Approximation of Cross-correlations between Galaxy Clustering spectroscopic and Photometric probes

Fabien DOURNAC

Supervised by Alain BLANCHARD

IRAP/Université Paul Sabatier

Ateliers Dark-Energy - May 20th, 2020

Outline

I. Recall : Galaxy Clustering (GC) spectro and Photometric probes (GC and WL)

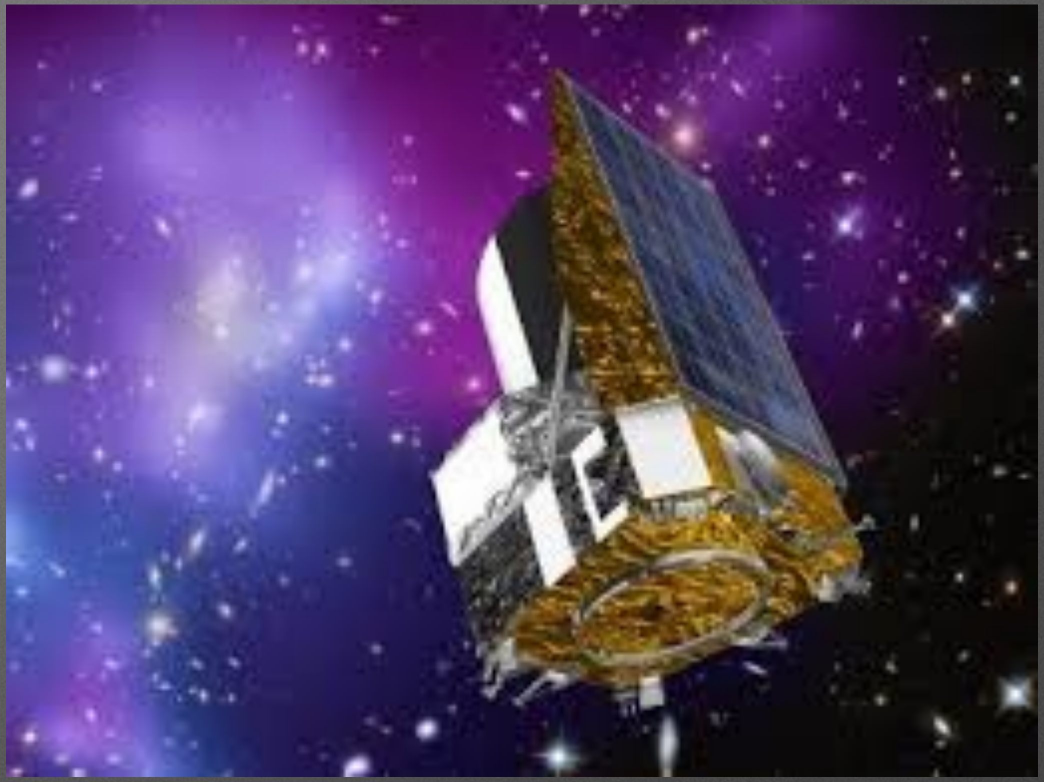
II. Methodology of our study in EUCLID survey

III. Results

IV. Conclusion

Recall : Galaxy Clustering (GC) spectro and Photometric probes (GC and WL)

- 3 Primary cosmological probes for EUCLID survey :
  - Galaxy Clustering Spectro (GCsp) probe : 3D distribution of galaxies
  - Photometric probes : 2D distribution
    - Galaxy Clustering Photo (GCph)
    - Weak lensing (WL)



Credits : CNES

⇒ Determining the Dark Energy E.o.S by Chevallier-Polarski-Linder (CPL) parametrization :

$$w(z) = w_0 + w_a \frac{z}{1+z}$$

- Goal : Reach at least a dark energy Figure of merit (FoM) > 400.

- How to get constraints on different cosmological parameters without experimental data ? By Forecast and Fisher formalism

- Forecast = estimating the performances of a future experiment for which data aren't yet available (Fisher 1935).

- 2 approaches :

