Cosmological constraints from weak lensing: present measurements and future challenges

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Outline:

I. Introduction

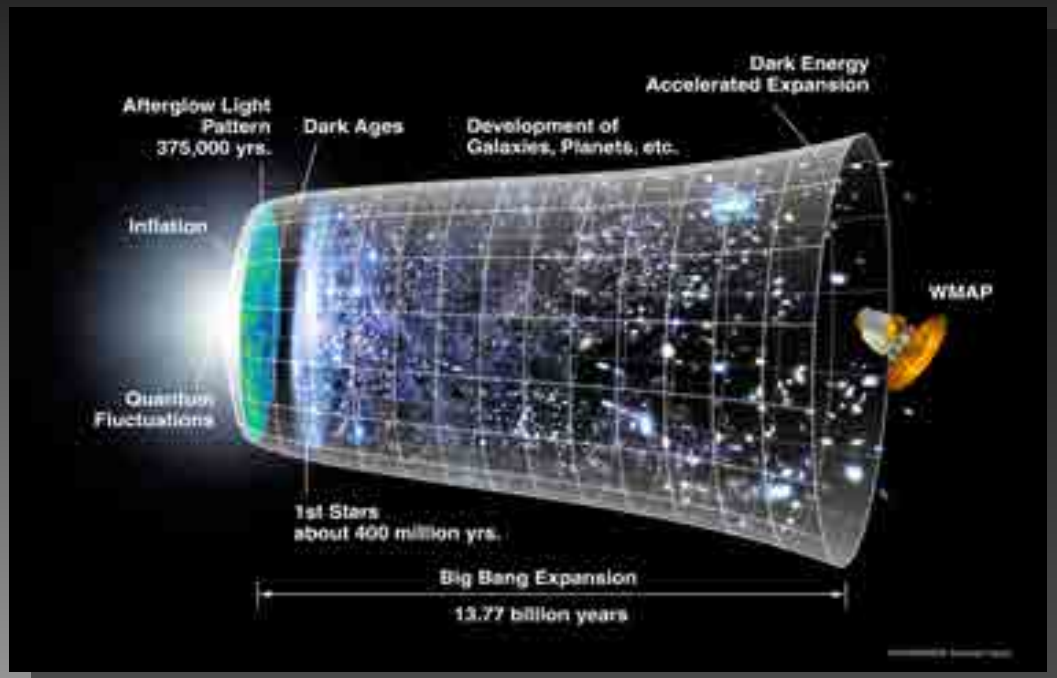
II. Cosmic Shear

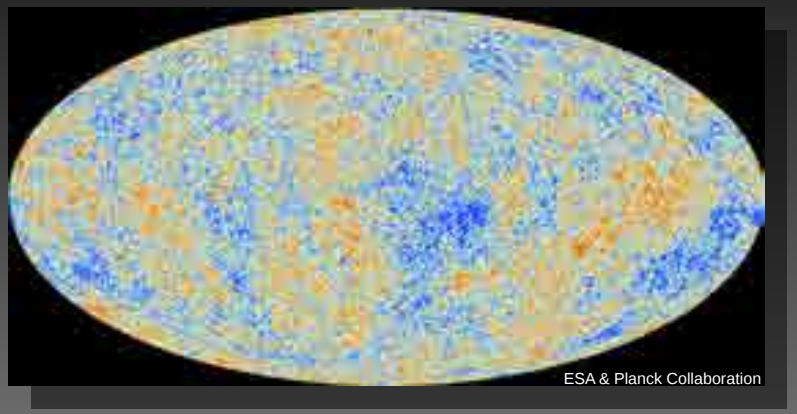
III. Galaxy-Galaxy Lensing

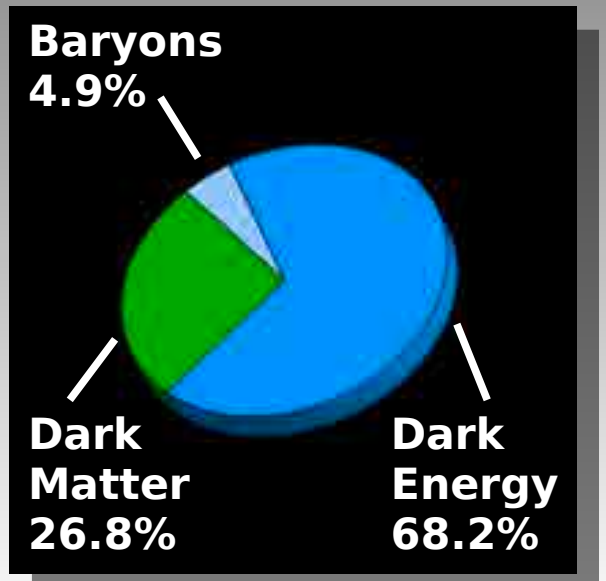
IV. Conclusions

I. Introduction

Cosmological model







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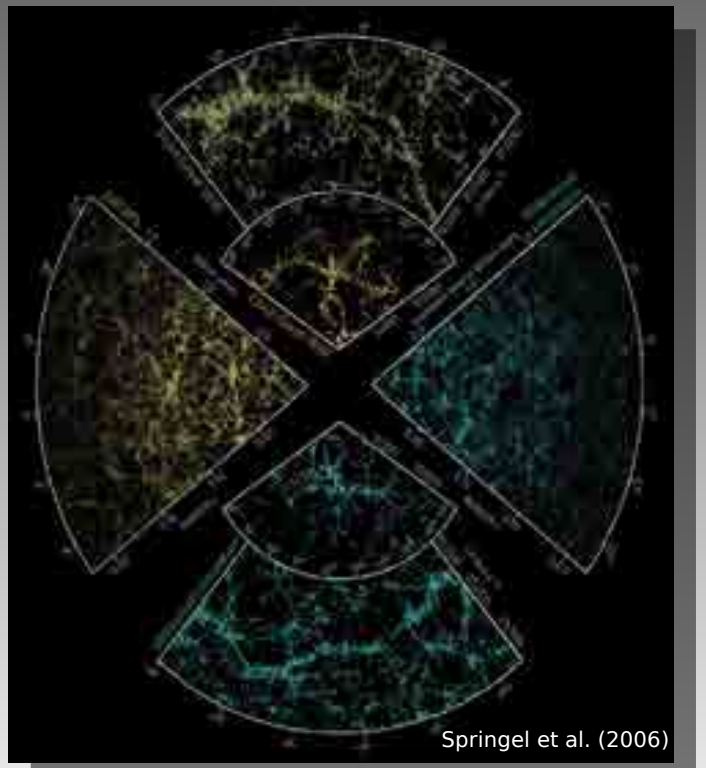
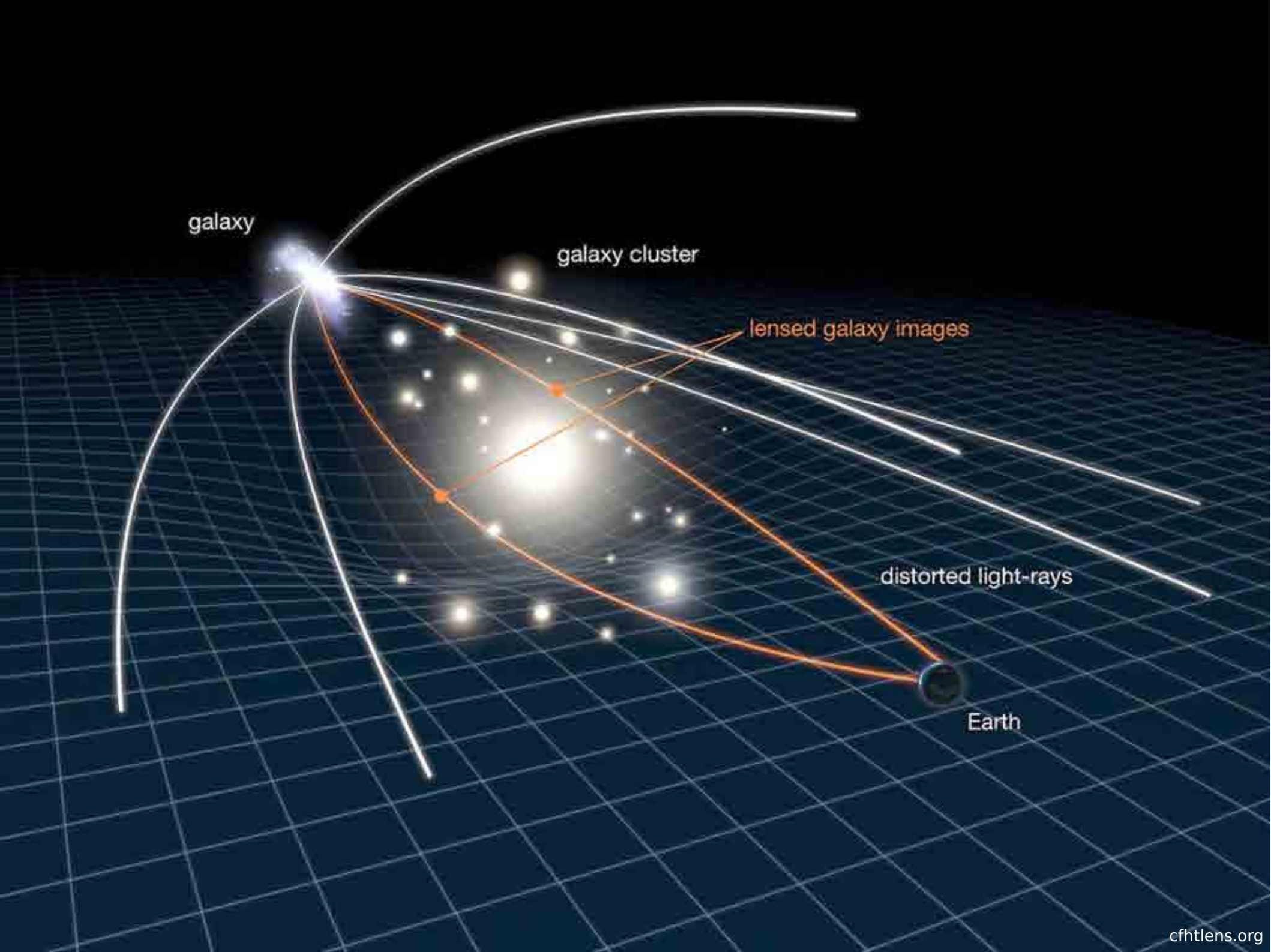
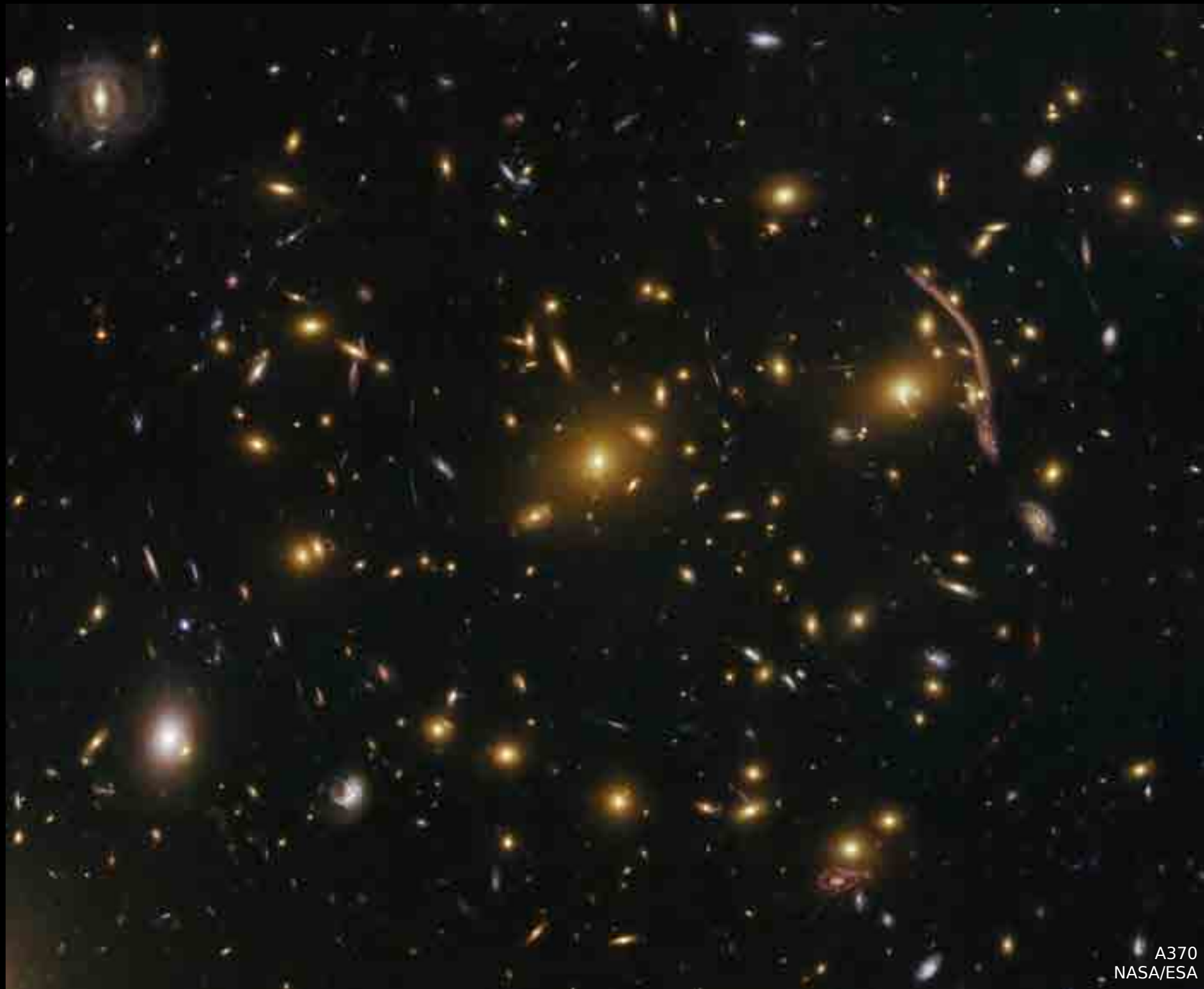


