Constraints on the B-anomalies-motivated U1 leptoquark parameters from the LHC data.

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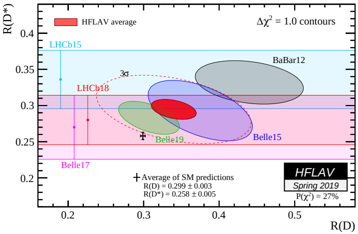
Flavour anomalies

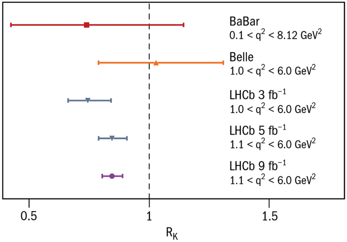
- Lepton Flavour Universality (LFU) $\implies$ flavour independent couplings to gauge bosons is one of the key predictions of SM.
- Recently, experiments such as BaBar, Belle, LHCb have observed a violation of this universality.
- Discrepancies between the theoretical and experimental values of the flavour observables.
- These "anomalies" are one of the keys for discovering new physics.

B Anomalies

– Prominent B anomalies are as follows,

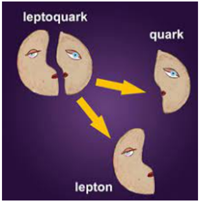
$$R_{D^{(*)}} = \frac{\mathscr{B}(B \to D^{(*)}\tau\bar{\nu})}{\mathscr{B}(B \to D^{(*)}\hat{\ell}\bar{\nu})} \quad \text{and} \quad R_{K^{(*)}} = \frac{\mathscr{B}(B \to K^{(*)}\mu^+\mu^-)}{\mathscr{B}(B \to K^{(*)}e^+e^-)}$$





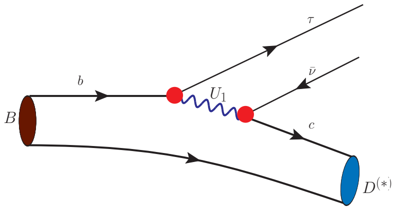
Leptoquarks to the rescue

- LQs are color triplet, weakly (singlet,doublet or triplet) and electrically charged scalar or vector bosons.
- They can be found in Pati-Salam models, RPV SUSY models, colored Zee-Babu models, SU(5) GUTs etc.
- A U_1 vector LQ with charge 2/3, a proposed model to explain both the B-anomalies simultaneously.



$(SU(3), SU(2), U(1))$	Spin	Symbol	Type	F
$(\bar{\mathbf{3}}, \mathbf{3}, 1/3)$	0	S_3	$LL\,(S_1^L)$	-2
$(\mathbf{3}, \mathbf{2}, 7/6)$	0	R_2	$RL\,(S_{1/2}^L),\ LR\,(S_{1/2}^R)$	0
$(\mathbf{3}, \mathbf{2}, 1/6)$	0	$\tilde{R}_2$	$RL\,(\tilde{S}_{1/2}^L),\ \overline{LR}\,(\tilde{S}_{1/2}^L)$	0
$(\bar{\mathbf{3}}, \mathbf{1}, 4/3)$	0	$\tilde{S}_1$	$RR\,(\tilde{S}_0^R)$	-2
$(\bar{\mathbf{3}}, \mathbf{1}, 1/3)$	0	S_1	$LL\,(S_0^L),\ RR\,(S_0^R),\ \overline{RR}\,(S_0^R)$	-2
$(\bar{\mathbf{3}}, \mathbf{1}, -2/3)$	0	$\bar{S}_1$	$\overline{RR}\,(\bar{S}_0^R)$	-2
$(\mathbf{3}, \mathbf{3}, 2/3)$	1	U_3	$LL\,(V_1^L)$	0
$(\bar{\mathbf{3}}, \mathbf{2}, 5/6)$	1	V_2	$RL\,(V_{1/2}^L),\ LR\,(V_{1/2}^R)$	-2
$(\bar{\mathbf{3}}, \mathbf{2}, -1/6)$	1	$\tilde{V}_2$	$RL\,(\tilde{V}_{1/2}^L),\ \overline{LR}\,(\tilde{V}_{1/2}^R)$	-2
$(\mathbf{3}, \mathbf{1}, 5/3)$	1	$\tilde{U}_1$	$RR\,(\tilde{V}_0^R)$	0
$(\mathbf{3}, \mathbf{1}, 2/3)$	1	U_1	$LL\,(V_0^L),\ RR\,(V_0^R),\ \overline{RR}\,(V_0^{\overline{R}})$	0
$(\mathbf{3}, \mathbf{1}, -1/3)$	1	$\bar{U}_1$	$\overline{RR}\,(\bar{V}_0^R)$	0

