Heavy Flavors at High pT, Edinburgh

Dec 1, 2023

B decays meet high-mass Drell-Yan

(and other correlations in the flavorful SMEFT and beyond)

Aleks Smolkovic

University of Basel

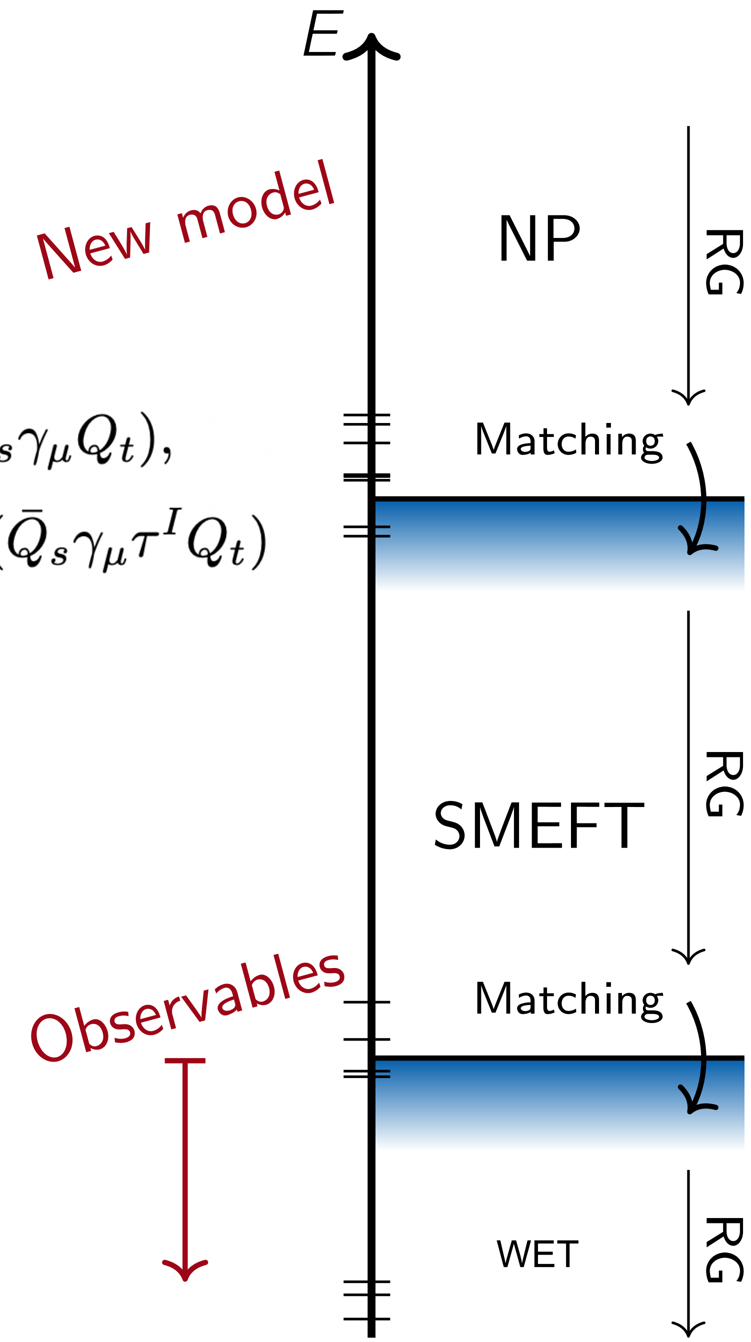
SMEFT

$$\mathscr{L} = \mathscr{L}_{\mathrm{SM}} + \sum_Q \frac{C_Q}{\Lambda_Q^{[Q]-4}} Q$$

Solid QFT principles

- SM fields and symmetries
- Scale separation
- Higher-dimensional operators encode generic short-distance physics

$$Q_{lq}^{(1)} = (\bar{L}_p \gamma^\mu L_r)(\bar{Q}_s \gamma_\mu Q_t),$$
$$Q_{lq}^{(3)} = (\bar{L}_p \gamma^\mu \tau^I L_r)(\bar{Q}_s \gamma_\mu \tau^I Q_t)$$
$$\cdots$$

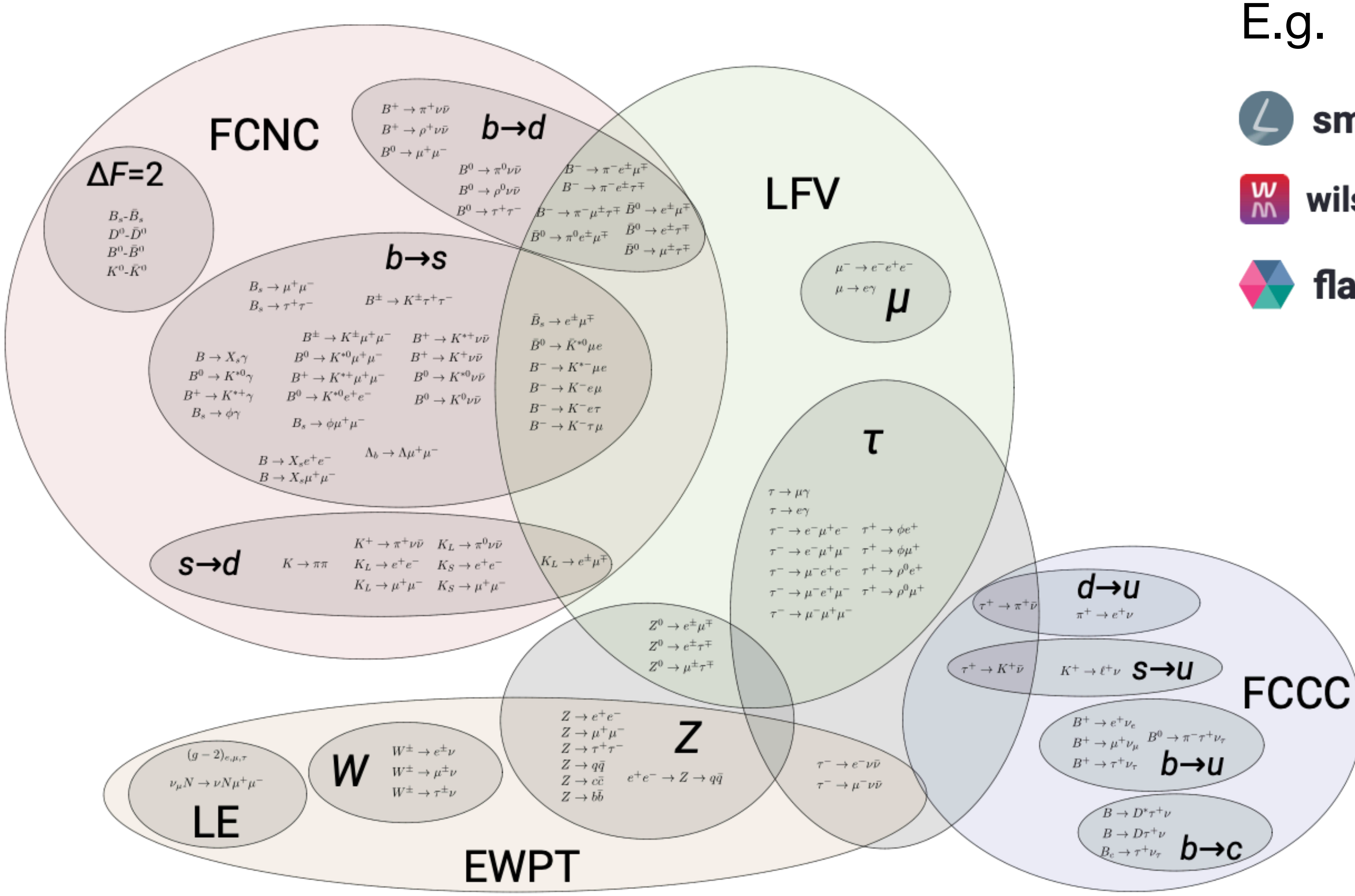


Attractive because of current state of affairs

- No preferred BSM model-building direction
- SM works well as a low-energy limit
- Experiments headed towards the precision era

Challenge:
Large number of parameters (2499 for 3 gen, flavor!)
SMEFT operators will impact observables from vastly different classes

Towards a global SMEFT likelihood



[not up to date]

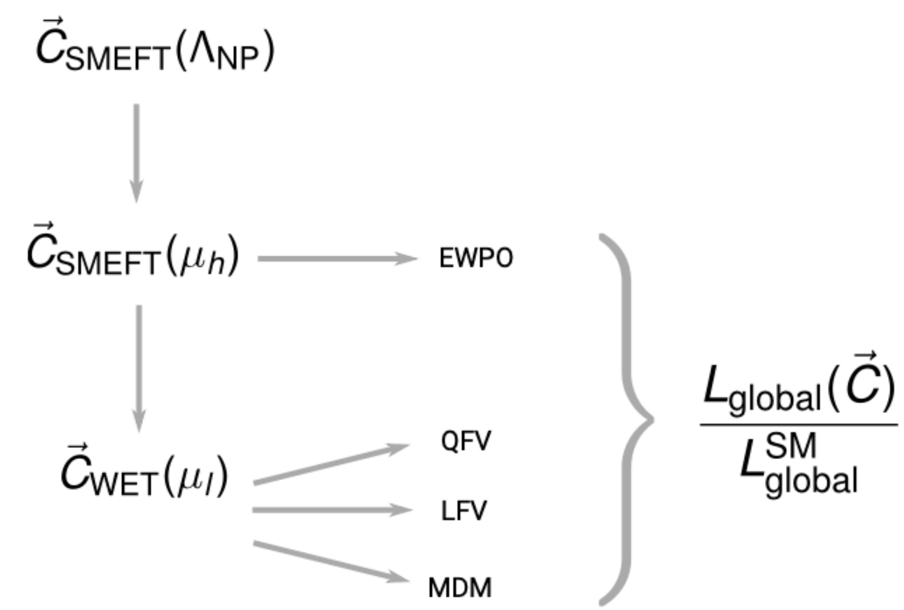
E.g.

smelli Aebischer, Kumar, Stangl, Straub, 1810.07698

wilson Aebischer, Kumar, Straub, 1804.05033

flavio Straub, 1810.08132

Also: `HEPfit`, SMEFiT, EOS, …

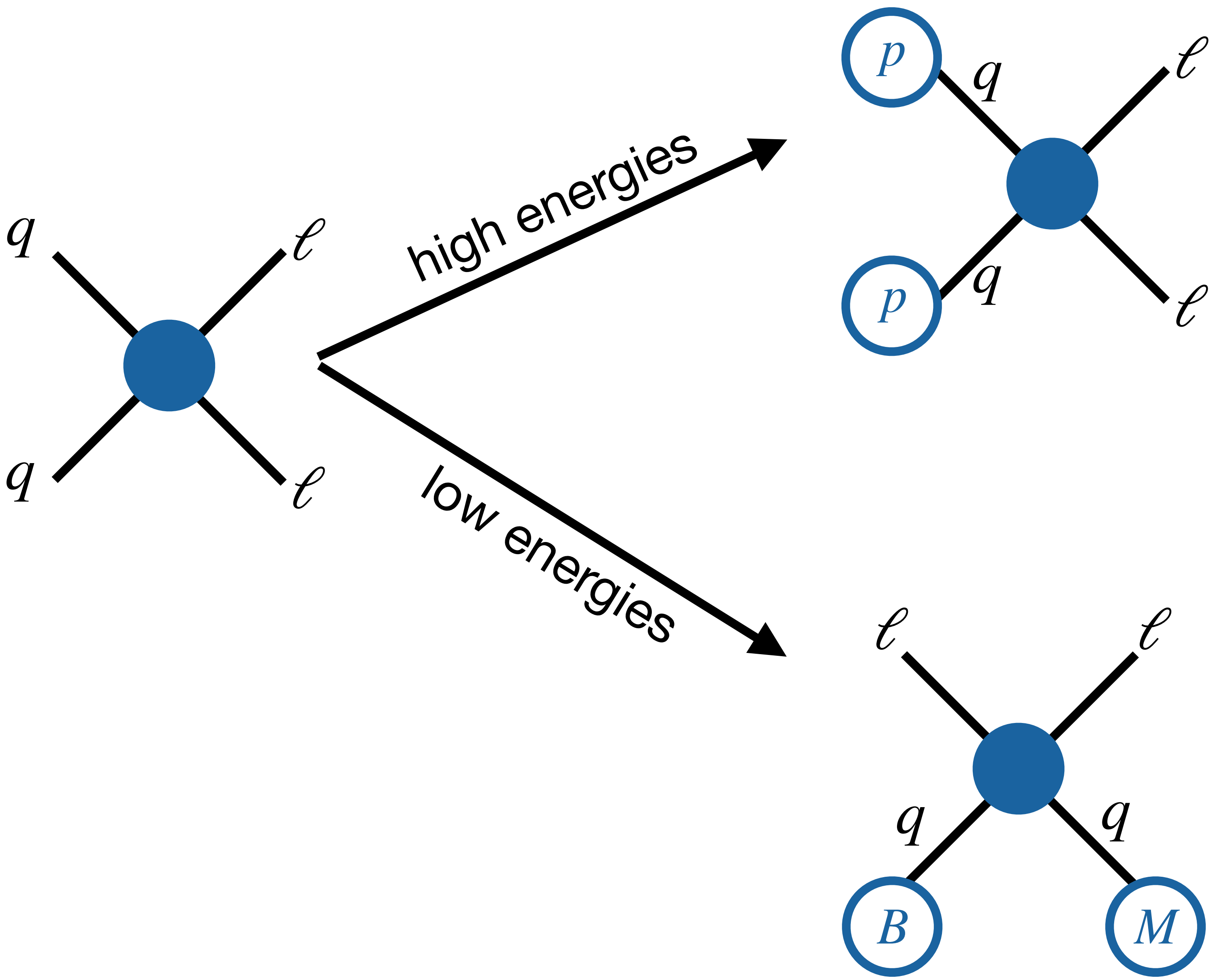


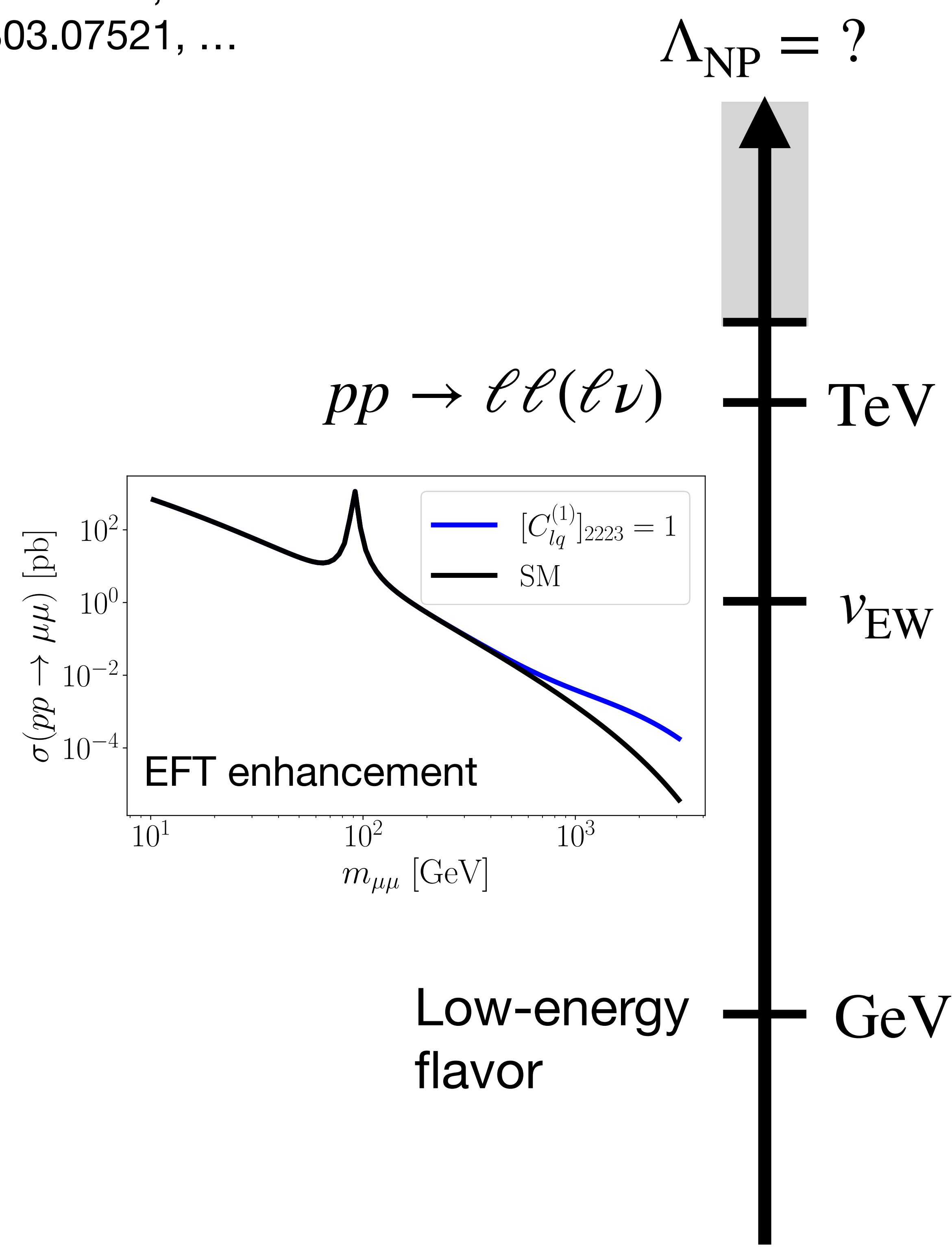
Crucially relies on RGE&matching computations
1308.2627, 1310.4838, 1312.2014, 1709.04486, 1908.05295, …

Example interplay in SMEFT

Low-energy meson decays vs high-mass Drell-Yan

1210.4553, 1605.07114, 1609.07138, 1704.09015, 1806.02370, 1809.01161, 1811.07920, 2002.05684, 2003.12421, 2008.07541, 2207.10714, 2303.07521, ...





In this talk:

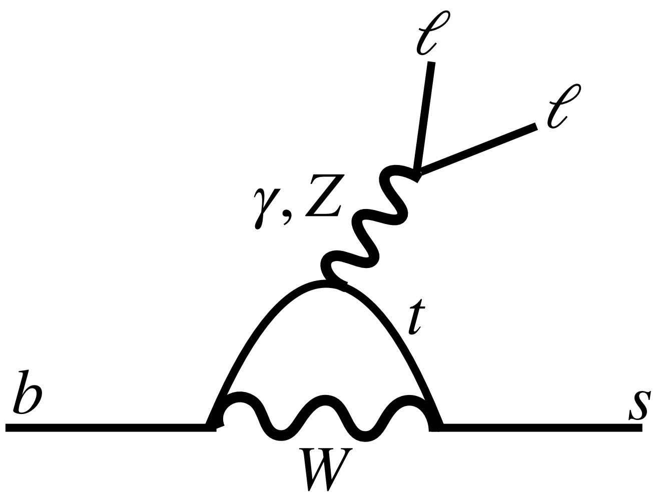
How realistic is it to discover short-distance NP in a given sector, given the global data?

