The cosmic infrared background and integrated Sachs-Wolfe effect: can we constrain the cosmological parameters?

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OCEVU
Origines, Constituants et EVolution de l'Univers

XIIIth School of Cosmology
The CMB from A to Z
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LAM
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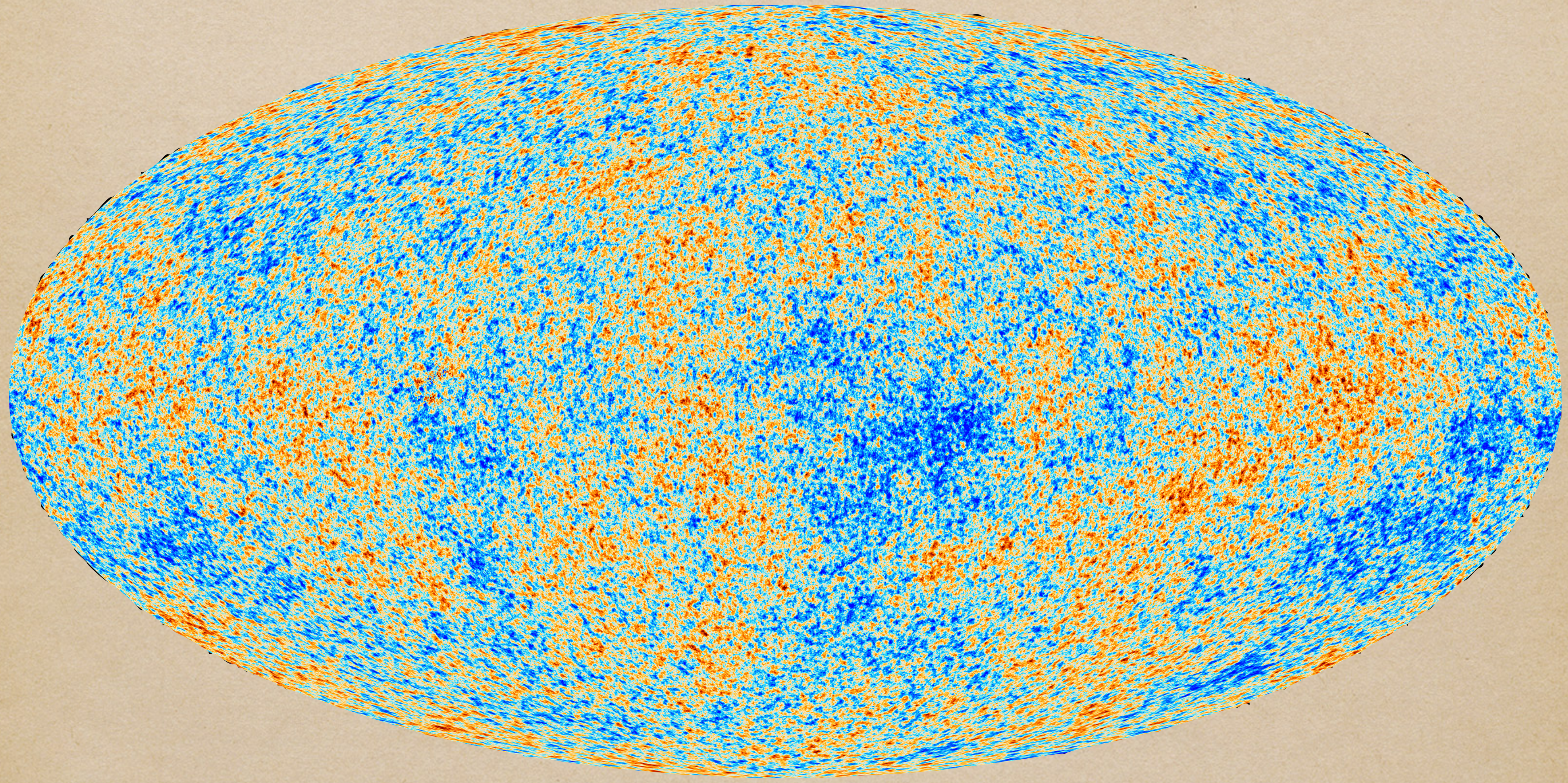
CMB

ISW

CIB

Fisher Analysis

Cosmic Microwave Background (CMB)



Planck 2013 Results XVI

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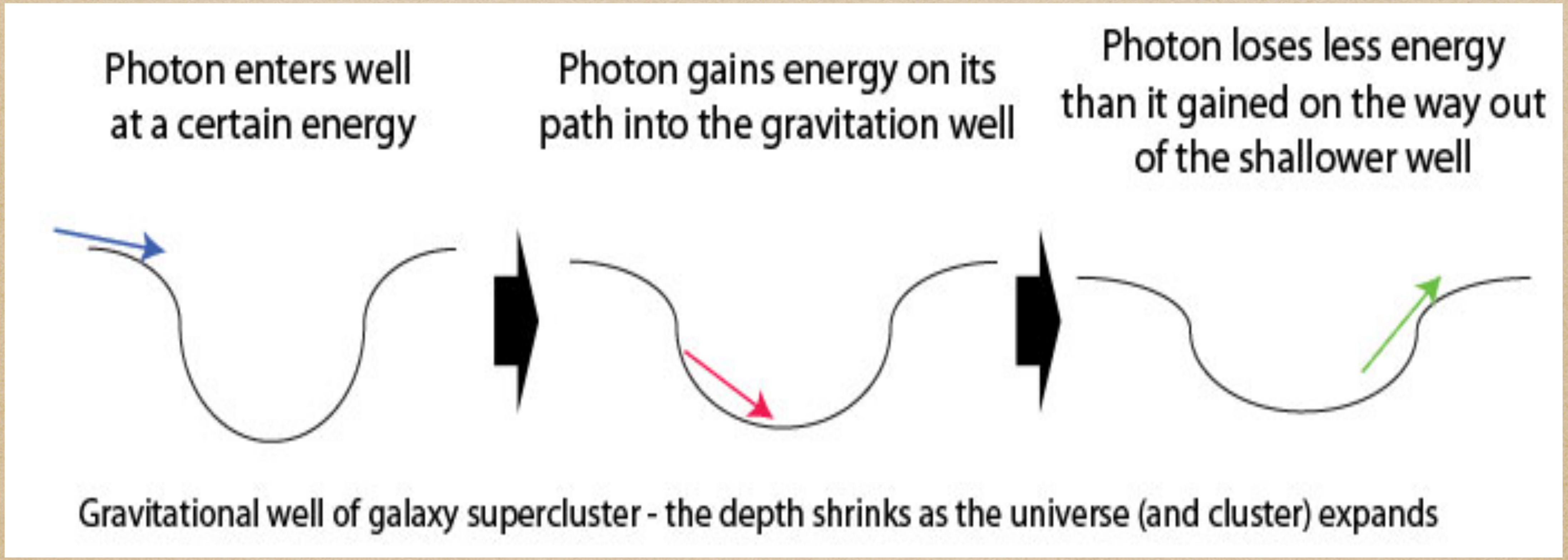
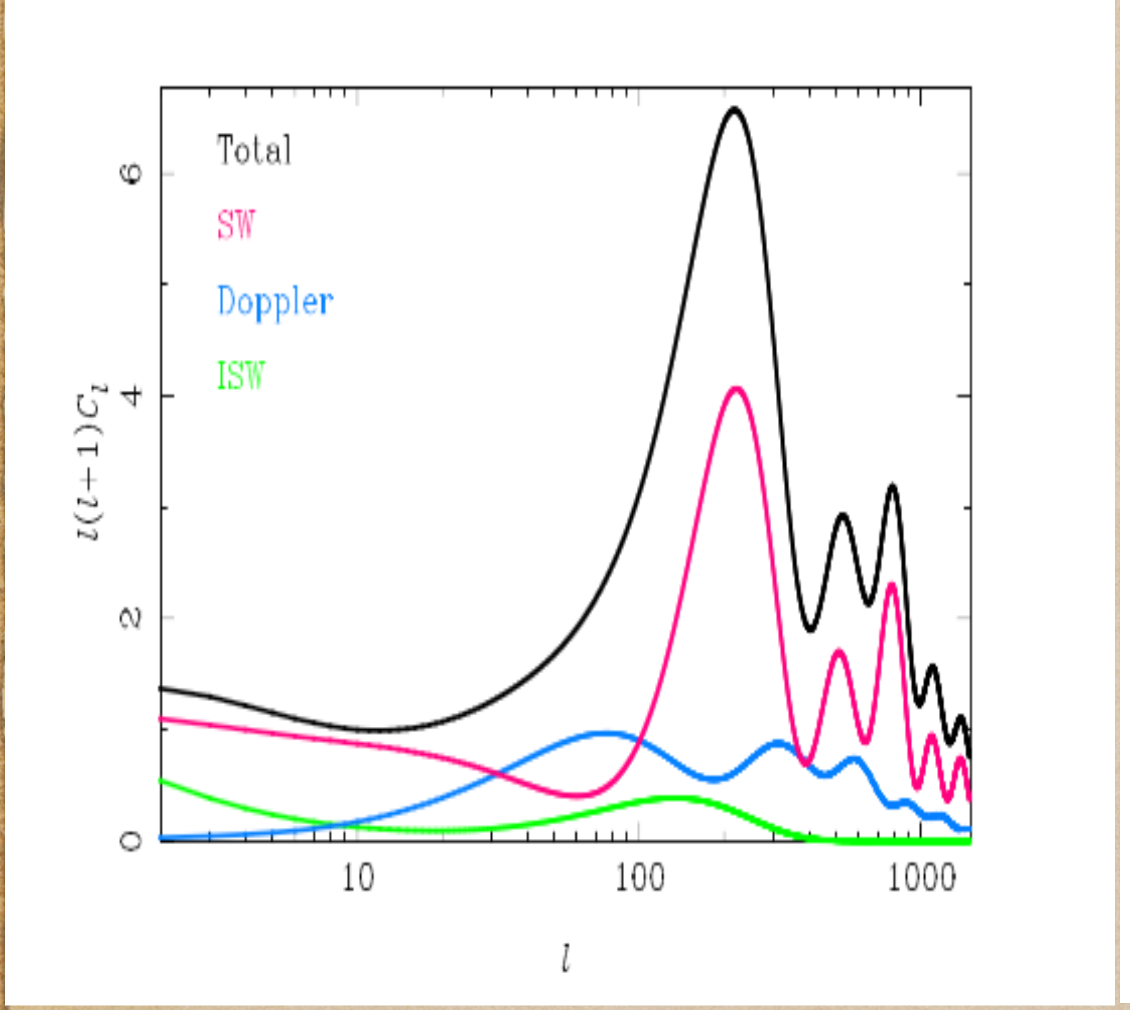
Integrated Sachs-Wolfe effect

