

# The Dark Energy Survey

<http://www.darkenergysurvey.org>



**Bob Nichol (University of Portsmouth)**

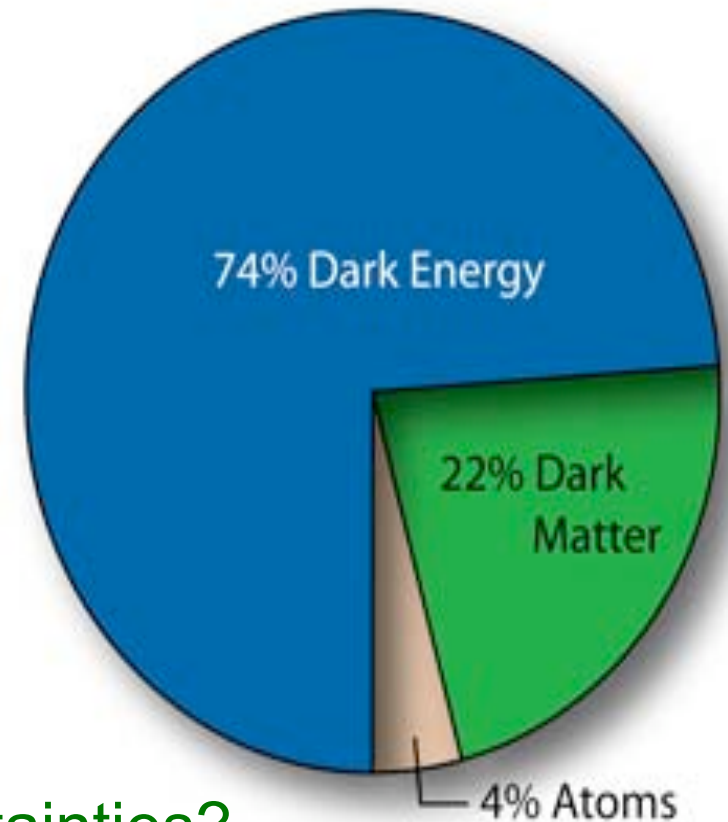
# My one slide on Dark Energy!

Strong evidence for “something” (last decade)

- Type Ia Supernovae
- Cosmic Microwave Background
- Large Scale Structure (BAO & ISW)
- Gravitational Lensing

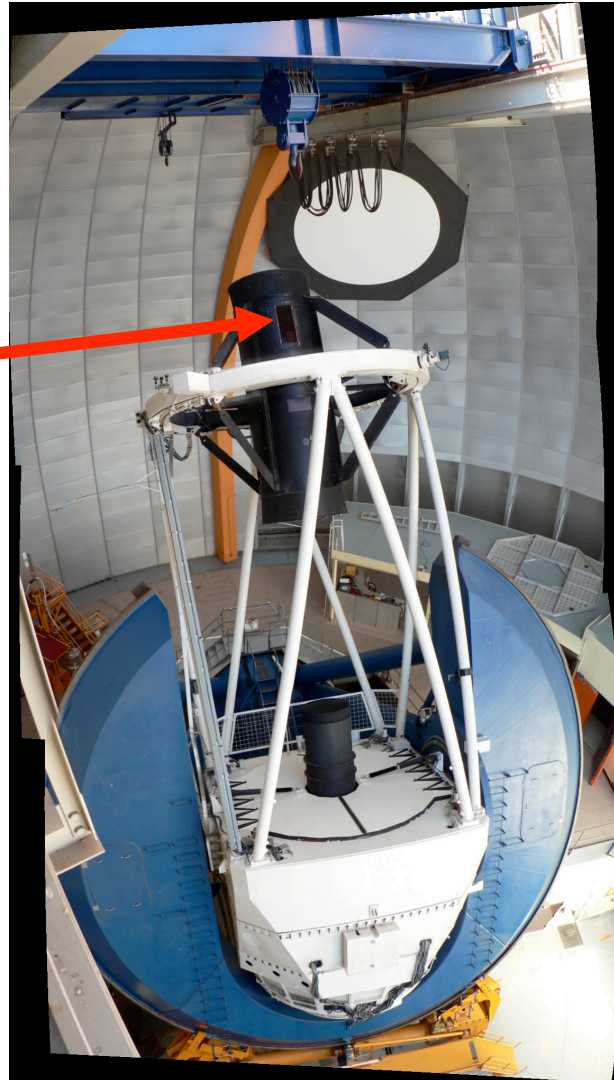
Critical questions (next decade)

- Is  $w(z) = -1$  ?
- Is there curvature? Non-gaussianity?
- Is GR sufficient on large scales?
- Can we control the systematic uncertainties?



