each redshift (mass function)

DES will have ~20000 clusters

**Sensitivity:** Volume/distance-redshift relation, growth rate of cosmic structure, power spectrum shape (transfer function)

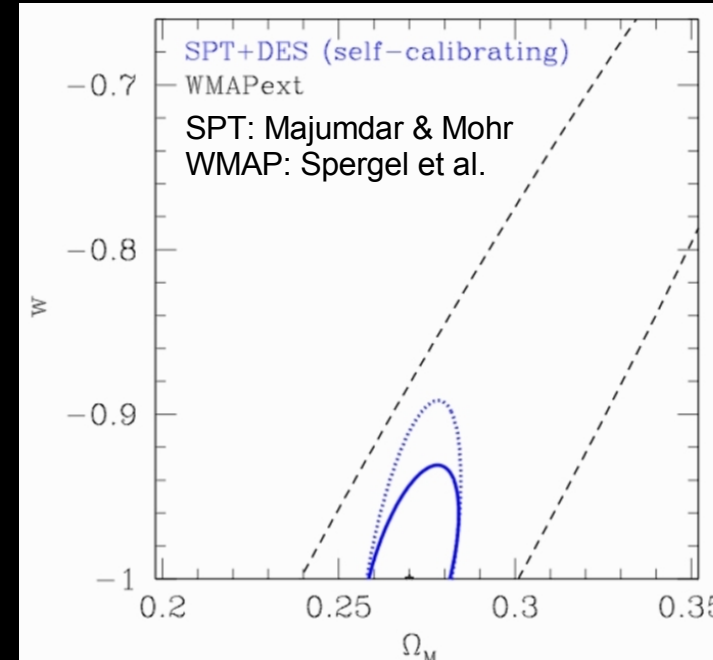
Use SZ effect (SPT Telescope), WL and X-ray to select clusters and measure masses

## Systematics:

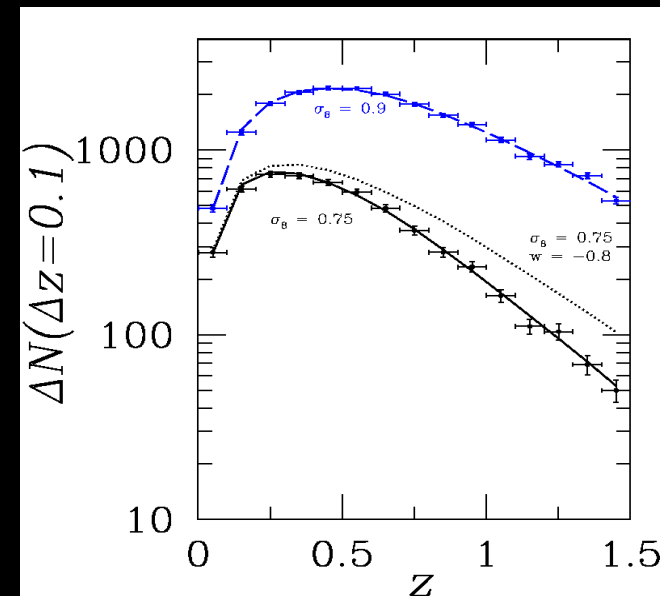
- Sample selection
- Statistical mass-observable calibration
- Sources contamination
- Photometric redshift

## Need:

- Understanding of the formation of dark matter halos
- Clean way of selecting a large number of clusters
- Redshift for each cluster
- Observables that can be used as mass estimators



