LSST Synergies with Euclid and SKA

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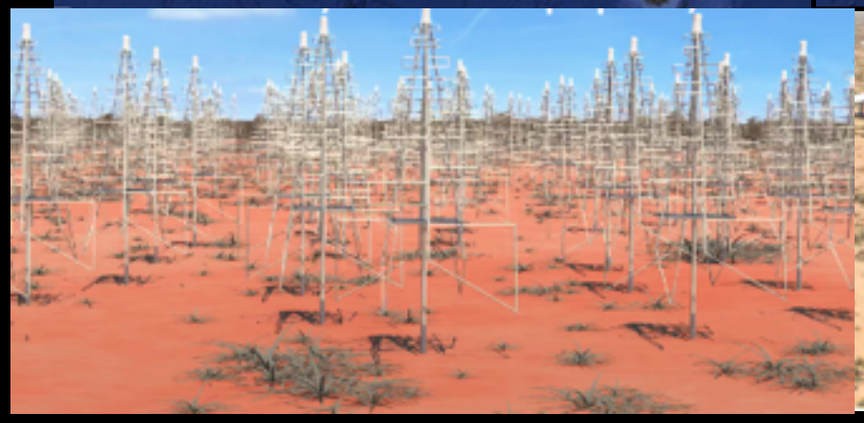
SQUARE KILOMETRE ARRAY

SKA Phase 1 baseline design:
Frequency range: 50MHz -14GHz

Construction 2019-23; commissioning & early science 21-23

SKA-Low ~130,000 low frequency dipoles



SKA-Mid ~130 15m dishes + 64 MeerKAT

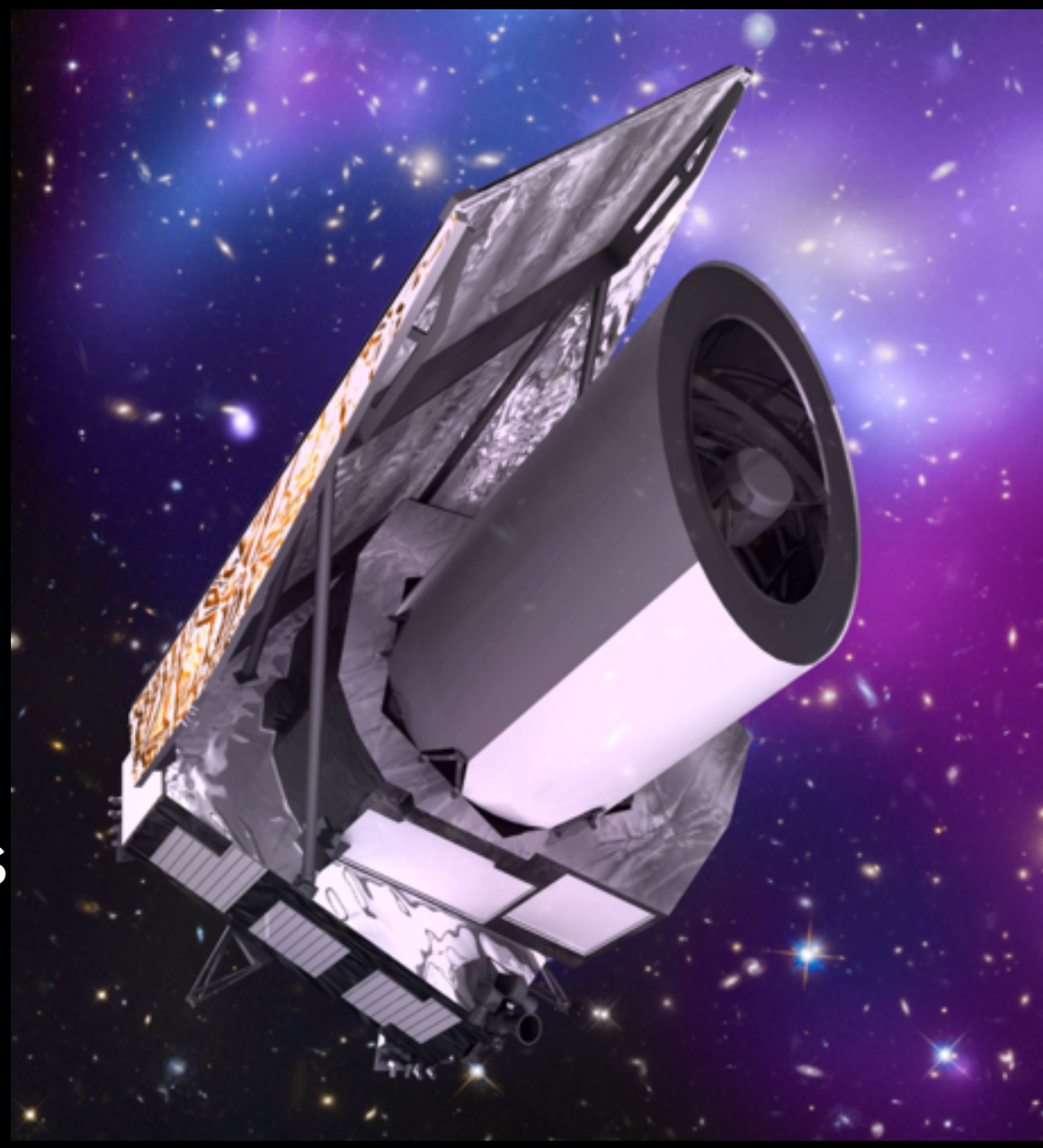
EUCLID

15000 sq deg wide survey
40 sq deg deep survey

1.2m mirror; FOV 0.53 sq deg

Visible (0.1”, R+I+Z)
1.6G galaxies (mag<24.5)
+NIR (Y,J,H) imaging
NIR spectroscopy - 45M galaxies

