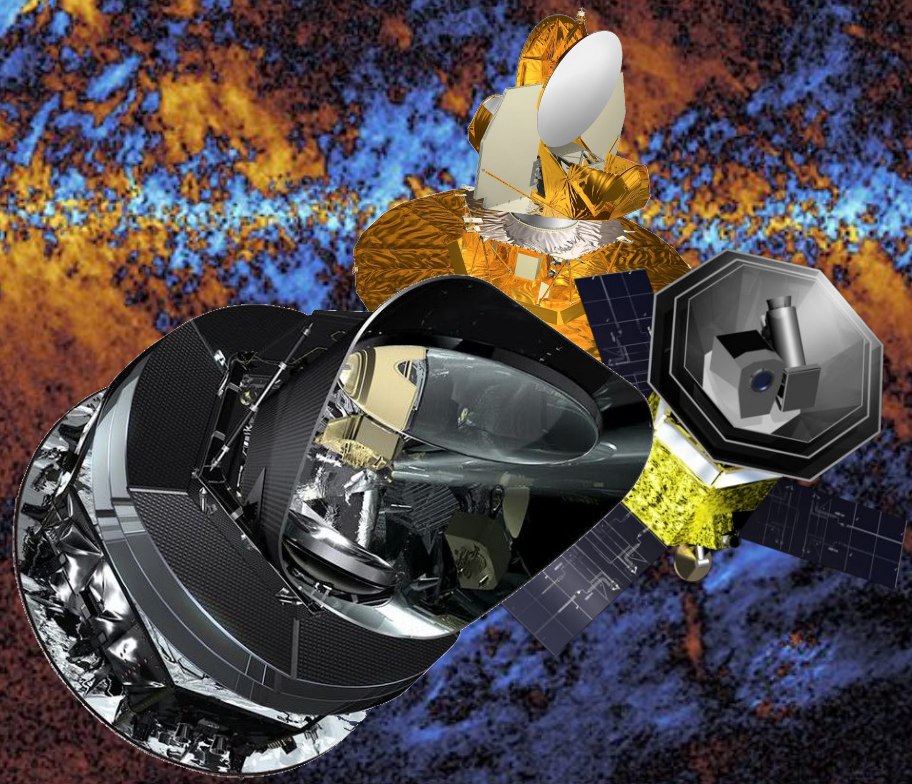
European Commission

Beyond PLANCK

Sidelobes

Mathew Galloway



BeyondPlanck online release conference, November 18-20, 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776282

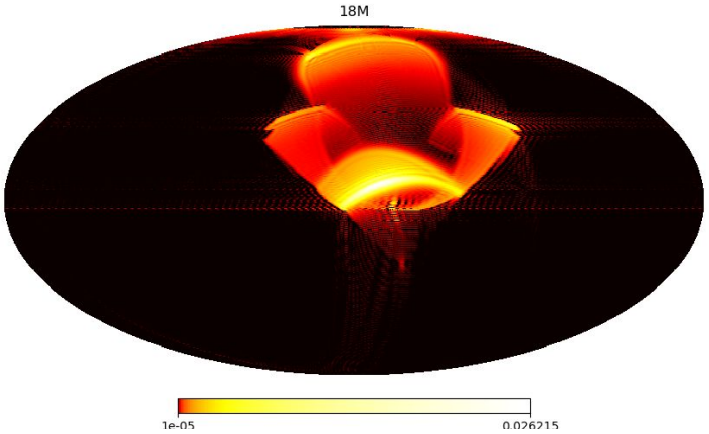
The Data Model

One more time to remind everyone:

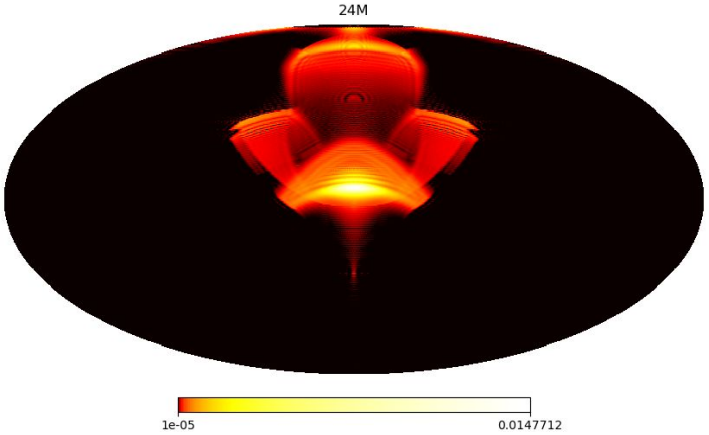
$$d_{j,t} = g_{j,t} \mathsf{P}_{tp,j} \left[\mathsf{B}^{\mathrm{symm}}_{pp',j} \sum_c \mathsf{M}_{cj}(\beta_{p'}, \Delta^j_{\mathrm{bp}}) a^c_{p'} + \mathsf{B}^{\mathrm{asymm}}_{j,t} \left(\boldsymbol{s}^{\mathrm{orb}}_j + \boldsymbol{s}^{\mathrm{fsl}}_t \right) \right] + n^{\mathrm{corr}}_{j,t} + n^{\mathrm{w}}_{j,t}.$$

