Effect of Band-pass mismatch

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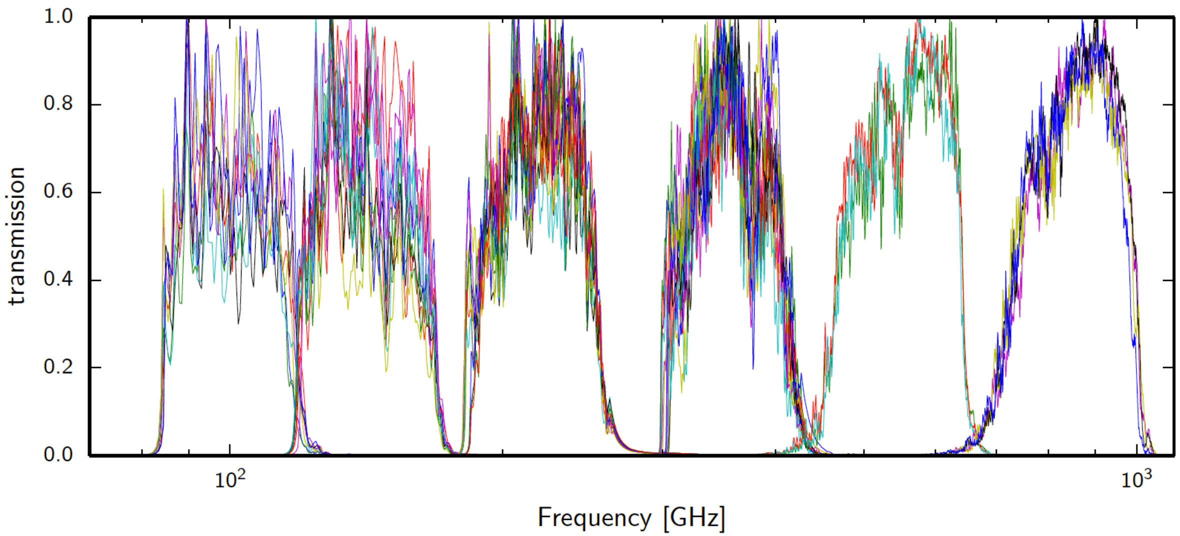
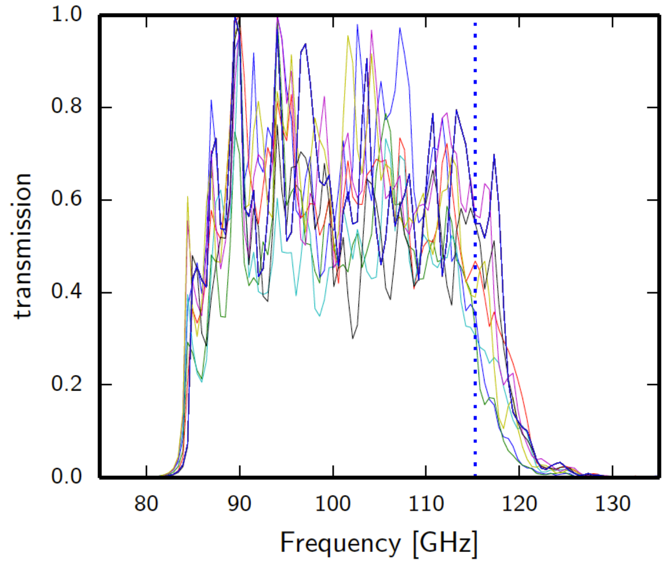
Detector Band passes

Differences in filter shapes from detector to detector might be present

Example: Filters of Planck HFI



CO transition line 1-> 0 falls at the edge of the 100 Hz filters so the CO components has very different amplitude from detector to detector



→ lead to different relative calibration between CMB and other components with different spectra

Calibration mismatch

Foreground relative calibration:

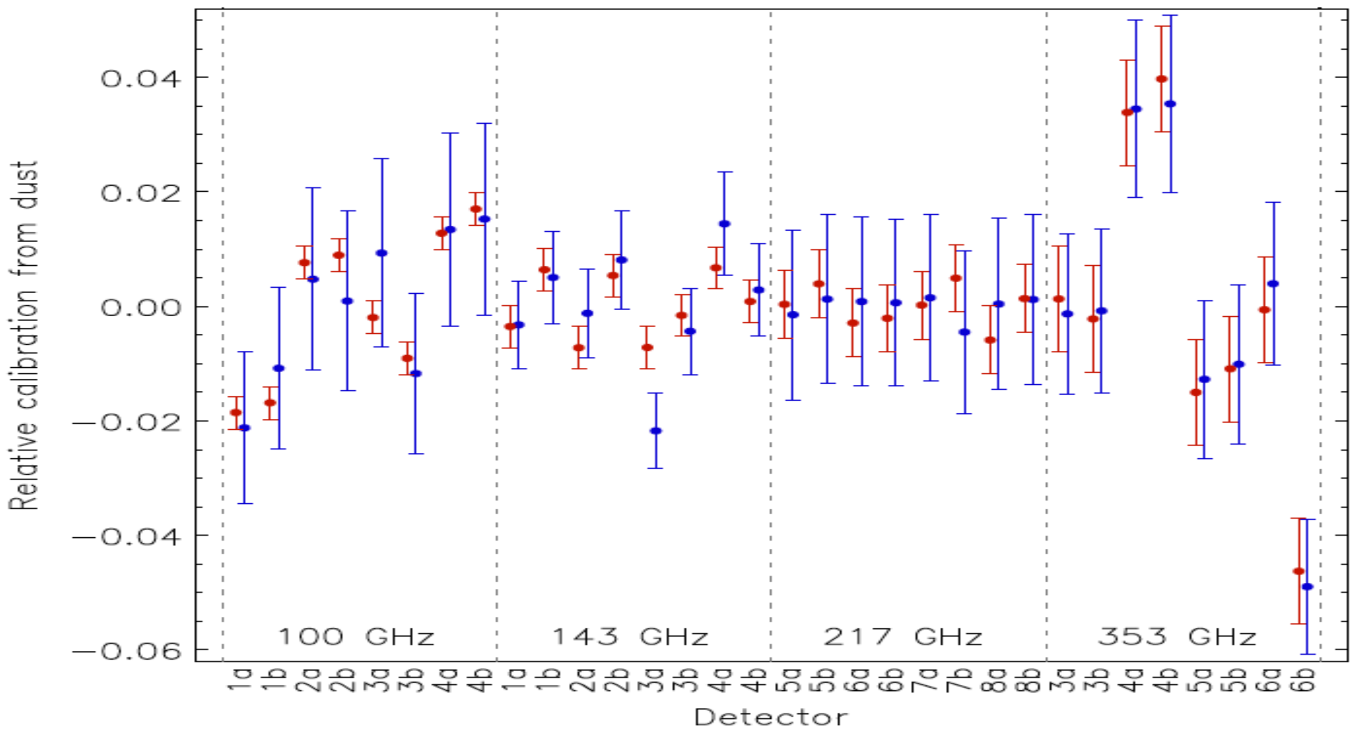
$$T_{sky} = T_{cmb} + \left(\frac{\int g_i(\nu) \left(\frac{\nu}{\nu_0}\right)^{\beta} \frac{B(\nu,T_d)}{B(\nu_0,T_d)} d\nu}{\int g_i(\nu) \left(\frac{\partial B(\nu,T)}{\partial T}\right)_{|T_0} d\nu} \right) \left(\frac{\partial B(\nu_0, T)}{\partial T} \right)_{|T_0} T_{dust}$$

Effect captured by a single number per detector and per component.

→ Lead to intensity to polarization leakage of foreground components

Maximum effect when a and b detectors, with polar oriented at 90 deg., have band mismatch. Difference cancels CMB intensity by not dust.

Relative calibration dust-CMB for Planck



- Processing of Planck HFI polarization required in-flight estimation of those parameters

- Corrected in Planck at the map-making level

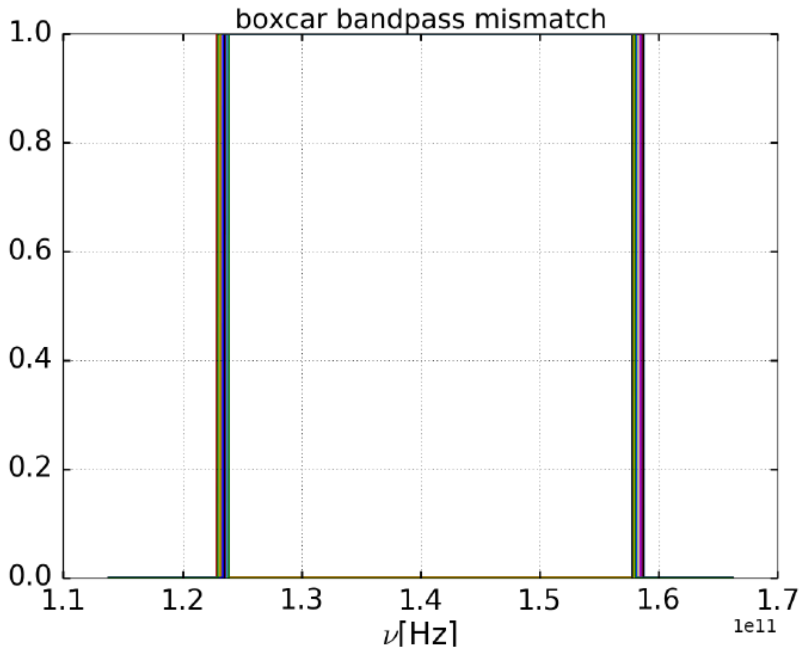
- Might be a severe problem for future mission given the required precision.

Accuracy of ground filter measurements with FTS required such that parameters can be fixed and not re-estimated from flight data.