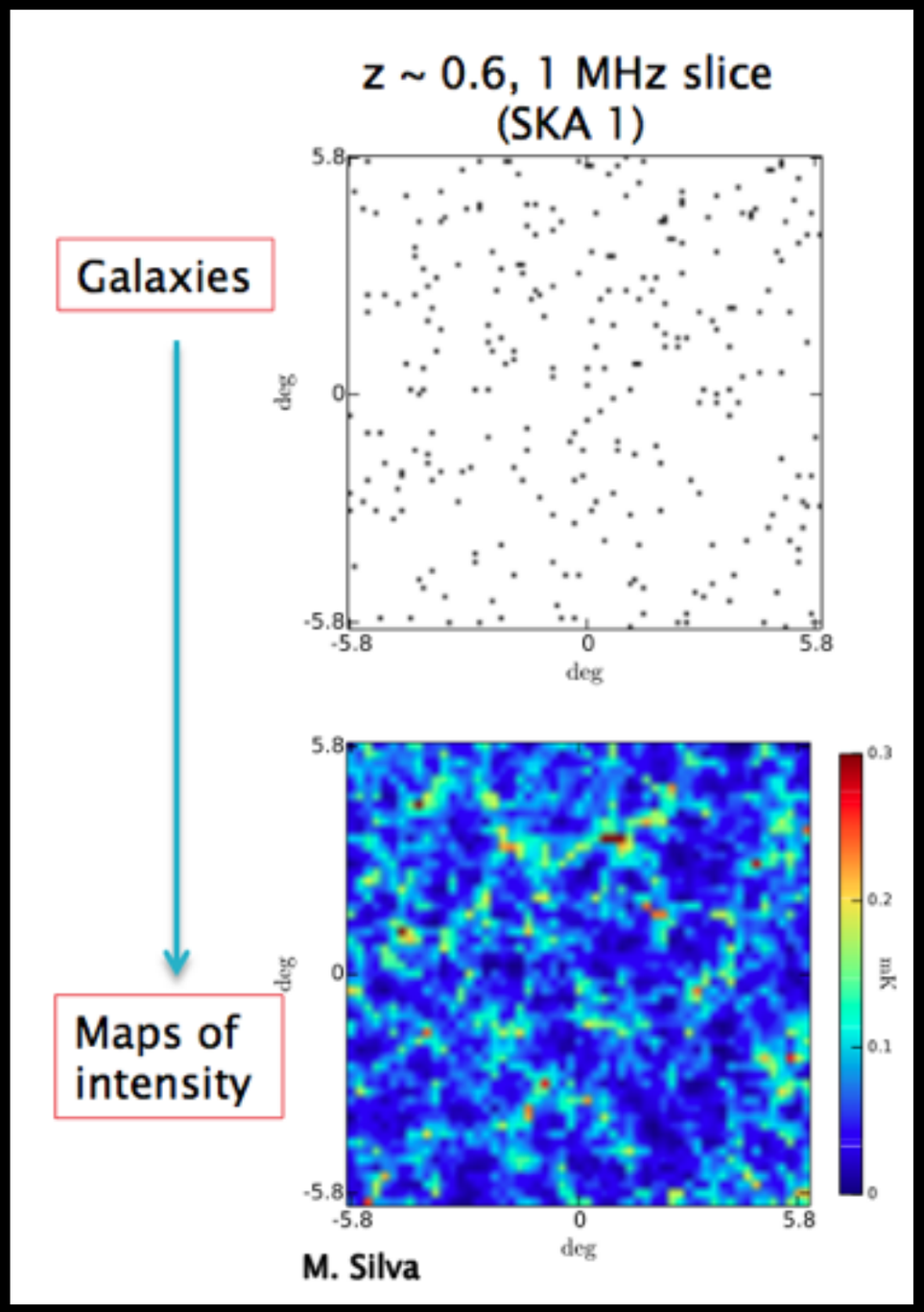
LSST provides time-resolved optical passbands, Euclid provides spatially-resolved optical and NIR data.

