

What I heard about Planck 2014

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[v1@IPMU] December 9, 2014

[v2@UTAP] December 22, 2014

Disclaimer

- I am not involved in Planck
- I did not attend the conference in Ferrara, Italy, for the Planck 2014 results
- [v1] What I am presenting here is based on what I was informed by two Planck team members during the conference and the press release at public.planck.fr
- [v2] The talk slides from the Ferrara Conference are now available

Background

- March 21, 2013: Planck 2013 Release
 - 15.5-month data, temperature only
- **December 1, 2014: Planck 2014 Conference**
 - Full mission data [HFI 29mo; LFI 49mo]. **The data release later this year (or in January 2015) will still be temperature only** (except for the polarisation data at 30, 44, 70 [LFI] and 353GHz [HFI])
 - Preliminary cosmology results using polarisation data were also presented, but **nothing on BICEP2**

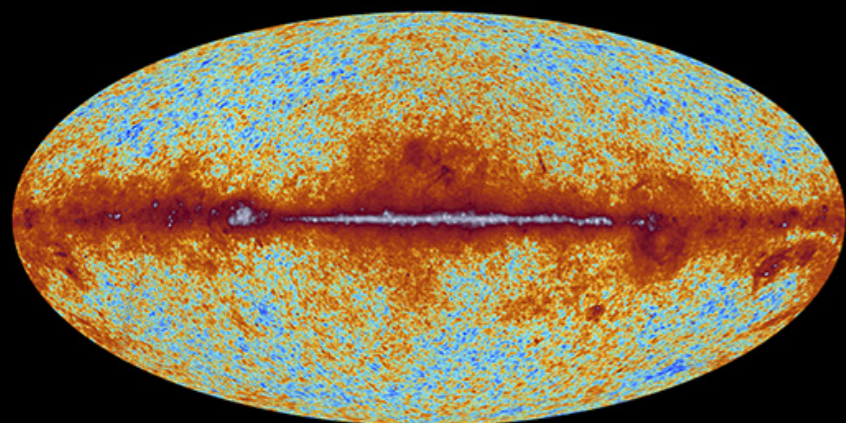


planck

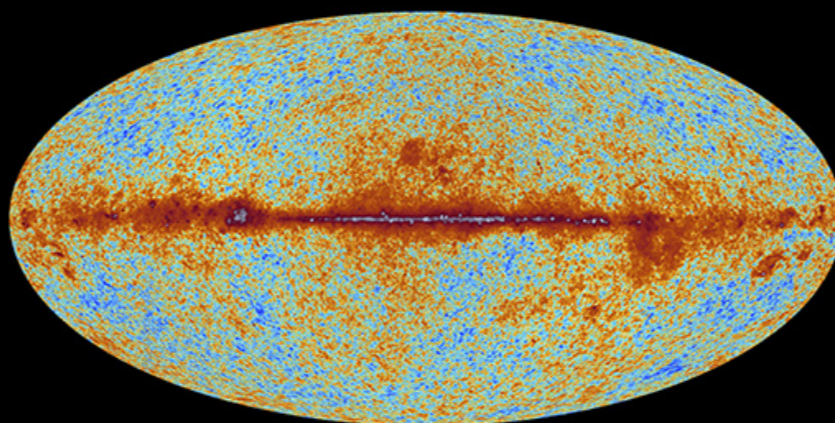
The sky as seen by Planck



