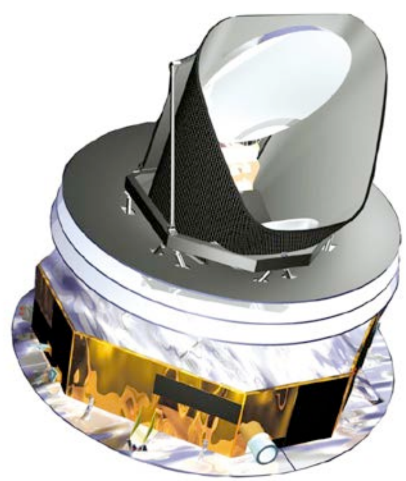
CMB Polarization from Planck: Status, consistency and prospects



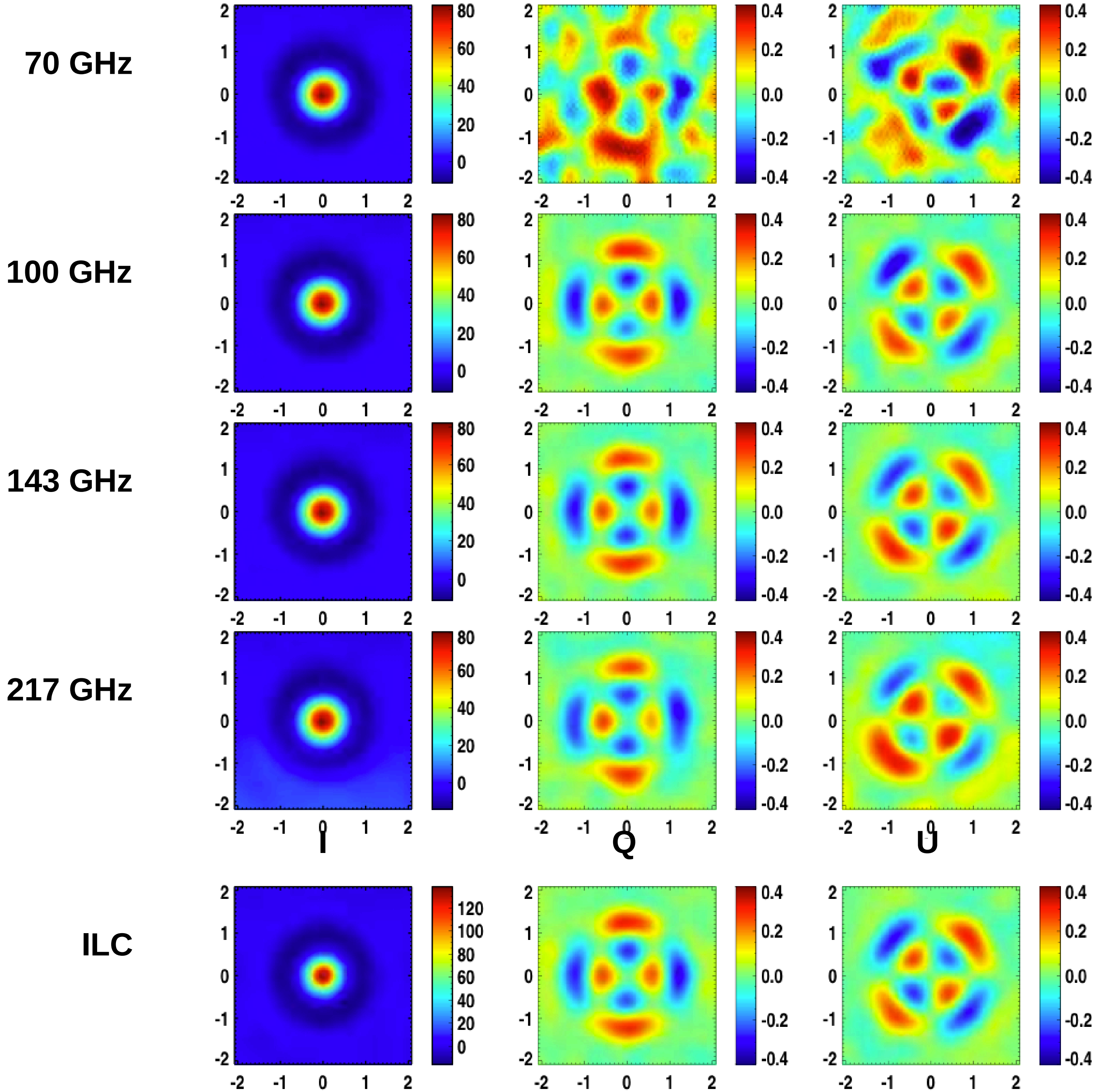
Planck Collaboration

P. Natoli (Università di Ferrara and ASDC)

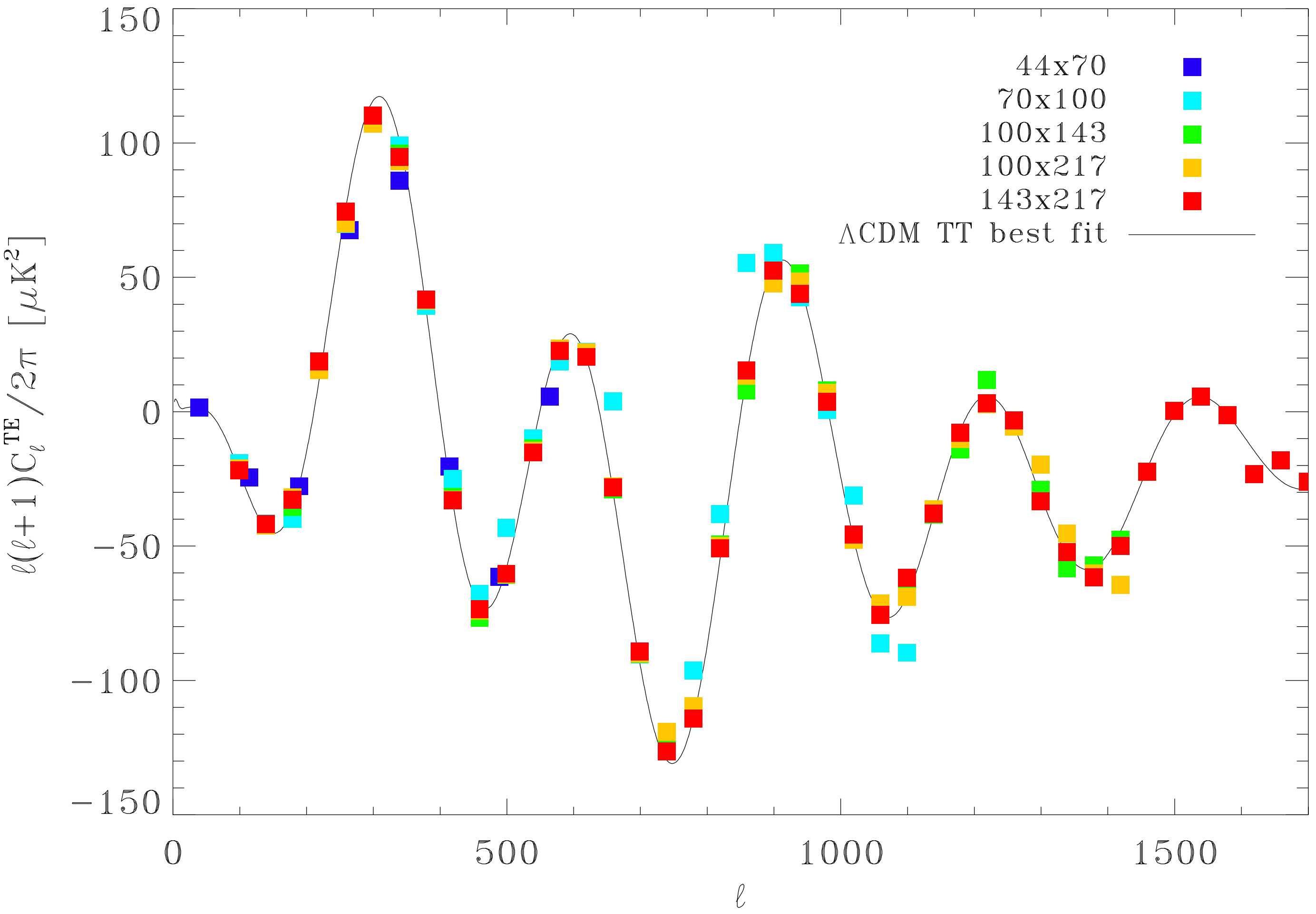
Outline

- Planck CMB polarization consistency at small angular scales.