# Dark Energy Survey (DES)

- **Proposal:**
  - Perform a 5000 sq. deg. survey of the southern galactic cap
  - Measure dark energy with 4 complementary techniques
- **New Instrument:**
  - Replace the PF cage with a new 3deg FOV, 520 Mega pixel optical CCD camera + corrector
- **Time scale:**
  - Instrument Construction 2008-2011
- **Survey:**
  - 525 nights during Oct.– Feb. 2011-2016



Use the Blanco  
4m Telescope  
at the Cerro Tololo  
Inter-American  
Observatory (CTIO)

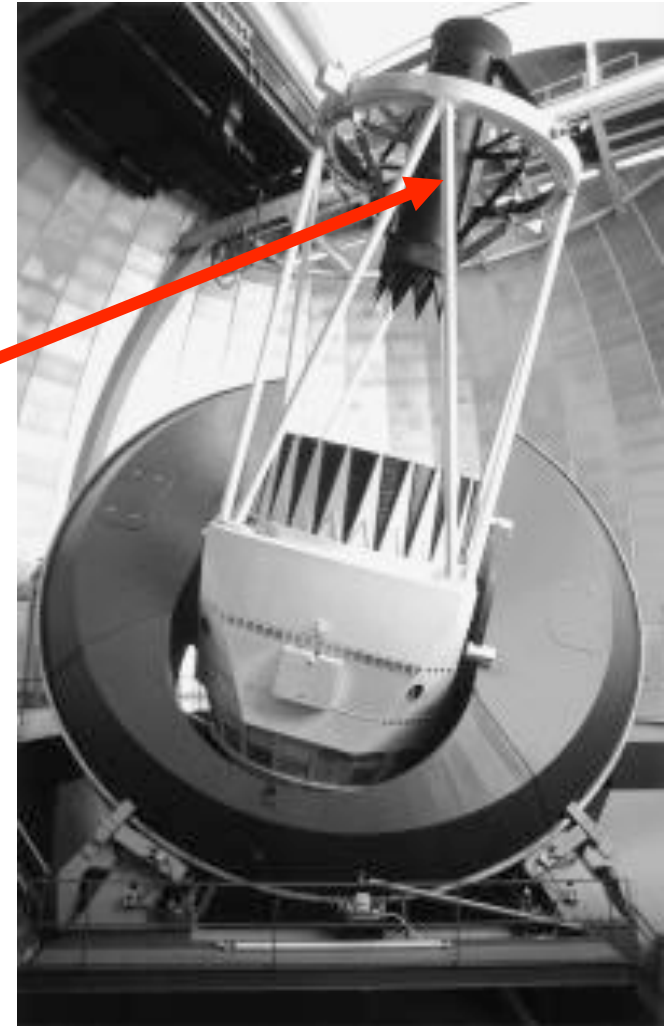
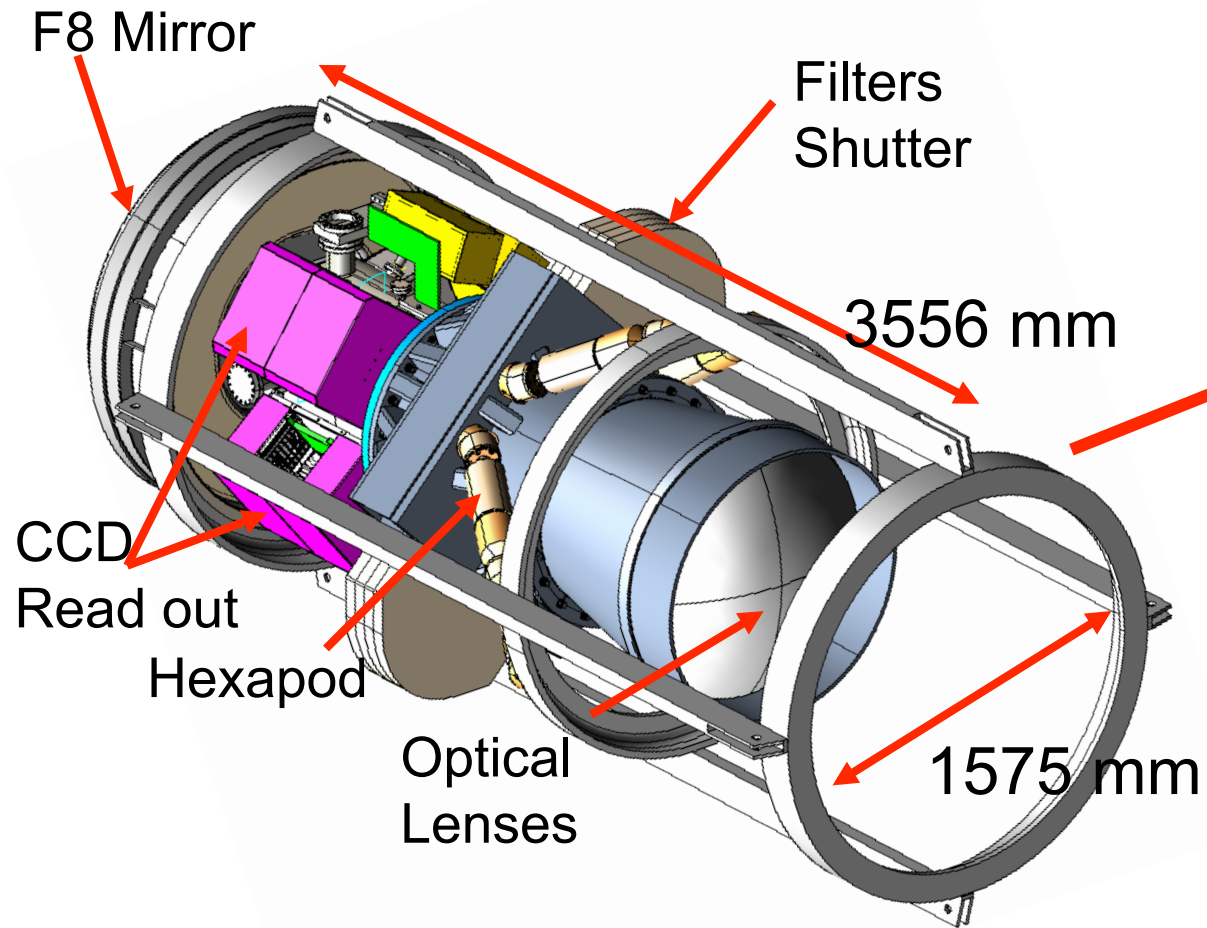
# DES Participating Institutions

