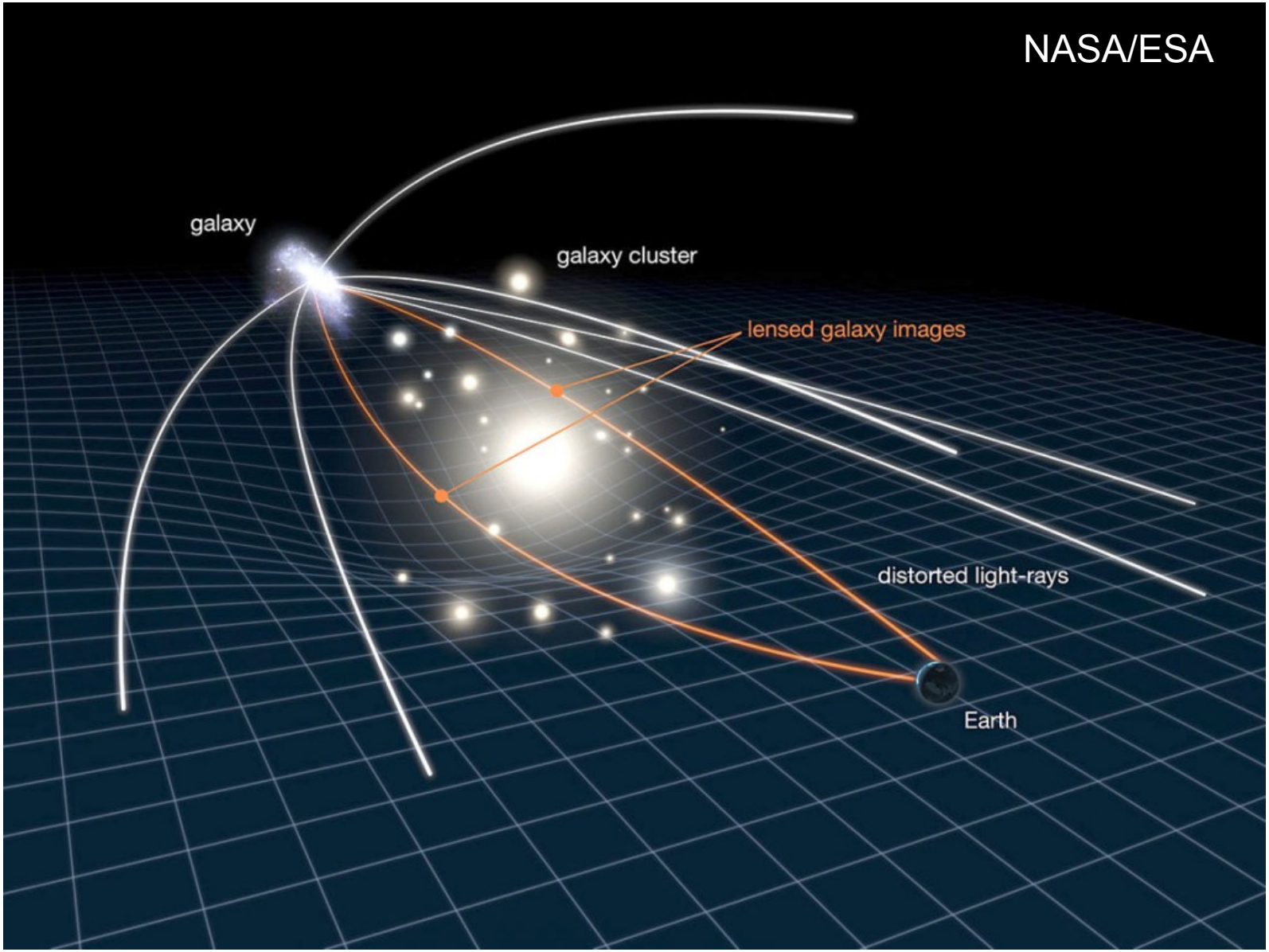
Dark Energy science
(and much more cosmology)
with the LSST

Benjamin Joachimi
University College London
b.joachimi@ucl.ac.uk

on behalf of the many DESC members in the UK

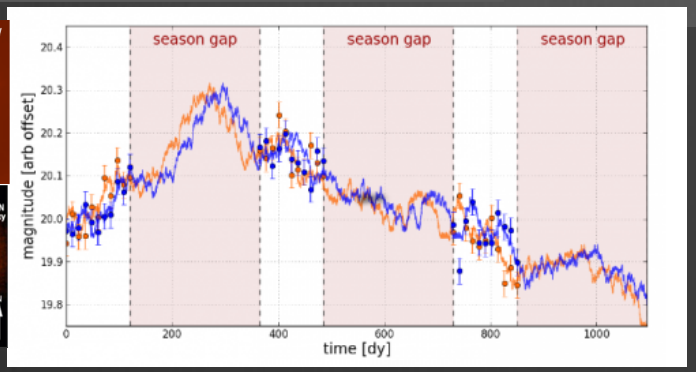
RAS Specialist Discussion Meeting, London May 12th, 2017

