



The Dark Energy Survey: New Results

Ofer Lahav (UCL)
on behalf of the DES collaboration



LSS@Munich – 21 July 2015

Outline

- DES: status of observations
- The challenges:
photo-z and galaxy shapes
- Low and high hanging fruit:
batch of 10 papers in April,
12 new papers on the arXiv today
- DM and DE from DES
- Non-DE science from DES
- Nuisance parameters: systematics vs. new physics



So what is Dark Energy?

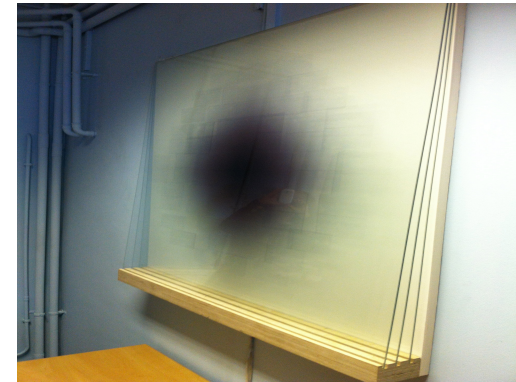
$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$$

- Systematics mimic DE?
- Lambda-CDM, EoS $w = -1.00$?
- Dynamical scalar field $w(z)$?
- Signatures of modified gravity?
- Inhomogeneous Universe?
- Multi-verse?
- Something else unpredictable??

LCDM:

“an almost perfect universe”

or “a simple but strange universe”?



3

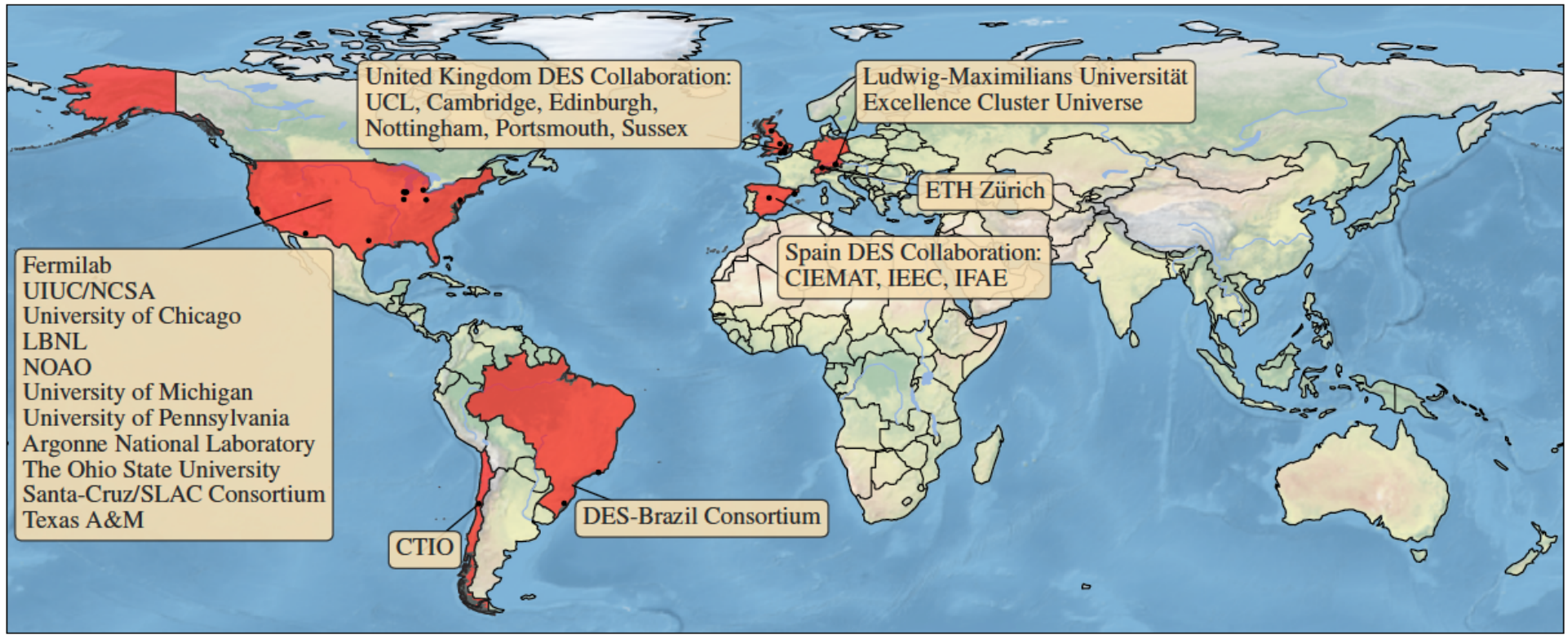
DES artwork by Marie Kaus

12 DES-SV papers (*) on today's arXiv1507

- Shear pipeline (Jarvis et al., [05603](#))
- Photo-z for WL (Bonnett et al.) – talk
- 2pt WL CF (Becker et al., [05598](#))
- Cosmology from 2pt WL CF (The DES Collaboration, [05552](#))
- WL around troughs (Gruen et al., [05090](#)) - poster
- RedMagic galaxies (Rozo et al., [05460](#)) - talk
- Galaxy clustering (Crocce et al., [05360](#))
- Combining probes (Park et al., [05353](#))
- DES x CMB (Giannantonio et al., [05551](#)) – talk
- Systematic maps (Leistedt et al.,) – talk by Peiris
- SN pipeline (Kessler et al., [05137](#))
- Solar system: Neptune Trojan objects (Gerdes et al., [05177](#))

