

# Early Dark Energy During Big Bang Nucleosynthesis

**DPF-PHENO 2024**

**Afif Omar (he/him), May 2024**  
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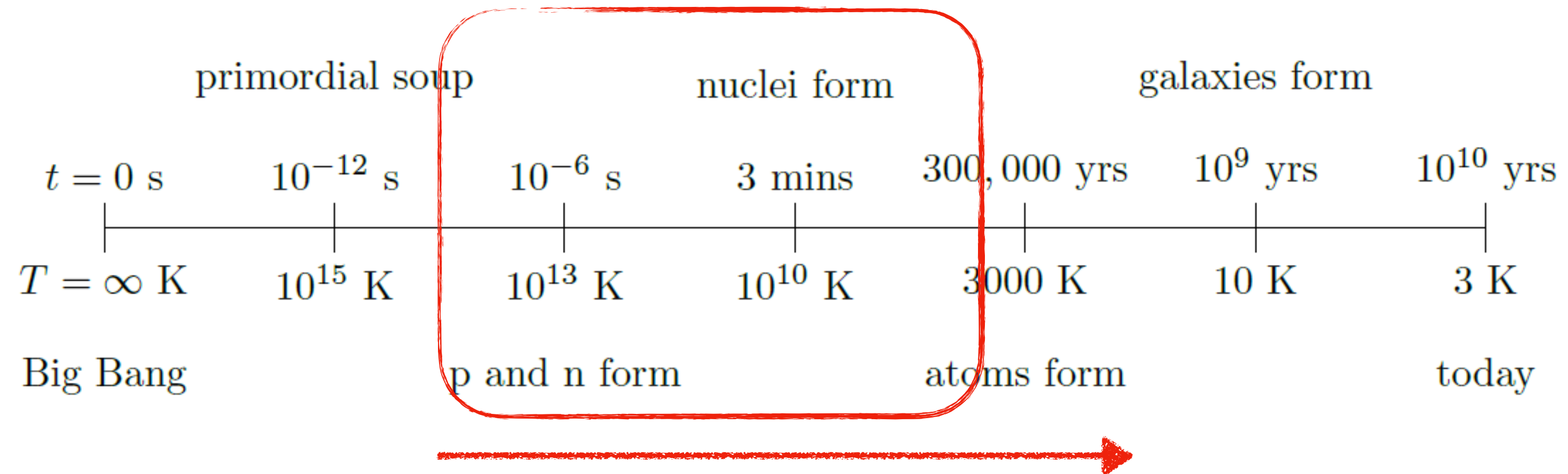
# Early Dark Energy During Big Bang Nucleosynthesis

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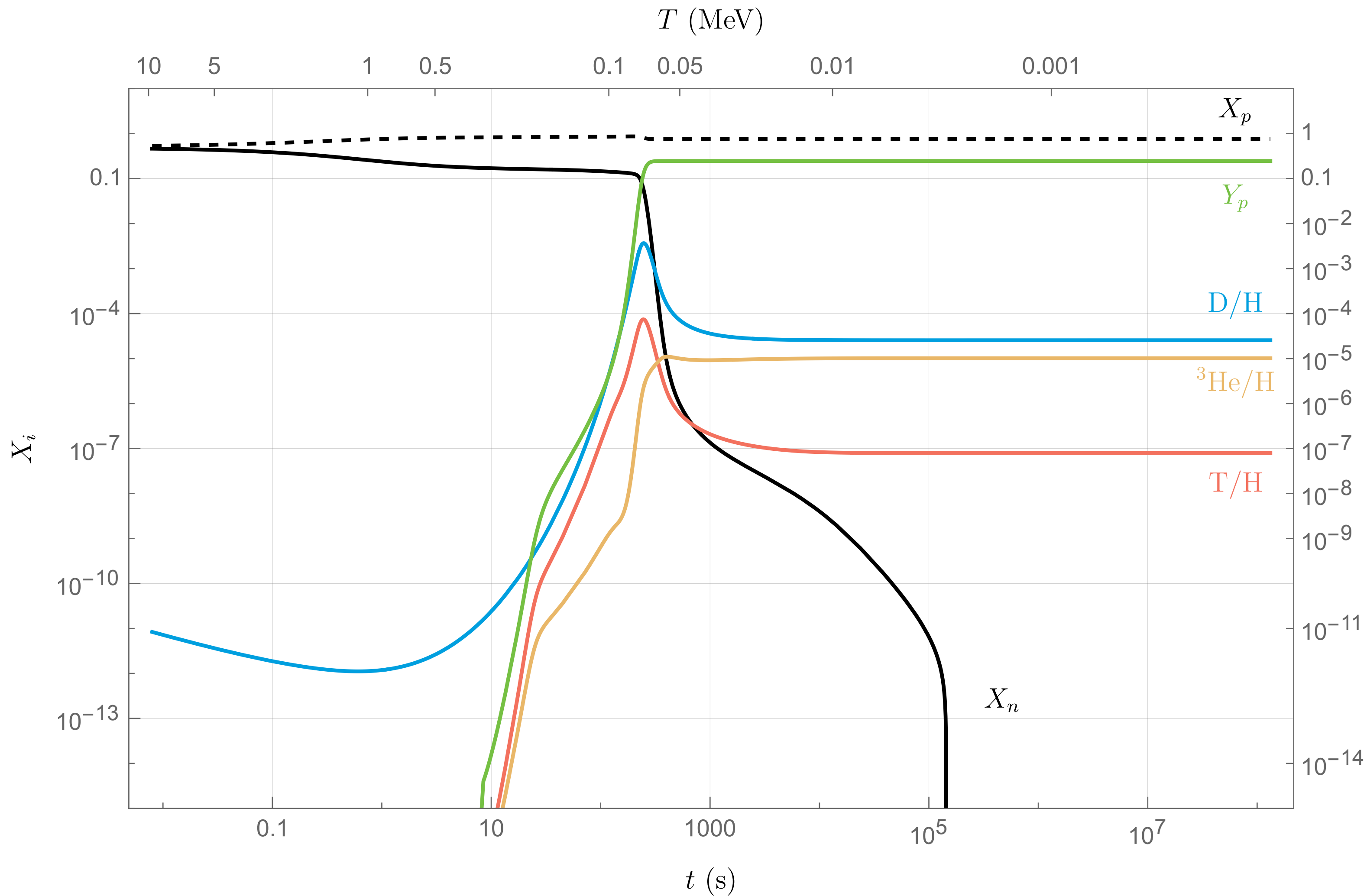
Or simply: EDE During BBN

