

Results from PRILC

Parallel session: Science and Simulations

Component Separation

Raúl Fernández-Cobos, PV, D. Bilbao, E. Martínez-González, R.B. Barreiro

- The method
- The simulations
- Sensitivity forecast
- Next steps

- The method
- The simulations
- Sensitivity forecast
- Next steps

The method

Our objective is to apply the new version of **SEVEM**, particularly designed to deal coherently with polarization data.

This improvement is based on the optimal combination of 2-spin linear combinations **[Fernández-Cobos et al. 2016]**.

This methodology describes not only Internal Template Fitting (**ITF**, like **SEVEM**), but also standard Internal Lineal Combination (**ILC**) approaches:

- Polarization ILC (**PILC**): $Q + iU$ linear combination with complex coefficients (**$2N_v$ dof**)
- Polarization Real ILC (**PRILC**): $Q + iU$ linear combination with real coefficients (**N_v dof**)
- Polarization ITF (**PITF**): covariant **SEVEM** with complex coefficients (**$2N_t$ dof**)
- Polarization Real ITF (**PRITF**): covariant **SEVEM** with real coefficients (**N_t dof**)

We focus on **linear combinations performed in the real space**. Our **preliminary results** are based on **PRILC**, but we aim to have results, at least, for **PRITF**

The method

The **PILC** solution recovers the CMB stokes parameters Q_{CMB} and U_{CMB} as:

$$Q_{CMB}(p) \pm iU_{CMB}(p) = \sum_{j=1}^{N_v} [w_j^{(R)} \pm iw_j^{(I)}] [q_j(p) \pm iu_j(p)]$$

with the constraints:

$$\sum_{j=1}^{N_v} w_j^{(R)} = 1 \quad \sum_{j=1}^{N_v} w_j^{(I)} = 0$$

The **PRILC** solution implies

$$w_j^{(I)} = 0, \forall j$$

The method

$q \pm iu$ can be expanded in terms of the spin-weighted spherical harmonics $_{\pm 2}Y_{\ell m}$ as:

$$[q_j \pm iu_j](p) = \sum_{\ell=2}^{\infty} \sum_{m=-\ell}^{\ell} a_{\ell m, j}^{\pm 2} Y_{\ell m}^{\pm 2}(p)$$

with:

$$a_{\ell m, j}^{\pm 2} = e_{\ell m}^j \pm b_{\ell m}^j$$

In terms of the E- and B-mode spherical harmonics, the **PILC** method is seen as:

$$\begin{pmatrix} E_{\ell m} \\ B_{\ell m} \end{pmatrix} = \sum_{j=1}^{N_v} \begin{pmatrix} w_j^{(R)} & -w_j^{(I)} \\ w_j^{(I)} & w_j^{(R)} \end{pmatrix} \begin{pmatrix} e_{\ell m}^j \\ b_{\ell m}^j \end{pmatrix}$$

The method

We describe our sensitivity to the determination of the parameters, assuming a Gaussian likelihood for the power spectrum (\mathbf{B}_ℓ). The parameters are:

- Amplitude of primordial B-mode (P_ℓ): r
- Amplitude of lensing B-mode (L_ℓ): A_L
- Amplitude of residual foregrounds (F_ℓ): A_F

$$-\log L = \frac{1}{2} \sum_{\ell} \frac{\left[B_{\ell} - (rP_{\ell} + A_L L_{\ell} + N_{\ell} + A_F F_{\ell}) \right]^2}{\frac{2}{2\ell+1} \left(r^* P_{\ell} + L_{\ell} + N_{\ell} + F_{\ell} \right)^2}$$

Or, more generally, in terms of a QML estimation:

$$-\log L = \frac{1}{2} \sum_{\ell} \left[B_{\ell} - (rP_{\ell} + A_L L_{\ell} + N_{\ell} + A_F F_{\ell}) \right] C_{QML}^{-1} \left[B_{\ell} - (rP_{\ell} + A_L L_{\ell} + N_{\ell} + A_F F_{\ell}) \right]^T$$

Where \mathbf{N}_ℓ is the **noise contribution** and r^* is the fiducial value of $r=0.001$.

- The method
- The simulations
- Sensitivity forecast
- Next steps

The simulations

Our baseline is **model18v6** (i.e., PRIMORDIAL CMB + LENSING + NOISE + “REALISTIC” FOREGROUNDS)

We work at **Nside=64** (based on initial estimation of sensitivity)

