Portoroz 2019: Precision era in High Energy Physics

Loop Effects solutions to B anomalies

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based on arXiv:1904.058xx in collaboration with:

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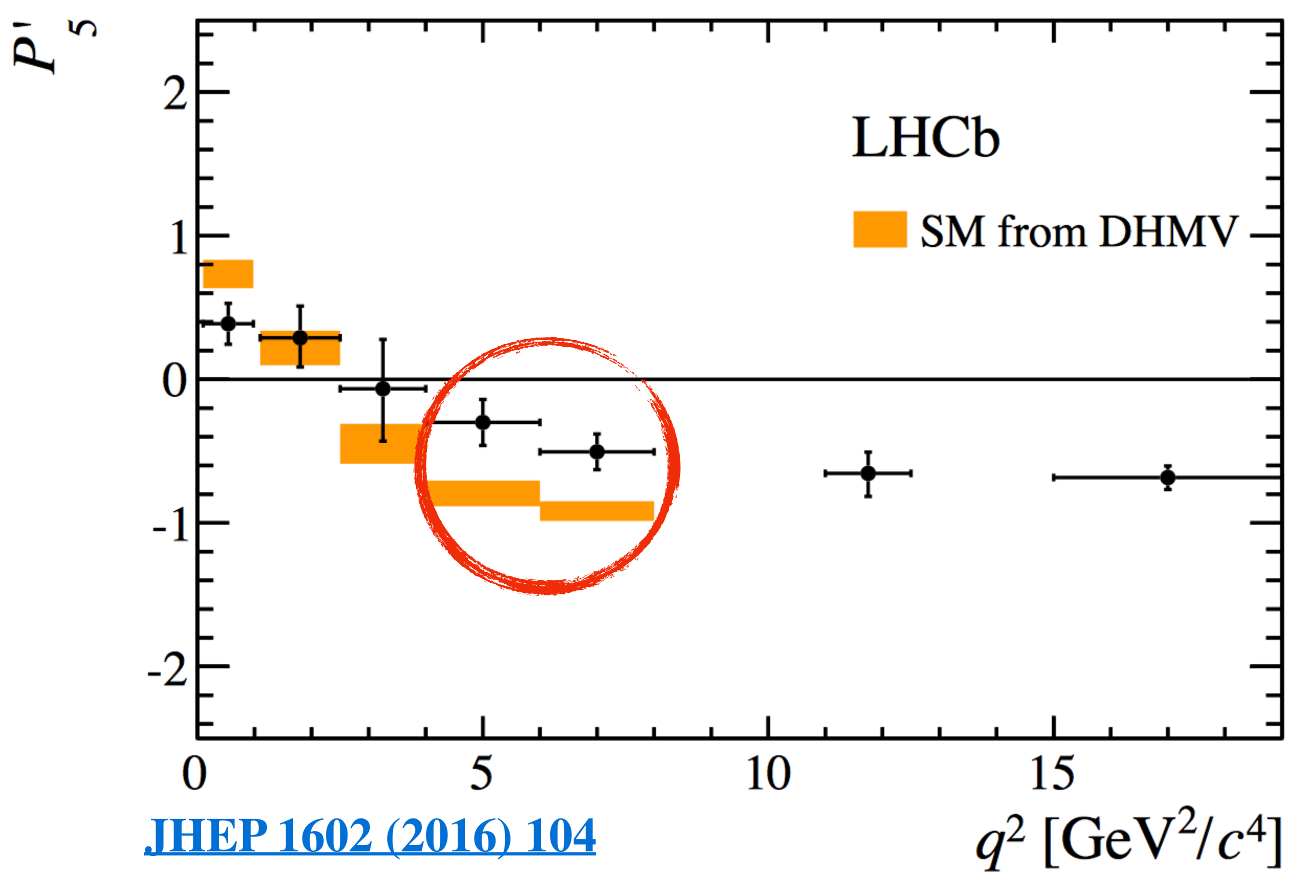
Opportunities with Semi-Leptonic B Decays

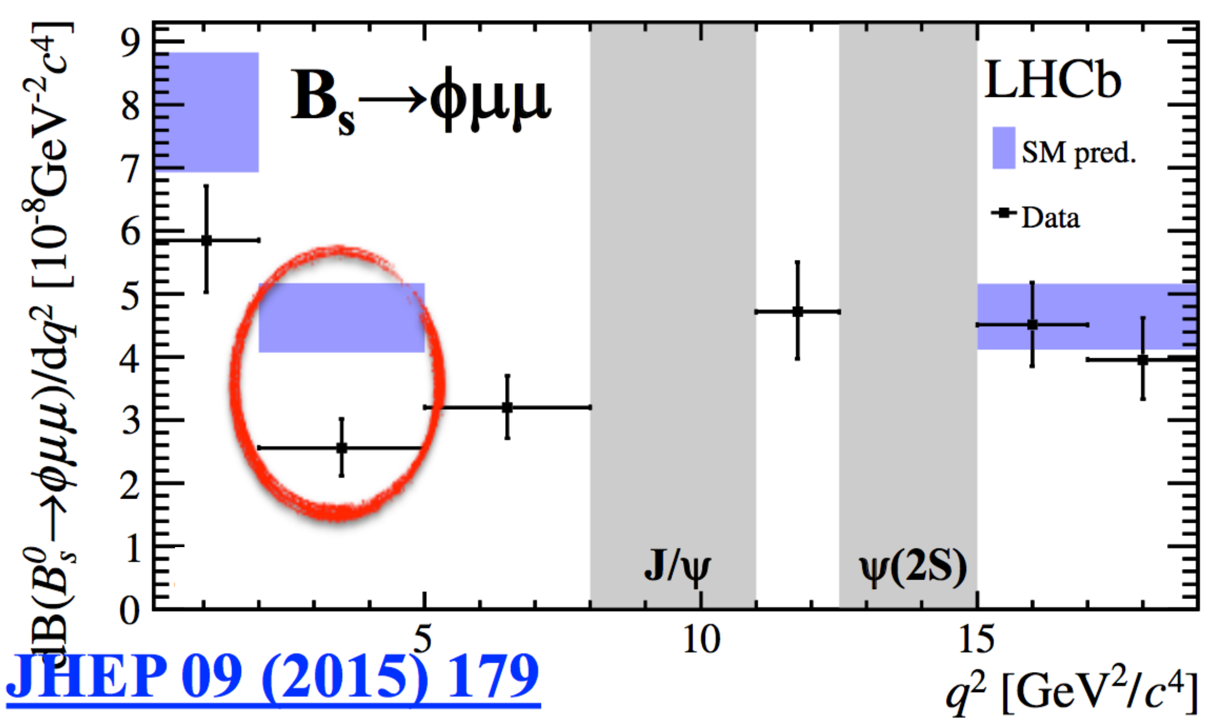
No tree-level flavour changing neutral currents (FCNC) in the SM

⇨ New Physics (NP) may sizably contribute in FCNC amplitudes

Intriguing set of “Anomalies” in data of exclusive B rare Decays



JHEP 1602 (2016) 104



JHEP 09 (2015) 179

~ 3.5 σ

Angular analysis of $B \longrightarrow K^*\mu\mu$ for small dilepton mass, $4 < q^2 / \mathrm{GeV}^2 < 8$.