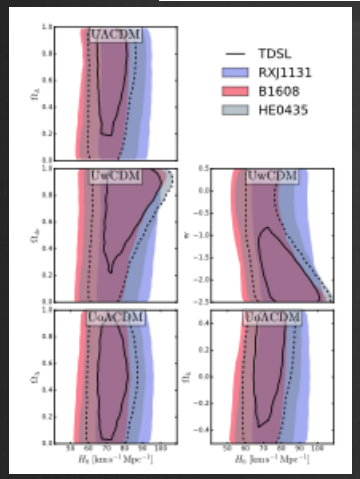
Gravitational lensing

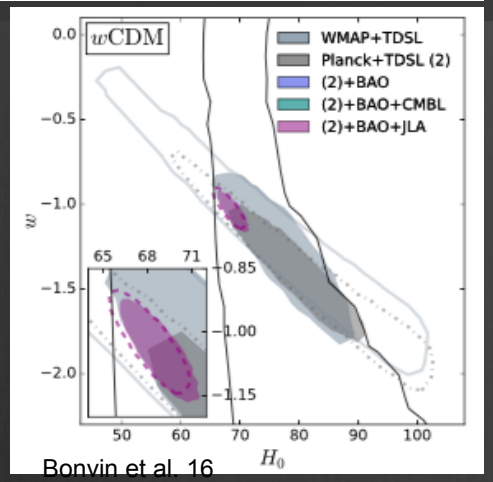


Independent H0 constraints with 100s LSST Strong Lenses

QSO/SNe Time Delays







Bonvin et al. 16

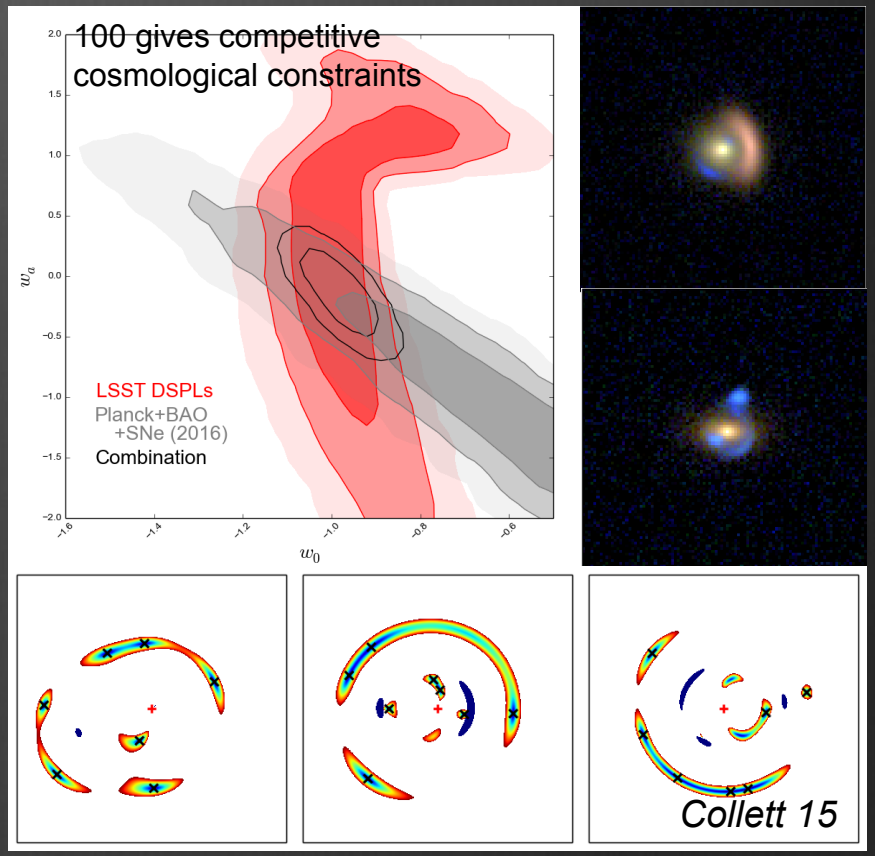
Couple the variability of quasars with lensed multiple images

Different path length through the lensing mass incurs a time delay in the light curves

Time delay distance $\propto 1/H_0$

Can achieve powerful constraints in combination with other probes (H0licow results above)

