Simulation Plans

Paolo Natoli

Università di Ferrara and INFN

Mark Ashdown

University of Cambridge

Context

1. At this level, simulations are useful to:

    a. Provide science forecasting activities with (more) realistic synthetic data, in terms of analysis tools and content (e.g., systematics
    b. Provide an assessment of the goodness of a configuration assuming a model of the instrument and a model of the sky. This information could feed the proposal or (perhaps) be set forth in a devoted ECO paper.

1. At a broader level, simulations are essential to support data analysis, in providing biases and covariances for estimators, for error budged of all sorts (statistical and systematic).

    a. These are end-to-end simulations. There is plenty of expertise for this approach in Planck and other CMB experiments

The CoRE++ simulation group

1. About 60 people in the email list (join if you wish!). Coordinated by P.N. and Mark Ashdown
2. Holds regular telecons (weekly-ish, Thursday at 16 CET). On wiki:

   coresat.planck.fr/index.php?n=E2ESims.E2ESims

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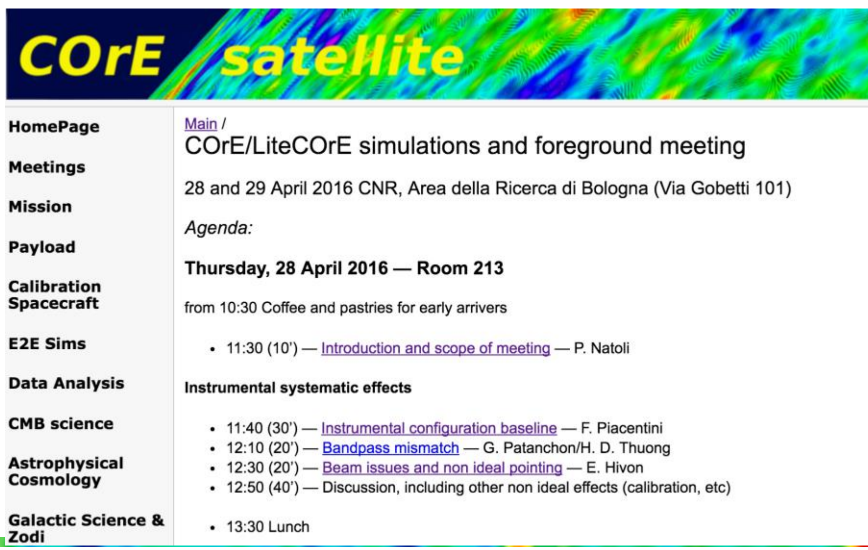
3. We held a dedicated meeting in Bologna on 28-30 April (jointly with foreground group). Presentations are on wiki:

   http://coresat.planck.fr/index.php?n=Main.2016-04-28Amp29



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3. We held a dedicated meeting in Bologna on 28-30 April (jointly with foreground group). Presentations are on wiki.
4. One output of the meeting was to agree on a common simulation framework and a simulation plan.

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Common infrastructure for simulations

1. First thing was to agree on a shared simulation level. This is provided by C[3] (Berkeley). See Julian Borrill's morning talk.

   a. Provides a scripting interface (python) to generate products
   b. Provides explicit interface to call libraries from within other codes
   c. Provides a robust, customizable destriper (madam) to generate maps
   d. Does not provide at the moment explicit timeline/pointing information to disk.
   e. Provides Monte Carlo capabilities (CMB signal, noise)
   f. Documented and "available" from github (at least for us)

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Sky model

1. Sky model is based on Planck sky model, which is an improving project
2. See Jacques Delabrouille's talk tomorrow.

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The work plan

1. Map making validation
    a. How effectively can we reconstruct polarization without HWP?
    b. Aim at single-detector maps
    c. Assess noise performance for various strategy via MC analysis
2. Cross-correlated noise (cross-talks)
    a. Evaluate impact for toy-model. Assess improvement with dedicated treatment (devoted GLS map-maker)
3. Band-pass mismatch
    a. Assess vulnerability to multi-detector map making
4. Non symmetric beams
    a. Correct for leakage both at map harmonic (power spectrum) level
5. Correct for toy model of “timeline” systematic (e.g. thermal in origin)
6. Other issues to consider: pointing error (second error), glitches