- Far sidelobe signal separated from main beam for performance reasons
- Sidelobes are not sampled, just re-computed every iteration as other parameters (like the sky) change
- Treated as a nuisance signal and subtracted out of the final maps
- Signal is computed in the time domain using a TotalConvolver-like algorithm
- Input sidelobe measurements are constant (for now)

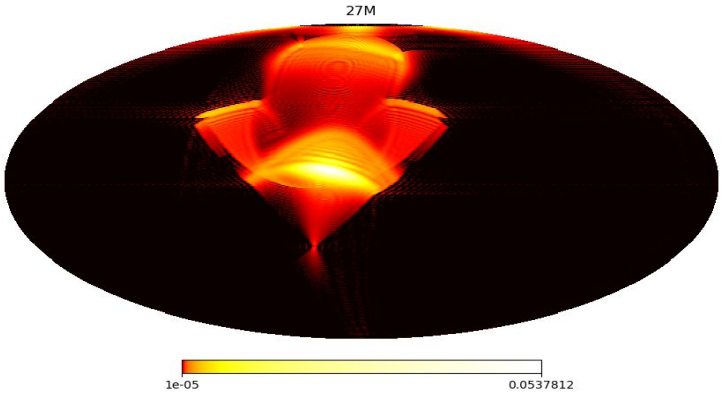
Sidelobe Maps and Normalization



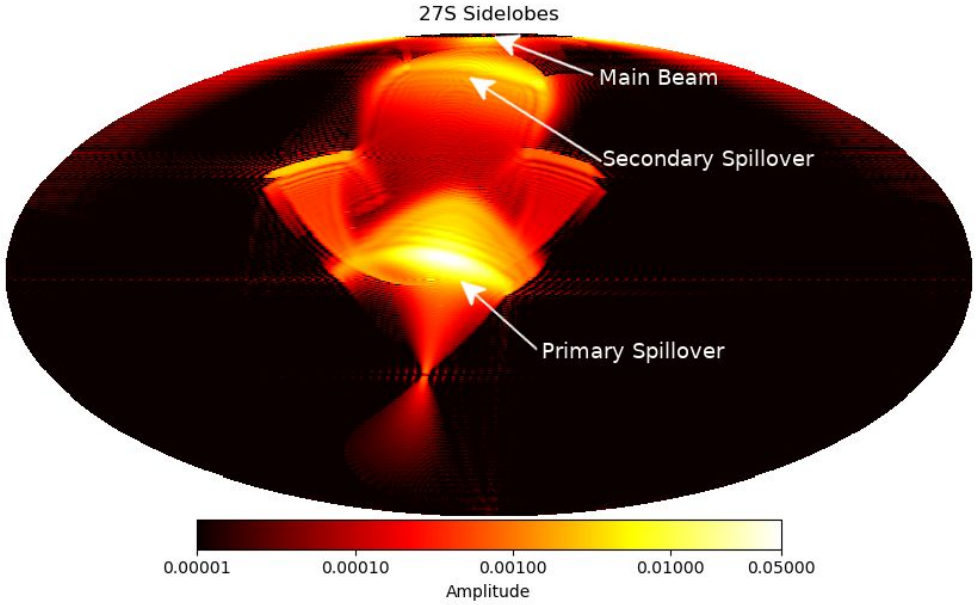
70 GHz



44 GHz



30 GHz



BeyondPlanck et al. (2020)

The beam and sidelobes are normalized such that the integral is 1.

This is different than the previous LFI normalization which did not assign the unknown power.

Sidelobe Algorithms

- BeyondPlanck has implemented a sidelobe estimation algorithm based on libConviqt (Prézeau and Reinecke 2010)

