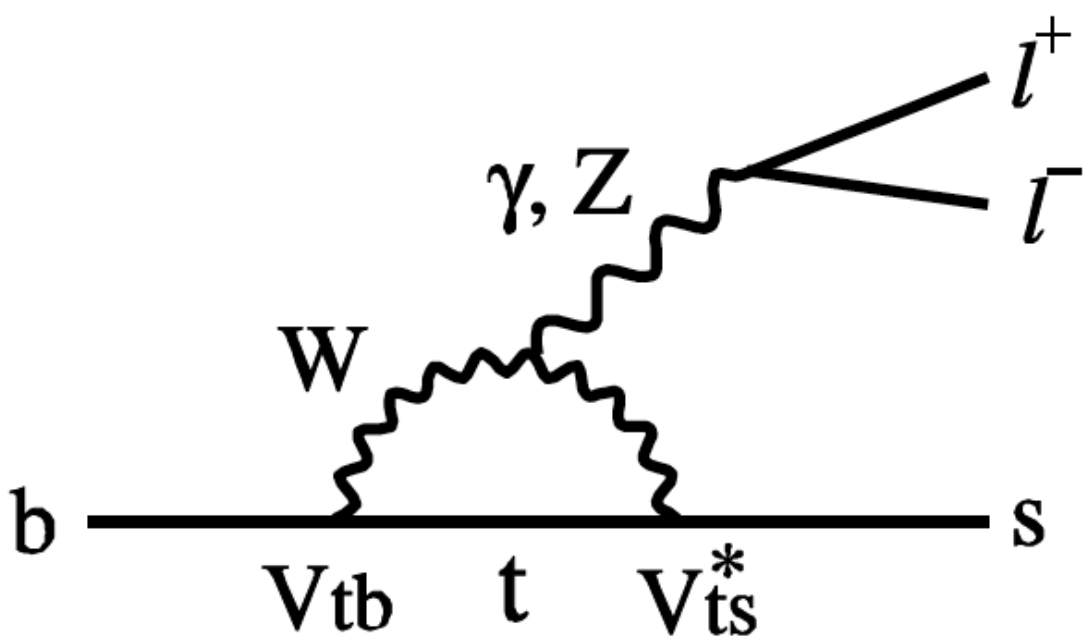
New Physics Interpretations of the B anomalies

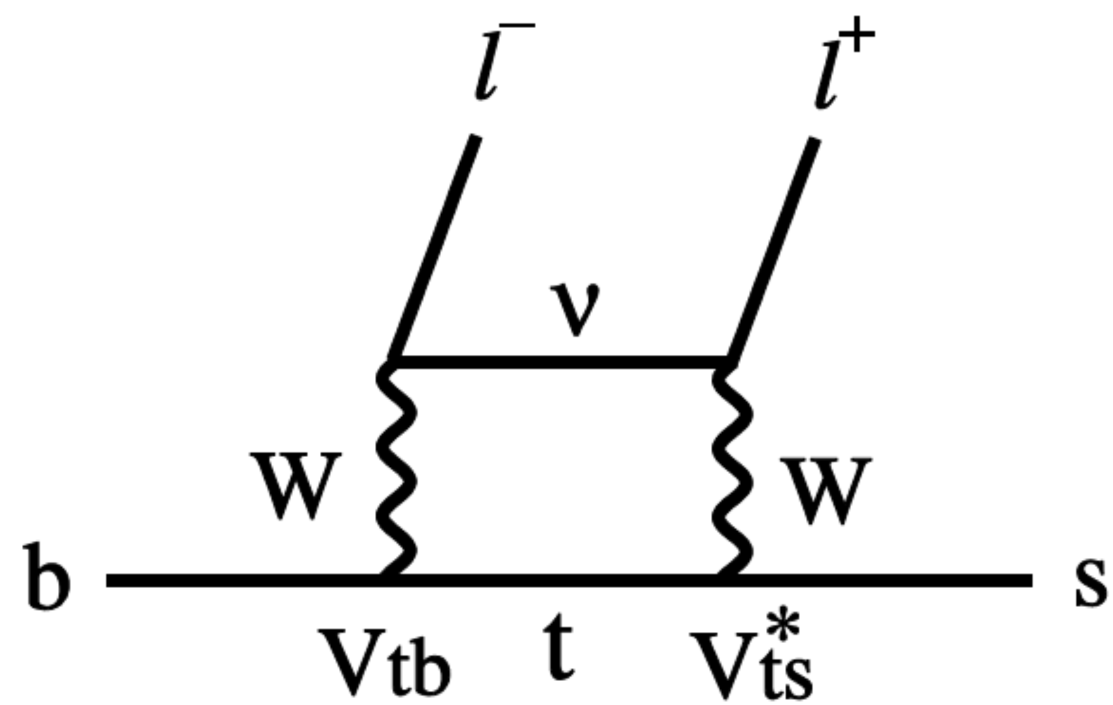
大村　雄司 (近畿大学)

Contents

1. b to s ll

b to s ll processes in the SM





理論的不定性が小さい観測量でdeviation あり!

ちょっと昔話

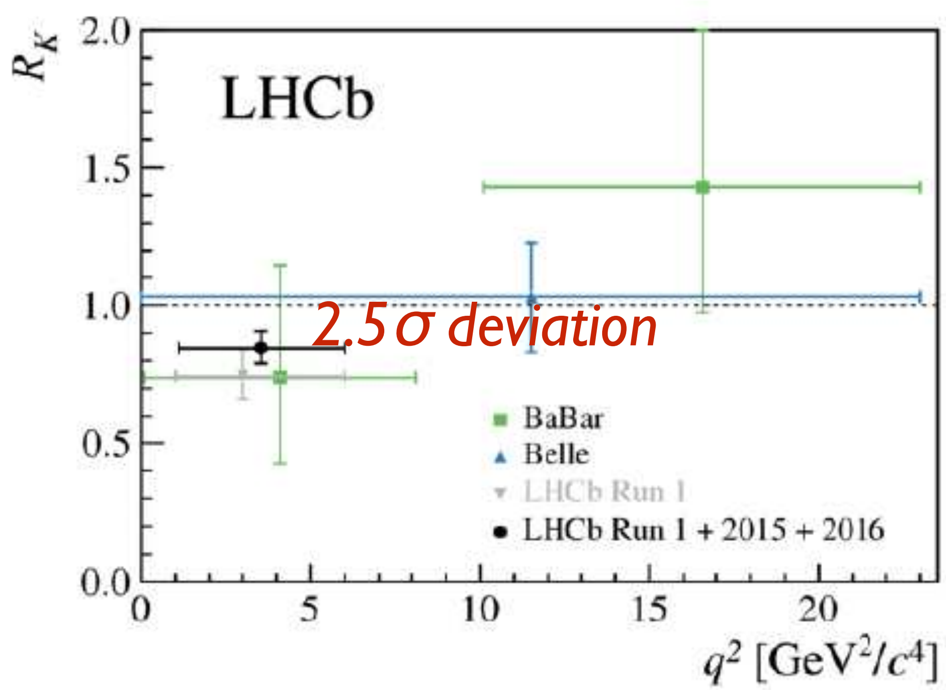
Deviation がかつて報告されたシグナル

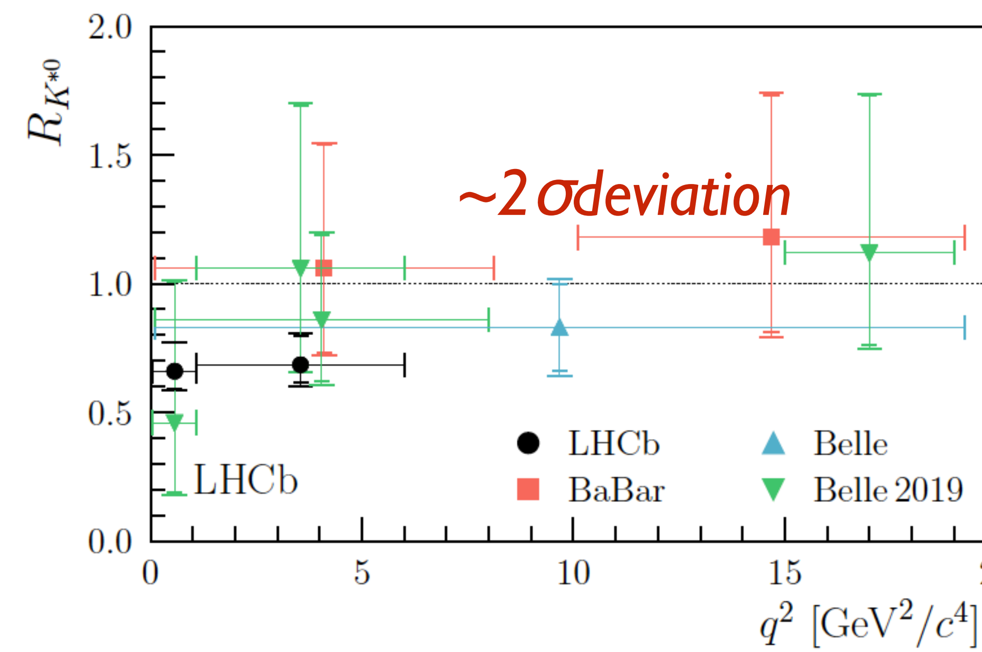
1. lepton universality

(1406.6482,1705.05802,1903.09252)

observable

$$R_K = \frac{\int_{q^2_{\rm min}}^{q^2_{\rm max}} \frac{{\rm d}\Gamma[B^+ \to K^+\mu^+\mu^-]}{{\rm d}q^2}{\rm d}q^2}{\int_{q^2_{\rm min}}^{q^2_{\rm max}} \frac{{\rm d}\Gamma[B^+ \to K^+e^+e^-]}{{\rm d}q^2}{\rm d}q^2}$$





現状は…

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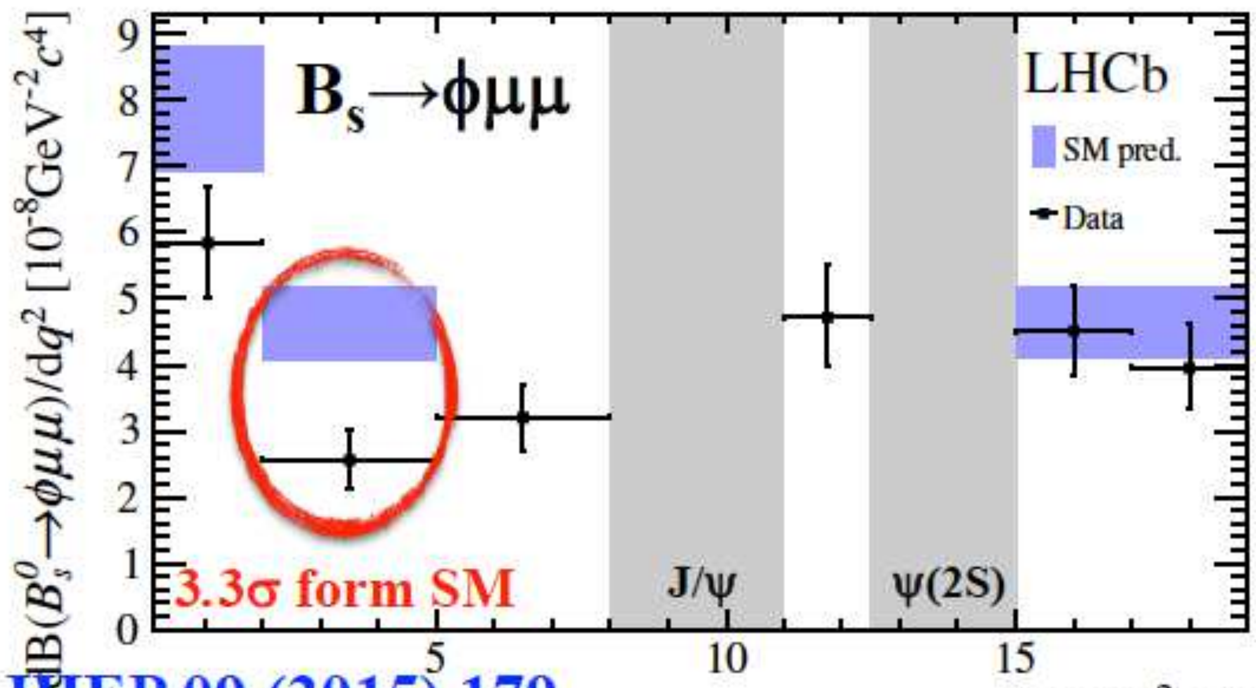
他にも「μが少ない」シグナルあり

2. other processes caused by b→sμμ

Branching ratio of $B_s \to \phi\mu^+\mu^-$

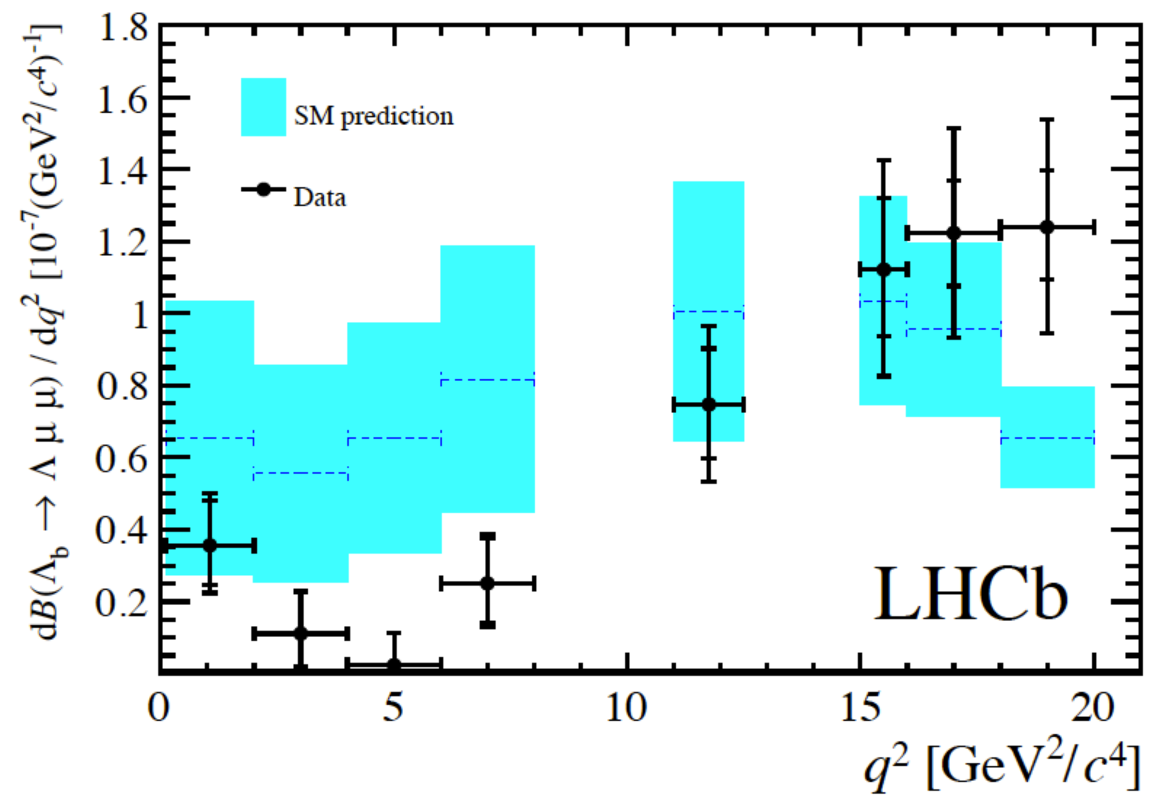
(1506.08777)



JHEP 09 (2015) 179

Branching ratio of $\Lambda_b^0 \to \Lambda\mu^+\mu^-$

(1503.07138)



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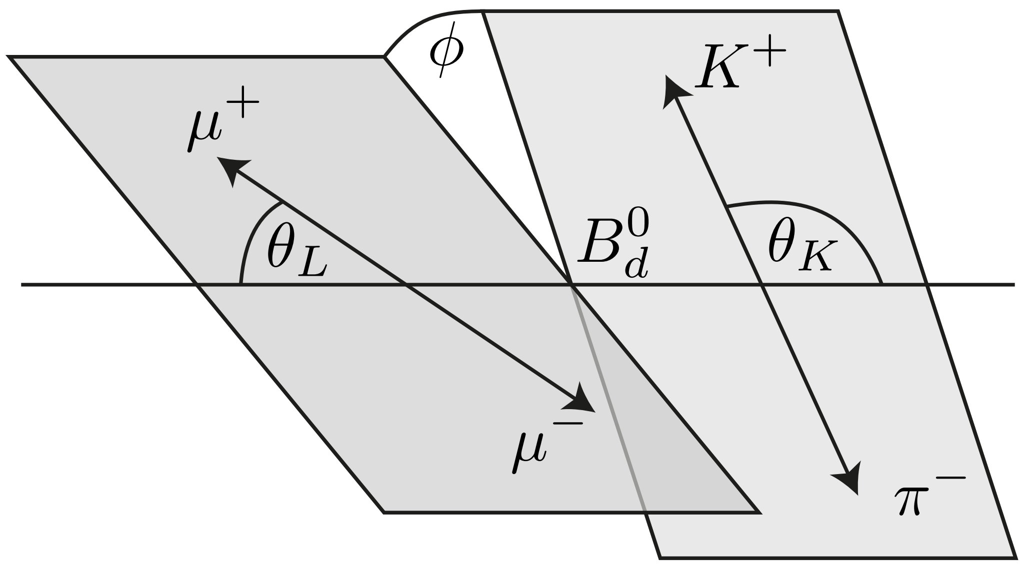
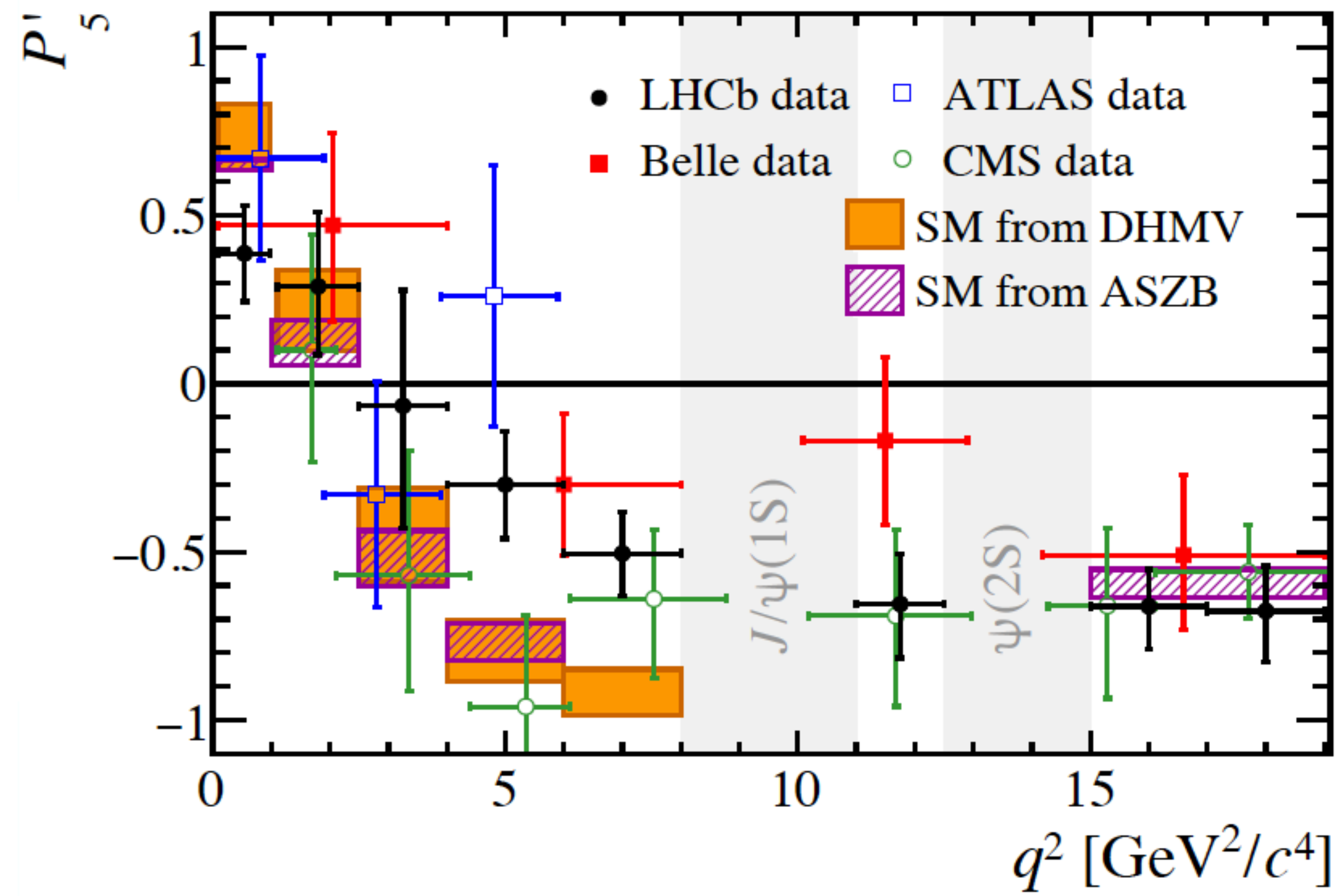
3. Angular analysis of $B_0 \to K_0^{*}\mu^+\mu^-$

