Fresh approaches to density maps

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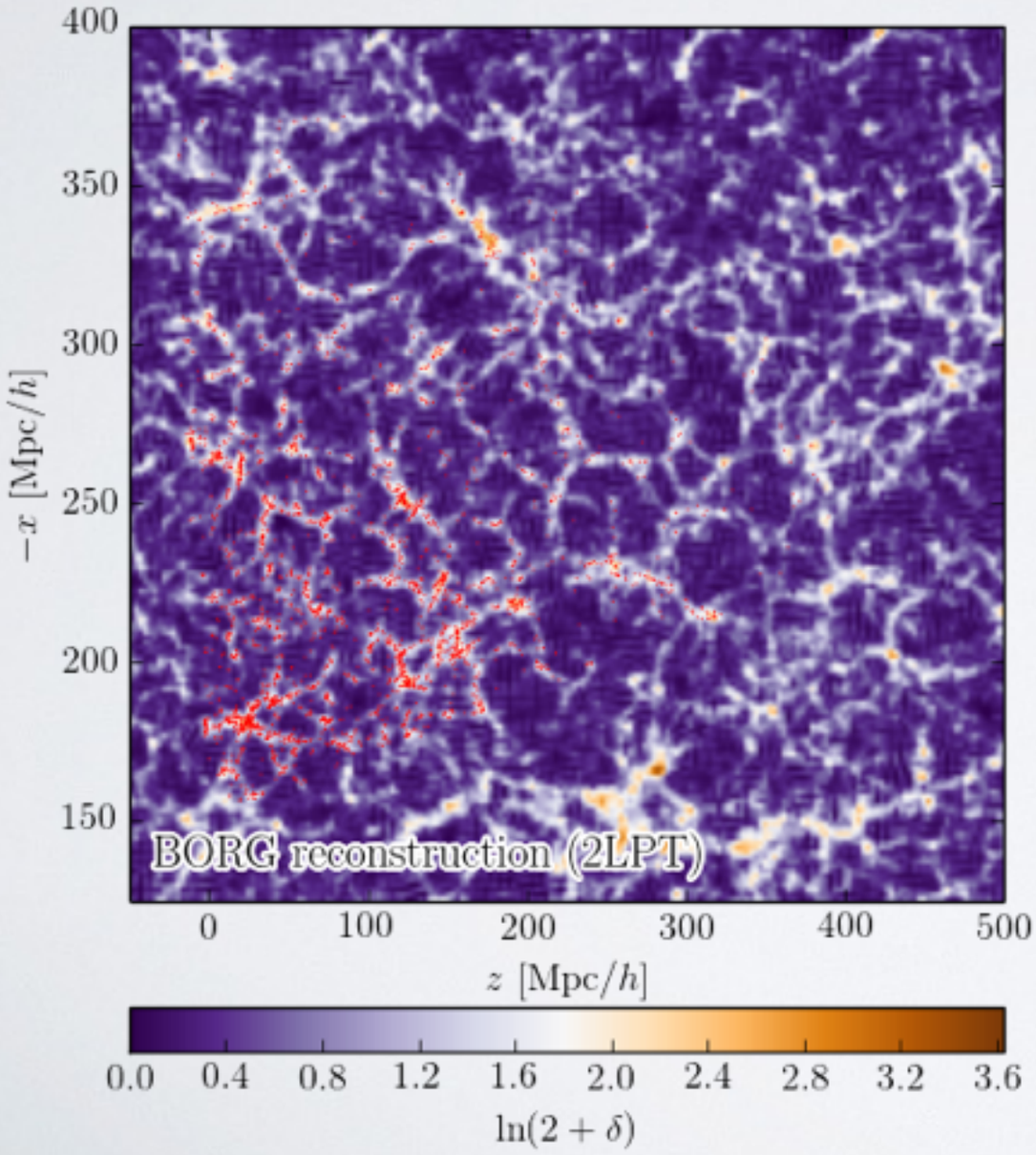
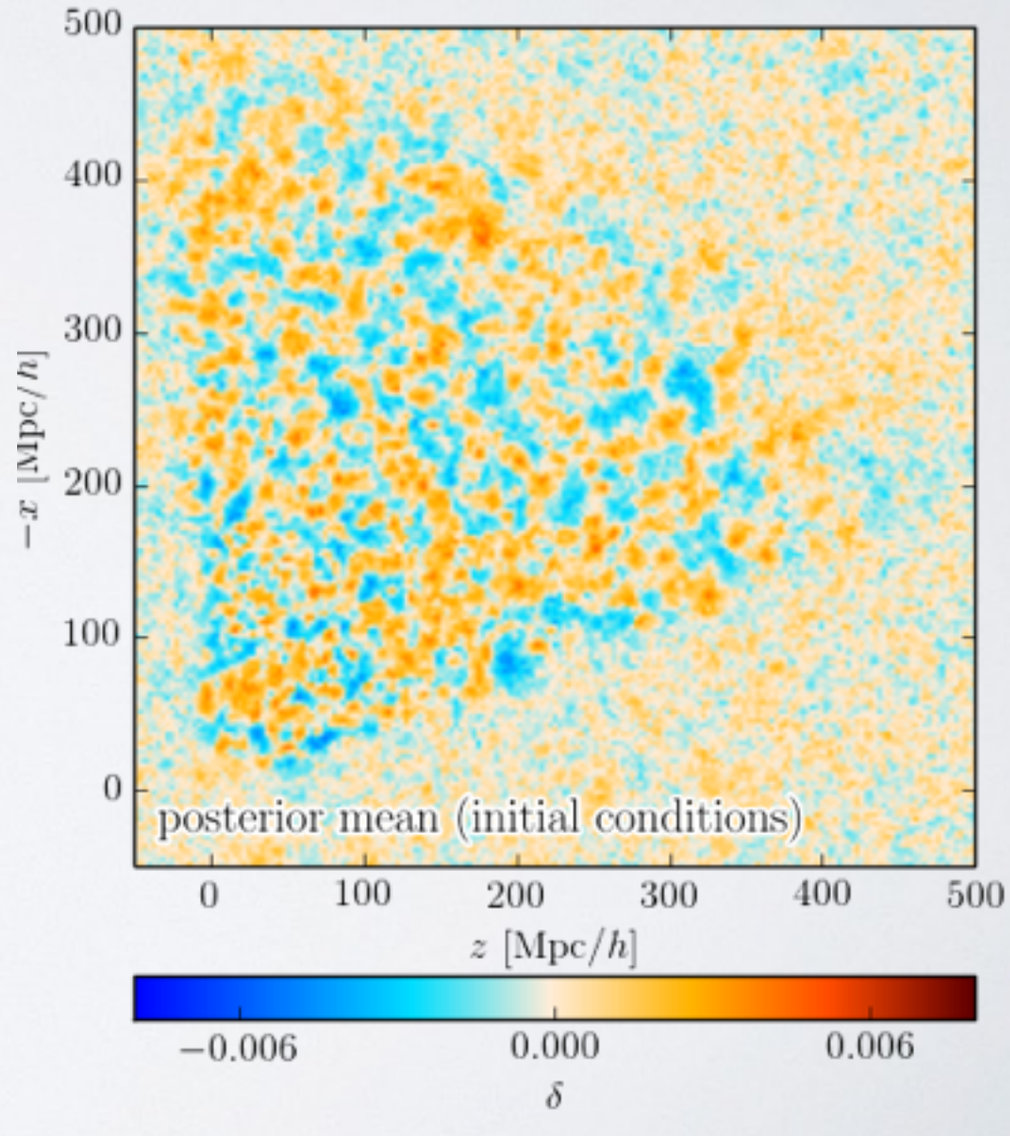
Density maps

e.g. with a Bayesian approach (including MCMC, 2LPT), infer initial conditions and matter distribution from SDSS (Jasche, Leclercq et al 15, Leclercq et al 15):



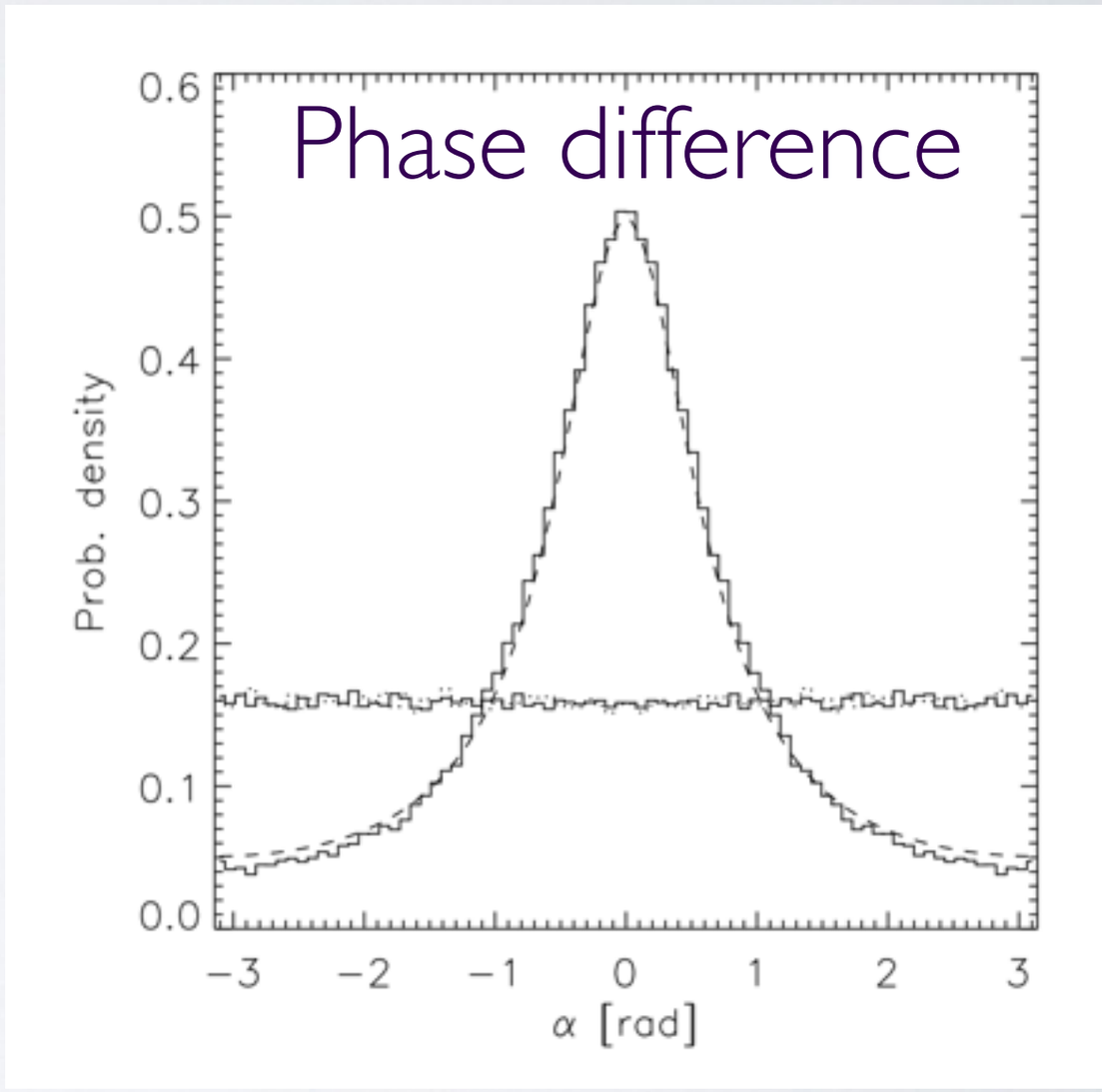


Inclusion of phase information

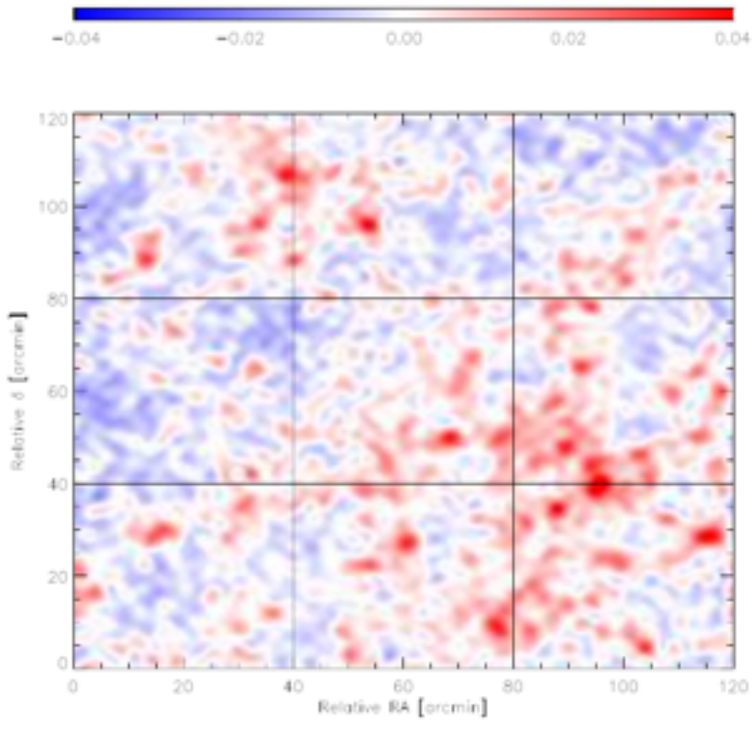
A related maximum probability approach can be used very nicely with gravitational lensing: Szepietowski et al 14

Shear estimators → Projected density (convergence)

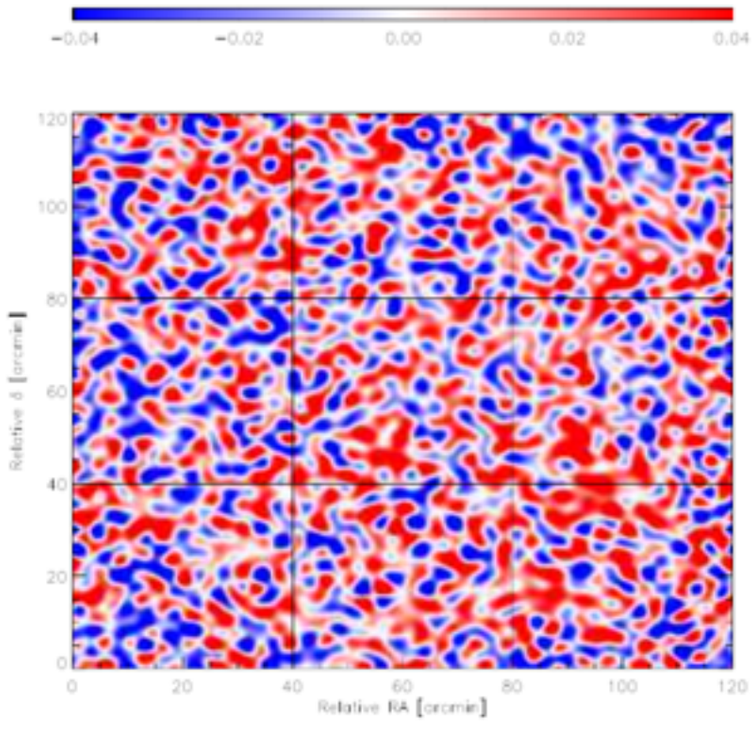
Galaxy counts → Projected density (biased)