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Map making validation

1. Two configuration studied for LiteCOrE (at 120 cm aperture, 0.5 and 1 rpm spin), plus one for LiteBird (with HWP)
2. Single detector at boresight (for the moment)

LiteCoRE fast

Precession period = 4 days
Spin rate = 1rpm
4 hits per beam: samplerate = 175.86 Hz

LiteCOrE slow

Precession period = 8 days
Spin rate = 0.5rpm
4 hits per beam: samplerate = 87.93 Hz

Common: 200 Hz 1/f knee, slope = 1, precession angle = 50° , spin angle = 45° , NET = 52.3 μK ·√ s, 5.79' FWHM (150 cm aperture)

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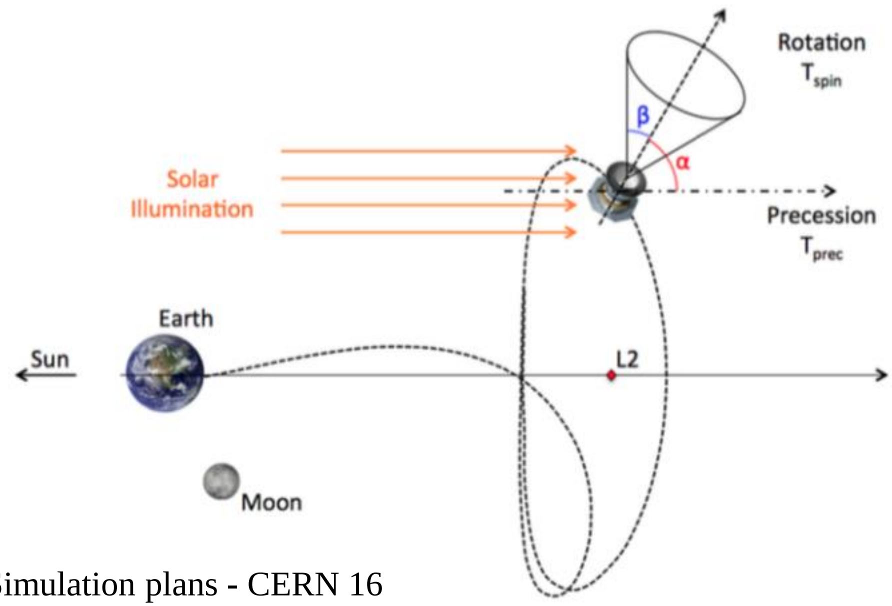
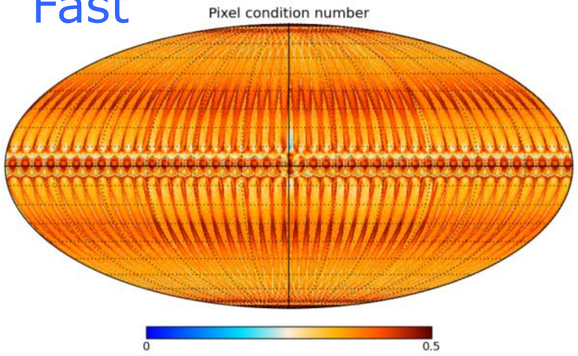
LiteBird

NET = 60 μK ·√ s
Knee frequency = 50 mHz
Slope = 1
Sample rate = 23 Hz
HWP rotating at 88 rpm
Precession opening angle = 65°
Spin opening angle = 30°
Precession period = 93 minutes
Spin period = 10 minutes

