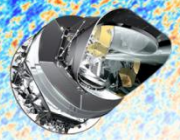
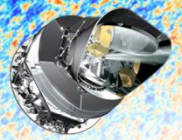


Internal Consistency of the Planck Data (selected topics)

P. R. Meinhold (For the Planck Team)

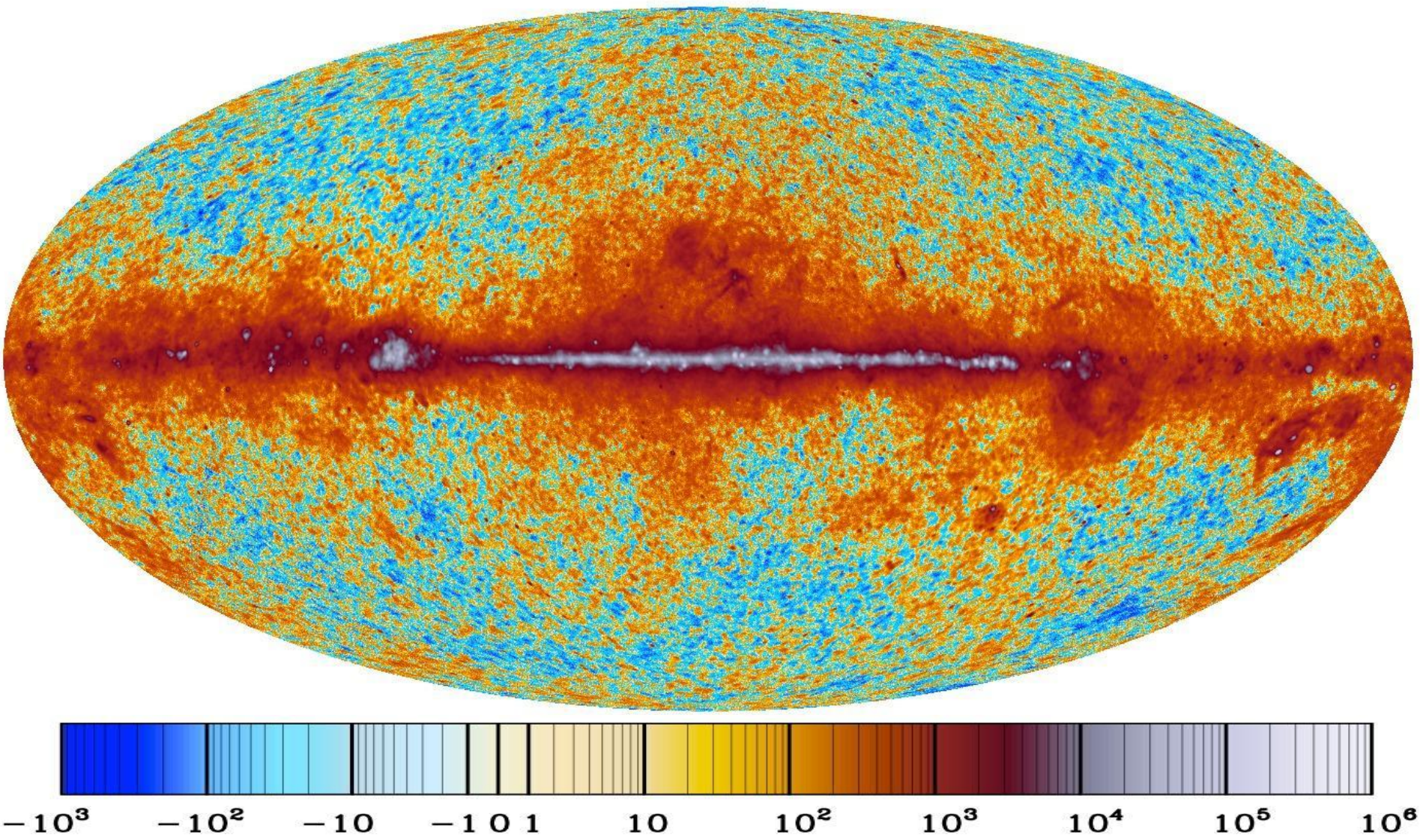
Mining the Cosmic Frontier
University of California at Davis
21 May 2013



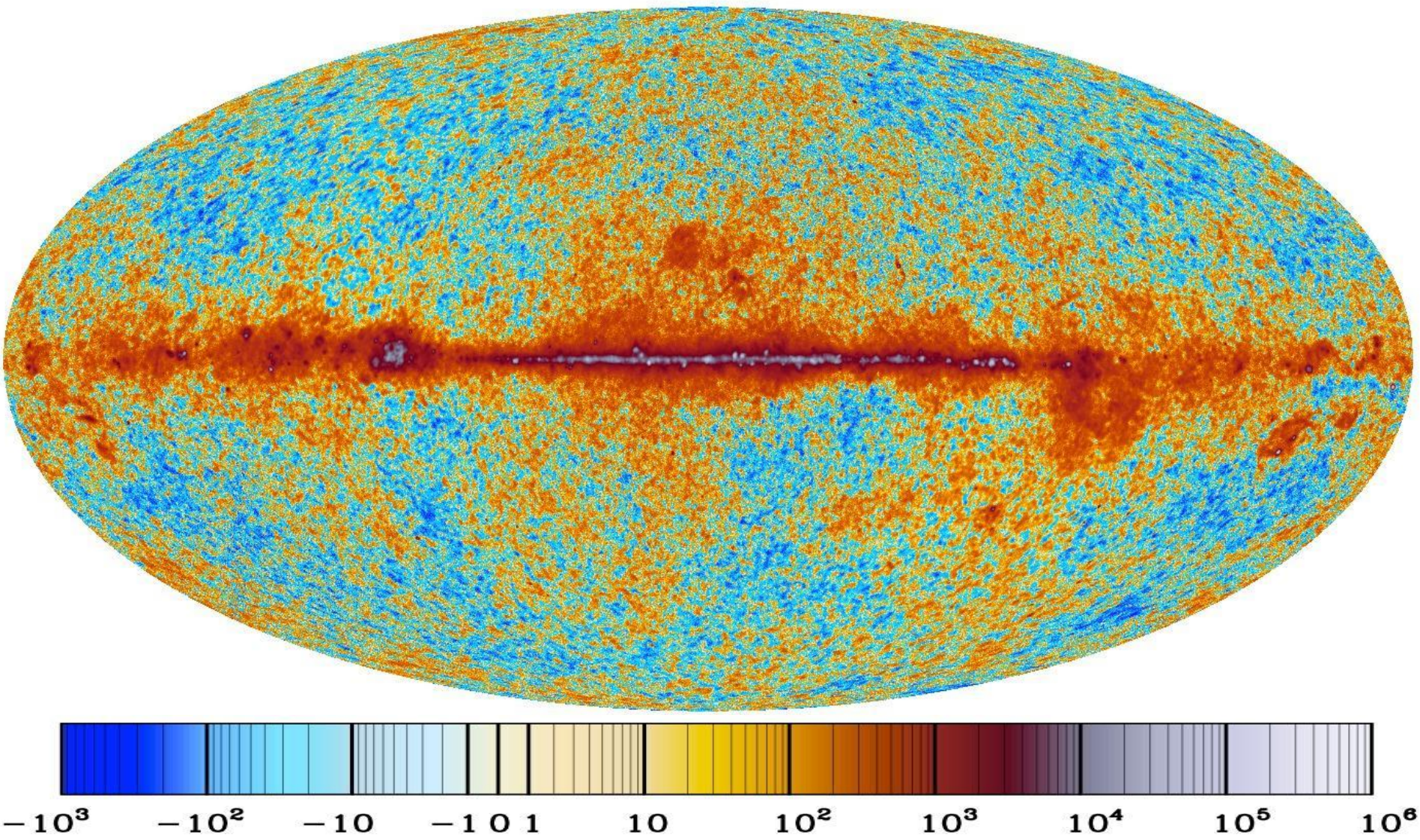
Consistency topics of current interest (to me)

- Some map domain comparisons
- Sample null maps
- Half ring/survey difference power spectra
- An angular power spectrum comparison around the first acoustic peak
- A comparison with WMAP (including the infamous 2.5% ™ discrepancy in power!)
- Consistency of the GRASP model of the Planck sidelobes.
- Some comments about WMAP sidelobes.

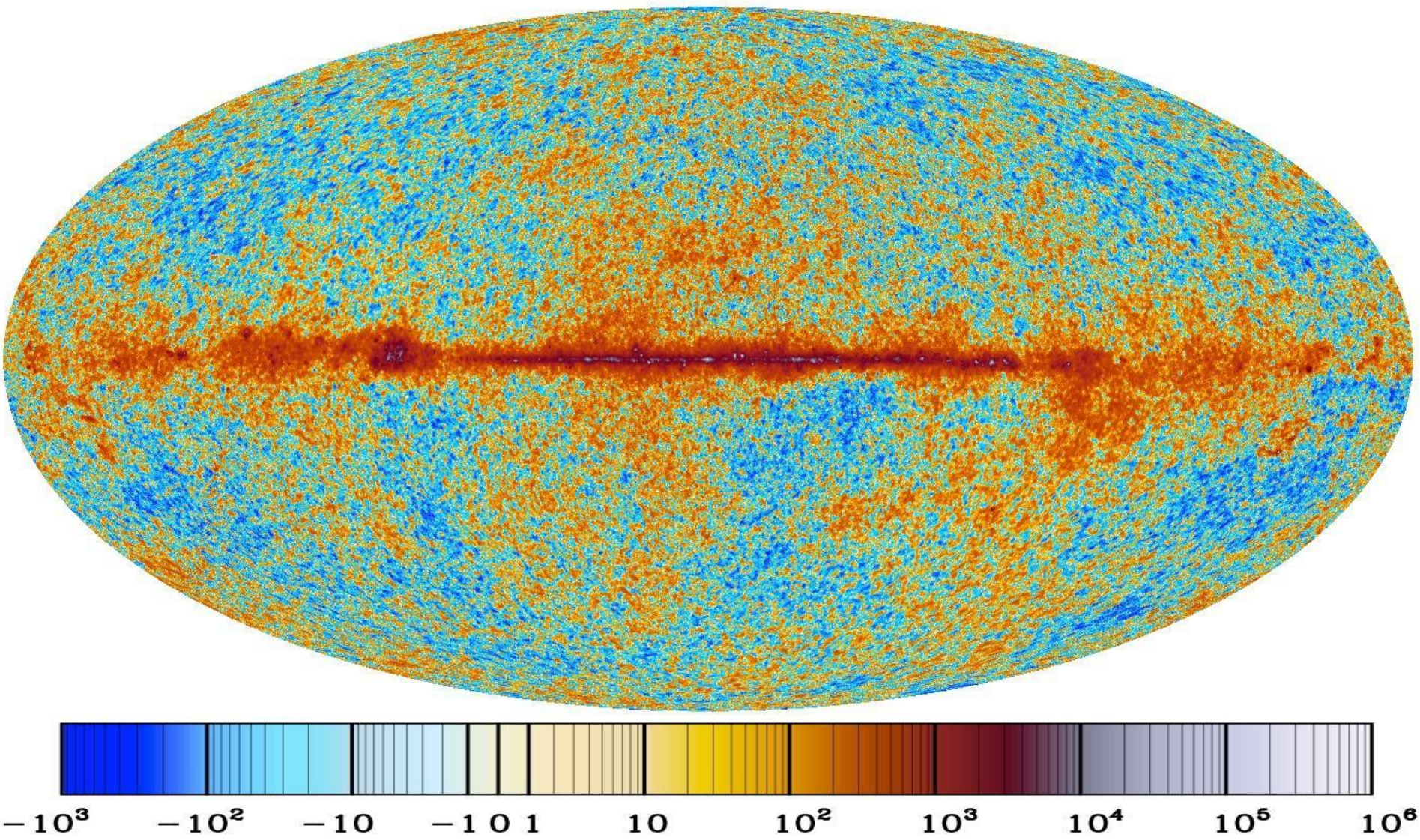
30 GHz


-10^3 -10^2 -10 -1 0 1 10 10^2 10^3 10^4 10^5 10^6
30−353 GHz: δT [μK_{CMB}]; 545 and 857 GHz: surface brightness [kJy/sr]

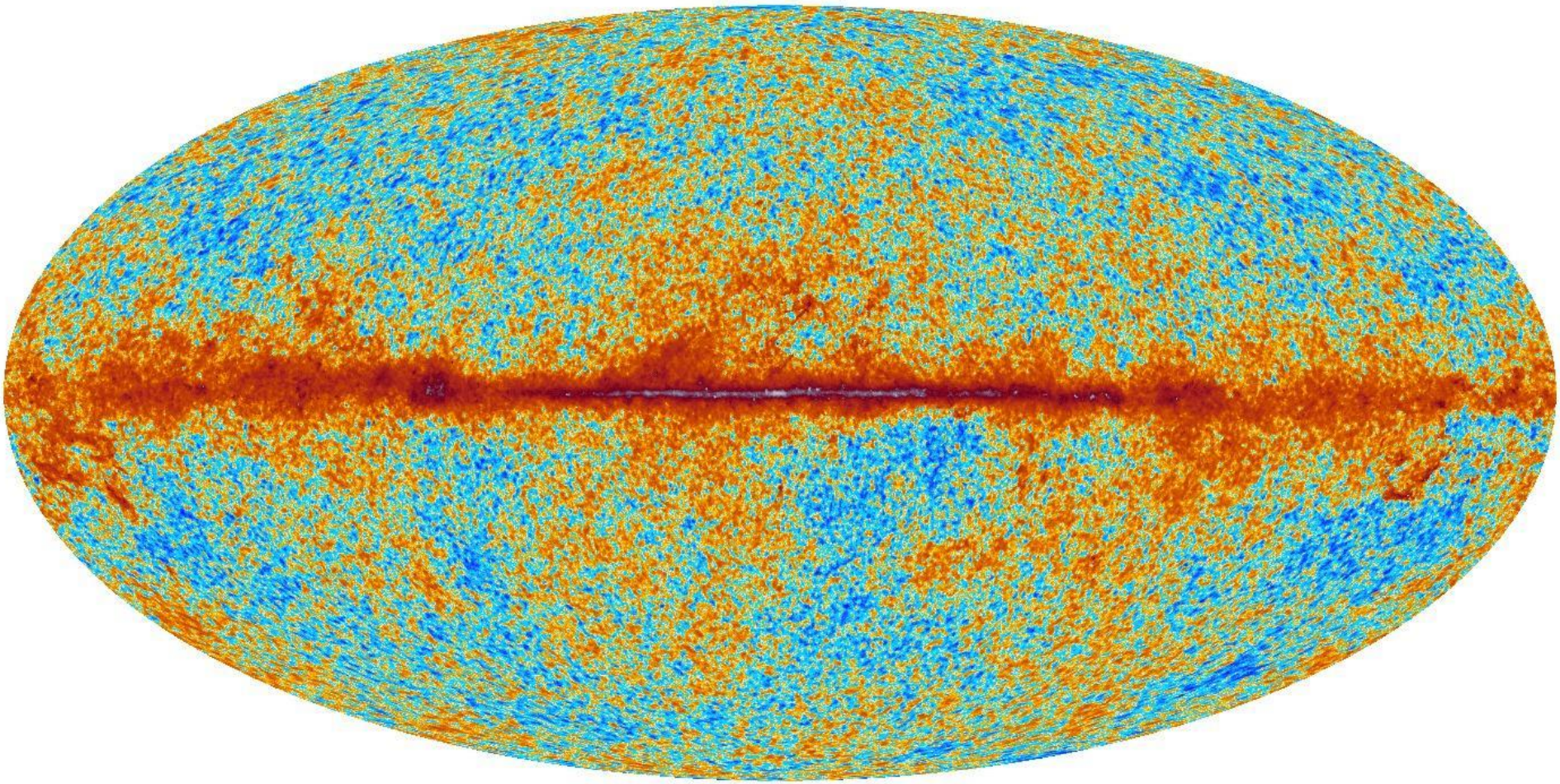
44 GHz


−10³ −10² −10 −1 0 1 10 10² 10³ 10⁴ 10⁵ 10⁶
30−353 GHz: δT [μK_CMB]; 545 and 857 GHz: surface brightness [kJy/sr]

70 GHz


-10^3 -10^2 -10 -1 0 1 10 10^2 10^3 10^4 10^5 10^6
30−353 GHz: δT [μK_{CMB}]; 545 and 857 GHz: surface brightness [kJy/sr]

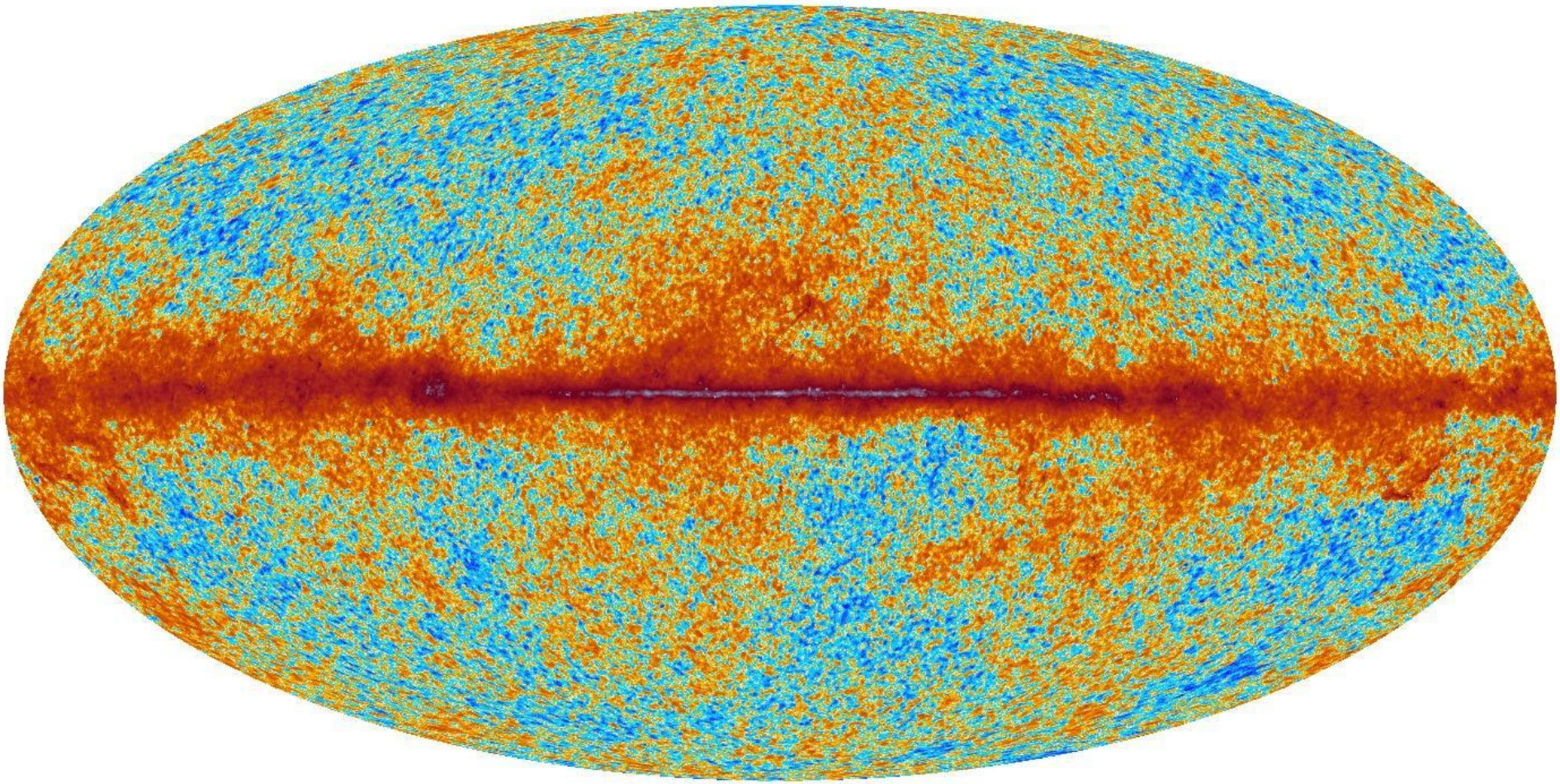
100 GHz



-10^3 -10^2 -10 -1 0 1 10 10^2 10^3 10^4 10^5 10^6

30−353 GHz: δT [μK_{CMB}]; 545 and 857 GHz: surface brightness [kJy/sr]

