ON THE INTERPLAY BETWEEN FLAVOUR ANOMALIES AND NEUTRINO PROPERTIES

ANTÓNIO PESTANA MORAIS

DEPARTAMENTO DE FÍSICA DA UNIVERSIDADE DE AVEIRO AND CENTER FOR RESEARCH AND DEVELOPMENT IN MATHEMATICS AND APPLICATIONS(CIDMA)

CO-AUTHORS: R. PASECHNIK, J. GONÇALVES, W. POROD, F. FREITAS

FLASY 2022 - IST

BASED UPON: 2206.01674

CENTRO 2020 PORTUGAL 2020 UNIÃO EUROPEIA Fundos Europeus Estruturais e de Investimento universidade de aveiro CIDMA CENTRO DE I&D EM MATEMÁTICA E APLICAÇÕES CENTER FOR R&D IN MATHEMATICS AND APPLICATIONS

The SM is a tremendously successful theory that explains “boringly” well all its predictions!

However, it fails to…

- Explain neutrino masses
- Explain dark matter
- Explain CP violation and matter/anti-matter assymetry
- Explain the observed flavour structure

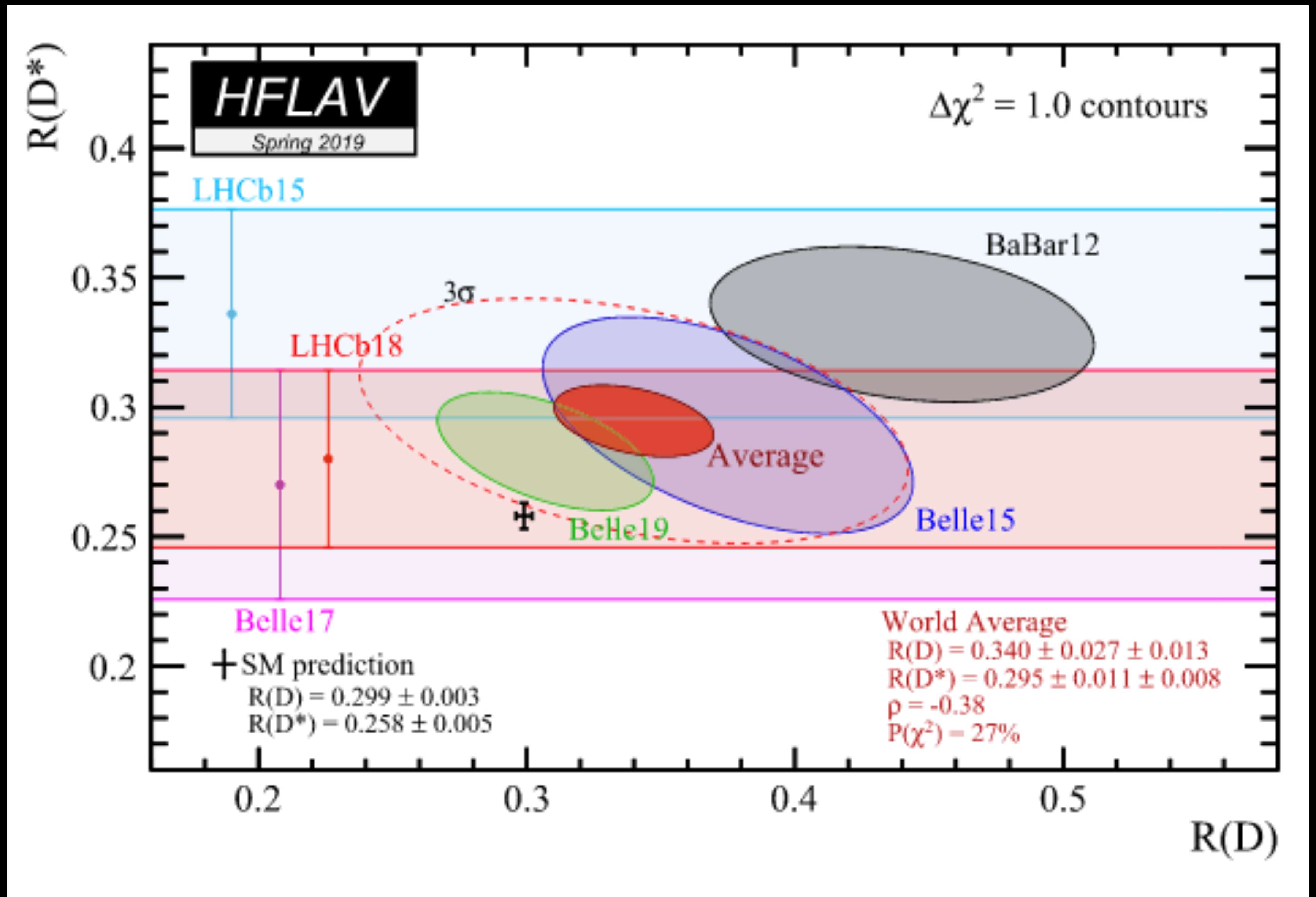
And it is in tension with several emergent anomalies

B-physics

$\overline{B} \to D^{(*)}\ell\overline{\nu}_\ell$ $\quad B \to K^*\ell^+\ell^-$ $\quad B^+ \to K^+\ell^+\ell^-$

$B_s \to \mu^+\mu^-$ $\quad B^0 \to \mu^+\mu^-$

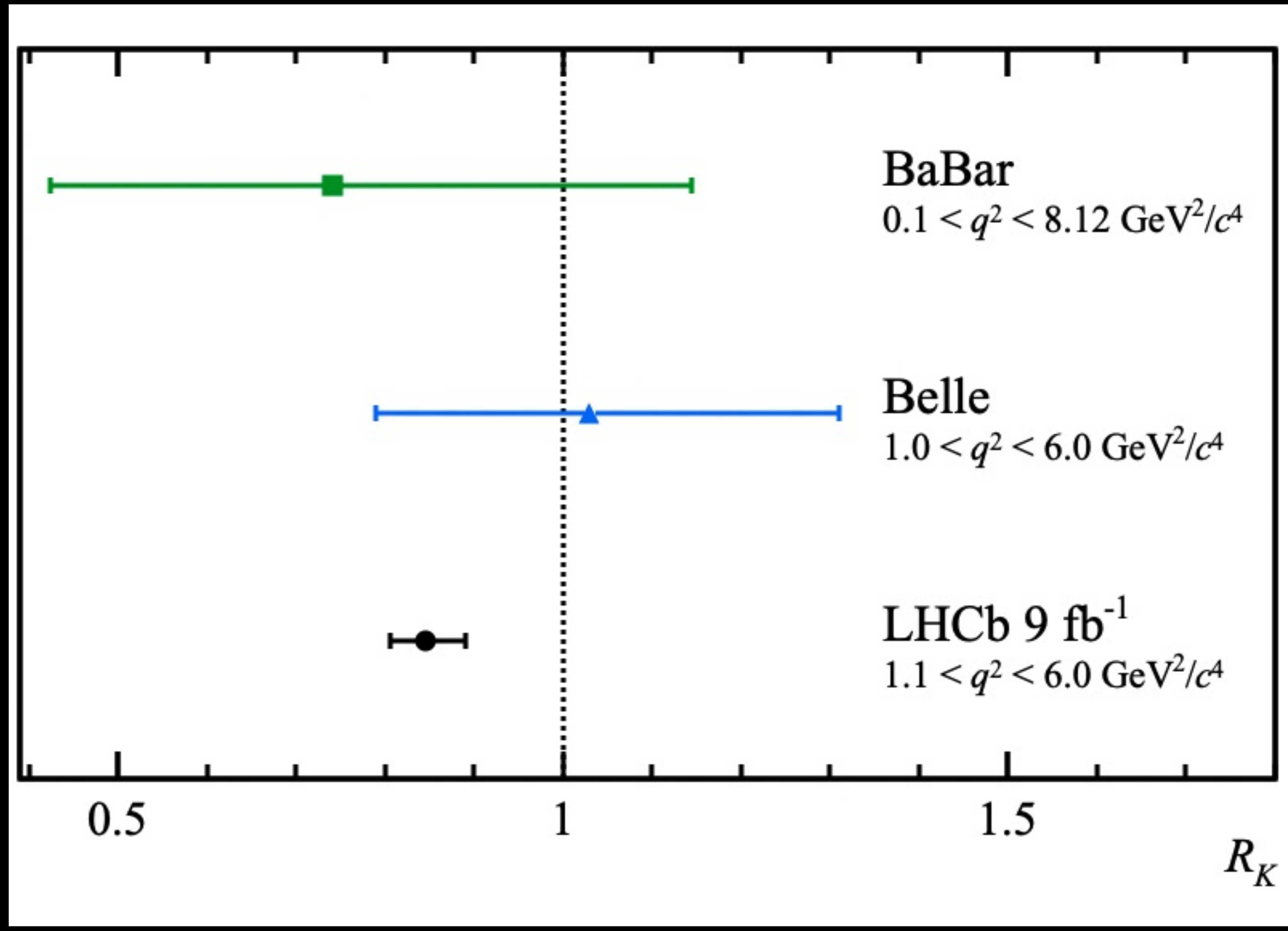
$a_\mu^{(?)}$ $\quad m_W^{\mathrm{CDF}}\ (?)$



