Lensing template generation for cmbs4

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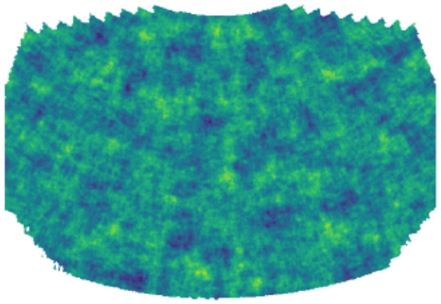
Context:

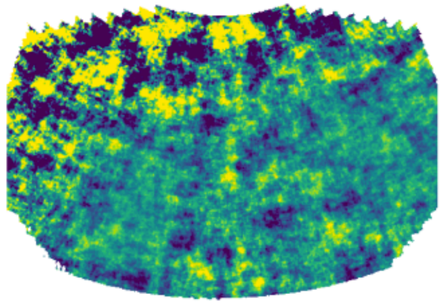
- First ‘real’ map-based delensing validation for cmbs4, and inclusive of foregrounds and ILC
- This uses a curved-sky iterative lensing map building algorithm, tested here for the first time for the past year

Main target (for me the template builder….) was to achieve a residual B-amplitude of 0.1 or more

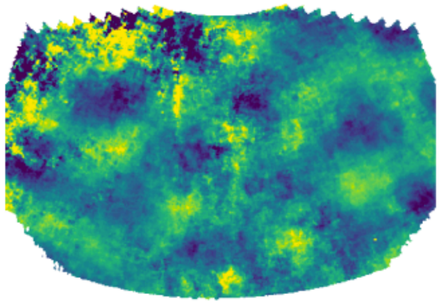
fg 00, Gaussian dust and synch



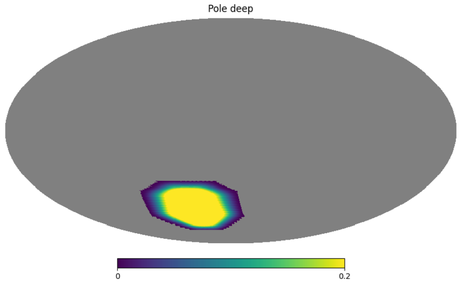
