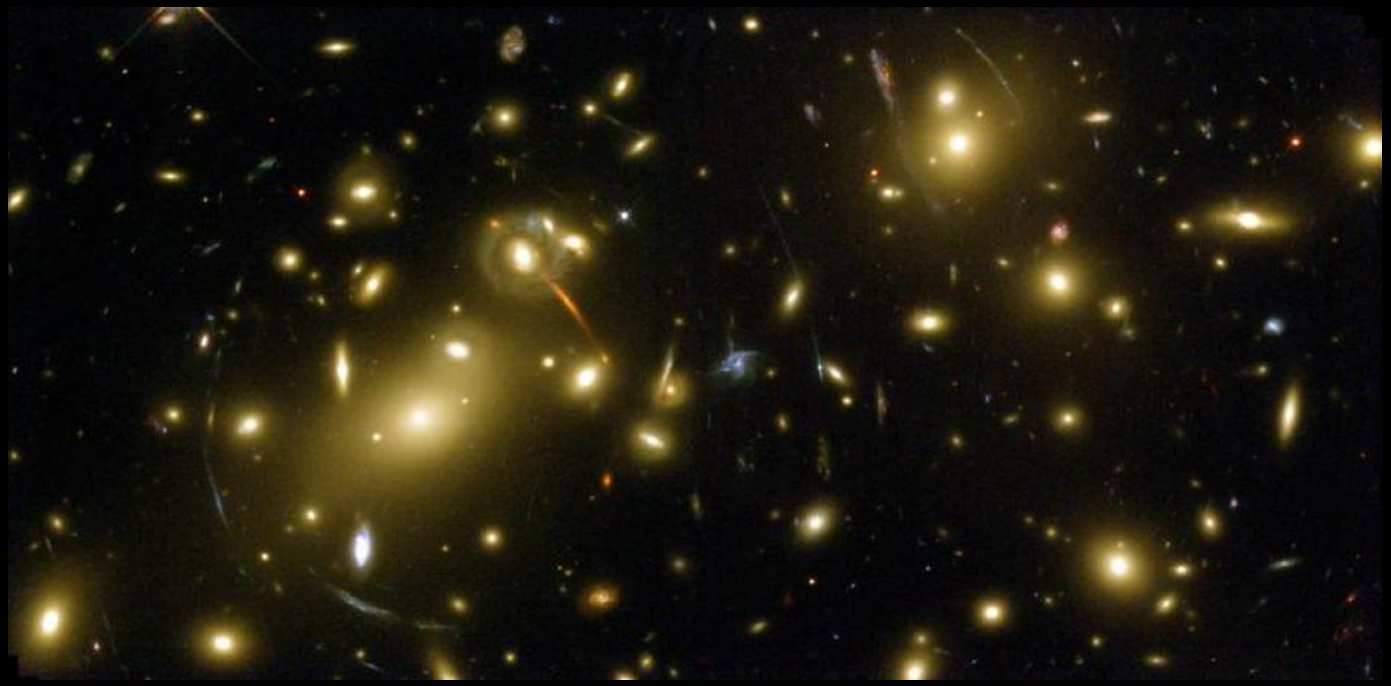
Progress on Cosmology



Sarah Bridle
University College London

Progress on Cosmology

1. Definition of “Cosmology” for this talk
2. The latest observations
   - 2.1 Type Ia supernovae
   - 2.2 Galaxy clustering
   - 2.3 Cosmic shear
3. The future

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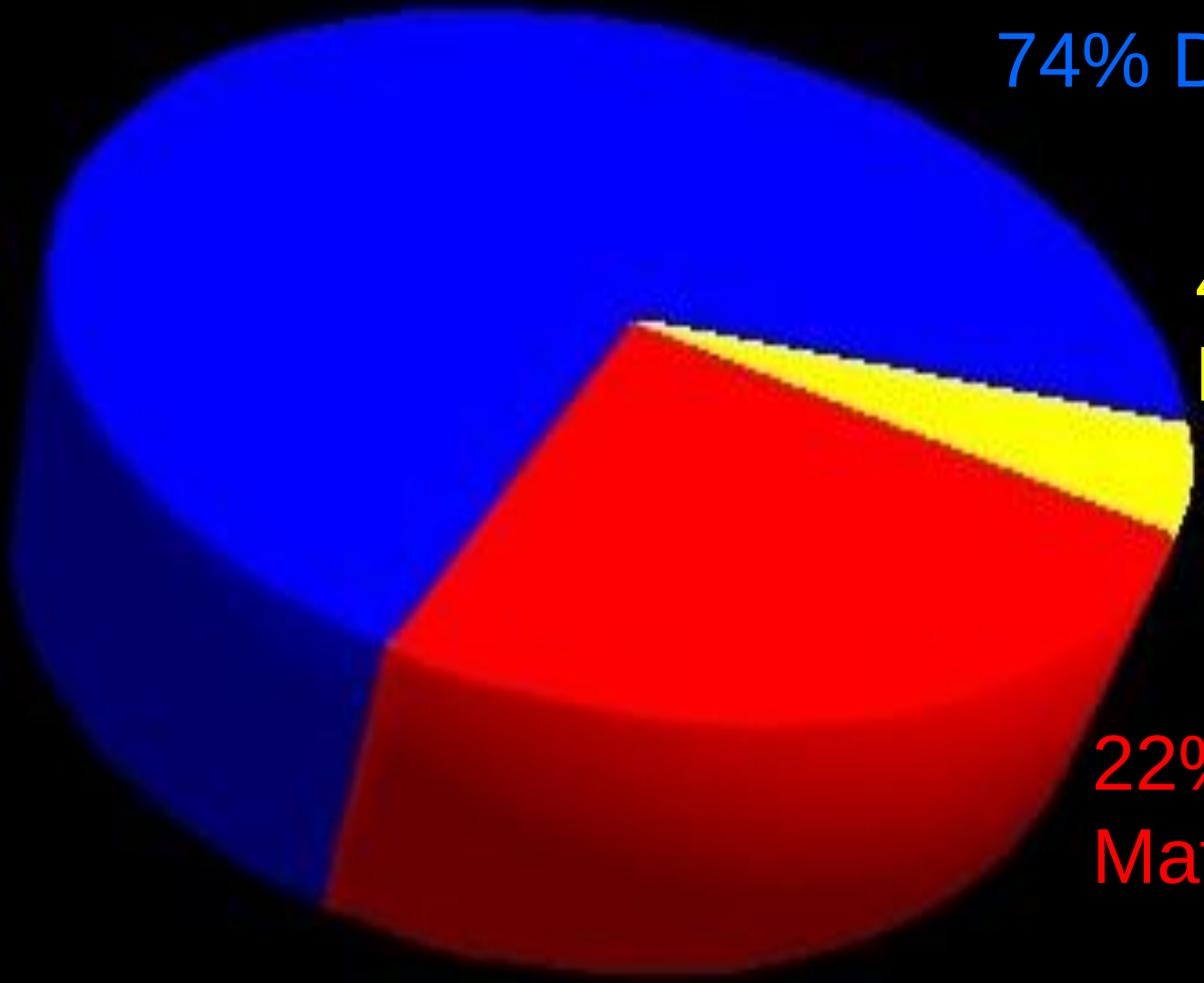
My Definition of Observational Cosmology

Telescope observations of the Universe aimed at measuring global parameters

- Cosmic Microwave Background (CMB)
  - See talk by Francois Bouchet next
- Large-scale structure of the Universe, especially
  - Galaxy clustering
  - Clusters of galaxies
  - Gravitational lensing
- Standard candles e.g. Type Ia supernovae

Concordance Model



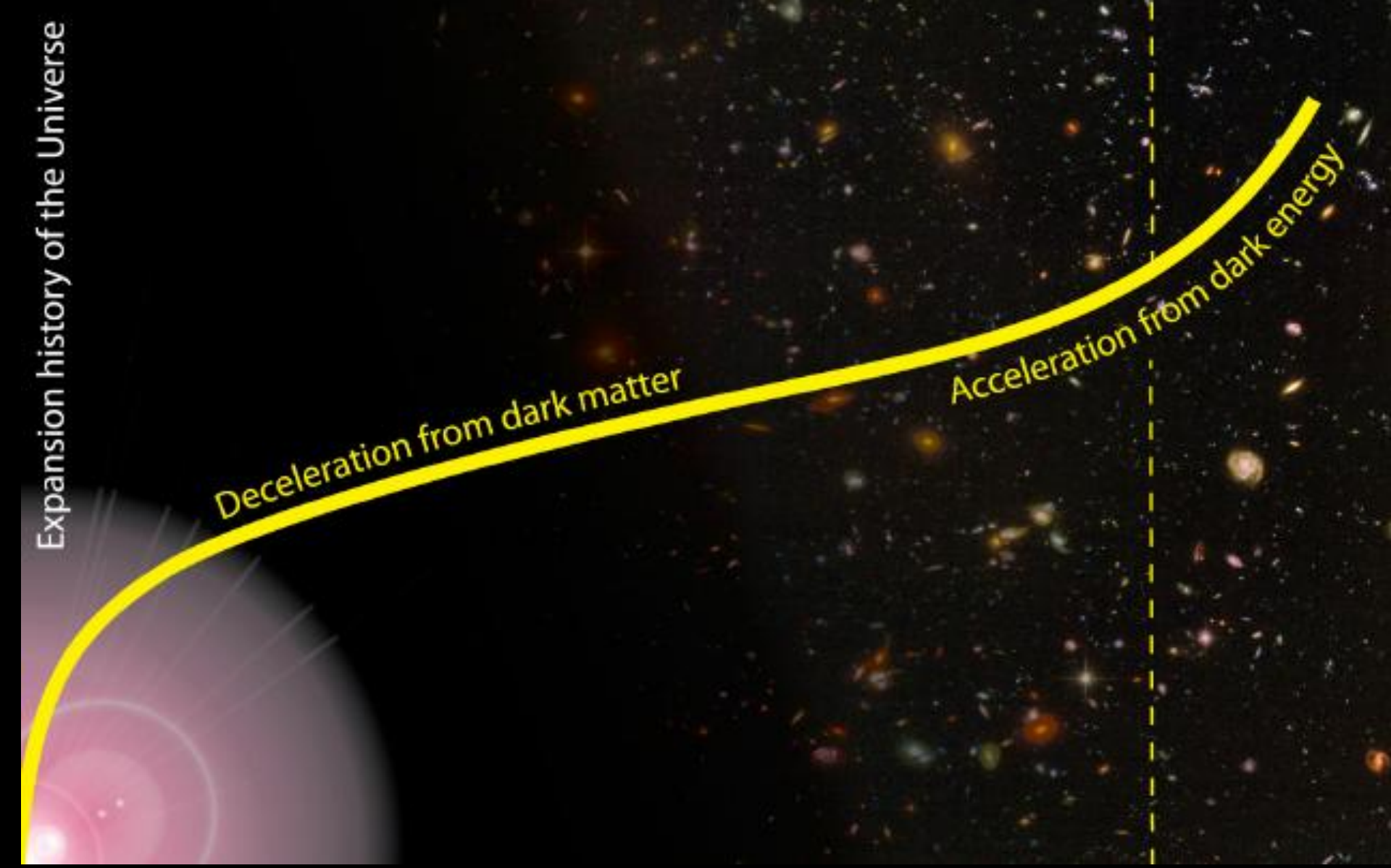
74% Dark Energy

4% Baryonic Matter

22% Cold Dark Matter

What Observational Cosmology Measures

- Post-inflation conditions
  - Scalar, tensor (+other?) perturbation power spectra
- The expansion rate (Hubble constant)
- Baryonic matter density
- Dark matter
  - density, distribution – as f(time)
- Dark energy
  - density, distribution – as f(time)
  - Or modifications to GR (see de Rham talk on Friday)



Credit: Richard Massey, NASA

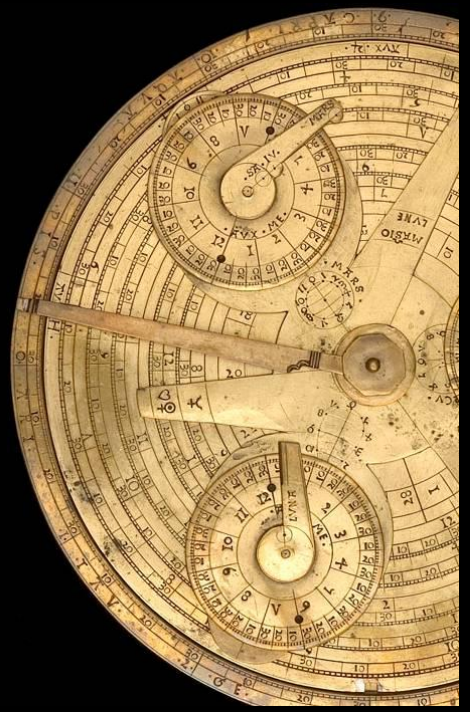
Why is the Universe Accelerating?