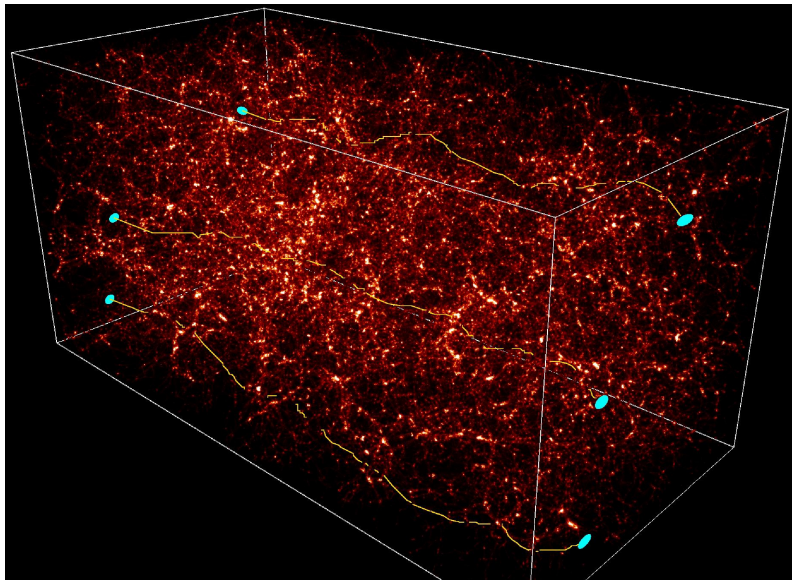
Double Source Plane Lenses

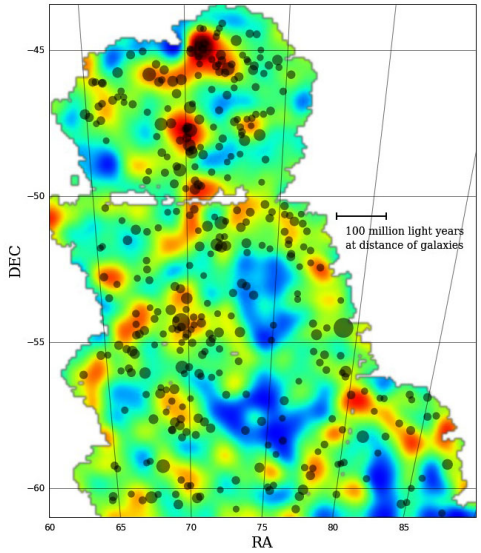


Ratio of Einstein radii is sensitive probe of cosmology (Collett & Auger 2014)

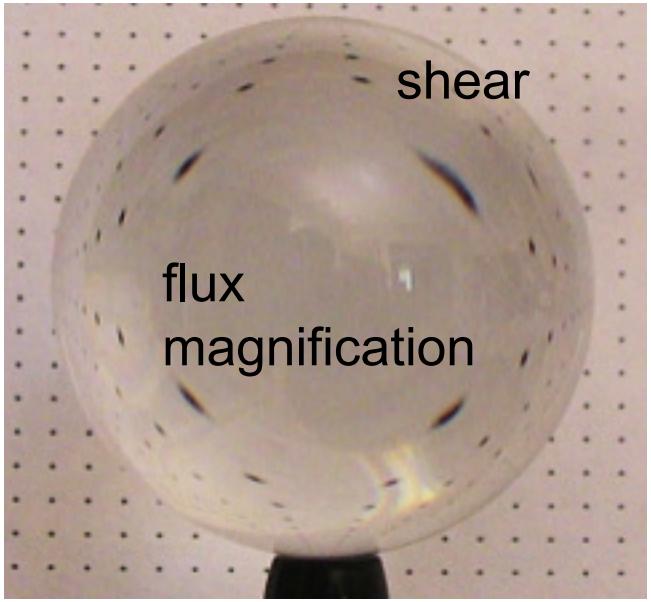
Don't follow conventional configurations, but finding them will be hard - especially if the first source has significant mass

