European Strategy
for Particle Physics

Status and open questions in flavour physics

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Outline

Part I: The open questions

- The SM flavour puzzle
- The NP flavour puzzle

Part II: How to address them

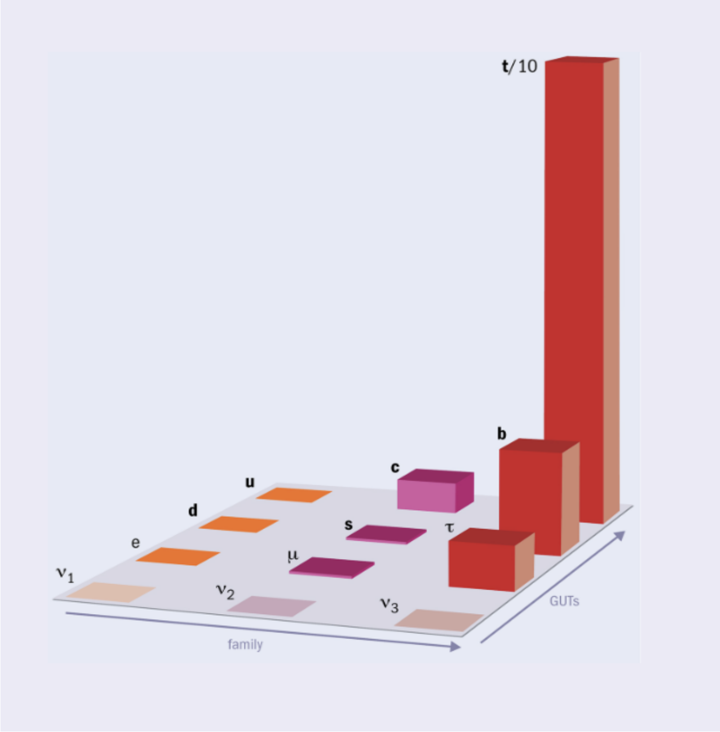
- The flavour of the SM-EFT
- NP-sensitive flavour transitions
- A closer look to FCNCs, LFU ratios & EDMs

Part III: Where we are & where we could go

- Generic bounds on NP scales
- Bounds under motivated flavour assumptions
- An explicit example of flavour-EW interplay

Part I.

The open questions

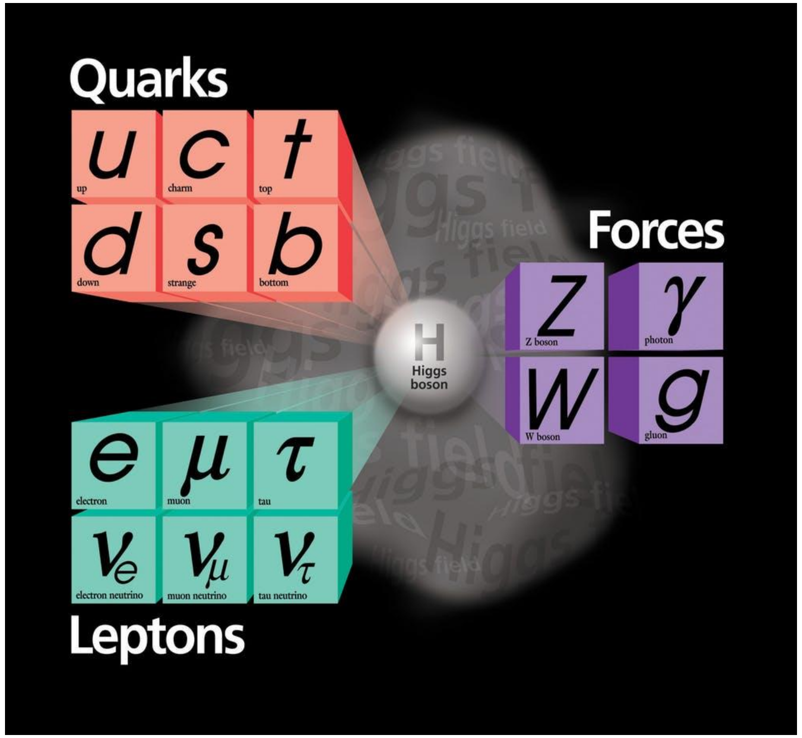


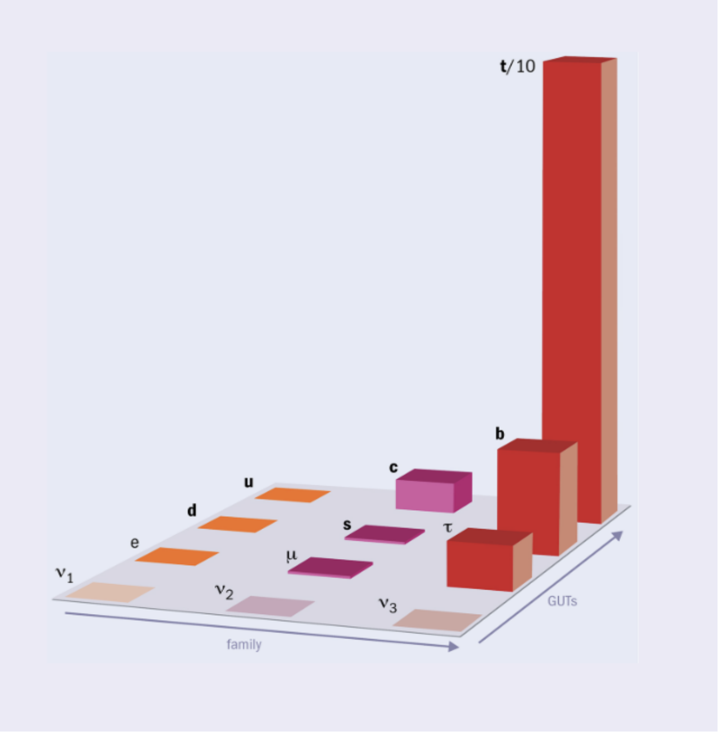
The open questions: *the SM flavour puzzle*

The “flavor puzzle” is an old problem, that emerged well before the Standard Model (SM) was conceived [*“Who ordered the muon ?”* - I. Rabi (~1950)].

Current (SM version) of the puzzle:

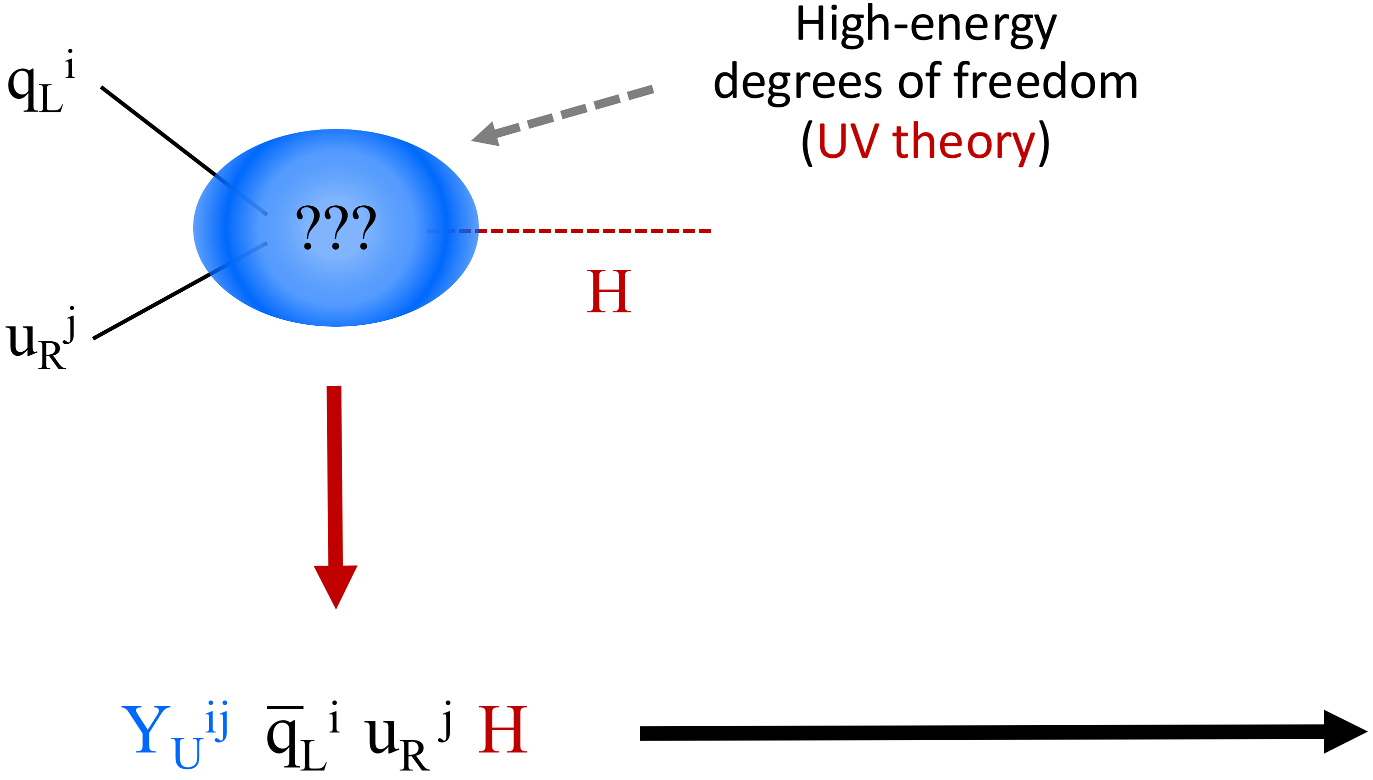
- Why do we have 3 copies of fermions with identical gauge quantum numbers
- What determines their highly non-trivial mass matrices?





The open questions: *the SM flavour puzzle*

Fermion masses are the results of the Yukawa interactions → Inescapable link between Higgs and flavor, whose origin can be addressed only beyond the SM…



$q_L{}^i$

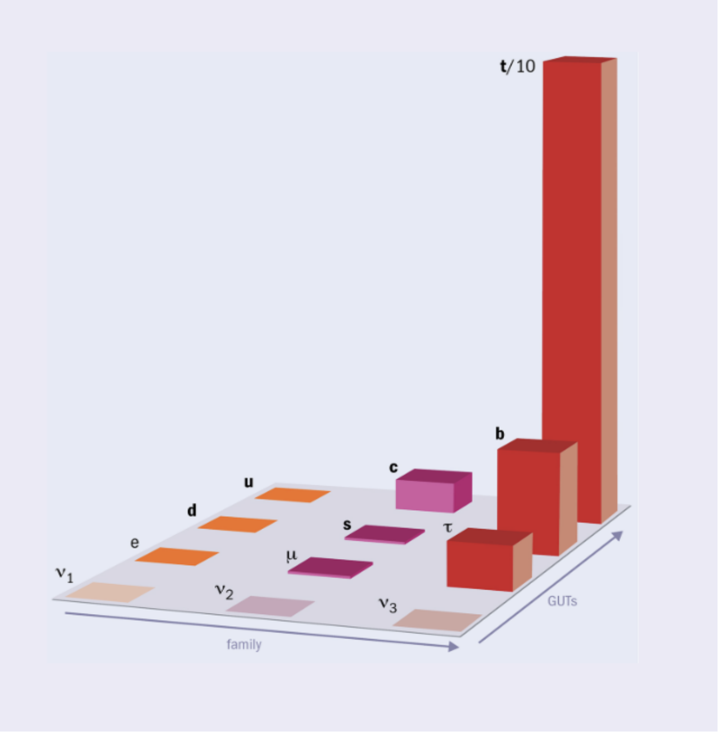
$u_R{}^j$

???

H

High-energy
degrees of freedom
(UV theory)

$Y_U{}^{ij}\ \bar{q}_L{}^i\ u_R{}^j\ H$



“Message from the UV”
that we need to “decode”

The open questions: *the SM flavour puzzle*

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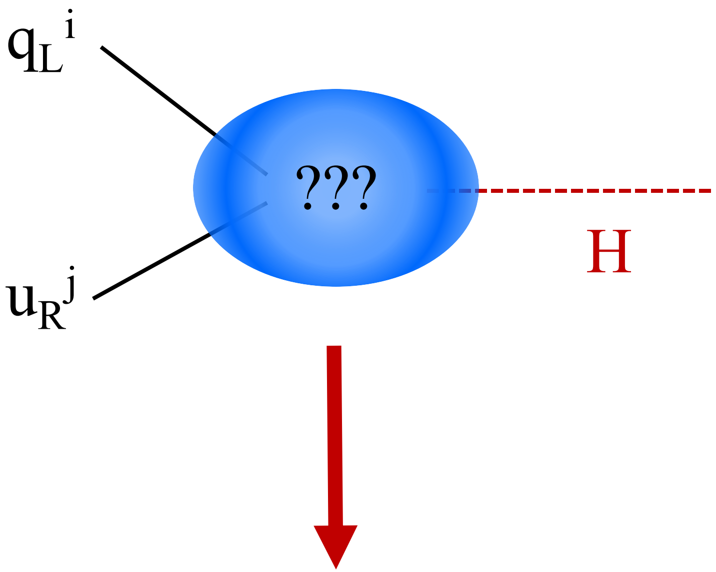


$Y_U^{ij}\ \bar{q}_L^{\ i}\ u_R^{\ j}\ H$

Contrary to gauge interactions, which are "protected" by gauge symmetries

[*universal couplings controlled only by field charges*]

the values of the Yukawa couplings provide more information about UV dynamics

↓

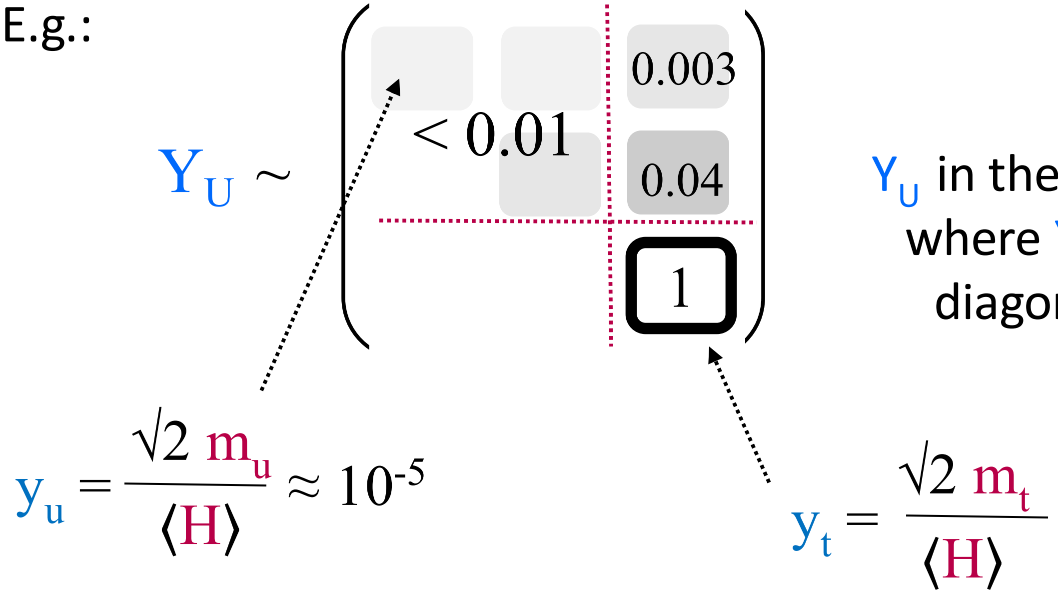
The UV dynamics responsible for the Higgs-fermion couplings is not universal among generations

The open questions: *the SM flavour puzzle*

Fermion masses are the results of the Yukawa interactions → Inescapable link between Higgs and flavor, whose origin can be addressed only beyond the SM…

The UV dynamics responsible for the Higgs-fermion couplings is flavor non universal and exhibits a strongly hierarchical pattern:

E.g.:



$$Y_U \sim \begin{pmatrix} \multicolumn{2}{c}{\multirow{2}{*}{< 0.01}} & 0.003 \\ & & 0.04 \\ & & \boxed{1} \end{pmatrix}$$

Y_U in the basis where Y_D is diagonal

$$y_u = \frac{\sqrt{2}\, m_u}{\langle H \rangle} \approx 10^{-5}$$

$$y_t = \frac{\sqrt{2}\, m_t}{\langle H \rangle}$$

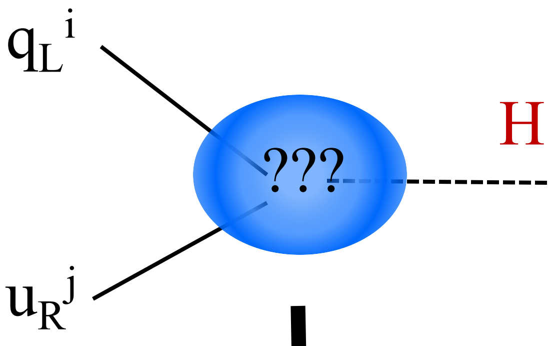
→

- Which is the nature of this dynamics?
- Which are the energy scales characterizing it?

