I. INTRODUCTION

The $W$-boson mass, $M_W$, is a precisely measured quantity, and even a slight deviation from the predicted value would hint toward physics beyond the Standard Model (SM). The SM predicts $M_W^{\text{SM}} = (80.357 \pm 0.004) \text{ GeV}$, which agrees with the most up-to-date PDG value $M_W^{\text{PDG}} = (80.379 \pm 0.012) \text{ GeV}$ at the $2\sigma$ confidence level [1]. Very recently, the CDF collaboration has reported a new precision measurement of $M_W$ using their full 8.8 fb$^{-1}$ data set that yields [2]

$$M_W^{\text{CDF-2022}} = (80.4335 \pm 0.0094) \text{ GeV},$$

which deviates from the SM prediction by $7\sigma$, clearly indicating the presence of new physics (NP) [3–73].

The muon’s anomalous magnetic moment (AMM) $\Delta a_\mu = (g-2)_\mu / 2$, is another quantity that has recently been measured with unprecedented accuracy in the Muon g-2 experiment [74]. The result from this experiment is in complete agreement with the previously measured value at BNL [75]. When these two results are combined, it shows a large 4.2$\sigma$ discrepancy compared to the SM prediction [76] (for original works, see Refs. [77–96]):

$$\Delta a_\mu = (2.51 \pm 0.59) \times 10^{-9},$$

hinting towards physics beyond the SM (BSM); for a recent review, see e.g. [97].

In addition, lepton flavor universality (LFU) violating $B$-meson decays have been persistently observed in a series of experiments [98–102]. The most noteworthy deviation is observed in neutral-current transitions associated with the $R_K - R_{K^*}$ ratios, which are defined as:

$$R_K = \frac{Br(B \to K \mu^+ \mu^-)}{Br(B \to K e^+ e^-)}, \quad R_{K^*} = \frac{Br(B \to K^* \mu^+ \mu^-)}{Br(B \to K^* e^+ e^-)}.$$

LFU in the SM predicts these ratios to be unity with uncertainties less than 1%. However, the most precise measurement by LHCb [102] finds a deficit with a significance of $3.1\sigma$ for $R_K$-ratio. There are several other related observables for which LHCb also found deficits with respect to the SM prediction, which are of order $O(1.5 - 3.5)\sigma$; for a comprehensive list, see e.g. [103]. However, if only the theoretically clean observables: $R_K, R_{K^*}$ ratios and $BR(B_s \to \mu^+ \mu^-)$ are taken into account, the data is found to be in 4.2$\sigma$ tension with the SM [104], for a recent review, see [105]. On the other hand, when both theoretically clean and dirty observables are considered, global analyses show preferences compared to the SM hypothesis with pulls more than $7\sigma$ (see [104, 106–112] for theoretical assumptions and data included in these fits).

On top of these downsides mentioned above, neutrinos remain massless in the SM. On the contrary, several experiments discovered non-zero masses of the neutrinos via observations of neutrino oscillations [113–119]. This work proposes a simultaneous explanation of the $W$-boson mass shift, the tension in the $(g-2)_\mu$, and the anomalies in the neutral current transitions in the $B$-meson decays, as well as neutrino oscillation data. The proposed model employs two scalar leptoquarks (LQs [120, 121]): $R_2 \sim (3, 2, 1/6)$ and $S_3 \sim (\overline{5}, 3, 1/3)$ and a vectorlike quark (VLQ) $\psi \sim (3, 2, -5/6)$. Non-zero mixing between $R_2$ and $S_3$ LQs leads to loop corrections to $W$-boson self-energy explaining the CDF anomaly. Utilizing this same mixing, the $(g-2)_\mu$ receives a large NP contribution via the mass flip of the VLQ inside the loop. The $S_3$ LQ, with its interactions with the SM fermions, addresses the discrepancies in the rare decays of $B$-mesons based on the neutral current $b \to s\ell\ell$ transitions. Furthermore, non-zero mixing between $R_2$ and $S_3$ LQs is also responsible for generating neutrino mass at the one-loop order, and the model put forward in this work can be tested in the ongoing and upcoming experiments.
**II. PROPOSAL**