- Preliminary results on large angular scales.
- Using Planck 353 as a dust tracer: impact on the Planck low ℓ likelihood.

peak-polarization correlation

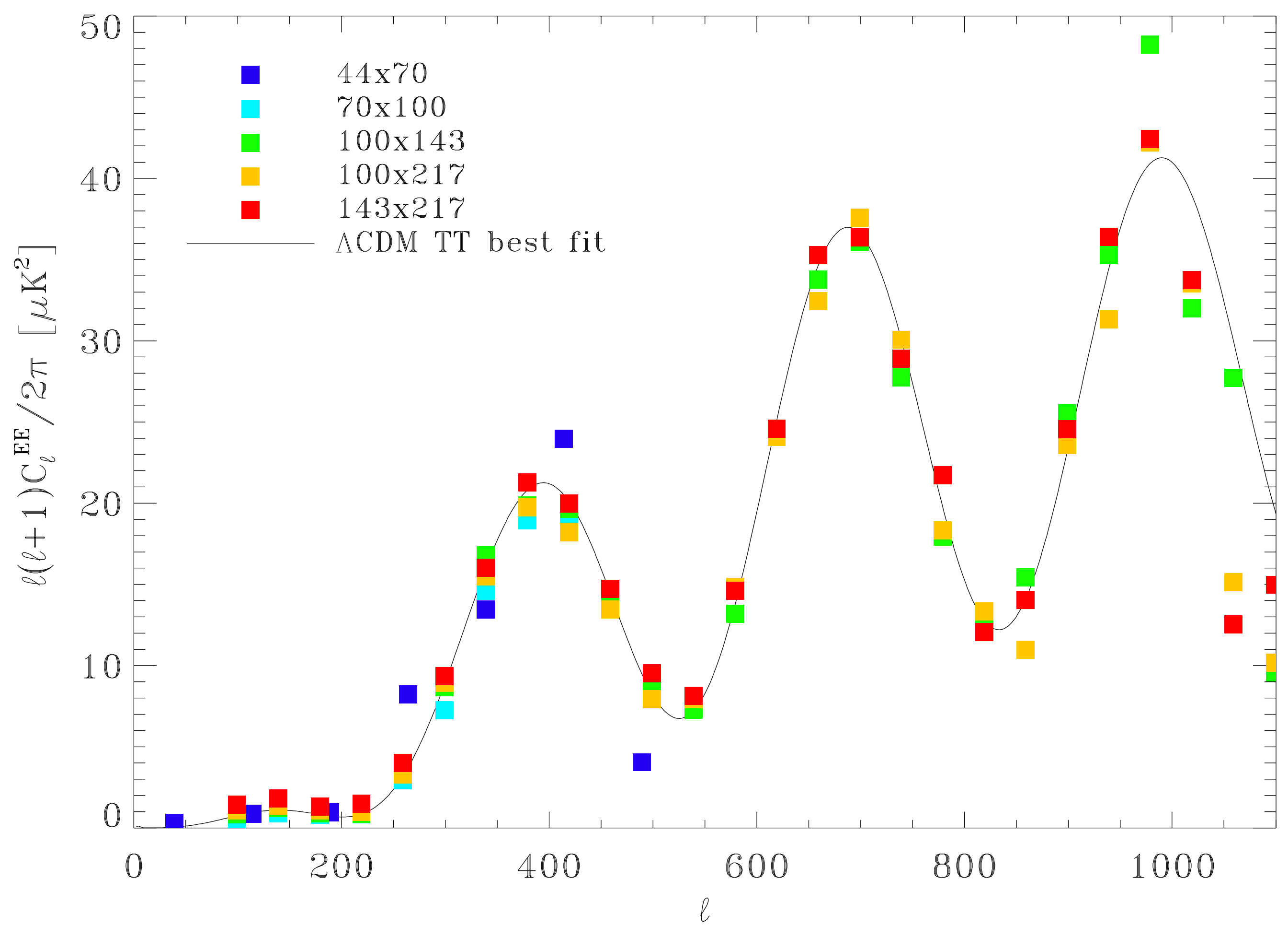


Planck polarization power xspectra, 44 to 217 GHz



No map cleaning except a sky mask
Prediction from Planck TT ΛCDM best fit model just displayed (no fit to TE data)