LQs to explain $R_{D^{(*)}}$ and $R_{K^{(*)}}$



- $R_{D^{(*)}}$ contributions: U_1-c-$\bar{\nu}$ ($\lambda_{c\nu}$) coupling and a U_1-b-τ ($\lambda_{c\nu}$) coupling.
- $R_{K^{(*)}}$ contributions: U_1-b-μ^- ($\lambda_{b\mu}$) coupling and U_1-s-μ^+ ($\lambda_{s\mu}$) coupling.

U_1 Lagrangian

- The U_1 Lagrangian is given as:

$$\mathscr{L} \supset x_{1\,ij}^{LL}\, \bar{Q}^i \gamma_\mu U_1^\mu P_L L^j + x_{1\,ij}^{RR}\, \bar{d}_R^i \gamma_\mu U_1^\mu P_R \ell_R^j + \text{H.c.},$$

- $\bar{Q}^i$ $(\bar{d}_R^i)$: Quark doublet(singlet).
  L^j (ℓ_R^j) : Lepton doublet(singlet).
- $x_{1\,ij}^{LL(RR)}$: 3×3 matrices in flavour space.

$$x_1^{LL} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & \lambda_{22}^L & \lambda_{23}^L \\ 0 & \lambda_{32}^L & \lambda_{33}^L \end{pmatrix} \quad x_1^{RR} = \begin{pmatrix} 0 & 0 & 0 \\ 0 & \lambda_{22}^R & 0 \\ 0 & \lambda_{32}^R & \lambda_{33}^R \end{pmatrix}$$

- $\lambda_{ij}^{L(R)}$: Real couplings, which contribute to $R_{D^{(*)}}$ and $R_{K^{(*)}}$ anomalies.

$R_{D^{(*)}}$ anomalies

– Generalized Lagrangian contributing to $b \to c\tau\bar{\nu}$ transitions is given as,

$$\mathscr{L} \supset -\frac{4G_F}{\sqrt{2}} V_{cb} \left[\left(1 + \mathscr{C}_{V_L}\right) \mathscr{O}_{V_L} + \mathscr{C}_{S_L} \mathscr{O}_{S_L} \right]$$

where,

$$\mathscr{C}_{V_L}^{U_1} = \frac{1}{2\sqrt{2} G_F V_{cb}} \frac{\lambda^L_{c\nu} \left(\lambda^L_{b\tau}\right)^*}{M^2_{U_1}}; \quad \mathscr{O}_{V_L} = [\bar{c}\gamma^\mu P_L b] \left[\bar{\tau}\gamma_\mu P_L \nu\right]$$

$$\mathscr{C}_{S_L}^{U_1} = -\frac{1}{2\sqrt{2} G_F V_{cb}} \frac{2\lambda^L_{c\nu} \left(\lambda^R_{b\tau}\right)^*}{M^2_{U_1}}; \quad \mathscr{O}_{S_L} = [\bar{c} P_L b] [\bar{\tau} P_L \nu]$$

$R_{D^{(*)}}$ anomalies

- The U_1 interaction Lagrangian is modified as follows,

$$\mathscr{L} \supset \lambda^L_{23}[\bar{c}_L\gamma_\mu\nu_L + \bar{s}_L\gamma_\mu\tau_L)]U_1^\mu$$
$$= \lambda^L_{23}[\bar{c}_L\gamma_\mu\nu_L + (V^*_{cd}\bar{d}_L + V^*_{cs}\bar{s}_L + V^*_{cb}\bar{b}_L)\gamma_\mu\tau_L)]U_1^\mu$$

which leads to, $\mathscr{C}^{U_1}_{V_L} = \frac{1}{2\sqrt{2}G_F}\frac{(\lambda^L_{23})^2}{M^2_{U_1}}, \mathscr{C}_{S_L} = 0. \equiv$ RD1A