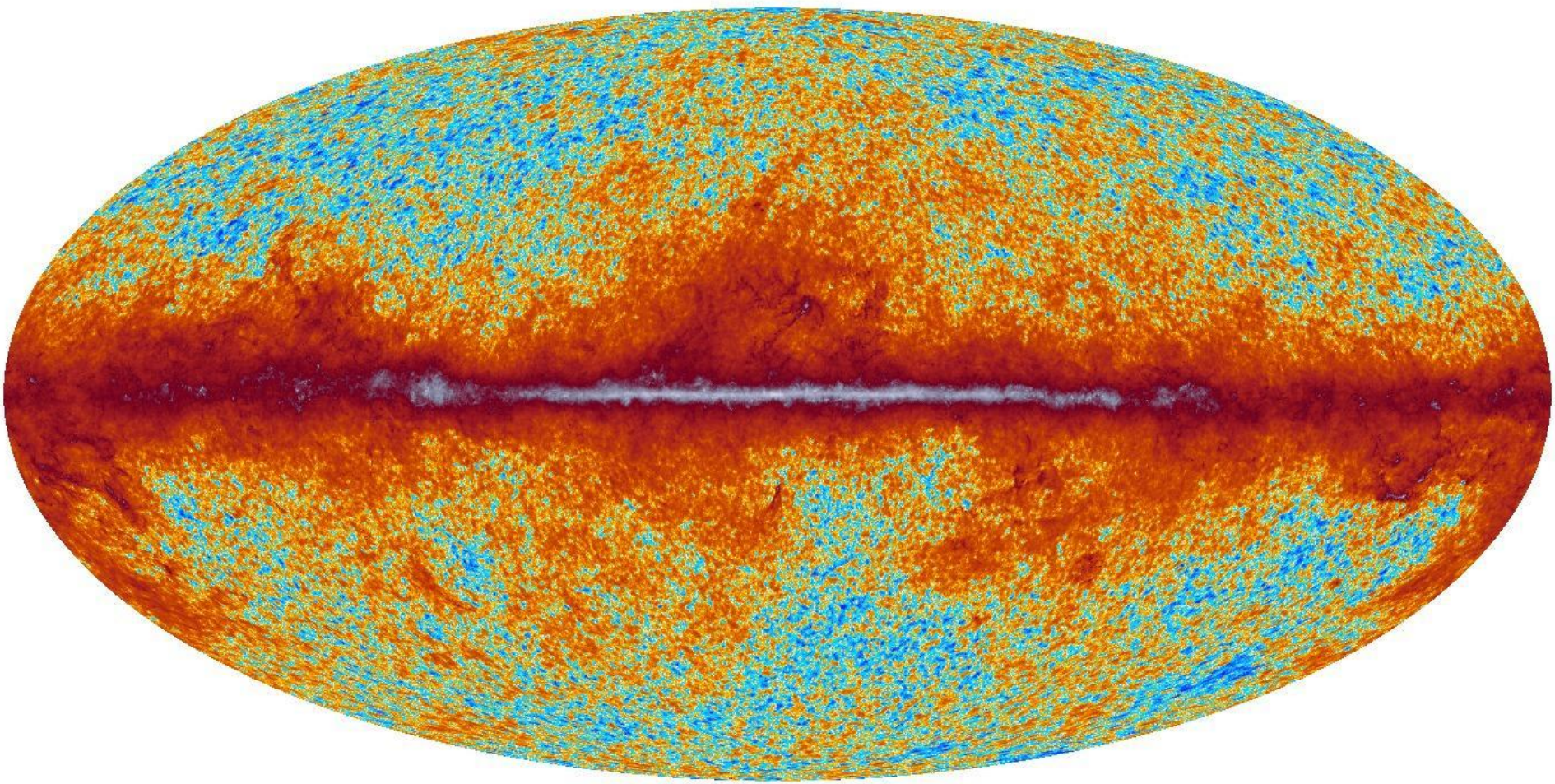
143 GHz



-10^3 -10^2 -10 -1 0 1 10 10^2 10^3 10^4 10^5 10^6

30−353 GHz: δT [μK_{CMB}]; 545 and 857 GHz: surface brightness [kJy/sr]

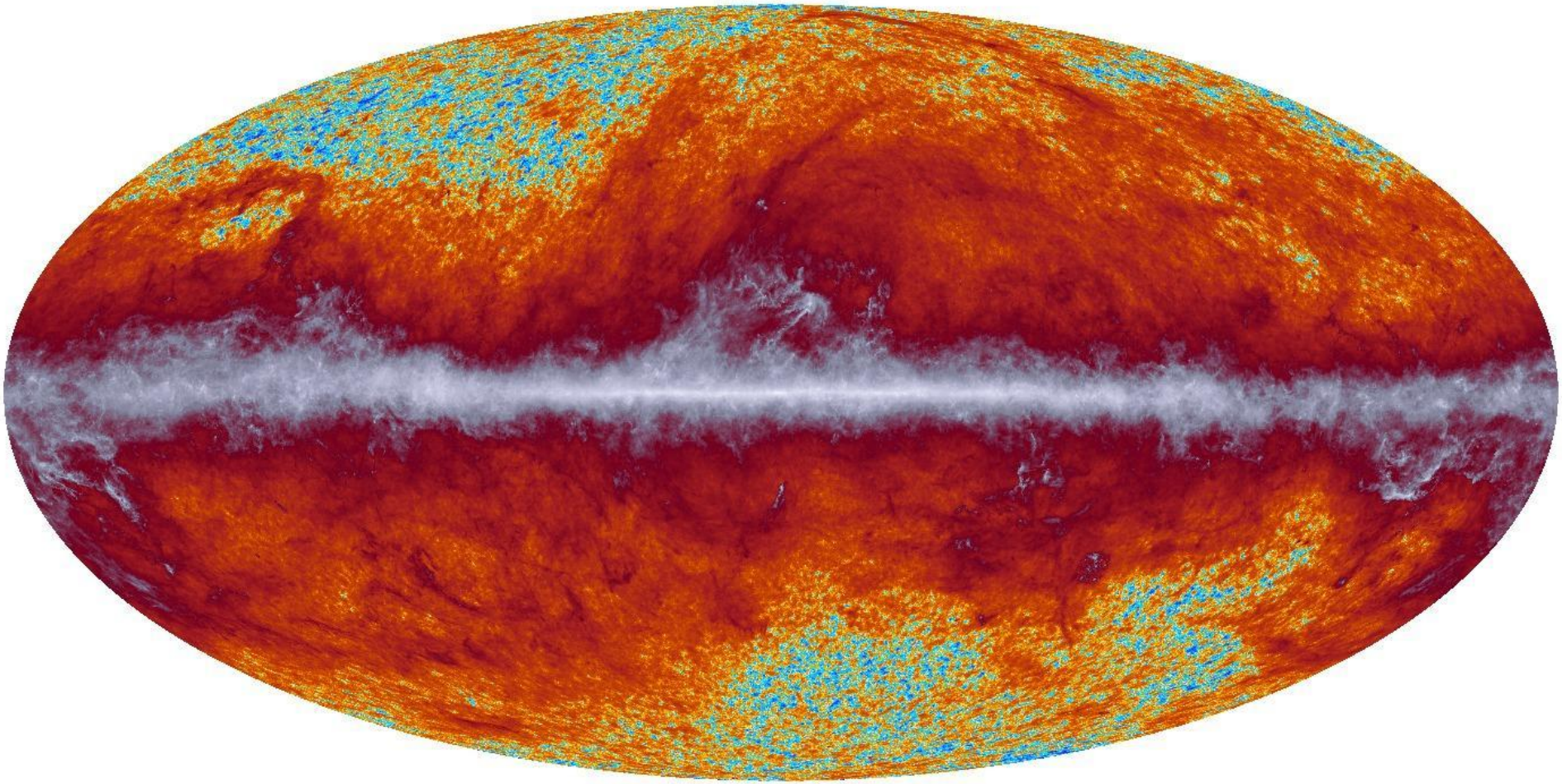
217 GHz



-10^3 -10^2 -10 -1 0 1 10 10^2 10^3 10^4 10^5 10^6

30−353 GHz: δT [μK_{CMB}]; 545 and 857 GHz: surface brightness [kJy/sr]

353 GHz

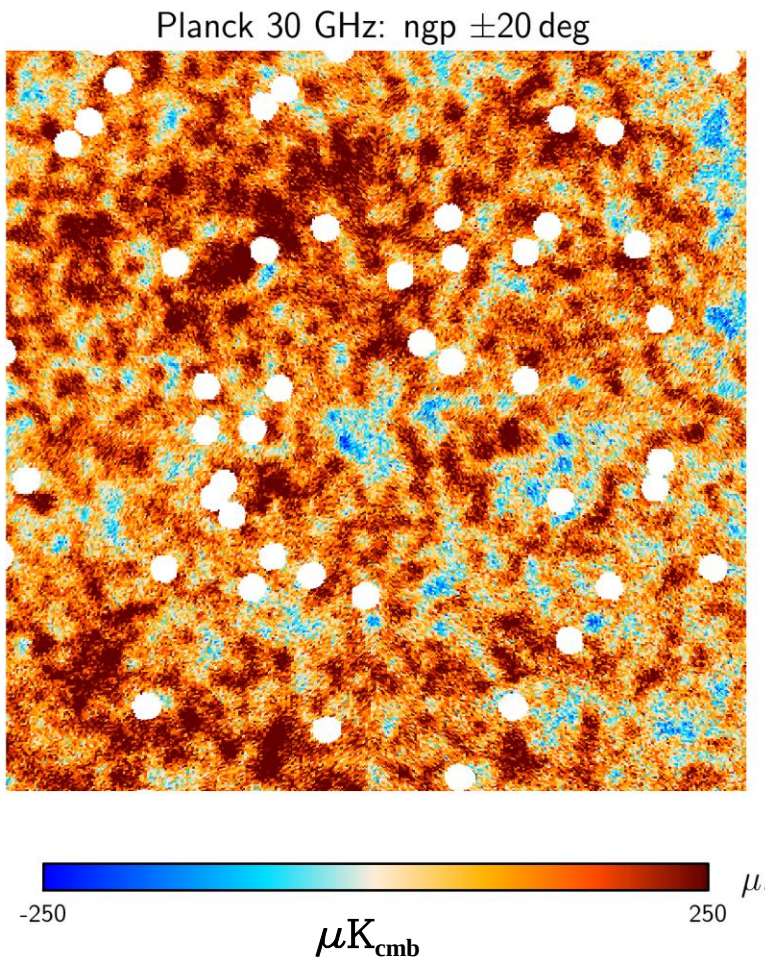


-10^3 -10^2 -10 -1 0 1 10 10^2 10^3 10^4 10^5 10^6

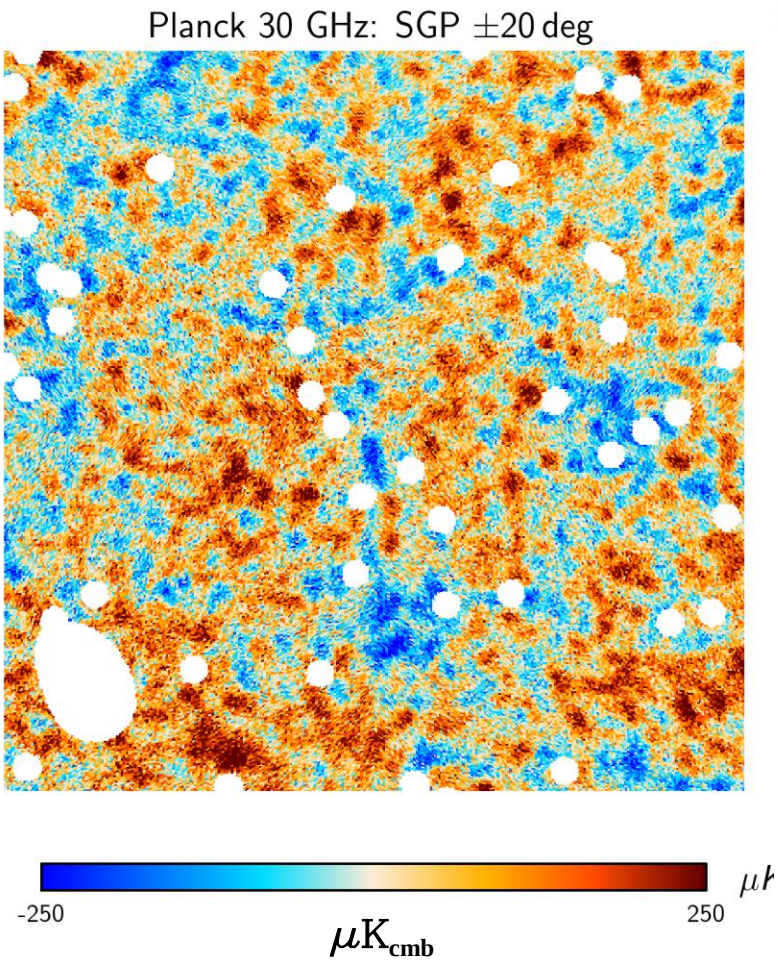
30−353 GHz: δT [μK_{CMB}]; 545 and 857 GHz: surface brightness [kJy/sr]

30 GHz
Galactic Poles

(North)

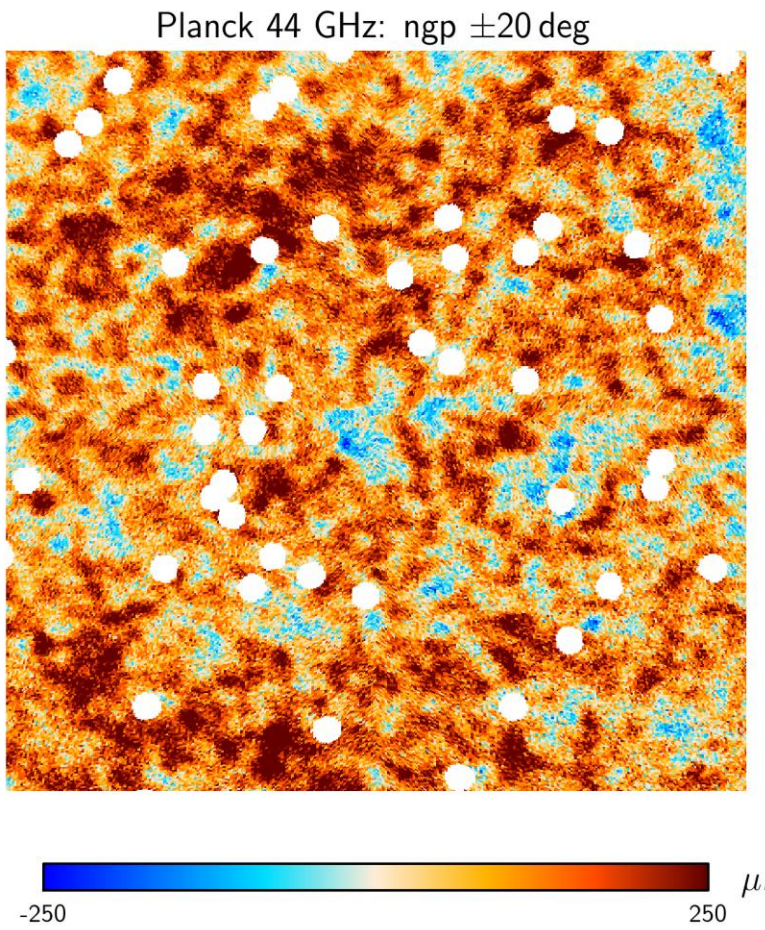


(South)

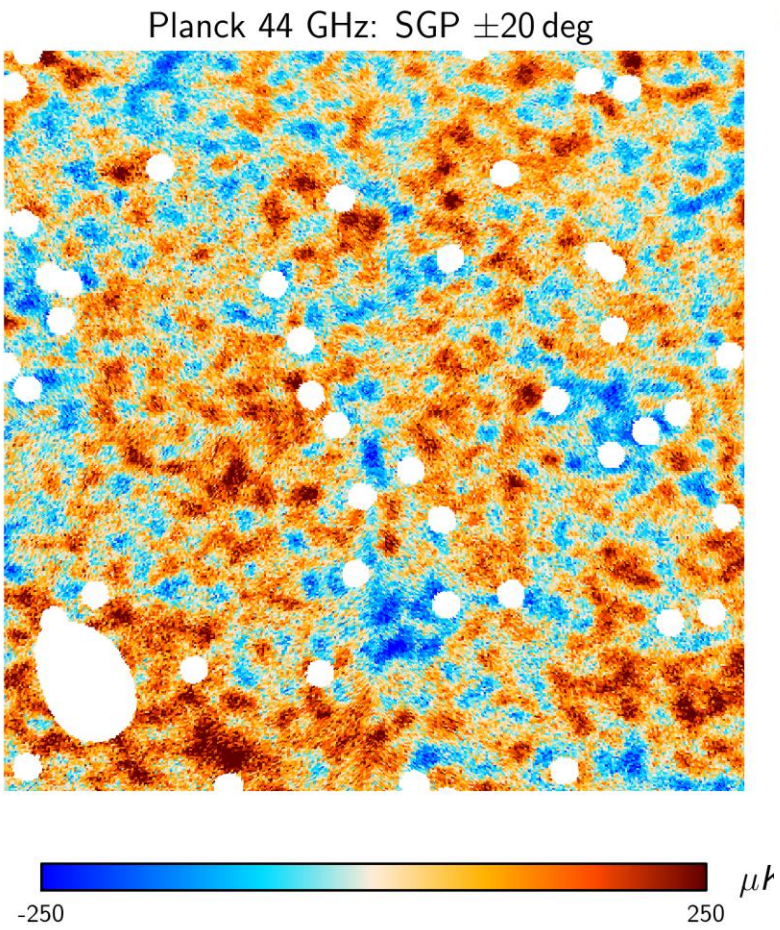


44 GHz
Galactic Poles

(North)

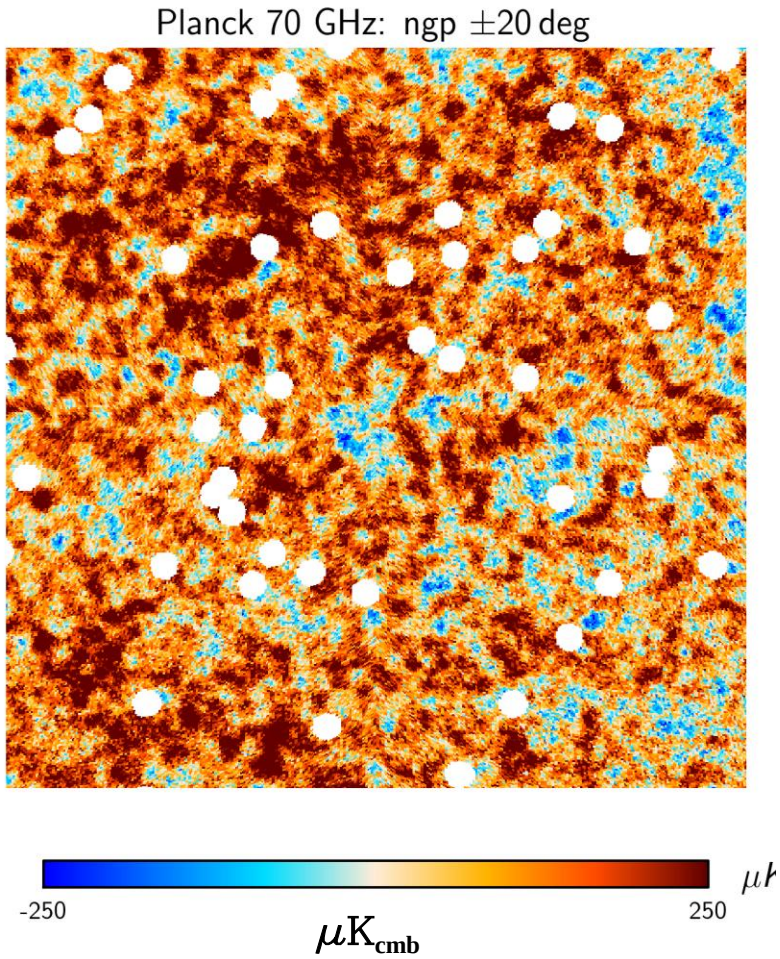


(South)