(LHCb, JHEP02(2016)104;
Belle, PRL118(2017)111801;
CMS-PAS-BPH-15-008;JHEP10(2018047))



$$
\begin{aligned}
&\frac{1}{\mathrm{d}\Gamma/dq^2}\frac{\mathrm{d}^4\Gamma}{\mathrm{d}\cos\theta_\ell\,\mathrm{d}\cos\theta_K\,\mathrm{d}\phi\,\mathrm{d}q^2}\\
&=\frac{9}{32\pi}\Big[\frac{3}{4}(1-F_\mathrm{L})\sin^2\theta_K + F_\mathrm{L}\cos^2\theta_K + \frac{1}{4}(1-F_\mathrm{L})\sin^2\theta_K\cos 2\theta_\ell\\
&\quad - F_\mathrm{L}\cos^2\theta_K\cos 2\theta_\ell + S_3\sin^2\theta_K\sin^2\theta_\ell\cos 2\phi\\
&\quad + S_4\sin 2\theta_K\sin 2\theta_\ell\cos\phi + S_5\sin 2\theta_K\sin\theta_\ell\cos\phi\\
&\quad + S_6\sin^2\theta_K\cos\theta_\ell + S_7\sin 2\theta_K\sin\theta_\ell\sin\phi\\
&\quad + S_8\sin 2\theta_K\sin 2\theta_\ell\sin\phi + S_9\sin^2\theta_K\sin^2\theta_\ell\sin 2\phi\Big],
\end{aligned}
$$



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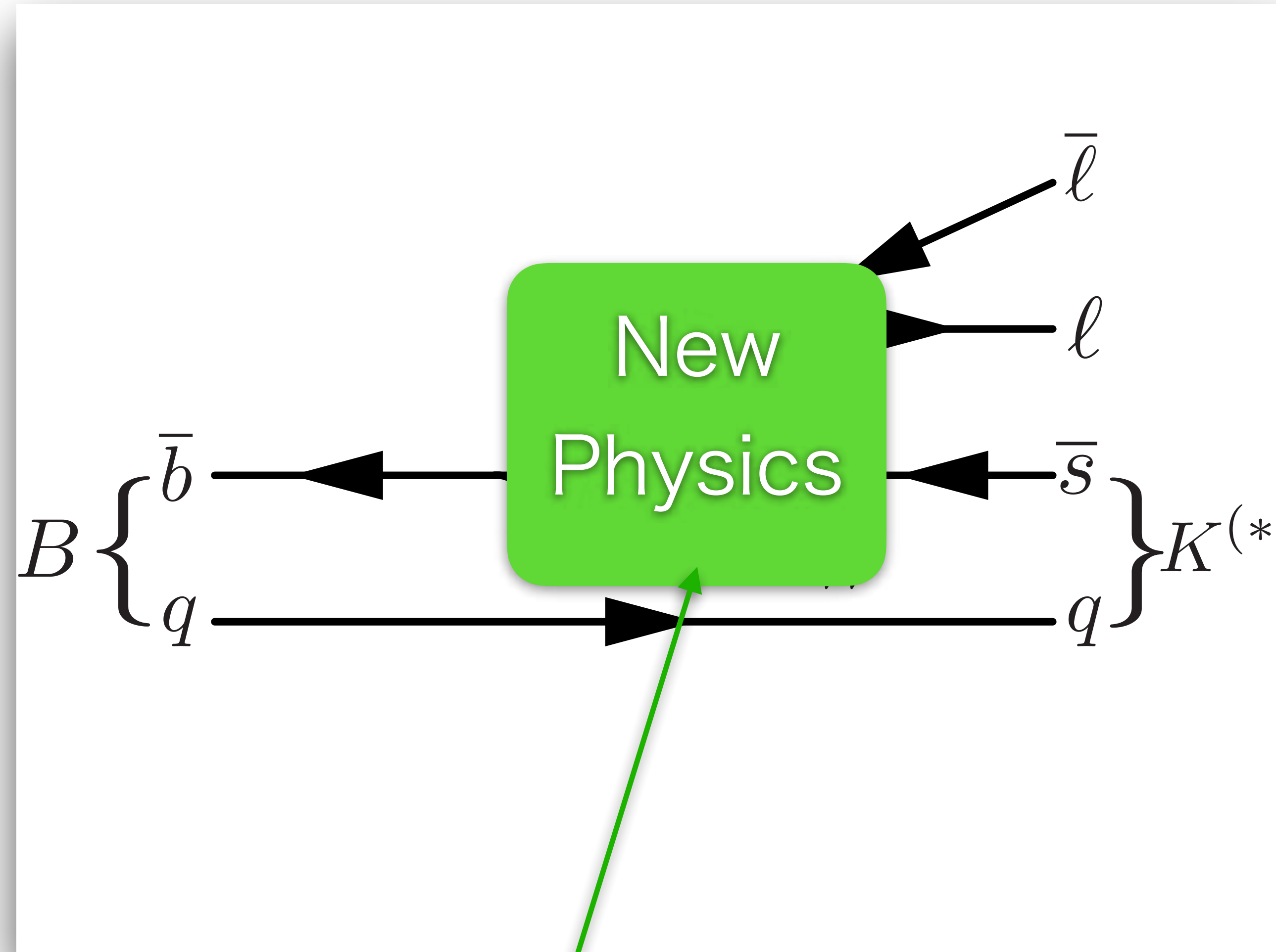
特に (g-2)μ もあってμに特別に結合する新物理は面白かった



μ とb,sに結合する新粒子?

leptoquark　*Z'*　*etc.*

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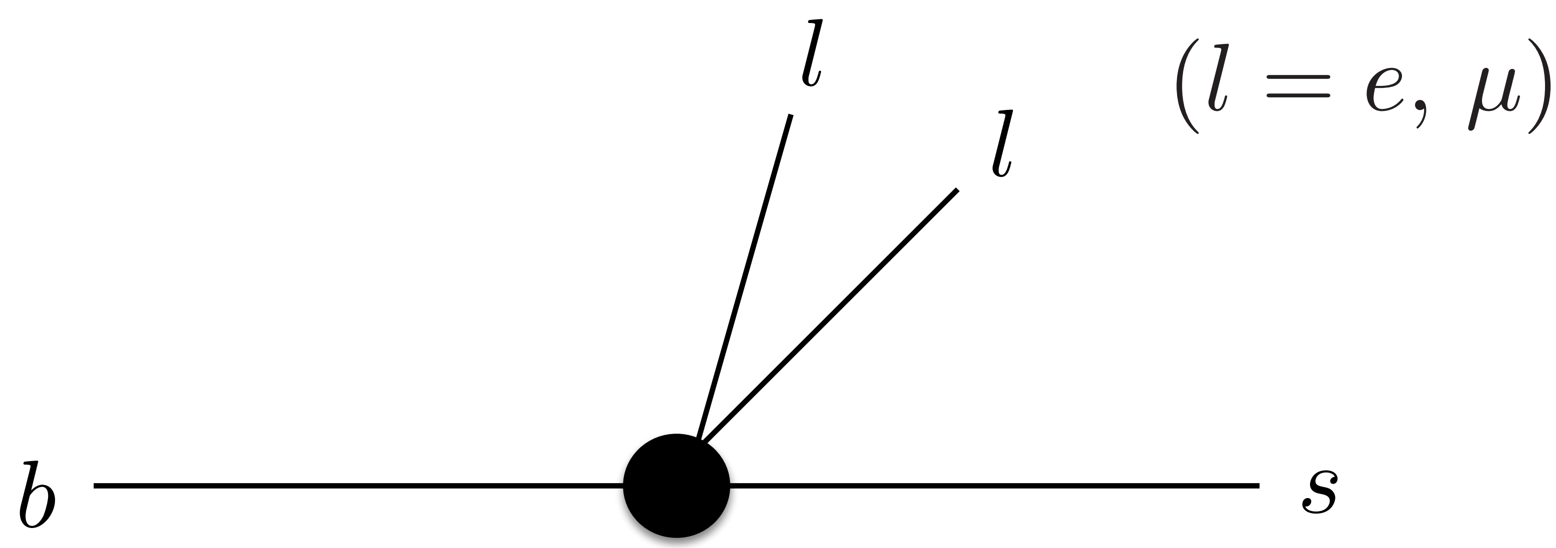
ちょっとおさらい

B 中間子の崩壊を引き起こす 4-fermi interaction



$$\mathcal{H}_{eff} = -\frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \frac{e^2}{16\pi^2} \sum_{i=7,9,10} \left(C_i O_i + C_i' O_i' \right) + h.c.$$

$$O_7 = \left(\overline{s_L} \sigma_{\mu\nu} b_R \right) F^{\mu\nu} \qquad O_7' = \left(\overline{s_R} \sigma_{\mu\nu} b_L \right) F^{\mu\nu}$$

$$O_9 = \left(\overline{s_L} \gamma_\mu b_L \right) \left(\bar{l} \gamma^\mu l \right) \qquad O_9' = \left(\overline{s_R} \gamma_\mu b_R \right) \left(\bar{l} \gamma^\mu l \right)$$

$$O_{10} = \left(\overline{s_L} \gamma_\mu b_L \right) \left(\bar{l} \gamma^\mu \gamma_5 l \right) \qquad O_{10}' = \left(\overline{s_R} \gamma_\mu b_R \right) \left(\bar{l} \gamma^\mu \gamma_5 l \right)$$

etc.

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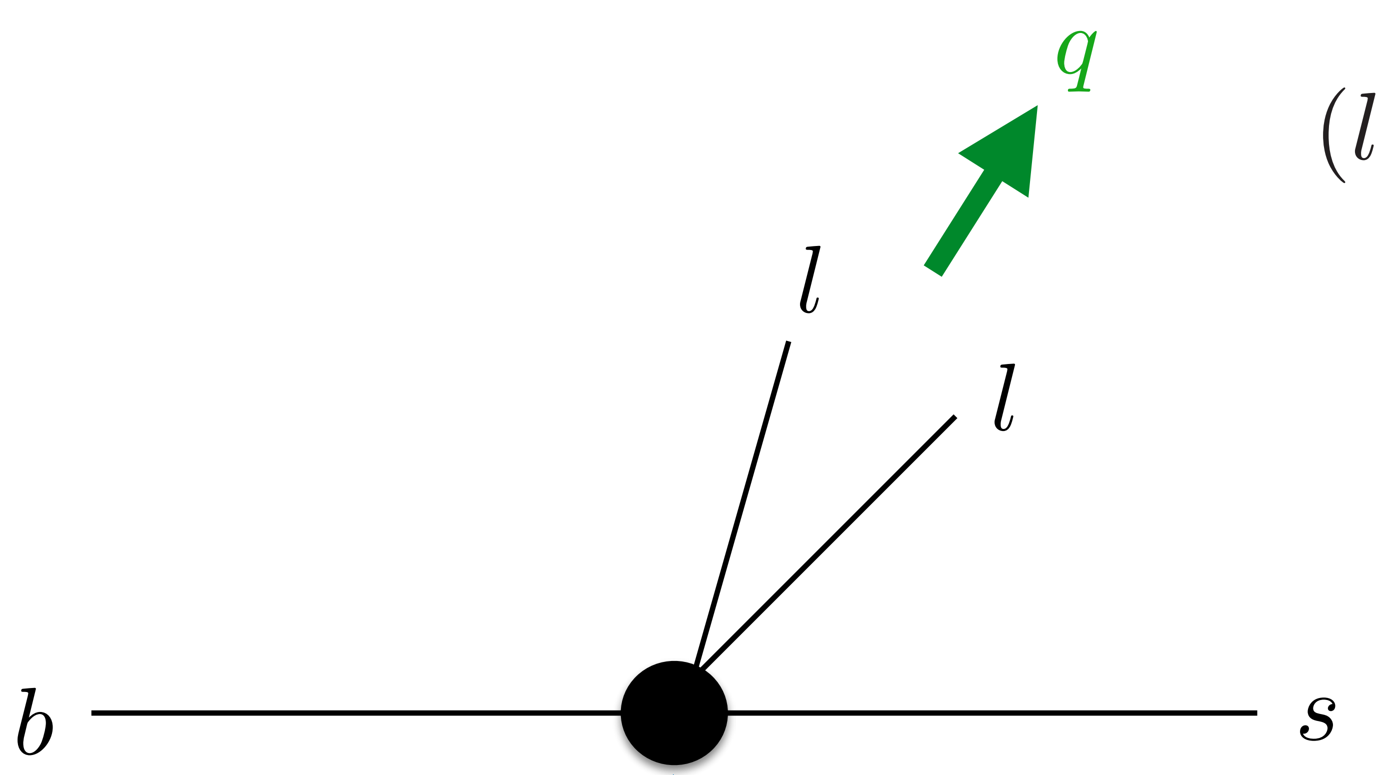
B 中間子の崩壊を引き起こす 4-fermi interaction



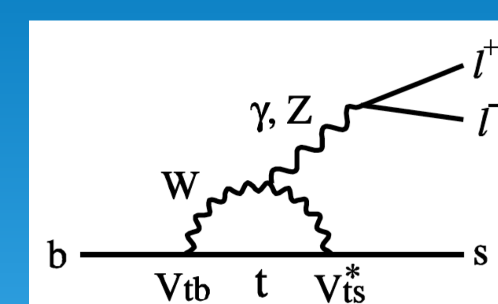
$(l = e,\ \mu)$

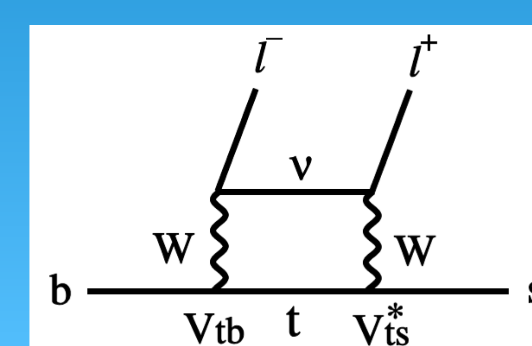
標準模型からの寄与:

$$O_7 = \left(\overline{s_L}\sigma_{\mu\nu}b_R\right)F^{\mu\nu}$$

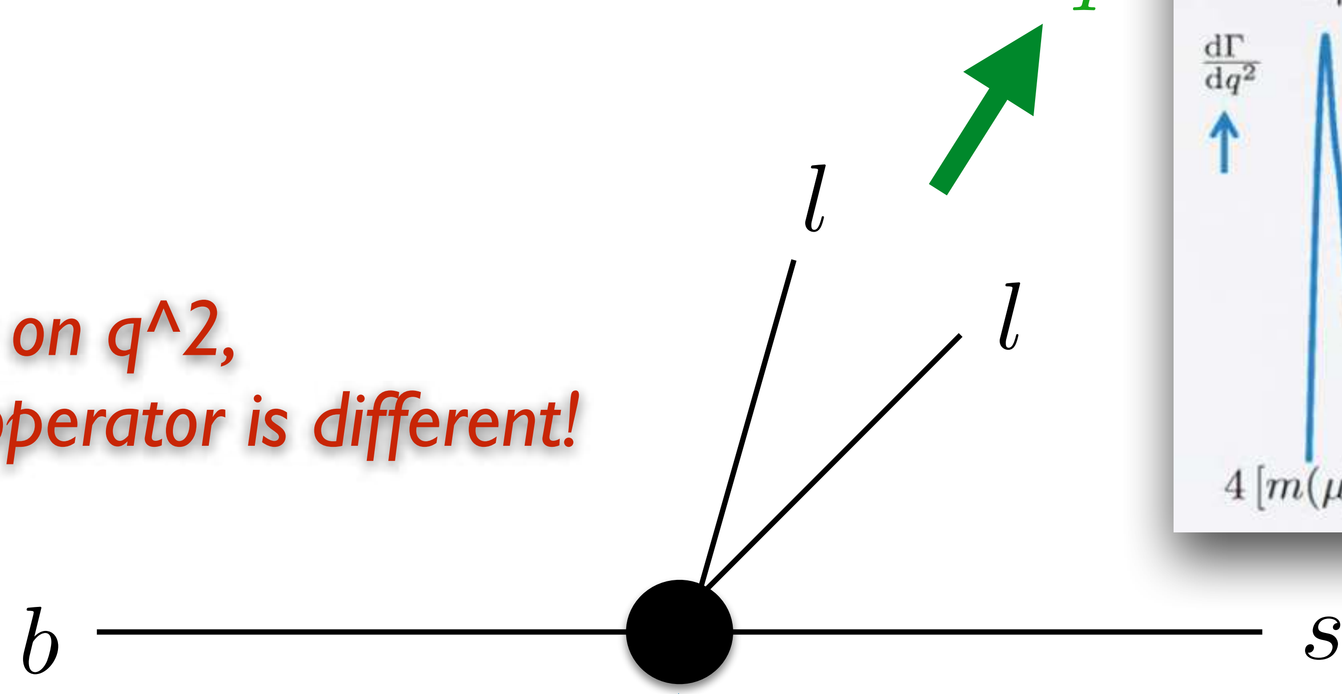
$$O_9 = \left(\overline{s_L}\gamma_\mu b_L\right)\left(\bar{l}\gamma^\mu l\right)$$

$$O_{10} = \left(\overline{s_L}\gamma_\mu b_L\right)\left(\bar{l}\gamma^\mu \gamma_5 l\right)$$

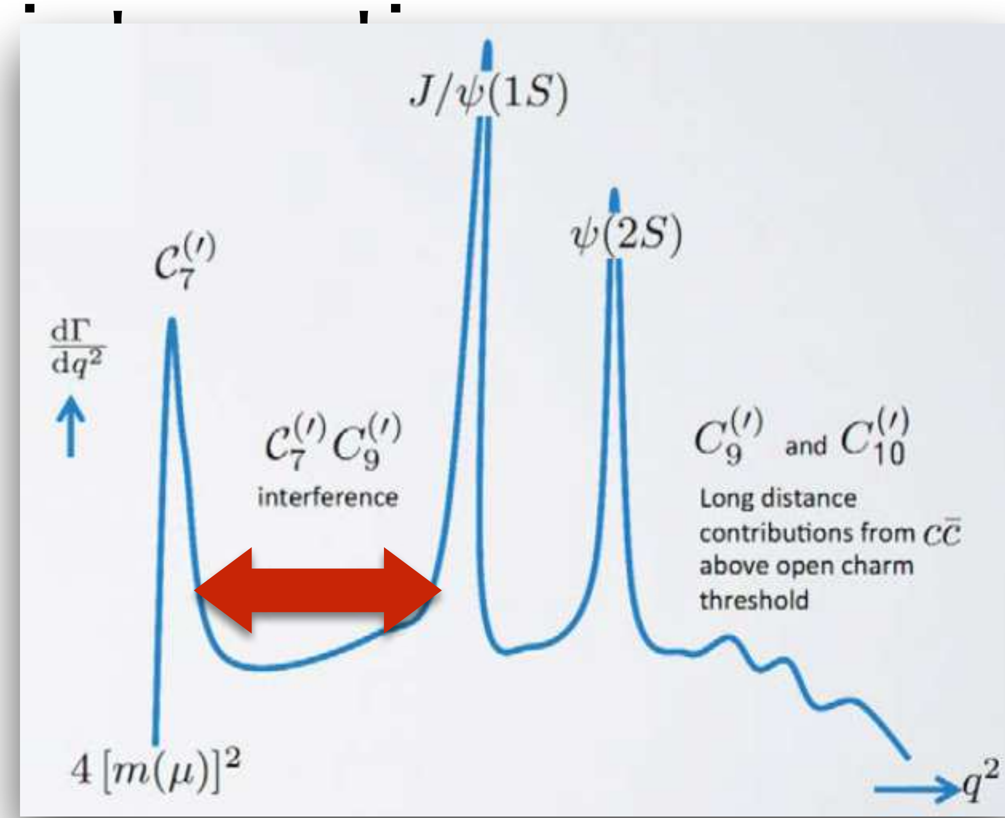




B 中間子の崩壊を引き起こす 4-fermi



Depending on q^2,
dominant operator is different!

