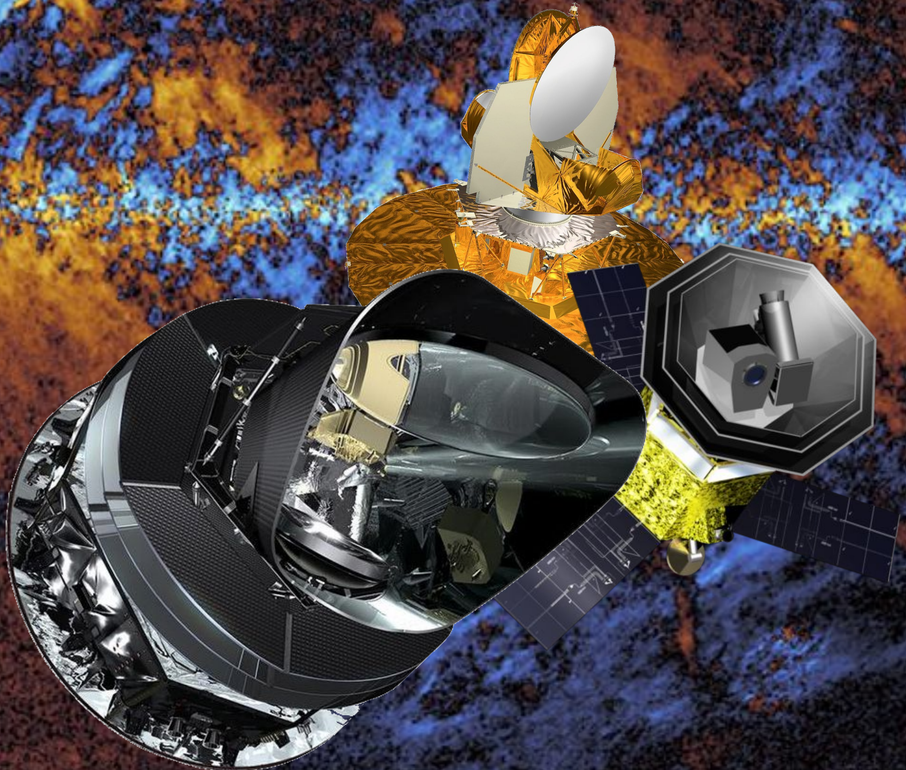
Calibration

Eirik Gjerløw



BeyondPlanck online release conference, November 18-20, 2020

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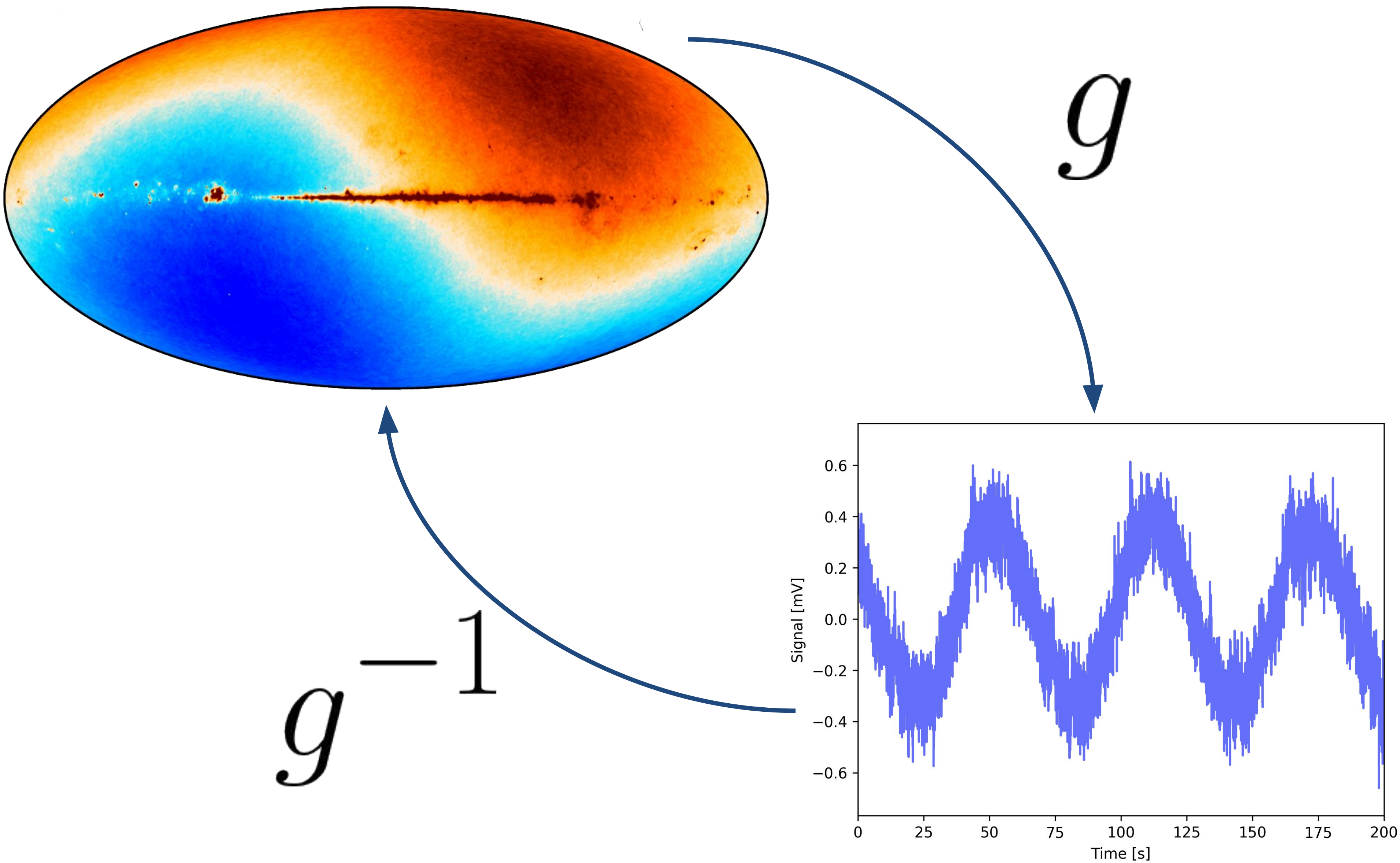
European Commission

What is calibration?



Data model

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

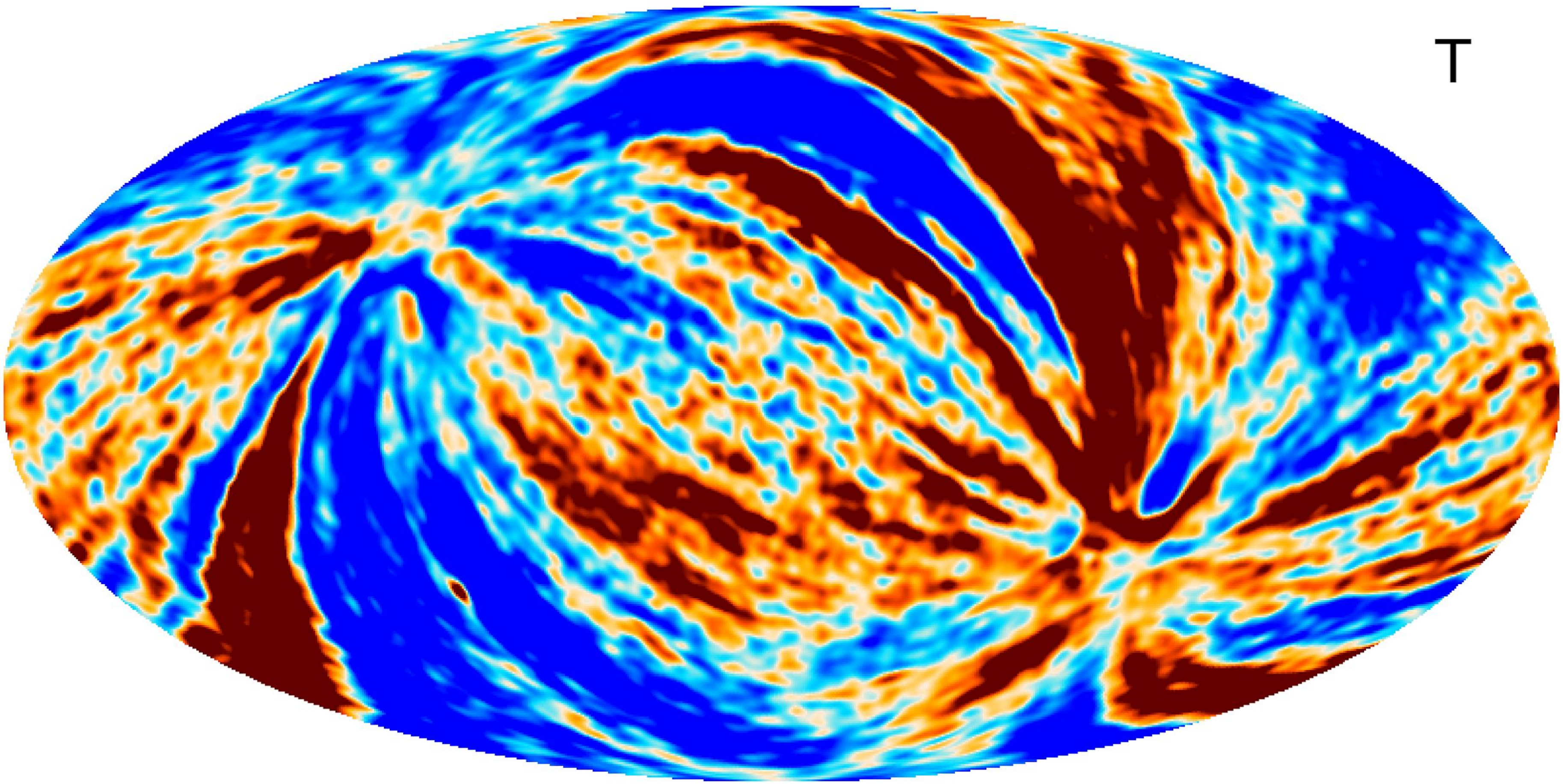
Measurement (V)

