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DI ASTROFISICA

Non:linear Modelling:
Weak Lensing Simulations

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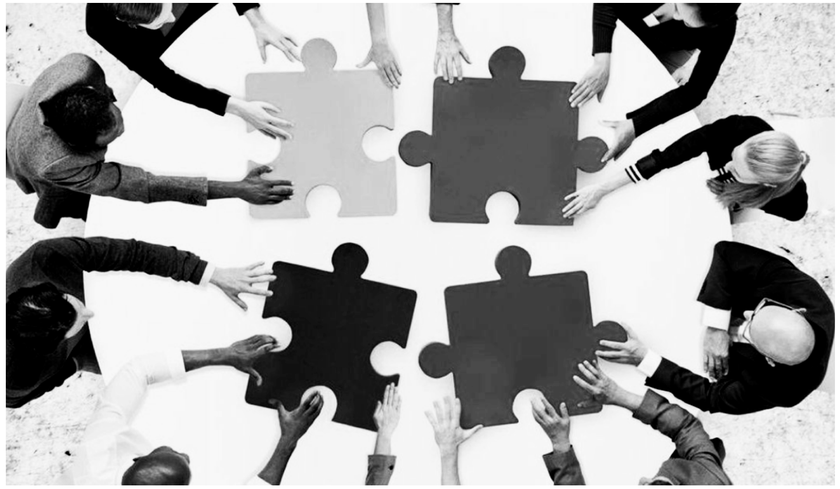
euclid consortium

Euclid meeting Italia 2022

Carlo Giocoli - INAF OAS Bologna

IST:NL team

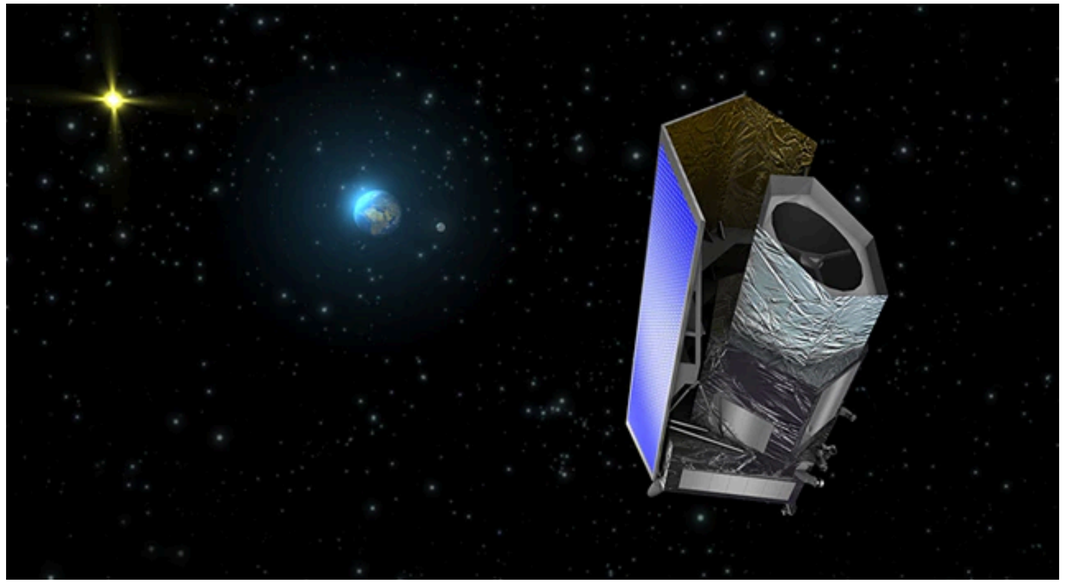
Dedicated simulations

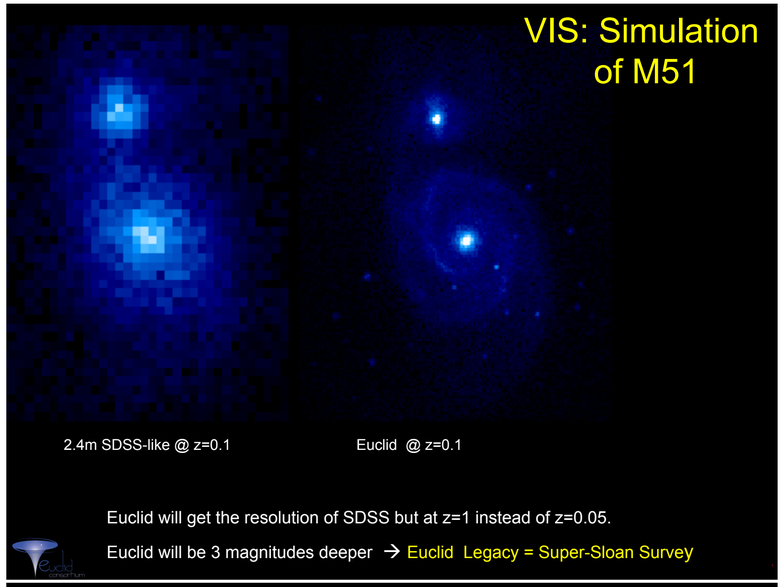


25-02-2022

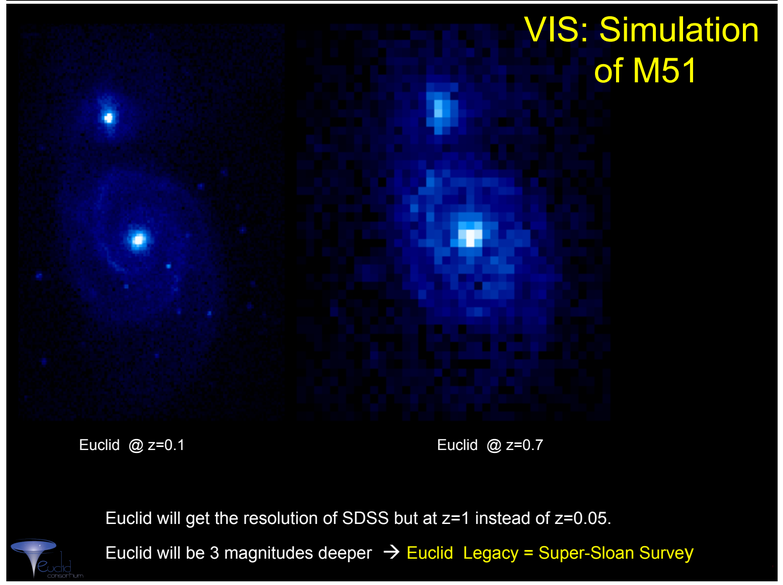
M. Bonici, S. Camera, C. Carbone, V. F. Cardone, M. Martinelli D. Sciotti …

Weak Lensing from Space Observatories





courtesy of Miller



approximately 30 gal/arcmin^2
15.0000 deg^2
the peak of the source redshift distribution will move toward redshift z~1;
large sample of tomographic bins for weak lensing analyses.

