

CMB lensing for PLANCK

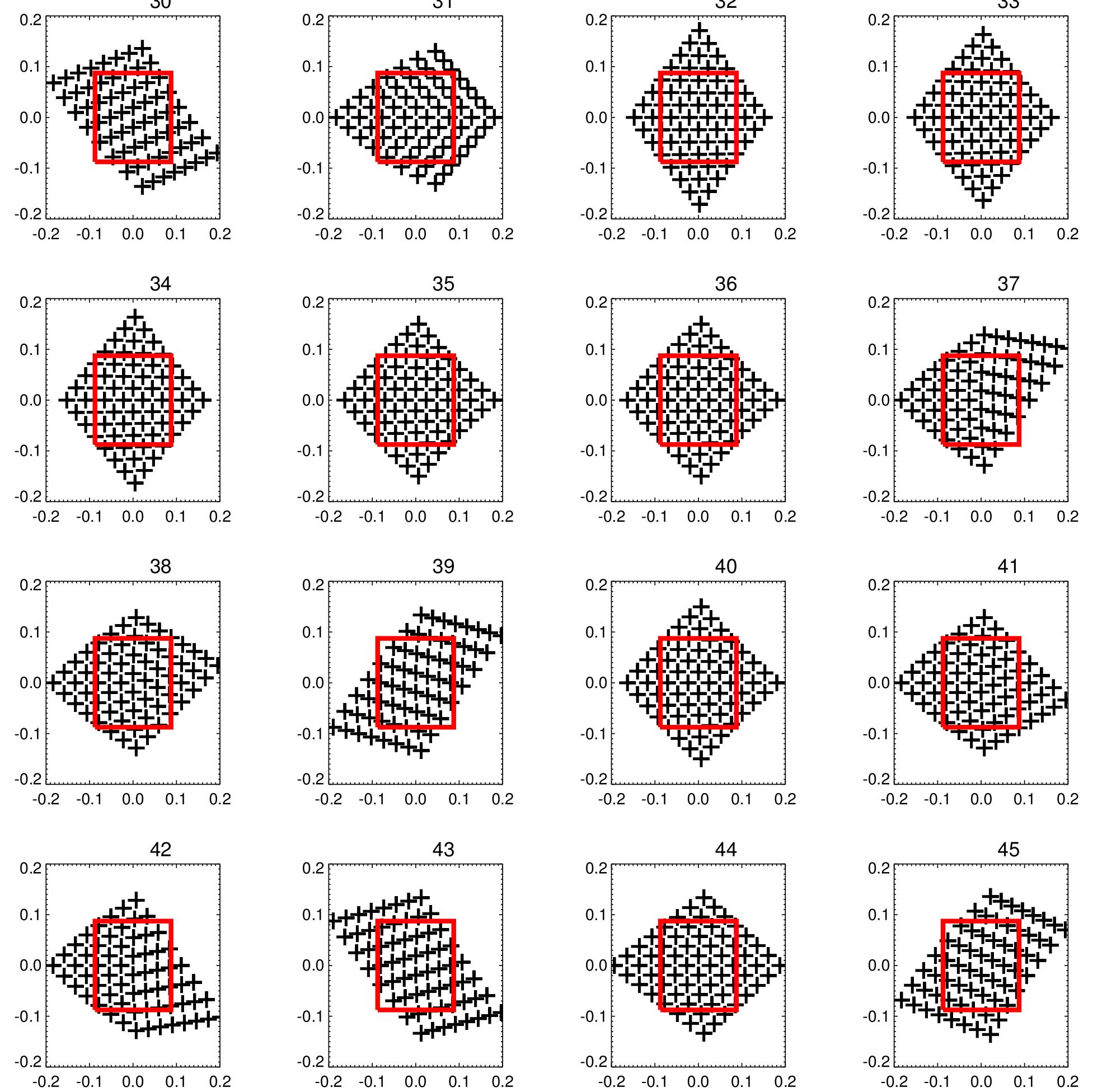
Effect of patch projection from HEALPix map

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Why patches?

Full sky

- PLANCK will produce hight resolution HEALPix maps
- NSIDE = 2048 => ~ 2 arcminutes resolution, $5 * 10^7$ pixels
- all sky calculations are really computer extensive
- contaminated regions has to be masked out
- problems to estimate lensing on masked maps



Patches

- avoid contaminated regions (galactic plane in particular)
- flat sky limit allows use of fft tools
- faster calculations
- problems of interpolation after projection