Key questions to investigate the nature of the Higgs field and, more generally, the UV completion of the the SM

The open questions: *the NP flavour puzzle*

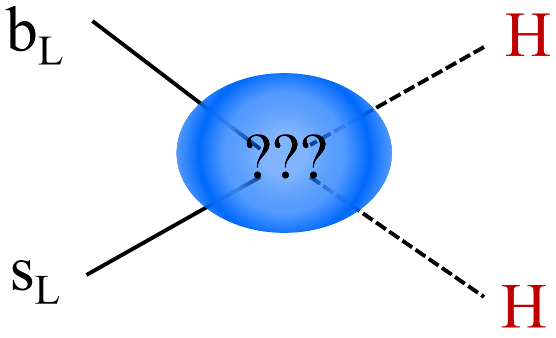
On general grounds, the flavor non-universal dynamics in the UV should give rise to new effective contact interactions → violations of exact & approximate symmetries of the SM:

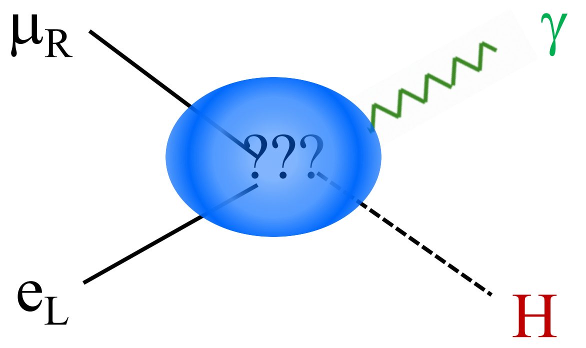


$$Y_U^{ij}\ \bar{q}_L^{\,i}\ u_R^{\,j}\ H$$

$$Y_U \sim \left(\begin{array}{cc:c} \multicolumn{2}{c:}{< 0.01} & < 0.1 \\ \hdashline & & 1 \end{array}\right)$$

E.g.:





Effective interaction which violates an approximate symmetry of the SM

$B_s \to \mu\mu$

Strength of the contact interaction ~ C_{eff}/Λ^2

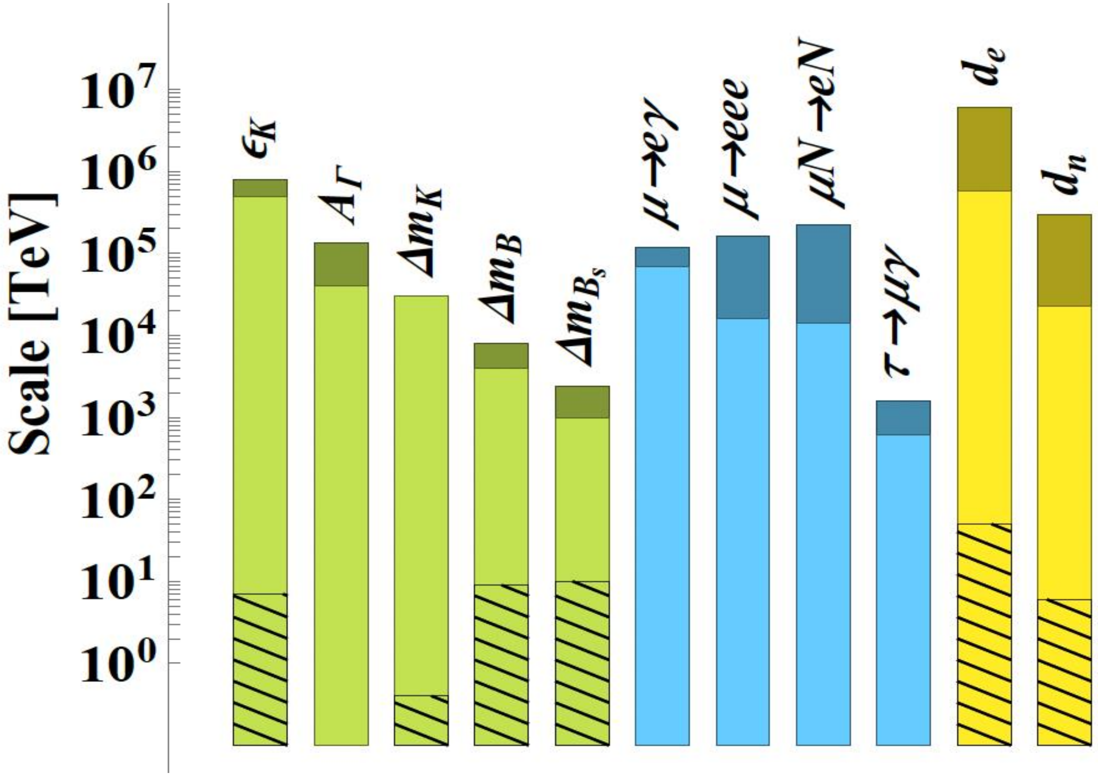
Effective interaction which violates an exact symmetry of the SM

$\mu \to e\gamma$

The open questions: *the NP flavour puzzle*

On general grounds, the flavor non-universal dynamics in the UV should give rise to new effective contact interactions ⟶ violations of exact & approximate symmetries of the SM.

At present we do not see any of these effects, and this is often expressed in terms of strong bounds on effective NP scales:



N.B.: These bounds are obtained assuming unit couplings for the effective coefficients

E.g.:

$$\frac{C_{\mu e\gamma}}{\Lambda^2} \longrightarrow \frac{1}{\Lambda^2}$$

Useful to show the potential, but rather misleading…

The open questions: *the NP flavour puzzle*

Two possible interpretations of the strong bounds on effective
New Physics scales from CP-violating & flavor-changing processes

Hypothesis: NP "badly violates" flavour [OK to assume C=O(1)]

↓

NP scale must be very high

Problems:

- We do not understand why the Yukawa coupl. are hierarchical
- Huge tuning problem in the Higgs potential (*EW hierarchy problem*)

Hypothesis: Light families couple to NP (at least to flavour non-universal NP) via small couplings

↓

NP scale can be as low as few TeV

Virtues:

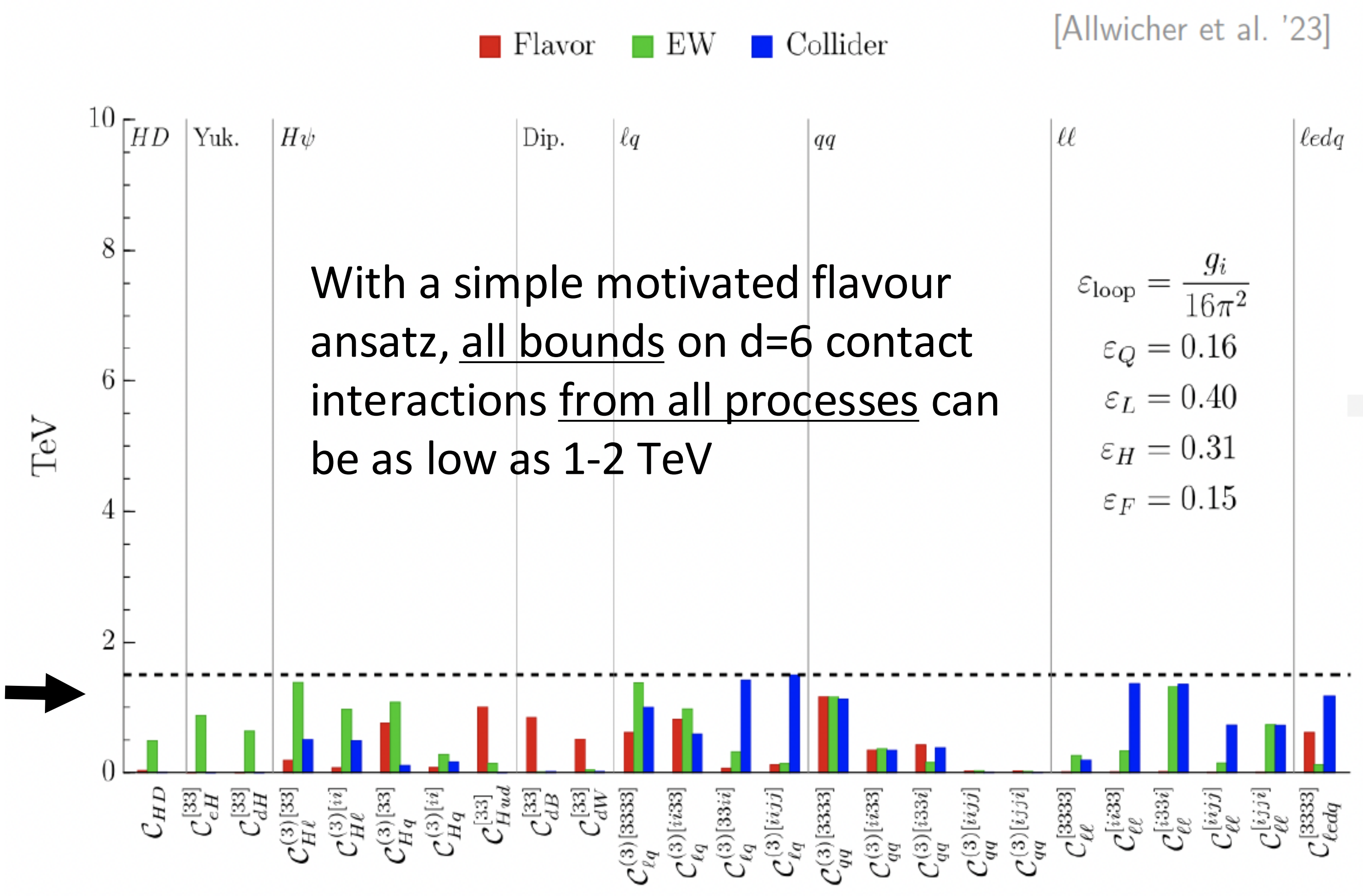
- We do understand why the Yukawa couplings are hierarchical
- Reduced tuning in the Higgs potential

The open questions: *the NP flavour puzzle*

Two possible interpretations of the strong bounds on effective
New Physics scales from CP-violating & flavor-changing processes

Caveats:

- The couplings <u>cannot be zero</u> (Yukawa couplings provide a minimum benchmark... → MFV)
- Reducing the scale to 1-2 TeV (minimal Higgs tuning) <u>requires flavour non-universality</u> (and flavour alignment in the light sector)

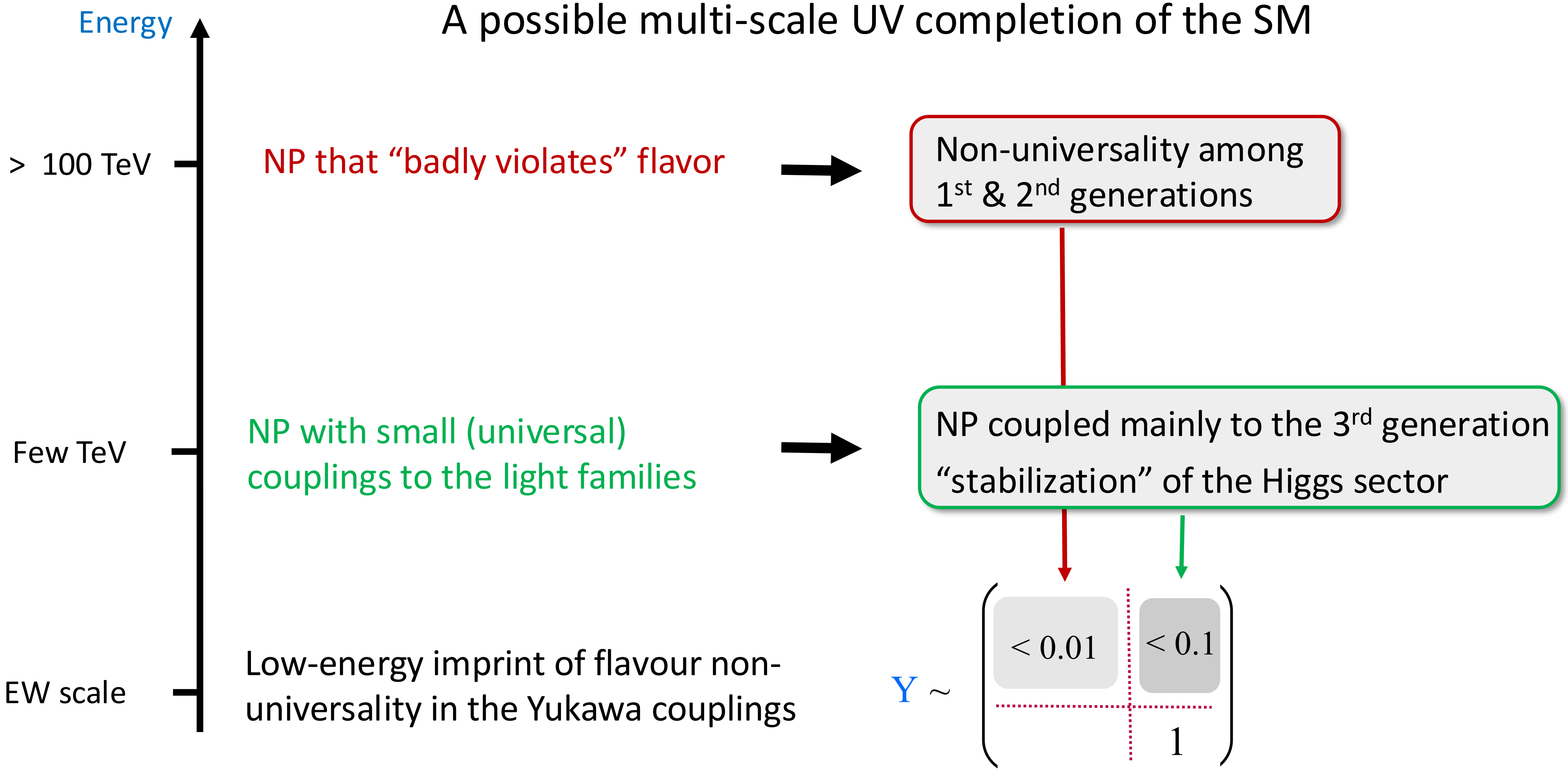


[Allwicher et al. '23]

With a simple motivated flavour ansatz, <u>all bounds</u> on d=6 contact interactions <u>from all processes</u> can be as low as 1-2 TeV

The open questions: *the NP flavour puzzle*

A possible multi-scale UV completion of the SM



NP that "badly violates" flavor → Non-universality among 1st & 2nd generations

NP with small (universal) couplings to the light families → NP coupled mainly to the 3rd generation "stabilization" of the Higgs sector

Low-energy imprint of flavour non-universality in the Yukawa couplings

$$Y \sim \left(\begin{array}{c:c} < 0.01 & < 0.1 \\ \hdashline & 1 \end{array}\right)$$

The open questions: *the NP flavour puzzle*

Two possible interpretations of the strong bounds on effective New Physics scales from CP-violating & flavor-changing processes

NP that "badly violates" flavour at high energies

Unique access to high scales not directly accessible at colliders

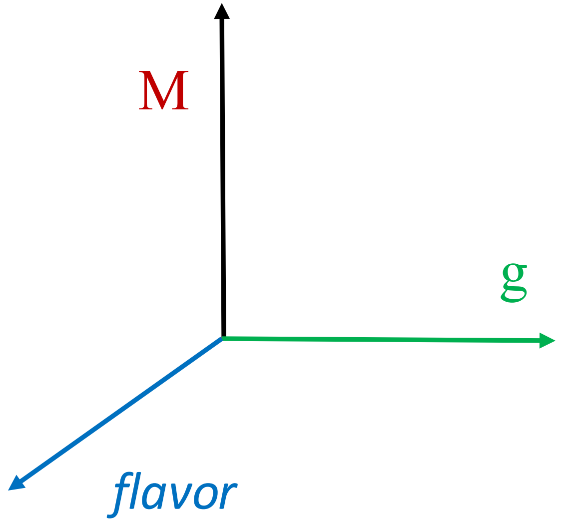
In both cases exp. + th. progress in the flavor sector is a must !

NP with small flavour-violating couplings to light family at nearby energies

Key interplay with electroweak and Higgs physics to indirectly "decode" NP at nearby energies

Part II.