In this work, we propose a new leptoquark-vectorlike quark model that contains three BSM particles: (i) an iso-doublet LQ, $\tilde{R}_2$, (ii) an iso-triplet LQ, $S_3$, and (iii) an iso-doublet vectorlike quark, $\psi$. For these particles, a complete list of quantum numbers is presented in Table I, and the corresponding component fields are defined in the following way:

\[
\tau.S_3 = \begin{pmatrix} S_{1}^{1/3} \\ \sqrt{2}S_{2}^{-2/3} \\ -S_{1}^{1/3} \end{pmatrix},
\]

\[
\tilde{R}_2 = \begin{pmatrix} \tilde{R}_2^{2/3} \\ R^{-1/3} \end{pmatrix},
\]

\[
\psi = \begin{pmatrix} \psi^{1/3} \\ \psi^{-1/3} \end{pmatrix}.
\]

The cubic coupling $\mu$ leads to mixing between $\tilde{R}_2$ and $S_3$ components, which is crucial in addressing both the $W$-boson mass and $(g - 2)_{\mu}$ anomalies within the proposed model. Remarkably, the existence of this cubic term also allows neutrinos to have non-zero masses at the one-loop order. In this theory, $\mu$ is one of the most important parameters, and in the limit $\mu \to 0$, one gets $\Delta m_{\nu} \to 0$, $\Delta a_{\mu} \to 0$, as well as $m_{\nu} \to 0$. Note that, to reduce the number of parameters and for the simplicity of our study, scalar quartic couplings are assumed to be somewhat smaller and are not included in Eq. (8). Consequently, all mass splittings are only a function of the trilinear coupling $\mu$.

From the above potential, the mass matrices in the $(S^Q, R^Q)$ basis are given by,

\[
M_{2/3}^2 = \begin{pmatrix} m_S^2 & \mu v & m_R^2 \\ \mu v & m_R^2 & -\mu v/\sqrt{2} \\ m_R^2 & -\mu v/\sqrt{2} & m_R^2 \end{pmatrix},
\]

with $v = 246$ GeV. We denote the weak and mass eigenstates with $X$ and $\tilde{X}$, respectively, which are related by,

\[
S^Q \sim c_X S^Q + s_X \tilde{X}^Q,
\]

\[
R^Q \sim s_X S^Q + c_X \tilde{X}^Q,
\]

with $x = \theta, \phi$ for $Q = 2/3, 1/3$. Masses and mixing for $\tilde{X}^Q$ states then take the form,

\[
m_{S,R}^2 = \frac{1}{2} \left\{ m_S^2 + m_R^2 \pm \left[ (m_S^2 - m_R^2)^2 + a_Q \mu^2 v^2 \right]^{1/2} \right\},
\]

\[
\sin 2x = \frac{b_{Q,\mu}}{m_{S,R}^2 - m_{S,R}^2},
\]

where, $a_Q(b_Q) = 4(2)$ and $2(-\sqrt{2})$ for $Q = 2/3$ and $1/3$, respectively.

**W-boson mass shift:**—The effects of NP phenomena on the electroweak (EW) gauge sector are parameterized in terms of oblique parameters [122, 123] $S$, $T$, and $U$. Then, the shift in the $W$-boson mass from the NP can be calculated as a function of these oblique parameters [124],

\[
m_W^2 = m_{W,SM}^2 \left\{ 1 + \frac{\alpha_{em} \left( c_{\omega} T - \frac{1}{2} S + \frac{c_{\omega}^2 - s_{\omega}^2}{2} U \right)}{c_{\omega}^2 - s_{\omega}^2} \right\}.
\]