1. Choose a WET sector ($b \to s\ell\ell$ and $b \to u\ell\nu$)

2. Study sector in the SMEFT including correlated effects from other observables (either minimalistic, or with a flavor assumption)

3. Assuming perturbativity, study additional leading correlations as imposed by UV completions

Example 1: $b \to s\ell\ell$



Rare b decays meet high-mass Drell-Yan
Greljo, Salko, AS, Stangl; *JHEP* 05 (2023) 087

$pp \to \ell\ell, \ell\nu$ with all dim. 6 CIs
now available in flavio
flav-io.github.io

	$pp \to \ell\ell$	$pp \to \ell\nu$
CMS	2103.02708	2202.06075
ATLAS	2006.12946	1906.05609

(light leptons for now)

$b \to s\ell\ell$ in WET

Greljo, Salko, AS, Stangl; 2212.10497

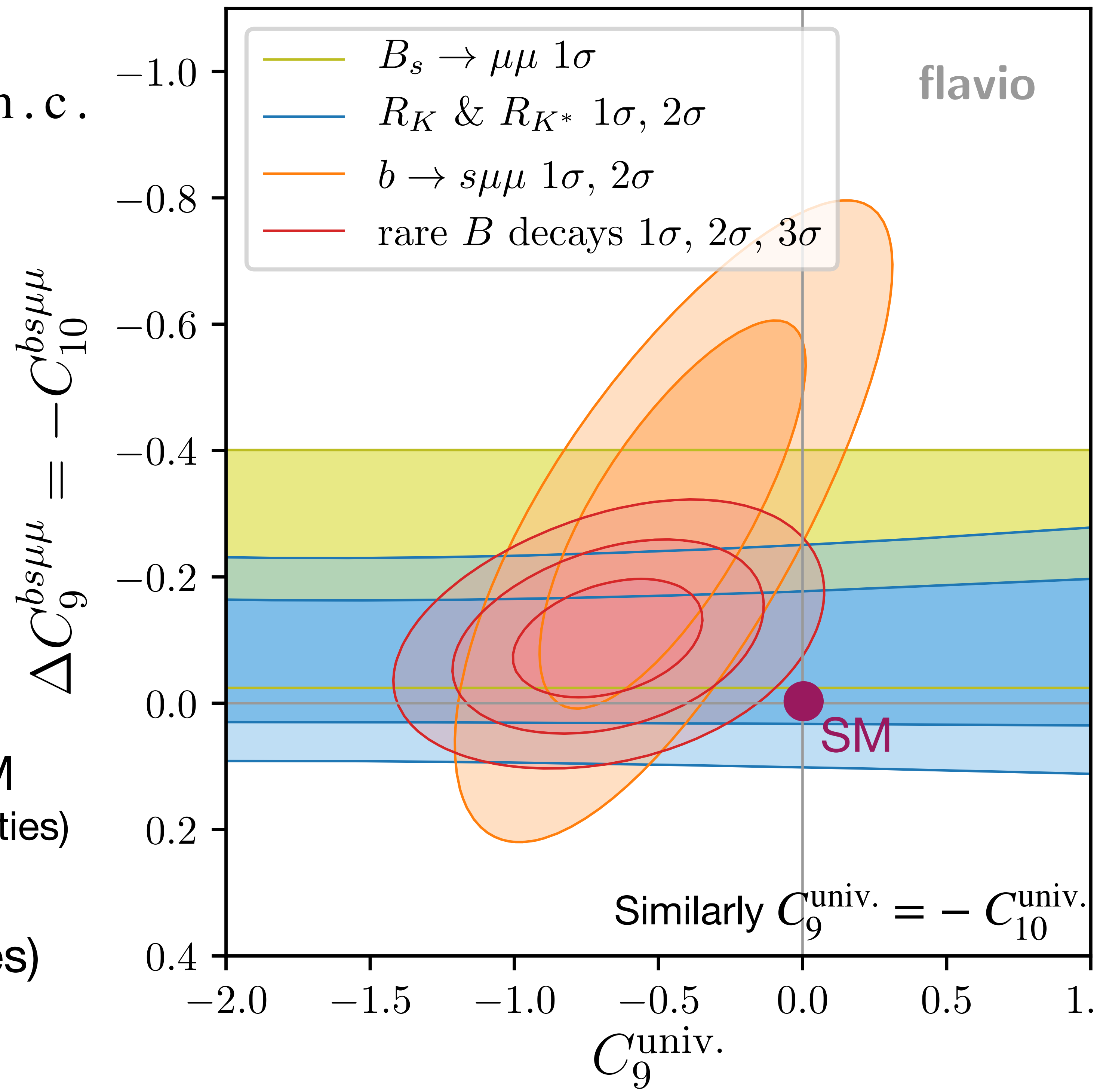
Weak effective Hamiltonian:

$$\mathcal{H}_{\rm eff}^{\rm NP} = -\frac{4G_F}{\sqrt{2}}\frac{\alpha}{4\pi}\sum_{q,\ell,i} V_{tb}V_{tq}^{*}C_i^{bq\ell\ell}O_i^{bq\ell\ell} + {\rm h.c.}$$

Local operators:

$$O_9^{bq\ell\ell} = (\bar{q}\gamma^\mu P_L b)(\bar{\ell}\gamma_\mu \ell)$$
$$O_{10}^{bq\ell\ell} = (\bar{q}\gamma^\mu P_L b)(\bar{\ell}\gamma_\mu\gamma_5 \ell)$$

observables $\sim \langle \mathcal{H}_{\rm eff}\rangle^2$



Preference for lepton flavor universal NP

NP could shift the values of WCs from SM
(rely on determinations of non-perturbative quantities)

Data mostly driven by LHCb (many modes)

CMS and ATLAS contribute importantly to fully leptonic

Flavorful connections in the SMEFT

Consider the $Q_{lq}^{(1)}$ operator + assume MFV flavor structure:

$$[C_{lq}^{(1)}]_{st}(\bar{l}\gamma_\mu l)(\bar{q}_s\gamma^\mu q_t)$$

Flavorful connections in the SMEFT

Consider the $Q_{lq}^{(1)}$ operator + assume MFV flavor structure:

$$[C_{lq}^{(1)}]_{st}(\bar{l}\gamma_\mu l)(\bar{q}_s\gamma^\mu q_t) \to [C_{lq}^{(1)}]_{st} = \delta_{st}[C_{lq}^{(1)}]_\delta + (Y_u Y_u^\dagger)_{st}[C_{lq}^{(1)}]_{Y_u Y_u^\dagger}$$

flavor conserving

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Flavorful connections in the SMEFT

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flavor conserving

$$\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

flavor violating

$$\sim y_t^2 \begin{pmatrix} |V_{td}|^2 & V_{ts}V_{td}^* & V_{tb}V_{td}^* \\ V_{td}V_{ts}^* & |V_{ts}|^2 & V_{tb}V_{ts}^* \\ V_{td}V_{tb}^* & V_{ts}V_{tb}^* & |V_{tb}|^2 \end{pmatrix}$$

$b \to d\ell\ell$

$b \to s\ell\ell$

Two UV parameters: $[C_{lq}^{(1)}]_\delta$ and $[C_{lq}^{(1)}]_{Y_u Y_u^\dagger}$

Flavorful connections in the SMEFT

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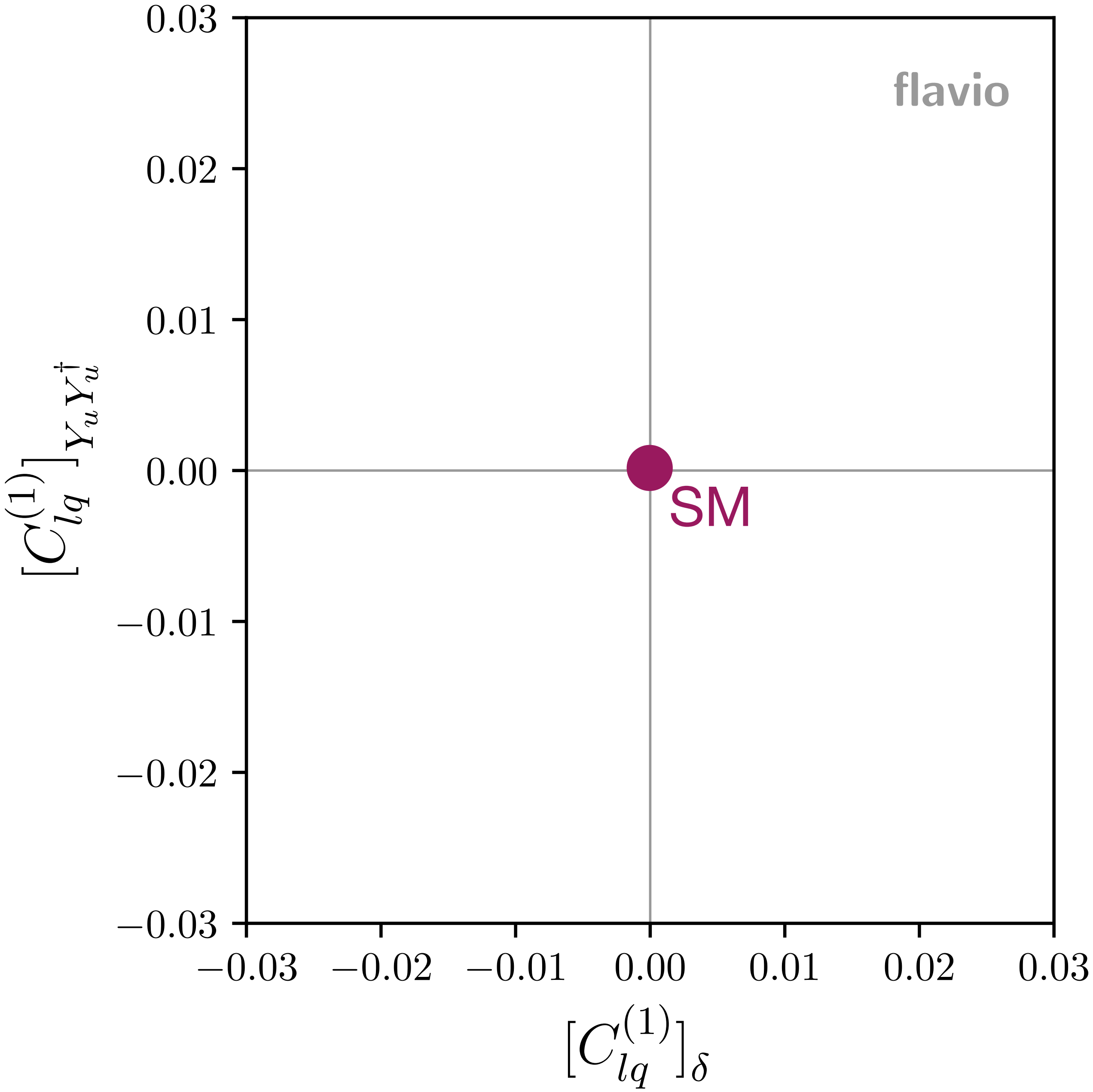

flavor violating

flavor conserving

Flavorful connections in the SMEFT

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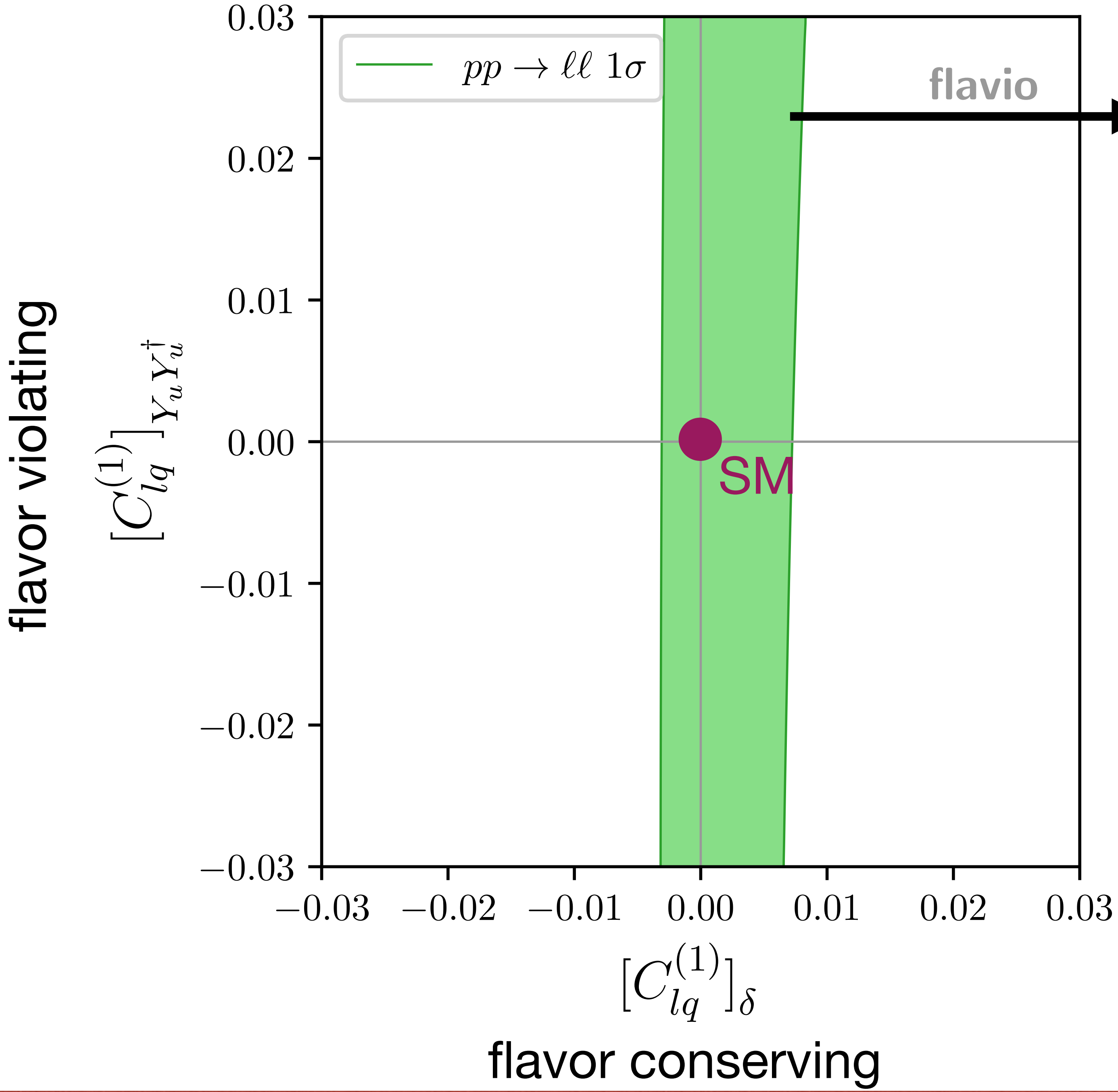

DY plays a major role

Flavorful connections in the SMEFT

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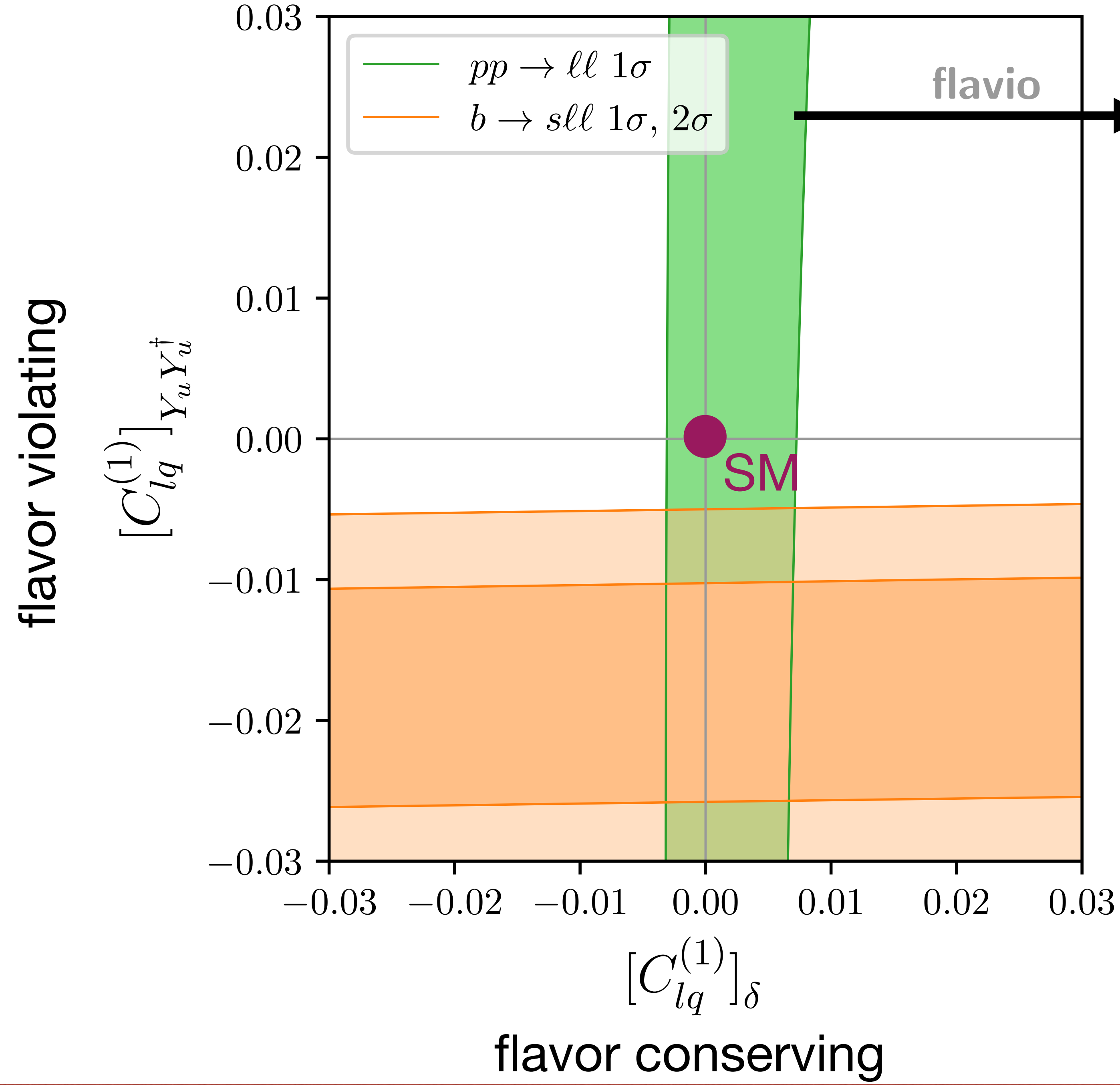

→ DY plays a major role

Flavorful connections in the SMEFT

Consider the $Q_{lq}^{(1)}$ operator + assume MFV flavor structure:

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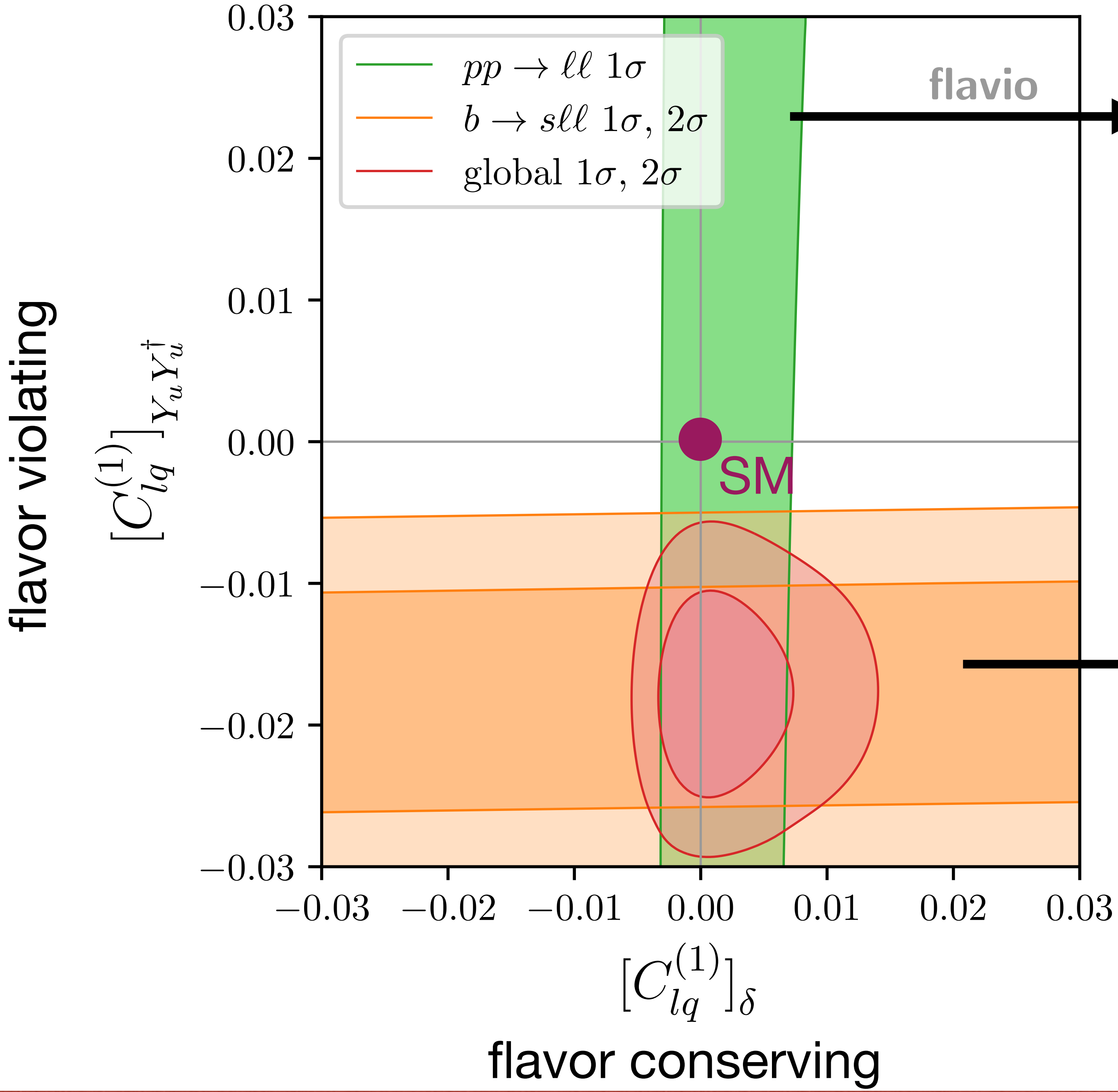


