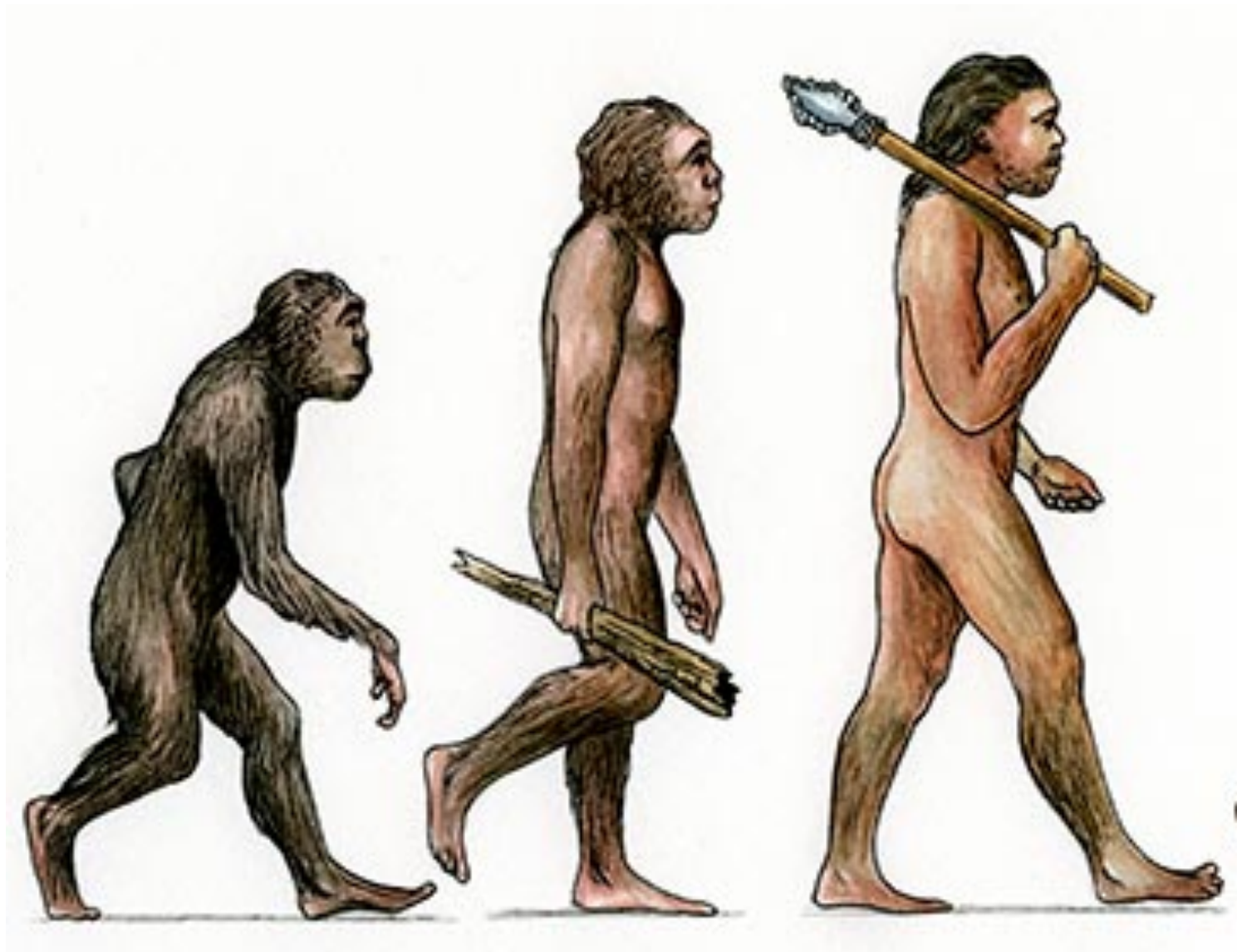
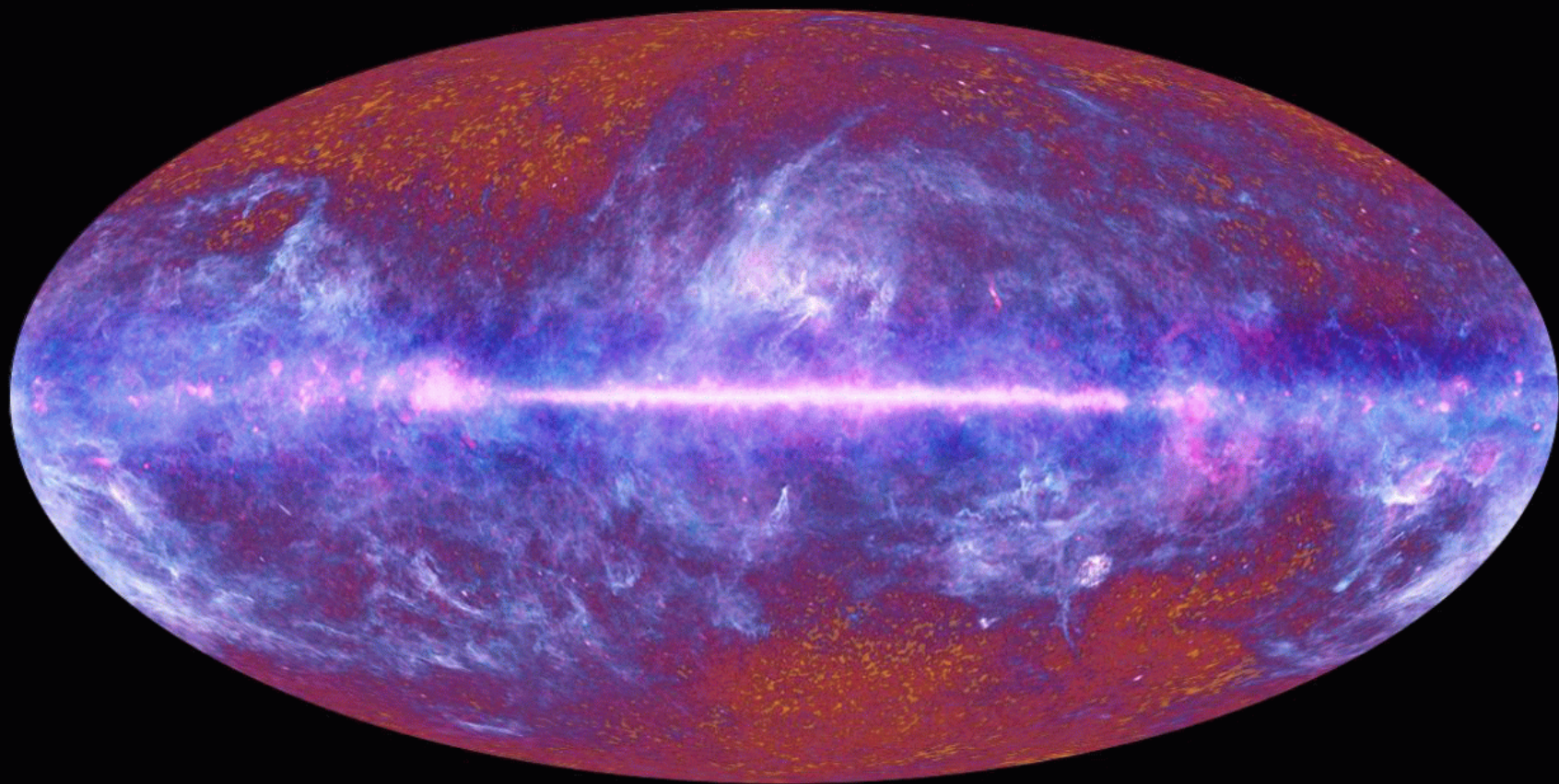


