

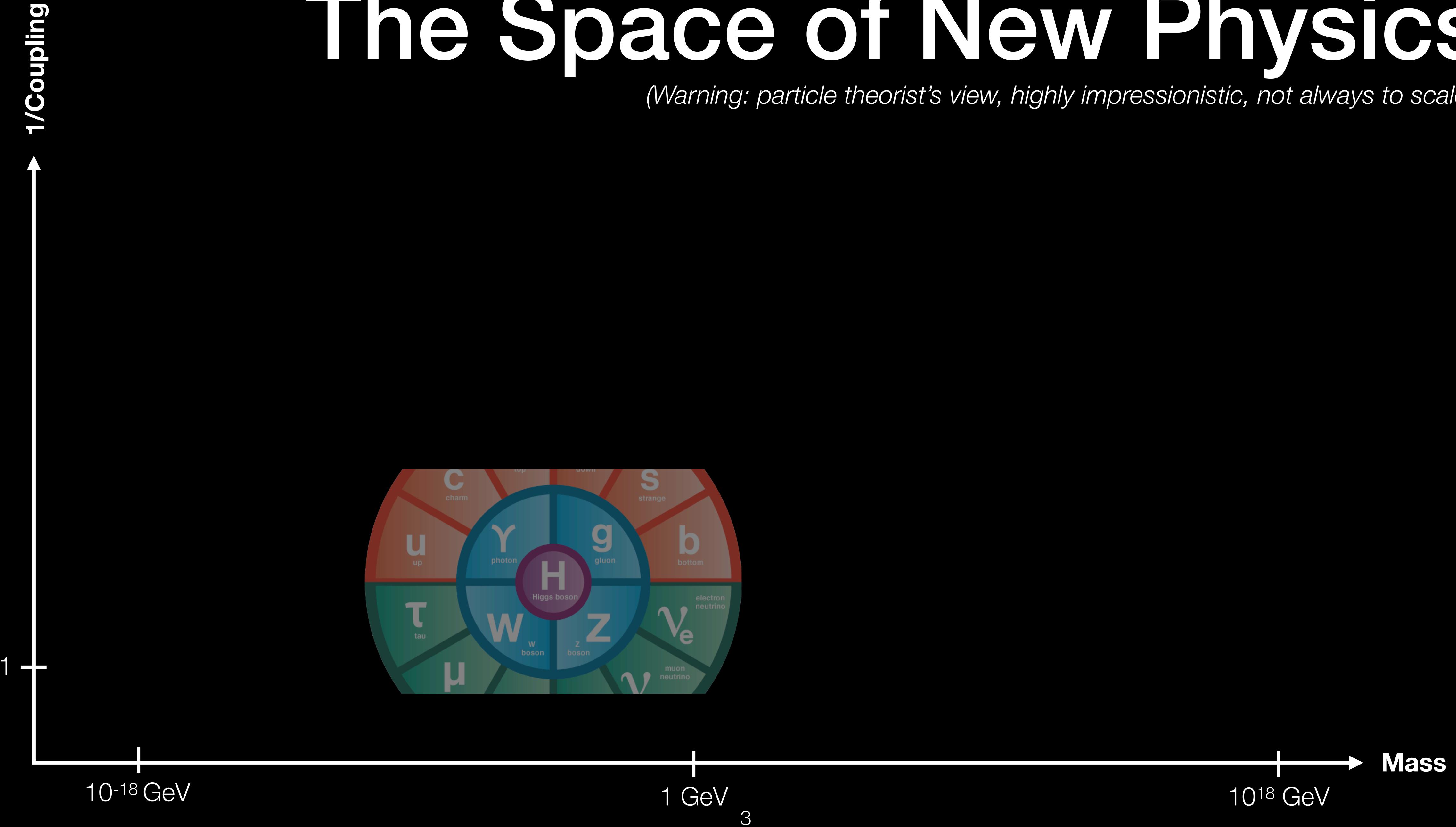


# Personal views ahead

Wildly oversimplified for talk length.  
Caveats abound. Your mileage may vary.

# The Space of New Physics

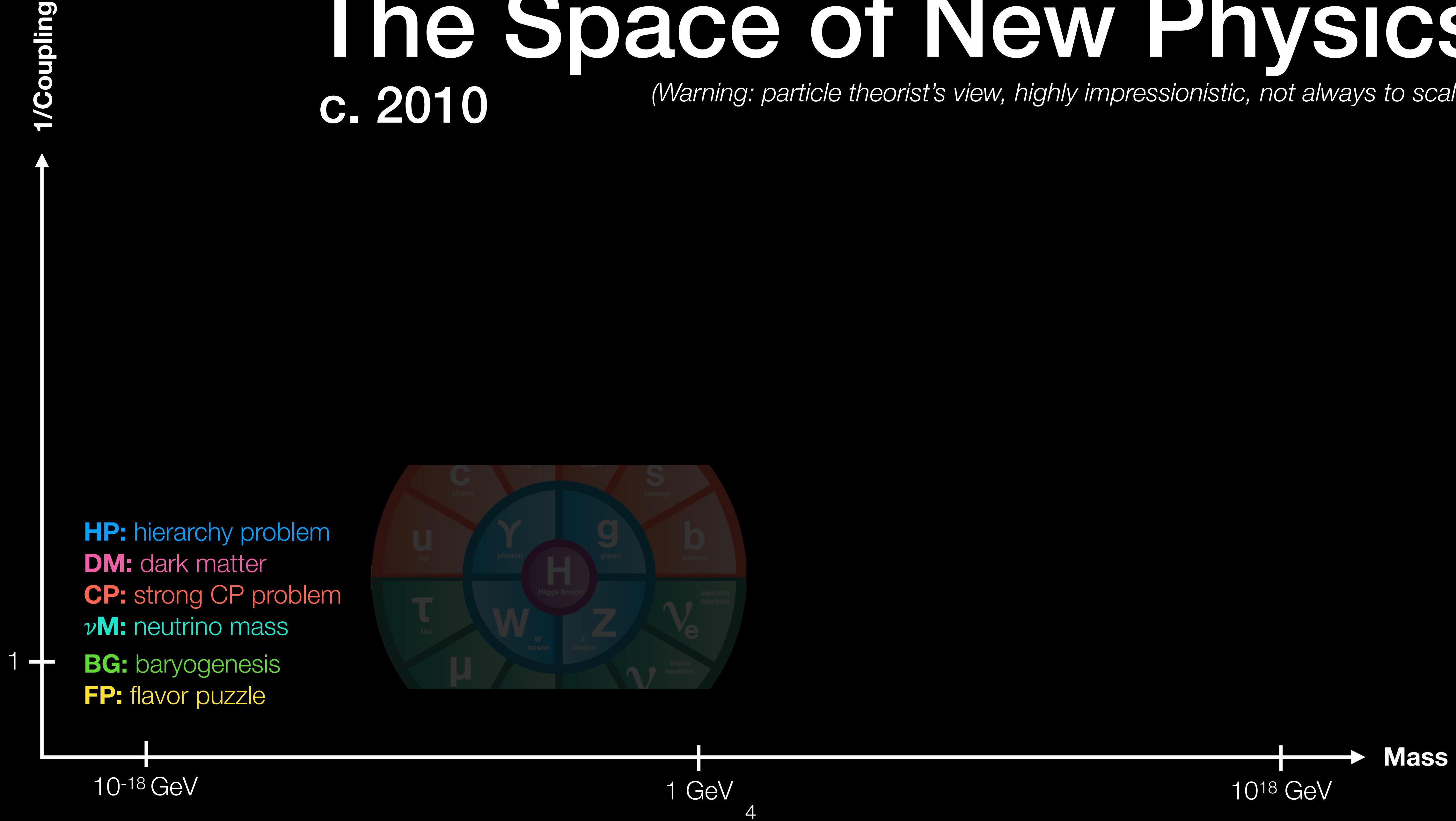
(Warning: particle theorist's view, highly impressionistic, not always to scale)



