# Simulation and Systematic report

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# The “systematic” work plan

- Map making validation
  - How effectively can we reconstruct polarization without HWP?
  - Aim at single-detector maps
  - Assess noise performance for various strategy via MC analysis
- Cross-correlated noise (cross-talks)
  - Evaluate impact for toy-model. Assess improvement with dedicated treatment (devoted GLS map-maker)
- Band-pass mismatch
  - Assess vulnerability to multi-detector map making
- Non symmetric beams
  - Correct for leakage both at map and harmonic (power spectrum) level
- Correct for toy model of “timeline” systematic

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# Simple model for a calibration related systematic effect

- Set-up a minimal version of the calibration pipeline
  - Assume model for dipole, and Galaxy, plus a mask (~ 20%), and noise
  - Assume a baseline to calibrate (days?)
  - Reconstruct gain (assume input equal to 1, actual shape unimportant)
- Need to get residual errors correlated across several detectors – otherwise the effect will just wash out
- A way to obtain this => distort the signal (e.g., Galaxy)
  - What amount reasonable?
- If effect "too large", we need to implement a correction scheme.
  - Jointly solve for map and gain? Codes exist, but application may require too long
- Still looking for a volunteer (but have good hopes!)



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# Map making validation

- Results for single detector at boresight in hands. Need to move to other cases.
- Two detectors away from boresight: simulations in progress, should get results soon
- Understand constrains when merging single detector maps with respect to multi detector map making
- Monte Carlo (~ 100 maps) over noise maps to assess level of residual noise 1/f noise for “slow” and “fast” spins: simulations expected soon
- L. Polastri is “volunteer”

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# Cross-correlated noise

- 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

# Cross-correlated noise

- Status: issues in interfacing proprietary map-making to TOAST
- Getting assistance from Berkeley
- Timescale?

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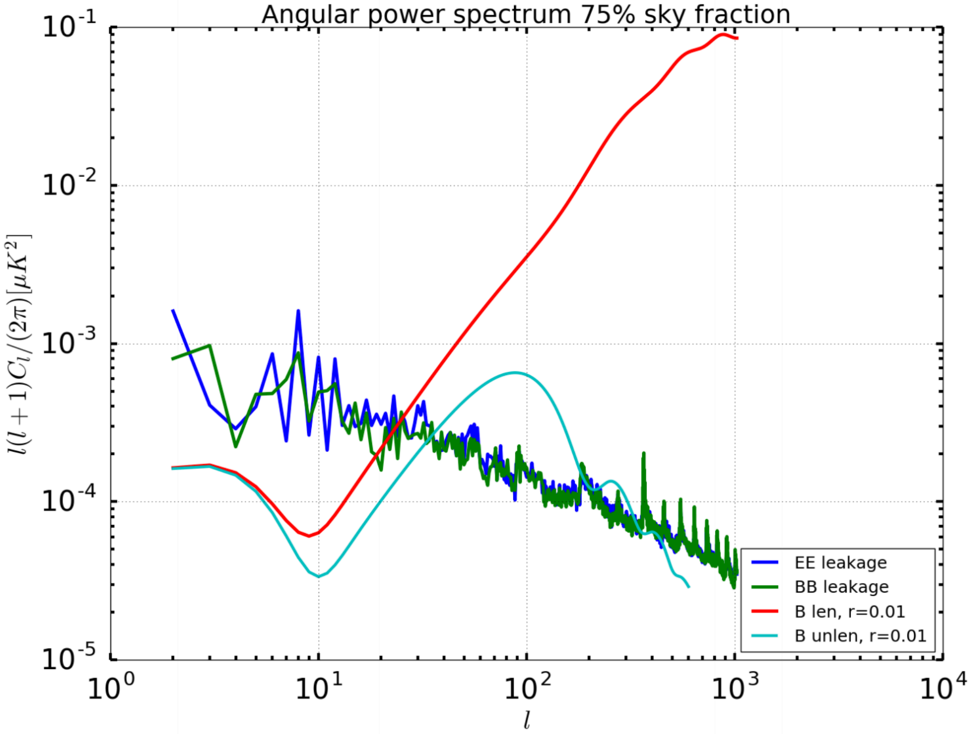
# Bandpass mismatch

