Standard Model at the LHC 2021

Low Energy and Flavour EFT Probes

— 30 / 04 / 2021 —

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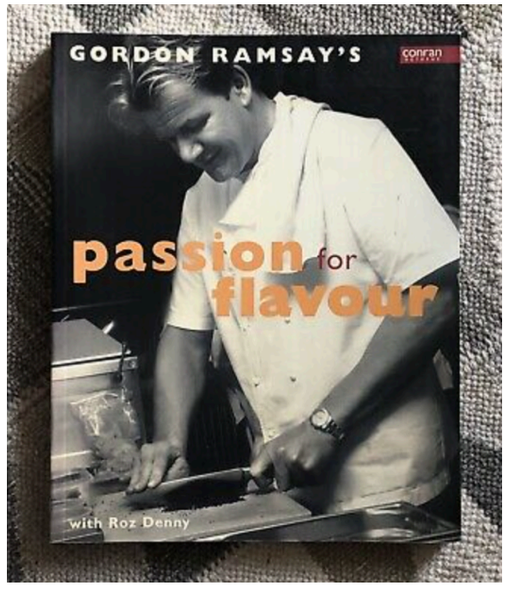
Mainly based on: *Phys.Lett.B 799 (2019) 135062*

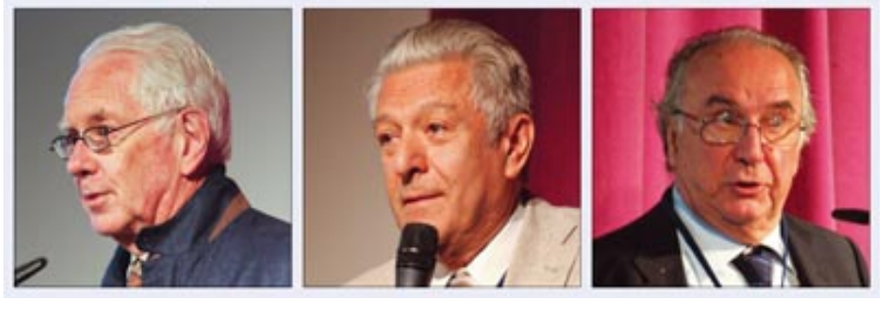
In collaboration with ***Luca Silvestrini***

Why Flavor matters ?



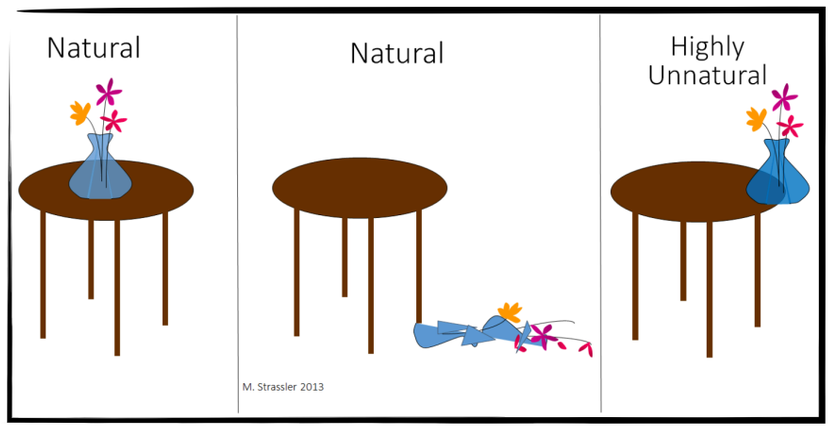
Historically, it lead to “New Physics”!

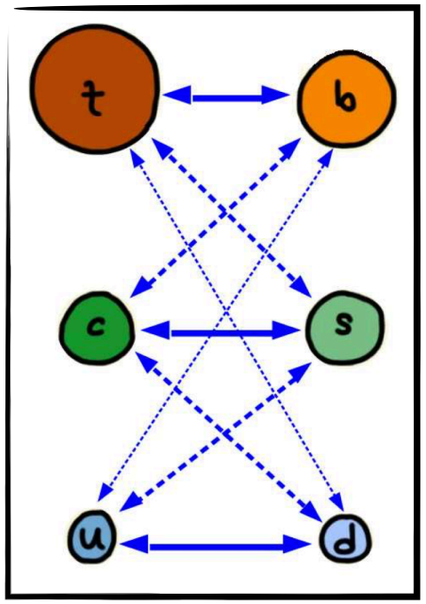
E.g., charm prediction:



Today:

Q: NP @ TeV ?





Flavor: low-energy probes retaining a central role for Physics Beyond the SM (BSM)

UTA : A PRECISION TEST OF THE SM

From Unitarity of the CKM

$$(V^\dagger V)_{db} = 0 \;\leftrightarrow\; \text{apex: } (\bar{\rho}, \bar{\eta})$$

Over-constrained global fit

$$\Delta m_{d,s} \;\leftrightarrow\; B\text{-}\bar{B} \text{ mixing}$$

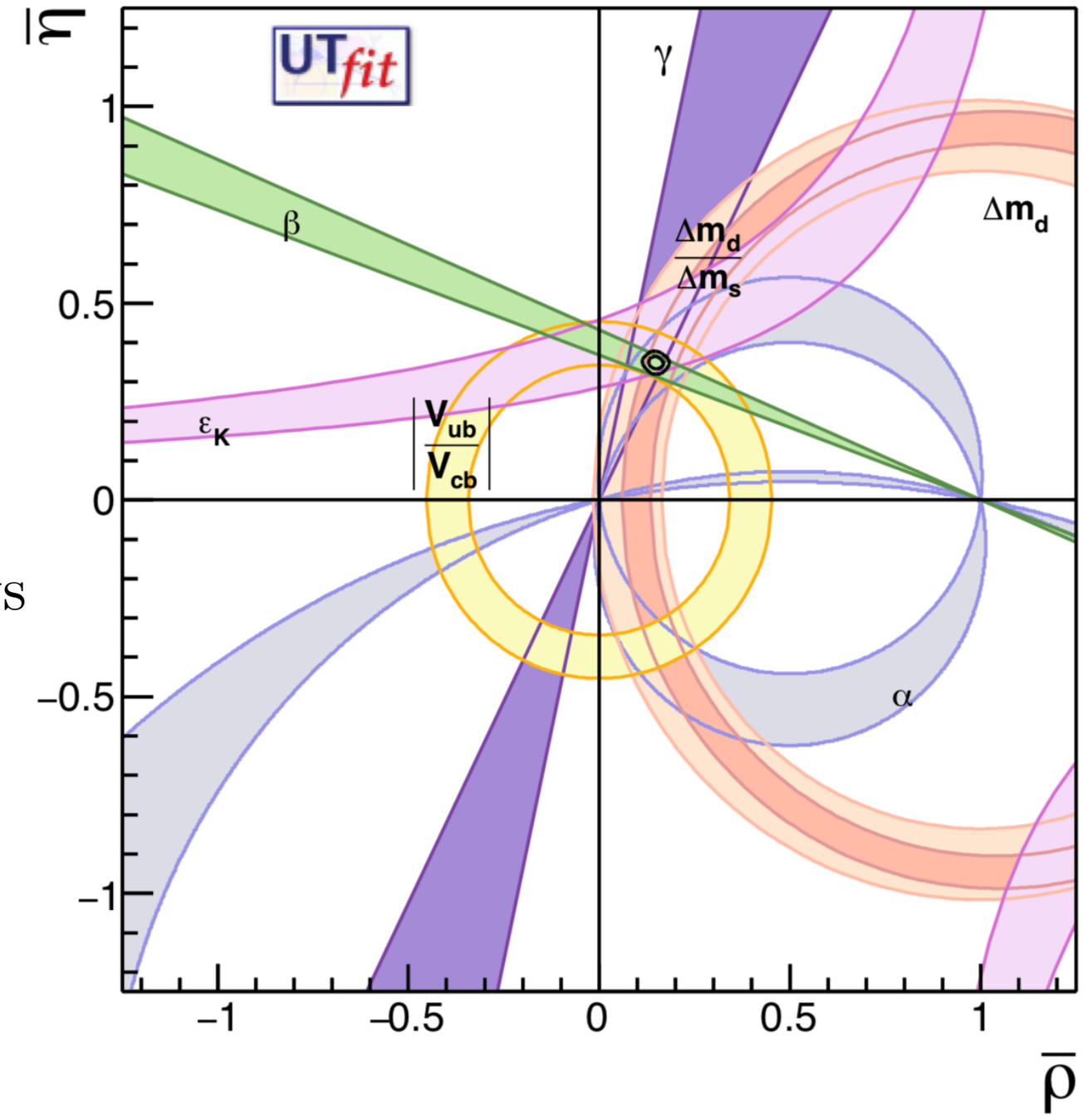
$$\epsilon_K \;\leftrightarrow\; K\text{-}\bar{K} \text{ mixing}$$

$$|V_{ub}/V_{cb}| \;\leftrightarrow\; \text{semileptonic } B \text{ decays}$$

$$\alpha, \beta, \gamma \;\leftrightarrow\; \text{hadronic } B \text{ decays}$$

$$\bar{\rho} = 0.148 \pm 0.013$$
$$\bar{\eta} = 0.348 \pm 0.010$$

http://www.utfit.org/UTfit



No tree-level Flavor-Changing-Neutral-Current processes (FCNCs) in the SM.

$\Delta F = 2$ *: excellent probe of BSM Physics!*

ΔF = 2 AT LOW ENERGY

$$O_1^{q_i q_j} = \bar{q}^{\alpha}_{jL}\gamma_\mu q^{\alpha}_{iL}\ \bar{q}^{\beta}_{jL}\gamma^\mu q^{\beta}_{iL}$$

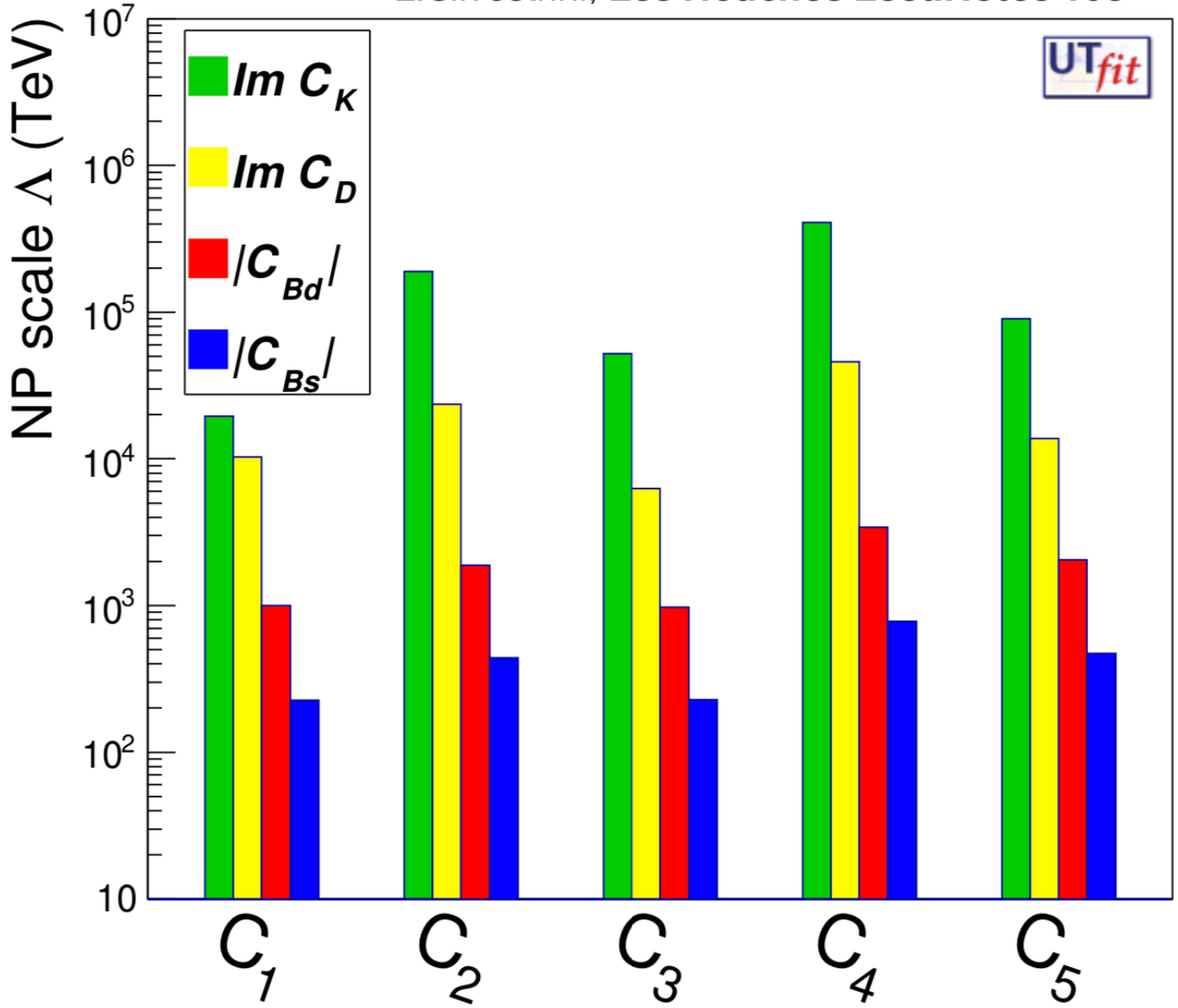
$$O_2^{q_i q_j} = \bar{q}^{\alpha}_{jR} q^{\alpha}_{iL}\ \bar{q}^{\beta}_{jR} q^{\beta}_{iL}$$

