(A Consumer's Guide to) Future Weak Lensing Surveys

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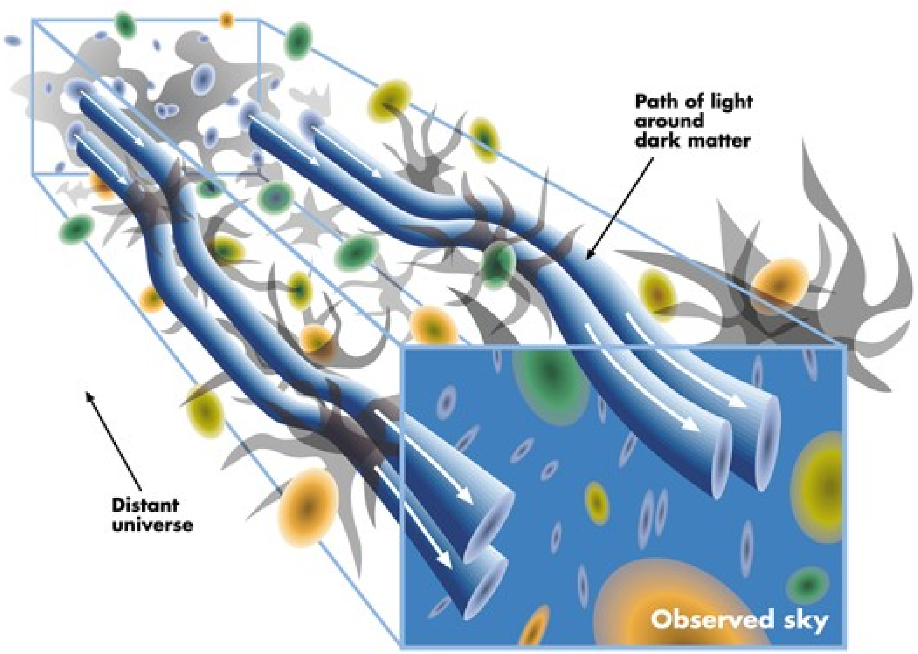
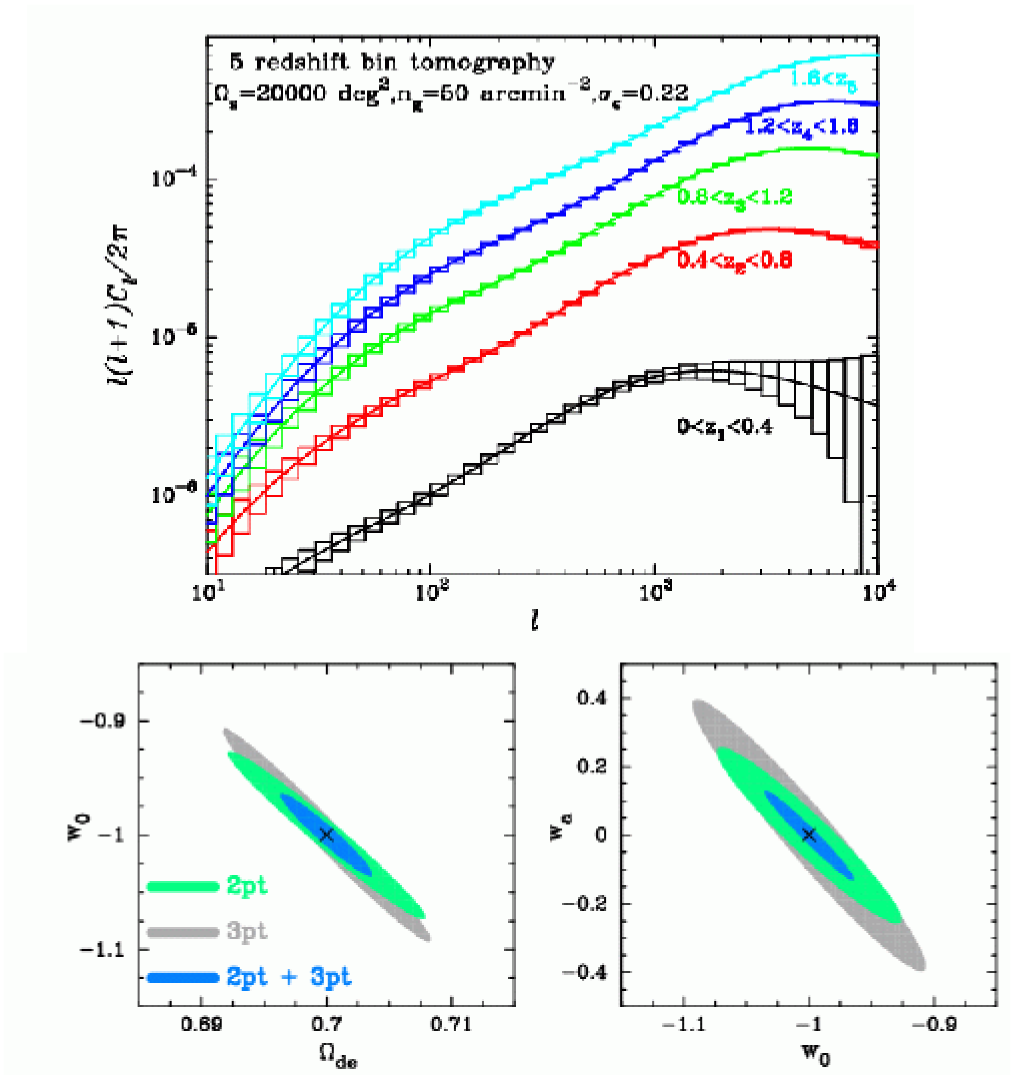
DSU 07

Cosmic Shear

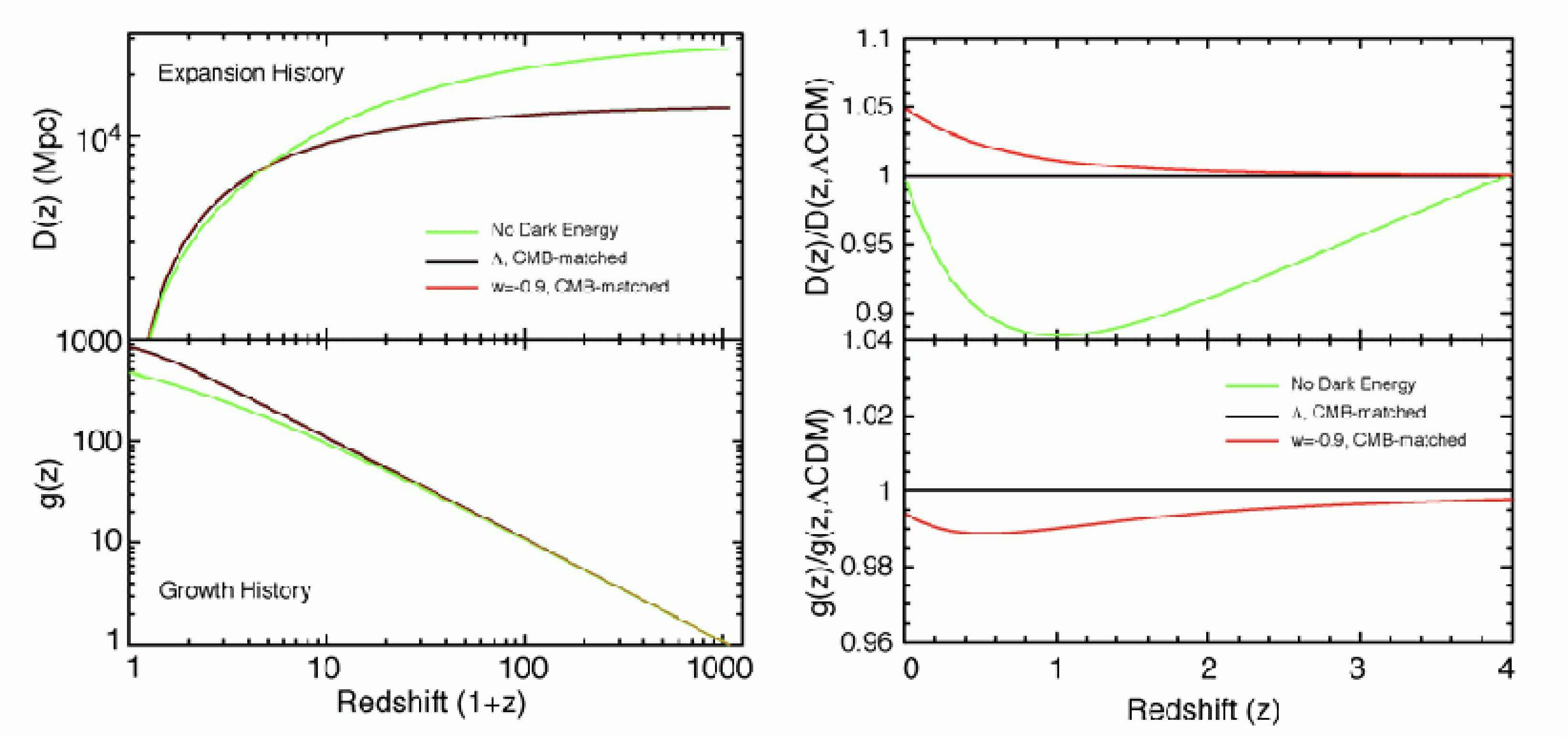


Wittman et al, Nature (2000)



