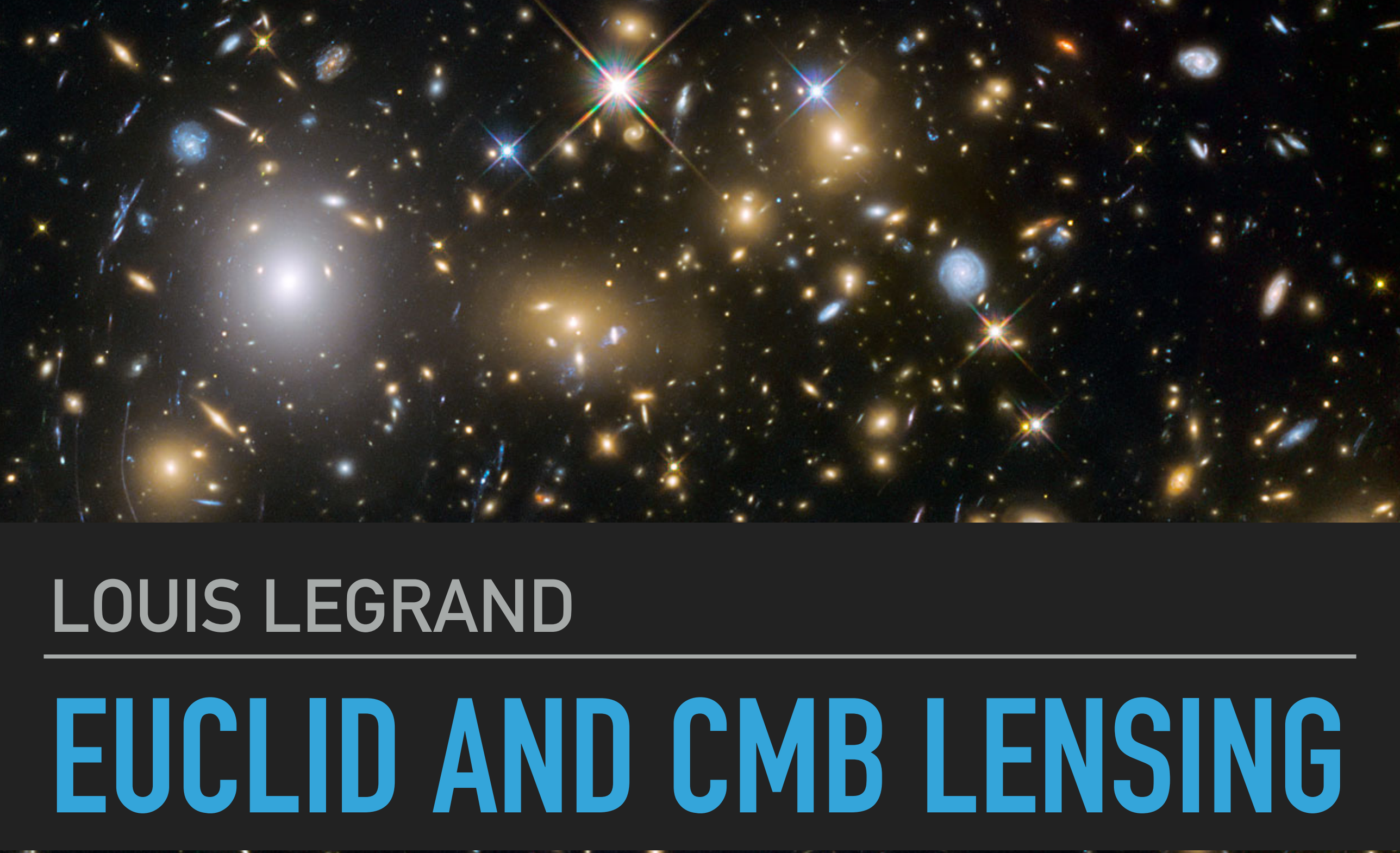


LOUIS LEGRAND

EUCLID AND CMB LENSING

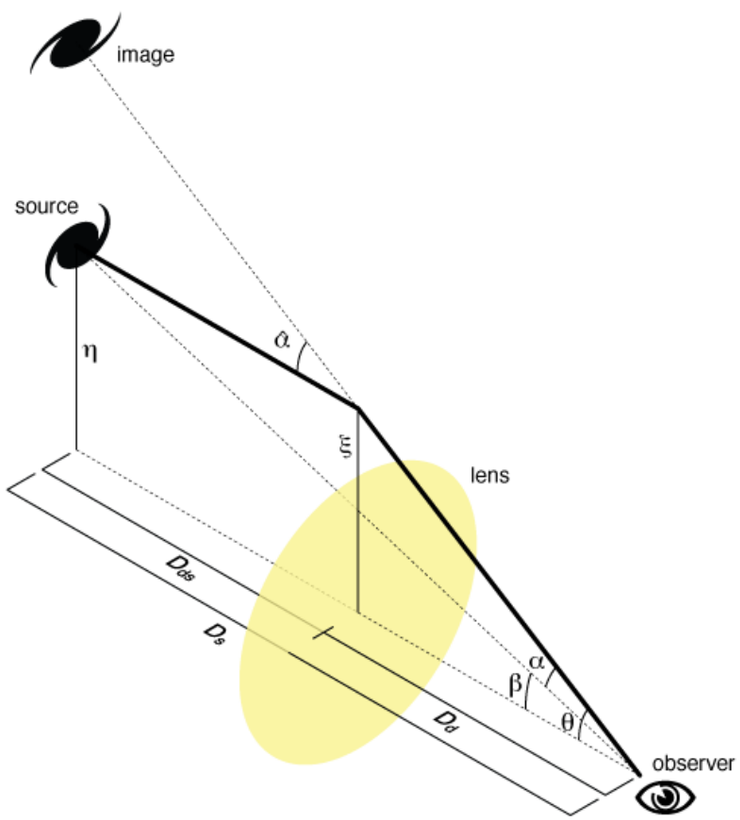
IAS Institut d'Astrophysique Spatiale Orsay

