Exploring the Landscape of Flavor Symmetries

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$$\underbrace{|DH|^2 + V(H)^2 + H\bar{\Psi}\Psi}_{\text{what lies behind ?}}$$

- most common approaches $\Longrightarrow$

- "solve" EWSB mystery (≡ hierarchy problem) $\Longrightarrow$ study pheno under the "best" flavor hypotheses (≡ forget flavor)

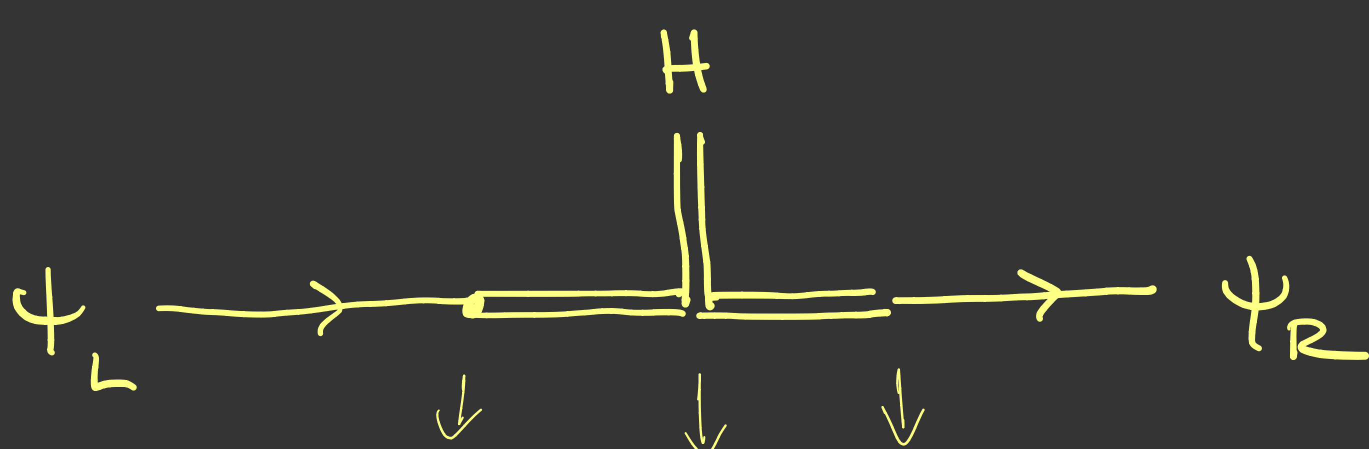
- Flavor Symm ⊕ EFT $\Longrightarrow$ (≡ forget EWSB)

▲ Goal: within definite EWSB scenario, explore the "space" of flavor hypotheses

$\Rightarrow$ correlate direct & indirect searches

▲ Our specific scenario: Composite Higgs $\oplus$ partial compositeness

$$\boxed{\text{Ex} \quad g_* \approx \frac{4\pi}{\sqrt{N_*}}}$$



$$\varepsilon_L \quad g_* \quad \varepsilon_R \quad \equiv \quad \varepsilon_L^{ik}\, c^{k\ell}\, \varepsilon_R^{\ell j} \cdot g_* = Y^{ij}$$

- All scenarios admit "holographic" realization based 5D warped compactification. Existence of full fledged corresponding 4D QFT's is open question.
- What is the space of strongly coupled 4D CFT's?

"Moving parts"

$$\left[g_* \, , \, m_* \right] \oplus \left[O(1) \text{ coeffs.} \right] \oplus \left[\begin{array}{l} \text{discrete set of hypotheses:} \\ \text{symmetries, operator spectrum, ..} \end{array} \right]$$

$g_* \rightarrow \dfrac{1}{[\text{Action}]^{1/2}}$, $m_* \rightarrow \dfrac{1}{\text{length}}$

△ Conceptually most attractive : <u>Flavor Anarchy Scenario</u>

$$Y_u^{ij} = \varepsilon_{Lu}^{ik}\, C_u^{kl}\, \varepsilon_{Ru}^{lj} \cdot g_* \qquad\qquad Y_d^{ij} = \varepsilon_{Ld}^{ik}\, C_d^{kl}\, \varepsilon_{Rd}^{lj} \cdot g_*$$

