Weak lensing: entering the precision era and CFHTLenS results

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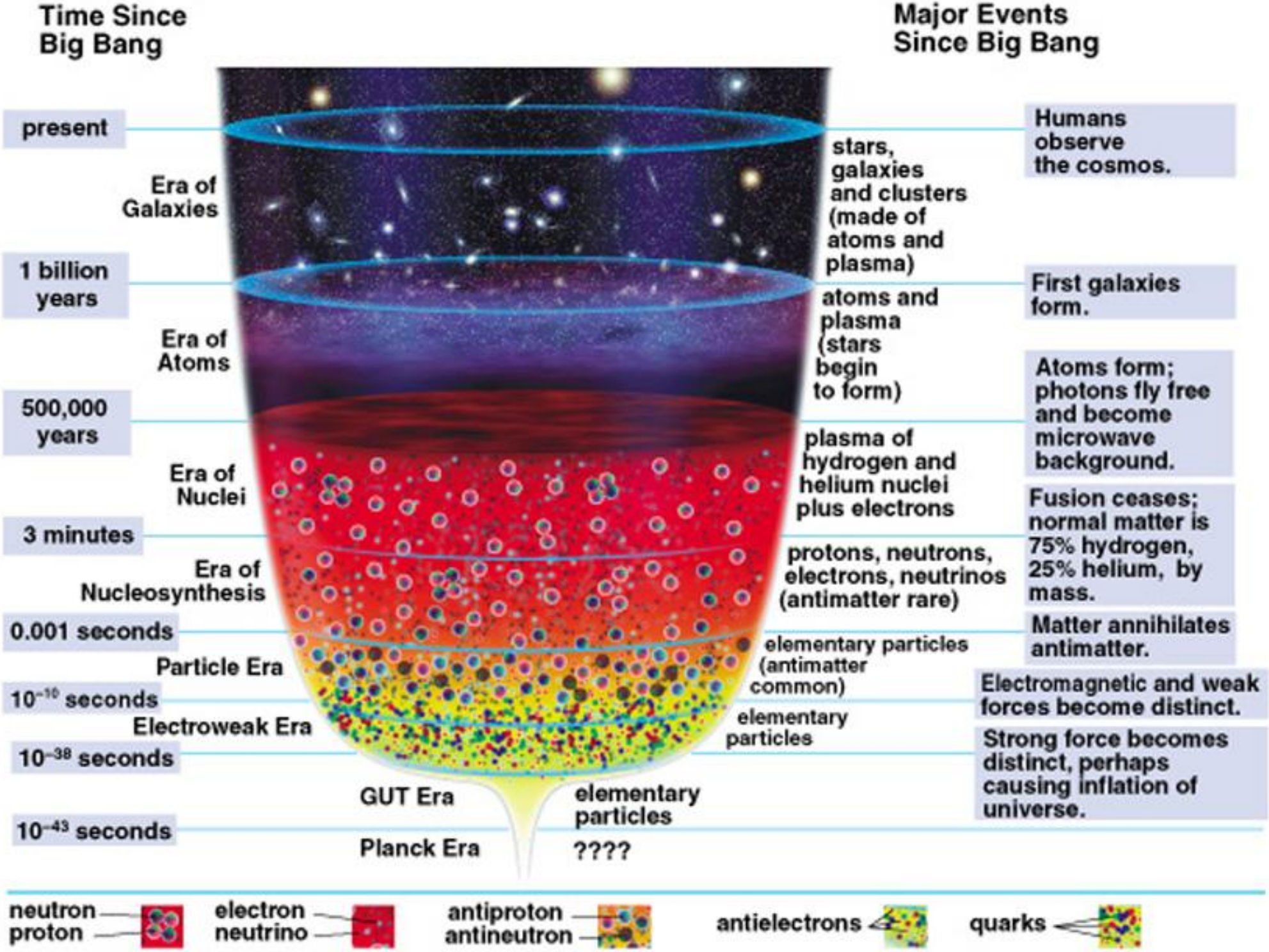
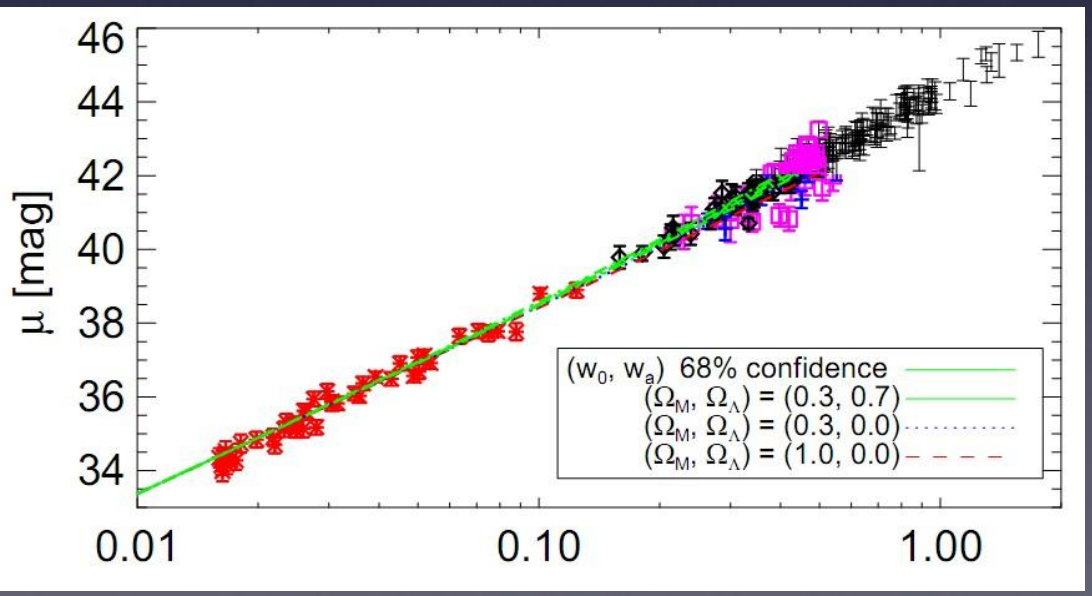


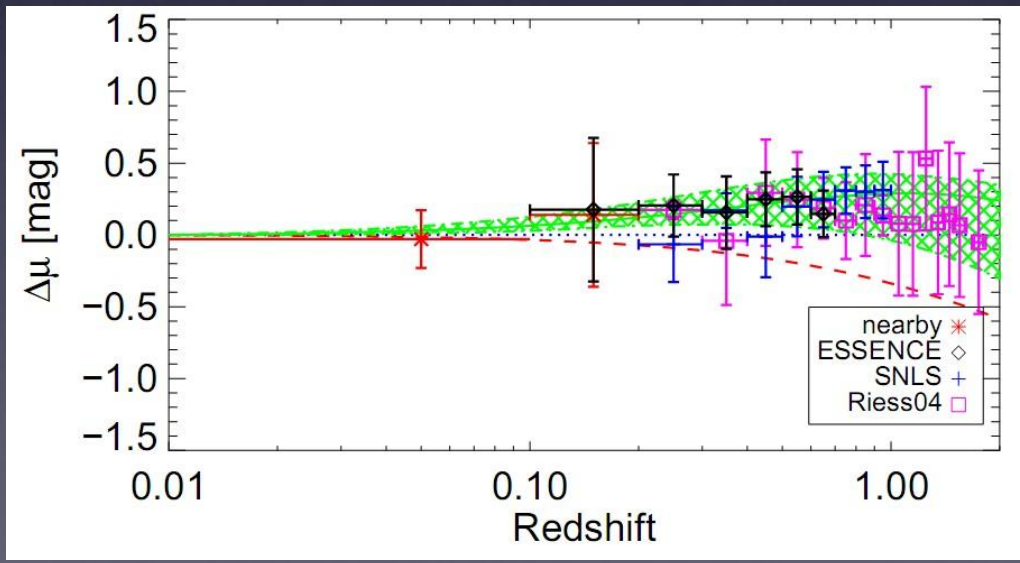
Observations indicate that the Universe expansion rate recently started an acceleration phase:

The expansion is described by a "fluid" with equation of state parameter w: $P=w\varepsilon_{DE}$

$$H^2(z) = H_0^2[\Omega_{m_0}(1+z)^3 + \Omega_{DE}(1+z)^{3(1+w)} + \Omega_{K_0}(1+z)^2]$$

