



UNIVERSITÀ
DEGLI STUDI
DI PADOVA



Neutrino Phenomenology from Flavour Deconstruction

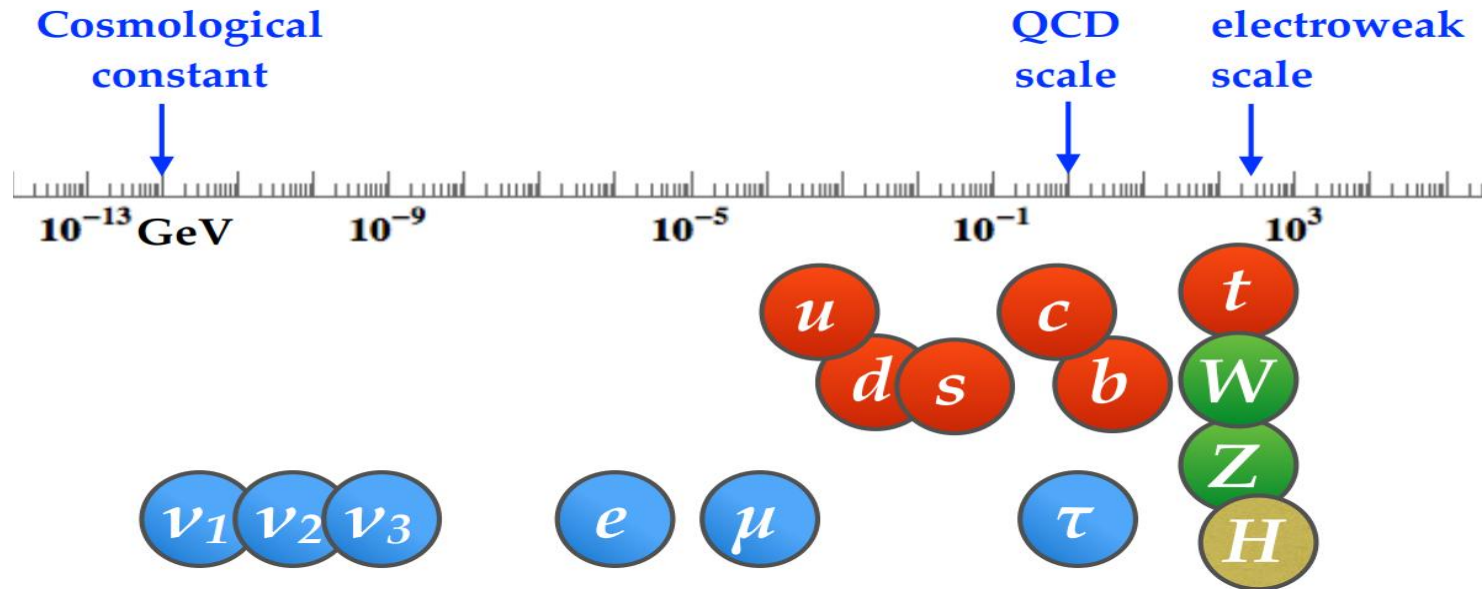
Andrea Sainaghi

In collaboration with Gino Isidori, Paride Paradisi and Nudžeim Selimović



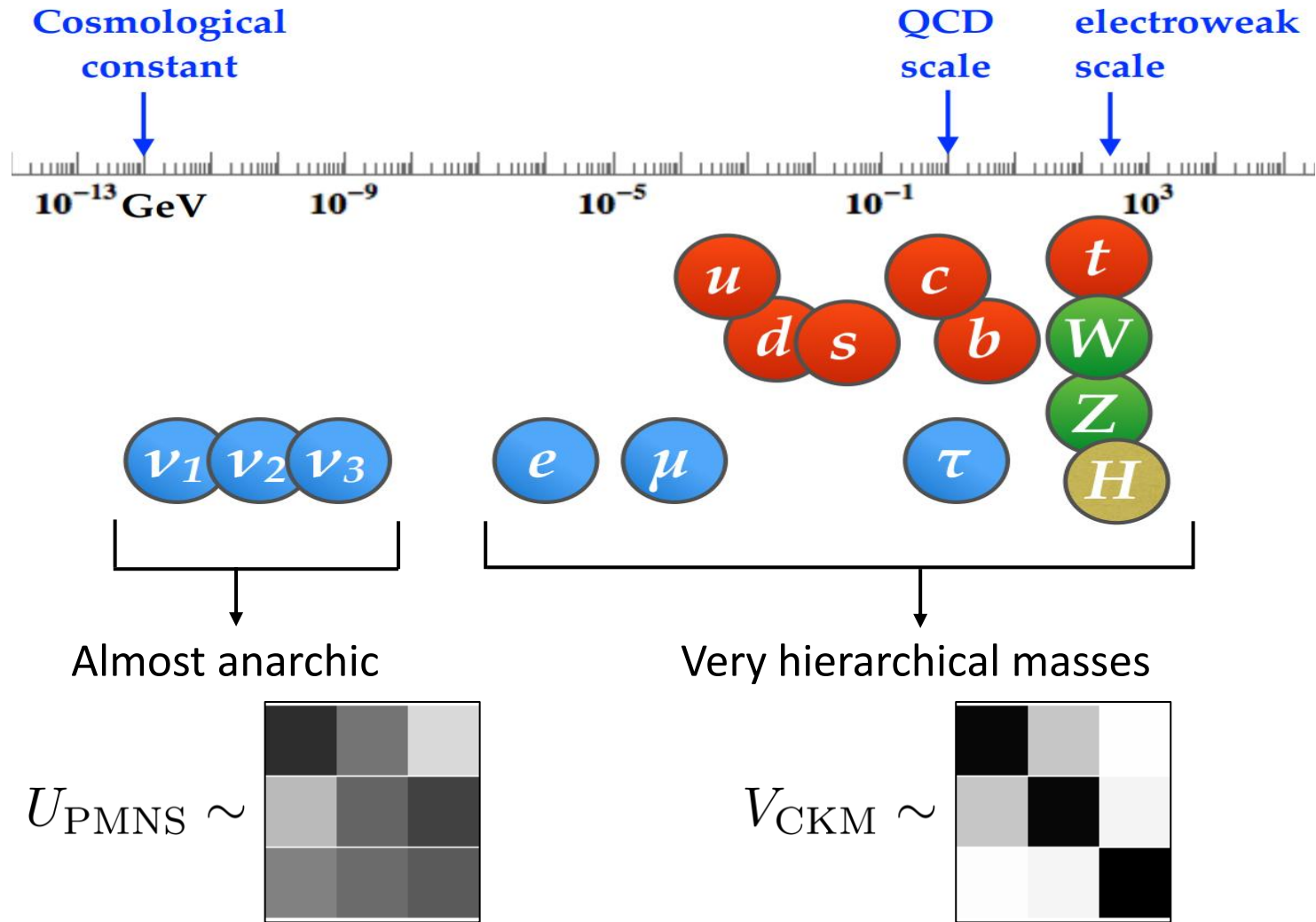
The Flavour Puzzle

Why are the SM-fermion masses so different?