2

~ 2.5 σ

Br of $B_s \longrightarrow \phi\mu\mu$

Opportunities with Semi-Leptonic B Decays

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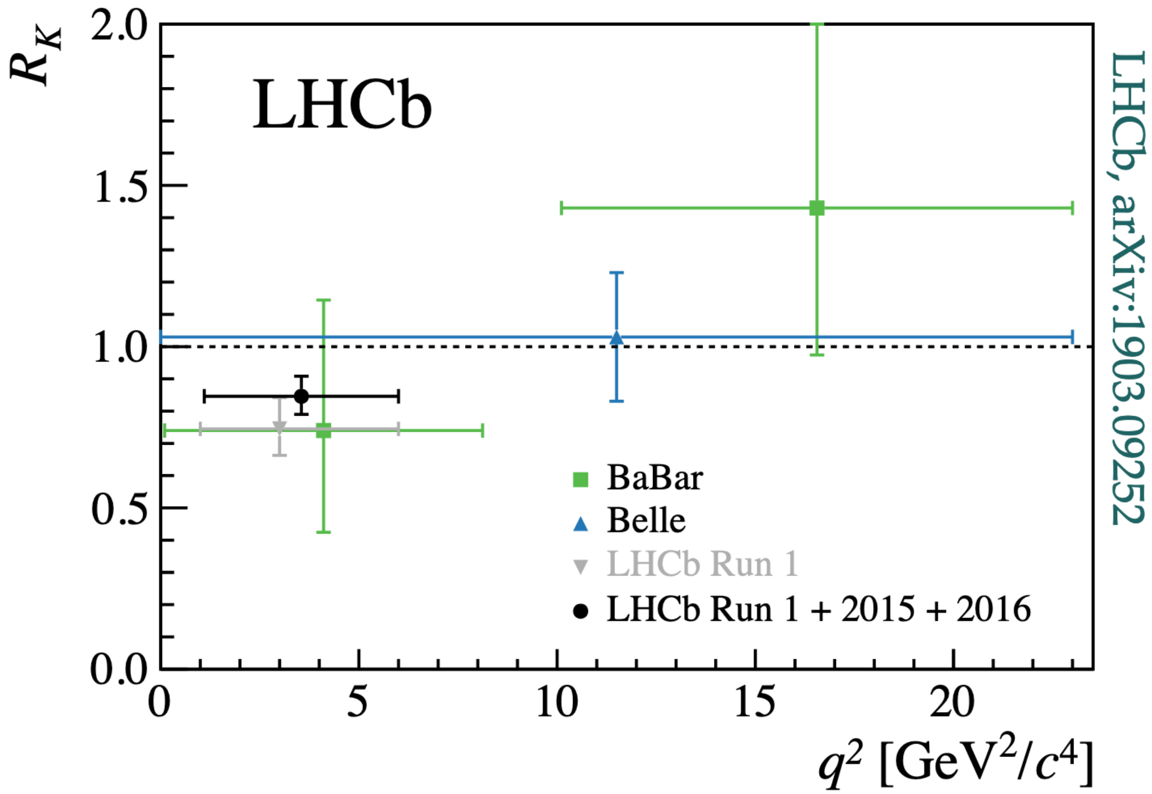
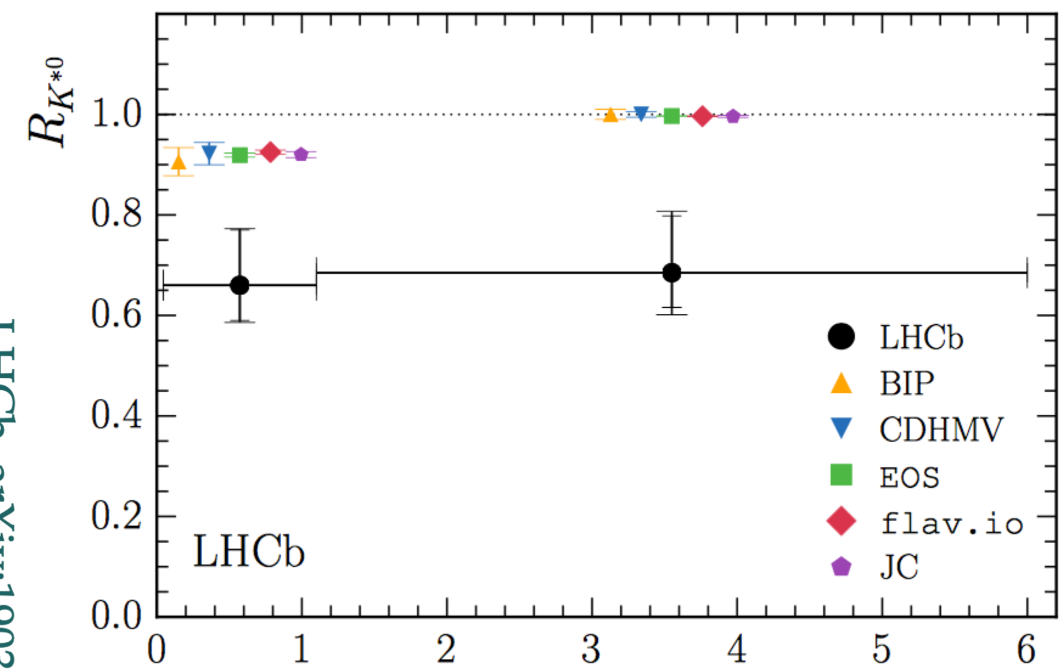
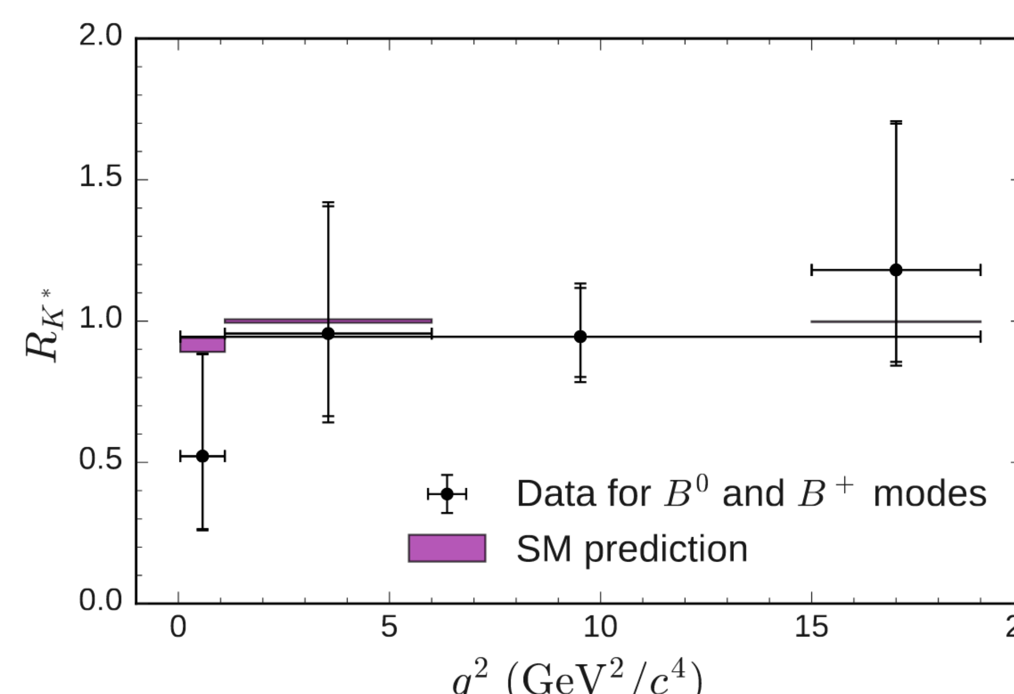






~ 2.5 σ

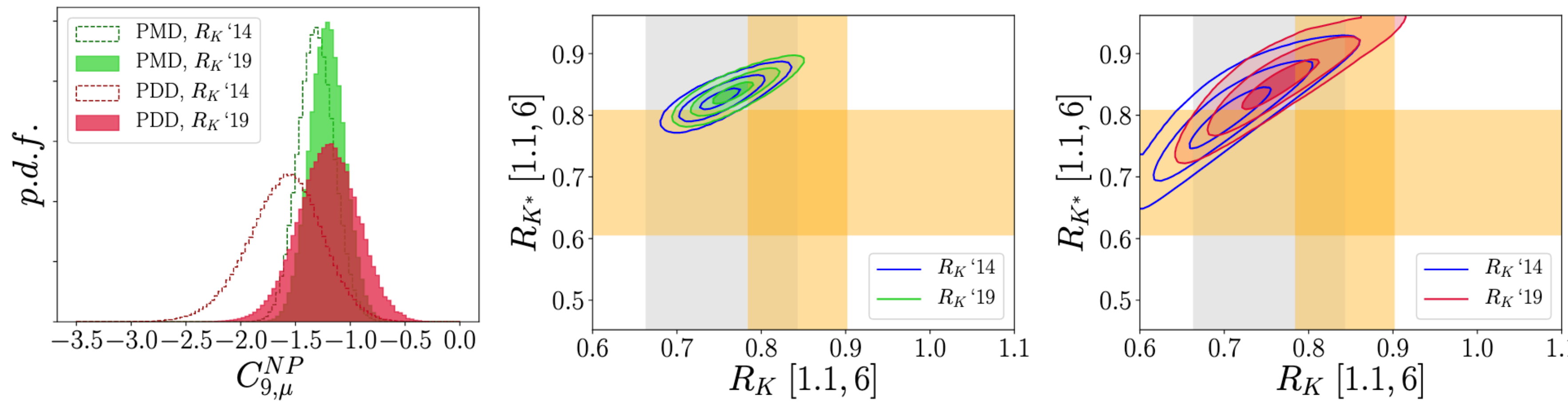
$R_{K^{(*)}}$ = Br(B —> $K^{(*)}ee$) / Br(B —> $K^{(*)}\mu\mu$)

Global fits after Moriond 2019

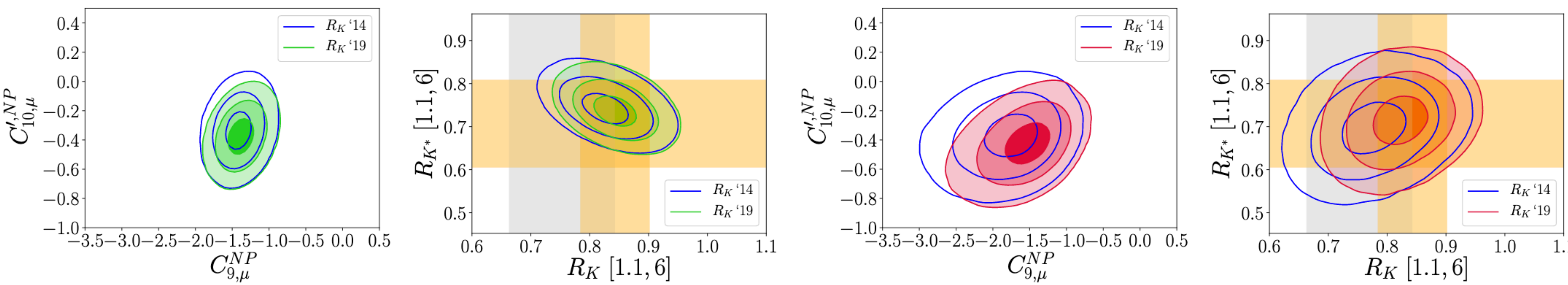
Purely left-handed solutions are no longer preferred by data:

Ciuchini, Coutinho, MF, Franco, Paul, Silvestrini, Valli (1903.09632)

LH:



LH + RH:

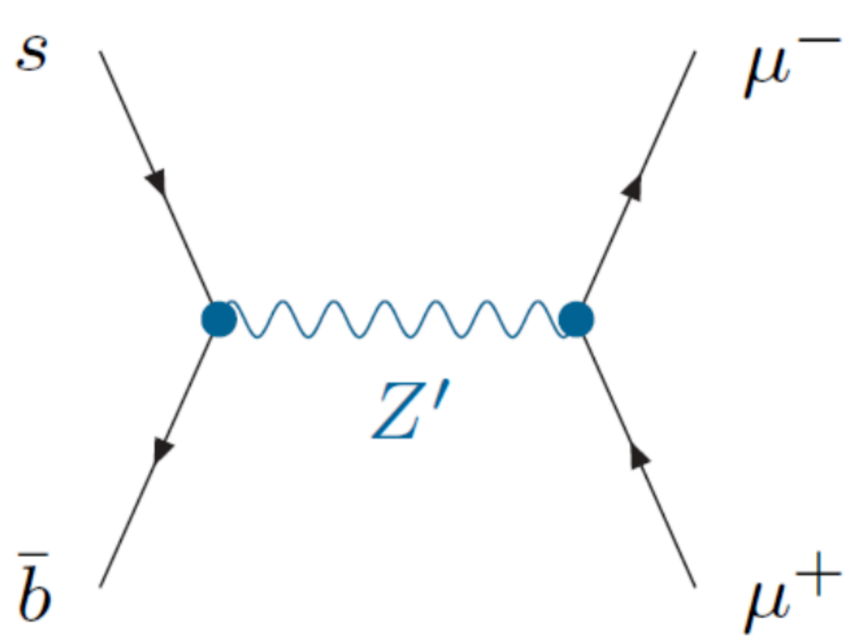


The inclusion of right-handed currents better reproduce data!

