Observing Patchy Reionization With CMB S4

Anirban Roy,
SISSA,
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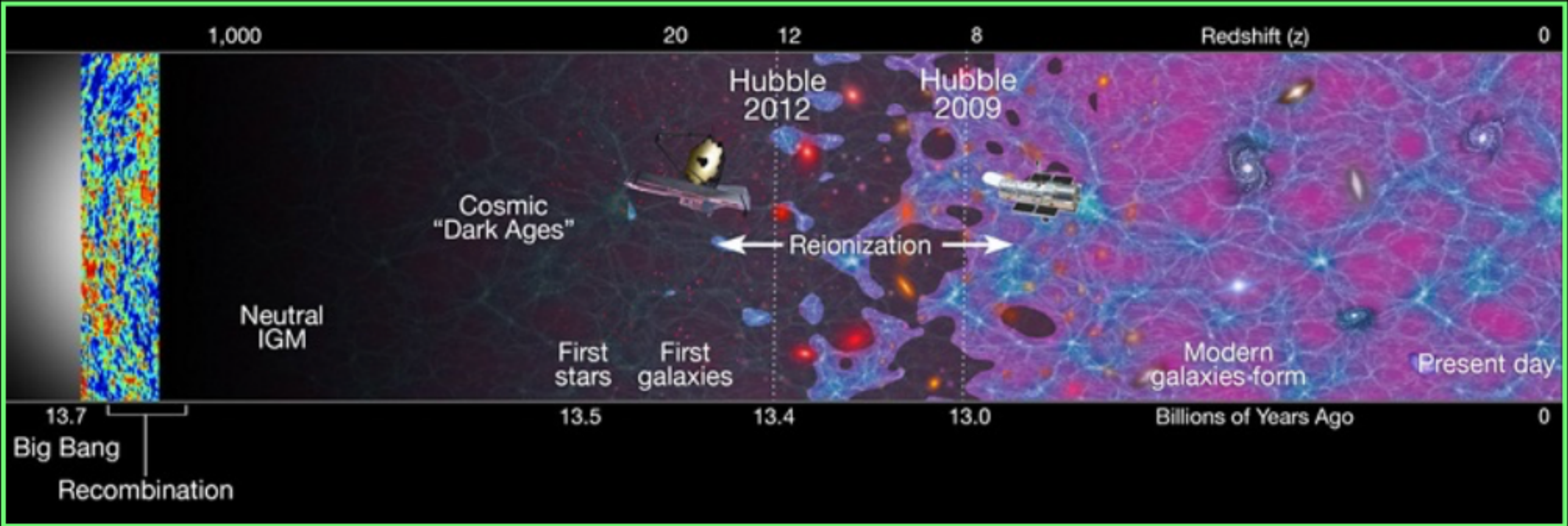
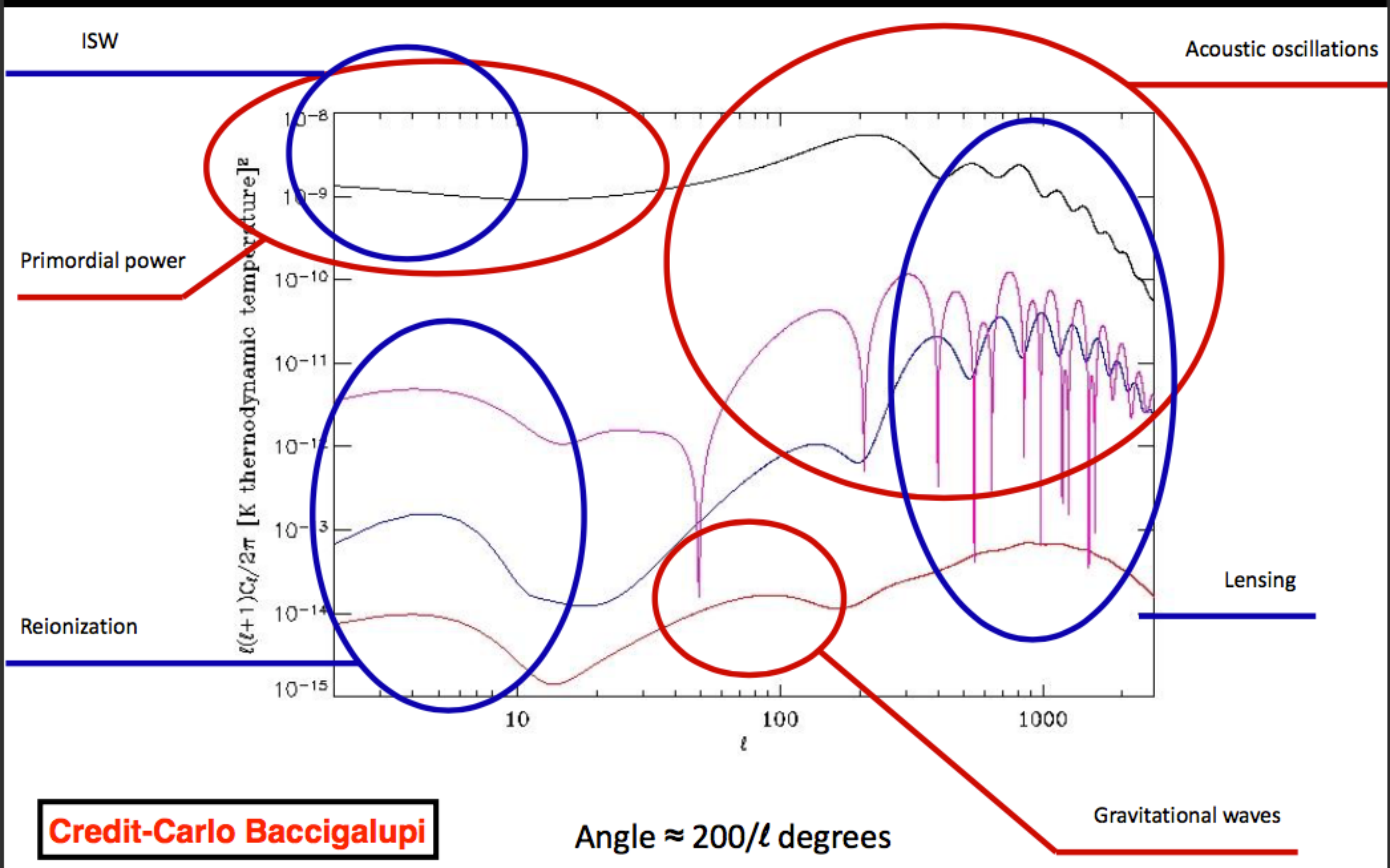
With Andrea Lapi, David Spergel and Carlo Baccigalupi