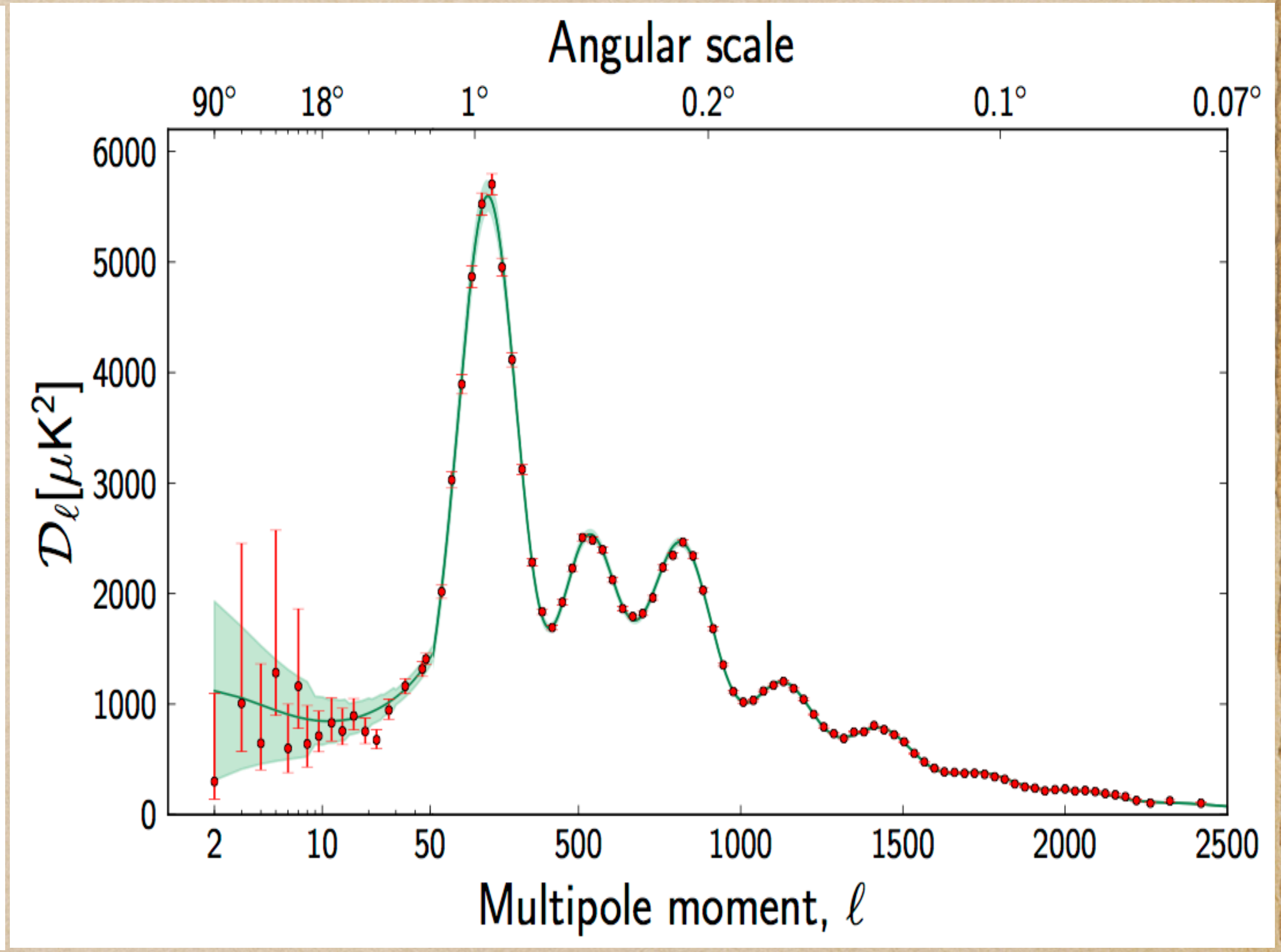


Brian Koberlein: https://briankoberlein.com/2015/04/22/stoking-the-fire/

CMB Power Spectrum



galaxies-cosmology-2015.wikidot.com



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Integrated Sachs-Wolfe effect
Really small!