# The Space of New Physics

c. 2010

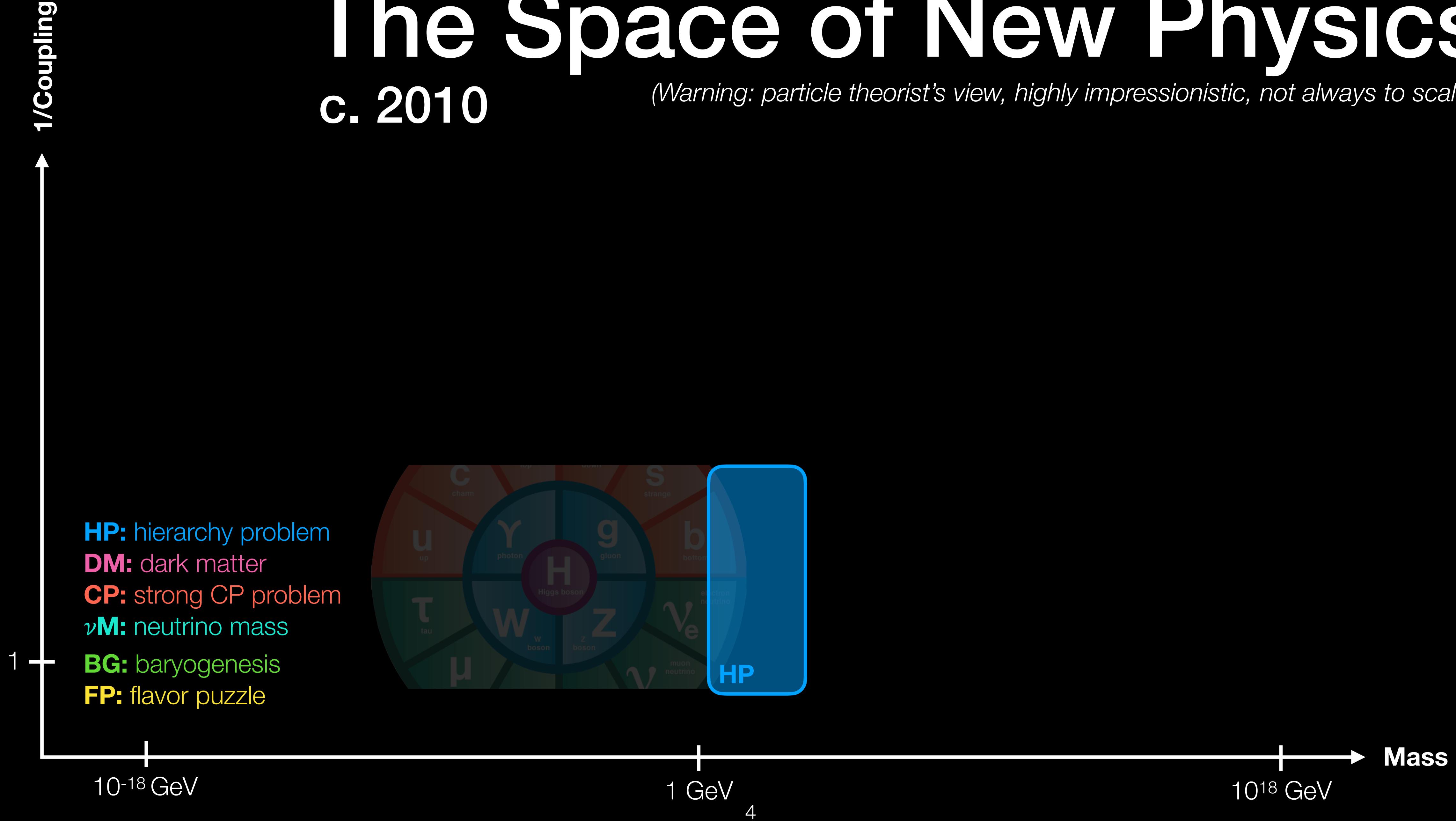
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# The Space of New Physics

c. 2010

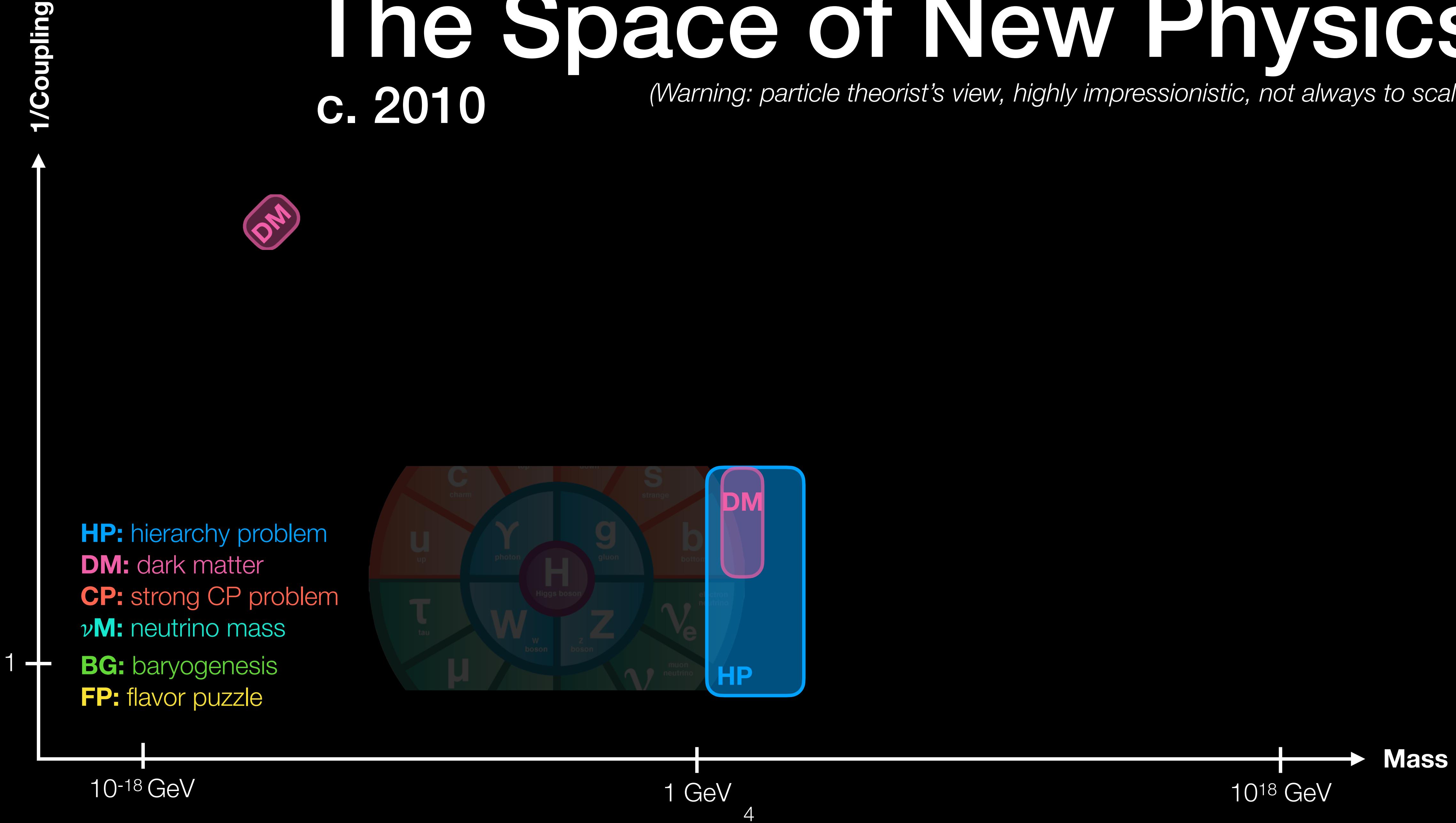
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# The Space of New Physics

c. 2010

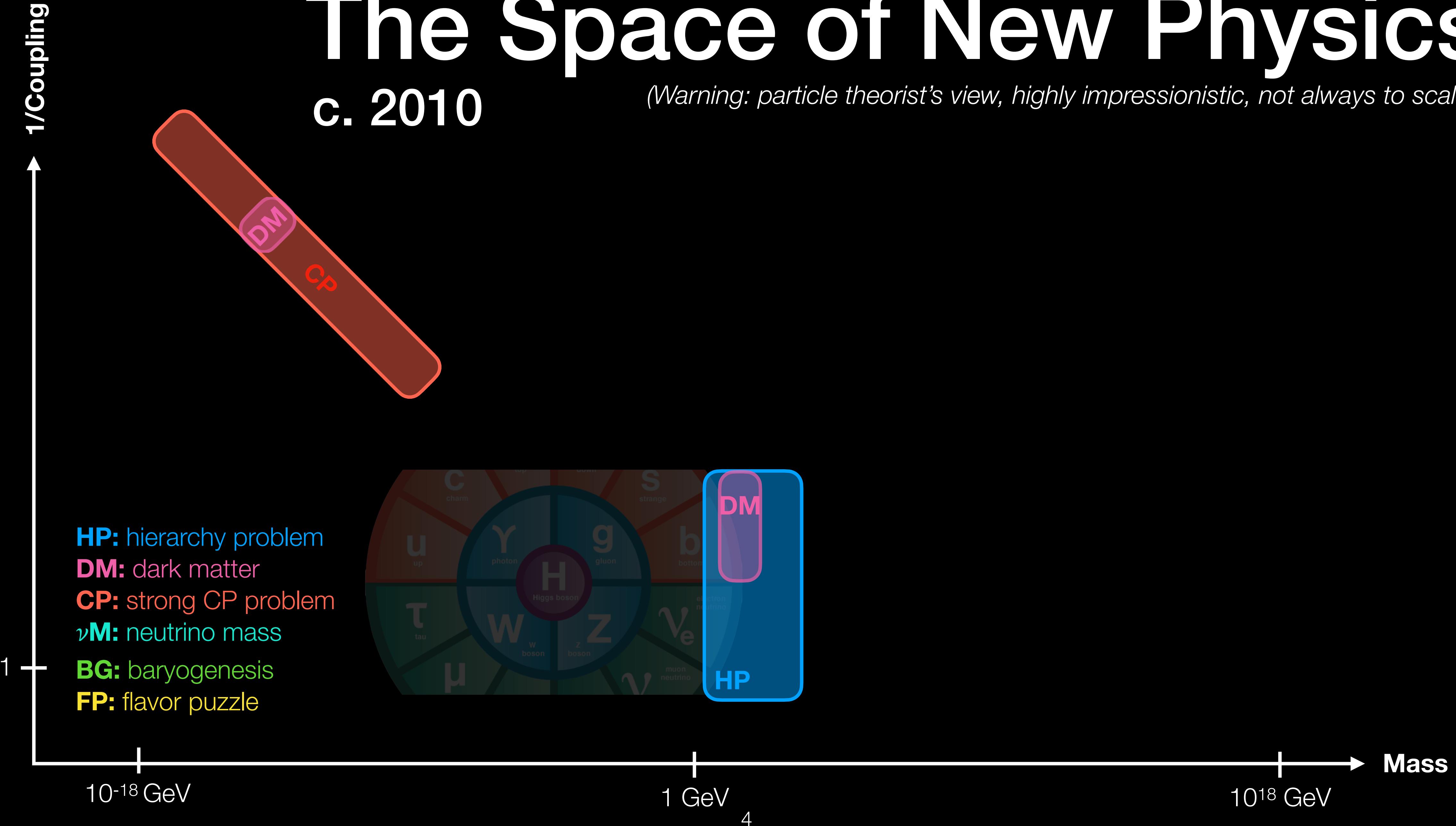
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c. 2010