- improve cosmological constraints
- trace the growth of structures
- dark energy equation of state
- eventually look for new physics

Laureijs et al. 2011

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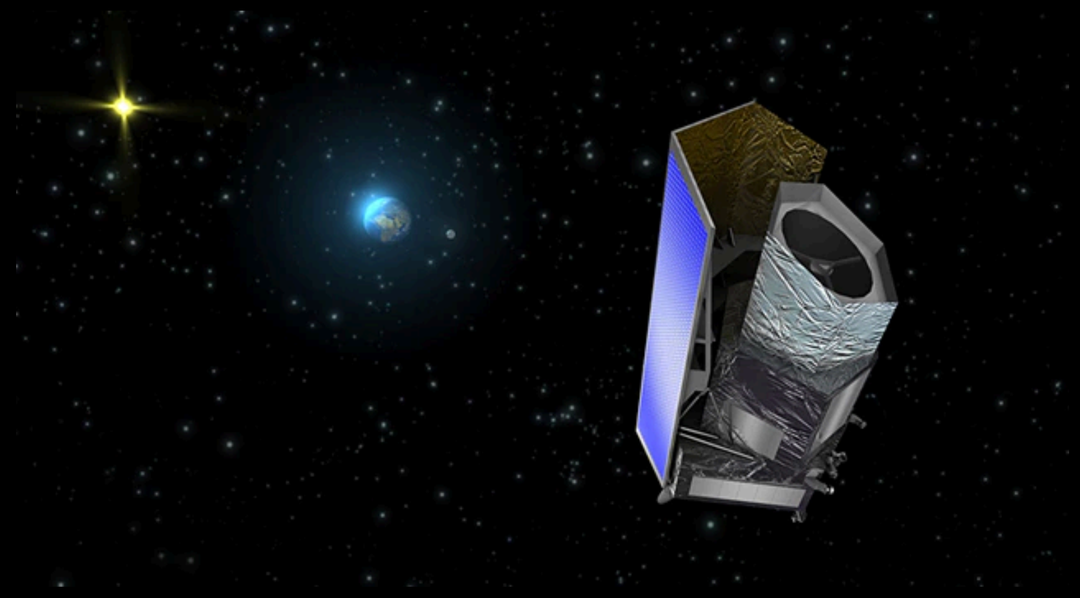

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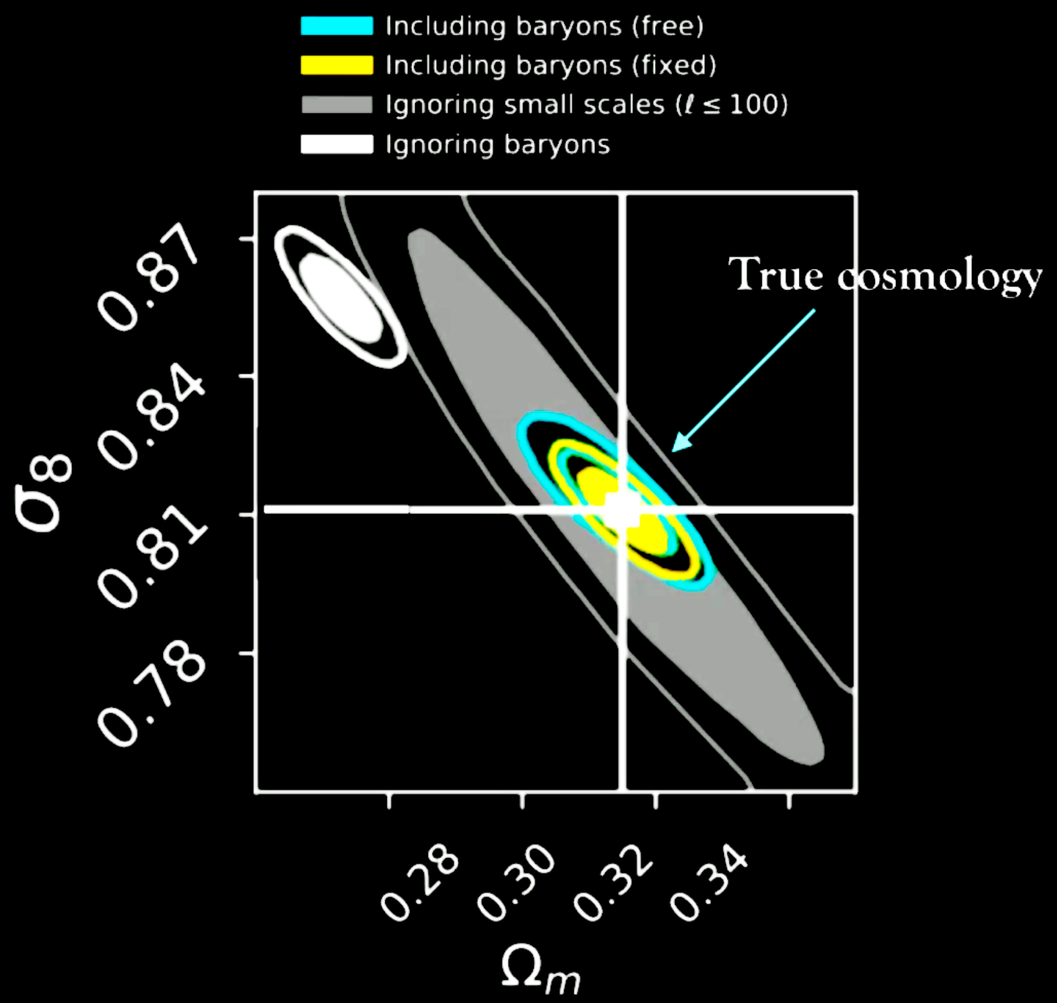

Forecasts by A. Schneider et al (2020)

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Non:linear Modelling

Full cosmological exploitation of observational data we need

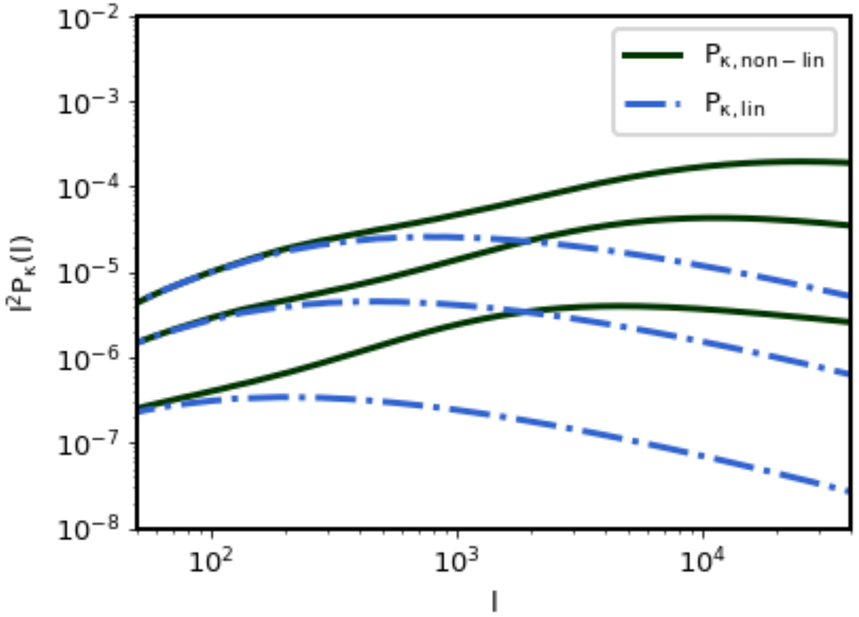
Theoretical models for the non-linear power spectrum

in the Limber and Born approximation regimes and sources at a given redshift z_s:

2D →

$$P_\kappa(l) = \frac{9H_0^4\Omega_{\rm m}^2}{4c^4}\int_0^{w_s} {\rm d}w \left(\frac{D(z,z_s)}{D(z_s)a(z)}\right)^2 P_\delta\left(l\frac{a(z)}{D(z)}, z\right)$$

← 3D non-linear



for the three-dimensional matter power spectrum:

- Models (Halofit, HM-Code, EuclidEmulator, Bacco etc.)
- Perturbation theory
- Halo Model & extended versions
- accurate numerical simulations (with baryons, beyond the standard model etc.) based on N-Body solvers
- approximate methods (COLA, Pinocchio, Patchy ...)