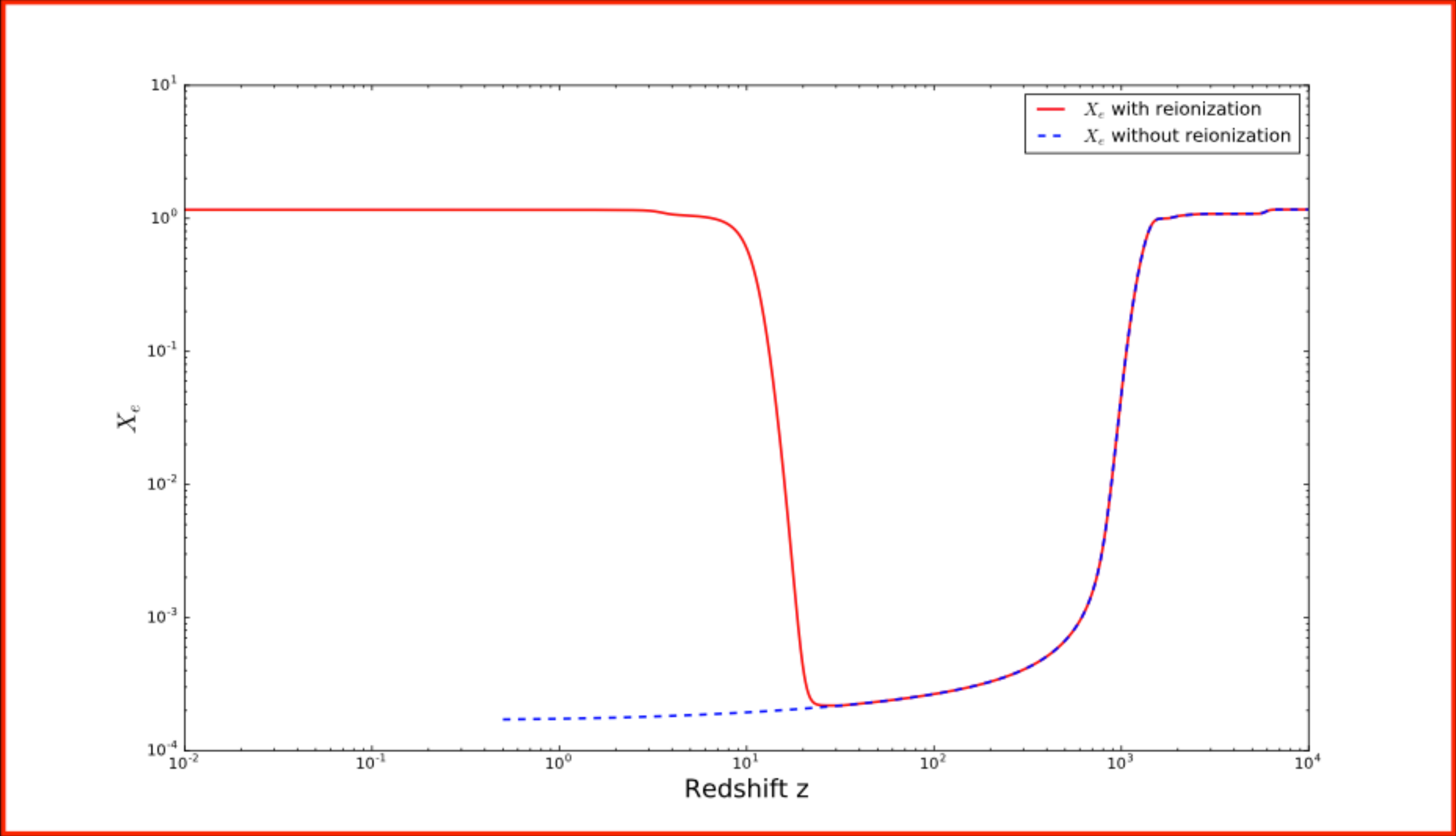


Universe started to evolve from a hot and dense plasma of particles in thermal equilibrium.

