The Dark Energy Survey http://www.darkenergysurvey.org





Ofer Lahav University College London



"I have now explained the TWO principle cases of attraction... which is very remarkable" Isaac Newton, Principia (1687)

Lucy Calder & OL A&G Feb 08 issue http://www.star.ucl.ac.uk/~lahav/CLrev.pdf (revised)

Planned photometric and spectroscopic surveys

Survey	Depth (man an addition)	Area	Imaging Filters/	Schedule
	(mag or redshift)	(sq deg)	Spectra Resolution	
KIDS(+Viking)	r' < 24.4	1500	ugri ZYH	2008-2013
DES(+VHS)	r < 24	5000	grizYJHK	2011-2016
Pan-STARRS1	r < 24	15000	grizY	2008-2012
Pan-STARRS4	r < 25.6	30000	grizY	2012-2017
Hyper-Suprime	r < 25	2000	BVRiz	2011-2016
Skymapper	g < 22.9	15000	Uvgriz	2008-2011
PAU	i < 23	8000	50 narrow bands	2010-2015
LSST	g< 26	30000	Ugriz	2014-2014
SNAP	R<28.3	4000	9 visible and IR	2015-2021
Euclid-	(RIZ)<24.5	20000	(RIZ)+YJH	2017-
Photometric				2020
WiggleZ	r< 22.5 (+ UV)	1000	~400	2006-2009
BOSS (SDSS3)	r <20 (LRG)	10000	2000	2009-2014
Hetdex	1.8 <z<3.8< td=""><td>200</td><td>850</td><td>2009-2009</td></z<3.8<>	200	850	2009-2009
WFMOS z=1	R_ab<22.7	2000	5000	2011-2016
WFMOS z=3	R_ab<24.5	300		2011-2016
SNAP	0.3 <z<1.7< td=""><td>4000</td><td>~200</td><td>2015-2021</td></z<1.7<>	4000	~200	2015-2021
ADEPT	z>0.8	2000		2015
SKA	z<1.5	20000		2020
Euclid- Spectroscopic	z<2.1	20000	400	2017- 2020

The 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 2.2 FOV, 520 Mega pixel optical CCD camera + corrector
- Time scale:
 - Instrument Construction 2008-2011
- Survey:
 - 525 nights during
 Oct.–Feb. 2011-2016
 - Area overlap with SPT SZ survey and VISTA VHS





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 Dark Energy Survey

- Study Dark Energy using
 - 4 complementary techniques:
 - I. Cluster Counts
 - II. Weak Lensing III. Baryon Acoustic Oscillations
 - IV. Supernovae
- Two multi-band surveys
 5000 deg² g, r, i, z, Y r < 24
 40 deg² repeat (SNe)

300,000,000 photometric redshifts within a volume of 23 (Gpc/h)^3, out to z = 2





New Study Groups:

Combined Probes, Strong Lensing, Galaxy Evolution, MW Archeology, QSOs

The 5 lenses are now being polished





Polishing & coating coordinated by UCL (with STFC funding)

DECam

- To meet the DES science requirements, within the allocated time period DECam must have:
 - 3 sq. deg. field of view
 - excellent image quality
 - red sensitive CCDs
 - g,r,i,Z,Y filters



62 2kx4k Image CCDs: 520 MPix 8 2kx2k Alignment/focus CCDs 4 2kx2k Guide CCDs

Synergy with VISTA DES recovers V in VISTA!



VISTA Hemisphere Survey (VHS), PI: McMahon

DES Area and Depth: Synergy with South Pole Telescope

- South Pole Telescope (10m, bolometer array, 150, 250, 270 GHz):
 - 4000 sq. deg. survey
 - Detect ~10,000 clusters through Sunyaev-Zel'dovich effect
- Dark Energy Survey: measure photometric redshifts for these clusters to z ~ 1-1.3





Galactic Dust Map

DES Forecasts: Power of Multiple Techniques



FoM factor 4.6 tigther compared to near term projects

Photo-z – Dark Energy cross talk

• Approximately, for a photo-z slice:

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

=> the target accuracy in w and photo-z scatter σ_z dictate the number of required spectroscopic redshifts $N_s = 10^5 - 10^6$

DES (5 filters) vs. DES+VISTA(8 filters)

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

Banerji, Abdalla, OL & Lin 0711.1059

LRG - photo-z code comparison

F. Abdalla, M. Banerji, OL, V. Rashkov, in prep

Comparison of P(k) from two photo-z methods

Comology-halo parameters cross talk (cluster-gal, gal-gal, both)

Growth of structure from low-z SNIa peculiar velocities

$$f = d\ln\delta/d\ln a \approx \Omega_m(z)^\gamma$$

 $\begin{array}{lll} \gamma \ \equiv \ 0.55 & {\rm lcdm} \\ \gamma \ \equiv \ 0.69 & {\rm dgp} \end{array}$

Measured:

$$\gamma = 0.72 \pm 0.21$$

Abate & OL, arXiv:0805.3160

Summary

- * Goal: Dark Energy parameters to a few % level
- •DES: observations to start 2011
- •DES output as input to LSST/JDEM/Euclid
- Non-DE science with DE surveys

 (e.g. Neutrino mass, galaxy evolution,
 MW structure, QSOs)