$R_{D^{(*)}}$ scenarios	$\lambda^L_{c\nu}$	$\lambda^L_{b\tau}$	$\lambda^R_{b\tau}$
RD1A	λ^L_{23}	$V^*_{cb}\lambda^L_{23}$	–
RD1B	$V_{cb}\lambda^L_{33}$	λ^L_{33}	–
RD2A	$V_{cs}\lambda^L_{23} + V_{cb}\lambda^L_{33}$	λ^L_{33}	–
RD2B	$V_{cs}\lambda^L_{23}$	–	λ^R_{33}

$R_{K^{(*)}}$ anomalies

– In the case of $b \to s\mu^+\mu^-$ transitions,

$$\mathscr{L} \supset \frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \sum_{i=9,10,S,P} (\mathscr{C}_i \mathscr{O}_i + \mathscr{C}_i' \mathscr{O}_i')$$

where,

$$\mathscr{C}_9^{U_1} = -\mathscr{C}_{10}^{U_1} = \frac{\pi}{\sqrt{2} G_F V_{tb} V_{ts}^*} \frac{\lambda_{s\mu}^L (\lambda_{b\mu}^L)^*}{M_{U_1}^2}; \qquad \mathscr{C}_9'^{\,U_1} = \mathscr{C}_{10}'^{\,U_1} = \frac{\pi}{\sqrt{2} G_F V_{tb} V_{ts}^*} \frac{\lambda_{s\mu}^R (\lambda_{b\mu}^{R*})}{M_{U_1}^2}$$

$$\mathscr{C}_S^{U_1} = -\mathscr{C}_P^{U_1} = \frac{\sqrt{2}\pi}{G_F V_{tb} V_{ts}^*} \frac{\lambda_{s\mu}^L (\lambda_{b\mu}^R)^*}{M_{U_1}^2}; \qquad \mathscr{C}_S'^{\,U_1} = \mathscr{C}_P'^{\,U_1} = \frac{\sqrt{2}\pi}{G_F V_{tb} V_{ts}^*} \frac{\lambda_{s\mu}^R (\lambda_{b\mu}^{L*})}{M_{U_1}^2}$$

$R_{K^{(*)}}$ anomalies

– To explain the $R_{K^{(*)}}$ anomalies, the Lagrangian is modified as,

$$\mathscr{L} \supset \lambda_{22}^{L}[\bar{c}_L\gamma_\mu \nu_L + (V_{cd}^{*}\bar{d}_L + V_{cs}^{*}\bar{s}_L + V_{cb}^{*}\bar{b}_L)\gamma_\mu \mu_L)]U_1^{\mu}.$$

Leading to, $\mathscr{C}_9^{RK1A} = -\mathscr{C}_{10}^{RK1A} = \frac{\pi V_{cb} V_{cs}^{*}}{\sqrt{2} G_F V_{tb} V_{ts}^{*} \alpha} \frac{(\lambda_{22}^{L})^2}{M_{U_1}^2}. \equiv$ RK1A

$R_{K^{(*)}}$ scenarios	$\lambda_{s\mu}^{L}$	$\lambda_{b\mu}^{L}$	$\lambda_{s\mu}^{R}$	$\lambda_{b\mu}^{R}$
RK1A	$V_{cs}^{*}\lambda_{22}^{L}$	$V_{cb}^{*}\lambda_{22}^{L}$	–	–
RK1B	$V_{ts}^{*}\lambda_{32}^{L}$	$V_{tb}^{*}\lambda_{32}^{L}$	–	–
RK1C	–	–	$V_{cs}\lambda_{22}^{R}$	$V_{cb}\lambda_{22}^{R}$
RK1D	–	–	$V_{ts}\lambda_{32}^{R}$	$V_{tb}\lambda_{32}^{R}$
RK2A	λ_{22}^{L}	λ_{32}^{L}	–	–
RK2B	λ_{22}^{L}	–	–	λ_{32}^{R}
RK2C	–	λ_{32}^{L}	λ_{22}^{R}	–
RK2D	–	–	λ_{22}^{R}	λ_{32}^{R}

