Planck Revisited

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w/ Renée Hlozek and David Spergel

Cosmology after Planck, University of Michigan, September 24, 2013

Introduction

Planck has provided us with truly remarkable data

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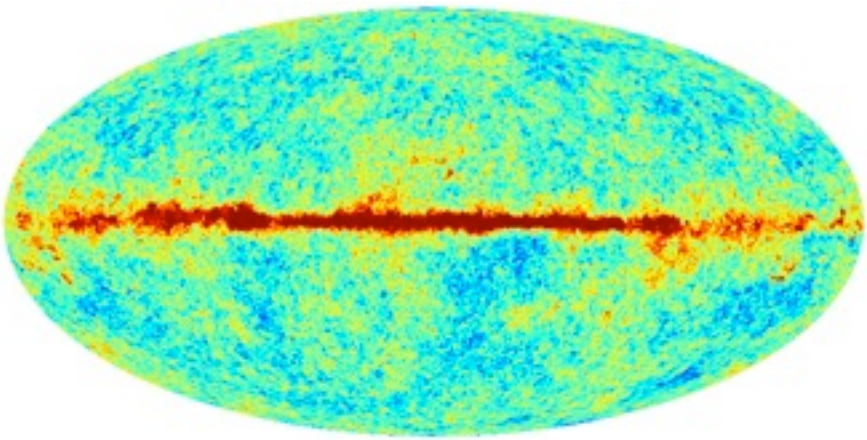
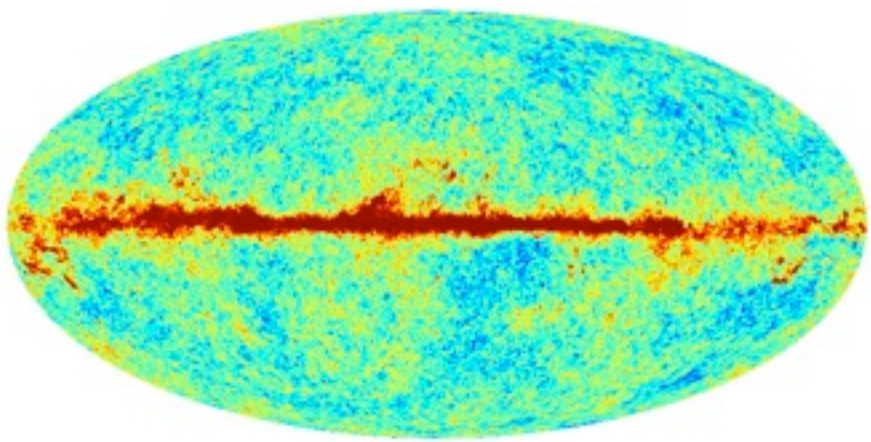
- It agrees very well with WMAP at WMAP resolution*

WMAP 94 GHz



Planck 100 GHz



* after rescaling by 1.012

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- but is much more powerful

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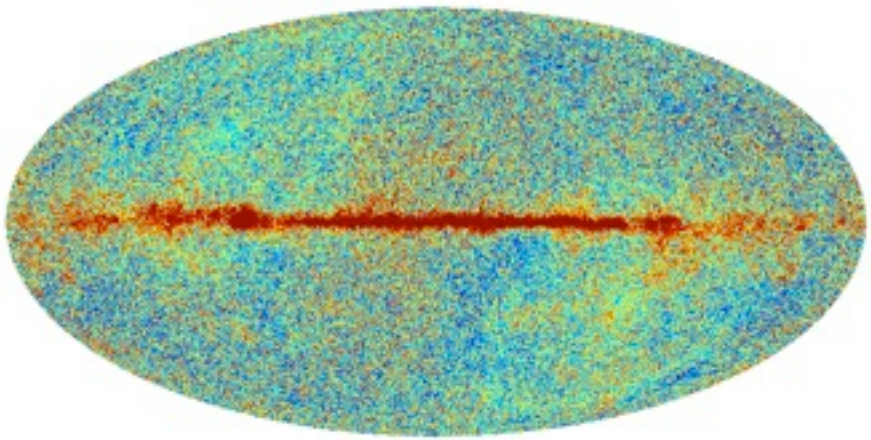
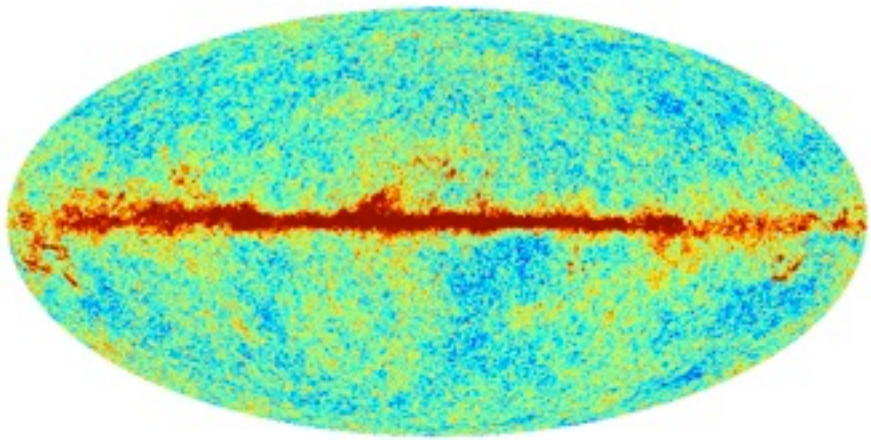


Planck 100 GHz



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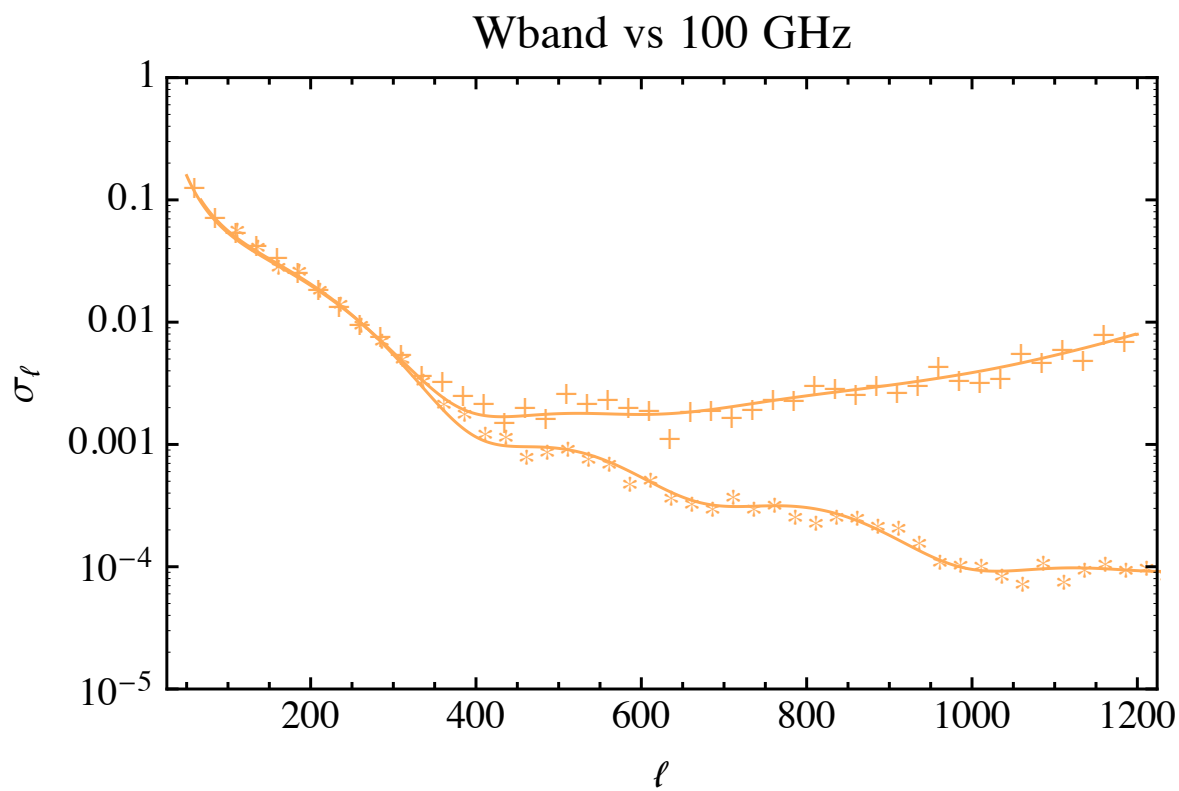

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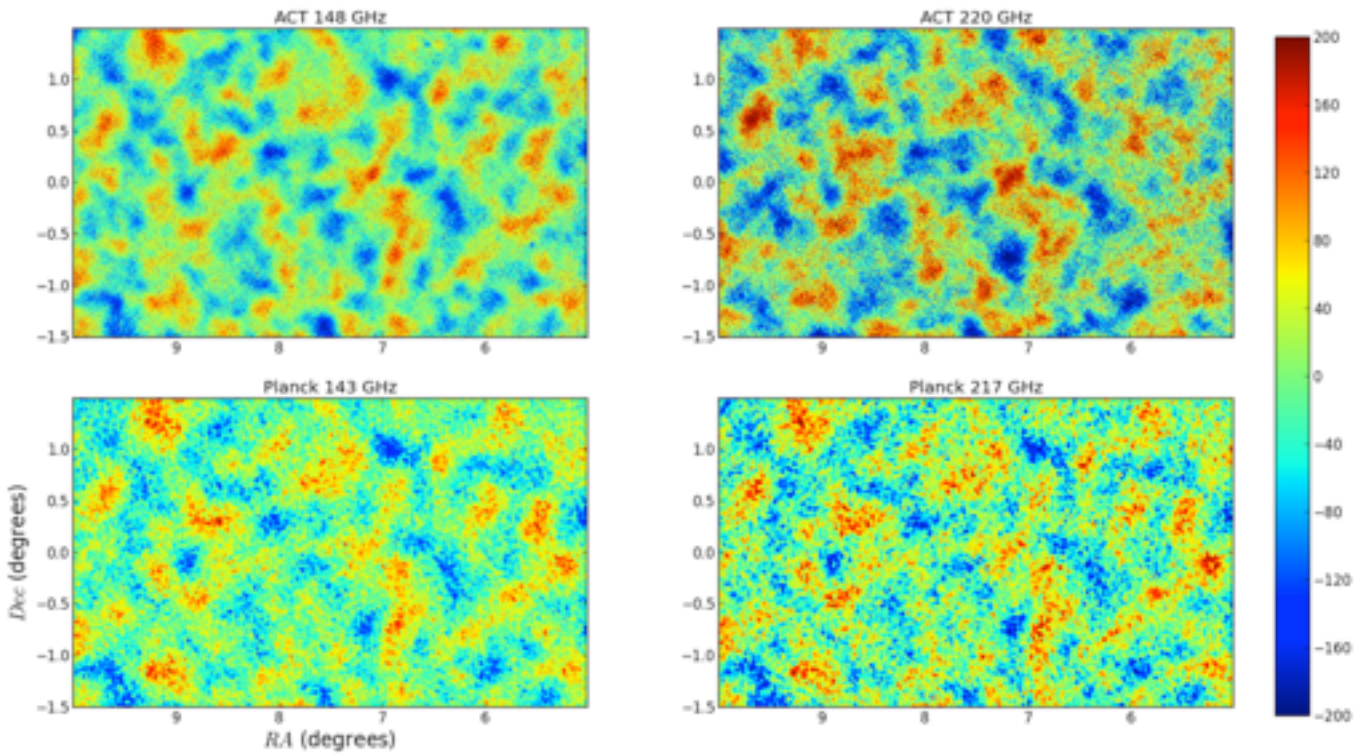
Planck has provided us with truly remarkable data