Planck polarization power xspectra, 44 to 217 GHz



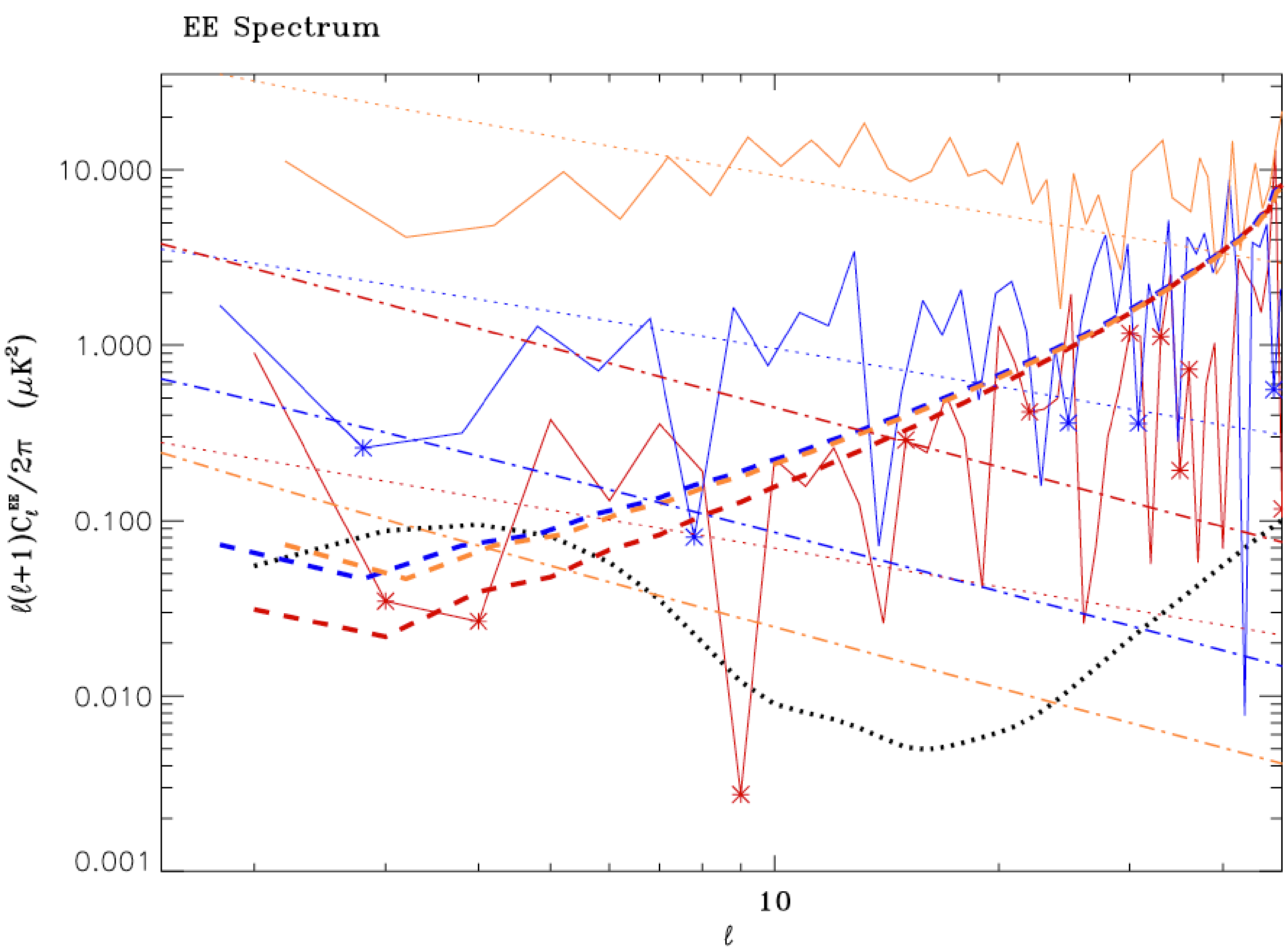
No map cleaning except a sky mask

Prediction from Planck TT ΛCDM best fit model just displayed (no fit to EE data)

Low resolution spectra are more troublesome

- Foreground emission is non negligible even at high galactic latitude: need mitigation
  - Synchrotron < 100 GHz
  - Dust > 70 GHz
- Spatial noise correlations due to detector *1/f* are non negligible
  - Maximum likelihood (map based) approach to beat low S/N
- Large scale systematic must be kept under control
  - Band pass mismatch
  - Gain variations & gain mismatch
  - Beam pattern far sidelobes

Uncleaned EE power at 30, 44 and 70 GHz – Galactic mask



30 GHz

44 GHz

70 GHz

Noise level

Dust emission level

Synchrotron emission level

Gold et. al 2011

Planck 70 GHz as a test case

- "Clean window" for CMB emission (large scales)
  - Use 30 GHz as synchrotron template and 353 GHz as a dust template

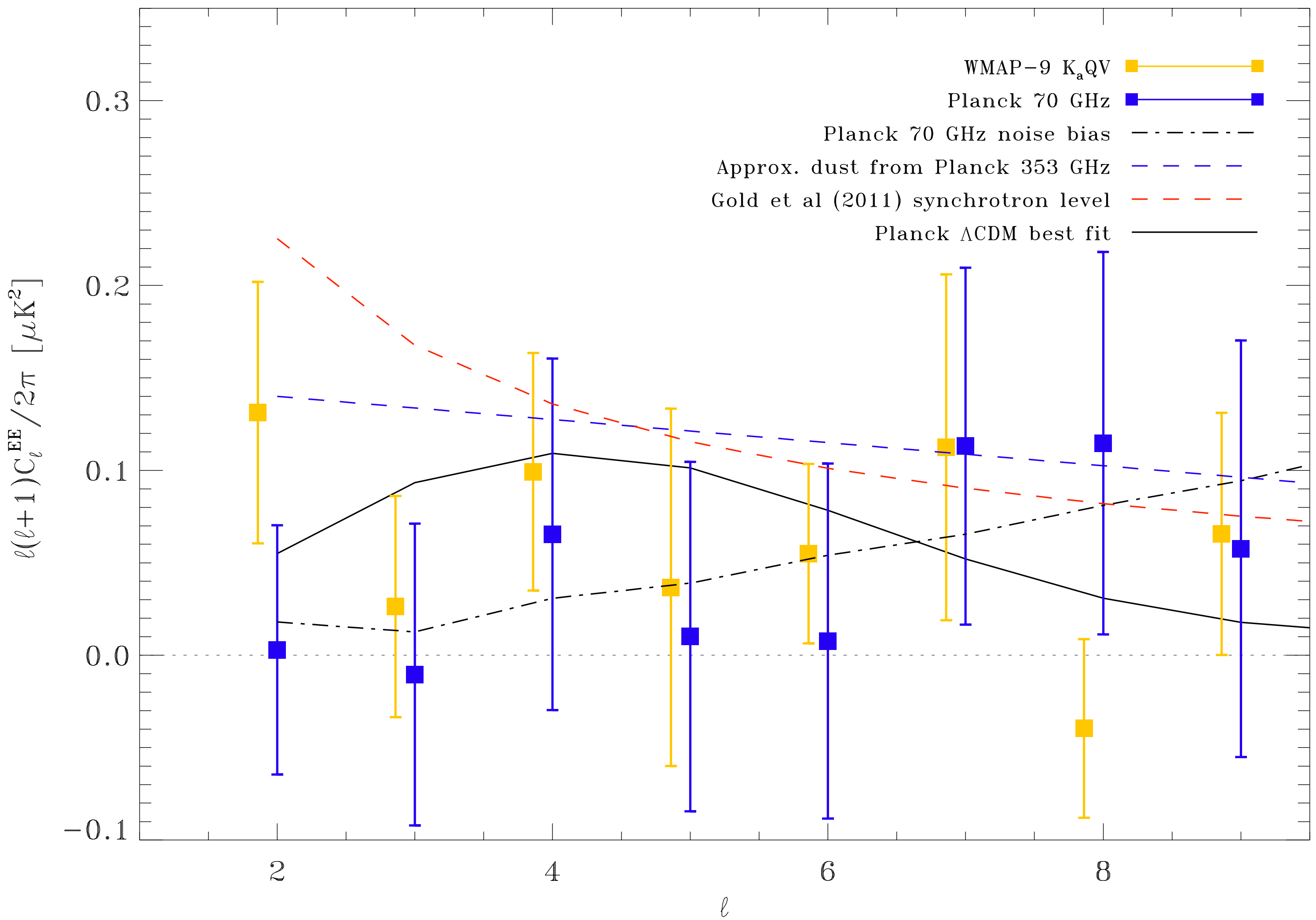
$$\chi^2(\alpha,\beta) = m_{70,\ \mathrm{clean}} C^{-1} m_{70,\ \mathrm{clean}}$$