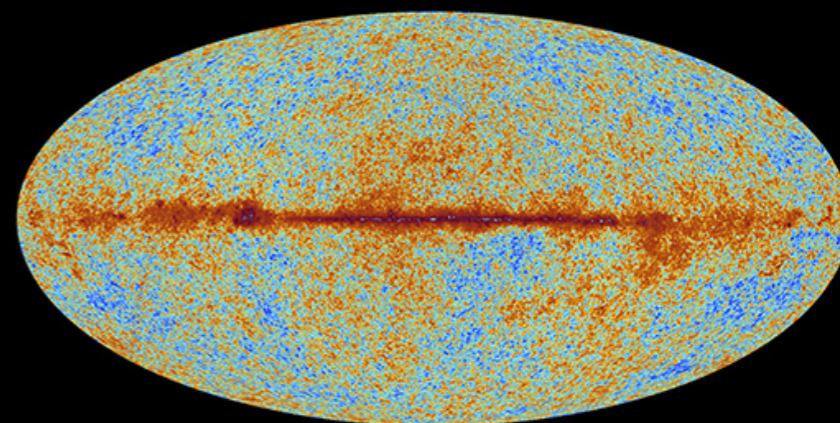
Planck 2013 Release



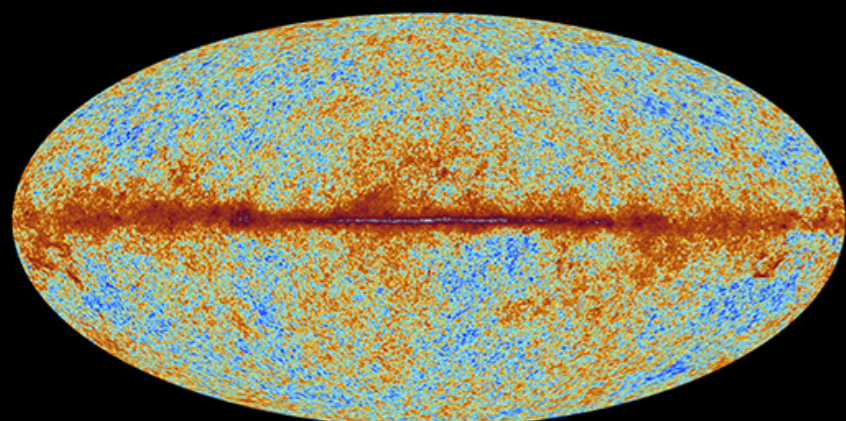
30 GHz



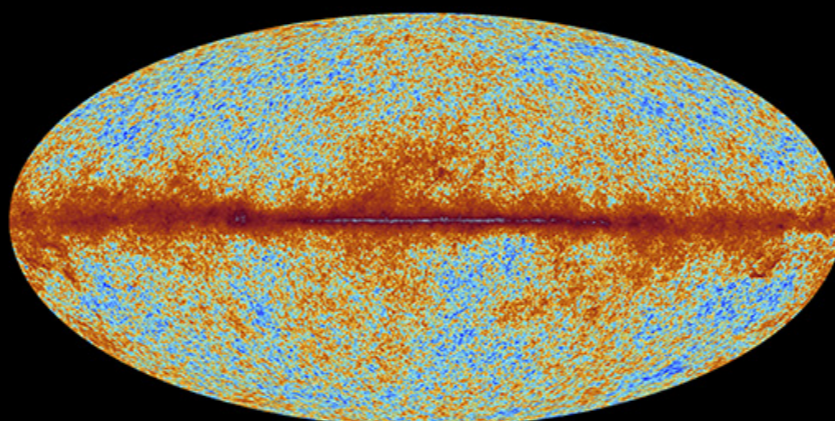
44 GHz



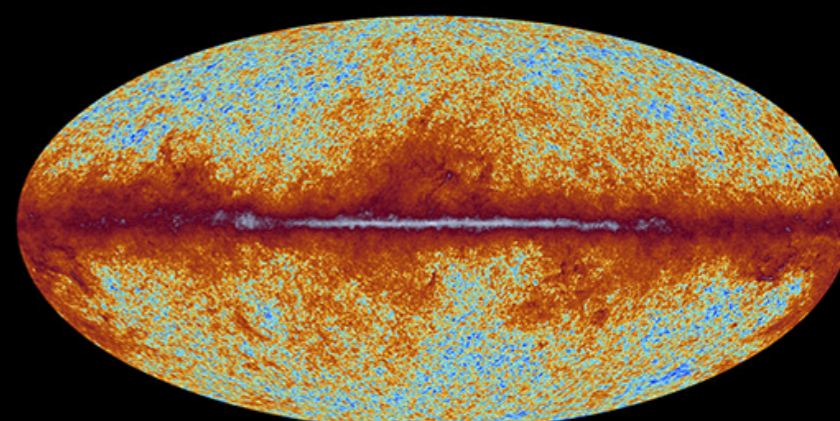
70 GHz



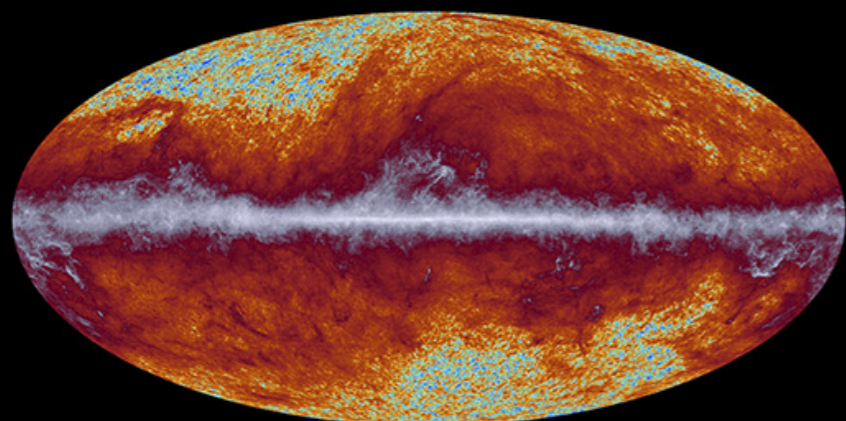
100 GHz



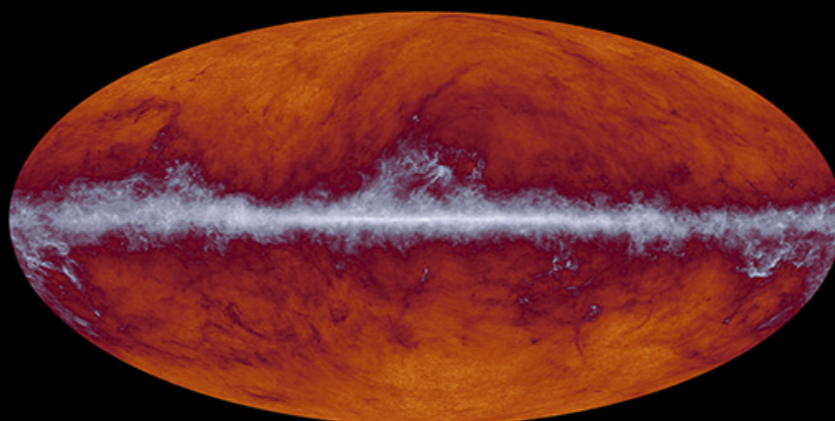
143 GHz



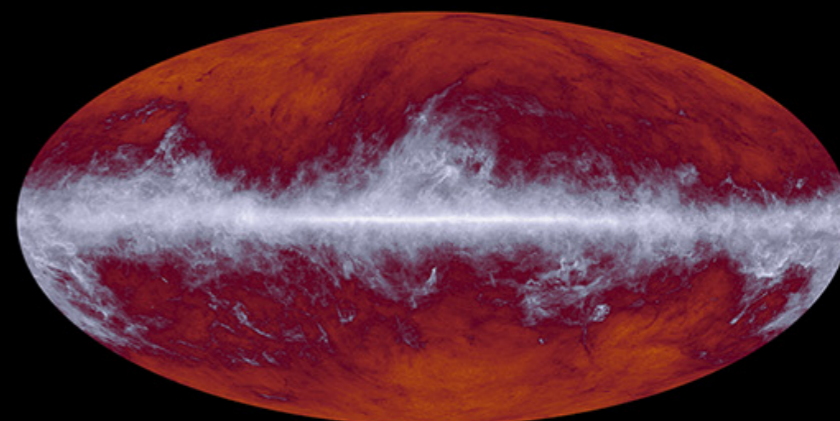
217 GHz



353 GHz



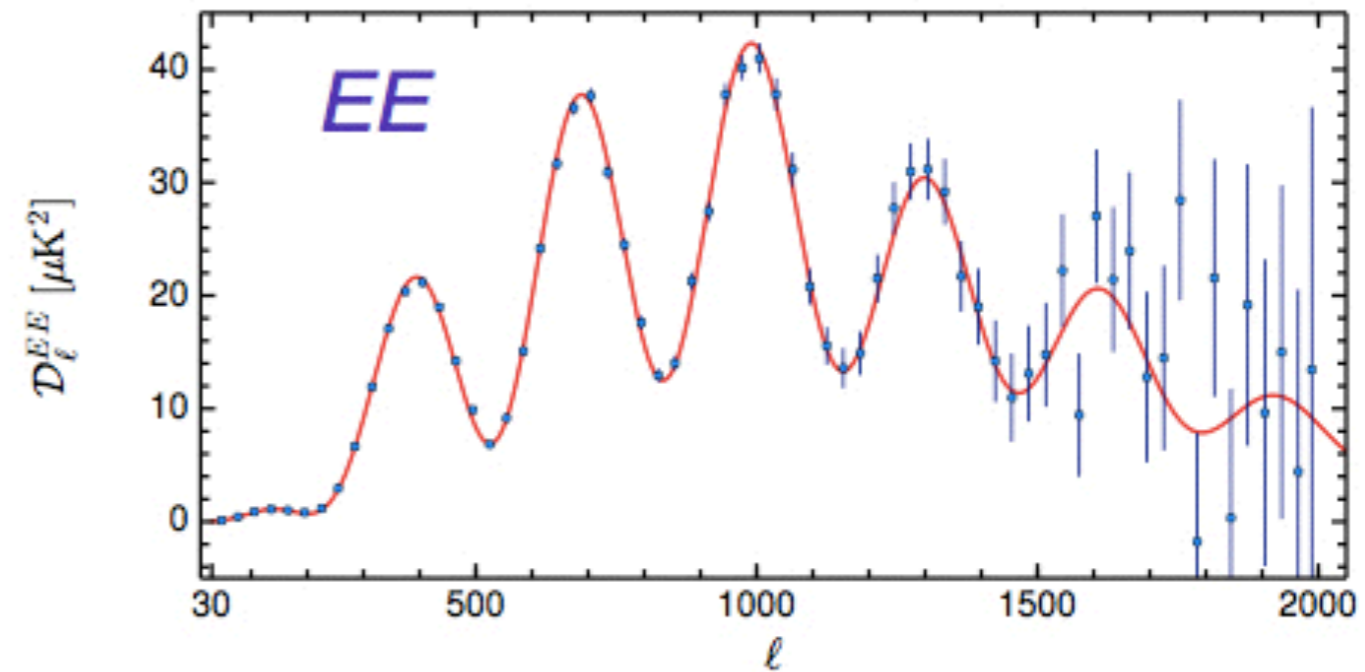
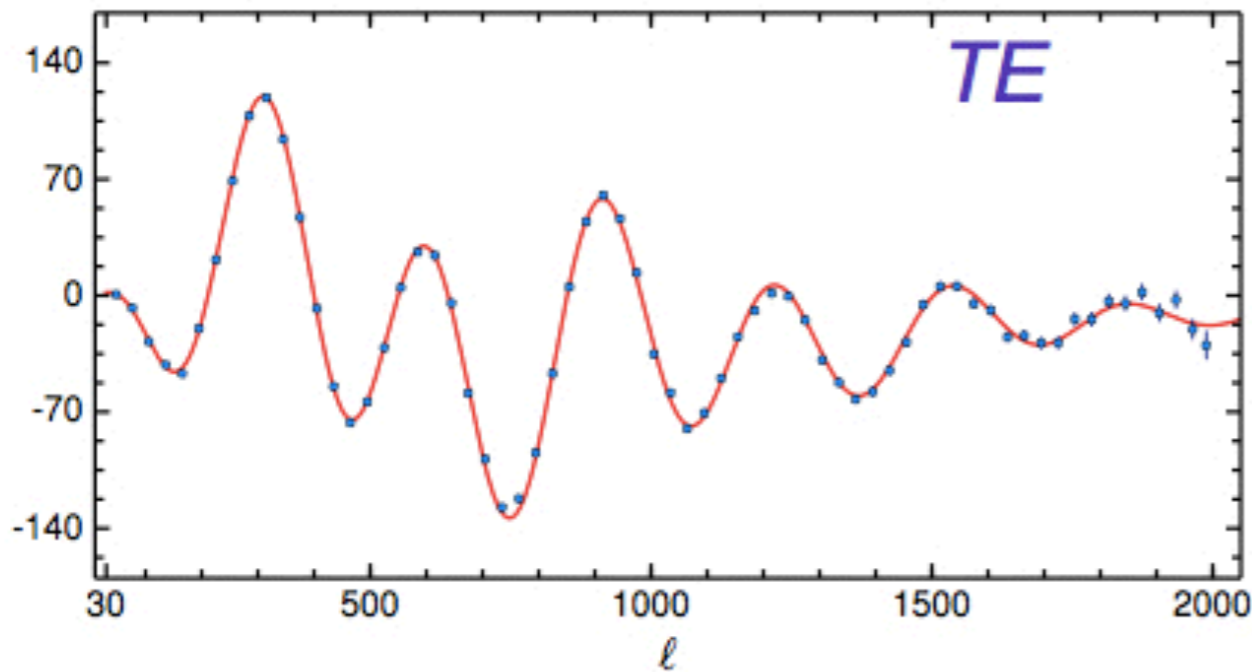
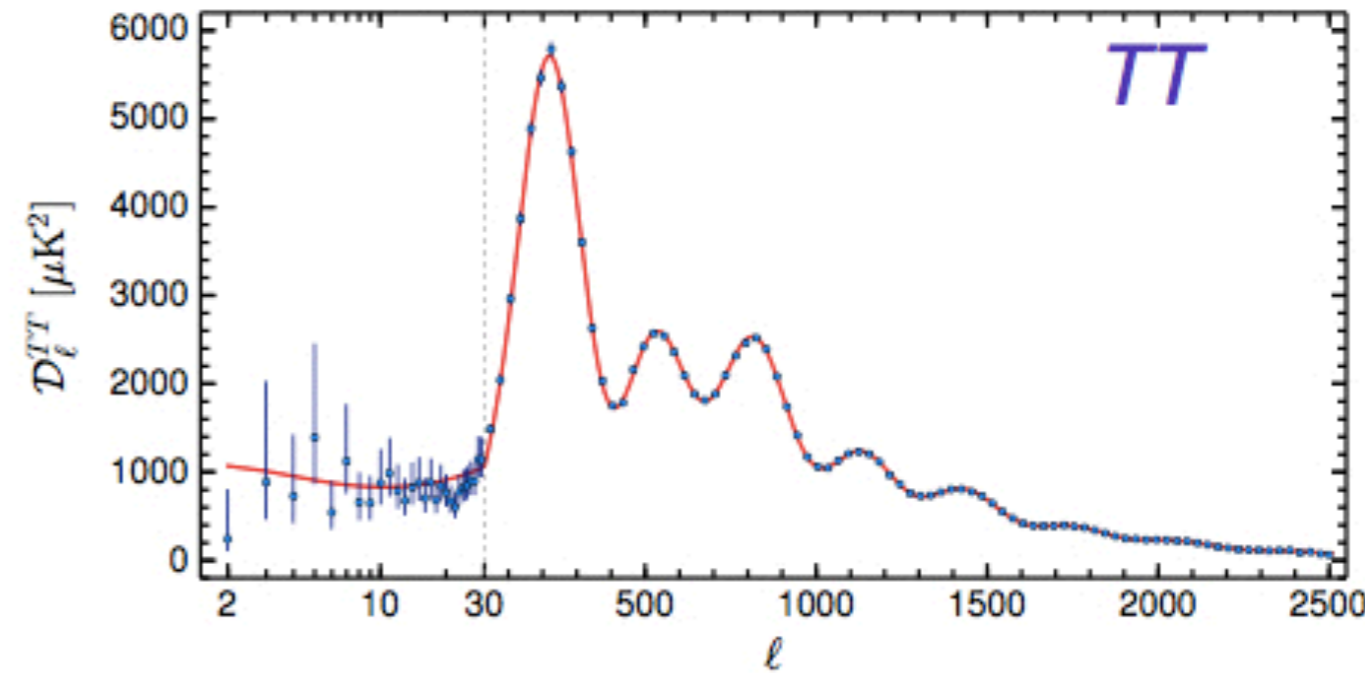
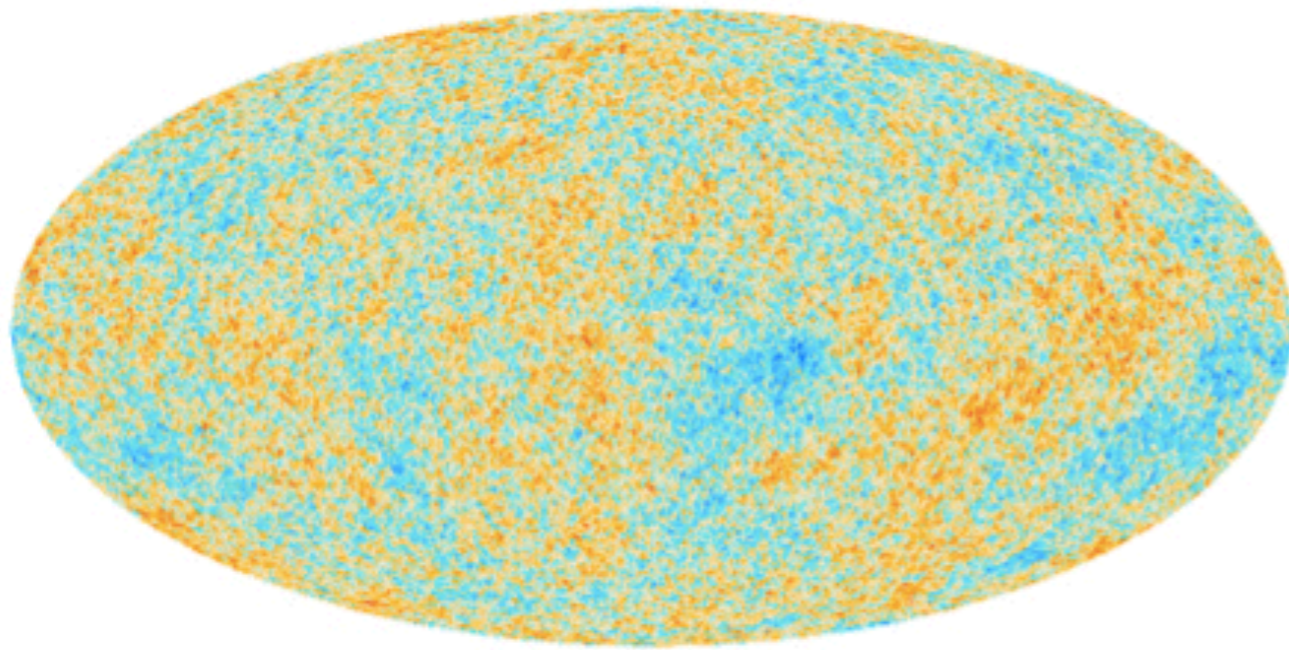
545 GHz