When the new CDF data is taken into account in a global electroweak precision fit, the oblique parameters would deviate from their previous (PDG) SM predictions, which several studies have already analyzed [15, 23, 26], and updated the $2\sigma$ allowed ranges for $S$, $T$, and $U$ parameters in light of the CDF result. By incorporating these new sets of values of oblique parameters in our numerical analysis, we find that for our model, the mass splitting of the mixed LQ states must be of order

| Field | $SU(3) \times SU(2) \times U(1)$ | B |
|-------|-------------------------------|---|
| $\psi$ | $(3, 2, -\frac{2}{3})$ | $\frac{1}{4}$ |
| $S_3$ | $(3, 3, \frac{3}{2})$ | $\frac{7}{2}$ |
| $\tilde{R}_2$ | $(3, 2, \frac{1}{3})$ | $\frac{7}{2}$ |

Table I. Quantum numbers of the BSM particles under the SM gauge group $SU(3)_C \times SU(2)_L \times U(1)_Y$. Their baryon number assignments are also presented.
$\Delta m_{LQ} \sim 100$ GeV to be compatible with the result reported by CDF collaboration.

In our model, NP contributions to these parameters originate from the mass splittings among the component fields as a result of mixing between the same charged states from $\tilde{R}_2$ and $S_3$. We obtain the following one-loop correction to the $T$-parameter for our model,

$$
\Delta T = \frac{N_c}{16\pi s_W^2 m_W^2} \left\{ \left( s_\phi c_\theta - \sqrt{2} c_\phi c_\theta \right)^2 \hat{F} \left[ m_{S_{-2/3}}, m_{S_{-1/3}} \right] 
+ \left( s_\phi c_\theta + \sqrt{2} c_\phi c_\theta \right)^2 \hat{F} \left[ m_{\tilde{R}_{-2/3}}, m_{\tilde{R}_{-1/3}} \right] 
+ \left( c_\phi c_\theta + \sqrt{2} s_\phi c_\theta \right)^2 \hat{F} \left[ m_{\tilde{S}_{-2/3}}, m_{\tilde{R}_{-1/3}} \right] 
+ \left( c_\phi c_\theta - \sqrt{2} s_\phi c_\theta \right)^2 \hat{F} \left[ m_{\tilde{R}_{-2/3}}, m_{\tilde{R}_{-1/3}} \right] 
+ 2 c_\phi^2 \hat{F} \left[ m_{\tilde{S}_{1/3}}, m_{S_{-1/3}} \right] 
- \frac{c_\phi^2 s_\phi^2}{2} \hat{F} \left[ m_{S_{1/3}}, m_{R_{-1/3}} \right] - \frac{c_\phi^2 s_\phi^2}{2} \hat{F} \left[ m_{S_{2/3}}, m_{R_{2/3}} \right] \right\},
$$

(15)

with,

$$
\hat{F}(m_1, m_2) = m_1^2 + m_2^2 - \frac{2m_1^2 m_2^2}{m_1^2 - m_2^2} \log \left( \frac{m_1^2}{m_2^2} \right).
$$

(16)

In contrast, we find that the NP contribution to $\Delta S$ is small compared to $\Delta T$, which in our model, takes the following form:

$$
\Delta S = \frac{N_c}{\pi m_Z^2} \left\{ \frac{1}{3} B_{22} \left[ m_Z^2, m_{S_{-2/3}}, m_{S_{-1/3}} \right]
+ \frac{1}{48} (3 + c_{2\theta})(1 + 3c_{2\theta}) B_{22} \left[ m_Z^2, m_{S_{-2/3}}, m_{S_{-1/3}} \right]
+ \frac{1}{96} (9 - 20c_\theta + 3c_{2\theta}) B_{22} \left[ m_Z^2, m_{R_{-2/3}}, m_{R_{-1/3}} \right]
- \frac{1}{24} (1 + 3c_\theta) c_\phi^2 B_{22} \left[ m_Z^2, m_{S_{1/3}}, m_{S_{1/3}} \right]
- \frac{1}{24} (1 - 3c_\theta) c_\phi^2 B_{22} \left[ m_Z^2, m_{S_{2/3}}, m_{S_{1/3}} \right]
+ \frac{1}{8} s_{2\theta}^2 B_{22} \left[ m_Z^2, m_{S_{2/3}}, m_{S_{2/3}} \right]
+ \frac{1}{8} s_{2\theta}^2 B_{22} \left[ m_Z^2, m_{S_{2/3}}, m_{S_{1/3}} \right]
\right\},
$$

(17)

here, the expression for the loop function $B_{22}(q^2, m_1^2, m_2^2)$ can be found in [125].