Number of clusters .vs. Redshift



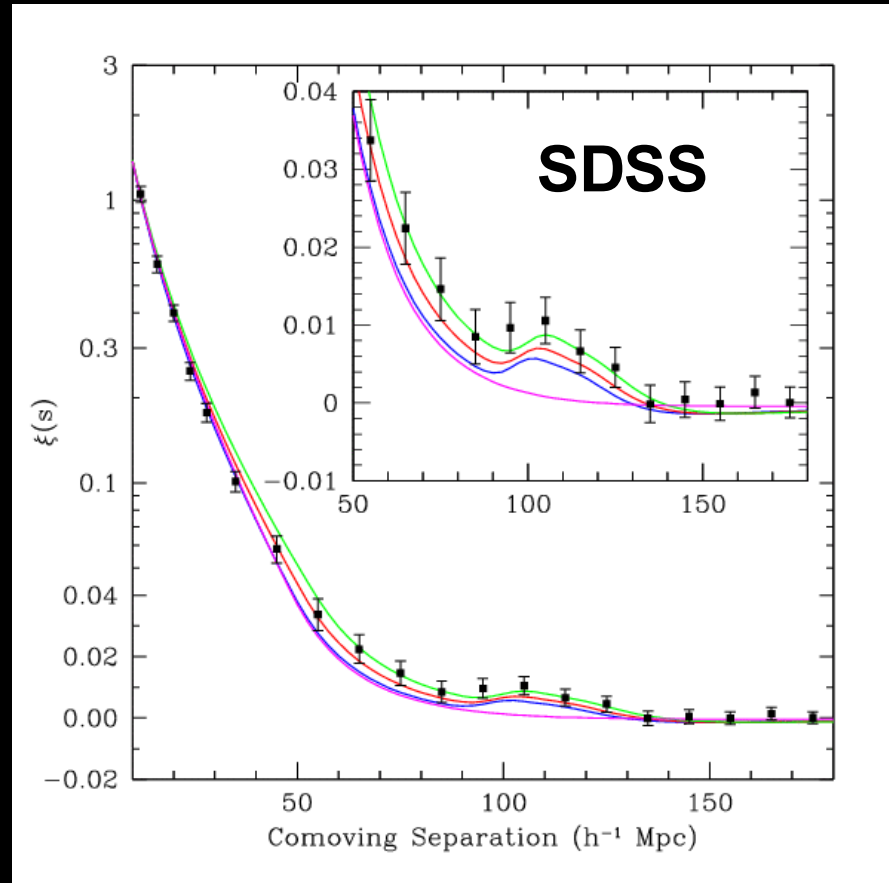
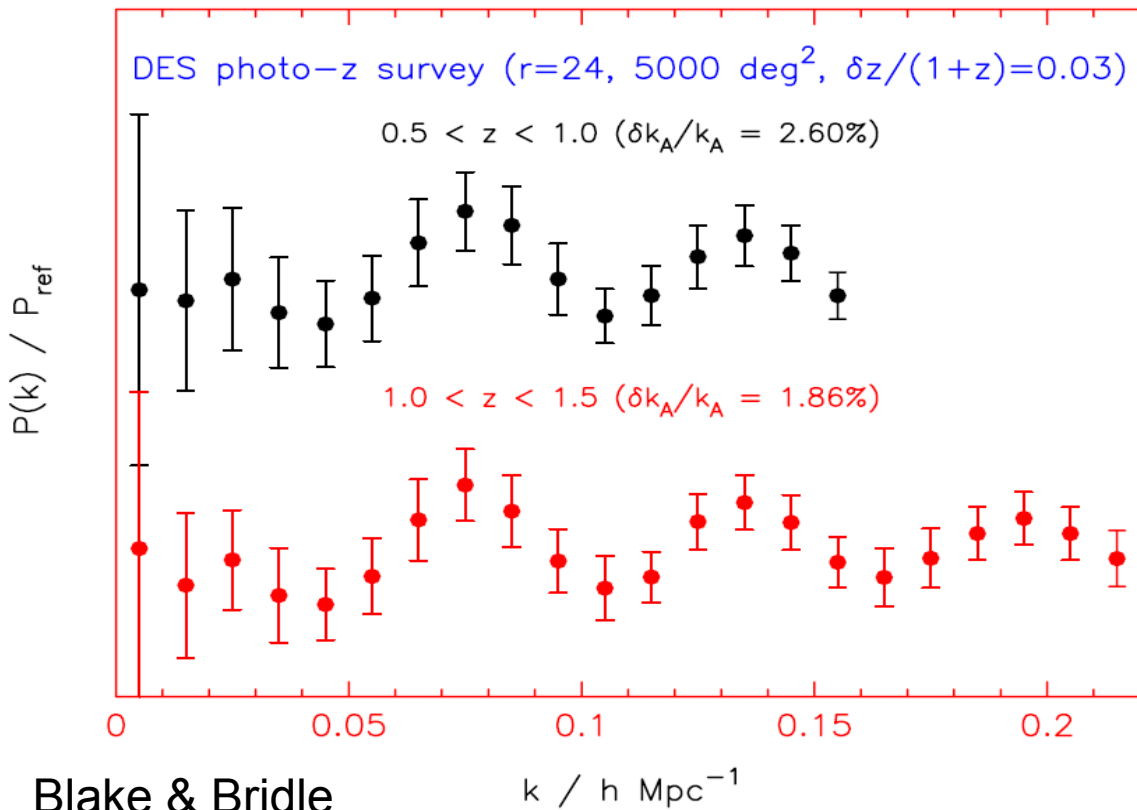


