Similarities and differences between DES and LSST

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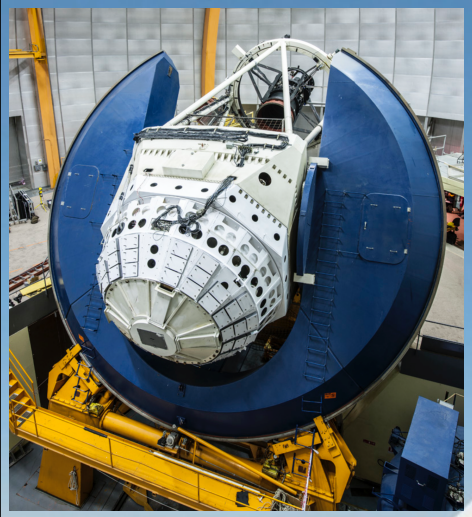
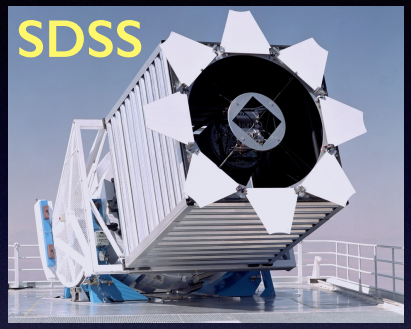
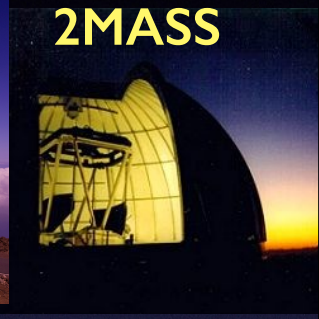


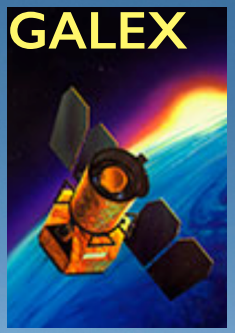
Joint DES-LSST workshop, Fermilab, March 24-27, 2014

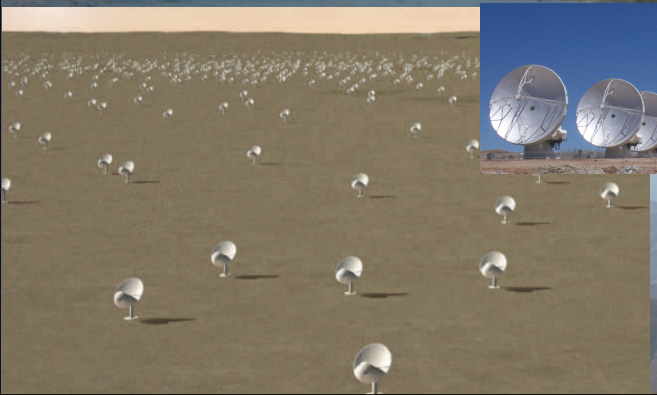
DES is more similar to LSST than is any other survey!

Deep optical surveys, science, technology, people…









Outline

1) Etendue and integrated etendue comparison
a sparrow in the hand or a pigeon on the roof?

2) Comparison of surveys properties
sky coverage, depth, cadence

3) Photometric performance
filter complement, calibration requirements

4) Extragalactic science
cosmology, galaxies, (AGNs)

5) Milky Way science
static science, proper motions, (RR Lyrae)

Etendue and integrated etendue comparison

Effective primary mirror diameters: 3.6m and 6.7m
Collecting area ratio: 3.46

Field-of-view areas: 2.93 and 9.79 sq.deg.
FOV area ratio: 3.34 (6 times more pixels for LSST)

Etendue ratio: 11.6
Observing time ratio: 10/(0.3*5) = 6.7

Integrated etendue ratio: 77.7

With a 4 times larger area, and everything else the same, about 1.6 mag deeper data with LSST.
Alternatively: LSST can obtain “DES” in 1.5 months.

Etendue … omparison

Effective … nd 6.7m
Collecting …

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FOV area… for LSST)

Etendue …
Observing…

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The Dark Energy Survey Timeline Recent

The Dark Energy Survey shared a link.
September 6, 2013

DES has changed its status to: taking data!

The Dark Energy Survey begins
www.symmetrymagazine.org

Over the next five years, scientists will capture some of the grandest images of the cosmos ever seen and use them to probe the mystery of dark energy.