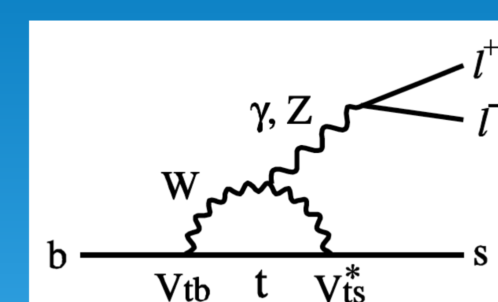


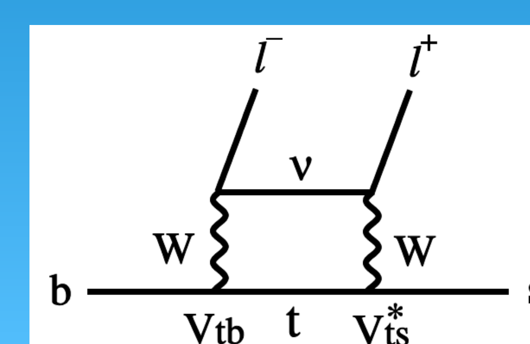
標準模型からの寄与:

$$O_7 = \left(\overline{s_L}\sigma_{\mu\nu}b_R\right)F^{\mu\nu}$$

$$O_9 = \left(\overline{s_L}\gamma_\mu b_L\right)\left(\bar{l}\gamma^\mu l\right)$$

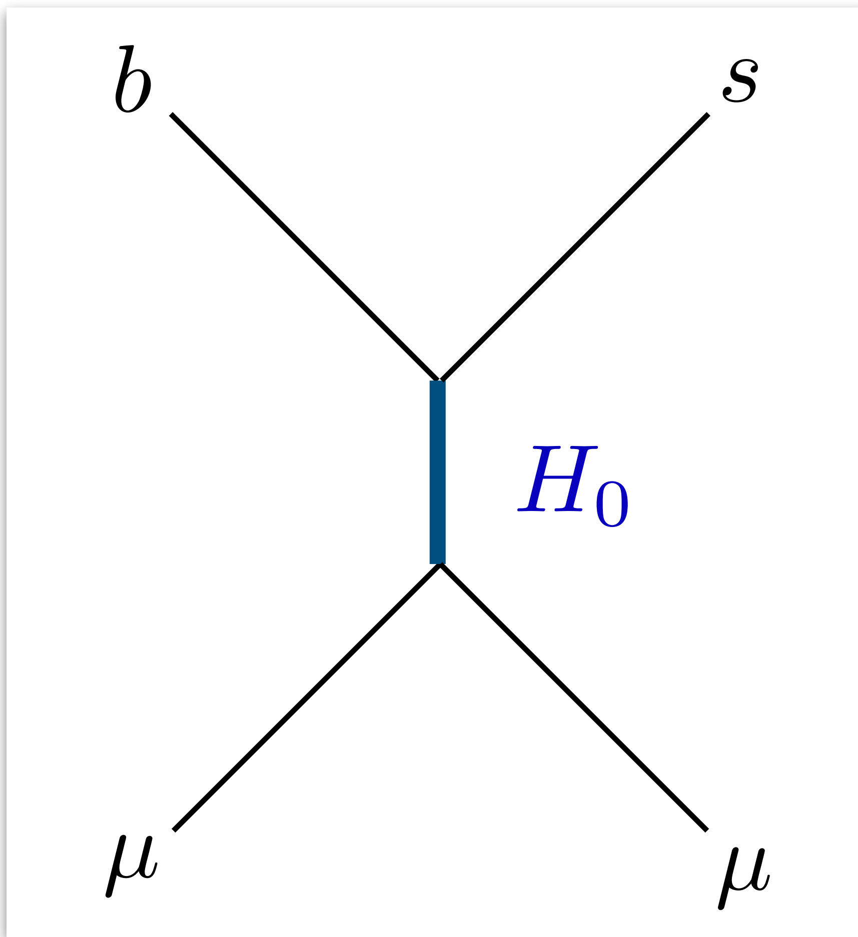
$$O_{10} = \left(\overline{s_L}\gamma_\mu b_L\right)\left(\bar{l}\gamma^\mu\gamma_5 l\right)$$





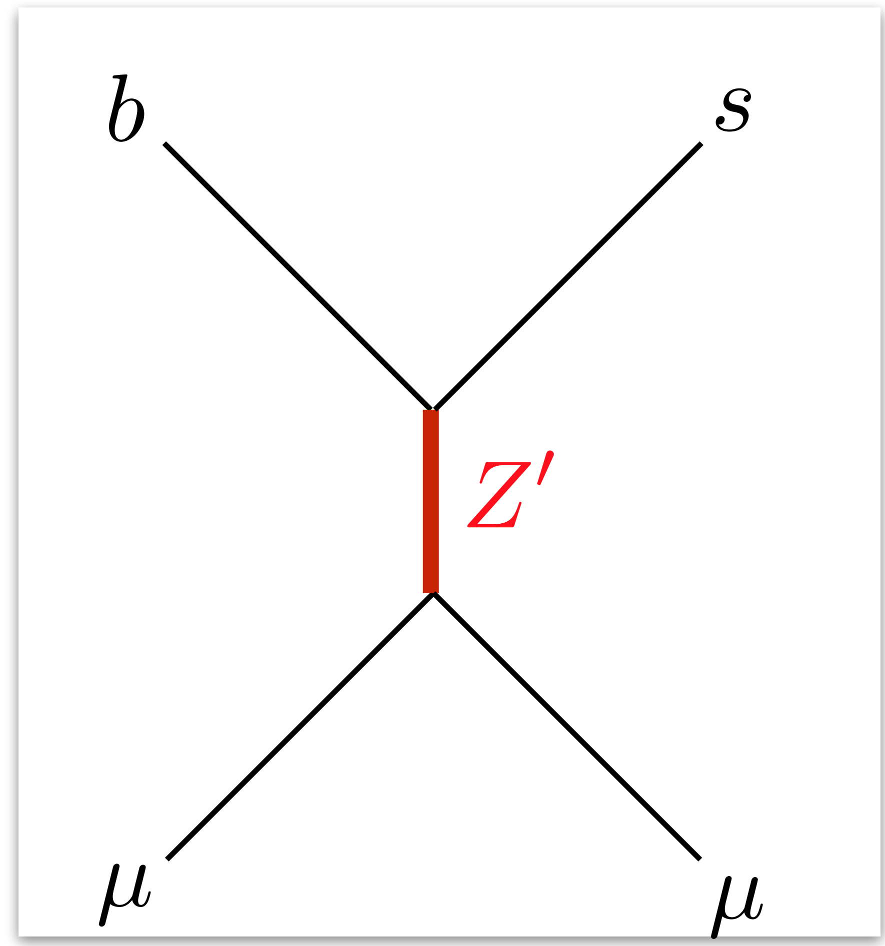
エクセスが見えた領域で重要

これを踏まえてNew Physics を考えてみると



$$\frac{1}{\Lambda^2}(\overline{s_L} b_R)(\overline{\mu_R}\mu_L)$$

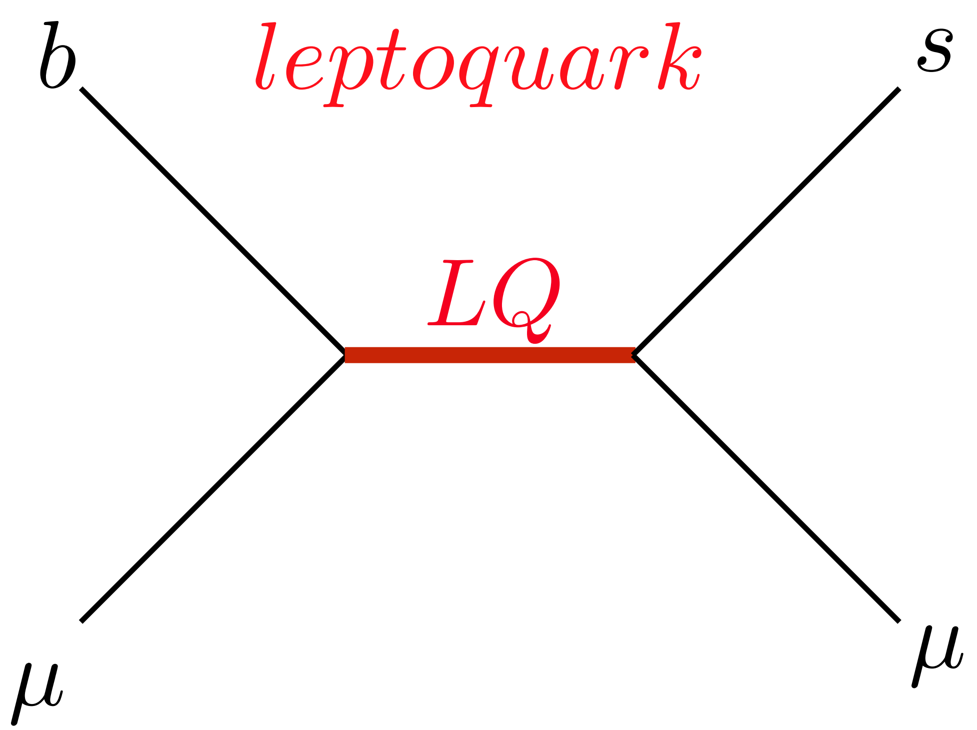
Bs →μμ を enhance

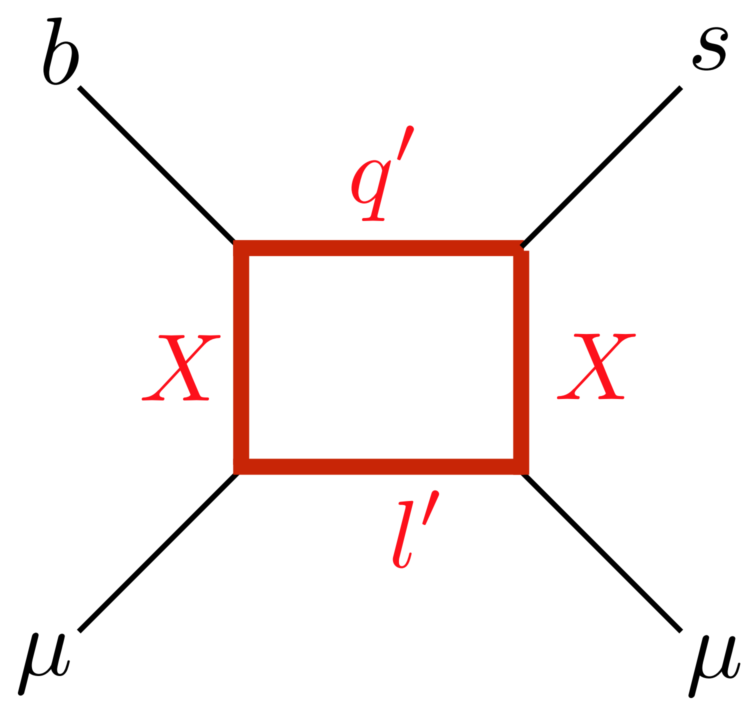


$$\frac{1}{\Lambda^2}(\overline{s_L}\gamma_\mu b_L)(\overline{\mu}\gamma^\mu \mu)$$

$$\frac{1}{\Lambda^2}(\overline{s_L}\gamma_\mu b_L)(\overline{\mu}\gamma^\mu \gamma_5 \mu)$$ etc.

ほかにも

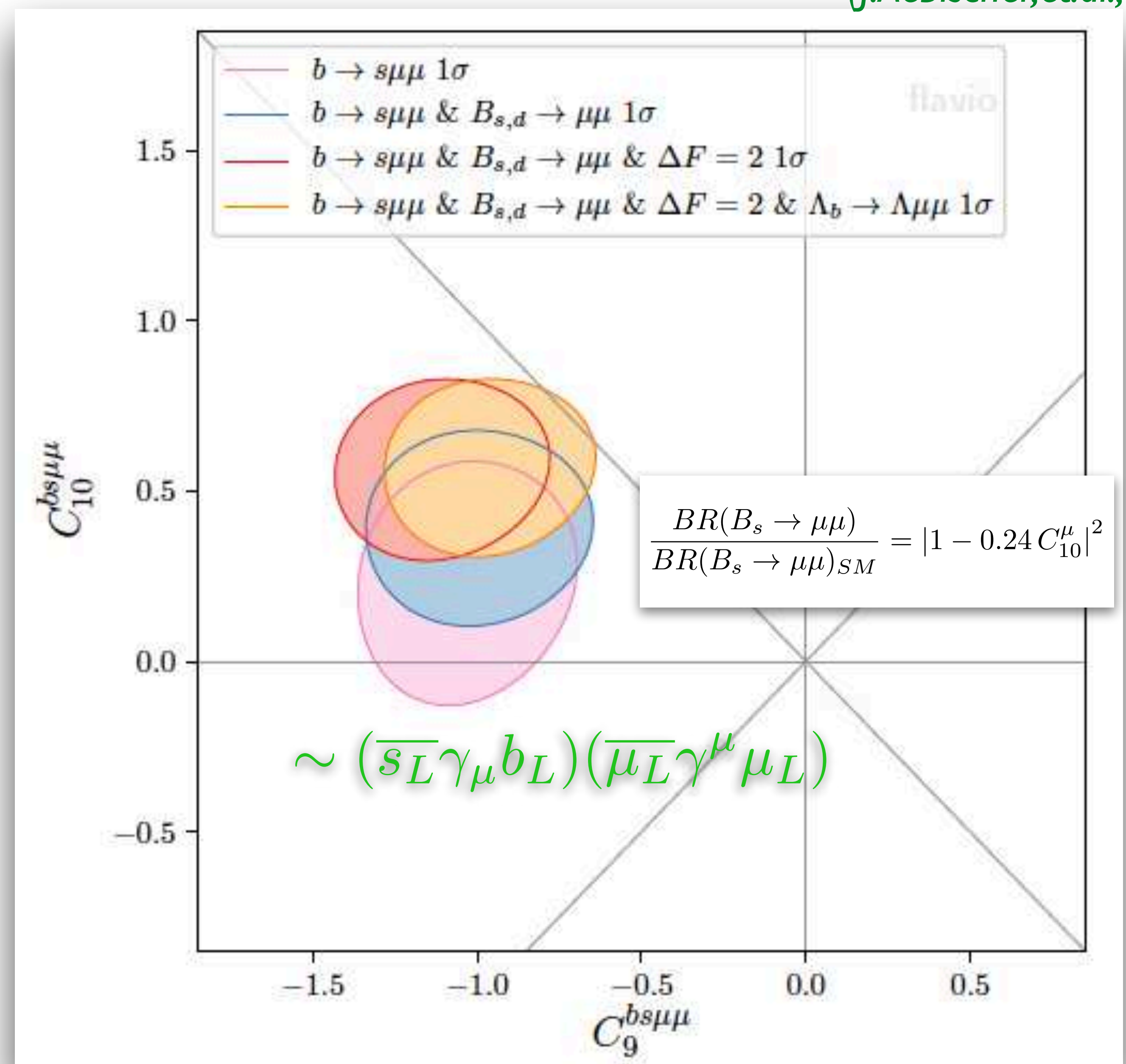




$$\frac{1}{\Lambda^2}(\overline{s_L}\gamma_\mu b_L)(\overline{\mu}\gamma^\mu\mu) \quad \frac{1}{\Lambda^2}(\overline{s_L}\gamma_\mu b_L)(\overline{\mu}\gamma^\mu\gamma_5\mu)$$ etc.

一昔前の結果を使った解析

(J.Aebischer,et.al., 1903.10434)



SM-like operators (*quarks are left-handed*) が良くて

SM の予言値を小さくする方向がfavored.

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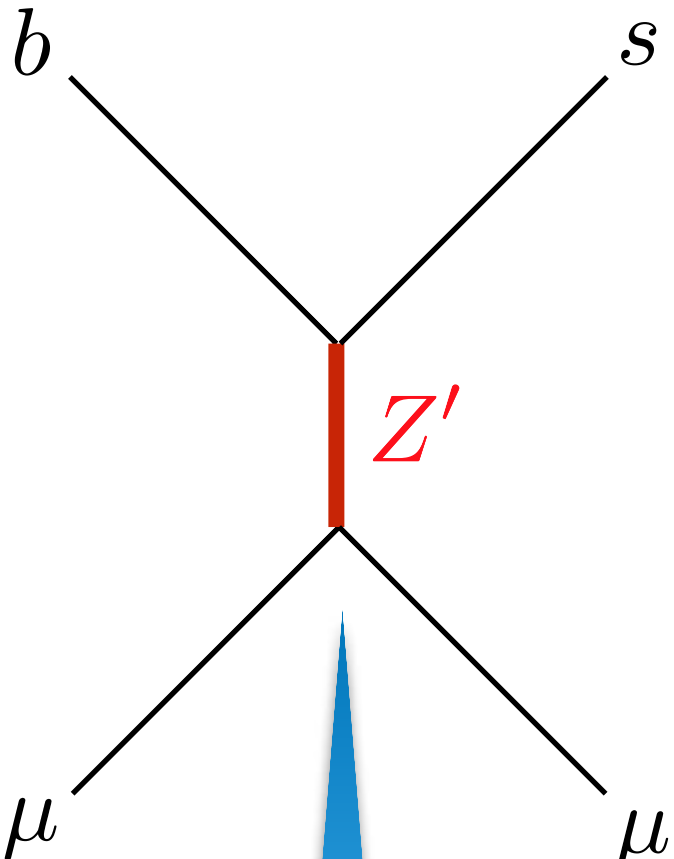
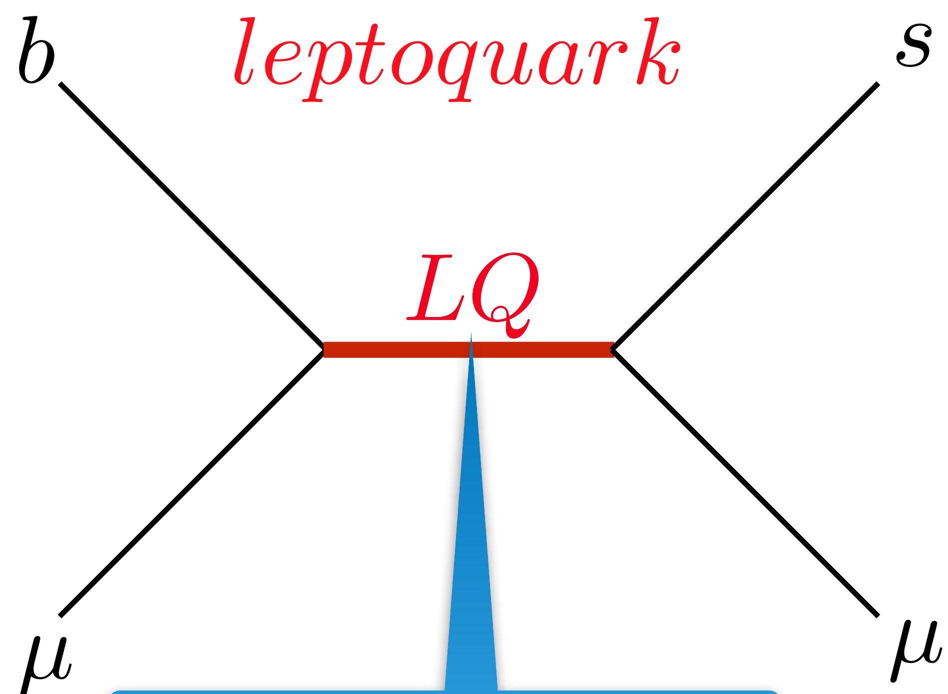
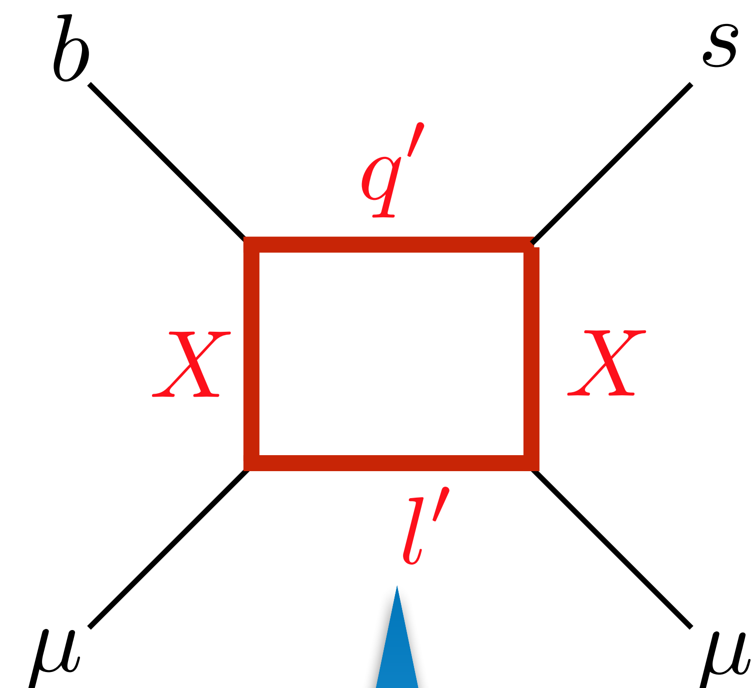
当時、考えられた新物理の候補者たち







フレーバー対称性

(Ko,Yu,Shigekami,YO,'17;King'17;
Bian, Choi, et.al.'17;
Ellis, et.al, 17';Alonso, Cox, et.al., '17 etc)

力の統一

(Blanke,Crivellin,'18;Calibbi,Crivellin,Li,'17,
etc.)

暗黒物質

(Belanger, et.al,'15;Kawamura,Okawa,
YO,'17)

ニュートリノ質量

生成機構

(Khalil, 17'; Cai, Gargalionis, et.al.,'17)

etc.

新物理のスケールは $\Lambda \approx 30\,\mathrm{TeV}$

(Luzio, Nardecchia,1706.01868)

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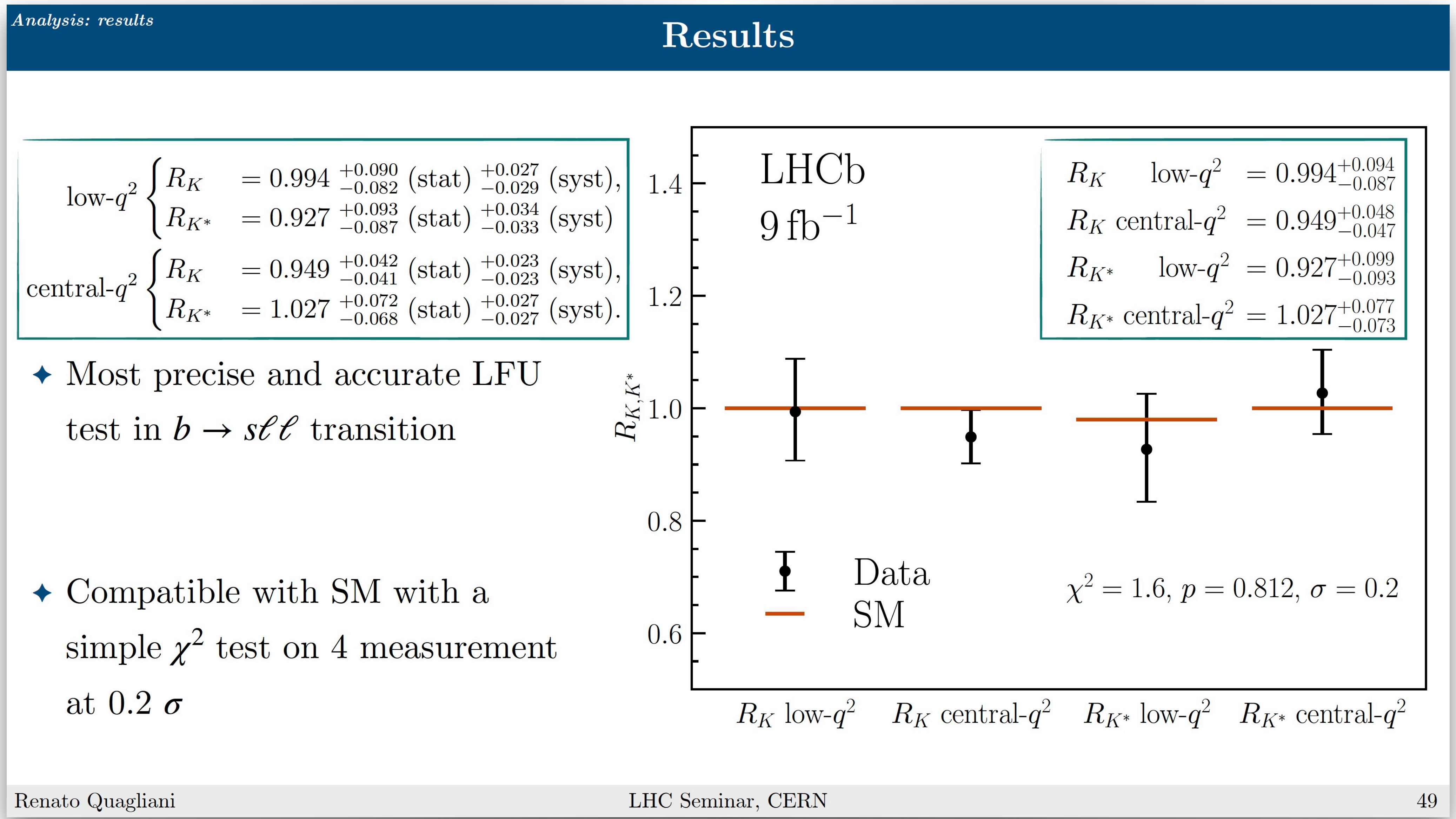
現状は…

R_K and R_{K^*} consistent with the SM!

