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[*University of Zürich*]

- Lecture 2: Rare decays & flavor physics beyond the SM
  - The MFV hypothesis
  - Flavor non-universal interactions
  - LFU tests in b→c$l\nu$ transitions
  - Rare b→sll decays
  - Speculations on present data: from EFT to the UV
  - Future prospects
  - Conclusions

University of Zurich[UZH]

European Research Council
Established by the European Commission

Very brief recap...

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

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

Yukawa couplings:
$U(3)^5 \to \sim U(2)^n$
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

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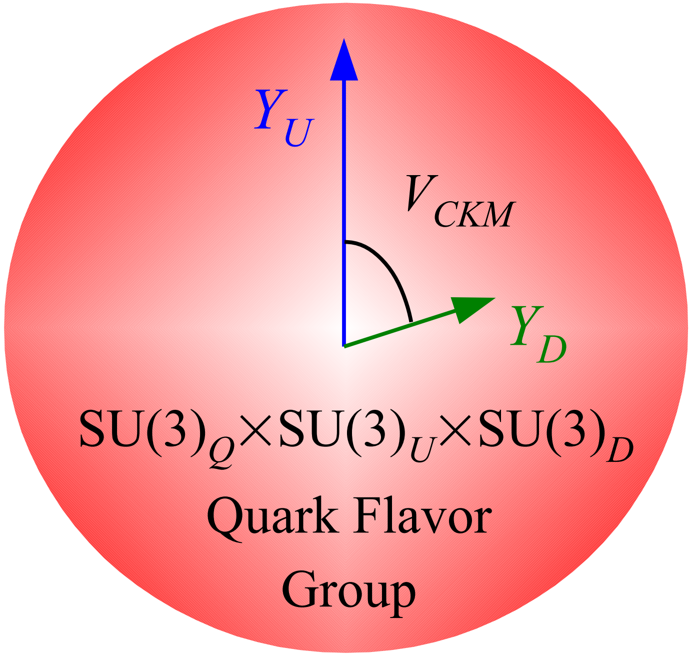
NP flavor puzzle

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

Operator	Bounds on Λ (TeV)		Bounds on c_{ij} ($\Lambda = 1$ 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}
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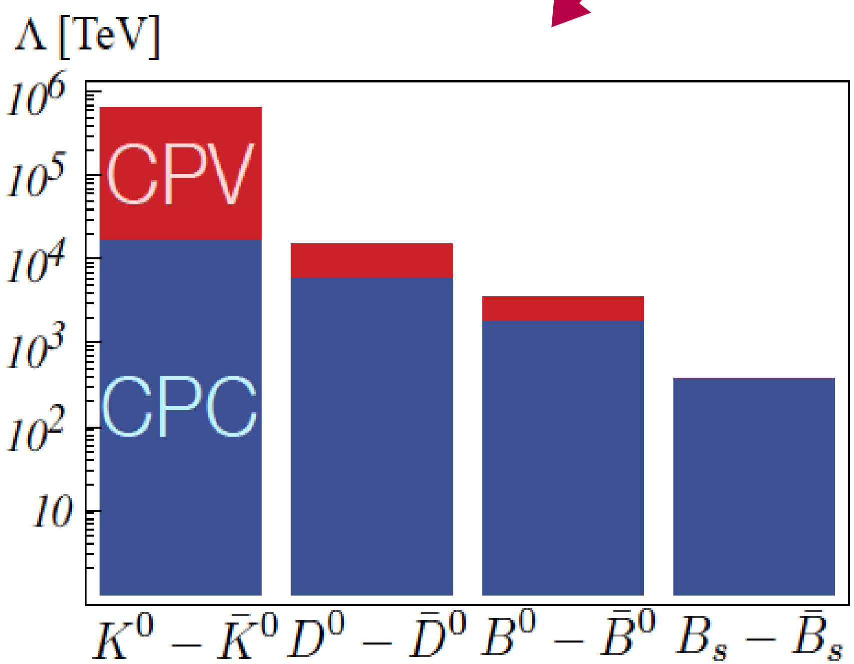


highly non trivial flavor structure

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:

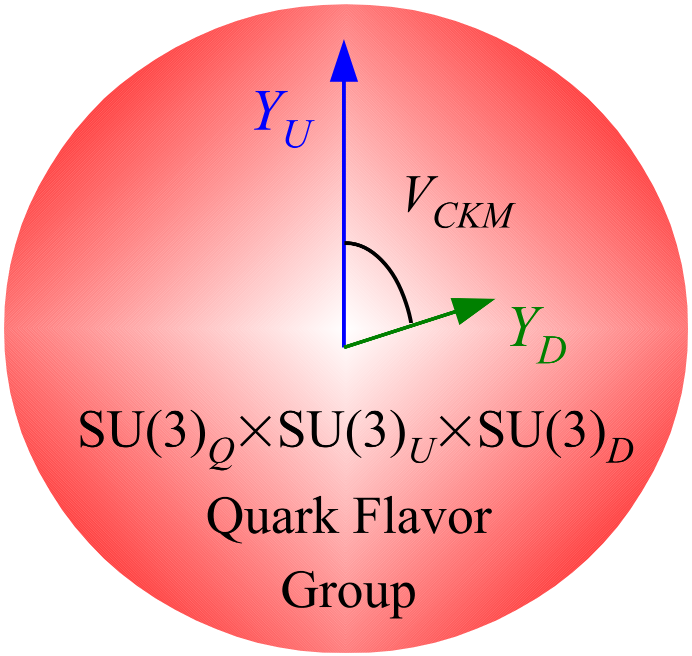
  $U(3)^5 = SU(3)_Q \times SU(3)_U \times SU(3)_D \times \ldots$

  (accidental) global symm. of the SM gauge sector
  → promoted to basic symm. of the eff. theory

- 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 unique breaking terms of the flavor symmetry



E.g.: $\mathscr{L}_{\text{Yukawa}} = \bar{Q}_L Y_D D_R H + \ldots$

$\bar{3}_Q \quad 3_Q \times \bar{3}_D \quad 3_D \quad \rightarrow$ invariant

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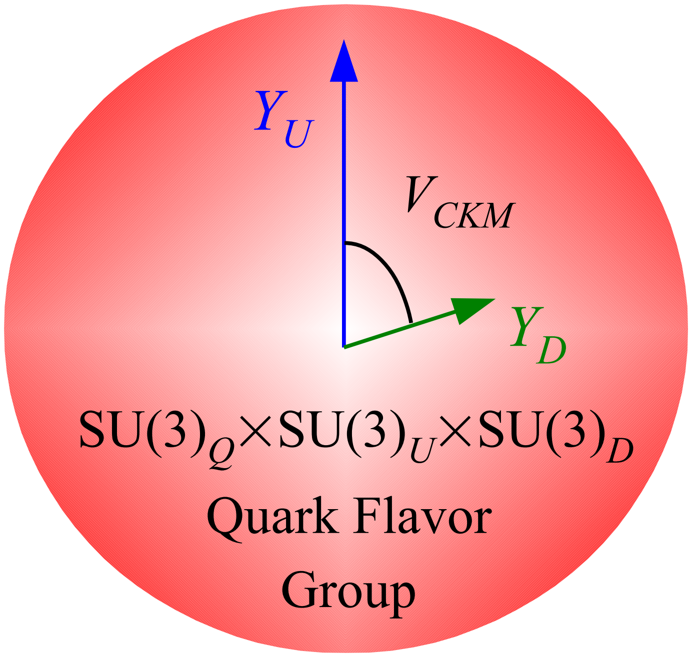

MFV hypothesis: *Yukawa couplings = unique sources of flavor symmetry breaking*

⬇

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

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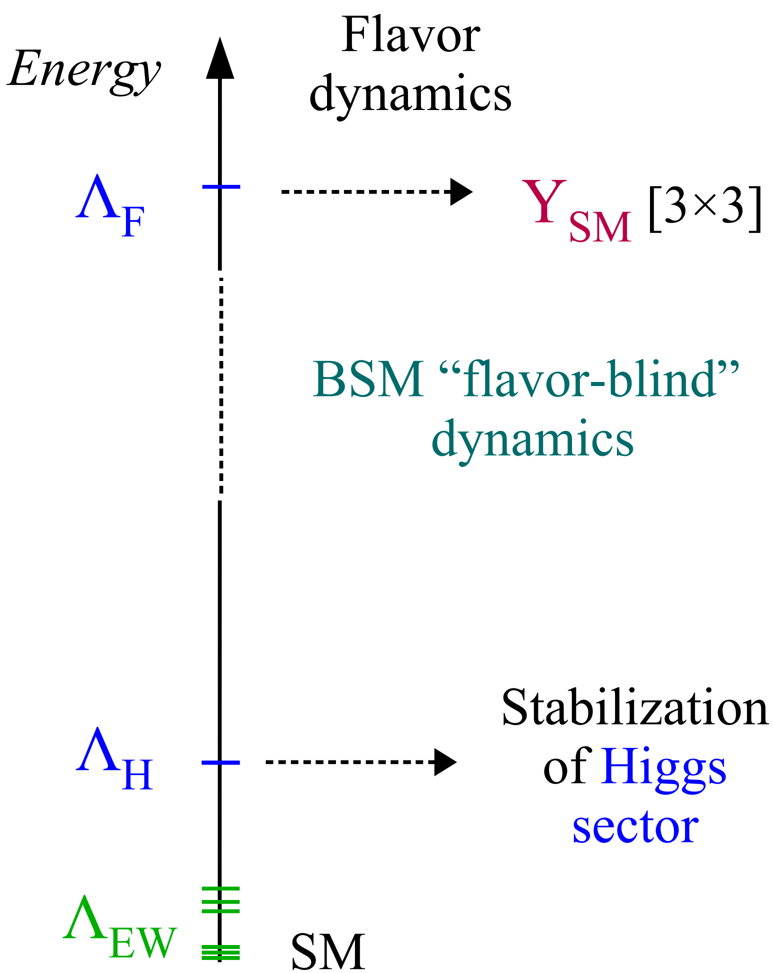
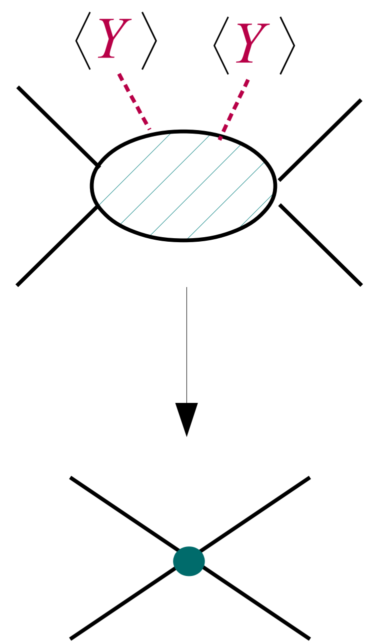


Basic idea: Yukawa coup.l generated at some heavy (unaccessible) energy scale → Y = only sources of flavor breaking accessible at low E



SMEFT with MFV

3 generations = “identical copies” up to high energies

The MFV hypothesis

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

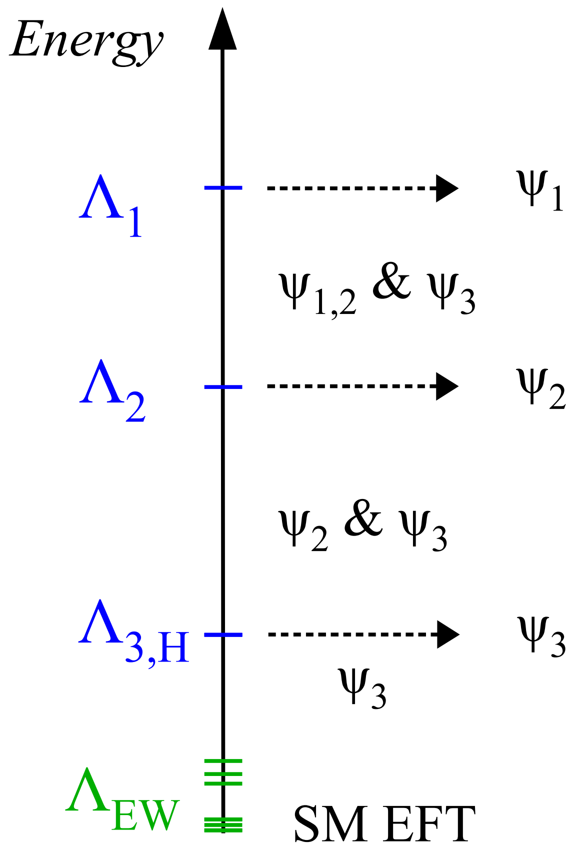
While this idea can be implemented in explicit NP models (*i.e. gauge-mediated SUSY breaking*) is far from being general...

"flavor anarchy" $\longleftarrow\text{-----}\longrightarrow$ 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.

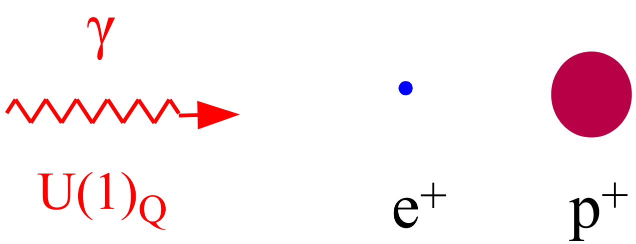
In the last few years it has become clear that there is an interesting alternative, able to address both flavor problems at the same time.

Flavor non-universal interactions



Flavor non-universal interactions

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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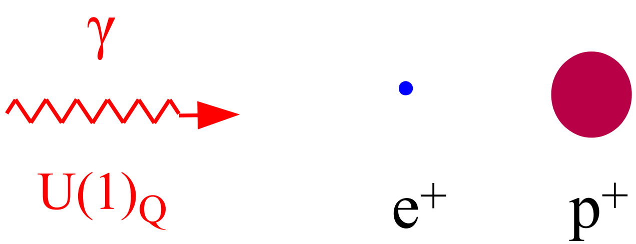
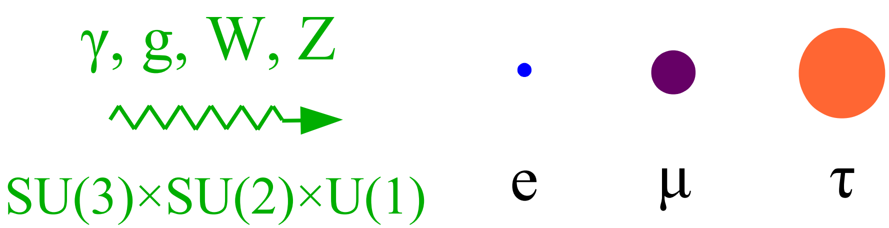


We would conclude that these two particles are "identical copies" but for their mass ...

That's exactly the same (misleading) argument we use to infer flavor symmetries..