857 GHz

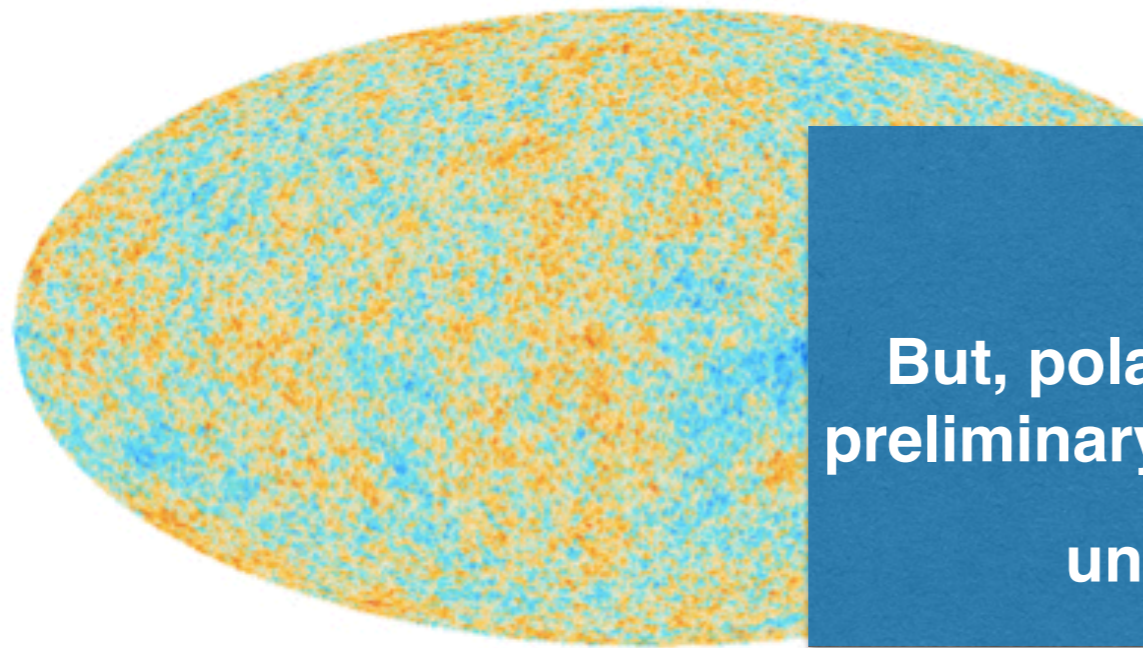
Planck 2014 Power Spectra [from "public.planck.fr"]

Le rayonnement fossile mesuré par Planck



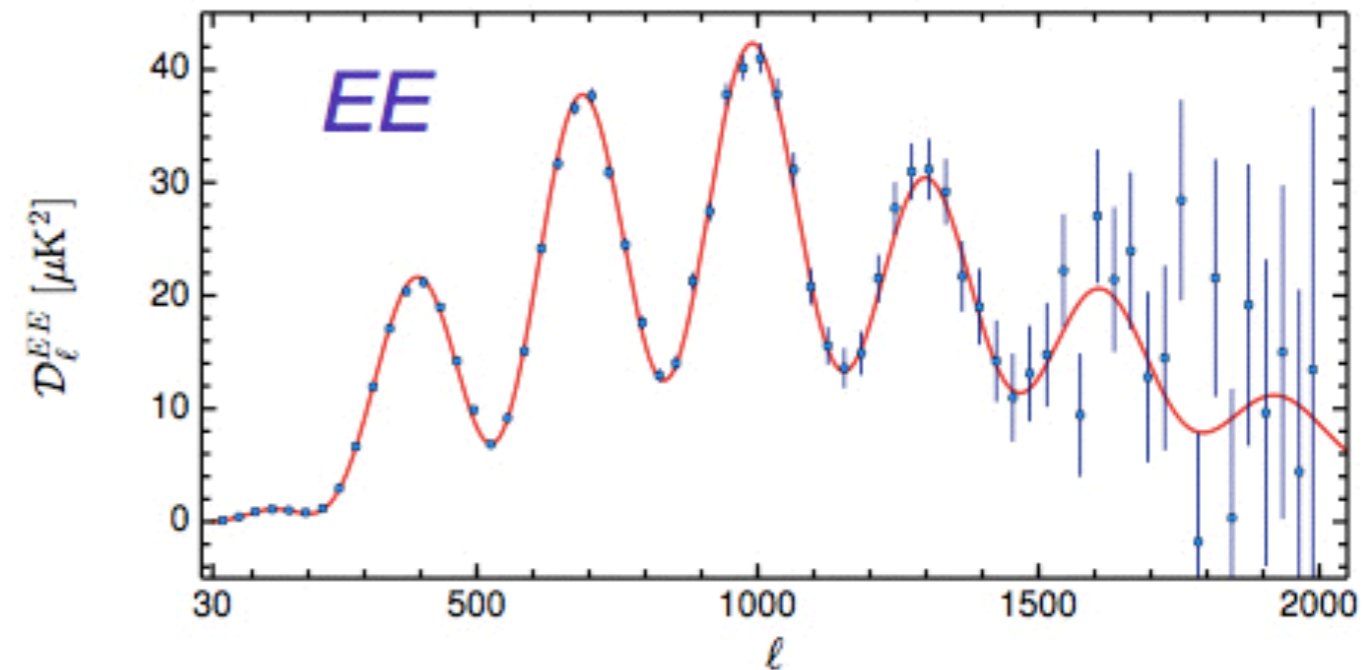
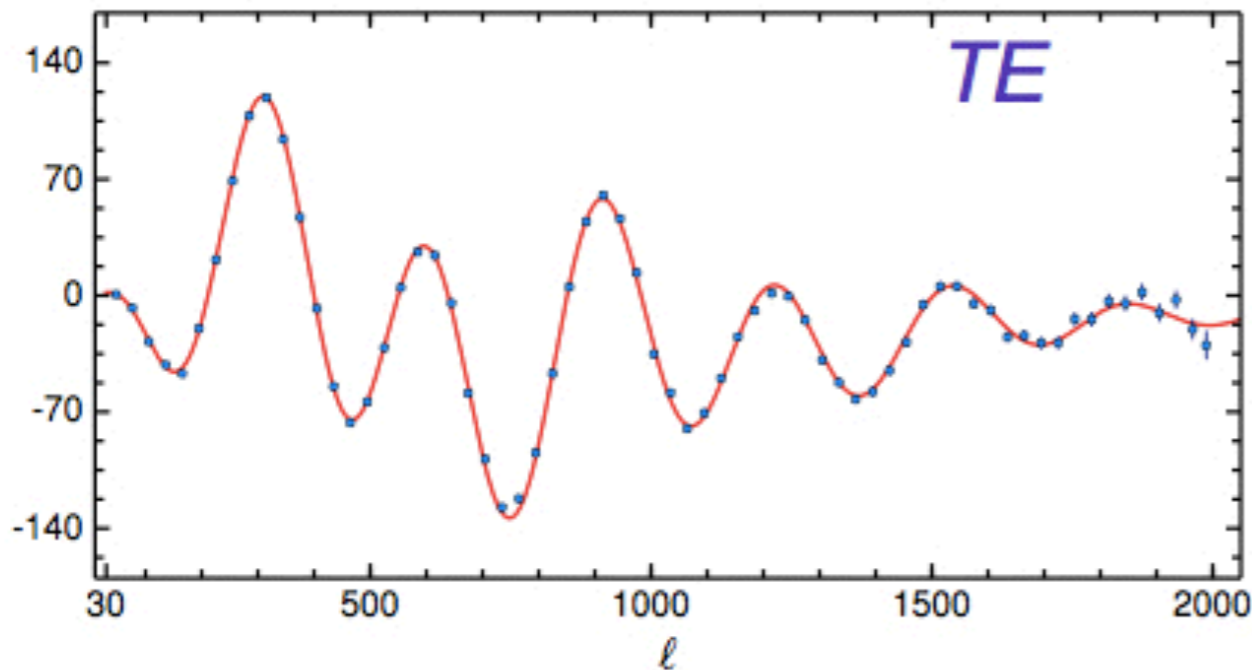
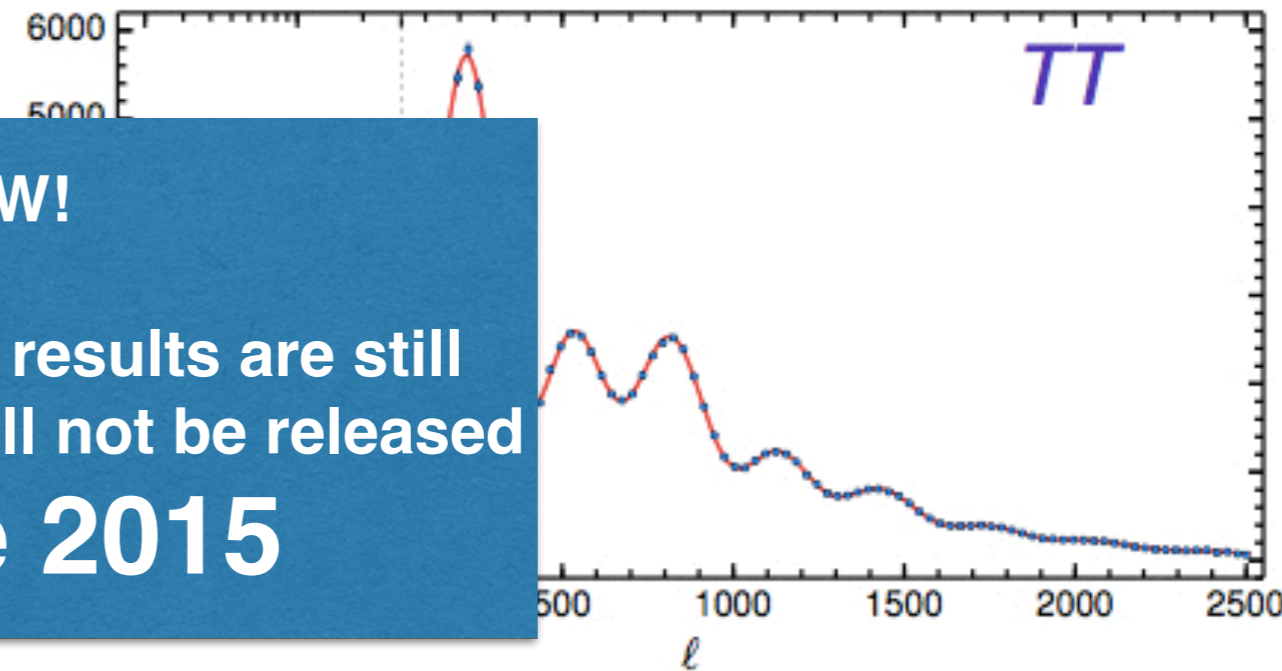
Planck 2014 Power Spectra [from "public.planck.fr"]