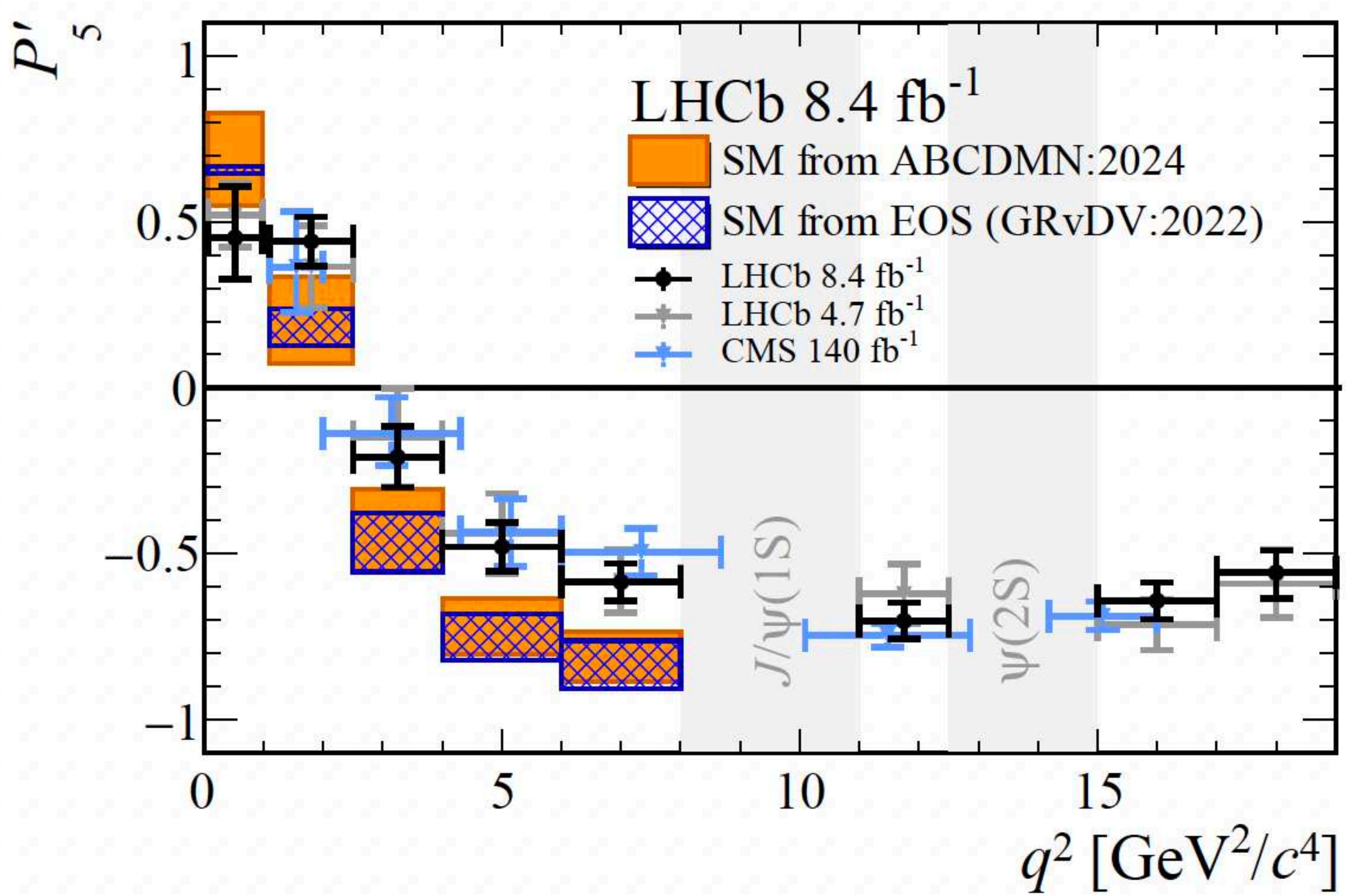


2022/12/20

Flavor universal?

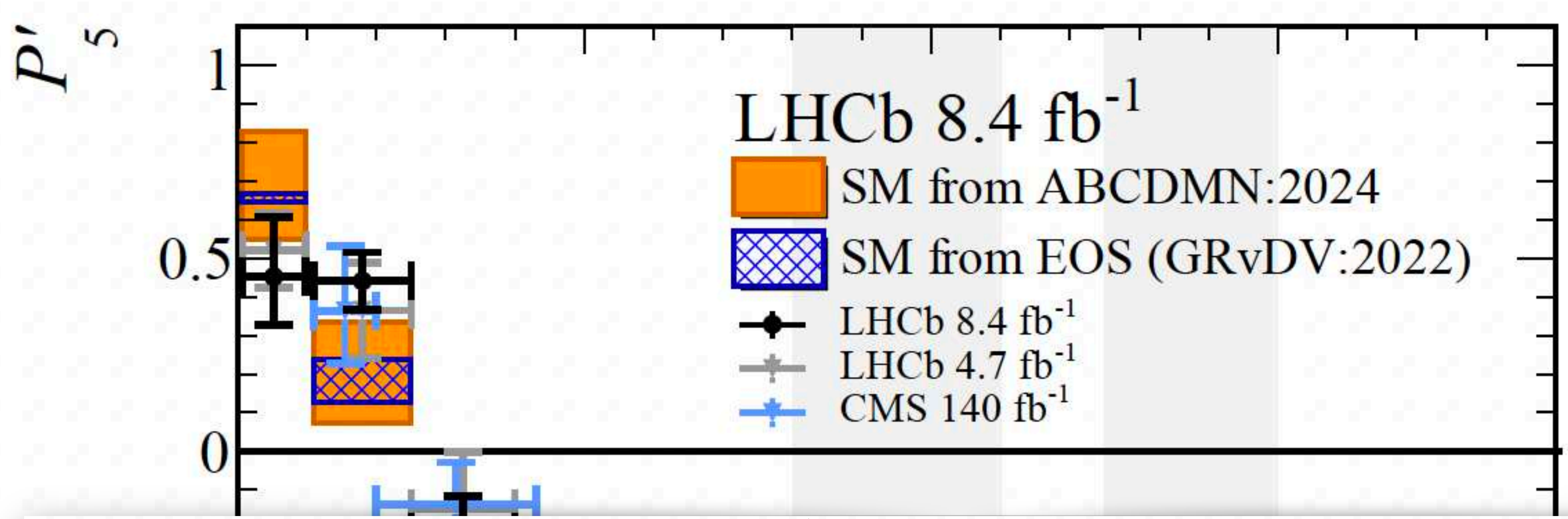
P_5' は

(LHCb, 2605.18084)

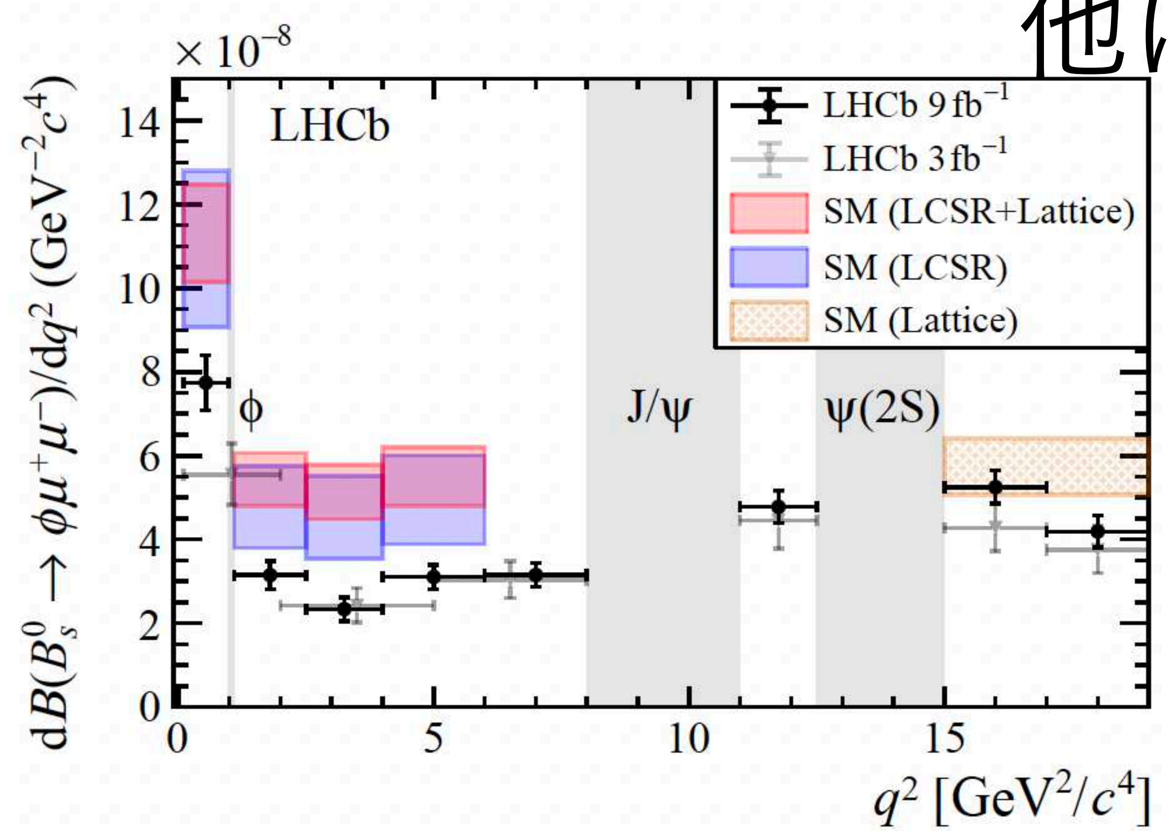


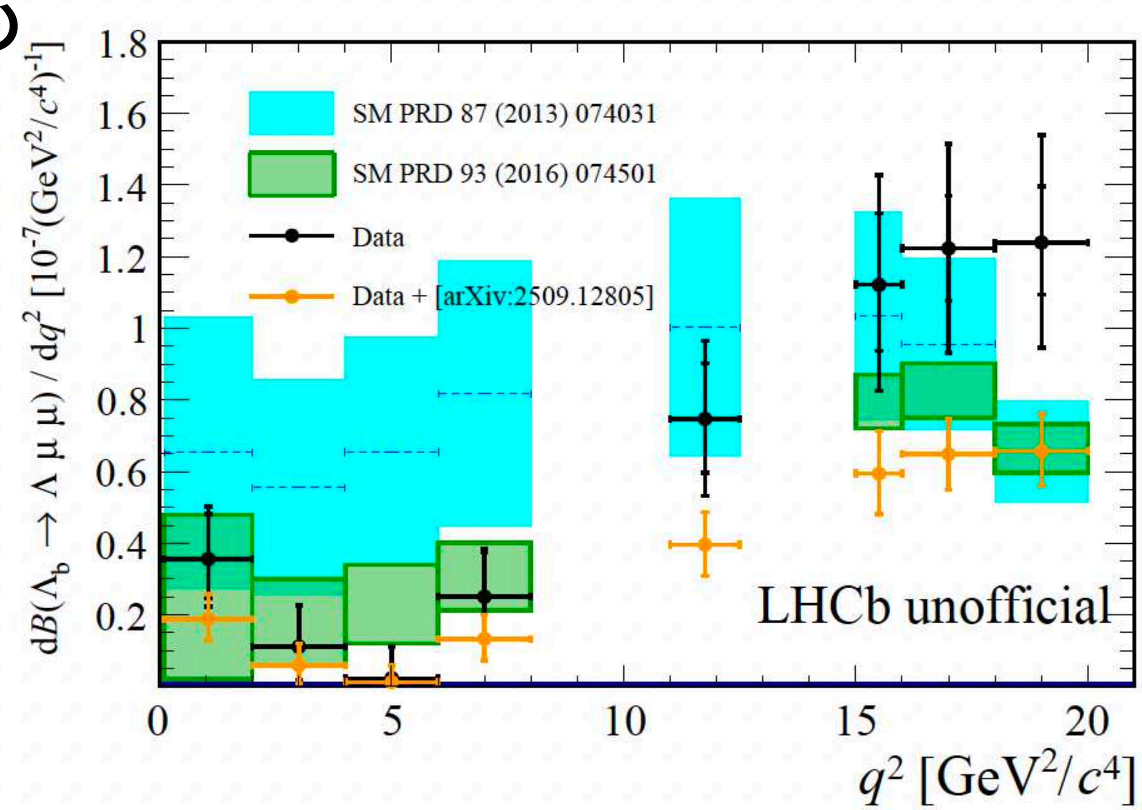
P_5' は

(LHCb, 2605.18084)



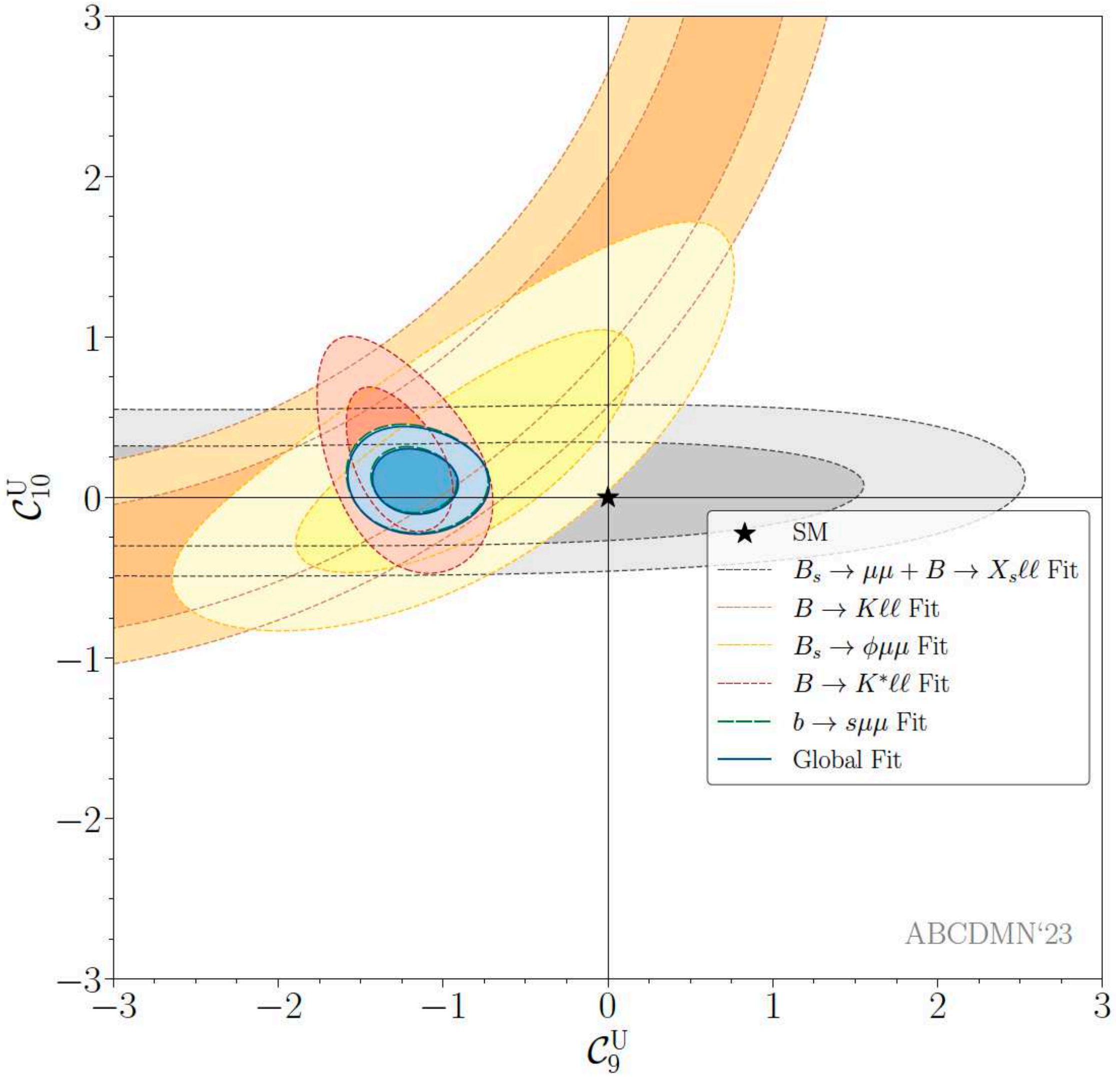
他にも

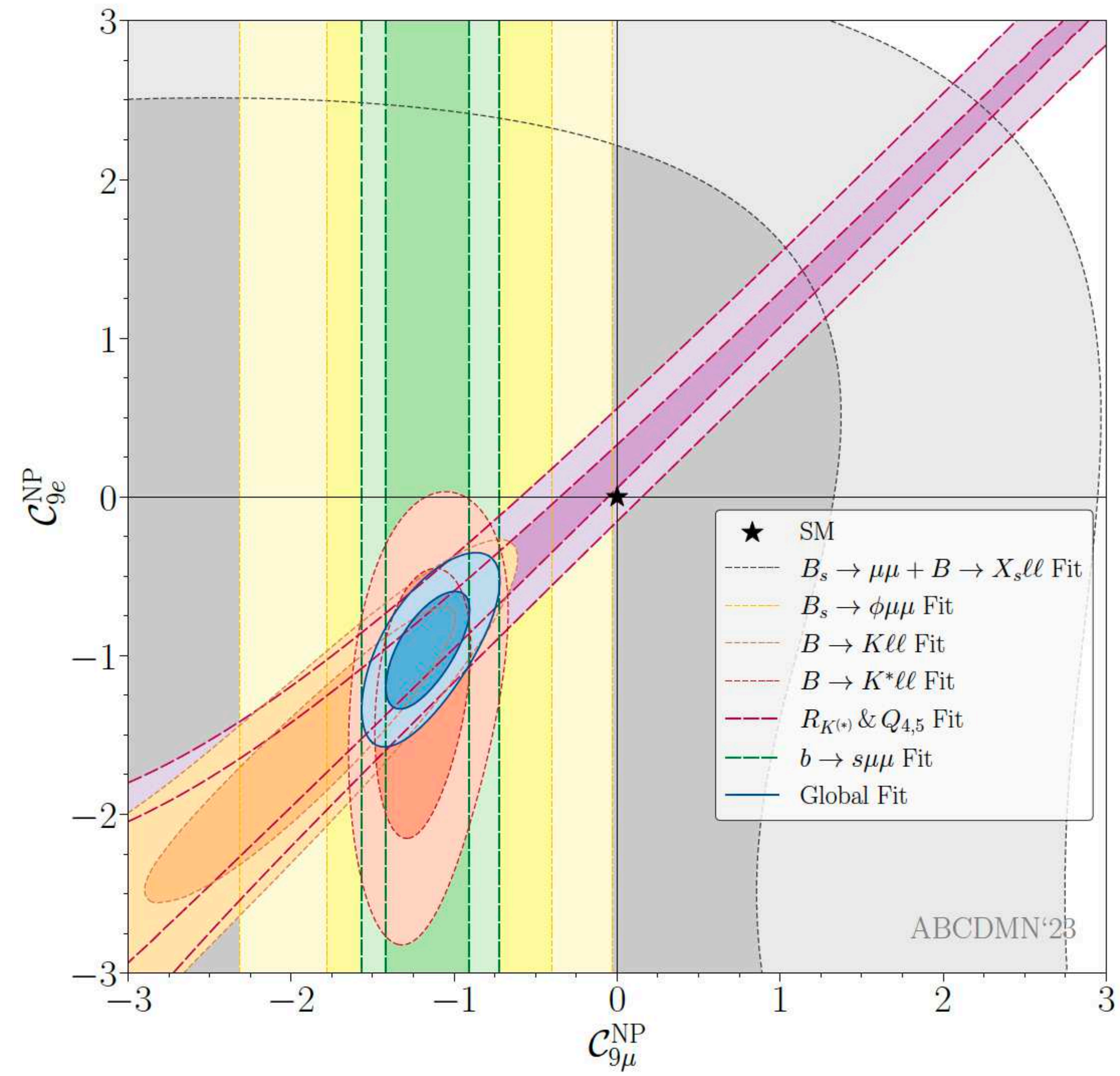




新しい結果を入れた global fitting

(Capdevila, et al.,2309.01311)