COBE

WMAP

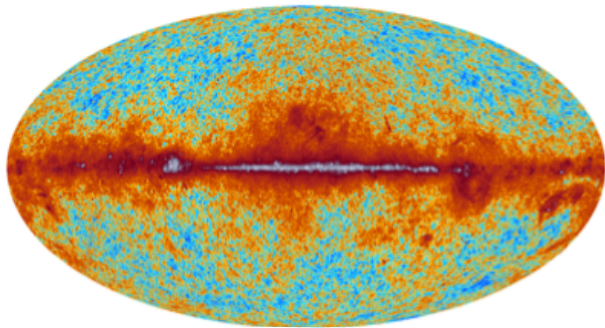
PLANCK



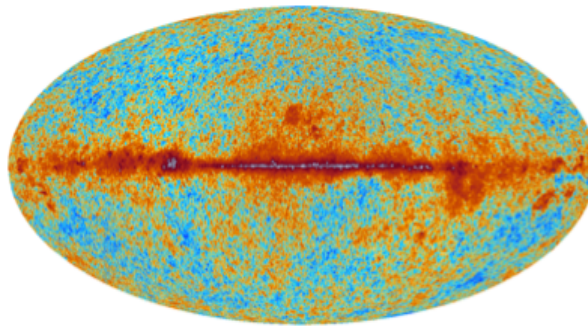


PLANCK FREQUENCYMAPS

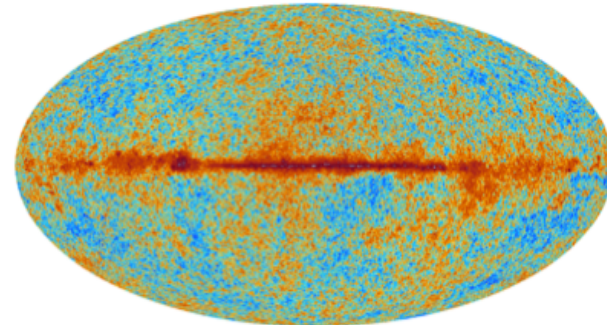
30 GHz



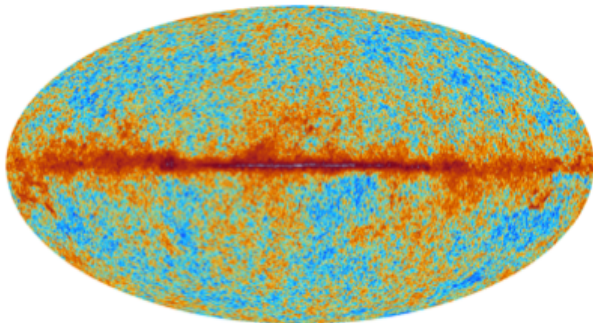
44 GHz



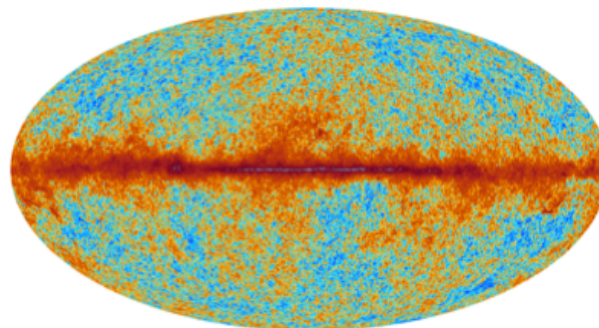
70 GHz



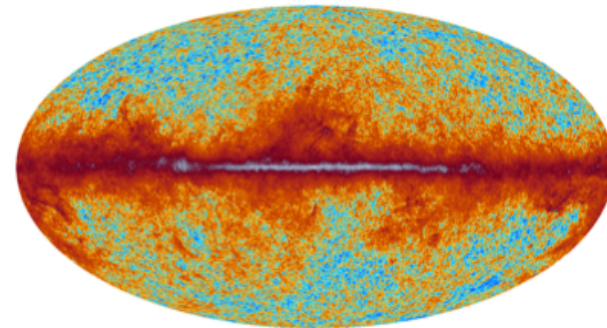
100 GHz



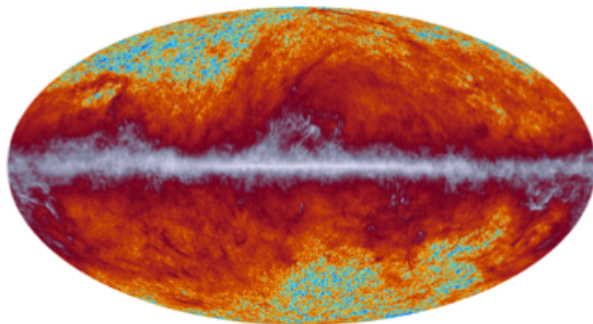
143 GHz



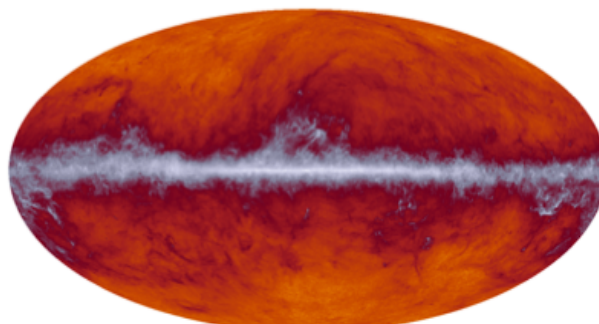
217 GHz



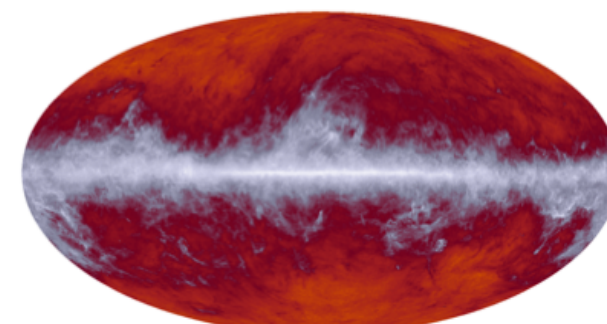
353 GHz



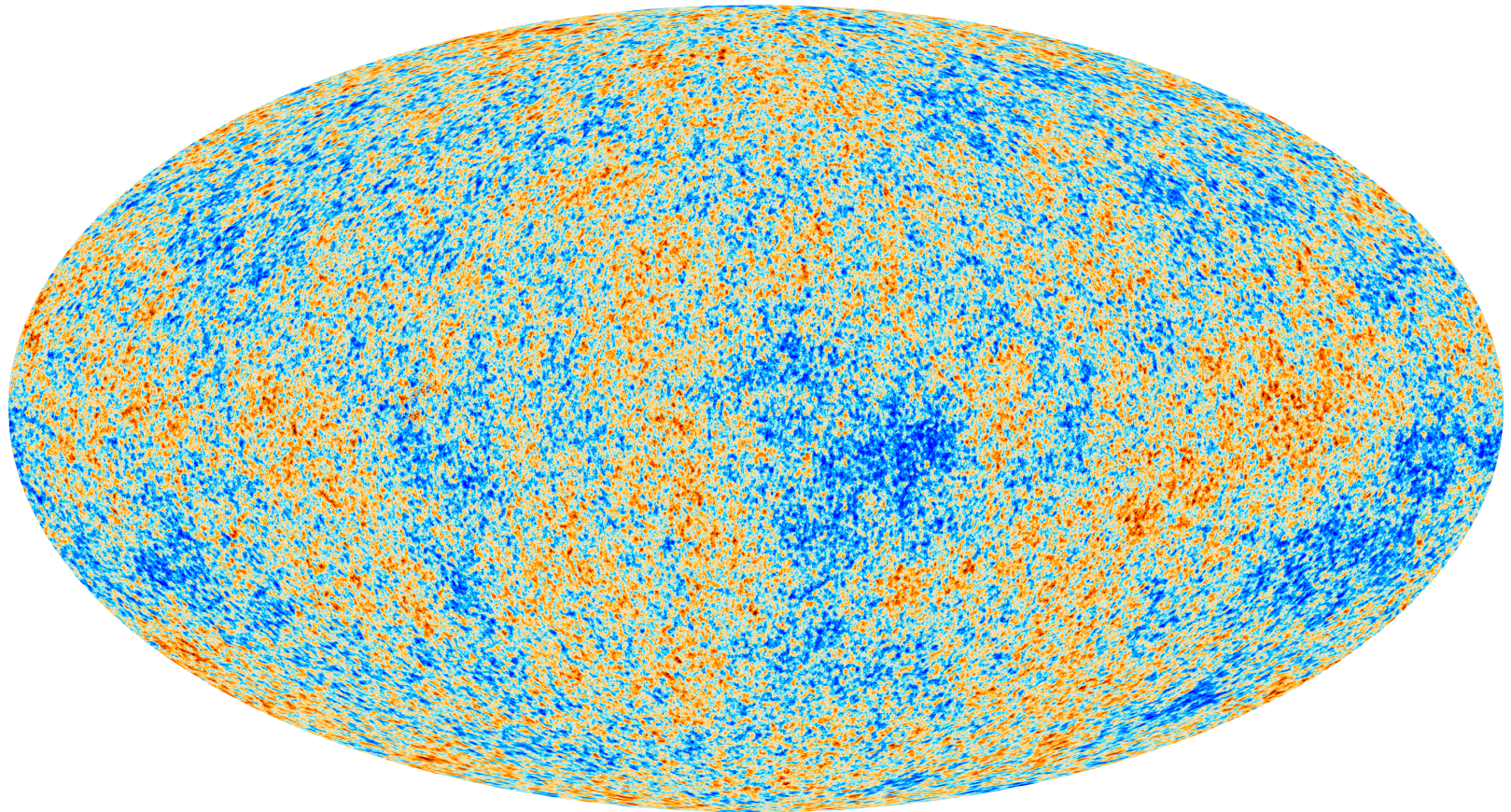
545 GHz



857 GHz



THE CMB AS SEEN BY PLANCK

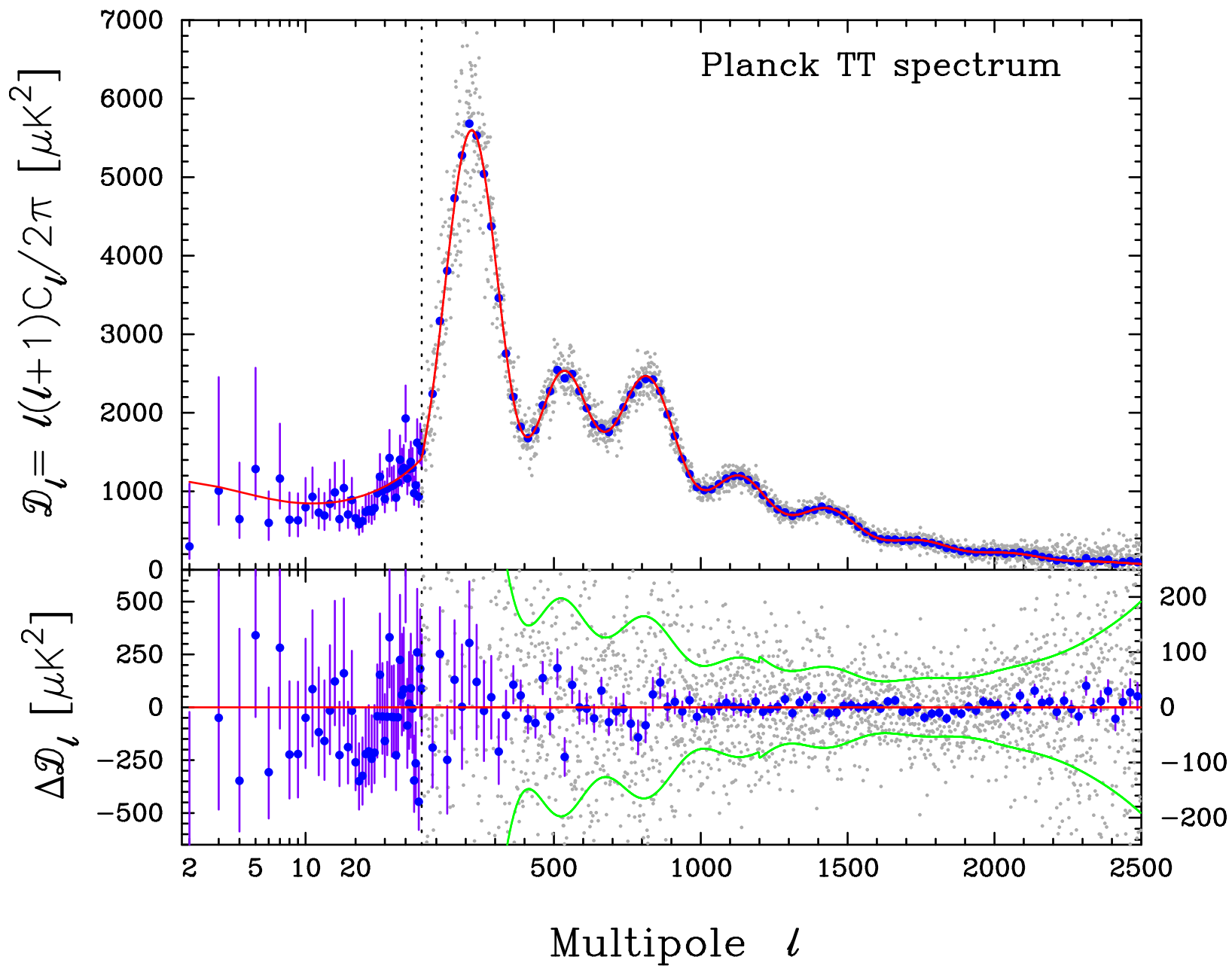


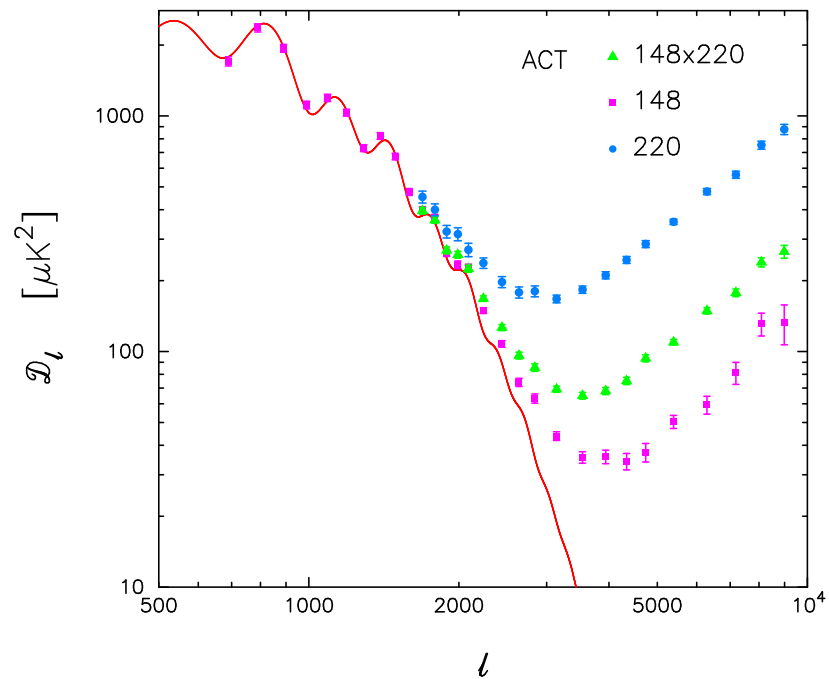
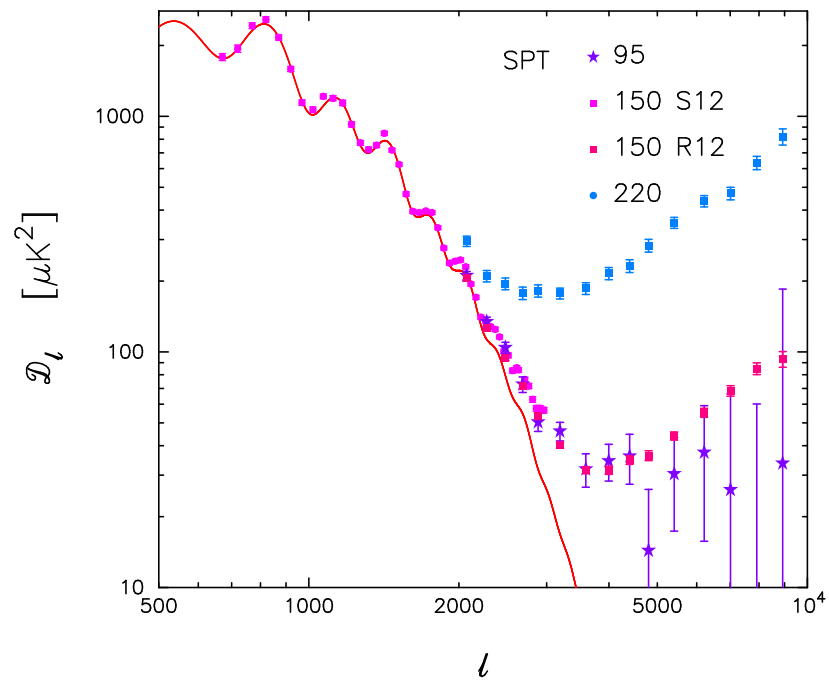
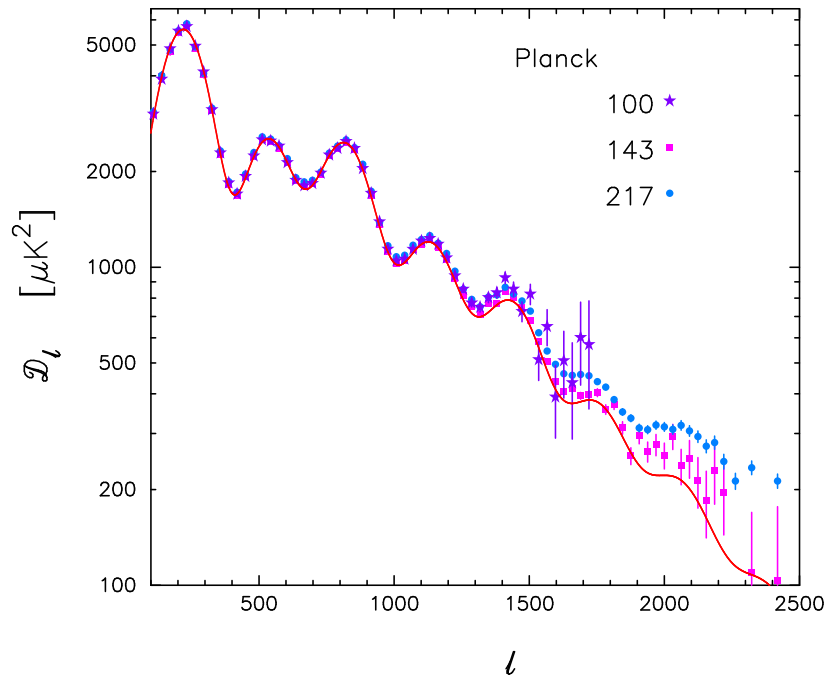
BY THE AUTHOR OF BEFORE THE BEGINNING