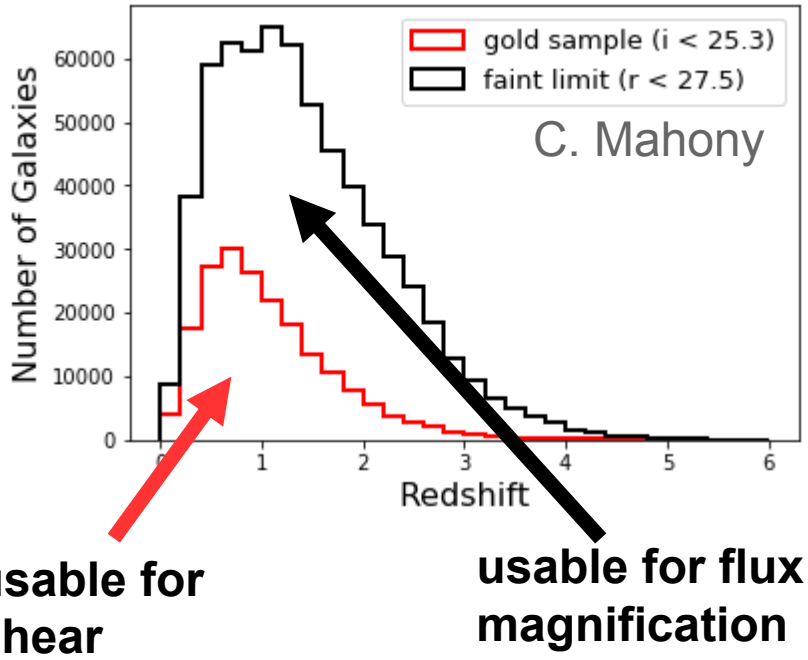
Weak lensing





DES

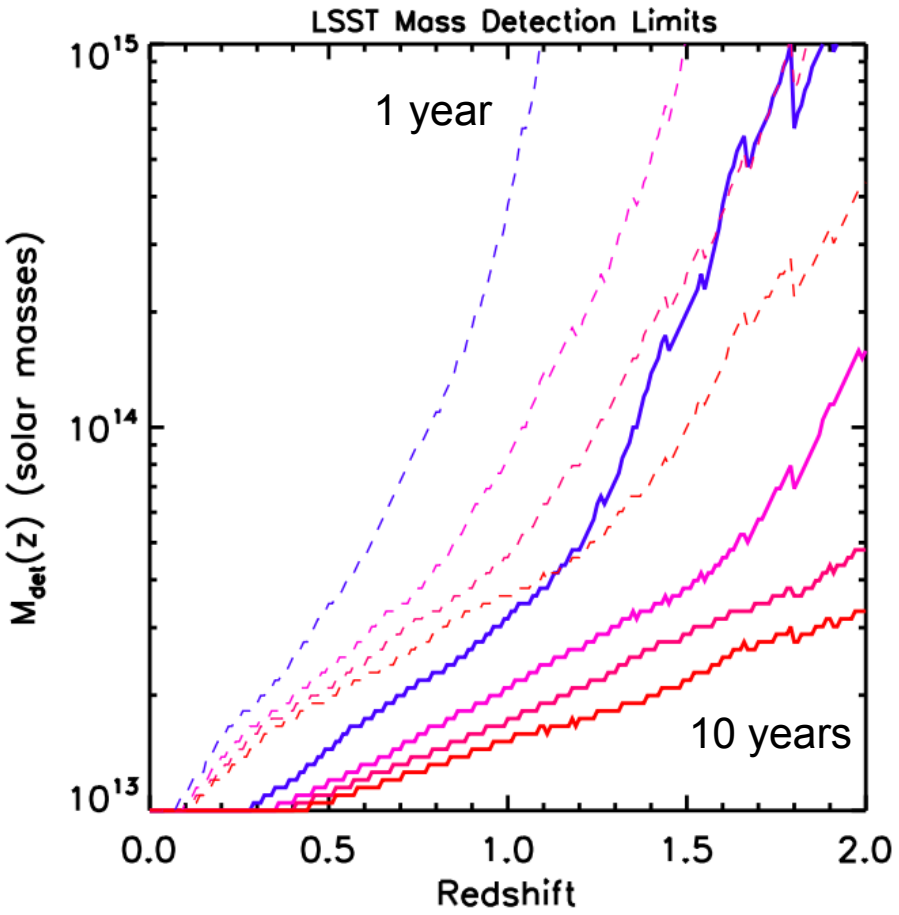




Galaxy clusters for cosmology

- cluster detection via red sequence in LSST bands
- cluster masses via weak lensing

For more cluster science see 'Galaxies' talk!



