BSM interpretations of B-physics and muon (g-2) anomalies

Based primarily on:

1) arXiv:1704.06659 [Altmannshofer, Dev+A.S]=>PRD (2017)

2) arXiv:2002.12910 [Altmannshofer, Dev, Yicong Sui+A.S]

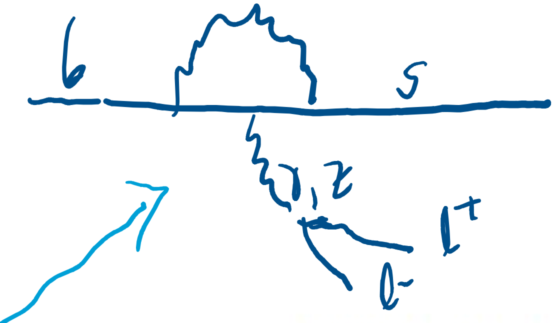
3) arXiv:2106.15647 [Fang Xu+ Dev + AS]

Pheno-2022

05/10/22

outline

- Recapitulate flavor anomalies….Pros & Cons
- Why RPV3
- Tests for IF
- Implications for LHC & beyond
- Summary



As of 2020

TABLE I. Summary of the anomalies in the observables $R_{D^{(*)}}$, $R_{J/\psi}$, $R_{K^{(*)}}$, and $(g-2)_\mu$. Listed are the pulls of various subsets of observables. The pulls are combined assuming the observables are independent from each other. The values in parentheses exclude the *BABAR* results for $R_{D^{(*)}}$.

Observable	$R_{D^{(*)}}, R_{J/\psi}$	$R_{K^{(*)}}$	$(g-2)_\mu$	All but $(g-2)_\mu$	All
Pull	3.3σ (2.2σ)	3.4σ	3.3σ	4.5σ (3.7σ)	5.3σ (4.6σ)

See ALTMANNSHOFER, DEV, SONI + AS 2020

PHYSICAL REVIEW D VOLUME 56, NUMBER 9 1 NOVEMBER 1997

Improving constraints on $\tan\beta/m_H$ using $B \to D\tau\overline{\nu}$

Ken Kiers* and Amarjit Soni†
Department of Physics, Brookhaven National Laboratory, Upton, New York 11973-5000
(Received 12 June 1997)

We study the q^2 dependence of the exclusive decay mode $B\to D\tau\overline{\nu}$ in type-II two Higgs doublet models (2HDM's) and show that this mode may be used to put stringent bounds on $\tan\beta/m_H$. There are currently rather large theoretical uncertainties in the q^2 distribution, but these may be significantly reduced by future measurements of the analogous distribution for $B\to D(e,\mu)\overline{\nu}$. We estimate that this reduction in the theoretical uncertainties would eventually (i.e., with sufficient data) allow one to push the upper bound on $\tan\beta/m_H$ down to about 0.06 GeV^{-1}. This would represent an improvement on the current bound by about a factor of 7. We

FF
f_1 f_0
Used HQS

⇒ Followed up by Nierste et al '08; Fajfer et al '12

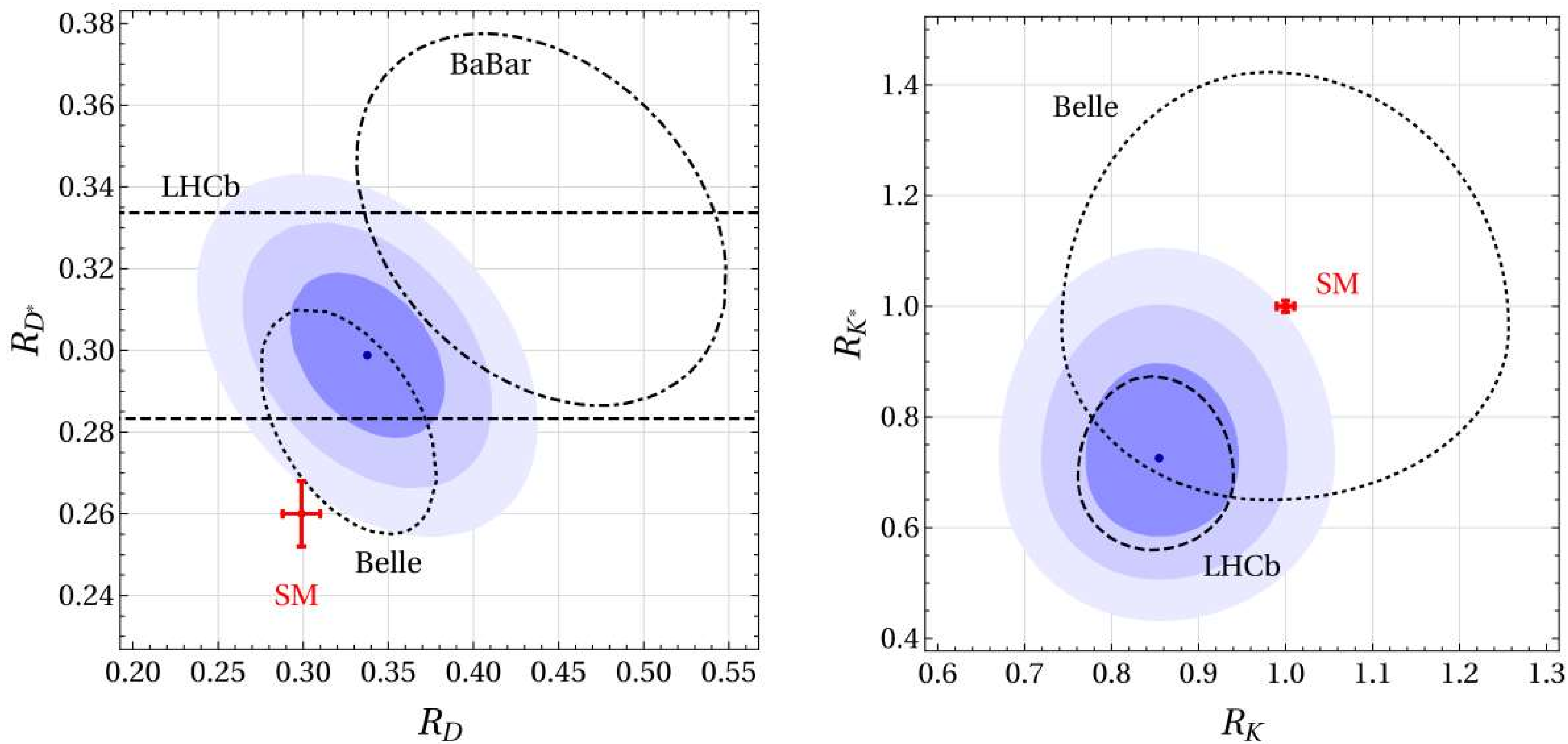


FIG. 1. Experimental averages (shown by the blue dot for the best-fit and darker-to-lighter shaded regions for $1\sigma, 2\sigma, 3\sigma$) and SM predictions (shown by red error bars) for the LFUV observables R_D and R_{D^*} (left), as well as R_K and R_{K^*} (right). The values for $R_{K^{(*)}}$ correspond to a dilepton invariant mass squared of $1.1\ \text{GeV}^2 < q^2 < 6\ \text{GeV}^2$. Individual 1σ regions from Belle, LHCb, and *BABAR* are also shown by the dotted, dashed, and dash-dotted contours, respectively.

FACT OR FARCE? [Charge Current only]