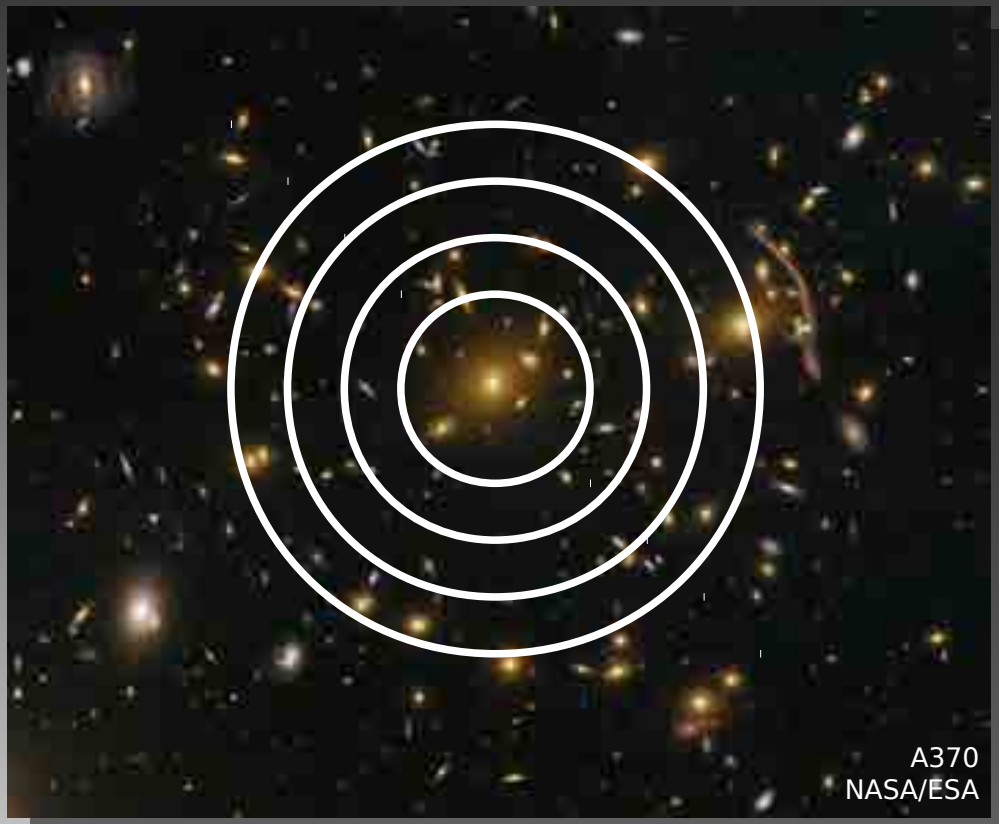

NASA



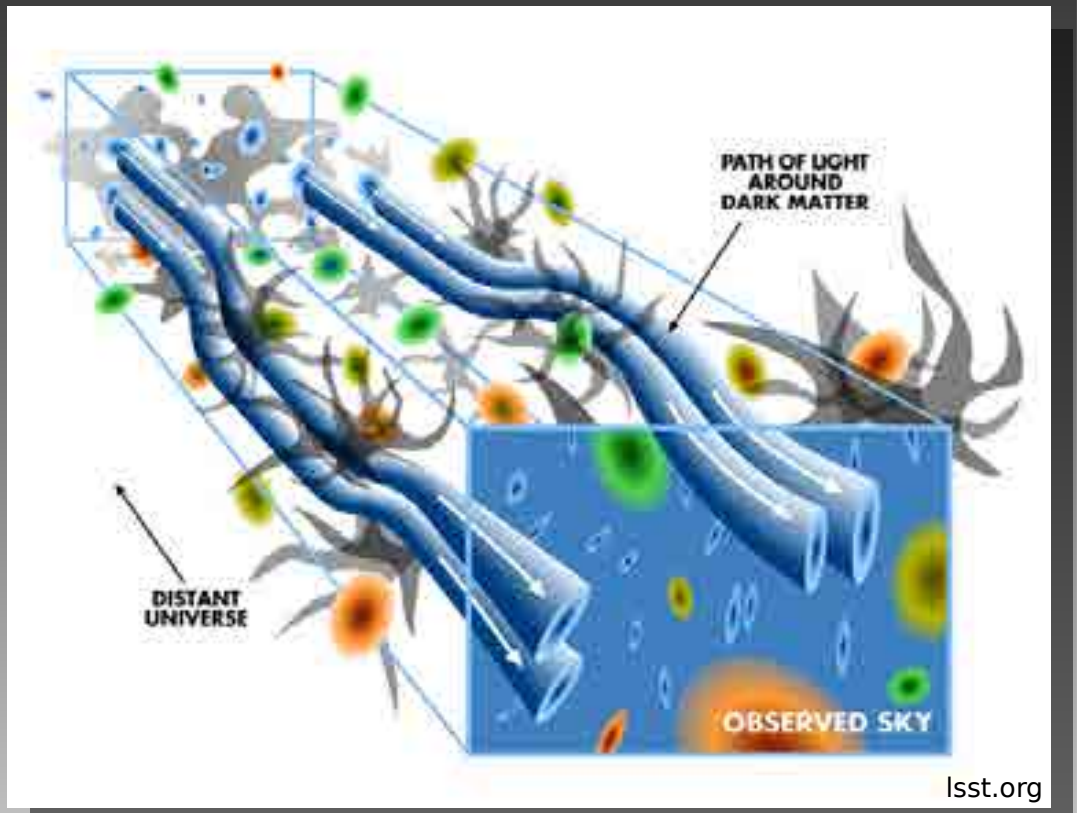
cfhtlens.org


A370
NASA/ESA

Two statistics:

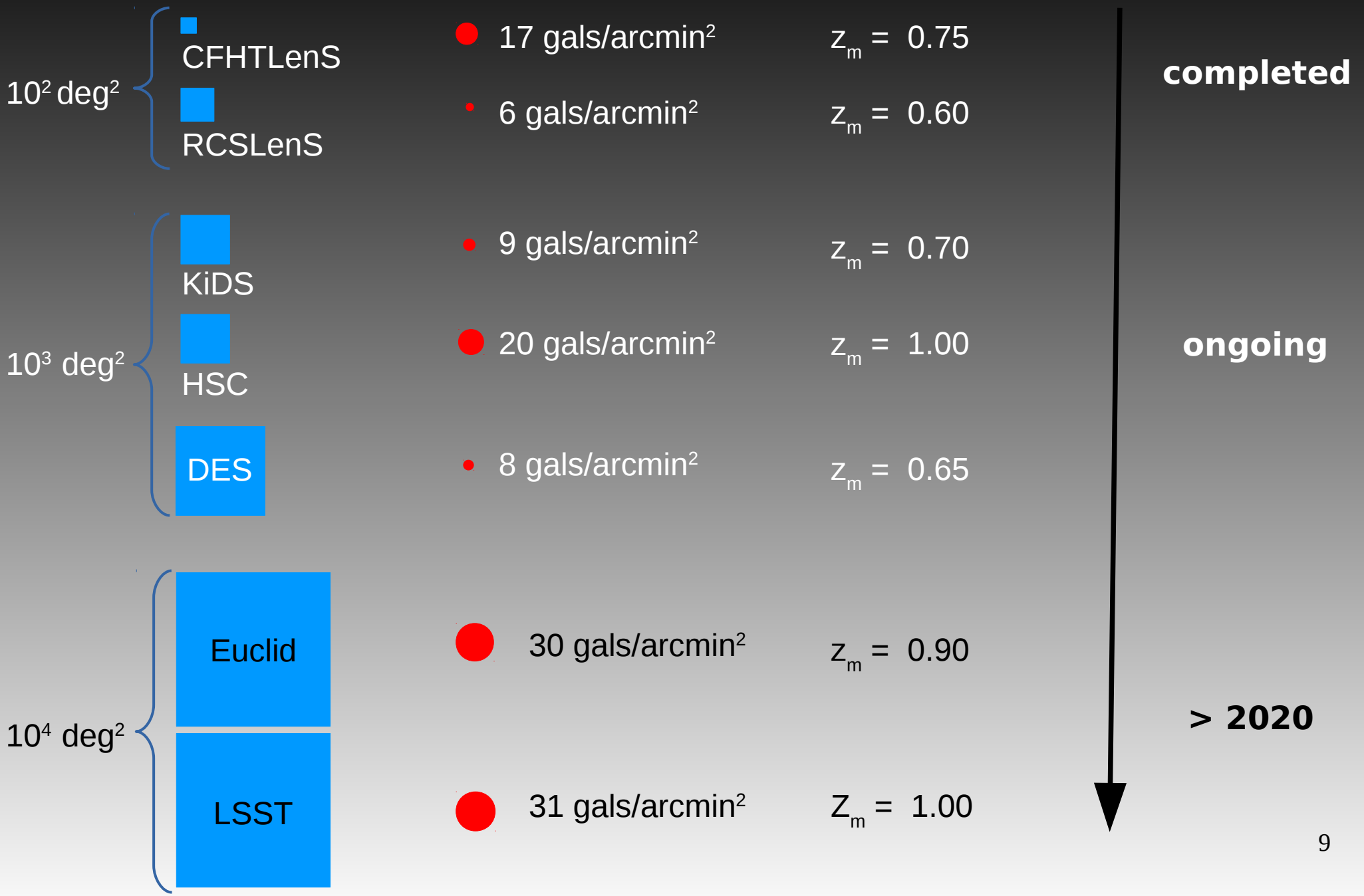


shear-position
(a.k.a. galaxy-galaxy lensing)



shear-shear
(a.k.a. cosmic shear)

Weak lensing: Surveys



Weak Lensing: Challenges

1) Accurate photometric redshifts

2) Shape noise:

Bridle et al. (2009)

“The bigger (deeper) the survey the smaller the uncertainties!”

3) Blending (!)