- Einstein's cosmological constant

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

- A new fluid called Dark Energy
  - Equation of state $w=p/\rho$

- General Relativity is wrong



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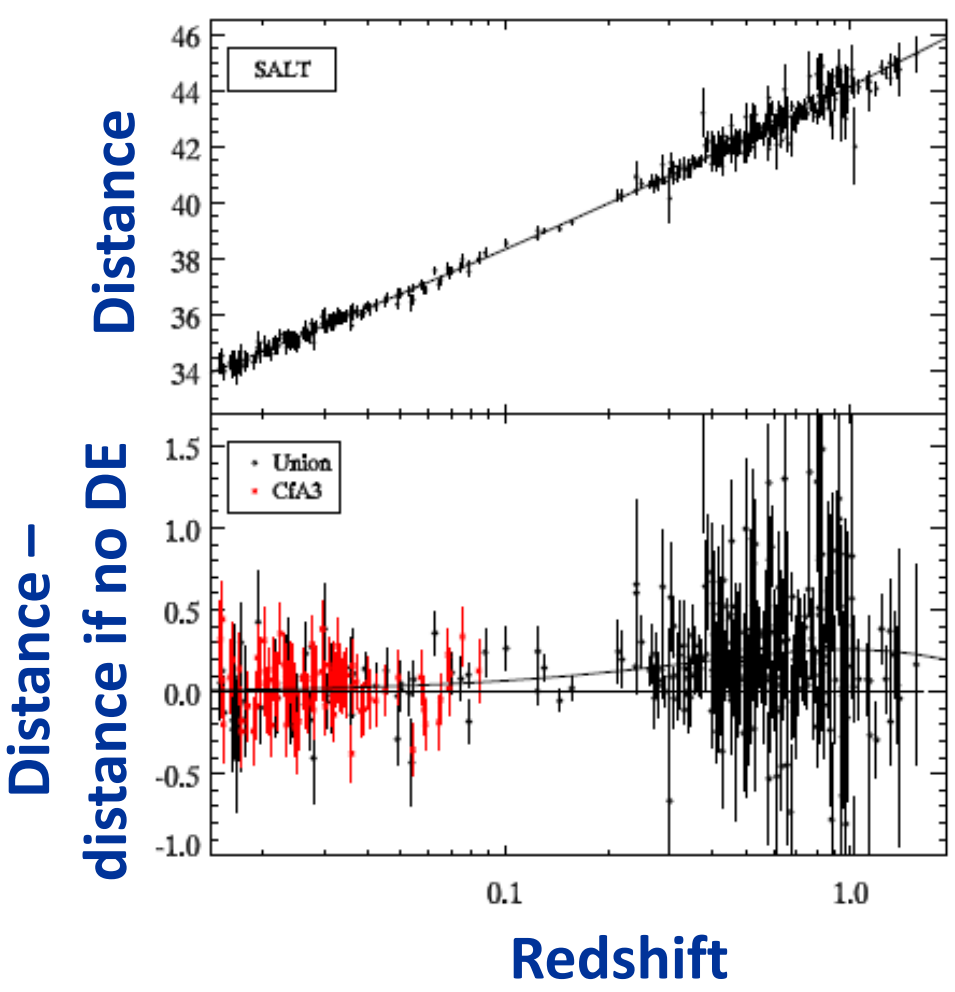
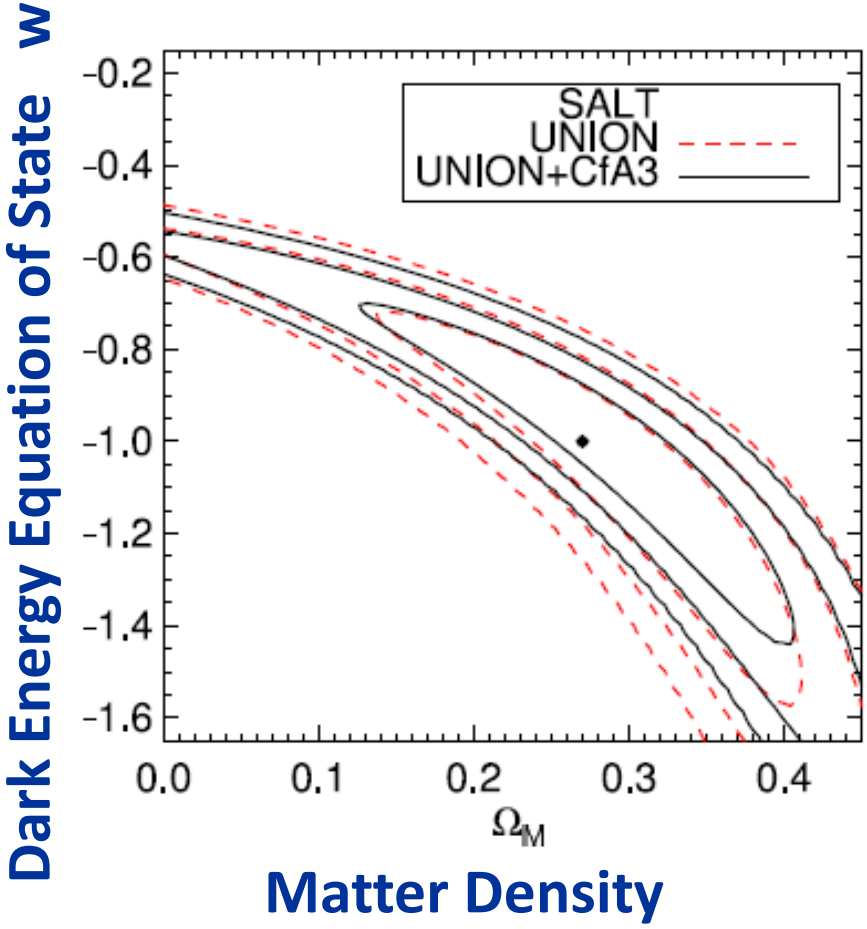
Latest Supernova Compilation





Hicken et al 2009

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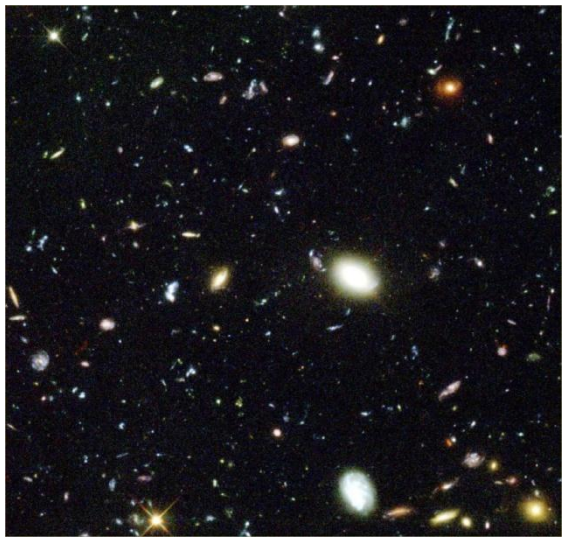
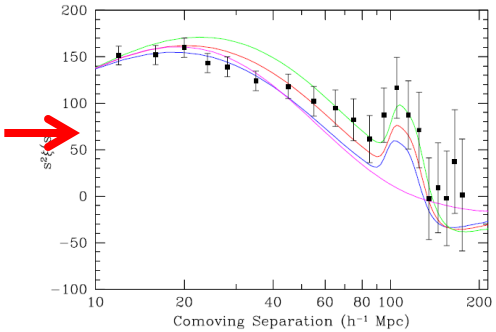
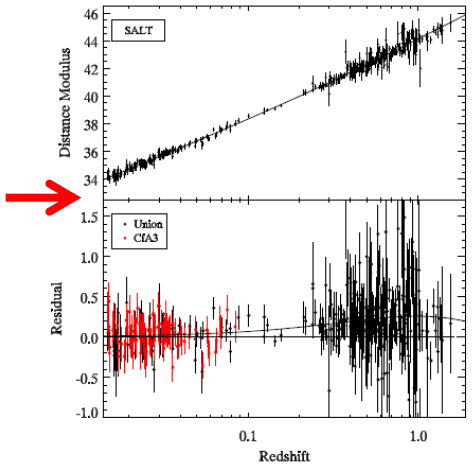
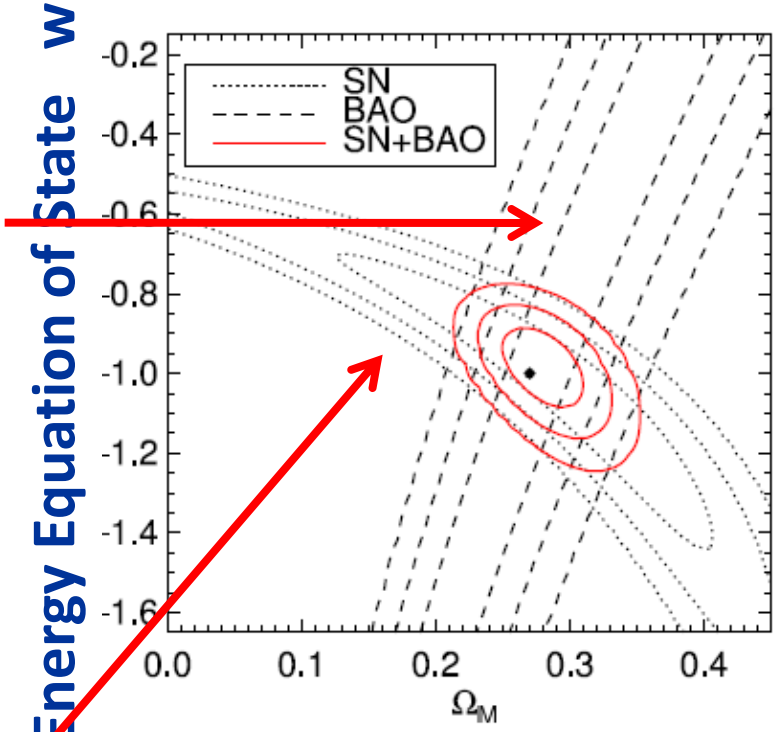
Galaxy Clustering Constraints on Dark Energy