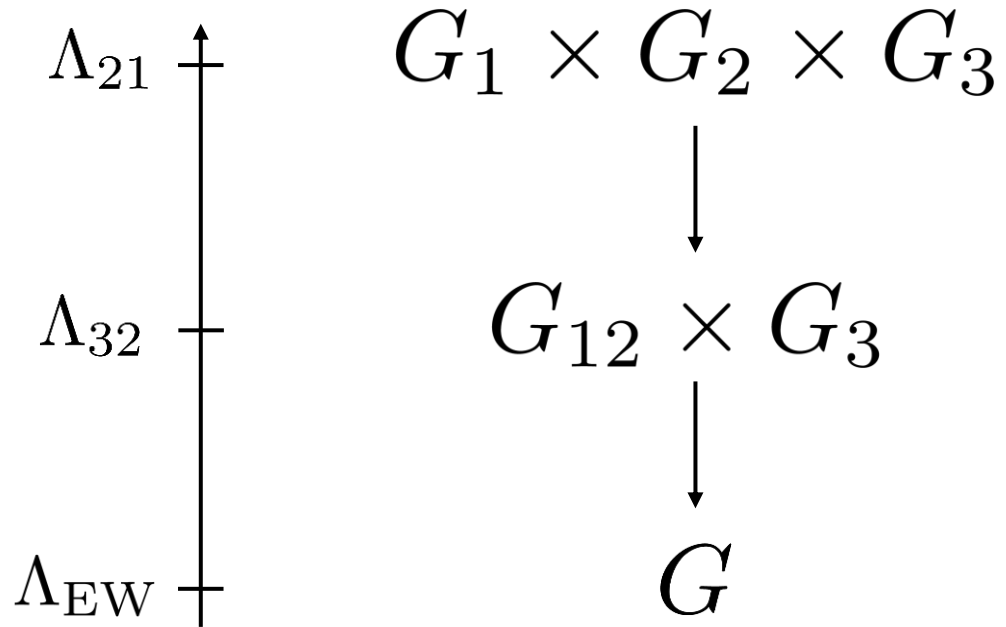
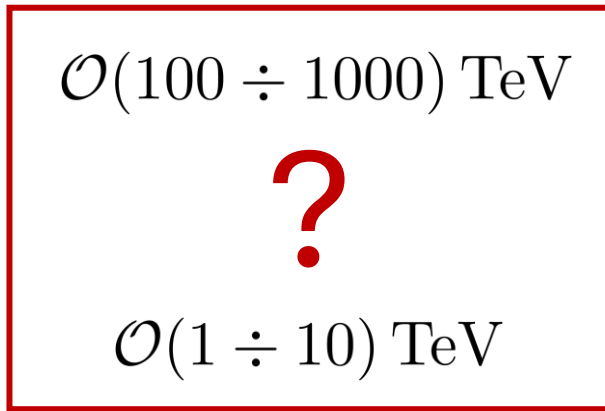
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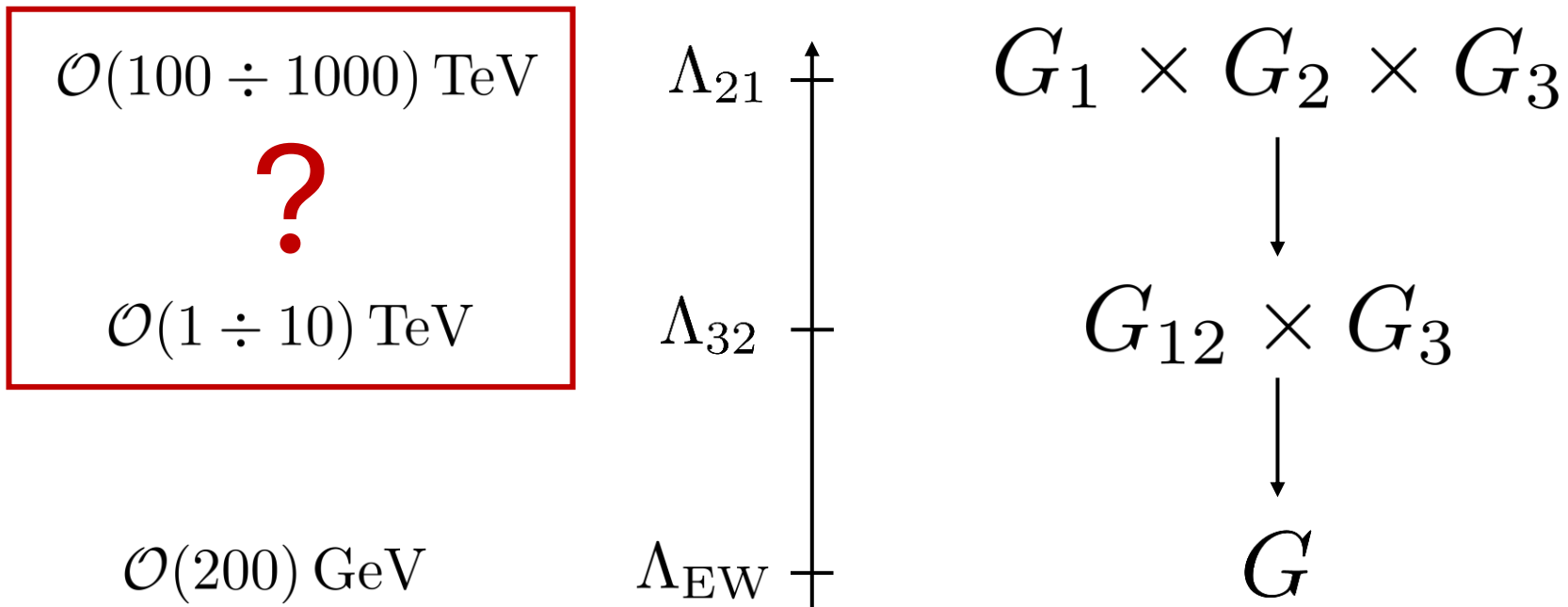
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It naturally generate the hierarchies among charged fermion masses