Similar findings by Algueró et al., Alok et al., Aebischer et al., Kowalska et al.

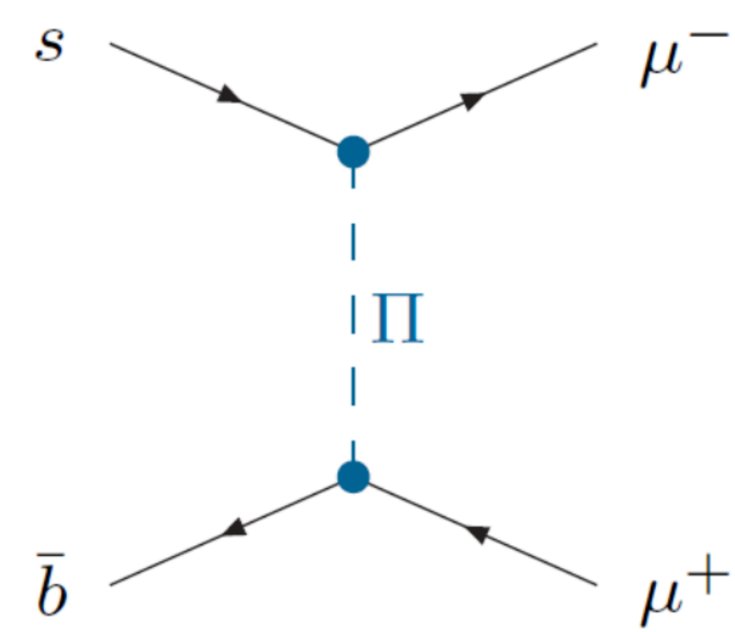
Tree-Level Models

Many possible solutions investigated so far involve tree-level NP



Z' models

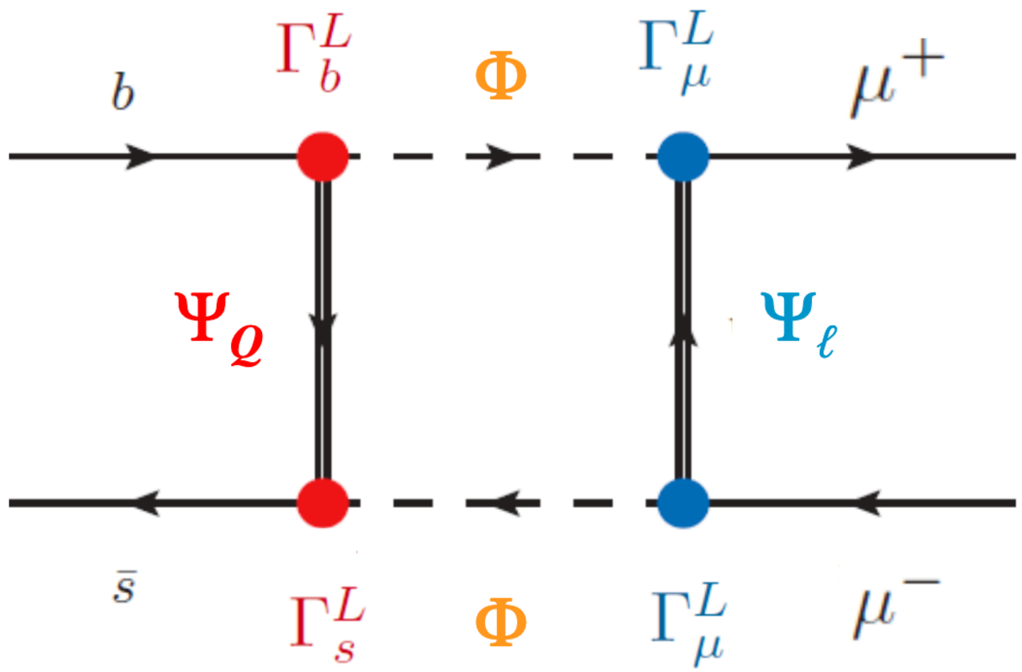
Allanach, Bordone, Buras, Crivellin, D'Ambrosio, De Fazio, Di Luzio, Falkowski, Fuentes-Martin, Gori, Isidori, Nierste, Vicente, …



Lepto-Quarks

Becirevic, Bordone, Crivellin, Di Luzio, Fajfer, Faroughy, Isidori, Kosnik, Marzocca, Sumensari, …

Loop Models

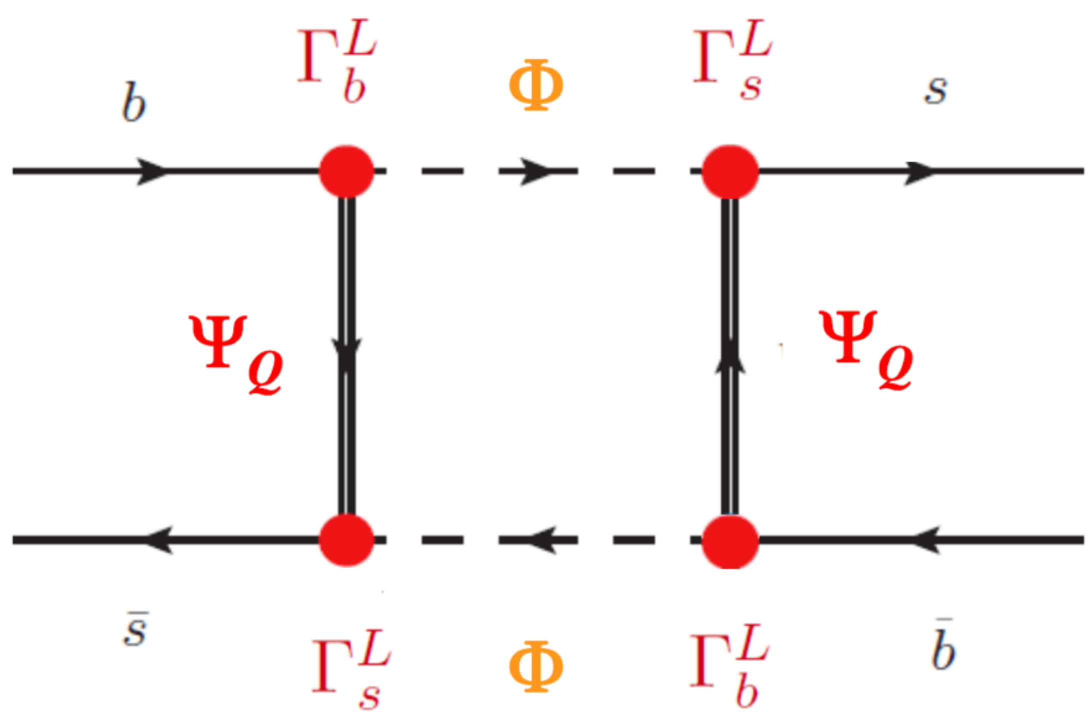


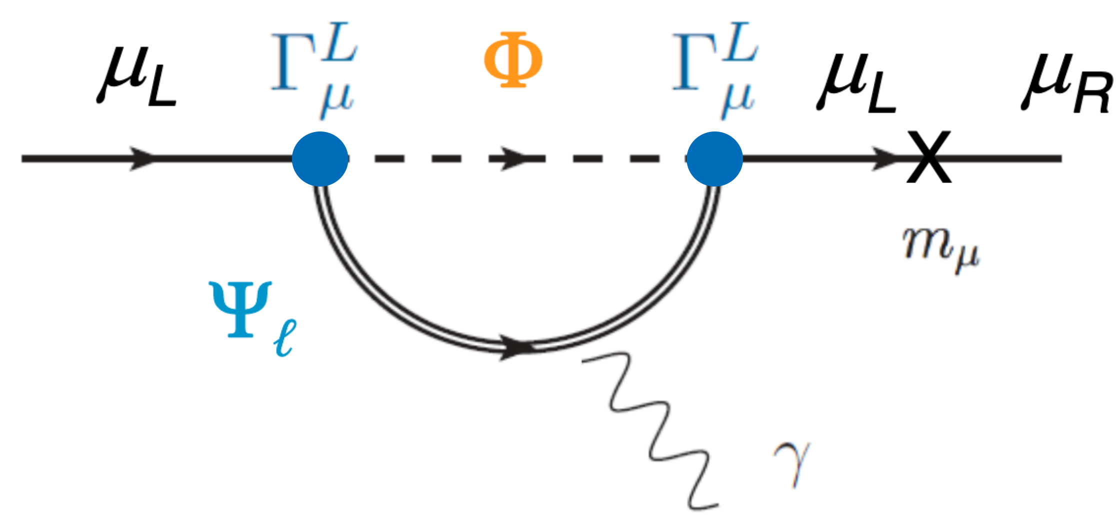
One scalar and 2 vector-like fermions (or vice versa)