U_1 LQ Resonant Production modes

- Pair Production
  - RD1A: ($\lambda^L_{23} = 1$)

$$pp \to \left\{ \begin{array}{l} U_1 U_1 \to s\tau\, s\tau \equiv \tau\tau + 2j \\ U_1 U_1 \to s\tau\, c\nu \equiv \tau + \not{E}_T + 2j \\ U_1 U_1 \to c\nu\, c\nu \equiv \not{E}_T + 2j \end{array} \right\}$$

  - RD1B: ($\lambda^L_{33} = 1$)

$$pp \to \left\{ \begin{array}{l} U_1 U_1 \to b\tau\, b\tau \equiv \tau\tau + 2j \\ U_1 U_1 \to b\tau\, t\nu \equiv \tau + \not{E}_T + j_t + j \\ U_1 U_1 \to t\nu\, t\nu \equiv \not{E}_T + 2j_t \end{array} \right\}$$

U_1 LQ Resonant Production modes

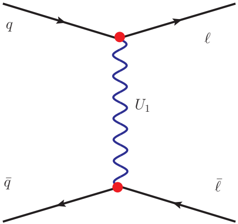
- Single Production
  - RD1A: ($\lambda^L_{23} = 1$)

$$pp \to \left\{ \begin{array}{l} U_1\tau + U_1\tau j \ \to \ (s\tau)\tau + (s\tau)\tau j \ \equiv \ \tau\tau + nj \\ U_1\nu + U_1\nu j \ \to \ (c\nu)\nu + (c\nu)\nu j \ \equiv \ \not{E}_T + nj \\ U_1\tau + U_1\tau j \ \to \ (c\nu)\tau + (c\nu)\tau j \ \equiv \ \tau + \not{E}_T + nj \\ U_1\nu + U_1\nu j \ \to \ (s\tau)\nu + (s\tau)\nu j \ \equiv \ \tau + \not{E}_T + nj \end{array} \right\}.$$

  - RD1B: ($\lambda^L_{33} = 1$)

$$pp \to \left\{ \begin{array}{l} U_1\tau + U_1\tau j \ \to \ (b\tau)\tau + (b\tau)\tau j \ \equiv \ \tau\tau + n\,j \\ U_1\tau + U_1\tau j \ \to \ (t\nu)\tau + (t\nu)\tau j \ \equiv \ \tau + \not{E}_T + j_t + n\,j \\ U_1\nu + U_1\nu j \ \to \ (b\tau)\nu + (b\tau)\nu j \ \equiv \ \tau + \not{E}_T + n\,j \\ U_1\nu + U_1\nu j \ \to \ (t\nu)\nu + (t\nu)\nu j \ \equiv \ \not{E}_T + j_t + n\,j \end{array} \right\}.$$

U_1 LQ Non-Resonant Production modes



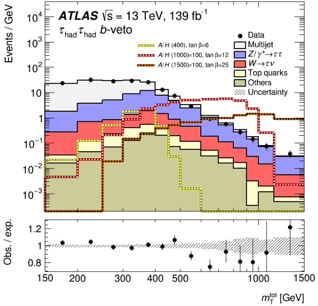
- Cross section of t-channel pure BSM grows as λ^4.
- Important for large values of the new couplings (λ).
- For large mass regions of U_1, the non-resonant production contributes more than the resonant pair and single productions.
- Non-resonant production interferes with SM backgrounds process of $pp \to \gamma/Z(W) \to \ell^+\ell^-$.
- Interference contribution grows as λ^2. For U_1, the interference is destructive in nature.

Effect of Branching Ratios on final states.