Gain (V/K)

Sky signal (K)

Noise (V)

Correlated noise-gain degeneracy

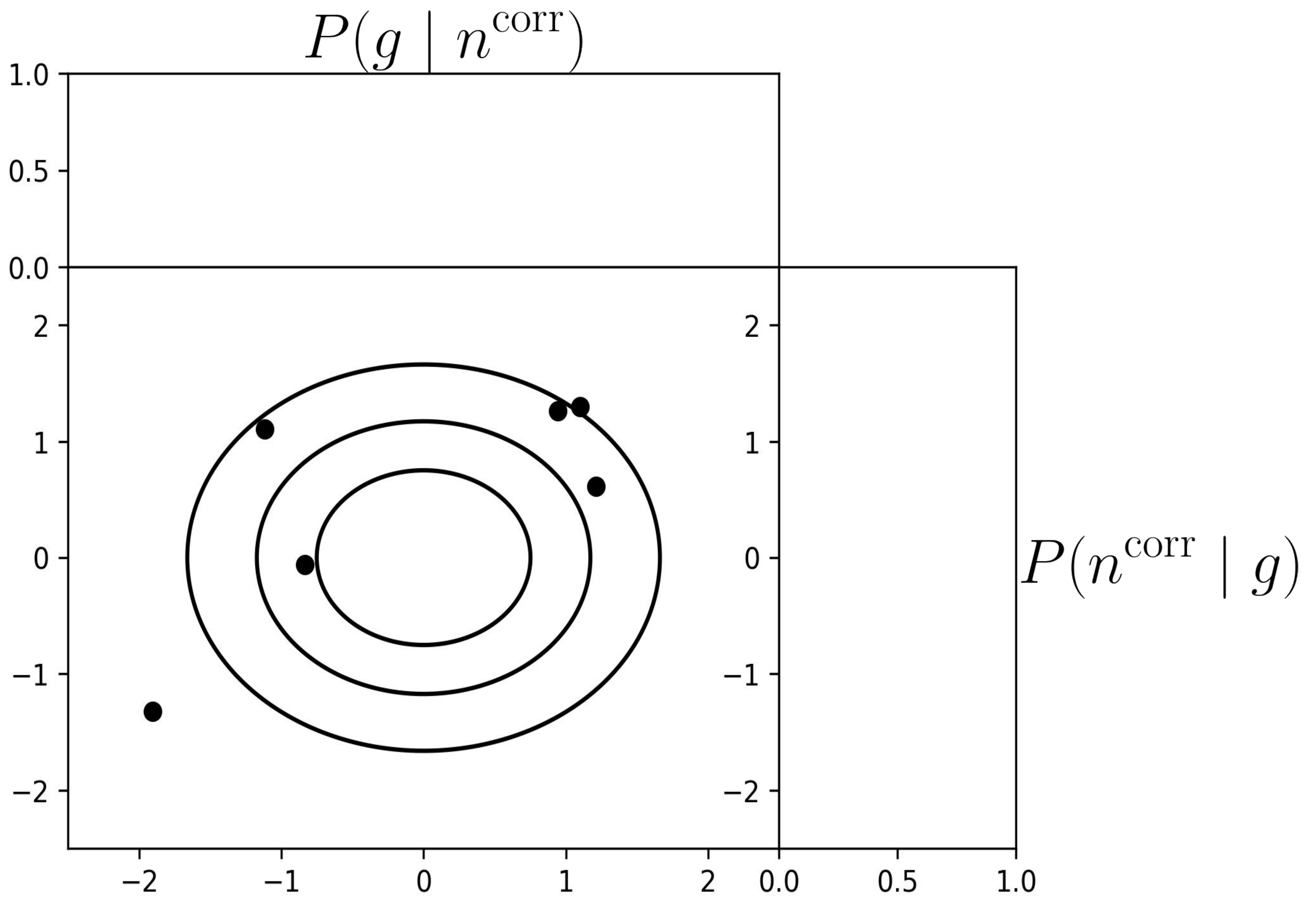


The BeyondPlanck framework

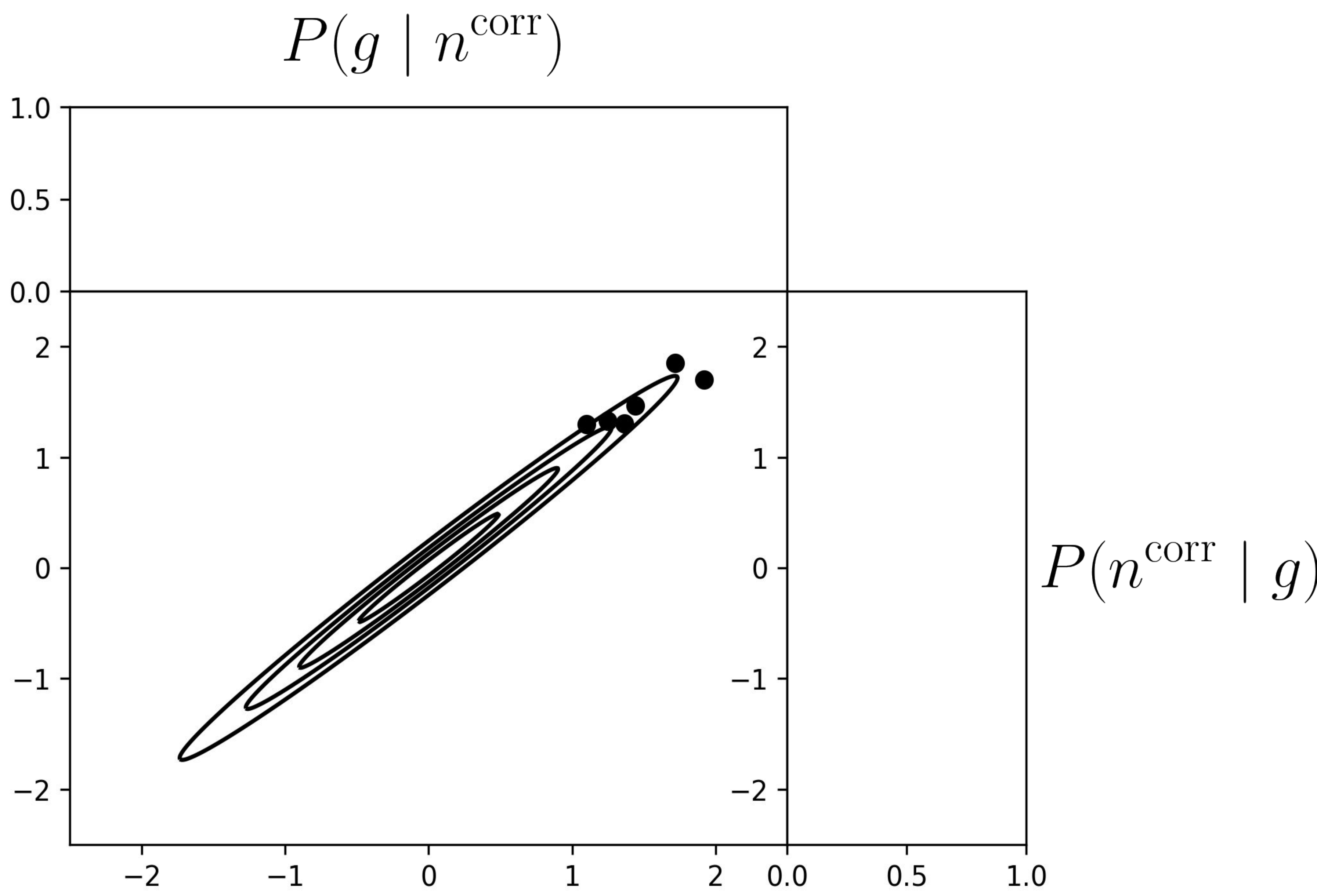
$$P(g, s^{\mathrm{tot}}, n^{\mathrm{corr}}, \ldots \mid d)$$