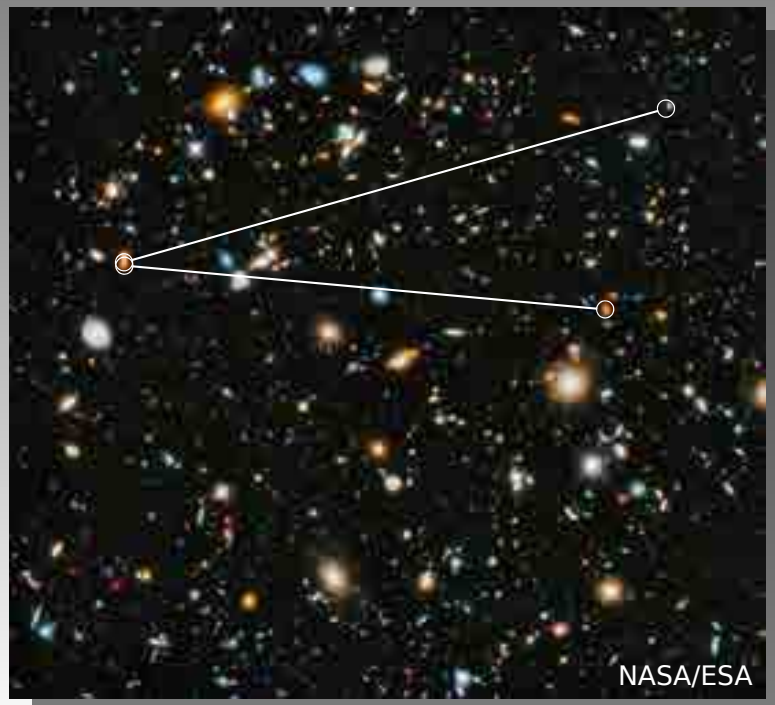
II. Cosmic Shear

Lensing of LSS

Theory:

$$C^{\mathrm{EE}}_{\ell,\mu\nu} = \int \mathrm{d}\chi \frac{w_\mu(\chi) w_\nu(\chi)(1+z)^2}{\chi^2_{\mathrm{m}}(\chi)} P_\delta\left(k = \frac{\ell}{\chi_{\mathrm{m}}(\chi)}; \chi\right)$$

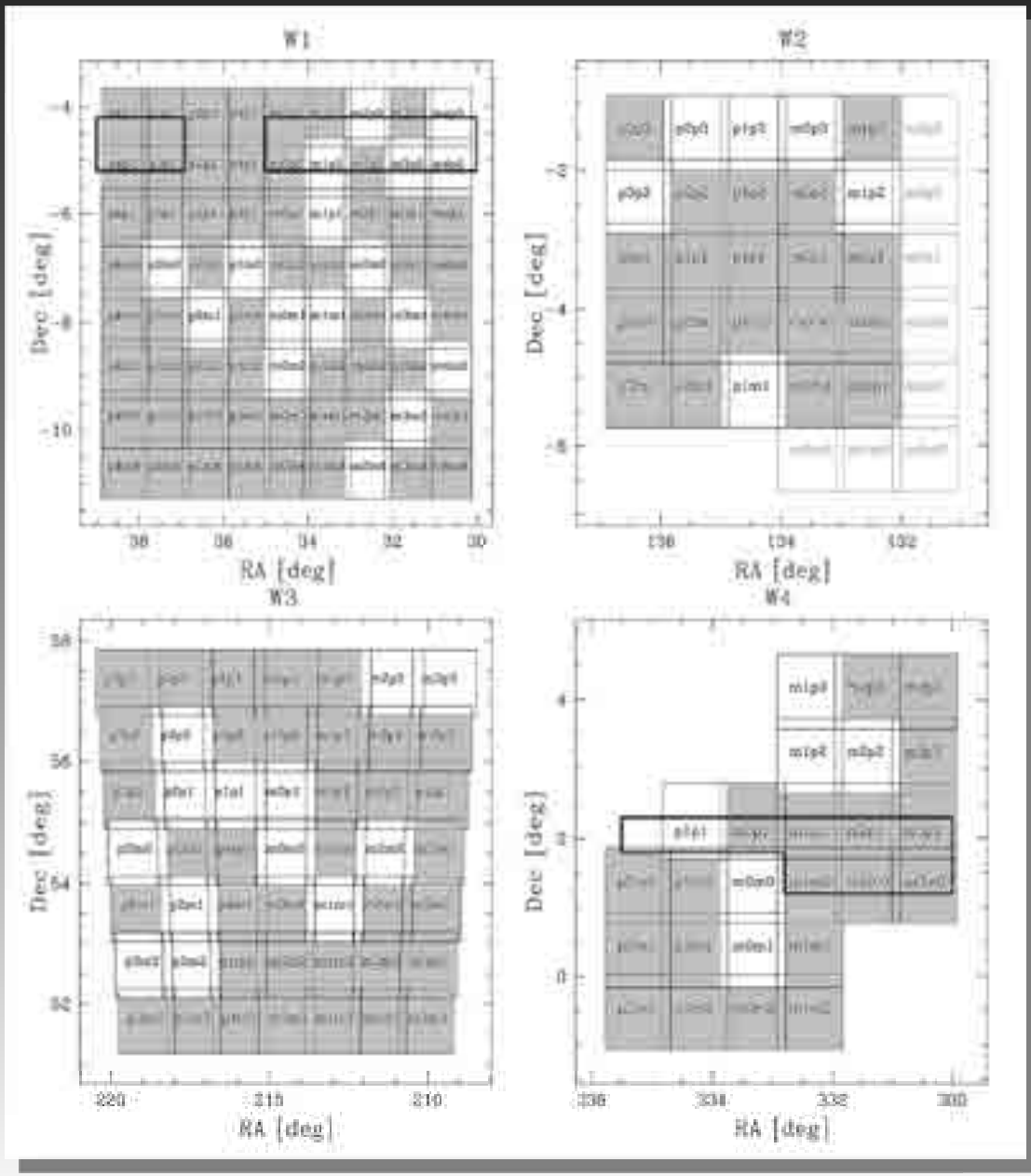
"geometry" "physics"



measurements:

correlation functions ⟺ **power spectra**

The CFHTLenS case



Erben et al. (2012)

~154 deg²

n_{gal} = 17 gals/arcmin²

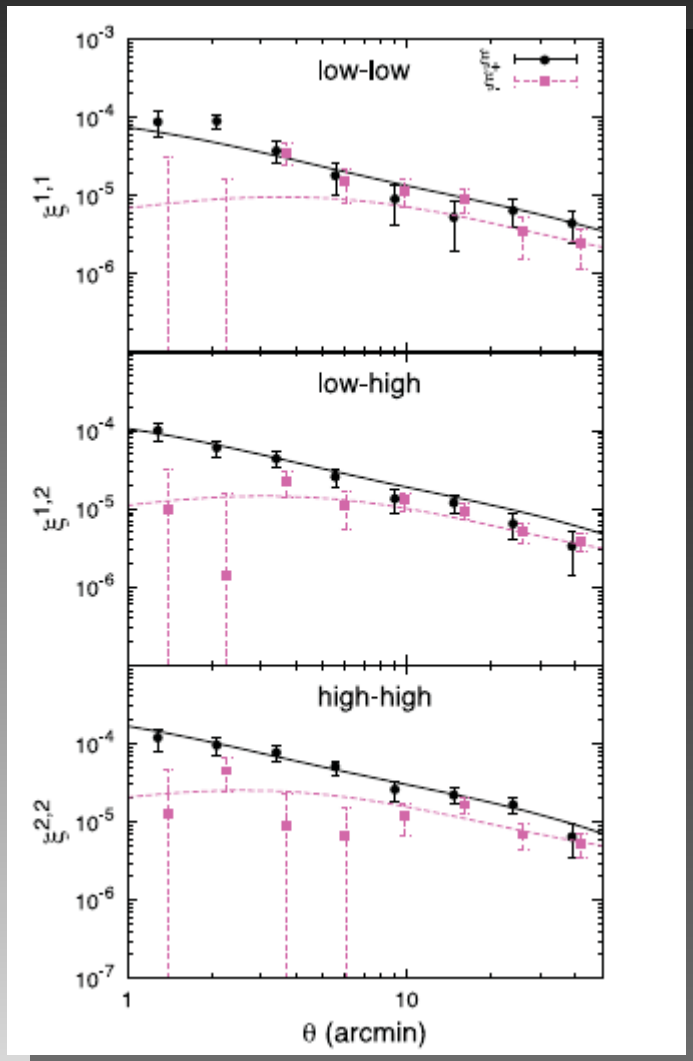
two redshift slices:

z_1: 0.50 < z ≤ 0.85
z_2: 0.85 < z ≤ 1.30

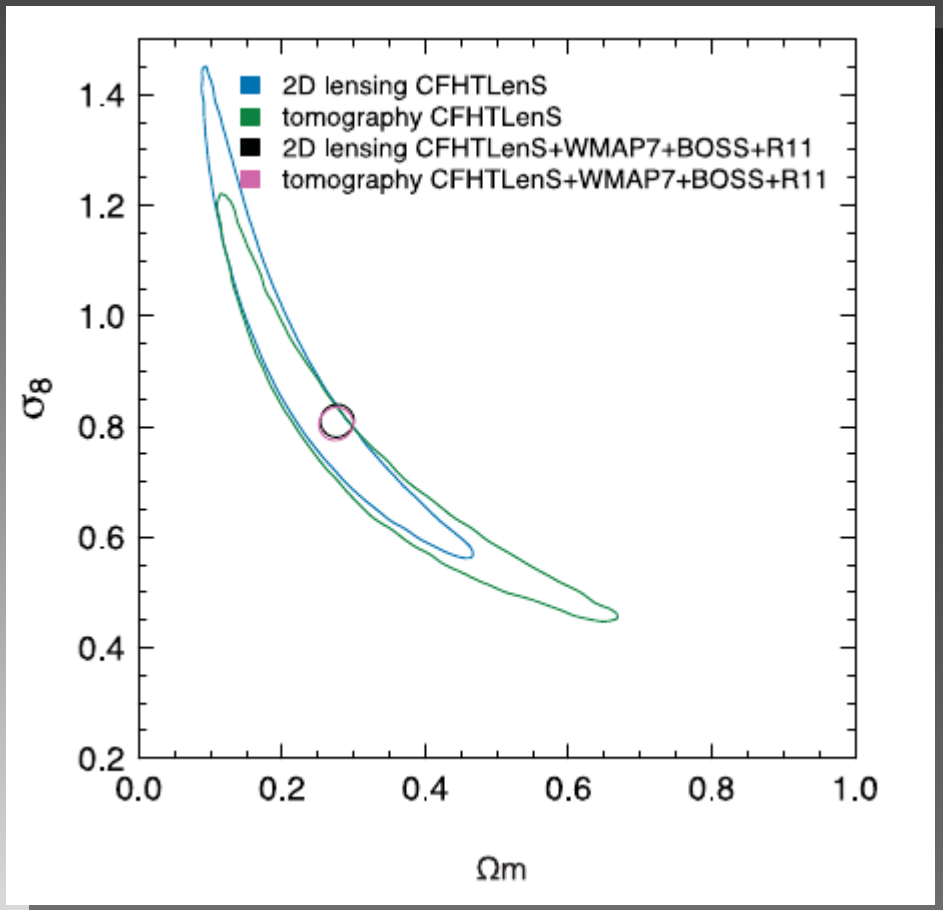
minimize intrinsic alignments

!!! PUBLIC data !!!

Results: Real Space



Benjamin et al. (2013)



Benjamin et al. (2013)

Goal:

measure cosmic shear **lensing power spectrum:**

- in multipole space
- include low multipoles (large scales)
- in redshift bins

Why?

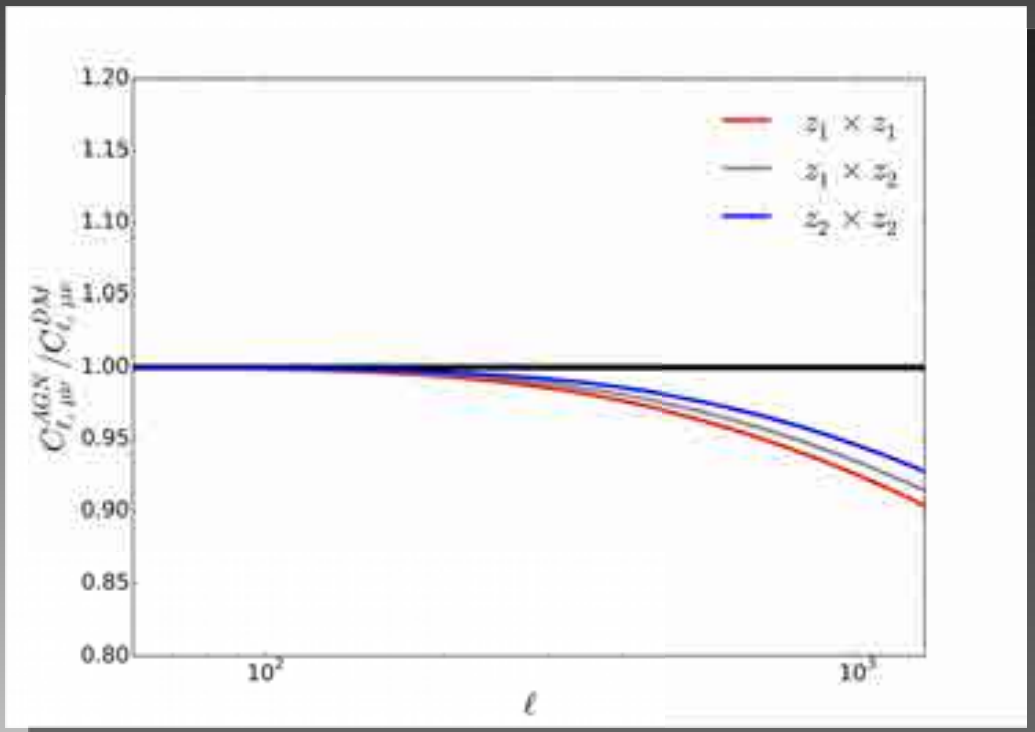
– better handling of scale mixing in multipole space (compared to real space analyses)

