

21CMMC: an MCMC framework for the astrophysics of reionisation

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SUPERIORE

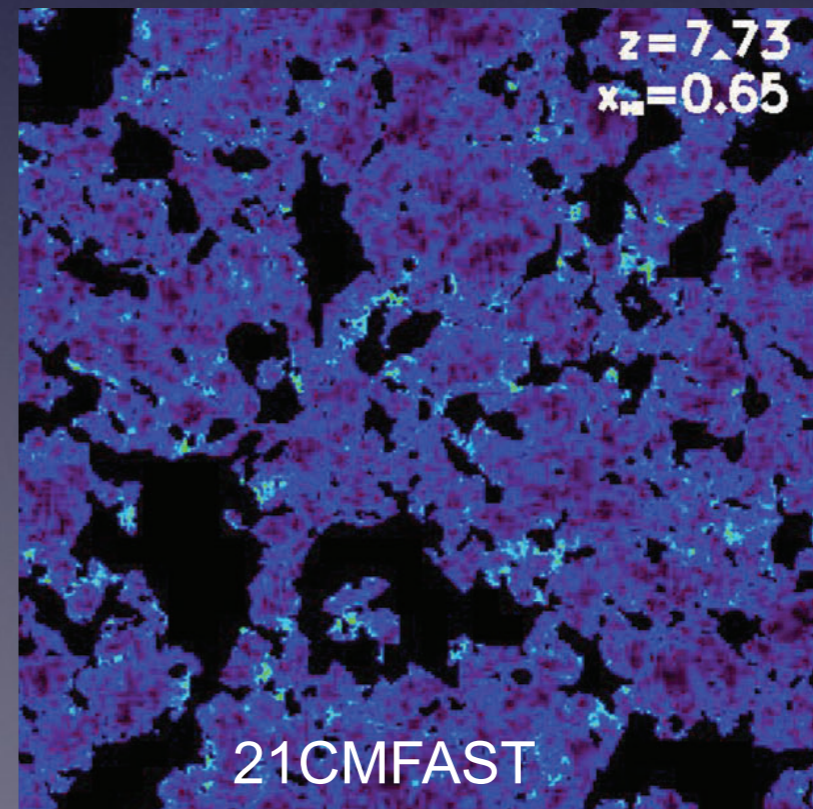
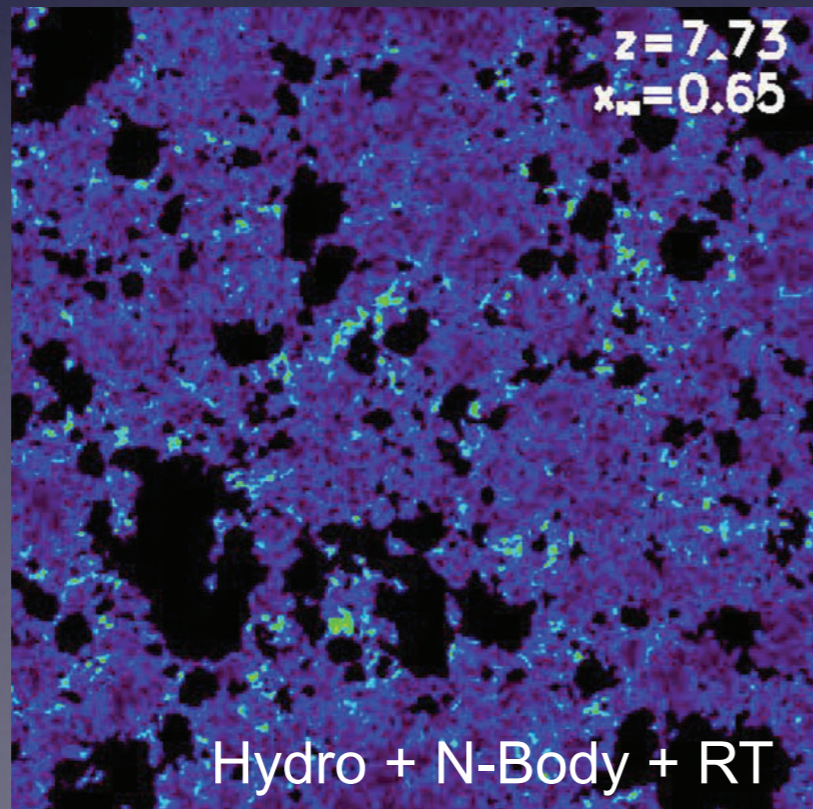
Peering towards Cosmic Dawn (IAUS333) Dubrovnik, Oct 2nd



European Research Council

21CMMC

- Massively parallel MCMC driver for the EoR simulation code 21CMFAST
- 21CMFAST provides:
 - **full 3D EoR simulations** at a fraction of the computing cost of RT simulations
 - preserves the 3D structure of reionisation (superior to analytic models of EoR)
- Recovers astrophysical parameter constraints from **any model** of the EoR for **any statistical measure** of the 21 cm signal

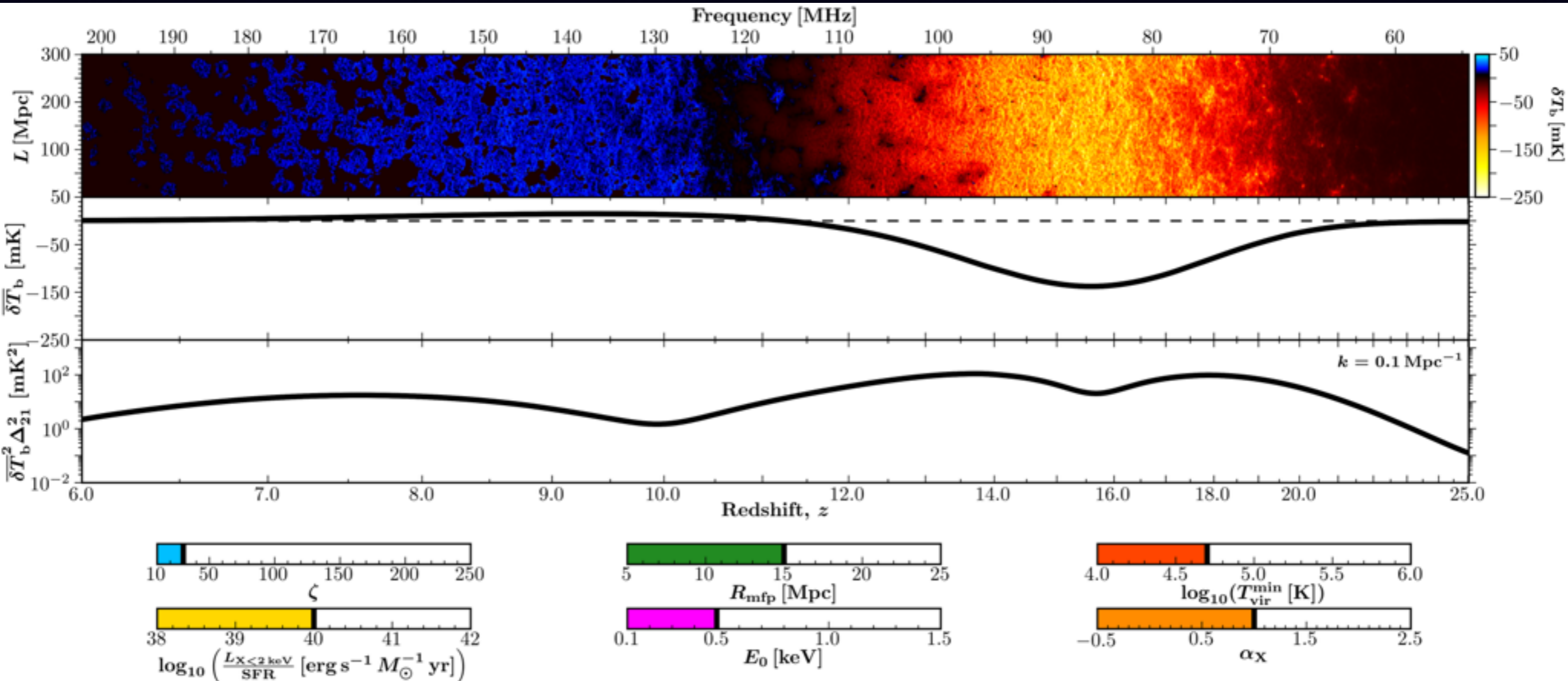


Astrophysical Parametrisation in 21CMMC

- Current implementation contains 6 parameters
- Have 3 parameters describing the EoR
- Another 3 parameters describing the heating (X-ray) epoch
- Assume the same minimum mass threshold for ionisation and X-ray sources