$\Longrightarrow$ C9 = -C10

Gripaios, Nardecchia, Renner ’15
Arnan, Crivellin, Hofer, Mescia ’16

Induces contributions to ΔMs and muon g-2





It is not possible to address everything with O(1) couplings and viable masses

Our Generic Loop Model

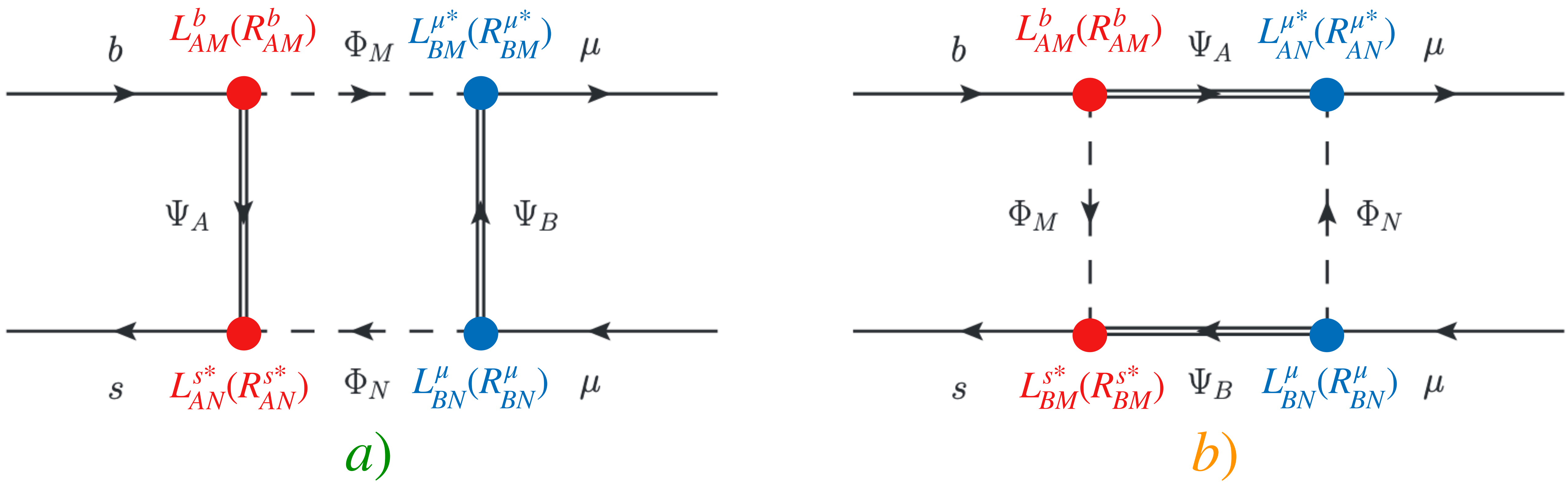
$$\mathcal{L}_{\text{int}} = \Big[\, \bar{\Psi}_A \left(L^b_{AM} P_L b + L^s_{AM} P_L s + L^\mu_{AM} P_L \mu \right) \Phi_M$$
$$+ \bar{\Psi}_A \left(R^b_{AM} P_R b + R^s_{AM} P_R s + R^\mu_{AM} P_R \mu \right) \Phi_M \Big] + \text{h.c.}$$

Ψ_A, Φ_M : Generic lists containing an arbitrary number of fields

$L^{b,s,\mu}_{AM}, R^{b,s,\mu}_{AM}$: Generic matrices in (A-M) space

- A and M also include implicitly SU(3) and SU(2) indices
- Non-vanishing entries of the coupling matrices ensure the preservation of colour and electric charge

b→sμμ



Two distinct solution, whether the fermion or the scalar is the NP field that couples to both quarks and leptons

$$x_{AM} \equiv (m_{\Psi_A}/m_{\Phi_M})^2$$

$$C_9^{\text{box}, a)} = -\mathcal{N}\frac{\chi L^{s*}_{AN} L^b_{AM}}{32\pi\alpha_{\text{EM}} m^2_{\Phi_M}} \left[L^{\mu*}_{BM} L^{\mu}_{BN} + R^{\mu*}_{BM} R^{\mu}_{BN}\right] F(x_{AM}, x_{BM}, x_{NM})$$

$$C_{10}^{\text{box}, a)} = \mathcal{N}\frac{\chi L^{s*}_{AN} L^b_{AM}}{32\pi\alpha_{\text{EM}} m^2_{\Phi_M}} \left[L^{\mu*}_{BM} L^{\mu}_{BN} - R^{\mu*}_{BM} R^{\mu}_{BN}\right] F(x_{AM}, x_{BM}, x_{NM})$$

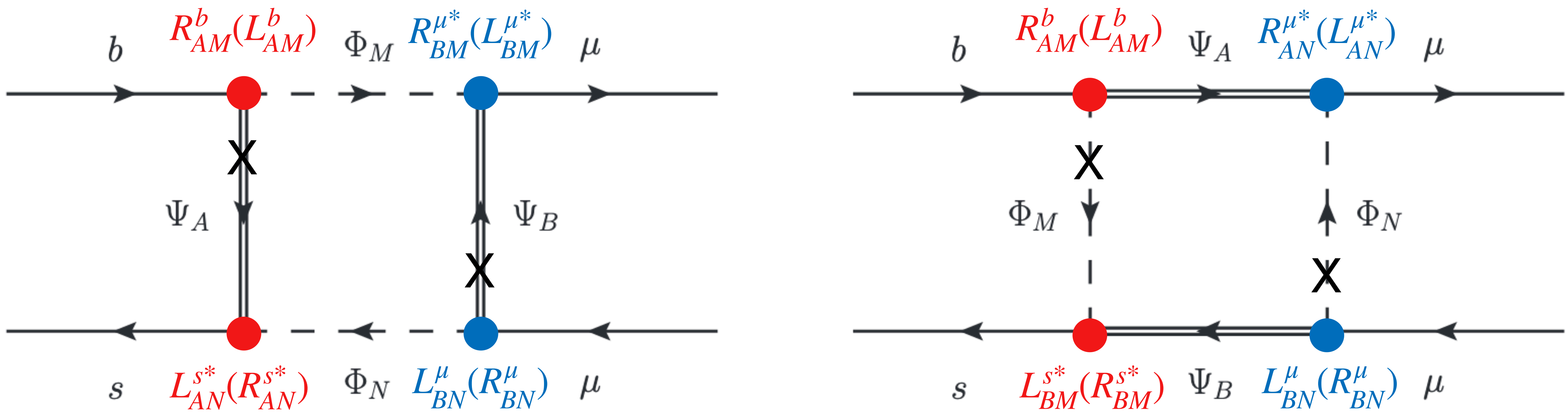
$$C'^{\text{box}}_{9(10)} = \pm\, C^{\text{box}}_{9(10)}(L \leftrightarrow R)$$

$$x_{NM} \equiv (m_{\Phi_N}/m_{\Phi_M})^2$$

$$C_9^{\text{box}, b)} = -\mathcal{N}\frac{\chi L^{s*}_{BM} L^b_{AM}}{32\pi\alpha_{\text{EM}} m^2_{\Phi_M}} \left[L^{\mu*}_{AN} L^{\mu}_{BN} F(x_{AM}, x_{BM}, x_{NM}) - R^{\mu*}_{AN} R^{\mu}_{BN} \frac{m_{\Psi_A} m_{\Psi_B}}{m^2_{\Phi_M}} G(x_{AM}, x_{BM}, x_{NM})\right]$$

$$C_{10}^{\text{box}, b)} = \mathcal{N}\frac{\chi L^{s*}_{BM} L^b_{AM}}{32\pi\alpha_{\text{EM}} m^2_{\Phi_M}} \left[L^{\mu*}_{AN} L^{\mu}_{BN} F(x_{AM}, x_{BM}, x_{NM}) + R^{\mu*}_{AN} R^{\mu}_{BN} \frac{m_{\Psi_A} m_{\Psi_B}}{m^2_{\Phi_M}} G(x_{AM}, x_{BM}, x_{NM})\right]$$

$b \to s\mu\mu$



a) *b)*

$$C_S^{\text{box},\,a)} = -\mathcal{N}\frac{\chi L^{s*}_{AN}R^b_{AM}}{16\pi\alpha_{\rm EM}m^2_{\Phi_M}}\left[R^{\mu*}_{BM}L^{\mu}_{BN} + L^{\mu*}_{BM}R^{\mu}_{BN}\right]\frac{m_{\Psi_A}m_{\Psi_B}}{m^2_{\Phi_M}}G(x_{AM},x_{BM},x_{NM})$$

$$C_P^{\text{box},\,a)} = \mathcal{N}\frac{\chi L^{s*}_{AN}R^b_{AM}}{16\pi\alpha_{\rm EM}m^2_{\Phi_M}}\left[R^{\mu*}_{BM}L^{\mu}_{BN} - L^{\mu*}_{BM}R^{\mu}_{BN}\right]\frac{m_{\Psi_A}m_{\Psi_B}}{m^2_{\Phi_M}}G(x_{AM},x_{BM},x_{NM})$$

$$C'^{\text{box}}_{S,T(P)} = \pm\, C^{\text{box}}_{S,T(P)}(L \leftrightarrow R)$$