– coupling to other cosmological probes (CMB)

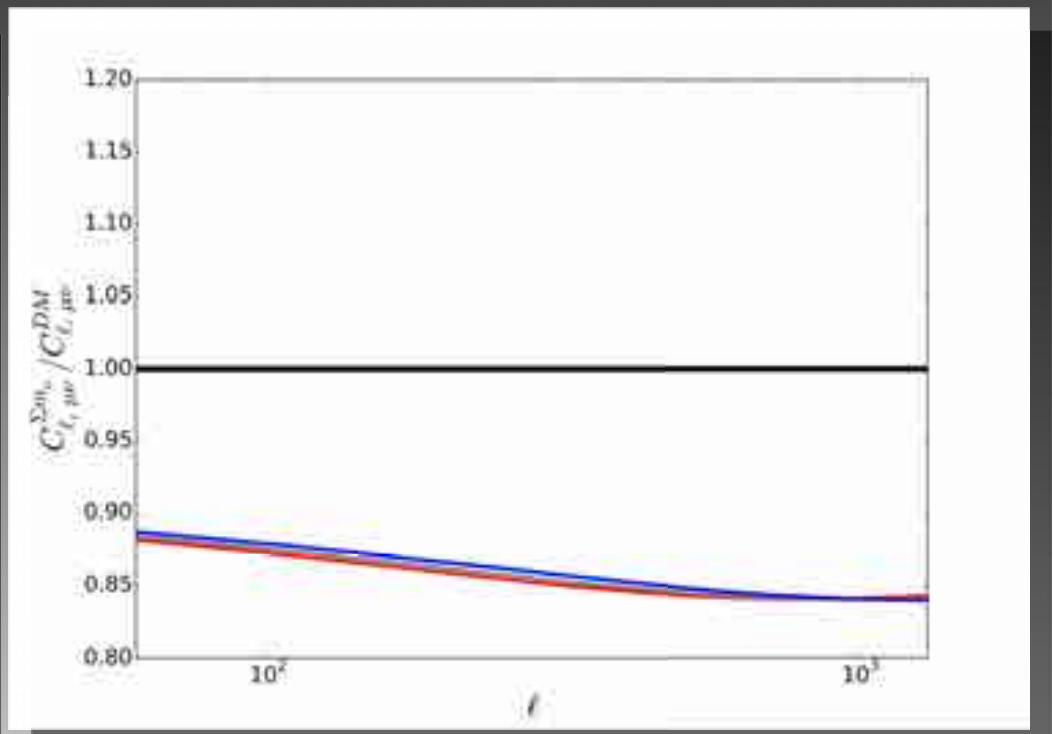
– account for scale dependent features:

→ **Neutrinos**, baryon feedback (e.g. Harnois-Déraps et al. 2015)!

Baryons & neutrinos

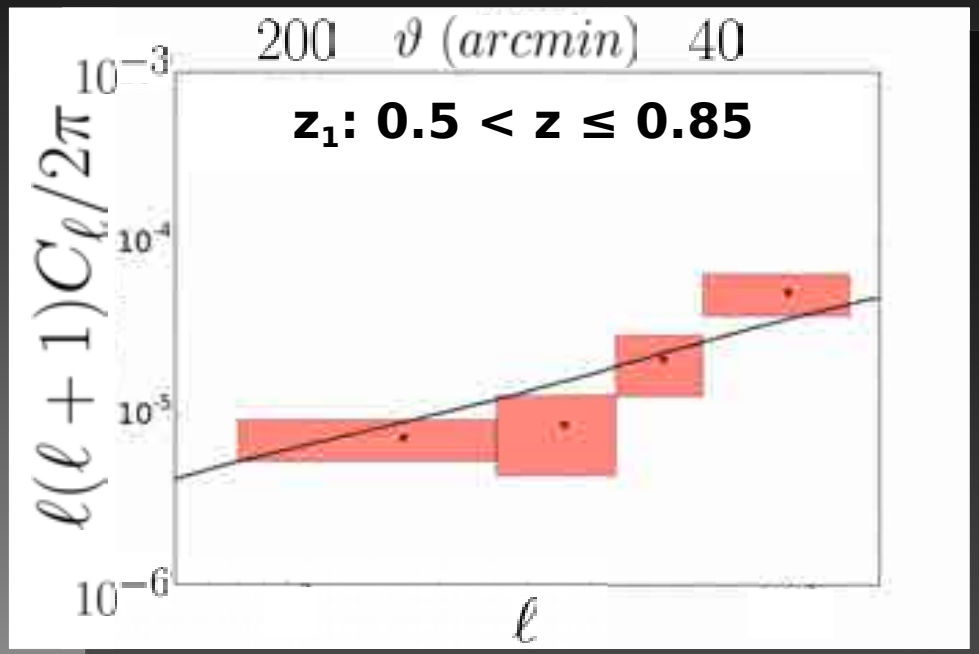


AGN from OWLS after Harnois-Déraps et al. (2014)



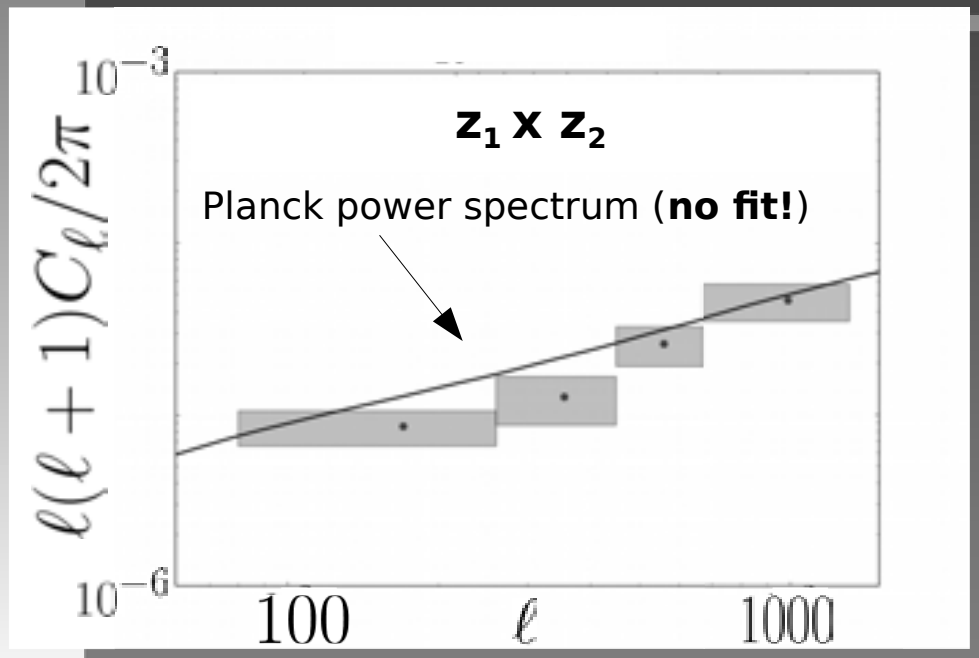
3 degenerate, massive neutrinos with $\Sigma m_\nu = 0.18$ eV

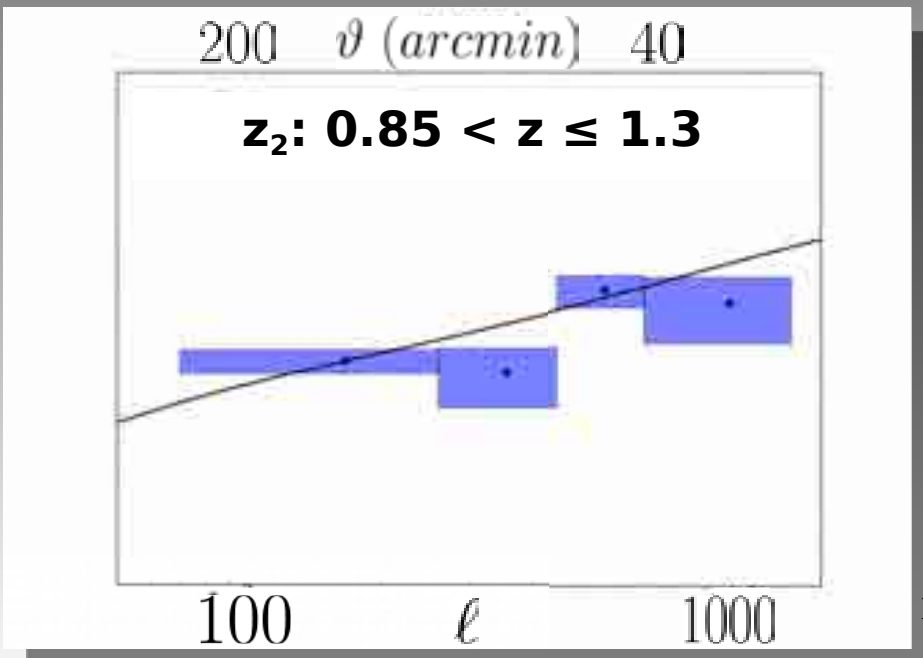
Multipole Space



WL power spectra from CFHTLenS (W1, W2, W3 & W4 combined)

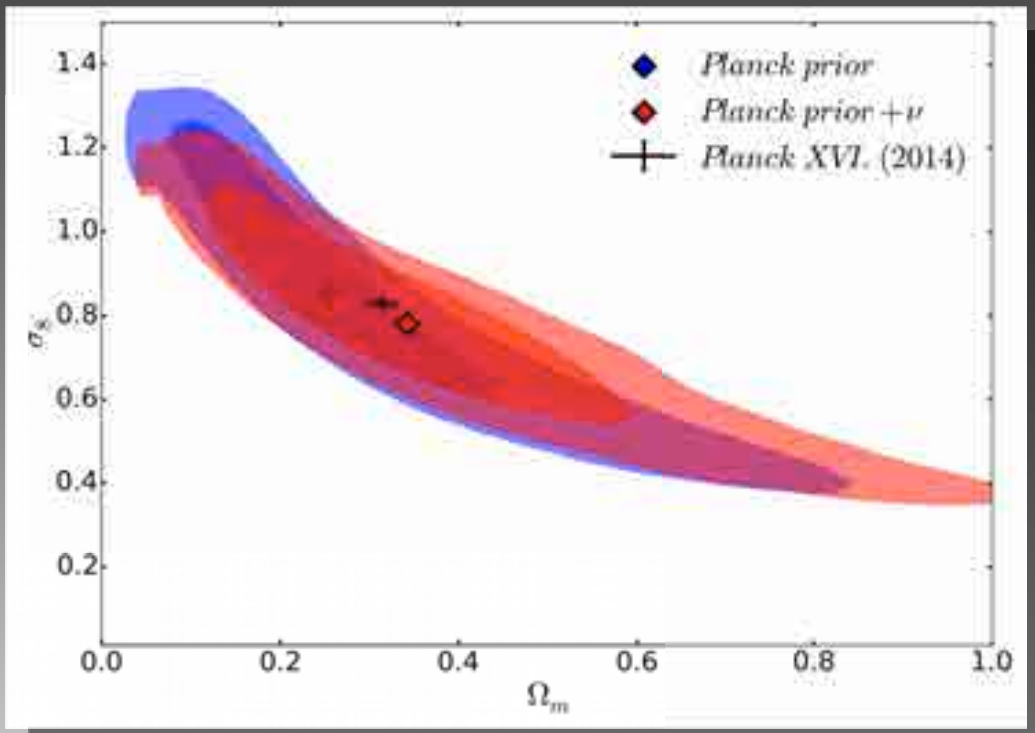
quadratic estimator method (Hu & White 2001, Lin et al. 2012)