- **Fermilab**
- **University of Illinois at Urbana-Champaign**
- **University of Chicago**
- **Lawrence Berkeley National Laboratory**
- **University of Michigan**
- **NOAO/CTIO**
- **Spain-DES Collaboration:**  
Institut d'Estudis Espacials de Catalunya (IEEC/ICE), Institut de Fisica d'Altes Energies (IFAE), CIEMAT-Madrid:
- **United Kingdom-DES Collaboration:**  
University College London, University of Cambridge, University of Edinburgh, University of Portsmouth, University of Sussex
- **The University of Pennsylvania**
- **Brazil-DES Consortium**
- **The Ohio State University**
- **Argonne National Laboratory**

**12 participating institutions and >100 participants**

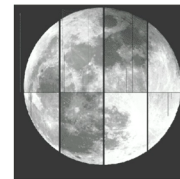
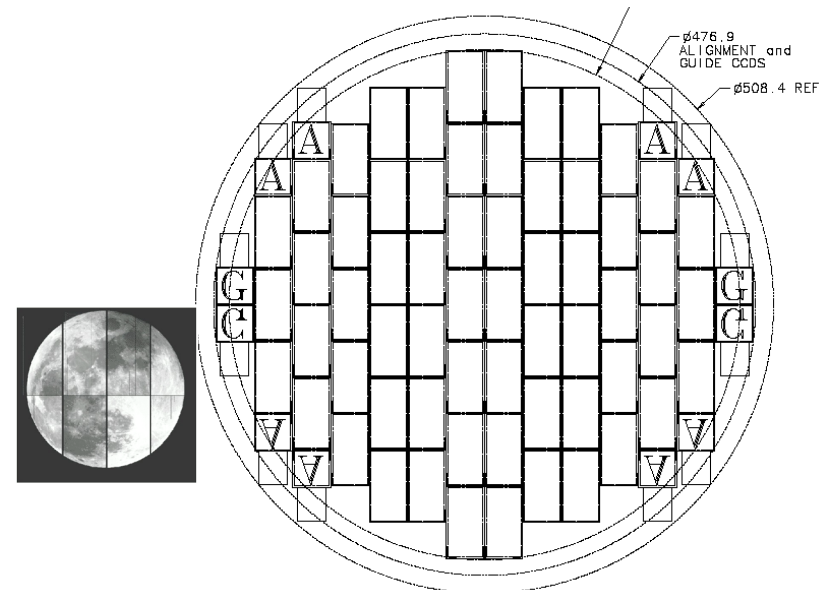
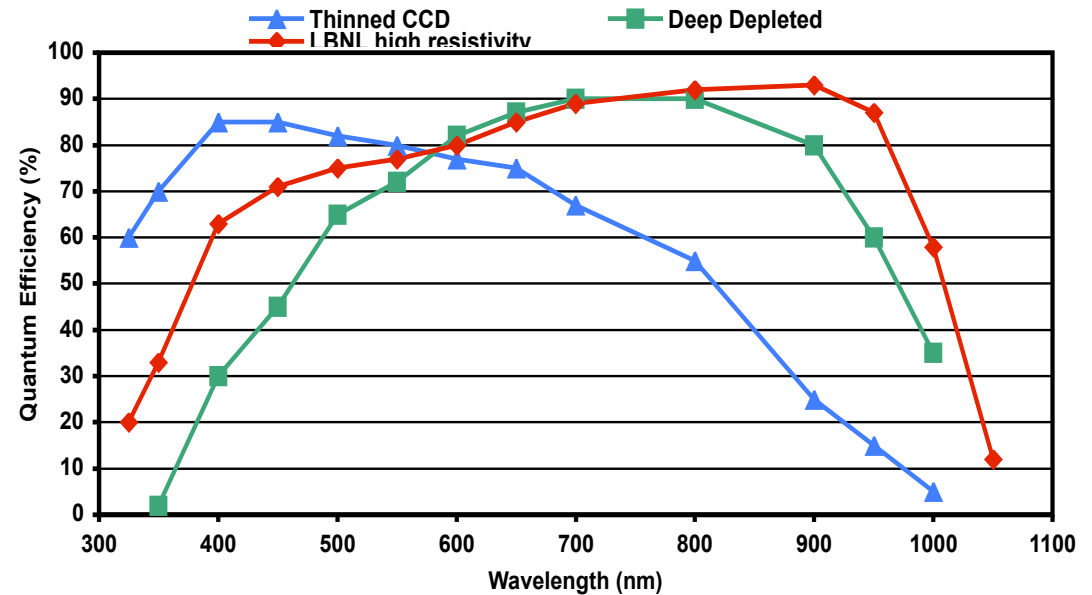
DES Funding from DOE, NSF, STFC (UK), Ministry of Education and Science (Spain), FINEP (Brazil), and the Collaborating Institutions