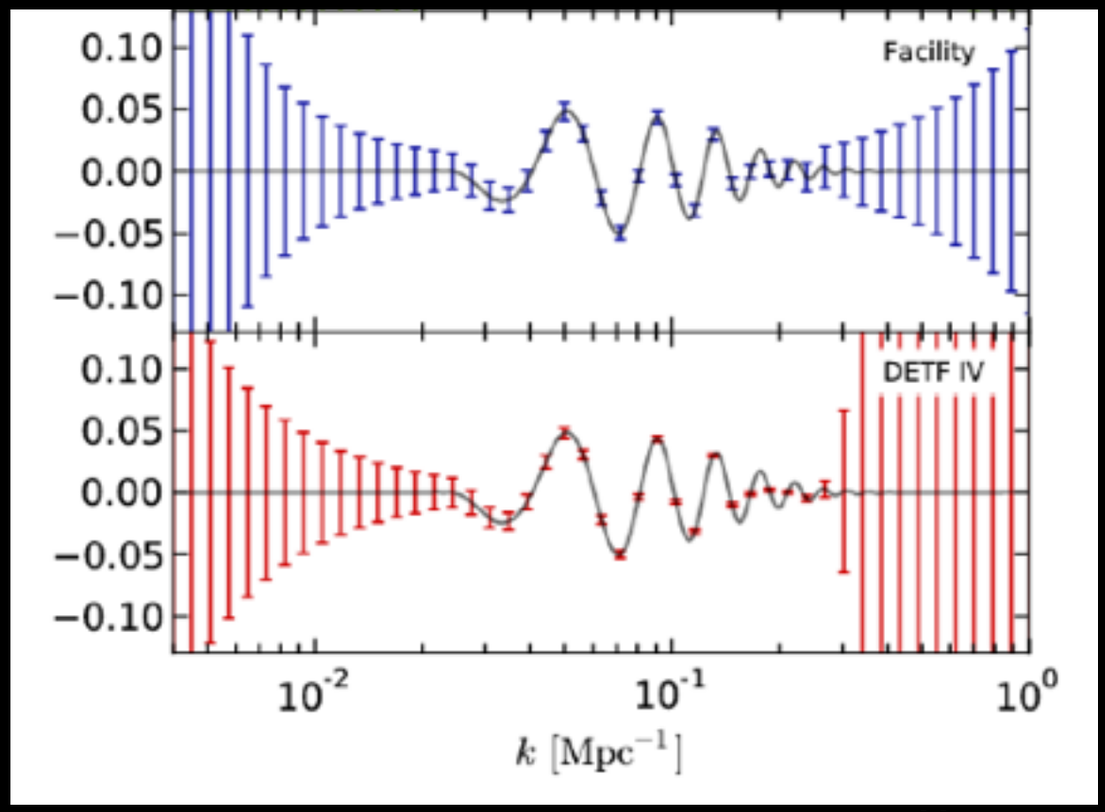


Launch 2020

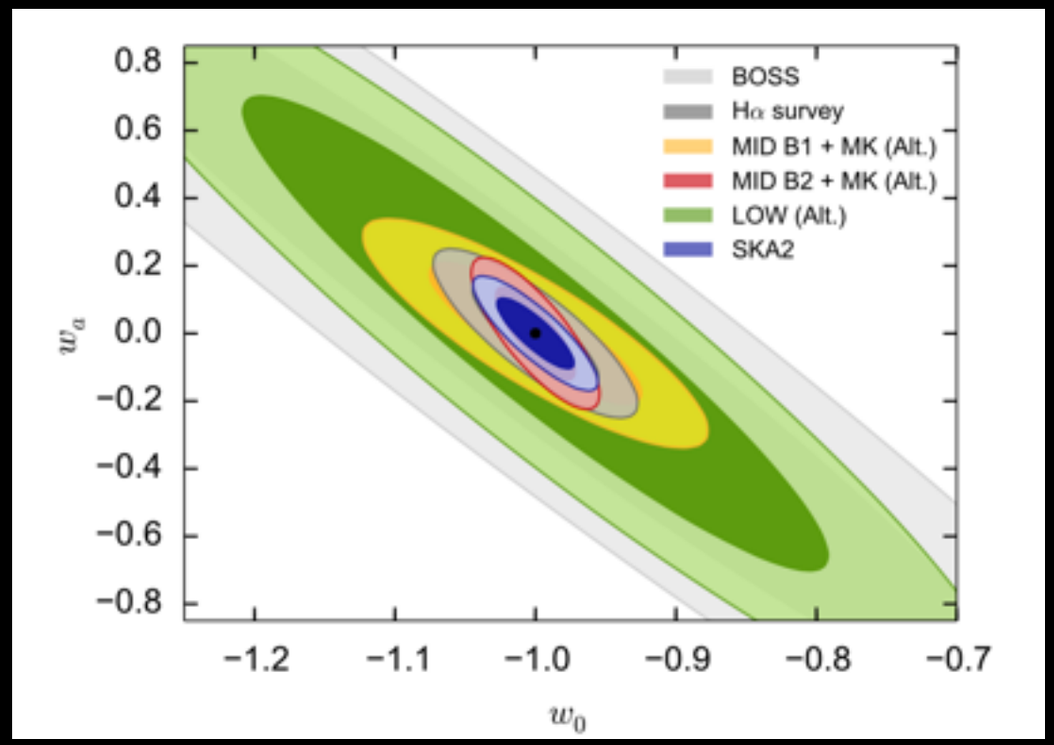
COMPARABLY POWERFUL SURVEYS

Intensity mapping (SKA1):