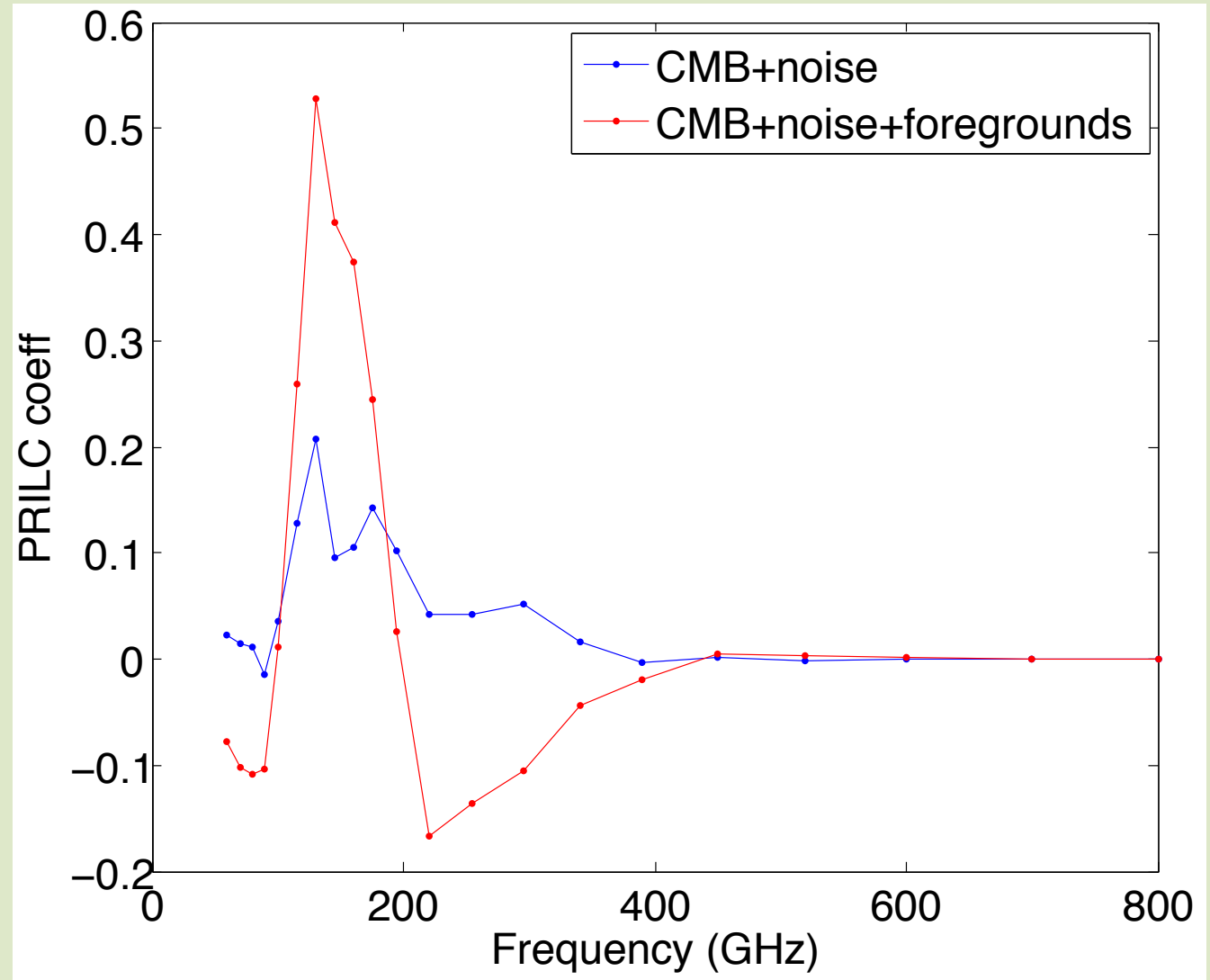
Common resolution of **FWHM=20 arcmin** (maps are degraded)

A mask covering **62.73% of the sky** is assumed

We also consider the case in which an **effective delensing** is performed, leaving **50% of the corresponding cosmic variance**