$$m_{70,\ \mathrm{clean}} = m_{70} - \alpha m_{30} - \beta m_{353}$$

$$C = (1-\alpha-\beta)^2 S_{CMB} + N_{70} + \alpha^2 N_{30} + \beta^2 N_{353}$$

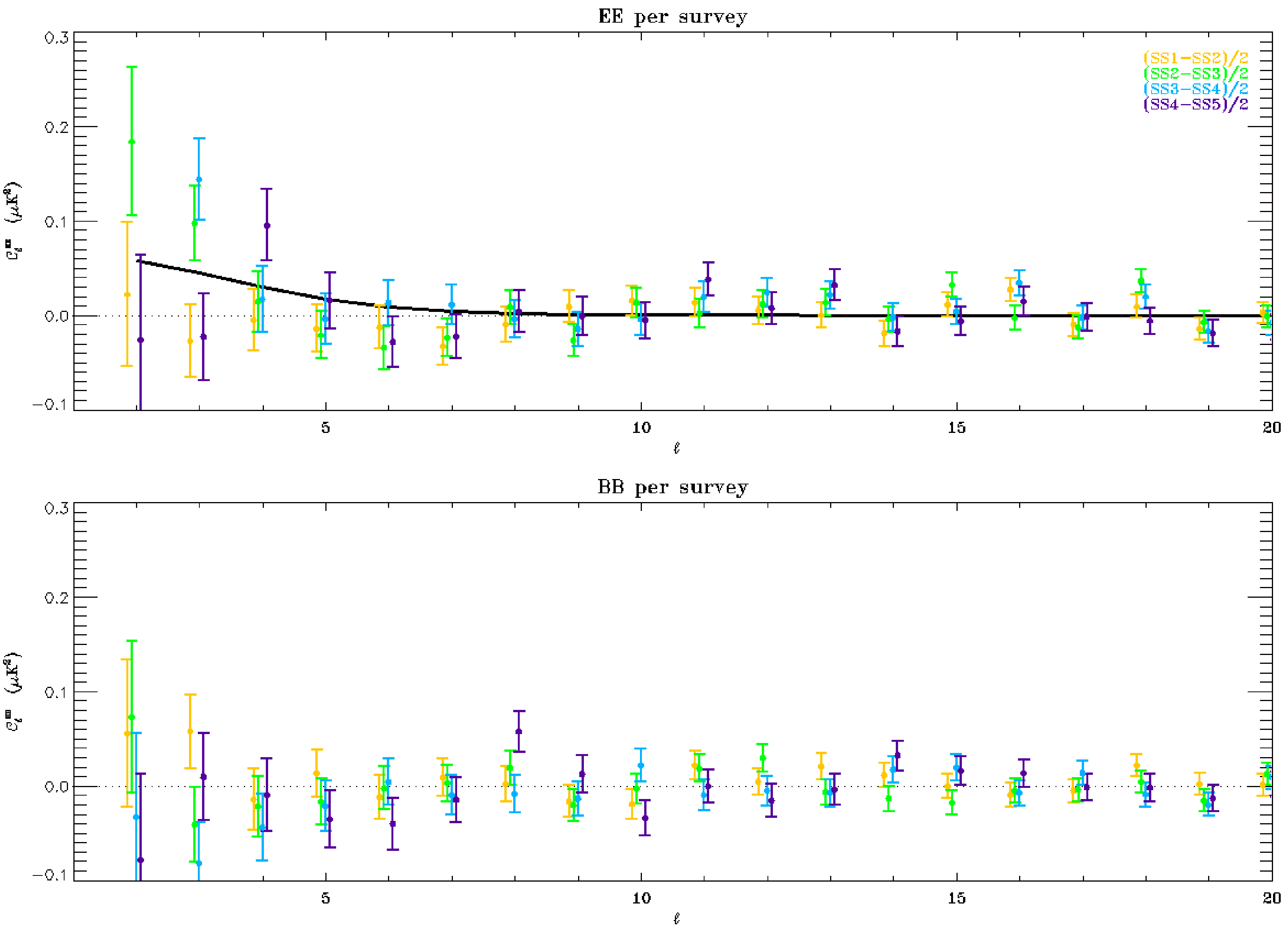
  - Stable to using WMAP K band instead of 30 GHz
- Very good control on systematics
  - Corrected for band pass mismatch (non critical outside Galactic mask)

Planck 70 GHz EE power spectrum



Based on Healpix N_{side} = 16 maps (3.4° pixels)

