

COSMOLOGICAL CONSTRAINTS ON THE DECAY OF HEAVY RELICS INTO NEUTRINOS

based on

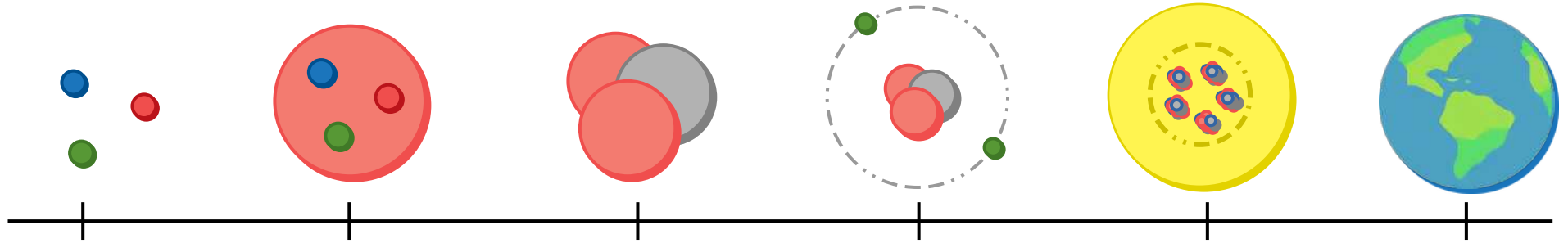
[2112.09137]

by

Thomas Hambye, [Marco Hufnagel](#), Matteo Lucca

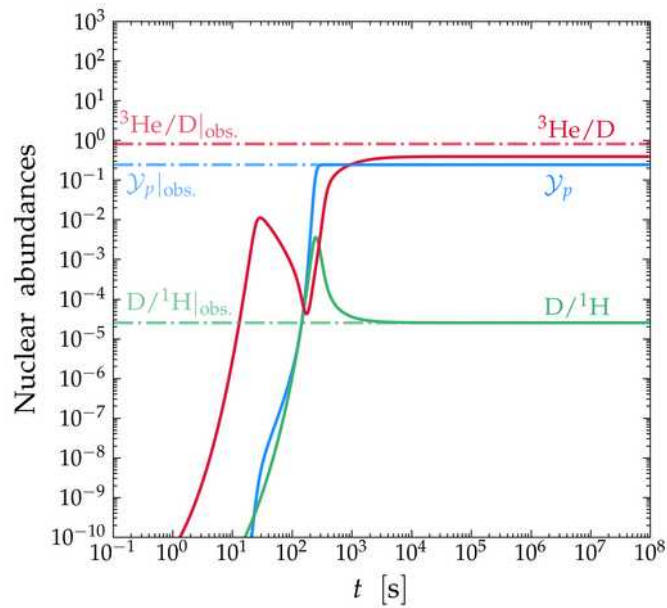
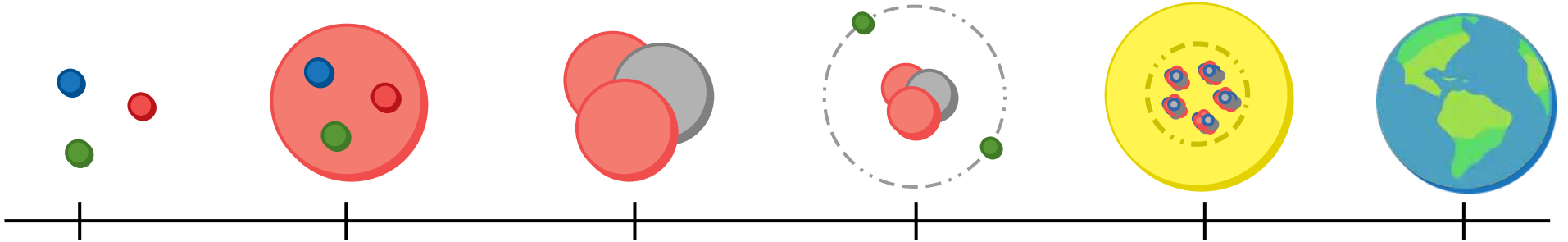
Wednesday, June 1, 2022

Exotic energy injections



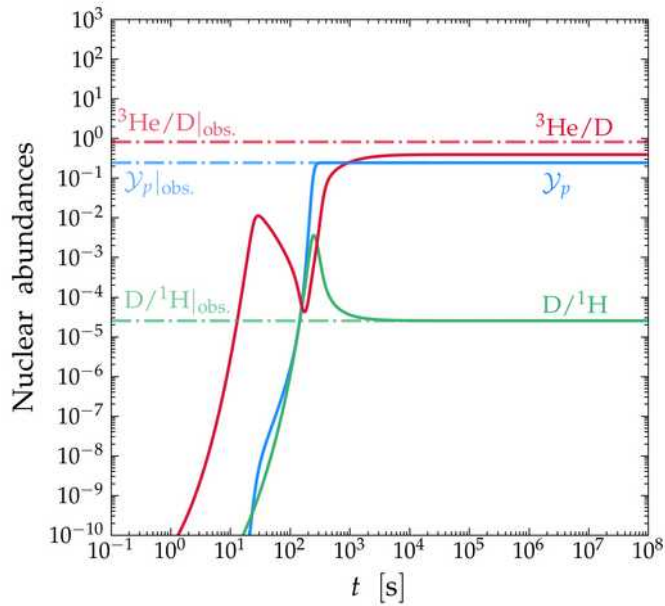
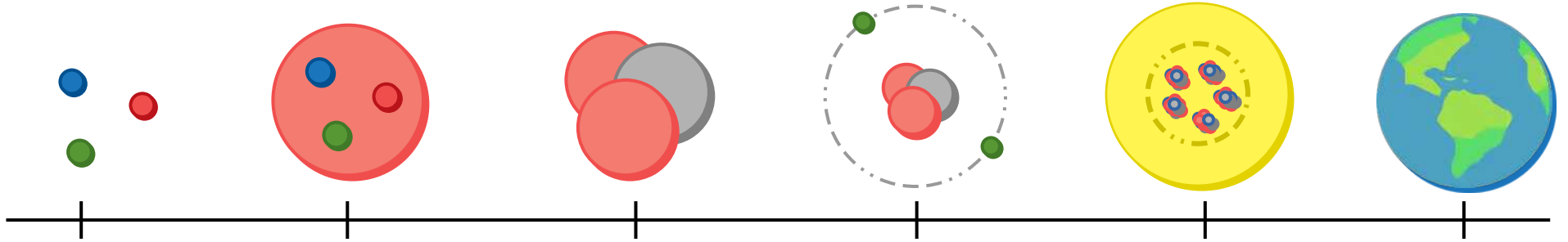
Exotic energy injections

$t \sim 10 - 10^3 \text{ s}$



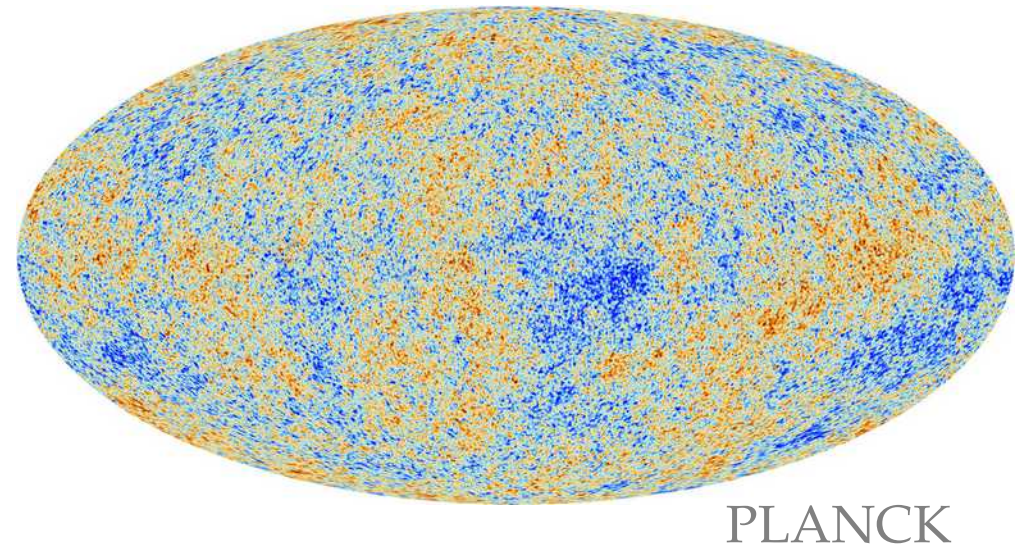
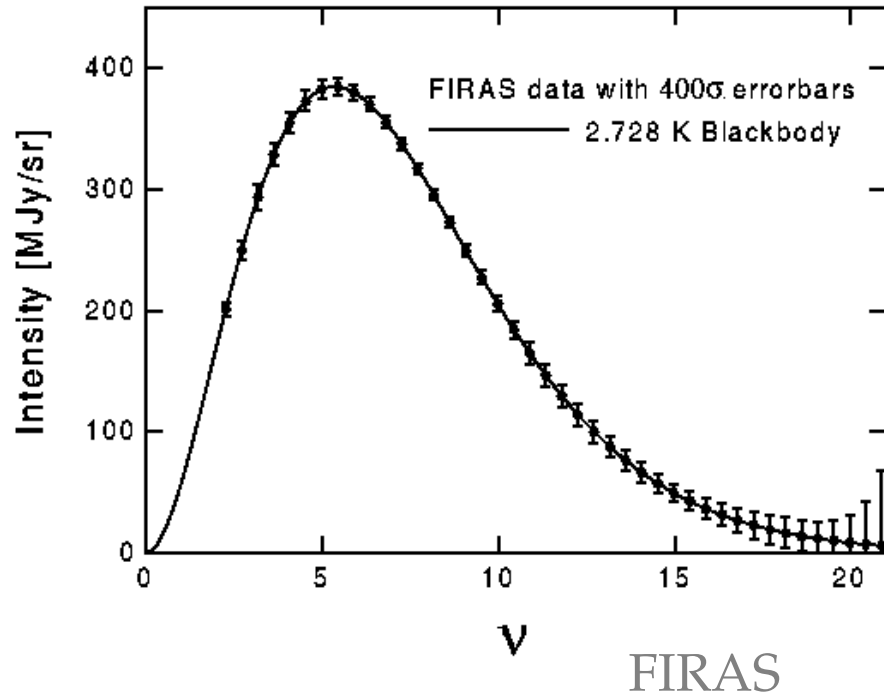
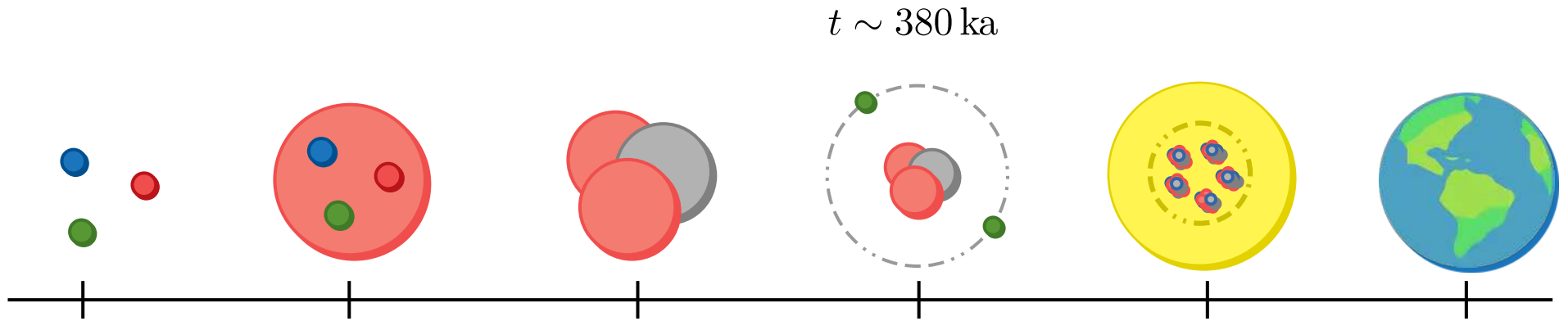
Exotic energy injections

$t \sim 10 - 10^3 \text{ s}$

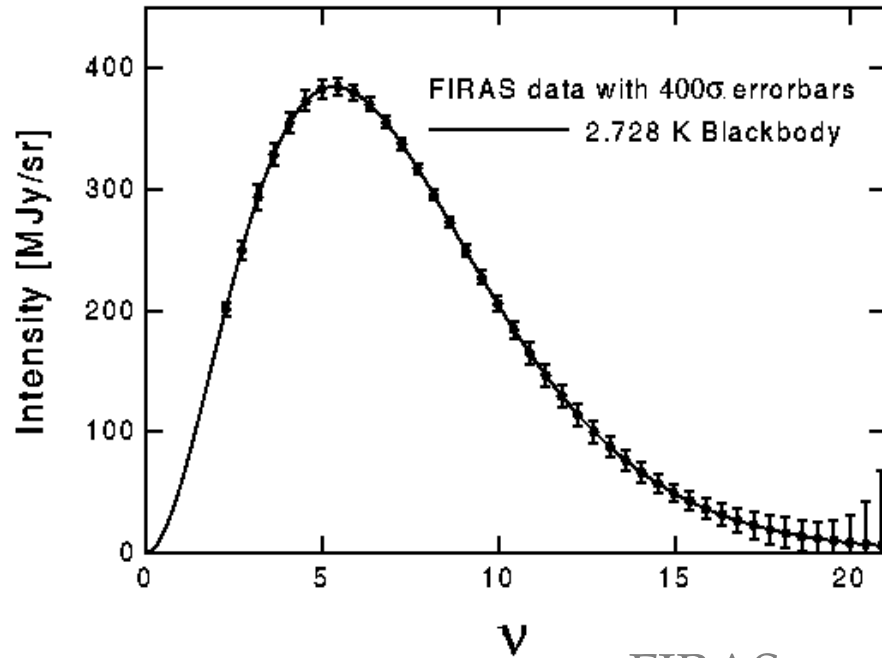
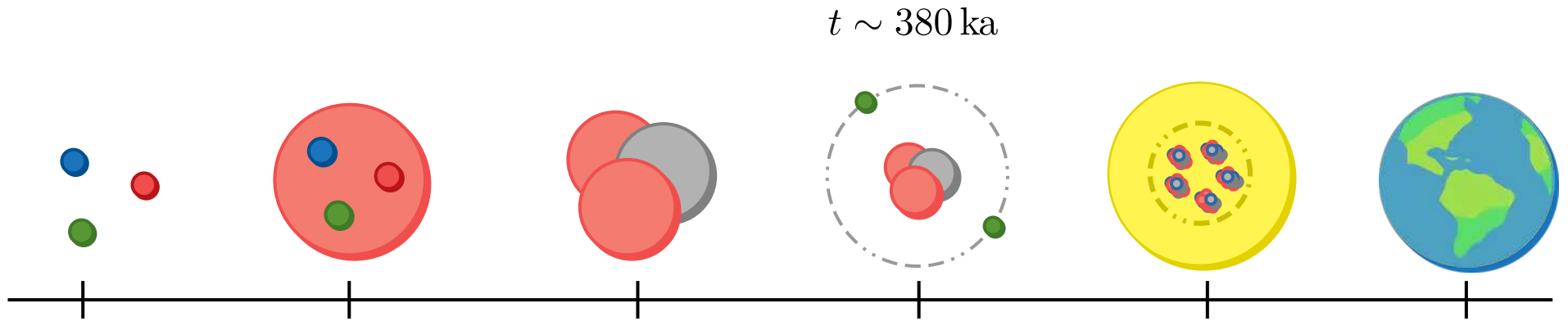