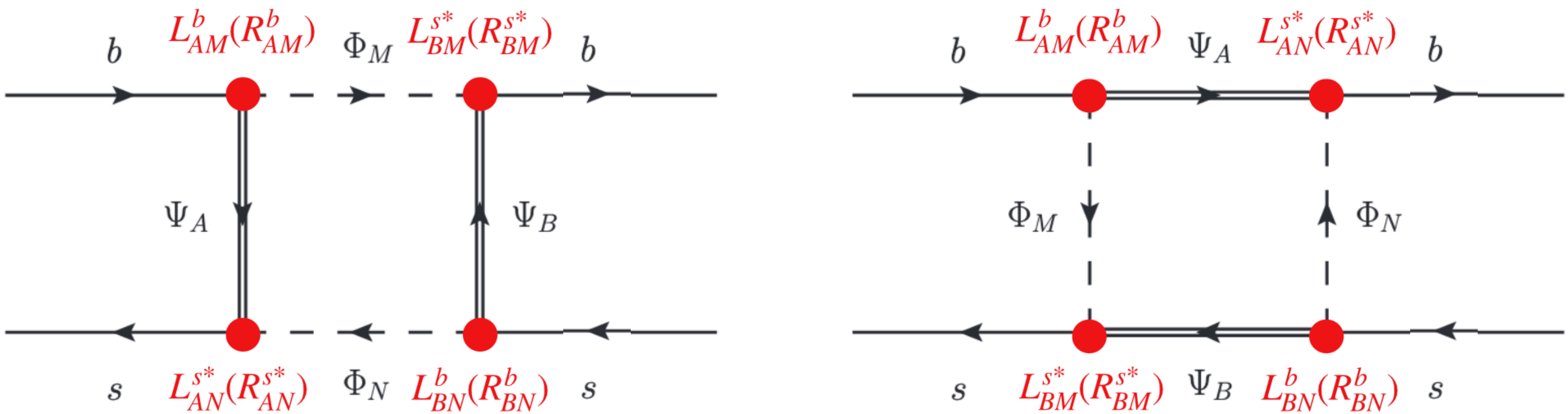
$$C_S^{\text{box},\,b)} = \mathcal{N}\frac{\chi L^{s*}_{BM}R^b_{AM}}{16\pi\alpha_{\rm EM}m^2_{\Phi_M}}\left[R^{\mu*}_{AN}L^{\mu}_{BN}F(x_{AM},x_{BM},x_{NM}) + L^{\mu*}_{AN}R^{\mu}_{BN}\frac{m_{\Psi_A}m_{\Psi_B}}{2m^2_{\Phi_M}}G(x_{AM},x_{BM},x_{NM})\right]$$

$$C_P^{\text{box},\,b)} = -\mathcal{N}\frac{\chi L^{s*}_{BM}R^b_{AM}}{16\pi\alpha_{\rm EM}m^2_{\Phi_M}}\left[R^{\mu*}_{AN}L^{\mu}_{BN}F(x_{AM},x_{BM},x_{NM}) - L^{\mu*}_{AN}R^{\mu}_{BN}\frac{m_{\Psi_A}m_{\Psi_B}}{2m^2_{\Phi_M}}G(x_{AM},x_{BM},x_{NM})\right]$$

$$C_T^{\text{box},\,b)} = -\mathcal{N}\frac{\chi L^{s*}_{BM}R^b_{AM}L^{\mu*}_{AN}R^{\mu}_{BN}}{16\pi\alpha_{\rm EM}m^2_{\Phi_M}}\frac{m_{\Psi_A}m_{\Psi_B}}{m^2_{\Phi_M}}G(x_{AM},x_{BM},x_{NM})$$

Additional WC present only in the presence of additional SU(2) breaking effects

ΔMs



Both diagrams appear, independently on b→s$\mu\mu$, since no leptons are involved in this channel

$$C_1 = (\chi_{BB} + \tilde{\chi}_{BB}) \frac{L^{s*}_{AN} L^b_{AM} L^{s*}_{BM} L^b_{BN}}{128\pi^2 m^2_{\Phi_M}} F(x_{AM}, x_{BM}, x_{NM}) \;,$$

$$C_2 = \chi_{BB} \frac{R^{s*}_{AN} L^b_{AM} R^{s*}_{BM} L^b_{BN}}{64\pi^2 m^2_{\Phi_M}} \frac{m_{\Psi_A} m_{\Psi_B}}{m^2_{\Phi_M}} G(x_{AM}, x_{BM}, x_{NM}) \;,$$

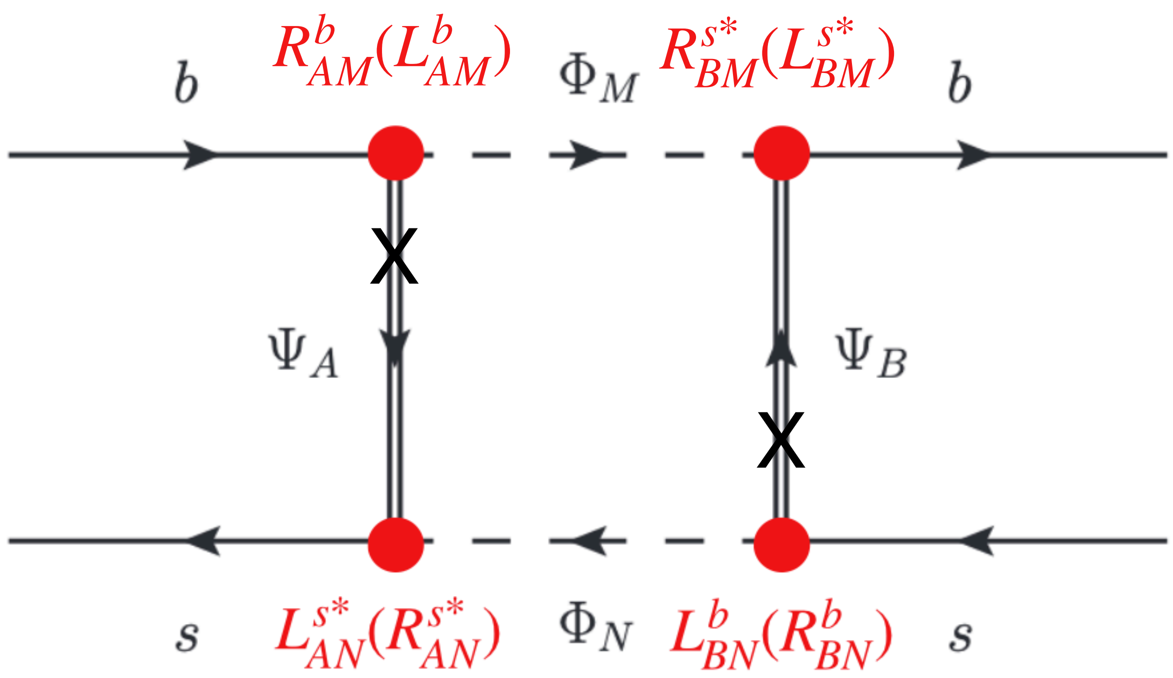
$$C_3 = \tilde{\chi}_{BB} \frac{R^{s*}_{AN} L^b_{AM} R^{s*}_{BM} L^b_{BN}}{64\pi^2 m^2_{\Phi_M}} \frac{m_{\Psi_A} m_{\Psi_B}}{m^2_{\Phi_M}} G(x_{AM}, x_{BM}, x_{NM}) \;,$$

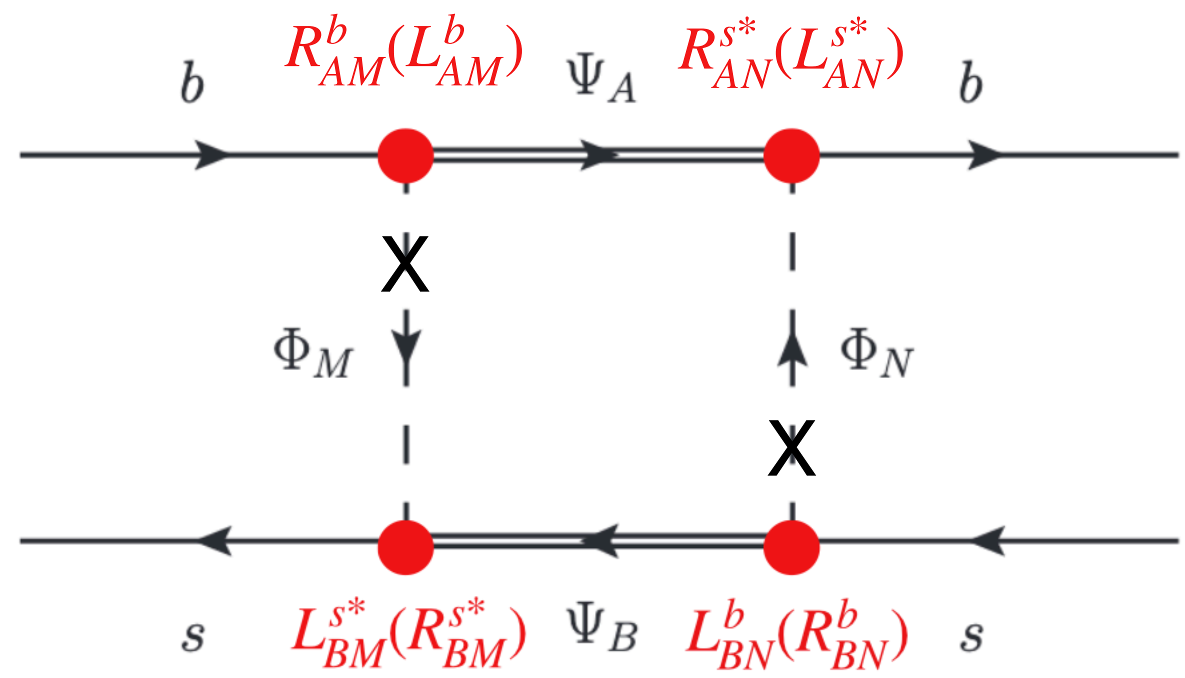
$$\widetilde{C}_{1,2,3} = C_{1,2,3}\,(L \leftrightarrow R)$$

$$C_4 = \chi_{BB} \frac{R^{s*}_{AN} L^b_{AM} L^{s*}_{BM} R^b_{BN}}{32\pi^2 m^2_{\Phi_M}} \frac{m_{\Psi_A} m_{\Psi_B}}{m^2_{\Phi_M}} G(x_{AM}, x_{BM}, x_{NM}) - \tilde{\chi}_{BB} \frac{R^{s*}_{AN} R^b_{AM} L^{s*}_{BM} L^b_{BN}}{32\pi^2 m^2_{\Phi_M}} F(x_{AM}, x_{BM}, x_{NM}) \;,$$

$$C_5 = \tilde{\chi}_{BB} \frac{R^{s*}_{AN} L^b_{AM} L^{s*}_{BM} R^b_{BN}}{32\pi^2 m^2_{\Phi_M}} \frac{m_{\Psi_A} m_{\Psi_B}}{m^2_{\Phi_M}} G(x_{AM}, x_{BM}, x_{NM}) - \chi_{BB} \frac{R^{s*}_{AN} R^b_{AM} L^{s*}_{BM} L^b_{BN}}{32\pi^2 m^2_{\Phi_M}} F(x_{AM}, x_{BM}, x_{NM}) \;,$$