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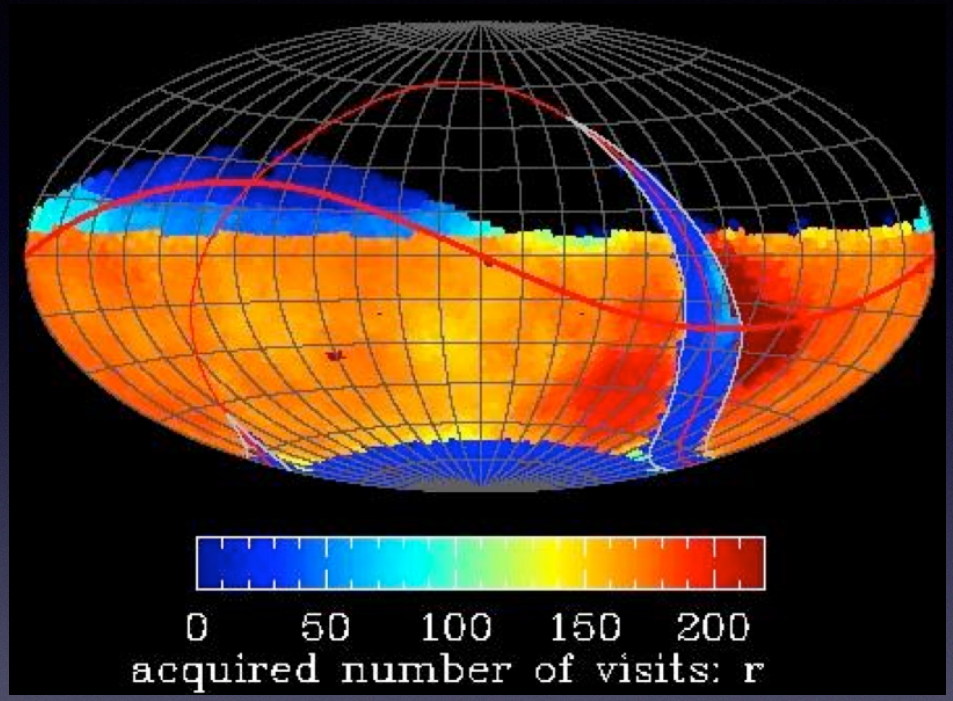
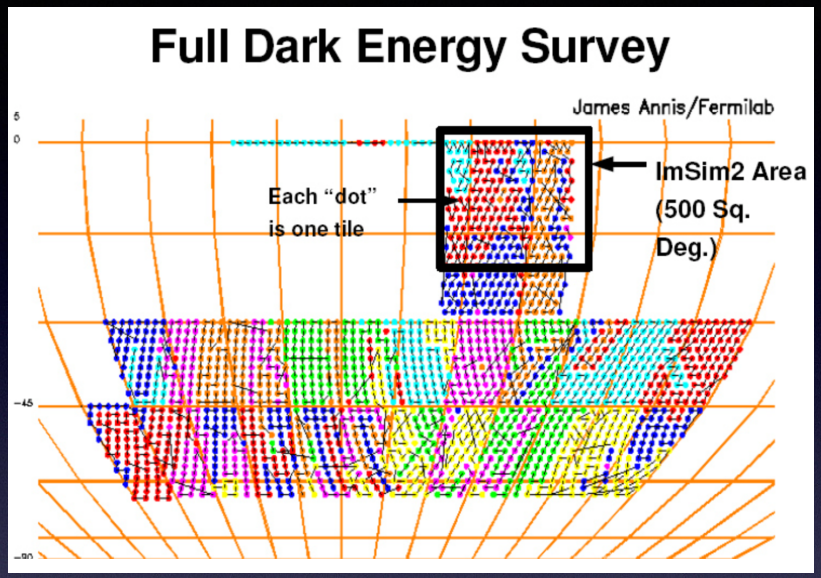
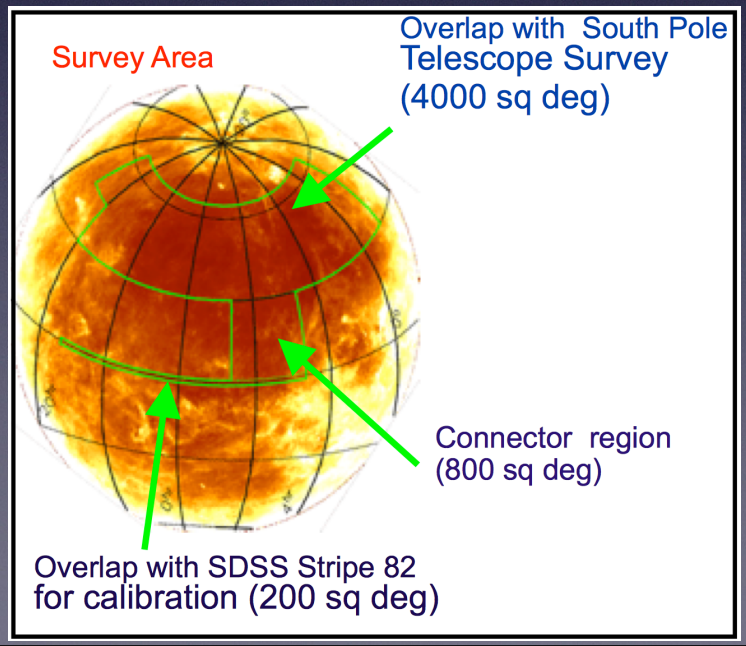
Comparison of survey properties

Sky coverage: 5,000 vs. 20,000 sq.deg.