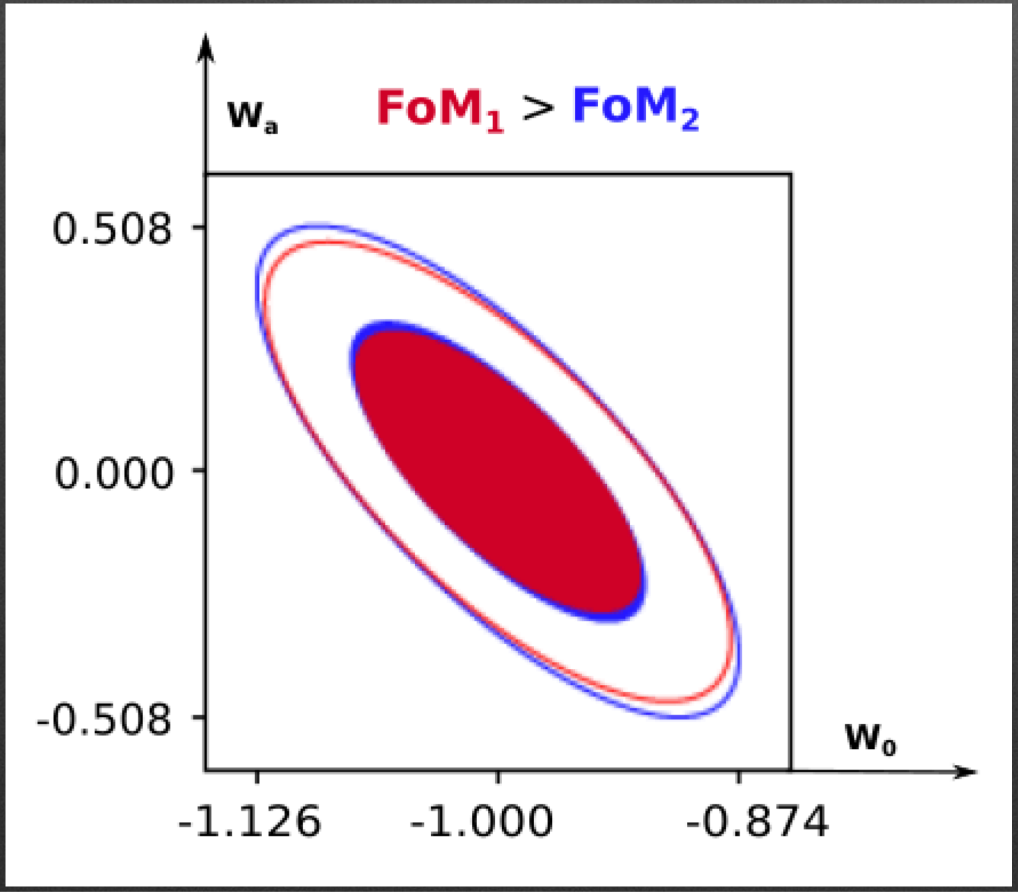
  - Fisher formalism [fast doesn't need any data but limited].

  - Monte Carlo Markov Chain (MCMC) [slow, performing at low or average dimensions problem. More tricky at high dimensions].

⇒ Here in our study, we consider only Fisher formalism for GCsp, GCph and WL probes

Recall : Galaxy Clustering (GC) spectro and Photometric probes (GC and WL)

- The Fisher matrix represents information on all cosmological parameters and their interdependence
- The Covariance matrix is by definition equal to the inverse of the Fisher matrix: we can therefore deduce the variance of a parameter and the covariance between 2 parameters
- Performance criterion - Figure of Merit (FoM): evaluates the accuracy on the uncertainties proportional to the inverse of the area of the contours on the parameters (w_0, w_a)



- Filled disk : 1σ C.L
- Contour : 2σ C.L

$\Longrightarrow$ In our study, FoM computed by :

- SpecSAF code for GCsp
- XSAF code for GCph, WL and cross-correlations (3x2pt)

Methodology of our study in EUCLID survey

- GCsp covers a range

  $0.9 < z < 1.8$

  with 4 bins spectro ⇒

```
z_bins = [
    [0.9, 1.1],
    [1.1, 1.3],
    [1.3, 1.5],
    [1.5, 1.8],
]
```

- GCph covers $0.001 < z < 2.5$

  with 10 bins photo ⇒

```
z_bins = [
    [0.001, 0.418],
    [0.418, 0.560],
    [0.560, 0.678],
    [0.678, 0.789],
    [0.789, 0.900],
    [0.900, 1.019],
    [1.019, 1.155],
    [1.155, 1.324],
    [1.324, 1.576],
    [1.576, 2.500],
]
```

- Principle of our analysis : we sample GCsp and GCph on a same volume. One takes the same bin of z for photometric/spectro to get rid off the Dark Matter Power Spectrum, so biais ratio is constant (ratio chosen here = 1) :
  - at $z = z_1 : P_{gal,sp}(k,z) = b_1^2 P_{DM}(k,z)$
  - at $z = z_2 : P_{gal,ph}(k,z) = b_2^2 P_{DM}(k,z)$

$$\Rightarrow \left\{ \frac{P_{gal,sp}}{P_{gal,ph}} = \left(\frac{b_1}{b_2}\right)^2 = constant = 1 \right.$$

⇒ We can start from $z = 0.9$ for the 2 probes

⇒ Need to apply a split for GCph at $z = 1.8$ to get a common interval : one creates a 11th photo bin and a 5th spectro bin ⇒ Finally, remains 5 bins (and so 5 bias)

