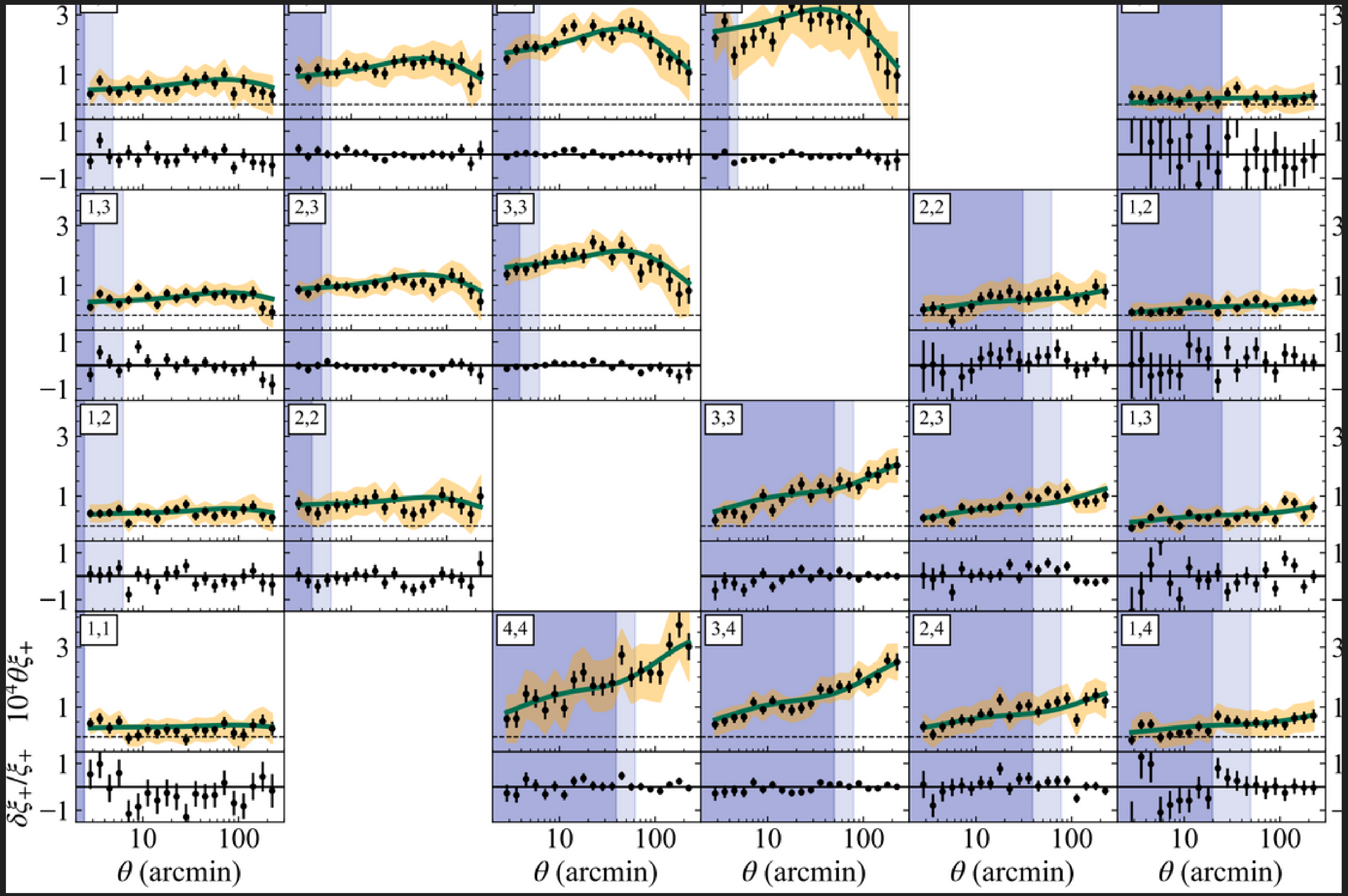
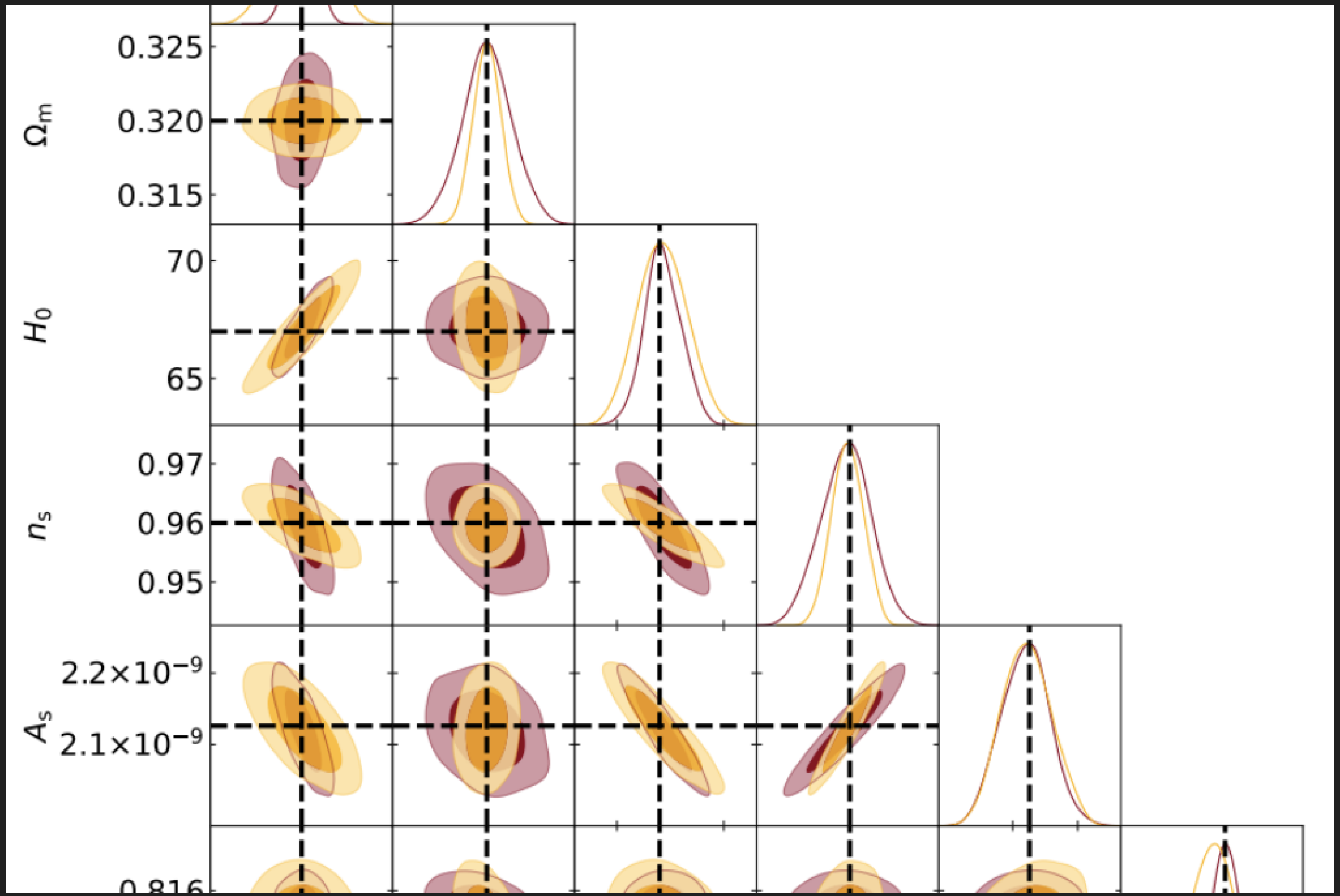
IST:Likelihood
Status of the likelihood code