Le rayonnement fossile mesuré par Planck



WOW!

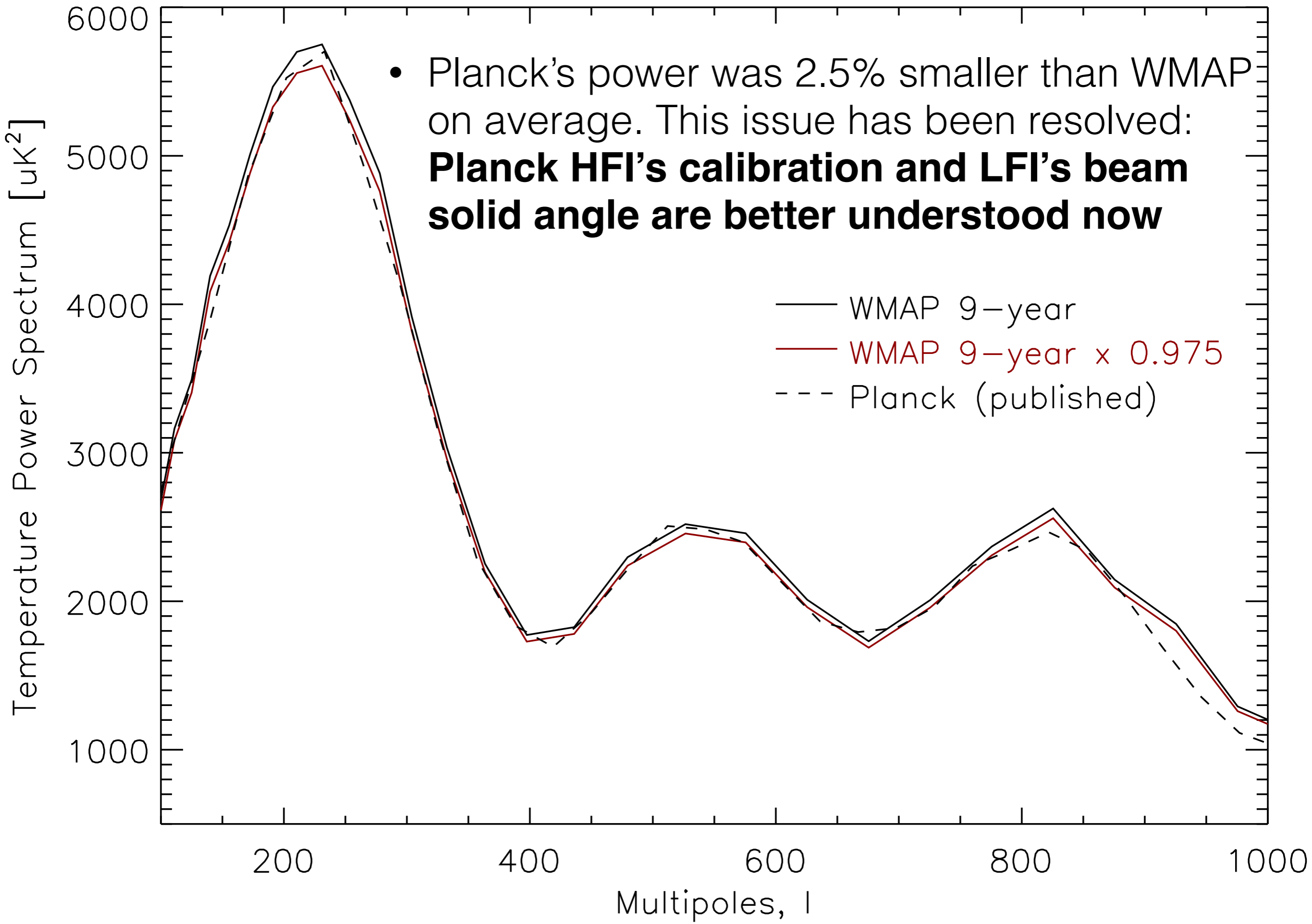
But, polarisation results are still preliminary, and will not be released until **late 2015**



Highlights [for me]

- The disagreement between the amplitudes of the power spectra of Planck and WMAP data has been resolved
- The parameters did not change from the 2013 release, except for the amplitude. The “tensions” on H_0 and σ_8 with the astrophysical data sets still remain
- For the first time, the high- l polarisation data (TE and EE) improve the parameter constraints significantly
- The optical depth, τ , from the WMAP9 data went down from 0.089 ± 0.014 to 0.071 ± 0.013 by 1.3σ , when the polarised dust was cleaned by Planck’s 353 GHz data

Planck 2013 vs WMAP9



WMAP vs Planck

- WMAP and Planck are now in excellent agreement at the data level
- Cosmological parameter shifts from WMAP to Planck come from the multipoles that WMAP does not measure
 - If we use the Planck data only up to $l=1200$, the Planck parameters agree with WMAP's
- So, why did the parameters shift from WMAP to Planck? Planck got more data on higher multipoles!