It fails in reproducing the anarchic neutrino sector

Theory Setup

Recently, [Greljo, Isidori, 2024] showed how to generate neutrino masses in a given flavour-deconstructed model using an Inverse Seesaw mechanism

$$-\mathcal{L} \supset \bar{\ell}_i Y_\nu^{ij} \tilde{H} \nu_j + \bar{s}_i M_R^{ij} \nu_j + \frac{1}{2} \bar{s}_i \mu^{ij} s_j^c + \text{h.c.}$$

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$$Y_\nu \sim \begin{pmatrix} \varepsilon_1 \varepsilon_2 & & \\ & \varepsilon_1 & \\ & & 1 \end{pmatrix} \quad M_R \sim \Lambda \begin{pmatrix} \eta_1 \eta_2 & \eta_1 & 1 \\ \eta_1 \eta_2 & \eta_1 & 1 \\ \eta_1 \eta_2 & \eta_1 & 1 \end{pmatrix}$$

$\mu \longrightarrow$ Anarchic

$\Lambda \equiv \langle \chi \rangle$, where χ is a scalar which is charged under the flavour gauge sector G_3

The flavour non-universal gauge group ensures the hierarchies $\varepsilon_{2,1}, \eta_{2,1} \ll 1$

Mass Spectrum

Below the EW scale we have as mass eigenstates:

- 3 light active neutrinos with Majorana masses ν_L^i

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$$A \equiv v Y_\nu M_R^{-1} \sim \frac{v}{\Lambda} \begin{pmatrix} \Delta_1 \Delta_2 & \Delta_1 \Delta_2 & \Delta_1 \Delta_2 \\ \Delta_1 & \Delta_1 & \Delta_1 \\ 1 & 1 & 1 \end{pmatrix} \quad \Delta_i \equiv \frac{\varepsilon_i}{\eta_i}$$