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

Sampling from conditional distributions



Sampling from conditional distributions



The BeyondPlanck framework

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

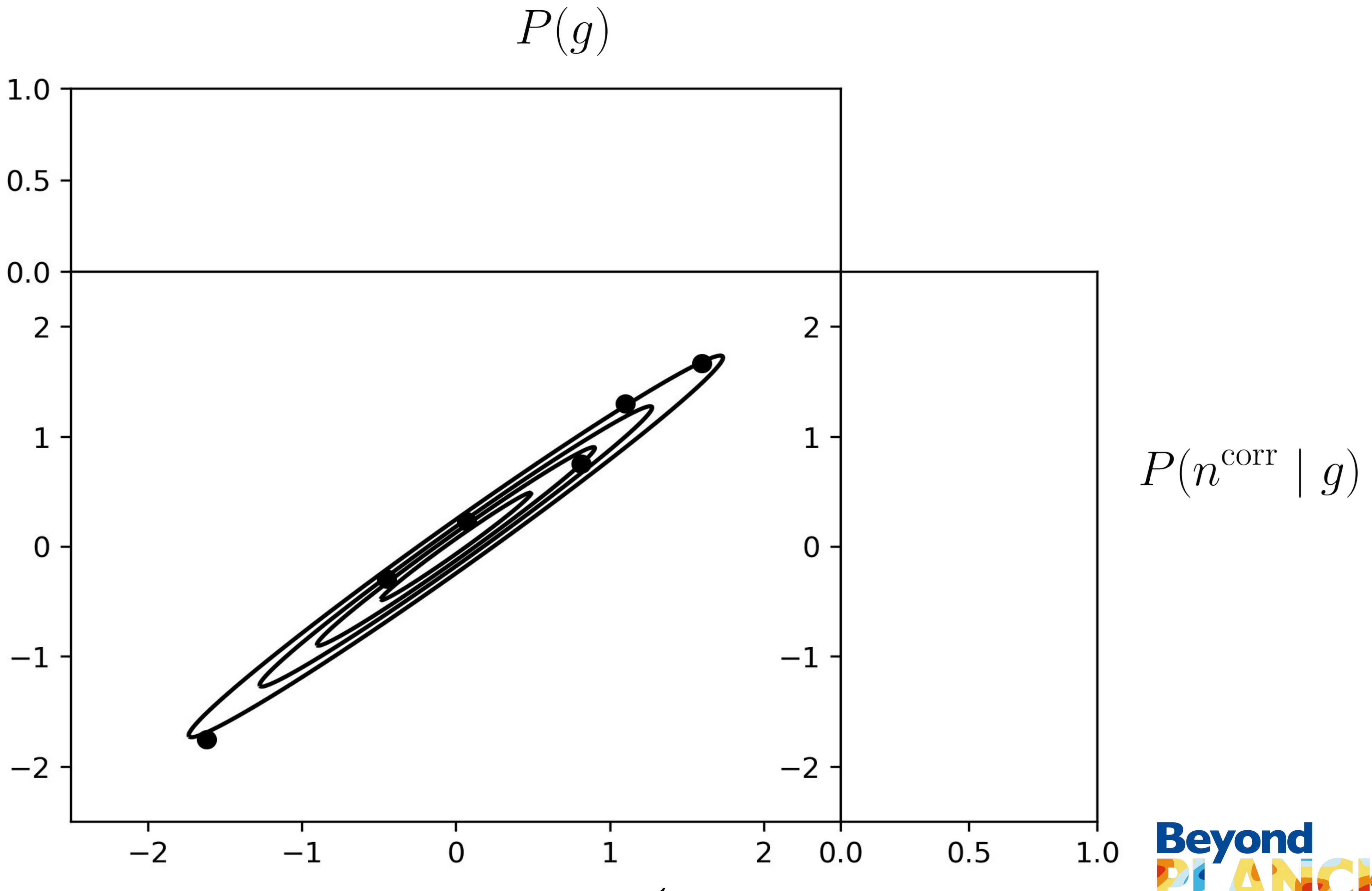
↓

$$\cancel{P(g \mid n^{\mathrm{corr}})}$$

↓

$$P(g, n^{\mathrm{corr}}) = P(g)P(n^{\mathrm{corr}} \mid g)$$

Sampling from the joint distribution



Absolute and relative calibration

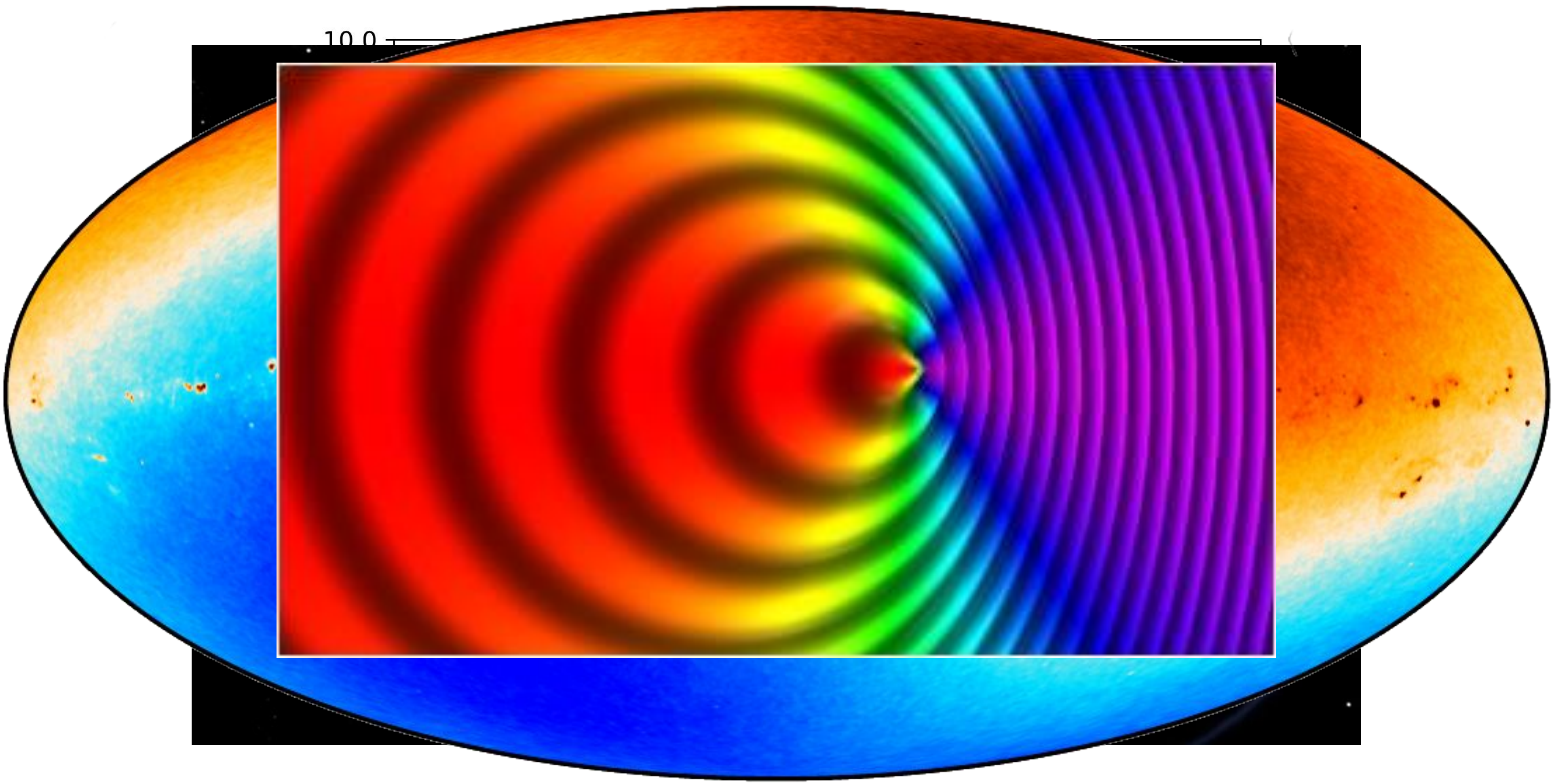
Absolute calibration:

- Estimating the "true" value of the gain.
- Important for correctly estimating the total intensity emitted.

Relative calibration:
- Estimating the gain factor of one detector relative to another.
- Important for reconstruction of the polarization signal.
- Requires a much higher accuracy than absolute calibration.

Calibration sources

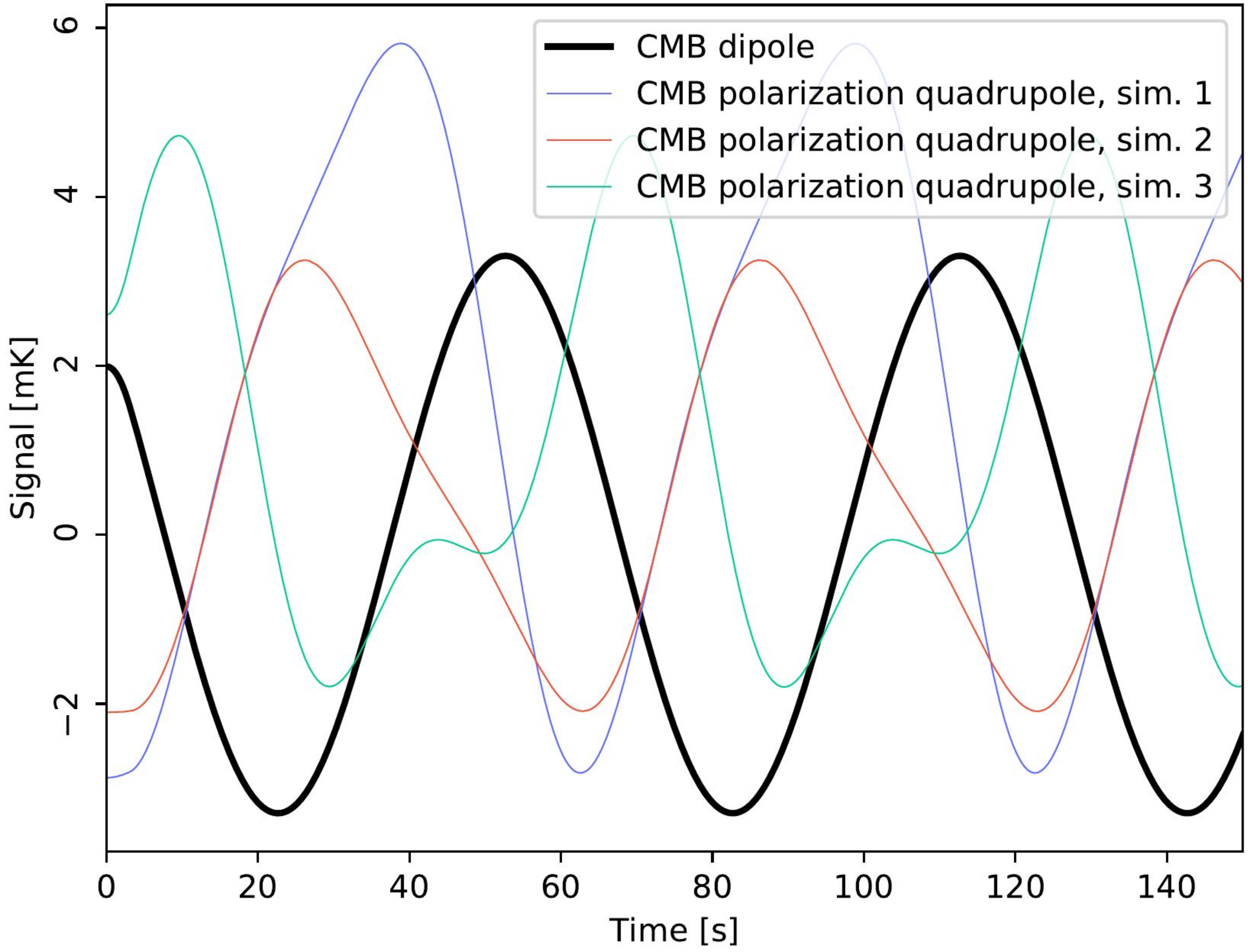
$$d_t = g_q s_t^{\mathrm{tot}} + n_t^{\mathrm{corr}} + n_t^{\mathrm{wn}}$$



