Calibration insights from BeyondPlanck

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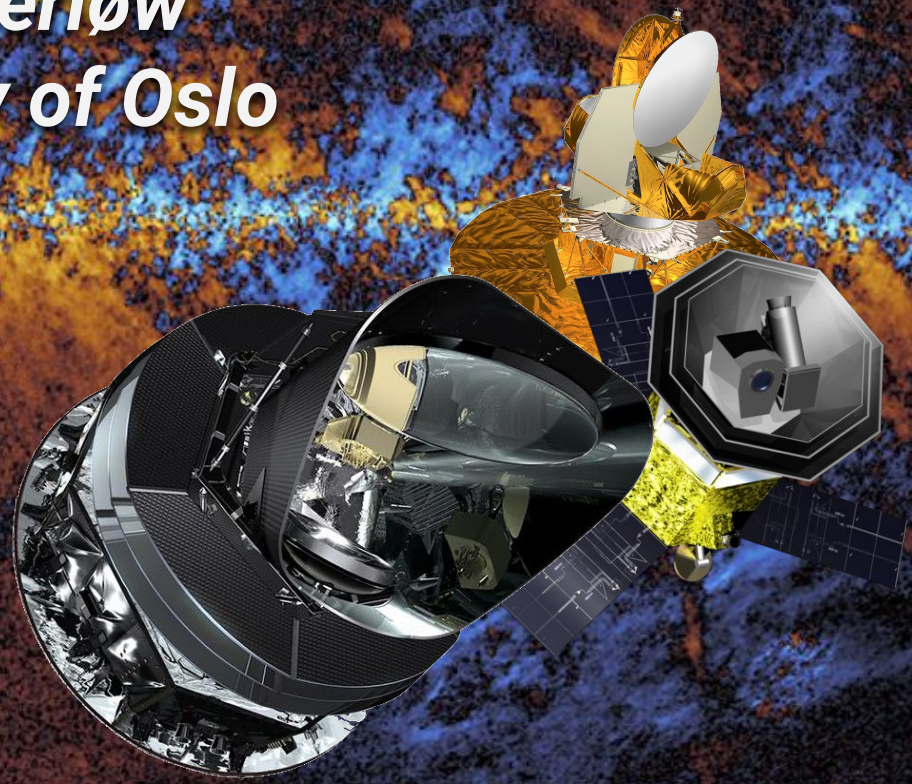

CMB systematics and calibration focus workshop, KAVLI IPMU, 30 Nov-3 Dec 2020

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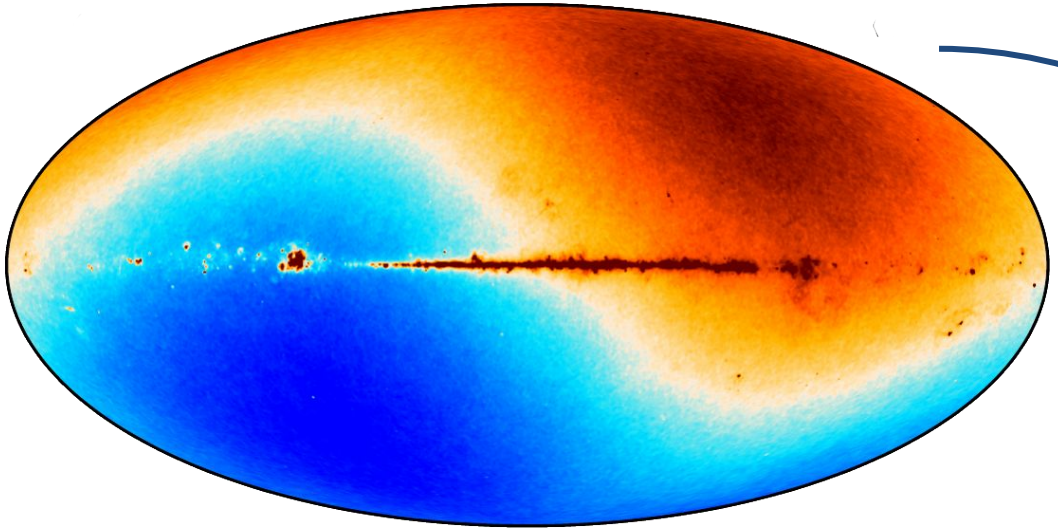
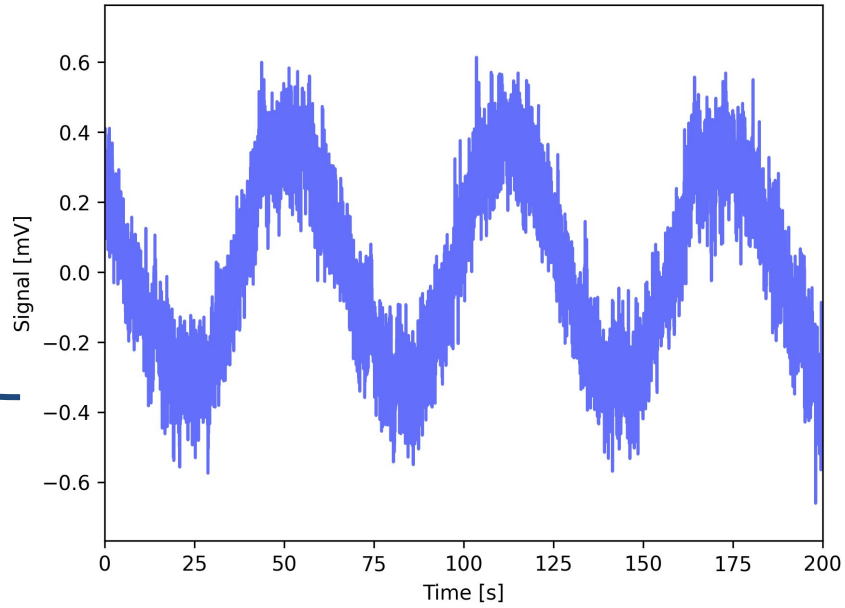
What is calibration?

