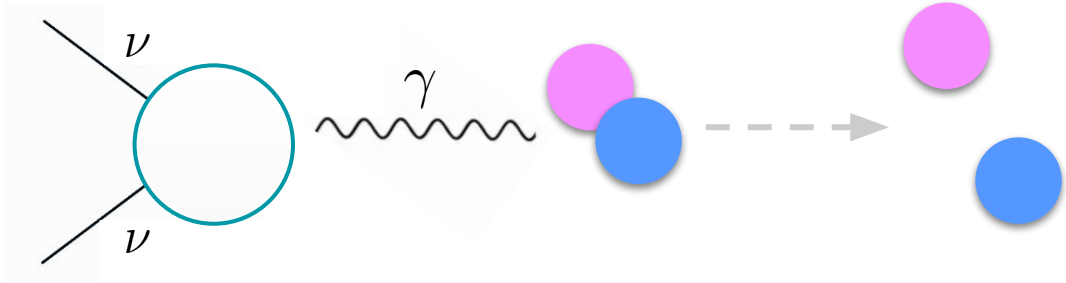
BBN photodisintegration limits from neutrino injections

Based on 2407.xxxxx

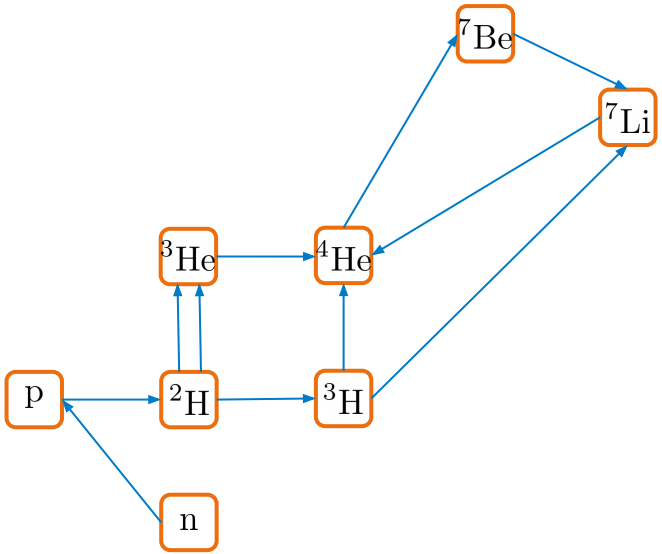
Sara Bianco
Invisibles2024 Workshop, Bologna
1st July 2024



In collaboration with: P. F. Depta, J. Frerick, T. Hambye, M. Hufnagel, and K. Schmidt-Hoberg