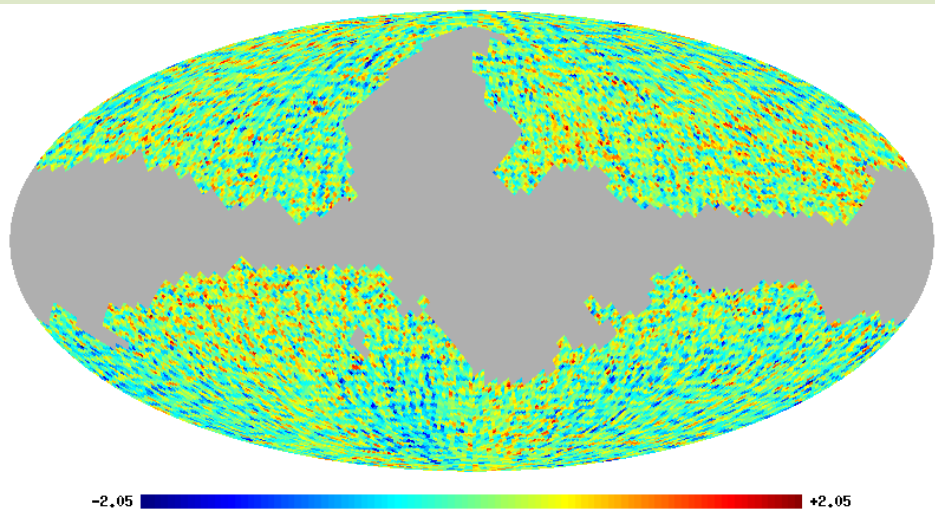
The simulations

Relative weight of the different channels

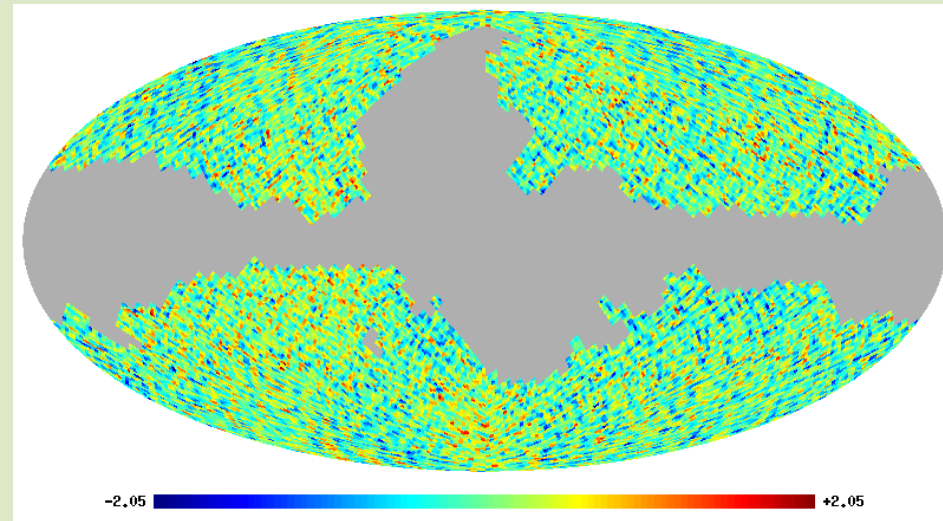


The simulations

Input CMB Q map



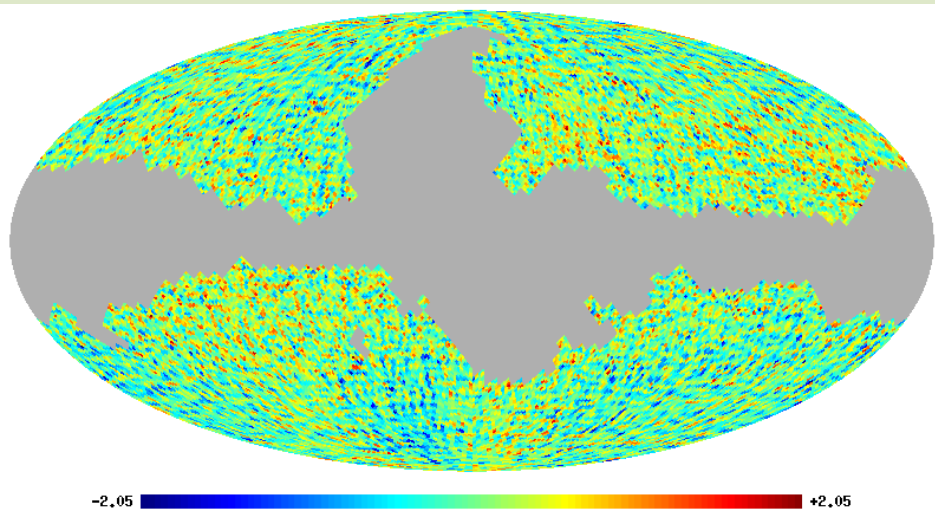
Input CMB U map



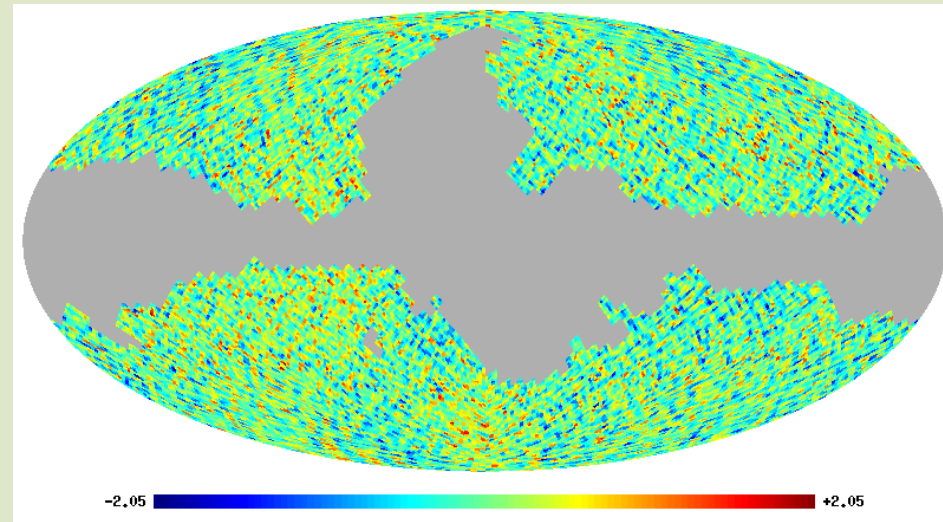
The simulations

Ideal case: Primordial B + lensing + noise (f_{sky})