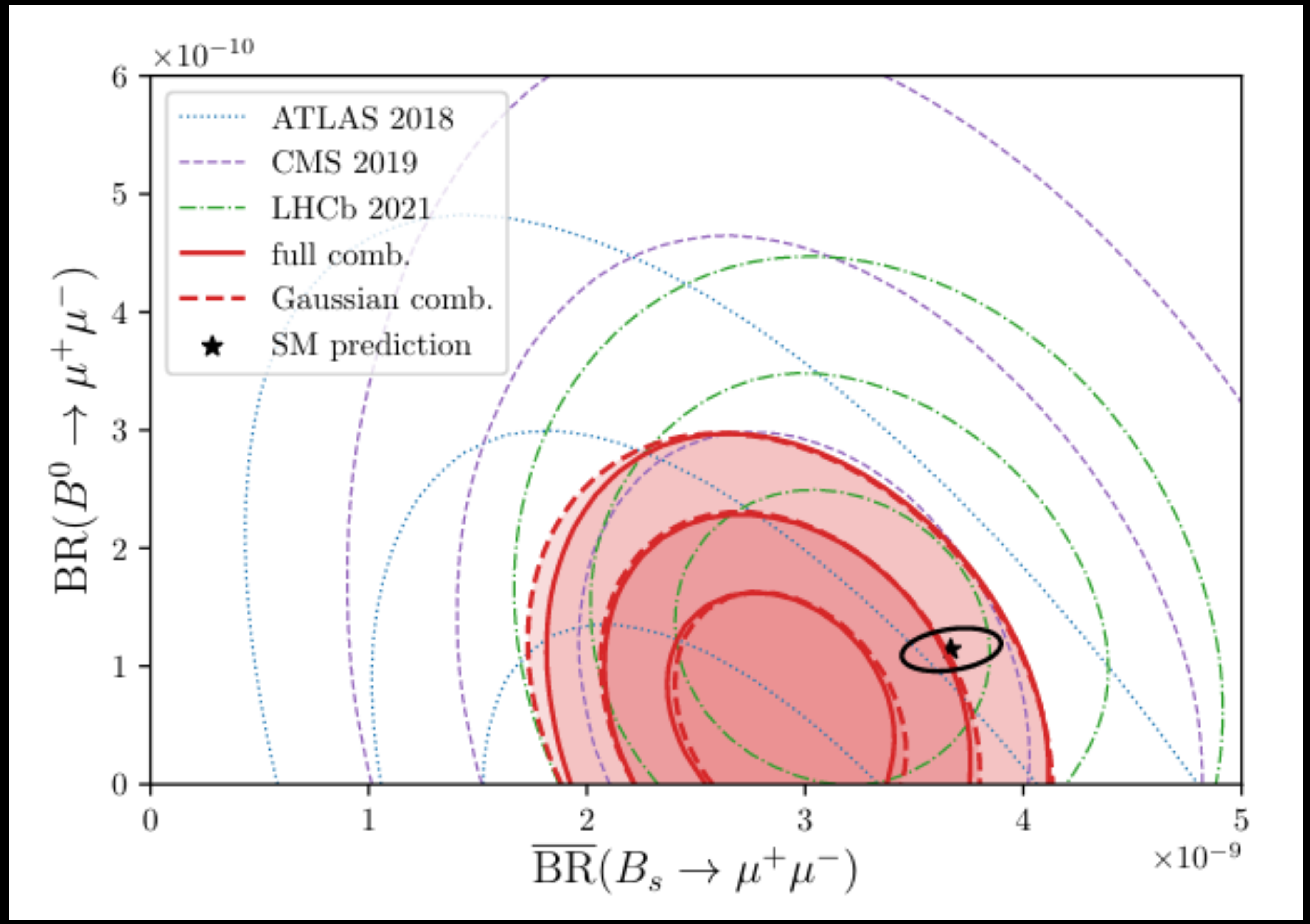
[Eur. Phys. J. C 81, 226 (2021)]

$$R_{D,D^*} = \frac{Br(\overline{B} \to D^{(*)}\tau\bar{\nu}_\tau)}{Br(\overline{B} \to D^{(*)}\ell\bar{\nu}_\ell))}$$

$$R_K = \frac{Br(B^+ \to K^+\mu^+\mu^-)}{Br(B^+ \to K^+e^+e^-)} = 0.846^{+0.055}_{-0.051}$$



[Nature Phys. 18, 277 (2022)]



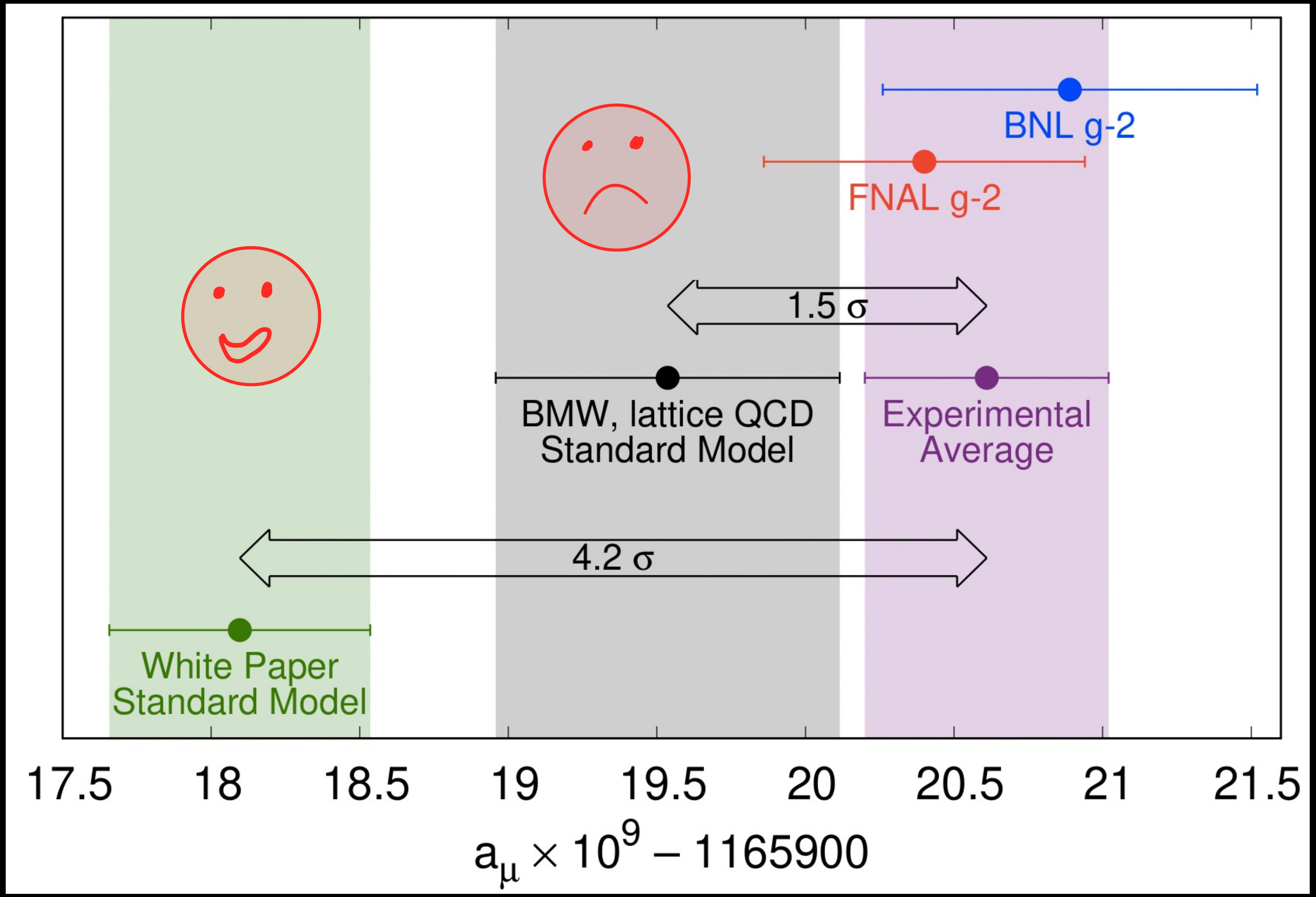
[Eur. Phys. J. C 81, 952 (2021)]

$$R_{K^*} = \frac{Br(B \to K^*\mu^+\mu^-)}{Br(B \to K^*e^+e^-)} = 0.685^{+0.160}_{-0.116}$$

[Phys. Rev. D 96, 095000 (2017)]

Tantalising hints for new physics in B decays

$a_\mu^{(?)}$

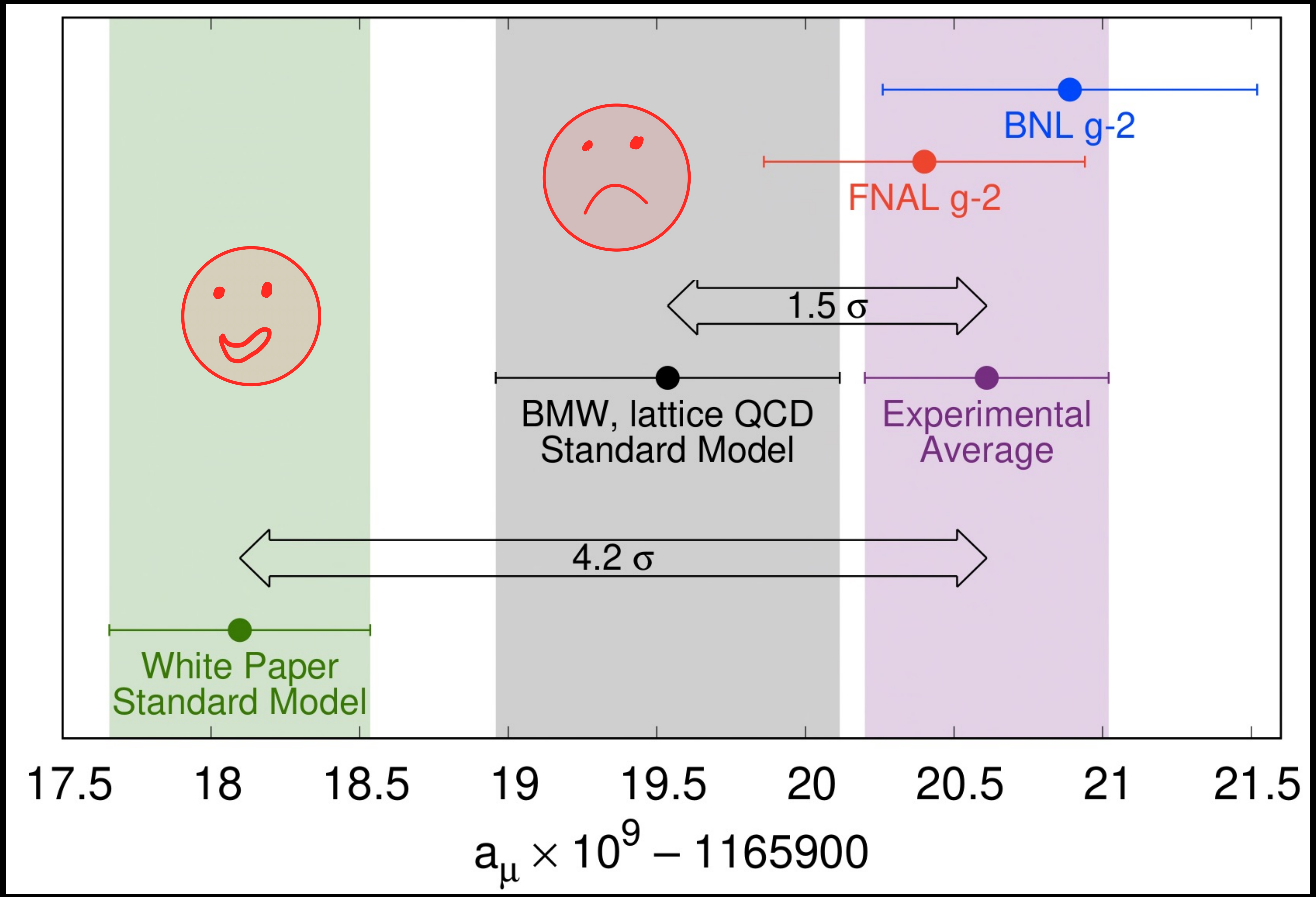


[K. Szabo talk at Moriond 2022 on behalf of the BMW collaboration]

$$a_\mu = 2.51(59) \times 10^{-9}$$

[Phys. Rev. Let. 126, 141801 (2021)]

a_μ (?)