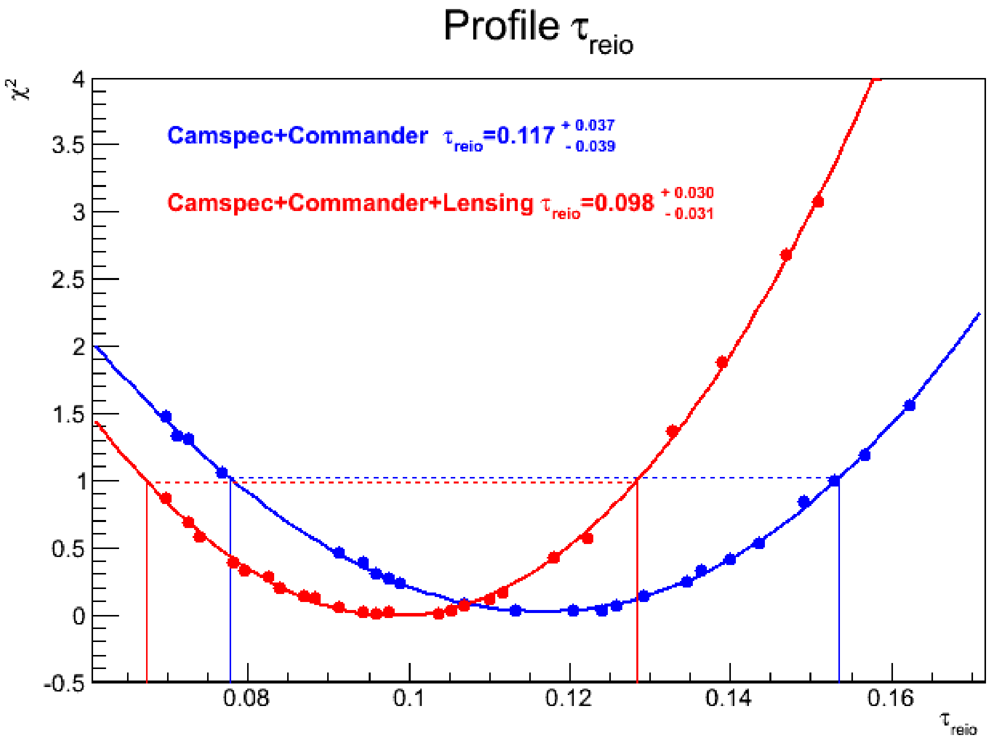
Survey null tests at 70 GHz



No Planck low ell polarization release in 2013

- Null tests still need work to clear completely.
- Low ℓ polarization helps constraining the Thomson scattering optical depth due to reionization, τ
  - Planck non polarized τ estimates (TT lensing)
- WMAP-9 is used in the Planck official likelihood
  - Tested how WMAP-9 performs with Planck 353 based dust cleaning.

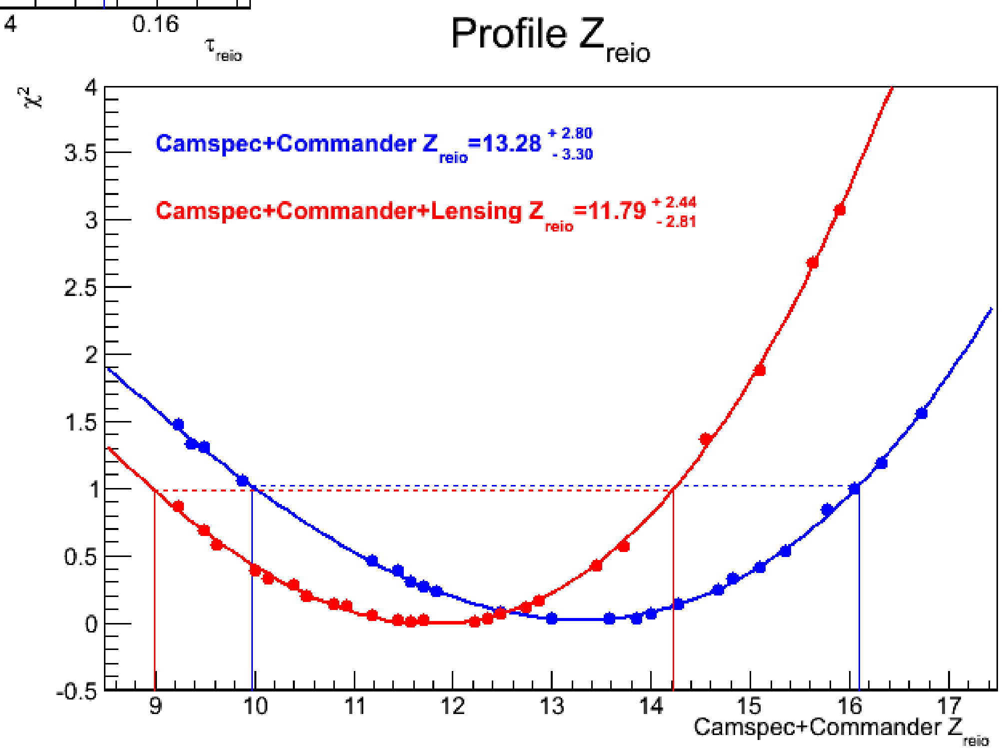
Non polarized τ and zreio estimates from Planck