Recovered CMB Q map



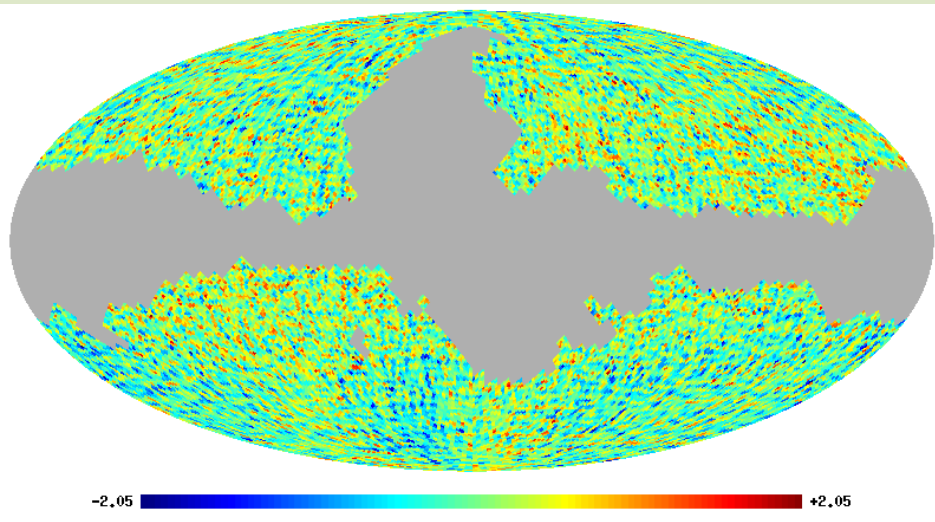
Recovered CMB U map



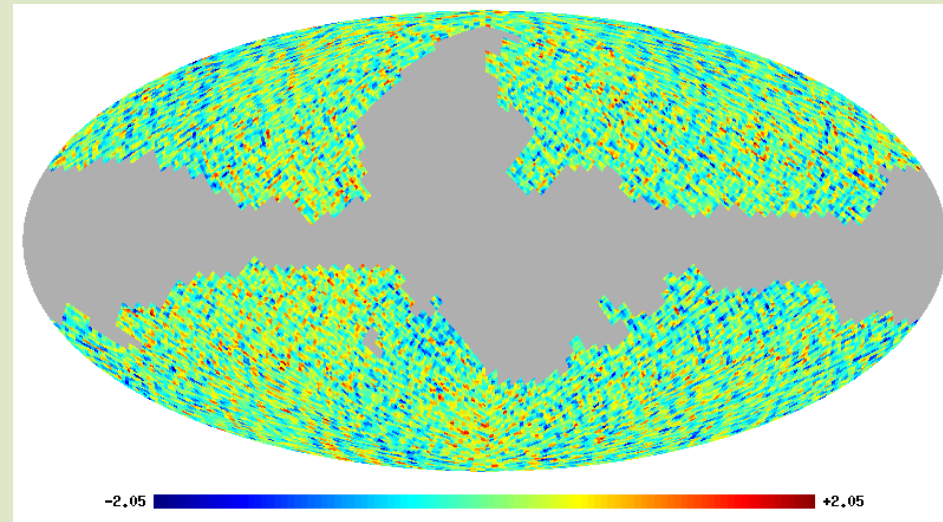
The simulations

“Realistic” case: Primordial B + lensing + noise + foregrounds (f_{sky})