# The Dark Energy Survey: BAO

**~300 million galaxies up to  $z \sim 1.5$ . BAO provide a ruler**

**Measure spatial clustering of galaxies as a function of redshift**

**Theory predicts how the shape of the power spectrum depends on redshift**



**SYSTEMATICS:**

**Bias prescription factor**

**Calibration and bias in photo-z**



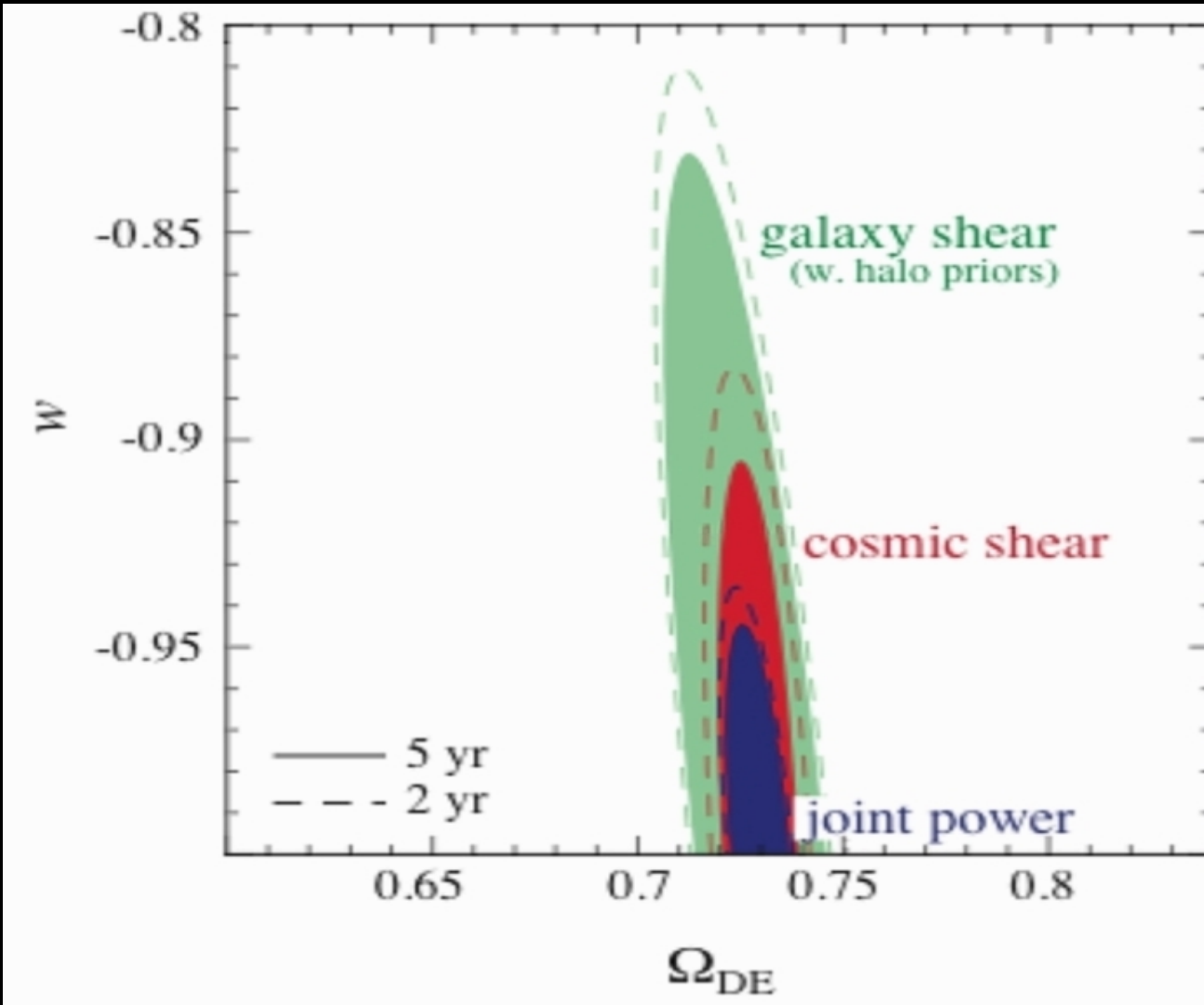
# The Dark Energy Survey: Weak Lensing

Measure shapes for ~300 million source galaxies with  $\langle z \rangle = 0.7$

Shear-shear and galaxy-shear correlations

Probe distances and growth rate of perturbations

Shear as a function of redshift. Intensity is different for different source galaxies for the same cluster lens



