CMB lensing X Euclid

Gaussian and Numerical covariances

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Oct 23 ‘23, Euclid XCMB SWG meeting, Milan

Baseline data vector

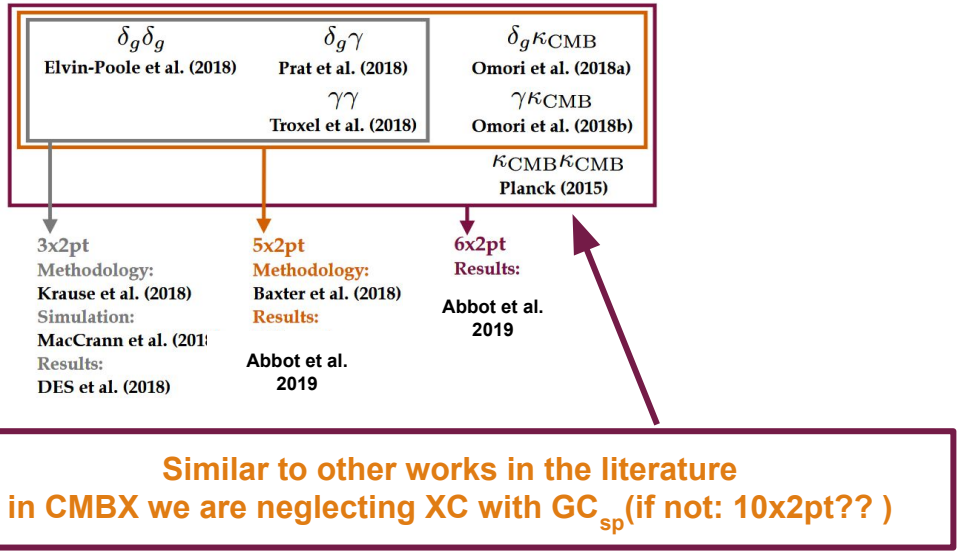
420 elements in total

$$\vec{\mathcal{O}}_{XC}(\ell) = \{C_\ell^{\kappa_{\rm CMB},\kappa_{\rm CMB}}, C_\ell^{\kappa_{\rm CMB},{\rm GCph_i}}, C_\ell^{\kappa_{\rm CMB},{\rm WL_i}}, C_\ell^{{\rm GCph_i},{\rm GCph_j}}, C_\ell^{{\rm WL_i},{\rm WL_j}}, C_\ell^{{\rm WL_i},{\rm GCph_j}}\}$$

CMB lensing: 20 elements in total (over *l*)

Xcorr: 400 elements in total (over l and z)

Euclid 3x2pt data vector: 4200 elements in total



Similar to other works in the literature
in CMBX we are neglecting XC with GC_{sp} (if not: 10x2pt??)

- N_l = 20 ell bins
- N_z = 10 redshift bins
- No correlation between different ells

Total data vector has 4620 elements

Binning in ell:
[11, 15, 21, 29, 40, 55, 75, 102, 140, 191, 261, 356, 486, 663, 905, 1235, 1685, 2299, 3137, 4280]

Baseline Covariance matrix

420 elements in total

$$\vec{\mathcal{O}}_{XC}(\ell) = \{C_\ell^{\kappa_{\rm CMB},\kappa_{\rm CMB}}, C_\ell^{\kappa_{\rm CMB},{\rm GCph_i}}, C_\ell^{\kappa_{\rm CMB},{\rm WL_i}}, C_\ell^{{\rm GCph_i},{\rm GCph_j}}, C_\ell^{{\rm WL_i},{\rm WL_j}}, C_\ell^{{\rm WL_i},{\rm GCph_j}}\}$$