+ talks by Fosalba & Wechsler including DES simulations + Posters ⁴

THE DES COLLABORATION (~400 scientists from 6 countries)



Director: Josh Frieman

Instrumentation lead: Brenna Flaugher

DES Science Committee

- SC co-chairs: G. Bernstein & O. Lahav
- Large Scale Structure: E. Gaztanaga & A. Ross
- Weak Lensing: S. Bridle & B. Jain
- Clusters: J. Mohr & C. Miller
- SN Ia: M. Sako & B. Nichol
- Photo-z: F. Castander & H. Lin
- Simulations: K. Heitmann & R. Wechsler
- Galaxy Evolution: D. Thomas & M. Banerji
- QSO: P. Martini & R. McMahon
- Strong Lensing: L. Buckley-Geer & A. Amara
- Milky Way: B. Santiago & B. Yanny
- Theory & Combined Probes: S. Dodelson & J. Weller
- Spectroscopy : F. Abdalla & C. D'Andrea
- + Analysis teams & Task Forces



The Dark Energy Survey

- **Multi-probe approach**
Wide field: Cluster Counts, Weak Lensing, Large Scale Structure
Time domain: Supernovae
- **Survey strategy**
300 million photometric redshifts (grizY)
over 5000 deg²
+ 2500 SN Ia (over 30 deg² fields)
overlap with **VHS + SPT+ OzDES + ...**
- **Science Verification (SV):** 140 sq deg to full depth
- **Y1:** approx 2000 sq deg 40% of depth.
Median seeing FWHM approx 0.9"
(as required for WL in riz)
- **Y2:** approx remaining 3000 sq deg same depth
- **Y3** will start in Aug 2015 - 3 more seasons to go!



Some milestones since 2004...

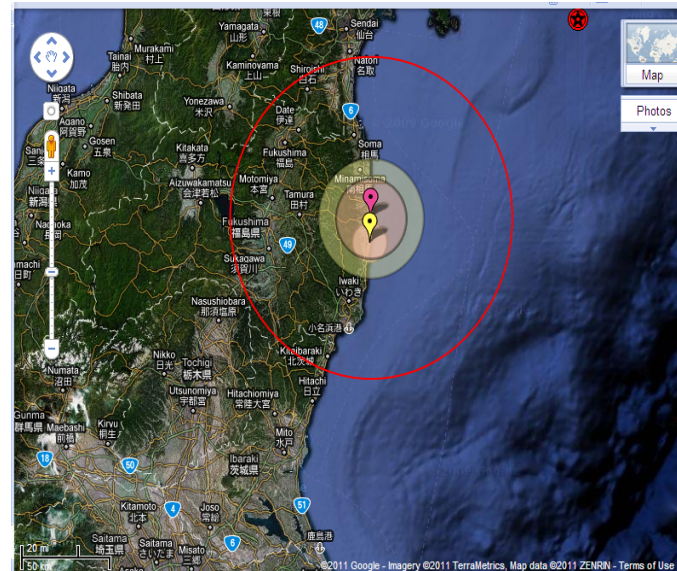


← Assembling the DECam optical corrector at UCL...

Filters made in Japan
(months after the Tsunami...)