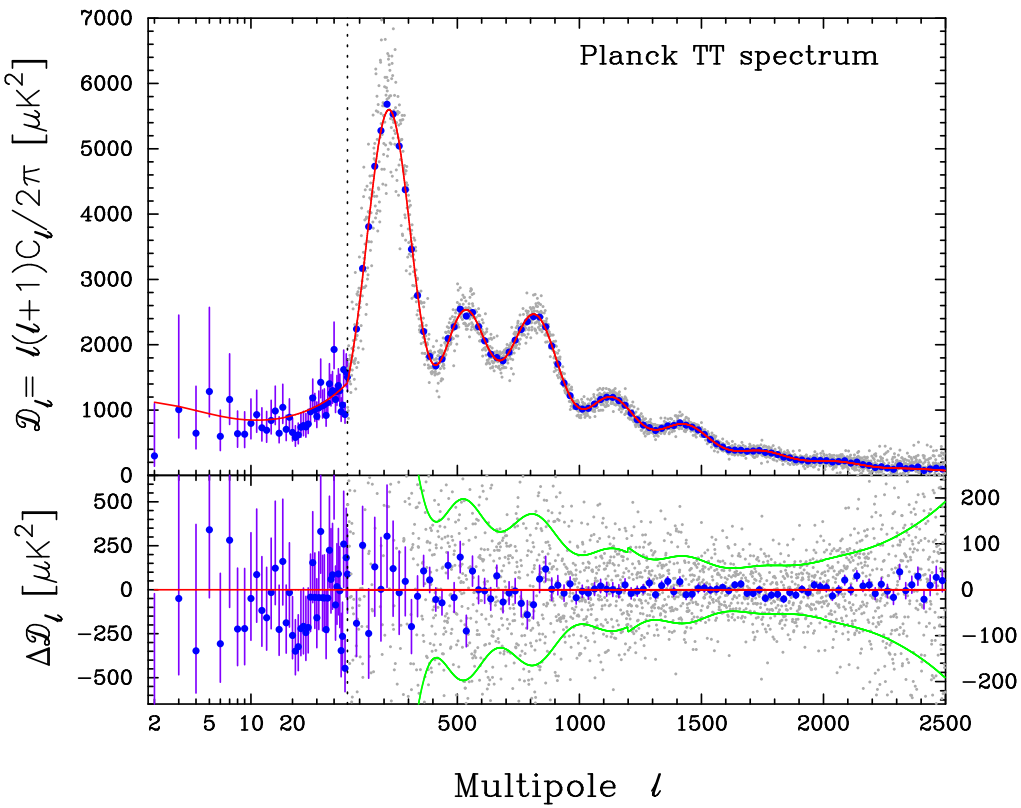
- It agrees very well with WMAP at WMAP resolution
- but is much more powerful
- the maps also agree well with ACT and SPT



(credit: Amir Hajian, Thibaut Louis)

Introduction

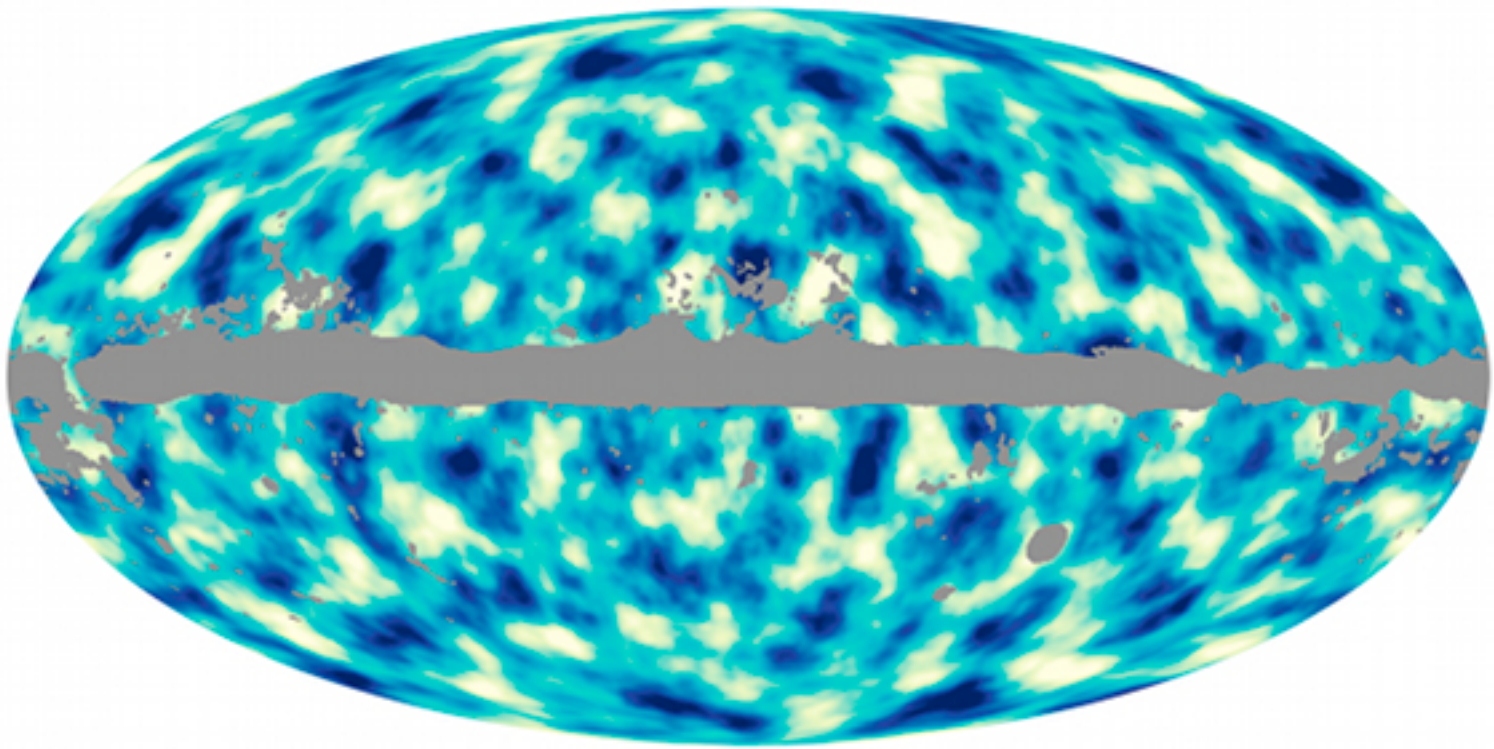
Planck has given us even more confidence than WMAP+ACT +SPT that LCDM describes our universe remarkably well



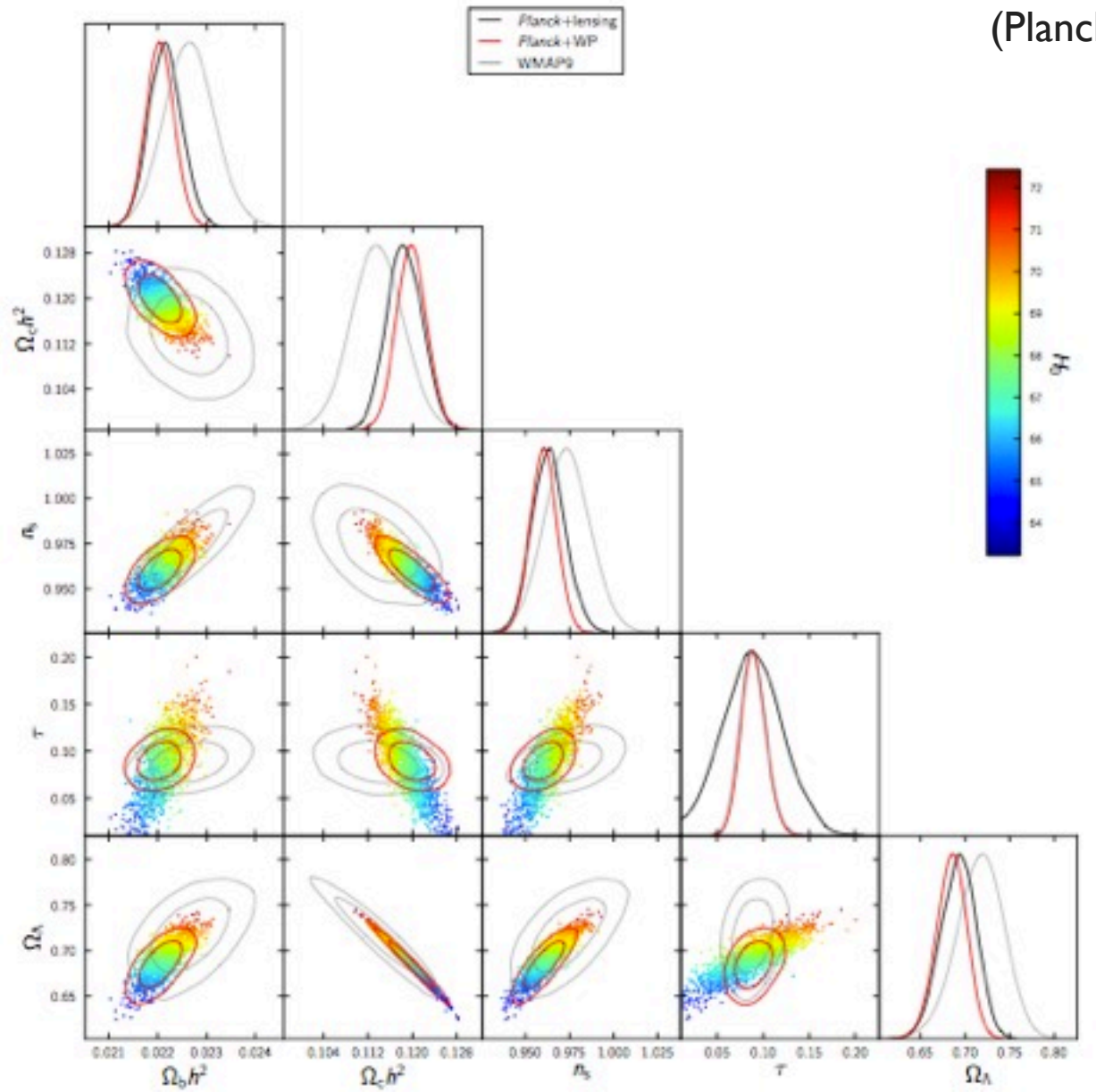
Local	**2.7 ± 5.8**
Equilateral	**−42 ± 75**
Orthogonal	**−25 ± 39**

Introduction

Planck has provided us with exciting new possibilities



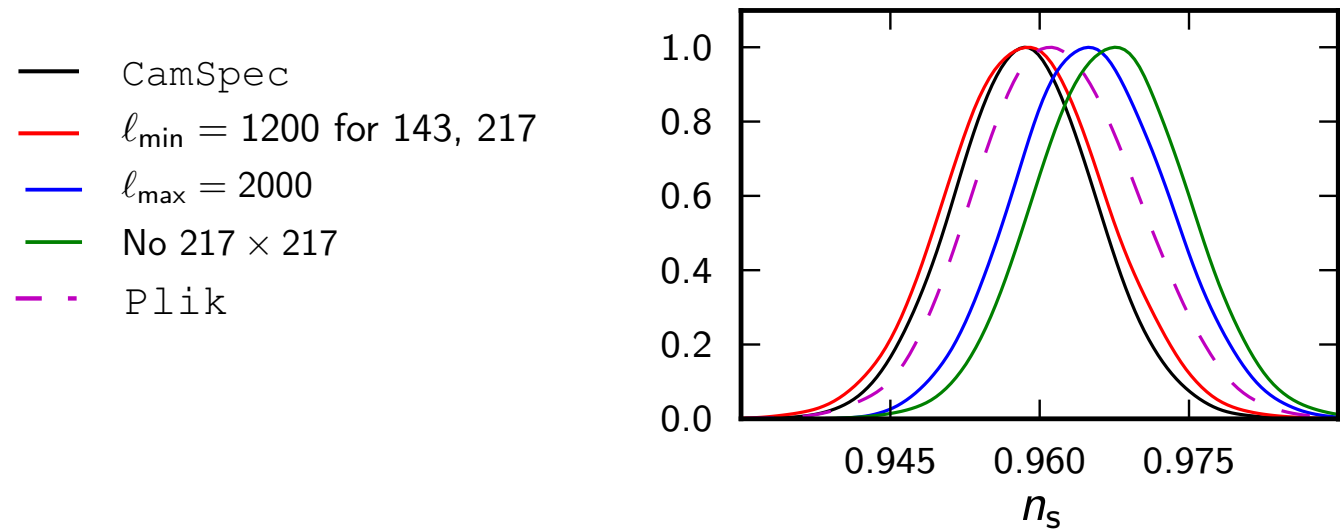
Parameter constraints



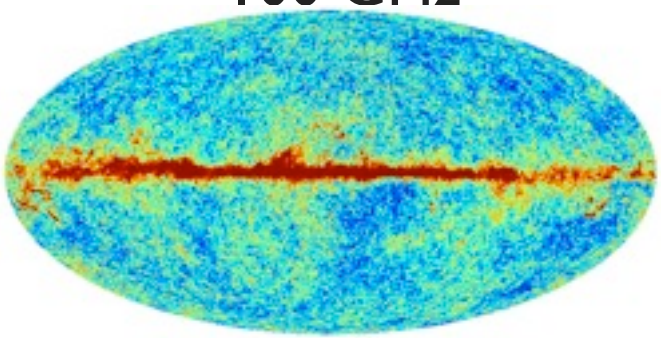
(Planck XVI)