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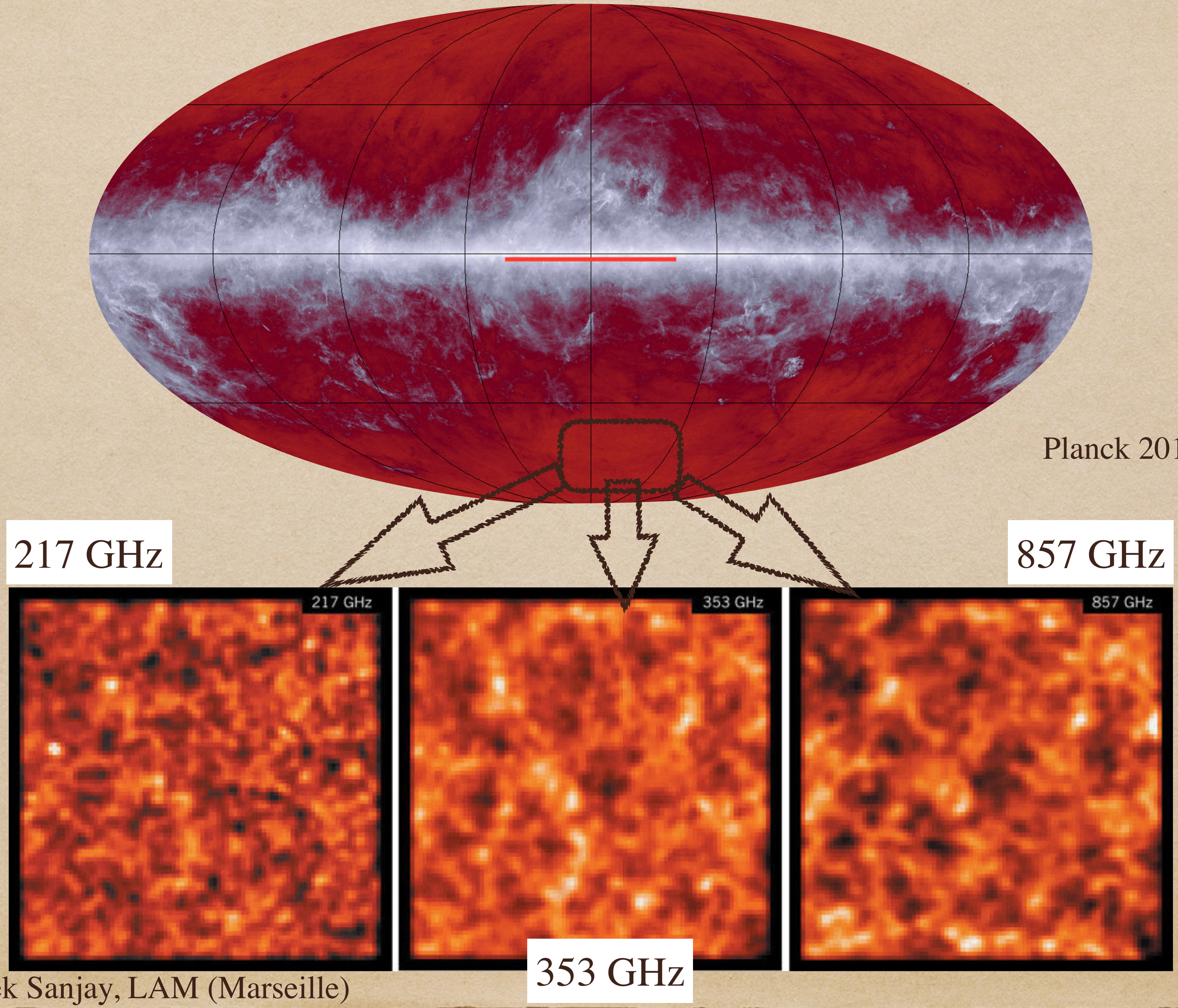
ISW measurements

LSS data	COMMANDER		NILC		SEVEM		SMICA		Expected
	$A \pm \sigma_A$	S/N	$A \pm \sigma_A$	S/N	$A \pm \sigma_A$	S/N	$A \pm \sigma_A$	S/N	S/N
NVSS	0.95 ± 0.36	2.61	0.94 ± 0.36	2.59	0.95 ± 0.36	2.62	0.95 ± 0.36	2.61	2.78
WISE-AGN ($\ell_{\min} \geq 9$)	0.95 ± 0.60	1.58	0.96 ± 0.60	1.59	0.95 ± 0.60	1.58	1.00 ± 0.60	1.66	1.67
WISE-GAL ($\ell_{\min} \geq 9$)	0.73 ± 0.53	1.37	0.72 ± 0.53	1.35	0.74 ± 0.53	1.38	0.77 ± 0.53	1.44	1.89
SDSS-CMASS/LOWZ	1.37 ± 0.56	2.42	1.36 ± 0.56	2.40	1.37 ± 0.56	2.43	1.37 ± 0.56	2.44	1.79
SDSS-MphG	1.60 ± 0.68	2.34	1.59 ± 0.68	2.34	1.61 ± 0.68	2.36	1.62 ± 0.68	2.38	1.47
Kappa ($\ell_{\min} \geq 8$)	1.04 ± 0.33	3.15	1.04 ± 0.33	3.16	1.05 ± 0.33	3.17	1.06 ± 0.33	3.20	3.03
NVSS and Kappa	1.04 ± 0.28	3.79	1.04 ± 0.28	3.78	1.05 ± 0.28	3.81	1.05 ± 0.28	3.81	3.57
WISE	0.84 ± 0.45	1.88	0.84 ± 0.45	1.88	0.84 ± 0.45	1.88	0.88 ± 0.45	1.97	2.22
SDSS	1.49 ± 0.55	2.73	1.48 ± 0.55	2.70	1.50 ± 0.55	2.74	1.50 ± 0.55	2.74	1.82
NVSS and WISE and SDSS	0.89 ± 0.31	2.87	0.89 ± 0.31	2.87	0.89 ± 0.31	2.87	0.90 ± 0.31	2.90	3.22
All	1.00 ± 0.25	4.00	0.99 ± 0.25	3.96	1.00 ± 0.25	4.00	1.00 ± 0.25	4.00	4.00

Planck 2015 Results XXI

Cosmic Infrared Background (CIB)