HELMHOLTZ

$$t \sim 1\text{s} - 10^3\text{s} \iff T \sim \text{MeV} - \text{keV}$$



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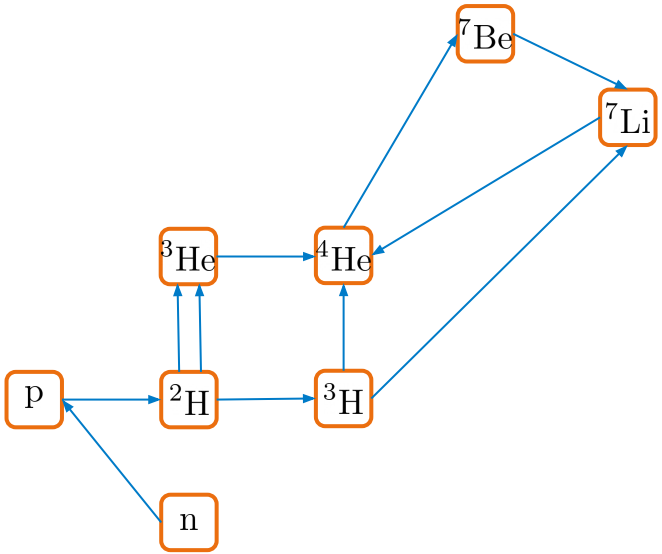
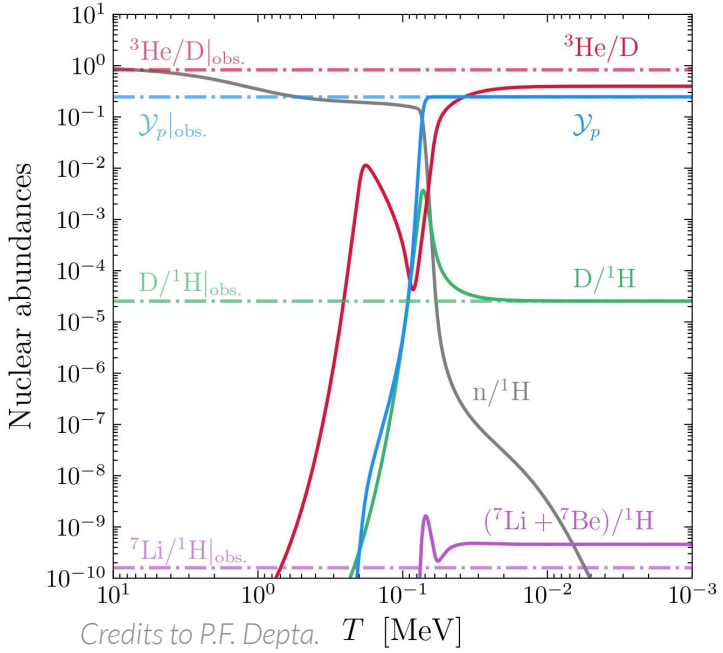


Agreement between predictions and observations:



$< 1\sigma$

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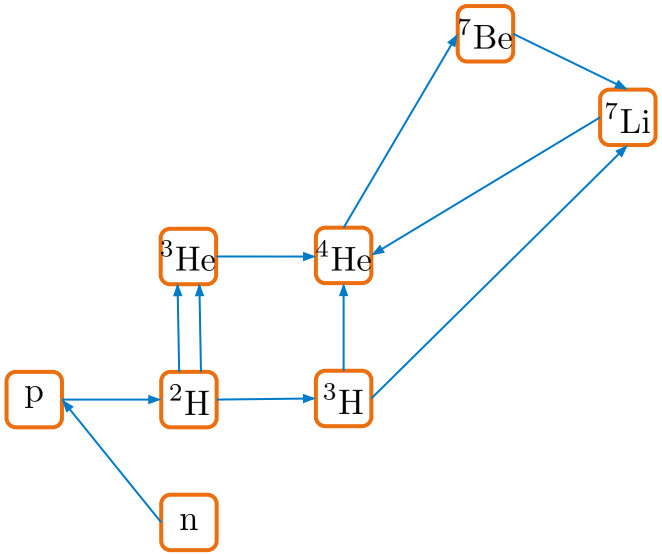

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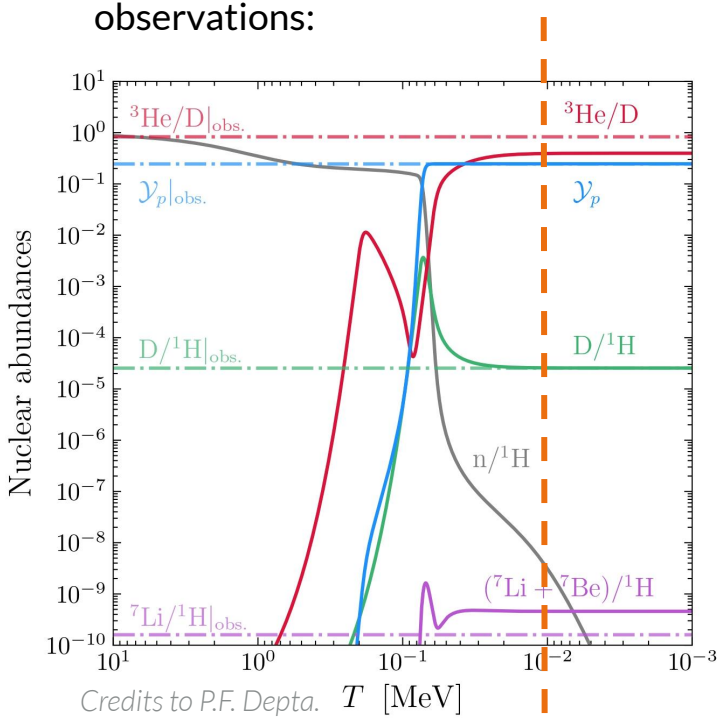