For a cosmological constant we have w=-1





Low redshift structure growth is also a cosmology probe

Today

z=2

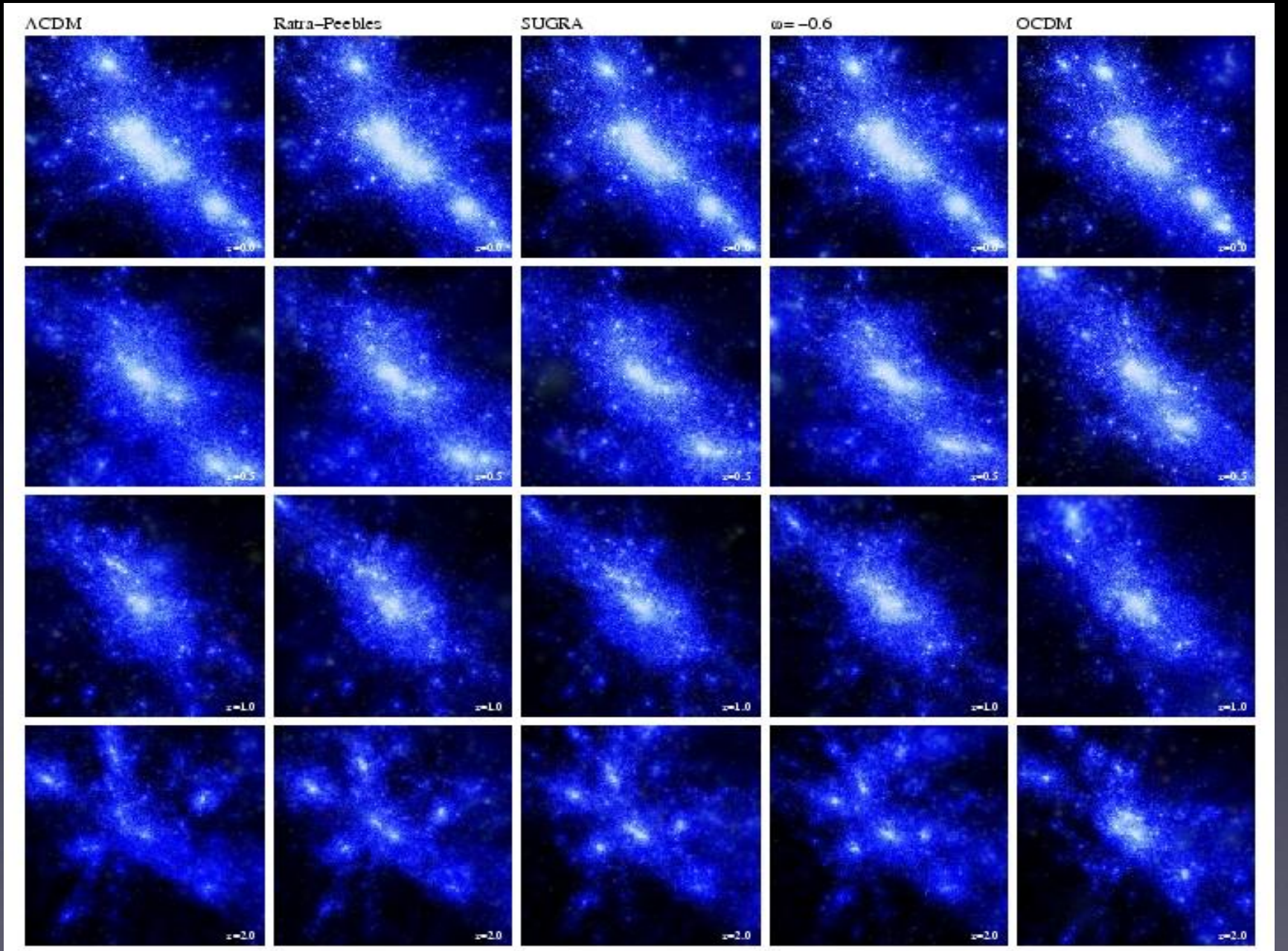
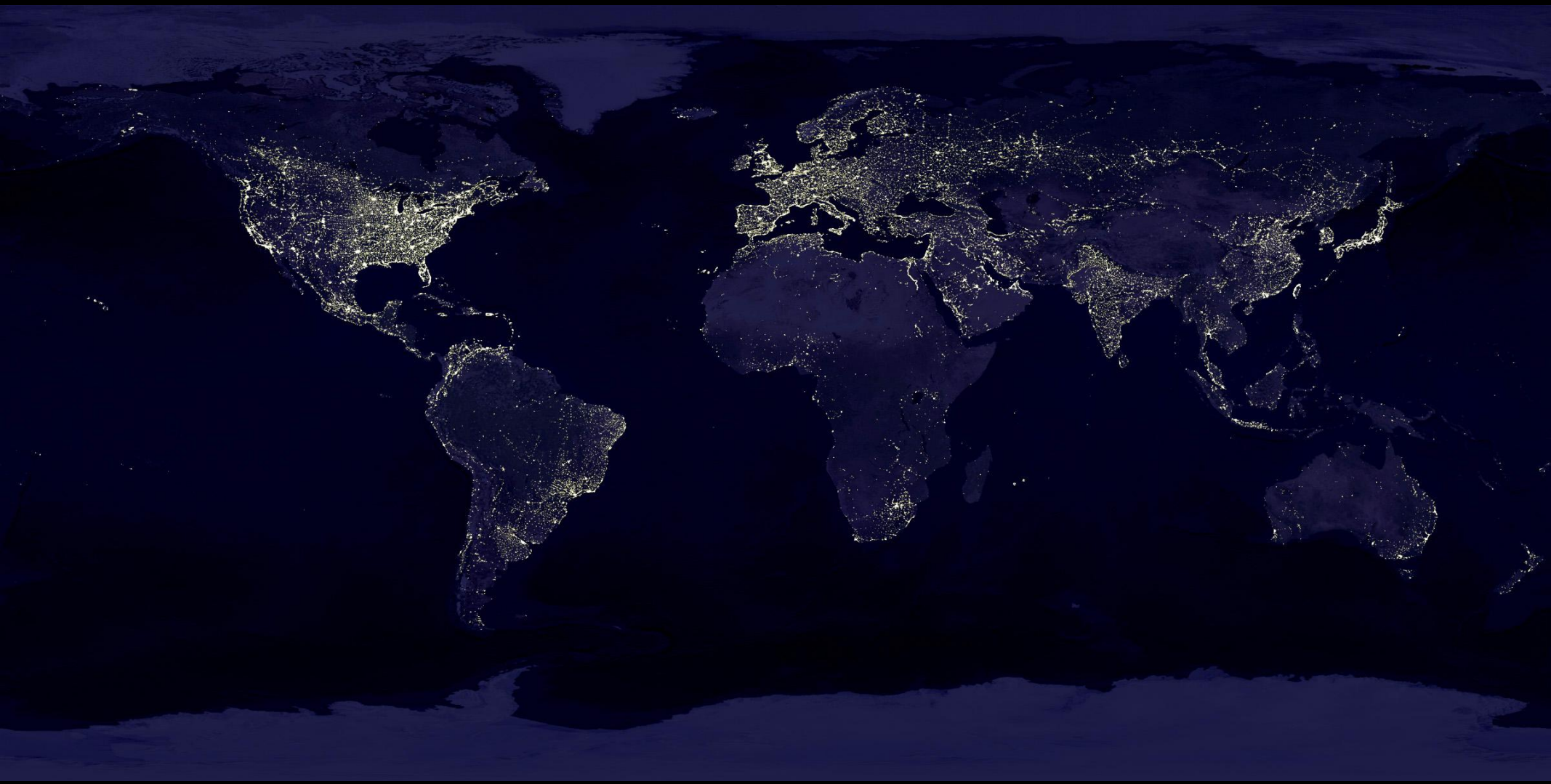
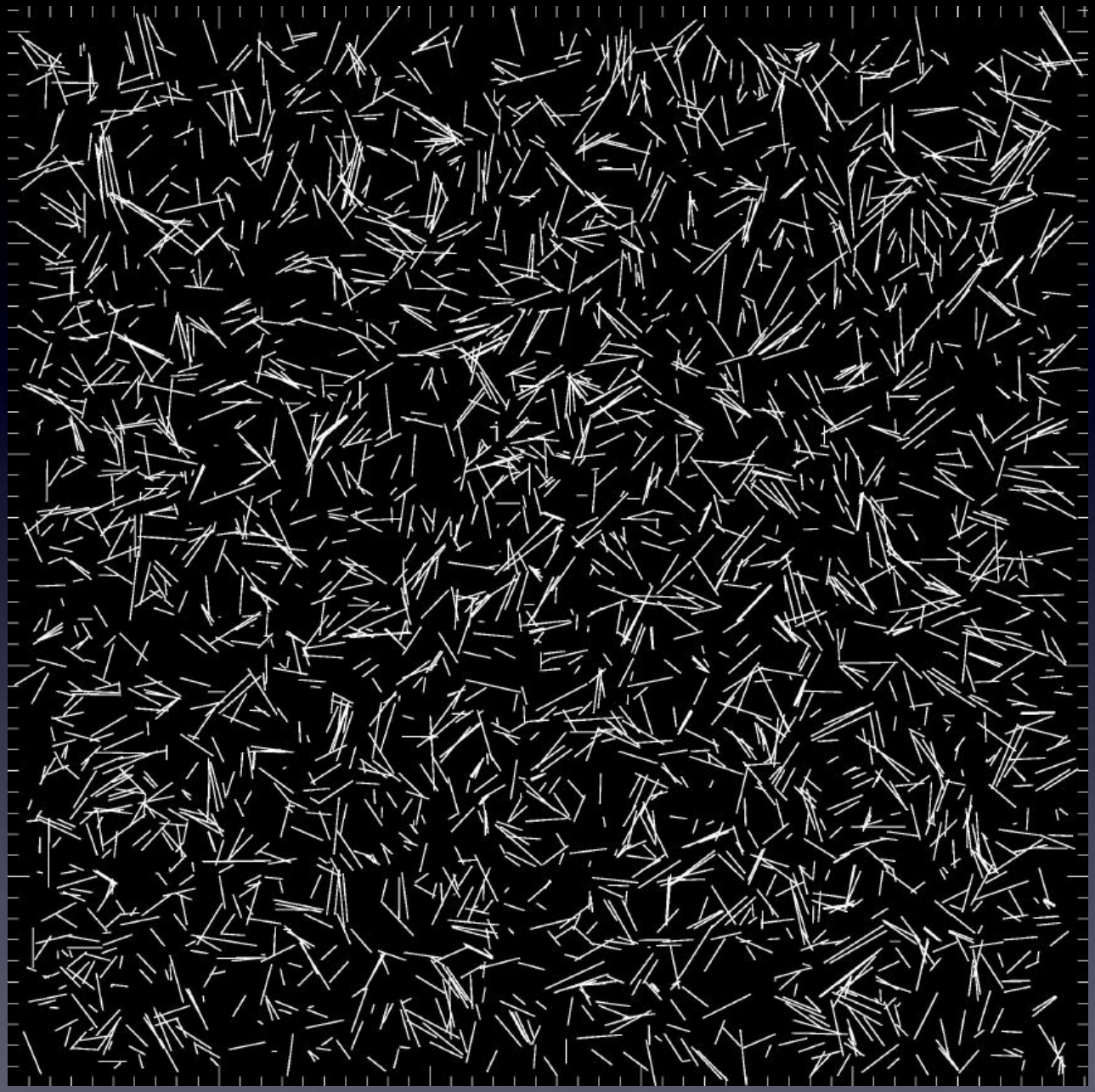