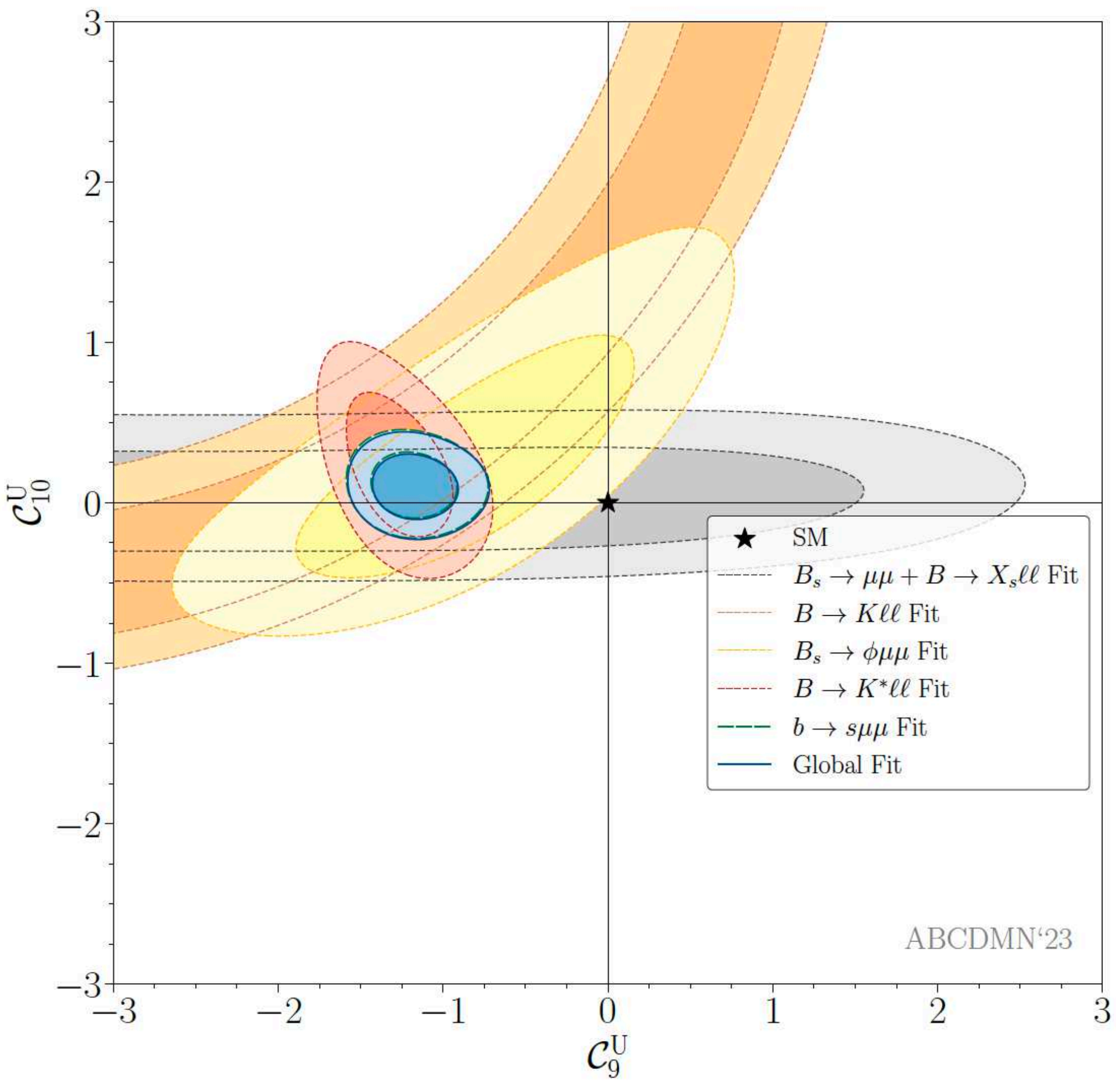


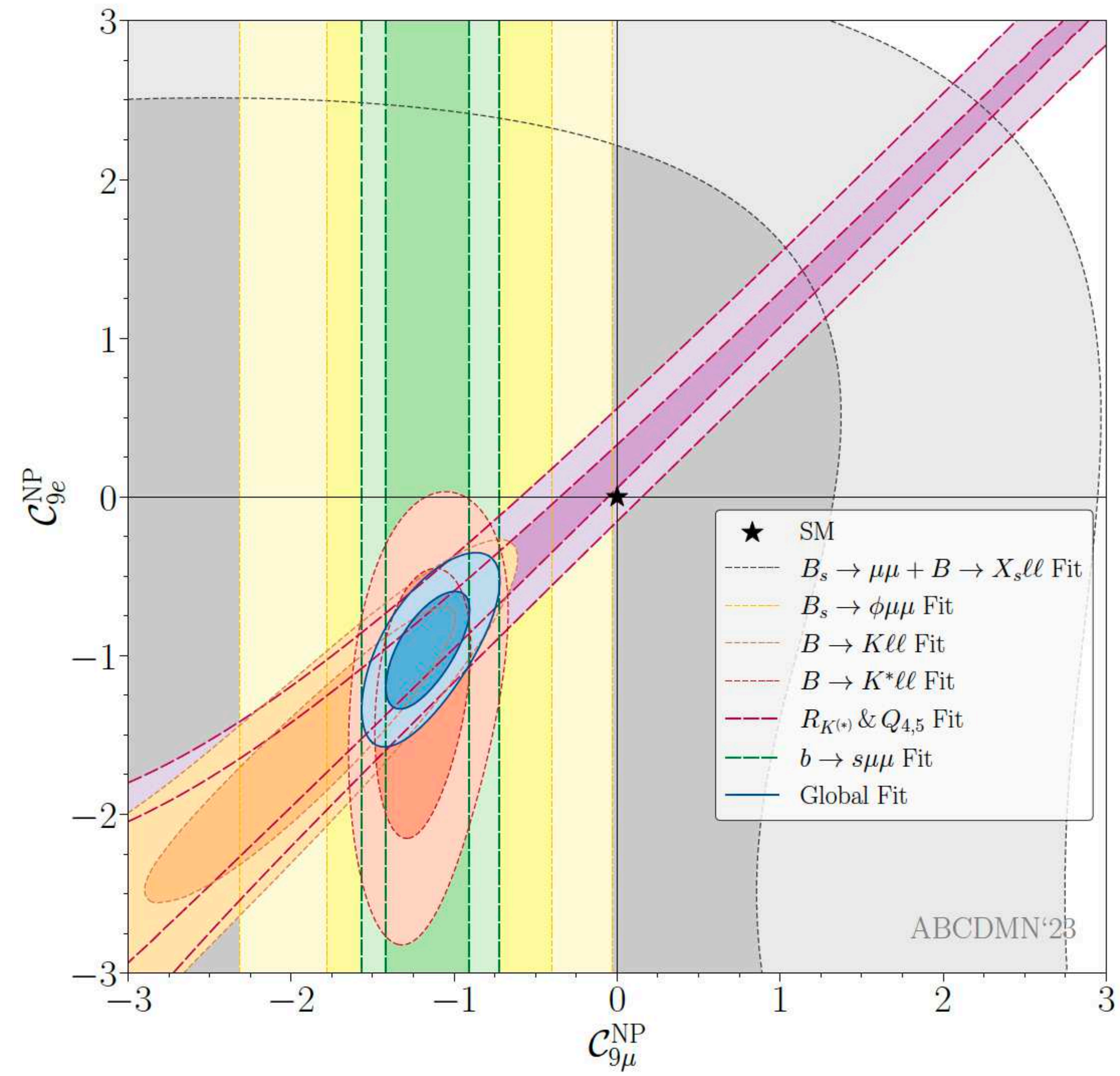
Point

Bs →μμ, R_K, R_{K^*} are consistent with SM prediction

新しい結果を入れた global fitting

(Capdevila, et al.,2309.01311)





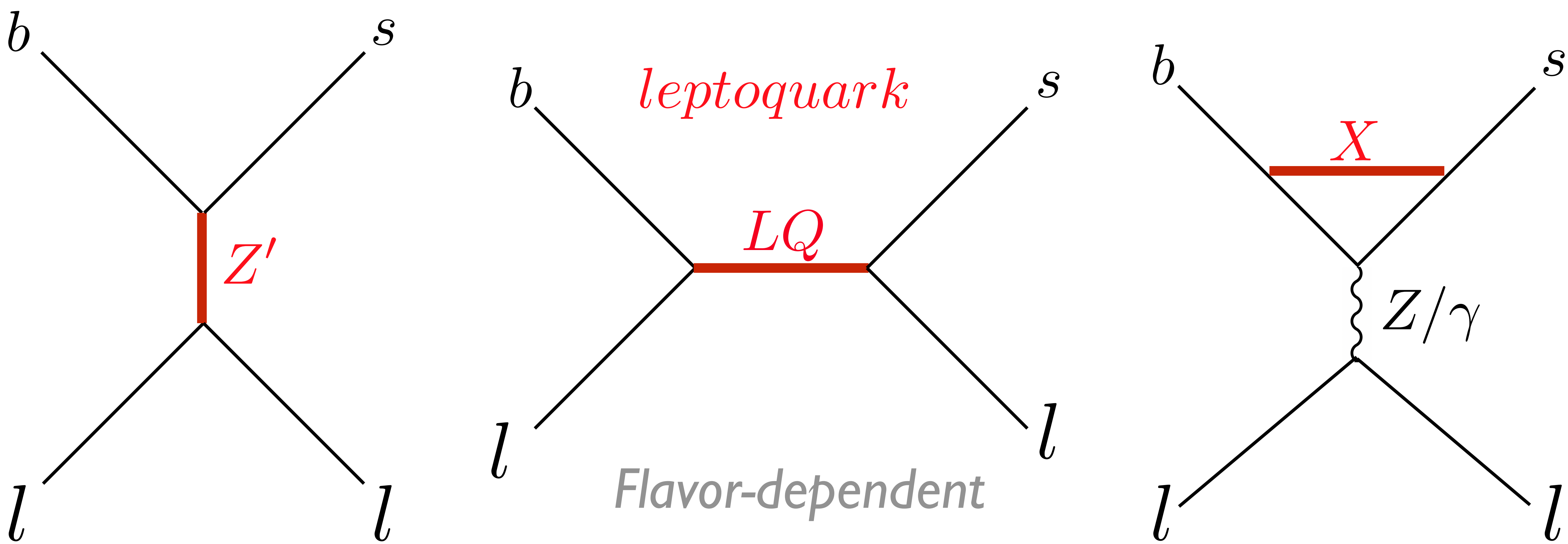
Point

C9 のみがsizable

Flavor universal

1-2. New physics interpretations

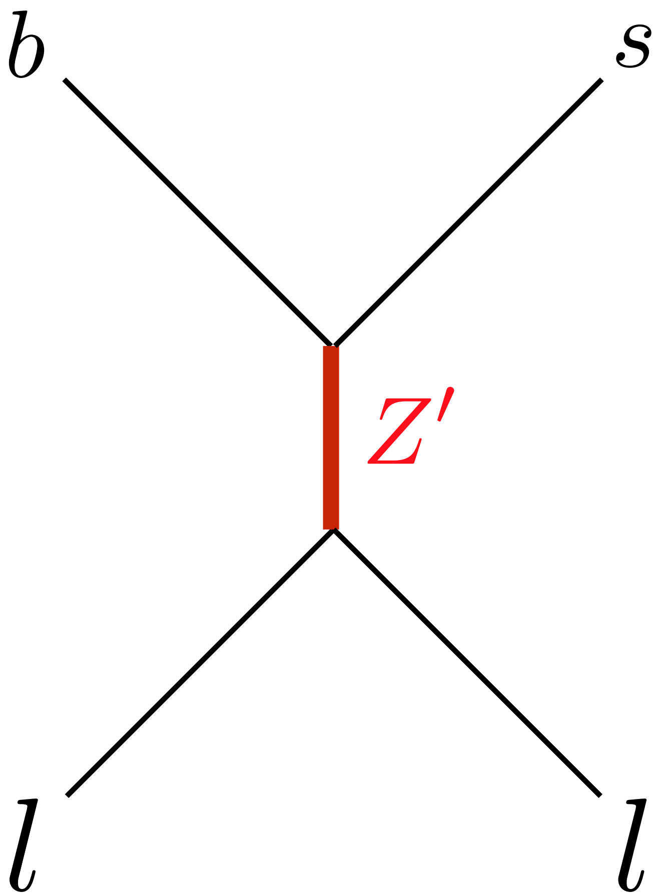
思いつくのは



$(l = e,\ \mu)$

Z' model

(Allanach and Gubernari, 2409.06804)



・flavor violating なanomaly-free のU(1)が欲しい

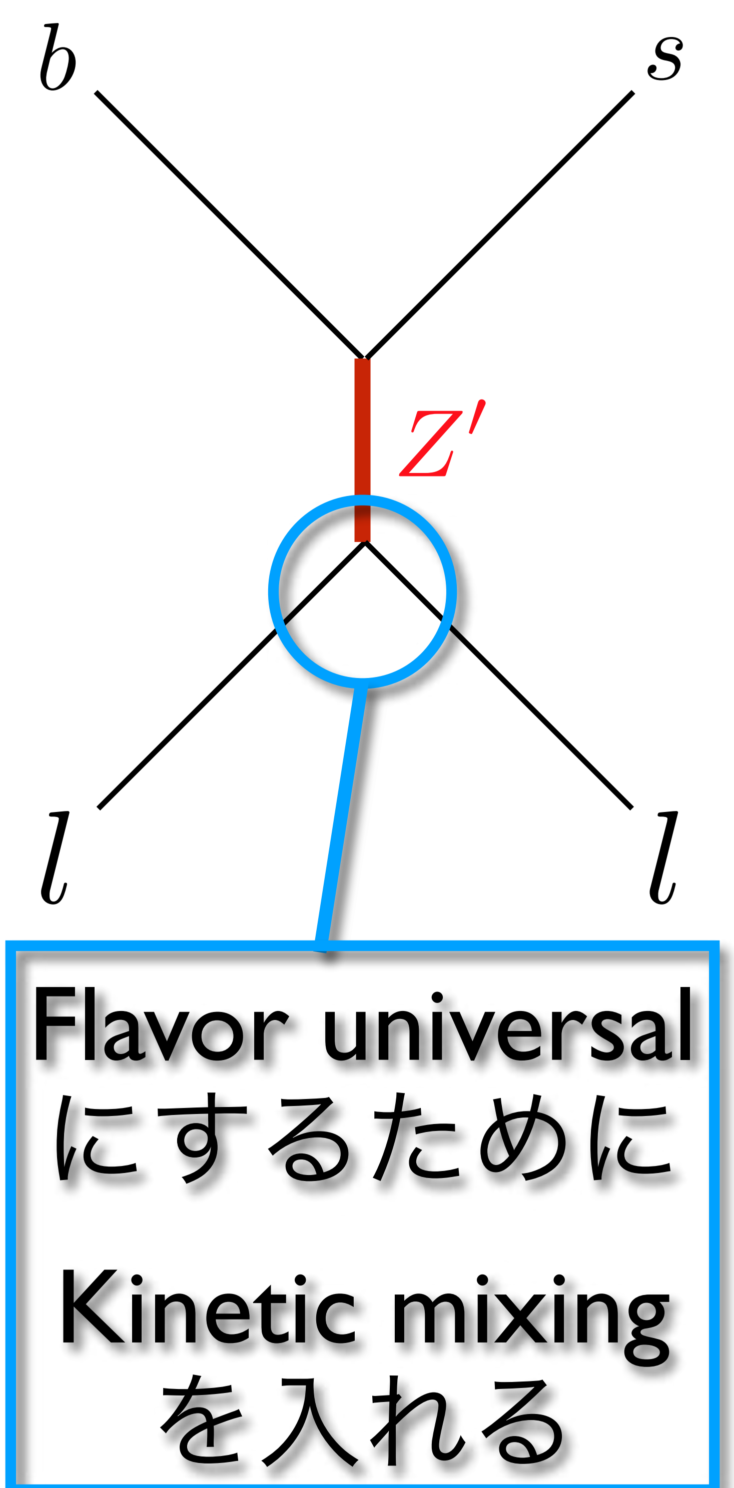
→ B-L の変形を考える

$B_3 - L_2$ model *(1705.00915;1705.03858;2009.02197)*

Fields	spin	$SU(3)_c$	$SU(2)_L$	$U(1)_{B_3-L_2}$
$Q_L^{1,2} = (u_L^{1,2}, d_L^{1,2})$	$1/2$	$\mathbf{3}$	$\mathbf{2}$	0
$Q_L^3 = (u_L^3, d_L^3)$	$1/2$	$\mathbf{3}$	$\mathbf{2}$	1
$u_R^{1,2}$	$1/2$	$\mathbf{3}$	$\mathbf{1}$	0
u_R^3	$1/2$	$\mathbf{3}$	$\mathbf{1}$	1
$d_R^{1,2}$	$1/2$	$\mathbf{3}$	$\mathbf{1}$	0
d_R^3	$1/2$	$\mathbf{3}$	$\mathbf{1}$	1
$L^{1,3} = (\nu_L^{1,3}, e_L^{1,3})$	$1/2$	$\mathbf{1}$	$\mathbf{2}$	0
$L^2 = (\nu_L^2, e_L^2)$	$1/2$	$\mathbf{1}$	$\mathbf{2}$	-3
$e_R^{1,3}$	$1/2$	$\mathbf{1}$	$\mathbf{1}$	0
e_R^2	$1/2$	$\mathbf{1}$	$\mathbf{1}$	-3
$\nu_R^{1,3}$	$1/2$	$\mathbf{1}$	$\mathbf{1}$	0
ν_R^2	$1/2$	$\mathbf{1}$	$\mathbf{1}$	-3
H	0	$\mathbf{1}$	$\mathbf{2}$	0

Z’ model

(Allanach and Gubernari, 2409.06804)



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$$B_3 - L_2 \text{ model}$$ (1705.00915;1705.03858;2009.02197)

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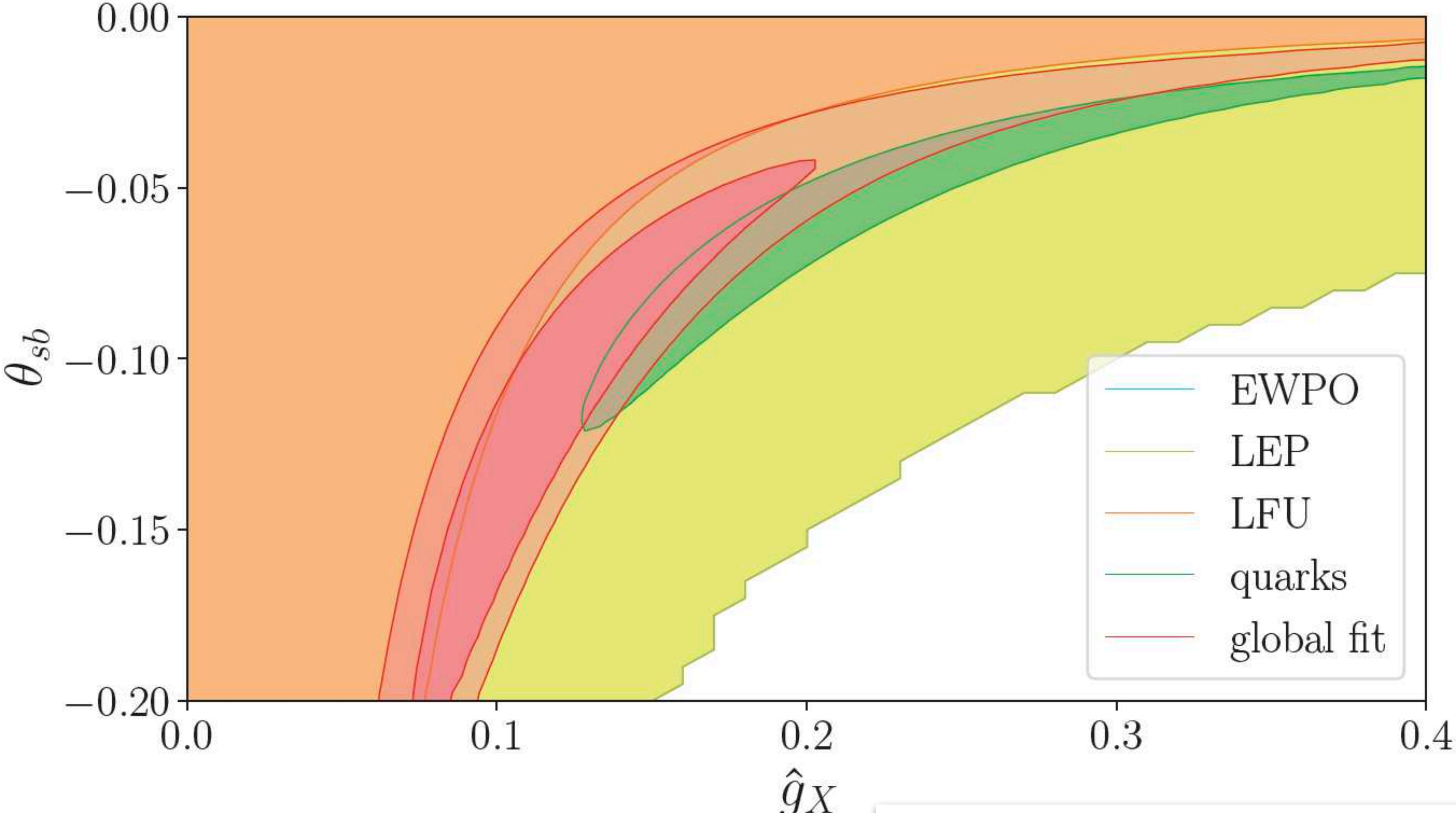
$d_R^{1,2}$	$1/2$	$\mathbf{3}$	$\mathbf{1}$	0
d_R^3	$1/2$	$\mathbf{3}$	$\mathbf{1}$	1
$L^{1,3} = (\nu_L^{1,3}, e_L^{1,3})$	$1/2$	$\mathbf{1}$	$\mathbf{2}$	0
$L^2 = (\nu_L^2, e_L^2)$	$1/2$	$\mathbf{1}$	$\mathbf{2}$	-3
$e_R^{1,3}$	$1/2$	$\mathbf{1}$	$\mathbf{1}$	0
e_R^2	$1/2$	$\mathbf{1}$	$\mathbf{1}$	-3
$\nu_R^{1,3}$	$1/2$	$\mathbf{1}$	$\mathbf{1}$	0
ν_R^2	$1/2$	$\mathbf{1}$	$\mathbf{1}$	-3
H	0	$\mathbf{1}$	$\mathbf{2}$	0