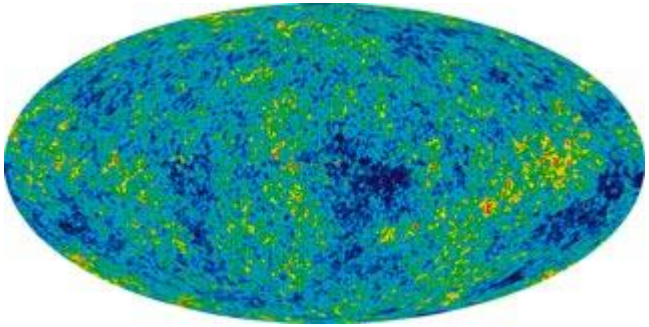


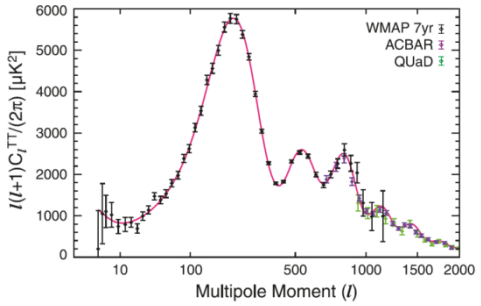


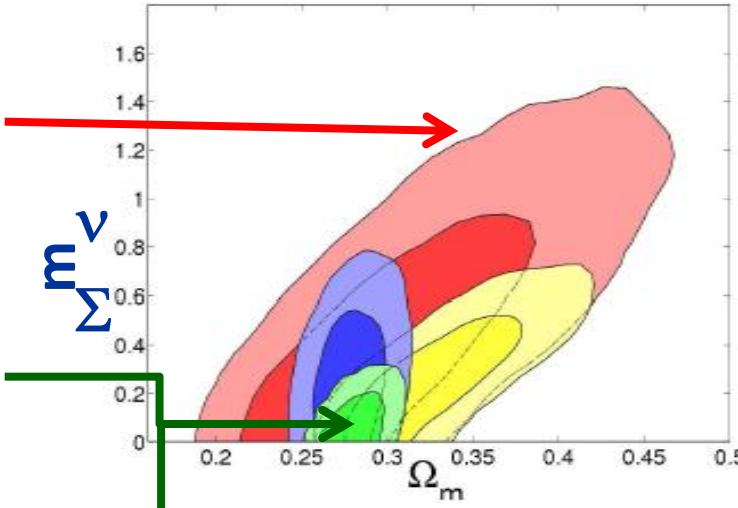
1-Matter Density

Hicken et al 2009, showing results using Eisenstein et al 2005

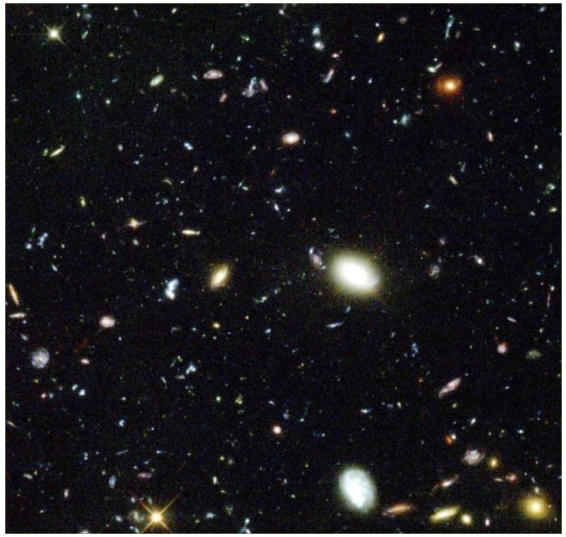
Neutrino Mass Constraints from Galaxy Clustering

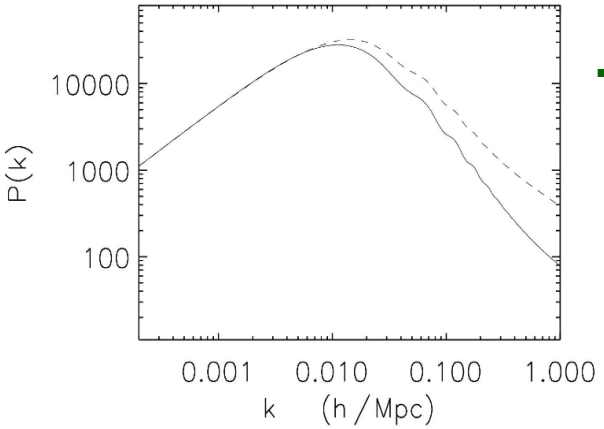






Matter Density





$$\sum m_\nu \leq 0.28\ (95\%\ \mathrm{CL})$$

Thomas, Abdalla & Lahav 2010

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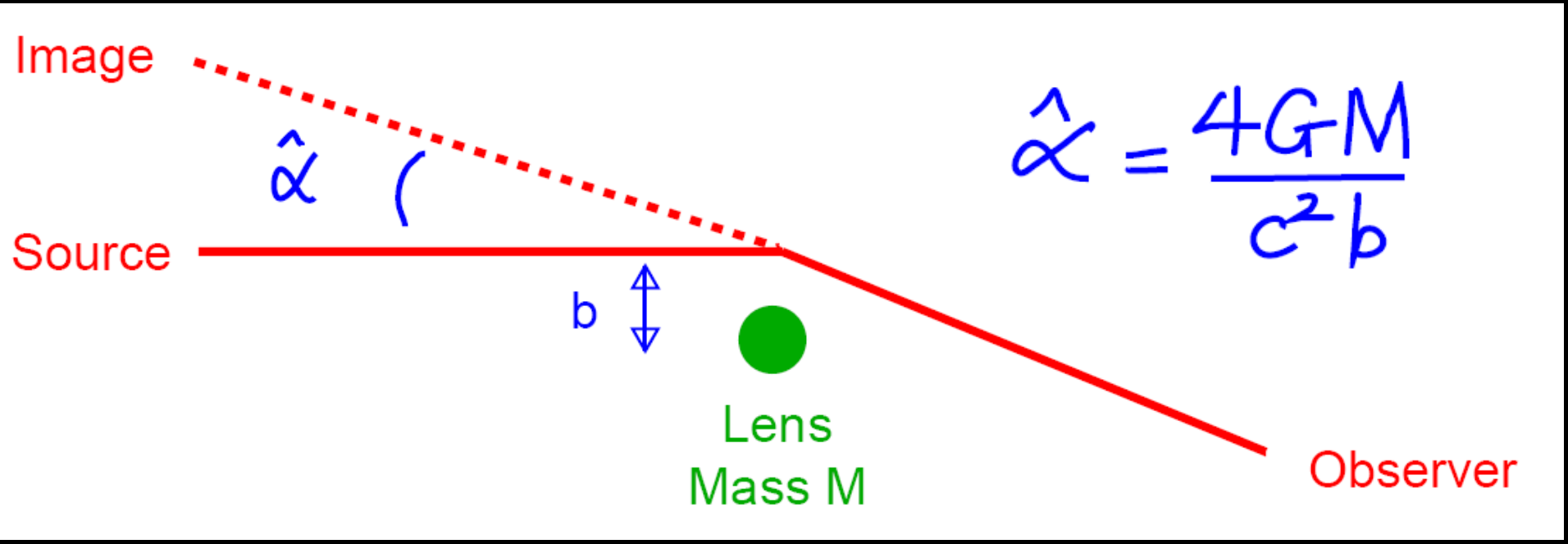
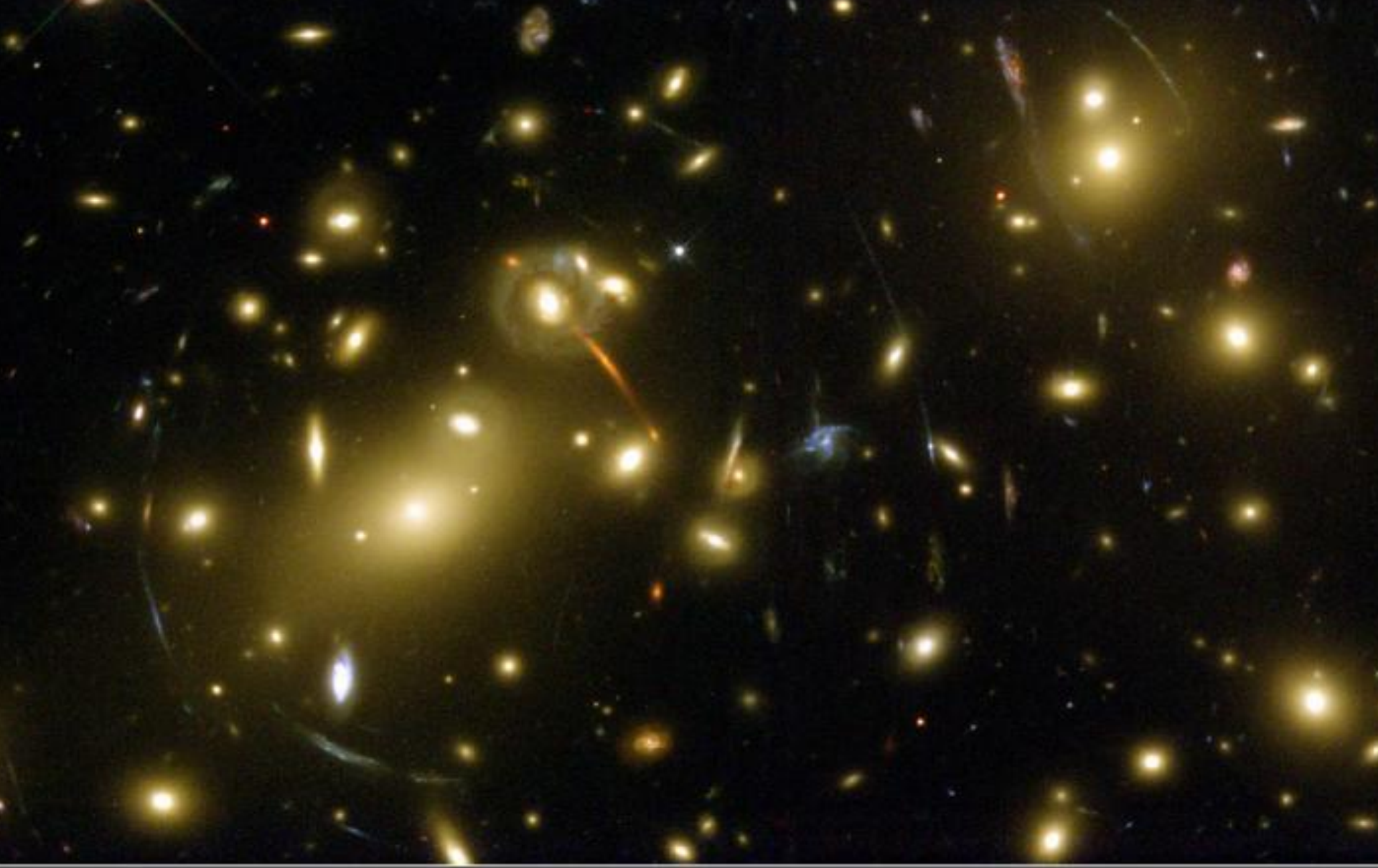
Gravitational Lensing