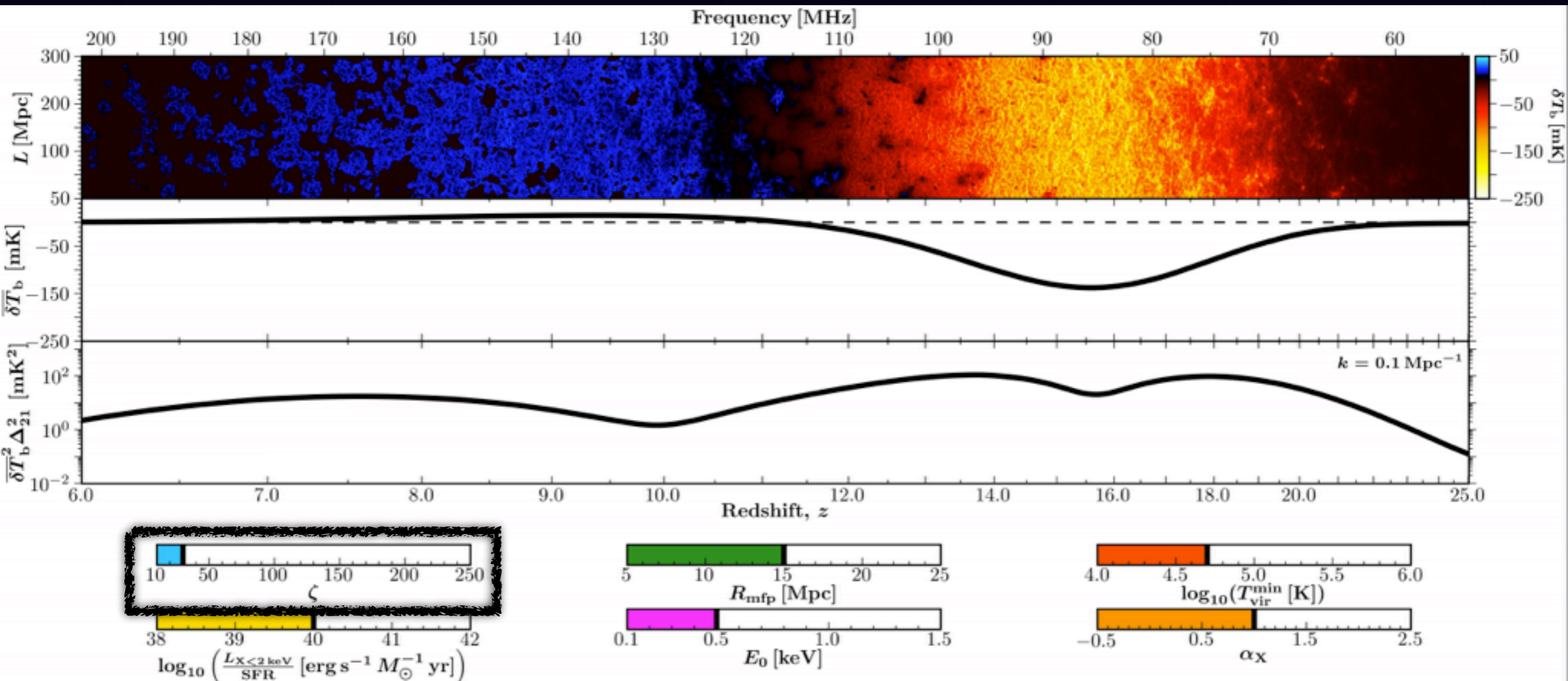
Epoch of Reionisation

ζ : Constant ionising efficiency; $\propto f_{\text{esc}} f_* N_{\gamma/b} (1 + n_{\text{rec}})^{-1}$



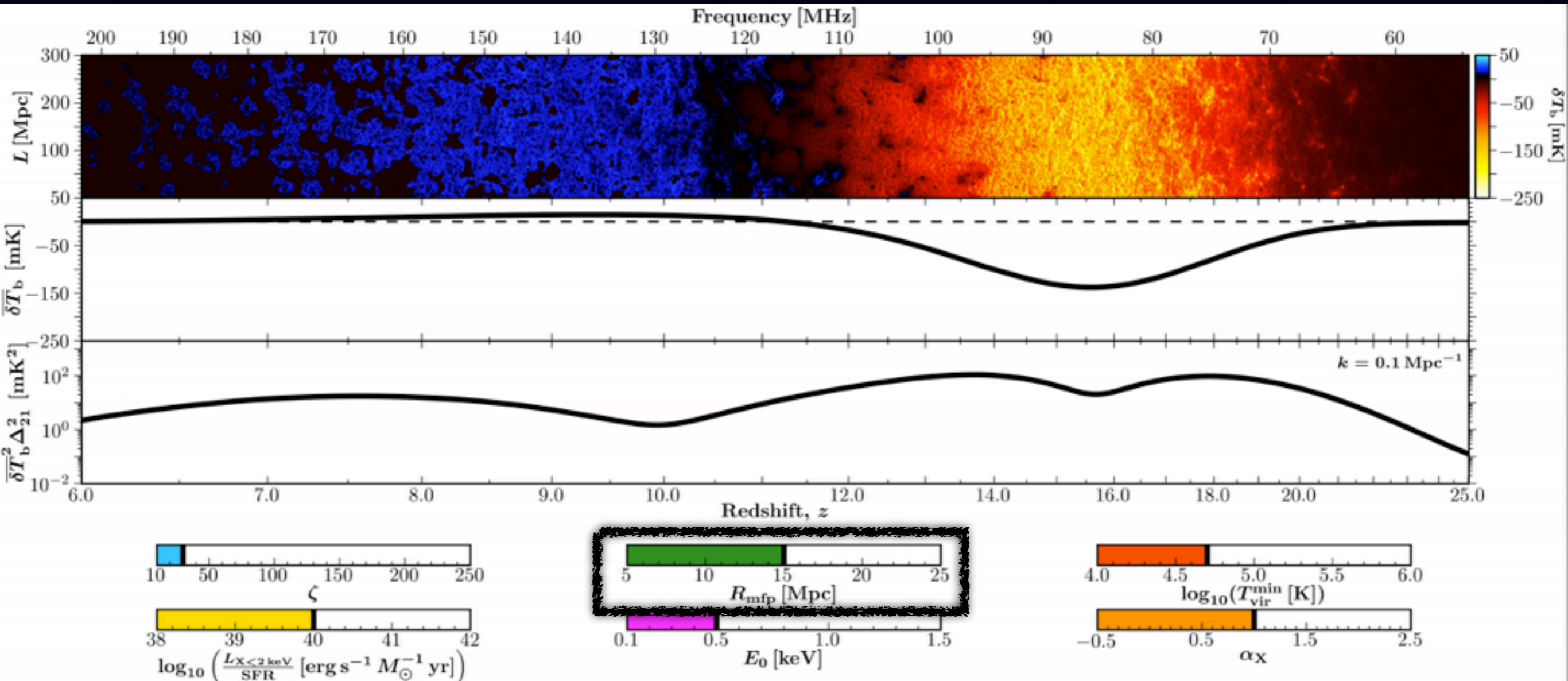
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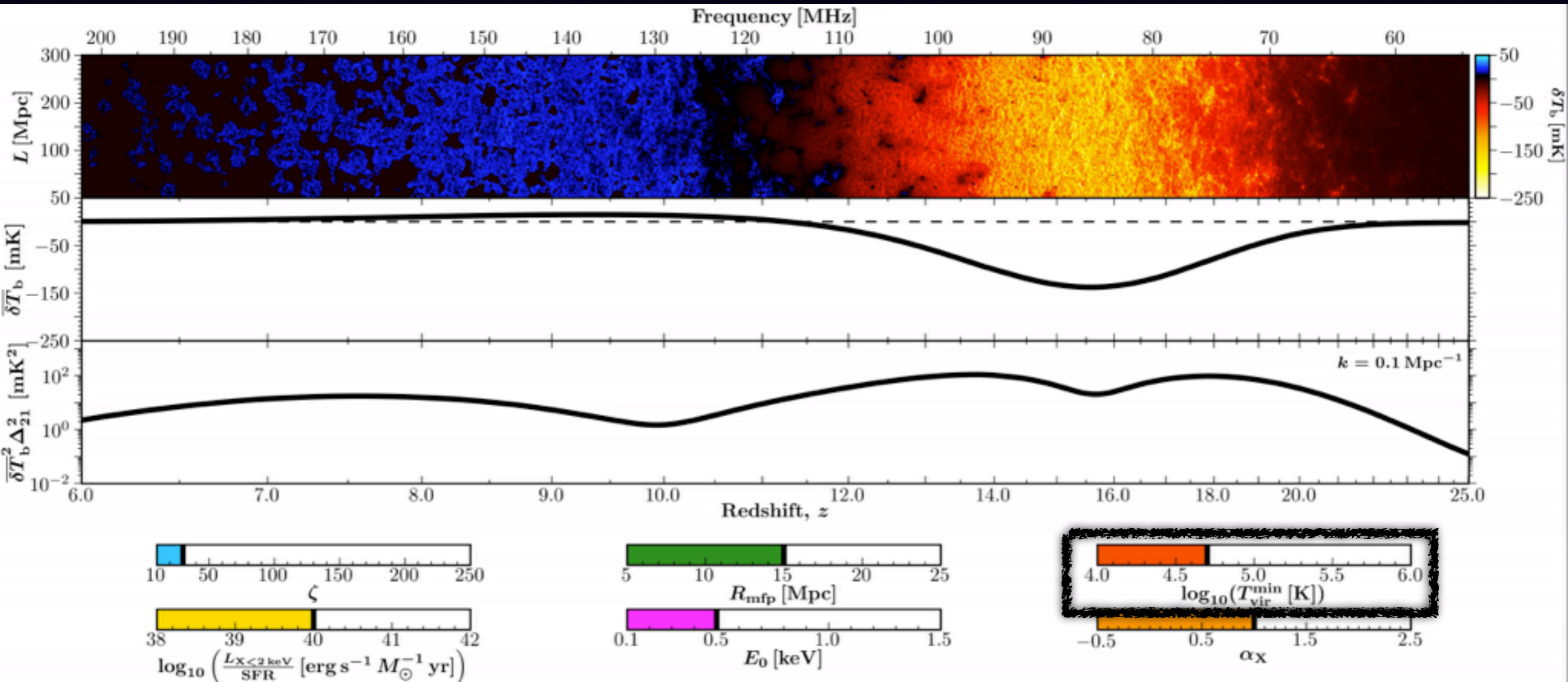
Epoch of Reionisation