Parameter shifts

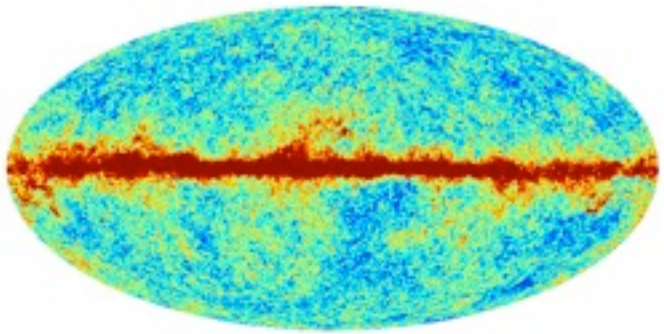
(Planck XVI)



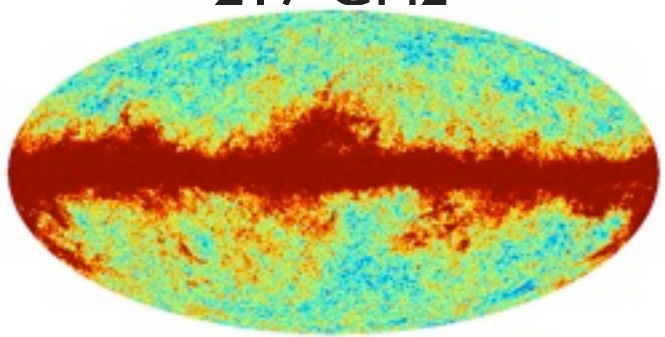
100 GHz



143 GHz

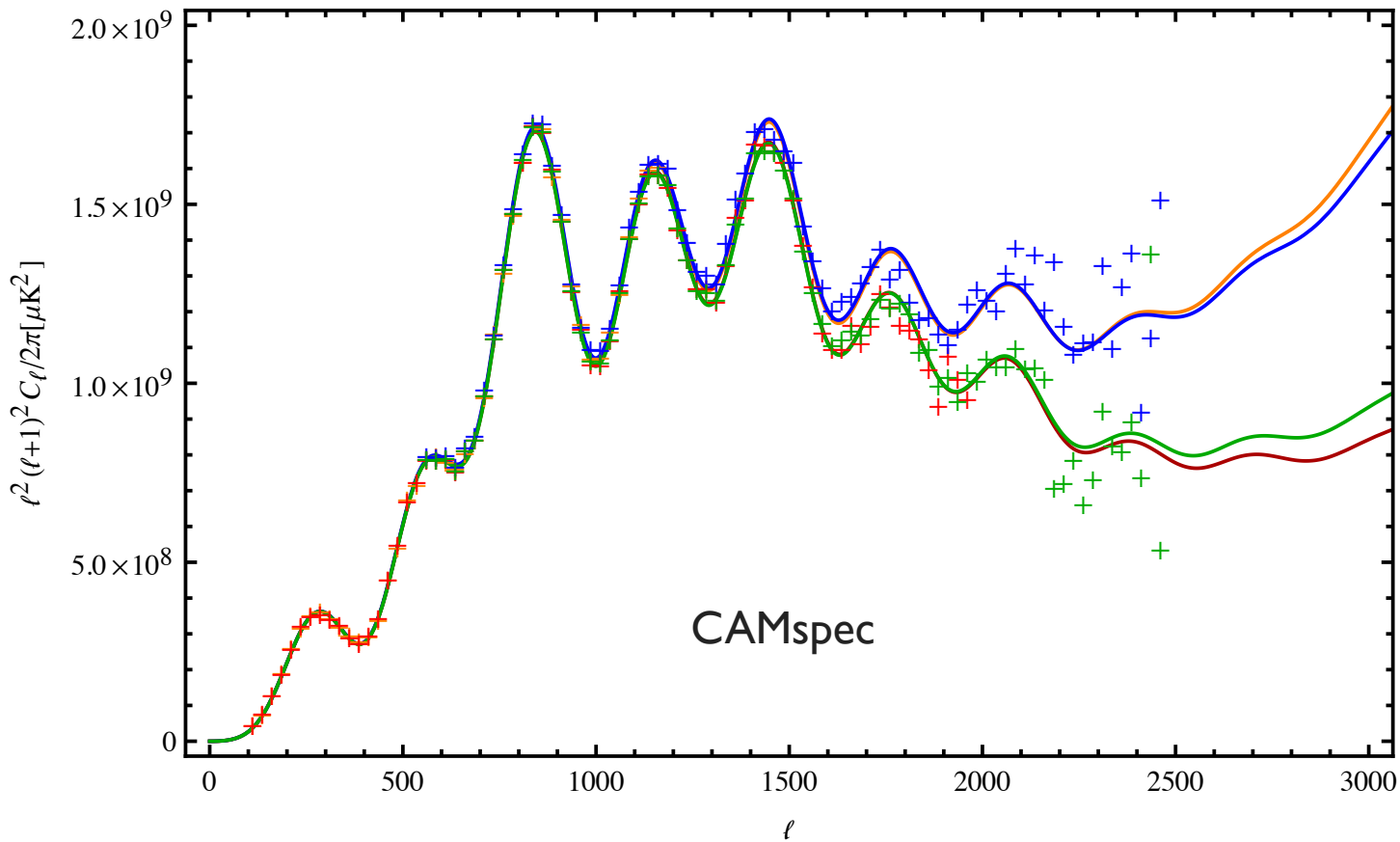


217 GHz



Parameter shifts

- The 217x217 foreground contribution is significant
- 217x217 shows a clear dip around $\ell \approx 1800$

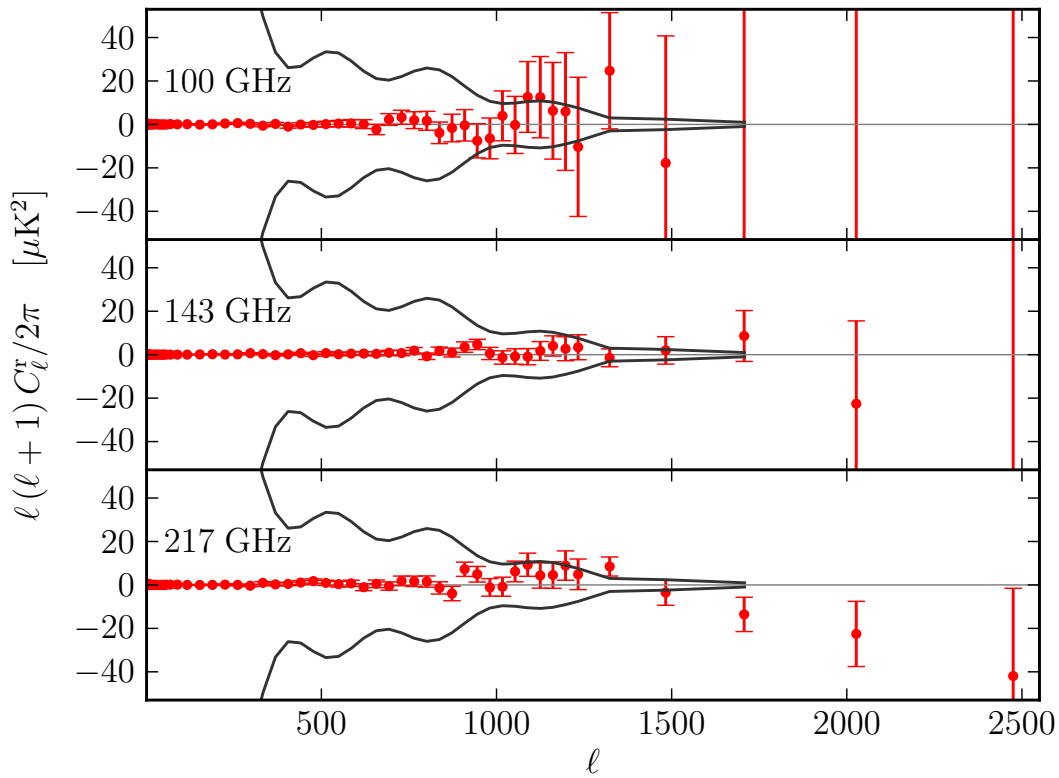


Parameter shifts

Null-tests provide additional motivation to take a closer look

(Paper VI)

survey 1 - survey 2



In addition to the 217-ds1 × 217-ds2 cross spectrum shown in Fig. 29, only two other cross-spectra fail this test, namely 217-1 × 217-ds2 and 217-1 × 217-3.

Parameter shifts

Is 217x217 consistent with the other frequencies?

Use Planck covariance matrix to compute

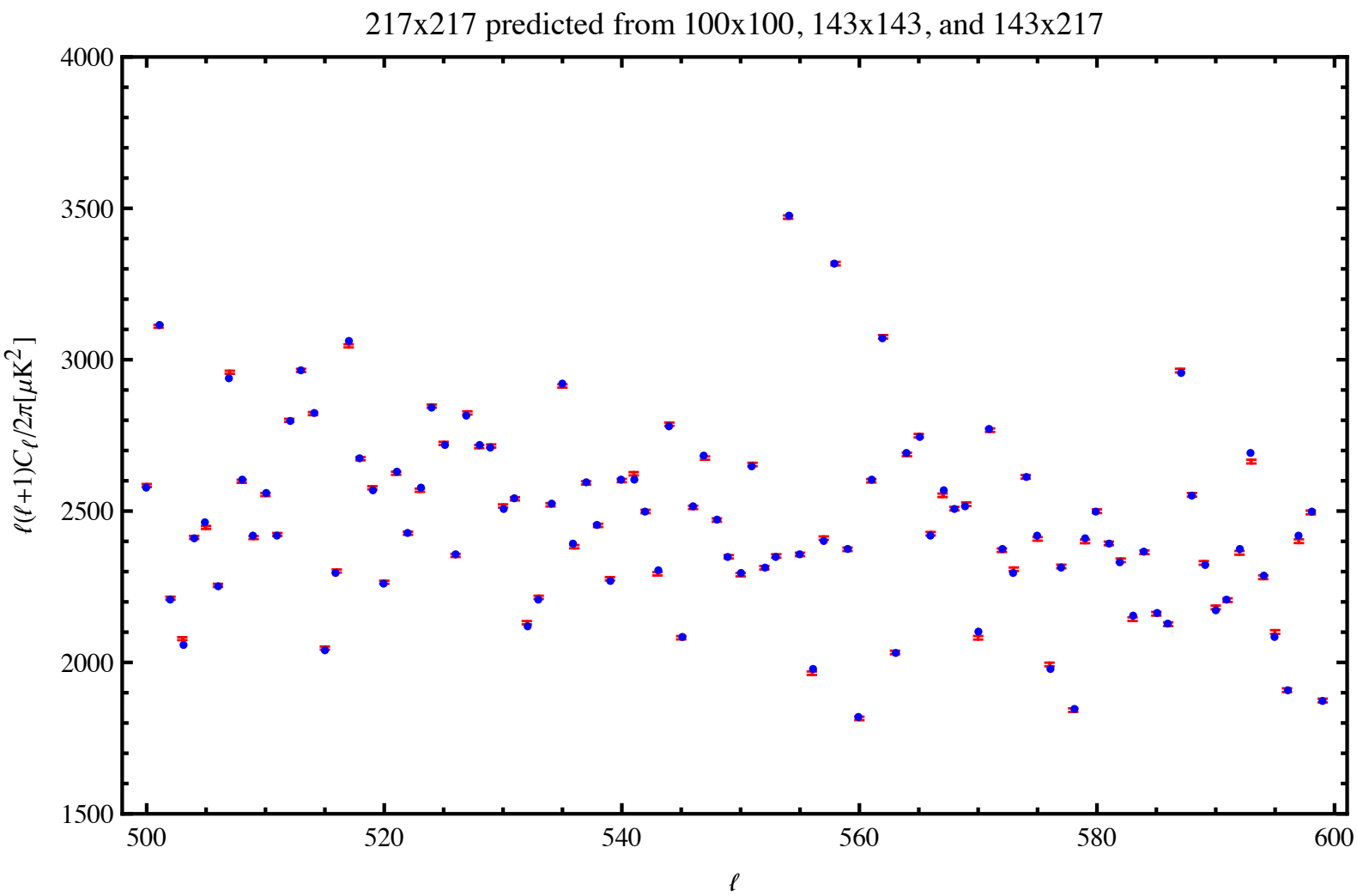
$$P(C_\ell^{217\times217}|\{C_\ell^{100\times100}, C_\ell^{143\times143}, C_\ell^{143\times217}\})$$

and $$\langle C_\ell^{217\times217}\rangle_{\{C_\ell^{100\times100}, C_\ell^{143\times143}, C_\ell^{143\times217}\}}$$

to predict the spectrum

Parameter shifts

Is it consistent with the other frequencies?