Result

(Allanach and Gubernari, 2409.06804)

kinetic mixing なし

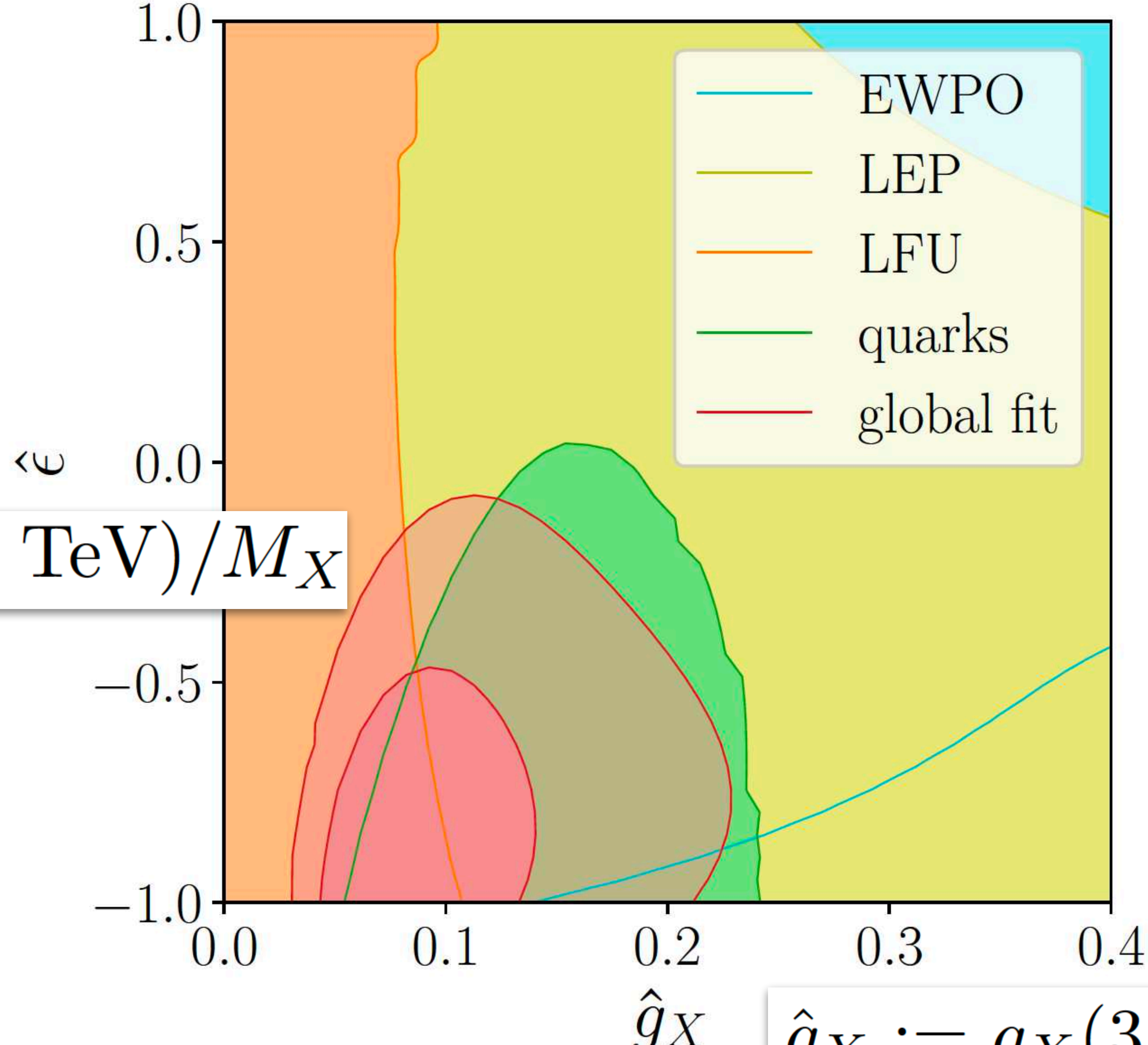


$$\hat{g}_X := g_X(3\ \text{TeV})/M_X$$

Result

(Allanach and Gubernari, 2409.06804)

kinetic mixing あり



$$\hat{\epsilon} := \epsilon(3\ \mathrm{TeV})/M_X$$

$$\hat{g}_X := g_X(3\ \mathrm{TeV})/M_X$$

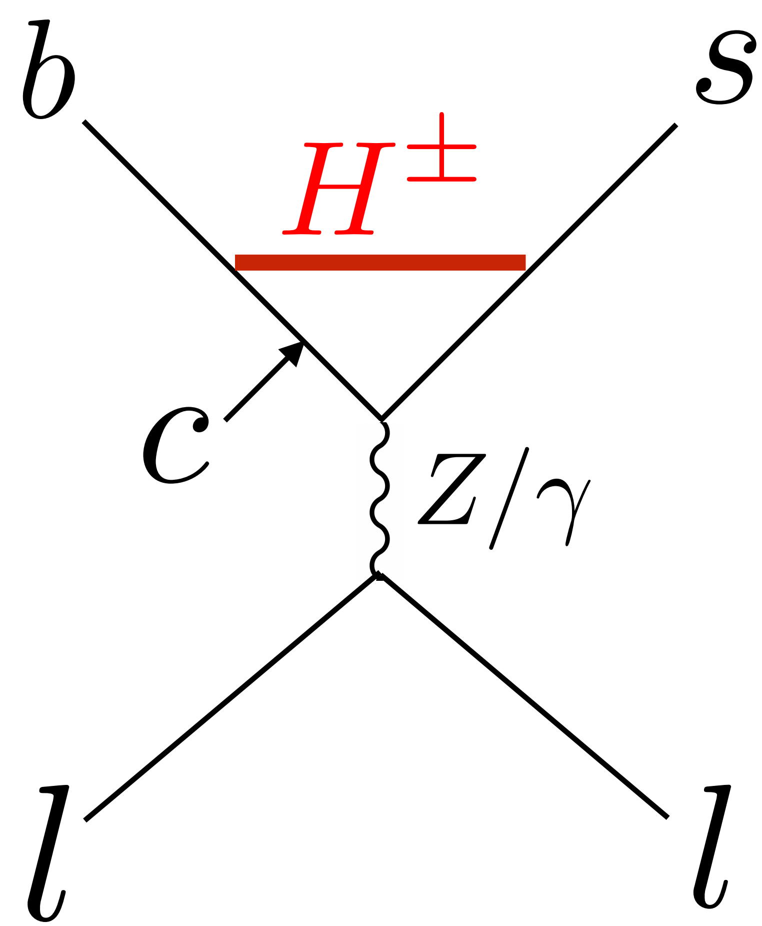
General 2 HDM

(Iguro and YO, 1802.01732)

特徴 : extra scalar が flavor violating Yukawa をもつ

$$V_{CKM}^{tb*}\left(\rho_u^{tt} H^- \overline{b_L} t_R + \rho_u^{tc} H^- \overline{b_L} c_R\right) + V_{CKM}^{ts*}\left(\rho_u^{tt} H^- \overline{s_L} t_R + \rho_u^{tc} H^- \overline{s_L} c_R\right)$$

Charged Higgs



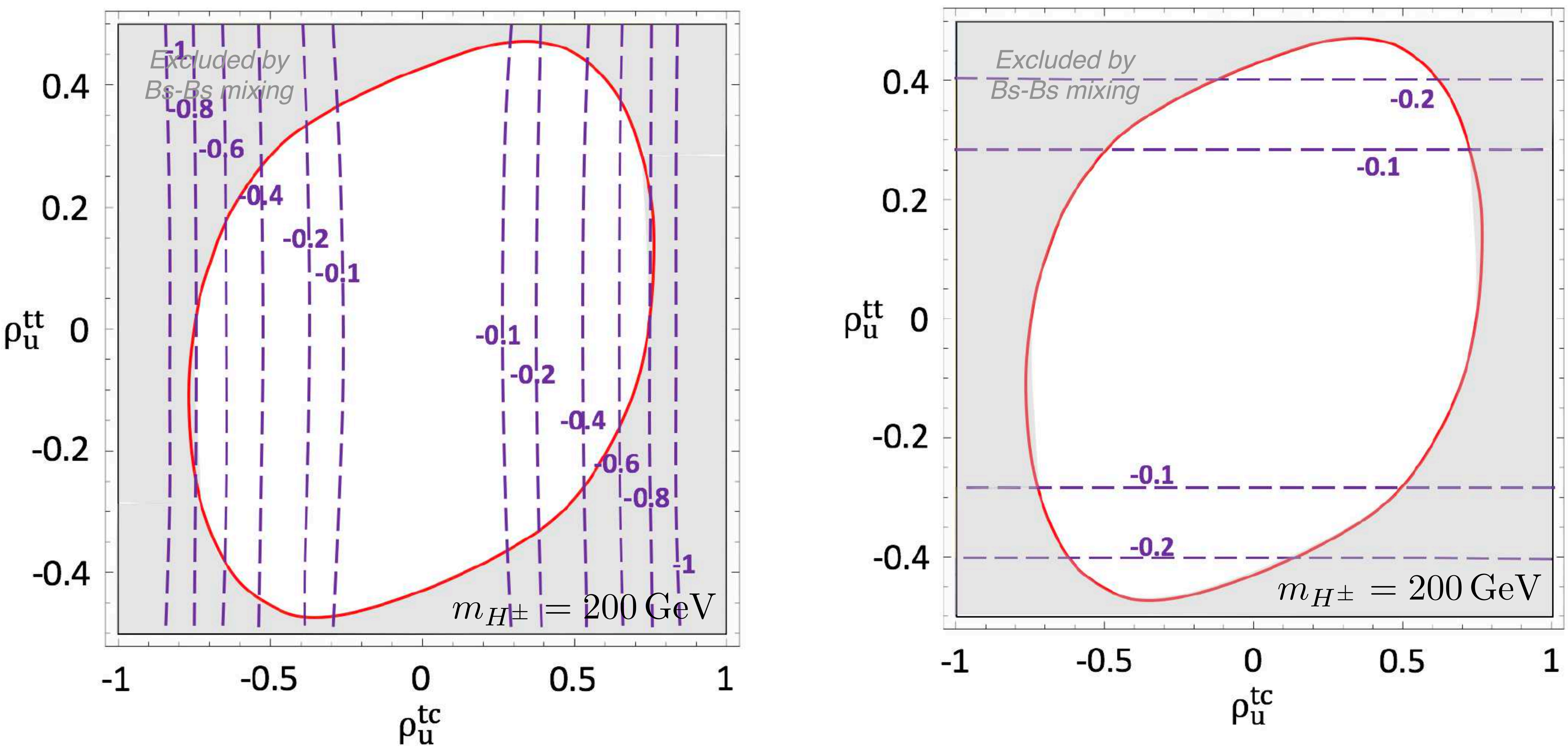
General２HDM

(Iguro and YO, 1802.01732)

特徴 : extra scalar が flavor violating Yukawa をもつ

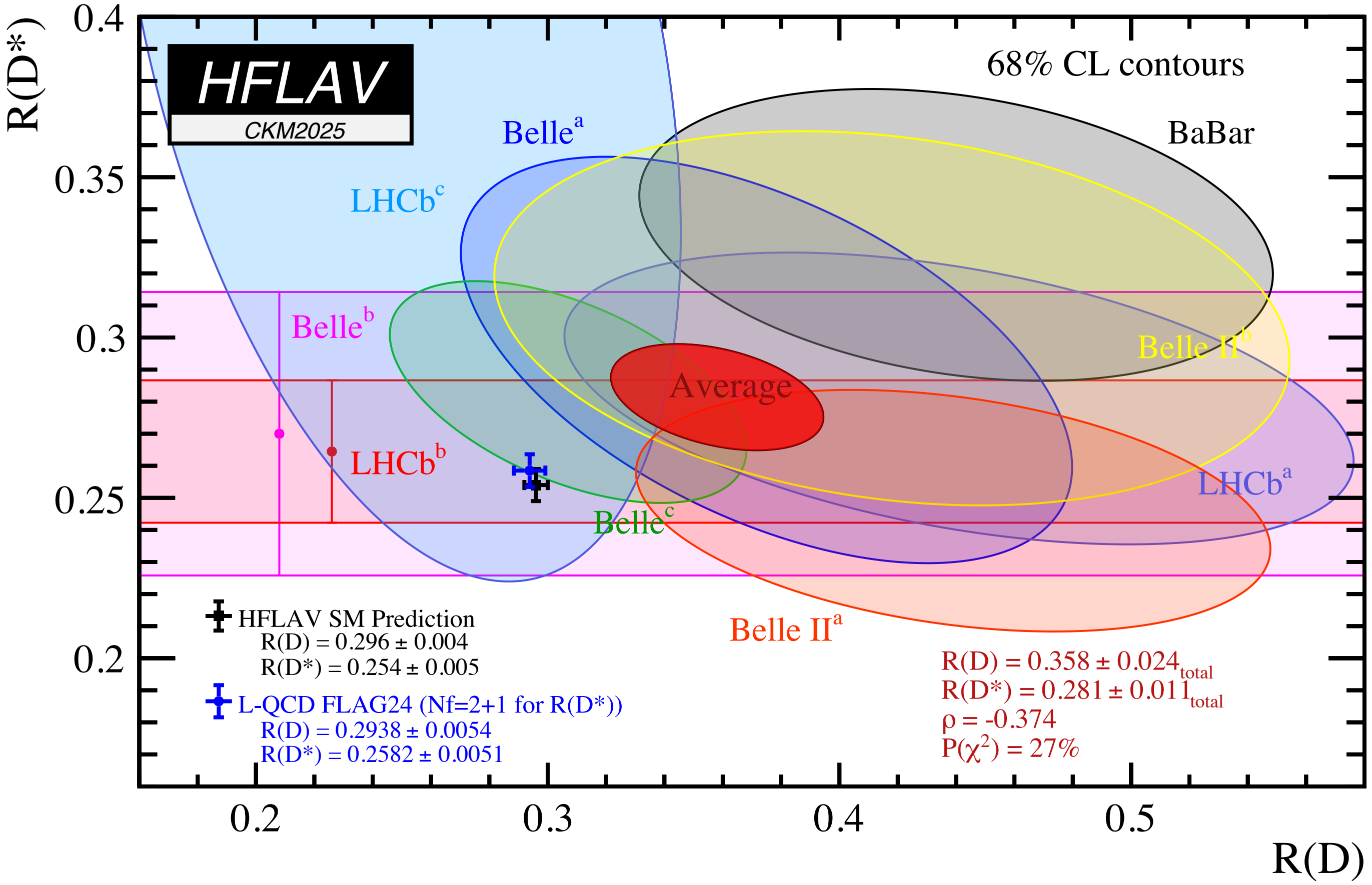
$$V_{CKM}^{tb*}\left(\rho_u^{tt}H^-\overline{b_L}t_R+\rho_u^{tc}H^-\overline{b_L}c_R\right)+V_{CKM}^{ts*}\left(\rho_u^{tt}H^-\overline{s_L}t_R+\rho_u^{tc}H^-\overline{s_L}c_R\right)$$

ΔC_9 ΔC_{10}



2. b to c τ ν

B→D(*)τνの実験結果

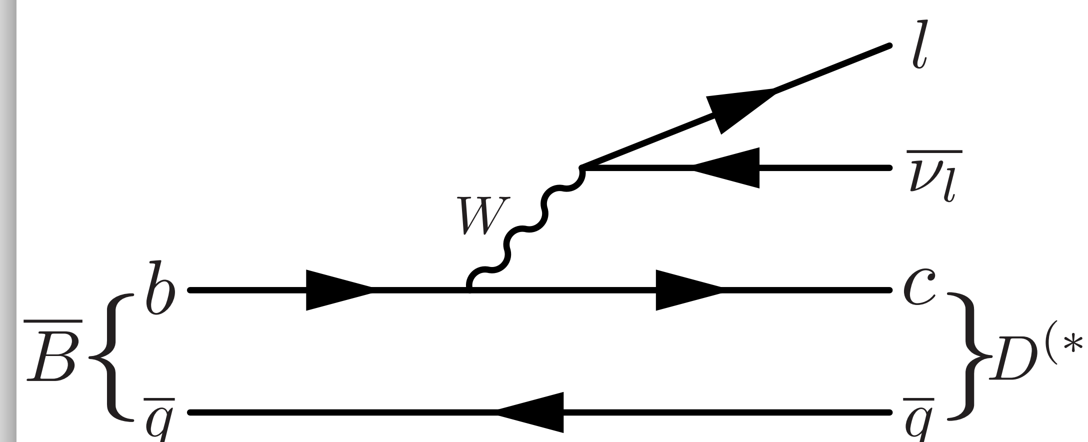


lepton universality of B→D(*)τν

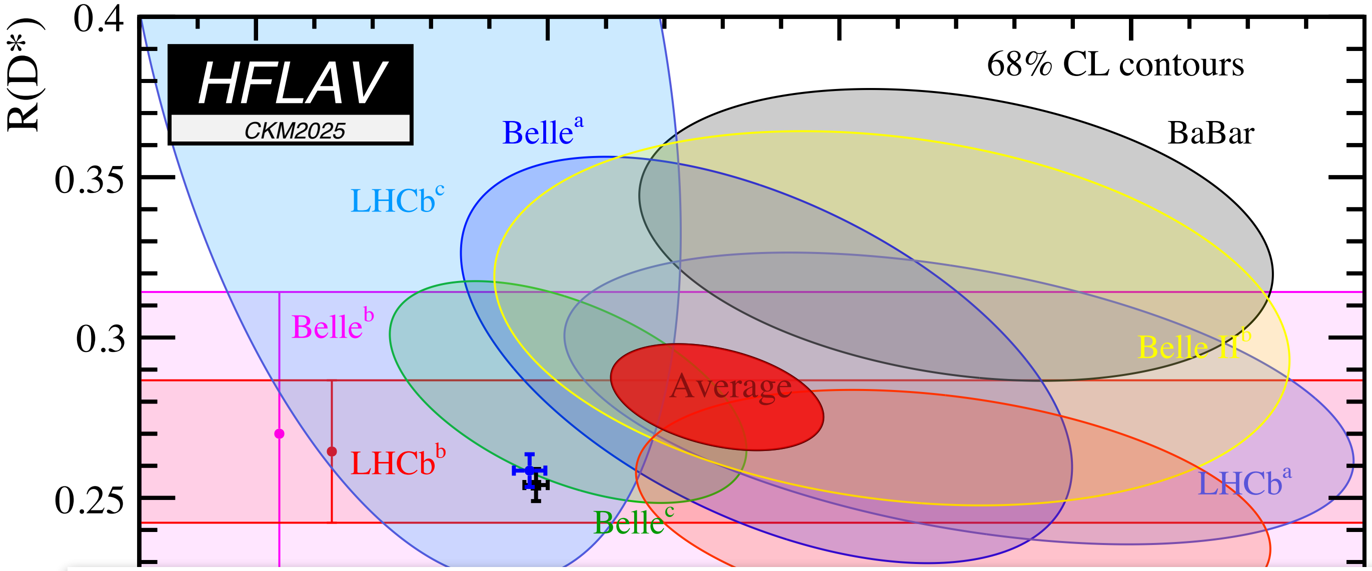
$$R(D^{(*)}) \equiv \frac{\Gamma(B \to D^{(*)}\tau\nu)}{\Gamma(B \to D^{(*)}\ell\nu)}$$