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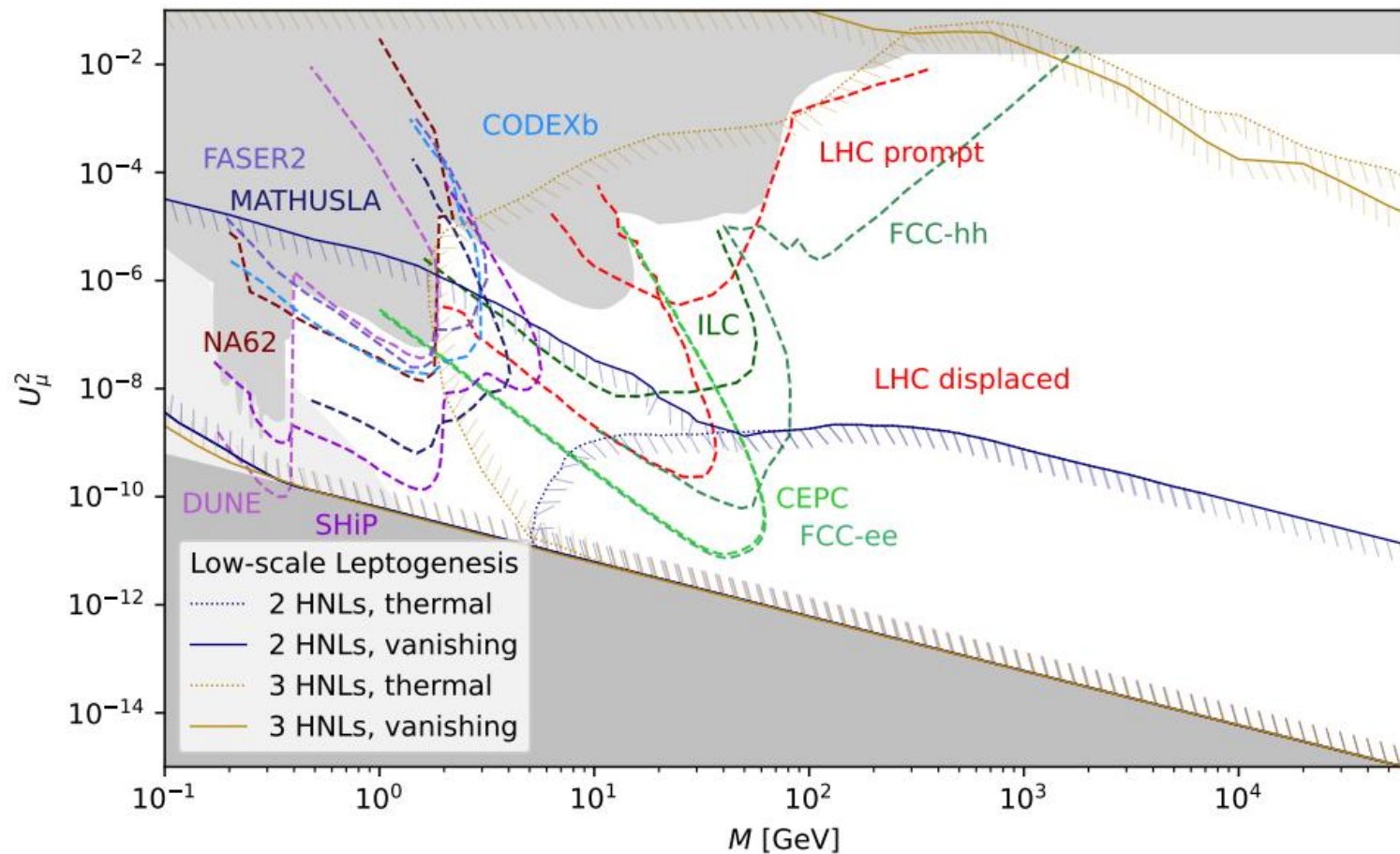
- 3 heavy neutral leptons (HNLs) with hierarchical and (almost) Dirac masses n^i