Parameter shifts

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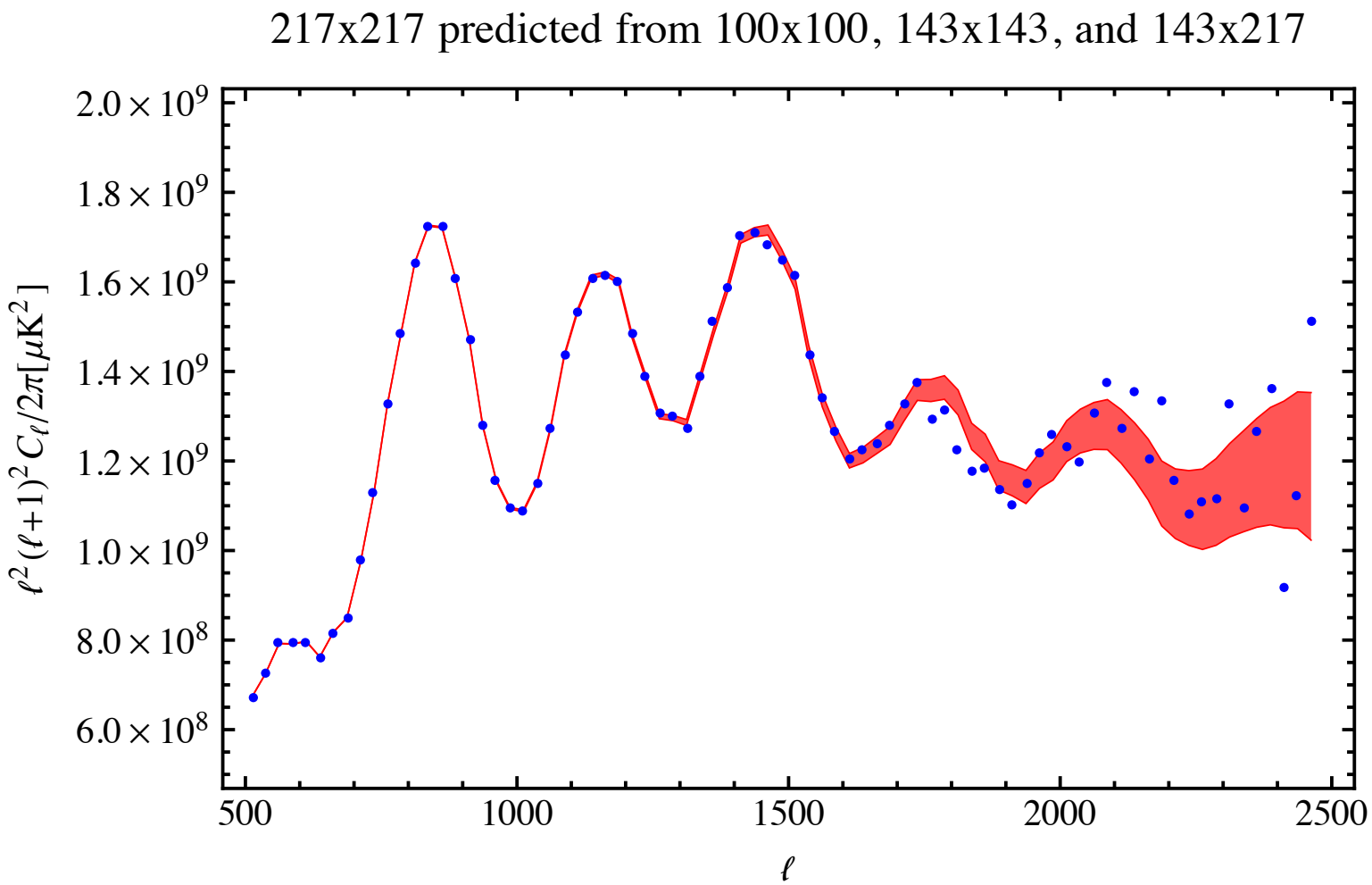
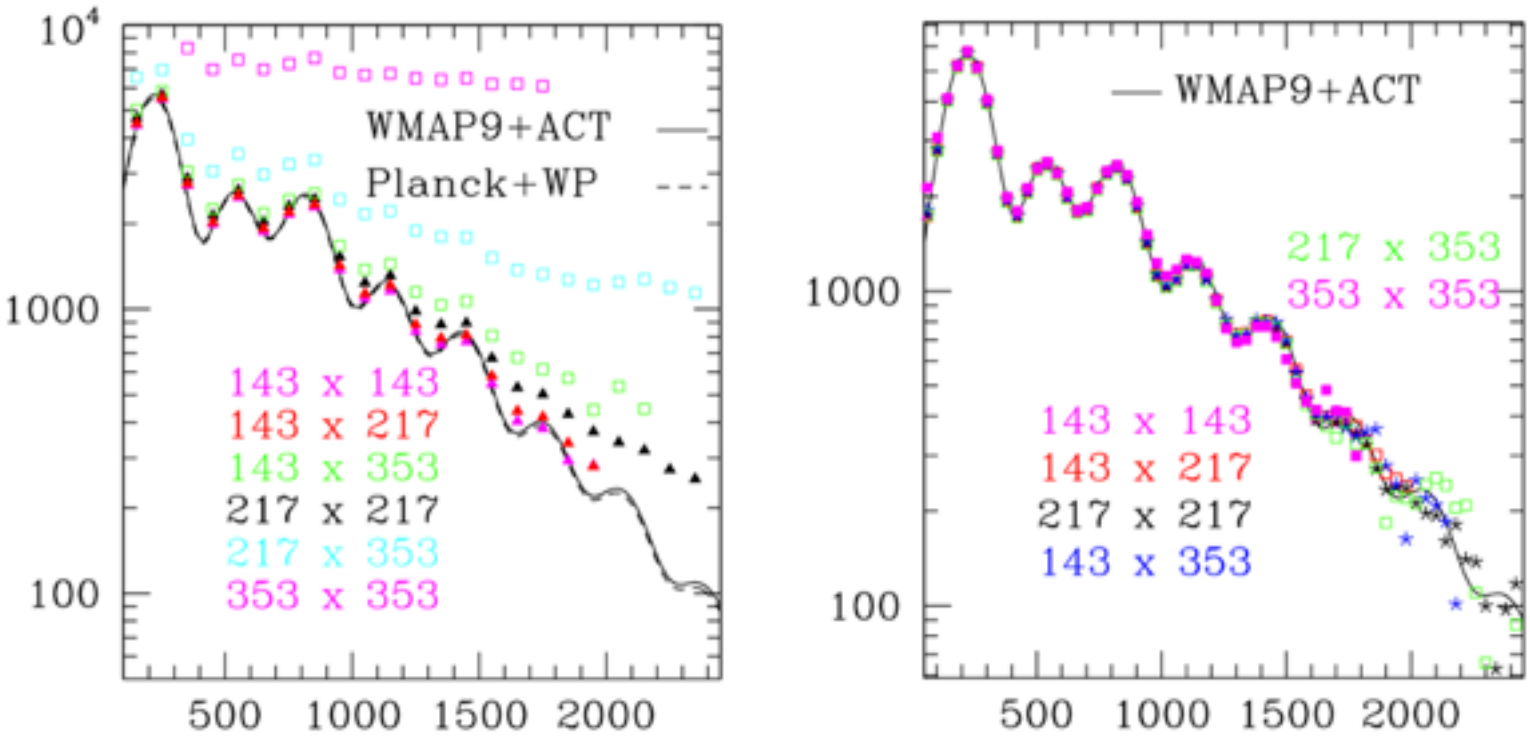


Parameter shifts

This motivated us to

- eliminate 217x217 (but keep 143x217)
- clean the spectra (with 353 and/or 545 GHz)



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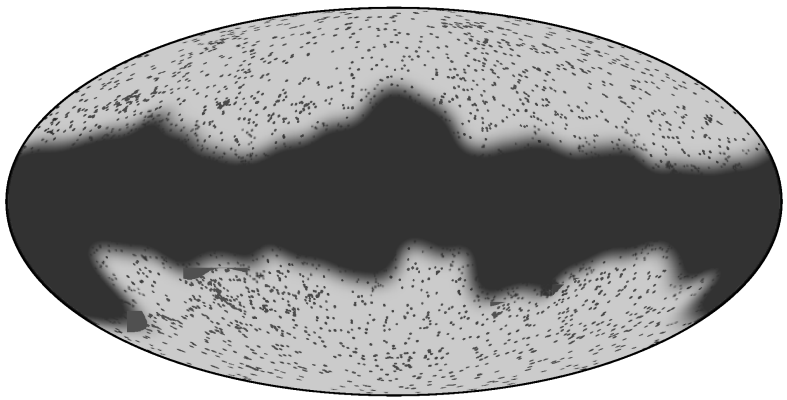
Also note that we use survey maps (because detector set maps are not public)

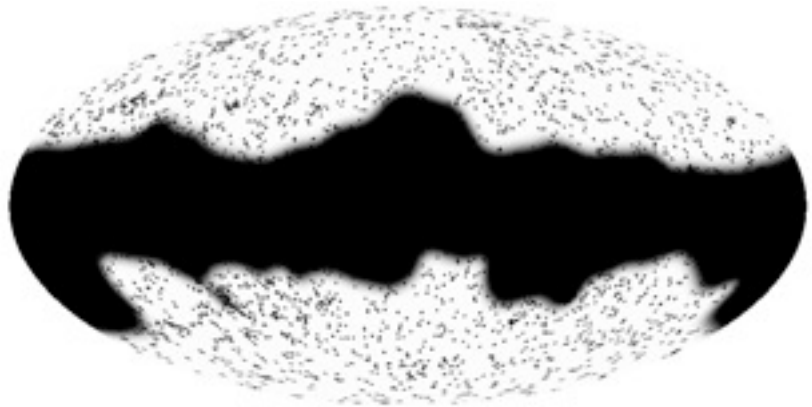
For the covariance matrix, we use the same approximations as in CAMspec. We need to specify

- the masks
- the noise
- the cleaning procedure

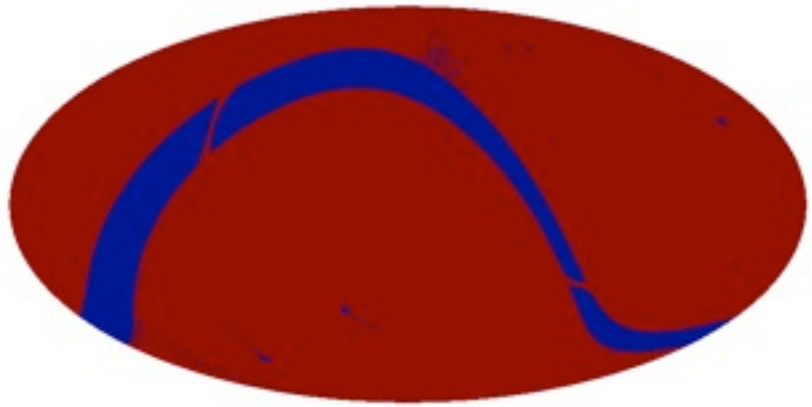
Parameter shifts

Reverse engineering the masks (e.g. CL49)