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# Standard Big Bang Nucleosynthesis



# Standard Big Bang Nucleosynthesis



Galaxies form

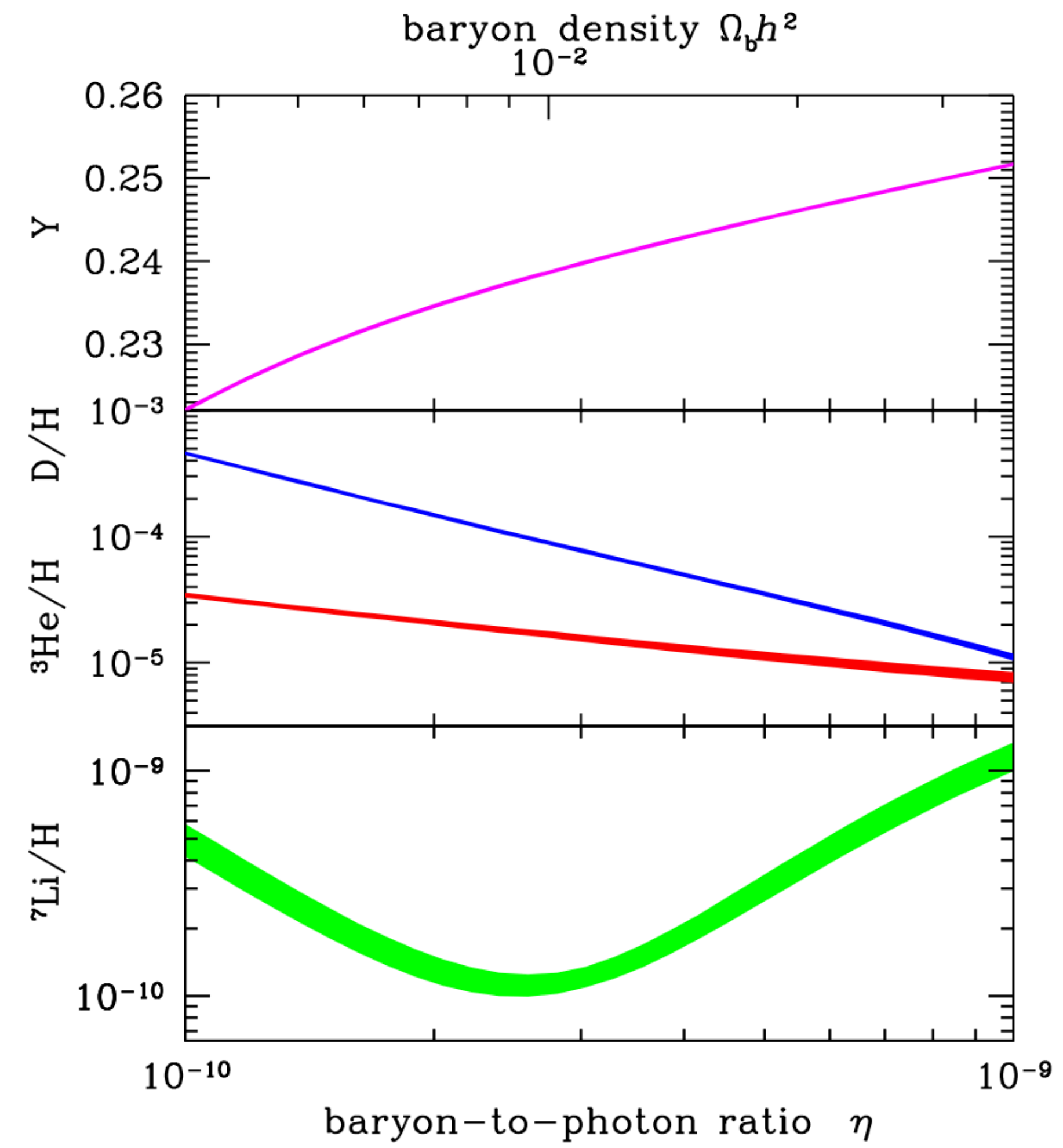
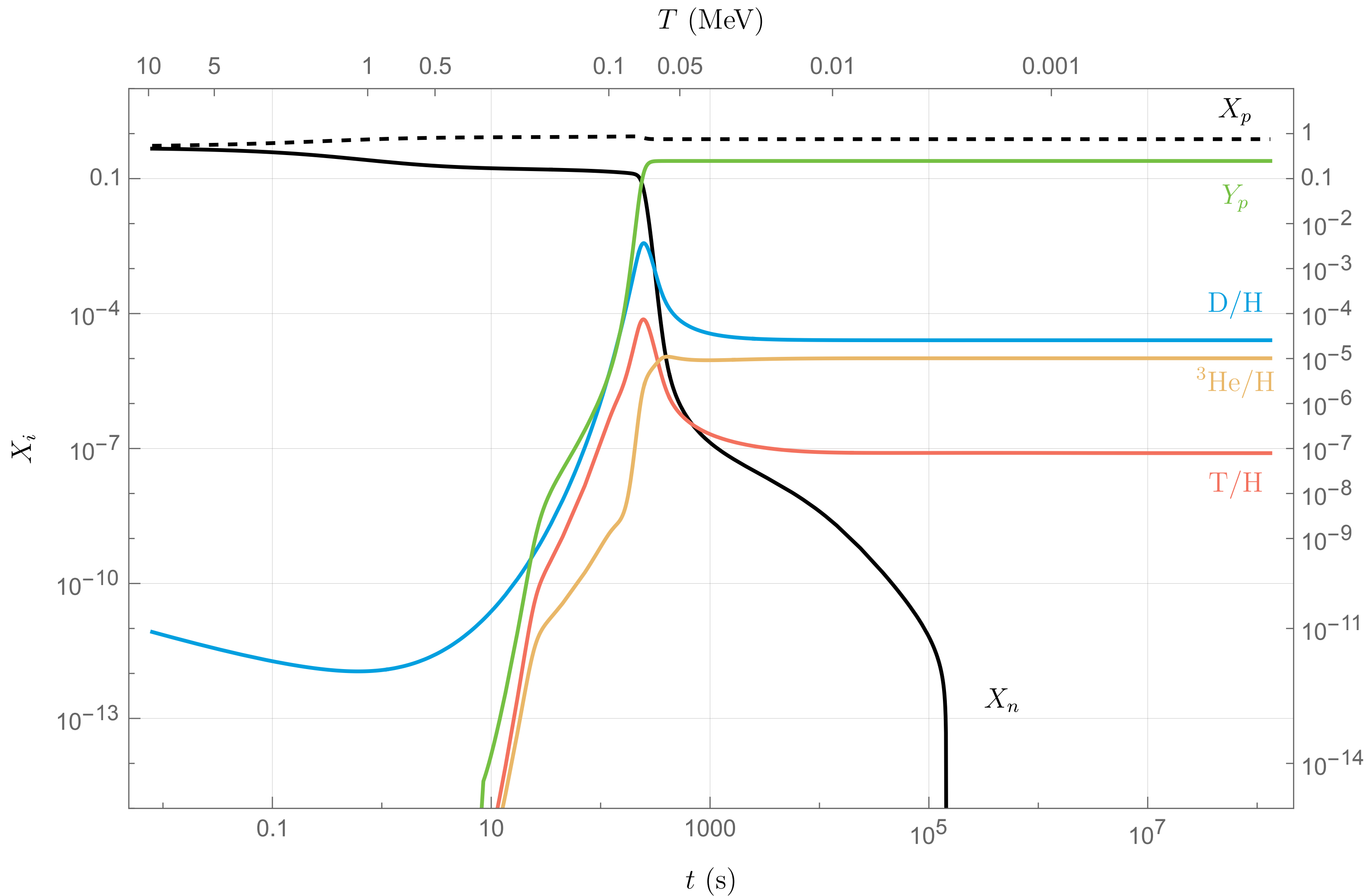
$10^9$  yrs       $10^{10}$  yrs