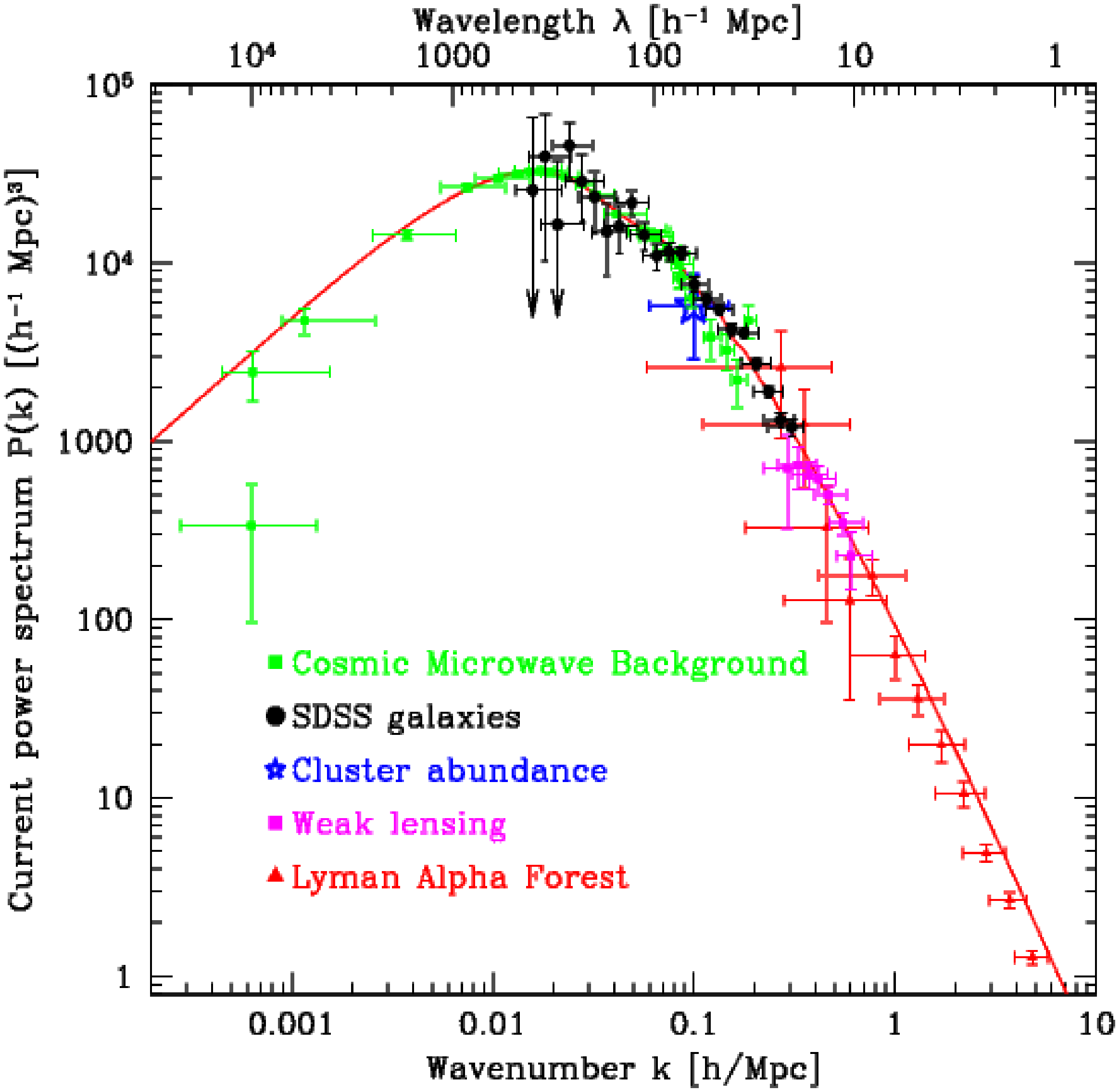
LSST DETF whitepaper

Cosmic Shear Probes
D(z) *and* g(z)



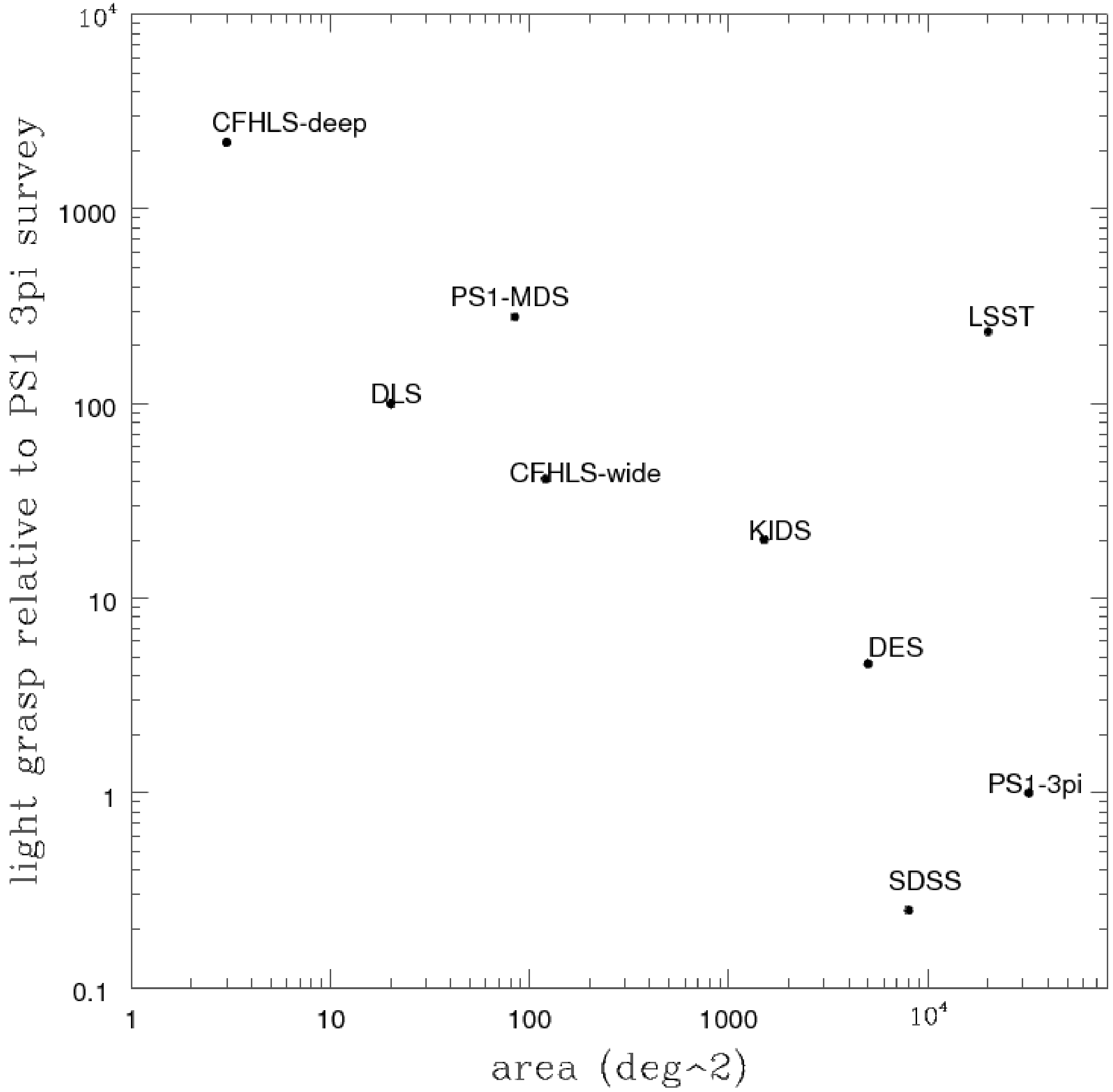
(DETF draft report)

Power Spectrum Probes

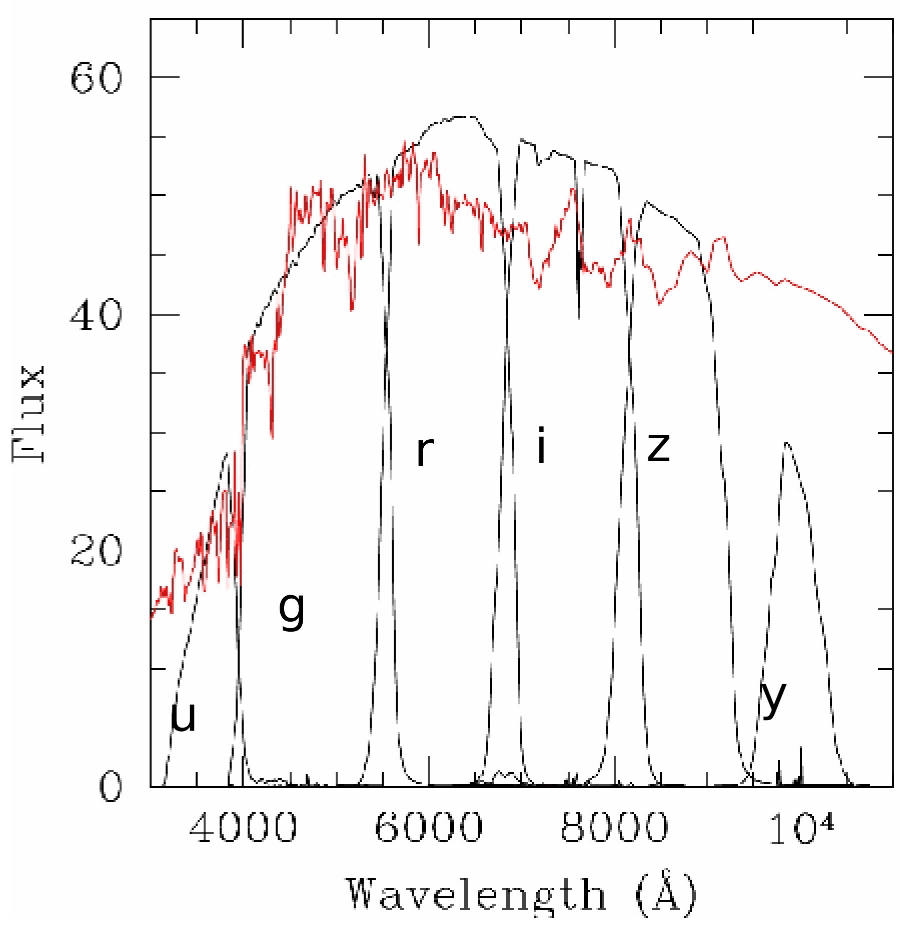


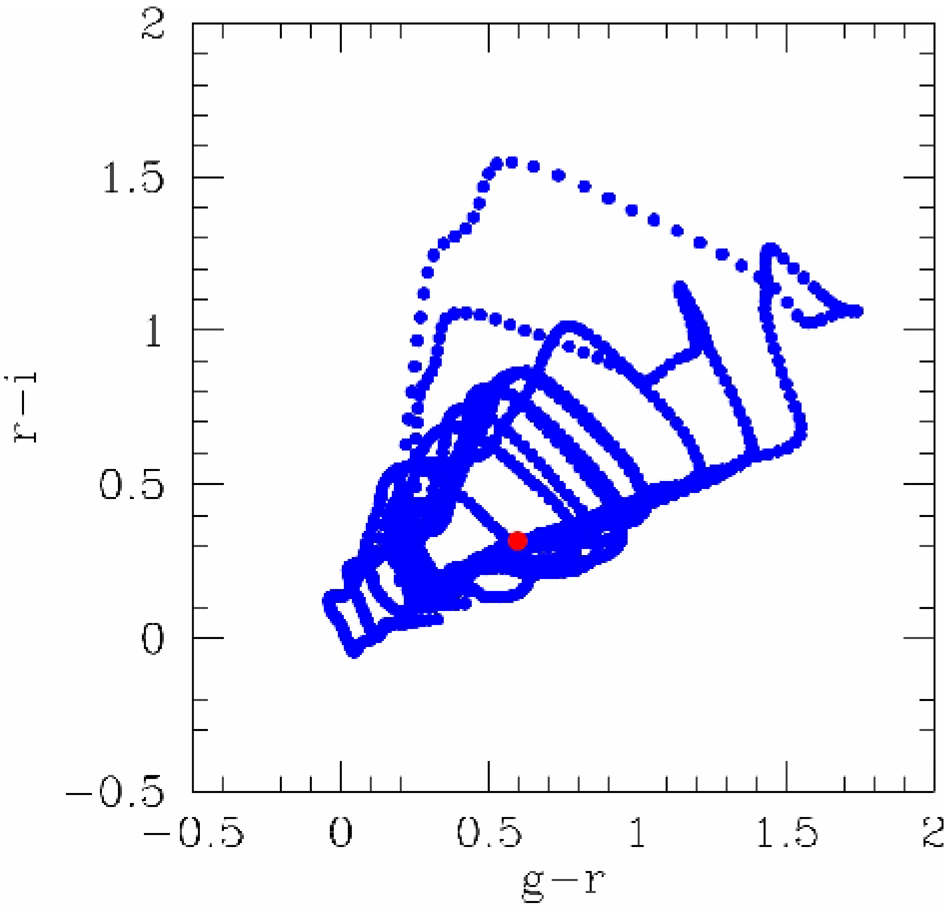
Matter power spectrum: Tegmark et al 2004