$$O_3^{q_i q_j} = \bar{q}^{\alpha}_{jR} q^{\beta}_{iL}\ \bar{q}^{\beta}_{jR} q^{\alpha}_{iL}$$

$$O_4^{q_i q_j} = \bar{q}^{\alpha}_{jR} q^{\alpha}_{iL}\ \bar{q}^{\beta}_{jL} q^{\beta}_{iR}$$

$$O_5^{q_i q_j} = \bar{q}^{\alpha}_{jR} q^{\beta}_{iL}\ \bar{q}^{\beta}_{jL} q^{\alpha}_{iR}$$

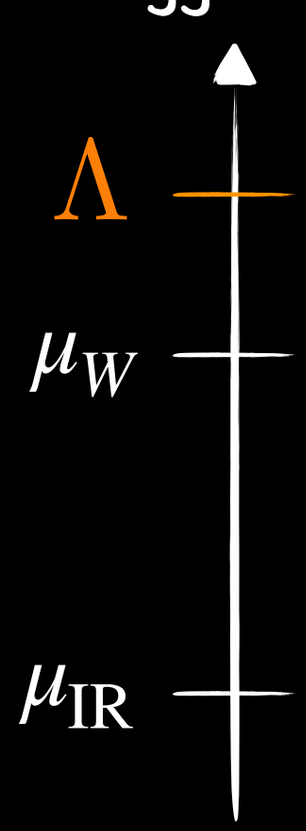
L.Silvestrini, ***Les Houches Lect.Notes 108***



⚠️ **New generic source of flavor / CP violation —> high NP scale**

$\Delta F = 2$ UNDER $SU(2)_L \times U(1)_Y$

ABOVE THE EW SCALE, WE MUST EXPLOIT SM GAUGE SYMMETRY



$\Delta F = 2$ IN THE SMEFT

$$O_{ijij}^{QQ(1)} = \bar{Q}_i \gamma_\mu Q_j \bar{Q}_i \gamma^\mu Q_j$$
$$O_{ijij}^{QQ(3)} = \bar{Q}_i \gamma_\mu \tau^A Q_j \bar{Q}_i \gamma^\mu \tau^A Q_j$$
$$O_{ijij}^{qq} = \bar{q}_i \gamma_\mu q_j \bar{q}_i \gamma^\mu q_j$$
$$O_{ijij}^{Qq(1)} = \bar{Q}_i \gamma_\mu Q_j \bar{q}_i \gamma^\mu q_j$$
$$O_{ijij}^{Qq(8)} = \bar{Q}_i \gamma_\mu T^a Q_j \bar{q}_i \gamma^\mu T^a q_j$$

CAPITAL CASE

$SU(2)_L$ Doublets

LOWER CASE

$SU(2)_L$ singlets

See, e.g.:

J.Aebischer et al.
1512.02830

A.Celis et al.
1704.04504

(q = u, d stands now on for RH fields ; τ^A Pauli matrices ; T^a color ones)

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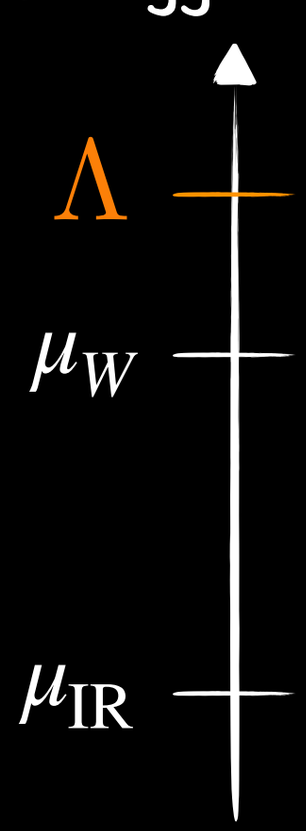

$\Delta F = 2$ MATCHING IN THE SMEFT

$$C_1(\mu_W) = -\left(C^{QQ^{(1)}}(\mu_W) + C^{QQ^{(3)}}(\mu_W)\right)/\Lambda^2$$

$$\tilde{C}_1(\mu_W) = -C^{qq}(\mu_W)/\Lambda^2$$

$$C_4(\mu_W) = C^{Qq^{(8)}}(\mu_W)/\Lambda^2$$

$$C_5(\mu_W) = \left(6C^{Qq^{(1)}}(\mu_W) - C^{Qq^{(8)}}(\mu_W)\right)/(3\Lambda^2)$$

$$\Rightarrow \quad C_2(\mu_W) = \tilde{C}_2(\mu_W) = C_3(\mu_W) = \tilde{C}_3(\mu_W) = 0$$

CAPITAL CASE

$SU(2)_L$ Doublets

LOWER CASE

$SU(2)_L$ singlets

See, e.g.:

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A.Celis et al. 1704.04504

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$\Delta F = 2$ BOUNDS — A modern view

95% BOUNDS $\mathbf{X}$ FROM MESON — ANTI-MESON MIXING AT THE EW SCALE IN $\mathbf{TeV}^{-2}$

		$\mathrm{Re}\,\mathrm{X}_1$	$\mathrm{Im}\,\mathrm{X}_1$	$\mathrm{Re}\,\mathrm{X}_4$	$\mathrm{Im}\,\mathrm{X}_4$	$\mathrm{Re}\,\mathrm{X}_5$	$\mathrm{Im}\,\mathrm{X}_5$
$\square$	$s \leftrightarrow d$	$5.9 \cdot 10^{-7}$	$2.0 \cdot 10^{-9}$	$4.0 \cdot 10^{-9}$	$1.8 \cdot 10^{-11}$	$7.5 \cdot 10^{-8}$	$2.0 \cdot 10^{-10}$
$\diamond$	$c \leftrightarrow u$	$2.5 \cdot 10^{-7}$	$7.5 \cdot 10^{-9}$	$4.2 \cdot 10^{-8}$	$1.3 \cdot 10^{-9}$	$2.5 \cdot 10^{-7}$	$7.7 \cdot 10^{-9}$
$\triangle$	$b \leftrightarrow d$	$9.5 \cdot 10^{-7}$	$8.0 \cdot 10^{-7}$	$2.0 \cdot 10^{-7}$	$1.5 \cdot 10^{-7}$	$5.0 \cdot 10^{-7}$	$4.8 \cdot 10^{-7}$
$\triangledown$	$b \leftrightarrow s$	$2.0 \cdot 10^{-5}$	$6.7 \cdot 10^{-6}$	$5.8 \cdot 10^{-6}$	$2.0 \cdot 10^{-6}$	$1.3 \cdot 10^{-5}$	$4.5 \cdot 10^{-6}$

$$C_{\mathrm{NP}}\ [\mathrm{TeV}^{-2}] \leq \mathrm{X} \quad \Leftrightarrow \quad \Lambda_{\mathrm{NP}}\ [\mathrm{TeV}] \geq 1/\sqrt{\mathrm{X}}$$

ij	$C_{ijij}^{QQ^{(1,3)}}$	C_{ijij}^{dd}	C_{ijij}^{uu}	$C_{ijij}^{Qd^{(1)}}$	$C_{ijij}^{Qd^{(8)}}$	$C_{ijij}^{Qu^{(1)}}$	$C_{ijij}^{Qu^{(8)}}$
12	(Re , Im)	...	...	...	...	...	...
13	...	...	...	...	...	...	...
23	...	...	...	...	...	...	...

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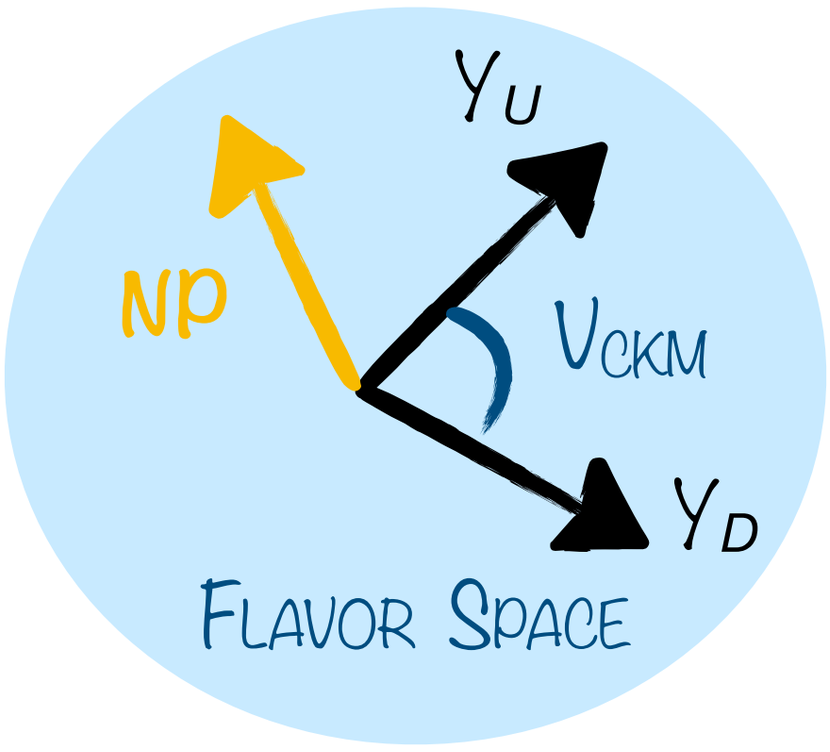
$\Delta F = 2$ BOUNDS — A modern view

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



Q: In which **basis** we are defining NP?

$$\mathcal{L}_{\rm SMEFT} = \mathcal{L}_{\rm SM} + \sum_{i,d>4} \frac{C_i \mathcal{O}_i^{(d)}}{\Lambda_{\rm NP}^{d-4}}$$

Y_D diag $\quad \xleftrightarrow{V_{\rm CKM}} \quad$ Y_U diag

Basis where down-quark Yukawa matrix is diagonal

Basis where up-quark Yukawa matrix is diagonal

Orientation in Flavor space imprints NP phenomenology: *2 extremes at hand.*

Important point, since in the SMEFT up and down sectors are correlated!

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$\Delta F = 2$ BOUNDS — A modern view

Let's take for instance: $O^{QQ}_{1111} = (\bar{Q}_1 \gamma_\mu Q_1)^2$

—> $\Delta F = 0$, still subject to Flavor constraints!

