Planck Cosmological Parameters

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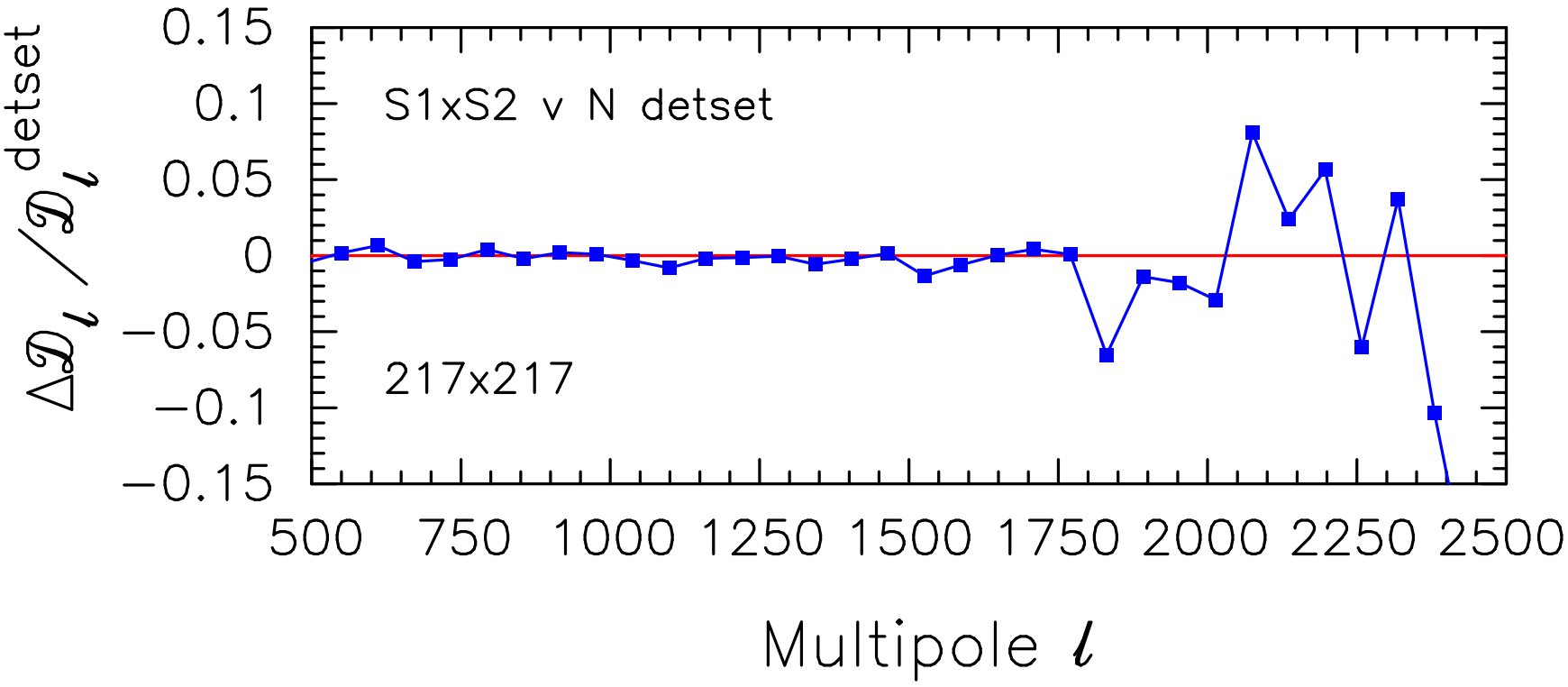
Planck Collaboration