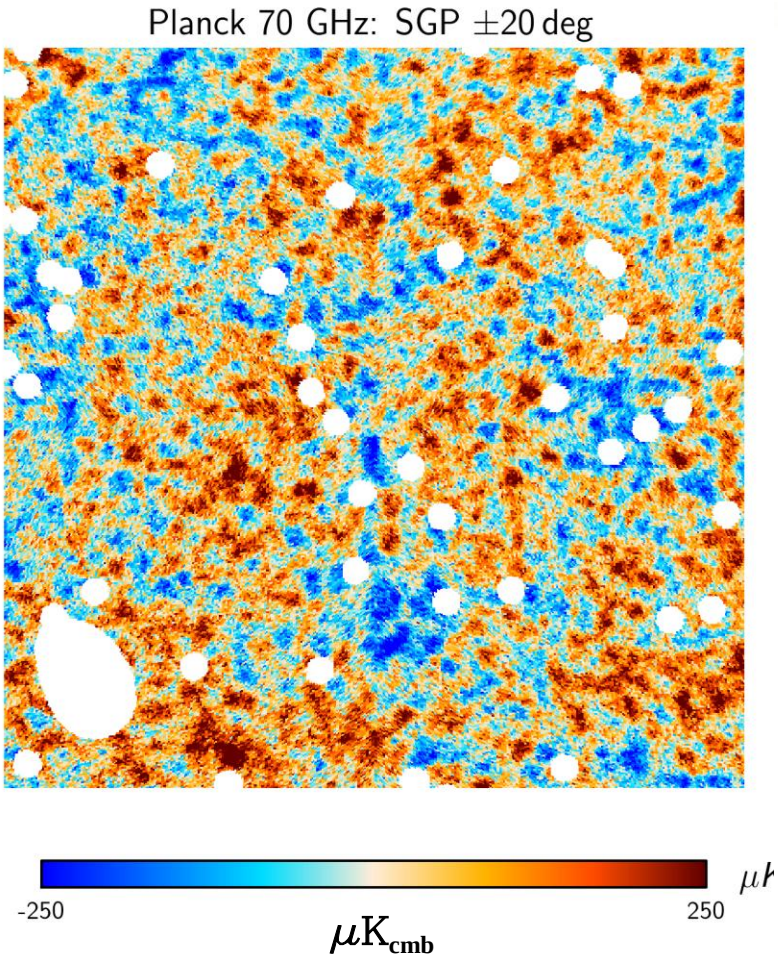


70 GHz
Galactic Poles

(North)

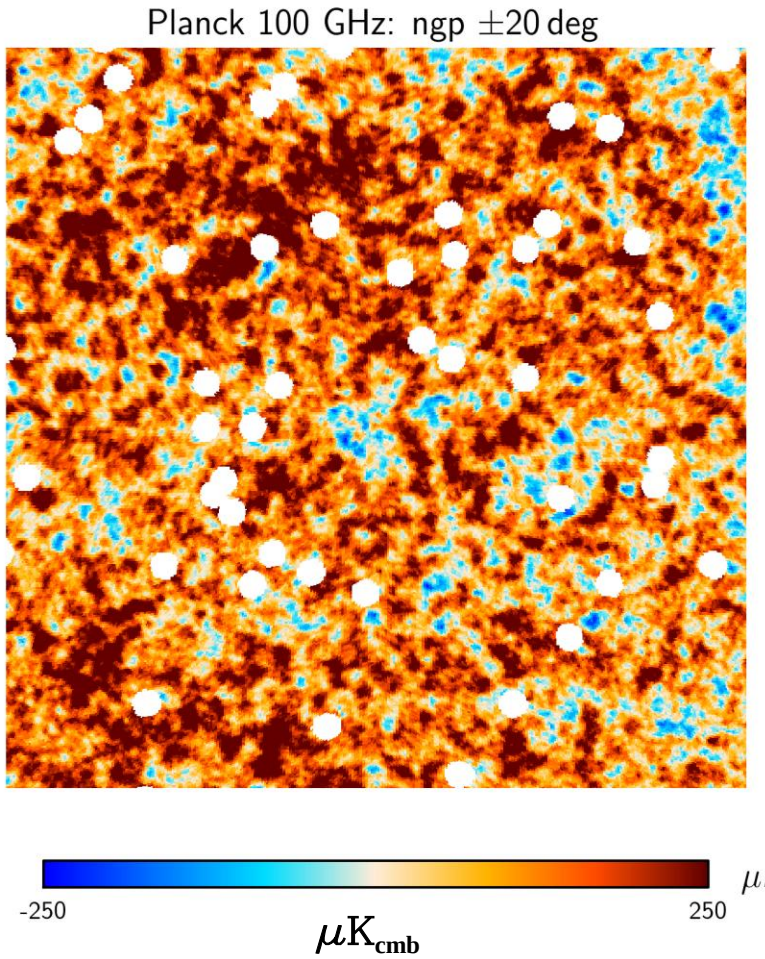


(South)

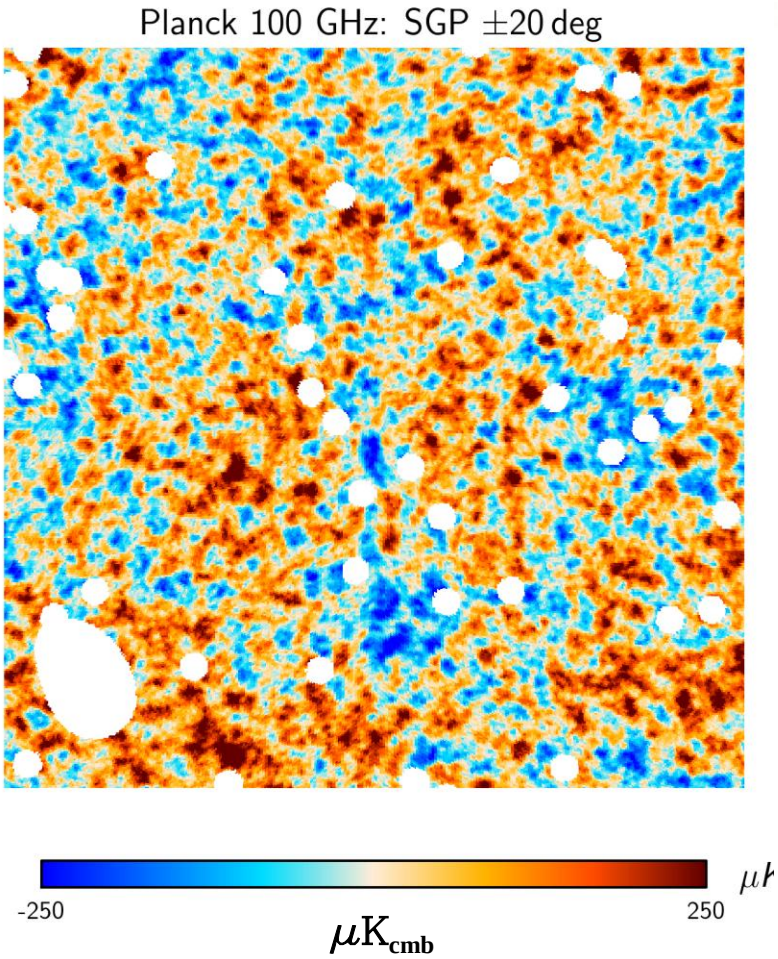


100 GHz
Galactic Poles

(North)

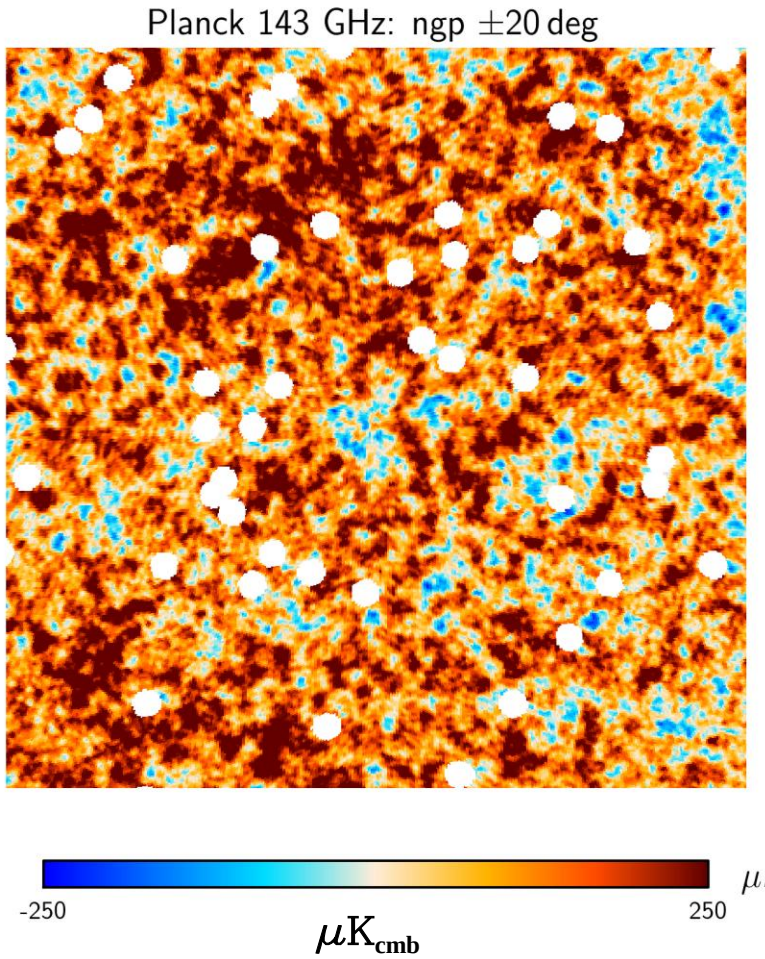


(South)

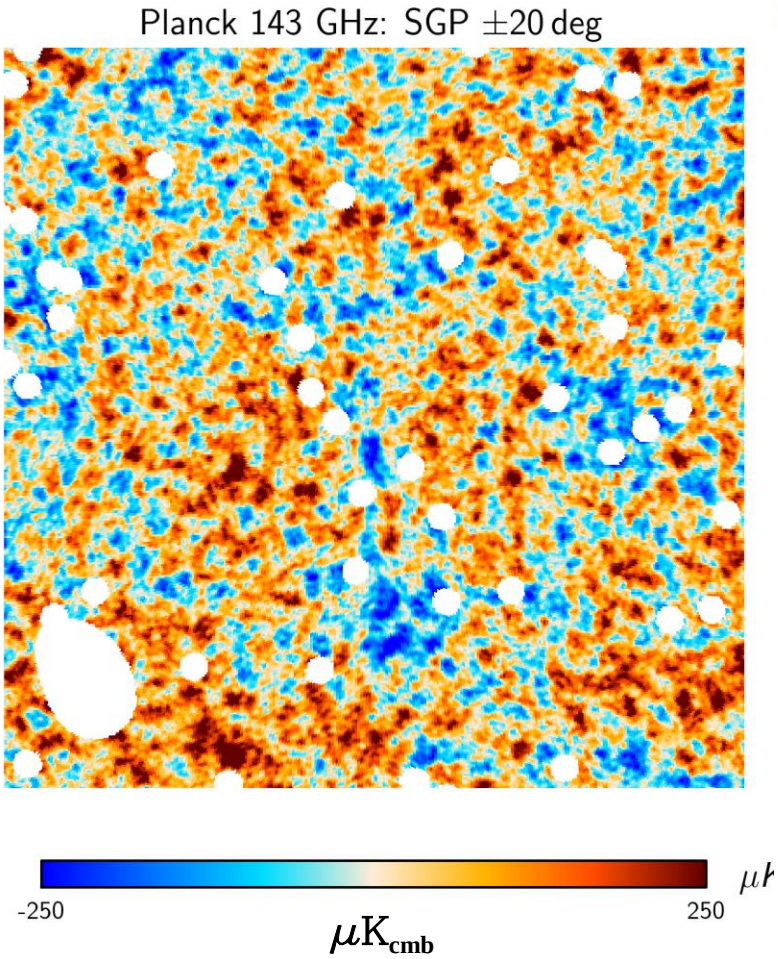


143 GHz
Galactic Poles

(North)

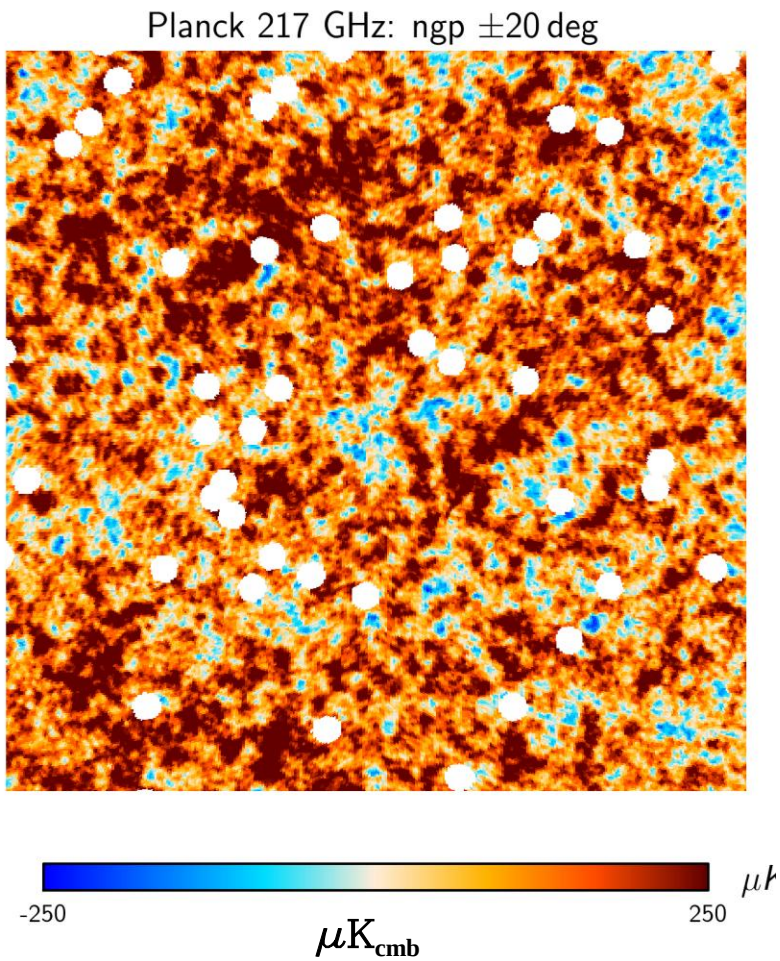


(South)

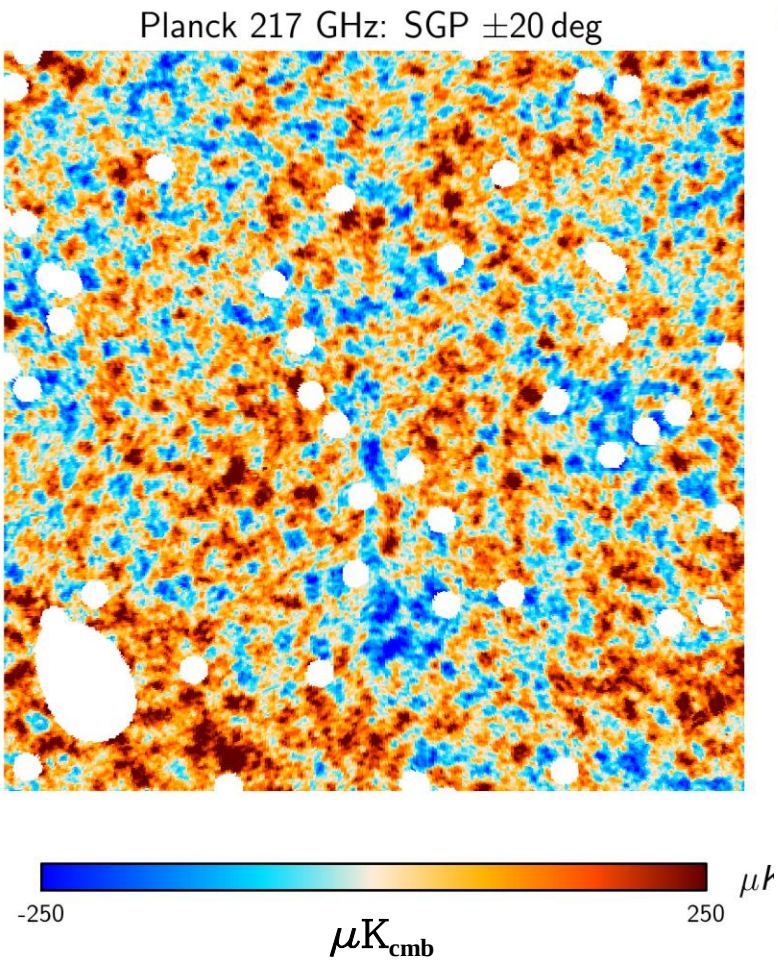


217 GHz
Galactic Poles

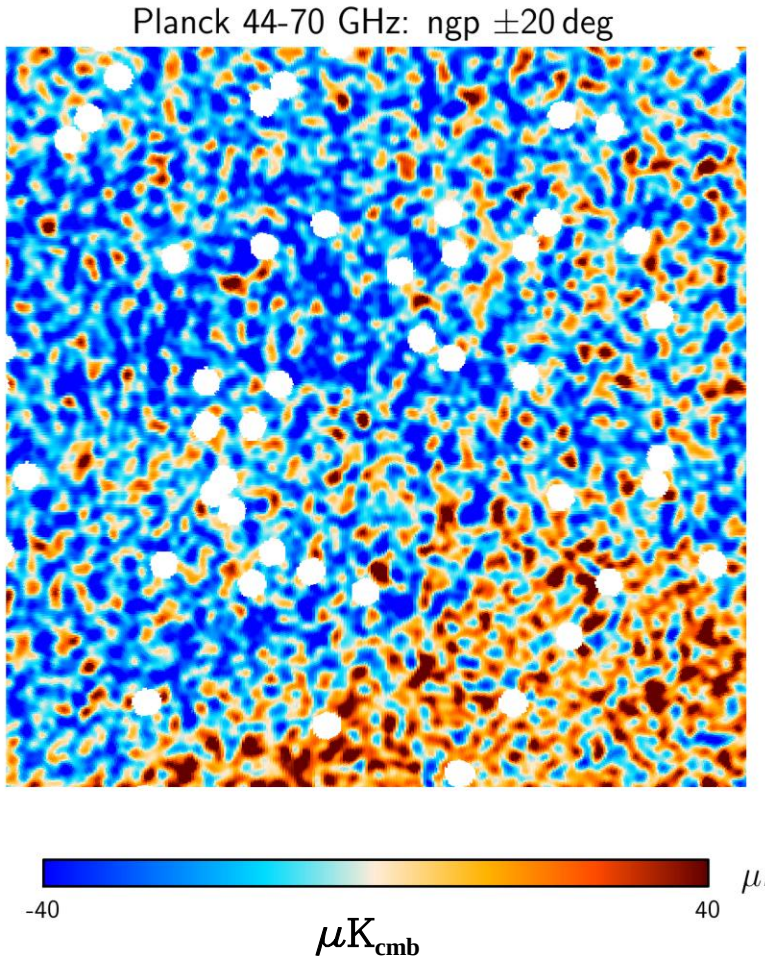
(North)