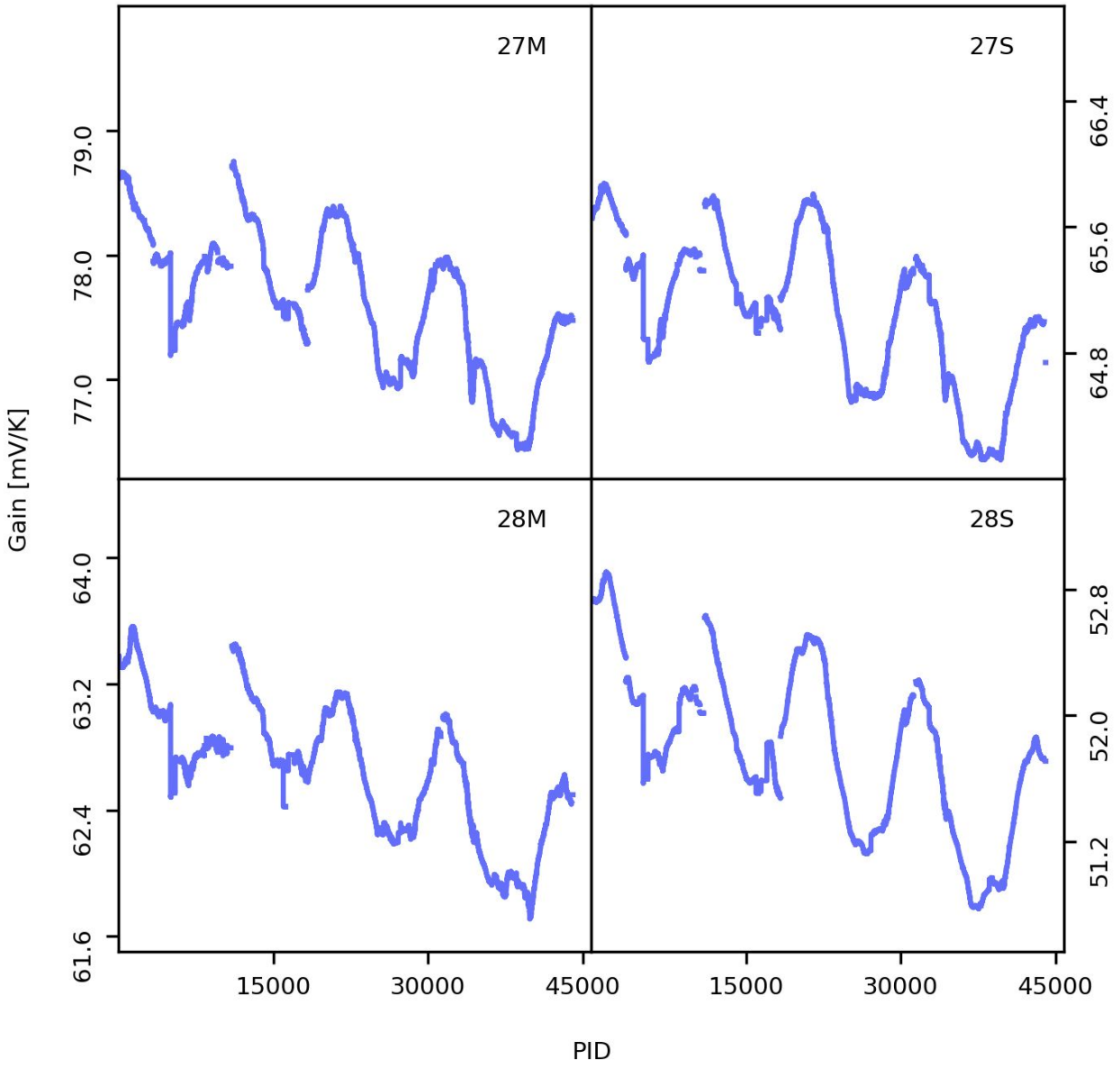


g



g^{-1}

The gain factor



The BeyondPlanck framework

$$P(g, \boldsymbol{n}^{\mathrm{corr}}, \Delta_{\mathrm{bp}}, \boldsymbol{a}, \boldsymbol{\beta}, C_\ell \mid \boldsymbol{d})$$

$$P(g \mid \boldsymbol{n}^{\mathrm{corr}}, \boldsymbol{a}, \boldsymbol{d}, \ldots)$$

Instrumental parameters

Sky parameters

Data model

$$d_t = g_q s_t^{\mathrm{tot}} + n_t^{\mathrm{corr}} + n_t^{\mathrm{wn}}$$

Measurement (V)