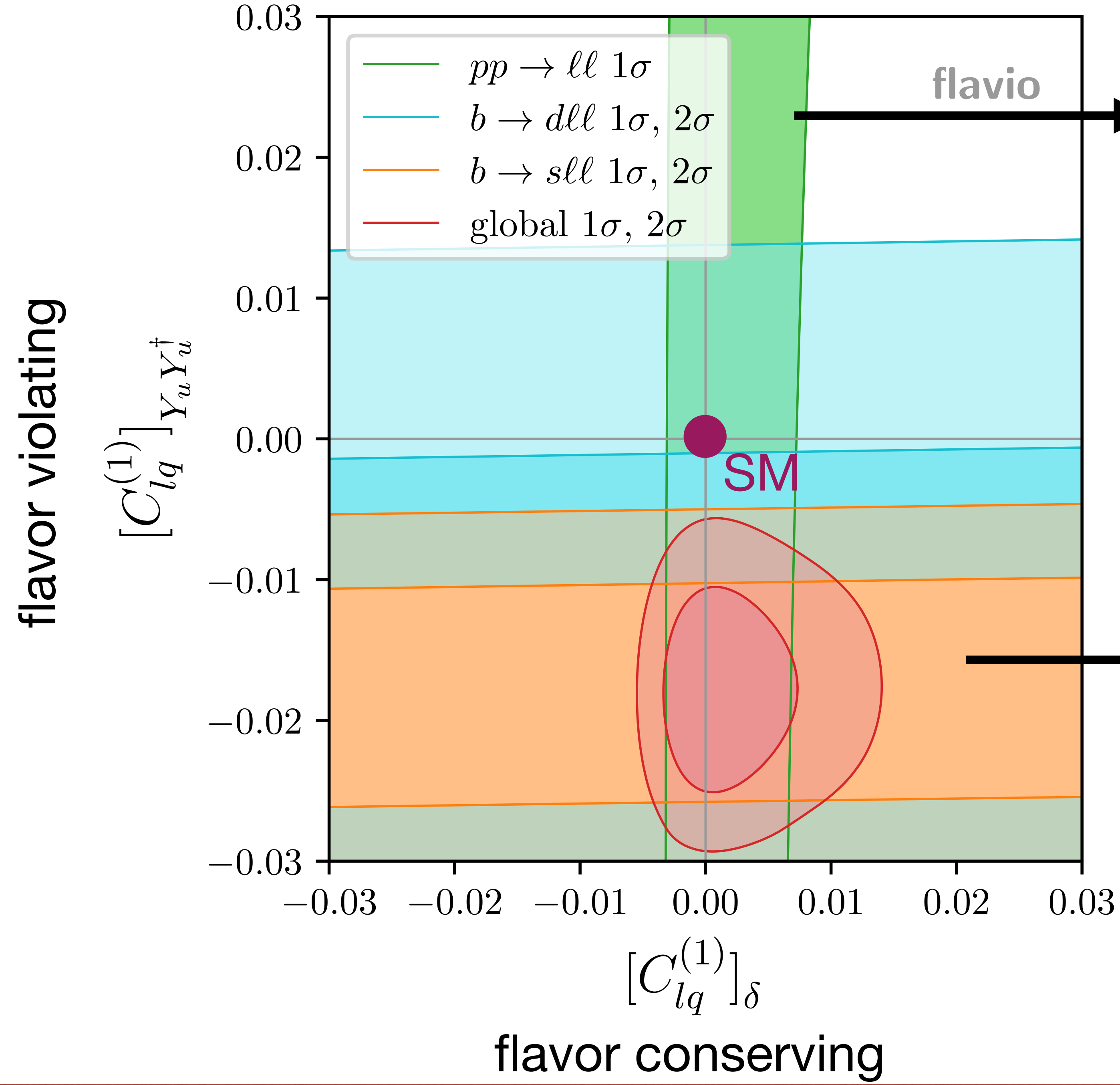
DY plays a major role

Presently dominated by $b \to s$

Flavorful connections in the SMEFT

Consider the $Q_{lq}^{(1)}$ operator + assume MFV flavor structure:

$$[C_{lq}^{(1)}]_{st}(\bar{l}\gamma_\mu l)(\bar{q}_s\gamma^\mu q_t) \rightarrow [C_{lq}^{(1)}]_{st} = \delta_{st}[C_{lq}^{(1)}]_\delta + (Y_u Y_u^\dagger)_{st}[C_{lq}^{(1)}]_{Y_u Y_u^\dagger}$$



DY plays a major role

Presently dominated by $b \rightarrow s$

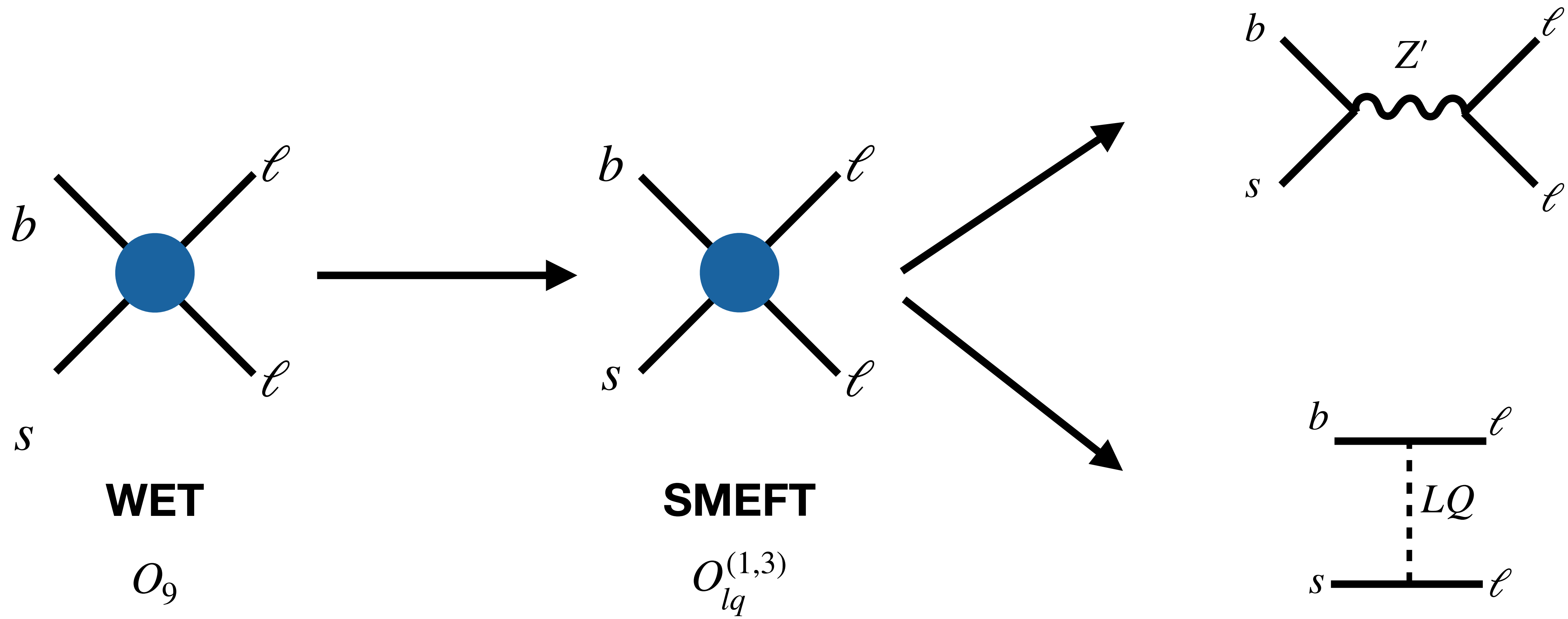
Improvements in $b \rightarrow d$ will allow to test flavorful BSM hypotheses

A. Greljo, J. Salko, AS, P. Stangl, 2212.10497

[see also 2209.04457]

If there is (LFU) NP in $b \to s\ell\ell$, what could it be?

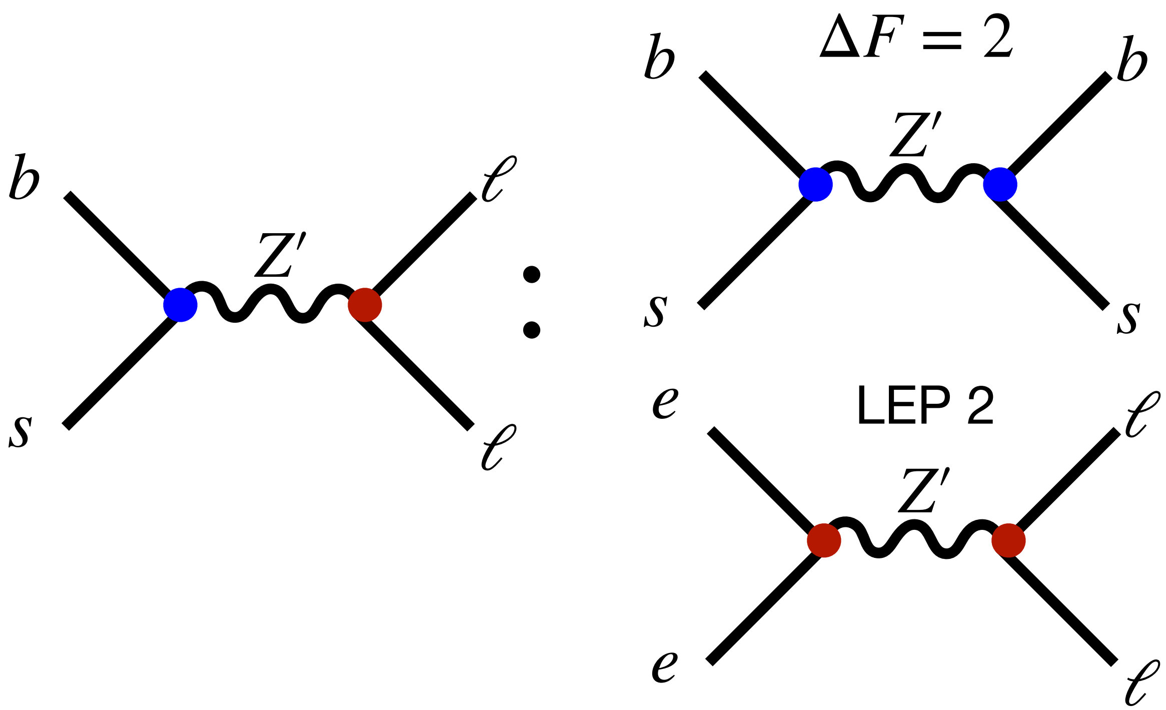
Systematic approach: start with leading effects, tree-level models



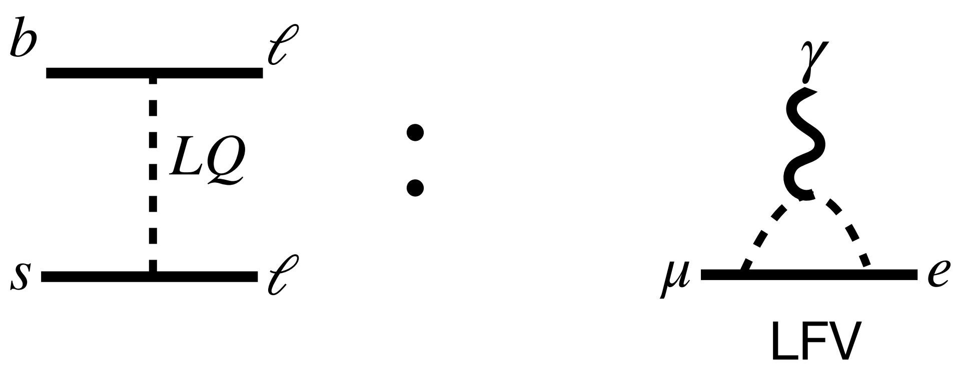
Then RGE, loop, etc.

But models imply further correlations

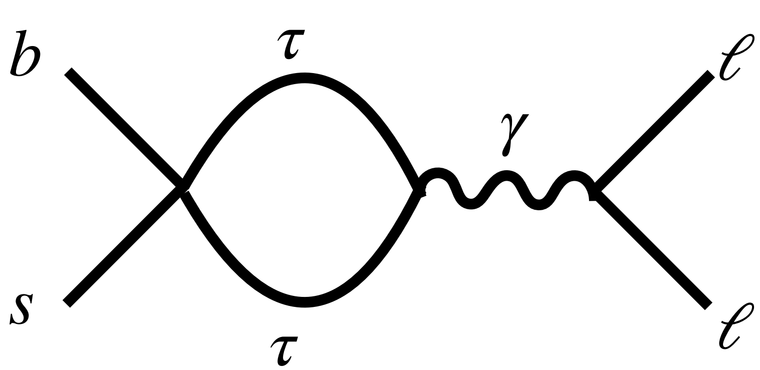
(simplified) models in a nutshell



Can easily be LFU (e.g. $U(1)_{B-L}$), stringent complementary constraints (there is wiggle room)
[2211.11766, 2212.10497, 2306.08669, …]



Not that easily LFU because of stringent cLFV constraints, can be done if LQ e.g. lepton-flavored
[1503.01084,1706.08511, 2212.10497, 2307.15117, …]



RG effect, connection with $R_{D^{(*)}}$ with τ, also possible through 4q operator
[1109.1826, 1701.09183, 1712.01919, 1807.02068, 1809.08447,1903.09578, 1910.12924, 2210.13422, 2304.07330, 2308.00034, 2309.01311, 2309.07205, …]

Example 2: $b \to u\ell\nu$

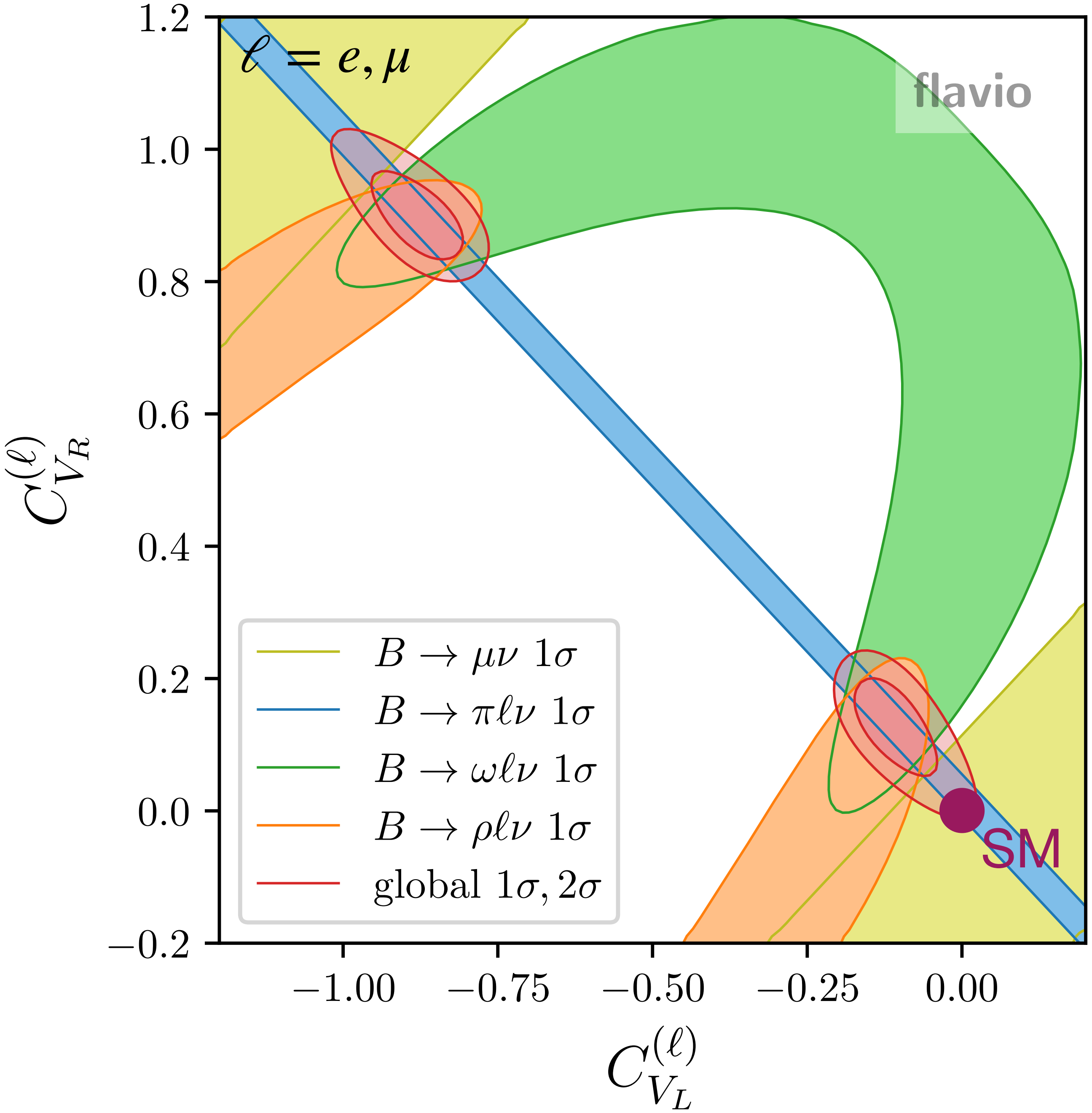
SMEFT restrictions on exclusive $b \to u\ell\nu$ decays
Greljo, Salko, AS, Stangl; *JHEP* 11 (2023) 023

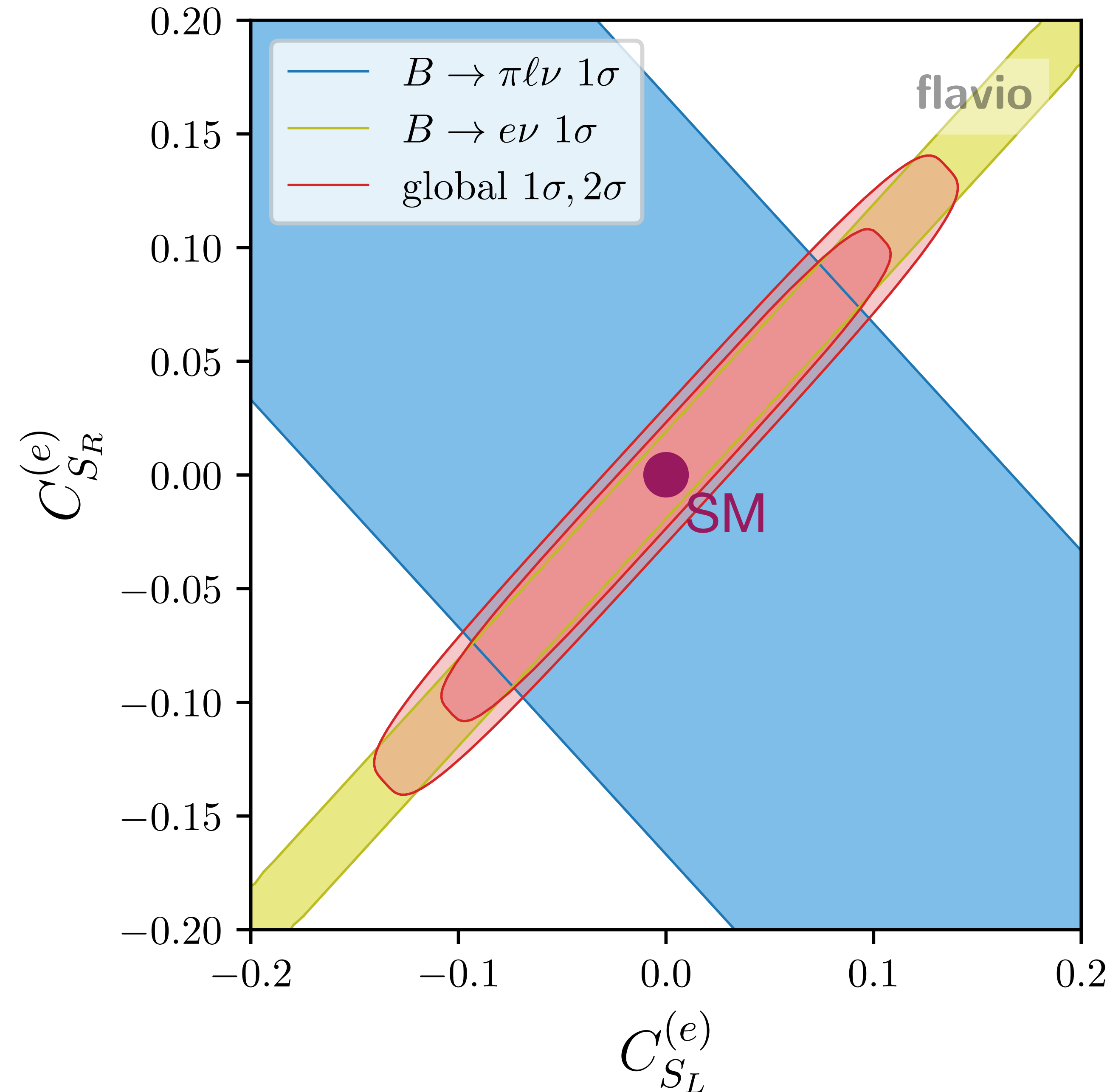
Is there room for NP in $b \to u\ell\nu$?