Ferrara, 1st Dec 2014

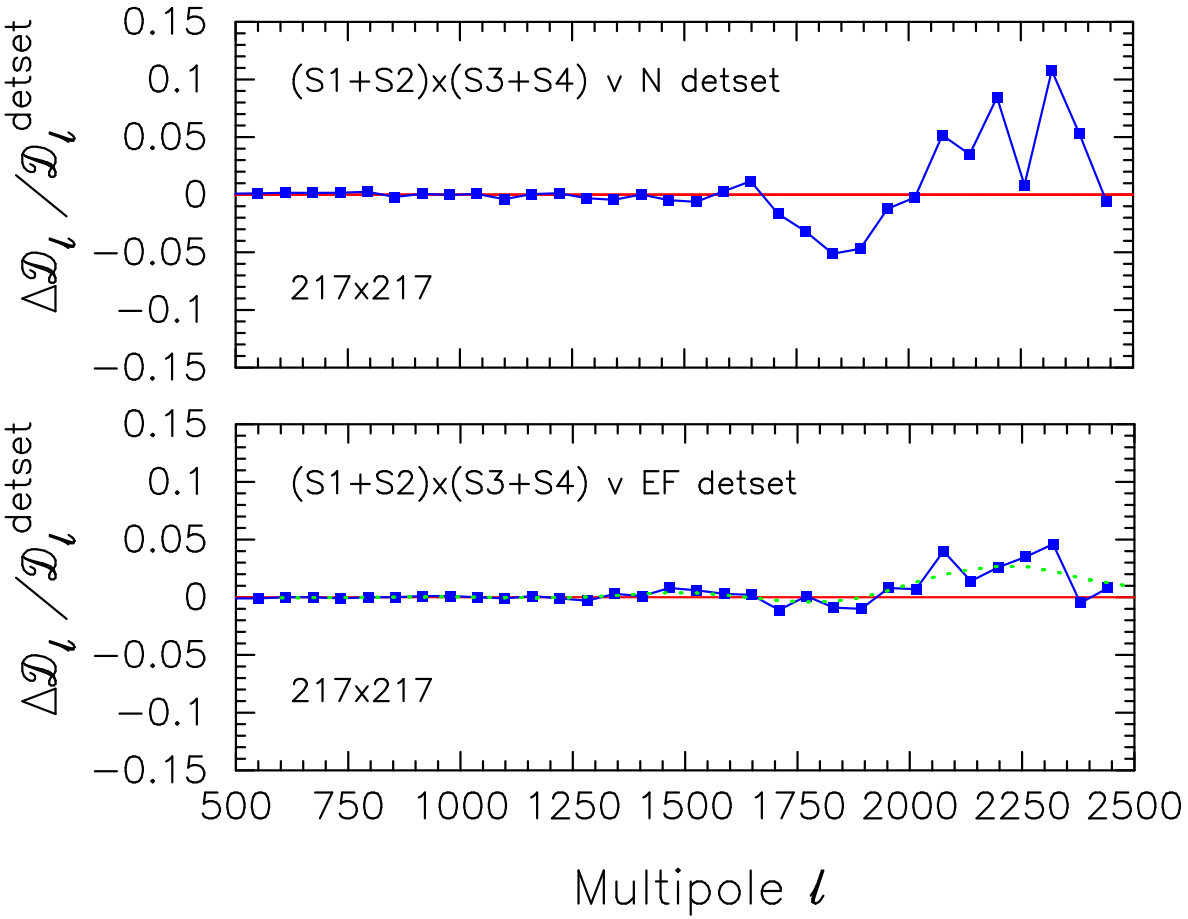
Changes for parameters, level 1

- Data from full mission
- Understanding of “4K” line systematics
- Increase in sky area used
- Corrections for low levels of correlated noise between detectors (though negligible for usual parameters)

2013 Survey1 x Survey2 *vs* 2013 detset nominal



2013 Year1 x Year2 extended sky *vs* DS nominal & DS full extended sky



2013 nominal to 2013 Y1xY2 extended

Parameter	**2013N**	**2013CYE**
$100\ \theta_{MC}$	1.04131 ± 0.00063	1.04121 ± 0.00048
$\Omega_b h^2$	0.02205 ± 0.00028	0.02230 ± 0.00023
$\Omega_c h^2$	0.1199 ± 0.0027	0.1188 ± 0.0022
H_0	67.3 ± 1.2	67.8 ± 1.0
n_s	0.9603 ± 0.0073	0.9655 ± 0.0062
Ω_m	0.315 ± 0.017	0.308 ± 0.013
σ_8	0.829 ± 0.012	0.828 ± 0.011
τ	0.089 ± 0.013	0.094 ± 0.013

2013: nominal to Y1xY2 extended

Parameter	**Δparam (% of 2013N σ's)**	**σ (% of 2013N σ's)**
$100\ \theta_{MC}$	-16	76
$\Omega_b h^2$	89	82
$\Omega_c h^2$	-41	81
H_0	42	83
n_s	71	85
Ω_m	-41	76
σ_8	-8	92
τ	38	100

Changes for parameters, level 2

- Improved TOI processing
- Calibration and beams
- Alternative implementation of likelihood used
- Improved foreground handling, including dust emission at all frequencies
- Cross-half-mission, not detsets, now the default
- Polarization now an option in the likelihood