DES survey area is fully included in LSST survey area



Comparison of survey properties

Sky coverage: 5,000 vs. 20,000 sq.deg.

LSST exposure time per visit is 30 sec.
For DES: 80, 80, 100, 100 and 50 sec, in grizy.

Single-visit depths are about the same!

DES: 50 visits (5 yrs) and LSST ~1000 visits (10 yrs).
(c.f. 4 x 20 = 80)

Coadded depths are ~2 mag deeper for LSST.

A depth difference of 2 mag corresponds to:

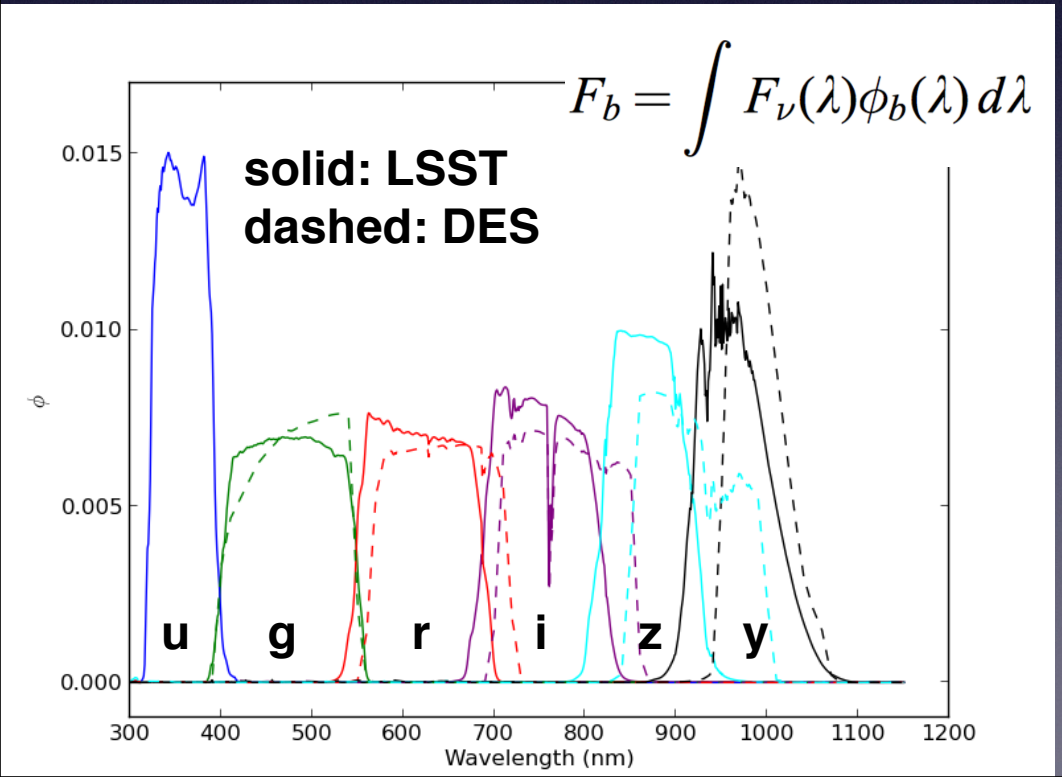
- about 10 times more galaxies
- improved distance limit by a factor of 2.5

Photometric calibration

Photometric Requirements:

	DES	LSST
Repeatability	1%	0.5%
Zeropoint rms	2%	1%
Colors	0.5%	0.5%
Absolute	0.5%	1%

Similar approaches to calibration:
talk by Tucker & Yoachim



DES and LSST filters are similar but not identical

A few % color terms for main sequence stars;
it could become advantage for science!

Extragalactic science

Due to different coadded depths,

n_{eff} ~ 10 gal/sq.arcmin for DES, and for LSST

n_{eff} ~ 35 gal/sq.arcmin

"Gold" galaxy samples:
0.3 billion and 4 billion

Photo-z precision:
0.08 for DES and
0.02 for LSST

Imaging systematics
must be smaller for LSST
(to not dominate errors)