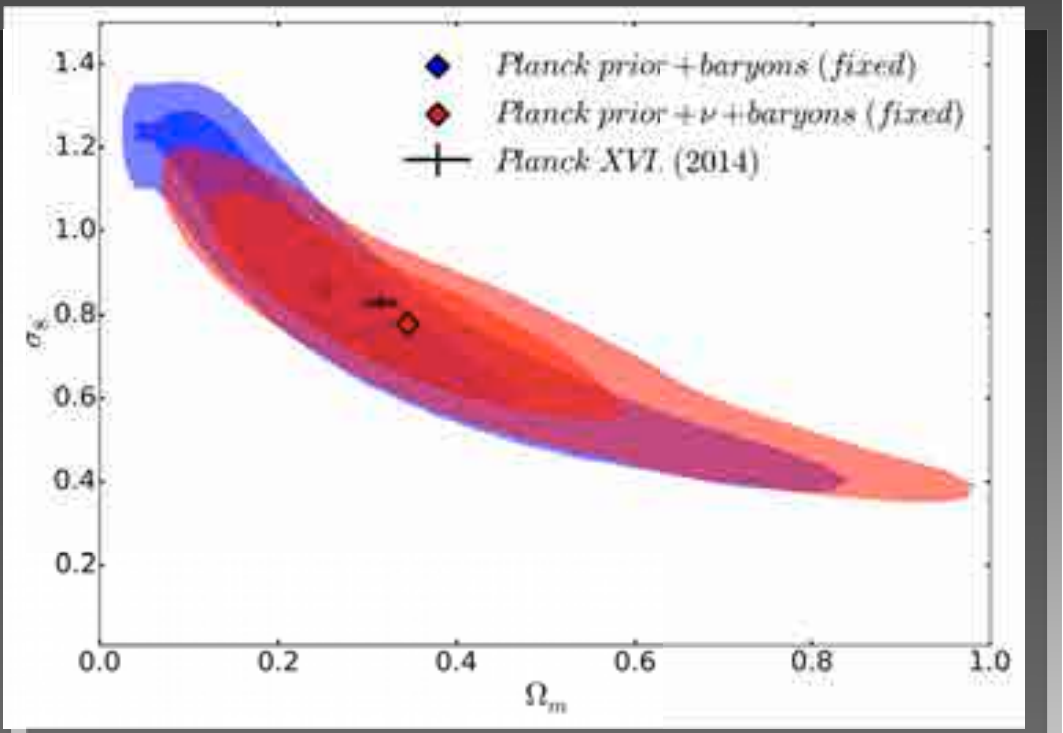




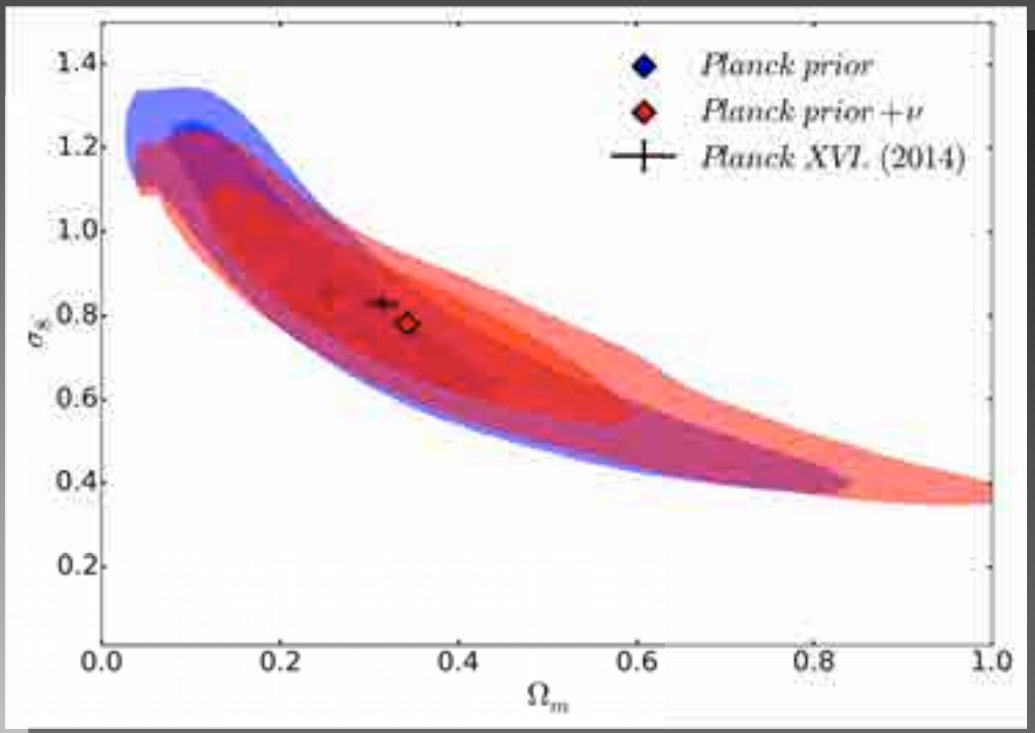
FK+ (in prep.)

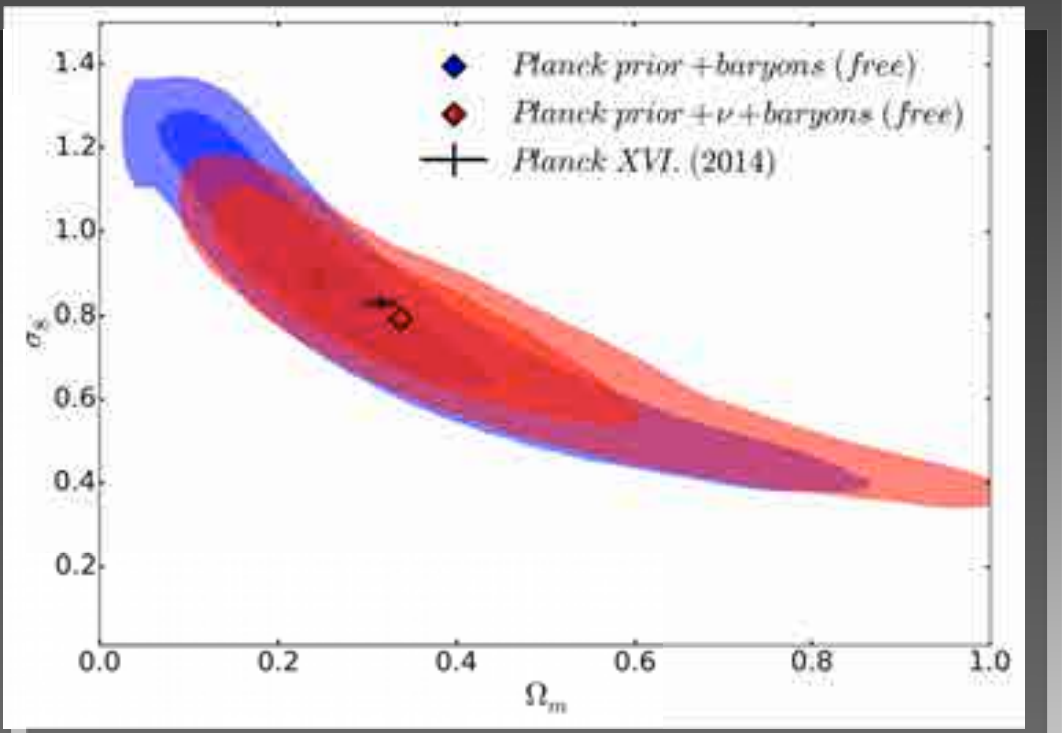
Cosmological inference





Cosmological inference





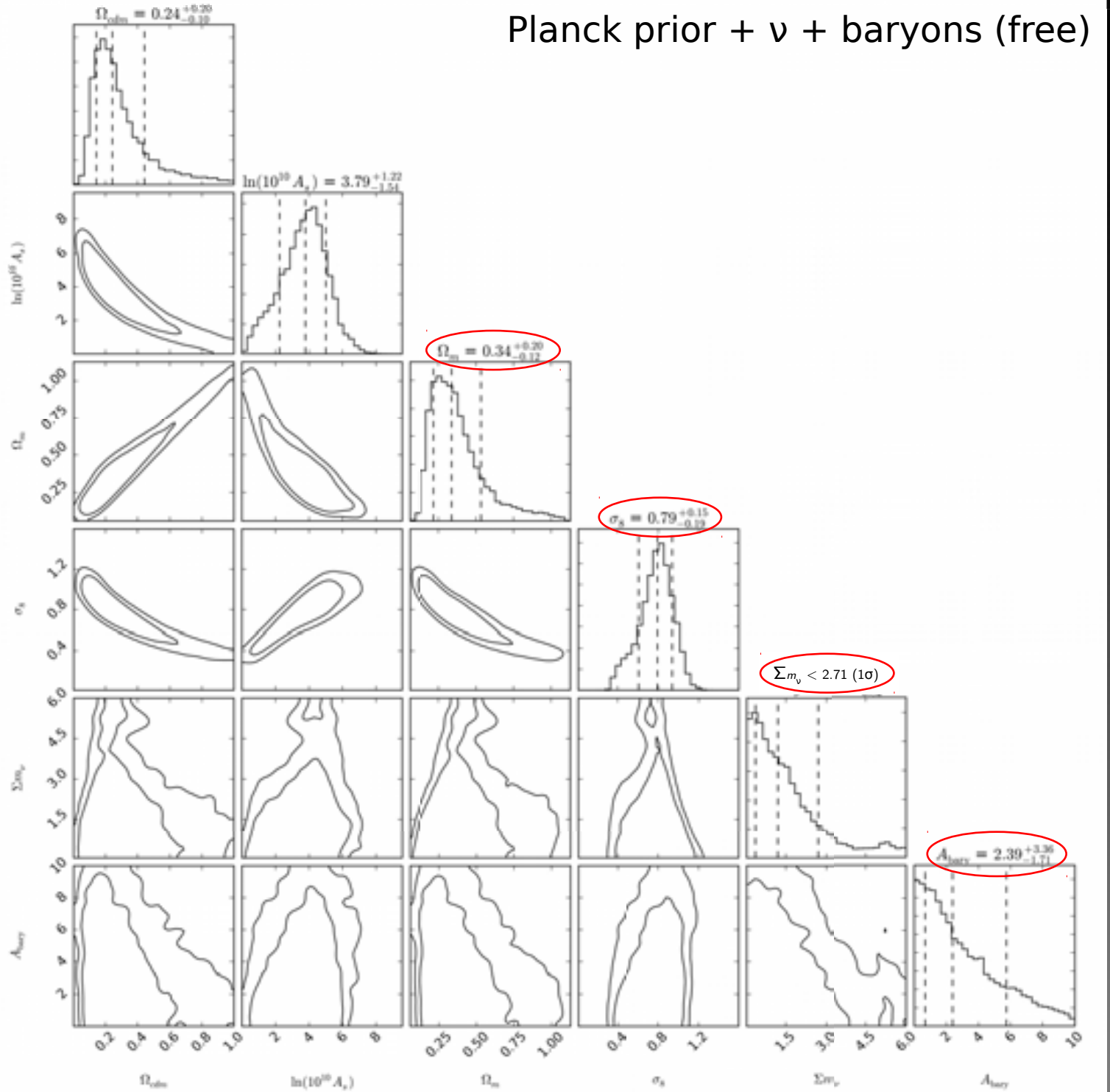
Evidences

likelihood analysis performed with *Monte Python* (Audren et al. 2012) and *Multinest* (Feroz et al. 2008, 2009, 2013)

evidences

models:	**log(evidence):**
Planck prior	-41.700 +/- 0.041
Planck prior + ν	-42.498 +/- 0.042
Planck prior + baryons (fixed)	-41.808 +/- 0.041
Planck prior + ν + baryons (fixed)	-42.731 +/- 0.043
Planck prior + baryons (free)	-42.421 +/- 0.042
Planck prior + ν + baryons (free)	-43.443 +/- 0.044

Planck prior + ν + baryons (free)