Survey Landscape



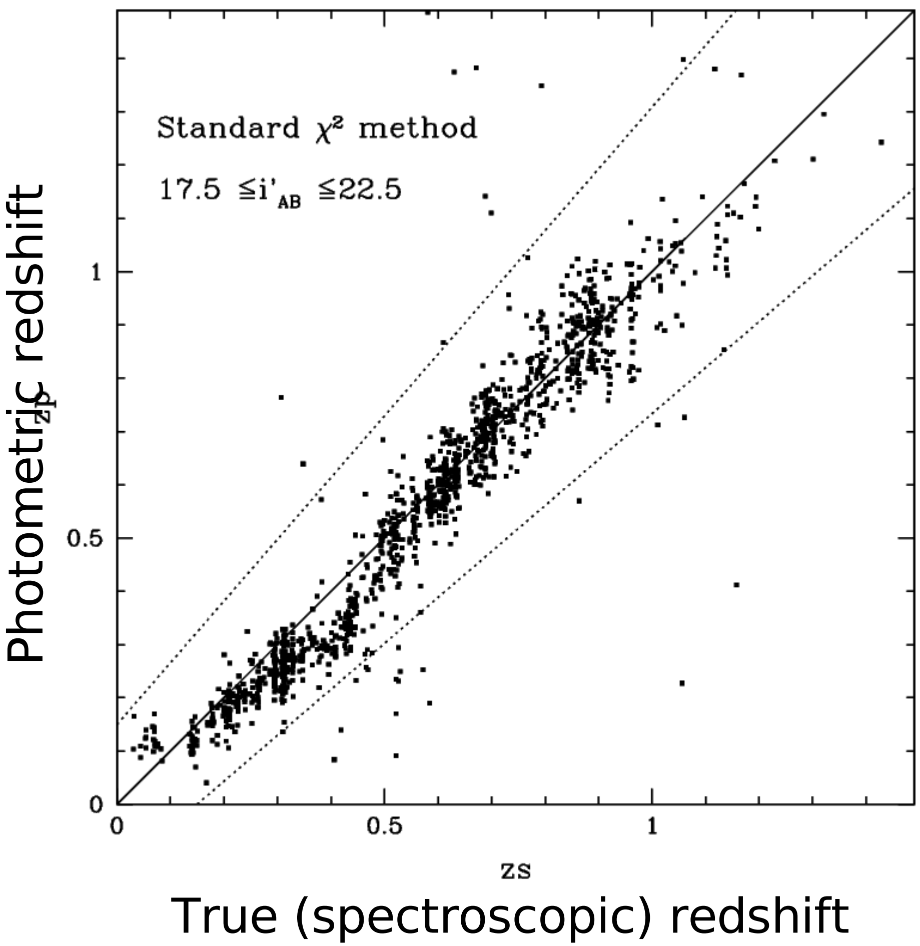
Photometric Redshifts

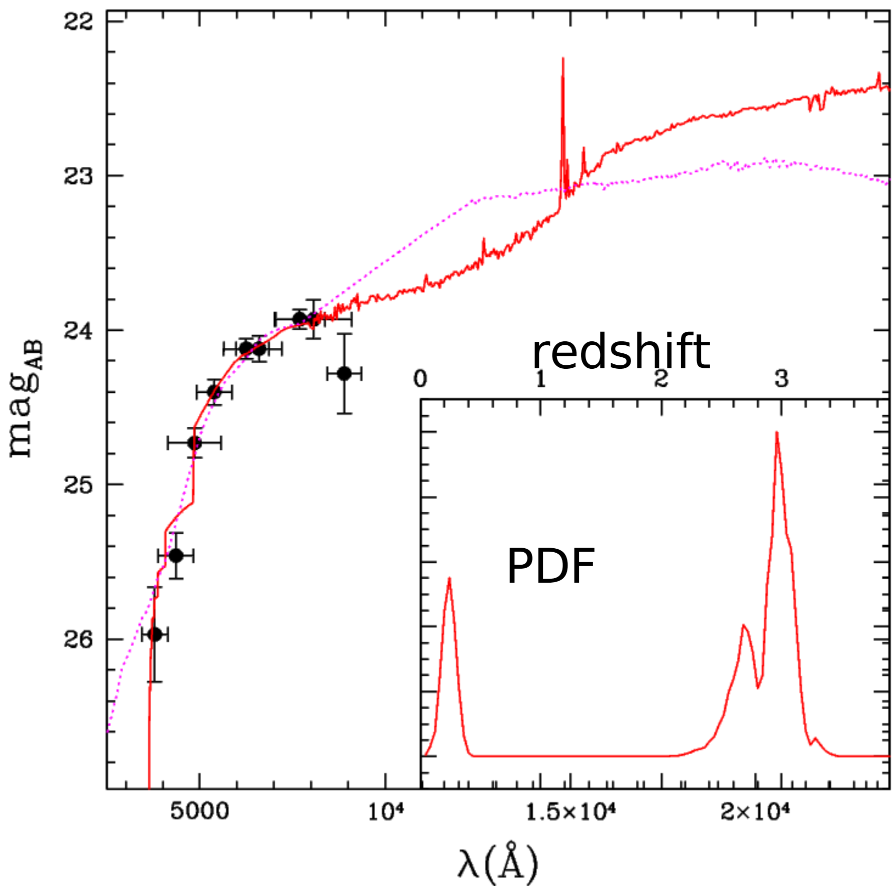




animation at lsst.org

Photometric Redshifts at Work

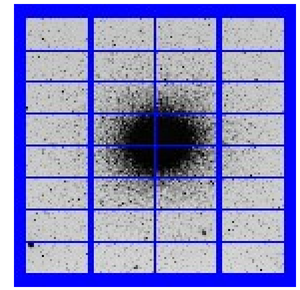


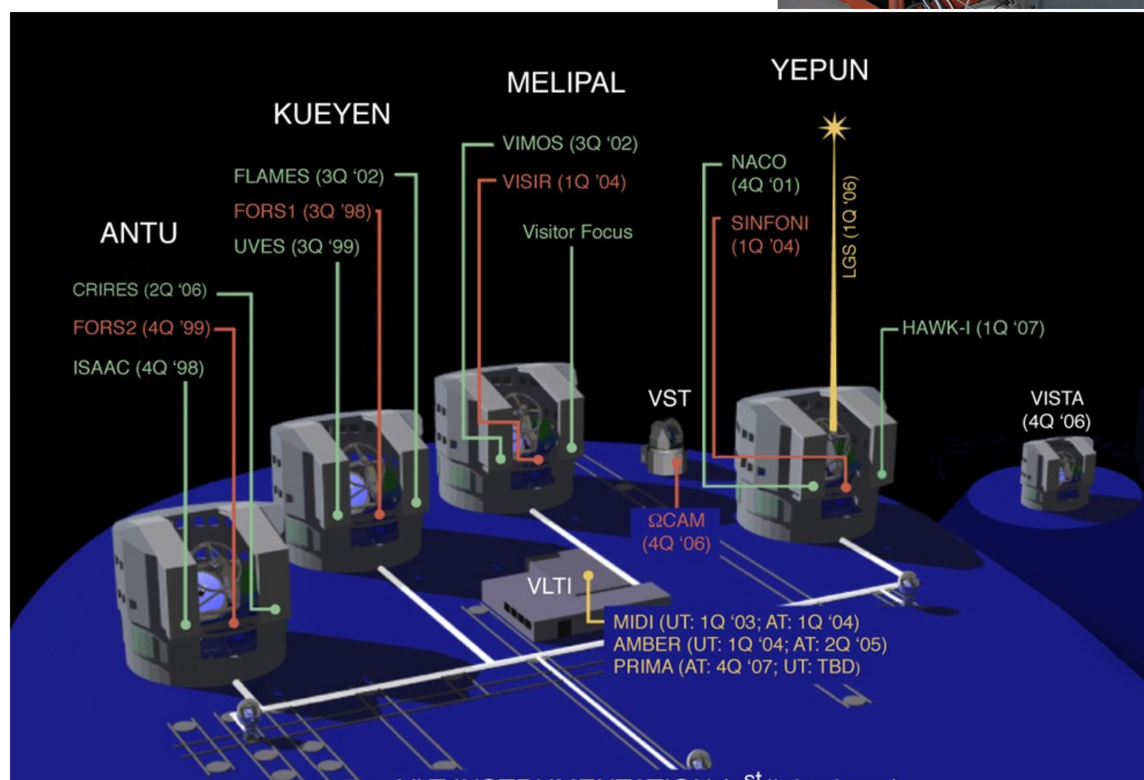


Ilbert et al, astro-ph/0603217

KIDS: Kilo-Degree Survey

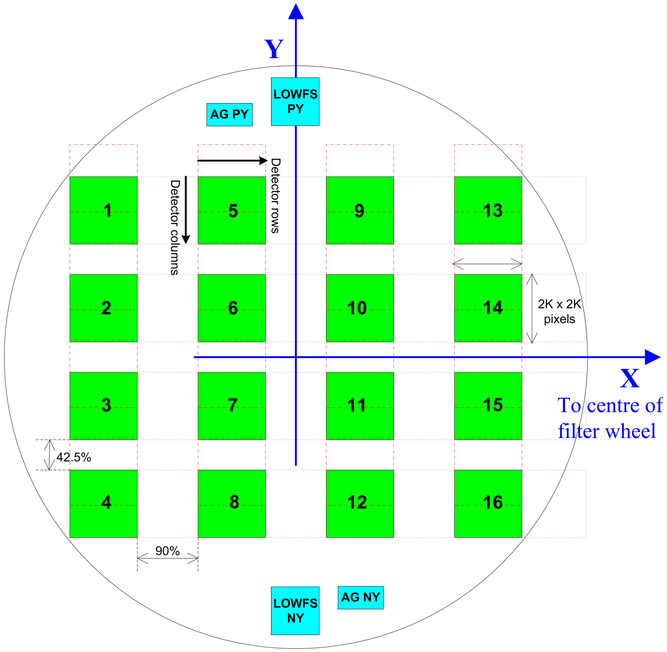
- 1500 deg^2
- 400 nights on VST 2.5m telescope
- OmegaCam: 1 deg^2 CCD camera
- PI: K. Kuijken (Leiden)
- Filter set: ugri+
- 2007-2012