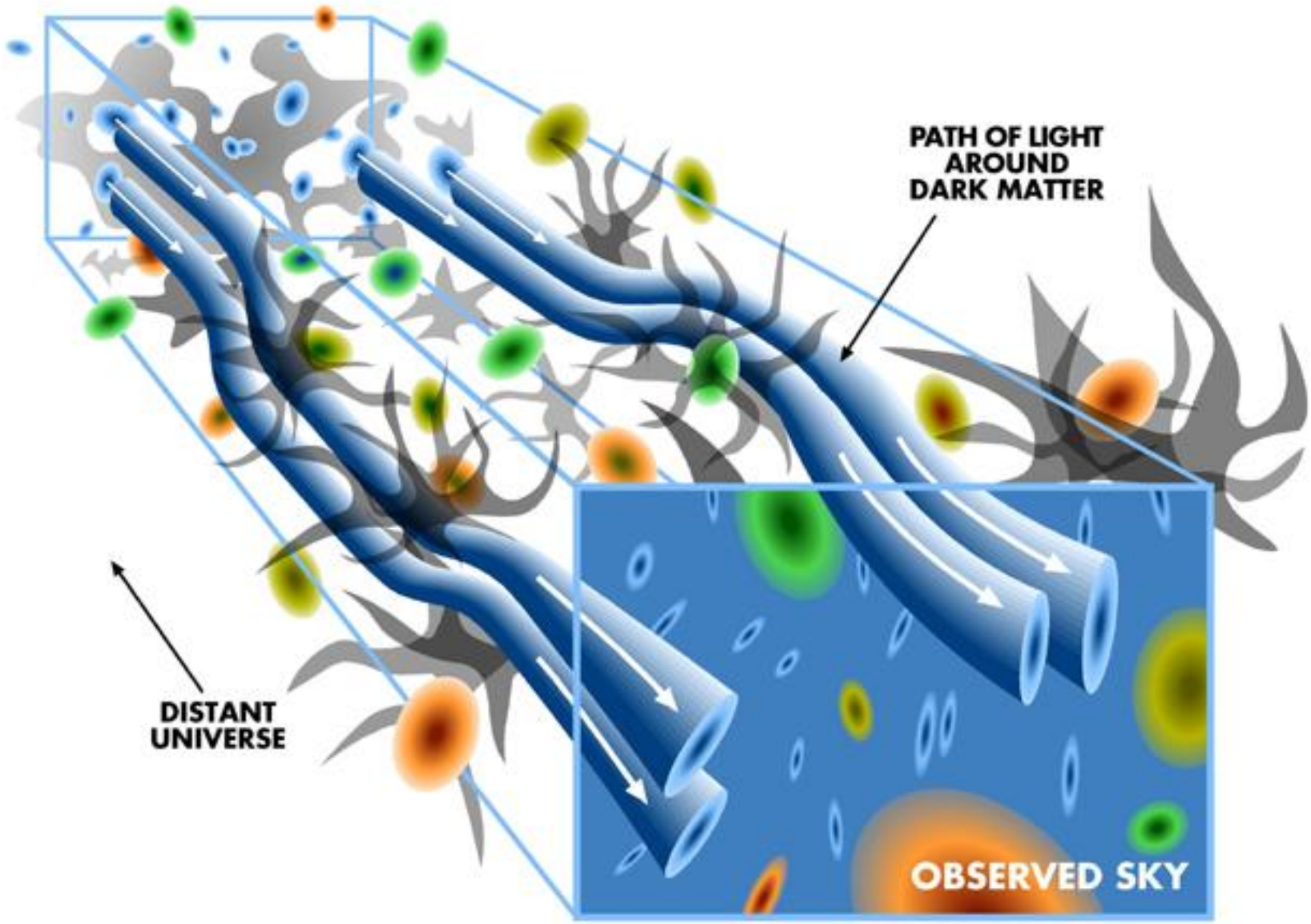




Galaxy Cluster Abell 2218

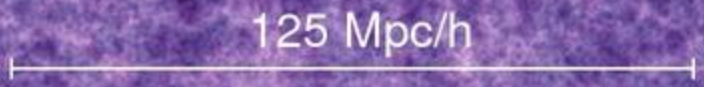
Hubble Space Telescope • WFPC2

Cosmic Lensing



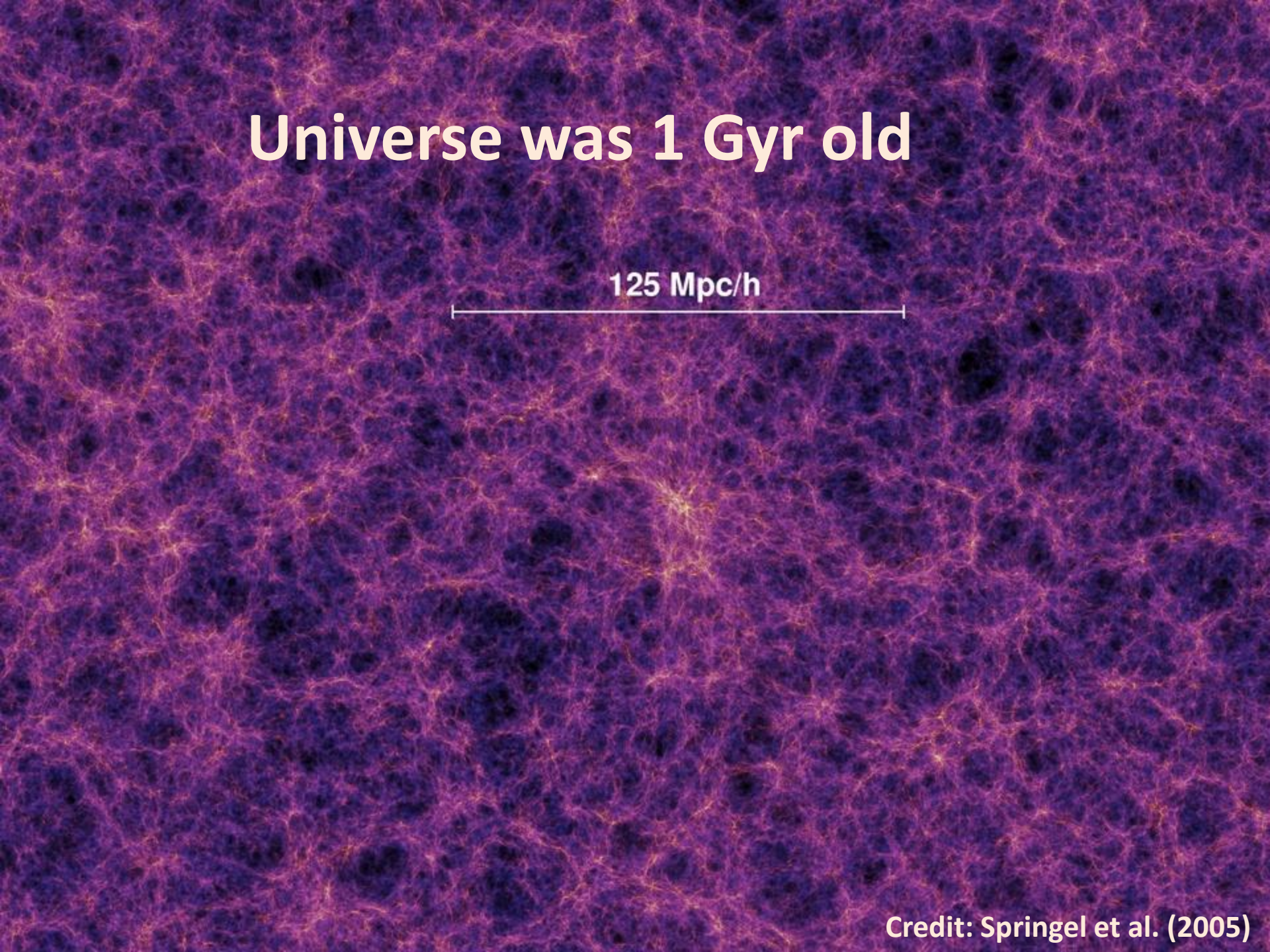
Tyson et al 2000

Universe was 0.2 Gyr old

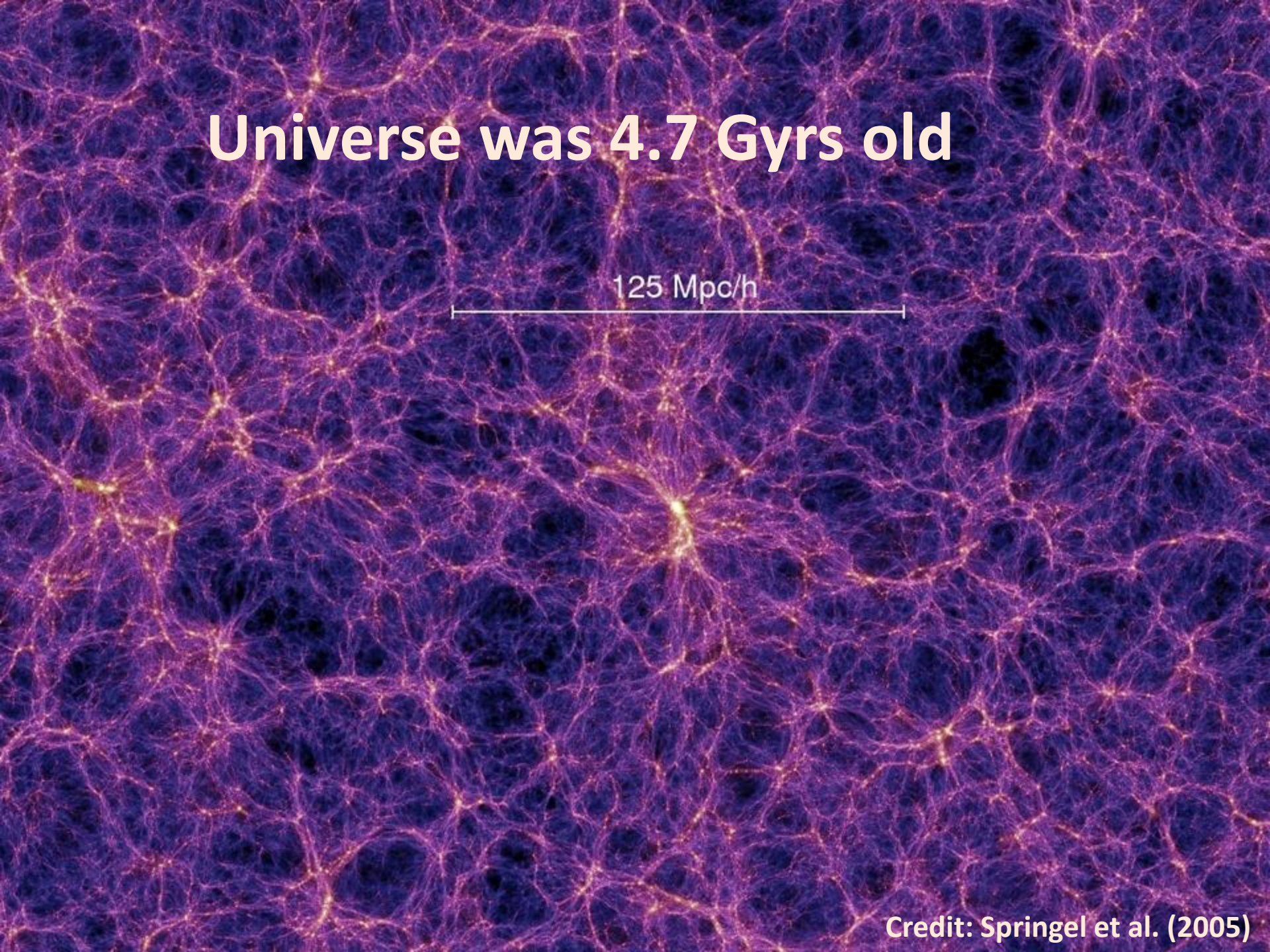


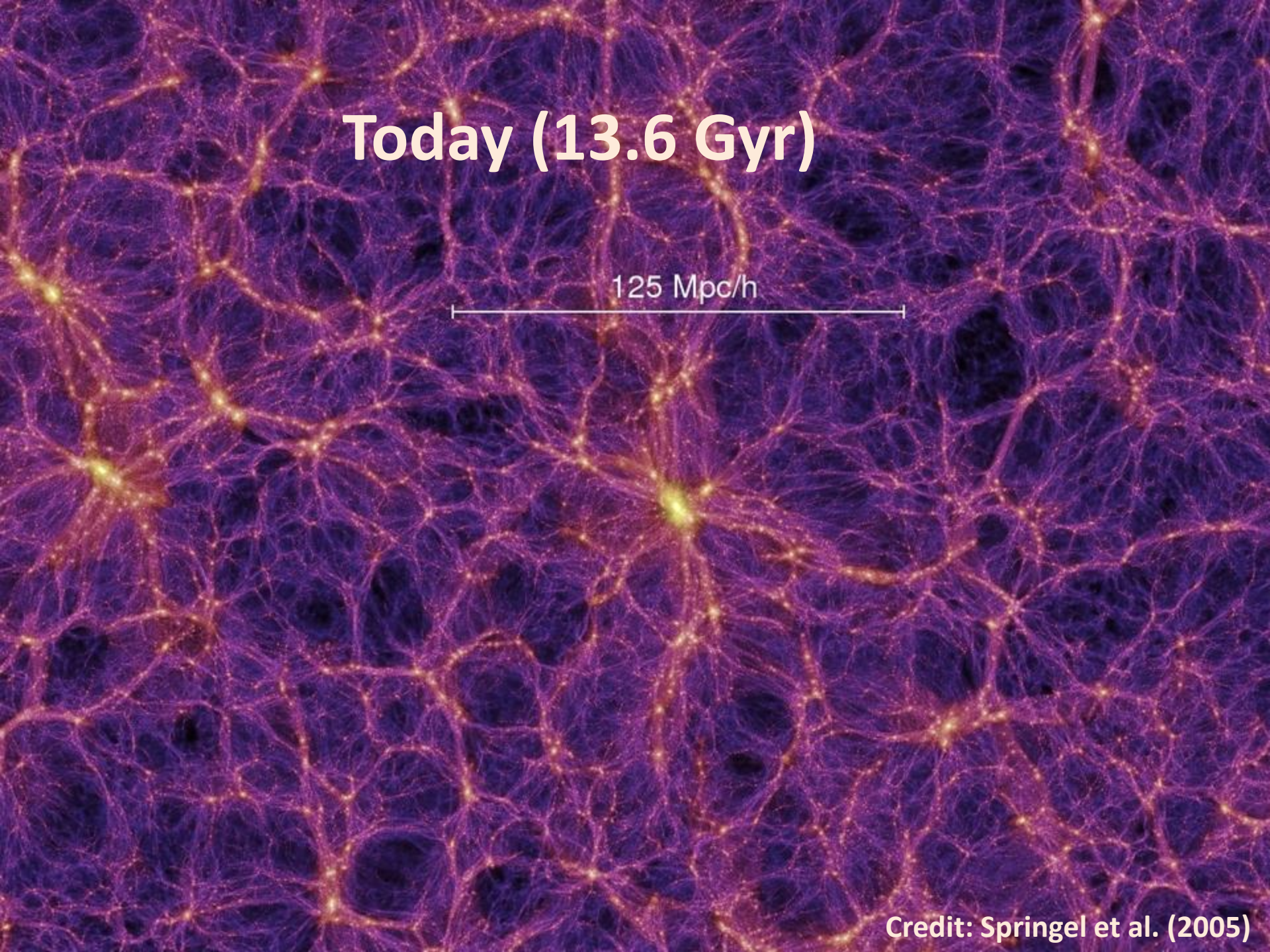
Credit: Springel et al. (2005)