III. Galaxy-Galaxy Lensing

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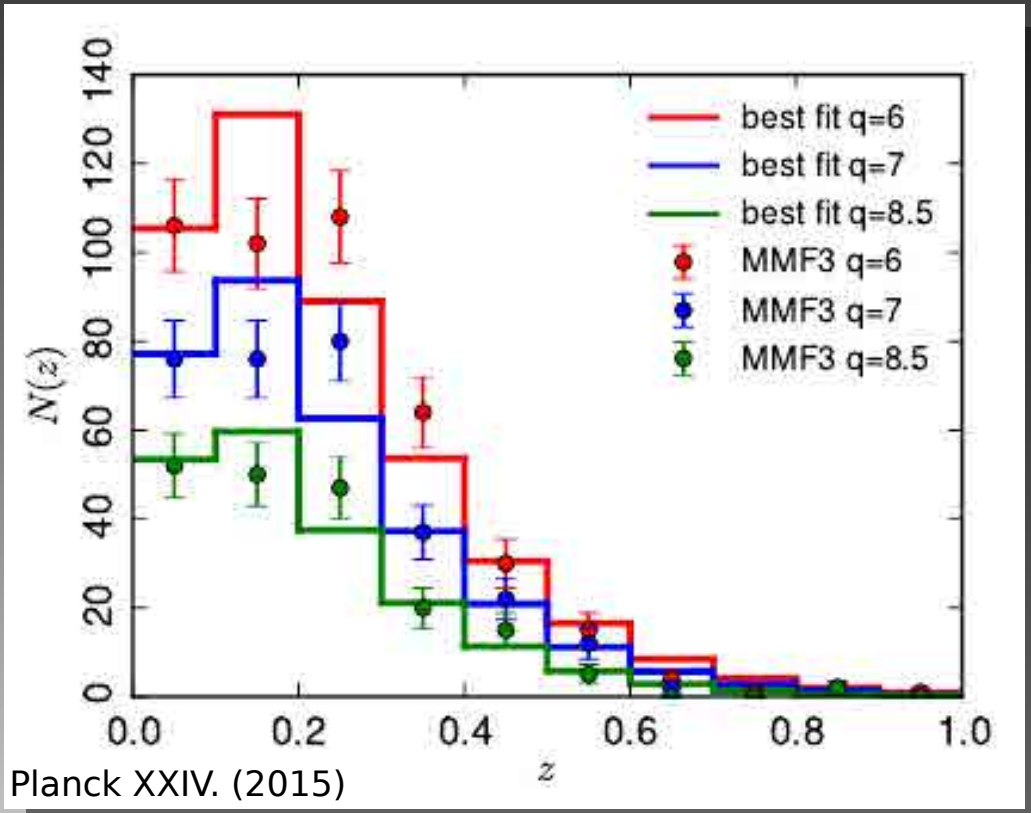
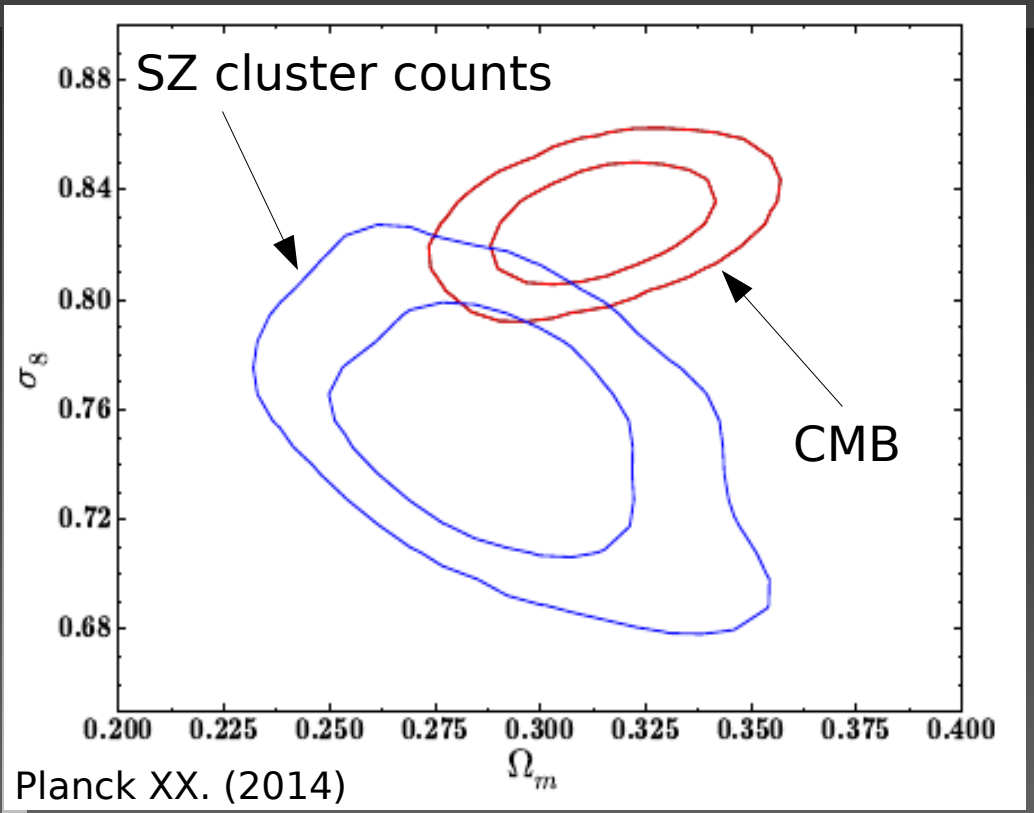
"Statistical uncertainties and systematic errors in weak lensing mass estimates of galaxy clusters"

FK, H. Hoekstra, M. Eriksen (submitted to MNRAS)

Cluster counts



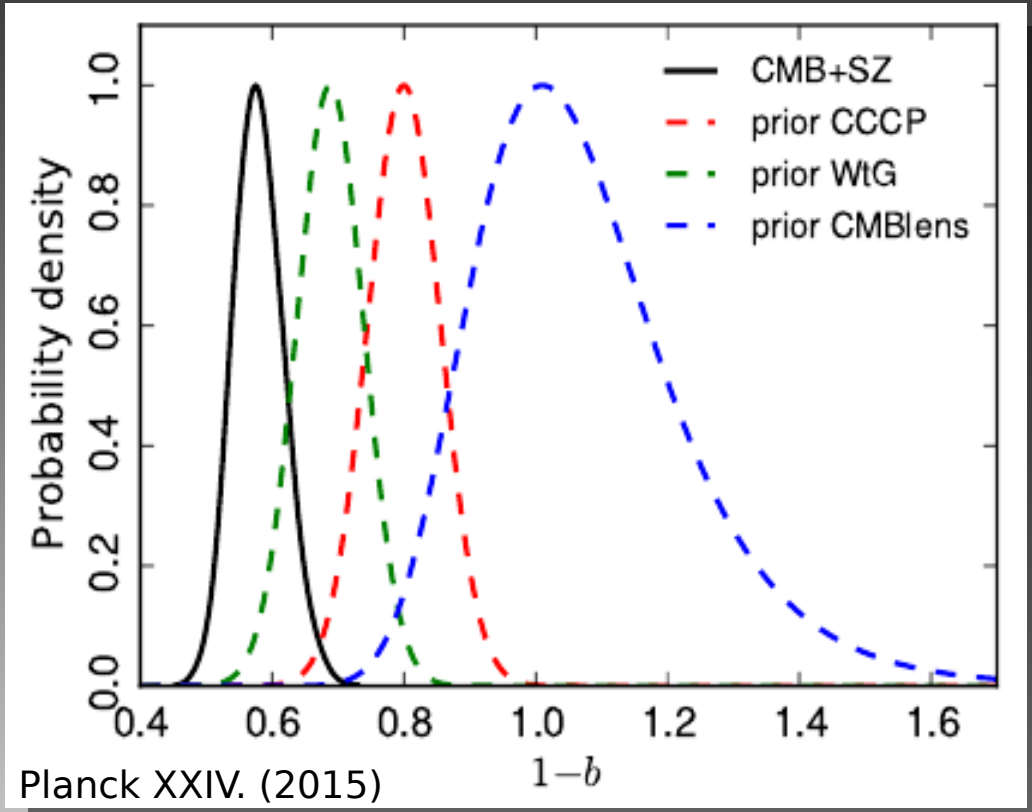
Planck XXIV. (2015)



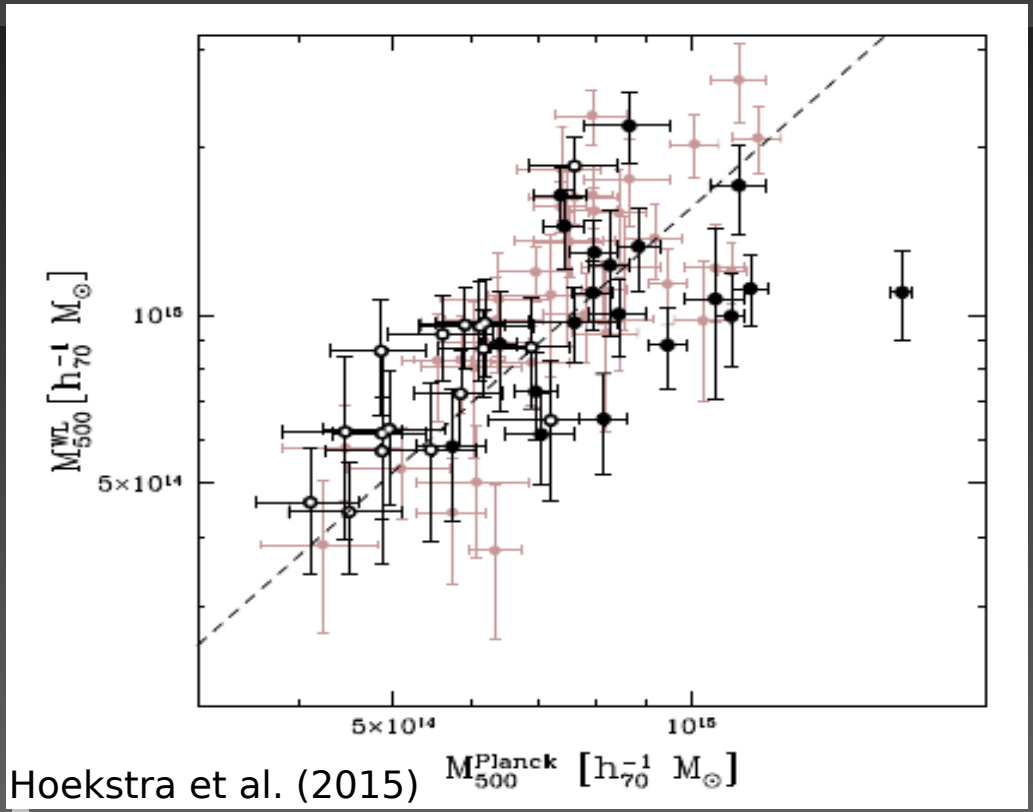
Planck XX. (2014)

Cosmological constraints from the CMB are in tension wrt. the ones derived from SZ-cluster counts.

Mass bias & scaling relations



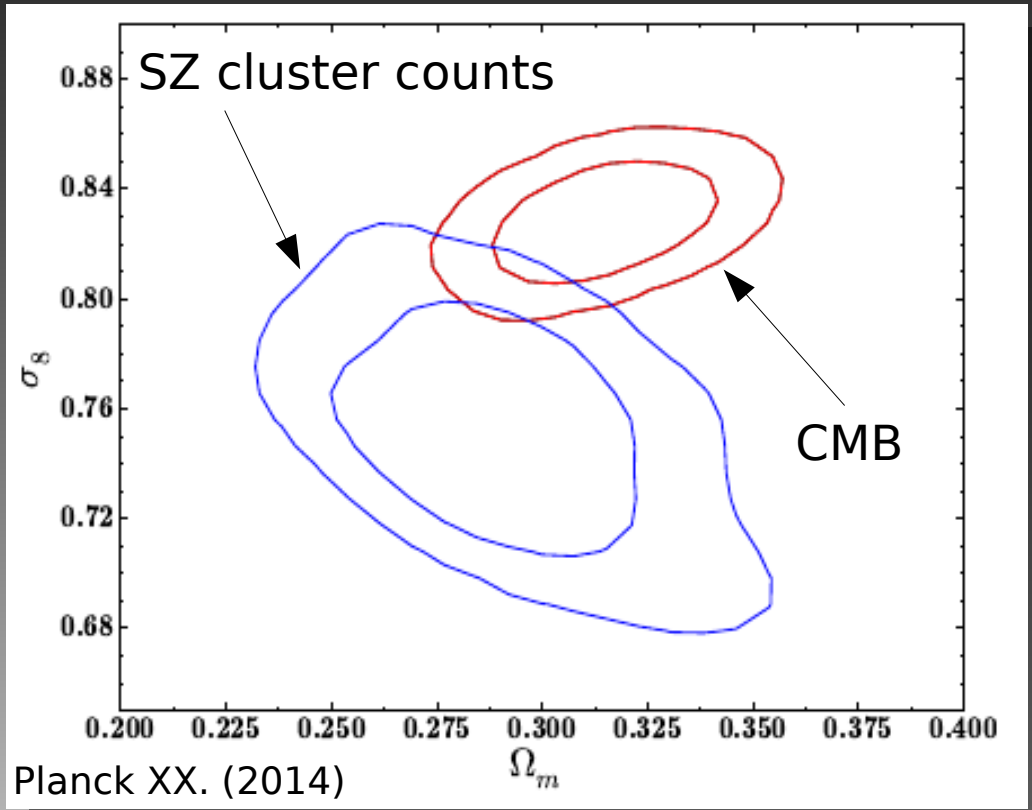
Planck XXIV. (2015)