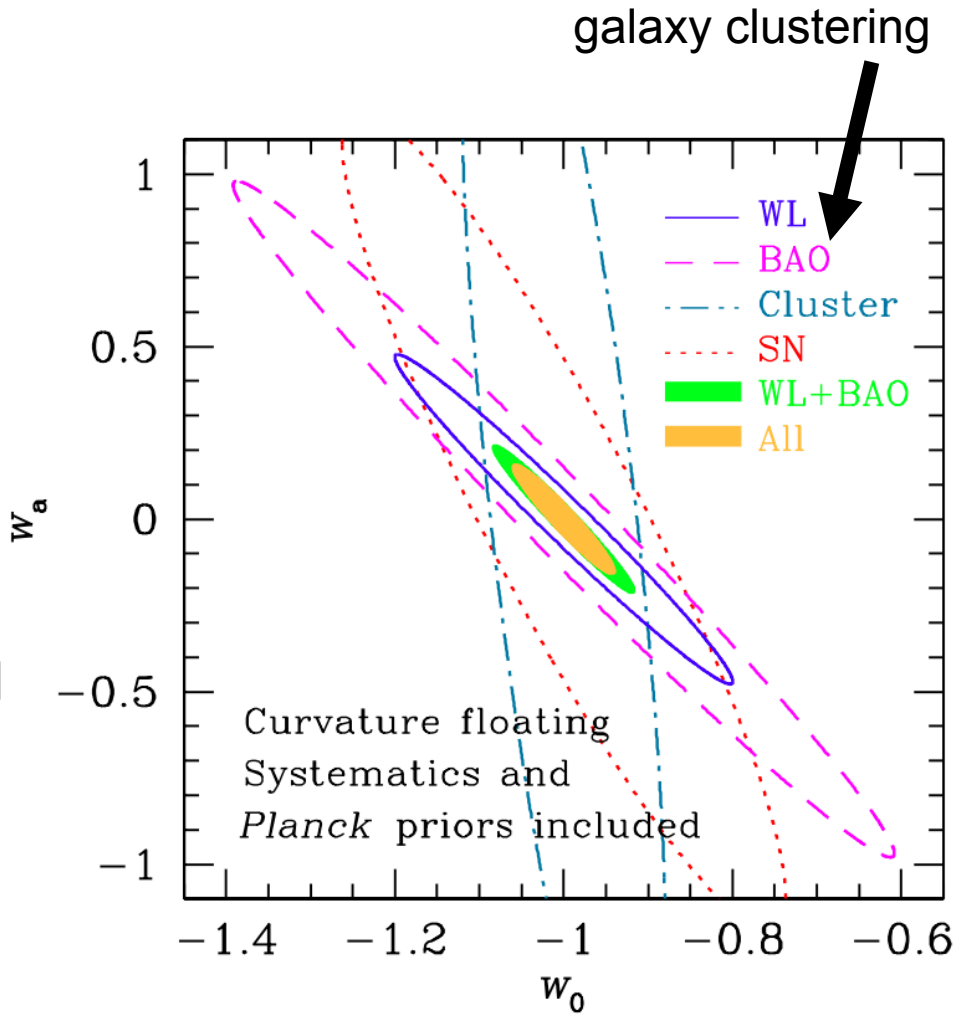
LSST Science Book

Constraining cosmology with LSST

- dark energy
- dark matter
- laws of gravity
- structure formation

→ LSST is a Stage IV experiment
highly complementary to Euclid

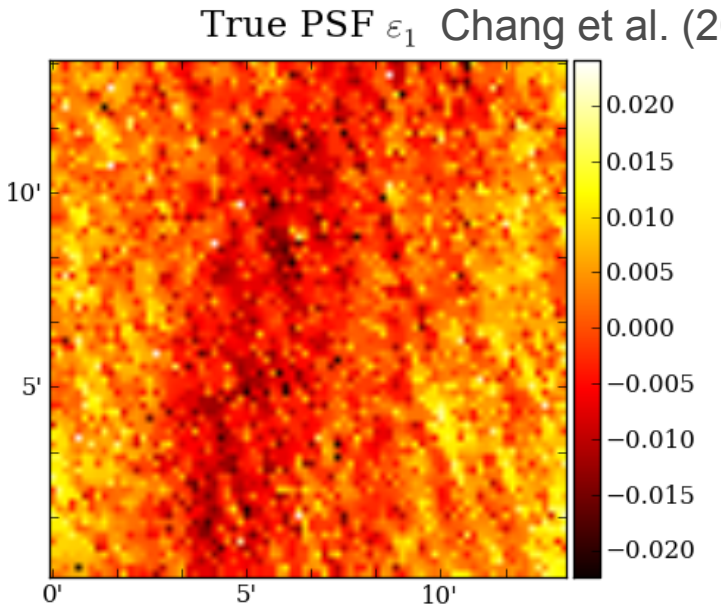
(*ugrizy* bands ↔ NIR bands)
(depth ↔ resolution)



LSST Science Book

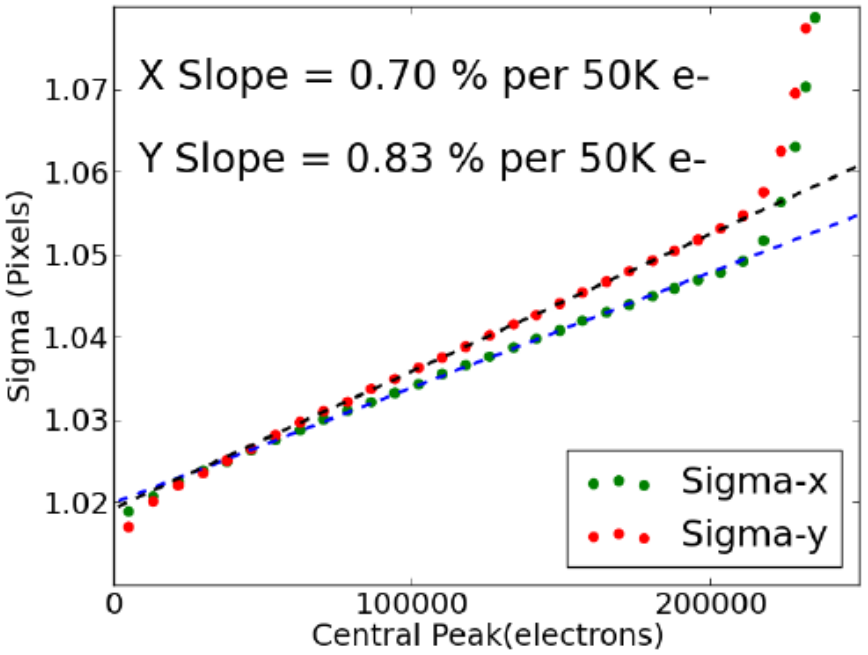
Challenges: the PSF

- short exposures → atmospheric contribution to PSF important
- generates stochastic PSF patterns over wide range of scales
- hard to model in single exposure due to limited number of stars



The brighter-fatter effect

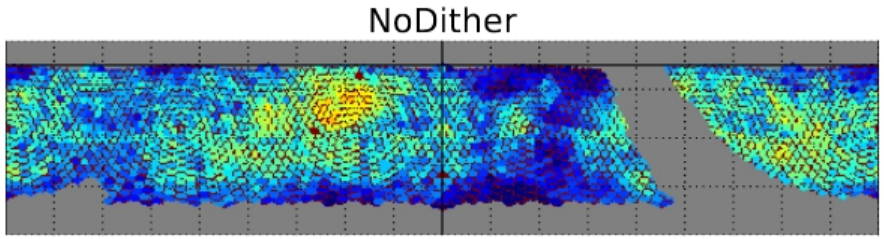
- PSF size increases with brightness

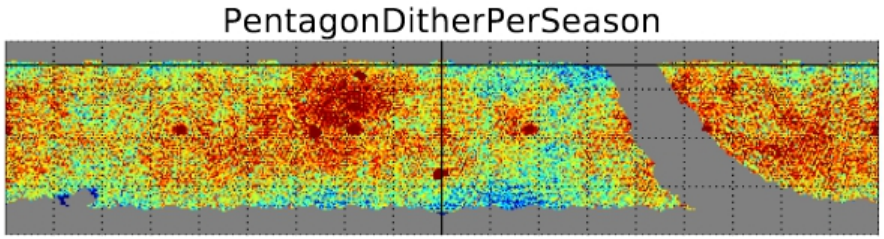


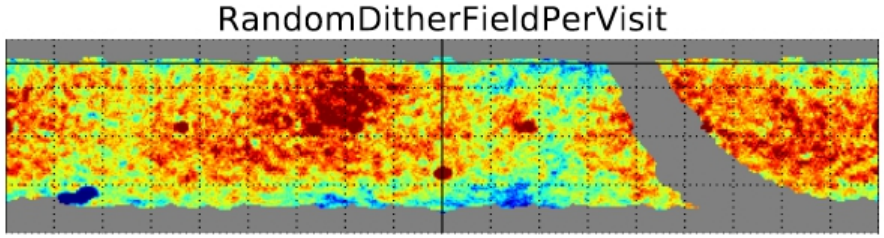
Lage et al. (2017)