## SYSTEMATICS:

calibration

False detections shear

Photo-z biases

Small scale power spectrum

Intrinsic alignments



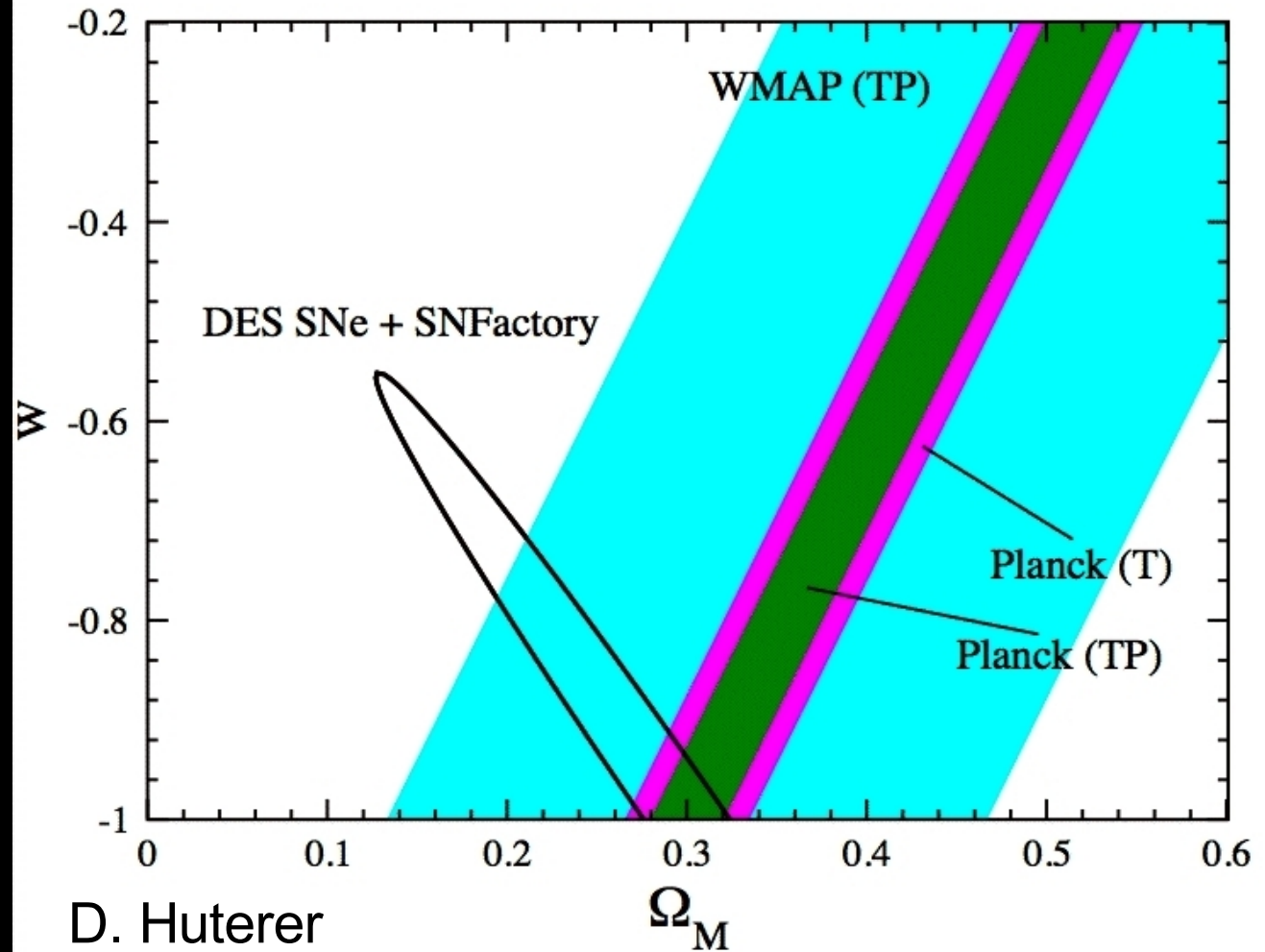
# The Dark Energy Survey: Supernovae

*Repeat observations  
of 40 sq-degrees,  
10% of survey time*

*~2000 well-measured  
griz snla light curves;  
 $0.2 < z < 0.8$*

*Larger sample and  
improved z-band  
response compared  
to other experiments*

*Identify supernovae  
type 1a using  
photometric and  
color methods*



## SYSTEMATICS:

**SN evolution**

**Extinction**

**Photometric errors and biases**



# The Dark Energy Survey: The Instrument

Survey 5000 sq-degrees in  
the South Galactic Cap  
30% DES, 70% of public use

Use 4m Blanco Telescope at  
CTIO (Chile); and existing  
and working telescope

DES will replace the entire  
cage at the prime focus

Install a new camera and  
new optics

SDSS g,r,i,z filters covering  
visible and infrared (correlate  
with Vista VHS to go further  
in IR)

Each image will cover 3 sq-  
degrees (~20 clusters and  
~20000 galaxies)