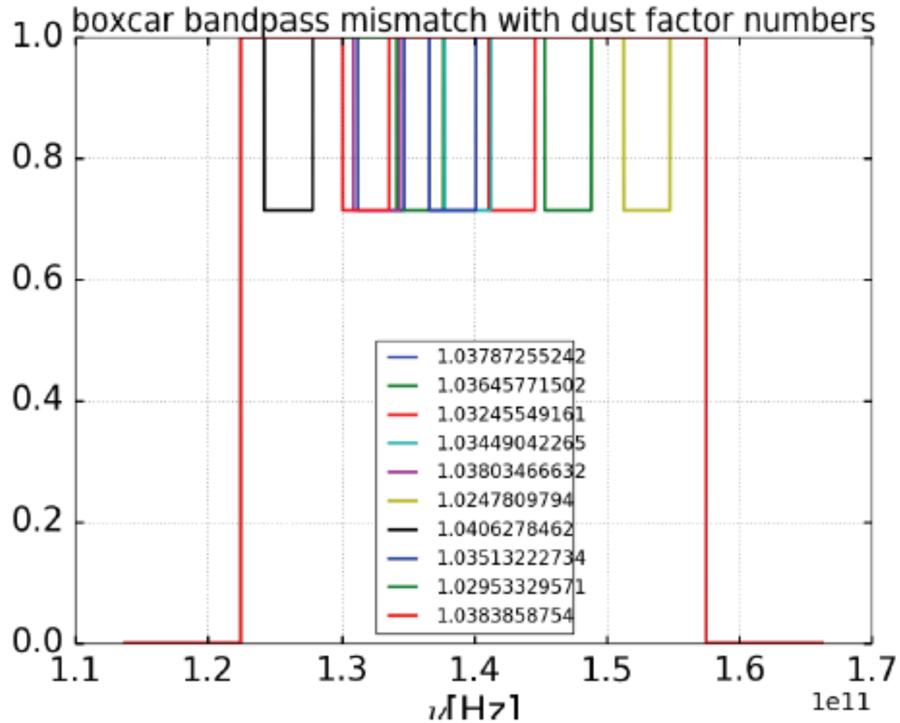
Filter simulations

We assume two kind of errors:

Planck-like errors



Typical measurement errors:



Recal. numbers for 10 detectors:

1.04785827
1.03624392
1.04635293
1.04052752
1.05881043
1.04705189
1.05527226
1.04787831
1.05176195
1.05254128

Lead to relative calibration errors of about half a percent from detector to detector

Data simulations

Very simple TOI simulations in order to isolate the effect of intensity to polar leakage
- include only CMB and dust intensity
- no polarization
- no noise
- same pixellisation between input and output maps
- band-pass integration at the TOI level

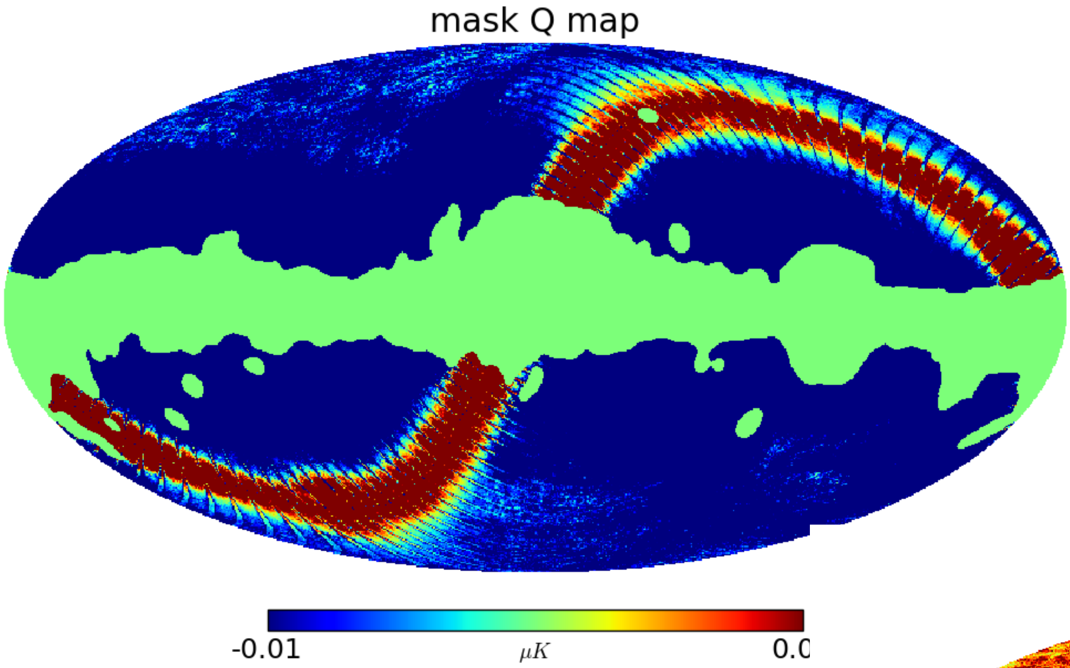
Simulations at 150 GHz using two configurations: Core+ and LiteBird

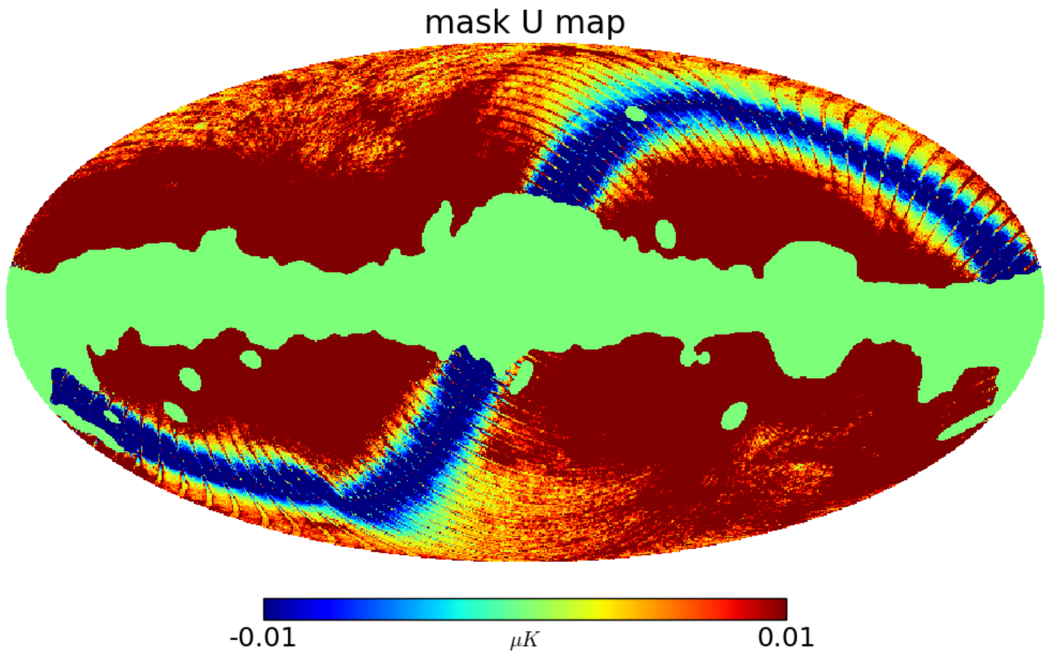
Map-making: solve for I, Q, U with simple linear projection