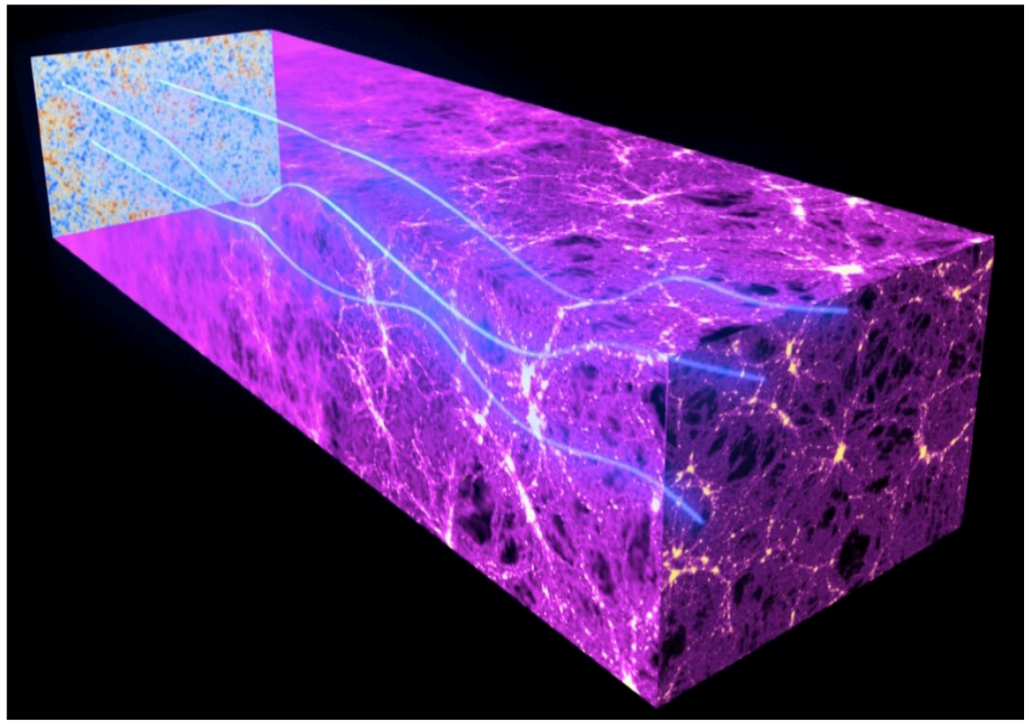
euclid consortium

UNIVERSITÉ PARIS SUD

université PARIS-SACLAY

CMB LENSING



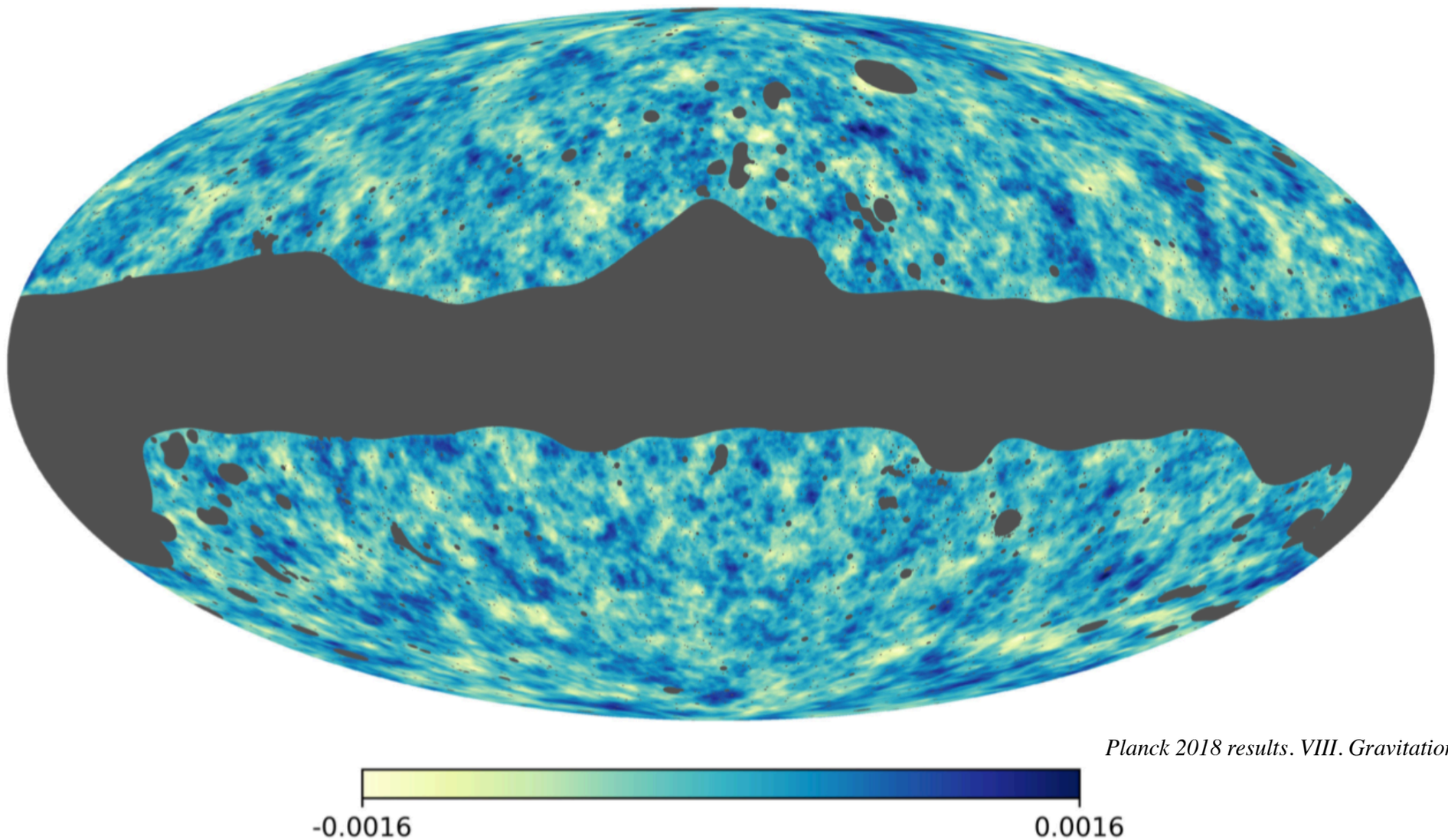


Credit: ESA and the Planck Collaboration

- The light rays of the CMB have been distorted by the matter along their trajectory.

PLANCK MAP OF THE INTEGRAL OF THE MASS

- Lensing field reconstructed with a quadratic estimator.