1) If aligned with Y_U : $d_{L,i} \to V_{1j}\, d_{L,j}$ —> $K - \bar{K}$

2) If aligned with Y_D : $u_{1,L} \to V^\dagger_{1j}\, u_{L,j}$ —> $D - \bar{D}$

going to mass basis

$\Lambda^{QQ_{1111}}_{\rm NP} \gtrsim$ 1) 415 TeV

2) 267 TeV

Similar bounds apply also to: $O^{Qu,Qd}_{ijkl}$

Note: **misalignment of NP in Flavor space NOT relevant for right-handed quark operators.**

$O^{uu}_{ijkl} = \bar{u}_i \gamma_\mu u_j \bar{u}_k \gamma^\mu u_l$

well constrained only in 1212

	$C^{QQ(1,3)}_{ijkl}$ [TeV^{-2}]		C^{dd}_{ijkl} [TeV^{-2}]
$ijkl$	Y_D diag	Y_U diag	$Y_{D,U}$ diag
1111	$5.8^{\diamond}\ 10^{-6}$	$1.4^{\square}\ 10^{-5}$	∅
1112	$(7.0^{\diamond}, 0.19^{\diamond})\ 10^{-7}$	$(17^{\square}, 0.051^{\square})\ 10^{-7}$	$(3.2^{\square}, 1.3^{\square})\ 10^{-3}$
1113	$(15^{\diamond}, 0.44^{\diamond})\ 10^{-6}$	$(39^{\triangle}, 0.12^{\square})\ 10^{-6}$	$(1.4^{\triangle}, 1.2^{\triangle})$
1122	$2.9^{\diamond}\ 10^{-6}$	$6.8^{\square}\ 10^{-6}$	∅
1123	$(5.6^{\diamond}, 2.3^{\diamond})\ 10^{-6}$	$(1.5^{\square}, 3.4^{\square})\ 10^{-6}$	(∅, ∅)
1133	$1.3^{\diamond}\ 10^{-4}$	$3.6^{\square}\ 10^{-5}$	∅
1212	$(31^{\diamond}, 0.22^{\square})\ 10^{-8}$	$(28^{\diamond}, 0.25^{\square})\ 10^{-8}$	$(65^{\square}, 0.22^{\square})\ 10^{-8}$
1213	$(3.5^{\diamond}, 0.1^{\diamond})\ 10^{-6}$	$(15^{\square}, 0.3^{\square})\ 10^{-7}$	$(16^{\square}, 0.3^{\square})\ 10^{-4}$
1221	$2.9^{\diamond}\ 10^{-6}$	$6.8^{\square}\ 10^{-6}$	∅
1222	$(7.0^{\diamond}, 0.19^{\diamond})\ 10^{-7}$	$(17^{\square}, 0.05^{\square})\ 10^{-7}$	$(3.2^{\square}, 1.3^{\square})\ 10^{-3}$
1223	$(15^{\diamond}, 0.44^{\diamond})\ 10^{-6}$	$(39^{\diamond}, 0.12^{\diamond})\ 10^{-6}$	(∅, ∅)
1231	$(5.6^{\diamond}, 2.3^{\diamond})\ 10^{-6}$	$(1.5^{\square}, 3.4^{\square})\ 10^{-6}$	(∅, ∅)
1232	$(1.3^{\diamond}, 2.2^{\diamond})\ 10^{-6}$	$(3.7^{\square}, 1.4^{\square})\ 10^{-7}$	$(7.2^{\square}, 2.9^{\square})\ 10^{-3}$
1233	$(3.1^{\diamond}, 6.2^{\diamond})\ 10^{-5}$	$(8.9^{\square}, 3.4^{\square})\ 10^{-6}$	(∅, ∅)
1313	$(1.1^{\triangle}, 0.90^{\triangle})\ 10^{-6}$	$(1.1^{\triangle}, 0.95^{\triangle})\ 10^{-6}$	$(1.0^{\triangle}, 0.88^{\triangle})\ 10^{-6}$
1322	$(15^{\diamond}, 0.44^{\diamond})\ 10^{-6}$	$(39^{\diamond}, 0.12^{\diamond})\ 10^{-6}$	(∅, ∅)
1323	$(3.3^{\diamond}, 0.1^{\diamond})\ 10^{-4}$	$(2.4^{\triangle}, 2.1^{\triangle})\ 10^{-6}$	$(6.3^{\triangle}, 5.3^{\triangle})\ 10^{-1}$
1331	$1.3^{\diamond}\ 10^{-4}$	$3.6^{\square}\ 10^{-5}$	∅
1332	$(3.1^{\diamond}, 6.2^{\diamond})\ 10^{-5}$	$(8.9^{\square}, 3.4^{\square})\ 10^{-6}$	(∅, ∅)
1333	$(6.7^{\diamond}, 15^{\diamond})\ 10^{-4}$	$(6.9^{\triangle}, 5.8^{\triangle})\ 10^{-5}$	$(1.4^{\triangle}, 1.2^{\triangle})$
2222	$5.8^{\diamond}\ 10^{-6}$	$1.4^{\square}\ 10^{-5}$	∅
2223	$(5.7^{\diamond}, 2.3^{\diamond})\ 10^{-6}$	$(1.5^{\square}, 3.4^{\square})\ 10^{-6}$	$(3.0^{\triangledown}, 0.98^{\triangledown})\ 10^{-1}$
2233	$1.3^{\diamond}\ 10^{-4}$	$3.6^{\square}\ 10^{-5}$	∅
2323	$(2.2^{\triangledown}, 0.75^{\triangledown})\ 10^{-5}$	$(2.1^{\triangle}, 0.80^{\triangle})\ 10^{-5}$	$(2.2^{\triangledown}, 0.74^{\triangledown})\ 10^{-5}$
2332	$1.3^{\diamond}\ 10^{-4}$	$3.6^{\square}\ 10^{-5}$	∅
2333	$(2.2^{\diamond}, 2.8^{\diamond})\ 10^{-3}$	$(2.8^{\triangledown}, 0.94^{\triangledown})\ 10^{-4}$	$(3.0^{\triangledown}, 0.98^{\triangledown})\ 10^{-1}$
3333	$4.2^{\diamond}\ 10^{-1}$	$1.3^{\triangledown}\ 10^{-2}$	∅

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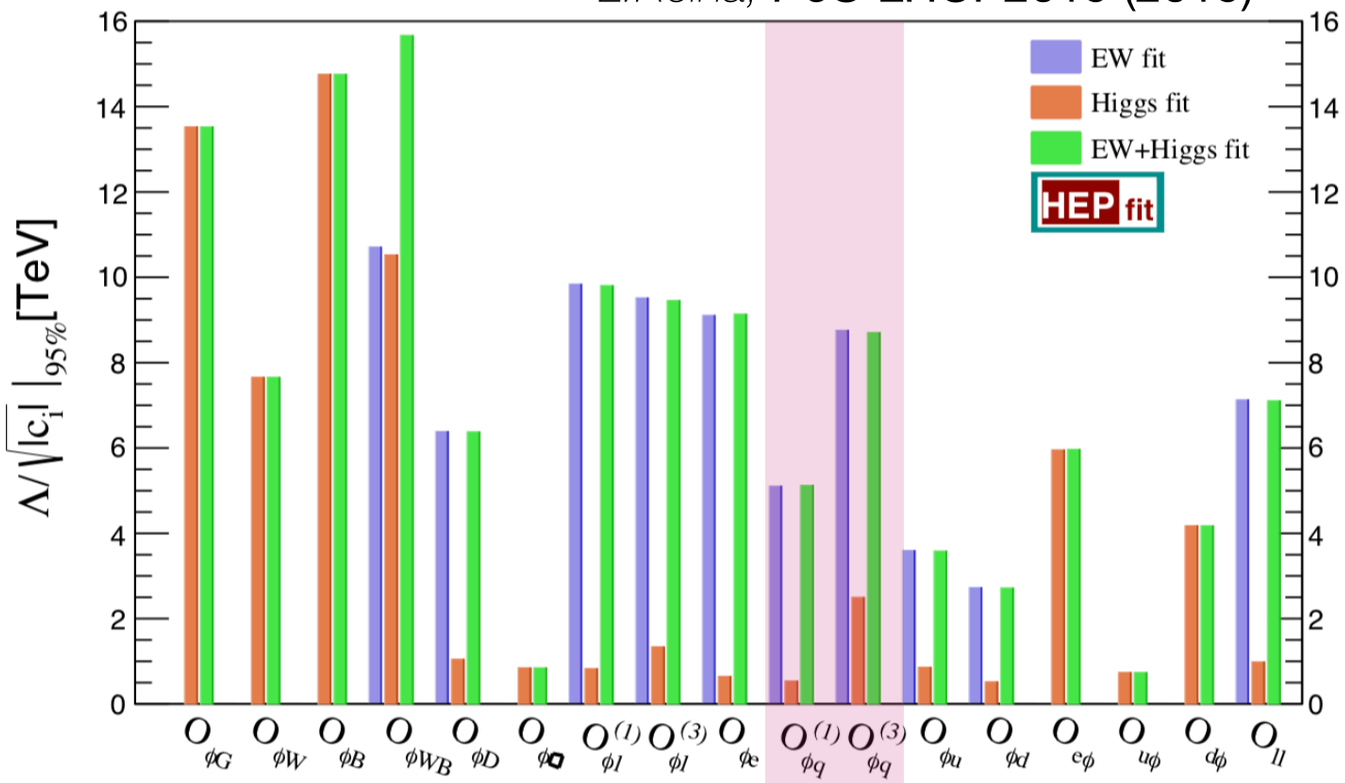
$\Delta F = 2$ BOUNDS — RGE driven ones

ij	$C_{ij}^{HQ^{(1,3)}}$ [TeV^{-2}] Y_D diag	Y_U diag
11	$\varnothing$	$4.1^{\square}\ 10^{-3}$
12	$(8.9^{\square}, 3.8^{\square})\ 10^{-4}$	$(9.9^{\square}, 3.8^{\square})\ 10^{-4}$
13	$(7.4^{\triangle}, 6.3^{\triangle})\ 10^{-3}$	$(7.6^{\triangle}, 6.4^{\triangle})\ 10^{-3}$
22	$\varnothing$	$4.1^{\square}\ 10^{-3}$
23	$(3.0^{\triangledown}, 1.0^{\triangledown})\ 10^{-2}$	$(3.1^{\triangledown}, 1.0^{\triangledown})\ 10^{-2}$
33	$\varnothing$	$7.3^{\triangle}\ 10^{-1}$

$\Rightarrow\ \Lambda_{\rm NP} \gtrsim 15$ TeV

$ijkl$	C_{ijkl}^{LeQu} [TeV^{-2}] Y_D diag	C_{ijkl}^{LedQ} [TeV^{-2}] Y_U diag
2221	$(5.1^{\diamond}, 1.6^{\diamond})\ 10^{-1}$	$(4.2^{\square}, 0.13^{\square})\ 10^{-1}$
2222	$(22^{\diamond}, 6.8^{\diamond})\ 10^{-1}$	$(18^{\square}, 0.58^{\square})\ 10^{-1}$
2223	$(\varnothing, \varnothing)$	$(4.3^{\square}, 1.6^{\square})$
3321	$(3.0^{\diamond}, 0.93^{\diamond})\ 10^{-2}$	$(24^{\square}, 0.8^{\square})\ 10^{-3}$
3322	$(1.3^{\diamond}, 0.4^{\diamond})\ 10^{-1}$	$(10^{\square}, 0.34^{\square})\ 10^{-2}$
3323	$(3.1^{\diamond}, 3.6^{\diamond})$	$(2.5^{\square}, 0.9^{\square})\ 10^{-1}$
3331	$(\varnothing, 9.5^{\diamond})$	$(8.5^{\triangle}, 11^{\triangle})$
3332	$(\varnothing, \varnothing)$	$(\varnothing, 8.9^{\triangledown})$

L.Reina, ***PoS*** LHCP2019 (2019)



$$O_{ijkl}^{LeQu} \equiv \bar{L}_i e_j \epsilon\, \bar{Q}_k u_l$$

mixes into ΔF = 2 operators in the up sector via $Y_U\ Y_L$ —> constraints from D-$\overline{\rm D}$

$$O_{ijkl}^{LedQ} \equiv \bar{L}_i e_j \bar{d}_k Q_l$$

mixes into ΔF = 2 operators in the down sector via $Y_D\ Y_L$ —> bounds from K-$\overline{\rm K}$ & B-$\overline{\rm B}$