Cumulative emission of dusty star forming galaxies



Planck 2013 Results XXX

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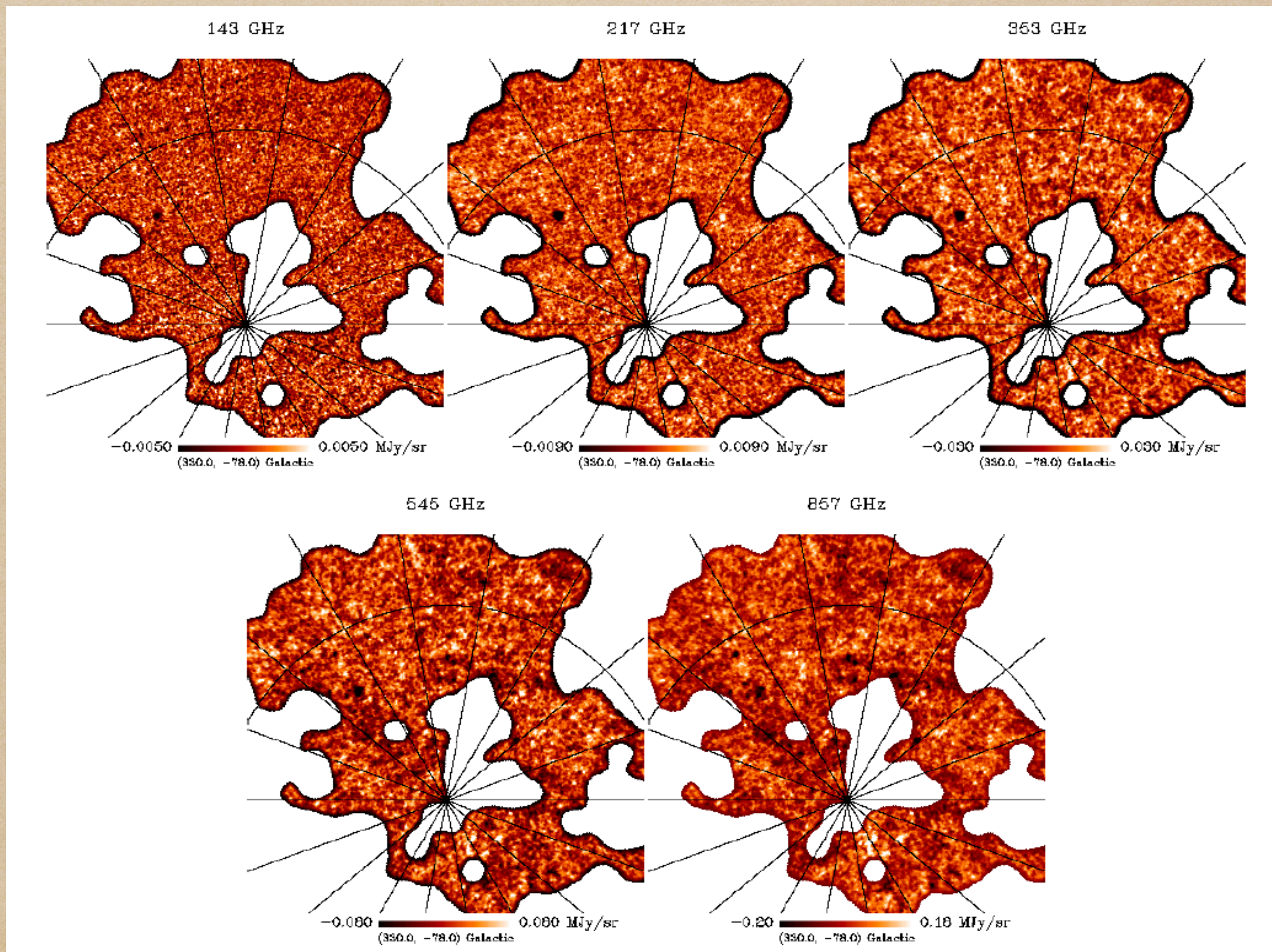
Cosmic Infrared Background (CIB)



Planck 2013 Results XXX

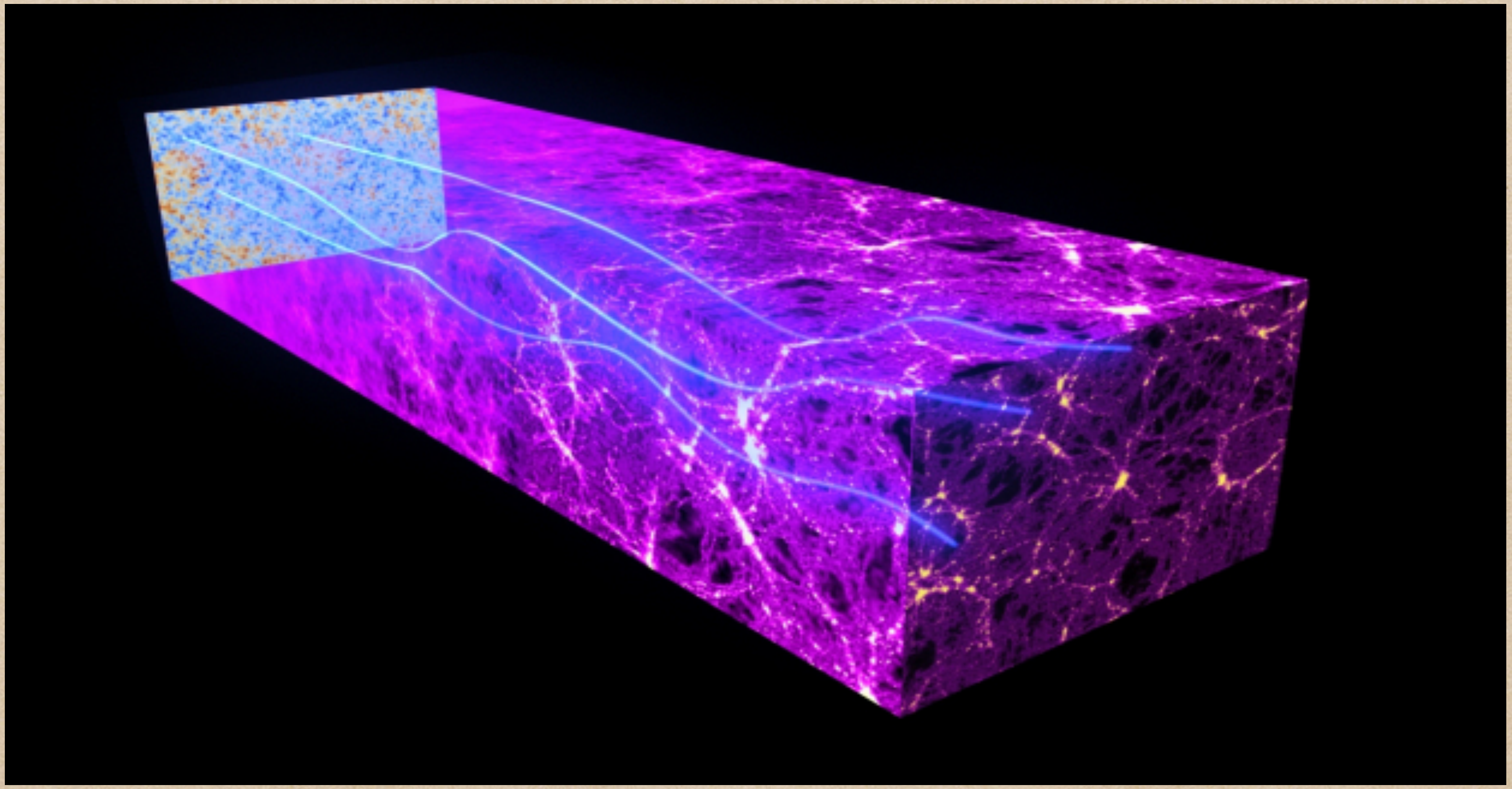
Cosmic Infrared Background (CIB)

$$C_l^{\nu\times\nu'} = \int \overbrace{\frac{dz}{\chi^2}\frac{d\chi}{dz}}^{\text{geometry}} a^2 \underbrace{b_{eff}^2}_{\text{galaxy clustering}} \bar{j}(\overbrace{\nu, z)\bar{j}(\nu'}^{\text{galaxy emissivity}}, z) P_{lin}\underbrace{(k = l/\chi, z)}_{\text{matter distribution}}$$

$$b_{eff}(z) = b_0 + b_1 z + b_2 z^2 \qquad \bar{j}(\nu, z) = \frac{\rho_{\mathrm{SFR}}(z)(1+z)S_{\nu,eff}(z)\chi^2(z)}{K}$$