Universe was 1 Gyr old



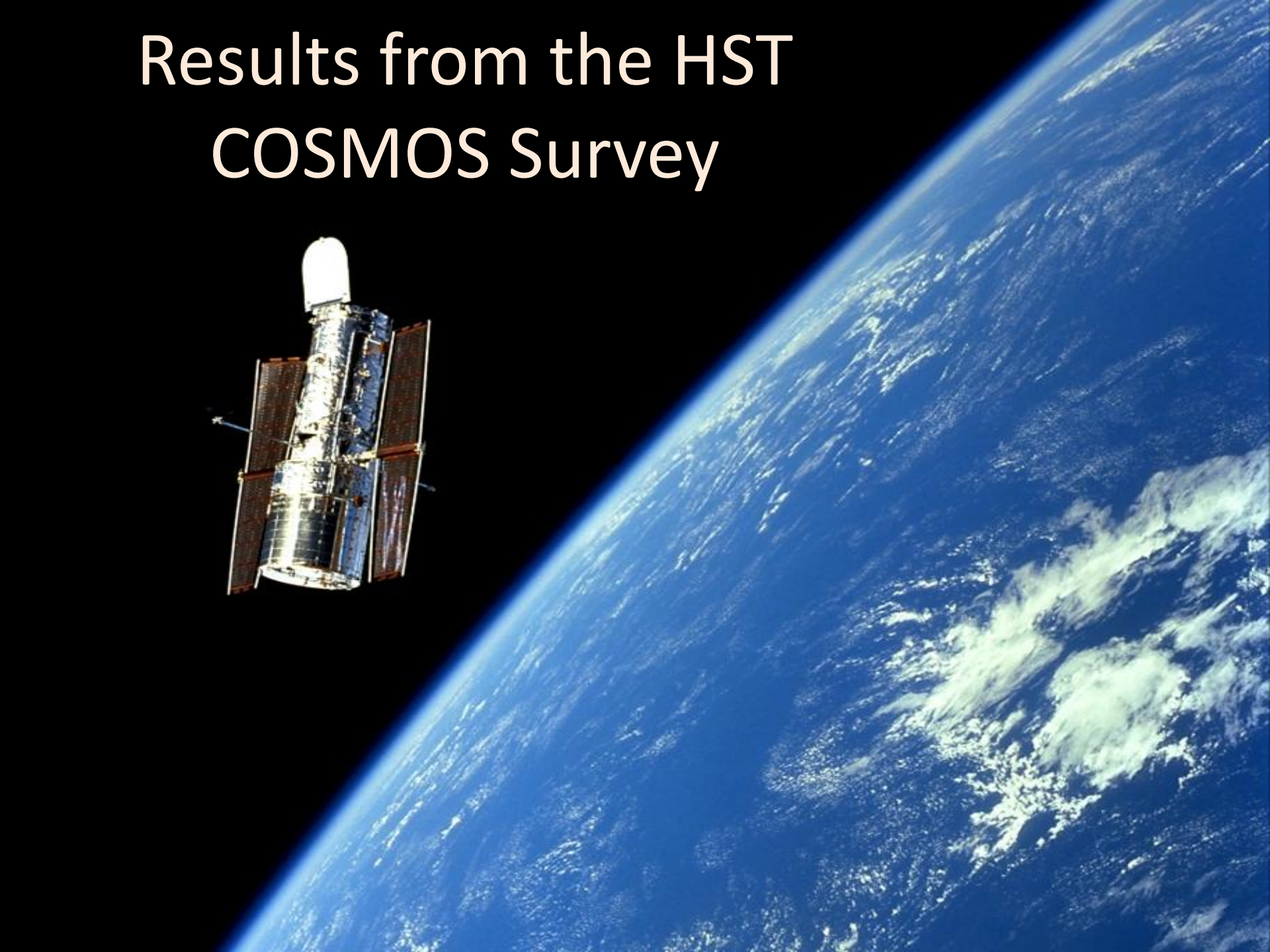
Credit: Springel et al. (2005)


Universe was 4.7 Gyrs old
125 Mpc/h
Credit: Springel et al. (2005)



Credit: Springel et al. (2005)

Results from the HST COSMOS Survey



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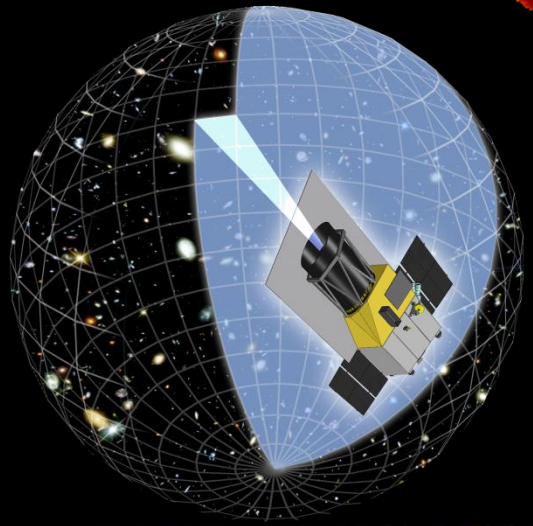
The Future