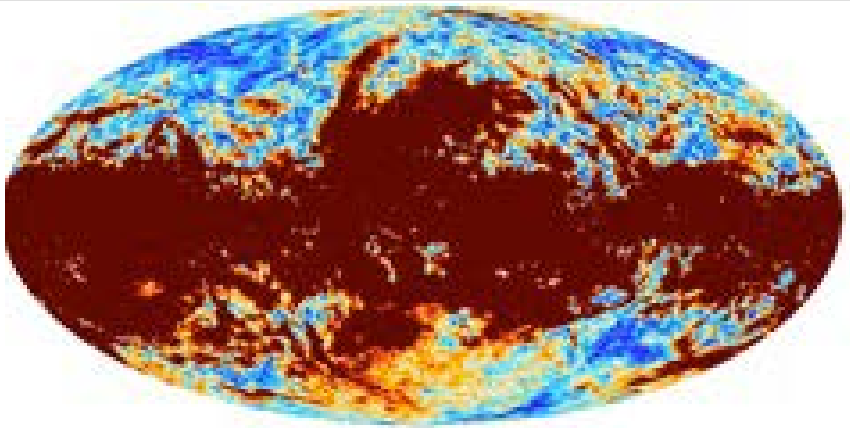
$$\tau = 0.089 \pm 0.032$$

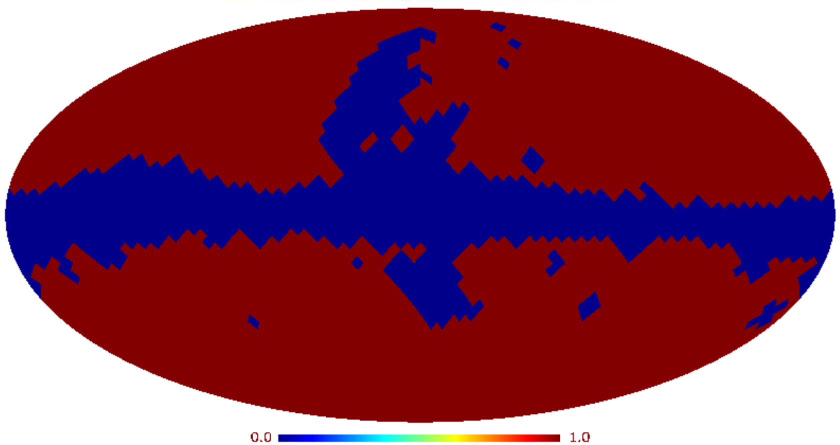
Planck + Lensing, MCMC based

Planck Collaboration. XVI

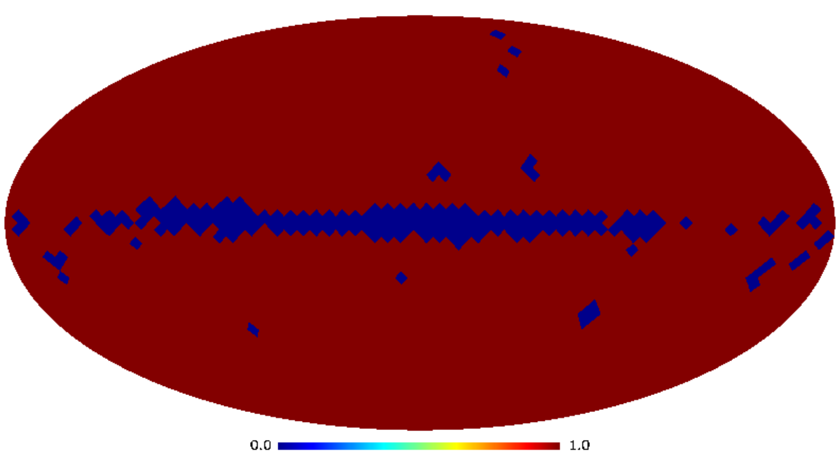


WMAP-9 dust cleaning using HFI 353



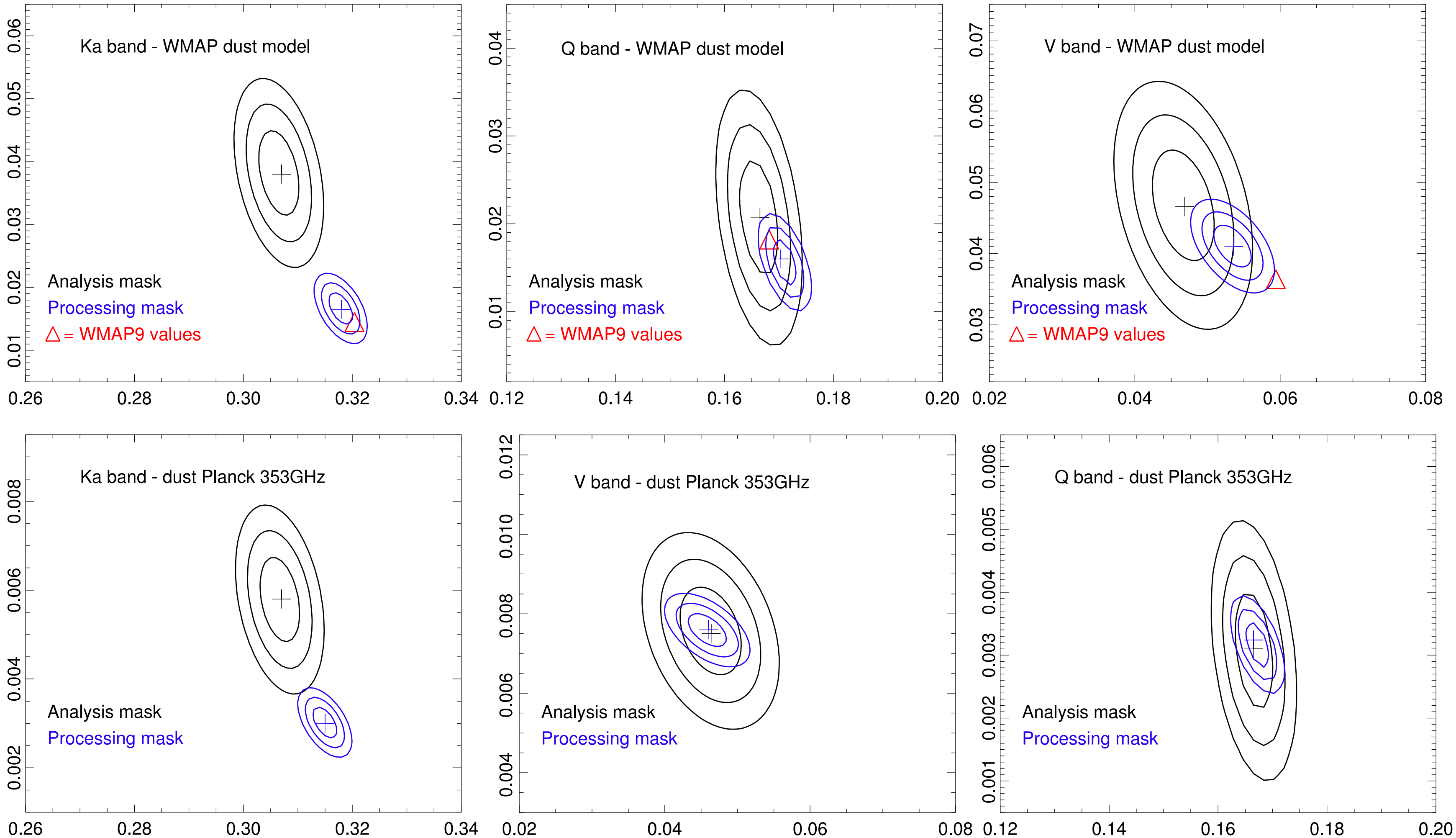


WMAP 9−year Q−band processing mask



- WMAP-9 low ell likelihood is cleaned from polarized dust emission by using a dust model
- We see how replacing it with Planck 353 data changes the picture
- Aim is to demonstrate stability of Planck cosmology to this choice
- WMAP-9 analysis and foreground processing masks shown at left, along with 353 polarized intensity.
- Machinery is preliminary and not implemented in the public release Planck likelihood.