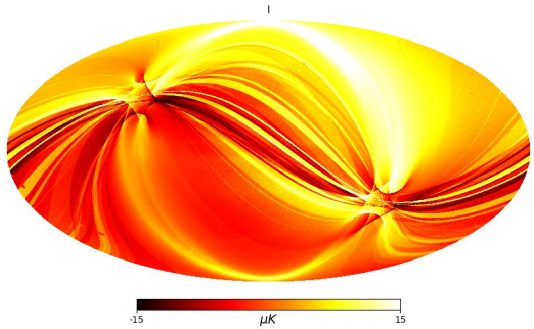
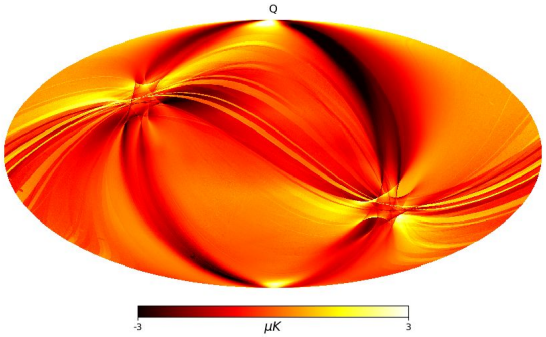
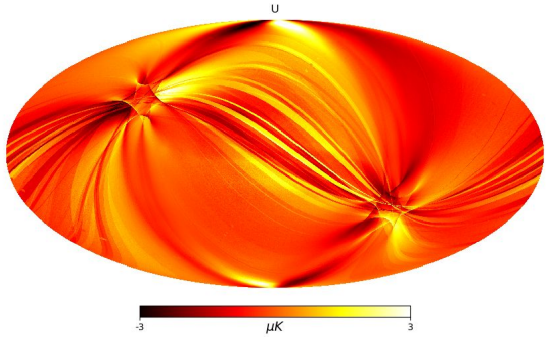
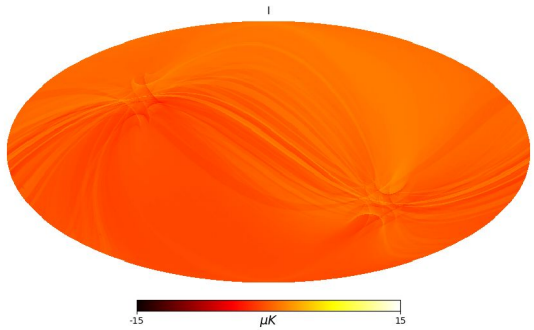
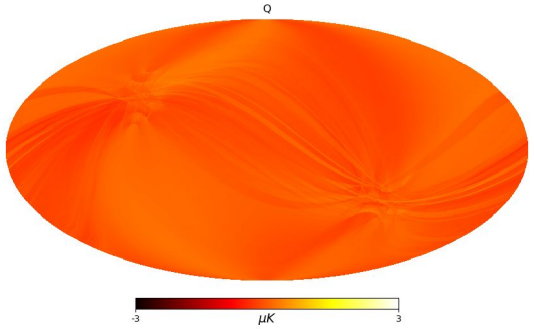
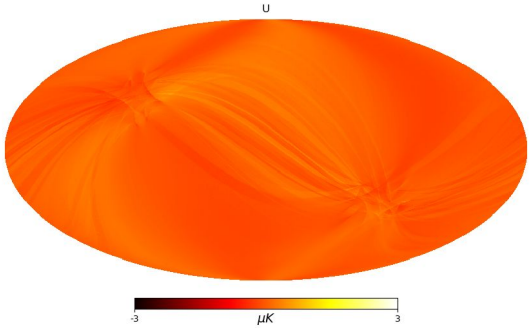
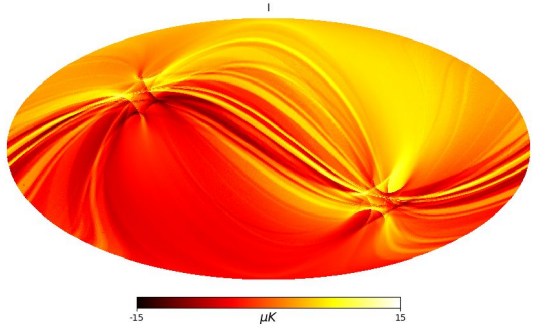
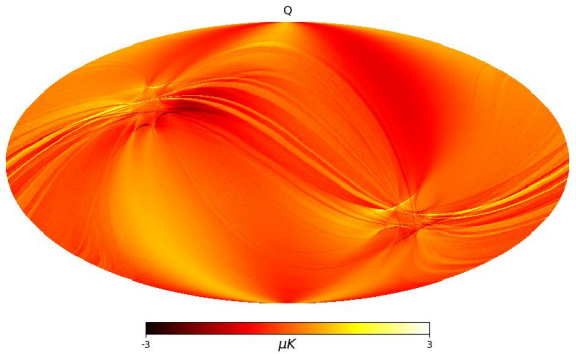
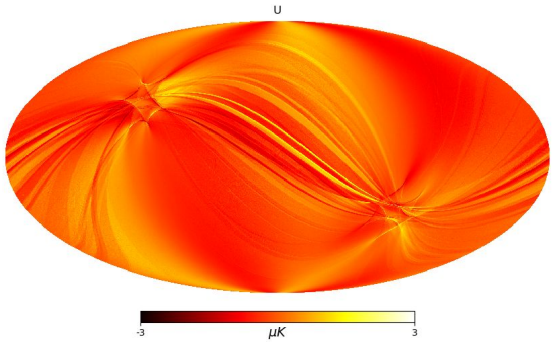
$$c(\vartheta,\varphi,\psi) = \sum_{m_b=-m_{b,\max}}^{m_{b,\max}} C(\vartheta,\varphi,m_b)e^{im_b\psi}$$