How to address the open questions

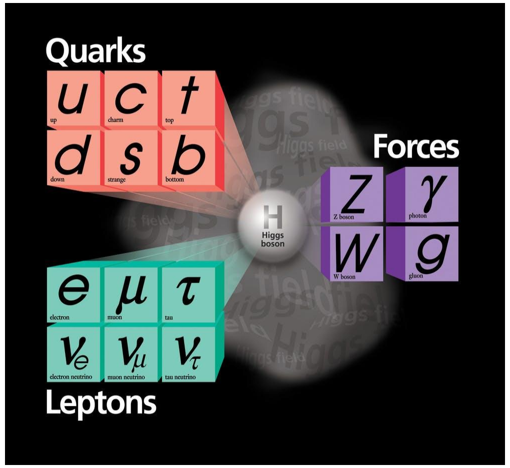


How to address the challenges: *Flavour in the SM EFT*

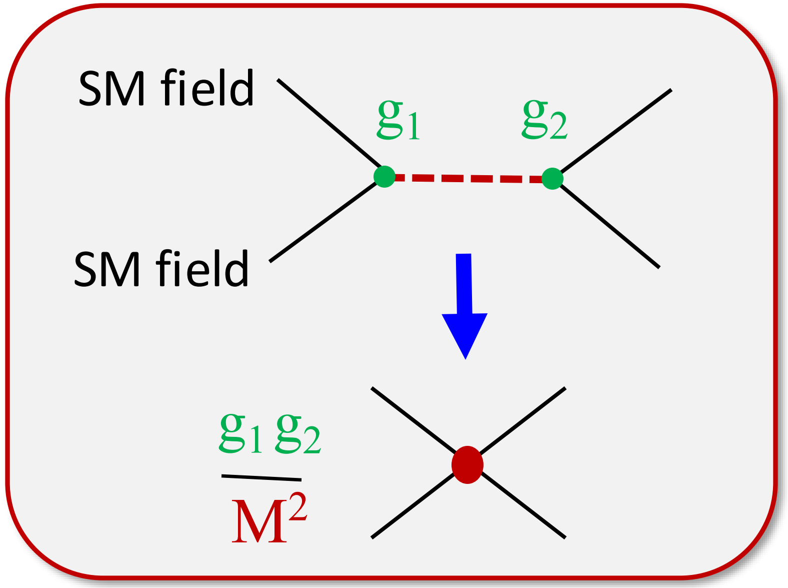
No matter if NP is at the TeV scale or well above, it is always very heavy compared to the energy scale of low-energy flavour experiments → systematic description via the "SM EFT"

$$\mathcal{L}_{\text{SM-EFT}} = \underline{\mathcal{L}_{\text{gauge}} + \mathcal{L}_{\text{Higgs}}} + \sum_{d>4} \frac{c_i^{[d]}}{\Lambda^{d-4}} O_i^{[d]} (\psi_{\text{SM}})$$

Long-range structure of the theory



Most general description of heavy NP that we are not able to directly "excite"



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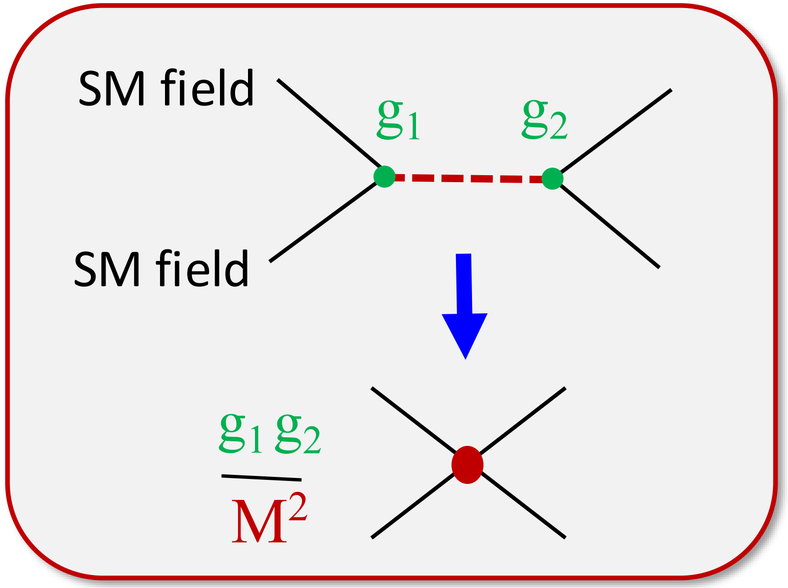
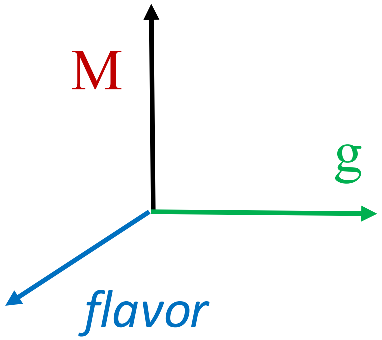


Understanding the flavour structure of the SM EFT is a question of pivotal importance.



N. of independent couplings:

No flavor symmetry	2499 [@d=6]
Maximal flavor symmetry	47 [@d=6]

How to address the challenges: *Flavour in the SM EFT*

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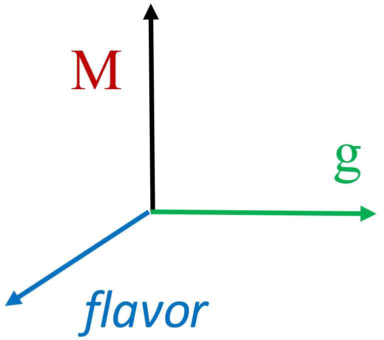

Don't be scared by the large number of independent couplings of eff. operators!

N. of independent couplings:

No flavor symmetry	2499 [@d=6]
Maximal flavor symmetry	47 [@d=6]

They do not indicate model parameters, but rather the number of observables we can probe (*whose correlations depend on the unknown underlying model*)

How to address the challenges @ large-scale facilities [b,c,τ]

	γ	quarks	μ	e	τ	ν
$3_q \to 2_q$	$b \to s\,\gamma$	$B_s \leftrightarrow \bar{B}_s$	$b \to s\,\mu\mu$ $b \to c\,\mu\nu$	$R_{bs}\,(e/\mu)$ $R_{bc}\,(e/\mu)$	$b \to s\,\tau\tau$ $b \to c\,\tau\nu$	$b \to s\,\nu\nu$
$3_q \to 1_q$	$b \to d\,\gamma$	$B_d \leftrightarrow \bar{B}_d$	$b \to d\,\mu\mu$ $b \to u\,\mu\nu$	$R_{bd}\,(e/\mu)$ $R_{bu}\,(e/\mu)$	$b \to d\,\tau\tau$ $b \to u\,\tau\nu$	$b \to d\,\nu\nu$
$2_q \to \begin{matrix} 2_q \\ 1_q \end{matrix}$	$c \to u\,\gamma$	$D \leftrightarrow \bar{D}$	$c \to u\,\mu\mu$ $c \to s\,\mu\nu$ $c \to d\,\mu\nu$	$R_{cu}\,(e/\mu)$ $R_{cs}\,(e/\mu)$ $R_{cd}\,(e/\mu)$		$c \to u\,\nu\nu$
$3_l \to \begin{matrix} 2_l \\ 1_l \end{matrix}$	$\tau \to \mu\,\gamma$ $\tau \to e\,\gamma$	$\tau \to \mu\,qq$ $\tau \to e\,qq$	$\tau \to \mu\,\mu\mu$ $\tau \to \mu\,ee$	$\tau \to \mu\,ee$ $\tau \to e\,ee$		$\tau \to \mu\,\nu\nu$ $\tau \to e\,\nu\nu$

How to address the challenges @ large-scale facilities [b,c,τ]

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$3_q \to 1_q$	$b \to$		$b \to d\,\mu\mu$ $b \to u\,\mu\nu$		$b \to d\,\tau\tau$ $b \to u\,\tau\nu$	
$2_q \to \begin{matrix} 2_q \\ 1_q \end{matrix}$	$c \to u\,\gamma$	$D \leftrightarrow \bar{D}$	$c \to u\,\mu\mu$ $c \to s\,\mu\nu$ $c \to d\,\mu\nu$	$R_{cu}\,(e/\mu)$ $R_{cs}\,(e/\mu)$ $R_{cd}\,(e/\mu)$		$c \to u\,\nu\nu$
$3_l \to \begin{matrix} 2_l \\ 1_l \end{matrix}$	$\tau \to \mu\,\gamma$ $\tau \to e\,\gamma$	$\tau \to \mu\,qq$ $\tau \to e\,qq$	$\tau \to \mu\,\mu\mu$ $\tau \to \mu\,ee$	$\tau \to \mu\,ee$ $\tau \to e\,ee$		$\tau \to \mu\,\nu\nu$ $\tau \to e\,\nu\nu$

$B(B_s \to \mu\mu)$,
$B(B \to K^* \mu\mu)$,
$A_{FB}(B \to K^* \mu\mu)$,
□

$R^{\tau/\mu}(D)$,
$R^{\tau/\mu}(D^*)$, …

$B(B \to K\,\nu\nu)$,
$B(B \to K^*\nu\nu)$,
□

N.B.: *several observables for each transition*

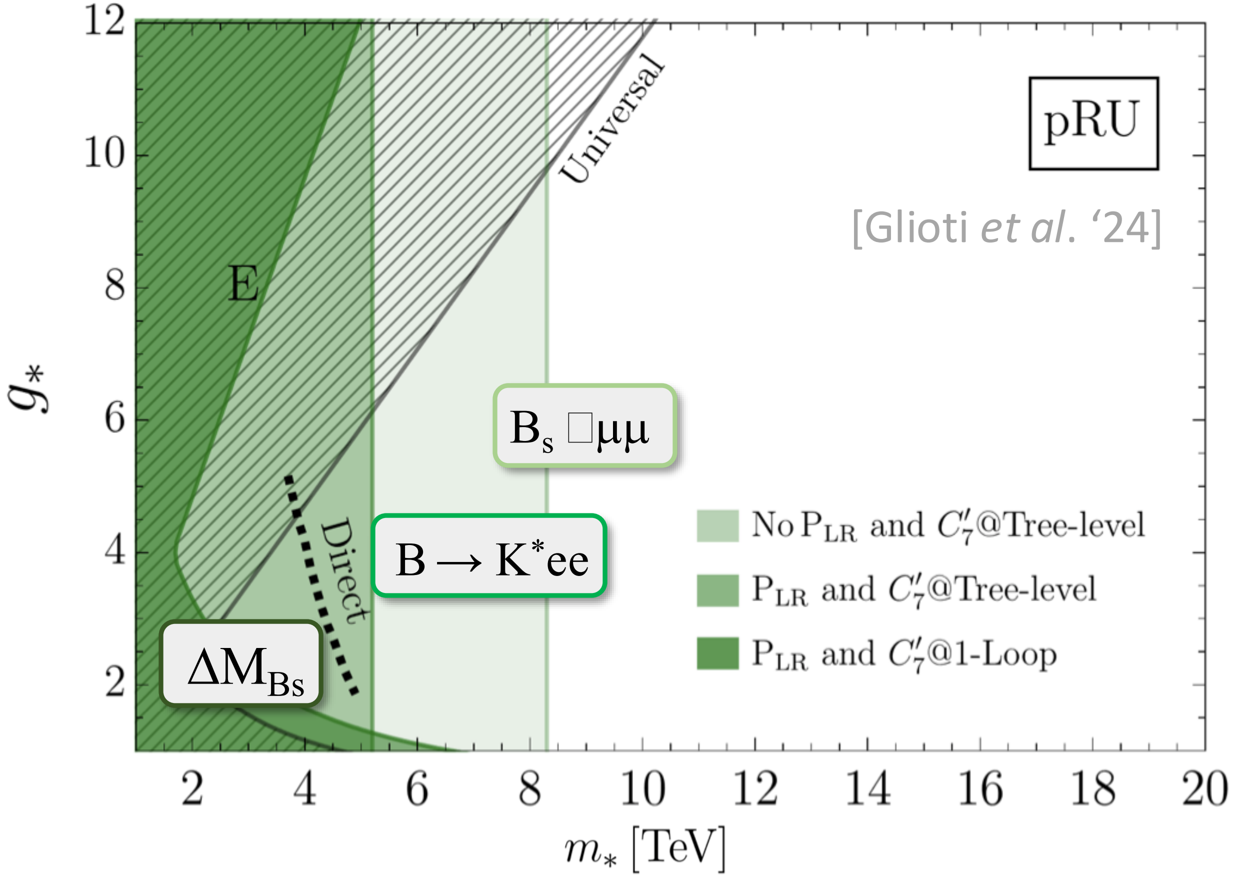
How to address the challenges @ large-scale facilities [b,c,τ]

	γ	quarks	μ	e	τ	ν
$3_q \to 2_q$	$b \to s\,\gamma$	$B_s \leftrightarrow \bar{B}_s$	$b \to s\,\mu\mu$	$R_{bs}\,(e/\mu)$	$b \to s\,\tau\tau$	$b \to s\,\nu\nu$
$3_q \to 1_q$	$b \to d\,\gamma$	$B_d \leftrightarrow \bar{B}_d$				

🟩 FCNCs currently @ 10-30%

- TeV-scale constraints in <u>realistic models</u>
- Current theory errors 5% - 20% → will reach 1-2%

E.g.: Partial fermion compositeness



How to address the challenges @ large-scale facilities [b,c,τ]

	γ	quarks	μ	e	τ	ν
			b → s μμ b → c μν	R_{bs} (e/μ) R_{bc} (e/μ)	b → s ττ b → c τν	b → s νν
$3_1 \rightarrow$ 2_1 1_1	τ → μ γ τ → e γ	τ → μ qq τ → e qq	τ τ			

🟨 Tests of Lepton Universality

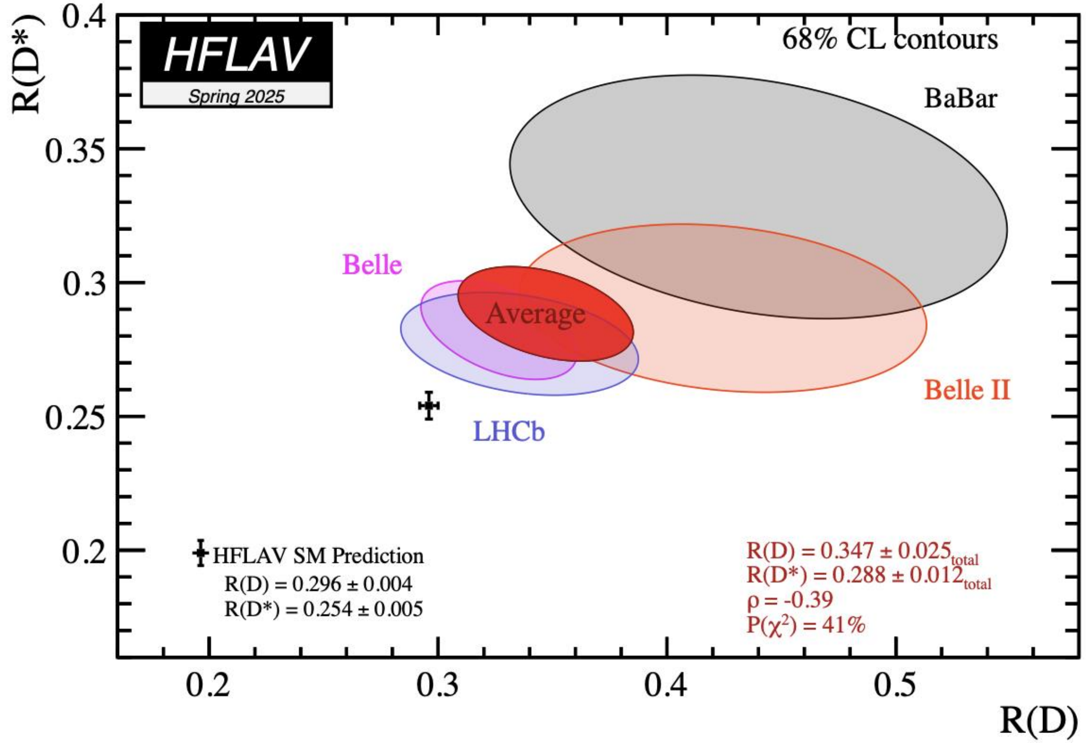
@ 5-10% in

- τ/μ (charged-current)
- μ/e (FCNCs)

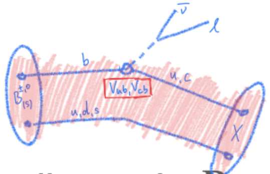
E.g.:

$$R(D^{(*)}) = \frac{B(B \to D^{(*)} \tau\nu)}{B(B \to D^{(*)} \mu\nu)}$$

"Clean" probes of a variety of motivated BSM (e.g. flavour non-universal gauge groups) → large room for improv.



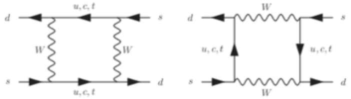
How to address the challenges @ large-scale facilities [b,c,τ]



Inclusive semileptonic $B_{(s)}$ and $D_{(s)}$ decay

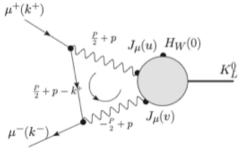
[Barone et al. JHEP (2023)], [Barone et al. arXiv:2504.03358],
[De Santis et al. arXiv:2504.06063], [De Santis et al. arXiv:2504.06064]

illustration arXiv:2404.02297



$\epsilon_K, \epsilon'/\epsilon, \Delta M_K$

[Bai et al. PRD 2024]

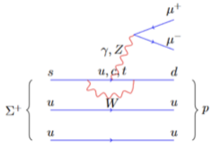


long-distance effects in rare leptonic decays

e.g. $K \to \ell\ell$

[Chao et al. PRD 2024]

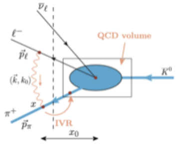
illustration LHCb



rare hyperon decay

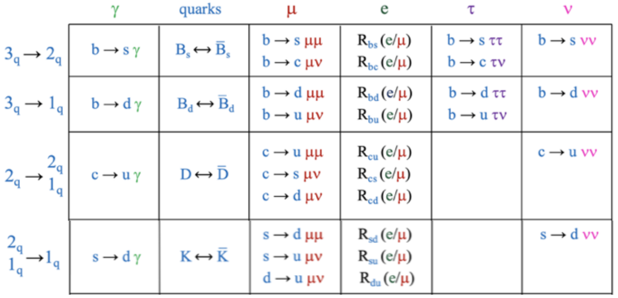
[Erben et al. arXiv:2504.07727]

Examples for new and exploratory directions in lattice QCD for flavour



QCD+QED for semileptonic decays

[Christ et al. arXiv:2402.08915]



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$\begin{smallmatrix}2_q\\1_q\end{smallmatrix} \to 1_q$	$s \to d\gamma$	$K \leftrightarrow \bar{K}$	$s \to d\mu\mu$ $s \to u\mu\nu$ $d \to u\mu\nu$	$R_{sd}(e/\mu)$ $R_{su}(e/\mu)$ $R_{du}(e/\mu)$		$s \to d\nu\nu$

long-distance contributions to rare kaon decay

[Boyle et al. PRD 2023]

long-distance contributions to charm mixing

[Di Carlo, Erben, Hansen arXiv:2504.16189]