VISTA Telescope

- 4m infrared-dedicated scope
- 0.6 deg^2 sparse camera
- Filter set: zyJHK
- Operation to start in late 2007
- IR component of KIDS



Pan-STARRS (1)

pan-starrs.ifa.hawaii.edu

- 1.8 m telescope
- 7 deg^2 CCD camera
- Filter set: grizy
- 3p survey: 31000 deg^2
- Deep survey: 80 deg^2
- 2007-2011
- Lead Institution: U. Hawaii

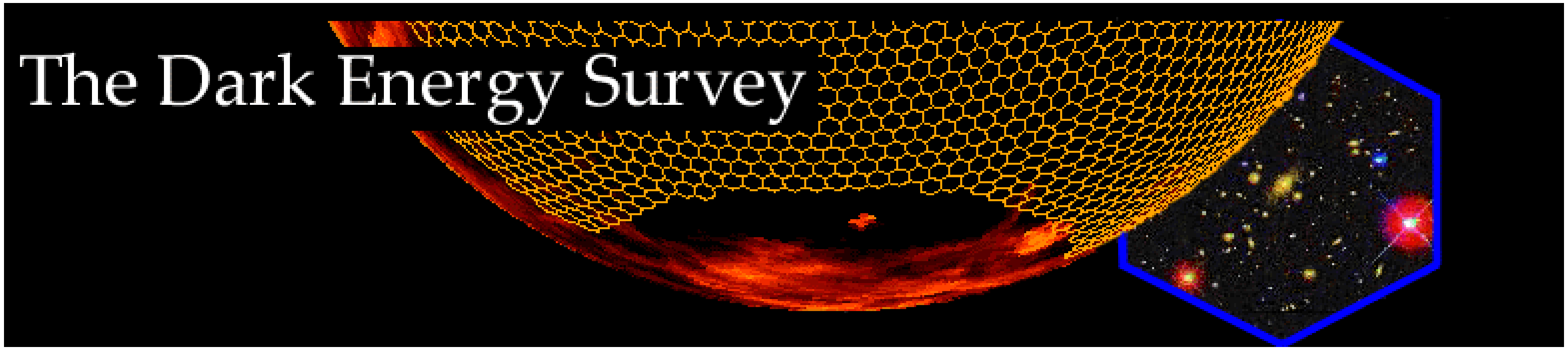
Pan-STARRS (4)

- 4 PS1 units on a common mount
- Possibly Mauna Kea instead of Haleakala
- 2011-?

DES: Dark Energy Survey

darkenergysurvey.org

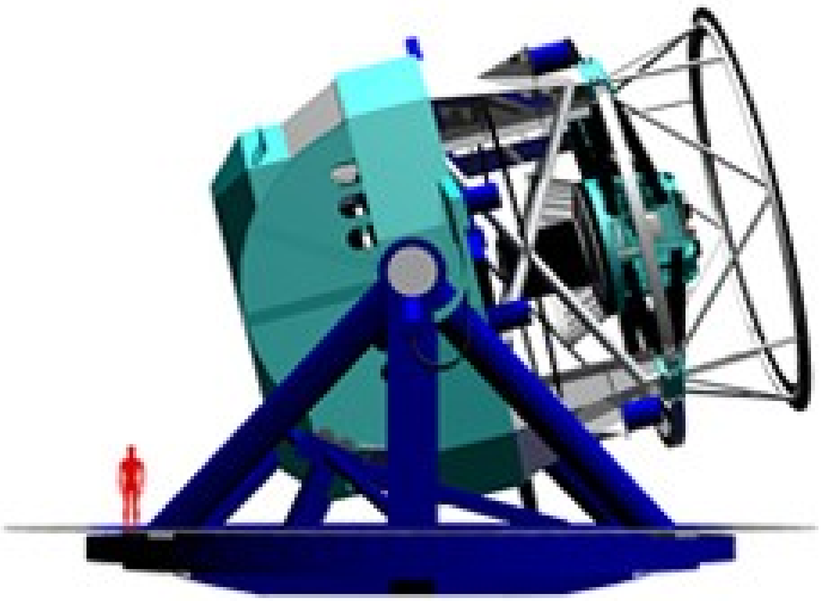
- 4-m refurbished telescope
- 3 deg^2 camera
- 5000 deg^2 survey
- Filter set: griz
- 2009-2013
- Lead Institution: Fermilab

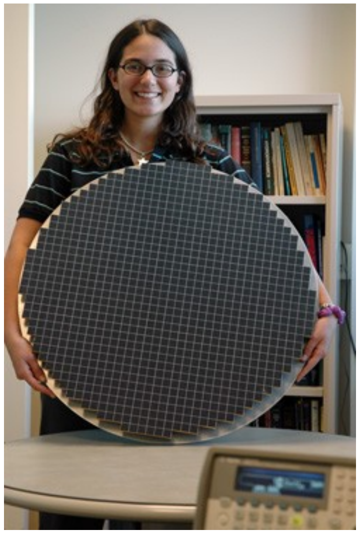


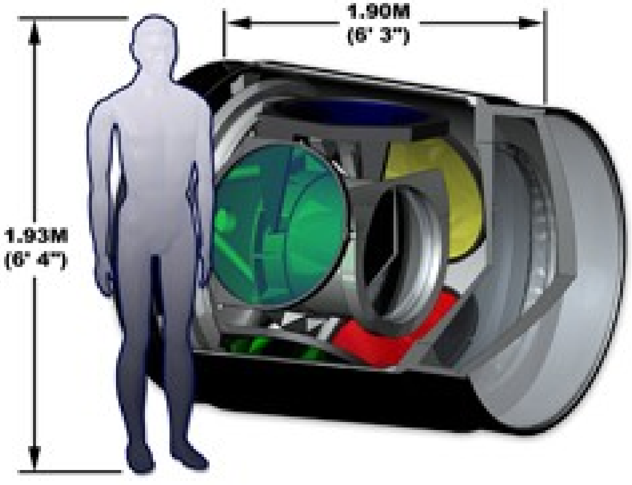
LSST

Large Synoptic Survey Telescope, lsst.org

- 8.4-m telescope
- 10 deg^2 camera
- ~20000 deg^2 survey
- Filter set: ugrizy
- 2013-2023

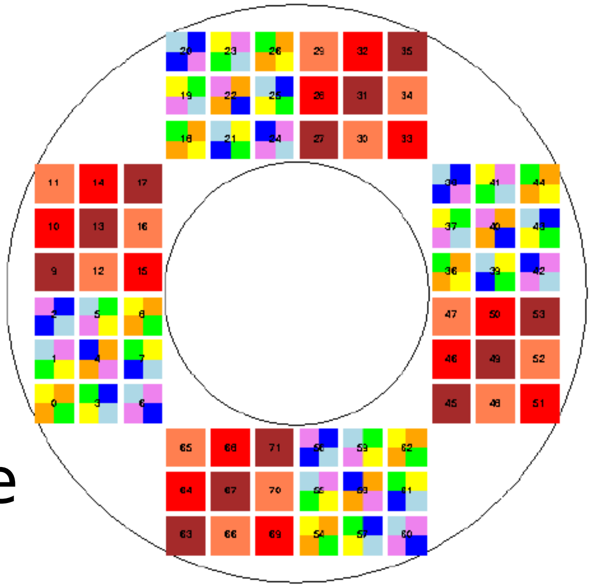






SNAP

Supernova/Acceleration Probe, snap.lbl.gov

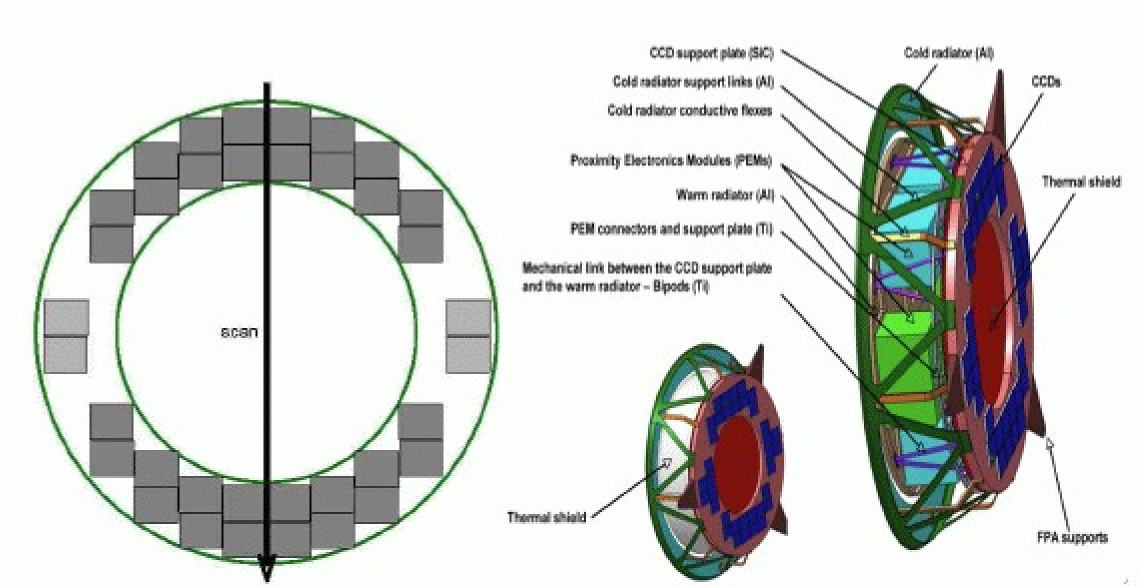


- 2-m *space-based* telescope
- 0.7 deg^2 instrumented (mixed CCD/IR)
- Filters: 9 covering 0.35-1.7 um
- Launch: 2018?, 1st yr dedicated to SNe
- Survey: 1000 deg^2 baseline, expandable
- Lead Institution: LBNL
- Ground/space complementarity