1 H 1.008	2											13	14	15	16	17	18 He 4.0026
3 Li 6.94	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305	3	4	5	6	7	8	9	10	11	12	13 Al 26.982	14 Si 28.085	15 P 30.974	16 S 32.06	17 Cl 35.45	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.38	31 Ga 69.723	32 Ge 72.630	33 As 74.922	34 Se 78.97	35 Br 79.904	36 Kr 83.798

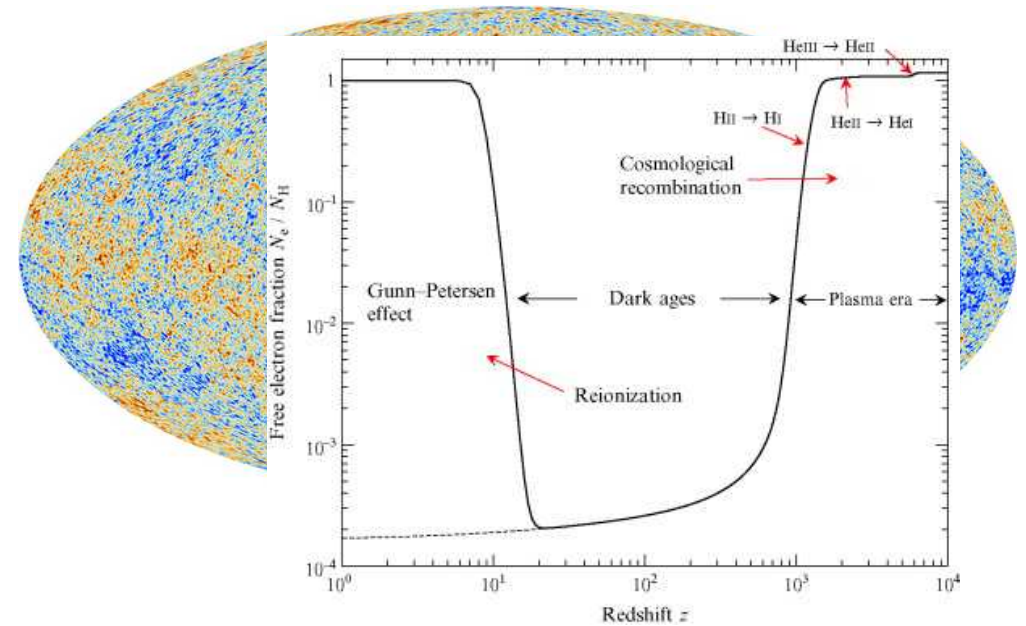
Exotic energy injections



Exotic energy injections

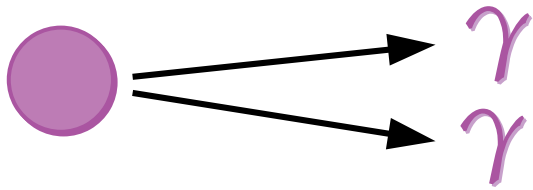
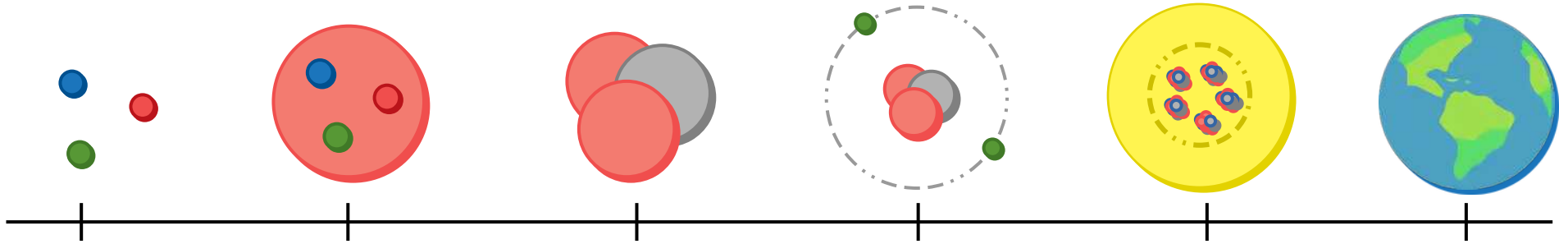


FIRAS

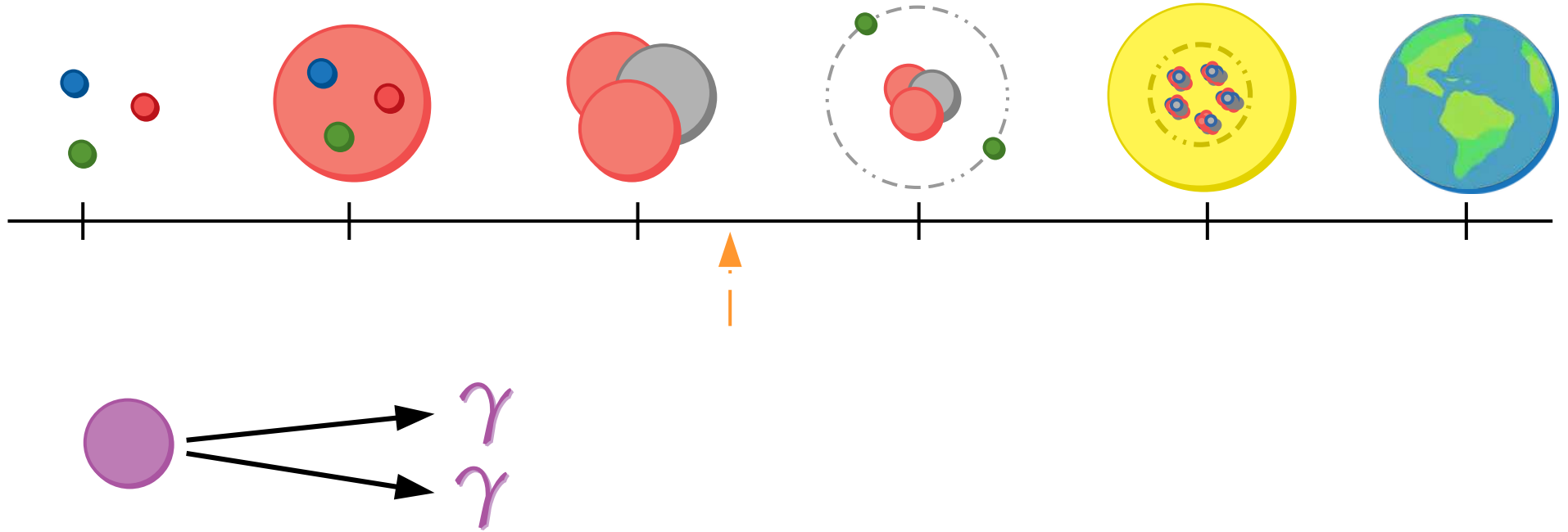


Glover et al '14

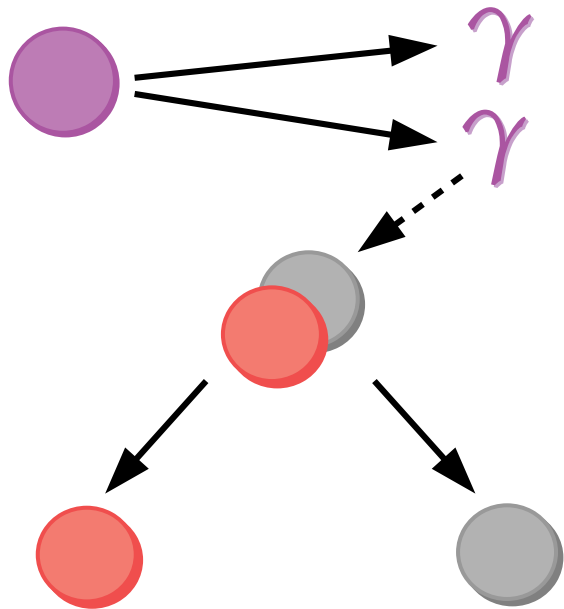
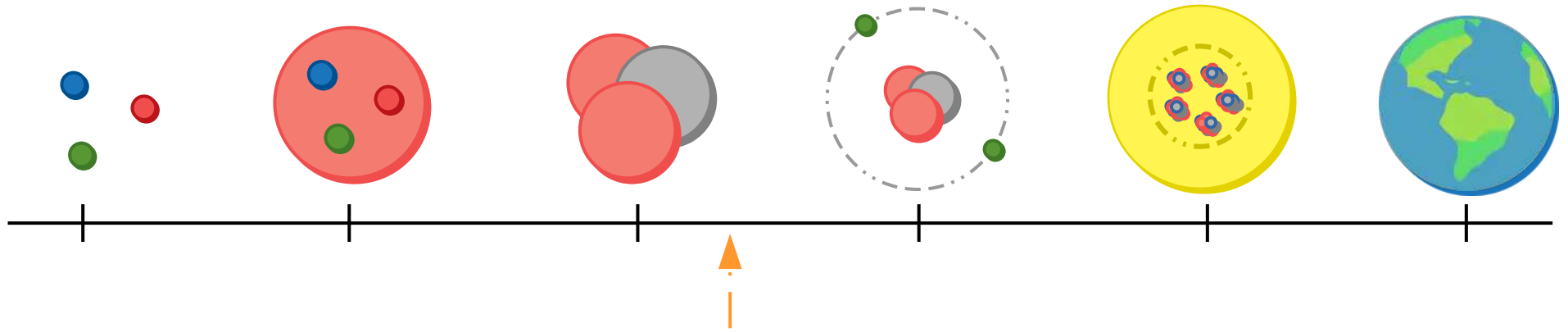
Exotic energy injections



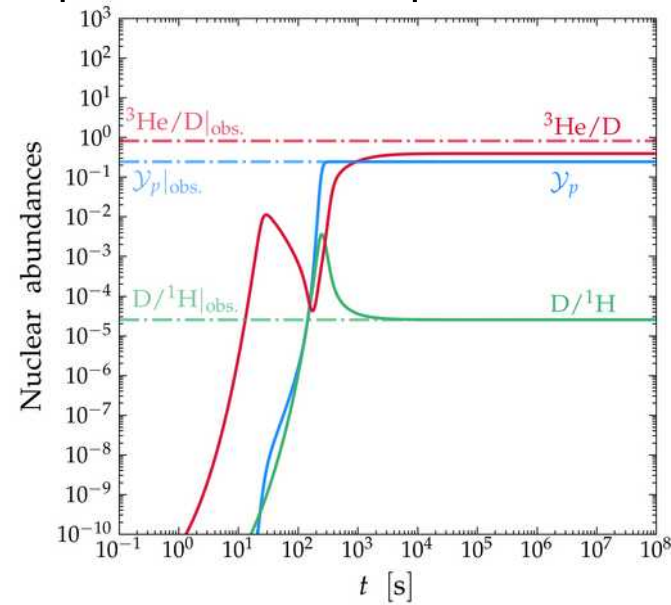
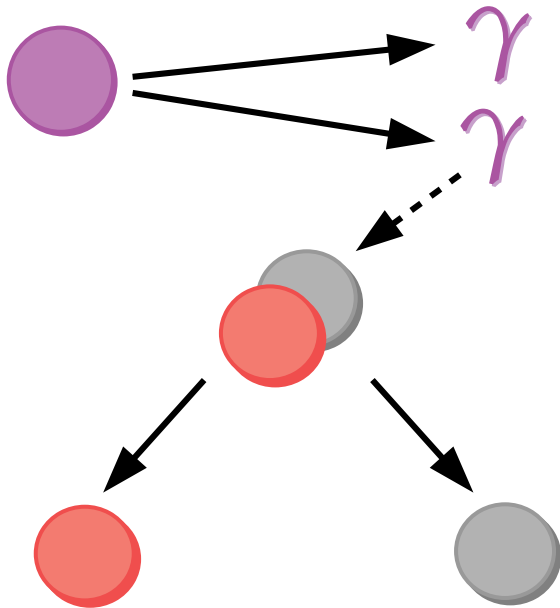
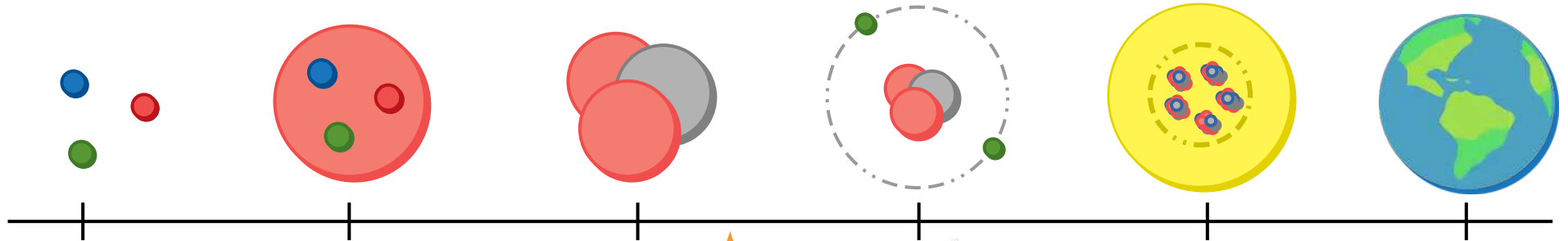
Exotic energy injections



