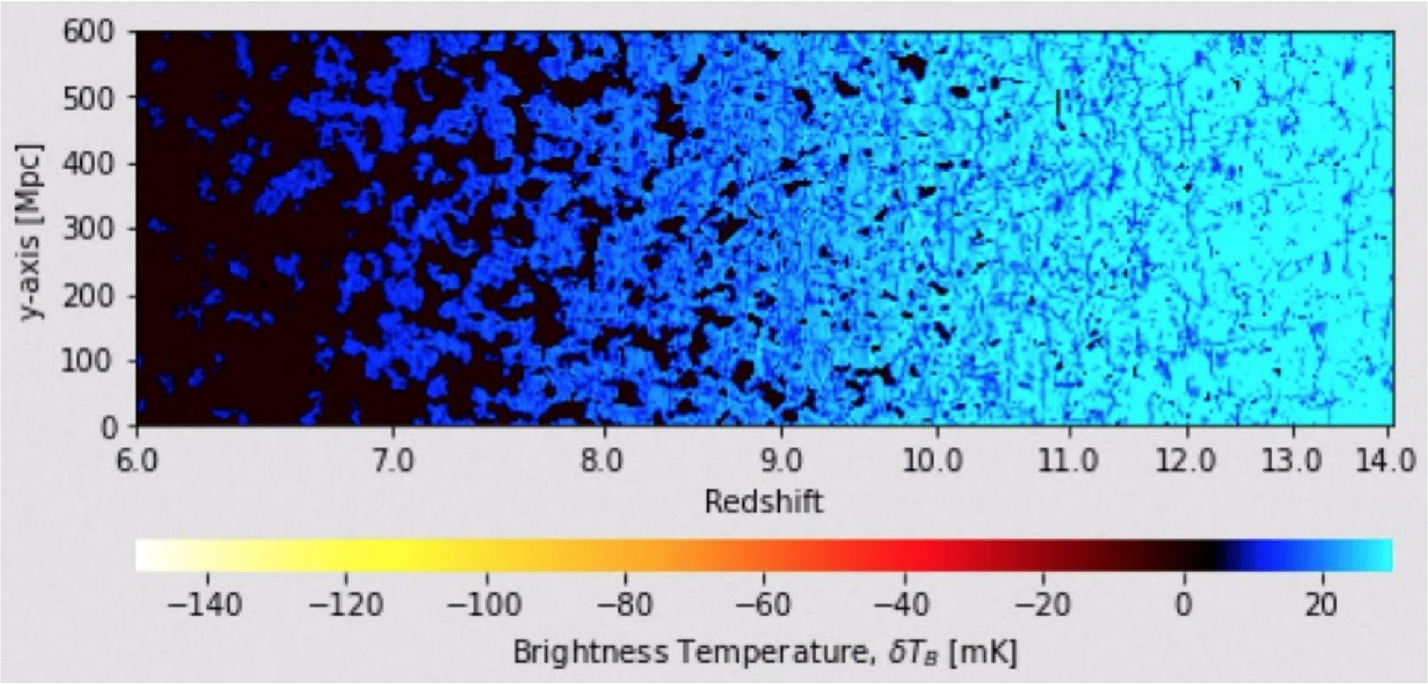
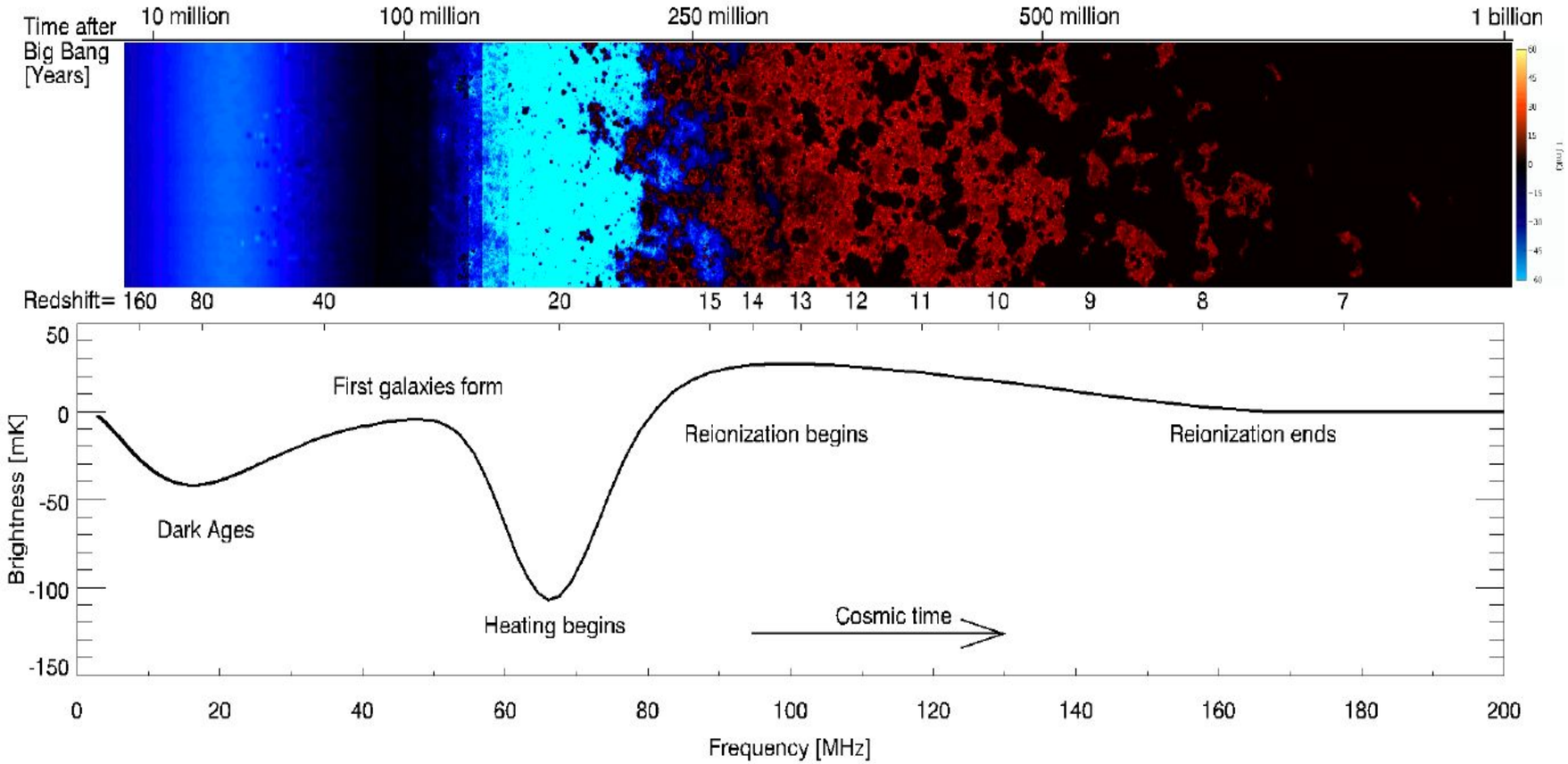
Experimenting with 21cmFAST for future radio observations