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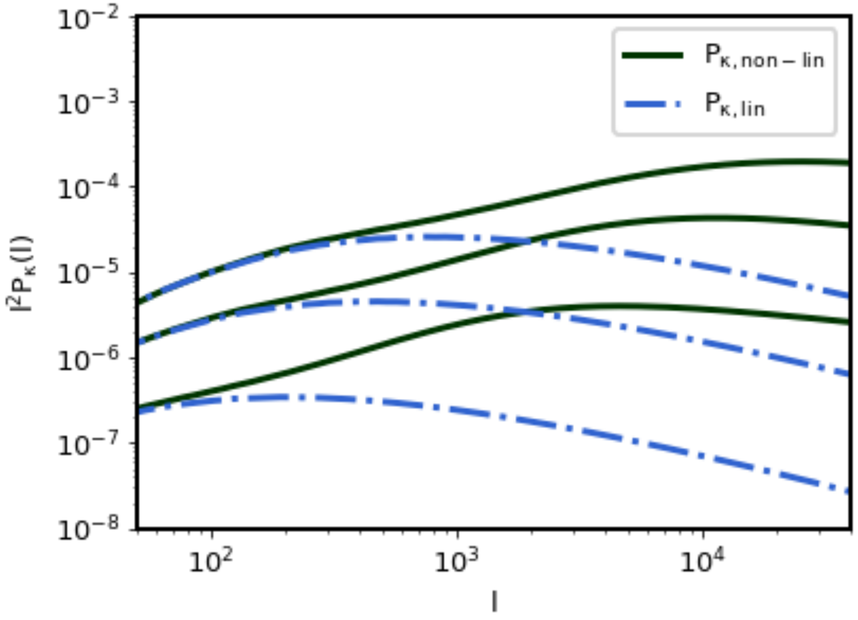

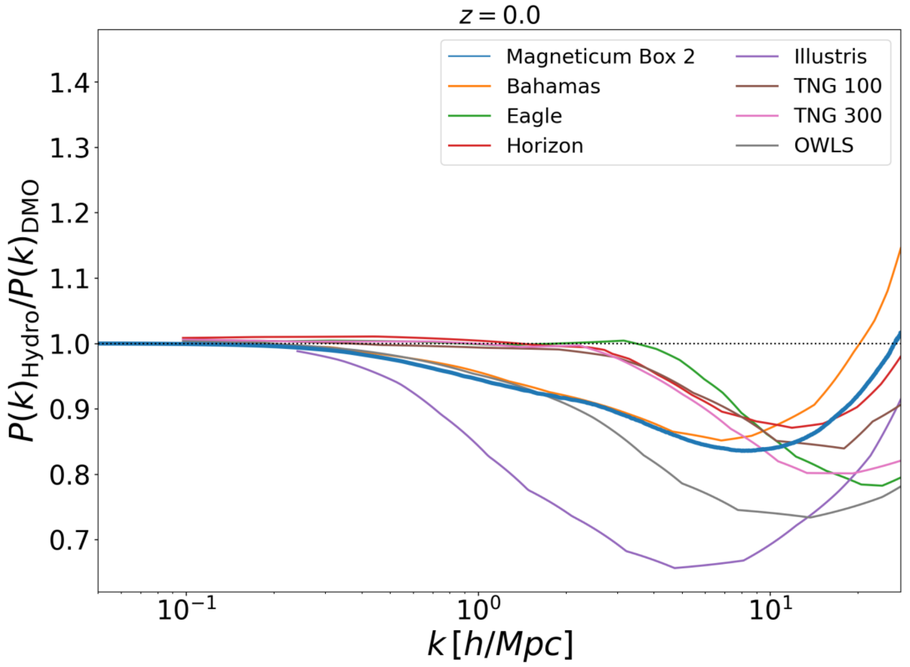

3D non-linear

Martinet et al. (incl. Giocoli) 2021

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Non:linear Modelling IST:NL

M. Crocce, **C. Giocoli**, A. Pourtsidou

Goal: develop consistent and unified models for the main Euclid observables – weak gravitational lensing by large scale structures, clustering & their cross correlation.

Our charge regards the main cosmological probes at the level of two point statistic.

Validate those models with the help of simulations and make them available to the scientific community.

Problem: cosmological models have been never faced before down to those scales – Euclid main observables require this!

Code for Cosmological Analyses

Non:linear

Likelihood

PythonWrapper

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Non:linear Modelling IST:NL

Milestones

Non:linear Modelling IST:NL

Milestones

Organisation of a strategic group to talk the problem:

- People from IST:L side: interface with Likelihood part of CLOE
- Experts on theoretical modelling beyond linear theory strong connection with the Theory, the Weak Lensing and the Galaxy Clustering SWGs
- Python programmers

Every Thursday at 13:15

Non:linear Modelling IST:NL

Milestones

Identifications of the Non:linear models to be implemented:

- Euclid Emulator 2
- BACCO
- HaloFit
- HM-Code versions: baryonic physic parameters

Definition of a strong interface with the Theory SWG for models beyond ΛCDM: how models are degenerate with baryons or with standard cosmological parameters.

