



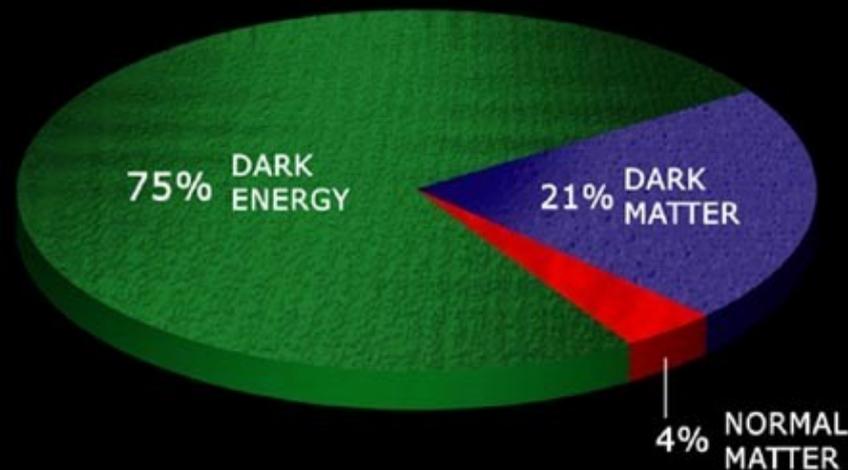
# Dark Energy Survey

- DES Overview **Josh Frieman**
  - Dark Energy Camera **Brenna Flaugher**
  - Improvements to the CTIO Blanco Telescope **Alistair Walker**
  - Processing, Calibration, and Archiving **Joe Mohr**
  - Precision Cosmology with Galaxy Clusters **Chris Miller**
  - Weak Lensing Tomography with DES **Bhuvnesh Jain**
  - The DES Supernova Survey **Masao Sako**
  - Large-scale Structure with DES **Enrique Gaztanaga**
- 
- See DES poster session 239 today
  - See DECam Community Use Splinter Session later today



# Dark Energy

- What is the physical cause of cosmic acceleration?
  - Dark Energy or modification of General Relativity?
    - If Dark Energy, is it  $\Lambda$  (the vacuum) or something else?
      - What is the DE equation of state parameter  $w$ ?
- DES will take the next step toward these goals





# The Dark Energy Survey

Blanco 4-meter at CTIO

- **Survey project using 4 complementary techniques:**
  - I. Cluster Counts
  - II. Weak Lensing
  - III. Large-scale Structure
  - IV. Supernovae
- **Two multiband surveys:**
  - 5000 deg<sup>2</sup> *grizY* to 24th mag
  - 30 deg<sup>2</sup> repeat (SNe)
- **Build new 3 deg<sup>2</sup> FOV camera and Data management system**
  - Survey 2012-2017 (525 nights)
  - Facility instrument for Blanco



# The DES Collaboration



Fermilab

University of Illinois at Urbana-Champaign/NCSA

University of Chicago

Lawrence Berkeley National Lab

NOAO/CTIO

DES Spain Consortium

DES United Kingdom Consortium

University of Michigan

Ohio State University

University of Pennsylvania

DES Brazil Consortium

Argonne National Laboratory

SLAC-Stanford-Santa Cruz Consortium

Universitats-Sternwarte Munchen

Texas A&M University

plus Associate members at: Brookhaven National Lab,

U. North Dakota, Paris, Taiwan

Over 120 members  
plus students &  
postdocs

Funding: DOE, NSF;  
UK: STFC, SRIF;  
Spain Ministry of  
Science, Brazil:  
FINEP, Ministry of  
Science, FAPERJ;  
Germany: Excellence  
Cluster; collaborating  
institutions