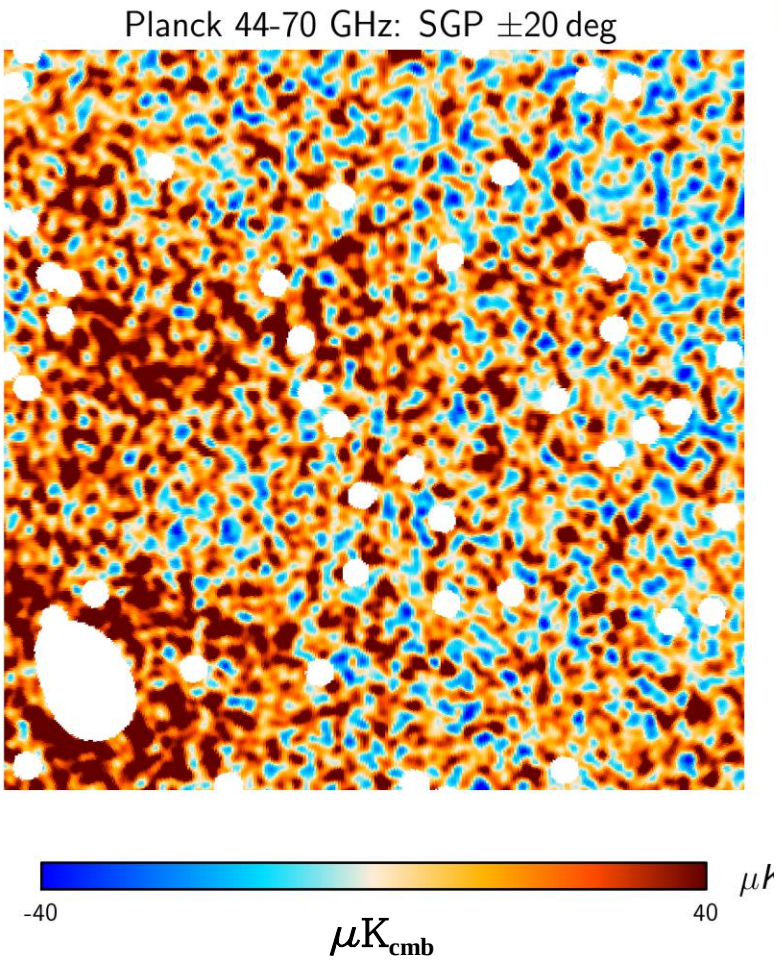


(South)



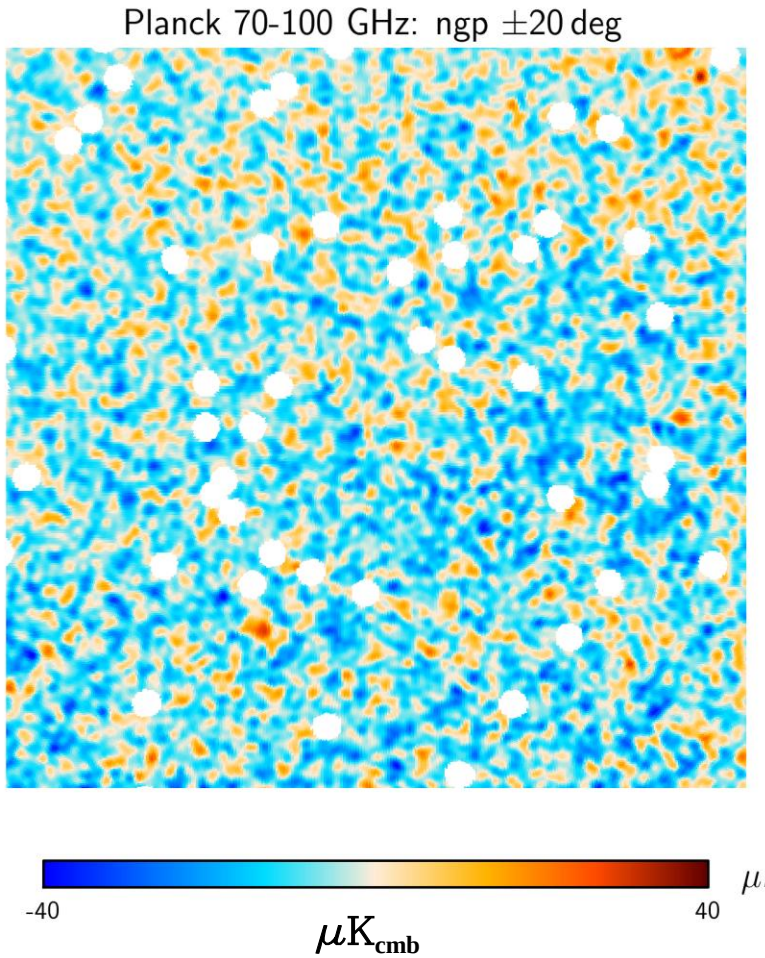
Selected differences, smoothed 0.5 degrees FWHM
44 GHz -70 GHz



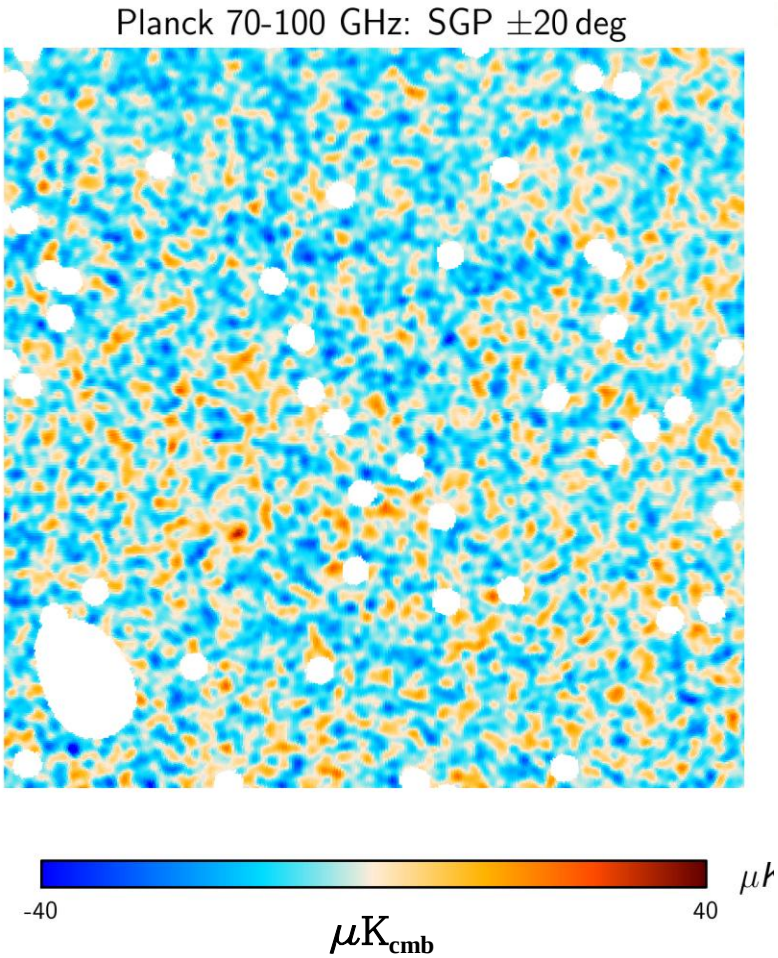


70 GHz-100GHz

(North)

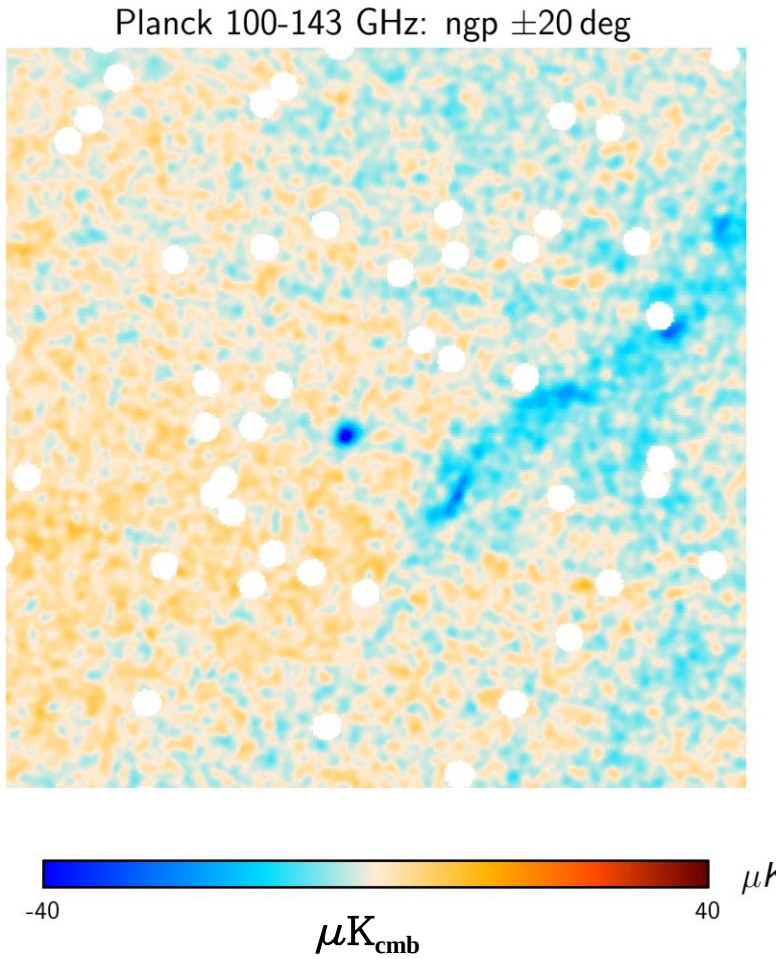


(South)

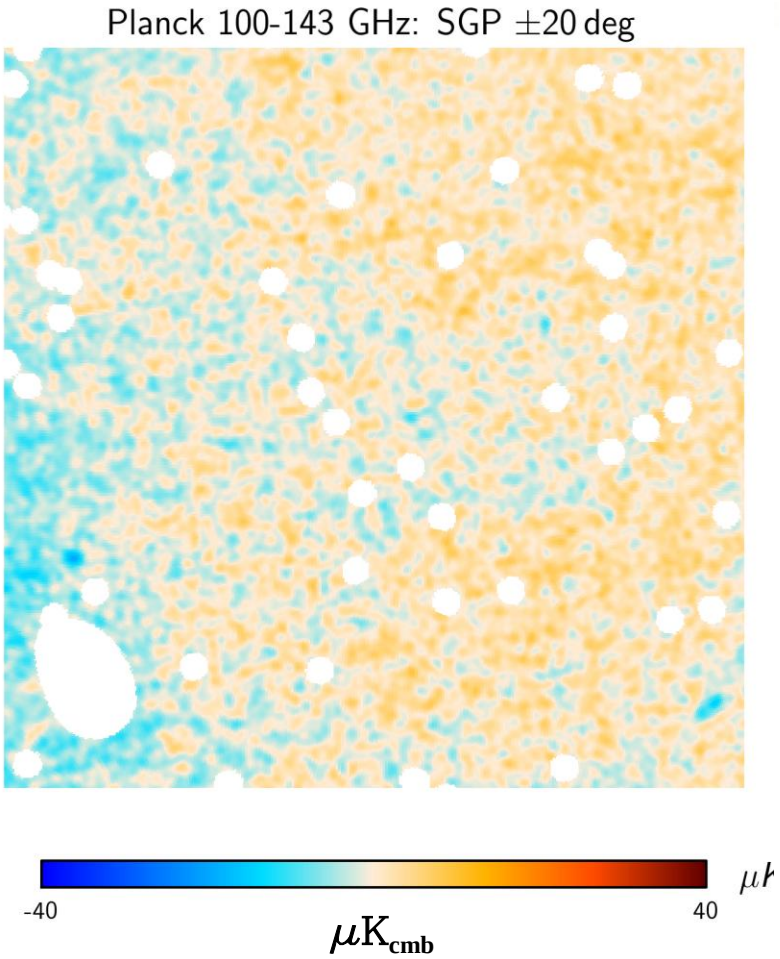


100 GHz -143 GHz

(North)

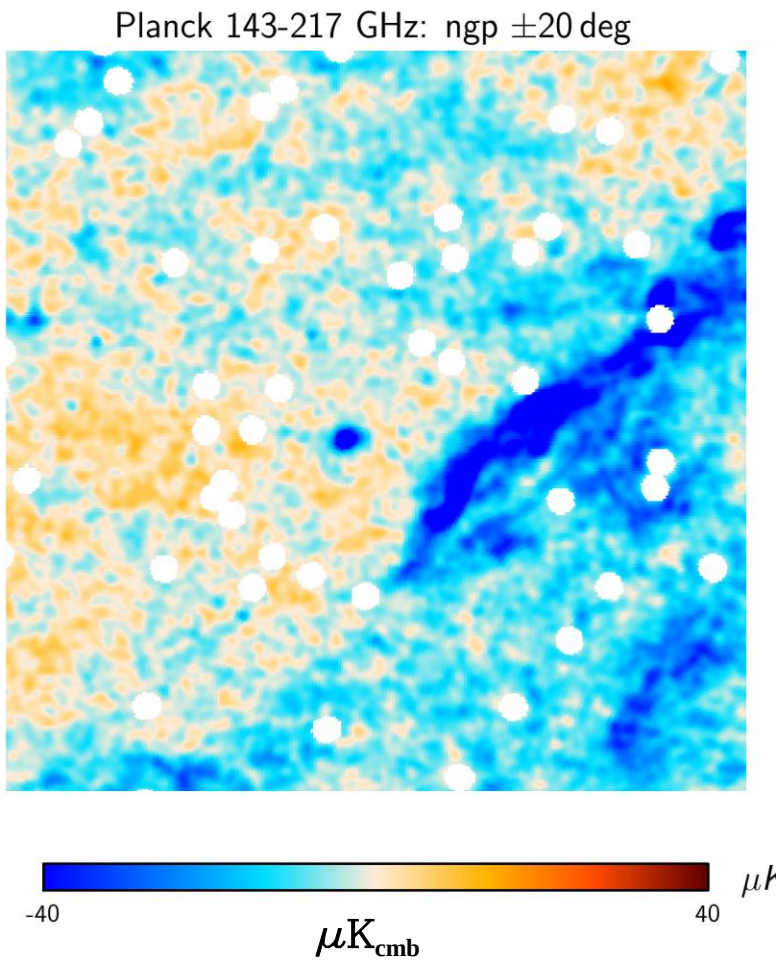


(South)

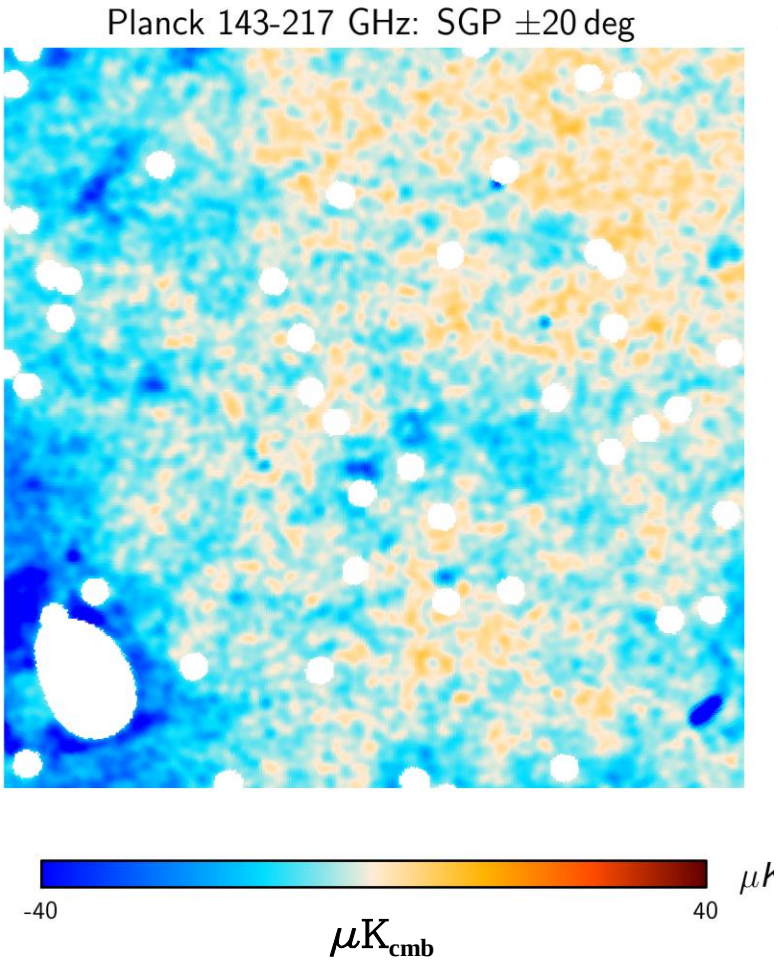


143 GHz – 217 GHz

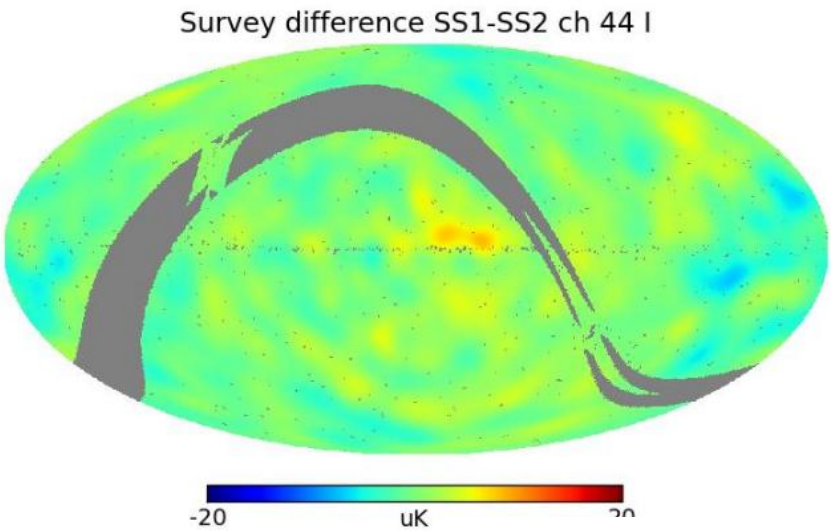
(North)

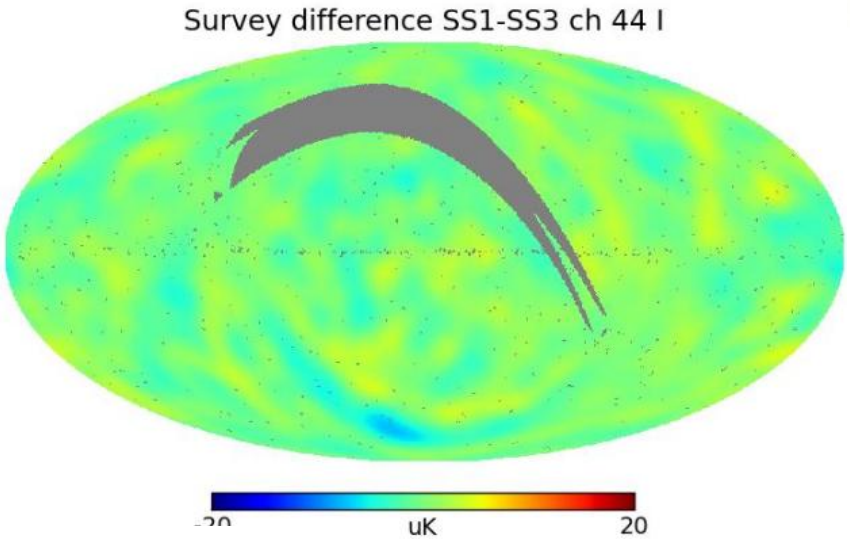


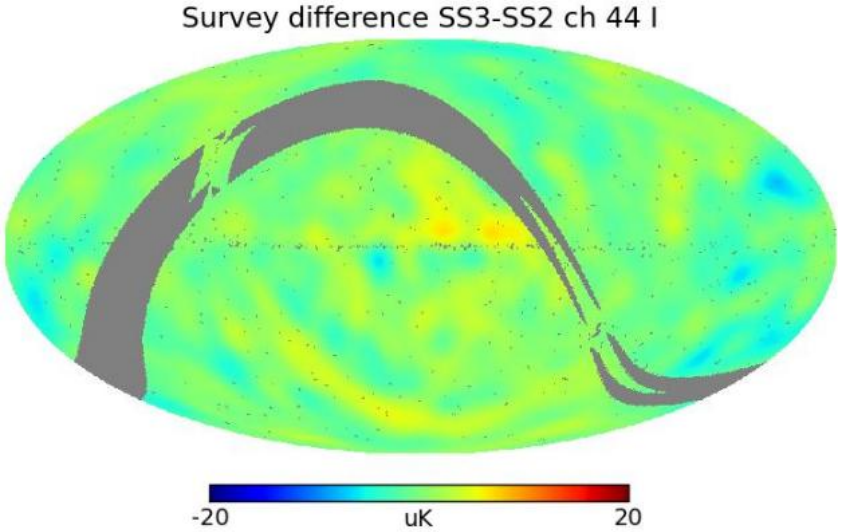
(South)