$$\mathrm{m} = \begin{pmatrix} I \\ Q \\ U \end{pmatrix} \qquad m = \left[A^T A \right]^{-1} A^T d$$

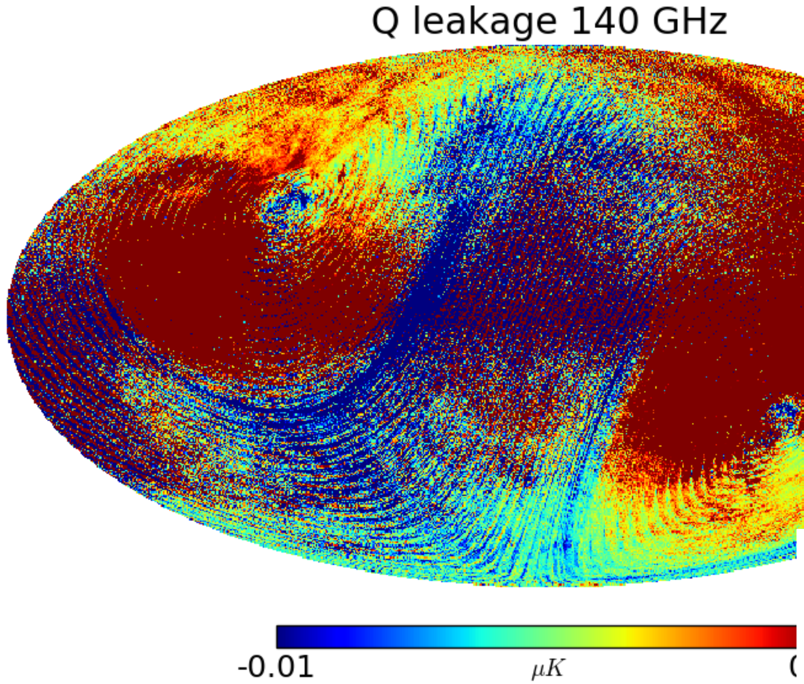
We have checked that in absence of band mismatch we get 0 polarization