Recombination: **At redshift z~1100, neutral hydrogen atom formed by the recombination of electron and proton and universe become transparent as photons can travel freely!**

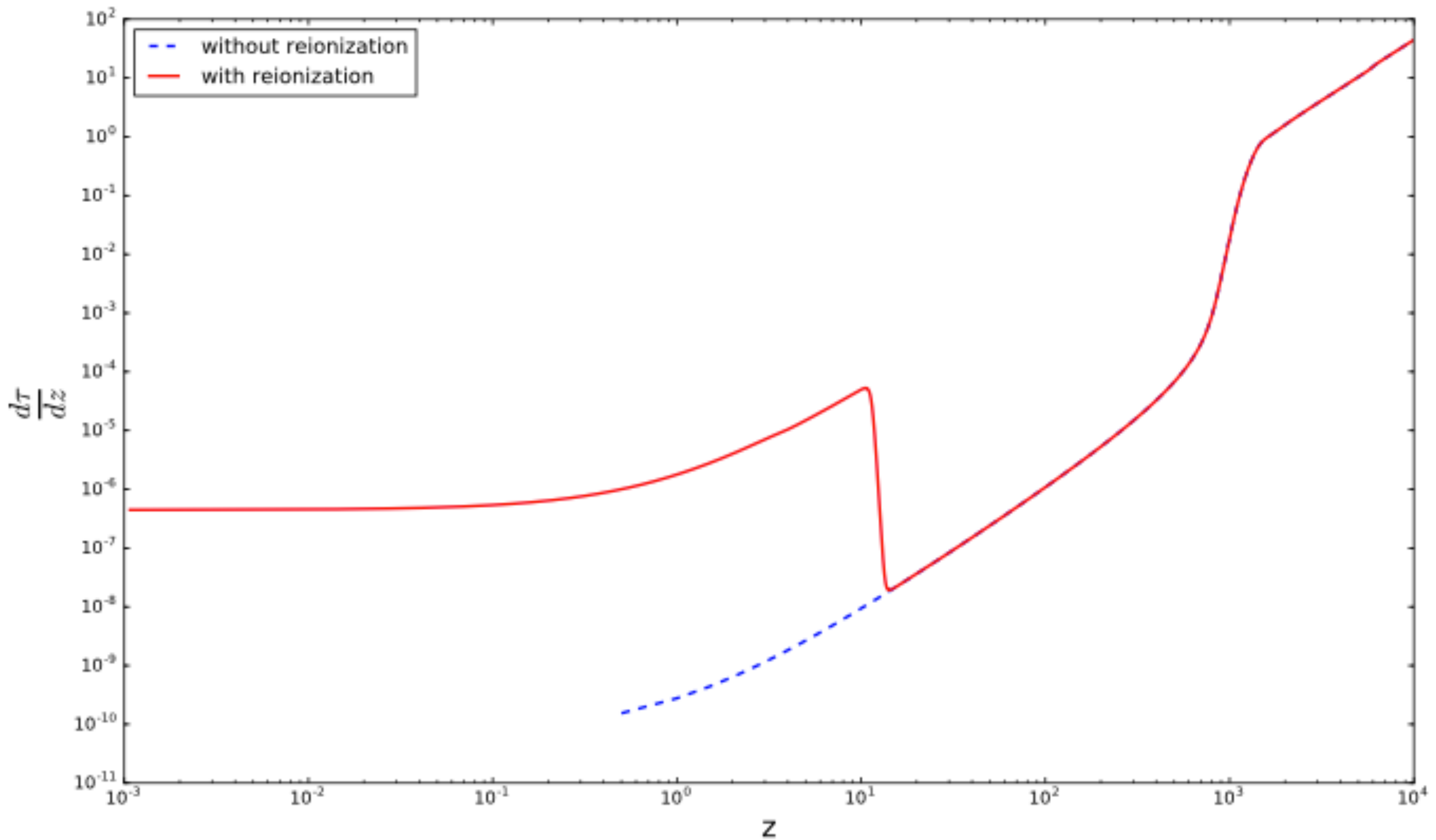
Reionization: **High energy sources (uncertain!) ionise the Universe between redshifts 7.7 to 10 (from CMB) and 10% of CMB photons scattered again.**