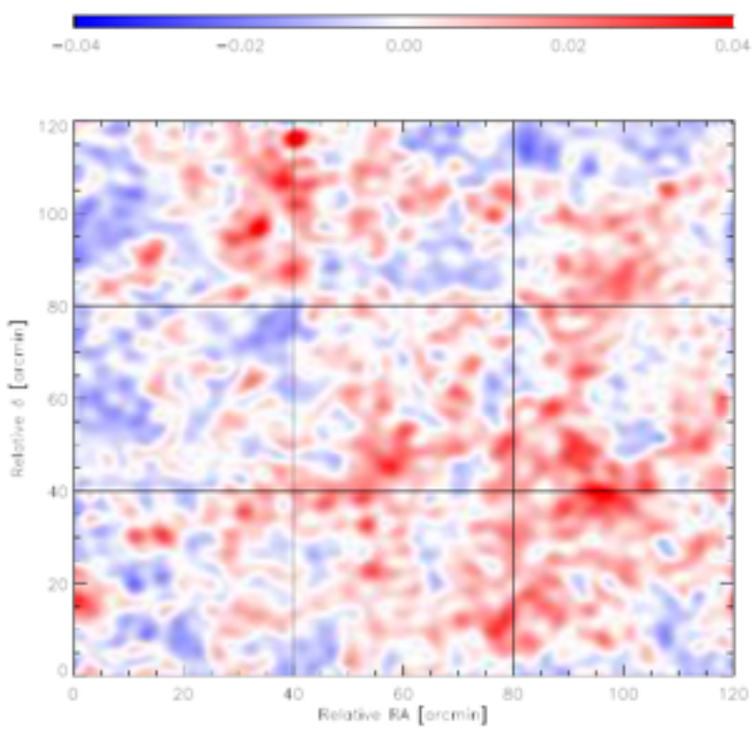
Phase prior maps



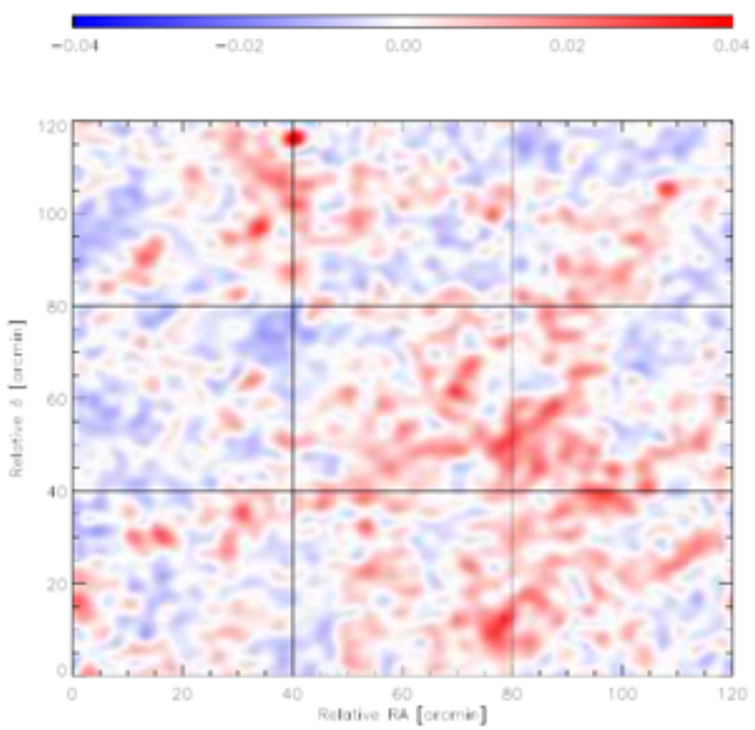
(a) True convergence in the simulation.



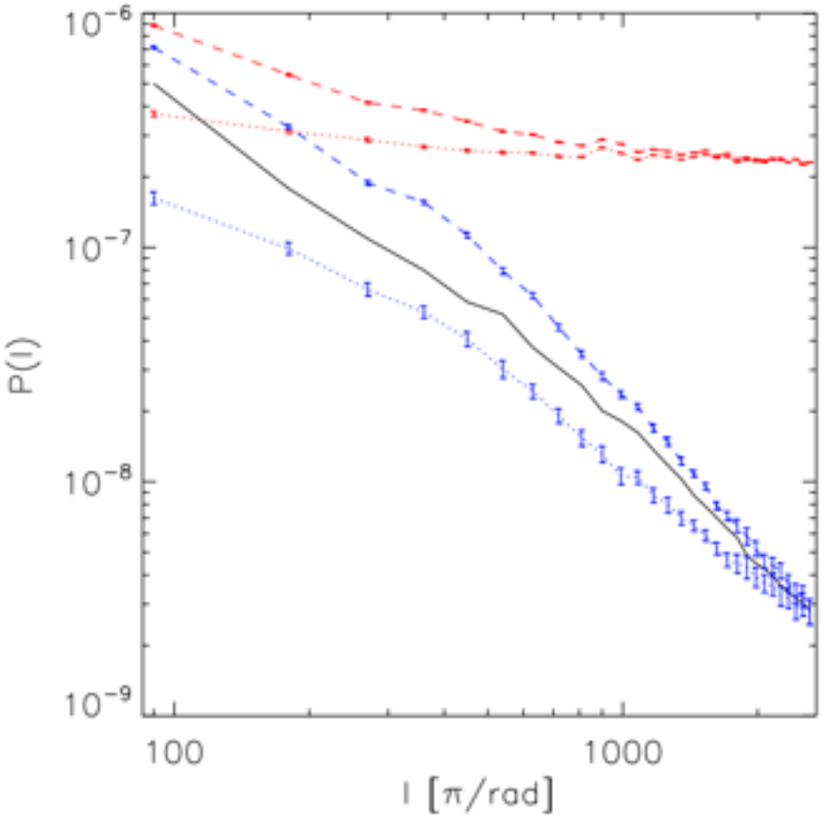
(b) Maximum-likelihood reconstruction.



(c) Maximum-probability, including phase information.

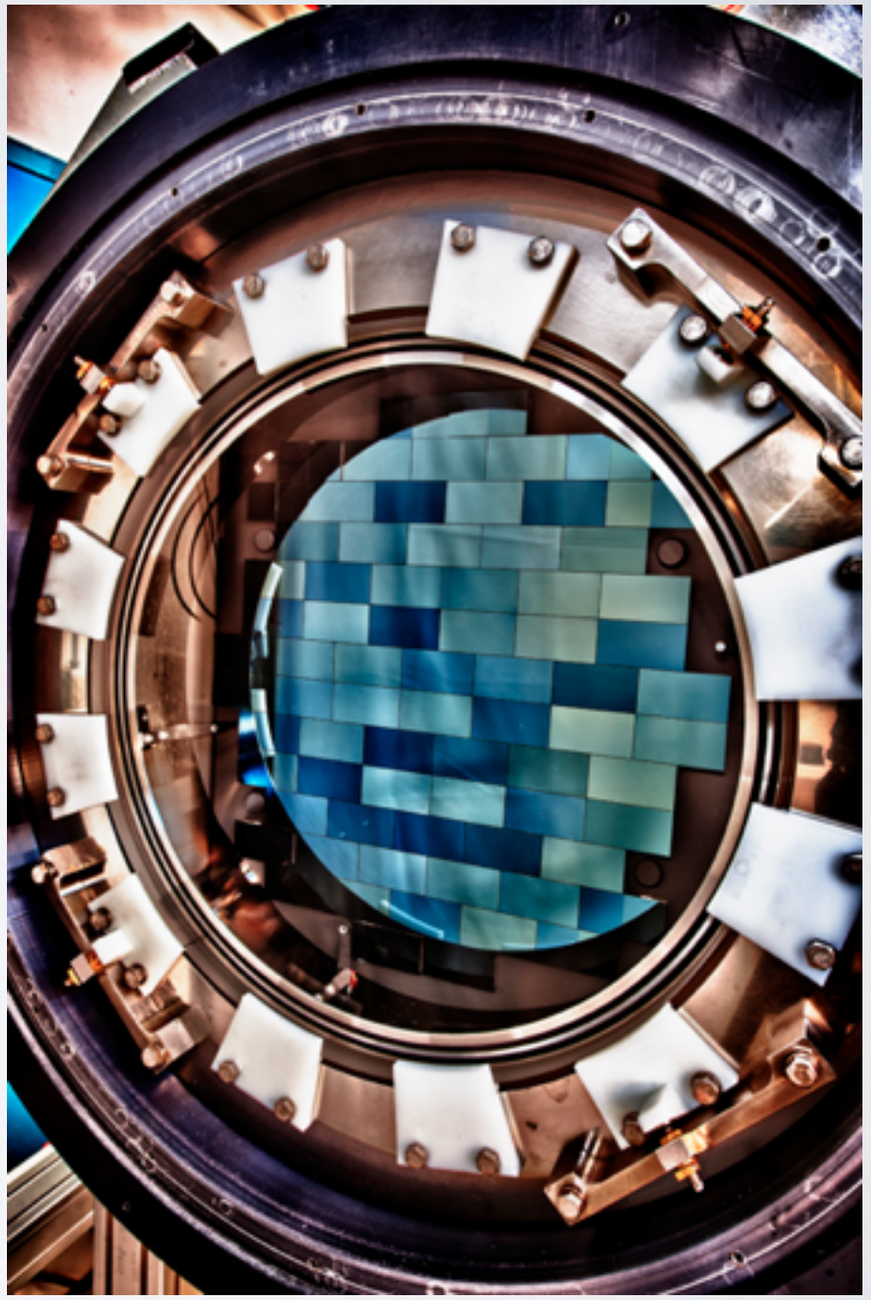


(d) Convergence estimate from galaxy positions.



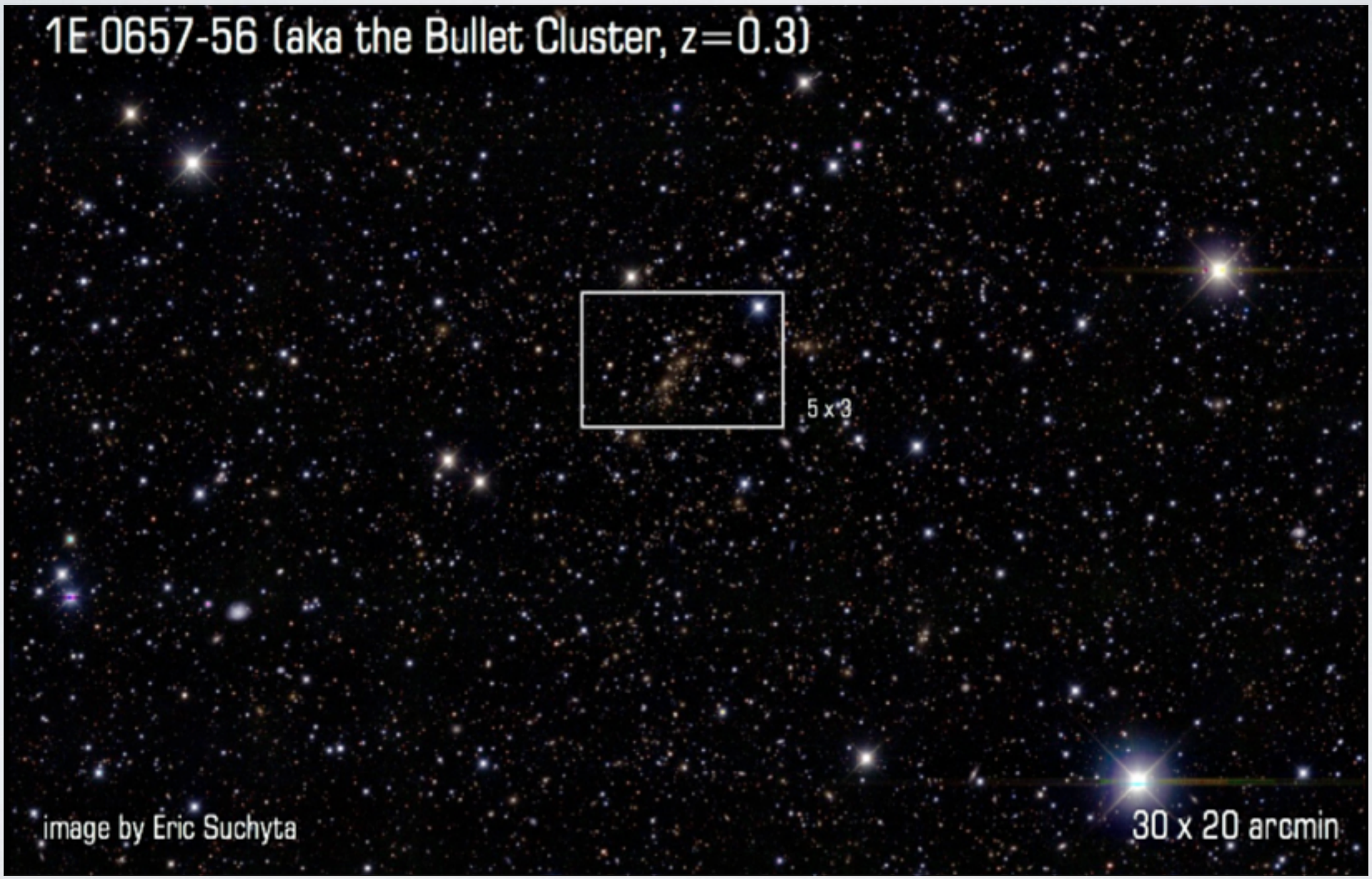
The Dark Energy Survey

CTIO, Chile
5000 sq degree map, z_{med}=0.7



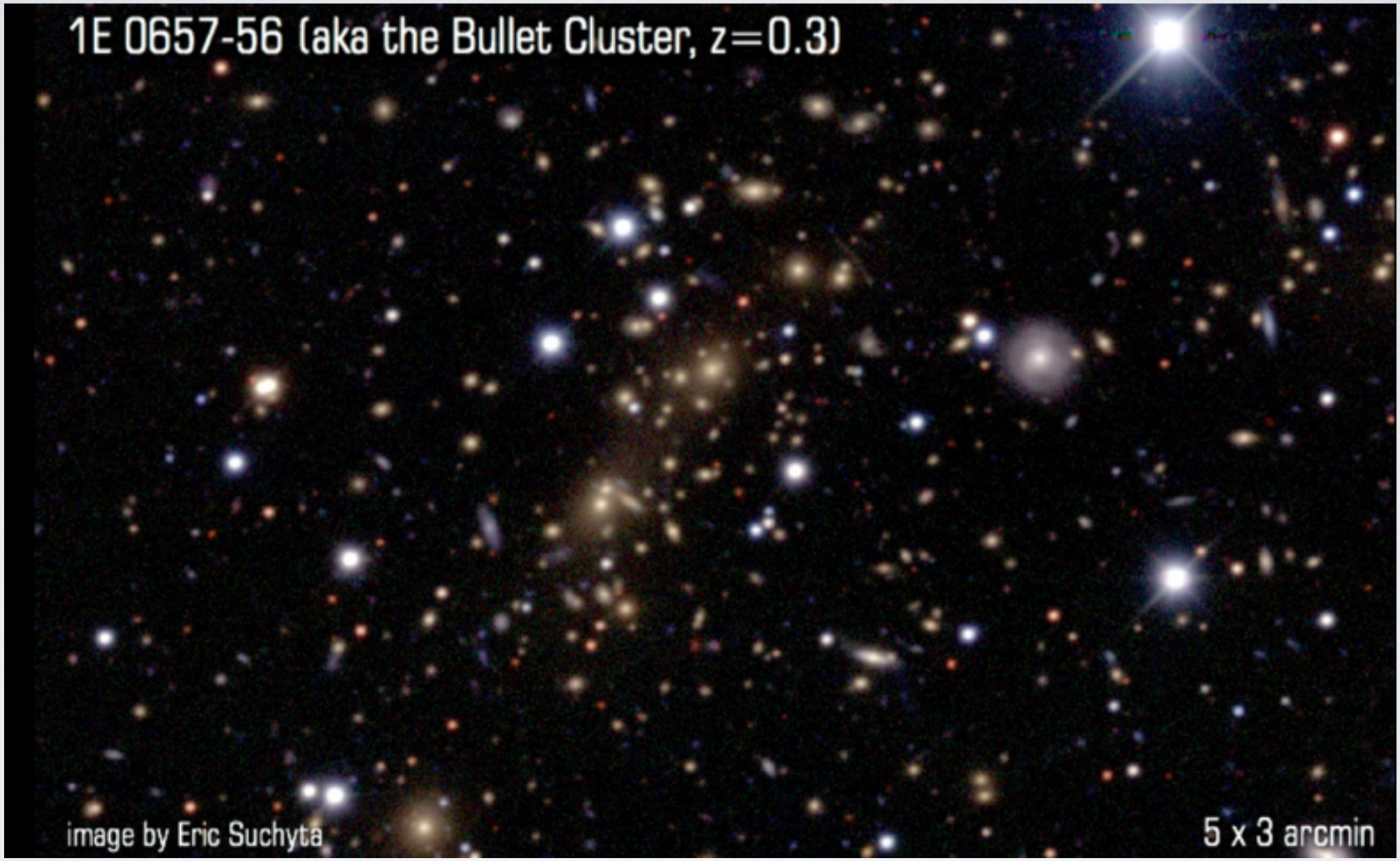
570 Megapixels, 2.2 deg field
0.26" per pixel