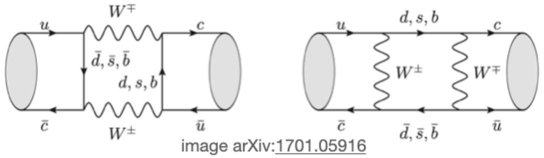
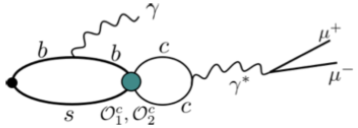


image arXiv:1701.05916



short/long-distance contributions to radiative decays

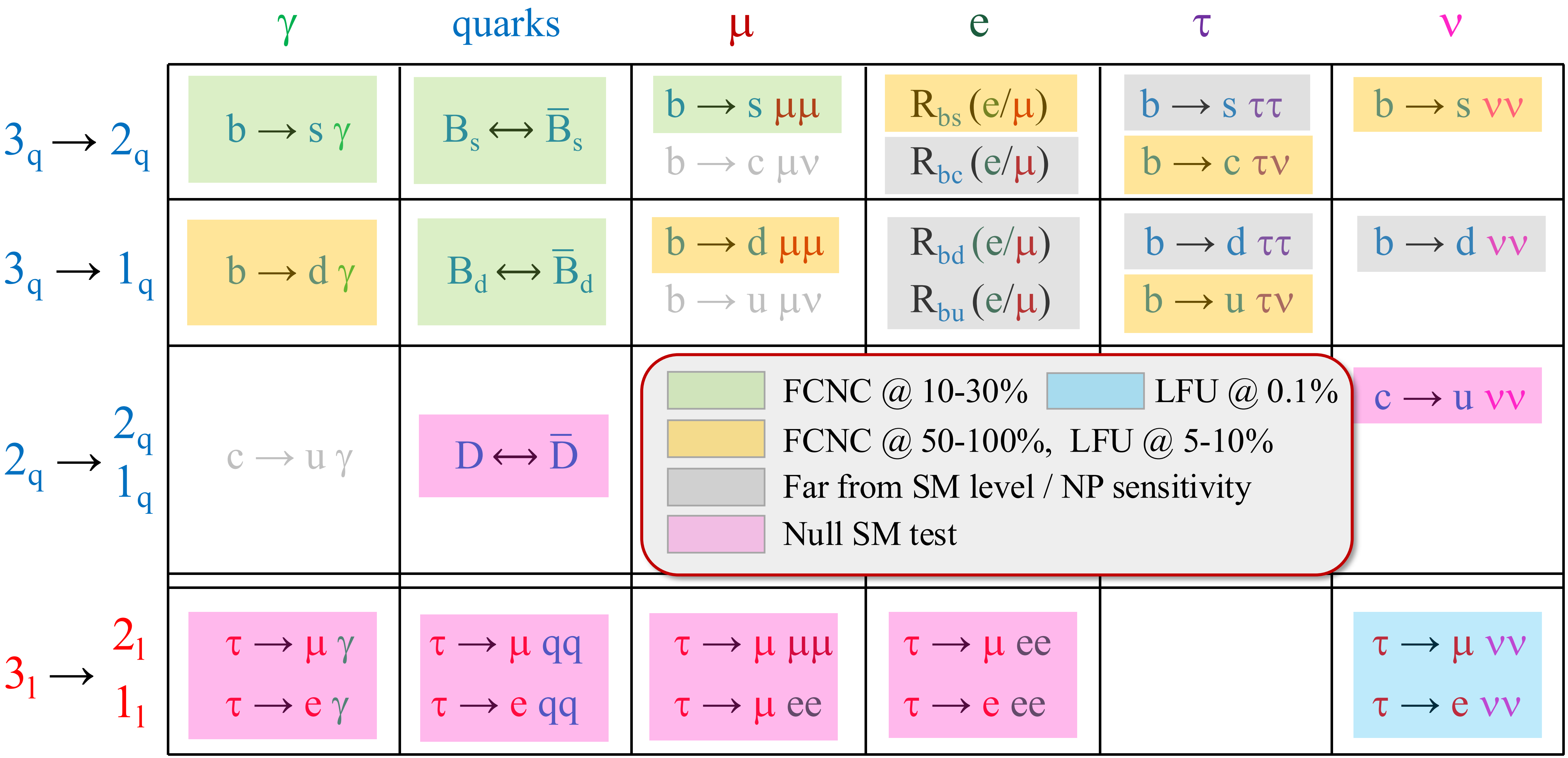
e.g. $B_s \to \mu\mu\gamma, D_s \to \ell\nu_\ell\gamma$

[Frezzotti et al. PRD 2024], [Frezzotti et al. PRD 2024]

A. Jüttner,
Flavour WG session

14

Large-scale facilities [b,c,τ]: *overview of present status*



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$3_q \to 1_q$	$b \to d\,\gamma$	$B_d \leftrightarrow \bar{B}_d$	$b \to d\,\mu\mu$ $b \to u\,\mu\nu$	$R_{bd}\,(e/\mu)$ $R_{bu}\,(e/\mu)$	$b \to d\,\tau\tau$ $b \to u\,\tau\nu$	$b \to d\,\nu\nu$
$2_q \to \begin{matrix} 2_q \\ 1_q \end{matrix}$	$c \to u\,\gamma$	$D \leftrightarrow \bar{D}$				$c \to u\,\nu\nu$
$3_l \to \begin{matrix} 2_l \\ 1_l \end{matrix}$	$\tau \to \mu\,\gamma$ $\tau \to e\,\gamma$	$\tau \to \mu\,qq$ $\tau \to e\,qq$	$\tau \to \mu\,\mu\mu$ $\tau \to \mu\,ee$	$\tau \to \mu\,ee$ $\tau \to e\,ee$		$\tau \to \mu\,\nu\nu$ $\tau \to e\,\nu\nu$

🟩 FCNC @ 10-30%

🟦 LFU @ 0.1%

🟨 FCNC @ 50-100%, LFU @ 5-10%

⬜ Far from SM level / NP sensitivity

🟪 Null SM test

Large-scale facilities [b,c,τ]: *future prospects*

	γ	quarks	μ	e	τ	ν
$3_q \to 2_q$	$b \to s\,\gamma$	$B_s \leftrightarrow \bar{B}_s$	$b \to s\,\mu\mu$ $b \to c\,\mu\nu$	$R_{bs}\,(e/\mu)$ $R_{bc}\,(e/\mu)$	$b \to s\,\tau\tau$ $b \to c\,\tau\nu$	$b \to s\,\nu\nu$
$3_q \to 1_q$	$b \to d\,\gamma$	$B_d \leftrightarrow \bar{B}_d$	$b \to d\,\mu\mu$ $b \to u\,\mu\nu$	$R_{bd}\,(e/\mu)$ $R_{bu}\,(e/\mu)$	$b \to d\,\tau\tau$ $b \to u\,\tau\nu$	$b \to d\,\nu\nu$
$2_q \to \begin{matrix} 2_q \\ 1_q \end{matrix}$	$c \to u\,\gamma$	$D \leftrightarrow \bar{D}$				$c \to u\,\nu\nu$
$3_l \to \begin{matrix} 2_l \\ 1_l \end{matrix}$	$\tau \to \mu\,\gamma$ $\tau \to e\,\gamma$	$\tau \to \mu\,qq$ $\tau \to e\,qq$	$\tau \to \mu\,\mu\mu$ $\tau \to \mu\,ee$	$\tau \to \mu\,ee$ $\tau \to e\,ee$		$\tau \to \mu\,\nu\nu$ $\tau \to e\,\nu\nu$

Progress from HL-LHC & Belle-II:

🟥 σ reduction by 4 – 10 times

Possible Tera-Z impact [6×10^{12} Z]:

🟨 Further σ reduction by 5 – 10

🟩 Further σ reduction ≥ 10

How to address the challenges @ dedicated facilities [K, π, μ, EDMs]

	γ	quarks	μ	e	τ	ν
$2_q 1_q \to 1_q$	$s \to d\,\gamma$	$K \leftrightarrow \bar{K}$	$s \to d\,\mu\mu$ $s \to u\,\mu\nu$ $d \to u\,\mu\nu$	$R_{sd}\,(e/\mu)$ $R_{su}\,(e/\mu)$ $R_{du}\,(e/\mu)$		$s \to d\,\nu\nu$
$2_l \to 1_l$	$\mu \to e\,\gamma$	$\mu N \to eN$		$\mu \to e\,ee$		$\mu \to e\,\nu\nu$
$2_l \to 2_l$	g_μ d_μ					
$1_l \to 1_l$	d_e					
$1_q \to 1_q$	d_N					

Extremely powerful probes of new sources of CP violations

Most sensitive probe of the θ-term [QCD vacuum]

How to address the challenges @ dedicated facilities [K, π, μ, EDMs]

	γ	quarks	μ	e	τ	ν
$2_q\,1_q \to 1_q$	$s \to d\,\gamma$	$K \leftrightarrow K$	$K_L \to \pi^0\mu\mu$ $s \to u\,\mu\nu$ $d \to u\,\mu\nu$	$R_{sd}\,(e/\mu)$ $R_{su}\,(e/\mu)$ $\pi^+ \to \pi^0\,e\nu$ $R_{du}\,(e/\mu)$		$K_L \to \pi^0\,\nu\nu$ $K^+ \to \pi^+\,\nu\nu$
$2_l \to 1_l$	$\mu \to e\,\gamma$	$\mu N \to eN$		$\mu \to e\,ee$		$\mu \to e\,\nu\nu$
$2_l \to 2_l$	$g_\mu \quad d_\mu$					
$1_l \to 1_l$	d_e					
$1_q \to 1_q$	d_N					

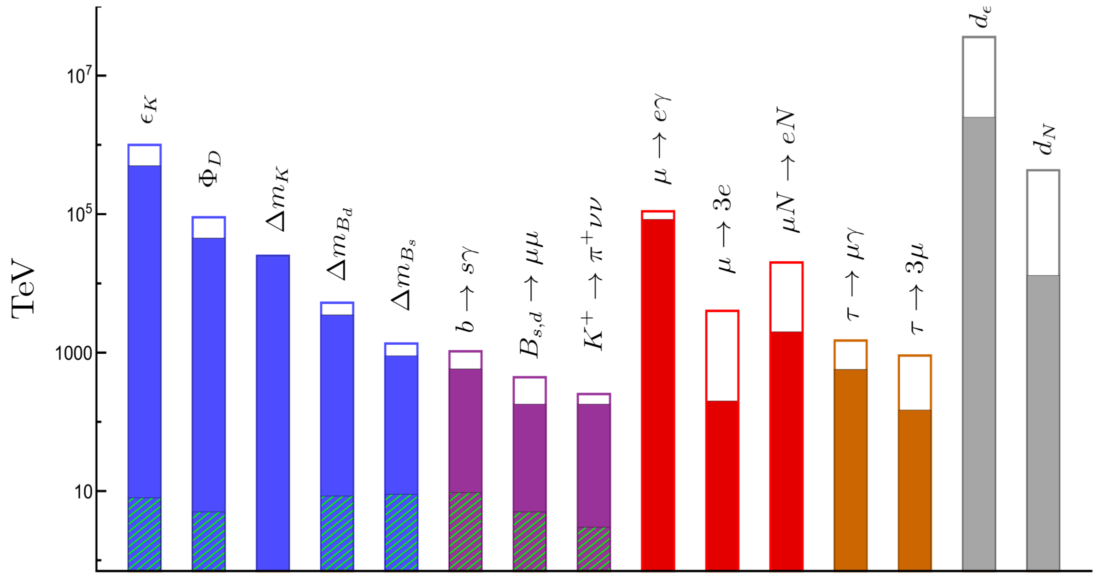
Long-term plans:

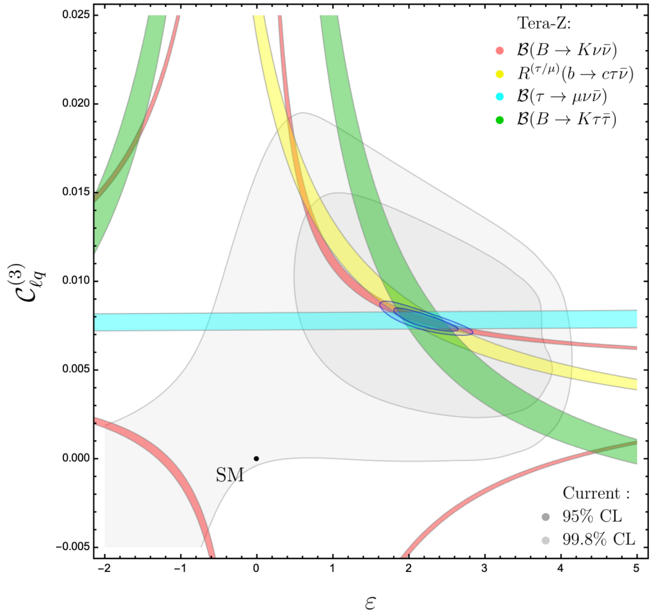
- 🟩 one or more dedicated projects
- 🟪 clean mode lacking dedicated project

Part III.

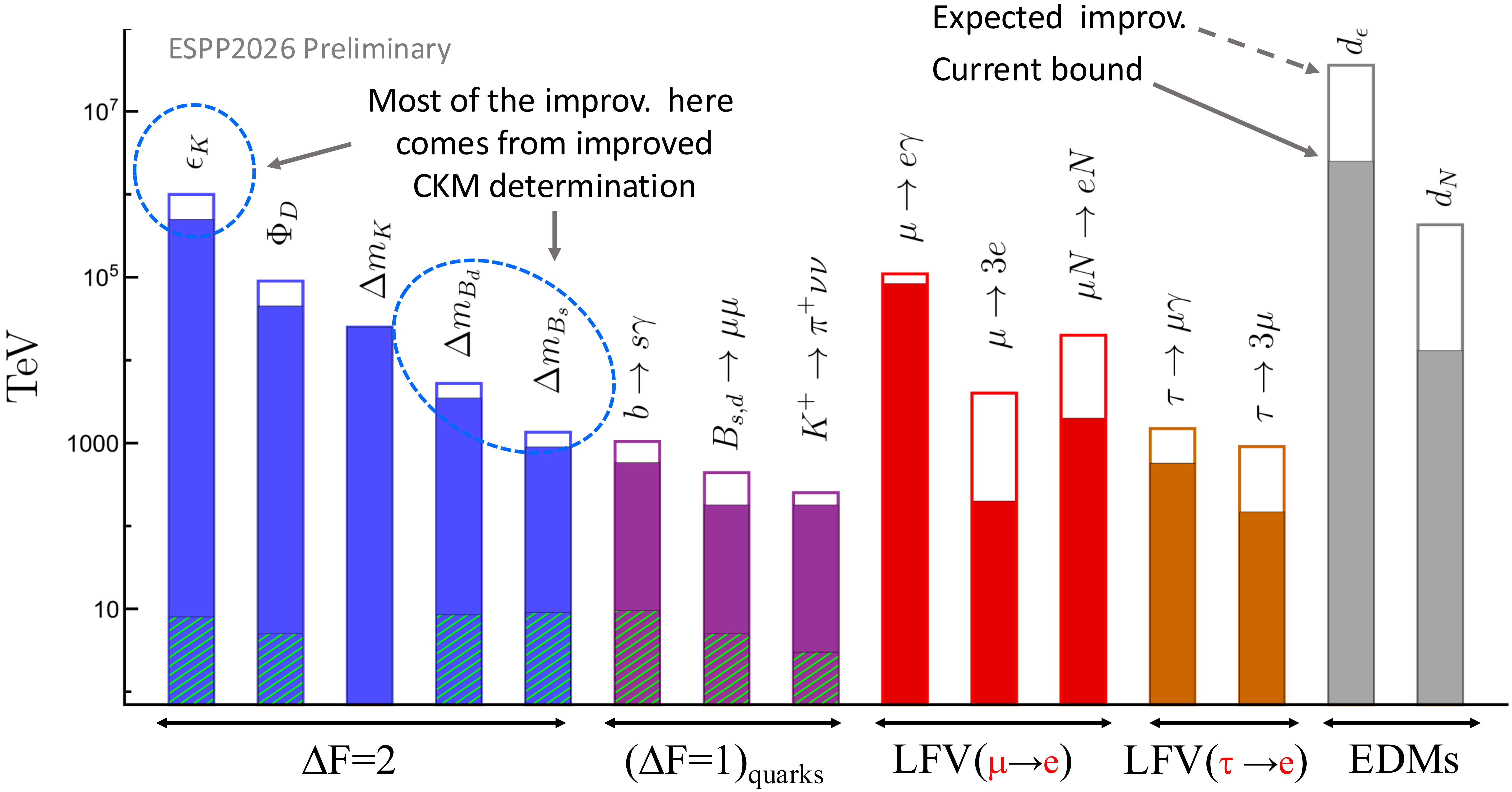
Where we are and where we could go

[From agnostic bounds to flavour-EW-Higgs interplay in concrete cases]