# The DES Instrument: DECam

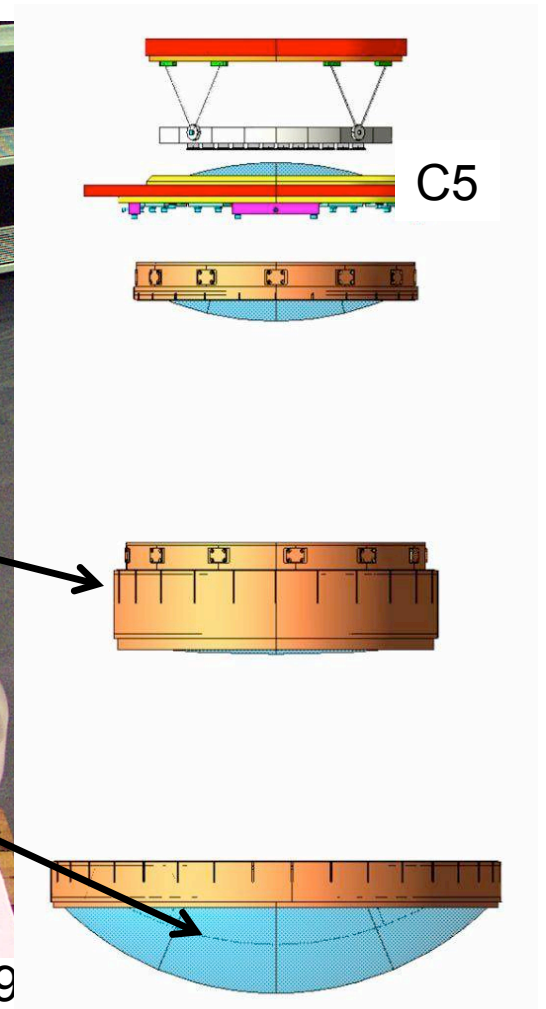
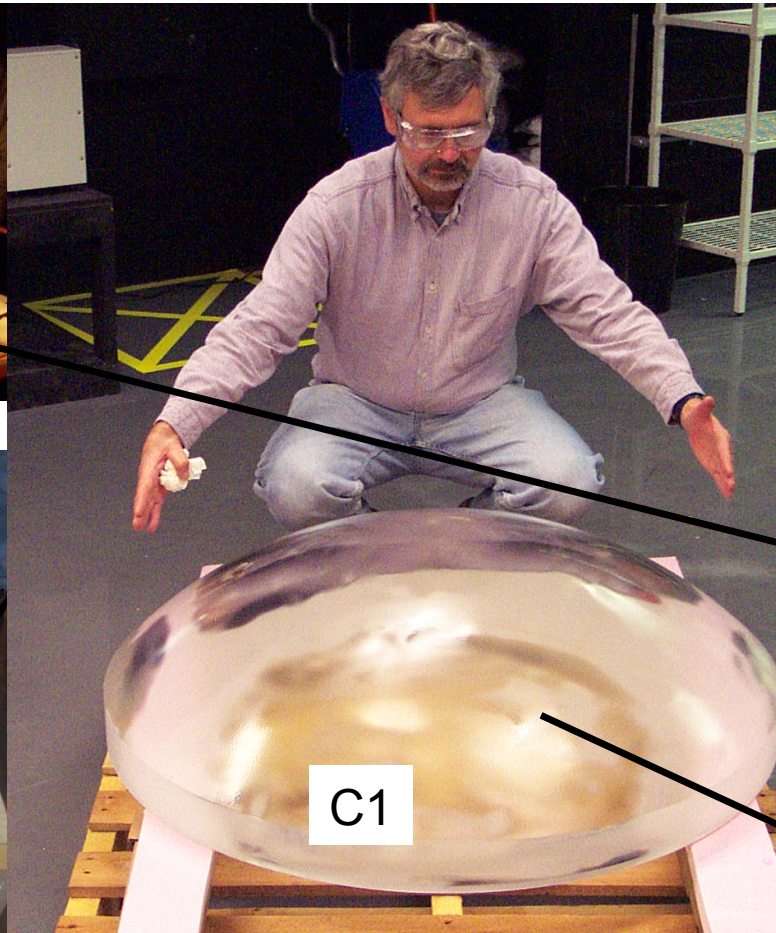


# DES CCDs

- 62 2kx4k fully depleted CCDs  
*520 Megapixels*