11 exptal results [not all independent]; ALL central values above Theory

~ O(6) are independent

IMPORTANT CAUTION

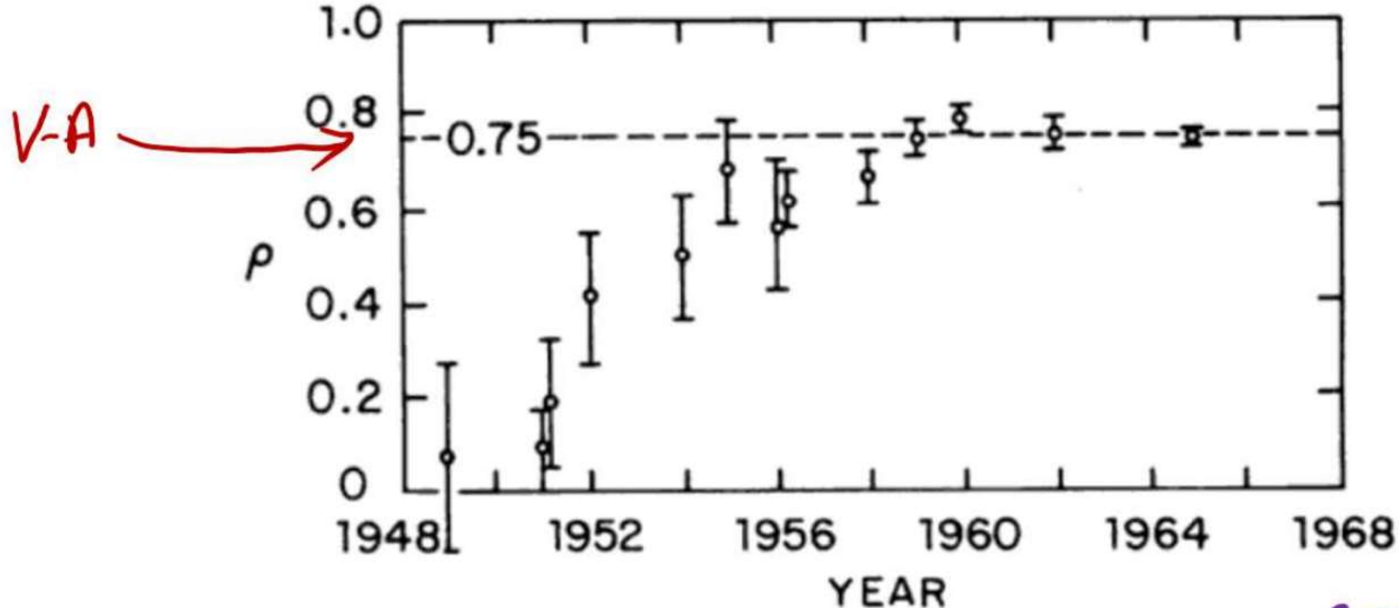
4

experiment	tag method	τ decay mode	R_D	R_D^*	R_ψ
Babar (2012)[1]	hadronic	$l\,\nu\nu$	$0.440 \pm 0.058 \pm 0.042$	$0.332 \pm 0.024 \pm 0.0.018$	
Belle (2015)[2]	hadronic	$l\,\nu\nu$	$0.375 \pm 0.064 \pm 0.026$	$0.293 \pm 0.038 \pm 0.015$	
LHCb (2015)[5]	hadronic	$l\,\nu\nu$	-	$0.336 \pm 0.027 \pm 0.030$	
Belle (2016)[2]	semileptonic	$l\,\nu\nu$	-	$0.302 \pm 0.030 \pm 0.011$	
Belle (2017)[4]	hadronic	$\pi(\rho)\nu$	-	$0.270 \pm 0.035 \pm 0.027$	
LHCb (2017)[6]	hadronic	$3\pi\nu$	-	$0.291 \pm 0.019 \pm 0.029$	
Belle (2019)[7]	semileptonic	$l\,\nu\nu$	$0.307 \pm 0.037 \pm 0.016$	$0.283 \pm 0.018 \pm 0.014$	
LHCb(2016) [9]	hadronic	$l\,\nu\nu$	-	-	$0.71 \pm 0.17 \pm 0.18$
SM	-	-	0.299 ± 0.011	0.260 ± 0.008	0.26 ± 0.02

TABLE I: All experimental results announced to date on R_D, R_{D^*} and on R_ψ versus the predictions of those for the SM

ALTMANNSHOfer, Dev+AS, Yicong Sui; see 2002.12910

Imp. # Historical ~~Aside~~ CAUTION



FROM M PUROHIT

Figure 16. The change of the Michel parameter ρ from year to year.

From T. D. Lee's text TD Lee + CS Wu

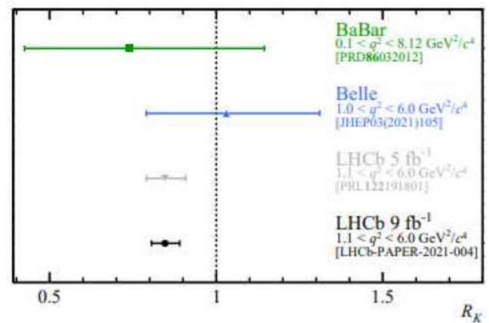
R_K with full Run1 and Run2 dataset

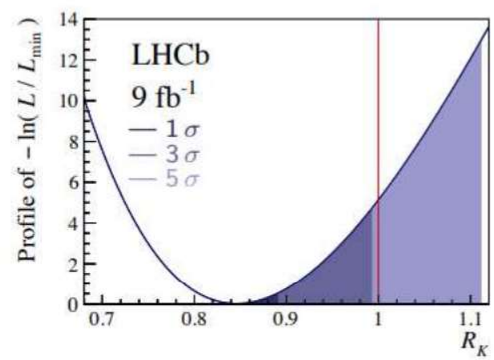
[LHCb-PAPER-2021-004] **Submitted to Nature Physics**

→ unchanged

$$R_K = 0.846 \,^{+0.042}_{-0.039}\,(\text{stat})\,^{+0.013}_{-0.012}\,(\text{syst})$$

- p-value under SM hypothesis: 0.0010
  → Evidence of LFU violation at 3.1σ
- Compatibility with the SM obtained by integrating the profiled likelihood as a function of R_K above 1
  - Taking into account the 1% theory uncertainty on R_K [EPJC76(2016)8,440]





Previously (2019) R_K = 2.5σ   5 → 9/fb

K.A. Petridis (UoB)   Test of LFU at LHCb   March 2021   18 / 20

$$a_\mu(\text{FNAL}) = 116\,592\,040(54) \times 10^{-11} \quad (0.46\,\text{ppm}),$$

← Unchanged from BNL 2002, 2006

where the statistical, systematic, and fundamental constant uncertainties that are listed in Table II are combined in quadrature. Our result differs from the SM value by $3.3\,\sigma$ and agrees with the BNL E821 result. The combined experimental (Exp) average[68] is

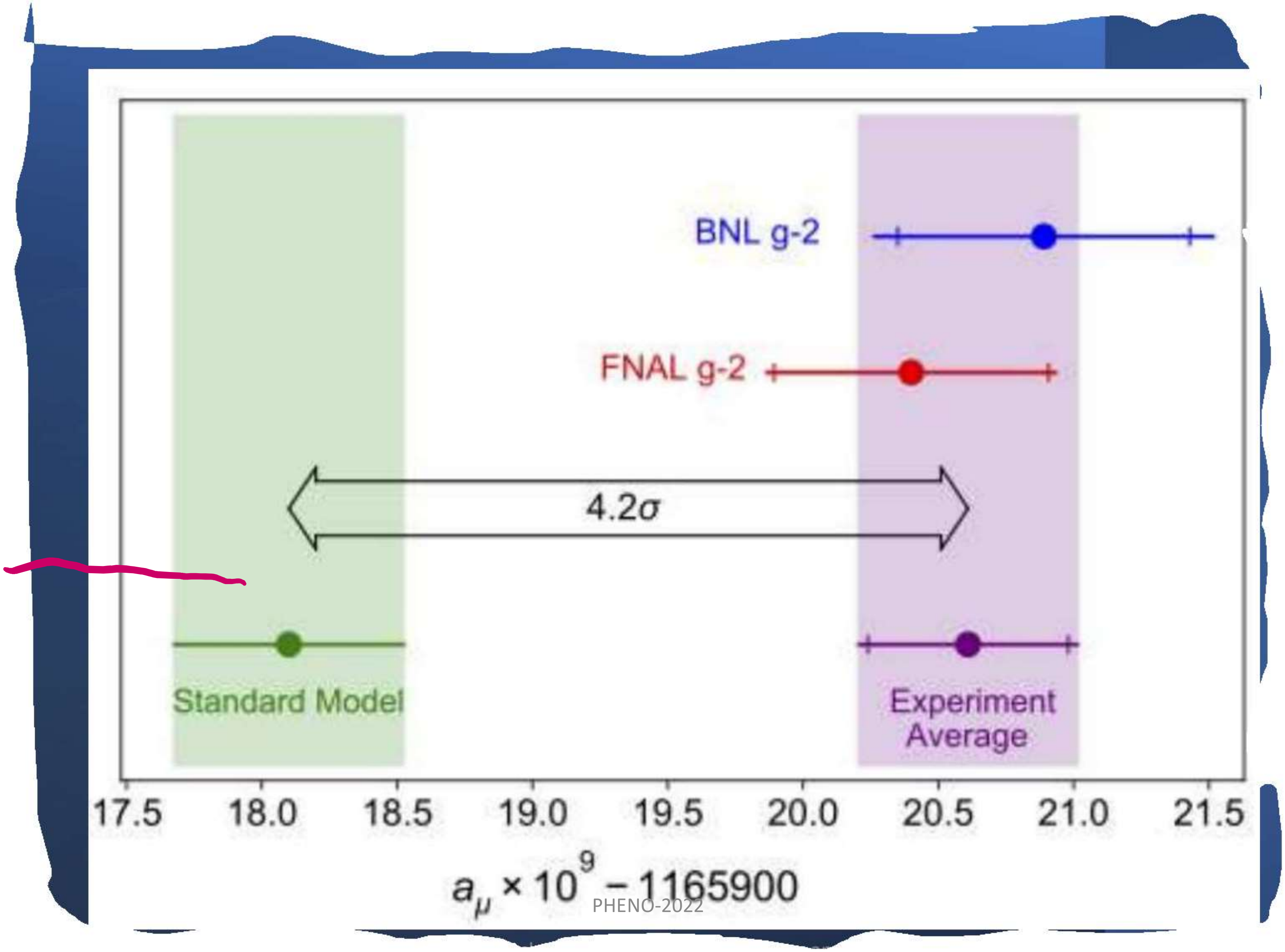
Huge exptal step forward!

