Gino Isidori
[University of Zürich]

- Lecture 1: Introduction to flavor physics
- Lecture 2: Meson mixing, rare decays, universality tests
- Lecture 3: Flavor physics beyond the SM
  - The MFV hypothesis
  - Flavor non-universal interactions
  - Flavor deconstruction
  - Future prospects
  - Conclusions

University of Zurich UZH

European Research Council
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Brief recap from the first lecture:

$$\mathscr{L}_{\text{SM-EFT}} = \mathscr{L}_{\text{gauge}} + \mathscr{L}_{\text{Higgs}} + \sum_{d,i} \frac{c_i^{[d]}}{\Lambda^{d-4}} O_i^{d\geq 5}$$

Flavor-degeneracy: $U(3)^5$ symmetry

Yukawa couplings: $U(3)^5 \rightarrow \sim U(2)^n$ *peculiar breaking of the flavor symm.*

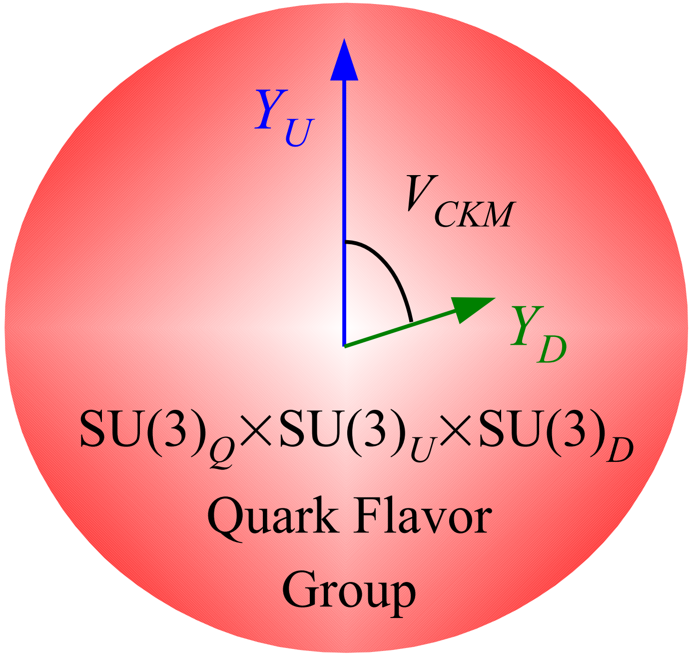
Stringent bounds on generic flavor-violating ops.

The big questions in flavor physics:

- Do we understand the origin of the approximate residual flavor symmetries giving rise to hierarchical Yukawa couplings ? — SM flavor puzzle

- Can we make sense of the tight NP bounds from flavor-violating processes and still hope to see NP signals somewhere? And in case where? — NP flavor puzzle

The MFV hypothesis



The MFV hypothesis

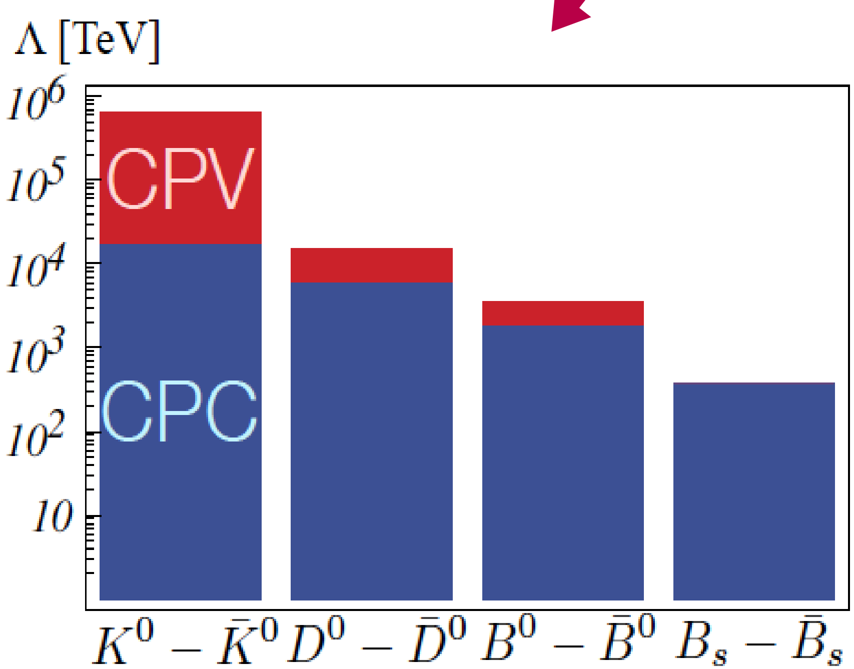
Current data show no significant deviations from the SM (at the 5%-30% level, depending on the specific amplitude) on $\Delta F = 2$ observables (mass differences and CP-violating phases) → strong bounds on possible BSM contributions:

$$M(B_d - \bar{B}_d) \sim \frac{(y_t^2 V_{tb}^* V_{td})^2}{16\pi^2 m_t^2} + c_{NP} \frac{1}{\Lambda^2}$$

c_{NP}:

- ~ 1 —tree/strong + generic flavor→ $\Lambda \gtrsim 2\times10^4$ TeV [K]
- $\sim 1/(16\pi^2)$ —loop + generic flavor→ $\Lambda \gtrsim 2\times10^3$ TeV [K]
- $\sim (y_t V_{ti}^* V_{tj})^2$ —tree/strong + "alignment"→ $\Lambda \gtrsim 5$ TeV [K & B]
- $\sim (y_t V_{ti}^* V_{tj})^2/(16\pi^2)$ —loop + "alignment"→ $\Lambda \gtrsim 0.5$ TeV [K & B]

Operator	Bounds on Λ (TeV)		Bounds on c_{ij} (Λ = 1 TeV)		Observables
	Re	Im	Re	Im	
$(\bar{s}_L\gamma^\mu d_L)^2$	9.8×10^2	1.6×10^4	9.0×10^{-7}	3.4×10^{-9}	Δm_K; ε_K
$(\bar{s}_R d_L)(\bar{s}_L d_R)$	1.8×10^4	3.2×10^5	6.9×10^{-9}	2.6×10^{-11}	Δm_K; ε_K
$(\bar{c}_L\gamma^\mu u_L)^2$	1.2×10^3	2.9×10^3	5.6×10^{-7}	1.0×10^{-7}	Δm_D; $\lvert q/p \rvert$, ϕ_D
$(\bar{c}_R u_L)(\bar{c}_L u_R)$	6.2×10^3	1.5×10^4	5.7×10^{-8}	1.1×10^{-8}	Δm_D; $\lvert q/p \rvert$, ϕ_D
$(\bar{b}_L\gamma^\mu d_L)^2$	5.1×10^2	9.3×10^2	3.3×10^{-6}	1.0×10^{-6}	Δm_{B_d}; $S_{B_d\to\psi K}$
$(\bar{b}_R d_L)(\bar{b}_L d_R)$	1.9×10^3	3.6×10^3	5.6×10^{-7}	1.7×10^{-7}	Δm_{B_d}; $S_{B_d\to\psi K}$
$(\bar{b}_L\gamma^\mu s_L)^2$	1.1×10^2	1.1×10^2	7.6×10^{-5}	7.6×10^{-5}	Δm_{B_s}
$(\bar{b}_R s_L)(\bar{b}_L s_R)$	3.7×10^2	3.7×10^2	1.3×10^{-5}	1.3×10^{-5}	Δm_{B_s}



highly non trivial flavor structure

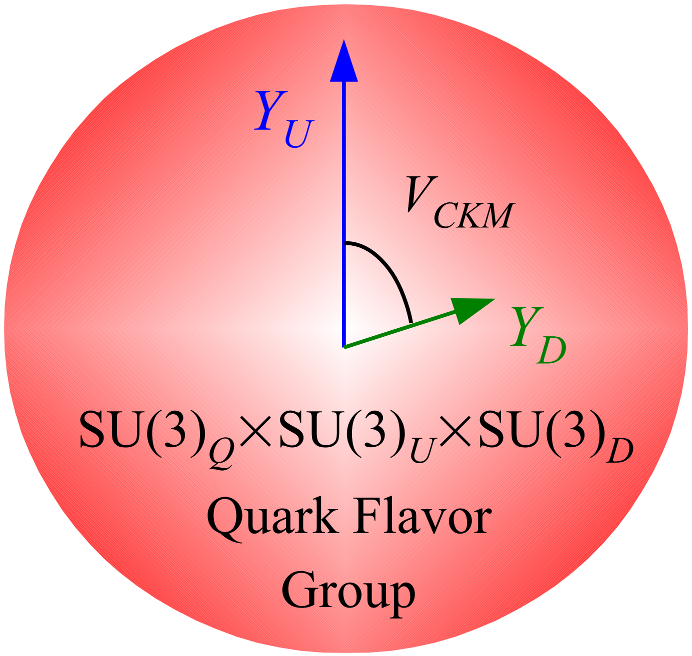
MFV hypothesis

The MFV hypothesis

The MFV hypothesis is the strongest assumption we can make to impose hierarchical structures also on physics beyond the SM:

- Flavor symmetry:
  $U(3)^5 = SU(3)_Q \times SU(3)_U \times SU(3)_D \times \ldots$
  accidental global symm. of the SM gauge sector
  → promoted to fundamental symm. of EFT

- Symmetry-breaking terms:
  $Y_D \sim 3_Q \times \bar{3}_D \qquad Y_U \sim 3_Q \times \bar{3}_U$
  SM Yukawa couplings → promoted to be the unique breaking terms of this flavor symmetry



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Automatic GIM & CKM suppression as in the SM
[bounds on the effective scale of BSM operators lowered to ~ TeV]

The MFV hypothesis

Since the global flavor symmetry is already broken within the SM, it is not consistent to impose it as an exact symmetry beyond the SM (*fine-tuned hypothesis, not invariant under quantum corrections*)

However, we can promote this symmetry to be an exact symmetry, treating (*formally*) the Yukawa matrices as the vacuum expectation values of appropriate auxiliary fields (*spurion technique*):

E.g.: $Y_D \sim (3,1,\bar{3})$ & $Y_U \sim (3,\bar{3},1)$ under $SU(3)_{Q_L} \times SU(3)_{U_R} \times SU(3)_{D_R}$

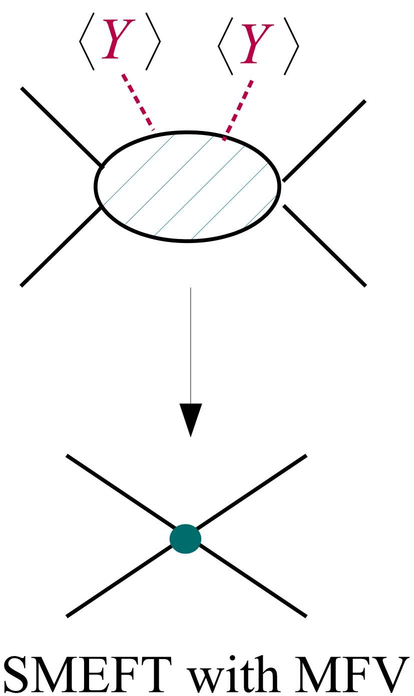
$$\mathscr{L}_{\text{Yukawa}} = \bar{Q}_L Y_D D_R \phi + \bar{Q}_L Y_U U_R \phi_c + \bar{L}_L Y_L e_R \phi + \text{h.c.}$$

$\bar{Q}_L$: $(\bar{3},1,1)$; Y_D: $(3,1,\bar{3})$; D_R: $(1,1,3)$

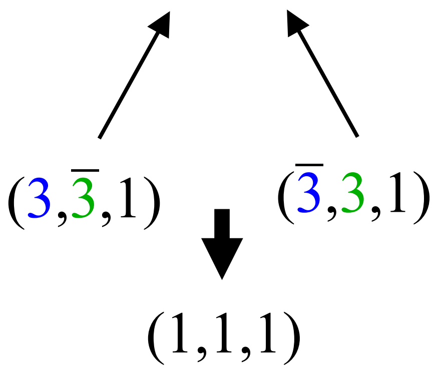
$\Rightarrow$ $(1,1,1)$ = invariant

The MFV hypothesis

Basic idea: Yukawa coupling generated at some heavy (*unaccessible*) energy scale → Y = only sources of flavor breaking accessible at low energies



Typical FCNC dim.-6 operator: $\bar{Q}_L^{\,i}\,(Y_U Y_U^{+})_{ij}\,\gamma_\mu Q_L^{\,j}\;\bar{L}_L^{\,i}\gamma^\mu L_L^{\,i}$



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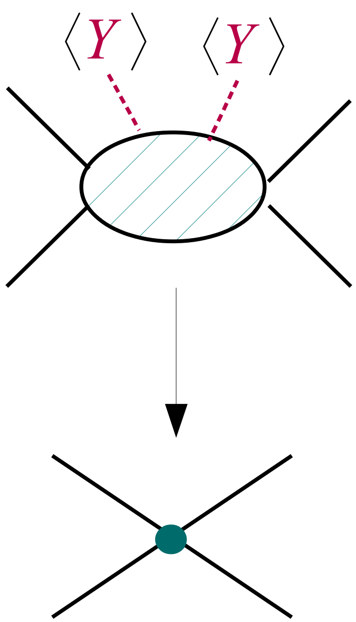

SMEFT with MFV

Typical FCNC dim.-6 operator: $\bar{Q}_L^{\,i}\,(Y_U Y_U^{+})_{ij}\,\gamma_\mu Q_L^{\,j}\ \bar{L}_L^{\,i}\gamma^\mu L_L^{\,i}$

$(3,\bar{3},1)$ $(\bar{3},3,1)$

↓

$(1,1,1)$

We know that $(Y_U Y_U^{+})_{ij} \approx y_t^2\, V_{3i}^{*} V_{3j}$

↓

$V^{+} \times \mathrm{diag}(y_u^2, y_c^2, y_t^2) \times V$

$\approx V^{+} \times \mathrm{diag}(0, 0, y_t^2) \times V$

Hence we achieve the same suppression of the leading SM amplitude

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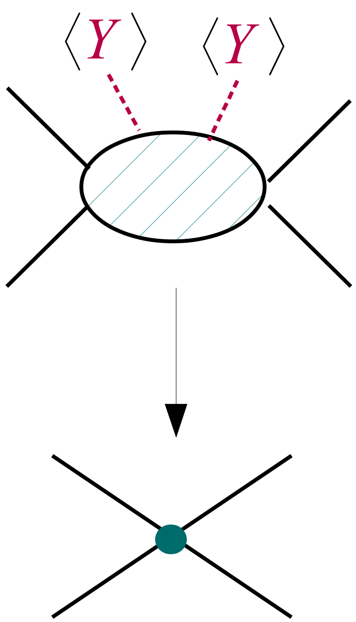

SMEFT with MFV

Phenomenological implications:

- deviations from the SM are small, usually at most few %, and "universal" with respect to the quark-flavor, relative to the SM:

$$A[\, q_i \to q_j + X \,]_{MFV} = A[\, q_i \to q_j + X \,]_{SM} \left[\, 1 + c_{NP} \frac{m_W^{\,2}}{\Lambda^2} \right]$$

- deviations from the SM in semi-leptonic processes are expected to respect Lepton Flavor Universality (→ *lepton flavor plays no relevant role*)

The MFV hypothesis

Basic idea: Yukawa coupling generated at some heavy (*unaccessible*) energy scale → Y = only sources of flavor breaking accessible at low energies

While this idea can be implemented in explicit NP models (*i.e. gauge-mediated SUSY breaking*) is far from being general...

"flavor anarchy" ←-------------------------→ MFV

...and it does not address the SM flavor problem (→ no justification for the observed hierarchies of the SM Yukawa couplings): it is only a (consistent) way to postpone the issue.