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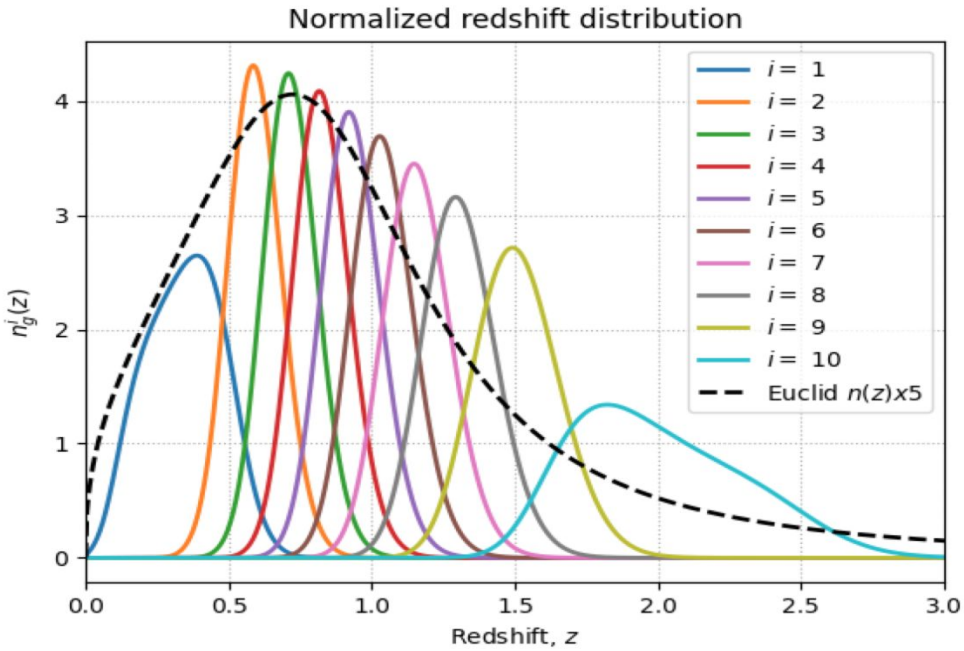
	$C_\ell^{\kappa_{\rm CMB},\kappa_{\rm CMB}}$	$C_\ell^{\kappa_{\rm CMB},{\rm GCph_i}}$	$C_\ell^{\kappa_{\rm CMB},{\rm WL_j}}$	$C_\ell^{{\rm GCph_i},{\rm GCph_j}}$	$C_\ell^{{\rm WL_i},{\rm WL_j}}$	$C_\ell^{{\rm WL_i},{\rm GCph_j}}$
$C_\ell^{\kappa_{\rm CMB},\kappa_{\rm CMB}}$	Cov(kk, kk)	Cov(kk, k-GC$_i$)	Cov(kk, k-WL$_j$)	Cov(kk, GC$_i$-GC$_j$)	Cov(kk, WL$_i$-WL$_j$)	Cov(kk, WL$_i$-GC$_j$)
$C_\ell^{\kappa_{\rm CMB},{\rm GCph_i}}$		Cov(k-GC$_j$, k-GC$_i$)	Cov(k-GC$_i$, k-WL$_j$)	Cov(k-GC$_i$,GC$_j$-GC$_k$)	Cov(k-GC$_i$,WL$_j$-WL$_k$)	Cov(k-GC$_i$,WL$_j$-GC$_k$)
$C_\ell^{\kappa_{\rm CMB},{\rm WL_j}}$			Cov(k-WL$_i$, k-WL$_j$)	Cov(k-WL$_i$, GC$_i$-GC$_j$)	Cov(k-WL$_i$, WL$_i$-WL$_j$)	Cov(k-WL$_i$, WL$_i$-GC$_j$)
$C_\ell^{{\rm GCph_i},{\rm GCph_j}}$				EUCLID 3X2pt COVARIANCE MATRIX		
$C_\ell^{{\rm WL_i},{\rm WL_j}}$	$Cov(A\,B, A'\,B') = \frac{\delta^{\rm K}_{\ell\ell'}}{(2\ell+1)}\left[\Delta C_{ik}^{AA'}(\ell)\Delta C_{jl}^{BB'}(\ell') + \Delta C_{im}^{AB'}(\ell)\Delta C_{jk}^{BA'}(\ell')\right]$			[N$_l$ N$_z$ (2N$_z$+1)] X [N$_l$ N$_z$ (2N$_z$+1)]		
$C_\ell^{{\rm WL_i},{\rm GCph_j}}$	$\Delta C_{ij}^{AB}(\ell) = \frac{1}{\sqrt{f_{\rm sky}\Delta\ell}}\left[C_{ij}^{AB}(\ell) + N_{ij}^{AB}(\ell)\right]$			4200 X 4200		

10 Euclid redshift bins + 1 CMB lensing bin



Input parameters

```
### Cosmology ###

OMEGA_m:          0.32                  # Matter (DM+Baryon) density parameter.
OMEGA_L:          0.68                  # Dark Energy (DE) density parameter.
```

```
NSIDE:            512                   # Healpix Nside (Npixels = 12*Nside^2).
```

Input redshift bins

```
# Field number, z bin number, mean, shift, field type, zmin, zmax
# Types: 1-galaxies 2-shear

     1      1   0.0000   1.0000      1   0.001   0.418
     1      2   0.0000   1.0000      1   0.418   0.560
     1      3   0.0000   1.0000      1   0.560   0.678
     1      4   0.0000   1.0000      1   0.678   0.789
     1      5   0.0000   1.0000      1   0.789   0.900
     1      6   0.0000   1.0000      1   0.900   1.019
     1      7   0.0000   1.0000      1   1.019   1.155
     1      8   0.0000   1.0000      1   1.155   1.324
     1      9   0.0000   1.0000      1   1.324   1.576
     1      10   0.0000   1.0000      1   1.576   2.5
     1      11   0.0000   1.0000      1   0   1100
     1      12   0.0000   1.0000      1   0.   2.5
     2      1   0.0000   1.0000      2   0.001   0.418
     2      2   0.0000   1.0000      2   0.418   0.560
     2      3   0.0000   1.0000      2   0.560   0.678
     2      4   0.0000   1.0000      2   0.678   0.789
     2      5   0.0000   1.0000      2   0.789   0.900
     2      6   0.0000   1.0000      2   0.900   1.019
     2      7   0.0000   1.0000      2   1.019   1.155
     2      8   0.0000   1.0000      2   1.155   1.324
     2      9   0.0000   1.0000      2   1.324   1.576
     2      10   0.0000   1.0000      2   1.576   2.5
     2      11   0.0000   1.0000      2   0.   1100
     2      12   0.0000   1.0000      2   0.   2.5
~
~
```

FLASK $nside = 512$

Covariance maps

- 2500 maps + Cl's auto and cross
- nsdide = 512
- lmax=1500
- DEMNUNi cosmology

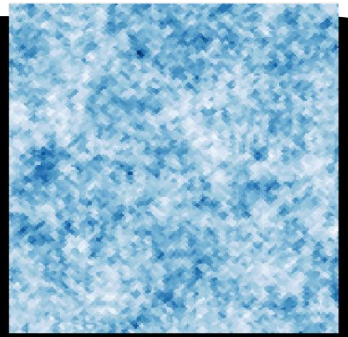
Gaussian covariance comparison

Binning in ell:
[11, 15, 21, 29, 40, 55, 75, 102, 140, 191, 261, 356, 486, 663, 905, 1235, 1685, 2299, 3137, 4280]