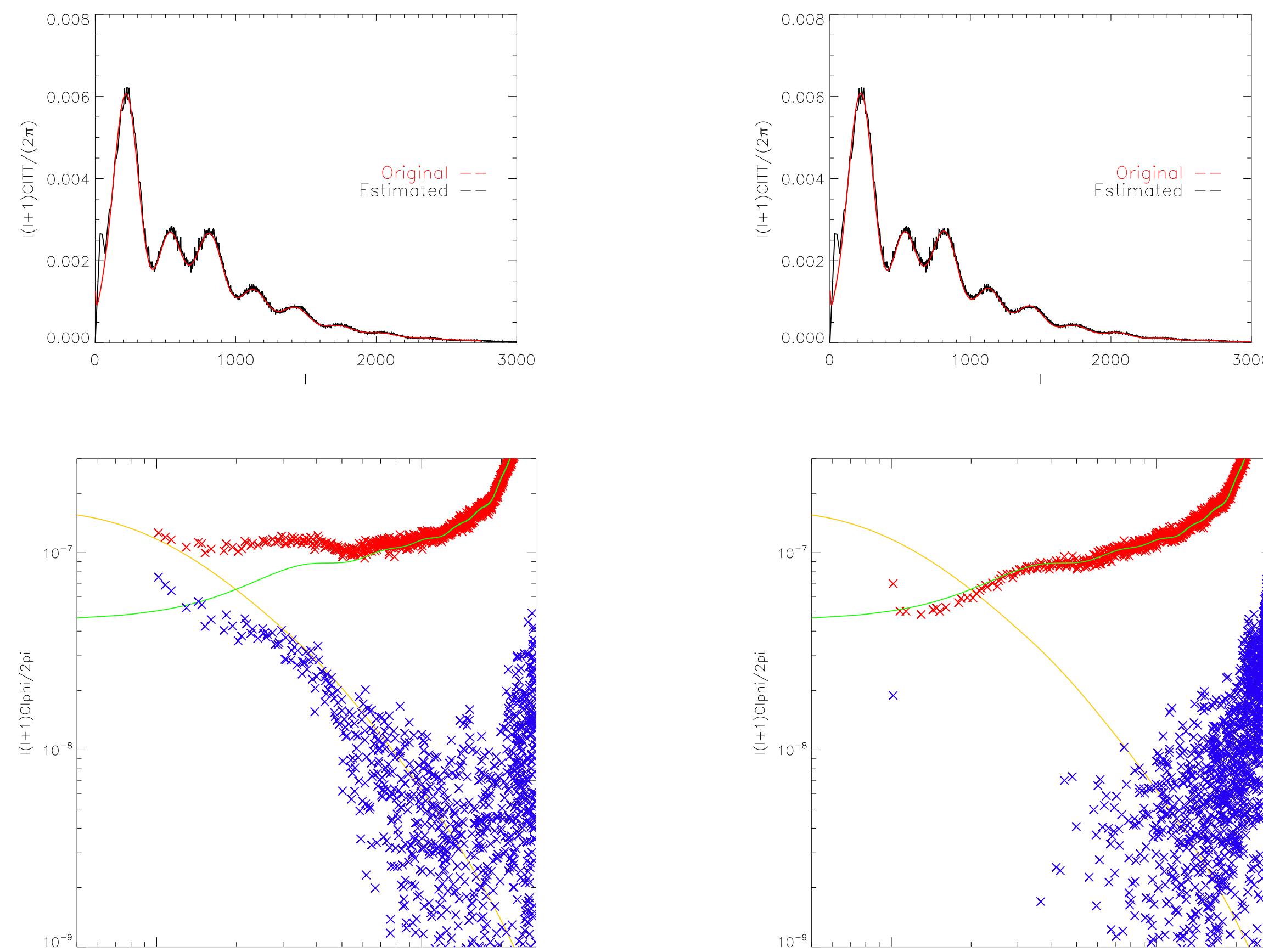
Estimator

- quadratic estimator
- general form :

$$d_{TT}(\mathbf{L}) = \frac{A_{TT}(L)}{L} \int \frac{d^2 l_1}{(2\pi)^2} T(\mathbf{l}_1) T(\mathbf{l}_2) F_{TT}(\mathbf{l}_1, \mathbf{l}_2)$$

- $A_{TT}(L)$ demanding that $\langle d_{TT}(\mathbf{L}) \rangle_{CMB} = d(\mathbf{L})$
- $F_{TT}(l_1, l_2)$ minimizing $\langle d_{TT}^*(L) d_{TT}(L) \rangle$
- $\mathbf{L} = \mathbf{l}_1 + \mathbf{l}_2$
- 4 points estimator of the deflection power spectrum :

$$\langle d_{TT}^*(\mathbf{L}) d_{TT}(\mathbf{L}') \rangle = (2\pi)^2 \delta(\mathbf{L} - \mathbf{L}') [C_L^{dd} + N_{TTTT}(L)]$$



Power spectrum of the temperature (top) and projected potential (bottom), for lensed (left) and unlensed map (right).

Interpolation

- projected HEALPix pixels don't fall into a regular grid
- need a step of interpolation to get a patch
- at first order we reconstruct well the power spectrum
- interpolation has non negligible effect on lensing

Estimate of Fourier coefficients on an irregular grid

Most methods *interpolate* (as NFFT). Here, *Solve* the exact least-square estimate:

$$\text{For 1D, assume model: } f(t) = \sum_{k=-M}^{k=M} a_k e^{2i\pi k t/T}$$

for N arbitrary values $u_i = t_i/T$ LSQ solution to $f_i = \sum_{k=-M}^{k=M} a_k e^{2i\pi k u_i}$ is:

$$(G^T G)X = G^T F \quad G_{kl} = e^{2i\pi k u_l}$$

matrix inversion un-tractable for large N...

”Second generation” algorithm:

- use conjugate gradient
- $(G^T G)$ is Toeplitz: use FFT to compute product.

Generalized to 2D

compute a 200×200 Fourier map on arbitrary grid in $\simeq 5$ min(1 proc.).

Advantages

- no interpolation
- no masking (use the values you have)
- can account for non-diagonal pixels error matrix.