	Planck 2013 TT +WMAP low-ell	Planck 2014 TT +LFI low-ell	Planck 2014 TT+TE +EE+LFI low-ell
$100\Omega_b h^2$	2.205 ± 0.028	2.222 ± 0.023	2.224 ± 0.015
$\Omega_{\text{cdm}} h^2$	0.1199 ± 0.0027	0.1199 ± 0.0022	0.1199 ± 0.0014
$100\theta_{\text{acoustic}}$	104.131 ± 0.063	104.086 ± 0.048	104.073 ± 0.032
n_s	0.9603 ± 0.0073	0.9652 ± 0.0062	0.9639 ± 0.0047
τ	0.089 ± 0.013	0.078 ± 0.019	0.079 ± 0.017
$10^9 A_s e^{-2\tau}$	1.836 ± 0.013	1.881 ± 0.014	1.883 ± 0.012
σ_8	0.829 ± 0.012	0.830 ± 0.015	0.831 ± 0.013
Ω_m	0.315 ± 0.017	0.316 ± 0.014	0.316 ± 0.009
H_0	67.3 ± 1.2	67.3 ± 1.0	67.23 ± 0.64

Re: Spergel, Flauger and Hlozek

- Spergel et al. (arXiv:1312.3313) noted an issue of the correlated noise over different detectors at 217 GHz, which is likely caused by an incomplete removal of noise of the 4K cooler
 - Using only the survey-survey cross-correlation mitigates this issue, and they reported slight ($\sim 0.5\sigma$) shifts in the parameters
- The survey-survey cross analysis is now adopted by the Planck 2014 analysis
 - The shifts in n_s and $\Omega_b h^2$ from 2013 to 2014 are similar to those reported in Spergel et al.
 - There is no shift in $\Omega_{\text{cdm}} h^2$ and H_0 , however

Optical Depth

	WMAP9	Planck 2014 +LFI cleaned by 353GHz	Planck 2014 +WMAP cleaned by 353GHz	Planck 2014 +WMAP+LFI both cleaned by 353GHz
τ	0.089 ± 0.014	0.078 ± 0.019	0.071 ± 0.013	0.074 ± 0.012
$Z_{\text{reionisation}}$	10.6 ± 1.1	9.9 ± 1.9	N/A	N/A