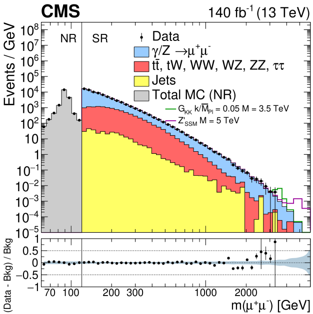
Nonzero couplings	Signatures					
	$\tau\tau+2j$	$\tau+\not{E}_T+2j$	$\not{E}_T+2j$	$\tau+\not{E}_T+j_t+j$	$\not{E}_T+2j_t$	$\not{E}_T+j_t+j$
λ^L_{23} (Scenario RD1A)	0.25	0.50	0.25	–	–	–
λ^L_{33} (Scenario RD1B)	0.25	–	–	0.50	0.25	–
λ^R_{33}	1.00	–	–	–	–	–
$\lambda^L_{23},\lambda^L_{33}$ (Scenario RD2A)	0.25	ξ	ξ^2	$\frac{1}{2}-\xi$	$\left(\frac{1}{2}-\xi\right)^2$	$2\xi\left(\frac{1}{2}-\xi\right)$
$\lambda^L_{23},\lambda^R_{33}$ (Scenario RD2B)	$\left(\frac{1}{2}+\xi\right)^2$	$2\left(\frac{1}{4}-\xi^2\right)$	$\left(\frac{1}{2}-\xi\right)^2$	–	–	–
	$\mu\mu+2j$	$\mu+\not{E}_T+2j$	$\not{E}_T+2j$	$\mu+\not{E}_T+j_t+j$	$\not{E}_T+2j_t$	$\not{E}_T+j_t+j$
λ^L_{22} (Scenario RK1A)	0.25	0.50	0.25	–	–	–
λ^L_{32} (Scenario RK1B)	0.25	–	–	0.50	0.25	–
λ^R_{22} (Scenario RK1C)	1.00	–	–	–	–	–
λ^R_{32} (Scenario RK1D)	1.00	–	–	–	–	–
$\lambda^L_{22},\lambda^L_{32}$ (Scenario RK2A)	0.25	ξ	ξ^2	$\frac{1}{2}-\xi$	$\left(\frac{1}{2}-\xi\right)^2$	$2\xi\left(\frac{1}{2}-\xi\right)$
$\lambda^L_{22},\lambda^R_{32}$ (Scenario RK2B)	$\left(\frac{1}{2}+\xi\right)^2$	$2\left(\frac{1}{4}-\xi^2\right)$	$\left(\frac{1}{2}-\xi\right)^2$	–	–	–
$\lambda^R_{22},\lambda^L_{32}$ (Scenario RK2C)	$\left(\frac{1}{2}+\xi\right)^2$	–	–	$2\left(\frac{1}{4}-\xi^2\right)$	$\left(\frac{1}{2}-\xi\right)^2$	–
$\lambda^R_{22},\lambda^R_{32}$ (Scenario RK2D)	1.00	–	–	–	–	–

Relevant searches at the LHC

– ATLAS $\tau\tau$ search 139 fb^{-1}



– CMS $\mu\mu$ search 140 fb^{-1}



– All the production modes considered above lead to dilepton final states.

– The destructive interference between the BSM and SM contributions lead to decrease in the number of events.

Cross-section Parametrization: Pair Production

Total cross section:

$$\sigma^{p}\left(M_{U_1},\lambda\right)=\sigma^{p_0}\left(M_{U_1}\right)+\sum_{i}^{n}\lambda_i^2\sigma_i^{p_2}\left(M_{U_1}\right)+\sum_{i\geq j}^{n}\lambda_i^2\lambda_j^2\sigma_{ij}^{p_4}\left(M_{U_1}\right)$$

No. of surviving events:

$$\mathcal{N}^{p}=\sigma^{p}\times\varepsilon^{p}\left(M_{U_1},\lambda\right)\times\mathscr{B}^2(M_{U_1},\lambda)\times L$$

$$=\left\{\sigma^{p_0}\times\varepsilon^{p_0}+\sum_{i}^{n}\lambda_i^2\sigma_i^{p_2}\times\varepsilon_i^{p_2}+\sum_{i\geq j}^{n}\lambda_i^2\lambda_j^2\sigma_{ij}^{p_4}\times\varepsilon_{ij}^{p_4}\right\}\times\mathscr{B}^2(M_{U_1},\lambda)\times L$$

Cross-section Parametrization: Single Production

Total cross section:

$$\sigma^s(M,\lambda_i) = \sum_i^n \lambda_i^2 \sigma_i^{s_2}(M_{U_1}) + \sum_{i\geq j\geq k}^n \lambda_i^2 \lambda_j^2 \lambda_k^2 \sigma_{ijk}^{s_6}(M_{U_1})$$