DUNE

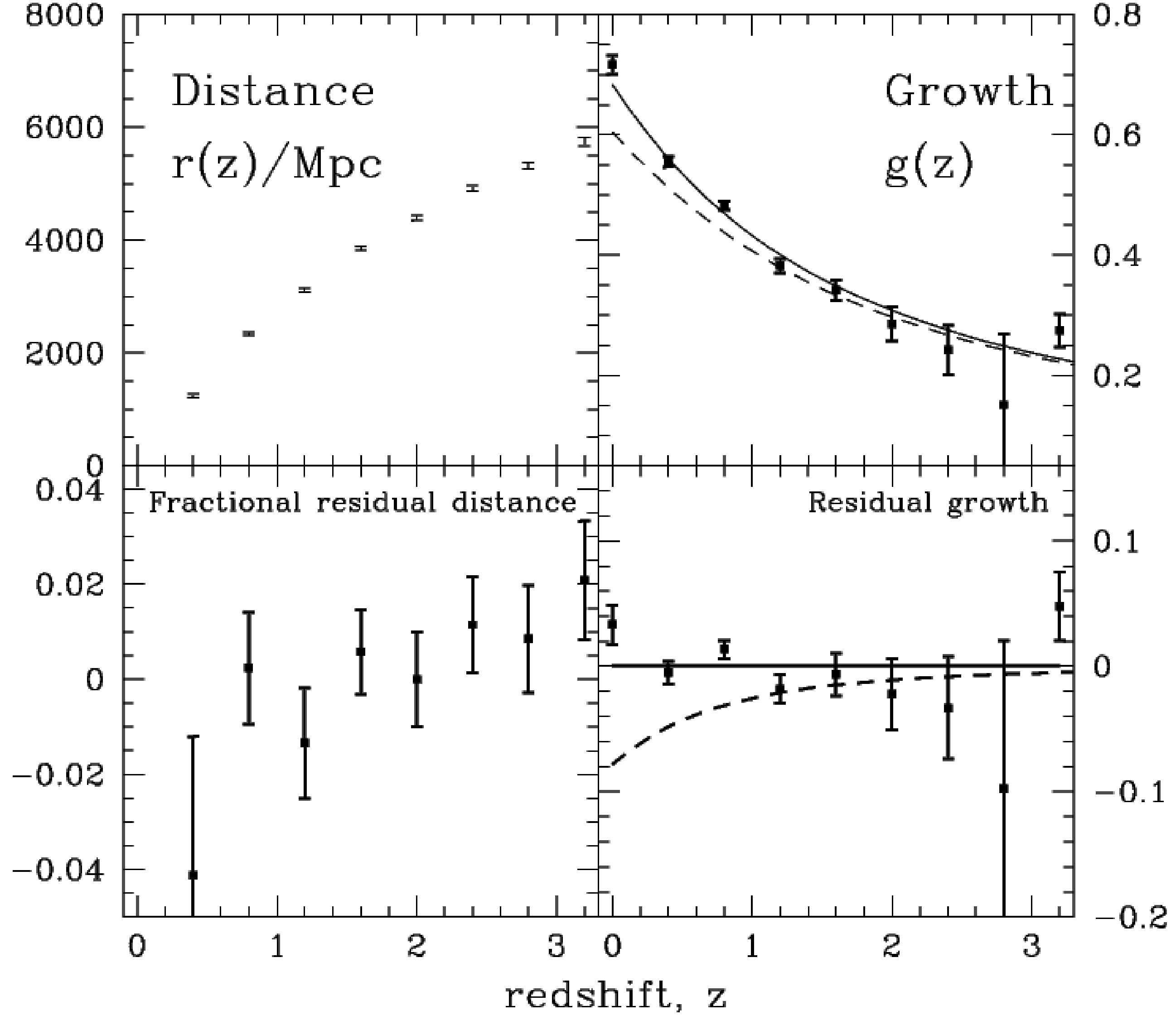
Dark Universe Explorer

- proposed 1.2-m *space-based* telescope
- mixed CCD/IR detectors
- Survey: 20000 deg^2 baseline
- Lead Institution: Saclay
- Ground/space complementarity



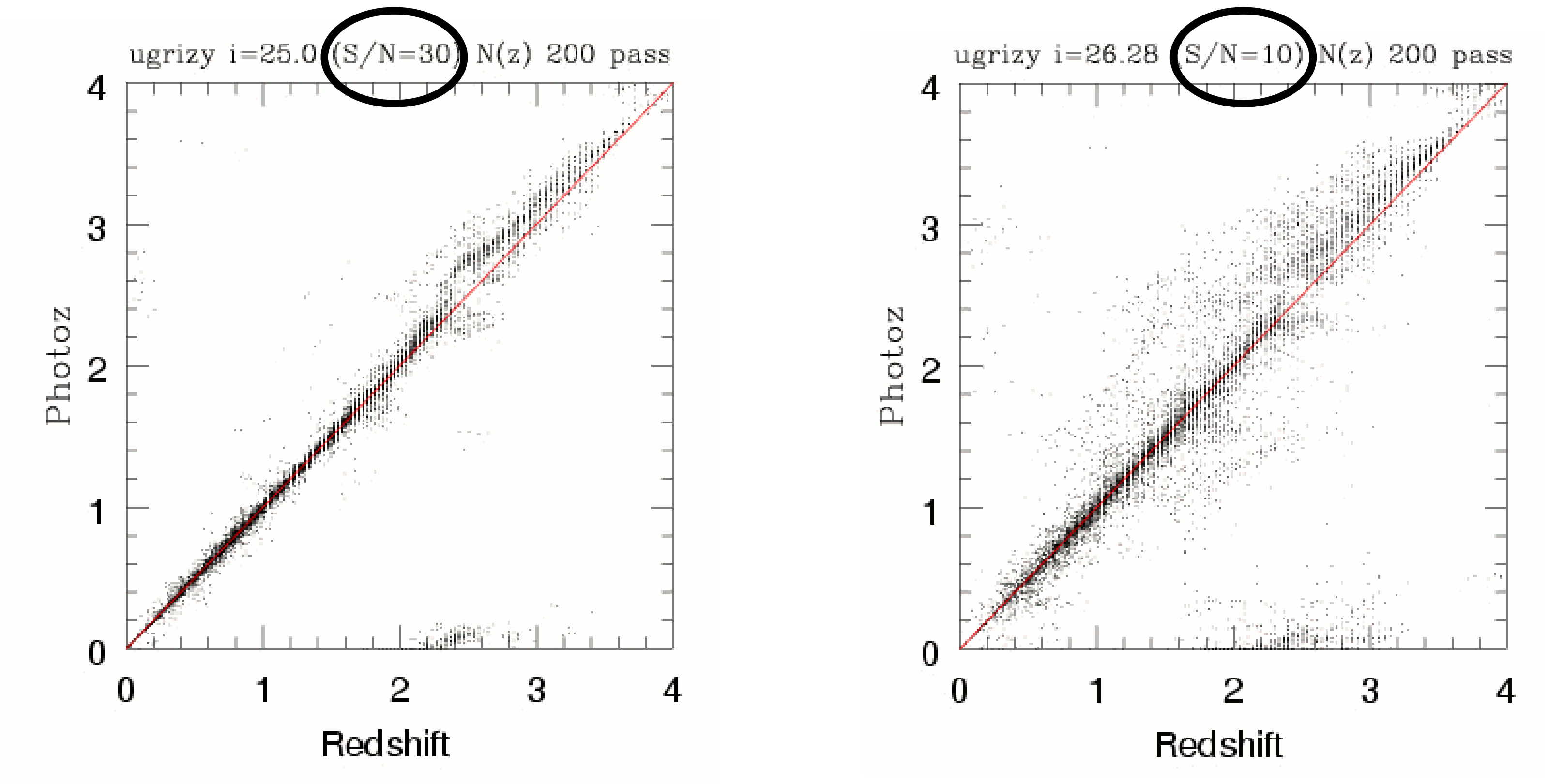
astro-ph/0610062

Testing Gravity With WL



Knox et al, PRD 74, 023512 (2006)

Photometric Redshift Issues: Importance of Photometric S/N



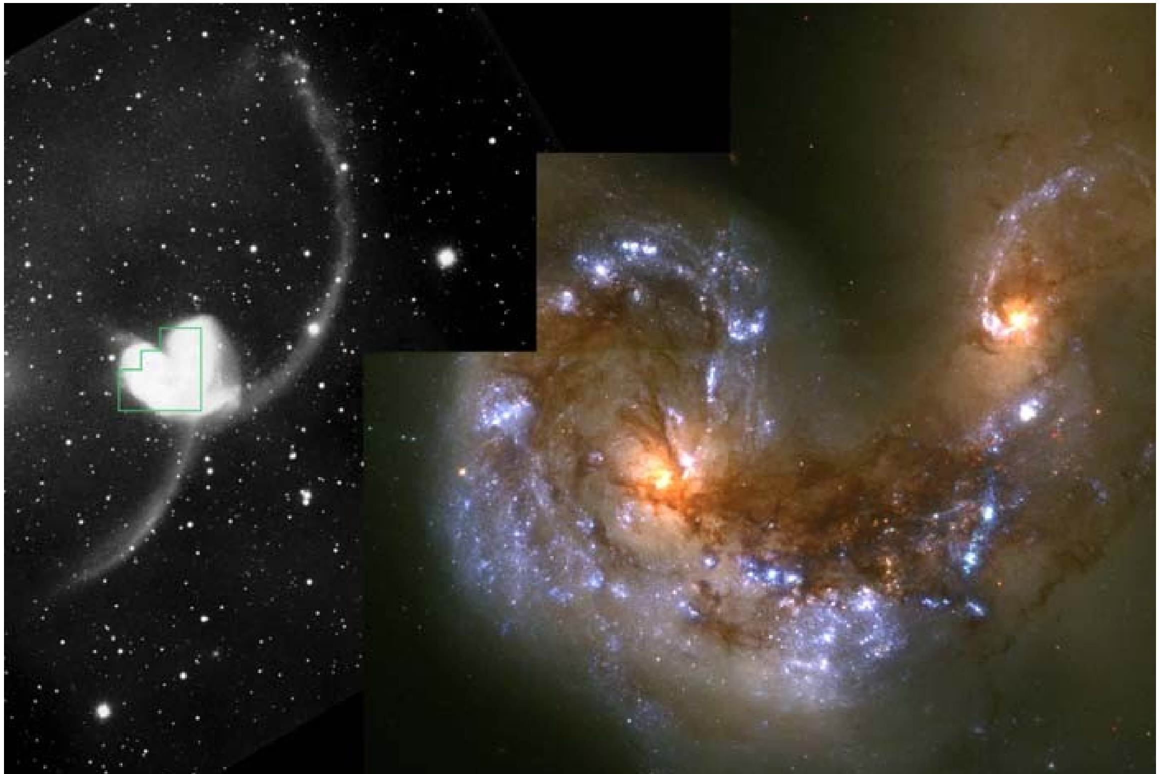
(Unpublished simulations by A. Connolly)

Beware direct comparisons with (bright) spectroscopic samples!