- Preliminary results for COre ++ already available (G. Patanchon)
- Will use the TOAST simulations, to increase number of detecors 10 -> ~ 100 (Should reduce the effect to manageable level)
- Sky model: three frequencies: 60, 145, 360 GHz
- If residual unacceptable will correct with dedicated code (e.g. IQUS)
- Timescale: can start as soon as simulations are ready

COrE scanning strategy angles

10 detectors



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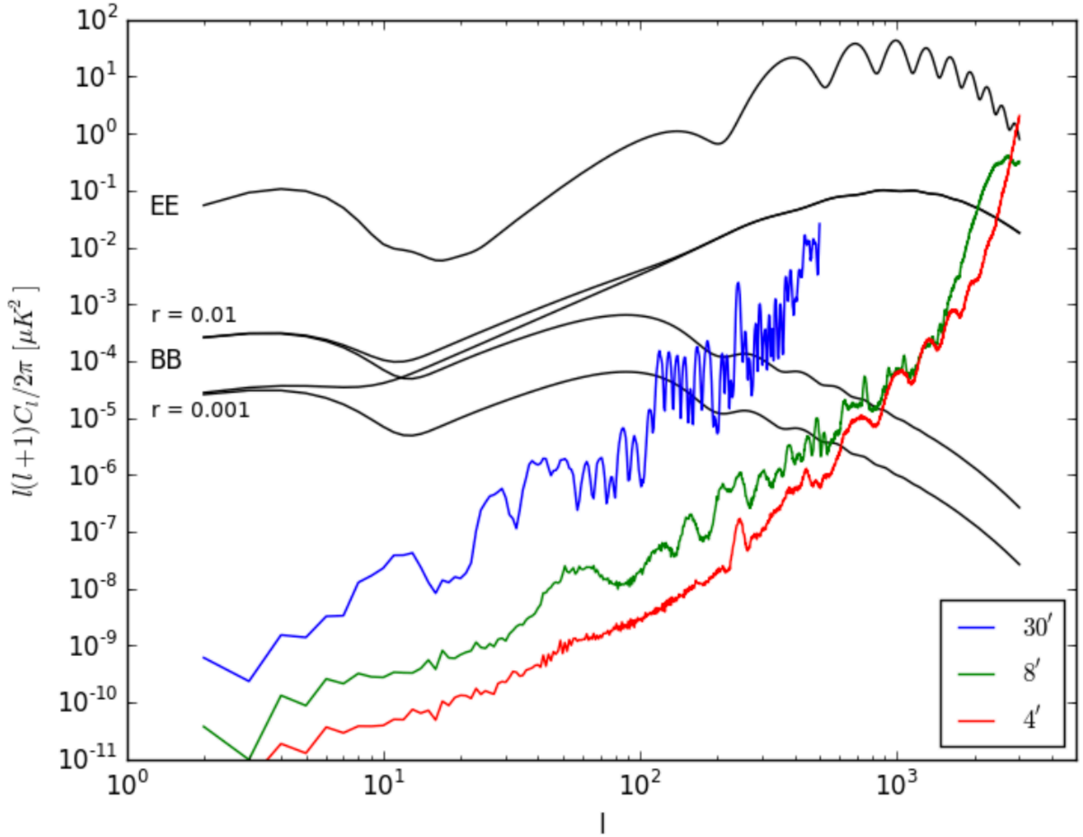
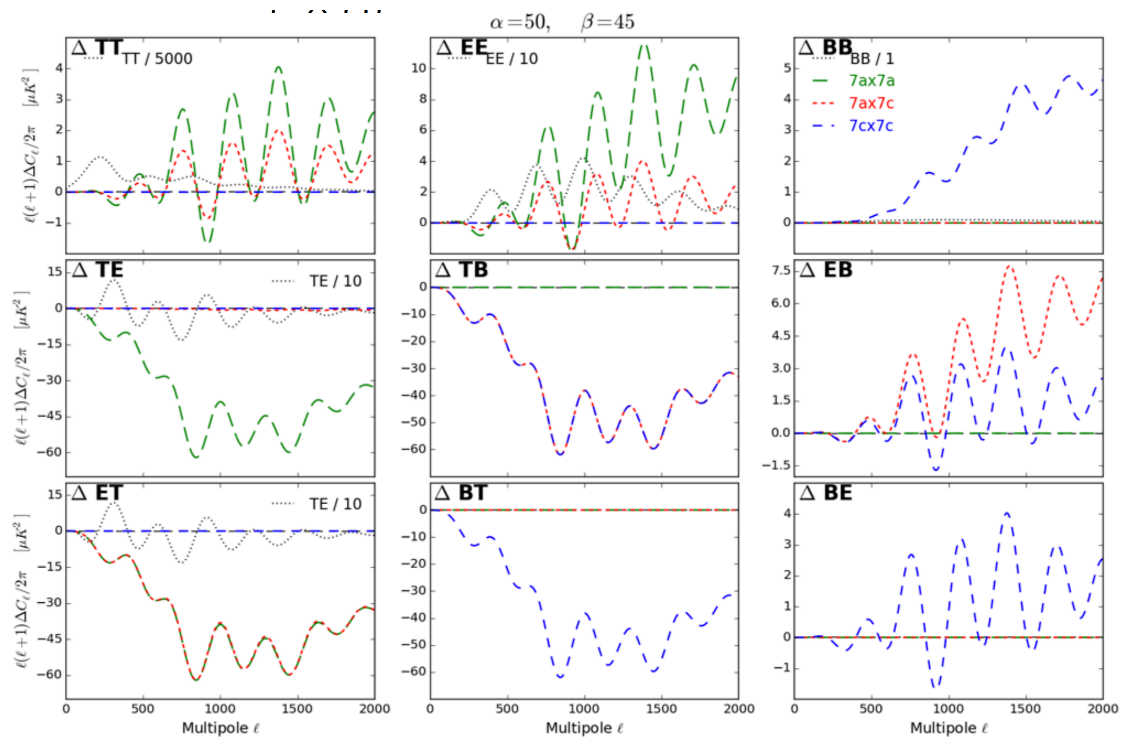
# Non symmetric beam: real space