~300 GB image data/night

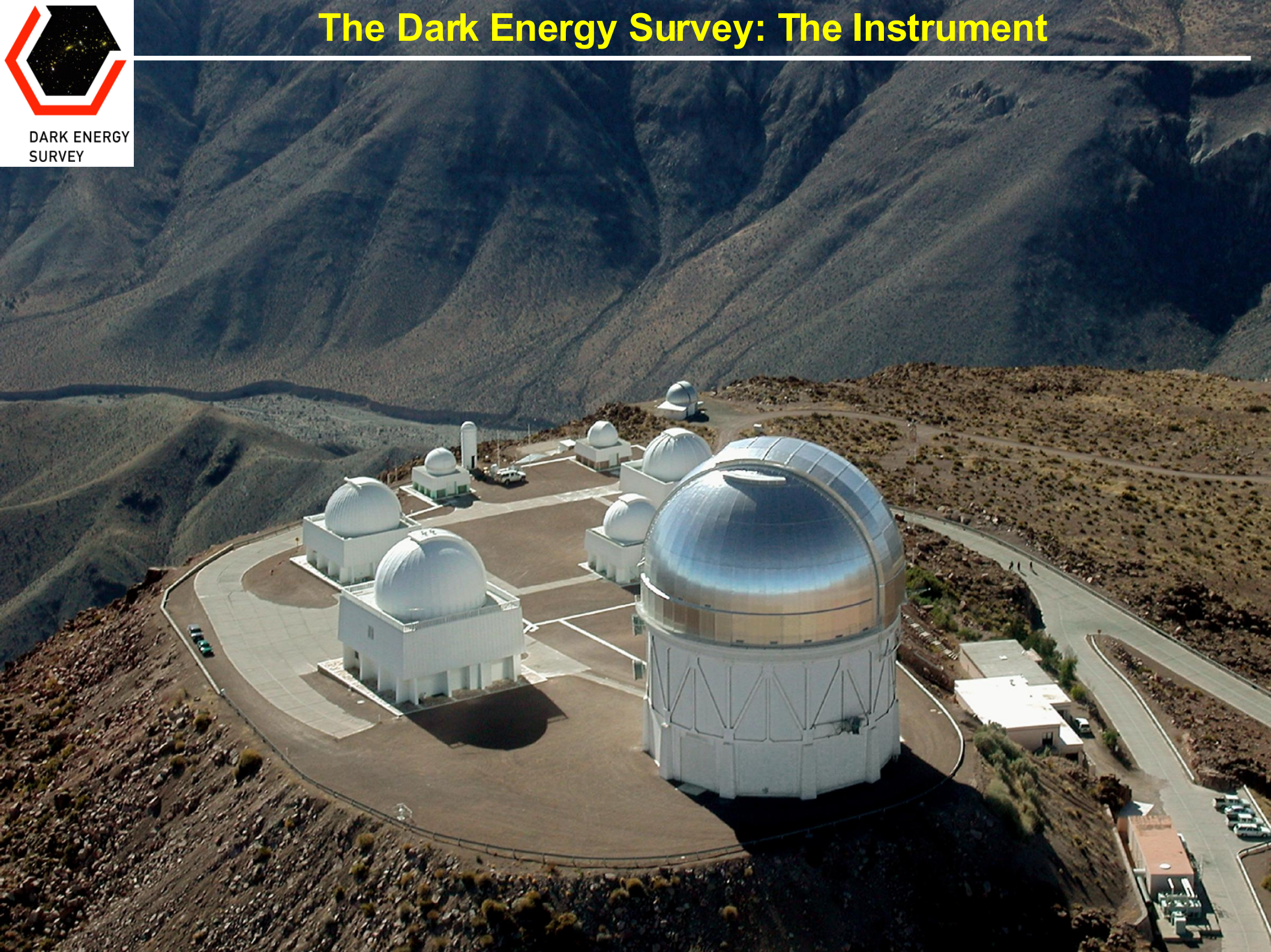




# The Dark Energy Survey: The Instrument



DARK ENERGY  
SURVEY





# The Dark Energy Survey: The Camera

*DES is building a new camera for Blanco: DECam*

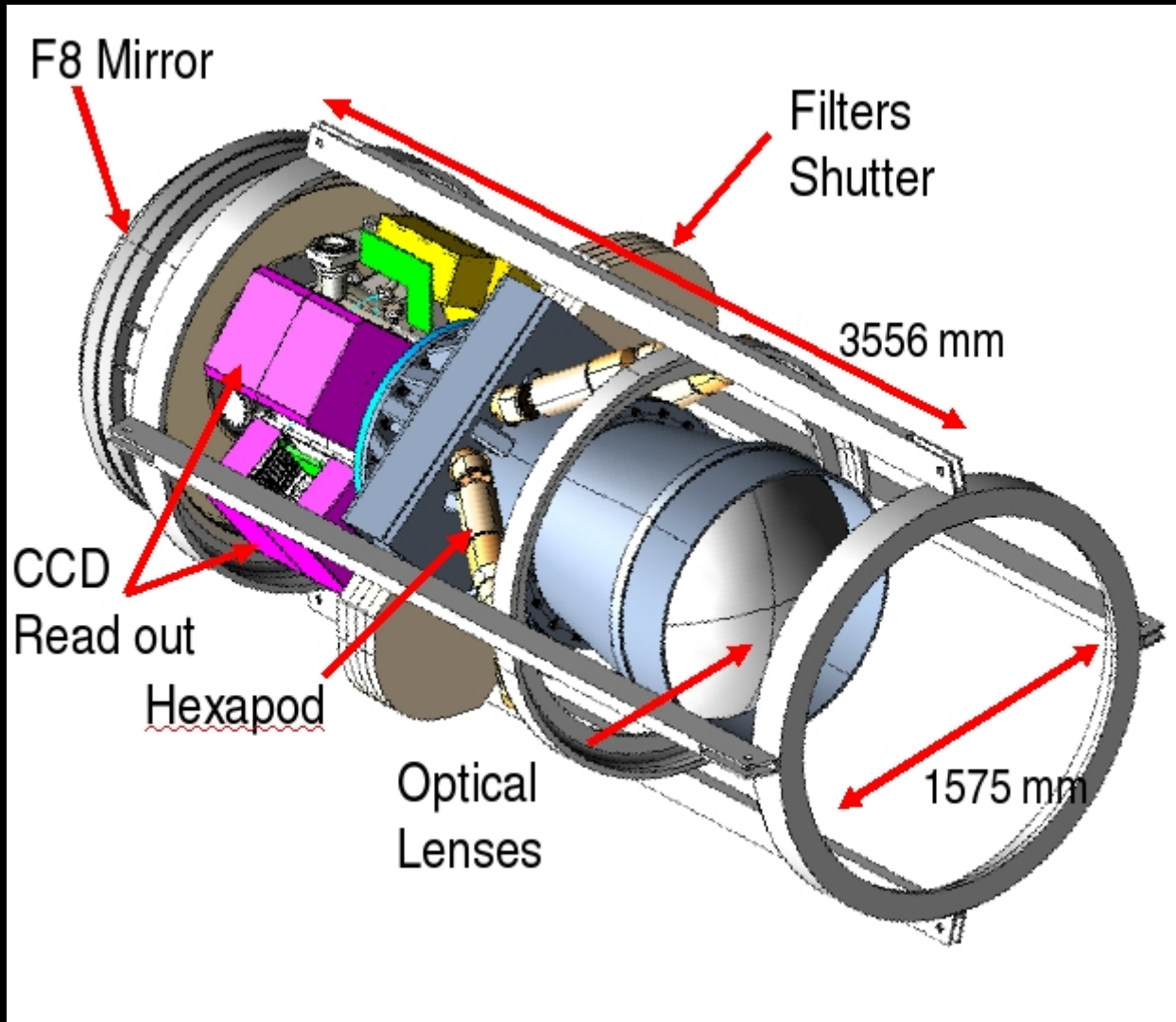
*500 million pixels*