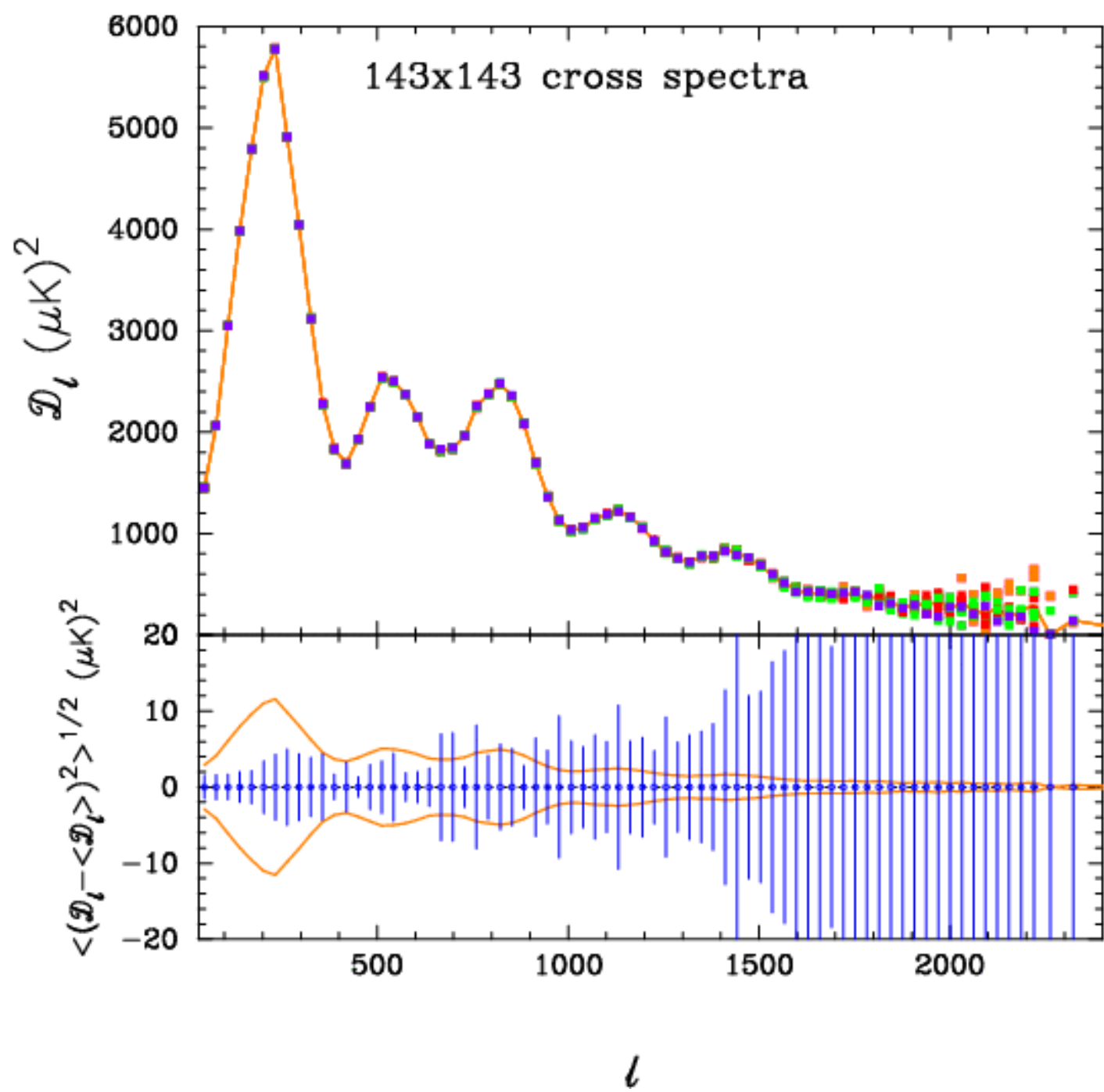
MARTIN REES

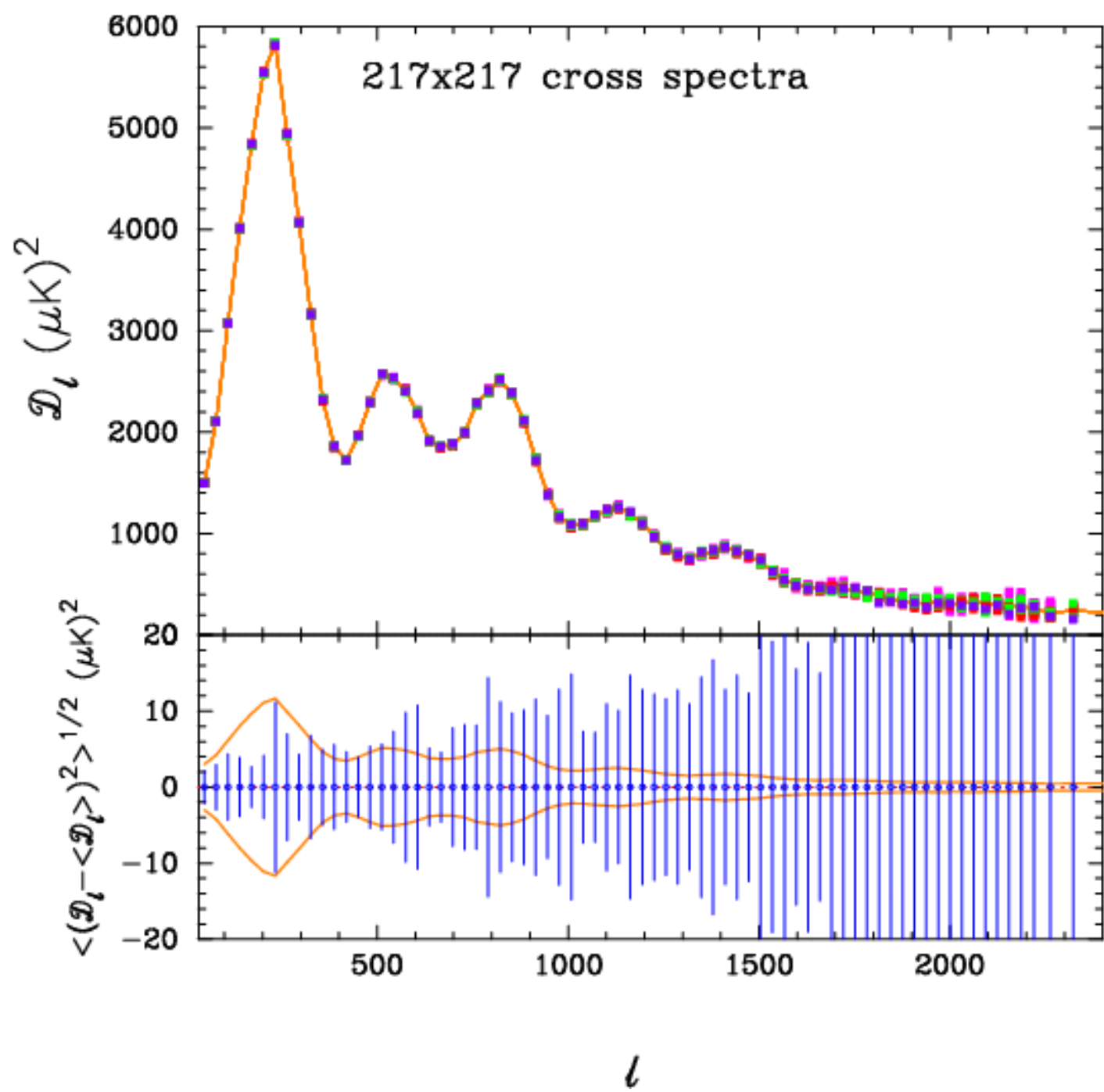
JUST SIX NUMBERS

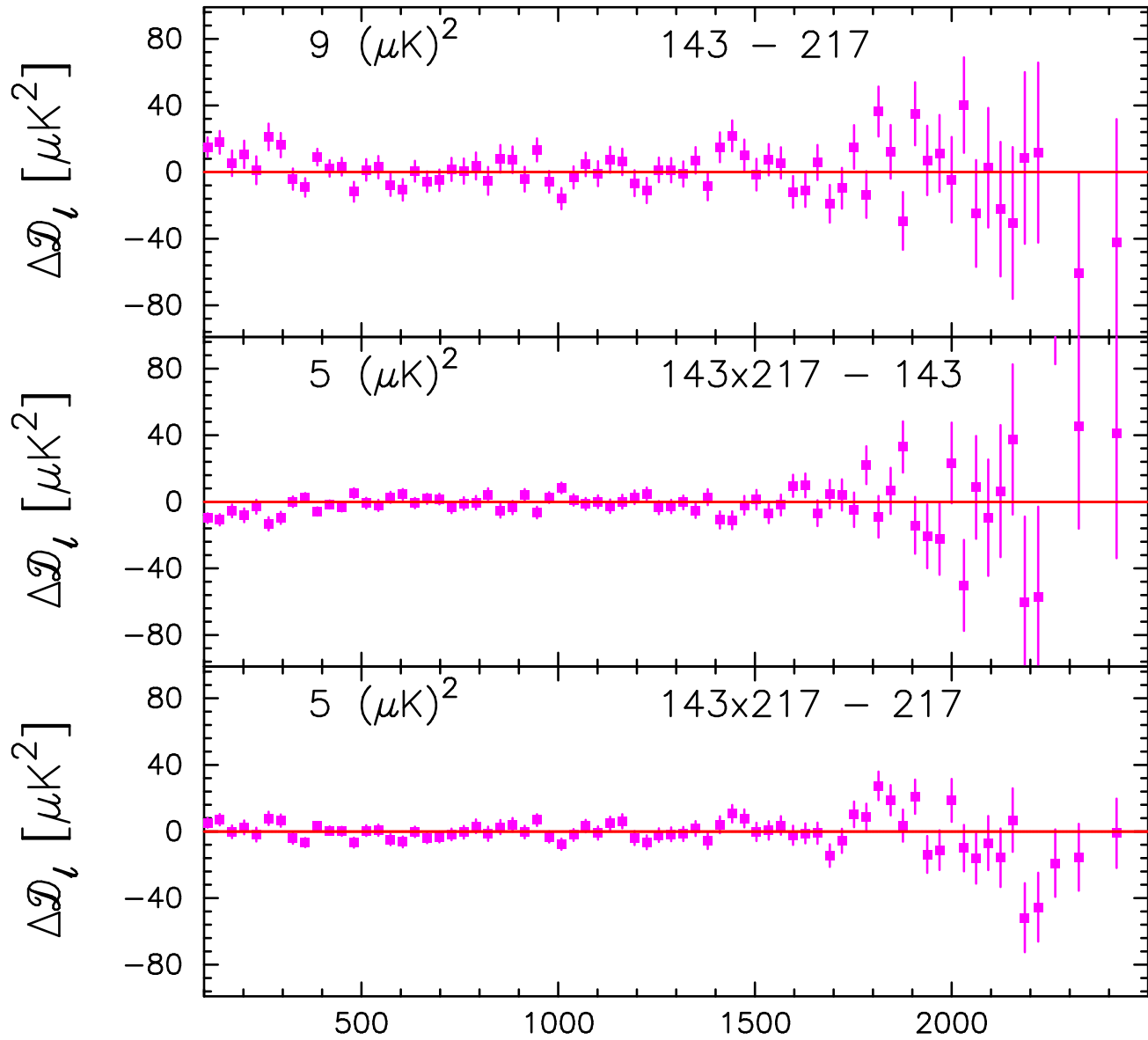
The Deep Forces That Shape the Universe



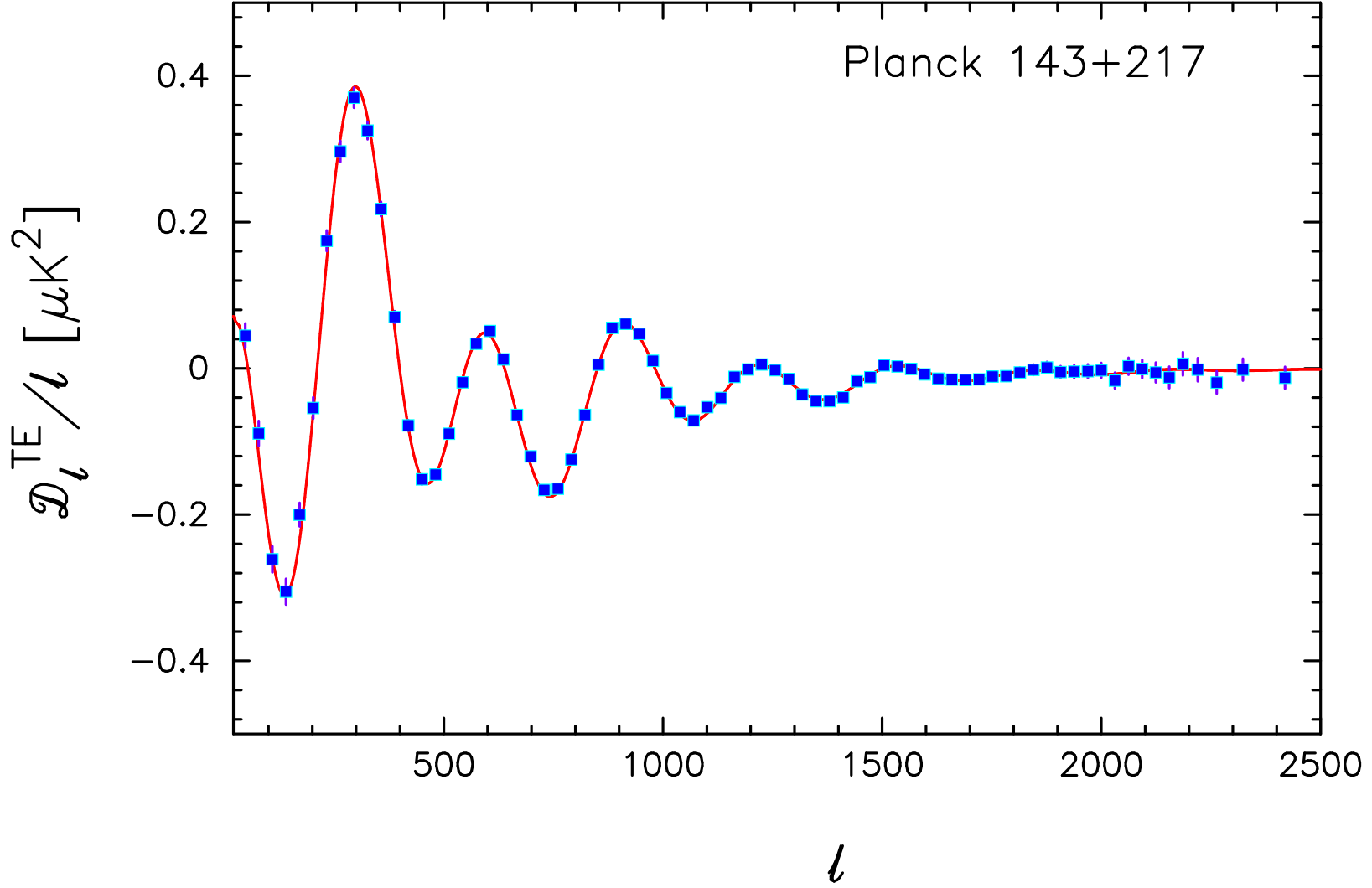


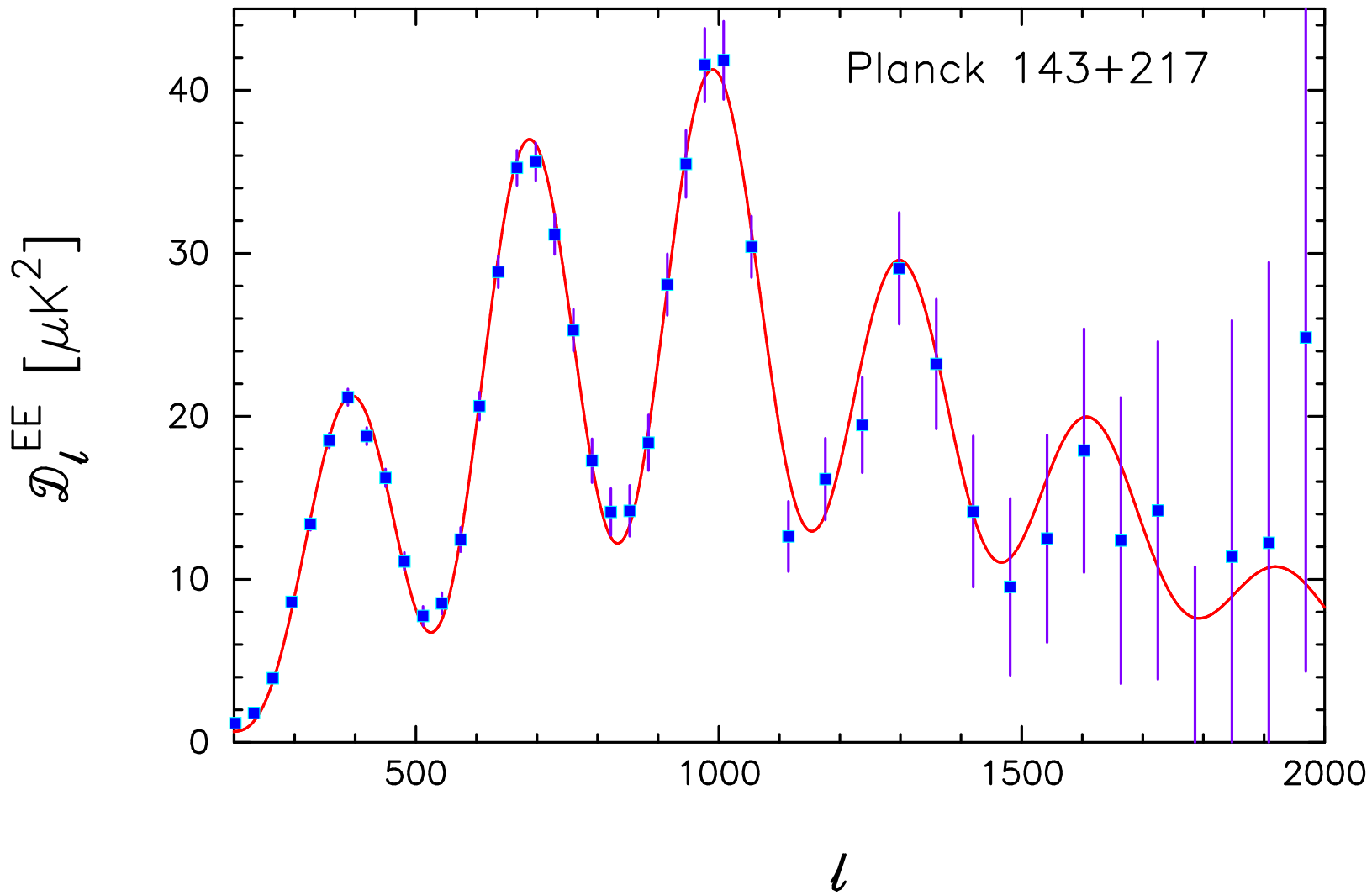


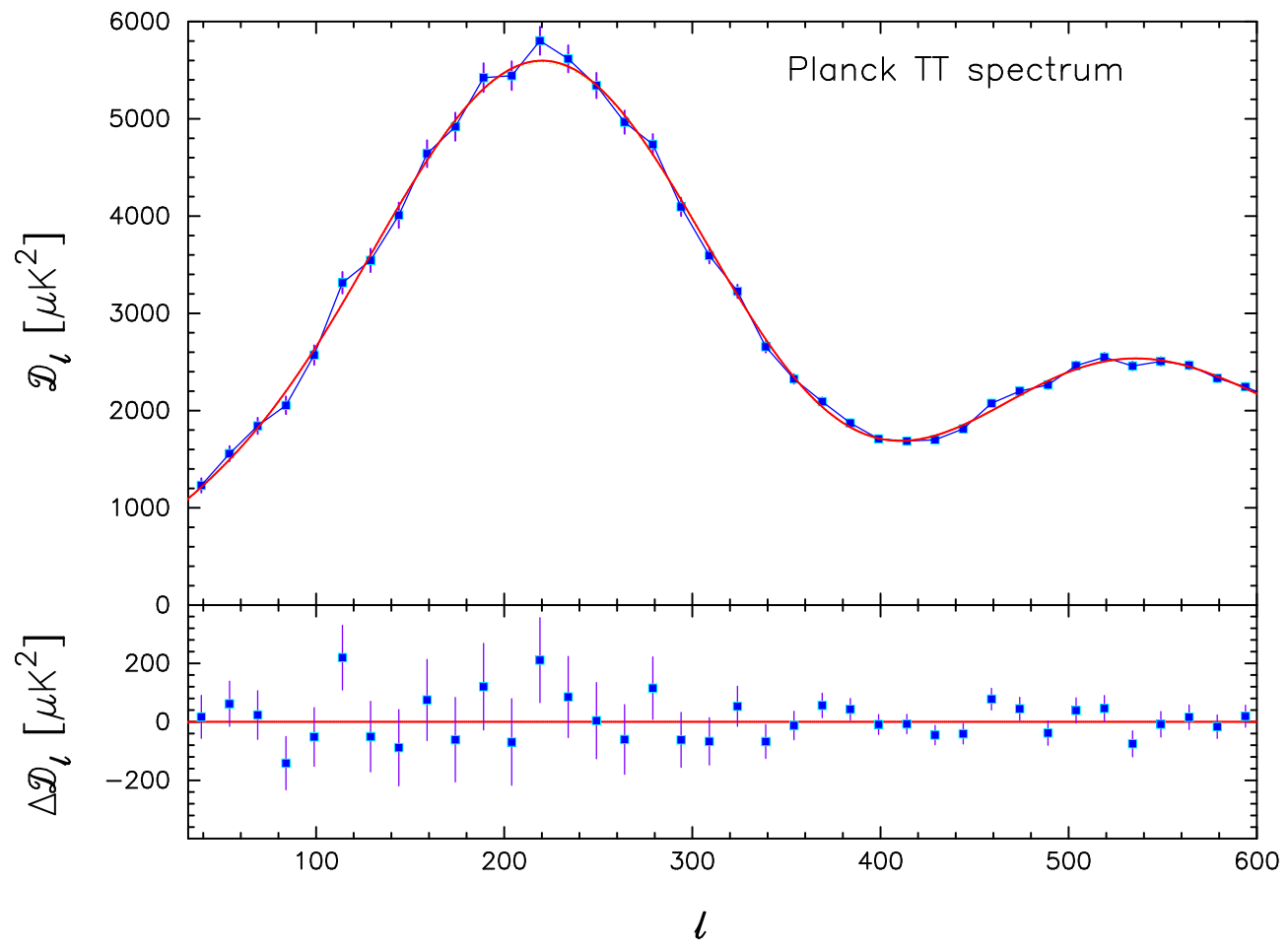


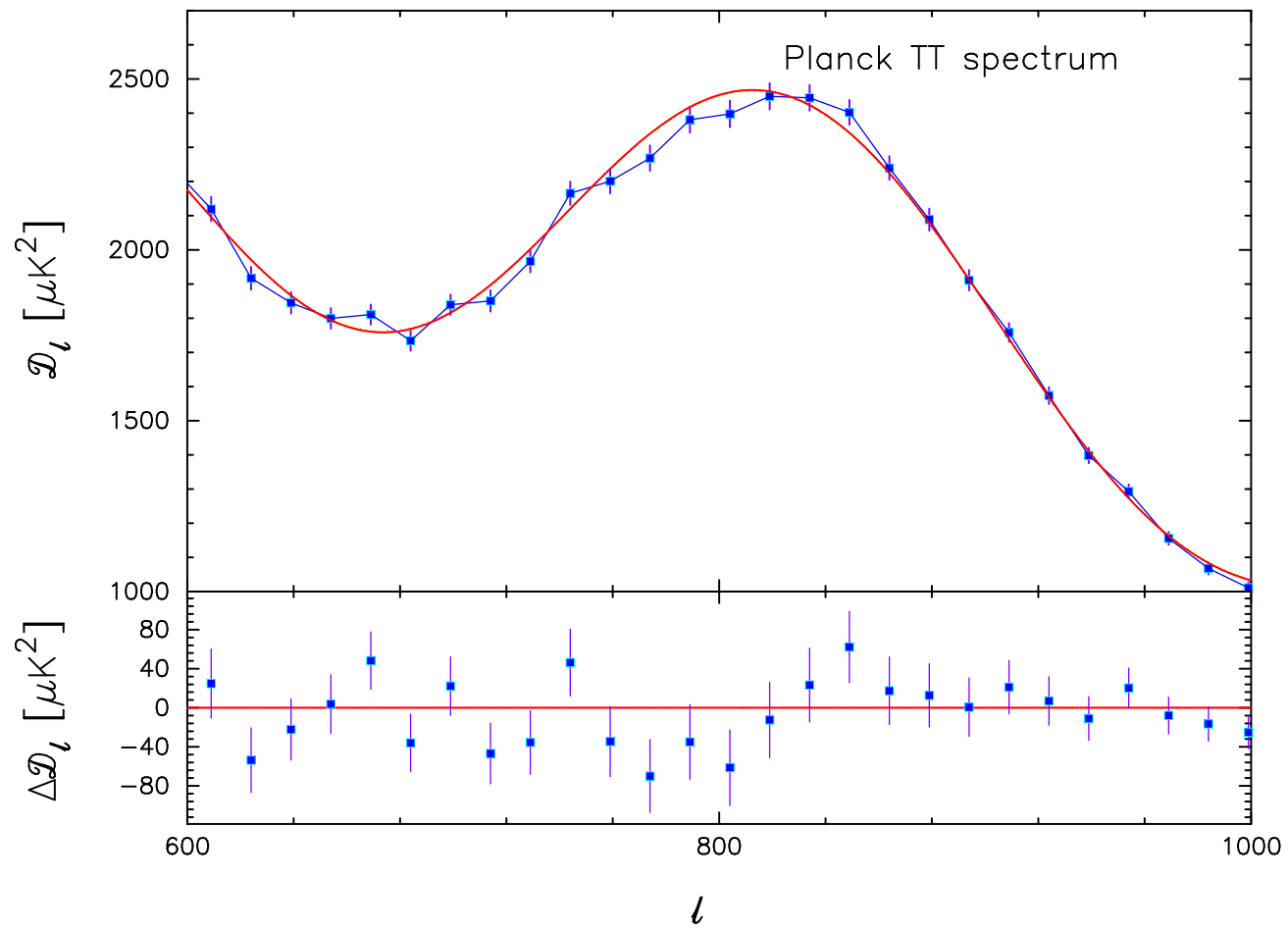


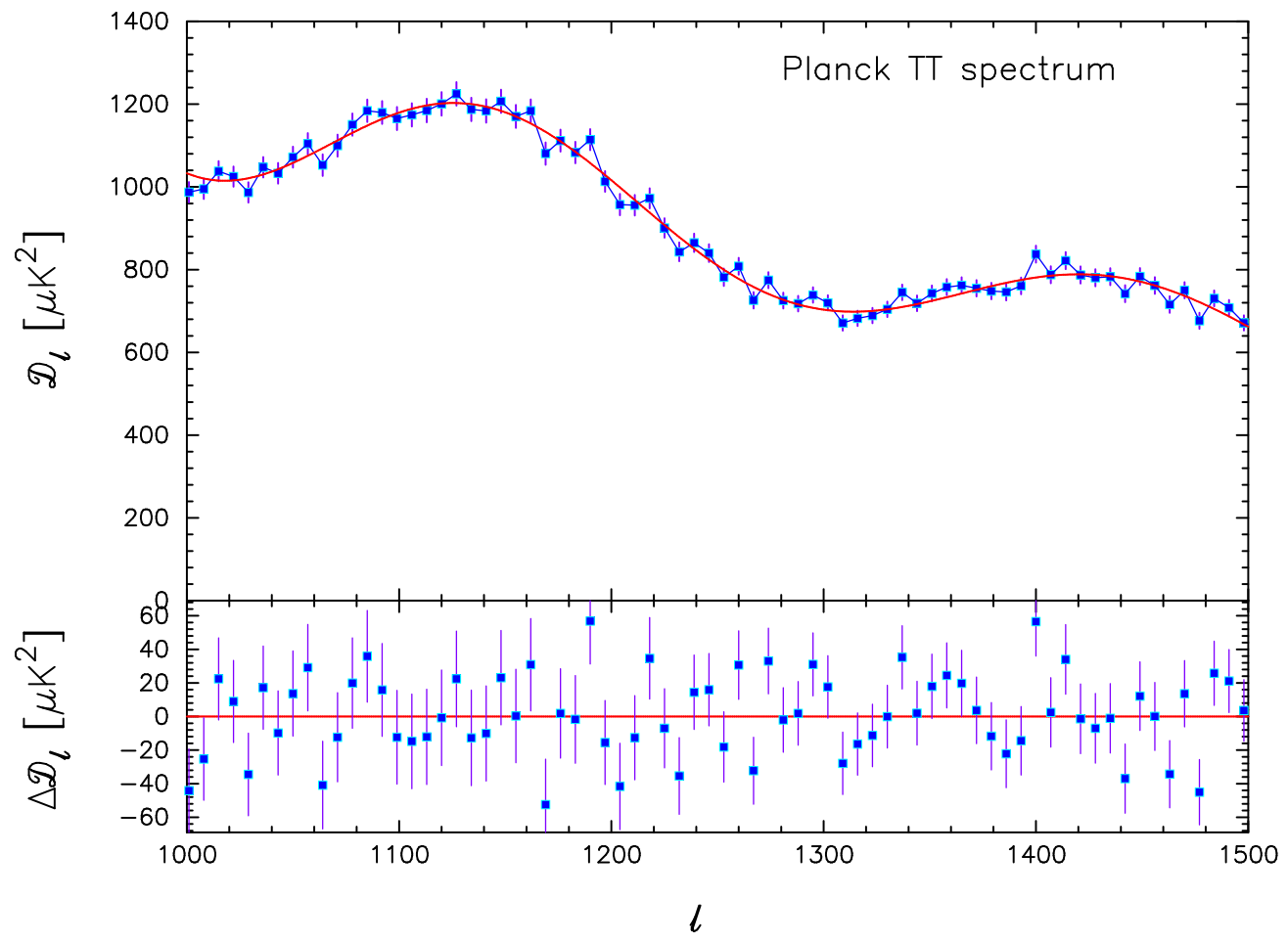
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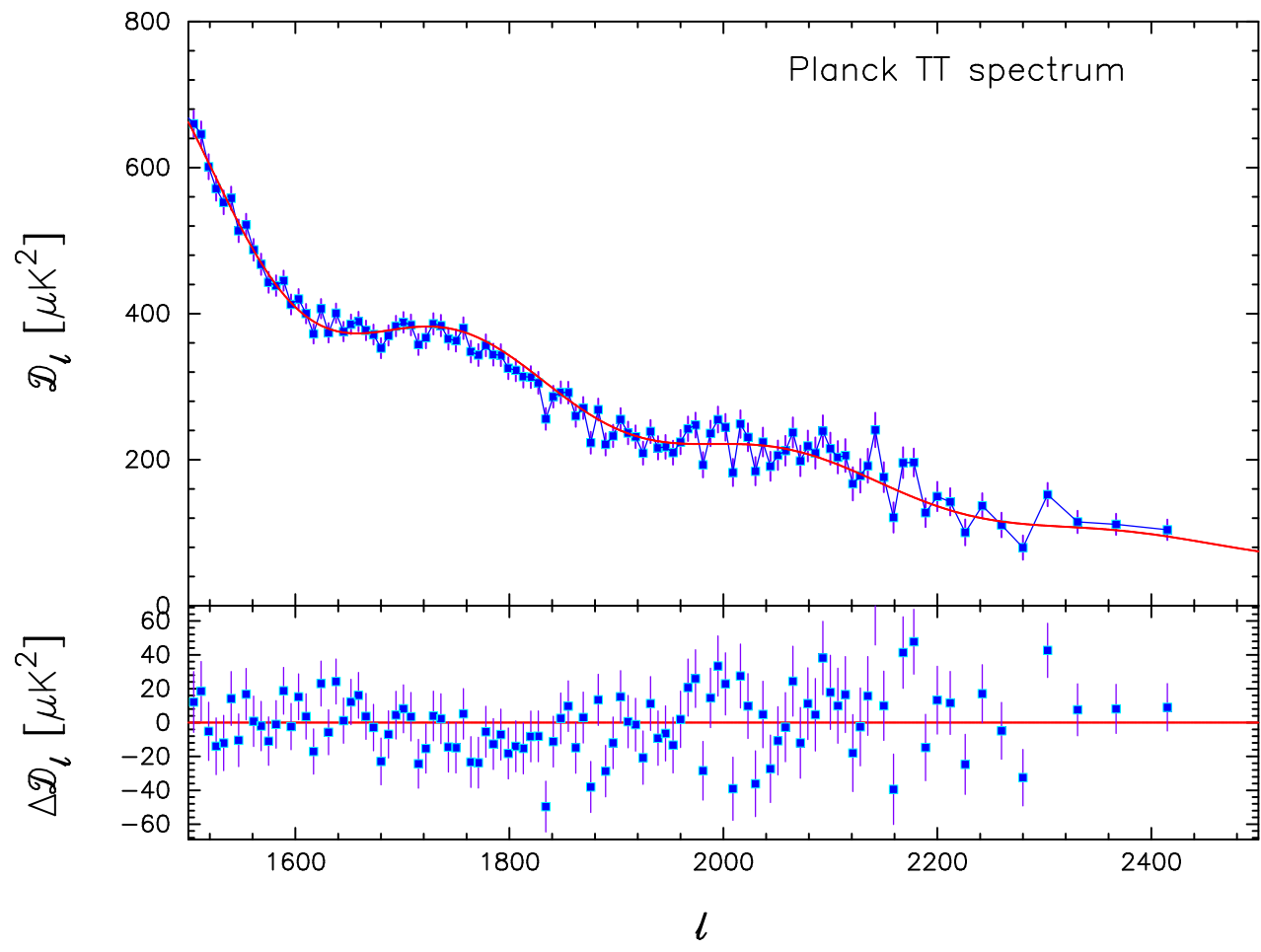