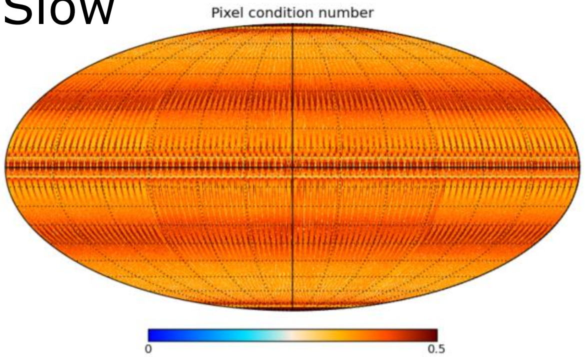


3x3 pixel condition numbers

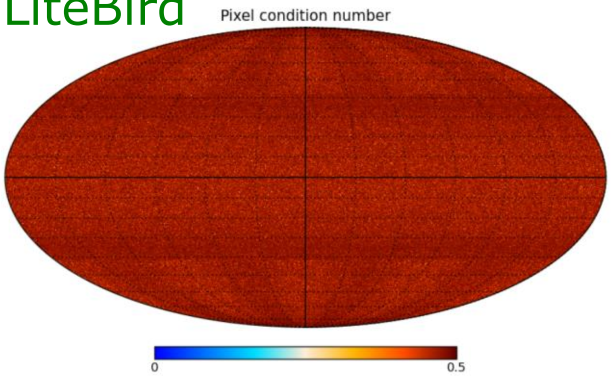
Fast



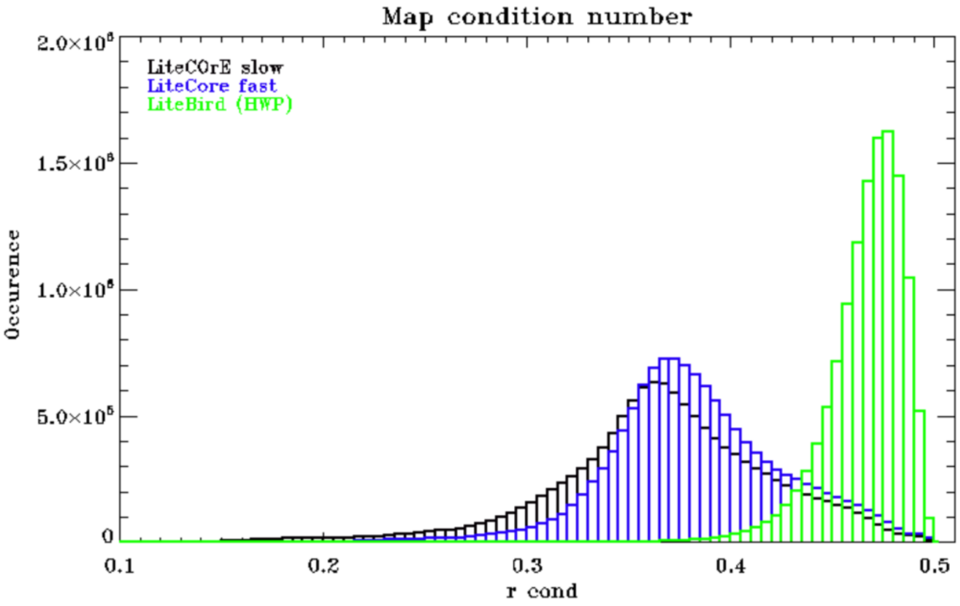
Slow



LiteBird



- Optimal condition r is ½ here
- No significant difference between slow and fast scans
- Both achieve very reasonable condition numbers