Exotic energy injections

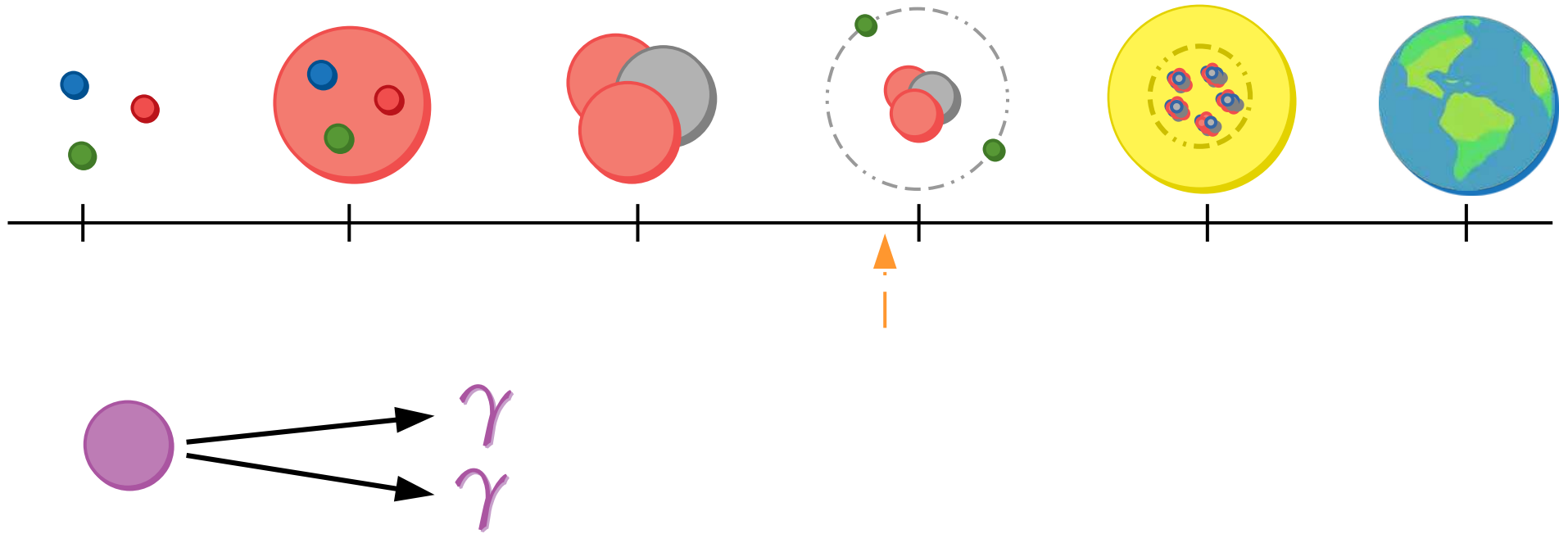


Exotic energy injections

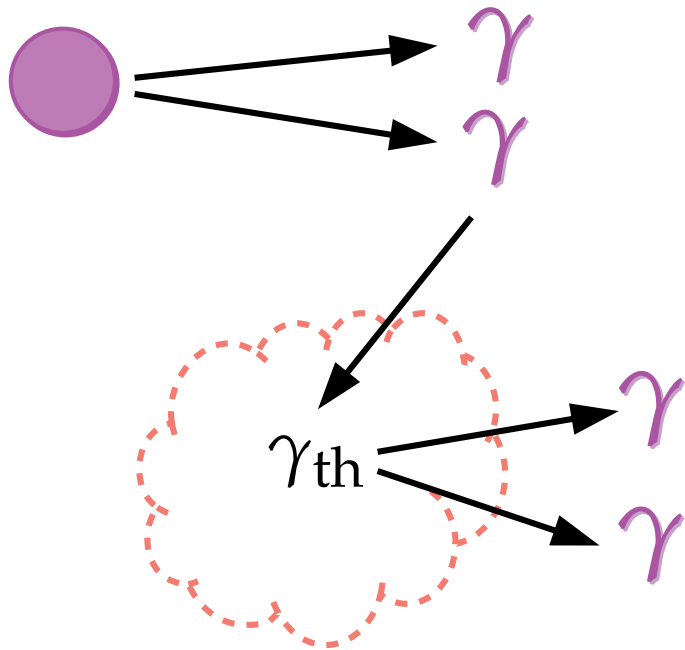
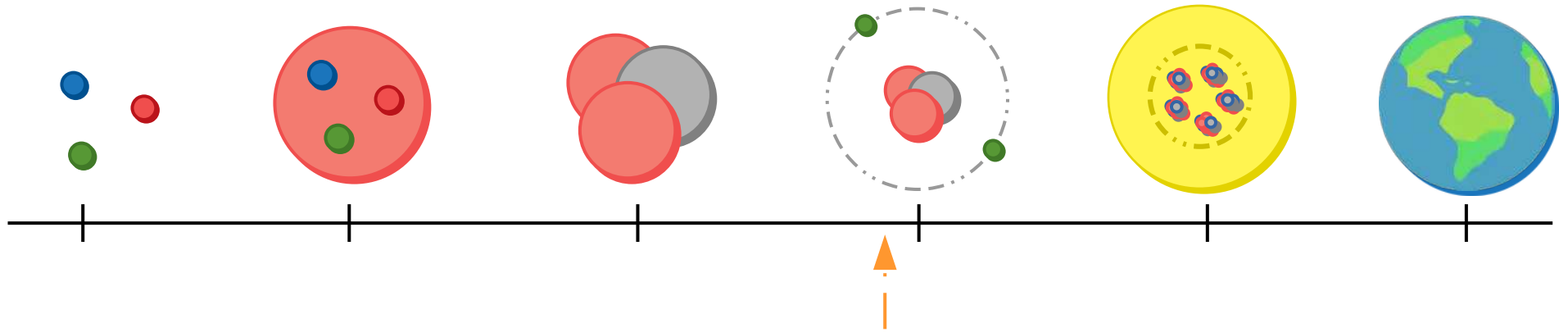


BBN photodisintegration

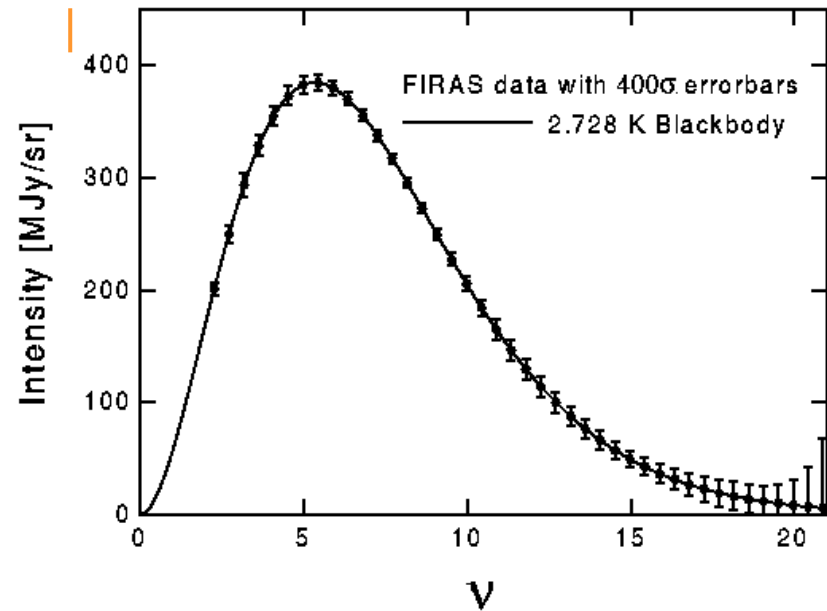
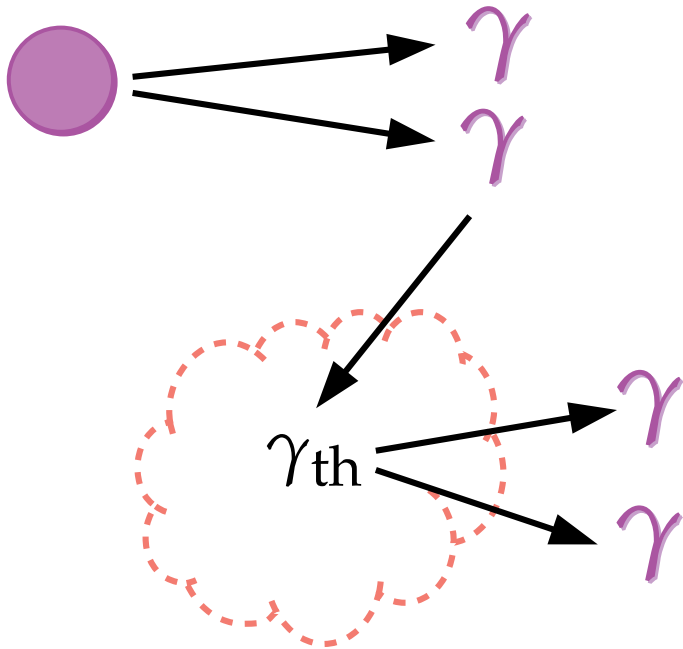
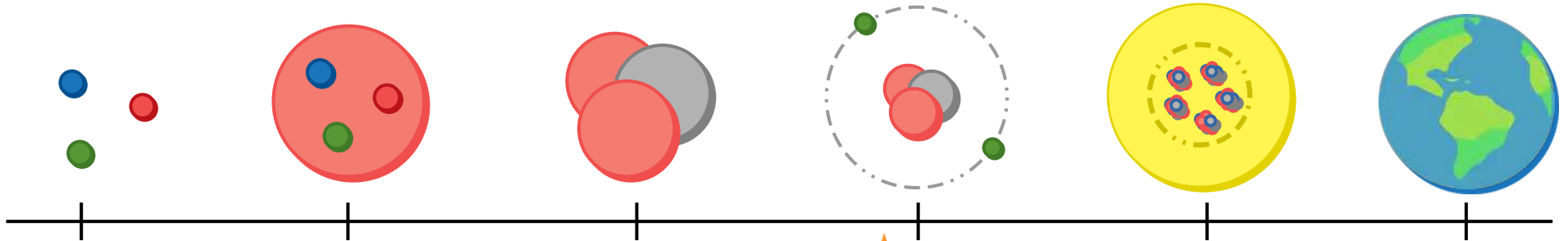
Exotic energy injections



Exotic energy injections

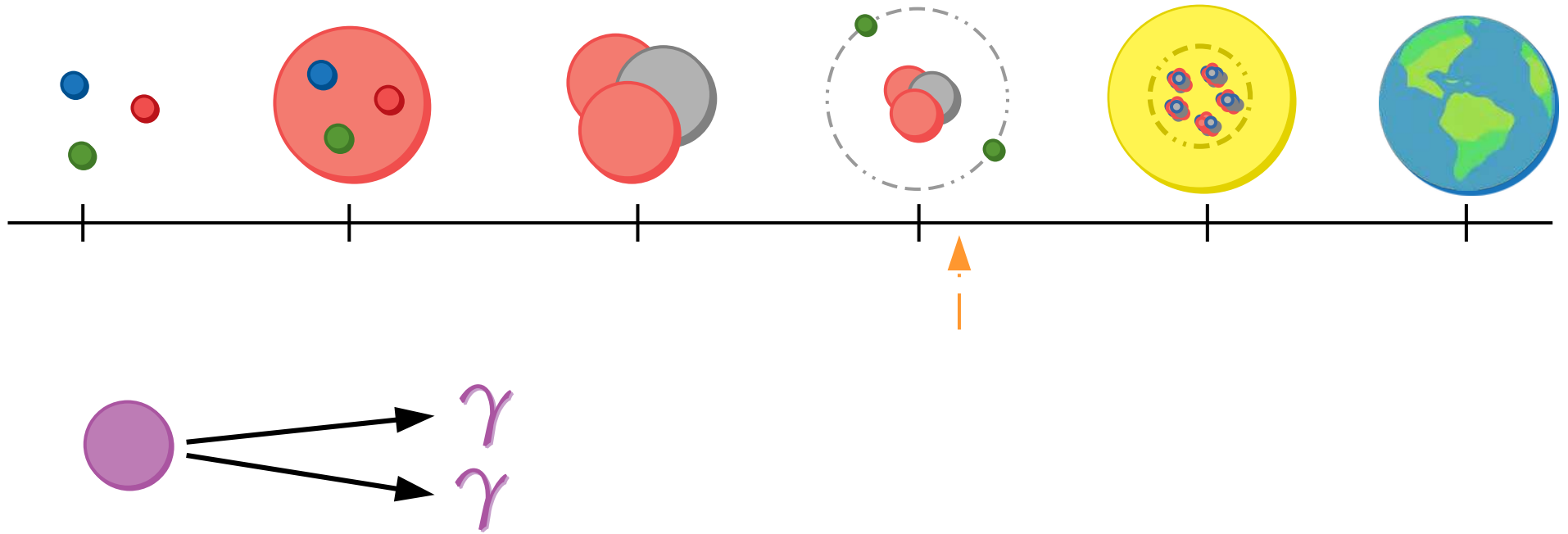


Exotic energy injections

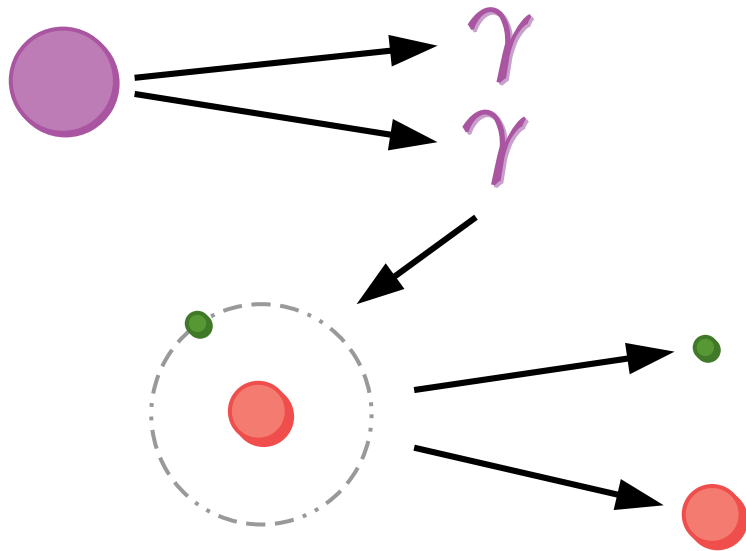
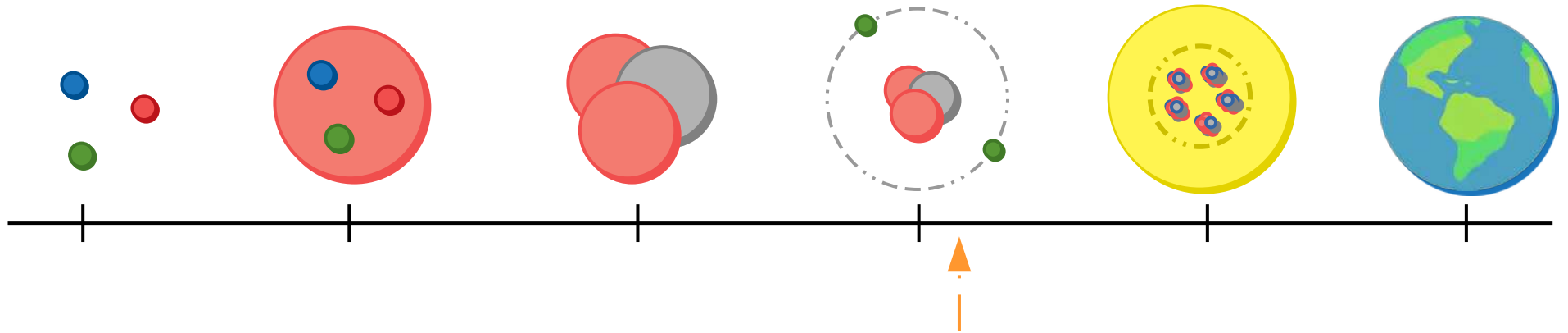