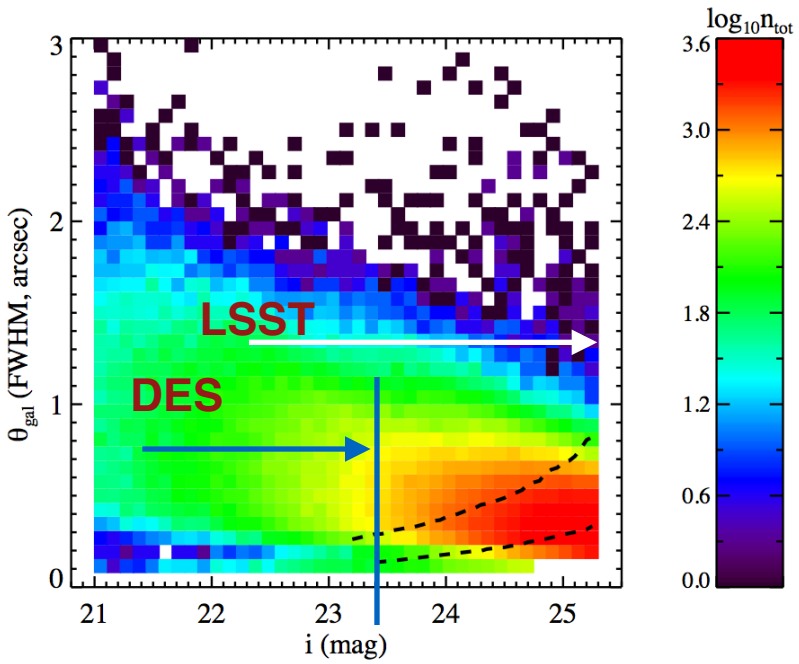


FIG. 1.— The bivariate distribution of galaxies from the HST COSMOS catalog in the size-magnitude diagram (the color corresponds to the number of galaxies per unit magnitude and unit size, shown on a logarithmic scale with an arbitrary normalization). The sky density of galaxies brighter than $i = 25.3$, which defines the LSST "gold sample" of ~4 billion galaxies, is 52 galaxies per square arcmin. The two dashed black lines show the locus of galaxies with ellipticity measurement error $\sigma_e = 0.3$ for two values of system contribution to seeing, bottom: $\theta_{sys} = 0.35$ arcsec and top: $\theta_{sys} = 1.0$ arcsec (with a conservative assumption that ellipticity $e = 0$). Galaxies along the corresponding locus have effective weight of 0.5 when computing $n_{\rm eff}$, and those below the locus are thus effectively by and large excluded. The ratio $n_{\rm eff}/n_{\rm tot}$ is illustrated in Figure 3.

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DETF figure of merit is
roughly proportional to
integrated etendue
(at least for LSST sims)

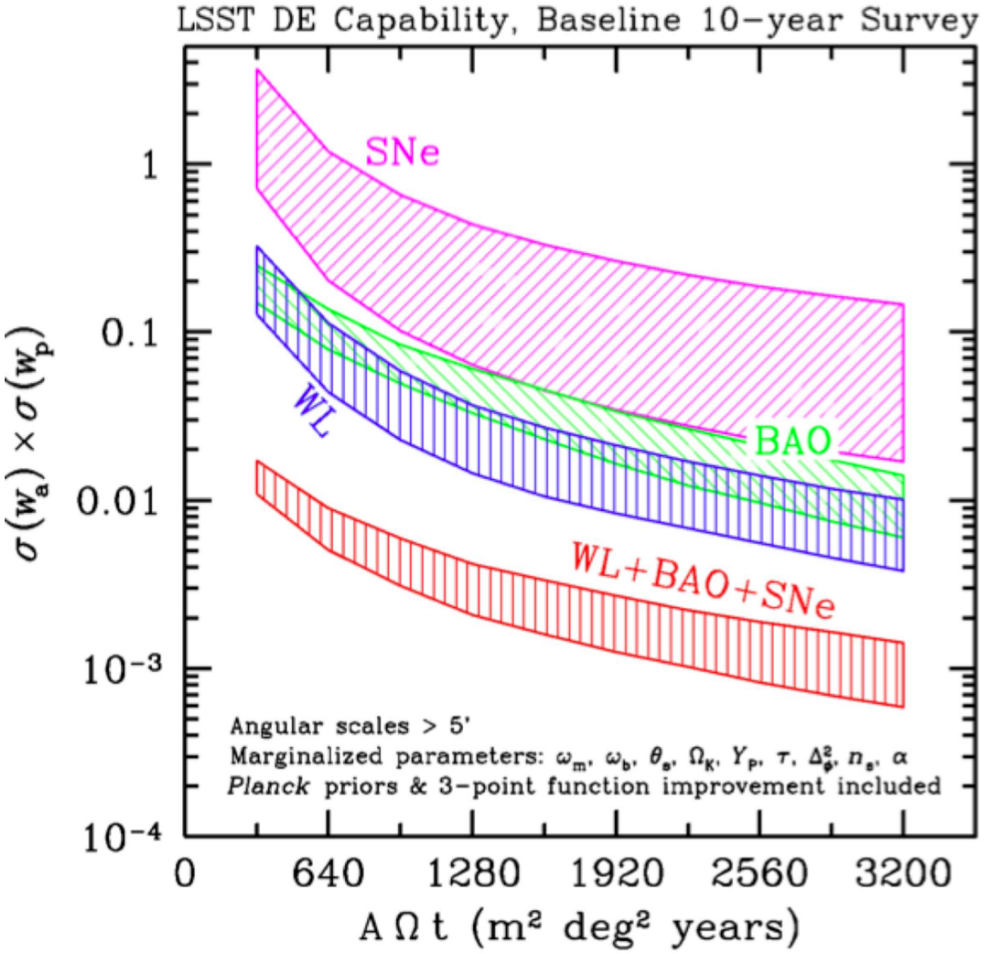
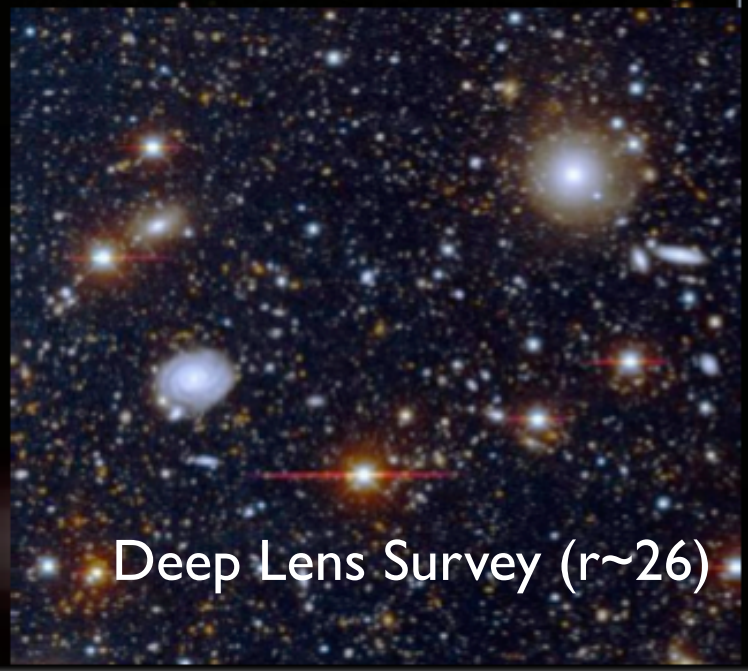