FLASK $nside = 1024$

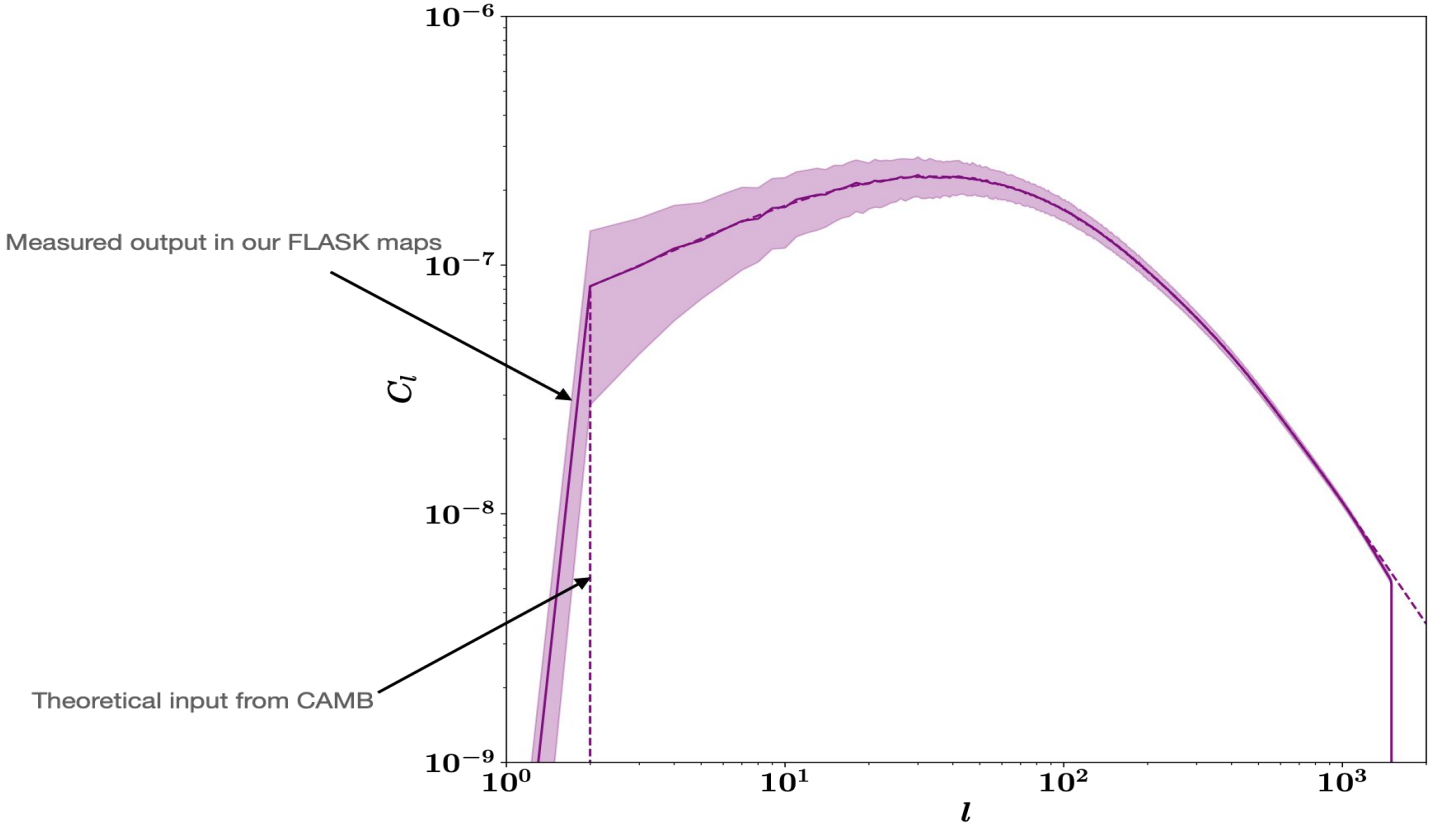
Map validation

- 40 maps + Cl's auto and cross
- nsdide = 1024
- lmax=3000
- DEMNUni cosmology



DEMNUni comparison

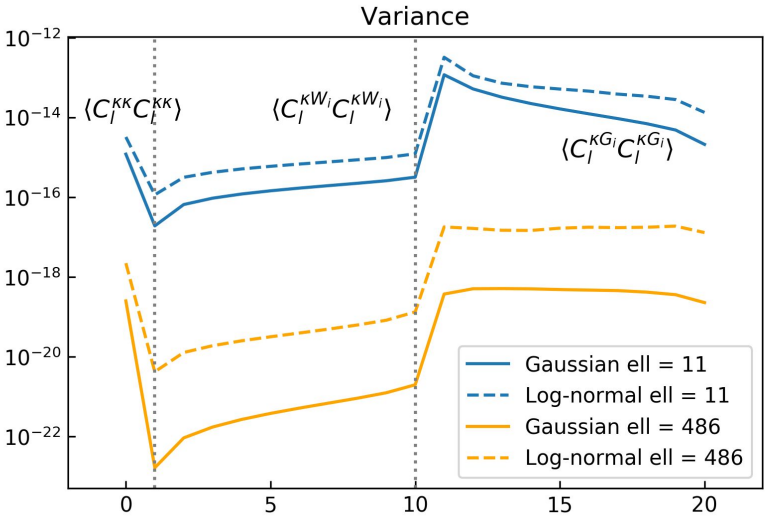
Cl_kk

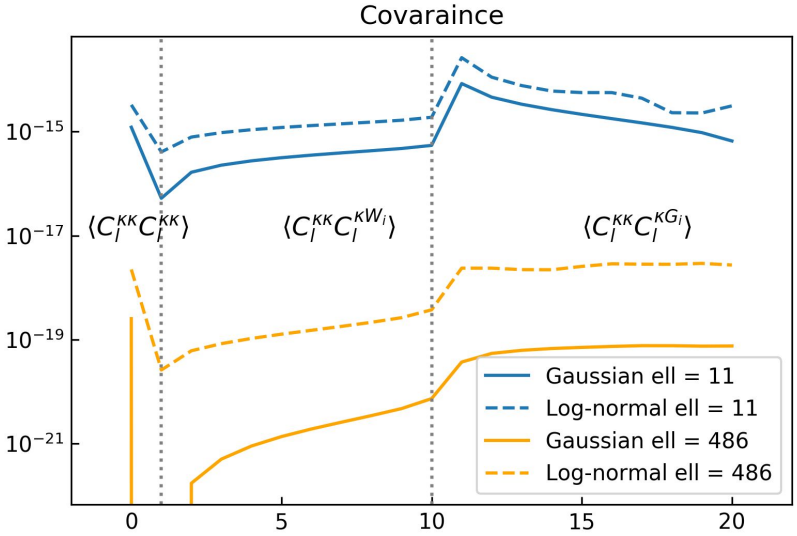

Measured output in our FLASK maps
Theoretical input from CAMB
10^{-6}
10^{-7}
10^{-8}
10^{-9}
C_l
10^0
10^1
10^2
10^3
l