$$a_\mu(\text{Exp}) = 116\,592\,061(41) \times 10^{-11} \quad (0.35\,\text{ppm}).$$

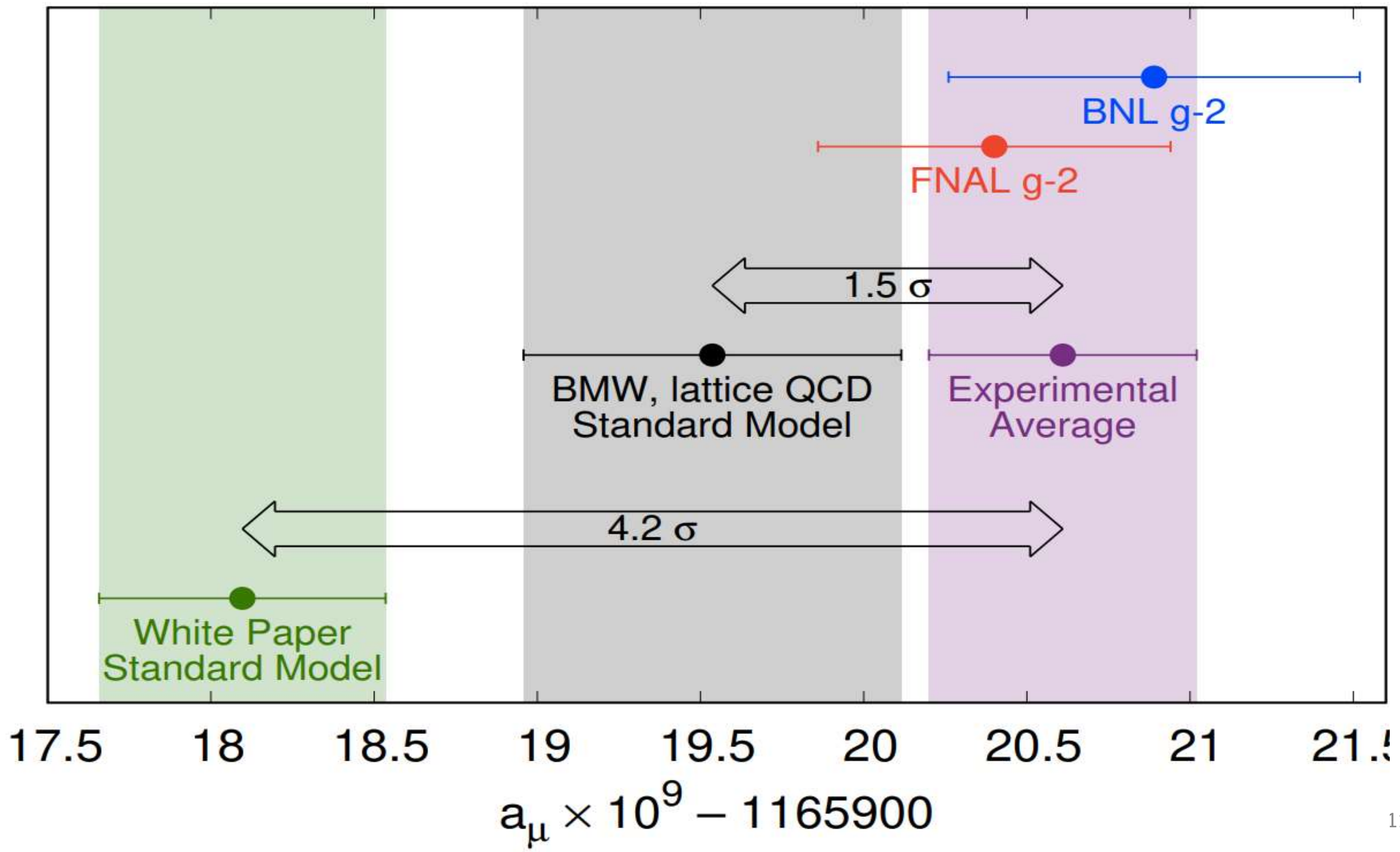
" " → DATA Driven

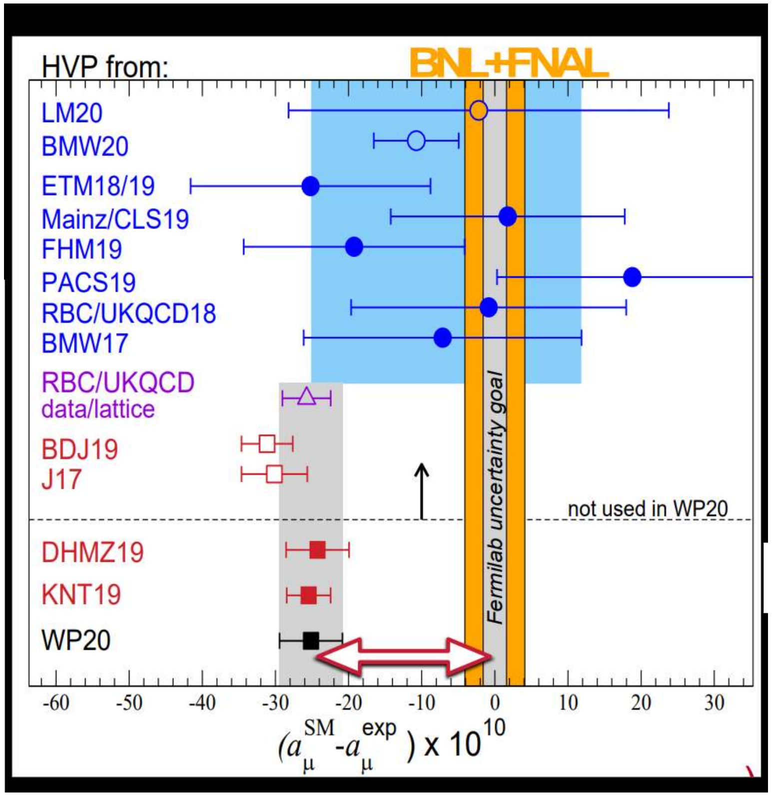
The difference, $a_\mu(\text{Exp}) - a_\mu(\text{SM}) = (251 \pm 59) \times 10^{-11}$, has a significance of $4.2\,\sigma$. These results are displayed in Fig. 4.

DATA DRIVEN R-ratio See White Paper



KALMAN SZABO (BMW) Talk @ "BNL"





BDJ e
pheno21

I

PHYSICAL REVIEW D **96,** 095010 (2017)

$R_{D^{(*)}}$ anomaly: A possible hint for natural supersymmetry with *R*-parity violation

Wolfgang Altmannshofer,[1] P. S. Bhupal Dev,[2] and Amarjit Soni[3]

[1]*Department of Physics, University of Cincinnati, Cincinnati, Ohio 45221, USA*

[2]*Department of Physics and McDonnell Center for the Space Sciences, Washington University, St. Louis, Missouri 63130, USA*

[3]*Physics Department, Brookhaven National Laboratory, Upton, New York 11973, USA*

(Received 5 July 2017; published 15 November 2017)

Recently, several *B*-physics experiments have reported an appreciable deviation from the standard model (SM) in the tree-level observables $R_{D^{(*)}}$; the combined weighted average now stands at $\approx 4\sigma$. We first show the anomaly necessarily implies model-independent collider signals of the form $pp \to b\tau\nu$ that should be expeditiously searched for at ATLAS/CMS as a complementary test of the anomaly. Next we suggest a possible interconnection of the anomaly with the radiative stability of the standard model Higgs boson and point to a minimal effective supersymmetric scenario with *R*-parity violation as the underlying cause. We also comment on the possibility of simultaneously explaining the recently reported $R_{K^{(*)}}$ anomaly in this setup.