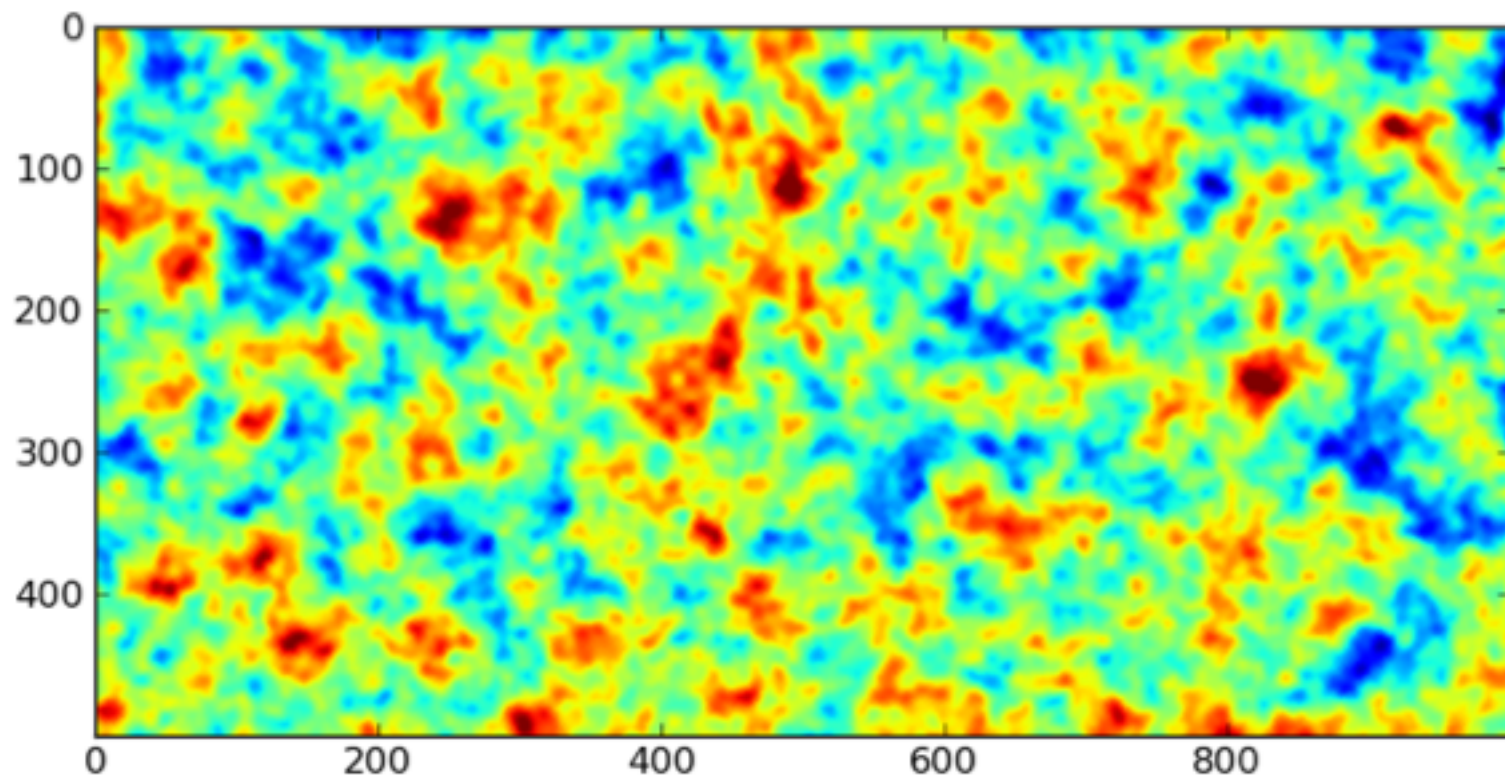


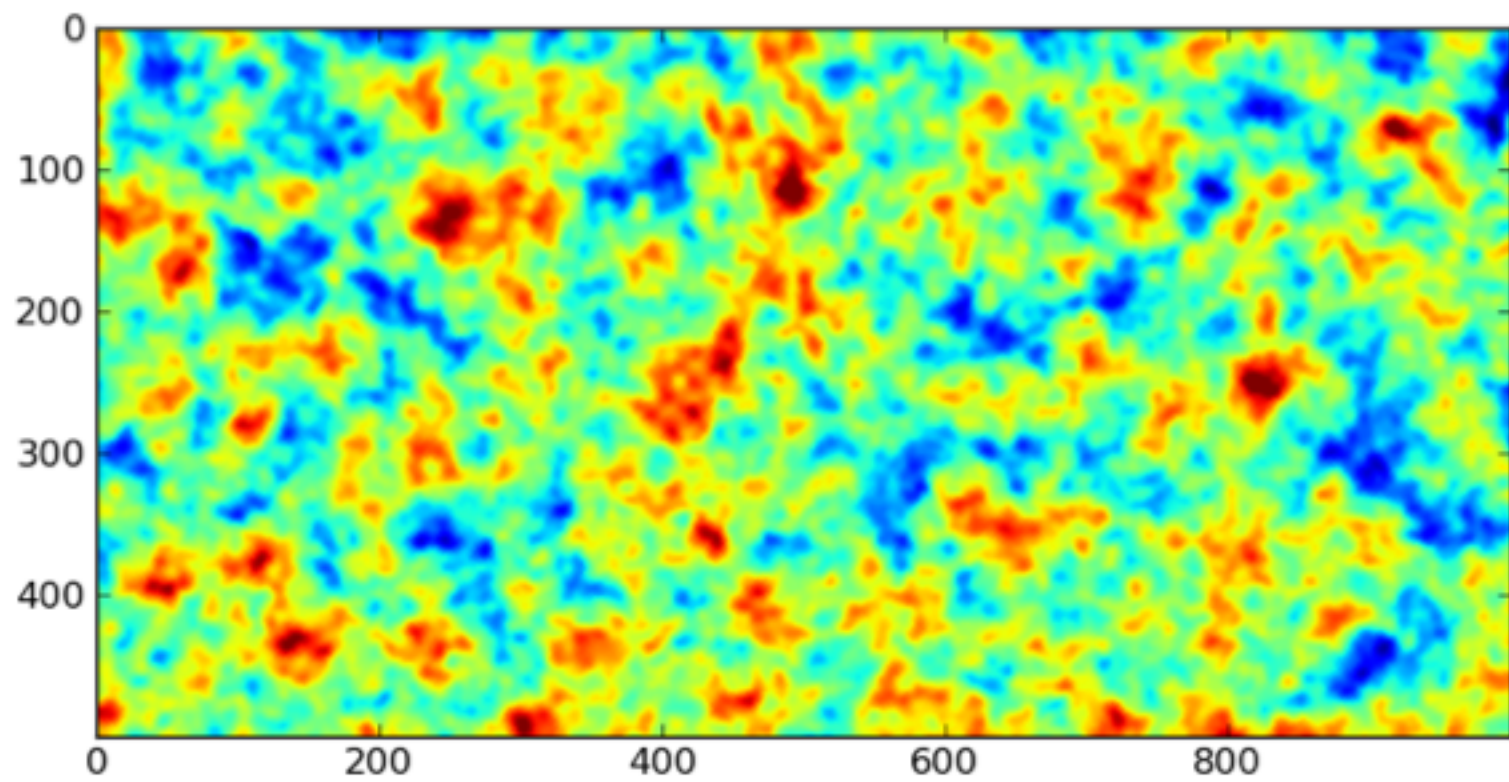


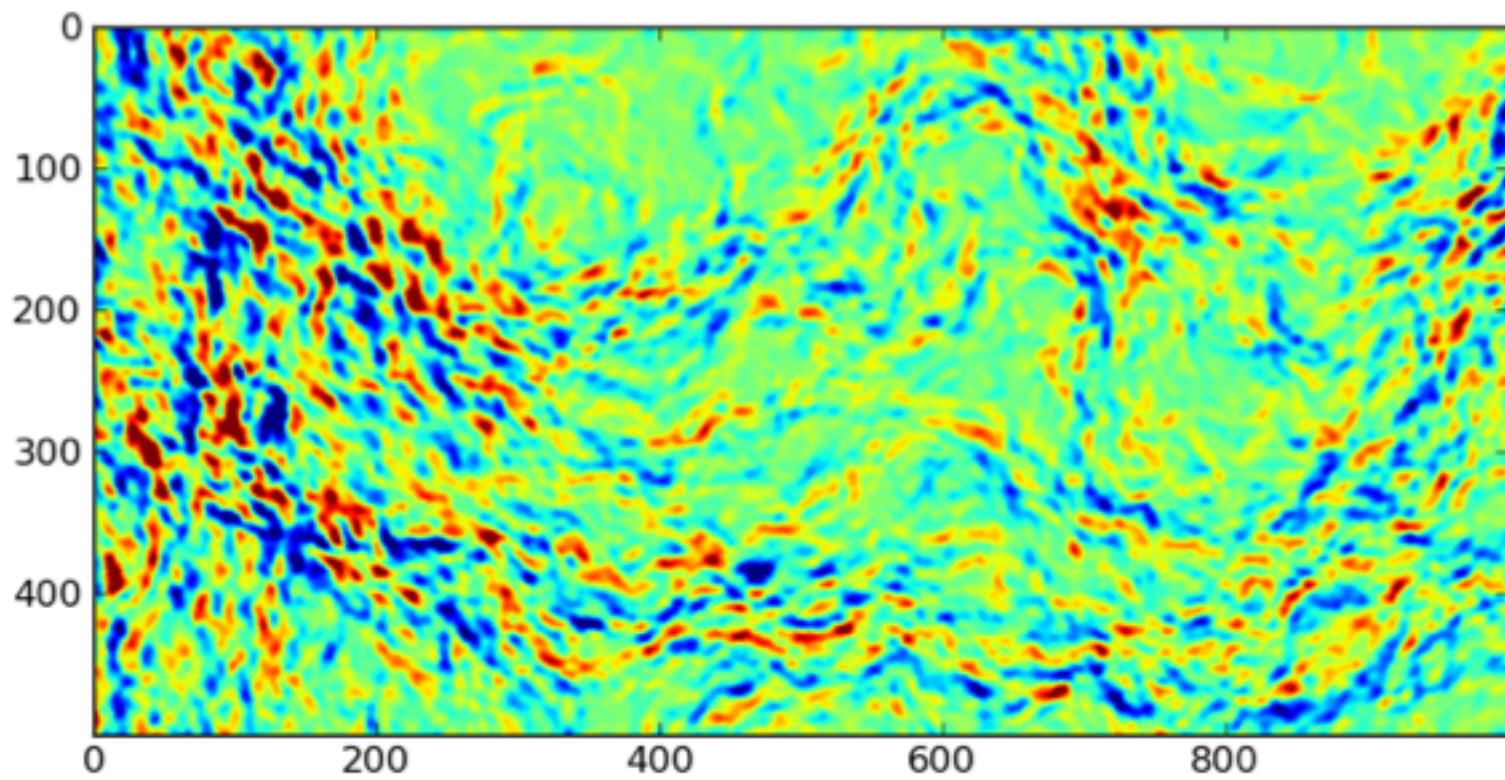


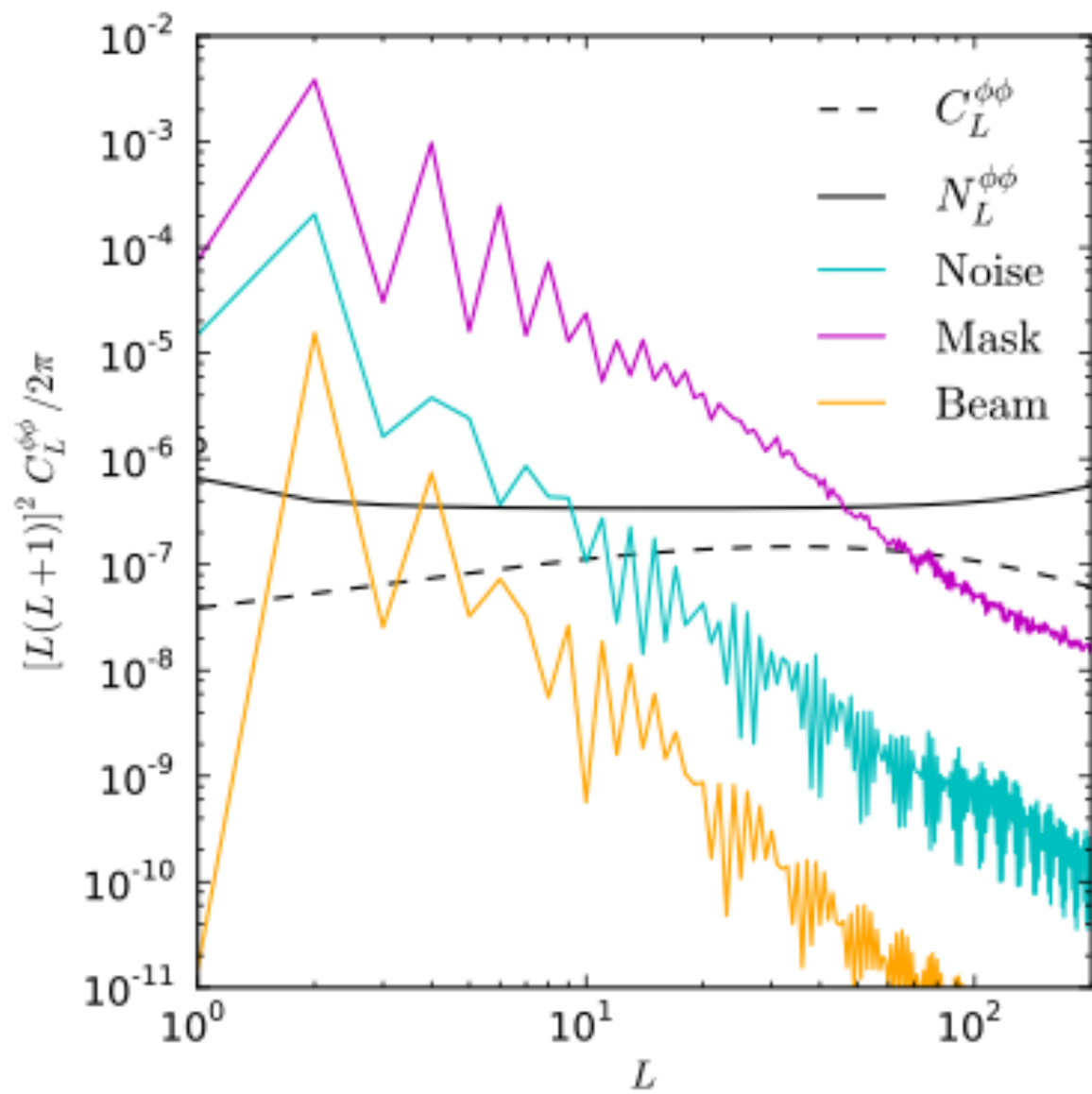






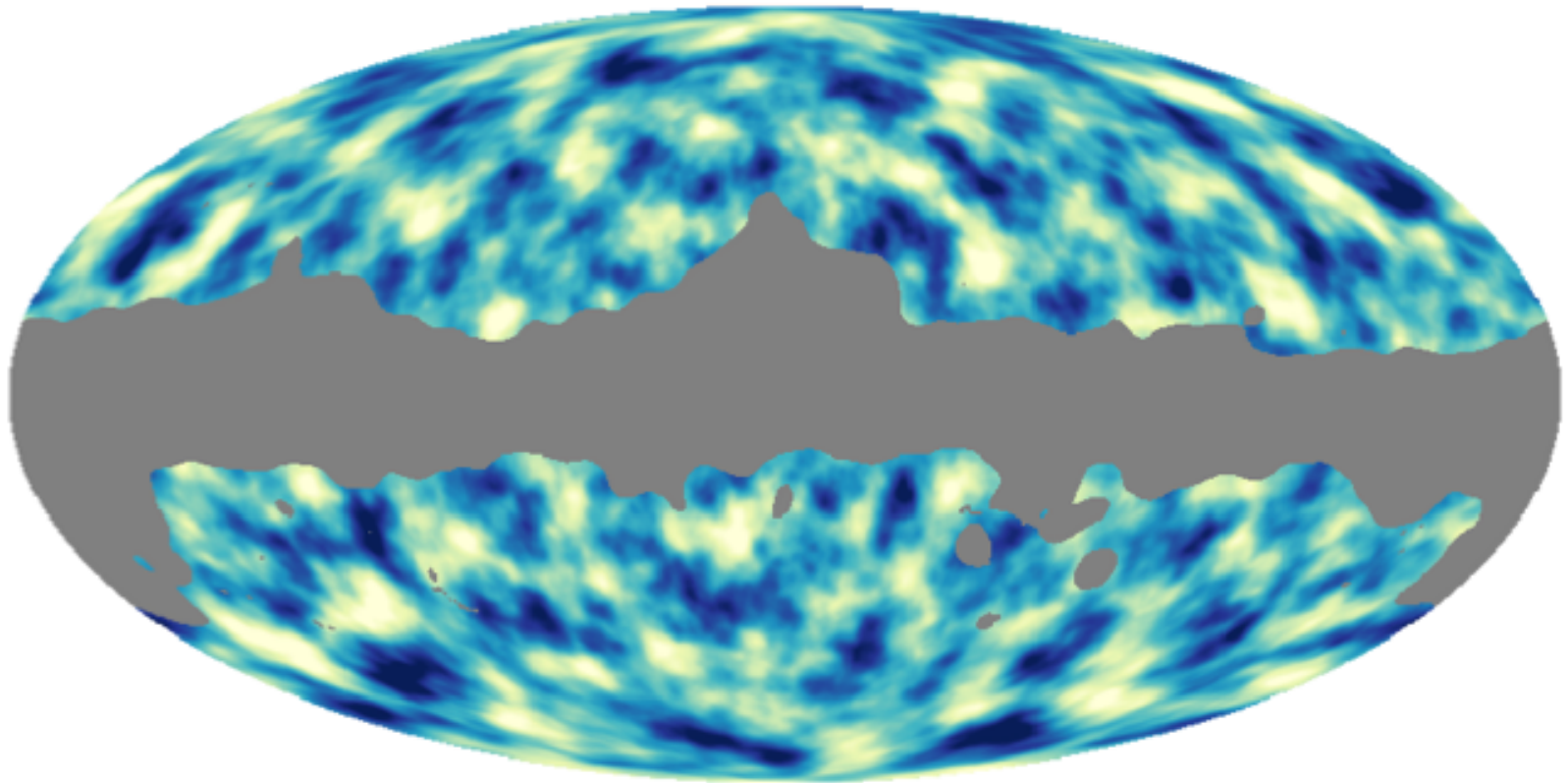




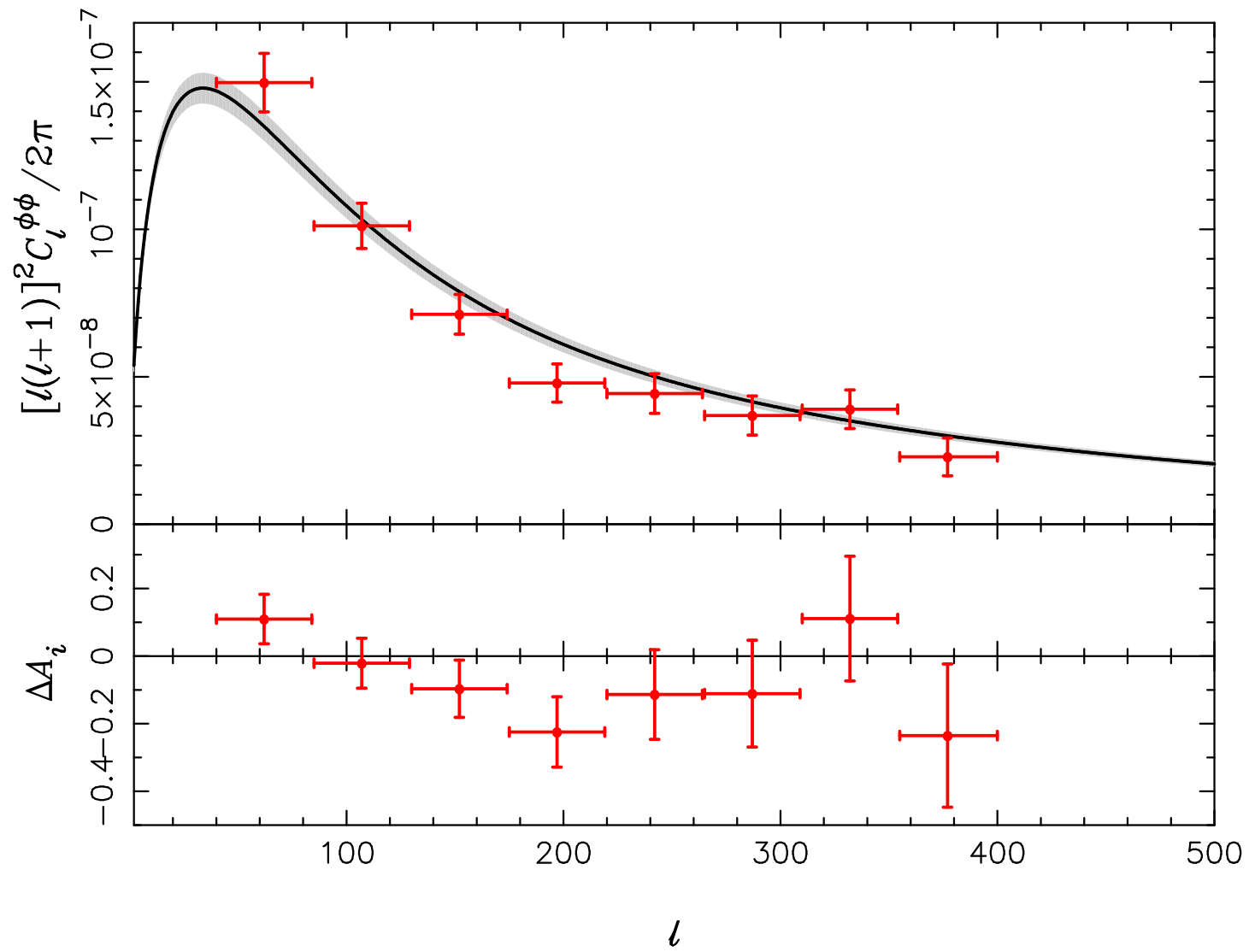


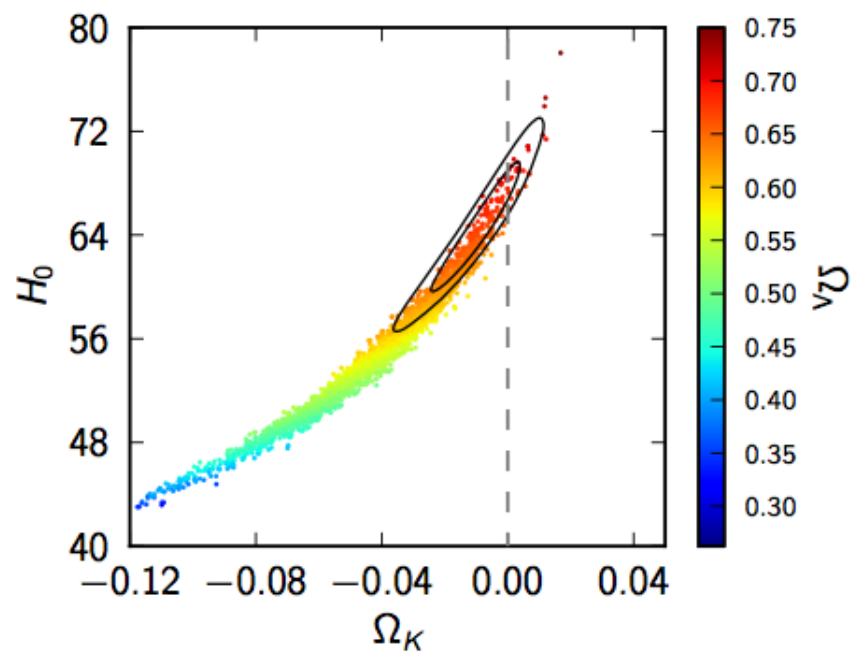
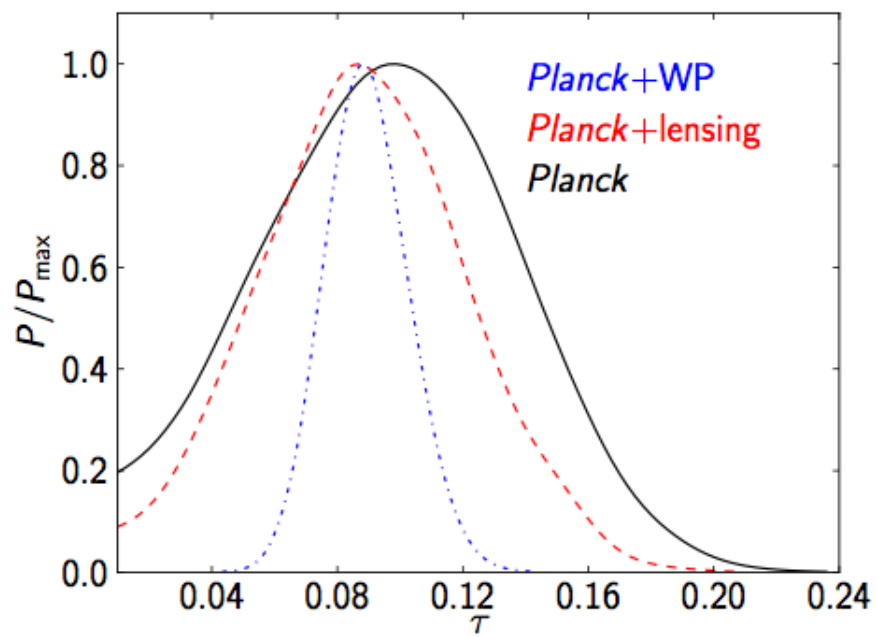
PLANCK'S FULL-SKY LENSING MAP