1. Preliminary results already available
2. Correction scheme successfully implemented, preliminary results available
3. Responsible: R. Banerji
4. Need to check consistency with TOAST "official" simulations



# Non symmetric beam: QuickPol

1. Code succesfully used for Planck (and available)
2. Responsible: E. Hivon
3. Status: preliminary results promising but need to be benchmarked against simulation.
4. Beam simulation is on way (based on a rescaled HFI-217 beam for now)
5. Scan information needed, will get from interface to TOAST



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# Paper status

- If there will be a paper, it will rather be a “systematics” paper that uses custom made simulations, rather than a pure simulation paper.
- The structure will closely follow the work plan, plus a section to describe common level simulation tools (TOAST)
- Remarks and questions
    - This assumes that if specific simulation request from other papers arrive (?) they will be described elsewhere.
    - Feedback about the work plan is appreciated. In particular, are we satisfied with the content? Do we need anything else?
    - Help is needed, especially in running/validating the simulations. If you feel you have time to do it, please contact me and Mark.

# Extra Slides

# LiteCoRE fast

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

# LiteCOrE slow

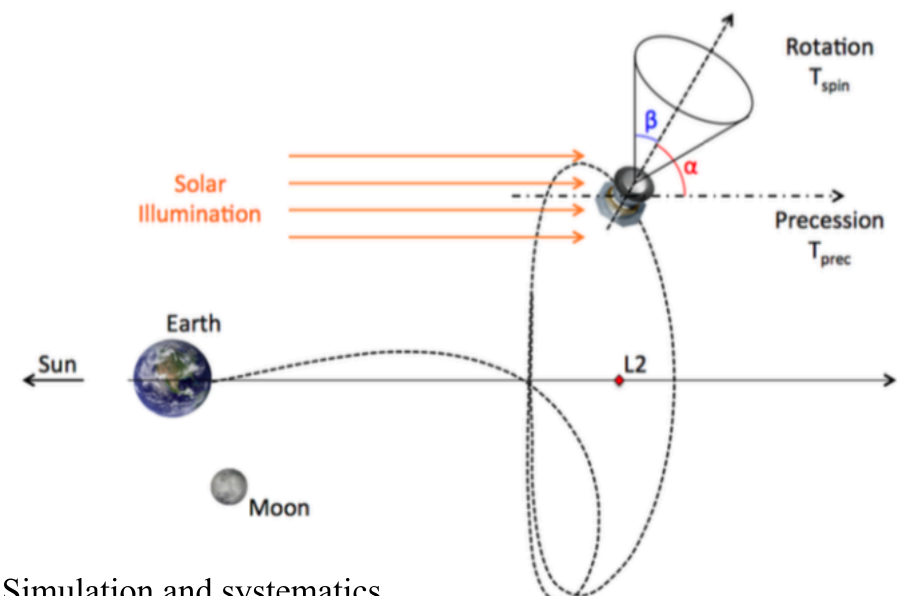
Precession period = 8 days
Spin rate = 0.5rpm
4 hits per beam: samplerate = 87.93 Hz

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)