Result for Core+

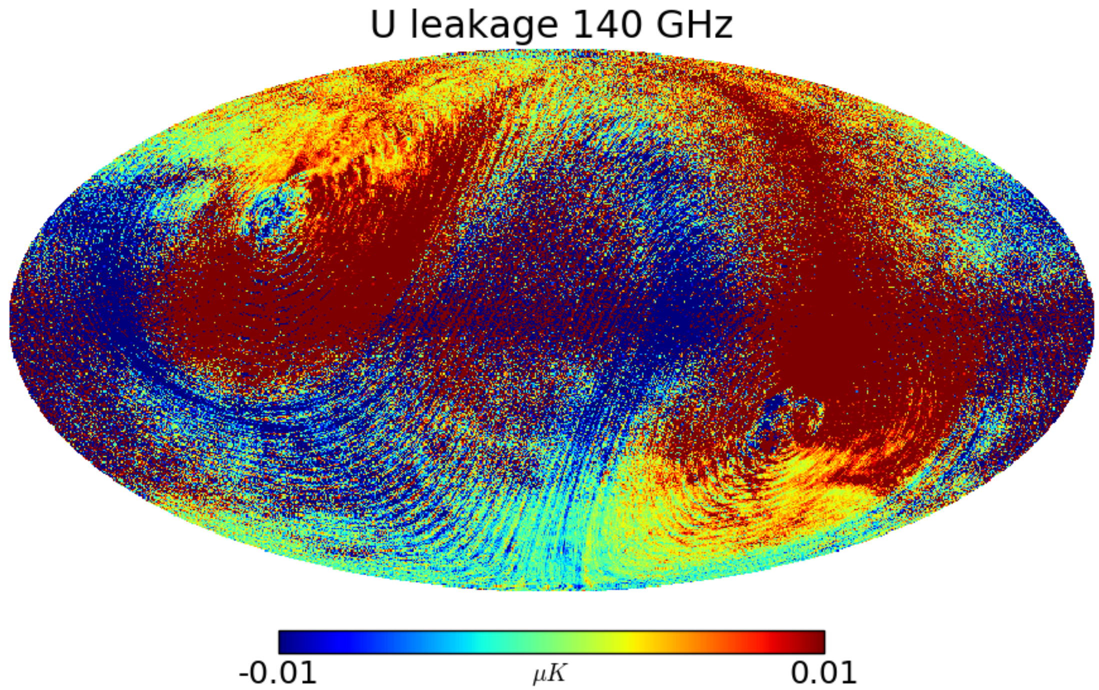




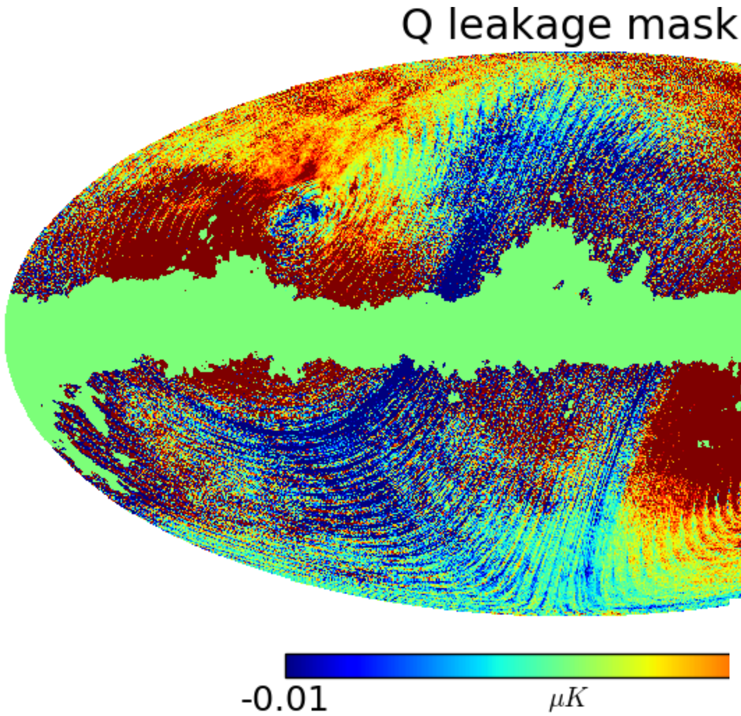
Results for LiteBird



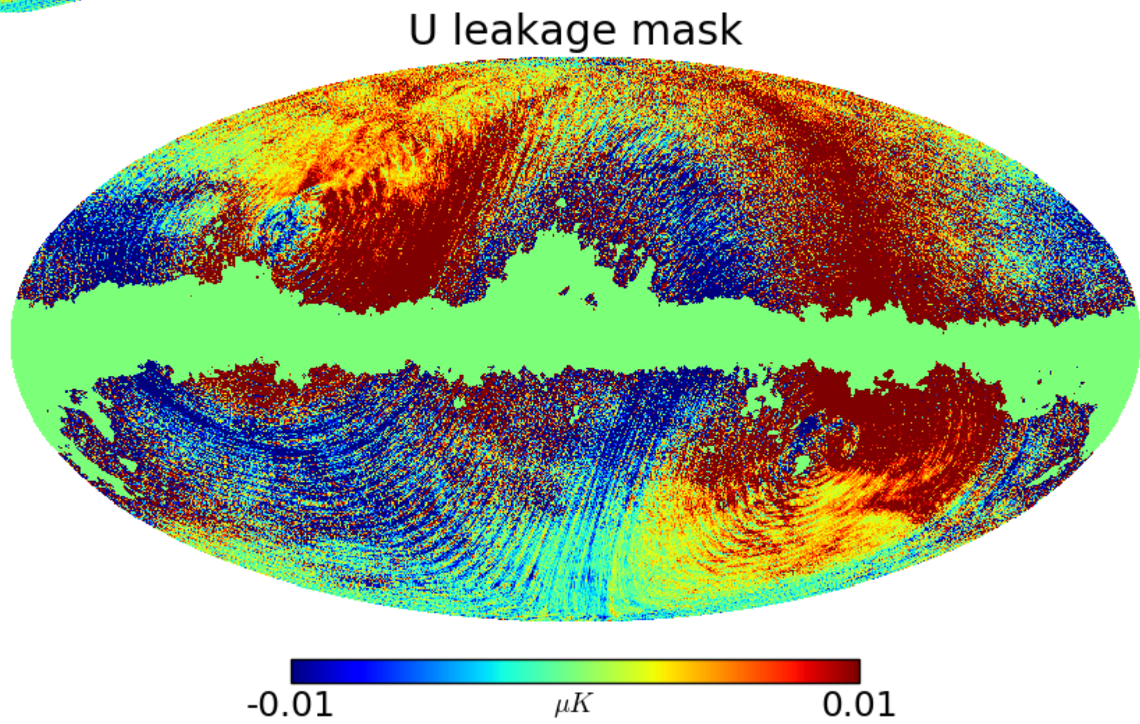
We use LiteBird scanning strategy with 50 detectors and 6 month observations