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

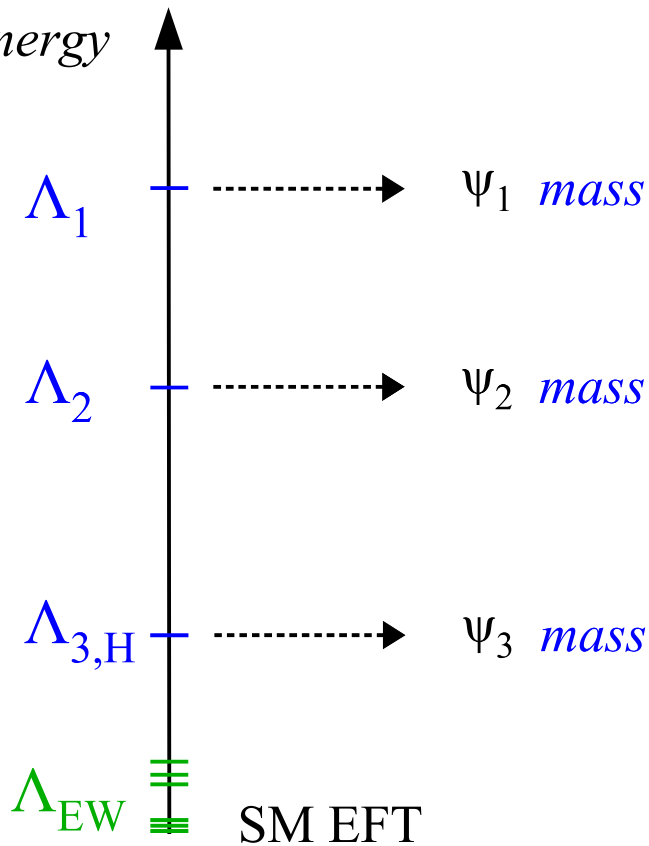
The SM quantum numbers of the three families could be an "accidental" low-energy property: the different families may well have a very different behavior at high energies, as signaled by their different mass

All flavor symmetries could well be only accidental low-energy properties [such as isospin or SU(3) in QCD].

Flavor non-universal interactions

Following this general idea → alternative paradigm to address both flavor puzzles via a *multi-scale* theory 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 dynamics at heavier scales
- *"flavor deconstruction"* of the SM gauge symmetry → flavor hierarchies emerge as accidental symmetries

⬇

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

Flavor non-universal interactions

Following this general idea → alternative paradigm to address both flavor puzzles via a ***multi-scale*** theory with ***flavor non-universal*** interactions

☆ *"flavor deconstruction"* of the SM gauge symmetries:

Last step of the symm. breaking chain: [@ few TeV]

$$G^{[3]} \times G^{[12]} \longrightarrow G^{[\mathrm{Univ}]}$$

Symmetry acting on 3^{rd} gen.

Symmetry acting on light gen.

G = subset of SM gauge

✔ This symmetry-breaking pattern is very general (*no need to tune couplings or potential*) → flavor universality emerges "naturally" at low energies

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- Charging the Higgs under $G_{SM}^{[3]}$ → only Yukawa of the third generation are allowed → "solution" of the SM flavor problem

$$\bar{\psi}_L^{[3]} Y \psi_R^{[3]} H^{[3]} \qquad \cancel{\bar{\psi}_L^{[2]} Y \psi_R^{[3]}} H^{[3]} \qquad \cancel{\bar{\psi}_L^{[2]} Y \psi_R^{[2]}} H^{[3]}$$

Flavor non-universal interactions

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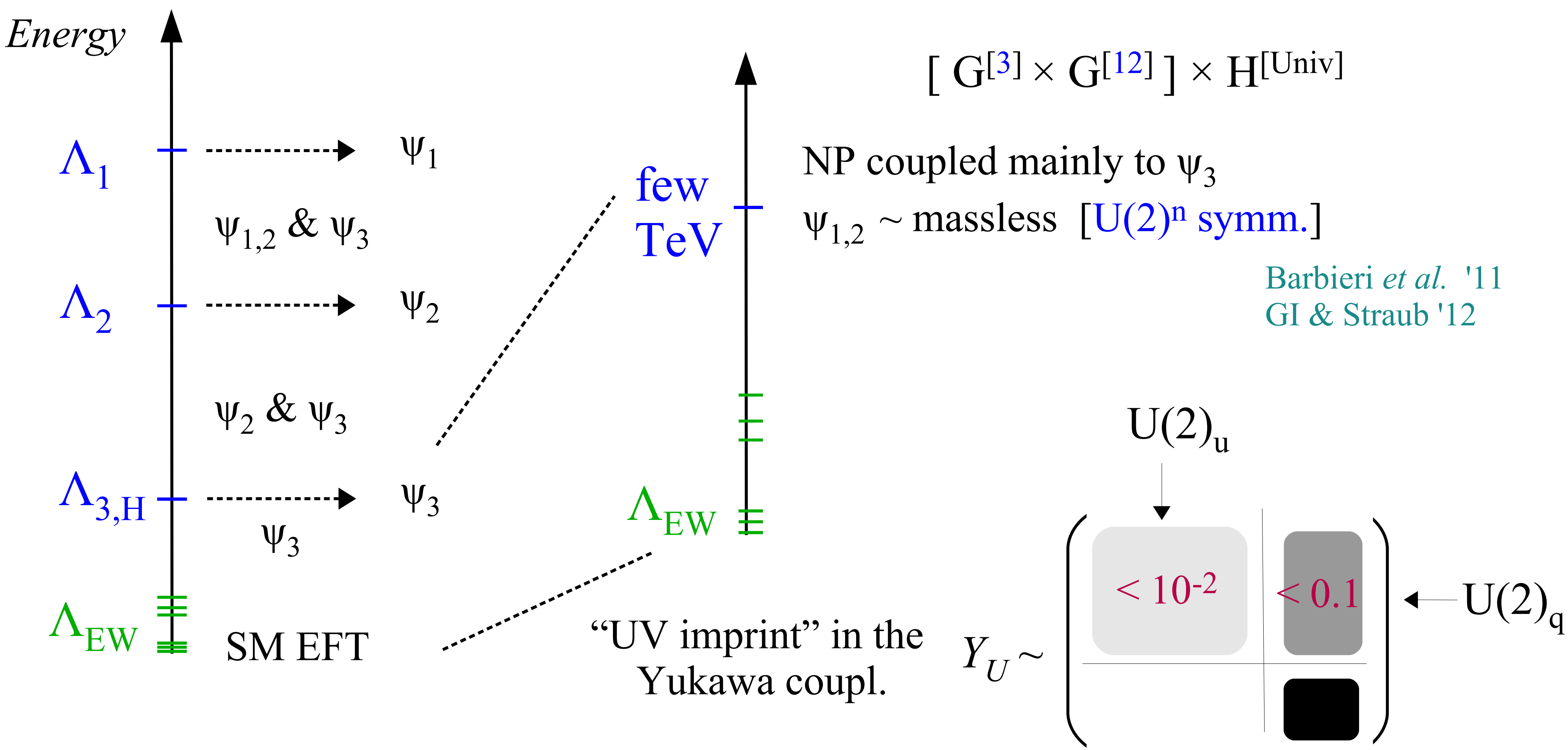
- Charging the Higgs under $G_{SM}^{[3]}$ → only Yukawa of the third generation are allowed → "solution" of the SM flavor problem
- $G_{SM}^{[12]}$ symmetry → accidental $U(2)^n$ flavor symmetry → protection of flavor-changing processes as effective as in MFV

Flavor non-universal interactions

Following this general idea → alternative paradigm to address both flavor puzzles via a *multi-scale* theory with *flavor non-universal* interactions



Effective organizing principle for the flavor structure of the SMEFT

MFV vs. flavor non-universal interactions

As a general rule, within MFV:

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

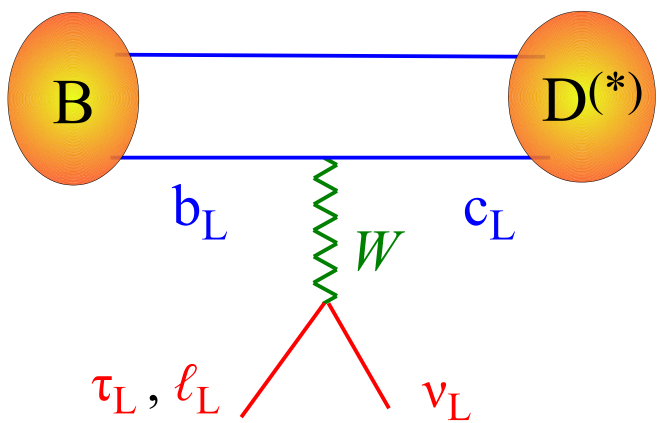
$$A[\, q_i \to q_j + X \,]_{MFV} = A[\, q_i \to q_j + X \,]_{SM} \left[1 + c_{NP} \frac{m_W^{\,2}}{\Lambda^2} \right]$$

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

On the contrary, within the $U(2)^n$ multi-scale framework:

- deviations are larger (relative to SM) in processes involving more 3rd generation fermions (→ *prominent role of B physics*)
- Sizable violations of Lepton Flavor Universality can be expected, especially in processes involving τ and/or ν_τ

LFU tests in $b \to c\ l\nu$ transitions

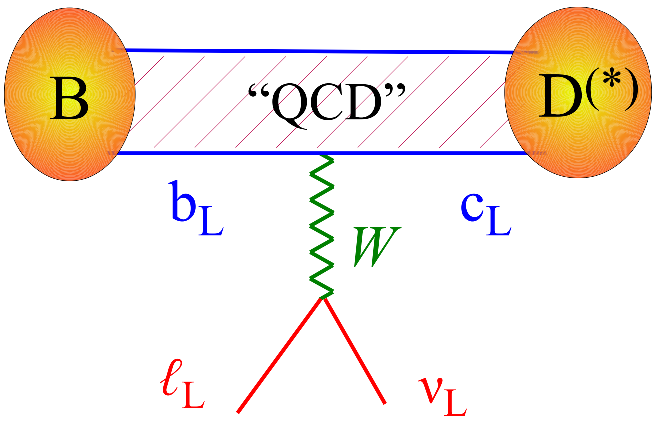


LFU tests in $b \to c l \nu$ transitions

One of the most interesting test of LFU [3^{rd} gen. quarks & leptons involved] can be performed in charged-current $b \to c$ transitions is via the ratios

$$R_{12}(H_c) = \frac{\Gamma(B \to H_c\, \ell_1 \nu_1)}{\Gamma(B \to H_c\, \ell_2 \nu_2)}$$

$$H_c = D,\ D^*,\ \ldots$$



We are not able to compute very precisely, separately, numerators and denominators in these ratios because of hadronic uncertainties...

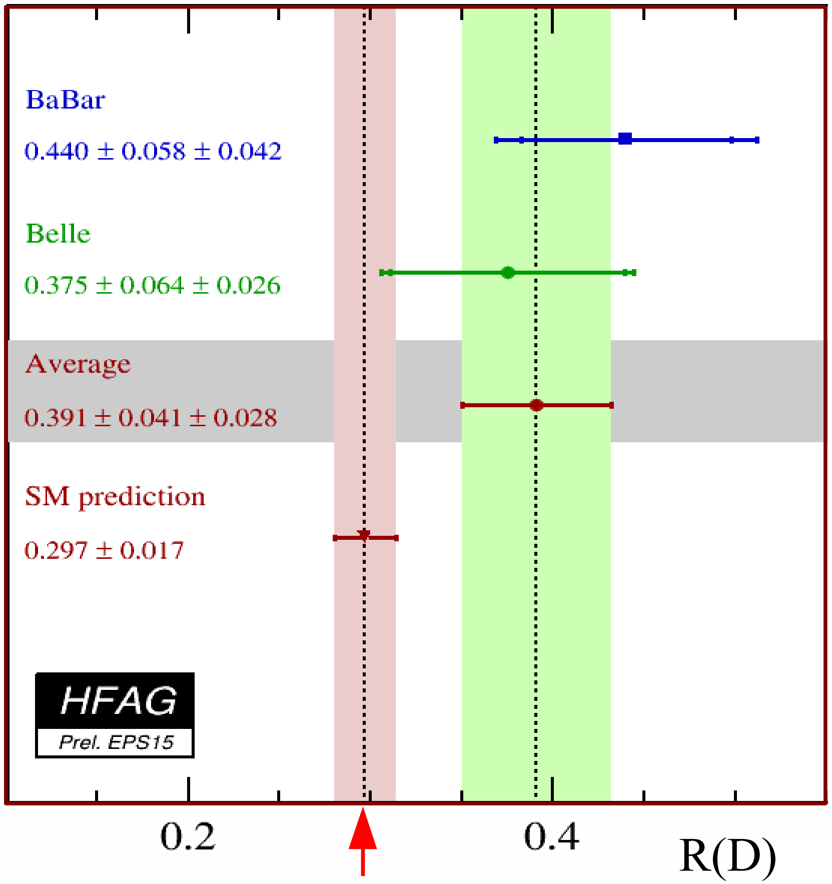
E.g.: $A(B \to D\ell\nu)_{SM} = G_{eff}\, V_{cb} \underbrace{< D \,|\, \bar{b}_L\, \gamma_\mu\, c_L \,|\, B >}\ \bar{\ell}\gamma^\mu\nu$

$\longrightarrow f_+(q^2)\,(p_B+p_D)_\mu + f_-(q^2)\,(p_B-p_D)_\mu$

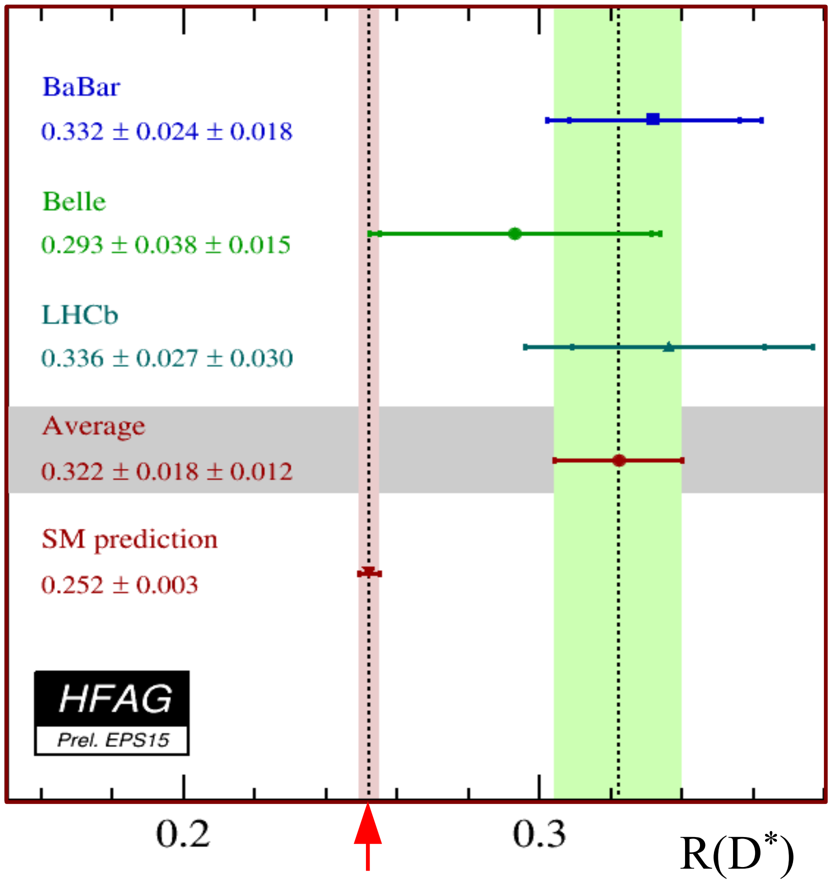
But these uncertainties cancels (to a large extent) in the ratios