Cristiano Sabiu



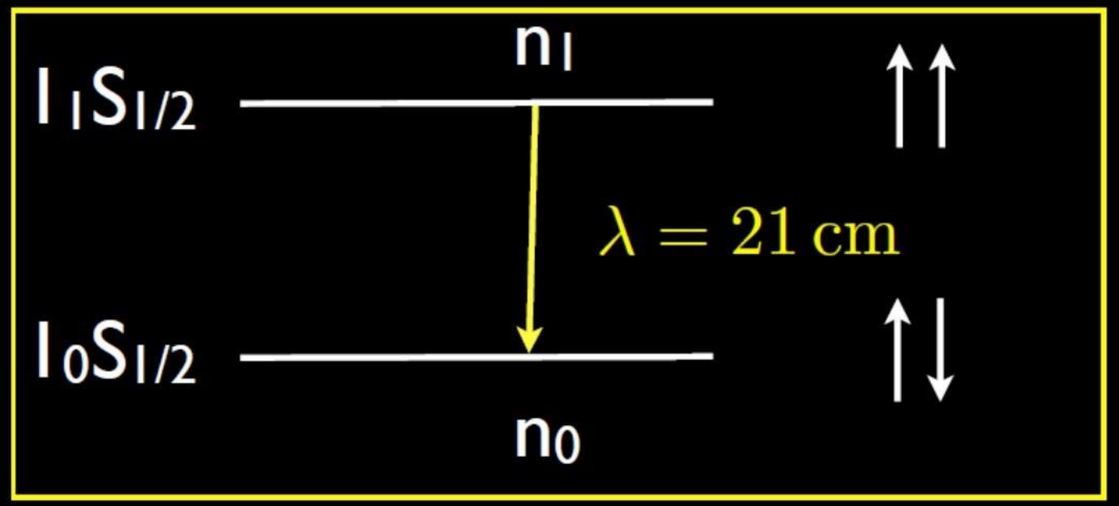
CPLUOS Group Meeting
19/2/2021

Cosmic Reionization History



$$\nu_{21cm} = 1,420,405,751.768 \pm 0.001\,\mathrm{Hz}$$

Hyperfine transition of neutral hydrogen



Spin temperature describes relative occupation of levels

$$n_1/n_0 = 3\exp(-h\nu_{21\mathrm{cm}}/kT_s)$$

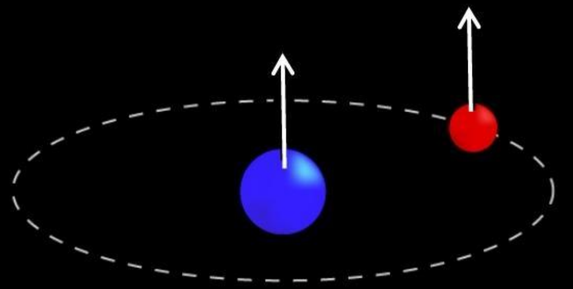
Useful numbers:

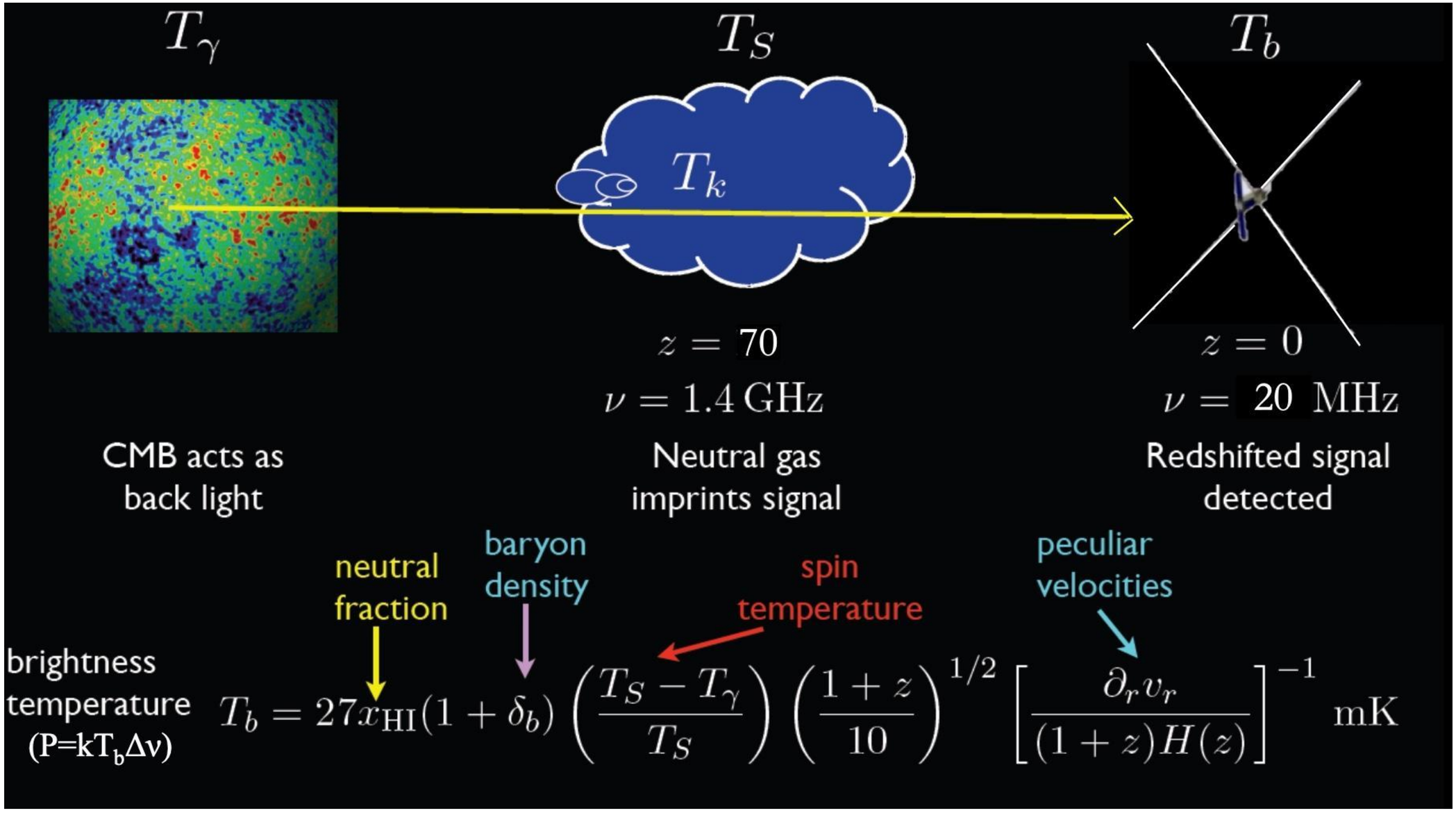
$200\,\mathrm{MHz} \rightarrow z = 6$
$100\,\mathrm{MHz} \rightarrow z = 13$
$70\,\mathrm{MHz} \rightarrow z \approx 20$
$40\,\mathrm{MHz} \rightarrow z \approx 35$