- Excellent red sensitivity
- Developed by LBNL



# Five lenses are now being polished & coated at SESO



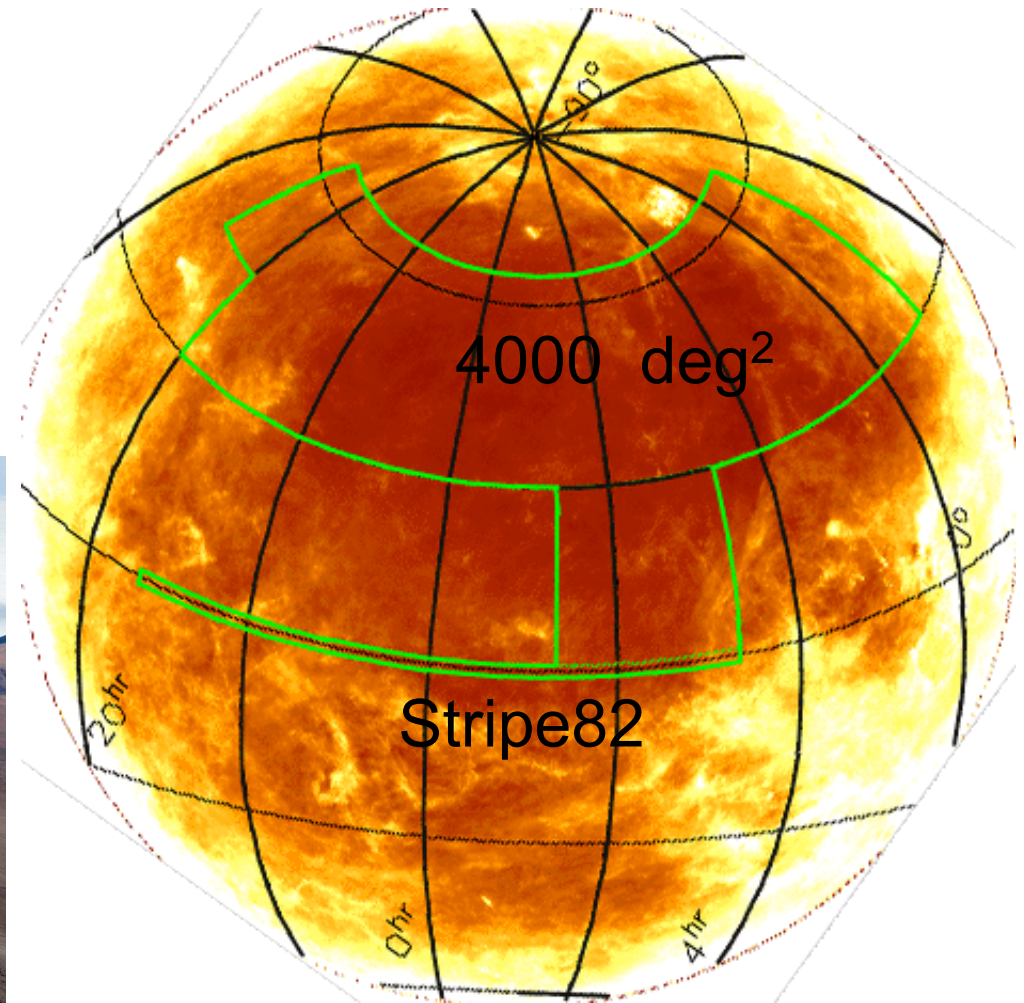
To be delivered Dec 09  
by UCL (with STFC funding)