Greljo, Salko, AS, Stangl; 2306.09401

Step 1: WET - Limited amount of flavor data available (Belle&BaBar)

See also 2302.05268





$$\mathscr{H}^{\rm NP}_{\rm eff} = \frac{4G_F}{\sqrt{2}} \sum_i C_i O_i$$

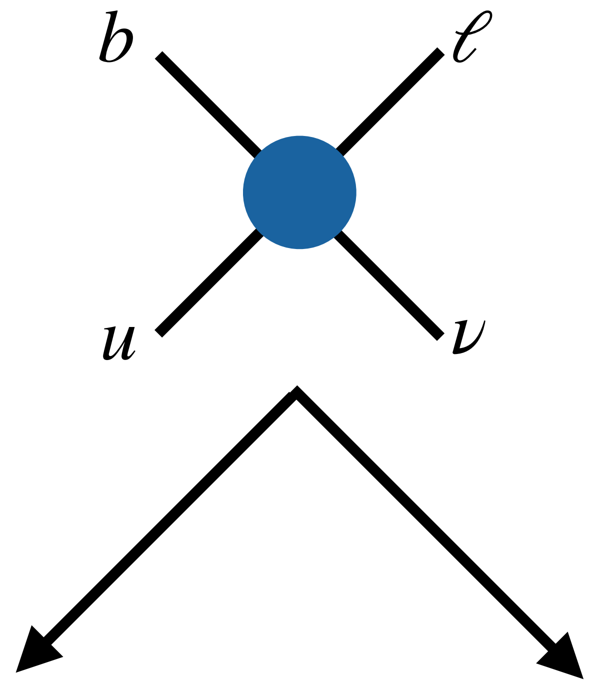
$$O^{(l)}_{V_L} = (\bar{u}_L \gamma^\mu b_L)(\bar{l}_L \gamma_\mu \nu_{lL})$$
$$O^{(l)}_{V_R} = (\bar{u}_R \gamma^\mu b_R)(\bar{l}_L \gamma_\mu \nu_{lL})$$

$$O^{(l)}_{S_L} = (\bar{u}_R b_L)(\bar{l}_R \nu_{lL})$$
$$O^{(l)}_{S_R} = (\bar{u}_L b_R)(\bar{l}_R \nu_{lL})$$

Is there room for NP in $b \to u \ell \nu$?

Greljo, Salko, AS, Stangl; 2306.09401

Step 2: SMEFT



Contact interactions

$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \sigma_a l_r)(\bar{q}_s \gamma^\mu \sigma^a q_t)$
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s q_{tj})$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r)\varepsilon_{jk}(\bar{q}_s^k u_t)$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar{q}_s^k \sigma^{\mu\nu} u_t)$

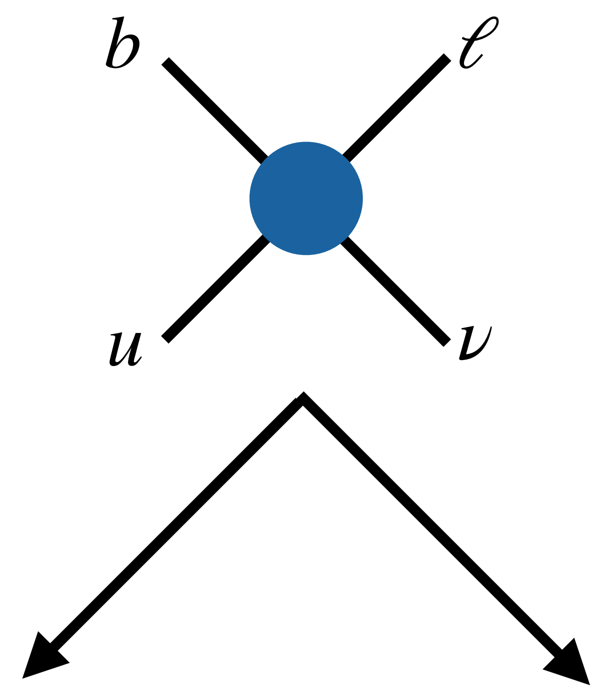
Vertex corrections

$Q_{\phi q}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{q}_p \sigma_a \gamma^\mu q_r)$
$Q_{\phi ud}$	$(\tilde{\phi}^\dagger i D_\mu \phi)(\bar{u}_p \gamma^\mu d_r)$

Greljo, Salko, AS, Stangl; 2306.09401

Is there room for NP in $b \to u\ell\nu$?

Step 2: SMEFT



Contact interactions

C_{V_L}	$\longleftarrow$	$Q_{lq}^{(3)}$	$(\bar{l}_p \gamma_\mu \sigma_a l_r)(\bar{q}_s \gamma^\mu \sigma^a q_t)$
C_{S_R}	$\longleftarrow$	Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s q_{tj})$
C_{S_L}	$\longleftarrow$	$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r)\varepsilon_{jk}(\bar{q}_s^k u_t)$
C_T	$\longleftarrow$	$Q_{lequ}^{(3)}$	$(\bar{l}_p^j \sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar{q}_s^k \sigma^{\mu\nu} u_t)$

Vertex corrections

$Q_{\phi q}^{(3)}$	$(\phi^\dagger i \overleftrightarrow{D}_\mu^a \phi)(\bar{q}_p \sigma_a \gamma^\mu q_r)$	$\longrightarrow$	C_{V_L}
$Q_{\phi ud}$	$(\tilde{\phi}^\dagger i D_\mu \phi)(\bar{u}_p \gamma^\mu d_r)$	$\longrightarrow$	C_{V_R}

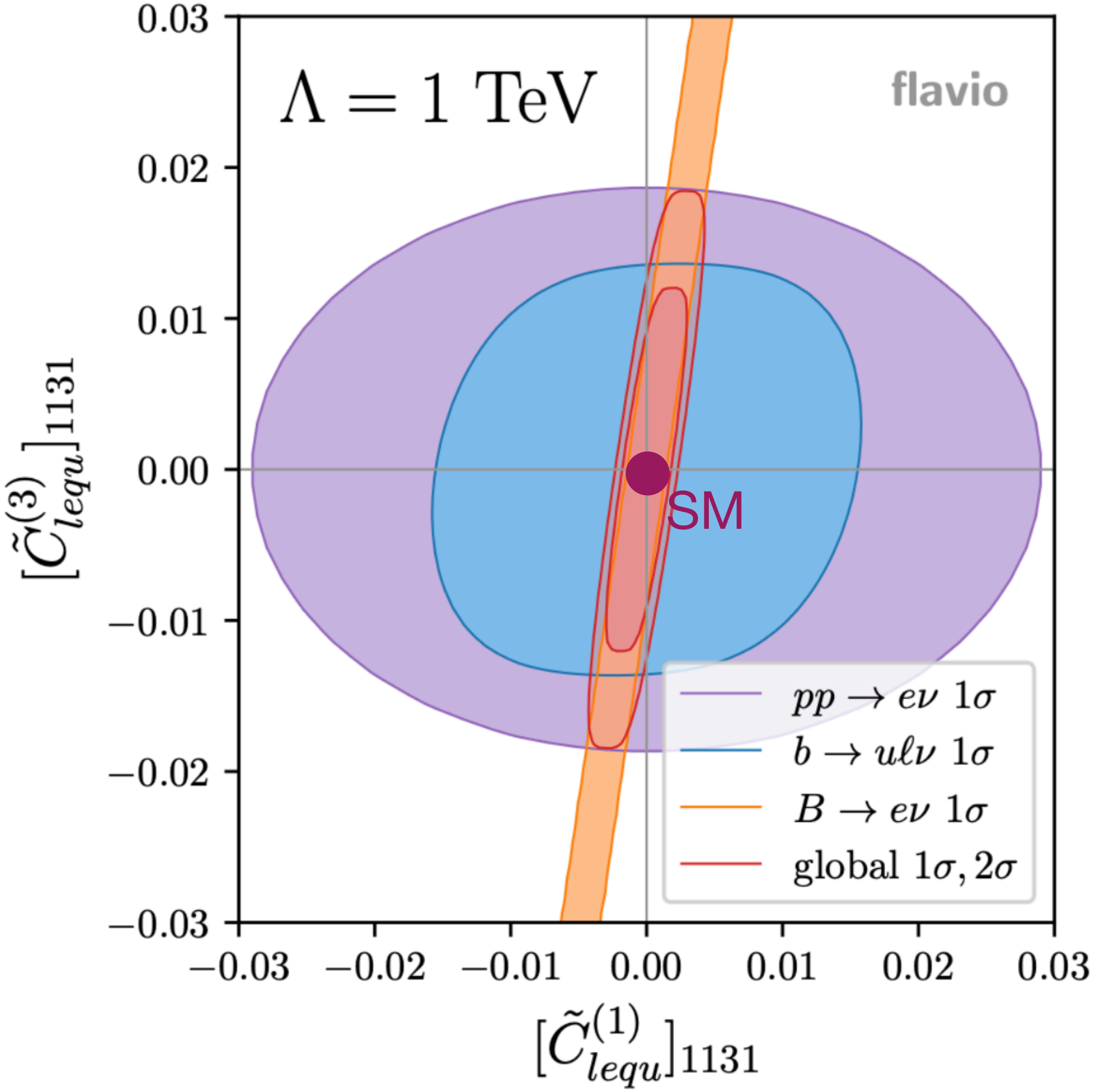
But SMEFT implies correlations!

e.g. Q_{ledq} contributes also to $b \to d\ell\ell$, DY, …

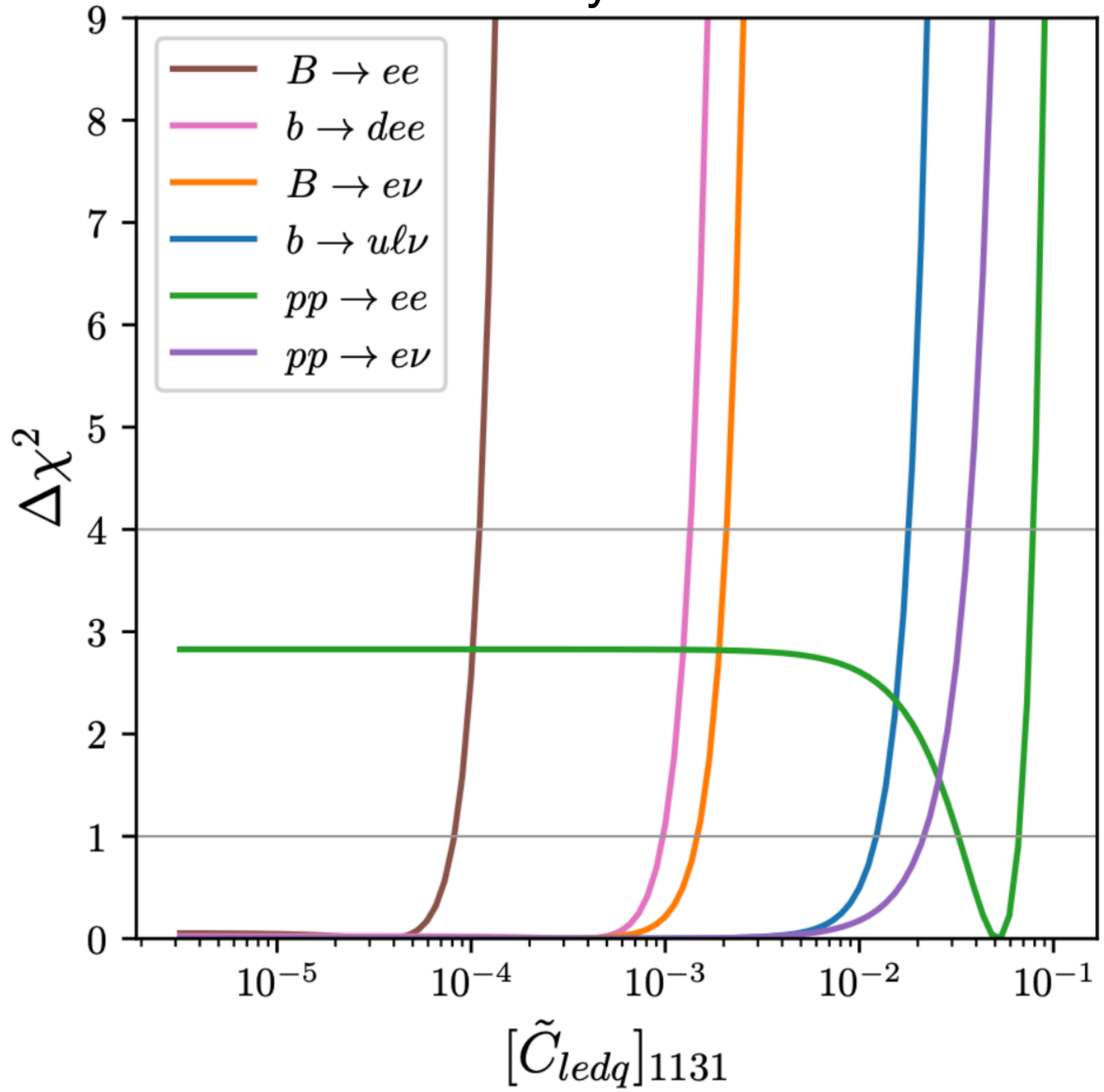
Is there room for NP in $b \to u \ell \nu$?

Greljo, Salko, AS, Stangl; 2306.09401

Contact interactions: scalars and tensor



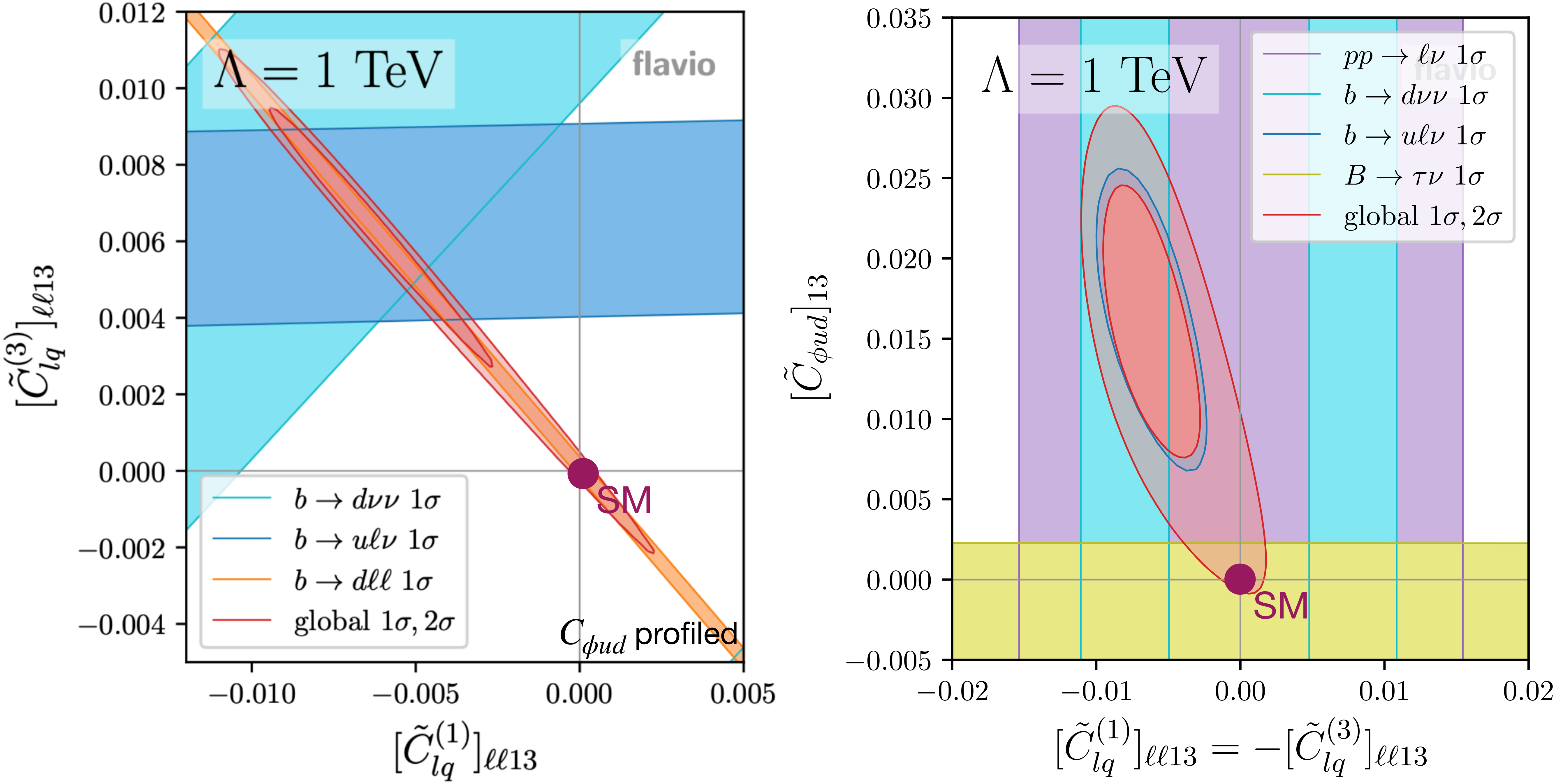
Hierarchy of constraints



Important complementary constraints, DY, neutral currents

Is there room for NP in $b \to u\ell\nu$?

Interesting scenario: $(Q_{lq}^{(1)}, Q_{lq}^{(3)}, Q_{\phi ud})$, in line with (C_{V_L}, C_{V_R}) tension



[$(C_{\phi q}^{(1)}, C_{\phi q}^{(3)})$ case dominated by complementary constraints]

Is there room for NP in $b \to u\ell\nu$?