[K. Szabo talk at Moriond 2022 on behalf of the BMW collaboration]

$$a_\mu = 2.51(59) \times 10^{-9}$$

[Phys. Rev. Let. 126, 141801 (2021)]

$m_W^{\rm CDF}$ (?)

CDF-II reported a 7.2 σ deviation

[Science 376, n6589, 170-176 (2022)]

Modification to the T-parameter (S = U = 0)

- Pre CDF-II: $\hat{T} = (0.39 \pm 0.47) \times 10^{-3}$ [PDG]
- CDF-II: $\hat{T} = (0.88 \pm 0.14) \times 10^{-3}$ [A. Strumia 2204:04191]

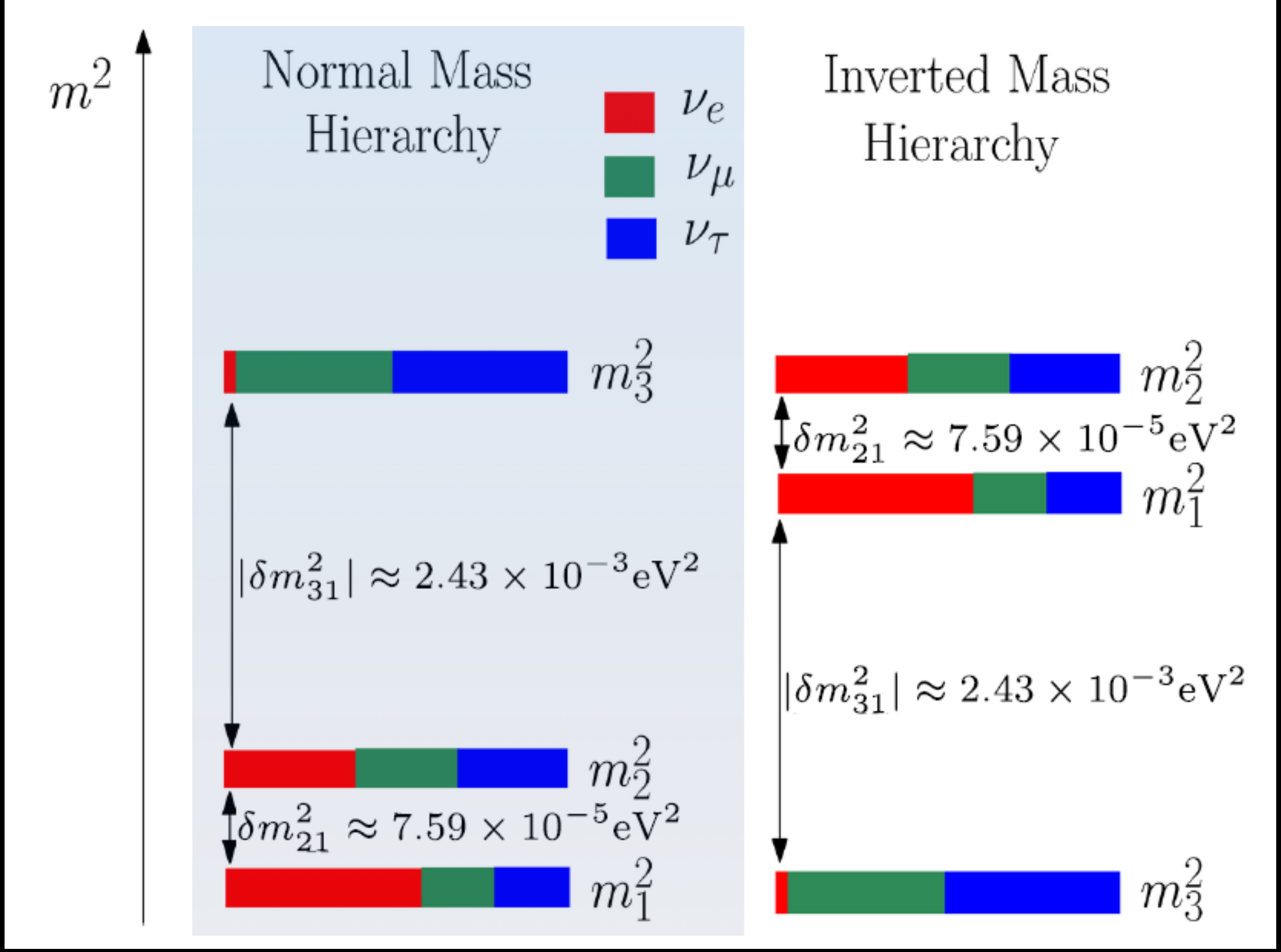
Must be independently confirmed

Neutrinos

On its own, neutrino masses are an extraordinary indication for new physics (NP)

Can neutrino properties and B-anomalies be two faces of the same NP?

Use N.O. and PMNS mixing as input parameters in our analysis



[Taken from mpi-hg.mpg.de]

Our proposal: Accommodate all the above in the most economical framework

B-physics $+ \; a_\mu + m_W \; + \; m_\nu + V_{\rm PMNS} + V_{\rm CKM} \; +$

$m_\ell + m_\ell + m_q \; +$

LFV $+$ LFC Z decays

SM $+$ Singlet leptoquark $+$ Doublet leptoquark

$S_1 \sim (\bar{\mathbf{3}}, \mathbf{1})_{1/3}$ $\tilde{R}_2 \sim (\mathbf{3}, \mathbf{2})_{1/6}$

This field content has an UV inspiration…

$[\mathrm{SU}(3)]^3 \times \mathrm{SU}(2)_\mathrm{F} \times \mathrm{U}(1)_\mathrm{F} \longrightarrow$ **Flavour Unified Theory**

[Morais, Pasechnik, Porod, Eur. Phys. J. C 80, (2020) 12, 1162]

$$L = \begin{pmatrix} H & \ell_\mathrm{L} \\ \ell_\mathrm{R} & \phi \end{pmatrix} \qquad Q_\mathrm{L} = \begin{pmatrix} q_\mathrm{L} & D_\mathrm{L} \end{pmatrix} \qquad Q_\mathrm{R} = \begin{pmatrix} q^c_\mathrm{R} & D^c_\mathrm{R} \end{pmatrix}^\mathsf{T}$$

$$\tilde{R}_2 \qquad S_1$$

This FUT contains an emergent $\mathbb{Z}_2$ B-parity

$$\mathbb{P}_B = (-1)^{3B+2S}$$

	L	$\tilde{L}$	Q_L	$\tilde{Q}_L$	Q_R	$\tilde{Q}_R$
$\mathbb{P}_B$	$-$	$+$	$+$	$-$	$+$	$-$
				$\tilde{R}_2$		S_1

- **Forbids di-quark interactions**
- **Only allows leptoquark interactions**

$$\overset{-}{L}\;\overset{+}{Q_{\mathrm{L}}}\;\overset{-}{\tilde{Q}_{\mathrm{R}}}+\overset{-}{L}\;\overset{-}{\tilde{Q}_{\mathrm{L}}}\;\overset{+}{Q_{\mathrm{R}}}$$

- **Proton is stable**

The model

$$\mathcal{L}_{\mathrm{Y}} = \Theta_{ij}\bar{Q}^c_j L_i S + \Omega_{ij}\bar{L}_i d_j R^\dagger + \Upsilon_{ij}\bar{u}_j e_i S^\dagger + \mathrm{h.c.}$$

$$V \supset -\mu^2|H|^2 + \mu_S^2|S|^2 + \mu_R^2|R|^2 + \lambda(H^\dagger H)^2 + g_{HR}(H^\dagger H)(R^\dagger R) + g'_{HR}(H^\dagger R)(R^\dagger H) + g_{HS}(H^\dagger H)(S^\dagger S) + \left(a_1 RSH^\dagger + \mathrm{h.c.}\right) .$$

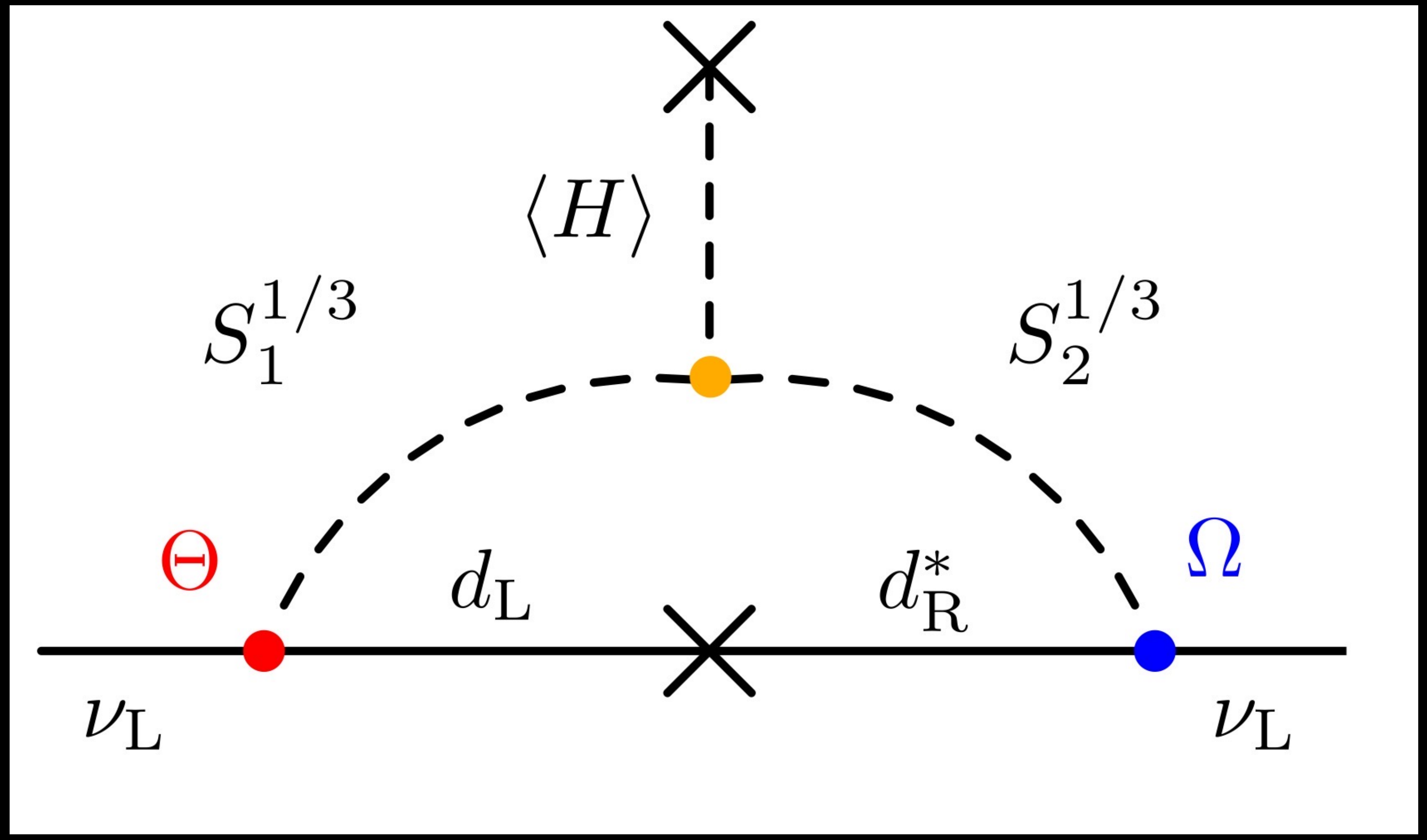
Gauge Basis

$$R \equiv \begin{pmatrix} R^{2/3} \\ R^{1/3} \end{pmatrix} , S$$

Mass Basis

$$S_1^{1/3} , S_2^{1/3} , S^{2/3}$$

Neutrino Masses



[40] I. Doršner, S. Fajfer, and N. Košnik, Eur. Phys. J. C **77**, 417 (2017), 1701.08322.
[41] D. Aristizabal Sierra, M. Hirsch, and S. G. Kovalenko, Phys. Rev. D **77**, 055011 (2008), 0710.5699.
[42] D. Zhang, JHEP **07**, 069 (2021), 2105.08670.
[43] H. Päs and E. Schumacher, Phys. Rev. D **92**, 114025 (2015), 1510.08757.
[44] Y. Cai, J. Herrero-García, M. A. Schmidt, A. Vicente, and R. R. Volkas, Front. in Phys. **5**, 63 (2017), 1706.08524