Non:linear Modelling IST:NL

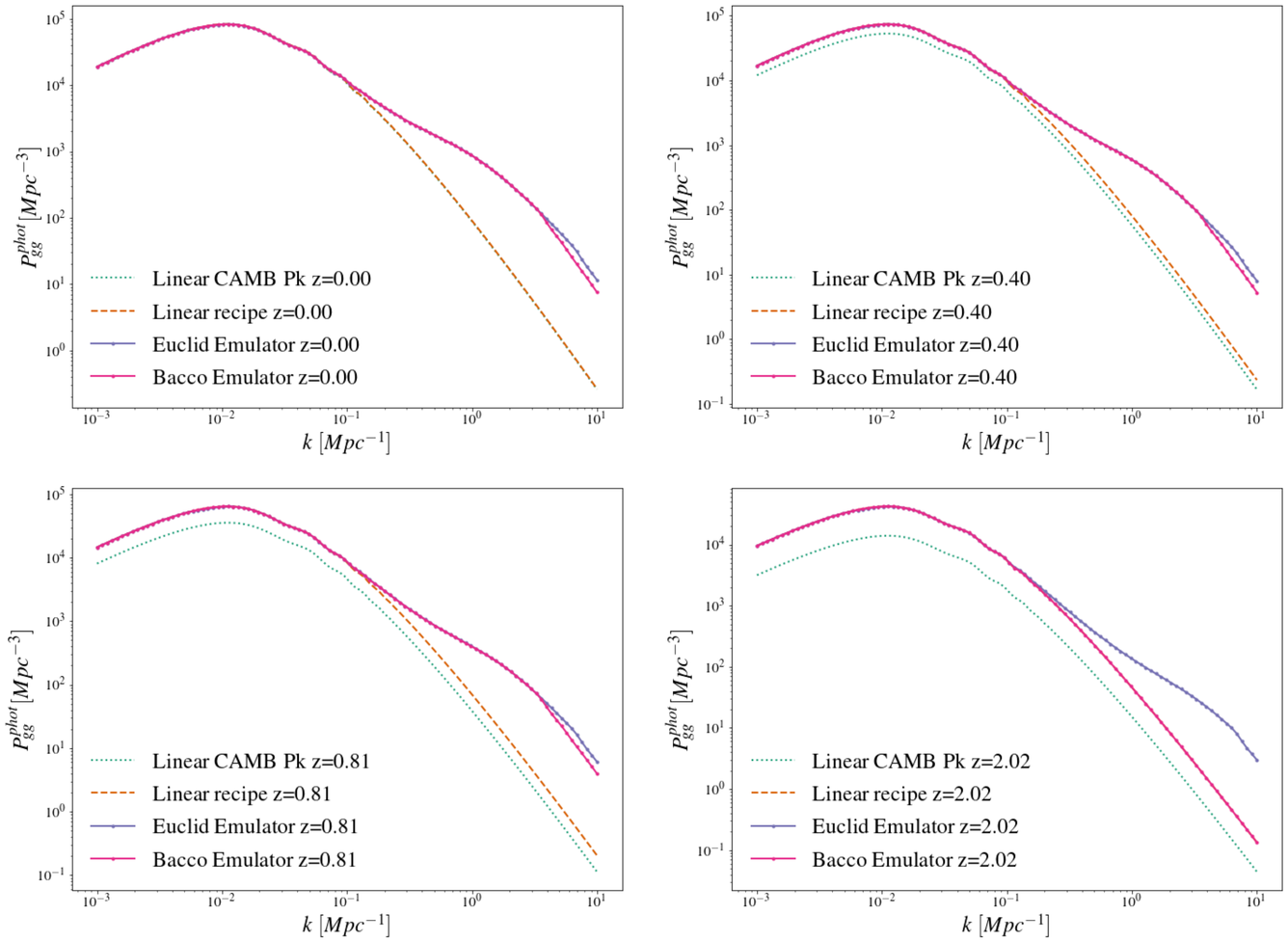
Milestones

Model choices using Flags

FUN FLAGS

Implementing and benchmarking them:
ISTNL_modelling DEMO (**Jupiter notebook**)

P. Carriho, G. Canas, M. Martinelli et al.



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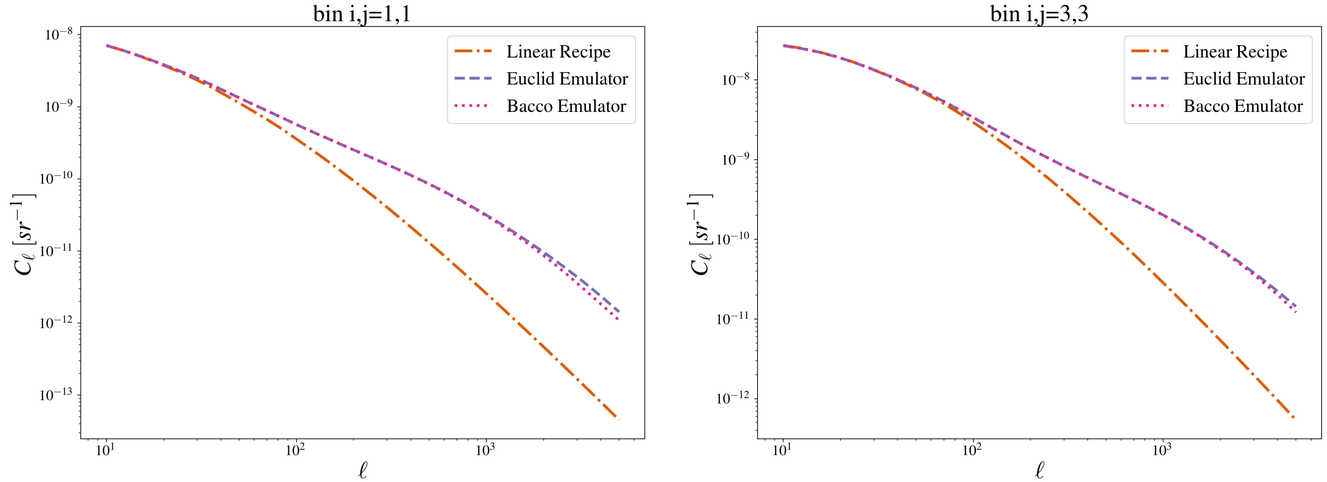
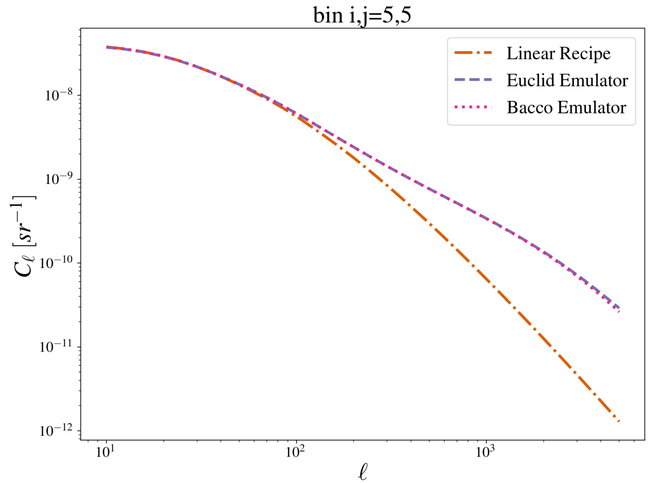
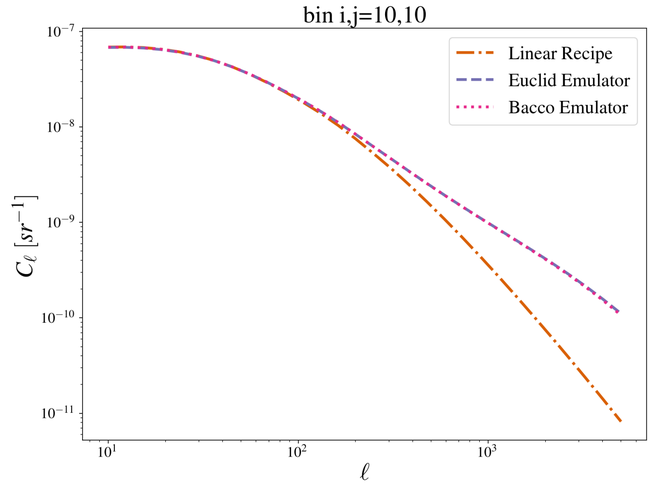
WL C_ℓ^{ij}