- RG evolution of ε's at strong coupling plausibly induces $\frac{m_i}{m_{i+1}} \ll 1$, $V^{ii} \gg V^{i,i+1} \gg V^{i,i+2}$ ☺

- many more ~~Flavor + CP~~ sources than SM ☹

$\Longrightarrow$ strong constraint on m_*

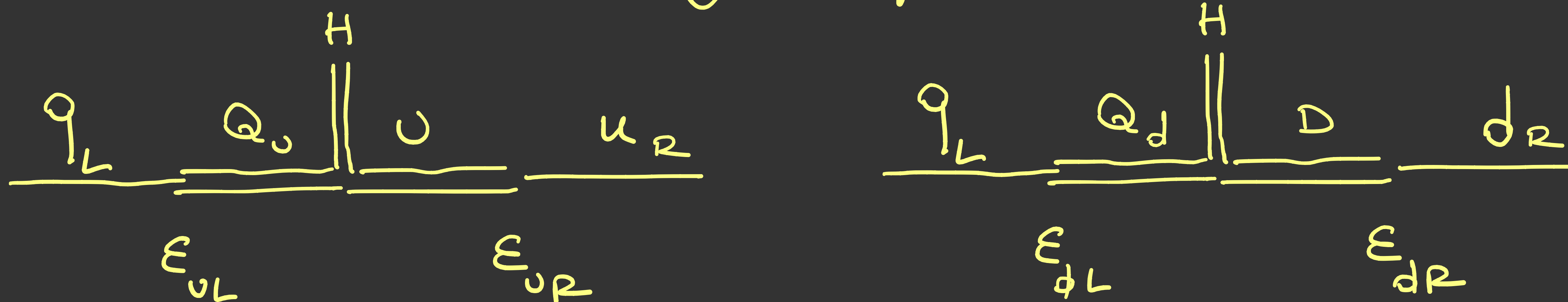
$$\boxed{\varepsilon_K,\ Q^D_{CP},\ b\to s\gamma,\ d_n \longrightarrow m_* \gtrsim 30\,\text{TeV}}$$

$$\boxed{\begin{array}{l} \mu\to e\gamma \longrightarrow 70\,\text{TeV} \\ d_e \longrightarrow 700\,\text{TeV} \end{array}}$$

$\triangle$ Flavor Symms (+CP):

- controls ~~Flavor+CP~~ sources
- no real explanation of spectrum
- allow m_* within reach

$\triangle$ Largest Symmetry Group at play



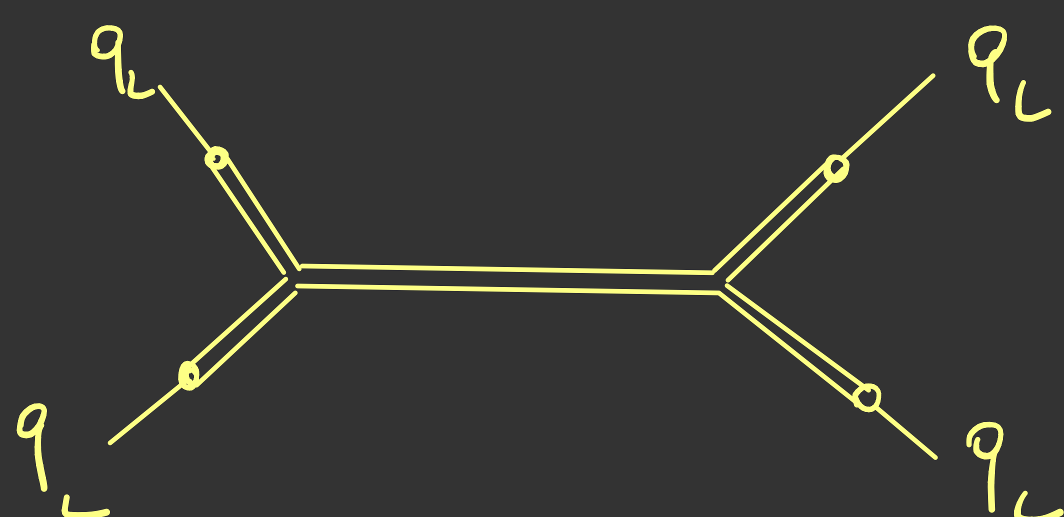
$$U(3)_q \times U(3)_u \times U(3)_d \times U(3)_U \times U(3)_D$$