Recovered CMB Q map



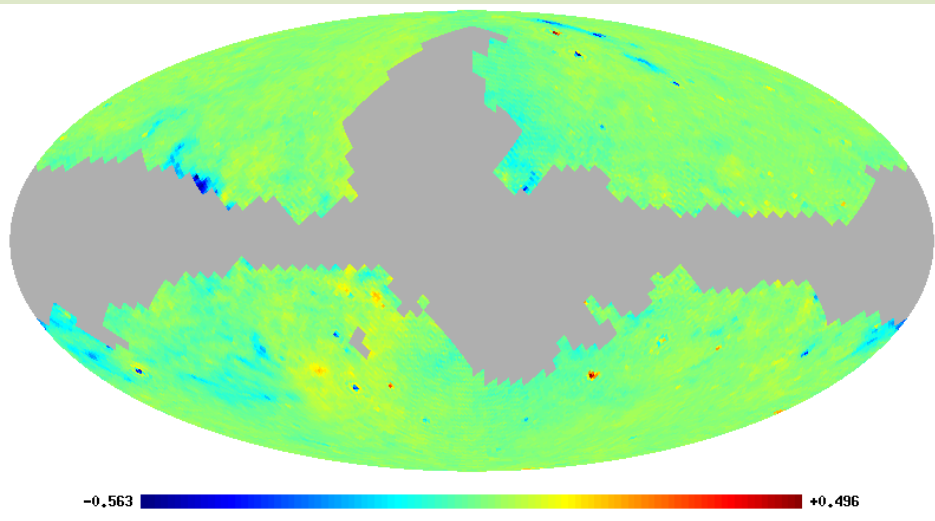
Recovered CMB U map



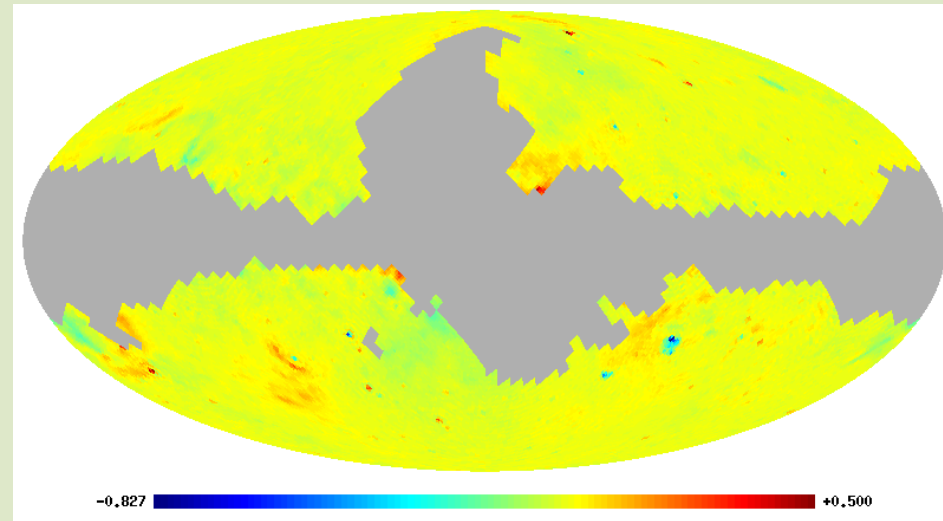
The simulations

“Realistic” case: Primordial B + lensing + noise + foregrounds (f_{sky})

Residual foregrounds Q map



Residual foregrounds U map



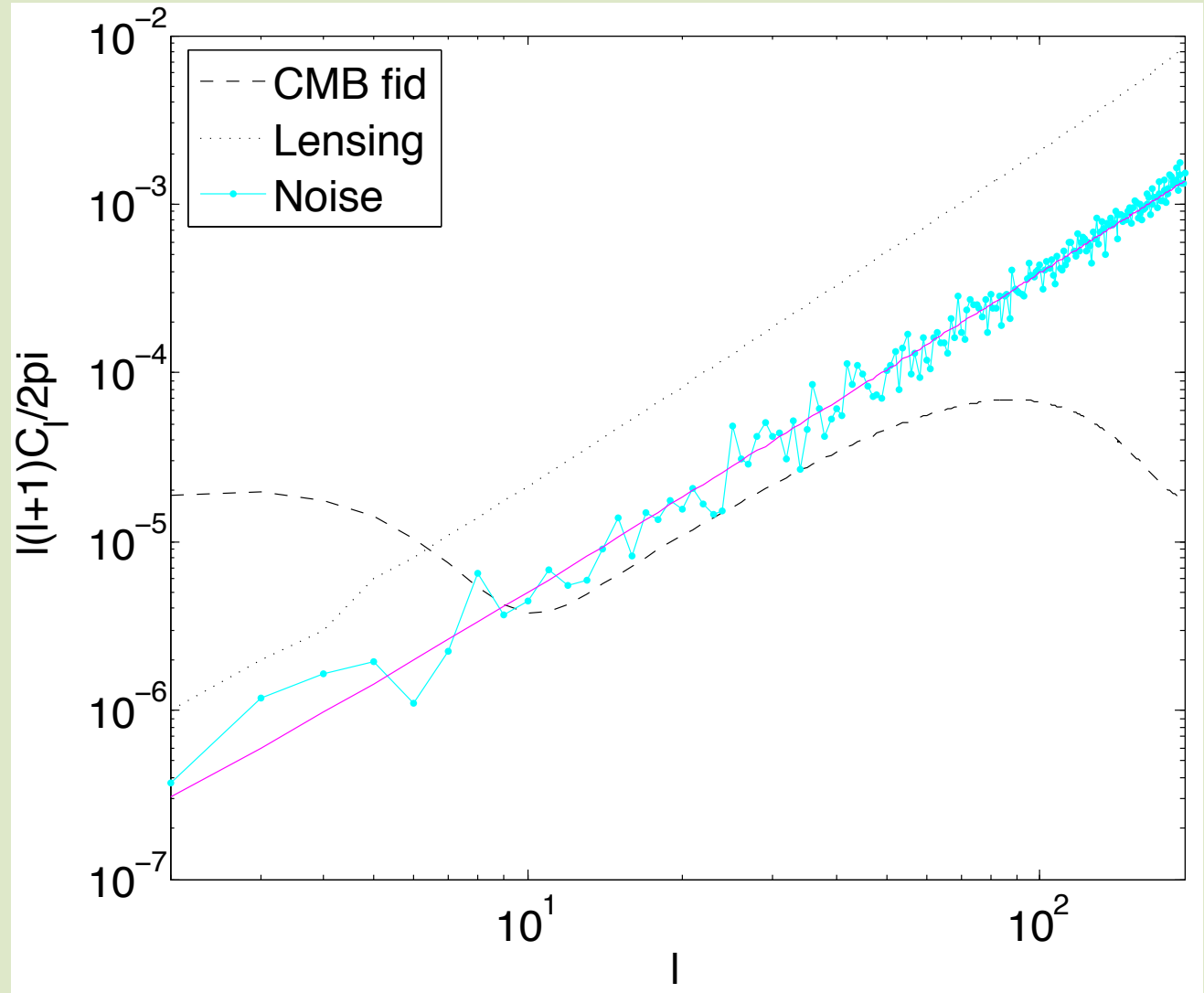
- The method
- The simulations
- Sensitivity forecast
- Next steps