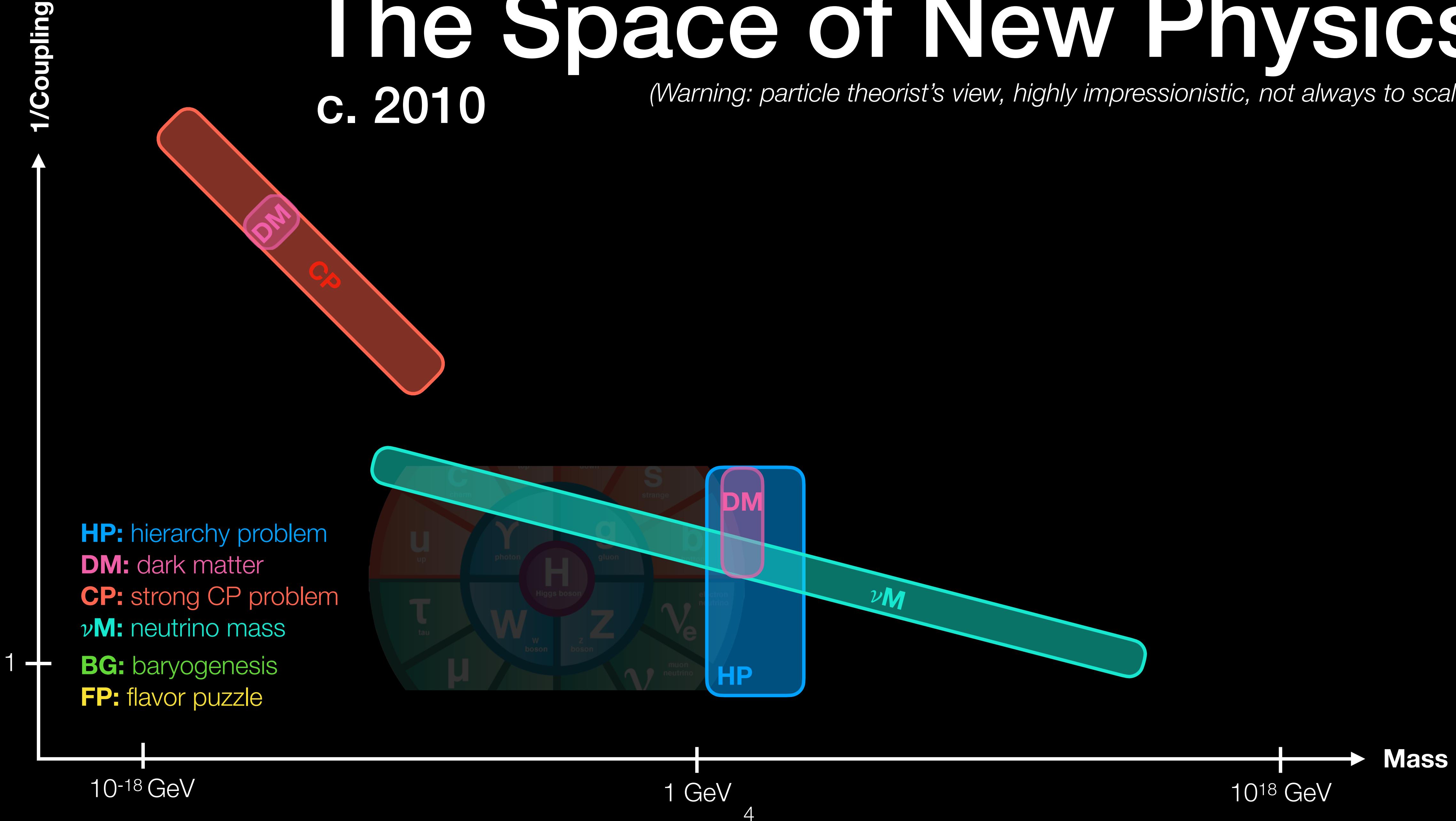
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# The Space of New Physics

c. 2010

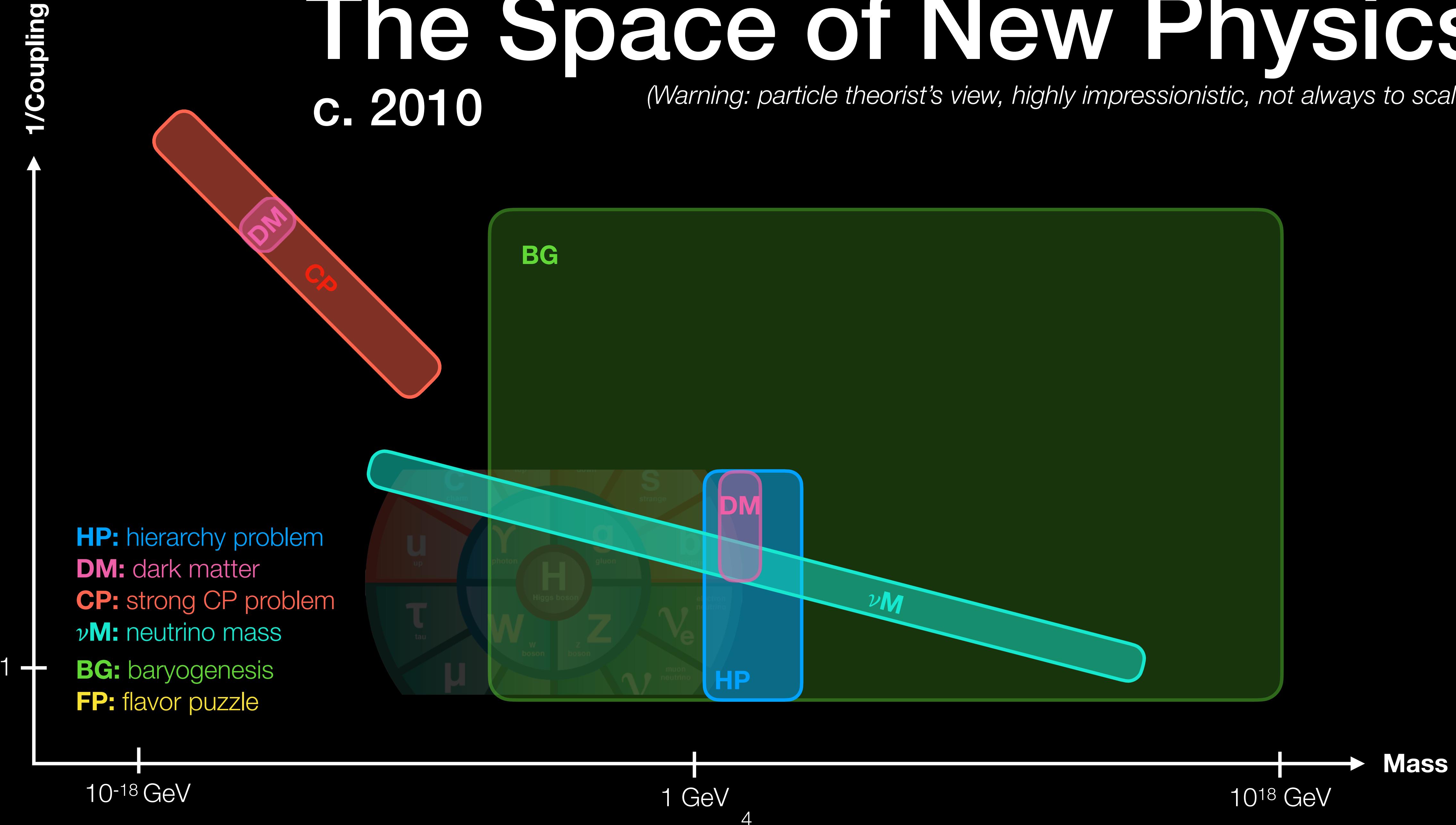
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# The Space of New Physics