**Muon AMM:** In this theory, the AMM of the muon receives NP contributions as shown in Fig. 1, which can be expressed as [126, 127],

$$
\Delta a_\mu = -\frac{m_\mu N_c}{4\pi^2} \sum_k \left\{ \left| \Gamma_k^L \Gamma_k^R \right|^2 \frac{m_\mu}{m_{\phi_k}} \right. F_k \left( \frac{m_{\phi_k}^2}{m_{\phi_k}^2} \right) +
\left[ \left| \Gamma_k^L \right|^2 + \left| \Gamma_k^R \right|^2 \right] \frac{m_\mu}{m_{\phi_k}} G_k \left( \frac{m_{\phi_k}^2}{m_{\phi_k}^2} \right) \right\},
$$

(18)

Figure 1. Leading order NP contribution to muon AMM (in the weak basis). Photon can be attached to either fermion line or the scalar line.

here sum is taken over $k = \{ \tilde{S}_{2/3}, \tilde{R}_{2/3}, \tilde{S}_{1/3}, \tilde{R}_{1/3} \}$ for which we define $\{ \Gamma_k^L, \Gamma_k^R \} = \{ y_{\mu}^L, y_{\mu}^R, \sqrt{2} y_{\phi_k}^L, \sqrt{2} y_{\phi_k}^R \}, \{ y_{\mu}^L, y_{\phi_k}^L, -\sqrt{2} y_{\phi_k}^R \}, \{ y_{\mu}^L, y_{\phi_k}^R, -\sqrt{2} y_{\phi_k}^L \}$, and $\{ y_{\mu}^L, y_{\phi_k}^L \}$, respectively. While $X^{2/3}$ is propagating in the loop $Q_\phi = -1/3$, and for $X^{-1/3}$ it is $Q_\phi = -4/3$. And the functions $F(x), G(x)$ are given by,

$$
F(x) = f(x) + Q_\phi g(x), \quad G(x) = \tilde{f}(x) + Q_\phi \tilde{g}(x),
$$

$$
f(x) = \frac{x^2 - 1 - 2x \log x}{4(x - 1)^4}, \quad g(x) = \frac{x - 1 - \log x}{2(x - 1)^2},
$$

$$
\tilde{f}(x) = \frac{2x^3 + 3x^2 - 6x + 1 - 6x^2 \log x}{24(x - 1)^4}, \quad \tilde{g}(x) = \frac{1}{2} f(x).
$$

(19)

(20)

(21)

By considering only the dominant chirally-enhanced terms, $(g - 2)_\mu$ takes the following simpler form:

$$
\frac{\Delta a_\mu}{3m_\mu m_\mu y_{\mu}^L y_{\mu}^R} = \frac{s_{2\theta}}{8\pi^2} \left[ \frac{F \left( \frac{m_\mu^2}{m_{S_{1/3}}^2} \right)}{m_{S_{1/3}}^2} - \frac{F \left( \frac{m_\mu^2}{m_{R_{1/3}}^2} \right)}{m_{R_{1/3}}^2} \right] - \sqrt{2} s_{2\theta} \left[ \frac{F \left( \frac{m_\mu^2}{m_{S_{2/3}}^2} \right)}{m_{S_{2/3}}^2} - \frac{F \left( \frac{m_\mu^2}{m_{R_{2/3}}^2} \right)}{m_{R_{2/3}}^2} \right].
$$

(22)