# The Surveys

- Two multi-band surveys
  - 5000 deg<sup>2</sup>  $g, r, i, z, Y$   $r < 24$
  - ~20 deg<sup>2</sup> repeat (SNe)
  - 300,000,000 photometric redshifts within a volume of 23 (Gpc/h)<sup>3</sup>, out to  $z \sim 1.5$



Synergy with VISTA (VHS)





# DES+VISTA(8 filters)

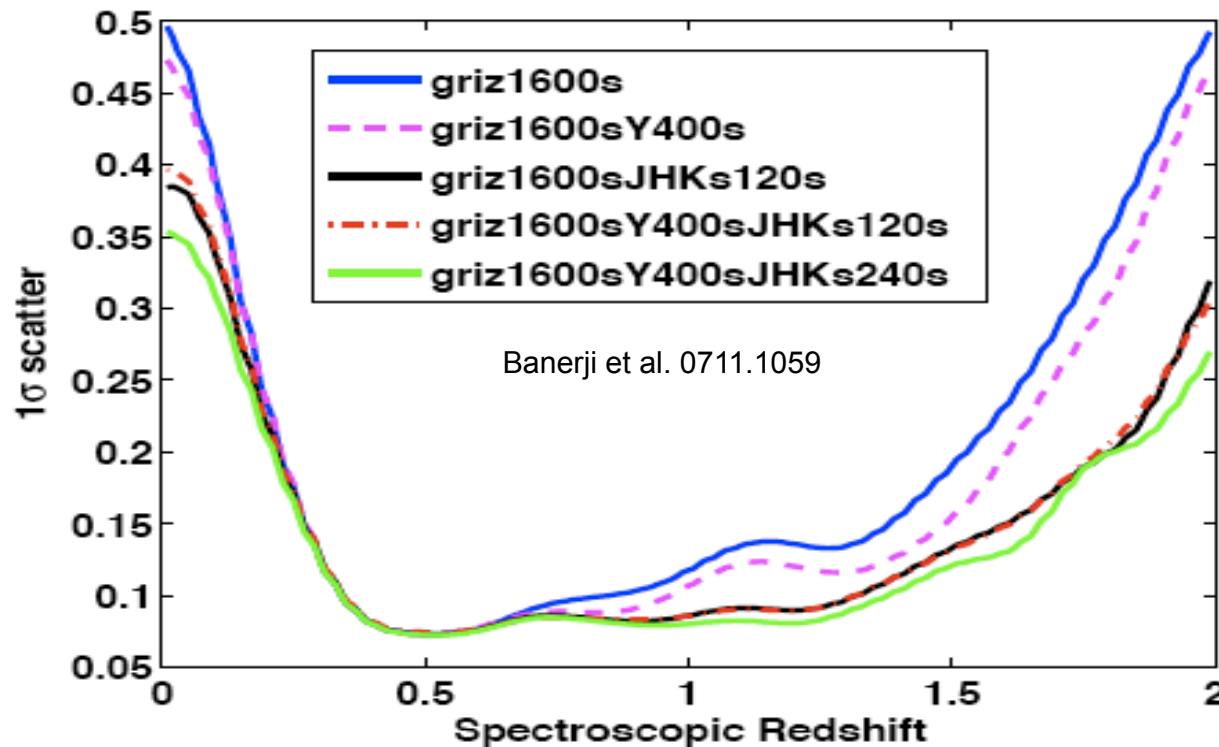


Photo-z  
with  
ANNz

*DES+VISTA would improve photo-z by a factor of 2 for  $z > 1$*

$$(\delta w / w) = 5 (\delta z / z) = 5 (\sigma_z / z) N_s^{-1/2}$$

photo-z scatter  $\sigma_z$  dictate the number of required spectroscopic redshifts eg.  $N_s = 10^5 - 10^6$

