Iterative curved-sky lensing estimates for cmbs4 deep

Julien Carron, CMB-S4 meeting March 31 2020

Iterative lens reconstruction

- ϕ_{LM} posterior maximizer given data and fiducial cosmology
- Approach similar than flat-sky version applied to POLARBEAR data

(JC & Lewis 2007 1704.08230 for flat-sky)

Polarbear collab. 1909.13832 PRL

$$-2\ln p(\phi\,|\,X^{\rm dat}) = X^{\rm dat}\cdot \mathbf{Cov}_\phi^{-1} X^{\rm dat} + \ln\det|\,\mathbf{Cov}_\phi\,| + \textbf{G. prior on } \phi$$

'Quadratic' part ***'-Mean-field'*** ***prior***

to solve for ϕ_{LM}^{MAP}, the point where this posterior is maximal.

- **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.
  Here the unseen unlensed CMB fields are marginalized over.

At each step, starting from QE:

- Estimate $E_{\ell m}^{\rm unlensed}$ (MAP $E^{\rm unl}$ if $\hat\phi$ were the truth) (conjugate-gradient inverse of Cov, the hardest part)
- Build the 3 gradients of the posterior from $E_{\ell m}^{\rm unl}$ and $\hat\phi_{LM}$
- Build the next point with gradient and curvature info, and a fancy L-dependent step-length