The Dark Energy Survey



n=10 per sq arcmin

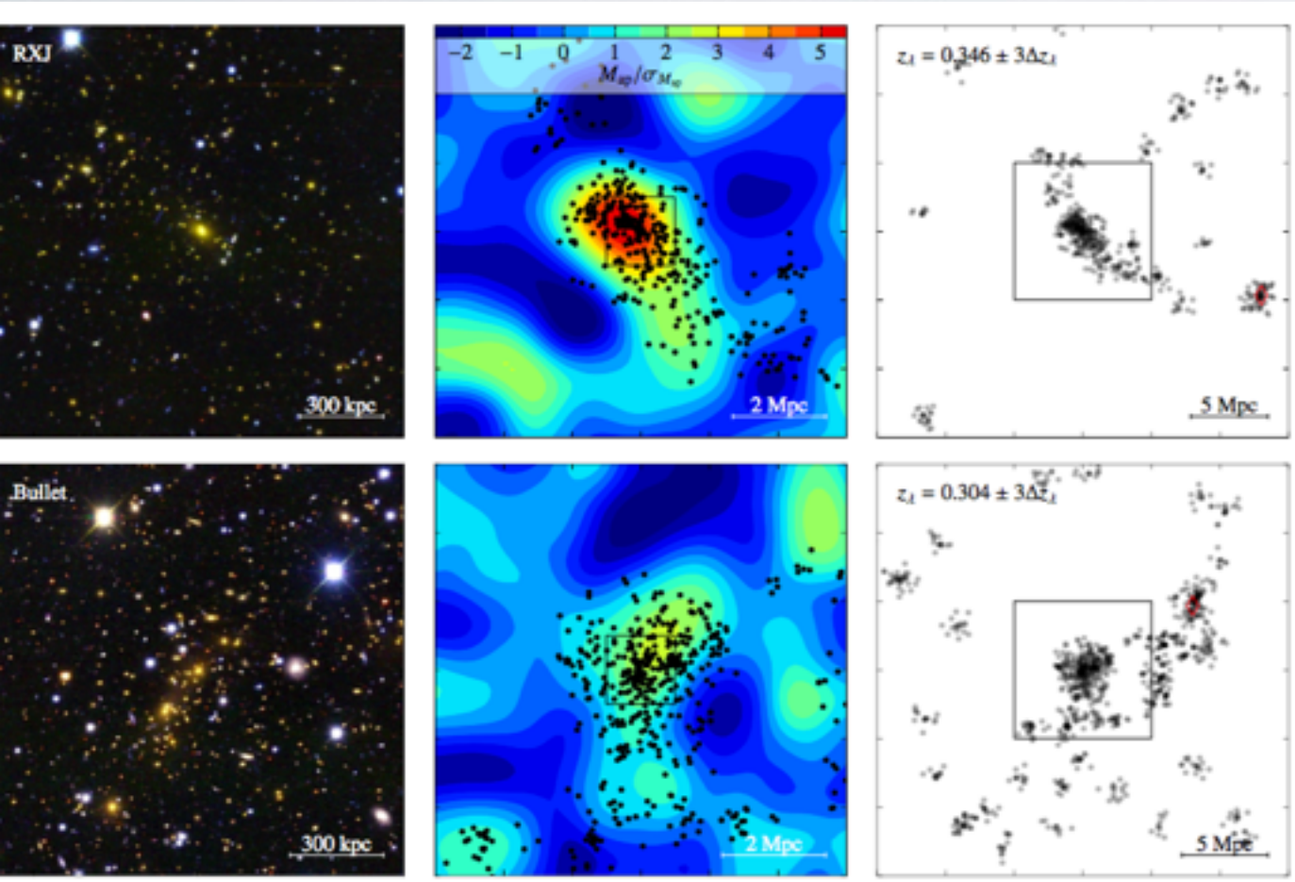
The Dark Energy Survey

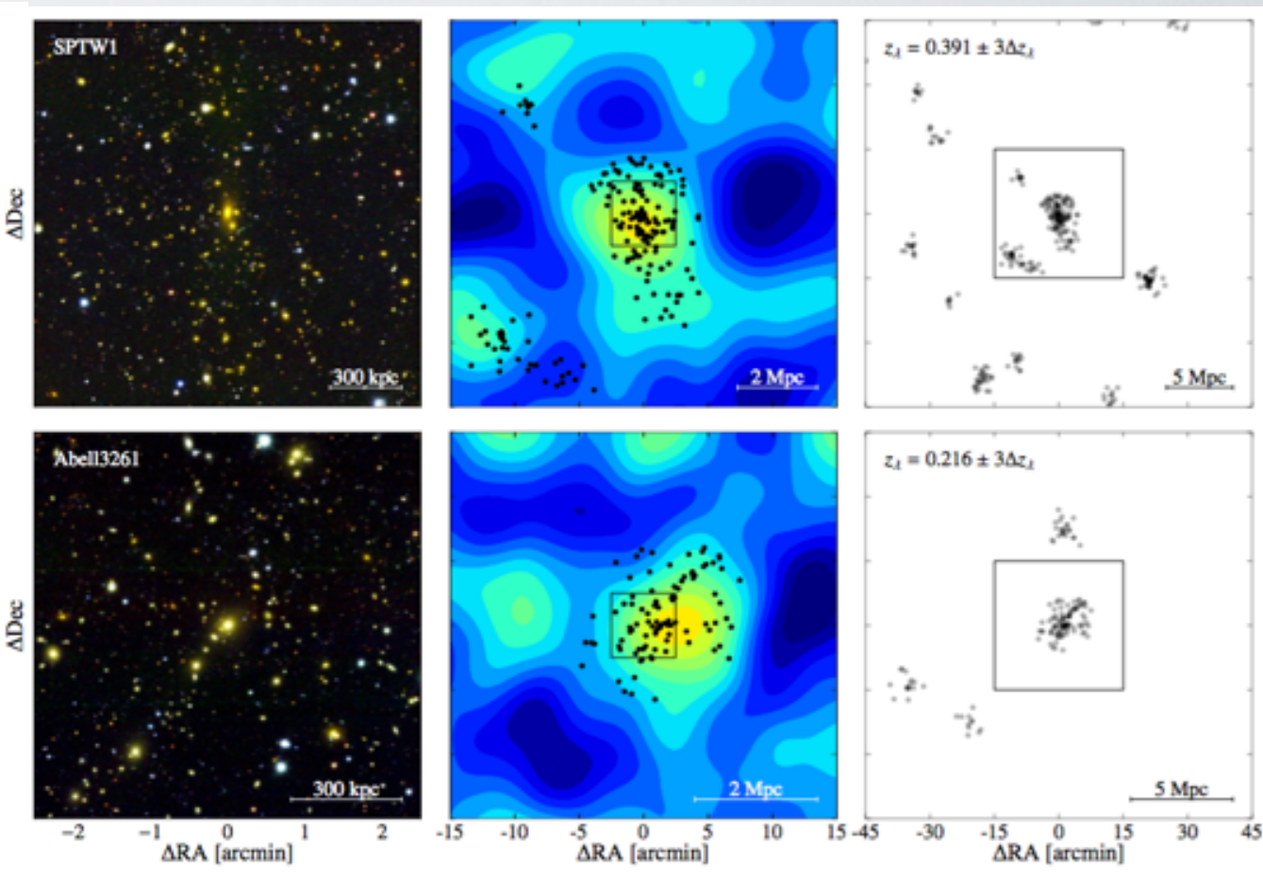


Shape fitting of galaxies - ngmix, im3shape

Mass maps around clusters

Melchior et al 15



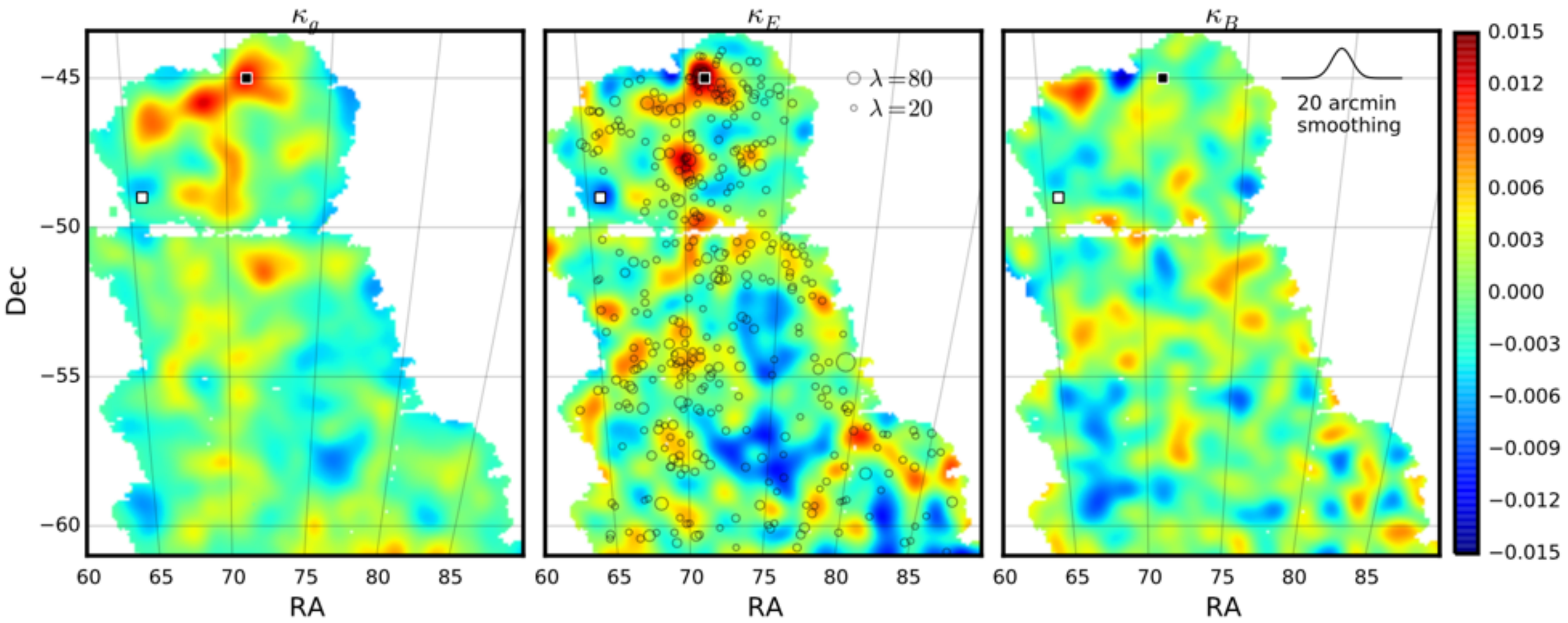


Convergence maps inform about DM environment - density, morphology

Accurate photo-zs provide high-res structure information

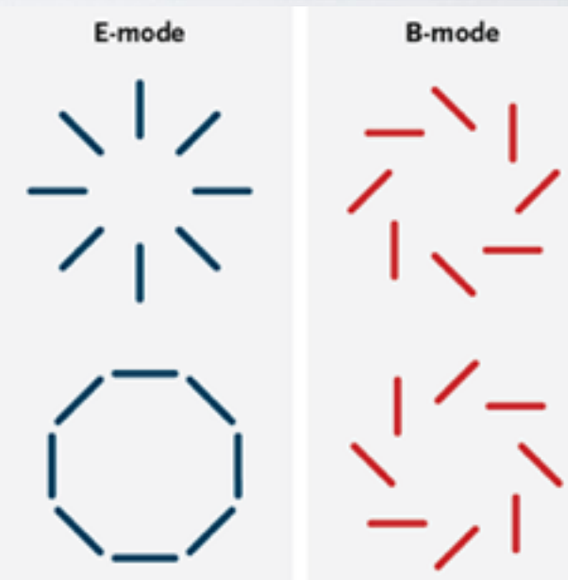
Larger scale maps

Vikram et al 15,
Chang et al 15

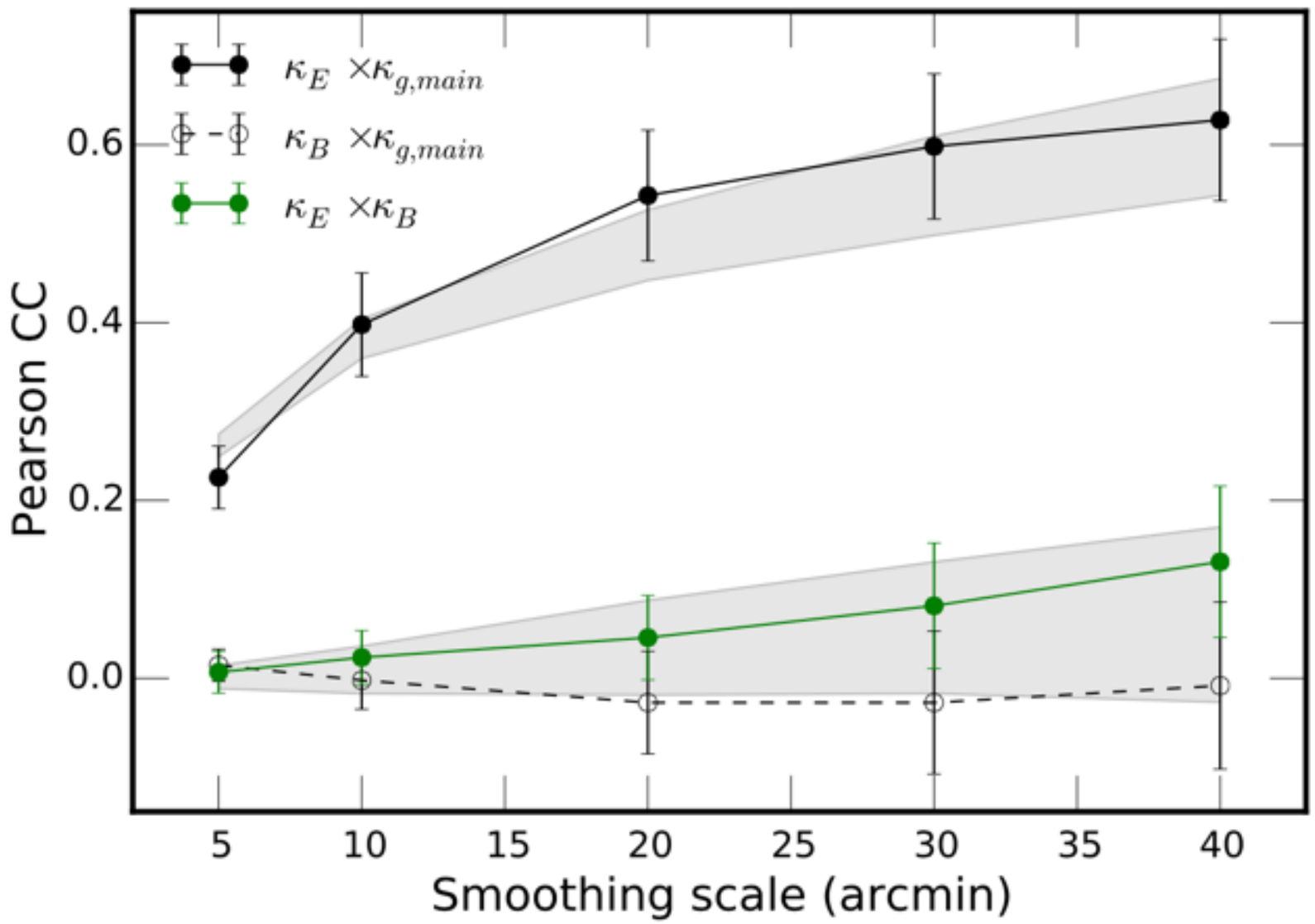


Direct inversion from shear to convergence (Kaiser & Squires 92)