Log-normal vs Gaussian comparison

Variance and Covariances

Recap





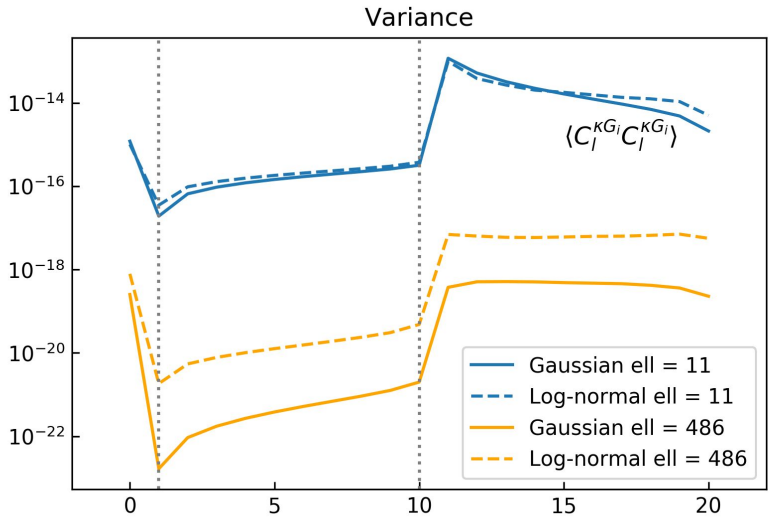
Fsky = 1.0

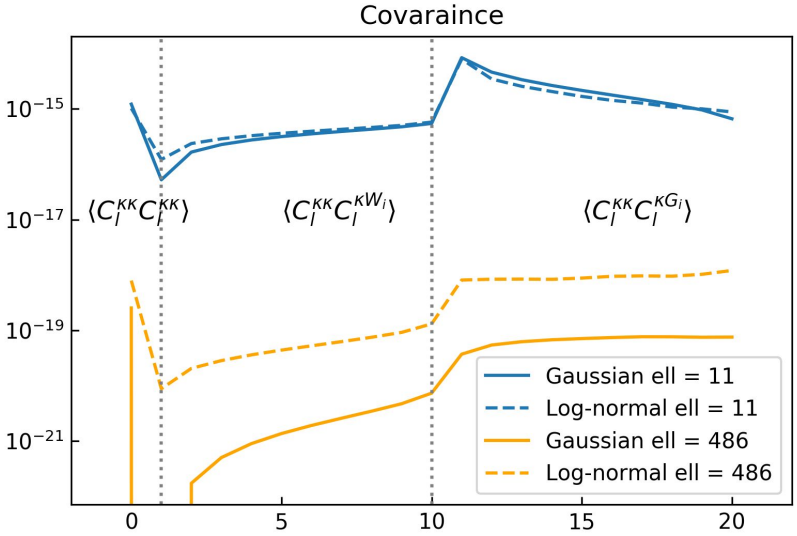
Using the old Flask maps without magnification bias and intrinsic alignment.