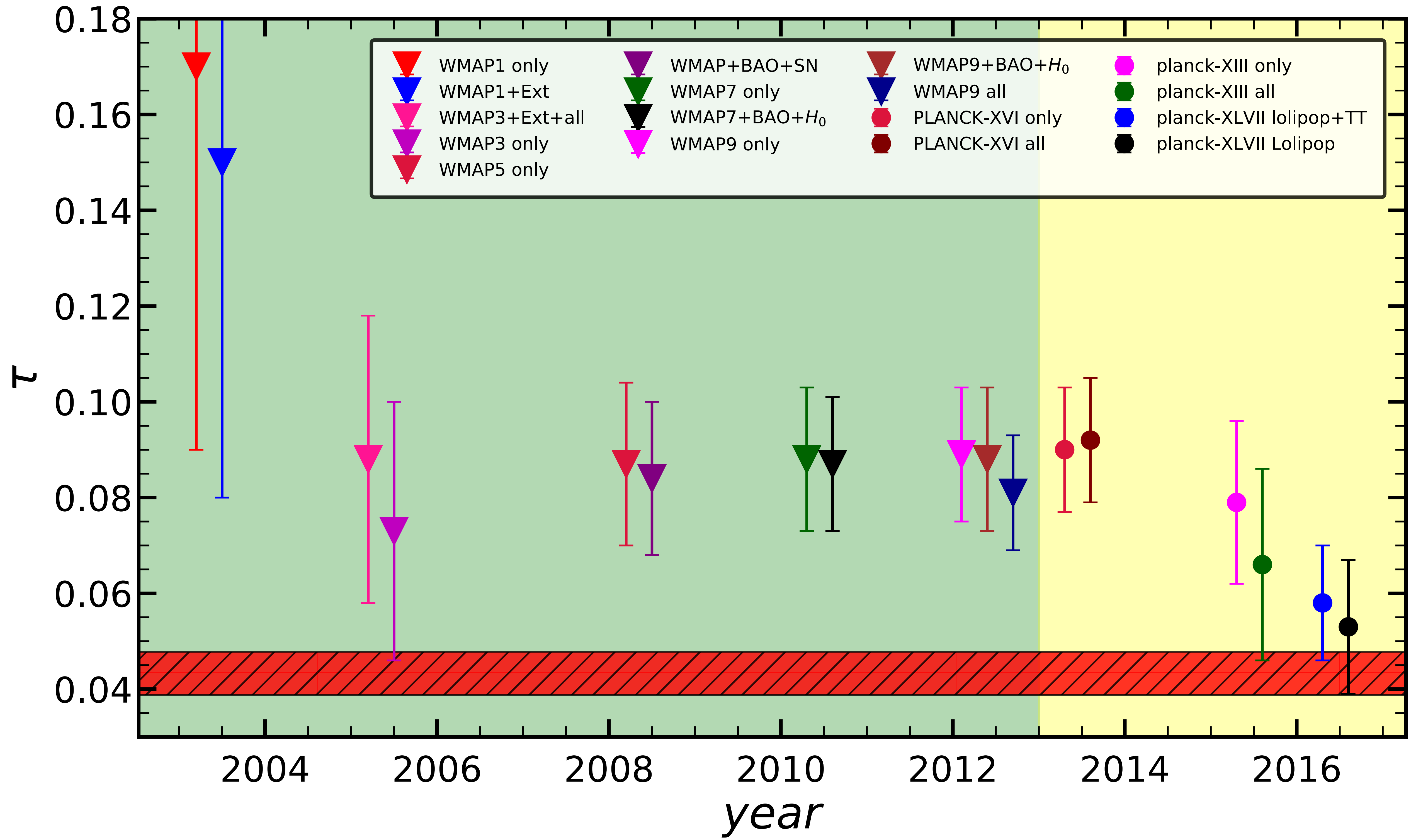

ISW
Acoustic oscillations
Primordial power
Lensing
Reionization
Gravitational waves
$\ell(\ell+1)C_\ell/2\pi$ [K thermodynamic temperature]^2
ℓ
10
100
1000
Credit-Carlo Baccigalupi
Angle ≈ 200/ℓ degrees