In the last few years it has also become clear that:

- MFV is becoming less and less effective in addressing the hierarchy problem given increasing strong bounds on universal New Physics from the LHC
- There are alternatives symmetry + symmetry-breaking assumptions achieving the same "protection" of flavor-changing processes

The MFV hypothesis

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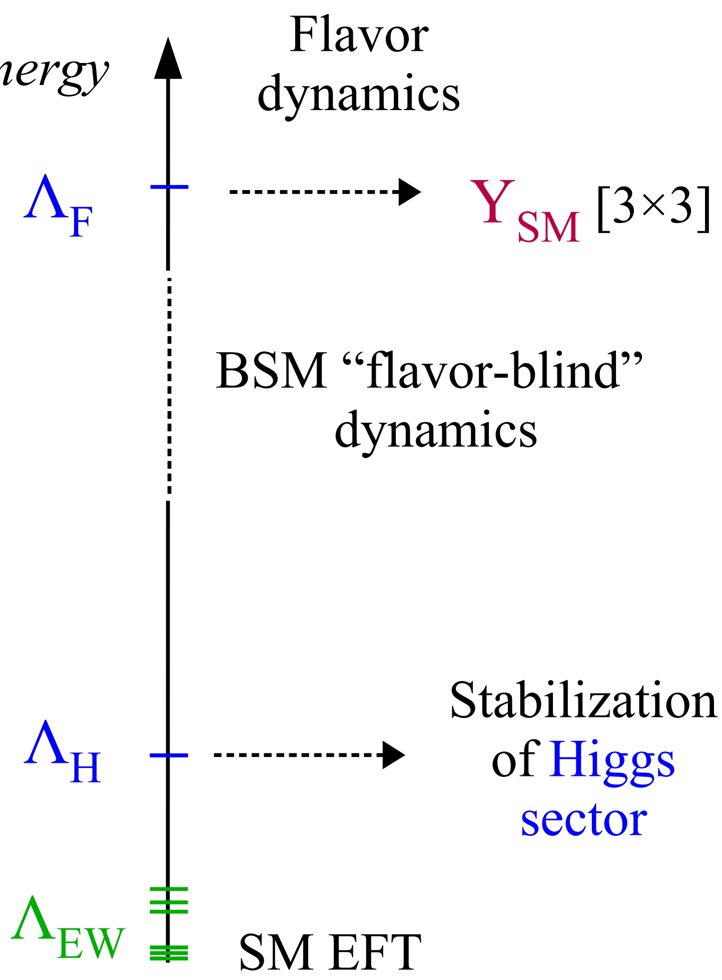

- Concentrate on the Higgs hierarchy problem
- Postpone the flavor problem to higher scales

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3 gen. = “identical copies” up to high energies

The MFV hypothesis

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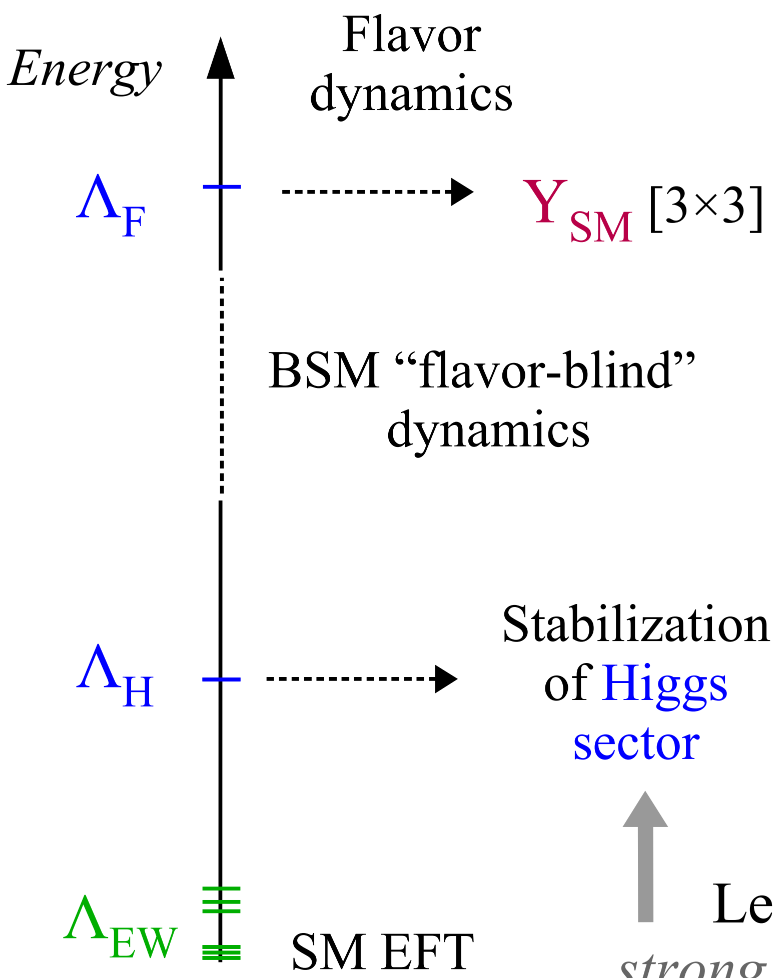

- Concentrate on the Higgs hierarchy problem
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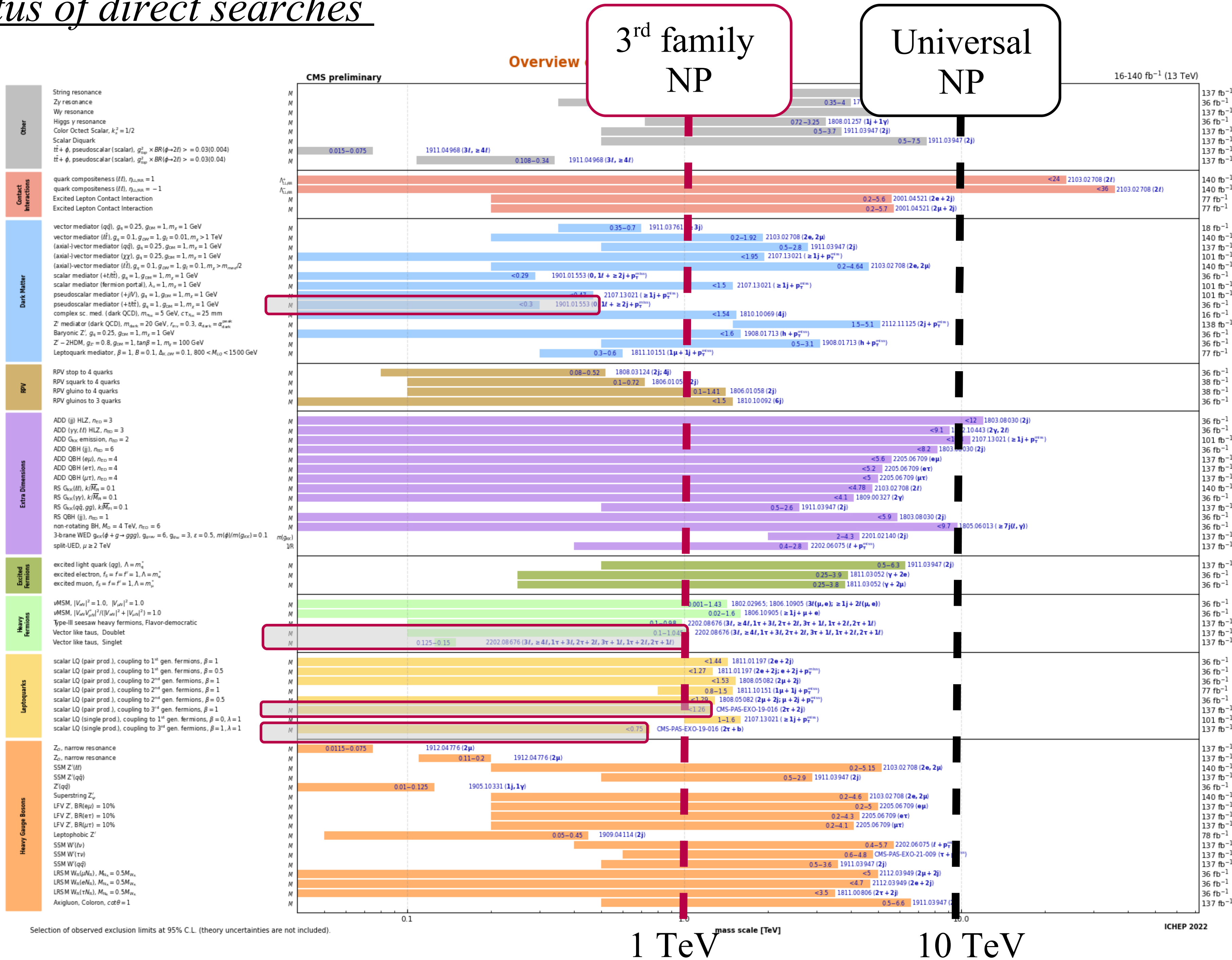
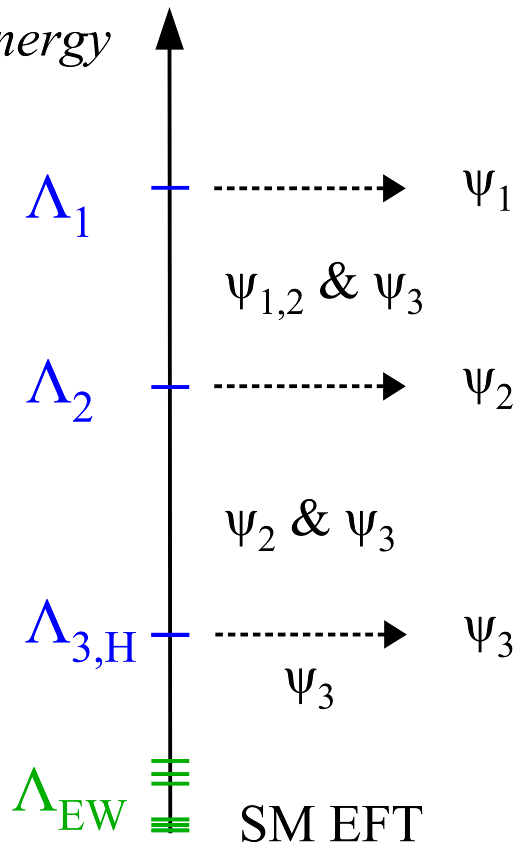
3 gen. = "identical copies" up to high energies

Less compelling after LHC results (run I+II):
strong bounds on NP coupled universally to all families
worsening of the Higgs hierarchy problem

Status of direct searches



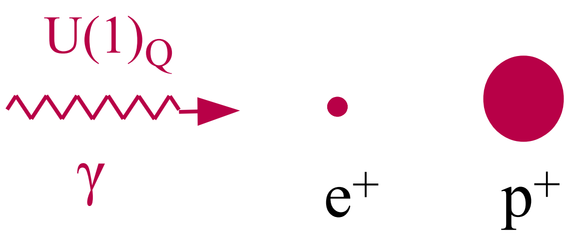
Flavor non-universal interactions



Flavor non-universal interactions

To better appreciate the change of perspective, let's consider the following analogy:

Suppose we could test matter only with long wave-length photons:



we would conclude that these two particles are "identical copies" but for their mass ...

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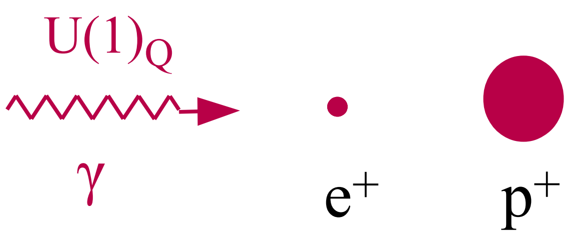
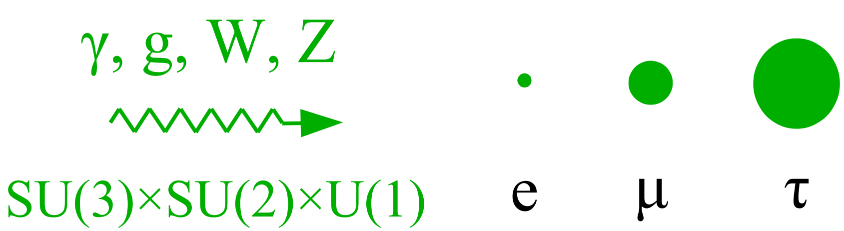


we would conclude that these two particles are "identical copies" but for their mass ...

This is exactly the same (*potentially misleading*) argument we use to infer flavor universality in the SM...



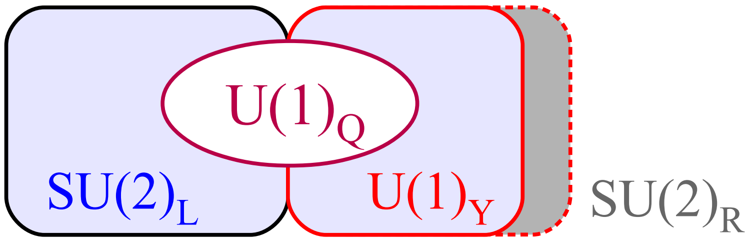
These three (families) of particles seems to be "identical copies" but for their mass ...

The SM quantum numbers of the three families could be an "accidental" low-energy property: the different families may well have a very different behavior at high energies, as signaled by their different mass

Flavor non-universal interactions

A further useful analogy is the chiral structure of long-range forces.

In the low-energy limit of the SM (= QED×QCD) we observe perfect universality of LH and RH gauge couplings. However, we know this is a low-energy artifact:

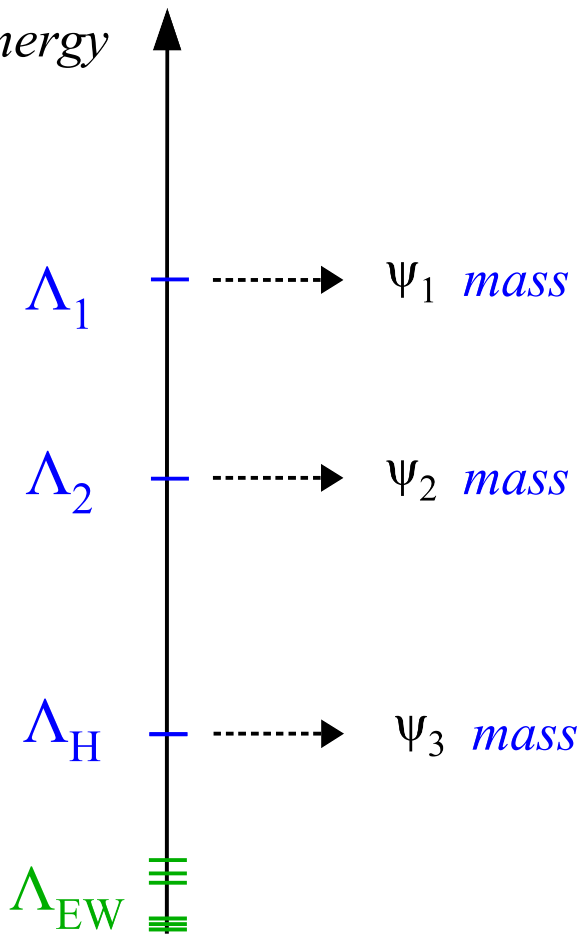


In a similar fashion, the flavor universality of all SM gauge interactions could be a low-energy artifact...

Flavor non-universal interactions

An efficient paradigm to address both flavor puzzles (I+II), & *possibly* the Higgs hierarchy, is a *multi-scale* UV with *flavor non-universal* interactions

Dvali & Shifman '00
Panico & Pomarol '16
⋮
Bordone *et al.* '17
Allwicher, GI, Thomsen '20
Barbieri '21
Davighi & G.I. '23



Basic idea:

1st & 2nd generations have small masses (+ small coupling to NP) because these are generated by new flavor non-universal dynamics at heavier scales

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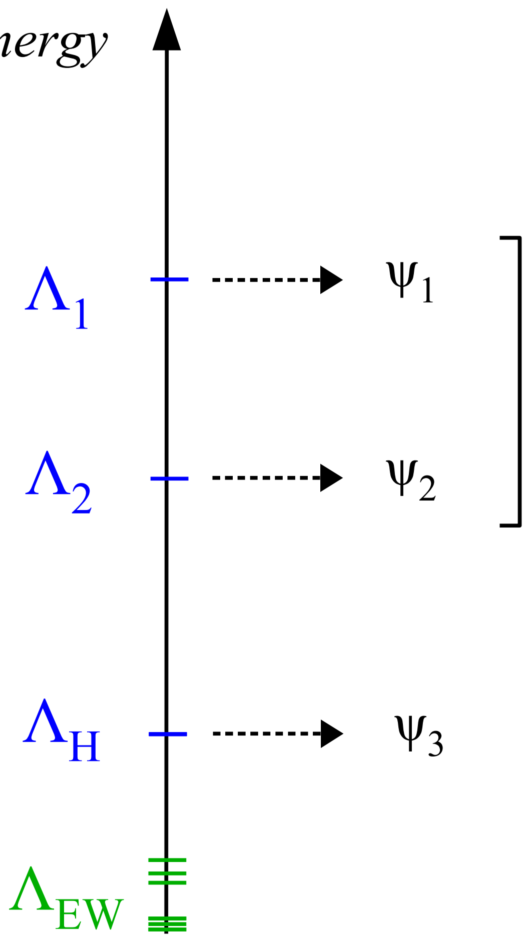
~~3 gen. = "identical copies" up to high energies~~

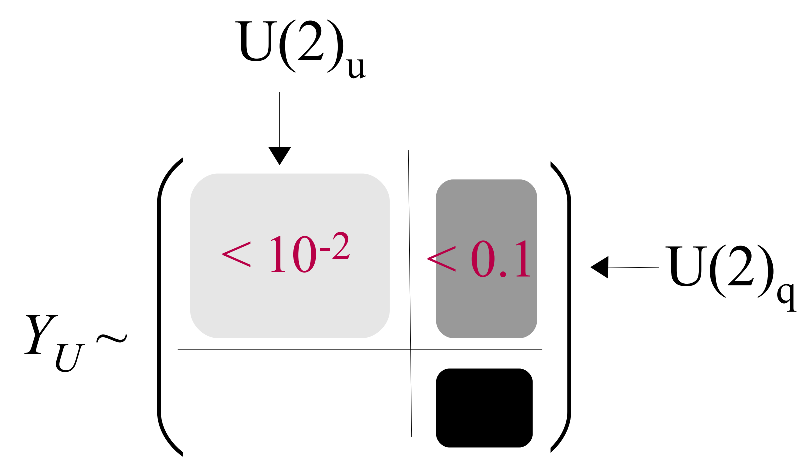
Flavor non-universal interactions

An efficient paradigm to address both flavor puzzles (I+II), & *possibly* the Higgs hierarchy, is a *multi-scale* UV with *flavor non-universal* interactions