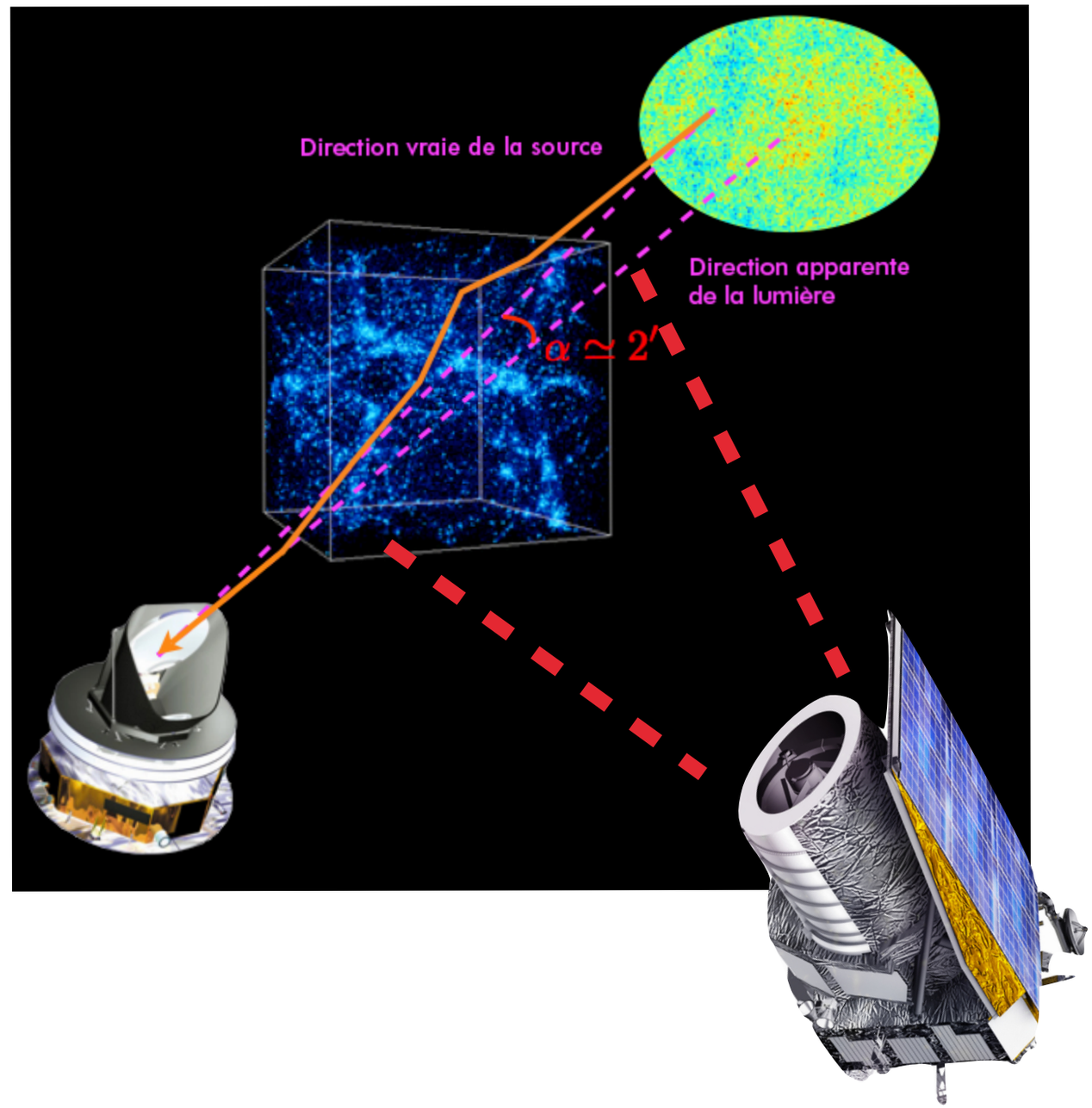


Planck 2018 results. VIII. Gravitational lensing

Fig. 1. Mollweide projection in Galactic coordinates of the lensing reconstruction map from our baseline minimum-variance (MV) analysis. We show the Wiener-filtered displacement-like scalar field with multipoles $\hat{\alpha}^{\rm MV}_{LM} = \sqrt{L(L+1)}\hat{\phi}^{\rm MV}_{LM}$, corresponding to the gradient mode (or