arxiv 2206.07713

$$T(\nu) = T_0 + T_R \left(\frac{\nu}{310\,\mathrm{MHz}}\right)^{\beta} \qquad \beta \sim \underbrace{-2.6}$$

$T_R \rightarrow 24.1\,\mathrm{K}$

$$C_\ell = \int \frac{dx}{x^2} \left(\frac{df}{dx}\right)^2 P_\ell \Bigg\} \; z \sim 5$$

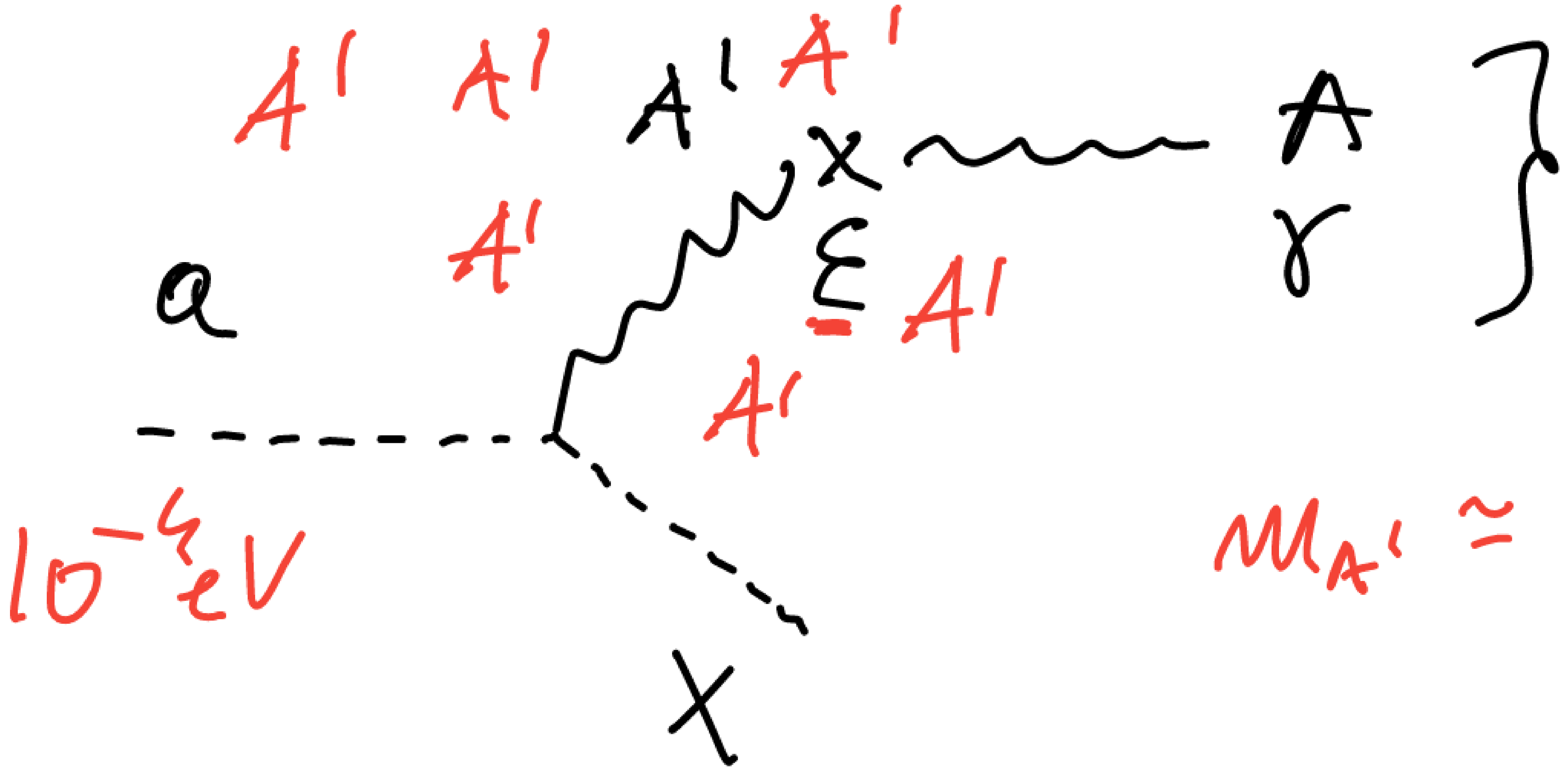
$$T(\omega) = \frac{\pi^2}{\omega} \underbrace{\frac{d\mu_r}{d\omega}}$$