ΔMs





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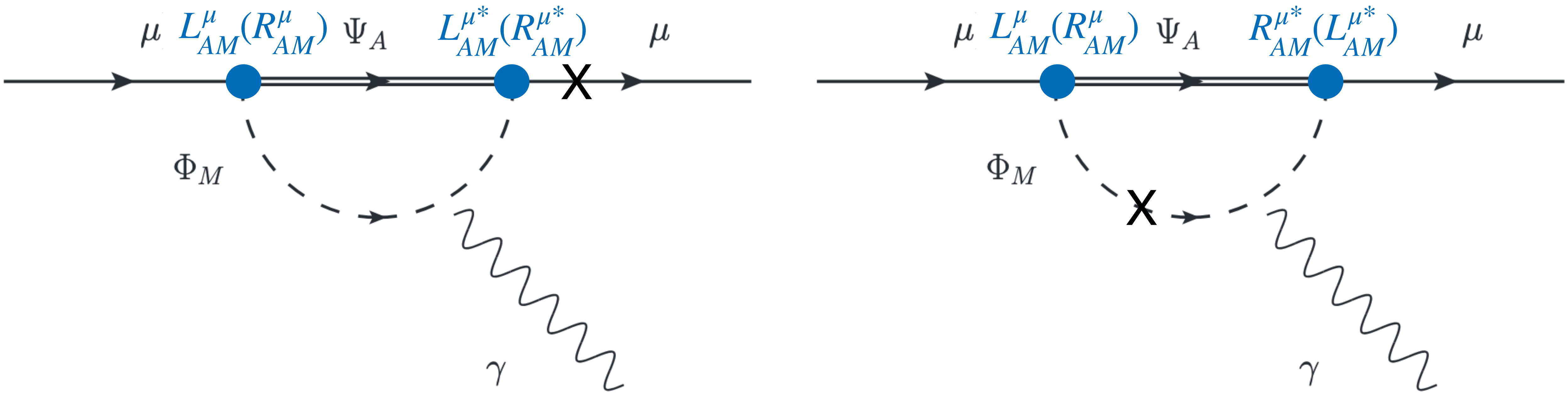
Additional contributions to WC present in the presence of additional SU(2) breaking effects

g-2



$$\Delta a_\mu = \frac{\chi_{a_\mu} m_\mu^2}{8\pi^2 m_{\Phi_M}^2} \Big[\left(L^{\mu*}_{AM} L^{\mu}_{AM} + R^{\mu*}_{AM} R^{\mu}_{AM} \right) \left(Q_{\Phi_M} \widetilde{F}_7(x_{AM}) - Q_{\Psi_A} F_7(x_{AM}) \right)$$
$$+ \left(L^{\mu*}_{AM} R^{\mu}_{AM} + R^{\mu*}_{AM} L^{\mu}_{AM} \right) \frac{2 m_{\Psi_A}}{m_\mu} \left(Q_{\Phi_M} \widetilde{G}_7(x_{AM}) - Q_{\Psi_A} G_7(x_{AM}) \right) \Big]$$

Additional term induced by SU(2) breaking, and chirally enhanced

4th Generation Model

$$L^{4\text{th}} = \sum_i \left(\Gamma^L_{q_i}\bar{\Psi}_q P_L q_i + \Gamma^L_{\ell_i}\bar{\Psi}_\ell P_L \ell_i + \Gamma^R_{u_i}\bar{\Psi}_u P_R u_i + \Gamma^R_{d_i}\bar{\Psi}_d P_R d_i + \Gamma^R_{e_i}\bar{\Psi}_e P_R e_i\right)\Phi + \text{h.c.}$$
$$+ \sum_{C=L,R}\left(\lambda^U_C \bar{\Psi}_q P_C \tilde{h}\Psi_u + \lambda^D_C \bar{\Psi}_q P_C h \Psi_d + \lambda^E_C \bar{\Psi}_\ell P_C h \Psi_e\right) + \text{h.c.}$$
$$+ \sum_{F=q,\ell,u,d,e} M_F \bar{\Psi}_F \Psi_F + \kappa\, h^\dagger h\, \Phi^\dagger \Phi + m^2_\Phi \Phi^\dagger \Phi$$

We start writing down the most general Lagrangian before EWSB including a 4th vector-like generation and a neutral scalar

	$SU(3)$	$SU(2)$	$U(1)$	$U'(1)$
Ψ_q	3	2	1/6	Z
Ψ_u	3	1	2/3	Z
Ψ_d	3	1	$-1/3$	Z
Ψ_ℓ	1	2	$-1/2$	Z
Ψ_e	1	1	-1	Z
Φ	1	1	0	$-Z$

NB. We work in the basis with diagonal down-type quarks

4th Generation Model

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$$+ \sum_{C=L,R}\left(\lambda^U_C \bar{\Psi}_q P_C \tilde{h}\Psi_u + \lambda^D_C \bar{\Psi}_q P_C h \Psi_d + \lambda^E_C \bar{\Psi}_\ell P_C h \Psi_e\right) + \text{h.c.}$$

$$+ \sum_{F=q,\ell,u,d,e} M_F \bar{\Psi}_F \Psi_F + \kappa\, h^\dagger h\, \Phi^\dagger \Phi + m_\Phi^2 \Phi^\dagger \Phi$$

We're interested only in couplings to bottom, strange, muon

4th Generation Model

$$L^{4\text{th}} = \sum_i \left(\Gamma^L_{q_i}\bar{\Psi}_q P_L q_i + \Gamma^L_{\ell_i}\bar{\Psi}_\ell P_L \ell_i + \Gamma^R_{u_i}\bar{\Psi}_u P_R u_i + \Gamma^R_{d_i}\bar{\Psi}_d P_R d_i + \Gamma^R_{e_i}\bar{\Psi}_e P_R e_i\right)\Phi + \text{h.c.}$$
$$+ \sum_{C=L,R}\left(\lambda^U_C \bar{\Psi}_q P_C \tilde{h}\Psi_u + \lambda^D_C \bar{\Psi}_q P_C h \Psi_d + \lambda^E_C \bar{\Psi}_\ell P_C h \Psi_e\right) + \text{h.c.}$$
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We neglect SU(2) breaking for down-type quarks
(responsible for phenomenological un-relevant scalar/tensor operators)

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$$+ \sum_{C=L,R}\left(\lambda^U_C\bar{\Psi}_q P_C\tilde{h}\Psi_u + \lambda^D_C\bar{\Psi}_q P_C h\Psi_d + \lambda^E_C\bar{\Psi}_\ell P_C h\Psi_e\right) + \text{h.c.}$$

$$+ \sum_{F=q,\ell,u,d,e} M_F\bar{\Psi}_F\Psi_F + \kappa\, h^\dagger h\,\Phi^\dagger\Phi + m^2_\Phi\Phi^\dagger\Phi$$

We're interested only in couplings to bottom, strange, muon

We neglect SU(2) breaking for down-type quarks
(responsible for phenomenological un-relevant scalar/tensor operators)

We need to diagonalize the lepton sector!

4th Generation Model

$$L^{4\text{th}} = \sum_i \left(\Gamma^L_{q_i}\bar{\Psi}_q P_L q_i + \Gamma^L_{\ell_i}\bar{\Psi}_\ell P_L \ell_i + \Gamma^R_{u_i}\bar{\Psi}_u P_R u_i + \Gamma^R_{d_i}\bar{\Psi}_d P_R d_i + \Gamma^R_{e_i}\bar{\Psi}_e P_R e_i\right)\Phi + \text{h.c.}$$
$$+ \sum_{C=L,R}\left(\lambda^U_C\bar{\Psi}_q P_C\tilde{h}\Psi_u + \lambda^D_C\bar{\Psi}_q P_C h\Psi_d + \lambda^E_C\bar{\Psi}_\ell P_C h\Psi_e\right) + \text{h.c.}$$
$$+ \sum_{F=q,\ell,u,d,e} M_F\bar{\Psi}_F\Psi_F + \kappa\, h^\dagger h\,\Phi^\dagger\Phi + m^2_\Phi\Phi^\dagger\Phi$$

Below EWSB:

$$L^{4\text{th}}_{\text{mass}} = \begin{pmatrix}\bar{\Psi}_{\ell,2}\\ \bar{\Psi}_e\end{pmatrix}^T \begin{pmatrix} M_\ell & \sqrt{2}v\lambda^E_R \\ \sqrt{2}v\lambda^{E*}_L & M_e\end{pmatrix} P_L \begin{pmatrix}\Psi_{\ell,2}\\ \Psi_e\end{pmatrix} \Rightarrow$$

$$P_L\begin{pmatrix}\Psi_{\ell,2}\\ \Psi_e\end{pmatrix}_I \to W^{E_L}_{IJ}\Psi^{E_L}_J$$

$$\begin{pmatrix}\bar{\Psi}_{\ell,2}\\ \bar{\Psi}_e\end{pmatrix}^T_I P_L \to \bar{\Psi}^{E_R}_J W^{E_R}_{IJ}$$