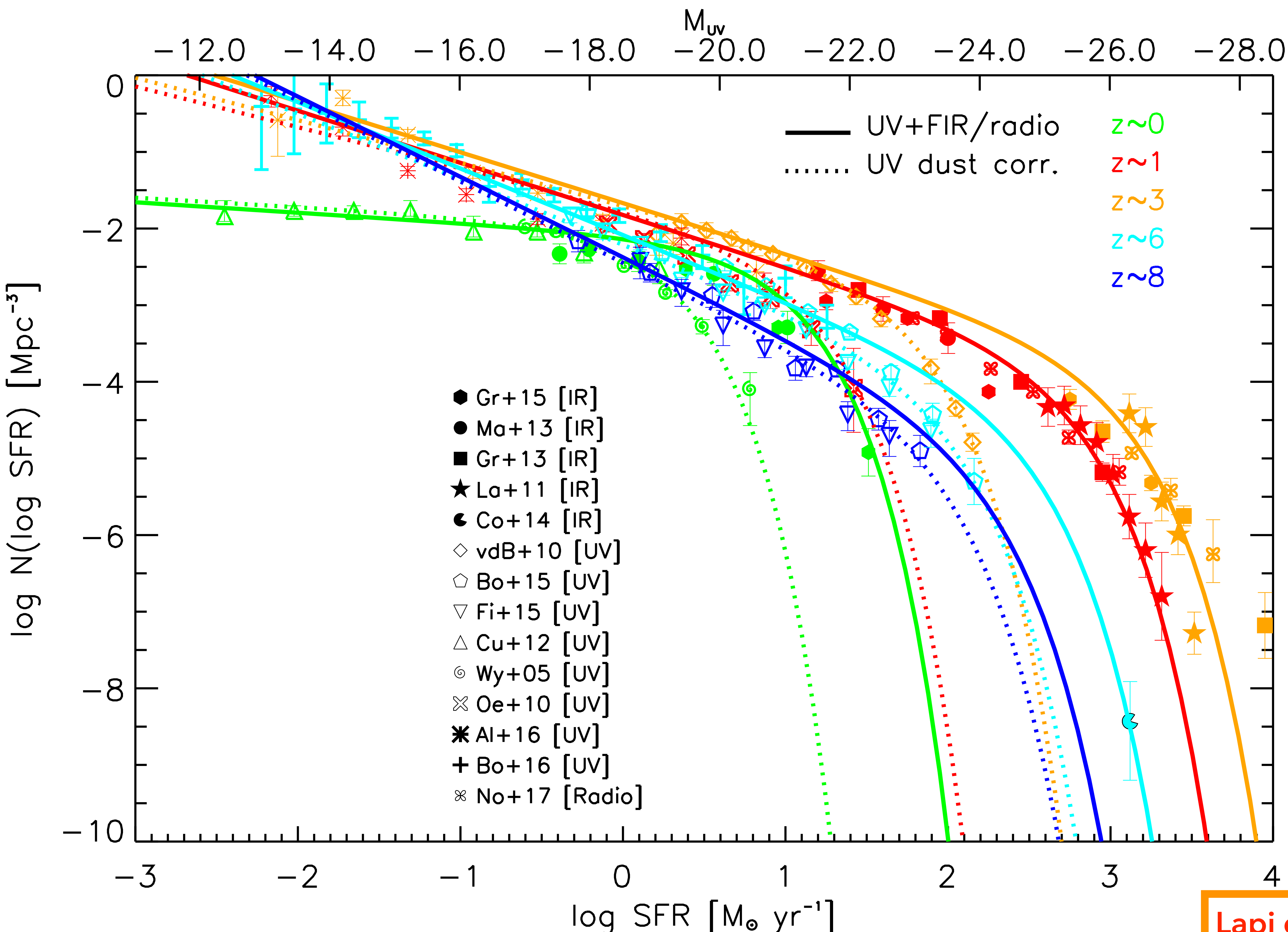
$$\bar{x}_e = \frac{1}{2}\left[1 - \tanh\left(\frac{y(z) - y_{re}}{\Delta y}\right)\right]$$