c. 2010

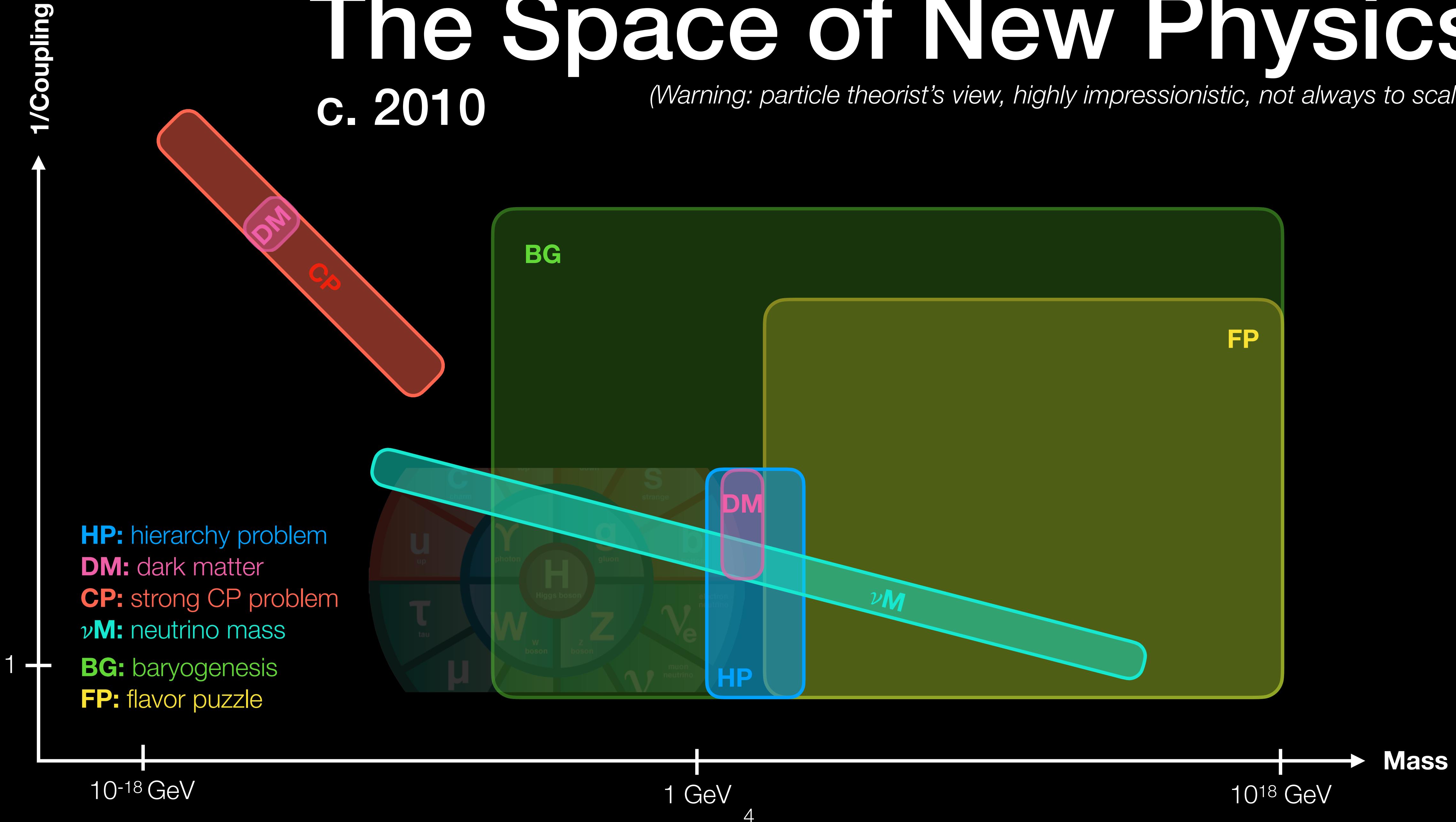
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# The Space of New Physics

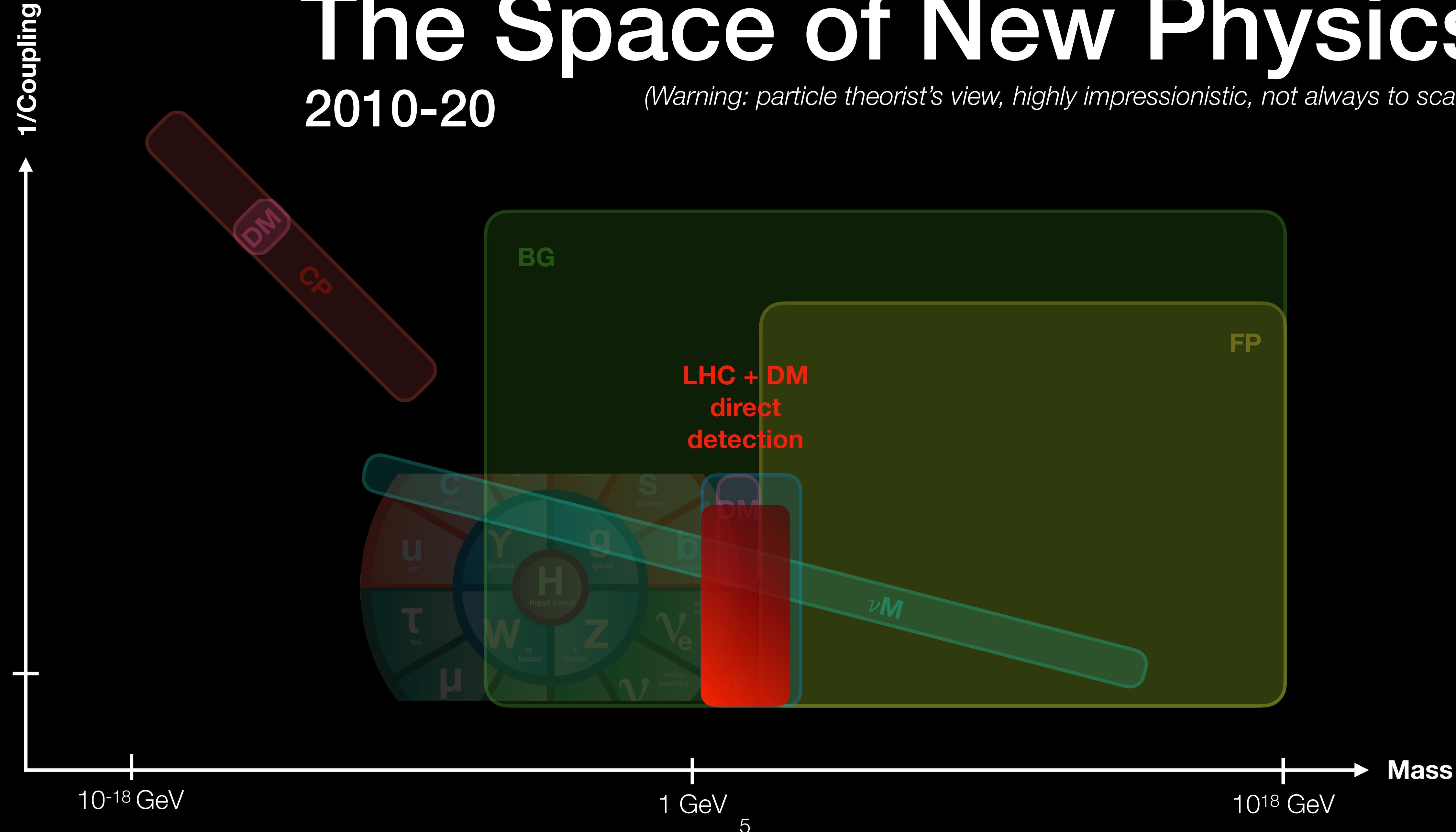
c. 2010

(Warning: particle theorist's view, highly impressionistic, not always to scale)



# The Space of New Physics

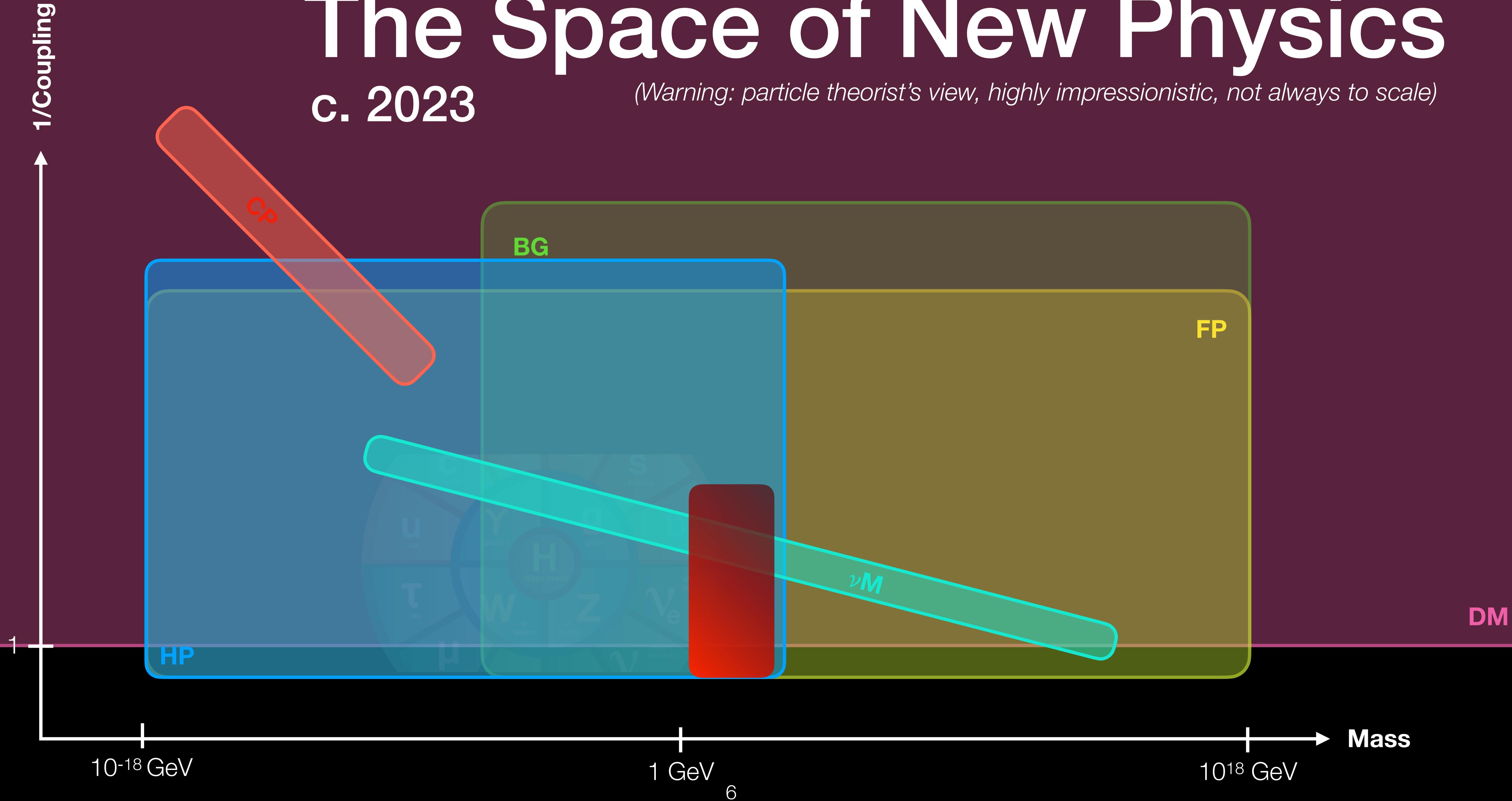
*(Warning: particle theorist's view, highly impressionistic, not always to scale)*