Results for LiteBird

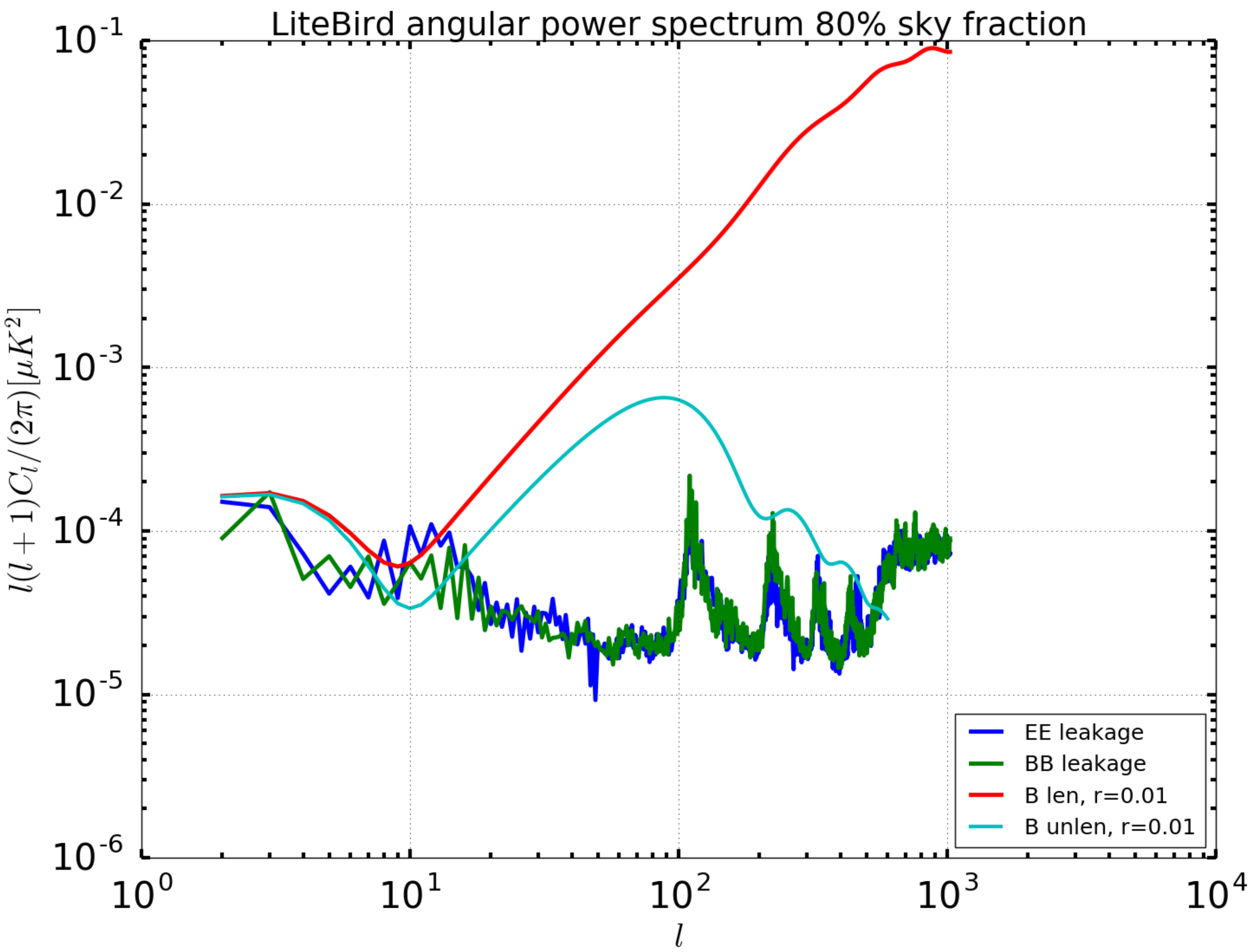


After masking 20% of the sky



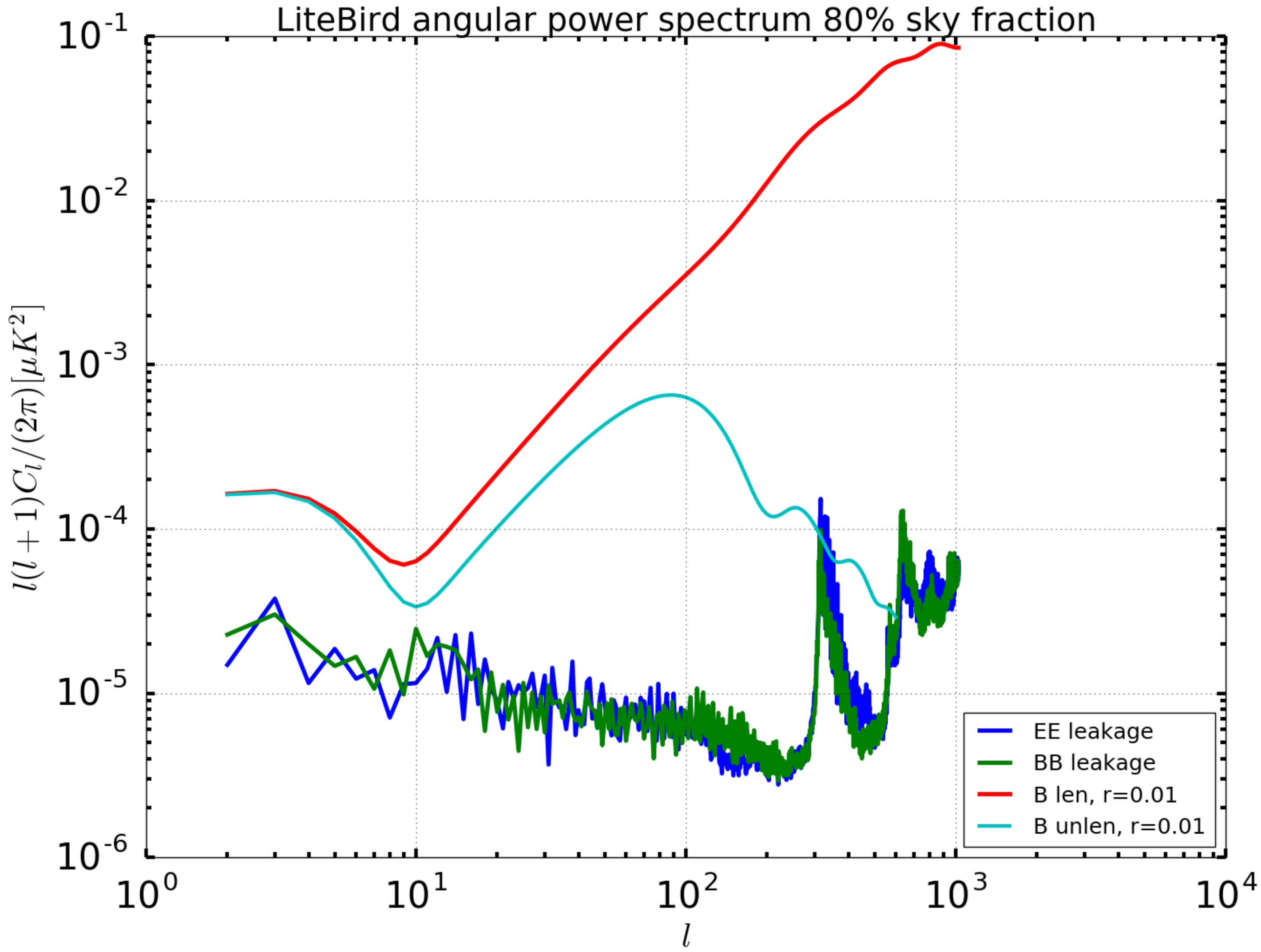
Leakage power spectrum

LiteBird scanning strategy angles
0.1 rpm
No HWP
50 detectors



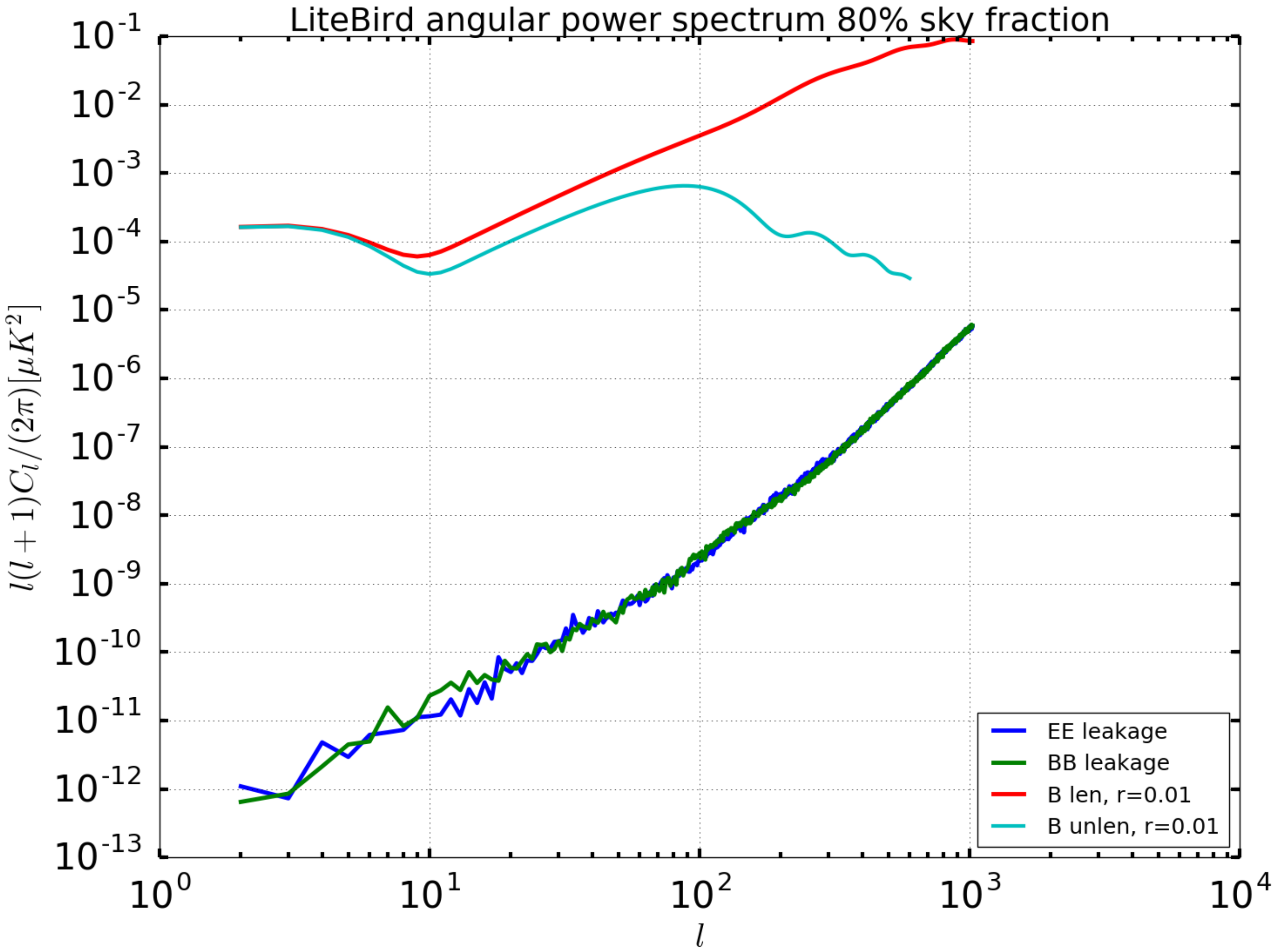
Leakage power spectrum

LiteBird scanning strategy angles
0.3 rpm
No HWP
50 detectors



Leakage power spectrum

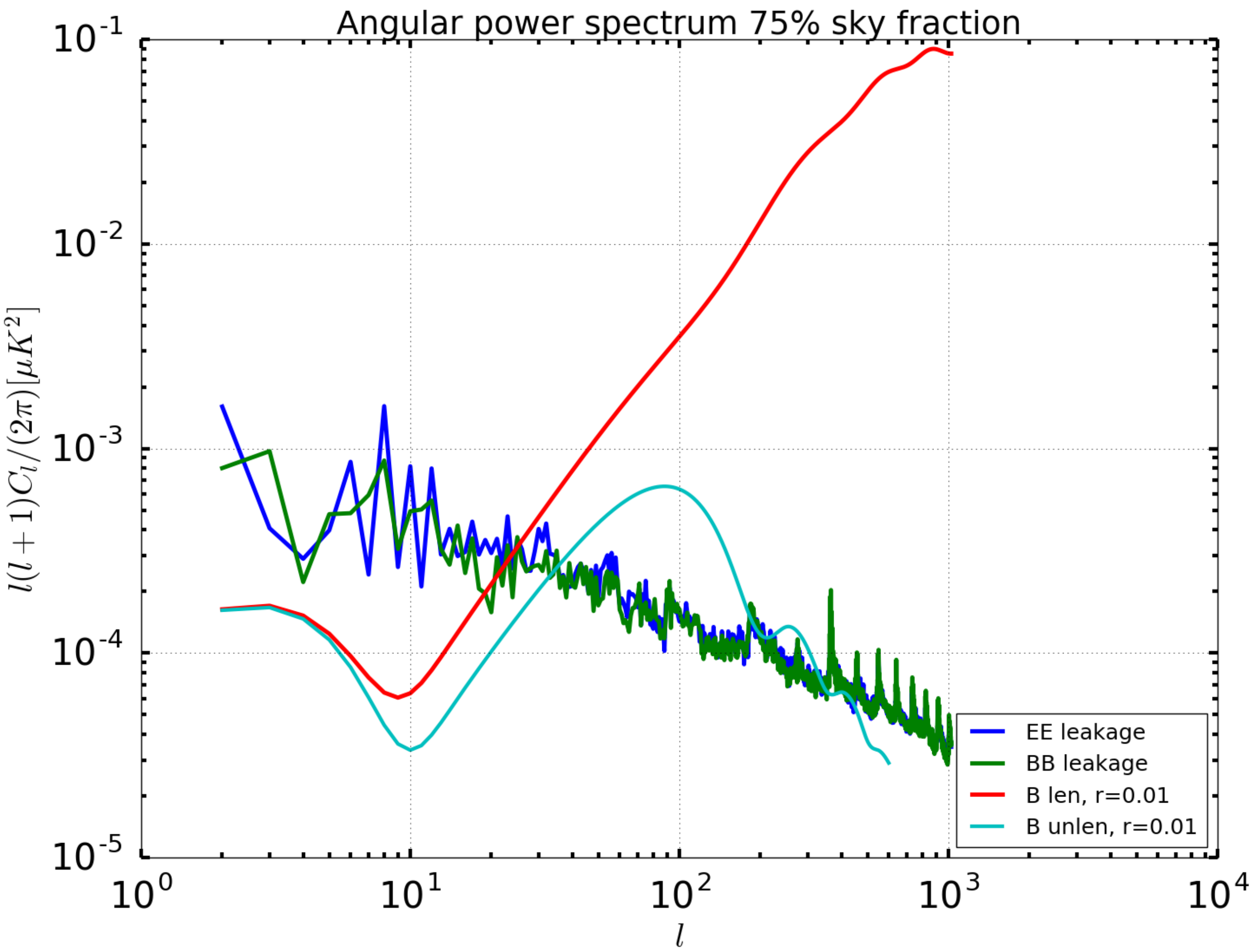
LiteBird scanning strategy angles
0.1 rpm
HWP
50 detectors



Leakage power spectrum

COrE scanning strategy angles

10 detectors



Preliminary conclusions