$$(M_\nu)_{ij} = \frac{3}{16\pi^2 (m^2_{S_2^{1/3}} - m^2_{S_1^{1/3}})} \frac{v a_1}{\sqrt{2}} \ln\left(\frac{m^2_{S_2^{1/3}}}{m^2_{S_1^{1/3}}}\right) \sum_{m,a} (m_d)_a V_{am} (\Theta_{im}\Omega_{ja} + \Theta_{jm}\Omega_{ia}) \,,$$

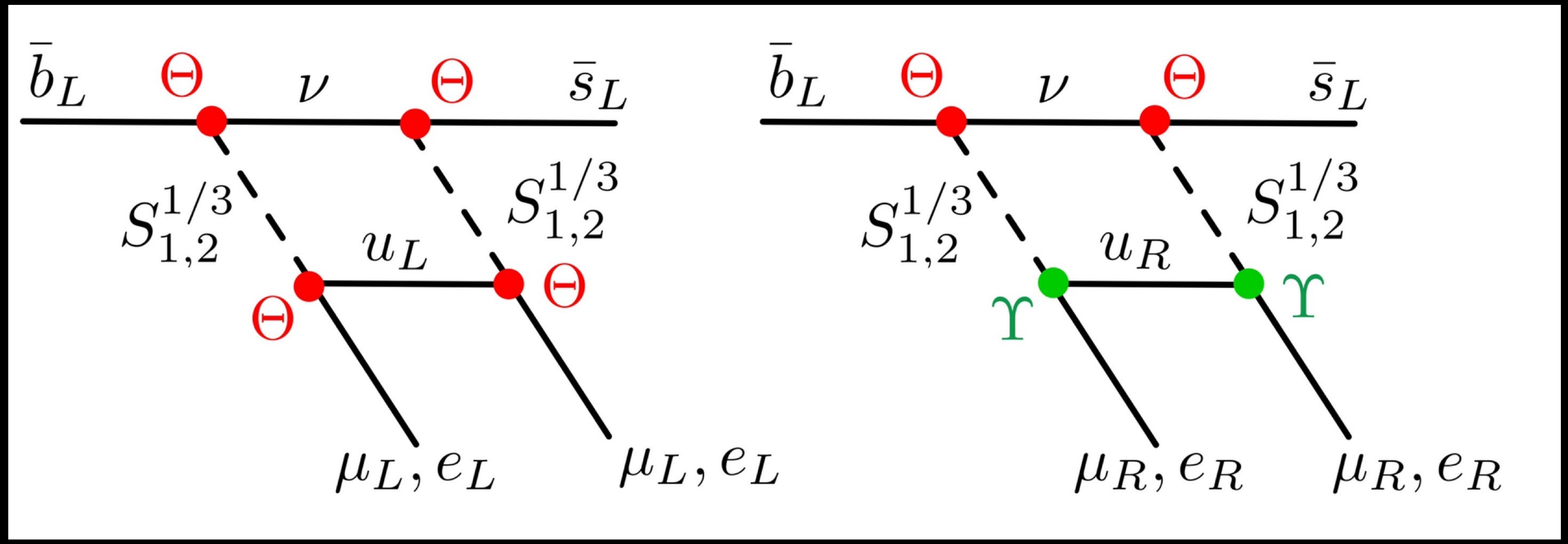
No flavour ansatz in Θ and Ω with several texture zeros

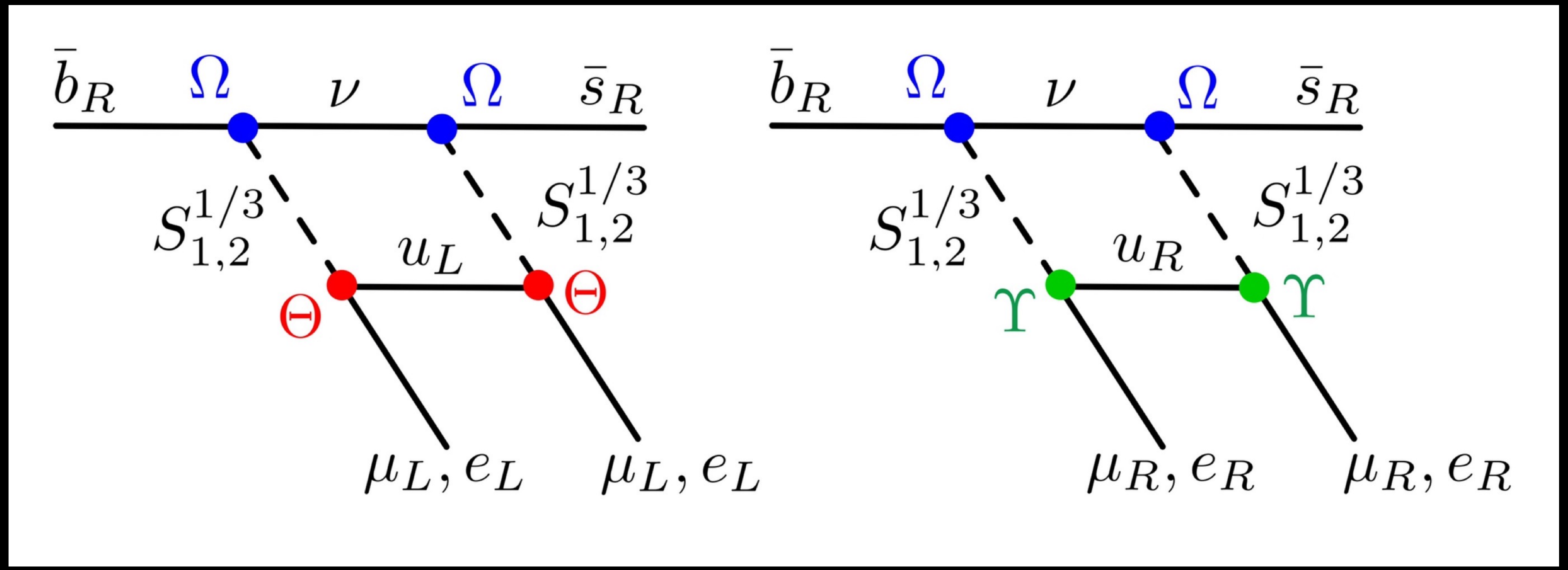
Left generic as well as Υ

LQ Yukawa matrices are left generic in order to fully accommodate 3 neutrino masses and a viable PMNS mixing

CHALLENGE: Keep all LFV and LFC observables under control while improving B-physics and a_μ

$b \to s\ell\ell$





$$C_9^{bs\ell\ell}(\bar{s}\gamma^\mu P_\mathrm{L} b)(\bar{\ell}\gamma_\mu \ell)$$

$$C_9^{\prime bs\ell\ell}(\bar{s}\gamma^\mu P_\mathrm{R} b)(\bar{\ell}\gamma_\mu \ell)$$

$$C_{10}^{bs\ell\ell}(\bar{s}\gamma^\mu P_\mathrm{L} b)(\bar{\ell}\gamma_\mu \gamma^5 \ell)$$

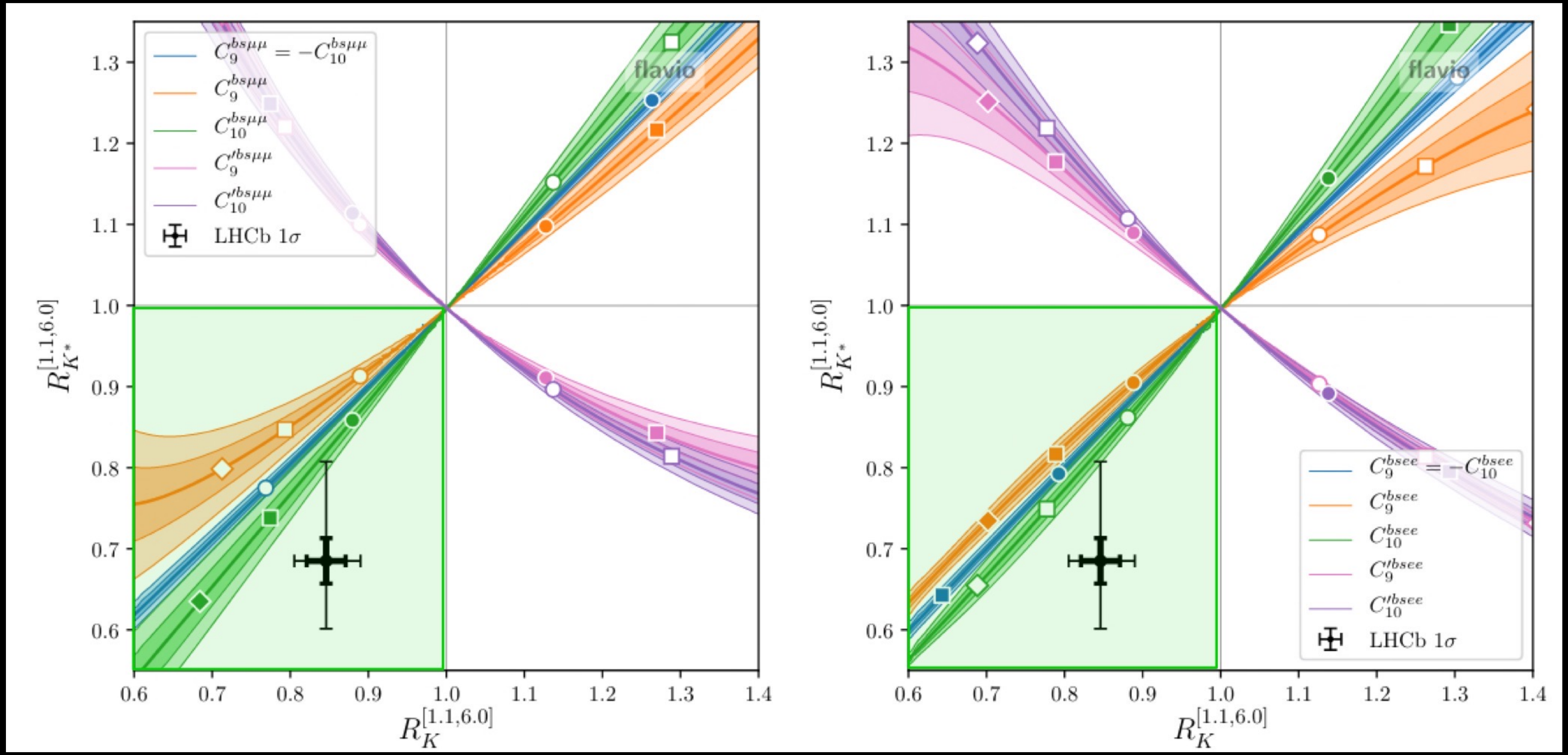
$$C_{10}^{\prime bs\ell\ell}(\bar{s}\gamma^\mu P_\mathrm{R} b)(\bar{\ell}\gamma_\mu \gamma^5 \ell)$$