Greljo, Salko, AS, Stangl; 2306.09401

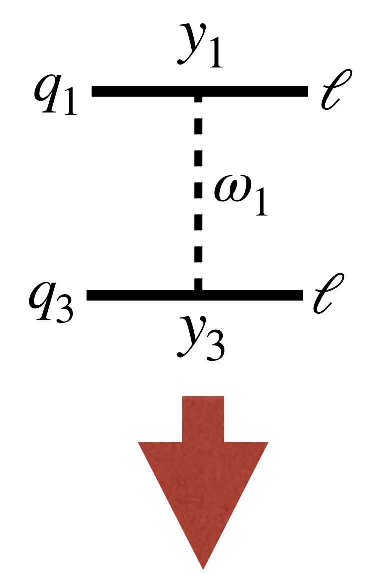
Step 3: Tree-level mediators

New scalar, fermionic, or vector mediators, with renormalizable couplings to SM fields

Operator	Mediator
$[Q_{lq}^{(3)}]_{\ell\ell 13}$	$\omega_1 \sim (\mathbf{3}, \mathbf{1}, -\frac{1}{3})_S$
$[Q_{lq}^{(3)}]_{\ell\ell 13}$	$\zeta \sim (\mathbf{3}, \mathbf{3}, -\frac{1}{3})_S$
$[Q_{lq}^{(3)}]_{\ell\ell 13}$	$\mathcal{W} \sim (\mathbf{1}, \mathbf{3}, 0)_V$
$[Q_{lq}^{(3)}]_{\ell\ell 13}$	$\mathcal{U}_2 \sim (\mathbf{3}, \mathbf{1}, \frac{2}{3})_V$
$[Q_{lq}^{(3)}]_{\ell\ell 13}$	$\mathcal{X} \sim (\mathbf{3}, \mathbf{3}, \frac{2}{3})_V$
$[Q_{\phi q}^{(3)}]_{13}$	$U \sim (\mathbf{3}, \mathbf{1}, \frac{2}{3})_F$
$[Q_{\phi q}^{(3)}]_{13}$	$D \sim (\mathbf{3}, \mathbf{1}, -\frac{1}{3})_F$
$[Q_{\phi q}^{(3)}]_{13}$	$T_1 \sim (\mathbf{3}, \mathbf{3}, -\frac{1}{3})_F$
$[Q_{\phi q}^{(3)}]_{13}$	$T_2 \sim (\mathbf{3}, \mathbf{3}, \frac{2}{3})_F$
$[Q_{\phi q}^{(3)}]_{13}$	$\mathcal{W} \sim (\mathbf{1}, \mathbf{3}, 0)_V$
$[Q_{ledq}]_{\ell\ell 31}$	$\varphi \sim (\mathbf{1}, \mathbf{2}, \frac{1}{2})_S$
$[Q_{ledq}]_{\ell\ell 31}$	$\mathcal{U}_2 \sim (\mathbf{3}, \mathbf{1}, \frac{2}{3})_V$
$[Q_{ledq}]_{\ell\ell 31}$	$\mathcal{Q}_5 \sim (\mathbf{3}, \mathbf{2}, -\frac{5}{6})_V$
$[Q_{lequ}^{(1)}]_{\ell\ell 31}$	$\varphi \sim (\mathbf{1}, \mathbf{2}, \frac{1}{2})_S$
$[Q_{lequ}^{(1)}]_{\ell\ell 31}$	$\omega_1 \sim (\mathbf{3}, \mathbf{1}, -\frac{1}{3})_S$
$[Q_{lequ}^{(1)}]_{\ell\ell 31}$	$\Pi_7 \sim (\mathbf{3}, \mathbf{2}, \frac{7}{6})_S$
$[Q_{lequ}^{(3)}]_{\ell\ell 31}$	$\omega_1 \sim (\mathbf{3}, \mathbf{1}, -\frac{1}{3})_S$
$[Q_{lequ}^{(3)}]_{\ell\ell 31}$	$\Pi_7 \sim (\mathbf{3}, \mathbf{2}, \frac{7}{6})_S$
$[Q_{\phi ud}]_{13}$	$Q_1 \sim (\mathbf{3}, \mathbf{2}, \frac{1}{6})_F$
$[Q_{\phi ud}]_{13}$	$\mathcal{B}_1 \sim (\mathbf{1}, \mathbf{1}, 1)_V$

But these imply directions..

e.g.

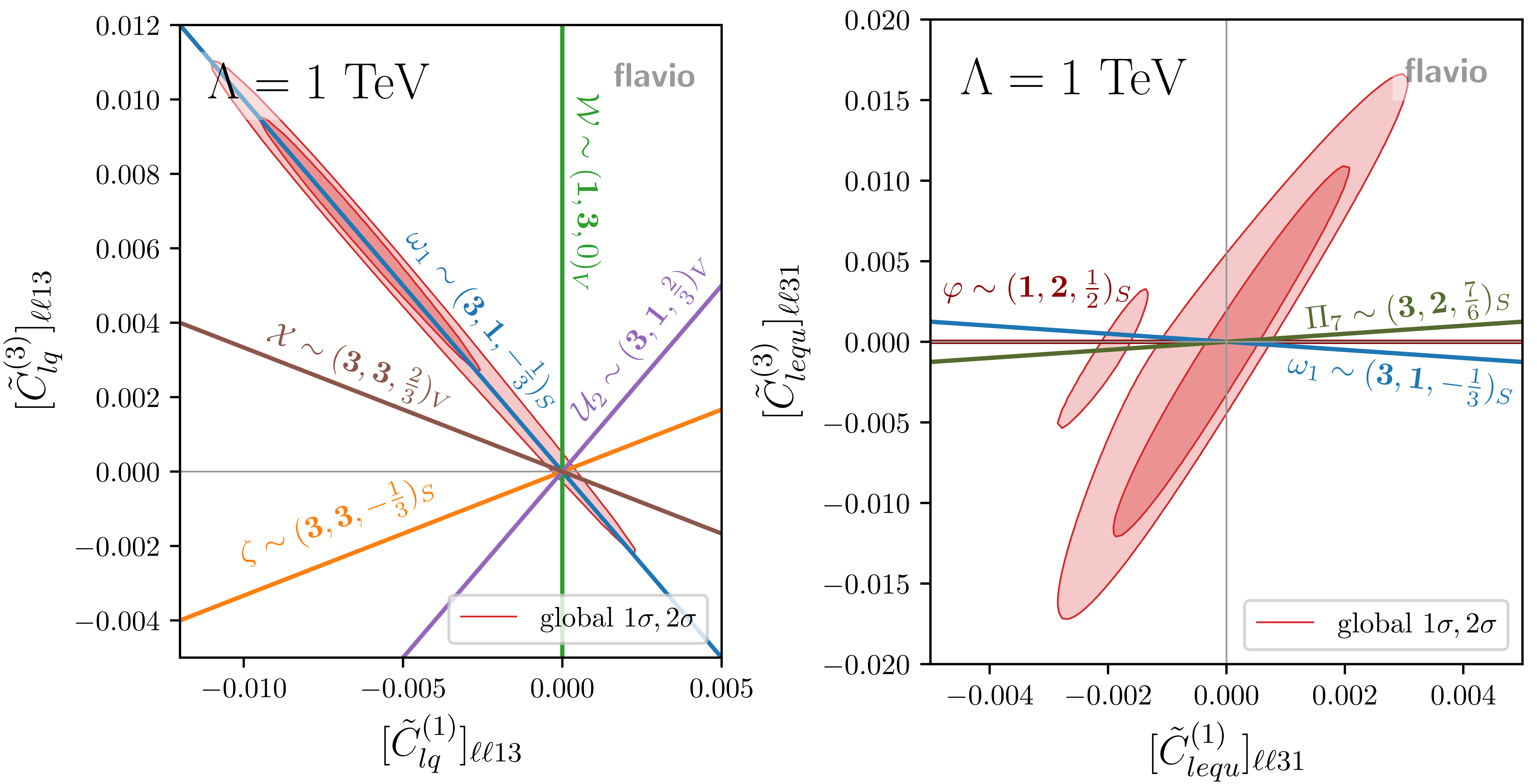


$$C_{lq}^{(1)} = -C_{lq}^{(3)} = \frac{y_1^* y_3}{4M_{\omega_1}^2}$$

Notation and matching from 1711.10391

Is there room for NP in $b \to u\ell\nu$?

Greljo, Salko, AS, Stangl; 2306.09401



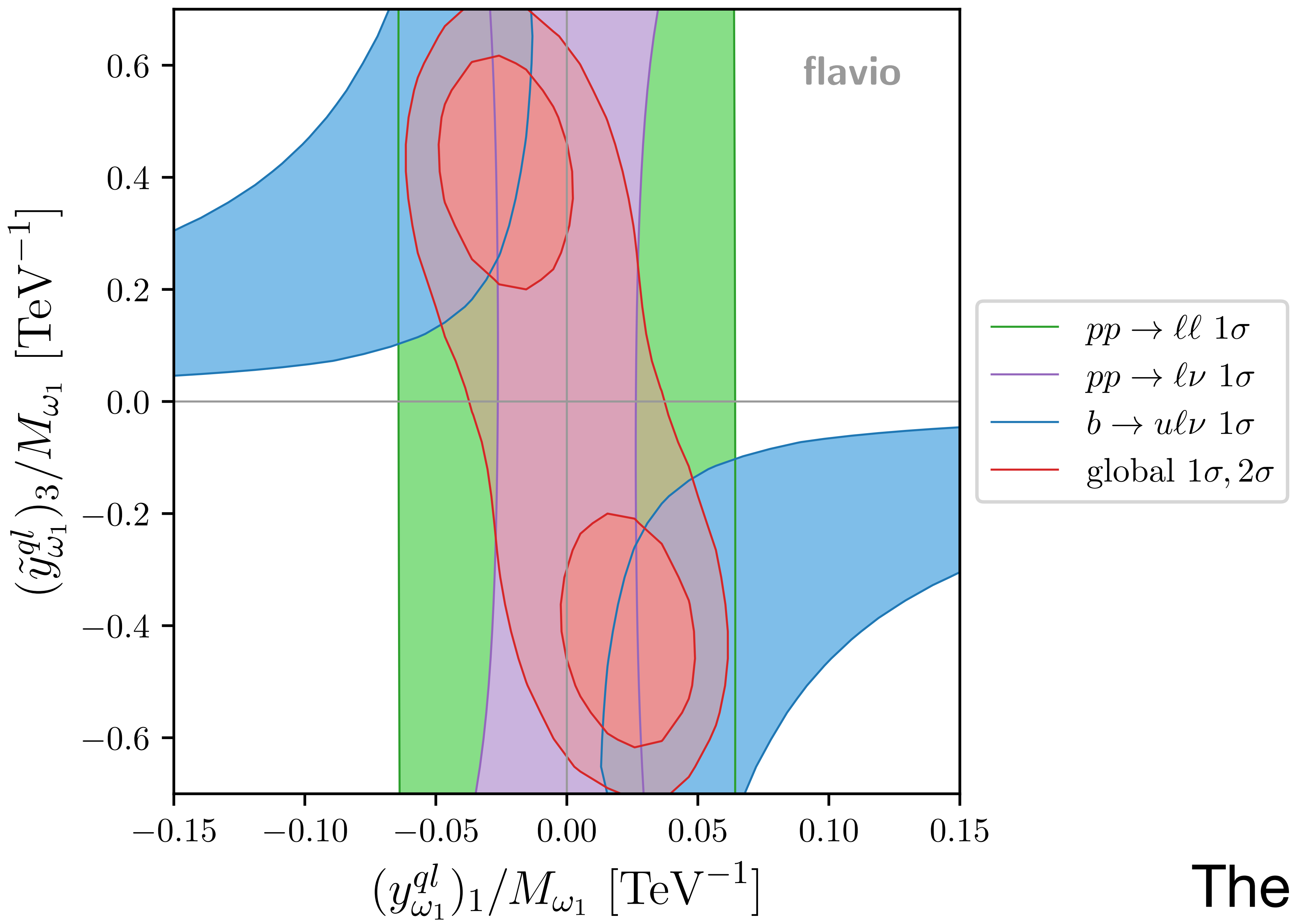
Exclusive semileptonic $b \to u\ell\nu$ (significantly) sensitive to only a handful of UV mediators - modulo cancellations

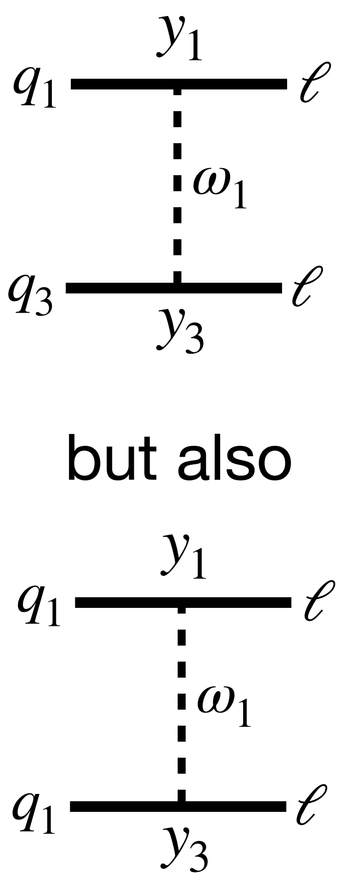
Greljo, Salko, AS, Stangl; 2306.09401

Is there room for NP in $b \to u\ell\nu$?

Take $\omega_1 \sim (\mathbf{3}, \mathbf{1} - 1/3)_S$ (gives $C_{lq}^{(1)} = -C_{lq}^{(3)}$)

and $Q_1 \sim (\mathbf{3}, \mathbf{2}, 1/6)_F$ (gives $C_{\phi ud}$, also $C_{\phi u}$, $C_{\phi d}$, profiled)





There is room, but not much

(also consistent with the rest of the smelli global likelihood, e.g. EWPT, β-decays, …)

Summary

- Model-independent approach to heavy NP
  -> tools for global analyses indispensable
  -> more can be done in terms of reporting exp. analyses

- Complicated data analyses done in the SMEFT parameter space
  -> relative importance of data can be assessed
  -> efficient reinterpretation in concrete heavy NP models possible
  -> e.g. tree-level completions imply interesting directions

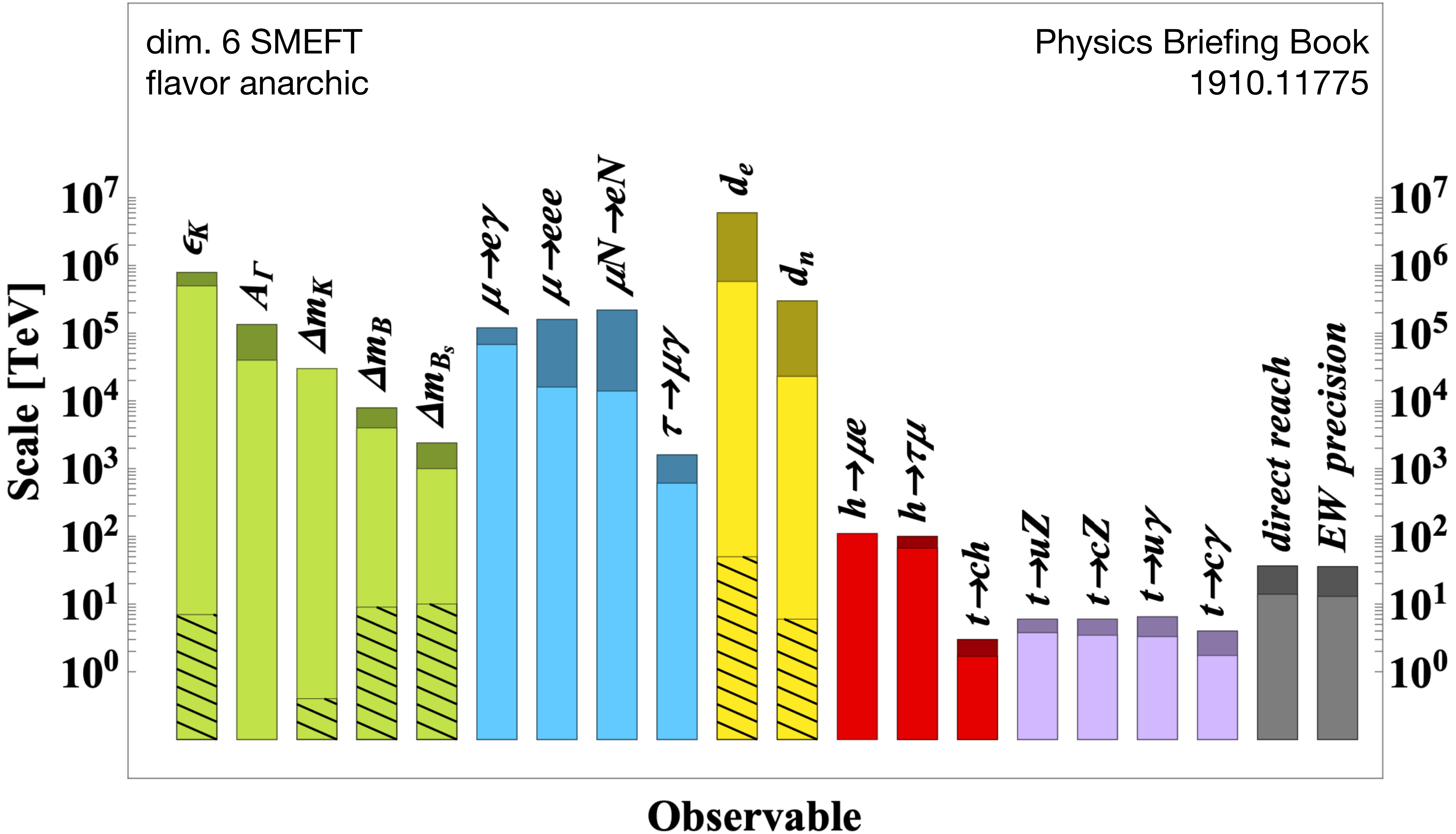
- High complementarity between observables from different sectors
  -> e.g. low-energy flavor observables and high-mass DY,
  also EWPT, APV, LEP, …
  -> more can be done, e.g. inclusion of b-tagged jets, study dijets, etc

Thank you

Additional slides

hep-ph/0207036, 2005.05366, 2203.09561

NP is expected to have some kind of flavor protection, e.g. MFV



With a **flavour assumption** we correlate various SMEFT Wilson coefficients and decrease the number of free parameters

Minimal flavour violation:

all the flavor structure is contained in $Y_{u,d}$ also beyond the SM

$$G_F = U(3)_Q \times U(3)_u \times U(3)_d$$

$$\begin{aligned} Q &\sim (3,1,1) \\ u &\sim (1,3,1) \\ d &\sim (1,1,3) \end{aligned} \quad \Rightarrow \quad \begin{aligned} Y_u &\sim (3,\bar{3},1) \\ Y_d &\sim (3,1,\bar{3}) \end{aligned}$$

Then we can decompose coefficients with spurion insertions:

$$[C_{lq}^{(1)}]_{iist} \bar{L}_i \gamma_\mu L_i \bar{Q}_s \gamma^\mu Q_t \to [C_{lq}^{(1)}]_{iist} = \delta_{st}[C_{lq}^{(1)}]_\delta + (Y_u Y_u^\dagger)_{st} [C_{lq}^{(1)}]_{Y_u Y_u^\dagger}$$