If current hints of LUV survive the test of time

- **Under such a watershed departure from the past, we believe, it is very likely that nature is also trying to address some long-standing, persistent issue(s) with the SM. One such basic concern with the SM is the fact that it is exceedingly fine-tuned, i.e. unnatural due to radiative instability of the Higgs which primarily originates from the heaviness of the top quark, a member of the third generation.**

PHYSICAL REVIEW D **96,** 095010 (2017)

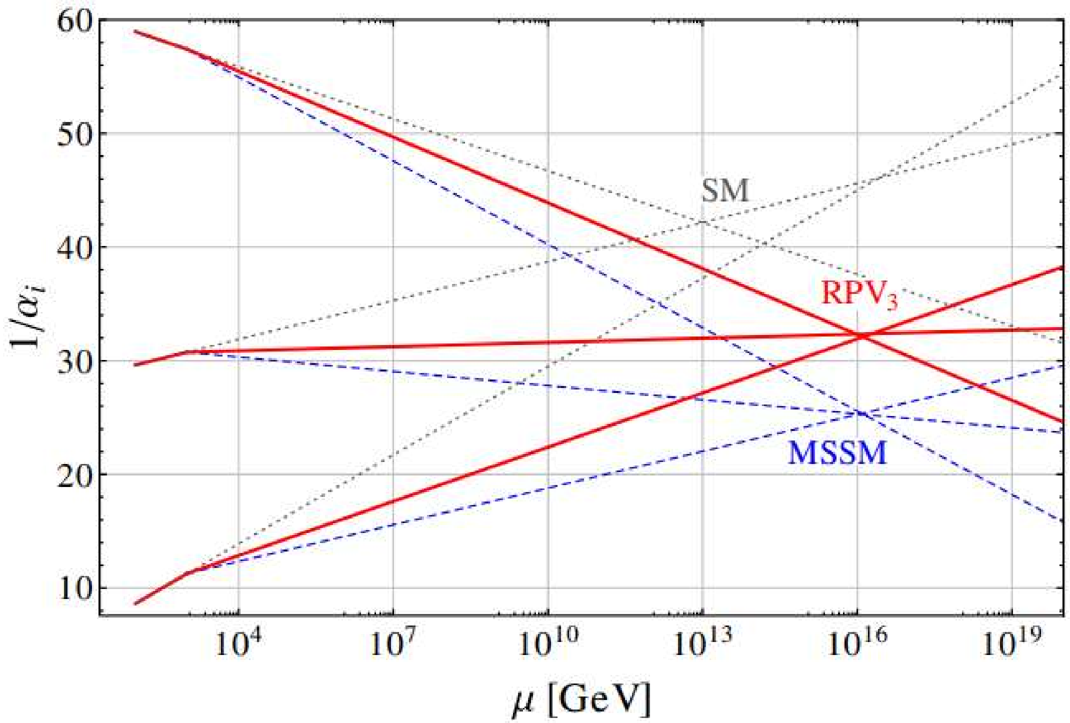


FIG. 2. RG evolution of the gauge couplings in the SM, MSSM and in our natural RPV SUSY scenario.

RPV_3

3rd gen superpartners are lightest

Hints of Natural Supersymmetry in Flavor Anomalies?

P. S. Bhupal Dev,[1,*] Amarjit Soni,[2,†] and Fang Xu[1,‡]

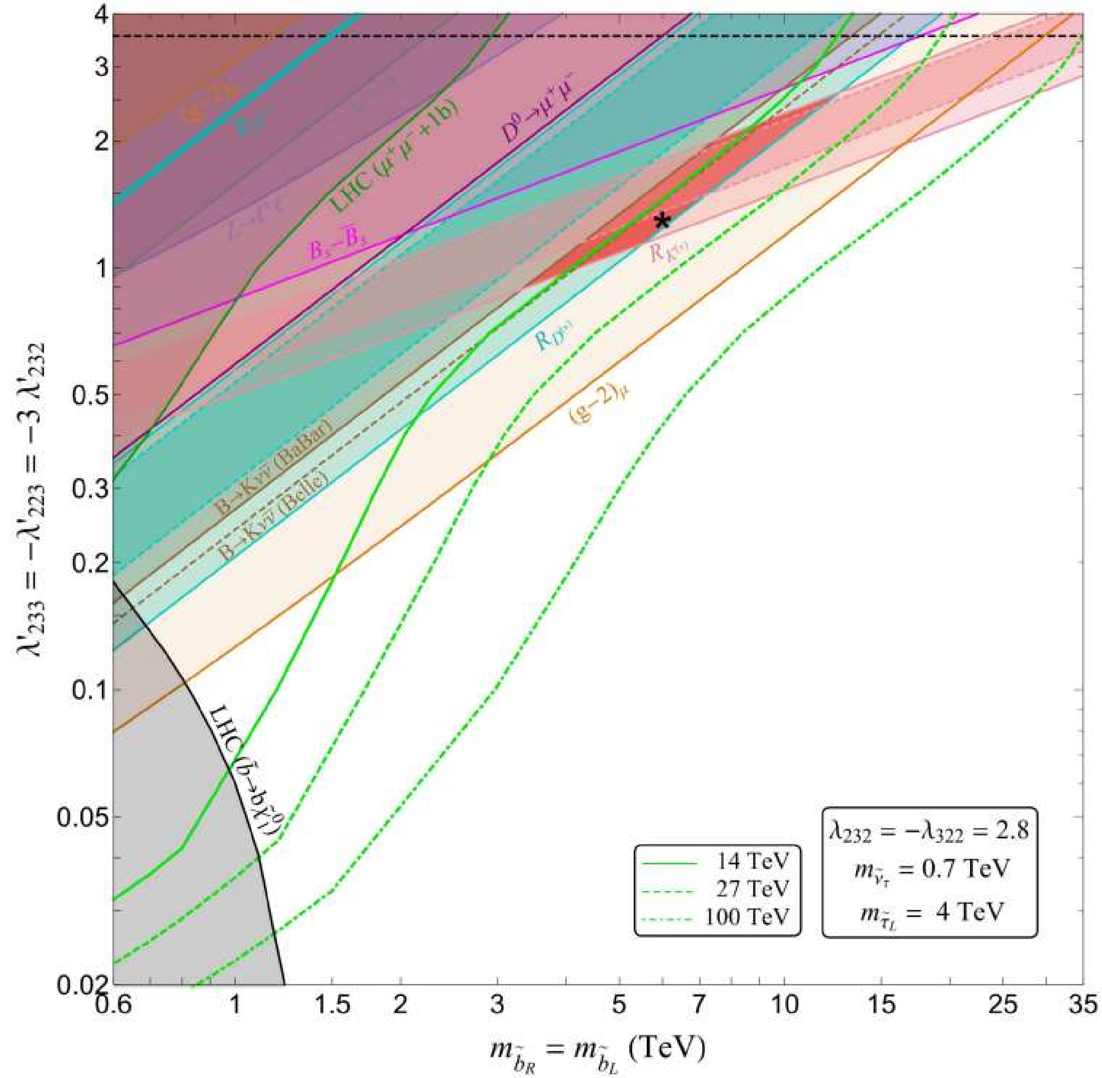
[1] *Department of Physics and McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130, USA*

[2] *Physics Department, Brookhaven National Laboratory, Upton, NY 11973, USA*

The recent results from the Fermilab muon $g-2$ experiment, as well as the persisting hints of lepton flavor universality violation in B-meson decays, present a very strong case for flavor-nonuniversal new physics beyond the Standard Model. We assert that a minimal R-parity violating supersymmetric scenario with relatively light third-generation sfermions (dubbed as 'RPV3') provides a natural, well-motivated framework for the simultaneous explanation of all flavor anomalies, while being consistent with a multitude of low-energy flavor constraints, as well as with limits from high-energy collider searches. We further propose complementary tests and distinct signatures of this scenario in the high-p_T searches at current and future colliders. Specifically, we find that an sbottom in the mass range of 2–12 TeV accounts for $R_{D^{(*)}}$ and $R_{K^{(*)}}$ flavor anomalies and it only plays a minor role in the $(g-2)_\mu$ anomaly, whereas a sneutrino with mass between 0.7–1 TeV is the dominant player for $(g-2)_\mu$. In this context, we propose specific collider signatures of sbottom via its decays to $\bar{t}(t)\mu^+\mu^-$, and of sneutrino pairs with their decays leading to a highly distinctive and spectacular four-muon final state, which can be used to completely probe the RPV3 parameter space of interest.

Generalization of YM=> RPV LUV arises rather naturally

- Note also that, as a necessary **generalization of the Yang-Mills theory [42], all the interactions allowed by the enlarged internal [Bose-Fermi] symmetry readily remove the accidental flavor symmetry of the SM and lead naturally to LFUV**.