10 K

3 K

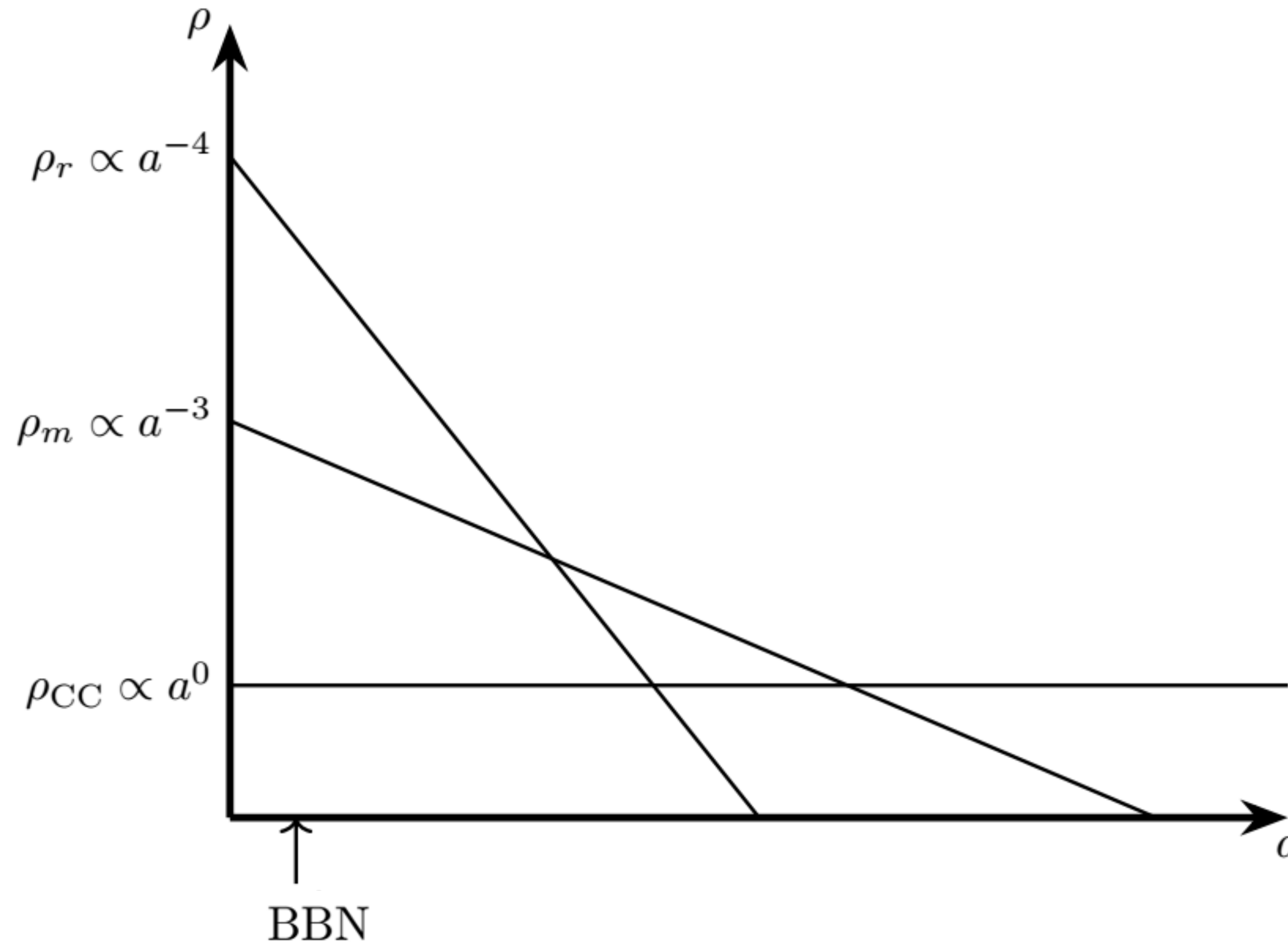
today

# Standard Big Bang Nucleosynthesis

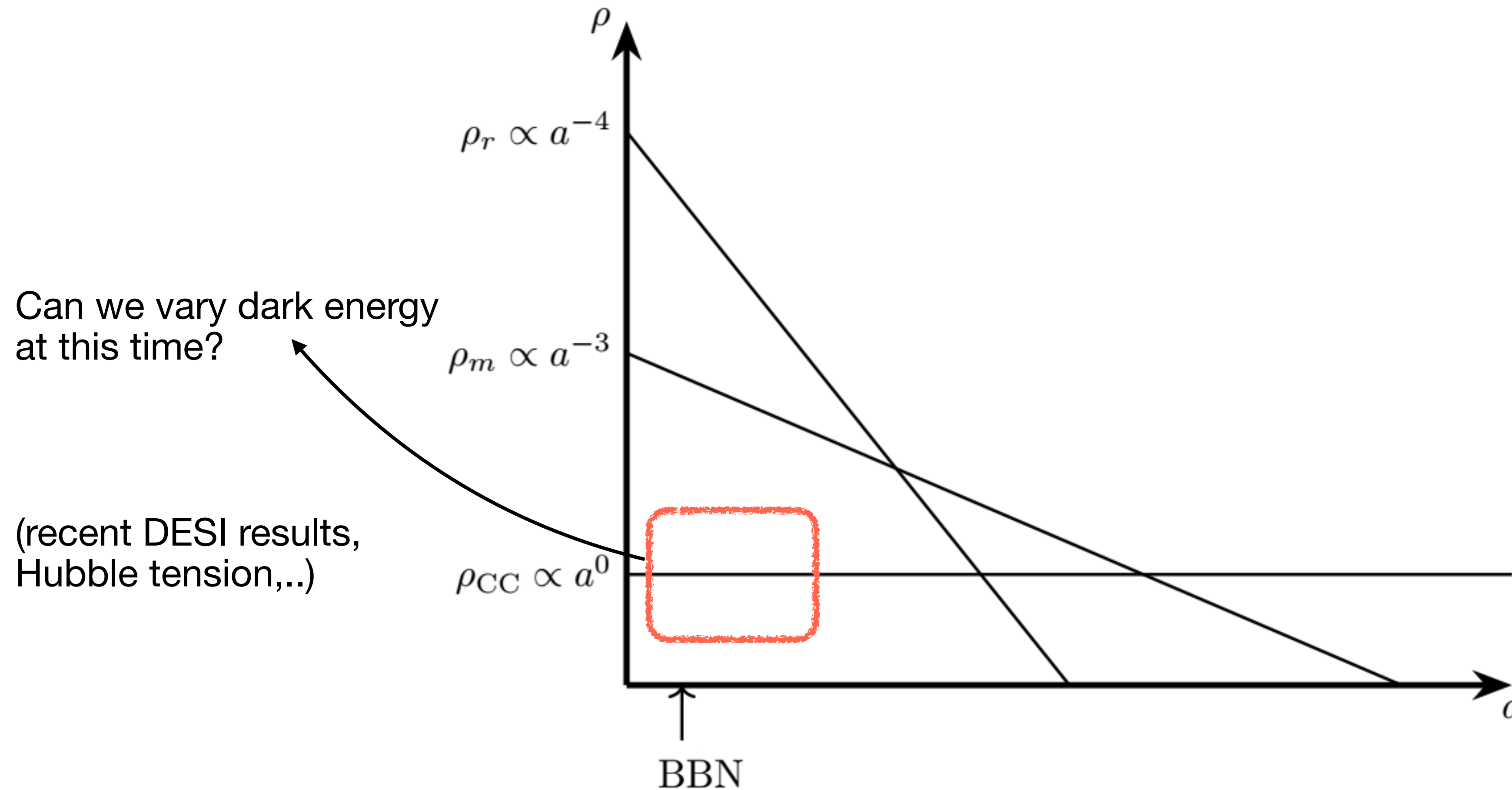


[Cyburt et al, 2016]