- Scenarios $\Longleftrightarrow$ ϵ-induced breaking patterns

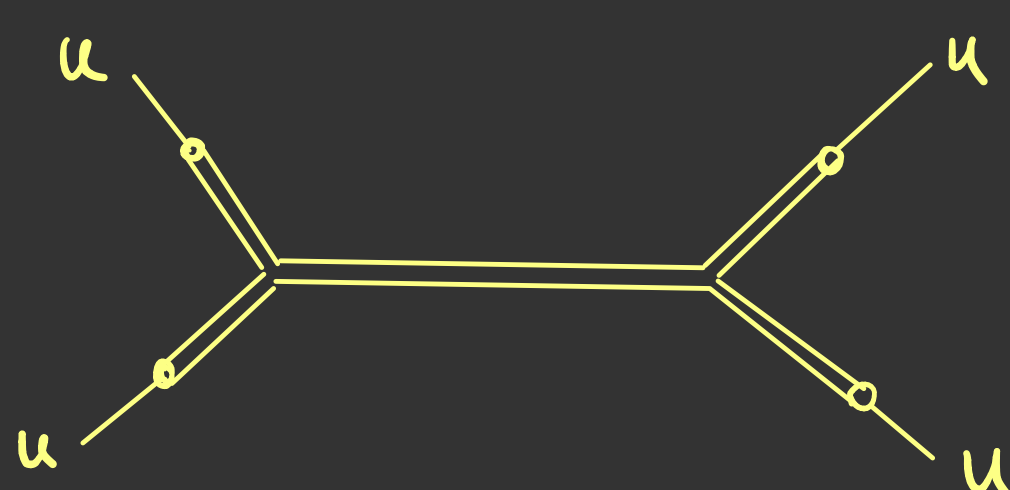
Ex "Right Universality"