FIG. 2.—One individual cluster is shown at different redshifts ($z = 2$ to $z = 0$ in steps of 0.5 from bottom to top) in different cosmologies (columns as labelled) all normalised to $\sigma_8 = 0.9$ today. The panels illustrate that the clusters in different cosmological models arose from the same initial conditions and thus appear morphologically similar, but subtle differences are visible in detail.

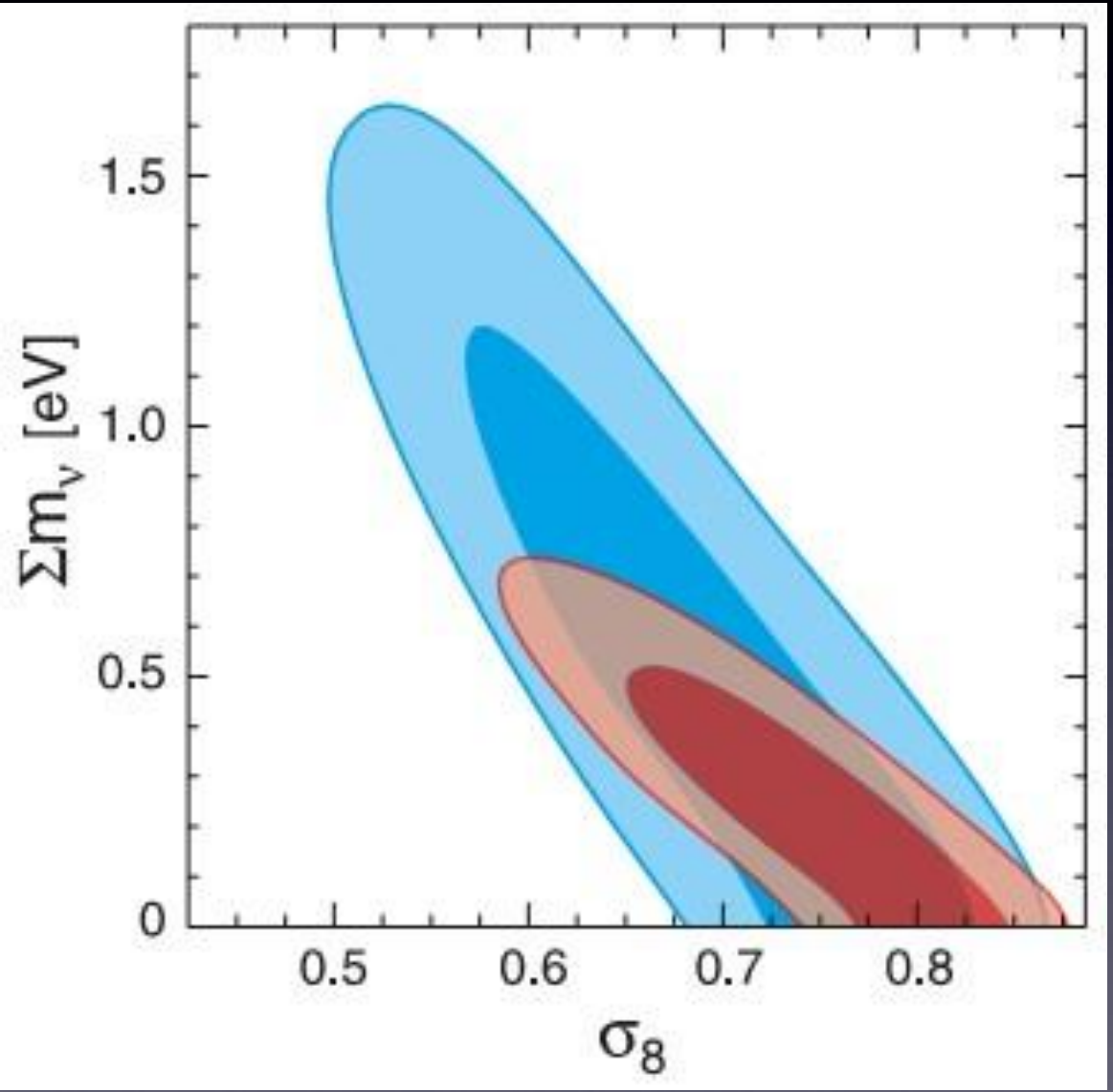


Light does not tell us where mass is…
Similarly galaxies are poor tracers of the mass