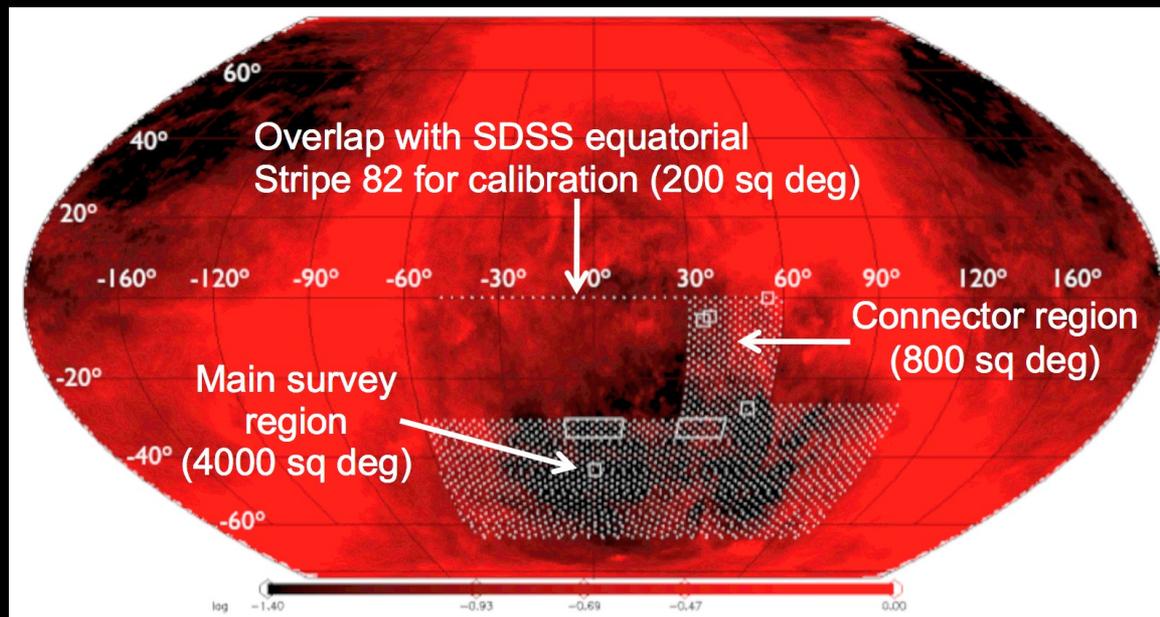
# Project Structure & Timeline

- 3 Construction Projects:
  - DECam (hosted by FNAL; DOE supported)
  - Data Management System (NCSA; NSF support)
  - **CTIO Facilities Improvement Project**
    - NOAO Blanco Announcement of Opportunity 2003
    - NSF/NOAO R&D 2004-8
    - Camera construction 2008-11
    - Final construction, testing, integration now on-going
    - Ship components to Chile: Sept 2010-July 2011
    - Installation: Jan-Oct 2011 (imager: Sept-Oct)
    - First light on telescope: ~Oct/Nov 2011
    - Commissioning: Oct/Nov 2011-Jan/Feb 2012
    - Science Verification: Feb/Mar 2012
    - Survey operations begin: Sept 2012

# DES Observing Strategy

- Sept-Feb observing seasons
- 80-100 sec exposures
- 2 filters per pointing (typically)
  - *gr* in dark time
  - *izy* in bright/grey time
- Photometric calibration: overlap tilings, standard stars, spectrophotometric calibration system, preCAM
- 2 survey tilings/filter/year
- Interleave 5-10 SN fields in *griz* if non-photometric or bad seeing or time gap (aim for ~5 day cadence)

Survey Area 5000 sq deg



2  
tilings

3  
tilings



# DES Science Summary

## Four Probes of Dark Energy

### Galaxy Clusters

- ~100,000 clusters to  $z > 1$
- Synergy with SPT
- Sensitive to growth of structure and geometry

### Weak Lensing

- Shape measurements of 300 million galaxies
- Sensitive to growth of structure and geometry

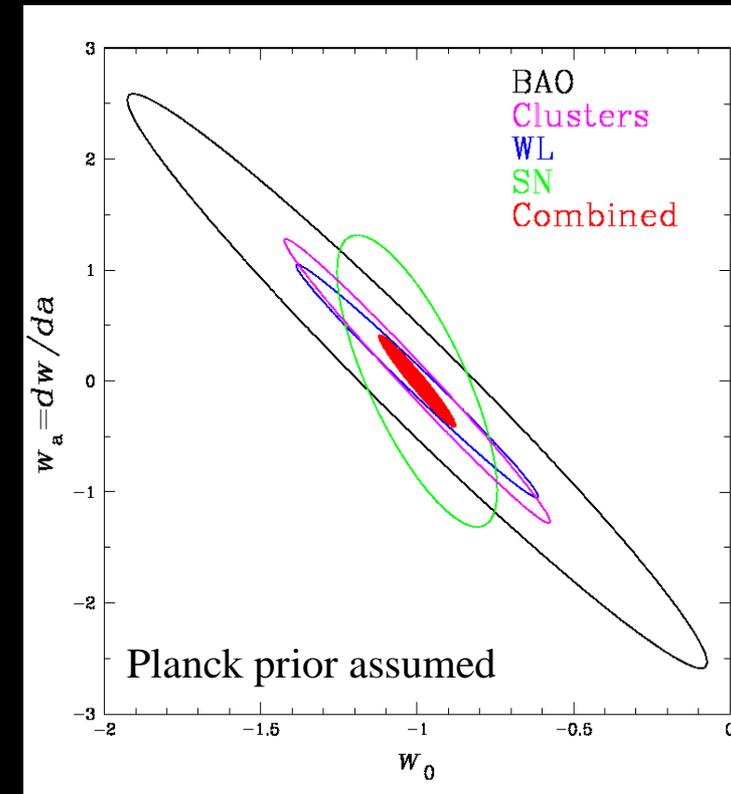
### Baryon Acoustic Oscillations

- 300 million galaxies to  $z = 1$  and beyond
- Sensitive to geometry

### Supernovae

- 30 sq deg time-domain survey
- ~4000 well-sampled SNe Ia to  $z \sim 1$
- Sensitive to geometry