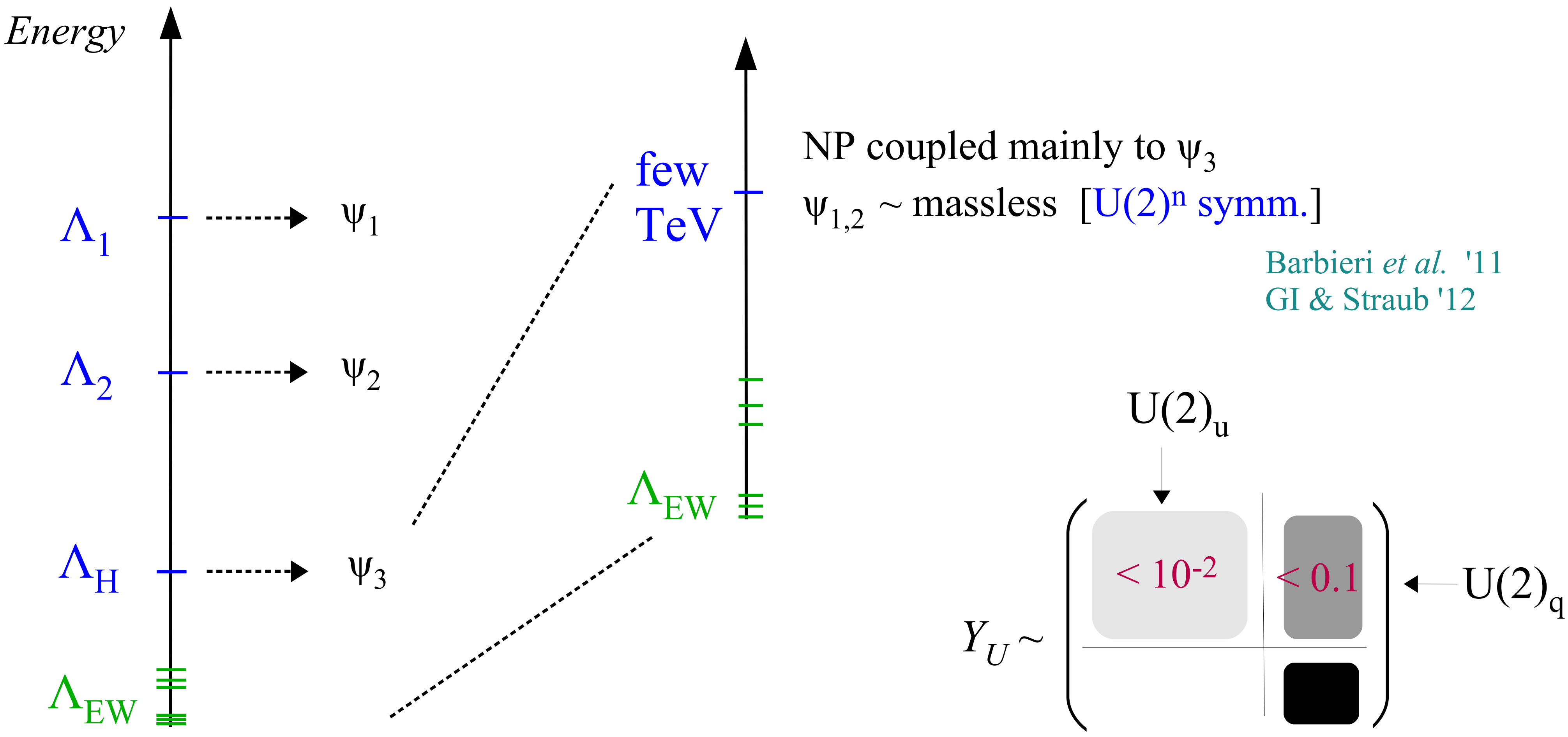
- The 2×2 light block of the Yukawa coupling originates from high-scale physics [→ origin of the *Cabibbo angle*]
- No additional breaking of $U(2)^n$ is mediated at low energies

"UV imprint" in the Yukawa couplings



Flavor non-universal interactions

An efficient paradigm to address both flavor puzzles (I+II), & *possibly* the Higgs hierarchy, is a ***multi-scale*** UV with ***flavor non-universal*** interactions



Effective organizing principle for the flavor structure of the SMEFT

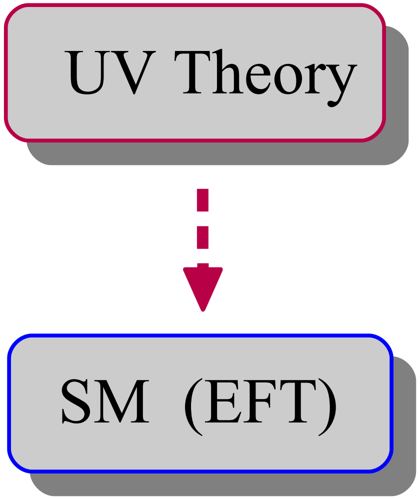
Flavor non-universal interactions: SMEFT bounds in the $U(2)^5$ *limit*

In the 1st lecture we have seen that

$$\mathscr{L}_{\text{SM-EFT}} = \mathscr{L}_{\text{gauge}}(A_a, \psi_i) + \mathscr{L}_{\text{Higgs}}(H, A_a, \psi_i) + \sum_{d,i} \frac{c_i^{[d]}}{\Lambda^{d-4}} O_i^{d\geq 5}(H, A_a, \psi_i)$$

Number of indpendent couplings @ d=6:

- No flavor symmetry ⟶ 2499
- Exact $U(3)^5$ ⟶ 47



If we assume exat $U(2)^5$ symmetry,
we have 120 indpendent operators.

E.g.:

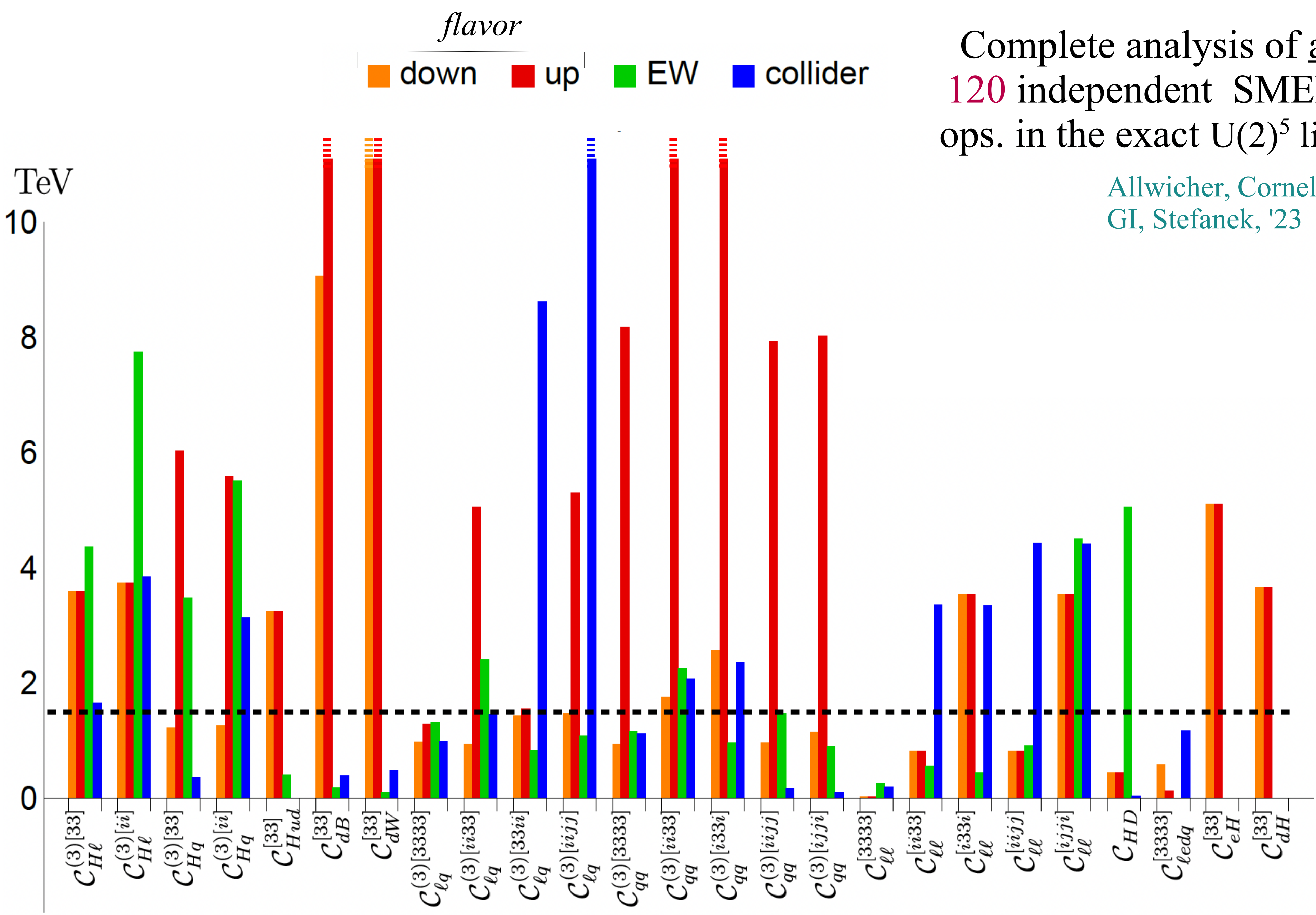
$$\bar{Q}_L^3 \gamma_\mu Q_L^3 \; \bar{L}_L^3 \gamma^\mu L_L^3 \qquad \bar{Q}_L^i \gamma_\mu Q_L^i \; \bar{L}_L^3 \gamma^\mu L_L^3 \qquad i = 1,2$$

~~$\bar{Q}_L^1 \gamma_\mu Q_L^2 \; \bar{L}_L^3 \gamma^\mu L_L^3$~~

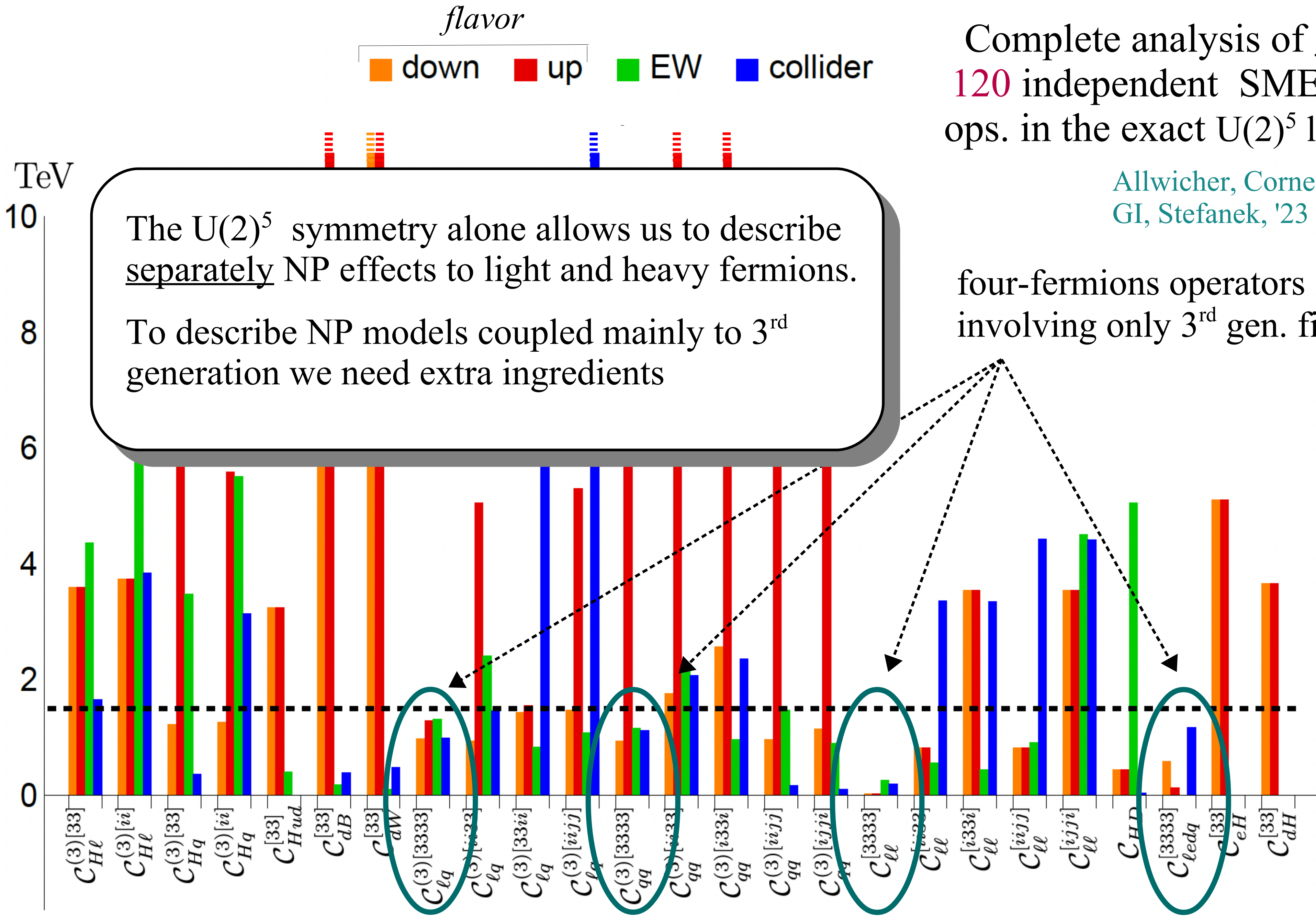
Flavor non-universal interactions: SMEFT bounds in the U(2)^5 limit

Complete analysis of all 120 independent SMEFT ops. in the exact U(2)^5 limit

Allwicher, Cornella, GI, Stefanek, '23



Flavor non-universal interactions: SMEFT bounds in the U(2)^5 *limit*



The U(2)^5 symmetry alone allows us to describe separately NP effects to light and heavy fermions.

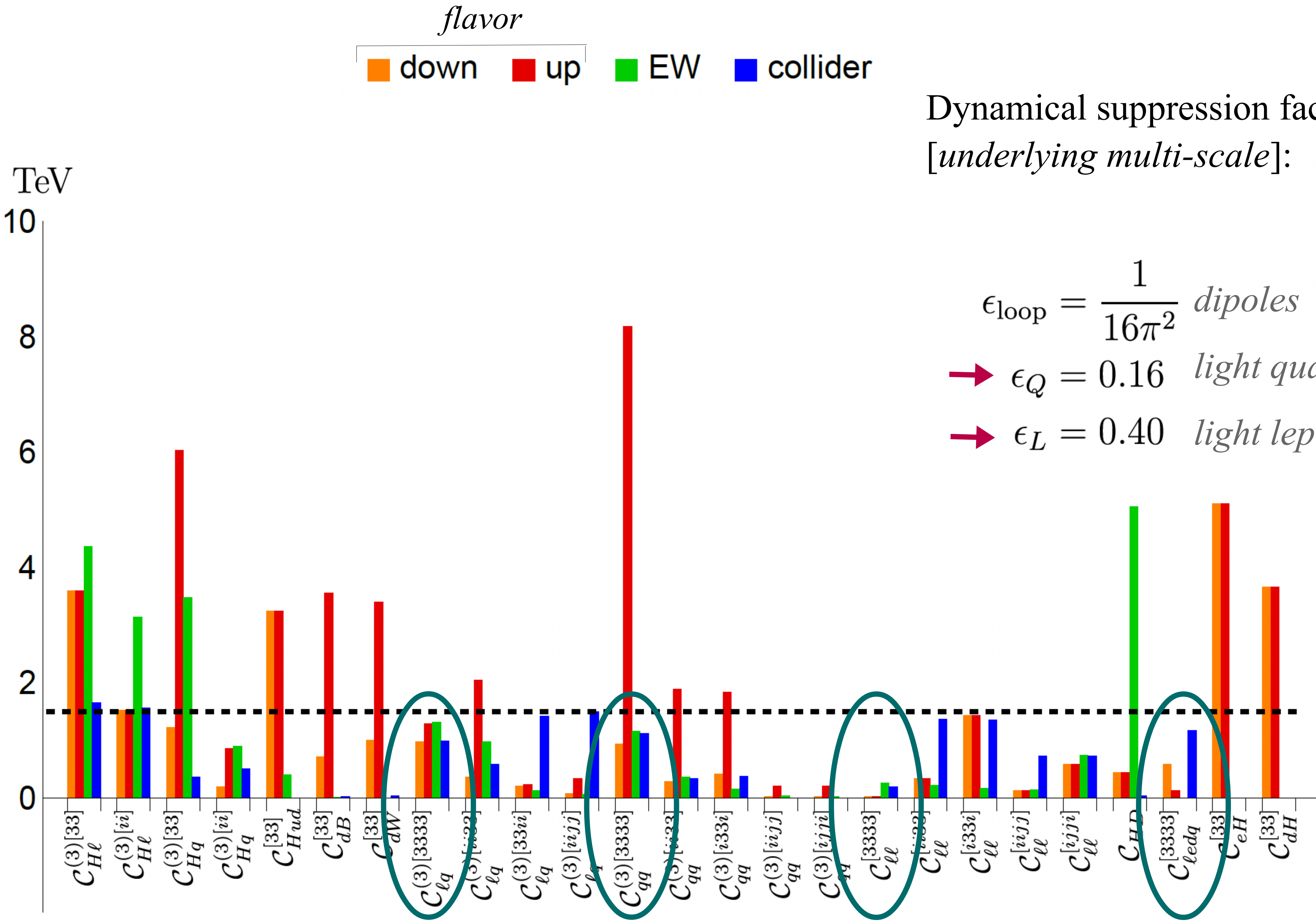
To describe NP models coupled mainly to 3rd generation we need extra ingredients