,

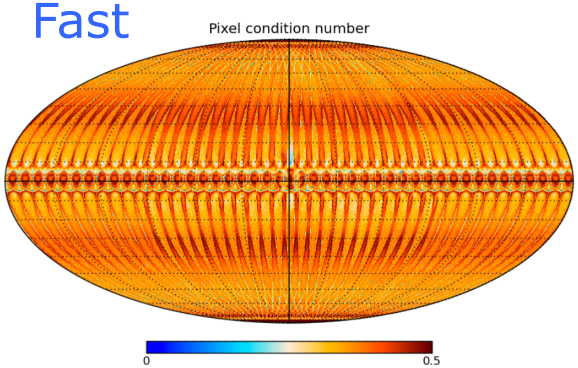
# LiteBird

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

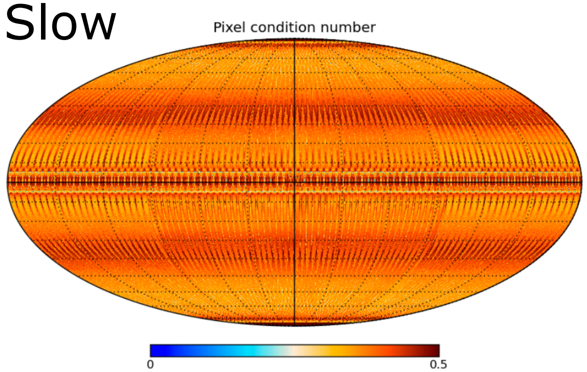


# 3x3 pixel condition numbers

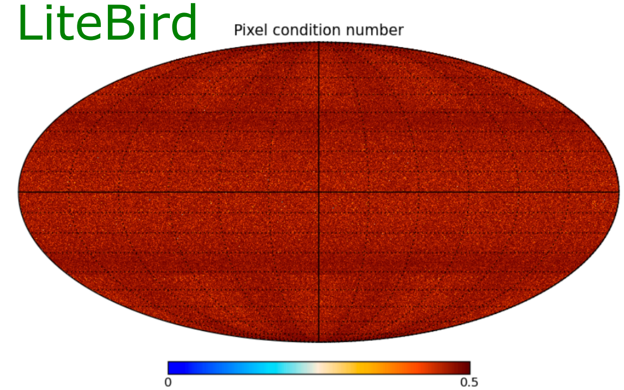
Fast