$\lambda'_{233} = -\lambda'_{223} = -3\ \lambda'_{232}$
$m_{\tilde{b}_R} = m_{\tilde{b}_L}$ (TeV)
LHC ($\mu^+\mu^-$+1b)
$D^0 \to \mu^+\mu^-$
$B_s - \bar{B}_s$
$R_{K^{(*)}}$
$R_{D^{(*)}}$
$(g-2)_\mu$
$B \to K\nu\bar{\nu}$ (BaBar)
$B \to K\nu\bar{\nu}$ (Belle)
LHC ($\tilde{b} \to b\tilde{\chi}_1^0$)
14 TeV
27 TeV
100 TeV
$\lambda_{232} = -\lambda_{322} = 2.8$
$m_{\tilde{\nu}_\tau} = 0.7$ TeV
$m_{\tilde{\tau}_L} =$ 4 TeV

(a) BP1 (Red)

FIG. 5. Three RPV3 benchmark cases in the $(m_{\tilde{b}_R}, \lambda'_{233})$ parameter space explaining the flavor anomalies. The cyan, pink and orange shaded regions with solid (dashed) boundaries explain the $R_{D^{(*)}}$, $R_{K^{(*)}}$ and $(g-2)_\mu$ anomalies at 3σ (2σ) respectively. The black-shaded region is excluded by the current LHC search for sbottoms in the bottom+neutralino channel, whereas the dark green-shaded region is the LHC exclusion derived from a $\mu^+\mu^- + 1b$ search. The horizontal dotted line shows the perturbativity limit of $\sqrt{4\pi}$. Other shaded regions show the relevant low-energy flavor constrains on the parameter space from $B \to K\nu\bar{\nu}$ (brown), $B_s - \bar{B}_s$ mixing (magenta), $D^0 \to \mu^+\mu^-$ (purple), $b \to s\gamma$ (grey) and $Z \to \ell^+\ell^-$ (violet). The allowed overlap regions simultaneously explaining the $R_{D^{(*)}}$, $R_{K^{(*)}}$ and $(g-2)_\mu$ anomalies are shown by the red (top), yellow (bottom left) and blue (bottom right) shaded regions for the three benchmark cases. The $*$ mark on the top panel gives representative values of $m_{\tilde{b}_R}$ and λ'_{233} in the BP1 scenario that are used in Fig. 6. The green solid, dashed and dot-dashed contours respectively show the 2σ sensitivities of the 14 TeV LHC, 27 TeV and 100 TeV pp colliders in the $\bar{t}\mu^+\mu^-$ channel discussed in the text.

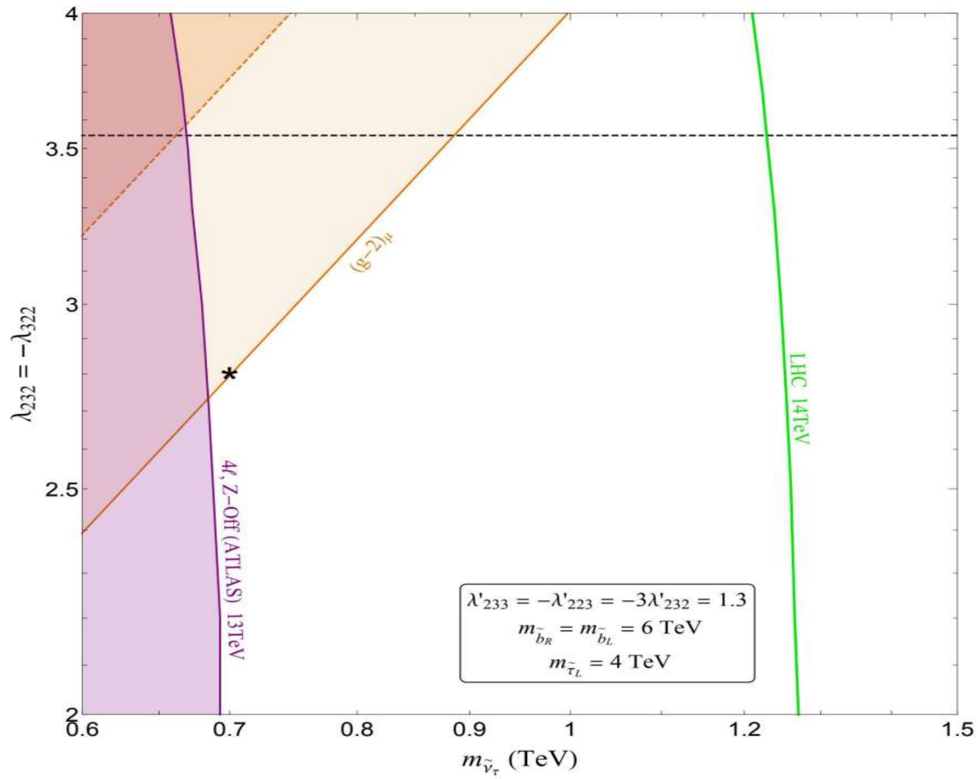


FIG. 6. The $(g-2)_\mu$-preferred region (orange-shaded) of the RPV3 parameter space. The purple-shaded region is excluded by a 13 TeV LHC multi-lepton search [98], whereas the green curve is the 14 TeV HL-LHC sensitivity. The horizontal dashed line is the perturbativity limit. The $*$ gives representative values of $m_{\tilde{\nu}_\tau}$ and λ_{232} used in Fig. 5.

Summary /Outlook/Conclusion

- **Hints of LUV are extremely interesting, intriguing and important.** ***There is nothing we know of that tells us that these hints cannot be true.***
- ***Babar deviations for RD(*) are the largest amongst the three experiments. Should this be a concern?***
- ***For the above reason as well as for confirming (or refuting) LHC results on RK(*), Belle-II results with increased luminosity are eagerly awaited.***
- **Fortunately significant experimental/theoretical progress should occur in < ~2 years and is eagerly awaited.**
- **Meantime, 3rd generation centric RPV_SUSY is an interesting theoretical framework that can accommodate such deviations from SM if they survive**

Conclusion

B Dev@LBL
April 2022

- Mounting evidence for the violation of lepton flavor universality.
  [Crivellin, Hoferichter, 2111.1273 (Science '21)]
- Can be explained by invoking BSM physics.
- Leptoquarks and RPV-SUSY remain as the most attractive scenarios for a simultaneous explanation of B-anomalies and muon $g-2$.
- Personal choice: **RPV3** – motivated by Higgs naturalness and other beautiful features of SUSY, while being consistent with null searches at the LHC.
  - Removes the accidental flavor symmetry of the SM.
  - Same chiral structure as the SM $\Longrightarrow$ correct D^* and τ polarizations, as well as $R_K - R_{K(*)}$ correlation come automatically.
  - Highly predictive and testable at Belle II, LHCb and high-p_T LHC experiments.
  - Improved lattice input for $B \to K\nu\bar{\nu}$ and $B_s - \overline{B}_s$ will be crucial.
  - **Flavor anomalies might be providing the first experimental hint of SUSY!**

RPV-SUSY
Subsumes
chirality SM

XTRAS

Parameters and benchmark scenario

- Furthermore, assume $(\lambda_{232}, \lambda'_{233} = -\lambda'_{223} = -3\lambda'_{232}, m_{\tilde{b}_R} = m_{\tilde{b}_L}, m_{\tilde{\nu}_\tau}, m_{\tilde{\tau}_L} = 4\text{TeV})$ then we can plot the anomalies and constraints in the two-dimensional parameter space: $(\lambda'_{233}, m_{\tilde{b}_R})$ and $(\lambda_{232}, m_{\tilde{\nu}_\tau})$
  - $m_{\tilde{b}_R} = m_{\tilde{b}_L}$ for simplicity.
  - $m_{\tilde{\tau}_L}$ has opposite contribution for $(g-2)_\mu$. The influence is not important as long as $m_{\tilde{\tau}_L} \gtrsim O(1\text{TeV})$. Here we choose 4 TeV.
  - $\lambda'_{233} = -\lambda'_{223} \Leftarrow \lambda'_{233}$, λ'_{223} and $m_{\tilde{b}_R}$ are the only parameters that influence $R_{D^{(*)}}$ and $R_{K^{(*)}}$ in our scenario. Assuming $\lambda'_{233} = \epsilon_1 \lambda'_{223}$, we found that $\epsilon_1 \sim (-3, -1)$ will give an overlap region of $R_{D^{(*)}}$ and $R_{K^{(*)}}$. When $|\epsilon_1|$ decrease, the coupling λ'_{233} of the overlap region will also decrease, so we choose $\epsilon_1 = -1$ here.
  - $\lambda'_{233} = -\lambda'_{223} = -3\lambda'_{232} \Leftarrow \lambda'_{233}$, λ'_{223}, λ'_{232}, $m_{\tilde{b}_R}$ and $m_{\tilde{b}_L}$ are relevant for the constraints of $B \to K\nu\overline{\nu}$, $B_s - \overline{B}_s$ mixing and $D^0 \to \mu^+\mu^-$. Assuming $\lambda'_{233} \approx -\lambda'_{223} = \epsilon_2 \lambda'_{232}$, we found that $\epsilon_2 \sim (-6, -2)$, where $\epsilon_2 = -3$ gives the best fit.