Gravitational lensing "sees" the dark matter

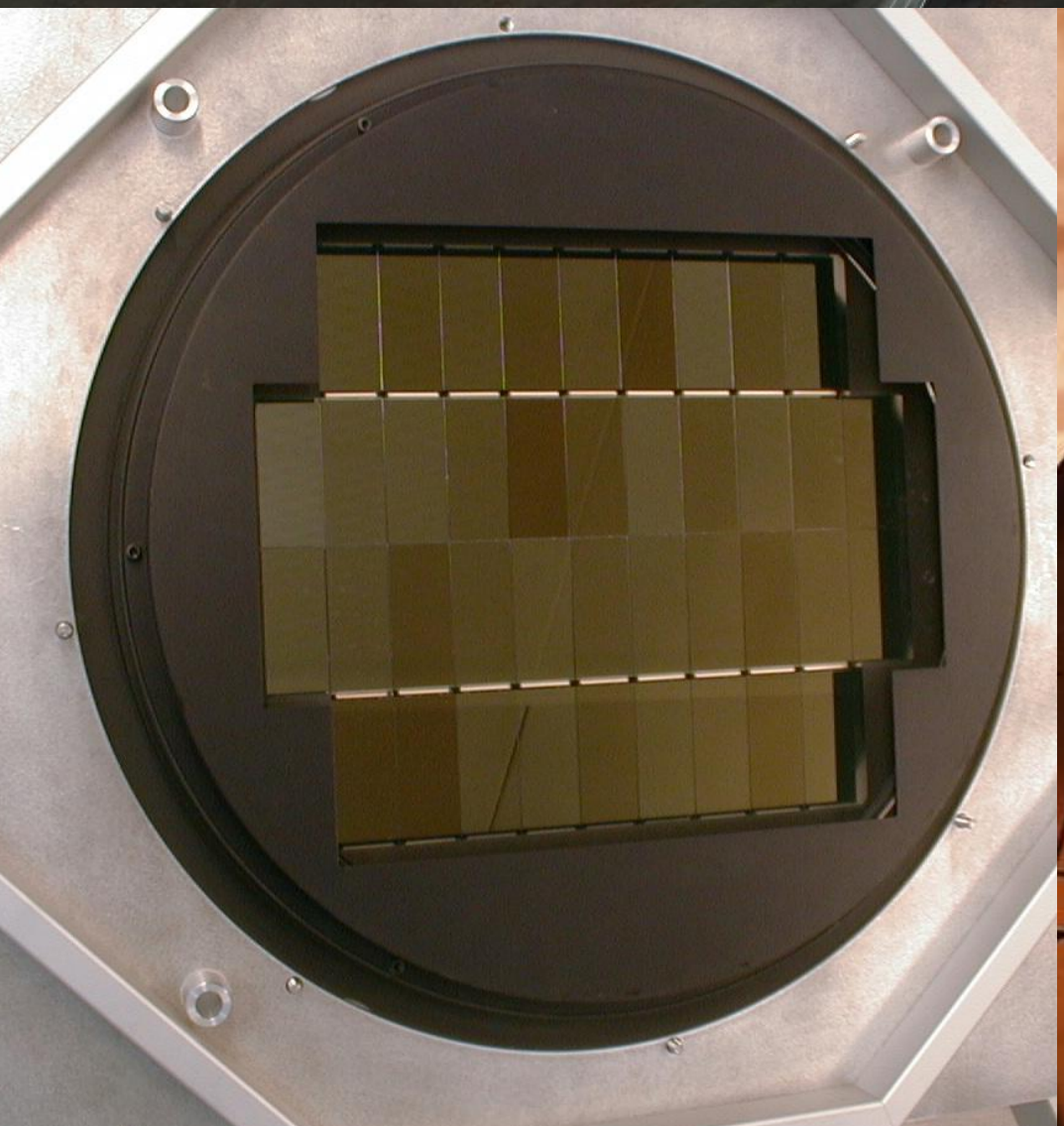


The power spectrum normalisation is a key parameter which helps to break many degeneracies, e.g. the Neutrino mass.



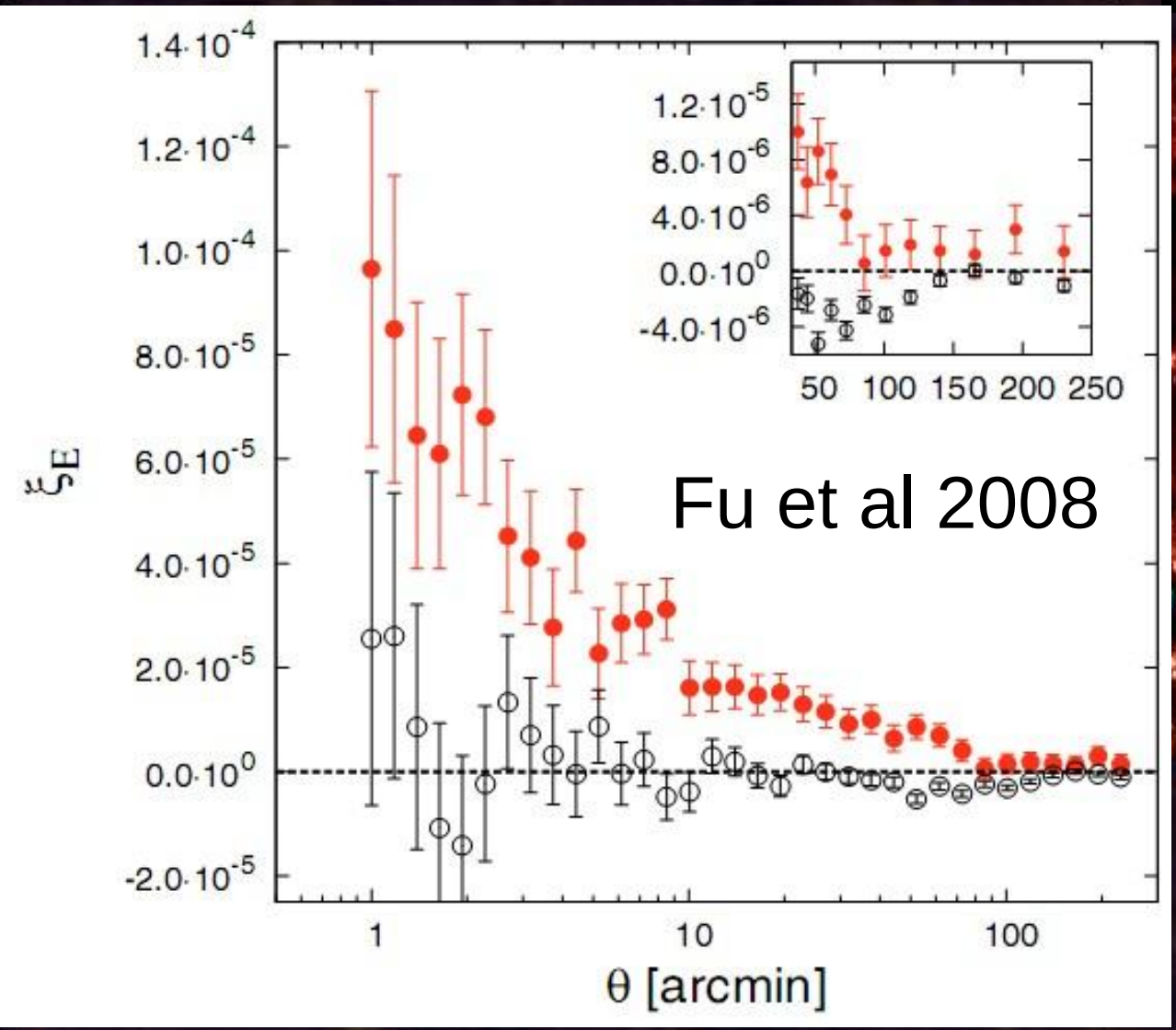
The Canada-France-Hawaii Telescope legacy survey