Also, extensive compilation of RGE-driven bounds for: $O_{ijkl}^{ud^{1[8]}} = \bar{u}_i \gamma_\mu [T^a] u_j\, \bar{d}_k \gamma^\mu [T^a] d_l$, $O_{ijkl}^{QuQd^{1[8]}} = \bar{Q}_i \gamma_\mu [T^a] u_j\, \epsilon\, \bar{Q}_k \gamma^\mu [T^a] d_l$

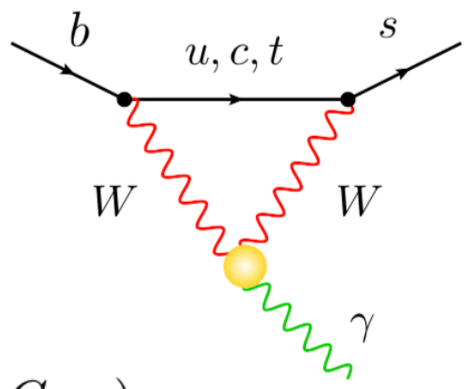
Beyond $\Delta F = 2$ — A couple of examples

Anomalous Triple Gauge Couplings

$$O_{\phi B} = (D_\mu \phi)^\dagger \, \hat{B}^{\mu\nu} \, (D_\nu \phi) \, ,$$

$$O_{\phi W} = (D_\mu \phi)^\dagger \, \hat{W}^{\mu\nu} \, (D_\nu \phi)$$

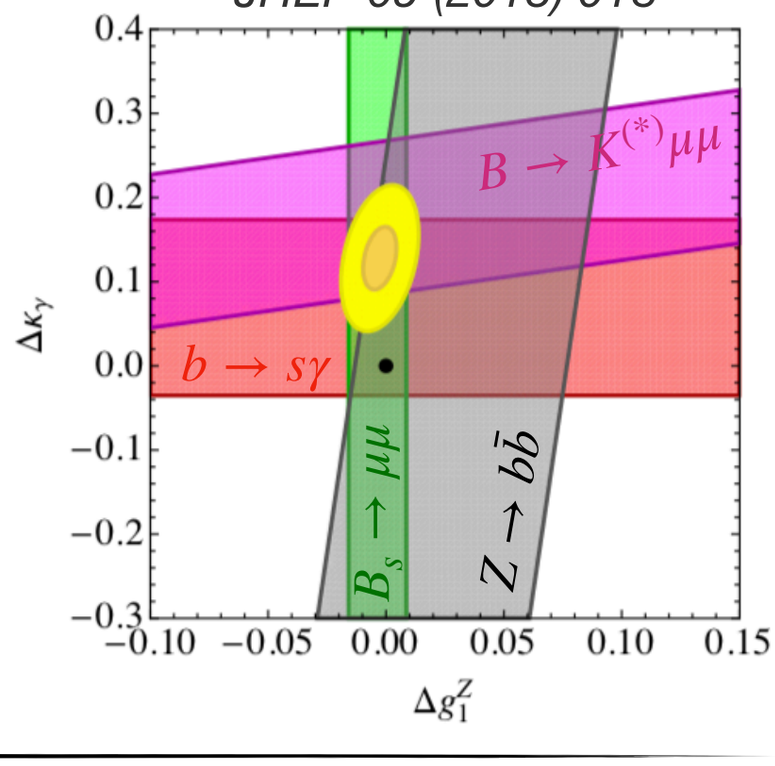
$$\Delta g_1^Z = \frac{m_Z^2}{2\Lambda^2} C_{\phi W} \, , \qquad \Delta \kappa_\gamma = \frac{m_W^2}{2\Lambda^2} (C_{\phi B} + C_{\phi W})$$



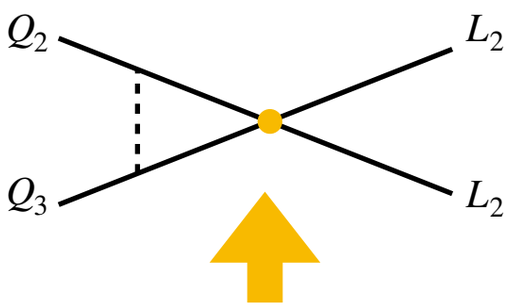
—> $\Delta B = 1$ can be competitive with LEP + LHC

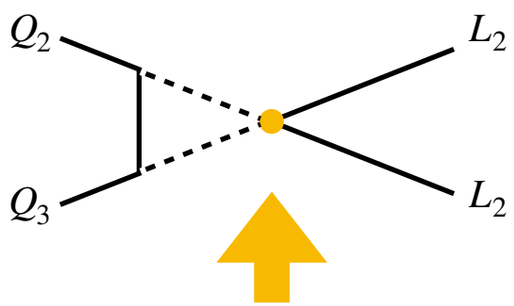
(see, e.g., *JHEP* 02 (2017) 115)

JHEP 09 (2015) 018



B anomalies in FCNCs

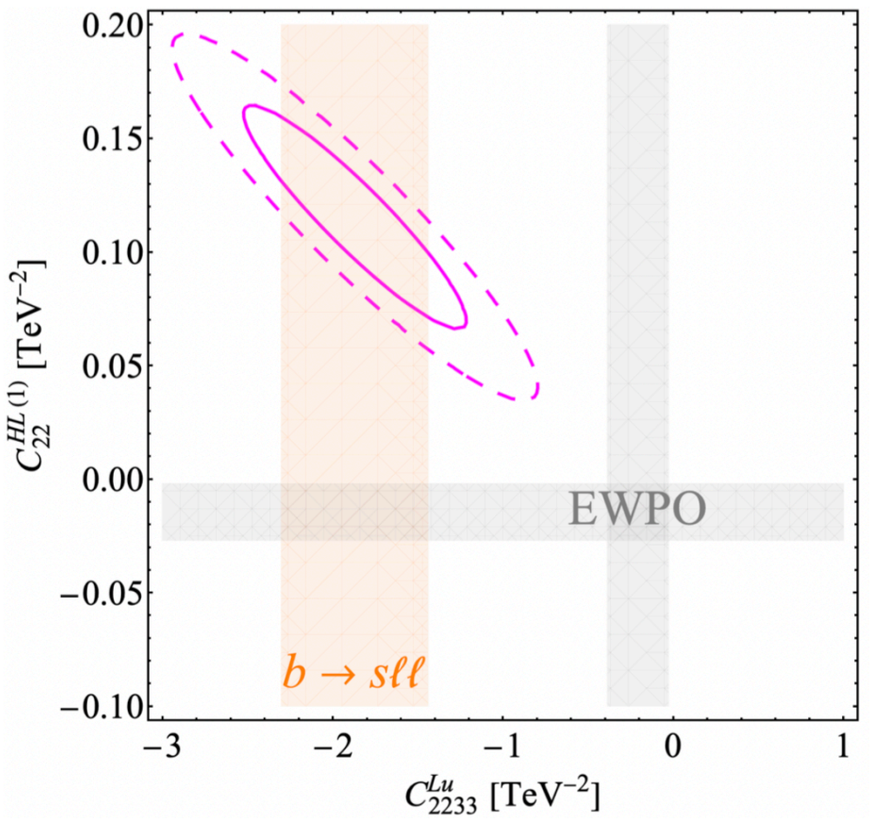




$$O^{Lu}_{2233} = \bar{L}_2 \gamma^\mu L_2 \, \bar{u}_3 \gamma_\mu u_3$$

$$O^{HL\,(1)}_{22} = H^\dagger i \overleftrightarrow{D}_\mu H \, \bar{L}_2 \gamma^\mu L_2$$

Interplay of Flavor & EW precision for a resolution of *B* anomalies @ TeV, see *JHEP* 12 (2020) 016



SMEFT: A FLAVORFUL SUMMARY

Key results from *Phys.Lett.B 799 (2019) 135062* *(arXiv:1812.10913)*

SMEFT RGE

$\boldsymbol{O_{jk}^{HQ^{(1[3])}}}$ $\left(H^\dagger i \overset{\leftrightarrow}{D}_\mu^{[A]} H\right)\left(\bar{Q}_j \gamma^\mu \left[\tau^A\right] Q_k\right)$	$\boldsymbol{O_{jjkl}^{LedQ}}$ $\left(\bar{L}_j e_j\right)\left(\bar{d}_k Q_l\right)$	$\boldsymbol{O_{jjkl}^{LeQu}}$ $\left(\bar{L}_j e_j\right) i\tau^2 \left(\bar{Q}_k u_l\right)$	$\boldsymbol{O^{ud_{jklm}^{(1[8])}}}$ $\left(\bar{u}_j \gamma_\mu [T^a] u_k\right)\left(\bar{d}_l \gamma^\mu [T^a] d_m\right)$	$\boldsymbol{O_{jklm}^{QuQd^{(1[8])}}}$ $\left(\bar{Q}_j \gamma_\mu [T^a] u_k\right) i\tau^2 \left(\bar{Q}_l \gamma^\mu [T^a] d_m\right)$
$\boldsymbol{O_{jklm}^{QQ^{(1[3])}}}$ $\left(\bar{Q}_j \gamma_\mu [\tau^A] Q_k\right)\left(\bar{Q}_l \gamma^\mu [\tau^A] Q_m\right)$	$\boldsymbol{O_{jklm}^{uu}}$ $\left(\bar{u}_j \gamma_\mu u_k\right)\left(\bar{u}_l \gamma^\mu u_m\right)$	$\boldsymbol{O_{jklm}^{dd}}$ $\left(\bar{d}_j \gamma_\mu d_k\right)\left(\bar{d}_l \gamma^\mu d_m\right)$	$\boldsymbol{O_{jklm}^{Qd^{(1[8])}}}$ $\left(\bar{Q}_j \gamma_\mu [T^a] Q_k\right)\left(\bar{d}_l \gamma^\mu [T^a] d_m\right)$	$\boldsymbol{O_{jklm}^{Qu^{(1[8])}}}$ $\left(\bar{Q}_j \gamma_\mu [T^a] Q_k\right)\left(\bar{u}_l \gamma^\mu [T^a] u_m\right)$

poorly constrained

FLAVOR MISALIGNMENT

—> beyond first leading-log analysis: *JHEP 12 (2020) 187* *(arXiv:2009.07276)*

Interesting future directions ahead:

- IMPACT OF OTHER FLAVOR MEASUREMENTS (e.g., ΔF = 1 FCNCs)
- ROLE OF SYMMETRIES IN FLAVOR SPACE <—> FLAVOR PROBLEM
- INTERPLAY WITH HIGH-ENERGY PROBES <—> EW NATURALNESS

BACK-UP

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$\Delta F = 2$ BOUNDS — Other bounds from misalignment

Along the same line, also remaining 4-quark operators are generally well probed by $\Delta F = 2$!

$$O_{ijkl}^{Qd^{(1,8)}}, O_{ijkl}^{Qu^{(1,8)}}$$

Strongest non-trivial bounds:

$$\Lambda_{\rm NP}^{\Delta F=1} \gtrsim 10^4 \text{ TeV}$$
$$\Lambda_{\rm NP}^{\Delta F=0} \gtrsim 10^2 \text{ TeV}$$