$$C(\vartheta,\varphi,m_b) = m_1 + im_2, \quad \text{where}$$

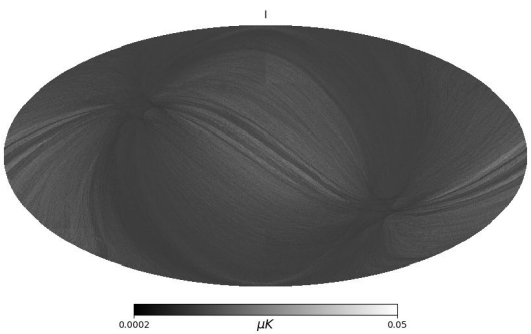
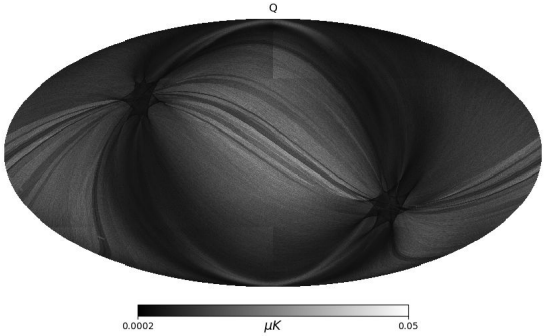
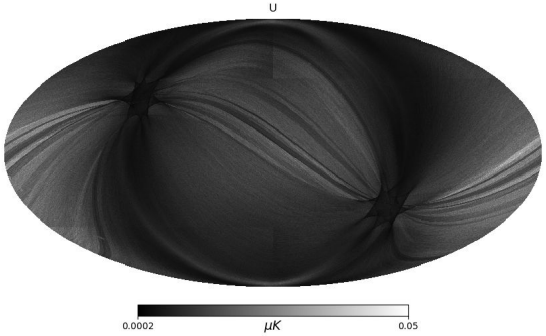
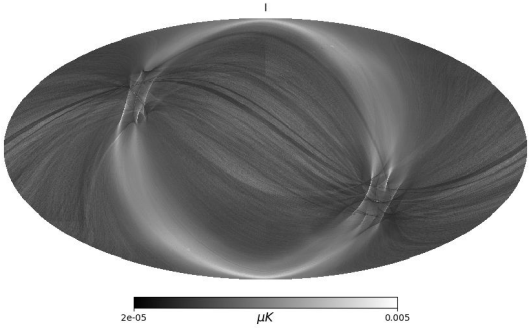
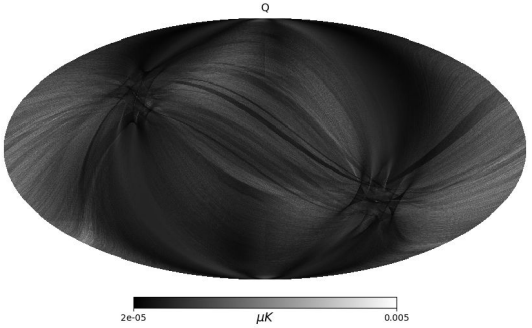
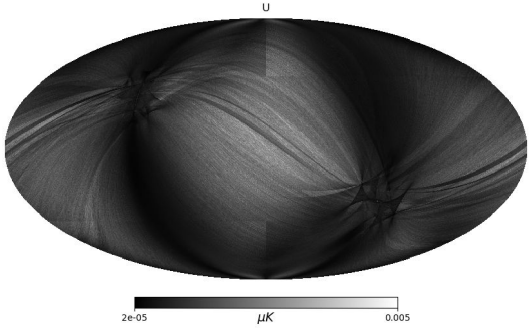
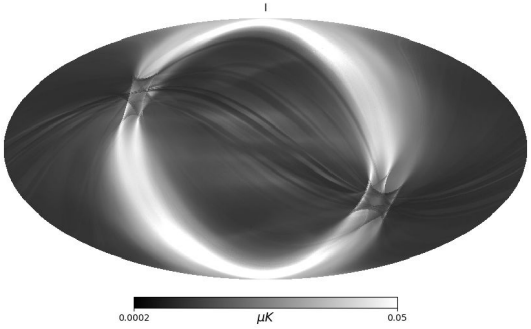
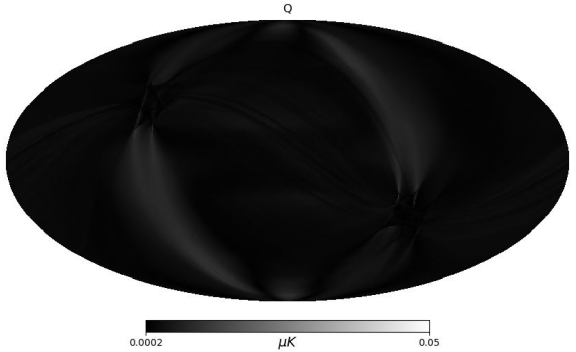
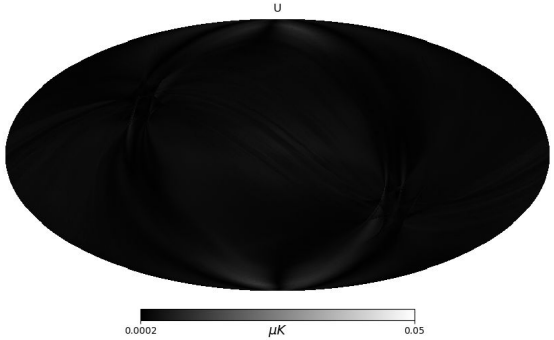
$$m_1, m_2 = \mathbf{A2M}_{m_b}\left(\sqrt{\frac{4\pi}{2l+1}}{}_{m_b}E_{lm_s}, \sqrt{\frac{4\pi}{2l+1}}{}_{m_b}B_{lm_s}\right).$$