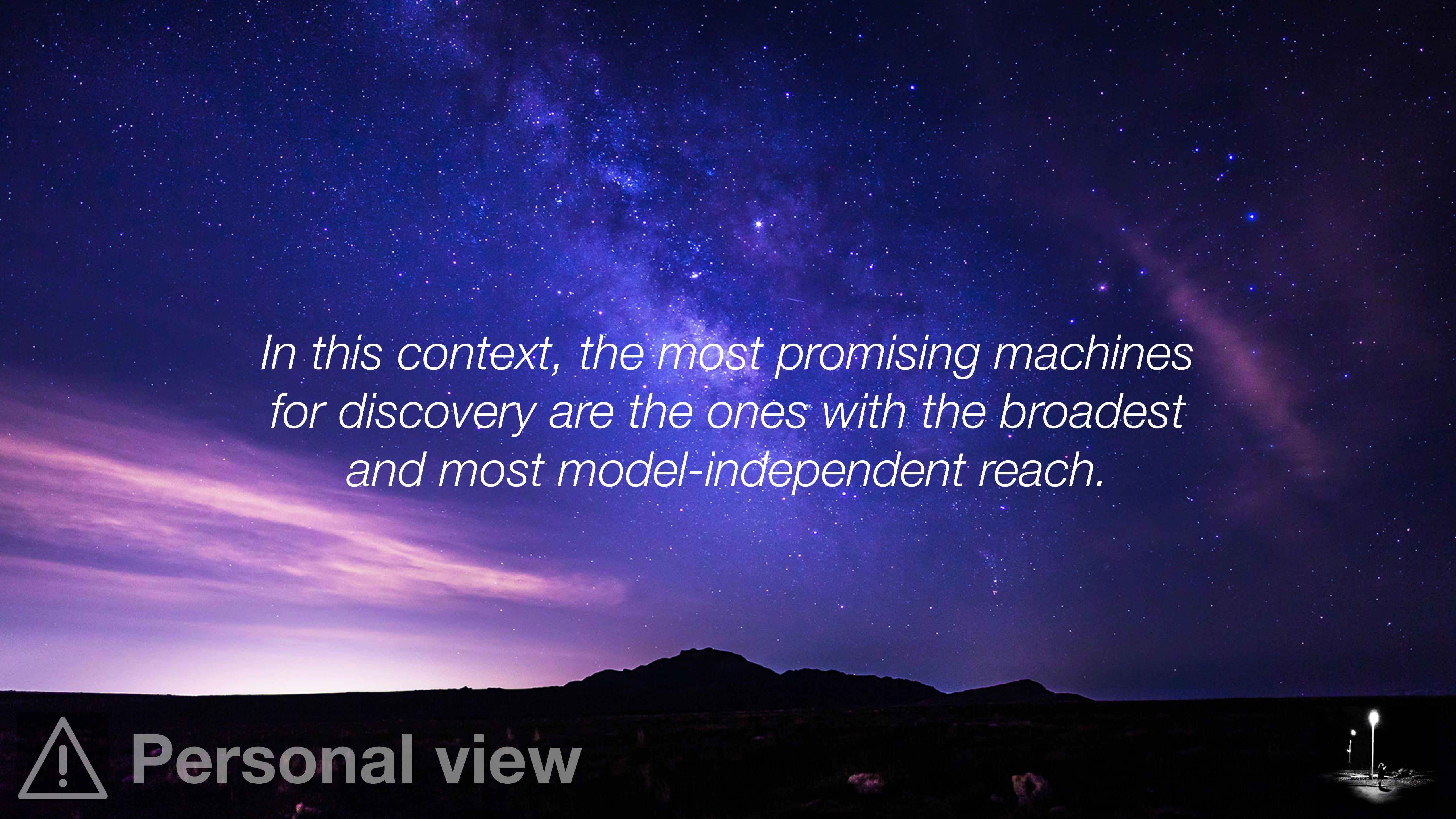
# The Space of New Physics

c. 2023

(Warning: particle theorist's view, highly impressionistic, not always to scale)





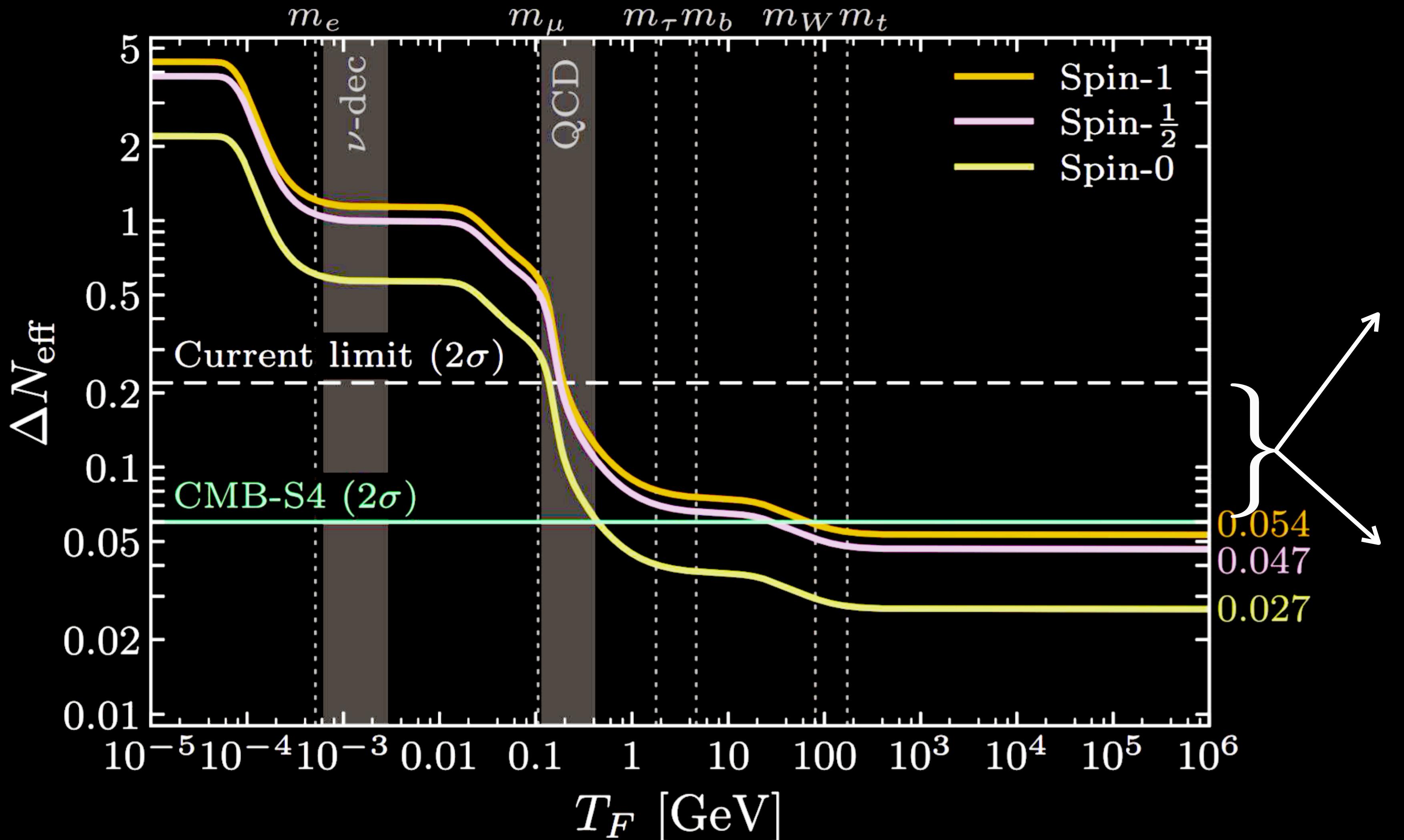


*In this context, the most promising machines  
for discovery are the ones with the broadest  
and most model-independent reach.*