fg 07, Modulated Gaussian dust and sync



fg 09: Vansyngel dust and sync

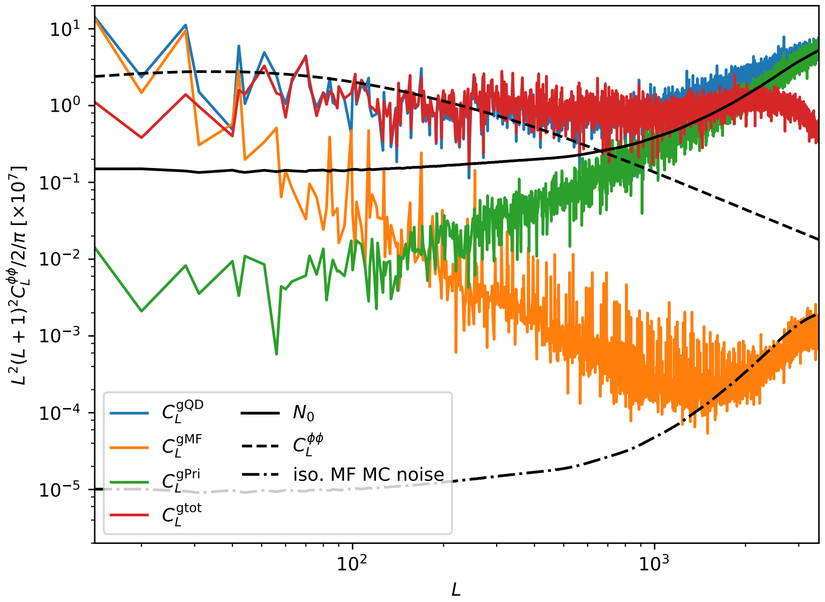


s06b pole deep, $f_{sky} = 3\,\%$



Iterative lens reconstruction

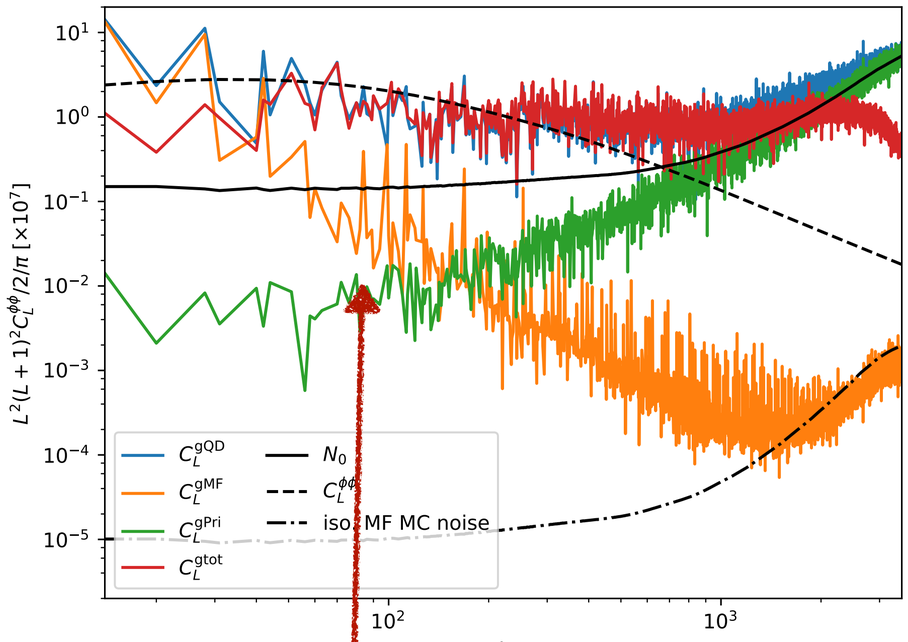
- ϕ_{LM} posterior maximizer given data and fiducial cosmology (JC & Lewis 2007 1704.08230 for flat-sky)
- Approach similar than flat-sky version applied to POLARBEAR data Polarbear collab. 1909.13832 PRL



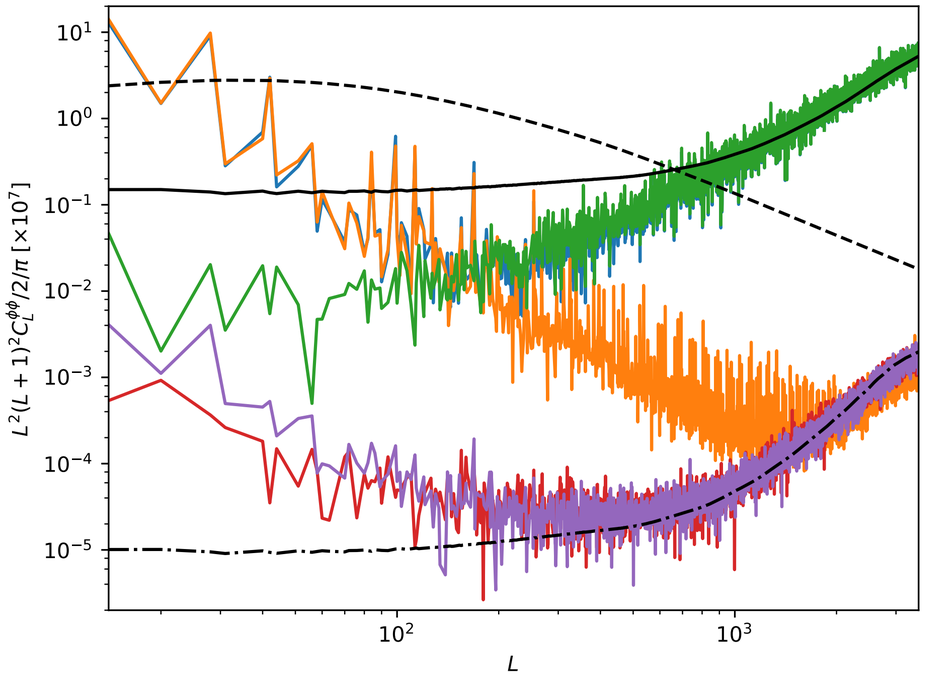
Figs from JC & Lewis, 1701.01712

$$g_{LM}^{\rm Quadratic} - g_{LM}^{\rm Mean-Field} + g_{LM}^{\rm Prior} = g_{LM}^{\rm Total}$$ ← Set this to zero