L. Polastri

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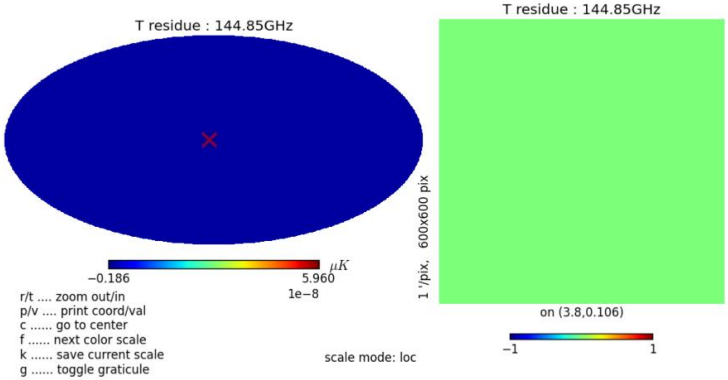
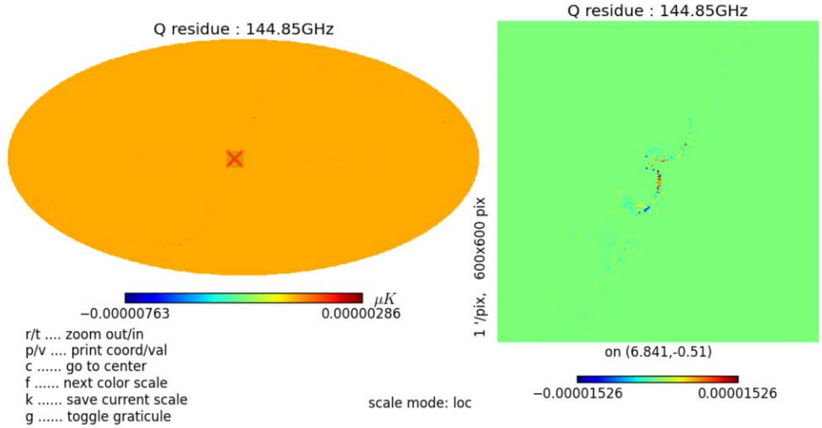
Another example (similar setup)