...and first light image of NGC 1365



Thanks to collaborators

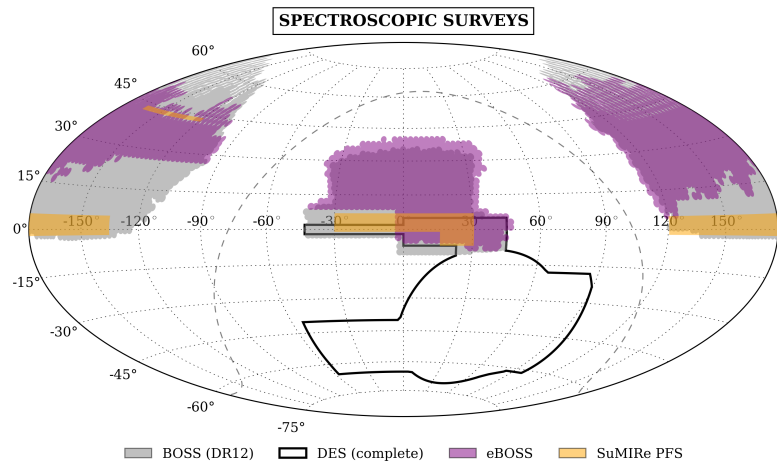
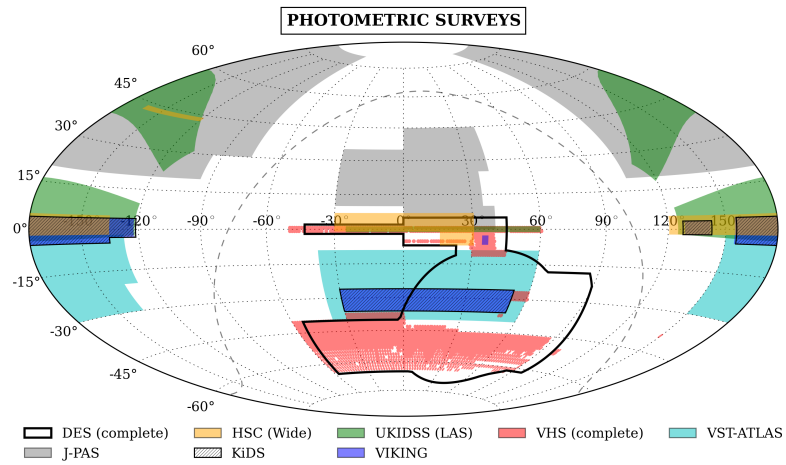
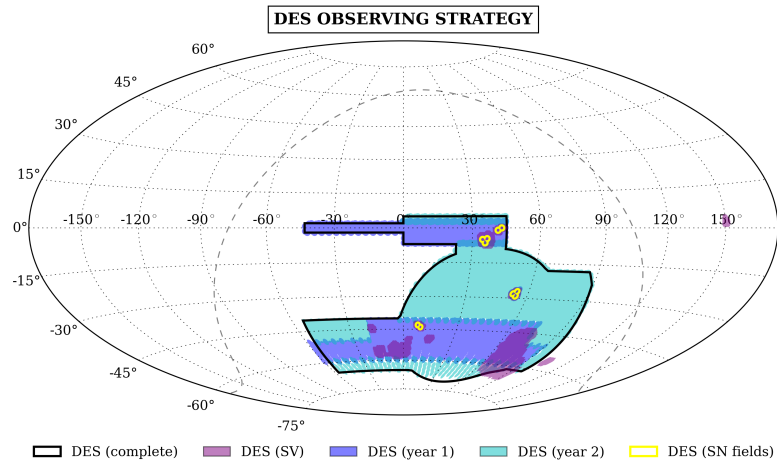


UCL's cosmologists



DES scientists

DES Footprint

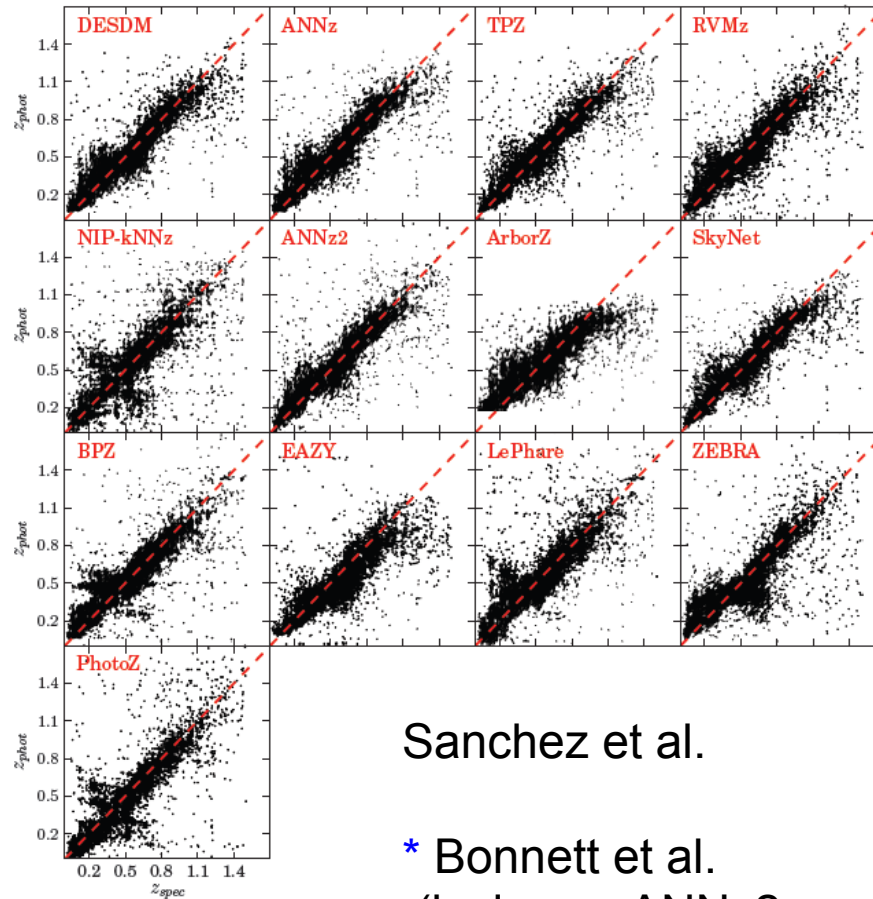


Overlapping Imaging Surveys

Overlapping Spectroscopic Surveys

Credit: Alex Merson (UCL)