$$\tau(z) = \sigma_T n_{p,0} \int_0^z \frac{dz'(1+z')^2}{H(z')} x_e(z')$$



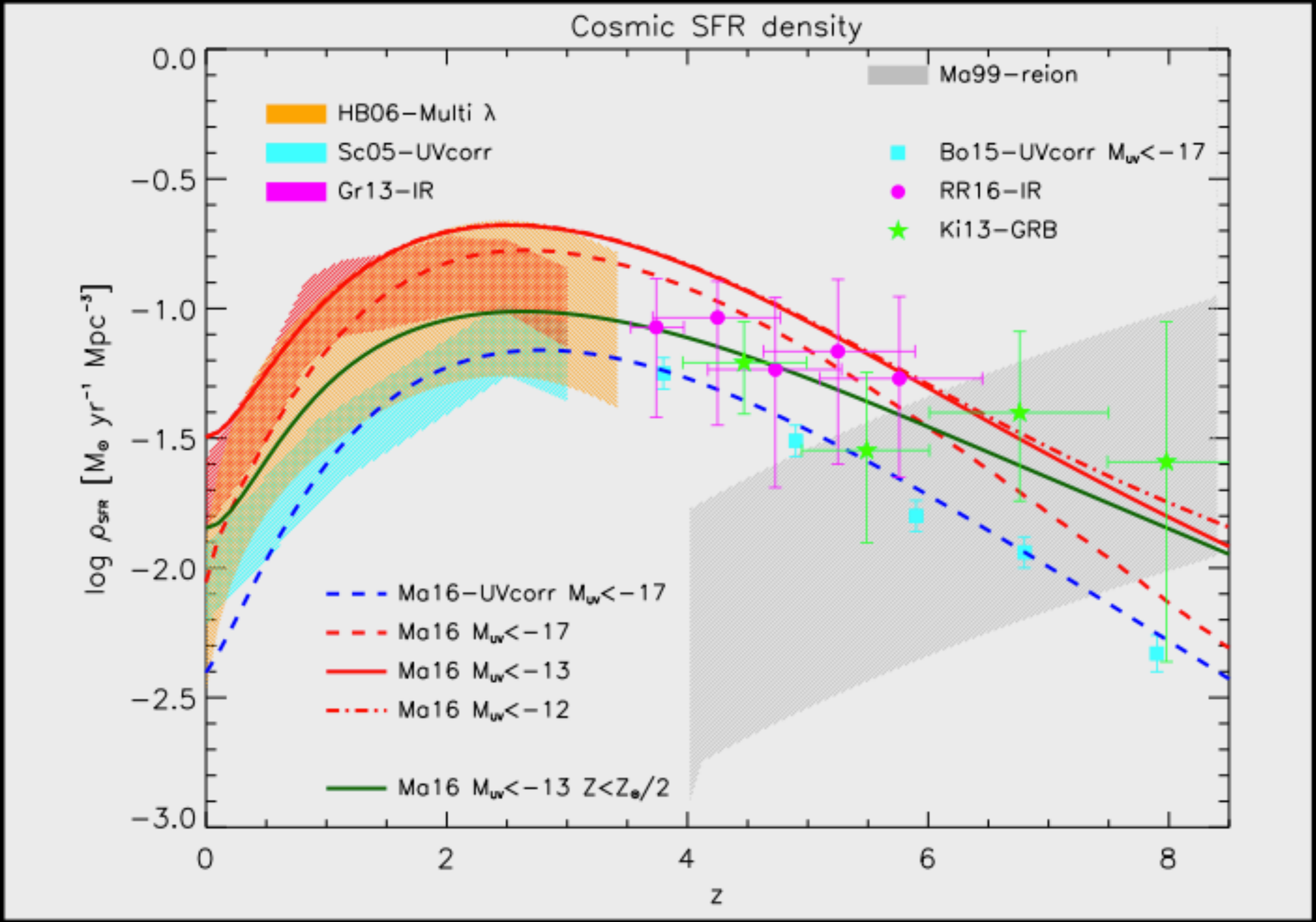


WMAP1 only
WMAP1+Ext
WMAP3+Ext+all
WMAP3 only
WMAP5 only
WMAP+BAO+SN
WMAP7 only
WMAP7+BAO+H_0
WMAP9 only
WMAP9+BAO+H_0
WMAP9 all
PLANCK-XVI only
PLANCK-XVI all
planck-XIII only
planck-XIII all
planck-XLVII lolipop+TT
planck-XLVII Lolipop
τ
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
2004
2006
2008
2010
2012
2014
2016
year