Fixed around 10 keV!

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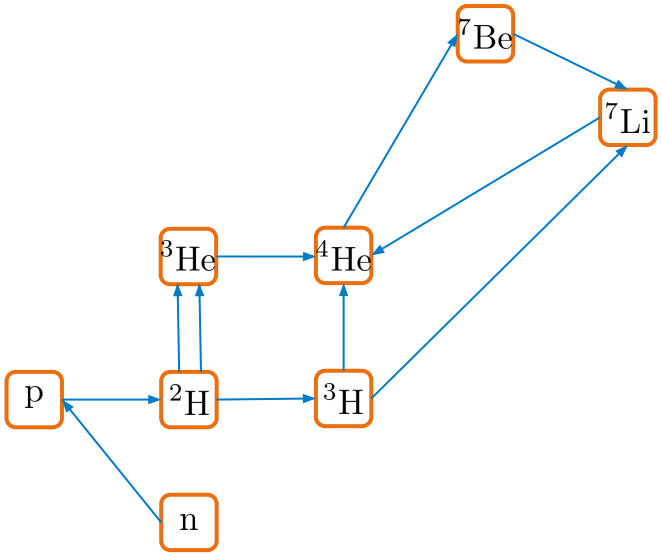

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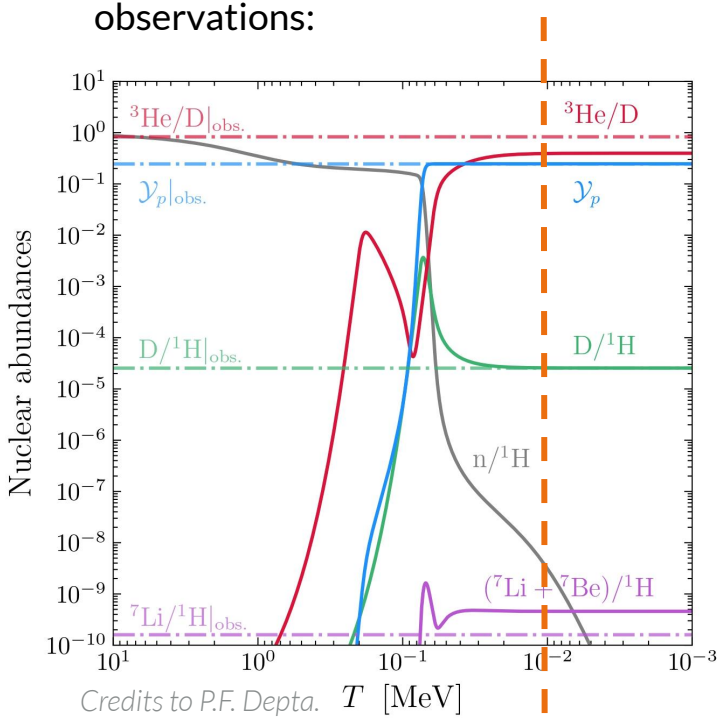

What happens if we inject electromagnetic material at *later times*?

M. Kawasaki and T. Moroi, astro-ph/9412055.

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$$E > 1.5\,\mathrm{MeV}$$
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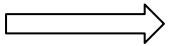

Electromagnetic cascade that leads to non-thermal parts of the photon, electron, and positron spectra.