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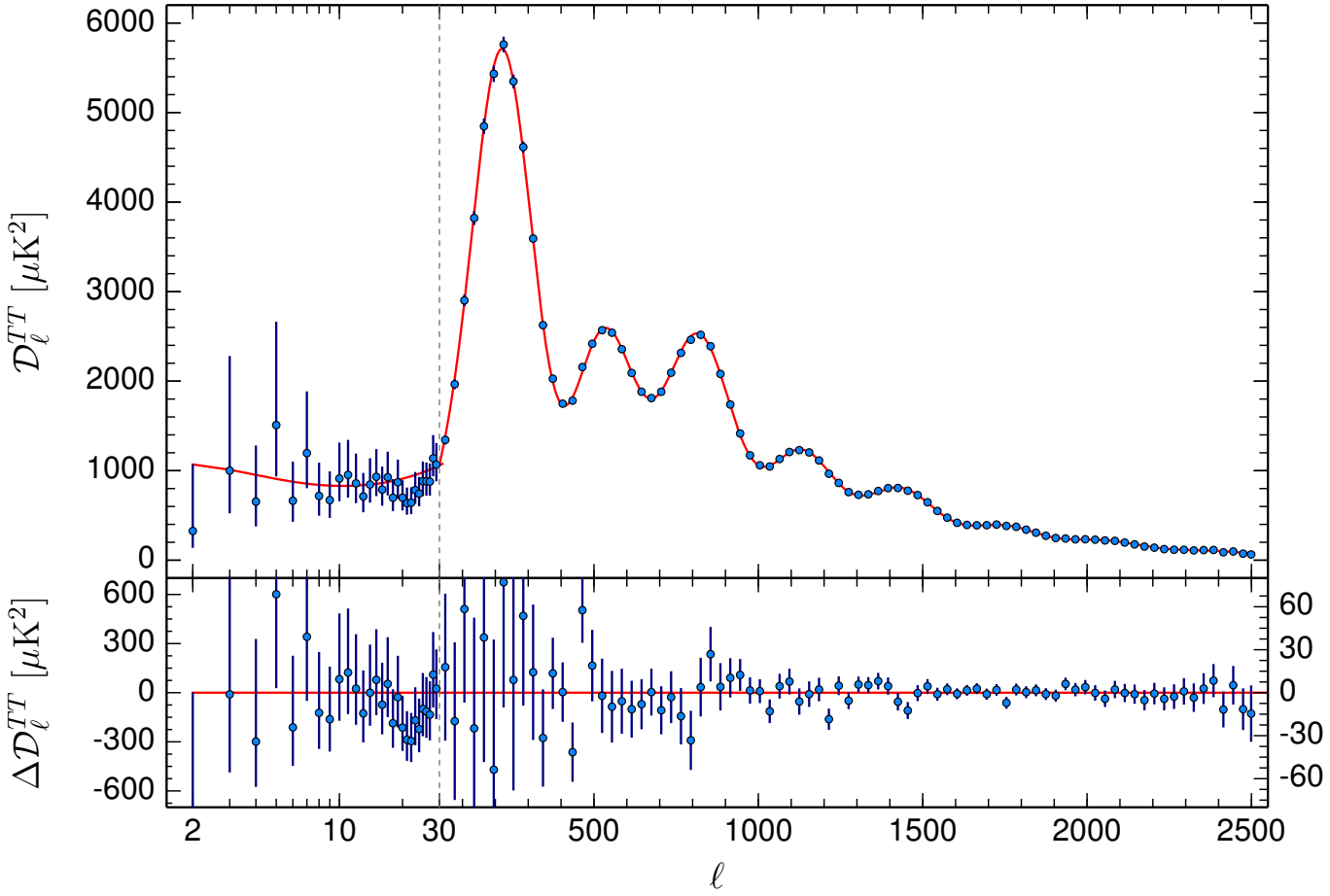
So now, with 2014 TT



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2013 Y1xY2 E (CamSpec) to 2014 cross-half-mission (Plik)

Parameter	2013CYE	2014 CHM Plik
$100\ \theta_{MC}$	1.04121 ± 0.00048	1.04086 ± 0.00048
$\Omega_b h^2$	0.02230 ± 0.00023	0.02222 ± 0.00023
$\Omega_c h^2$	0.1188 ± 0.0022	0.1199 ± 0.0022
H_0	67.8 ± 1.0	67.26 ± 0.98
n_s	0.9655 ± 0.0062	0.9652 ± 0.0062
Ω_m	0.308 ± 0.013	0.316 ± 0.014
σ_8	0.828 ± 0.011	0.830 ± 0.015
τ	0.094 ± 0.013	0.078 ± 0.019
$10^9 A_s e^{-2\tau}$	1.831 ± 0.011	1.881 ± 0.014

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So, how did we do for 2013?

Parameter	Δparam (% of 2014 σ's)
$100\,\theta_{MC}$	94
$\Omega_b h^2$	-74
$\Omega_c h^2$	0
H_0	4
n_s	-79
Ω_m	-7
σ_8	-7
τ	58
$10^9 A_s e^{-2\tau}$	-320

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How are we doing for 2014?

Parameter	CamSpec-Plik (% of 2014 σ's)
$100\,\theta_{MC}$	17
$\Omega_b h^2$	13
$\Omega_c h^2$	-23
H_0	22
n_s	48
Ω_m	-21
σ_8	-7
τ	5
$10^9 A_s e^{-2\tau}$	-43

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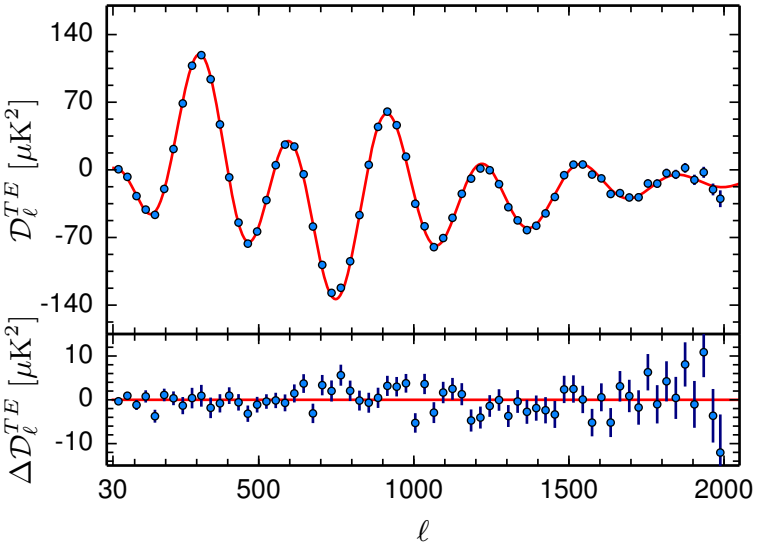
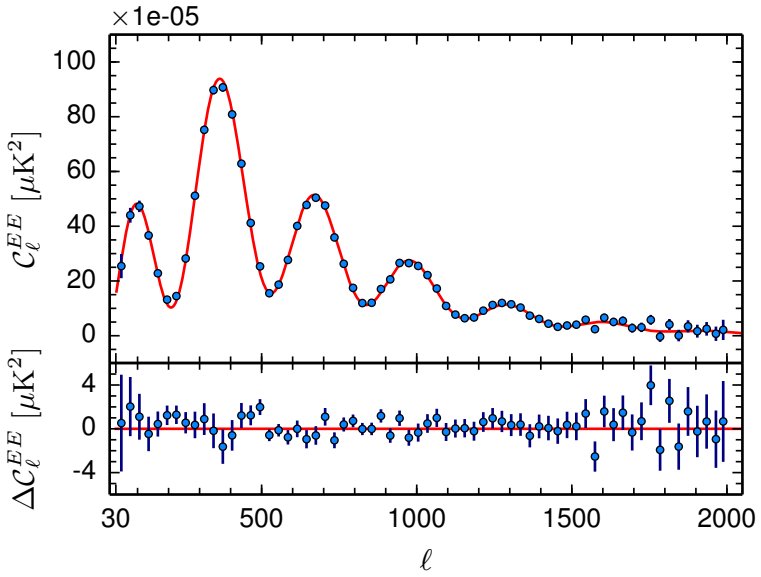
Now we have 2014 TE & EE…