Personal view

# Machines for Discovery



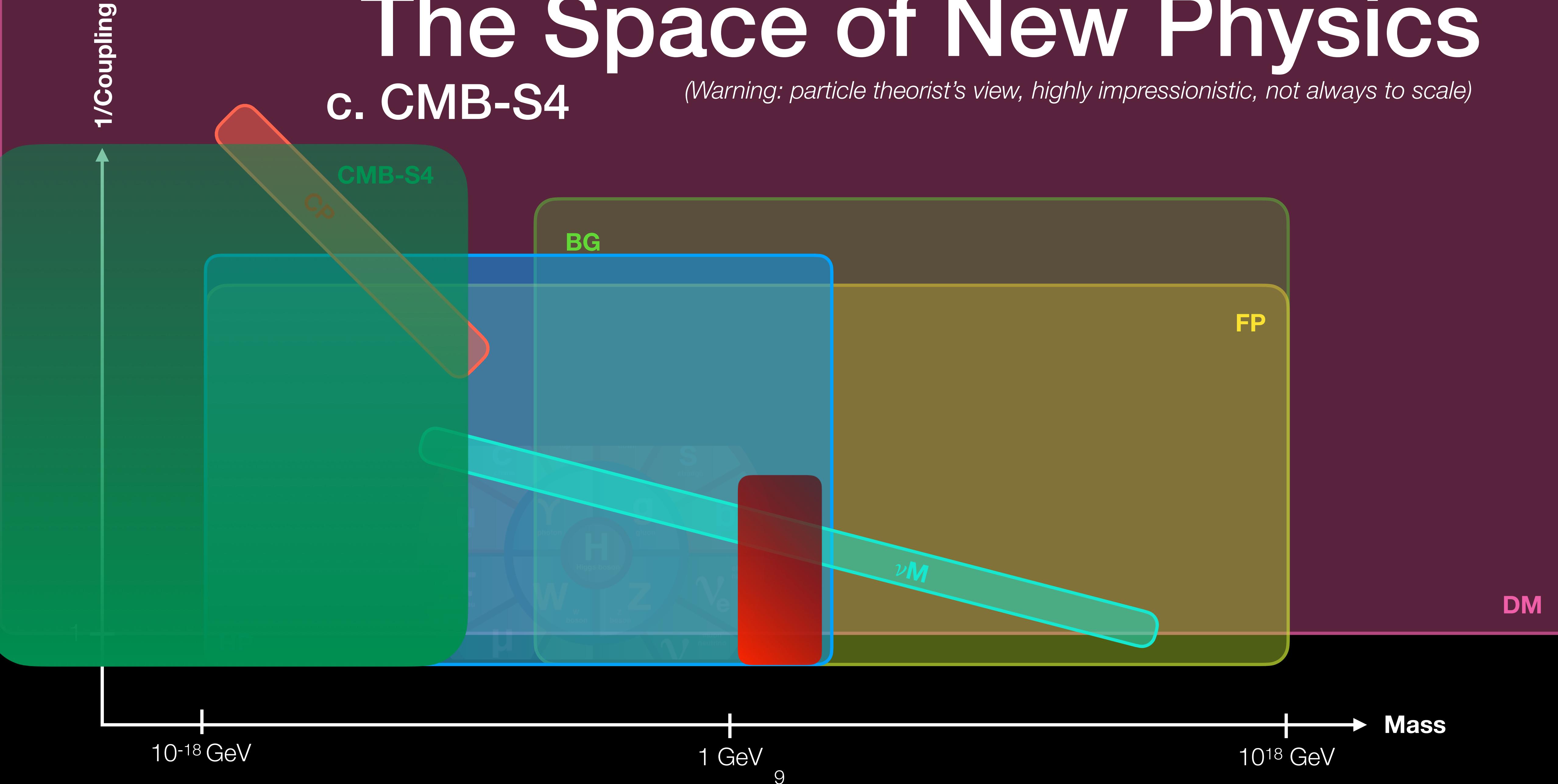
**CMB-S4  $N_{\text{eff}}$  sensitive to:**

- Any sub-eV particle decoupling from SM between EW phase transition and QCD phase transition.
- More than ~one copy of any sub-eV particle ever in thermal equilibrium with the SM.

# The Space of New Physics

c. CMB-S4

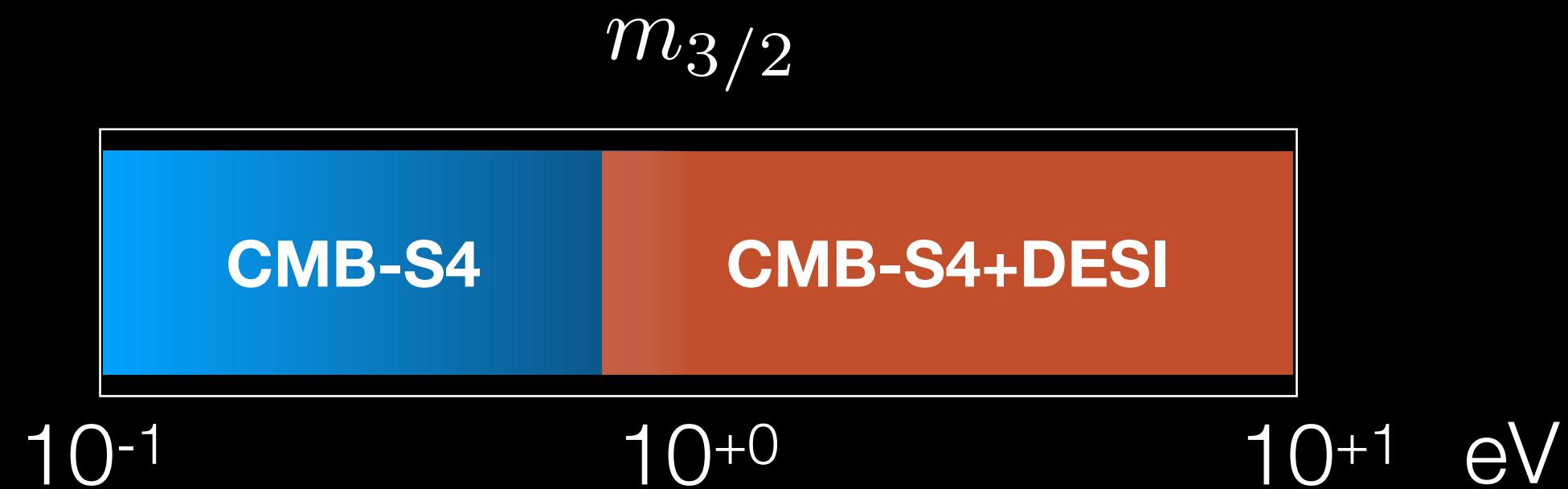
(Warning: particle theorist's view, highly impressionistic, not always to scale)