R_{mfp} : Maximum horizon of ionising photons



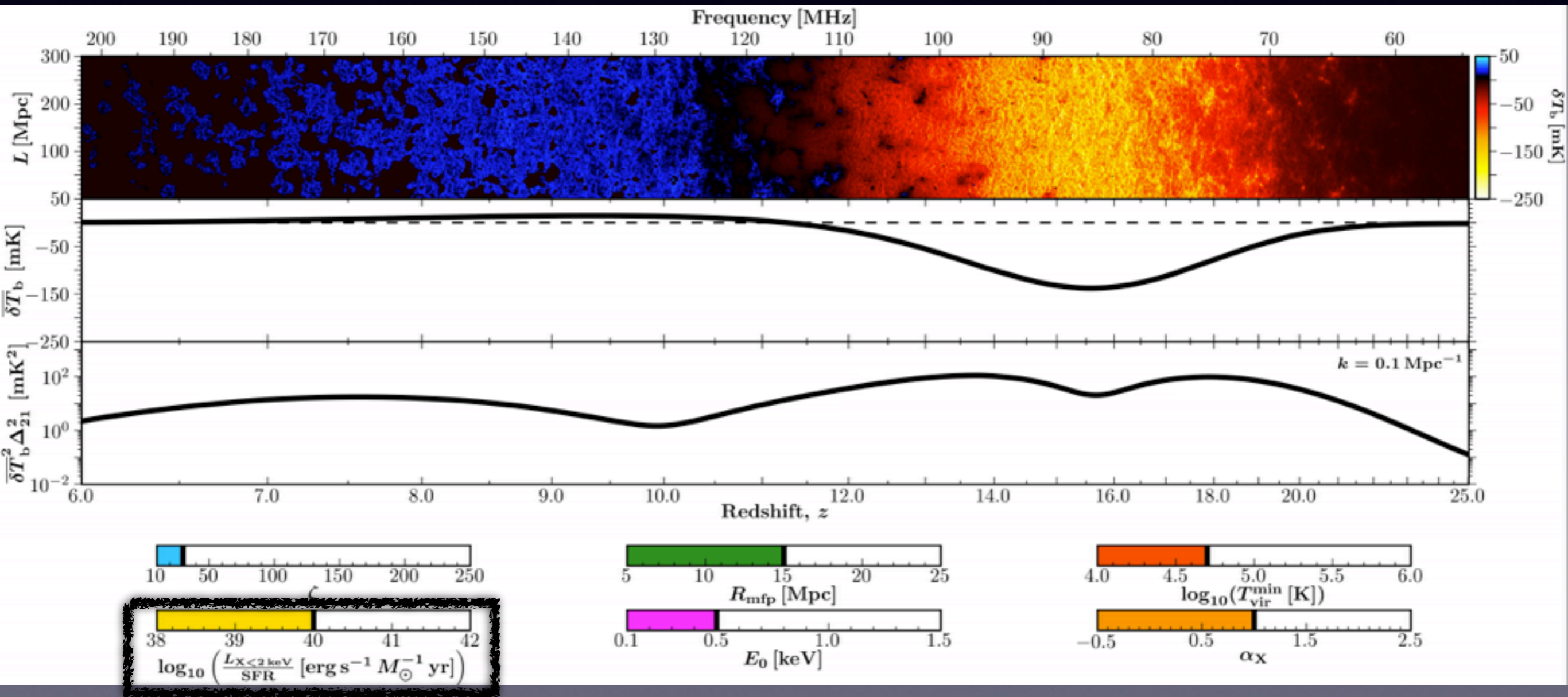
Epoch of Reionisation

T_{vir} : Minimum mass threshold for the formation of star-forming haloes



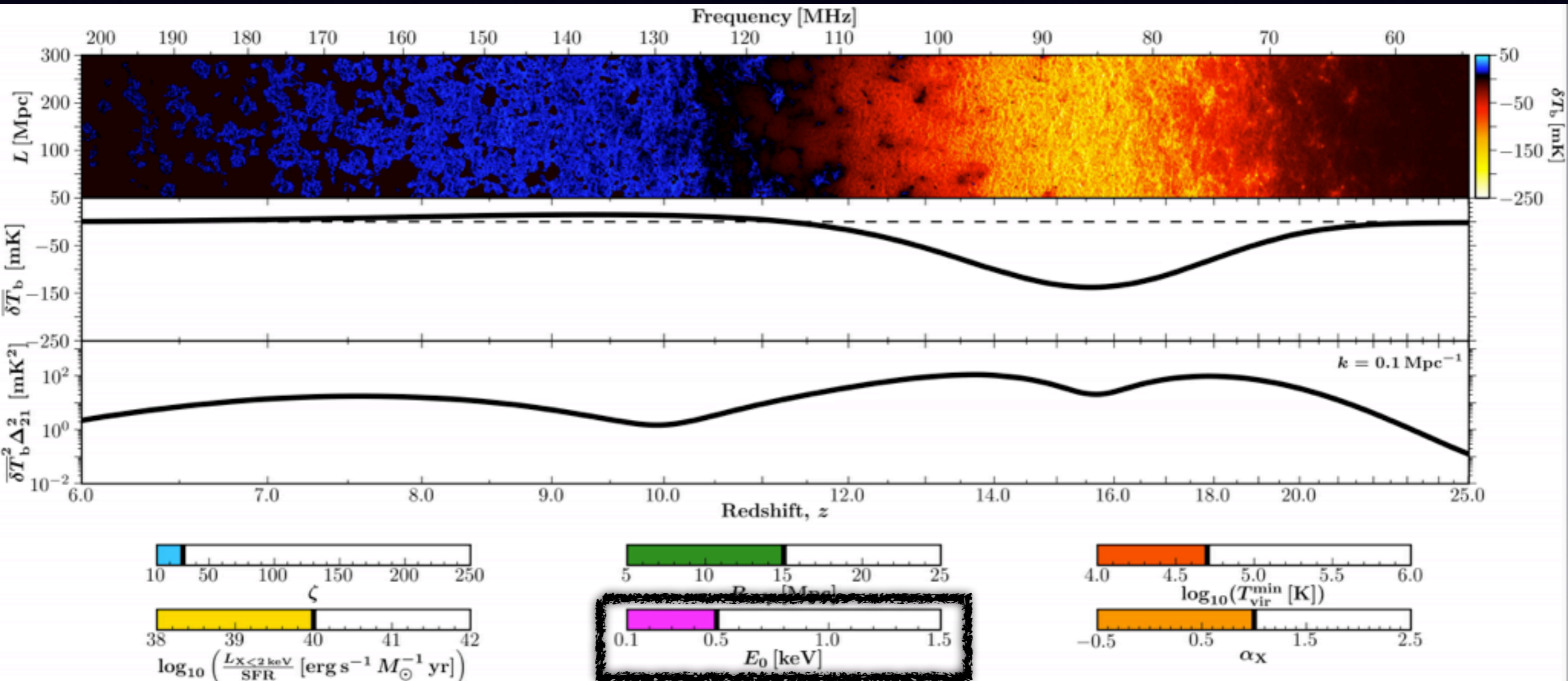
Epoch of (X-ray) Heating

L_X/SFR : Integrated soft-band (<2keV) luminosity of the X-ray sources



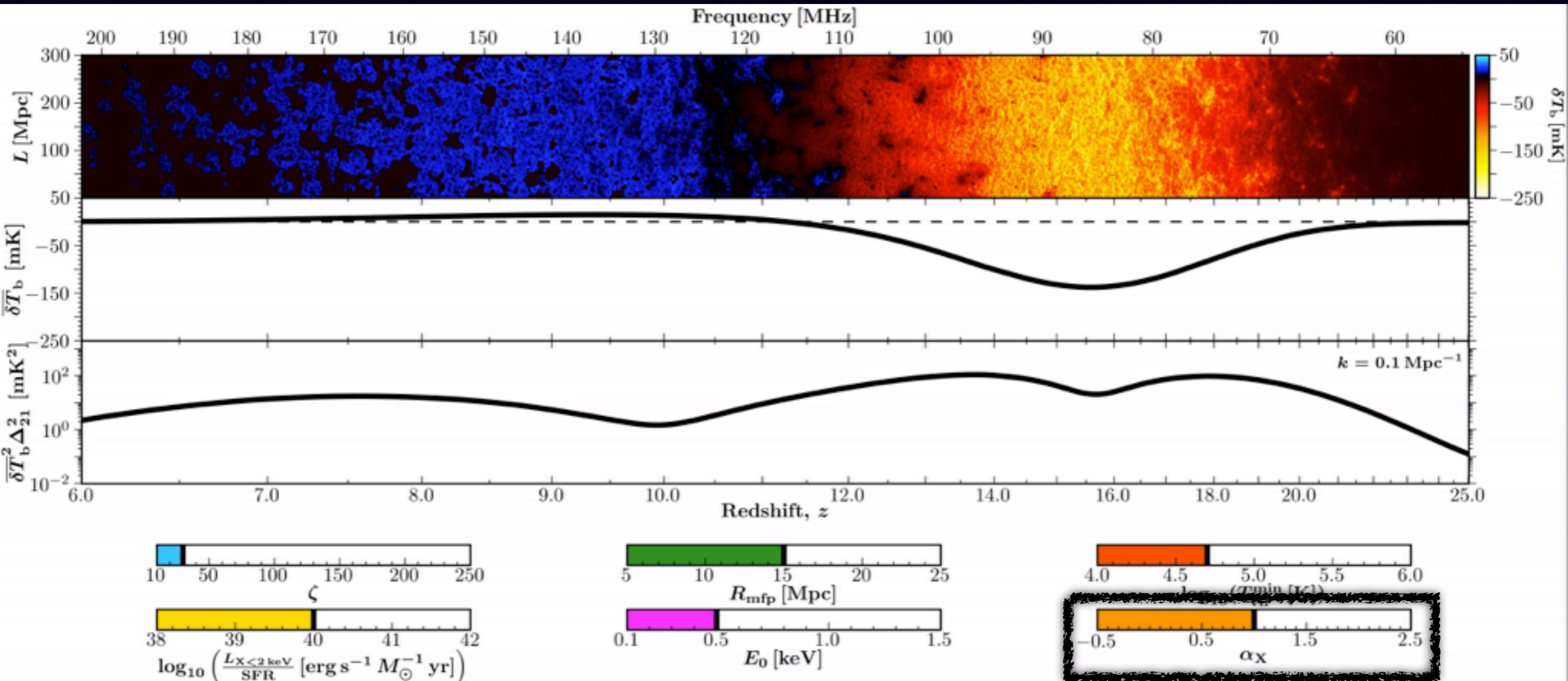
Epoch of (X-ray) Heating

E_0 : energy threshold below which X-ray photons are absorbed by the host galaxy

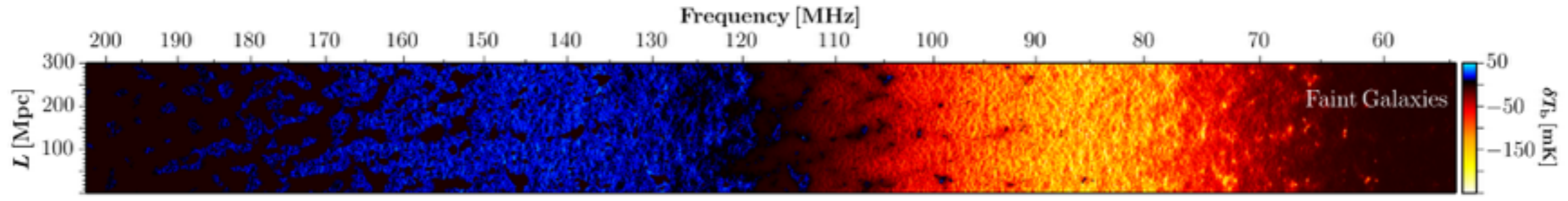


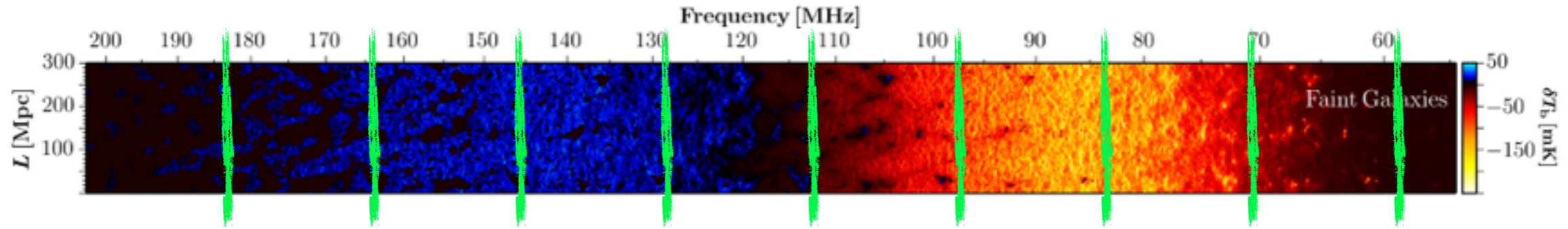
Epoch of (X-ray) Heating

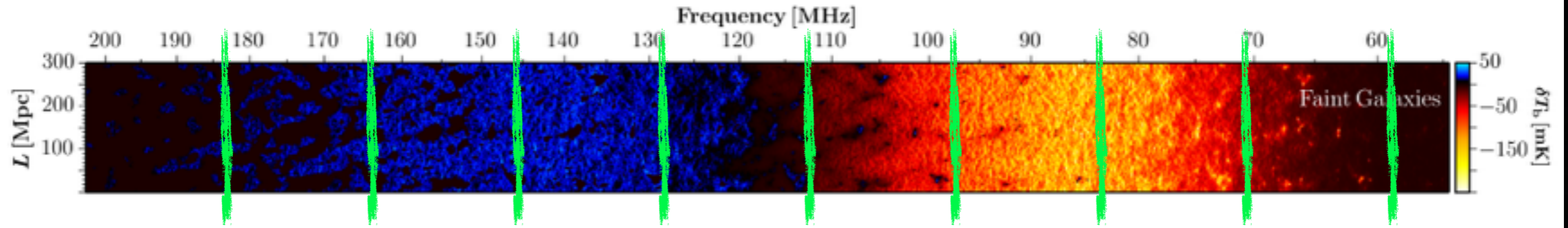
α_X : The spectral index of the X-ray emission from early galaxies