LFU tests in b → clν transitions

Exp. status of of Lepton Flavor Universality tests in $b \to c$ transitions
[τ vs. light leptons (μ, e)]:



2015



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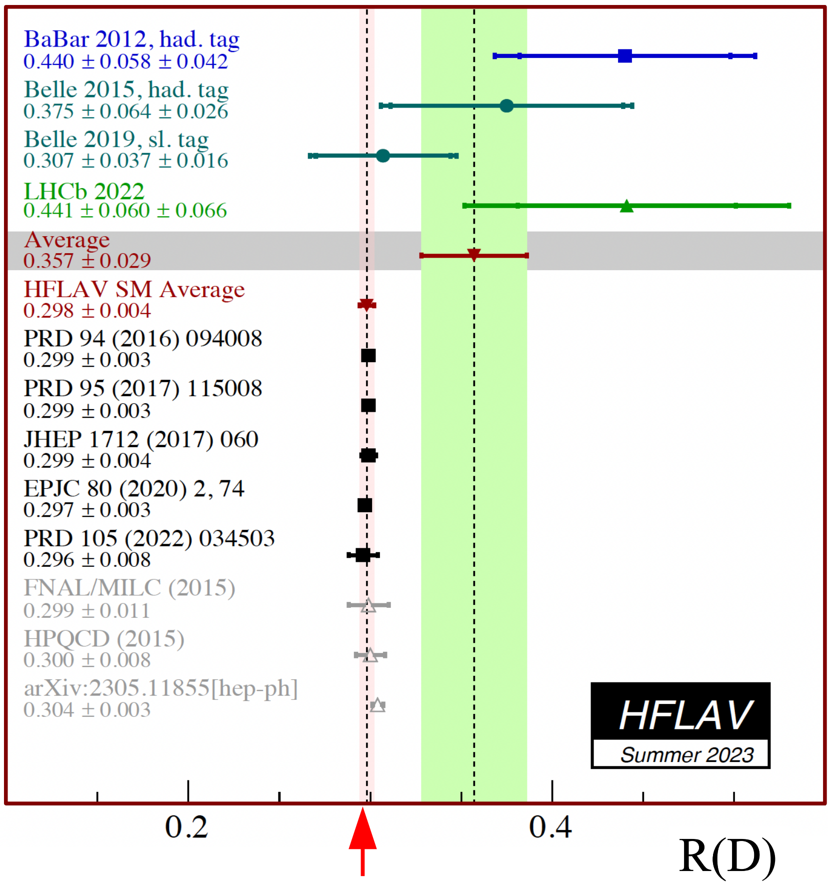
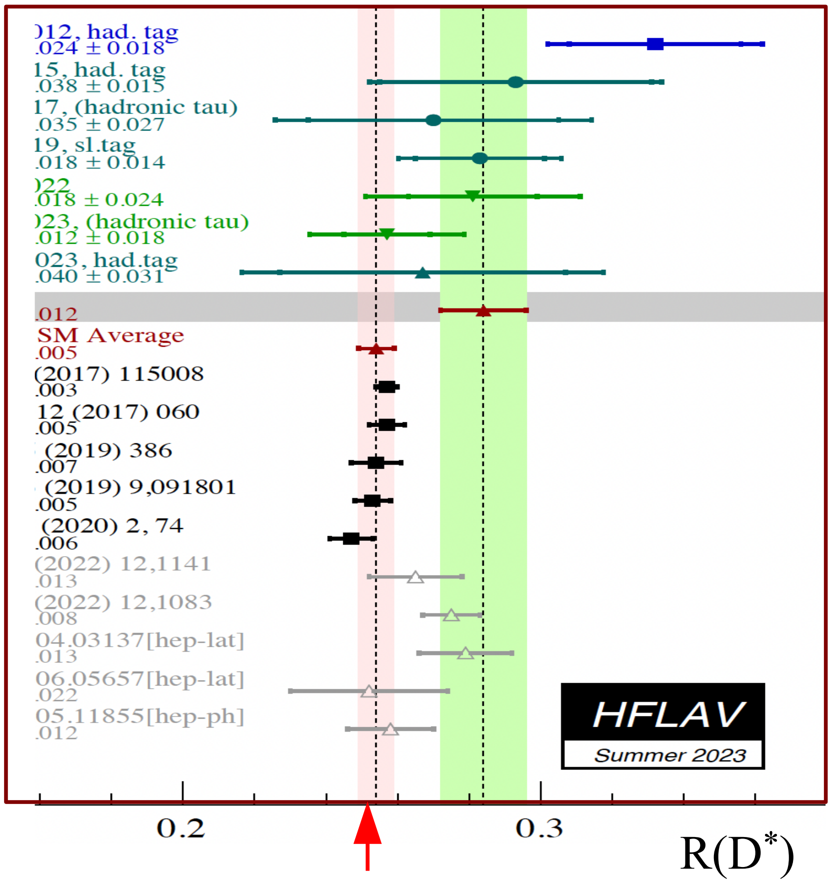


2023

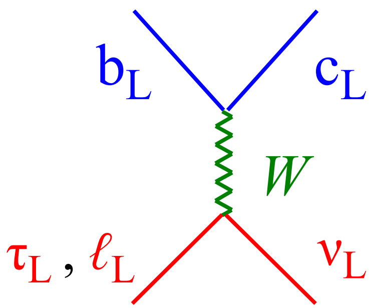


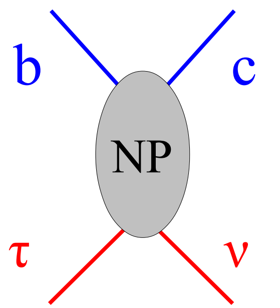
LFU tests in $b \to c l \nu$ transitions

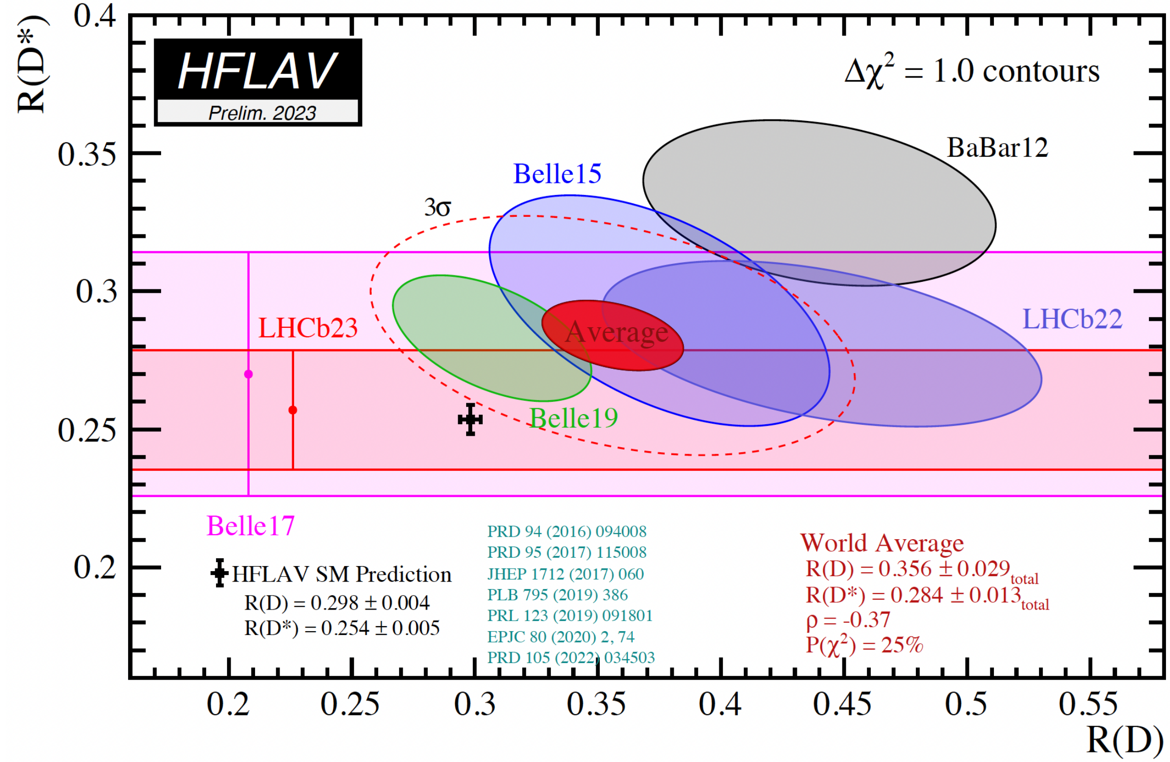
Exp. status of of Lepton Flavor Universality tests in $b \to c$ transitions [τ vs. light leptons (μ, e)]:

$$R(H_c) = \frac{\Gamma(B \to H_c\, \tau\nu)}{\Gamma(B \to H_c\, \ell\nu)}$$

$$H_c = D \text{ or } D^*$$

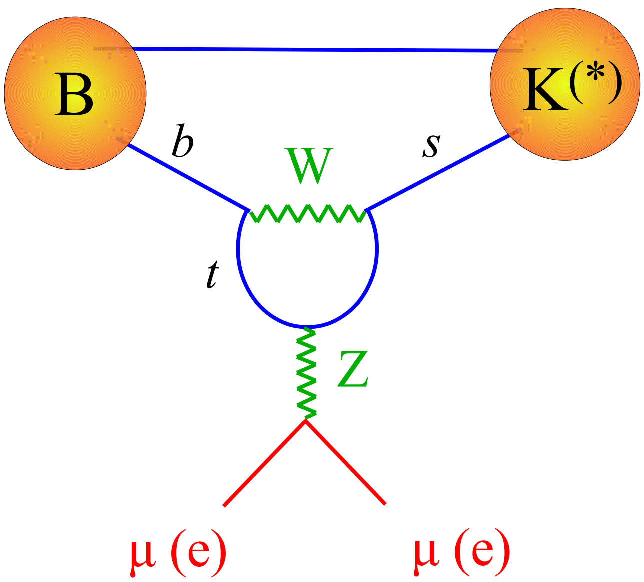






- SM prediction quite solid: hadronic uncertainties cancel (*to large extent*) in the ratio and deviations from 1 in $R(X)$ expected only from phase-space differences
- Consistent results by 3 different exps. $\to$ $\boxed{\sim 3\sigma}$ excess over SM

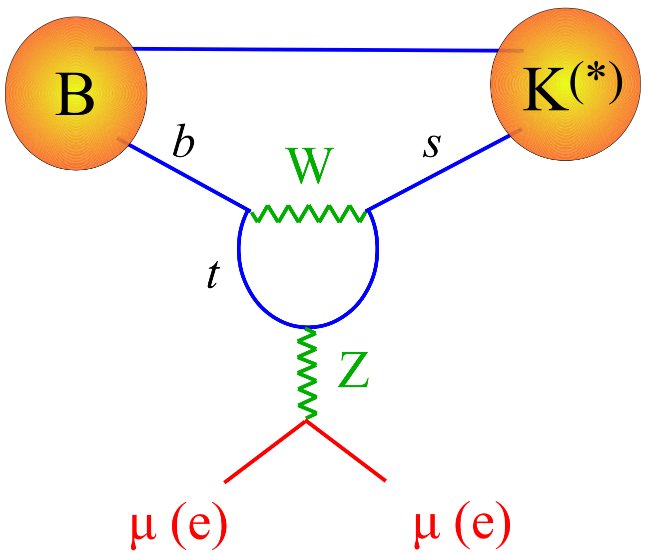
Rare $b \to s\ ll$ *decays*



Rare $b \to s\, ll$ decays

$b \to s\ l^+l^-$ transitions are Flavor Channing Neutral Current amplitudes

- No SM tree-level contribution
- Strong suppression within the SM because of CKM hierarchy
- Hadronic uncertainties more subtle with respect to charged-current decays



The strong suppression within the SM implies a natural high sensitivity to physics beyond the SM.

On the experimental side, having two charged leptons in the final state allows us to access several kinematical distributions (*di-lepton spectra, angular distributions, …*) in both exclusive & inclusive modes.

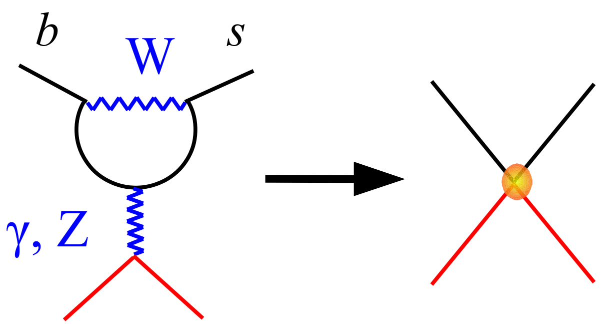
→ lectures by Y. Amhis

On the theoretical, these processes involves different energy scales & necessitate a careful treatment.