B-mode map gives indication of systematics and noise level



Visible and dark matter correlation



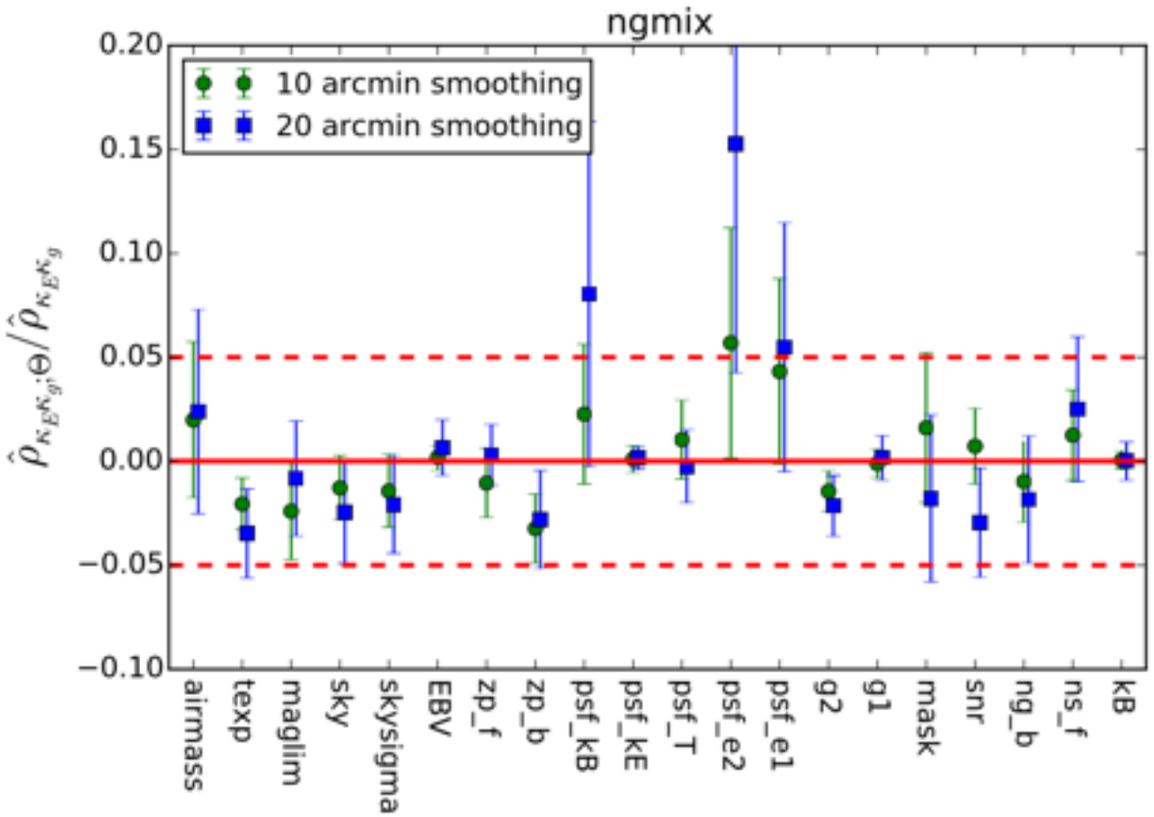
Chang et al 15

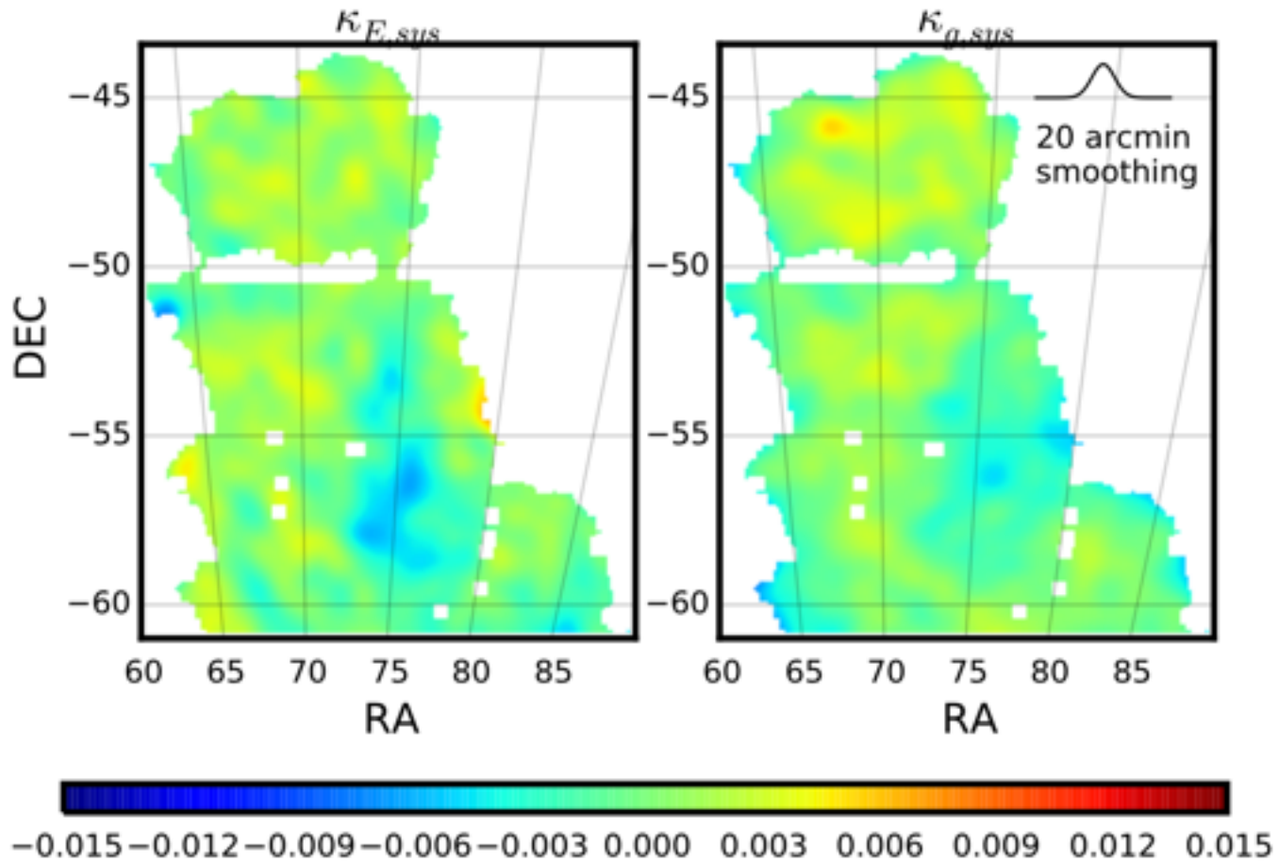
5-7 sigma significance depending on smoothing scale