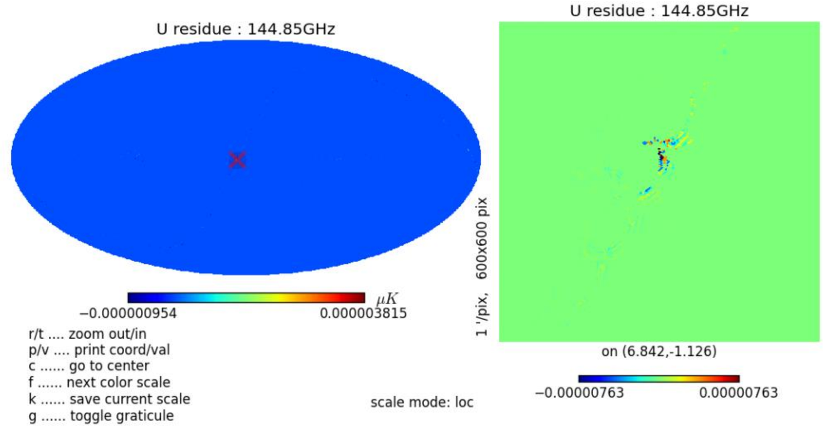
Residue maps : CMB + Galaxy

Ranajoy Banerji

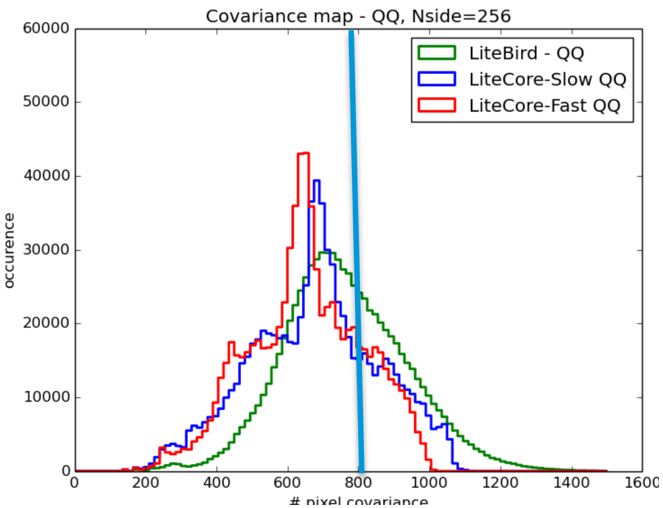
- NSIDE = 1024
- α = 45, β = 45

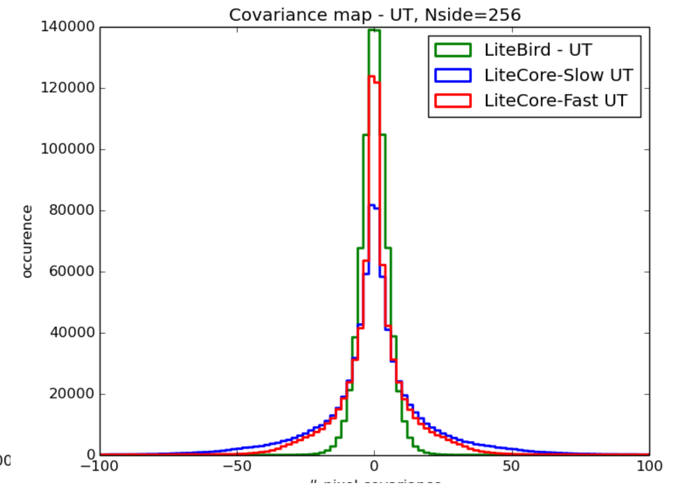


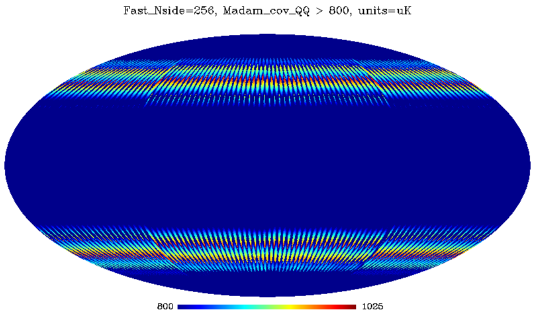


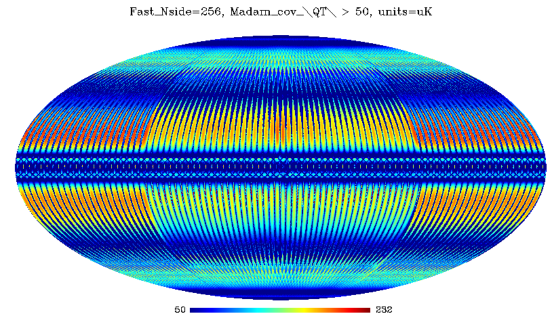


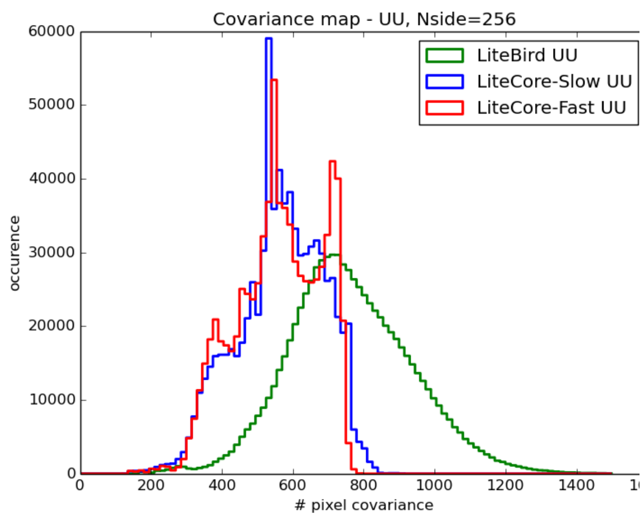
3x3 pixel covariance matrices

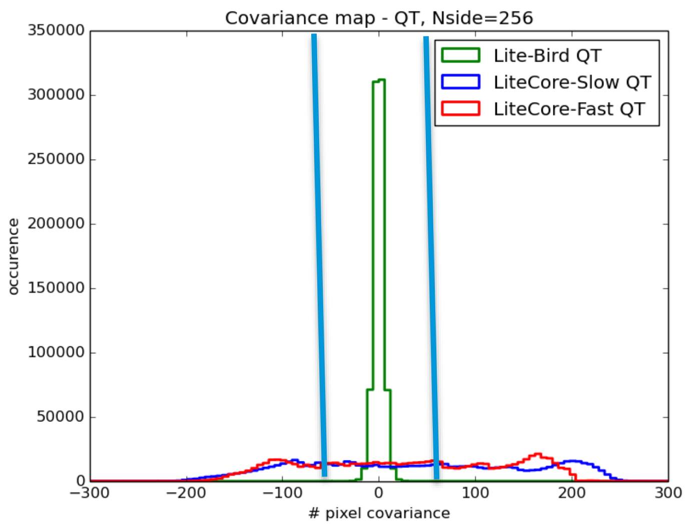






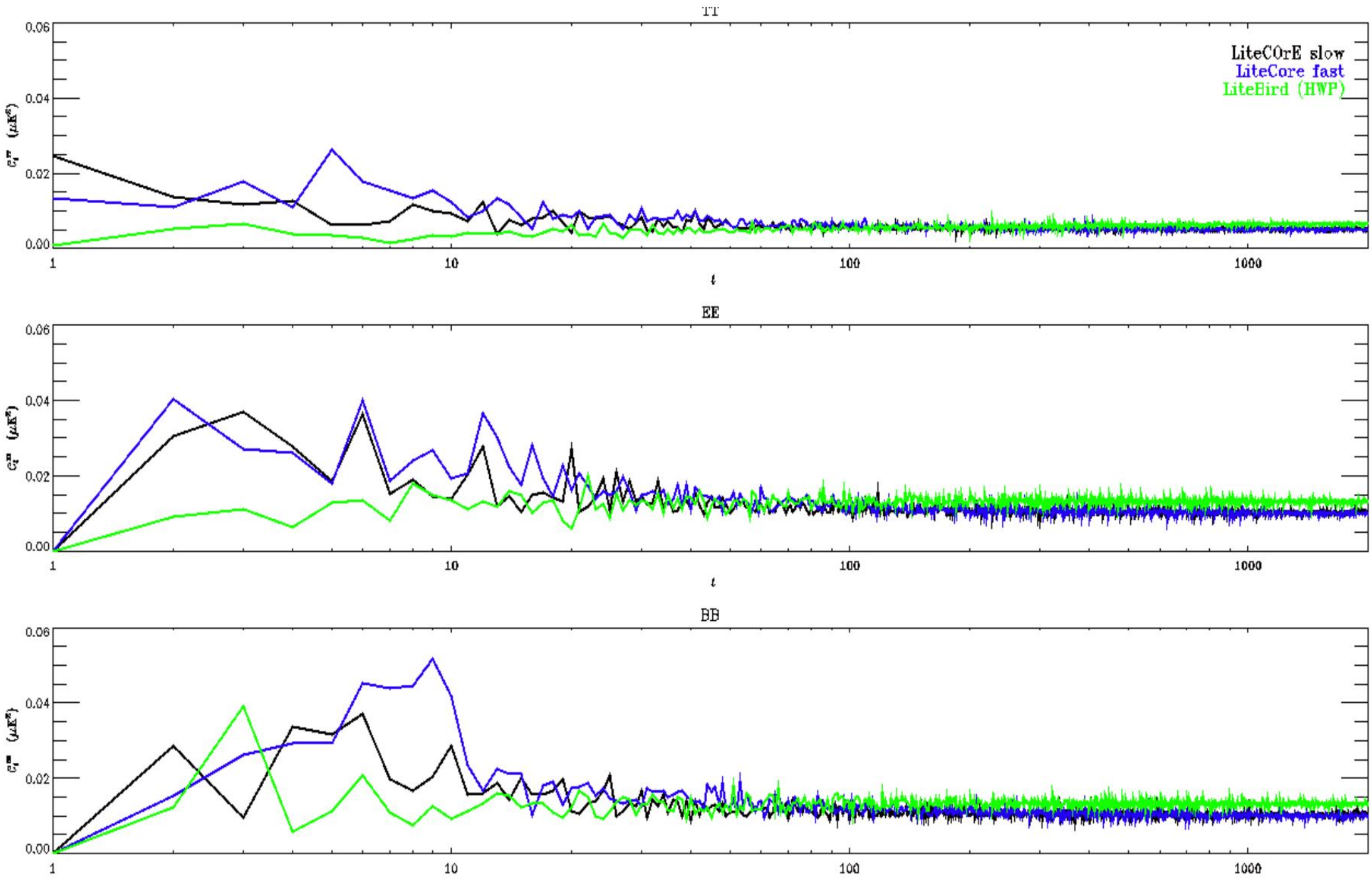






L. Polastri

Noise power spectra



1. See Linda Polastri’s talk tomorrow
2. Still to do:
    a. Non boresight detectors (“edge” of focal plane)
    b. Montecarlo over noise (100 maps for each case)

- Data model: $d(t) = [I + Q\cos(2\theta) + U\sin(2\theta)] + n(t)$
- then: $\widetilde{\mathbf{S}} = \left(\mathbf{A}^T\mathbf{N}^{-1}\mathbf{A}\right)^{-1}\mathbf{A}^T\mathbf{N}^{-1}\mathbf{D}$

$$\mathbf{A} \equiv \frac{1}{2}\begin{pmatrix} A_{tp}^{(1)} & A_{tp}^{(1)}\cos 2\phi_t^{(1)} & A_{tp}^{(1)}\sin 2\phi_t^{(1)} \\ \vdots & \vdots & \vdots \\ A_{tp}^{(k)} & A_{tp}^{(k)}\cos 2\phi_t^{(k)} & A_{tp}^{(k)}\sin 2\phi_t^{(k)} \end{pmatrix}.$$