- Computes a full sky convolution datacube per detector, c(ϑ,φ, ψ), the expected sidelobe signal amplitude at a given pointing
- Uses libsharp's spin-weighted Spherical Harmonics Transforms to efficiently compute the polarized convolutions
- Uses splines to interpolate the finite resolution data cube to the desired pointing in the time domain at runtime

Sidelobe Maps

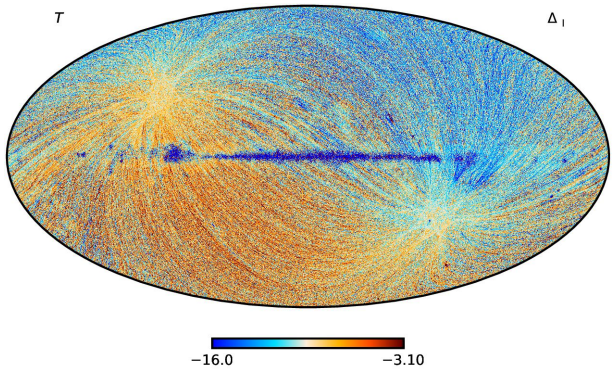
	I	Q	U
30 GHz			
44 GHz			
70 GHz			

Sidelobe RMS Maps

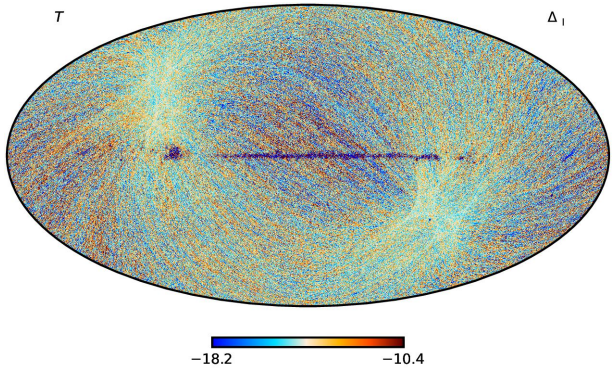
	I	Q	U
30 GHz			
44 GHz			
70 GHz			

Effects of the Sidelobes - Frequency Maps

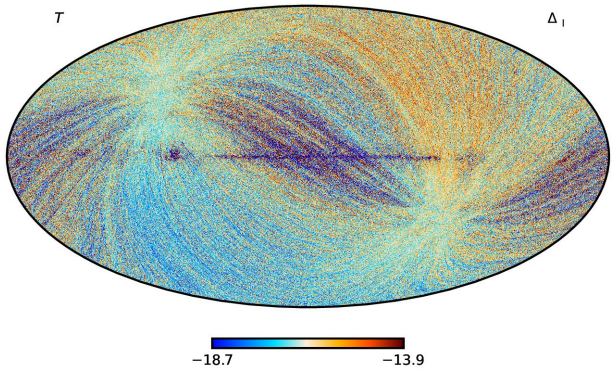
30 GHz



44 GHz

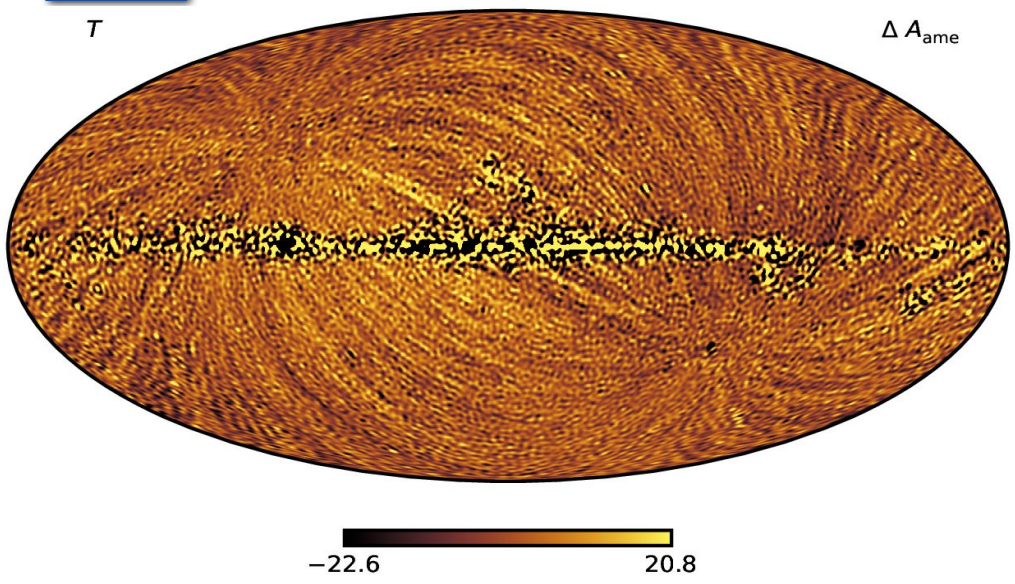


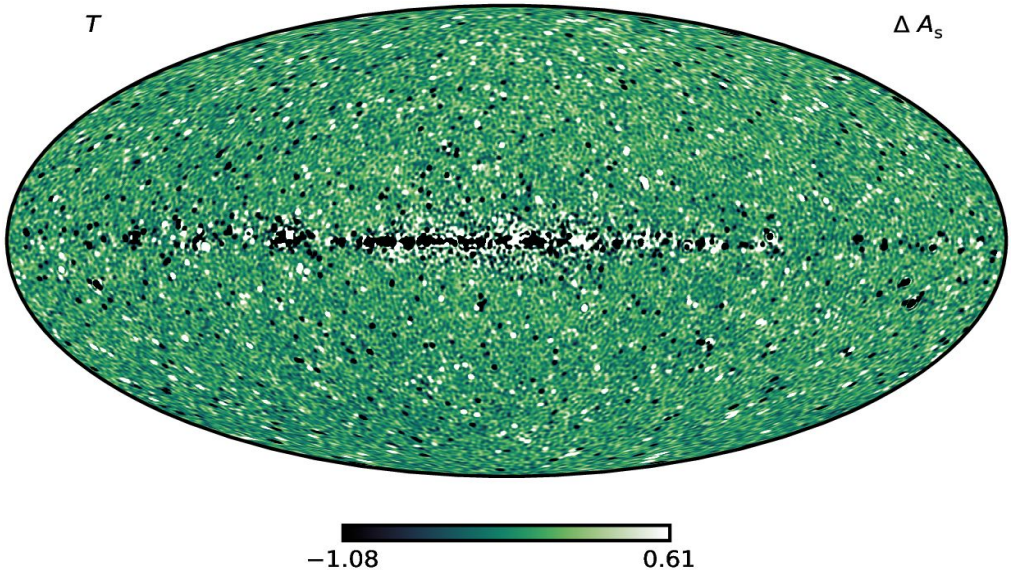
70 GHz

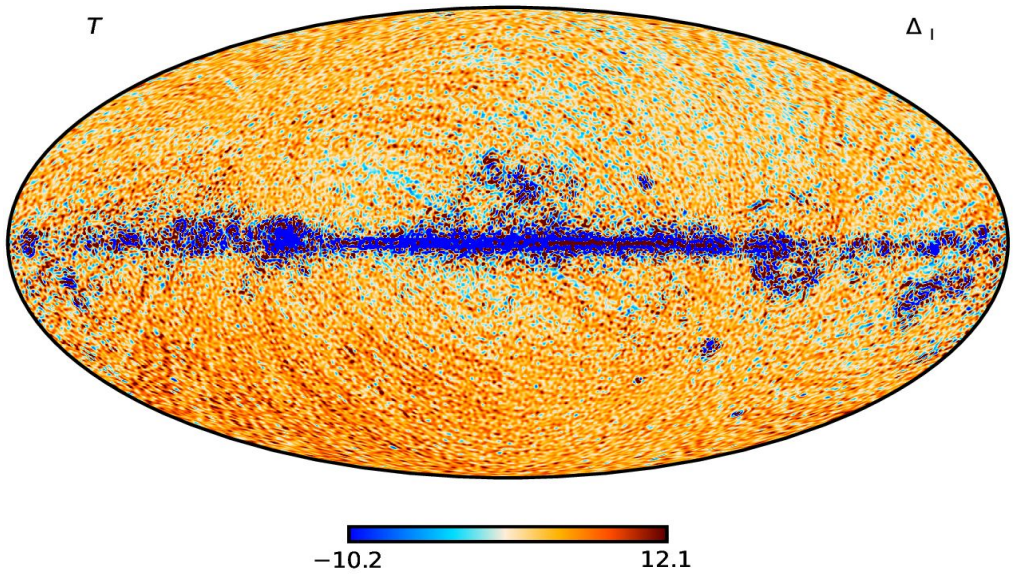


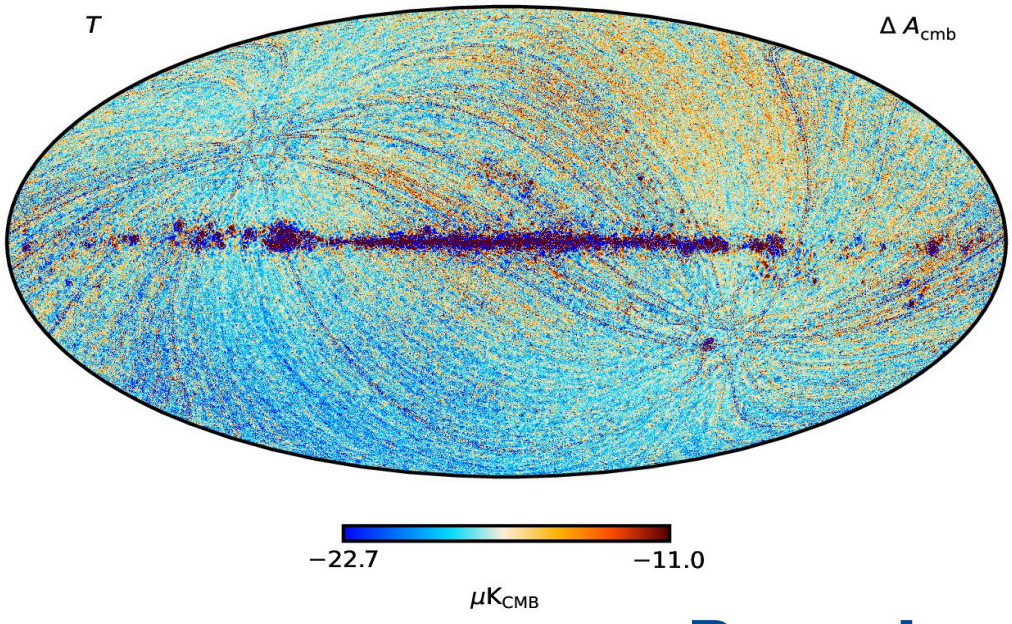
- Without proper modeling and removal of sidelobes, the calibrations are wrong
- Big monopole offsets at all frequencies
- Strong dipoles at 30 GHz and 70 GHz
- Residual rings that look like the sidelobe signals
- Our current incomplete knowledge of the sidelobes implies that signals like this are still in the data at a lower level
- Future experiments: Know Your Beams + Sidelobes!