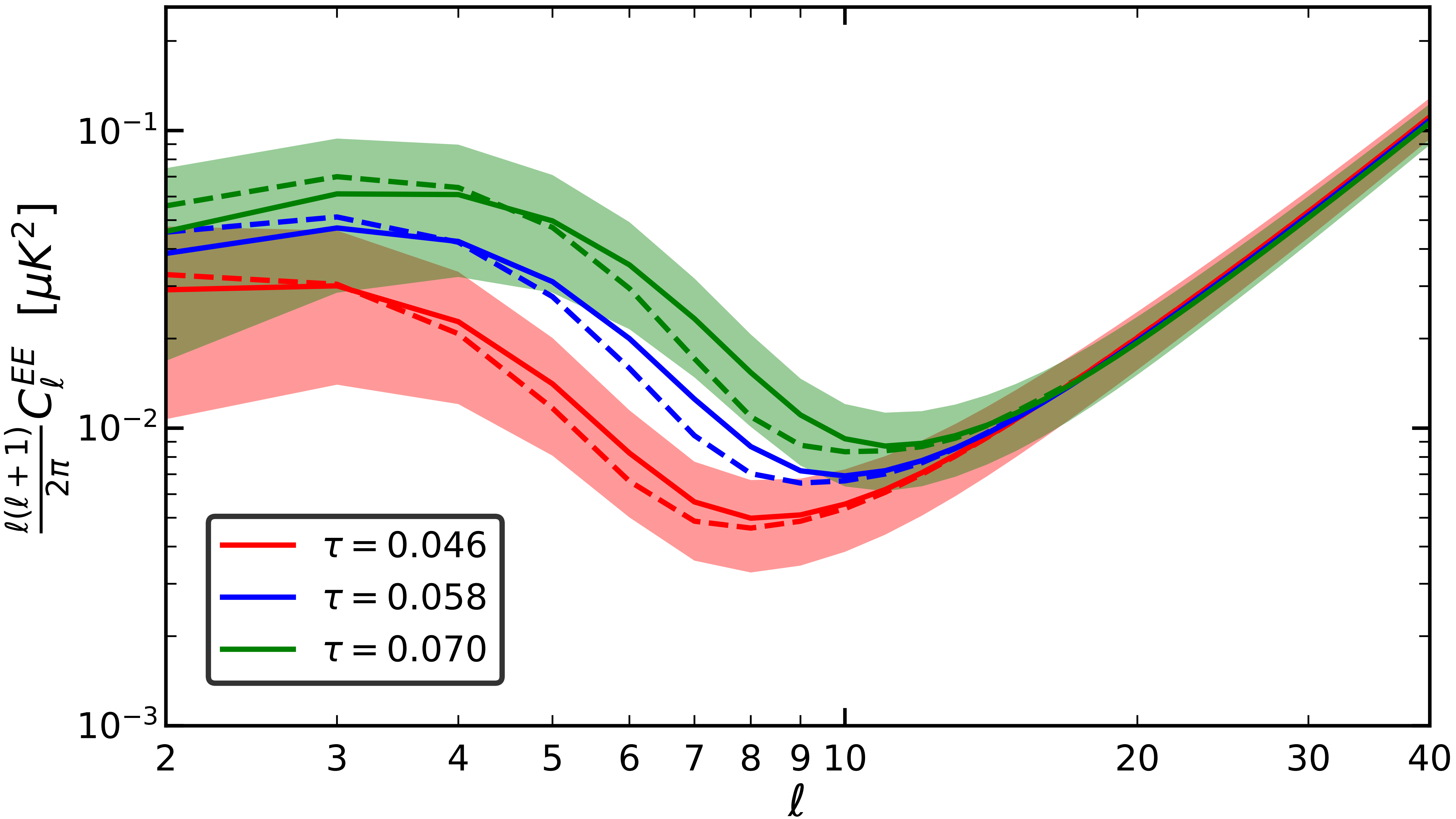
Lapi et. al 2017

$$\dot{N}_{ion} = f_{esc} k_{ion} \rho$$



$$\dot{Q}_{HII} = \frac{\dot{N}_{ion}}{\bar{n}_H} - \frac{Q_{HII}}{t_{rec}}$$

Modified E mode Spectra



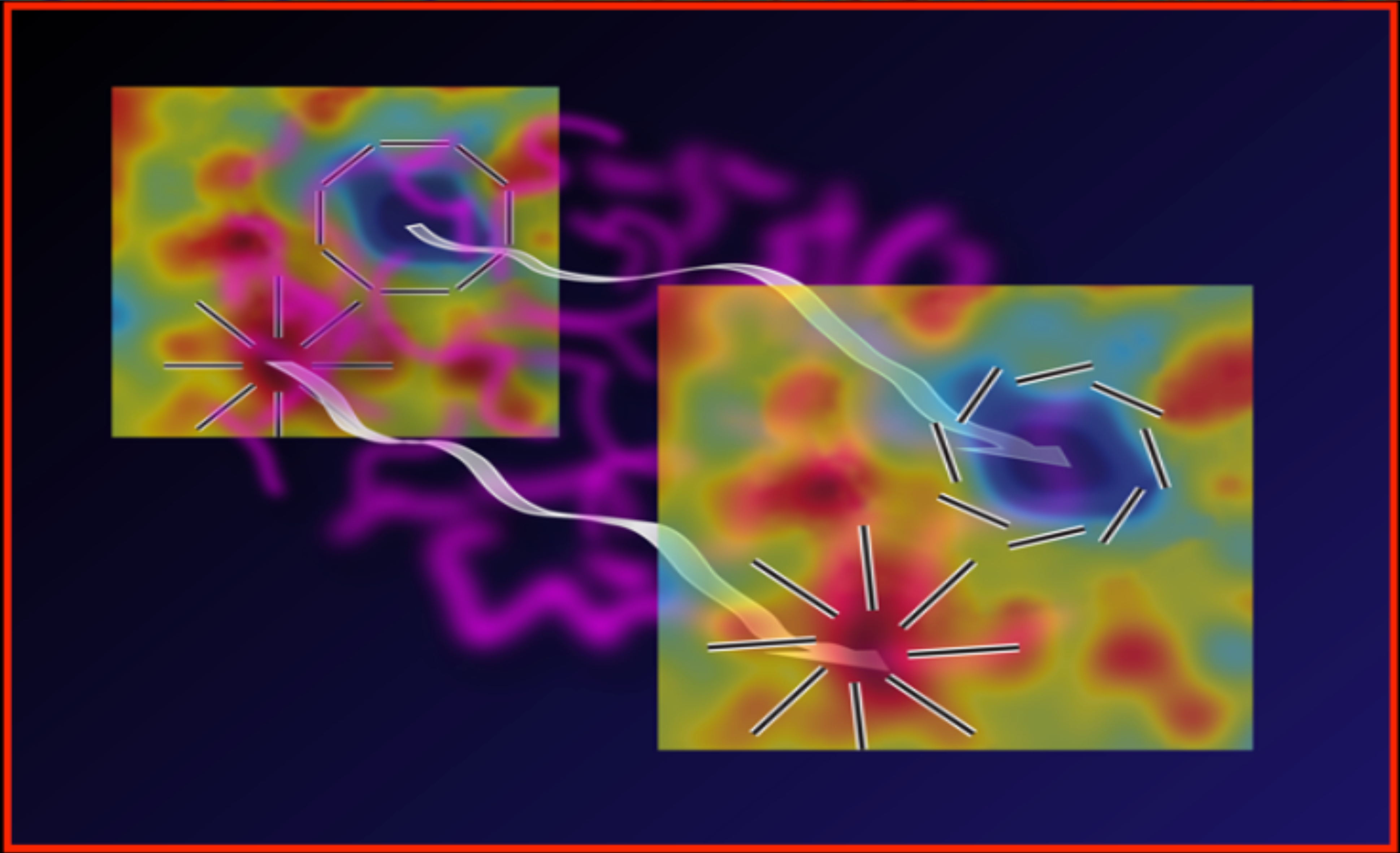
optical depth will be position depended quantity due to patchy reionization. So it is possible to construct tau powerspectrum.