# DES Forecast Constraints

Method	$\sigma(\Omega_{DE})$	$\sigma(w_0)$	$\sigma(w_a)$	$z_p$	$\sigma(w_p)$	DETF FoM
						$[\sigma(w_a)\sigma(w_p)]^{-1}$
BAO	0.010	0.097	0.408	0.29	0.034	72.8
Clusters	0.006	0.083	0.287	0.38	0.023	152.4
Weak Lensing	0.007	0.077	0.252	0.40	0.025	155.8
Supernovae	0.008	0.094	0.401	0.29	0.023	107.5
Combined DES	0.004	0.061	0.217	0.37	0.018	263.7
DETF Stage II Combined	0.012	0.112	0.498	0.27	0.035	57.9

Table 1: 68% CL marginalized forecast errorbars for the 4 DES probes on the dark energy density and equation of state parameters, in each case including Planck priors *and* the DETF Stage II constraints. The last column is the DETF FoM;  $z_p$  is the pivot redshift. Stage II constraints used here agree with those in the DETF report to better than 10%.

- DES+Stage II combined = **Factor 4.6 improvement** over Stage II combined
- Systematics remain!

# Clusters: Synergy with SPT

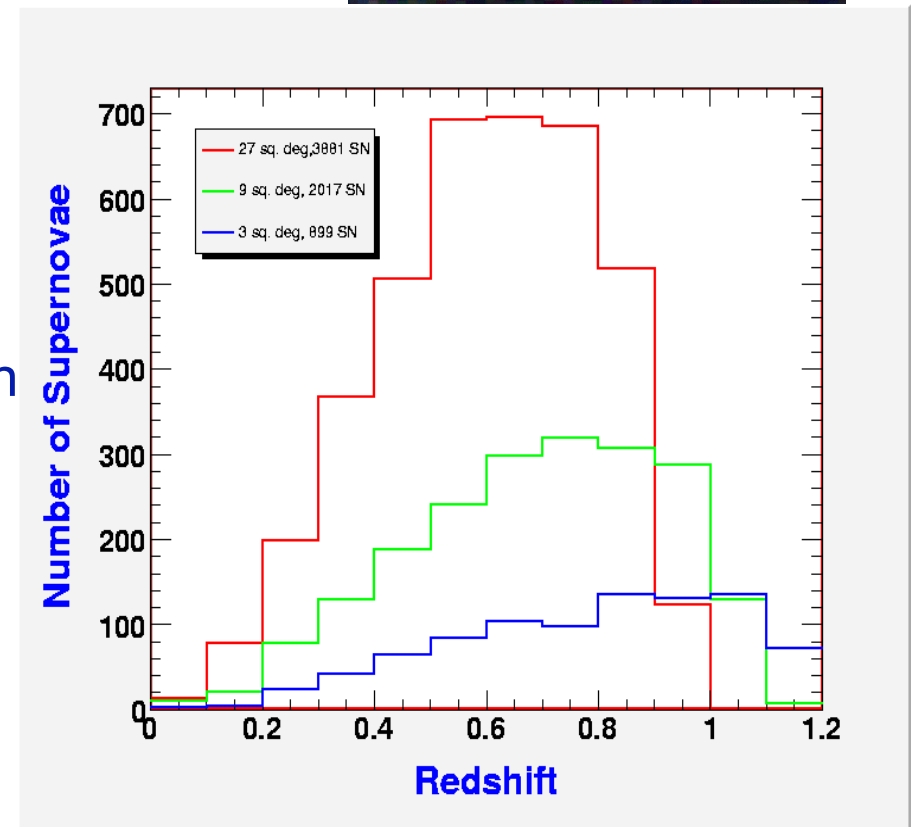


- 10m, bolometer array (150, 250, 270 GHz)
- Detect  $\sim 10,000$  clusters through Sunyaev-Zel'dovich effect
- Measure photo-z's to  $\sim 1.5$
- Mass from optical, SZ and lensing signals