RECAP

- **3 different major B-experiments**
- **3 with B => D**
- **7 with B=> D***
- **1 with Bc => ψ**
- **9 with tau => l (l=μ or e) nu nu'** → Total 3ν's/event
- **2 with tau => hadron + nu** → 2ν's/event
- **Each and everyone of the 11 experimental results seem to imply tau is NOT just a heavy muon(electron) as dictated by SM.**
- **Does it mean then a breakdown of LU in charge currents?**

Conclusions

LHCb-PAPER-2021-044
arxiv:2201:03497

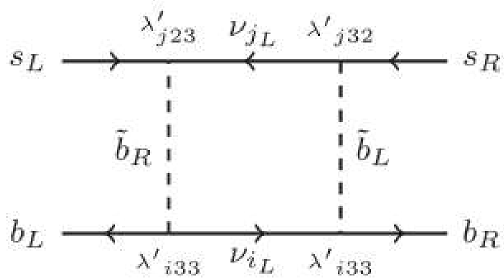
- The decay $\Lambda_b^0 \to \Lambda_c^+ \tau^- \overline{\nu}_\tau$ has been observed for the first time with a significance of 6.1 σ
  - $\mathcal{K}(\Lambda_c^+)$ = 2.46 ± 0.27 (stat) ± 0.40 (syst)
  - $\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ \tau^- \overline{\nu}_\tau)$= (1,50 ± 0,16 (stat) ± 0,25 (sys) ± 0,23 (ext)) %
  - $\mathcal{R}(\Lambda_c^+)$=0.242 ± 0.026 (stat) ± 0.040 (syst) ± 0.059 (ext)
- Everything compatible with SM (~1 σ below)
- A fraction of the parameter space of effective theories with only one vector, axial-vector or tensor couplings can be excluded

Similarly, we do not include the $(g-2)_e$ anomaly, because of a $> 5\sigma$ discrepancy between the Cs [73] and Rb [74] measurements of the fine-structure constant, so it is not clear which of these results should be used for comparison of the experimental value with the SM prediction [75] for $(g-2)_e$.

$$\mathcal{L}_{LQD} = \lambda'_{ijk}[\tilde{\nu}_{iL}\bar{d}_{kR}d_{jL} + \tilde{d}_{jL}\bar{d}_{kR}\nu_{iL} + \tilde{d}^*_{kR}\bar{\nu}^c_{iL}d_{jL} - \tilde{e}_{iL}\bar{d}_{kR}u_{jL} - \tilde{u}_{jL}\bar{d}_{kR}e_{iL} - \tilde{d}^*_{kR}\bar{e}^c_{iL}u_{jL}] + \text{H.c.} \quad (21)$$

$$\mathcal{L}_{LLE} = \frac{1}{2}\lambda_{ijk}[\tilde{\nu}_{iL}\bar{e}_{kR}e_{jL} + \tilde{e}_{jL}\bar{e}_{kR}\nu_{iL} + \tilde{e}^*_{kR}\bar{\nu}^c_{iL}e_{jL} - (i \leftrightarrow j)] + \text{H.c.} \quad (22)$$

$$\Delta a_\mu = \frac{m_\mu^2}{96\pi^2}\sum_{k=1}^{3}\left(\frac{2(|\lambda_{32k}|^2 + |\lambda_{3k2}|^2)}{m^2_{\tilde{\nu}_\tau}} - \frac{|\lambda_{3k2}|^2}{m^2_{\tilde{\tau}_L}} - \frac{|\lambda_{k23}|^2}{m^2_{\tilde{\tau}_R}} + \frac{3|\lambda'_{2k3}|^2}{m^2_{\tilde{b}_R}}\right).$$

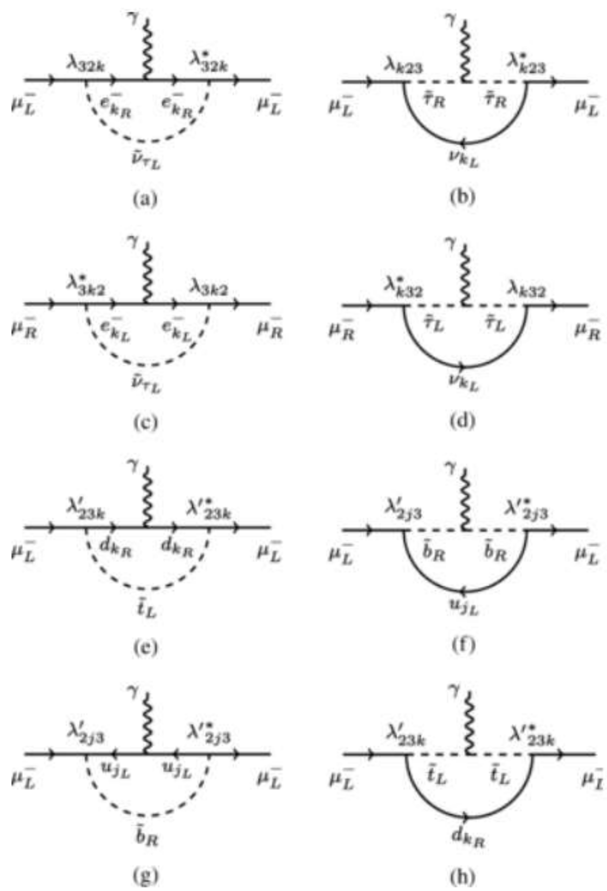


(c)

ADSS '20

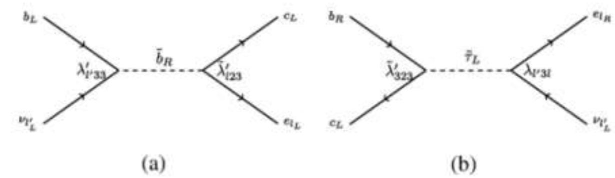
Explanation of anomalies in RPV3 SUSY

$(g-2)_\mu$ Kim, Kyae, Lee (PLB 2001)



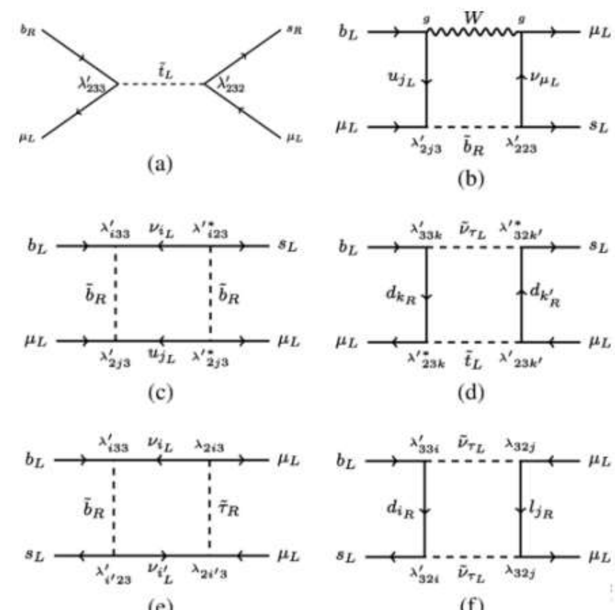
$R_{D^{(*)}}$ Deshpande, He (EPJC 2017); Altmannshofer, Dev, Soni (PRD 2017) etc.

RPV



RPV3

$R_{K^{(*)}}$ Das, Hati, Kumar, Mahajan (PRD 2017); Trifinopoulos (EPJC 2018) etc.



For $R_K + R_{K^*}$ BOTH Tree + LOOP ARE ESSENTIAL

PHENO-2022

Crossing-symmetry on RD(*); RK(*)=> c ADS’[17]; ADSS[20]