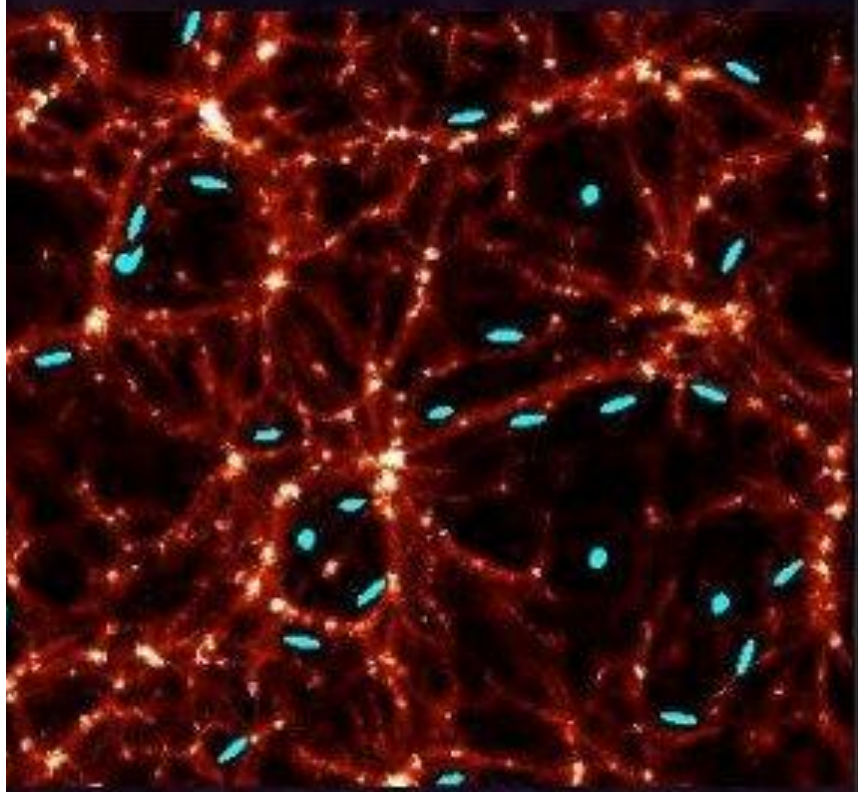
ugriz 170 s



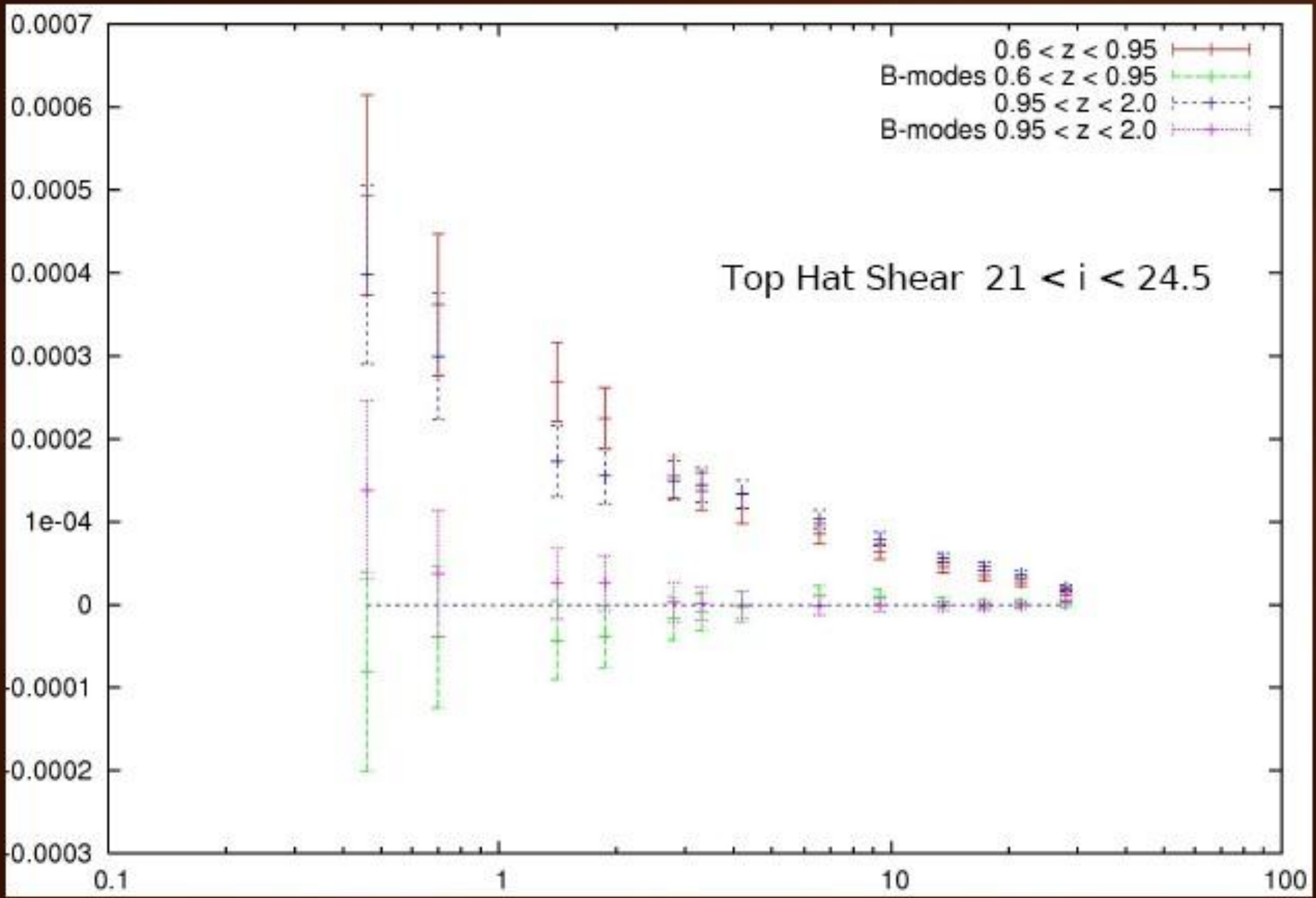
The challenge:

Weak lensing measurement





First Step Towards Tomography



The CFHTLenS Team

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Science goals (~20 papers in preparation):

-galaxy-galaxy lensing (biasing, redshift & luminosity dependence, halo shapes, halo model)

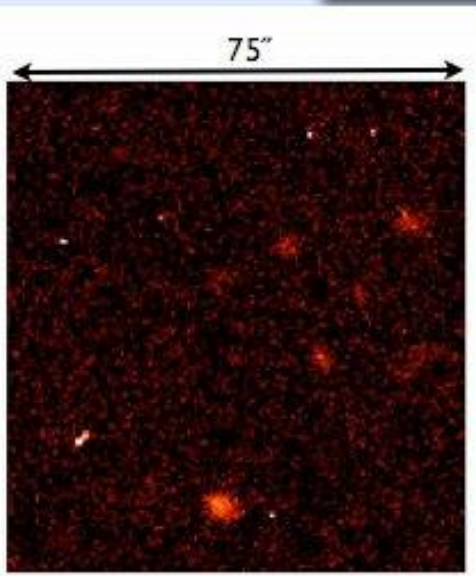
-groups and clusters lensing (structural parameters, mass calibration, cosmology, baryonic physics, mass function)

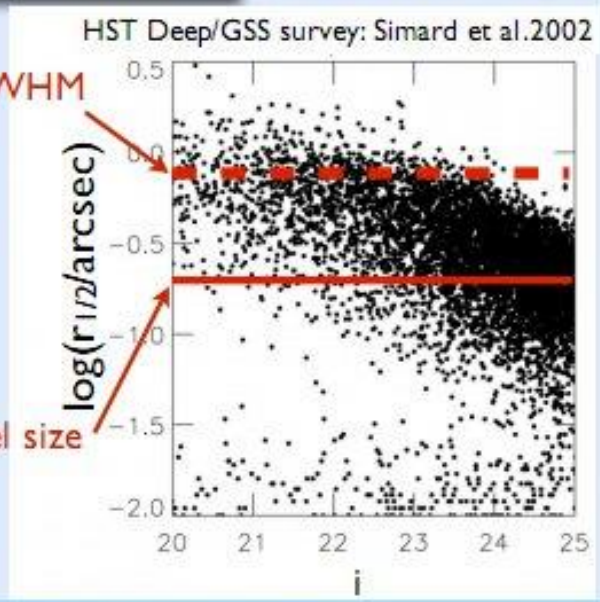
-cosmological lensing (second and high order statistics, tomography, IA-shear connection, full cosmo params analysis (CMB+BAO+SN+BBN+Lensing), magnification, extinction-dust)

-cosmic maps (LSS web and mass maps, cross-correlation with Xray and use of specz)