*Sensitive to visible and near IR*

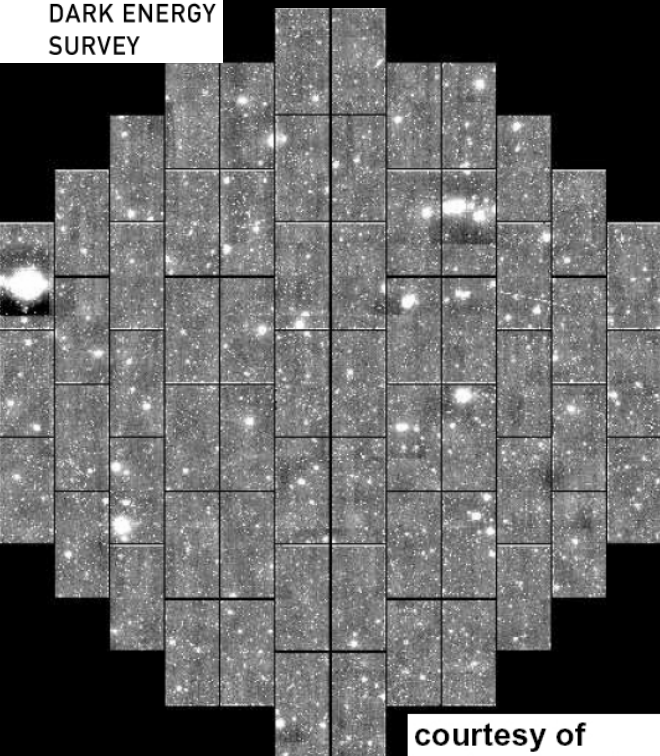
*DES is building also the associated optics*

*DECam will be installed at the prime focus of the telescope*

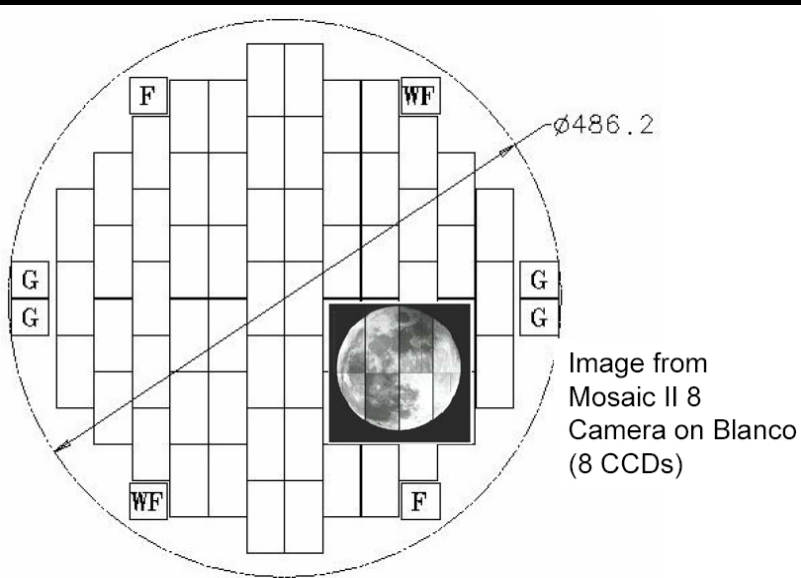
*It is a mobile piece. It can be rotated to use a mirror at the back*