Complete analysis of all 120 independent SMEFT ops. in the exact U(2)^5 limit

Allwicher, Cornella, GI, Stefanek, '23

four-fermions operators involving only 3rd gen. fields

Flavor non-universal interactions: SMEFT bounds in the U(2)^5 *limit*



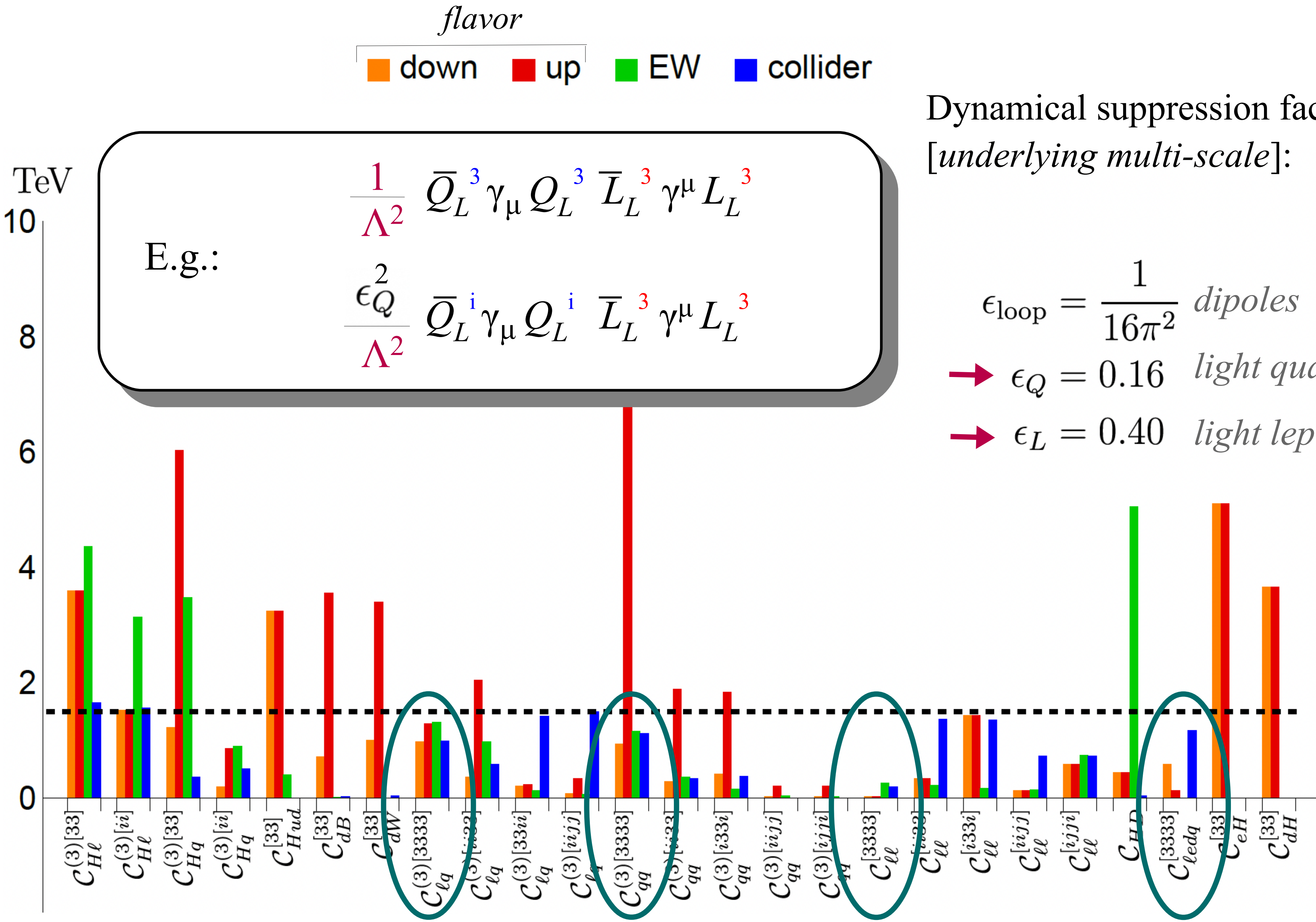
Dynamical suppression factors [*underlying multi-scale*]:

$$\epsilon_{\rm loop} = \frac{1}{16\pi^2}$$ *dipoles*

$$\epsilon_Q = 0.16$$ *light quarks*

$$\epsilon_L = 0.40$$ *light leptons*

Flavor non-universal interactions: SMEFT bounds in the U(2)^5 *limit*



E.g.:

$$\frac{1}{\Lambda^2}\ \bar{Q}_L^3 \gamma_\mu Q_L^3\ \bar{L}_L^3 \gamma^\mu L_L^3$$

$$\frac{\epsilon_Q^2}{\Lambda^2}\ \bar{Q}_L^i \gamma_\mu Q_L^i\ \bar{L}_L^3 \gamma^\mu L_L^3$$

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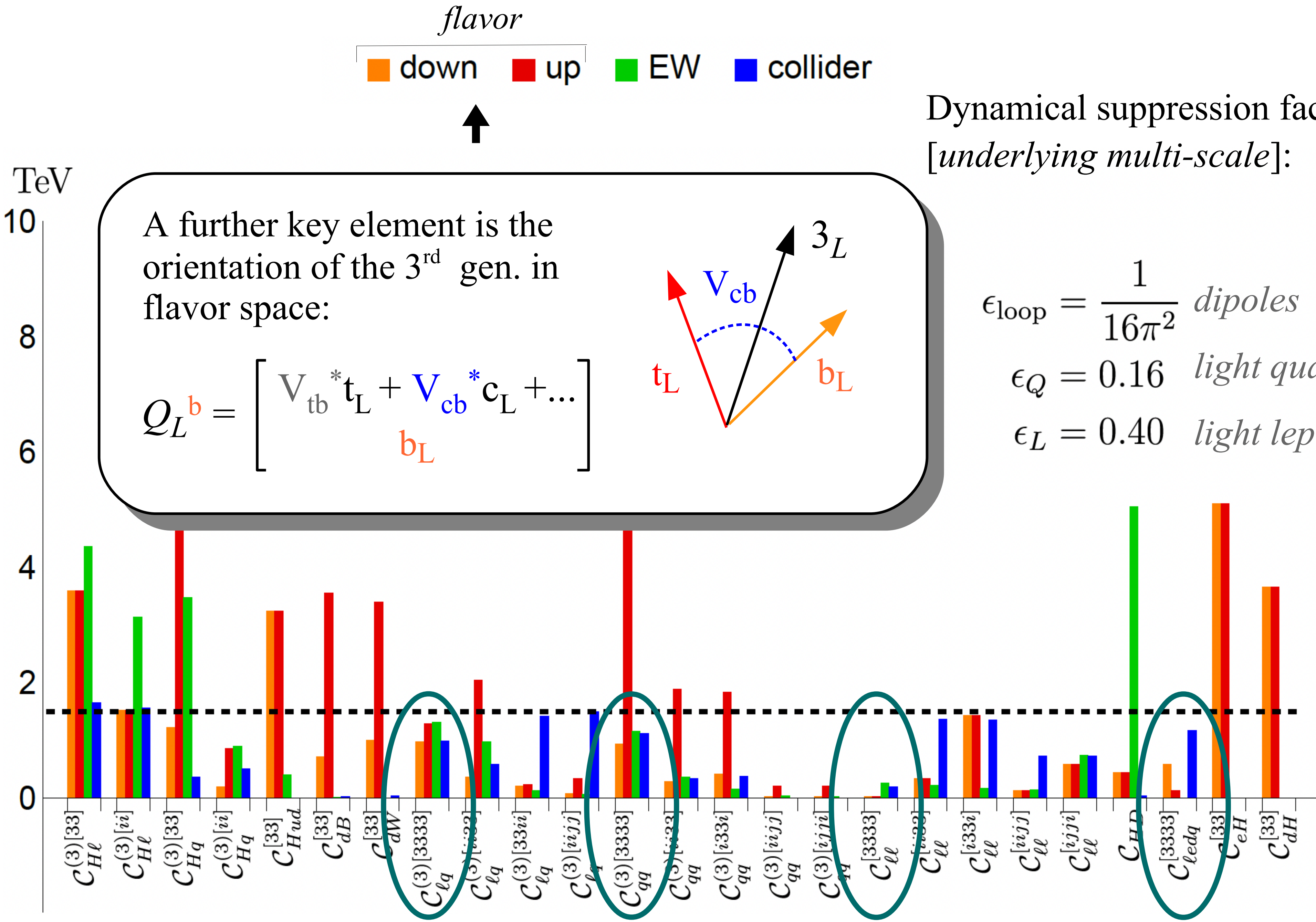
Flavor non-universal interactions: SMEFT bounds in the U(2)^5 limit



A further key element is the orientation of the 3rd gen. in flavor space:

$$Q_L^{b} = \left[V_{tb}^{*} t_L + V_{cb}^{*} c_L + \ldots \right] \quad (b_L)$$

Dynamical suppression factors [*underlying multi-scale*]:

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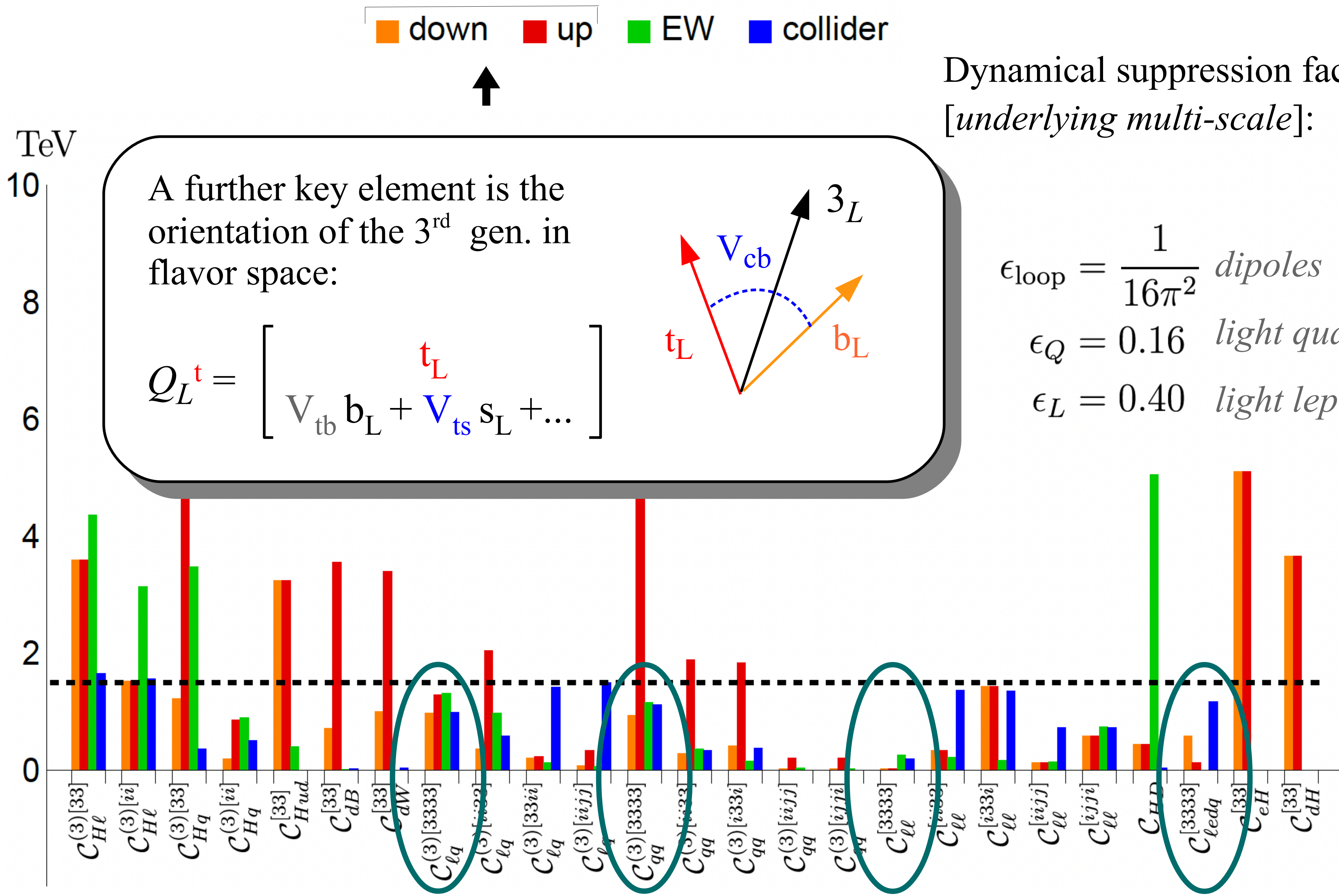
▸ *Flavor non-universal interactions: SMEFT bounds in the* U(2)^5 *limit*



A further key element is the orientation of the 3rd gen. in flavor space:

$$Q_L^t = \begin{bmatrix} t_L \\ V_{tb}\, b_L + V_{ts}\, s_L + \ldots \end{bmatrix}$$

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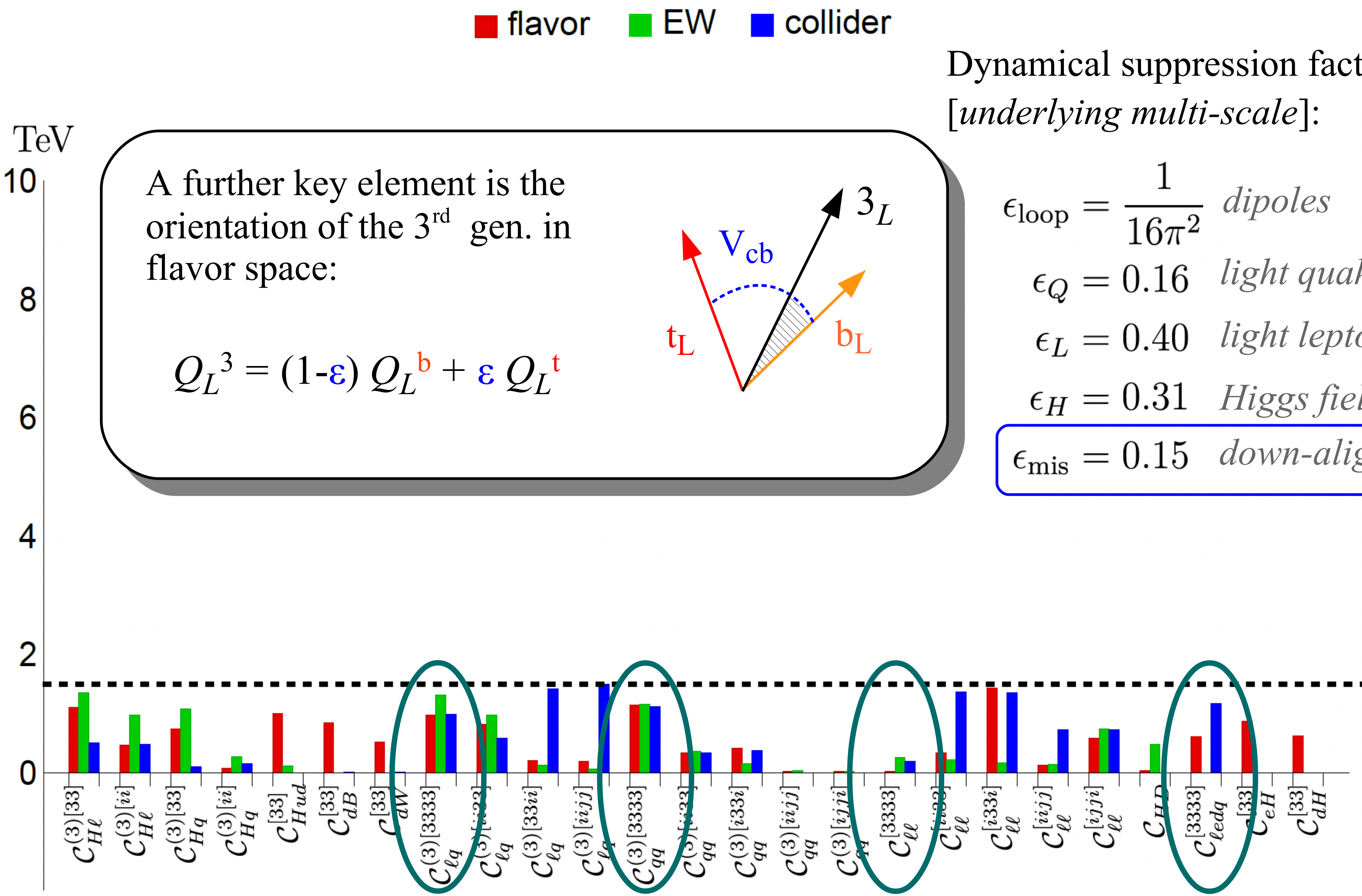
Flavor non-universal interactions: SMEFT bounds in the U(2)^5 limit



A further key element is the orientation of the 3rd gen. in flavor space:

$$Q_L^{3} = (1-\varepsilon)\, Q_L^{b} + \varepsilon\, Q_L^{t}$$

Dynamical suppression factors [*underlying multi-scale*]:

$\epsilon_{\rm loop} = \dfrac{1}{16\pi^2}$ *dipoles*

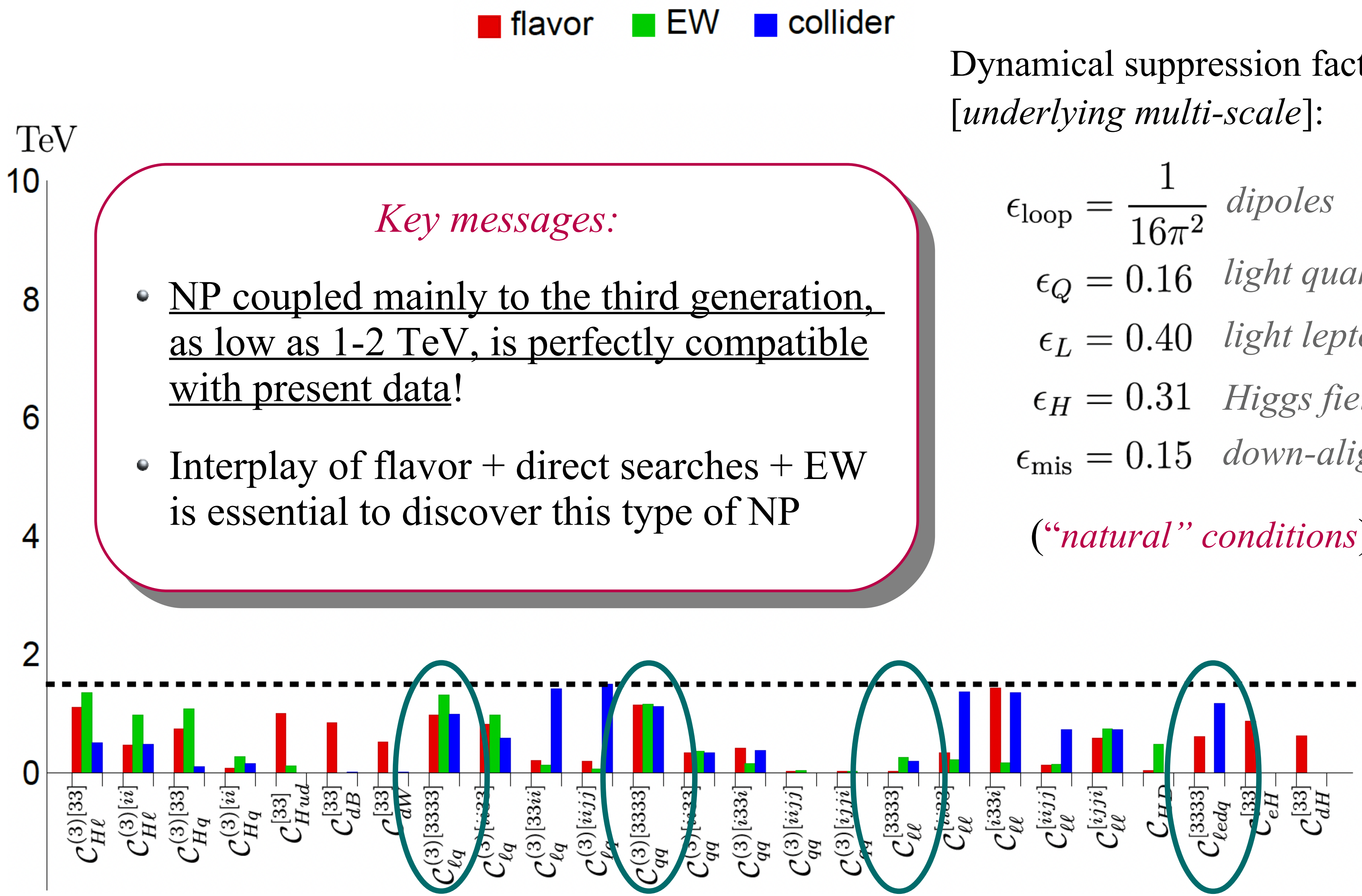
$\epsilon_Q = 0.16$ *light quaks*

$\epsilon_L = 0.40$ *light leptons*

$\epsilon_H = 0.31$ *Higgs fields*

$\epsilon_{\rm mis} = 0.15$ *down-align.*

Flavor non-universal interactions: SMEFT bounds in the U(2)^5 *limit*



Key messages:

- NP coupled mainly to the third generation, as low as 1-2 TeV, is perfectly compatible with present data!
- Interplay of flavor + direct searches + EW is essential to discover this type of NP

Dynamical suppression factors [*underlying multi-scale*]:

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(*"natural" conditions*)

Flavor deconstruction

Flavor deconstruction

Going beyond the EFT approach, a consistent way to construct a multi-scale theory with flavor non-universal interactions is via a "*flavor deconstruction*" of the SM gauge symmetries:

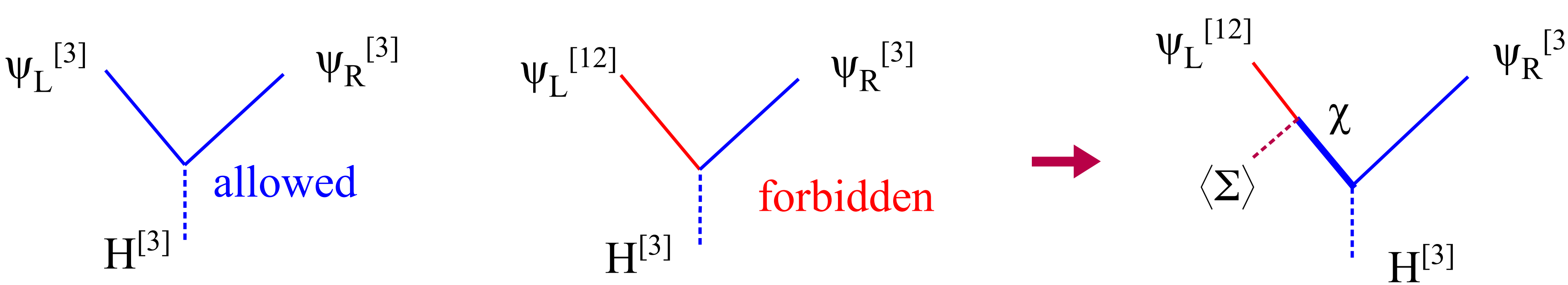
E.g.: $SU(3)_c \times SU(2)_L \times U(1)_Y^{[3]} \times U(1)_Y^{[12]}$

Acts on 3rd gen. Acts on 1st & 2 rd gen.

Flavor deconstruction

Going beyond the EFT approach, a consistent way to construct a multi-scale theory with flavor non-universal interactions is via a "*flavor deconstruction*" of the SM gauge symmetries:

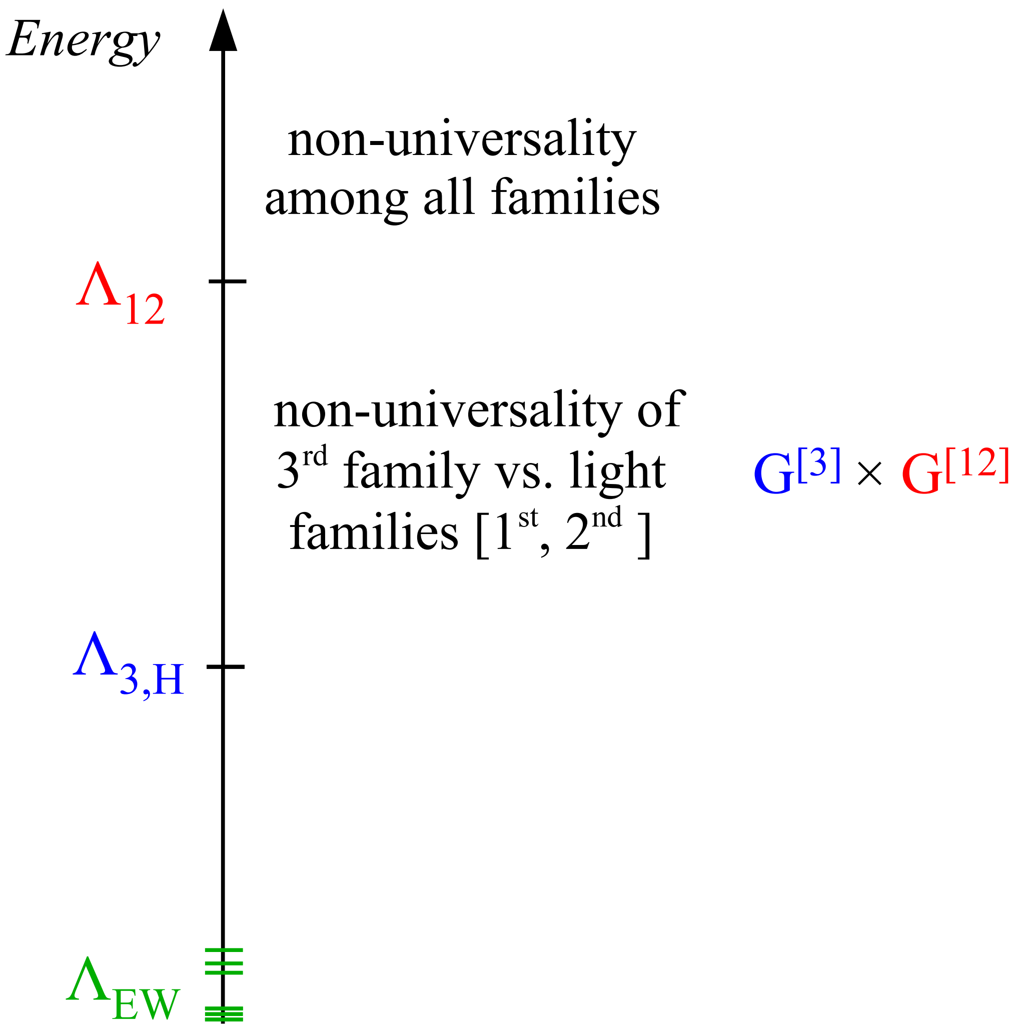
E.g.: $SU(3)_c \times SU(2)_L \times U(1)_Y^{[3]} \times U(1)_Y^{[12]} \xrightarrow{\langle \Sigma \rangle} SU(3)_c \times SU(2)_L \times U(1)_Y$

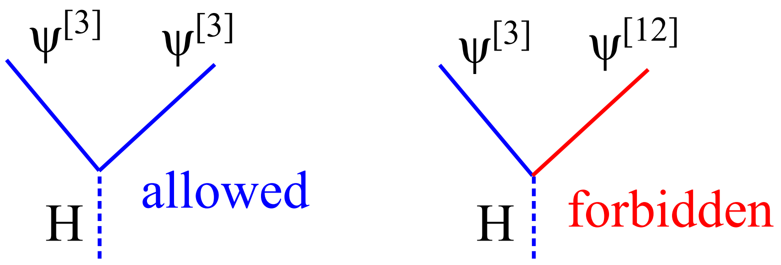


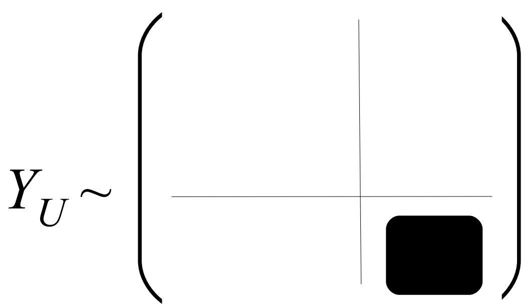
$$V_{cb} \sim \frac{\langle \Sigma \rangle}{M_\chi}$$

Flavor deconstruction

Basic idea of flavor deconstruction, implemented in theory with at least two well-separated scales:

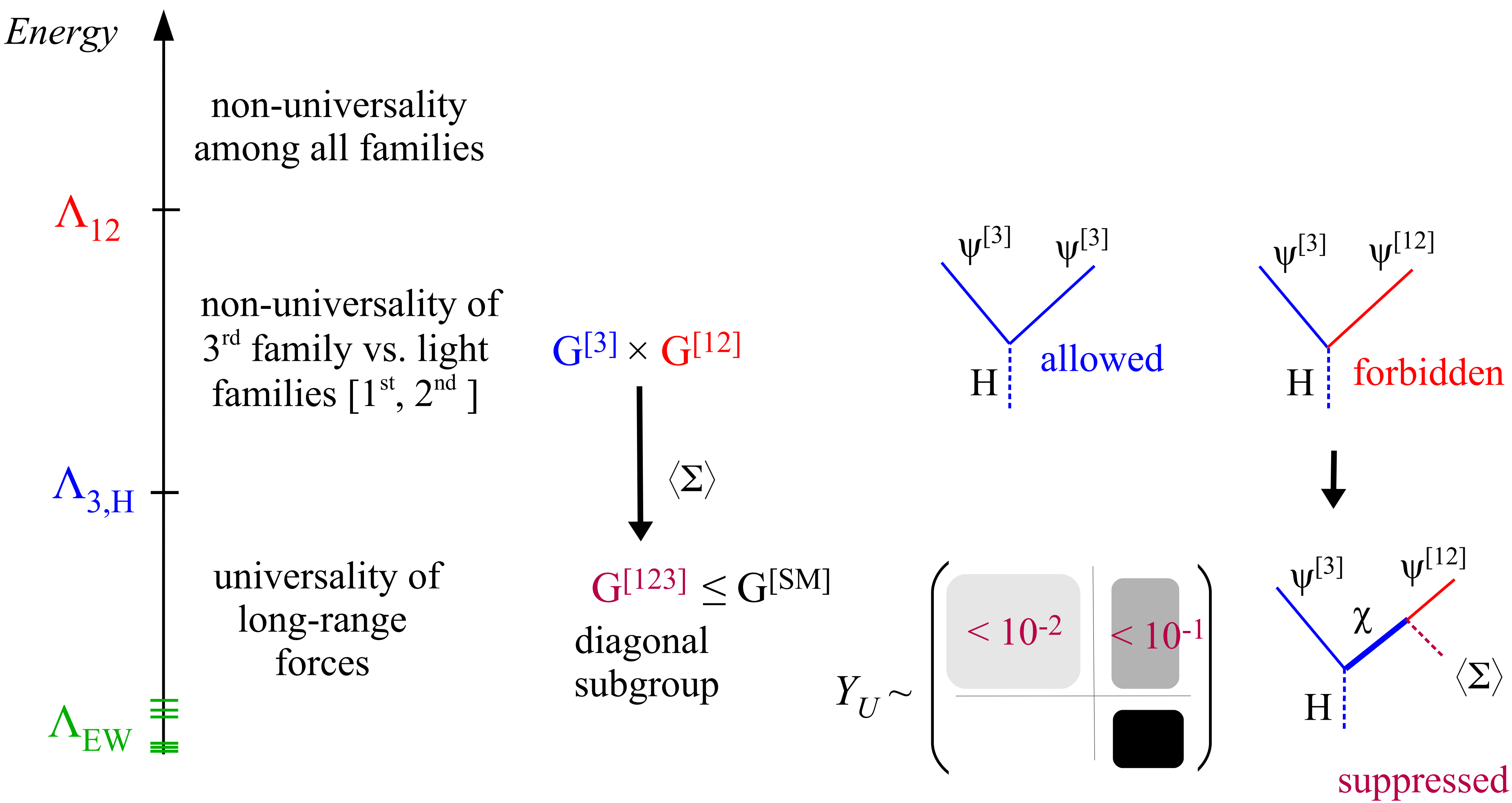






Flavor deconstruction

Basic idea of flavor deconstruction, implemented in theory with at least two well-separated scales:



Flavor deconstruction

Basic idea of flavor deconstruction, implemented in theory with at least two well-separated scales:

Energy

non-universality among all families → non-universality among the first two families "frozen" at high scales

✔ *precision tests*

Λ_{12}

non-universality of 3rd family vs. light families [1st, 2nd]

$G^{[3]} \times G^{[12]}$ → U(2)^5 emerge as accidental symmetry

✔ *precision tests*

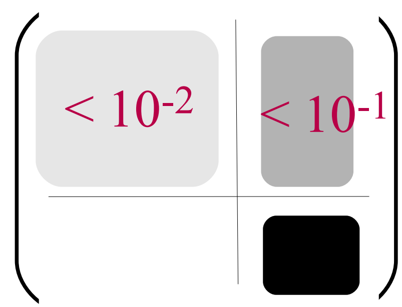
$\langle\Sigma\rangle$

$\Lambda_{3,H}$

universality of long-range forces

$G^{[123]} \leq G^{[SM]}$

diagonal subgroup

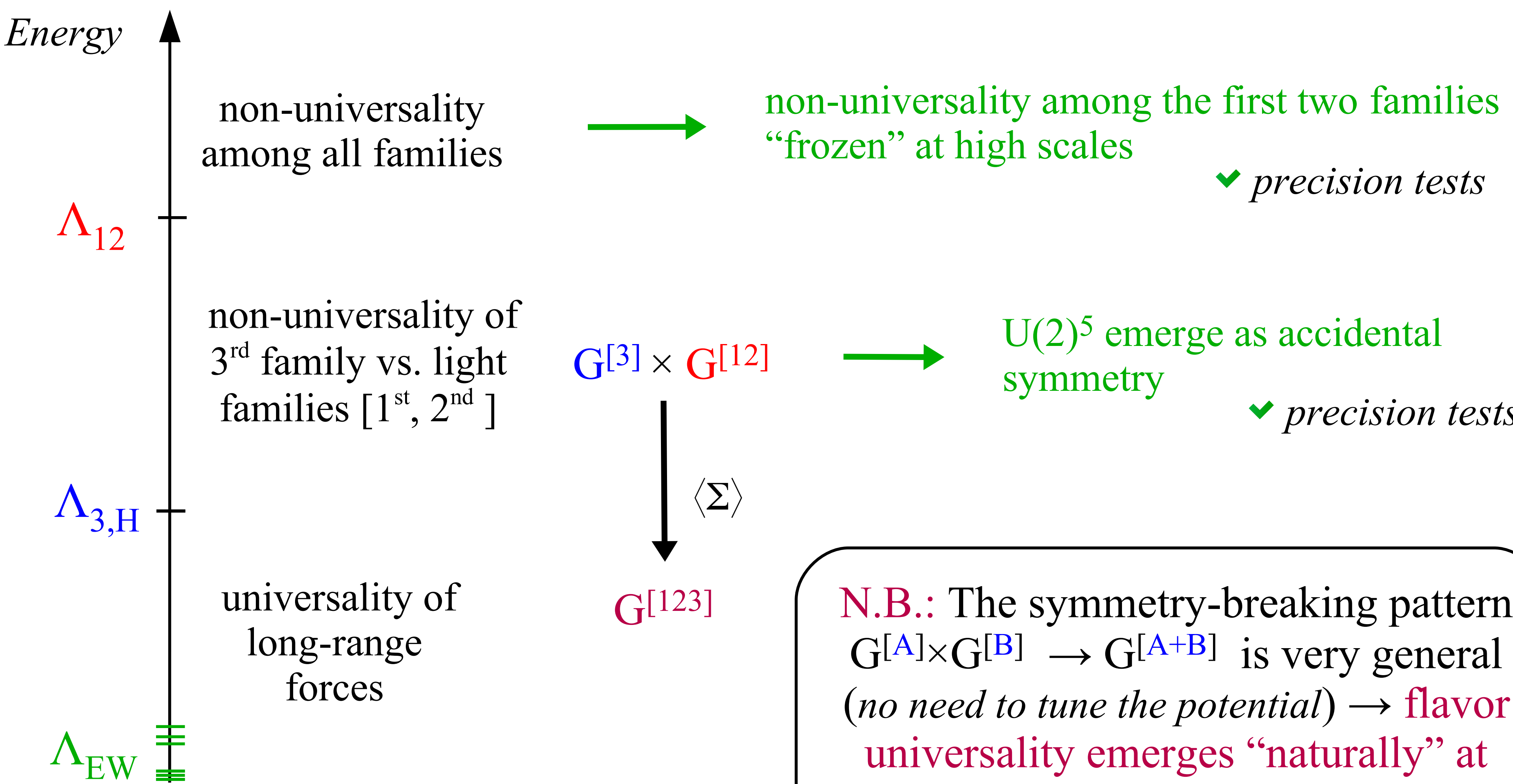
$Y_U \sim$ 

Λ_{EW}

"imprint" of the scale hierarchy in the Yukawa couplings

Flavor deconstruction

Basic idea of flavor deconstruction, implemented in theory with at least two well-separated scales:



N.B.: The symmetry-breaking pattern $G^{[A]} \times G^{[B]} \rightarrow G^{[A+B]}$ is very general (*no need to tune the potential*) $\rightarrow$ flavor universality emerges "naturally" at low energies

Flavor deconstruction: quark-lepton unification for the 3rd generation

All possible options have been classified (*not many consistent choices*).