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Non:linear Modelling IST:NL

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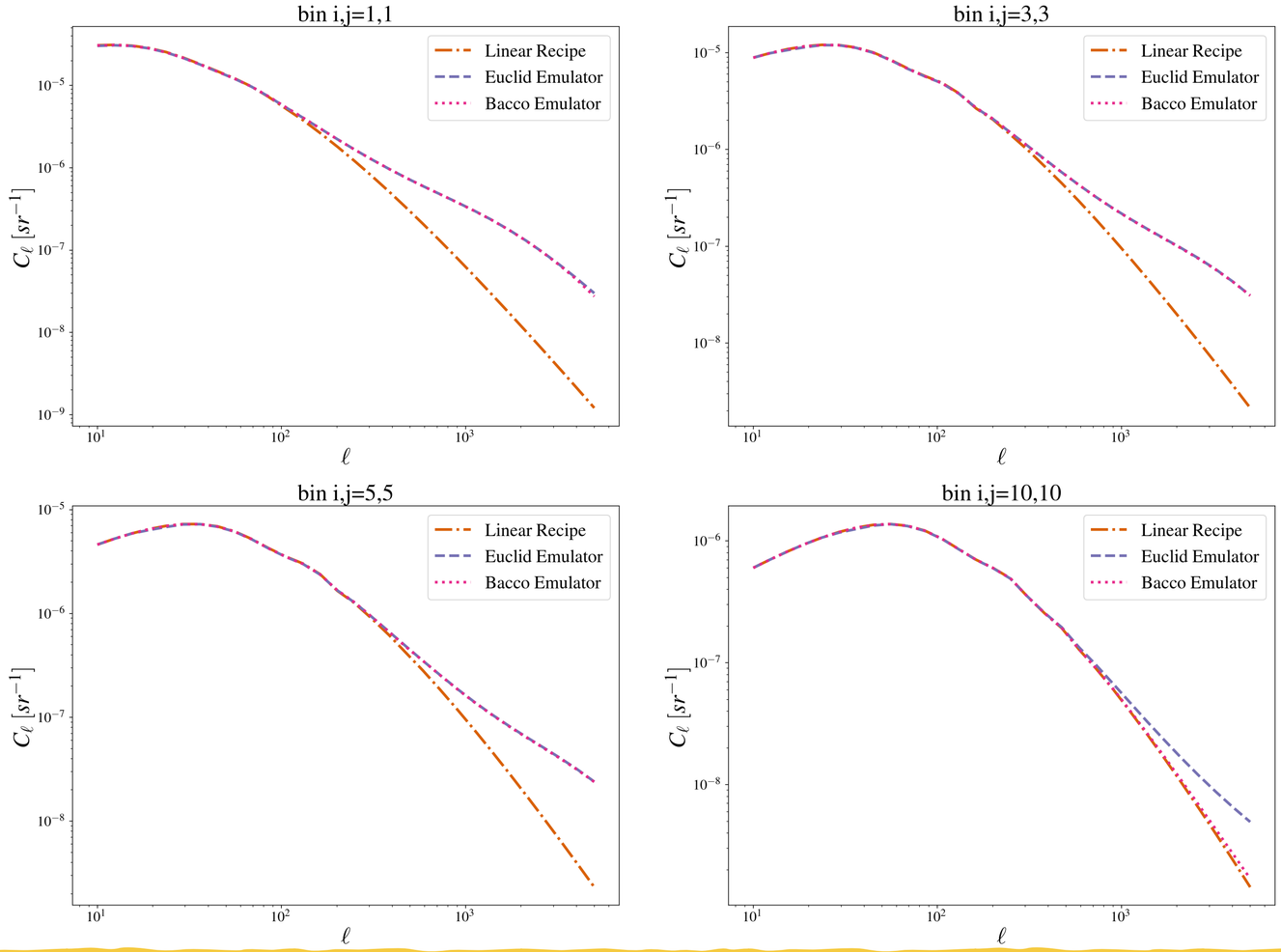
GC photo C_ℓ^{ij}



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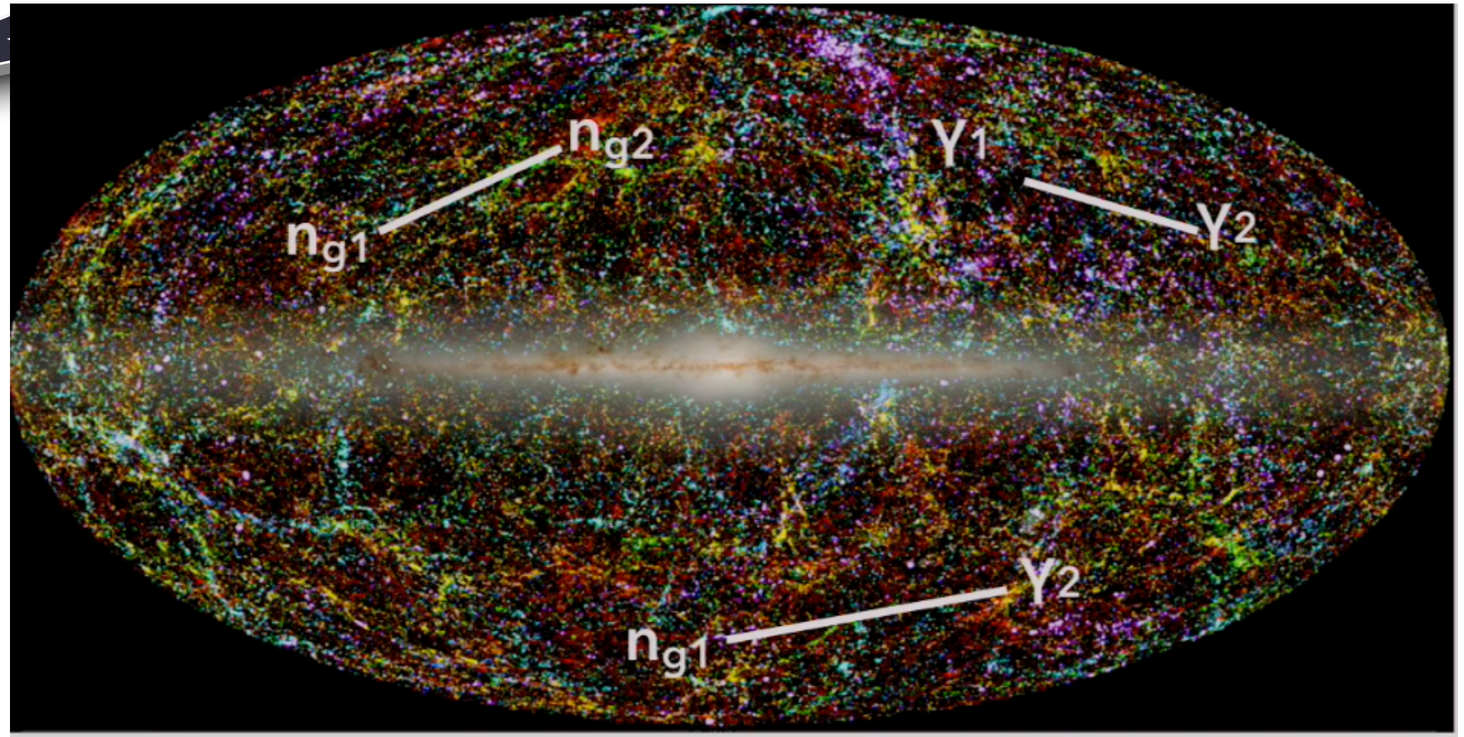
Milestones

Divided in different redshift bins

Photometric catalogue



Three types of 2 point correlations (3x2pt)