$R_K - R_{K^*}$ anomalies: The part of the Lagrangian relevant for $R_{K^*}$-observable is the first term given in Eq (6). We choose to work with the ‘down-type diagonal’ flavor ansatz for which the CKM matrix enters in the interactions associated with the up-type quarks. Then $S_3$ couplings to SM fermions contain a term of the form:

$$
L_{S_3} \supset -\sqrt{2} y_S \left( \bar{u}_i \gamma_5 d_j \right) \tilde{c}_{L,i} \mu_{L,j} S_{1/3}^3 + h.c.,
$$

(23)

which leads to $b \to s \mu^+ \mu^-$ transition as shown in Fig 2. The Wilson coefficients relevant for generating such neutral current processes that we are interested in are given by,

$$
\Delta C_{9}^{\mu \mu} = -\Delta C_{10}^{\mu \mu} = \frac{\psi^2}{V_{tb} V_{ts}^*} \alpha_{em} \frac{y_{\mu}^S (y_{\mu}^S)^*}{M_{4/3}^2}.
$$

(24)
A global fit to the data that includes all $b \to s \mu \mu$ observables, the $R_{K^{(*)}}$ ratios, and $B_s \to \mu^+\mu^-$ branching ratio prefers $\Delta C_{9}^{\mu\mu} = -\Delta C_{10}^{\mu\mu} = -0.39 \pm 0.07$ [106].

Figure 2. Feynman diagram leading to $b \to s \mu^+\mu^-$ transition.

**Neutrino mass:** Non-zero mixing between the $\tilde{R}_2$ and $S_3$ LQs and BSM Yukawa interactions of the SM fermions with these LQs give rise to neutrino oscillations [128, 129] in this theory (for LQ effects in leptonic processes, see e.g. [130, 131]).

Feynman diagram that leads to non-zero neutrino mass is shown in Fig. 3, and the neutrino mass formula takes the following form [128]:

$$M'_{ij} = \frac{\sin 2\phi}{32\pi^2} \sum_{k=d,s,b} m_k \left[ (y^R)_{ki}(y^S)_{kj} + (y^R)_{kj}(y^S)_{ki} \right]$$

$$\times \left[ \frac{m^2_{S_{1/3}} \ln \frac{m^2_S}{m^2_k}}{m^2_{S_{1/3}} - m^2_k} - \frac{m^2_{R_{1/3}} \ln \frac{m^2_R}{m^2_k}}{m^2_{R_{1/3}} - m^2_k} \right].$$

(25)

Since down-type quark masses are much smaller than the LQ masses, the above formula can be further simplified,

$$M' \approx \frac{\sin 2\phi}{16\pi^2} \left( \frac{m_{R_{1/3}}}{m_{S_{1/3}}} \right) \left\{ (y^R)^T m_D y^S + (y^S)^T m_D y^R \right\}.$$

(26)

**Collider constraints:** At LHC, $\tilde{R}_2$ and $S_3$ LQs can be pair produced [132, 133] via gluon-fusion $pp \to$ LQ LQ†. Once produced, each of these LQs would decay to SM fermions. Several searches for LQ pairs have been made at ATLAS and CMS for different final states with or without neutrinos. The strongest constraints for our scenario come from decay of these LQs to a third generation quark and a second generation charged lepton, namely $b\mu$ and $\tau\mu$. For 100% branching ratio to $pp \to b\tilde{R}_2 \mu^- \mu^-$ channel, LHC provides a lower bound of $m_{\text{LQ}} \gtrsim 1.7$ (1.5) TeV [134, 135]. For similar processes with third generation charged lepton, the corresponding bounds are $m_{\text{LQ}} \gtrsim 1$ TeV ($pp \to t\tilde{R}_3 \mu^+$) and $m_{\text{LQ}} \gtrsim 1.4$ TeV ($pp \to t\tilde{R}_3 \tau^+$), respectively [136, 137].

The single production of LQ becomes only relevant for larger Yukawa couplings to the first and second-generation quarks, which is not the case in our scenario. For a similar reason, non-resonant diphoton searches at the LHC do not provide strong constraints for the parameter space we are interested in.