## Forecast Constraints on DE Equation of State

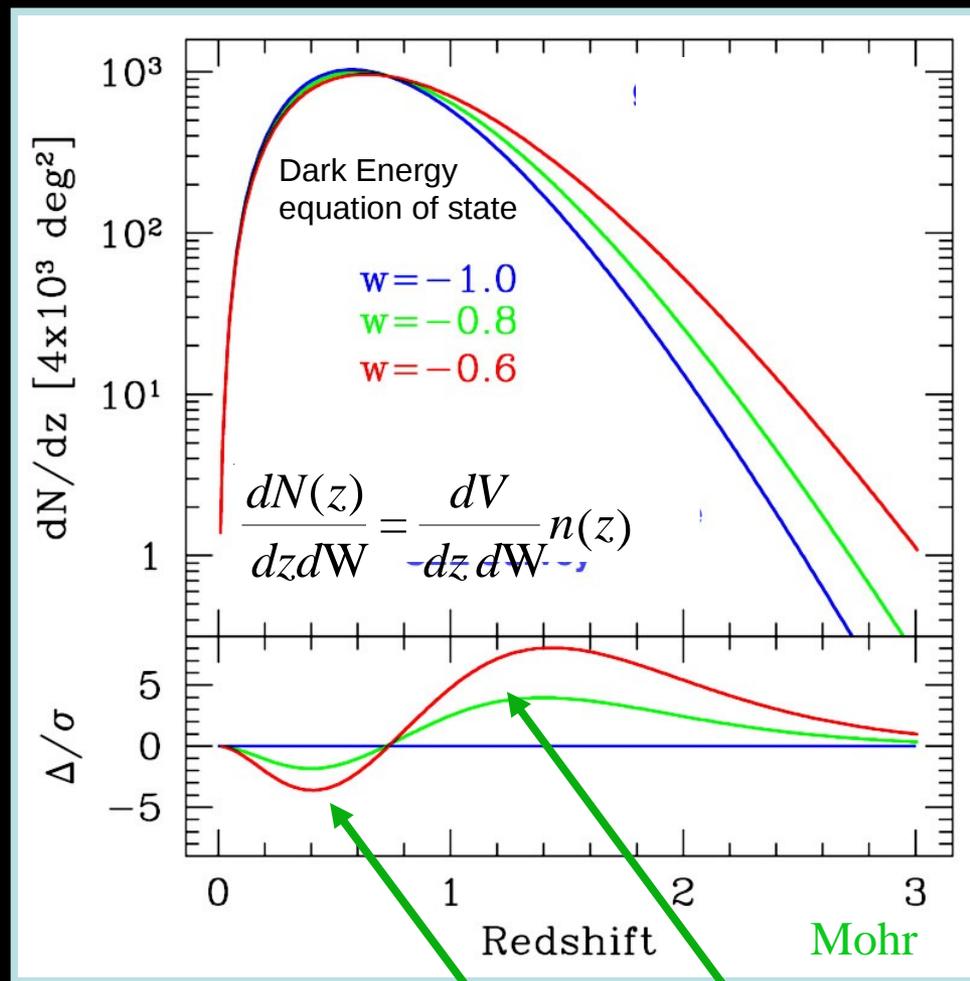


Factor 3-5 improvement over Stage II DETF Figure of Merit

# I. Clusters

- **Elements of the Method:**
  - Clusters are proxies for massive halos and can be identified optically to redshifts  $z > 1$
  - Galaxy colors provide photometric redshift estimates for each cluster
  - Observable proxies for cluster mass: optical richness (DES), SZ flux decrement (SPT), weak lensing mass (DES)
  - Cluster spatial correlations help calibrate mass estimates