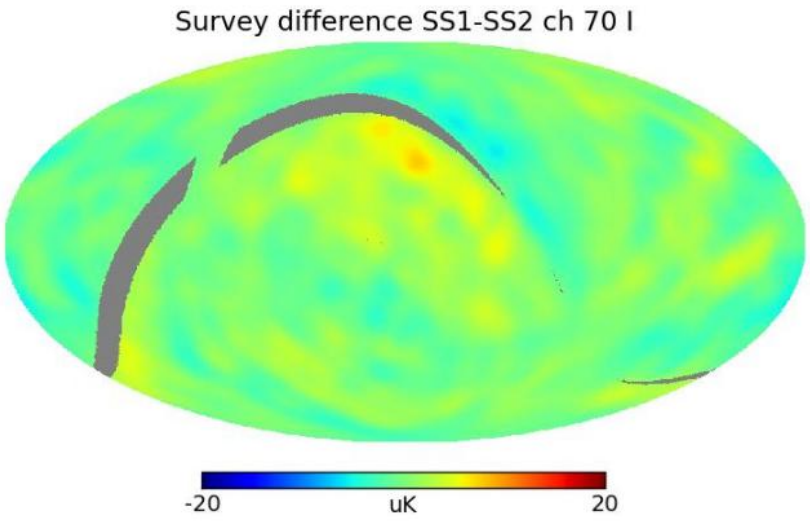
Survey differences, 44 GHz (smooth 10 degrees)

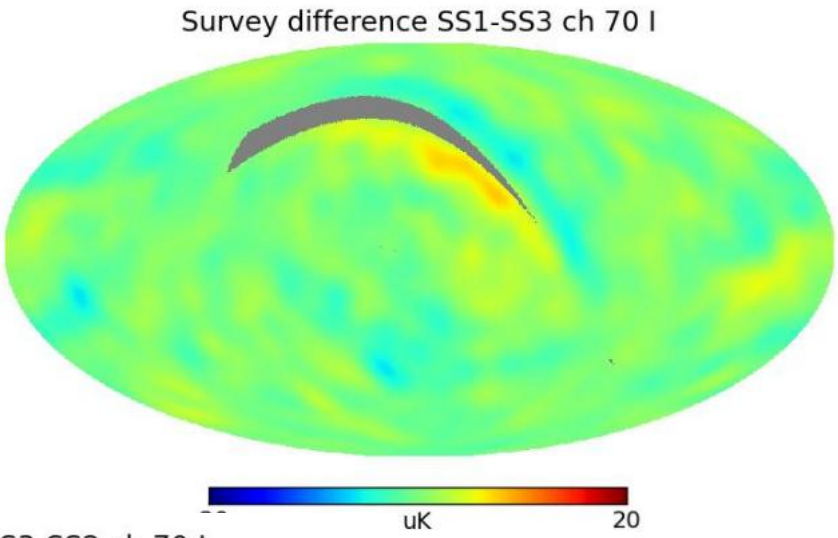


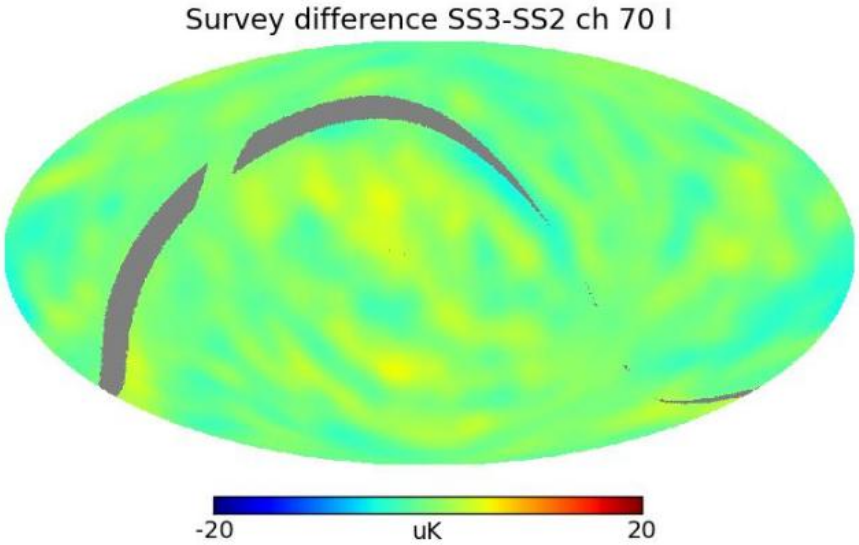




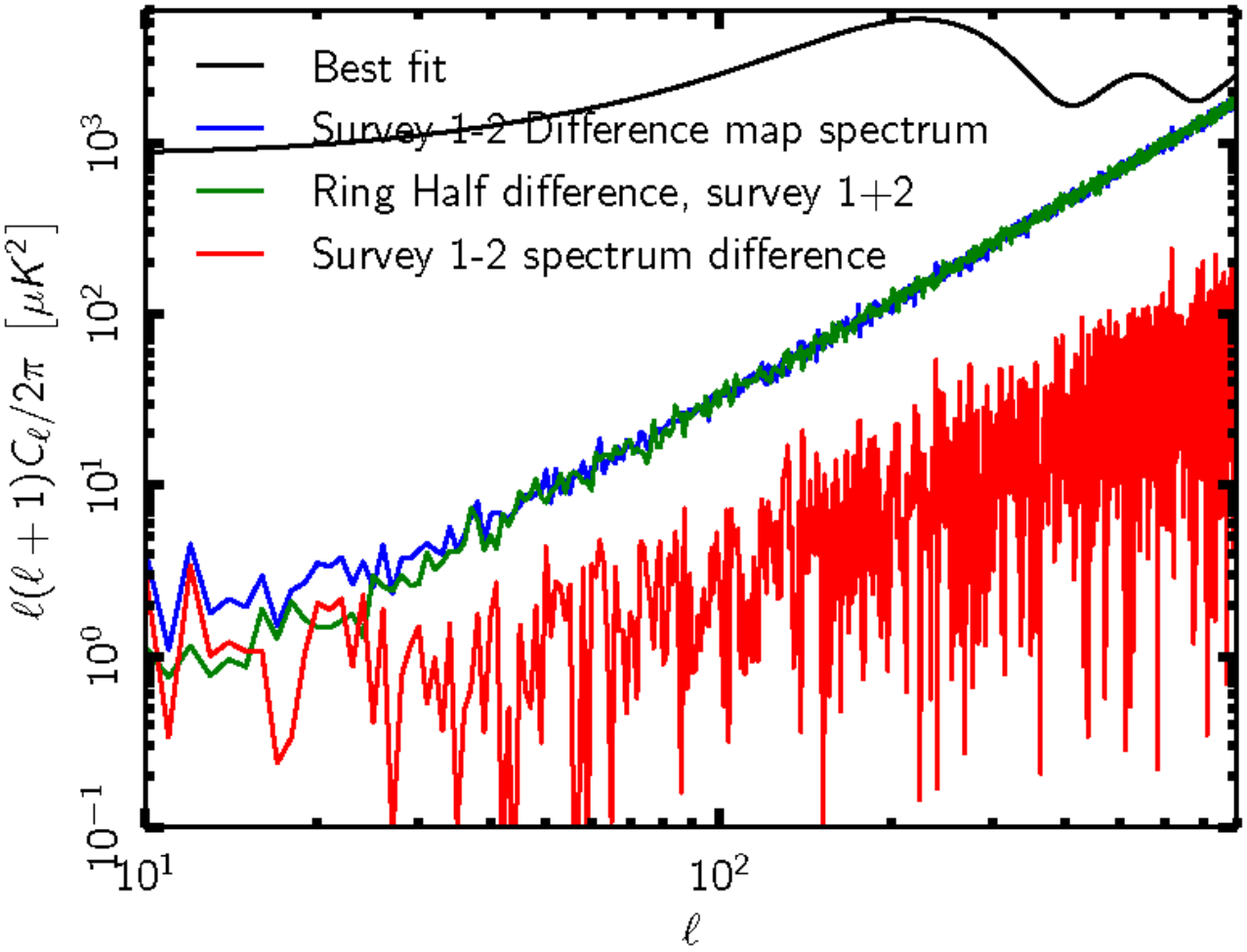
Survey differences, 70 GHz (smooth 10 degrees)



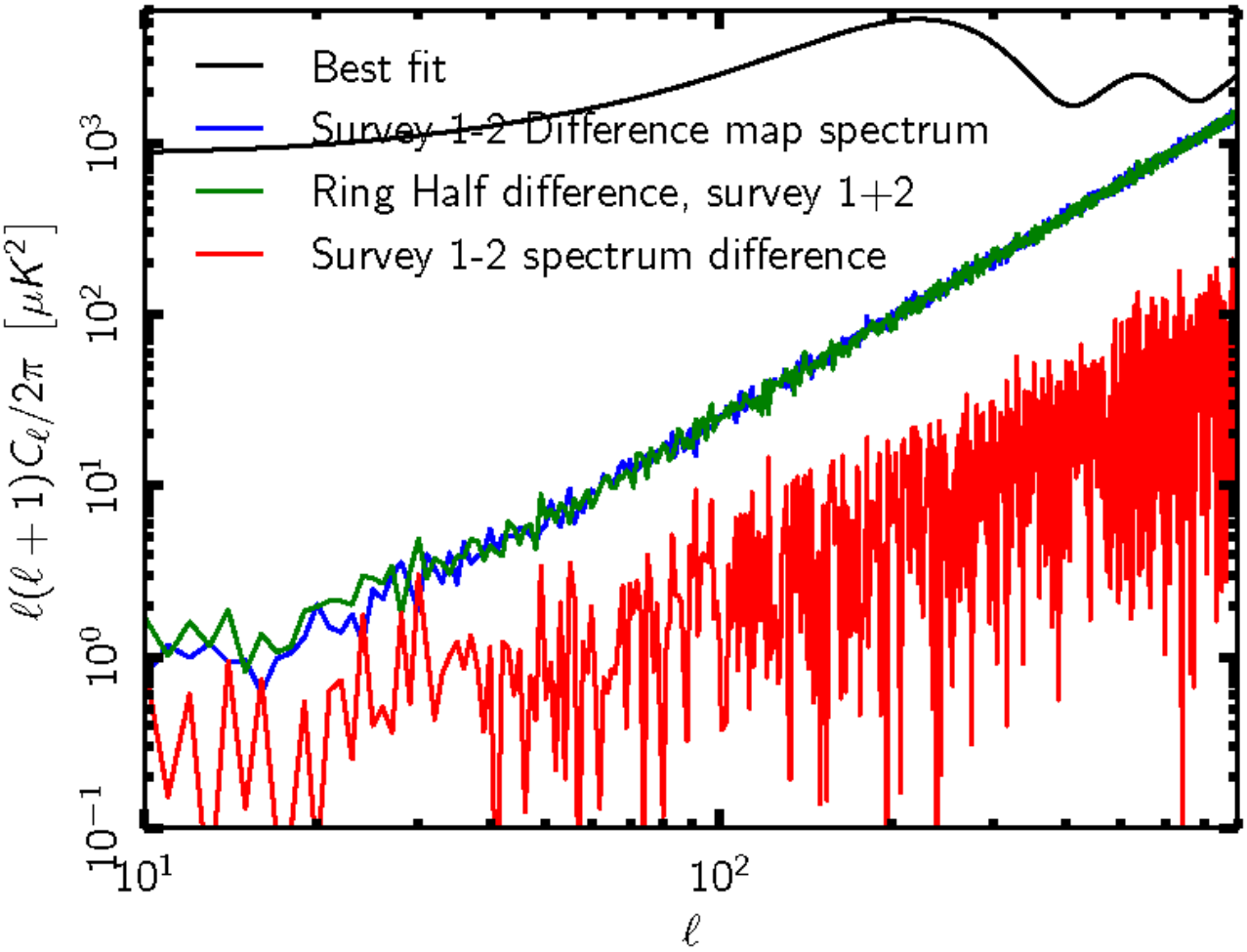


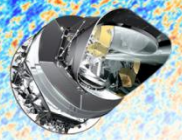


44 GHz


Best fit
Survey 1-2 Difference map spectrum
Ring Half difference, survey 1+2
Survey 1-2 spectrum difference
$\ell(\ell+1)C_\ell/2\pi\ [\mu K^2]$
10^{-1}
10^0
10^1
10^2
10^3
10^1
10^2
ℓ

Spectra From null tests (70 GHz)

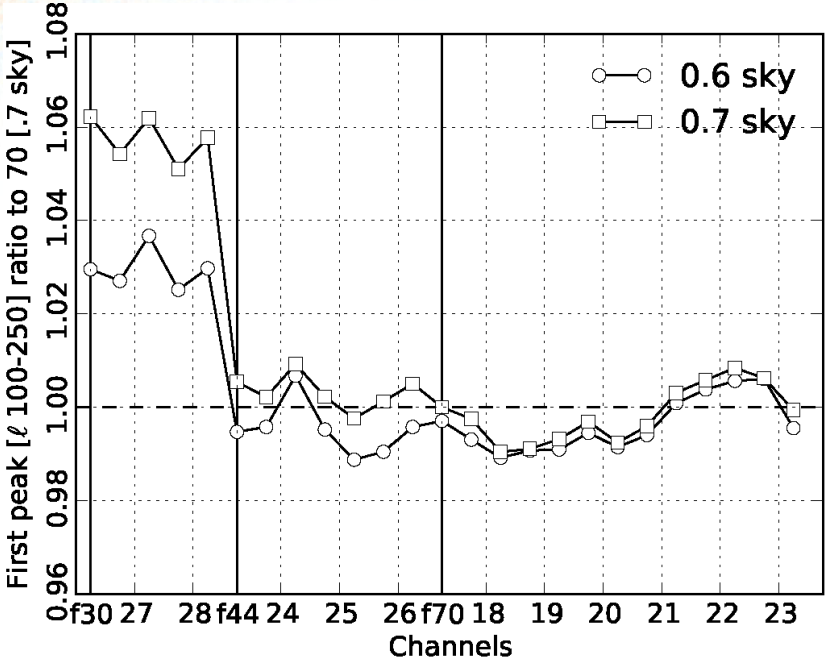


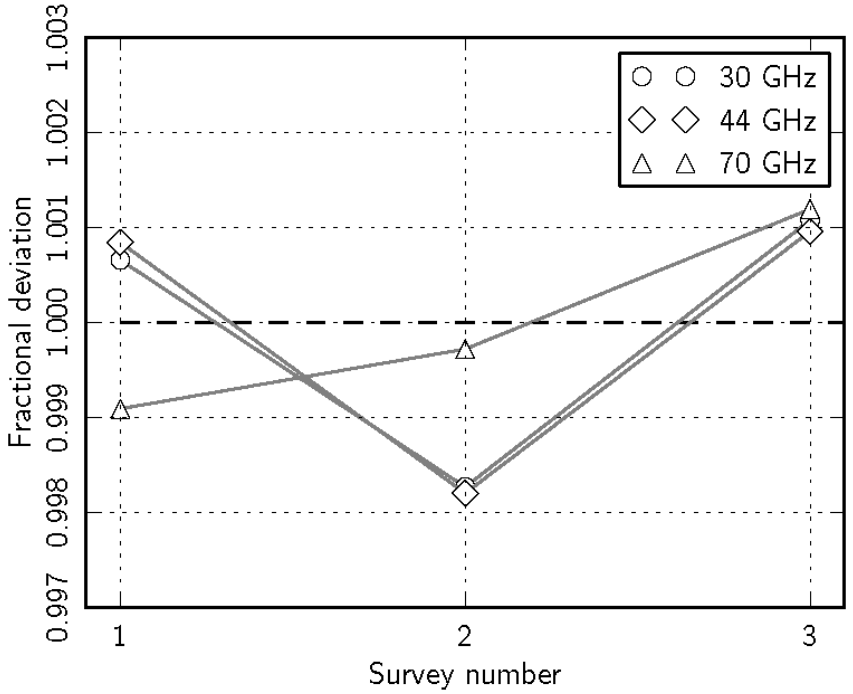


Angular power spectrum comparisons near the first acoustic peak

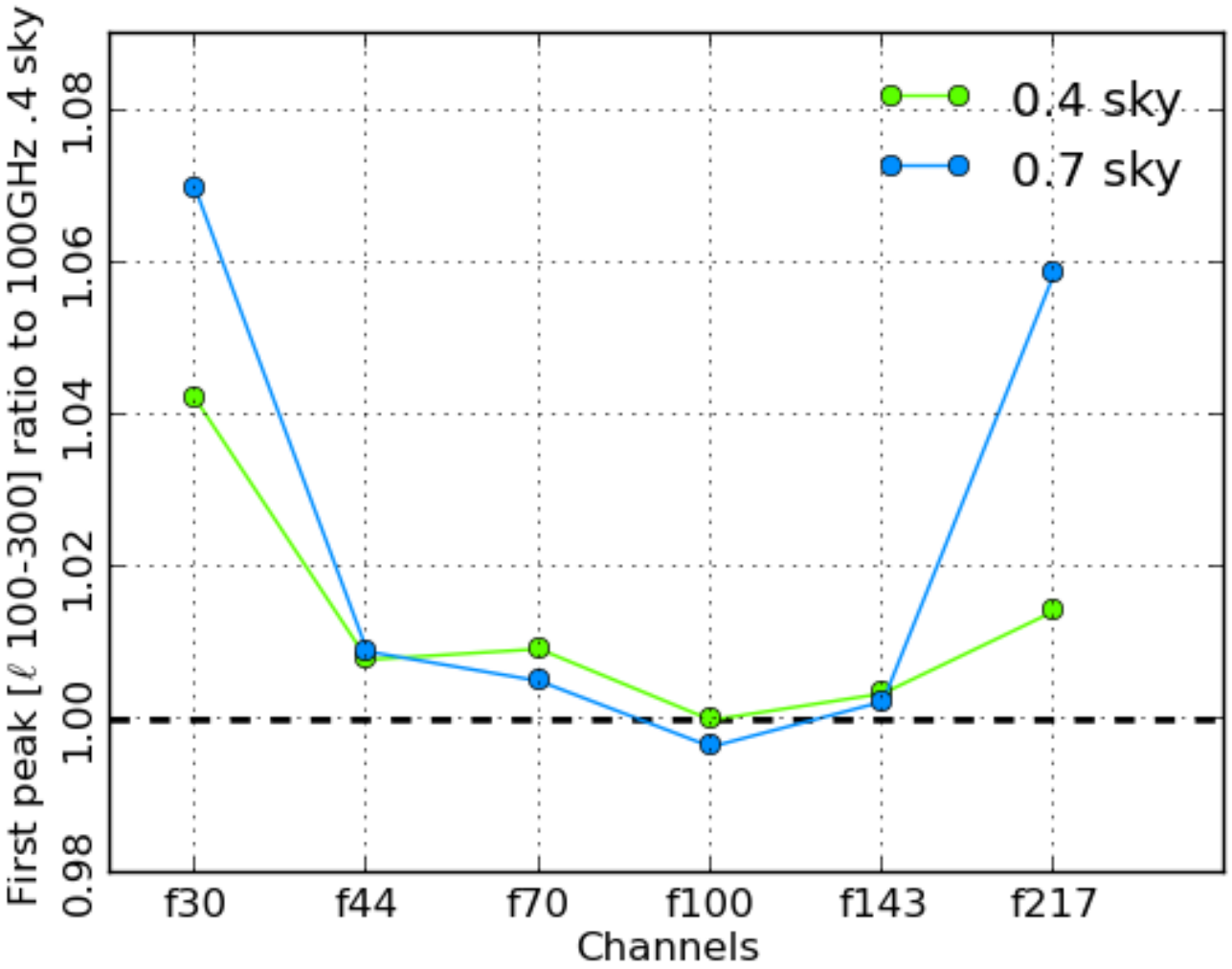
- Compute cross spectra from halfrings
  - mask with union point source mask (LFI and HFI) + WMAP KQ85 + component separation .4 and .7 sky fraction
  - Remove monopole
  - Deconvolve mask
- Correct for beams
  - Divide by the FEBECOP window function
    - W_ls provided full sky
    - Or: W_ls computed by masking FEBECOP maps with the mask
  - Correct for the pixel window function
- Relative peak height
  - Divide by 100 GHz spectrum
  - Take the mean $100 < \ell < 300$