E mode) of the lensing deflection angle. Modes with $L < 8$ have been filtered out.

PROBE COMBINATION

- Cosmology, astrophysics, and systematic uncertainties: degeneracies specific to each probes.
- Combination raise degeneracies.
- Check for inconsistency in Euclid data by using external data.



ANGULAR POWER SPECTRA

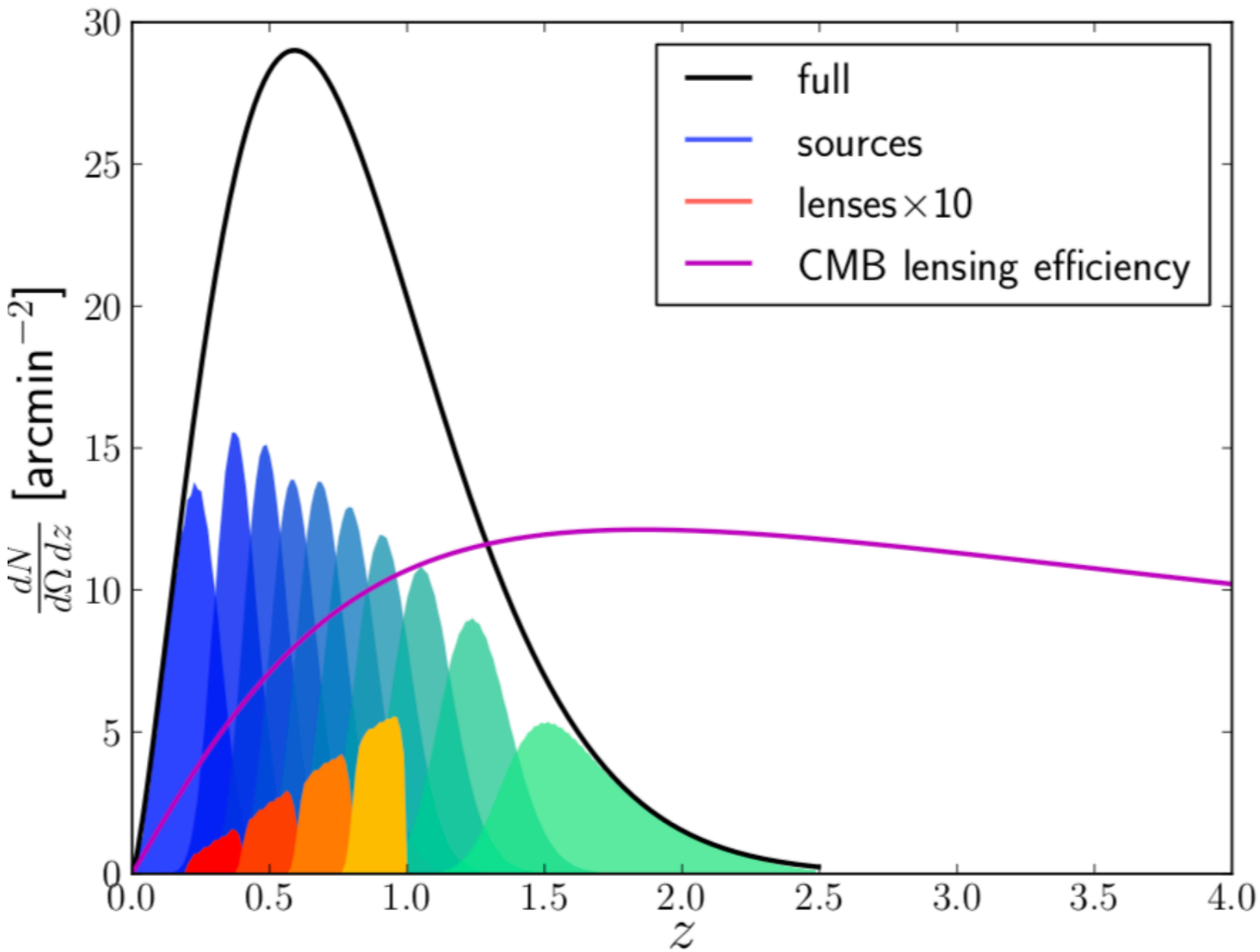
- Our tool to probe the distribution of matter:

$$C_\ell^{\alpha,\beta} = \frac{2}{\pi}\int_0^\infty dk k^2 P(k)\Delta_\ell^\alpha(k)\Delta_\ell^\beta(k),$$

Matter power spectrum

Kernels specific to the probes

EUCLID AND CMB LENSING EFFICIENCY



Schaan et al. 2017

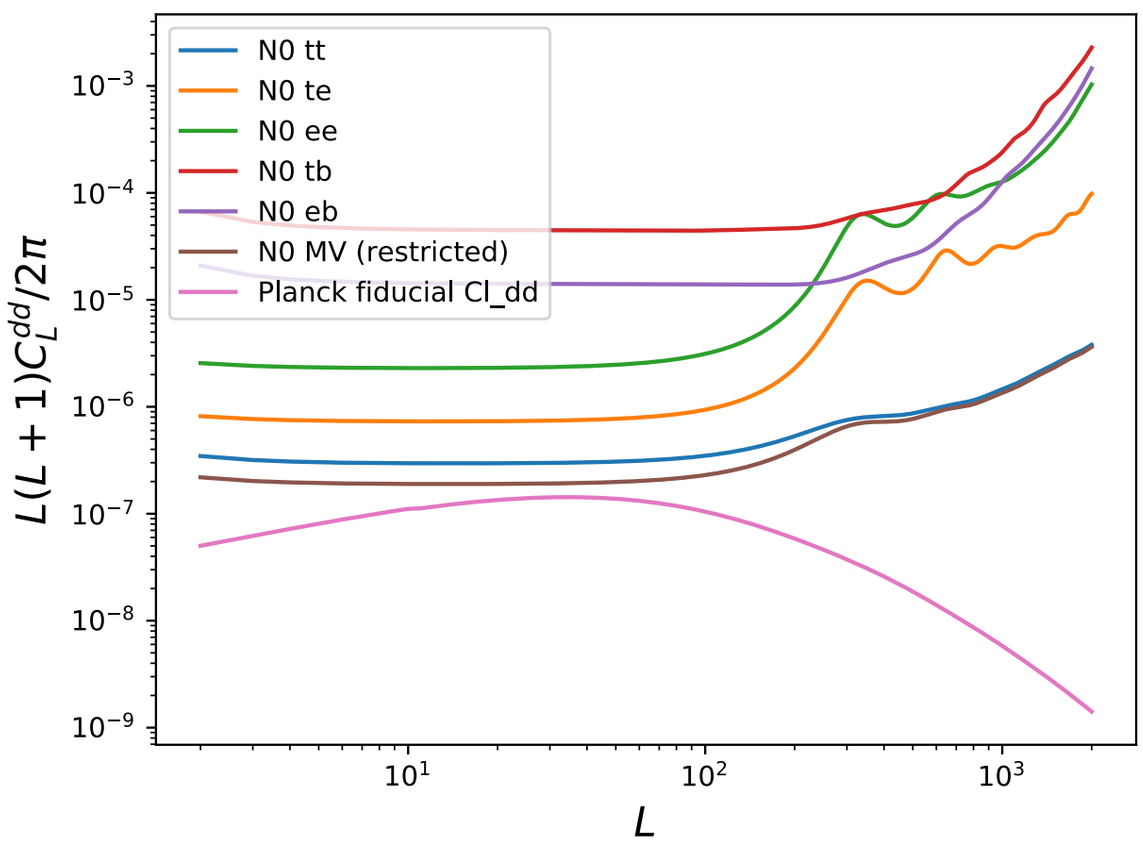
FISHER ANALYSIS

- Fisher forecast with galaxy over-density and CMB lensing:

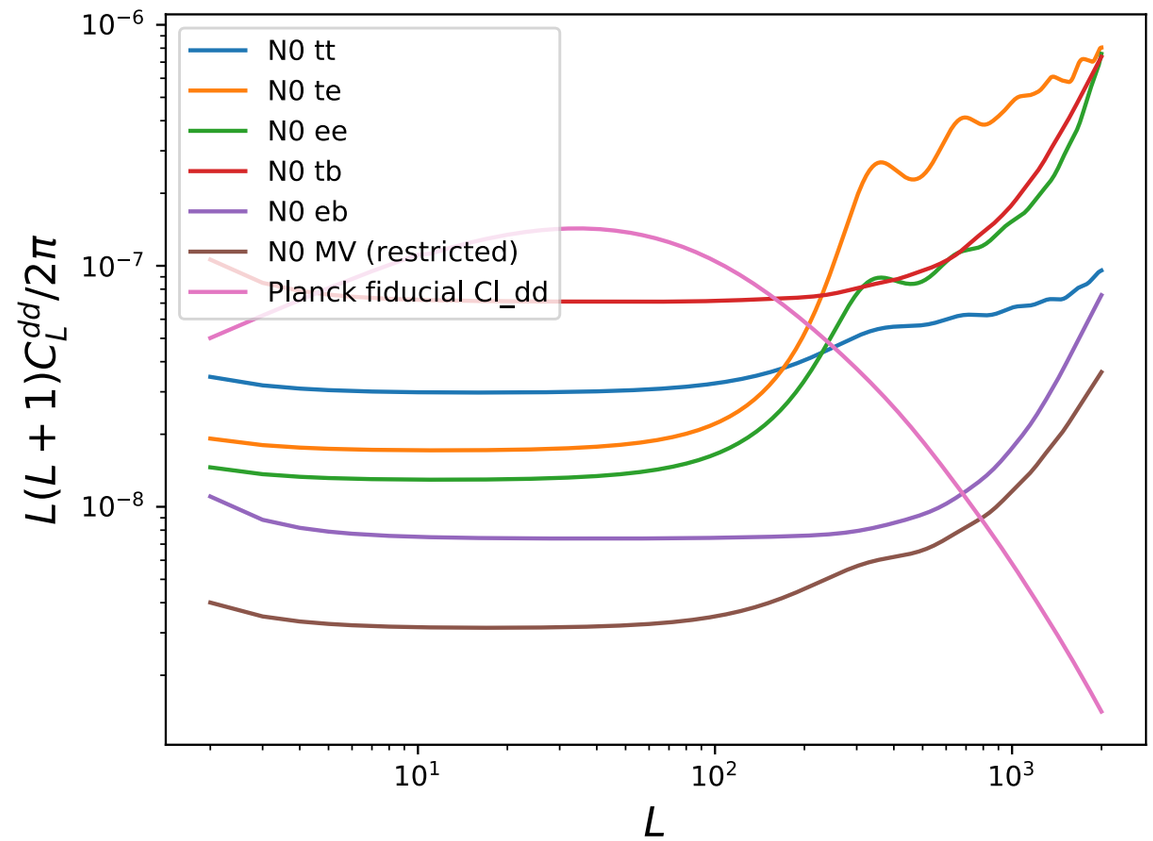
$$C_\ell^{\delta_i^g,\delta_j^g}, \quad C_\ell^{\delta_i^g,\kappa_{CMB}}, \quad C_\ell^{\kappa_{CMB},\kappa_{CMB}}.$$

- Fisher matrix: $(F)_{i,j} = \sum_\ell \frac{\partial C_\ell}{\partial \lambda_i} \boldsymbol{C}^{-1} \frac{\partial C_\ell}{\partial \lambda_j},$
- Tomography in ten bins of redshift.
- Galaxy bias fixed but evolving with redshift.
- Gaussian likelihood, covariance takes into account:
  - Shot noise and sky coverage of the Euclid survey.
  - Noise from Planck CMB lensing reconstruction (N0 bias).
- Lmin = 20, Lmax = 300, keep only large scales to avoid non linear effects.