Correlations agree well with N-body simulations

Systematics tests

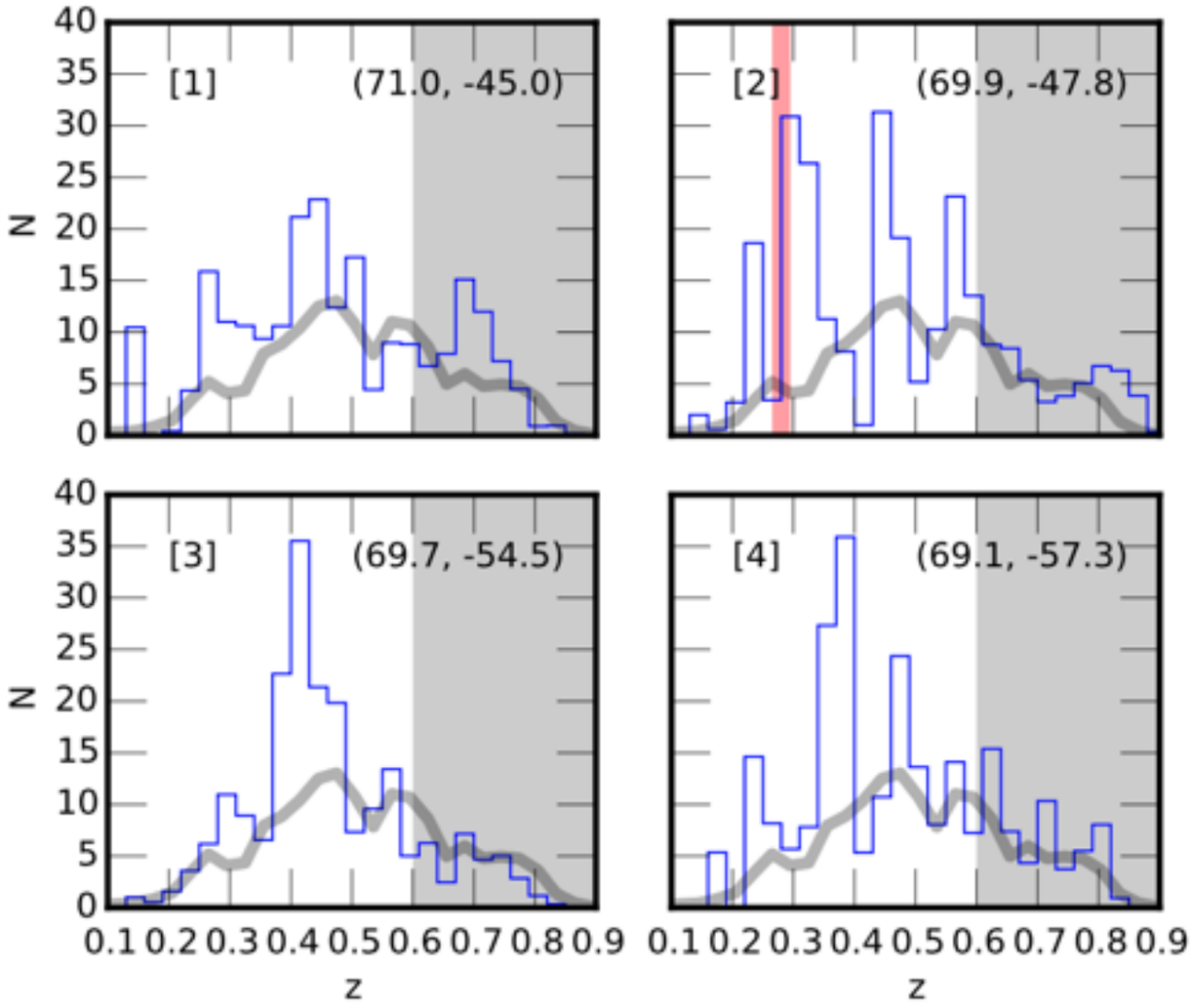
Vikram et al 15

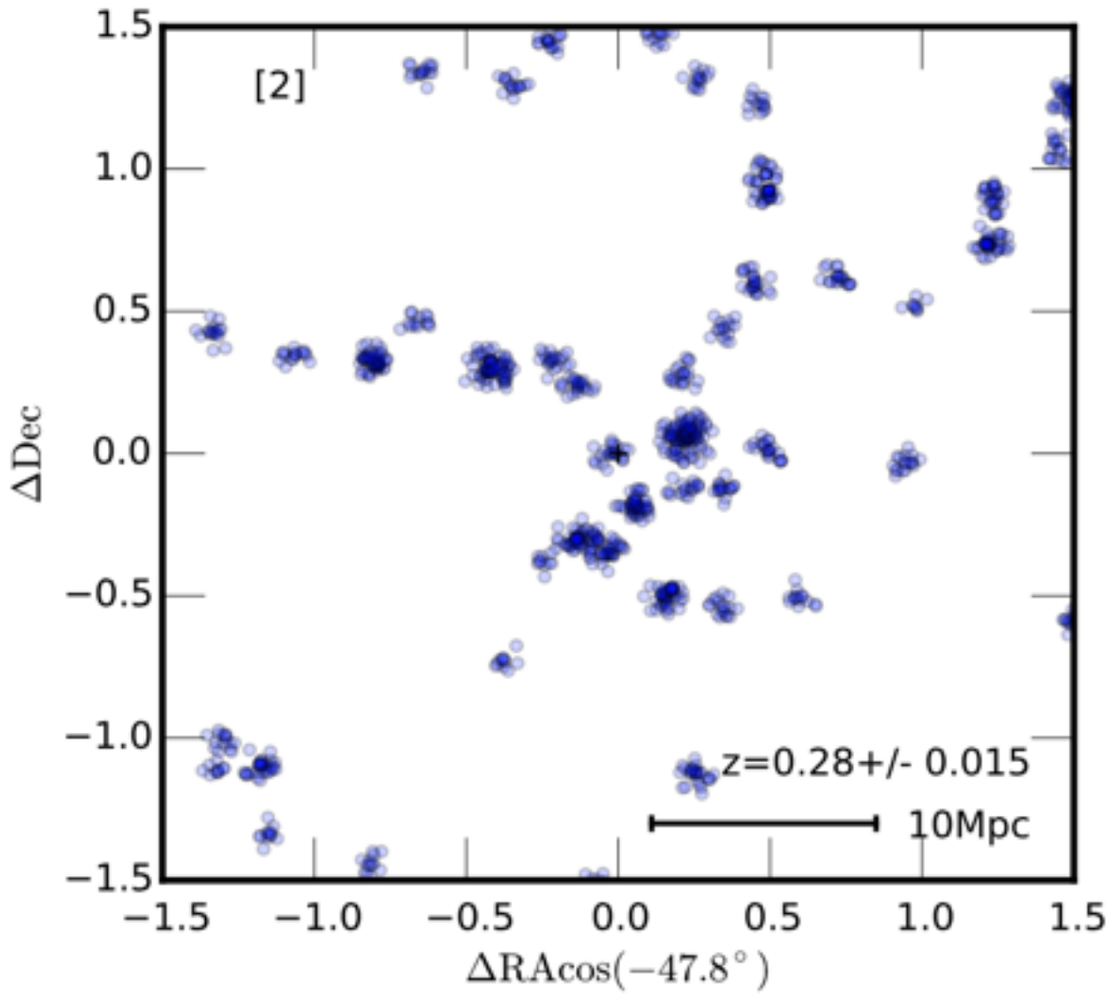




Correlations with many systematic maps
All show subdominant contamination

Applications:
Finding superstructures

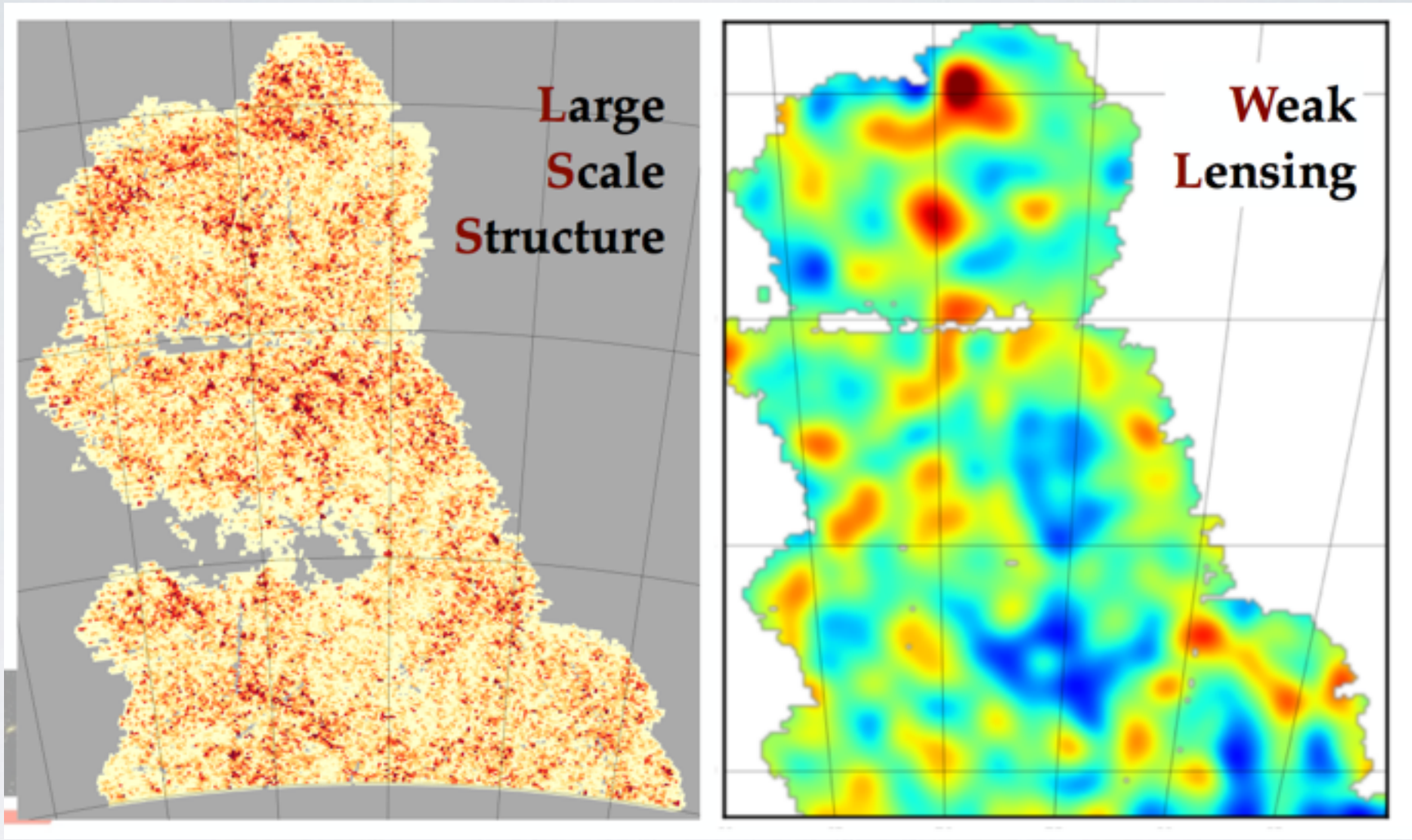




Vikram et al 15

90Mpc extent

Measuring bias

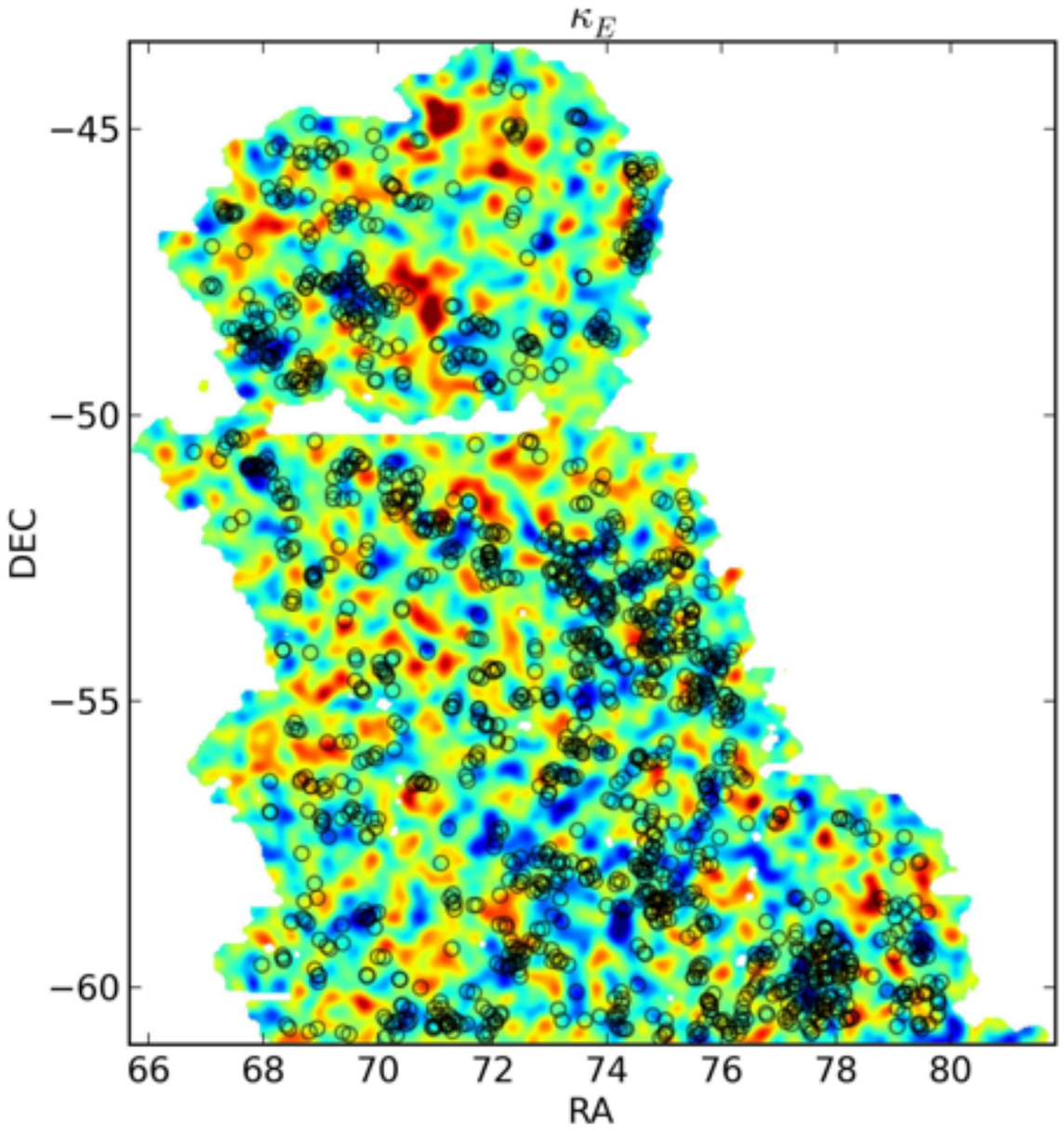


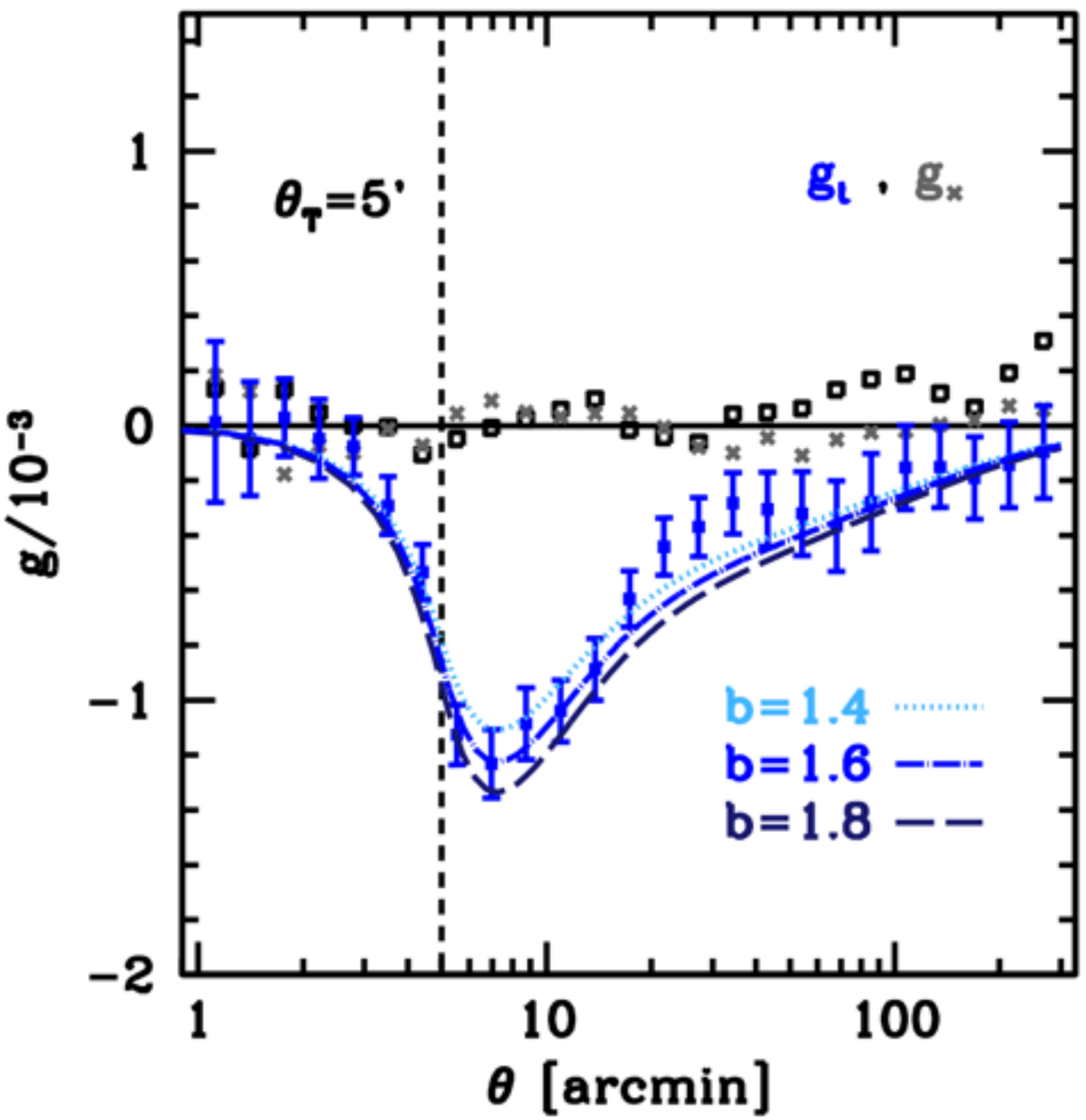
Lensing ⟷ Galaxy counts (biased)

Chang et al 15,
Pujol et al 15

Troughs

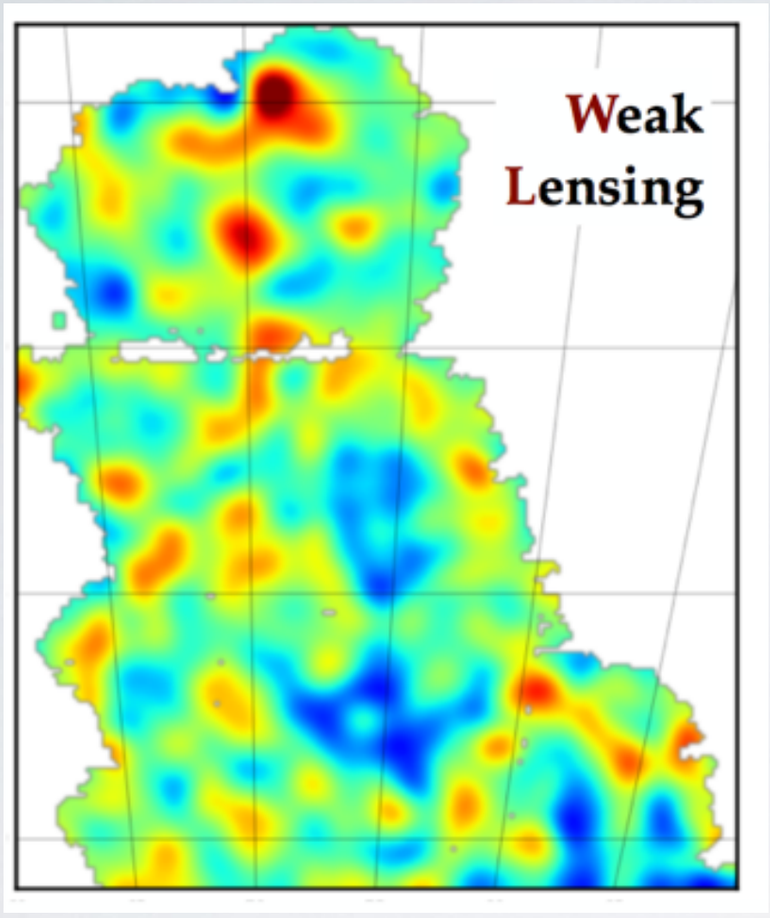
Projected galaxy count map, find most underdense columns:





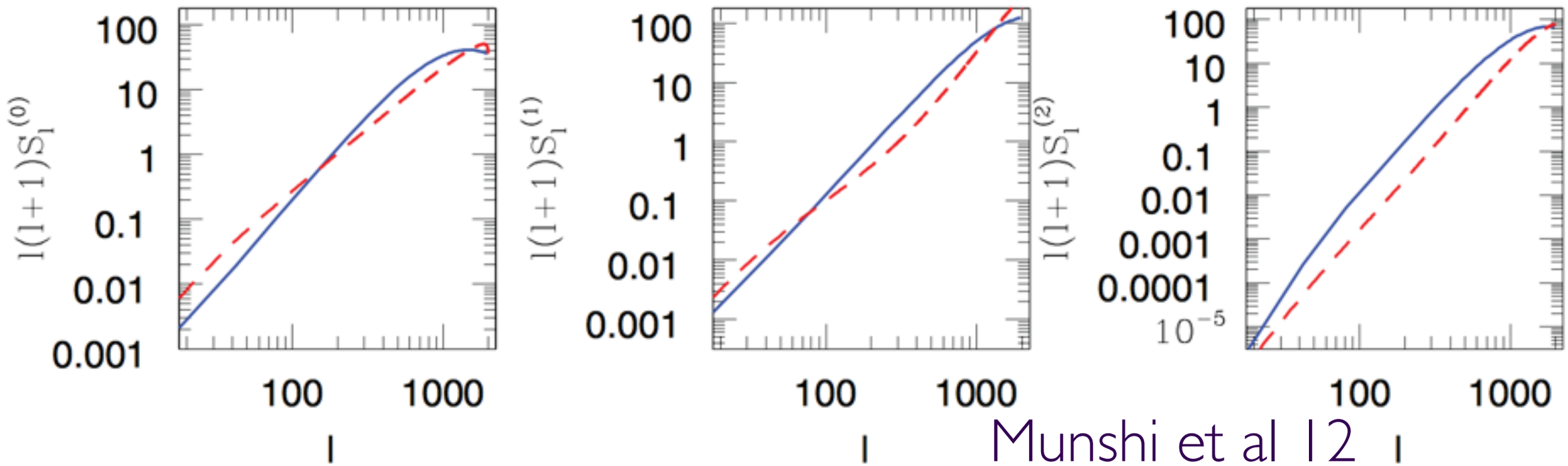
Gruen et al 15

Topology measures



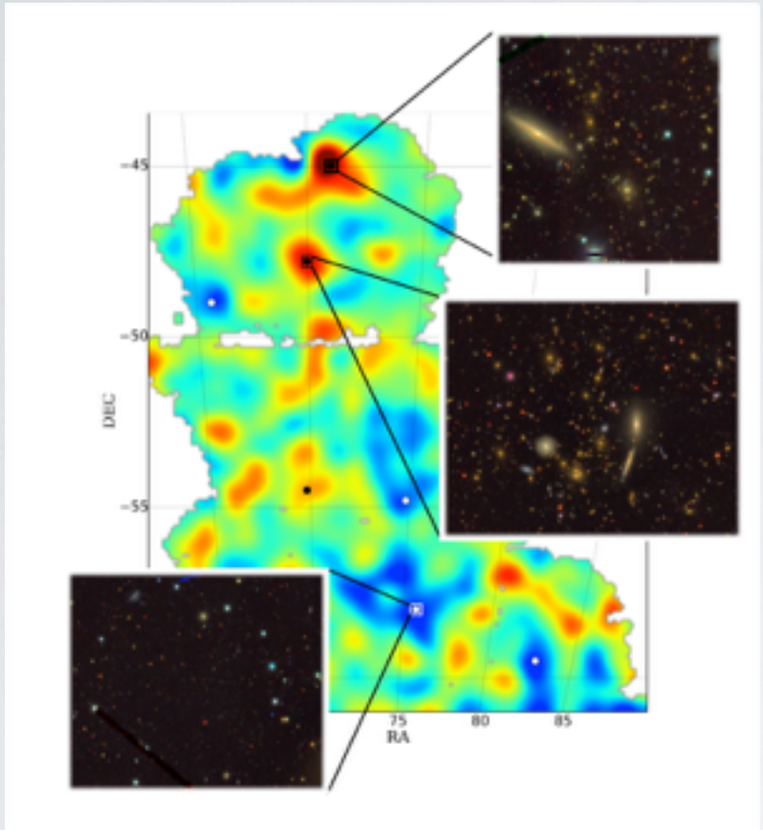
The topology of the field contains information about the density PDF and hence cosmology.