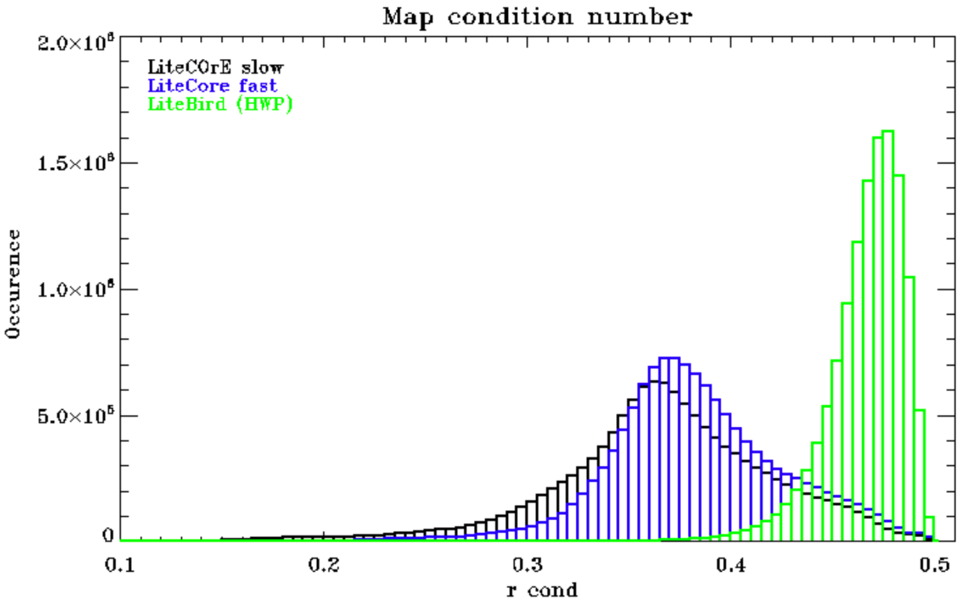

Slow




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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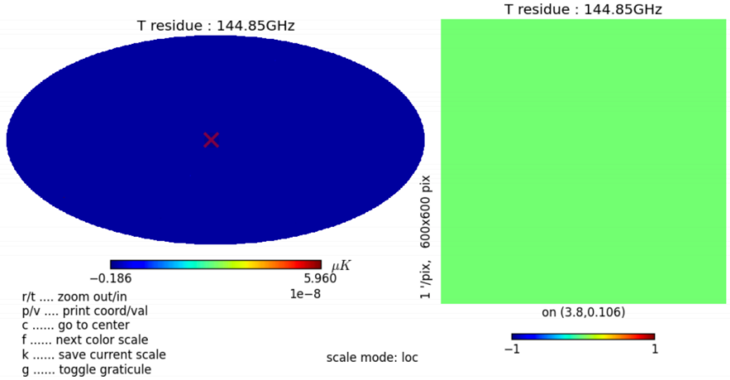
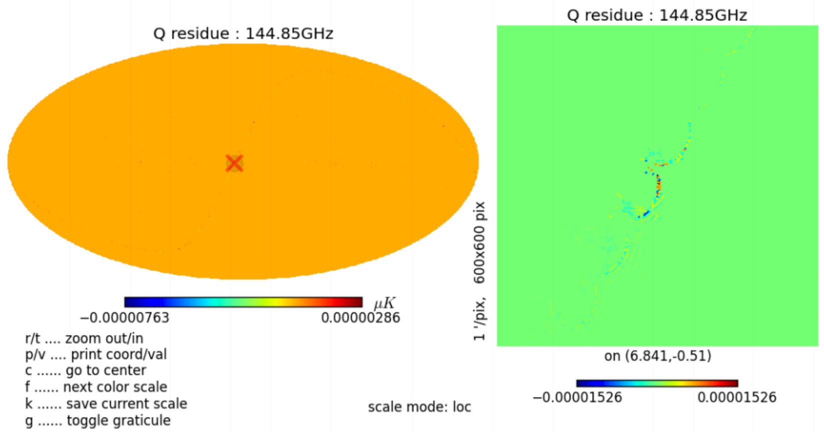
# Another example (similar setup)