Attr: en:TxAlien - en:Image:Velocity0.70c.jpg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1066460

Attr: DJ Sadhu

The polarization quadrupole



Methodology

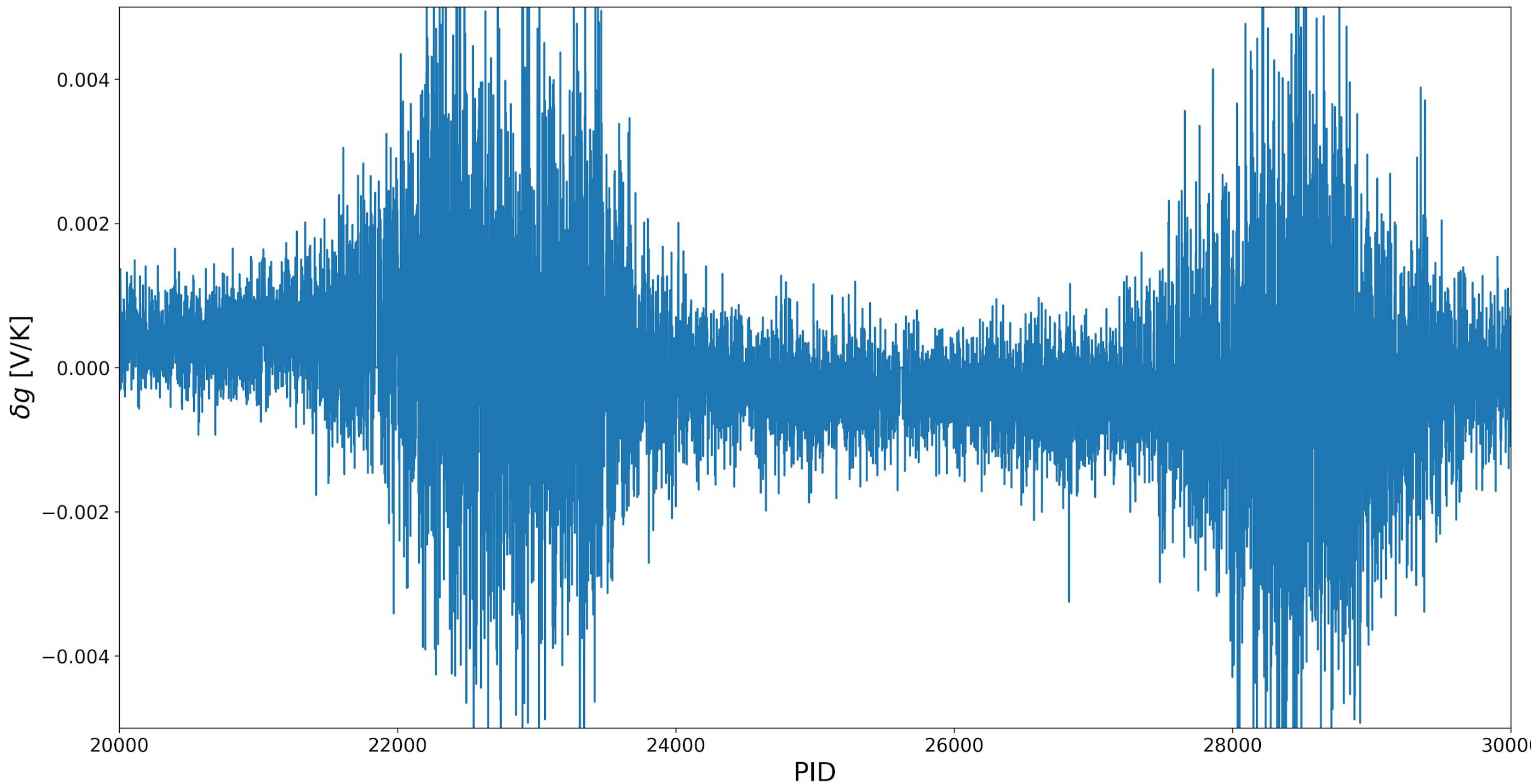
$$g_{q,i} = g_0 + \Delta g_i + \delta g_{q,i}$$