Photo-z: DES SV data

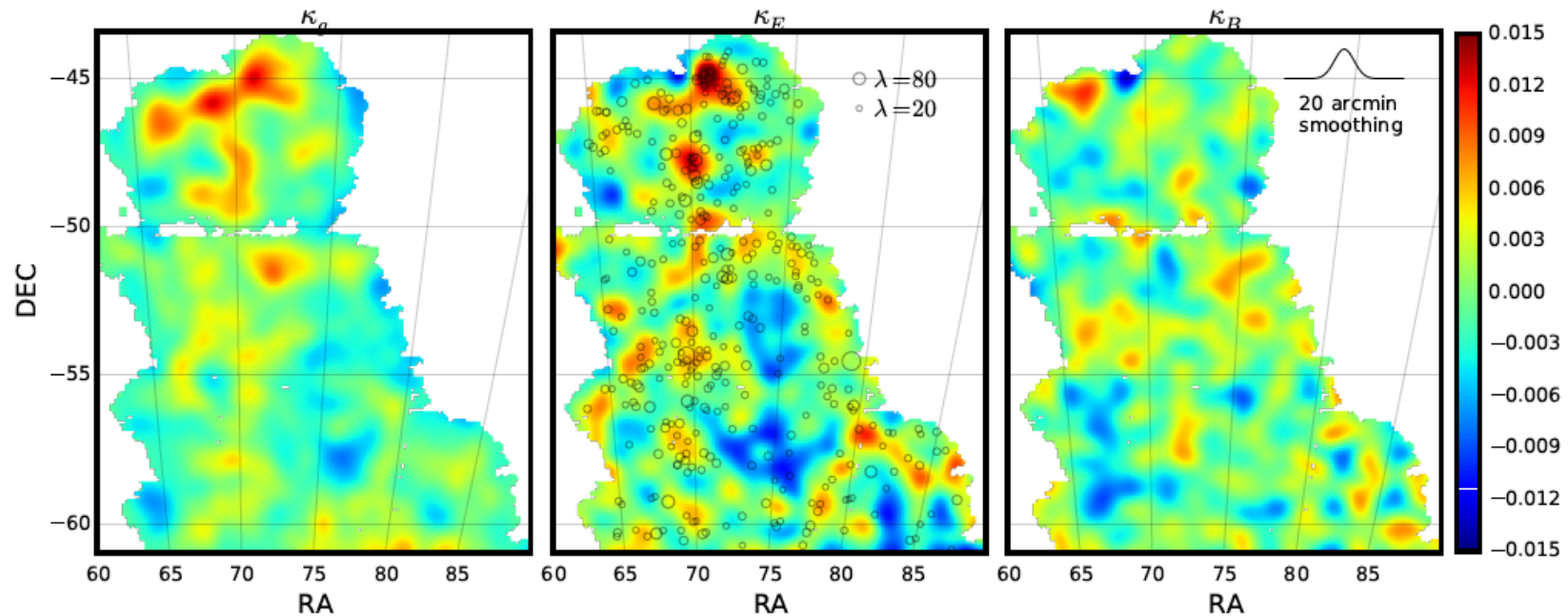


Sanchez et al.

* Bonnett et al.
(incl. new ANNz2,
Sadeh, Abdalla & OL, 1507.00490)

WL convergence: κ_{gal} , κ_E , κ_B

SV area 139 sq deg (only 3% of final DES)
Cross correlation signal: 5-7 sigma



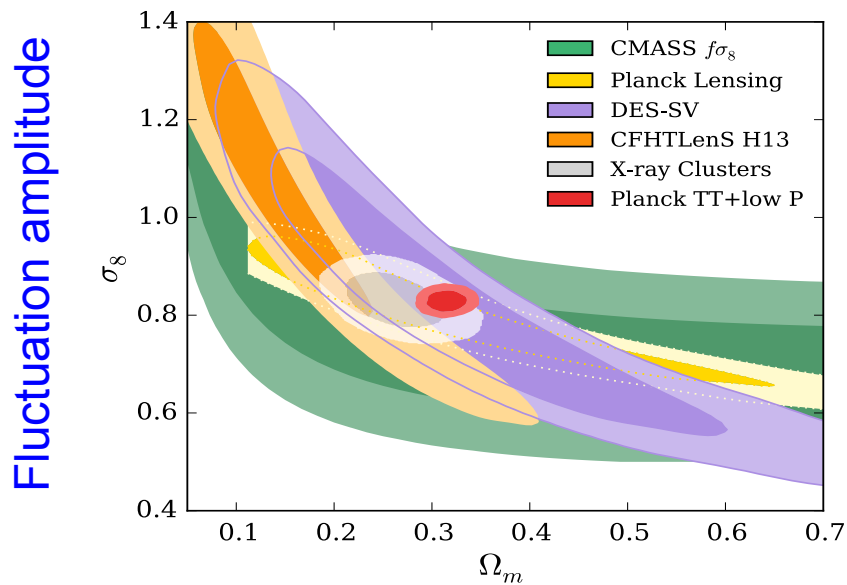
Chang, Vikram, Jain et al. (PRL)