# Hierarchy Problem

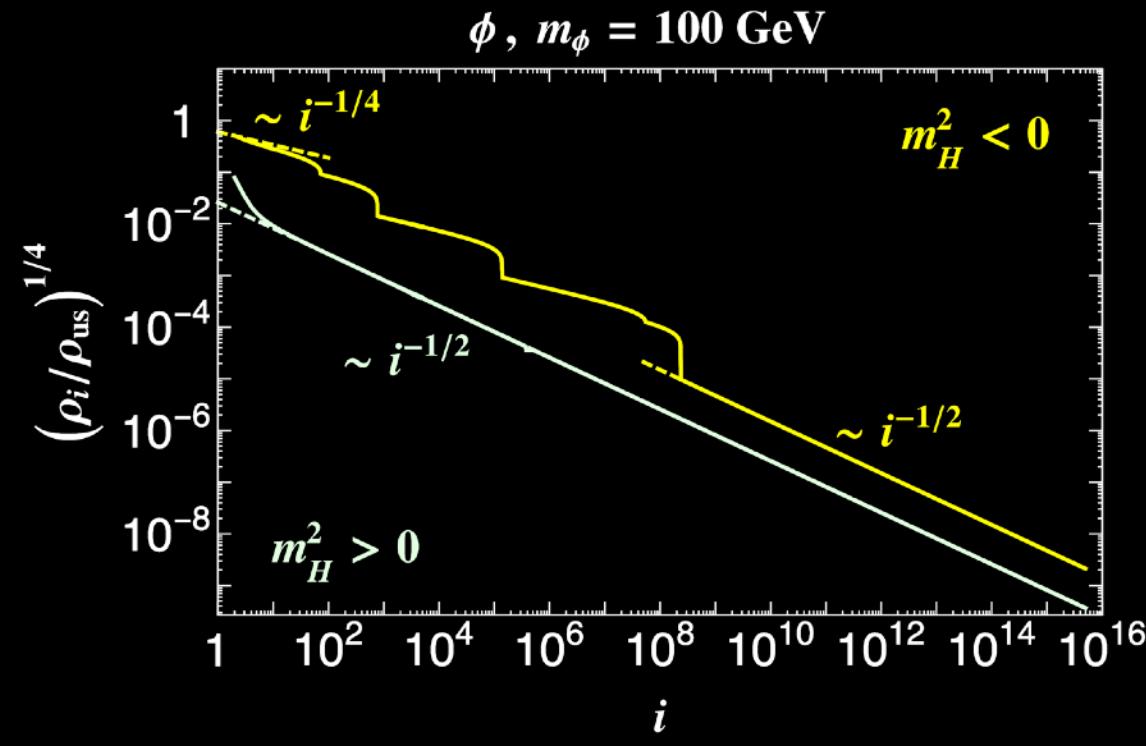
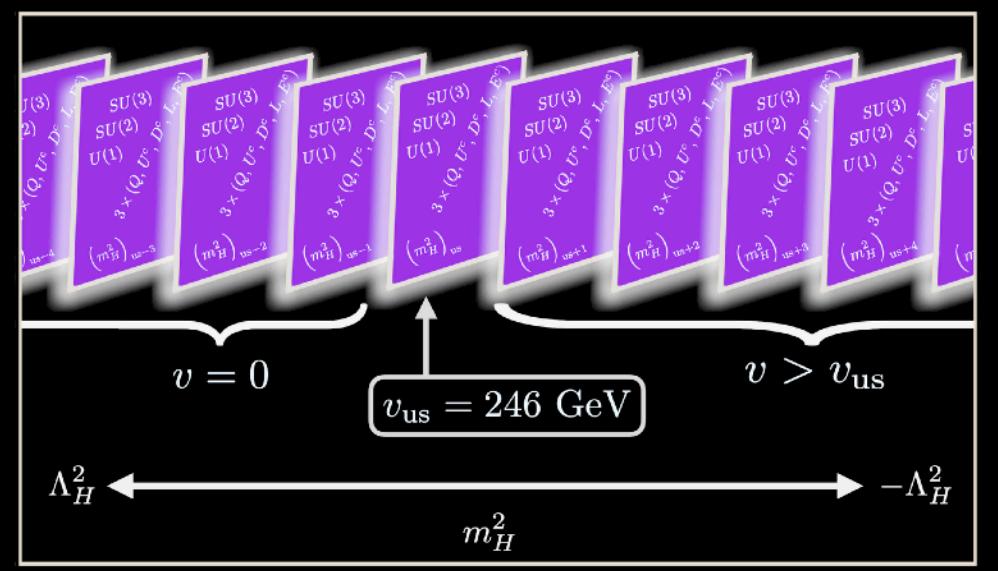
# Supersymmetry

**For  $m_{3/2} < 1$  eV, gravitinos decouple below 100 GeV**

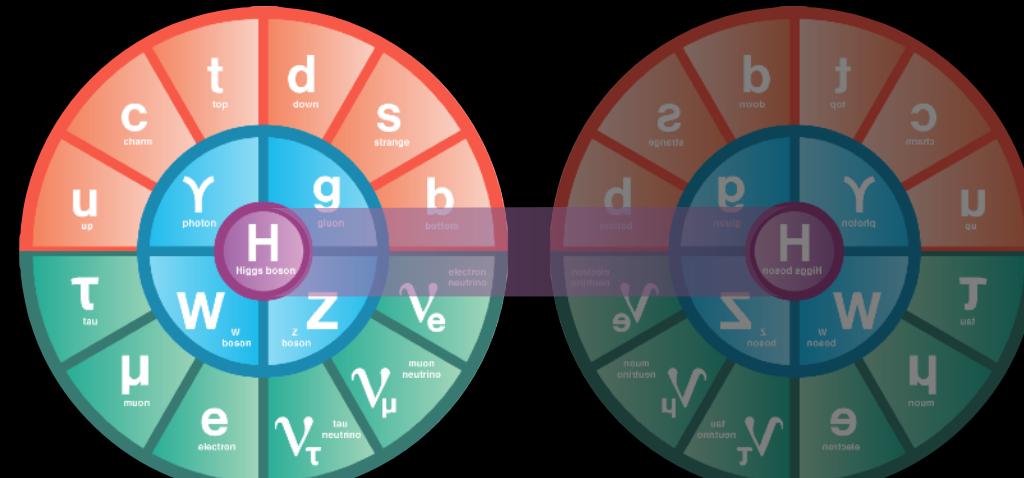


# Nnaturalness

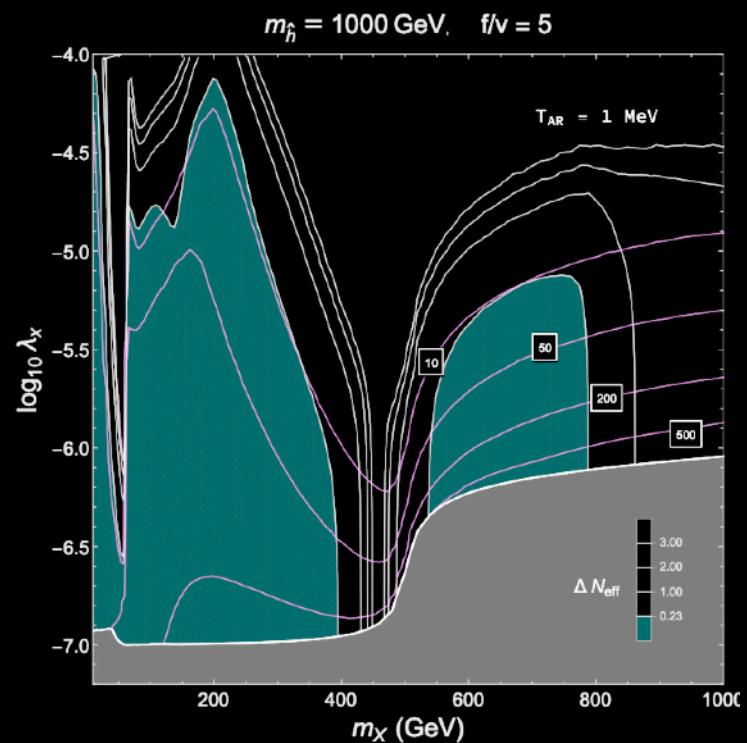
## **N<sub>eff</sub> from subleading energy density in (many) other copies of the SM**



# Neutral naturalness



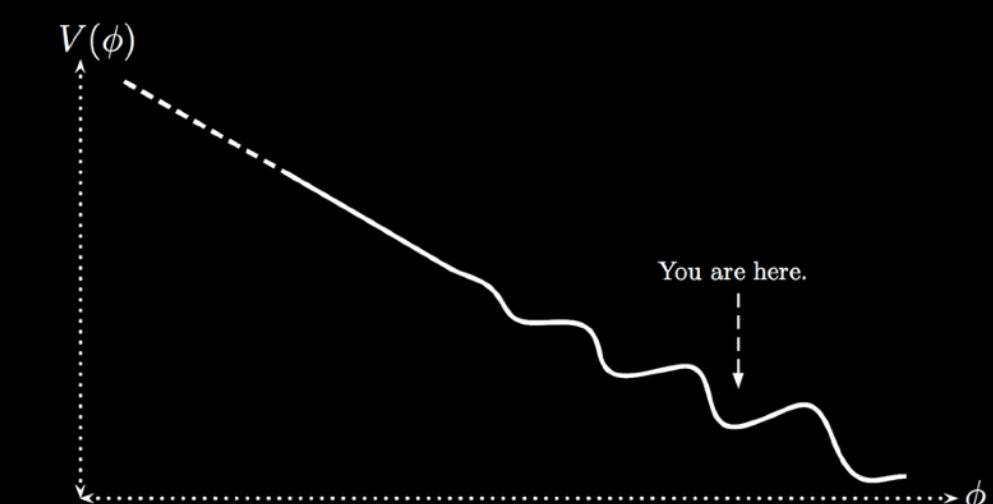
# **N<sub>eff</sub> from dark sector photons & neutrinos**



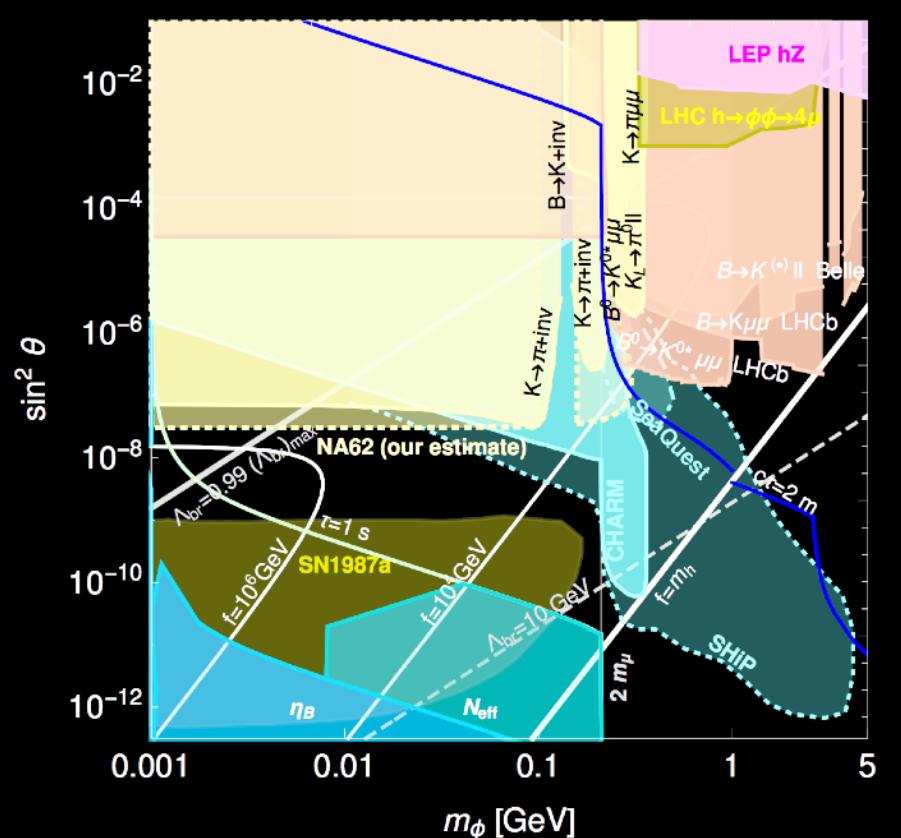
[Curtin, Gryba '21]