Results

- FoM in Pessimistic/Optimistic cases :

    - Gain factor about 30% and 50% FoM in Pessimistic/Optimistic cases

⇒ Finally, our approach improves significantly the Figure of Merit

⇒ Actually, this study is a first step into the synthesis of cross-correlation between photo and spectro since we still don't know how to do cross-correlations between GCsp and Photometric probes (2D + 3D)

1) New specifications • Bias independent : (5 bias spectro) : GCs + (GCp + WL + XC)	FoM (Pessimistic/Optimistic)	571.35	1239.43
2) Unique bias : • Bias dependent : 5 last before bias photo in extended case (11) = 5 bias spectro : same variables GCs + (GCp + WL + XC)	FoM (Pessimistic/Optimistic)	781.09	1565.86

Results

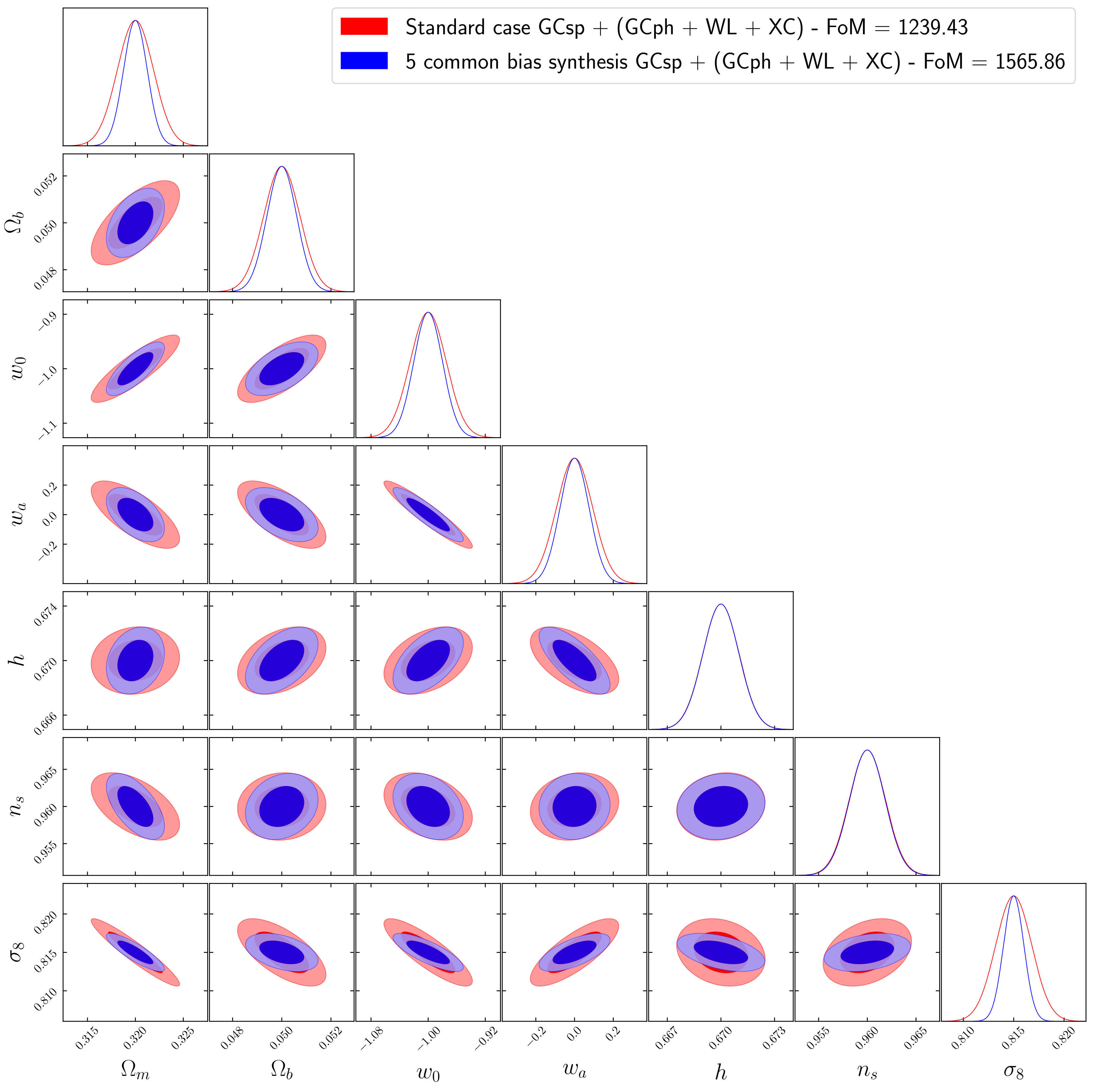
- Triplot showing joint distribution and Likelihood :