	$C_{ijkl}^{Qd^{(1)}}$ [TeV^{-2}]		$C_{ijkl}^{Qd^{(8)}}$ [TeV^{-2}]		$C_{ijkl}^{Qu^{(1)}}$ [TeV^{-2}]		$C_{ijkl}^{Qu^{(8)}}$ [TeV^{-2}]	
$ijkl$	Y_D diag	Y_U diag	Y_D diag	Y_U diag	Y_D diag	Y_U diag	Y_D diag	Y_U diag
1111	$11^{\square}$	$8.2^{\square}\ 10^{-4}$	$3.3^{\square}$	$1.7^{\square}\ 10^{-4}$	$3.7^{\diamond}\ 10^{-1}$	∅	$2.2^{\diamond}$	∅
1112	$(1.9^{\square}, 0.81^{\square})\ 10^{-5}$	$(64^{\square}, 0.29^{\square})\ 10^{-9}$	$(5.5^{\square}, 2.3^{\square})\ 10^{-6}$	$(14^{\square}, 0.062^{\square})\ 10^{-9}$	$(6.0^{\diamond}, 0.18^{\diamond})\ 10^{-7}$	$(5.0^{\diamond}, 4.9^{\diamond})$	$(14^{\diamond}, 0.45^{\diamond})\ 10^{-8}$	$(1.4^{\diamond}, 1.4^{\diamond})$
1113	$(2.2^{\triangle}, 2.1^{\triangle})\ 10^{-3}$	$(7.7^{\triangle}, 0.77^{\square})\ 10^{-5}$	$(1.1^{\triangle}, 0.81^{\triangle})\ 10^{-3}$	$(3.4^{\triangle}, 0.16^{\square})\ 10^{-5}$	$(3.9^{\diamond}, 0.12^{\diamond})\ 10^{-2}$	$(\varnothing, 1.8^{\square})$	$(24^{\diamond}, 0.74^{\diamond})\ 10^{-2}$	$(\varnothing, 5.5^{\square})$
1122	$12^{\square}$	$8.2^{\square}\ 10^{-4}$	$3.3^{\square}$	$1.7^{\square}\ 10^{-4}$	$1.9^{\diamond}\ 10^{-1}$	∅	$1.4^{\diamond}\ 10^{-1}$	∅
1123	$(\varnothing, \varnothing)$	$(1.9^{\square}, 0.75^{\square})\ 10^{-3}$	$(7.4^{\square}, 7.4^{\square})$	$(4.0^{\square}, 1.6^{\square})\ 10^{-4}$	$(7.9^{\diamond}, 6.5^{\diamond})\ 10^{-3}$	$(4.8^{\square}, 11^{\square})\ 10^{-2}$	$(5.9^{\diamond}, 4.9^{\diamond})\ 10^{-3}$	$(1.4^{\square}, 3.2^{\square})\ 10^{-1}$
1133	∅	∅	∅	$10^{\square}$	∅	$4.1^{\square}\ 10^{-3}$	∅	$1.2^{\square}\ 10^{-2}$
1211	$(1.8^{\square}, 0.76^{\square})\ 10^{-4}$	$(2.0^{\square}, 0.76^{\square})\ 10^{-4}$	$(3.8^{\square}, 1.6^{\square})\ 10^{-5}$	$(4.3^{\square}, 1.6^{\square})\ 10^{-5}$	$(9.1^{\diamond}, 2.5^{\diamond})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(5.4^{\diamond}, 1.5^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$
1212	$(140^{\square}, 0.63^{\square})\ 10^{-10}$	$(150^{\square}, 0.67^{\square})\ 10^{-10}$	$(30^{\square}, 0.14^{\square})\ 10^{-10}$	$(32^{\square}, 0.14^{\square})\ 10^{-10}$	$(14^{\diamond}, 0.43^{\diamond})\ 10^{-8}$	$(13^{\diamond}, 0.40^{\diamond})\ 10^{-8}$	$(3.3^{\diamond}, 0.1^{\diamond})\ 10^{-8}$	$(32^{\diamond}, 0.98^{\diamond})\ 10^{-9}$
1213	$(9.2^{\square}, 0.17^{\square})\ 10^{-5}$	$(6.4^{\triangle}, 1.8^{\square})\ 10^{-6}$	$(20^{\square}, 0.36^{\square})\ 10^{-6}$	$(36^{\triangle}, 3.8^{\triangle})\ 10^{-7}$	$(9.1^{\diamond}, 0.28^{\diamond})\ 10^{-3}$	$(\varnothing, 4.4^{\diamond})\ 10^{-1}$	$(5.5^{\diamond}, 0.17^{\diamond})\ 10^{-2}$	$(\varnothing, 5.2^{\diamond})\ 10^{-1}$
1221	$(1.2^{\square}, 1.2^{\square})$	$(28^{\square}, 0.13^{\square})\ 10^{-8}$	$(2.5^{\square}, 2.7^{\square})\ 10^{-1}$	$(60^{\square}, 0.27^{\square})\ 10^{-9}$	$(26^{\diamond}, 0.8^{\square})\ 10^{-7}$	$(\varnothing, \varnothing)$	$(6.2^{\diamond}, 0.19^{\diamond})\ 10^{-7}$	$(\varnothing, \varnothing)$
1222	$(1.8^{\square}, 0.76^{\square})\ 10^{-4}$	$(2.0^{\square}, 0.77^{\square})\ 10^{-4}$	$(3.9^{\square}, 1.6^{\square})\ 10^{-5}$	$(4.3^{\square}, 1.6^{\square})\ 10^{-5}$	$(4.5^{\diamond}, 1.3^{\diamond})\ 10^{-2}$	$(\varnothing, 4.5^{\diamond})\ 10^{-2}$	$(3.4^{\diamond}, 0.95^{\diamond})\ 10^{-2}$	$(\varnothing, 1.3^{\diamond})\ 10^{-1}$
1223	$(4.6^{\square}, 2.1^{\square})$	$(7.3^{\triangledown}, 2.5^{\triangledown})\ 10^{-4}$	$(9.8^{\square}, 4.4^{\square})\ 10^{-1}$	$(4.6^{\triangledown}, 1.6^{\triangledown})\ 10^{-4}$	$(3.4^{\diamond}, 2.8^{\diamond})\ 10^{-2}$	$(120^{\square}, 0.38^{\square})\ 10^{-2}$	$(2.6^{\diamond}, 2.1^{\diamond})\ 10^{-2}$	$(37^{\square}, 0.11^{\square})\ 10^{-1}$
1231	$(\varnothing, \varnothing)$	$(3.3^{\triangle}, 0.33^{\square})\ 10^{-4}$	$(\varnothing, \varnothing)$	$(15^{\triangle}, 0.71^{\square})\ 10^{-5}$	$(4.8^{\square}, 0.53^{\diamond})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(14^{\square}, 3.2^{\diamond})\ 10^{-2}$	$(\varnothing, \varnothing)$
1232	$(4.1^{\square}, 1.7^{\square})\ 10^{-4}$	$(4.3^{\square}, 1.7^{\square})\ 10^{-4}$	$(8.7^{\square}, 3.6^{\square})\ 10^{-5}$	$(9.2^{\square}, 3.7^{\square})\ 10^{-5}$	$(3.8^{\diamond}, 1.1^{\diamond})\ 10^{-3}$	$(12^{\square}, 4.4^{\square})\ 10^{-3}$	$(2.8^{\diamond}, 0.82^{\diamond})\ 10^{-3}$	$(3.5^{\square}, 1.3^{\square})\ 10^{-2}$
1233	$(10^{\square}, 4.5^{\square})$	$(12^{\square}, 4.3^{\square})$	$(2.2^{\square}, 0.95^{\square})$	$(2.5^{\square}, 0.95^{\square})$	$(2.5^{\square}, 1.0^{\square})\ 10^{-1}$	$(9.9^{\square}, 3.8^{\square})\ 10^{-4}$	$(7.6^{\square}, 3.1^{\square})\ 10^{-1}$	$(3.0^{\square}, 1.1^{\square})\ 10^{-3}$
1311	$(1.8^{\square}, 0.80^{\square})\ 10^{-1}$	$(4.7^{\square}, 1.8^{\square})\ 10^{-3}$	$(3.0^{\square}, 1.4^{\square})\ 10^{-2}$	$(10^{\square}, 4.0^{\square})\ 10^{-4}$	$(1.8^{\diamond}, 0.6^{\diamond})$	$(\varnothing, \varnothing)$	$(11^{\diamond}, 3.5^{\diamond})$	$(\varnothing, \varnothing)$
1312	$(36^{\square}, 0.65^{\square})\ 10^{-7}$	$(8.6^{\square}, 0.16^{\square})\ 10^{-8}$	$(6.1^{\square}, 0.11^{\square})\ 10^{-7}$	$(18^{\square}, 0.34^{\square})\ 10^{-9}$	$(31^{\diamond}, 0.96^{\diamond})\ 10^{-7}$	$(3.6^{\diamond}, 0.11^{\diamond})\ 10^{-1}$	$(7.5^{\diamond}, 0.23^{\diamond})\ 10^{-7}$	$(9.4^{\diamond}, 0.29^{\diamond})\ 10^{-2}$
1313	$(2.6^{\triangle}, 2.5^{\triangle})\ 10^{-7}$	$(2.7^{\triangle}, 2.6^{\triangle})\ 10^{-7}$	$(1.5^{\triangle}, 1.1^{\triangle})\ 10^{-7}$	$(1.6^{\triangle}, 1.2^{\triangle})\ 10^{-7}$	$(20^{\diamond}, 0.63^{\diamond})\ 10^{-2}$	$(8.5^{\triangle}, 7.1^{\triangle})$	$(12^{\diamond}, 0.38^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$
1321	$(5.2^{\square}, 5.2^{\square})\ 10^{-2}$	$(8.6^{\square}, 3.5^{\square})\ 10^{-8}$	$(1.1^{\square}, 1.1^{\square})\ 10^{-2}$	$(1.8^{\square}, 0.75^{\square})\ 10^{-8}$	$(5.2^{\diamond}, 12^{\diamond})\ 10^{-6}$	$(\varnothing, \varnothing)$	$(1.3^{\diamond}, 2.8^{\diamond})\ 10^{-6}$	$(\varnothing, \varnothing)$
1322	$(1.8^{\square}, 0.8^{\square})\ 10^{-1}$	$(4.7^{\square}, 1.8^{\square})\ 10^{-3}$	$(3.0^{\square}, 1.4^{\square})\ 10^{-2}$	$(10^{\square}, 4.0^{\square})\ 10^{-4}$	$(9.2^{\diamond}, 3.0^{\diamond})\ 10^{-1}$	$(\varnothing, 1.1^{\square})$	$(7.0^{\diamond}, 2.2^{\diamond})\ 10^{-1}$	$(\varnothing, 3.2^{\square})$
1323	$(3.2^{\triangle}, 3.1^{\triangle})\ 10^{-1}$	$(3.1^{\triangledown}, 1.1^{\triangledown})\ 10^{-5}$	$(1.8^{\triangle}, 1.4^{\triangle})\ 10^{-1}$	$(2.0^{\triangledown}, 0.67^{\triangledown})\ 10^{-5}$	$(7.4^{\triangle}, 6.2^{\triangle})\ 10^{-2}$	$(7.6^{\triangle}, 6.4^{\triangle})\ 10^{-2}$	$(2.2^{\triangle}, 1.9^{\triangle})\ 10^{-1}$	$(2.3^{\triangle}, 2.0^{\triangle})\ 10^{-1}$