# Introducing EDE

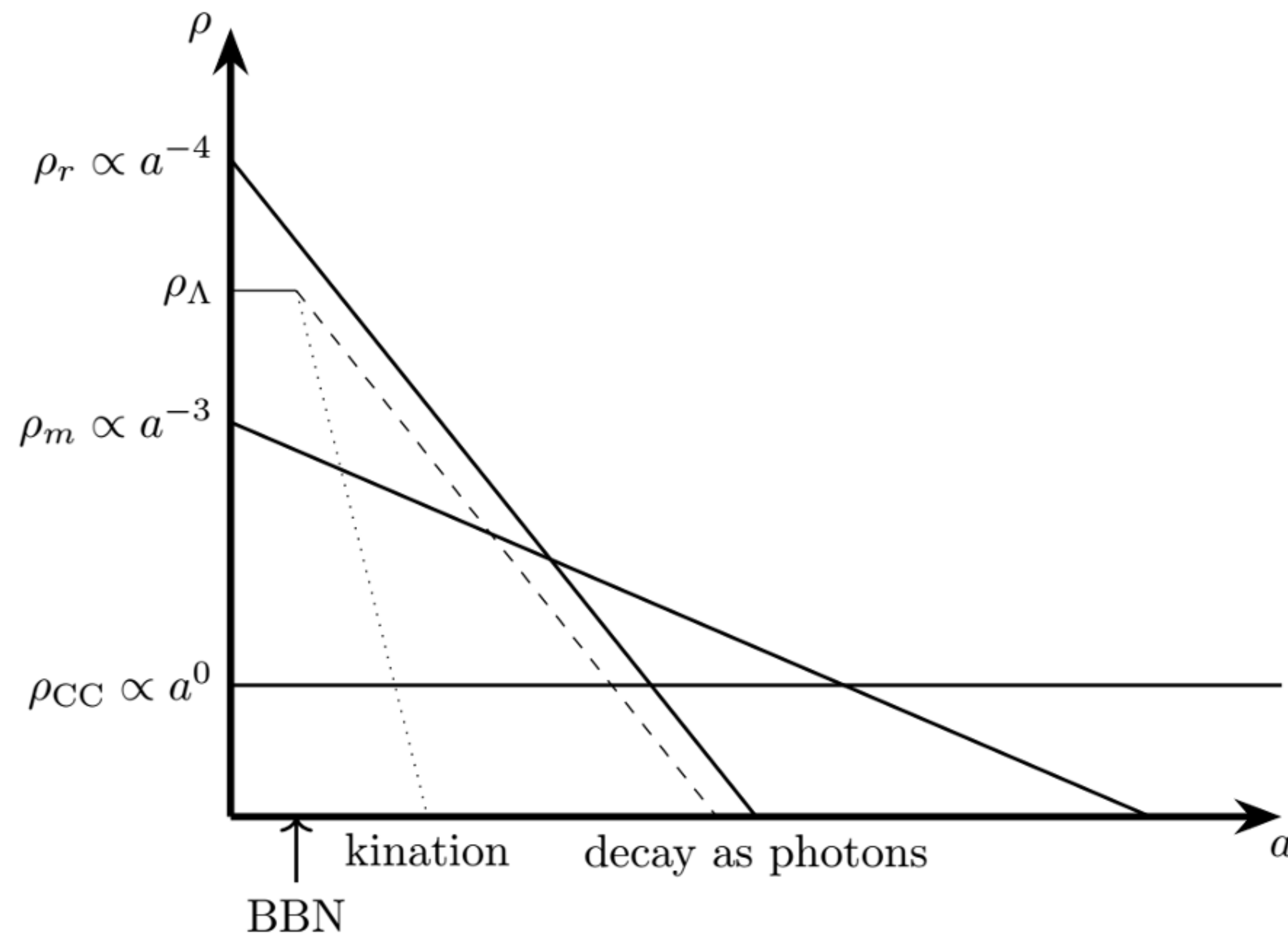


# Introducing EDE



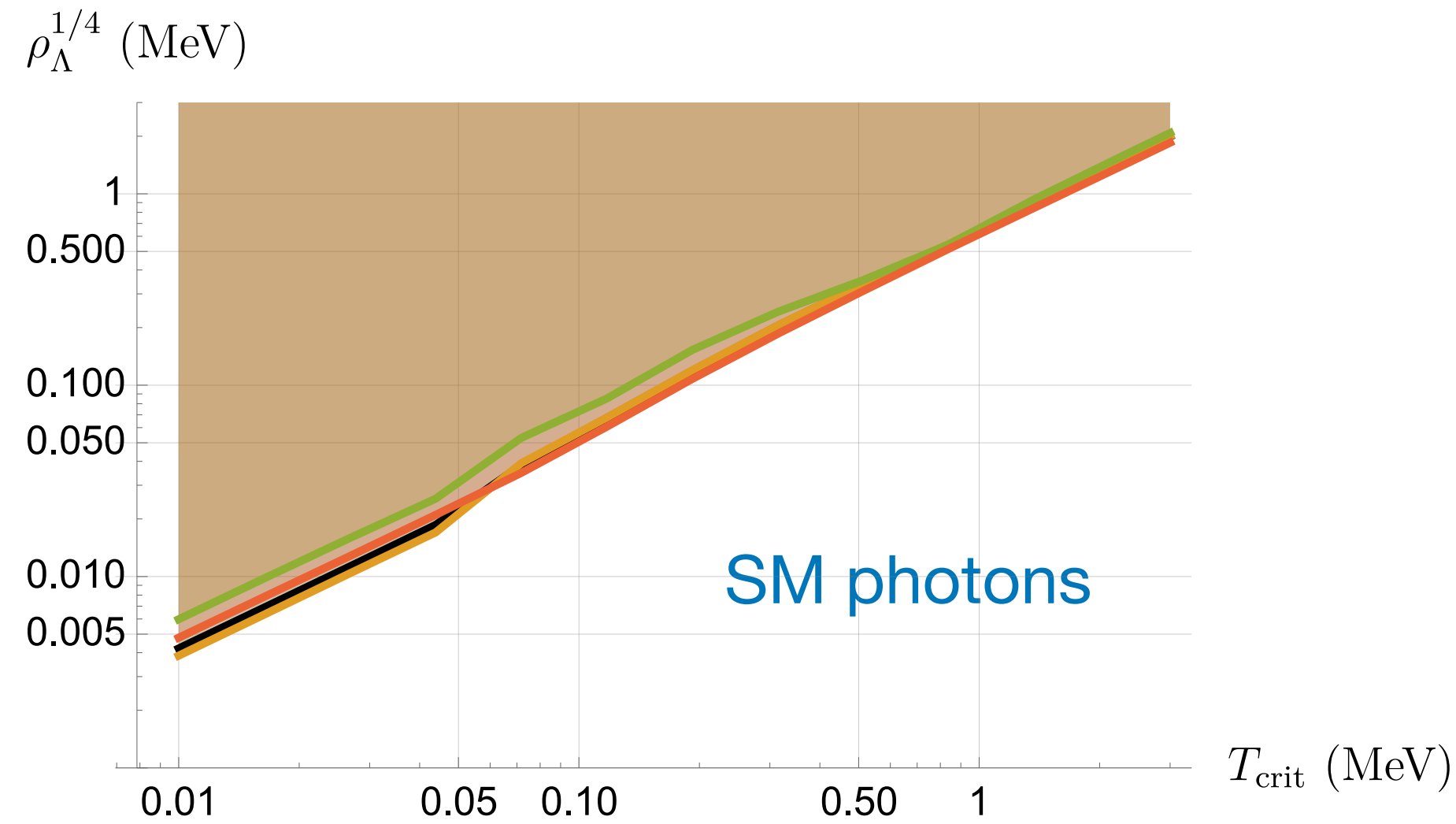
# Introducing EDE

- The parameters of the theory are
  - The initial amount of EDE  $\rho_\Lambda$
  - The temperature when it starts decaying  $T_{\text{crit}}$
  - The type of decay mode (photons, dark radiation, or kination).