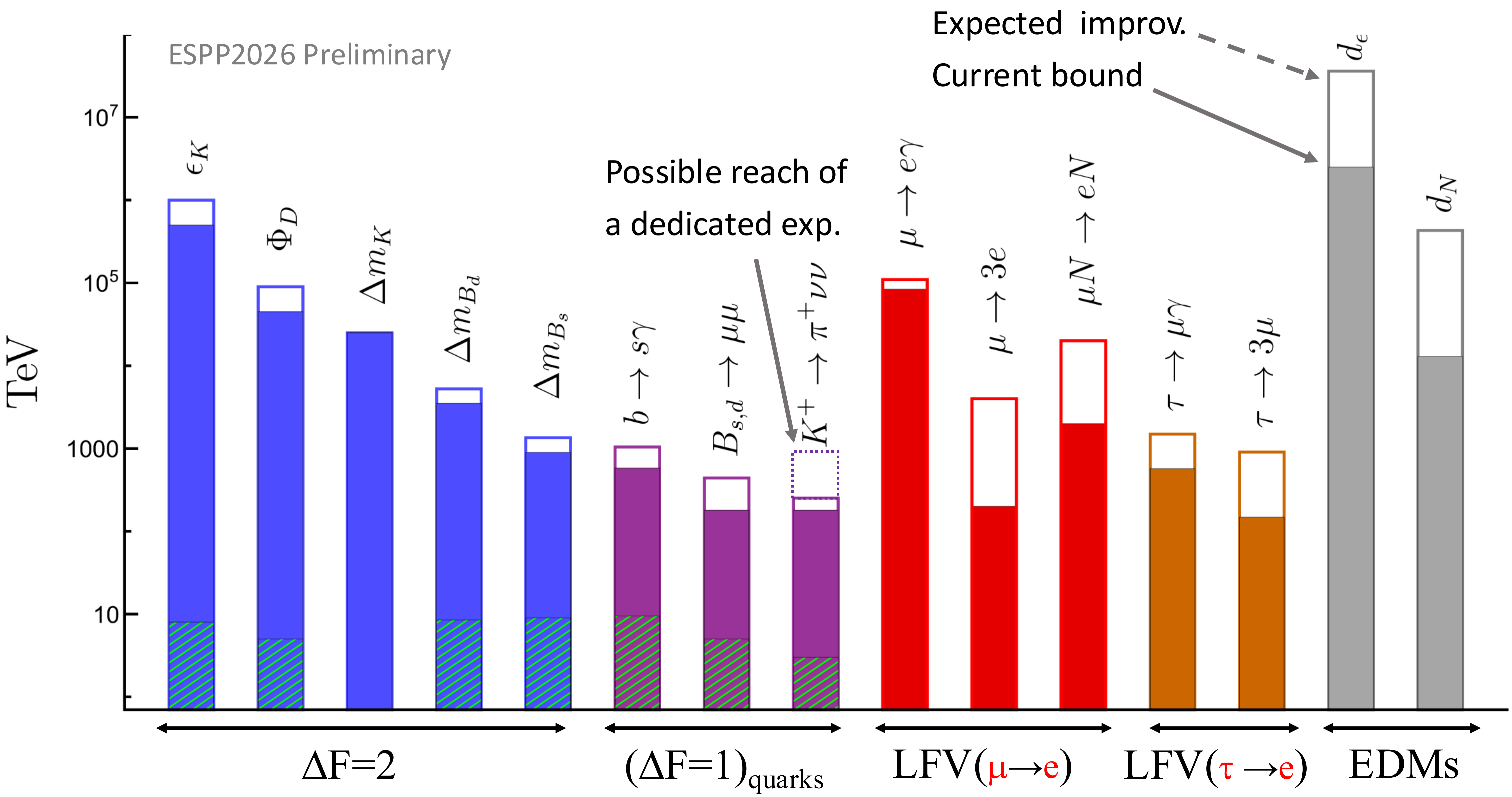




Bounds on effective scales for generic (unit) couplings



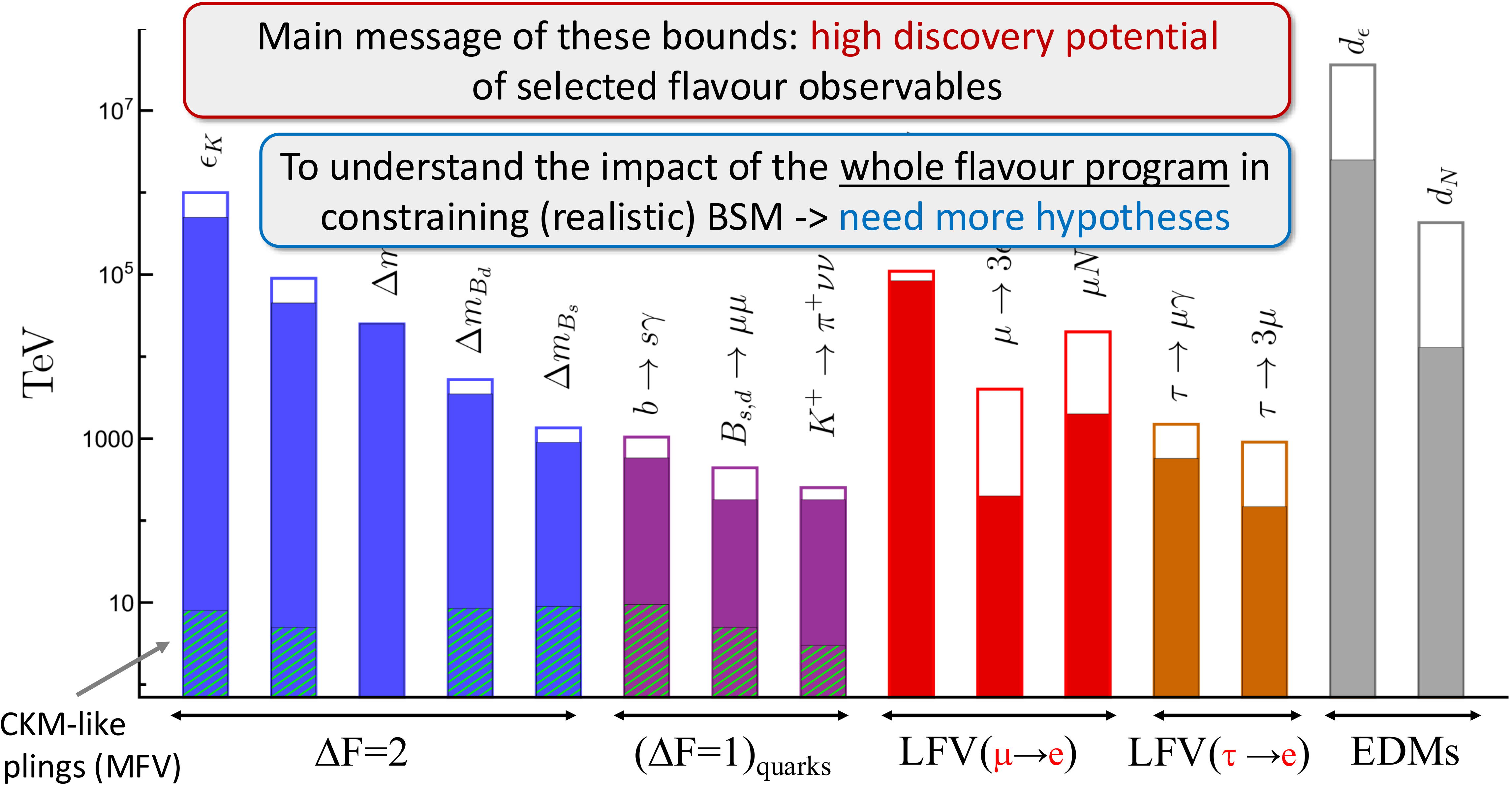
Bounds on effective scales for generic (unit) couplings



Bounds on effective scales for generic (unit) couplings

Main message of these bounds: high discovery potential of selected flavour observables

To understand the impact of the <u>whole flavour program</u> in constraining (realistic) BSM -> need more hypotheses



CKM-like couplings (MFV)

Bounds on effective scales in motivated setup (*low-scale NP*)

Conservative reference framework: NP with no new sources of quark flavour mixing, that differentiates between 3rd and light generations [e.g. it couples mainly to the 3rd gen., as in many motivated models] → analysis of all the contact interactions involving 3rd gen. quarks and lepton doublets:

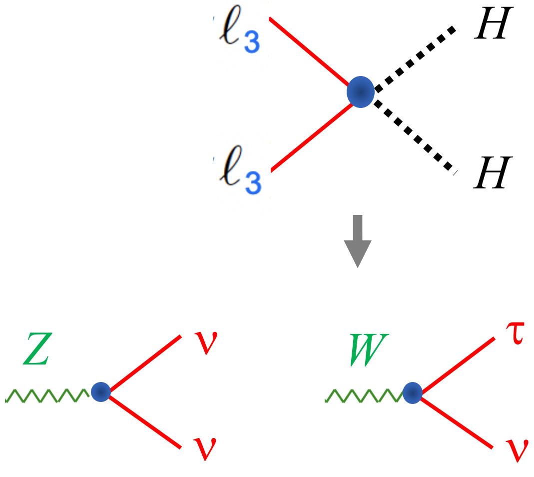
E.g.:

$$Q_{H\ell}^{(1)} = (H^\dagger i \overleftrightarrow{D}_\mu H)(\bar{\ell}_3 \gamma^\mu \ell_3)$$

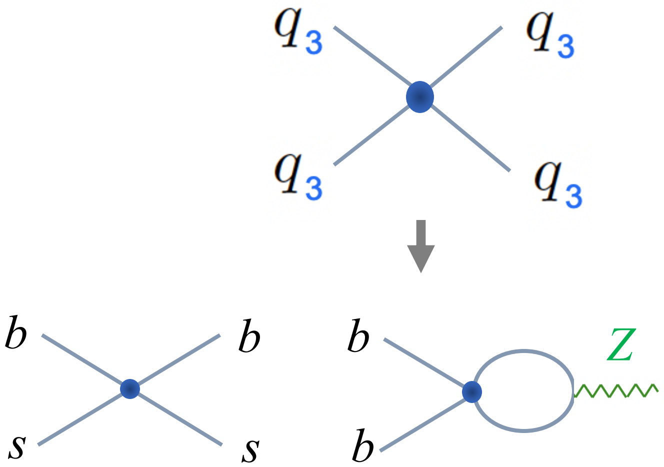
$$Q_{H\ell}^{(3)} = (H^\dagger i \overleftrightarrow{D}^I_\mu H)(\bar{\ell}_3 \tau^I \gamma^\mu \ell_3)$$

$$Q_{qq}^{(1)} = (\bar{q}_3 \gamma_\mu q_3)(\bar{q}_3 \gamma^\mu q_3)$$

$$Q_{qq}^{(3)} = (\bar{q}_3 \gamma_\mu \tau^I q_3)(\bar{q}_3 \gamma^\mu \tau^I q_3)$$



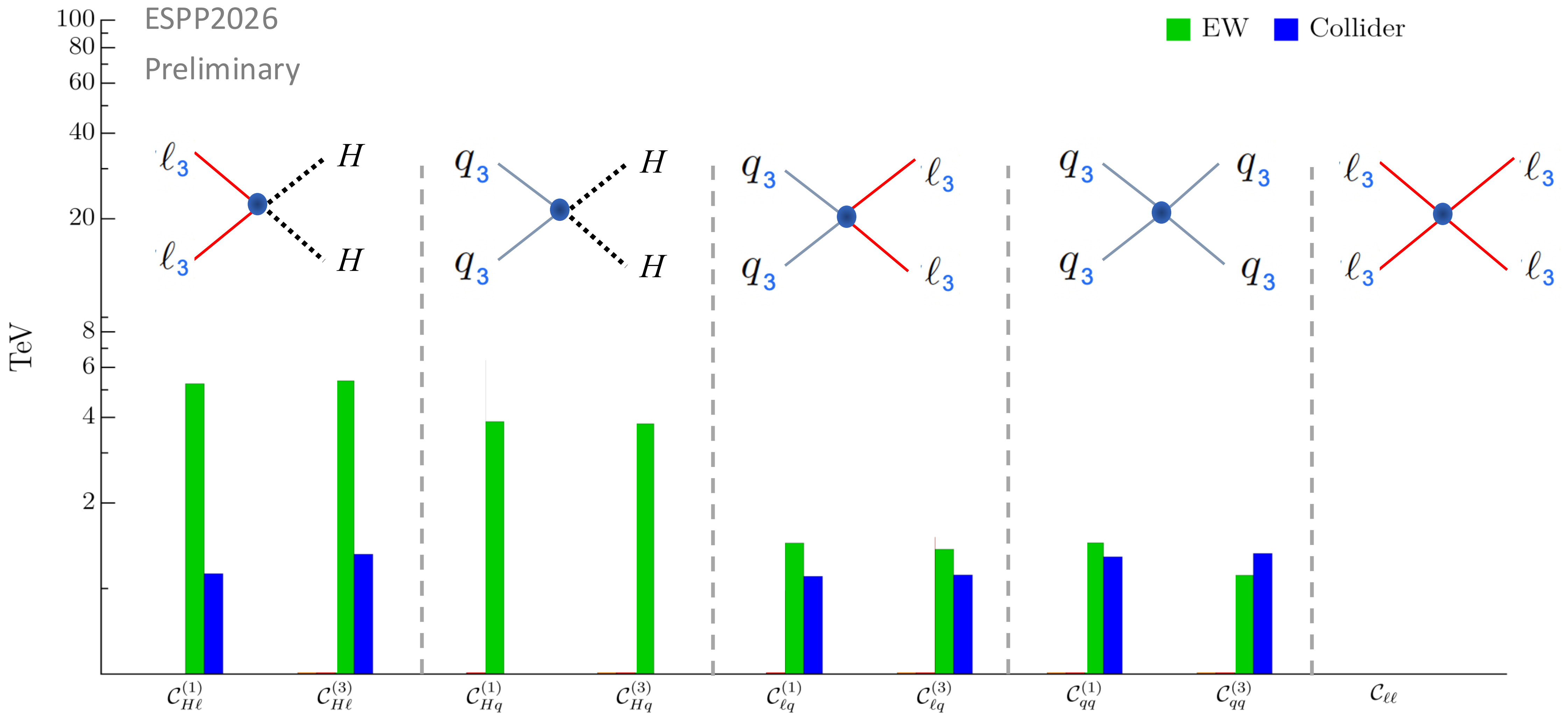
Z → νν τ → *l*νν + …



Δm_{B_s} Z → bb + …

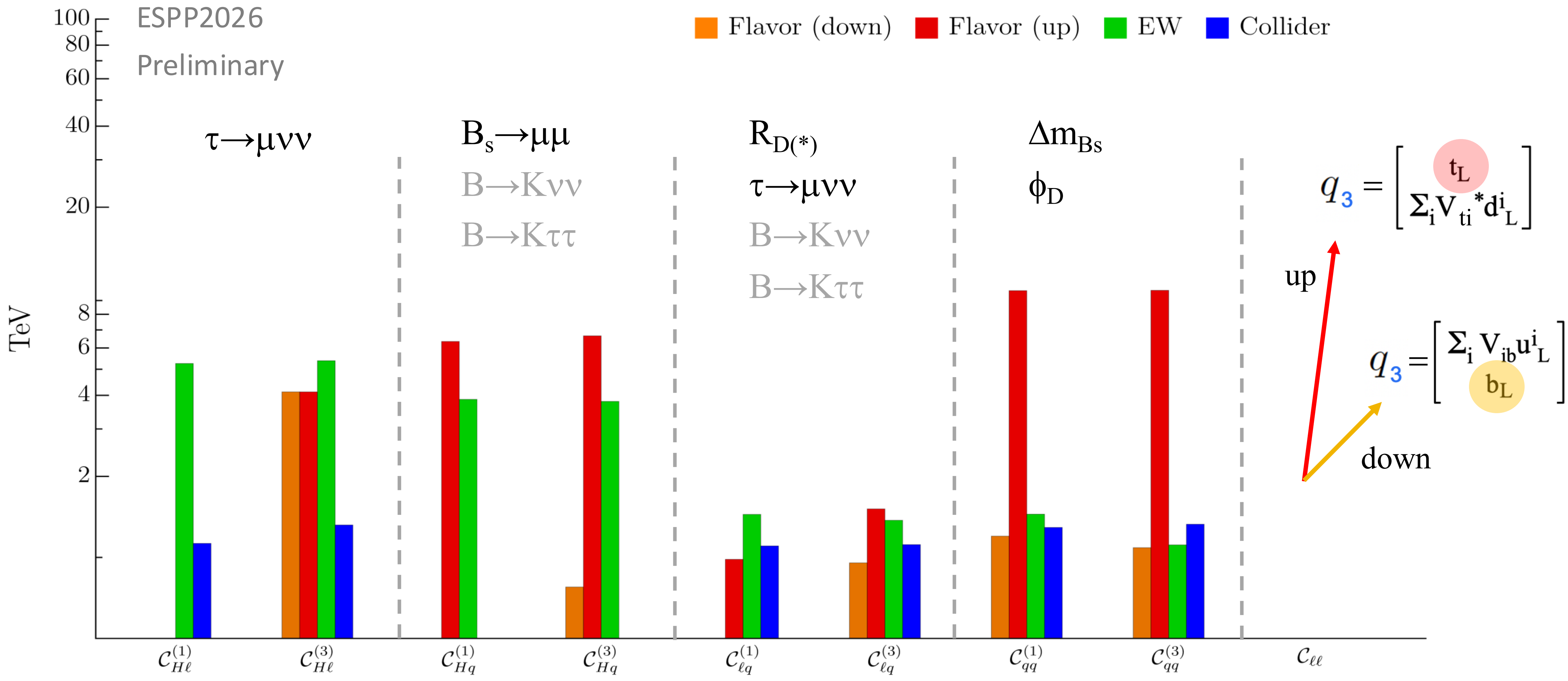
Bounds on effective scales in motivated setup (*low-scale NP*)

Analysis of all the contact interactions involving 3rd gen. quarks and lepton doublets:



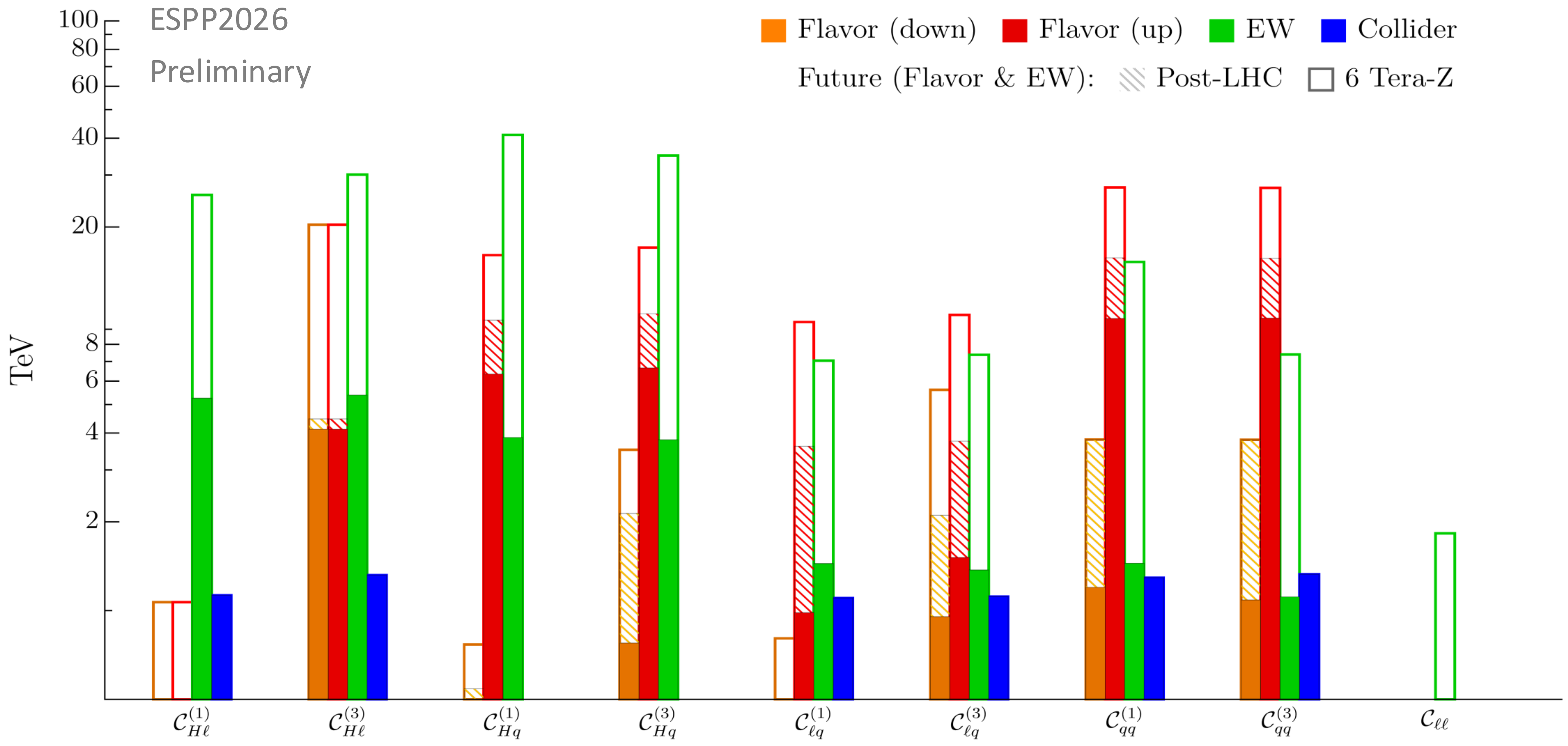
Bounds on effective scales in motivated setup (*low-scale NP*)

Analysis of all the contact interactions involving 3rd gen. quarks and lepton doublets:



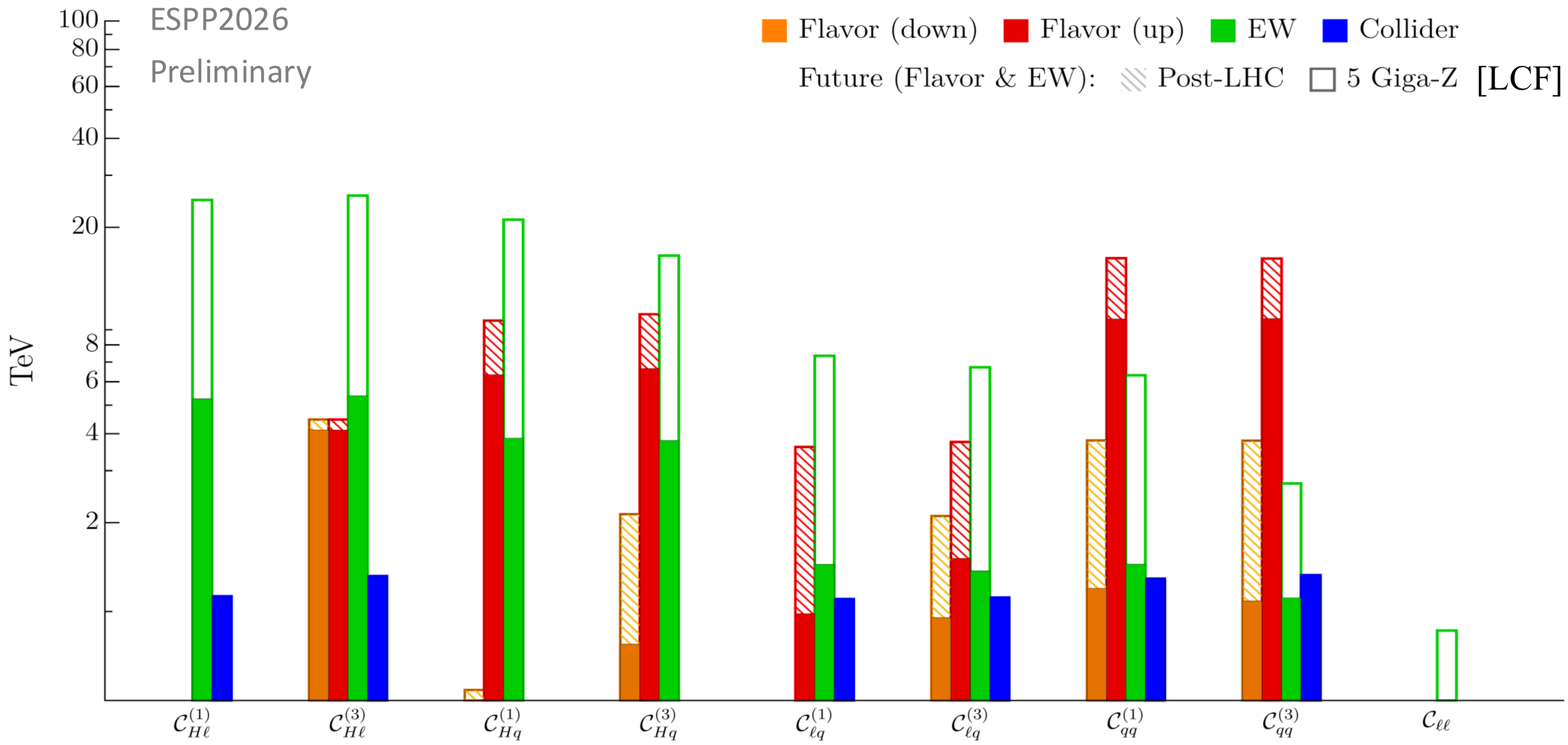
Bounds on effective scales in motivated setup (*low-scale NP*)

Analysis of all the contact interactions involving 3rd gen. quarks and lepton doublets:



Bounds on effective scales in motivated setup (*low-scale NP*)

Analysis of all the contact interactions involving 3rd gen. quarks and lepton doublets:

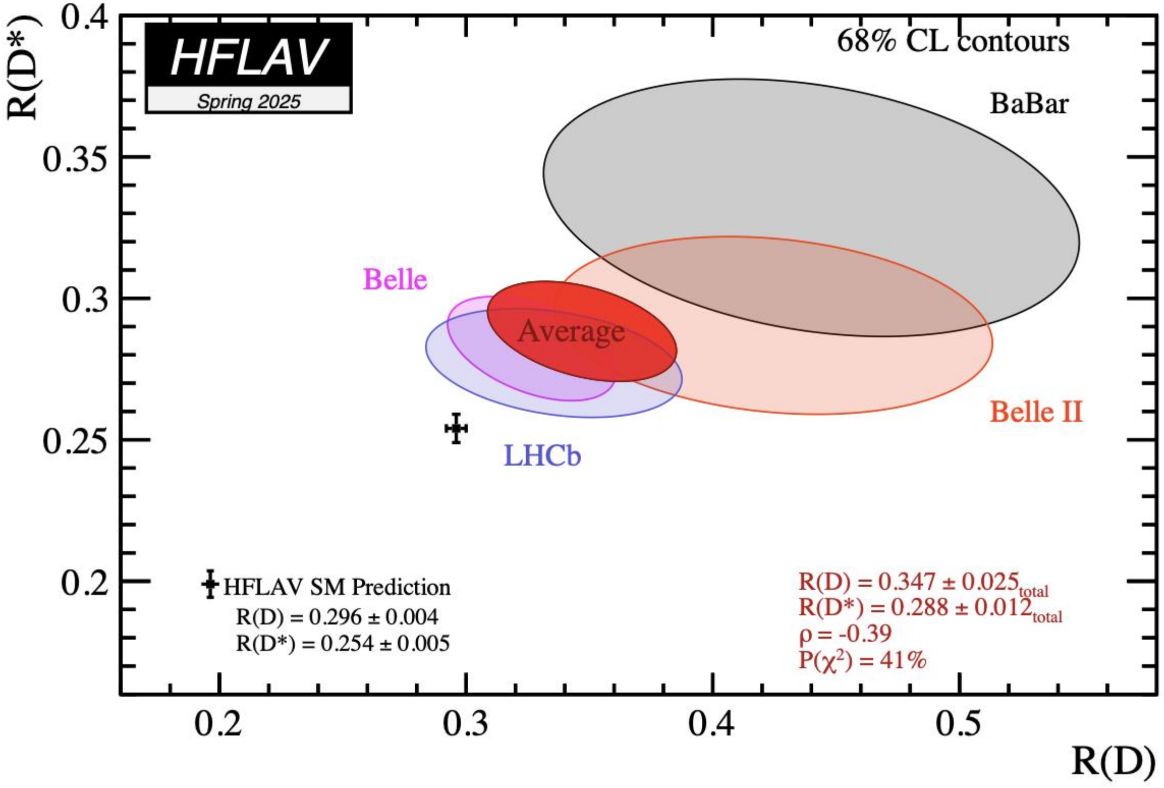


An explicit example of flavour – EW interplay (*assuming NP signal*)

Looking at bounds from individual observables misses the main point of indirect NP searches, which is the interplay of a large number of observables in "decoding" the underlying theory

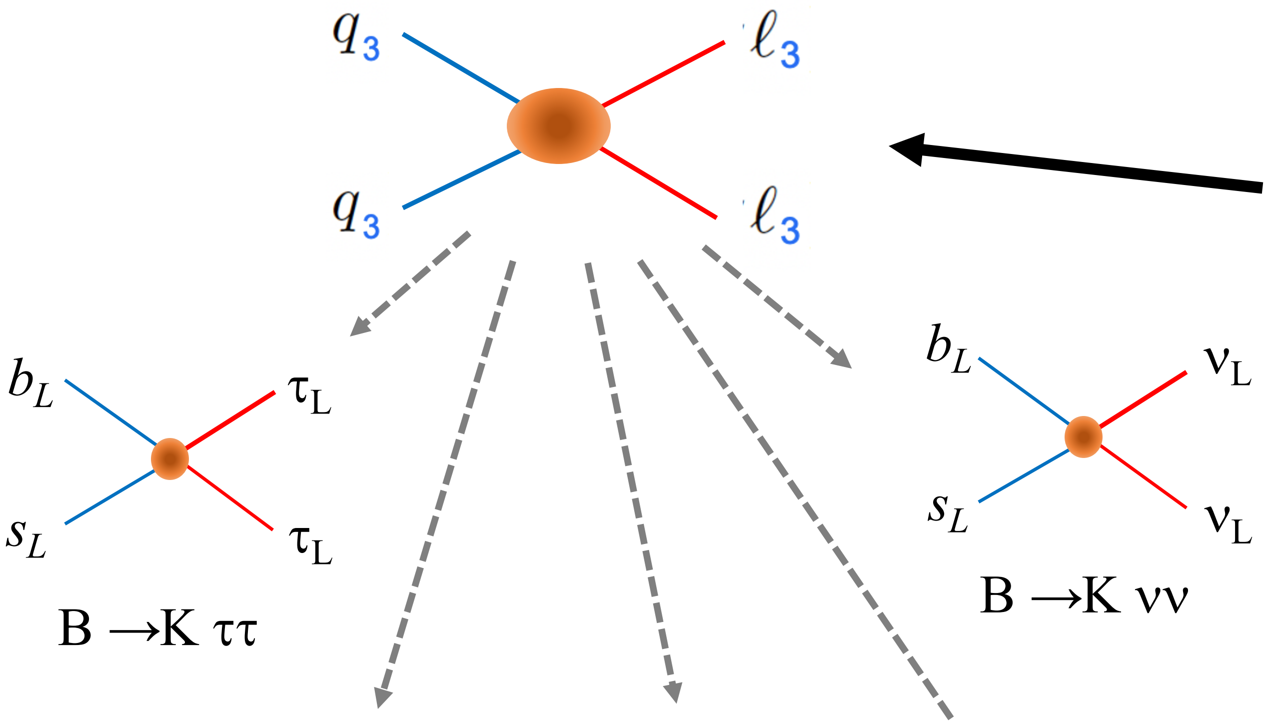
To illustrate this point worth to consider an explicit example assuming a NP signal →

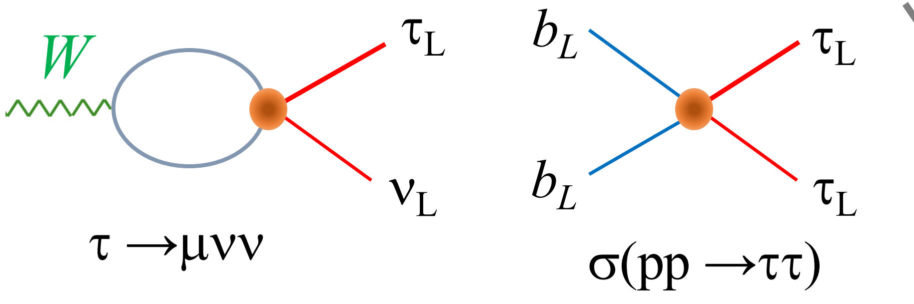
$$R(D^{(*)}) = \frac{B(B \to D^{(*)}\tau\nu)}{B(B \to D^{(*)}\mu\nu)}$$

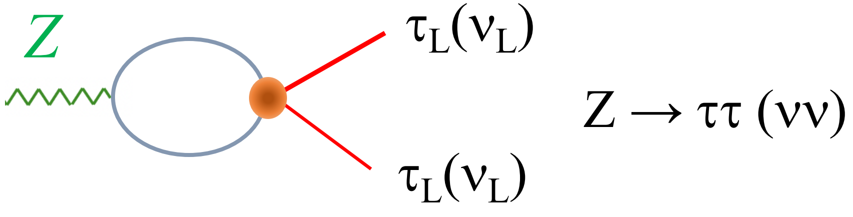


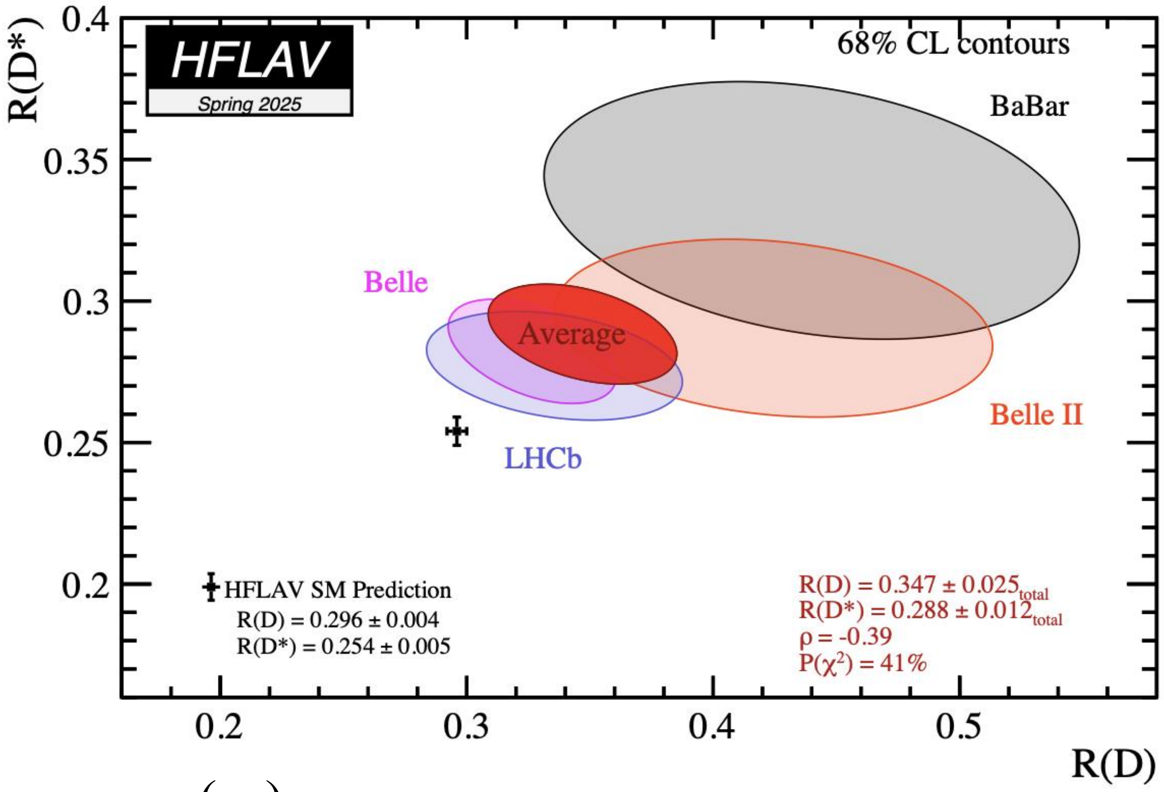
An explicit example of flavour – EW interplay (*assuming NP signal*)