No. of surviving events:

$$\mathscr{N}^s = \sigma^s \times \varepsilon^s\ (M_{U_1},\lambda) \times \mathscr{B}(M_{U_1},\lambda) \times L$$

$$= \left\{ \sum_i \lambda_i^2 \sigma_i^{s_2}(M_{U_1}) \varepsilon_i^{s_2}(M_{U_1}) + \sum_{i\geq j\geq k} \lambda_i^2 \lambda_j^2 \lambda_k^2 \sigma_{ijk}^{s_6}(M_{U_1}) \varepsilon_{ijk}^{s_6}(M_{U_1}) \right\} \cdot \mathscr{B}(M_{U_1},\lambda_i) \cdot L$$

Cross-section Parametrization: Non-resonant Production

Total cross section:

$$\sigma^{nr}(M_{U_1},\lambda) = \sum_{i}^{n} \lambda_i^2 \sigma_i^{nr_2}(M_{U_1}) + \sum_{i \geq j}^{n} \lambda_i^2 \lambda_j^2 \sigma_{ij}^{nr_4}(M_{U_1})$$

No. of surviving events:

$$\mathcal{N}^{nr} = \sigma^{nr} \times \varepsilon^{nr}\ (M_{U_1},\lambda) \times L$$

$$= \left\{ \sum_{i}^{n} \lambda_i^2 \sigma_i^{nr_2}(M_{U_1}) \cdot \varepsilon_i^{nr_2}(M_{U_1}) + \sum_{i \geq j}^{n} \lambda_i^2 \lambda_j^2 \sigma_{ij}^{nr_4}(M_{U_1}) \cdot \varepsilon_{ij}^{nr_4}(M_{U_1}) \right\} \times L$$

Number of Events

Mass (Tev)	Pair production σ^p	ϵ^p	$\mathcal{N}^p$	Single production σ^s	ϵ^s	$\mathcal{N}^s$	t-channel LQ σ^{nr4}	ϵ^{nr4}	$\mathcal{N}^{nr4}$	Interference σ^{nr2}	ϵ^{nr2}	$\mathcal{N}^{nr2}$
Contribution to $\tau\tau$ signal												
$\lambda^L_{23} = 1$ (Scenario RD1A)												
1.0	40.87	2.33	8.59	58.80	3.30	35.07	70.57	7.22	183.33	-232.63	3.17	-266.21
1.5	1.39	1.50	0.19	3.91	2.74	1.93	14.94	7.00	37.77	-104.31	3.34	-125.62
2.0	0.08	1.01	0.01	0.44	2.50	0.20	5.04	7.25	13.19	-58.79	3.28	-69.57
$\lambda^L_{33} = 1$ (Scenario RD1B)												
1.0	35.67	1.69	5.43	29.00	2.57	13.46	20.20	6.21	45.26	-75.02	3.08	-83.41
1.5	1.17	1.09	0.11	1.72	2.16	0.67	4.31	6.22	9.68	-33.62	2.88	-33.01
2.0	0.06	0.81	0.00	0.17	1.98	0.06	1.39	6.27	3.15	-18.97	2.88	-19.71
Contribution to $\mu\mu$ signal												
$\lambda^L_{22} = 1$ (Scenario RK1A)												
1.0	40.89	71.88	265.27	58.68	72.66	769.52	70.40	62.77	1595.21	-233.00	42.73	-3594.15
1.5	1.39	64.44	8.10	3.91	71.35	50.30	15.20	64.33	352.97	-105.00	42.59	-1614.37
2.0	0.08	52.62	0.36	0.44	70.15	5.60	5.00	64.22	115.92	-58.80	43.08	-914.54
$\lambda^L_{32} = 1$ (Scenario RK1C)												
1.0	35.67	71.59	230.45	28.93	72.74	379.76	20.00	63.49	458.17	-75.30	39.10	-1062.87
1.5	1.17	64.46	6.78	1.72	72.33	22.44	4.29	64.58	100.49	-33.70	39.82	-484.39
2.0	0.06	52.47	0.29	0.17	71.77	2.22	1.41	64.90	33.04	-19.00	40.12	-275.17