TWO CASES OF CMB LENSING

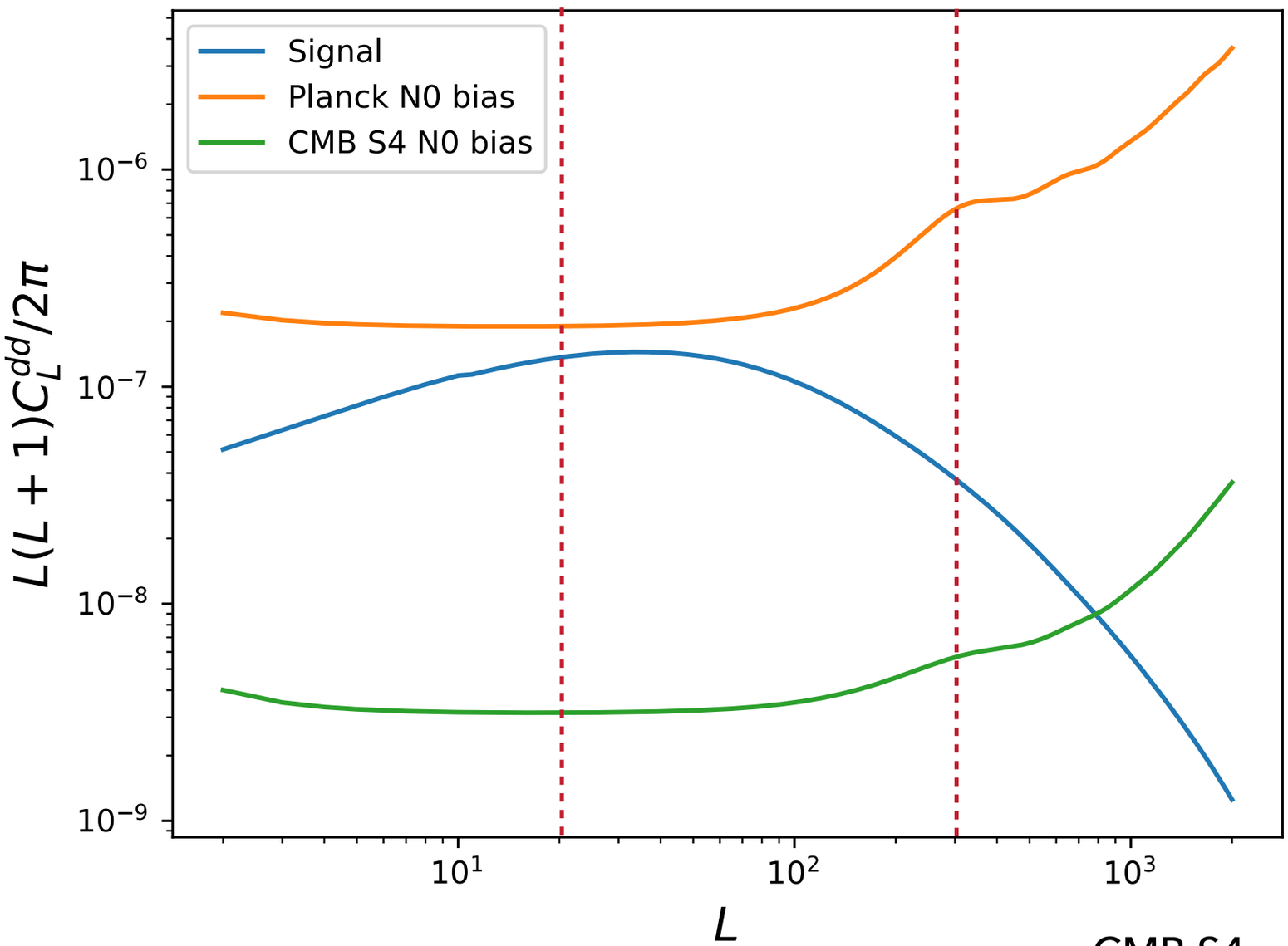


Noise = 49 muK.arcmin
Theta_fwhm = 7 arcmin



Noise = 1 muK.arcmin
Theta_fwhm = 4 arcmin

TWO CASES FOR CMB LENSING

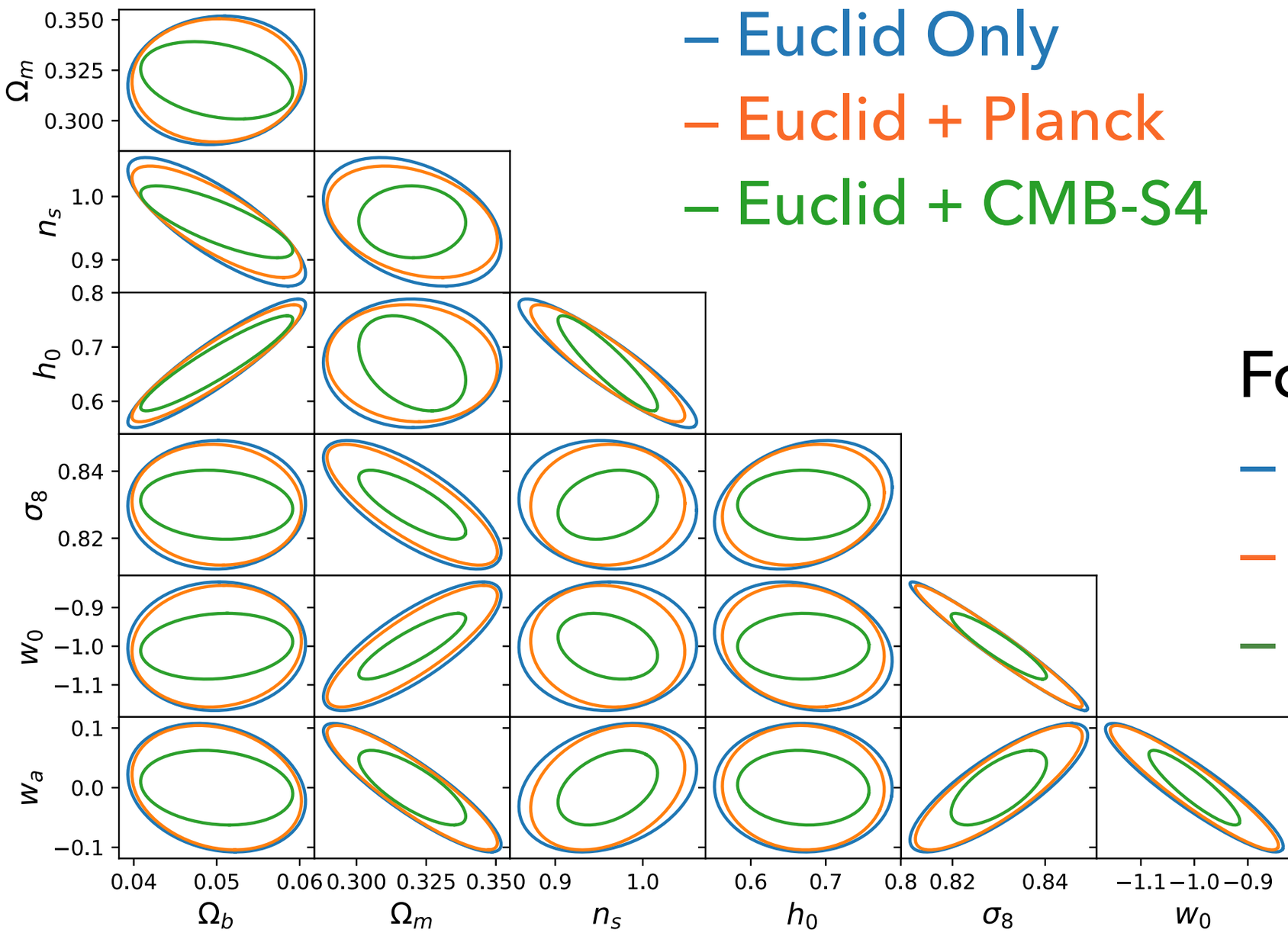


Planck:
Noise T = 49 muK.arcmin
Theta_fwhm = 7 arcmin

CMB S4:
Noise T = 1 muK.arcmin
Theta_fwhm = 4 arcmin

FISHER FORECASTS

Varying parameters : $\Omega_b, \Omega_m, n_s, h_0, \sigma_8, w_0, w_a$



– Euclid Only

– Euclid + Planck

– Euclid + CMB-S4

FoM of w0 - wa :

– 314

– 372

– 957

PERSPECTIVES

- Compare code to what is done in the working group in terms of lensing.
- Let free and marginalise over systematic parameters, like the bias.
- Develop the code to model more subtle effects, like non linearities.

THANK YOU FOR YOUR ATTENTION

BACKUP – PROBE COMBINATION