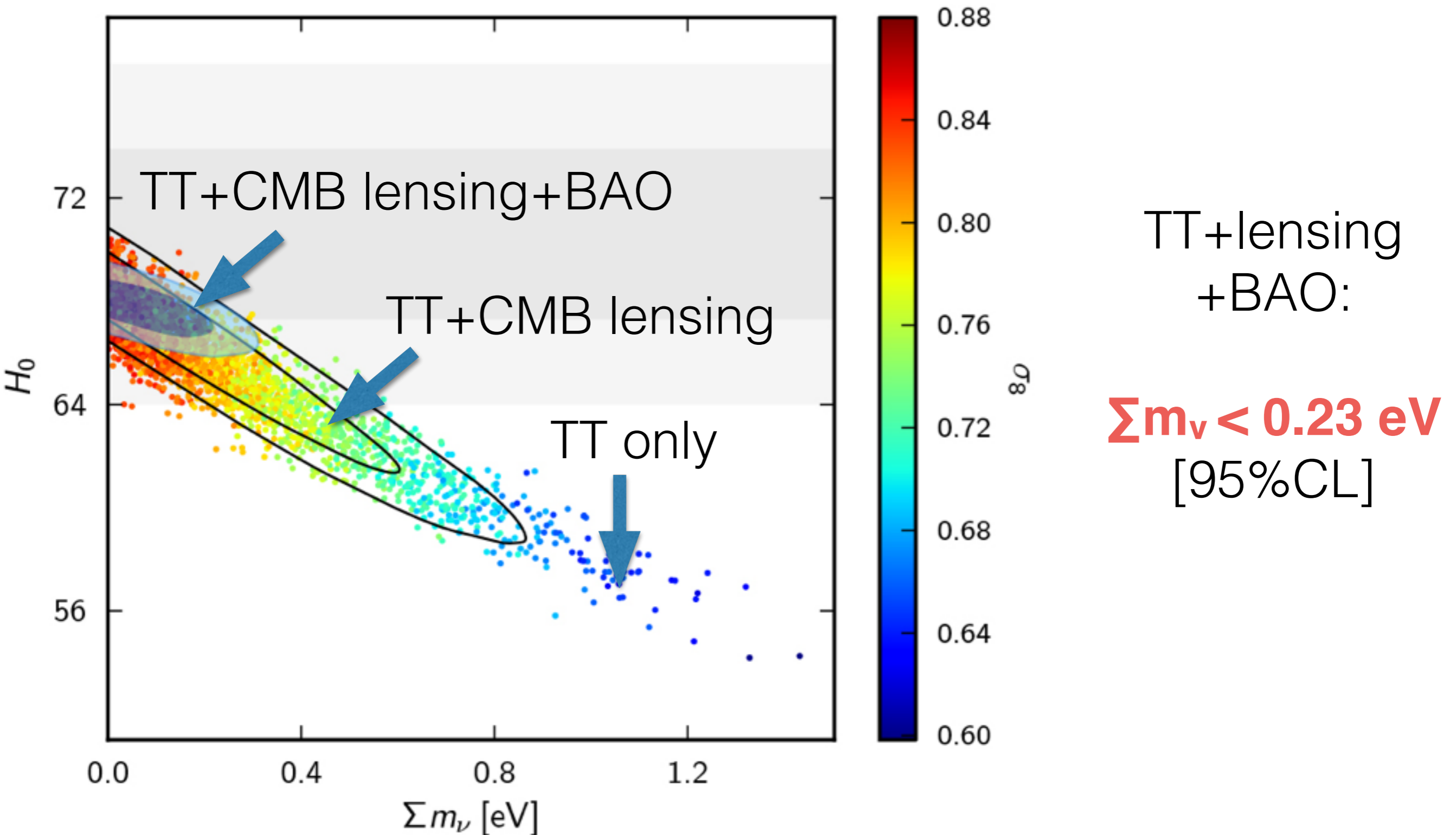
Neutrino Results

- The number of neutrino species

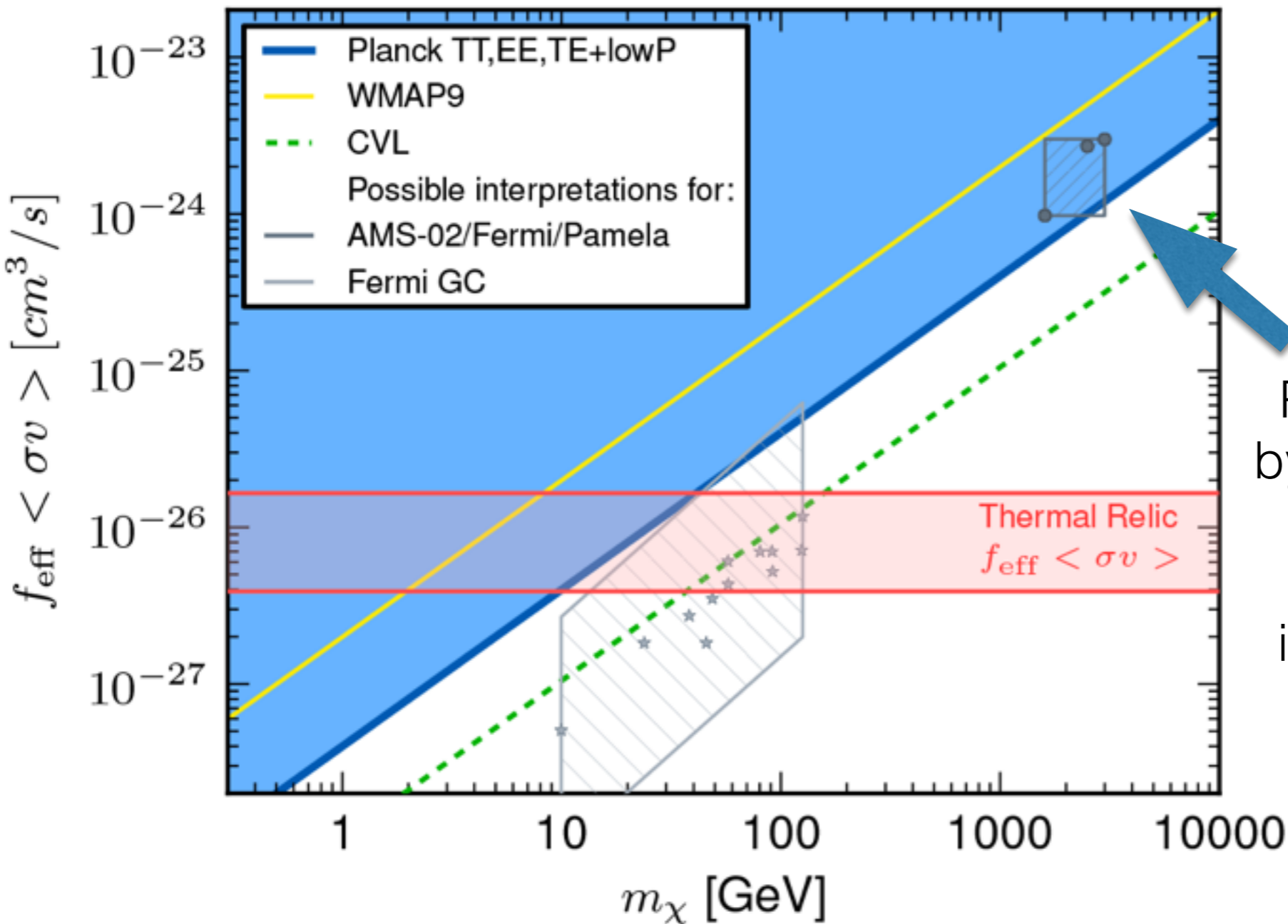
PARAMETRE	VALEUR THEORIQUE	TOUT PLANCK	TOUT PLANCK + BAO
N_{eff}	3.046	2.98 +/- 0.20	3.04 +/- 0.18

Neutrino Results

- The sum of neutrino masses



Dark Matter Annihilation

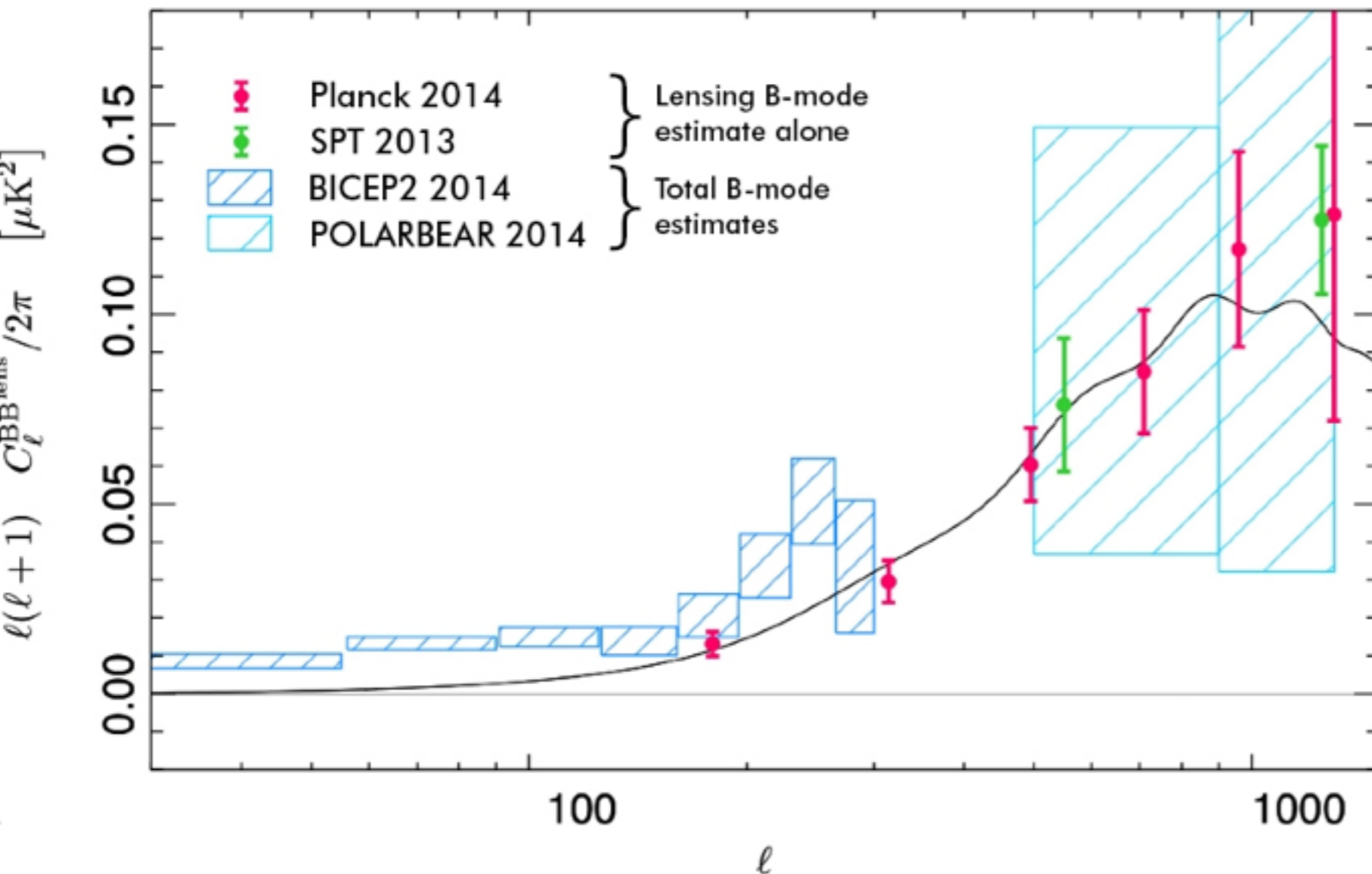


Parameter space favoured by the positron excess of the cosmic-ray experiments (PAMELA/Fermi/AMS2) is now excluded by Planck