A particularly interesting one is allowing quark-lepton unification a la Pati-Salam for the 3rd generation

$$SU(4)^{[3]} \times SU(3)^{[12]} \times G_{EW}$$

$$\downarrow$$

$$SU(3) \times SU(2)_L \times U(1)_Y$$

Fermions in SU(4): $\begin{bmatrix} Q^\alpha \\ Q^\beta \\ Q^\gamma \\ L \end{bmatrix}$

Main Pati-Salam idea:
Lepton number as "the 4th color"

✔ Explain charge quantization

$$SU(4) \sim \left[\begin{array}{c|c} SU(3)_C & 0 \\ \hline 0 & 0 \end{array}\right] + \left[\begin{array}{c|c} 0 & LQ \\ \hline LQ & \end{array}\right] + \left[\begin{array}{c|c} \frac{1}{3} & 0 \\ \hline 0 & -1 \end{array}\right]$$

B-L generator

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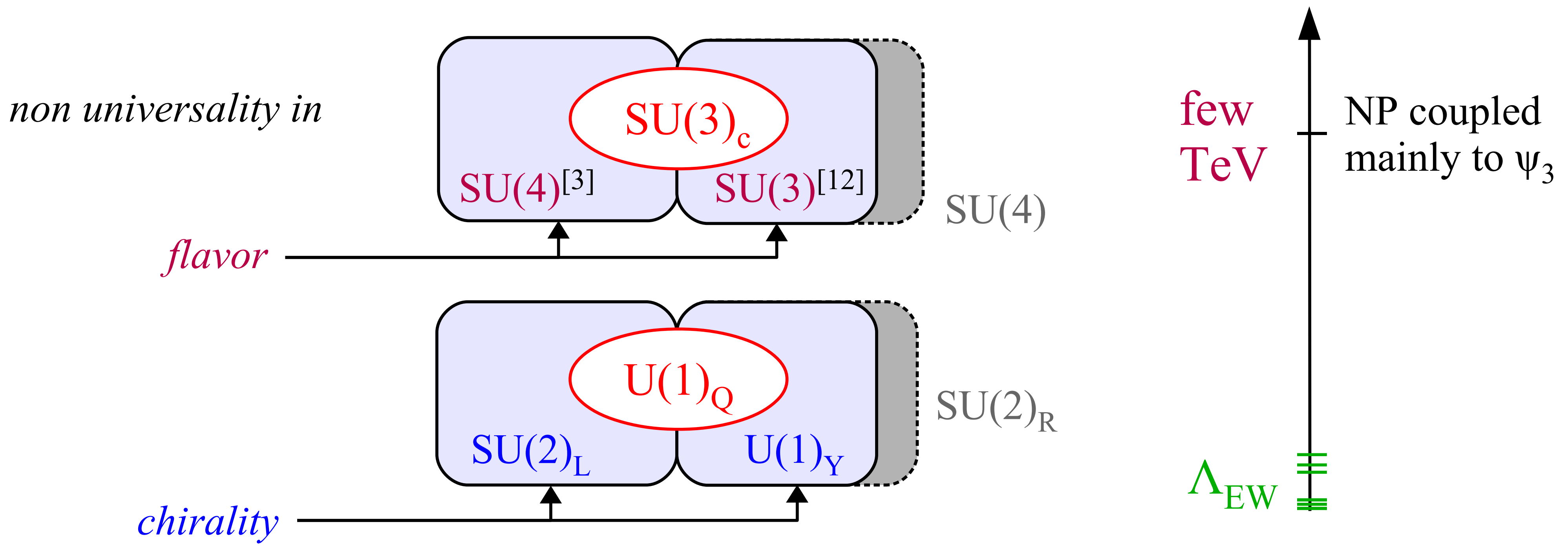

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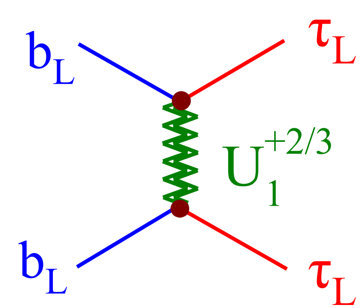
$SU(4)^{[3]} \times SU(3)^{[12]} \times G_{EW}$

↓

$SU(3) \times SU(2)_L \times U(1)_Y$

→ vector leptoquark



✔ Explain charge quantization

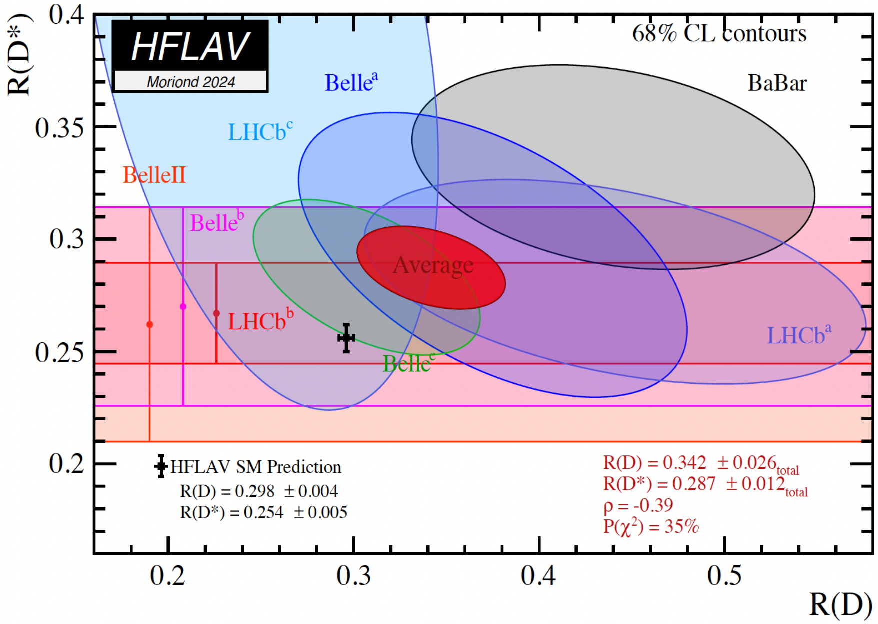
✔ Might explain the existing tensions in B-physics data

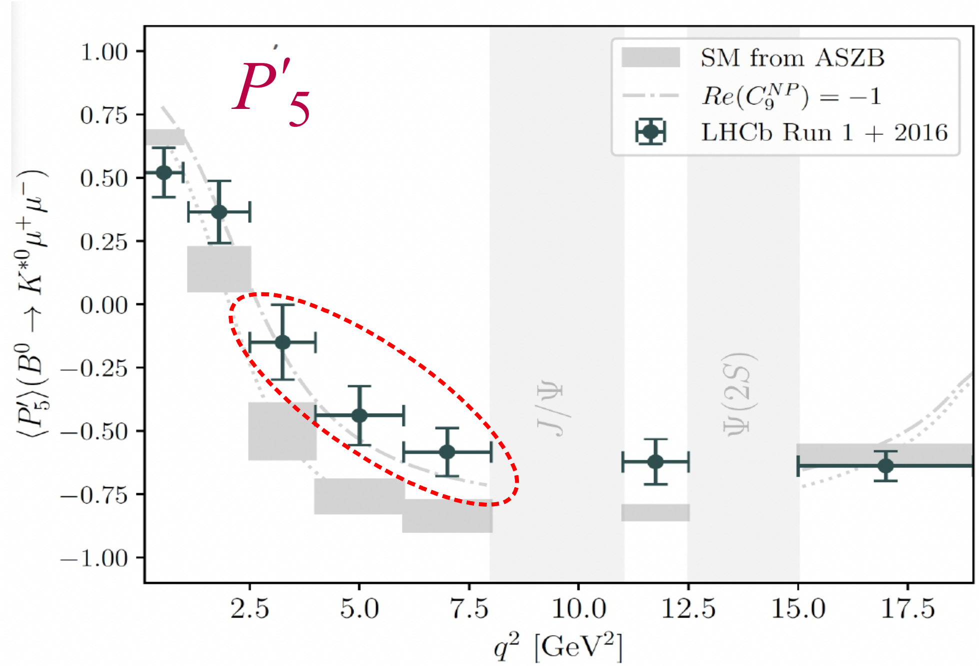
$$SU(4) \sim \begin{bmatrix} SU(3)_C & 0 \\ 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & LQ \\ LQ & \end{bmatrix} + \begin{bmatrix} \frac{1}{3} & 0 \\ 0 & -1 \end{bmatrix}$$

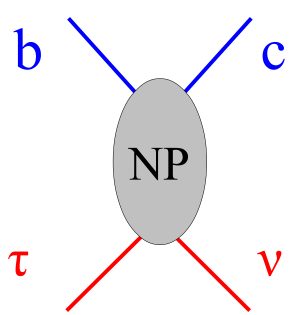
B-L generator

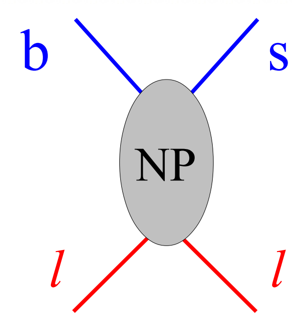
Flavor deconstruction: back to B-physics data

Remember the two "anomalies" we discussed yesterday...









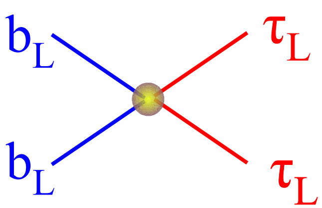
and don't forget all the caveats...

Flavor deconstruction: back to B-physics data

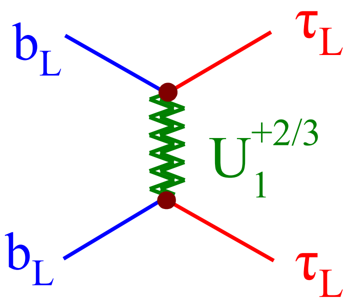
~~L~~FU in $b \rightarrow c\, l\nu$ [R_D, ...]

CKM rotation

$\frac{1}{\Lambda^2}$



EFT limit



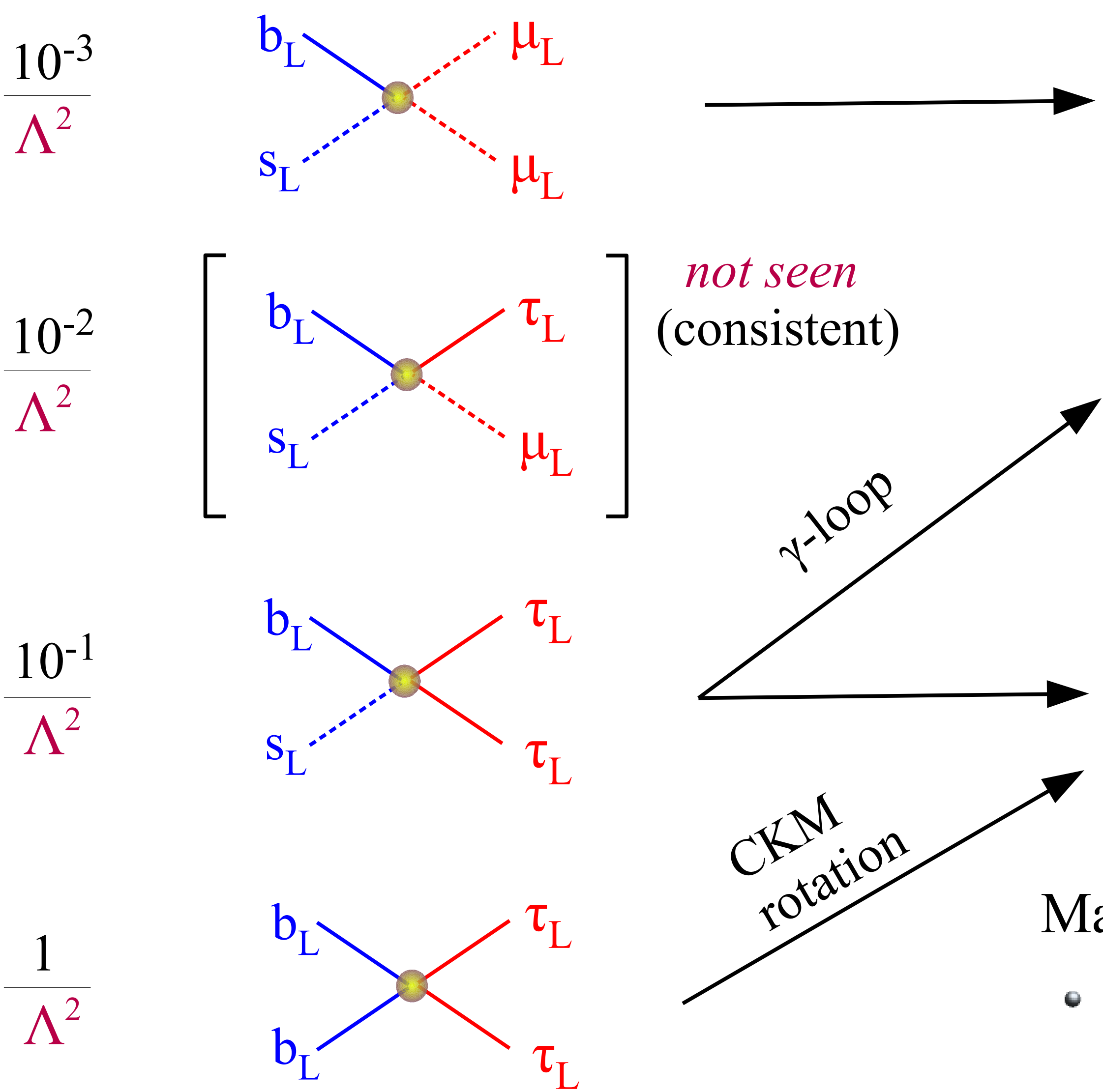
Barbieri, GI, Pattori, Senia '15
Buttazzo, Greljo, GI, Marzocca '17

(*or similar with scalar LQ*)

Marzocca '18, Angelescu *et al.* '18
...

$\Lambda \approx 1.5$ TeV

Flavor deconstruction: back to B-physics data



~~LFU~~ in $b \to s\, l^+ l^-$ [R_K, ...]

LFU conserv. NP
in $b \to s\, l^+ l^-$ [$\Delta C_9^{\rm Univ}$]

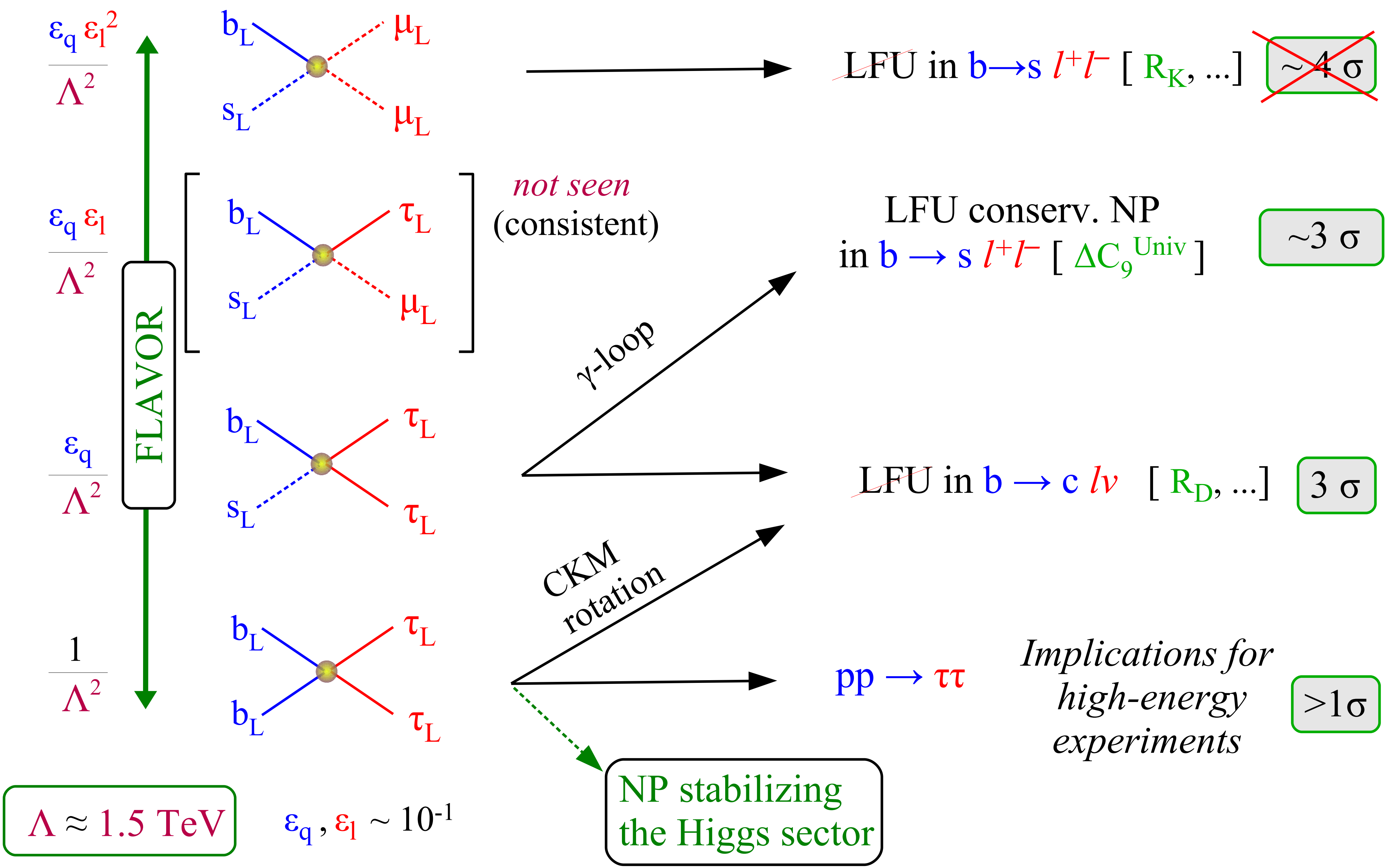
~~LFU~~ in $b \to c\, l\nu$ [R_D, ...]