To be estimated using the orbital dipole

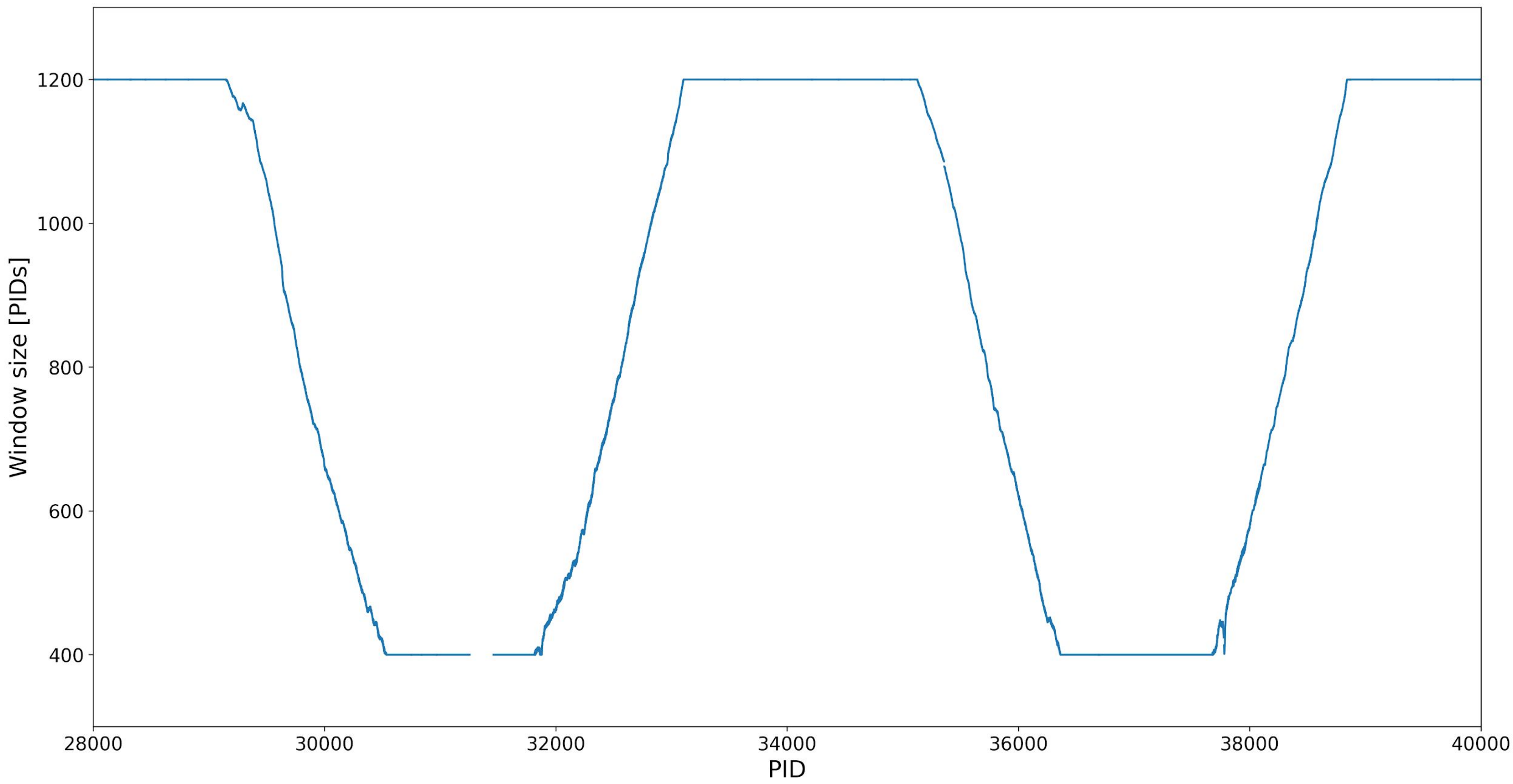
To be estimated using the full signal

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

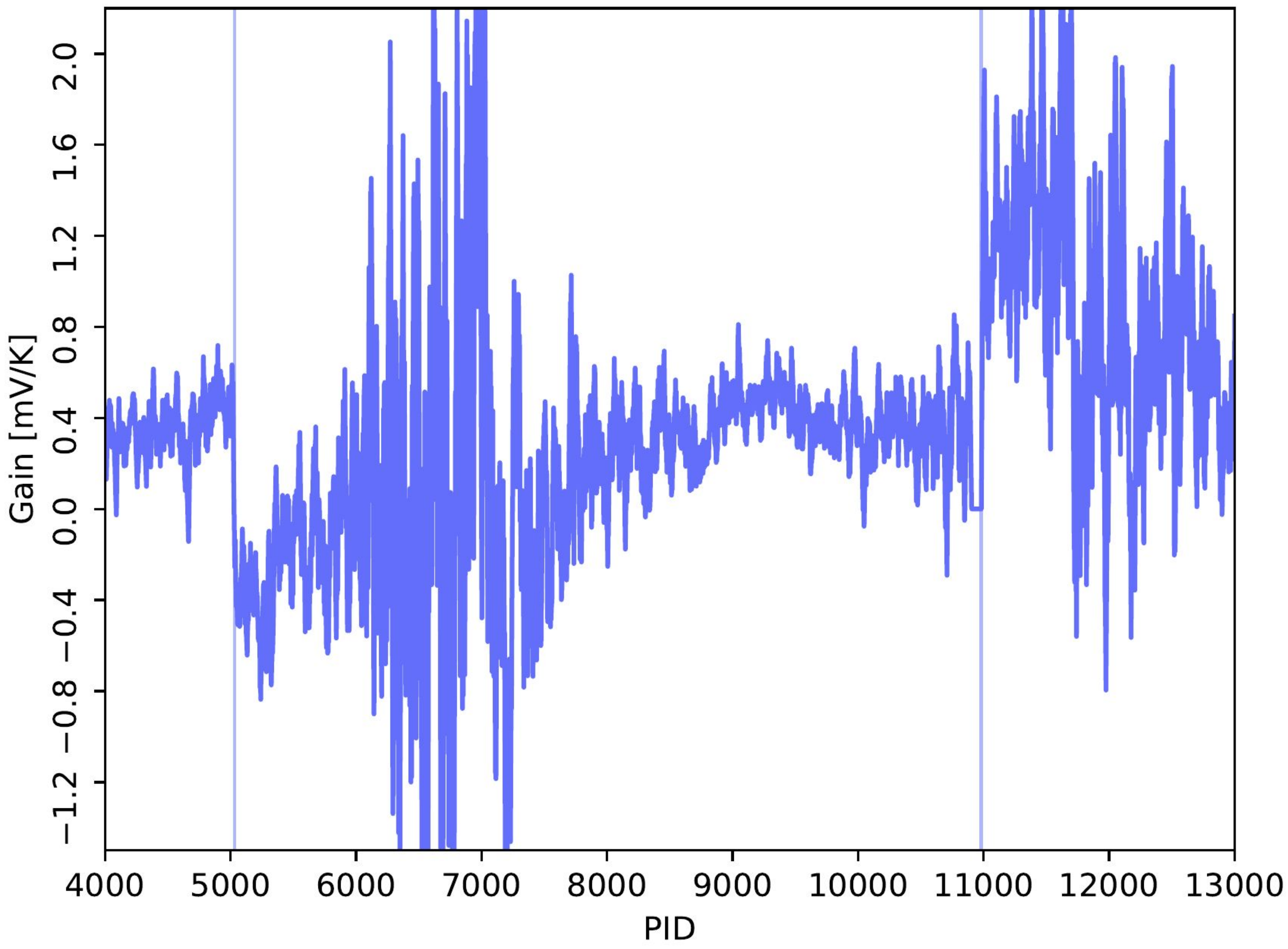
Smoothing the time variable gain



Smoothing the time variable gain

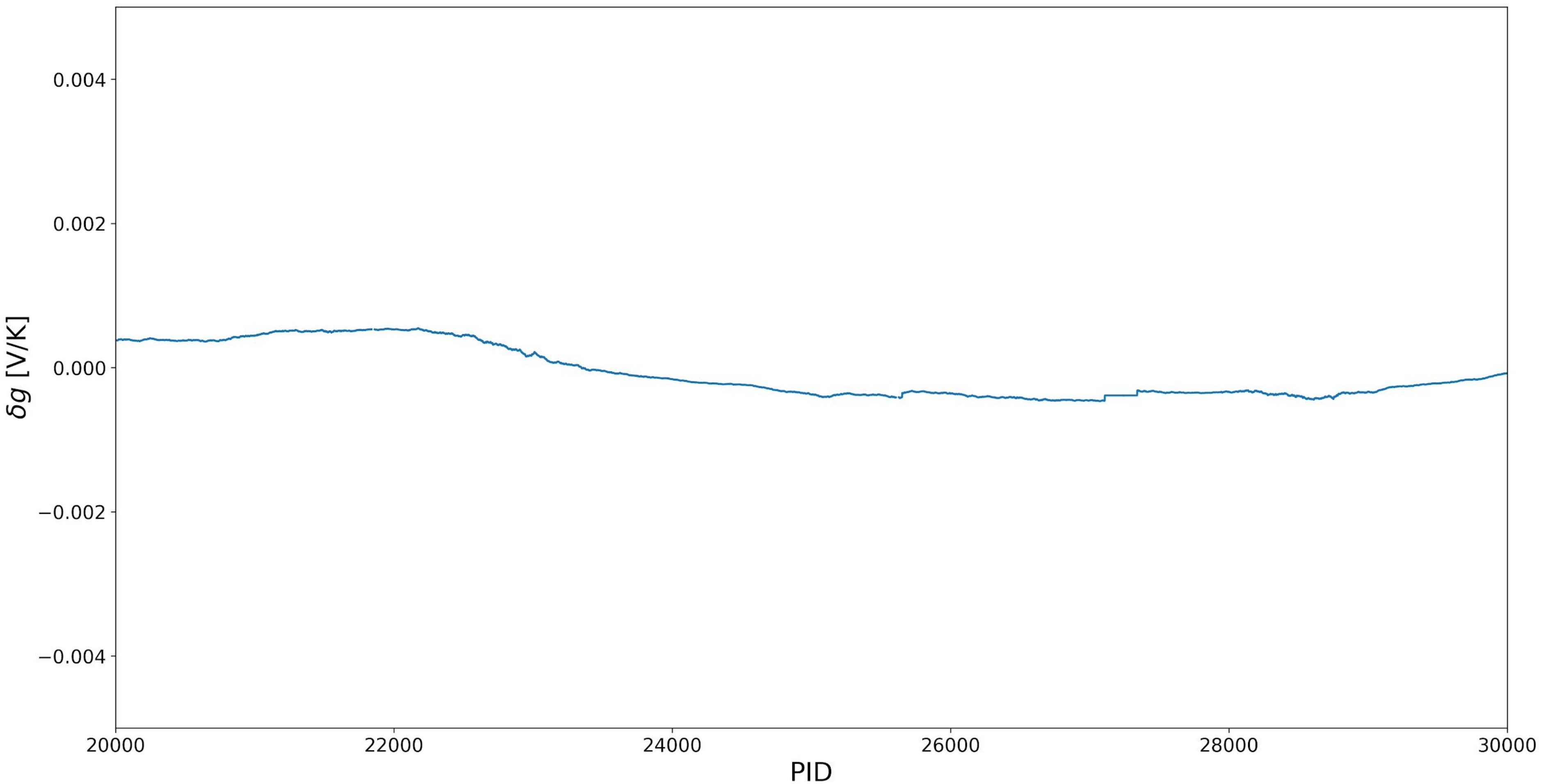


Gain jumps

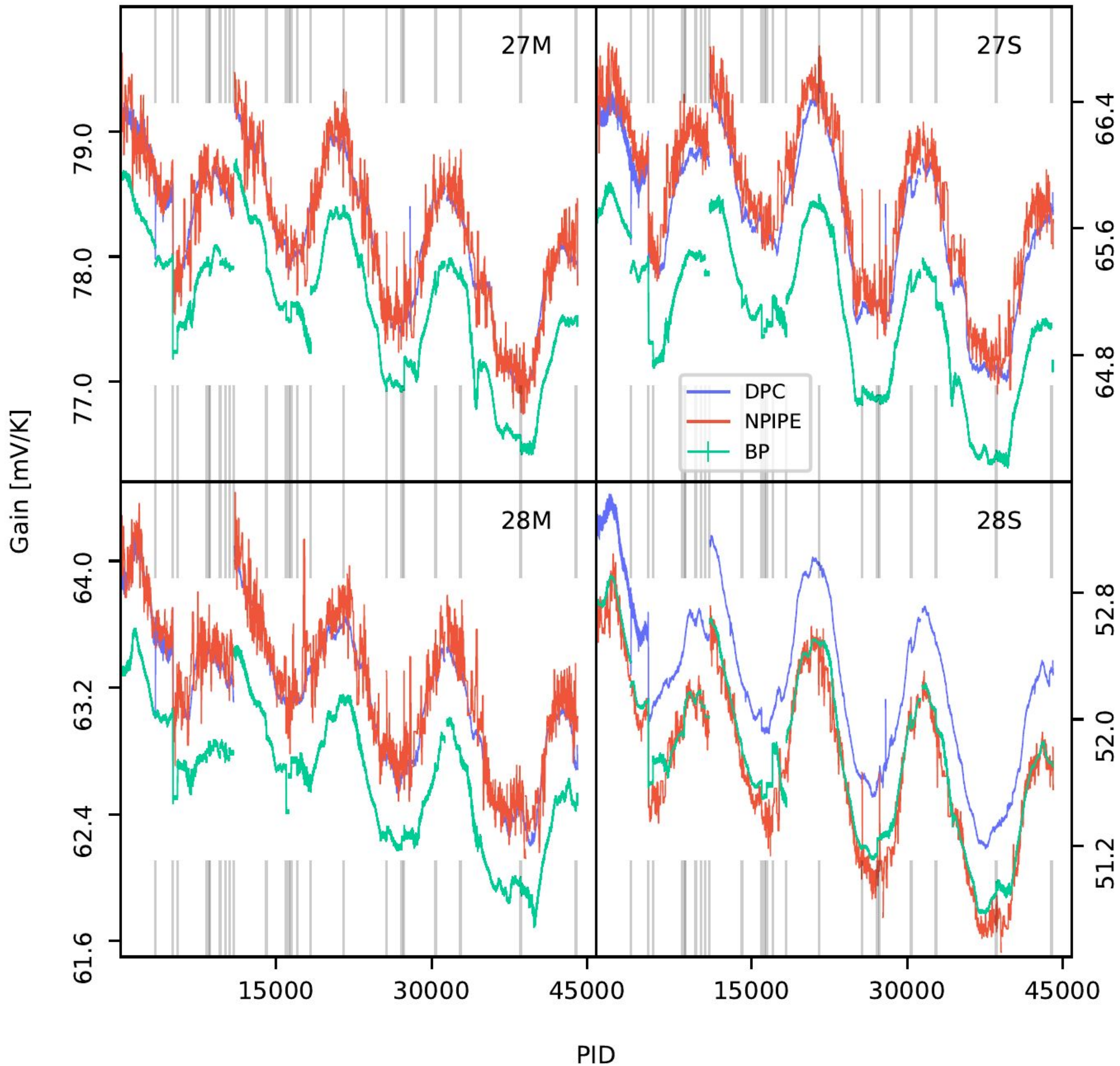