VLQs can also be pair produced at the LHC through gluon-fusion. If LQs are lighter than VLQs, then each VLQ would mostly decay to a muon and a LQ leading to $\nu L d R \nu L$ processes of these types have been previously considered in Ref. [138]. We take the LHC bounds on VLQ from [139, 140] that typically correspond to $m_\psi \gtrsim 1.3 - 1.4$ TeV. For our numerical analysis, we consider both LQ and VLQ masses around or somewhat above 2 TeV to evade stringent collider constraints.

**Results:** One of the most important parameters in this model is the $\mu$, which mixes the two LQs. As described above, for $\mu \to 0$, $(g-2)_\mu, \Delta m_W, m_\nu \to 0$. In Fig. 4, $(g-2)_\mu$ and $\Delta T$ are presented as a function of $\mu$ for two benchmark (BM) scenarios.

Figure 3. Feynman diagram leading to non-zero neutrino masses (in the weak basis).

Figure 4. Muon $(g-2)$ and $\Delta T$-parameter for two benchmark (BM) scenarios as a function of $\mu$. Green (pink) shaded region corresponds to the experimentally allowed $1\sigma$ ($2\sigma$) range for $(g-2)_\mu$ ($m_W$). Yellow shaded region represents the correct range for $\mu$ that is compatible with both $(g-2)_\mu$ and $m_W$ (CDF II).

BM-I (BM-II) corresponds to $m_R = m_S = 2$ TeV ($m_R = 2$ TeV, and $m_S = 2.2$ TeV) and mass of the VLQ is varied with $\mu$ as $m_\psi = (2050 + \mu)$ GeV ($m_\psi = (2150 + \mu)$ GeV). For both these cases $y^\psi_L = -y^\psi_R = 1$ are taken. In Fig. 4, green and pink shaded regions correspond to the experimentally allowed $1\sigma$ and $2\sigma$ ranges.
The most crucial cLFV for the given texture is \( \tau \rightarrow \mu \mu \gamma \), which is constrained from neutrino oscillations as well as meson-antimeson oscillations; for details, see e.g. [144, 145]. As aforementioned, the 23-block in \( y^S \) plays an important role in fitting neutrino observables; some of its entries address the \( R_K^{(\pm)} \) anomalies and are required to be sizable. By randomly varying these couplings, interrelations between \( BR[\tau \rightarrow \mu \gamma] \) and \( B \rightarrow K^{(\pm)}\nu\bar{\nu} \) observables are depicted in Fig. 5 along with their respective experimental bounds.

In addition to the above-mentioned parameters for BM-I, from a combined fit, we obtain the following Yukawa couplings addressing \( R_K - R_{K^*} \) anomalies as well as neutrino oscillation data:

\[
y^S = \begin{pmatrix}
0 & 0 & 0 \\
0 & 0.01216 & -0.01495 \\
0.07729 & 0.19480 & 0.07439
\end{pmatrix}, \quad (27)
\]

\[
y^R = 10^{-7} \begin{pmatrix}
0.8756 & 0.2081 & -0.5057 \\
0.1519 & -0.4183 & -0.02171 \\
0.08701 & -0.6155 & -1.0380
\end{pmatrix}. \quad (28)
\]

This fit corresponds to the following neutrino observables:

\[
(m_1, m_2, m_3) = (1.59 \times 10^{-2}, 8.60, 50.27) \text{ meV}, \quad (29)
\]

\[
(\sin^2 \theta_{12}, \sin^2 \theta_{23}, \sin^2 \theta_{13}) = (0.309, 0.574, 0.02224), \quad (30)
\]

which are in excellent agreement with experimental data and satisfy all flavor constraints.