Mollweide view

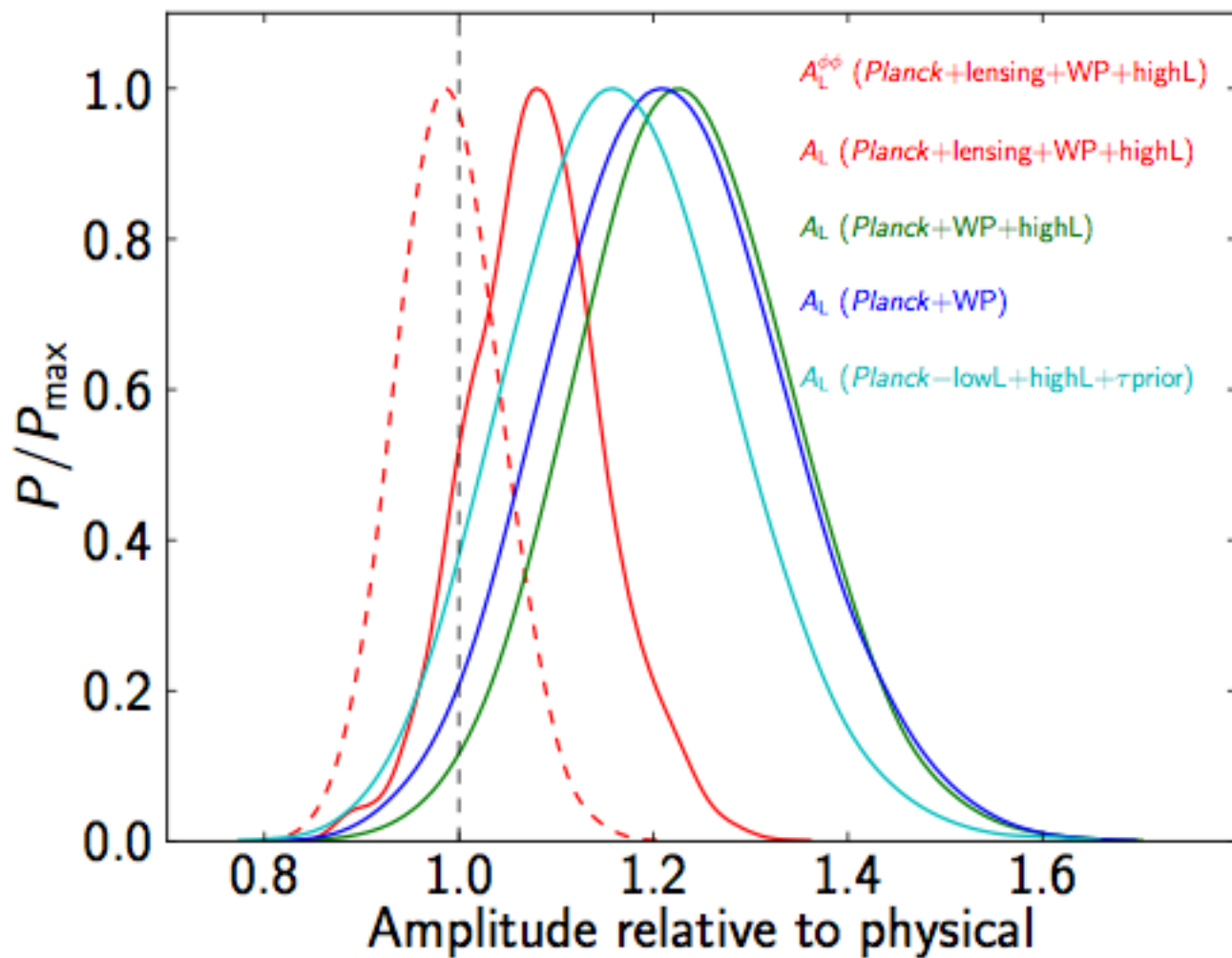


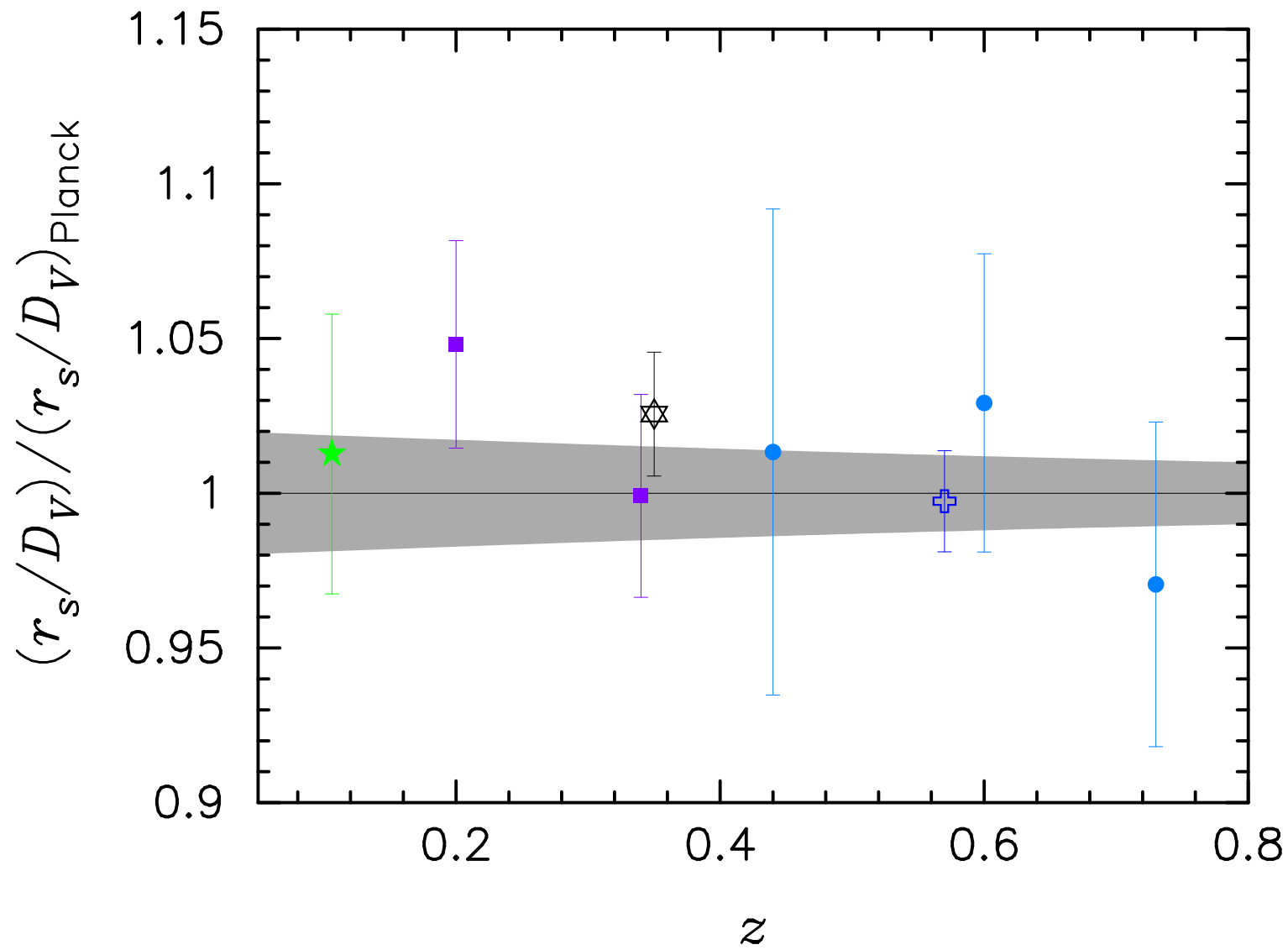
- Wiener-filtered reconstruction based on 143+217 GHz map

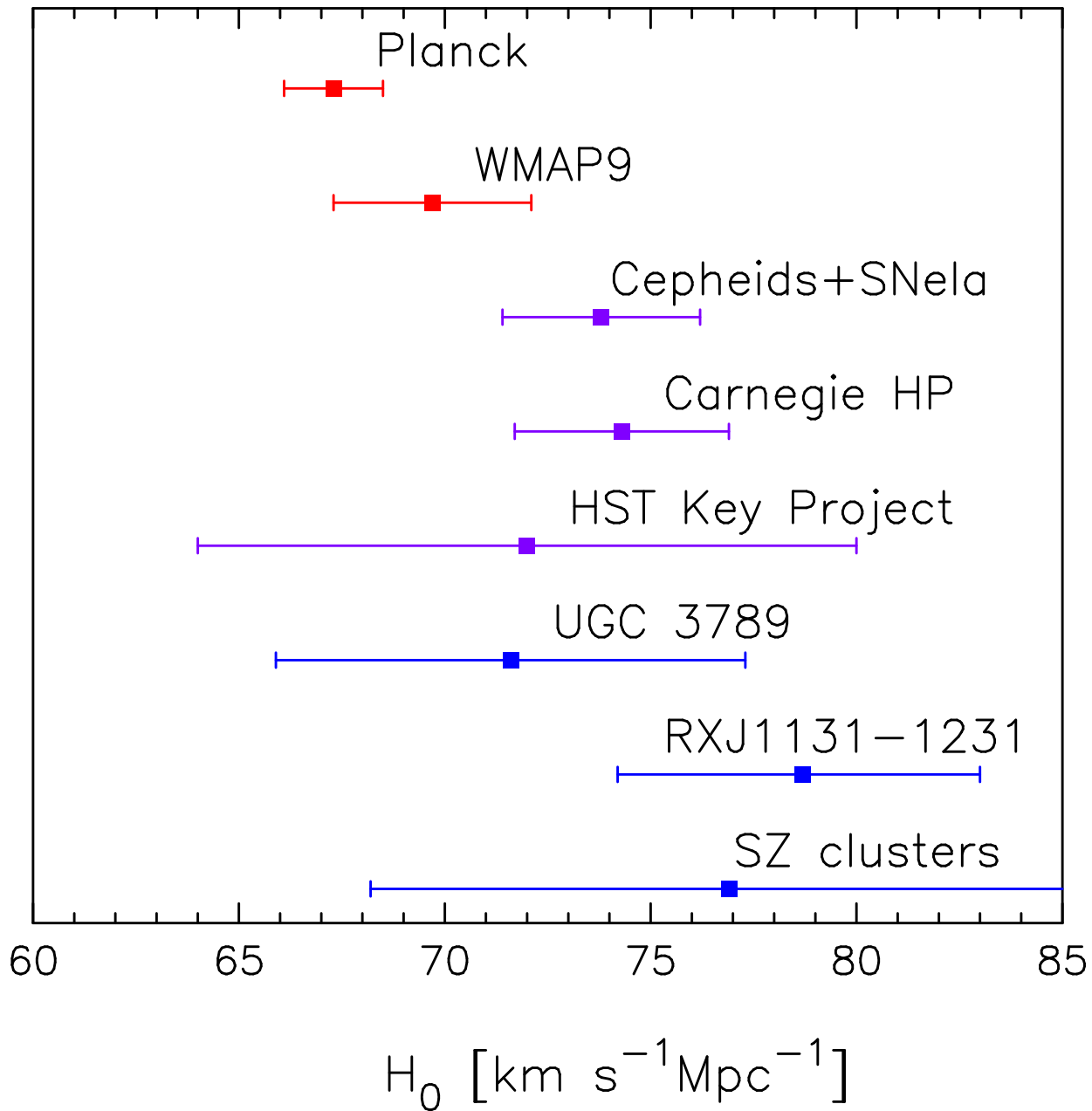


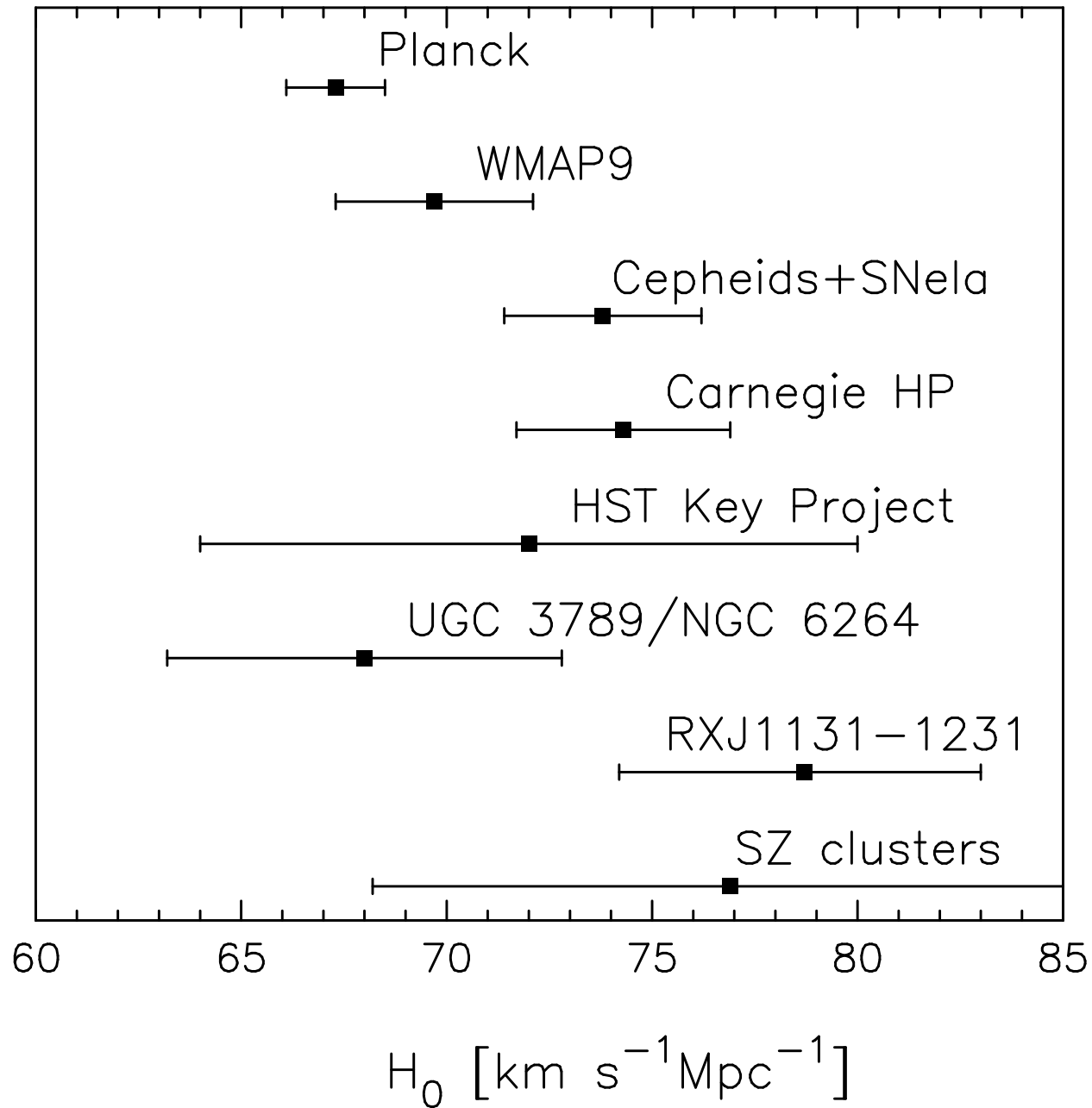


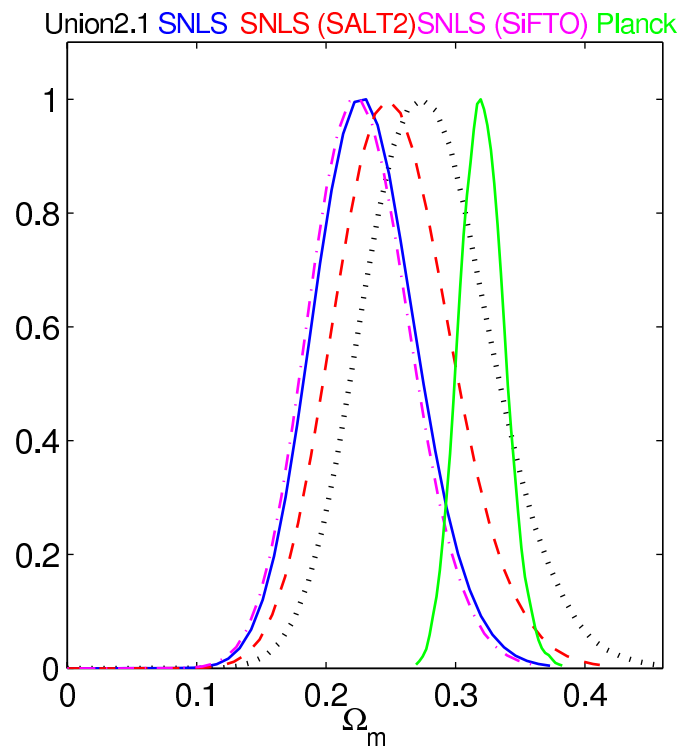
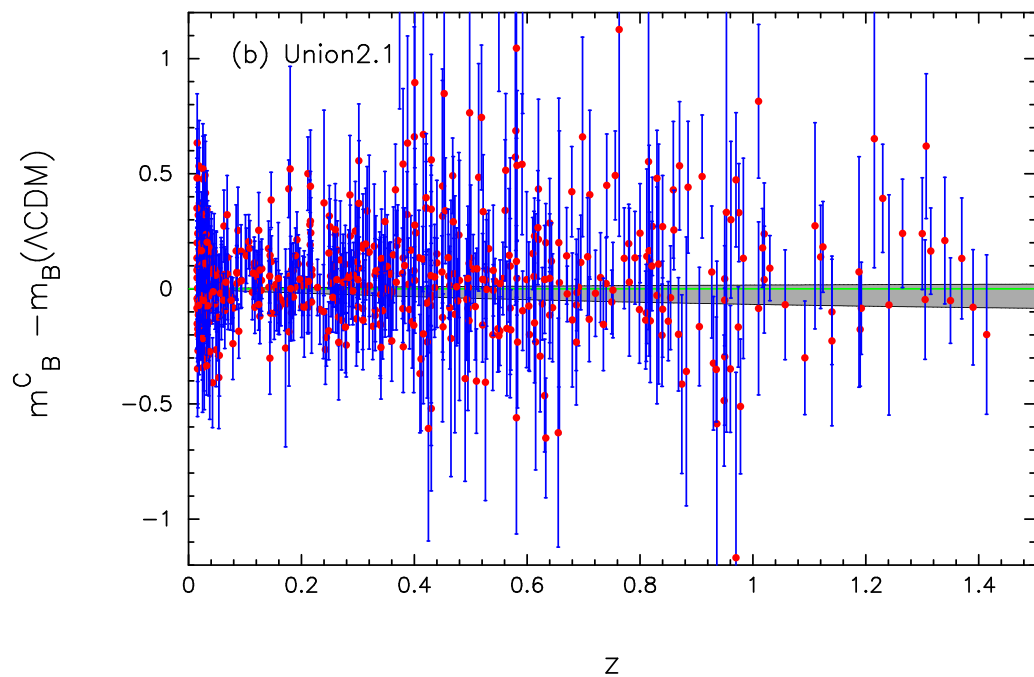
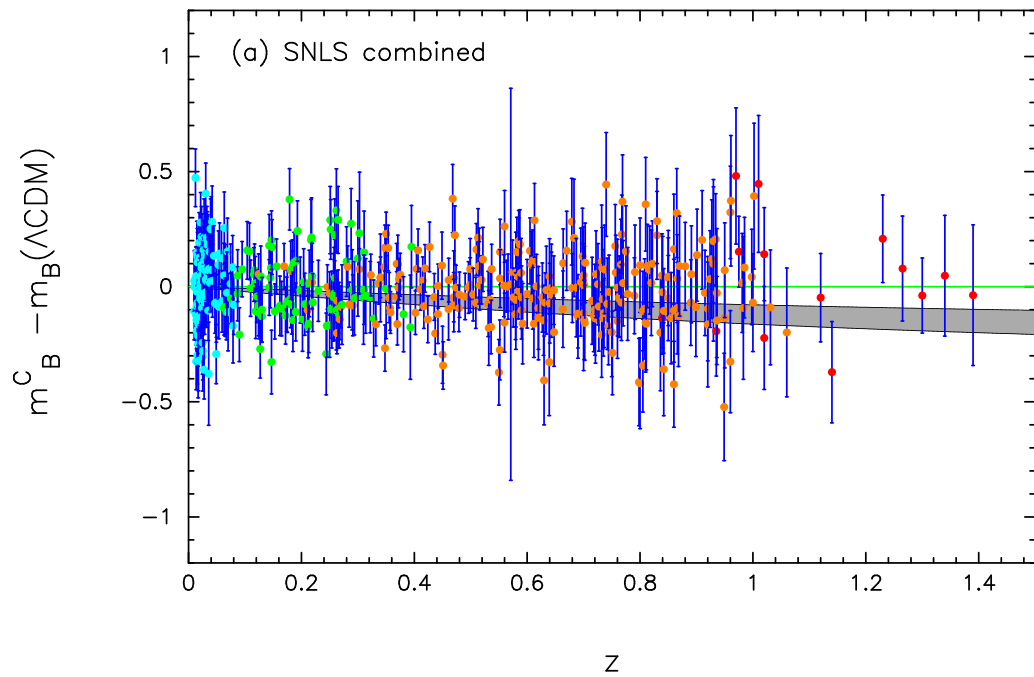
$$C_l^\phi \rightarrow A_L C_l^\phi$$