1331	$(8.9^{\triangle}, 8.7^{\triangle})$	$(2.2^{\square}, 0.94^{\square})\ 10^{-3}$	$(4.0^{\triangle}, 4.0^{\triangle})$	$(4.7^{\square}, 2.0^{\square})\ 10^{-4}$	$(3.5^{\diamond}, 6.7^{\triangle})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(2.1^{\diamond}, 2.0^{\triangle})$	$(\varnothing, \varnothing)$
1332	$(4.0^{\square}, 2.7^{\square})\ 10^{-1}$	$(4.2^{\square}, 0.25^{\square})\ 10^{-3}$	$(6.9^{\square}, 3.0^{\square})\ 10^{-2}$	$(15^{\square}, 2.2^{\square})\ 10^{-4}$	$(15^{\diamond}, 4.7^{\diamond})\ 10^{-5}$	$(2.8^{\square}, 1.1^{\square})\ 10^{-1}$	$(11^{\diamond}, 3.5^{\diamond})\ 10^{-5}$	$(8.3^{\square}, 3.2^{\square})\ 10^{-1}$
1333	$(7.0^{\triangle}, 7.0^{\triangle})\ 10^{-1}$	$(7.1^{\triangle}, 2.8^{\triangledown})\ 10^{-1}$	$(4.0^{\triangle}, 3.0^{\triangle})\ 10^{-1}$	$(3.8^{\triangle}, 1.8^{\triangledown})\ 10^{-1}$	$(7.4^{\triangle}, 6.3^{\triangle})\ 10^{-3}$	$(7.6^{\triangle}, 6.4^{\triangle})\ 10^{-3}$	$(2.2^{\triangle}, 1.9^{\triangle})\ 10^{-2}$	$(2.3^{\triangle}, 2.0^{\triangle})\ 10^{-2}$
2211	$11^{\square}$	$8.3^{\square}\ 10^{-4}$	$2.0^{\square}$	$1.8^{\square}\ 10^{-4}$	$3.7^{\diamond}\ 10^{-1}$	∅	$2.2^{\diamond}$	∅
2212	$(1.9^{\square}, 0.79^{\square})\ 10^{-5}$	$(64^{\square}, 0.29^{\square})\ 10^{-9}$	$(3.2^{\square}, 1.3^{\square})\ 10^{-6}$	$(140^{\square}, 0.62^{\square})\ 10^{-10}$	$(6.0^{\diamond}, 0.18^{\diamond})\ 10^{-7}$	$(3.2^{\diamond}, 3.2^{\diamond})$	$(14^{\diamond}, 0.45^{\diamond})\ 10^{-8}$	$(8.5^{\diamond}, 8.4^{\diamond})\ 10^{-1}$
2213	$(4.8^{\square}, 2.1^{\square})\ 10^{-1}$	$(2.8^{\triangle}, 0.77^{\square})\ 10^{-5}$	$(8.1^{\square}, 3.6^{\square})\ 10^{-2}$	$(1.6^{\square}, 0.16^{\square})\ 10^{-5}$	$(4.0^{\diamond}, 0.12^{\diamond})\ 10^{-2}$	$(\varnothing, 1.8^{\square})$	$(24^{\diamond}, 0.74^{\diamond})\ 10^{-2}$	$(\varnothing, 5.5^{\square})$
2222	$11^{\square}$	$8.2^{\square}\ 10^{-4}$	$2.0^{\square}$	$1.8^{\square}\ 10^{-4}$	$1.9^{\diamond}\ 10^{-1}$	∅	$1.4^{\diamond}\ 10^{-1}$	∅
2223	$(1.2^{\triangledown}, 0.39^{\triangledown})\ 10^{-2}$	$(1.7^{\triangledown}, 0.57^{\triangledown})\ 10^{-4}$	$(6.1^{\triangledown}, 2.1^{\triangledown})\ 10^{-3}$	$(1.1^{\triangledown}, 0.36^{\triangledown})\ 10^{-4}$	$(16^{\diamond}, 4.7^{\diamond})\ 10^{-3}$	$(4.8^{\square}, 11^{\square})\ 10^{-2}$	$(12^{\diamond}, 3.5^{\diamond})\ 10^{-3}$	$(1.4^{\square}, 3.2^{\square})\ 10^{-1}$
2233	∅	$4.5^{\triangledown}$	∅	$2.9^{\triangledown}$	∅	$4.1^{\square}\ 10^{-3}$	∅	$1.2^{\square}\ 10^{-2}$
2311	$(4.9^{\square}, 4.9^{\square})\ 10^{-1}$	$(0.72^{\square}, 2.7^{\square})\ 10^{-2}$	$(8.3^{\square}, 8.4^{\square})\ 10^{-2}$	$(1.5^{\square}, 6.0^{\square})\ 10^{-3}$	$(\varnothing, 3.5^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
2312	$(1.8^{\square}, 0.8^{\square})\ 10^{-2}$	$(39^{\square}, 0.68^{\square})\ 10^{-8}$	$(2.6^{\square}, 1.2^{\square})\ 10^{-3}$	$(8.3^{\square}, 0.15^{\square})\ 10^{-8}$	$(13^{\diamond}, 0.42^{\diamond})\ 10^{-6}$	$(\varnothing, \varnothing)$	$(3.2^{\diamond}, 0.10^{\diamond})\ 10^{-6}$	$(\varnothing, \varnothing)$
2313	$(2.4^{\triangle}, 2.3^{\triangle})\ 10^{-2}$	$(1.2^{\triangle}, 1.1^{\triangle})\ 10^{-6}$	$(1.5^{\triangle}, 1.1^{\triangle})\ 10^{-2}$	$(6.7^{\triangle}, 5.0^{\triangle})\ 10^{-7}$	$(8.9^{\diamond}, 0.27^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(5.3^{\diamond}, 0.17^{\diamond})$	$(\varnothing, \varnothing)$
2321	$(8.3^{\square}, 3.4^{\square})\ 10^{-7}$	$(2.0^{\square}, 0.81^{\square})\ 10^{-8}$	$(14^{\square}, 5.7^{\square})\ 10^{-8}$	$(8.3^{\square}, 1.7^{\square})\ 10^{-9}$	$(1.2^{\diamond}, 2.7^{\diamond})\ 10^{-6}$	$(1.4^{\diamond}, 3.1^{\diamond})\ 10^{-1}$	$(3.0^{\diamond}, 6.5^{\diamond})\ 10^{-7}$	$(3.6^{\diamond}, 8.2^{\diamond})\ 10^{-2}$
2322	$(1.9^{\triangledown}, 0.63^{\triangledown})$	$(0.72^{\square}, 2.8^{\square})\ 10^{-2}$	$(8.3^{\square}, 4.0^{\triangledown})\ 10^{-2}$	$(1.5^{\square}, 6.0^{\square})\ 10^{-3}$	$(8.6^{\triangledown}, 1.8^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, 1.3^{\diamond})$	$(\varnothing, \varnothing)$
2323	$(7.0^{\triangledown}, 2.4^{\triangledown})\ 10^{-6}$	$(7.2^{\triangledown}, 2.4^{\triangledown})\ 10^{-6}$	$(4.4^{\triangledown}, 1.5^{\triangledown})\ 10^{-6}$	$(4.5^{\triangledown}, 1.6^{\triangledown})\ 10^{-6}$	$(3.6^{\diamond}, 1.2^{\triangledown})\ 10^{-1}$	$(3.3^{\triangle}, 1.2^{\triangledown})\ 10^{-1}$	$(2.7^{\diamond}, 3.2^{\triangledown})\ 10^{-1}$	$(10^{\triangle}, 3.7^{\triangledown})\ 10^{-1}$
2331	$(2.1^{\square}, 1.0^{\square})\ 10^{-2}$	$(5.1^{\square}, 2.2^{\square})\ 10^{-4}$	$(3.6^{\square}, 1.5^{\square})\ 10^{-3}$	$(11^{\square}, 4.7^{\square})\ 10^{-5}$	$(0.46^{\diamond}, 1.8^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(4.8^{\diamond}, 11^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$
2332	$(7.4^{\triangledown}, 2.5^{\triangledown})$	$(4.0^{\triangledown}, 1.1^{\square})\ 10^{-3}$	$(4.7^{\triangledown}, 1.6^{\triangledown})$	$(2.5^{\triangledown}, 0.86^{\triangledown})\ 10^{-3}$	$(6.5^{\diamond}, 2.0^{\diamond})\ 10^{-4}$	$(5.7^{\square}, \varnothing)\ 10^{-1}$	$(5.0^{\square}, 1.5^{\square})\ 10^{-4}$	$(1.7^{\square}, \varnothing)$
2333	$(1.9^{\triangledown}, 0.63^{\triangledown})\ 10^{-1}$	$(2.0^{\triangledown}, 0.65^{\triangledown})\ 10^{-1}$	$(1.2^{\triangledown}, 0.40^{\triangledown})\ 10^{-1}$	$(1.2^{\triangledown}, 0.42^{\triangledown})\ 10^{-1}$	$(3.4^{\triangledown}, 1.0^{\triangledown})\ 10^{-2}$	$(3.1^{\triangledown}, 1.0^{\triangledown})\ 10^{-2}$	$(9.1^{\triangledown}, 3.0^{\triangledown})\ 10^{-2}$	$(9.4^{\triangledown}, 3.1^{\triangledown})\ 10^{-2}$
3311	∅	$2.7^{\square}\ 10^{-1}$	∅	$5.8^{\square}\ 10^{-2}$	∅	∅	∅	∅
3312	$(8.0^{\square}, 3.4^{\square})\ 10^{-4}$	$(4.5^{\square}, 2.0^{\square})\ 10^{-7}$	$(12^{\square}, 5.0^{\square})\ 10^{-5}$	$(9.6^{\square}, 8.1^{\square})\ 10^{-8}$	$(2.7^{\diamond}, 6.1^{\diamond})\ 10^{-5}$	$(\varnothing, \varnothing)$	$(6.6^{\diamond}, 15^{\diamond})\ 10^{-6}$	$(\varnothing, \varnothing)$
3313	$(1.0^{\triangle}, 1.0^{\triangle})\ 10^{-3}$	$(3.3^{\triangle}, 3.2^{\triangle})\ 10^{-5}$	$(6.4^{\triangle}, 4.8^{\triangle})\ 10^{-4}$	$(1.9^{\triangle}, 1.4^{\triangle})\ 10^{-5}$	$(1.8^{\diamond}, 4.0^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, 11^{\diamond})$	$(\varnothing, \varnothing)$
3322	∅	$2.7^{\square}\ 10^{-1}$	∅	$5.8^{\square}\ 10^{-2}$	∅	∅	∅	∅
3323	$(5.3^{\triangledown}, 1.8^{\triangledown})\ 10^{-3}$	$(1.7^{\triangledown}, 0.58^{\triangledown})\ 10^{-4}$	$(3.6^{\triangledown}, 1.2^{\triangledown})\ 10^{-3}$	$(1.1^{\triangledown}, 0.37^{\triangledown})\ 10^{-4}$	$(1.5^{\diamond}, 1.8^{\diamond})\ 10^{-2}$	$(8.7^{\triangledown}, 2.9^{\triangledown})$	$(1.1^{\diamond}, 1.3^{\diamond})\ 10^{-2}$	$(\varnothing, 8.7^{\triangledown})$
3333	∅	$4.5^{\triangledown}$	∅	$2.9^{\triangledown}$	∅	$7.3^{\triangledown}\ 10^{-1}$	∅	$2.2^{\triangledown}$