Recasting

– Chi-square test is performed, with the test statistic:

$$\chi^2 = \sum_i \left[\frac{N_T^i - N_D^i}{\Delta N^i} \right]^2$$

Events are combined as follows:

$$\begin{aligned} N_T^i &= N_{U_1}^i + N_{BG}^i \\ &= \left[N_p + N_s^{incl} + N_t - N_\times \right]^i + N_{BG}^i \end{aligned}$$

using total uncertainity,

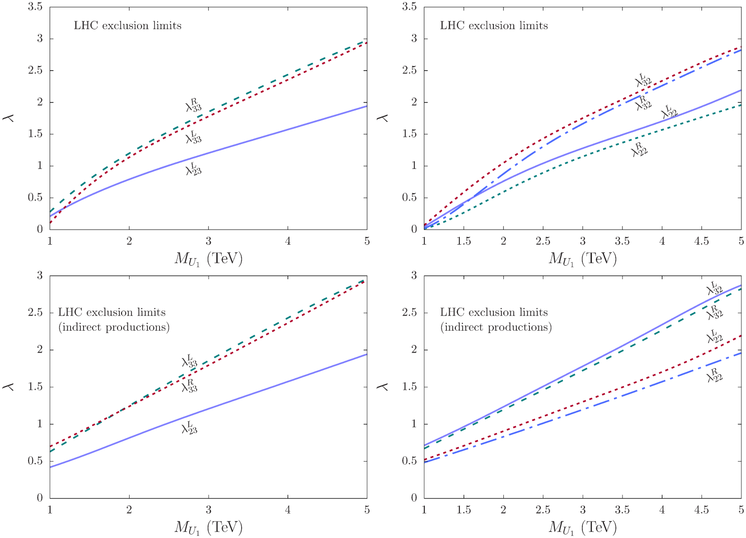
$$\Delta N^i = \sqrt{\left(\Delta N_{Stat}^i\right)^2 + \left(\Delta N_{Syst}^i\right)^2}$$

where, $\Delta N_{stat}^i = \sqrt{N_D^i}$ and we assume $\Delta N_{sys}^i = \delta^i \times N_D^i$