Vincenzo F. Cardone

From Euclid Data to Constraints

why do we need a likelihood code





Photometric + Spectroscopic Data

- 3x2pt (pseudo - Cl and/or 2pCFs and/or COSEBIs)
- GCsp (Legendre multipoles and/or 2pCF)
- beware of systematics

Constraints on Cosmological Parameters

- dark energy equation of state (FoM > 400)
- dark matter properties and initial conditions
- General Relativitity vs Modified Gravity

Boltzmann Module

Background quantities

Matter power spectrum

Theory Module

Theoretical predicions for

WL + GCp + XC + GCs

Sampling and Analysis

Sampler

Parameters constraints

Model comparison

Data Module

WL + GCp + XC + GCs data

Covariance matrices

Likelihood Module

Theory vs data

Posterior and priors

What is inside a likelihood code

IST:Likelihood - Inter SWG Taskforce for Likelihood

A.G. SANCHEZ

on behalf of GC - SWG
(up to 04/2021)

S. JOUDAKI

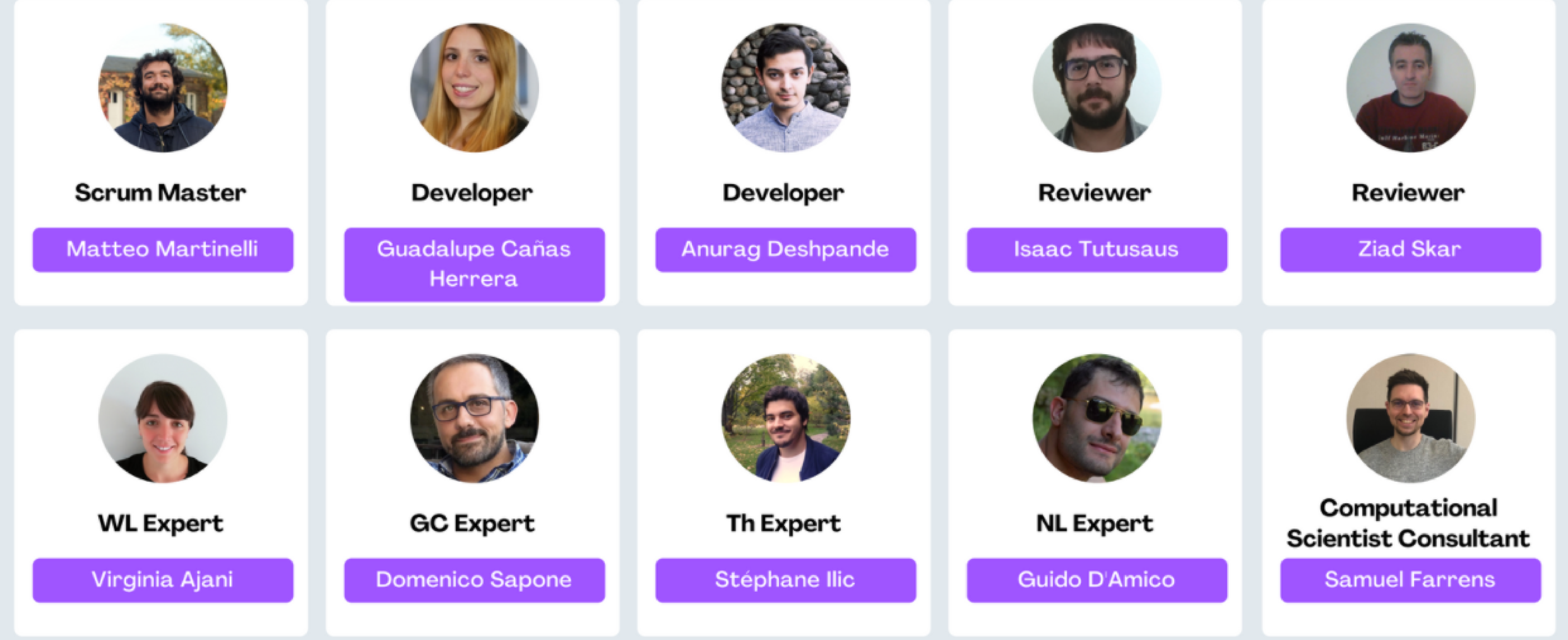
on behalf of GC - SWG
(from to 04/2021)