Vikram, Chang, Jain et al. (PRD)

1M Background sources @ $z \sim 0.8$

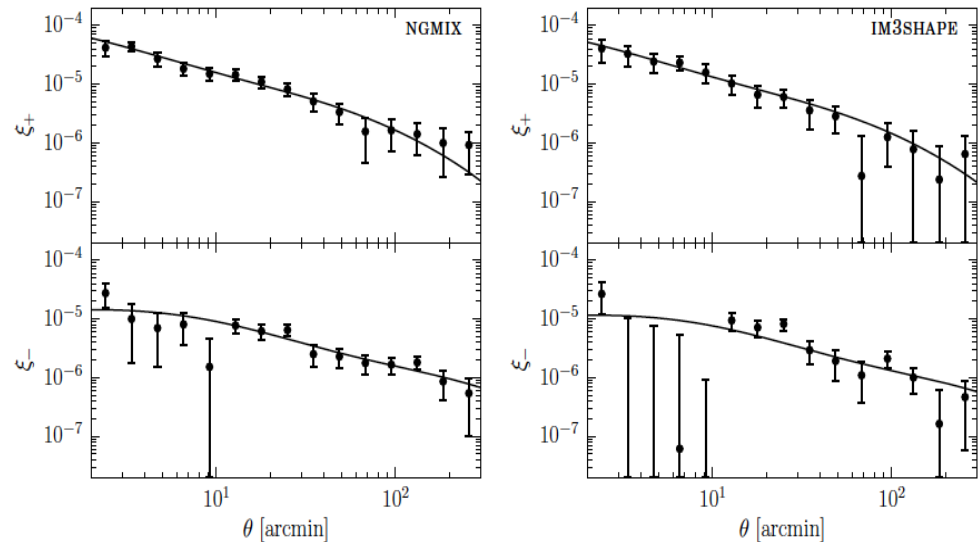
1M Foreground lenses @ $z \sim 0.3$

WL 2pt function from DES-SV: Measurement and Cosmology



Cosmological parameters

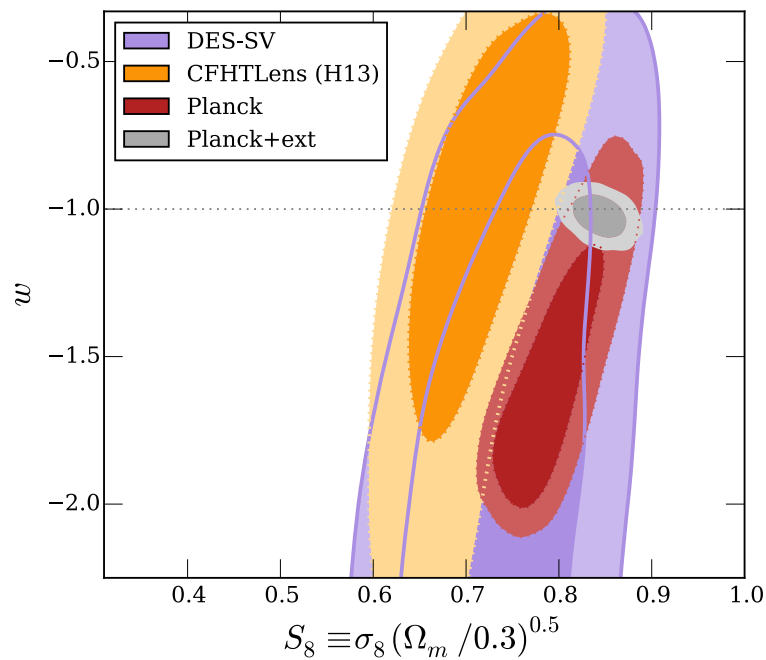
*The DES collaboration
(Bridle, McCrann, Zunz et al.)



2pt ξ (+-) from two shear pipelines

* Becker et al.
* Jarvis et al.

DE EoS w vs. fluctuation amplitude



- Possibly (first) signature of DE in DES-SV data alone
- S8 is not sensitive to w
- S8 from DES is in between Planck and CFHTLenS values