Looking at bounds from individual observables misses the main point of indirect NP searches, which is the interplay of a large number of observables in "decoding" the underlying theory



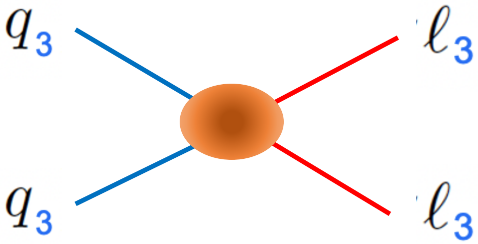


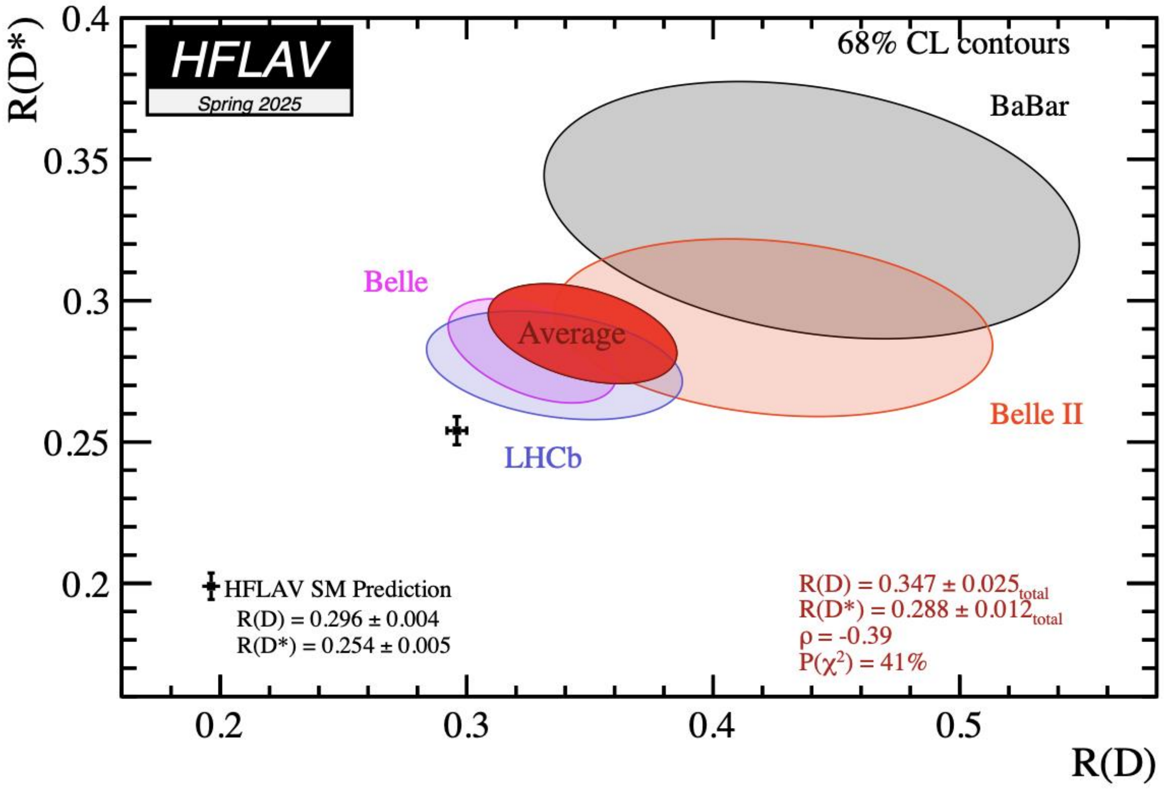




An explicit example of flavour – EW interplay (*assuming NP signal*)

Looking at bounds from individual observables misses the main point of indirect NP searches, which is the interplay of a large number of observables in "decoding" the underlying theory

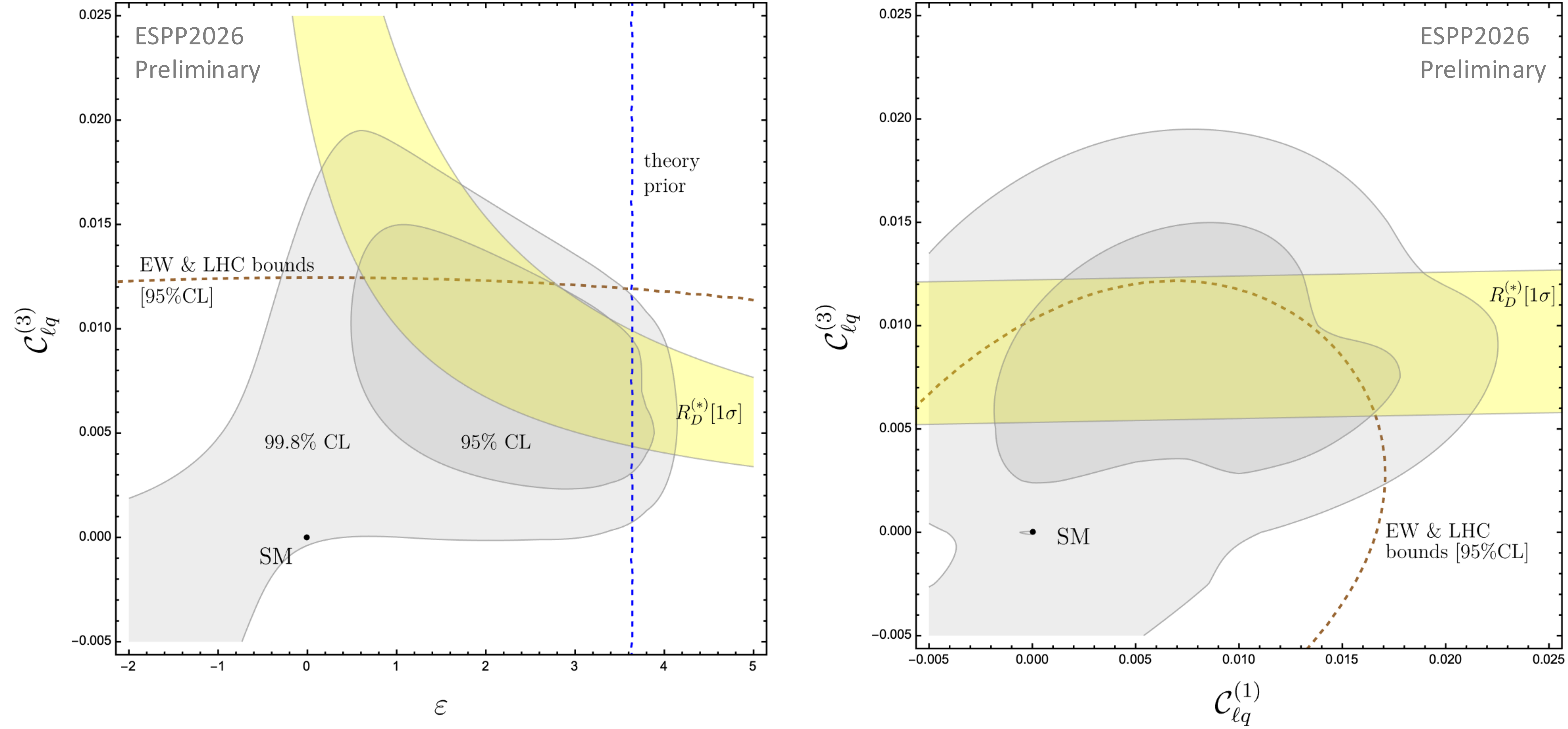




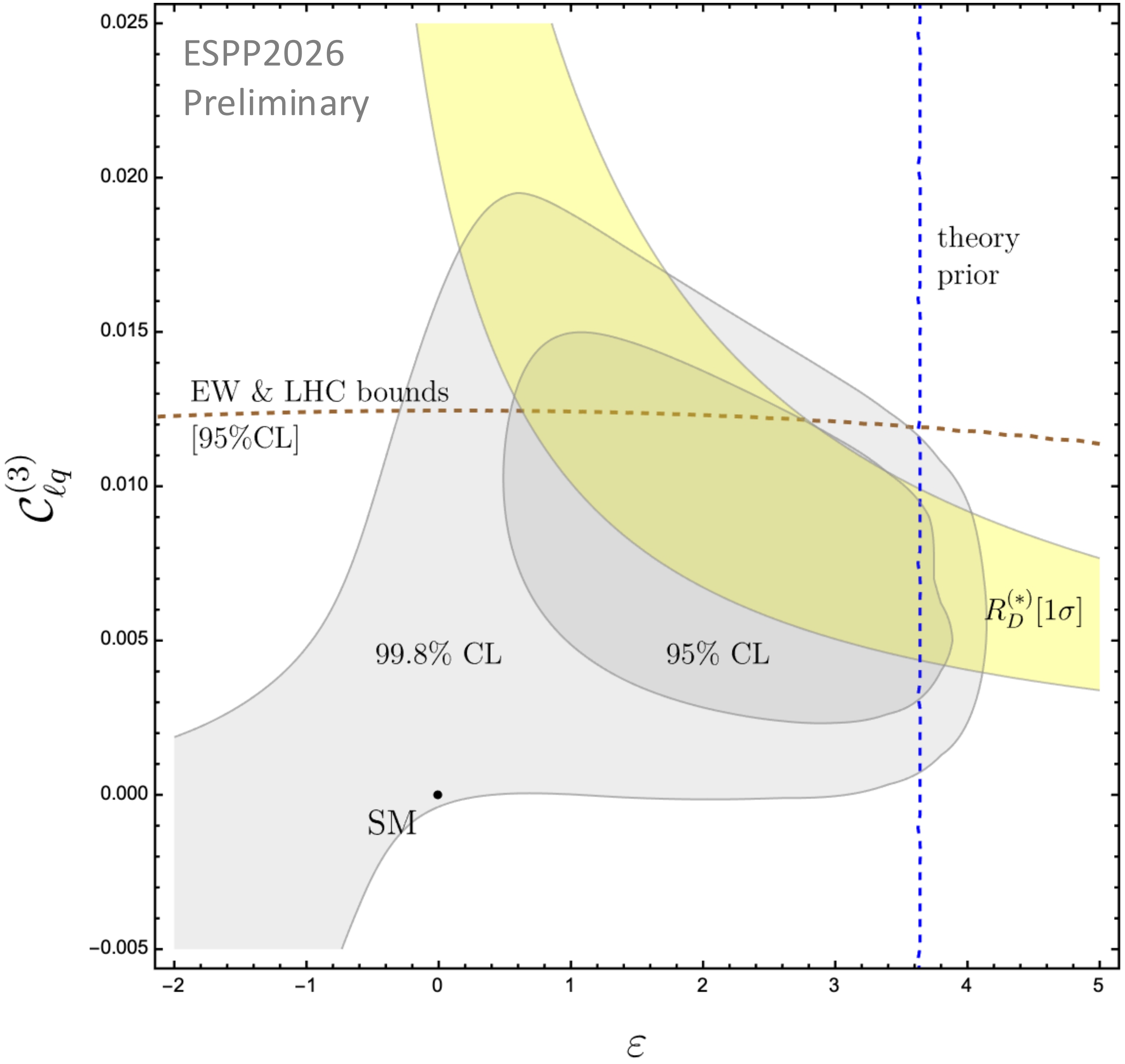
A simple, consistent, description of the system involves (*at least*) 3 parameters:

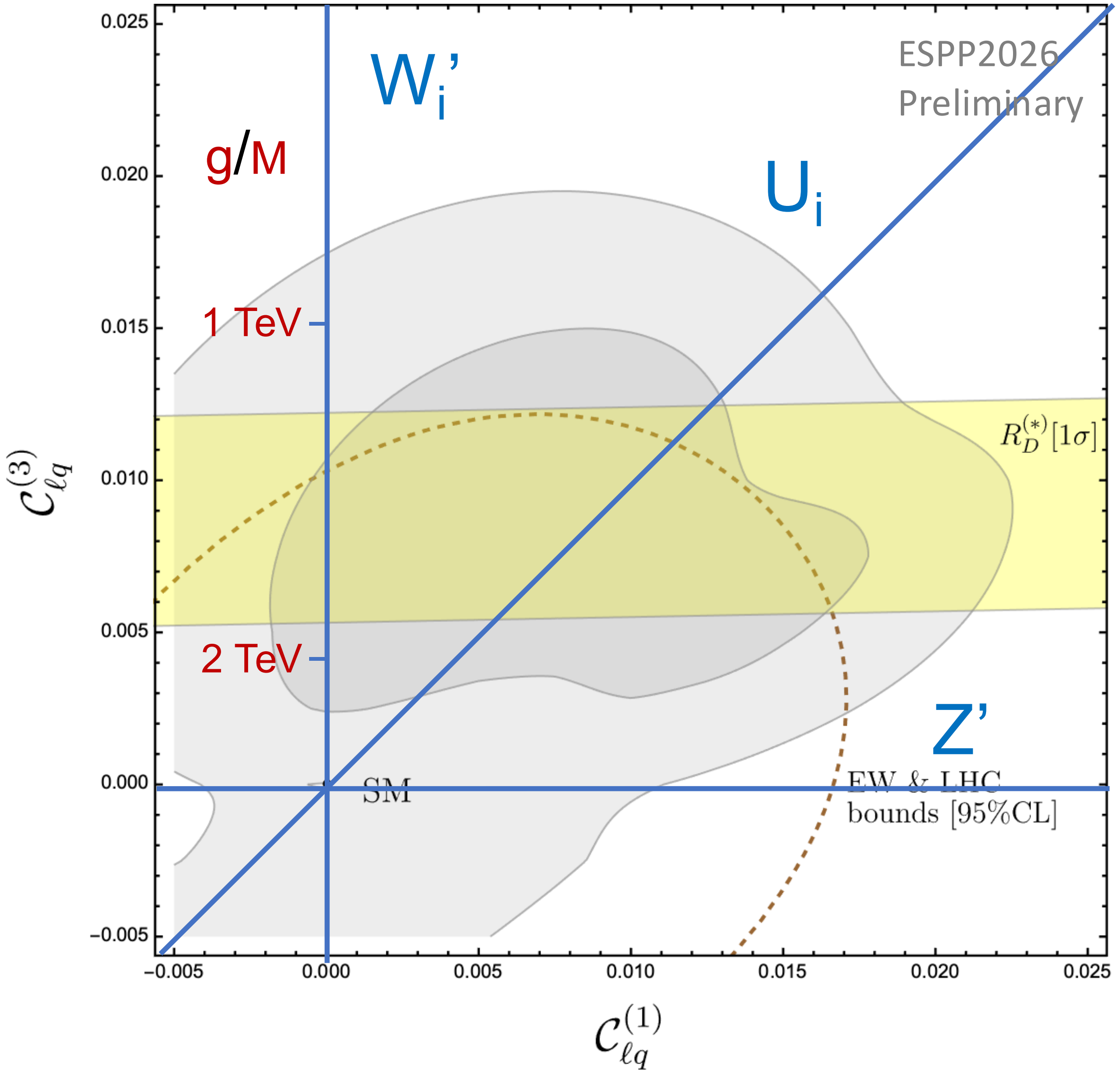
- Two Wilson coefficients, $\mathcal{C}_{\ell q}^{(1)}$ $\mathcal{C}_{\ell q}^{(3)}$
- One flavour-mixing parameter, $\varepsilon = \mathrm{O}(1)$: $q_3 = b_L + \varepsilon\,|V_{ts}|\,s_L$

An explicit example of flavour – EW interplay (*assuming NP signal*)

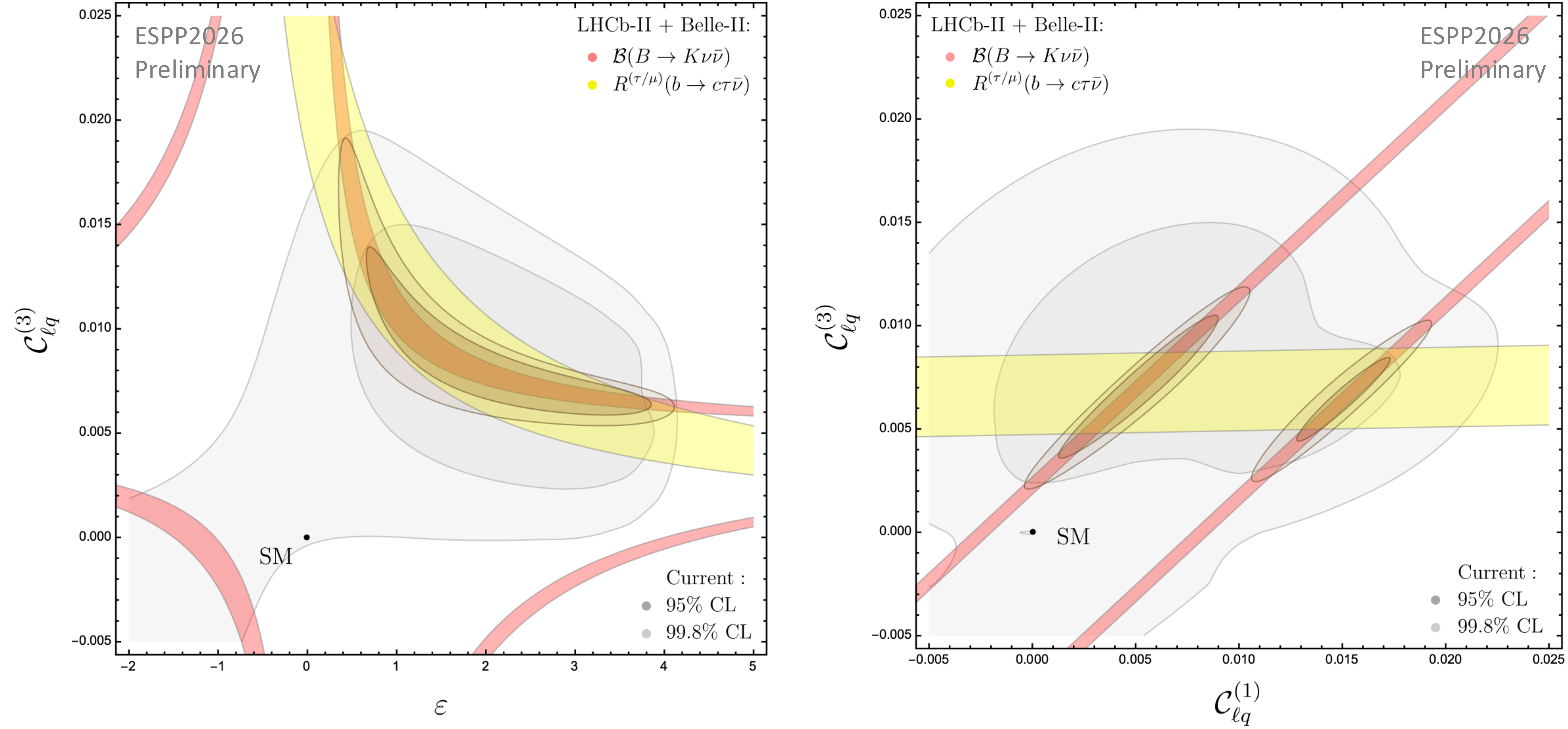


An explicit example of flavour – EW interplay (*assuming NP signal*)