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⟹

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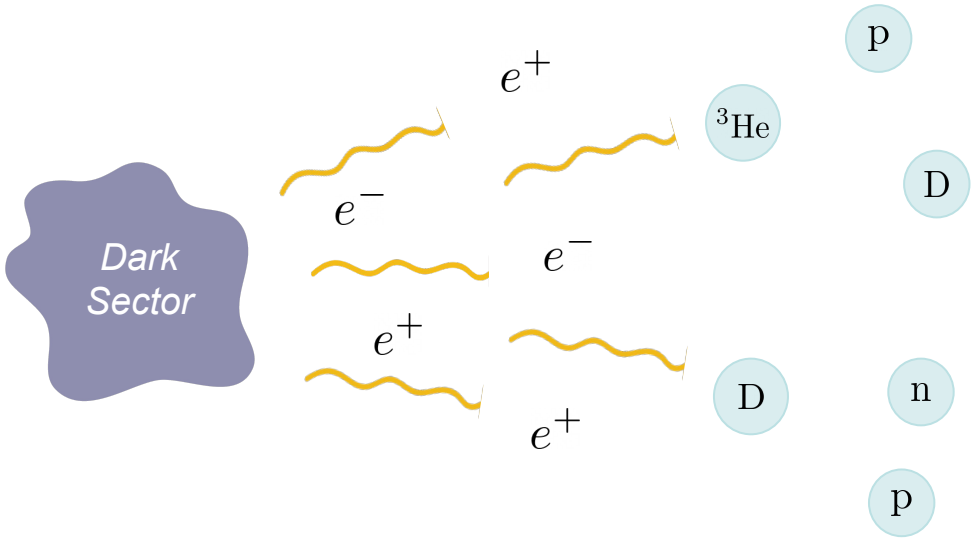

What if we inject *neutrinos*?

T. Hambye, M. Hufnagel and M. Lucca, 2112.09137.

T. Kanzaki, M. Kawasaki, K. Kohri and T. Moroi, 0705.1200.

$$\phi \rightarrow \nu\nu$$

What if we inject *neutrinos*?

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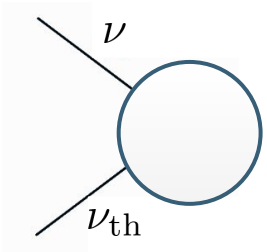
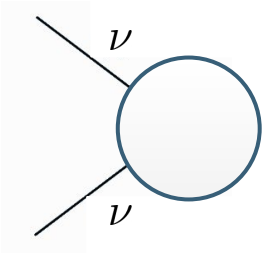
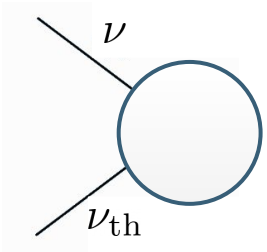
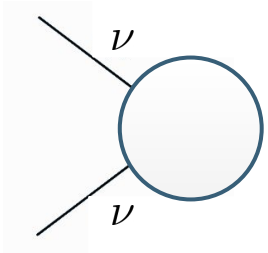




What if we inject *neutrinos*?