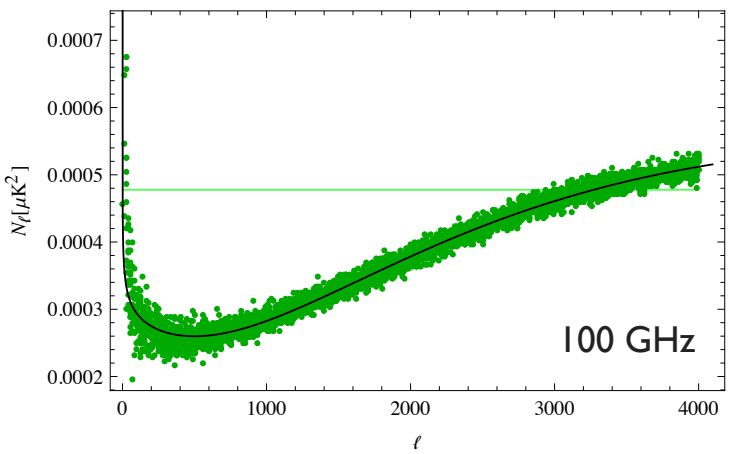


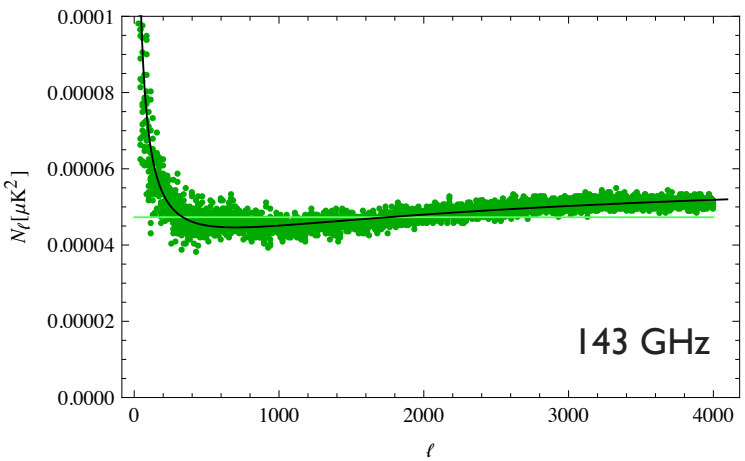
additional pixels masked
for survey cross correlations