The Dark Energy Survey



EUCLID

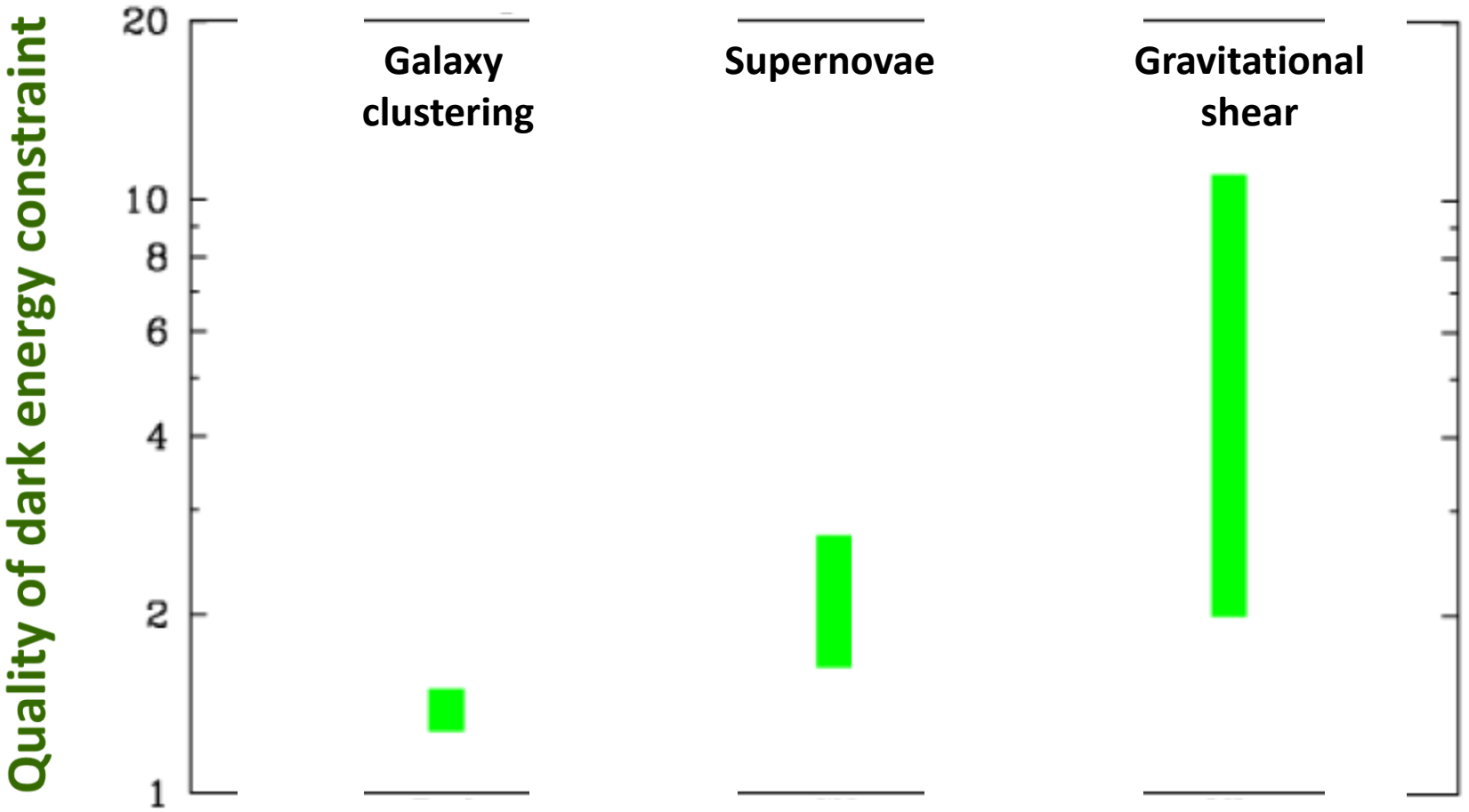
JDEM

LSST
Large Synoptic Survey Telescope

See Moniez talk on Friday

SKA
SQUARE KILOMETRE ARRAY

Comparison of different methods



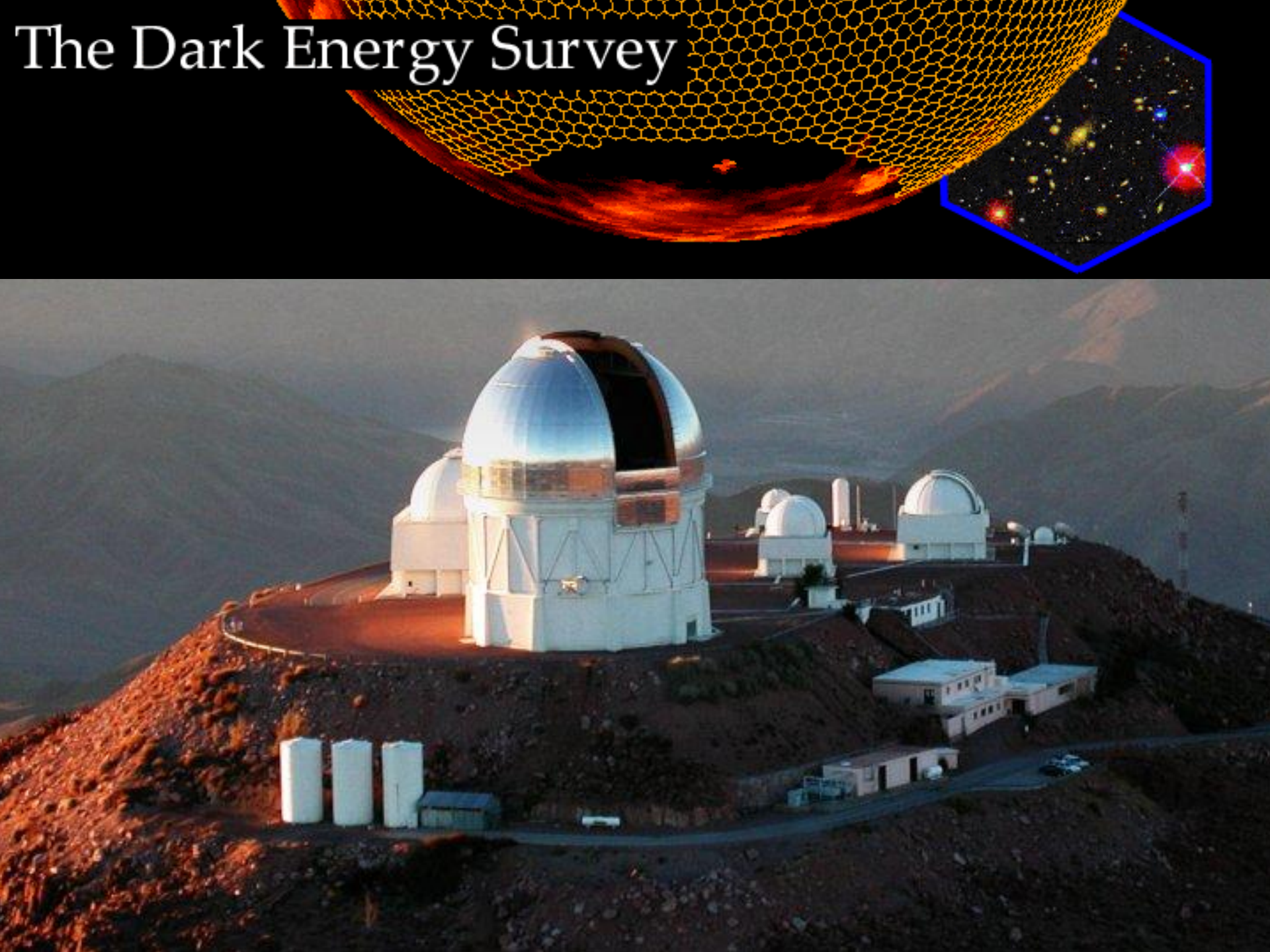
Example for optical ground-based surveys
Dark Energy Task Force report Albrecht et al. astro-ph/0609591

Gravitational shear has the greatest potential

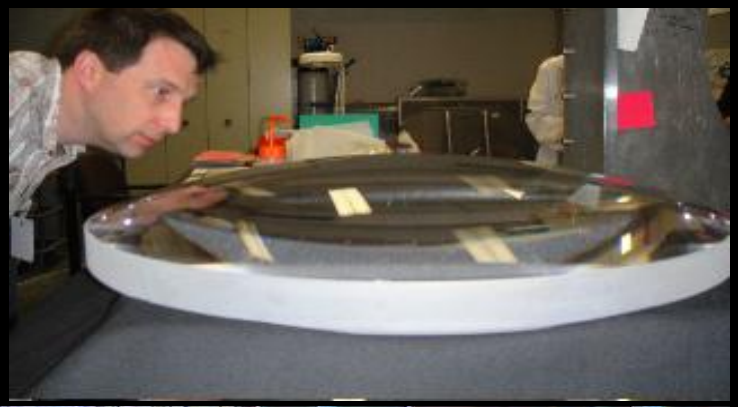
Big uncertainty largely due to shear measurement techniques

Maybe dark energy is the wrong model...