$\Lambda \approx 1.5$ TeV

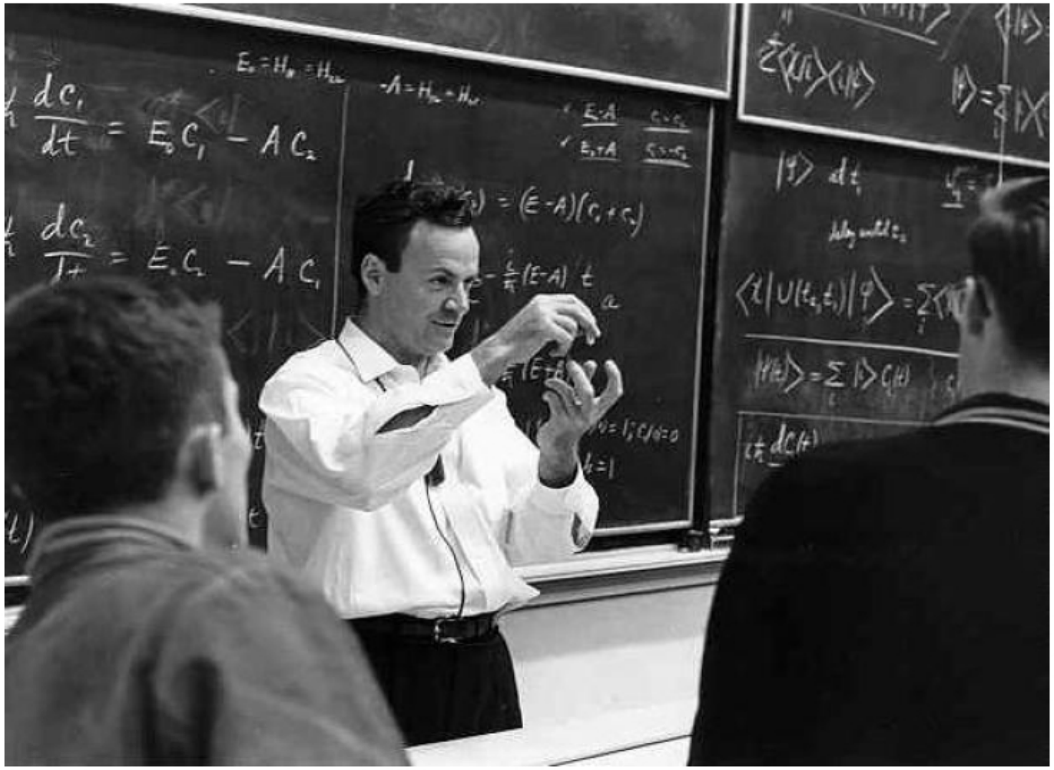
Main EFT hypotheses:

- Leading NP effect in <u>semileptonic</u> operator with 3rd gen. fields
- Replacing 3rd → 2nd implies $O(10^{-1})$ suppression

Flavor deconstruction: back to B-physics data



Implications & future prospects



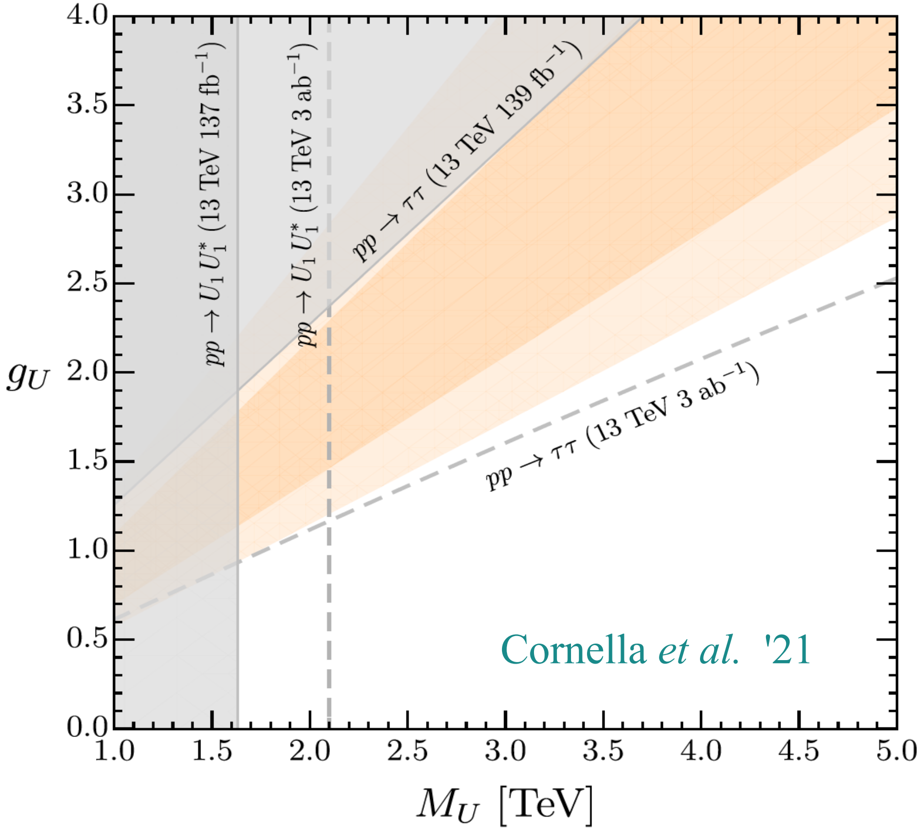
"It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong." [Feynman]

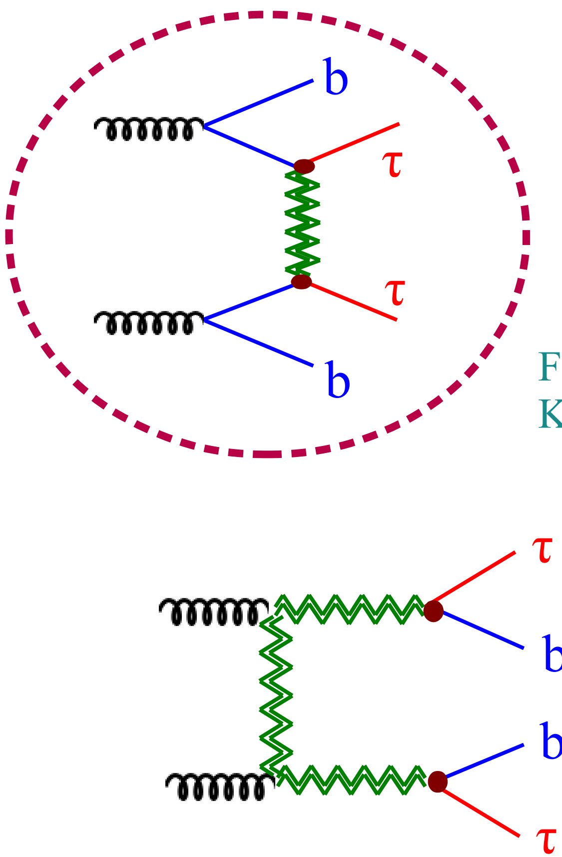
Implications & future prospects

If the ideas I sketched before are correct (*even only in part...*), we can expect several interesting new phenomena, at both low and high energies

I The U_1 exchange @ high-energies
[very general, directly connected to the EFT analysis]

pp → ττ





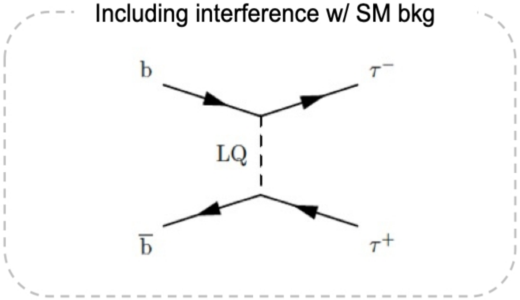
Faroughi, Greljo, Kamenik '16

Implications & future prospects

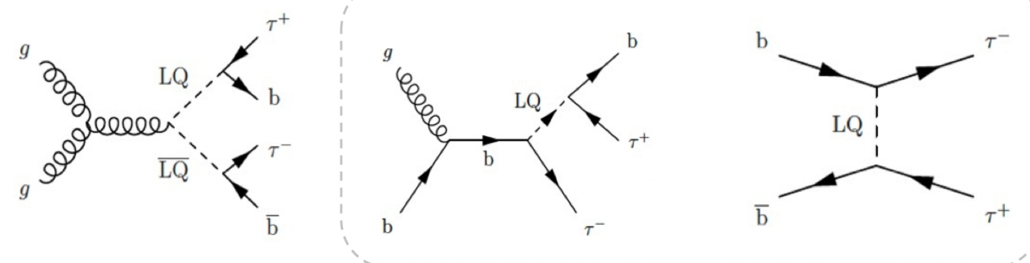
Aurelio Juste [*Moriond EW* '23]

LQ-b-τ: Comparison of recent results

Including interference w/ SM bkg

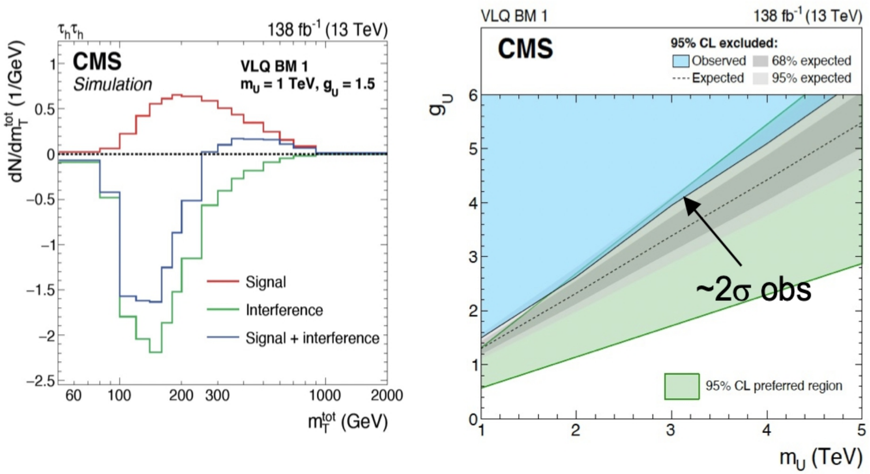


Neglecting interference w/ SM bkg



Caveat: BR=1 (CMS) vs BR=0.5 (ATLAS)

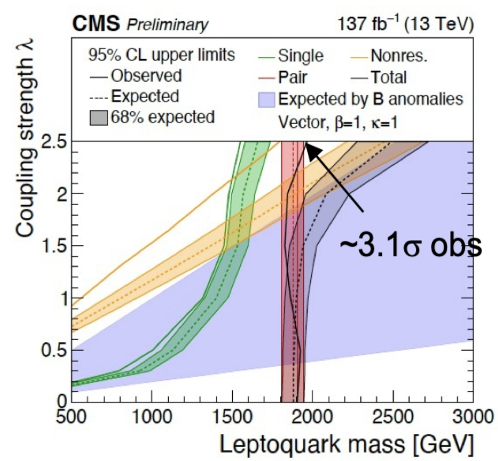
CMS-HIG-21-001



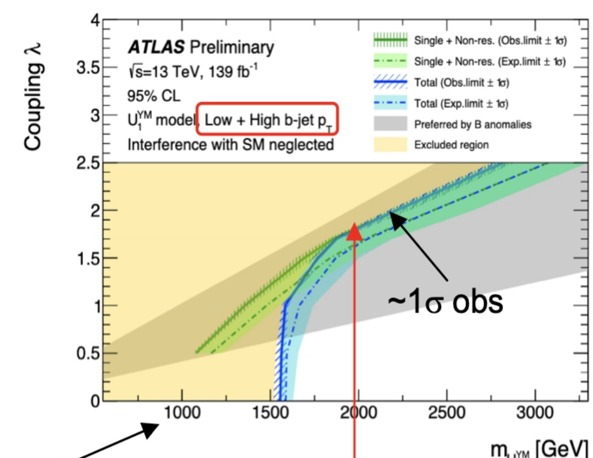
Shown at Moriond EW 2022

Need to clarify interference issue for future interpretations

CMS-PAS-EXO-19-016



EXOT-2022-39



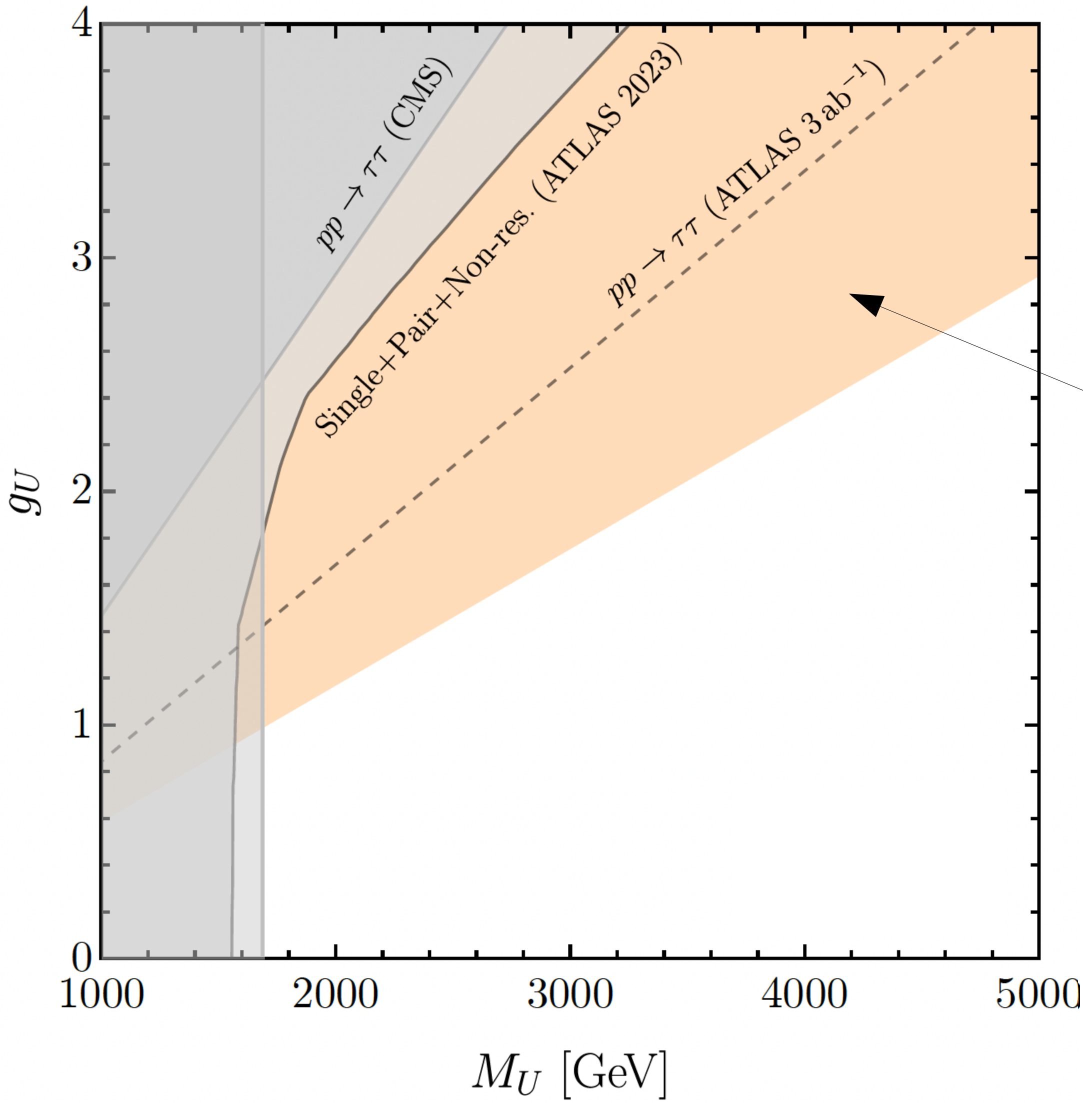
Large improvement in sensitivity when adding low b-jet p_T category

Excludes CMS' excess

Implications & future prospects

I The U_1 exchange @ high-energies

[very general, directly connected to the EFT analysis]