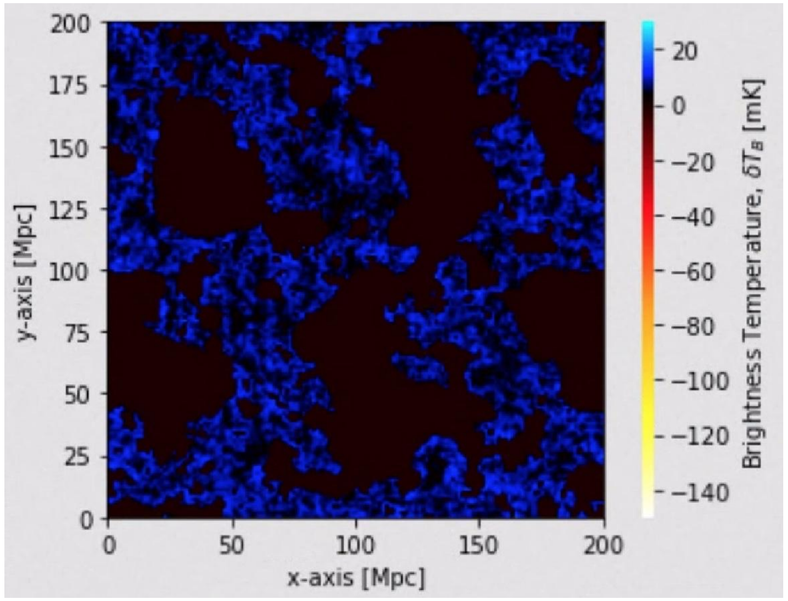
$t_{\mathrm{Age}}(z = 6) \approx 1\,\mathrm{Gyr}$

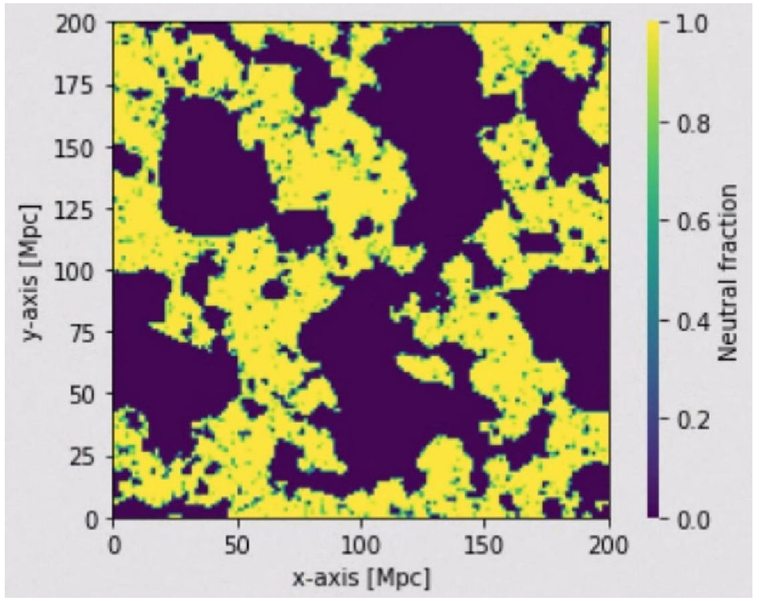
$t_{\mathrm{Age}}(z = 10) \approx 500\,\mathrm{Myr}$