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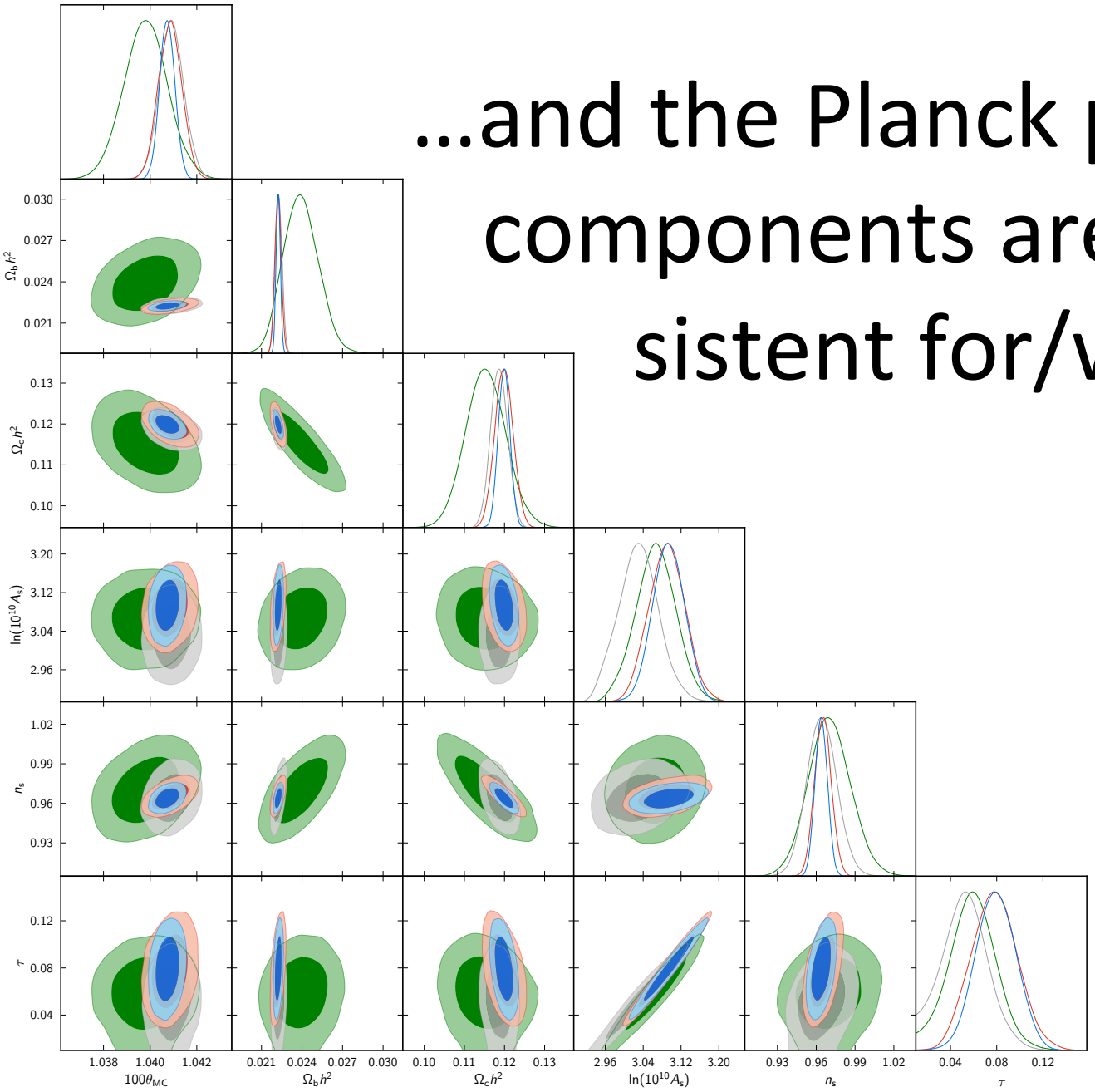
…and the Planck polarization components are quite consistent for/with ΛCDM!