Log-normal vs Gaussian comparison

Variance and Covariances

Recap

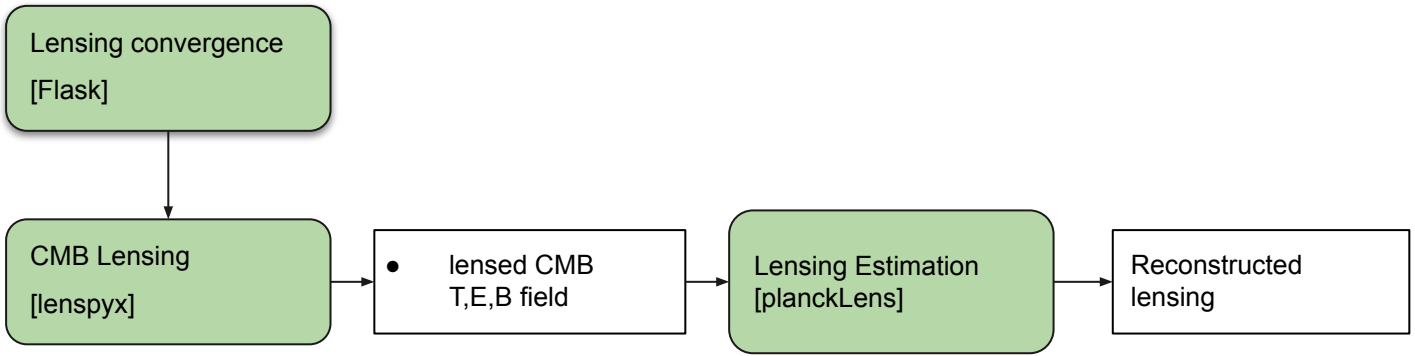




Fsky = 0.36, Nside = 512, Nsims = 2500

Simulating the CMB observables - Old pipeline

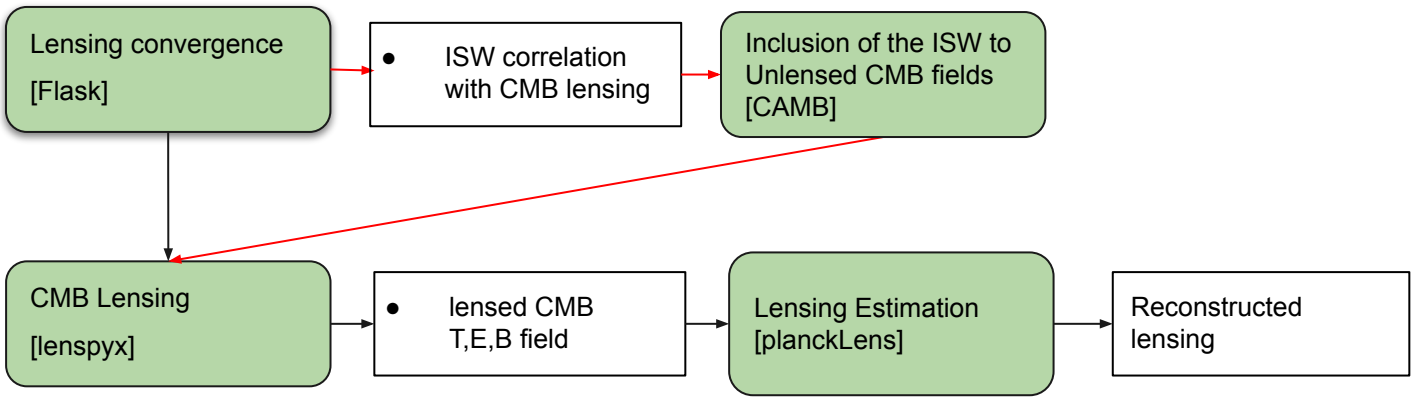
- Simulate lensed CMB observables using the Flask generated lensing potential



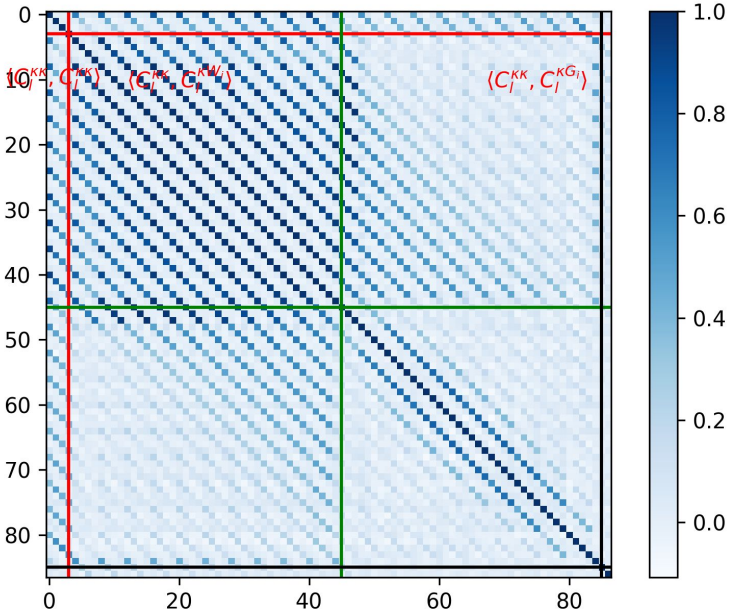
Update to the covariance pipeline - New pipeline

- Simulate lensed CMB observables using the Flask generated lensing potential

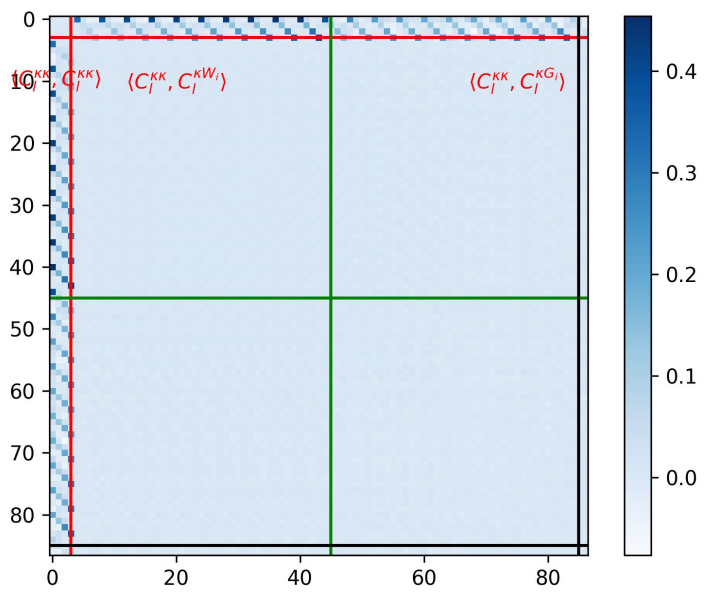
Updated implementation - To include correlated ISW signal