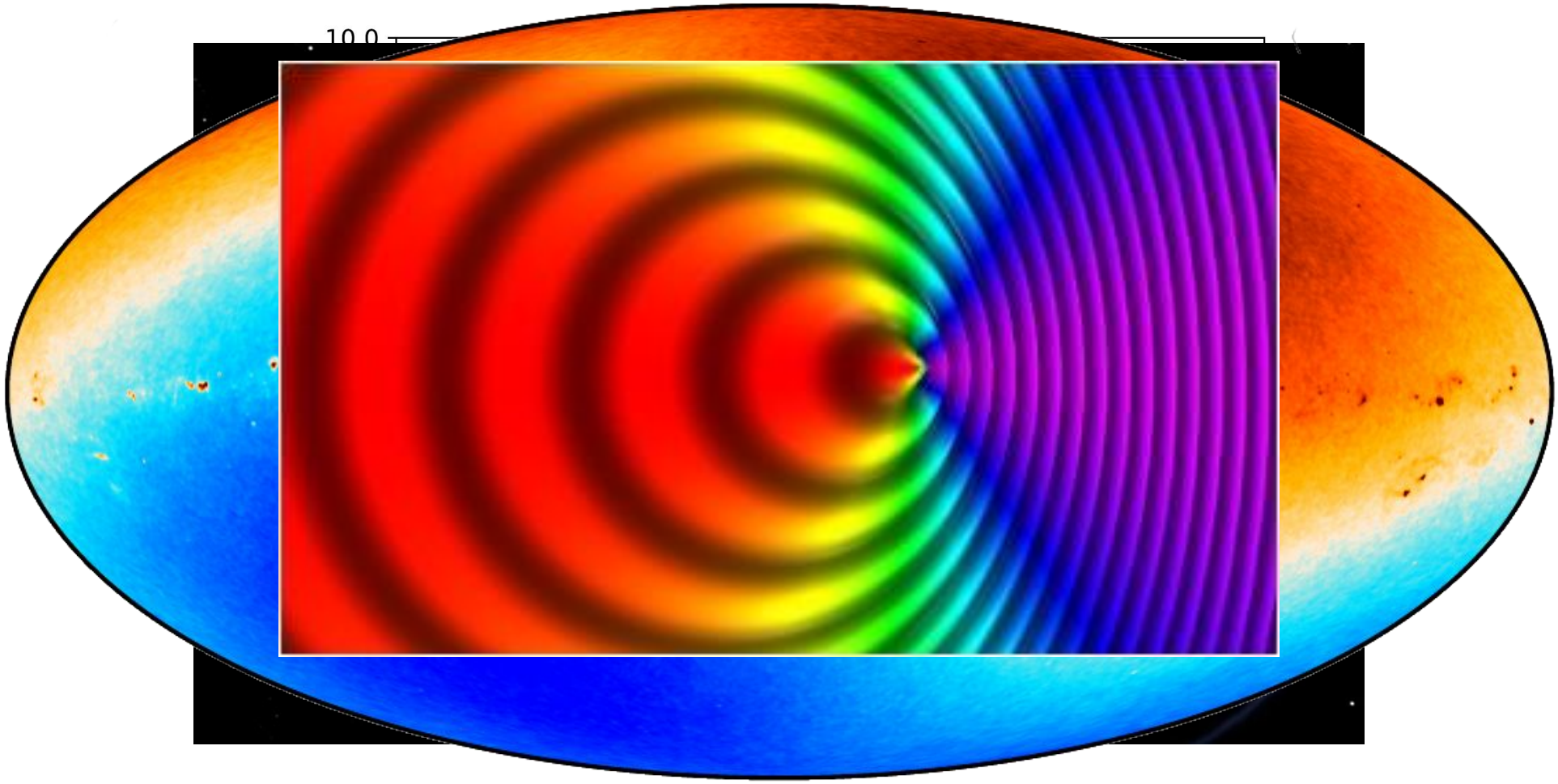
Gain (V/K)

Sky signal (K)

Noise (V)

Calibration sources

$$d_t = g_q s_t^{\mathrm{tot}} + n_t^{\mathrm{corr}} + n_t^{\mathrm{wn}}$$



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Attr: DJ Sachnu

Methodology

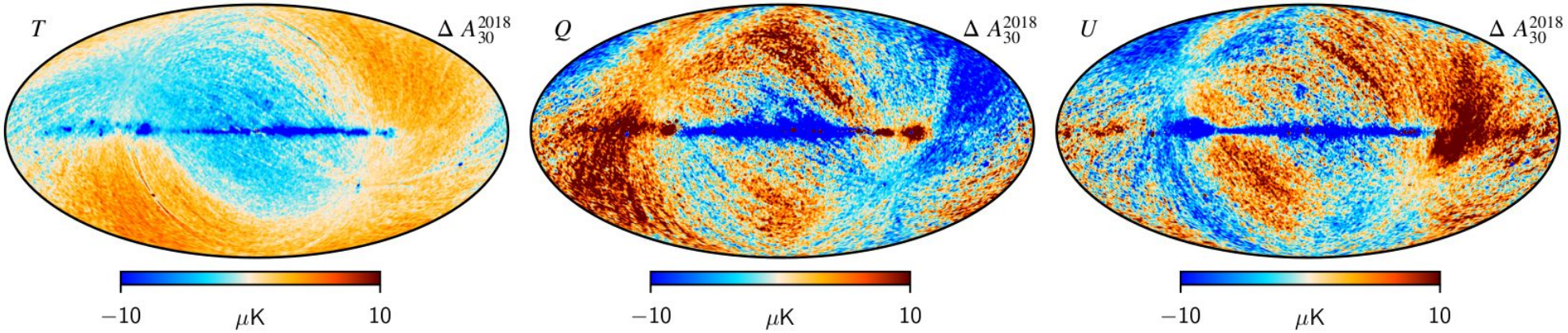
$$g_{q,i} = g_0 + \Delta g_i + \delta g_{q,i}$$