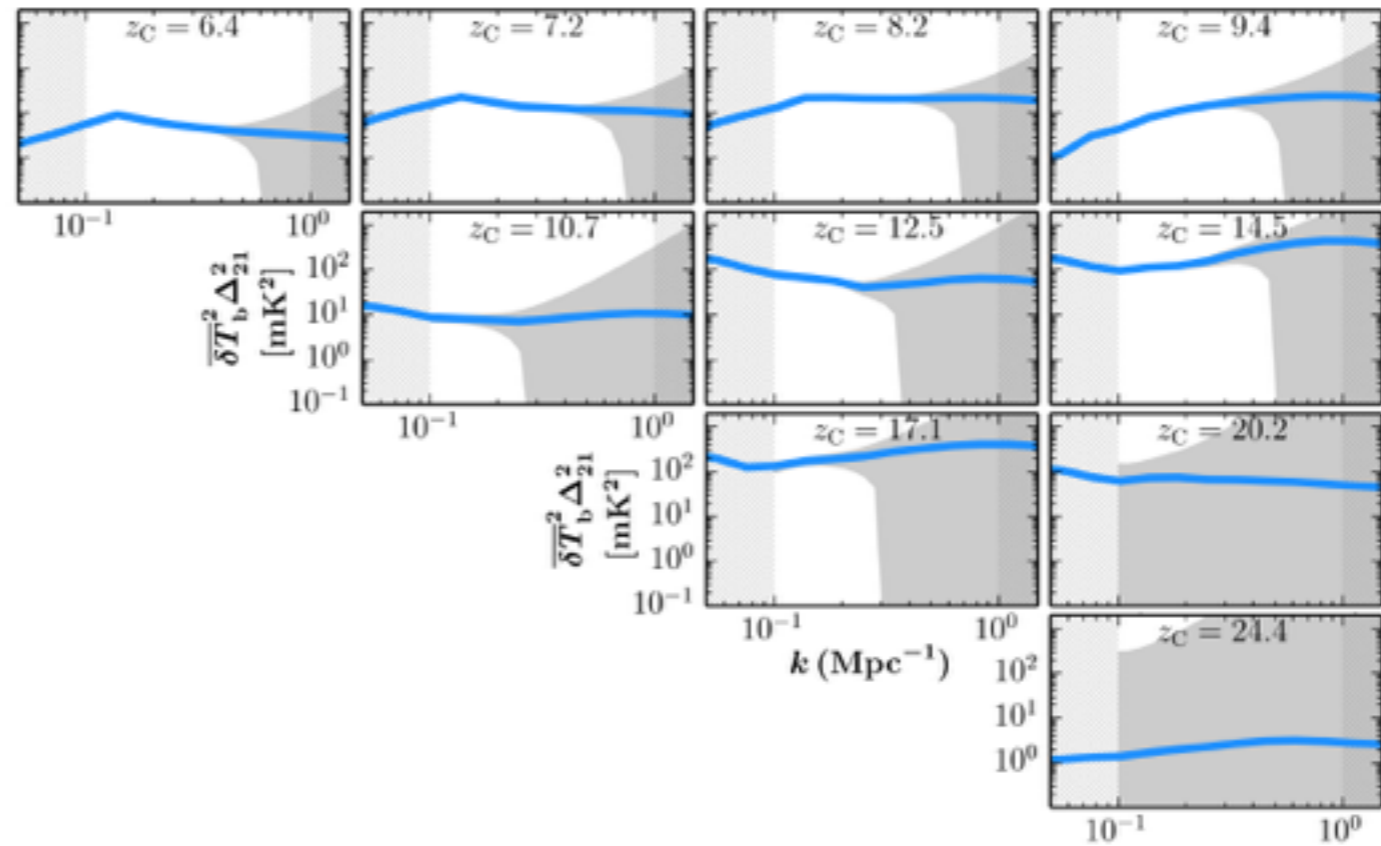
What does 21CMMC do?