V. PETTORINO

on behalf of Theory - SWG

V.F. CARDONE

on behalf of WL - SWG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CLOE: Cosmology Likelihood of Observables in Euclid

CONCEPT

- structure the code in modular blocks
- individuate what is needed for each
- interact with people providing input
- close connection with nonlinear part
- interface with other SWGs codes

RECIPE

- which observables must be considered
- how to go from theory to observables
- how to account for systematics
- what are the input quantities
- what are the output quantities

DATASET

- 3x2pt
  - 2pCF and COSEBIs
  - Pseudo - Cl and band powers
- GCsp
  - Legendre multipoles

LIKELIHOOD

- covariance matrix as external input
- (see C. Giocoli talk)
- different likelihood expressions
  - Gaussian vs non Gaussian
  - depending on the covariance

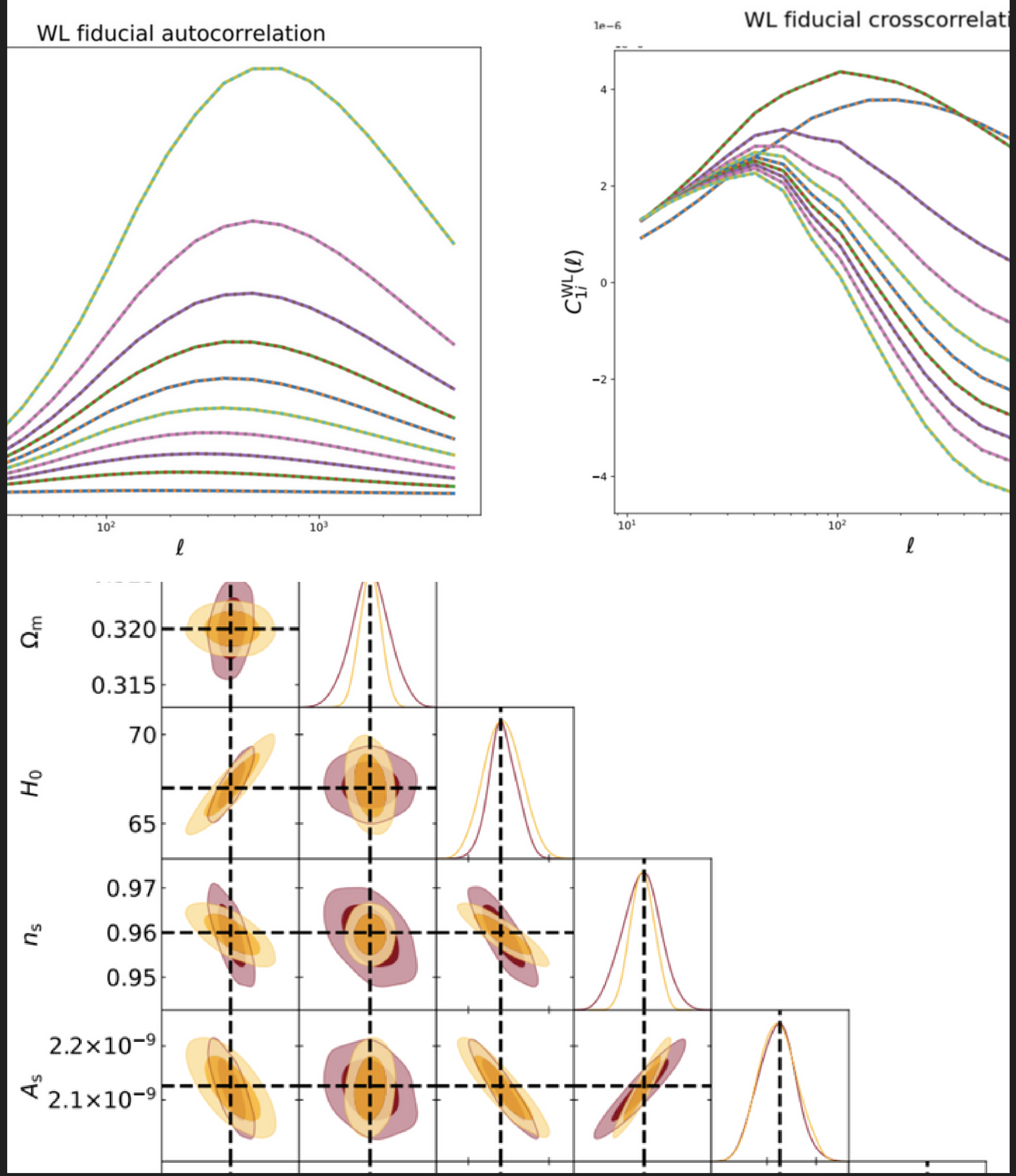
CLOE v1.0 delivered to EC on May 2021

$$C_{ij}(\ell) = \int_0 \frac{\ldots}{H(z) f_K^2[r(z)]} P_{mm}(k_\ell, z) dz$$

$$C_{ij}^{\gamma I}(\ell) = \int_0^{z_h} \frac{\mathcal{W}_i^{\gamma}(\ell,z)\mathcal{W}_j^{IA}(\ell,z) + \mathcal{W}_j^{\gamma}(\ell,z)\mathcal{W}_i^{IA}(\ell,z)}{H(z) f_K^2[r(z)]} P_{mI}(k_\ell, z) dz$$

$$C_{ij}^{II}(\ell) = \int_0^{z_h} \frac{\mathcal{W}_i^{IA}(\ell,z)\mathcal{W}_j^{IA}(\ell,z)}{H(z) f_K^2[r(z)]} P_{II}(k_\ell, z) dz$$

$$\begin{aligned} C_{ij}^{\gamma,RSB}(\ell) &= \frac{(\ell+2)!}{(\ell-2)!} \frac{\ell(\ell+1)}{(\ell+1/2)^6} \\ &\times \int \frac{d^2\ell'}{(2\pi)^2} \cos(2\phi_{\ell'} - 2\phi_\ell) \\ &\times \left\{ [2(1+\alpha_i^{eff}(z)] B_{iij}^{\kappa\kappa\kappa}(\ell, \ell', -\ell-\ell') \right. \end{aligned}$$