Planck EE+lowP
Planck TE+lowP
Planck TT+lowP
Planck TT,TE,EE+lowP

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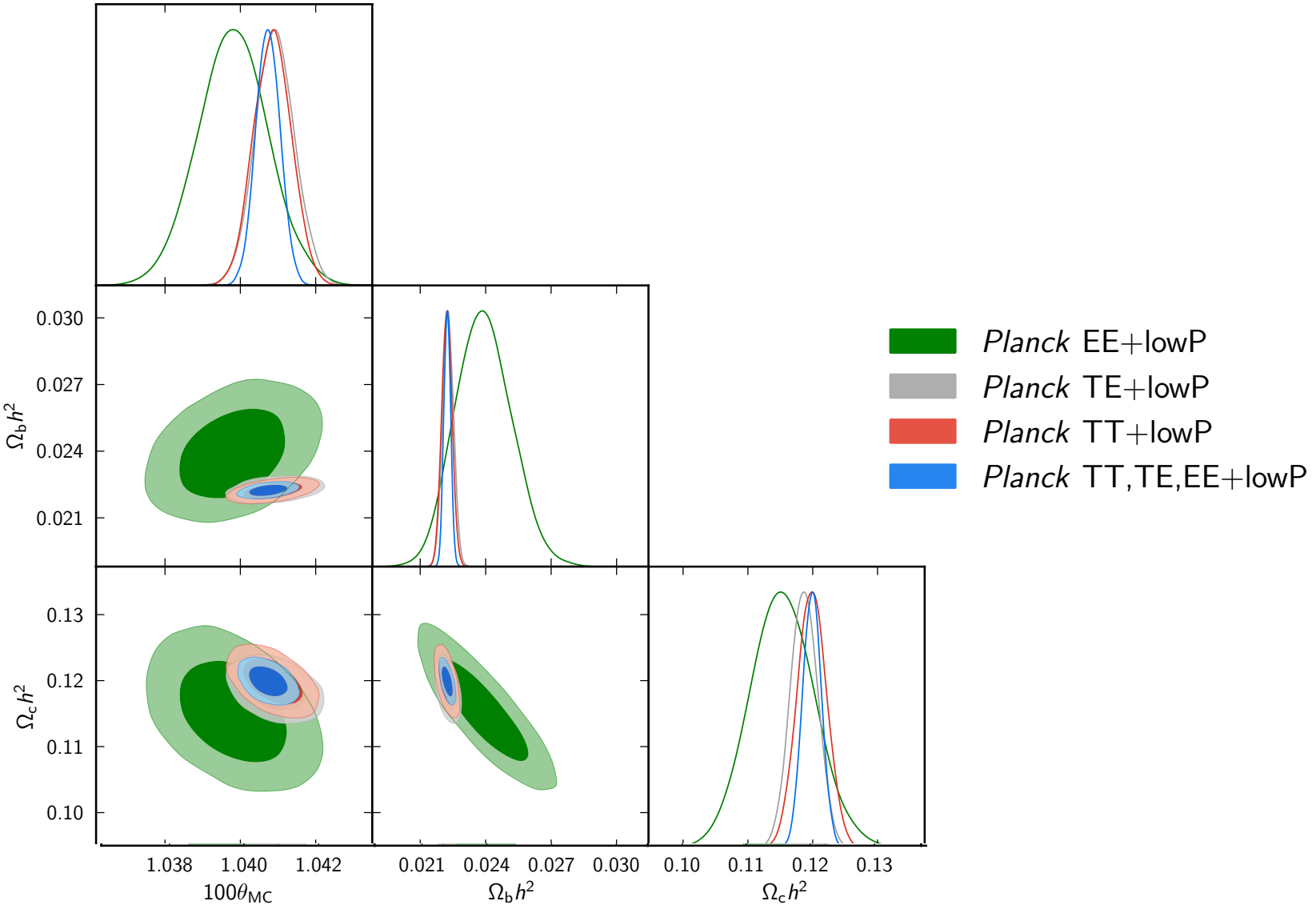
Zoom 1:



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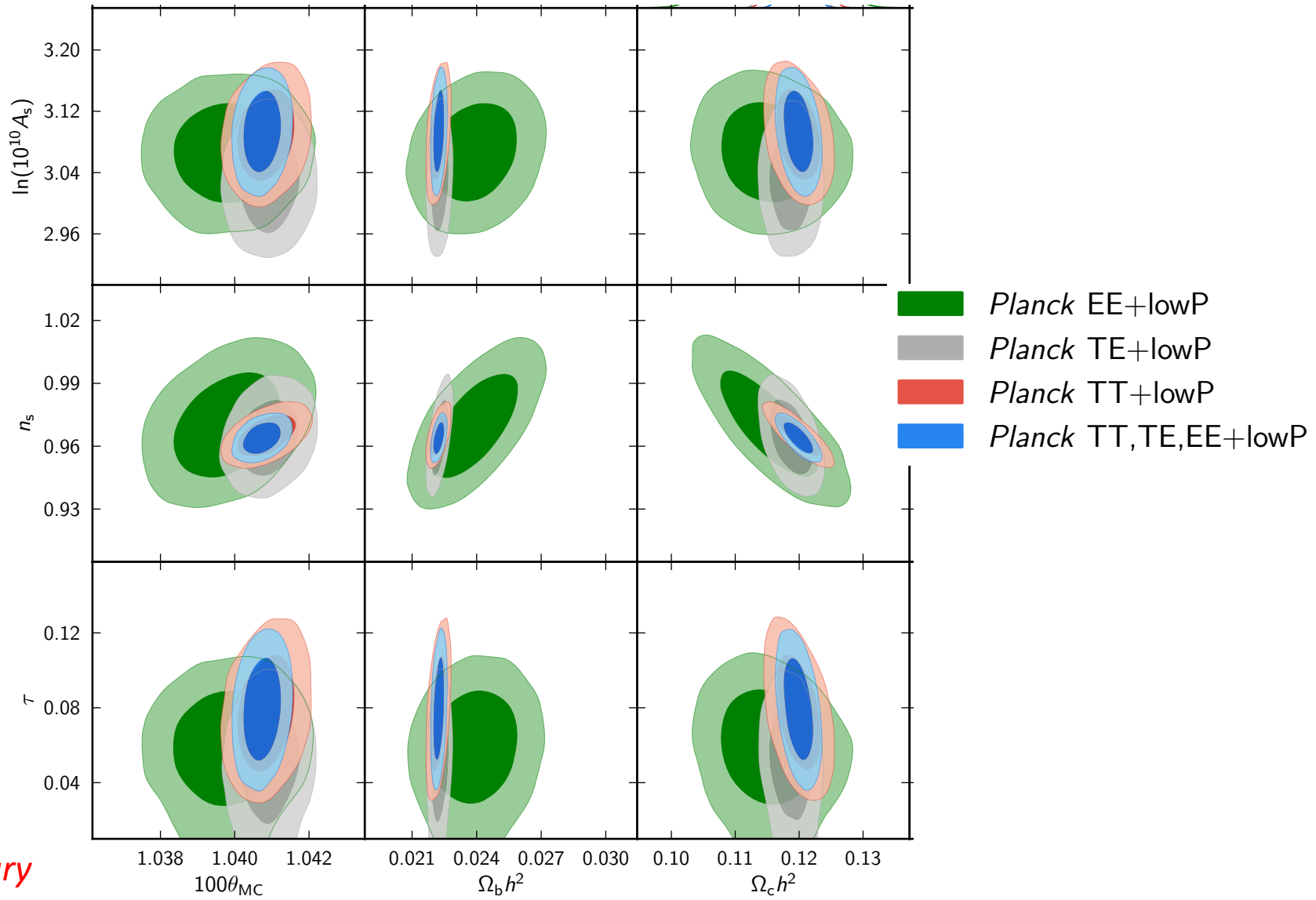
Zoom 2:



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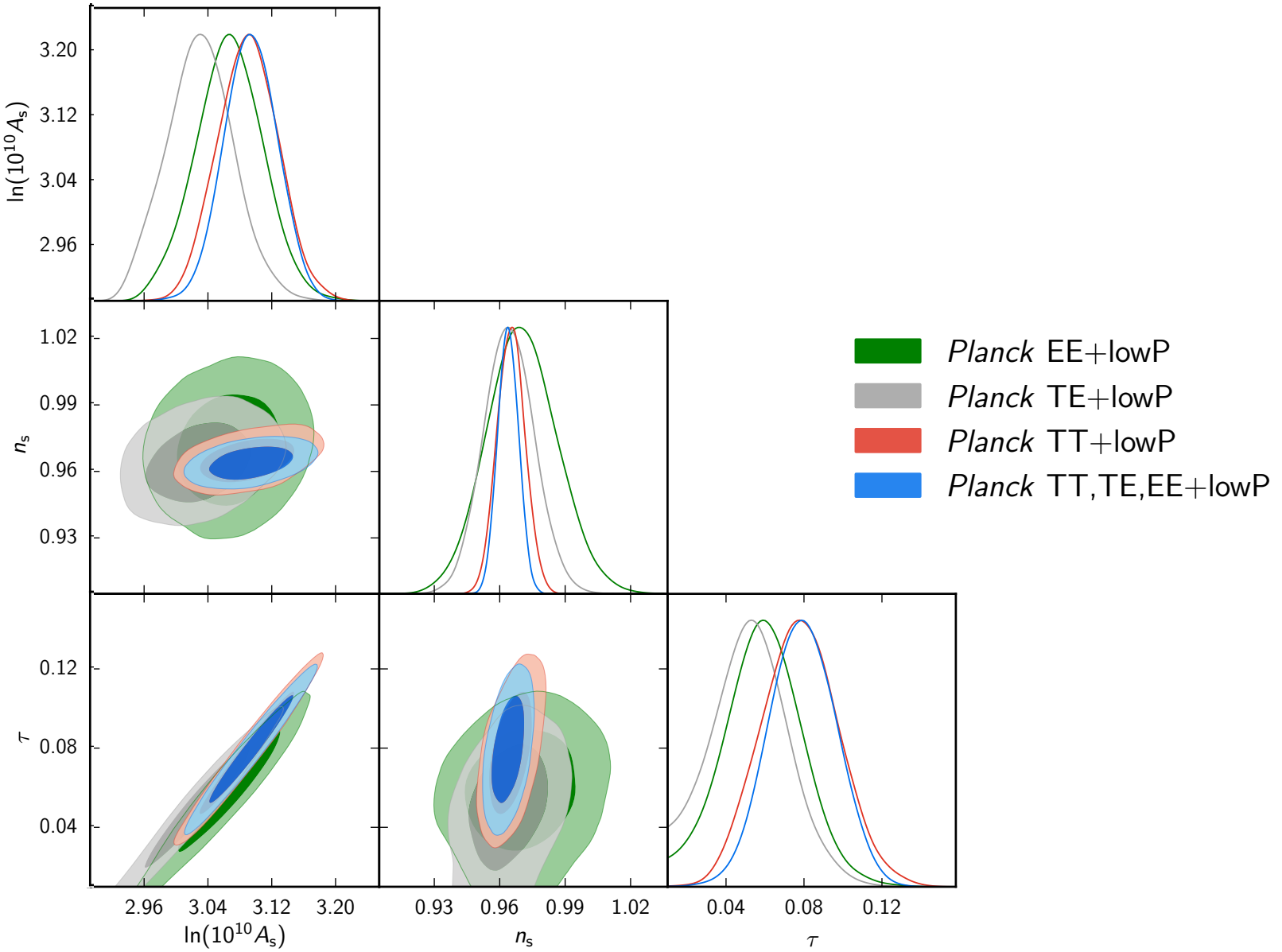
Zoom 3:



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2014 TT to TT,TE,EE

Parameter	2014 Planck TT + lowP	2014 Planck TT,TE,EE+lowP
$100\,\theta_{MC}$	1.04086 ± 0.00048	1.04073 ± 0.00032
$\Omega_b h^2$	0.02222 ± 0.00023	0.02224 ± 0.00015
$\Omega_c h^2$	0.1199 ± 0.0022	0.1199 ± 0.0014
H_0	67.26 ± 0.98	67.22 ± 0.64
n_s	0.9652 ± 0.0062	0.9639 ± 0.0047
Ω_m	0.316 ± 0.014	0.316 ± 0.009
σ_8	0.830 ± 0.015	0.831 ± 0.013
τ	0.078 ± 0.019	0.079 ± 0.017
$10^9 A_s e^{-2\tau}$	1.881 ± 0.014	1.883 ± 0.012

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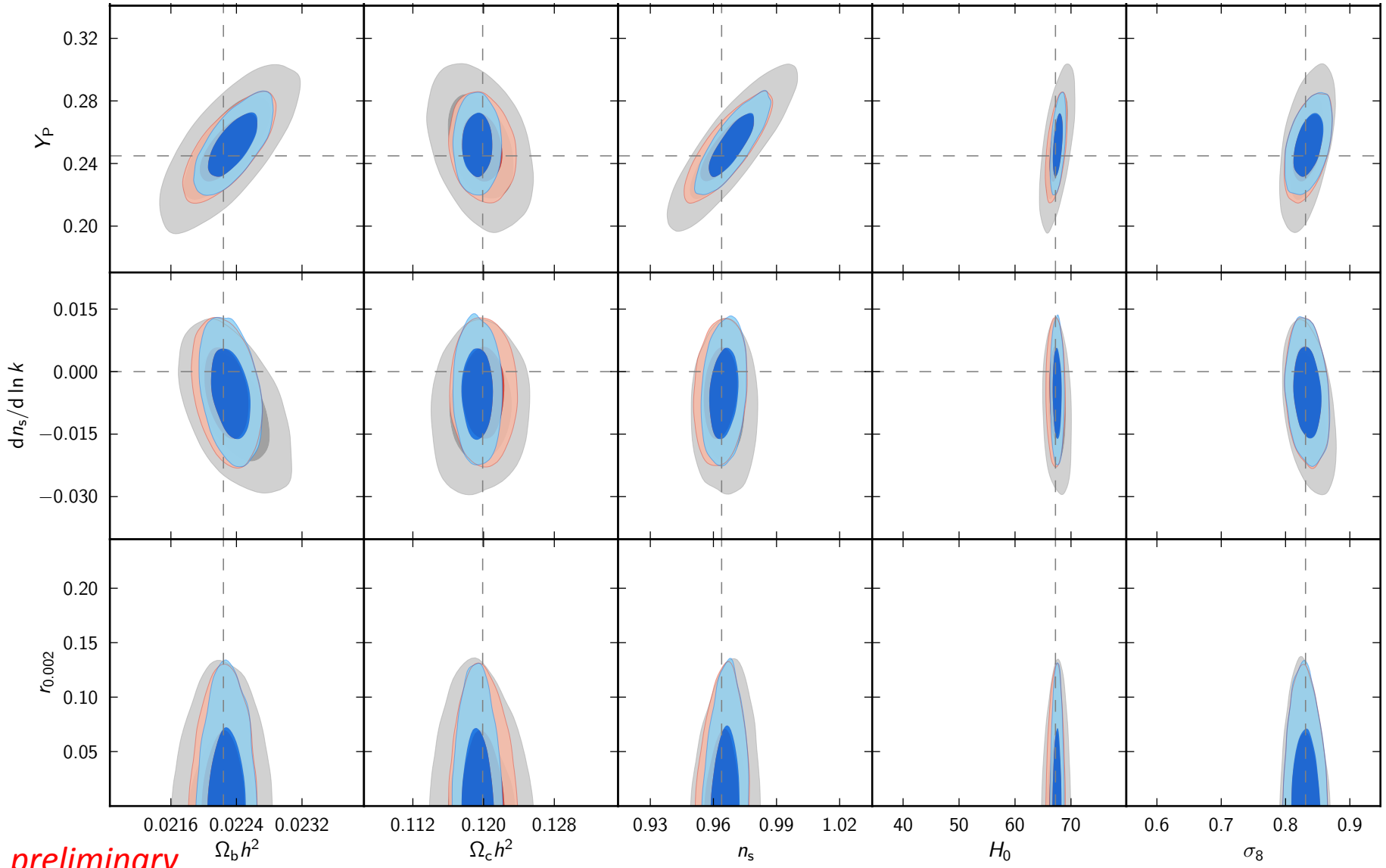
The grid: Y_p, $dn_s/d\ln k$ & r...