Sensitivity forecast

Ideal case: Primordial B + lensing + noise (f_{sky})

$$\sigma(r) = 2.6 \times 10^{-4}$$

$$\sigma(A_L) = 0.01$$



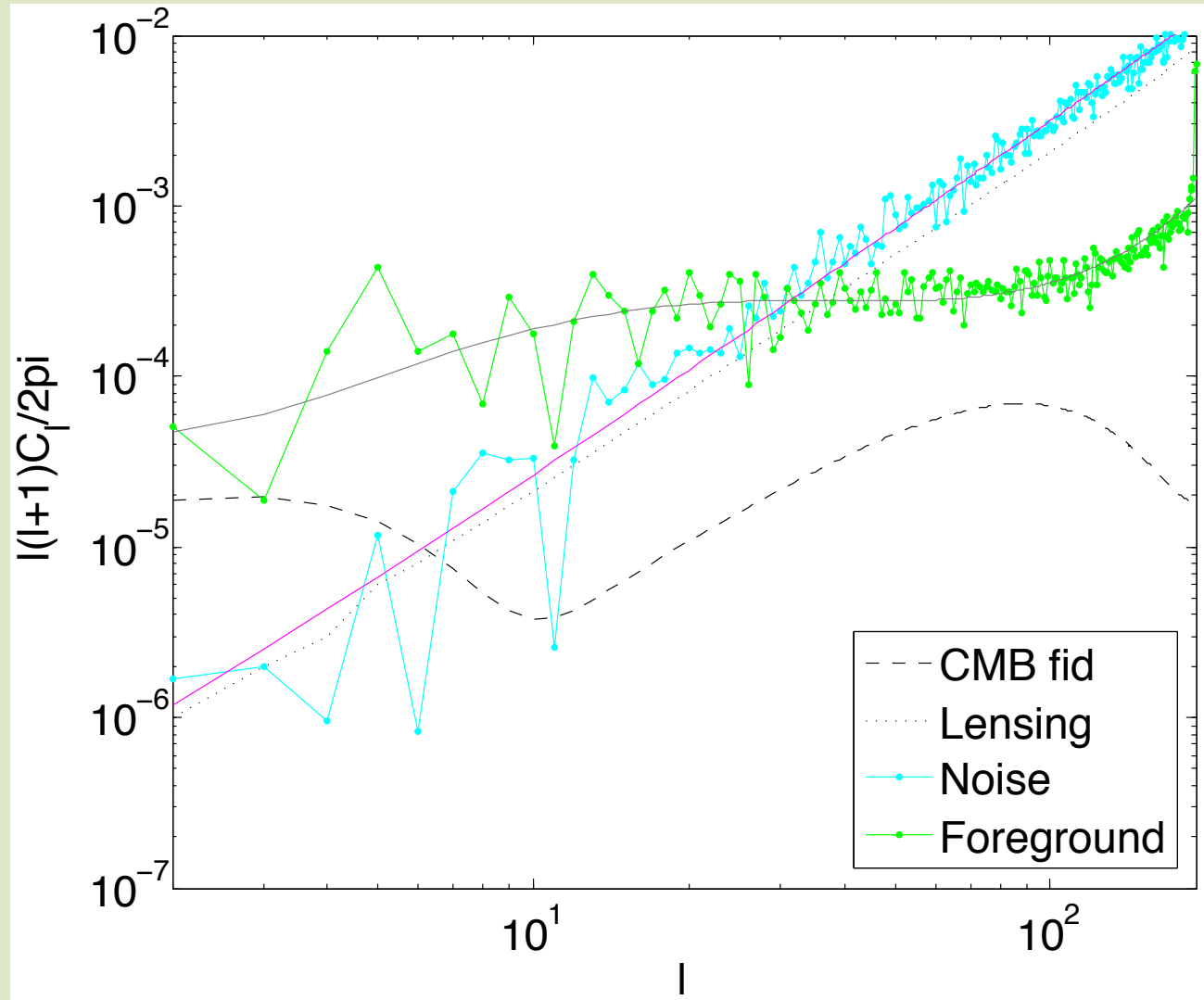
Sensitivity forecast

“Realistic” case: Primordial B + lensing + noise + foregrounds (f_{sky})