$t_{\mathrm{Age}}(z = 20) \approx 150\,\mathrm{Myr}$

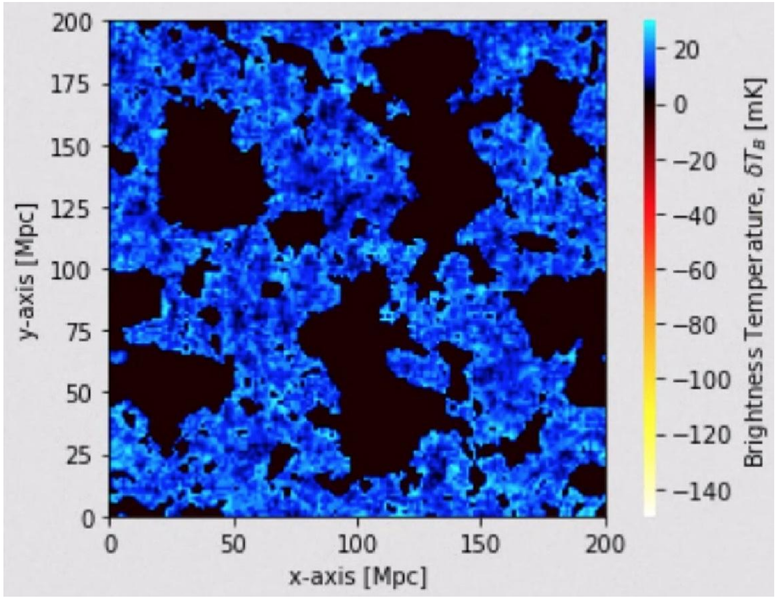


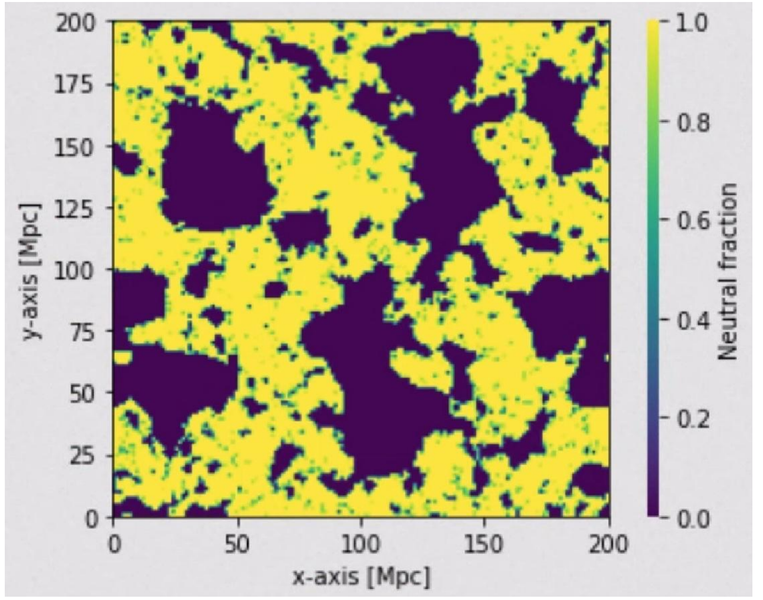

T_γ
T_S
T_b
T_k
$z = 70$
$\nu = 1.4\,\mathrm{GHz}$
$z = 0$
$\nu = 20\ \mathrm{MHz}$
CMB acts as back light
Neutral gas imprints signal
Redshifted signal detected
neutral fraction
baryon density
spin temperature
peculiar velocities
brightness temperature
(P=kT$_b$Δν)
$T_b = 27 x_{\mathrm{HI}}(1+\delta_b)\left(\frac{T_S - T_\gamma}{T_S}\right)\left(\frac{1+z}{10}\right)^{1/2}\left[\frac{\partial_r v_r}{(1+z)H(z)}\right]^{-1}\ \mathrm{mK}$