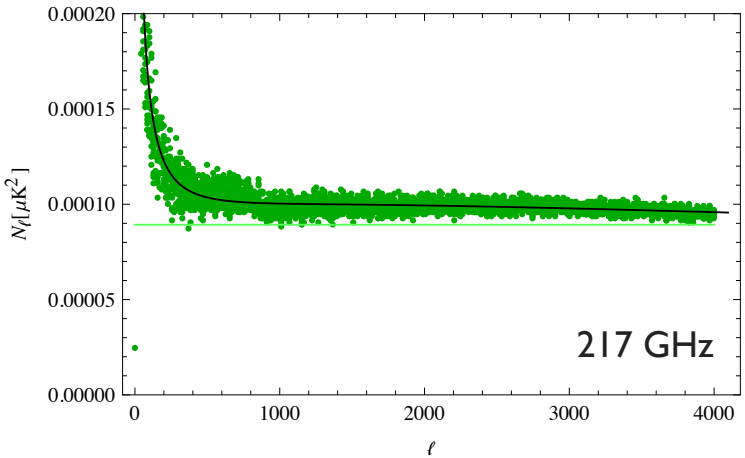


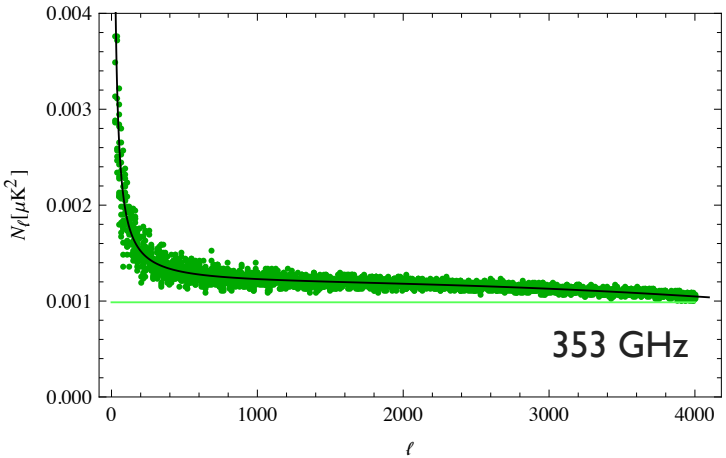
Parameter shifts

Noise from survey differences



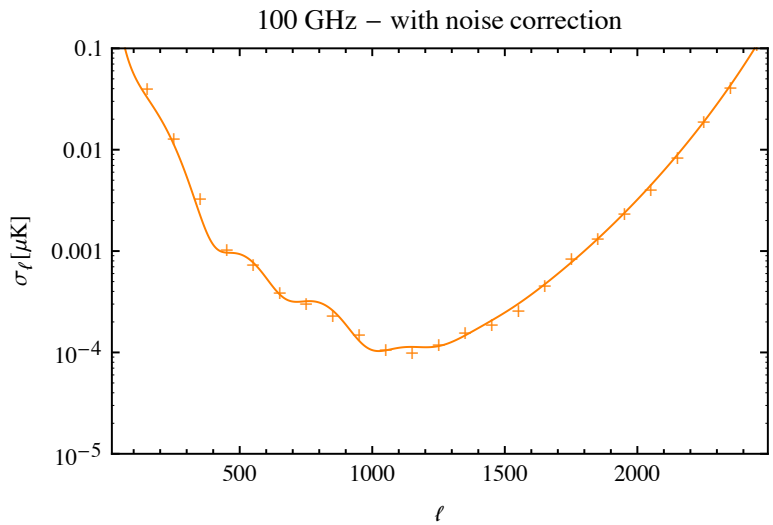


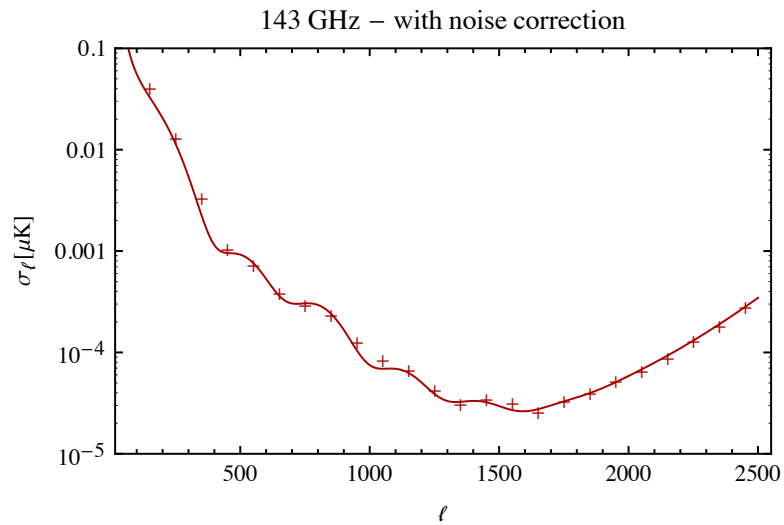


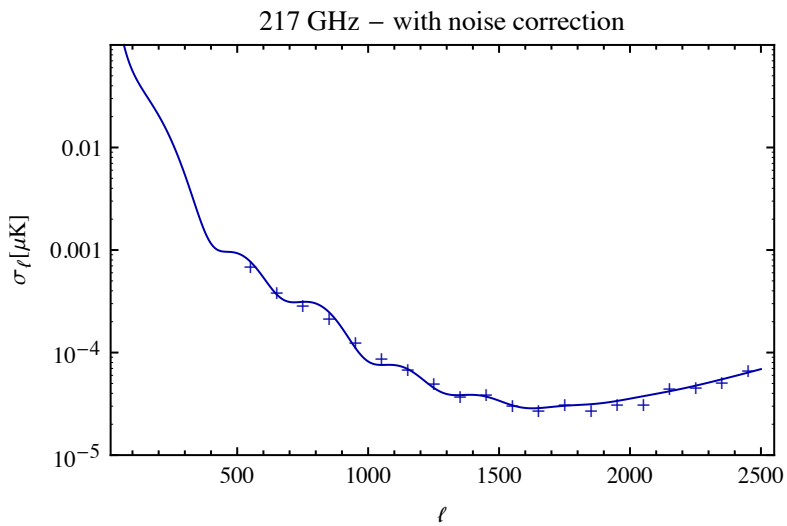


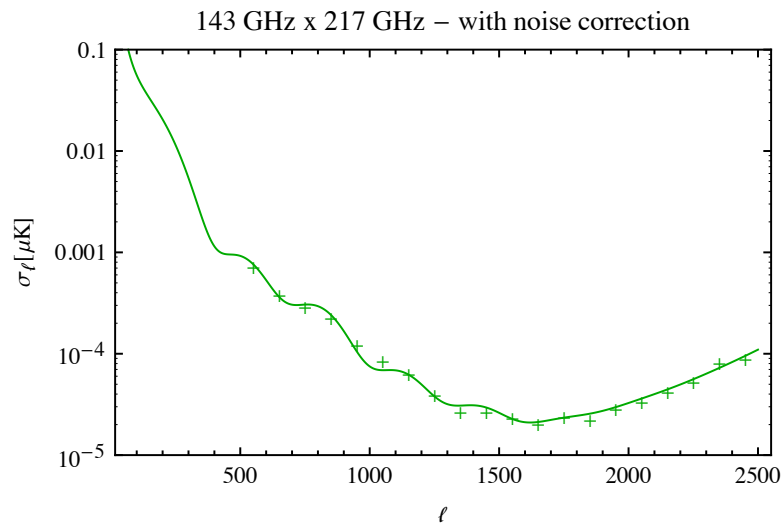
Parameter shifts

Covariance matrix, e.g. for 353 GHz cleaning





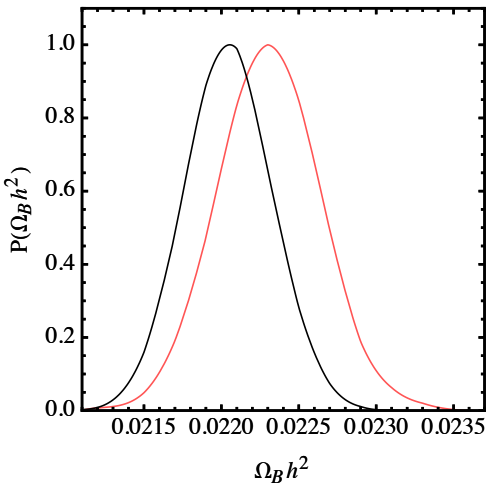


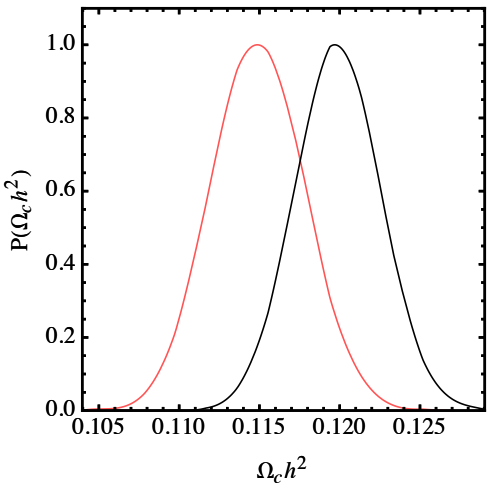


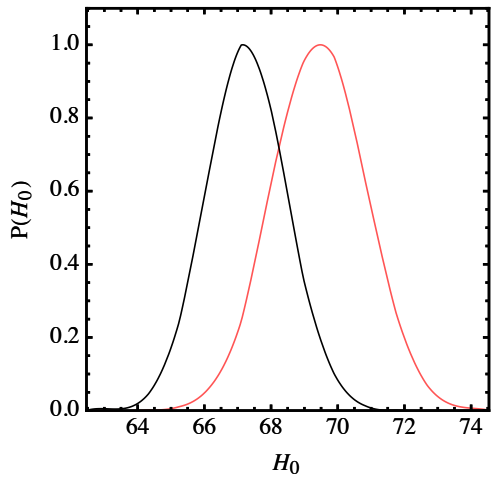
Parameter shifts

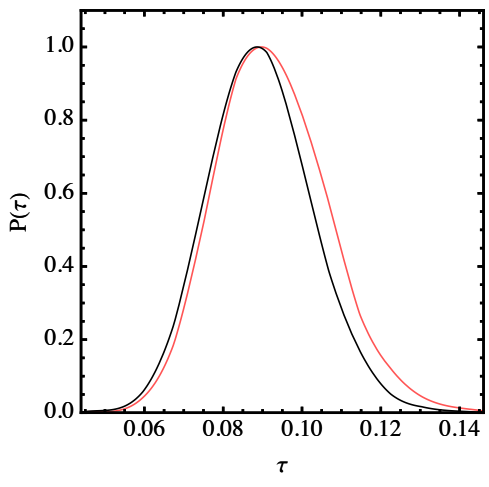
CAMspec

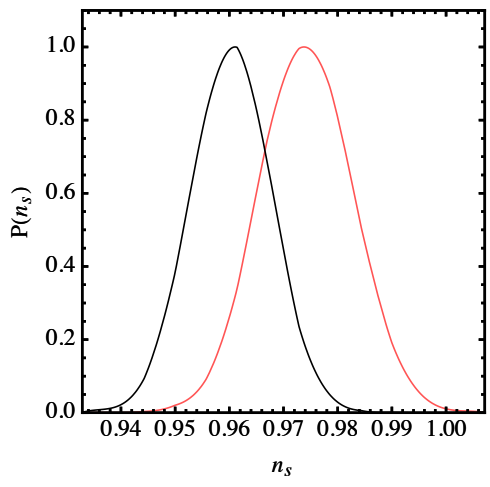
Cleaned with 353 GHz - no 217x217

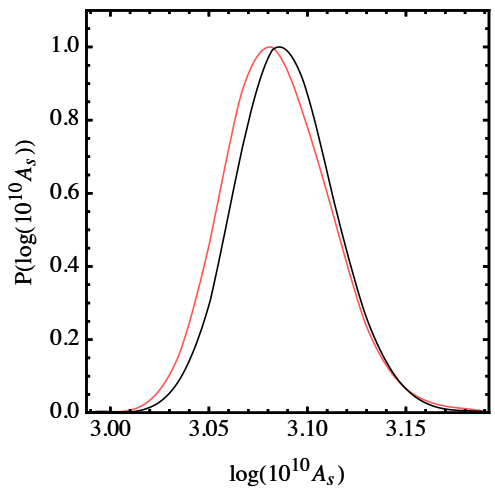












Parameter shifts

	cleaned P+WP no 217x217	WMAP9+ACT	PLANCK+WP
Spectral Index	0.9722±0.0076	0.973 ± 0.011	0.9603±0.0073
Matter Density	1.154±0.028	1.146±0.044	1.199±0.027
Baryon Density	2.241±0.030	2.260±0.040	2.205±0.028
Hubble Constant	69.3±1.2	69.7±2.0	67.3±1.2

Parameter shifts

We cleaned spectra, removed data, changed masks and used survey maps.

Let's go step by step:

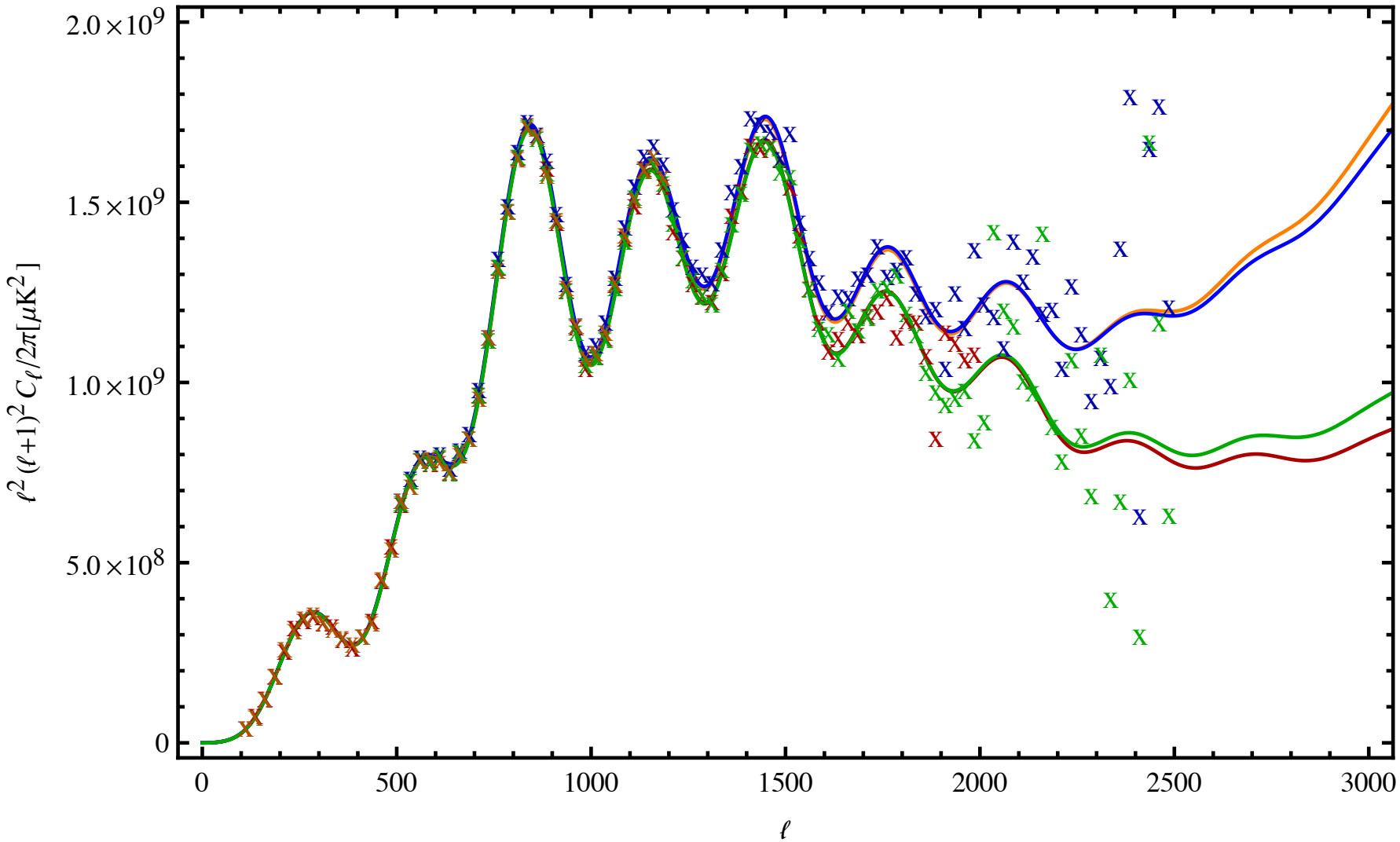
Can we reproduce the Planck results from survey cross-correlations with the Planck model for foregrounds and same masks (adapted for survey crosses)?

Extragalactic foreground model is in CAMspec.

Diffuse galactic emission can be measured from 857 GHz maps.