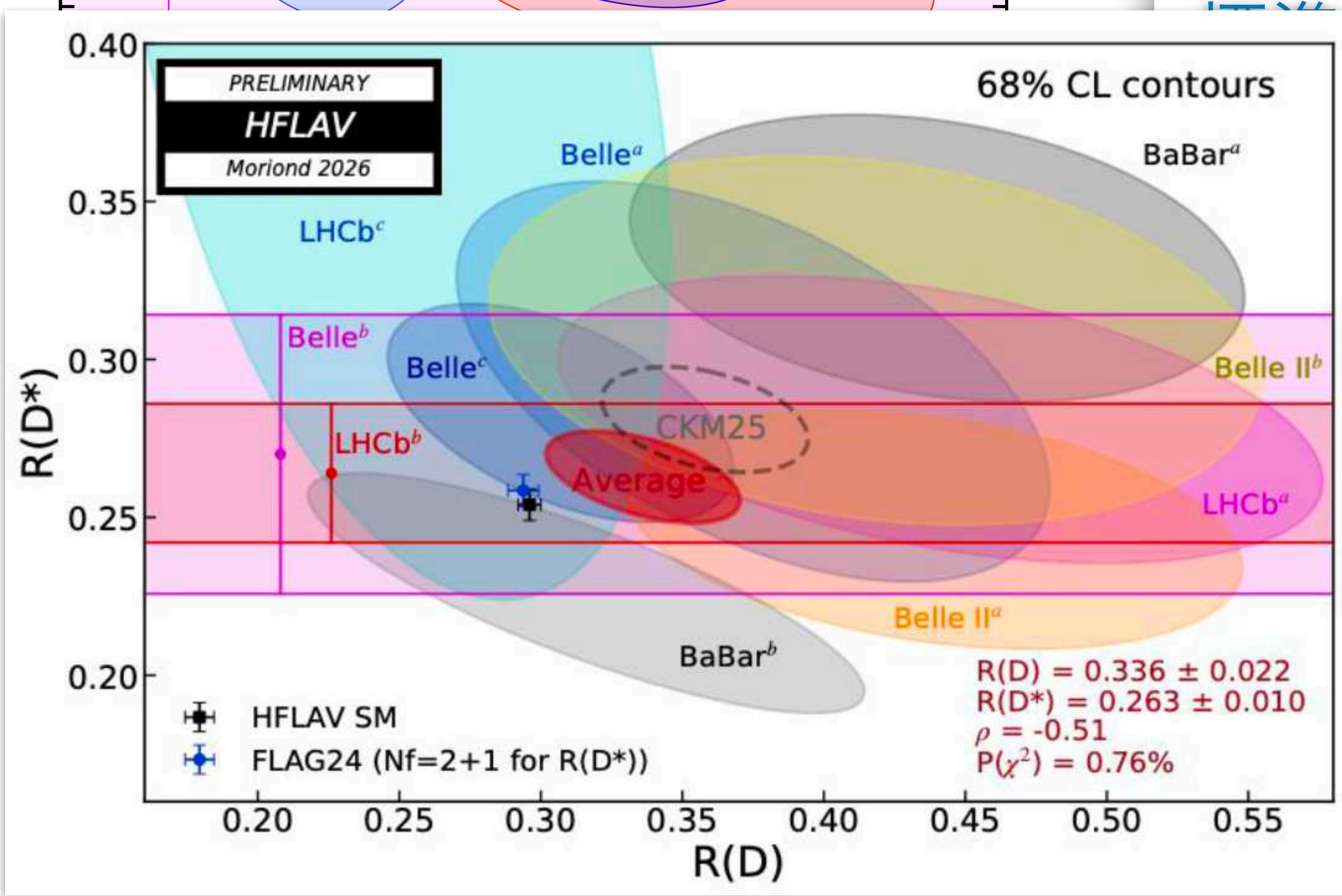
where $\ell = e, \mu$

標準模型の予言



B→D(*)τνの実験結果





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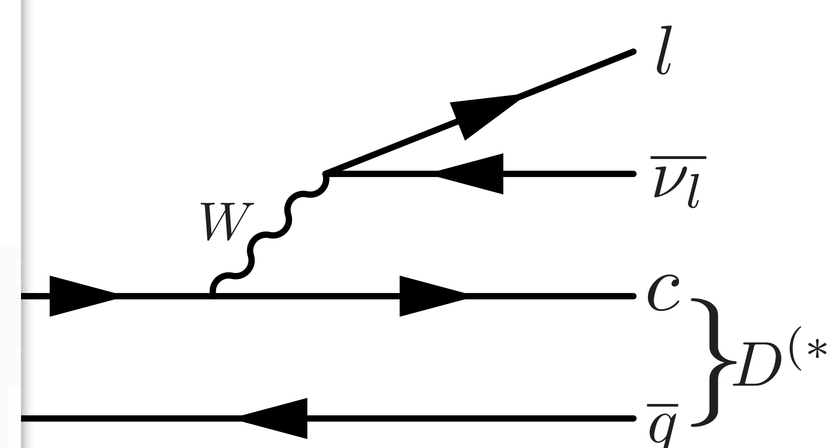
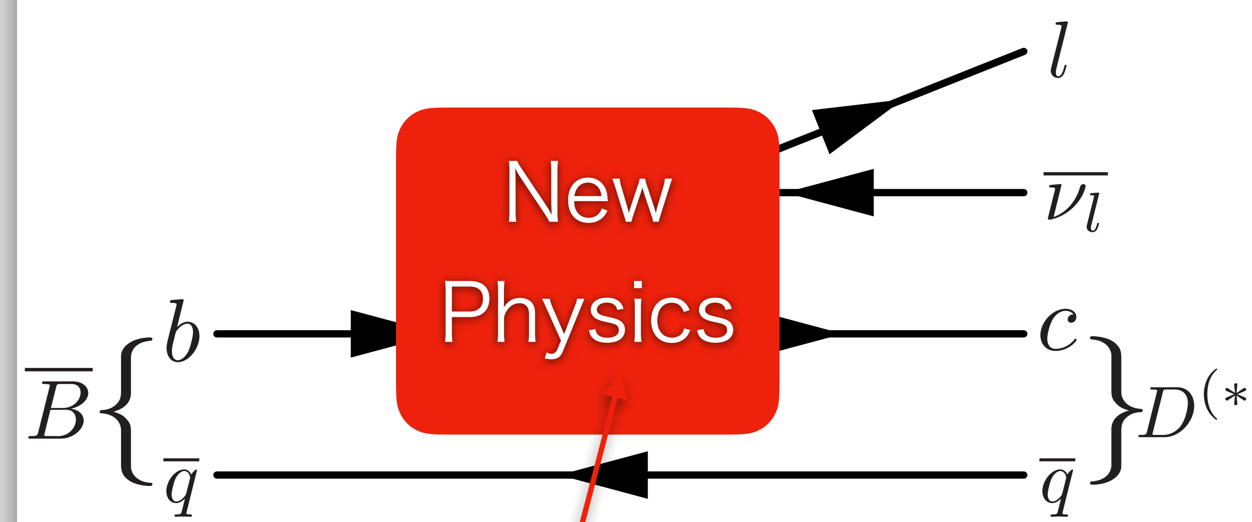


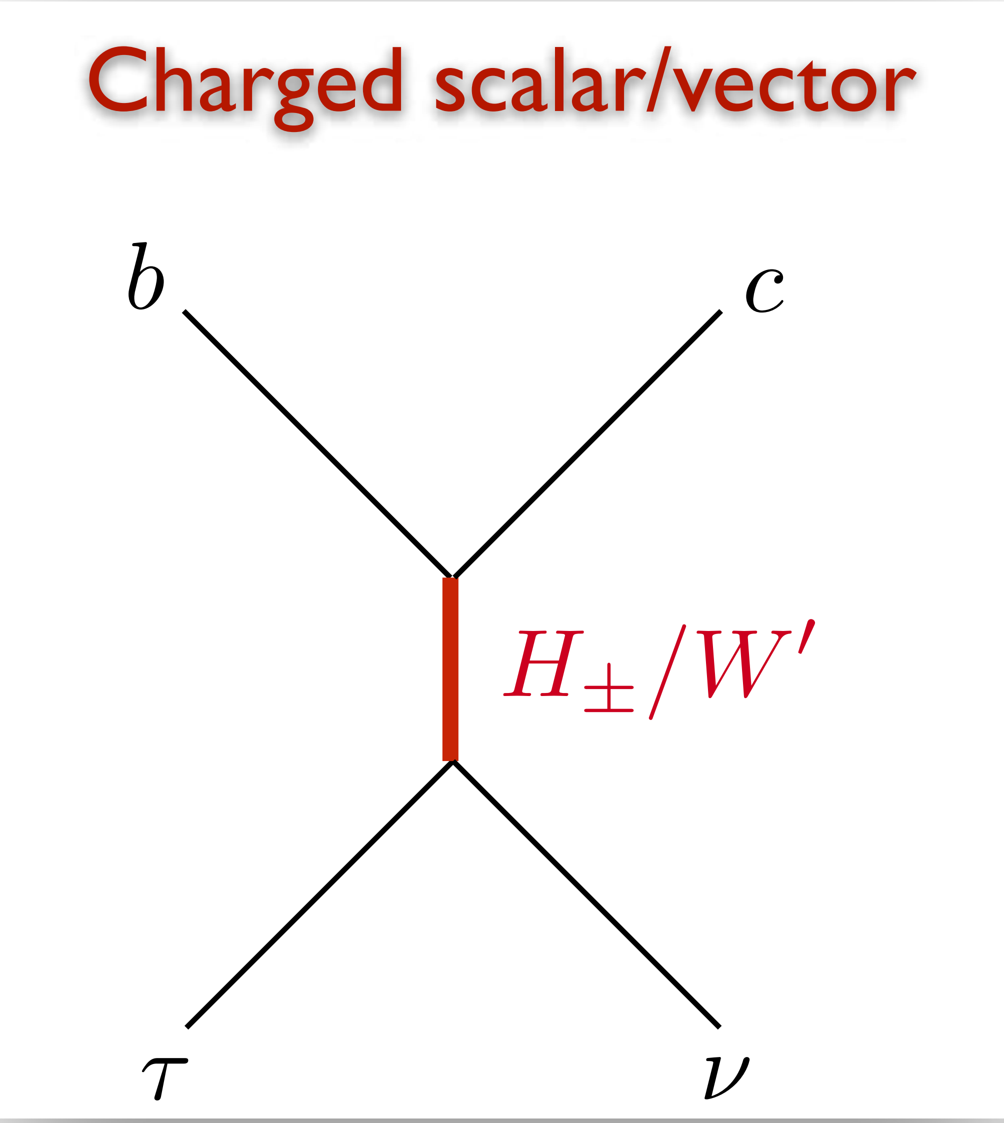
B→D(*)lν (l = e, μ, τ) processes

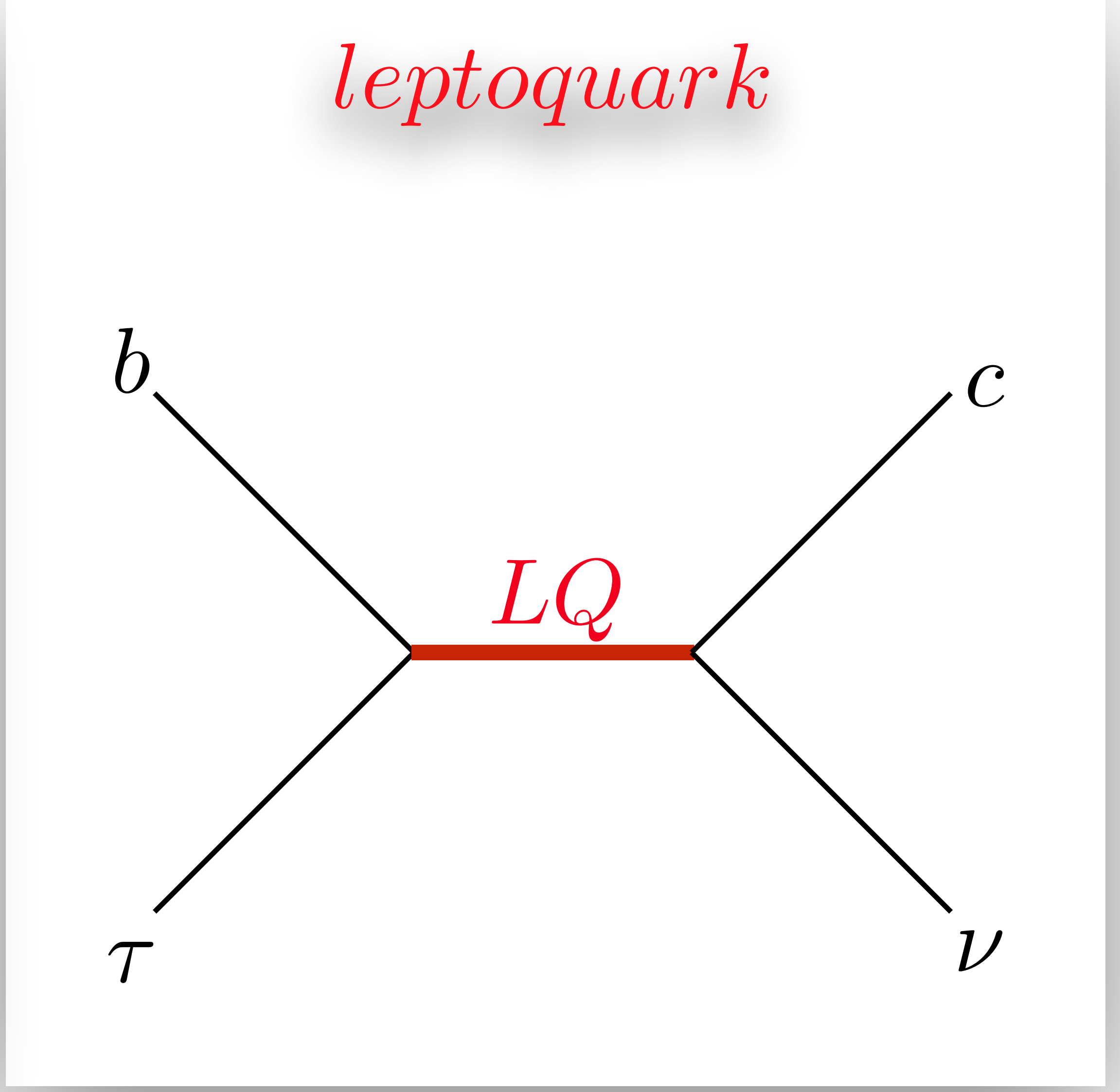


τと b,cに結合する新粒子?

leptoquark W’ charged Higgs etc.

R(D(*)) anomaly は？



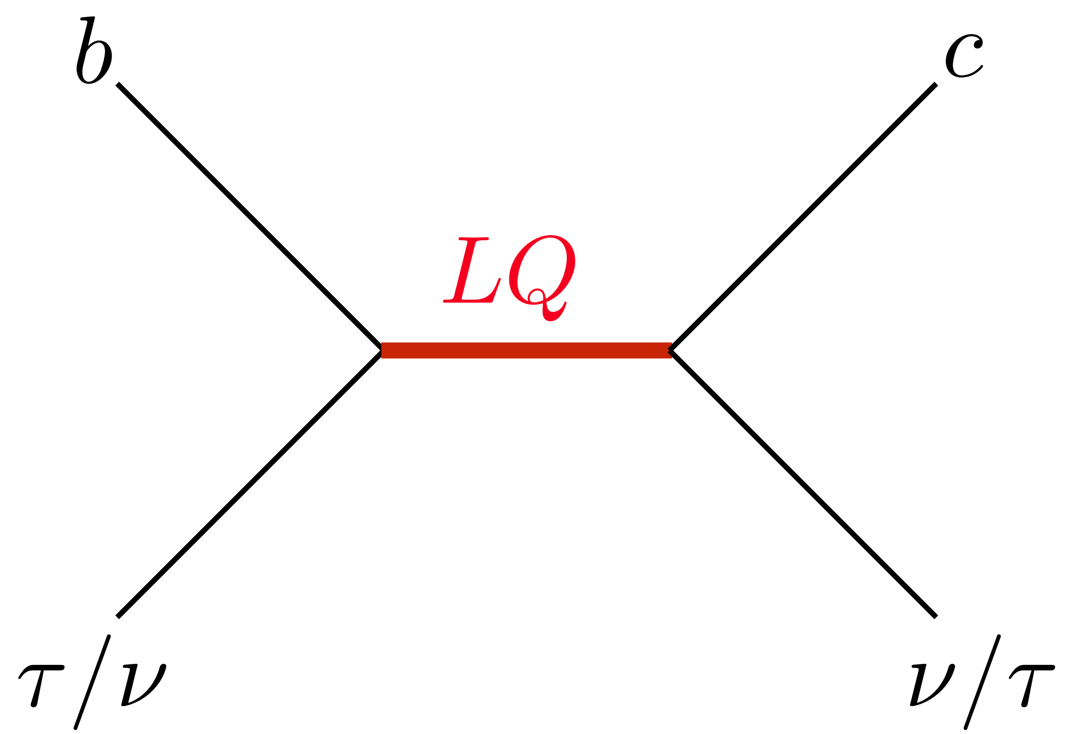


B→D(*) τν anomaly が要求する新物理のスケールは

SM prediction が*tree* なので低い *(TeV scale)*

2-2. New physics interpretations

leptoquark (LQ) シナリオ



Leptoquark, は 例えば Pati-Salam 模型(SU(4)×SU(2)L×SU(2)R)
から予言.

素粒子標準模型: SU(3)×SU(2)L×U(1)Y

非常にキレイに埋め込める

Pati-Salam 模型: SU(4)×SU(2)L×SU(2)R

quark, lepton のunification

$$F_L^i = \begin{pmatrix} L_i \\ Q_L^i \end{pmatrix}$$

$$L^i = \begin{pmatrix} \nu_L^i \\ e_L^i \end{pmatrix}$$

$$Q_L^i = \begin{pmatrix} u_L^i \\ d_L^i \end{pmatrix}$$

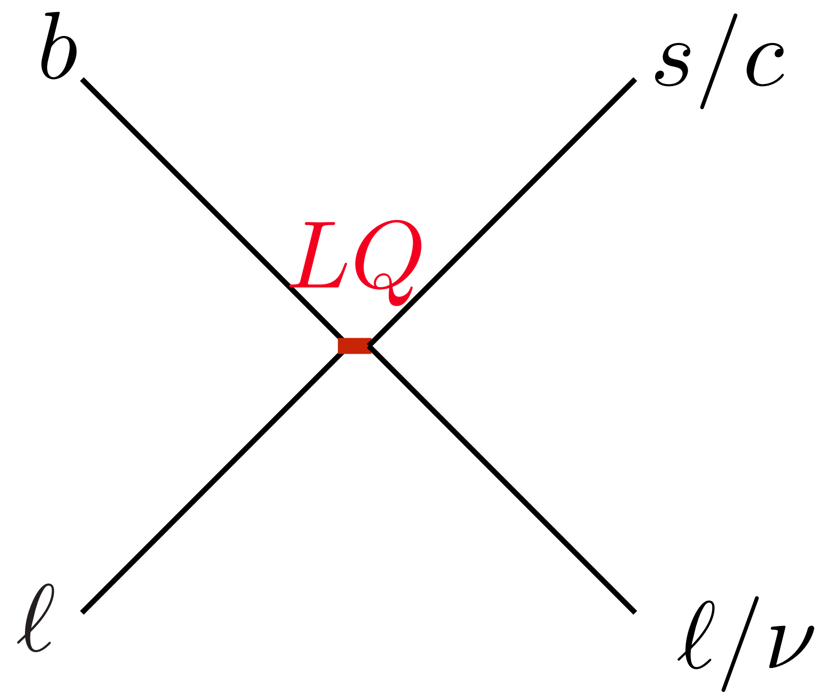
leptoquark はWのように
対称性の自発的破れに伴うmassive gauge boson

$$g_4 \begin{pmatrix} \overline{L_i} & \overline{Q_L^i} \end{pmatrix} \begin{pmatrix} B_\mu & \boxed{U_{1\mu}^\dagger} \\ \boxed{U_{1\mu}} & G_\mu \end{pmatrix} \gamma^\mu \begin{pmatrix} L_i \\ Q_L^i \end{pmatrix} \Rightarrow x_L^{ij} \left(\overline{d_L^i} \gamma^\mu e_L^j + \overline{u_L^i} \gamma^\mu \nu_L^j \right) \boxed{U_{1\mu}}$$

LQ

(L→R の結合もある)

Integrating out LQ で 4-fermi int. が現れる



$b \to s\ell\ \ell$

$$\frac{x_L^{3\ell} x_L^{2\ell}}{m_{U_1}^2} \left(\overline{s_L}\gamma^\mu b_L\right)\left(\overline{\ell_L}\gamma_\mu \ell_L\right)$$

$b \to c\ell\ \nu$

$$\frac{x_L^{3\ell}(V x_L)^{c\ell'}}{m_{U_1}^2} \left(\overline{c_L}\gamma^\mu b_L\right)\left(\overline{\ell_L}\gamma_\mu \nu_L\right)$$

色々なタイプが考えられる

Pati-Salam模型のLQ

LQ classification

(Angelescu, et al., 1808.08179)

LQ	spin	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$	coupling
U_1	1	$\mathbf{3}$	$\mathbf{1}$	$2/3$	$\left(x_L^{ij}\,\overline{Q_L^i}\gamma_\mu L^j + x_R^{ij}\,\overline{d_R^i}\gamma_\mu e_R^j\right) U_1^\mu$
U_3	1	$\mathbf{3}$	$\mathbf{3}$	$2/3$	$x_L^{ij}\,\overline{Q_L^i}\gamma_\mu(\tau_k U_3^{k\mu})L^j$
U_2	1	$\overline{\mathbf{3}}$	$\mathbf{2}$	$5/6$	$x_L^{ij}\,\overline{Q_L^{iC}}\gamma_\mu e_R^j U_2^\mu + x_R^{ij}\,\overline{d_R^{iC}}\gamma_\mu U_2^\mu i\tau_2 L^j$
S_1	0	$\overline{\mathbf{3}}$	$\mathbf{1}$	$1/3$	$\left(y_L^{ij}\,\overline{Q_L^{iC}}i\tau_2 L^j + y_R^{ij}\overline{u_R^{iC}}\,e_R^j\right) S_1$
S_3	0	$\overline{\mathbf{3}}$	$\mathbf{3}$	$1/3$	$y_L^{ij}\,\overline{Q_L^{iC}}i\tau_2(\tau_k S_3^k)L^j$
R_2	0	$\mathbf{3}$	$\mathbf{2}$	$7/6$	$y_R^{ij}\,\overline{Q_L^i}e_R^j R_2 + y_L^{ij}\,\overline{u_R^i}R_2 i\tau_2 L^j$
$\widetilde{R}_2$	0	$\mathbf{3}$	$\mathbf{2}$	$1/6$	$y_L^{ij}\,\overline{d_R^i}\widetilde{R}_2 i\tau_2 L^j$

$$Q_L^i = \begin{pmatrix} u_L^i \\ d_L^i \end{pmatrix} \qquad L^i = \begin{pmatrix} \nu_L^i \\ e_L^i \end{pmatrix}$$

それぞれの特徴

Pati-Salam模型

LQ	proton decay	$b \to c\tau\nu$	$b \to s\ell\ell$
U_1	○	minimal Pati-Salam 模型では LFV, Z' search から制限	$C_9 = -C_{10}$
U_3	○	$B \to K\nu\nu$ から強い制限 (Angelescu, et al., 1808.08179)	$C_9 = -C_{10}$
U_2	×	$B \to K\tau\tau$, $B_s \to \tau\tau$ と相関あり (Iguro, YO, 2306.00052)	$C_9 = C_{10}$
S_1	×		C_9, C_{10} は one-loop
S_3	×	$B \to K\nu\nu$ から強い制限 (Angelescu, et al., 1808.08179)	$C_9 = -C_{10}$
R_2	○		$C_9 = C_{10}$ (tree) $C_9 = -C_{10}$ (one-loop)
$\widetilde{R}_2$	○	no $R(D^{(*)})$ without ν_R	$C'_9 = -C'_{10}$