LFI internal results (relative calibration validation)



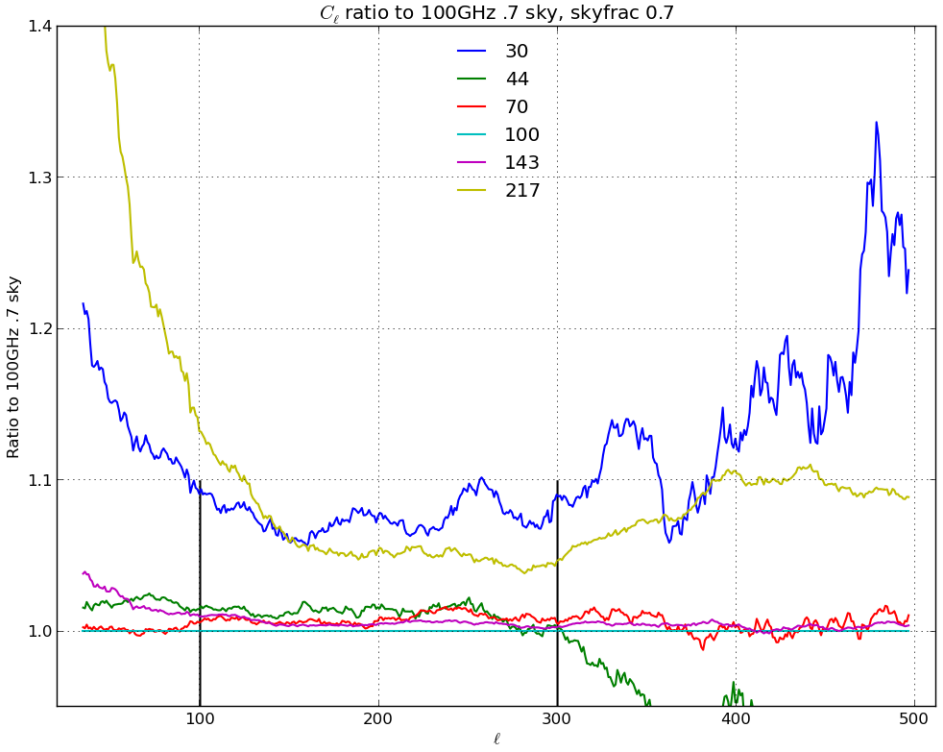


Planck internal consistency: First Acoustic Peak

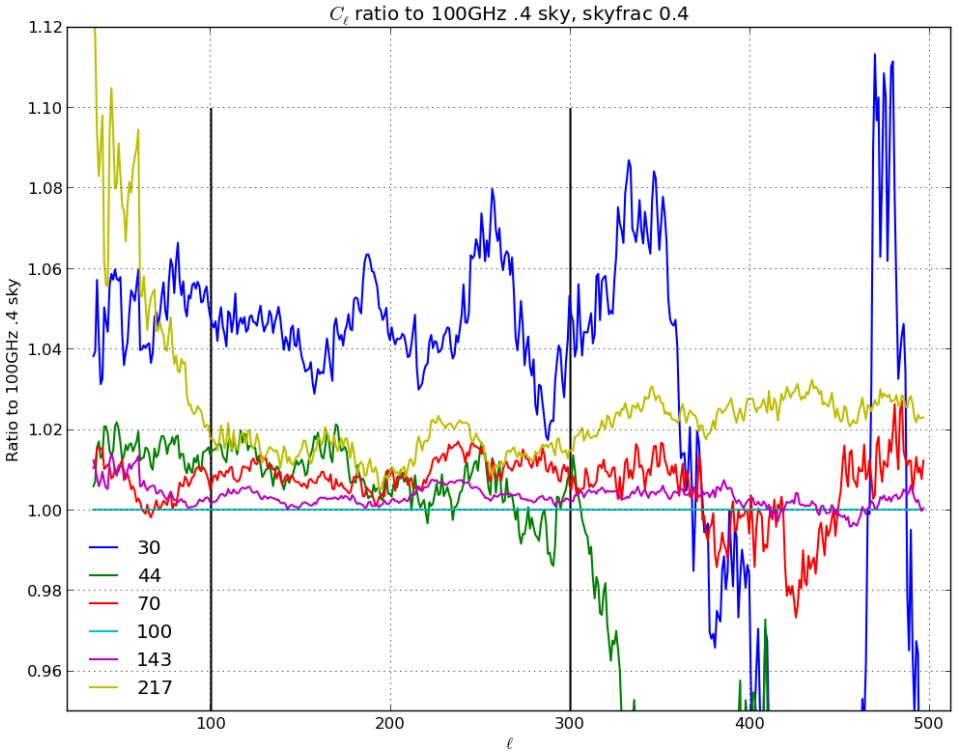


Spectra vs Sky Fraction

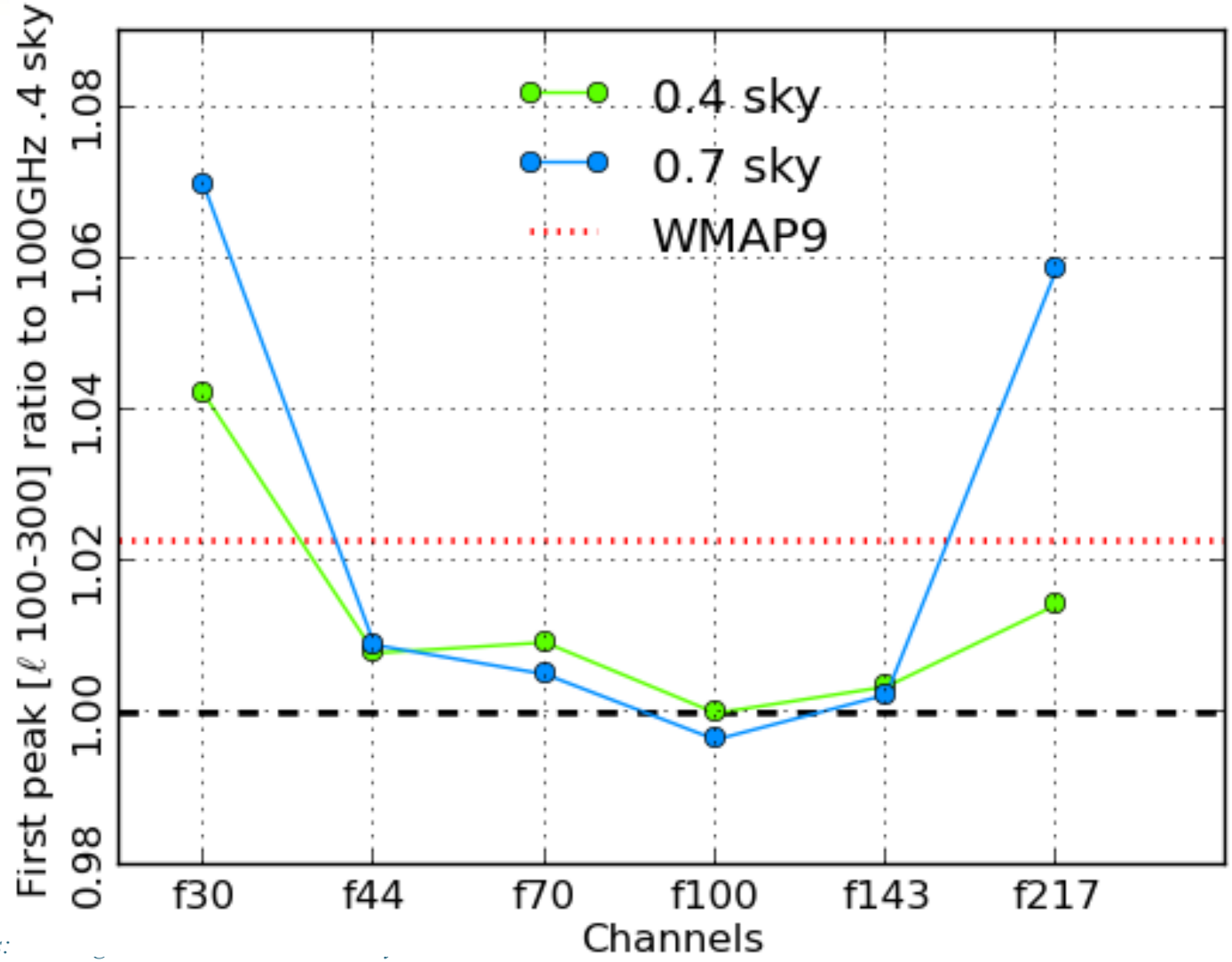
0.7



0.4

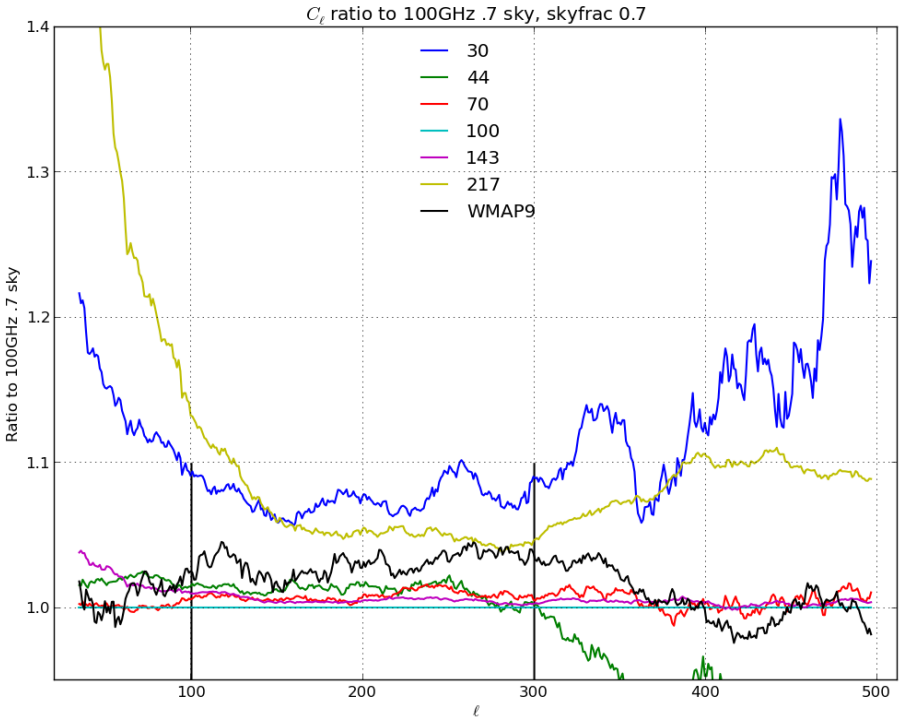


WMAP/Planck "Marriage"
… meeting the family

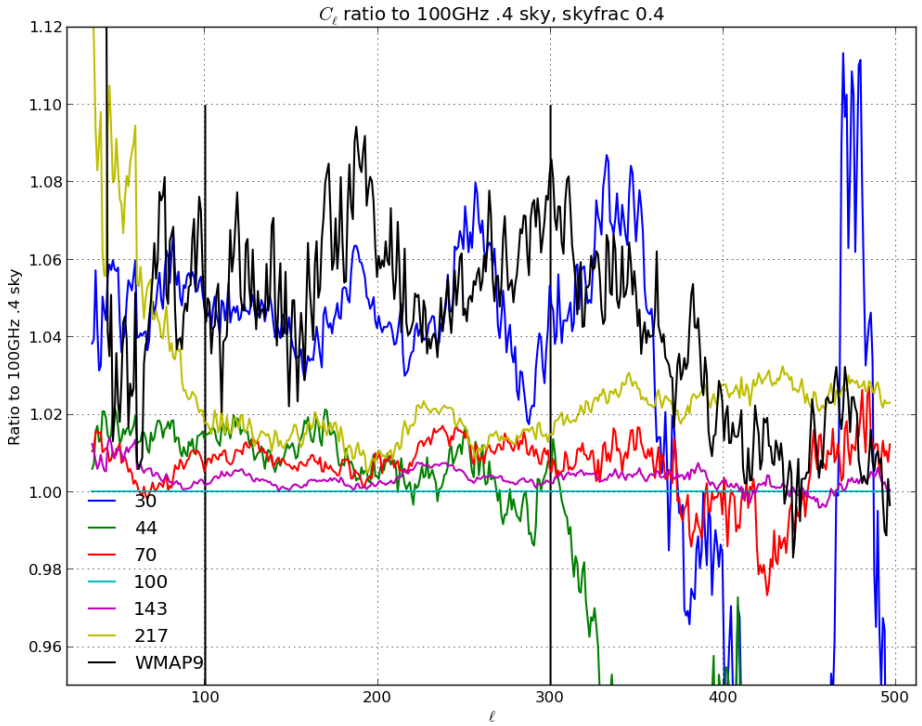


Spectra vs Sky Fraction(with WMAP)