To be estimated using the orbital dipole

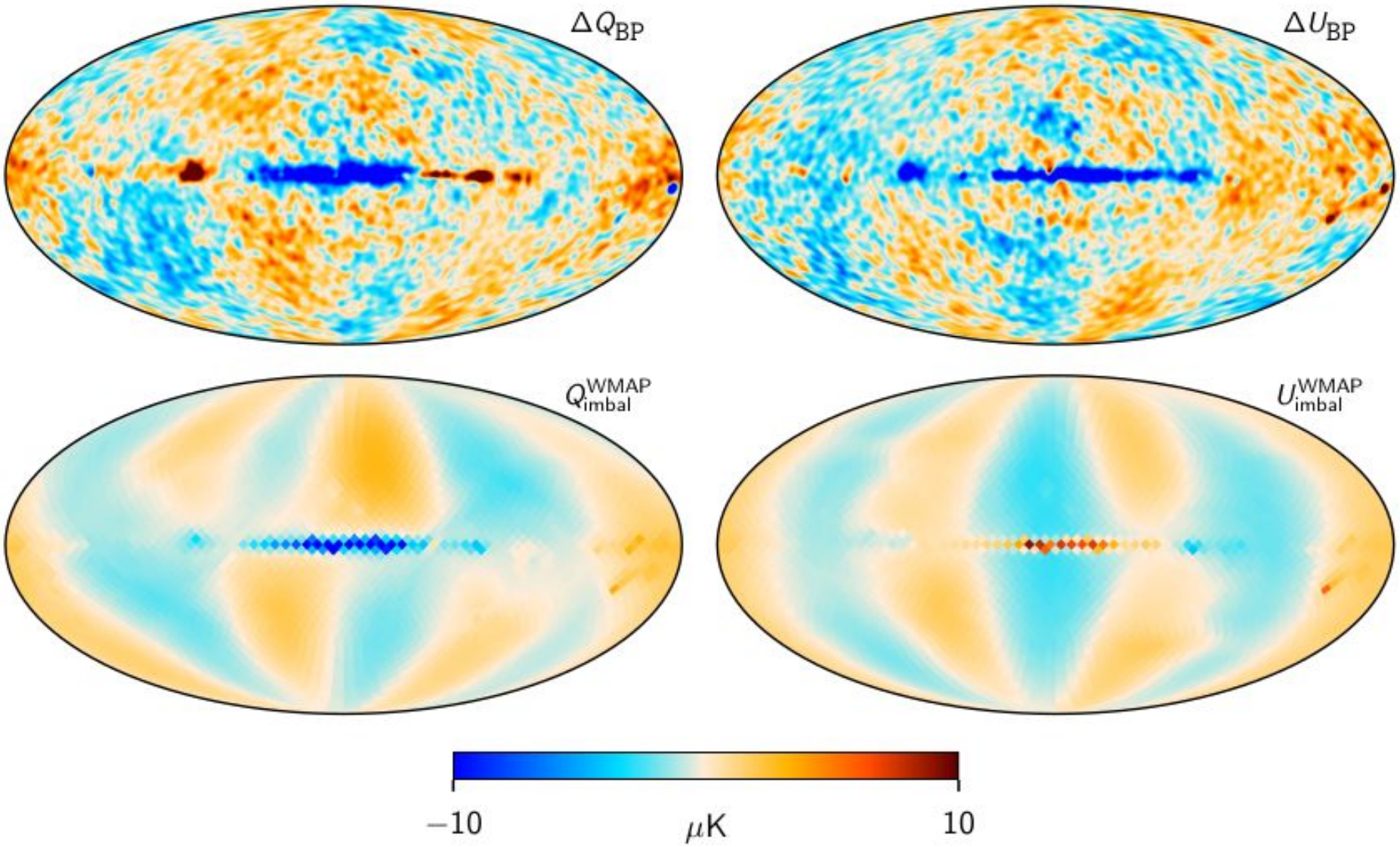
To be estimated using the full signal

$$\sum_i \Delta g_i = 0 \quad \text{and} \quad \sum_q \delta g_{q,i} = 0$$

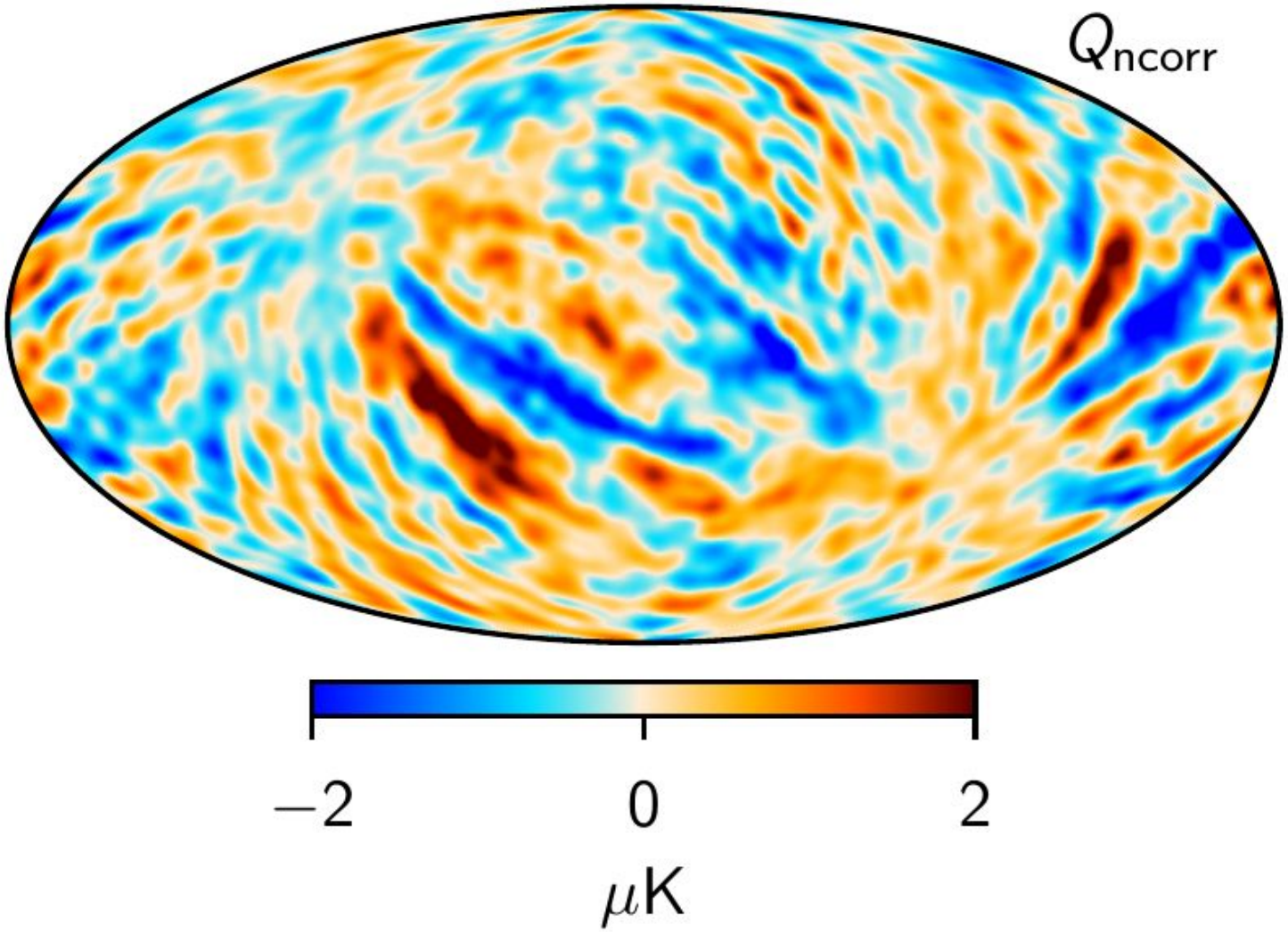
LFI poorly measured modes



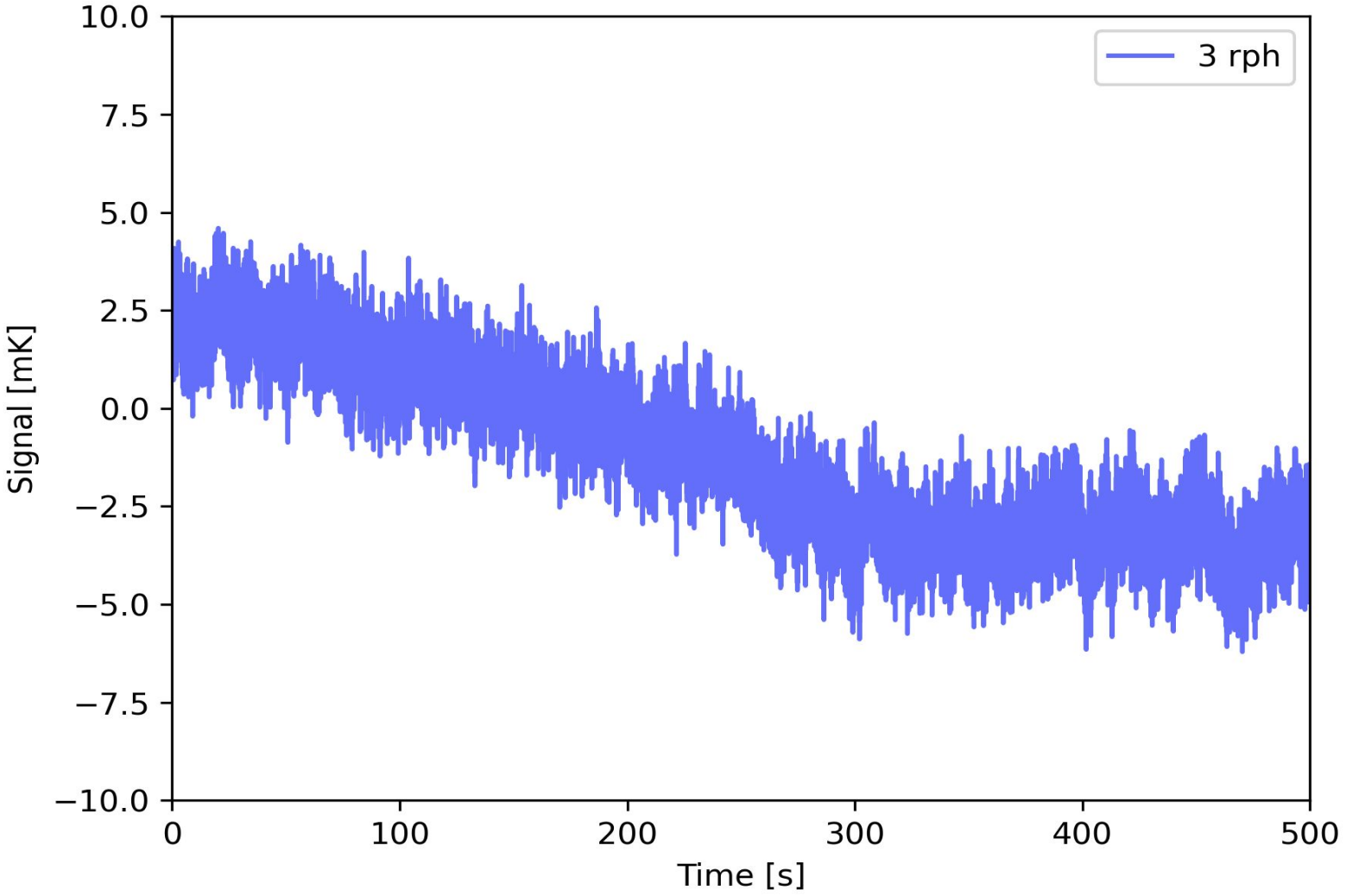
WMAP poorly measured modes



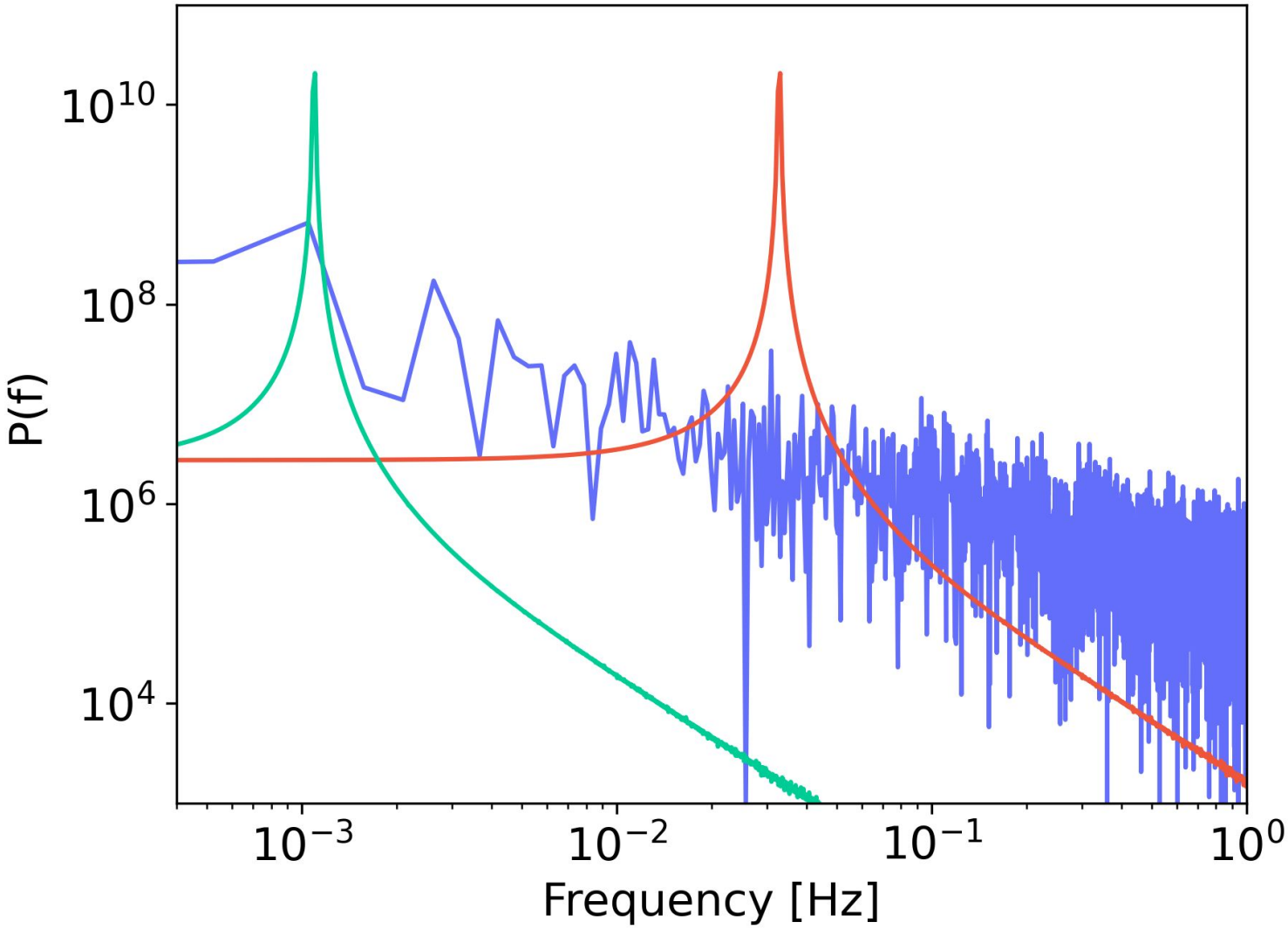
Gain and correlated noise



Correlated noise and precession frequency



Correlated noise and precession frequency



Conclusions

- Precise calibration is essential for the sensitivities needed for future CMB experiments.
- The solar and orbital dipoles are the best calibrators available to us.
- Poorly measured modes are propagated to final data, and orthogonal measurements are needed to decouple them.
- If possible, including such orthogonal modes of measurement into a single experiment would be advantageous.
- Tight degeneracies between gain and correlated noise highlight the importance of high signal-to-noise dipole measurements.
- As 1/f noise dominates at low scanning frequencies, from a calibration standpoint, shorter precession periods are preferred.

The BeyondPlanck collaboration

EU-funded institutions

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Bruce Partridge

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- "*BeyondPlanck*"
  - COMPET-4 program
  - PI: Hans Kristian Eriksen
  - Grant no.: 776282
  - Period: Mar 2018 to Nov 2020

Collaborating projects:

- "*bits2cosmology*"
  - ERC Consolidator Grant
  - PI: Hans Kristian Eriksen
  - Grant no: 772 253
  - Period: April 2018 to March 2023
- "*Cosmoglobe*"
  - ERC Consolidator Grant
  - PI: Ingunn Wehus
  - Grant no: 819 478
  - Period: June 2019 to May 2024