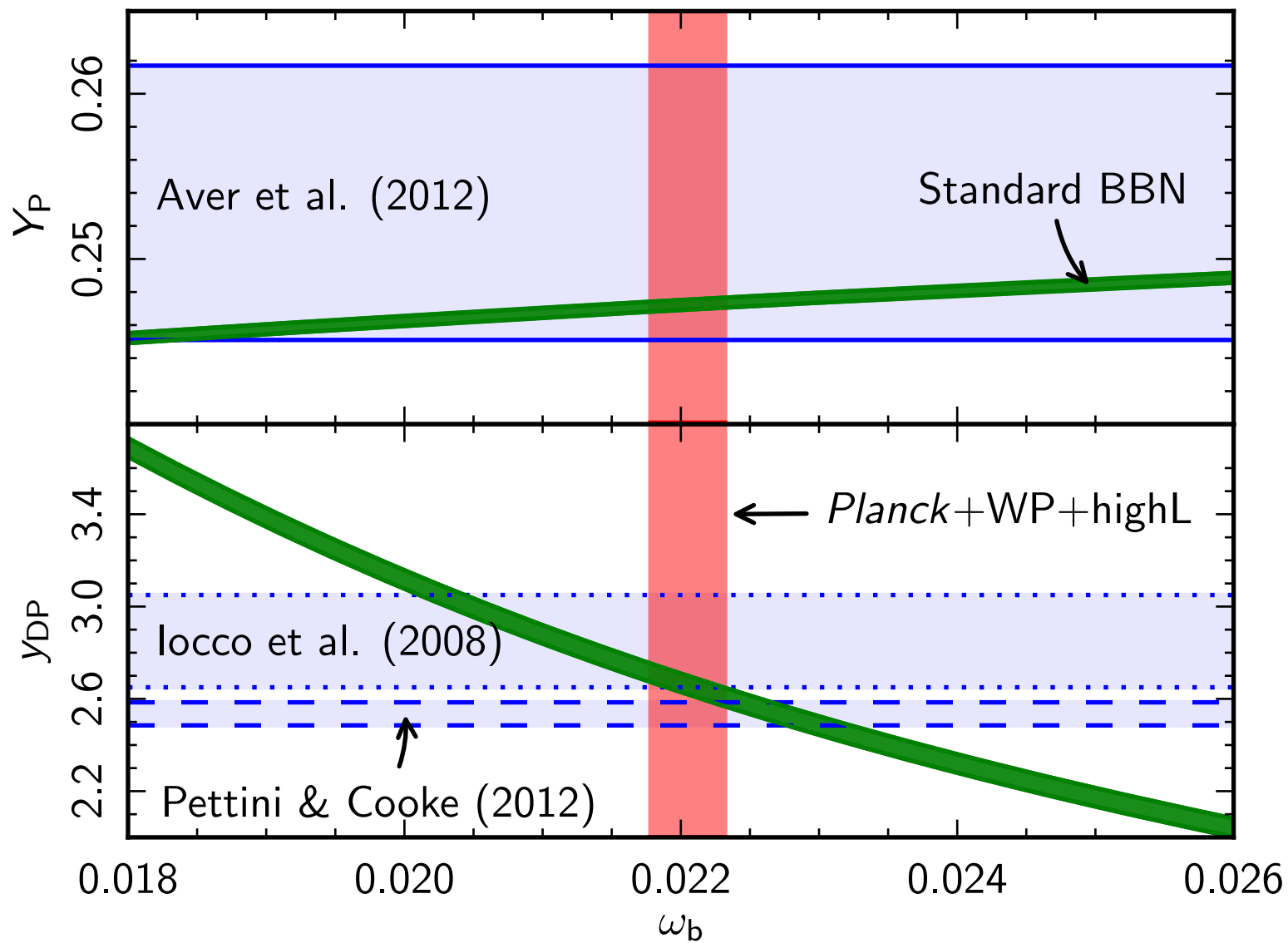


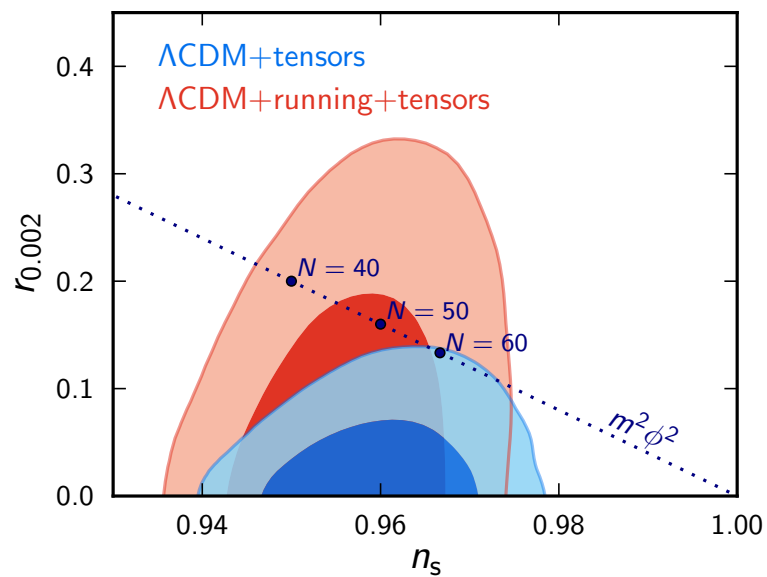
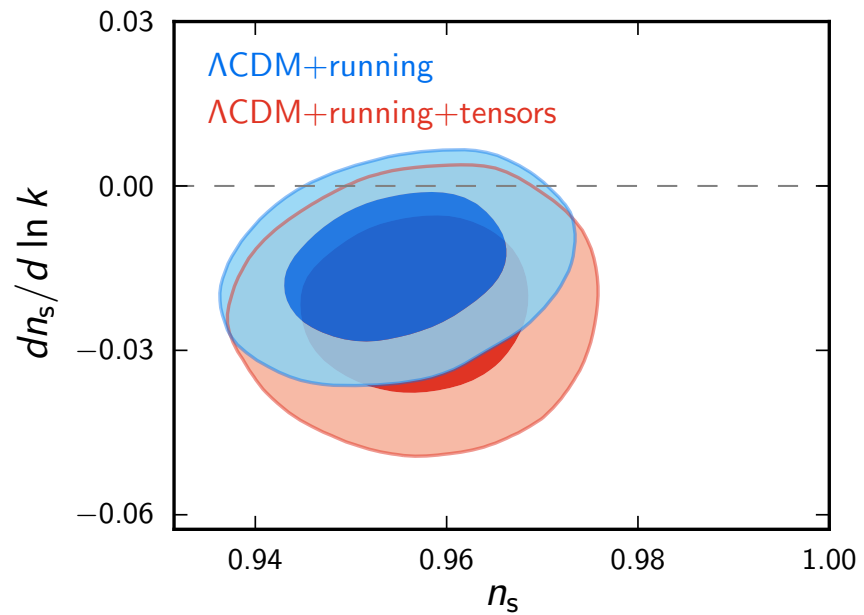
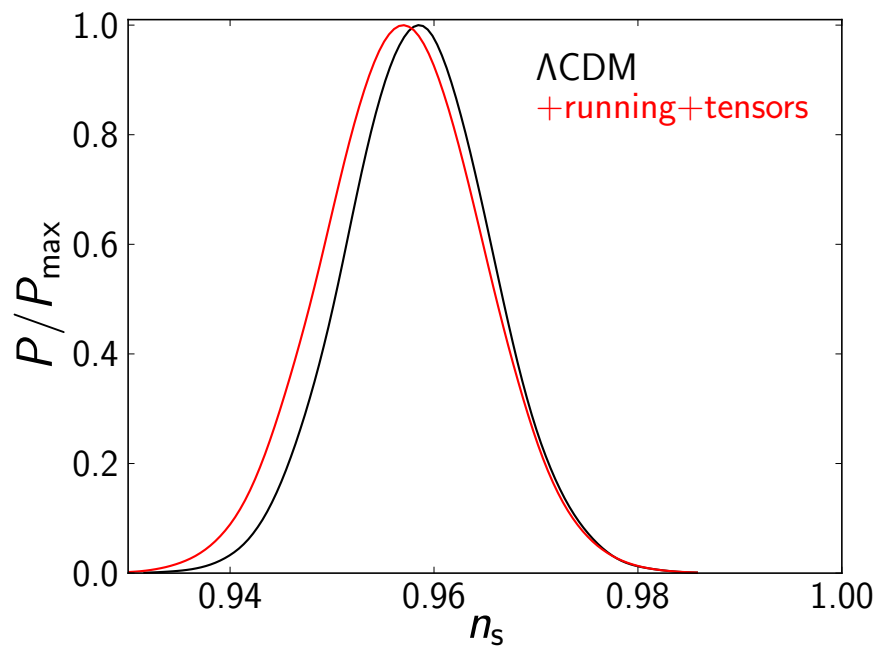






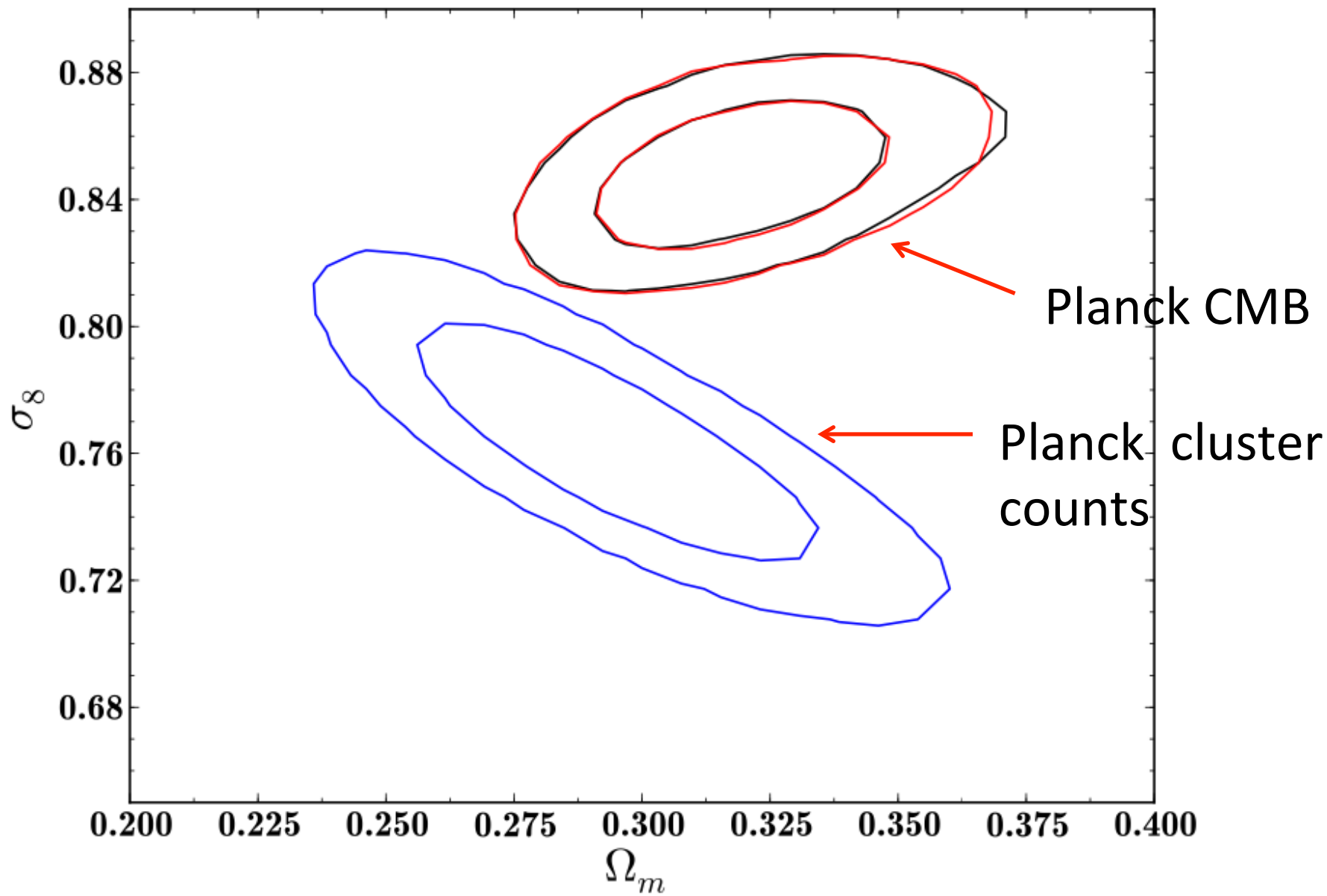






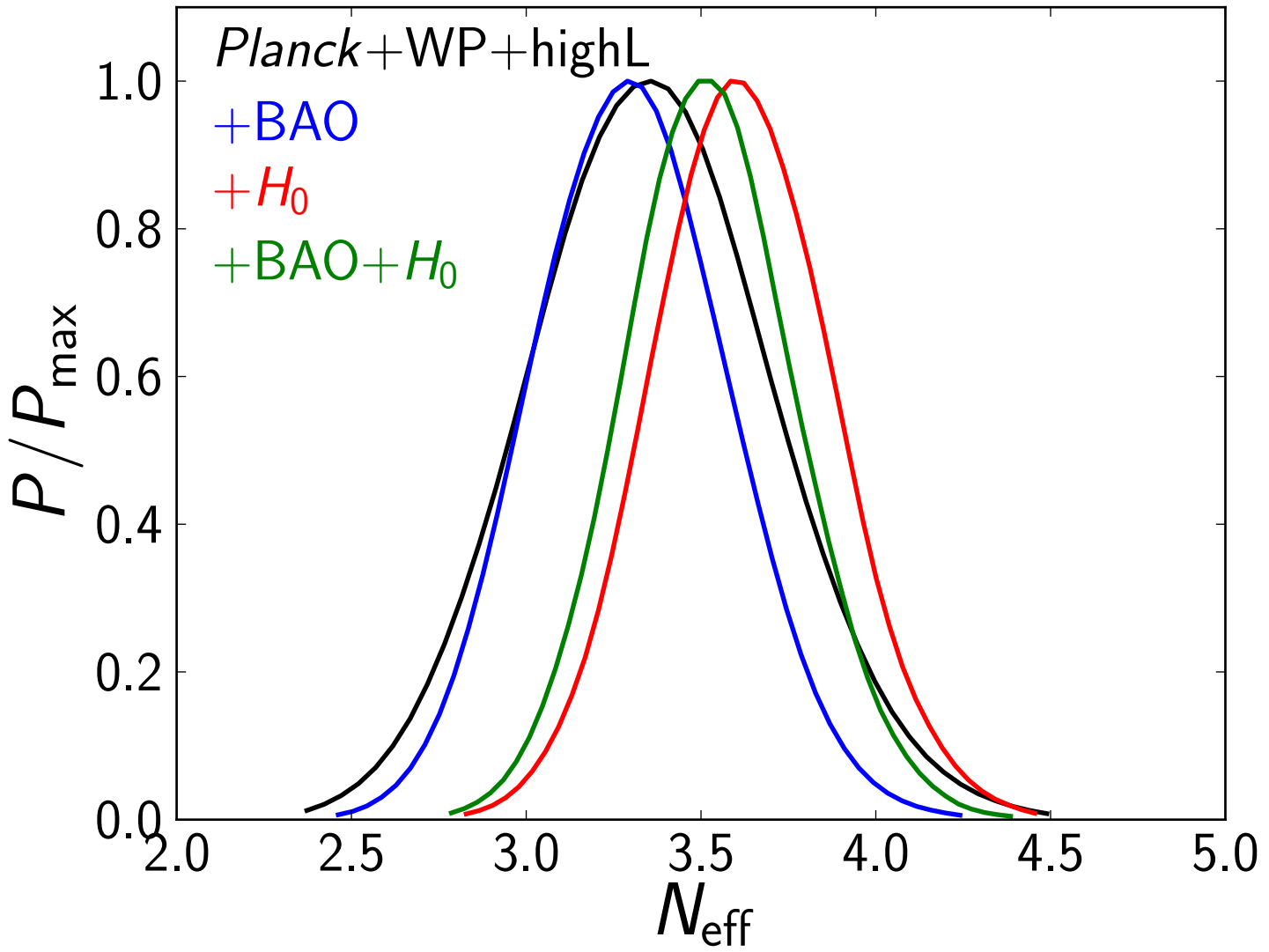
BASE Λ CDM MODEL

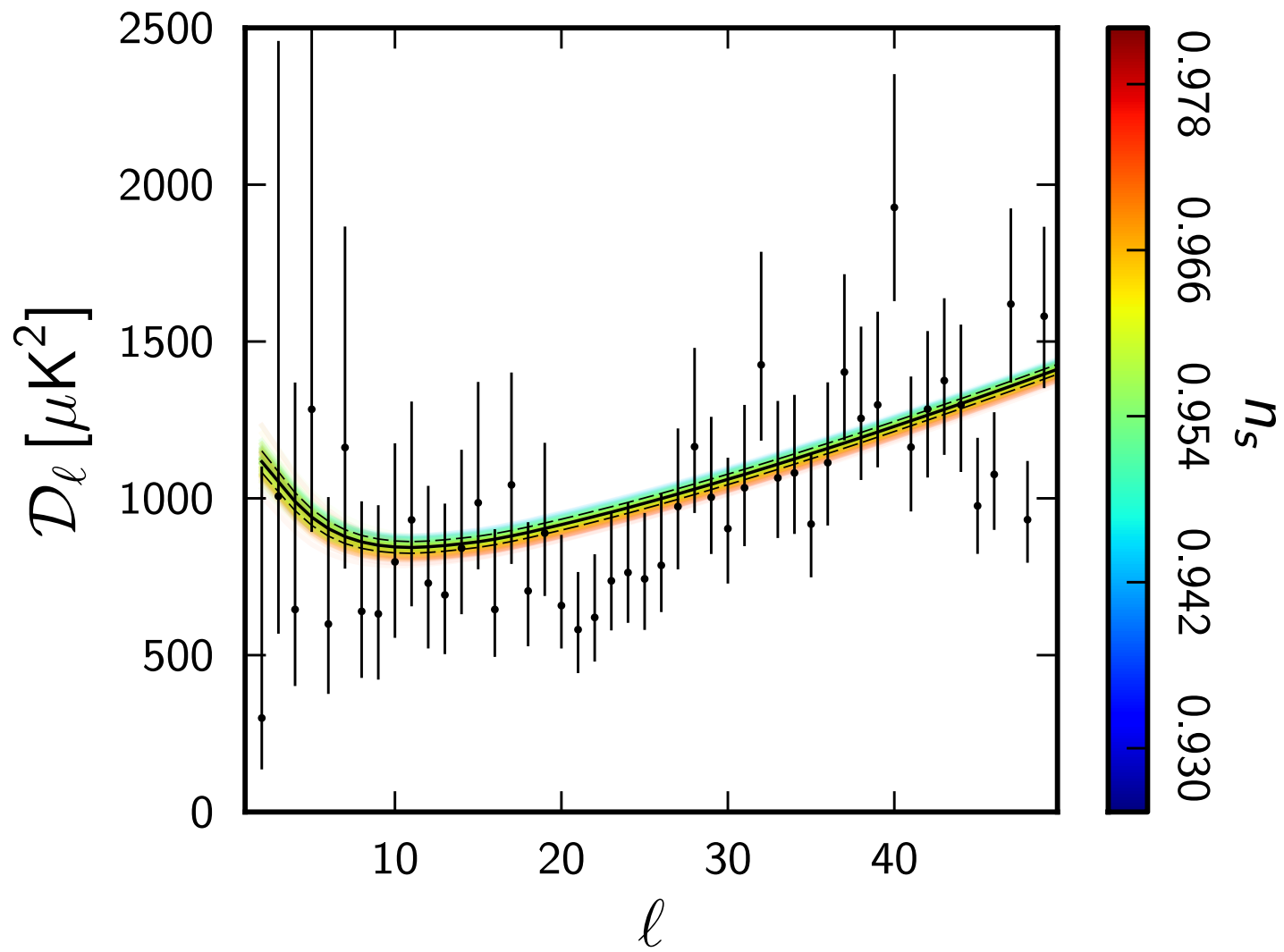
Parameter	Value (68%)
$\Omega_b h^2$	0.02207 ± 0.00027
$\Omega_c h^2$	0.1198 ± 0.0026
$100\theta_*$	1.04148 ± 0.00062
τ	0.091 ± 0.014
n_s	0.9585 ± 0.0070
H_0	67.3 ± 1.2
Ω_Λ	0.685 ± 0.017
σ_8	0.828 ± 0.012
z_{re}	11.1 ± 1.1