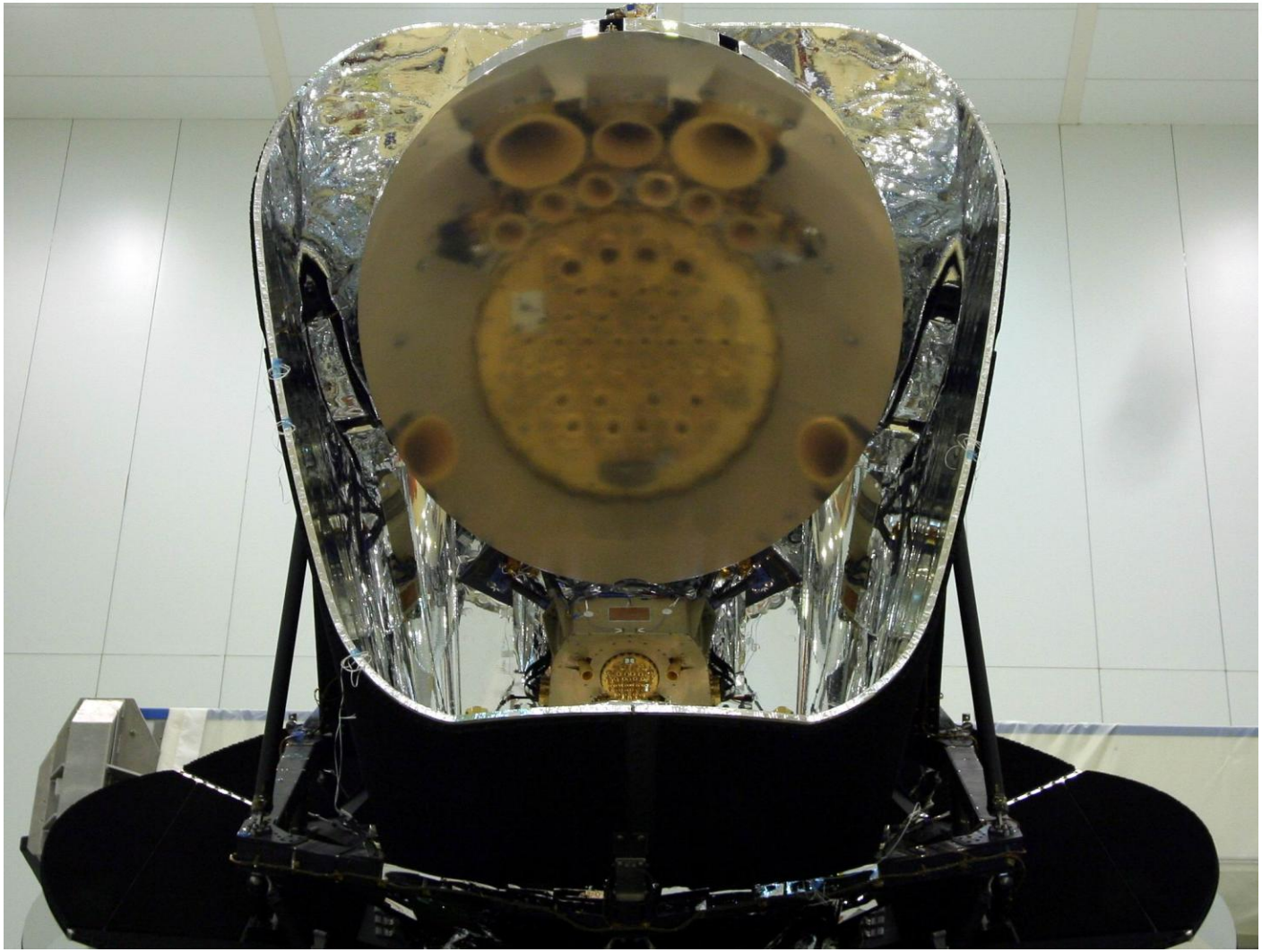
0.7



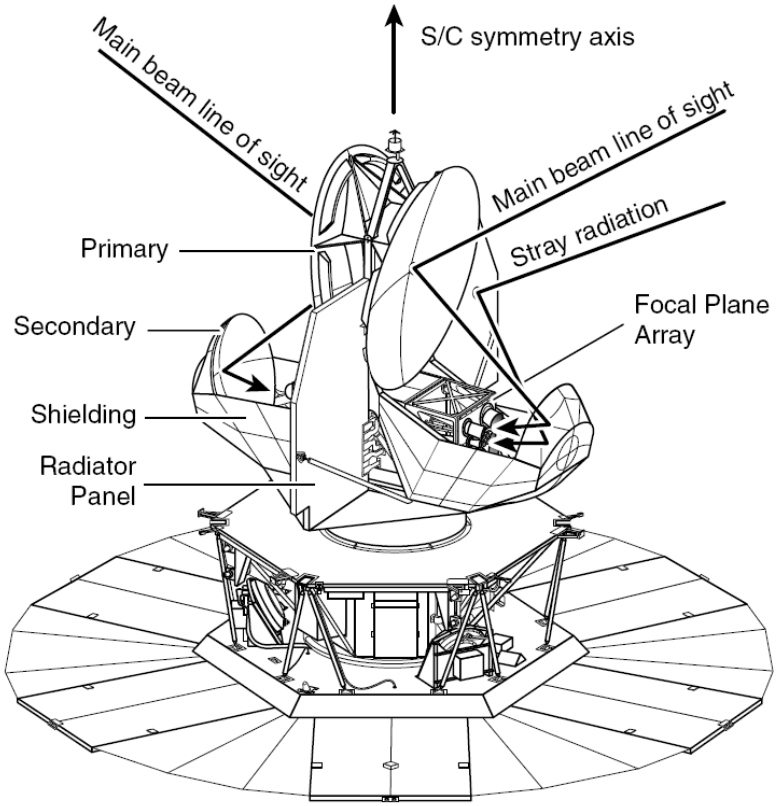
0.4

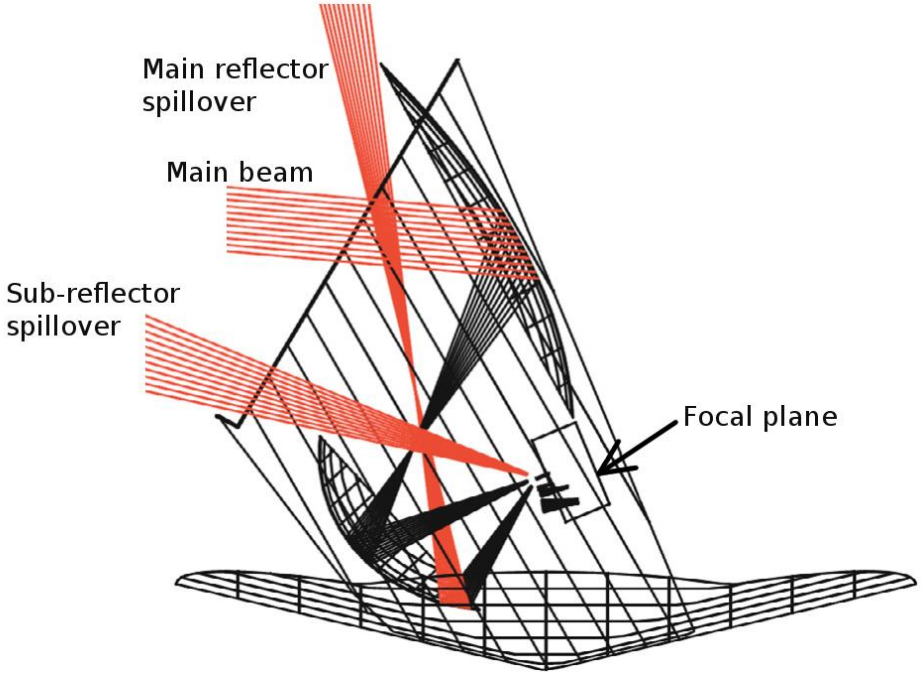


Lets talk about sidelobes



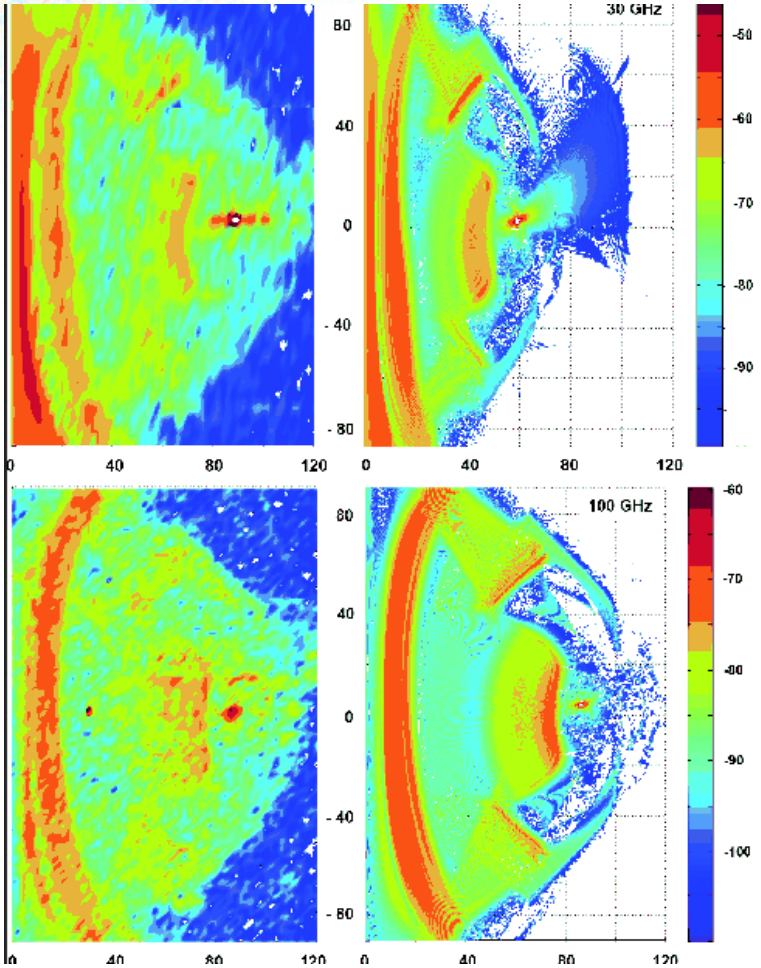
Routes for off axis response on Planck and WMAP





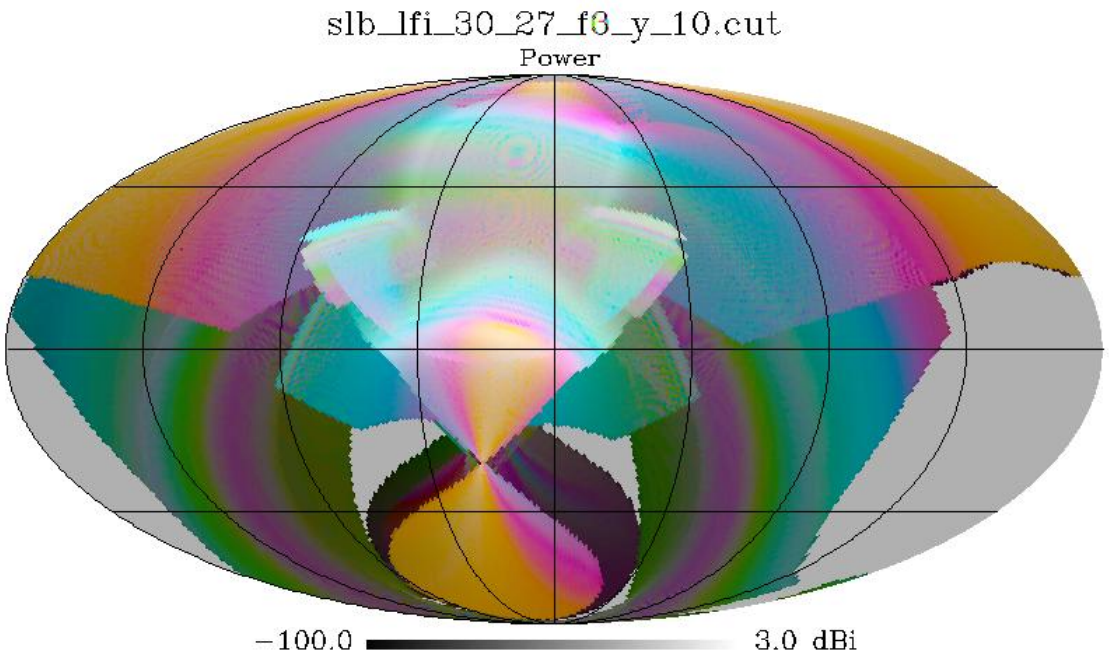
(C. Barnes, et al., 2003, ApJS, 148, 51)

Planck Sidelobe estimates



Prelaunch monochromatic

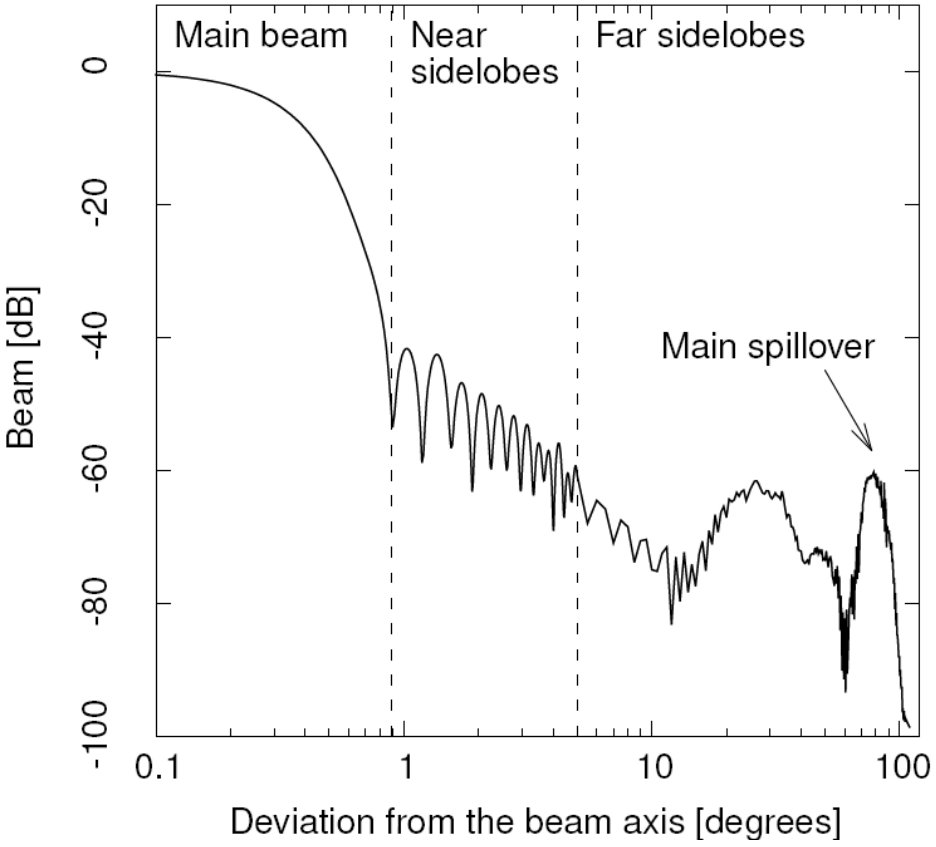
(Tauber et al. 2010 A&A 520, A2)



In Flight Tuned model, 3 sample frequencies (RGB)

(from Planck exp. Supp.)

GRASP simulated beam profile (representative cut, 30 GHz)

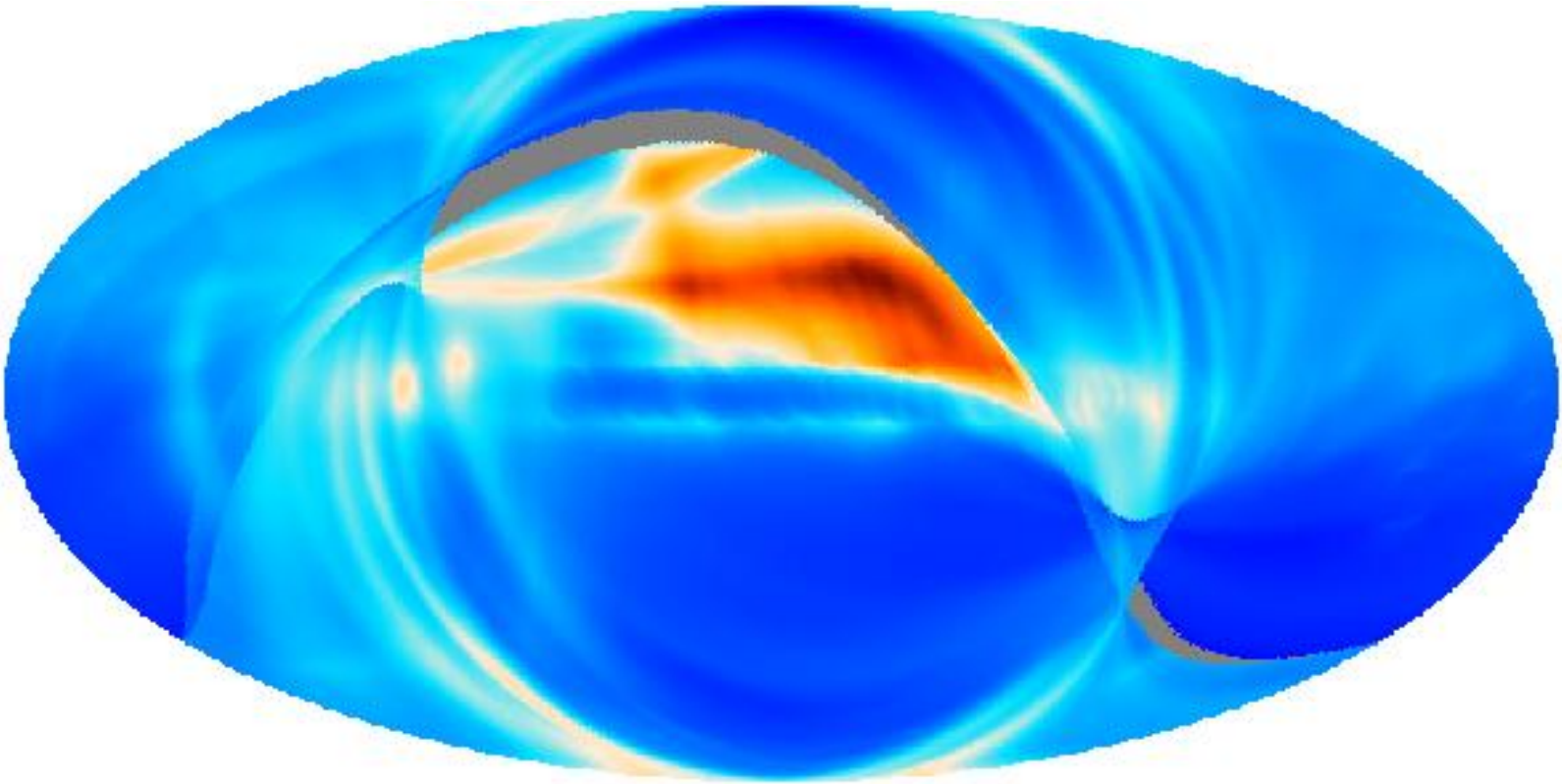


For Calibration

What fraction of the beam response is:

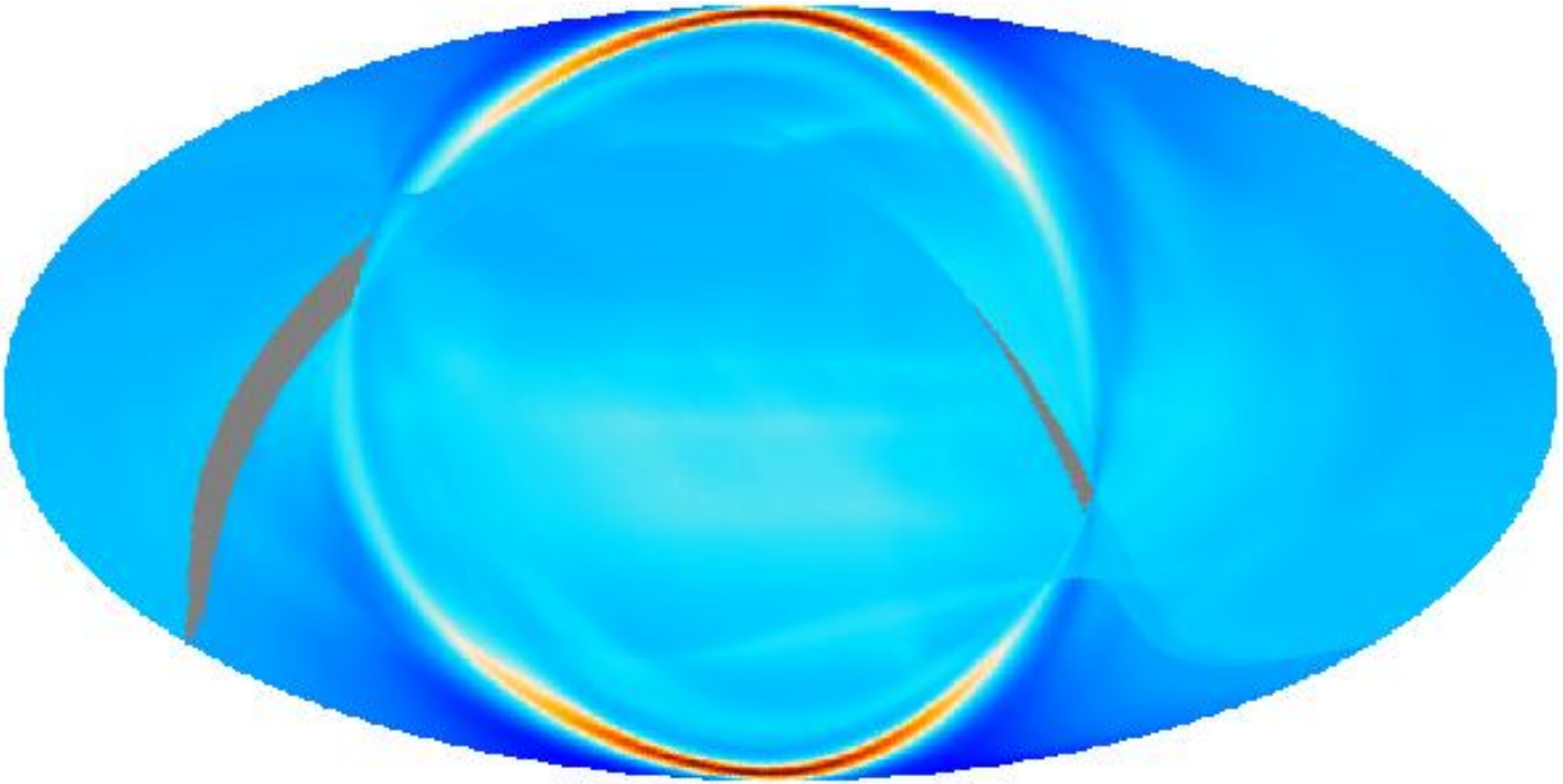
- Main beam
  - Captured by window function
- (‘Very’) Far sidelobes ~ 90 degrees
  - Functionally orthogonal to dipole signal
- ‘Not Very’ Far Sidelobes
  - Somewhat Sensitive to dipole signal but not captured in window function