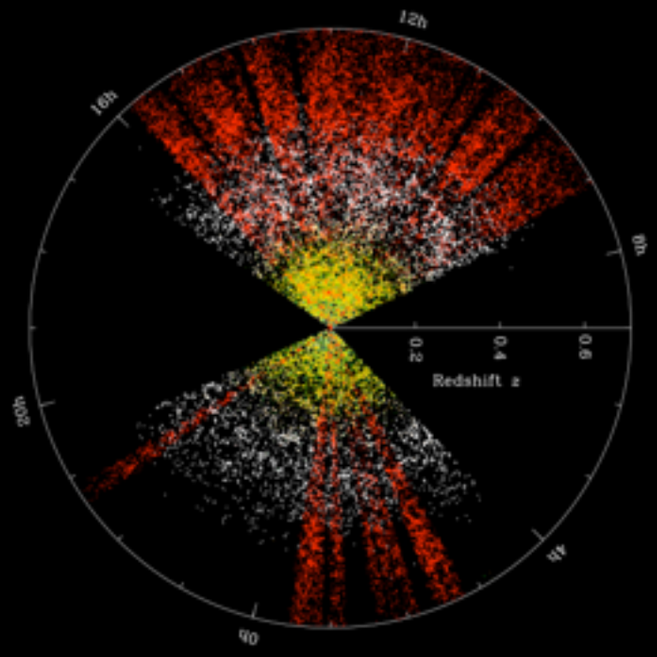


Bull et al 15



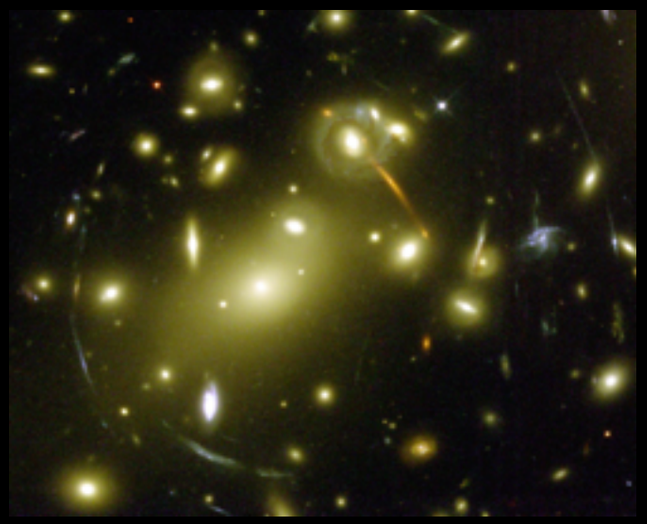
Bull 2015

COSMOLOGICAL PROBES WITH THREE TELESCOPES



- e.g. Source clustering

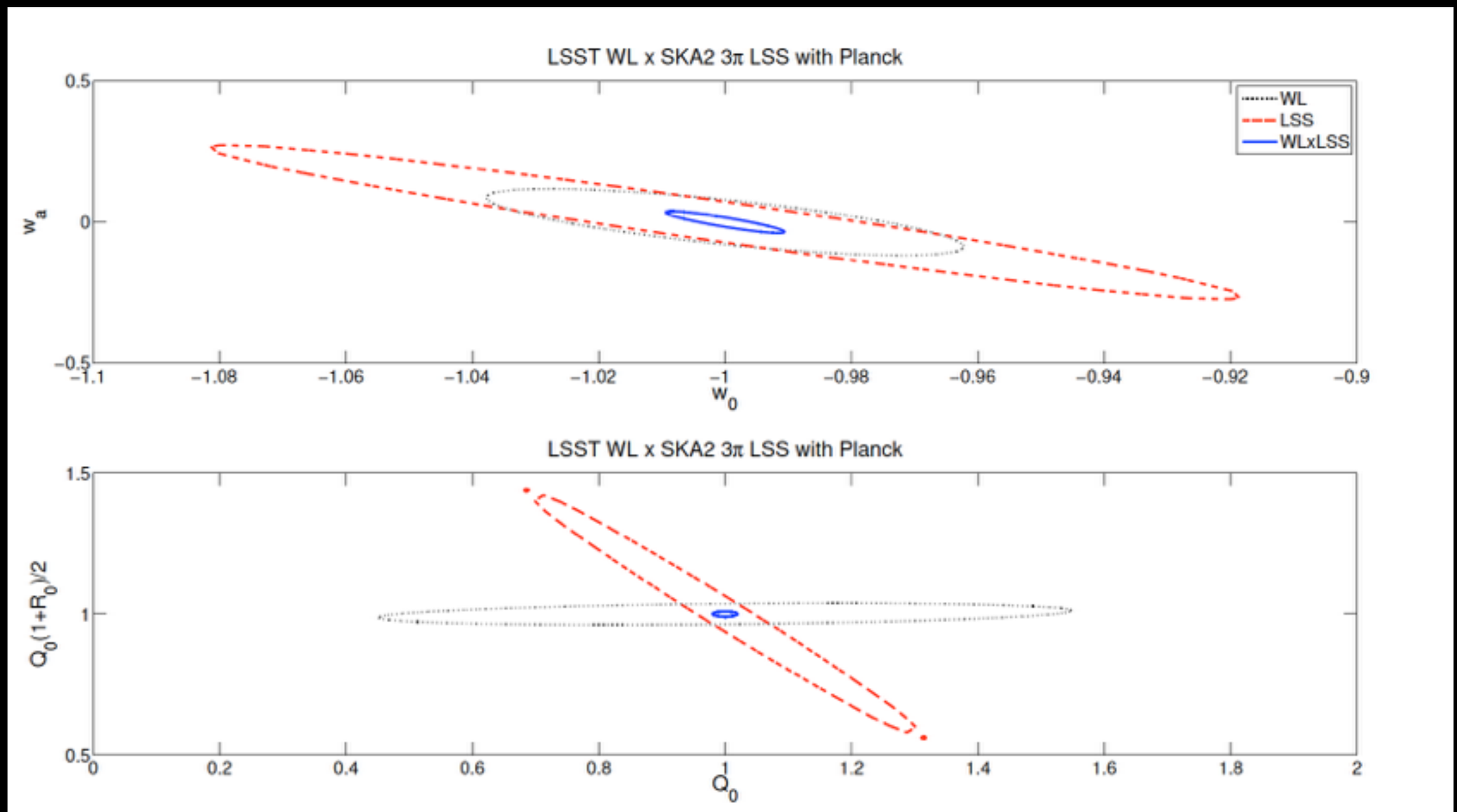
- including Baryon Acoustic Oscillations and Redshift Space Distortions (Euclid, SKA)



- Cosmic shear, shear-galaxy, strong lensing.