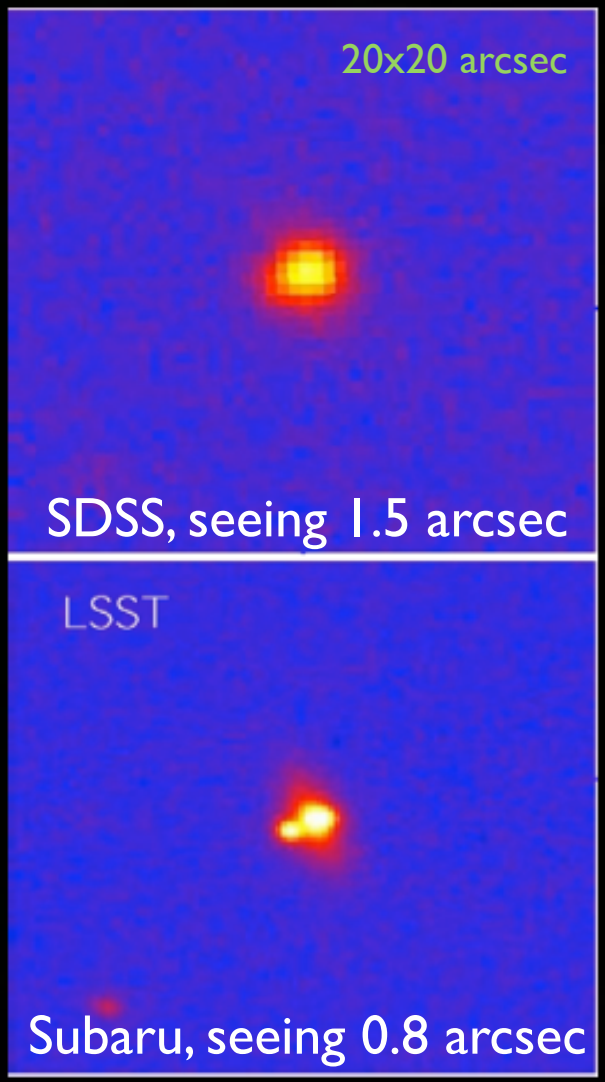
FIG. 3.— The DETF figure of merit error product for simple 2-D dark energy models is plotted as a function of integrated étendue (the value of 3200 $m^2 deg^2 yr$ corresponds to a 10-year survey). The width of the bands reflects the assumed range of systematic errors.