$$Y_u^{ij} = \varepsilon_{Lu}^{ij}\,\varepsilon_u\, g_*$$

$$Y_d^{ij} = \varepsilon_{Ld}^{ij}\,\varepsilon_d\, g_*$$



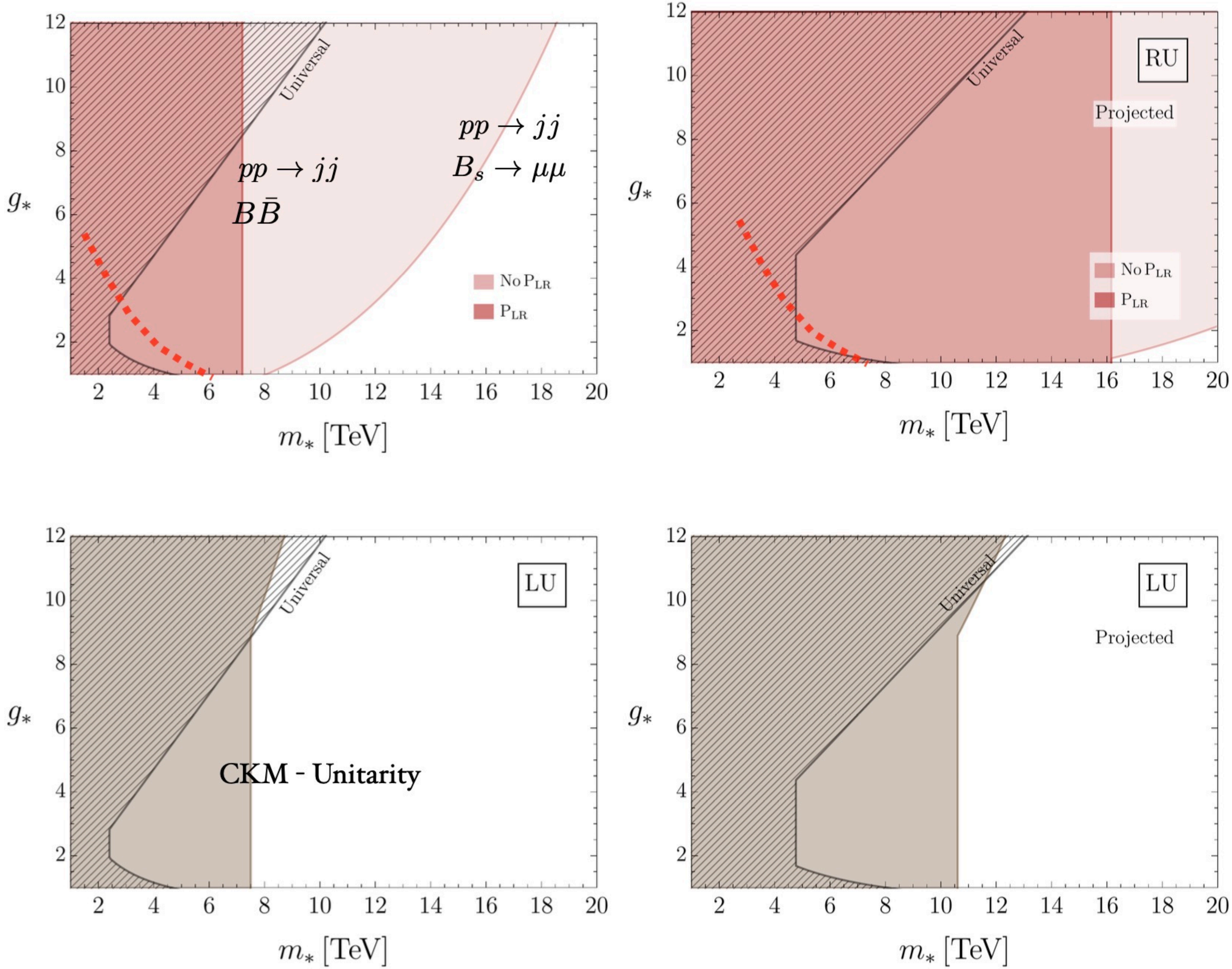
$$\sim \frac{\left(Y_u^\dagger Y_u\right)^2}{g_*^2\,\varepsilon_u^4}\,\frac{1}{m_*^2} \Longrightarrow m_* \gtrsim \frac{6.6\ \mathrm{TeV}}{g_*\,\varepsilon_u^2}$$