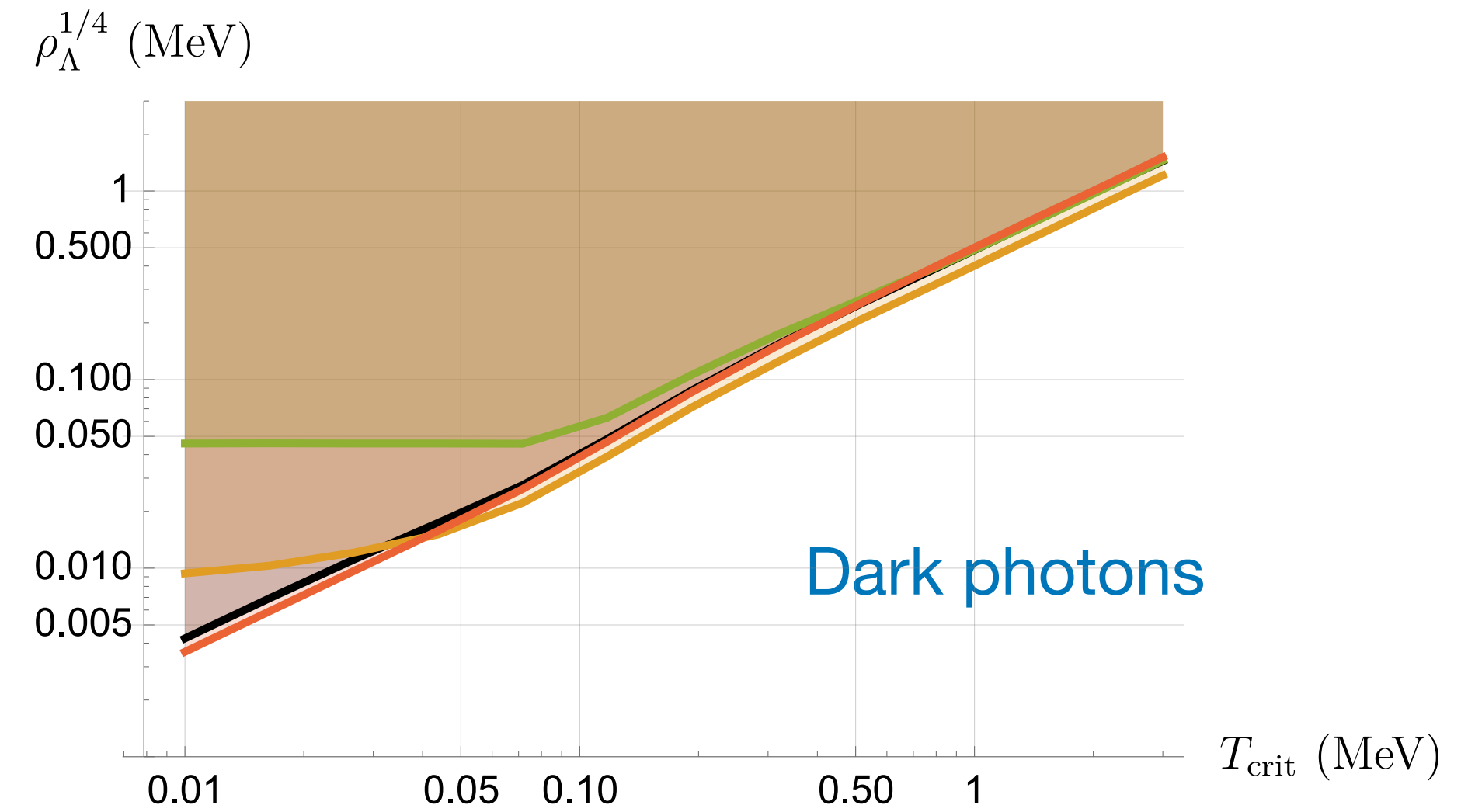




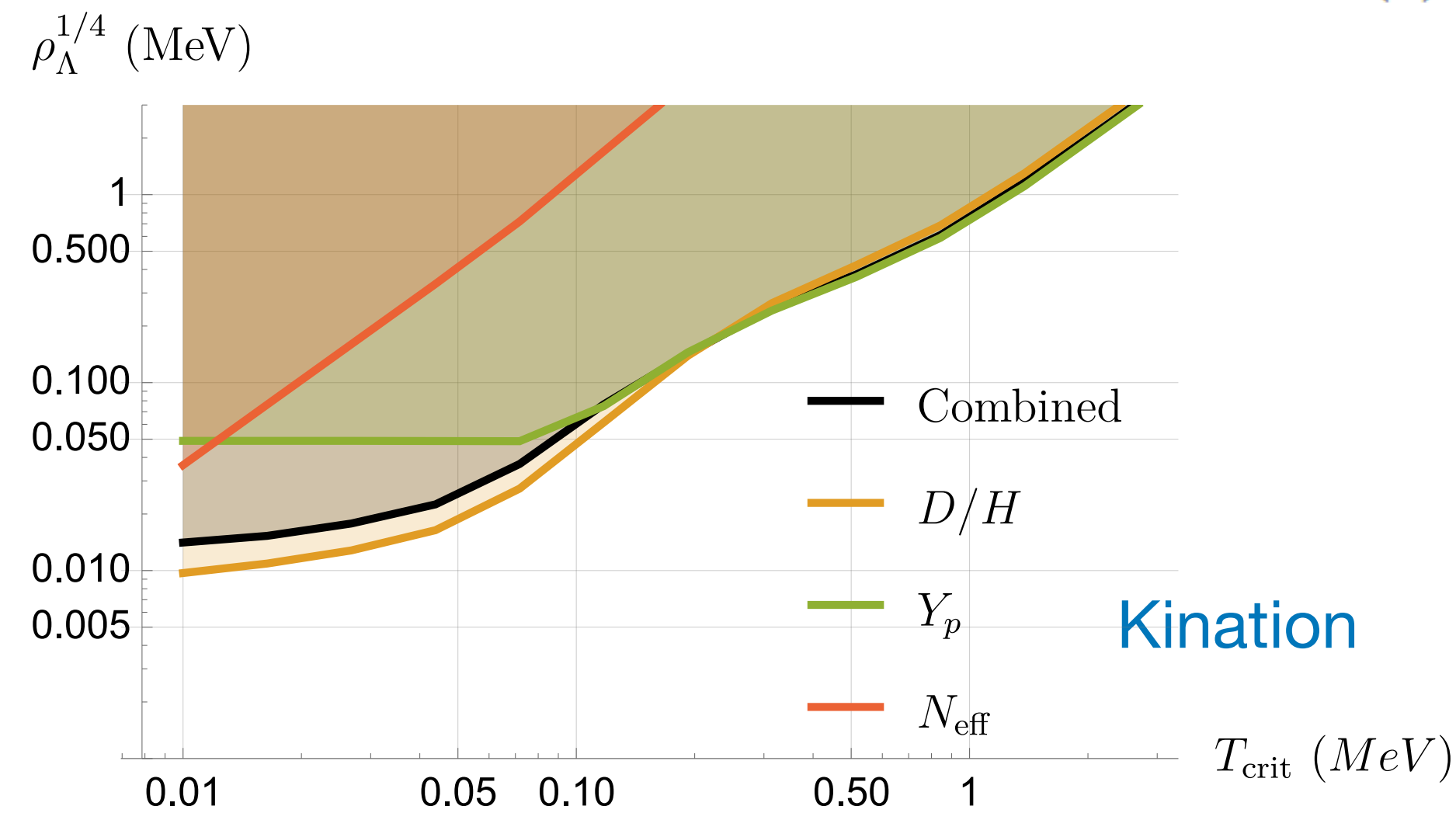
# The EDE parameter space



(a)



(b)