Number of clusters above mass threshold



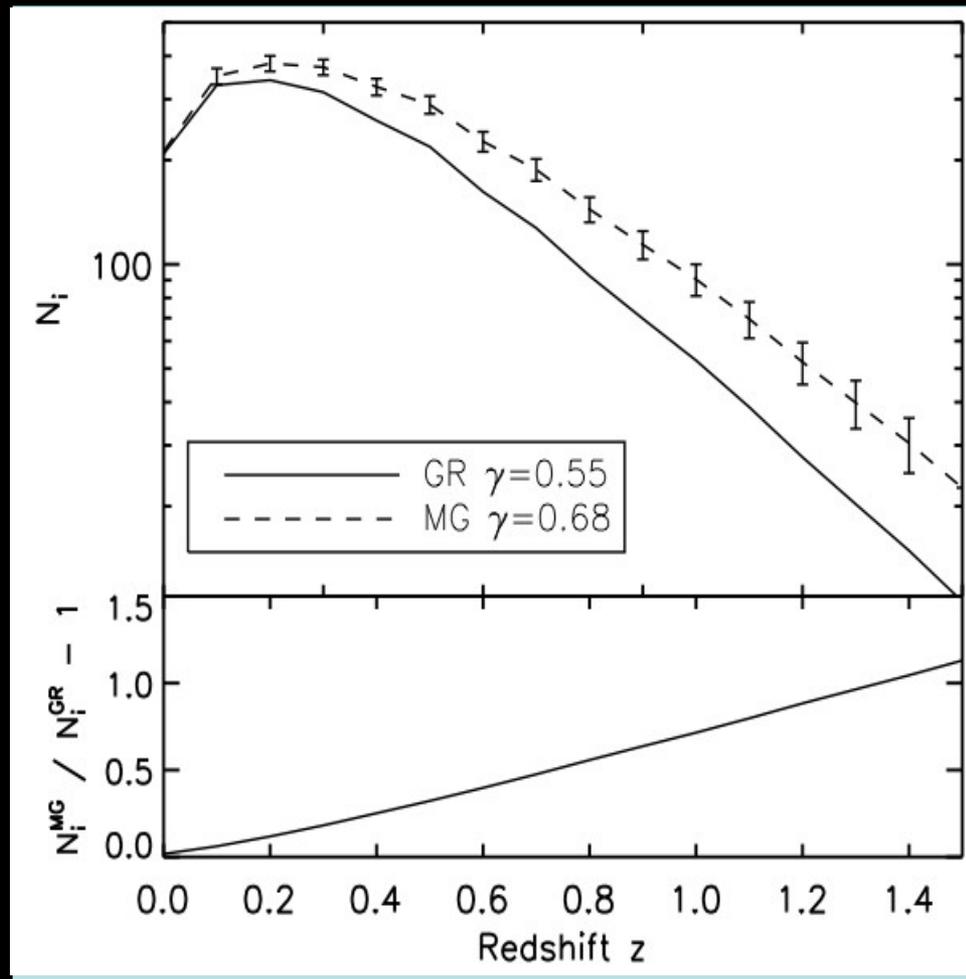
Volume

Growth

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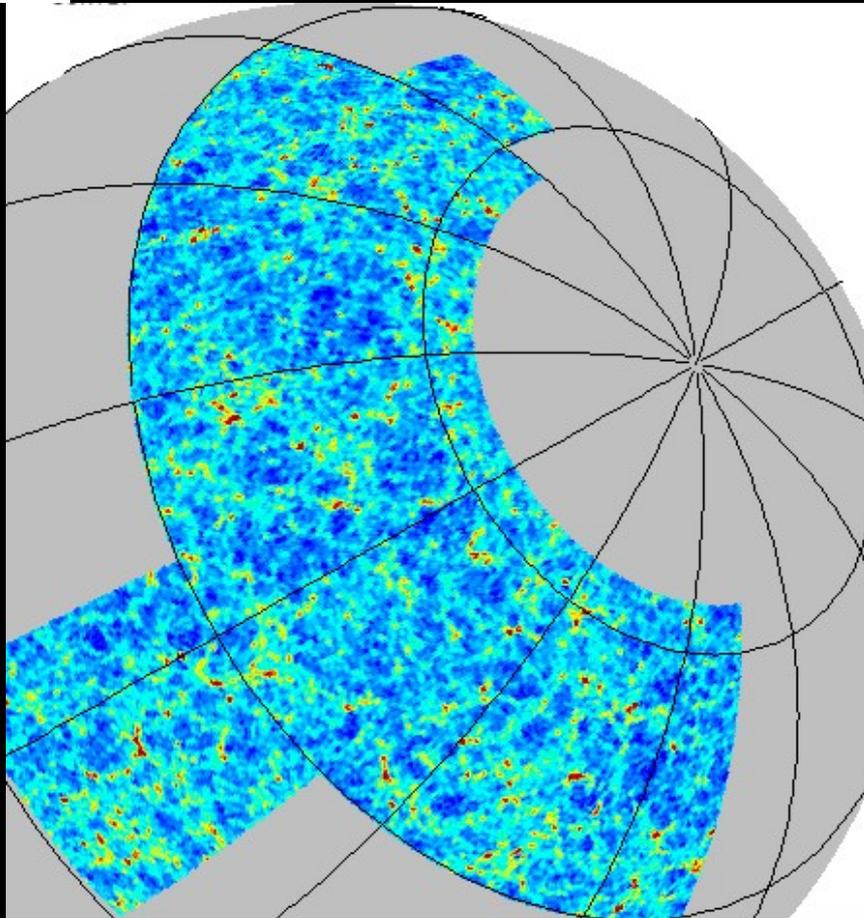




# Synergy with South Pole Telescope

DARK ENERGY  
SURVEY

DES footprint: 5000 sq deg



DES survey area encompasses SPT Sunyaev-Zel'dovich Cluster Survey  
Also partnering with VISTA Hemisphere Survey (NIR): improve photo-z's

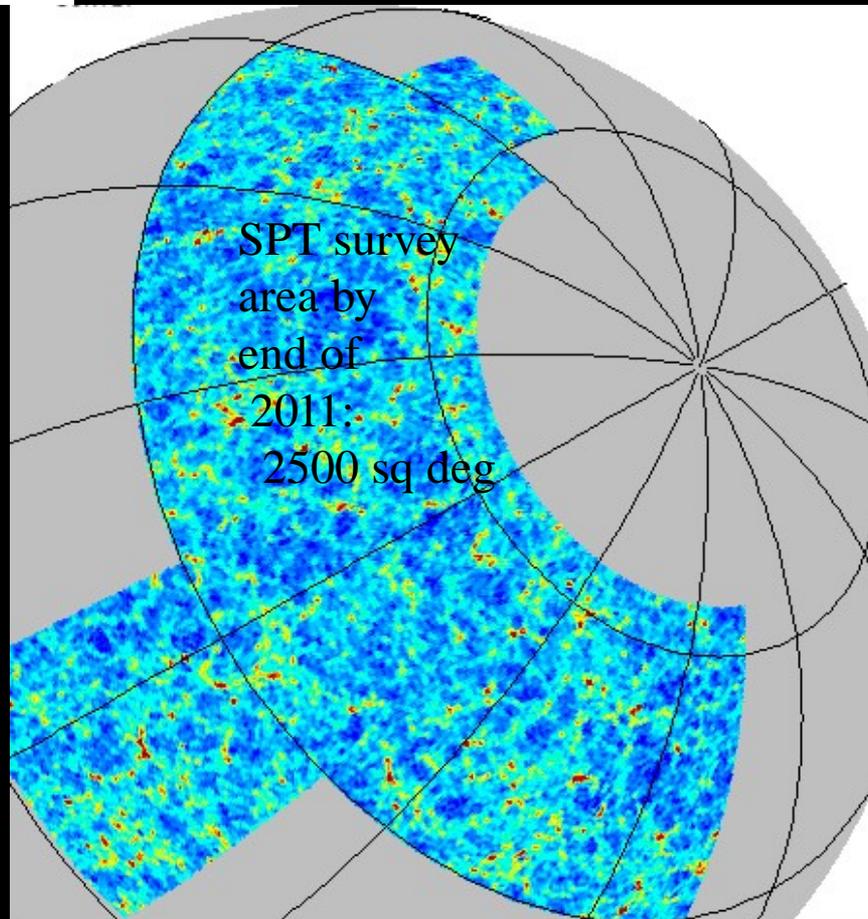
Josh Frieman, AAS Special Session on DES  
Seattle, Jan. 11, 2011