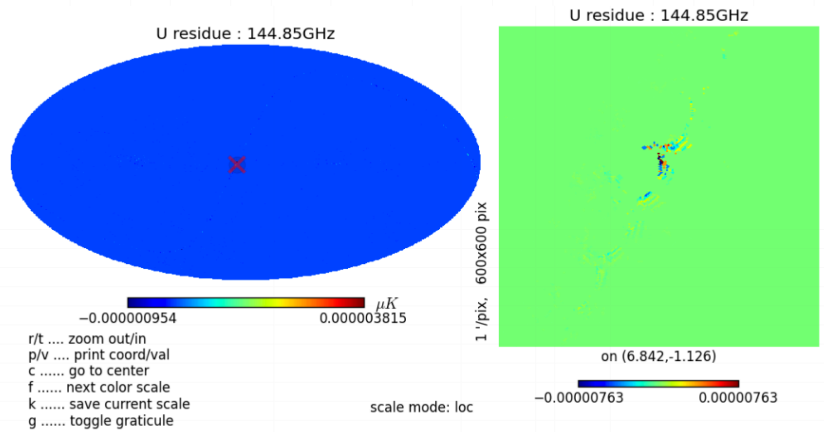
## Residue maps : CMB + Galaxy

Ranajoy Banerji

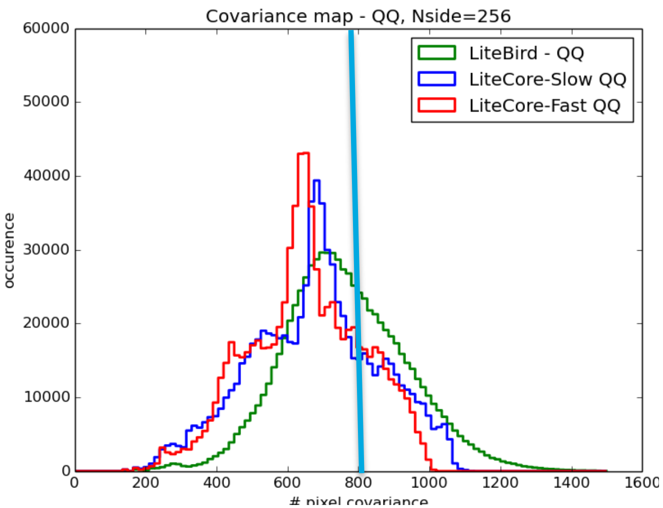
- NSIDE = 1024
- α = 45, β = 45

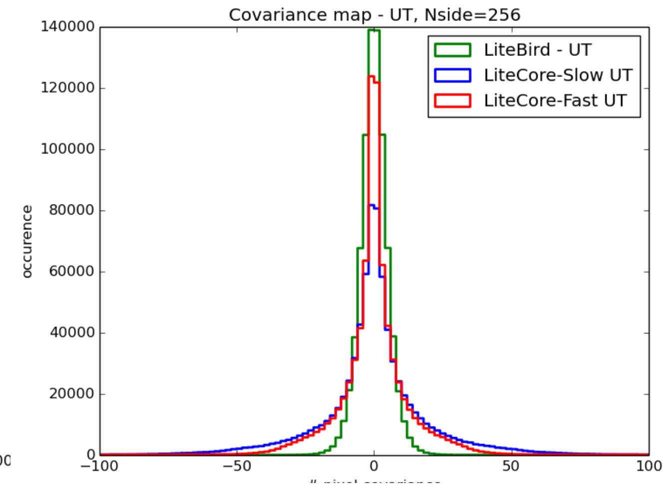


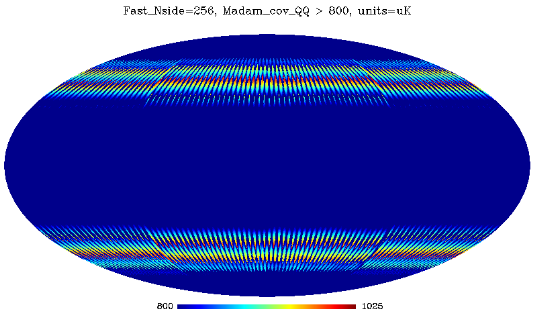