# Relaxion

[Graham, Kaplan, Rajendran '15]

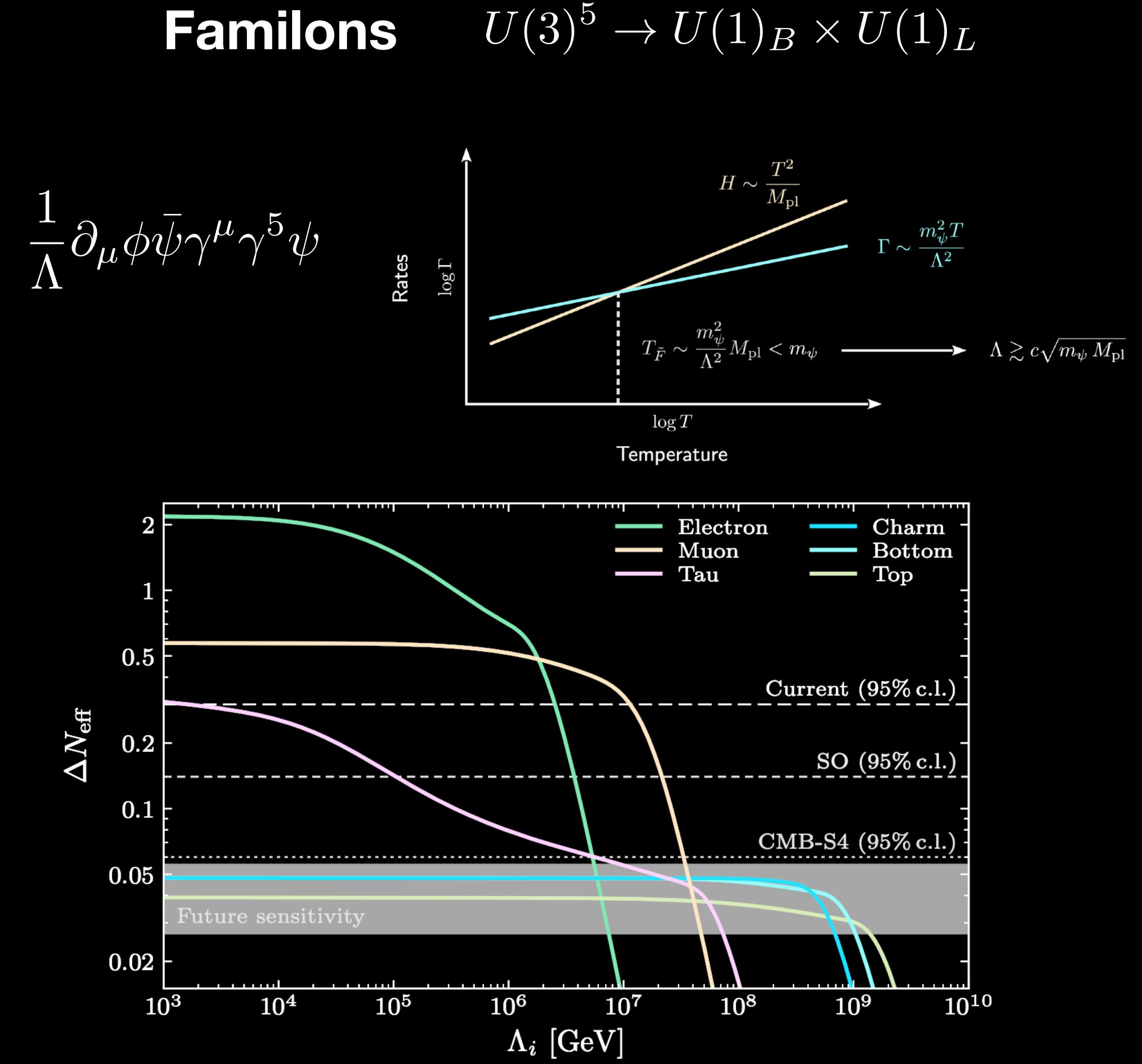
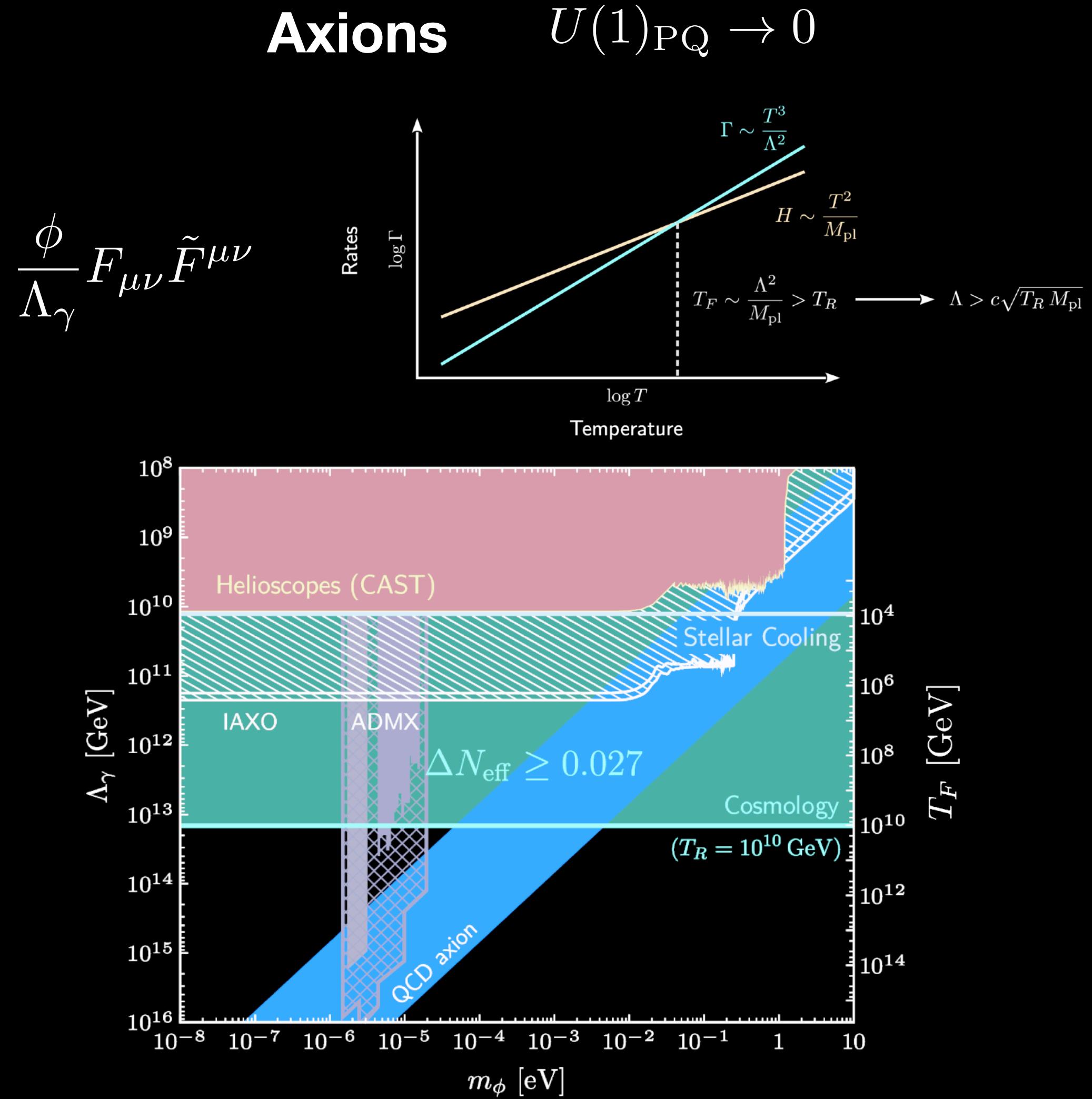


# Decays of relaxion after neutrino decoupling lower $N_{\text{eff}}$



[Flacke, Frugiuele, Fuchs, Gupta, Perez '16]

# Strong CP & Flavor



# Dark Matter



*The most promising machines for discovery are the ones with the broadest and most model-independent reach.*

*The CMB-S4 measurement of  $N_{\text{eff}}$  is among the most compelling such measurements for particle physics on the ~decade timescale, and splendidly complementary to colliders.*

*A hook for particle physicists now: solving the inverse problem.*

**Thank you!**