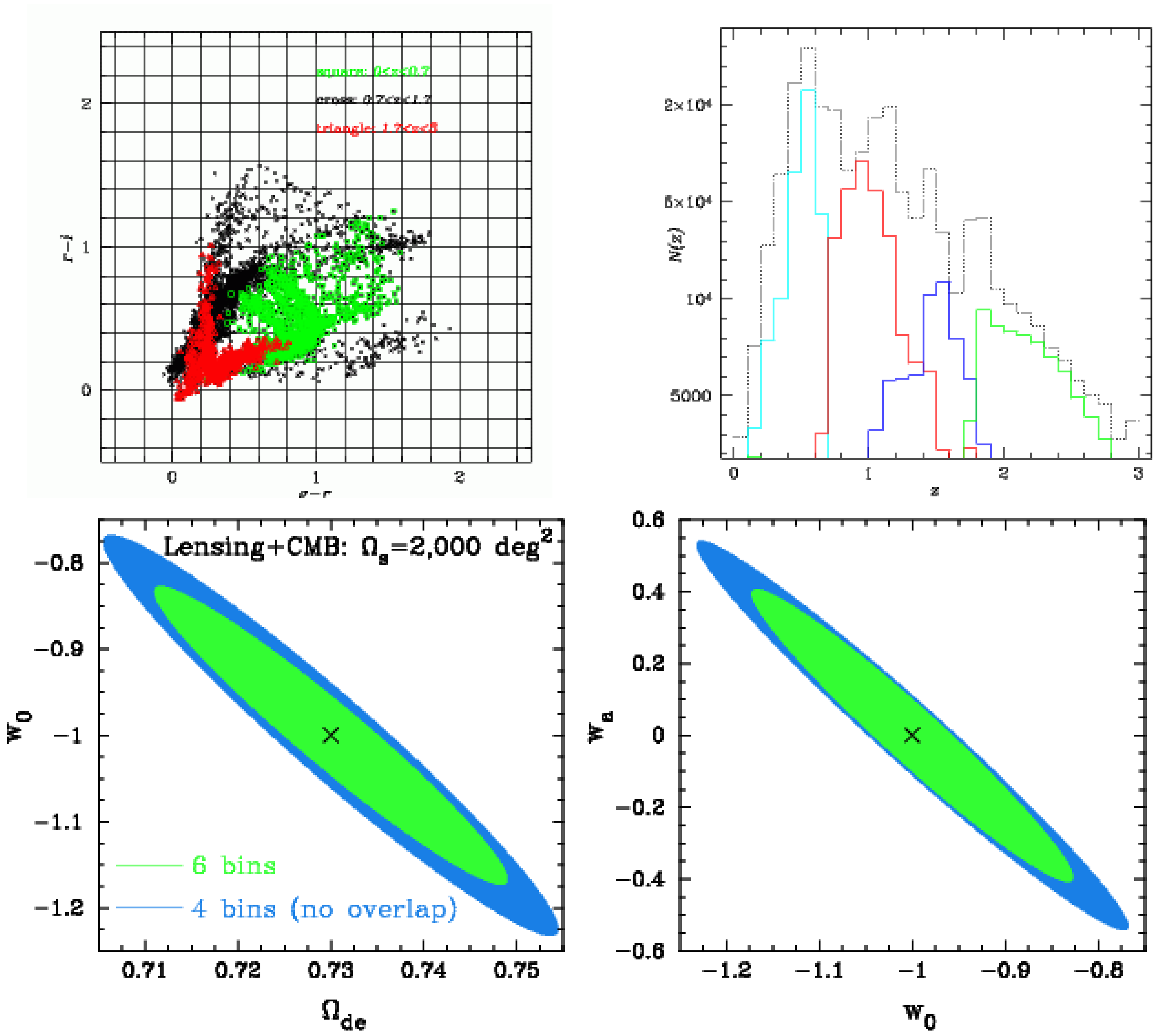
Photometric Redshift Issues: Evolution

- Each galaxy's spectral energy distribution (SED) changes with time
  - “passive evolution” = existing stars fade
  - but even a small amount of new star formation greatly changes SED
- Mix of galaxies changes with cosmic time, e.g. through mergers

=> *Potential source of systematics*



Color Cuts



Jain et al, astro-ph/0609338

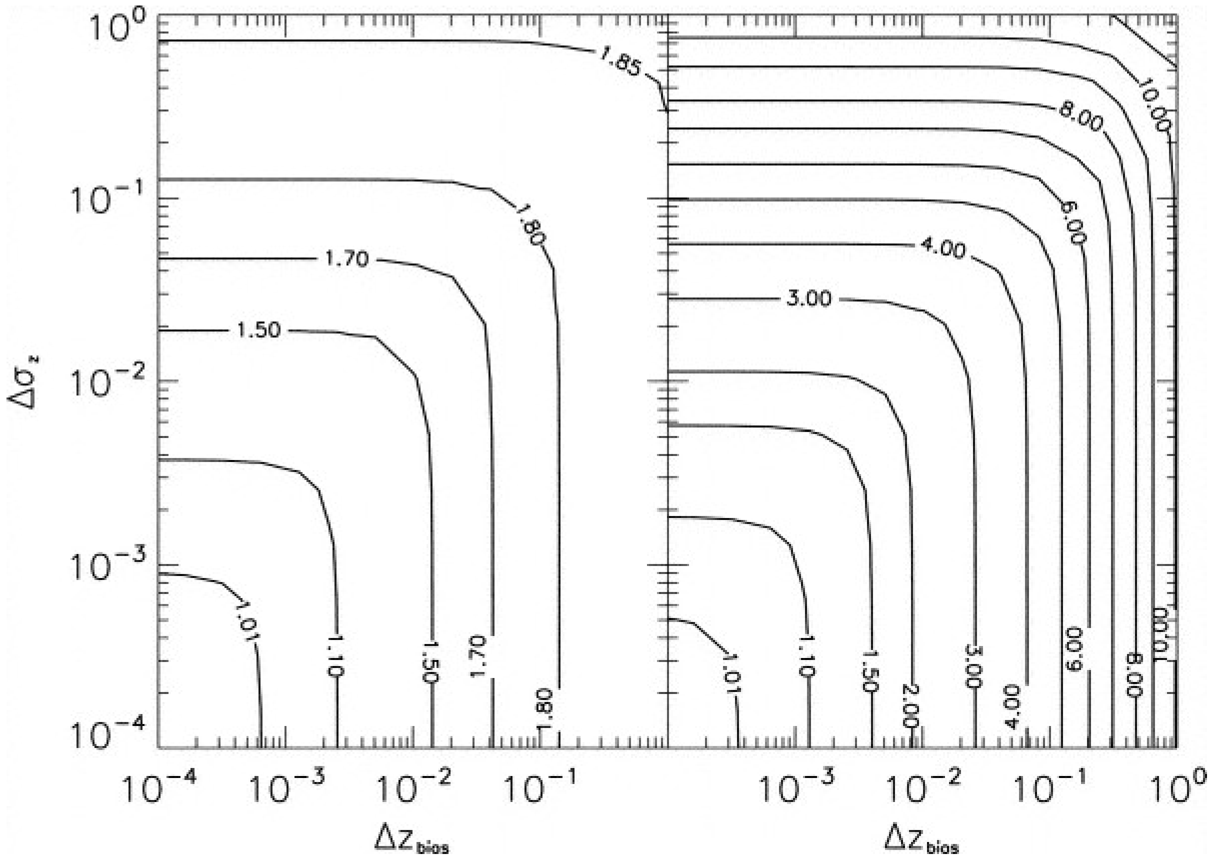
Spectroscopic Redshift Failures

- 20-30% of DEEP2 targets did not yield a redshift (Cooper et al, astro-ph/0607512)
- only half are simply explainable as outside the range of their spectrograph
- "the redshift failure rate is a complex function of redshift itself, and of other parameters such as magnitude and colour." (Cannon et al, astro-ph/0607631)

Spectroscopic verification of photometric redshifts is necessary but not sufficient.

Dark Energy Parameter Degradation Due to Photometric Redshift Errors

calibration accuracy of redshift scatter in each bin



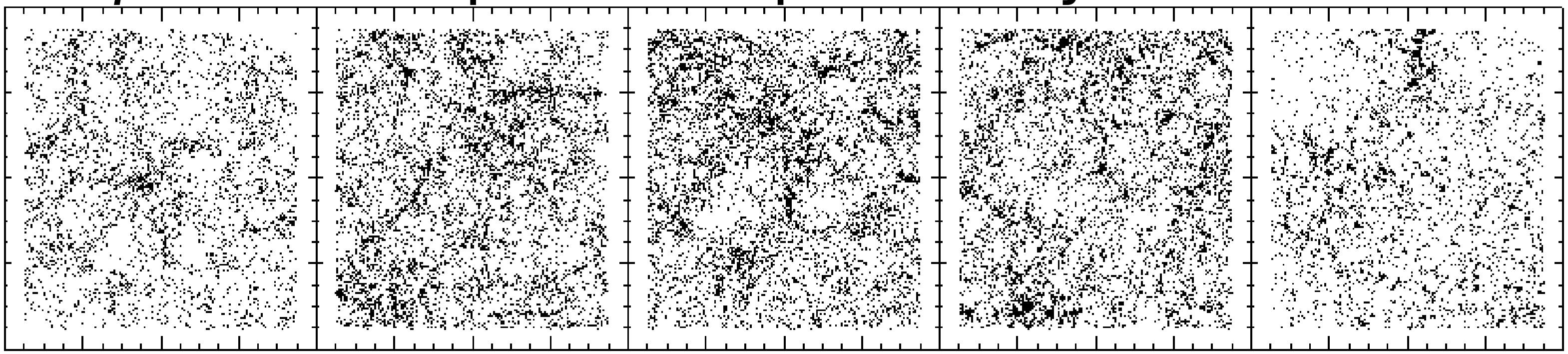
calibration accuracy of mean redshift in each bin

degradation is relative to already-tight LSST constraints

Ma et al, ApJ 636, 21 (2006)

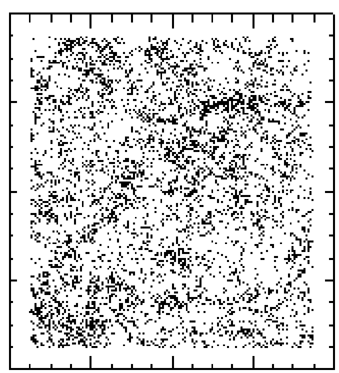
Independent z_{phot} calibration

Step 1: cut a spectroscopic survey into redshift slices.