$\propto \nu^{-1.6}$

$\sim \underline{\nu^{-3/2}}$

$z \gtrsim 9 \Rightarrow$ 21 cm

DM candidate ALP



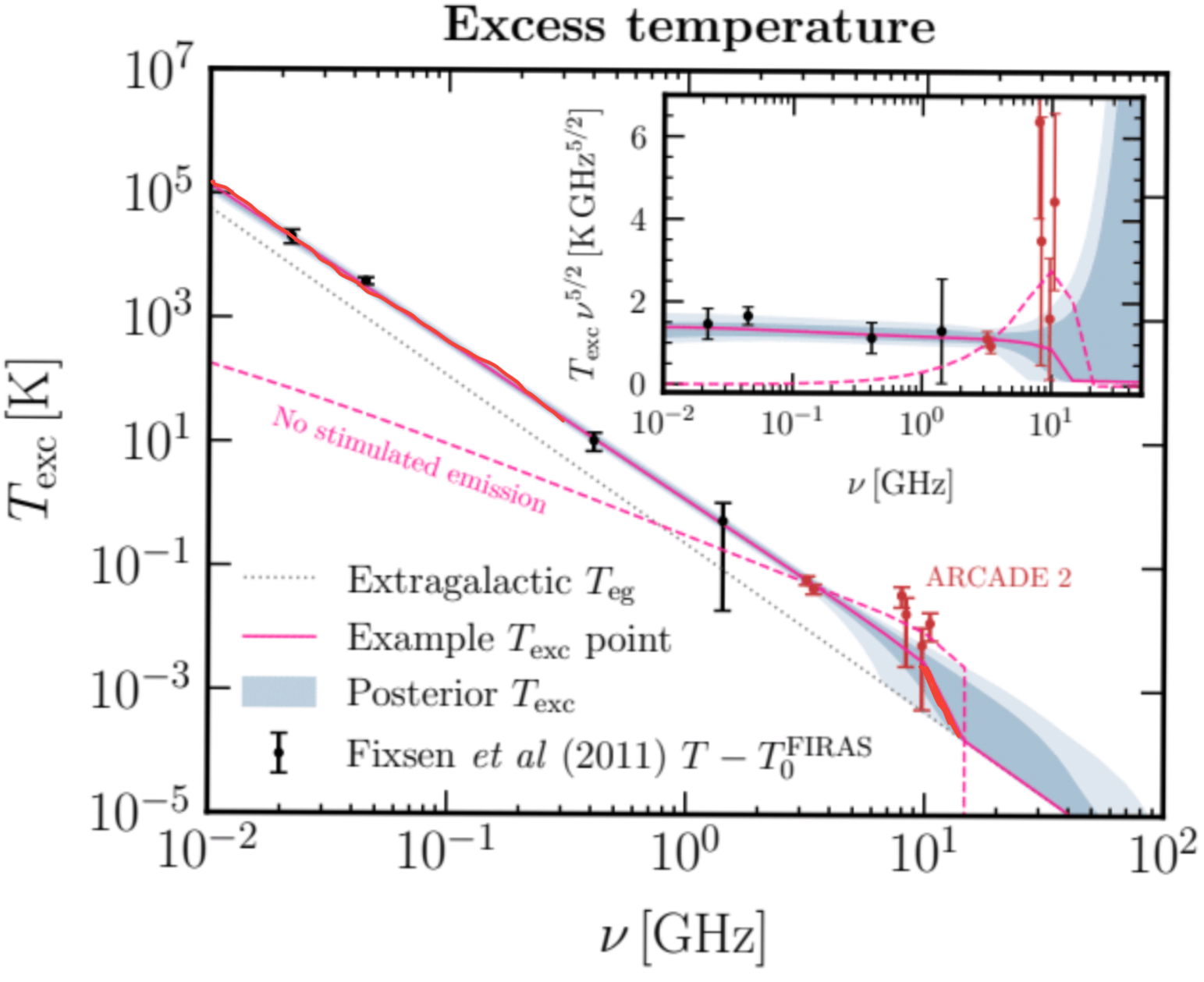
$m_{A'} \simeq 10^{-14}$ eV

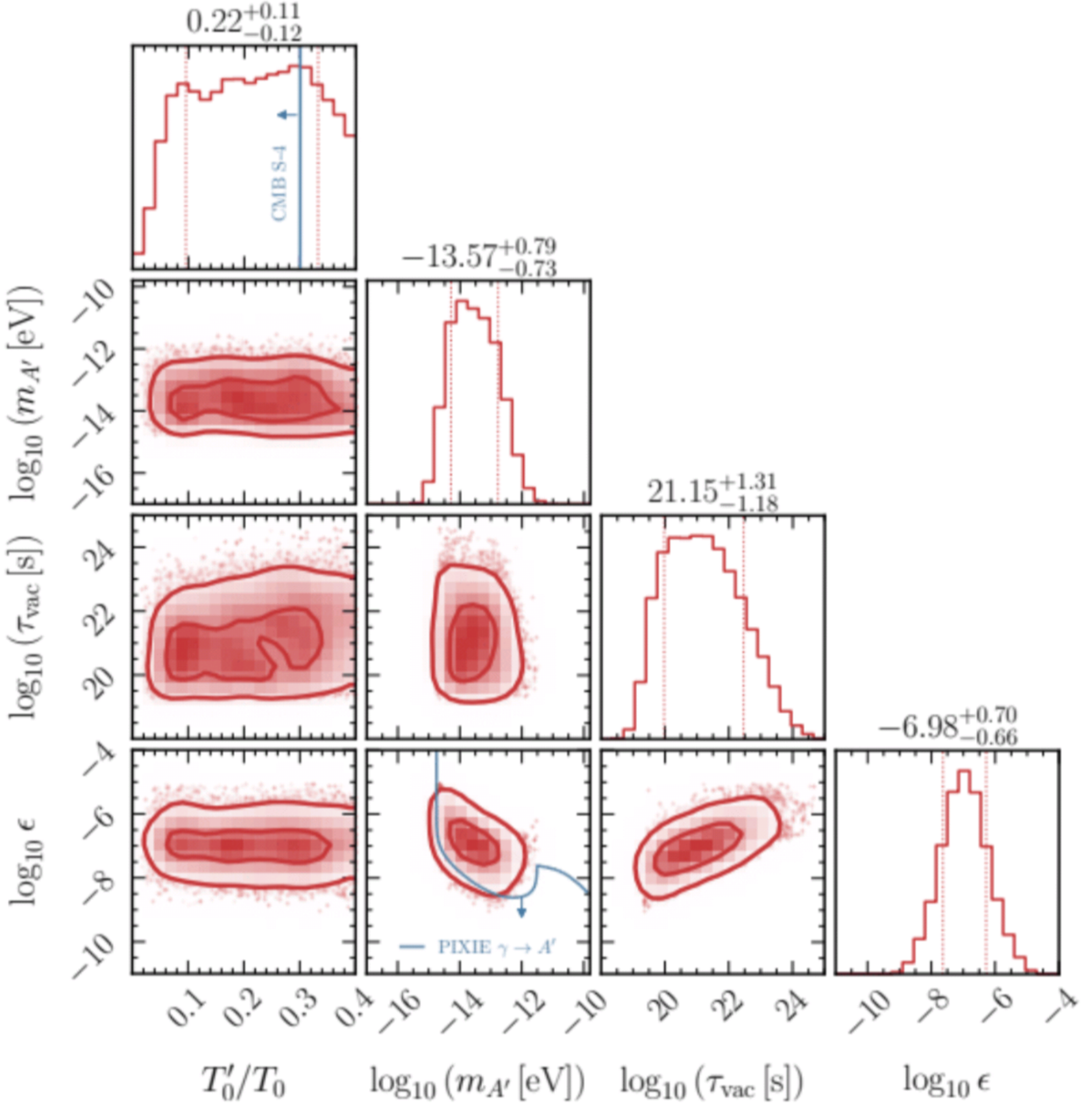
$T_0' = 0.2\, T_0$

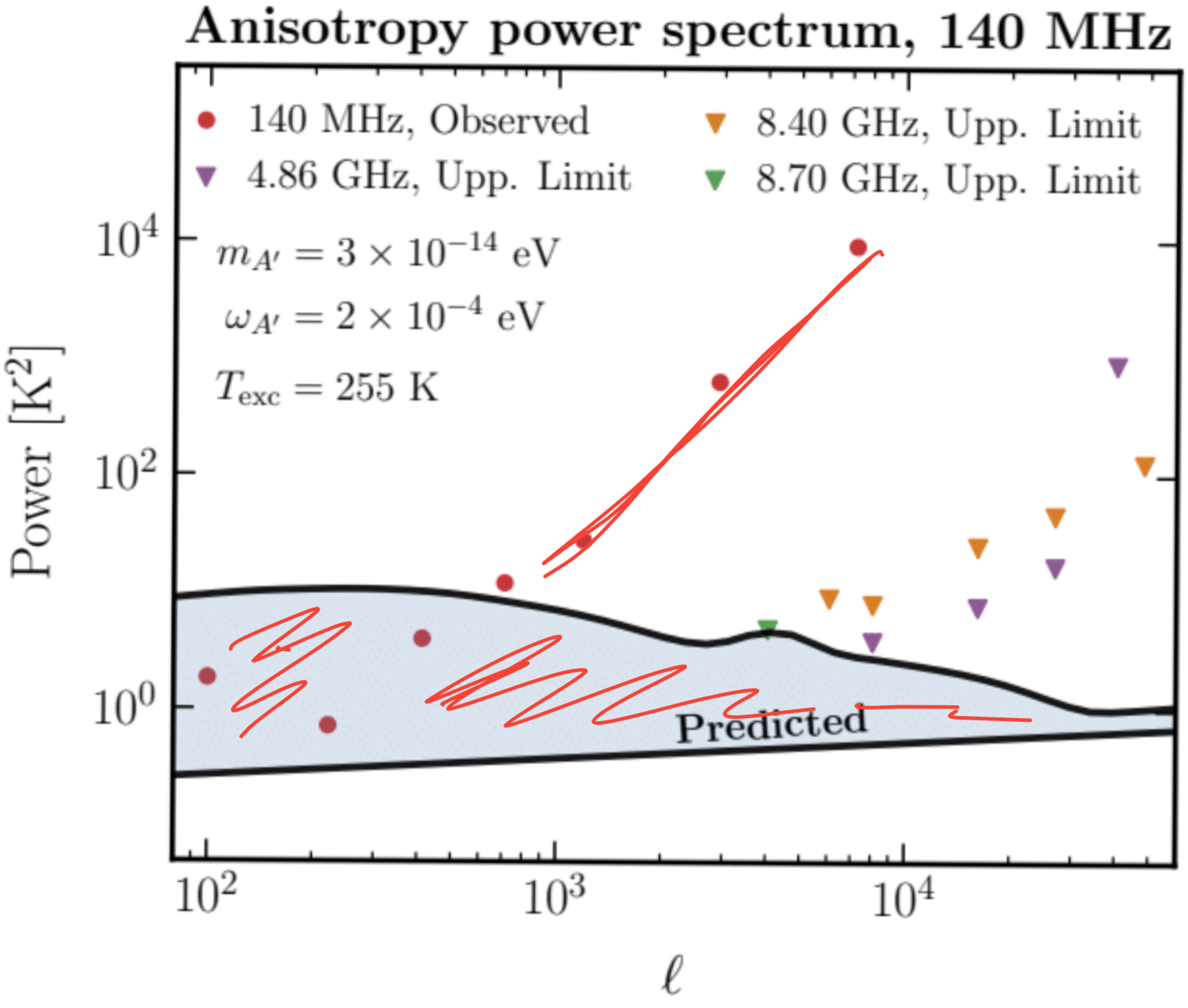
$$\frac{d n_\gamma(\omega, z)}{d\omega} = \frac{\rho_a(z)}{\omega\, \tau\, H(z_*)} \int_{z_*}^{z} dz \frac{\langle dP \rangle_{A' \to \gamma}}{dz} \propto \omega^{-3/2}$$