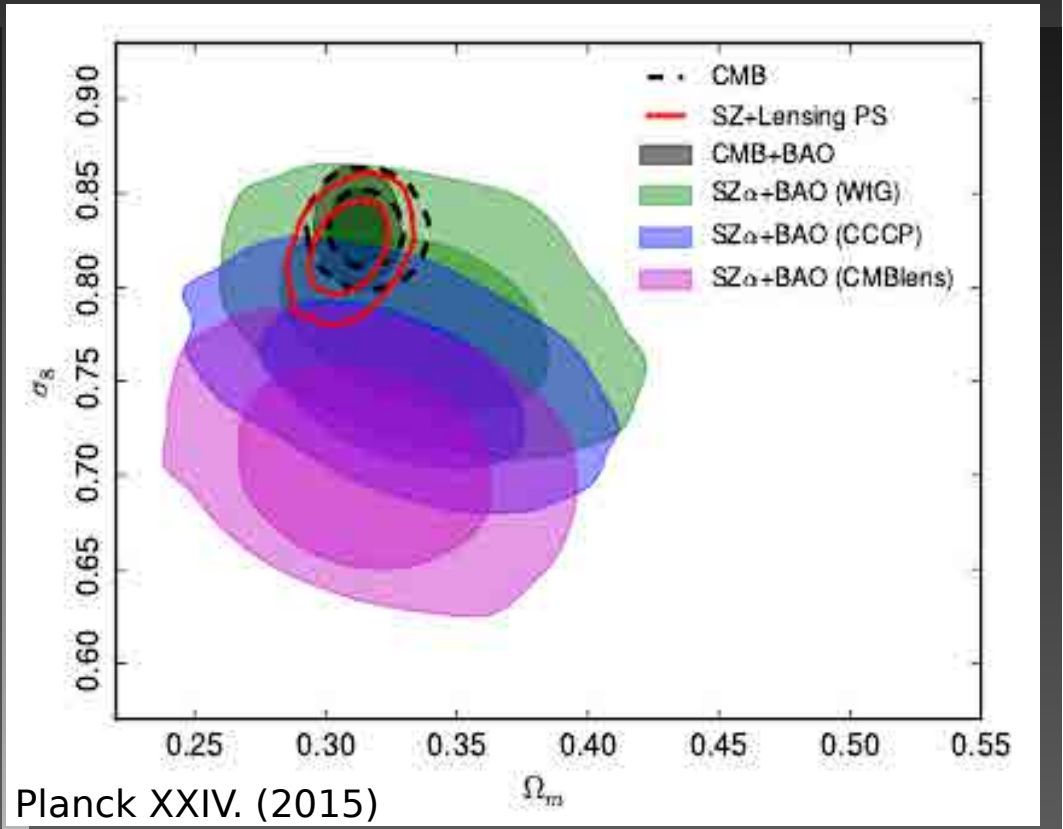
Hoekstra et al. (2015)

Weak lensing of clusters can be used to derive tight scaling relations independent of the dynamical state of matter for example.

Cluster counts revised



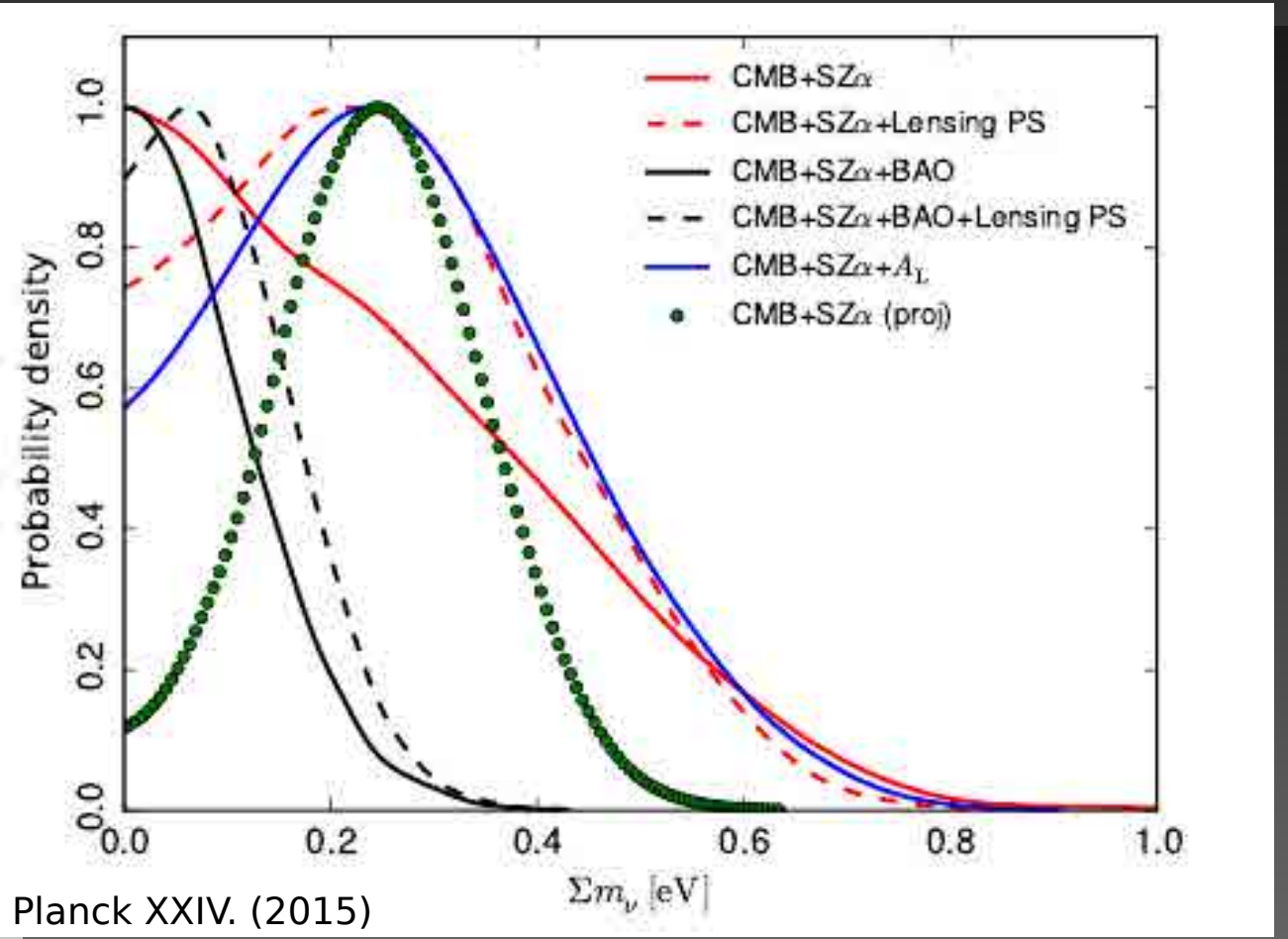
Planck XX. (2014)



Planck XXIV. (2015)

Scaling relations gauged with weak lensing masses alleviate the tension...

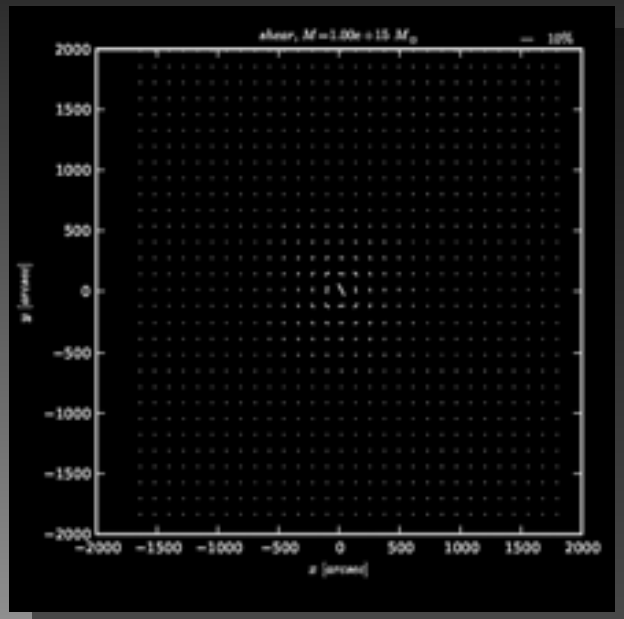
The possibilities

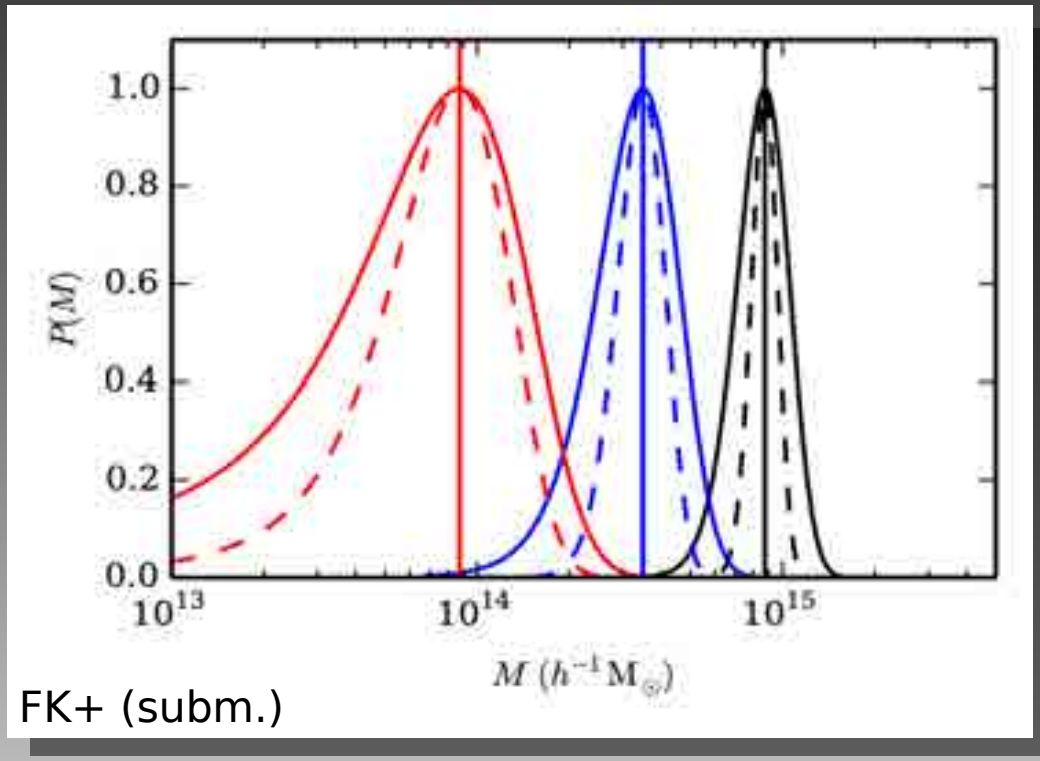


Planck XXIV. (2015)

If the uncertainty on the mass bias can be reduced to 1% tight constraints on the mass of neutrinos are possible.

Cosmic shear as noise

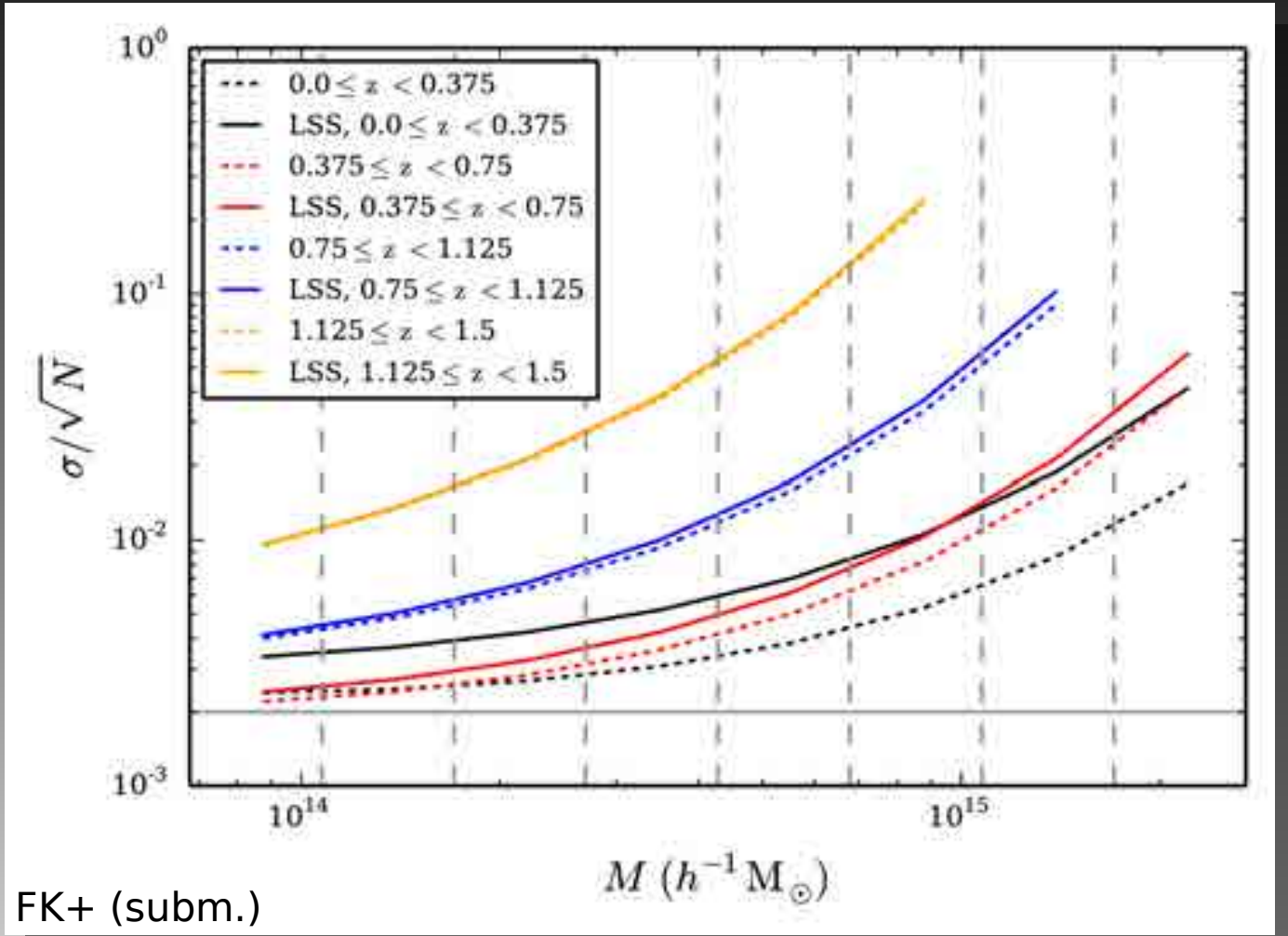




FK+ (subm.)