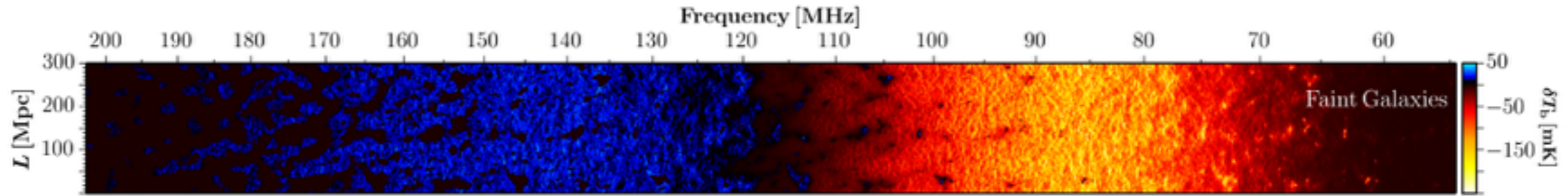




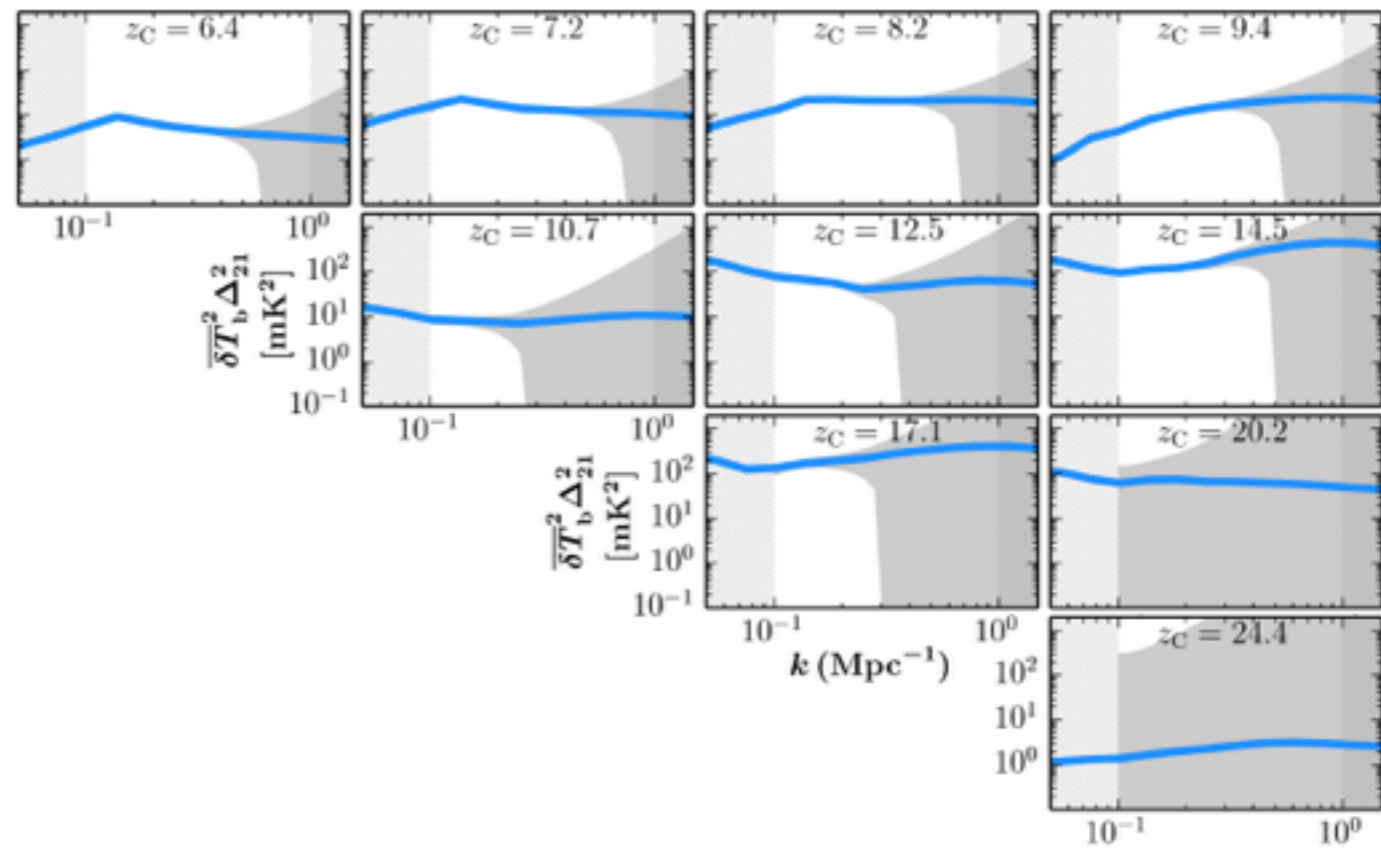


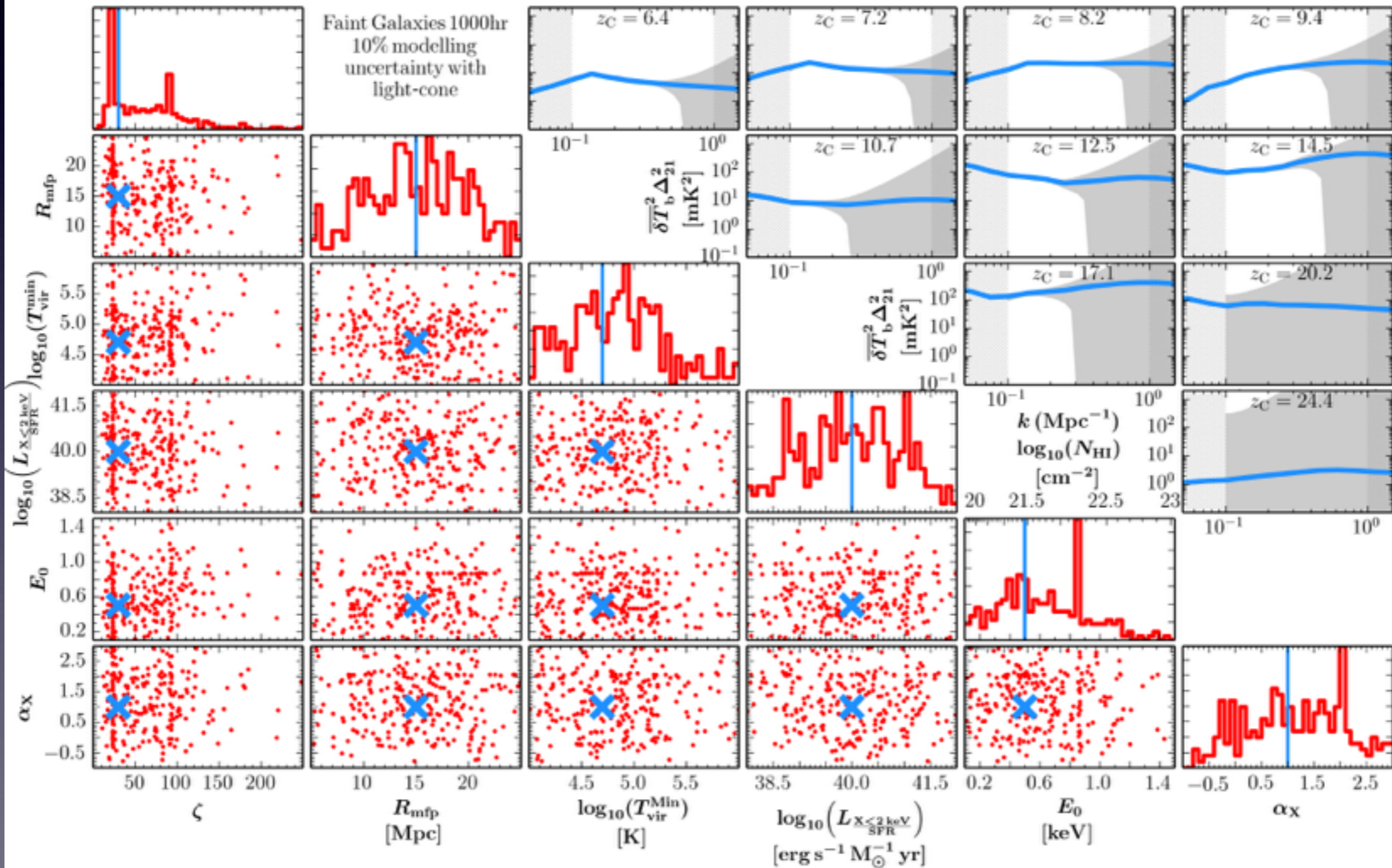
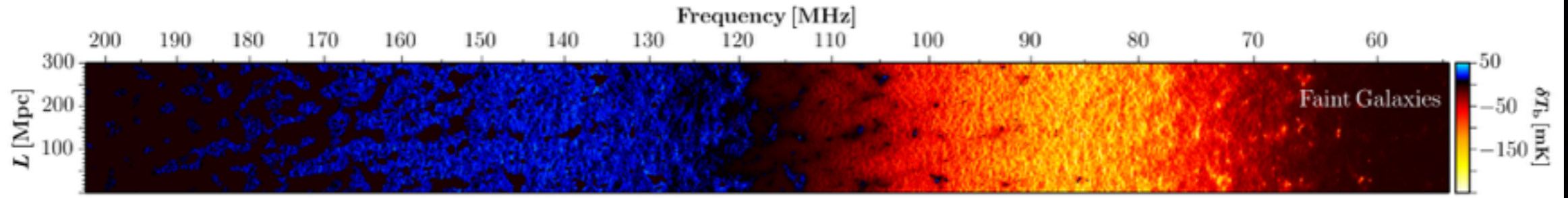
Faint Galaxies 1000hr
10% modelling
uncertainty with
light-cone