- can notice anti-correlation for (w_0, w_a)

- Hubble constant very well constrained

- For some joint parameters, useful information :
  For example (Ω_m, σ_8)

- For some joint parameters, useless information :
  For example (h, n_s)

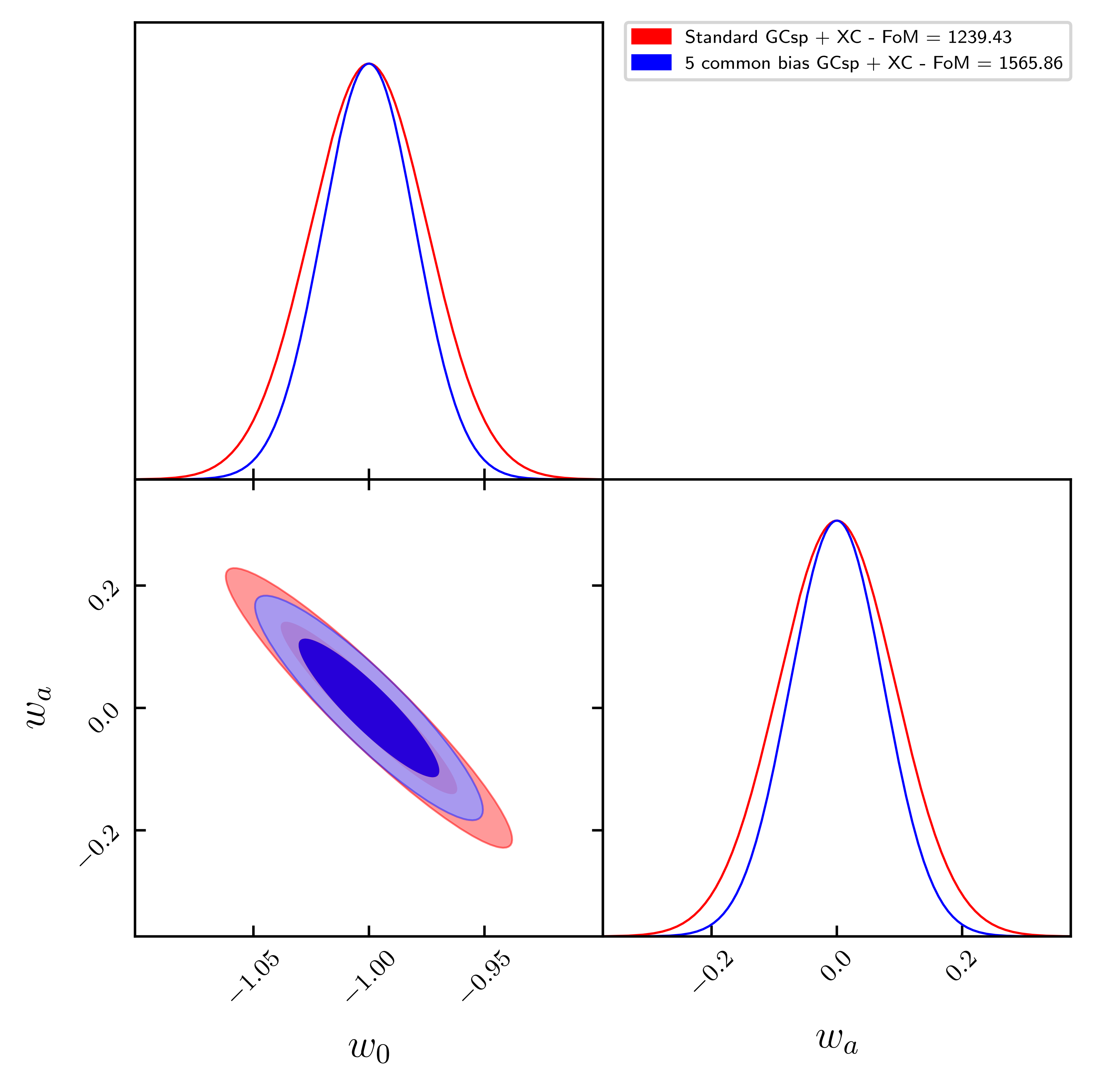


Results

- One single plot showing joint distribution and Likelihood for (w_0, w_a) : Optimistic case

- Compensation effect for (w_0, w_a) :

  $\Rightarrow$ when w_0 decreasing, w_a increasing and inversely



Conclusion

- We present here a way to get an approximation of what could be the cross-correlations between spectroscopic Galaxy Clustering and Photometric probes

- Similarities with Multi-tracers approaches : ratio of bias can be fixed or depending of different populations or samples. We can say this is a multi-tracers study with angular probes

- This method should be integrated in future survey to obtain the approximation of combination Spectro/Photo probes since FoM is improved by ~ 30 up 50 %