SDSS vs. "DES/LSST" comparison

3x3 arcmin, gri



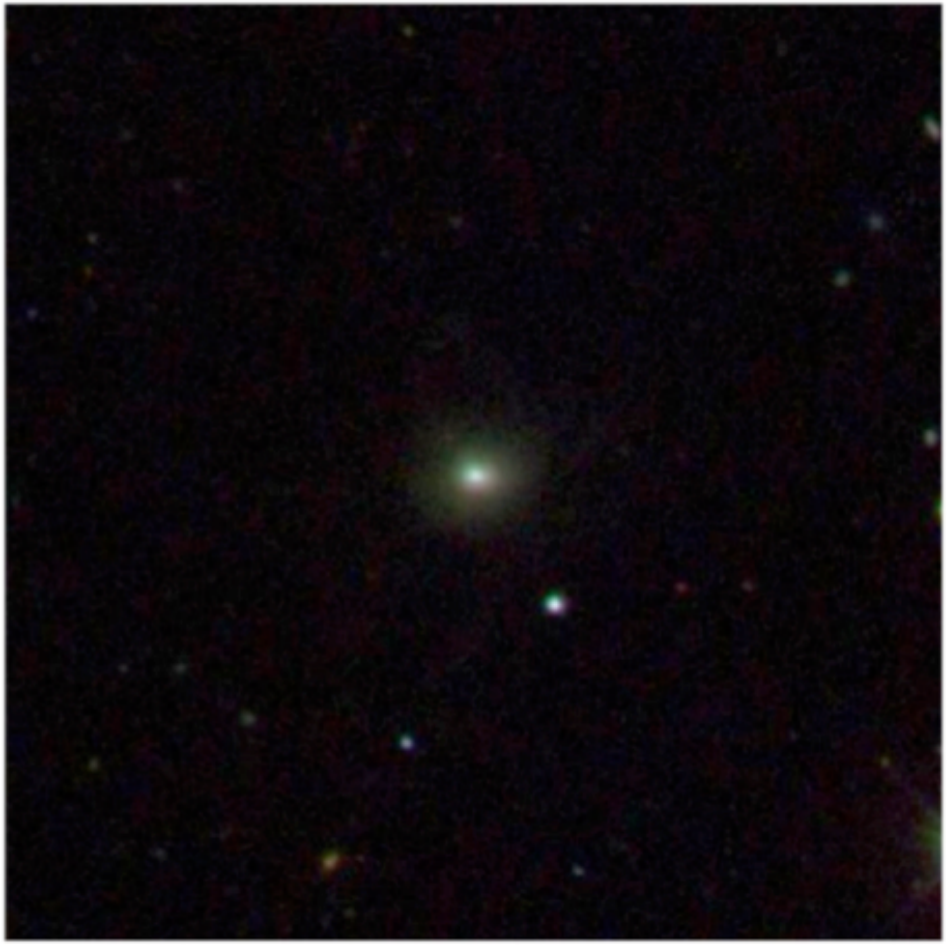
20x20 arcsec; lensed SDSS quasar
(SDSS J1332+0347, Morokuma et al. 2007)



Fainter surface brightness limit for DES/LSST than for SDSS

SDSS

3x3 arcmin, gri



MUSYC r ~26

Milky Way science

For LSST, one of four key science goals (drives disk coverage and cadence via variability, parallax and proper motion measurements): 20 billion stars

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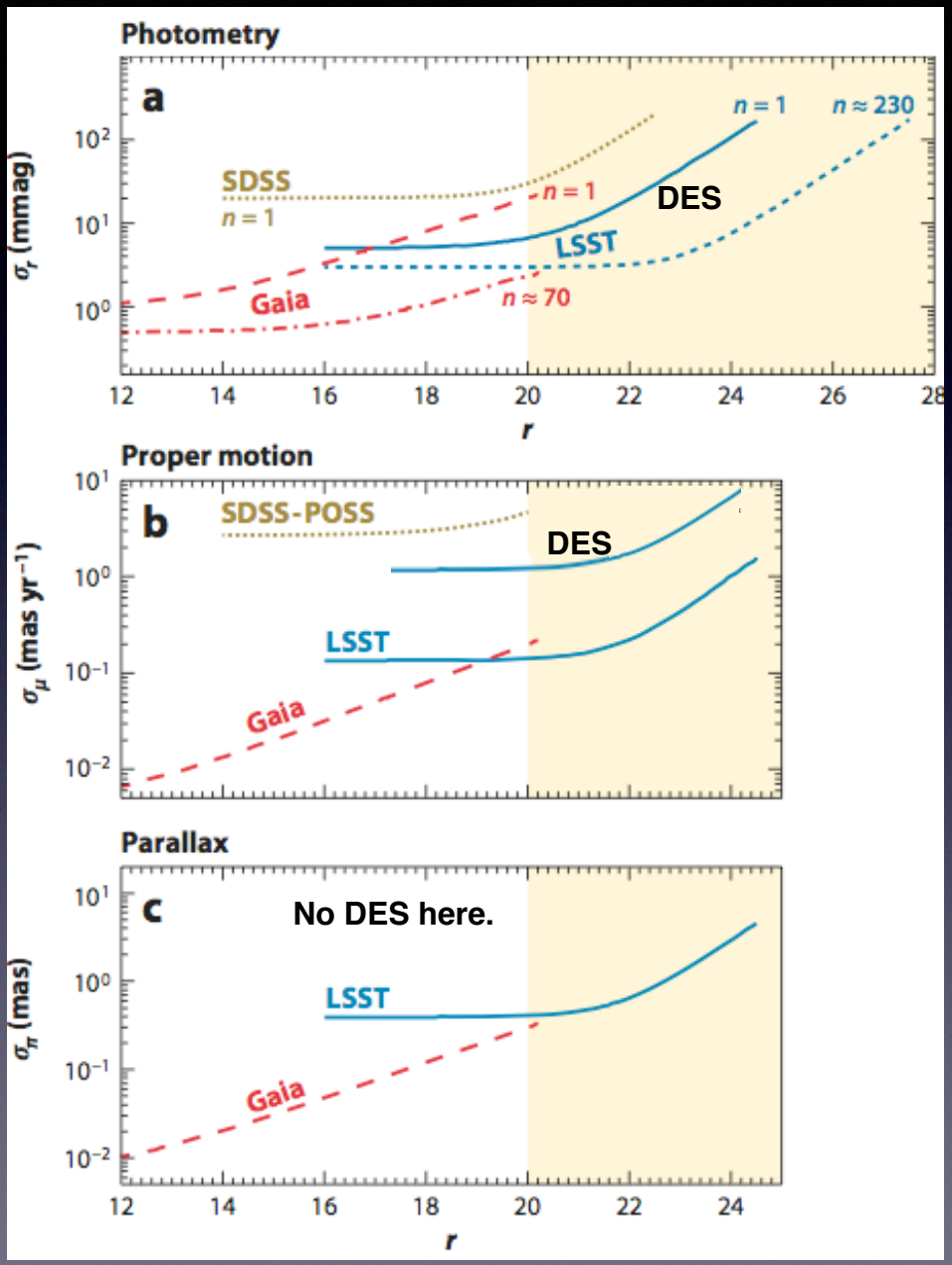
E.g. DES proper motions: 20 times fewer visits and a factor of 2 shorter baseline result in ~10 times larger errors
But due to depth and red sensitivity, still very competitive!