RECIPE

- linear matter power spectrum
- eNLA model for IA
- Gaussian only covariance
- Gaussian likelihood

VALIDATION

- comparison against benchmark for
  - 3x2pt auto and cross spectra
  - Legendre multipoles
- speed test and profiling

MCMC TEST

- observables
  - WL + GCph spectra
  - Legendre multipoles
- recovering input cosmology

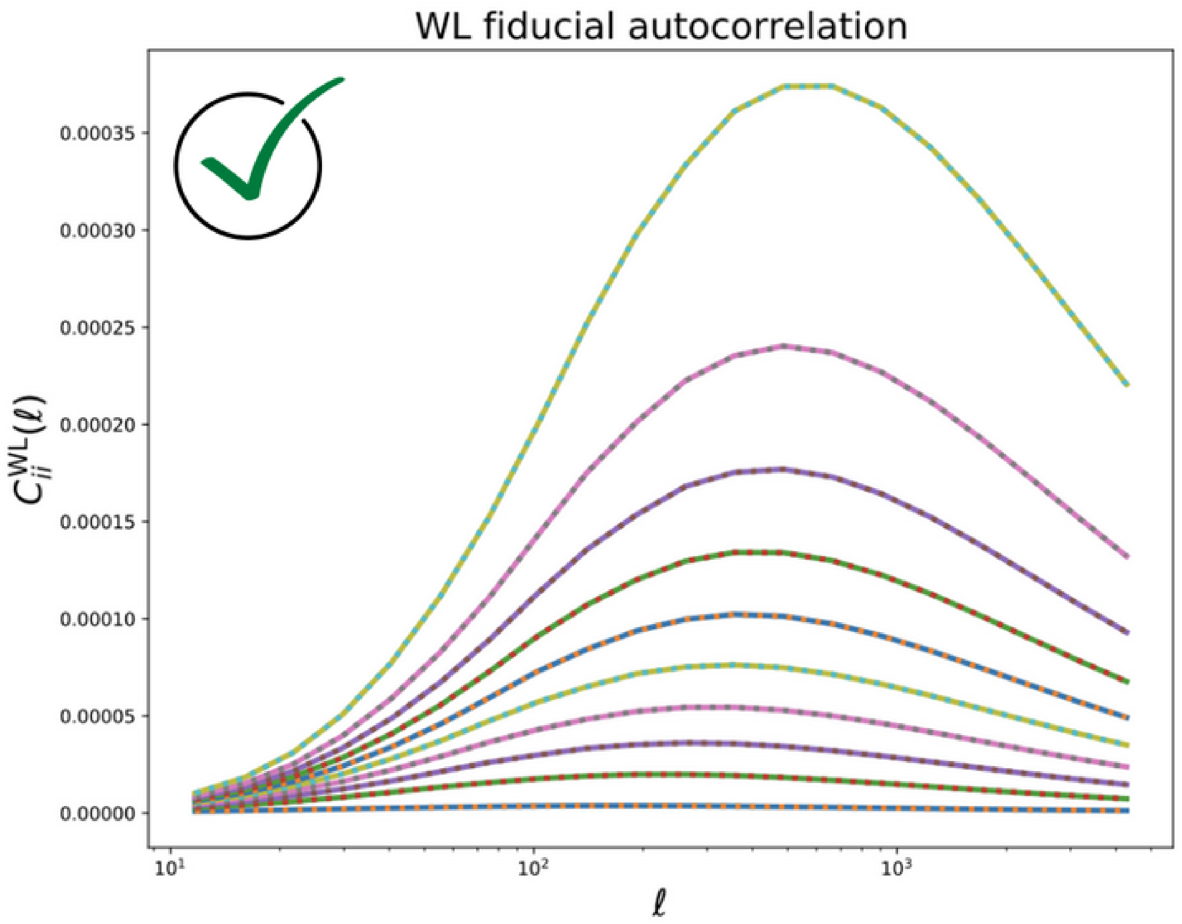
PHOTOMETRIC

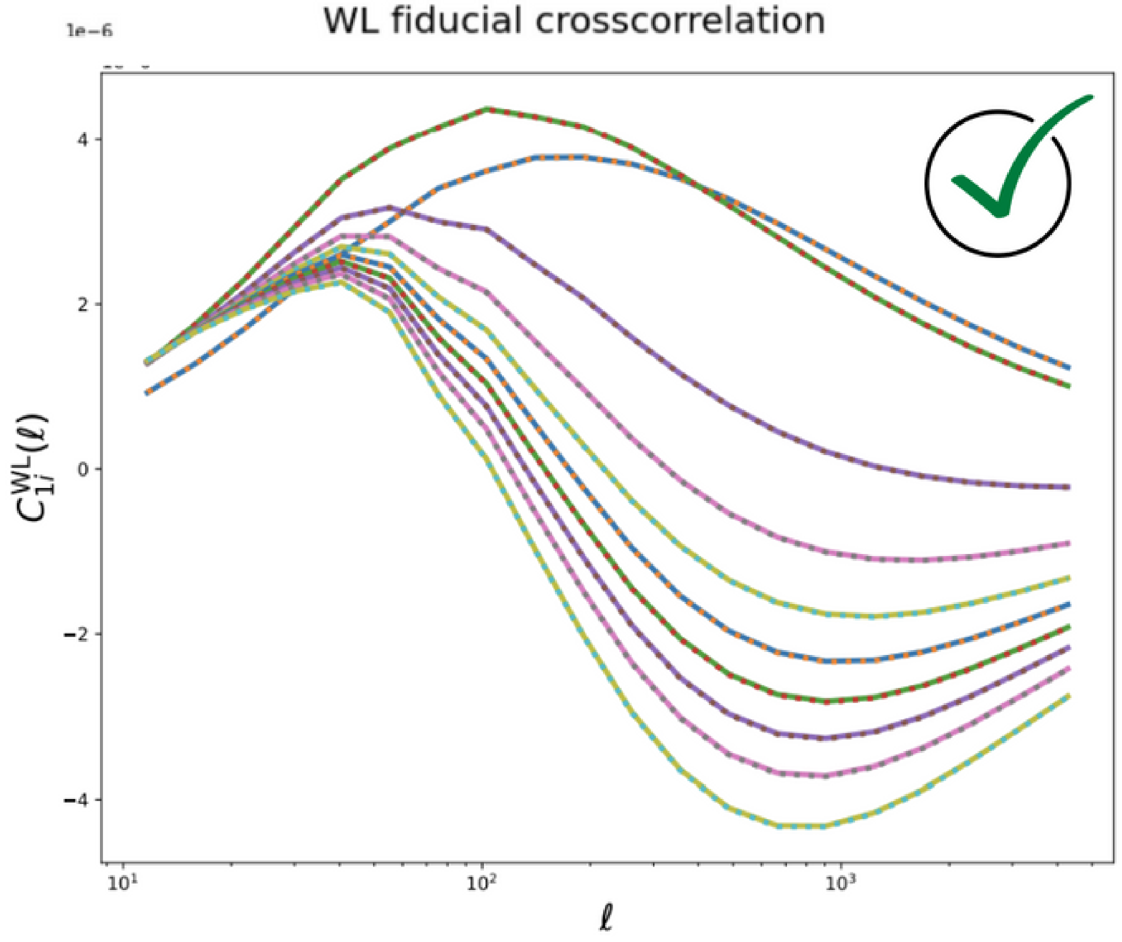
rely on external benchmarks

WL within 0.2 - 1%

GCph within 1 - 2%

WL x GCph within 1 - 2%