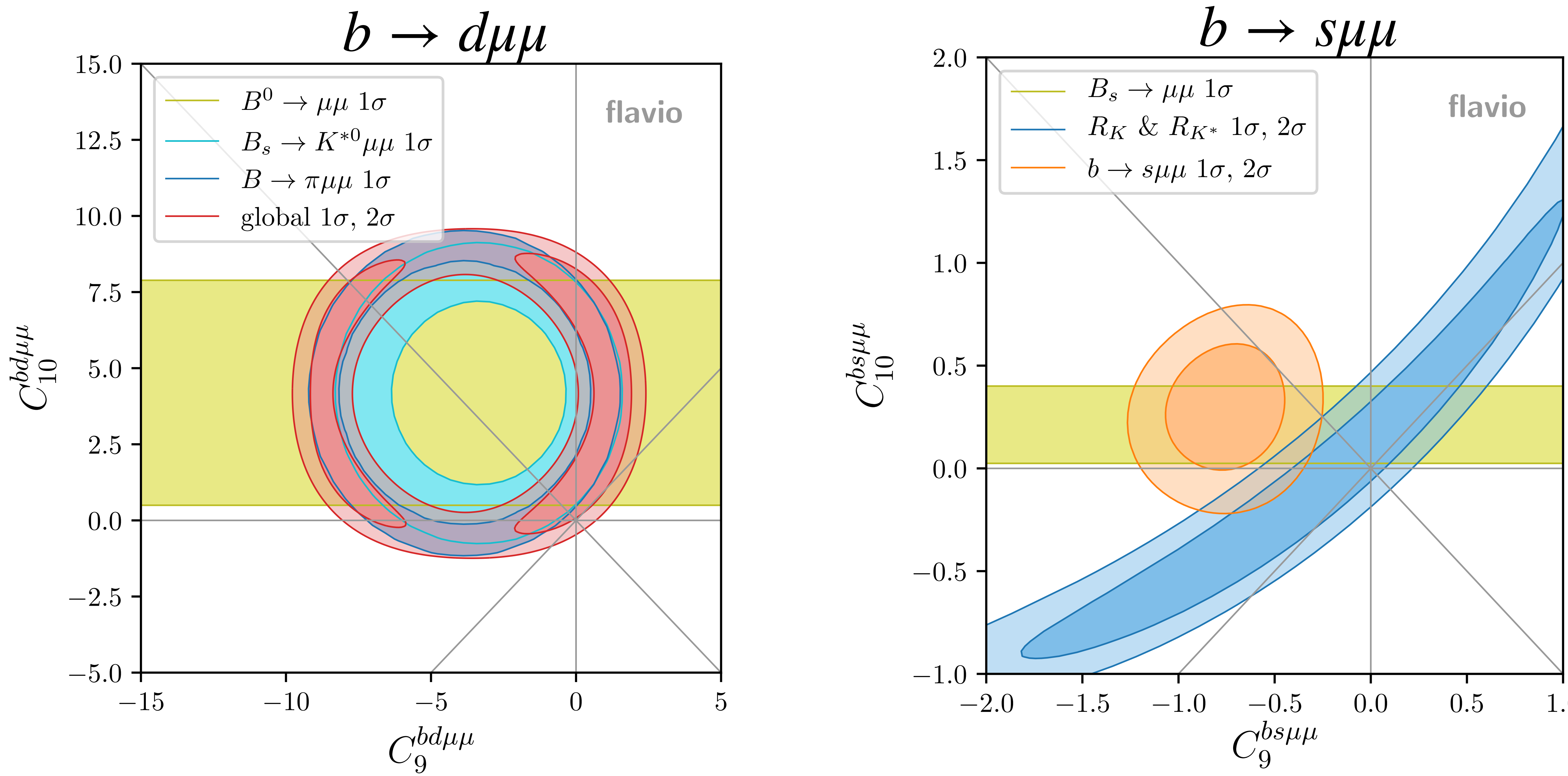
(and similar for other operators involving $\bar{Q}Q$)

$$\sim y_t^2 \begin{pmatrix} |V_{td}|^2 & V_{ts}V_{td}^* & V_{tb}V_{td}^* \\ V_{td}V_{ts}^* & |V_{ts}|^2 & V_{tb}V_{ts}^* \\ V_{td}V_{tb}^* & V_{ts}V_{tb}^* & |V_{tb}|^2 \end{pmatrix}$$

$b \to d, s$ in WET

Greljo, Salko, AS, Stangl; 2212.10497

$$O_9^{bq\ell\ell} = (\bar{q}\gamma^\mu P_L b)(\bar{\ell}\gamma_\mu \ell)$$
$$O_{10}^{bq\ell\ell} = (\bar{q}\gamma^\mu P_L b)(\bar{\ell}\gamma_\mu \gamma_5 \ell)$$



$B \to \pi$ FFs from 2102.07233

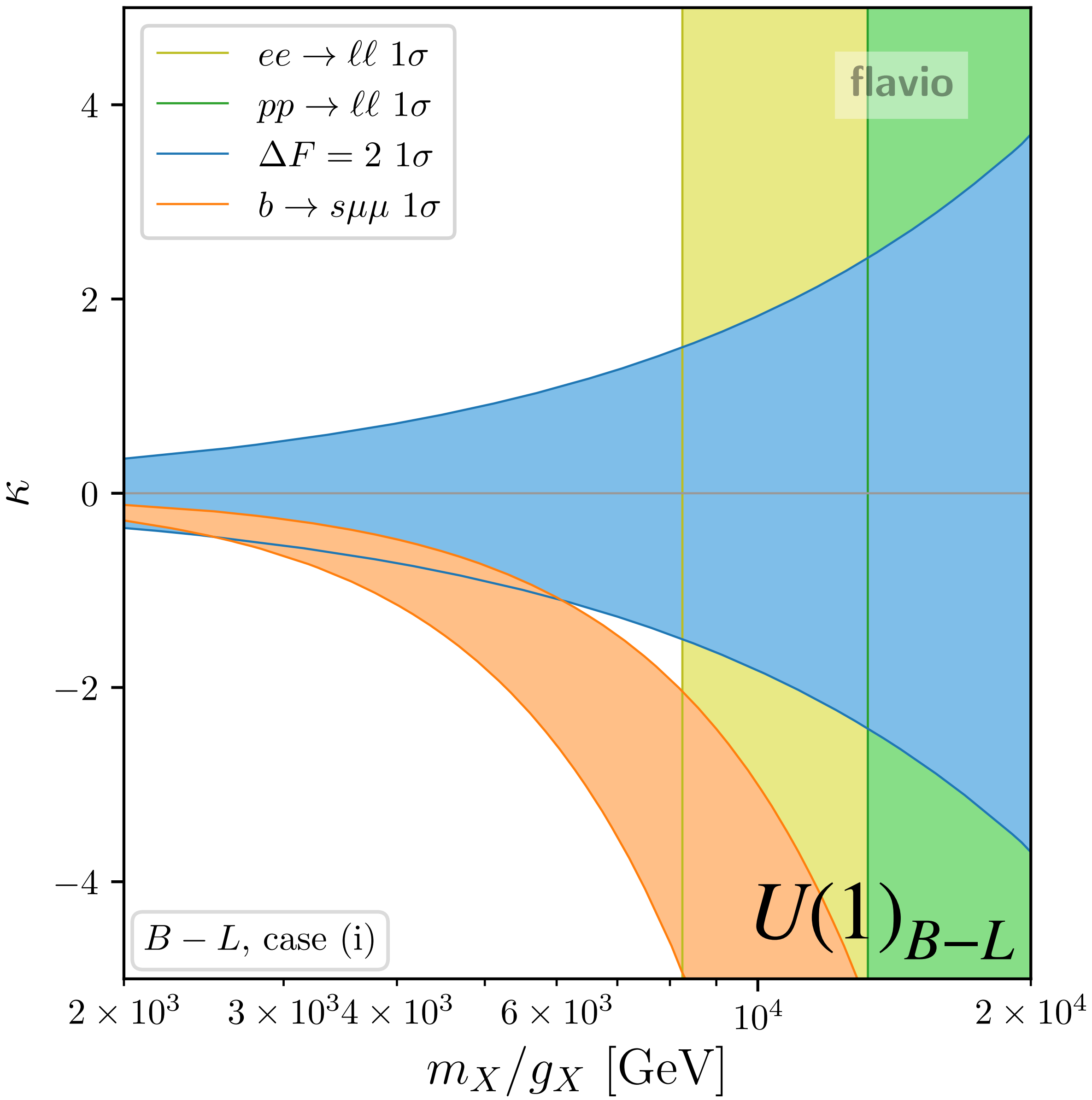
Also e.g. *R. Bause et al* (2209.04457), *M. Ciuchini et al* (2212.10516)

Greljo, Salko, AS, Stangl; 2212.10497

LFU Z'

$$J^\mu = J^\mu_{B-L} + \frac{1}{3}\epsilon_{ij}\,\bar{q}_i\gamma^\mu q_j$$

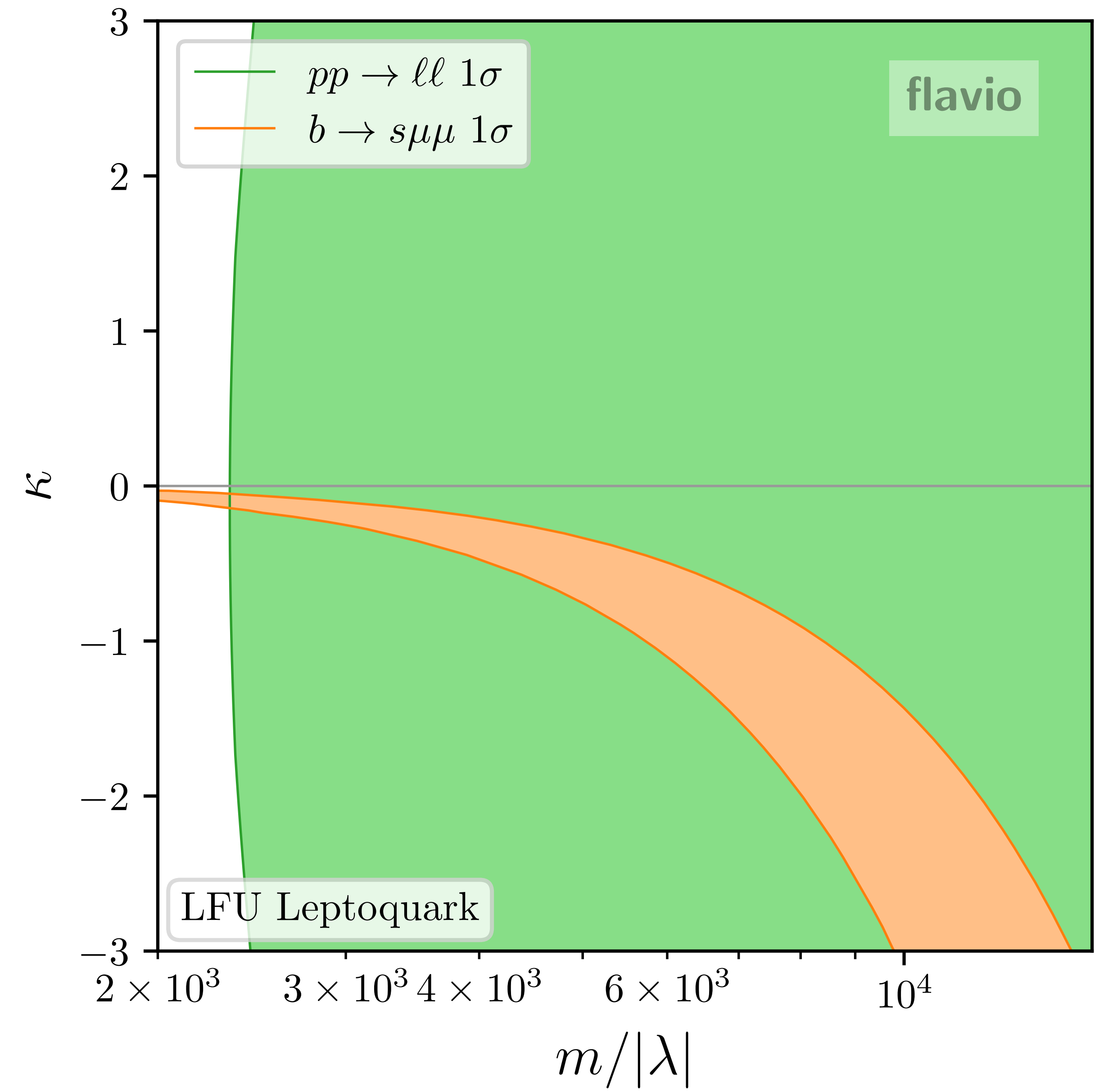
$$\epsilon_{ij} = -\kappa\ \ V_{ts}\ \ (\delta_{i2}\delta_{j3} + \delta_{i3}\delta_{j2})$$



LFU LQ

E.g. doublet of scalar S_3 LQs: $S^\alpha \sim (\bar{\mathbf{3}}, \mathbf{3}, 1/3)$

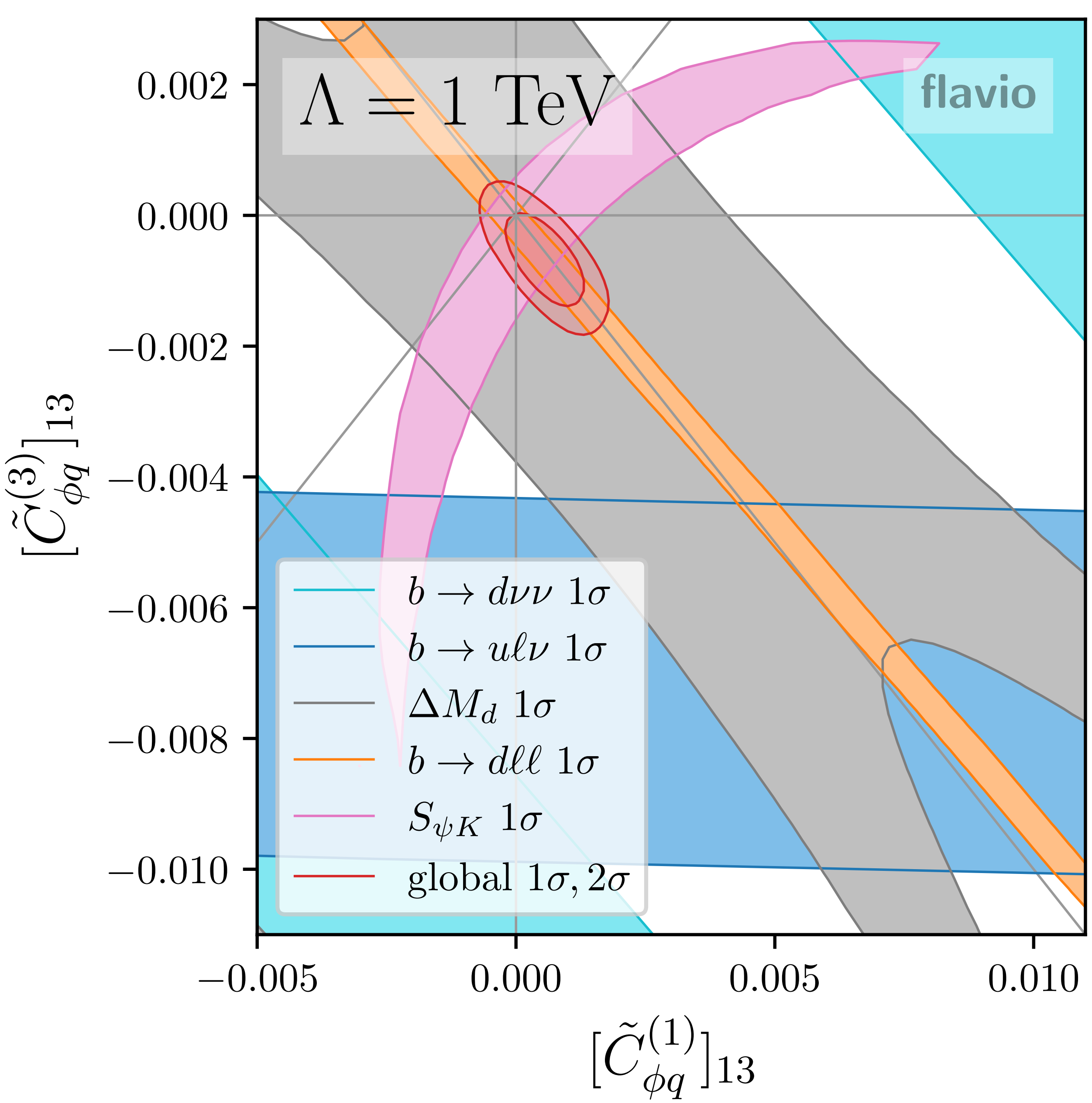
$$\mathscr{L} \supset -(\lambda_i\,\bar{q}^c_i l_\alpha S^\alpha + \mathrm{h.c.})$$

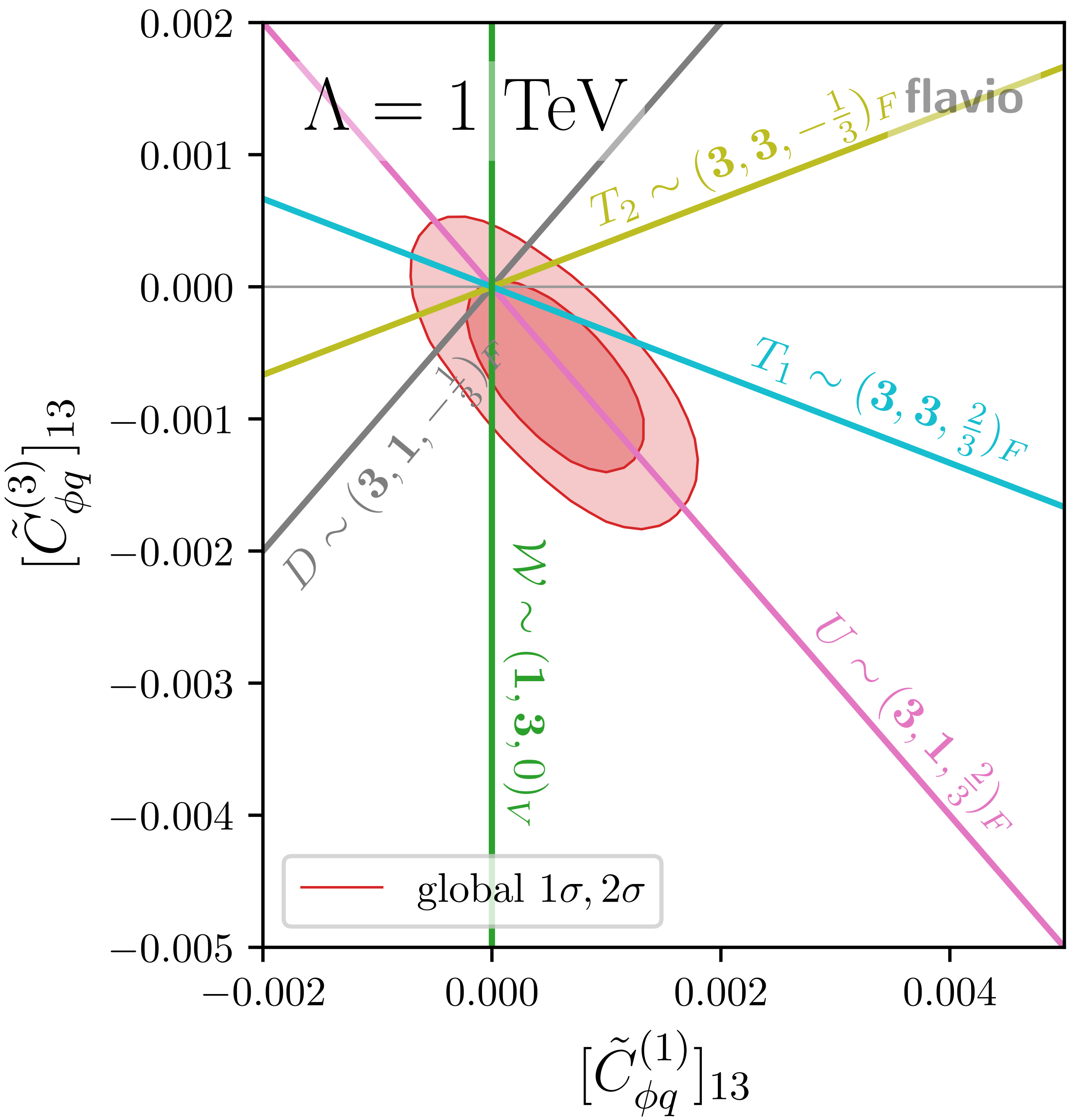


See 2306.08669 for variations

[$(C_{\phi q}^{(1)}, C_{\phi q}^{(3)})$ case dominated by complementary constraints]