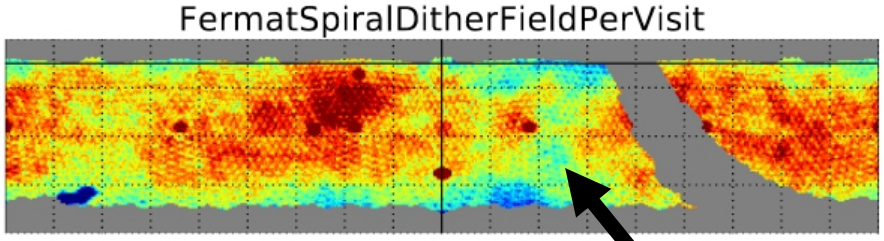
→ need to characterise PSF effects in the lab and on the sky

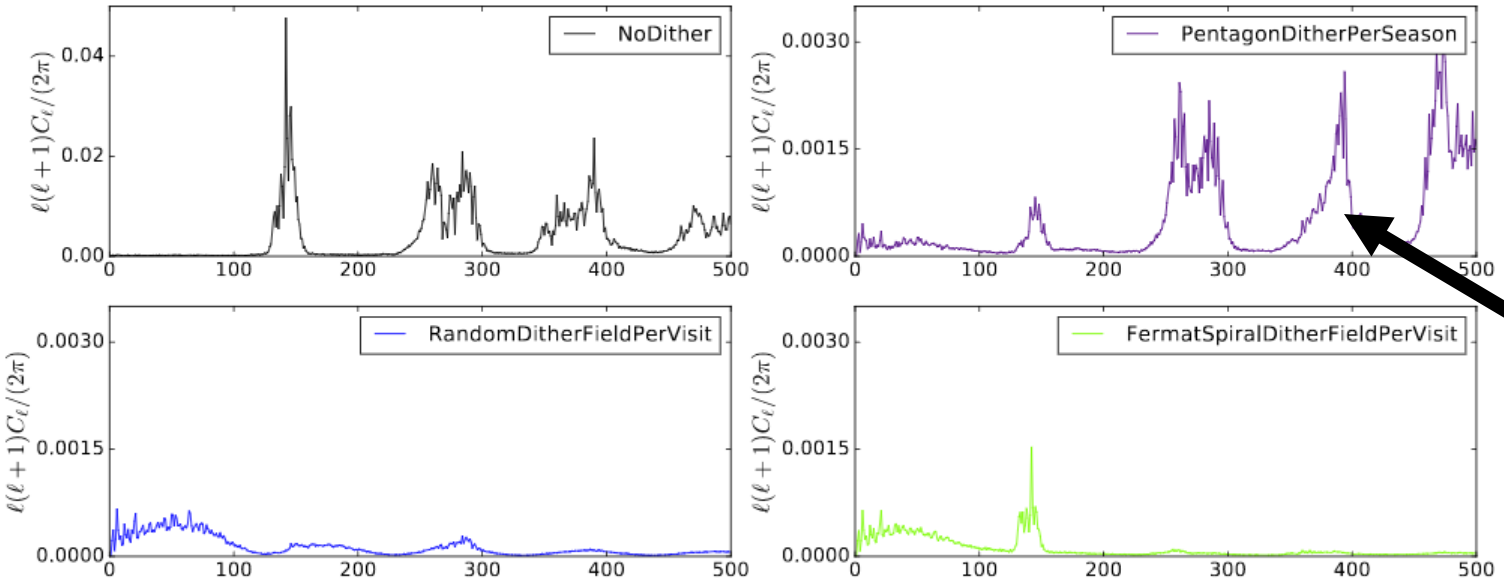
Challenges: dithering and depth











magnitude limit

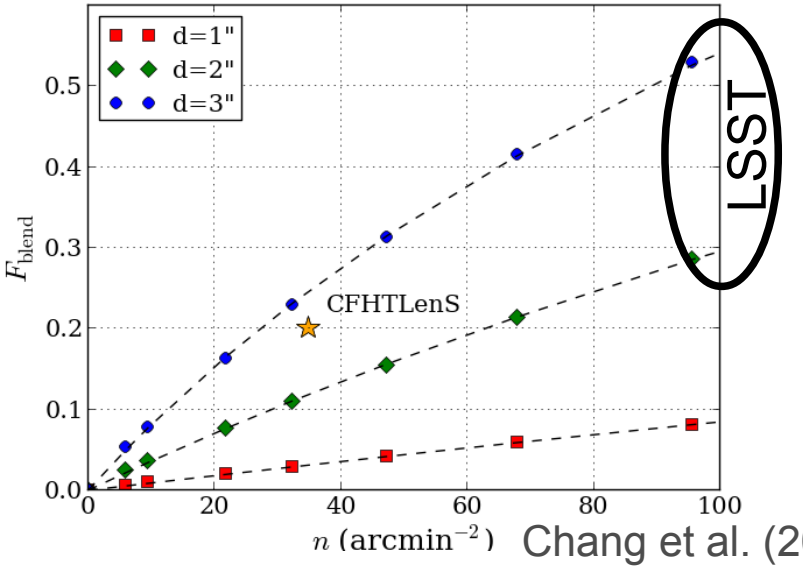
spurious power spectrum

Awan et al. (2016)