-modified gravity

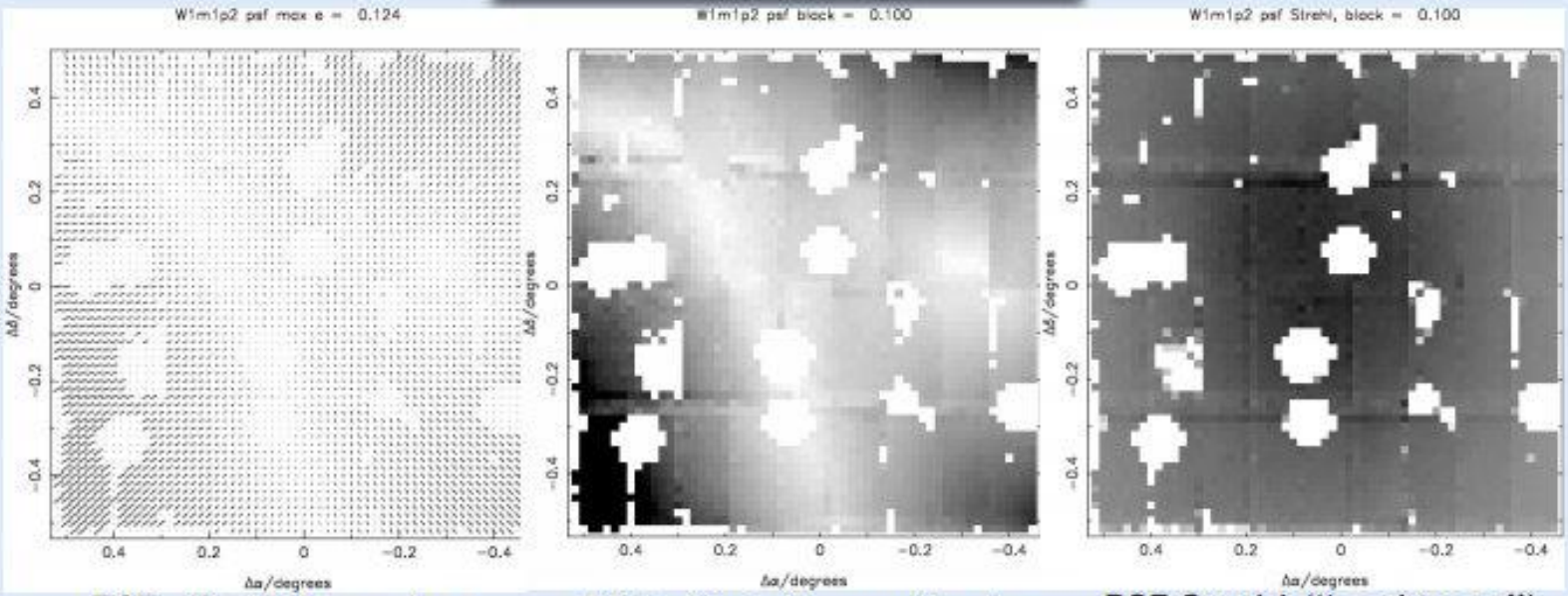
The problem





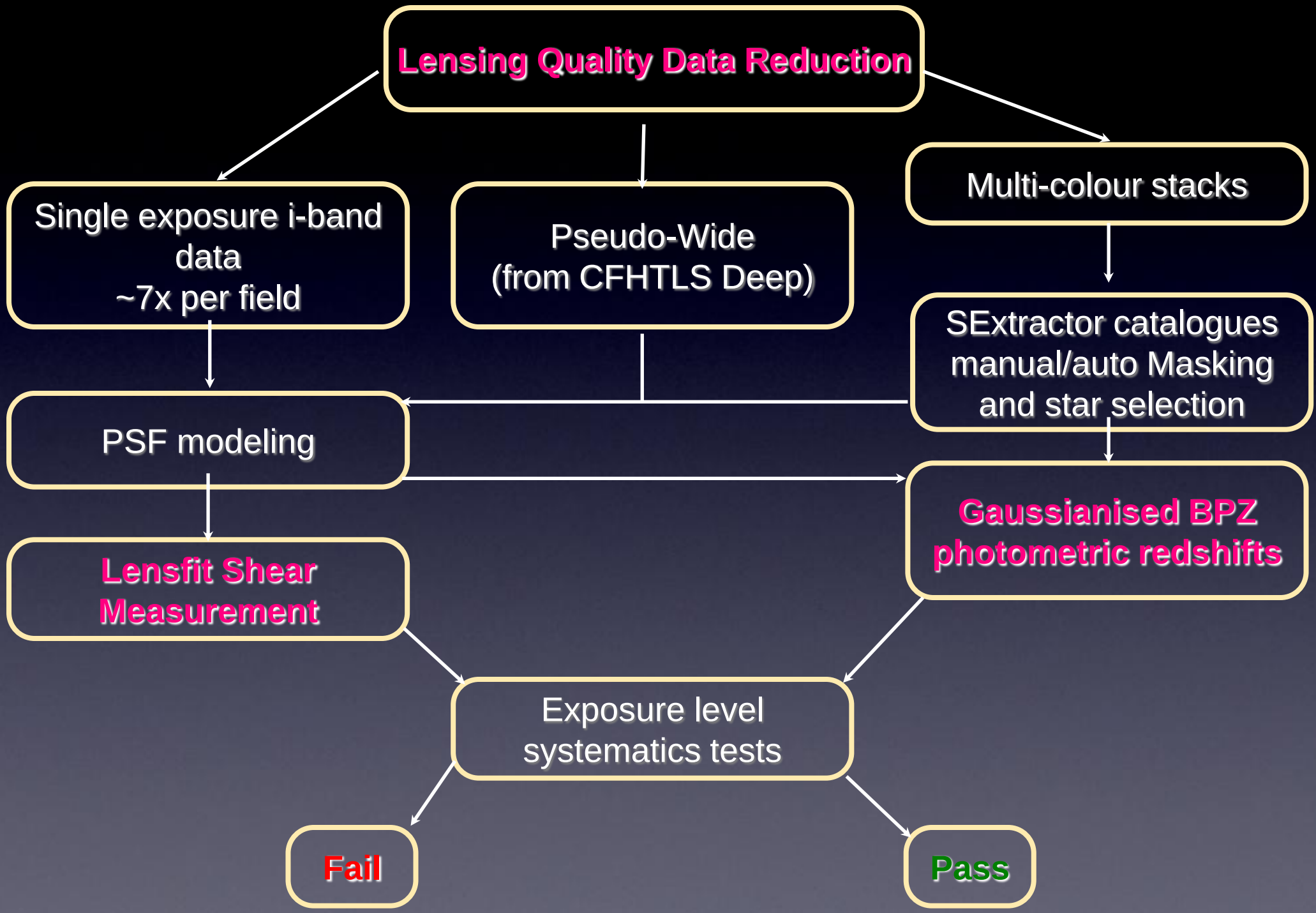
- The weak lensing signal is carried by the faintest galaxies with low S/N.
- Galaxy half-light radii are smaller than the PSF and comparable to the pixel scale!

The PSF



PSF ellipticity vectors | PSF ellipticity amplitude | PSF Strehl ("peakiness")

The CFHTLenS Pipeline



What have we learnt?

Data

- Avoid stacking and re-pixelising
- Automatic masking is sufficient. Typically loose 20% area.

PSF

- The PSF in exposures shorter than 70 seconds is dominated by high spatial frequency turbulence
- PCA did not produce a significant improvement with this volume of ground data

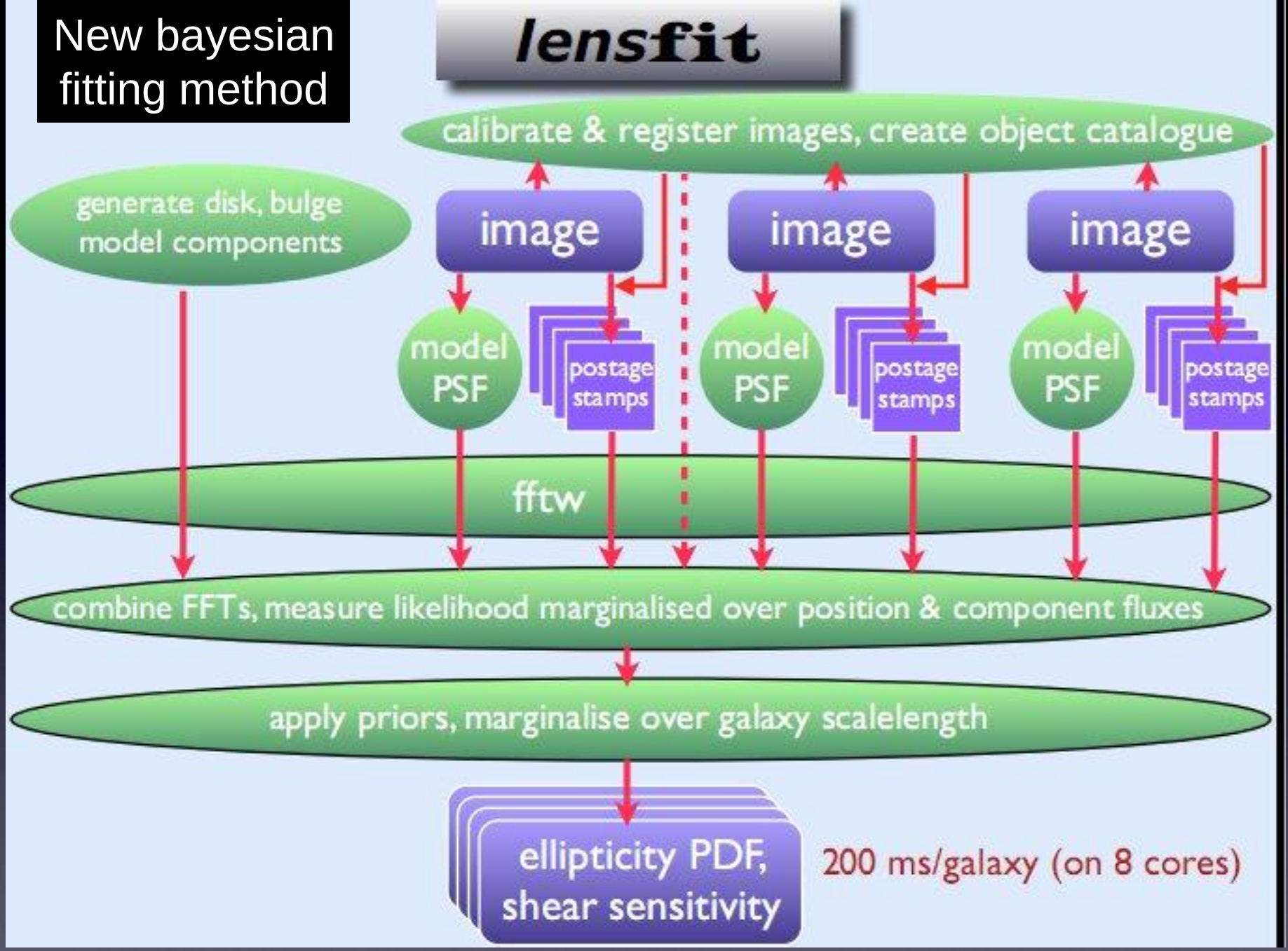
Shape measurement

- Test many methods: KSBx2, Shapeletsx3, Lensfit. Only Lensfit catalogues passed redshift scaling tests and systematics tests.
- IQ is not the full story