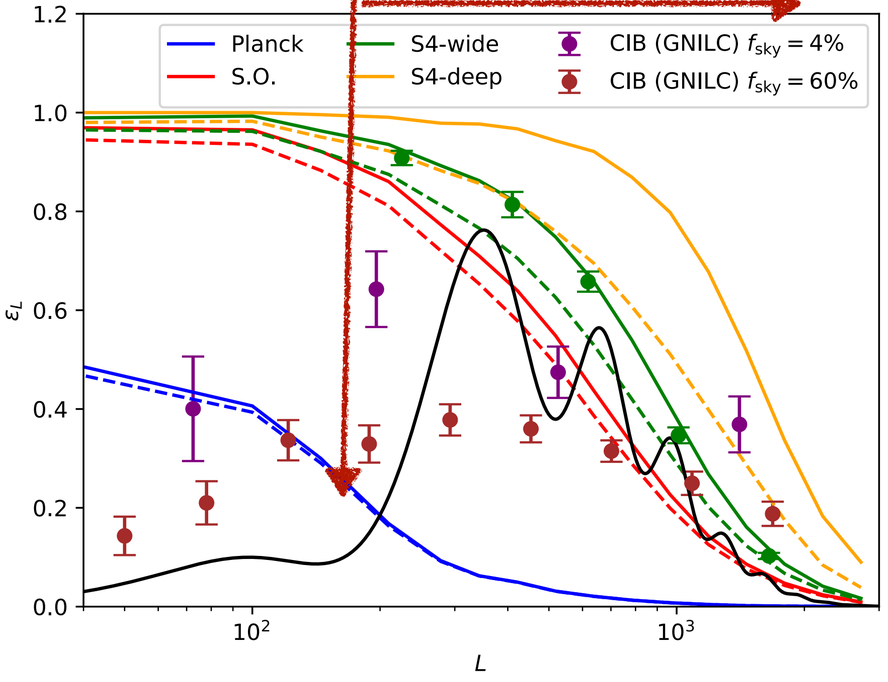
- **This gives the best lensing map given the data provided the posterior model ingredients above are close to the data.**
  —-> See Marius works and talk for alternative approach giving joint CMB-lensing posterior maxima.



Iterations



Most relevant L's for B-mode degree-scale delensing



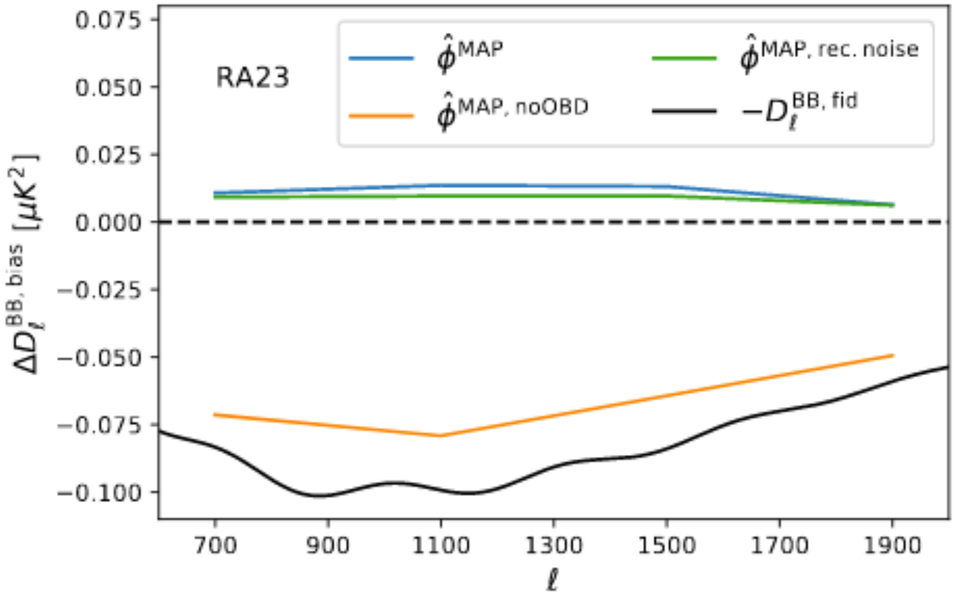
Figs from JC & Lewis, 1701.01712

Good points for cmbs4 polarization template building:

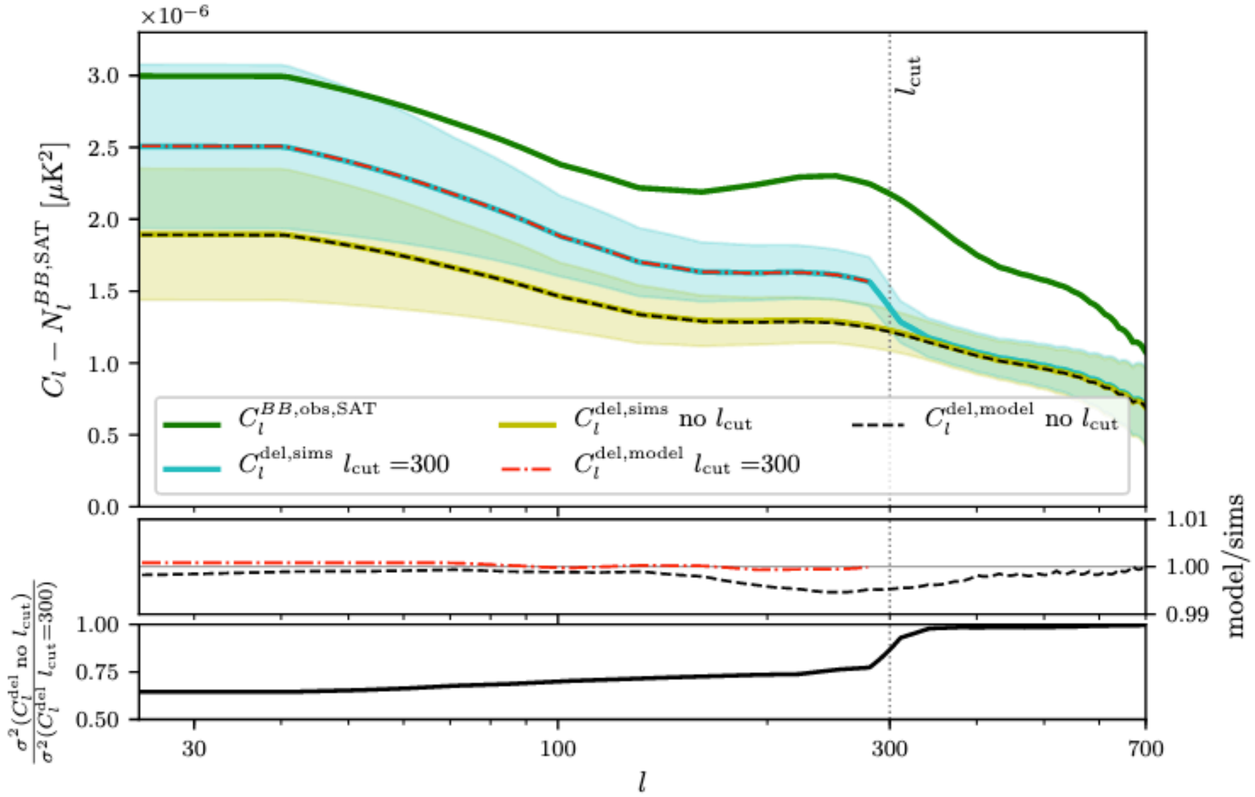
- Large lensing L's have little relevance for degree-scale B delensing
  -> mean field not too annoying
- (! Not true for T or E delensing! Peaks at L = 100)
- Large scale CMB contributes very little to the lensing reconstruction signal
  -> Foregrounds not too annoying (+ this makes the algorithm quite a bit faster !)

  Foregrounds are completely ignored!