# The Dark Energy Survey: The Camera



courtesy of  
F. Valdes/NOAO



62 2k x 4k image CCDs +  
guide and focus CCDs

0.27"/pixel

Scroll shutter: < 3 sec open-  
close

4 filters (g, r, i, z) < 10 sec  
exchange

5 elements optical corrector

Approximately hexagonal



DARK ENERGY SURVEY

# The Dark Energy Survey: CCDs

**Pixel size: 15x15 microns**

**Readout time: 17 sec.**

**Noise: 5e at 250 kpix/sec**

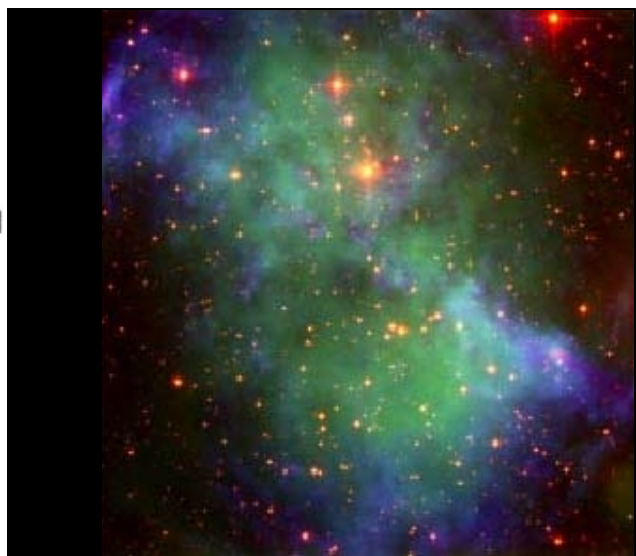
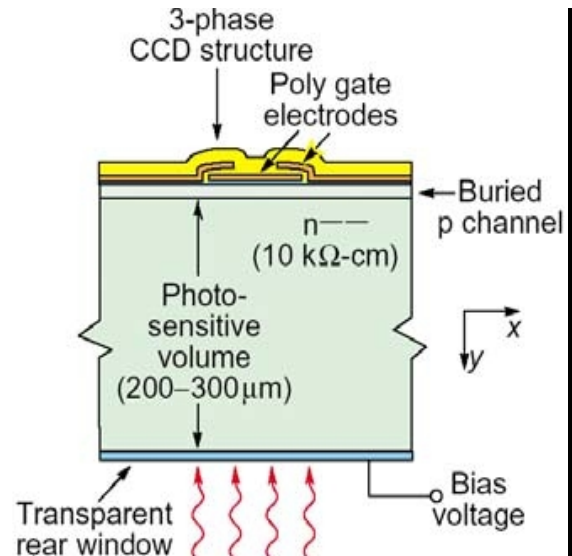
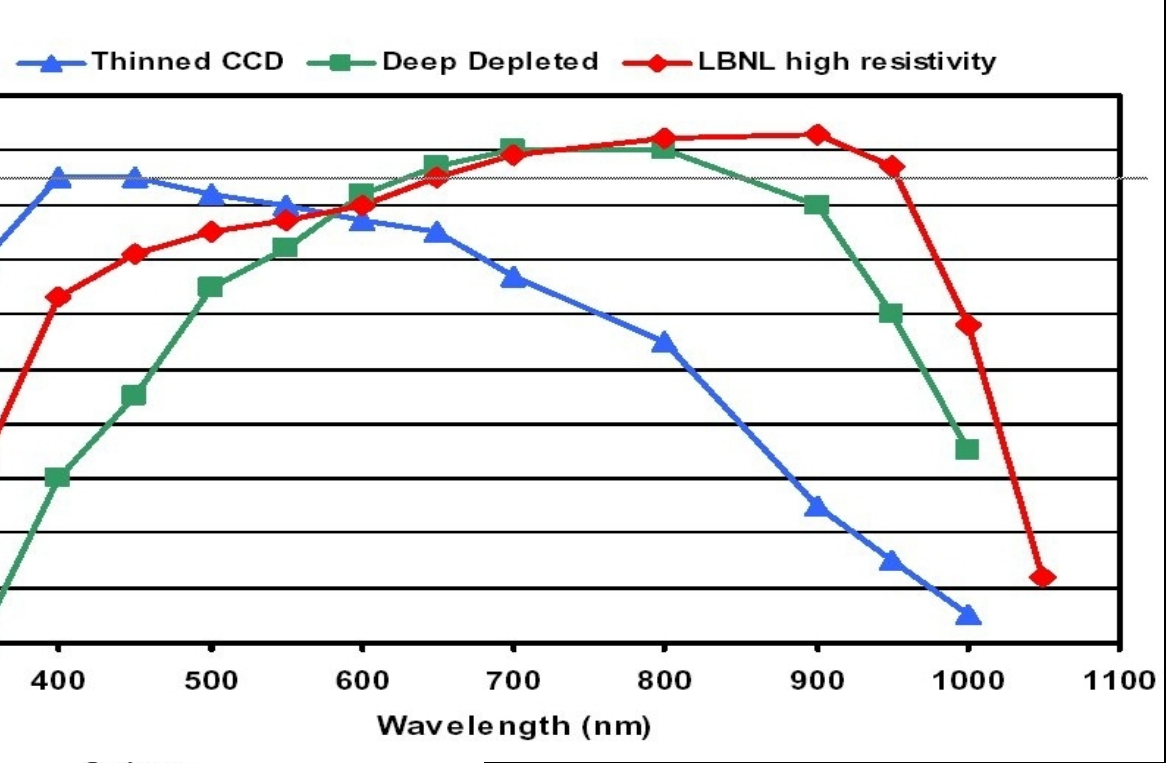
**Quantum Efficiency > 50% at 1000 nm**

**250 microns thick**

**2 Readout channels device**

**Developed by LBNL for SNAP**

**These CCDs have already been used on telescopes in small numbers**



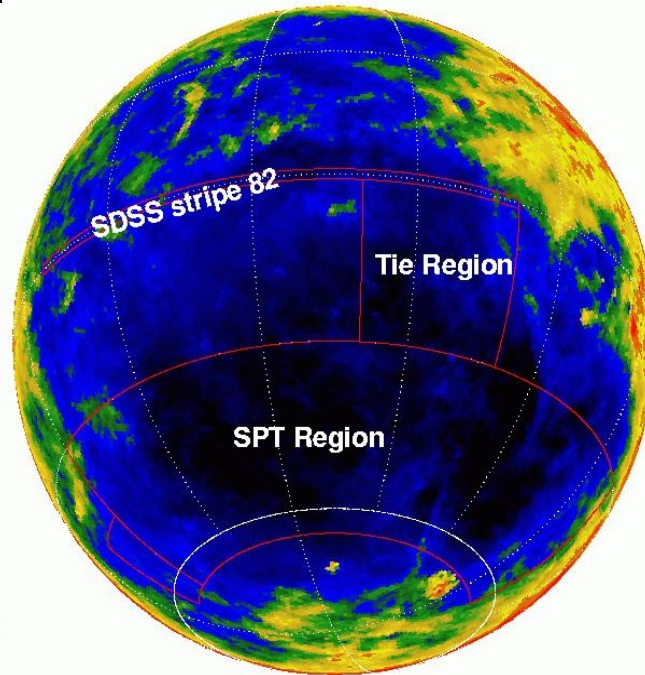
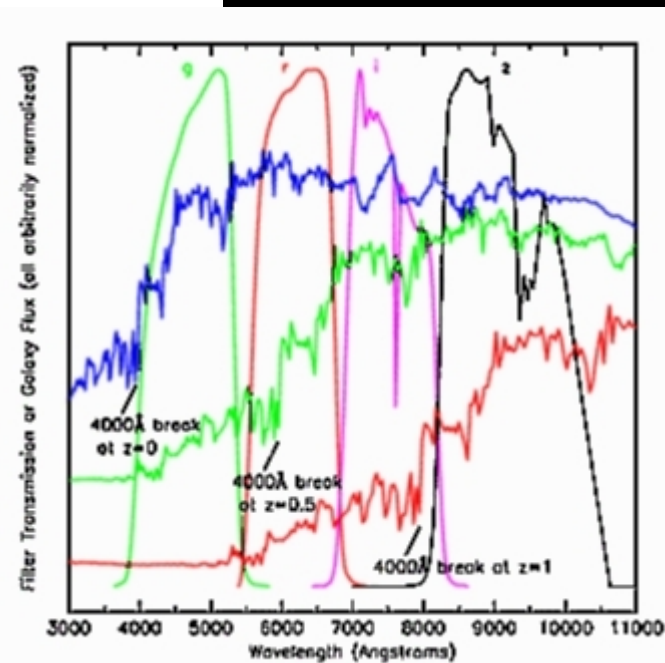