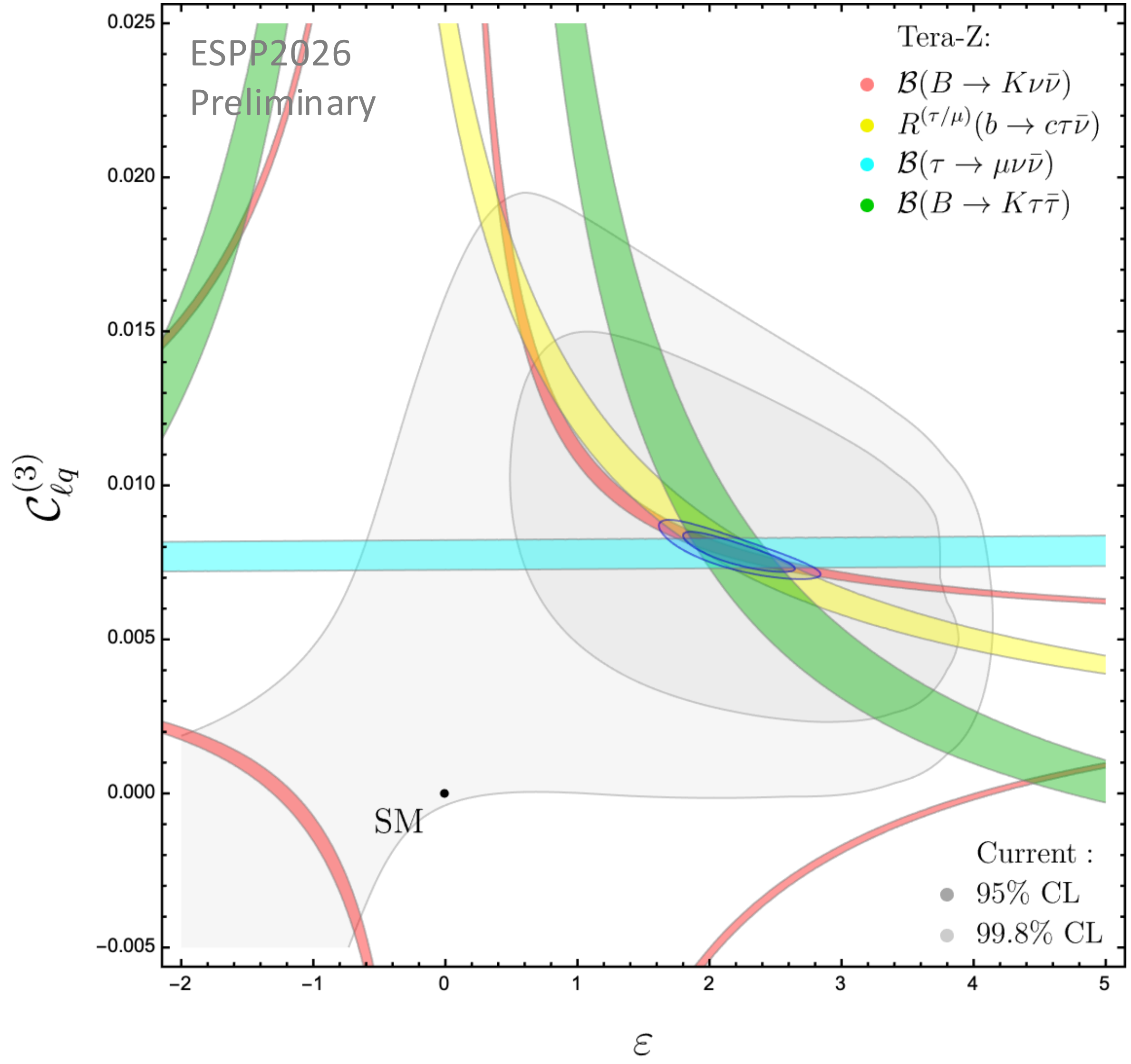


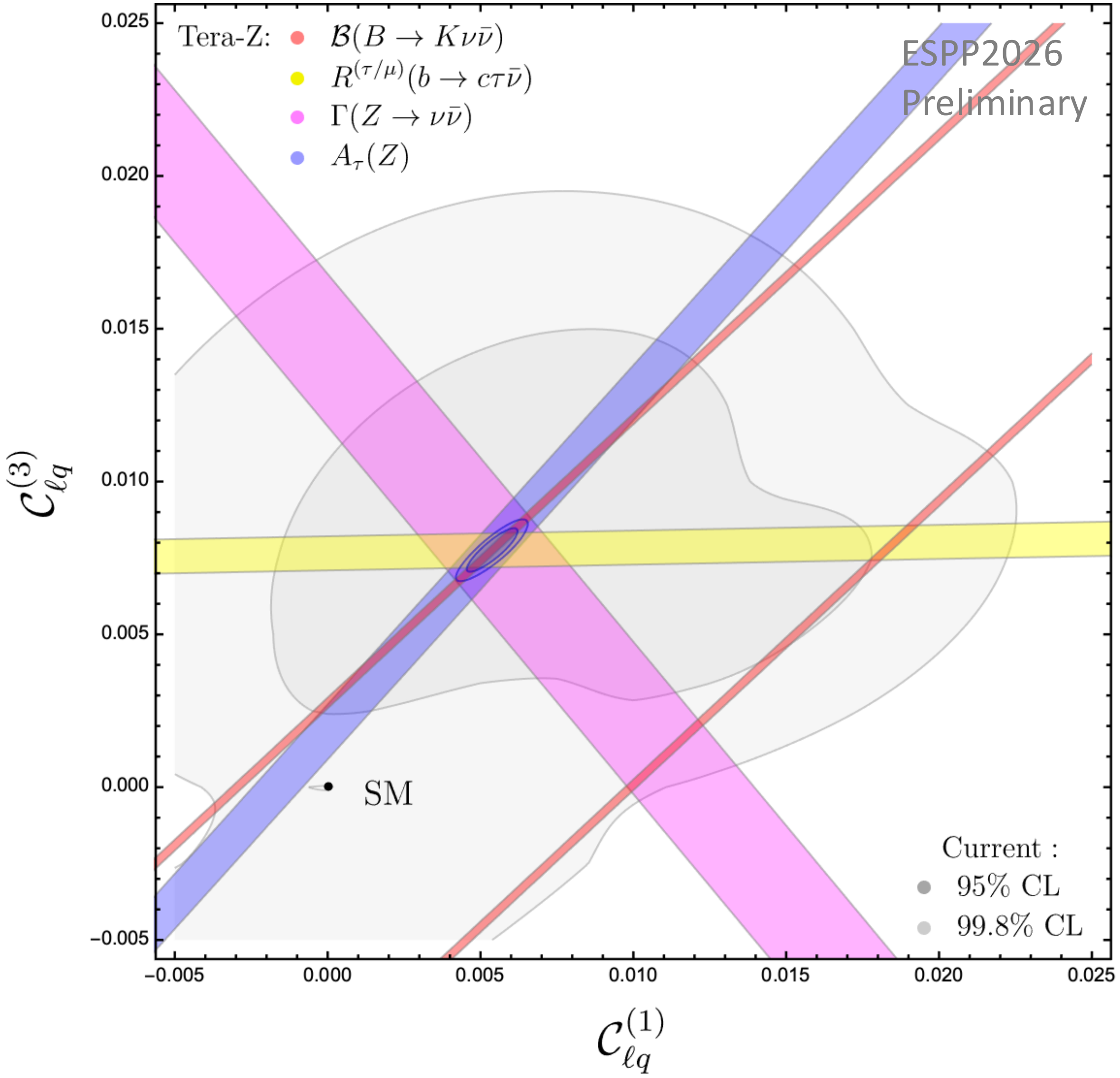


An explicit example of flavour – EW interplay (*assuming NP signal*)



An explicit example of flavour – EW interplay (*assuming NP signal*)





About flavour, EW, and Higgs physics interplay

What we have illustrated is only an example, but the conclusions are very general:

The interplay of a large number of observables is a key ingredient if we aim to "decode" the underlying theory via indirect measurements and/or "validate" indirect BSM evidences (*in concrete models there are not hundreds parameters, but likely more than three…*) and flavour physics represent a particularly "rich" domain of NP sensitive observables.

Precision Higgs, electroweak, and flavour physics are three faces of the same strategy:

- for all of them the primary objective is indirect discovery
- in realistic models, with TeV-scale NP, they provide very complementary information

Conclusions

What Archimedes would have said, in 200 B.C., if he knew about our strategy…

"Give me enough statistics for flavour physics,
precision in theory & experiment to exploit it (*)
and I will unveil what's beyond the SM !"

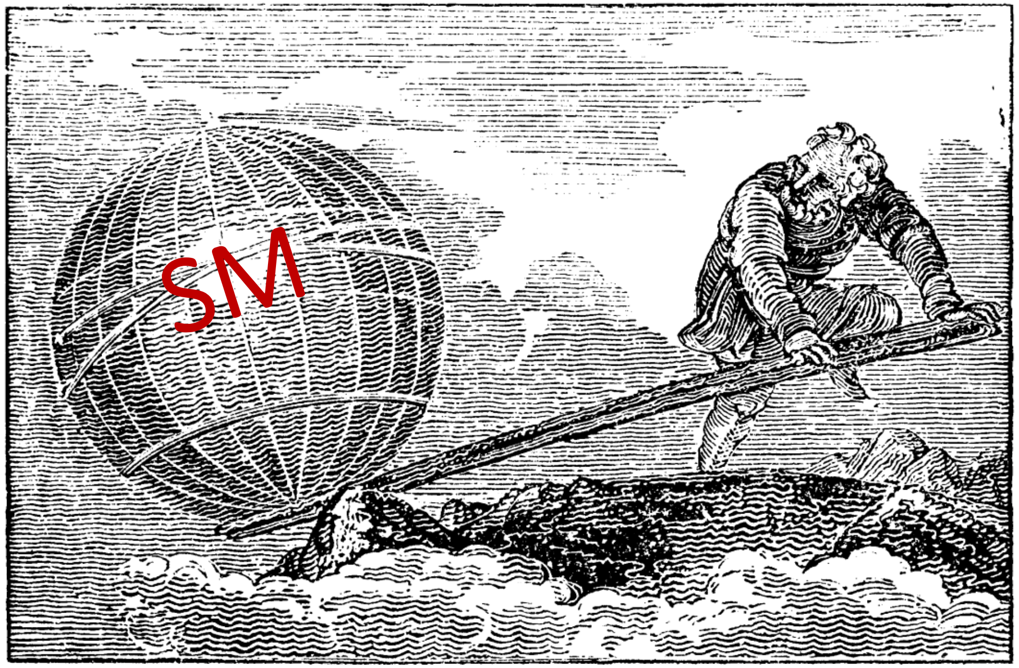
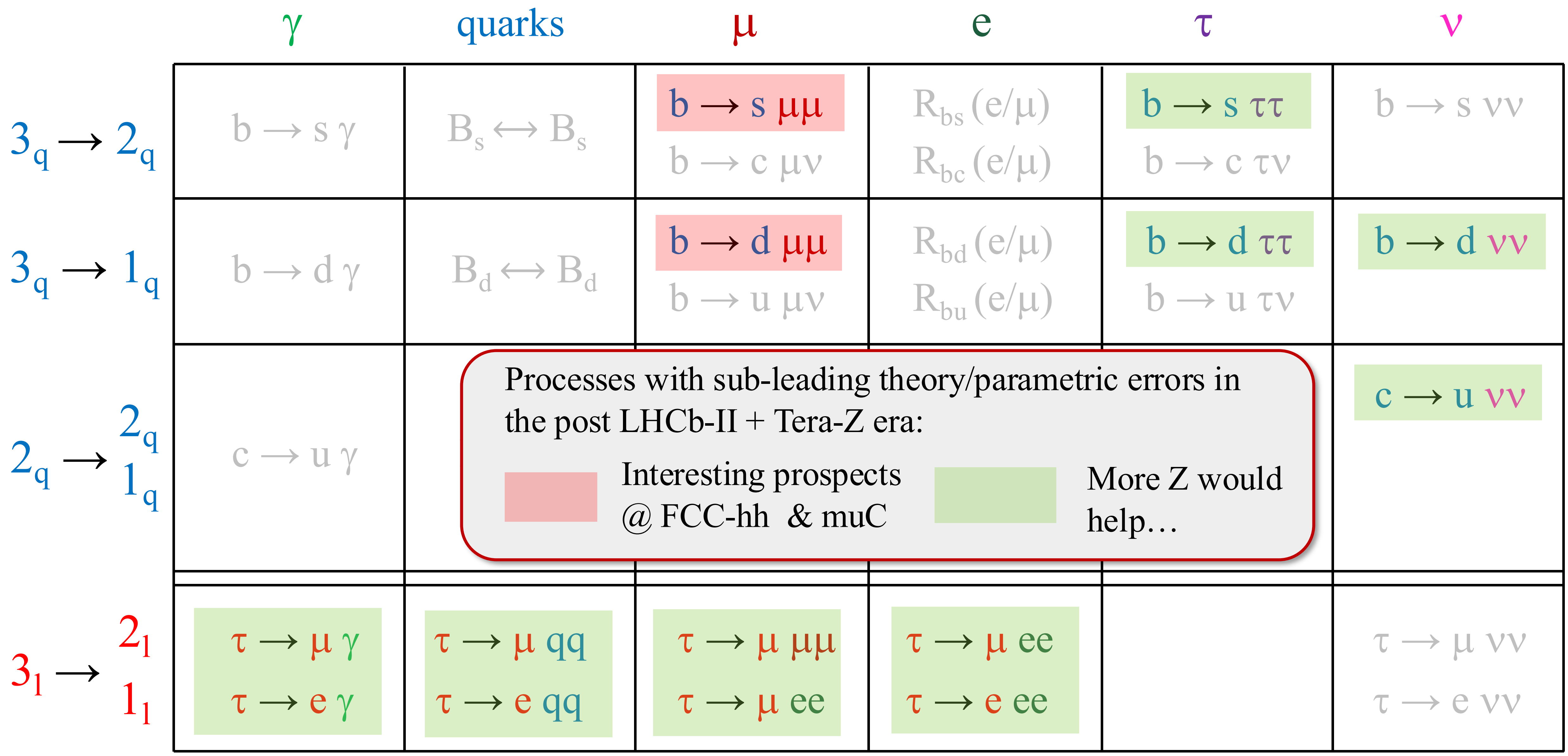


Image from Wikimedia Commons

(*) Next talk will clarify what this really means…

Backup

Large-scale facilities [b,c,τ]: *future prospects*



	γ	quarks	μ	e	τ	ν
$3_q \to 2_q$	$b \to s\,\gamma$	$B_s \leftrightarrow B_s$	$b \to s\,\mu\mu$ $b \to c\,\mu\nu$	$R_{bs}\,(e/\mu)$ $R_{bc}\,(e/\mu)$	$b \to s\,\tau\tau$ $b \to c\,\tau\nu$	$b \to s\,\nu\nu$
$3_q \to 1_q$	$b \to d\,\gamma$	$B_d \leftrightarrow B_d$	$b \to d\,\mu\mu$ $b \to u\,\mu\nu$	$R_{bd}\,(e/\mu)$ $R_{bu}\,(e/\mu)$	$b \to d\,\tau\tau$ $b \to u\,\tau\nu$	$b \to d\,\nu\nu$
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$3_l \to \begin{matrix} 2_l \\ 1_l \end{matrix}$	$\tau \to \mu\,\gamma$ $\tau \to e\,\gamma$	$\tau \to \mu\,qq$ $\tau \to e\,qq$	$\tau \to \mu\,\mu\mu$ $\tau \to \mu\,ee$	$\tau \to \mu\,ee$ $\tau \to e\,ee$		$\tau \to \mu\,\nu\nu$ $\tau \to e\,\nu\nu$

Processes with sub-leading theory/parametric errors in the post LHCb-II + Tera-Z era:

🟥 Interesting prospects @ FCC-hh & muC

🟩 More Z would help…