# Supernovae

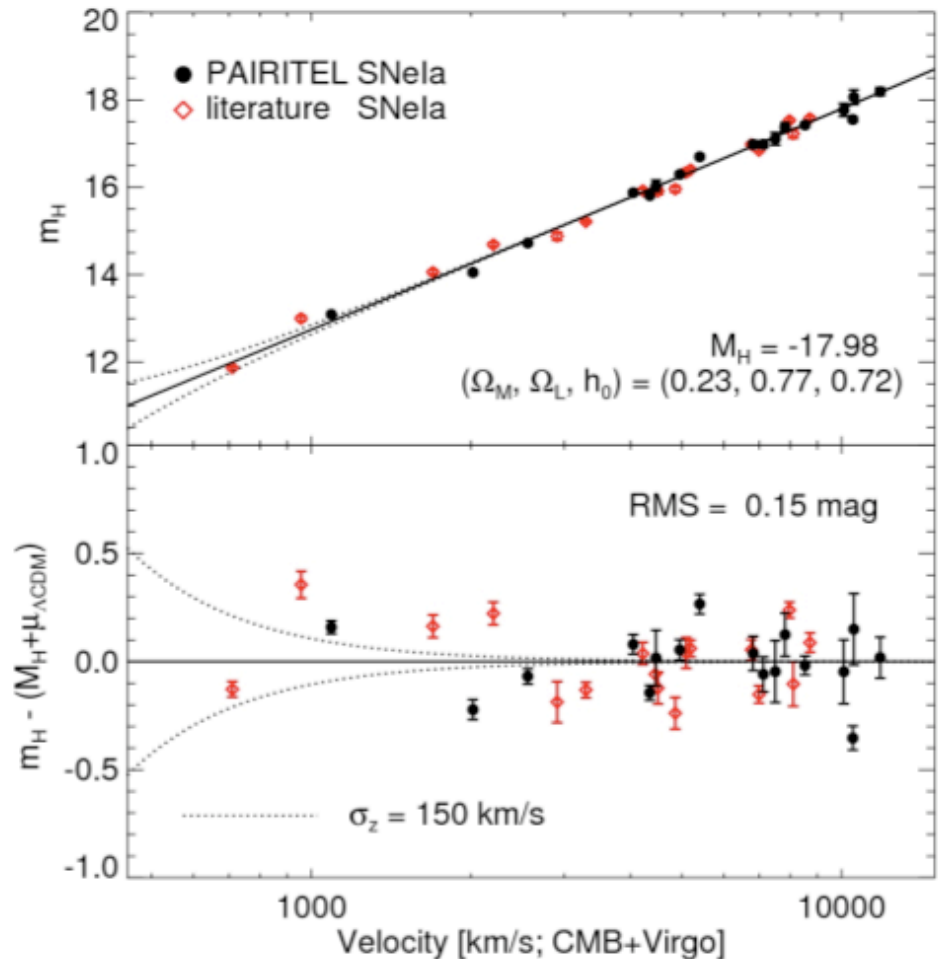


- Use 10% of photometric time, most of the non-photometric time: 5 visits per lunation in *riz*
- ~900-4000 well-measured SN Ia lightcurves to  $z \sim 1$
- Improved z-band response (fully depleted CCDs) reduces dependence on rest-frame *u*-band and Malmquist bias
  - SDSS *u*-band anomaly changes *w* by -0.4! (Lampeitl et al. 2009; Kessler et al. 2009)
- Spectroscopic follow-up of SN subsample+host galaxies (LBT, Magellan, Gemini, Keck, VLT,...) e.g., focus on ellipticals (low dust extinction)



# SNe Systematics: Color & Dust

- Better to probe rest-frame red (i-band) or IR (YJHK)
- Interesting synergy with VIDEO
  - Will target same field
  - Could sync obs to get IR colors for ~6deg<sup>2</sup>
  - ~200 SNIa's to z~0.5 with restframe Y-band



Wood-Vasey et.al 2008

# DES Status

- Low-risk, near-term (2011-16) project with high discovery potential
  - Survey strategy delivers substantial DE science after 2 years
  - Synergy with SPT and VISTA (VHS and VIDEO)
  - Science collaboration now formed and working on final survey strategies and data challenges (>100 scientists)
  - Total cost is relatively modest (~ \$30M)
- 
- ❖ DES in the US President budget request for FY08, FY09
  - ❖ DOE approved for CD3a (last one)
  - ❖ NSF contribution to data management
  - ❖ International contributions in science and hardware

# Summary

- Dark Energy constraints to a few % level through the combination of methods. Focus on the systematics!
- Observations to start 2011 and surveys done by 2016 (before LSST/Euclid)
- Construction underway and on schedule
- Science teams working hard with final strategies