Comparing Flask vs Reconstructions

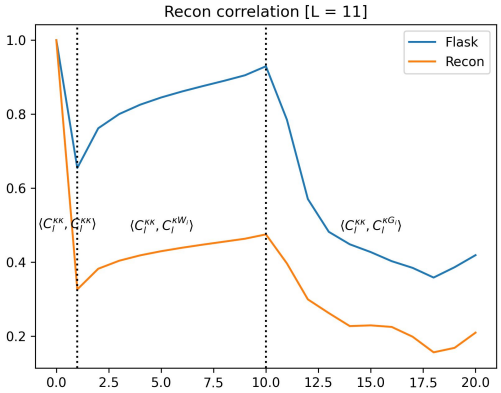


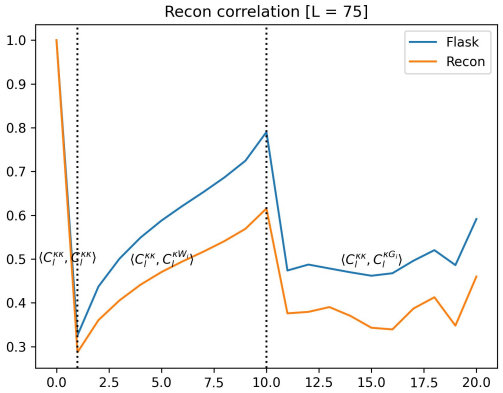
Reconstructed correlation

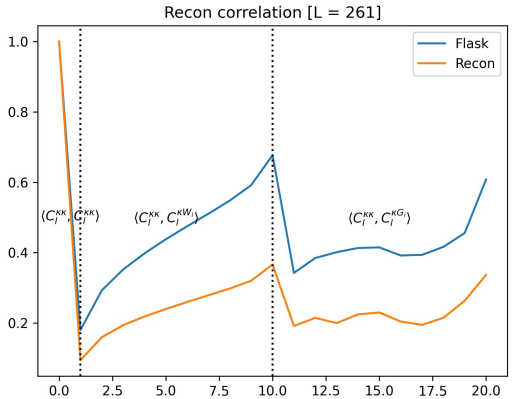


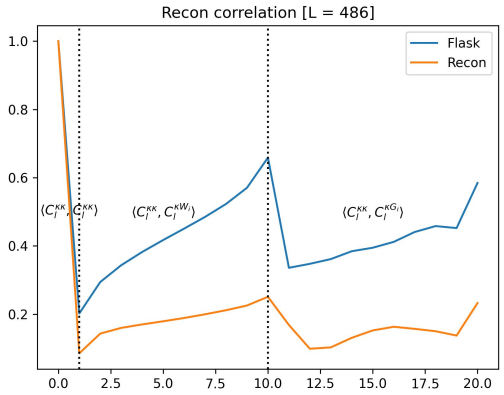
Recon - Flask

Comparing Flask vs Reconstructions



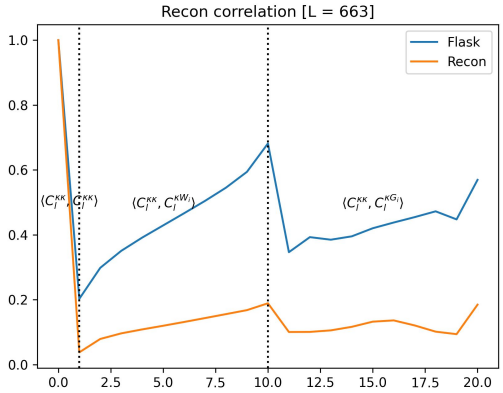


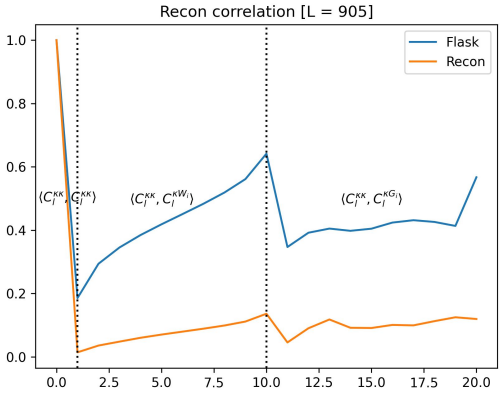


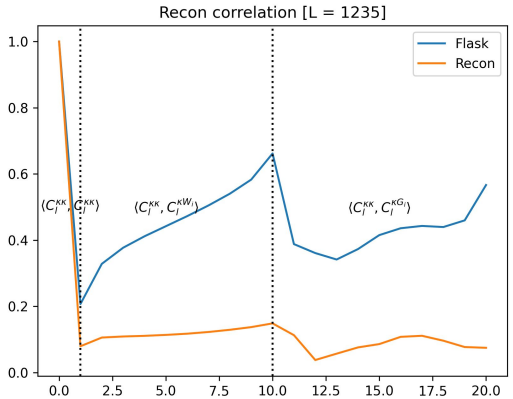


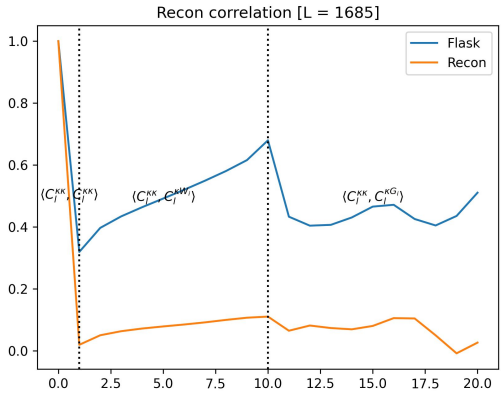
1000 sims for L= [11, 75, 261, 486]