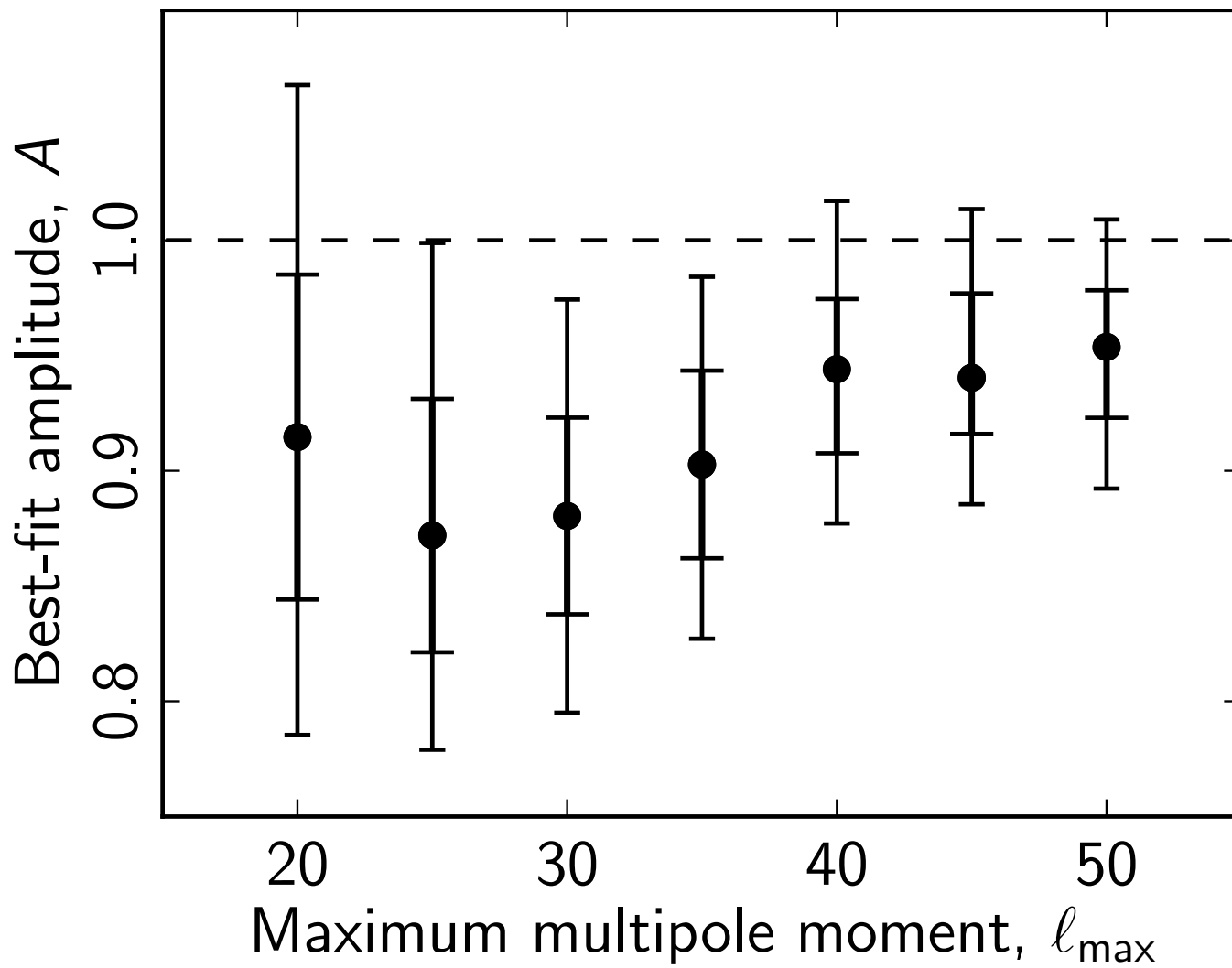


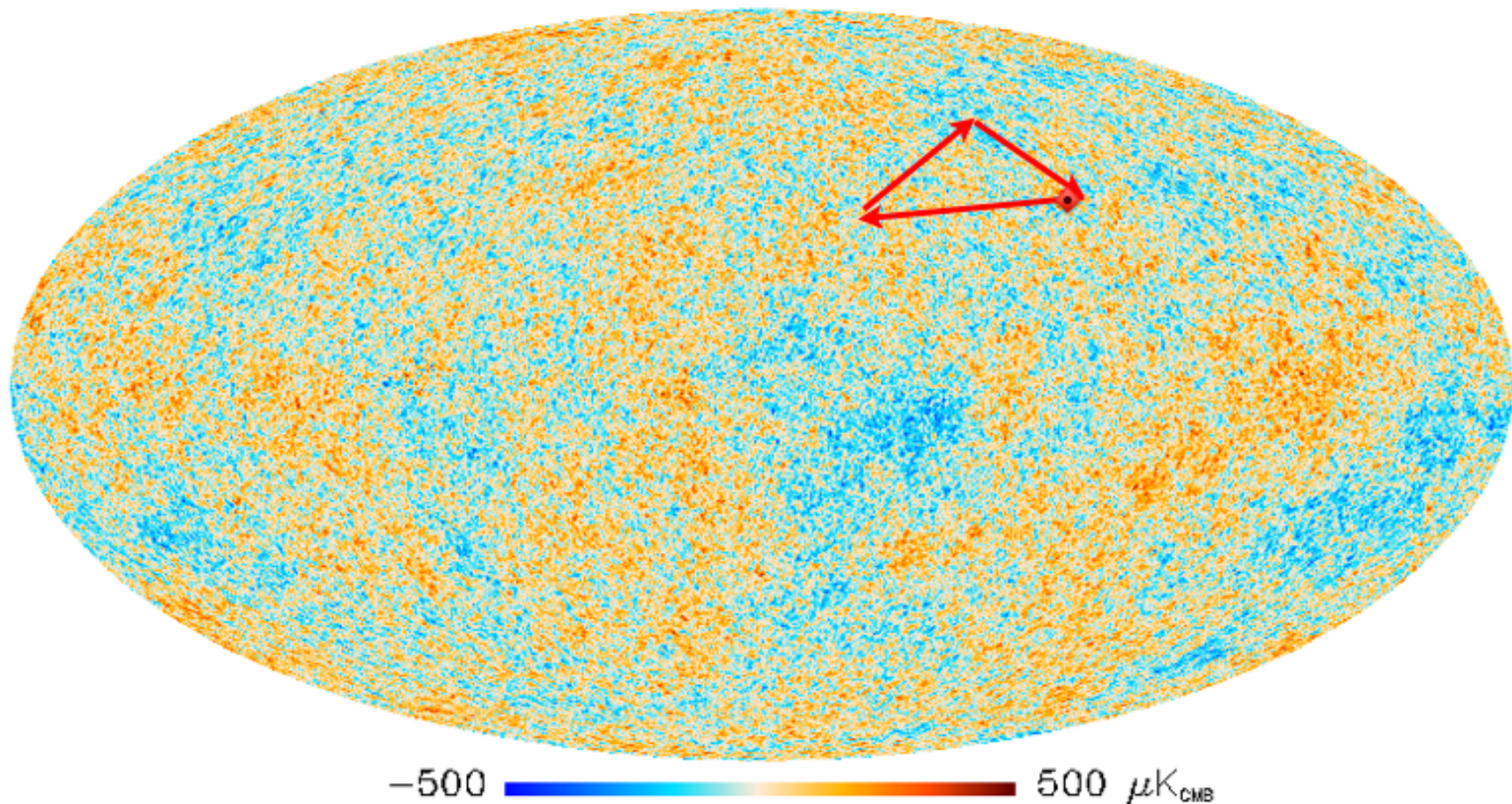
EXTENDED Λ CDM MODELS (Planck+BAO)

Parameter	Value (95%)
Ω_K	-0.0005 ± 0.0066
Σm_ν (eV)	< 0.23
N_{eff}	3.30 ± 0.54
Y_p	0.267 ± 0.040
$dn_s/d\ln k$	-0.014 ± 0.017
$r_{0.002}$	< 0.11
w	-1.13 ± 0.24



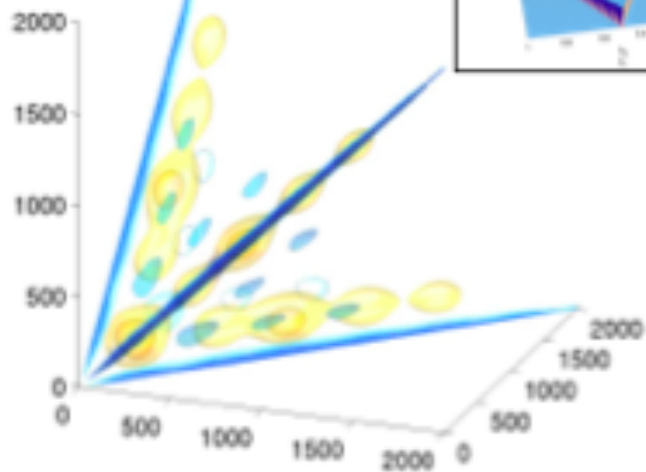
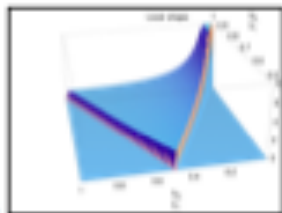
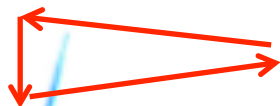




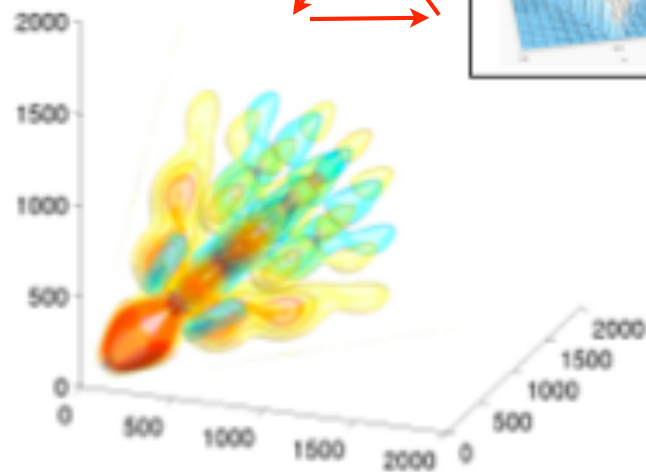
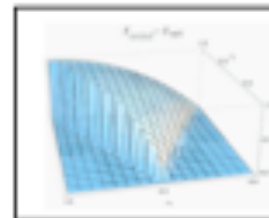
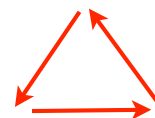


$$\langle \Phi(\mathbf{k}_1)\Phi(\mathbf{k}_2)\Phi(\mathbf{k}_3) \rangle = (2\pi)^3 \delta(\mathbf{k}_1 + \mathbf{k}_2 + \mathbf{k}_3) B_\Phi(k_1, k_2, k_3)$$
$$B_\Phi(k_1, k_2, k_3) = f_{NL} F(k_1, k_2, k_3)$$

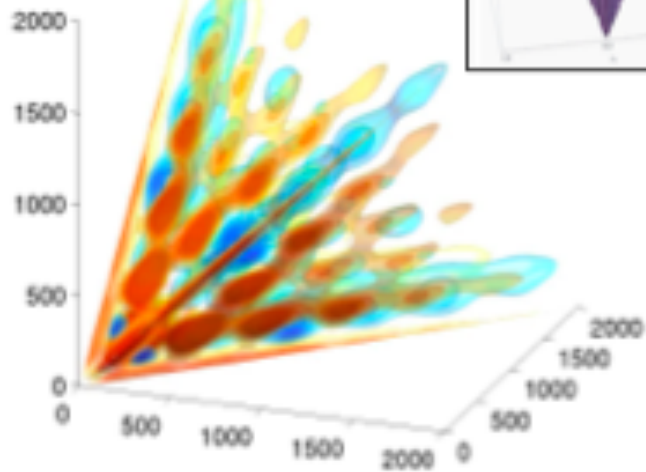
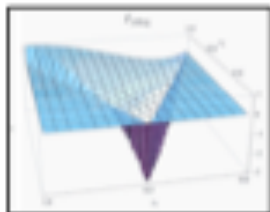
Local



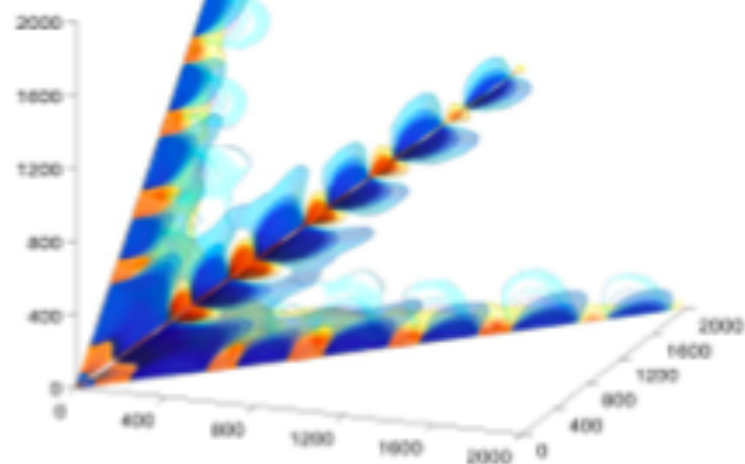
Equilateral

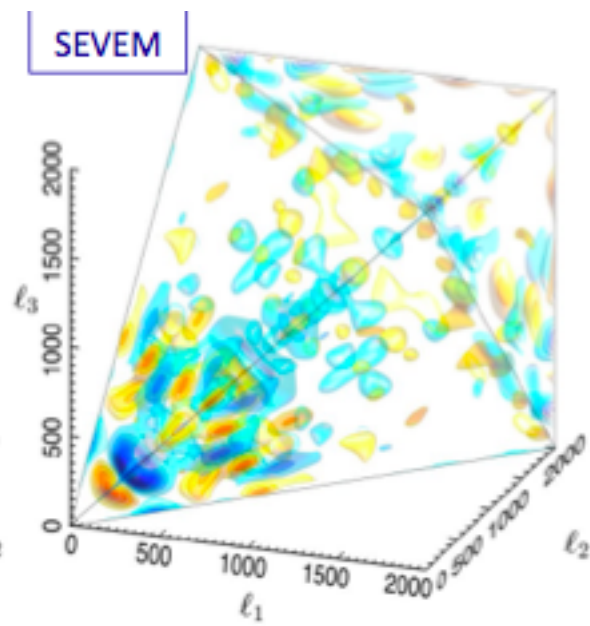
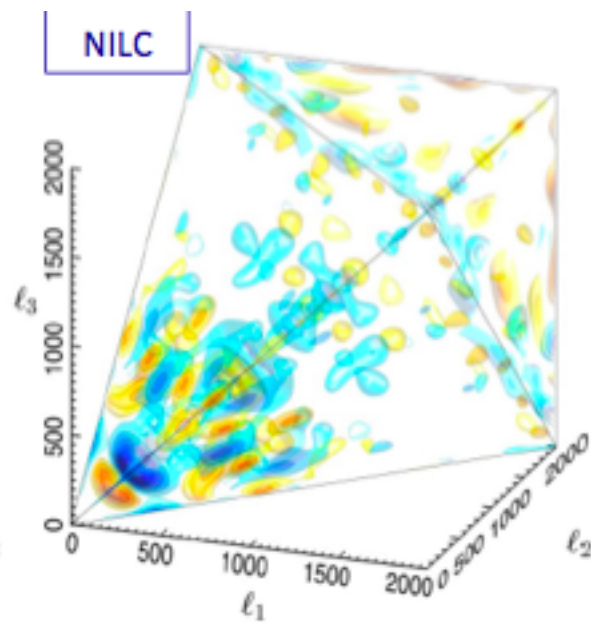
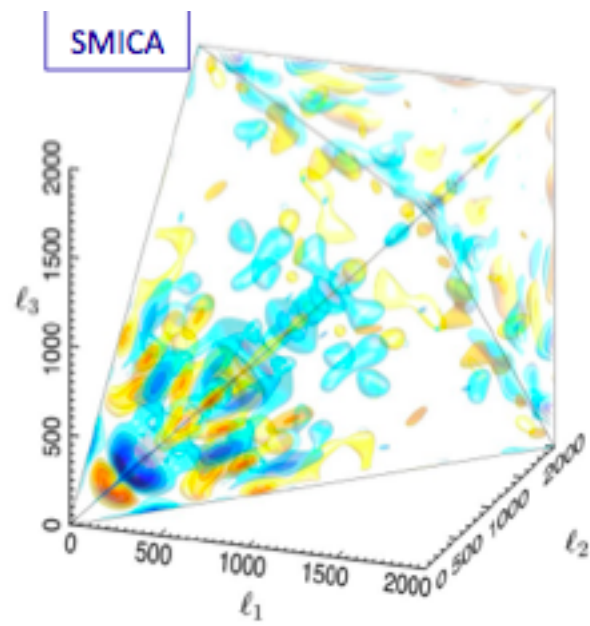


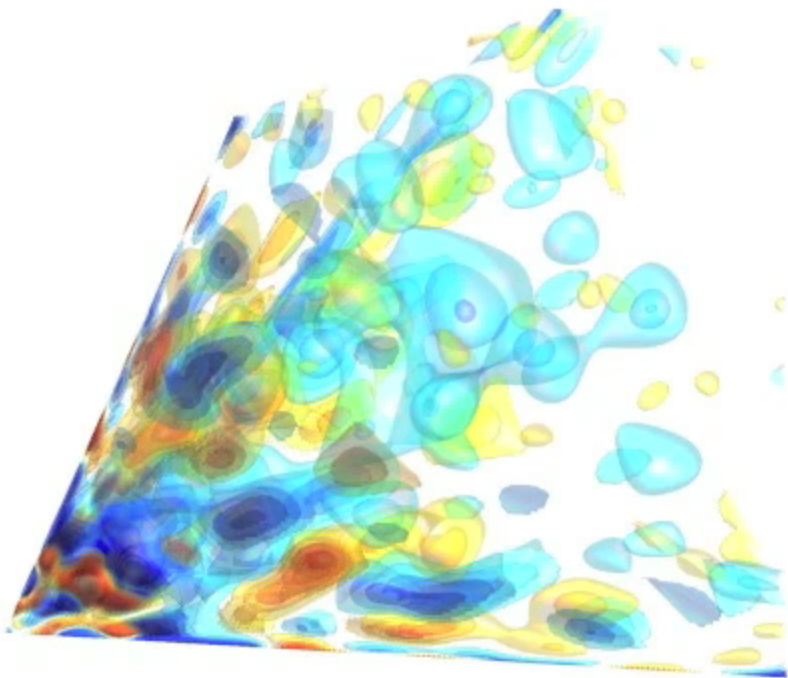
Orthog.



ISW-I.







Modal FLS Bispectrum Reconstruction (Planck Collaboration 2013)

	Independent			ISW-lensing subtracted			
	KSW	Binned	Modal	KSW	Binned	Modal	
SMICA							
Local	9.8 ± 5.8	9.2 ± 5.9	8.3 ± 5.9	.....	2.7 ± 5.8	2.2 ± 5.9	1.6 ± 6.0
Equilateral	-37 ± 75	-20 ± 73	-20 ± 77	.....	-42 ± 75	-25 ± 73	-20 ± 77
Orthogonal	-46 ± 39	-39 ± 41	-36 ± 41	.....	-25 ± 39	-17 ± 41	-14 ± 42
NILC							
Local	11.6 ± 5.8	10.5 ± 5.8	9.4 ± 5.9	.....	4.5 ± 5.8	3.6 ± 5.8	2.7 ± 6.0
Equilateral	-41 ± 76	-31 ± 73	-20 ± 76	.....	-48 ± 76	-38 ± 73	-20 ± 78
Orthogonal	-74 ± 40	-62 ± 41	-60 ± 40	.....	-53 ± 40	-41 ± 41	-37 ± 43
SEVEM							
Local	10.5 ± 5.9	10.1 ± 6.2	9.4 ± 6.0	.....	3.4 ± 5.9	3.2 ± 6.2	2.6 ± 6.0
Equilateral	-32 ± 76	-21 ± 73	-13 ± 77	.....	-36 ± 76	-25 ± 73	-13 ± 78
Orthogonal	-34 ± 40	-30 ± 42	-24 ± 42	.....	-14 ± 40	-9 ± 42	-2 ± 42
C-R							
Local	12.4 ± 6.0	11.3 ± 5.9	10.9 ± 5.9	.....	6.4 ± 6.0	5.5 ± 5.9	5.1 ± 5.9
Equilateral	-60 ± 79	-52 ± 74	-33 ± 78	.....	-62 ± 79	-55 ± 74	-32 ± 78
Orthogonal	-76 ± 42	-60 ± 42	-63 ± 42	.....	-57 ± 42	-41 ± 42	-42 ± 42

Some inconsistencies with Λ CDM

- ❑ “Anomalies” – as WMAP, including hemispherical power asymmetry, cold spot, low multipole alignments, ‘Bianchi’ type large-scale anisotropy.
- ❑ “Favouritism” for a power-spectrum feature at $k \approx 0.1 \text{ Mpc}^{-1}$.
- ❑ “Feature” model non-Gaussianity seen in modal estimator.
- ❑ Cluster count σ_8 - Ω_m discrepancy with power spectrum parameters.
- ❑ Compton y map σ_8 - Ω_m discrepancy with power spectrum parameters.
- ❑

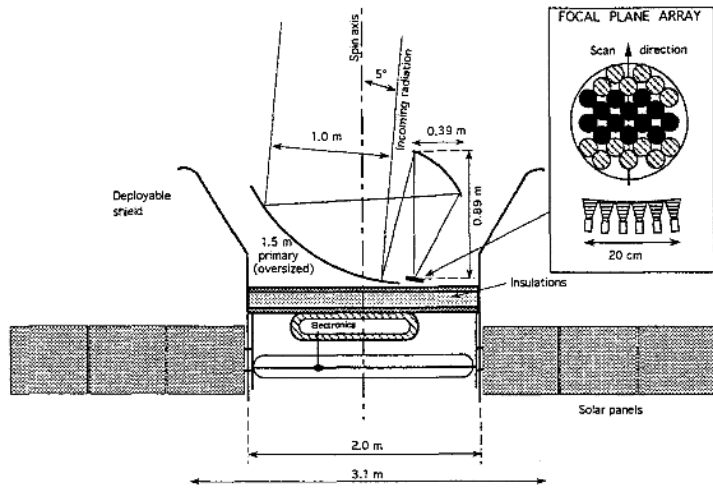
The scientific results that we present today are a product of the Planck Collaboration, including individuals from more than 100 scientific institutes in Europe, the USA and Canada



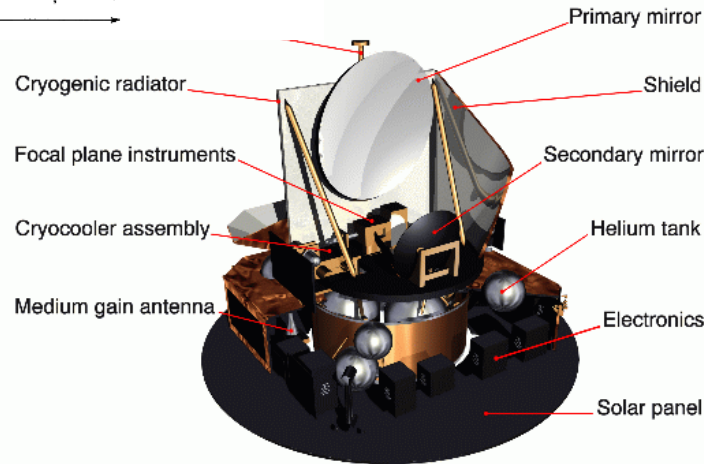
planck

Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.