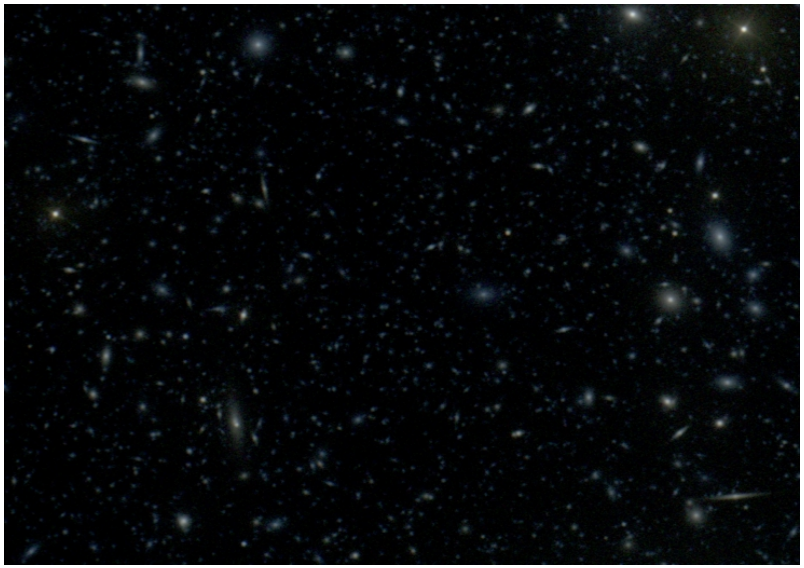
Challenges: blending

- deep ground-based data has high fraction of blends
- ~20% reduction in usable galaxies
- unidentified blends modify noise distributions
- blends of galaxies at different redshifts cause systematics

→ need to analyse realistic simulations and early data and establish impact on cosmology



Chang et al. (2013b)



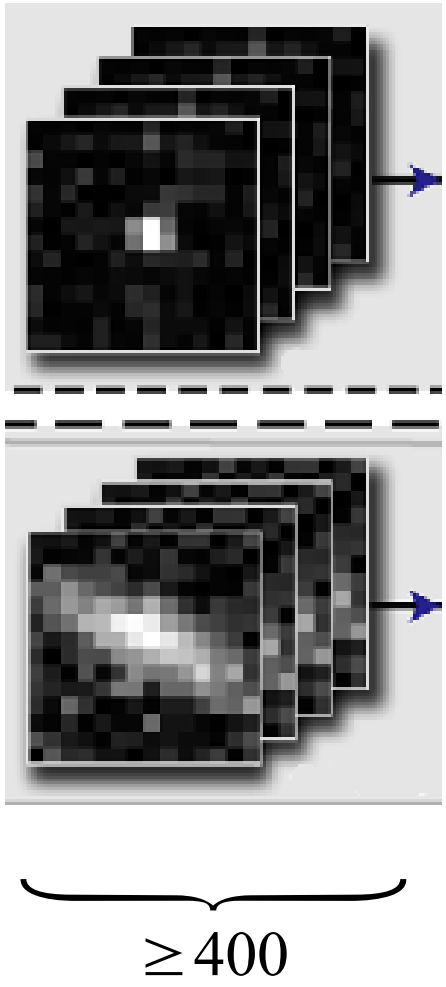
LSST image simulation

Challenges: big data analysis

- shear & PSF measurement on individual exposures
  [current codes slow on <10% of exposures on <10% of survey area]

- photometric redshifts: forced photometry on 3×10^{13} LSST objects
  + ingestion of infrared bands and calibration data

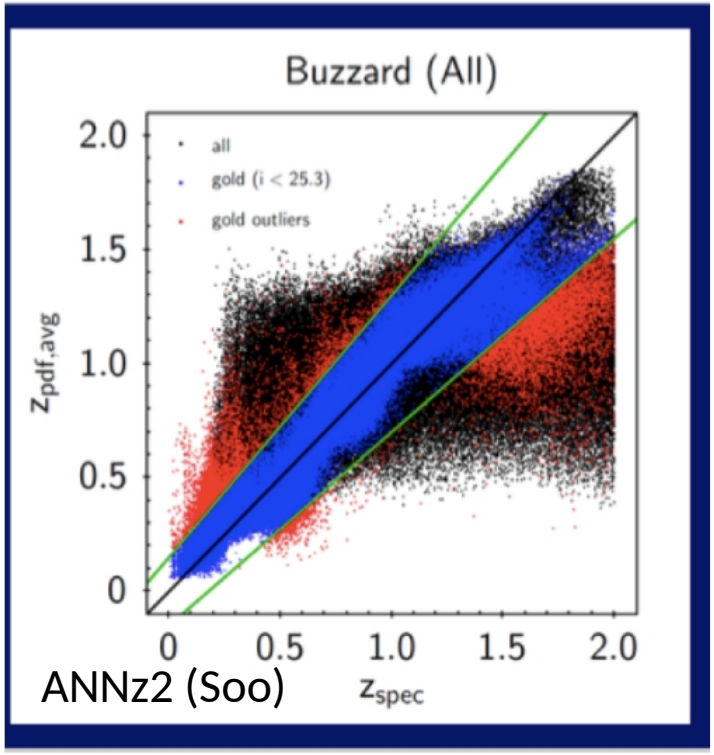
→ ideally analyse all of this jointly and consistently propagate statistical and systematic errors