Updated preferred region by b → c low-energy data

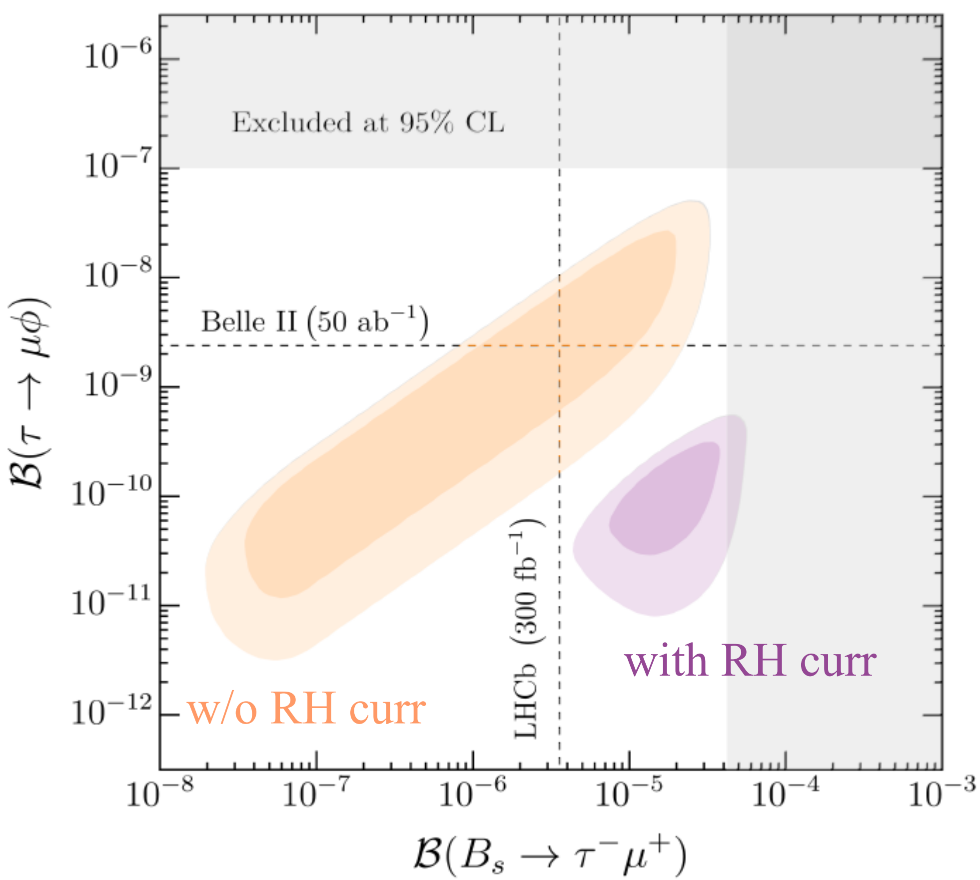
Implications & future prospects

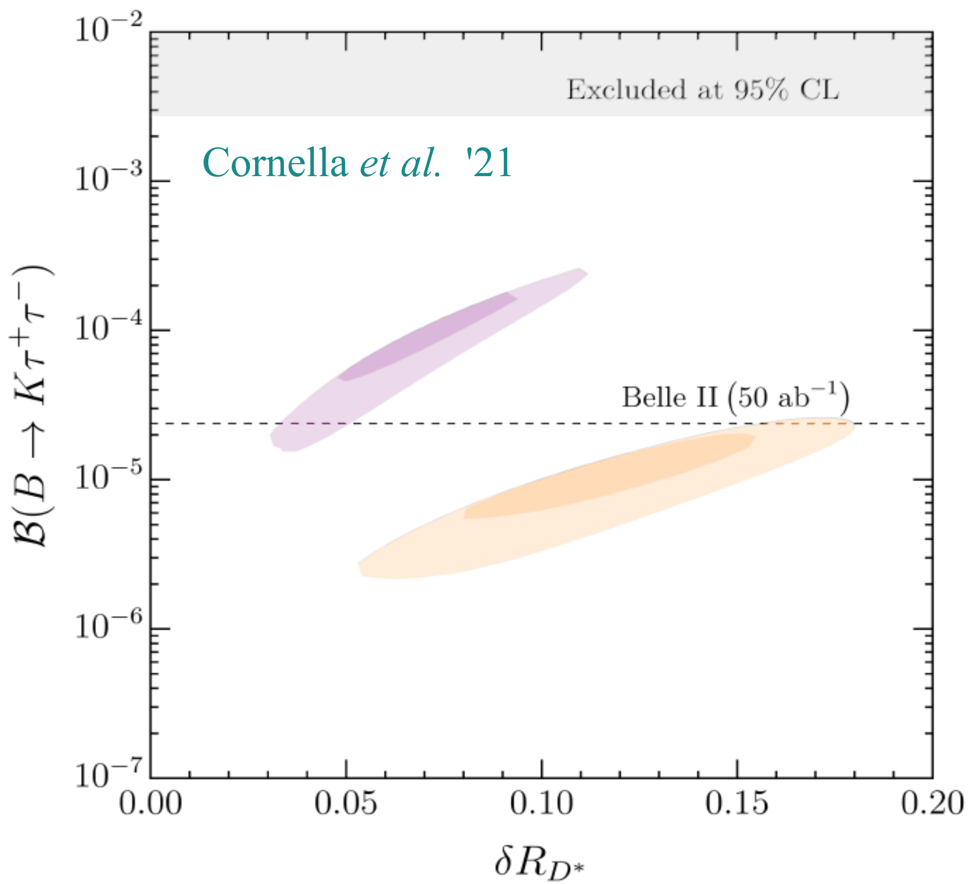
II General predictions of U_1 exchange @ low-energies

[UV insensitive observables, closely connected to the EFT analysis]

$\tau \to \mu$ LFV (in B and tau decays)

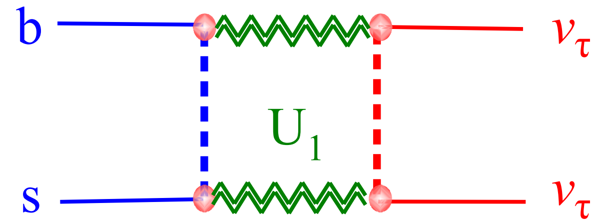
largely enhanced $b \to s\tau\tau$ rates (in all channels)





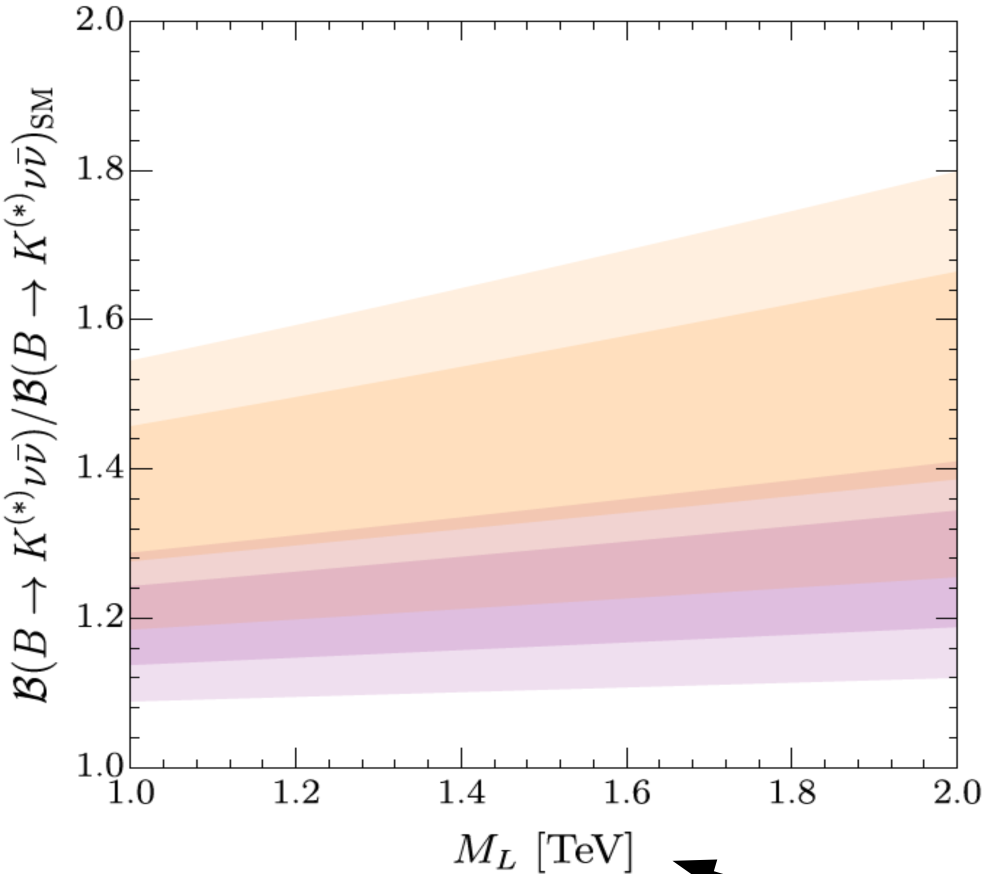
Implications & future prospects

III Specific predictions of the complete model @ low-energies [UV sensitive observables]



$R_D \to$ enhancement of $B \to K\nu\nu$

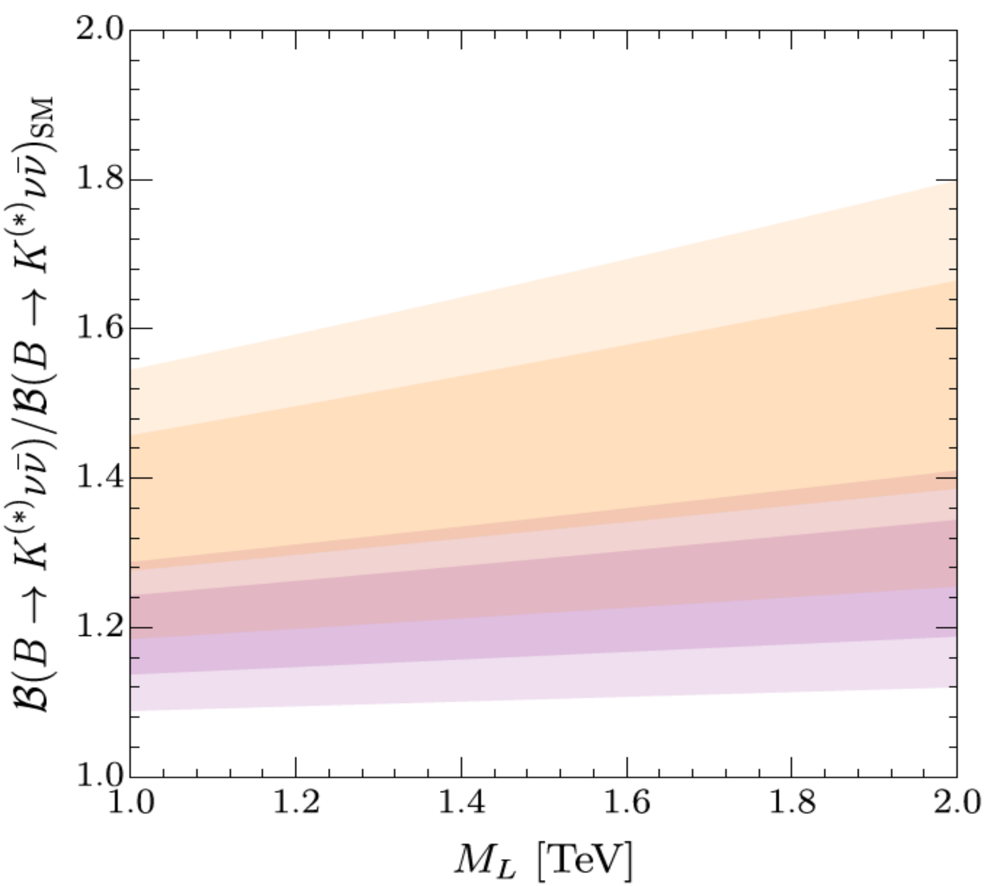
Fuentes-Martin, GI, Konig, Selimovic, '20



Mass of new heavy (vector-like) fermions which are necessary ingredients of the model

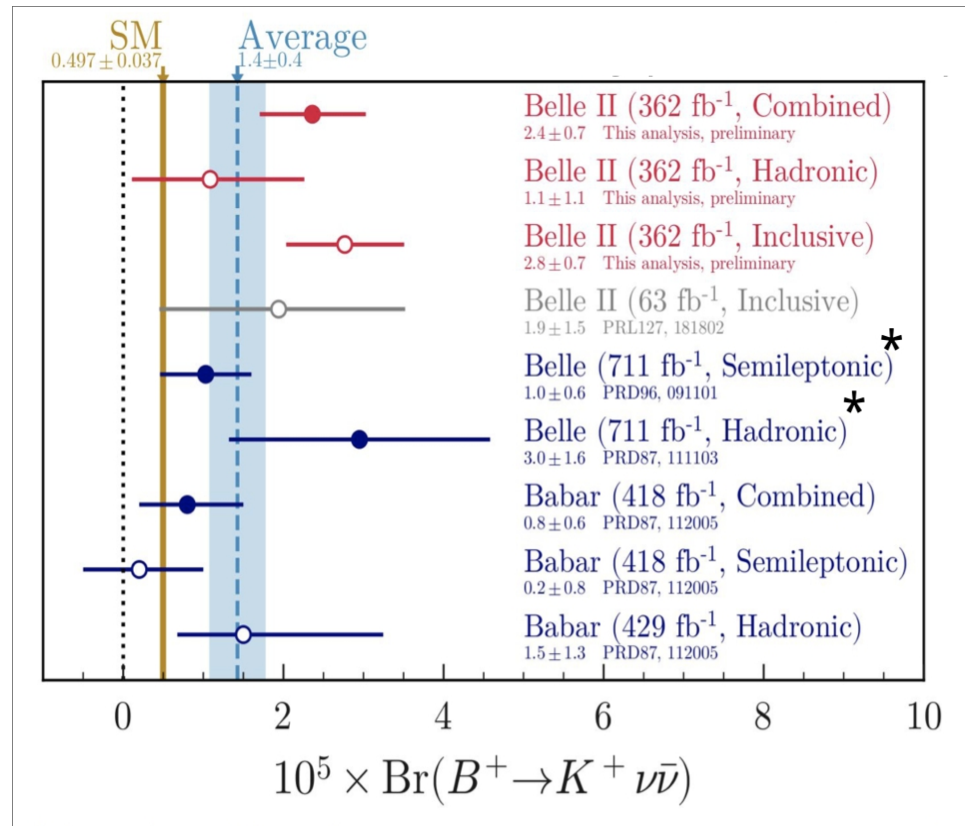
▶ Implications & future prospects

III Specific predictions of the complete model @ low-energies [UV sensitive observables]



Belle II physics highlights

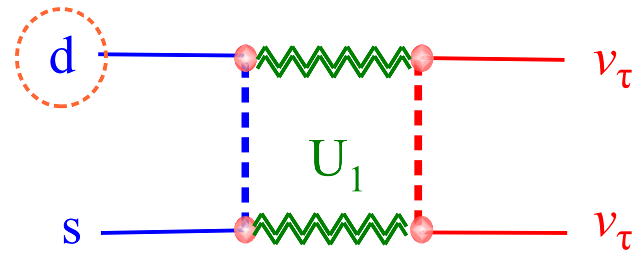
EPS, 24 Aug 2023
Sasha Glazov, on behalf of Belle II

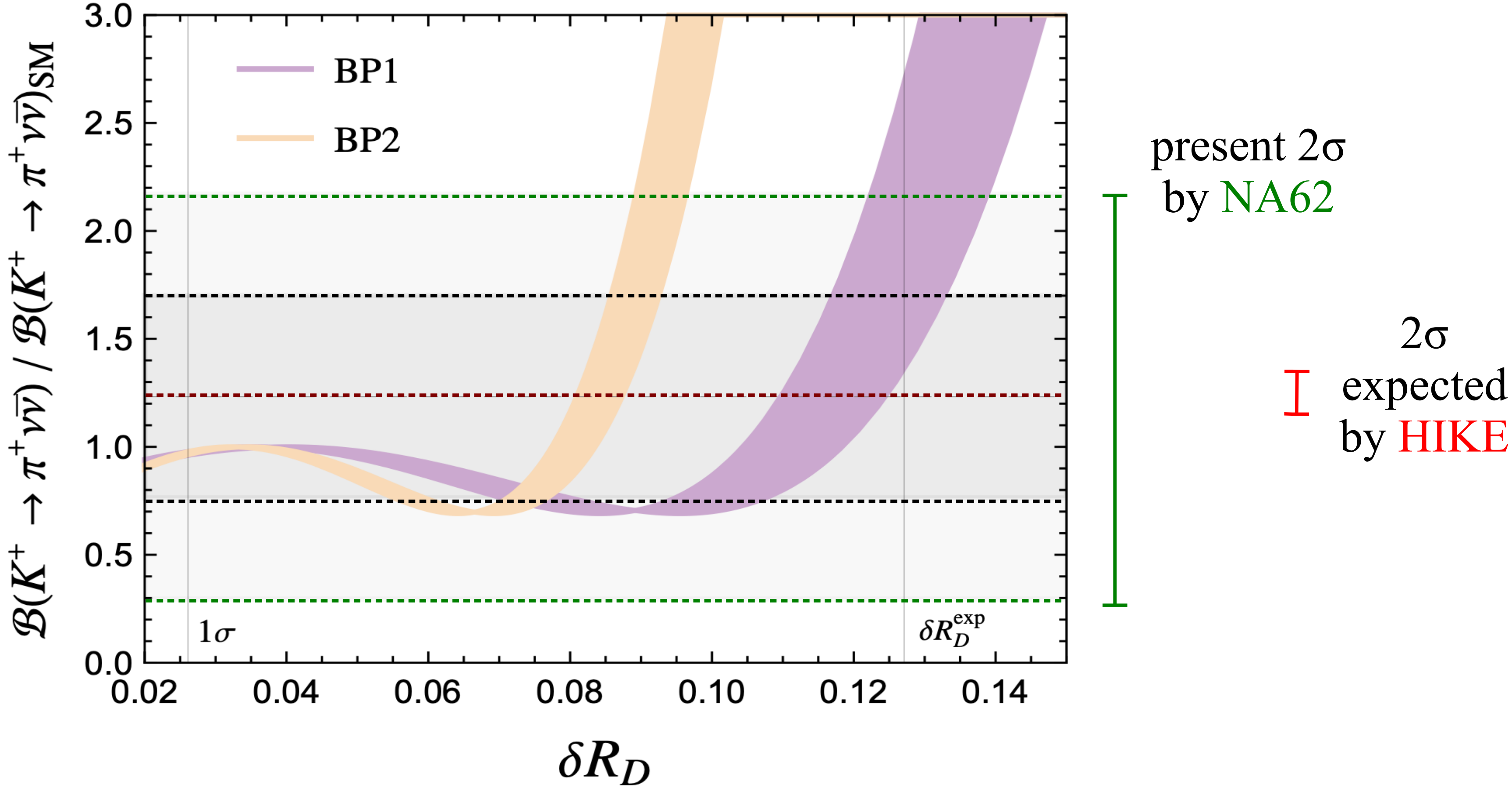


Evidence for $B^+ \to K^+ \nu\bar{\nu}$ decay with a branching fraction 2.8σ above the standard model

Implications & future prospects

III Specific predictions of the complete model @ low-energies [UV sensitive observables] also beyond B-physics...





Conclusions

- Flavor physics represents one the most intriguing aspects of the SM and, at the same time, a great opportunity to investigate physics beyond the SM.

- The apparently strong bounds on NP scales derived by flavor observables might be a "mirage": motivated models are compatible with new degrees of freedom in the TeV domain

- The idea of a *multi-scale construction at the origin of the flavor hierarchies* has several appealing aspects:
  - it addresses both "flavor problems"
  - is compatible with present data (*even favored by some "anomalies"*)
  - is compatible with motivated UV completions of the SM
  - it implies that new non-standard effects should emerge soon

- The models and the observables I discussed are explicit examples (*by no means exhaustive...*) that illustrate well the general statement that precision flavor physics is a key element to make progress in the field