$$M_n \approx \begin{pmatrix} 0 & M_R \\ M_R^T & \mu \end{pmatrix}$$

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Direct Searches

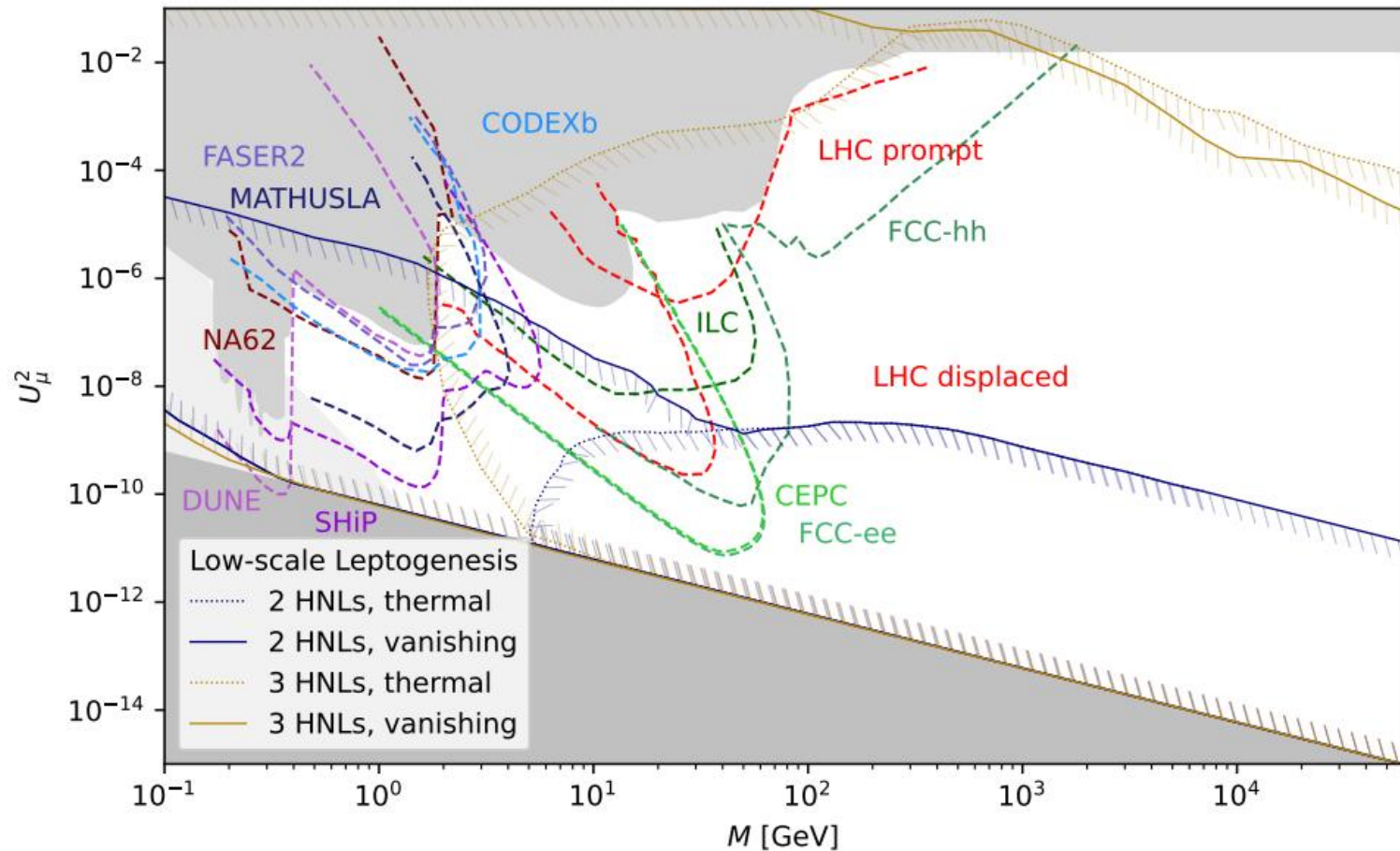


[Abdullahi et al, 2022]

The HNLs have hierarchical masses and interact with the charged leptons

The lightest state can be detected at future colliders

Direct Searches

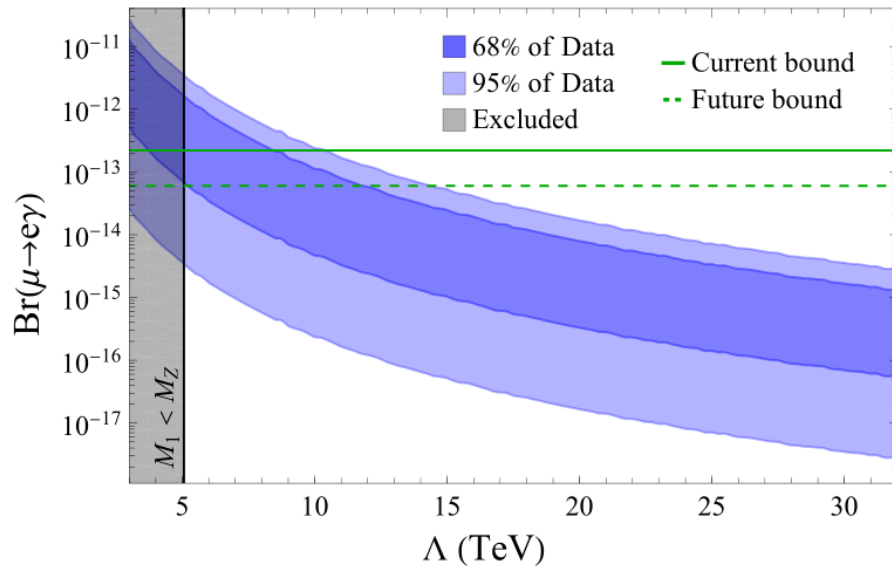


[Abdullahi et al, 2022]

If $M_1 < M_{W,Z}$ \rightarrow $\Lambda \gtrsim 20$ TeV Compatible with NP at TeV scale!