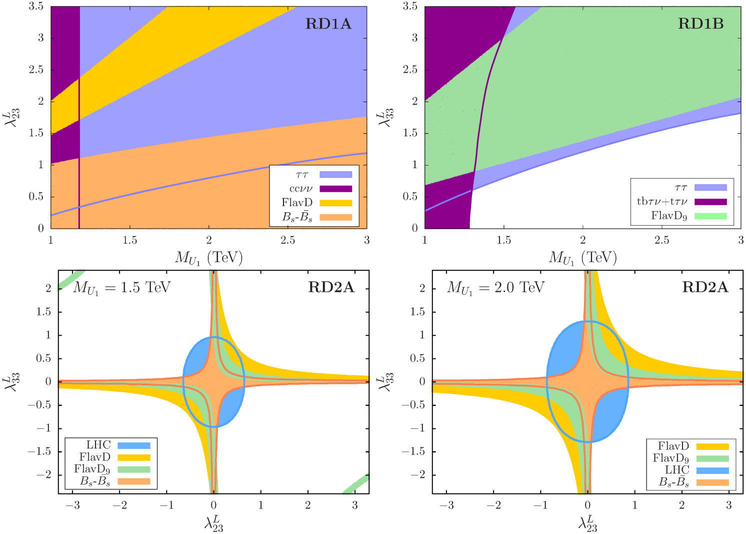
Existing bounds on LQ

	Integrated Luminosity [fb^{-1}]	Scalar LQ Mass [GeV]	Vector LQ, $\kappa = 0$ Mass [GeV]	Vector LQ, $\kappa = 1$ Mass [GeV]
LQ $\to t\nu$ ($\mathscr{B} = 1.0$) [85, 87]	35.9 (36.1)	1020 (992)	1460	1780
LQ $\to q\nu$ ($\mathscr{B} = 1.0$) [85]	35.9	980	1410	1790
LQ $\to b\nu$ ($\mathscr{B} = 1.0$) [85, 87]	35.9 (36.1)	1100 (968)	1475	1810
LQ $\to b\tau$ /$t\nu$($\mathscr{B} = 0.5$) [88]	137	950	1290	1650
LQ $\to b\tau$ ($\mathscr{B} = 1.0$) [87] *	(36.1)	(1000)	–	–
LQ $\to \mu j$ ($\mathscr{B} = 1.0$) [86] *	(139)	(1733)	–	–
LQ $\to \mu c$ ($\mathscr{B} = 1.0$) [86]	(139)	(1680)	–	–
LQ $\to \mu b$ ($\mathscr{B} = 1.0$) [86] *	(139)	(1721)	–	–

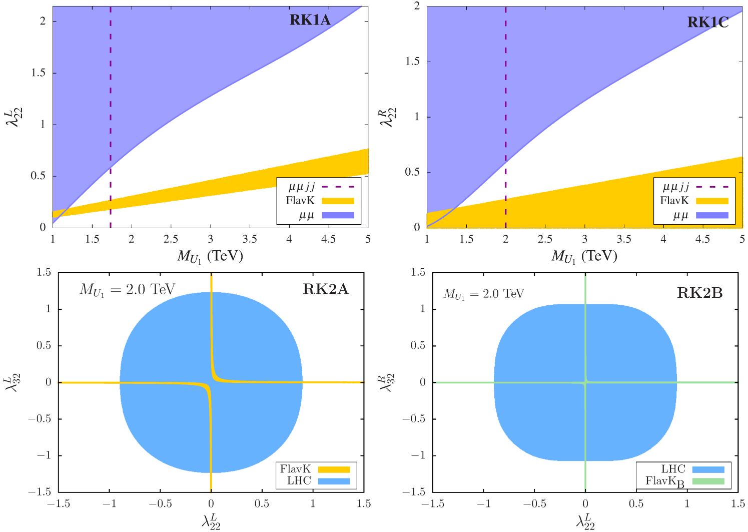
LHC Exclusion limits



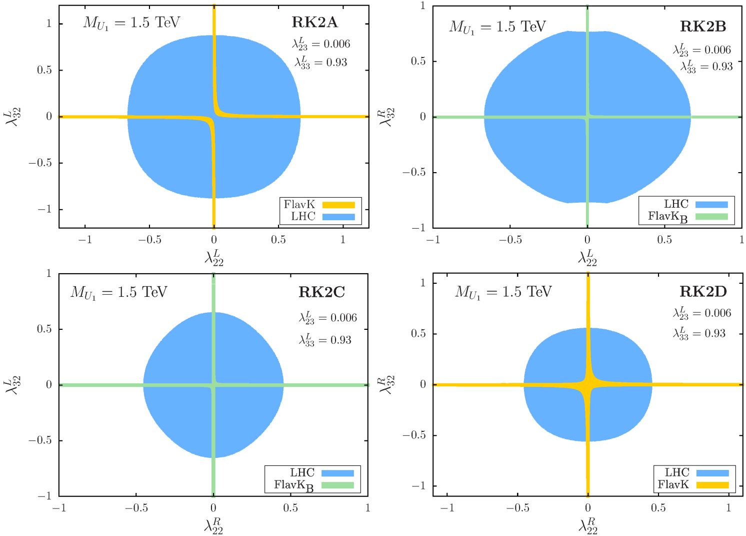
Bounds from LHC and $R_{D(*)}$ flavor data



Bounds from LHC and $R_{K^{(*)}}$ flavor data



A 1.5 TeV U_1 can explain $R_{D^{(*)}}$ and $R_{K^{(*)}}$



Conclusions

- The $R_{D^{(*)}}$ and $R_{K^{(*)}}$ scenarios lead to different signatures at the LHC. From an EFT approach the new couplings may appear same but decay modes of the LQ due to the couplings are different.
- At the low mass regions, the contributions from the resonant production are significant.
- The interference between the t-channel U_1 process and the SM is destructive.
- A 1.5 TeV LQ can explain $R_{D^{(*)}}$ and $R_{K^{(*)}}$ anomalies.
- For a detailed study, please refer to Phys. Rev. D **104**, 035016