$$C_l^{\tau\tau} = \int d\chi \frac{\sigma_T^2 n_{p,0}^2}{a^4\chi^2} P_{\Delta x_e \Delta x_e}\left(\chi, k = \frac{l}{\chi}\right)$$

Like lensing, patchy reionization will also generate B mode signal which can be written as

$$C_l^{BB} = \frac{3\sigma_T^2 n_{p,0}^2}{100} \int \frac{d\chi}{a^4\chi^2} e^{-2\tau(\chi)} Q_{rms}^2(\chi) P_{\Delta x_e \Delta x_e}\left(\chi, k = \frac{l}{\chi}\right)$$

Dvorkin & smith 2009, Hu 2000, Mortonson & Hu 2006



$$X^{len}(\hat{n}) = X^{Unl}(\hat{n} + \vec{d}(\hat{n})) = X^{Unl}(\hat{n} + \nabla\phi(\vec{n}))$$

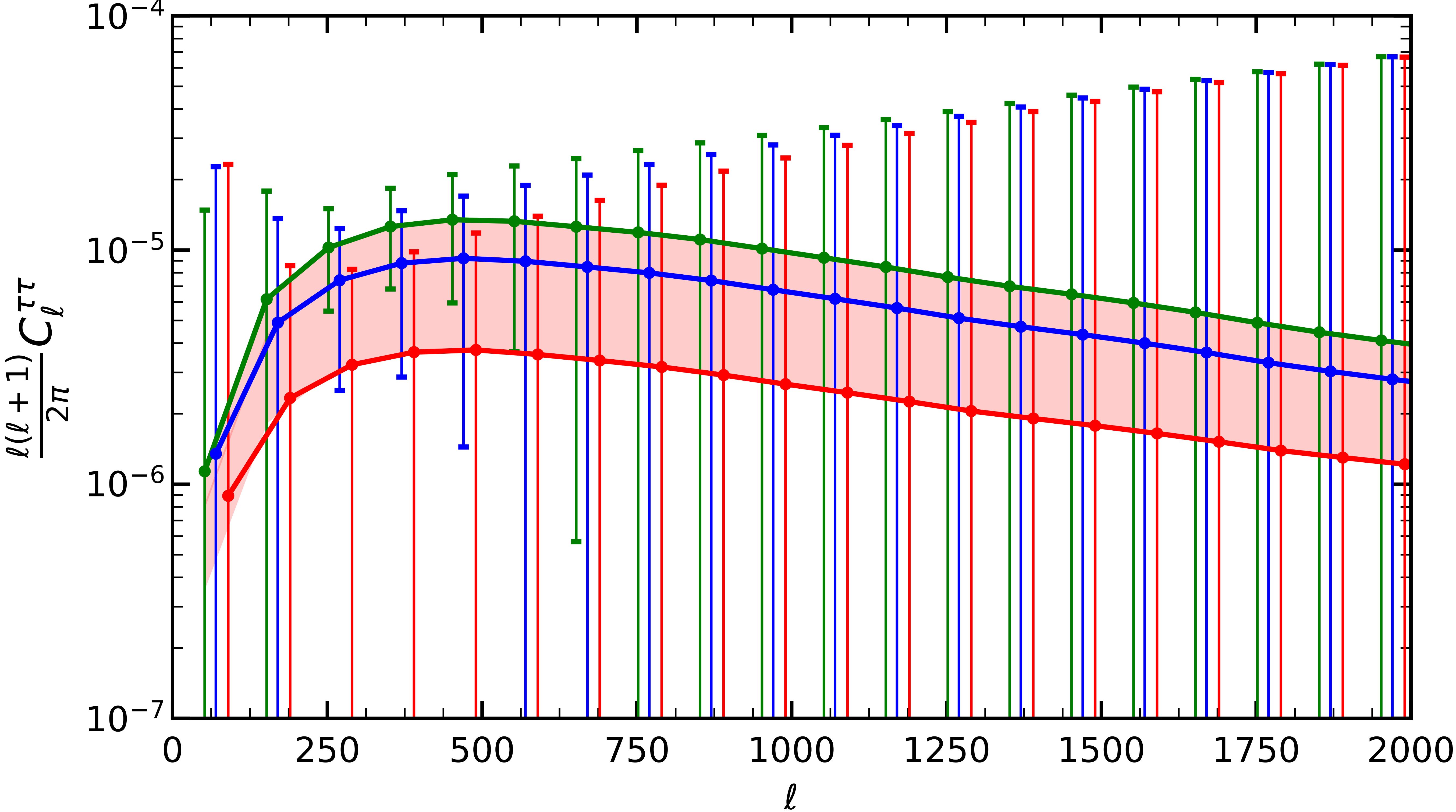
$$\phi(\vec{n}) = -2\int dD \frac{D_s - D}{DD_s}\Psi(D\hat{n}, D)$$

credit: Eiichiro Komatsu

~ 500000 detectors will operate between 30 to 300 GHz

Sensitivity ~ 1 micro K, fsky=50%, beam width ~ 1arc min

Reconstructed Tau spectra



Thank You