Gain [mV/K]
−1.2
−0.8
−0.4
0.0
0.4
0.8
1.2
1.6
2.0
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
PID

Smoothing the time variable gain

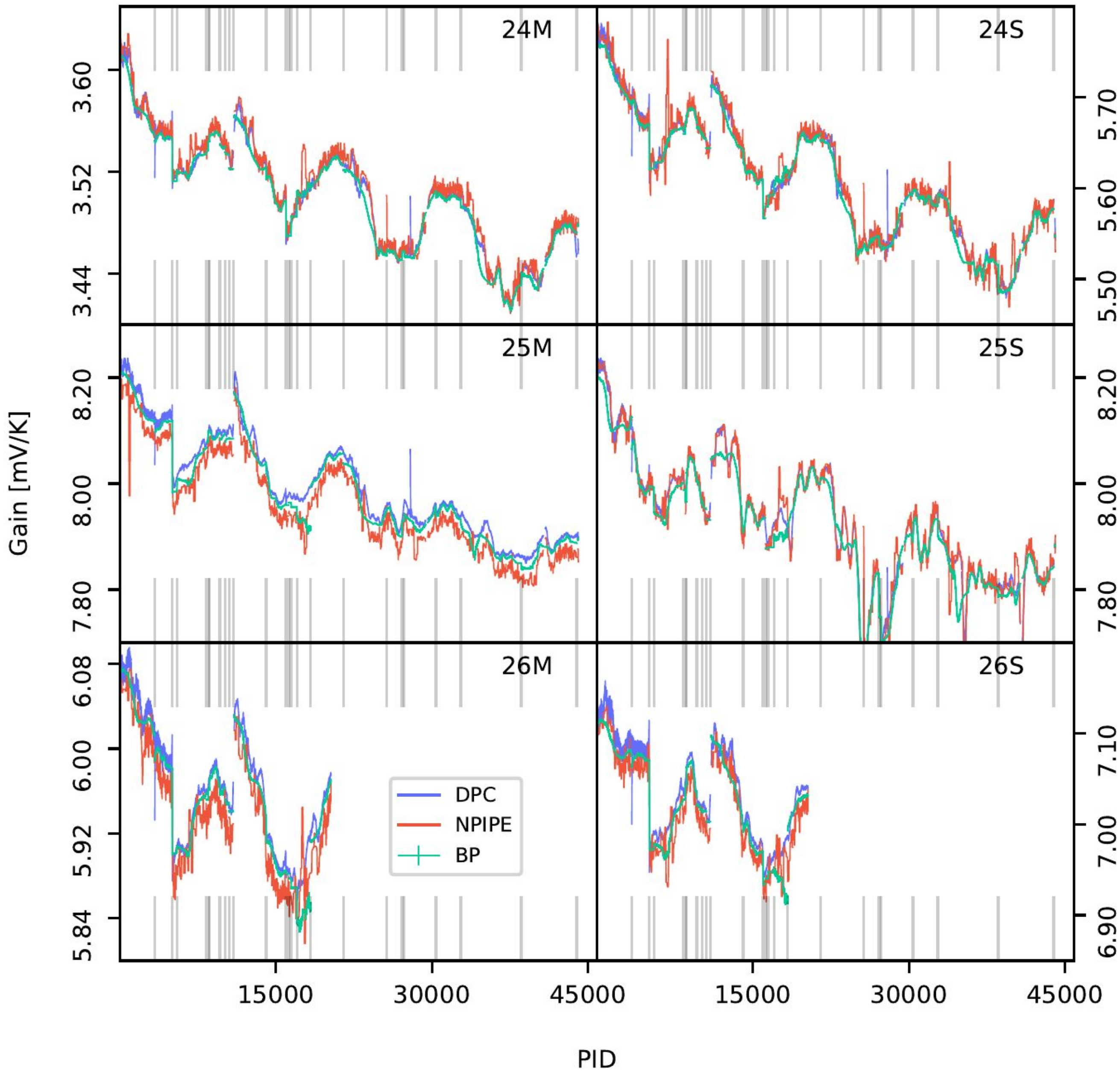


Results



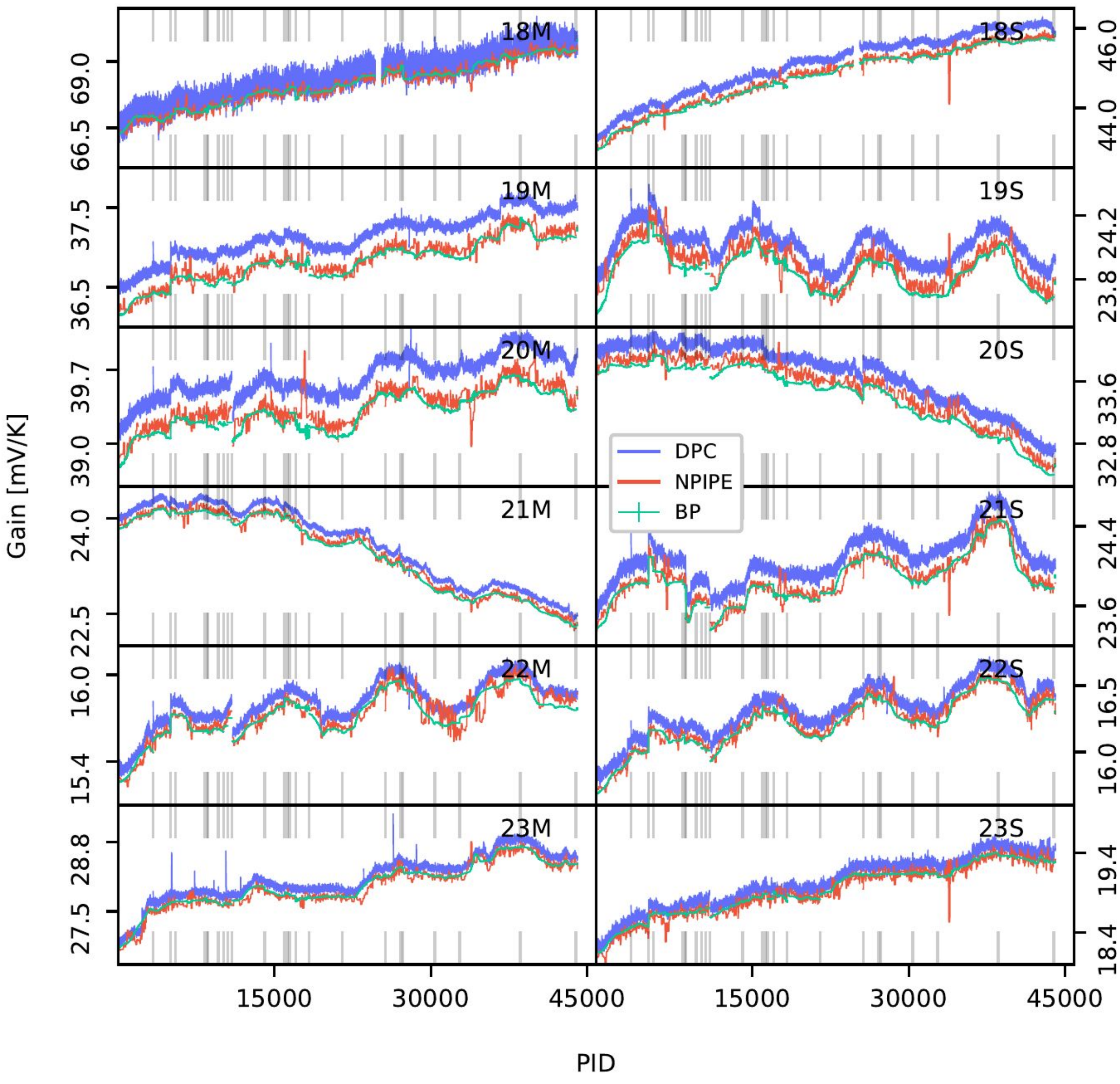
27M
27S
28M
28S
DPC
NPIPE
BP
Gain [mV/K]
79.0
78.0
77.0
64.0
63.2
62.4
61.6
66.4
65.6
64.8
52.8
52.0
51.2
15000
30000
45000
PID