Contribution to $R_{K,K*}$ and $B_s \to \mu\mu$

Recall that...

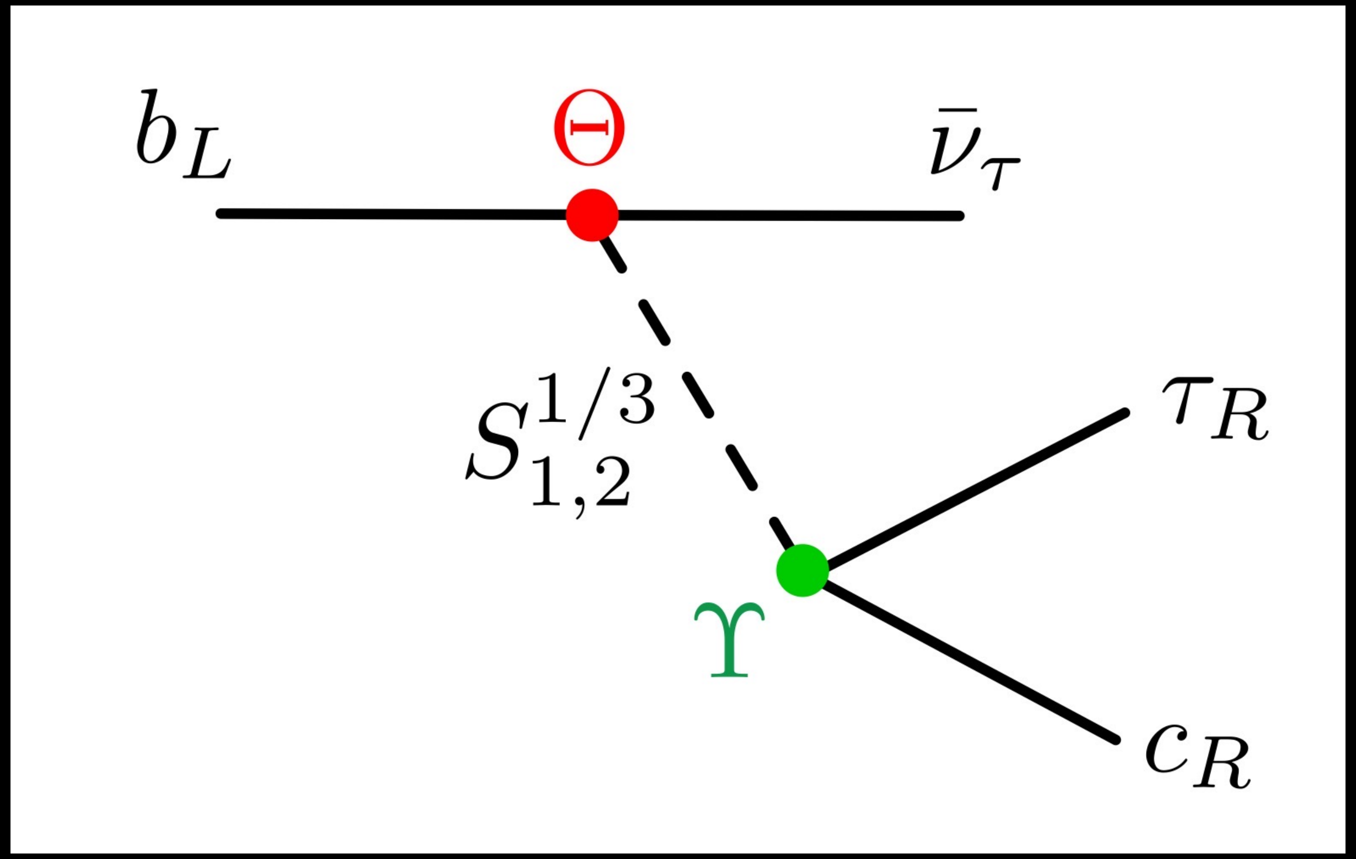
$C_{9,10}^{bs\mu\mu}$ and $C_{9,10}^{bsee} \longrightarrow R_K\ ,\ R_{K*} < 1$

$C_{9,10}^{\prime bs\mu\mu}$ and $C_{9,10}^{\prime bsee} \longrightarrow R_K < 1$ and $R_{K*} > 1$ or $R_K > 1$ and $R_{K*} < 1$



[Altmannshofer, Stangl, Eur. Phys. J. C. 81 (2021), 10, 952]

$b \to c\tau\overline{\nu}$



$(\bar{c}_\mathrm{R} b_\mathrm{L})(\bar{\tau}_\mathrm{R}\nu_\tau)$ only to R_D as QCD form factor $\langle D^* | \bar{c}b | \overline{B} \rangle = 0$

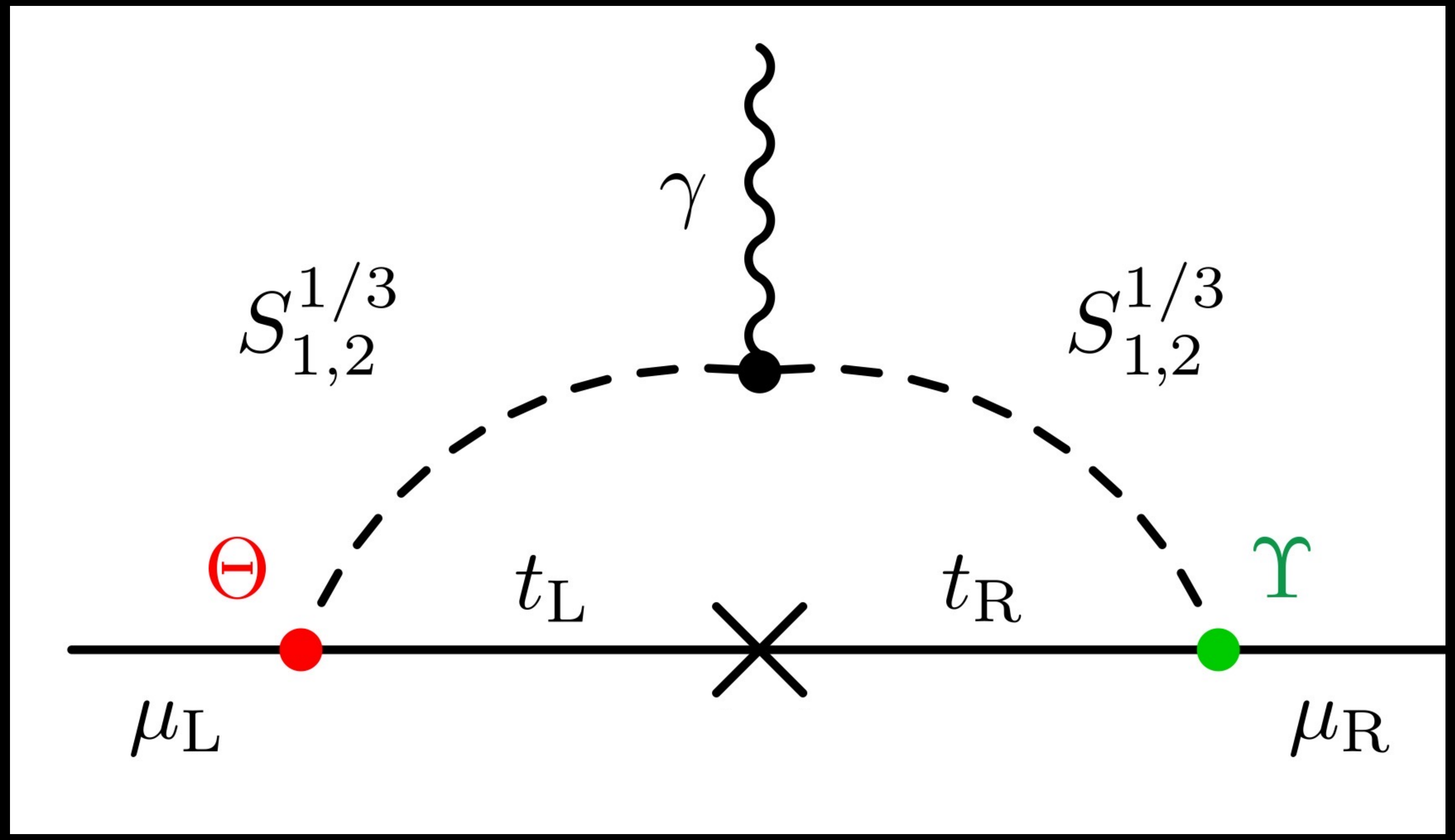
$(\bar{c}_\mathrm{R}\gamma_5 b_\mathrm{L})(\bar{\tau}_\mathrm{R}\nu_\tau)$ only to R_{D^*} as QCD form factor $\langle D | \bar{c}\gamma_5 b | \overline{B} \rangle = 0$

[Bardhan, Bhakti, Ghosh, JHEP 01 (2017) 125]

R_D and R_{D^*} compete with $R_{K^*}^{\nu\nu} = \dfrac{Br(\overline{B} \to K^*\bar{\nu}\nu)}{Br(\overline{B} \to K^*\bar{\nu}\nu)^{\mathrm{SM}}} < 2.7$ (replace $\Upsilon \to \Theta$)