CMB spectral distortions

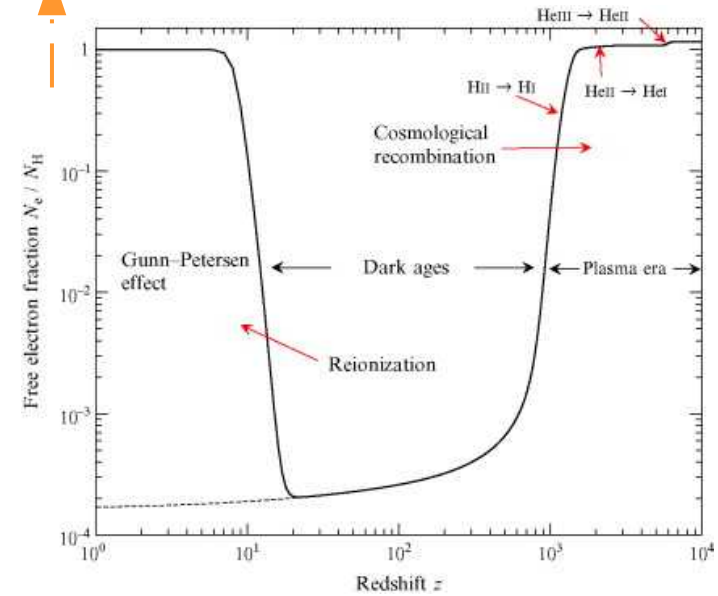
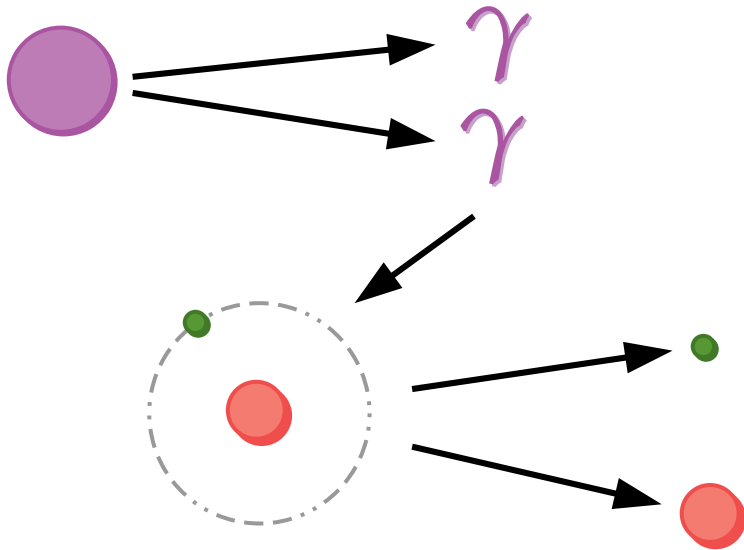
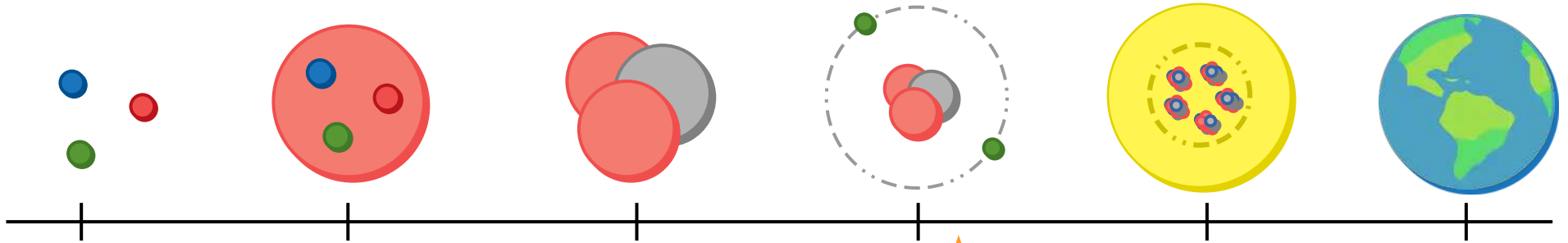
Exotic energy injections