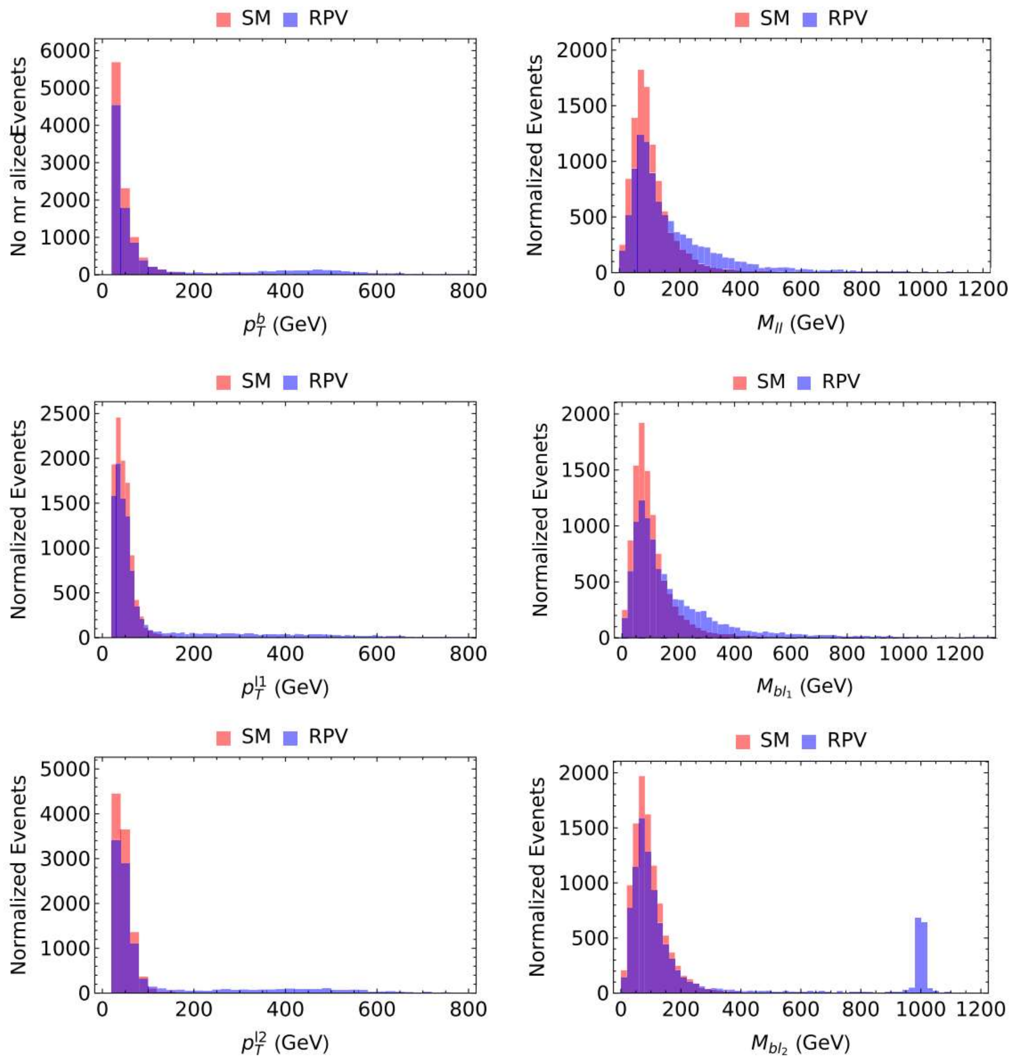


FIG. 23. Kinematic distributions for the $pp \to b\ell_1\ell_2$ signal in the RPV model (blue) and the corresponding SM background (red). The left panels show the transverse momentum distributions for the bottom quark and the two charged leptons, whereas the right panel shows the invariant mass distributions for the dilepton and the two bottom quark–lepton combinations. In the RPV3 model under consideration, the right combination of M_{bl} gives a peak at the squark mass, as shown in the last plot.

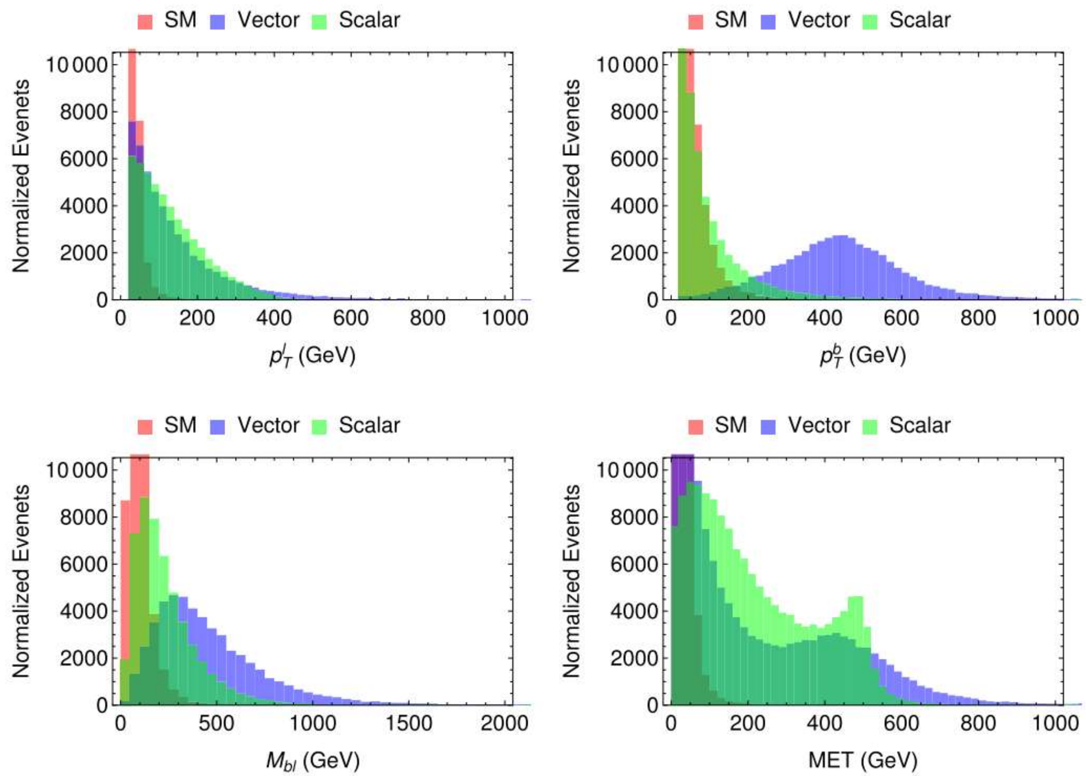


FIG. 1. Normalized kinematic distributions for the $pp \to b\tau\nu \to b\ell + \not{E}_T$ signal and background.

c+g→bℓν

RPV3 SUSY

- More natural to include RPV couplings. [Brust, Katz, Lawrence, Sundrum (JHEP '12)]
- Preserves gauge coupling unification. [Altmannshofer, BD, Soni (PRD '17)]
- **RPV3**: RPV SUSY with light 3rd-generation sfermions.
- Can naturally accommodate $R_{D^{(*)}}$ ($b \to c\tau\nu$) via LQD interactions. [Deshpande, He (EPJC '17); Altmannshofer, BD, Soni (PRD '17); Trifinopoulos (EPJC '18); Hu, Li, Muramatsu, Yang (PRD '19)]

$$\mathcal{L}_{LQD} = \lambda'_{ijk}\left[\widetilde{\nu}_{iL}\bar{d}_{kR}d_{jL} + \widetilde{d}_{jL}\bar{d}_{kR}\nu_{iL} + \widetilde{d}^{*}_{kR}\bar{\nu}^{c}_{iL}d_{jL} - \widetilde{e}_{iL}\bar{d}_{kR}u_{jL} - \widetilde{u}_{jL}\bar{d}_{kR}e_{iL} - \widetilde{d}^{*}_{kR}\bar{e}^{c}_{iL}u_{jL}\right] + \mathrm{H.c.}$$

- Can *simultaneously* explain $R_{K^{(*)}}$ ($b \to s\ell\ell$) by invoking LLE interactions, together with LQD. [Das, Hati, Kumar, Mahajan (PRD '17); Earl, Grégoire (JHEP '18); Trifinopoulos (EPJC '18); Hu, Huang (PRD '20); Altmannshofer, BD, Soni, Sui '20]

$$\mathcal{L}_{LLE} = \frac{1}{2}\lambda_{ijk}\left[\widetilde{\nu}_{iL}\bar{e}_{kR}e_{jL} + \widetilde{e}_{jL}\bar{e}_{kR}\nu_{iL} + \widetilde{e}^{*}_{kR}\bar{\nu}^{c}_{iL}e_{jL} - (i \leftrightarrow j)\right] + \mathrm{H.c.}$$

- Restricting to RPV3 and using some ansatz, we'll limit the number of independent λ' and λ couplings.

7'

B-anomalies in RPV3

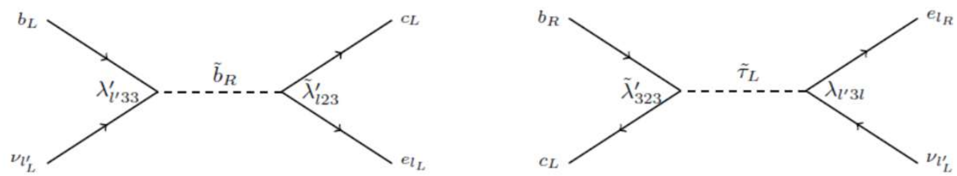


Figure: RPV3 contributions to $R_{D^{(*)}}$. [Deshpande, He (EPJC ’17); Altmannshofer, BD, Soni (PRD ’17); · · ·]