Effects of the Sidelobes - Component Maps

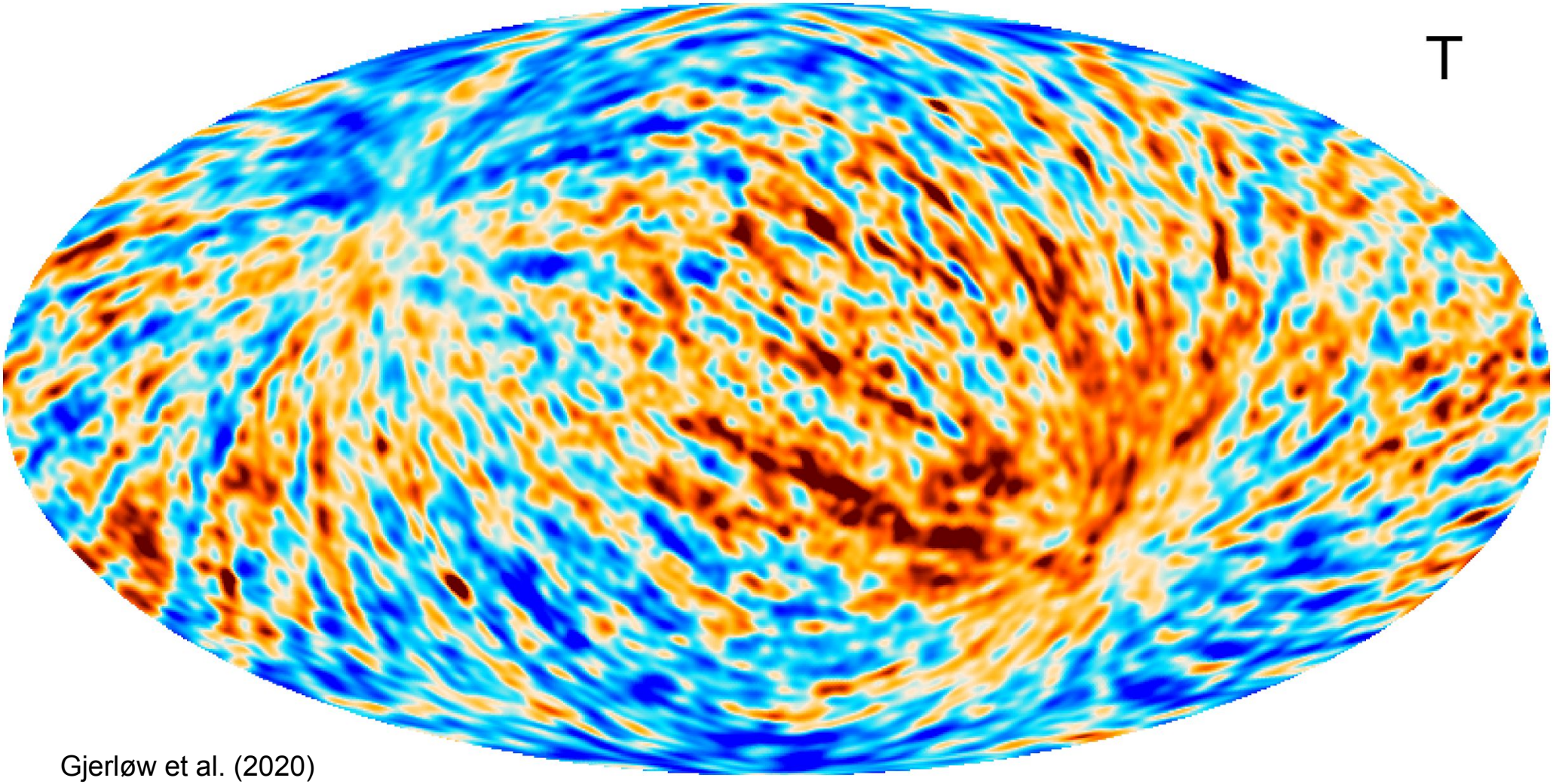








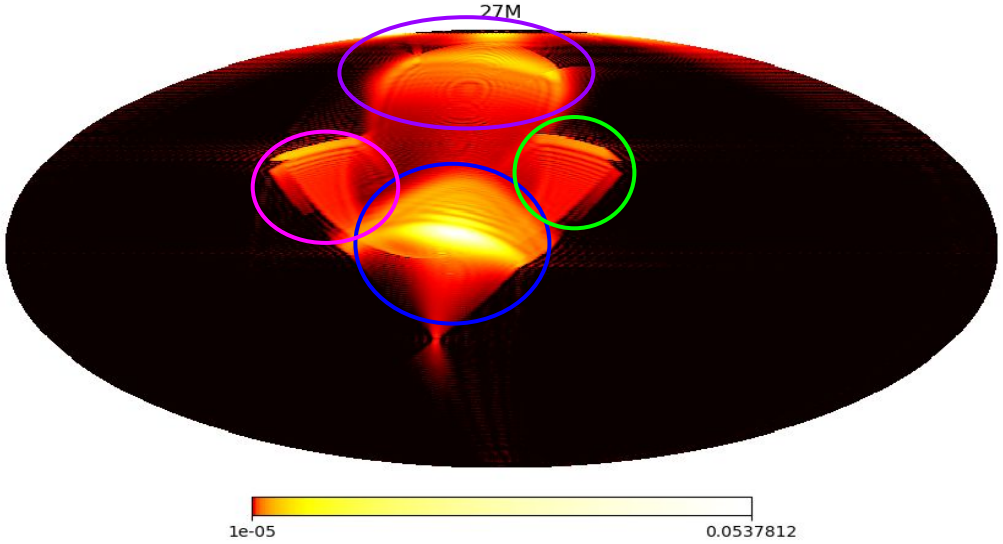
Effects in the Noise



Gjerløw et al. (2020)

Future Plans

Realistic(ish) parameterized beam models



- Sample the beams and sidelobe models as free parameters
- Accurately propagate beam uncertainties into the final results

4π Beam Convolution per timestep

- Extend this approach to the entire 4π beam, get a total signal estimate instead of just subtracting the sidelobes
- Works for asymmetric beams as well
- Feasible at lower resolutions, could be slow at nside>2048
- Needs faster interpolation method - this is already working in a standalone code

Funding

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776282

- "*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