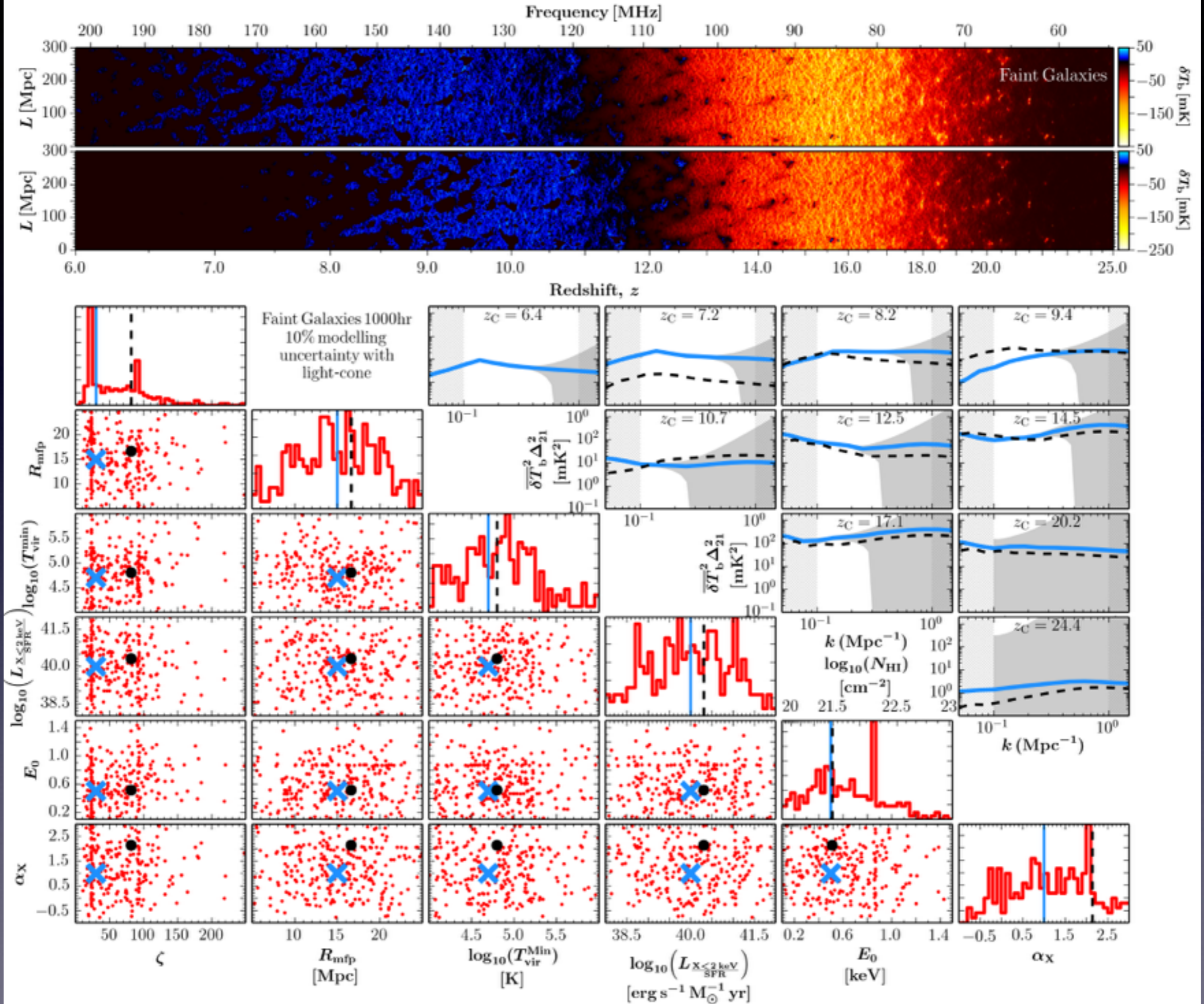


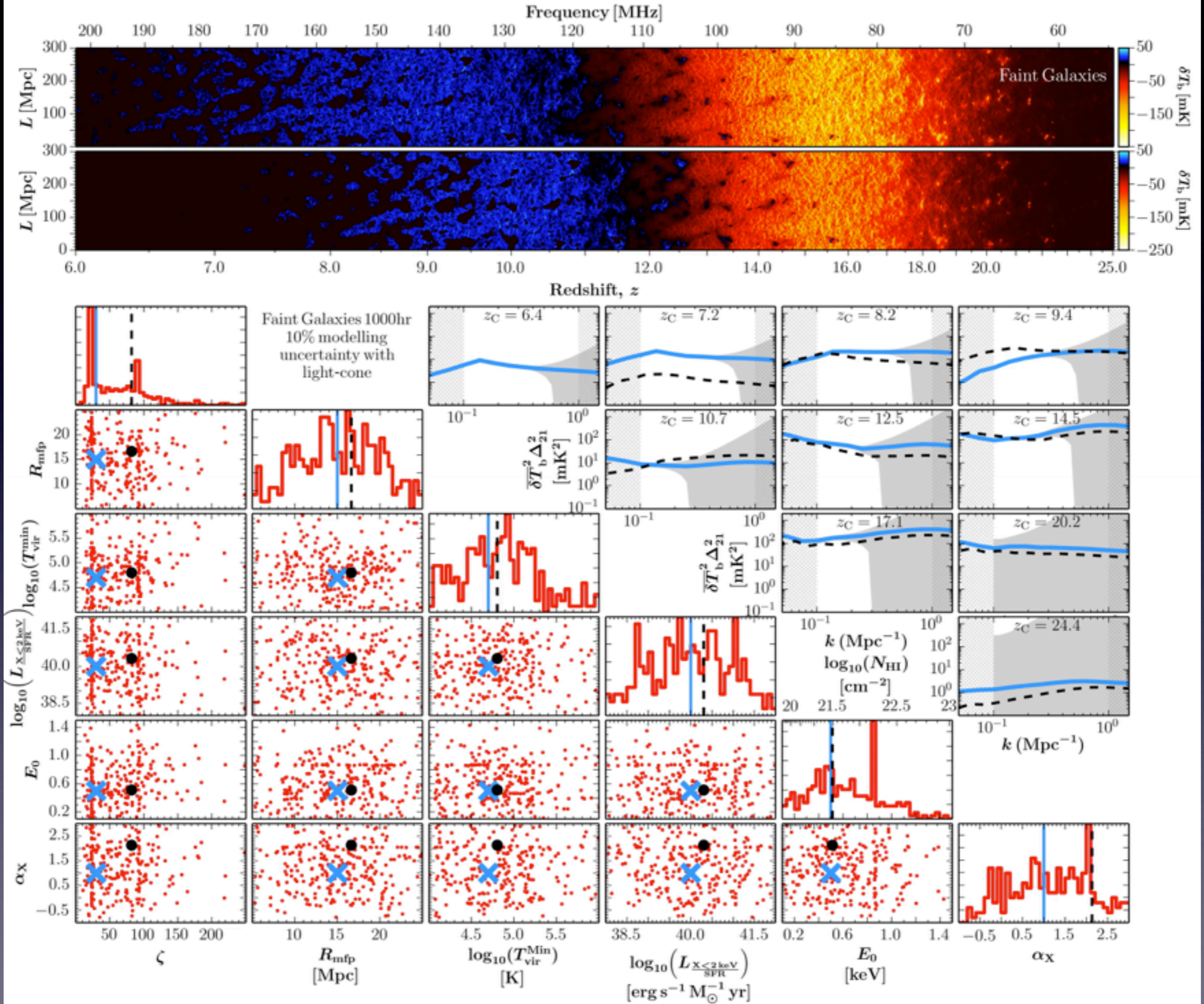


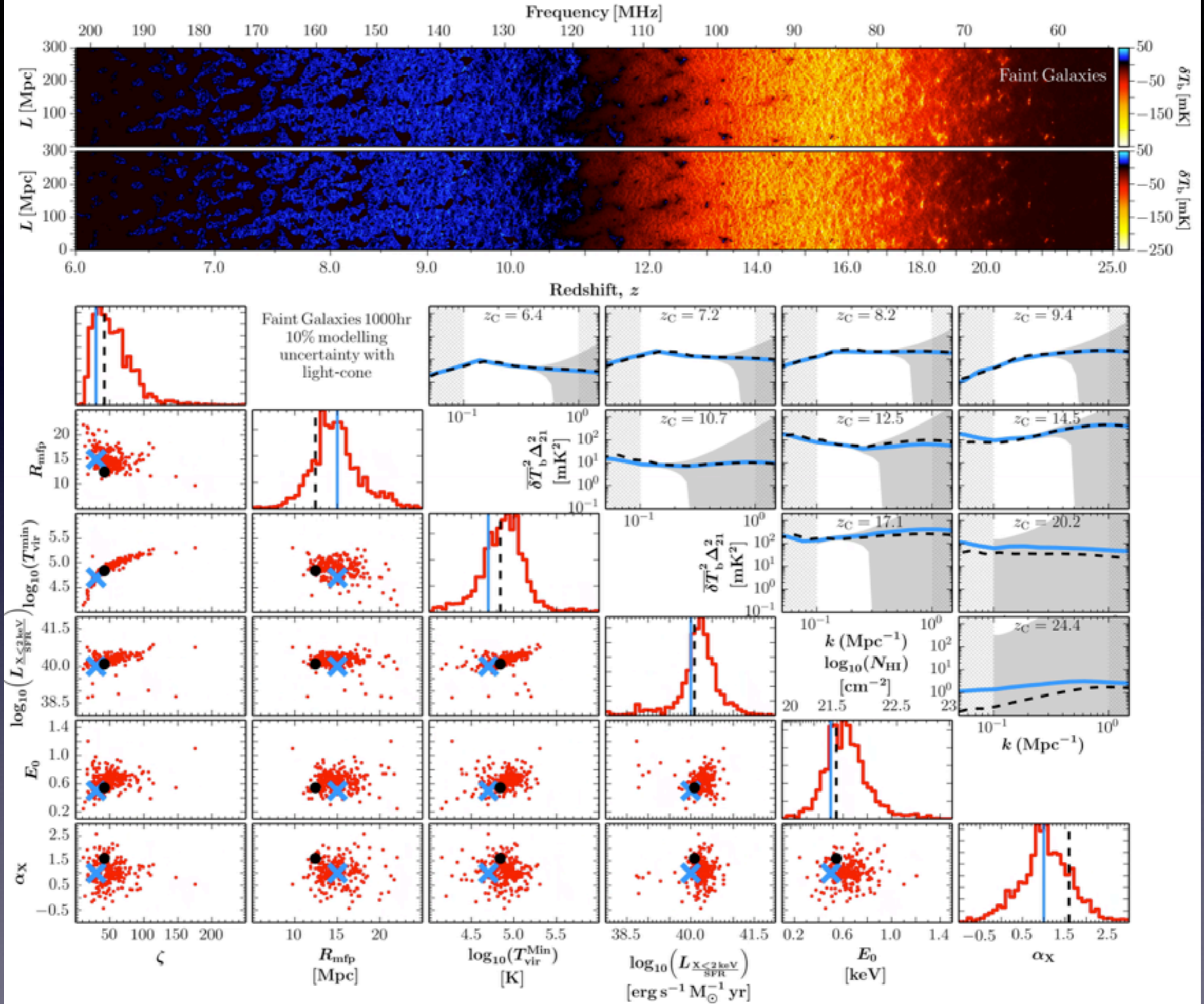