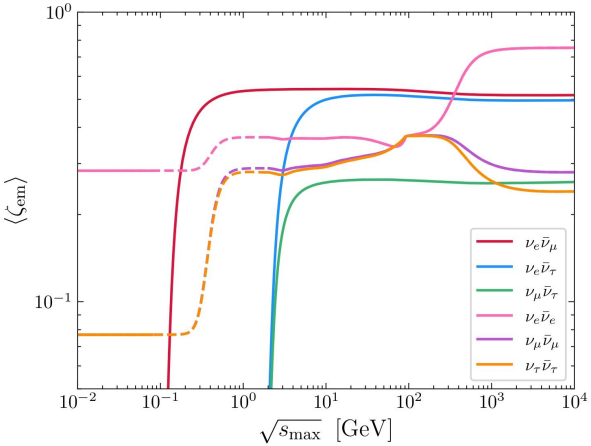
$$\phi \to \nu\nu$$

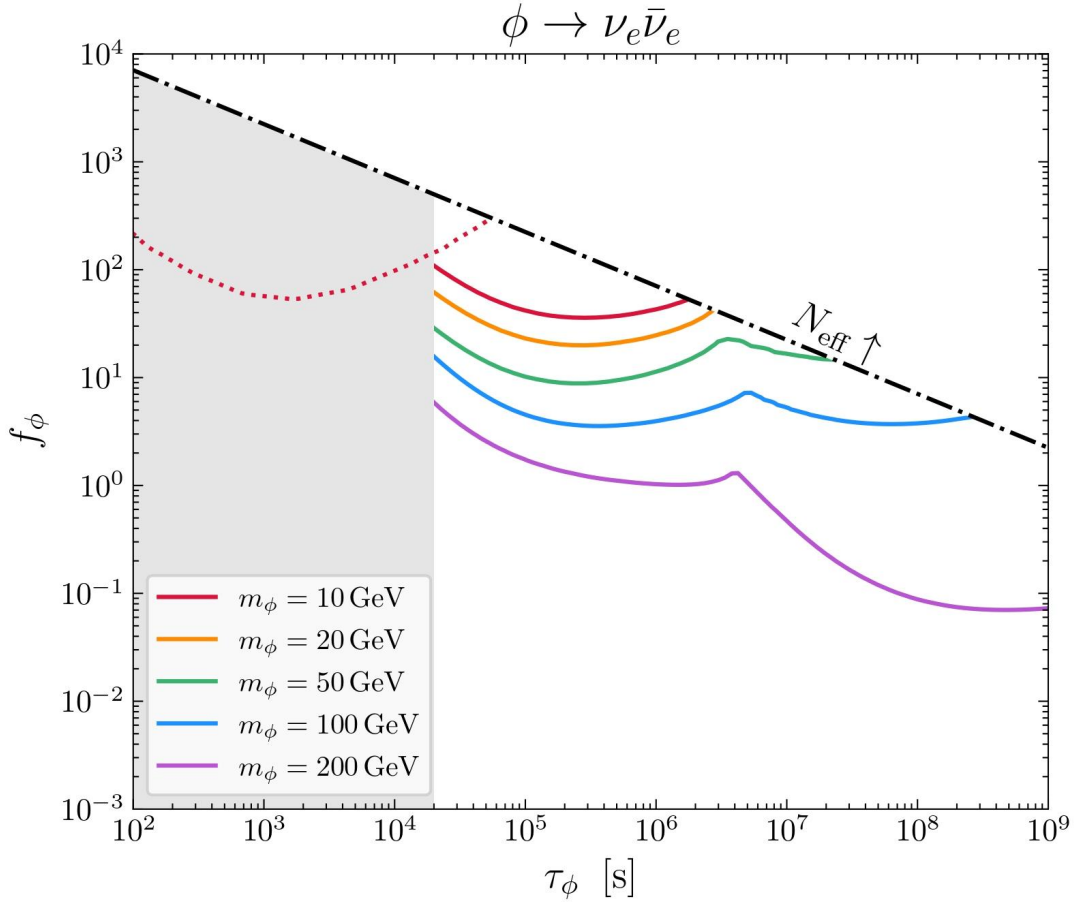


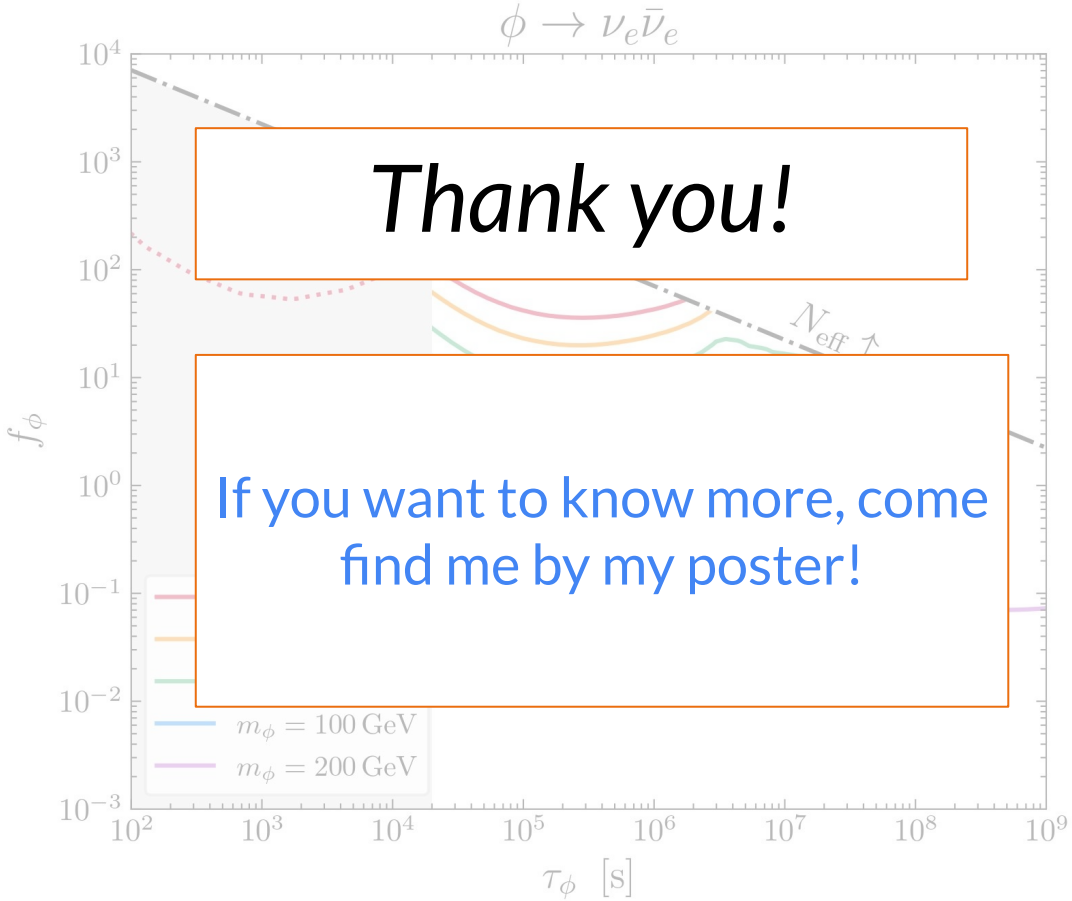


$$s_{\rm max} = 4EE'$$

$$\nu\nu_{\rm th} \to \nu\nu$$
$$\nu\overline{\nu}_{\rm th} \to \nu\overline{\nu}$$
$$\nu\overline{\nu}_{\rm th} \to e^+e^-$$
$$\nu\overline{\nu} \to \pi^-\pi^+$$
$$\dots$$




$\phi \to \nu_e \bar{\nu}_e$
$N_{\rm eff}$ ↑
$m_\phi = 10\,\mathrm{GeV}$
$m_\phi = 20\,\mathrm{GeV}$
$m_\phi = 50\,\mathrm{GeV}$
$m_\phi = 100\,\mathrm{GeV}$
$m_\phi = 200\,\mathrm{GeV}$
f_ϕ
τ_ϕ [s]
10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}
10^{2} 10^{3} 10^{4} 10^{5} 10^{6} 10^{7} 10^{8} 10^{9}



Thank you!

If you want to know more, come find me by my poster!

Backup slides

Photodisintegration

Late time decays or residual annihilations of dark sector particles can alter BBN abundances at later times.

$$\dot{Y}_N(t) = \sum_j Y_j(t) \int_0^\infty dE f_\gamma(t,E)\sigma_{j\gamma\to N}(E) - Y_N(t)\sum_{j'}\int_0^\infty dE f_\gamma(t,E)\sigma_{N\gamma\to j'}(E)$$

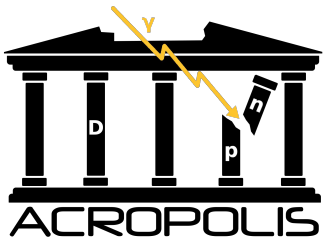
$$E_{e^\pm}^{\rm th} \simeq m_e^2/(22T)$$

If above pair-production threshold, high-energy photons are rapidly depleted.