Cosmic noise must be taken into account for deriving realistic uncertainties.

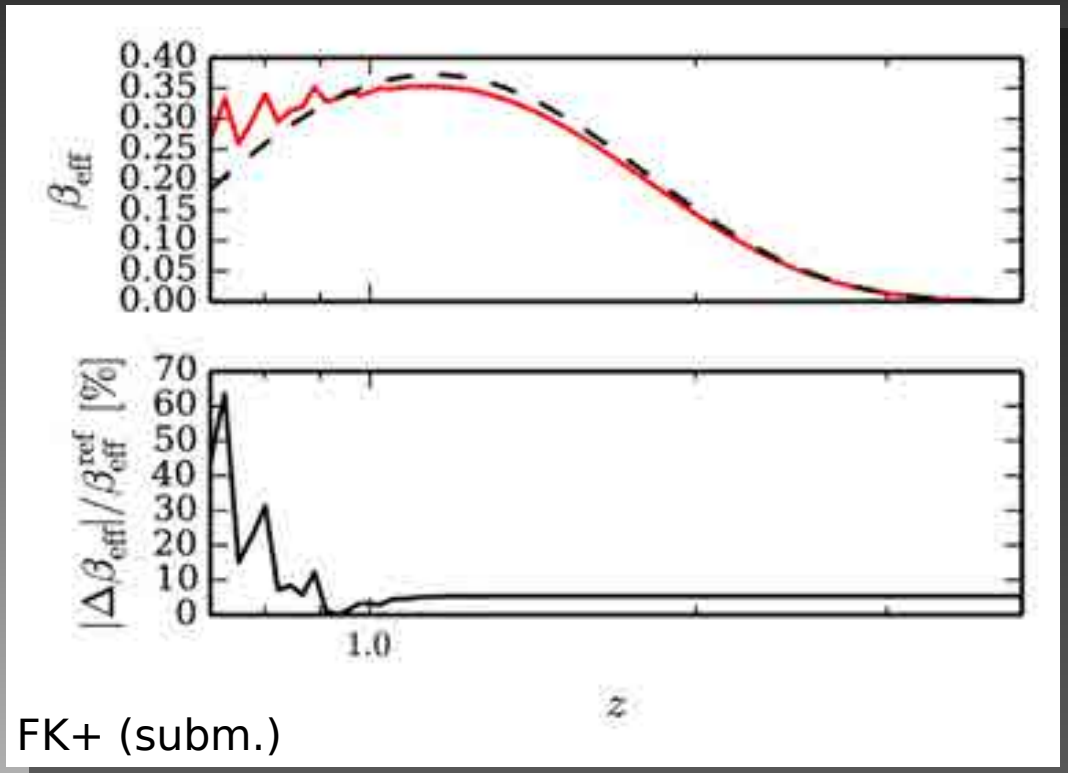
Statistical uncertainties



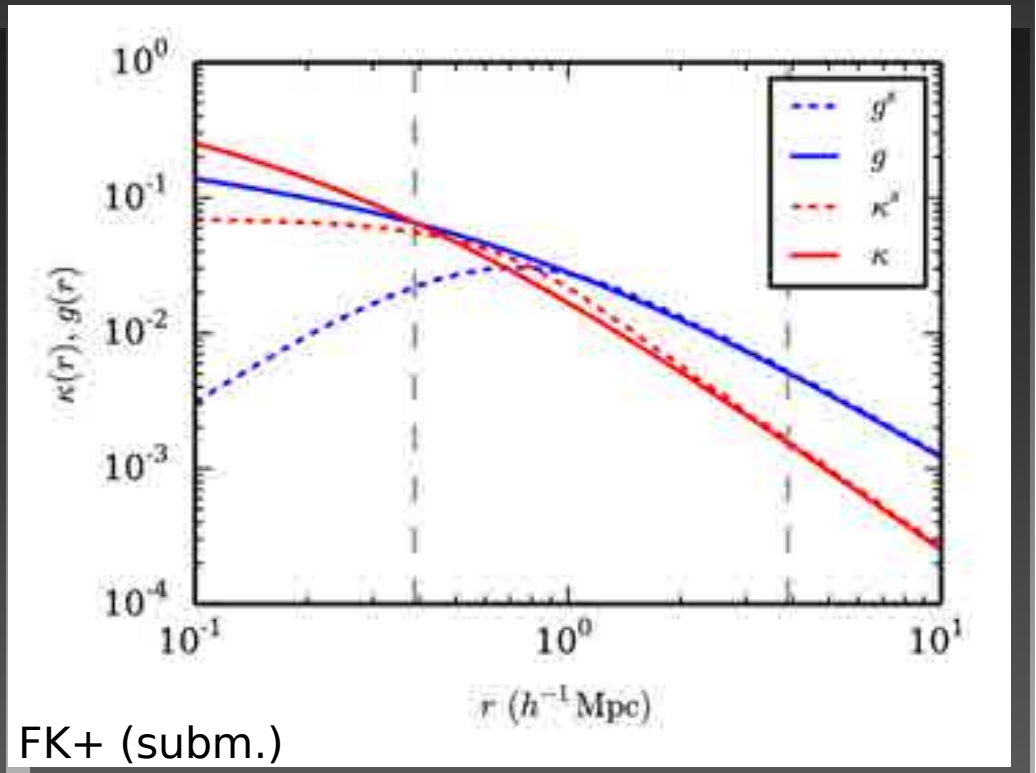
FK+ (subm.)

A *Euclid* cluster survey will yield very precise mass measurements of galaxy clusters.

Systematic errors



FK+ (subm.)

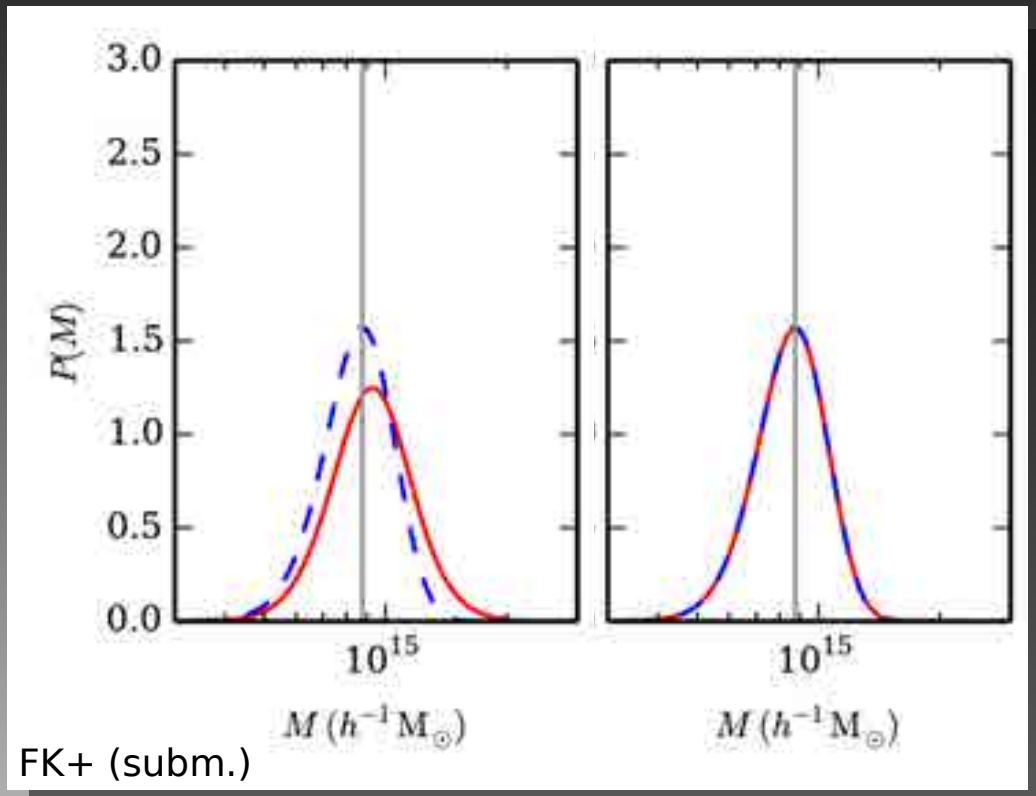


FK+ (subm.)

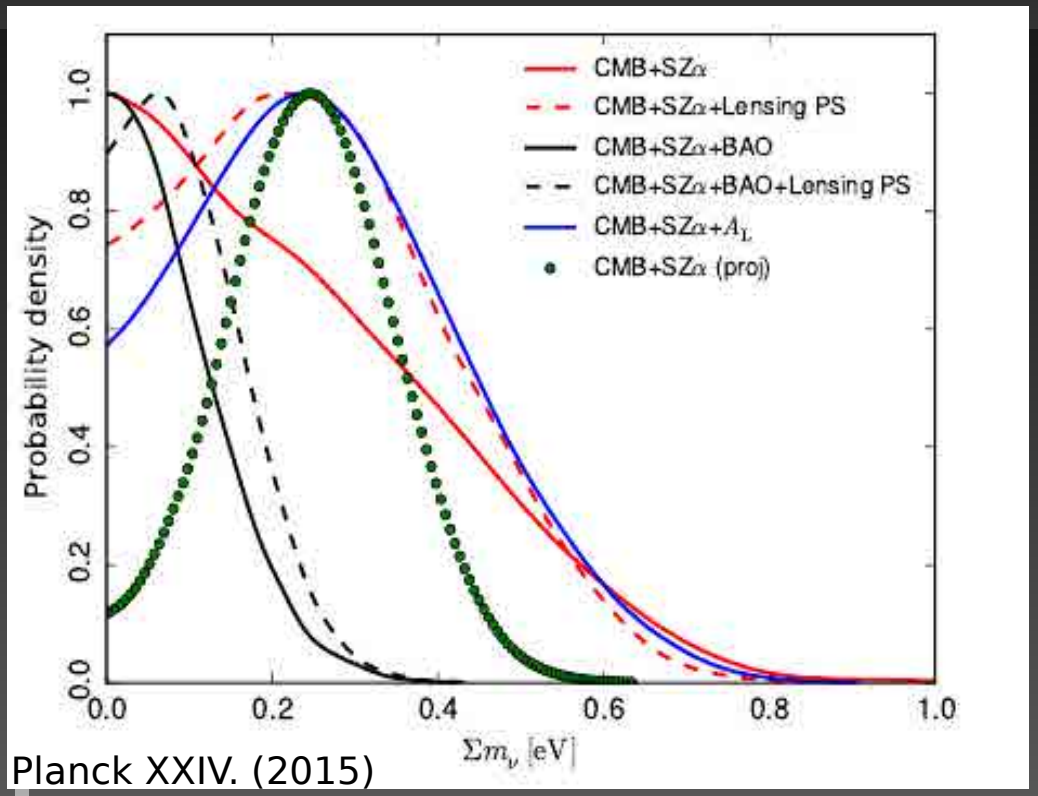
cluster member scattering (due to photo-z errors)

miscentring

Miscentring



FK+ (subm.)



Planck XXIV. (2015)

***Euclid* and *eROSITA* promise to become a powerful tool for constraining the neutrino mass.**

IV. Conclusions

A direct extraction of the lensing power spectrum is the “cleanest” way to compare data with theory.

First results show the potential of this method to constrain ΛCDM extensions.

Future weak lensing galaxy cluster surveys will provide unprecedented statistical power, however, this requires to account also for (tiny) systematic errors.

↳ **If these are accounted for, cluster surveys are a powerful, complementary approach for testing ΛCDM extensions.**