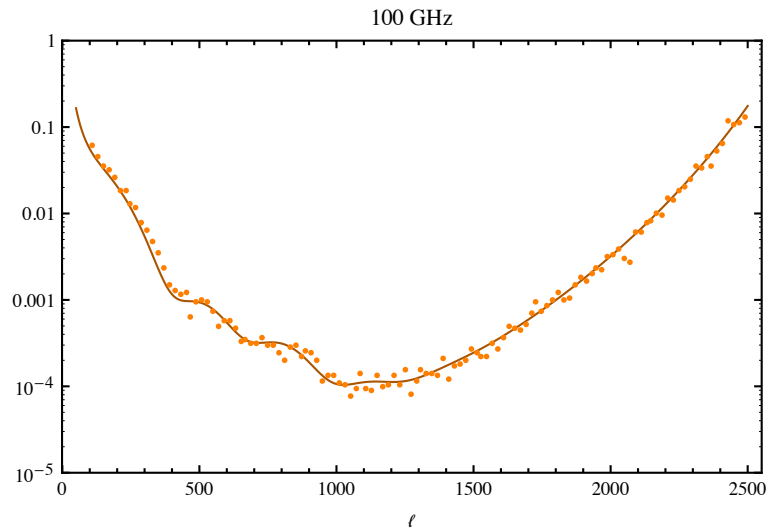
Parameter shifts

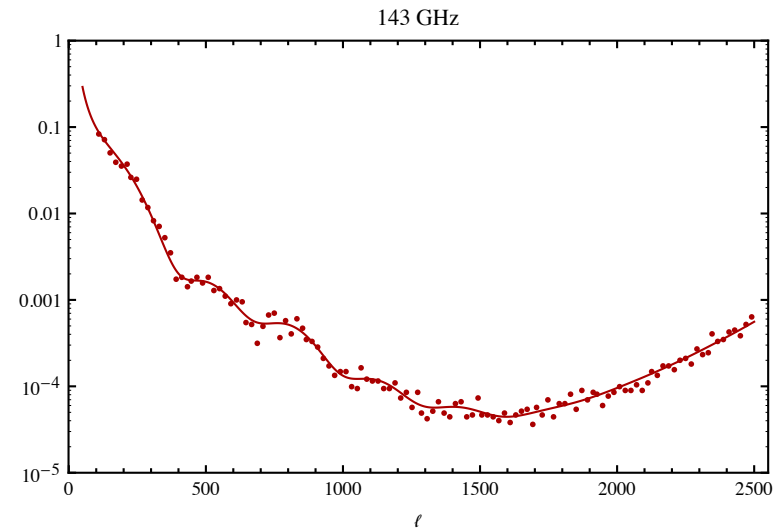
Survey cross-spectra

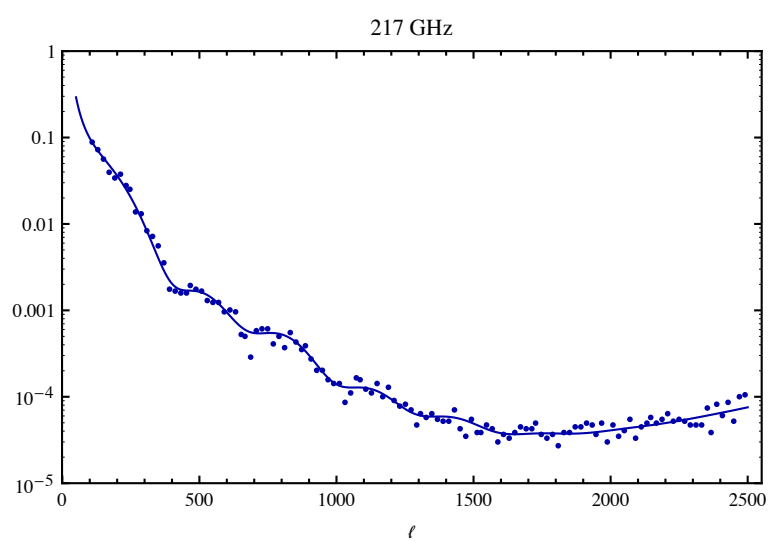


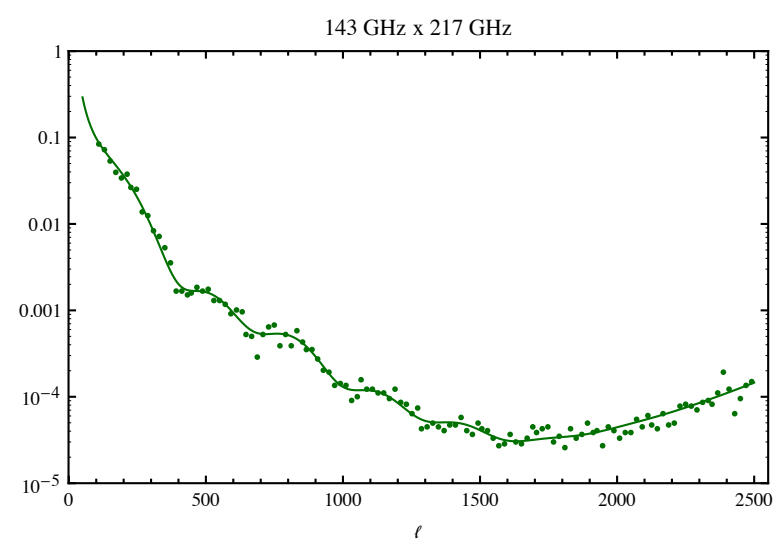
Parameter shifts

Covariance matrix for survey cross-spectra



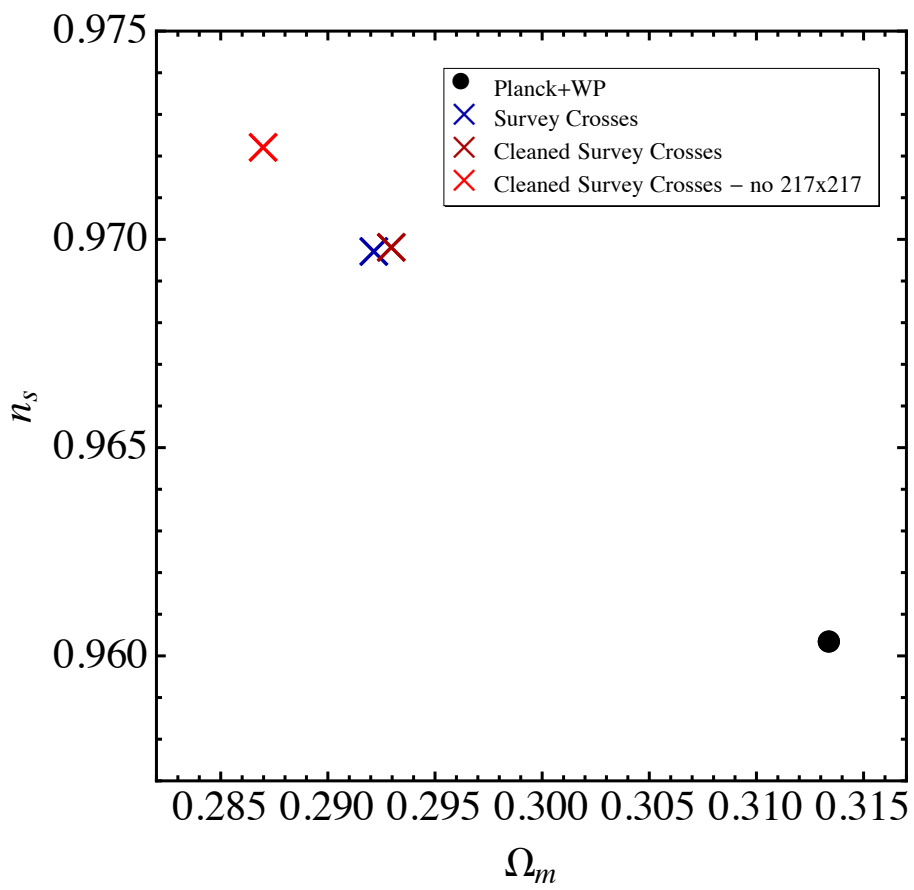


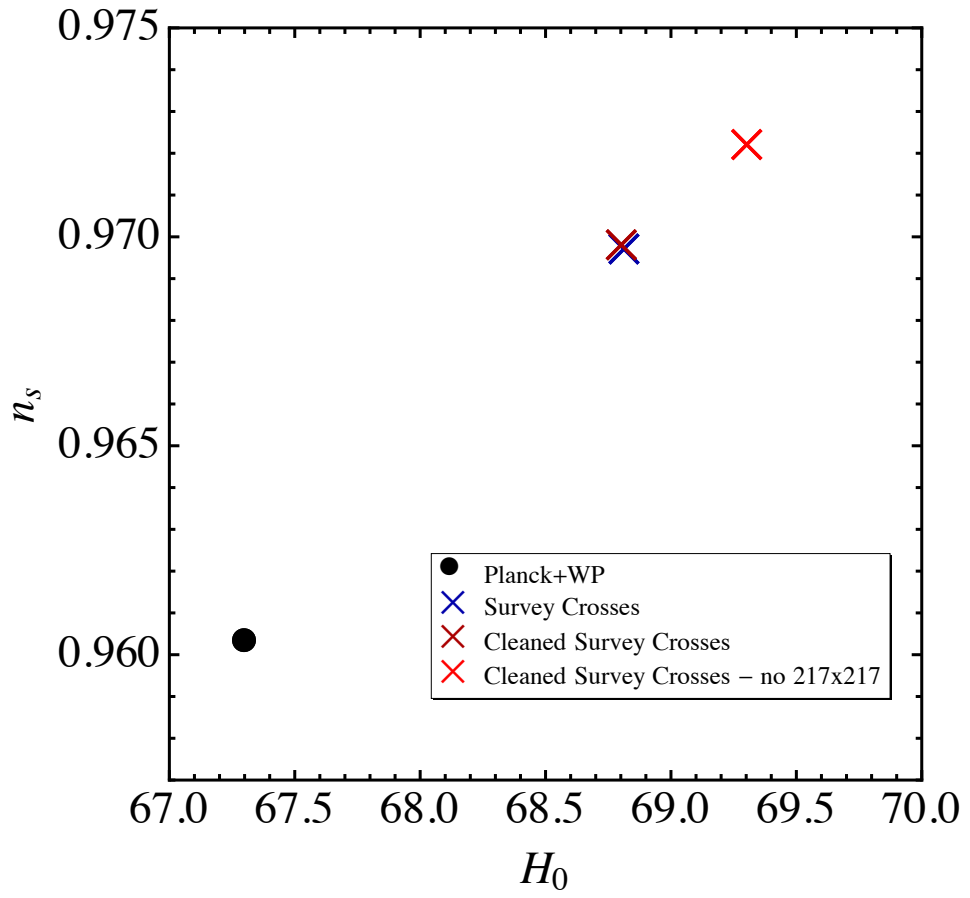




Parameter shifts

Comparison of key cosmological parameters

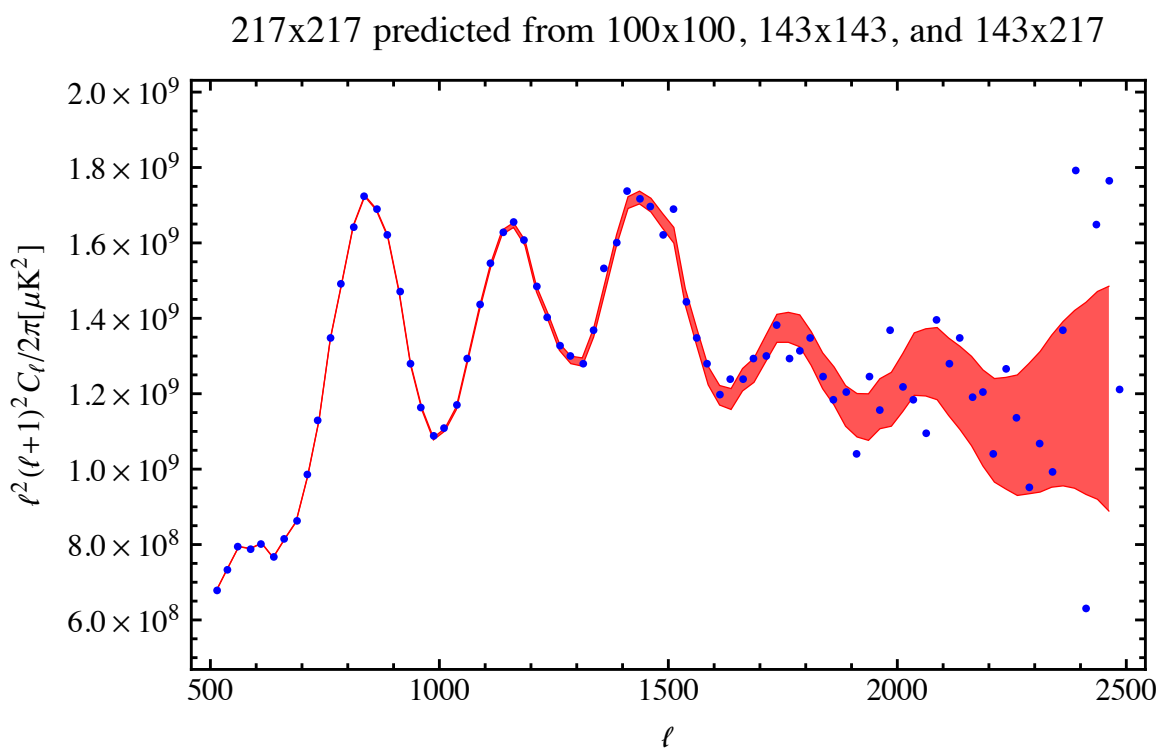




Parameter shifts

Lessons:

- The Planck foreground model seems to work well
- 217x217 spectra from survey crosses are less affected by systematics and cause smaller shifts than for detector sets



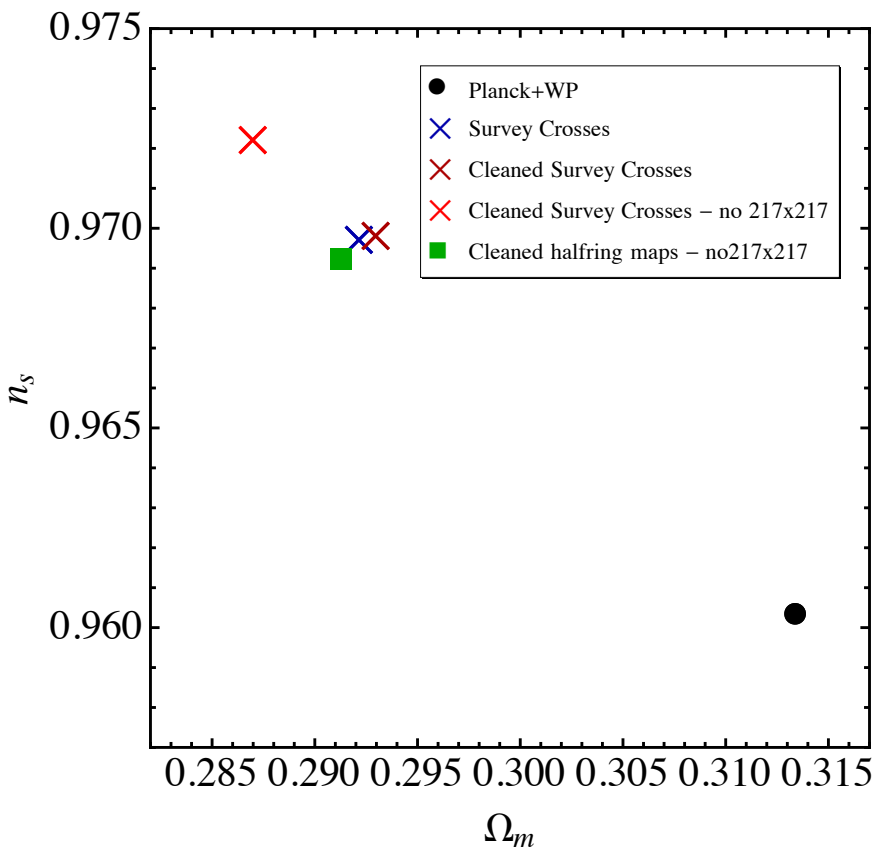
Parameter shifts

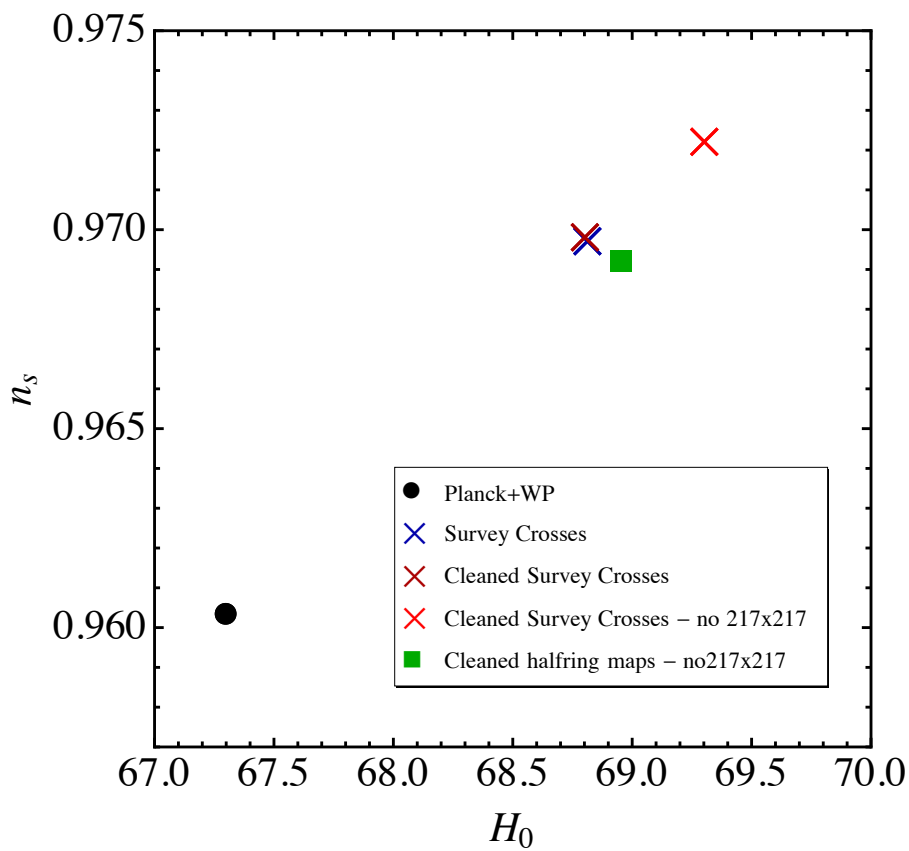
In the absence of detector set maps, consider halfring maps.