Exotic energy injections

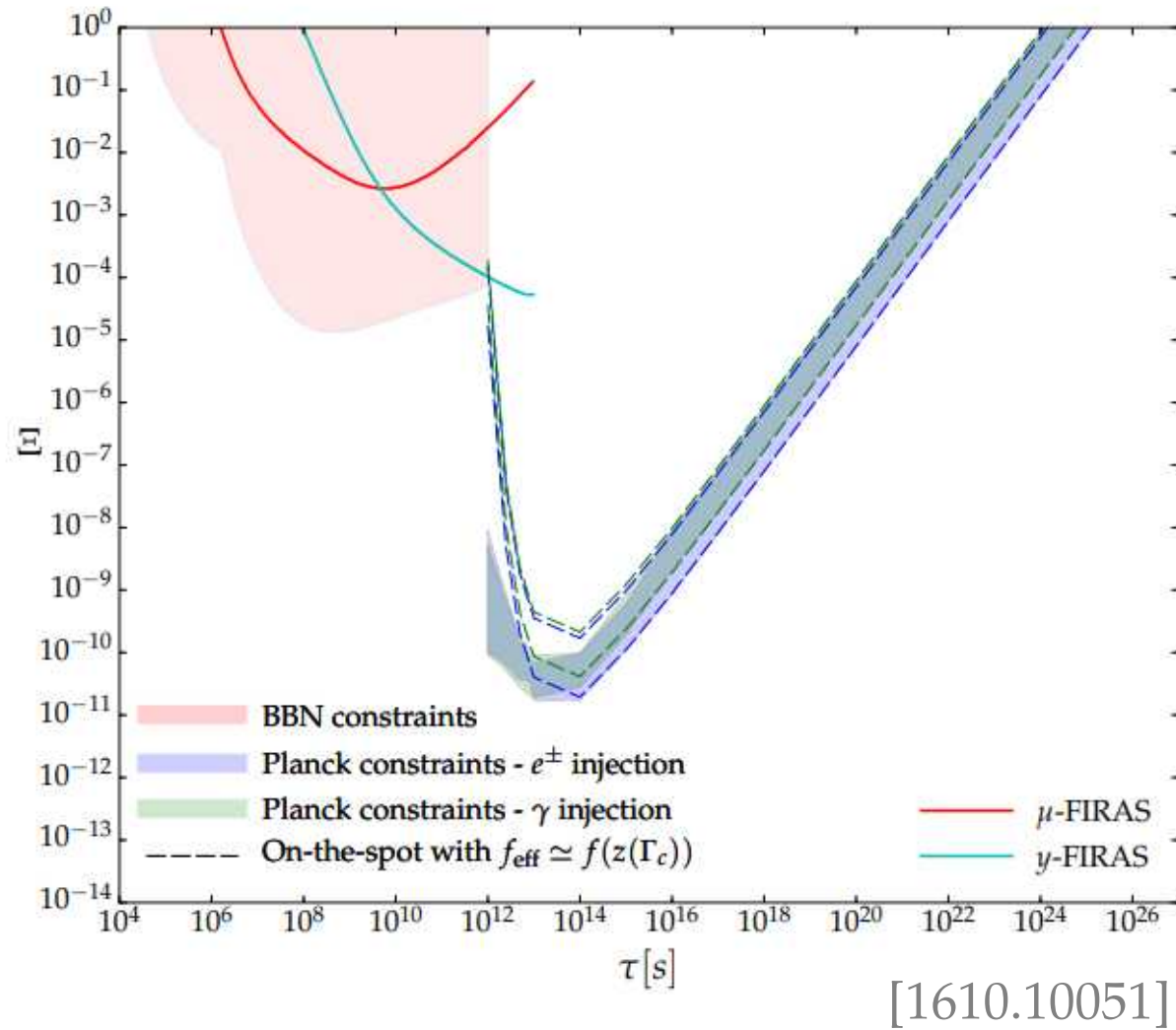


Exotic energy injections

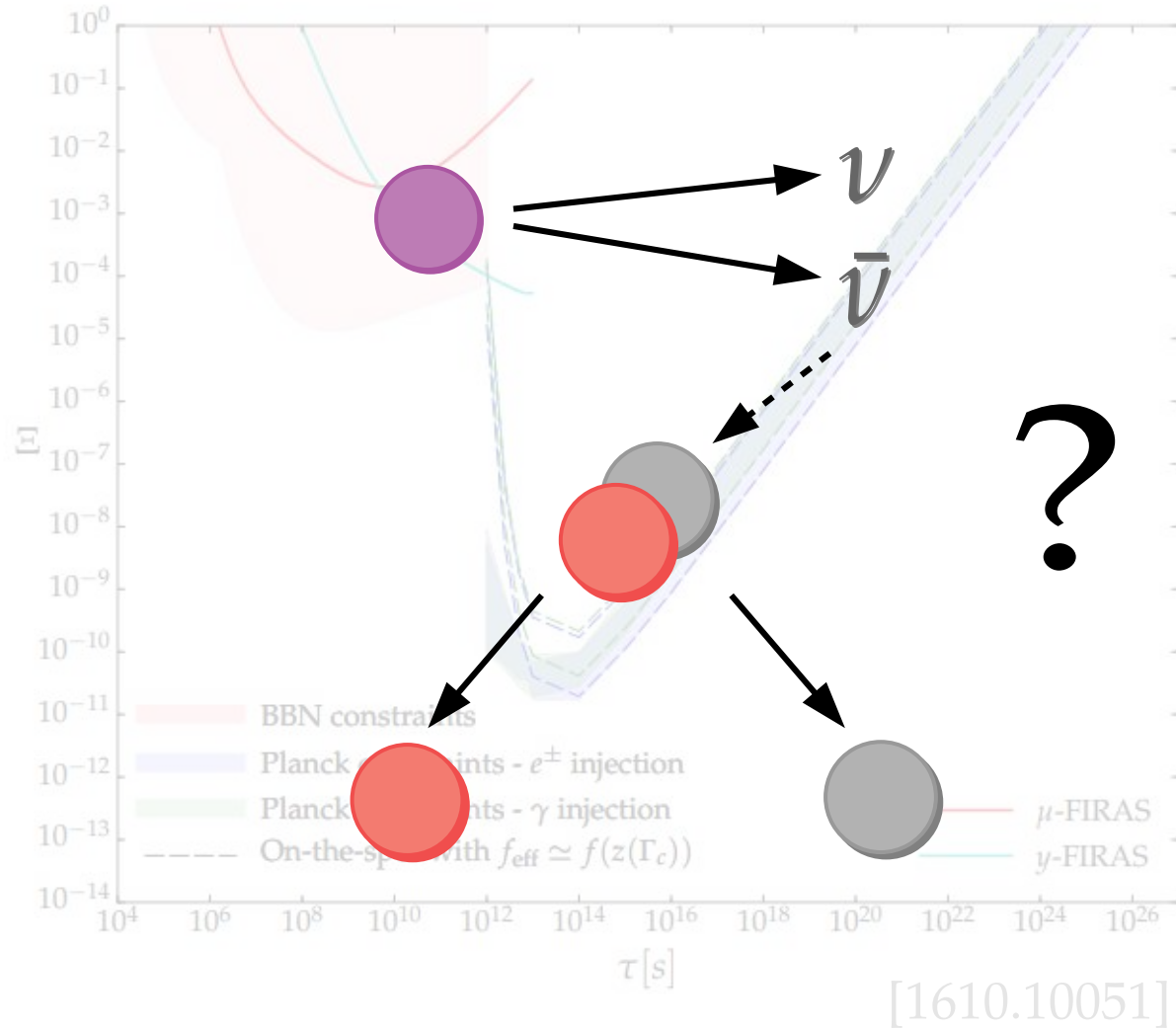


CMB anisotropies

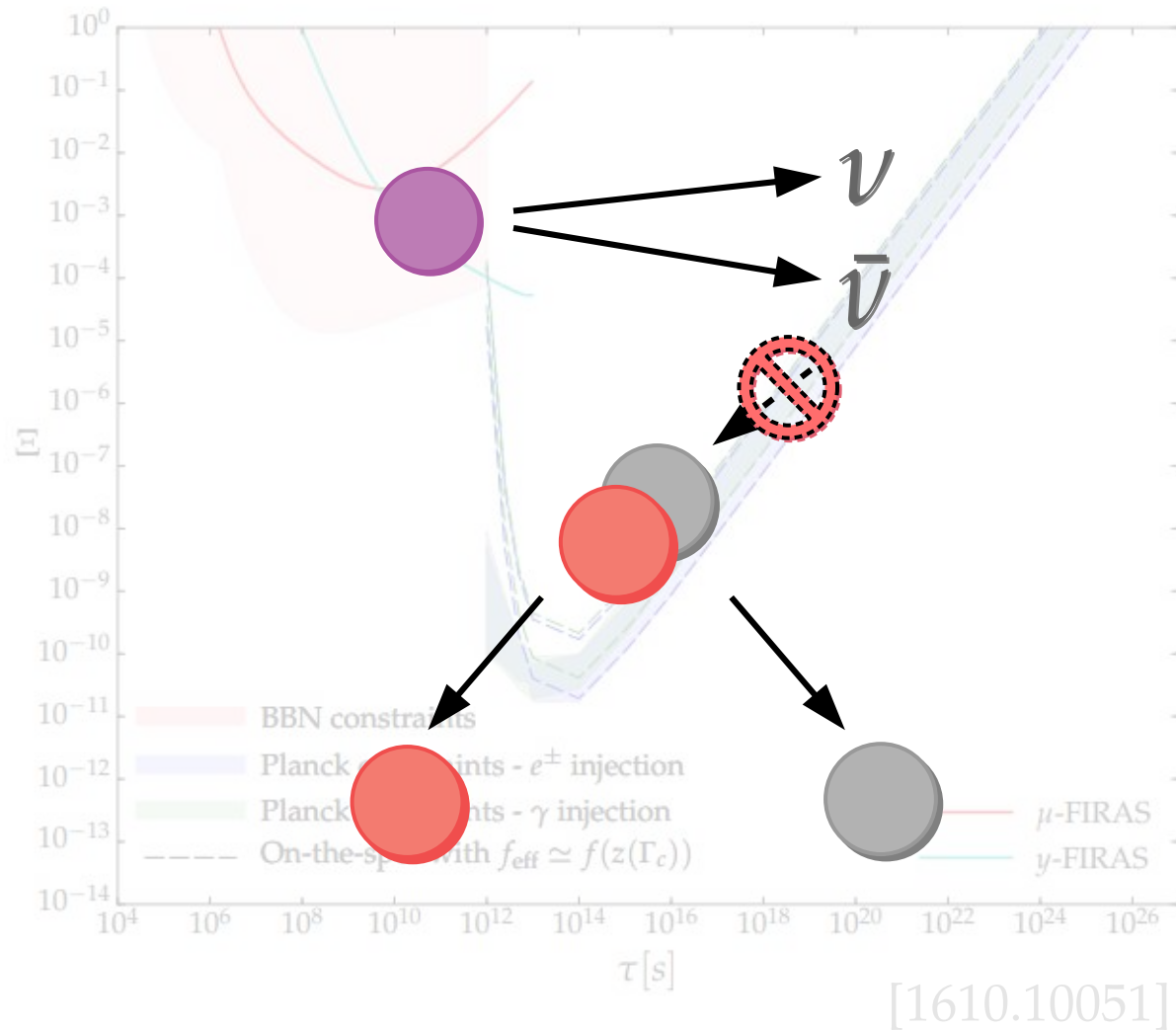
Exotic energy injections



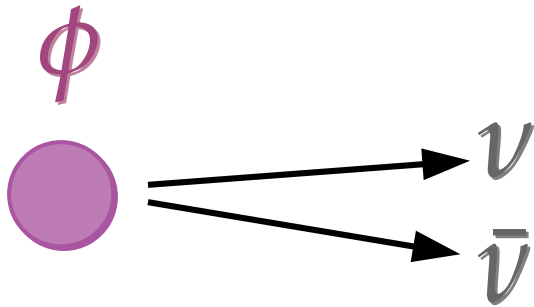
Exotic energy injections



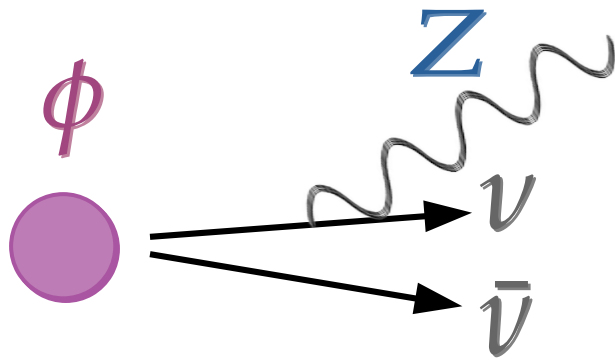
Exotic energy injections



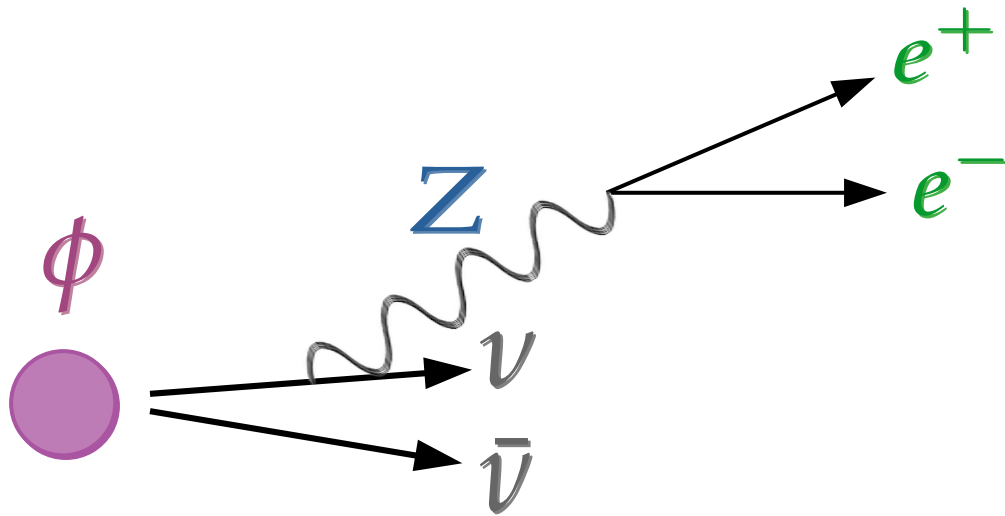
Electroweak shower



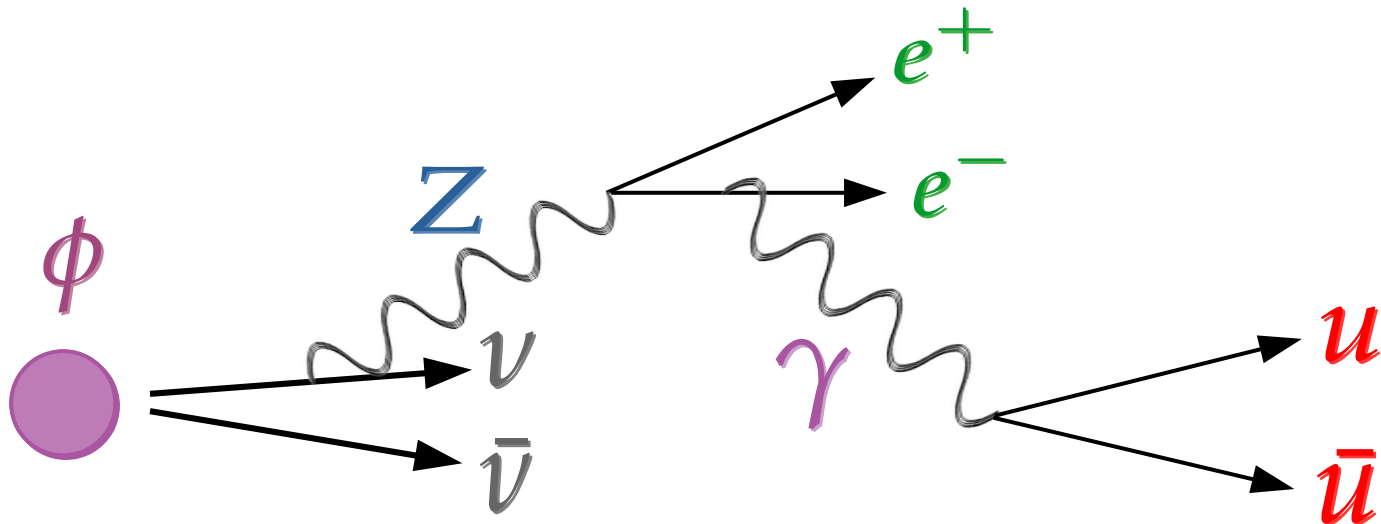
Electroweak shower



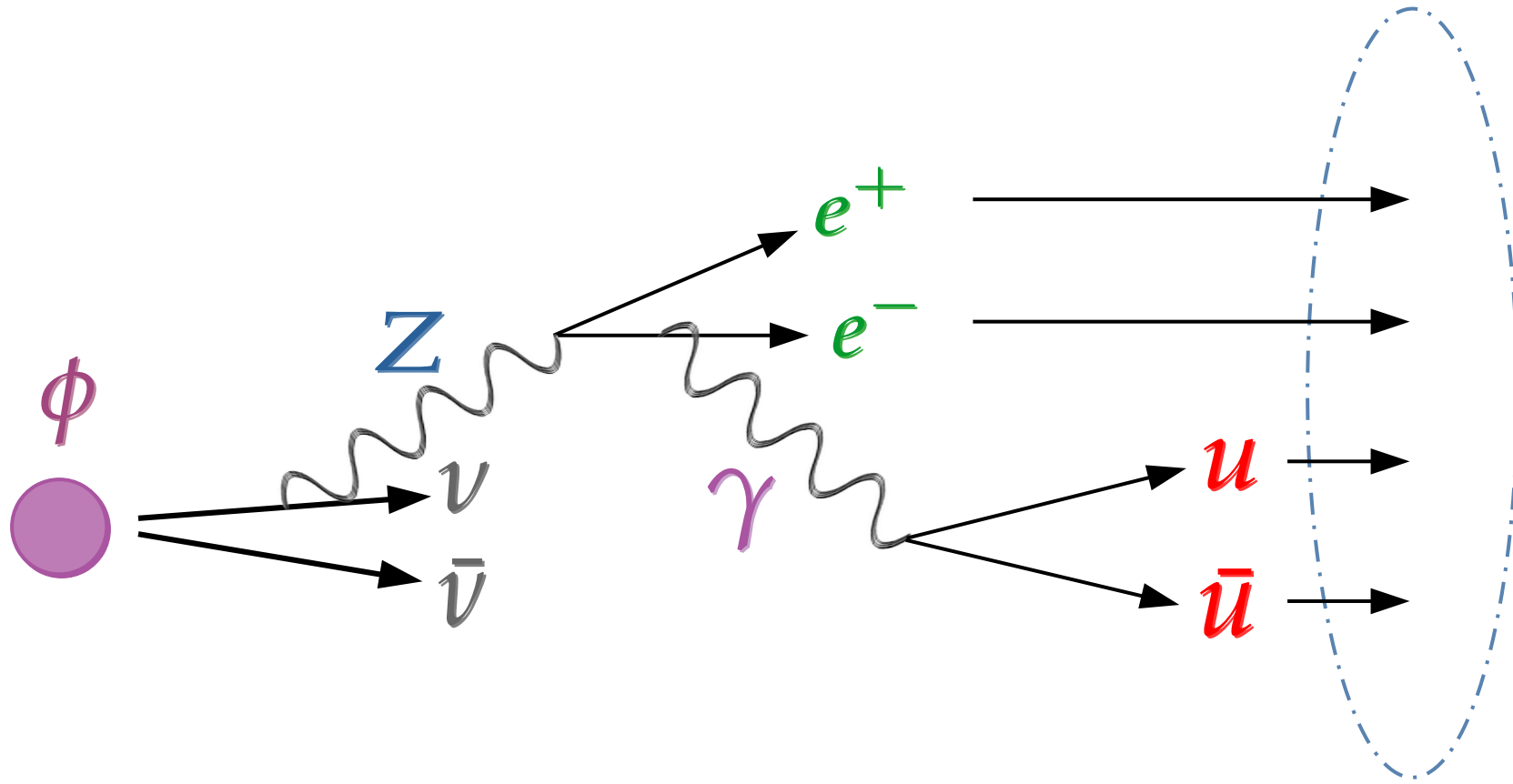
Electroweak shower



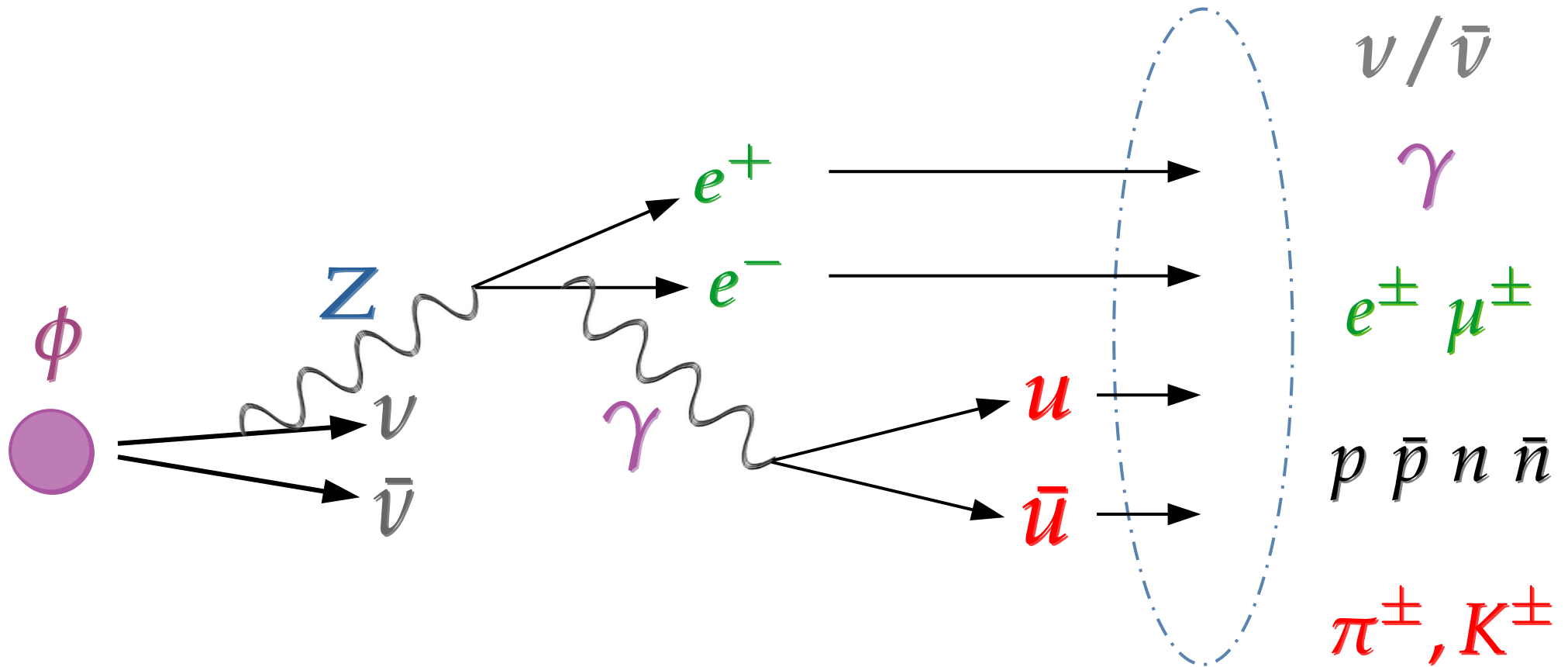
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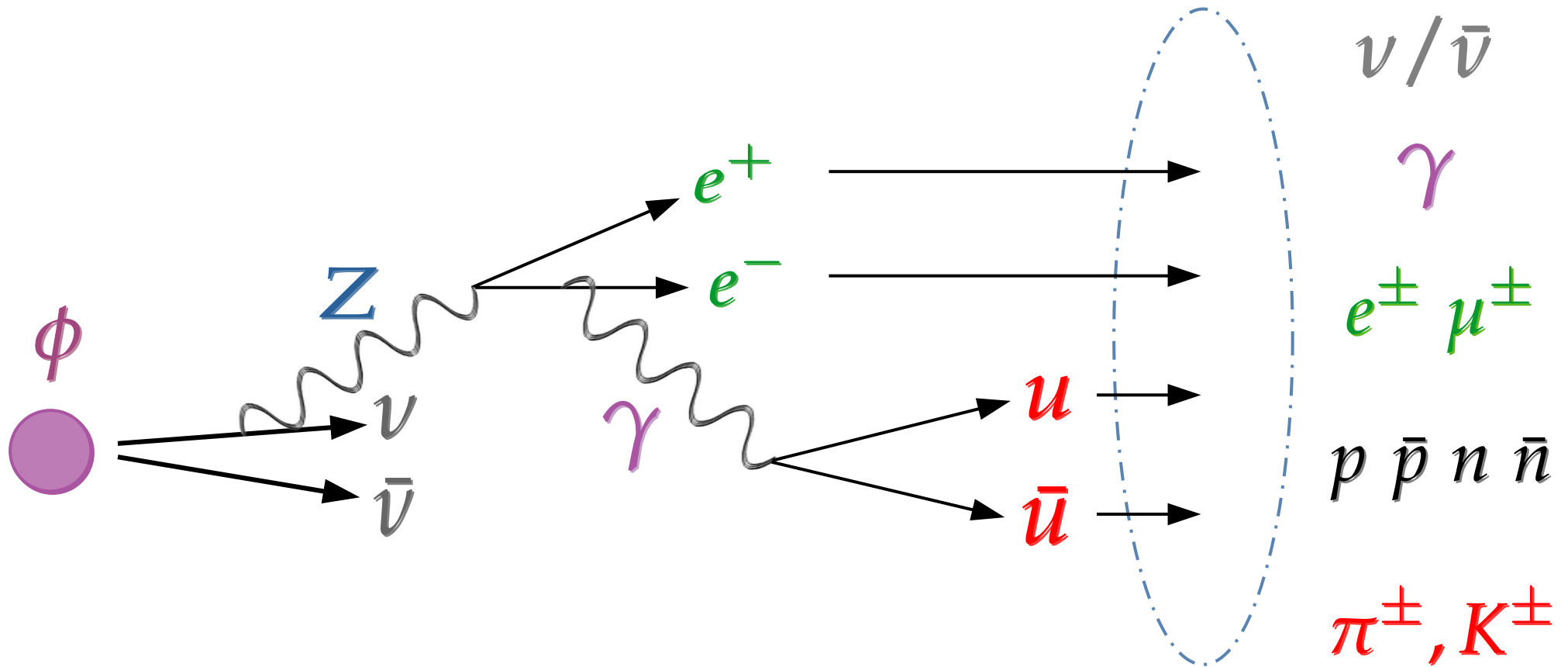
Electroweak shower