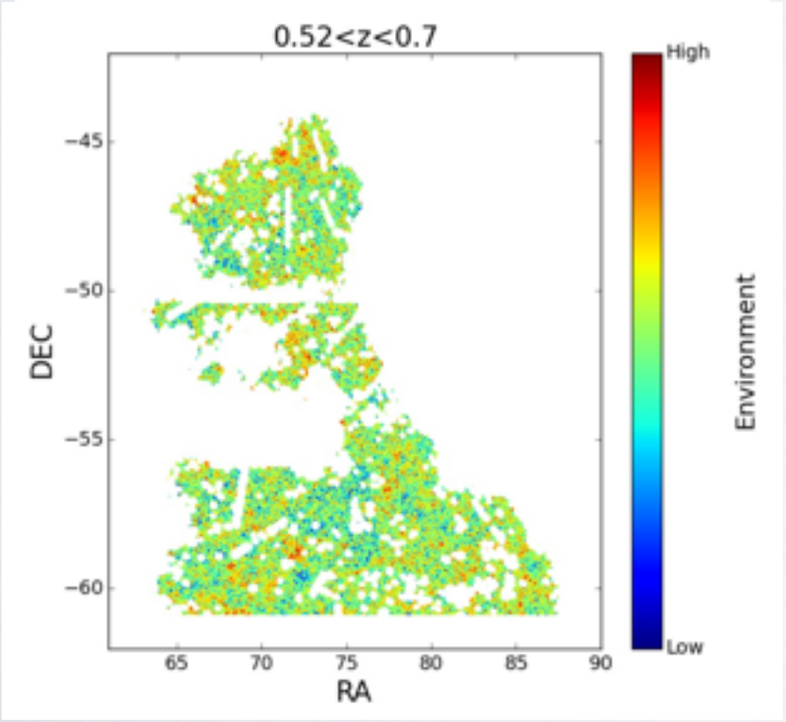
Minkowski functionals: area and line element for excursion set, integral of curvature on boundary



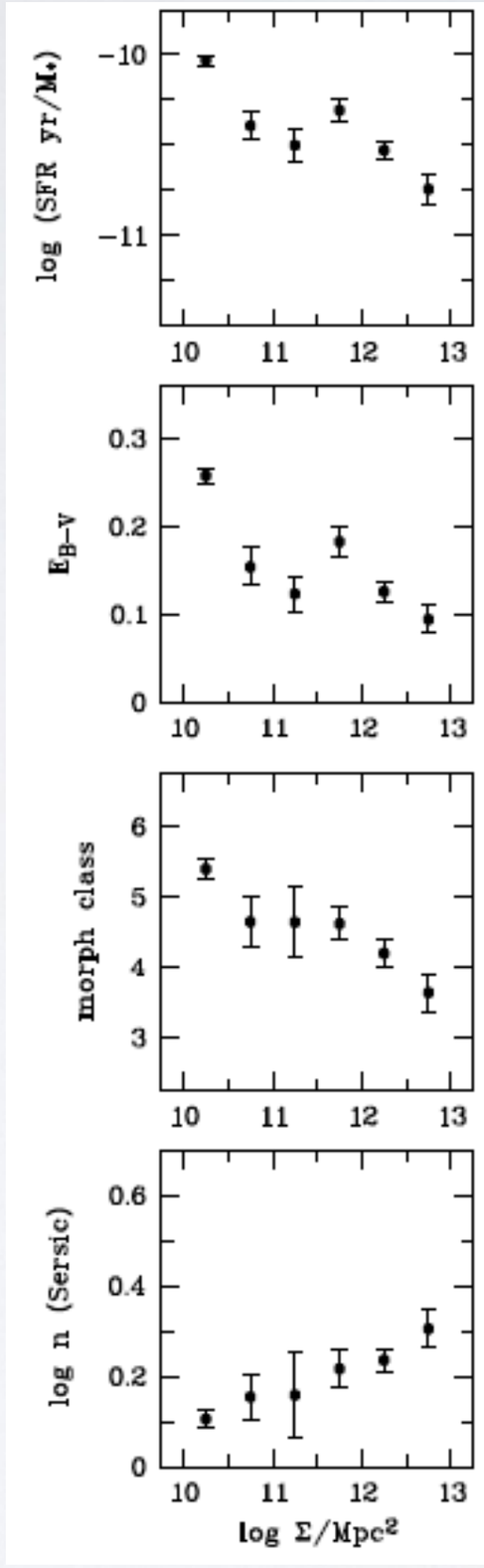
Munshi et al 12

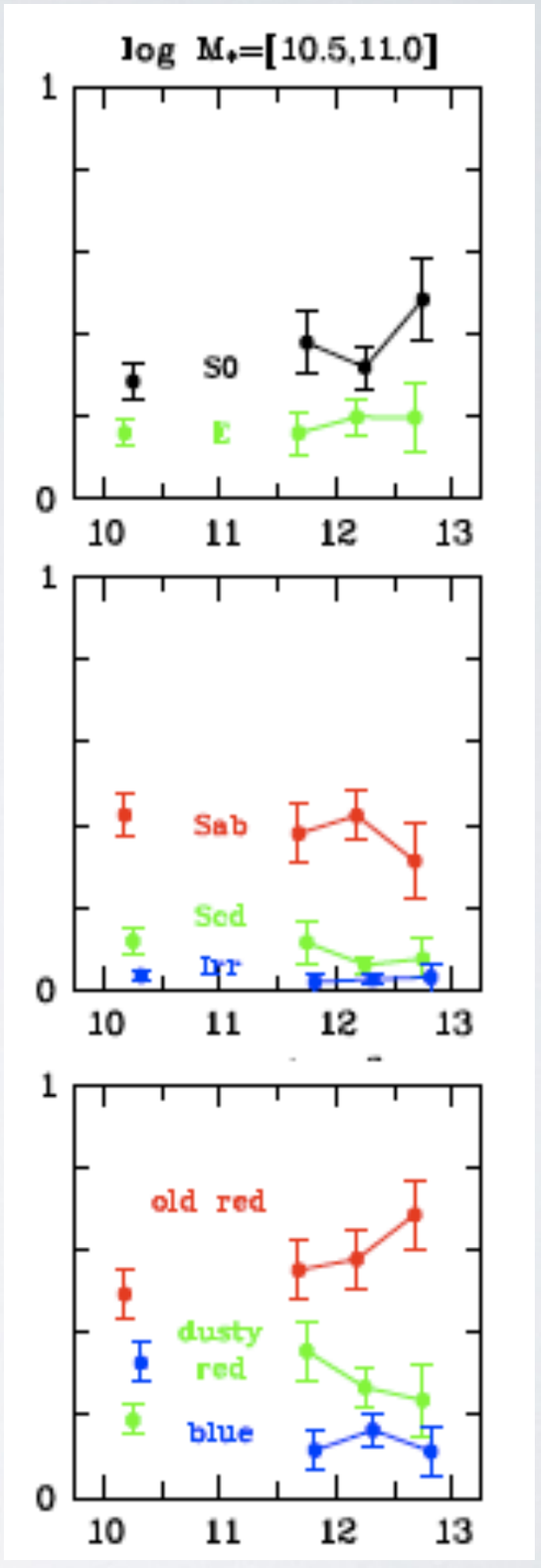
Galaxy - dark matter connection





Lahav et al 16

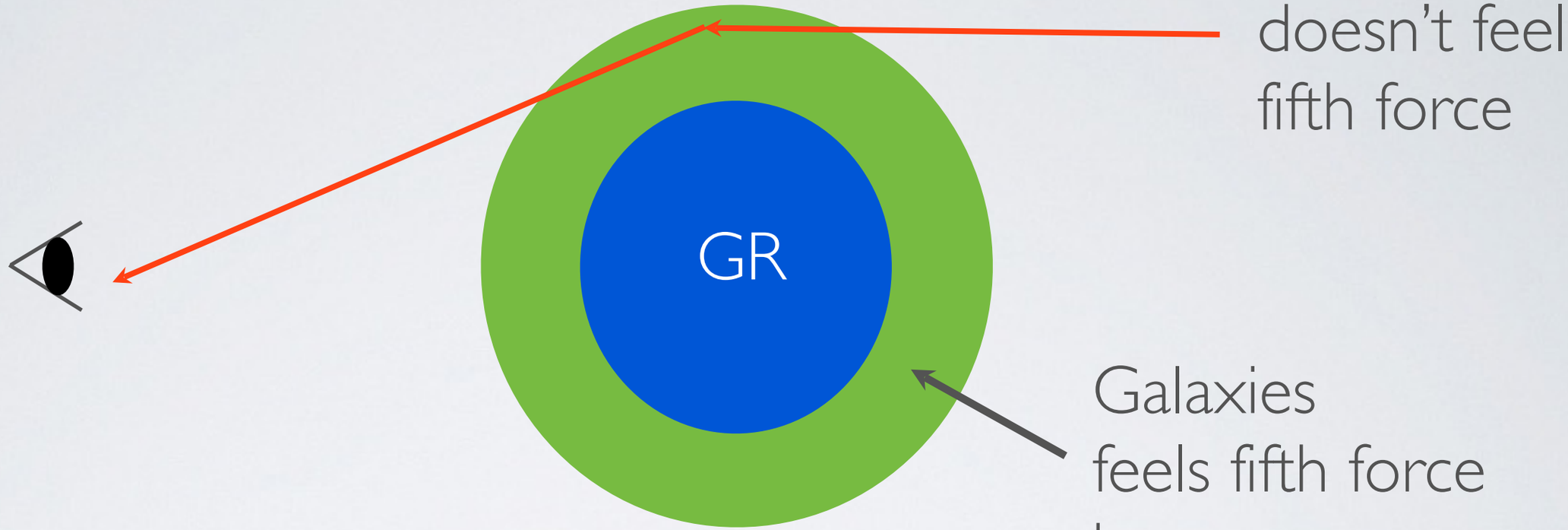


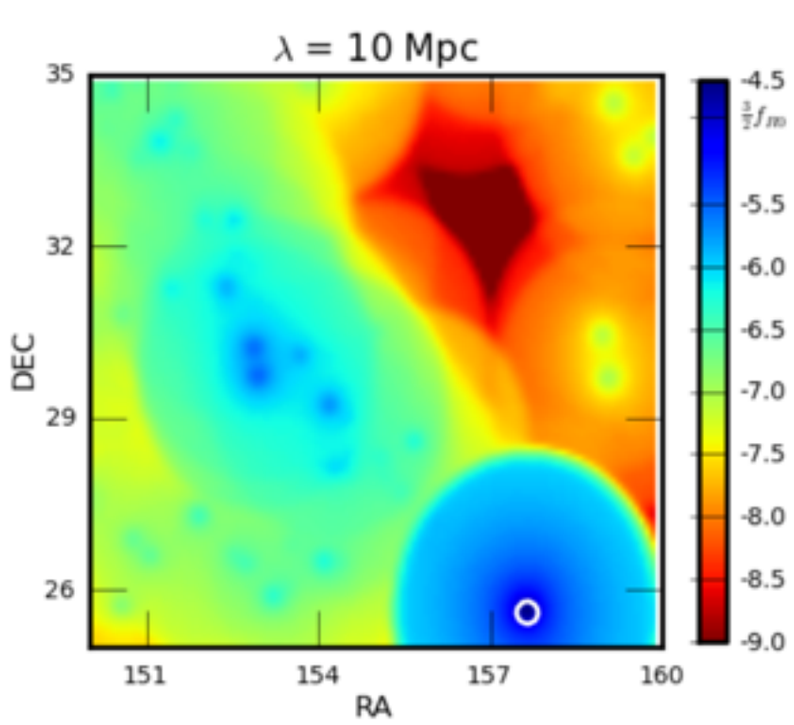


Wolf et al 2009

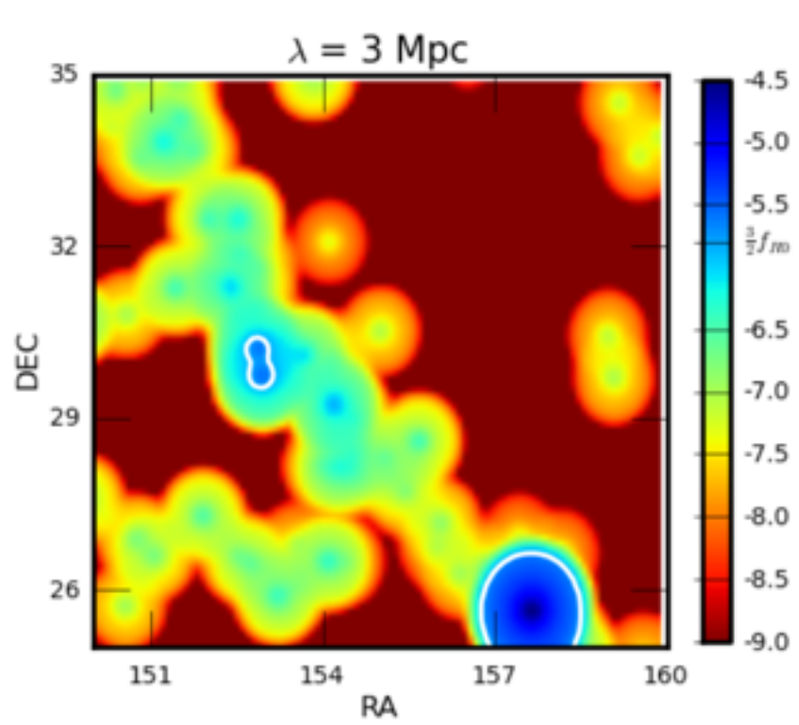
Testing gravity

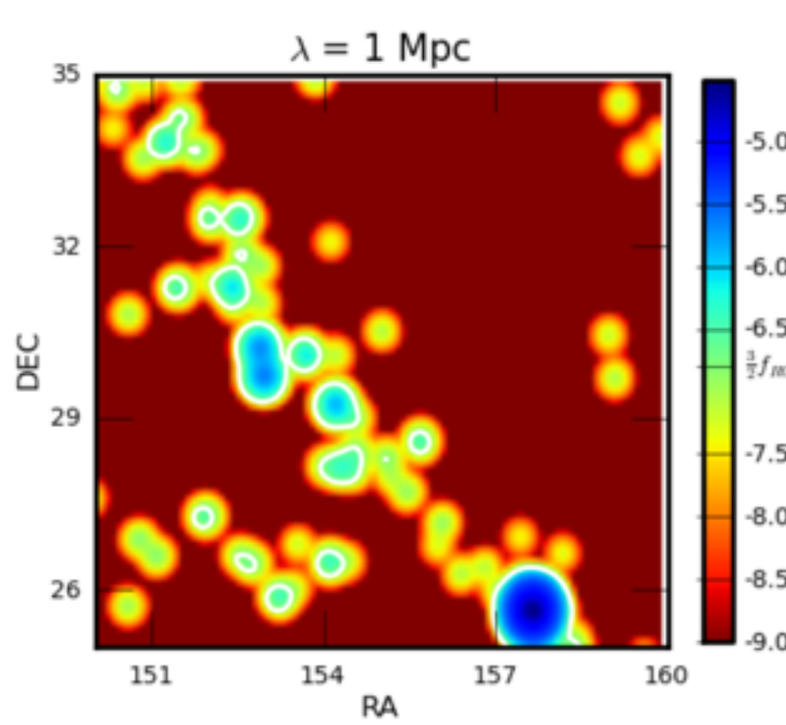
e.g. chameleon mechanism:





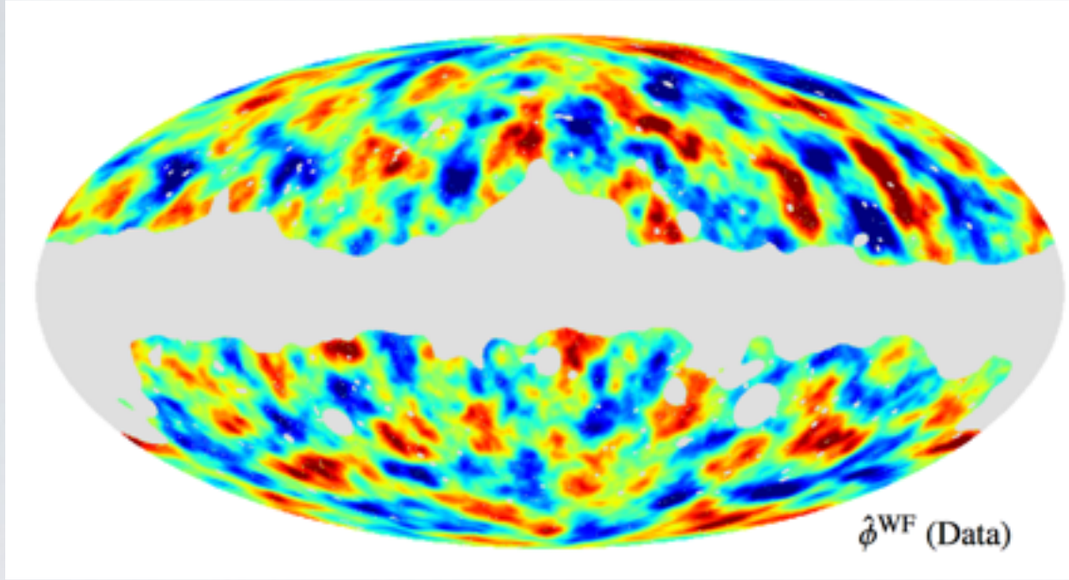
SDSS screening map



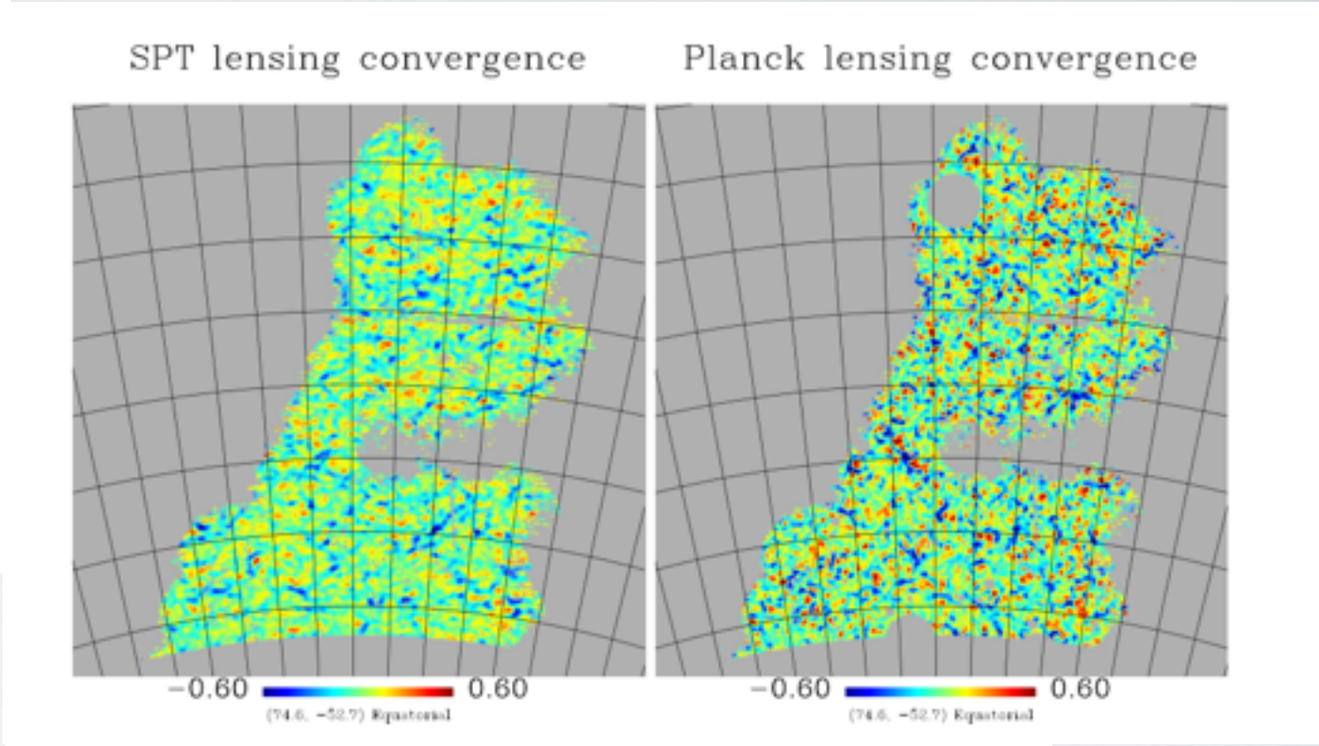


Cabre et al 12

Lensing maps from the CMB



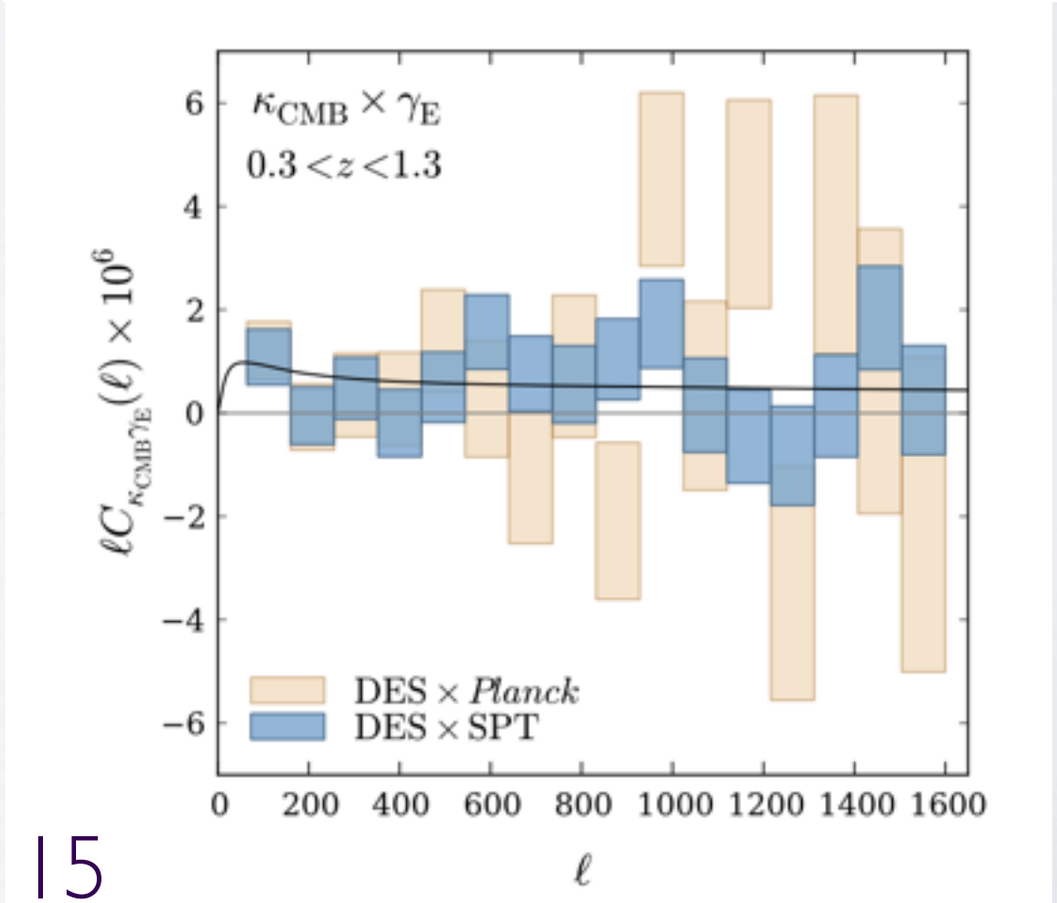
Ade et al XV 2015



DES shear correlation with CMB convergence

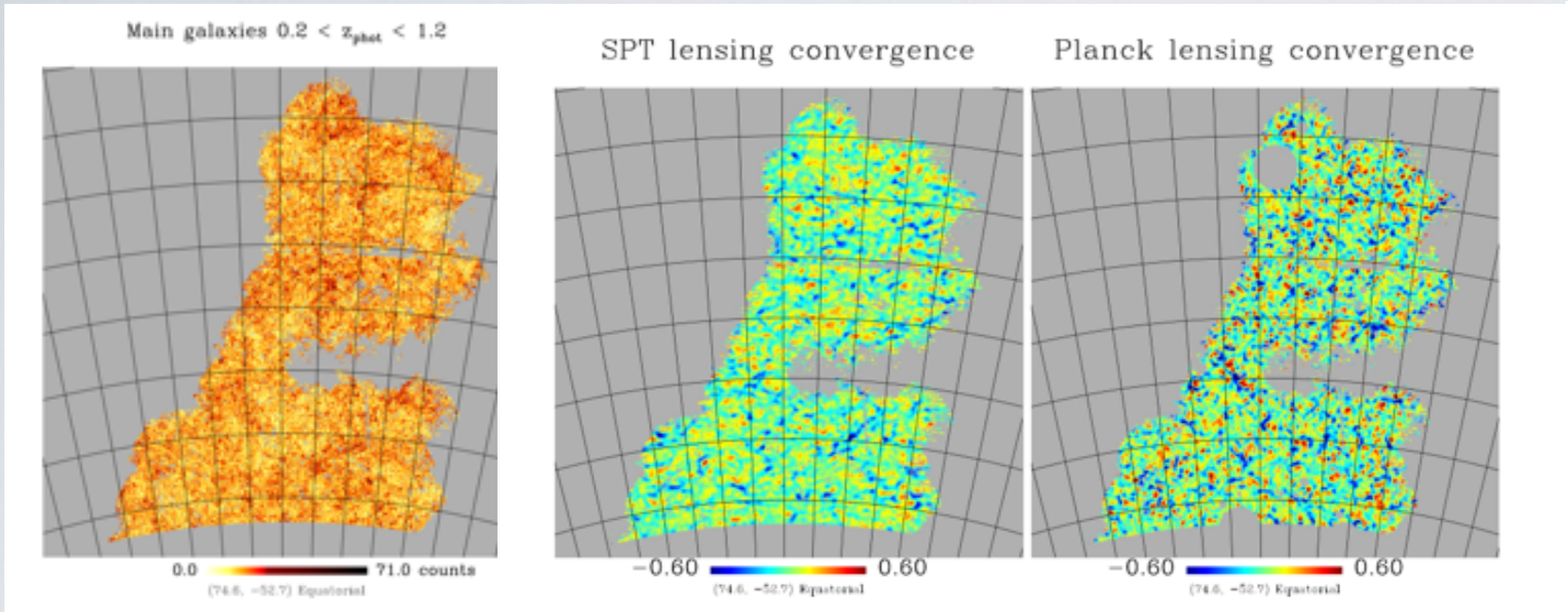
3 sigma detection

Sensitive to dark Universe alone!