# Synergy with South Pole Telescope

DARK ENERGY  
SURVEY

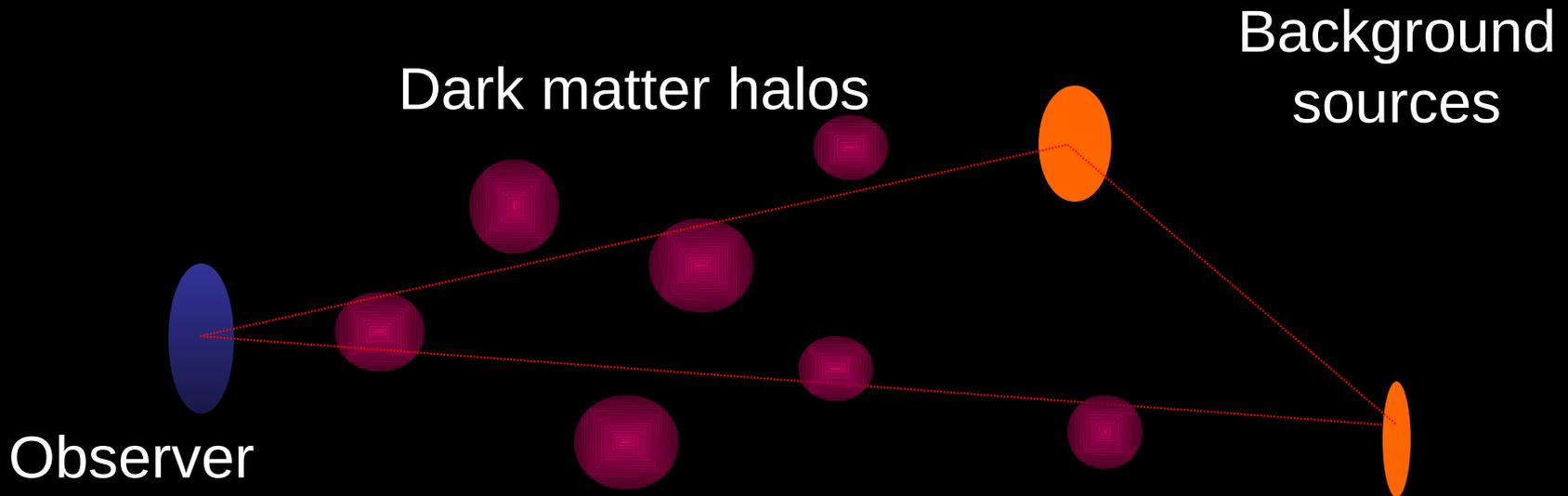
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## II. Weak Lensing: Cosmic Shear

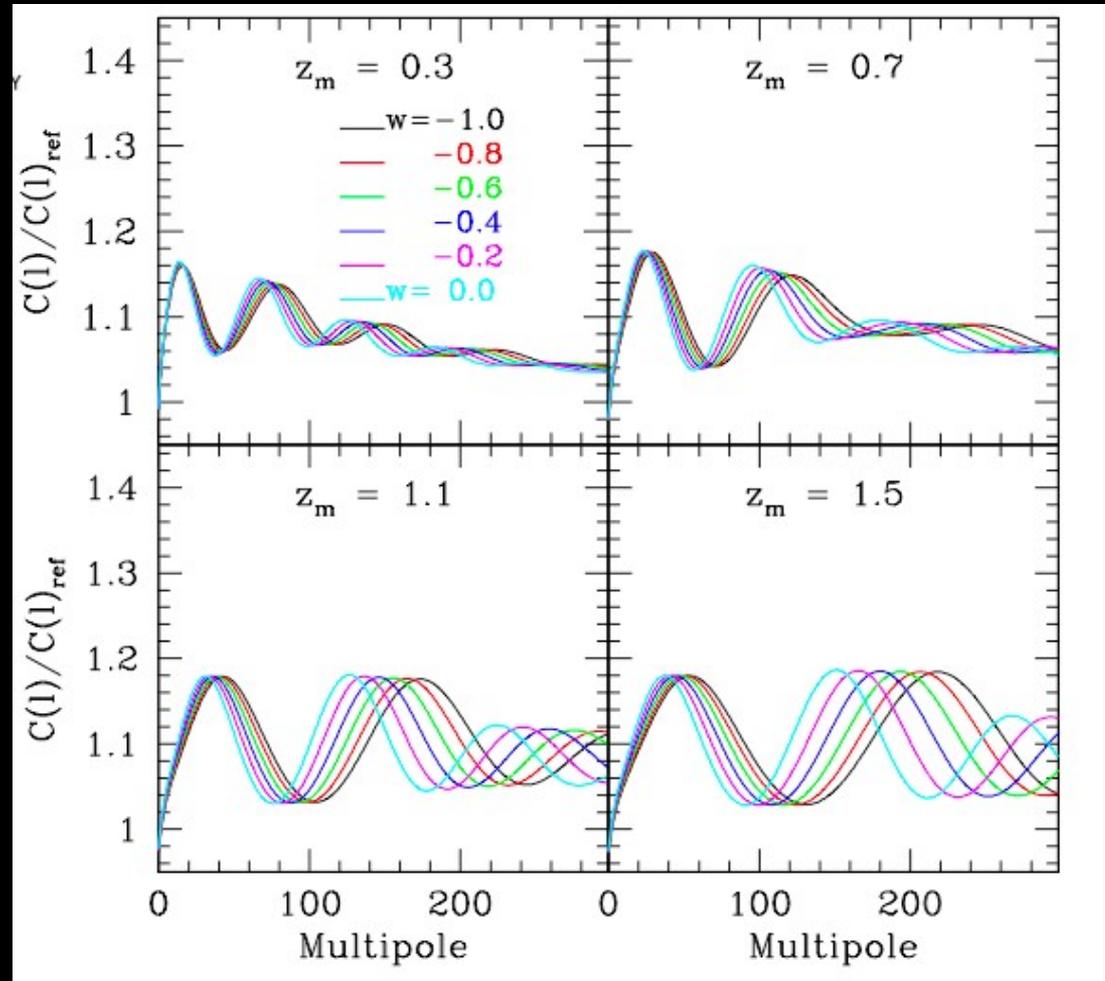


- Spatially coherent shear pattern,  $\sim 1\%$  distortion
- Radial distances depend on *geometry* of Universe
- Foreground mass distribution depends on *growth* of structure

# III. Baryon Acoustic Oscillations

Galaxy angular power spectrum in photo-z bins (relative to model without BAO)