Electroweak shower

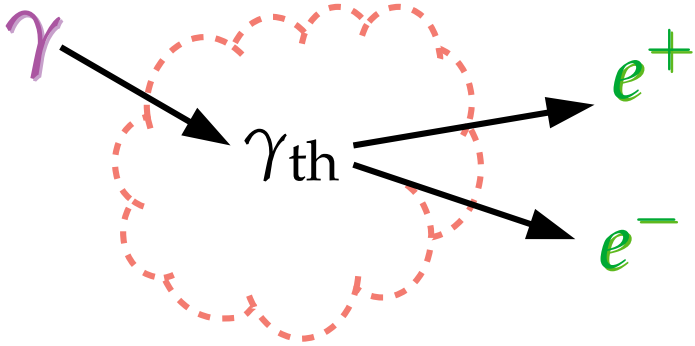


Electroweak shower

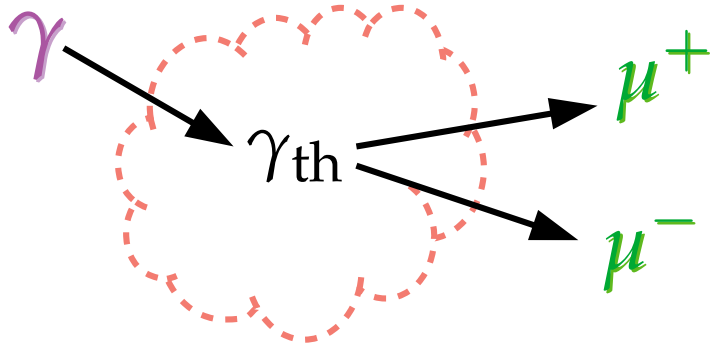


PyTHIA8.3

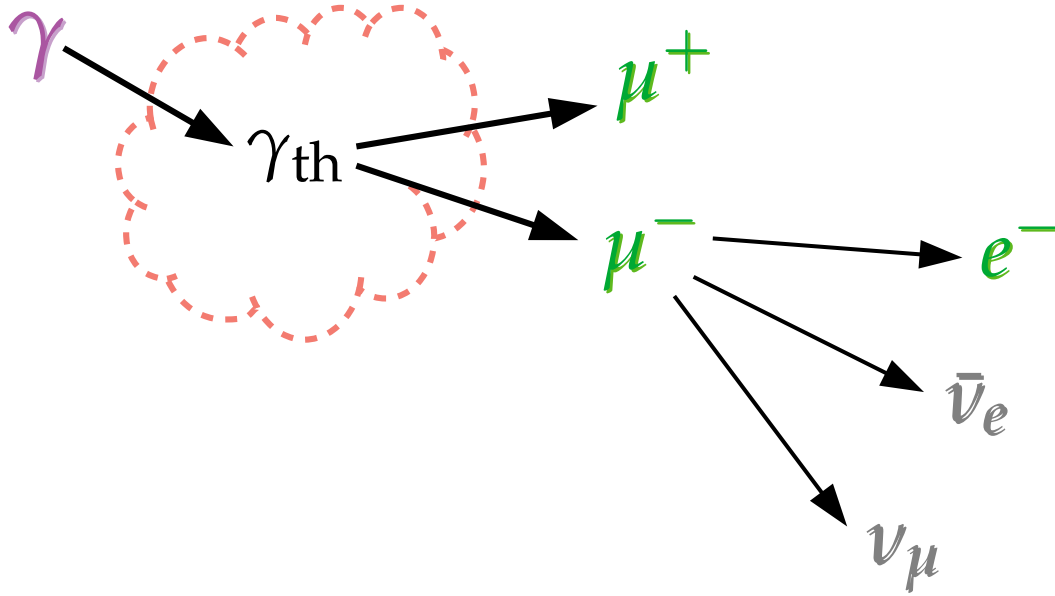
Electromagnetic cascade



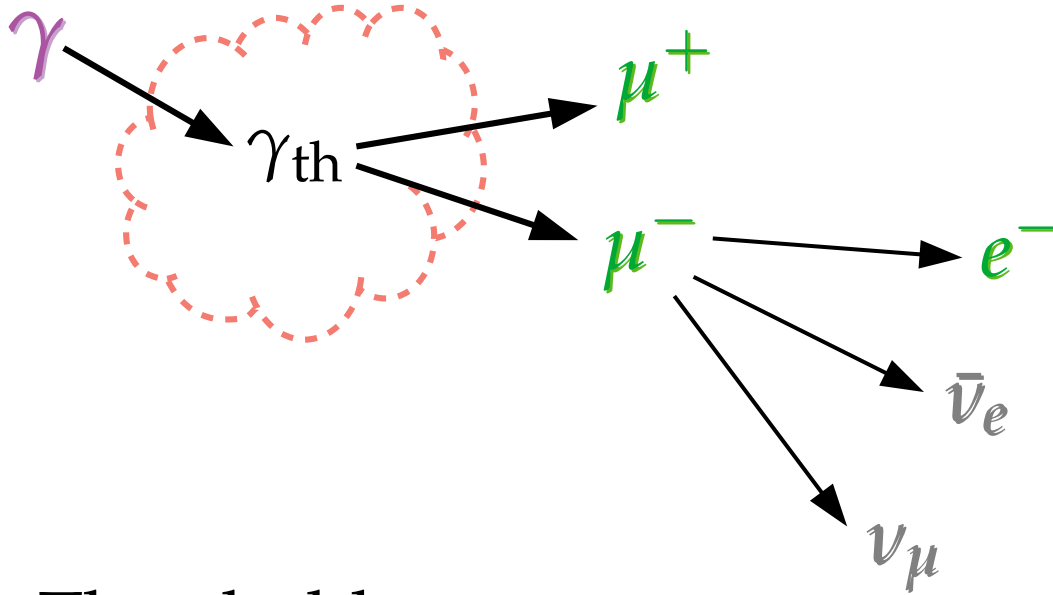
Electromagnetic cascade



Electromagnetic cascade



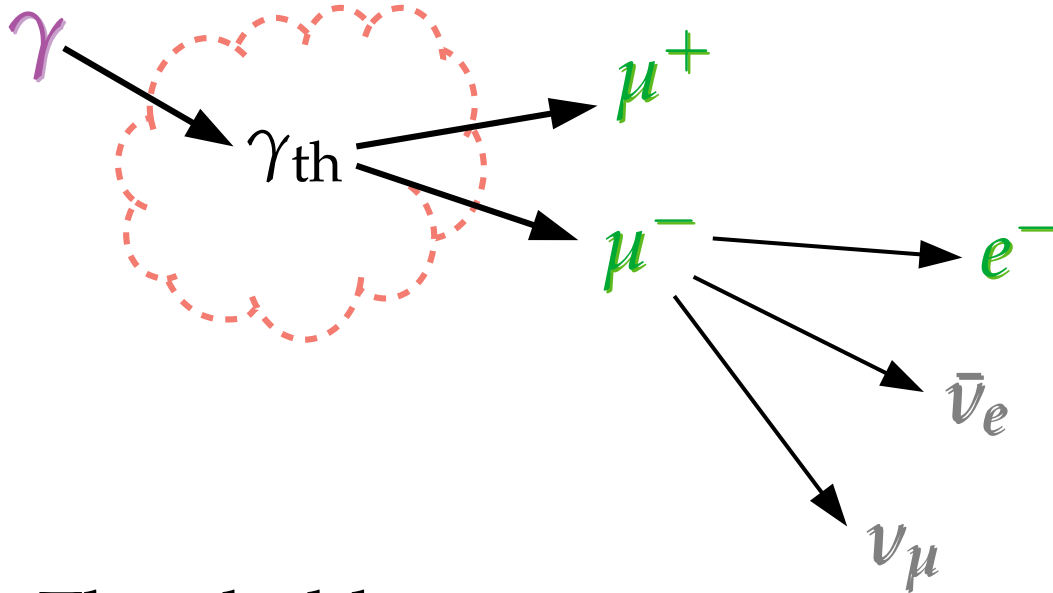
Electromagnetic cascade



Threshold:

$$E_{\text{th}} \sim m_\mu^2 / T$$

Electromagnetic cascade

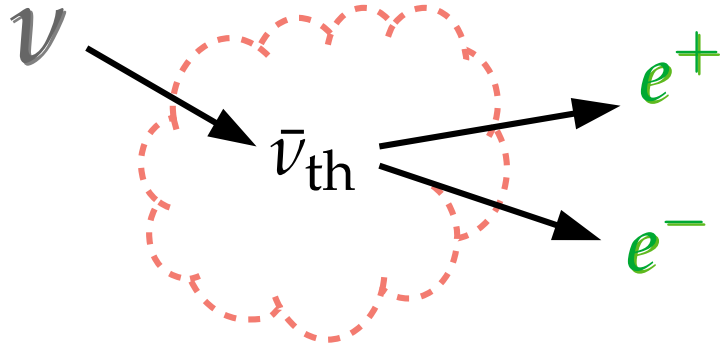


Threshold:

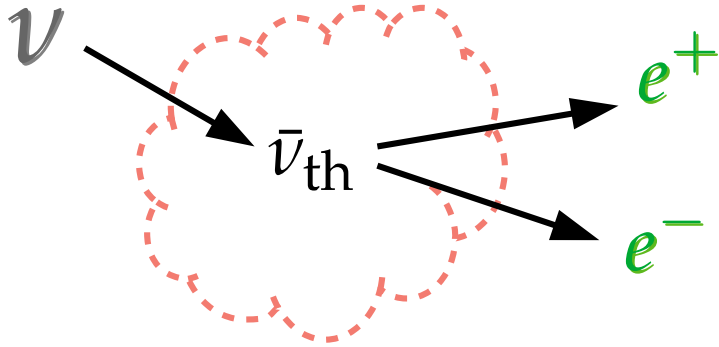
$$E_{\text{th}} \sim m_\phi^2 / T \longrightarrow \tau_\phi \lesssim 10^4 \text{ s} \times (m_\phi / \text{PeV})^2$$