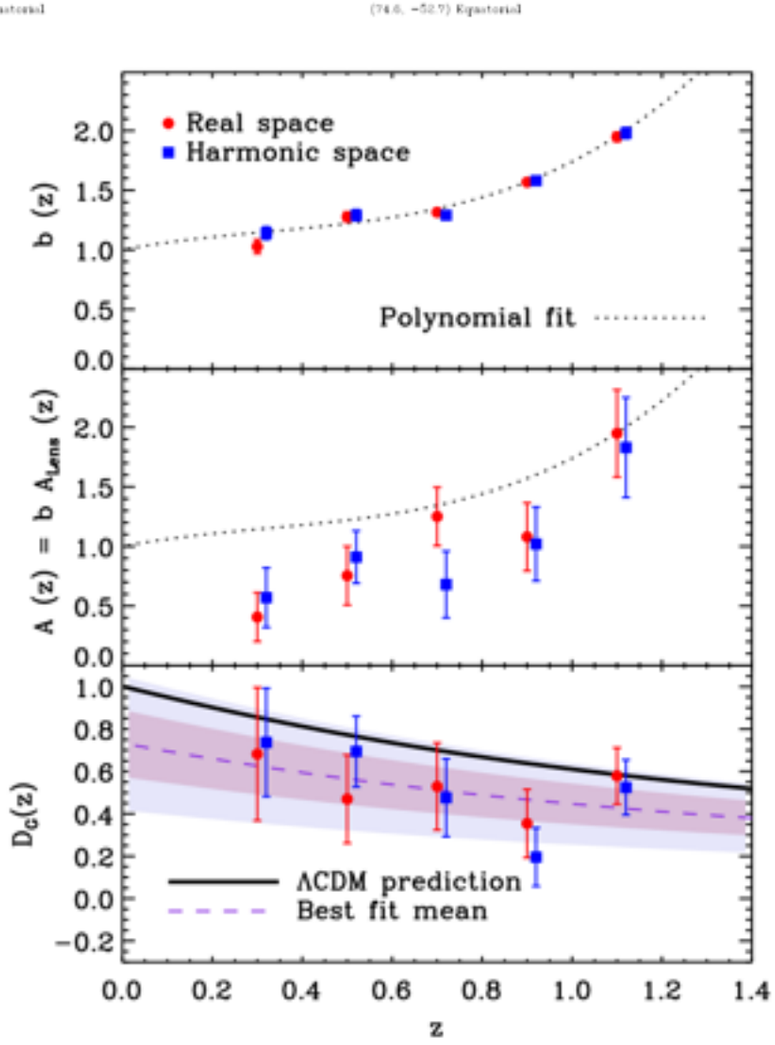
Kirk et al 15

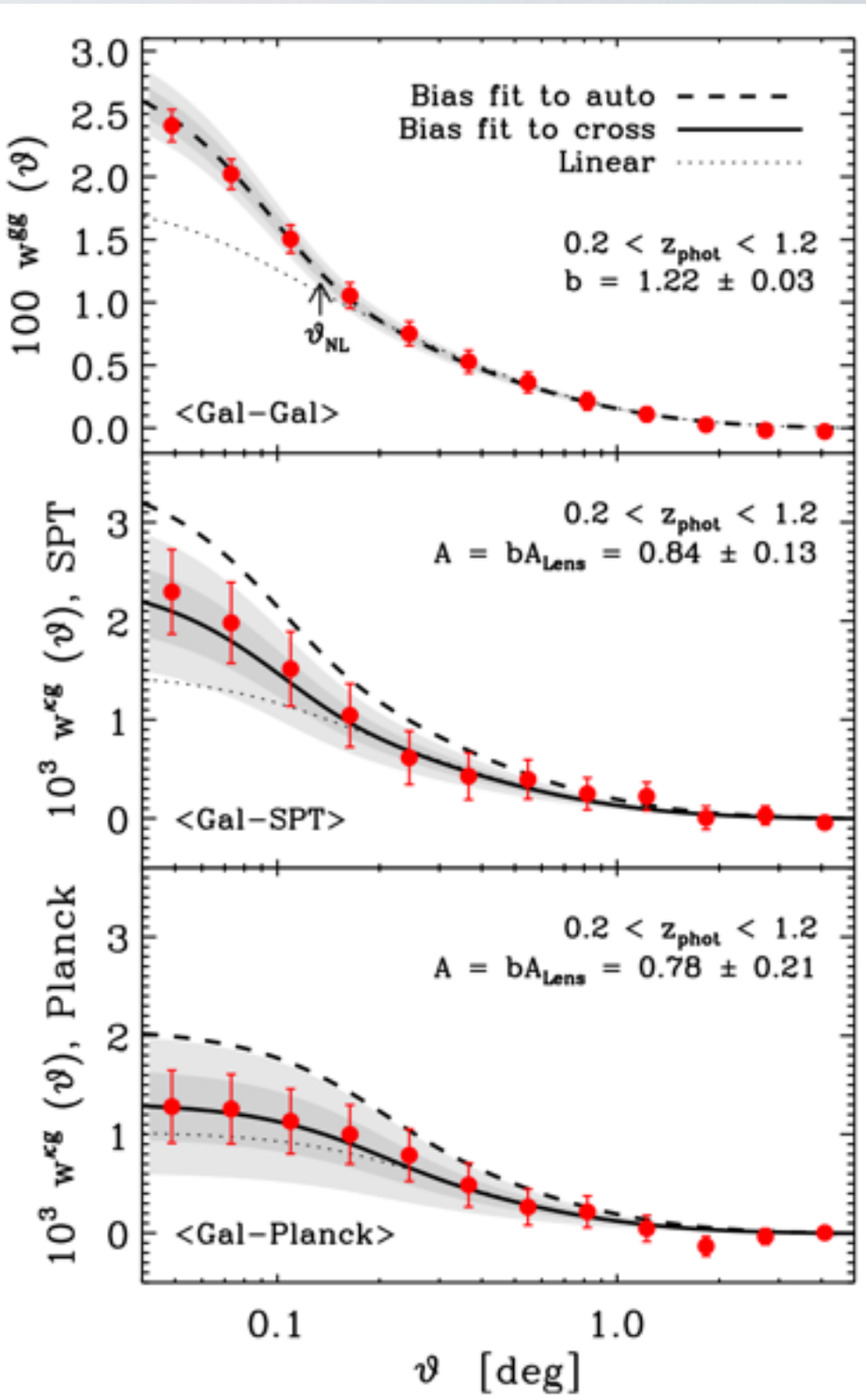
Lensing maps from the CMB



Galaxy correlations with CMB lensing

6 sigma detection



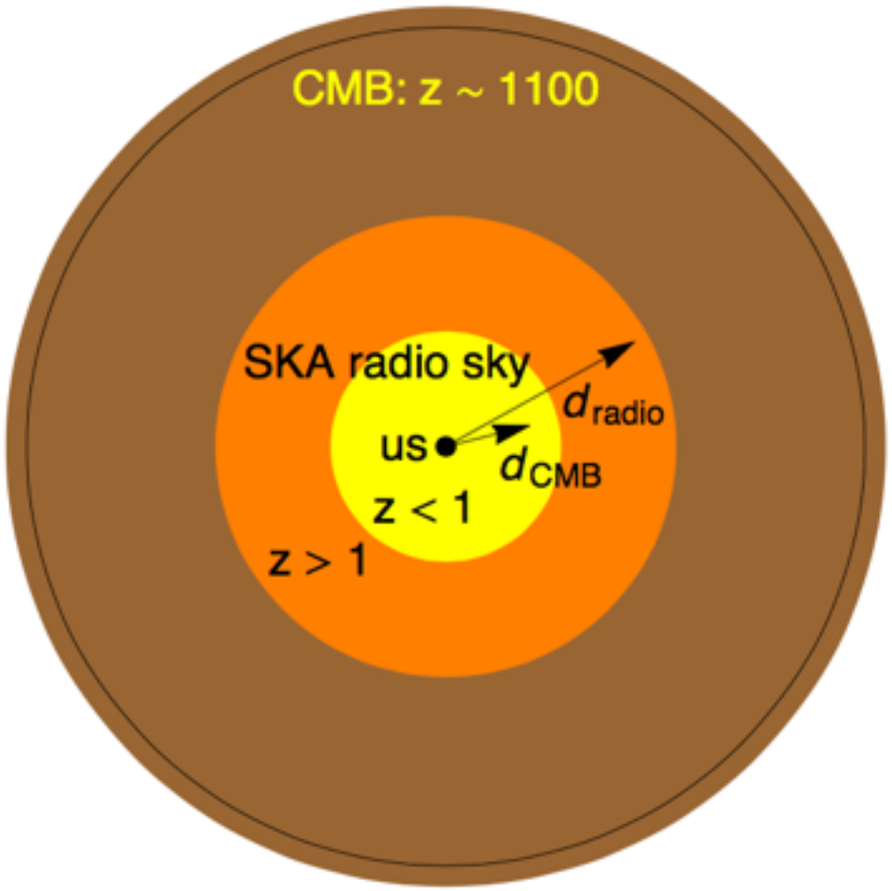


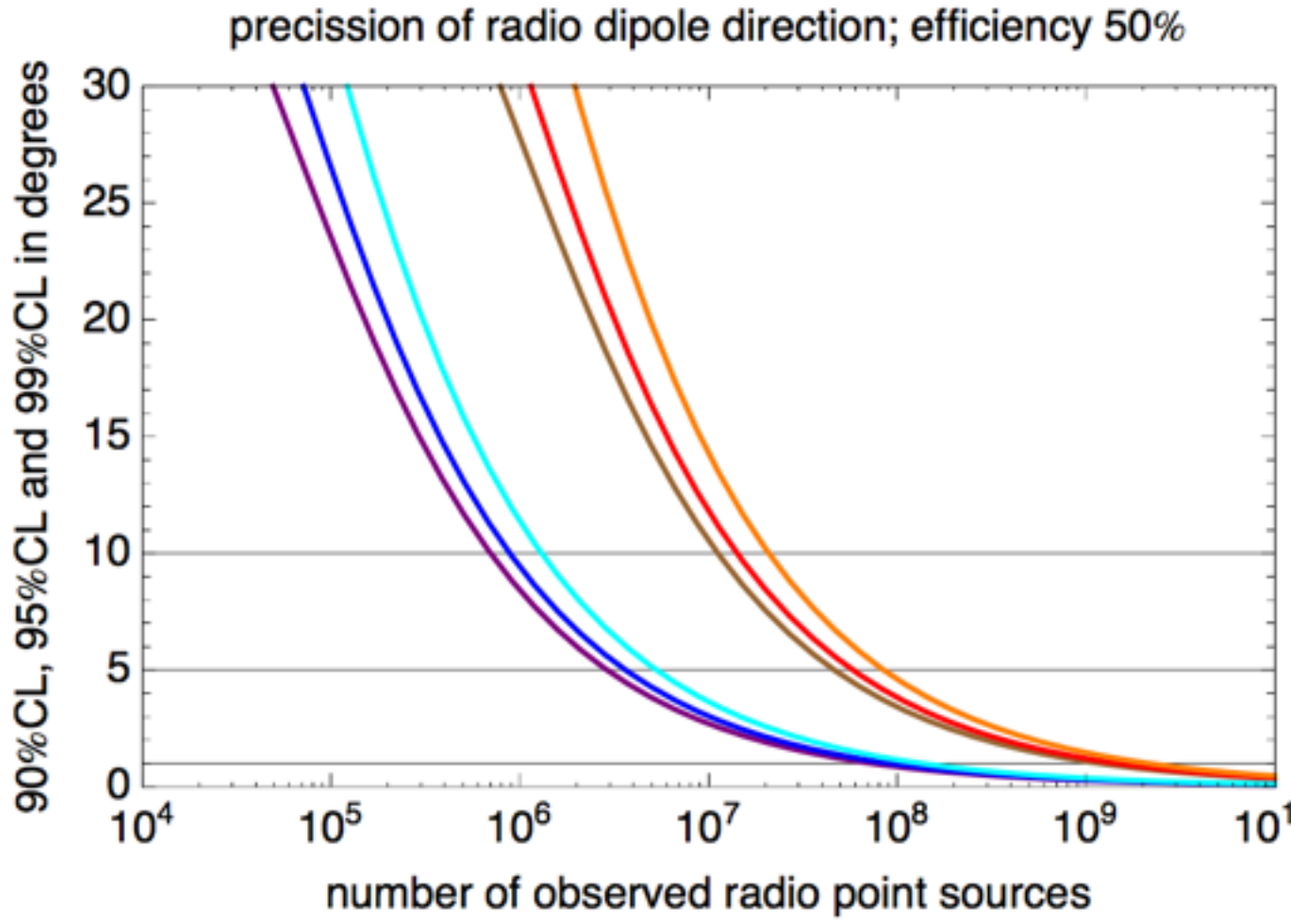
Giannantonio et al 16

Large-scale maps

"All-sky" maps will be very interesting - large-scale anomalies?

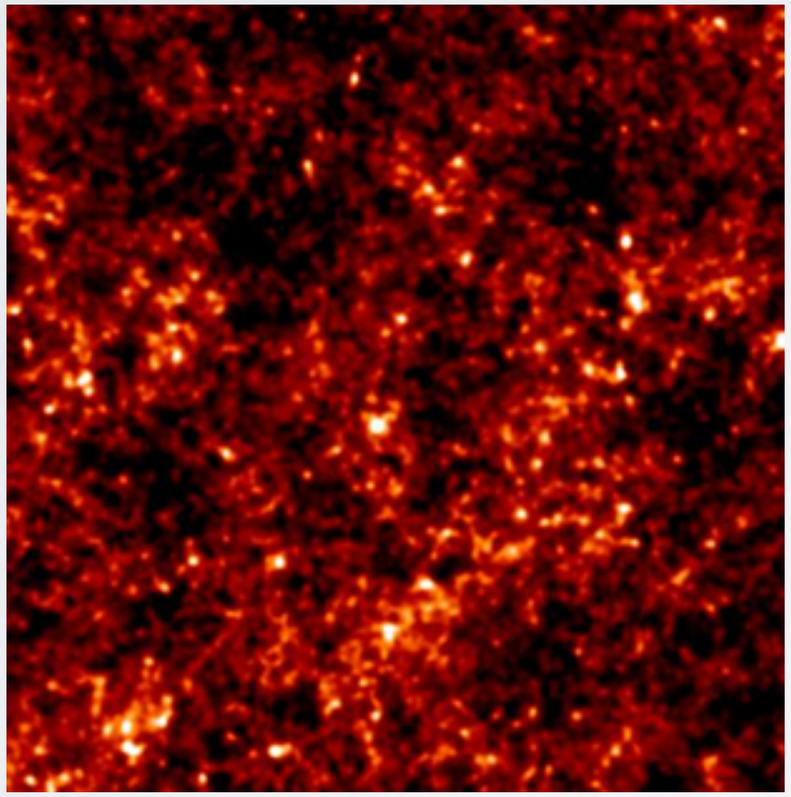
e.g. CMB dipole and radio dipole amplitude differ by factor of 4?? (Rubart et al 13)





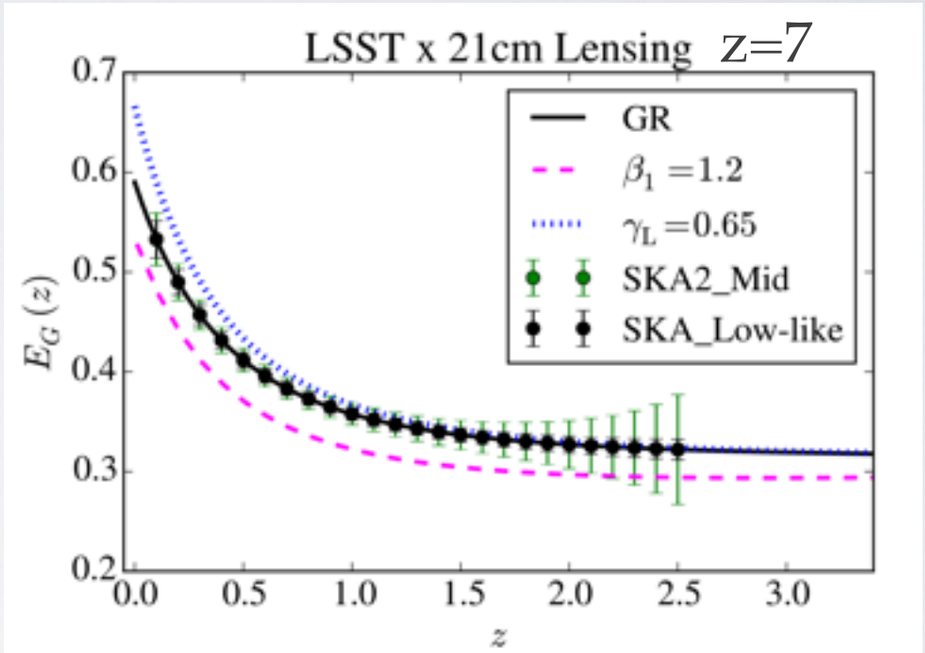
Large-scale maps

21 cm lensing at
Epoch of Reionization:

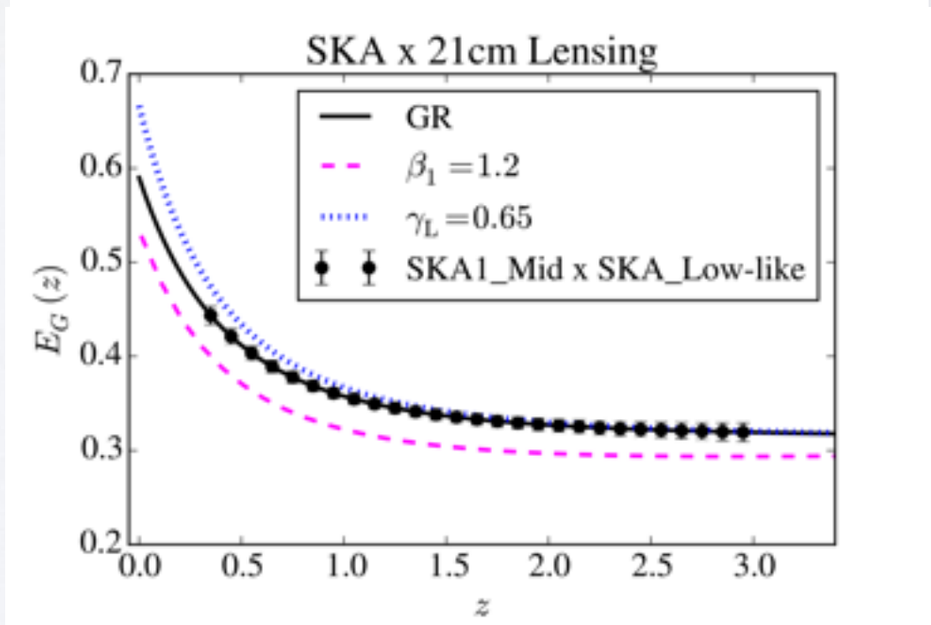


Hilbert et al 07

E_G parameter,
sensitive to theory of gravity:



SNR =238



SNR =279

Pourtsidou 2015

Conclusions

- Probabilistic mapping is very valuable for understanding large-scale structure.
- Lensing and galaxy counts can be combined for better map fidelity and bias estimation.
- Systematics maps give important information about spatial fidelity of a survey.
- Maps allow new spatially-dependent statistics (troughs, topology)
- Count and lensing maps allow studies of astrophysical environment and spatially varying gravity theories
- Large-scale maps will be an exciting test of the foundations of cosmology.