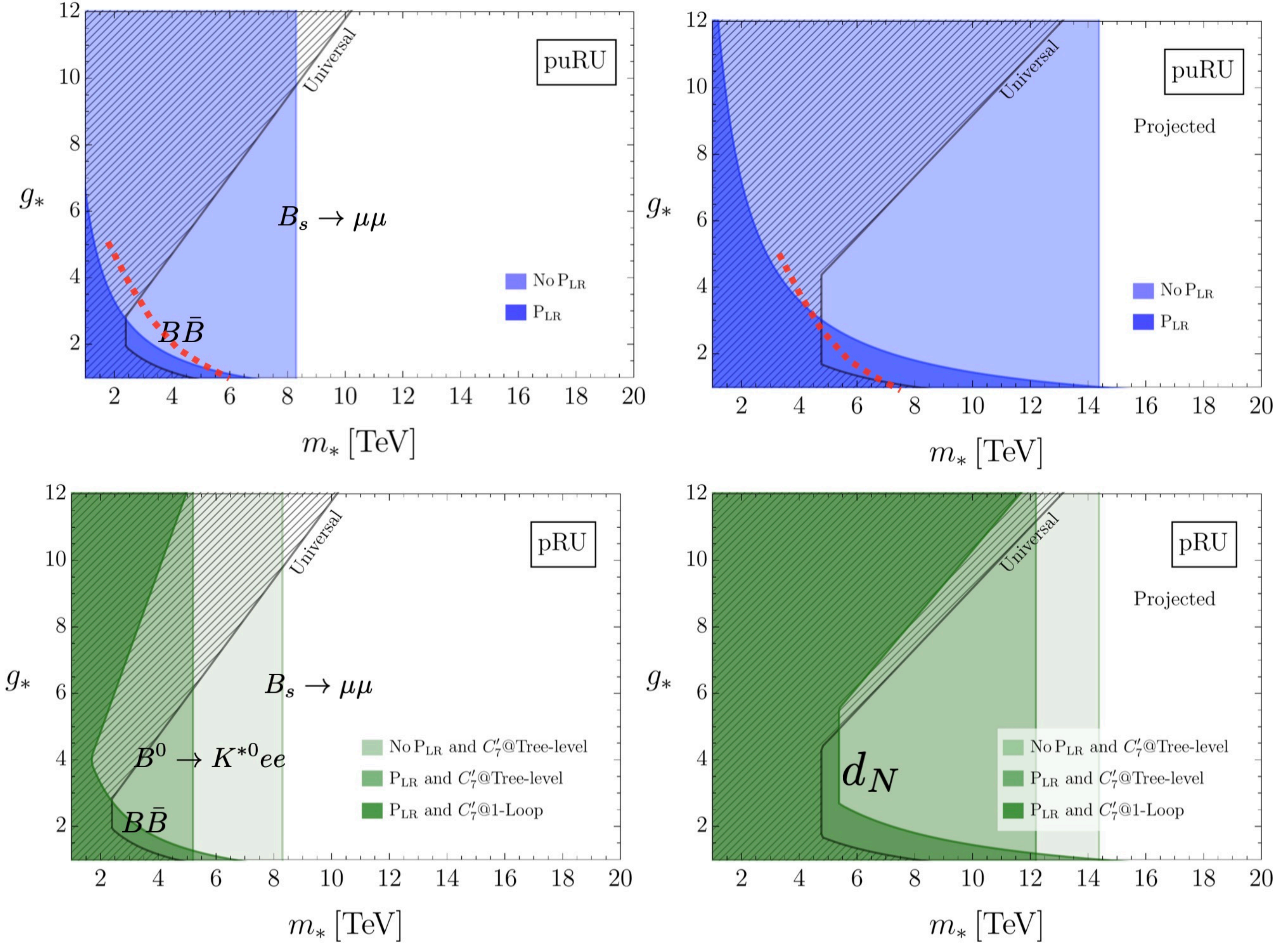
$$\sim \frac{g_*^2\,\varepsilon_u^4}{m_*^2} \Longrightarrow m_* \gtrsim (5 \div 8)\ \mathrm{TeV}\cdot g_*\,\varepsilon_u^2$$