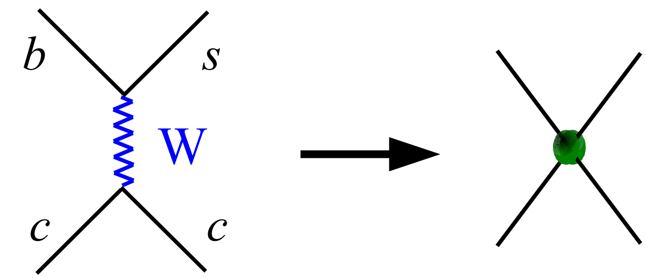
Rare $b \to s\, ll$ decays

In order to describe these processes within the SM (& beyond) we use a 3-step procedure which allows us to separate the different scales involved:

1st step: Construction of an effective Lagrangian at the electroweak scale integrating out all the heavy fields around m_W (including the heavy SM fields)



$$\mathscr{L}_{\rm eff} = \Sigma_{\rm i}\, C_i(M_W)\, Q_i$$



FCNC operators:

$$\mathcal{O}_{10}^{\ell} = (\bar{s}_L \gamma_\mu b_L)(\bar{\ell}\gamma^\mu \gamma_5 \ell) \quad [Z\ \textit{penguin}\ \&\ \textit{box}]$$

$$\mathcal{O}_{9}^{\ell} = (\bar{s}_L \gamma_\mu b_L)(\bar{\ell}\gamma^\mu \ell) \quad [\gamma\ \&\ Z\ \textit{penguin}]$$

$$Q_7 = m_b (\bar{s}_L \sigma^{\mu\nu} b_R) F_{\mu\nu} \quad [\gamma\ \textit{penguin}]$$

Four-quark operators:

$$Q_1^c = (\bar{s}_L \gamma_\mu T^a c_L)(\bar{c}_L \gamma^\mu T^a b_L)$$

$$Q_2^c = (\bar{s}_L \gamma_\mu c_L)(\bar{c}_L \gamma^\mu b_L)$$

$$\vdots$$

- The interesting short-distance info (sensitive to NP) is encoded in the $C_i(M_W)$ (*initial conditions*) of the Wilson coefficients of the FCNC operators (especially C_9 & C_{10})
- In generic extensions of the SM, the basis of FCNC operators can be larger

Rare $b \to s\, ll$ decays

In order to describe these processes within the SM (& beyond) we use a 3-step procedure which allows us to separate the different scales involved:

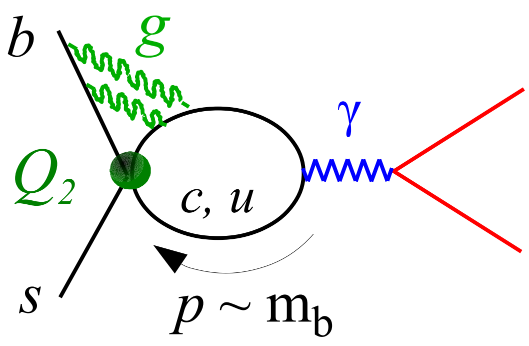
2nd step: Evolution of $\mathcal{L}_{\rm eff}$ down to low scales using RGE

$$\boxed{\mathcal{L}_{\rm eff} = \Sigma_i\, C_i(M_W)\, Q_i} \longrightarrow \boxed{\mathcal{L}_{\rm eff} = \Sigma_i\, C_i(\mu \sim m_b)\, Q_i}$$

Potential dilution of the interesting short-distance information:

Mixing of the four-quark Q_i into the FCNC Q_i [perturbative long-distance contribution]

e.g.:



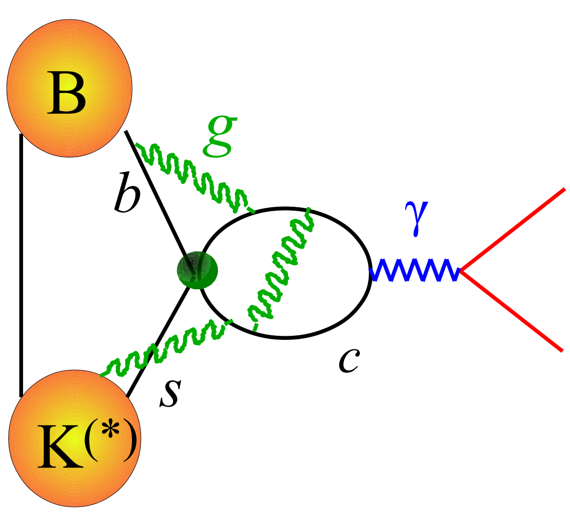
- Small in the case of the Z penguin (Q_{10}) because of the heavy Z mass (top-quark dominance → fully dominated by short distances)
- Large for most other operators; however, the effect can be computed with high accuracy

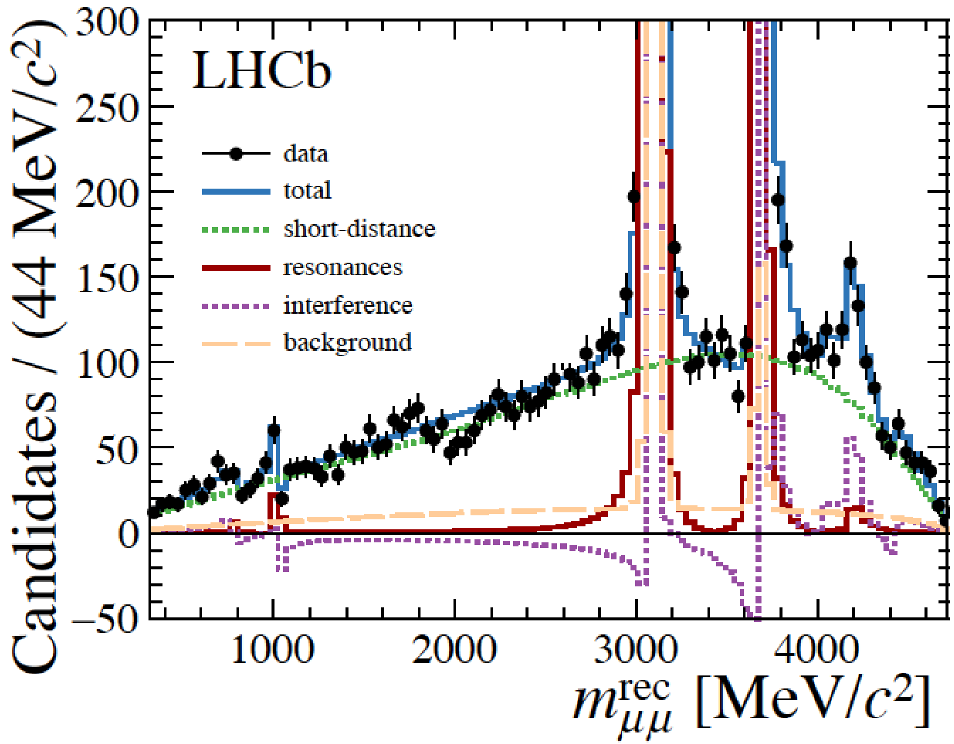
Rare $b \to s\, ll$ decays

3rd step: Evaluation of the hadronic matrix elements

$$A(B \to f) = \Sigma_i\, C_i(\mu)\ \langle f |\, Q_i\, | B \rangle (\mu) \qquad [\ \mu \sim m_b\ ]$$

- Hadronic uncertainty due to form factors (as in all exclusive decays)
- Irreducible th. error due to long-distance effects not included in f.f. (*charm* threshold → particularly large close to $\underline{cc}$ resonances)





Rare b → s ll decays

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Despite the difficulties of estimating precisely long-distance dynamics, there are two properties which are very simple/clean:

- cannot induce LFU breaking terms (→ LFU ratios *"clean"*)
- cannot induce axial-current contributions (→ $B_s \to \mu\mu$ *"clean"*)

Rare $b \to s\, ll$ decays

3rd step: Evaluation of the hadronic matrix elements

$$A(B \to f) = \Sigma_i\, C_i(\mu)\ \langle f |\, Q_i\, | B \rangle (\mu) \qquad [\ \mu \sim m_b\ ]$$

- Hadronic uncertainty due to form factors (as in all exclusive decays)
- Irreducible th. error due to long-distance effects not included in f.f. (*charm* threshold $\to$ particularly large close to $\underline{c}c$ resonances)

Despite the difficulties of estimating precisely long-distance dynamics, there are two properties which are very simple/clean:

- cannot induce LFU breaking terms ($\to$ LFU ratios *"clean"*)
- cannot induce axial-current contributions ($\to$ $B_s \to \mu\mu$ *"clean"*)

For other observables the situation is more complex:

- as a general rule, differential distributions helps to disentangle short- vs. long-distance effects [long-distance "flat" in $q^2 = m_{ll}^2$]
- in the near future, with the help of high-statistics data, we should be able to disentangle "QCD pollution" from short-distance dynamics

▸ *Rare $b \to s\, ll$ decays*

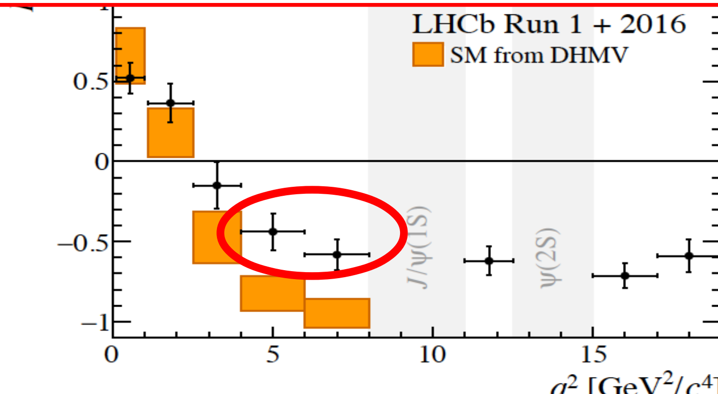
Since about 10 years, data on different modes & different $b \to sll$ observables indicate tensions with respect to the SM predictions.

Most of the effects are well described by a (*lepton-universal*) shift in C_9

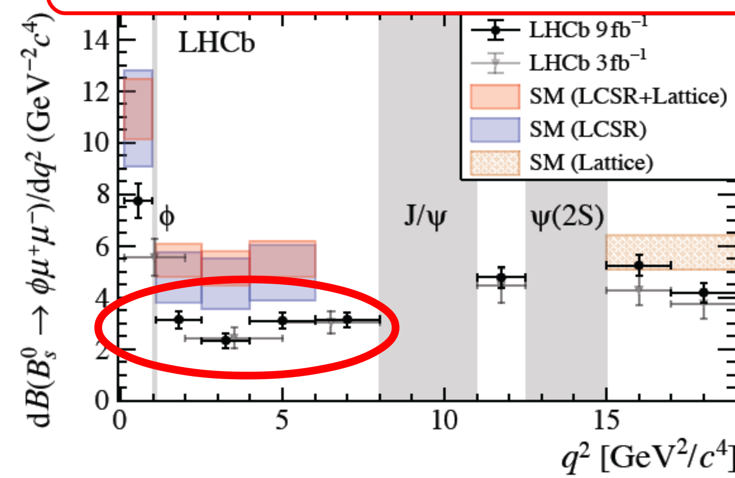
$$\mathcal{O}_9^{\ell} = (\bar{s}_L \gamma_\mu b_L)(\bar{\ell}\gamma^\mu \ell)$$

- Possible contamination from SM long-distance (not favored by the q^2 distrib.)
- Conservative attempts to <u>compute</u> the effect agree on $\boxed{\sim 3\sigma}$ deviation

$B \to K^* \mu\mu$ angular distribution



$B \to H\, \mu\mu$ branching ratios



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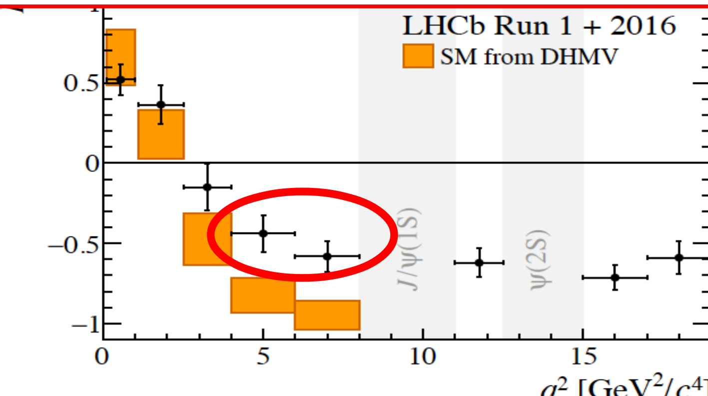

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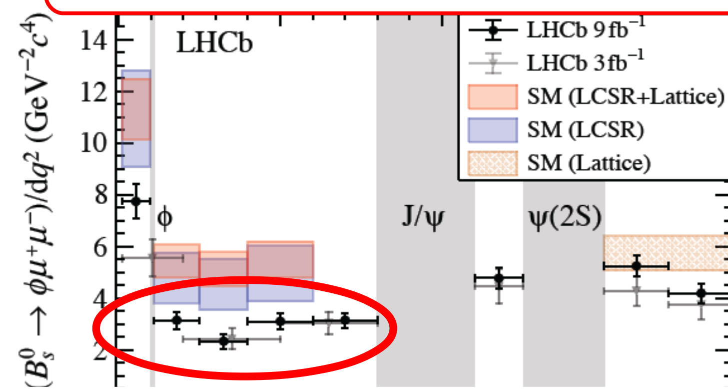
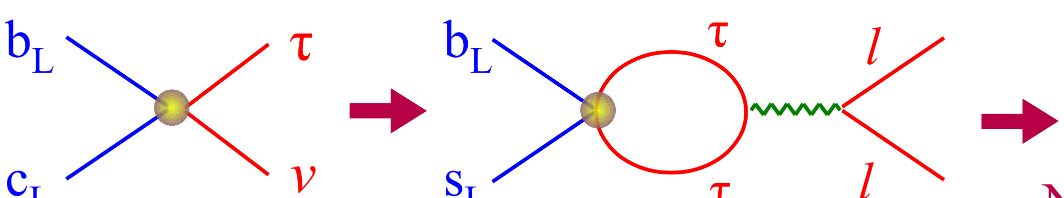


Possible explanation connected to CC (hence 3rd family LFU violation):



$\to \Delta C_9^{\rm Univ}$

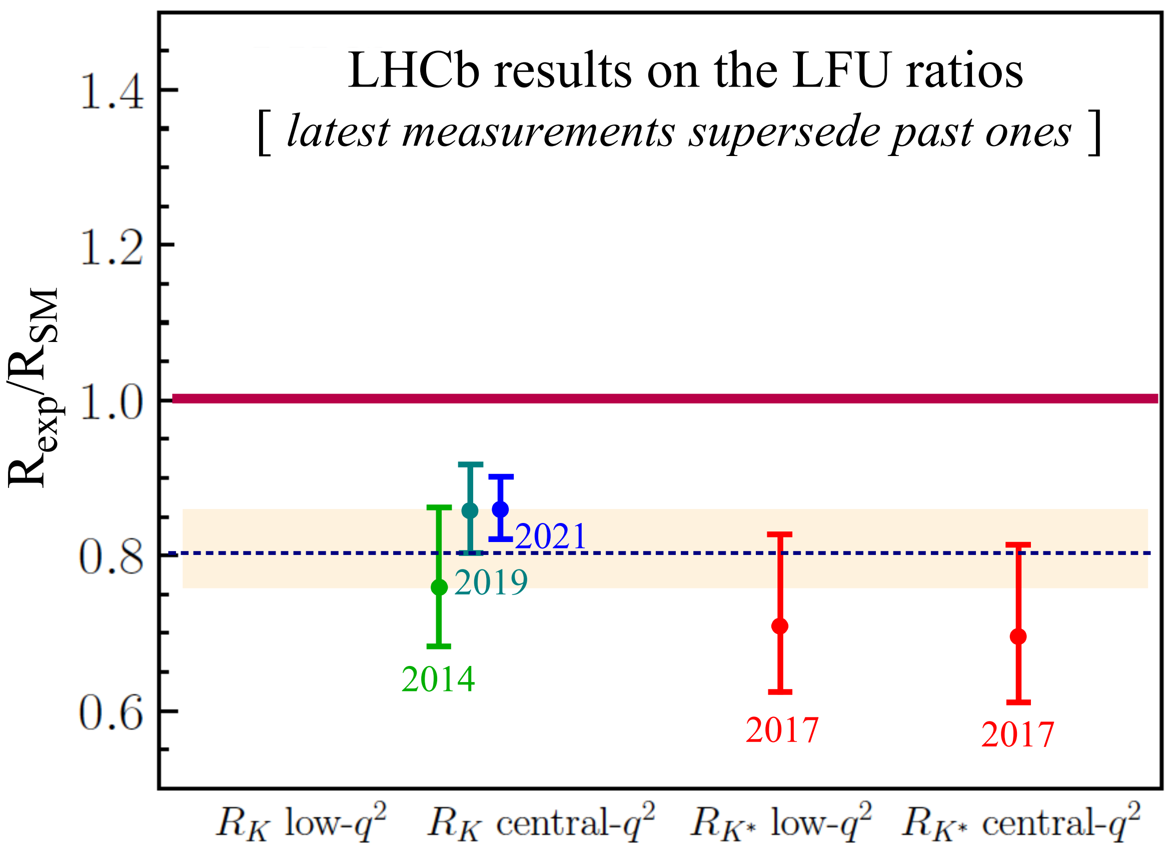
N.B.: correct sign & size !