Results

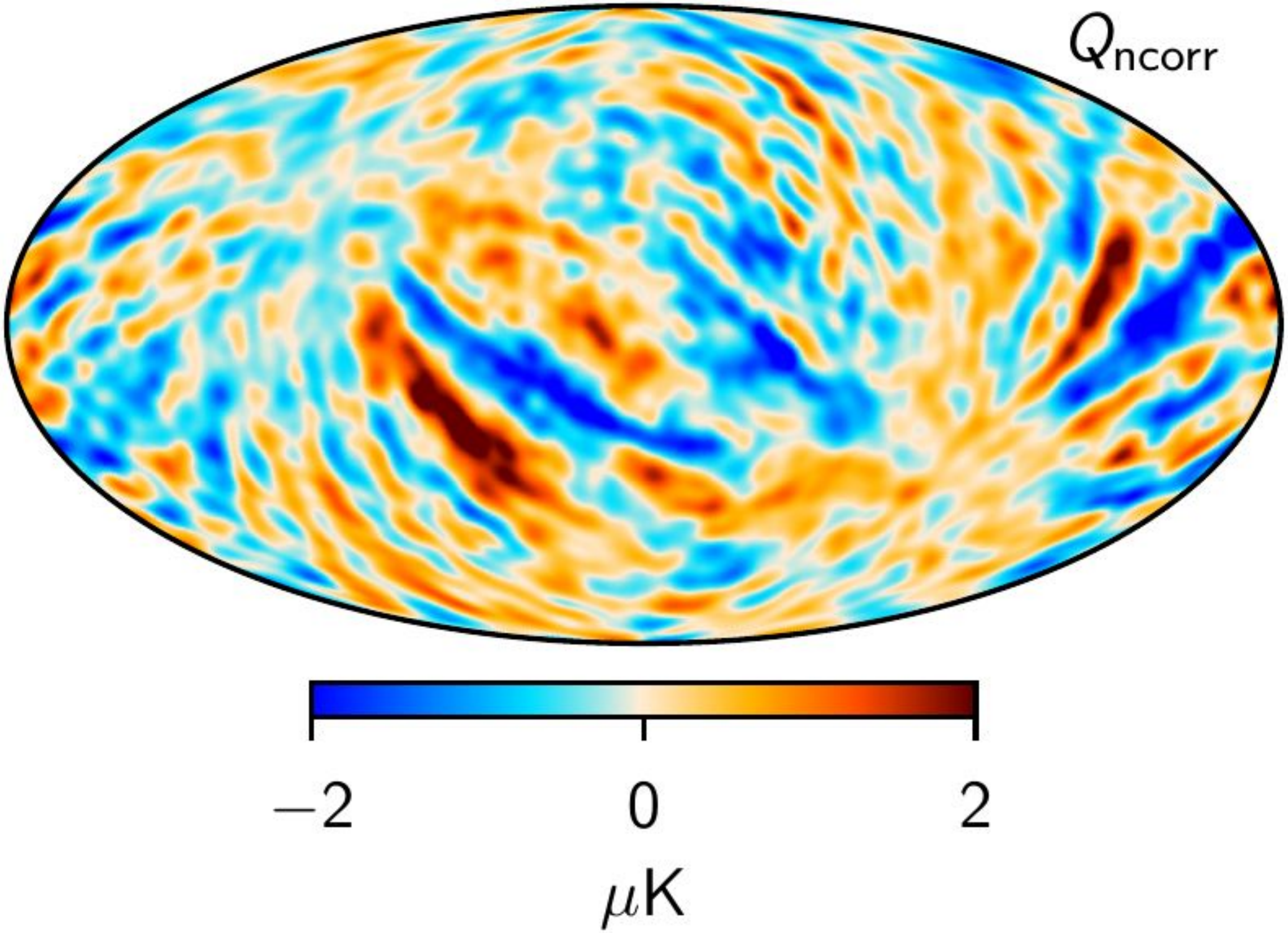


24M
24S
25M
25S
26M
26S
3.60
3.52
3.44
8.20
8.00
7.80
6.08
6.00
5.92
5.84
5.70
5.60
5.50
7.10
7.00
6.90
Gain [mV/K]
15000
30000
45000
PID
DPC
NPIPE
BP

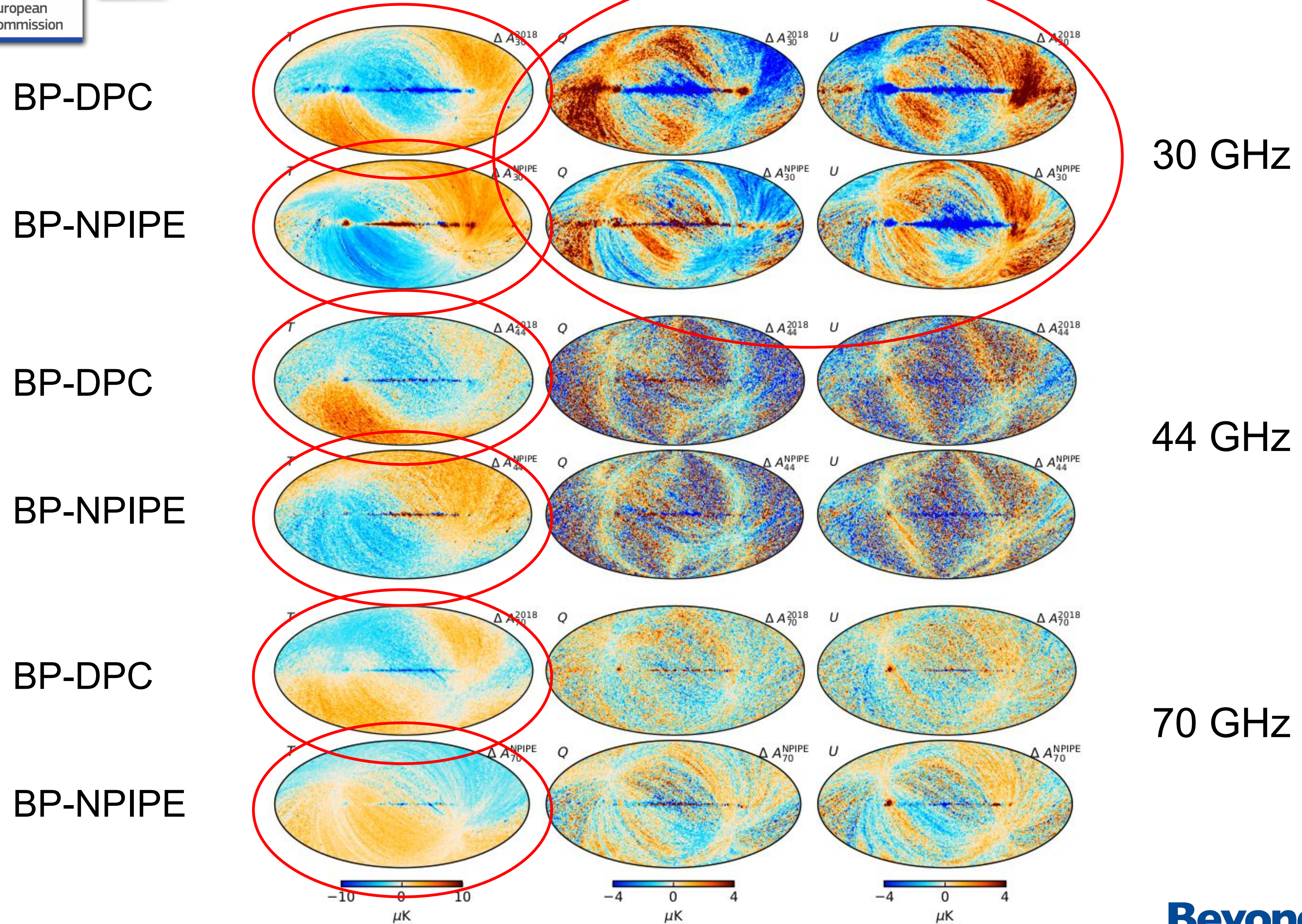
Results

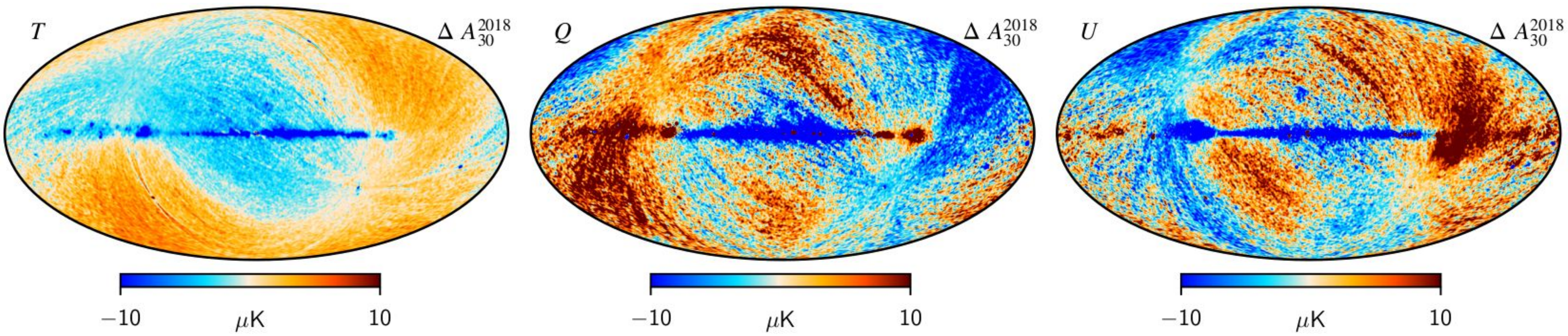

18M
18S
19M
19S
20M
20S
21M
21S
22M
22S
23M
23S
DPC
NPIPE
BP
Gain [mV/K]
PID
66.5
69.0
36.5
37.5
39.0
39.7
22.5
24.0
15.4
16.0
27.5
28.8
44.0
46.0
23.8
24.2
32.8
33.6
23.6
24.4
16.0
16.5
18.4
19.4
15000
30000
45000