z=1.4 **z=1.2** **z=0.9** **z=0.7** **z=0.4**

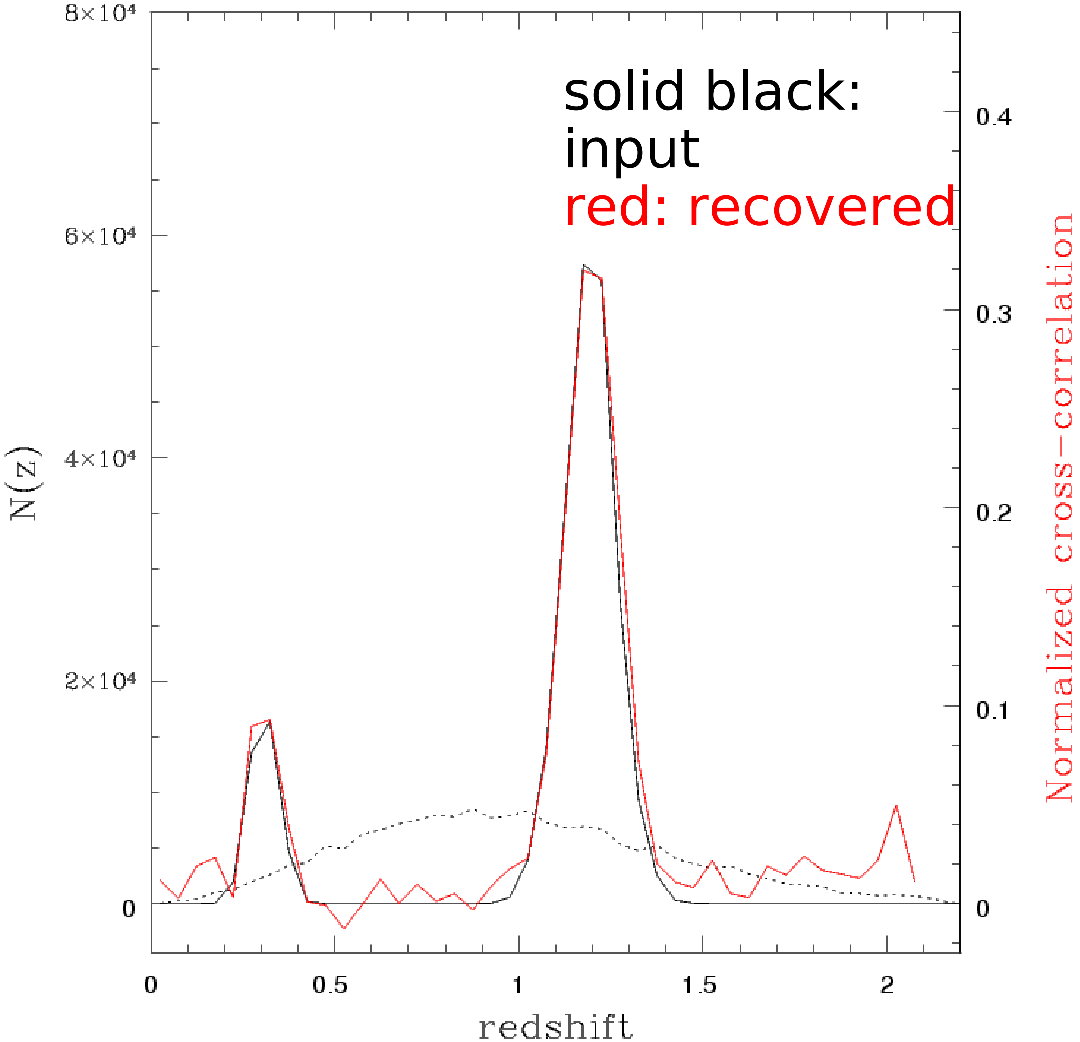
Step 2: this *photometric* redshift slice matches which spectroscopic redshift?



(idea from Newman 2007)

Answer: z=1.2

Redshift Distributions from Angular Cross-Correlation



Newman (2007) estimates that LSST requires $N_{spec} \sim 10^5$

Many details remain to be explored: optimal z distribution, systematic limits, etc.

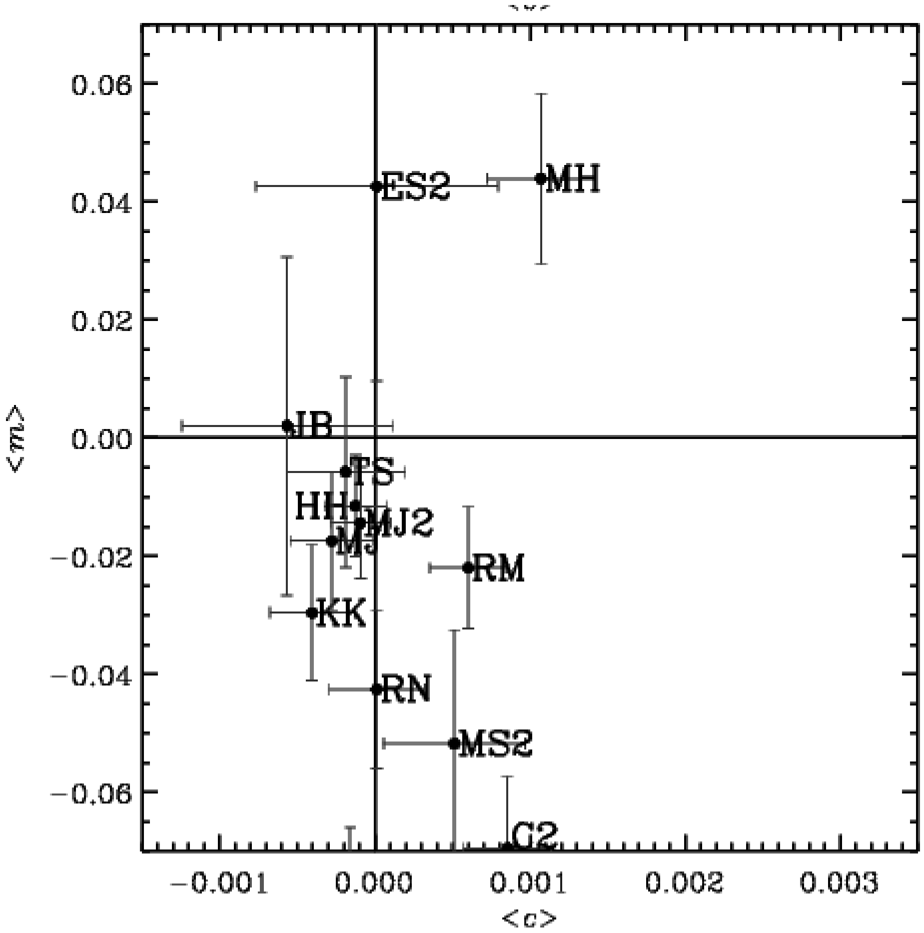
Simplest possible simulation at left.

M. Schneider et al (astro-ph/0606098): cross-correlate different z_{phot} bins to determine leakage.

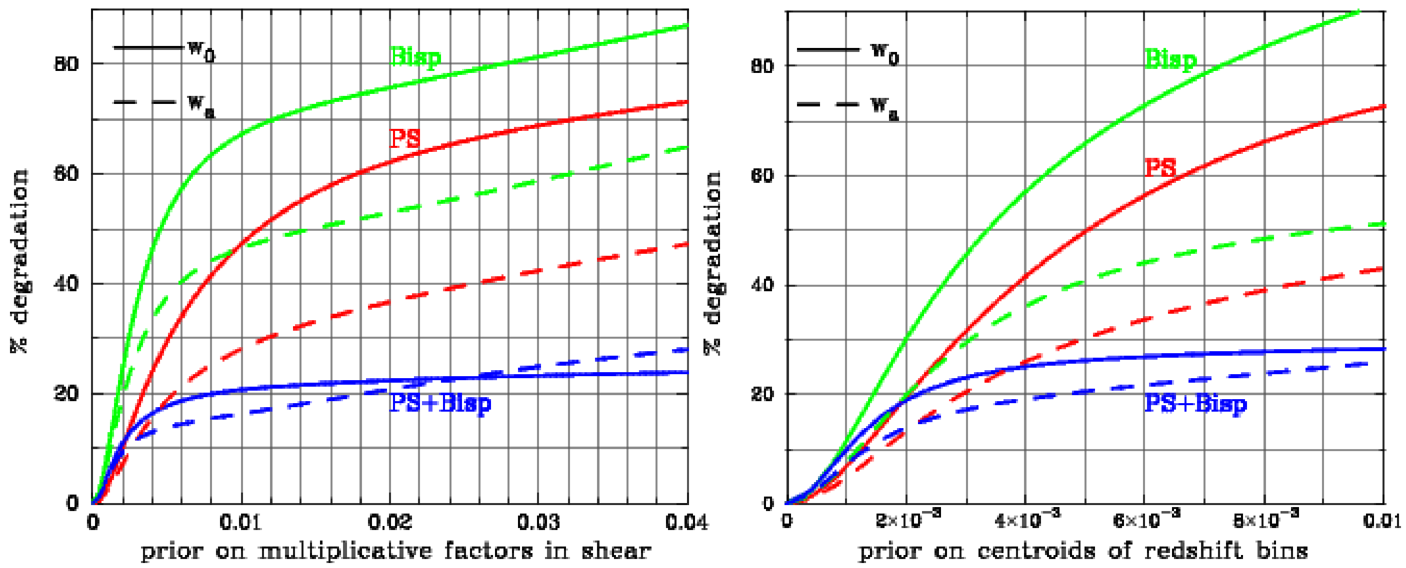
LSST precision is doable with planned spectroscopic surveys

Shear Calibration

- SteP (Shear Testing Program): blind analysis of synthetic datasets by 10-15 different pipelines worldwide
- best methods yield ~1% accuracy currently
- clear improvement from SteP 1 (Heymans et al, MNRAS 368, 1323 (2006)) to SteP 2 (Massey et al, astro-ph/0608643, at right) despite very different (and more sophisticated) synthetic data
- continuing effort



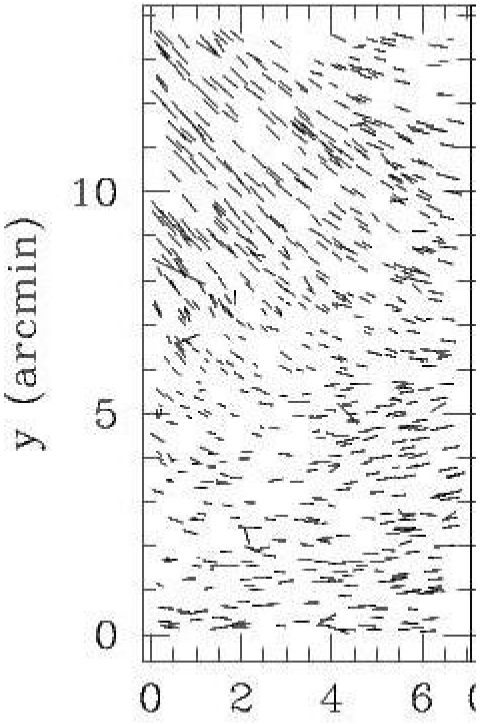
Shear Calibration Requirement



- Huterer et al (MNRAS 366, 101 (2006)) requirements for various surveys (SNAP shown above).
- Nontrivial degradation if *today's* software had to be used on future data
- Using 2 *and* 3 point functions breaks degeneracies in nuisance parameters
- Self-calibration regime possible