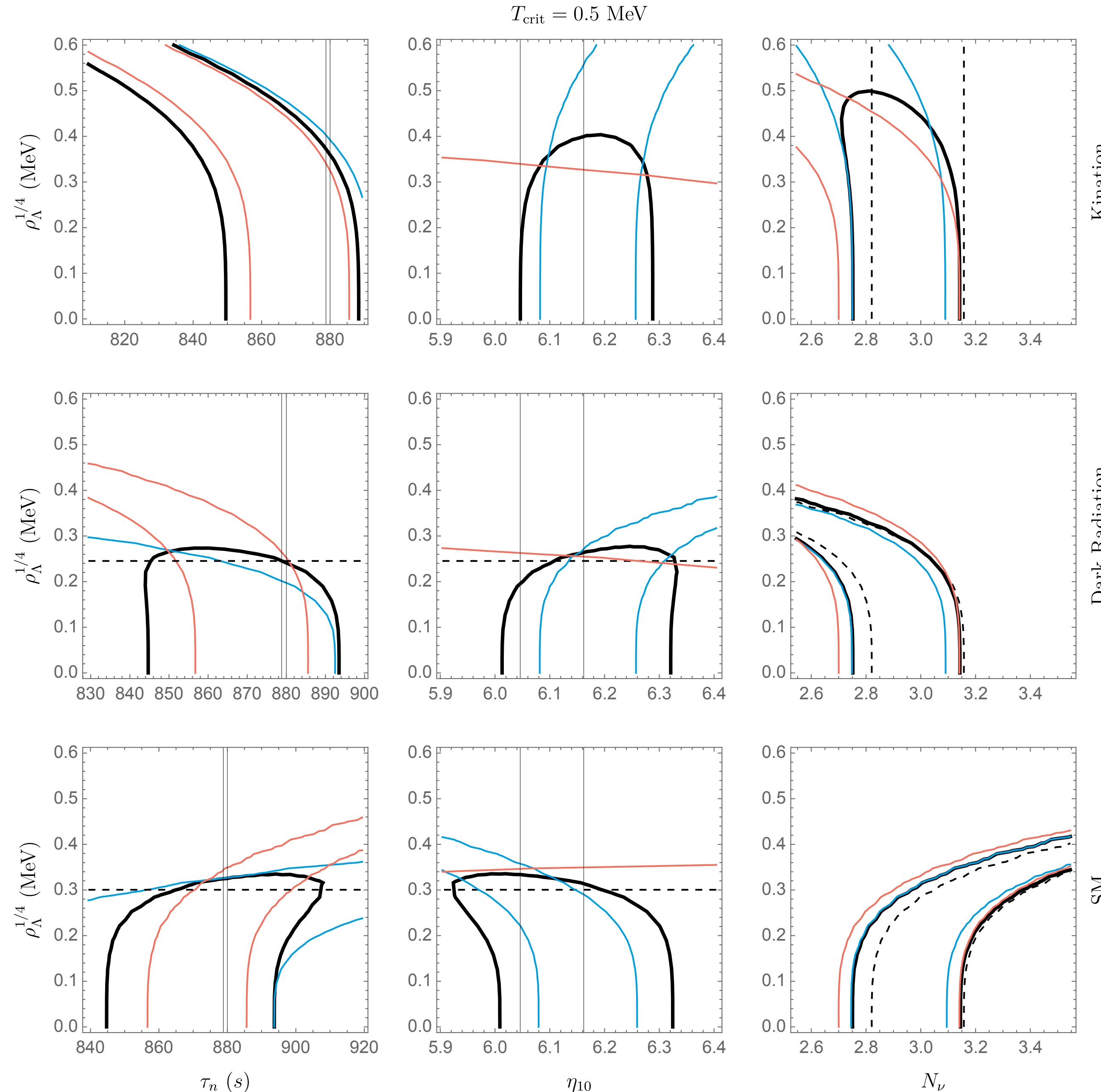


(c)

[David McKeen, AO, in prep]

# Varying the other BBN parameters

$T_{\text{crit}} = 0.5 \text{ MeV}$



Kinematic

Dark Radiation

SM

- D/H limits
- $Y_p$  limits
- ⋯  $N_{\text{eff}}$  limits
- Combined limit

[David McKeen, AO, in prep]

**Afif Omar - TRIUMF/UVic**

# Key Takeaways

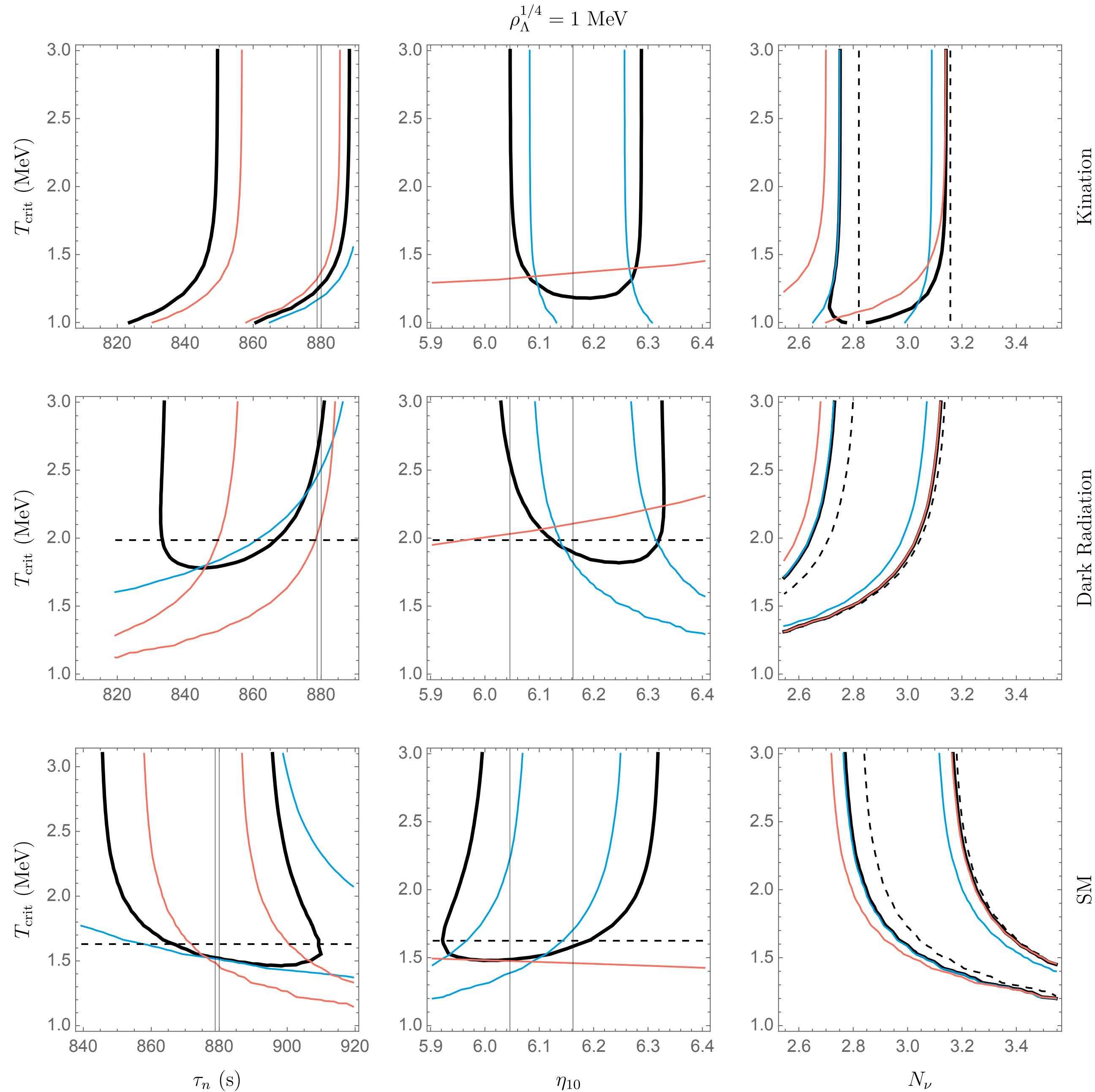
- BBN is a good test of new physics as it's essentially parameter-free.
- Introducing an EDE component alters the expansion rate of the universe which in turns alters the outcomes of BBN.
- Altered BBN outcomes set limits on the input parameters of EDE, namely  $\rho_\Lambda$  and  $T_{\text{crit}}$ .
- Fixing one parameter, one could explore varying other typically-fixed BBN parameters (like  $\tau_n$ ,  $\eta_b$ , and  $N_\nu$ ).

Thank you for listening!

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# Backup Slides

# Varying the other BBN parameters



$$\rho_{\Lambda}^{1/4} = 1 \text{ MeV}$$

[David McKeen, AO, in prep]

# Effect of entropy injections