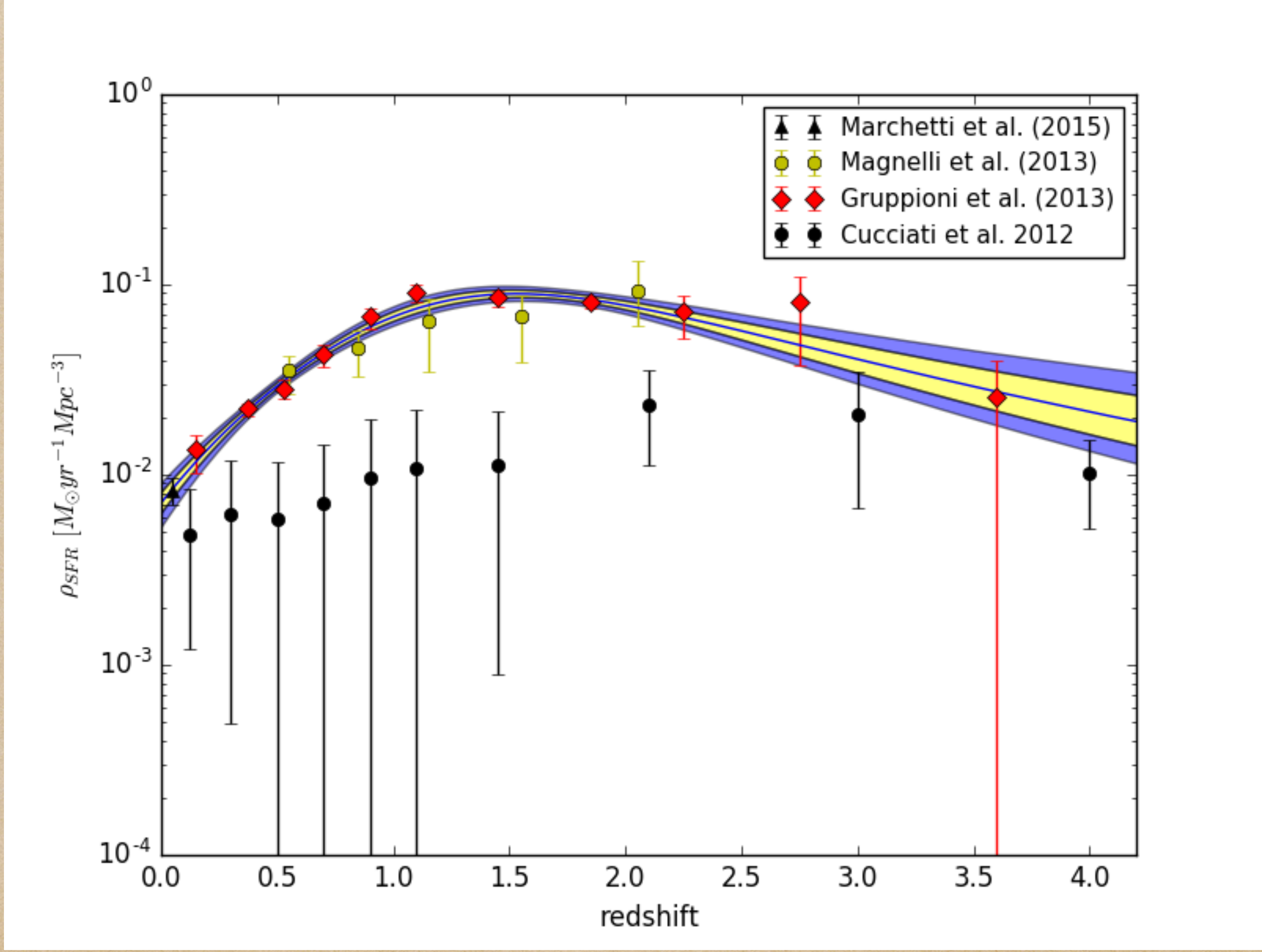
DEGENERACY!!!

CIB - CMB Lensing cross-correlation

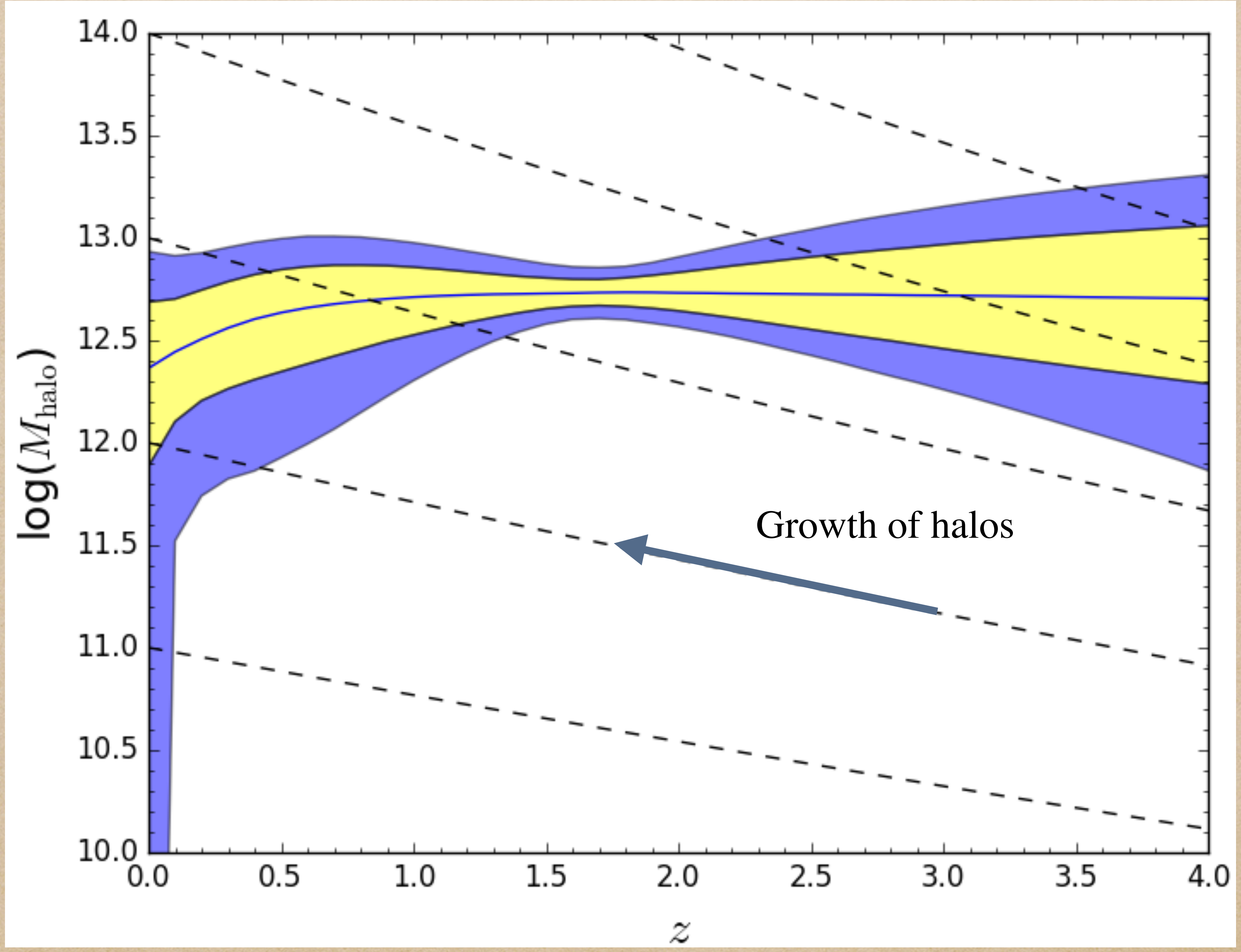


$$C_l^{\nu\phi} = \int \underline{b_{eff}}\bar{j}(\nu, z)\frac{3}{l^2}\Omega_m H_0^2\left(\frac{\chi_* - \chi}{\chi_*\chi}\right)P_{lin}(k = l/\chi, z)d\chi$$