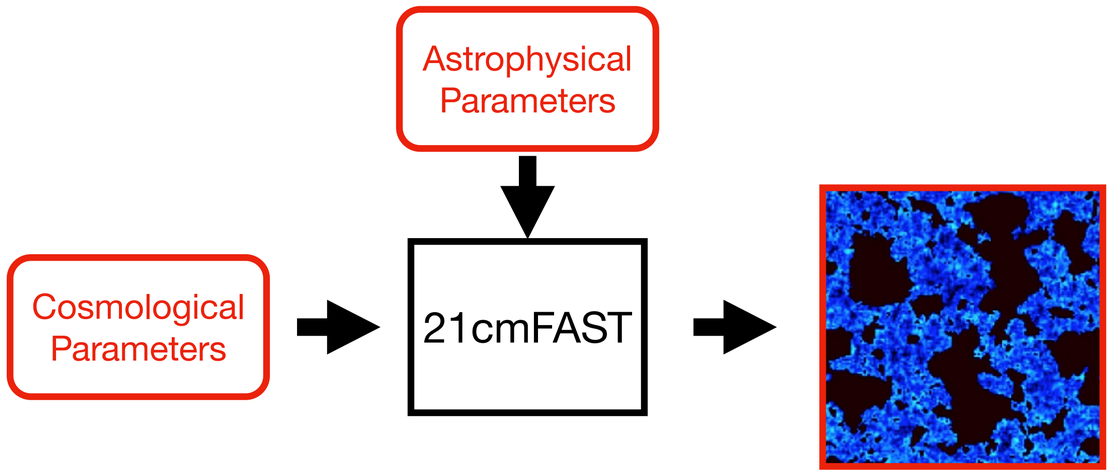
Low baryon fraction



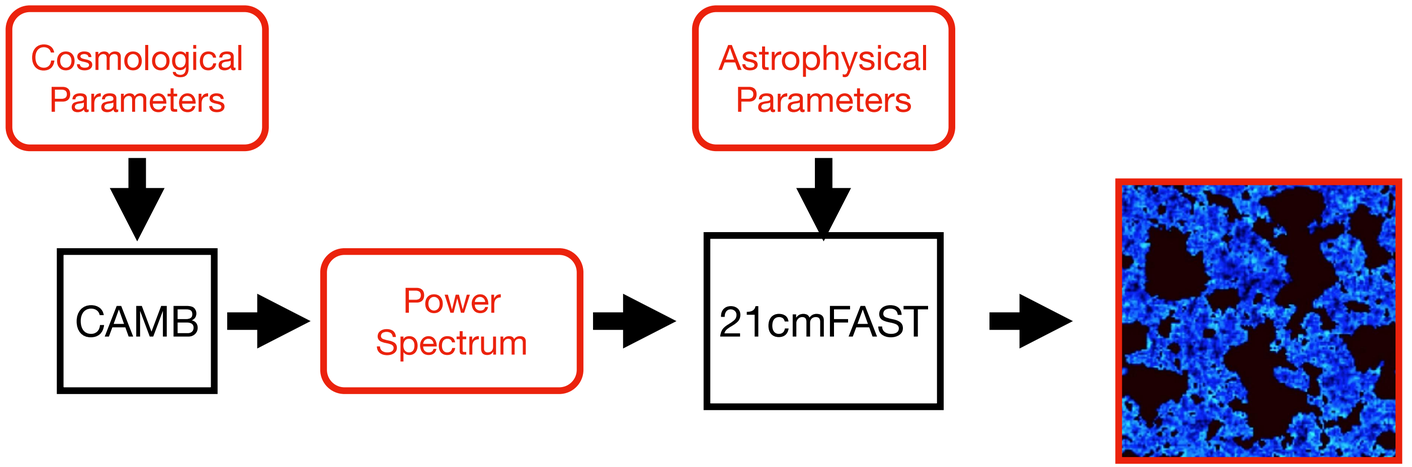


High baryon fraction

Pipeline

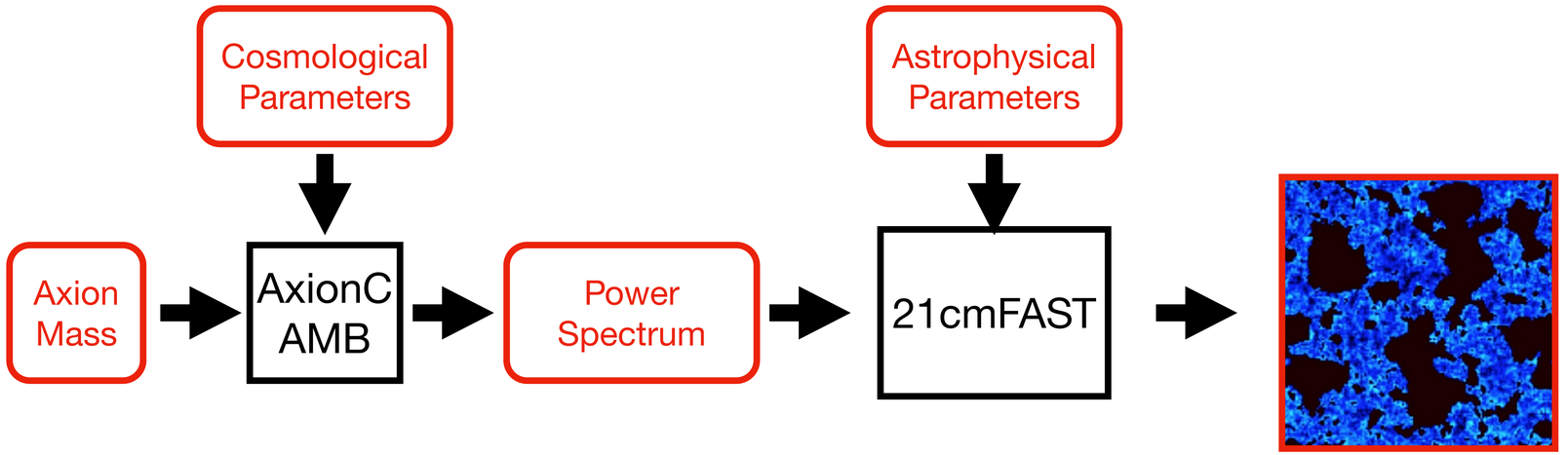

Astrophysical Parameters
Cosmological Parameters
21cmFAST

Pipeline



Thanks to Jaehong Park (KIAS), I can now run 21cmFAST with a custom Power Spectrum

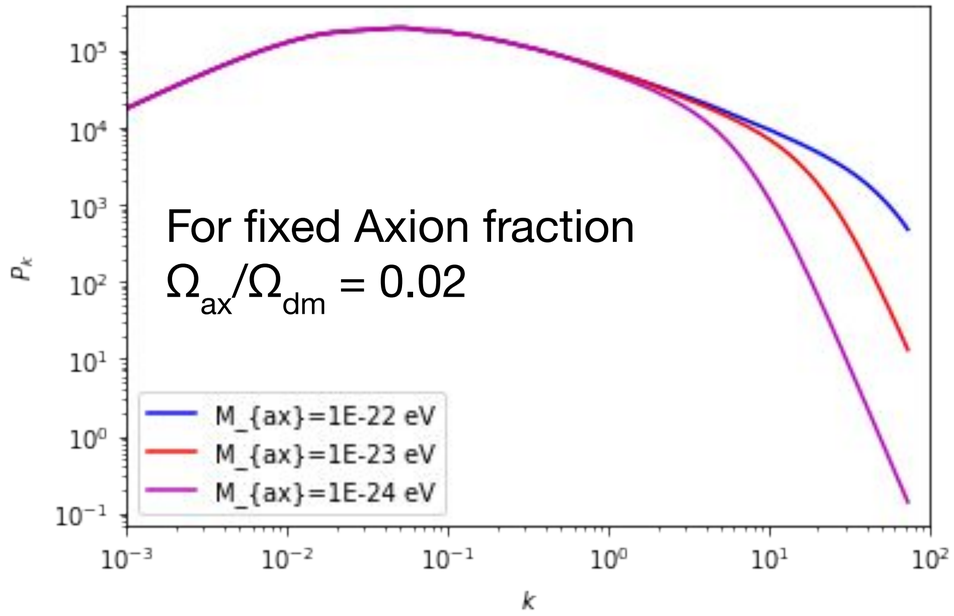
Pipeline



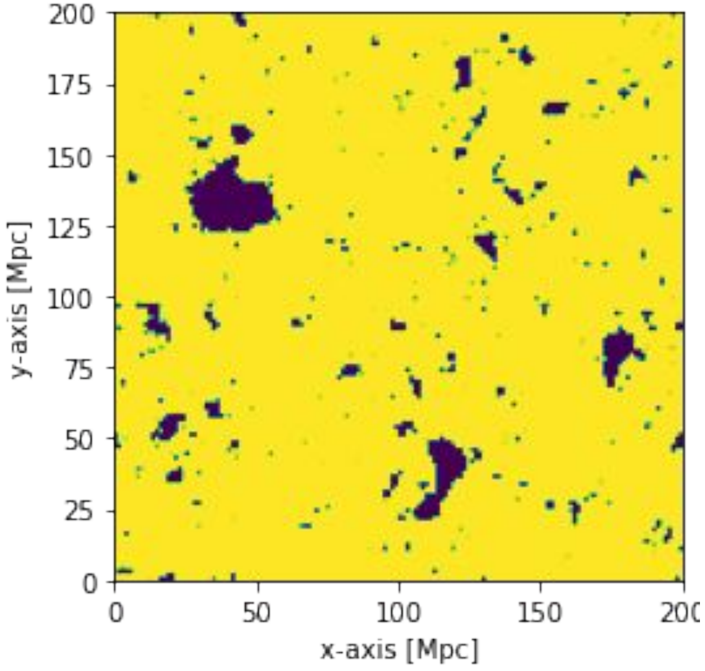
With Kenji Kadota (IBS, Daejeon) we want to see the effect of Axion particles on early structure formation