Photometric Redshifts

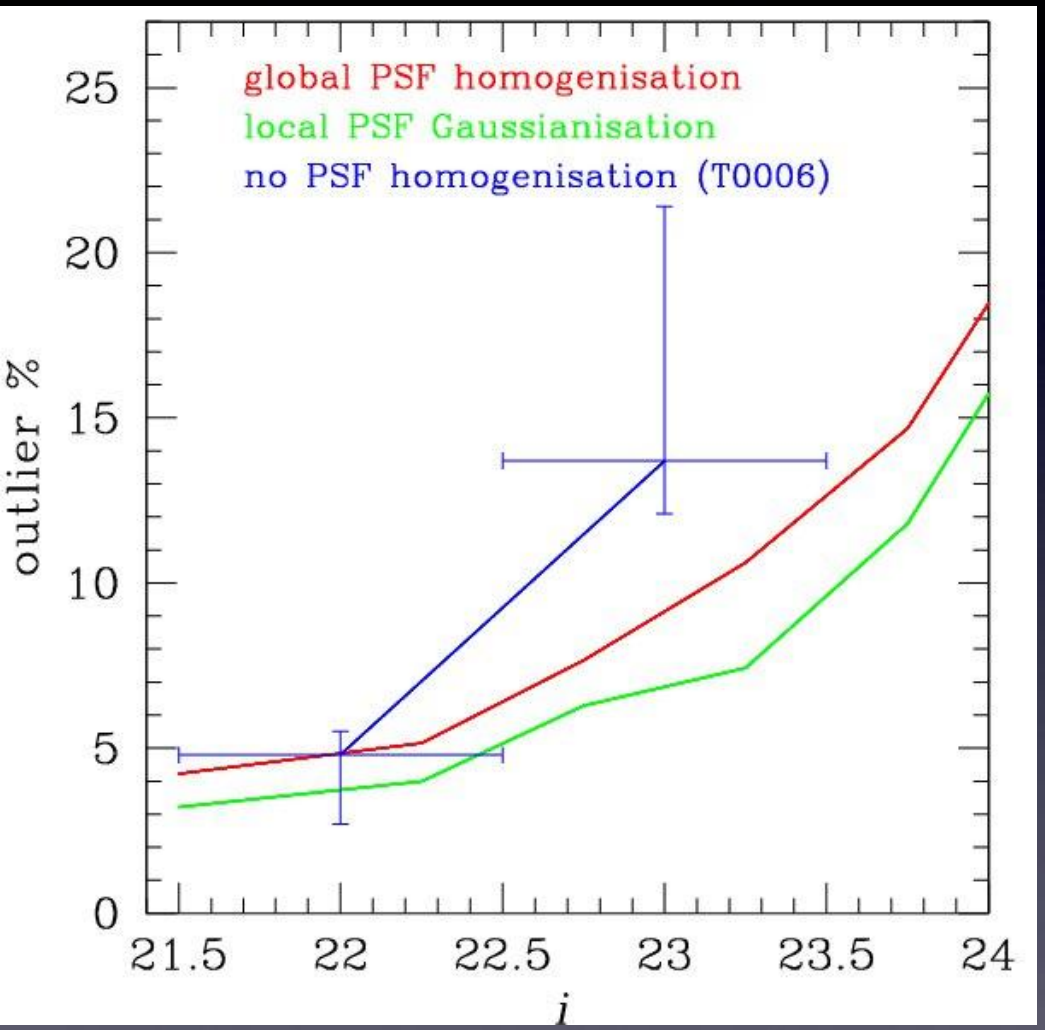
- Fixed aperture photometry must consider the spatially varying PSF for accurate photometric redshift measurements

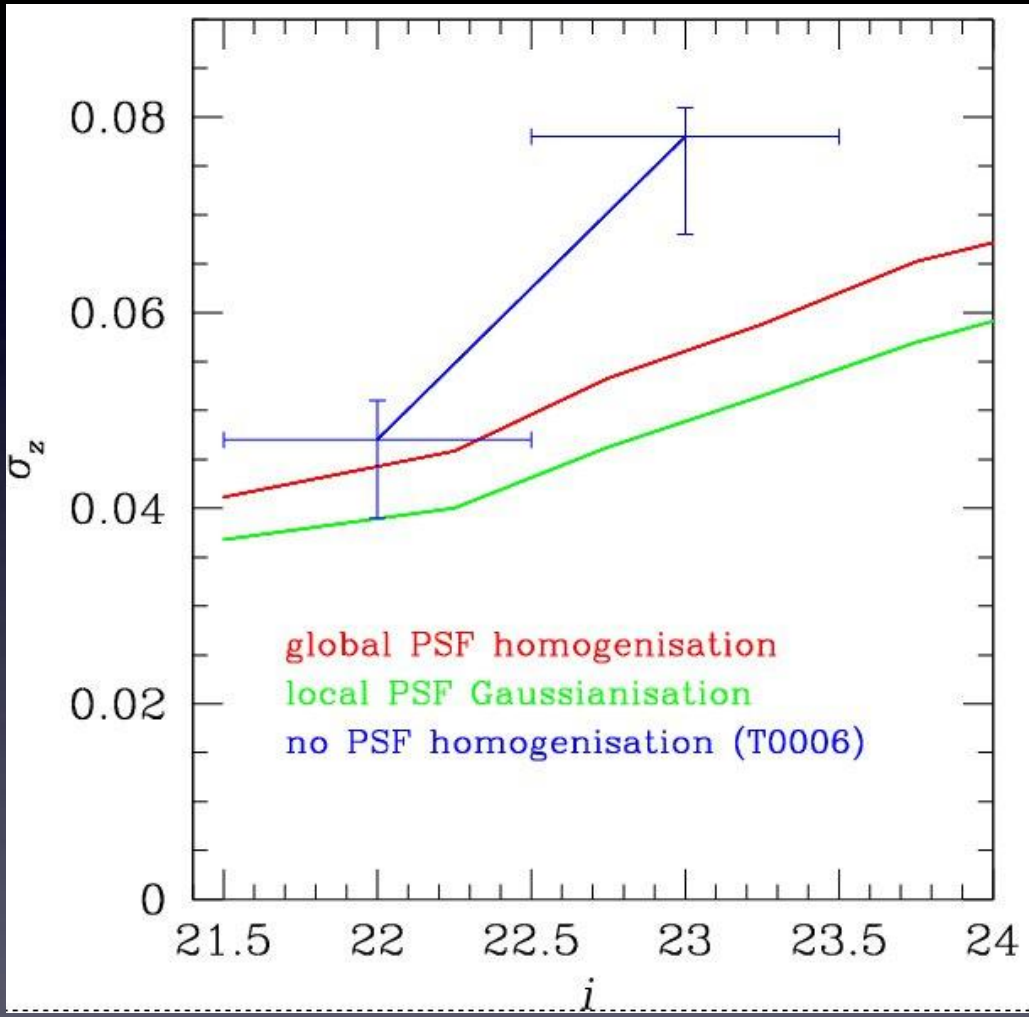
New bayesian fitting method



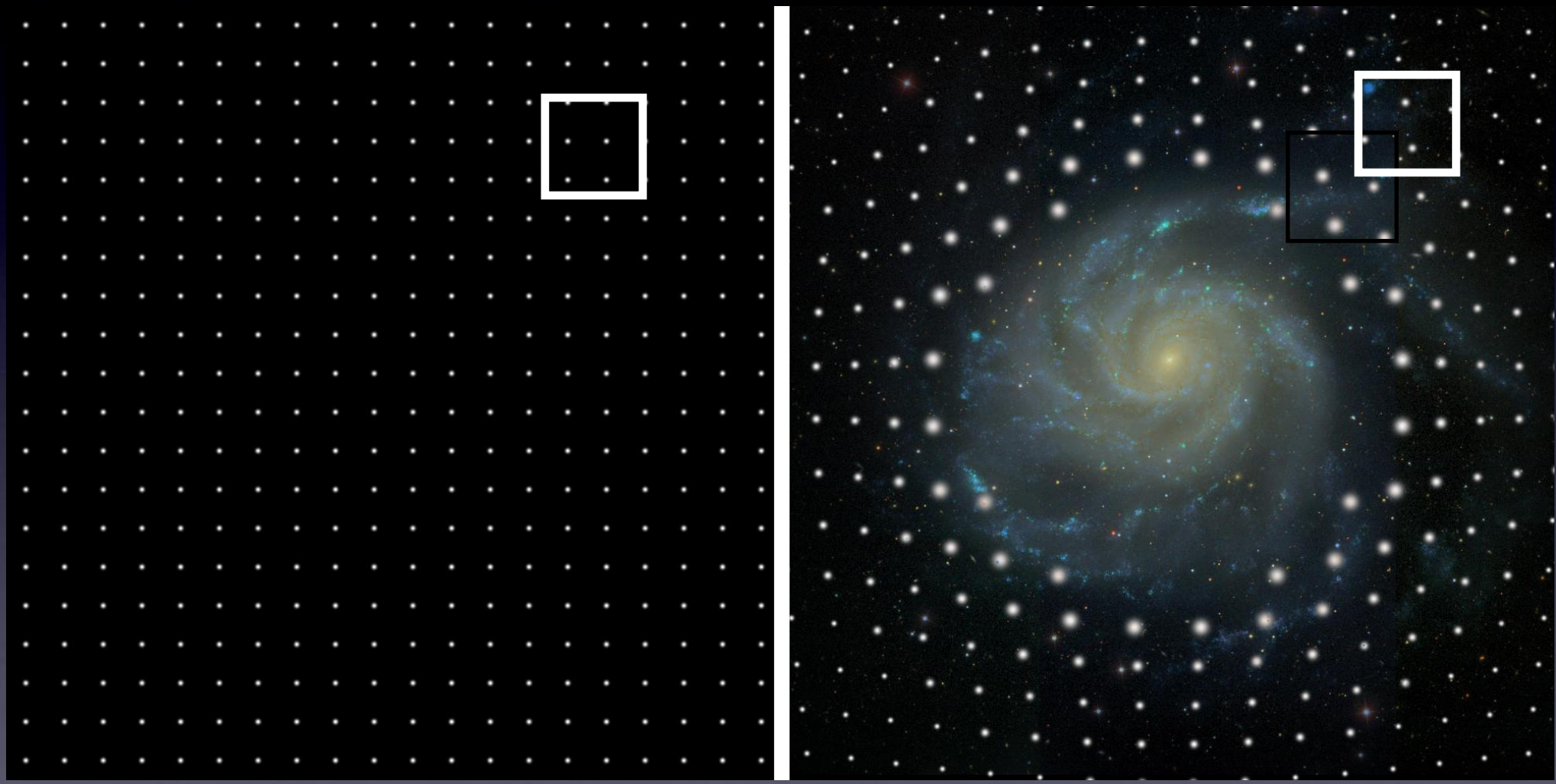
Any method should use individual exposures, not stacked images!