Star formation density history



Mean host halo mass



Effect of Cosmology on CIB?

$$C_l^{\nu\times\nu'} = \int \frac{dz}{\chi^2}\frac{d\chi}{dz} a^2 b_{eff}^2 \bar{j}(\nu,z)\bar{j}(\nu',z) P_{lin}(k=l/\chi,z)$$

Cosmological distances

Cosmological matter distribution

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Fisher Information Matrix

$$I_{ij} \equiv \left\langle -\frac{\partial^2 \log \mathcal{L}}{\partial\theta_i \partial\theta_j} \right\rangle$$

$$I_{m,n} = \frac{\partial\mu^T}{\partial\theta_m}\Sigma^{-1}\frac{\partial\mu}{\partial\theta_n} + \frac{1}{2}\mathrm{tr}\left(\Sigma^{-1}\frac{\partial\Sigma}{\partial\theta_m}\Sigma^{-1}\frac{\partial\Sigma}{\partial\theta_n}\right)$$

$\mu(\theta)$ - Mean values of the parameters

$\Sigma(\theta)$ - Covariance matrix

- Measurements:
  - ➡ CIB, CIB x CMB lensing, Planck cosmological parameters MC chains, priors on SFRD, mean CIB intensity
- Prediction:
  - ➡ ISW through CIB x CMB

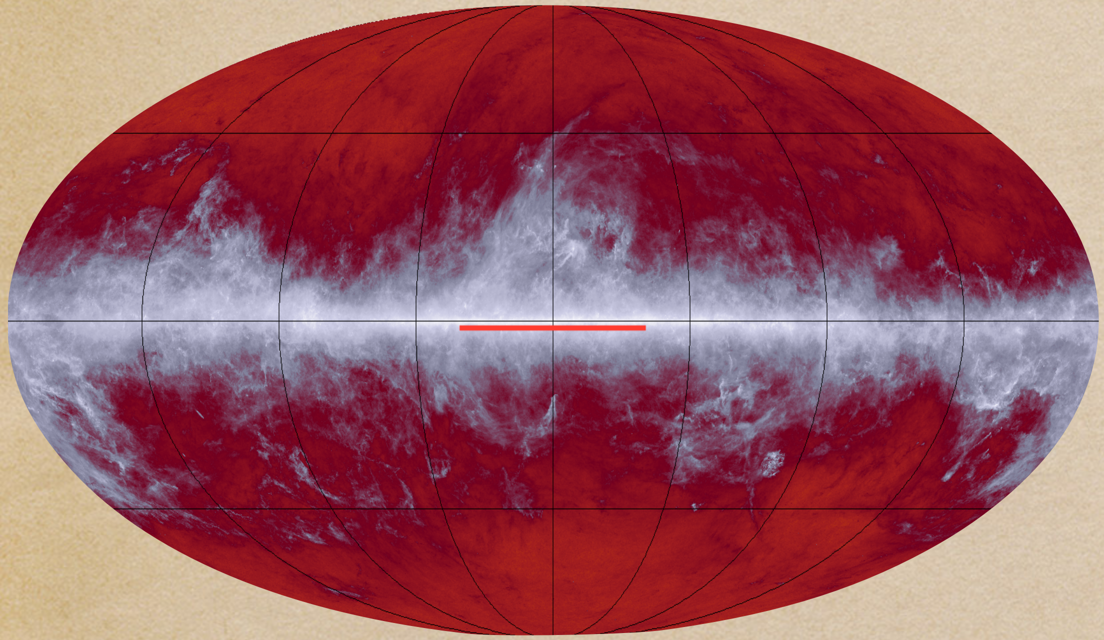
Effect of cosmology on CIB

Parameter	% change on error bars due to cosmology
α	0.014
β	0.18
γ	0.18
δ	0.84
b_0	0.39
b_1	1.01
b_2	1.06

Negligible

Cross correlation

- ISW - Large scales in CMB; cosmic variance limited
- CIB - tracer of Large scale structure



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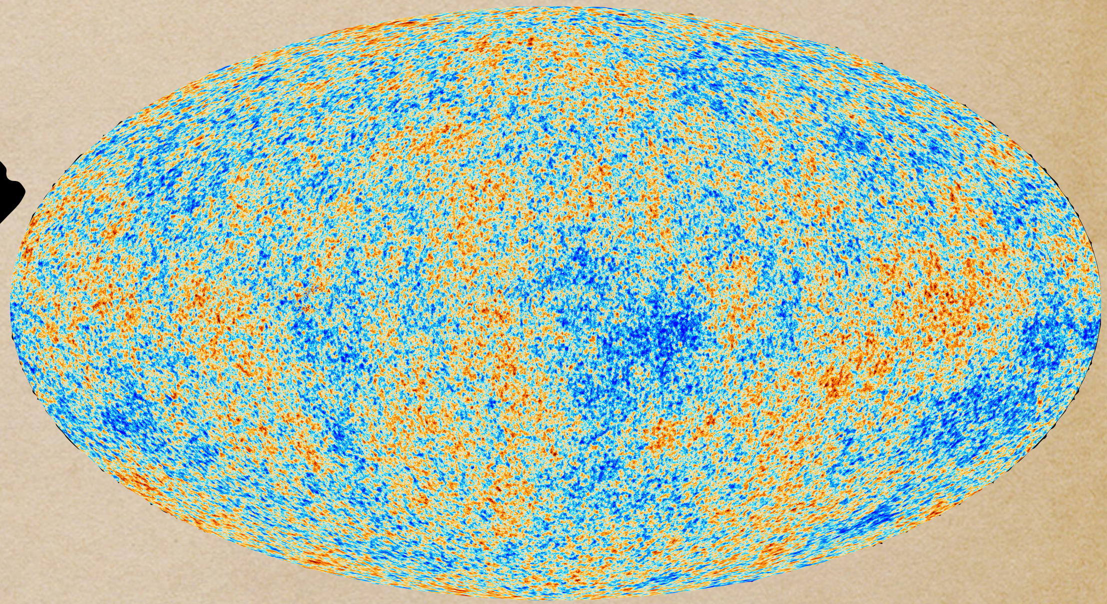
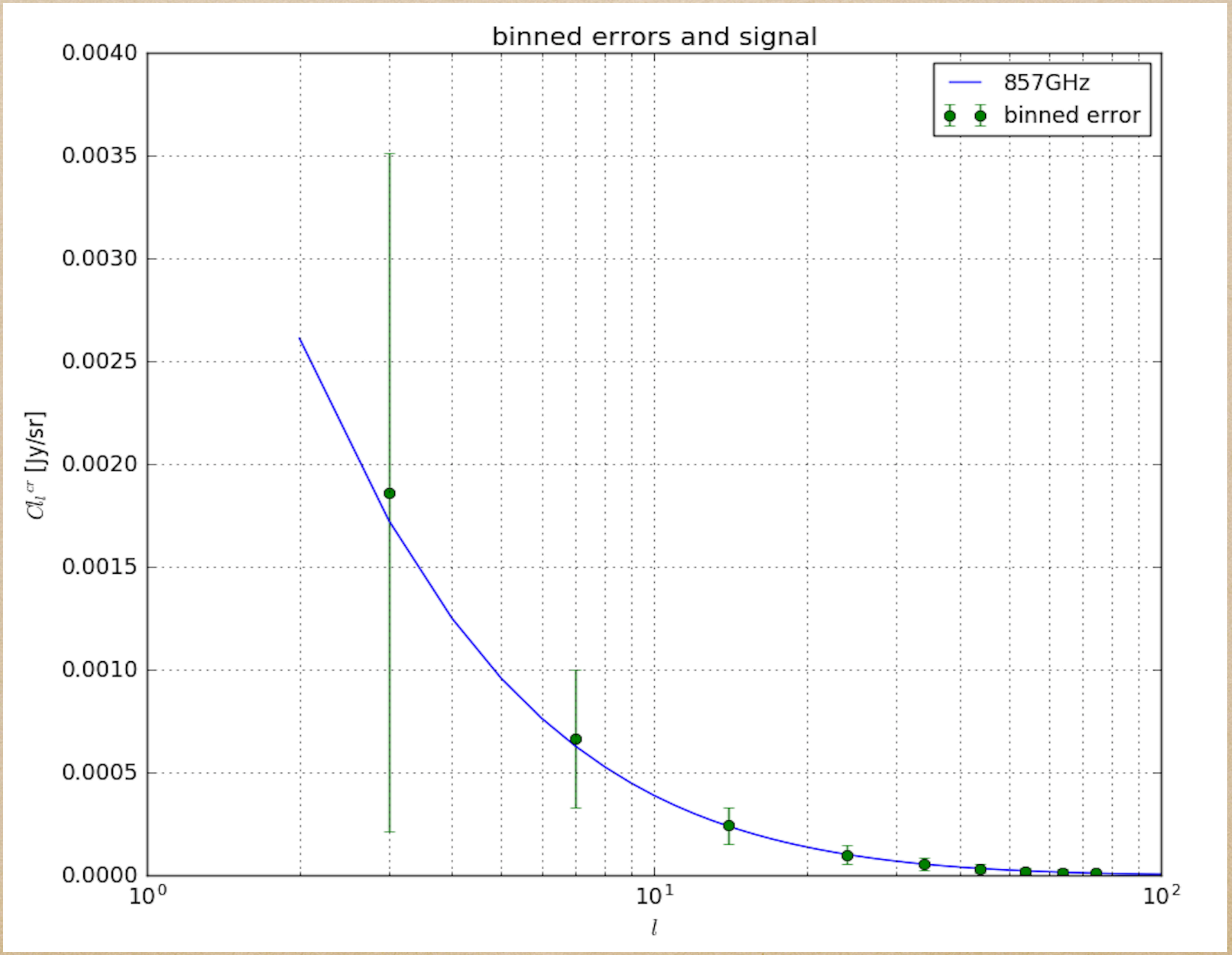