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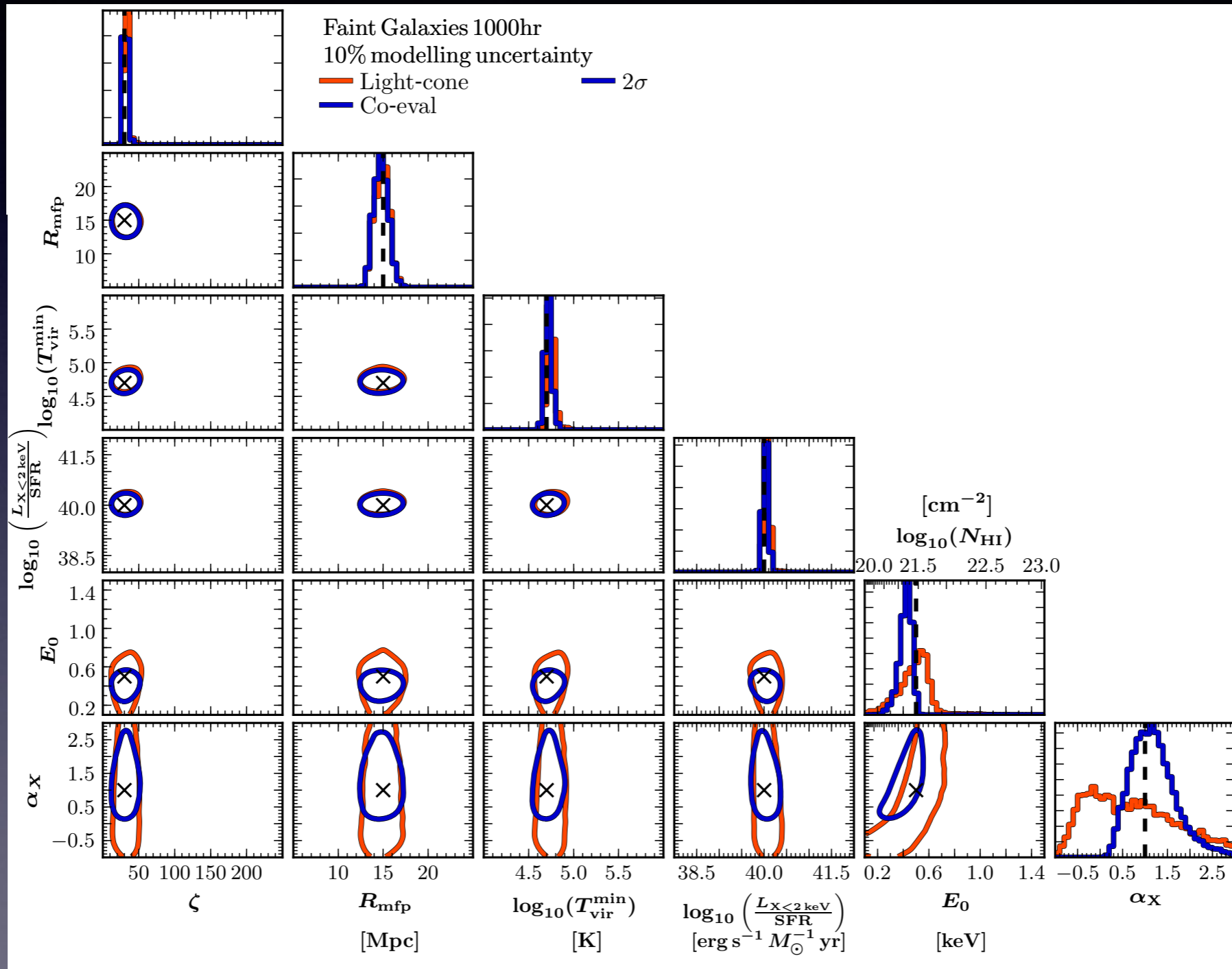