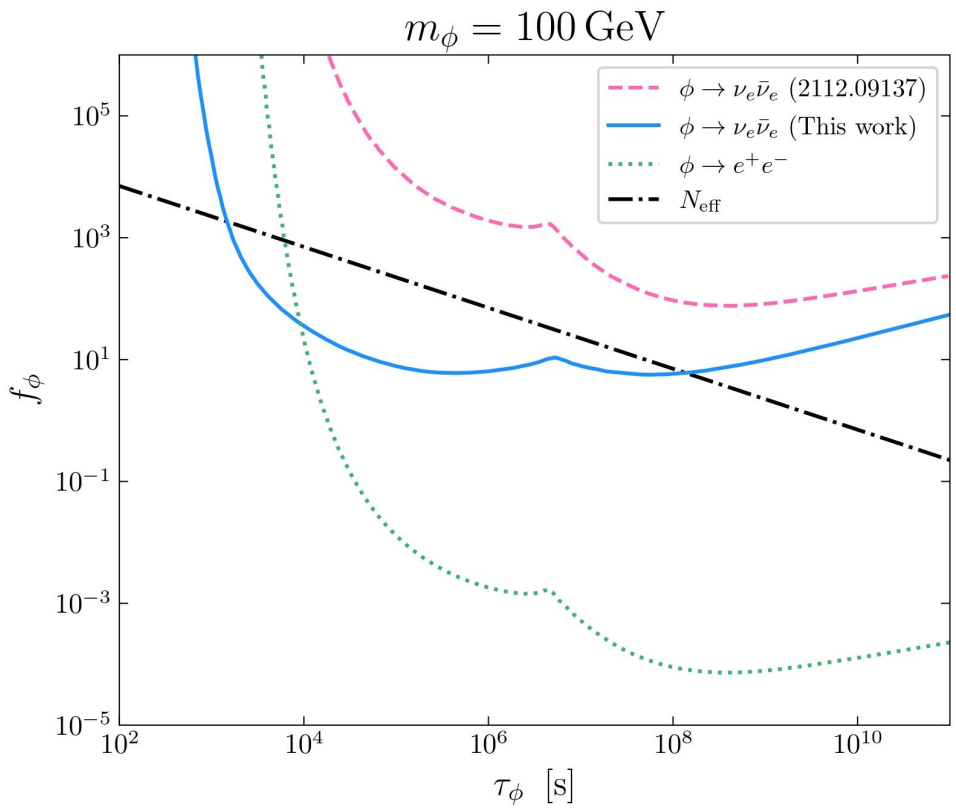
	T (keV)	$E^{\rm th}$ (MeV)
D	5.34	2.22
^{3}H	1.90	6.26
^{3}He	2.16	5.49
^{4}He	0.60	19.81
^{6}Li	3.21	3.70
^{7}Li	4.81	2.47
^{7}Be	7.48	1.59

BBN at these T has already finished.

Final abundances of BBN are initial abundances of photodisintegration.



Publicly available code 2011.06518, *P. F. Depta, M. Hufnagel, and K. Schmidt-Hoberg.*


$m_\phi = 100\,\mathrm{GeV}$
$\phi \to \nu_e\bar{\nu}_e$ (2112.09137)
$\phi \to \nu_e\bar{\nu}_e$ (This work)
$\phi \to e^+e^-$
N_{eff}
f_ϕ
10^5
10^3
10^1
10^{-1}
10^{-3}
10^{-5}
10^2
10^4
10^6
10^8
10^{10}
τ_ϕ [s]

Neutrino oscillations