- Band-pass mismatch should lead to non-negligible intensity to polarization leakage if not corrected, specially at very low ells
- Power spectrum $\alpha\ \ell^{-2}$
- Features in the power spectrum might depend on the scanning strategy
- Work in progress for CORE+ scanning strategy
- First order correction are possible using frequency channels where galactic components dominate

Future work

- Leakage disappears if we perform single detector I, Q, U maps. Need to check what is the prize to pay in term of signal to noise.

- First order correction can be performed easily using bolometer pair difference:

$$S_{1a} = I_{\rm CMB} + Q\cos 2\psi + U\sin 2\psi + \alpha_a I_{\rm Gal}$$
$$S_{1b} = I_{\rm CMB} - Q\cos 2\psi - U\sin 2\psi + \alpha_b I_{\rm Gal}$$

$$S_{1a} - S_{1b} = 2Q\cos 2\psi + 2U\sin 2\psi + (\alpha_a - \alpha_b) I_{\rm Gal}$$

Basic idea:
- use the 350 GHz channel providing a good proxy for I_{Gal} .
- Then fit amplitude coefficients of dust template built from the 350 GHz channel at the TOI level
- subtract the template from each bolometer pair

Main limitations:
- Reduce data to bolometer pair.
- Assume a single component of dust
- Might be coupled with inter-calibration coefficients.

Global approach: global map-making solution: Solve jointly I, Q, U, ΔI