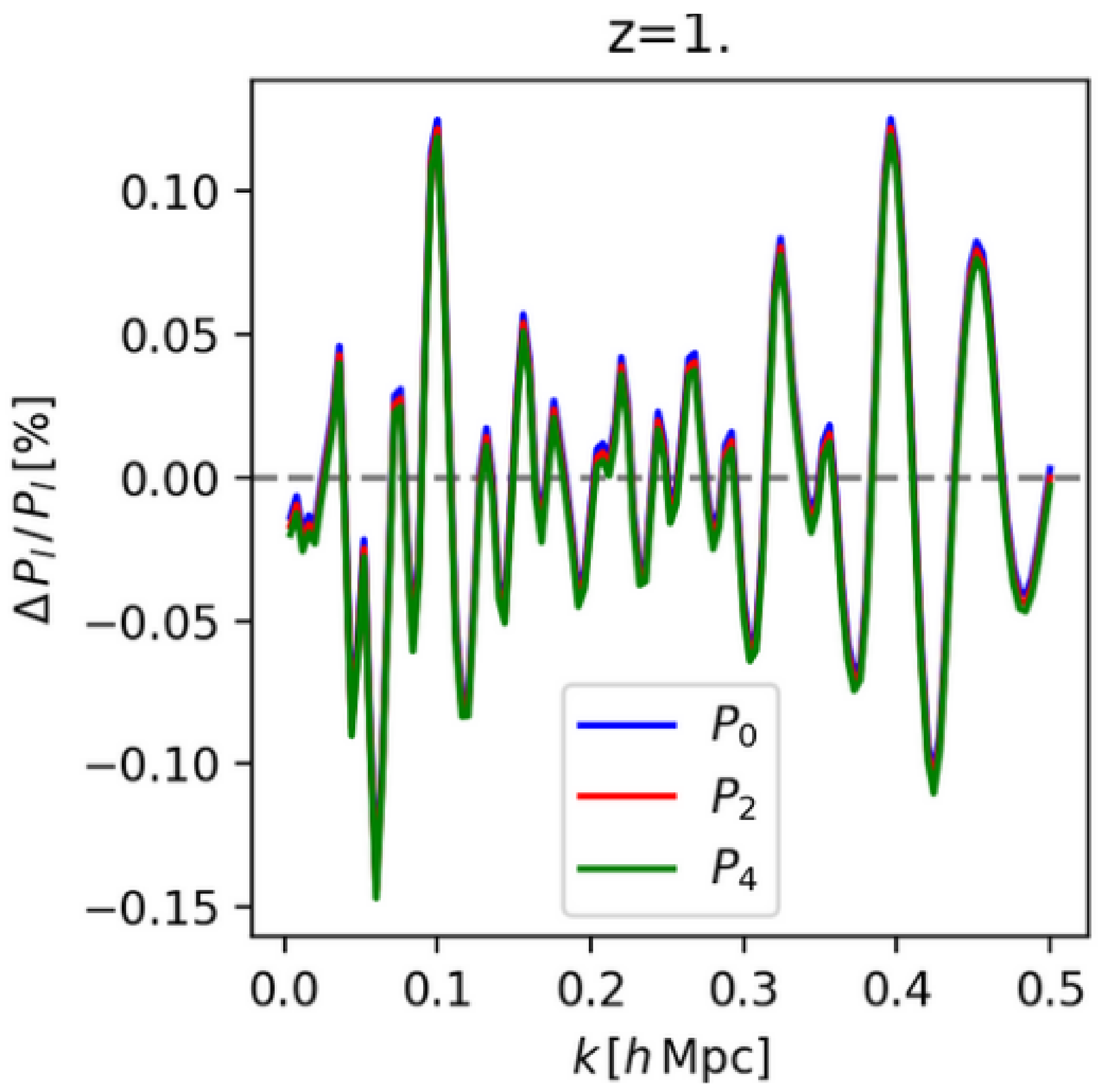


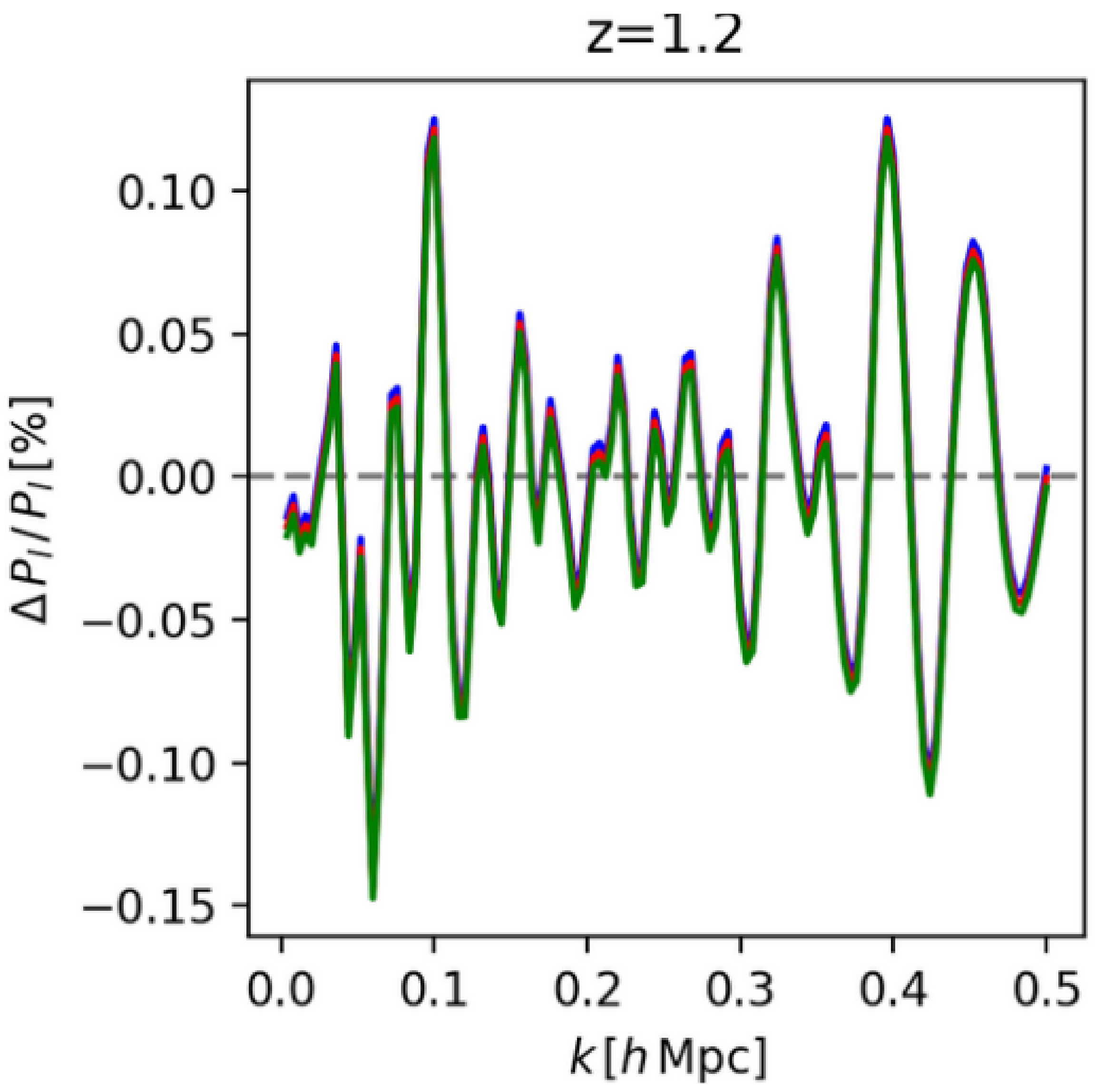
SPECTROSCOPIC

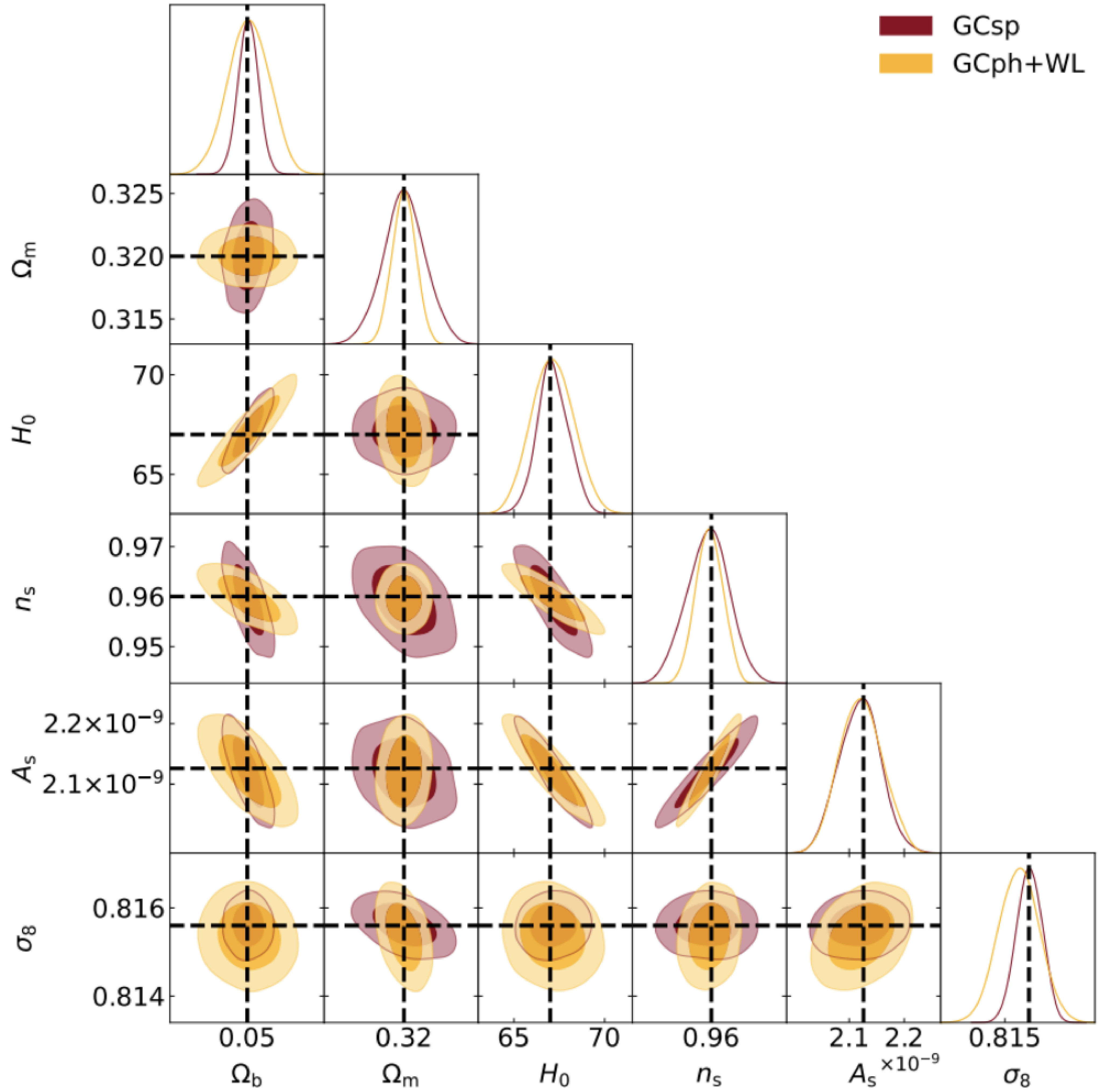
rely on external benchmarks

GCsp within 0.1%

(slower than 3x2pt)







MCMC TEST

photometric probes only

spectroscopic probes only

WL + GCph + GCsp

mock data with no noise

Gaussian covariance

unbiased estimate of parameters

CLOE v1.1

NEW USER INTERFACE

- run as executable and interactively
- use command - line arguments
- read yaml files with settings
- interface with CAMB/CLASS
- embedded in Cobaya

MASKING VECTOR

- composed by 1s and 0s
- mapping with the data vector
- first choose which probes to be used
- scale cuts in separate yaml files
- cut data vector and covariance

INTERFACE WITH IST:NL

- added nonlinear flags
- HaloFit and HMCode from Cobaya
- boost factors from emulators
- defined nuisance parameters files
- skipping CAMB for liner if needed

CODE OPTIMIZATION

- continuous integration
- revised unit tests
- updated API documentation
- fixed bugs in v1.0
- recoded some parts for speeding up