\updownarrow m_ϕ \updownarrow τ_ϕ

Electromagnetic cascade



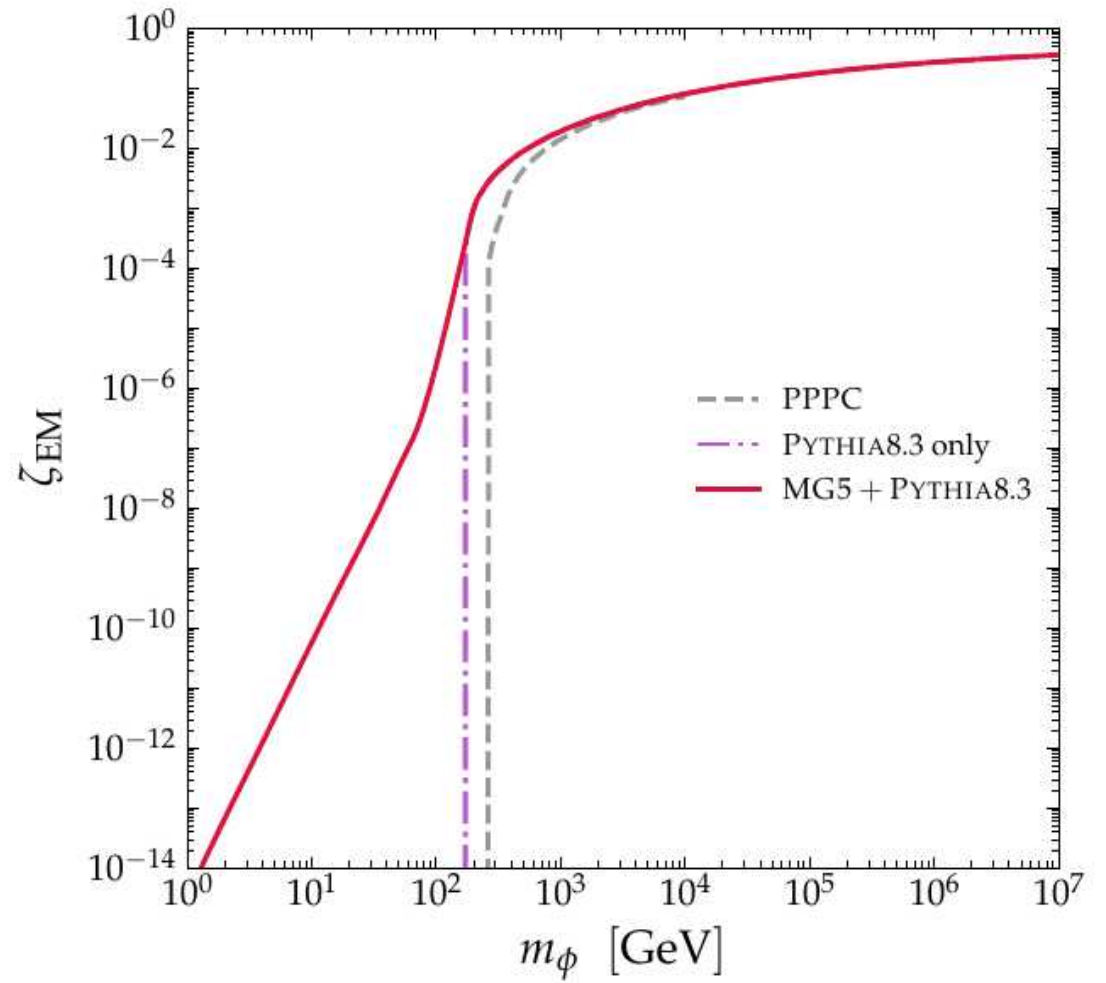
Electromagnetic cascade



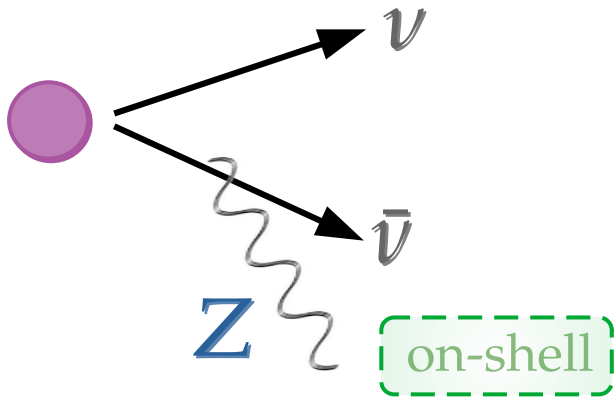
Glashow-like resonance @

$$E_{\text{GR}} \sim m_Z^2 / T_\nu \longrightarrow m_\phi > 10^7 \text{ GeV}$$

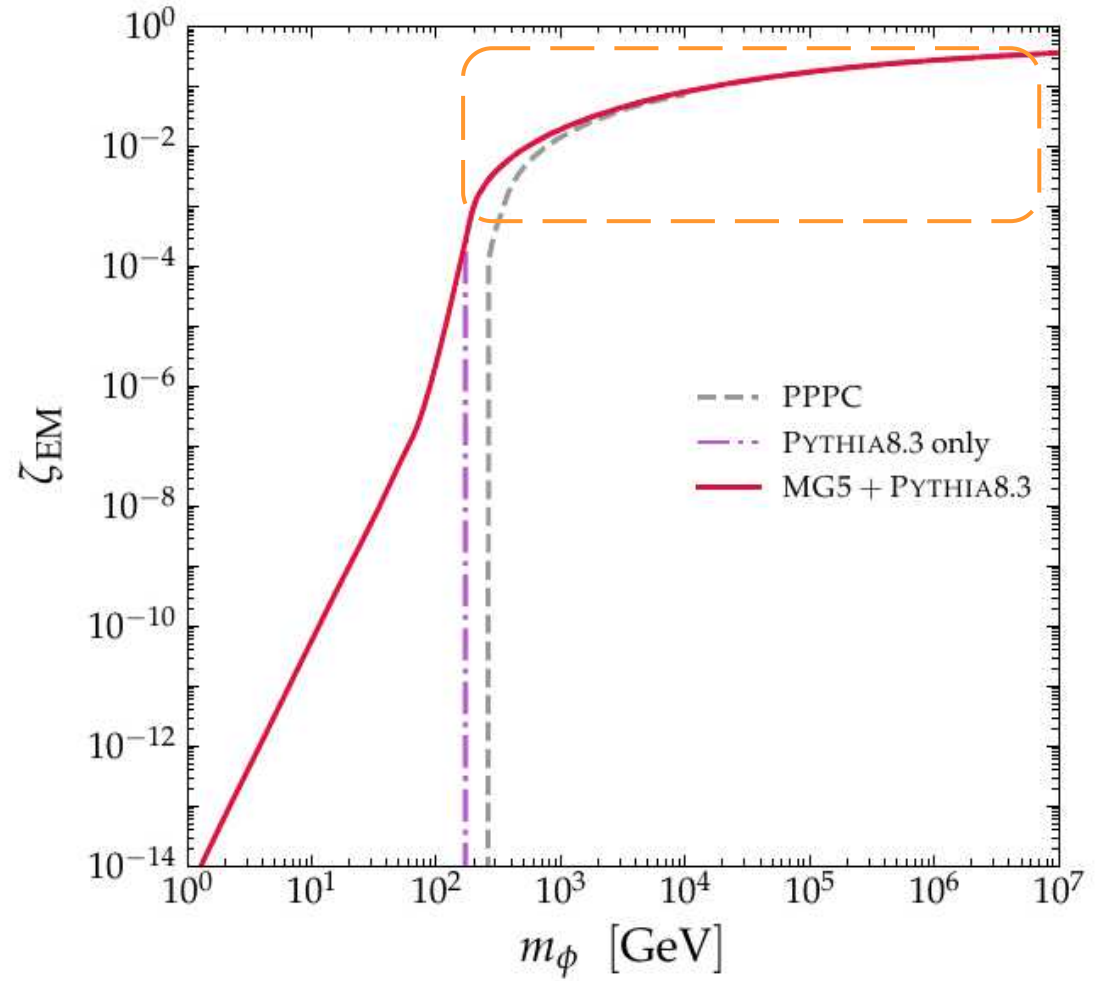
Results



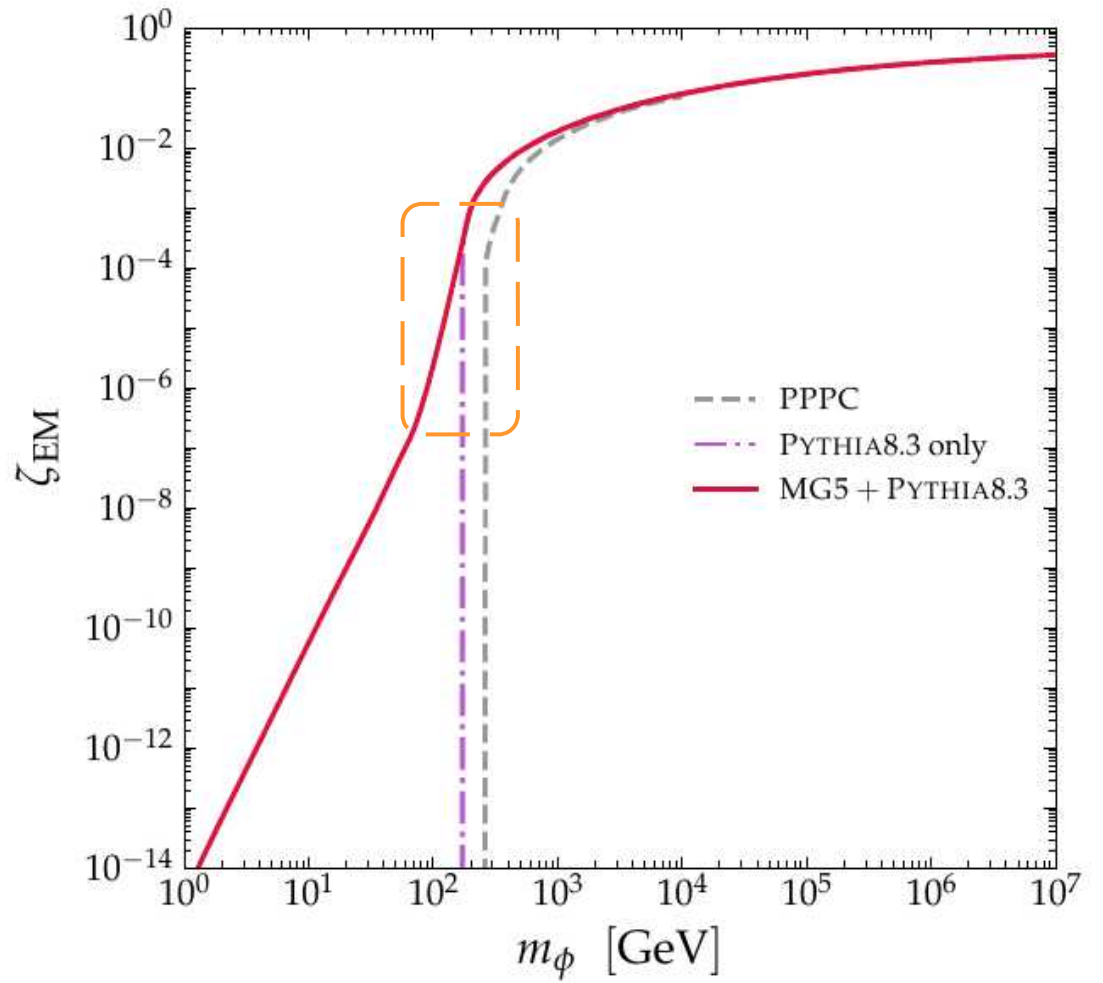
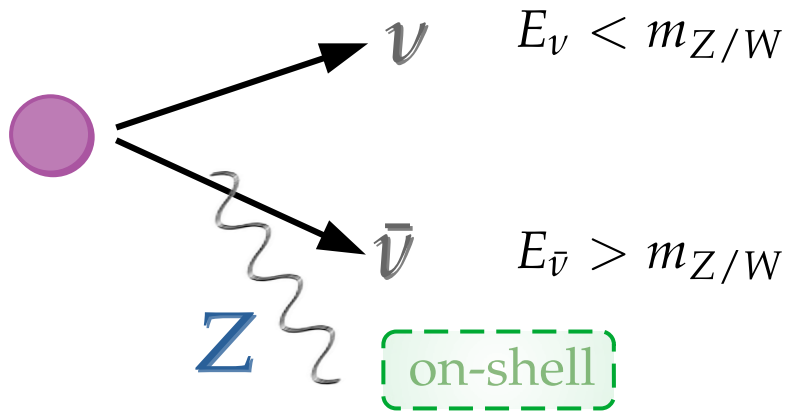
Results



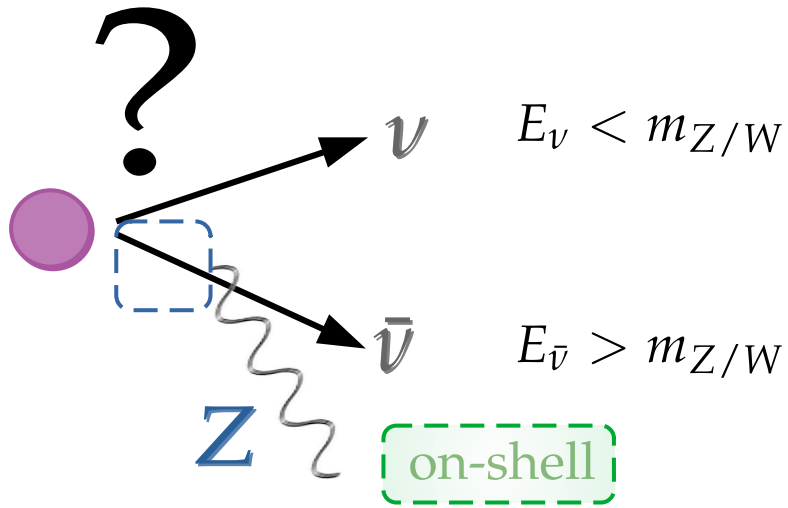
$$E_{\nu, \bar{\nu}} = m_{\phi}/2 > m_{Z, W}$$



Results

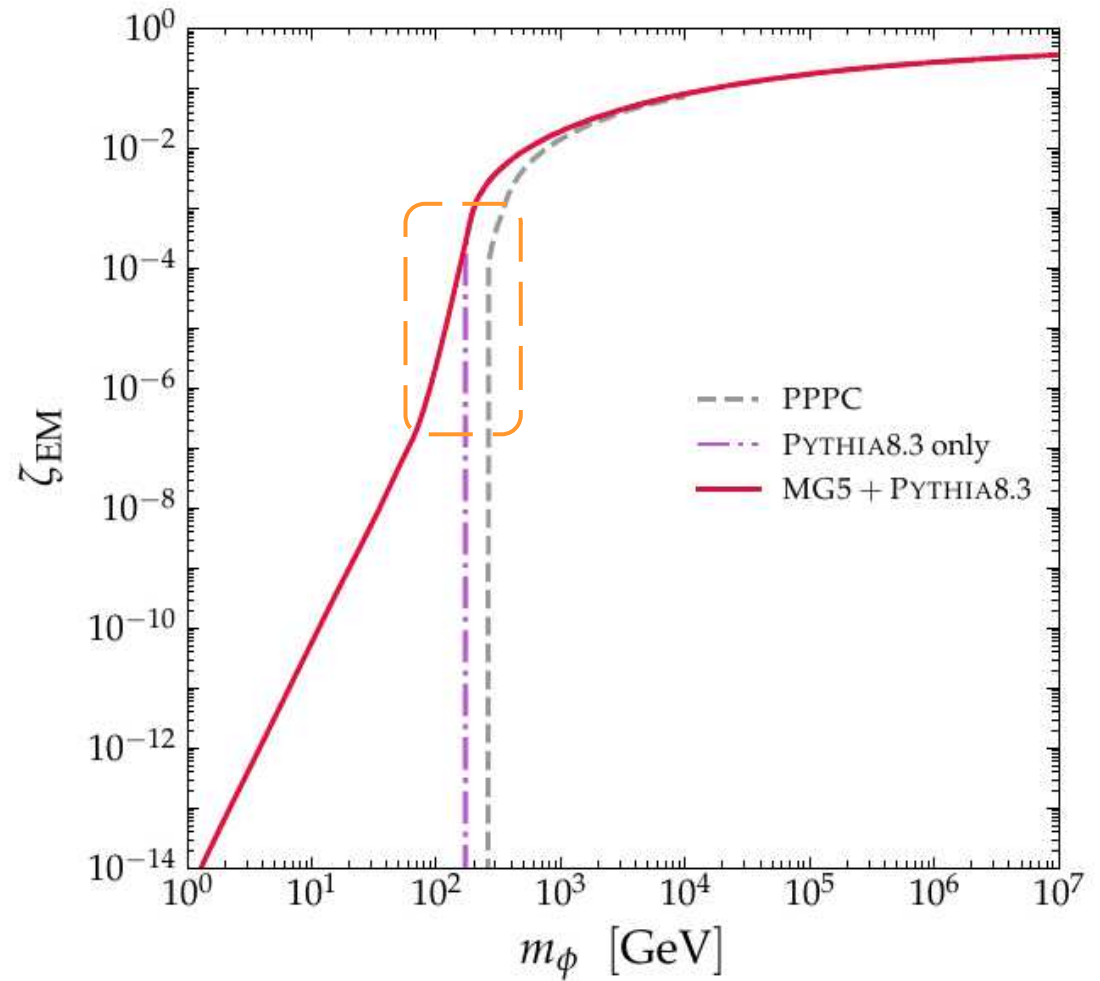


Results

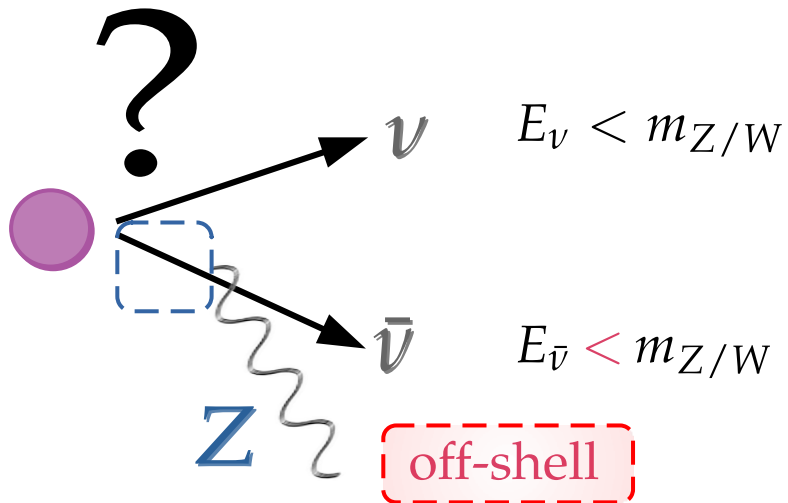


Toy Model:

$$\mathcal{L} \subset \lambda_e \phi_\mu \bar{\nu}_e \gamma^\mu P_L \nu_e$$

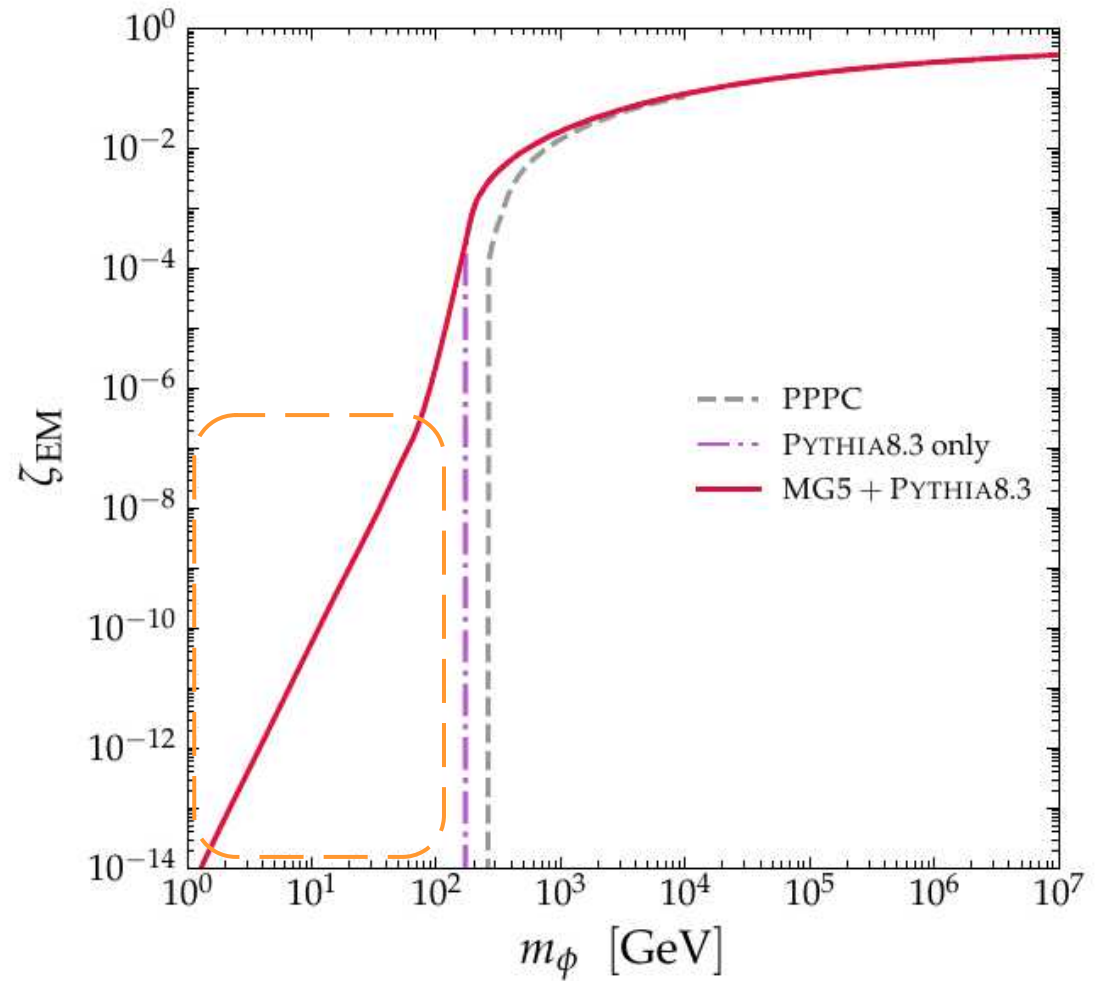


Results



Toy Model:

$$\mathcal{L} \subset \lambda_e \phi_\mu \bar{\nu}_e \gamma^\mu P_L \nu_e$$



Results

BBN

ACROPOLIS

[2011.06518]

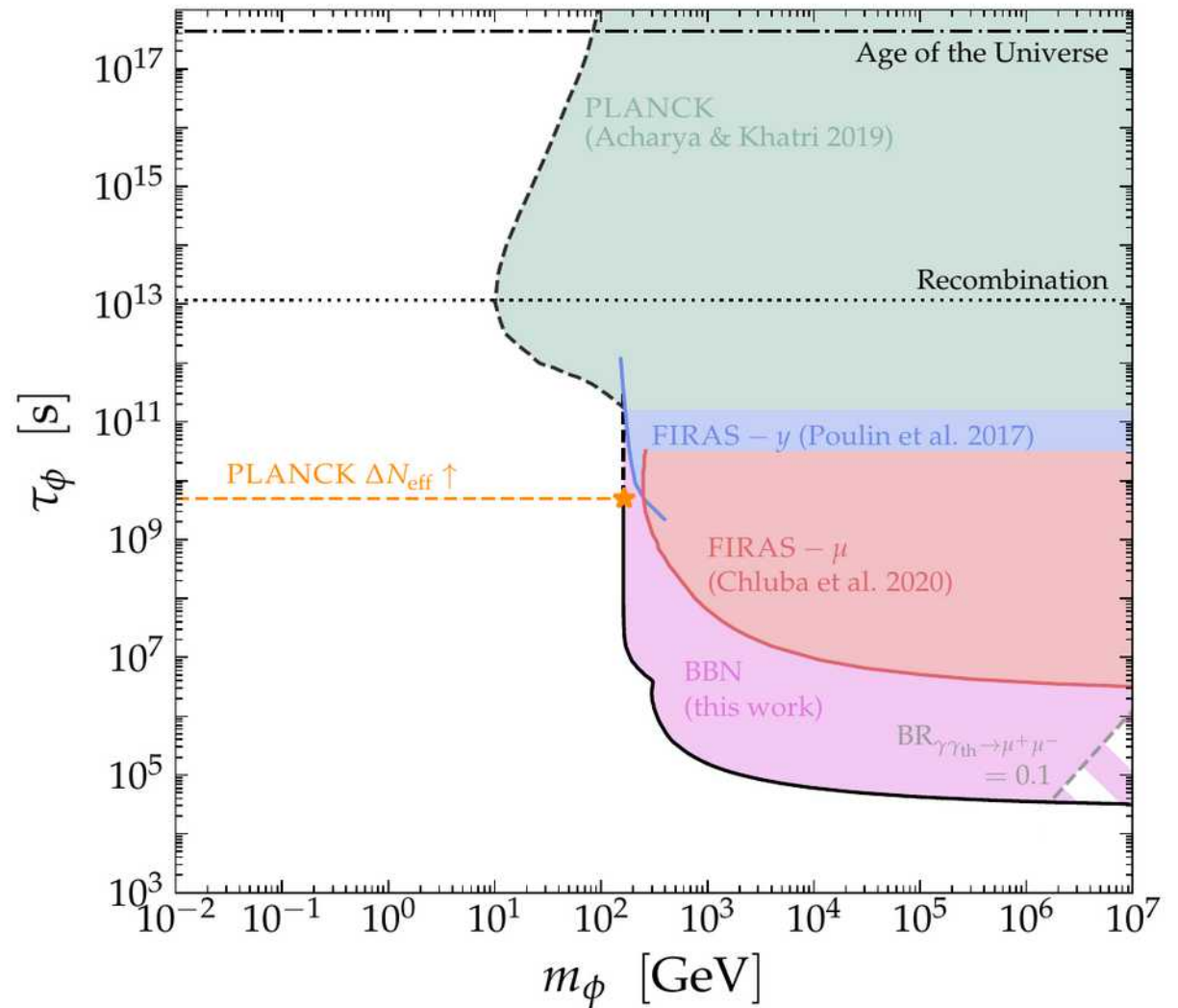
CMB

Rescale results in
 $f_\phi \zeta_{\text{EM}} - \tau_\phi$ plane

[1910.06272]

[1610.10051]

[2005.11325]



Results

BBN

ACROPOLIS

[2011.06518]

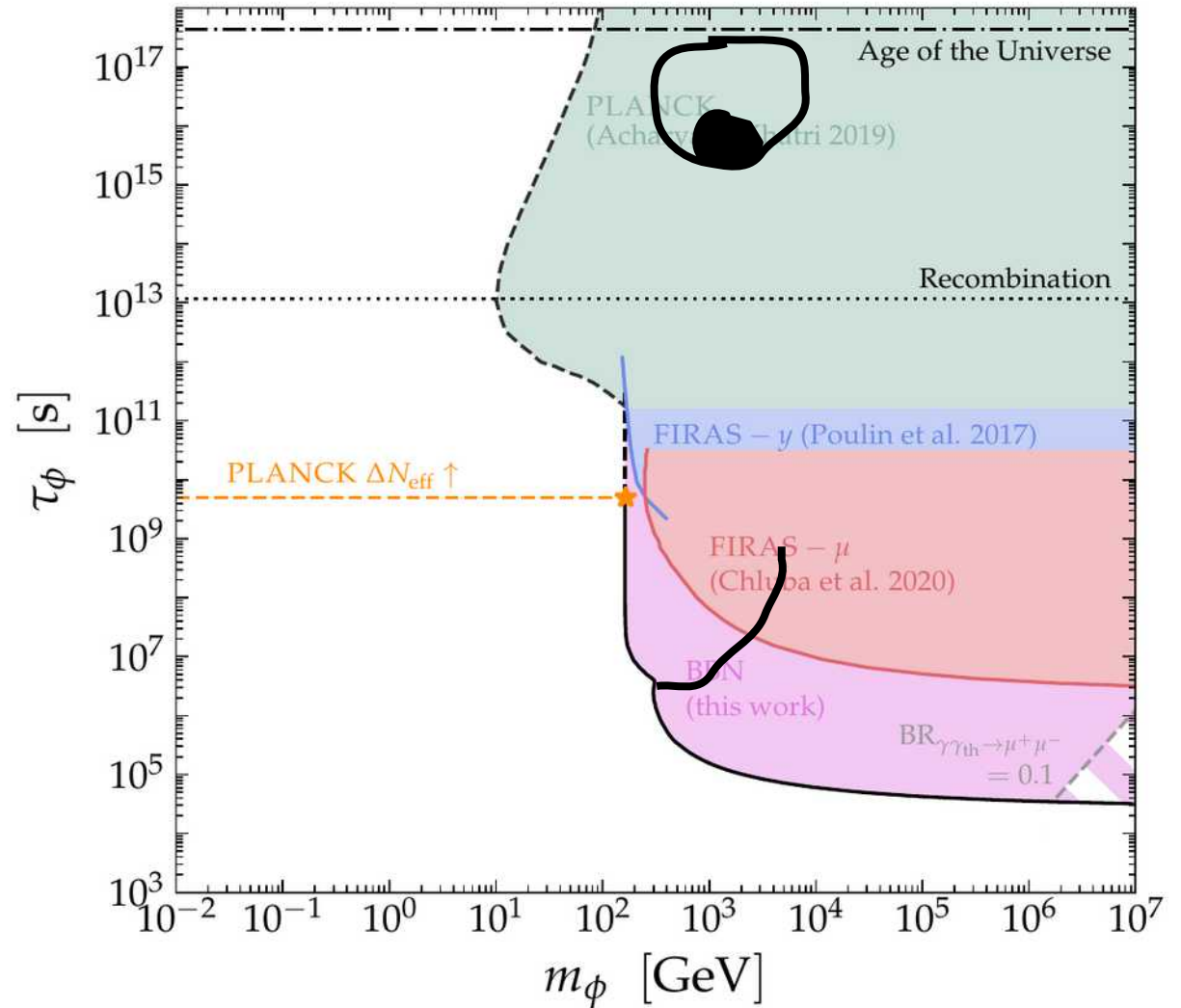
CMB

Rescale results in
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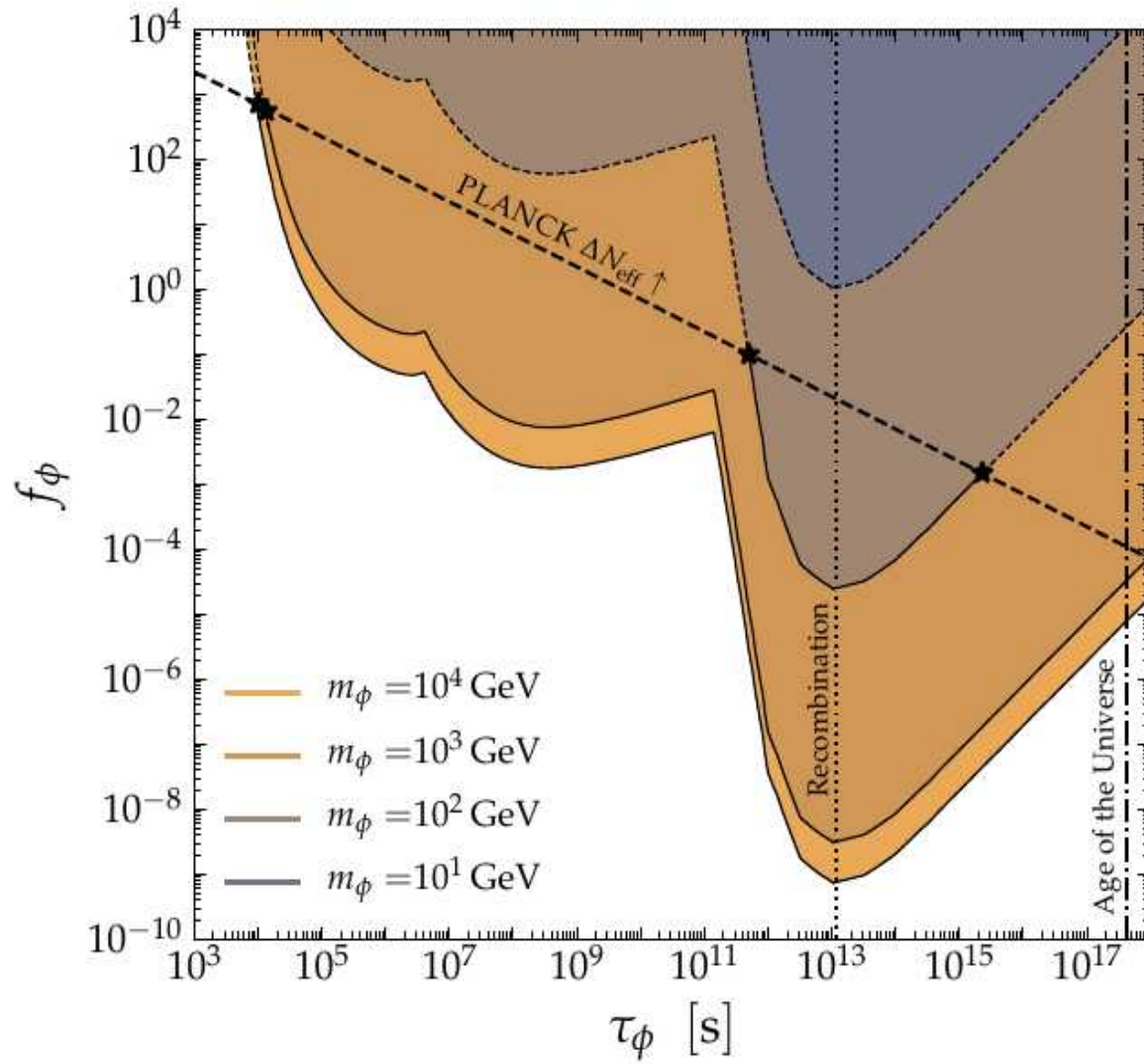
[1910.06272]

[1610.10051]

[2005.11325]



Results



Conclusions

- Even particles decaying into neutrinos can be severely constrained by cosmological observables
- The evaluation of ζ_{EM} is possible down to a few GeV (up to a slight model dependence)
- The improved curve for $\zeta_{\text{EM}}(m_\phi)$ might also have consequences for other scenarios
 - Potentially stronger limits