Weak lensing-Weak lensing Galaxy-Galaxy Galaxy-Weak Lensing

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Non:linear Modelling IST:NL

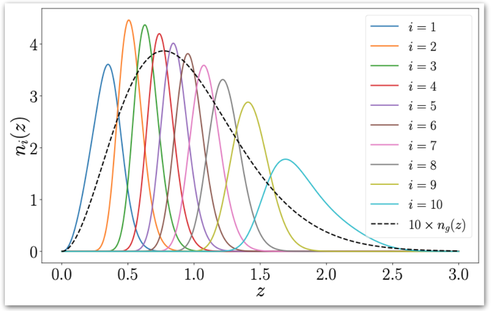
Milestones

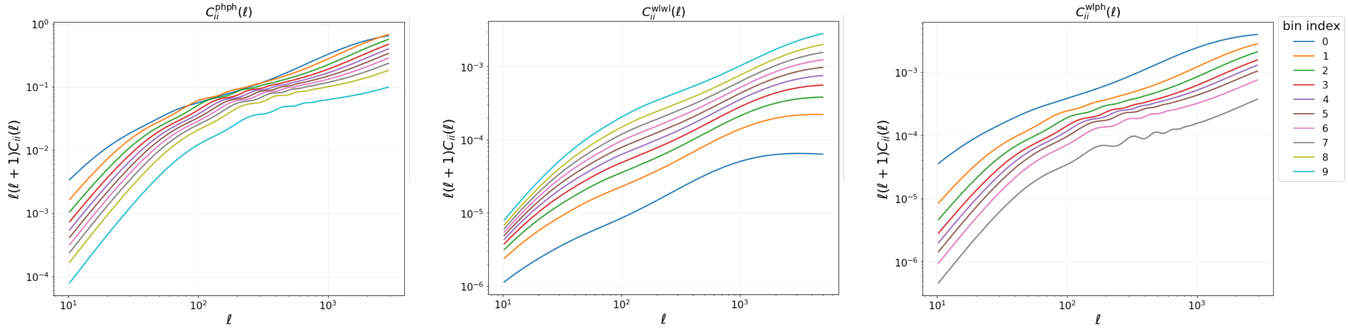
Every second Friday at 15:00

M. Bonici & D. Sciotti

3x2pt Covariance Taskforce

Write down the analytical recipes for the 3x2pt covariance in term of the Angular Fourier Space modes C(l)





Necessary to go beyond IST:forecast
and run MCMC analyses
Leading the cosmologica analysis in SPV3

Non:linear Modelling IST:NL

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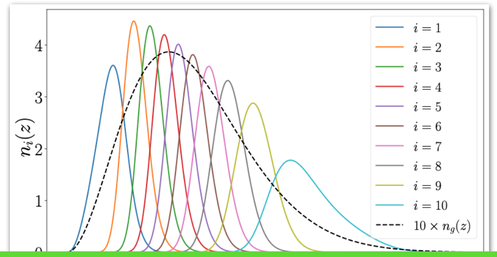
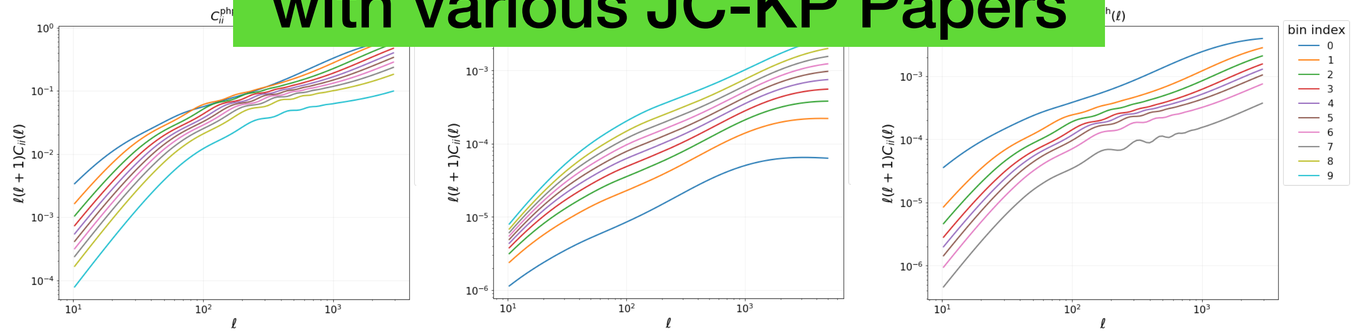


Created strong synergies with various JC-KP Papers



Necessary to go beyond IST:forecast and run MCMC analyses
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Non:linear Modelling IST:NL

Milestones

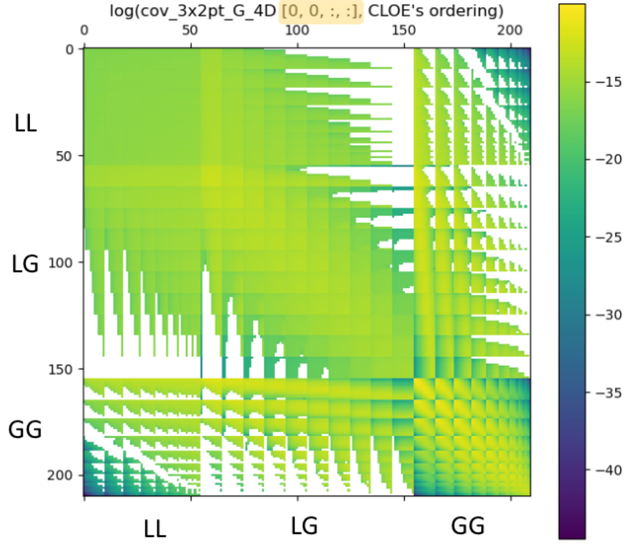
Frozen the covariance for SPV-3: **Gaussian** plus **Super Sample Term** consistently accounting for **non-linear effects.** Interfaced with **PySSC.**

Building a much more direct interface with **CLOE**

- The Covariance Calculation will remain external to CLOE -

- additional computation method via use of AngPow
- massively parallelised
- computation in flat sky
  (small circular survey, an approx often used in previous literature)
- computation for **partial sky coverage** (masks…)

Strong interface with the PySSC developers



Necessary to go beyond IST:forecast and run MCMC analyses
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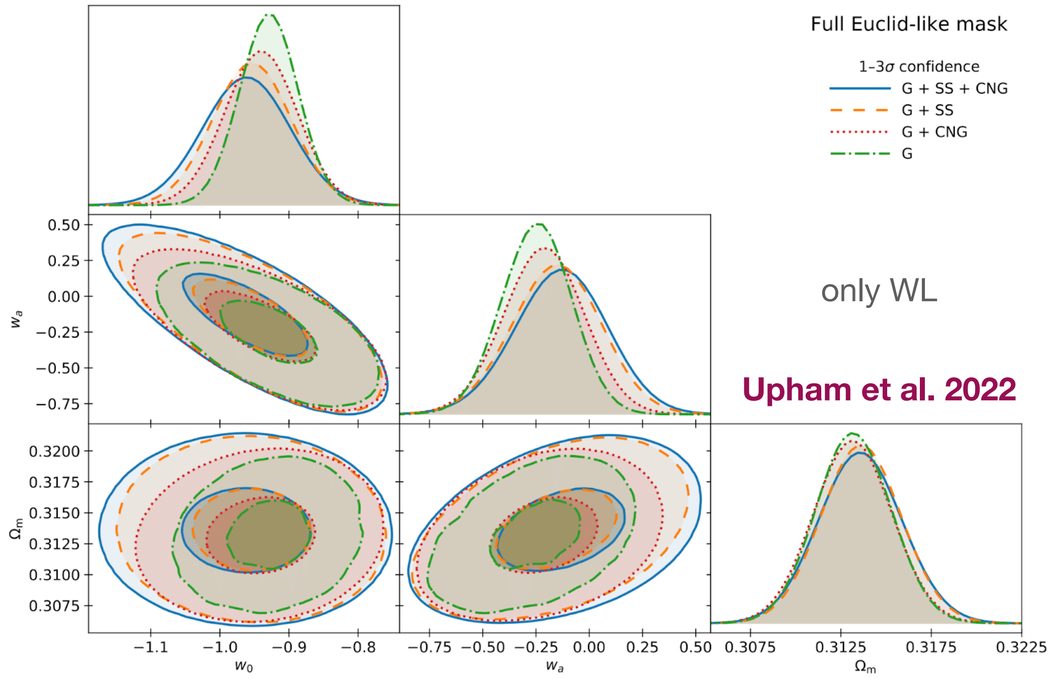
Milestones