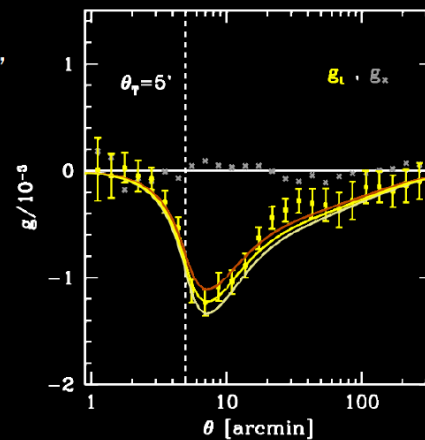
*The DES collaboration

WL image distortion: 1% effect,
to be measured to 1%, to get w to 1%

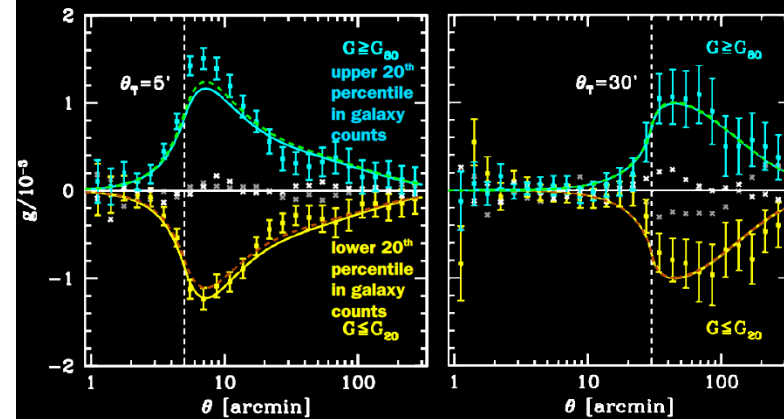
Weak lensing by troughs in the galaxy distribution

Measurement

- DES SV: ~ 150 sq. deg, full DES depth
- tracers: Rykoff/Rozo redMaGiC galaxies, $0.2 < z < 0.5$, $L > 0.5L^*$, $1/[1000 \text{ Mpc}^3]$
- troughs = lower 20th percentile
- sources: $\sim 2 \times 10^6$ at $z > 0.6$
- significance $\sim 15\sigma$

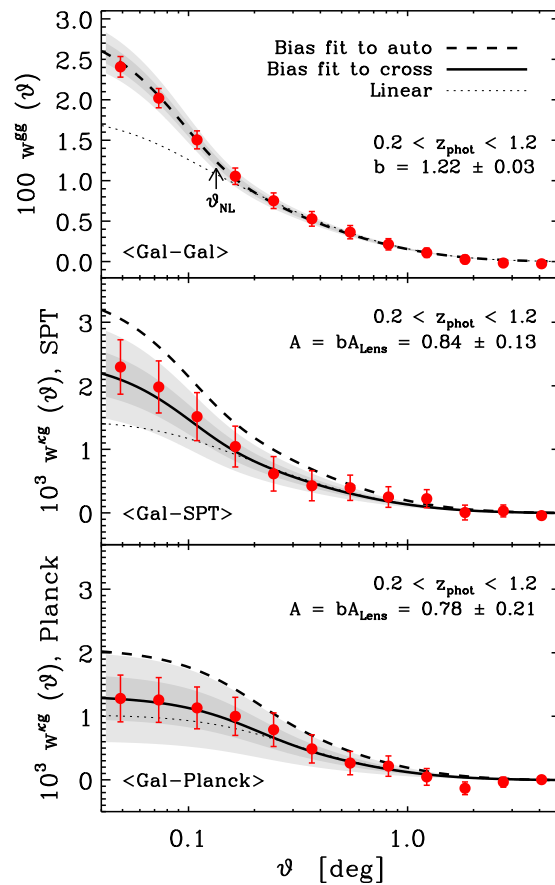


Measurement: under/overdensity



*Gruen et al.

Cross correlation of DES galaxies and mass fluctuations derived from the CMB



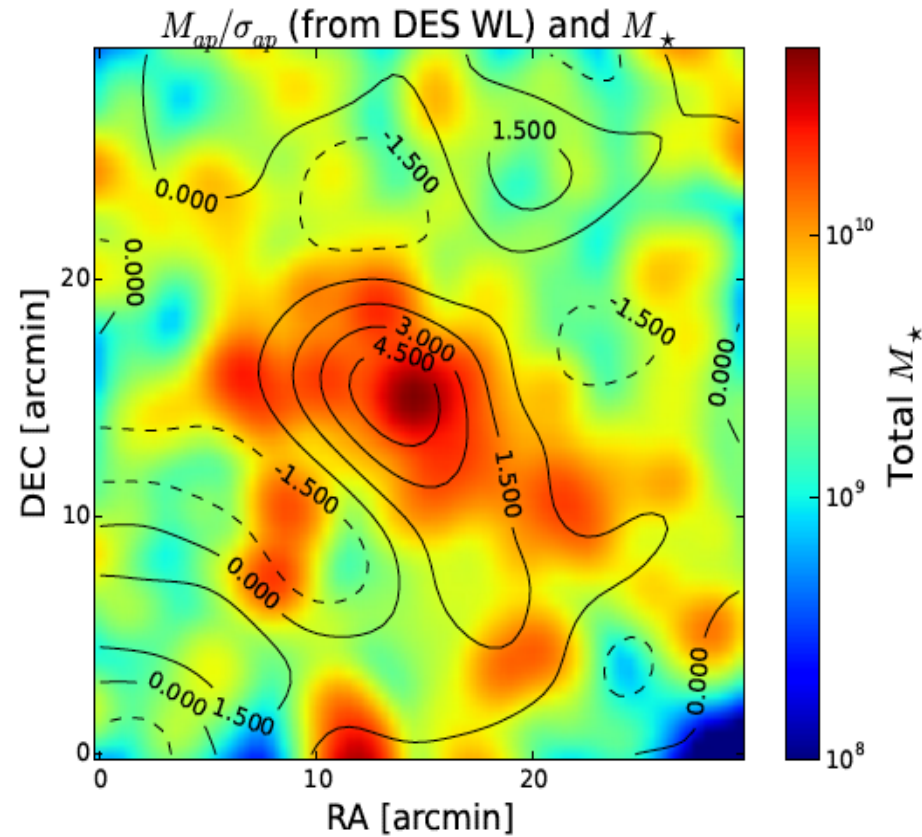
DES Gal-Gal
($0.2 < z < 1.2$)
(cf. [Crocce et al](#))