For \((g-2)_{\mu}\) and \(m_W\), respectively and the yellow shaded region constitutes the correct range for \(\mu\), which is compatible with both \((g-2)_{\mu}\) and \(m_W\) (CDF II) experimental data. Further correlations in the \(m_\psi\) versus \(\mu\) plane is demonstrated in Fig. 5. As shown in [141], even though the current LHC measurements [142, 143] of \(h \rightarrow \mu\mu\) allow a large trilinear coupling, future colliders such as the FCC may be able to measure this coupling and constraint the theory parameter space.

From Fig. 4, it can be seen that for BM-I, a choice of \(\mu = 950\) GeV simultaneously solves \((g-2)_{\mu}\) and \(m_W\) (CDF II) anomalies. We take these reference values and perform a fit to the neutrino observables to demonstrate the viability of the theory. Note, however, that this fitting procedure is highly non-trivial since the same Yukawa couplings addressing the \(R_K - R_{K^*}\) anomalies also enter in neutrino observables. In fact, with the texture for \(y^S\) with only two non-zero elements as given in Eq. (7), neutrino masses and mixings utilizing the formula Eq. (26) cannot be accommodated. To generate viable neutrino masses and mixings, a few more entries must be introduced in \(y^S\), which would lead to both charged lepton flavor violation as well as flavor violations in the quark sector [144–146] (see also [129, 147–156]).

Our detailed numerical analysis shows that a non-zero 23-block in \(y^S\) is insufficient to satisfy neutrino oscillation data. Therefore, we also introduce a non-zero 31-entry, which is constrained from \(\mu \rightarrow e\) transition (through CKM rotations). The most crucial cLFV for the given texture is \(\tau \rightarrow \mu \gamma\), via which this model may be probed at the upcoming experiment [157]. In addition, various other flavor violating processes are considered in our numerical analysis that includes \(Z \rightarrow \ell\ell, \ell \rightarrow \ell' \ell' \ell'^*\), \(\tau \rightarrow \mu \gamma\), and several meson decay observables as well as meson-antimeson oscillations; for details, see e.g. [144, 145].

Figure 5. Correlation between \(m_\psi\) and \(\mu\) for a fixed \(m_S = m_R = 2\) TeV and \(y^V_{\ell} = -0.65, y^V_\mu = 0.4\). Here the green and light-red shaded regions corresponds to \((m_\psi, \mu)\) values satisfying the \((g-2)_{\mu}\) (within allowed 1σ) and \(m_W\) (CDF II) (within 2σ), respectively. The magenta shaded region is compatible with both experimental data.

Figure 6. The results of random scans showing the correlations between \(BR[\tau \rightarrow \mu \gamma]\) and \(R_{K^{(\pm)}}\). Current (future) bounds on \(BR[\tau \rightarrow \mu \gamma]\) from BaBar Collaboration [158] (Super B Factory [157]) and on \(R_{K^{(\pm)}}\) from Belle collaboration [159] are also depicted. In making this plot, \(y^S_{32,33}\) couplings are randomly varied within ranges \((-0.1, 0.1)\) and \((-1, 1)\), respectively.
III. CONCLUSION

In this work, we proposed a simple new physics scenario to simultaneously address several puzzles that cannot be accounted for by the Standard Model alone. The model is comprised of two scalar leptoquarks and a vectorlike quark. One of the most crucial parameters in this theory is the mixing parameter between the two leptoquarks. This mixing generates neutrino masses via quantum corrections at one loop, provides additional contributions to the W-boson mass consistent with recent CDF measurement, and plays a non-trivial role in incorporating the longstanding tension in the muon anomalous magnetic moment. The vectorlike quark, assisted with both the leptoquarks, gives rise to the required sizeable new physics contributions to the $(g - 2)_\mu$ via chirally enhanced terms proportional to its mass. Furthermore, the iso-triplet leptoquark is responsible for accounting for the deviations observed persistently in the $R_{K^{(*)}}$ ratios. By performing a numerical analysis, we have illustrated how to consistently resolve all these mysteries mentioned above by keeping flavor violations under control. Moreover, the model is within reach of the current and future upgrades of the LHC and has the potential to be probed by the $B$ meson factories.

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