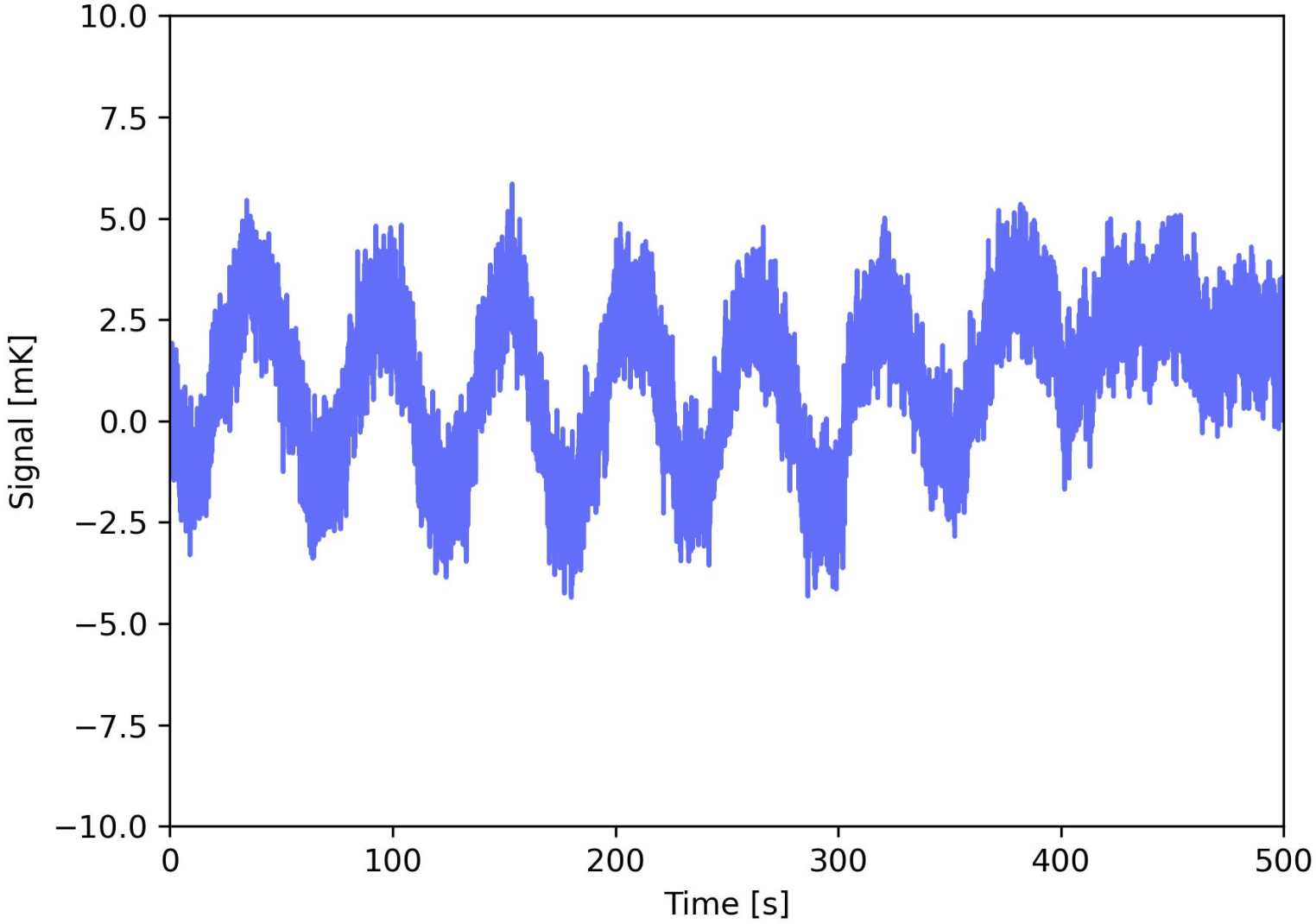
Questions?