$$C_l^{gg} = \frac{2}{\pi}\int_0^\infty dk k^2 P(k) W_l^g(k) W_l^g(k)$$

$$C_l^{\kappa g} = \frac{2}{\pi}\int_0^\infty dk k^2 P(k) W_l^\kappa(k) W_l^g(k)$$

$$W_l^g(k) = \int_0^\infty d\chi \chi^2 \bar{n}_g(\chi) w(\chi) b_g(\chi) D_{\delta m}(\chi) j_l(k\chi)$$

$$W_l^\kappa(k) = \frac{3\Omega_{m,0}}{2}\left(\frac{H_0}{c}\right)^2 \int_0^\infty d\chi \frac{\chi}{a(\chi)} \frac{\chi_* - \chi}{\chi_*} D_{\delta m}(\chi) j_l(k\chi)$$

$$\mathrm{Cov}\left(C_{\ell_1}^{a,b}, C_{\ell_2}^{c,d}\right) = \frac{\delta_{\ell_1}^{\ell_2}}{f_{sky}(2\ell_1+1)\Delta\ell_1} \times \left[\left(C_{\ell_1}^{a,c} + \delta_c^a N_{\ell_1}^a\right)\left(C_{\ell_2}^{b,d} + \delta_d^b N_{\ell_2}^b\right) + \left(C_{\ell_1}^{a,d} + \delta_d^a N_{\ell_1}^a\right)\left(C_{\ell_2}^{b,c} + \delta_c^b N_{\ell_2}^b\right)\right]$$