Correlated noise stripes



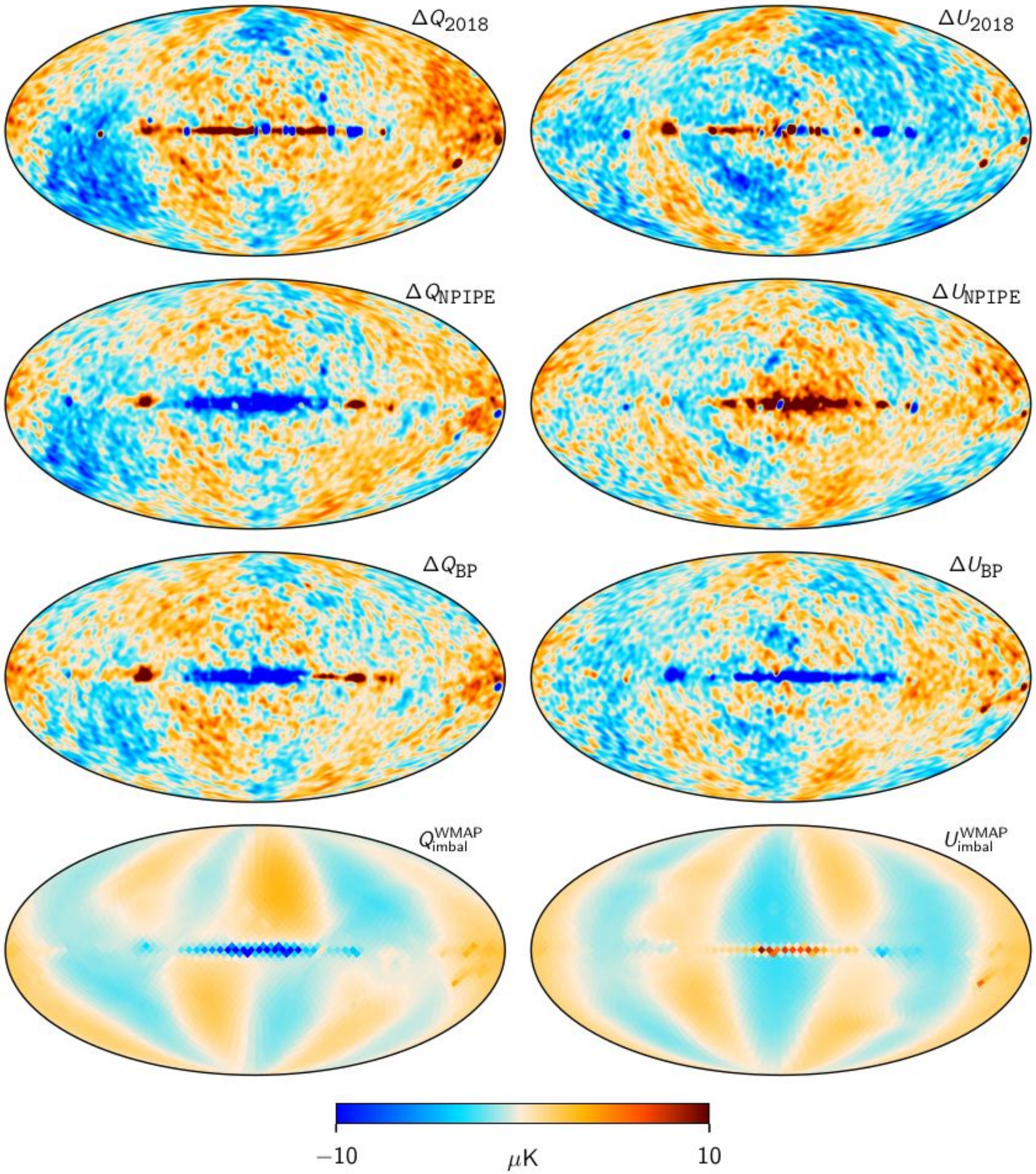
BP and other pipelines





T
ΔA_{30}^{2018}
-10
μK
10
Q
ΔA_{30}^{2018}
-10
μK
10
U
ΔA_{30}^{2018}
-10
μK
10

WMAP differences



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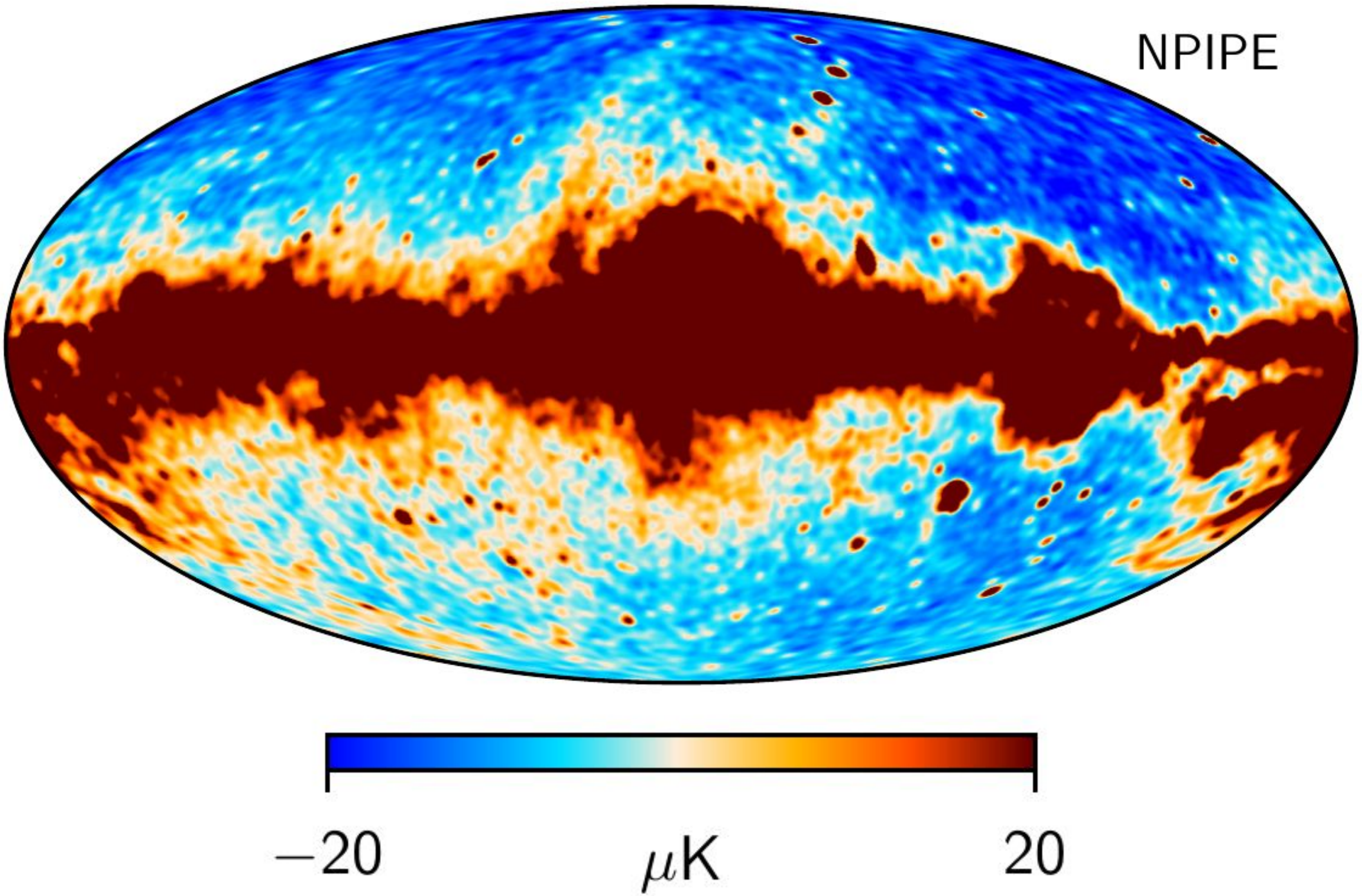
Difference between 70 GHz and 44 GHz



Conclusions

- A working calibration solution, sampled jointly with correlated noise and sky signal.
- Certain differences from previous pipelines, especially for 30 GHz.
- Some residual problems with correlated noise stripes, to be investigated further.
- Overall better fit to WMAP polarization data - and should become even better with WMAP time-domain data included.

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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

European Commission

Questions?

Beyond PLANCK

Commander

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THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

HORIZON 2020

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