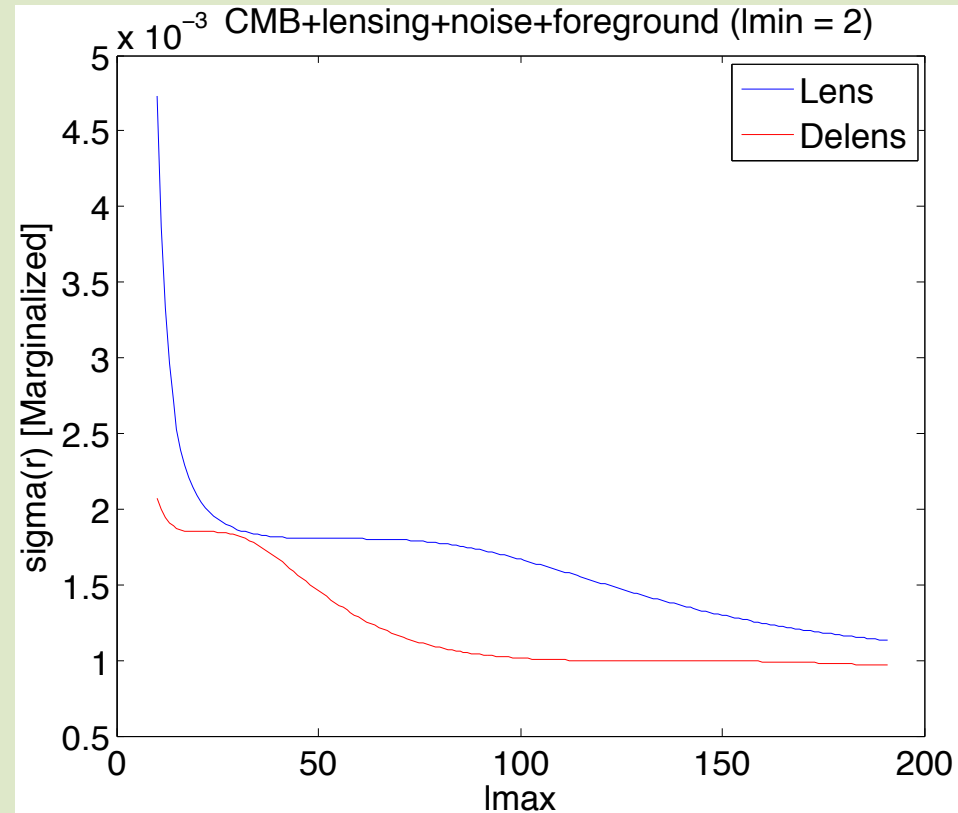
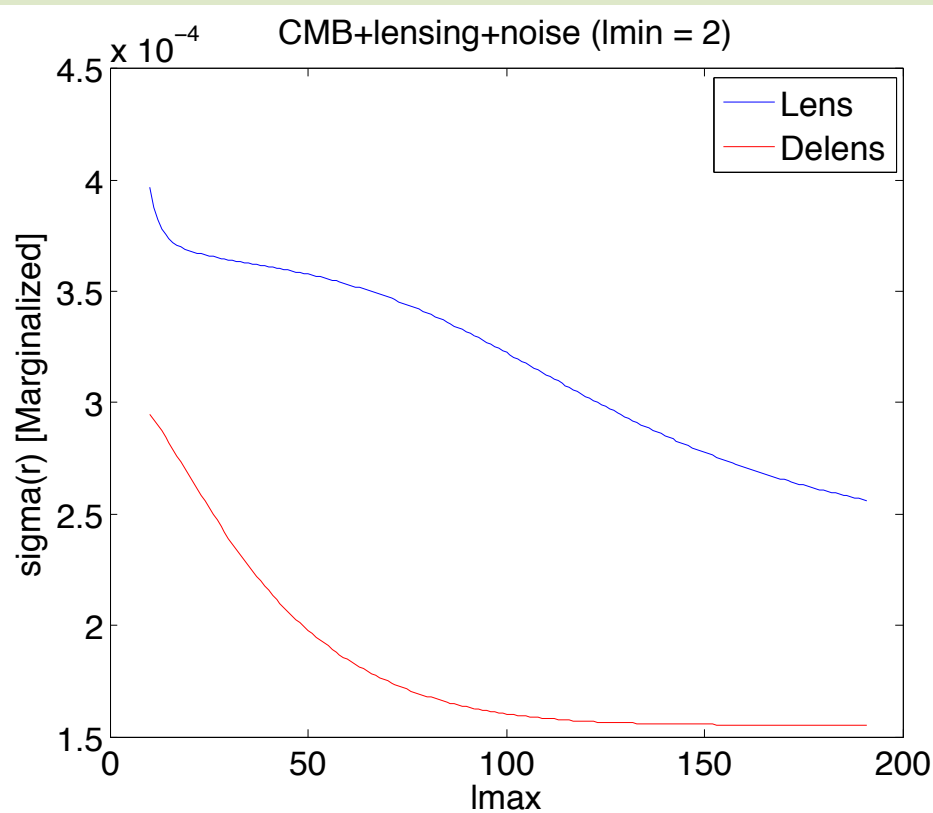
$$\sigma(r) = 1.0 \times 10^{-3}$$