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$\Delta F = 2$ BOUNDS — Other bounds from RGE

$ijkl$	$C_{ijkl}^{ud(1)}$ [TeV^{-2}] Y_D diag	$C_{ijkl}^{ud(1)}$ [TeV^{-2}] Y_U diag	$C_{ijkl}^{ud(8)}$ [TeV^{-2}] Y_D diag	$C_{ijkl}^{ud(8)}$ [TeV^{-2}] Y_U diag
1112	$(\varnothing, 1.1^{\square})$	$(\varnothing, \varnothing)$	$(\varnothing, 0.10^{\square})$	$(\varnothing, \varnothing)$
1212	$(\varnothing, 2.5^{\square})\ 10^{-1}$	$(\varnothing, 2.5^{\square})\ 10^{-1}$	$(99^{\square}, 0.45^{\square})\ 10^{-1}$	$(99^{\square}, 0.45^{\square})\ 10^{-1}$
1213	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, 7.0^{\diamond})$	$(\varnothing, \varnothing)$
1221	$(360^{\square}, 0.95^{\square})\ 10^{-2}$	$(\varnothing, 4.6^{\square})$	$(38^{\square}, 0.17^{\square})\ 10^{-2}$	$(\varnothing, 8.3^{\square})\ 10^{-1}$
1222	$(\varnothing, 11^{\diamond})$	$(\varnothing, 11^{\diamond})$	$(\varnothing, 3.6^{\diamond})$	$(\varnothing, 3.6^{\diamond})$
1223	$(\varnothing, 4.7^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, 1.6^{\diamond})$	$(\varnothing, \varnothing)$
1231	$(2.4^{\triangle}, 2.3^{\triangle})$	$(\varnothing, \varnothing)$	$(1.9^{\triangle}, 1.4^{\triangle})$	$(\varnothing, \varnothing)$
1232	$(12^{\triangledown}, 5.0^{\triangledown})$	$(\varnothing, \varnothing)$	$(4.6^{\diamond}, 4.5^{\triangledown})$	$(4.6^{\diamond}, 10^{\diamond})$
1233	$(6.0^{\diamond}, \varnothing)$	$(\varnothing, \varnothing)$	$(2.0^{\diamond}, 4.5^{\diamond})$	$(\varnothing, \varnothing)$
1312	$(\varnothing, 5.7^{\square})$	$(11^{\square}, 0.21^{\square})\ 10^{-1}$	$(\varnothing, 1.0^{\square})$	$(21^{\square}, 0.37^{\square})\ 10^{-2}$
1313	$(2.2^{\triangle}, 2.1^{\triangle})$	$(2.2^{\triangle}, 2.1^{\triangle})$	$(1.7^{\triangle}, 1.3^{\triangle})$	$(1.7^{\triangle}, 1.3^{\triangle})$
1321	$(2.3^{\square}, 0.96^{\square})\ 10^{-3}$	$(12^{\square}, 4.7\ ^{\square})\ 10^{-1}$	$(4.2^{\square}, 1.7\ ^{\square})\ 10^{-4}$	$(2.0^{\square}, 0.84\ ^{\square})\ 10^{-1}$
1331	$(2.1^{\triangle}, 2.0^{\triangle})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(1.7^{\triangle}, 1.2^{\triangle})\ 10^{-1}$	$(\varnothing, \varnothing)$
1332	$(1.0^{\triangledown}, 4.3\ ^{\triangledown})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(8.9^{\triangledown}, 3.8\ ^{\triangledown})\ 10^{-1}$	$(\varnothing, \varnothing)$
2212	$(83^{\square}, 0.22^{\square})\ 10^{-2}$	$(83^{\square}, 0.22^{\square})\ 10^{-2}$	$(89^{\square}, 0.4^{\square})\ 10^{-3}$	$(89^{\square}, 0.4^{\square})\ 10^{-3}$
2213	$(4.7^{\triangle}, 4.5\ ^{\triangle})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(3.7^{\triangle}, 2.8\ ^{\triangle})\ 10^{-1}$	$(\varnothing, 11^{\square})$
2223	$(\ 28^{\triangledown}, 9.7^{\triangledown})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(\ 25^{\triangledown}, 8.6^{\triangledown})\ 10^{-1}$	$(\varnothing, \varnothing)$
2312	$(\varnothing, 5.1^{\square})\ 10^{-2}$	$(\ 11^{\square}, 0.19^{\square})\ 10^{-3}$	$(\ 200^{\square}, 0.92^{\square})\ 10^{-2}$	$(\ 11^{\square}, 0.33^{\square})\ 10^{-4}$
2313	$(1.9^{\triangle}, 1.9^{\triangle})\ 10^{-2}$	$(1.9^{\triangle}, 1.9^{\triangle})\ 10^{-2}$	$(1.5^{\triangle}, 1.2^{\triangle})\ 10^{-2}$	$(1.5^{\triangle}, 1.2^{\triangle})\ 10^{-2}$
2321	$(5.5^{\square}, 2.2^{\square})\ 10^{-4}$	$(5.5^{\square}, 2.2^{\square})\ 10^{-4}$	$(9.9^{\square}, 4.0^{\square})\ 10^{-5}$	$(9.9^{\square}, 4.0^{\square})\ 10^{-5}$
2323	$(1.2^{\triangledown}, 0.40^{\triangledown})\ 10^{-1}$	$(1.2^{\triangledown}, 0.40^{\triangledown})\ 10^{-1}$	$(1.0^{\triangledown}, 0.36^{\triangledown})\ 10^{-1}$	$(1.0^{\triangledown}, 0.36^{\triangledown})\ 10^{-1}$
2331	$(4.7^{\triangle}, 4.5^{\triangle})\ 10^{-2}$	$(\varnothing, 6.0\ ^{\square})$	$(3.8^{\triangle}, 2.8\ ^{\triangle})\ 10^{-2}$	$(2.5^{\square}, 1.1^{\square})$
2332	$(2.4^{\triangledown}, 0.82^{\triangledown})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(2.1^{\triangledown}, 0.72^{\triangledown})\ 10^{-1}$	$(\varnothing, \varnothing)$
3311	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(4.8^{\square}, \varnothing)$
3312	$(13^{\square}, 5.1^{\square})\ 10^{-3}$	$(4.4^{\square}, 2.0^{\square})\ 10^{-5}$	$(2.3^{\square}, 0.92^{\square})\ 10^{-3}$	$(8.0^{\square}, 3.4^{\square})\ 10^{-6}$
3313	$(2.0^{\triangle}, 1.9^{\triangle})\ 10^{-3}$	$(2.0^{\triangle}, 1.9^{\triangle})\ 10^{-3}$	$(1.6^{\triangle}, 1.2^{\triangle})\ 10^{-3}$	$(1.6^{\triangle}, 1.2^{\triangle})\ 10^{-3}$
3322	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(4.8^{\square}, \varnothing)$
3323	$(10^{\triangledown}, 3.4\ ^{\triangledown})\ 10^{-3}$	$(10^{\triangledown}, 3.4\ ^{\triangledown})\ 10^{-3}$	$(8.7^{\triangledown}, 3.0\ ^{\triangledown})\ 10^{-3}$	$(8.7^{\triangledown}, 3.0\ ^{\triangledown})\ 10^{-3}$