- more data
- systematics more similar to detector set maps
- contain correlated noise

Parameter shifts

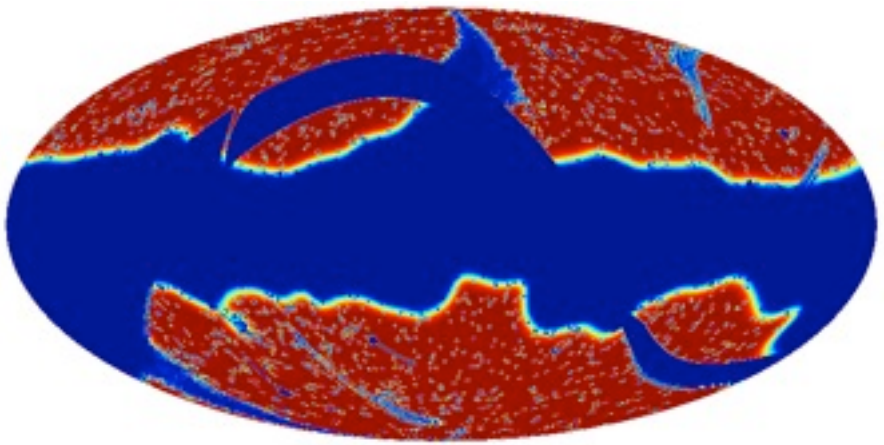
Halfring maps with same masks as before





Parameter shifts

Recall that we have been masking pixels only observed in one of the surveys, e.g.



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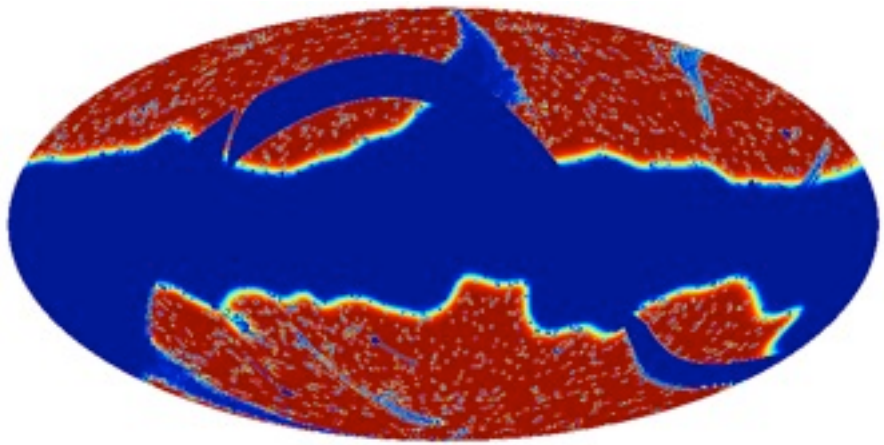
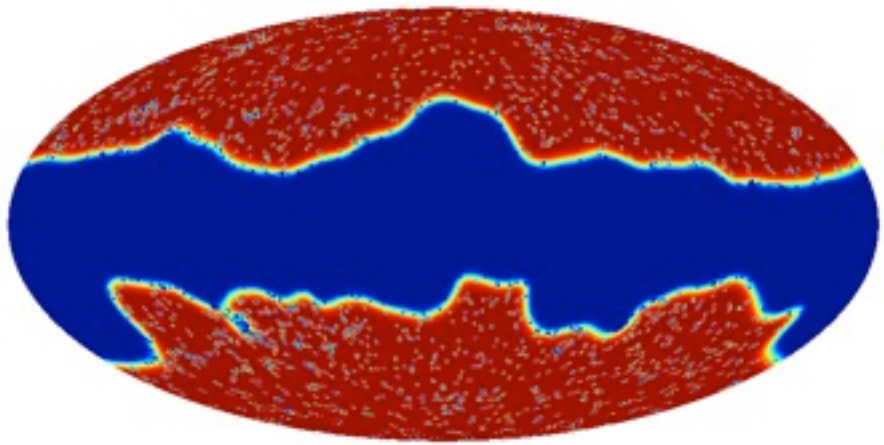


Planck uses



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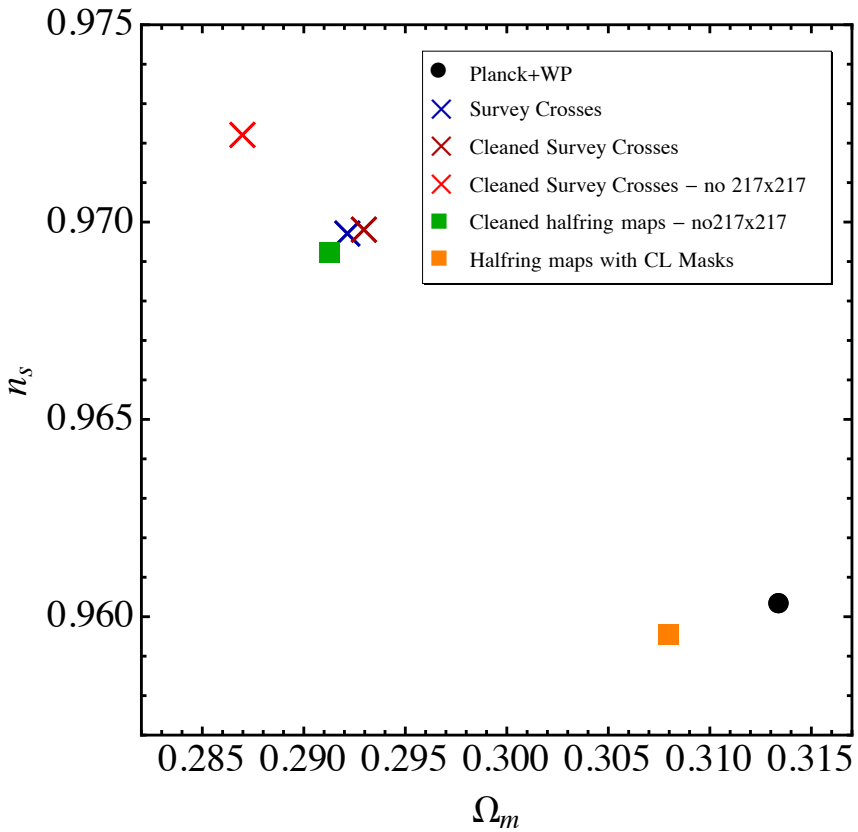
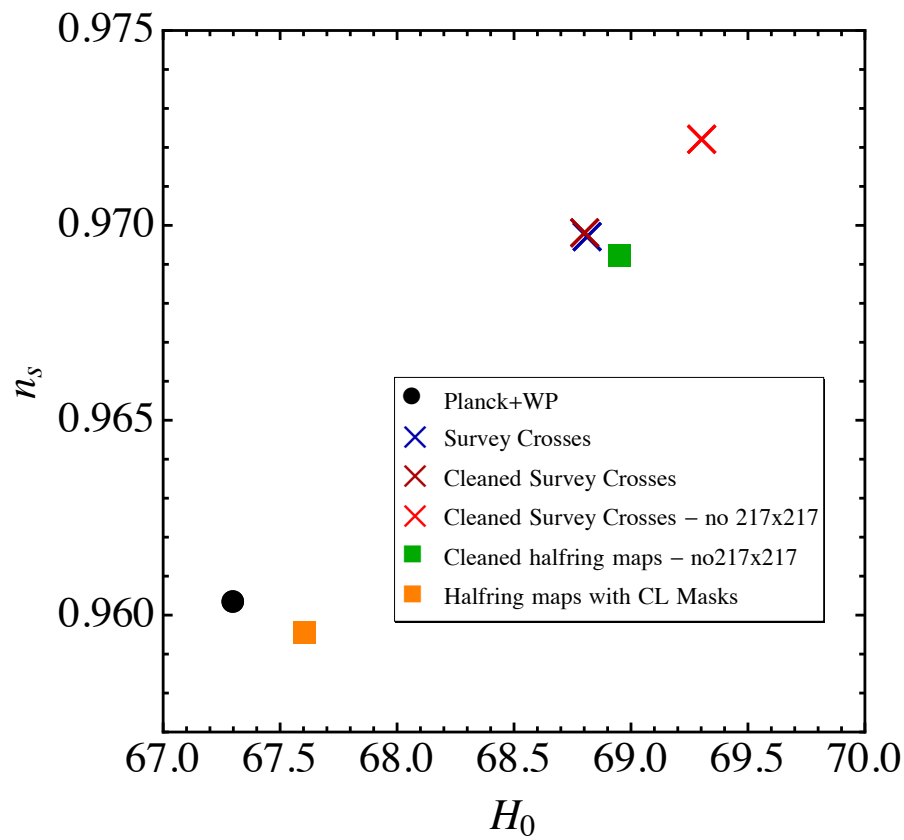
In the absence of detector set maps, consider halfring maps





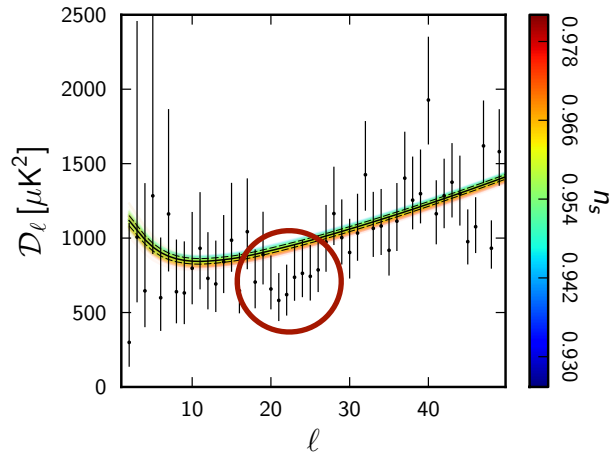
Tentative Conclusions

- The foreground model seems to work well and produces results very consistent with cleaning
- It is possible that the shifts are simply caused by additional data in the strip and/or 217x217.
  This needs to be checked with simulations, but does not seem entirely plausible.
  - Masking other parts of the sky of the size of strip lead to smaller effects.
  - Most of the shift comes from the part of the sky only observed in survey 1.
- This should be checked with detector set maps

Tentative Conclusions

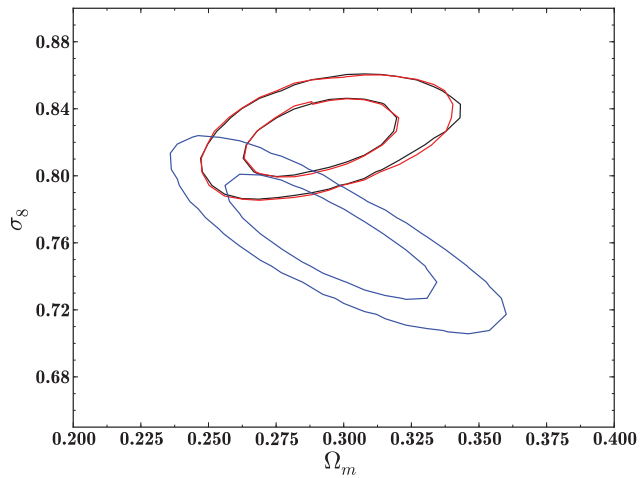
With the cosmological parameters from survey crosses

- The tension between amplitudes inferred from large and small scales is reduced $\Delta\chi^2_{\rm Commander} \approx 2$



- The effective number or relativistic species is even closer to the standard value.

- The tension between CMB and SZ cluster counts is reduced



Thank you