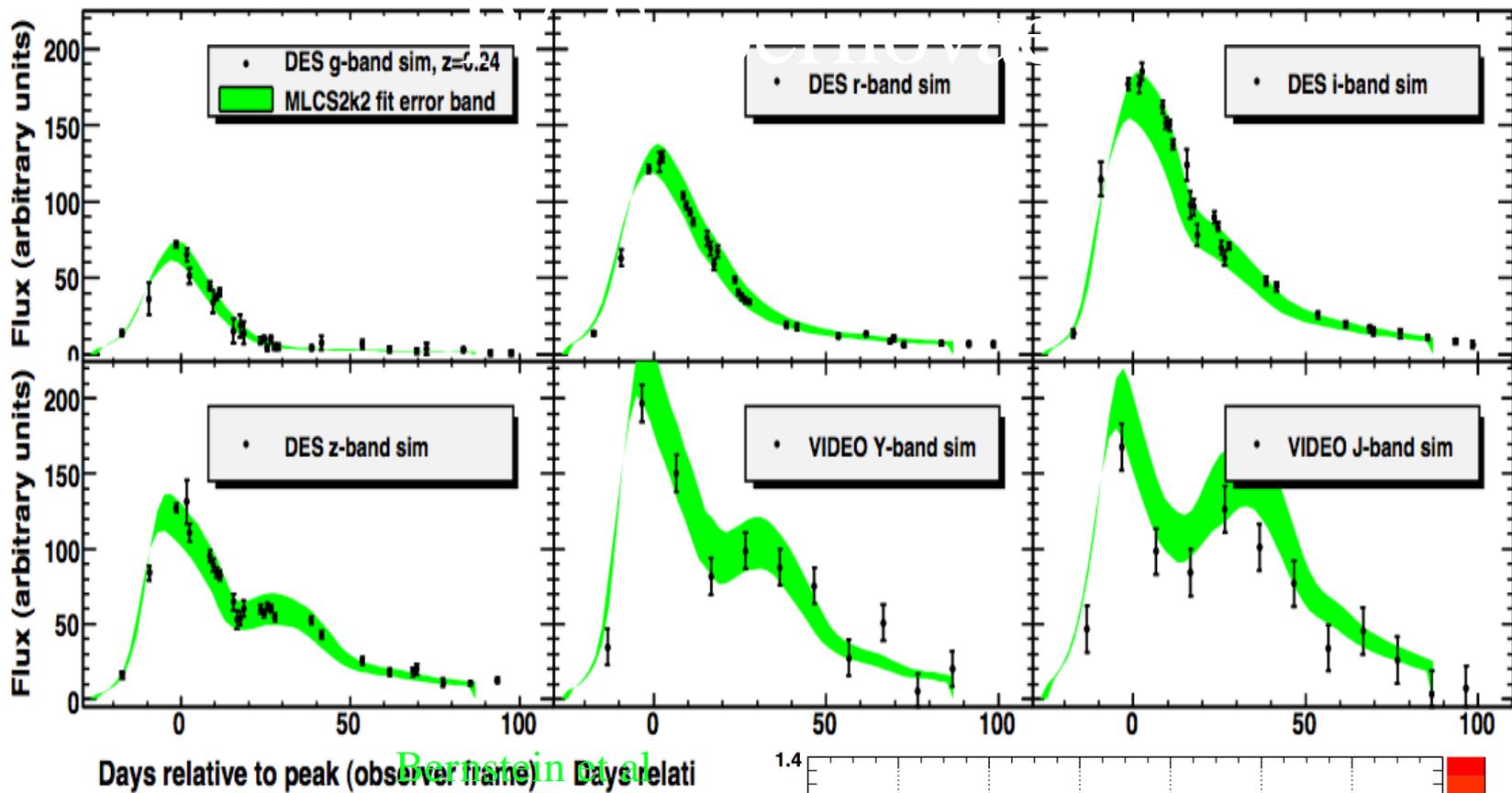
Probe deeper than SDSS redshift survey



Fosalba & Gaztanaga

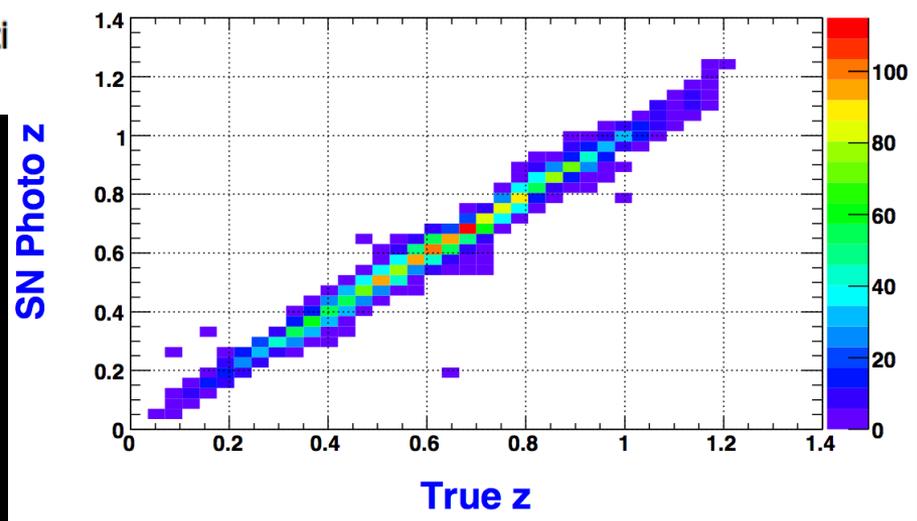


DARK ENERGY SURVEY



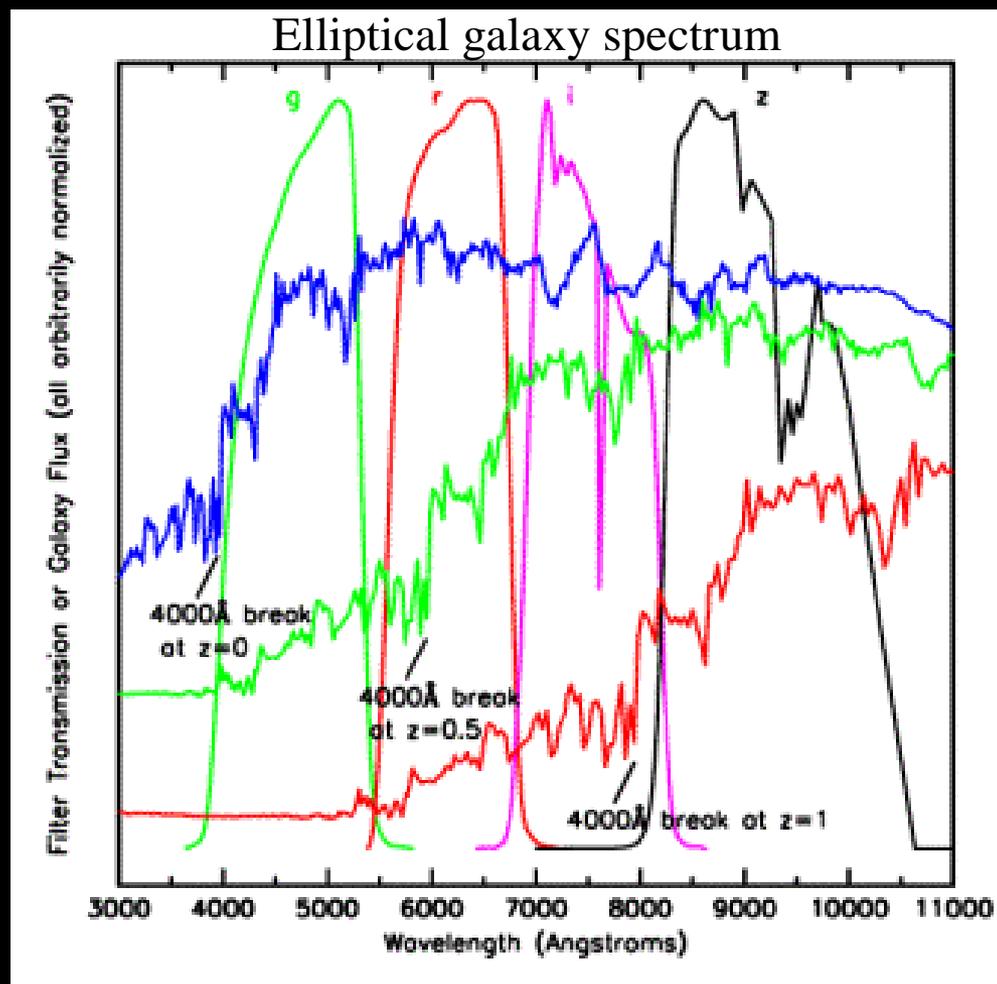
Bernstein et al

- Broader redshift range than SDSS SN
- Higher S/N in red passbands than SNLS
- Add NIR from VISTA VIDEO survey
- Factor ~10x statistics vs. current samples



# Photometric Redshifts

- Measure relative flux in multiple filters: track the 4000 Å break
- Estimate individual galaxy redshifts with accuracy  $\sigma(z) < 0.1$  ( $\sim 0.02$  for clusters)
- Precision is sufficient for Dark Energy probes, provided error distributions well measured.