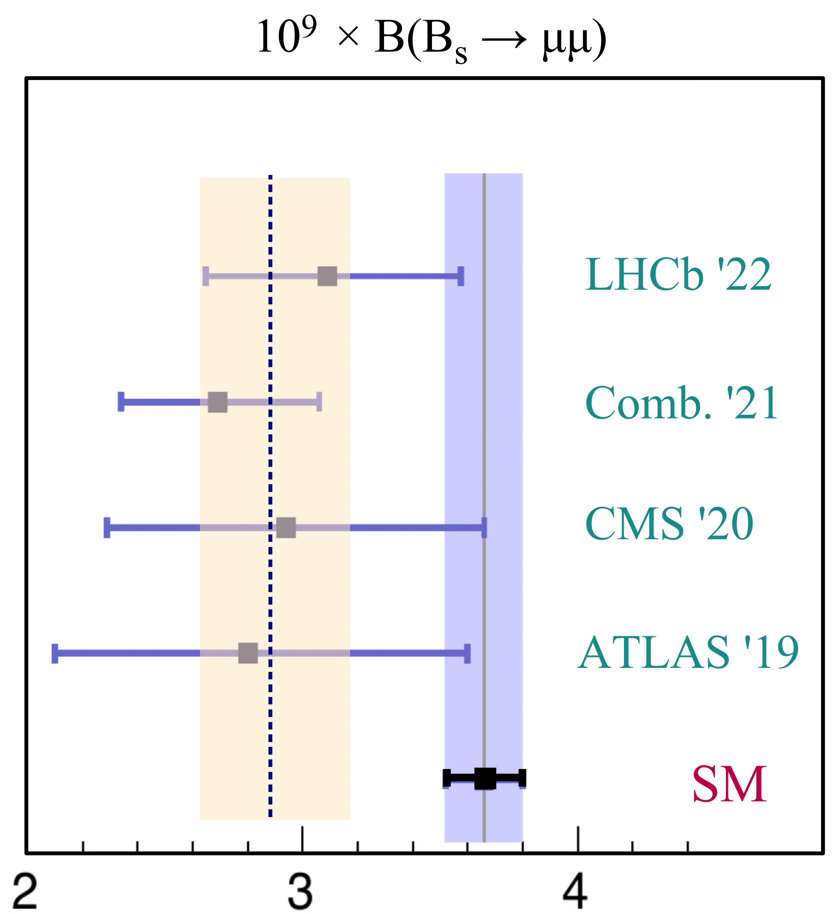
Bobeth & Haisch '11
Crivellin *et al.* '18
Alguero *et al.* '18

Rare $b \to s\, ll$ decays

Till ~ 1 year ago, a tiny but very interesting effect was also observed in the "clean" observables: LFU ratios [μ vs. e] & BR($B_s \to \mu\mu$)

- Both deviations compatible with a single non-universal left-handed operator: $Q_9^{(\mu)} - Q_{10}^{(\mu)}$
- High significance when combined





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- Both deviations compatible with a single non-universal left-handed operator: $Q_9^{(\mu)} - Q_{10}^{(\mu)}$
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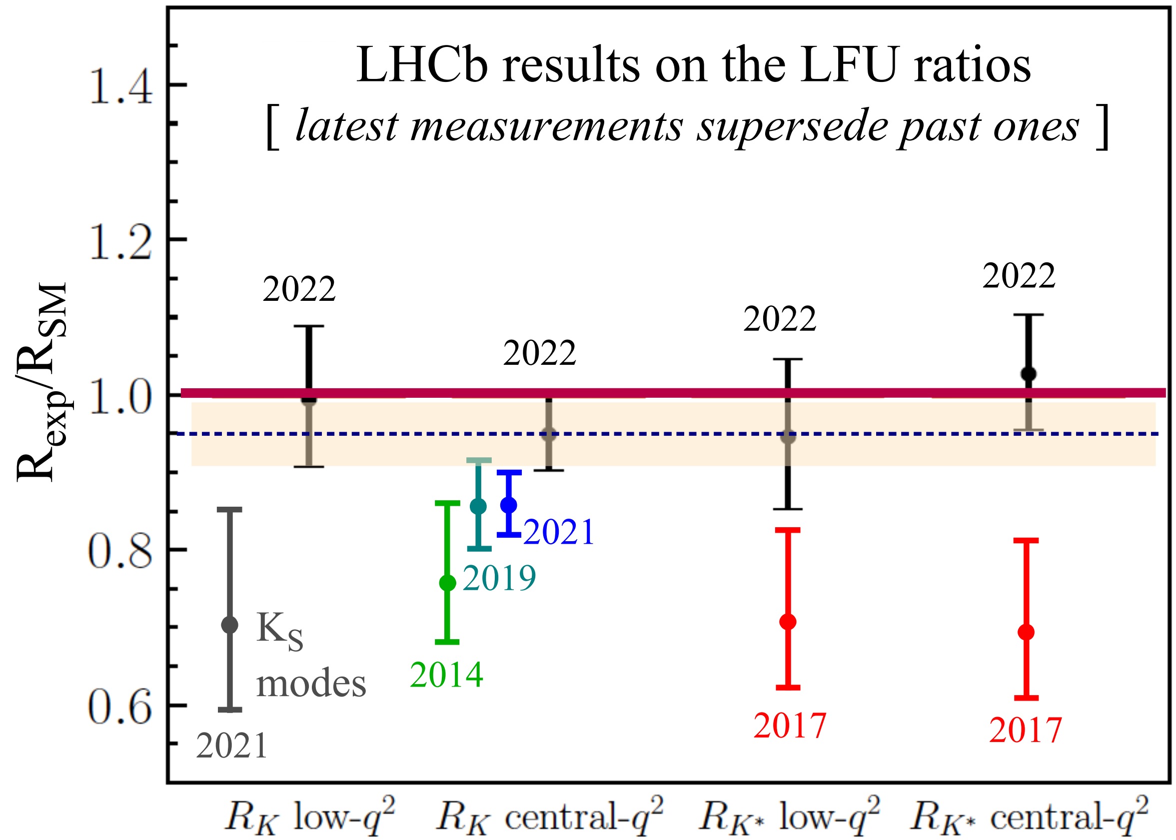
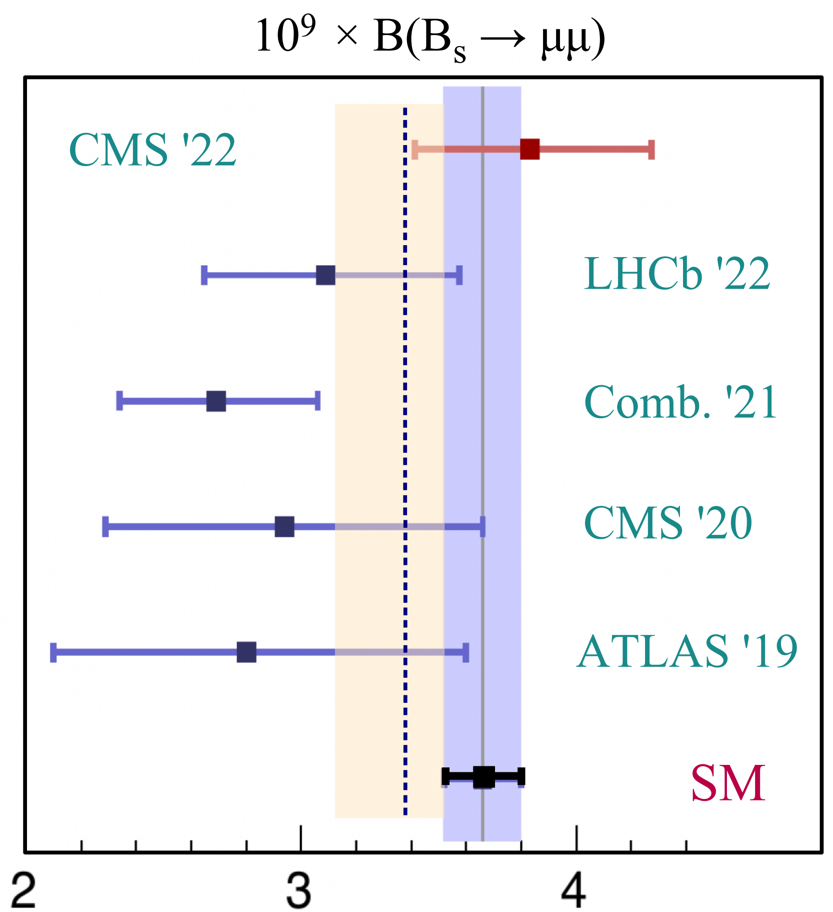
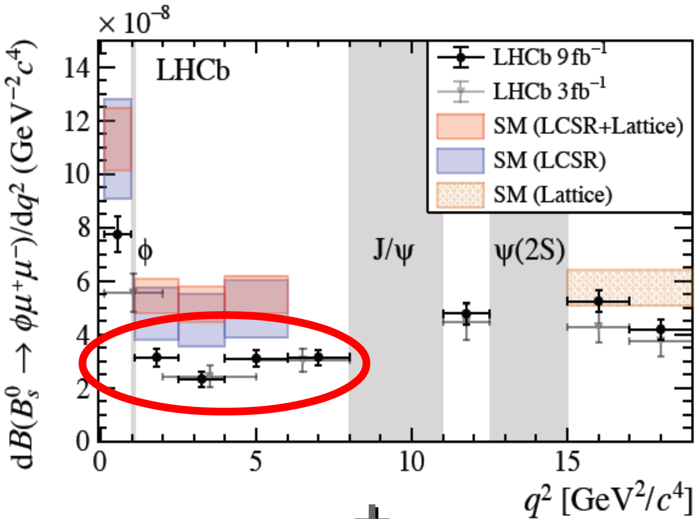
- *high overall significance loss for NP hypotheses*
- *modest implications for NP coupled mainly to 3^{rd} gen.*





Speculations on present data: from EFT to the UV

[*an illustration of how model-building works…*]



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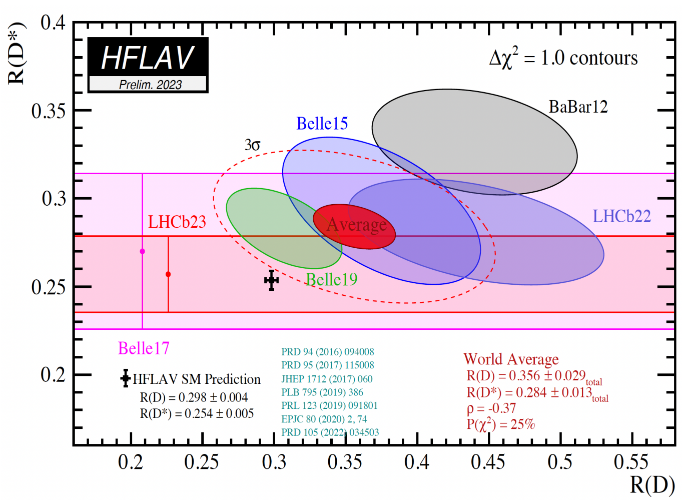
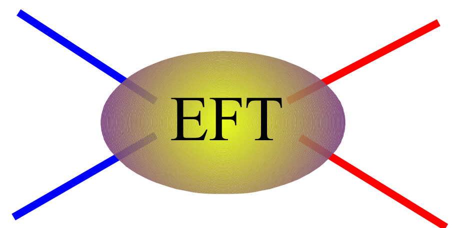
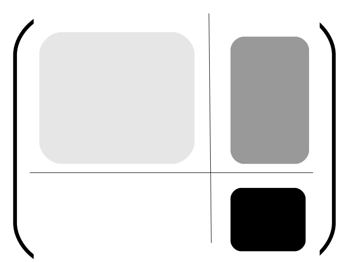
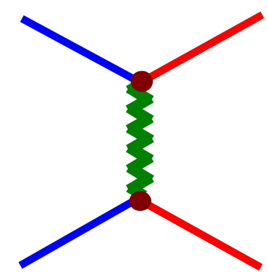


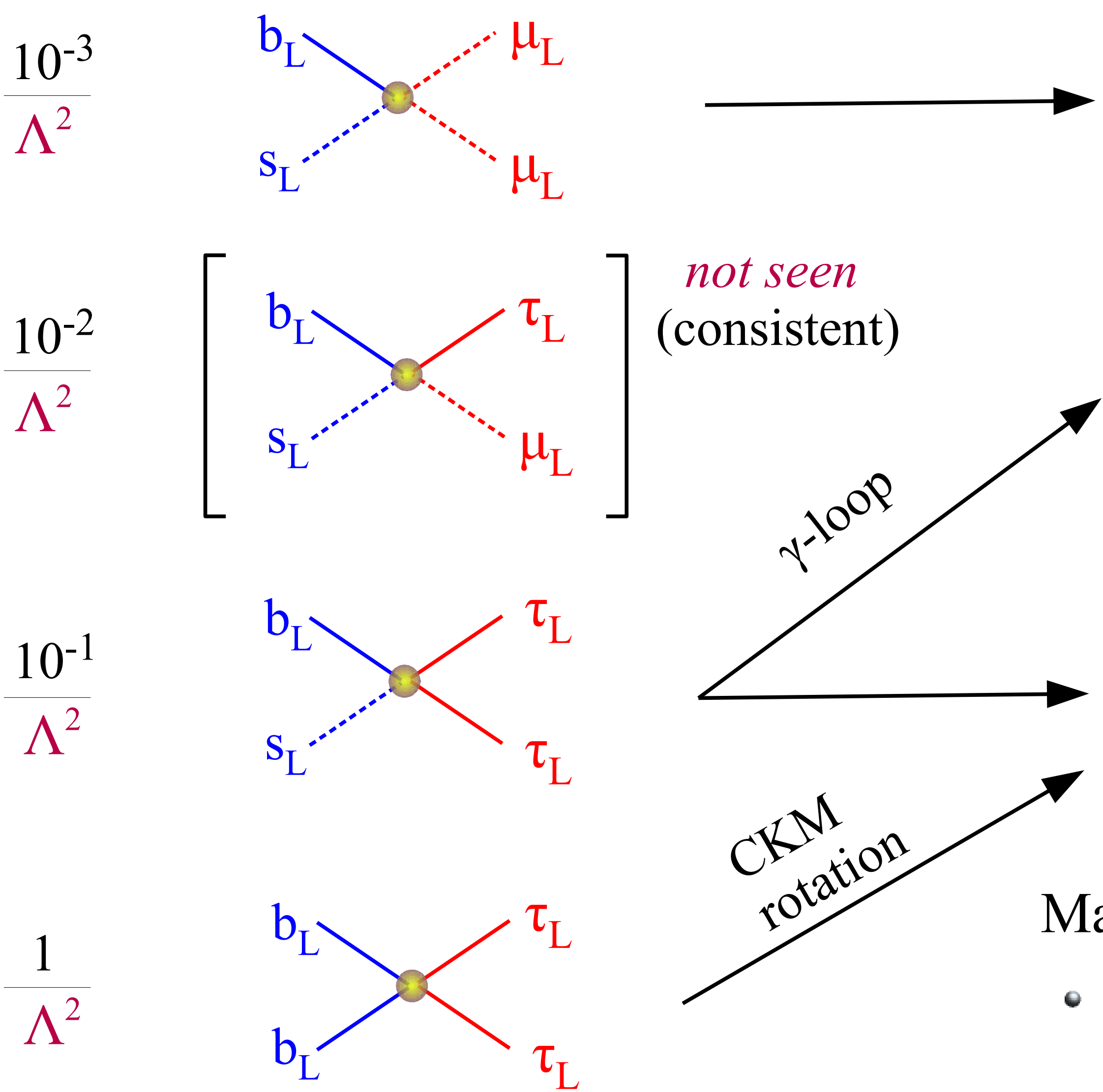


+

$Y_U \sim$ 



Speculations on present data: from EFT...