Broad Scenarios

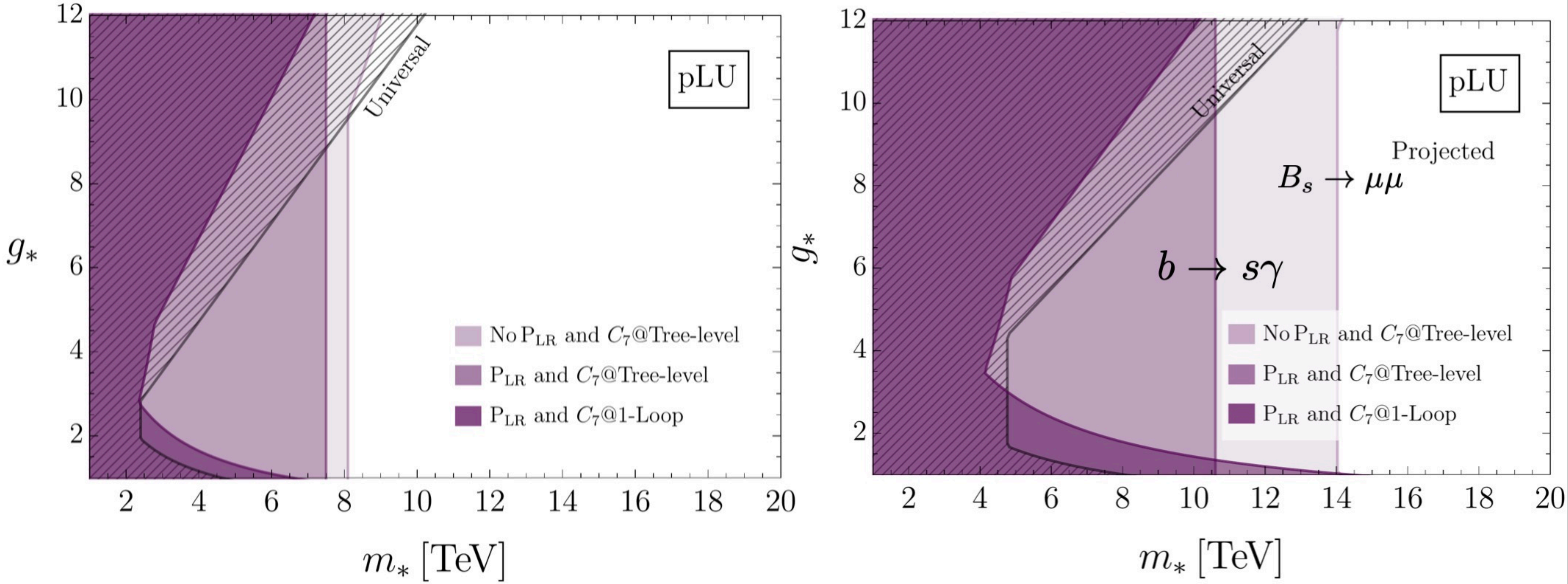
- R.U. $\quad U(3)_q \times U(3)_{U+u} \times U(3)_{D+d}$
- partial up R.U. $\quad U(3)_q \times [U(2) \times U(1)]_{U+u} \times U(3)_{D+d}$
- partial R.U. $\quad U(3)_q \times [U(2) \times U(1)]_{U+u} \times [U(2) \times U(1)]_{D+d}$
- L.U. $\quad U(3)_{q+Q} \times U(3)_u \times U(3)_d$
- partial L.U. $\quad [U(2) \times U(1)]_{q+Q} \times U(3)_u \times U(3)_d$



Universal
$pp \to jj$
$B\bar{B}$
$pp \to jj$
$B_s \to \mu\mu$
No P_{LR}
P_{LR}
g_*
m_* [TeV]
RU
Projected
Universal
No P_{LR}
P_{LR}
g_*
m_* [TeV]
LU
Universal
CKM - Unitarity
g_*
m_* [TeV]
LU
Projected
Universal
g_*
m_* [TeV]



puRU
Universal
$B_s \to \mu\mu$
$B\bar{B}$
No P$_{LR}$
P$_{LR}$
g_*
m_* [TeV]
puRU
Projected
Universal
No P$_{LR}$
P$_{LR}$
g_*
m_* [TeV]
pRU
Universal
$B_s \to \mu\mu$
$B^0 \to K^{*0}ee$
$B\bar{B}$
No P$_{LR}$ and C_7'@Tree-level
P$_{LR}$ and C_7'@Tree-level
P$_{LR}$ and C_7'@1-Loop
g_*
m_* [TeV]
pRU
Projected
Universal
d_N
No P$_{LR}$ and C_7'@Tree-level
P$_{LR}$ and C_7'@Tree-level
P$_{LR}$ and C_7'@1-Loop
g_*
m_* [TeV]



pLU
Universal
No P_{LR} and C_7@Tree-level
P_{LR} and C_7@Tree-level
P_{LR} and C_7@1-Loop
g_*
m_* [TeV]
pLU
Universal
Projected
$B_s \to \mu\mu$
$b \to s\gamma$
No P_{LR} and C_7@Tree-level
P_{LR} and C_7@Tree-level
P_{LR} and C_7@1-Loop
g_*
m_* [TeV]