[Phys.Rev.D 96, 091101 (2017), Phys.Rev.D 97, 099902 (2018) addendum]

a_μ



Largest contribution for the pairing: $\Theta_{\mu t}$ and $\Upsilon_{\mu t}$

However, other pairings can induce LFV decays as E.g.:

$$\Upsilon_{\mu t} \to \Upsilon_{et} : \mu \to e\gamma,\ \mu \to eee$$

Hierarchies in the entries of LQ Yukawa matrices needed

Numerical Results

- Use `SPheno` for spectrum generation, calculate Br's and Wilson Coefficients
- Use `flavio` to calculate flavour observables

• Us ’s and Wilson Coefficients

• Us

Observable	Experimental measurement
$(g-2)_\mu$	$(251 \pm 59) \times 10^{-11}$ [8]
$\hat{T}$	$(0.88 \pm 0.14) \times 10^{-3}$ [21]
$R_K[1.1, 6.0]$	$0.846^{+0.042+0.013}_{-0.039-0.012}$ [18]
$R_{K*}[1.1, 6.0]$	$0.685^{0.113+0.047}_{-0.069-0.047}$ [74]
$R_K[0.045, 1.1]$	$0.660^{0.110+0.024}_{-0.070-0.024}$ [74]
R_D	$0.340 \pm 0.027 \pm 0.013$ [75]
R_{D^*}	$0.295 \pm 0.011 \pm 0.008$ [75]
$\mathrm{BR}(h \to e\mu)$	$< 6.1 \times 10^{-5}$ [95% CL] [63]
$\mathrm{BR}(h \to e\tau)$	$< 4.7 \times 10^{-3}$ [95% CL] [63]
$\mathrm{BR}(h \to \mu\tau)$	$< 2.5 \times 10^{-3}$ [95% CL] [63]
$\mathrm{BR}(\mu \to e\gamma)$	$< 4.2 \times 10^{-13}$ [90% CL] [63]
$\mathrm{BR}(\mu \to eee)$	$< 1.0 \times 10^{-12}$ [90% CL] [63]
$\mathrm{BR}(\tau \to e\gamma)$	$< 3.3 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(\tau \to \mu\gamma)$	$< 4.4 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(\tau \to eee)$	$< 2.7 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(\tau \to e\mu\mu)$	$< 2.7 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(\tau \to \mu ee)$	$< 1.5 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(Z \to \mu e)$	$7.5 < \times 10^{-7}$ [95% CL] [63]
$\mathrm{BR}(Z \to \tau e)$	$9.8 < \times 10^{-6}$ [95% CL] [63]
$\mathrm{BR}(Z \to \mu\tau)$	$1.2 < \times 10^{-5}$ [95% CL] [63]
$\mathrm{BR}(\tau \to \pi e)$	$< 8.0 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(\tau \to \pi\mu)$	$< 1.1 \times 10^{-7}$ [90% CL] [63]
$\mathrm{BR}(\tau \to \phi e)$	$< 3.1 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(\tau \to \phi\mu)$	$< 8.4 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(\tau \to \rho e)$	$< 1.8 \times 10^{-8}$ [90% CL] [63]
$\mathrm{BR}(\tau \to \rho\mu)$	$< 1.2 \times 10^{-8}$ [90% CL] [63]
d_e	$< 1.1 \times 10^{-29}$ e.cm [90% CL] [63]
d_μ	$< 1.8 \times 10^{-19}$ e.cm [95% CL] [63]
d_τ	$< (1.15 \pm 1.70) \times 10^{-17}$ e.cm [95% CL] [76]
$\mathrm{BR}(B^0 \to \mu\mu)$	$(0.56 \pm 0.70) \times 10^{-10}$ [19]
$\mathrm{BR}(B_s \to \mu\mu)$	$(2.93 \pm 0.35) \times 10^{-9}$ [19]
$\mathrm{R}(B \to \chi_s\gamma)$	1.009 ± 0.075
$R_K^{\nu\nu}$	3.9 [77]
$R_{K^*}^{\nu\nu}$	2.7 [77]
$\lvert\mathrm{Re}\ \delta g_R^e\rvert$	$\leq 2.9 \times 10^{-4}$ [37, 78]
$\lvert\mathrm{Re}\ \delta g_L^e\rvert$	$\leq 3.0 \times 10^{-4}$ [37, 78]
$\lvert\mathrm{Re}\ \delta g_R^\mu\rvert$	$\leq 1.3 \times 10^{-3}$ [37, 78]
$\lvert\mathrm{Re}\ \delta g_L^\mu\rvert$	$\leq 1.1 \times 10^{-3}$ [37, 78]
$\lvert\mathrm{Re}\ \delta g_R^\tau\rvert$	$\leq 6.2 \times 10^{-4}$ [37, 78]
$\lvert\mathrm{Re}\ \delta g_L^\tau\rvert$	$\leq 5.8 \times 10^{-4}$ [37, 78]

Observable	Experimental measurement
$F_L(B^+ \to K\mu\mu)$	$0.34 \pm 0.10 \pm 0.06$ [79]
$S_3(B^+ \to K\mu\mu)$	$0.14^{+0.15+0.02}_{-0.14-0.02}$ [79]
$S_4(B^+ \to K\mu\mu)$	$-0.04^{+0.17+0.04}_{-0.16-0.04}$ [79]
$S_5(B^+ \to K\mu\mu)$	$0.24^{+0.12+0.04}_{-0.15-0.04}$ [79]
$A_{FB}(B^+ \to K\mu\mu)$	$-0.05 \pm 0.12 \pm 0.03$ [79]
$S_7(B^+ \to K\mu\mu)$	$-0.01^{+0.19+0.01}_{-0.17-0.01}$ [79]
$S_8(B^+ \to K\mu\mu)$	$0.21^{+0.22+0.05}_{-0.20-0.05}$ [79]
$S_9(B^+ \to K\mu\mu)$	$0.28^{+0.25+0.06}_{-0.12-0.06}$ [79]
$P_1(B^+ \to K\mu\mu)$	$0.44^{+0.38+0.11}_{-0.40-0.11}$ [79]
$P_2(B^+ \to K\mu\mu)$	$-0.05 \pm 0.12 \pm 0.03$ [79]
$P_3(B^+ \to K\mu\mu)$	$-0.42^{+0.20+0.05}_{-0.21-0.05}$ [79]
$P_4'(B^+ \to K\mu\mu)$	$-0.092^{+0.36+0.12}_{-0.35-0.12}$ [79]
$P_5'(B^+ \to K\mu\mu)$	$0.51^{+0.30+0.12}_{-0.28-0.12}$ [79]
$P_6'(B^+ \to K\mu\mu)$	$-0.02^{+0.40+0.06}_{-0.34-0.06}$ [79]
$P_8'(B^+ \to K\mu\mu)$	$-0.45^{+0.50+0.09}_{-0.39-0.09}$ [79]
$F_L(B^0 \to K\mu\mu)$	$0.255 \pm 0.032 \pm 0.007$ [80]
$S_3(B^0 \to K\mu\mu)$	$0.034 \pm 0.044 \pm 0.003$ [80]
$S_4(B^0 \to K\mu\mu)$	$0.059 \pm 0.050 \pm 0.004$ [80]
$S_5(B^0 \to K\mu\mu)$	$0.227 \pm 0.041 \pm 0.008$ [80]
$A_{FB}(B^0 \to K\mu\mu)$	$-0.004 \pm 0.040 \pm 0.004$ [80]
$S_7(B^0 \to K\mu\mu)$	$0.006 \pm 0.042 \pm 0.002$ [80]
$S_8(B^0 \to K\mu\mu)$	$-0.003 \pm 0.051 \pm 0.001$ [80]
$S_9(B^0 \to K\mu\mu)$	$-0.055 \pm 0.041 \pm 0.002$ [80]
$P_1(B^0 \to K\mu\mu)$	$0.090 \pm 0.119 \pm 0.009$ [80]
$P_2(B^0 \to K\mu\mu)$	$-0.003 \pm 0.038 \pm 0.003$ [80]
$P_3(B^0 \to K\mu\mu)$	$-0.073 \pm 0.057 \pm 0.003$ [80]
$P_4'(B^0 \to K\mu\mu)$	$-0.135 \pm 0.118 \pm 0.003$[80]
$P_5'(B^0 \to K\mu\mu)$	$-0.521 \pm 0.095 \pm 0.024$ [80]
$P_6'(B^0 \to K\mu\mu)$	$-0.015 \pm 0.094 \pm 0.007$ [80]
$P_8'(B^0 \to K\mu\mu)$	$-0.007 \pm 0.122 \pm 0.002$ [80]
$C_9^{bs\mu\mu}$	-0.82 ± 0.23 [80]
$C_{10}^{bs\mu\mu}$	0.14 ± 0.23 [80]
$C_9^{\prime bs\mu\mu}$	-0.10 ± 0.34 [80]
$C_{10}^{\prime bs\mu\mu}$	-0.33 ± 0.23 [80]
C_9^{bsee}	-0.24 ± 1.17 [80]
C_{10}^{bsee}	-0.24 ± 0.78 [80]

To assess the quality of the results one uses the likelihood function:

$$\chi^2 = (\mathcal{O}_{\rm exp} - \mathcal{O}_{\rm th})^{\rm T}(\mathbf{\Sigma}_{\rm th} + \mathbf{\Sigma}_{\rm exp})^{-1}(\mathcal{O}_{\rm exp} - \mathcal{O}_{\rm th})$$

- Take a conservative approach by assuming that $\chi^2_{\rm SM,LFV} = 0$
- Use reported experimental correlations and determine theoretical ones with sampled points

To assess the quality of the results one uses the likelihood function:

$$\chi^2 = (\mathcal{O}_{\rm exp} - \mathcal{O}_{\rm th})^{\rm T}(\boldsymbol{\Sigma}_{\rm th} + \boldsymbol{\Sigma}_{\rm exp})^{-1}(\mathcal{O}_{\rm exp} - \mathcal{O}_{\rm th})$$

- Take a conservative approach by assuming that $\chi^2_{\rm SM,LFV} = 0$
- Use reported experimental correlations and determine theoretical ones with sampled points
- Consider 3 scenarios:
  - a) a_μ and m_W both consistent with SM,
  - b) only m_W consistent with SM,
  - c) neither of them consistent with SM

Inputs SM + neutrinos: $v,\ m_h,\ m_q,\ m_\ell,\ m_\nu,\ V_{\rm CKM},\ V_{\rm PMNS}$

Inputs LQs:

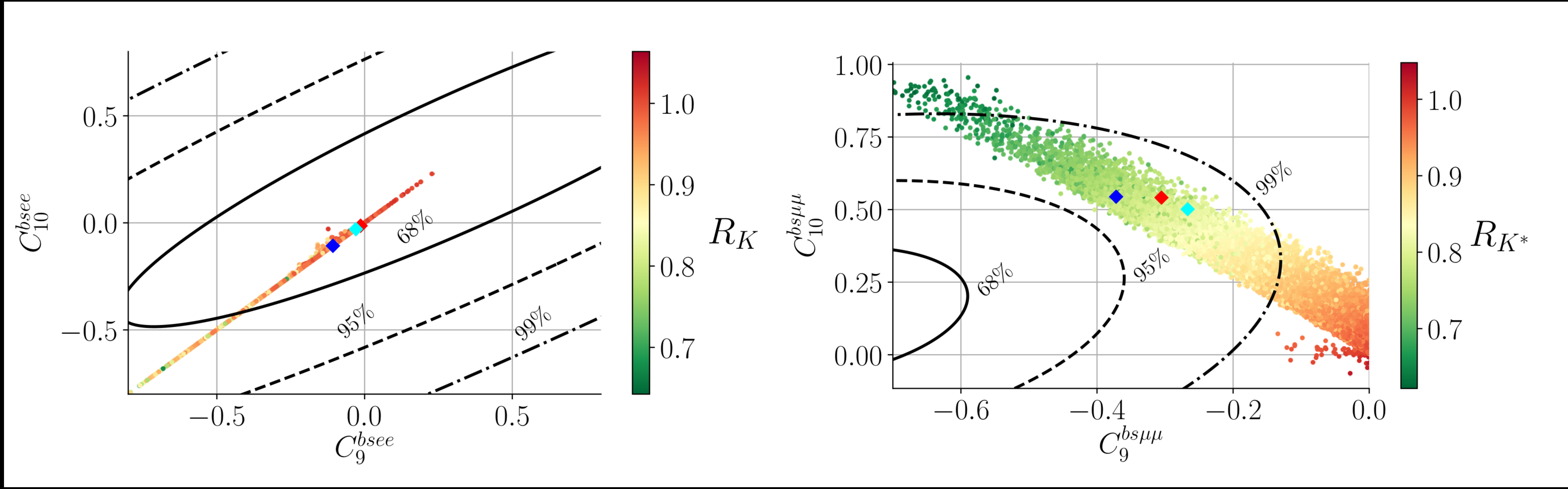
$$1.5 < m_{\rm LQs}/{\rm TeV} < 8 \qquad -100 < a_1/{\rm GeV} < 100$$

$$g_{HS}, g_{HR}, g'_{HR} \in \pm[10^{-8}, 4\pi] \qquad \Upsilon,\ \Theta,\ \Omega \in \pm[10^{-8}, \sqrt{4\pi}]$$

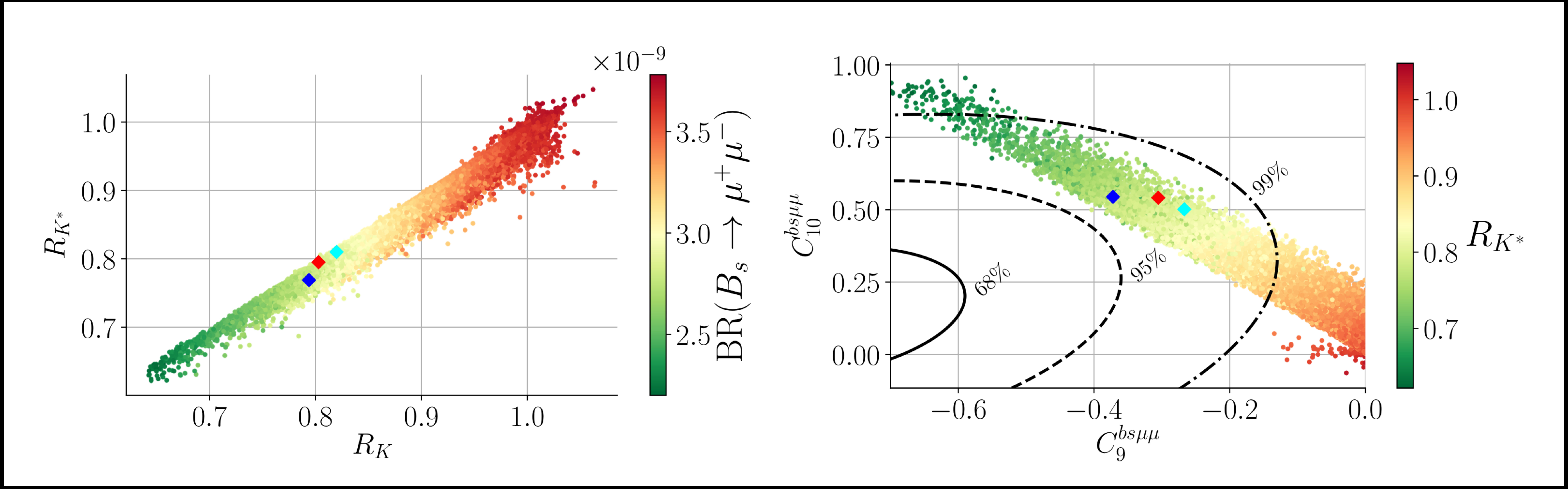
$$m^2_{S^{1/3}_{1,2}} = \begin{bmatrix} \mu_S^2 + \frac{g_{HS}v^2}{2} & \frac{va_1^*}{\sqrt{2}} \\ \frac{va_1}{\sqrt{2}} & \mu_R^2 + \frac{Gv^2}{2} \end{bmatrix} \qquad m^2_{S^{2/3}} = \mu_R^2 + \frac{Gv^2}{2} \qquad G = (g_{HR} + g'_{HR})$$

Obtain a total of 9 entries of the Θ and Ω inverting the neutrino mass form

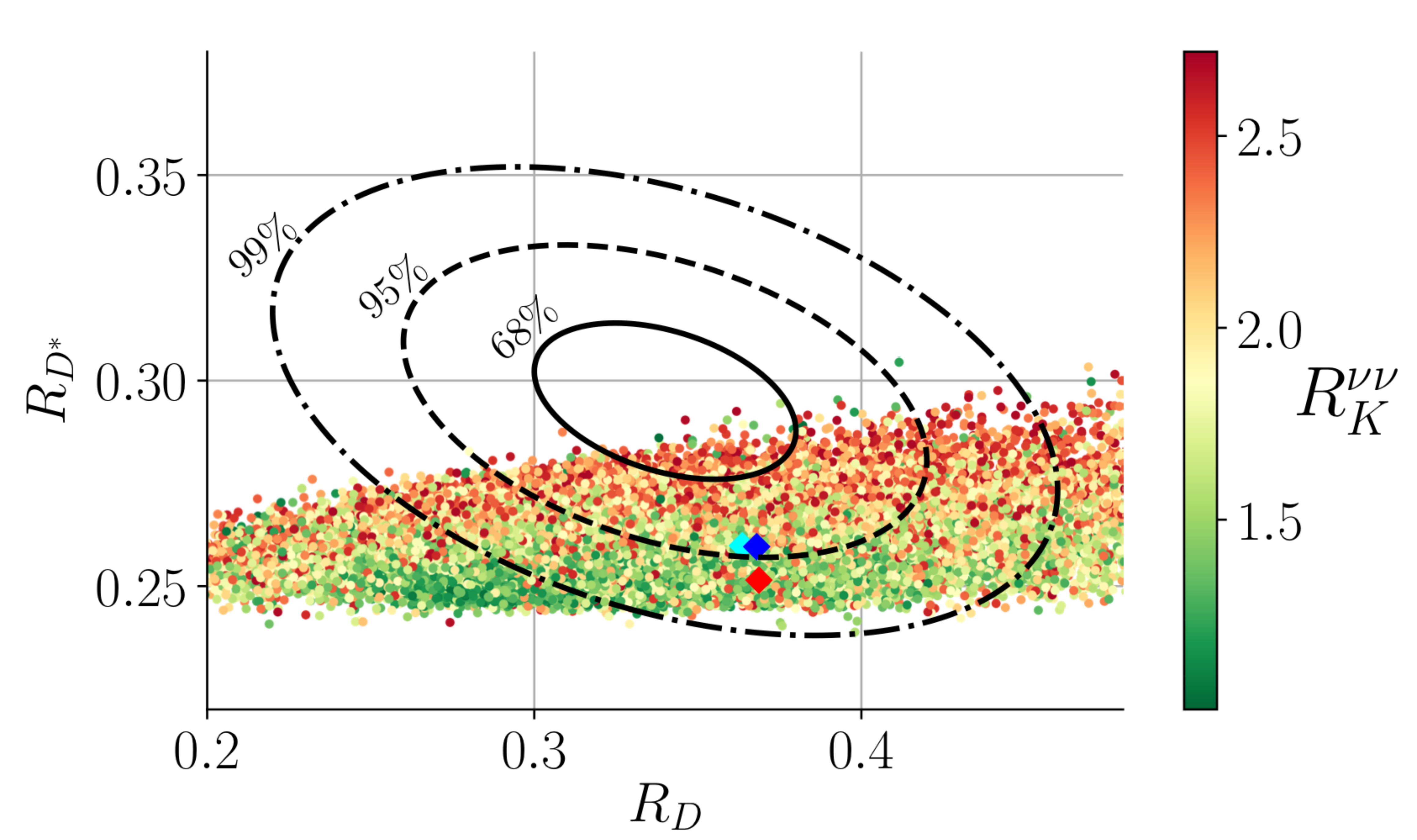
$$(M_\nu)_{ij} = \frac{3}{16\pi^2 (m^2_{S_2^{1/3}} - m^2_{S_1^{1/3}})} \frac{va_1}{\sqrt{2}} \ln\left(\frac{m^2_{S_2^{1/3}}}{m^2_{S_1^{1/3}}}\right) \sum_{m,a} (m_d)_a V_{am} (\Theta_{im}\Omega_{ja} + \Theta_{jm}\Omega_{ia}),$$



- **a) blue:** $\chi^2/\mathrm{d.o.f.} = 1.70$, $m_{S_1^{1/3}} = 3.00$ TeV, $m_{S_2^{1/3}} = 6.95$ TeV, $m_{S^{2/3}} = 6.97$ TeV
- **b) cyan:** $\chi^2/\mathrm{d.o.f.} = 1.70$, $m_{S_1^{1/3}} = 2.60$ TeV, $m_{S_2^{1/3}} = 4.65$ TeV, $m_{S^{2/3}} = 4.64$ TeV
- **c) red:** $\chi^2/\mathrm{d.o.f.} = 1.75$, $m_{S_1^{1/3}} = 2.64$ TeV, $m_{S_2^{1/3}} = 4.13$ TeV, $m_{S^{2/3}} = 4.18$ TeV