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

LFU conserv. NP
in $b \to s\, l^+ l^-$ [ΔC_9^{Univ}]

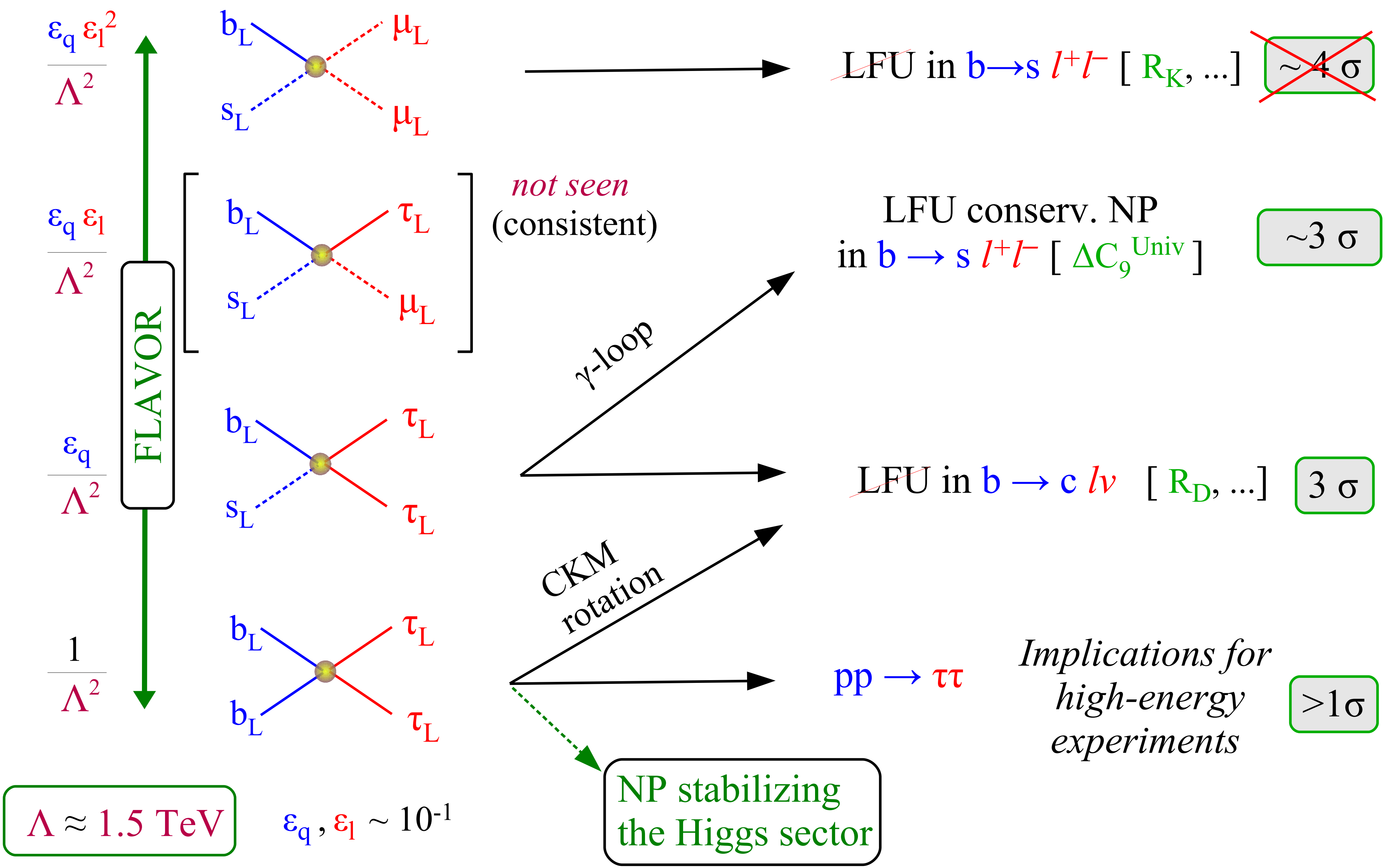
~~LFU~~ in $b \to c\, l\nu$ [R_D, ...]

Main EFT hypotheses:

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

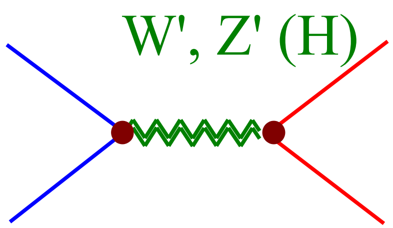
$\Lambda \approx 1.5$ TeV

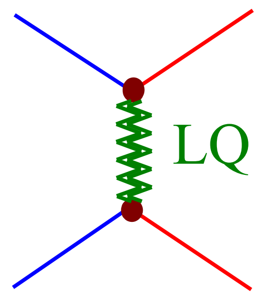
Speculations on present data: from EFT...



Speculations on present data: from EFT to the UV

Which mediators can generate the effective semileptonic operators required by EFT analysis? Not many possibilities...





Leptoquarks (both scalar and vectors) have a strong advantage: only semileptonic operators at the tree-level (*no four-quark operators → strong bounds from meson-antimeson mixing*)

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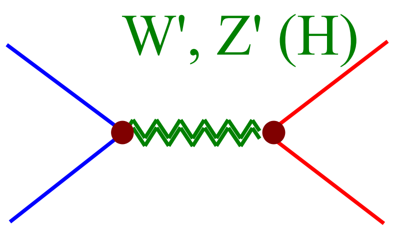
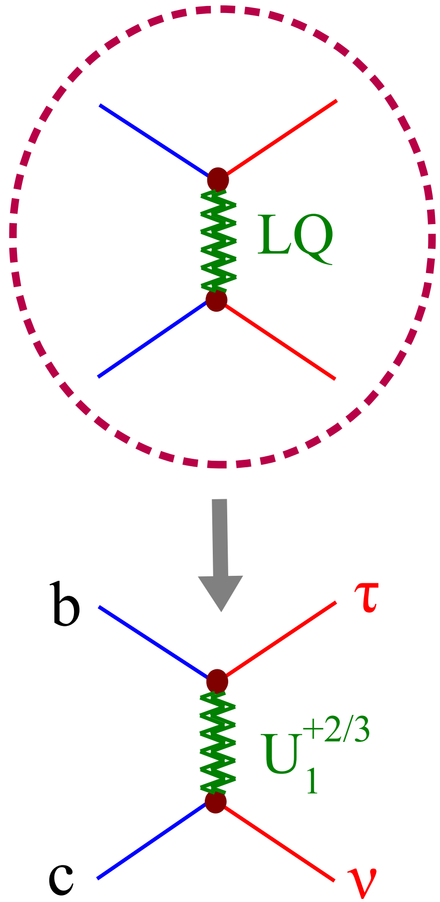




Leptoquarks (both scalar and vectors) have a strong advantage: only semileptonic operators at the tree-level (*no four-quark operators → strong bounds from meson-antimeson mixing*)

Simplest option:

LQ of the Pati-Salam gauge group:

$SU(4)\times SU(2)_L\times SU(2)_R$

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

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

Speculations on present data: from EFT to the UV

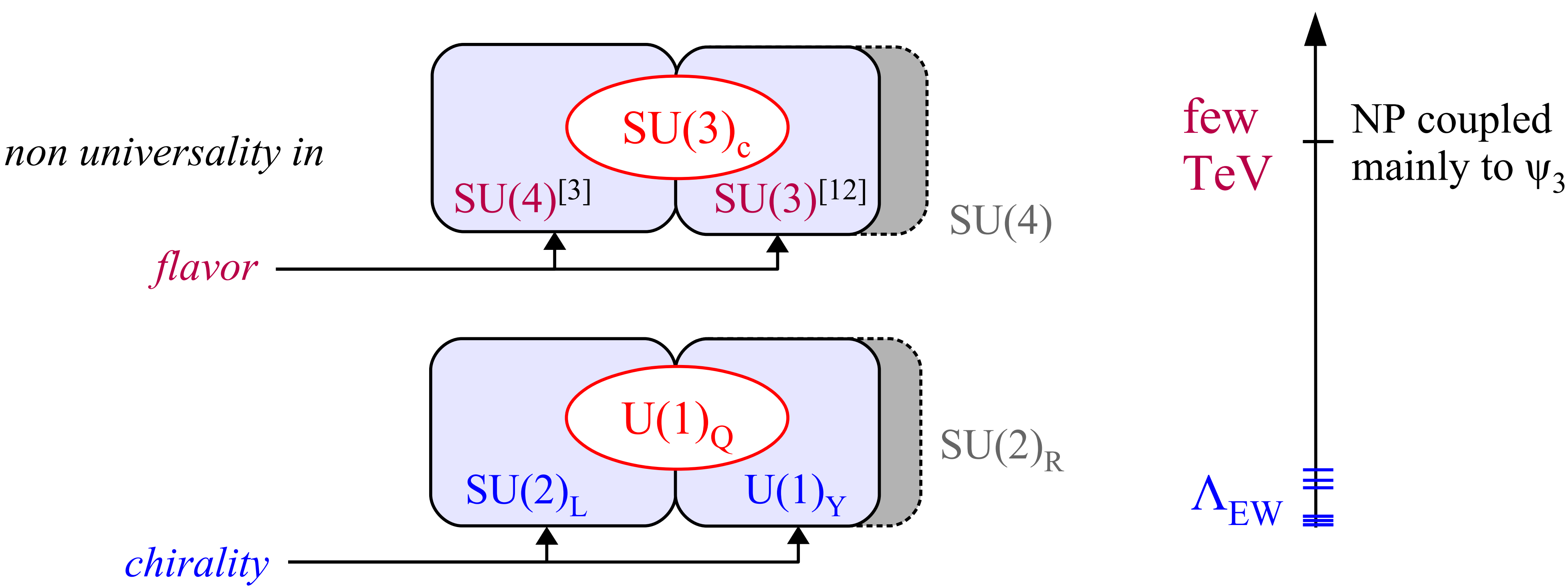
Theory arguments [flavor hierarchies, charge quantization] $\longrightarrow$ $SU(4)^{[3]} \times SU(3)^{[12]} \times SU(2)_L \times U(1)'$

$\downarrow$

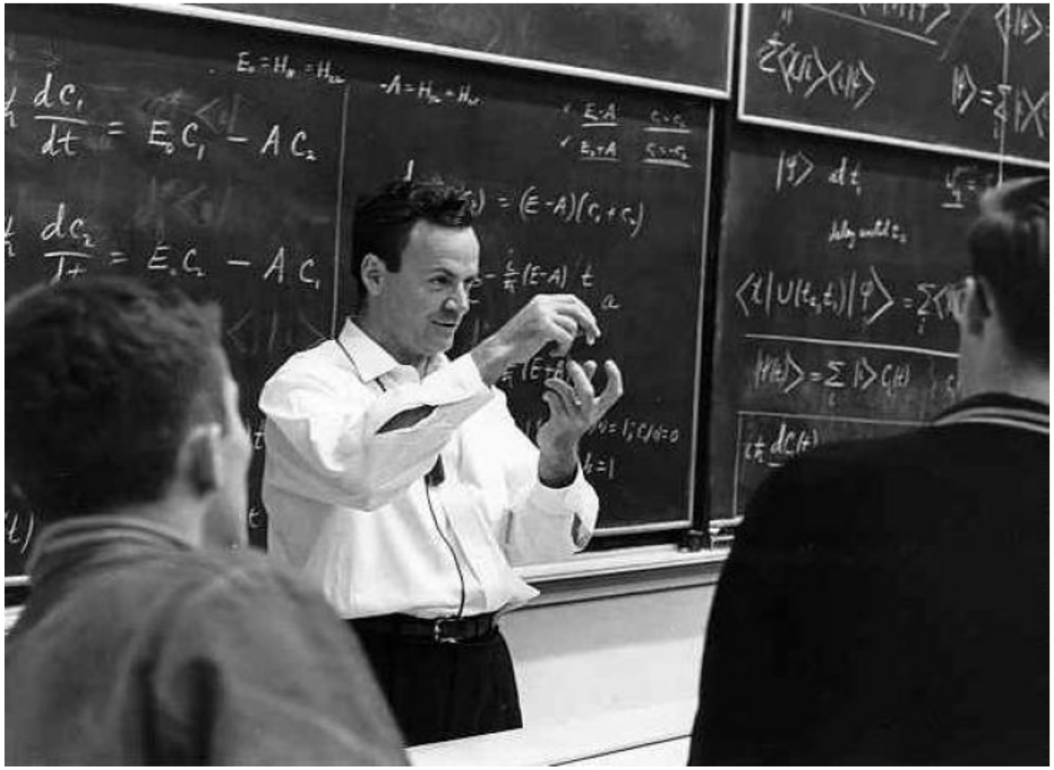
$SU(3) \times SU(2)_L \times U(1)_Y$

U_1

B-physics "anomalies"