30 GHz: galaxy as seen through sidelobes, survey 1 (frequency dependent ‘band-weighted’ grasp model)

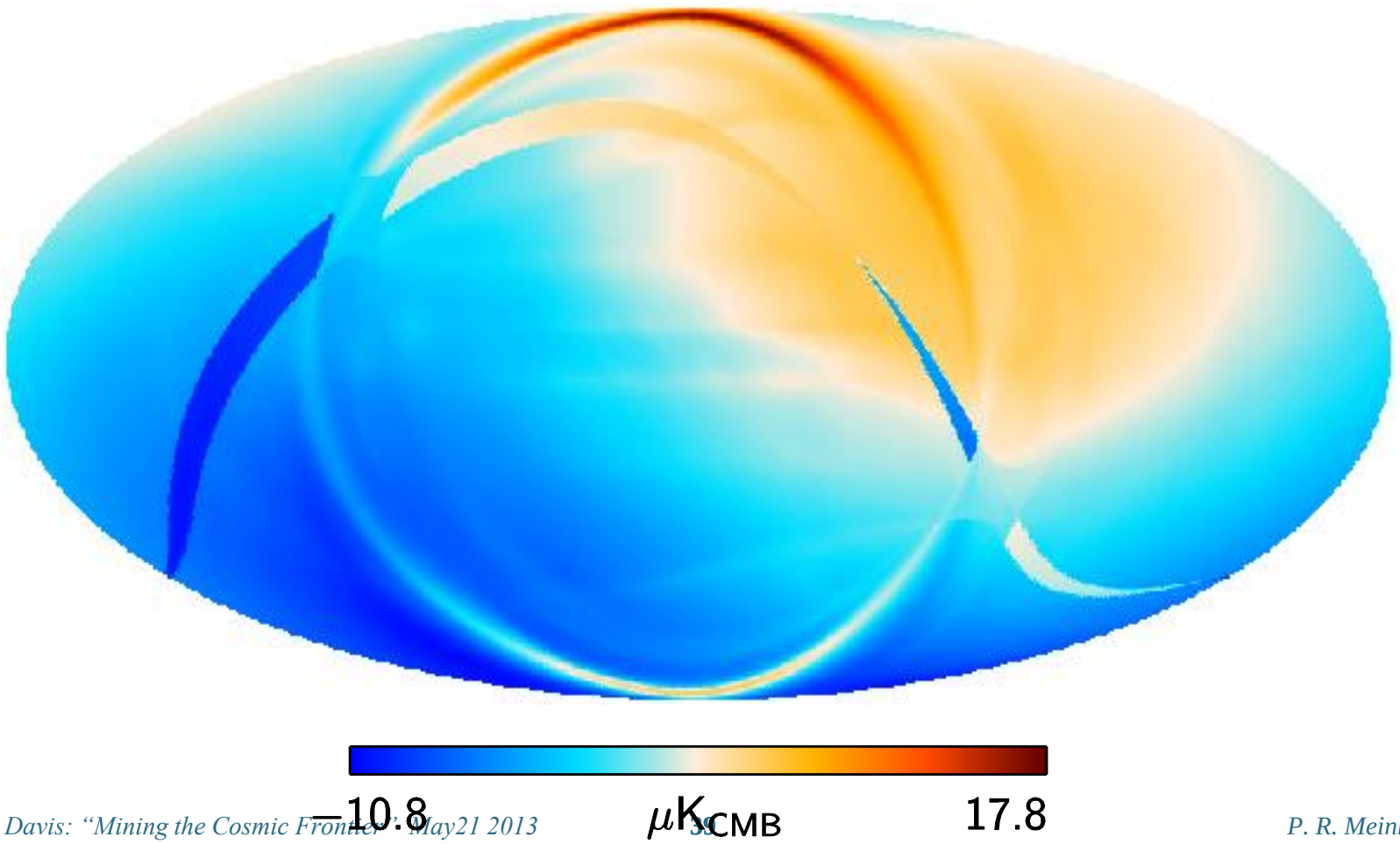


−1.4 μK_{CMB} 4.2

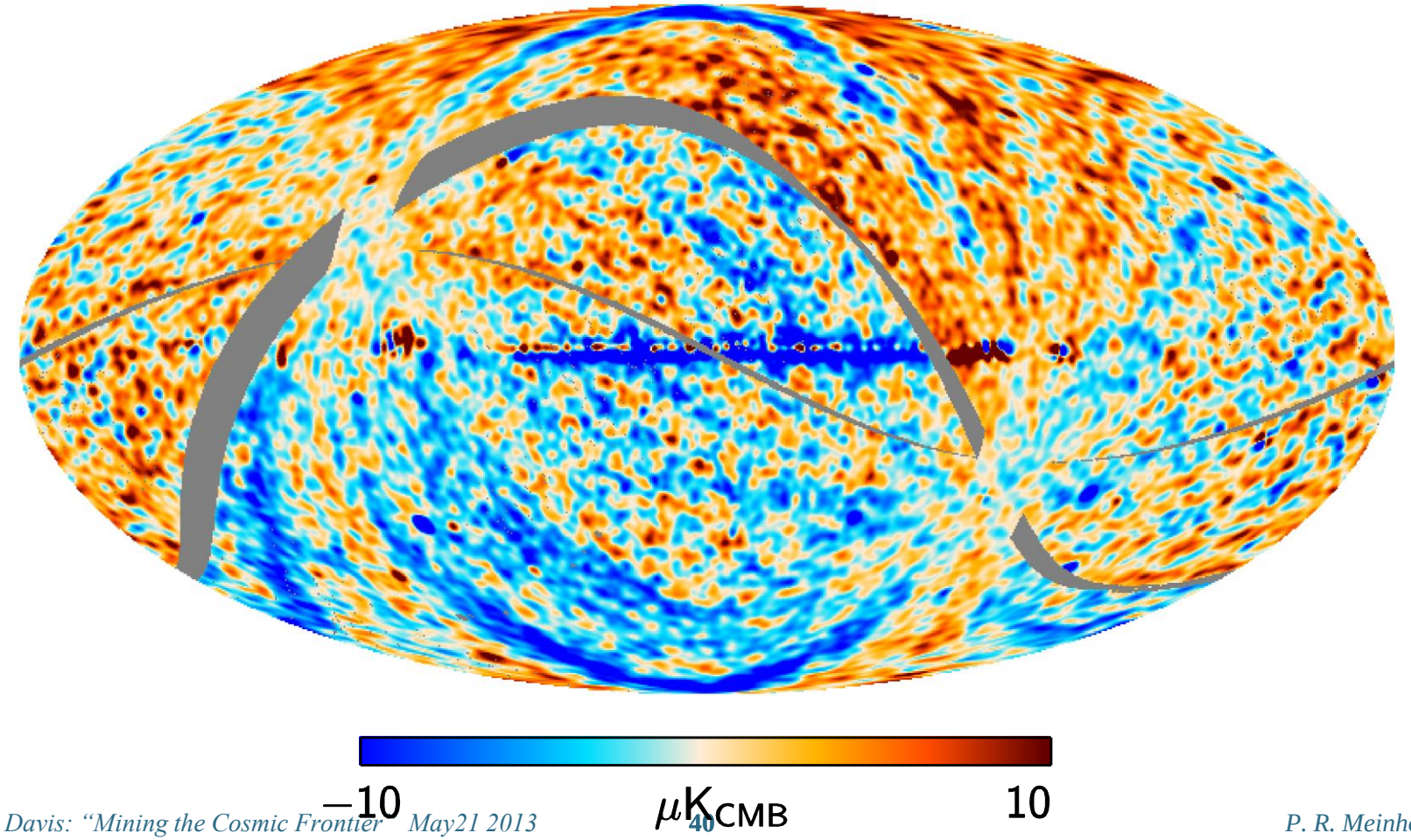
30 GHz: galaxy as seen through sidelobes, survey 2 (frequency dependent ‘band-weighted’ grasp model)



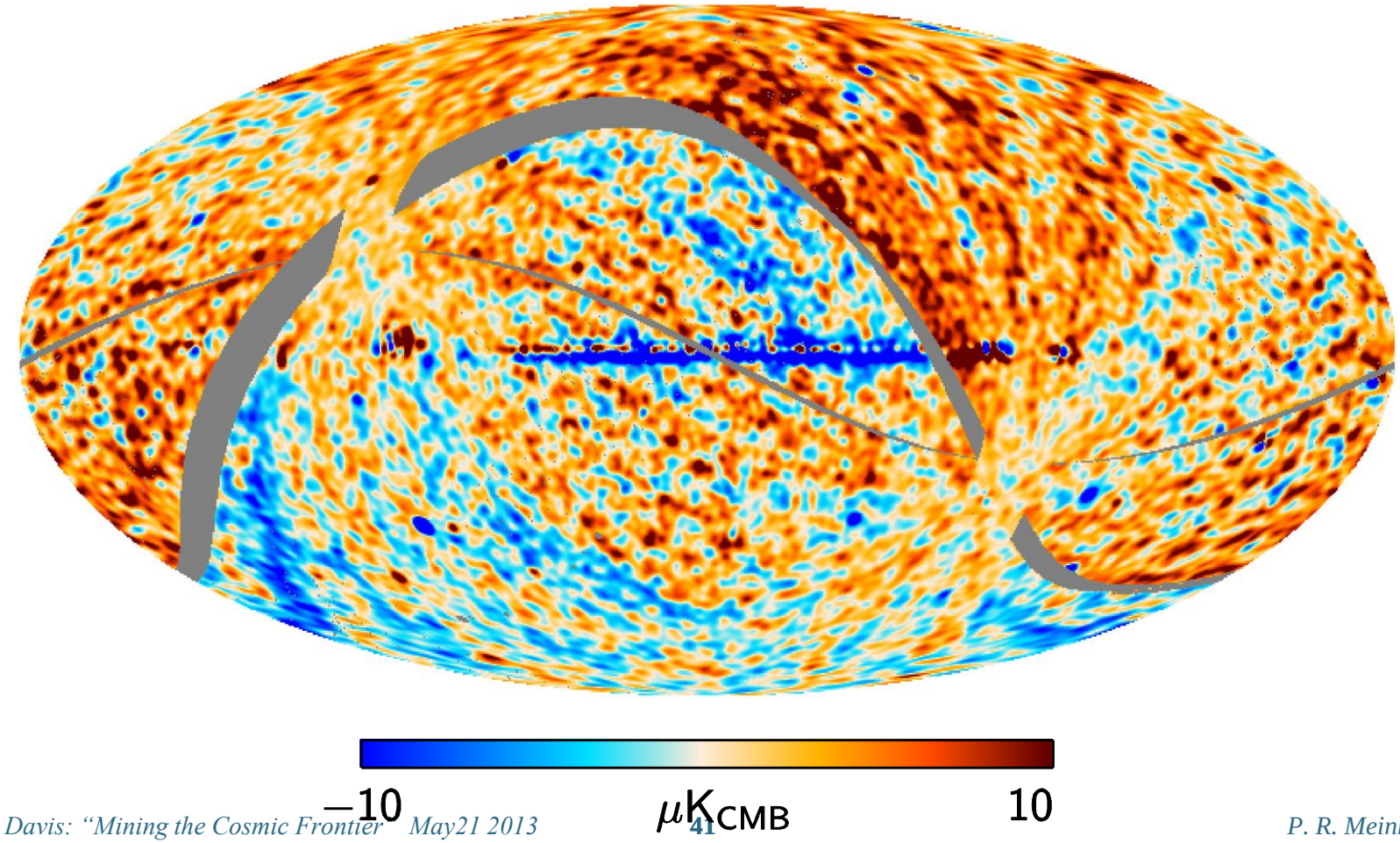
30 GHz: Galaxy + dipole seen through sidelobes, survey 2- survey 1



30 GHz Data: Survey 1- survey 2
(sorry, sign is flipped!)



30 GHz Survey1-Survey2 – sidelobe model (dipole+galaxy seen by sidelobes)

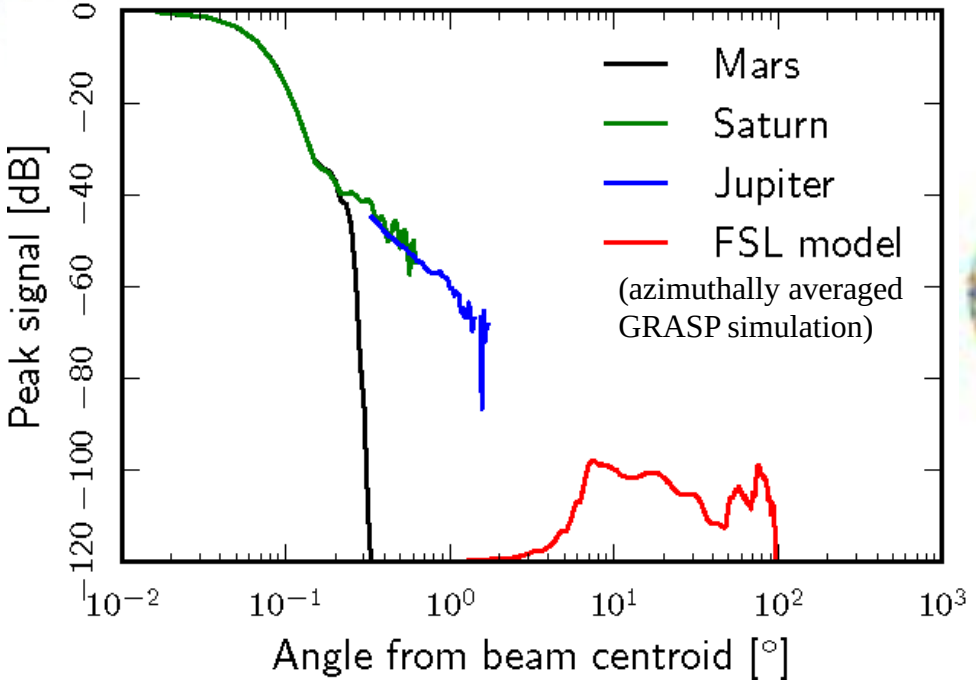


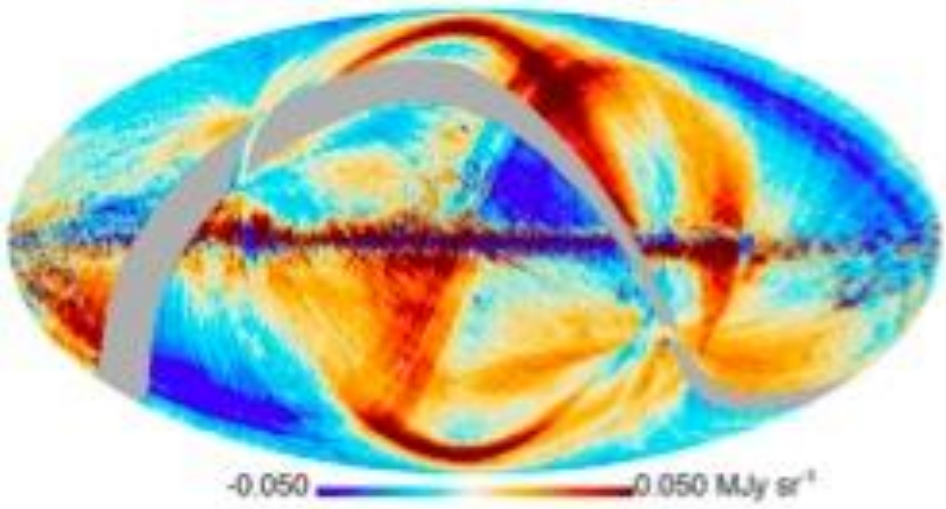
Far sidelobe beam fraction, estimated from GRASP

Beam	η (%)	f_{sl} (%)	Ω_{opt} (arcmin^2)	Ω_{sim} (arcmin^2)	Ω_{scn} (arcmin^2)
70 GHz					
18S	99.34	0.66	198.10	203.28	205.81
18M	99.42	0.58	196.89	201.84	203.98
19S	99.29	0.71	188.65	193.34	193.51
19M	99.35	0.65	148.23	191.60	195.04
20S	99.18	0.82	181.21	185.63	185.51
20M	99.21	0.79	180.43	185.20	185.45
21S	99.20	0.80	182.50	186.94	186.63
21M	99.21	0.79	181.26	185.71	183.87
22S	99.27	0.73	188.18	193.07	190.22
22M	99.34	0.66	187.45	192.07	188.24
23S	99.35	0.65	199.95	204.84	200.91
23M	99.43	0.57	198.74	203.72	200.99
44 GHz					
24S	99.84	0.16	576.85	590.99	591.86
24M	99.79	0.21	589.99	602.42	594.76
25S	99.80	0.20	1020.68	1041.63	1040.47
25M	99.79	0.21	967.93	990.28	996.72
26S	99.80	0.20	1006.67	1027.13	1019.03
26M	99.79	0.21	967.93	989.89	993.56
30 GHz					
27S	99.33	0.67	1153.02	1181.94	1184.64
27M	99.30	0.70	1158.00	1186.14	1174.48
28S	99.34	0.66	1153.14	1180.99	1188.41
28M	99.29	0.71	1152.56	1181.98	1179.34

These beam efficiencies **can** affect calibration. Our calibration method automatically corrects for contributions far from the main lobe, which is the bulk of the sidelobe fraction.

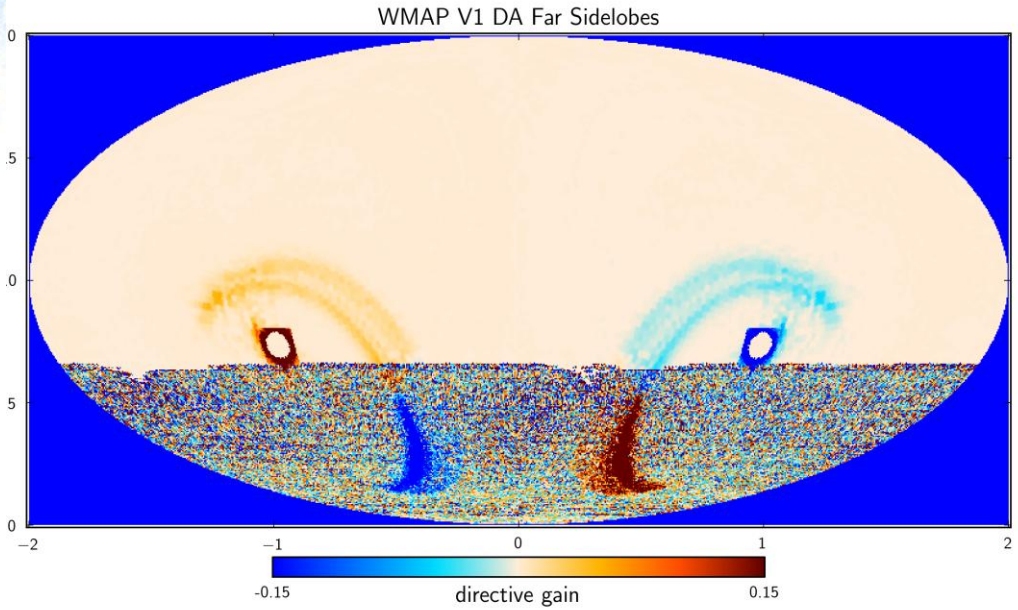
HFI 353 GHz

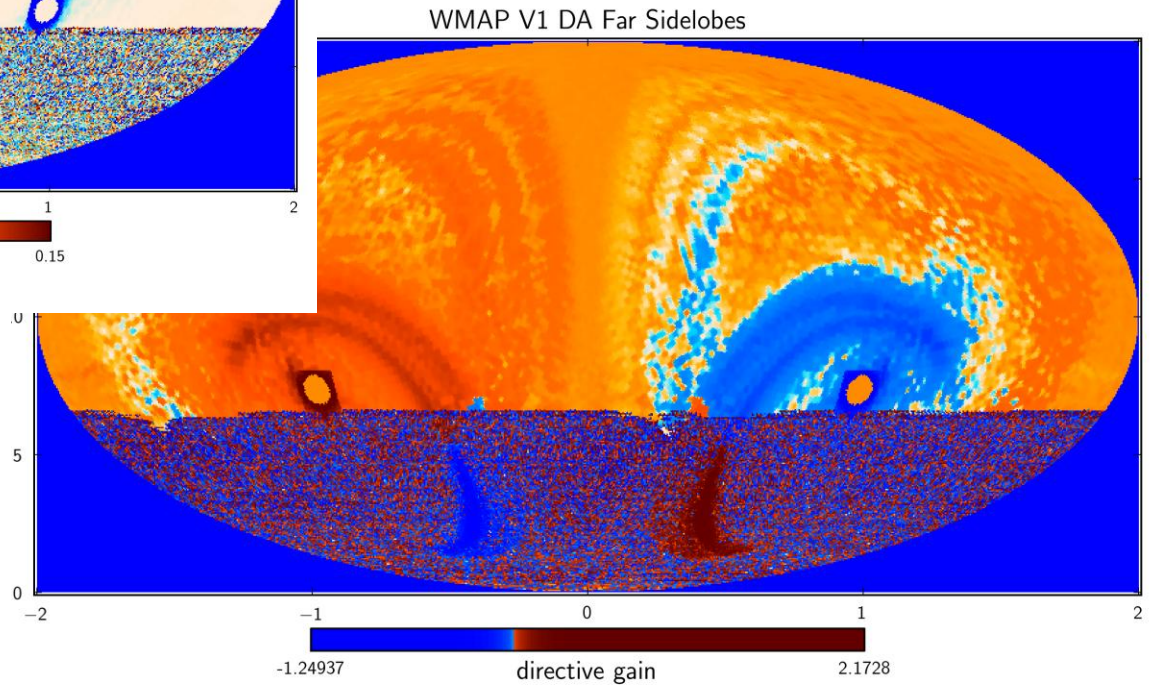




353 GHz Survey difference

WMAP DA sidelobes





WMAP's differential design means that certain underestimated sidelobe power can affect the calibration/window function in ***either*** direction


esa
planck
cnes
agenzia spaziale italiana
NASA
cnrs
DTU Space
National Space Institute
Science & Technology Facilities Council
CSIC
National Research Council of Italy
CSA ASC
DLR
Deutsches Zentrum für Luft- und Raumfahrt e.V.
UK SPACE AGENCY
PLANCK LFI
HFI PLANCK
IAS orsay
IAP
INAF - IASF BO
ISTITUTO NAZIONALE DI ASTROFISICA
UNIVERSITY OF CAMBRIDGE
CARDIFF UNIVERSITY
irfu
saclay
CESR
CITA–ICAT
IASF
INSU
IN2P3
ipac
HELSINKI INSTITUTE OF PHYSICS
IFCA
Imperial College London
UNIVERSITÀ DEGLI STUDI DI MILANO
NÉEL Institut
IPAG
iSDC
JPL
LAL
LERMA
LPSC
MilliLab
NUI MAYNOOTH
SAPIENZA
Rutherford Appleton Laboratory
UBC
UC
UCSB
SISSA
US
HAVERFORD
esa
UNIVERSITÉ DE GENÈVE
UNIVERSITY OF TORONTO
UNIVERSITÉ DE PARIS-SUD XI
asdc