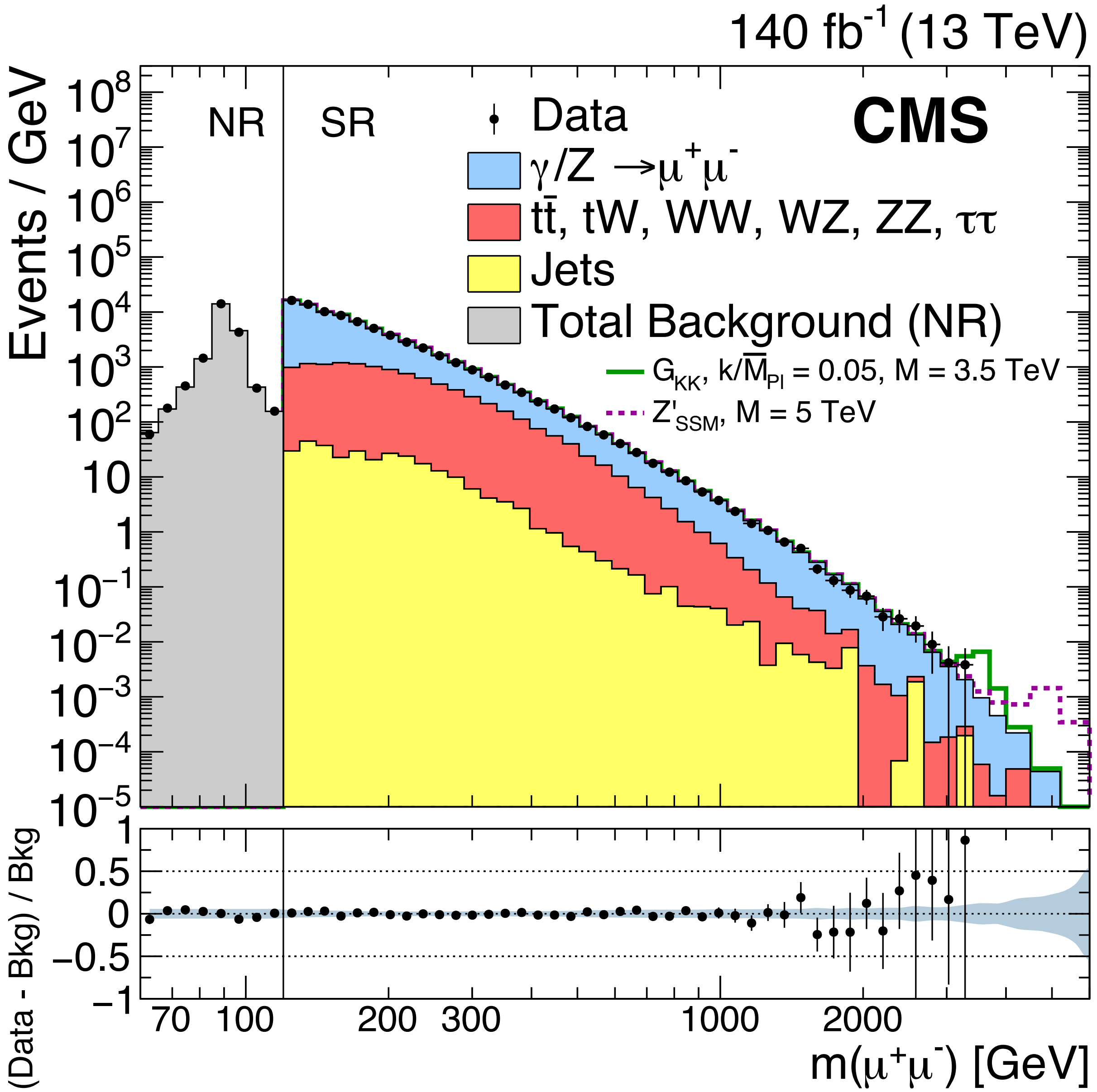
Greljo, Salko, AS, Stangl; 2306.09401





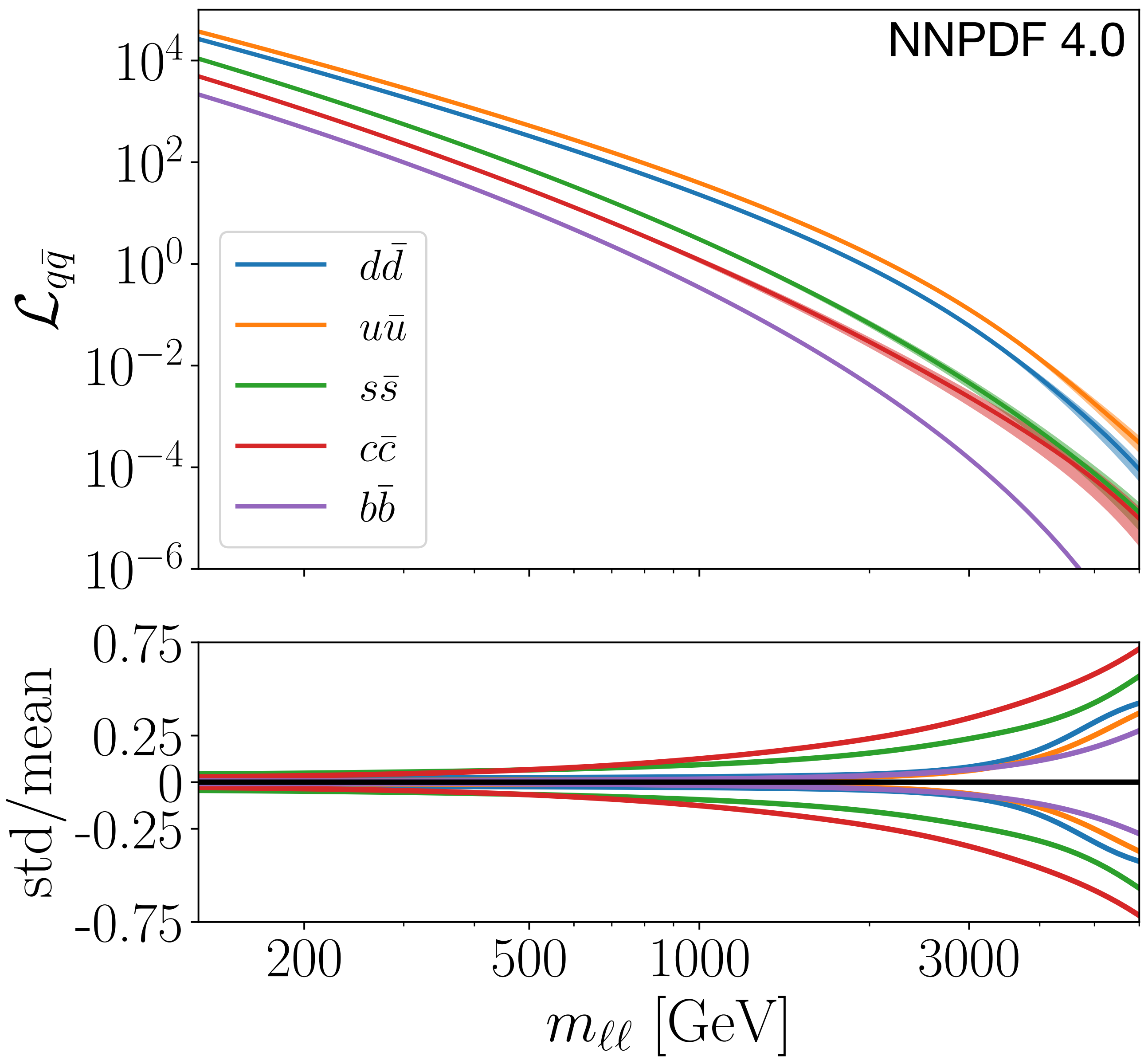
Why high-mass Drell-Yan?

5 flavors in the proton



[m_T in CC]

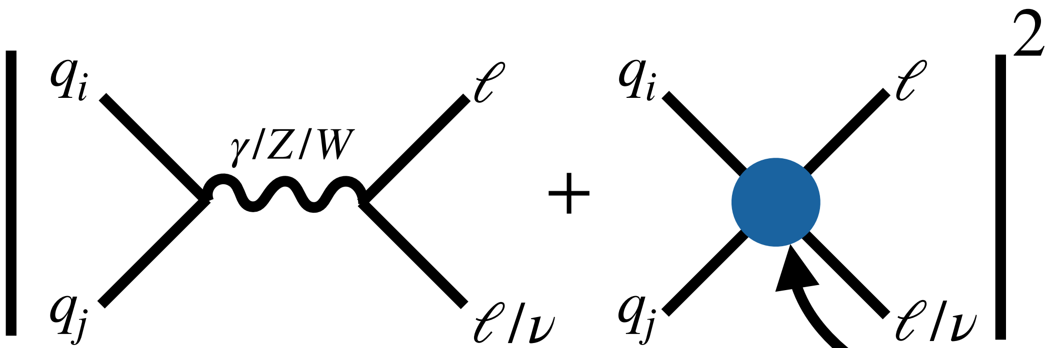
$$\mathcal{L}_{\bar{q}q}(\tau, \mu_F) = \int_\tau^1 \frac{dx}{x} f_{\bar{q}}(x, \mu_F) f_q(\tau/x, \mu_F), \quad \tau = m_{\ell\ell}^2/s$$



Why high-mass Drell-Yan?

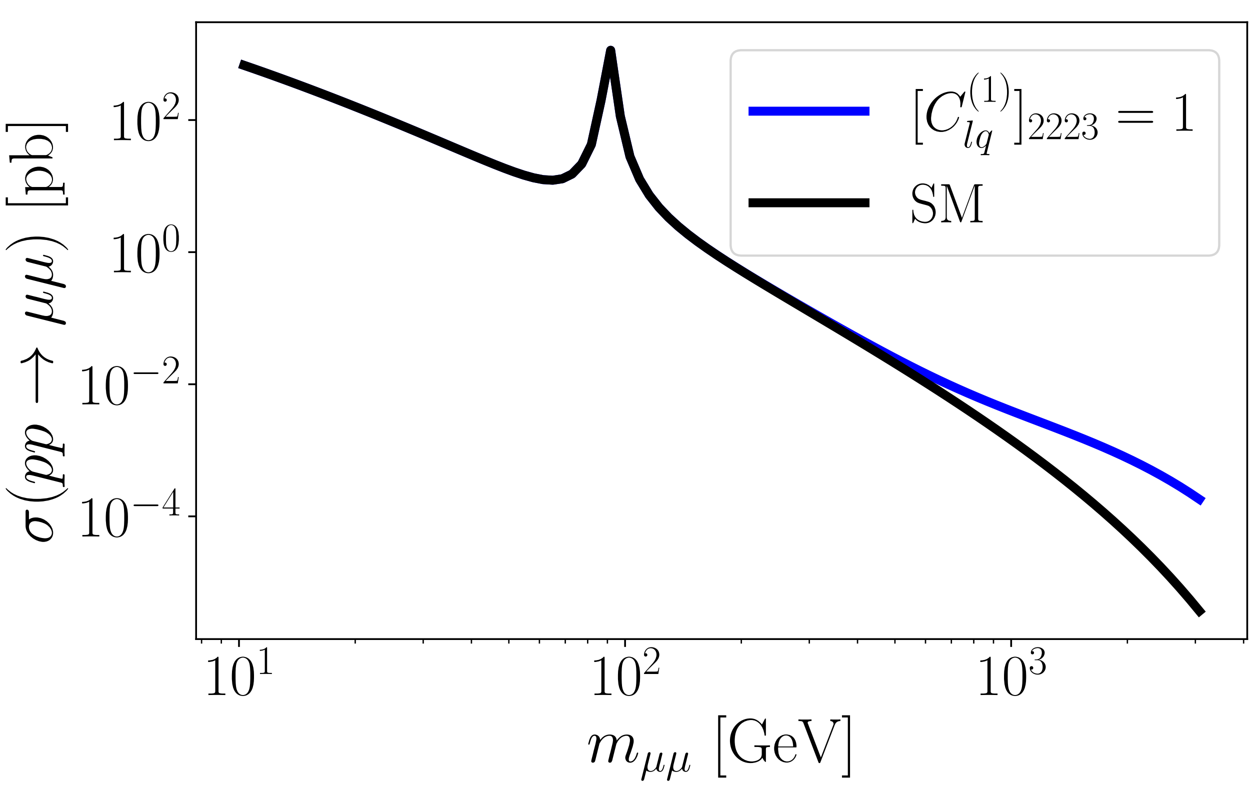
Many operators contribute, especially sensitive to contact interactions

$\sigma_{\text{part}}^{q\bar{q}} \sim$



$$\sigma_{\text{had}} \sim \mathscr{L}_{q\bar{q}} * \sigma_{\text{part}}^{q\bar{q}}$$

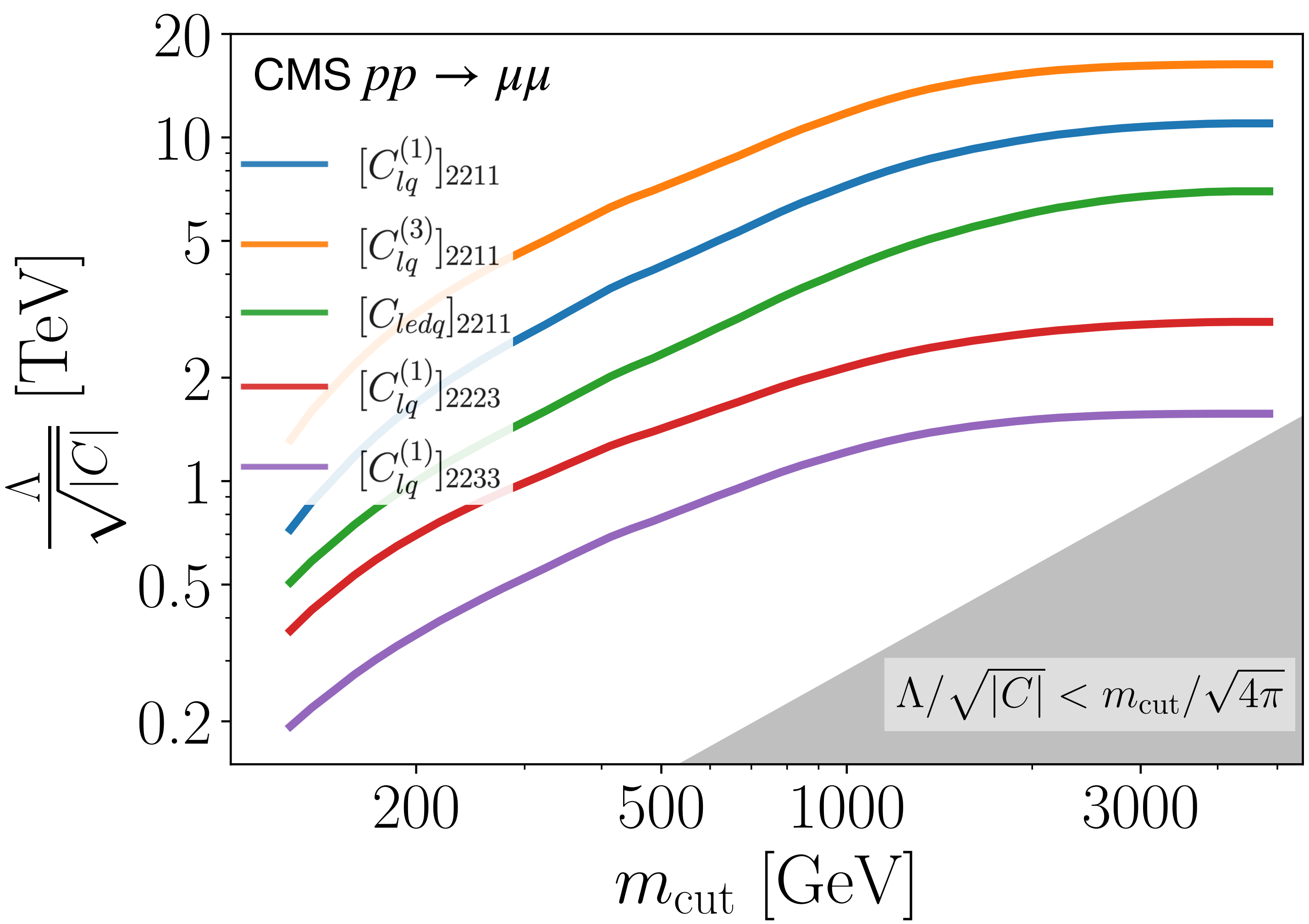
$Q_{lq}^{(1)}$	$(\bar{l}_p\gamma_\mu l_r)(\bar{q}_s\gamma^\mu q_t)$
$Q_{lq}^{(3)}$	$(\bar{l}_p\gamma_\mu\sigma^i l_r)(\bar{q}_s\gamma^\mu\sigma^i q_t)$
Q_{lu}	$(\bar{l}_p\gamma_\mu l_r)(\bar{u}_s\gamma^\mu u_t)$
Q_{ld}	$(\bar{l}_p\gamma_\mu l_r)(\bar{d}_s\gamma^\mu d_t)$
Q_{qe}	$(\bar{q}_p\gamma_\mu q_r)(\bar{e}_s\gamma^\mu e_t)$
Q_{eu}	$(\bar{e}_p\gamma_\mu e_r)(\bar{u}_s\gamma^\mu u_t)$
Q_{ed}	$(\bar{e}_p\gamma_\mu e_r)(\bar{d}_s\gamma^\mu d_t)$
Q_{ledq}	$(\bar{l}_p^j e_r)(\bar{d}_s q_{tj})$
$Q_{lequ}^{(1)}$	$(\bar{l}_p^j e_r)\varepsilon_{jk}(\bar{q}_s^k u_t)$
$Q_{lequ}^{(3)}$	$(\bar{l}_p^j\sigma_{\mu\nu} e_r)\varepsilon_{jk}(\bar{q}_s^k\sigma^{\mu\nu} u_t)$



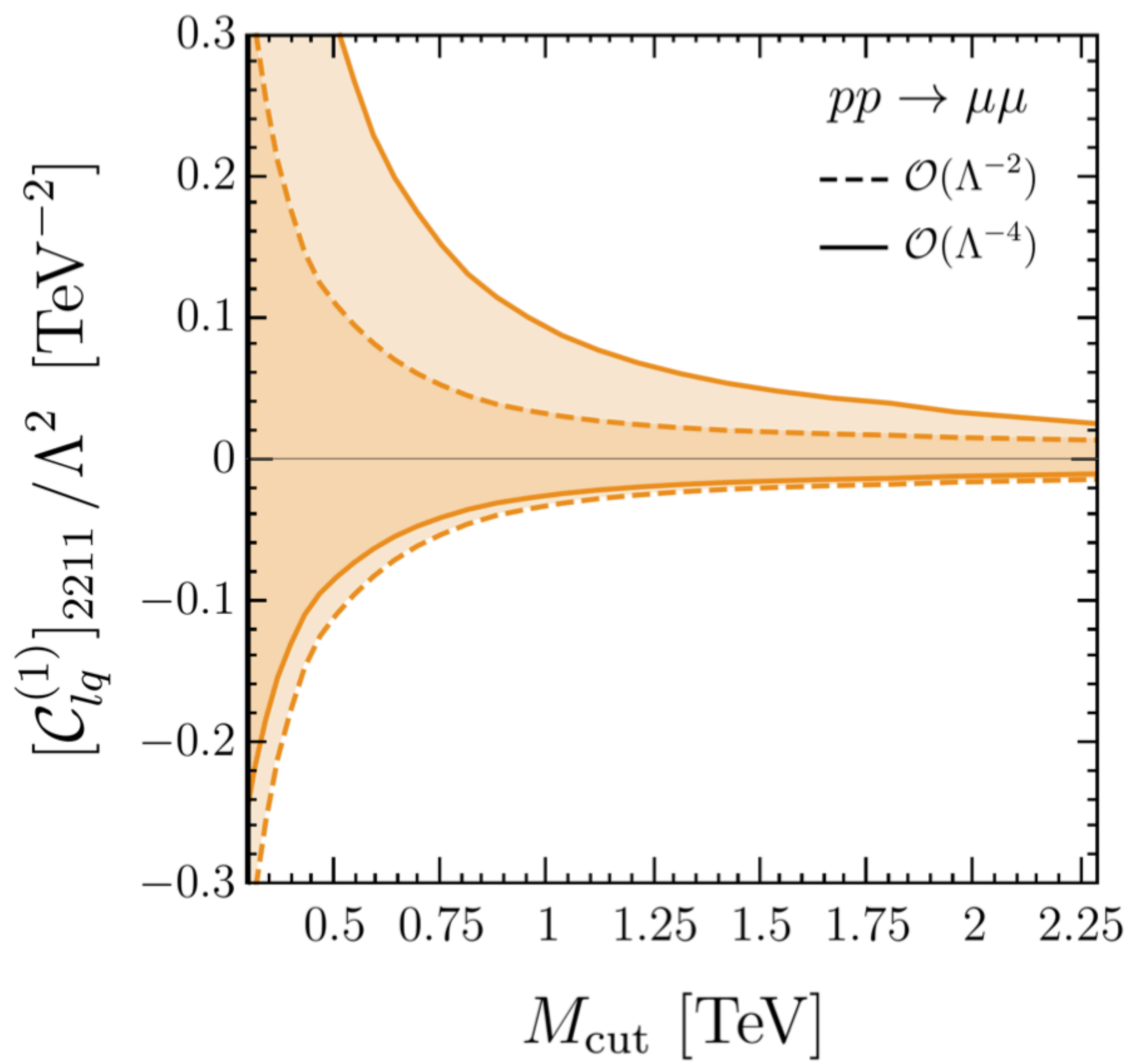
PDF suppression compensated by energy enhancement