A. Buazzelli, G. De Gasperis

$$\mathbf{N} \equiv \langle \mathbf{n}_t \mathbf{n}_{t'} \rangle = \begin{pmatrix} \left\langle n_t^{(1)} n_{t'}^{(1)} \right\rangle & \cdots & \left\langle n_t^{(1)} n_{t'}^{(k)} \right\rangle \\ \vdots & \ddots & \vdots \\ \left\langle n_t^{(k)} n_{t'}^{(1)} \right\rangle & \cdots & \left\langle n_t^{(k)} n_{t'}^{(k)} \right\rangle \end{pmatrix}$$

- assume $\left\langle n_t^{(i)} n_{t'}^{(j)} \right\rangle \propto f(|t - t'|)$ (quite a strong condition for cross-correlation). . .
- Standard solution since $\mathbf{N}^{-1} = \bar{F}^T\mathbf{R}^{-1}\bar{F}$ and $\mathbf{R}$ is "block-circulant".

<n1 n1> = <n2 n2> = A [1 + (f/f0)^(-1)]
<n3 n3> = A [(f/f1)^(-2) + c]
n_a = n1 + n3
n_b = n2 + n3

Model by G. Patanchon

Planck-ish values for f0 = 110 mHz, f1= 21 mHz

The work plan

1. Map making validation **(Linda Polastri's talk)**
   a. How effectively can we reconstruct polarization without HWP?
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2. Cross-correlated noise (cross-talks)
   a. Evaluate impact for toy-model. Assess improvement with dedicated treatment (devoted GLS map-maker)
3. Band-pass mismatch **(Guillaume Patanchon's talk)**
   a. Assess vulnerability to multi-detector map making
4. Non symmetric beams **(talks by Ranojoy Banjeri and Eric Hivon)**
   a. Correct for leakage both at map harmonic (power spectrum) level
5. Correct for toy model of "timeline" systematic (e.g. thermal in origin)
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Conclusions

- We have agreed on and started to setup a minimal work plan to produce and analyze simulations aimed at systematic effects.
- The plan is evolving. Some activities well defined and on track, others need better characterization
- Join the group if you feel you can contribute! (email me or Mark)
- There is still a (slim) margin to serve other paper needs. Anyone interested: act fast!

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