Comparing Flask vs Reconstructions





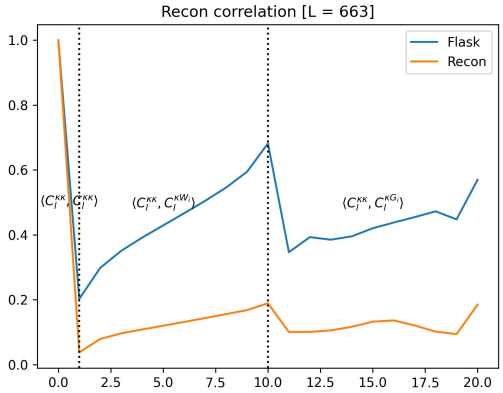


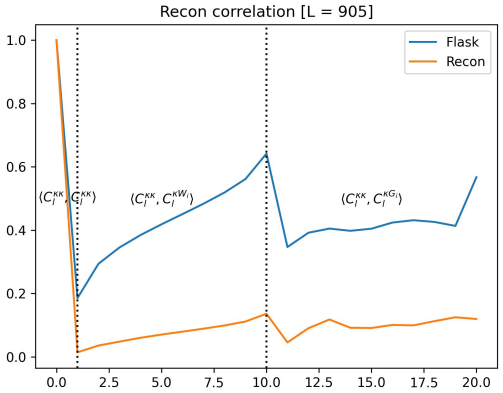


High-l comparison

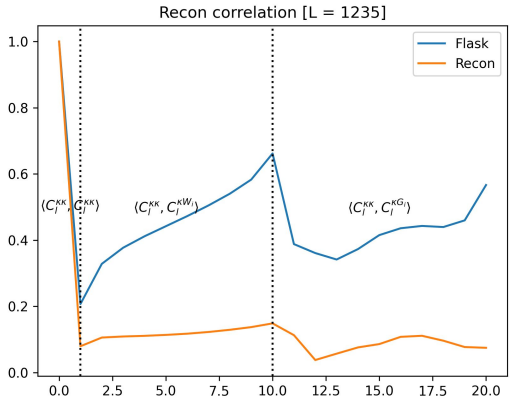
L= [663, 905,1235, 1685]

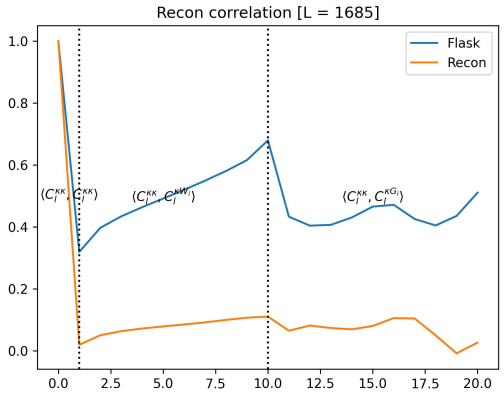
Comparing Flask vs Reconstructions





Should be validated against the updated Flask sims





High-l comparison

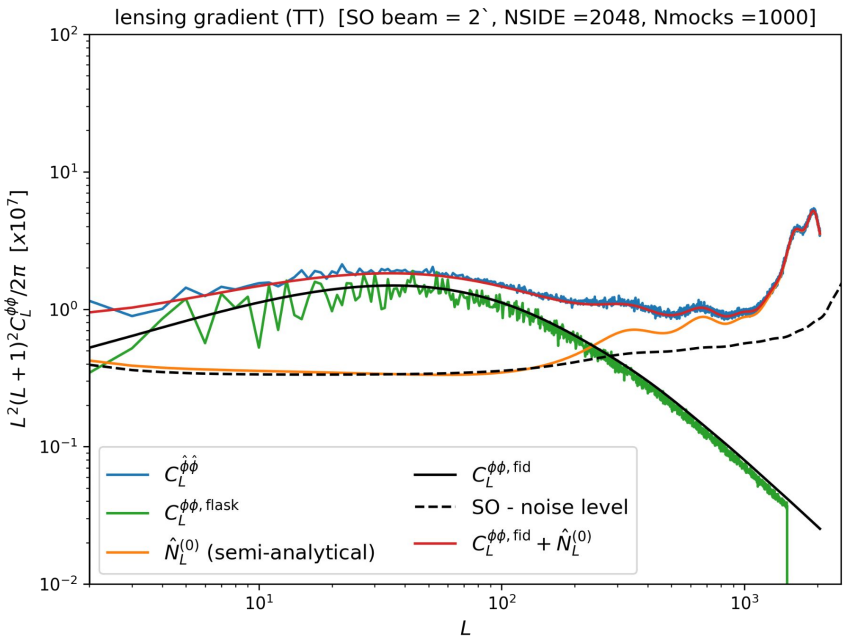
L= [663, 905,1235, 1685]

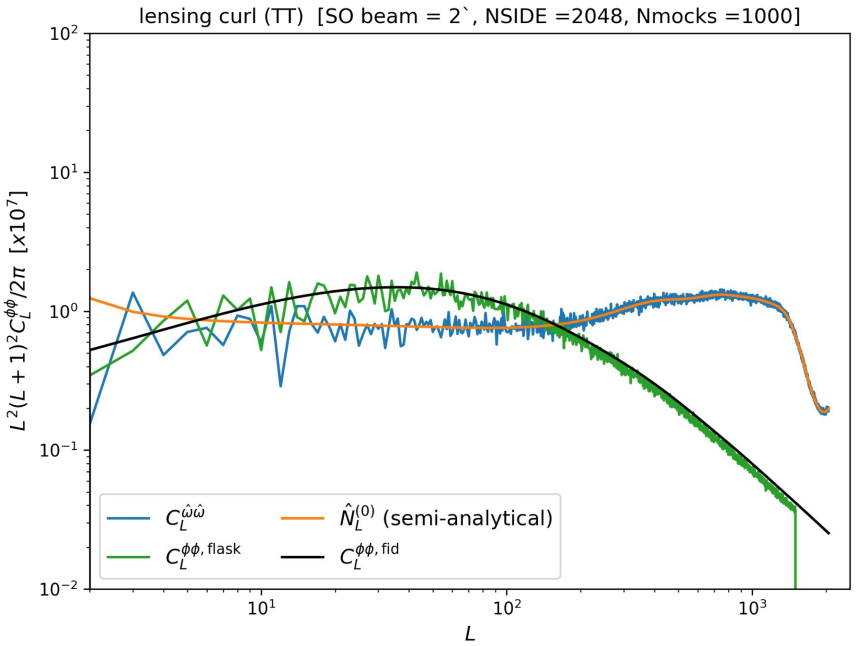
UPDATES/On-going - 23/10/2023

- Modifications to the Flask simulations
  - Validating the higher order statistics discrepancy - In progress
- Implementation of ISW- cross- correlation - Done
  - To be integrated to the pipeline
- Final numerical covariance
  - Pipeline using TT estimator - Done
  - Pipeline extending to MV - In progress
  - To implement against the new updated flask simulations - To-do