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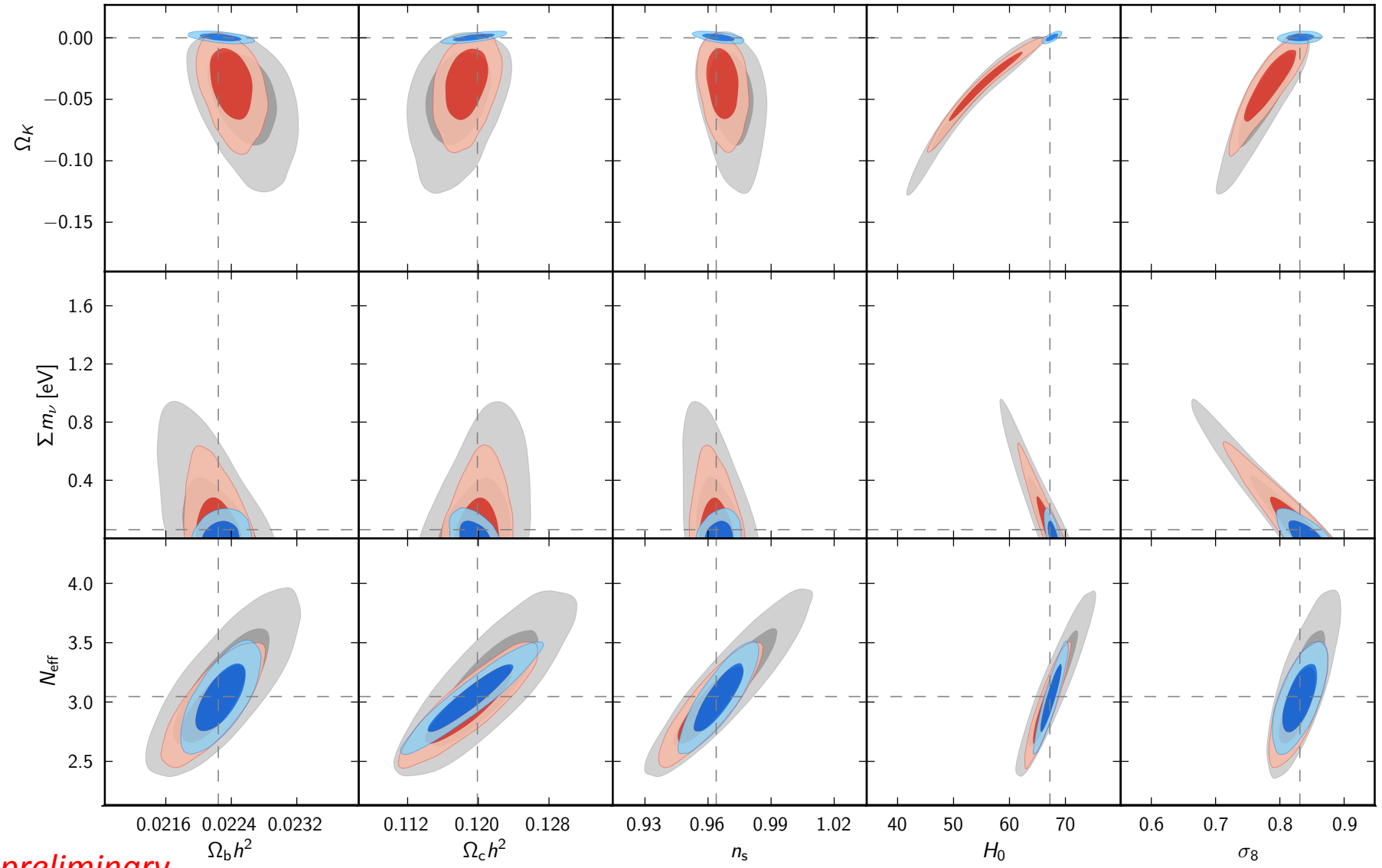
Ω_k, m_ν & $N_{\rm eff}$...



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Summary

- 2014 TT a significant evolution over 2013
  - Improved parameter constraints, driven by larger sky area used and full vs nominal data
- Polarization data now included, though not as well-tested as temperature
- ΛCDM still seems to fit well, now both the temperature and polarization data, though
  - Marginal tensions (curvature, A_lens… as 2013)
  - low-*l* anomalies

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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.