× ・・・diquark coupling が書ける

○ ・・・ diquark coupling が書けない

ref) 1708.06350

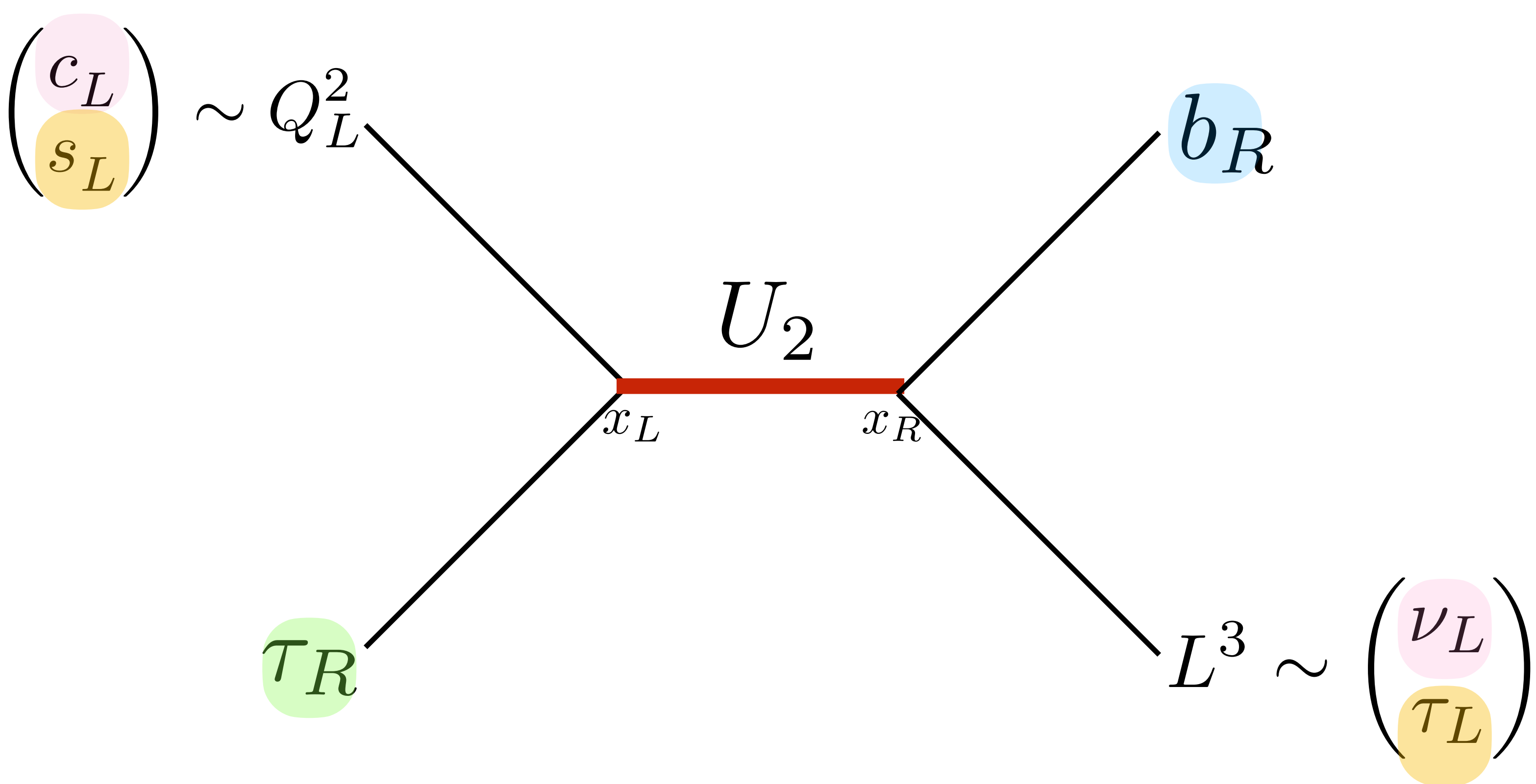
SU(2)L の破れが小さいと, LQ の種類によって

$b \to c\tau\nu \longleftrightarrow b \to s\tau\ell$ or $b \to s\nu\nu$

強い相関

例えば、U2 model (Iguro, YO, 2306.00052)

$$x_L\,\overline{Q_L^{2C}}\gamma_\mu \tau_R U_2^\mu + x_R\,\overline{b_R^C}\gamma_\mu U_2^\mu i\tau_2 L^3$$



$b \to c\tau\nu$

$b \to s\tau\tau$

Minimal Pati-Salam 模型の場合

SU(4)×SU(2)L×SU(2)R

⬇ LQ appears

SU(3)×U(1)B-L×SU(2)L×SU(2)R

⬇ Z' appears

SU(3)×SU(2)L×U(1)Y

・Z' とLQ の質量に関係がつく

$$m_{Z'} < m_{U_1}\sqrt{\frac{2g_R^2 + 3g_4^2}{g_4^2}}$$

(Iguro, Kawamura, Okawa,YO, 2103.11889)

・LQ coupling がunitary 行列になってしまい flavor violating coupling がたくさん出てしまう

unitary 行列 $\boxed{x_L^{ij}}\left(\overline{d_L^i}\gamma^\mu e_L^j + \overline{u_L^i}\gamma^\mu \nu_L^j\right) U_{1\mu}$

それぞれの特徴

Pati-Salam模型

LQ	proton decay	$b \to c\tau\nu$	$b \to s\ell\ell$
U_1	◯	minimal Pati-Salam 模型では LFV, Z' search から制限	$C_9 = -C_{10}$
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U_2	×	$B \to K\tau\tau$, $B_s \to \tau\tau$ と相関あり (Iguro, YO, 2306.00052)	$C_9 = C_{10}$
S_1	×		C_9, C_{10} は one-loop
S_3	×	$B \to K\nu\nu$ から強い制限 (Angelescu, et al., 1808.08179)	$C_9 = -C_{10}$
R_2	◯		$C_9 = C_{10}$ (tree) $C_9 = -C_{10}$ (one-loop)
$\widetilde{R}_2$	◯	no $R(D^{(*)})$ without ν_R	$C'_9 = -C'_{10}$

× ・・・diquark coupling が書ける

◯ ・・・diquark coupling が書けない

ref) 1708.06350

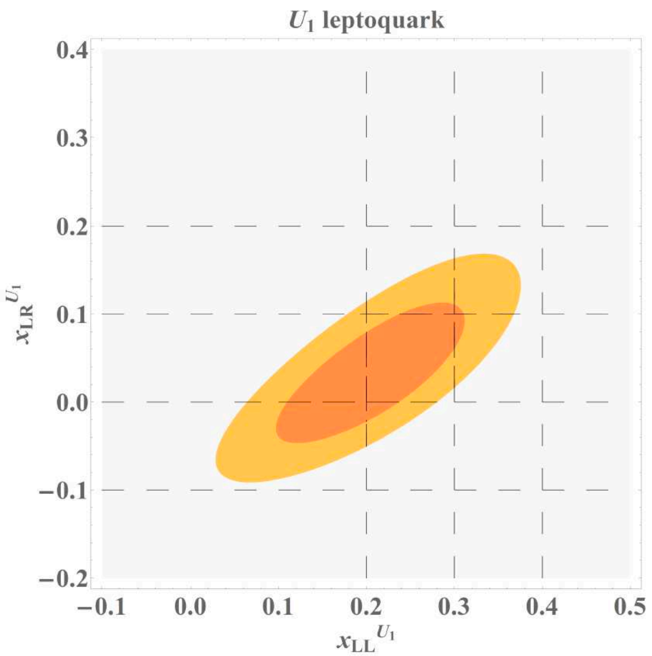
SU(2)L の破れが小さいと, LQ の種類によって

$b \to c\tau\nu$ ⟷ $b \to s\tau\ell$ or $b \to s\nu\nu$

強い相関

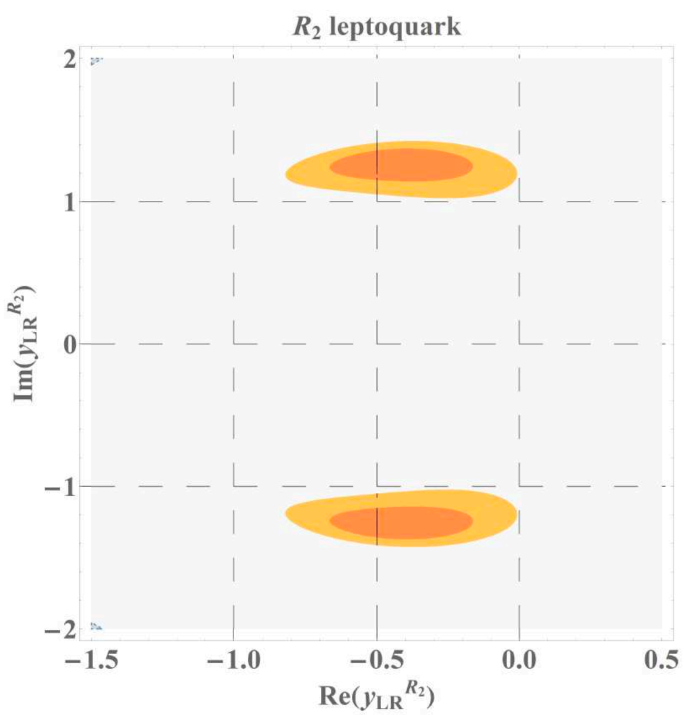
U1, S1, R2 LQ のfit

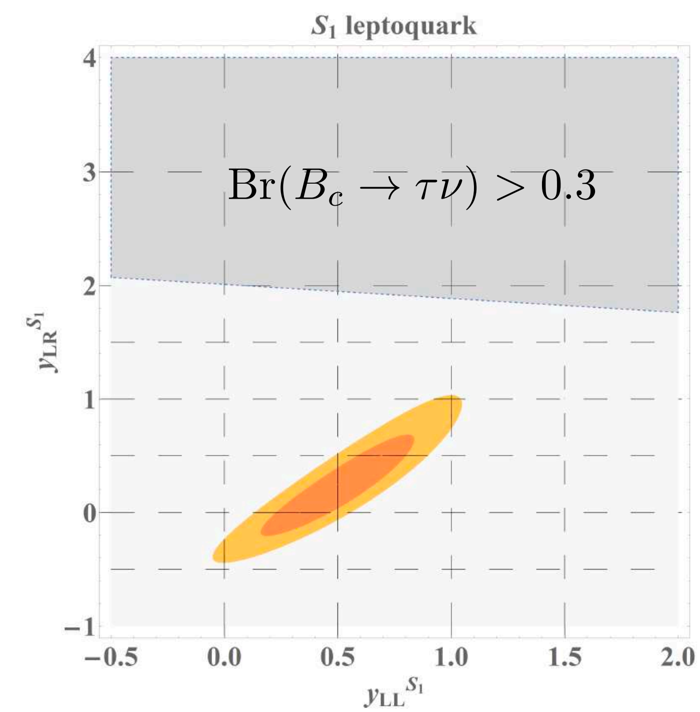
(Huang, et al.,2501.03734)



	R_D	R_{D^*}	Correlation	$P_\tau(D^*)$
BaBar [53, 54]	0.440(58)(42)	0.332(24)(18)	−0.27	–
Belle [55]	0.375(64)(26)	0.293(38)(15)	−0.49	–
Belle [56]	–	0.302(30)(11)	–	–
Belle [57]	–	$0.270(35)(^{+0.028}_{-0.025})$	0.33	$-0.38(51)(^{+0.21}_{-0.16})$
LHCb [58–60]	–	0.257(12)(18)	–	–
Belle [61]	0.307(37)(16)	0.283(18)(14)	−0.54	–
LHCb [62, 63]	0.281(18)(24)	0.441(60)(66)	-0.43	–
Belle II [64]	–	$0.262(^{+0.041}_{-0.039})(^{+0.035}_{-0.032})$	–	–
LHCb [65]	0.249(43)(47)	0.402(81)(85)	−0.39	–

	$R_{J/\psi}$	$F_L^{D^*}$	R_{Λ_c}
LHCb [66]	0.71(17)(18)	–	–
Belle [67, 68]	–	0.60(8)(4)	–
LHCb [69]	–	–	0.242(26)(40)(59)
LHCb [70]	–	0.43(6)(3)	–
CMS [71]	$0.17(^{+0.18}_{-0.17})(^{+0.21}_{-0.22})(^{+0.19}_{-0.18})$	–	–





Best fit values

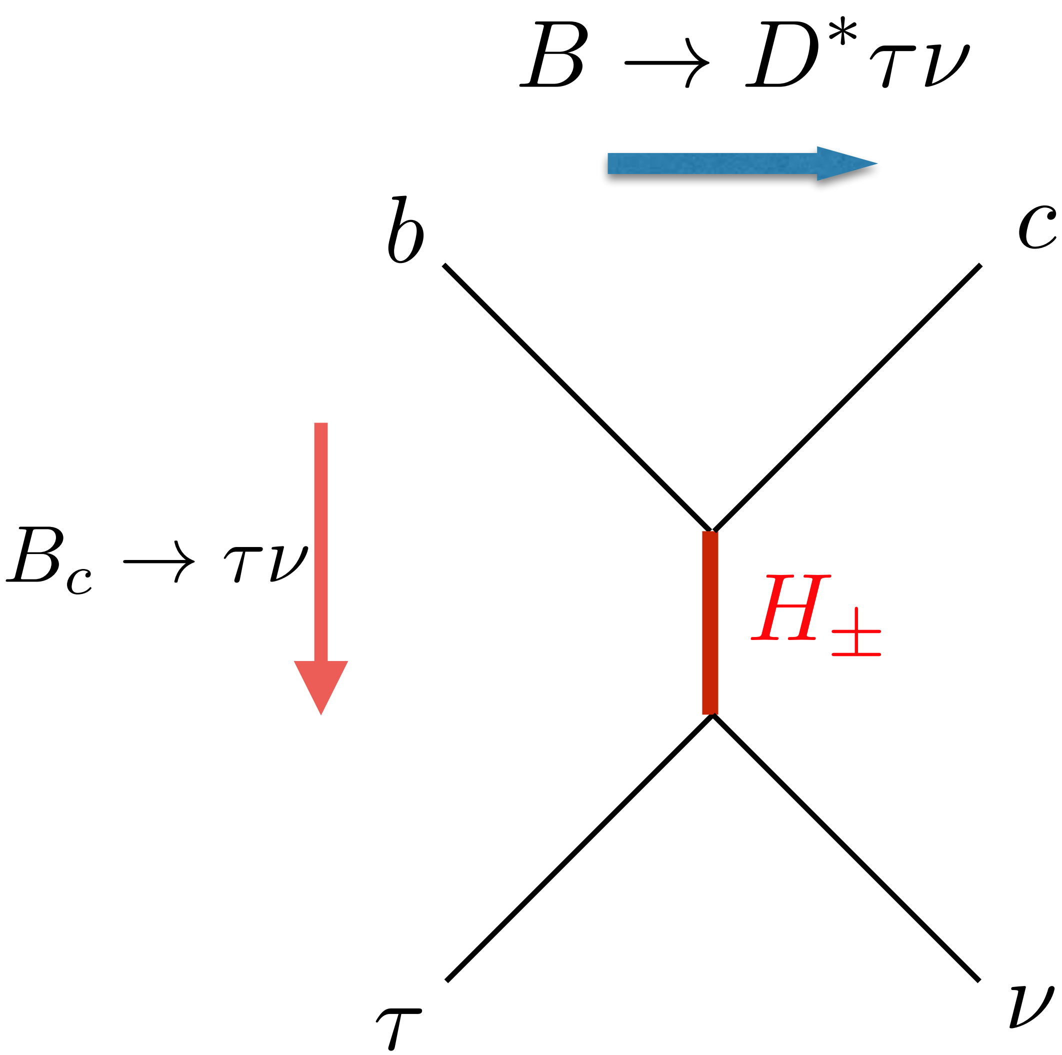
Scenario	R_D	R_{D^*}	$P_\tau(D)$	$P_\tau(D^*)$	$F_L^{D^*}$	$\mathcal{A}_D^{FB}$	$\mathcal{A}_{D^*}^{FB}$
SM	0.300(3)(0)	0.251(1)(0)	0.325(3)(0)	−0.507(3)(0)	0.453(3)(0)	0.360(0)(0)	−0.052(4)(0)
S_1	0.314(5)(21)	0.299(10)(13)	0.131(7)(122)	−0.464(7)(19)	0.485(4)(10)	0.377(1)(9)	−0.063(5)(4)
R_2	0.235(4)(38)	0.284(11)(19)	0.222(3)(10)	−0.410(7)(21)	0.470(6)(2)	0.325(3)(9)	0.011(8)(19)
U_1	0.318(5)(20)	0.296(10)(13)	0.255(4)(73)	−0.509(4)(12)	0.461(4)(4)	0.368(1)(4)	−0.067(6)(7)

Charged Higgs シナリオ

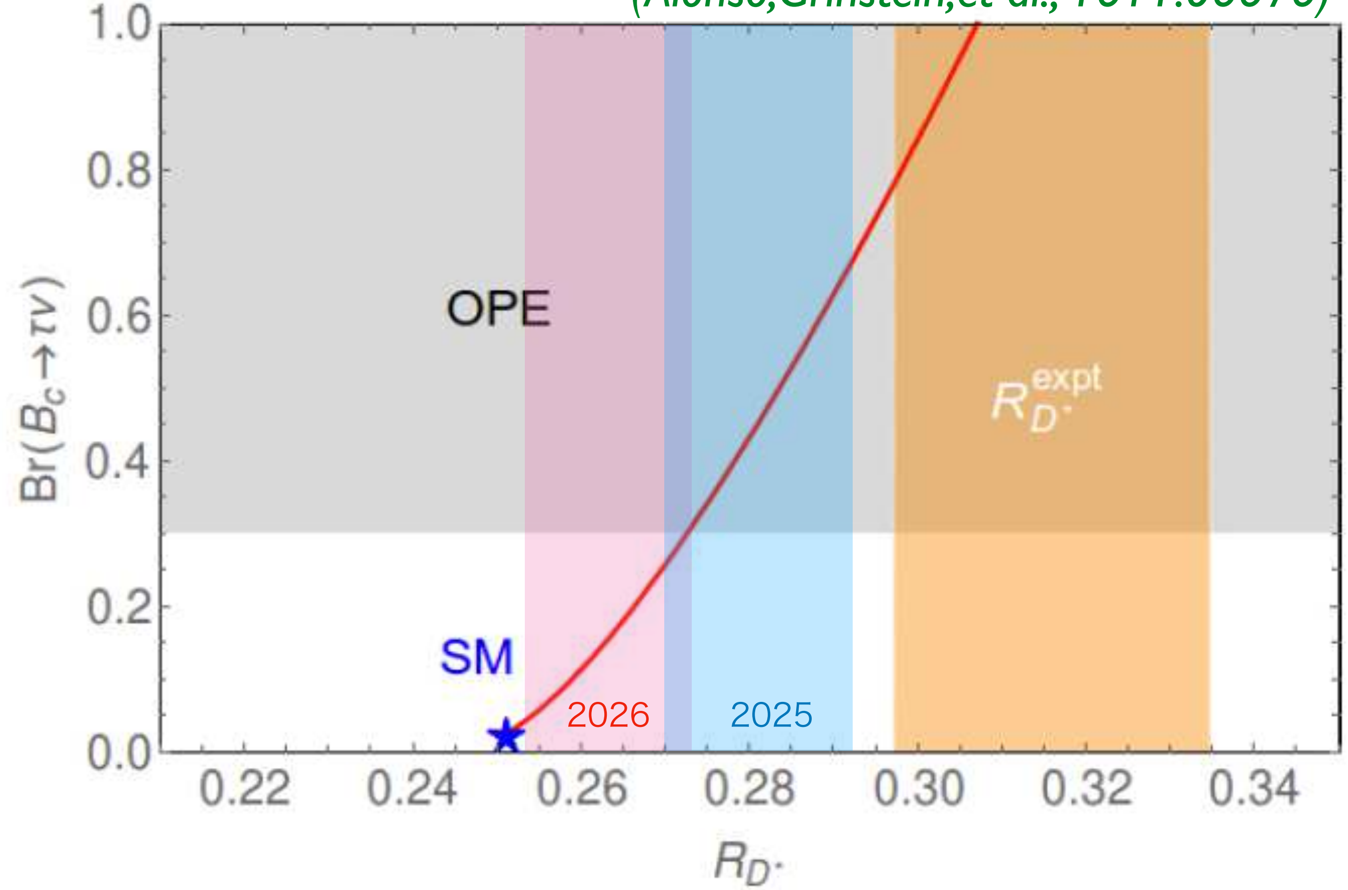
Bc decay が charged Higgs シナリオを制限

(Alonso,Grinstein,et al., 1611.06676;Akeroyd,Chen,1708.04072; Blanke,Crivellin,Kitahara, et al., 1905.08253)

but revival (?)



(Alonso,Grinstein,et al., 1611.06676)



Summary

- b→sll のズレを新物理で説明には

$$C_9\,(\overline{s_L}\gamma_\mu b_L)\,(\overline{\mu}\gamma^\mu\mu)$$

が必要. Bs →μμ, RK がSM consistent なので

小さい C10, flavor universal (特に eと μ に関して)が好まれる.

➡ kinetic mixing があるZ'やペンギンダイアグラムで可能

- b→cτν のズレを新物理で説明には

TeV-scale のb, c, τ, νと結合するnew particle が必要.

➡ LQ を紹介した. LQの種類によって b→sτl, b→sννと強い相関.

charged Higgs はBc 崩壊から強い制限を受けたが今は可能.

END