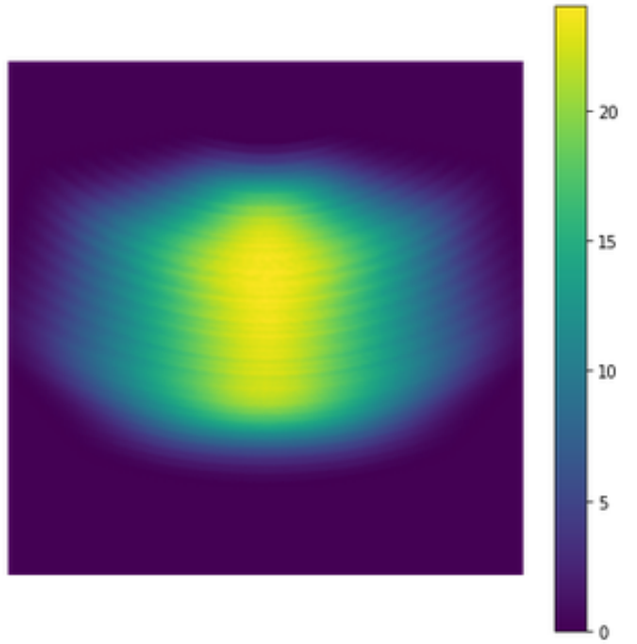
Reconstruction on s06b at 95 GHz

$f_{\rm sky} = 5\,\%$

beam 2.3 amin

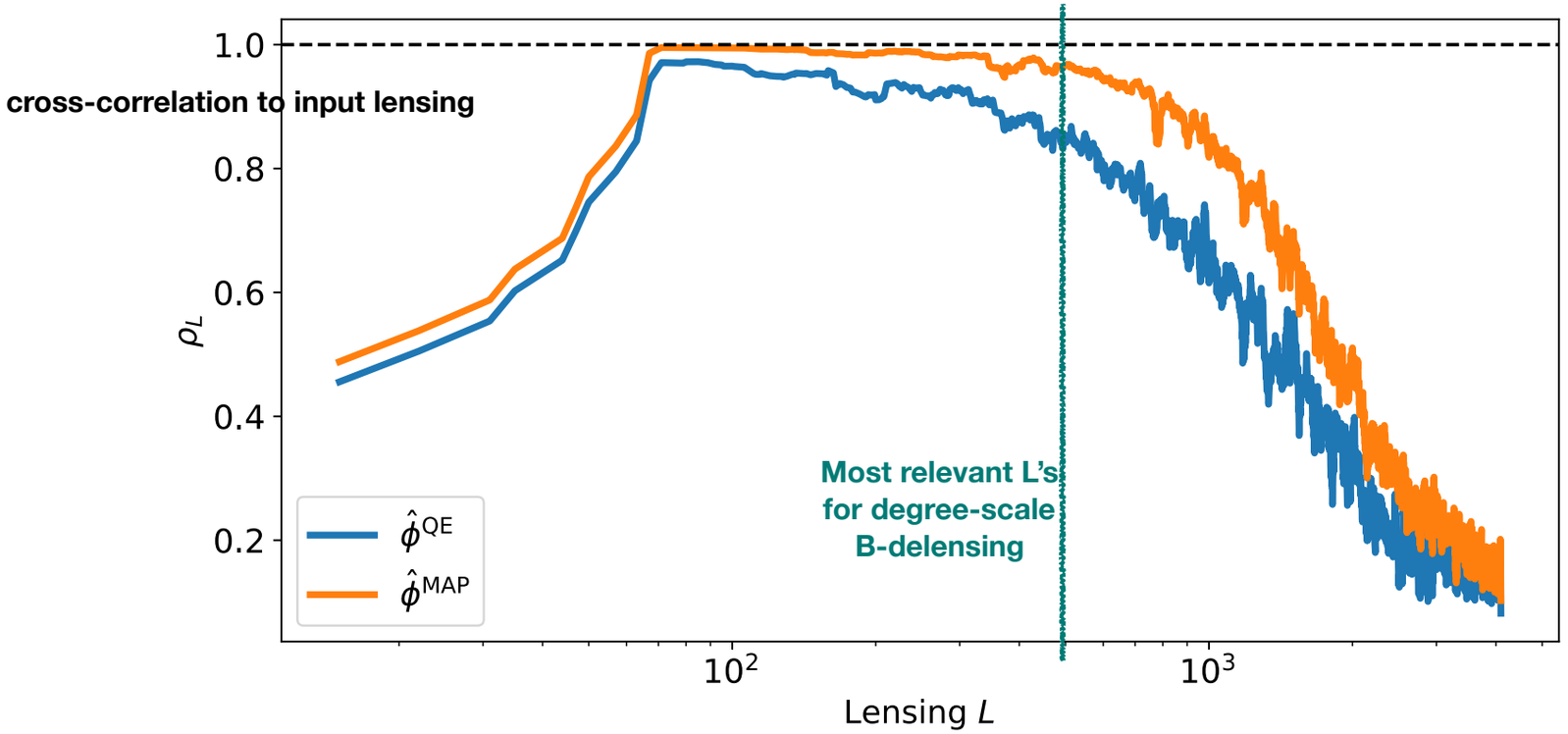
center pol noise level ~ 0.35 uK-amin

sort of 'if can do this one can do them all'-map



Cov inverse variance

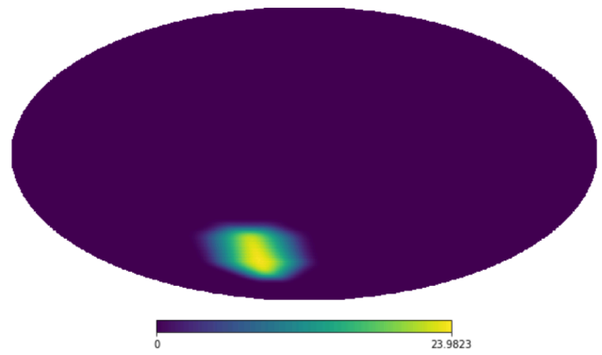
Results on map without foregrounds:



At L~500 goes from 85% (QE) to 96-97%(MAP) correlation
(suggests can bring down lensing power AL from 0.3 (QE) to ~0.07)

Ingredients:

- **Sky curvature**



- **Inhomogeneous noise (hit map)**

- **Identical mask and noise mean-field for each step** **(but that's OK! see last slide)**

- **$\hat{\phi}$-induced mean-field neglected** **(but that's OK! see last slide)**

- **low-ℓ_B masking (all ℓ_B, m_B below $\ell_B \leq 200$)** performed with a dense 40397^2 matrix