COMBINING SURVEYS - 1) AT THE END

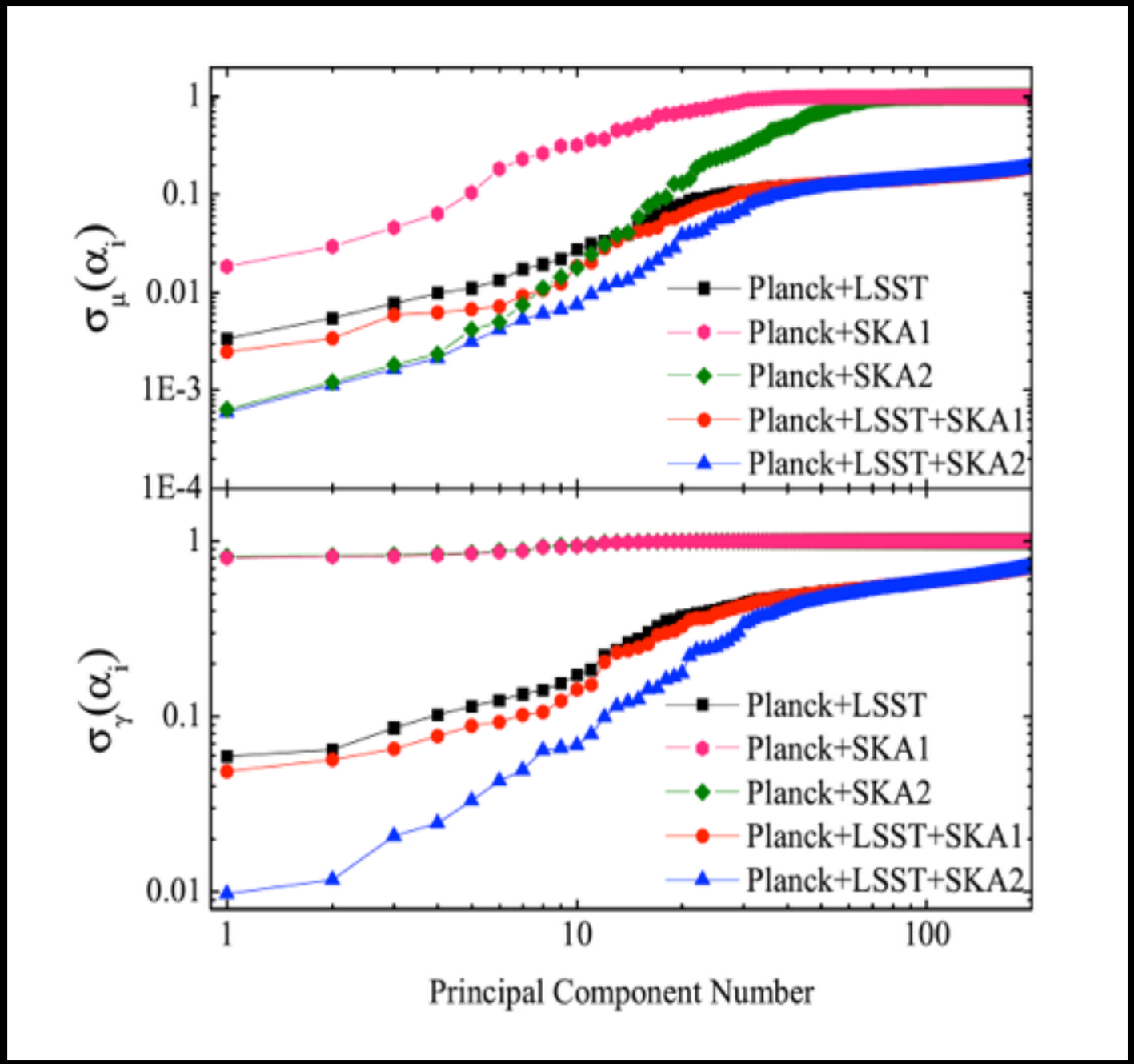
e.g. Combining constraints from LSST lensing+SKA2 HI galaxy clustering (including RSD):



Bacon et al 15

COMBINING SURVEYS - 2) IN COMBINED STATISTICS

e.g. PCA approach: LSST lensing + SKA HI clustering



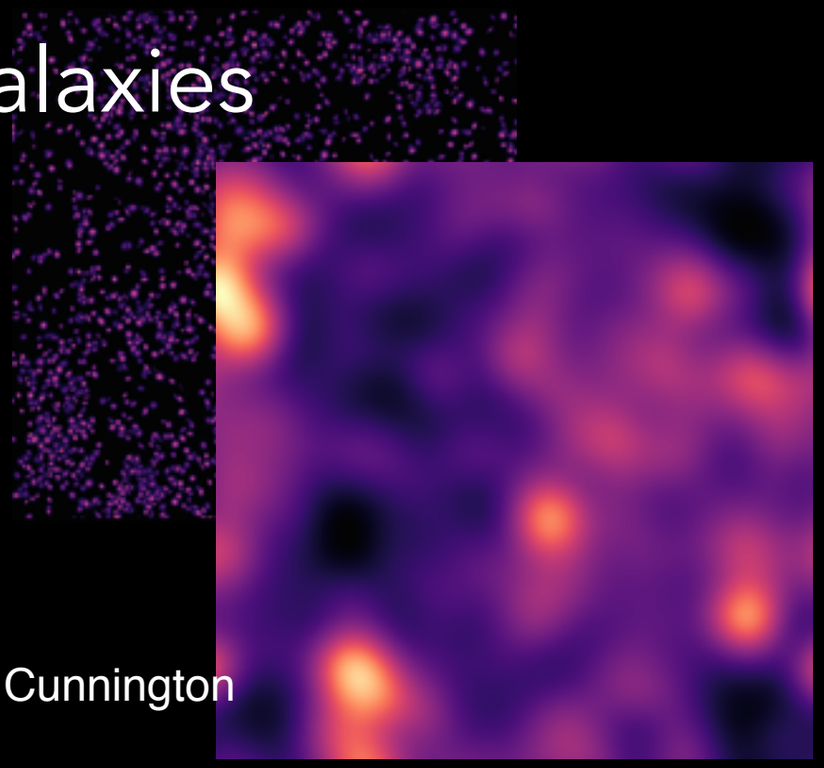
Allow gravity/DE parameters to be scale and z-dependent functions:

$$g(z)+1 = \sum \alpha_i \, e_i(z)$$

Bacon et al 15, Zhao et al 15

INTENSITY MAPPING CROSS-CORRELATIONS

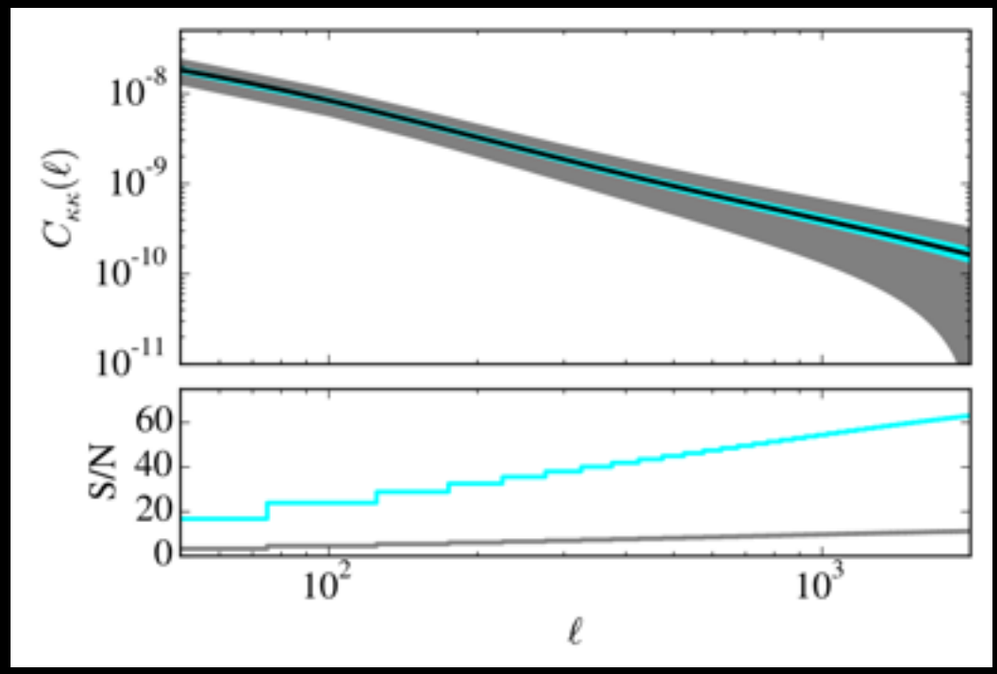
Galaxies



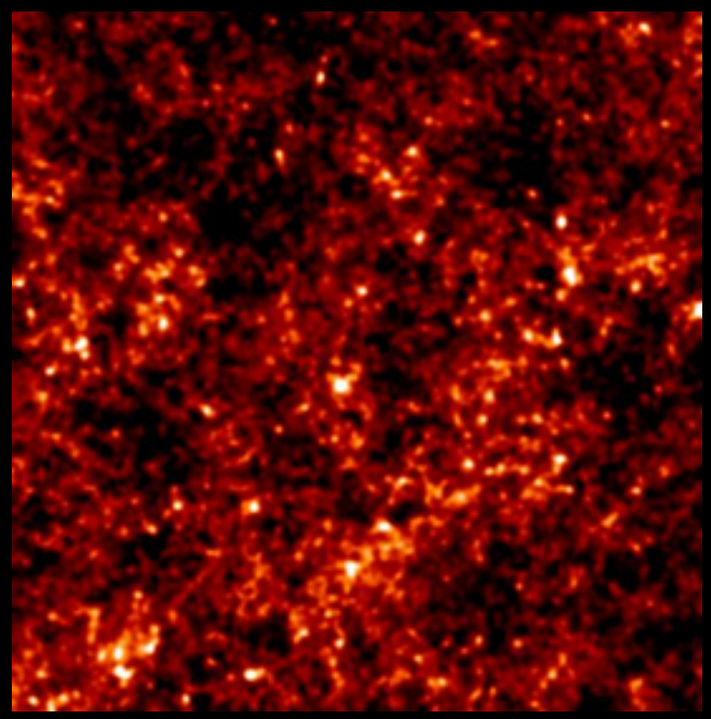
IM

Steve Cunnington

Pourtsidou et al 16



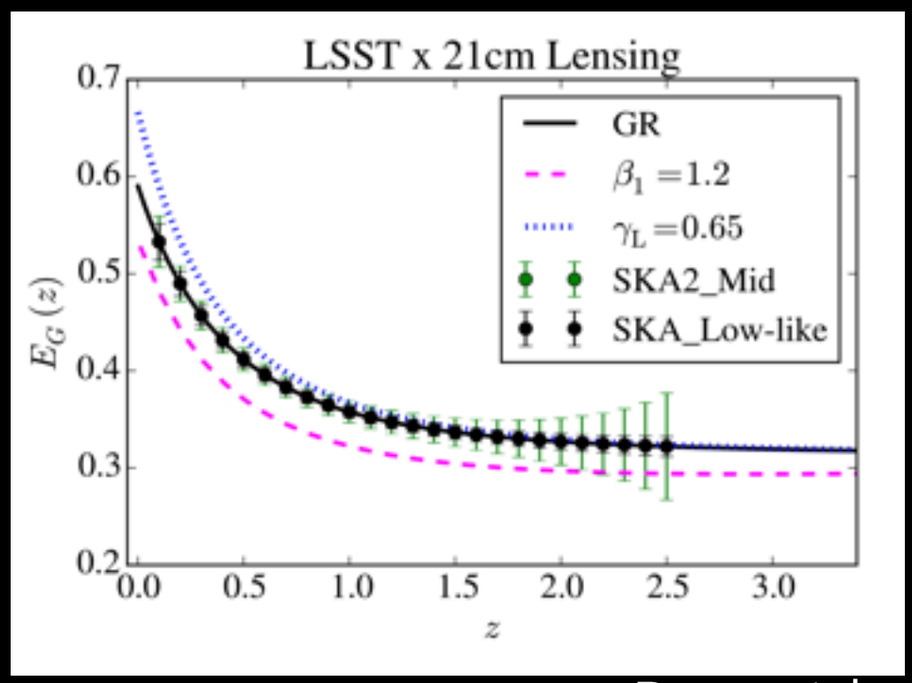
21 cm lensing at Epoch of Reionization:



20′

Hilbert et al 07

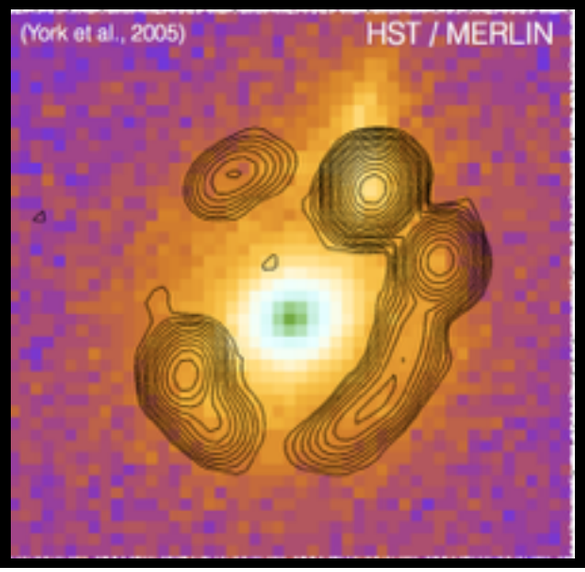
E_G parameter, sensitive to theory of gravity:



SNR =238

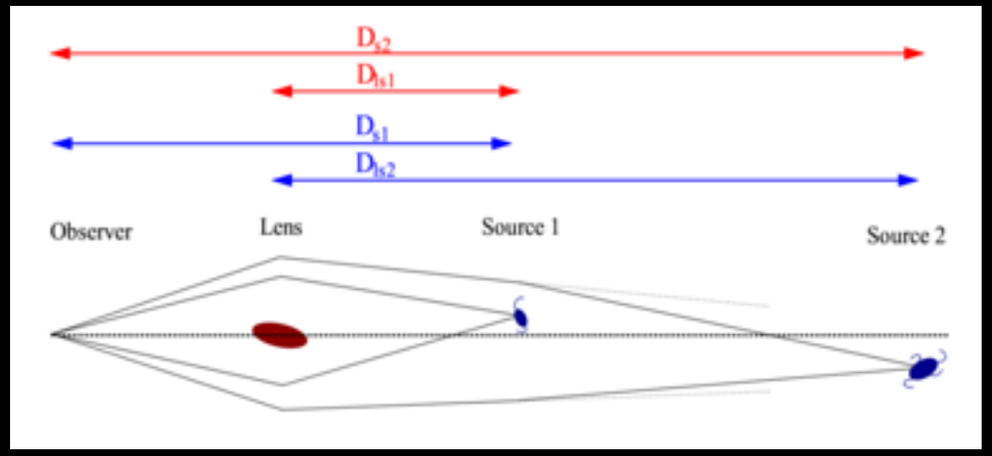
Pourtsidou 2015

RADIO + OPTICAL PRESENT DIFFERENT FEATURES

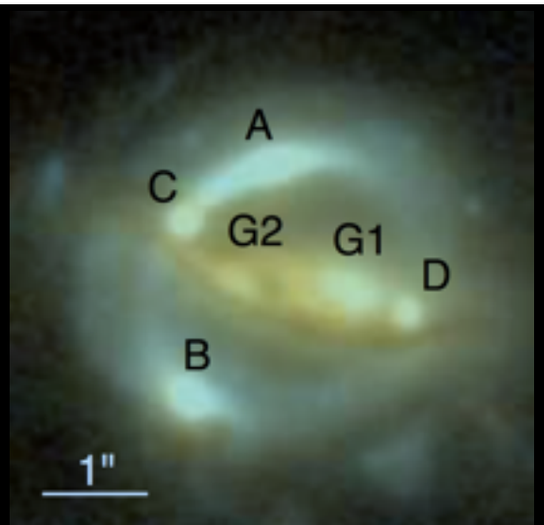


Joint selection of strong lensing systems (e.g. optical ellipticals + radio b/g sources)

10^4-10^5 lenses - examine sources at high magnification (McKean et al 15)

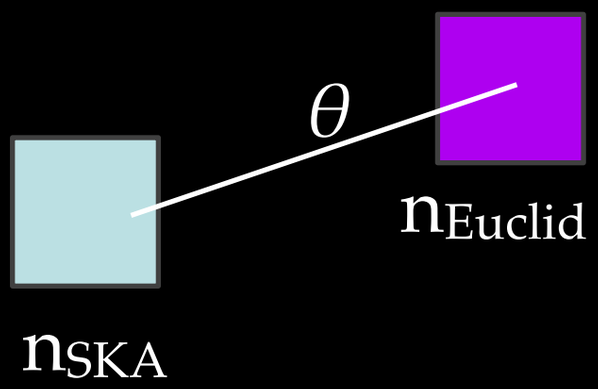


SL Cosmography (e.g. Collett & Auger 15, Collett & Bacon 16) - may find multiple arcs in optical + radio

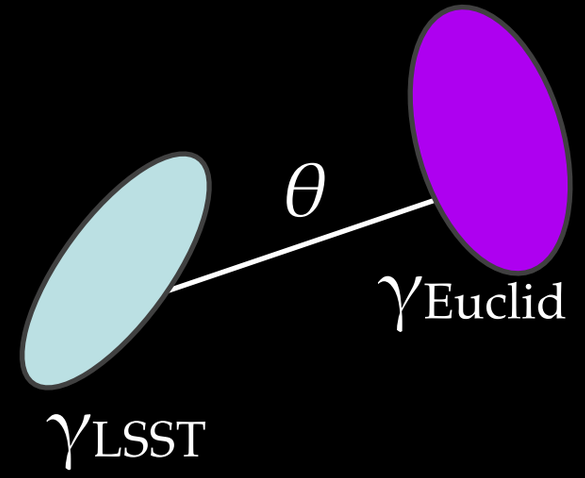


Time delays: radio quasars + optical extended arcs for mass model. (e.g. Suyu et al 2010)

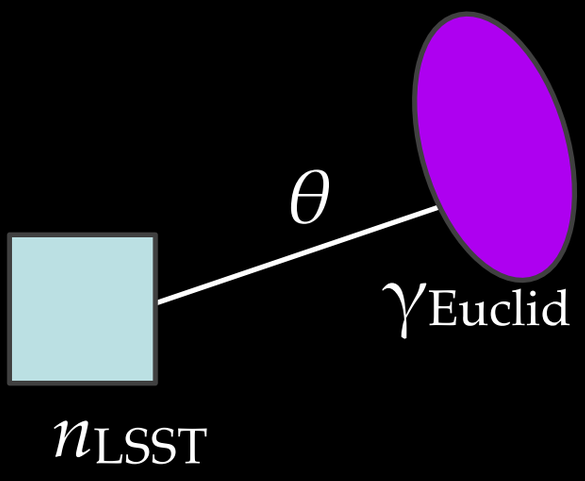
COMBINING SURVEYS - 3) OVERCOMING SYSTEMATIC ERRORS



Cross correlation of clustering picks out fluctuations which are not due to instrumental effects or e.g. stars.



Cross correlation of lensing shear picks out signal which is not due to telescope systematics.