Varying Axion Mass

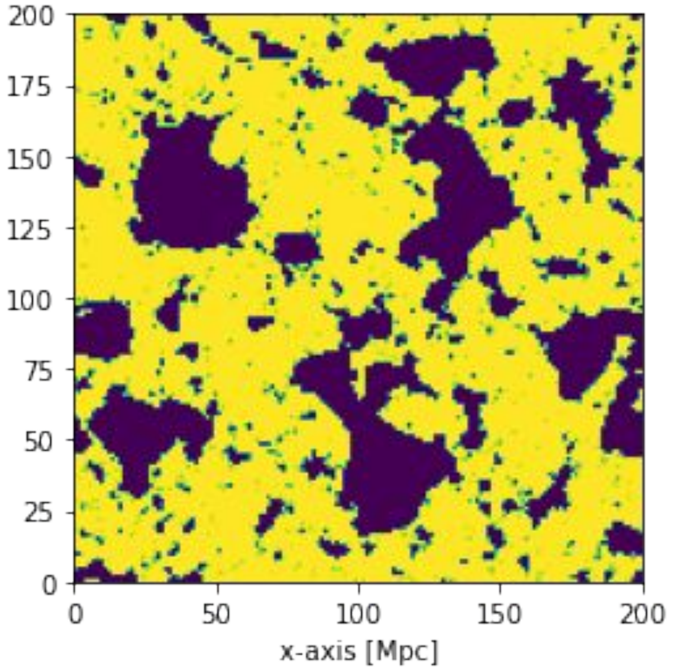
for $m_x<10^{-24}$ eV neutral hydrgen intact at z=8.0