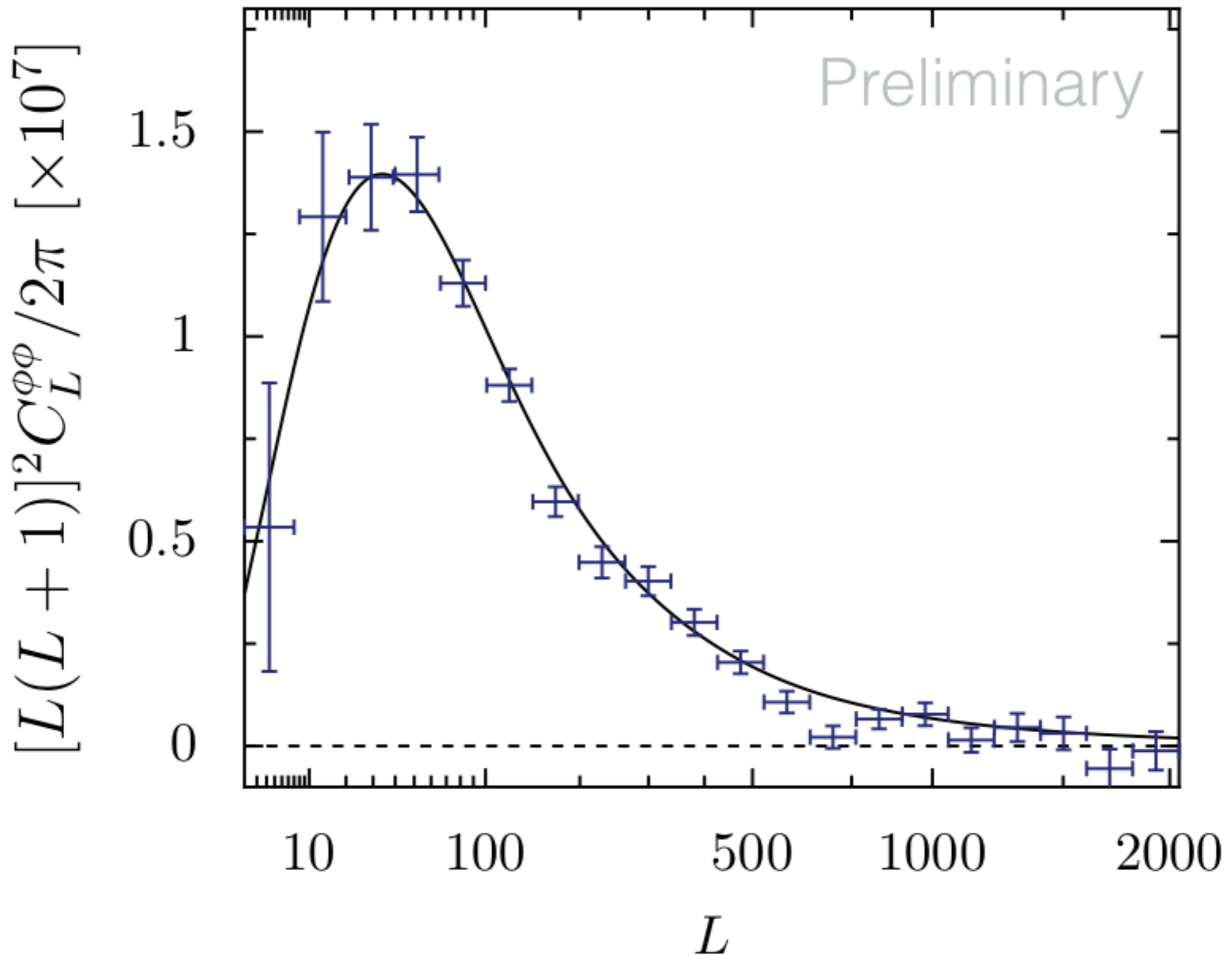
- Exclu par Planck
- Prédiction de modèles "naturels" de matière noire
- Zone favorisée par des expérience de détection du rayonnement cosmique dans le cadre d'une interprétation matière noire de leur excès de signal

CMB Lensing Results

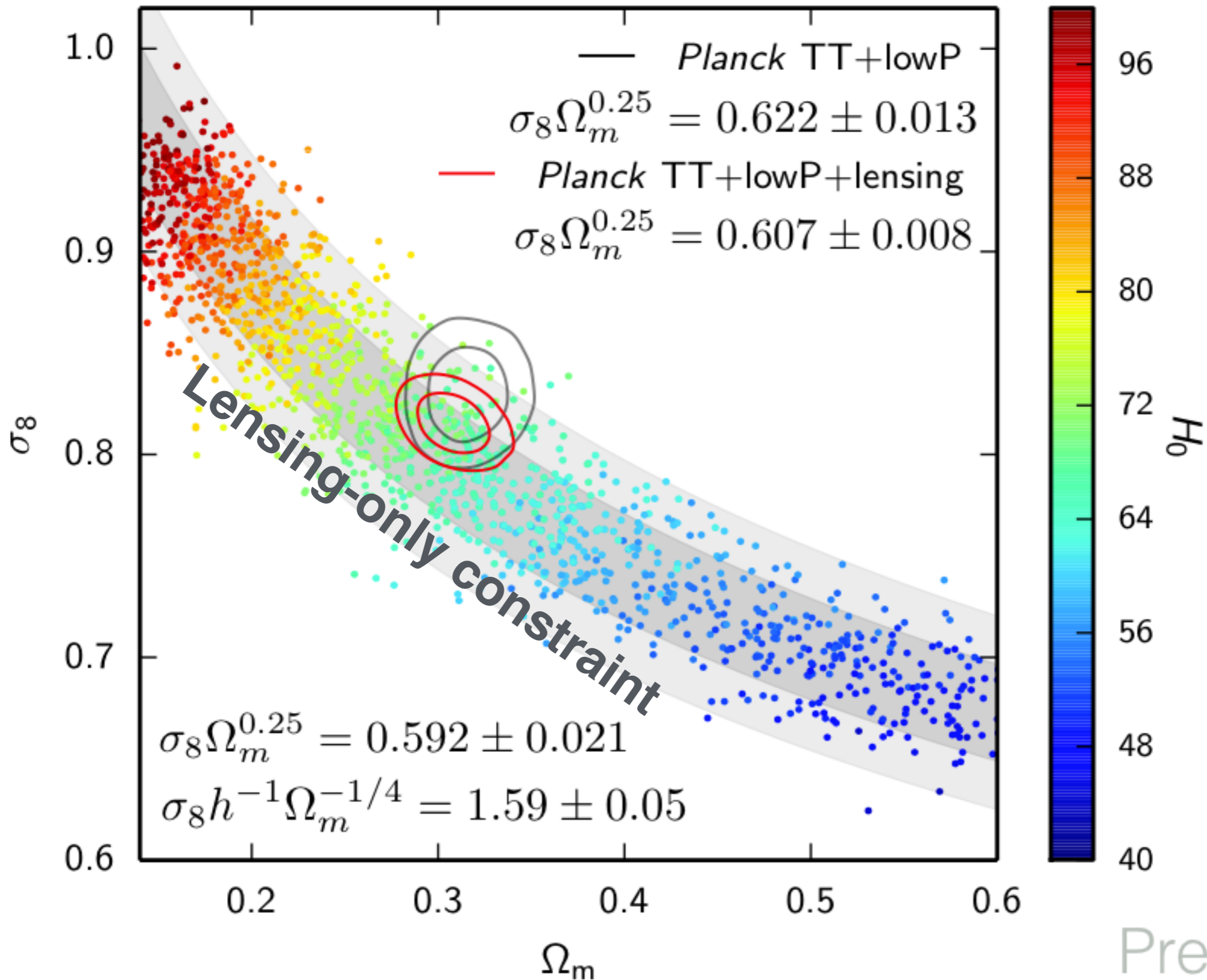
- The total signal-to-noise of the lensing power spectrum is now **40 σ**
- They also see the B-mode lensing **in cross-correlation with** Planck's infrared background data



Caution:
This plot has absolutely nothing to do with the interpretation of BICEP2 results!



- The total signal-to-noise of the lensing power spectrum is now **40σ**



Non-Gaussianity

Shape and method	$f_{\text{NL}}(\text{KSW})$		Planck 2013		
	Independent	ISW-lensing subtracted	ISW-lensing subtracted		
			KSW	Binned	Modal
SMICA (T)					
Local	9.5 ± 5.6	1.8 ± 5.6			
Equilateral	-10 ± 69	-9.2 ± 69			
Orthogonal	-43 ± 33	-20 ± 33			
SMICA (T+E)					
Local	6.5 ± 5.1	0.71 ± 5.1	2.7 ± 5.8	2.2 ± 5.9	1.6 ± 6.0
Equilateral	-8.9 ± 44	-9.5 ± 44	-42 ± 75	-25 ± 73	-20 ± 77
Orthogonal	-35 ± 22	-25 ± 22	-25 ± 39	-17 ± 41	-14 ± 42

Preliminary

Constraint volume in LEO space shrunk by factor of 3.

Summary

- WMAP and Planck are now in agreement at the data level
- Planck 2014 parameters are essentially the same as Planck 2013, despite 2x more data and better analysis
 - “Tensions” on H_0 and σ_8 still remain
- Impressive polarisation data! - eagerly waiting for the data release [in late 2015] before we believe them
- Impacts of dust cleaning on τ need to be understood better
 - The WMAP team will re-analyse the polarisation data with Planck’s 353 GHz cleaning once the data become available
- Great results on neutrinos, dark matter annihilation, and CMB lensing