Cross correlation of clustering and lensing picks out signal with different combination of systematics, and measures galaxy bias.

MUTUAL HELP WITH REDSHIFTS

LSST is able to provide photometric redshifts for Euclid overlap, and SKA continuum survey (~40 galaxies per sq arcmin)

LSST + Euclid NISP-P can provide z>1 photometric redshifts essential for e.g. high-z cluster studies.

SKA2 can provide spectroscopic redshifts for >half of Euclid and all LSST area, about 10 galaxies per square arcminute.

SKA HI redshifts/IM can calibrate optical photo-zs, using cross-correlation of clustering (Newman 08).

GALAXY EVOLUTION

SKA continuum will probe e.g. AGN and SF history over cosmic time and wide area

Redshifts and stellar masses from LSST+Euclid

Hi-res optical info from Euclid

Pathway from neutral (SKA HI) to molecular gas (ALMA) to star formation (SKA continuum, optical).

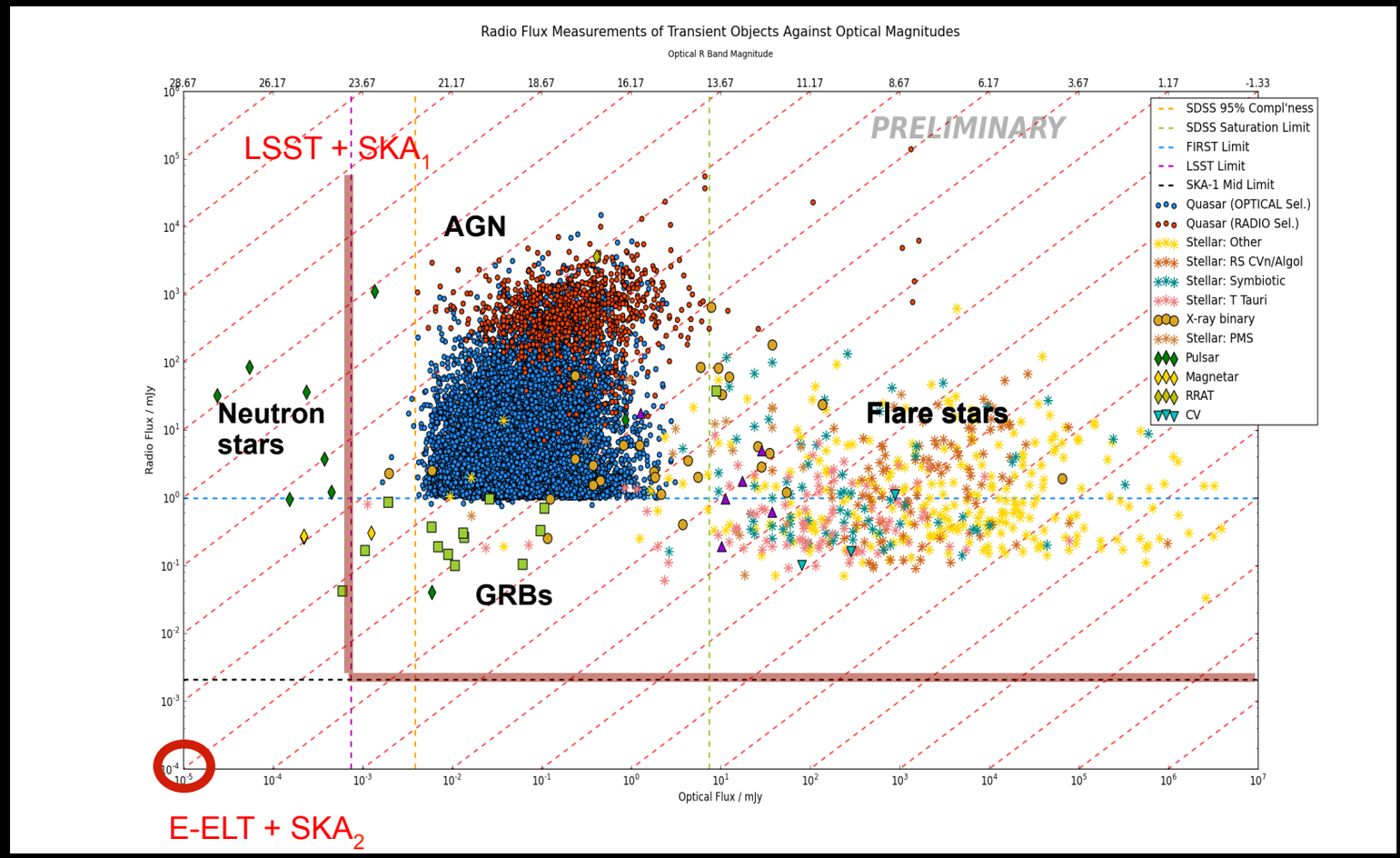
NB LSST deep drilling fields - will see high z objects (match with SKA)

TIME DOMAIN

Stuart, Munoz-Darias & Fender

LSST transient events:
20 billion objects
routinely monitored;
10,000 events per night

If coordinated with SKA:



Euclid will provide well-resolved images of host galaxies.

If Fast Radio Bursts can be made into reliable probe, they may complement SNe Ia at higher redshifts (Zhou et al 14); ~10^3 with SKA1

POSSIBLE COMMON/JOINT EFFORTS

The surveys share large computational challenges;
e.g. need $10^{9??}$ simulations for covariance matrices.

Can attempt joint shape fitting at the raw data level

Joint catalogues

Measure many cross-power spectra between the surveys,
to constrain systematics and cosmology.

SUMMARY

Using all three surveys gives:

- Complementary physical constraints
- Removal of systematics
- Cross checks of results
- Mutual support (e.g. redshifts)
- A more complete picture (e.g. galaxy evolution)
- Exploitation of the time domain.

GET INVOLVED

Euclid-LSST white paper - contact Jason Rhodes, Bob Nichol

SKA working groups; including Synergies in the Cosmology WG - contact David Bacon, Stefano Camera

LSST:UK <-> SKA - contact David Bacon