Gaia, DES,LSST comparison



- **Gaia:** excellent astrometry (and photometry), but only to r < 20 (perhaps 21)
- **DES/LSST:** time resolved measurements to r ~ 24.5, and much deeper coadds
- **Gold mine for DES:** proper motions for 20<r<24 and for very red objects

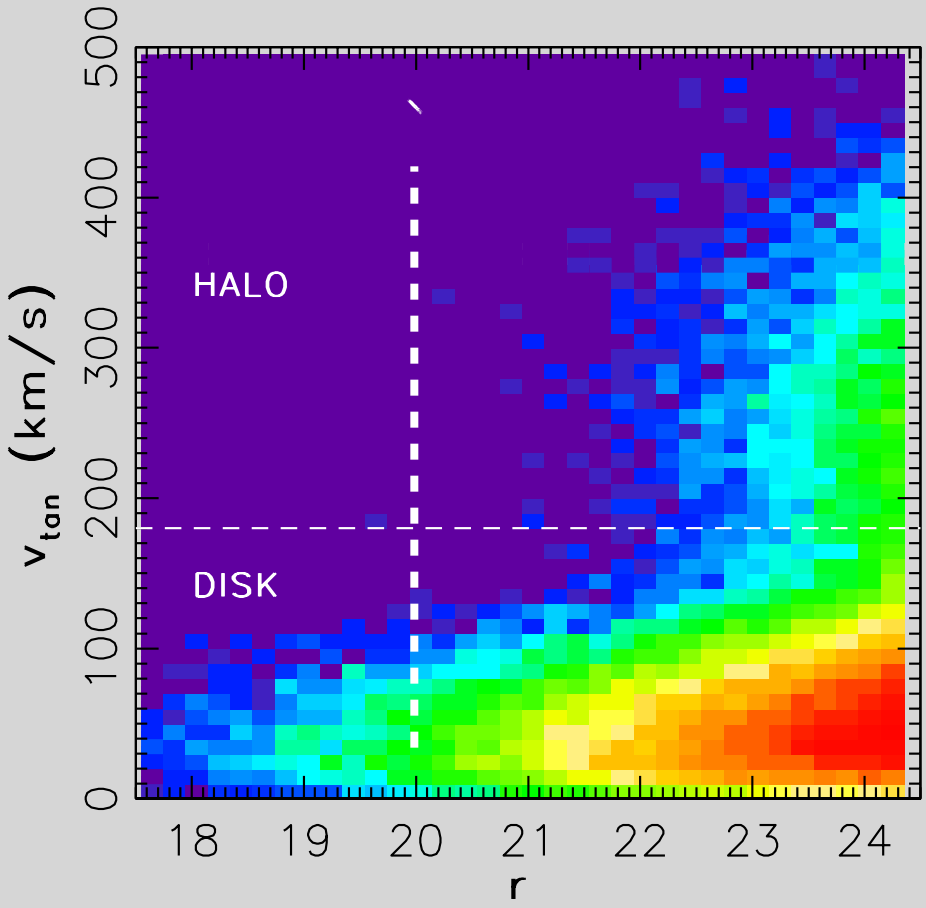
The Milky Way disk "belongs" to Gaia, and the halo to DES and LSST (plus very faint and/or very red sources, such as white dwarfs and LT(Y) dwarfs).