At some point we need to think about the CNG to the 3x2pt covariance

… studying how to fully include it studying Rubin-LSST (PYCCL),
DES (Cosmo-like) & KiDS (Halo Model based covariance)



3x2pt Covariance Taskforce

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Milestones

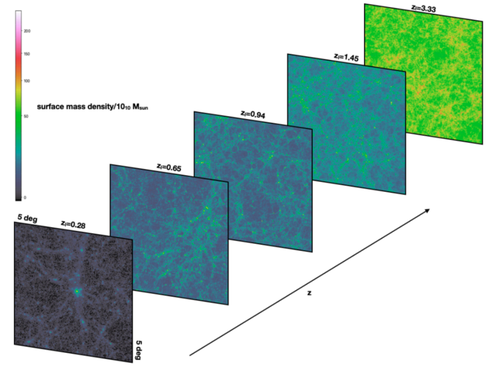
Weak lensing cosmological simulations

No KP associated to this yet. **J, Harnois-Deraps & C. Giocoli**

WP work:

- Make mock data for HOWLS Key Paper 1, 2, 3
- Make mock data to construct numerical covariance matrix for 3x2pts
- Develop suite of lensing mocks with baryons & IA to enable modelling of key systematics

The above currently use the DUSTGRAIN-*pathfinder*, SLICS & cosmo-SLICS simulations
We are in the process of upgrading with the BACCO simulations for key paper 3.
Dedicated moks using the DEMNUni_cov: 50 runs, 1 Gpc/h by side and 3200 light-cones 10 deg by side.



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Milestones

3x2pt Covariance Taskforce

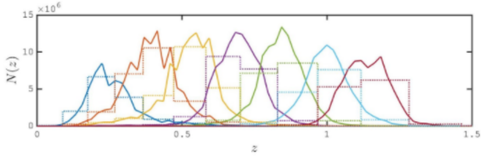
J, Harnois-Deraps

Mocks Lenses

Interface with numerical covariance (WL-simulations)

N(z)

Use bins 2-8 out of the 13 proposed by the Euclid photo-z group.
See Fig. 5 of Euclid Collaboration, A. Pocino et al.

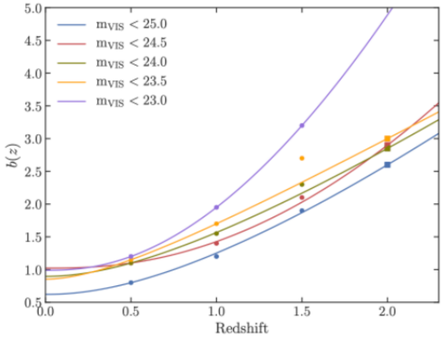


N_eff:

The paper uses N_gal/bin =
[1110056 4172539 7690737 7742576 7525914 7295429 6241444 5981201 4223985 2982428 1921137 1449159 976552]
[see their Table A1].
That makes 59313157 gal over 402 deg^2, or n_eff = 40.9848 gal/arcmin^2, as listed in the paper.I match this n_eff, but with 7 bins instead of 13, keeping the relative galaxy density between bins 2-8.

Linear bias:

b(z) = A*z^b/(1+z) = C (their eq. 11), with
A = 1, b = 2.58, C = 0.6



927 LOS ready [100 sq. deg. each]
543Gb for all [ascii] catalogues

Necessary to go beyond IST:forecast and run MCMC analyses
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Milestones

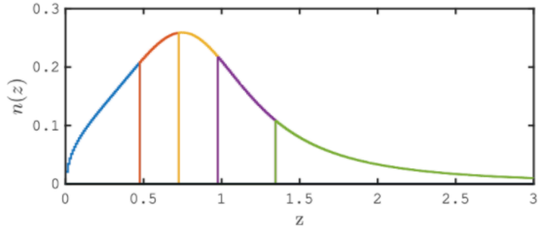
3x2pt Covariance Taskforce

J, Harnois-Deraps

Mocks sources

Interface with numerical covariance (WL-simulations)

N(z)
Galaxy catalogues can be split in tomographic bins.
E.g. Use 5 bins as in Martinet+ (2021), A&A, 646A, 62



N_eff:
30.0 gal/arcmin**2 (6.0 per bin)

No source-lens coupling.

927 LOS ready [100 sq. deg. each]
231Gb for all [fits] catalogues

Goal:
-load the source & lens catalogues
-split sources in (5?) tomo bins
-measure NN, NG & GG
-repeat with different noise realisations
-average the matrices
-reproduce n(z), b(z) and cosmo in the analytical covariance matrix
-compare matrices (or inverses?)

Necessary to go beyond IST:forecast and run MCMC analyses
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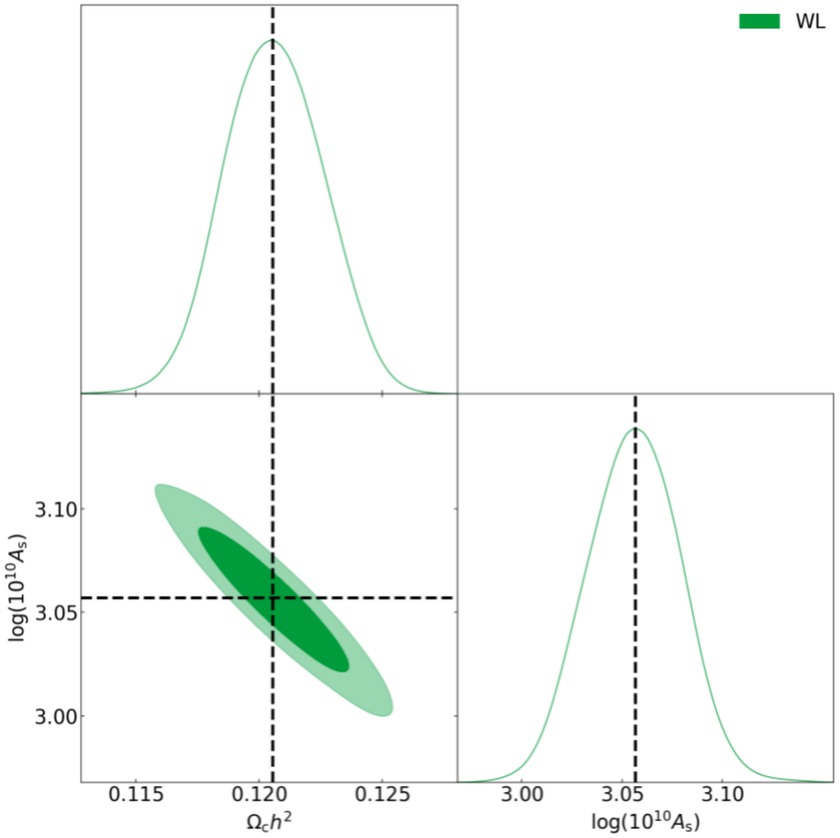
Non:linear Modelling IST:NL