Deprojection of degree-scale B-modes



POLARBEAR collaboration 1909.13832



Baletao Lizancos, Challinor & JC 2020b 2007.01622

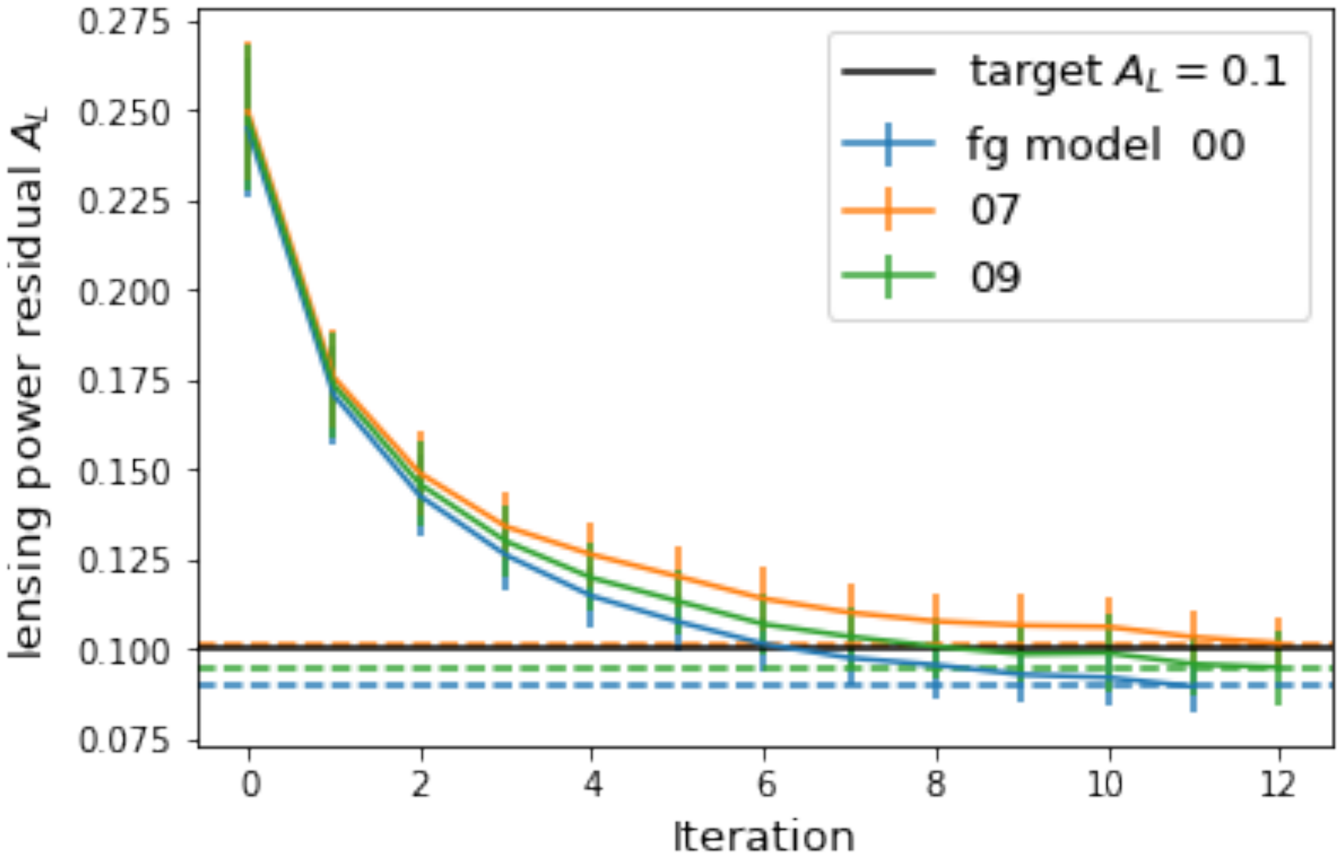
Internal delensing bias:

Teng, et al 2011 1102.5729, JC, Lewis & Challinor 2007 1701.01712, …

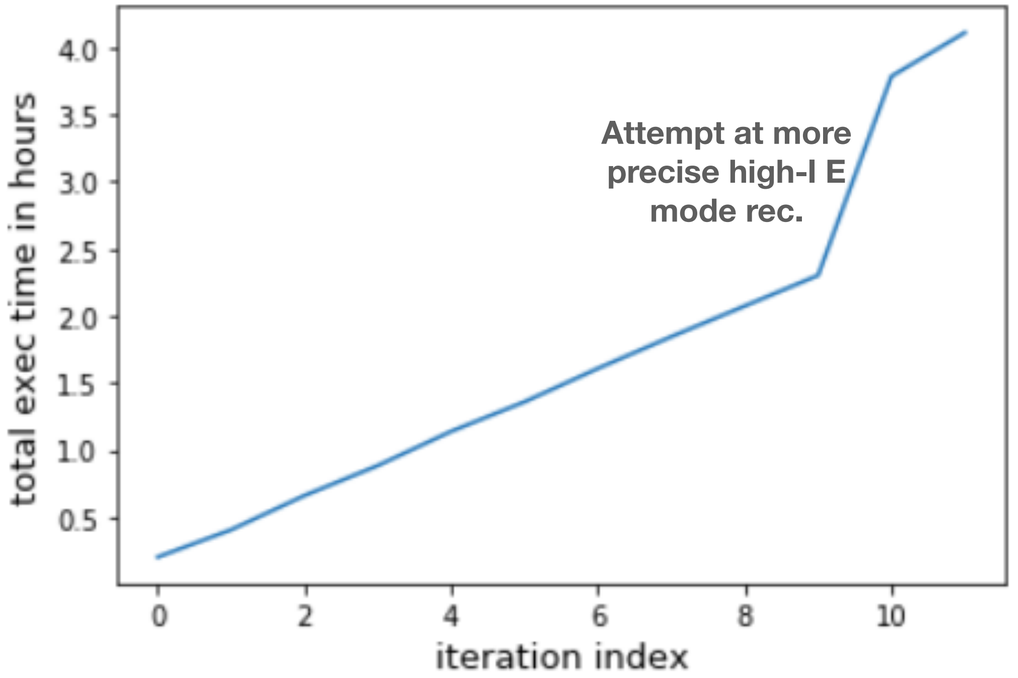
The reconstruction noise of the lensing tracer is completely in sync with the random anisotropies of the CMB data used to build it. One must not have overlap between the modes used for the tracer and the modes to delens!

Here: careful deprojection of all $B_{\ell<200}$ **in the likelihood model from the data using a large dense template matrix**

Results on s06b ILC maps



16 OMP threads



00:

Error bars from scatter of the 100 simulations.
(~ 1% delensing point)

Results and perspectives

- Target of AL 0.1 met for all, also for largest foreground model 07 after ILC. Analytical predictions match within 1%!

- Templates degraded in high foregrounds regions. Seems consistent with predictions of degradation from just higher Gaussian noise.

- Can see some algorithmic effects in spectra shape, and in the patch edges, but that does not seem to really matter for our purposes.

Can we *better delens than that on these sims* ?

Yes but not by a lot. I believe this is close to optimal already

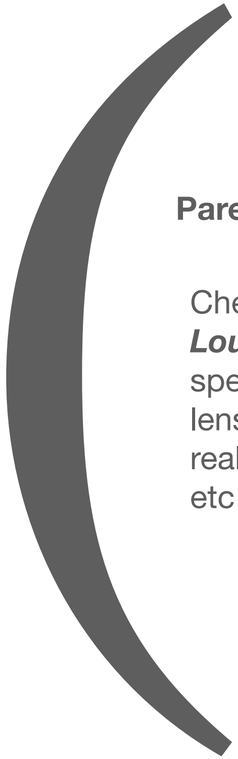
- Extend lmax (~1% delensing point)
- Better noise model in the filtering (~0.5% delensing point)
- Better mean-field treatment (<0.5% ?, but can improve it for free)

Could we do it *faster*?

Oh yes

- Several (full factors) speedups possible in relevant places (SHTs bits and others)
- Better designed search, especially at higher iterations

Probably achievable is flat-sky runtime x a sizeable factor, which is fast



Parenthesis for lensers:

Check out fireslide by ***Louis Legrand*** on power spectrum from optimal lensing map, with realisation-dependent N0 etc