# Galaxy Photo-z Simulations

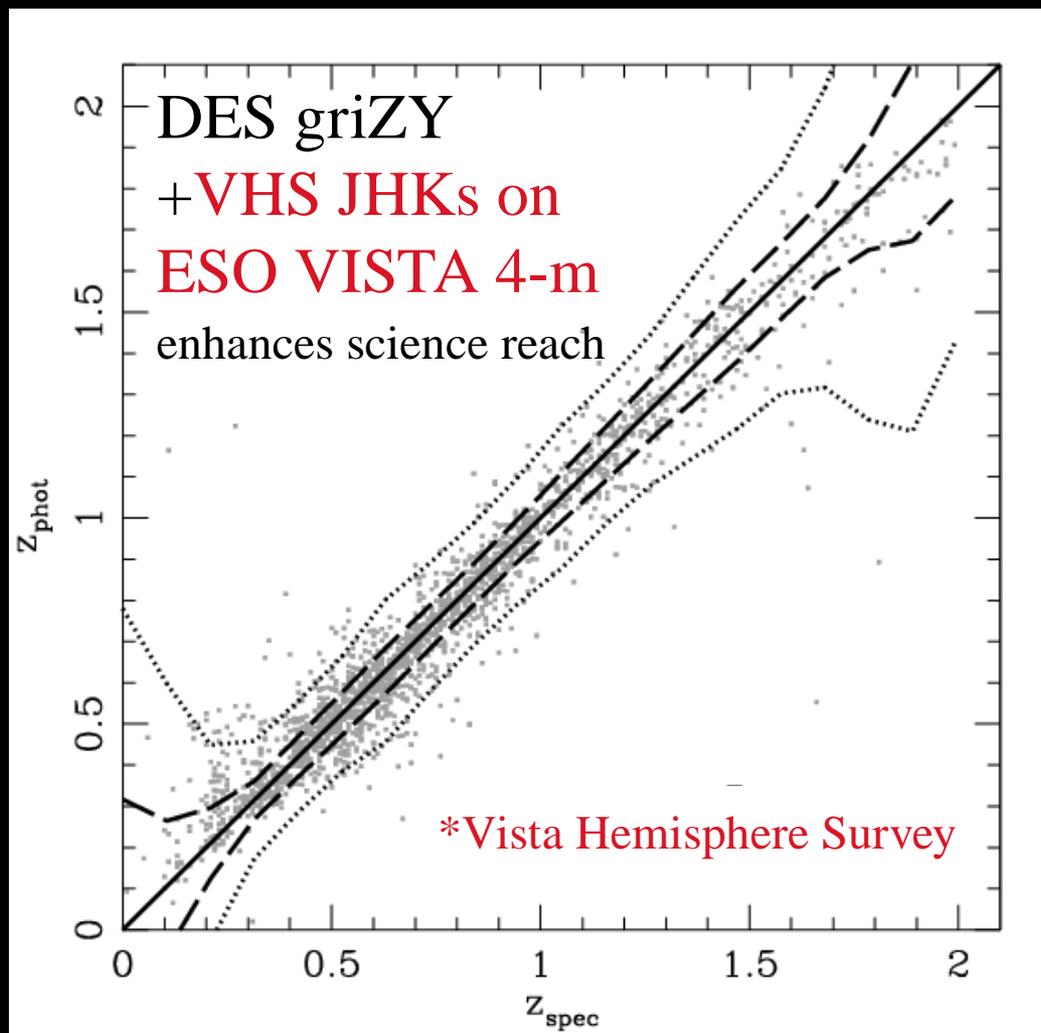
## DES + VHS\*

$10^\circ$  Limiting Magnitudes

g	24.6	
r	24.1	
i	24.0	J 20.3
z	23.8	H 19.4
Y	21.6	Ks 18.3

+2% photometric calibration error added in quadrature

Spectroscopic training sets comparable to DES depth exist



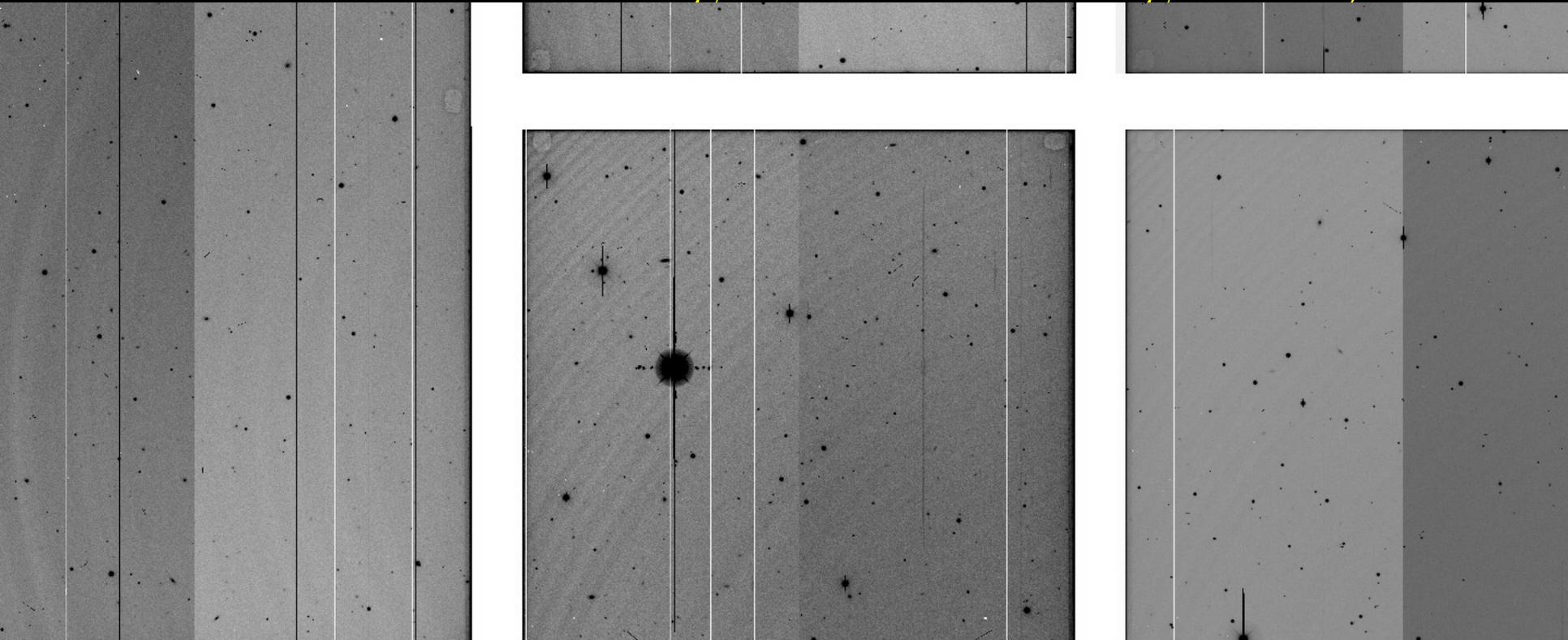


# DECam Image Simulations



# DECam Image Simulations

Series of Data Challenges to test Data Management System



- Note bright star artifacts, cosmic rays, cross talk, glowing edges, flatfield (“grind marks”, tape bumps), bad columns, 2 amplifiers/CCD.
- Working groups analyze DM outputs  $\Rightarrow$  feedback to pipeline



# Conclusion

- DES is poised to take the next step in understanding the nature of dark energy, with installation and commissioning later this year, survey operations starting next year.
- DES data will be available to the public 12 months after it's taken (raw and processed images), with periodic releases of co-added images and catalogs.
- DECam, with its associated Community Pipeline, will be a powerful imaging instrument for community use: Splinter Session today at 5:30 pm.