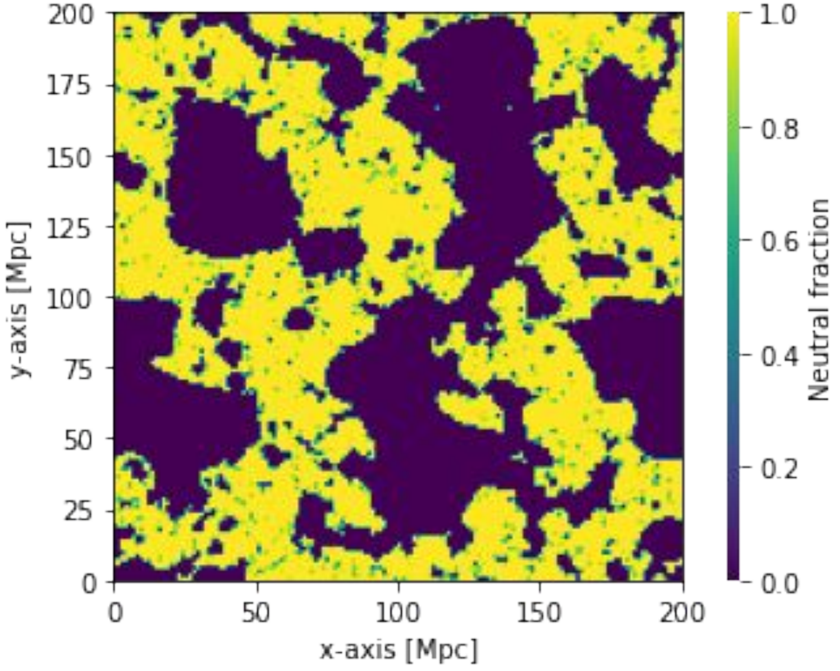
$m_x=10^{-24}$ eV



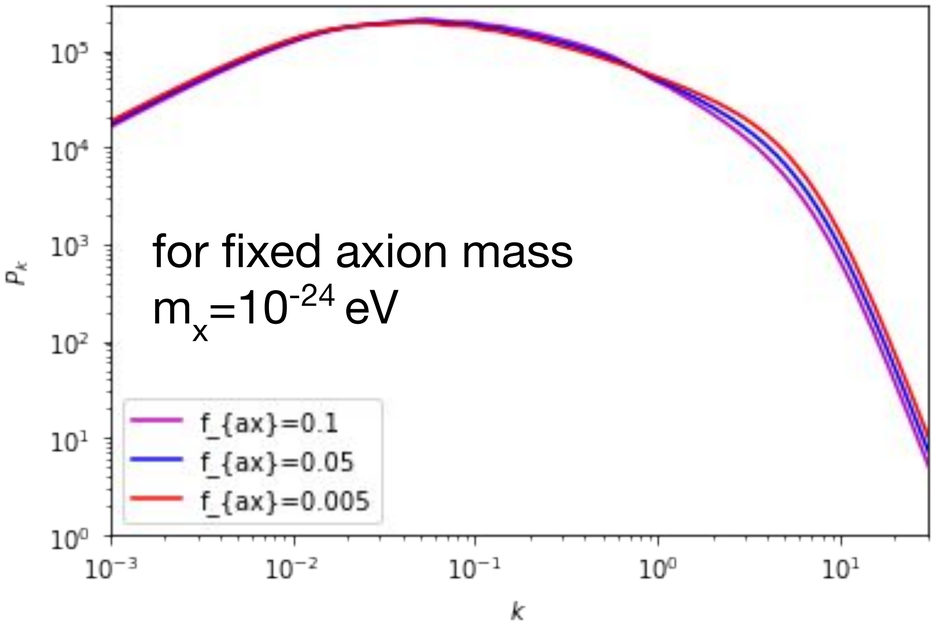
$m_x=10^{-23}$ eV



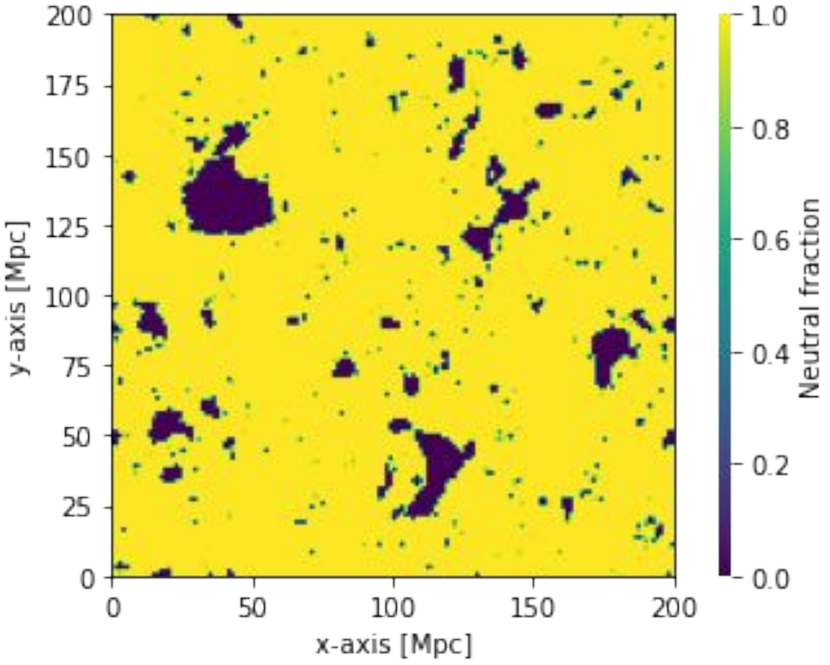
$m_x=10^{-22}$ eV



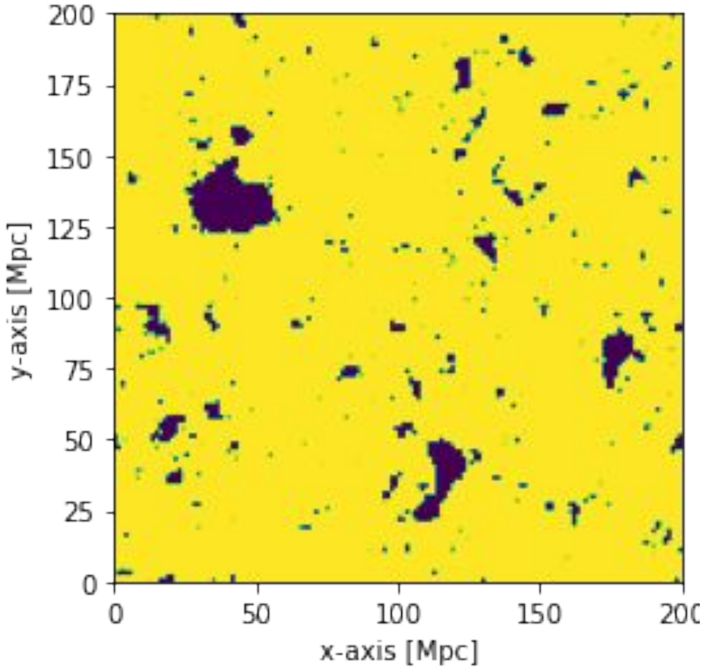
Varying Axion Fraction



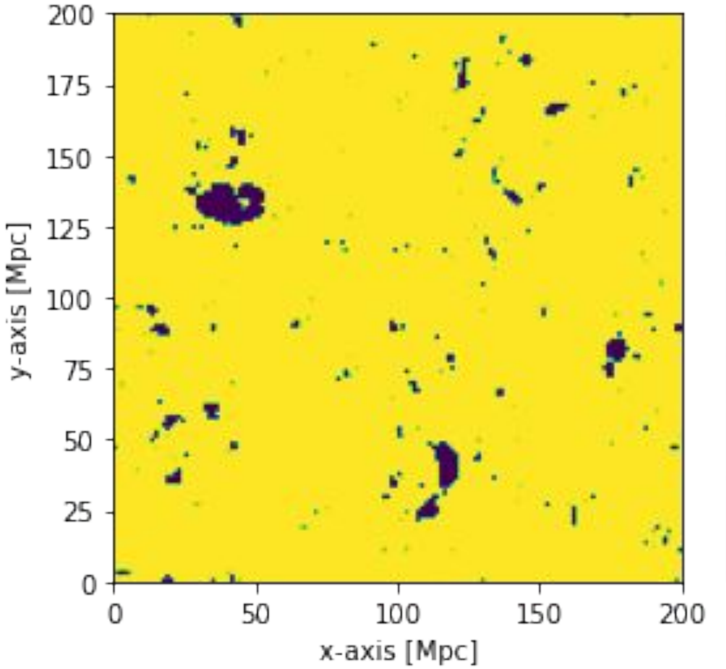