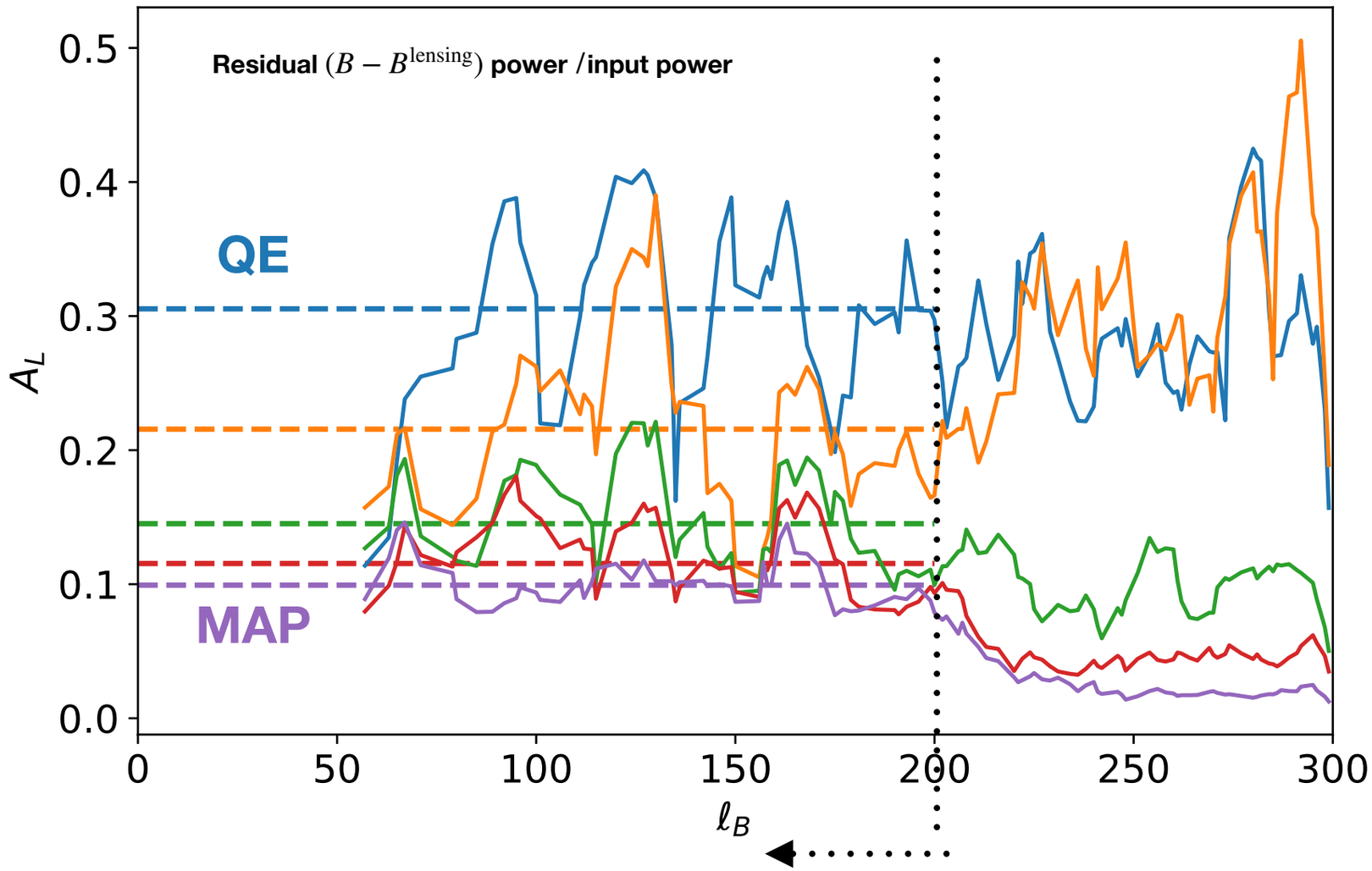
  Lensing tracer *completely* blind to these modes

  (can't just simply remove these modes from the data to start with)

From $\hat{\phi}_{LM}$ to $\hat{B}^{\rm lensing}_{\ell m}$:

Here I just remap the estimated $E^{\rm unl,WF}_{\ell m}$ with $\hat{\phi}_{LM}$

Reaches residual lensing power amplitude of 0.1 on s06b wo fg:



All these modes projected out when building the tracer

Summary:

- ‘exact’ curved-sky MAP lensing estimation work on cmbs4 s06b wo fg with reasonable execution time

- At L~500 correlation to lensing input from 85% (QE) to 96-97%(MAP) (suggests can bring down lensing power AL from 0.3 (QE) to ~0.07

- Simplest B-template has residual lensing power amplitude of 0.1

Thanks !

Possibly for technical details