$$\sigma(A_L) = 0.032$$

$$\sigma(A_F) = 0.12$$



Sensitivity forecast



- The method
- The simulations
- Sensitivity forecast
- Next steps

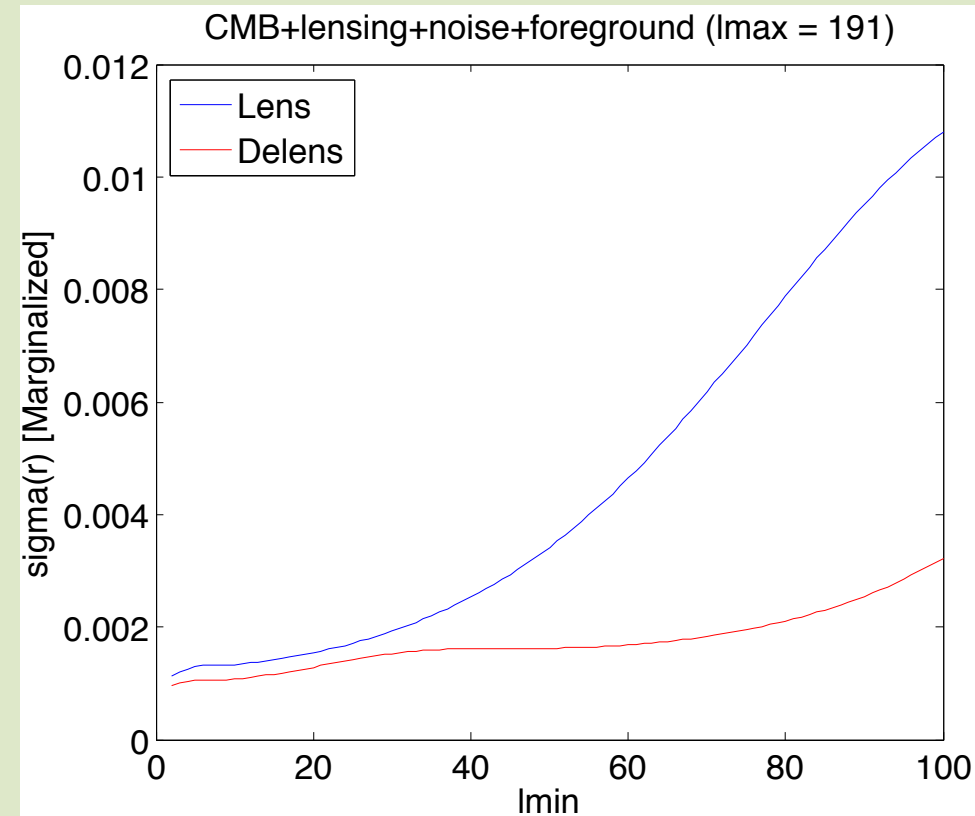
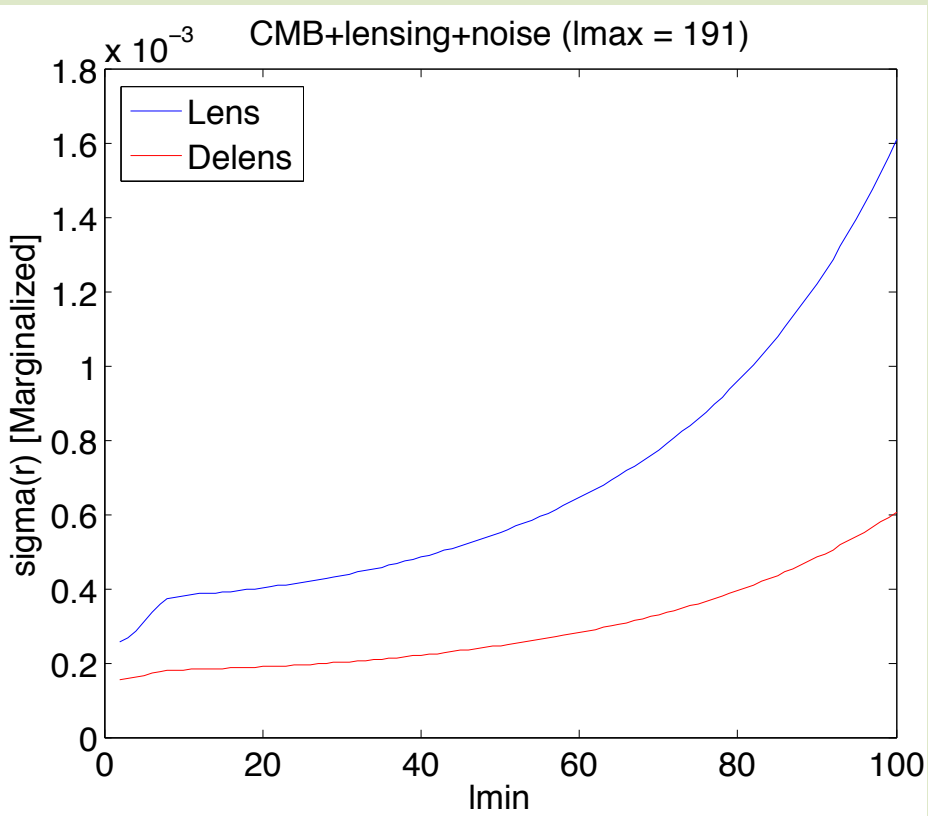
1

Our current effort is focused on investigating the **role of the foreground residuals**:

- Sensitivity test shows that foreground residuals reduces the r detection by a factor around 4 (or around 6, when effective delensing is considered)
- This leaves us already with a $\sigma(r)$ of around 10^{-3}
- Besides, we are working on characterizing the possible bias on r , by performing a set of simulations and computing QML estimations of the power spectra. This is a work in progress in which, at a first stage, we are characterizing the residual foregrounds by a single parameter (amplitude), but that will be further generalized to a parametric function of 2 or 3 parameters
- Just neglecting the multipole range which is expected to bias the r determination, already degrades the sensitivity by a factor 1.5 to 2.

Next steps

1



2

Increase the resolution

- When delensing is not assumed, it seems that it is enough to explore scales up to 1 degree to extract all the signal to constrain r . However, when (even an effective) delensing is taking into account, more information is available at high resolution.
- We need to decide how we want characterize this delensing, looking for a common approach among methods

3

Explore results obtained with covariant SEVEM (PRITF) → specific gain on foreground residual characterization from having several clean bands?