

## Is Lepton Flavour Universality **Violation** a hint on nonunitary New Physics Couplings?

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Based on: JHEP12(2019)006 with C. Hati, J. Orloff and A. M. Teixeira

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## Motivation

Deviations in charged and neutral current  $B$ -meson decays persist  
 ⇒ pointing towards Lepton Flavour Universality **Violation**

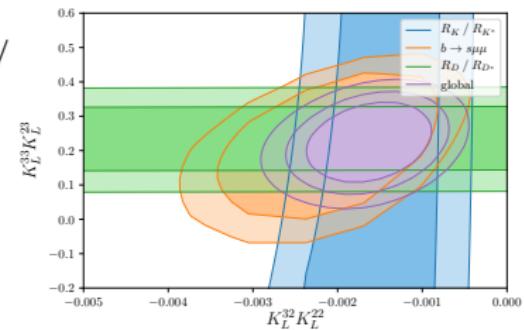
In particular: deviations in  $R_{D(*)} = \frac{\text{BR}(B \rightarrow D^{(*)}\tau\nu)}{\text{BR}(B \rightarrow D^{(*)}\ell\nu)}$  and  $R_{K(*)} = \frac{\text{BR}(B \rightarrow K^{(*)}\mu\mu)}{\text{BR}(B \rightarrow K^{(*)}ee)}$  exceed  $3\sigma$

### Explanations:

$Z'$ , (scalar) LQs, composite Higgs, RPV SUSY.../

TeV-scale  $\mathbf{V}_1$ -leptoquark appealing NP scenario

$$\mathcal{L} \supset V_1^\mu \left( \bar{d}_L^i \gamma_\mu K_L^{ik} \ell_L^k + \bar{u}_L^j V_{ji}^\dagger \gamma_\mu K_L^{ik} U_{kj}^P \nu_L^j \right)$$



⇒ Taking  $\mathbf{V}_1$ -model coupled to all  $(q, \ell)$ -generations in a consistent framework

Effects from RG running are crucial: A. Crivellin et. al. PRL 122, 011805

## Non-universality from universal gauge interactions

Gauge couplings are strictly universal; how to explain **LFU Violation?**

- ▶ Add ***n* vector-like** (VL) leptons mixing with (left-handed) SM leptons

effective LQ- $q\ell$  couplings  $K_L^{q\ell}$  parametrised via **non-unitary matrix**  
(from mixing with heavy states)

- ⇒ Induce **LFUV structure** in  $C_{9,10}^{ij;\ell\ell'}$  **Wilson coefficients** (tree-level):

$$C_{9,10}^{ij;\ell\ell'} = \mp \frac{\pi}{\sqrt{2}G_F \alpha V_{3j} V_{3i}^*} \frac{1}{m_U^2} K_L^{i\ell'} K_L^{j\ell*}$$

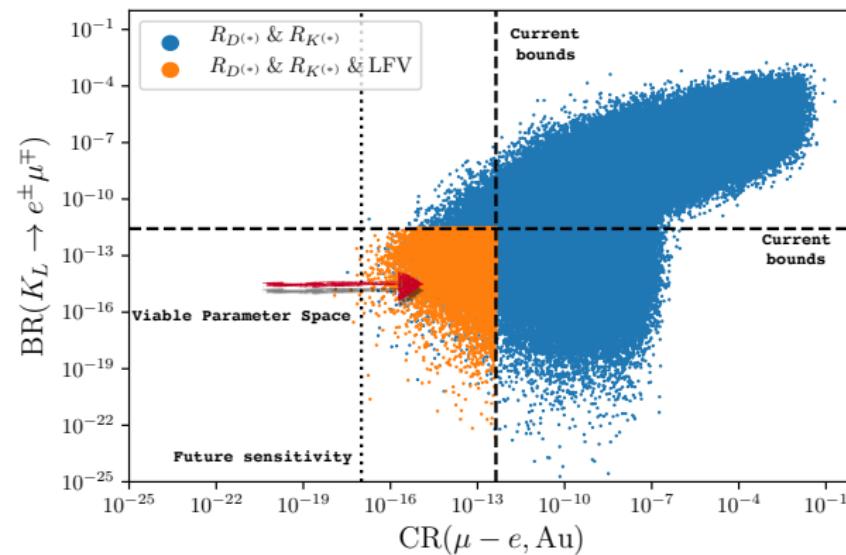
- ⇒ Required mixing pattern could induce nonuniversal  $Z \rightarrow \ell\ell^{(\prime)}$

↔ VL leptons have to be  **$SU(2)_L$ -doublets!!**

- ⇒  $R_{K(*)}$  and  $R_{D(*)}$  can be explained, tight constraints from **cLFV**, **EWPO**, Collider...

## Results: $V_1$ leptoquark & non-unitary mixing from VL leptons

Confrontation with the most constraining observables (cLFV decays)



- $m_V \sim 1.5 \text{ TeV} \& n = 3$  generations of VL leptons
- Future limits:  
 $\text{CR}(\mu - e, \text{Au}) \lesssim 8 \times 10^{-17}$   
 $(\text{MU2E}), \lesssim 2.6 \times 10^{-17}$   
 $(\text{COMET})$
- ⇒ Most of the remaining parameter space probed in the near future!