Proposal (1992)



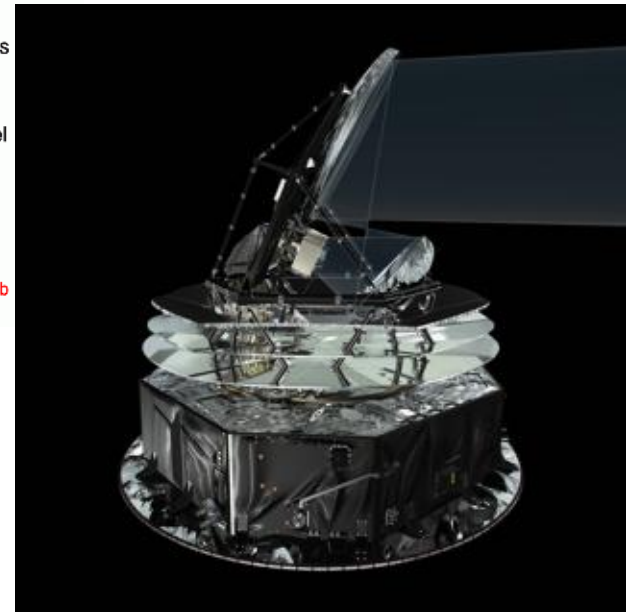
Selection (1996)

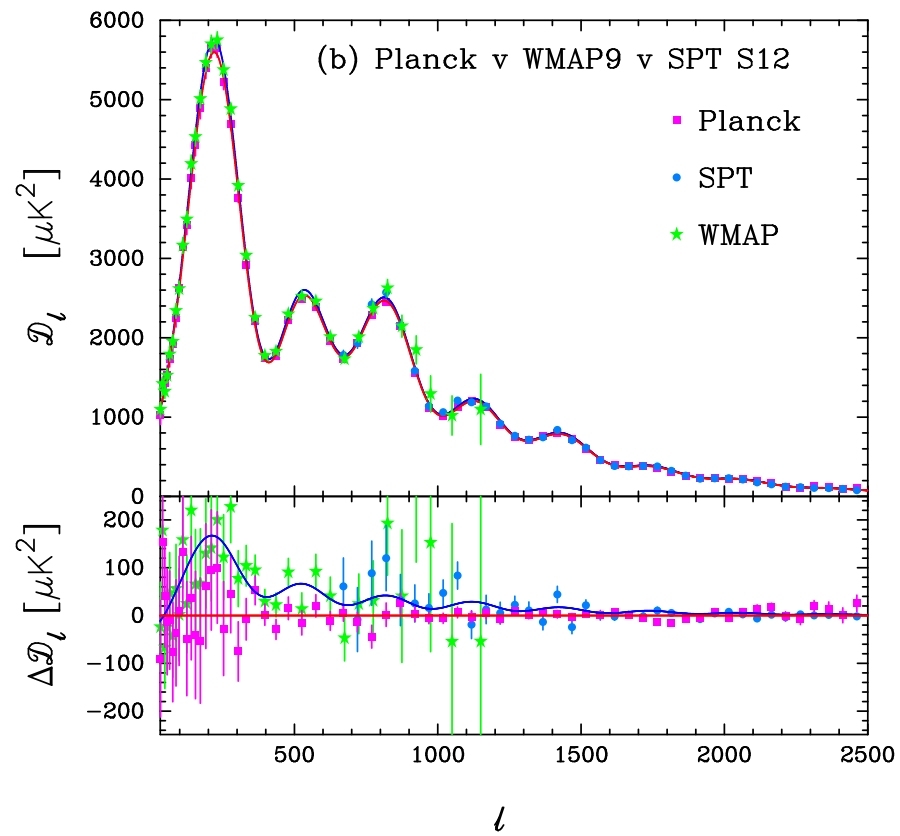
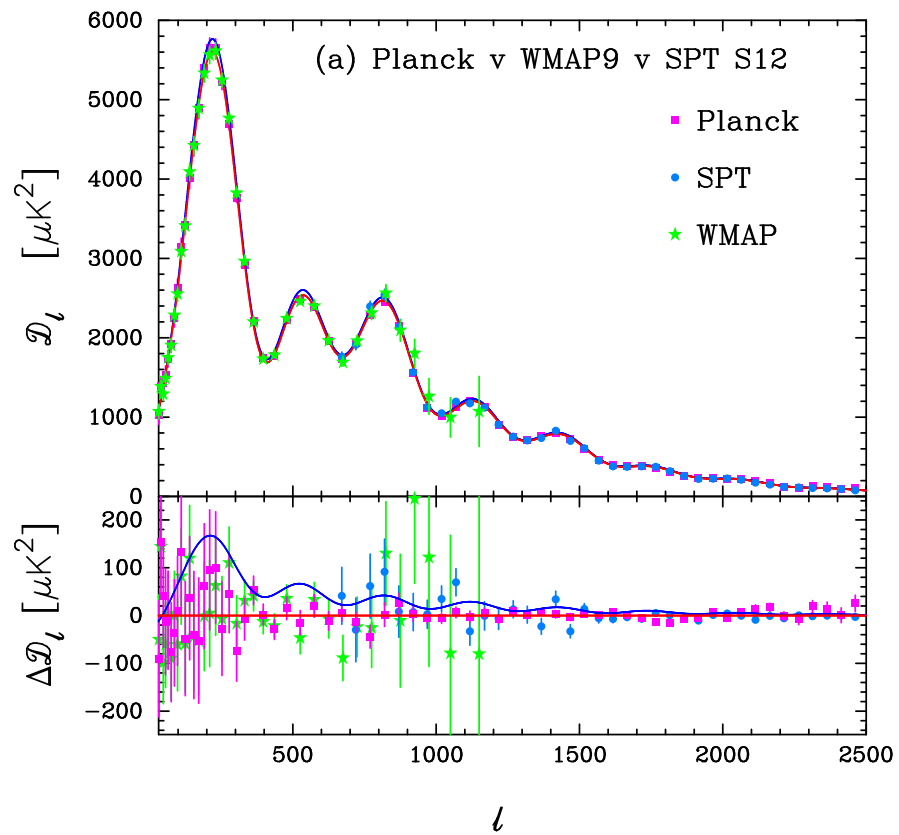


COBRAS/SAMBA

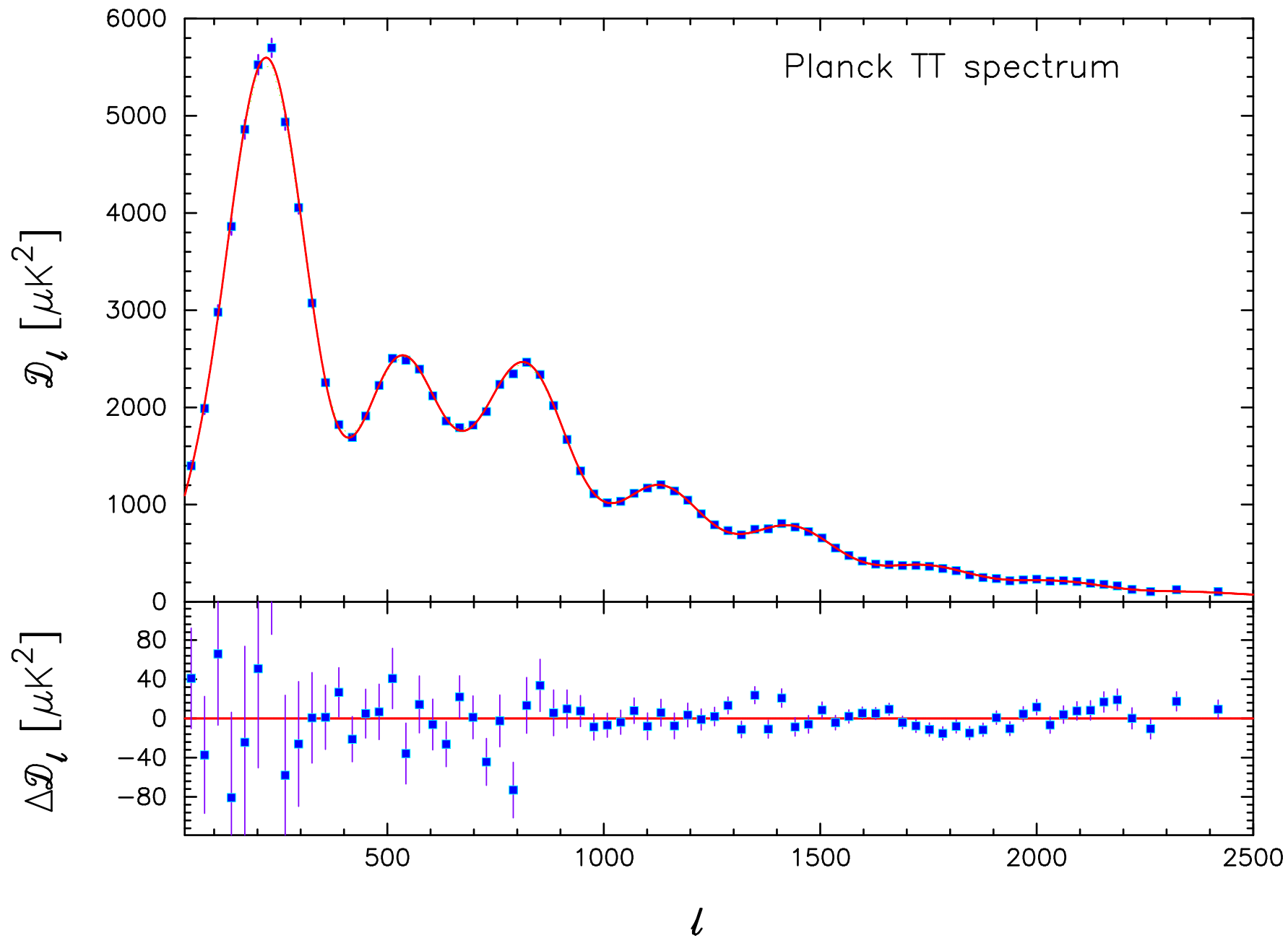
esa
ISD VisuLab

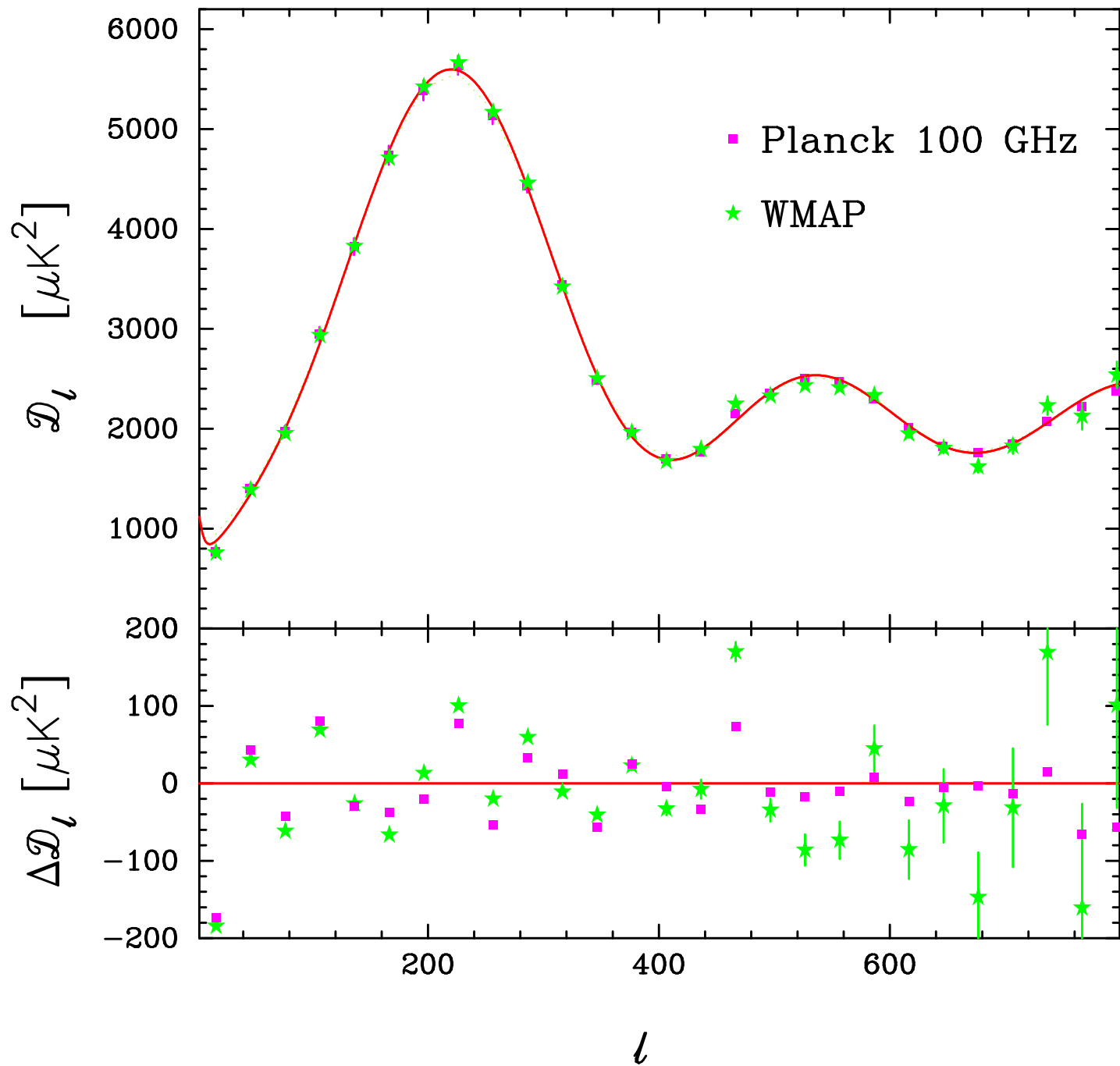
Launch May 2009!!



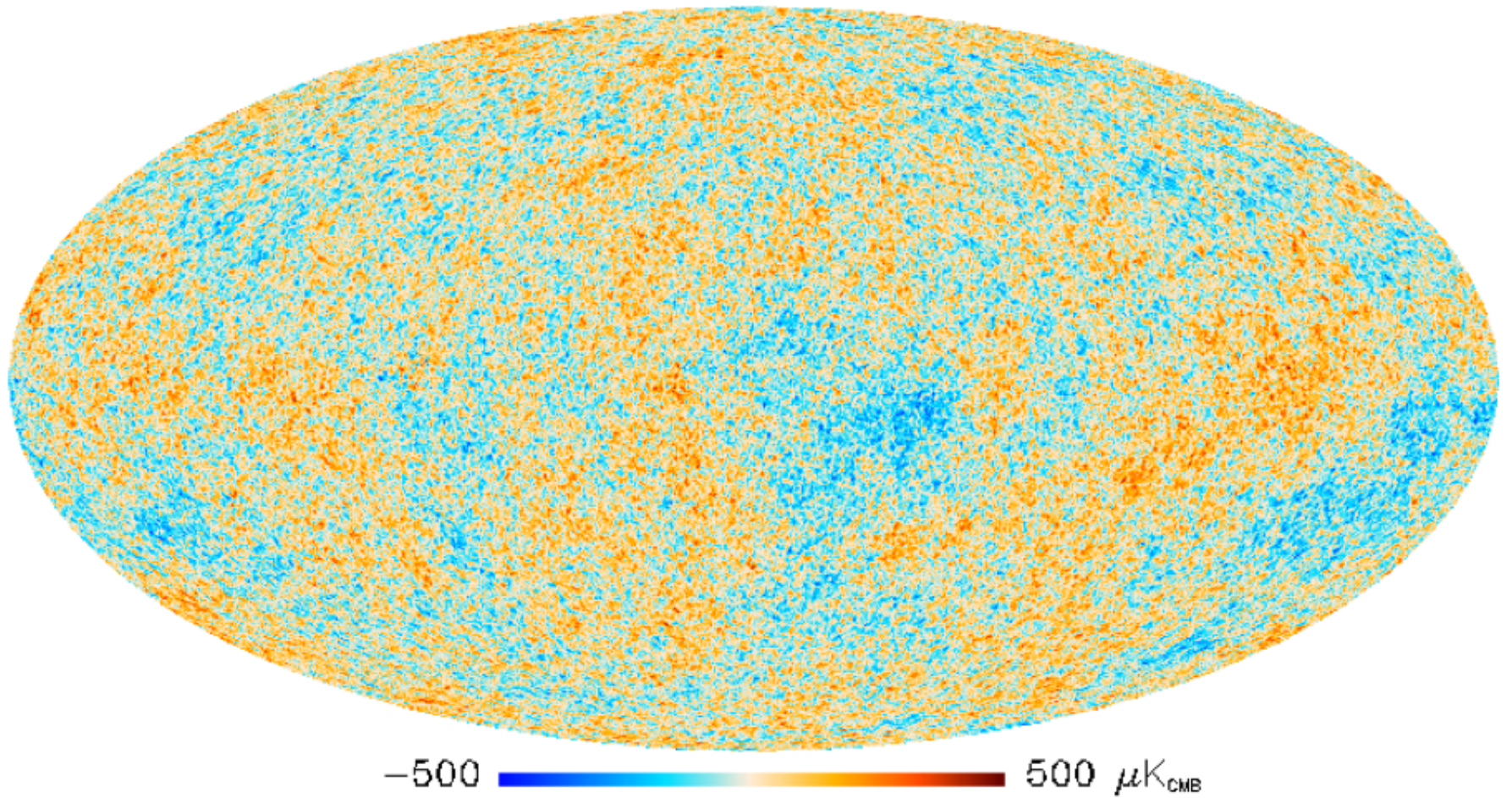


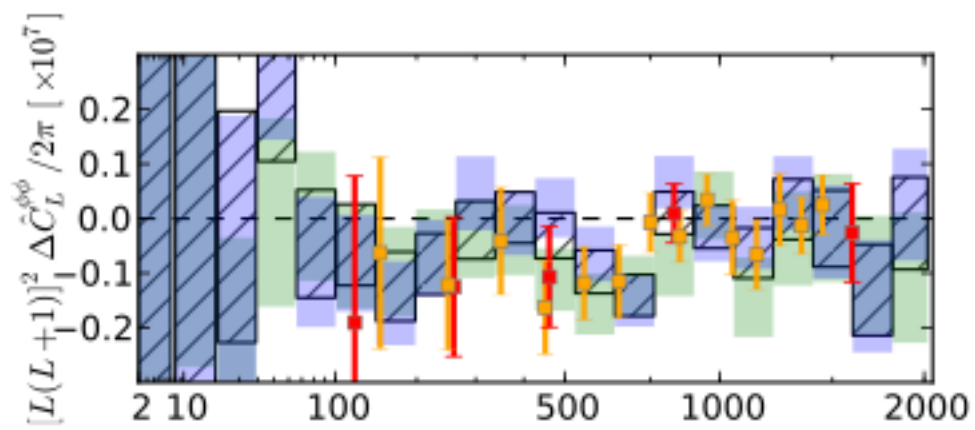
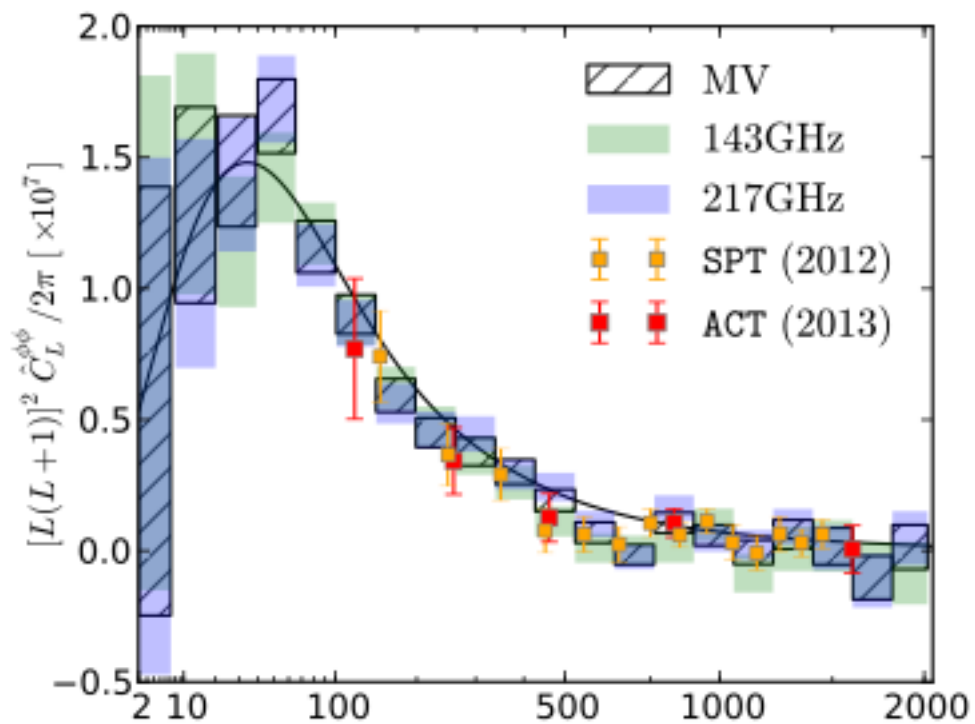






THE CMB AS SEEN BY PLANCK





L

$$\tilde{T}(\hat{n}) = T(\hat{n}) + \alpha_i \phi \nabla^i T + \dots$$

- Basic idea:
 - Estimat