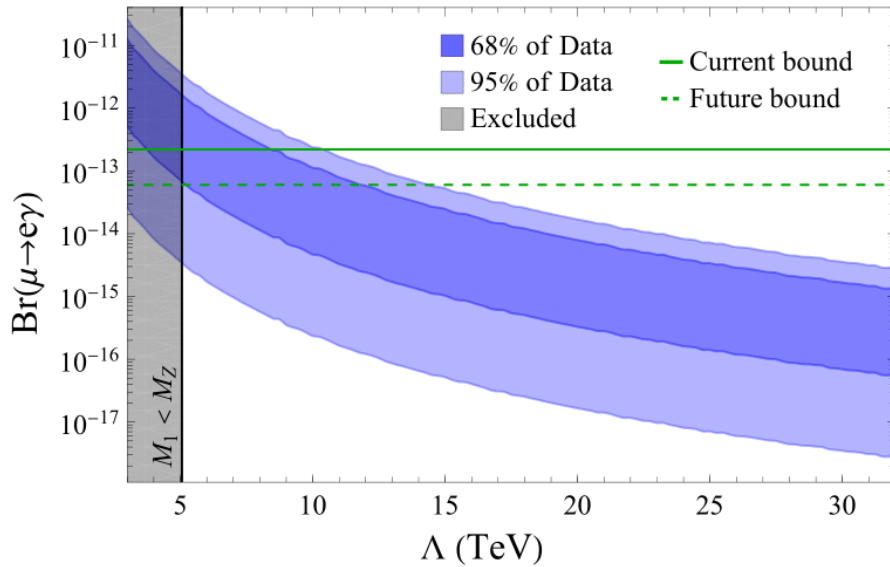
If $M_1 > M_{W,Z}$ \rightarrow $\Lambda \gtrsim$ few TeV

LFV Processes



Currently, $\mu \rightarrow e\gamma$ is the most constraining LFV process

LFV Processes

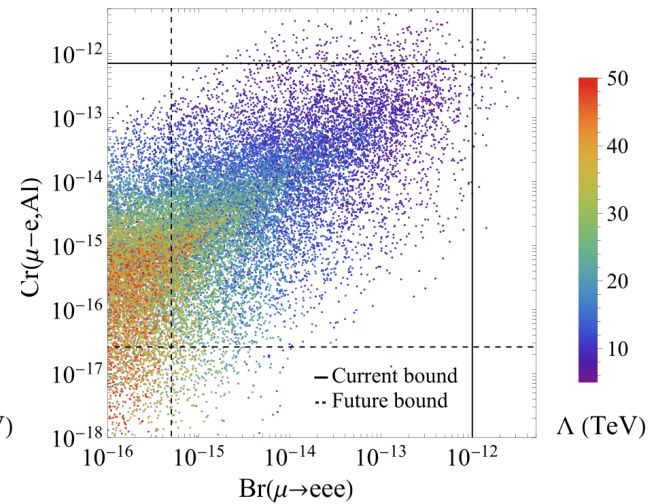
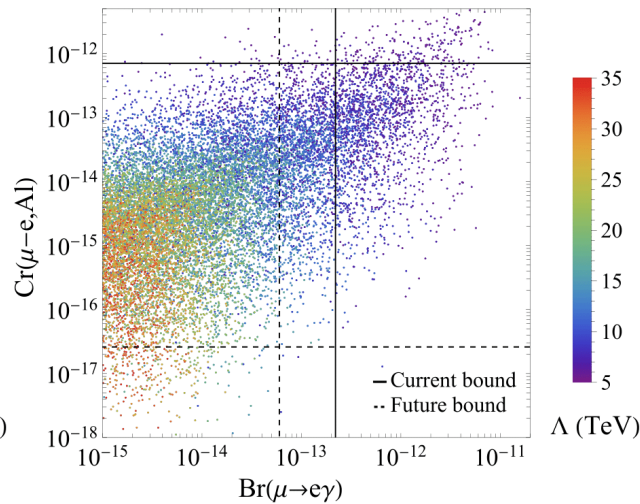
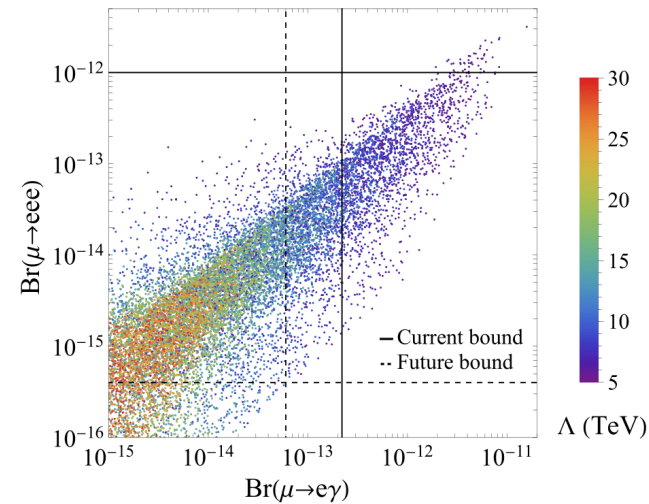