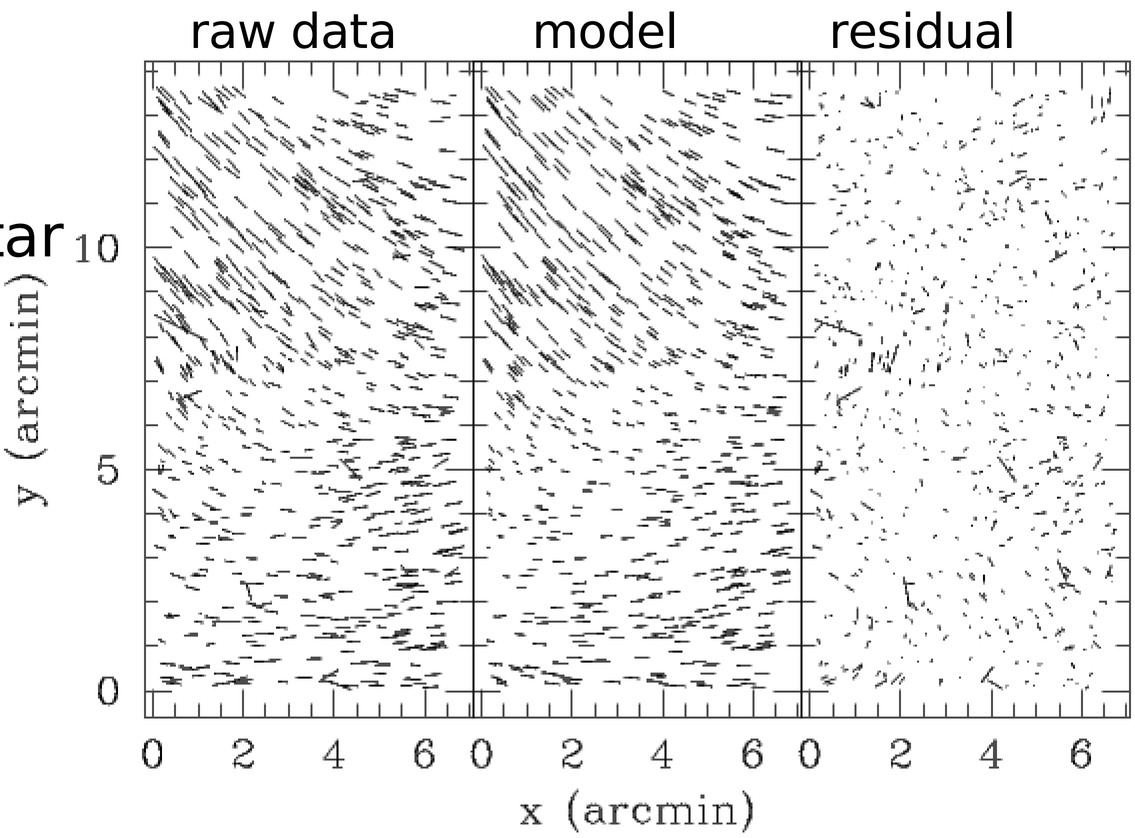
Spurious Shear

- in raw data, contribution from optics can be 10x larger than cosmic shear
- small additional contribution from atmosphere (Wittman 2005)
- additional power on large (>camera) scales due to depth/seeing/calibration variations (Vale et al 2004, Guzik & Bernstein 2005)



Shear Systematics: Mitigation

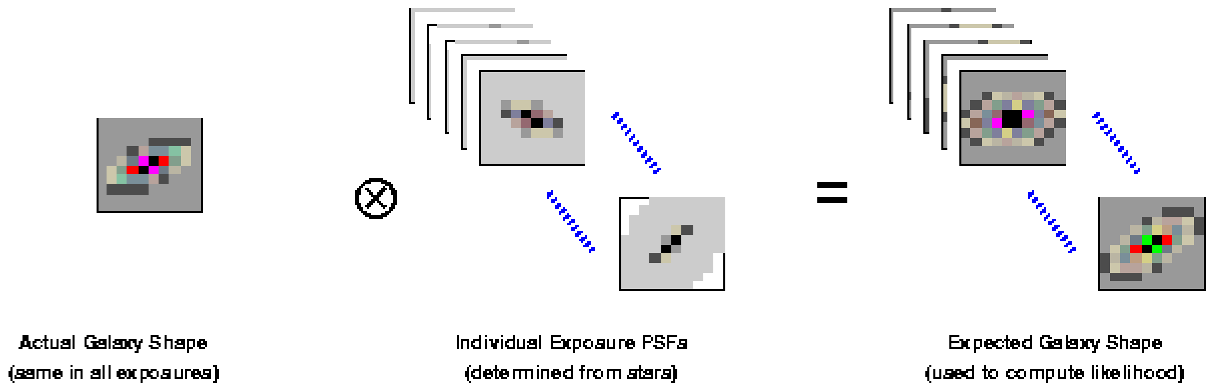
- first: control PSF
- second: know PSF. Naively, limited by ~1 star per arcmin^2 (right)
- 3rd: cross-correlate galaxies on different exposures (Jain & Jarvis 2005)



New telescopes/detectors vastly improve on current systems

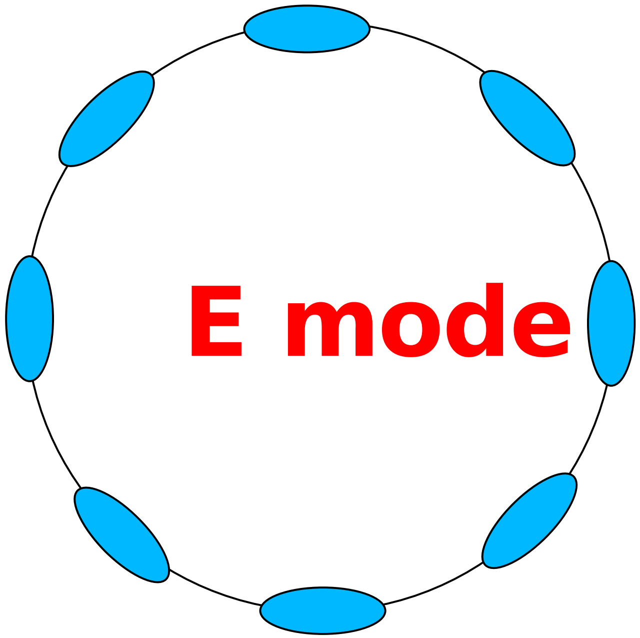
Source Modeling Using Full Dataset

(as opposed to coadd)

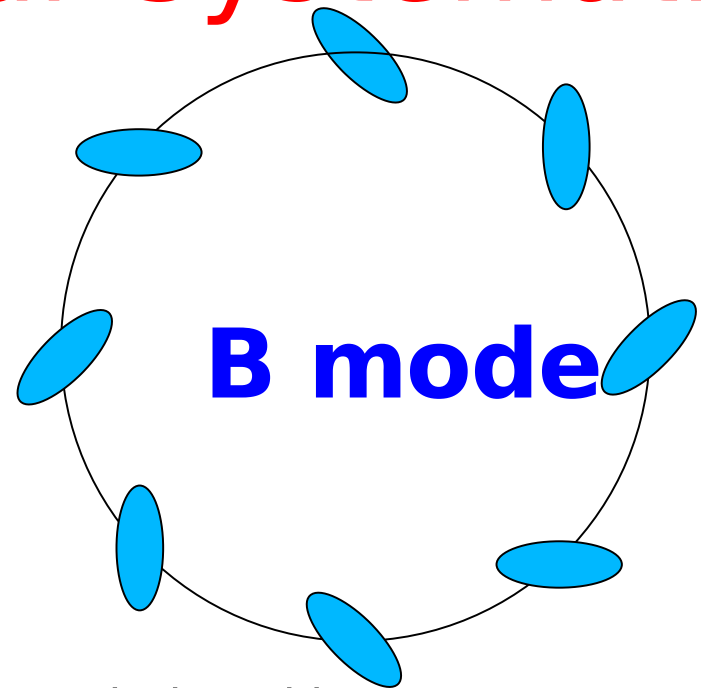


- PSF estimation errors random, not systematic
- Weights better-seeing images properly
- Computationally feasible?

Containing Shear Systematics



induced by:
- -lensing
- -intrinsic alignments?
- -systematic errors?

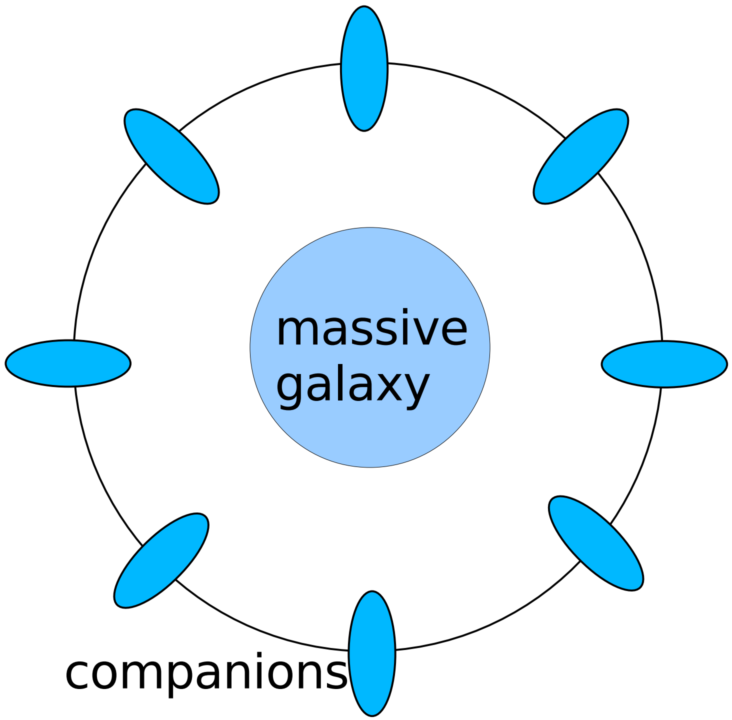


induced by:
- -intrinsic alignments?
- -systematic errors?
- -multiple scattering (~1% effect)

Vale et al (2004), Guzik & Bernstein (2005): some systematics can change E mode much more than B mode

B mode test is necessary but not sufficient

Intrinsic Alignments



- present at some level, not clear how much it affects precision (Mandelbaum et al 2006, MNRAS 367, 611)
- naïve rejection method: correlate only different redshift slices. Removes II (intrinsic-intrinsic) contribution.
- but GI correlations may remain, causing possibly 20% bias in σ_8 (Mandelbaum et al)

- possible mitigation strategies: exclude the offending massive elliptical galaxies (Mandelbaum et al); template fitting (King 2005, AA 441, 247); marginalize over nuisance parameters (Bridle & King 2007)

Summary
(written by DETF!)

The WL technique is also an emerging technique. Its eventual accuracy will also be limited by systematic errors that are difficult to predict. If the systematic errors are at or below the level asserted by the proponents, it is likely to be the most powerful individual Stage-IV technique and also the most powerful component in a multi-technique program.

Results on structure growth, obtainable from weak lensing or cluster observations, provide additional information not obtainable from other techniques. In particular, they allow for a consistency test of the basic paradigm: spatially constant dark energy plus general relativity.

. Optical, NIR, and x-ray experiments with very large numbers of astronomical targets will rely on photometrically determined redshifts. The ultimate accuracy that can be attained for photo-z's is likely to determine the power of such measurements.