The Dark Energy Survey



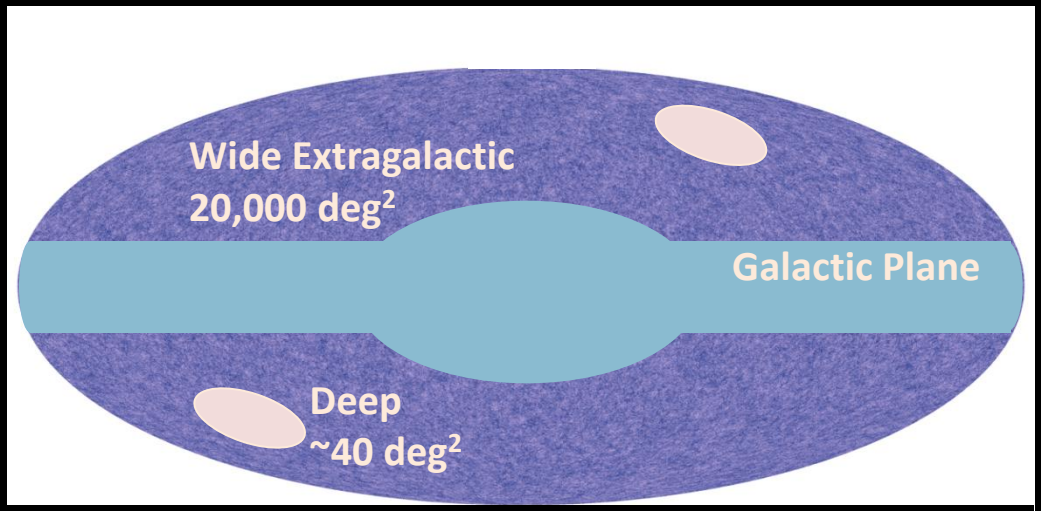
The Dark Energy Survey

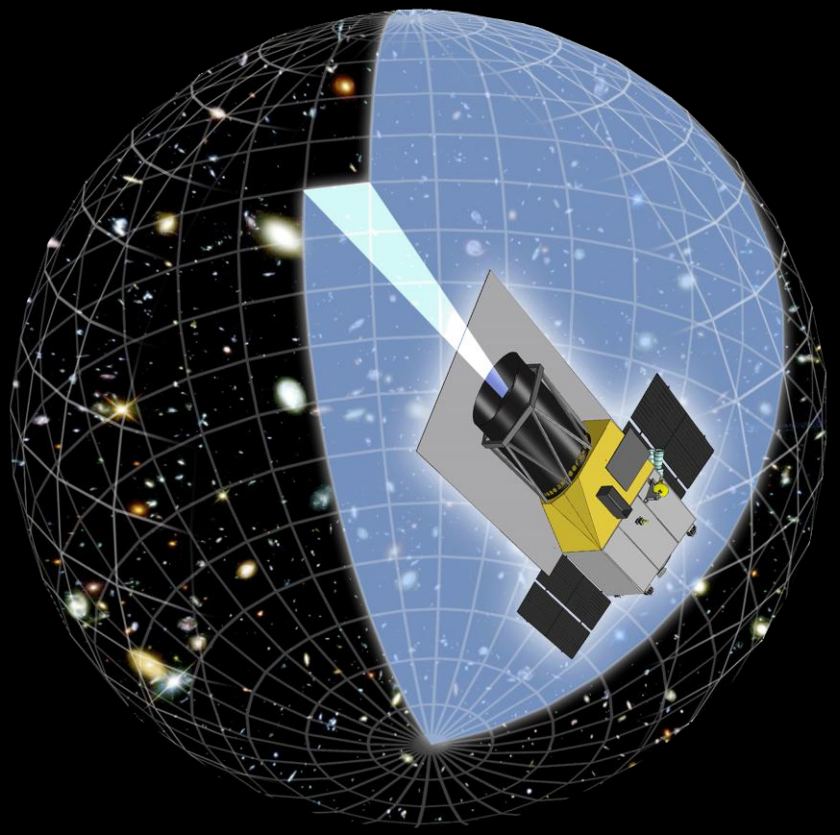


C3

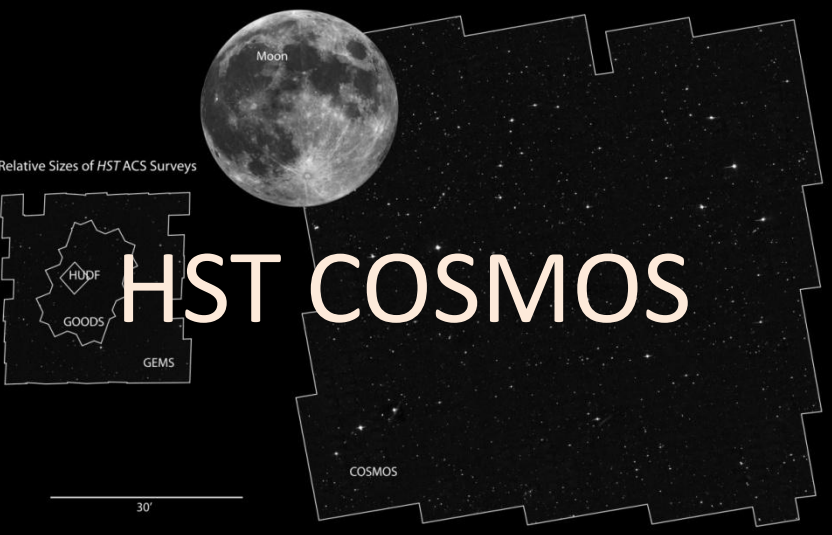
C1

EUCLID

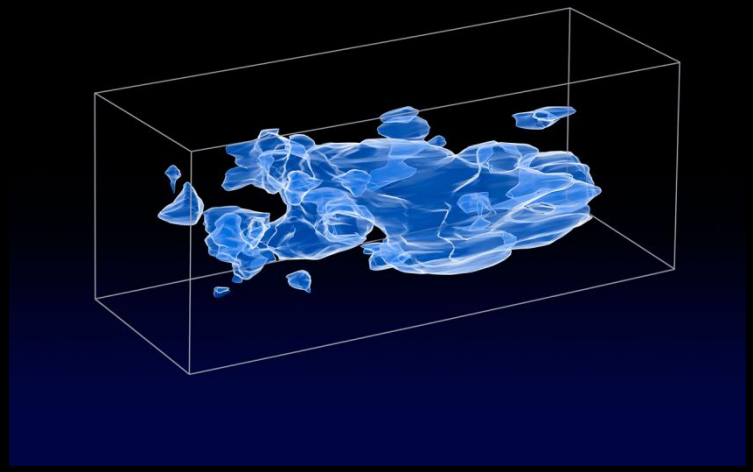




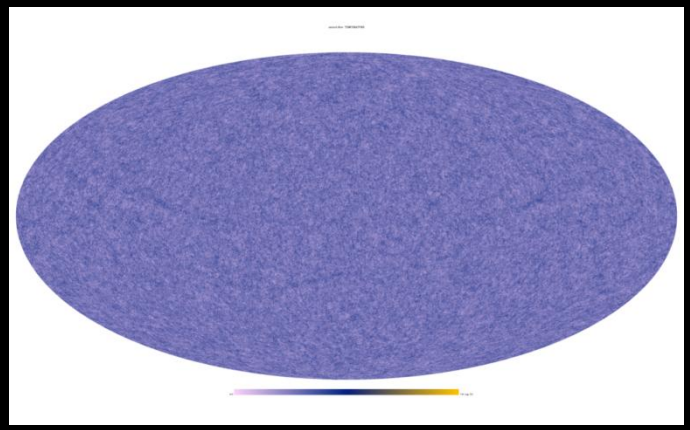
20 000 sq deg $RIZ_{AB} \leq 24.5$ at 0.16" FWHM, yielding 30-40 resolved galaxies/amin², $z \sim 0.9$
NIR photometry: Y, J, H ≤ 24 (AB, 5σ PS). Spectroscopy.
Refregier et al Science Book arxiv:1001.0061



HST COSMOS



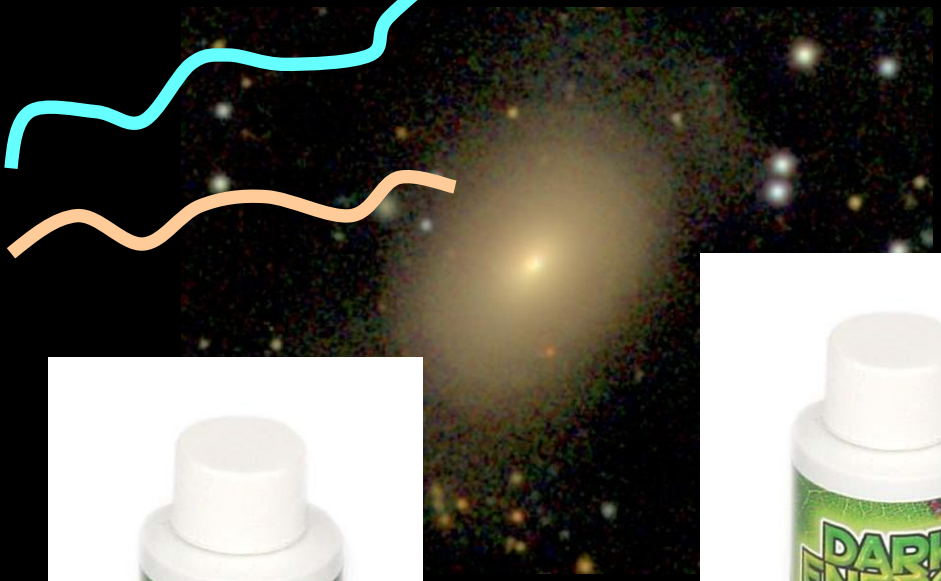
EUCLID

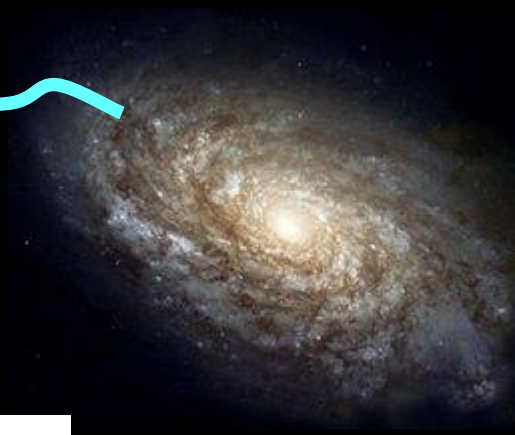


	Δw_p	Δw_a	$\Delta\Omega_m$	$\Delta\Omega_\Lambda$	$\Delta\Omega_b$	$\Delta\sigma_8$	Δn_s	Δh	DE FoM
Current + WMAP	0.13	-	0.01	0.015	0.0015	0.026	0.013	0.013	~ 10
Planck	-	-	0.008	-	0.0007	0.05	0.005	0.007	-
Weak Lensing	0.03	0.17	0.006	0.04	0.012	0.013	0.02	0.1	180
EIC probes	0.018	0.15	0.004	0.02	0.007	0.009	0.014	0.07	400
EIC + Planck	0.013	0.08	0.001	0.004	0.0005	0.0016	0.003	0.002	1000

End

Map in 3d

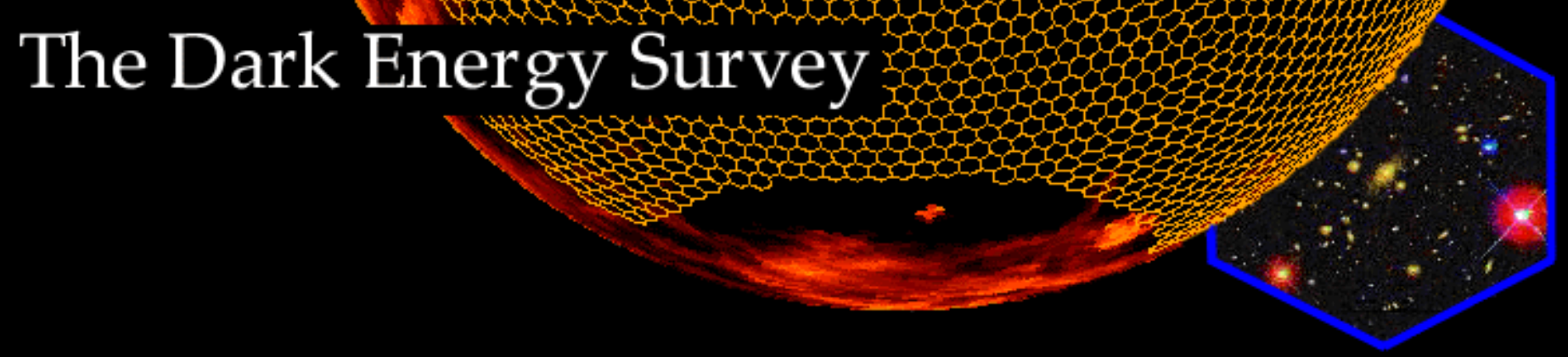


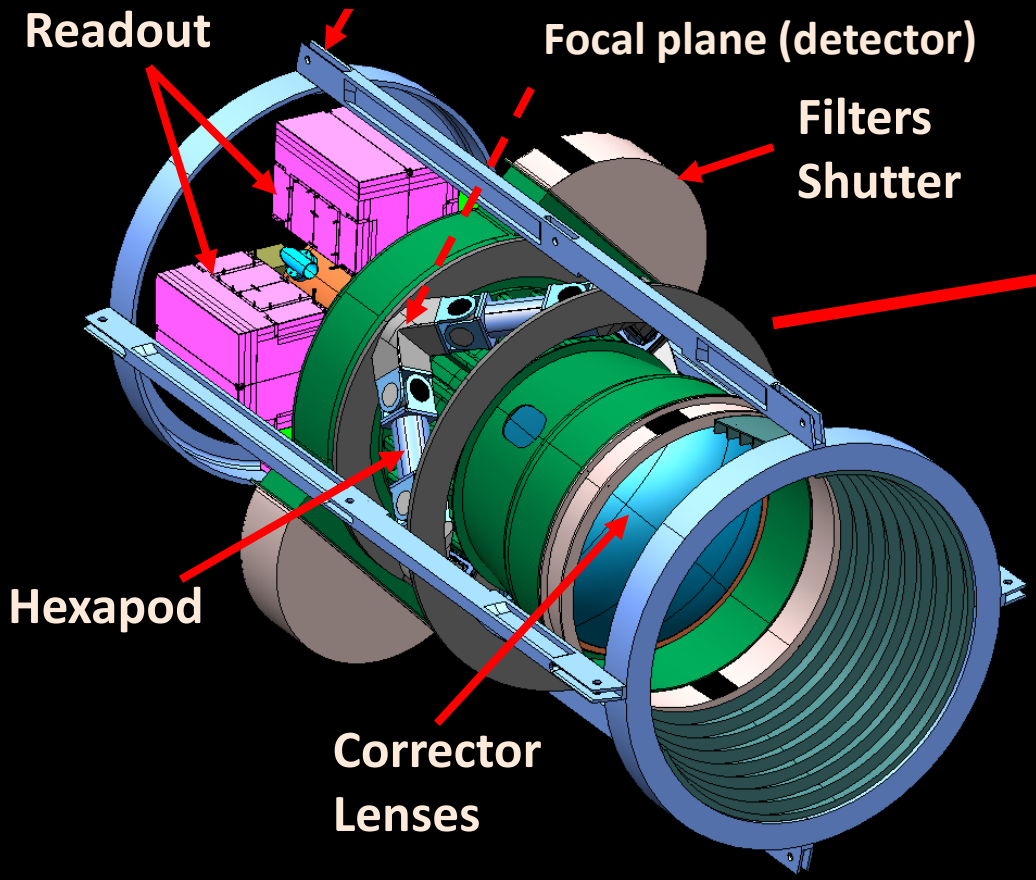



DARK ENERGY
PLANT NUTRIENT ADDITIVE
It Stinx But It Rocks!