Milestones

Preliminar Non:linear MCMC runs

S. Casas



First MCMC run using non-linear recipes: 10 redshift bins

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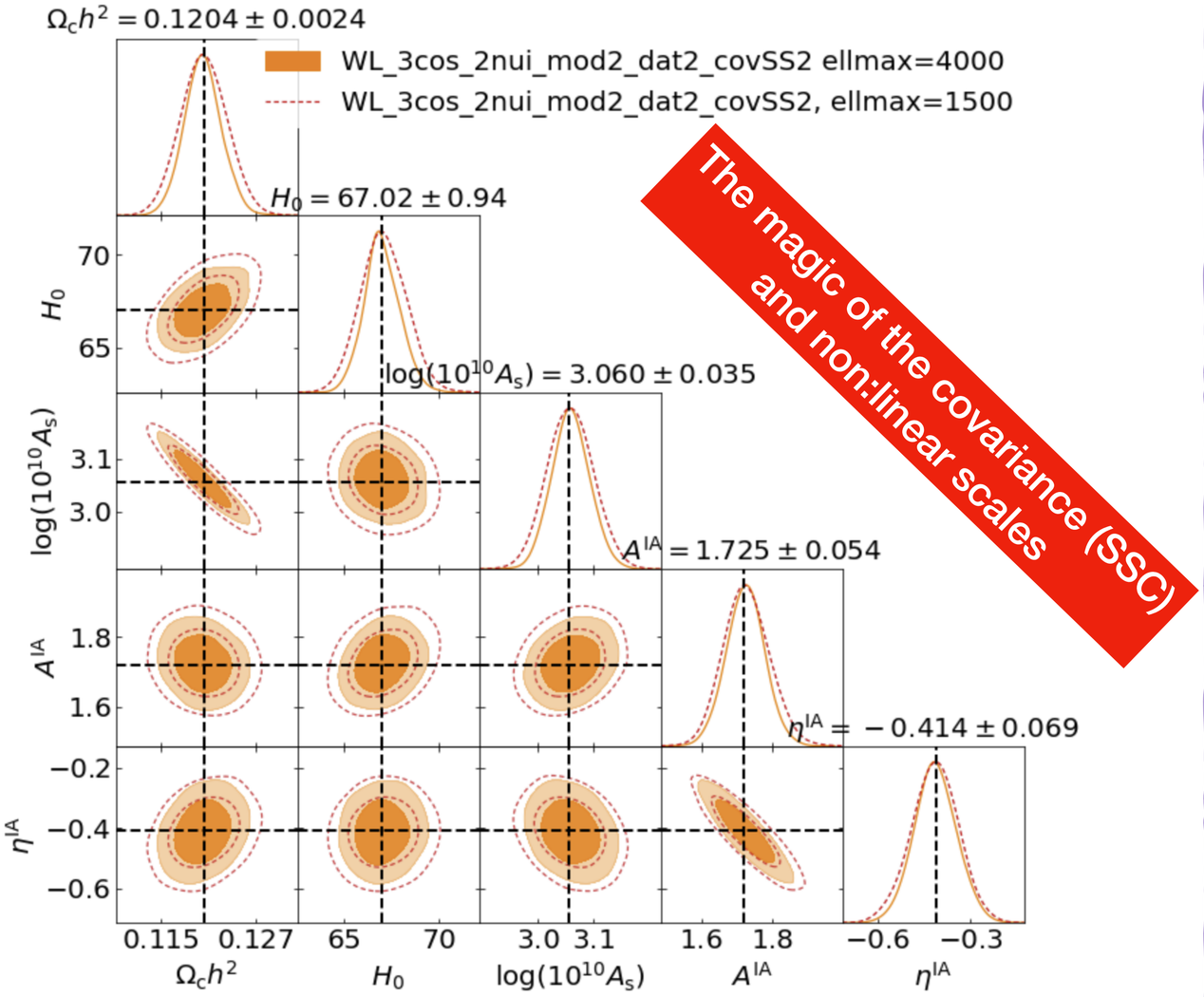
Milestones

Preliminar Non:linear MCMC runs

σ_8 - Ω_m are fully consistent with IST:Forecast

S. Casas



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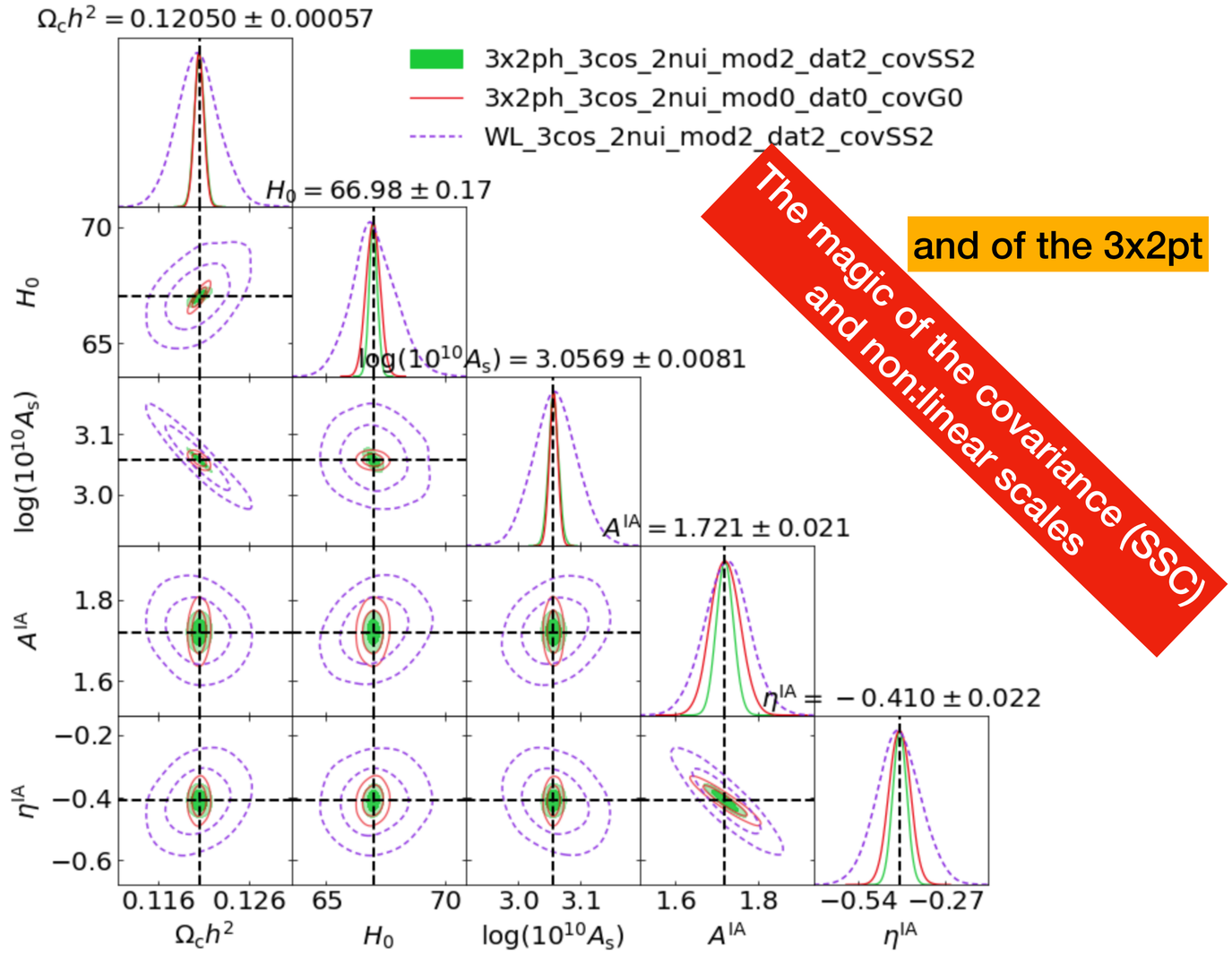

The magic of the covariance (SSC) and non:linear scales

and of the 3x2pt

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