$\underbrace{\int dz \frac{\langle dP\rangle}{dz}}_{\propto 1/\omega}$, $\quad \tau \to \frac{1}{\omega}$, $\quad H(z_*) \to \omega^{3/2}$

$$\omega = \frac{m_e}{2} \frac{(1+z)}{(1+z_*)}$$


Excess temperature
$T_{\rm exc}$ [K]
ν [GHz]
$T_{\rm exc}\,\nu^{5/2}$ [K GHz$^{5/2}$]
No stimulated emission
Extragalactic $T_{\rm eg}$
Example $T_{\rm exc}$ point
Posterior $T_{\rm exc}$
Fixsen *et al* (2011) $T - T_0^{\rm FIRAS}$
ARCADE 2


$0.22^{+0.11}_{-0.12}$
CMB S-4
$-13.57^{+0.79}_{-0.73}$
$21.15^{+1.31}_{-1.18}$
$-6.98^{+0.70}_{-0.66}$
PIXIE $\gamma \to A'$
$\log_{10}(m_{A'}\,[\mathrm{eV}])$
$\log_{10}(\tau_{\mathrm{vac}}\,[\mathrm{s}])$
$\log_{10}\epsilon$
T'_0/T_0
$\log_{10}(m_{A'}\,[\mathrm{eV}])$
$\log_{10}(\tau_{\mathrm{vac}}\,[\mathrm{s}])$
$\log_{10}\epsilon$


Anisotropy power spectrum, 140 MHz
140 MHz, Observed
4.86 GHz, Upp. Limit
8.40 GHz, Upp. Limit
8.70 GHz, Upp. Limit
$m_{A'} = 3 \times 10^{-14}$ eV
$\omega_{A'} = 2 \times 10^{-4}$ eV
$T_{\rm exc} = 255$ K
Predicted
Power [K^2]
10^4
10^2
10^0
10^2
10^3
10^4
ℓ