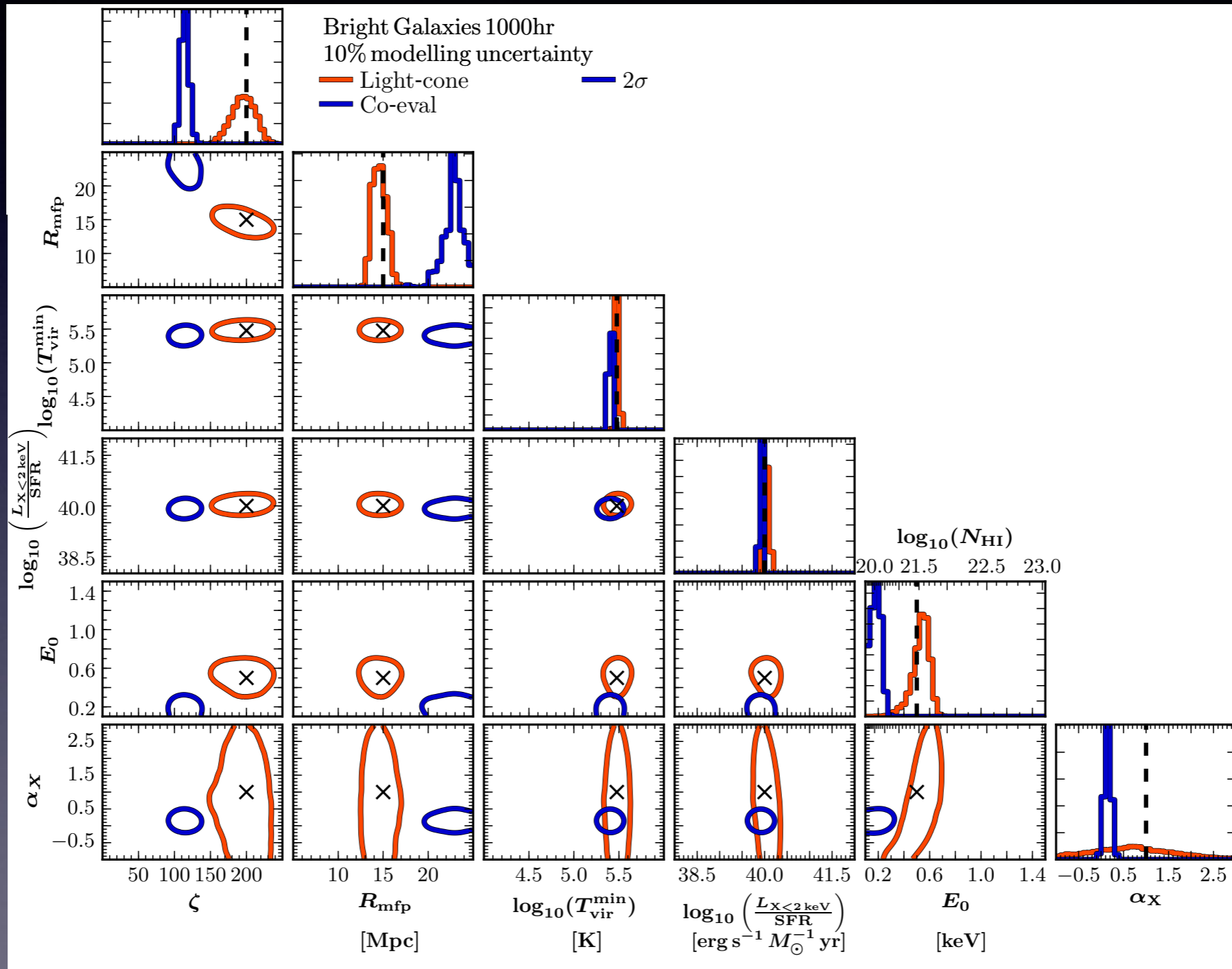
Flexibility of 21CMMC

- Produces a full, 3D 21cm light-cone at every step in the MCMC.
- Enables exploring any metric describing/characterising the 21cm signal (i.e. statistical/tomographical).
- Can simultaneously constrain cosmology and astrophysical parameters.

Investigating light-cone effects



Investigating light-cone effects



Conclusion

- First MCMC code to sample full 3D simulations of the EoR
- Can provide astrophysical parameter constraints on **any EoR model**, recovered from **any statistical measure** of the 21 cm signal
- New version to appear on github very shortly (<https://github.com/BradGreig/21CMMC>)
- Under going continual development, adding in more features and generalising the astrophysical parametrisation (source models etc.)
- Animations can be found on Andrei's homepage, under 21CMMC (<http://homepage.sns.it/mesinger/21CMMC>)