DARK ENERGY SURVEY

# The Dark Energy Survey: Photo-z and data management

4 SDSS filters: **g**, **r**, **i**, **z**. From  $\sim 3500$  to  $\sim 10500$  A

Target red galaxy spectra at  $z=0$ , **0.5**, **1**



The 4000 A break in brightness seen through the different filters gives a measurement of the redshift

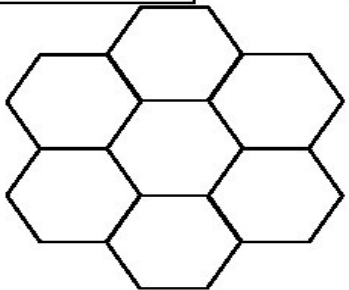
This is not as precise as full spectrum but it is **MUCH FASTER** and can go **FAINTER** (45 min for spectra; 100 sec for photo-z)

Covered Area: 5000 sq-degrees

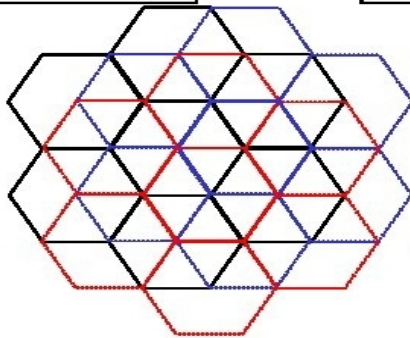
Overlap with SPT SZ survey: SPT masses+DES redshifts. SDSS stripe 82 provides photo-z calibration spectra

2 tilings of the full area per year per filter

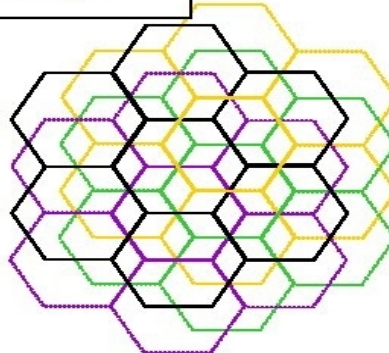
1 tiling



2 tilings



3 tilings



Support acquisition and reliable transfer of 300 GB/night on 500 nights over 5 years from CTIO (Chile) to NCSA (Illinois)

Maintain DES archive over the long term ( $\sim 1$  PB data at the end of the survey)



# The Dark Energy Survey: The Collaboration

Fermilab

U. Illinois at Urbana-Champaign

U. Chicago

LBNL

U. Michigan

NOAO/CTIO

U. Pennsylvania

U. Ohio State

Argonne National Laboratory

**Brazil Consortium:**

Observatorio Nacional,

Centro Brasileiro de Pesquisas Físicas,

U. Federal do Rio de Janeiro,

U. Federal do Rio Grande do Sul

**UK Consortium:**

U. College London,

U. Cambridge,

U. Edinburgh,

U. Portsmouth,

U. Sussex

**Spanish Consortium:**

ICE/IEEC,

IFAE,

CIEMAT

**19 Institutions**

**~100 members**

**(+ technical staff +students)**

Spokesperson:

**JOHN PEOPLES (Fermilab)**



# The Dark Energy Survey: Timetable

## 2007-2008: Design and R&D

CCDs: Testing and packing. Develop characterization procedure

OPTICS: Lens polishing, assembly and alignment

ELECTRONICS: Final design and production

## 2008-2010: Construction

Selection of final high quality CCDs

Tests of the full camera

End optics

## Summer 2010: Transport full instrument to Chile

## Fall 2010: Start data taking

## 2010-2015: SURVEY!



**DES is a next generation sky survey aimed to study the dark energy which will start in 2010**

**The goal is to measure  $w$  at 5% precision and  $dw/dz$  at 15% precision with 4 techniques:**

- **Galaxy clusters counting**
- **Clusters/Galaxies angular power spectrum and BAO**
- **Weak Lensing**
- **Supernovae Ia**

**It will cover 5000 sq-degrees in the southern hemisphere and will overlap with SPT SZ survey**

**Large international collaboration, almost a dedicate telescope and large volume of data**