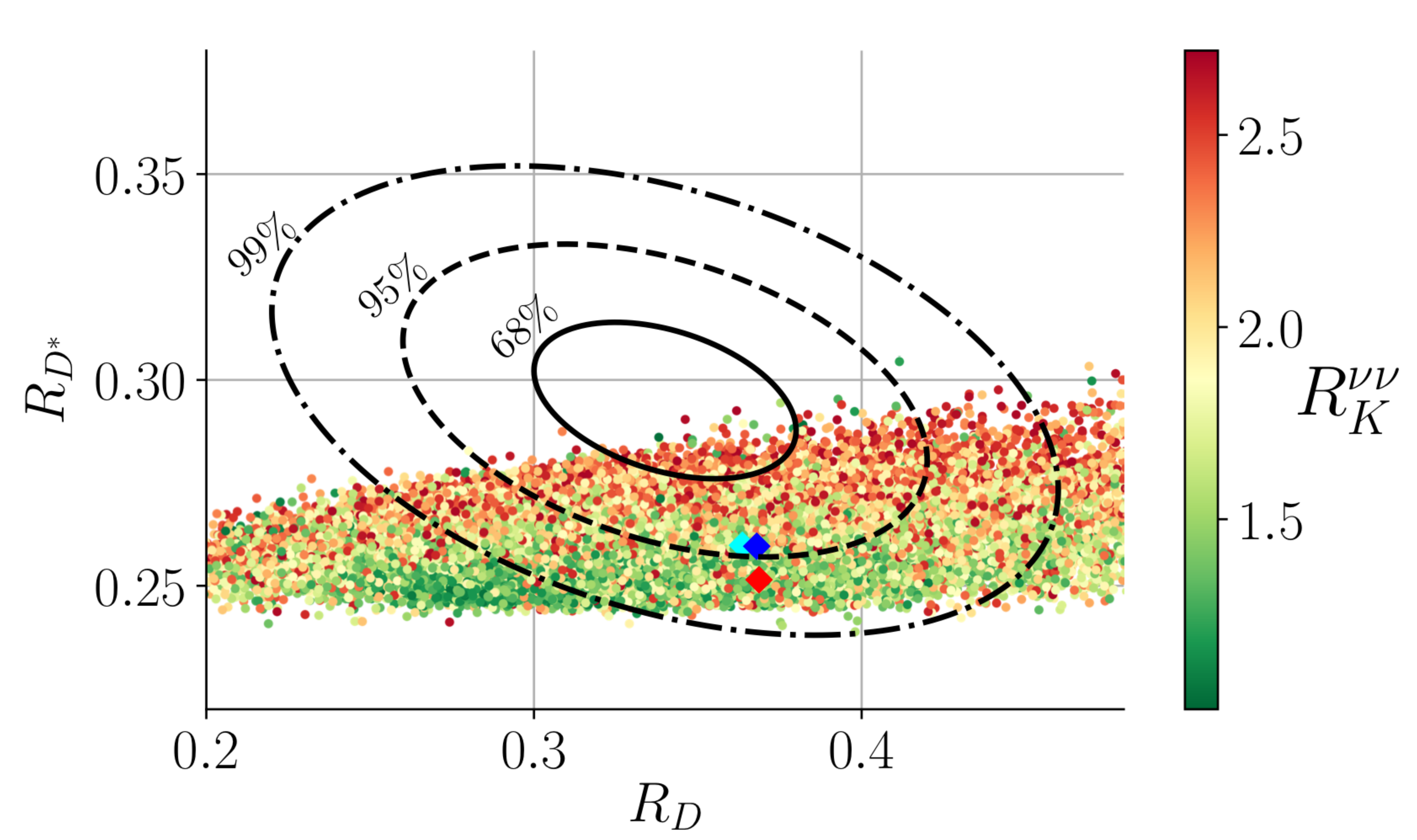


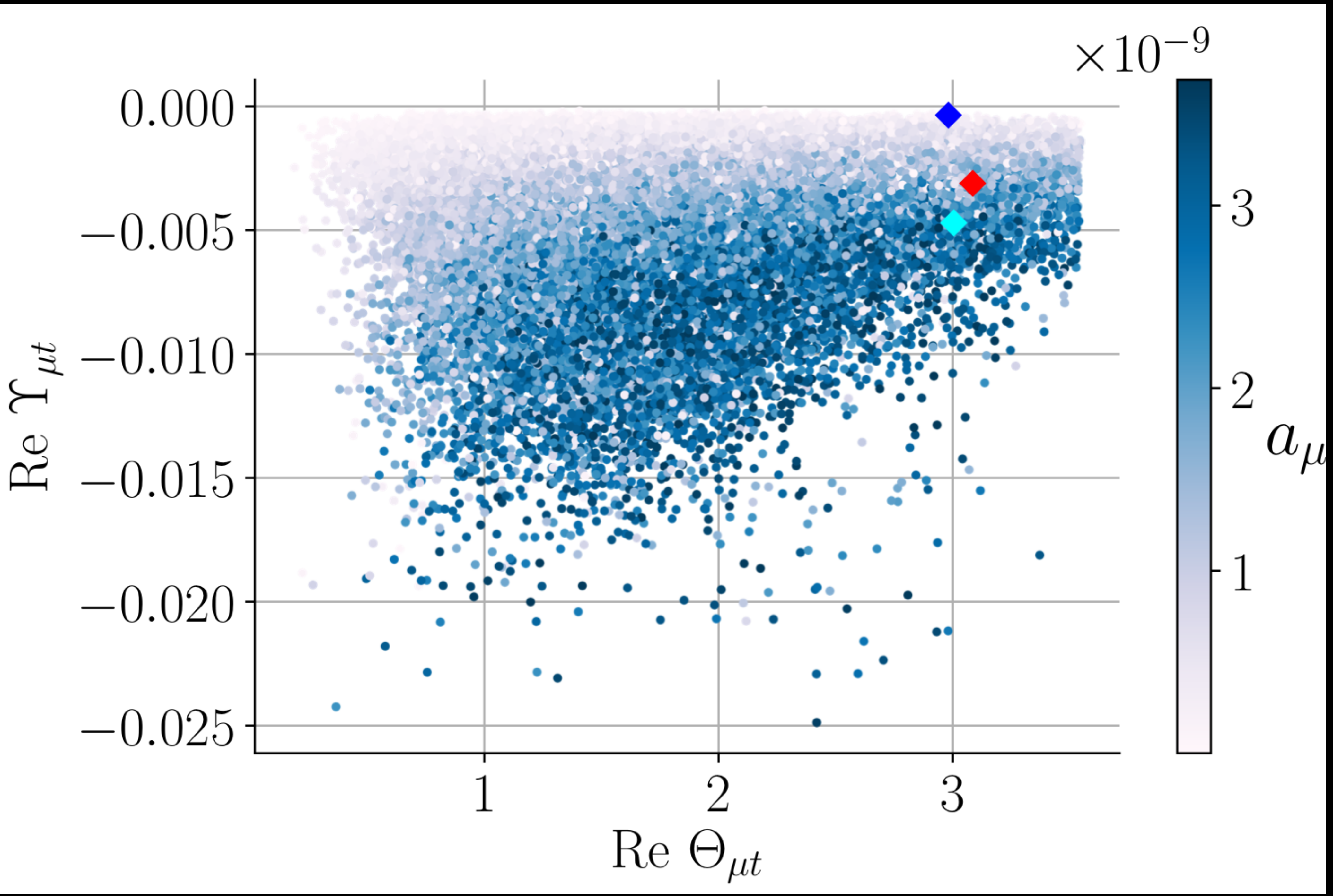
- **Muon channel dominates the R_{K,K^*} anomalies**
- **Strongly correlated with $B_s \to \mu\mu$**



- We can simultaneously accommodate R_{D,D^*} and $R^{\nu\nu}_{K,K^*}$

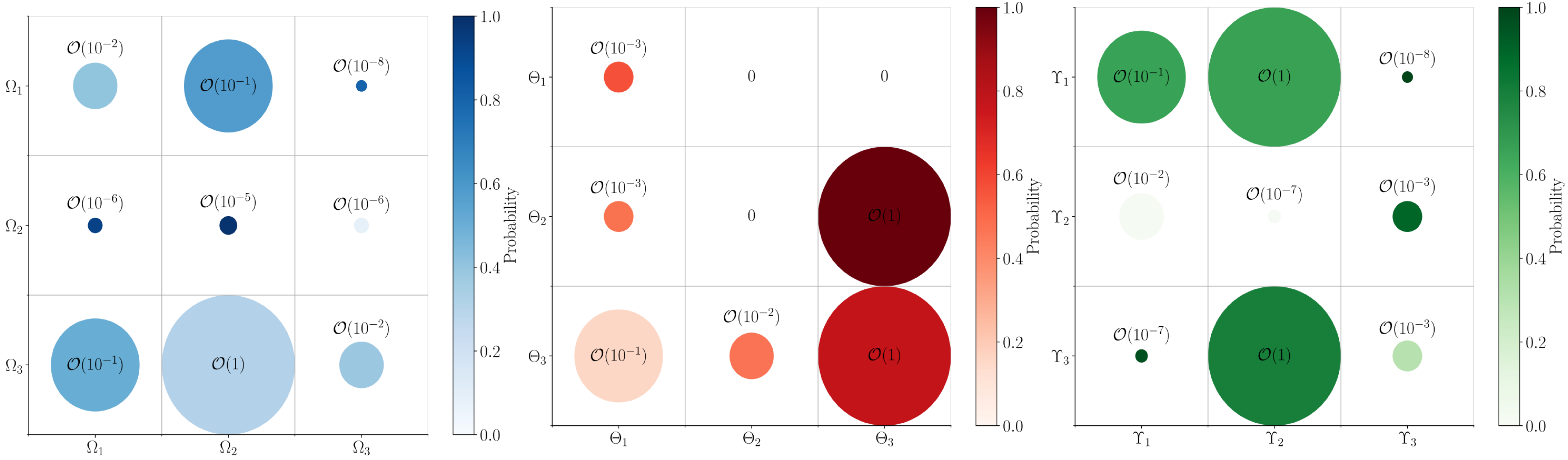
- R_{D^*} competes with $R^{\nu\nu}_{K^*}$





- We can simultaneously accommodate R_{D,D^*} and $R^{\nu\nu}_{K,K^*}$
- R_{D^*} competes with $R^{\nu\nu}_{K^*}$
- $\Upsilon_{\mu t}$ controls the size of a_μ

Preferred sizes to simultaneously address all anomalies in consistency with neutrino physics, LFV and LFC $Z \to \ell\ell$ decays



- **Provides information to test the model at colliders**
- **E.g. t-channel single production: $\Theta_{\tau u} \sim 0.1 \to$ di-tau final state, $\Upsilon_{\ell u} \sim 0.1 \to$ electrons and muons in the final state**

Concluding remarks

- Simple, economical, constrained and falsifiable model
- Well motivated by unification principles
- Can explain B-physics, a_μ, m_ν in consistency with LFV observables and LFC Z-boson decays: $\chi^2/\mathrm{d.o.f.} = 1.70$
- Can also potentially address W-mass anomaly while slightly disfavoured: $\chi^2/\mathrm{d.o.f.} = 1.75$
- Lightest LQ with mass in the range 1.5 to $6\ \mathrm{TeV}$


THANK YOU