Sensitivity of DY to CIs

Bound saturates at bins of ~TeV



Greljo, Salko, AS, Stangl; 2212.10497



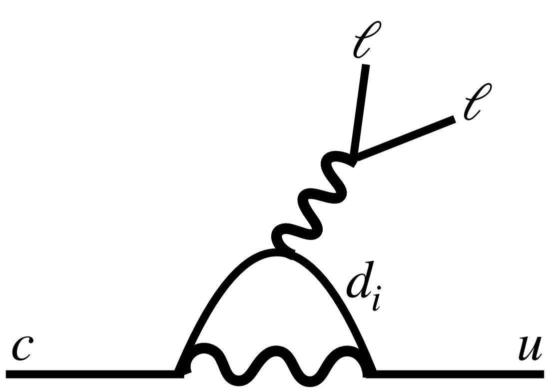
Allwicher, Faroughy, Jaffredo, Sumensari, Wilsch; 2207.10714

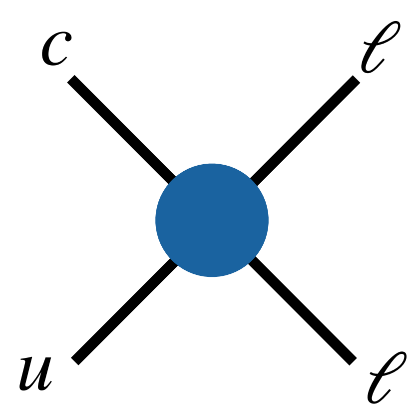
Charm Physics Confronts High-pT Lepton Tails

Fuentes-Martin, Greljo, Camalich, Ruiz-Alvarez; 2003.12421

Rare $c \to u\ell\ell$ decays

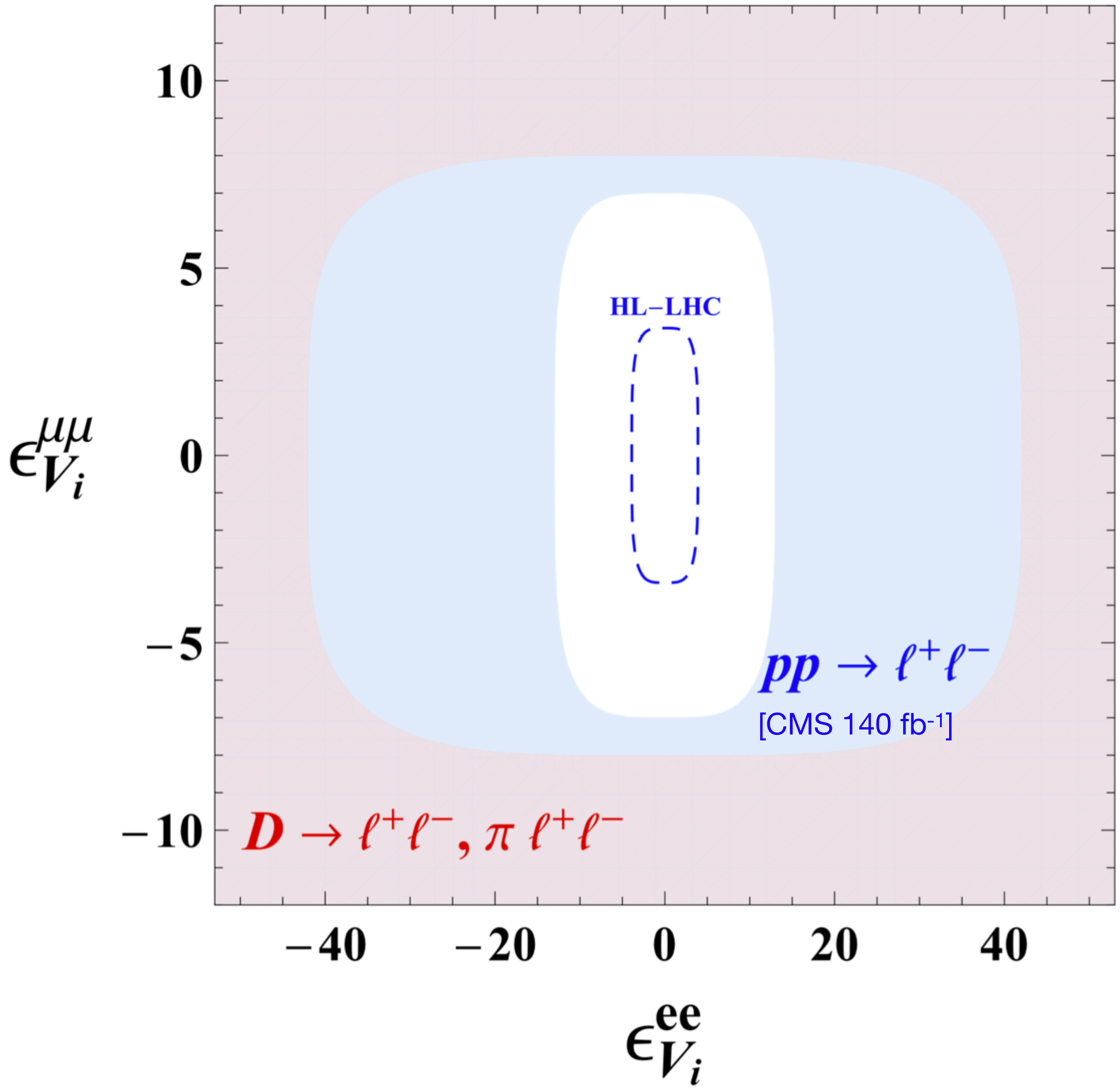
- Efficient GIM suppression
- long-distance dominated





$$\mathscr{L}_{NP}^{\Delta C=1} \approx \frac{\epsilon_V^{\ell\ell}}{(15\mathrm{TeV})^2} \left(\bar{u}\gamma^\mu c\right)\left(\bar{\ell}\gamma_\mu \ell\right)$$

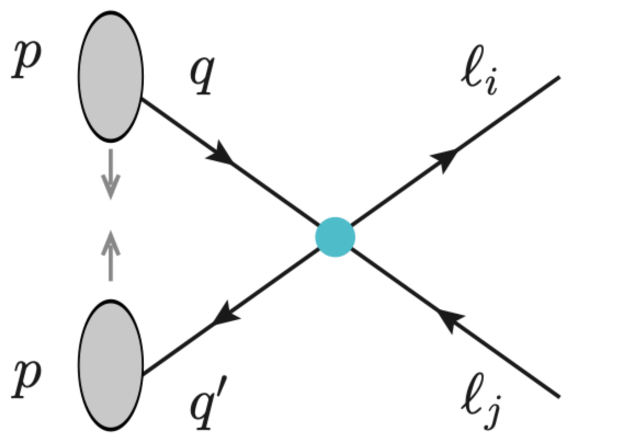
High-mass DY leads to compatible/ stronger constraints

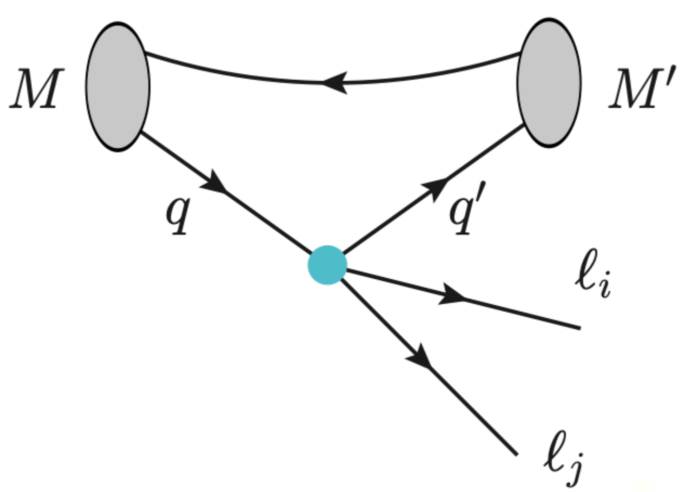


Probing LFV in Meson Decays with LHC Data

Descotes-Genon, Faroughy, Plakias, Sumensari; 2303.07521

Comparing $pp \to \ell_i \ell_j$ (CMS, 140 fb^{-1}) to LFV meson decays





See also 2002.05684

LHC competitive

LHC only constraint

Observable	LHC (140 fb^{-1})	HL-LHC (3 ab^{-1})	Exp. limit
$\mathcal{B}(B^0 \to \mu^\pm\tau^\mp)$	8×10^{-4}	1.7×10^{-4}	1.4×10^{-5}
$\mathcal{B}(B^+ \to \pi^+\mu^\pm\tau^\mp)$	1.1×10^{-4}	2×10^{-5}	9.4×10^{-5}
$\mathcal{B}(B_s \to K_S^0\mu^\pm\tau^\mp)$	4×10^{-5}	8×10^{-6}	–
$\mathcal{B}(B^0 \to \rho\mu^\pm\tau^\mp)$	7×10^{-5}	1.5×10^{-5}	–
$\mathcal{B}(B_s \to \mu^\pm\tau^\mp)$	8×10^{-3}	1.7×10^{-3}	4.2×10^{-5}
$\mathcal{B}(B^+ \to K^+\mu^\pm\tau^\mp)$	9×10^{-4}	1.9×10^{-4}	3.9×10^{-5}
$\mathcal{B}(B^0 \to K^{*0}\mu^\pm\tau^\mp)$	4×10^{-4}	1.0×10^{-4}	–
$\mathcal{B}(B_s \to \phi\mu^\pm\tau^\mp)$	5×10^{-4}	1.0×10^{-4}	–
$\mathcal{B}(B^0 \to e^\pm\tau^\mp)$	1.7×10^{-3}	4×10^{-4}	2.1×10^{-5}
$\mathcal{B}(B^+ \to \pi^+e^\pm\tau^\mp)$	2×10^{-4}	5×10^{-5}	9.8×10^{-5}
$\mathcal{B}(B_s \to K_S e^\pm\tau^\mp)$	8×10^{-5}	1.7×10^{-5}	–
$\mathcal{B}(B^0 \to \rho e^\pm\tau^\mp)$	1.4×10^{-4}	3×10^{-5}	–
$\mathcal{B}(B_s \to e^\pm\tau^\mp)$	1.8×10^{-2}	4×10^{-3}	7.3×10^{-4}
$\mathcal{B}(B^+ \to K^+e^\pm\tau^\mp)$	2×10^{-3}	4×10^{-4}	3.9×10^{-5}
$\mathcal{B}(B^0 \to K^{*0}e^\pm\tau^\mp)$	1.1×10^{-3}	2×10^{-4}	–
$\mathcal{B}(B_s \to \phi e^\pm\tau^\mp)$	1.2×10^{-3}	2×10^{-4}	–

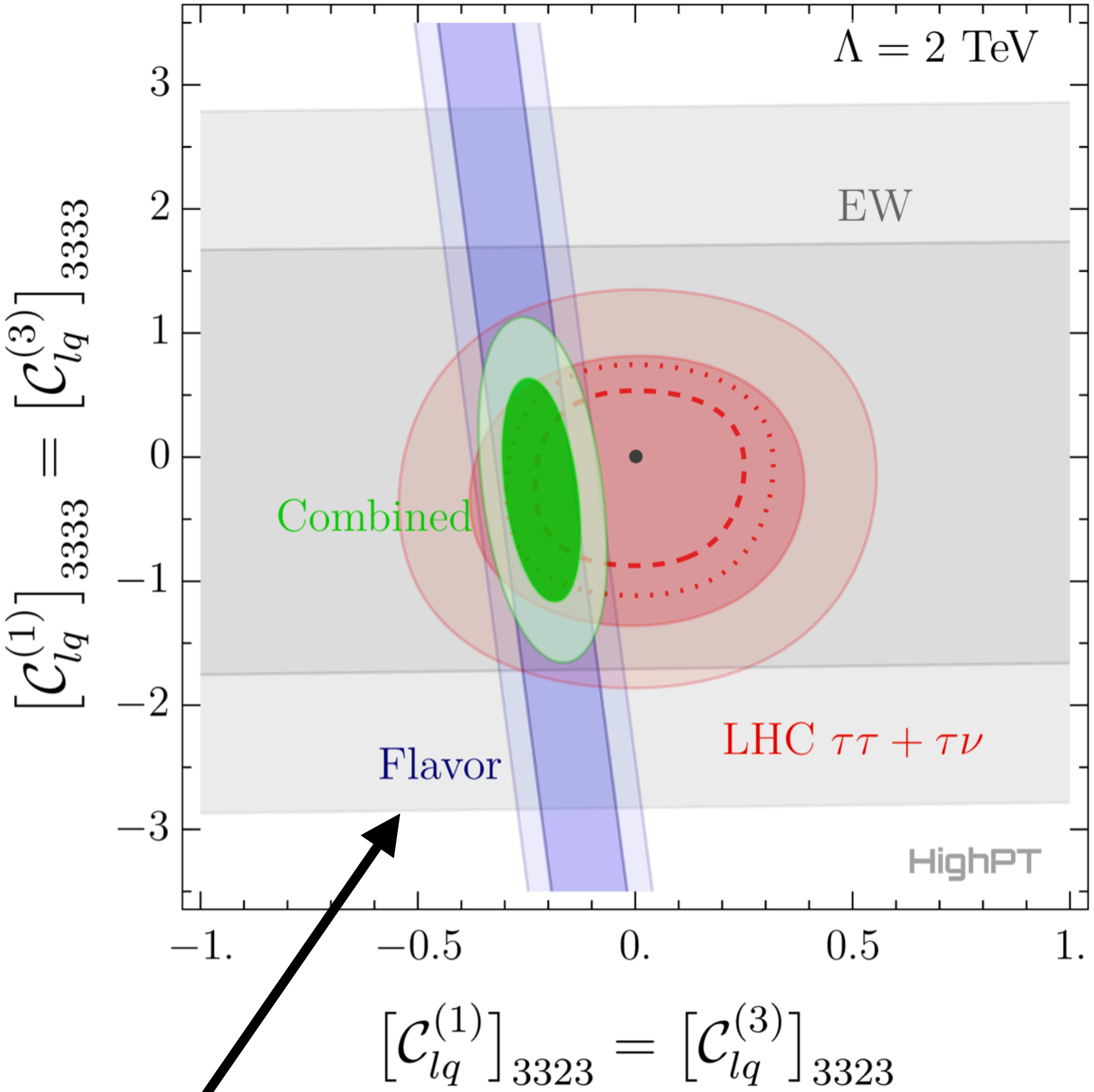
Drell-Yan Tails Beyond the Standard Model

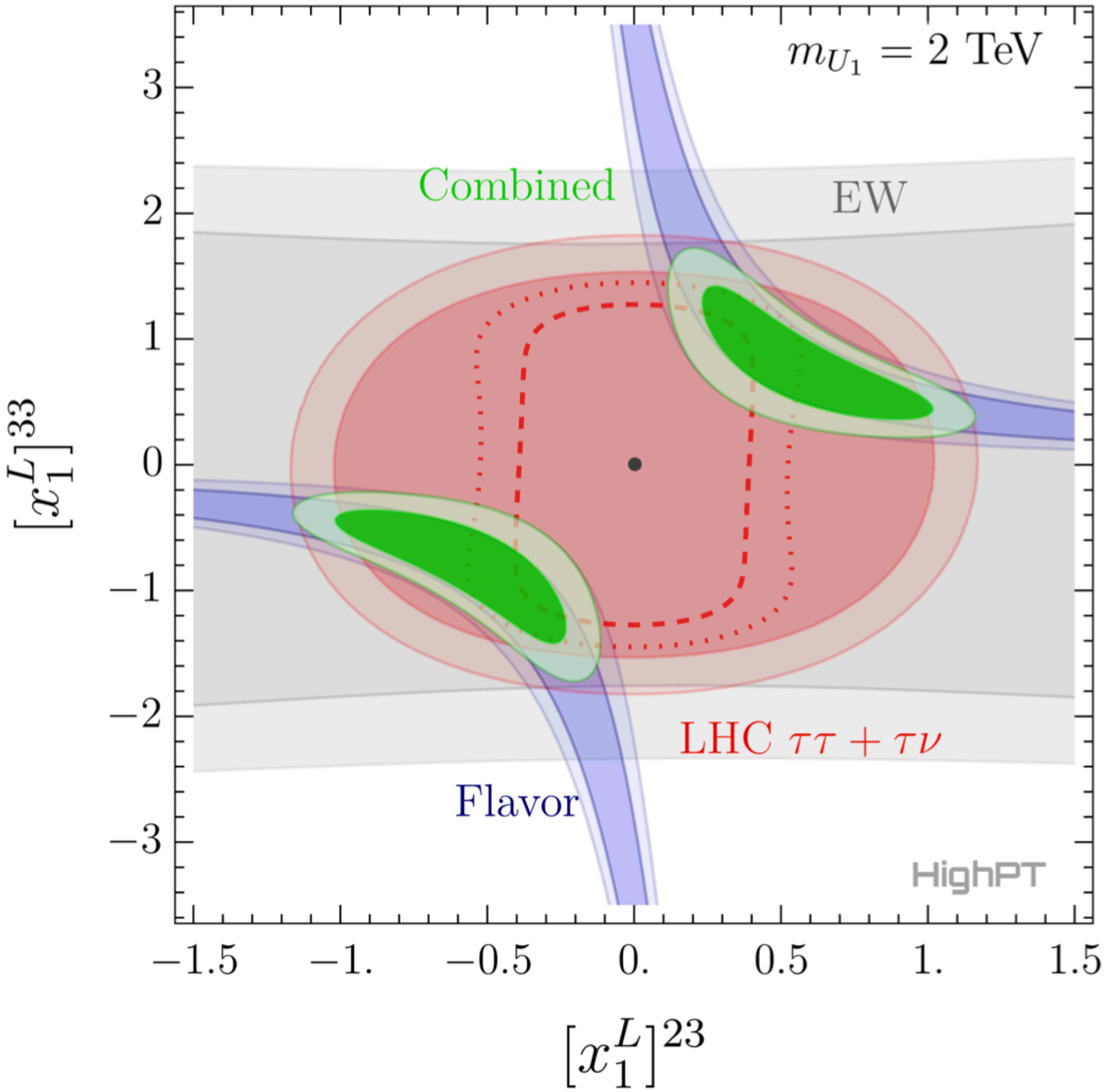
Allwicher, Faroughy, Jaffredo, Sumensari, Wilsch; 2207.10714

Study of $pp \to \ell\ell, \ell\nu$ in SMEFT (up to d=8)
+ concrete UV mediators

See also 1609.07138

$U_1 \sim (\mathbf{3}, \mathbf{1}, 2/3)$





Dominated by $b \to c\tau\nu$

Released HighPT Mathematica package (2207.10756, **github.com/HighPT**)