Ω_{ax}/Ω_{dm} = 0.005



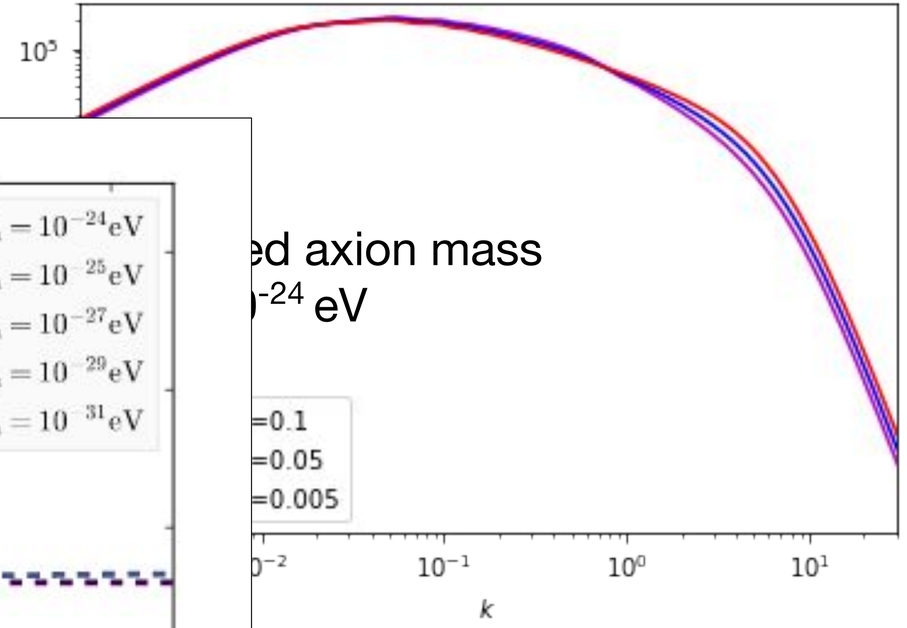
Ω_{ax}/Ω_{dm} = 0.02



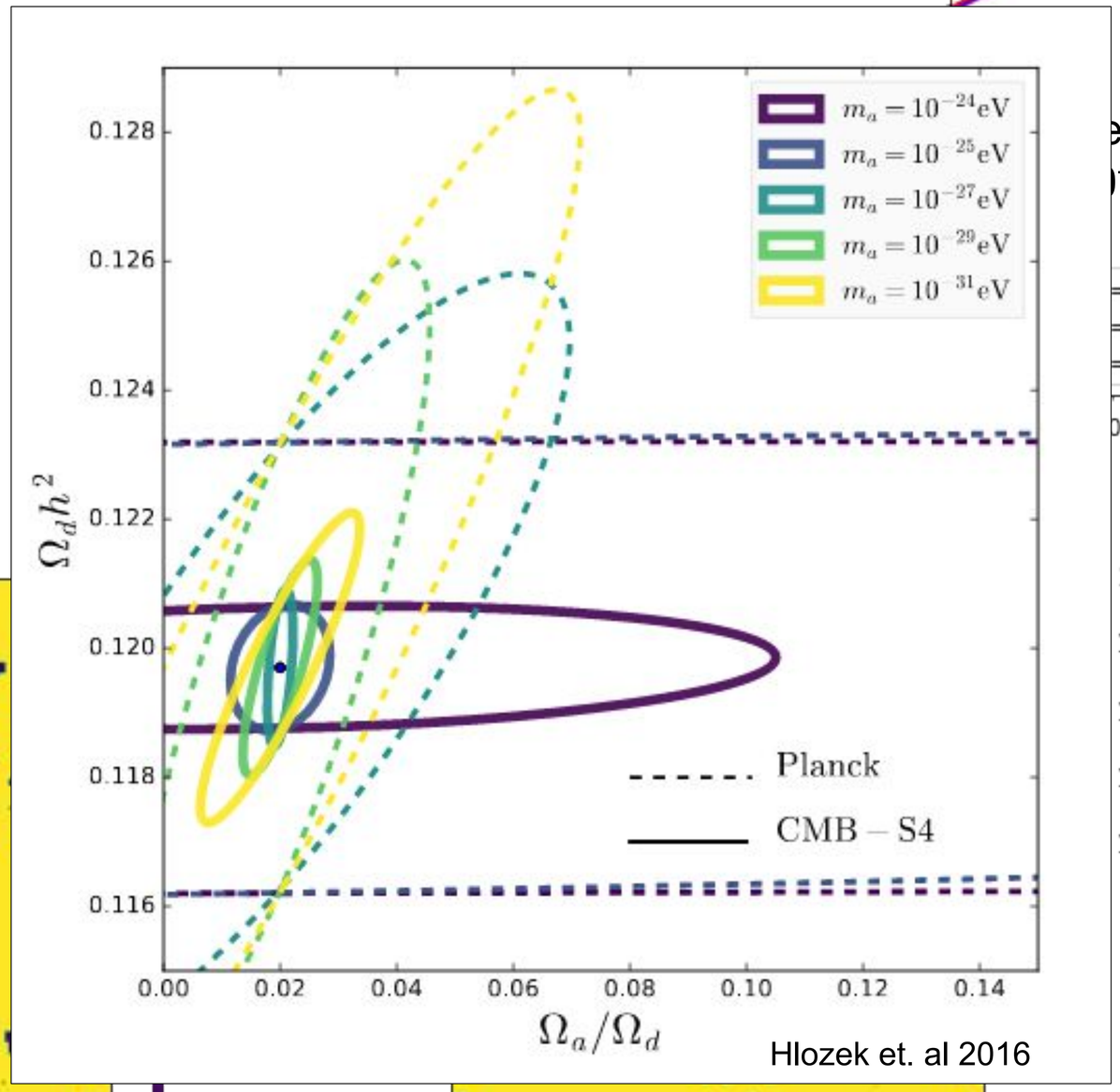
Ω_{ax}/Ω_{dm} = 0.05



Varying Axion Fraction

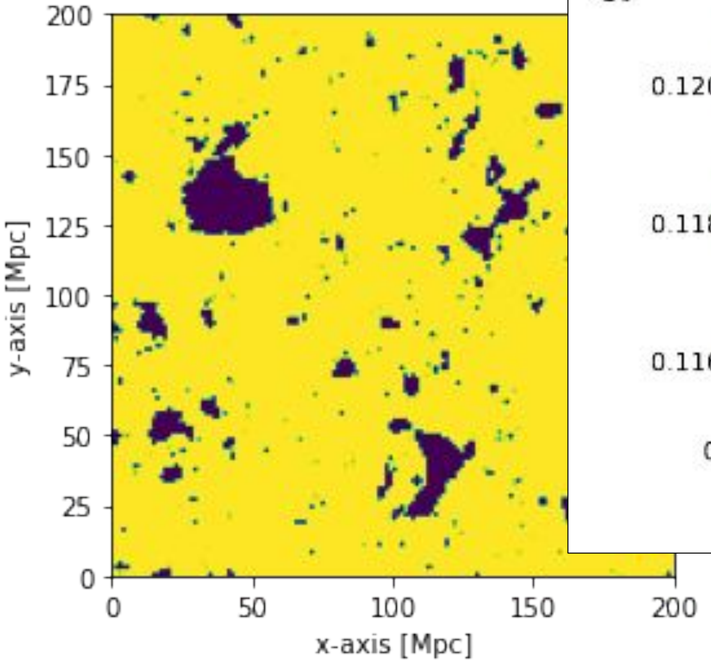


ed axion mass
$^{-24}$ eV



Hlozek et. al 2016

Ω_{ax}/Ω_{dm} = 0.005



Ω_{ax}/Ω_{dm} = 0.05