Implications & future prospects



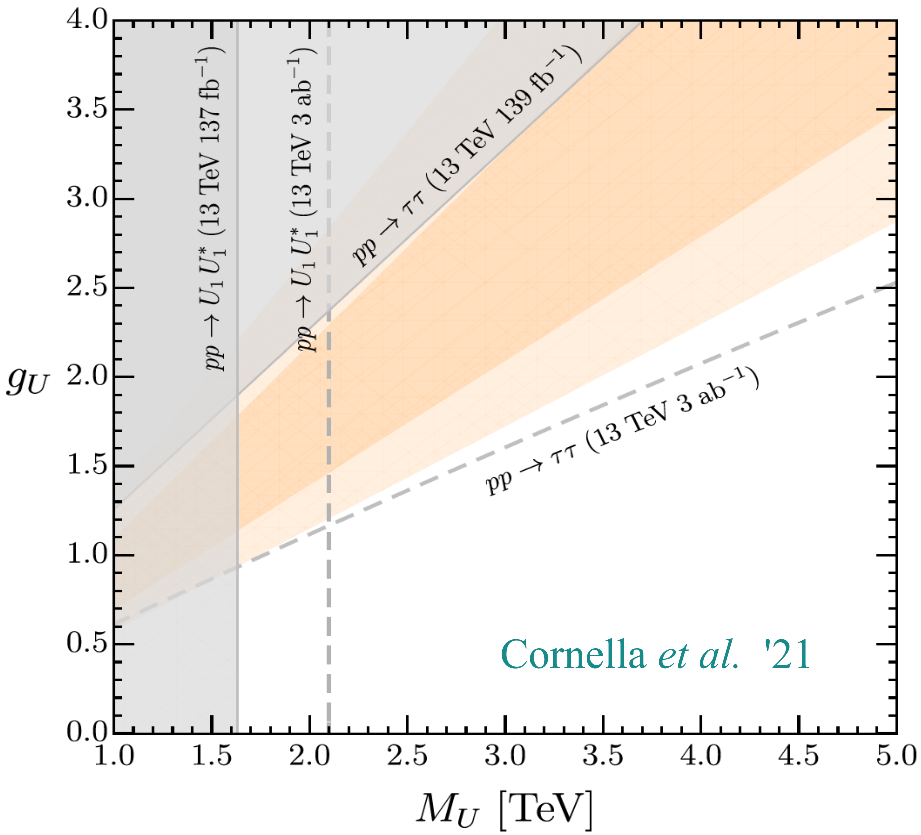
"It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong." [Feynman]

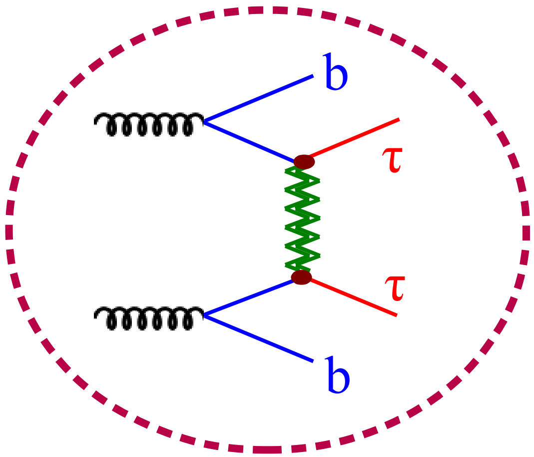
▶ *Implications & future prospects*

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

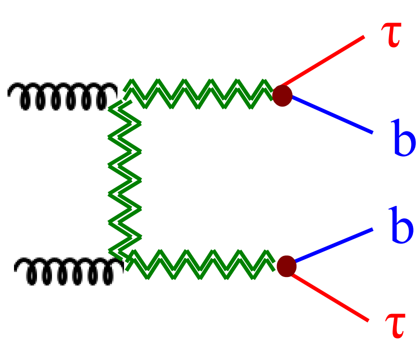
I The U_1 exchange @ high-energies
[very general, directly connected to the EFT analysis]

pp ⟶ ττ





Faroughi, Greljo, Kamenik '16

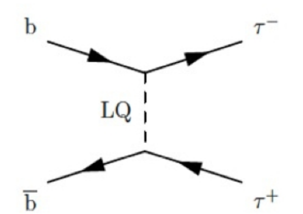


Implications & future prospects

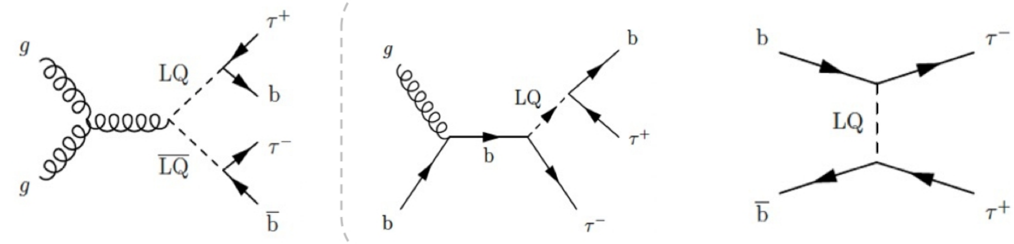
Aurelio Juste [*Moriond EW* '23]

LQ-b-τ: Comparison of recent results

Including interference w/ SM bkg

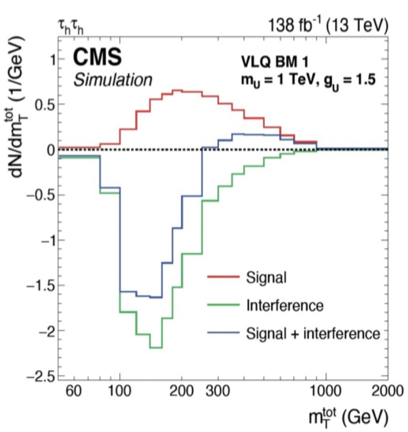


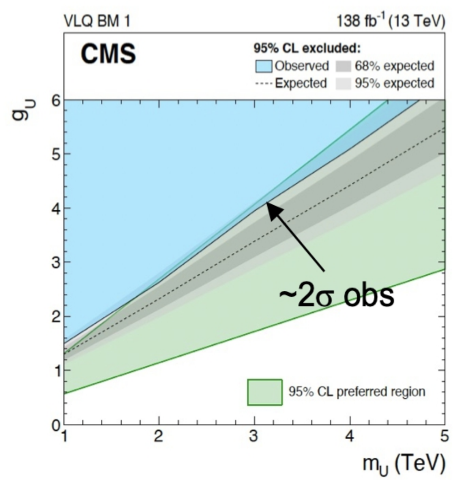
Neglecting interference w/ SM bkg



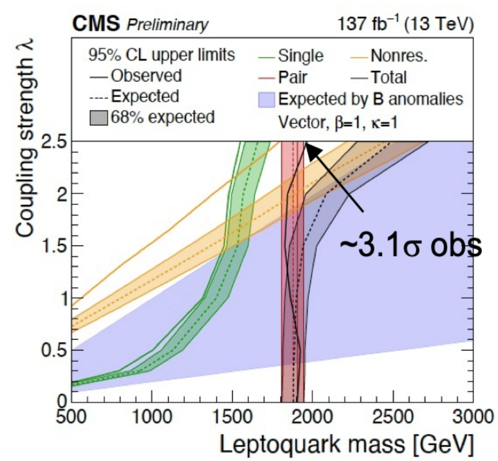
Caveat: BR=1 (CMS) vs BR=0.5 (ATLAS)

CMS-HIG-21-001

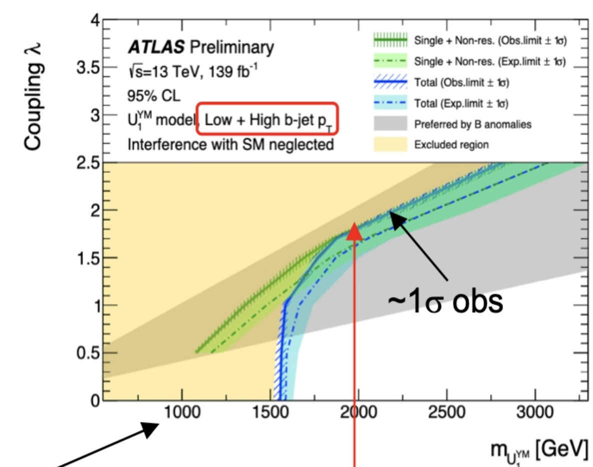




CMS-PAS-EXO-19-016



EXOT-2022-39



Shown at Moriond EW 2022

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

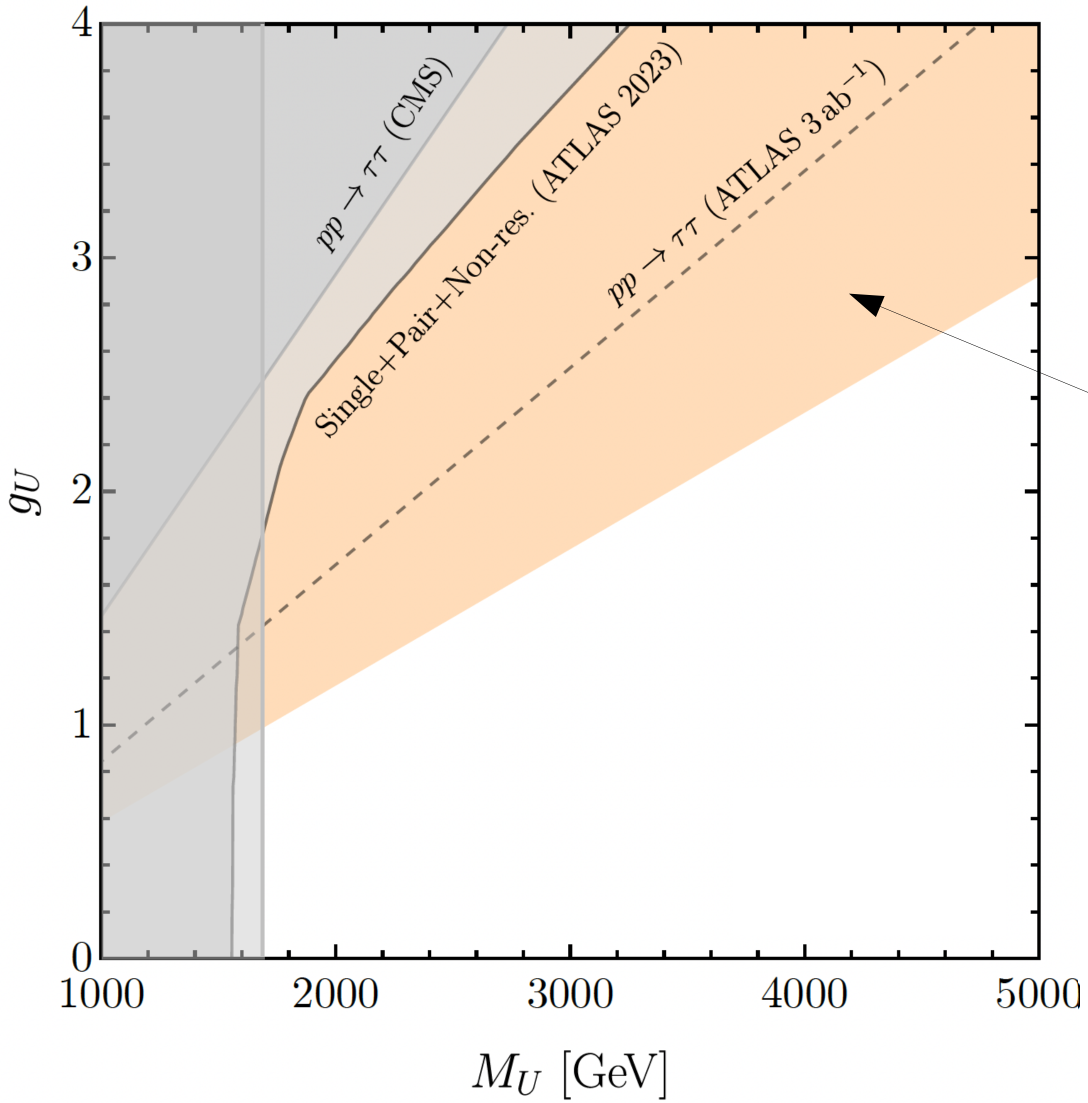
Excludes CMS' excess

Need to clarify interference issue for future interpretations

Implications & future prospects

I The U_1 exchange @ high-energies

[very general, directly connected to the EFT analysis]

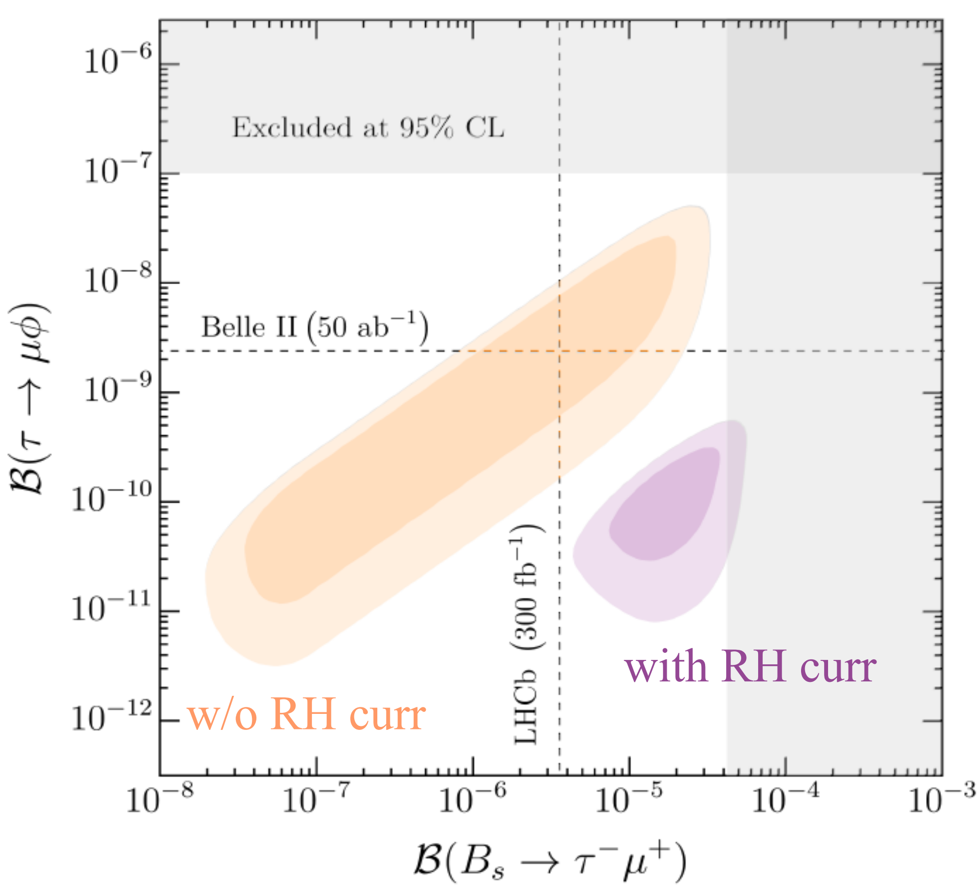


Updated preferred region by b → c low-energy data

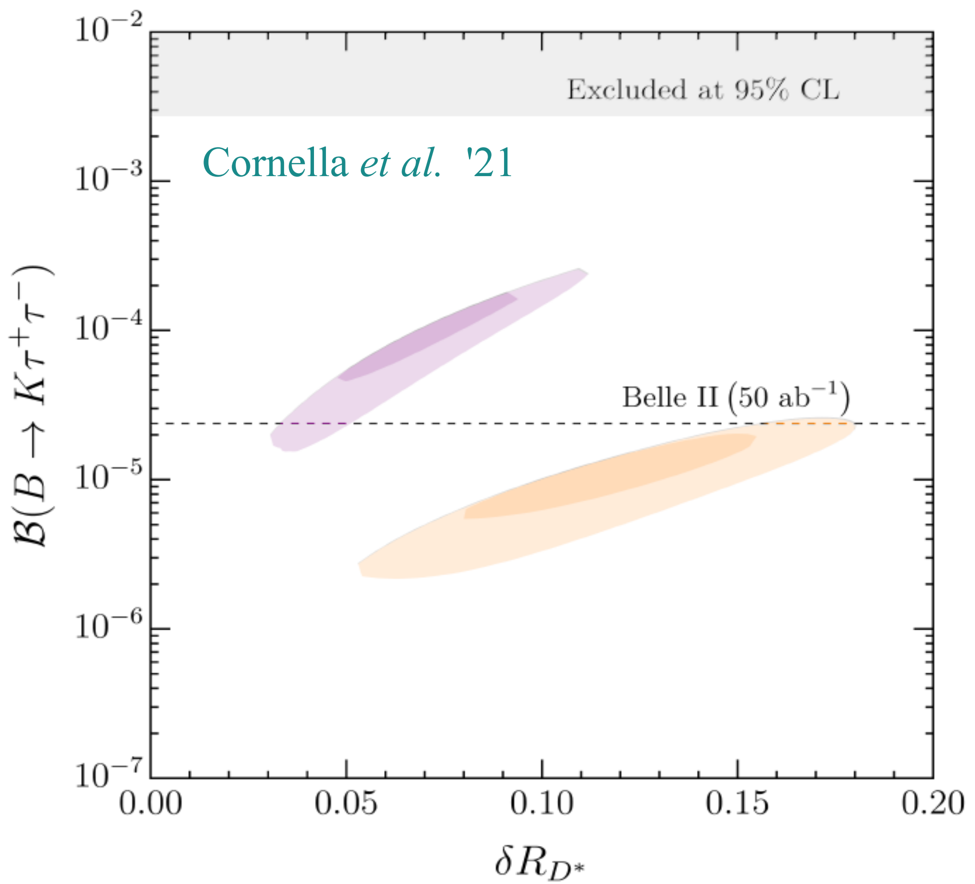
Implications & future prospects

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)