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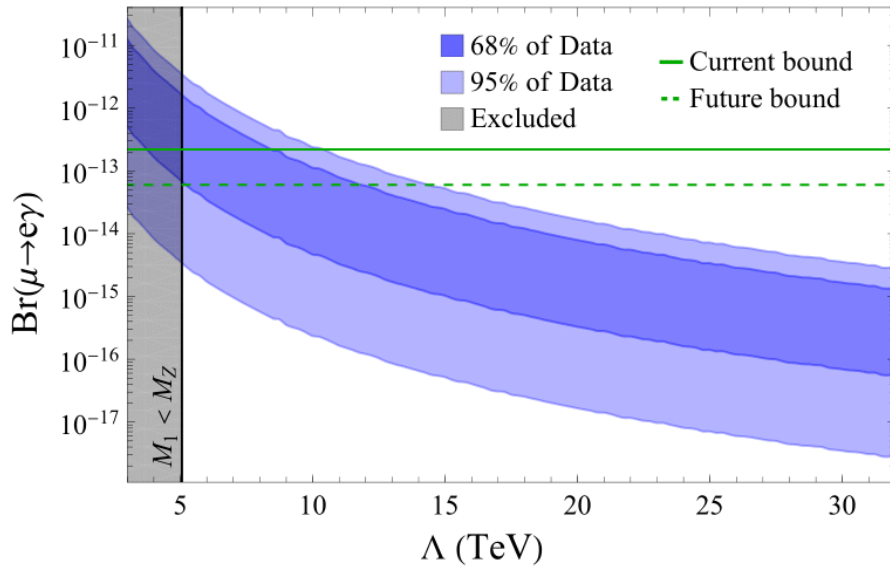
We can also consider correlation plots between the main LFV processes

$$\text{Br}(\mu \rightarrow e\gamma) \quad \text{Br}(\mu \rightarrow eee)$$

$$\text{Cr}(\mu - e, N)$$



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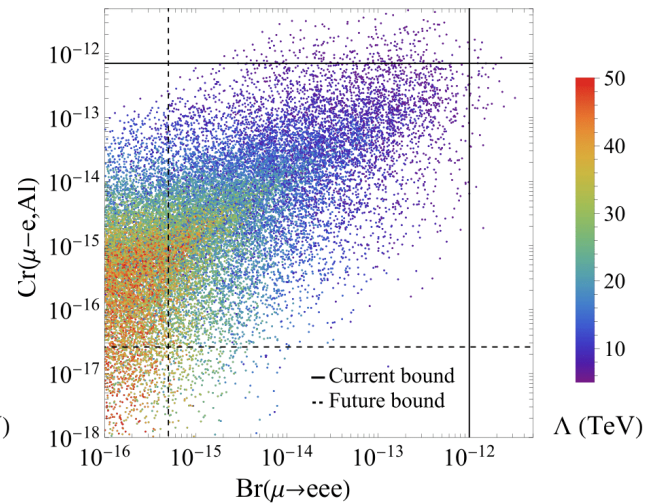
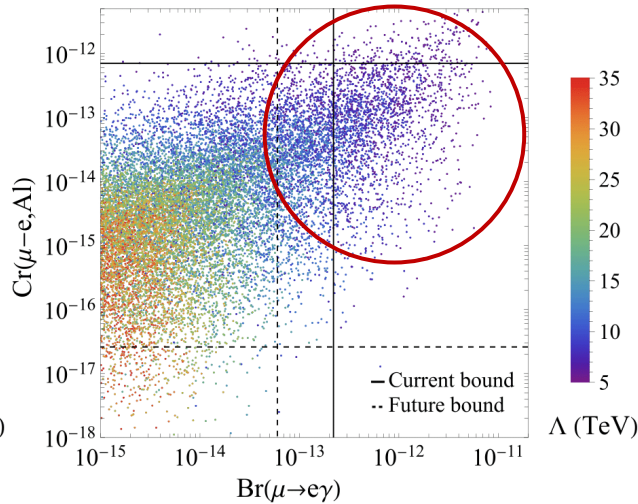
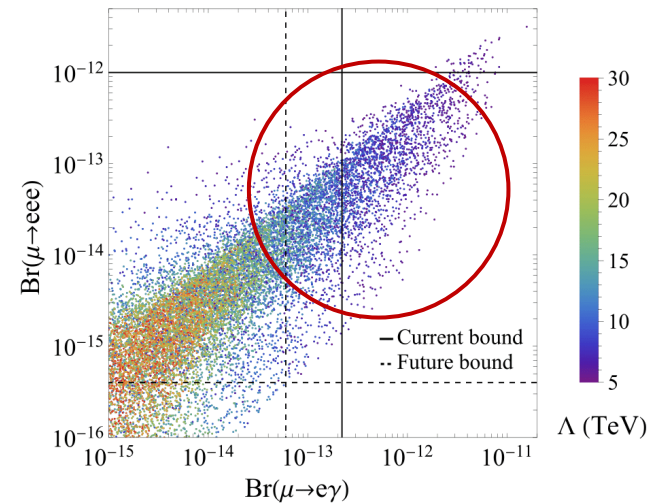