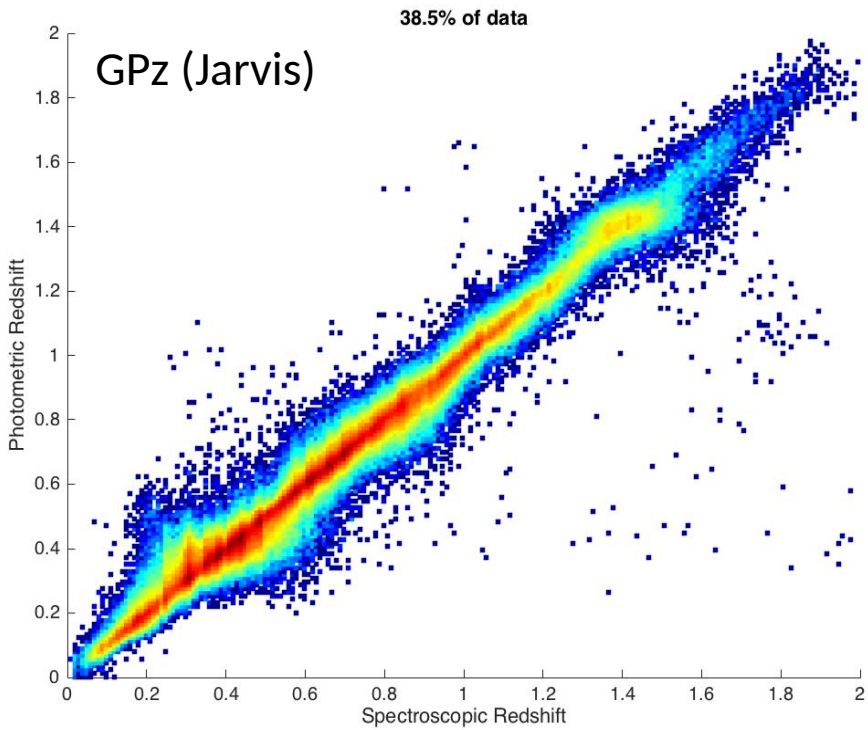


GREAT10 Handbook

Challenges: photometric redshifts

- critical enabling science for various key probes, esp. weak lensing and galaxy clustering
- LSST has no dedicated spectroscopic follow-up, so distance information largely relies on 6 broad-band photometry





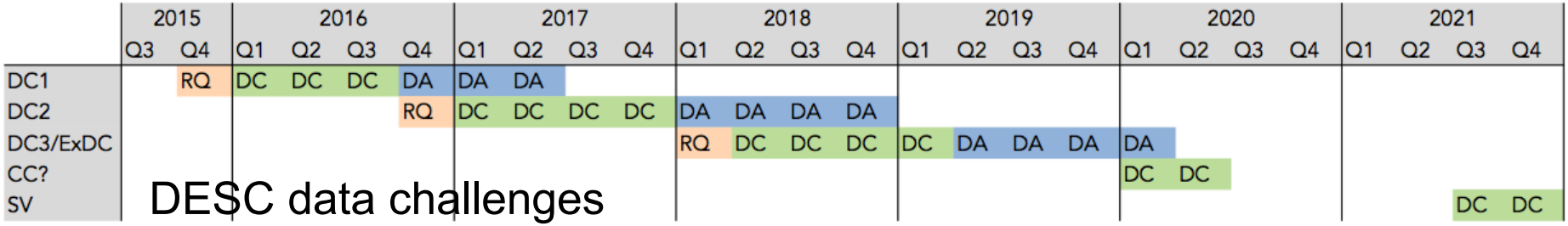
The Dark Energy Science Collaboration

- about 600 members
- led by spokesperson (2yr term): Phil Marshall (SLAC)
- has its own council with representation from all career stages

Analysis WGs:
- weak lensing
- large-scale structure
- supernovae
- galaxy clusters
- strong lensing
- theory and joint probes
- photometric redshifts

Technical & computing WGs:
- cosmological simulations
- survey simulations
- infrastructure
- sensor anomalies
- photometric corrections

DESC Science Roadmap: http://lsst-desc.org/sites/default/files/DESC_SRM_V1_0.pdf



DESC data challenges

UK engagement in DESC

Official DESC roles:

- Weak Lensing WG co-lead: J. Zuntz (Edinburgh)
- LSS [clustering] WG co-lead: D. Alonso (Oxford)
- Photo-z WG co-lead: O.Lahav (UCL)
- Main developers Core Cosmology Library: E. Chisari (Oxford), D. Alonso

Additional UK opportunities:

- ample experience with photometric LSS surveys: KiDS, DES
- cross-wavelength expertise: Euclid, SKA, VISTA, …
- deep spectroscopic calibration (?)

Want to get involved?

- weak lensing PoC: Benjamin Joachimi
- large-scale structure PoC: Jon Loveday
- photometric redshifts PoC: Ofer Lahav