Fitted scalings for Planck 353 based WMAP-9 dust cleaning

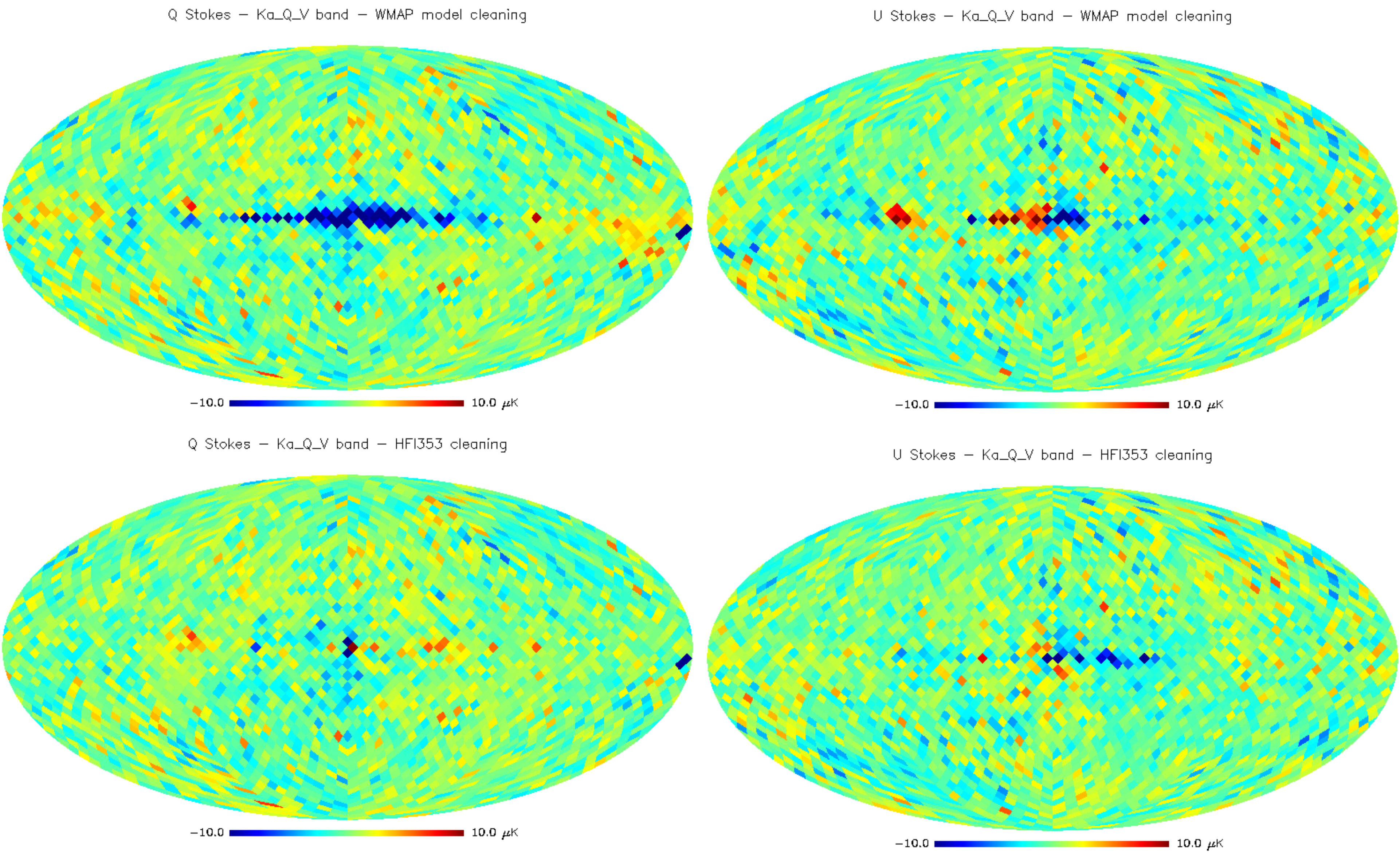


$$\chi^2(\alpha,\beta) = m_{\mathrm{clean}} C^{-1} m_{\mathrm{clean}}$$

$$m_{\mathrm{clean}} = m_{KaQV} - \alpha m_K - \beta m_{353}$$

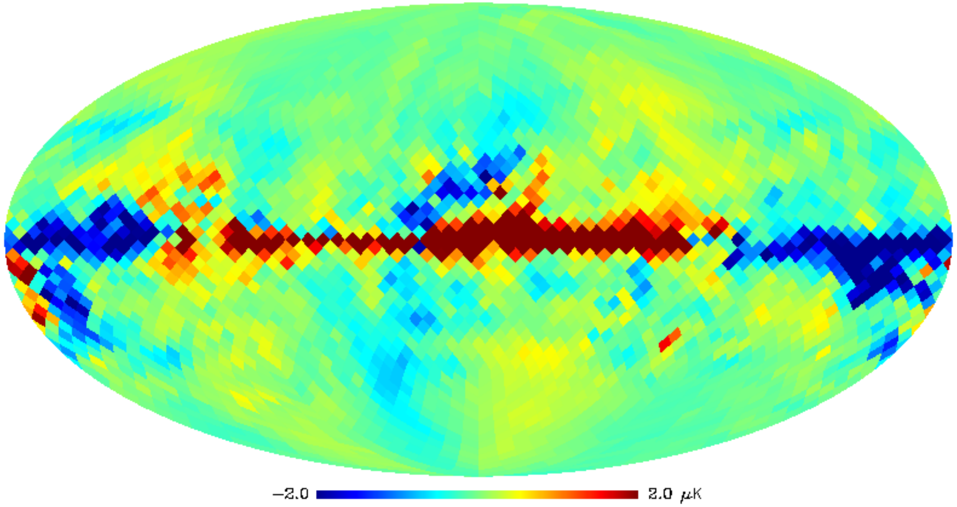
$$C = N_{KaQV} \quad \text{(diagonal as in WMAP analysis)}$$