4th Generation Model

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$$P_L \begin{pmatrix}\Psi_{\ell,2}\\ \Psi_e\end{pmatrix}_I \to W^{E_L}_{IJ}\Psi^{E_L}_J$$

$$\begin{pmatrix}\bar{\Psi}_{\ell,2}\\ \bar{\Psi}_e\end{pmatrix}^T_I P_L \to \bar{\Psi}^{E_R}_J W^{E_R}_{IJ}$$

$$P_L \begin{pmatrix}\Psi_{q,2}\\ \Psi_d\end{pmatrix}_I \to \delta_{IJ}\Psi^{D_L}_J$$

$$\begin{pmatrix}\bar{\Psi}_{q,2}\\ \bar{\Psi}_d\end{pmatrix}^T_I P_L \to \bar{\Psi}^{D_R}_J \delta_{IJ}$$

$$L^{4\text{th}}_{\text{int}} = \left(L^b_1\bar{\Psi}^D_1 P_L b + L^s_1\bar{\Psi}^D_1 P_L s + L^\mu_I\bar{\Psi}^E_I P_L \mu\right)\Phi + \left(R^b_2\bar{\Psi}^D_1 P_R b + R^s_2\bar{\Psi}^D_1 P_R s + R^\mu_I\bar{\Psi}^E_I P_R \mu\right)\Phi$$

$$L^s_1 = \Gamma^L_s\,, \qquad L^b_1 = \Gamma^L_b\,, \qquad R^s_2 = \Gamma^R_s\,, \qquad R^b_2 = \Gamma^R_b\,,$$

$$L^\mu_1 = \Gamma^L_\mu \cos\theta_L\,, \qquad L^\mu_2 = -\Gamma^L_\mu \sin\theta_L\,, \qquad R^\mu_1 = \Gamma^R_\mu \sin\theta_R\,, \qquad R^\mu_2 = \Gamma^R_\mu \cos\theta_R$$

4th Generation Model - WC

$$\Gamma^L \equiv L_1^b L_1^{s*}\,, \qquad \Gamma^R \equiv R_2^b R_2^{s*}$$

- $b \to s\mu\mu$

$$C_9^{\rm box} = -\mathcal{N}\frac{\Gamma^L}{32\pi\alpha_{\rm EM} m_\Phi^2}\left(|\Gamma_\mu^L|^2 + |\Gamma_\mu^R|^2\right) F(x_D, x_E)$$

$$C_{10}^{\rm box} = \mathcal{N}\frac{\Gamma^L}{32\pi\alpha_{\rm EM} m_\Phi^2}\left(|\Gamma_\mu^L|^2 - |\Gamma_\mu^R|^2\right) F(x_D, x_E)$$

$$C_{9(10)}^{\prime\rm box} = \pm\, C_{9(10)}^{\rm box}(L \leftrightarrow R)$$

- ΔM_S

$$C_1 = \frac{|\Gamma^L|^2}{128\pi^2 m_\Phi^2} F(x_D)\,, \quad C_5 = -\frac{\Gamma^L\Gamma^R}{32\pi^2 m_\Phi^2} F(x_D)\,, \quad \widetilde{C}_1 = \frac{|\Gamma^R|^2}{128\pi^2 m_\Phi^2} F(x_D)$$

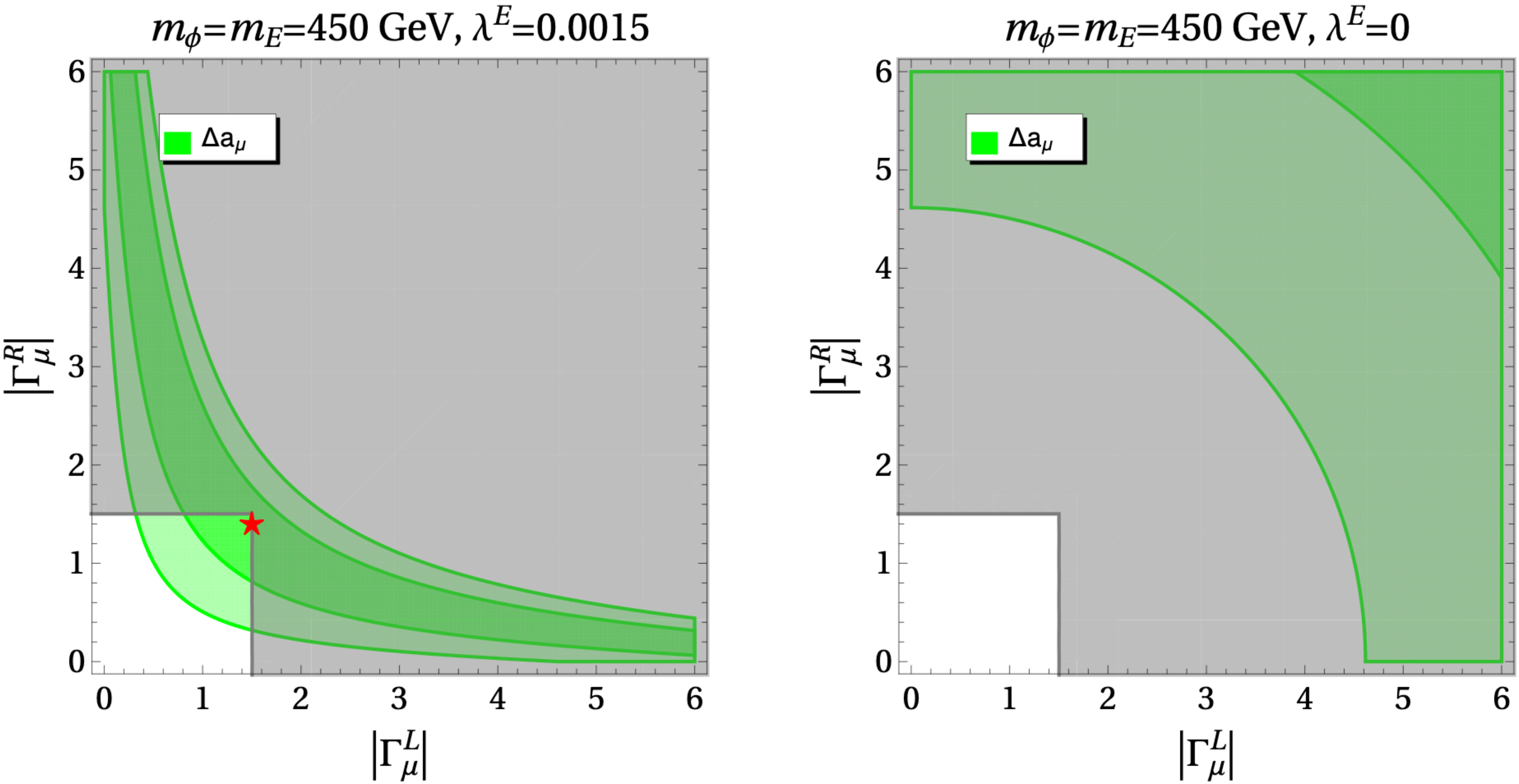
- g-2

$$\lambda_R^E = -\lambda_L^E \equiv \lambda^E$$

$$\Delta a_\mu = \frac{m_\mu^2}{8\pi^2 m_\Phi^2}\left[\left(|\Gamma_\mu^L|^2 + |\Gamma_\mu^R|^2\right) F_7(x_E) + \frac{8}{\sqrt{2}}\frac{v\,\lambda^E}{m_\mu}\Gamma_\mu^L\Gamma_\mu^R G_7(x_E)\right]$$

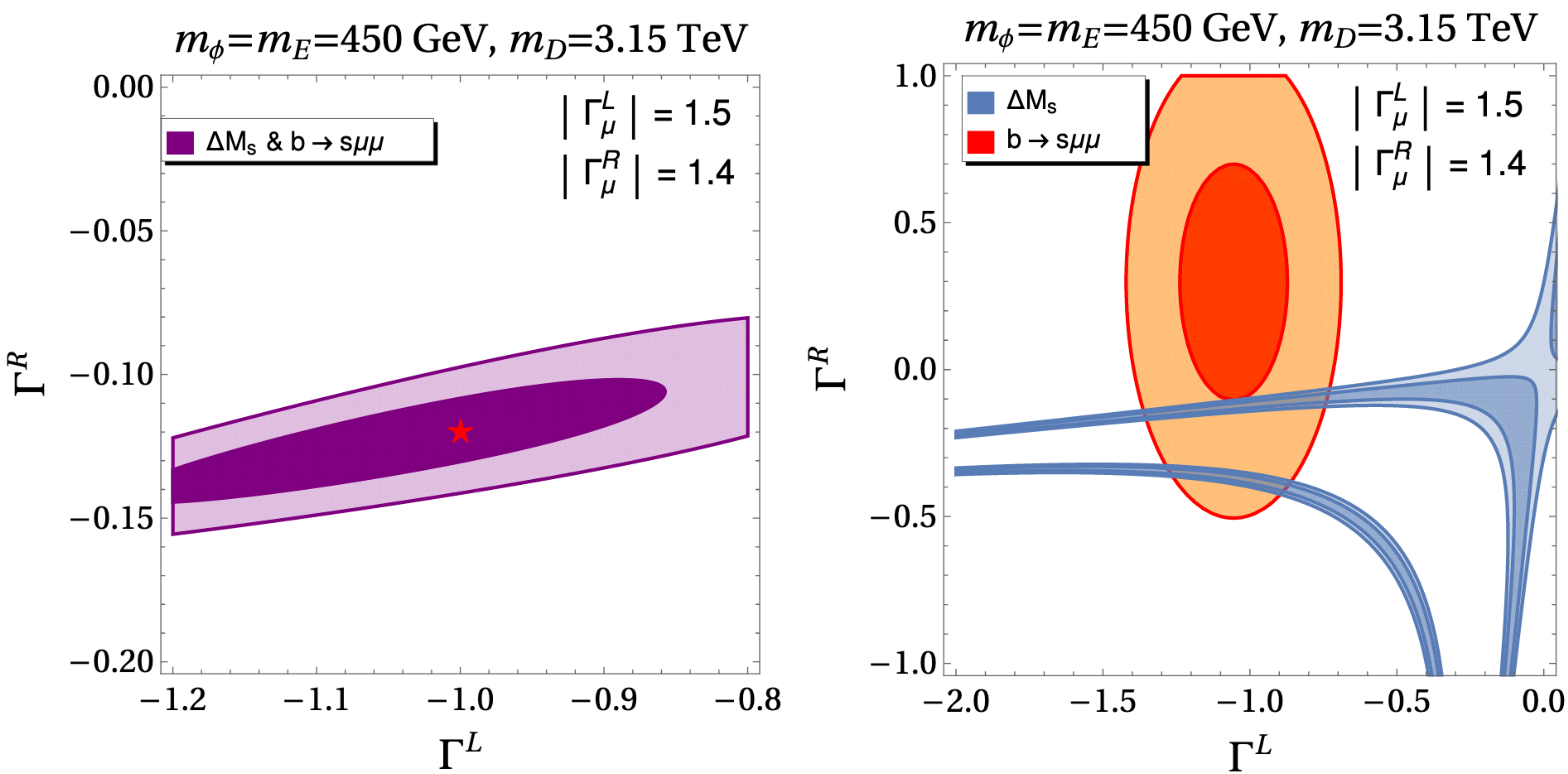
$$|\Gamma_\mu^L| = 1.5\,, \qquad |\Gamma_\mu^R| = 1.4\,, \qquad \lambda^E = 0.0015\,, \qquad \Gamma^L = -1.0\,, \qquad \Gamma^R = -0.12$$