$$O_{ijkl}^{ud\,1\,[8]}$$

$$\bar{u}_i \gamma_\mu [T^a] u_j\ \bar{d}_k \gamma^\mu [T^a] d_l$$

$$O_{ijkl}^{QuQd\,1\,[8]}$$

$$\bar{Q}_i \gamma_\mu [T^a] u_j \epsilon\, \bar{Q}_k \gamma_\mu [T^a] d_l$$

$ijkl$	$C_{ijkl}^{QuQd(1)}$ [TeV^{-2}] Y_D diag	$C_{ijkl}^{QuQd(1)}$ [TeV^{-2}] Y_U diag	$C_{ijkl}^{QuQd(8)}$ [TeV^{-2}] Y_D diag	$C_{ijkl}^{QuQd(8)}$ [TeV^{-2}] Y_U diag
1111	$(\varnothing, \varnothing)$	$(\varnothing, 4.8^{\square})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
1112	$(92^{\square}, 0.41^{\square})\ 10^{-1}$	$(9.5^{\square}, 0.31^{\square})$	$(\varnothing, 0.49^{\square})$	$(\varnothing, 1.6^{\square})$
1113	$(4.0^{\diamond}, 8.9^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
1121	$(\varnothing, 3.2^{\diamond})$	$(\varnothing, 1.1^{\square})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
1122	$(\varnothing, 0.71^{\diamond})$	$(\varnothing, 1.6^{\square})$	$(\varnothing, 8.6^{\diamond})$	$(\varnothing, \varnothing)$
1123	$(9.2^{\diamond}, 21^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(11^{\diamond}, \varnothing)$	$(\varnothing, \varnothing)$
1211	$(5.1^{\diamond}, 1.6^{\diamond})$	$(95^{\square}, 0.43^{\square})\ 10^{-1}$	$(\varnothing, 8.3^{\diamond})$	$(\varnothing, 5.1^{\square})\ 10^{-1}$
1212	$(210^{\square}, 0.96^{\square})\ 10^{-2}$	$(22^{\square}, 0.1^{\square})\ 10^{-1}$	$(\varnothing, 1.1^{\square})\ 10^{-1}$	$(\varnothing, 1.2^{\square})\ 10^{-1}$
1213	$(8.9^{\triangle}, 3.6^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
1221	$(\varnothing, 11^{\diamond})$	$(220^{\square}, 0.99^{\square})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(\varnothing, 1.2^{\square})\ 10^{-1}$
1222	$(3.1^{\diamond}, 2.3^{\diamond})\ 10^{-1}$	$(14^{\square}, 0.4^{\square})\ 10^{-2}$	$(\varnothing, 9.8^{\diamond})\ 10^{-1}$	$(10^{\square}, 0.53^{\square})\ 10^{-2}$
1223	$(22^{\diamond}, 0.69^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(\varnothing, 4.3^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$
1231	$(3.4^{\diamond}, 1.4^{\diamond})$	$(\varnothing, 0.23^{\square})$	$(\varnothing, 8.2^{\diamond})$	$(\varnothing, 2.8^{\square})$
1232	$(4.0^{\diamond}, 1.7^{\diamond})\ 10^{-2}$	$(6.5^{\square}, 15^{\square})\ 10^{-2}$	$(2.4^{\diamond}, 1.1^{\diamond})\ 10^{-1}$	$(1.2^{\square}, 2.6^{\square})\ 10^{-2}$
1233	$(9.0^{\diamond}, 1.5^{\diamond})\ 10^{-3}$	$(\varnothing, \varnothing)$	$(11^{\diamond}, 4.4^{\diamond})\ 10^{-2}$	$(\varnothing, \varnothing)$
1311	$(\varnothing, \varnothing)$	$(11^{\square}, 4.3^{\square})\ 10^{-3}$	$(\varnothing, \varnothing)$	$(13^{\square}, 5.2^{\square})\ 10^{-2}$
1312	$(\varnothing, 2.2^{\square})\ 10^{-1}$	$(470^{\square}, 8.5^{\square})\ 10^{-4}$	$(\varnothing, 2.6^{\square})$	$(5.6^{\square}, 0.1^{\square})\ 10^{-1}$
1313	$(3.7^{\triangle}, 2.8^{\triangle})\ 10^{-1}$	$(3.9^{\triangle}, 2.9^{\triangle})\ 10^{-1}$	$(2.2^{\triangle}, 2.1^{\triangle})$	$(2.4^{\triangle}, 2.3^{\triangle})$
1321	$(\varnothing, \varnothing)$	$(2.4^{\square}, 0.11^{\square})\ 10^{-3}$	$(\varnothing, \varnothing)$	$(2.9^{\square}, 1.2^{\square})\ 10^{-2}$
1322	$(\varnothing, \varnothing)$	$(21^{\square}, 0.37^{\square})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(41^{\square}, 0.74^{\square})\ 10^{-3}$
1323	$(\varnothing, \varnothing)$	$(4.5^{\triangle}, 4.3^{\triangle})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(3.4^{\triangle}, 2.6^{\triangle})\ 10^{-1}$
1331	$(\varnothing, \varnothing)$	$(5.5^{\square}, 2.3^{\square})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(6.7^{\square}, 2.8^{\square})\ 10^{-1}$
1332	$(\varnothing, \varnothing)$	$(5.0^{\square}, 0.16^{\square})\ 10^{-4}$	$(\varnothing, \varnothing)$	$(5.9^{\square}, 0.12^{\square})\ 10^{-4}$
1333	$(\varnothing, \varnothing)$	$(1.7^{\triangle}, 2.3^{\triangle})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(2.0^{\triangle}, 2.7^{\triangle})\ 10^{-1}$
2111	$(\varnothing, 3.15^{\diamond})$	$(\varnothing, 1.1^{\square})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
2112	$(\varnothing, 7.1^{\diamond})\ 10^{-1}$	$(\varnothing, 3.2^{\square})$	$(\varnothing, 8.6^{\diamond})$	$(\varnothing, 9.4^{\square})$
2113	$(9.2^{\diamond}, 21^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(11^{\diamond}, \varnothing)$	$(\varnothing, \varnothing)$
2121	$(\varnothing, 2.4^{\square})\ 10^{-1}$	$(\varnothing, 2.6^{\square})\ 10^{-1}$	$(\varnothing, 2.9^{\square})$	$(\varnothing, 3.1^{\square})$
2122	$(5.3^{\diamond}, 0.17^{\diamond})$	$(5.1^{\diamond}, 0.16^{\diamond})$	$(\varnothing, 2.0^{\diamond})$	$(\varnothing, 1.9^{\diamond})$
2123	$(2.1^{\diamond}, 4.7^{\diamond})\ 10^{-1}$	$(2.0^{\diamond}, 4.5^{\diamond})\ 10^{-1}$	$(2.6^{\diamond}, 5.7^{\diamond})$	$(2.4^{\diamond}, 5.4^{\diamond})$
2131	$(\varnothing, \varnothing)$	$(\varnothing, 6.0^{\square})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
2132	$(\varnothing, 3.7^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
2133	$(4.8^{\diamond}, 10^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
2211	$(\varnothing, 8.0^{\diamond})$	$(22^{\square}, 0.1^{\square})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(\varnothing, 1.2^{\square})\ 10^{-1}$
2212	$(1.9^{\diamond}, 0.527^{\diamond})$	$(2.3^{\square}, 0.11^{\square})\ 10^{-2}$	$(1.4^{\diamond}, 1.3^{\diamond})$	$(28^{\square}, 0.13^{\square})\ 10^{-1}$
2213	$(\varnothing, 8.6^{\diamond})\ 10^{-1}$	$(8.0^{\triangle}, 10^{\triangle})$	$(9.0^{\diamond}, 0.28^{\diamond})$	$(\varnothing, \varnothing)$
2221	$(48^{\square}, 0.22^{\square})\ 10^{-2}$	$(51^{\square}, 0.23^{\square})\ 10^{-2}$	$(58^{\square}, 0.26^{\square})\ 10^{-1}$	$(61^{\square}, 0.27^{\square})\ 10^{-1}$
2222	$(12^{\diamond}, 7.0^{\diamond})\ 10^{-1}$	$(8.3^{\square}, 0.38^{\square})\ 10^{-2}$	$(6.1^{\diamond}, 2.4^{\diamond})$	$(4.3^{\square}, 0.16^{\square})\ 10^{-1}$
2223	$(9.7^{\diamond}, 0.30^{\diamond})$	$(\varnothing, 7.1^{\triangledown})$	$(\varnothing, 3.4^{\diamond})$	$(\varnothing, \varnothing)$
2231	$(\varnothing, 2.2^{\square})$	$(31^{\square}, 0.53^{\square})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(\varnothing, 0.64^{\square})$
2232	$(1.8^{\diamond}, 0.72^{\diamond})\ 10^{-1}$	$(2.8^{\square}, 1.3^{\square})\ 10^{-1}$	$(11^{\diamond}, 4.3^{\diamond})\ 10^{-1}$	$(5.0^{\square}, 11^{\square})\ 10^{-2}$
2233	$(3.9^{\diamond}, 0.64^{\diamond})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(4.7^{\diamond}, 1.9^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$
2311	$(\varnothing, \varnothing)$	$(2.4^{\square}, 1.1^{\square})\ 10^{-3}$	$(\varnothing, \varnothing)$	$(2.9^{\square}, 1.2^{\square})\ 10^{-2}$
2312	$(\varnothing, \varnothing)$	$(10^{\square}, 0.2^{\square})\ 10^{-3}$	$(\varnothing, \varnothing)$	$(5.9^{\square}, 0.1^{\square})\ 10^{-2}$
2313	$(\varnothing, \varnothing)$	$(8.9^{\triangle}, 6.7^{\triangle})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(4.4^{\triangle}, 3.7^{\triangle})\ 10^{-1}$
2321	$(5.3^{\square}, 2.2^{\square})\ 10^{-4}$	$(5.7^{\square}, 2.3^{\square})\ 10^{-4}$	$(6.4^{\square}, 2.6^{\square})\ 10^{-3}$	$(6.8^{\square}, 2.8^{\square})\ 10^{-3}$
2322	$(\varnothing, \varnothing)$	$(48^{\square}, 0.83^{\square})\ 10^{-3}$	$(\varnothing, \varnothing)$	$(57^{\square}, 1.0^{\square})\ 10^{-2}$
2323	$(5.7^{\triangledown}, 2.0^{\triangledown})\ 10^{-1}$	$(3.9^{\triangle}, 2.1^{\triangledown})\ 10^{-1}$	$(3.1^{\triangledown}, 1.1^{\triangledown})$	$(2.3^{\triangle}, 1.1^{\triangledown})$
2331	$(5.3^{\square}, 2.3^{\square})\ 10^{-1}$	$(13^{\square}, 5.4^{\square})\ 10^{-3}$	$(6.4^{\square}, 2.7^{\square})$	$(15^{\square}, 6.5^{\square})\ 10^{-2}$
2332	$(\varnothing, \varnothing)$	$(25^{\square}, 0.7^{\square})\ 10^{-4}$	$(\varnothing, \varnothing)$	$(25^{\square}, 0.51^{\square})\ 10^{-4}$
2333	$(\varnothing, \varnothing)$	$(5.0^{\triangledown}, 1.7^{\triangledown})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(6.2^{\triangledown}, 2.1^{\triangledown})\ 10^{-1}$
3112	$(\varnothing, \varnothing)$	$(6.2^{\square}, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
3121	$(\varnothing, \varnothing)$	$(\varnothing, 6.0^{\square})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
3122	$(\varnothing, 3.7^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
3123	$(4.8^{\diamond}, 11^{\diamond})$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$	$(\varnothing, \varnothing)$
3211	$(\varnothing, \varnothing)$	$(\varnothing, 0.23^{\square})$	$(\varnothing, 5.5^{\diamond})$	$(\varnothing, 2.8^{\square})$
3212	$(4.8^{\diamond}, 2.1^{\diamond})\ 10^{-1}$	$(2.9^{\square}, 6.6^{\square})\ 10^{-3}$	$(16^{\diamond}, 6.6^{\diamond})\ 10^{-2}$	$(1.8^{\square}, 4.0^{\square})\ 10^{-2}$
3213	$(3.6^{\diamond}, 1.0^{\diamond})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(4.3^{\diamond}, 0.6^{\diamond})\ 10^{-2}$	$(\varnothing, \varnothing)$
3221	$(\varnothing, 2.2^{\square})$	$(31^{\square}, 0.54^{\square})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(\varnothing, 0.64^{\square})\ 10^{-1}$
3222	$(2.1^{\diamond}, 0.85^{\diamond})$	$(1.3^{\square}, 2.7^{\square})\ 10^{-2}$	$(7.1^{\diamond}, 2.9^{\diamond})\ 10^{-1}$	$(0.80^{\square}, 2.4^{\square})\ 10^{-1}$
3223	$(15^{\diamond}, 4.8^{\diamond})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(1.9^{\diamond}, 0.28^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$
3231	$(4.6^{\triangle}, 3.5^{\triangle})\ 10^{-1}$	$(4.6^{\triangle}, 3.5^{\triangle})\ 10^{-1}$	$(2.8^{\triangle}, 2.7^{\triangle})$	$(2.8^{\triangle}, 2.7^{\triangle}$
3232	$(3.1^{\triangledown}, 1.1^{\triangledown})$	$(0.3^{\square}, 1.1^{\triangledown})$	$(\varnothing, 5.8^{\triangledown})$	$(3.6^{\square}, 5.8^{\square})$
3233	$(4.0^{\diamond}, 5.9^{\diamond})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(2.4^{\diamond}, 3.1^{\diamond})$	$(\varnothing, \varnothing)$
3311	$(\varnothing, \varnothing)$	$(5.5^{\square}, 2.3^{\square})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(6.6^{\square}, 2.8^{\square})\ 10^{-1}$
3312	$(\varnothing, \varnothing)$	$(12^{\square}, 0.26^{\square})\ 10^{-5}$	$(\varnothing, \varnothing)$	$(1.5^{\square}, 3.5^{\square})\ 10^{-3}$
3313	$(\varnothing, \varnothing)$	$(4.3^{\triangle}, 5.7^{\triangle})\ 10^{-2}$	$(\varnothing, \varnothing)$	$(5.2^{\triangle}, 5.7^{\triangle})\ 10^{-1}$
3321	$(5.3^{\square}, 2.3^{\square})\ 10^{-1}$	$(13^{\square}, 5.4^{\square})\ 10^{-3}$	$(6.4^{\square}, 2.7^{\square})$	$(15^{\square}, 6.2^{\square})\ 10^{-2}$
3322	$(\varnothing, \varnothing)$	$(5.2^{\square}, 0.11^{\square})\ 10^{-4}$	$(\varnothing, \varnothing)$	$(0.62^{\square}, 1.3^{\square})\ 10^{-2}$
3323	$(\varnothing, \varnothing)$	$(1.3^{\triangledown}, 0.44^{\triangledown})\ 10^{-1}$	$(\varnothing, \varnothing)$	$(1.2^{\triangledown}, 0.41^{\triangledown})$
3331	$(4.7^{\triangle}, 3.5^{\triangle})\ 10^{-2}$	$(4.7^{\triangle}, 3.5^{\triangle})\ 10^{-2}$	$(2.8^{\triangle}, 2.7^{\triangle})\ 10^{-1}$	$(2.8^{\triangle}, 2.7^{\triangle})\ 10^{-1}$
3332	$(2.6^{\triangledown}, 0.9^{\triangledown})\ 10^{-1}$	$(7.1^{\square}, 2.7^{\square})\ 10^{-4}$	$(1.4^{\triangledown}, 0.49^{\triangledown})$	$(3.8^{\square}, 1.4^{\square})\ 10^{-3}$
3333	$(\varnothing, \varnothing)$	$(2.4^{\triangledown}, 0.83^{\triangledown})$	$(\varnothing, \varnothing)$	$(10^{\triangledown}, 3.6^{\triangledown})$

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$\Delta F = 2$ BOUNDS vs $\Delta F = 1$

Leading-log RGE effects may be also relevant …

Let's compare bounds in the SMEFT on ΔF = 1 operators that run into ΔF = 2 via RGE:

$$\mathcal{A}_{\rm NP}^{\Delta F=2} \lesssim \mathcal{A}_{\rm SM}^{\Delta F=2} \varepsilon_{\Delta F=2} \quad \Big| \quad \mathcal{A}_{\rm NP}^{\Delta F=1} \lesssim \mathcal{A}_{\rm SM}^{\Delta F=1} \varepsilon_{\Delta F=1}$$

$\mathcal{A}$ being short-distance amplitude, $\varepsilon_{\Delta F=i}$ amount of NP allowed in $\Delta F = i$

$$\mathcal{A}_{\rm SM}^{\Delta F=2} \sim \frac{(Y_{\rm SM} Y_{\rm SM}^\dagger)^2}{\Lambda_{\rm EW}^2}\,,\ \mathcal{A}_{\rm NP}^{\Delta F=2} \sim \frac{C_{\rm NP}^{\Delta F=2}}{\Lambda_{\rm NP}^2} \quad \Big| \quad \mathcal{A}_{\rm SM}^{\Delta F=1} \sim \frac{Y_{\rm SM} Y_{\rm SM}^\dagger}{\Lambda_{\rm EW}^2}\,,\ \mathcal{A}_{\rm NP}^{\Delta F=1} \sim \frac{C_{\rm NP}^{\Delta F=1}}{\Lambda_{\rm NP}^2}$$

ΔF = 2 BOUND ON NEW PHYSICS SCALE IS STRONGER IFF:

$$\frac{C_{\rm NP}^{\Delta F=2}\,\Lambda_{\rm EW}^2}{(Y_{\rm SM} Y_{\rm SM}^\dagger)^2 \varepsilon_{\Delta F=2}} \gtrsim \frac{C_{\rm NP}^{\Delta F=1}\,\Lambda_{\rm EW}^2}{Y_{\rm SM} Y_{\rm SM}^\dagger \varepsilon_{\Delta F=1}}$$

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$\Delta F = 2$ BOUNDS vs $\Delta F = 1$

Leading-log RGE effects may be also relevant …

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$$\mathcal{A}_{\rm SM}^{\Delta F=2} \sim \frac{(Y_{\rm SM} Y_{\rm SM}^\dagger)^2}{\Lambda_{\rm EW}^2}\,,\ \mathcal{A}_{\rm NP}^{\Delta F=2} \sim \frac{C_{\rm NP}^{\Delta F=2}}{\Lambda_{\rm NP}^2} \quad \Big| \quad \mathcal{A}_{\rm SM}^{\Delta F=1} \sim \frac{Y_{\rm SM} Y_{\rm SM}^\dagger}{\Lambda_{\rm EW}^2}\,,\ \mathcal{A}_{\rm NP}^{\Delta F=1} \sim \frac{C_{\rm NP}^{\Delta F=1}}{\Lambda_{\rm NP}^2}$$

RGE in the SMEFT implies: $C_{\rm NP}^{\Delta F=2} = Y_{\rm SM} Y_{\rm SM}^\dagger\, C_{\rm NP}^{\Delta F=1}\, \mathcal{R} \equiv \frac{1}{16\pi^2} \log\left(\frac{\Lambda_{\rm NP}}{\Lambda_{\rm EW}}\right)$

$\sim \mathcal{O}(\%)$

THEN, ΔF = 2 BOUND RELEVANT IFF $\boxed{\mathcal{R} \gtrsim \varepsilon_{\Delta F=2} / \varepsilon_{\Delta F=1}}$