WMAP-9 KaQV: dust model vs Planck 353

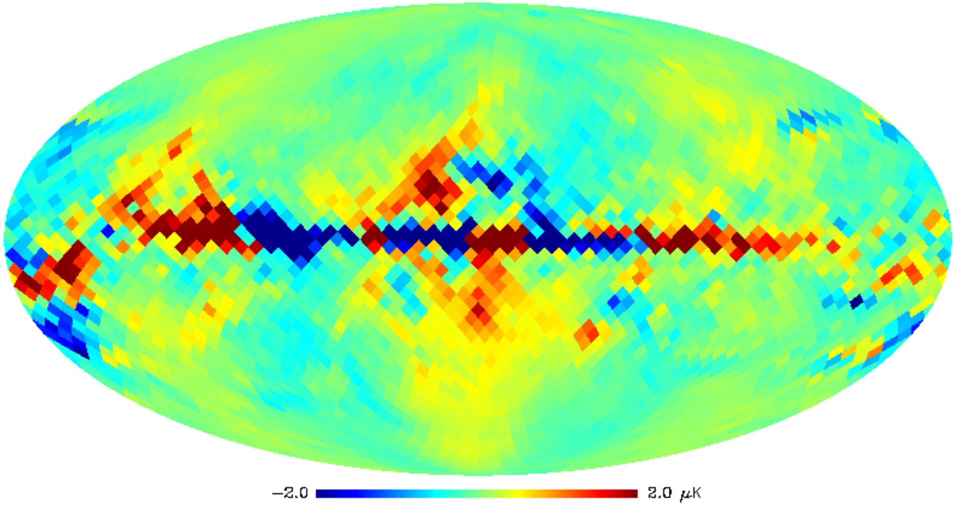


Difference maps KaQV, dust model and HFI 353

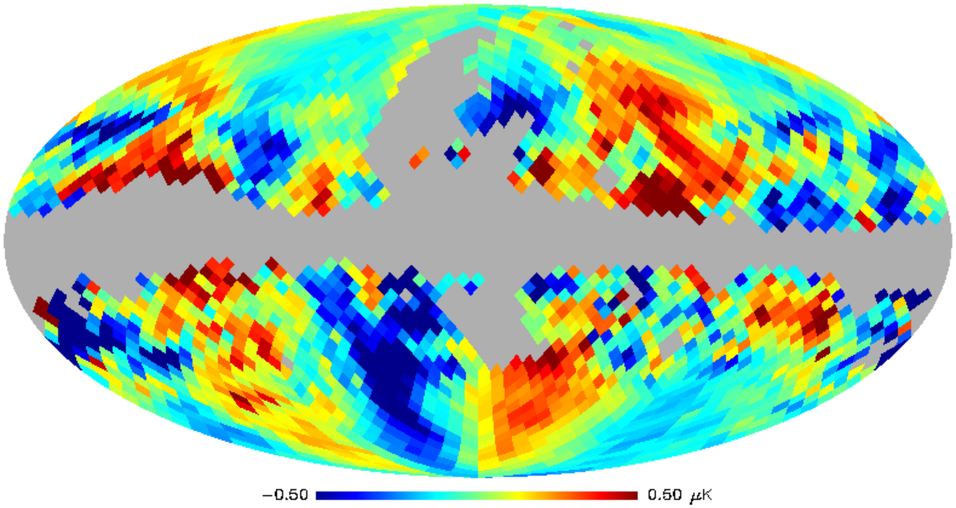
Q stokes – Ka+Q+V – diff (HFI cln – WMAP cln)



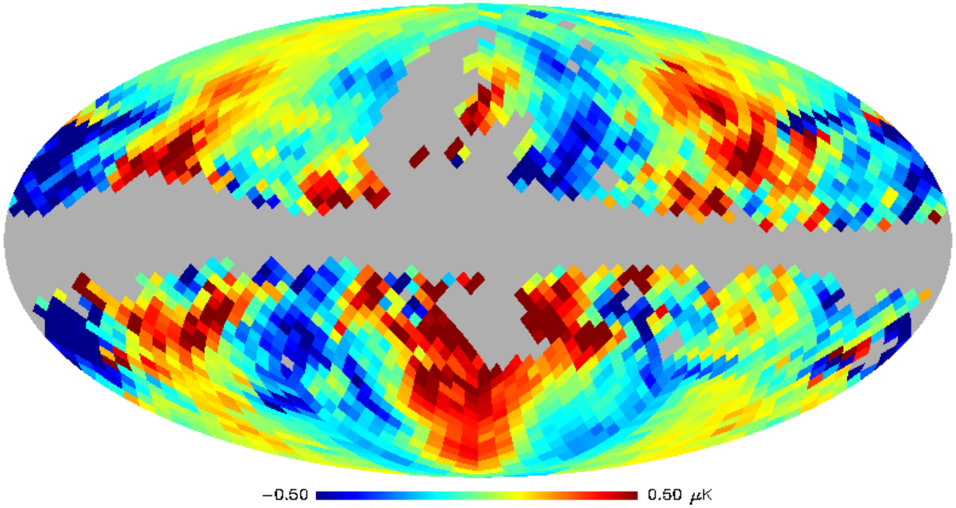
U stokes – Ka+Q+V – diff (HFI cln – WMAP cln)



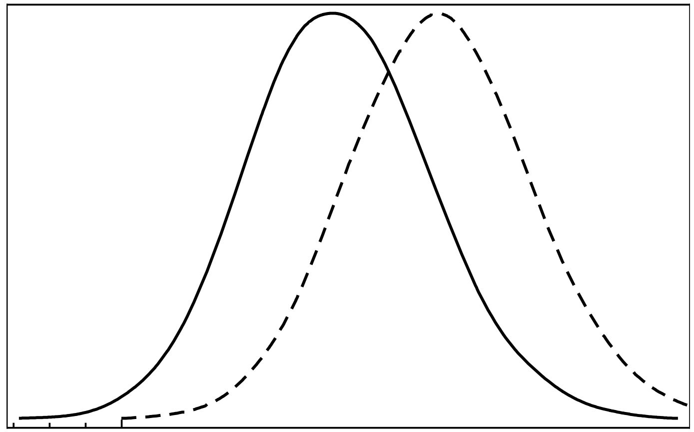
Q stokes – Ka+Q+V – diff (HFI cln – WMAP cln)



U stokes – Ka+Q+V – diff (HFI cln – WMAP cln)



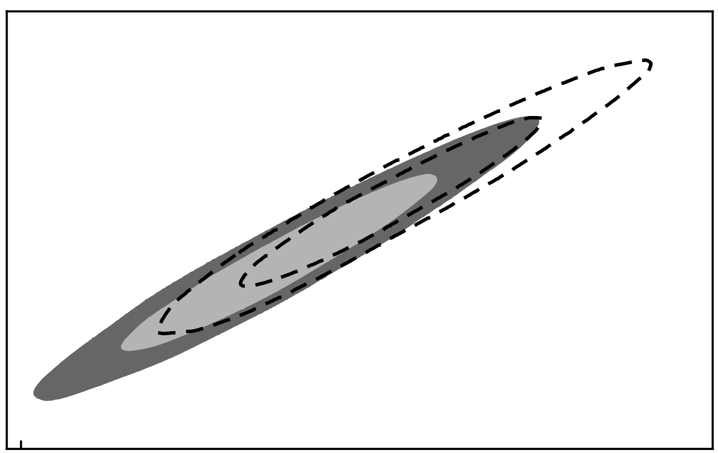
Impact on parameters (Planck TT high and low ell)

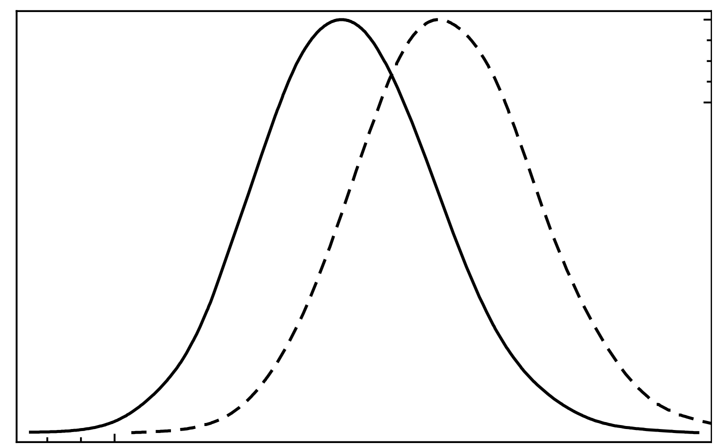


1σ	Planck 353	Dust model
τ	0.075 ± 0.013	0.089 ± 0.013
$\log 10^{10} A_s$	3.061 ± 0.025	3.088 ± 0.025

Effect on other LCDM parameters is negligible

]





τ

Conclusions

- We have shown consistency in CMB estimates from Planck in the 44 to 217 GHz range at small scales
- Low ℓ CMB is a more delicate business. Preliminary results are promising, but more work is needed before we can deliver a low ell polarized likelihood at Planck accuracy.
- Preliminary results on dust cleaning using Planck 353 are also encouraging when the machinery is applied on WMAP-9

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 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.