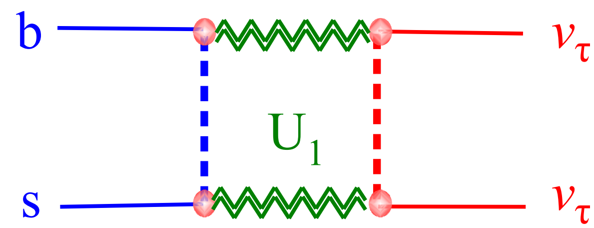


largely enhanced $b \to s\tau\tau$ rates
(in all channels)



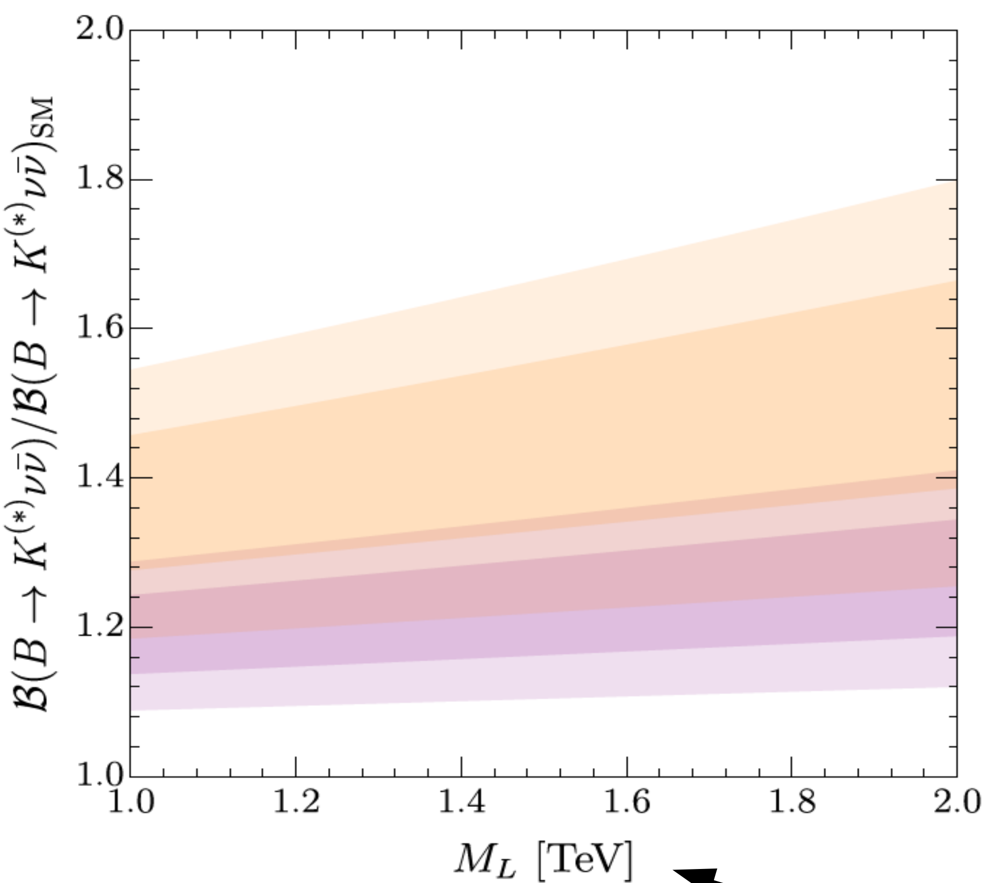
▶ *Implications & future prospects*

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



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

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



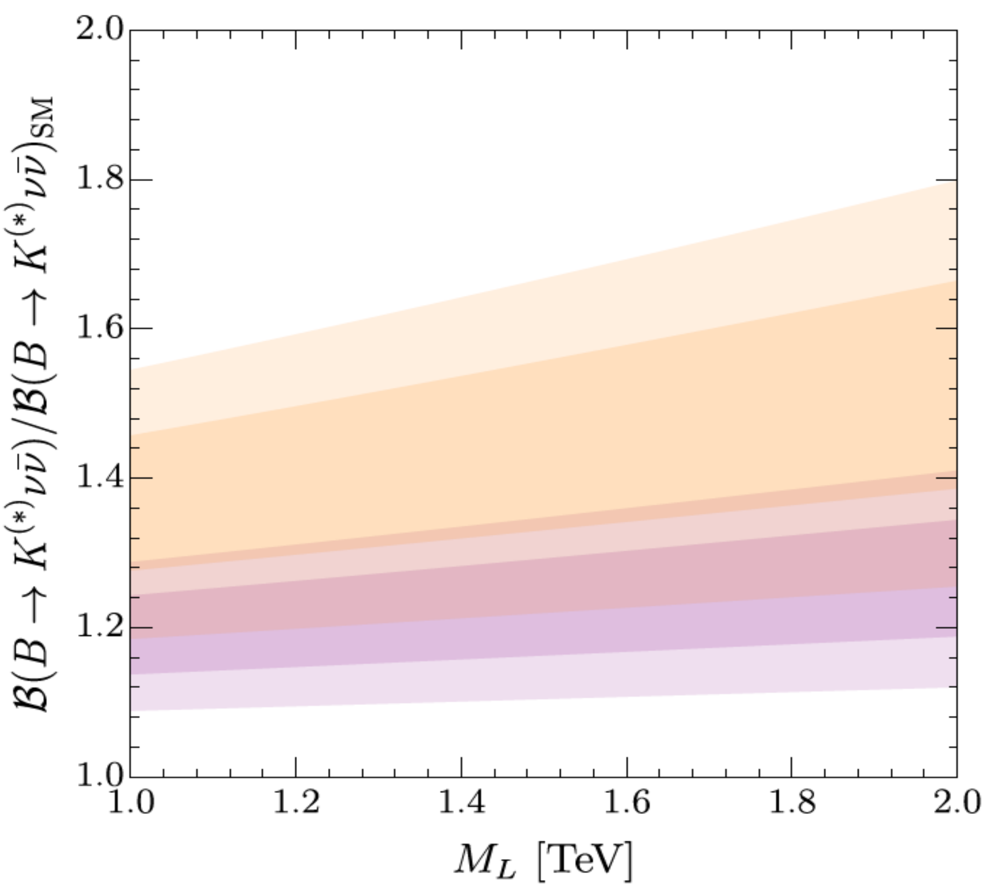
Mass of new heavy (vector-like) fermions which are necessary ingredients of the model

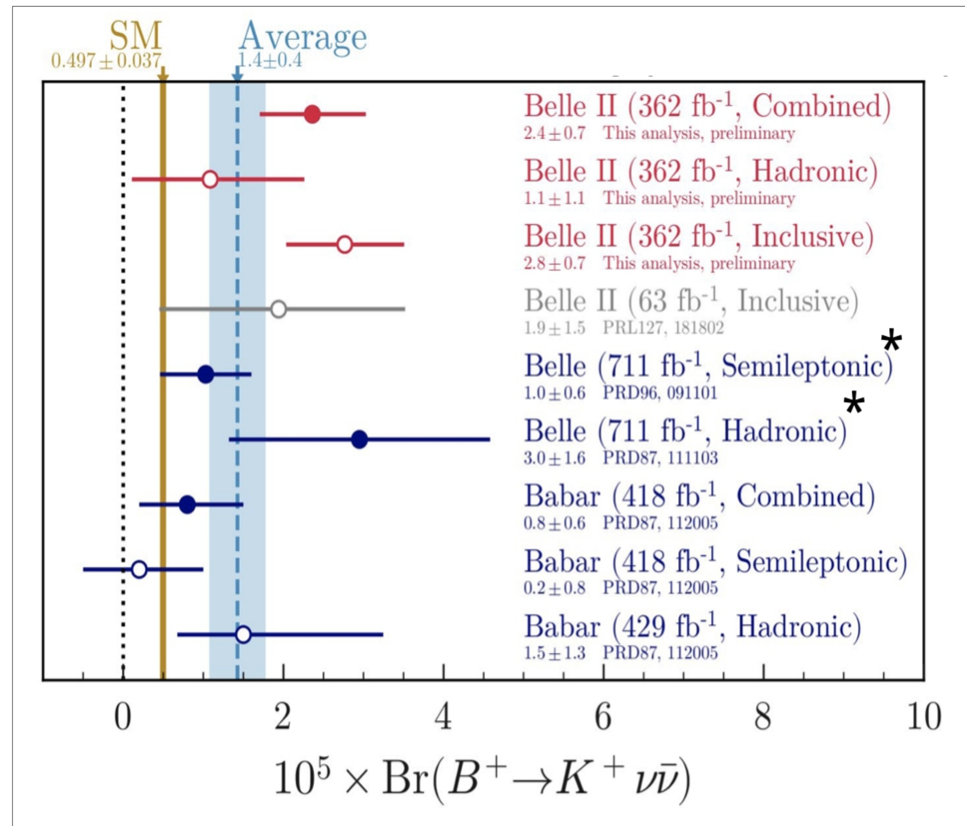
Implications & future prospects

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

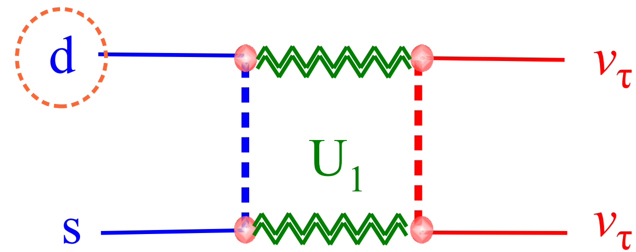


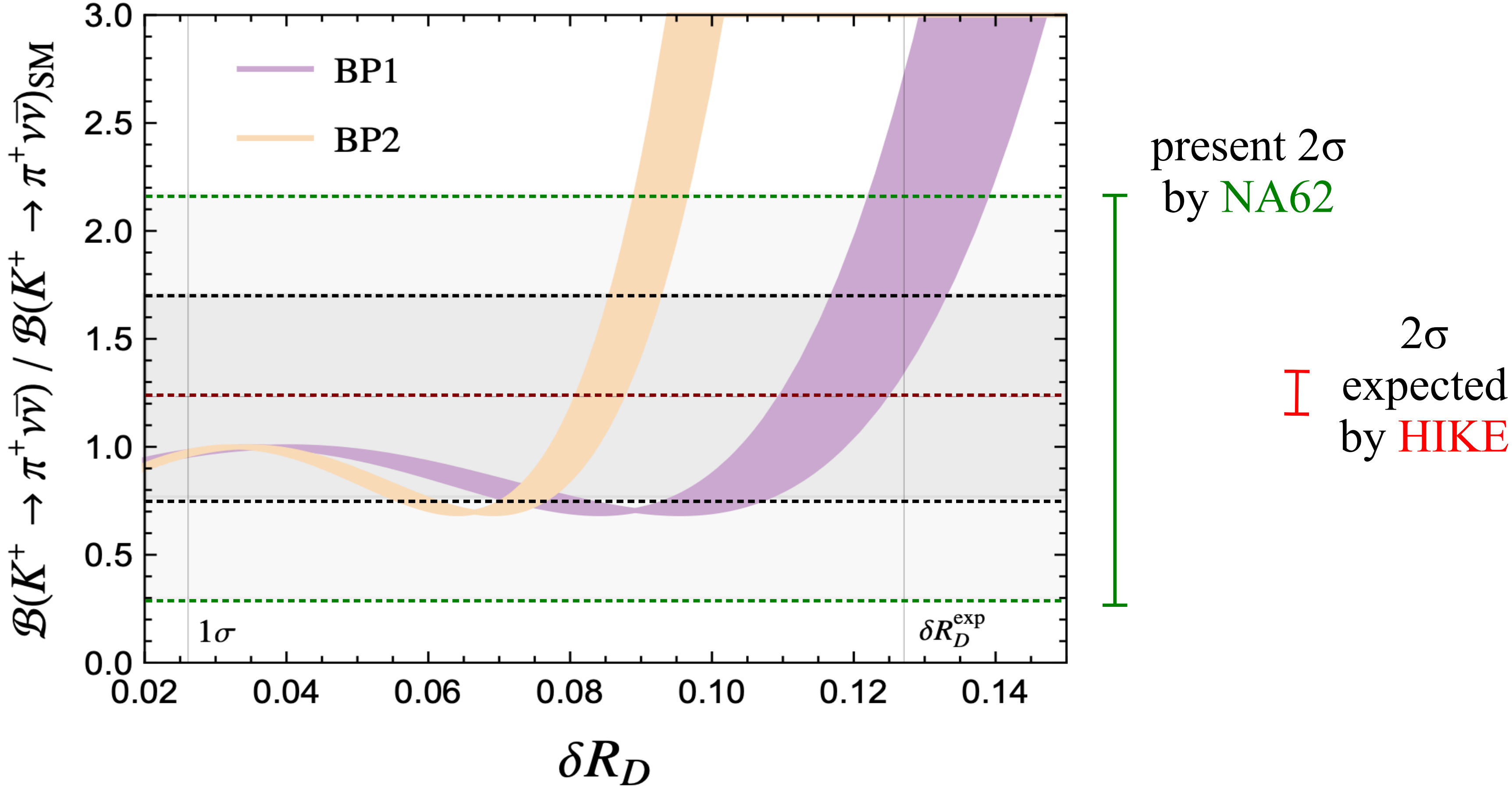


Evidence for $B^+ \to K^+ \nu\bar{\nu}$ decay with a branching fraction 2.8σ above the standard model

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