Fit g-2



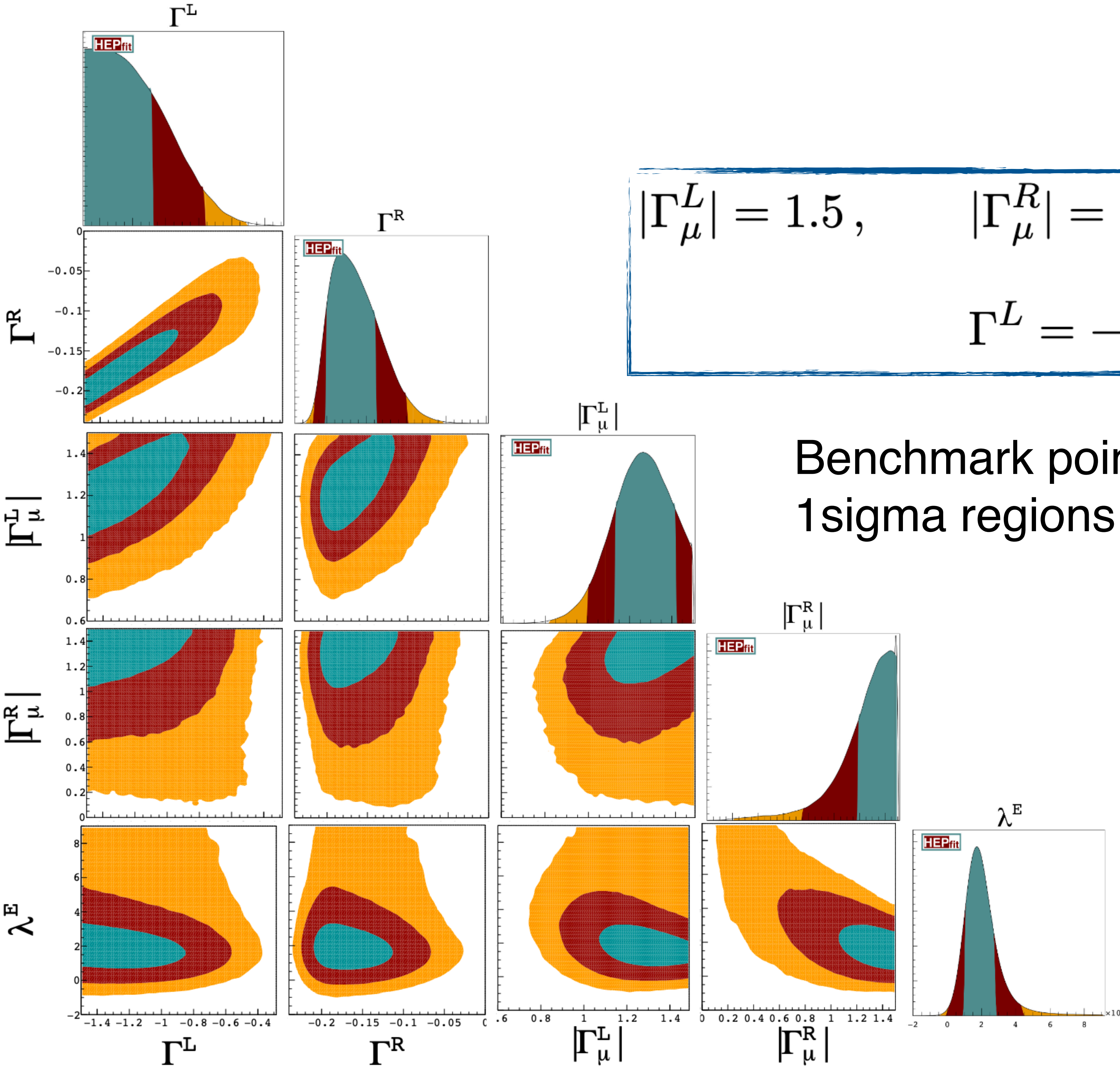
Right-handed coupling and SU(2) breaking both fundamental!

Fit B decays



Right-handed coupling fundamental!

Global Fit



$$|\Gamma_\mu^L| = 1.5\,, \qquad |\Gamma_\mu^R| = 1.4\,, \qquad \lambda^E = 0.0015$$

$$\Gamma^L = -1.0\,, \qquad \Gamma^R = -0.12$$

Benchmark point, compatible with all 1sigma regions of combined pdf

Conclusions

- We have provided analytical formulae for studying B anomalies, BBbar mixing and g-2 in the context of general loop models
- We have investigated the additional effects provided by right-handed couplings and additional SU(2) breaking effects
- We have investigated the phenomenology in a specific model, i.e. 4th generations of vector-like fermions + neutral scalar, and addressed all the above anomalies with viable masses and O(1) couplings
- The neutral scalar is a viable (stable) DM candidate, which however require a further detailed analysis still to be addressed

Back-up

Colour Factors

$SU(3)$	$b\to s\ell\bar{\ell}$ type $a)$				$b\to s\ell\bar{\ell}$ type $b)$				χ
	Ψ_A	Ψ_B	Φ_M	Φ_N	Ψ_A	Ψ_B	Φ_M	Φ_N	
I	3	1	1	1	1	1	$\bar{3}$	1	1
II	1	$\bar{3}$	$\bar{3}$	$\bar{3}$	3	3	1	3	1
III	3	8	8	8	8	8	$\bar{3}$	8	4/3
IV	8	$\bar{3}$	$\bar{3}$	$\bar{3}$	3	3	8	3	4/3
V	$\bar{3}$	3	3	3	$\bar{3}$	$\bar{3}$	3	$\bar{3}$	2

Table 1. Table of the possible $SU(3)$ representations that can give an effect in $b\to s\ell^+\ell^-$ or $b\to s\nu\nu$ transitions via box diagrams. χ denotes the resulting group factor appearing in Eqs. (2.4)-(2.8) which also enters in $b\to s\nu\nu$ transitions.

$SU(3)$	Ψ_A	Ψ_B	Φ_M	Φ_N	χ_{BB}	$\tilde{\chi}_{BB}$
I	3	3	1	1	1	0
II	1	1	$\bar{3}$	$\bar{3}$	0	1
III	3	3	8	8	1/36	7/12
IV	8	8	$\bar{3}$	$\bar{3}$	7/12	1/36
V	3	3	(1,8)	(8,1)	-1/6	1/2
VI	(1,8)	(8,1)	$\bar{3}$	$\bar{3}$	1/2	-1/6
VII	$\bar{3}$	$\bar{3}$	3	3	1	1

Table 3. Table of the different $SU(3)$ representations that can give a non-zero effect via box diagrams to $B_s-\bar{B}_s$ mixing. χ_{BB} and $\tilde{\chi}_{BB}$ denote the resulting group factors.

$SU(3)$	Ψ_A	Φ_M	χ_{a_μ}
I	1	1	1
II	(3,$\bar{3}$)	(3,$\bar{3}$)	3
III	8	8	8

Table 4. Table of the different $SU(3)$ representations that can give a non-zero effect to a_μ.

D-Dbar mixing

$$L^{4\mathrm{th}} = \sum_i \left(\Gamma^L_{q_i}\bar{\Psi}_q P_L q_i + \Gamma^L_{\ell_i}\bar{\Psi}_\ell P_L \ell_i + \Gamma^R_{u_i}\bar{\Psi}_u P_R u_i + \Gamma^R_{d_i}\bar{\Psi}_d P_R d_i + \Gamma^R_{e_i}\bar{\Psi}_e P_R e_i\right)\Phi + \mathrm{h.c.}$$

SU(2) + CKM $\Downarrow$

$$L^u_1 = V^*_{us}\,\Gamma^L_s + V^*_{ub}\,\Gamma^L_b\,, \qquad L^c_1 = V^*_{cs}\,\Gamma^L_s + V^*_{cb}\,\Gamma^L_b$$

Only the product of down-type coupling is constrained

$$\Downarrow$$

$\Gamma^L_b \gg \Gamma^L_s$ implies negligible effects due to CKM suppressions

Fit Results for Relevant Observables

$$R_K[1.1,6] = 0.781(45)\,,\quad R_{K^*}[1.1,6] = 0.885(39)\,,\quad \bar{\mathcal{B}}(B_s \to \mu^+\mu^-) = 3.30(21)\cdot 10^{-9}\,,$$

$$P_5'[4,6] = -0.454(69)\,,\qquad P_5'[6,8] = -0.626(59)\,,$$

$$\Delta a_\mu = 235(87)\cdot 10^{-11}\,,\qquad R_{\Delta M_s} = -0.02(8)\,.$$