Beyond PLANCK

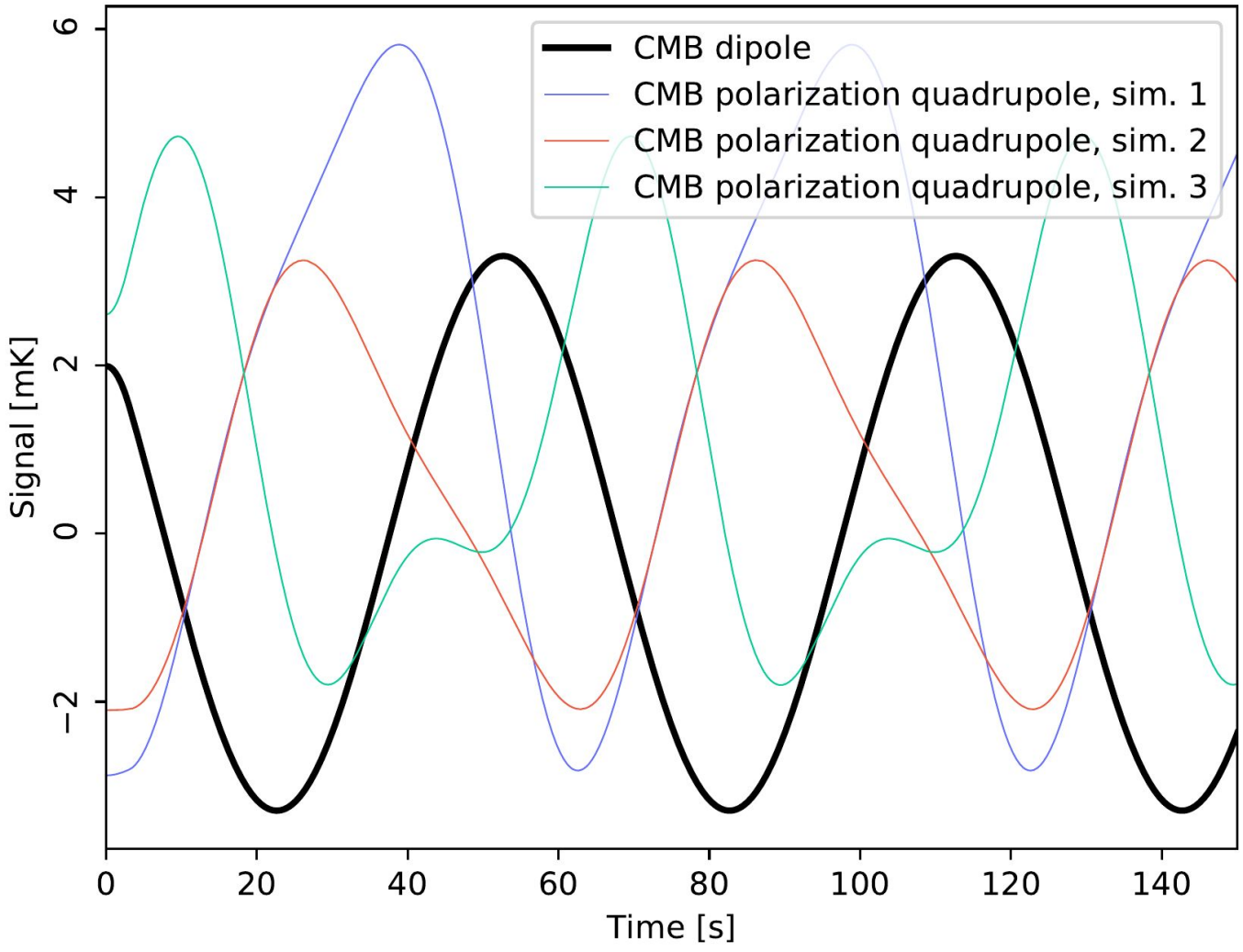
Commander

Cosmoglobe

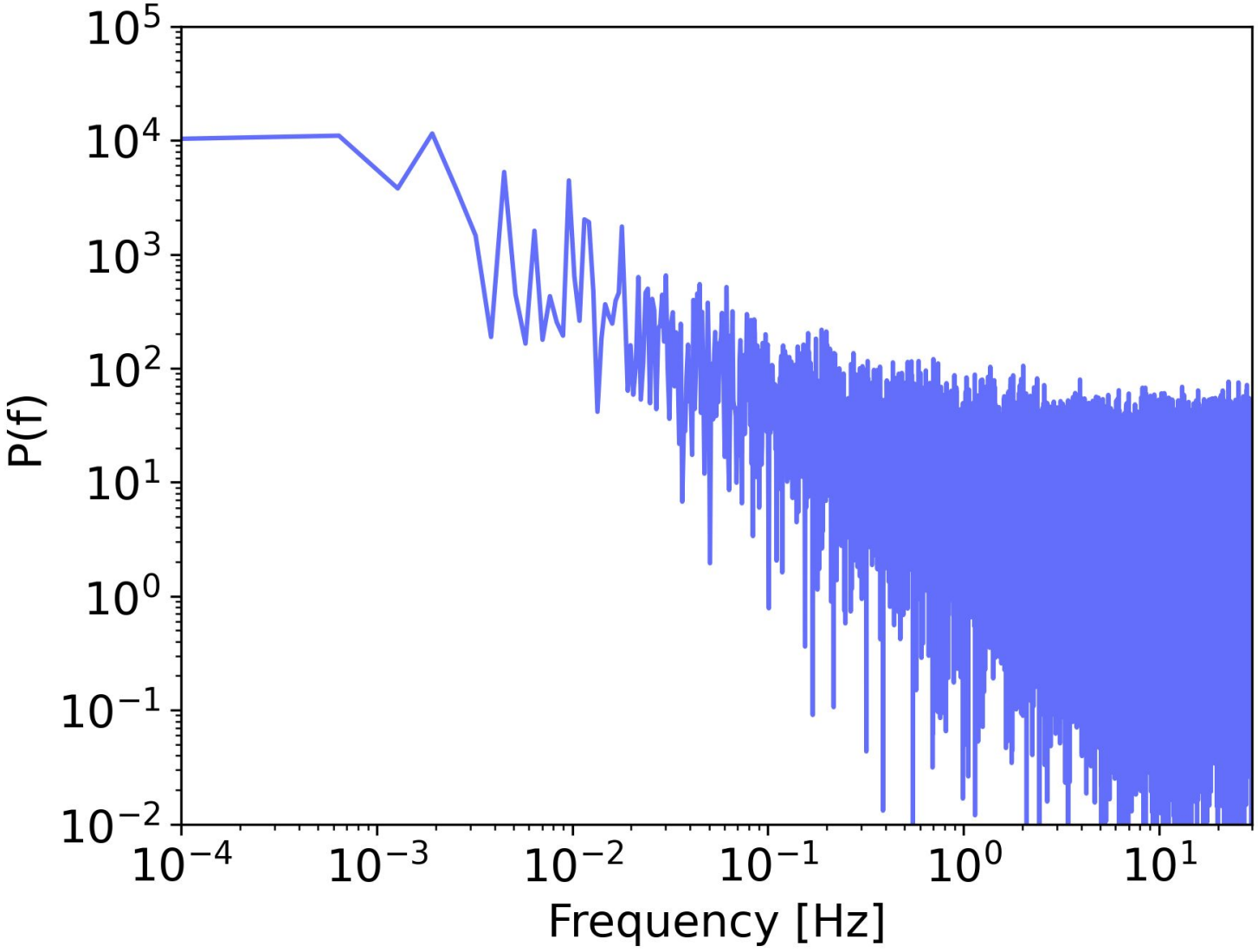
Correlated noise and precession frequency



The polarization quadrupole



Correlated noise and precession frequency



Gain correlations