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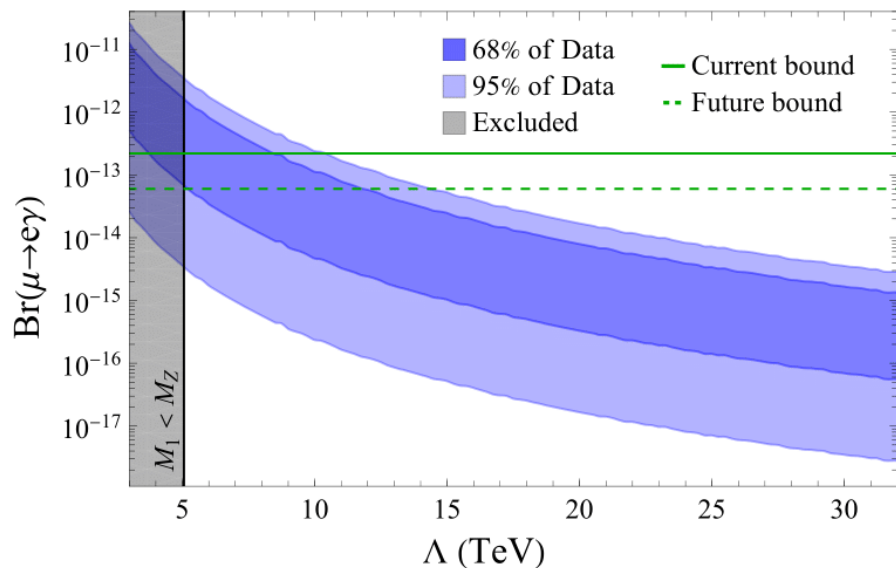
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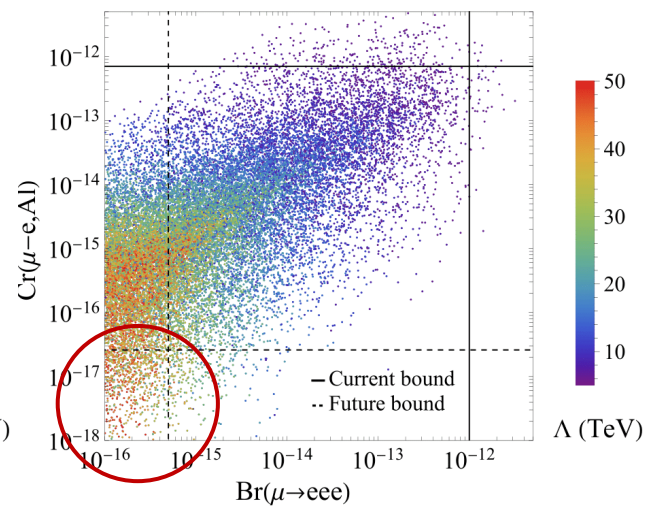
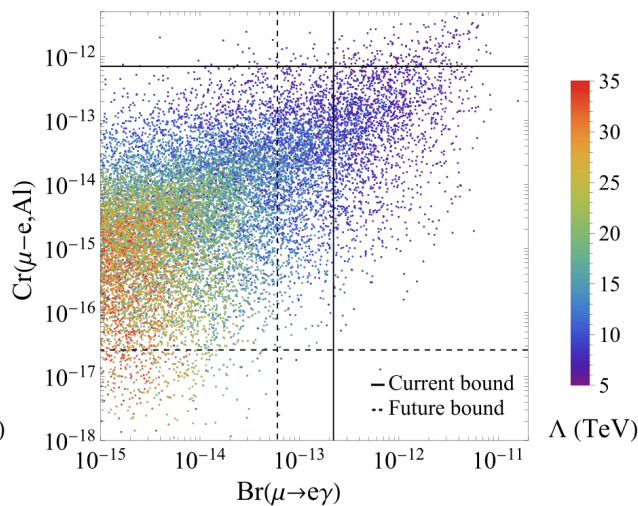
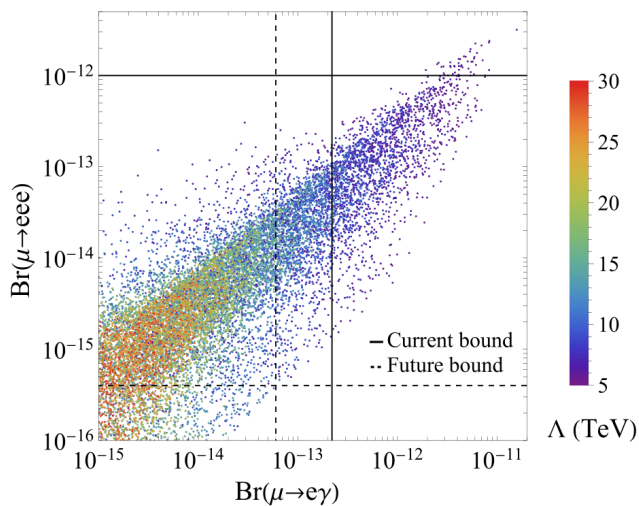


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Conclusions

In this work we have considered the leading phenomenological implications of neutrino anarchy in flavour deconstruction
[Greljo, Isidori, 2024]

We have possible probes in direct searches at colliders like FCC-ee, or in LFV processes such as $\text{Mu}3e$ or COMET

In some cases, the NP scale Λ can be as low as few TeV, under the reach of near-future experiments