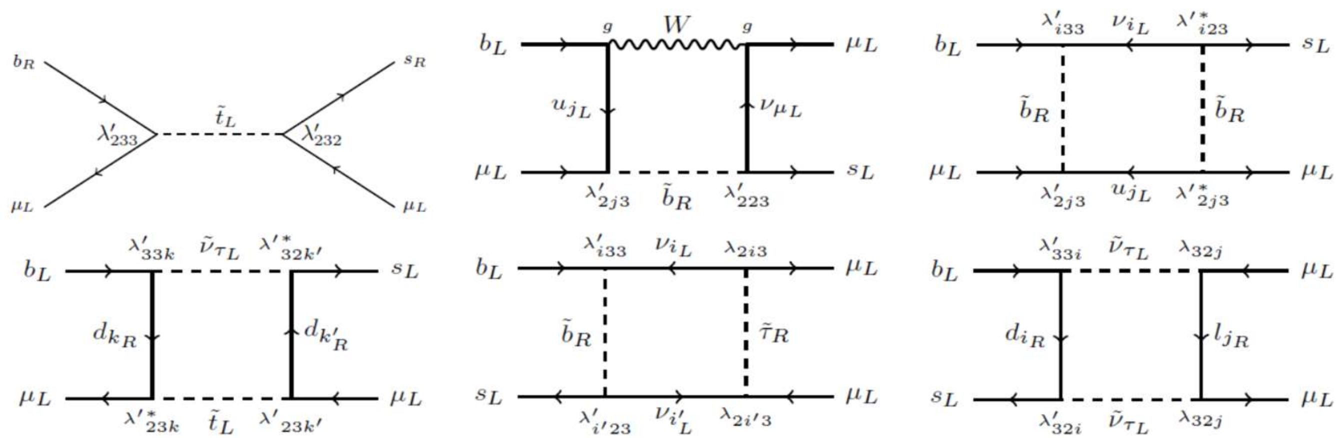


Figure: RPV3 contributions to $R_{K^{(*)}}$. [Das, Hati, Kumar, Mahajan (PRD ’17); Trifinopoulos (EPJC ’18)]

Muon $g-2$ and ANITA

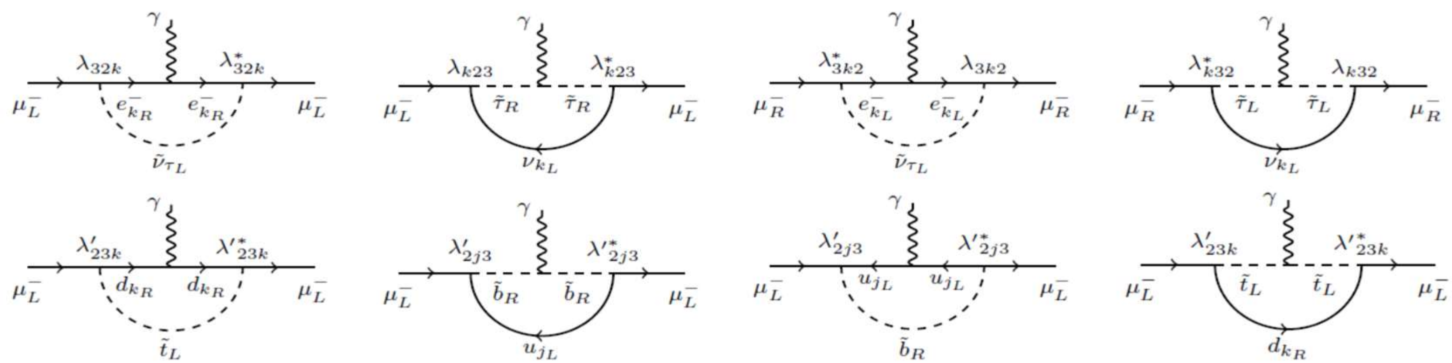


Figure: RPV3 contributions to $(g-2)_\mu$. [Kim, Kyae, Lee (PLB '01)]

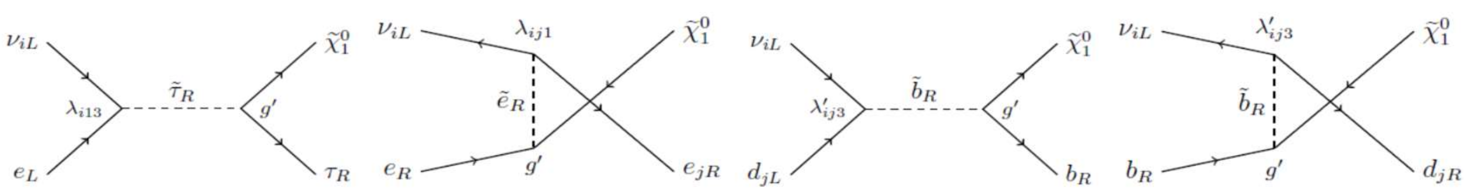
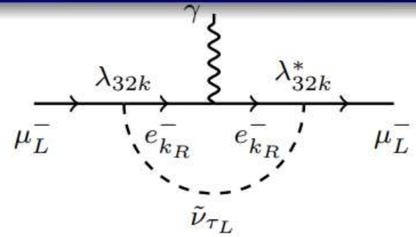
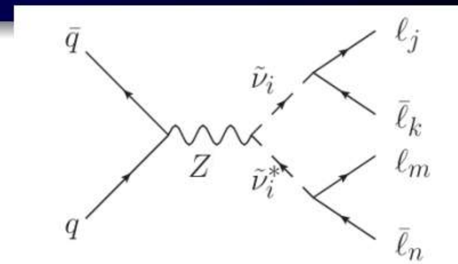
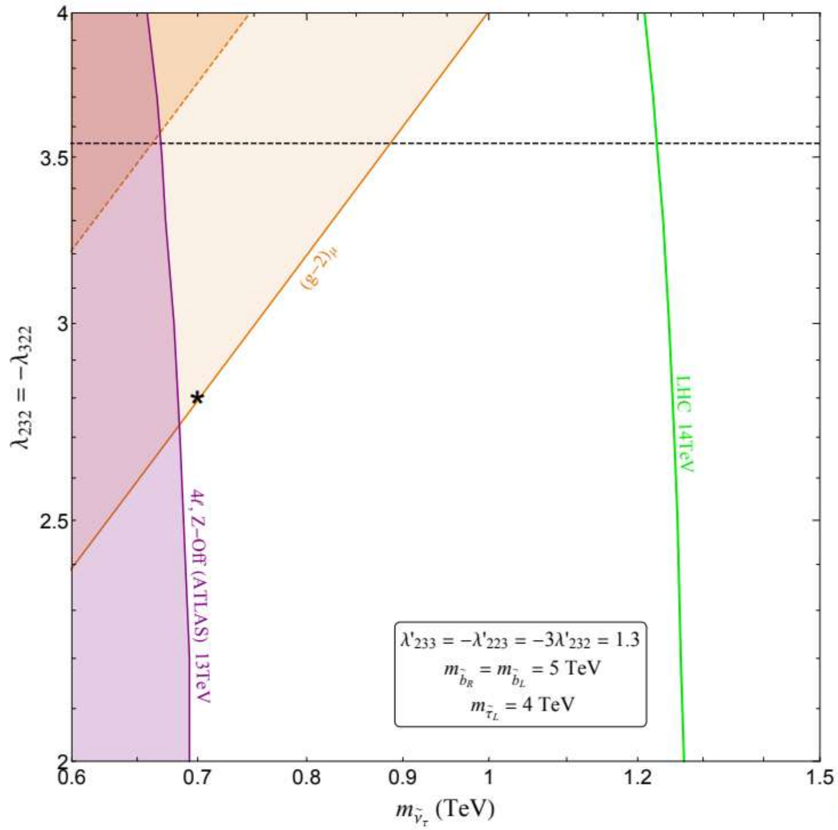


Figure: RPV3 contributions to ANITA anomalous events. [Collins, BD, Sui (PRD '19)]

An LHC Test of Muon $g-2$







[BD, Soni, Xu (2106.15647)]

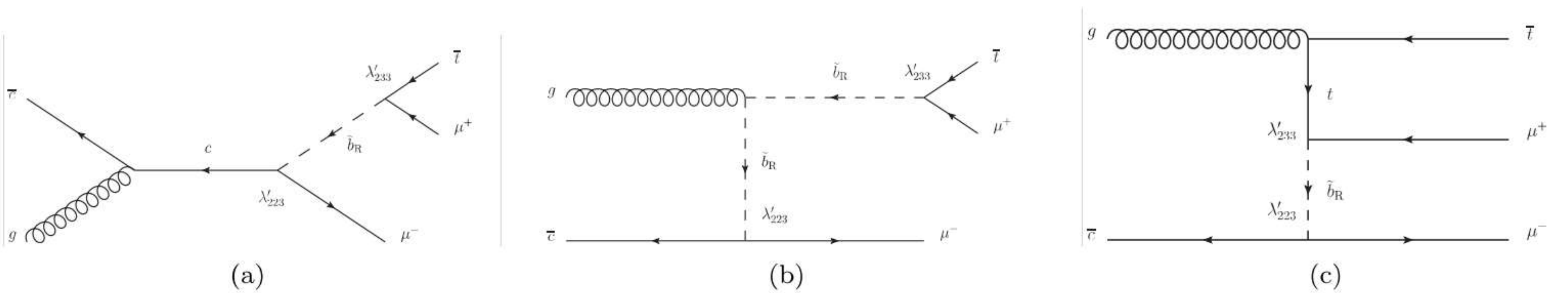


FIG. 7. Representative Feynman diagrams for the signal process $pp \to \bar{t}\mu^+\mu^-$. There are similar diagrams for the process $pp \to t\mu^+\mu^-$, however the SM background is larger for top-quark final states, compared to the anti-top, so we only consider the latter case for drawing the sensitivity contours in Fig. 5.