DES Gal – SPT mass
(6-sigma)

DES Gal – Planck mass
(4-sigma)

*Giannantonio et al

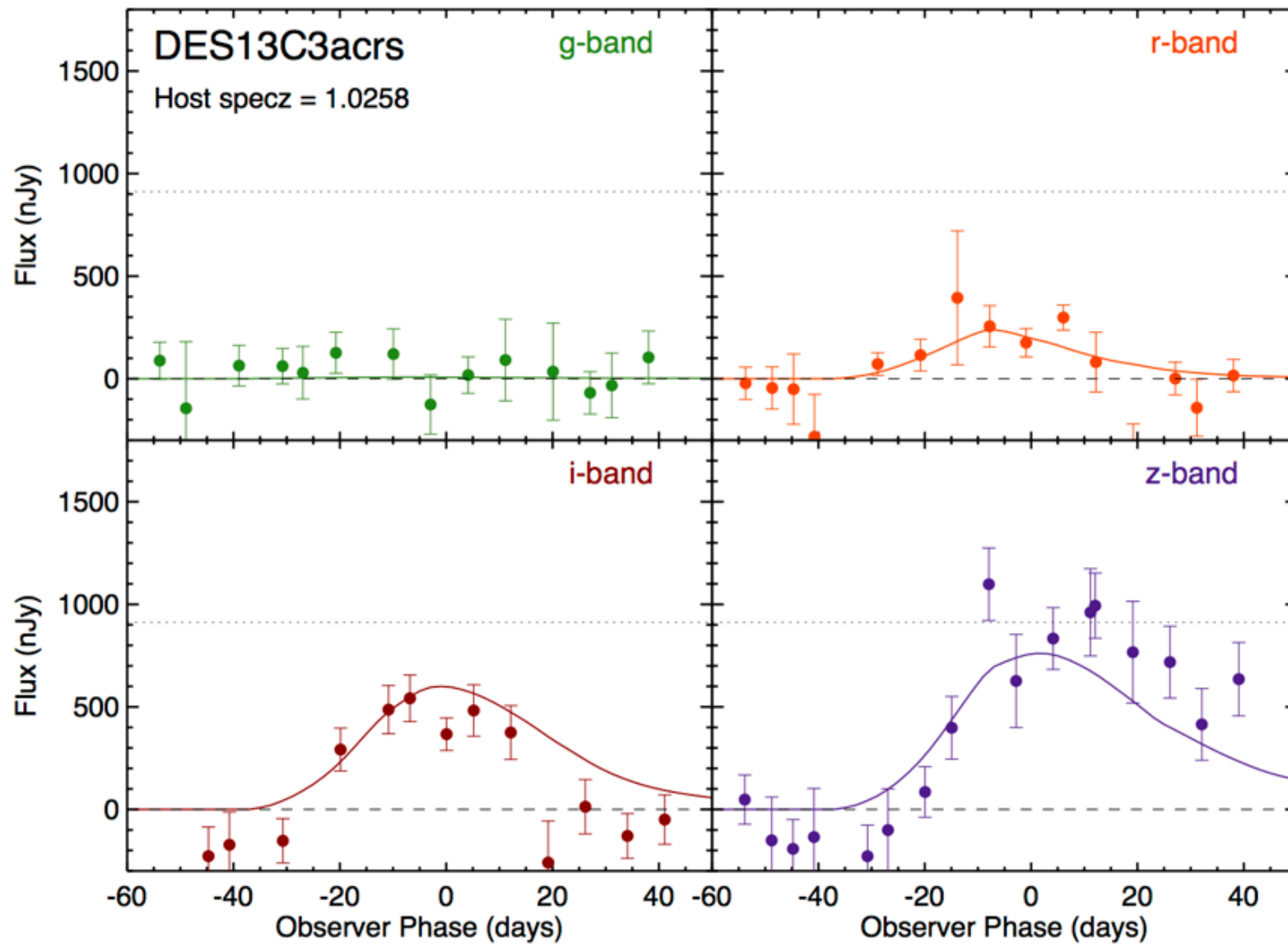
Weak Lensing mass vs. stellar mass: Cluster RXJ 2248



Melchior et al (2014)

Palmase, Banerji, Jouvel, OL et al. (in prep)