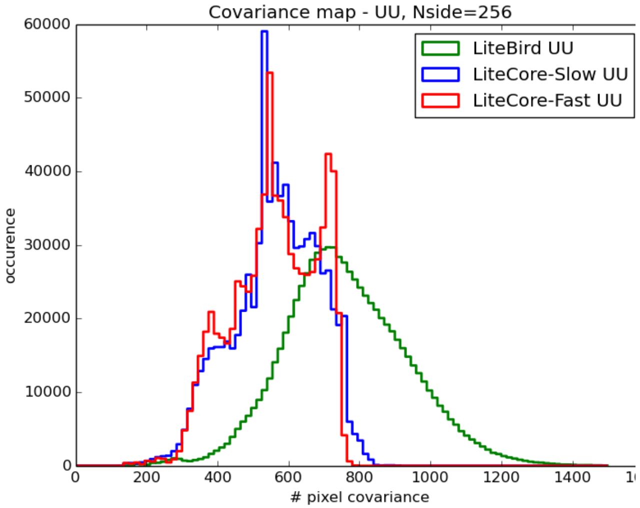



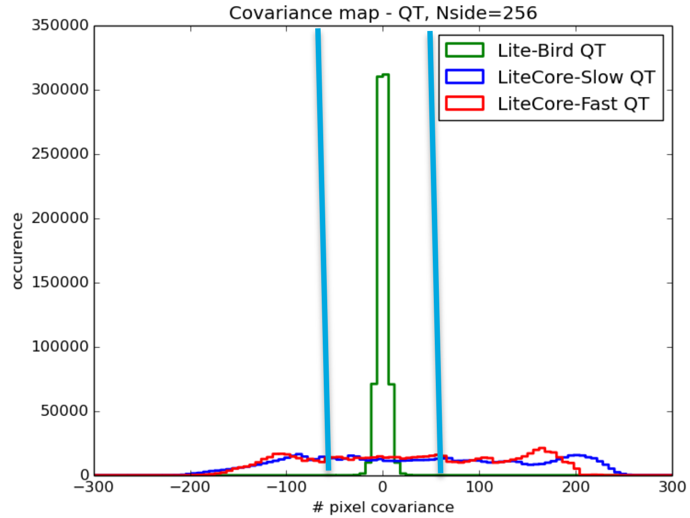
# 3x3 pixel covariance matrices

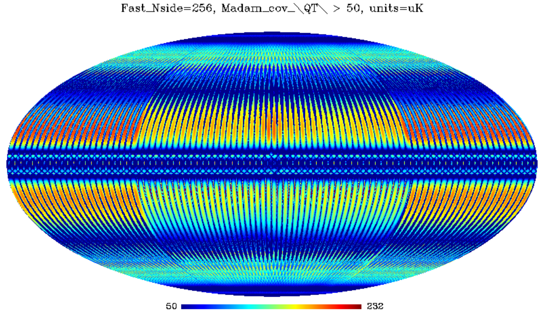


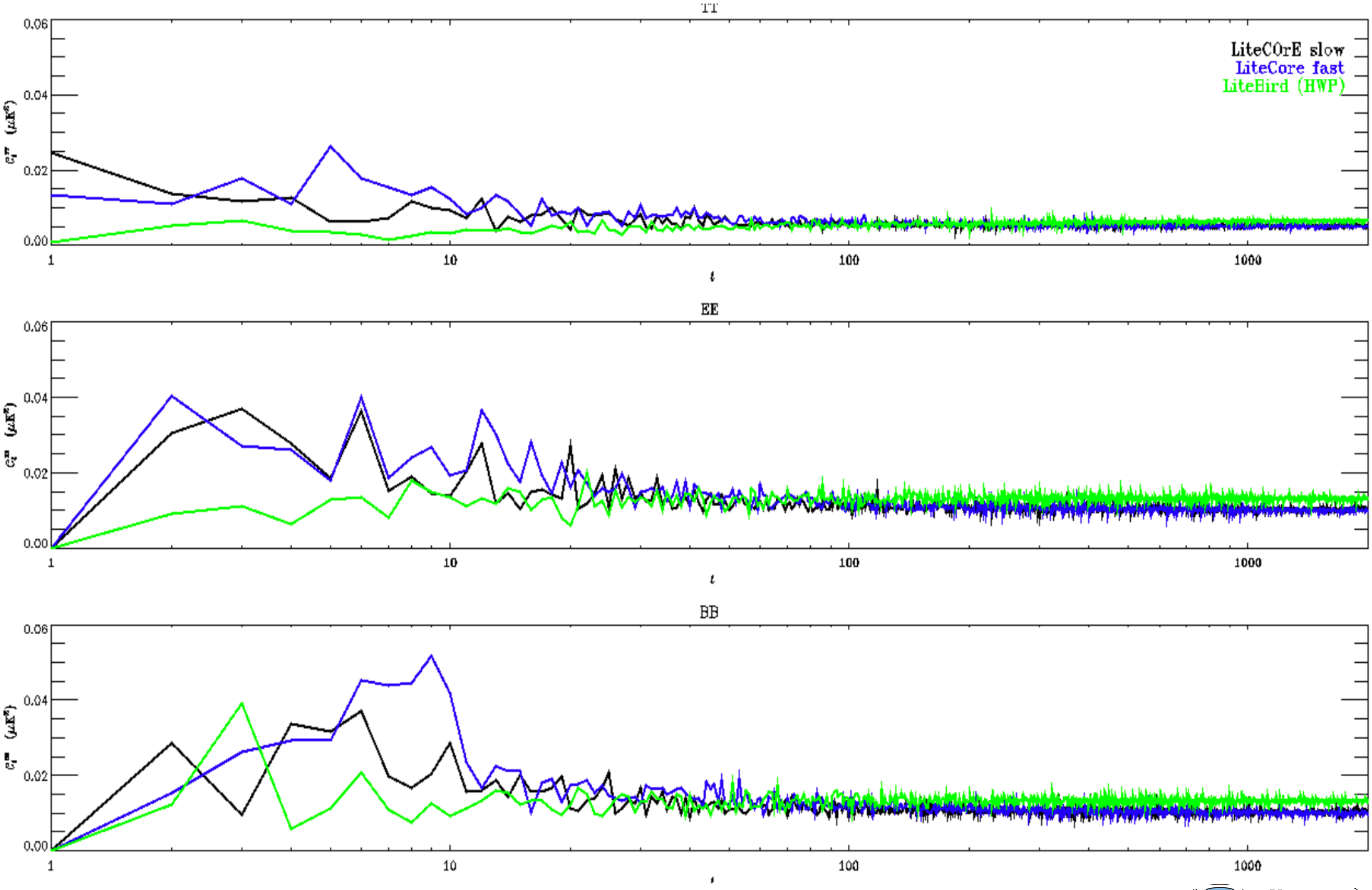




L. Polastri

# Noise power spectra

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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)



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Model by G. Patanchon

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

# 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!