Scrum Master

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Developer

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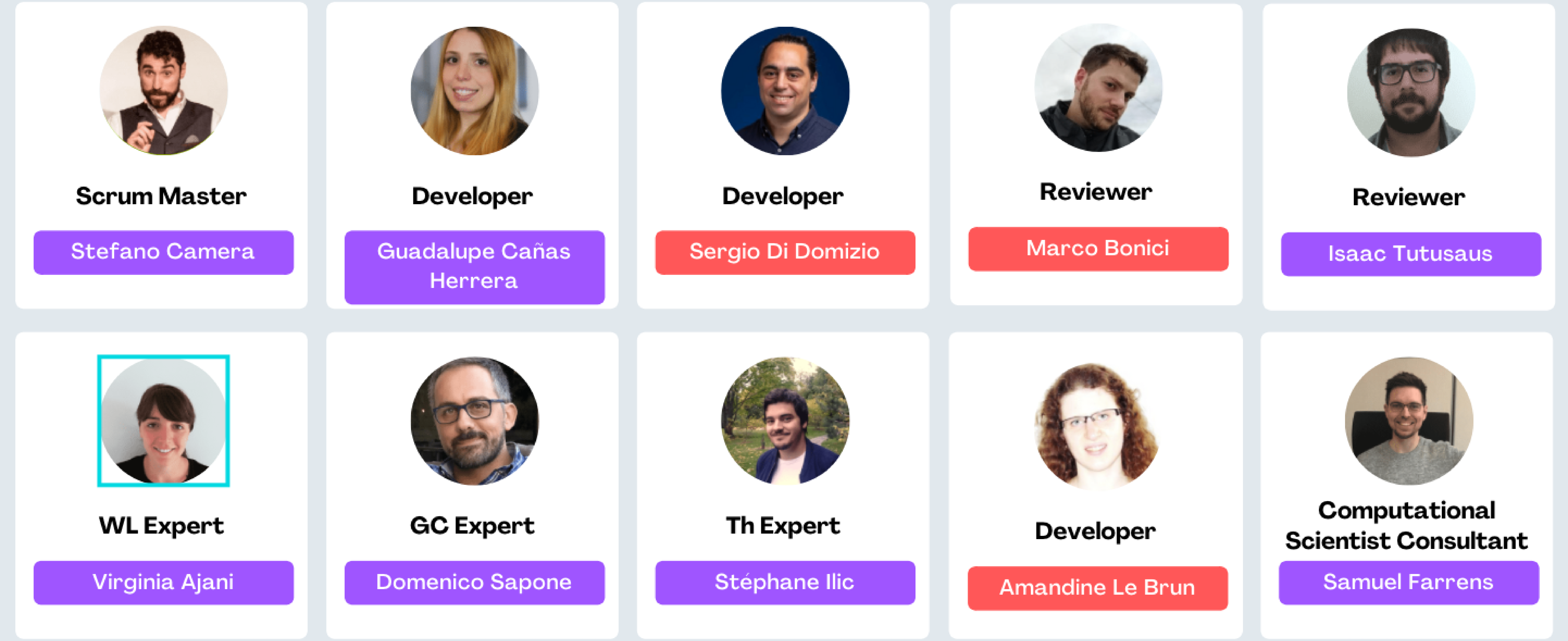
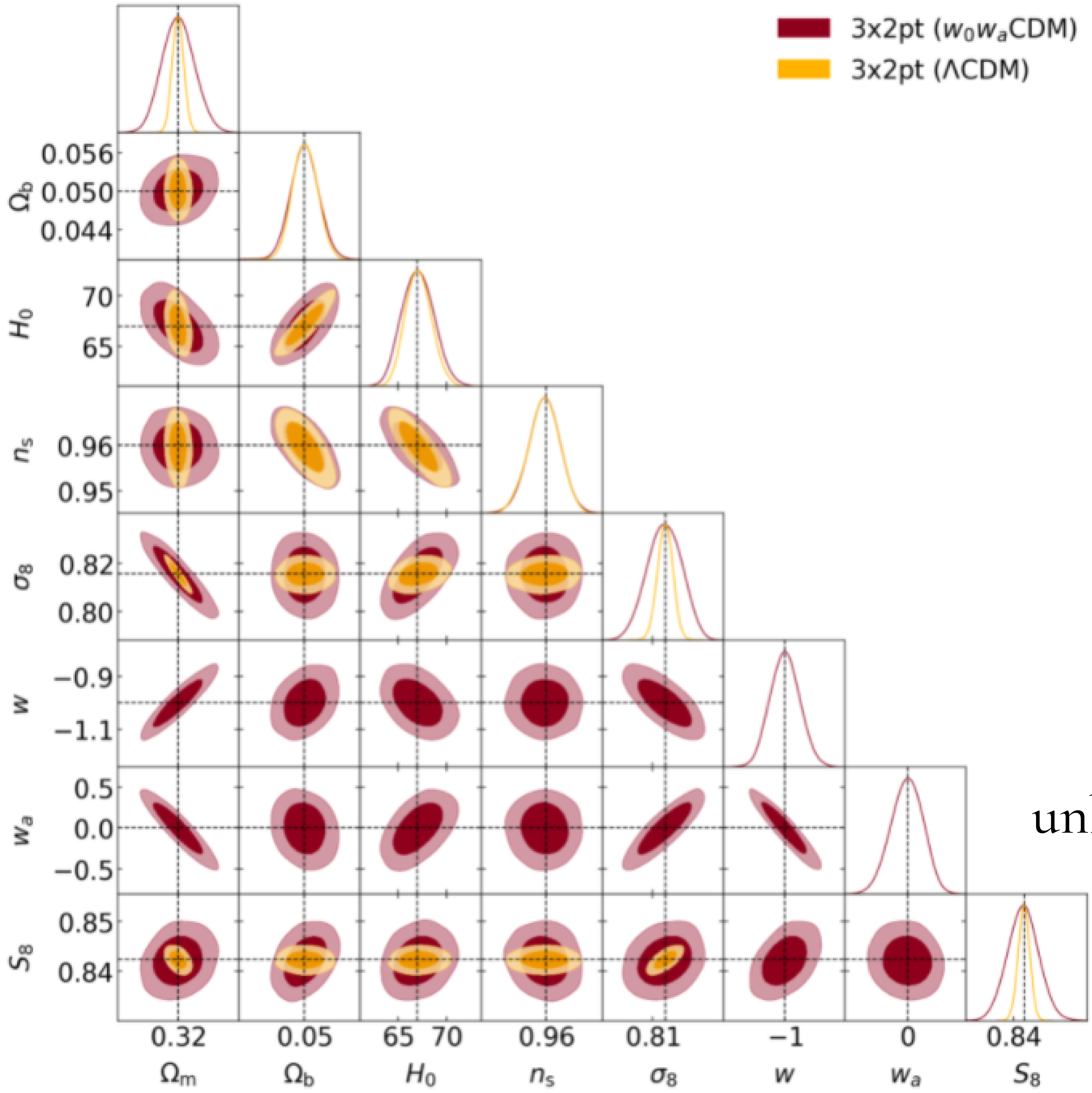


Mare Nostrum Team



MCMC TEST

photometric probes only

spectroscopic probes only

WL + GCph + GGL + GCsp

fixed and free nuisance parameters

LCDM and wowaCDM model

same recipe and covariance as v1.0

unbiased recovery of the input parameters

From v1.1 to v2.0

UPDATED RECIPE FOR PHOTOMETRIC PROBES

- include magnification bias into GCph and GGL
- account for Redsfhift Space Distortion in GCph and GGL
- move to nonlinear recipe and improved IA modelling
- allow for different n(z) for lens and source samples
- include multiplicative shear and photo - z systematics

MORE REALISTIC OBSERVABLES

- 2pCFs in configuration space
- Pseudo - Cl in harmonic space
- n(z) from OU-PHZ group
- Gaussian + Super Sample Covariance
- scale cuts to avoid bias from baryon contamination

TO BE USED FOR SPV3 AND KEY PROJECTS

- adopt SPV3 specifics for both photo and spec probes
- MCMC based forecasts for standard models (by IST:L)
- MCMC based forecasts for extended models (by other SWGs)

From v1.1 to v2.0

UPDATED RECIPE FOR PHOTOMETRIC PROBES

- non flat models
- magnification bias
- redshift space distortion
- shear multiplicative bias
- photo - z systematics

MORE REALISTIC OBSERVABLES

- 2pCFs in configuration space for 3x2pt
- Pseudo - Cl in harmonic space
- GCsp 2pCF in redshift space
- Gaussian + Super Sample Covariance
- scale cuts to avoid bias from baryon contamination

TO BE USED FOR SPV3 AND KEY PROJECTS

- adopt SPV3 specifics for both photo and spec probes
- MCMC based forecasts for standard models (by IST:L)
- MCMC based forecasts for extended models (by other SWGs)

The Importance of Choosing the Right Likelihood Code

Disclaimer: no money has been given to the speaker for the advertising the shop mentioned in the picture