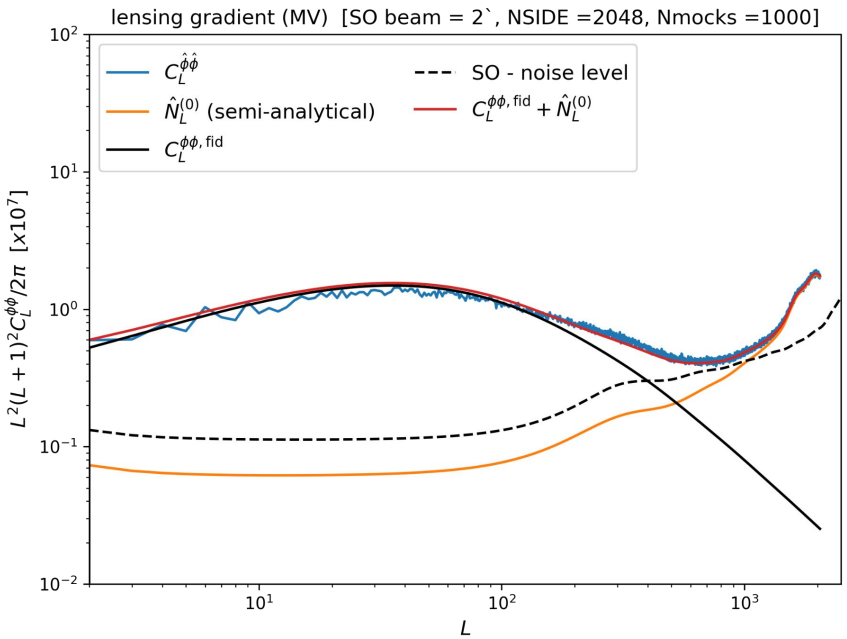
  - Definitely some more validations to do !!

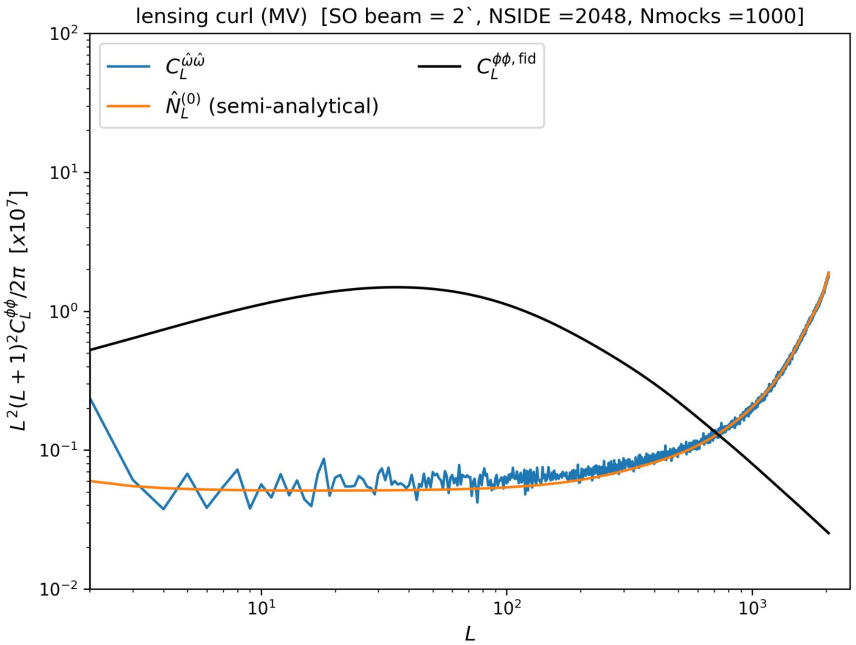
Lensing reconstruction using `plancklens' - TT



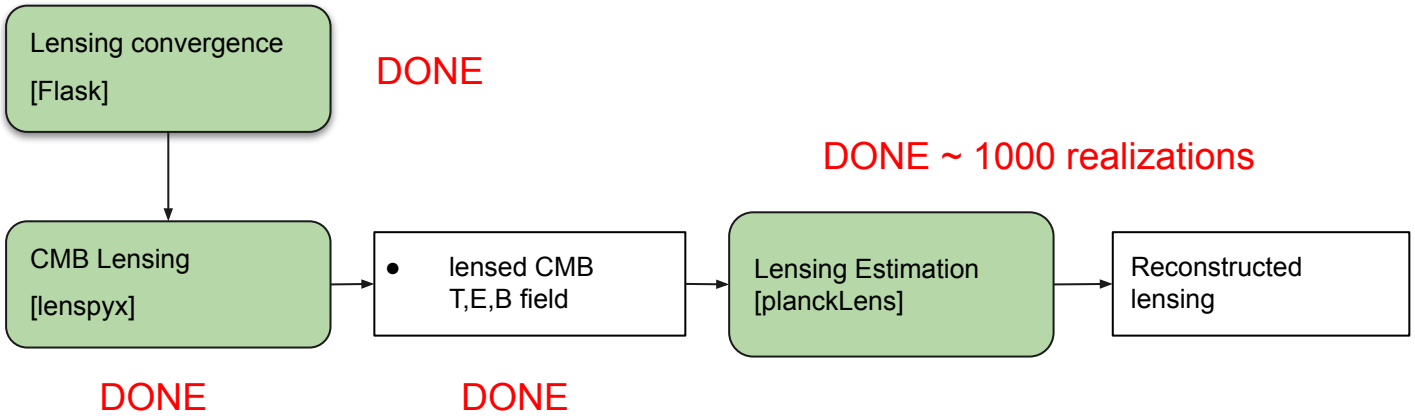


Lensing reconstruction using `plancklens' - MV





Simulating the CMB observables



- To verify the MV estimator
- Complete with ~2500 realizations
- A few validations to perform !!
- Compute the covariance matrix