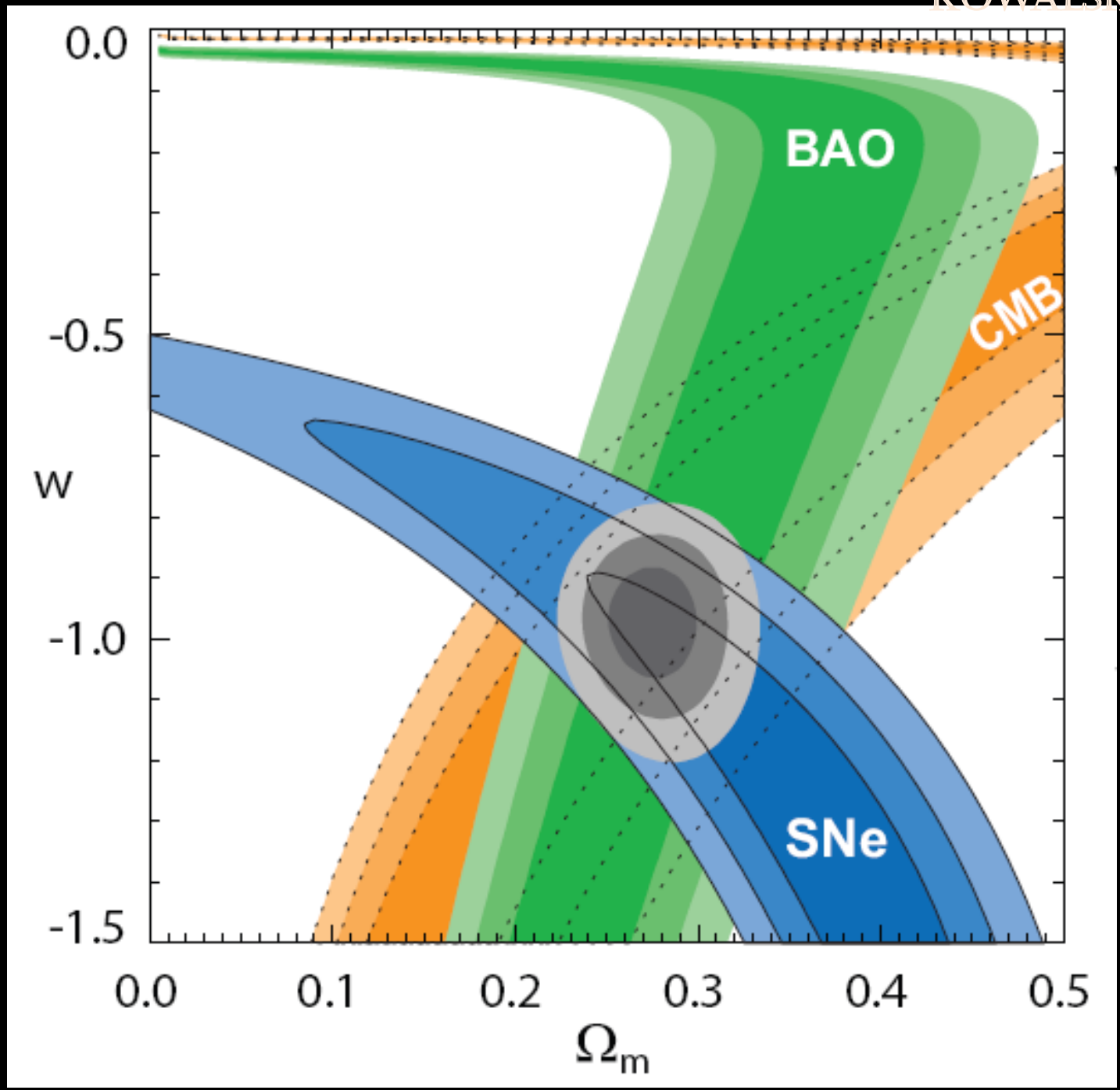

DARK ENERGY
PLANT NUTRIENT ADDITIVE
It Stinx But It Rocks!

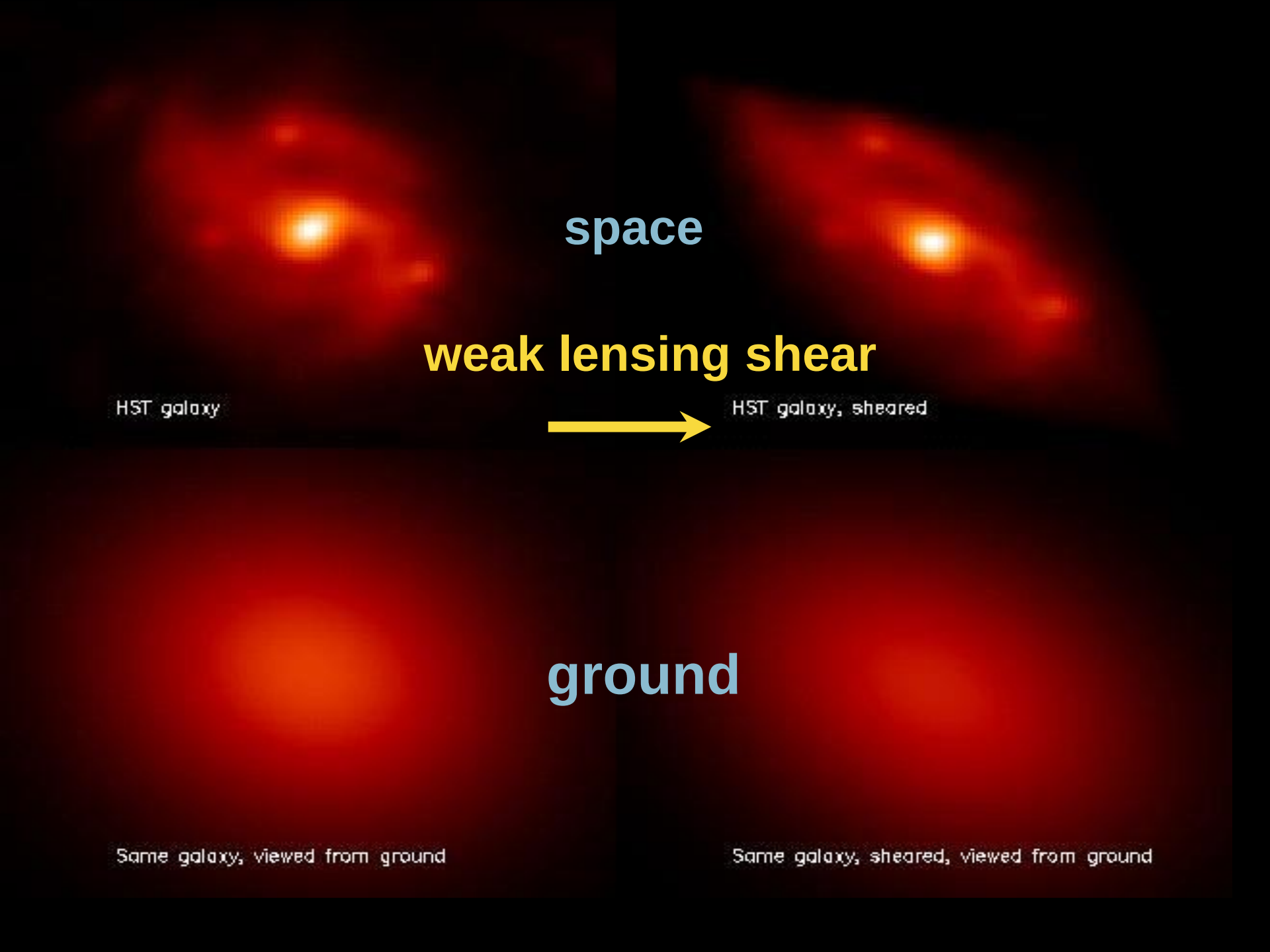
The Dark Energy Survey

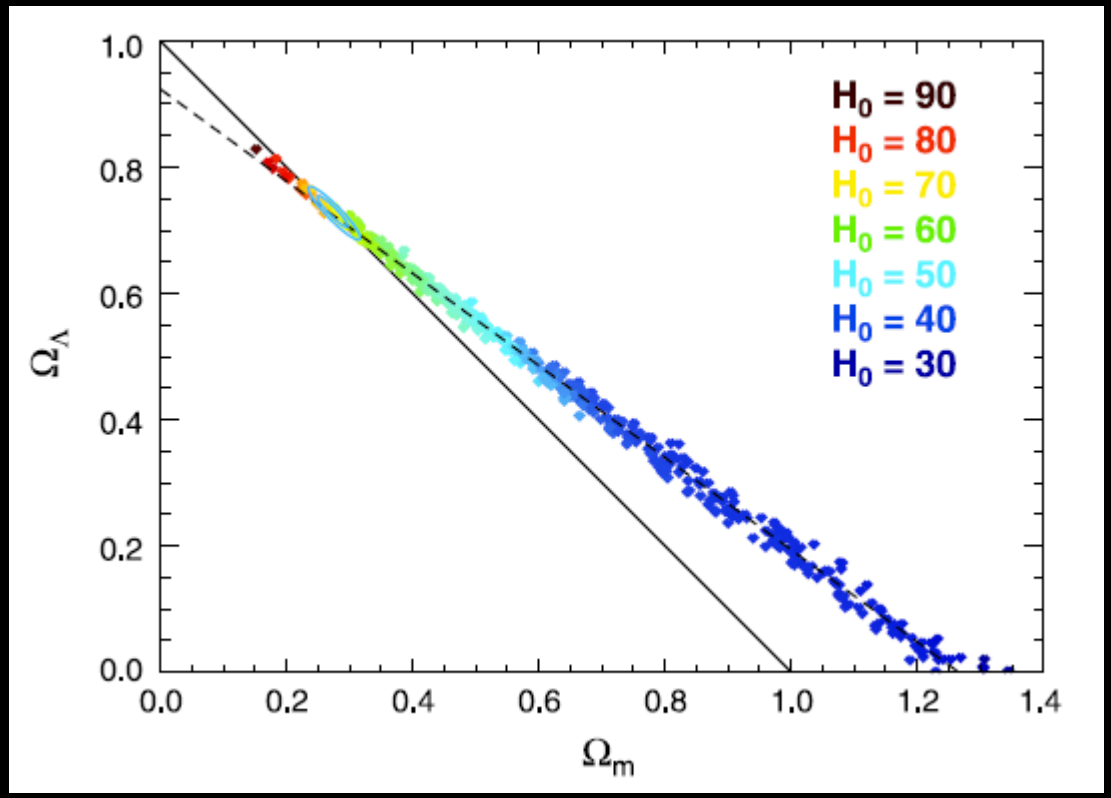




KOWALSKI ET AL 2008




space
weak lensing shear
HST galaxy
HST galaxy, sheared
ground
Same galaxy, viewed from ground
Same galaxy, sheared, viewed from ground



Larson et al 2010, WMAP7