Ivezić, Beers, Jurić 2012, ARA&A, 50, 251

Dwarfs (white, red, brown) in DES and LSST

White dwarfs: LF is age probe

~400,000 halo white dwarfs from LSST (10 million total):

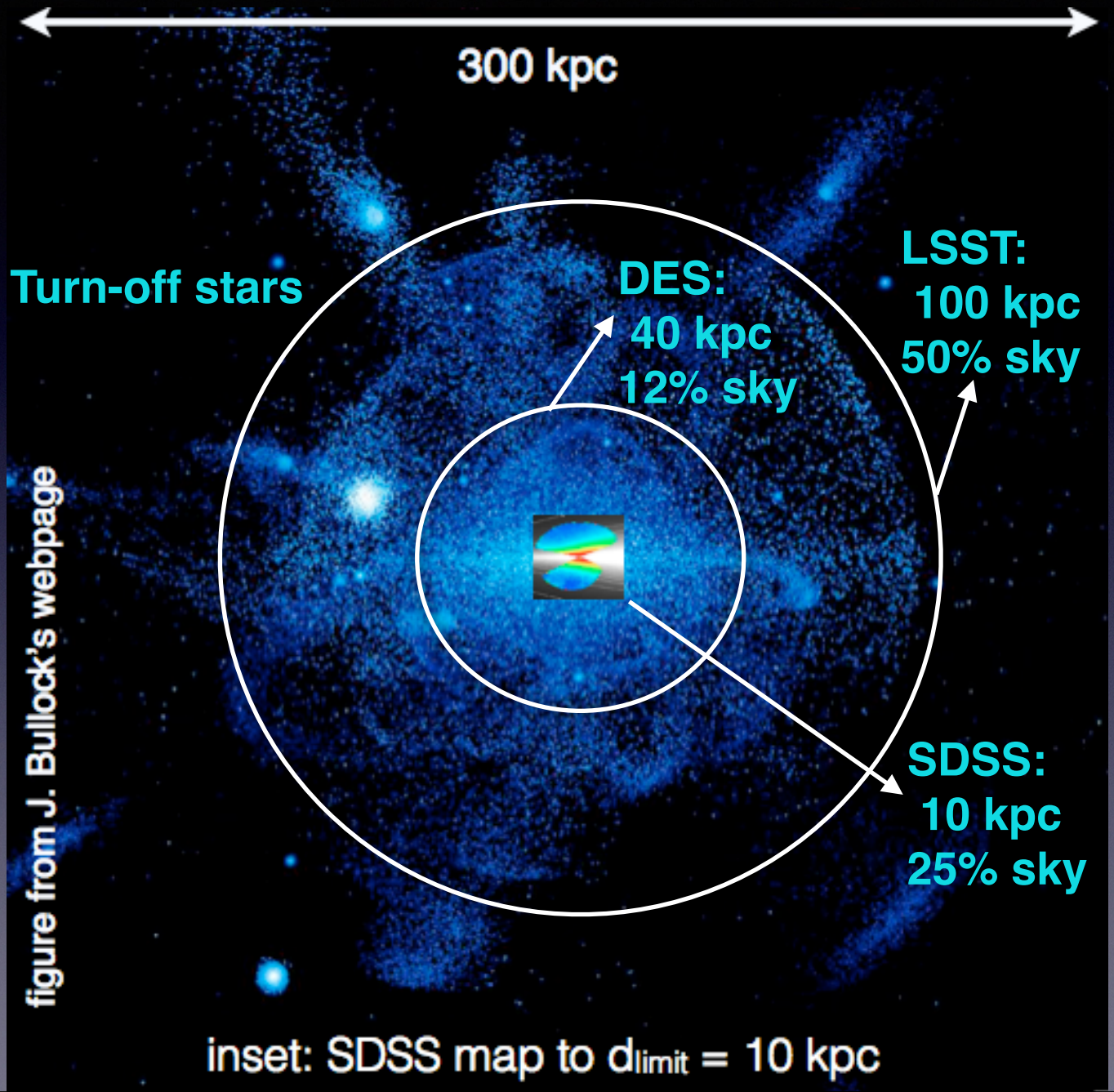


L / T dwarfs: L dwarfs are dime a dozen: 200,000 in LSST with proper motion and trigonometric parallax measurements, and 50,000 in DES with prop. mot.

Simulations predict 2400 T dwarfs with >5σ proper motion and parallax measurements in LSST; some fraction will be discovered by DES

About 100,000 halo white dwarfs will be discovered with DES (using proper motions): **significant science result!**

Milky Way science with coadded DES and LSST data



Summary

1) Both DES and LSST are deep optical surveys; while LSST's integrated etendue is 77 times larger, DES is happening now and will finish 14 years before LSST!

2) DES will accomplish a lot of science, but we need not worry about LSST being "scooped" (2 mag deeper, 4 times larger coverage, time domain, u band)

3) DES and LSST share science drivers, use similar technologies, and have strong people overlap

4) DES has a lot to offer to LSST!

5) LSST probably can return the favor (data management, simulations, career paths?)

Let's make this a useful and interactive workshop!