Photometric redshifts (BPZ): PSF gaussianisation is key

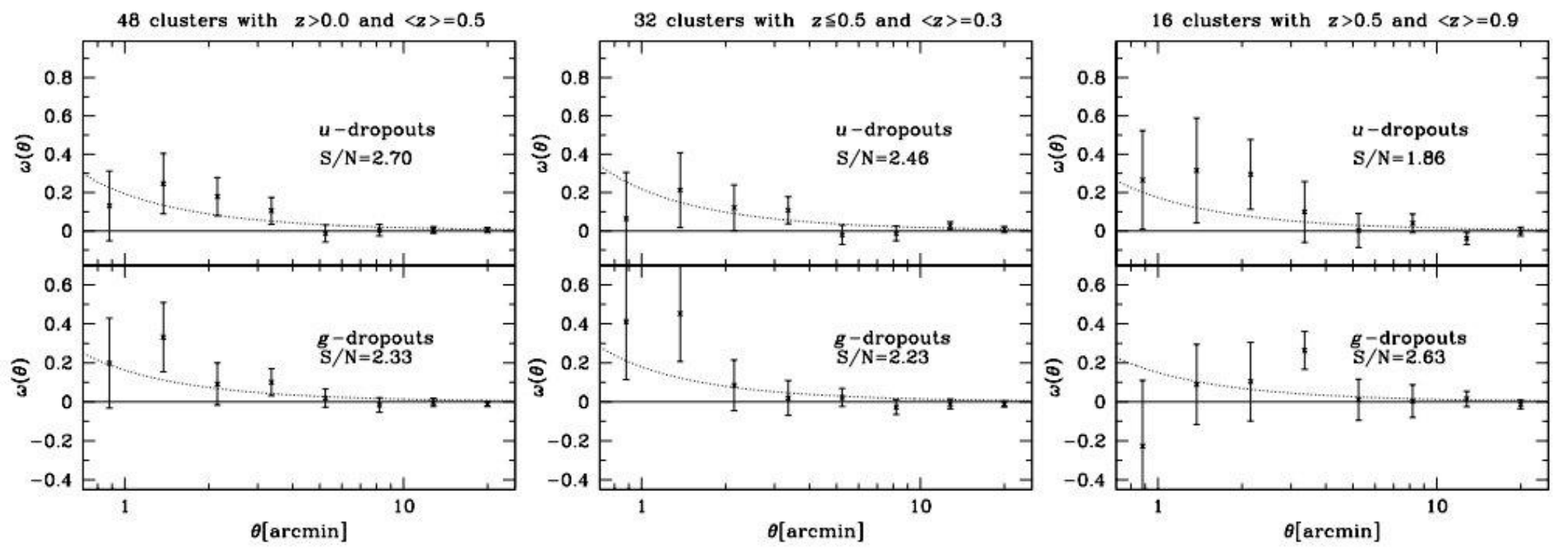




What is cosmic magnification?



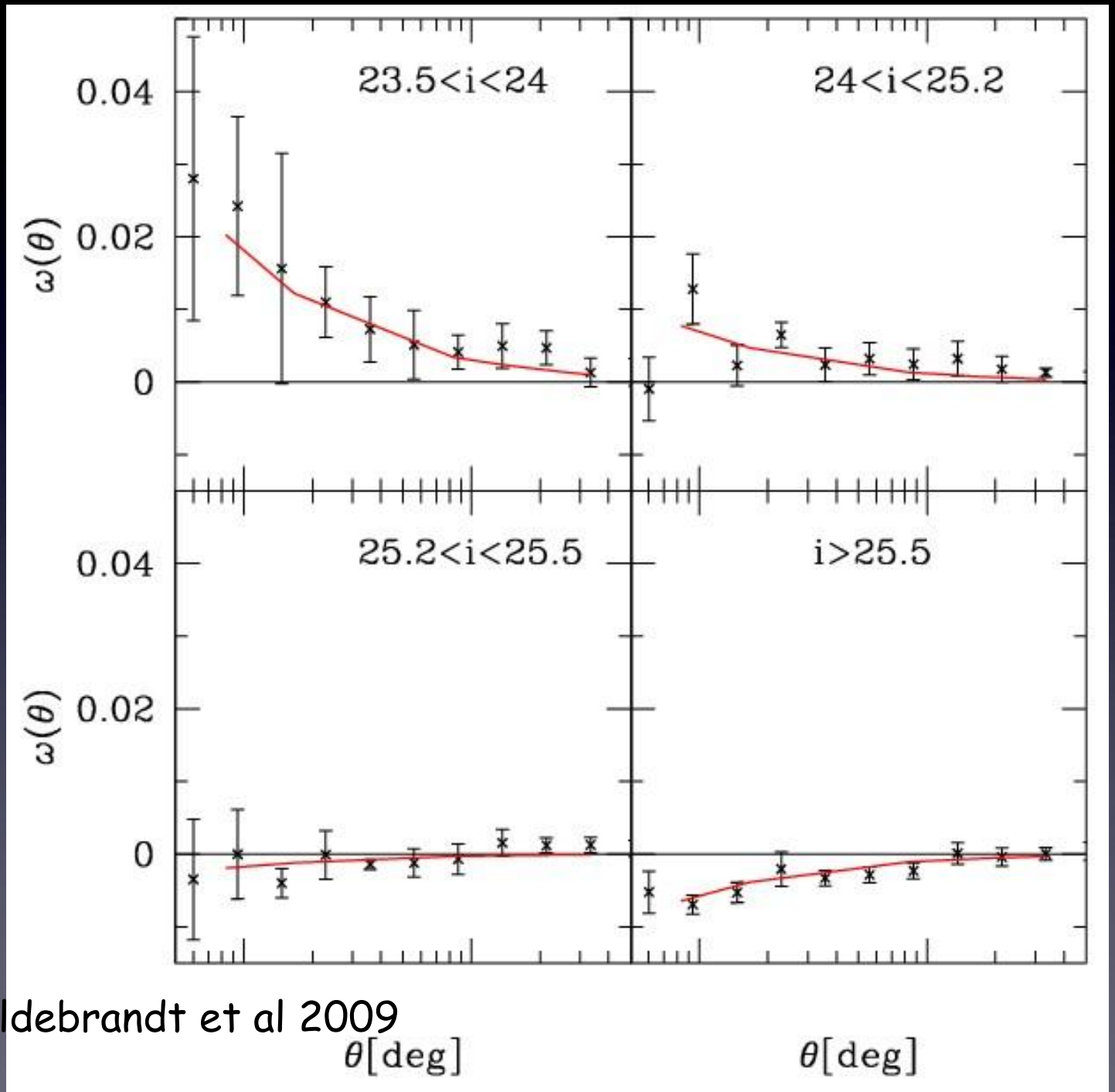
Calibration of galaxy clusters mass at high redshift using z>3 LBGs as source galaxies



arXiv:1103.4407 Hildebrandt et al. 2011

Magnification correlation fct

ug dropout with z=[0.5,1] foregrounds



Hildebrandt et al 2009

Summary/what next?

-CFHTLenS brought optical gravitational lensing to the next level in terms of precision and systematics control.

-Everything will be publicly available: data products/data reduction recipes (lensing optimized)/softwares available one year from now.

[Some of our tools could have non cosmological applications (e.g. lensfit for GC profile measurement, proper motion, extremely accurate PSFmodel per exposure for SNLS)]

-next step is KIDS/DES and then LSST (ground based) and Euclid (space based). Canadian involvement in Euclid still under discussion. A canadian-only alternative could be balloon mission and CFHText (IMAKA, ngCFHT)

IMAKA: GLAO MEGACAM on CFHT

Image from an `Imaka simulation by E. Bertin showing a small portion (25" x25") of the field of view in one-hour g-, r-, and i-band observations of a crowded 10Gyr-old stellar population at a distance modulus of 18.5 (~50kpc) with CFHT/`Imaka (left) and CFHT/MegaCam (right). The gains from `Imaka's superb delivered image quality are readily apparent. The images have been zoomed to show the pixel structure of the data.