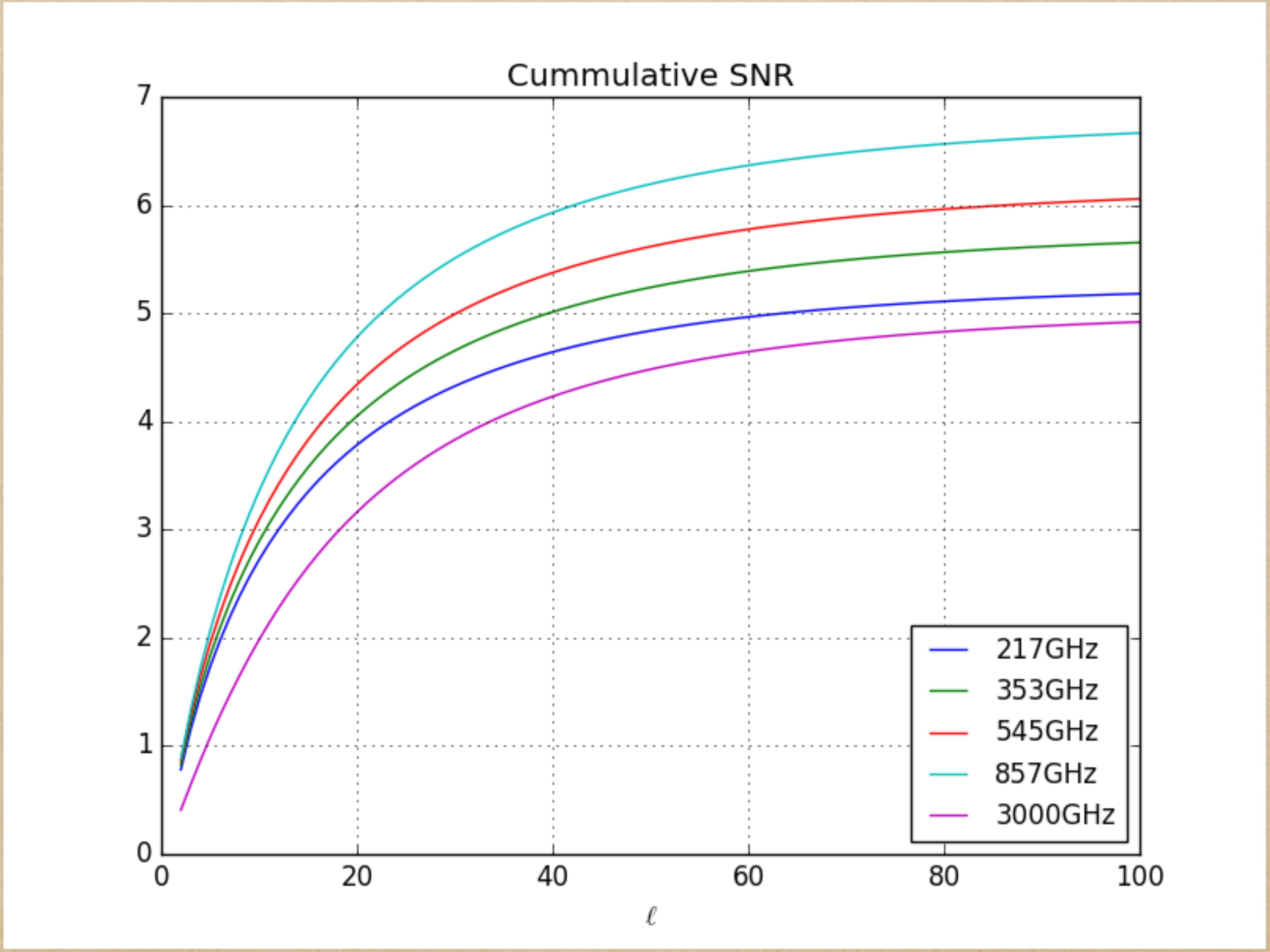
Planck 2013 Results XVI

- Cross correlation over 40% non contaminated sky

Prediction for cross-correlation at 857 GHz



ISW SNR



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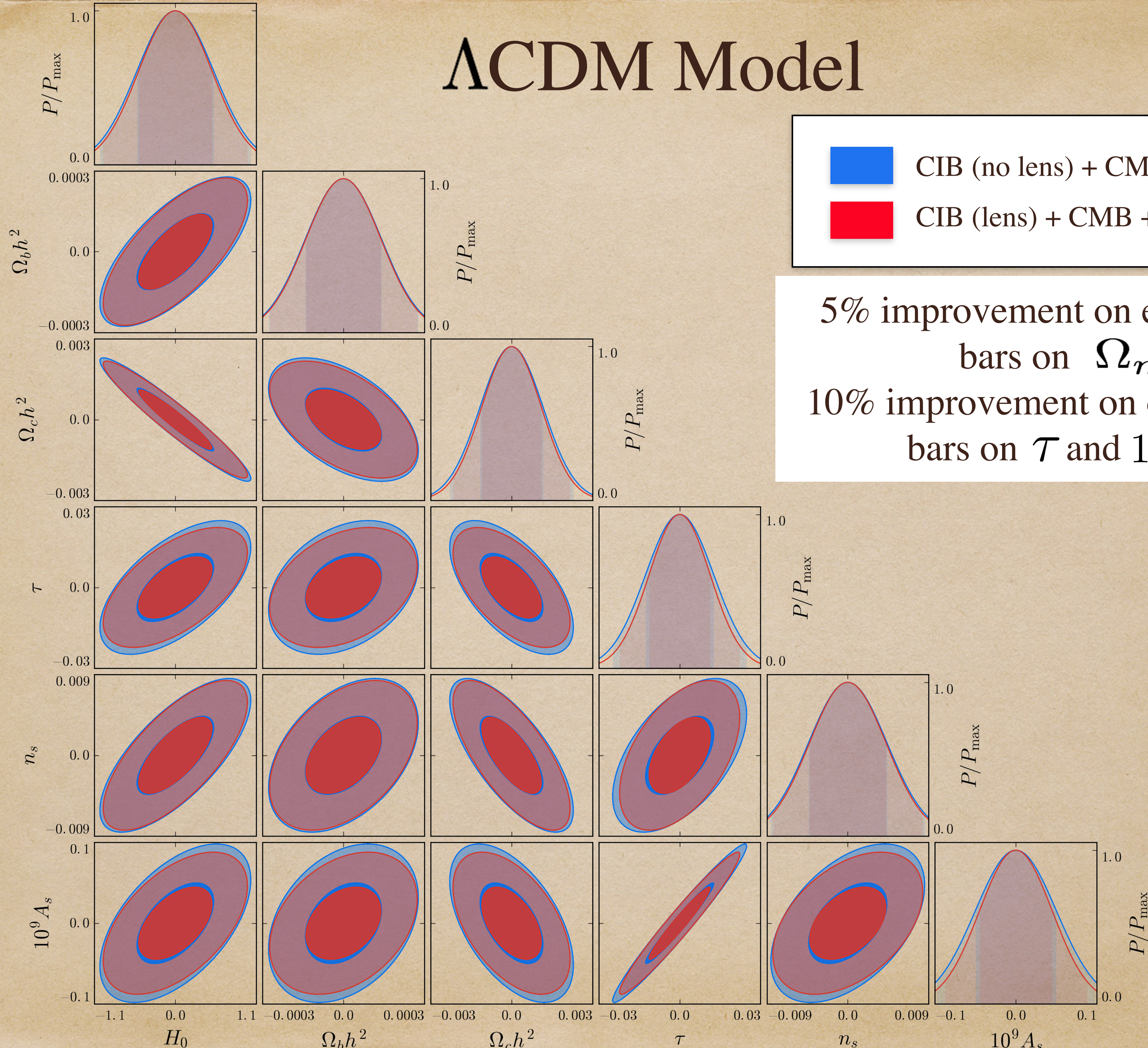
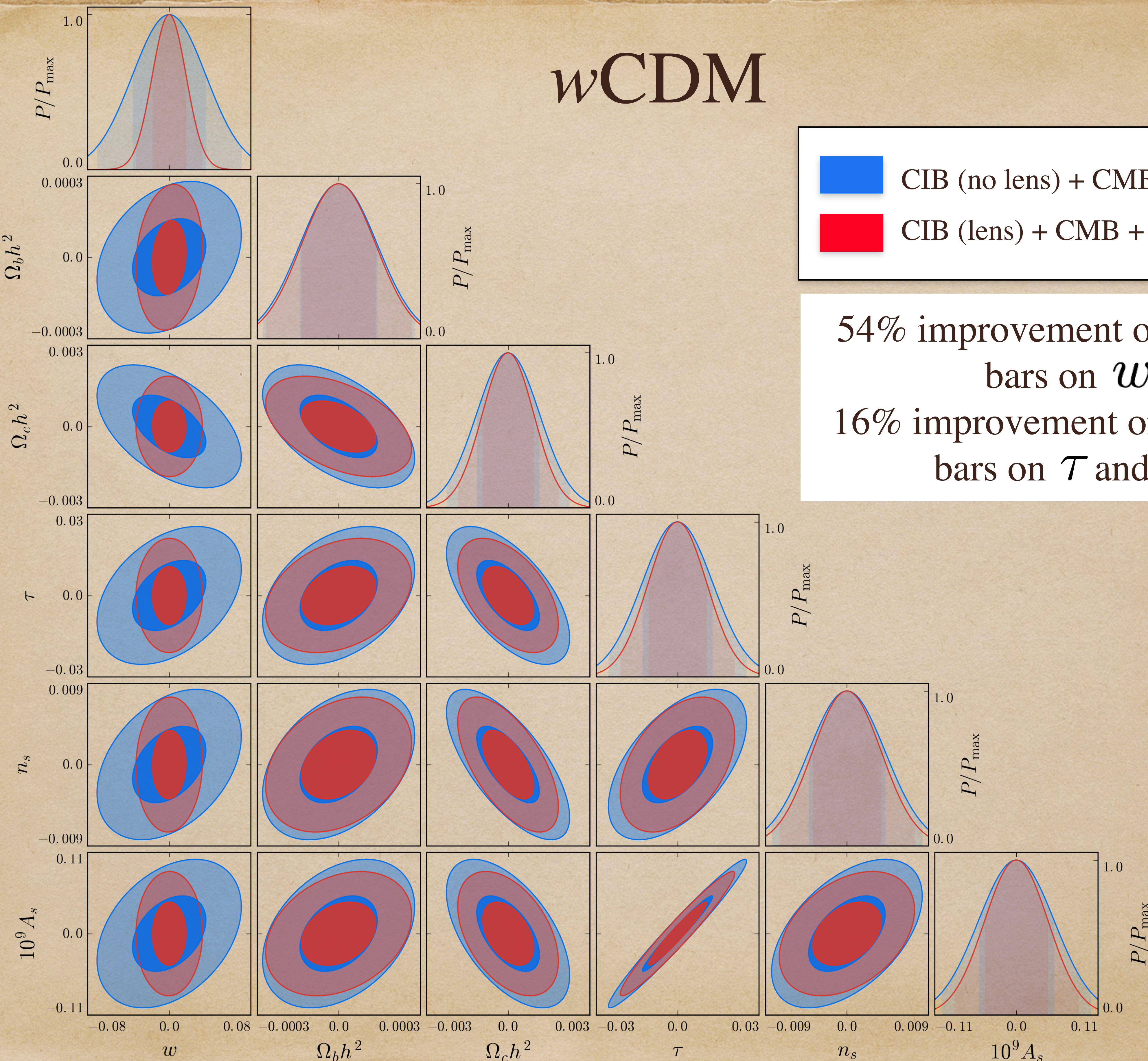
ΛCDM Model



5% improvement on error bars on Ω_m
10% improvement on error bars on τ and $10^9 A_s$

wCDM



CIB (no lens) + CMB + Ext

CIB (lens) + CMB + Ext + ISW

54% improvement on error bars on w

16% improvement on error bars on τ and $10^9 A_s$

Conclusions and Future Perspectives

- CIB an effective tool to understand galaxy evolution
  - ➡ SFRD at very high redshift (hard to obtain from galaxy surveys in sub mm) - history of dust production in the Universe (important to understand the galaxy formation in early universe)
  - ➡ Most efficient dark-matter halo mass: essential ingredient for models of galaxy formation
- Cosmology doesn't affect CIB
- CIB provides the best SNR to calculate ISW
- ISW probed through CIB-CMB cross-correlation can constrain the cosmological parameters; especially w
- Include the effects of dust in the analysis for ISW
- Extraction of the CIB-CMB cross-correlation and hence measuring ISW from the maps
  - ➡ Constraining cosmological models: ΛCDM, wCDM, w(z) models

Thank you!