$z > 0.9$ Type Ia Supernovae



Nuisance Parameters

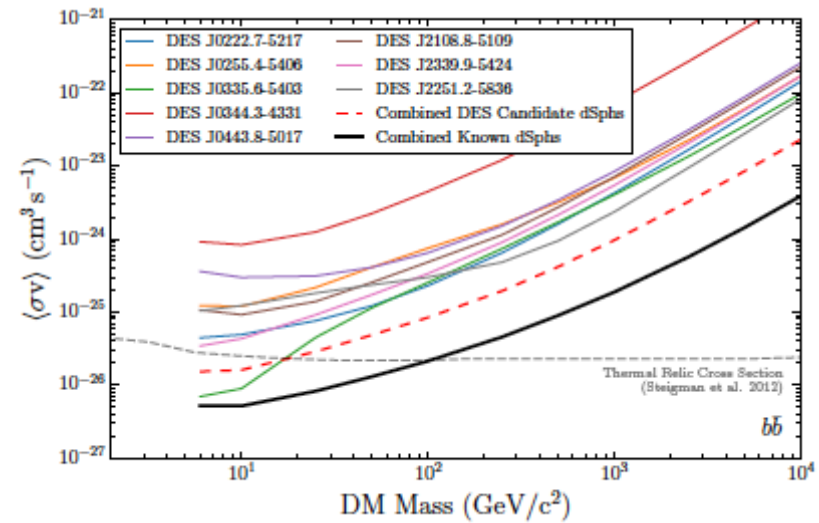
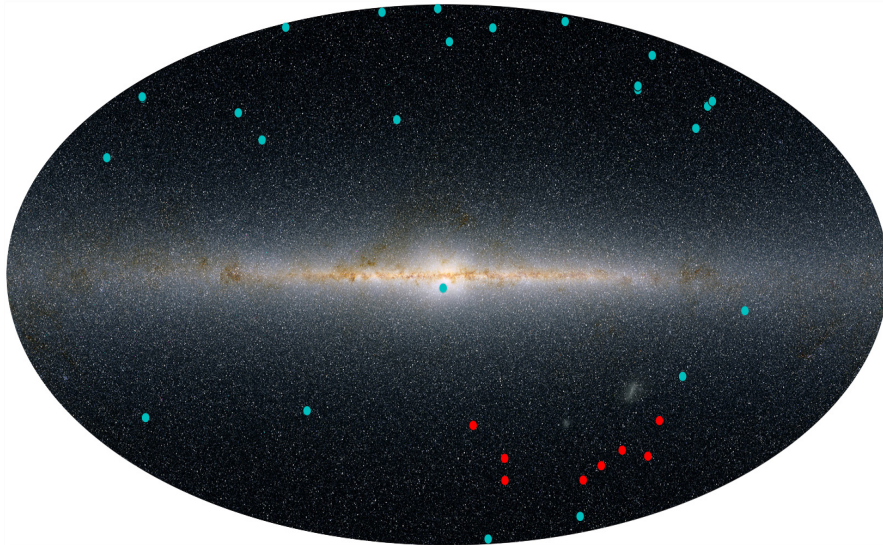
- Theoretical (the cosmological model & parameters, e.g. w/out neutrino mass)
- Astrophysical (e.g. galaxy biasing in LSS, dust in SN, intrinsic alignments in WL)
- Instrumental (e.g. image quality, photo-z)

Potentially hundreds of nuisance parameters
(while the whole universe is fitted by 6
parameters!)

DES – more than Dark Energy

- Solar system objects
- MW, dwarf satellites, LMC
- Galaxy evolution (including biasing and intrinsic alignments)
- Strong lensing
- QSOs (+ lensed QSOs)
- Super-luminous SN

The tale of 8 MW dwarf satellites from Y1 (in red):
 strong evidence for Dark Matter,
 but no evidence for what it is!



Drlica-Wagner et al.
 Bechtol et al.

From Ret 2's spectroscopy (Simon et al.)
 $M/L = 470 (M/L)_{\text{sun}}$

+ Independent papers by a Cambridge team (Koposov et al.)

Search for more dwarfs in Y2 21

Summary

- Both photo-z and cosmic shear can be measured reliably.
- Many Cosmology and Astrophysics results from early DES data, many studies led by ECS.
- DES does see DM, and good correlations between DM and galaxies.
- On the path to DE results from Y1&Y2 (...Y5) from LSS, WL, Clusters and SN Ia (+ cross correlations)
- What are the prospects for a new paradigm shift, beyond LCDM?

Extra slides

The DES surveys

	Area (deg ²)	Exposure time (s) (per visit for SNe) Specified median PSF FWHM (arcsec)					Dithering	Cadence
		g	r	i	z	Y		
Wide	5000	10x90 -	10x90 0.9"	10x90 0.9"	10x90 0.9"	10x45 -	10 fully interlaced tilings	10 tilings over 5 years
SN Shallow	24	1x175 -	1x150 -	1x200 -	2x200 -	-	Minimal dithers	Seeing >1.1" or 7 days since last observed
SN Deep	6	3x200 -	3x400 -	5x360 -	10x330 -			