The anatomy of quark flavour observables in the flavour precision era

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Two topics

- Improving data precision and reducing theoretical uncertainties (FPE) would it be possible to understand from flavour observables if the lightest NP messanger is a new Z' gauge boson?
- an existing tension: exclusive semileptonic b $\to$ c decays: anomalous enhancement of modes with a τ in the final state

Based on works in collaboration with
A.J. Buras, J. Girrbach (Munich)
&
P. Biancofiore, P. Colangelo (Bari)

Anatomy of Z' with FCNC in the FPE

A.J. Buras, J. Girrbach, FDF
JHEP 1302 (2013) 116

- CKM parameters have been determined by means of tree-level decays
- Non-perturbative parameters are affected by very small uncertainties and fixed

Let us consider the following case

- There exists a new neutral gauge boson Z' mediating tree-level FCNC processes $M_{Z'}$=1 TeV for definiteness

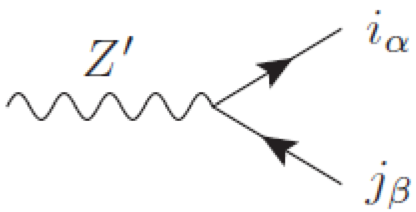
- Couplings to quarks are arbitrary while those to leptons are assumed already determined by purely leptonic modes

Existing data constrain Z' couplings to quarks

Four possible scenarios for such couplings can be considered

Predictions on correlations among flavour observables provide the path to identify which, in any, of them is realized in nature

Anatomy of Z' with FCNC in the FPE



$$i\gamma_\mu\delta_{\alpha\beta}\left[\Delta_L^{ij}(Z')P_L + \Delta_R^{ij}(Z')P_R\right]$$

1. Left-handed Scenario (LHS) with complex $\Delta_L^{bq} \neq 0$ and $\Delta_R^{bq} = 0$,
2. Right-handed Scenario (RHS) with complex $\Delta_R^{bq} \neq 0$ and $\Delta_L^{bq} = 0$,
3. Left-Right symmetric Scenario (LRS) with complex $\Delta_L^{bq} = \Delta_R^{bq} \neq 0$,
4. Left-Right asymmetric Scenario (ALRS) with complex $\Delta_L^{bq} = -\Delta_R^{bq} \neq 0$

Analogous scenarios can be considered for the quark pairs (bs) and (sd)

Two cases

1. |Vub| fixed to the exclusive (smaller) value
2. |Vub| fixed to the inclusive (larger) value

Anatomy of Z' with FCNC in the FPE: the B_s system

We consider the four observables:

$$\Delta M_s, \quad S_{\psi\phi}, \quad \mathcal{B}(B_s \to \mu^+\mu^-), \quad S^s_{\mu^+\mu^-},$$

- ΔM_s: Mass difference in the $\bar{B}_s - B_s$ system
- $S_{\psi\phi}$: CP asymmetry in $B_s \to J/\psi\, \phi$
- $S^s_{\mu^+\mu^-}$: CP asymmetry in $B_s \to \mu^+\mu^-$

They depend all on

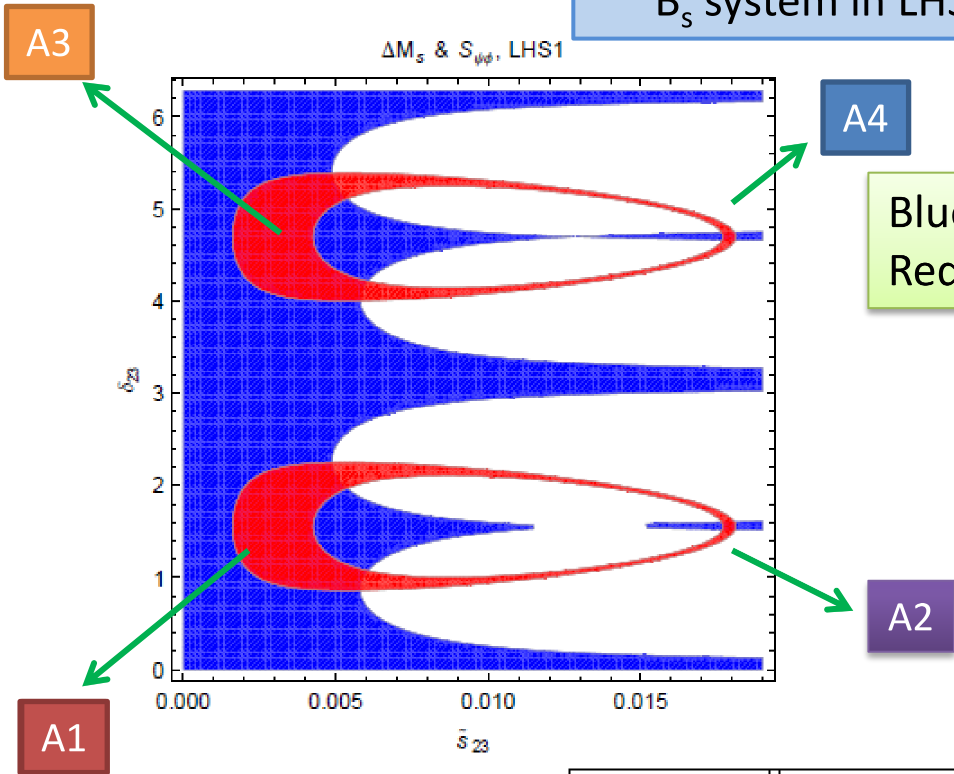
$$\frac{\Delta_L^{bs}(Z')}{M_{Z'}} = -\frac{\tilde{s}_{23}}{M_{Z'}} e^{-i\delta_{23}}$$

Imposing the experimental constraints:
we find allowed ranges for the parameters

$$16.9/\text{ps} \le \Delta M_s \le 18.7/\text{ps}, \quad -0.18 \le S_{\psi\phi} \le 0.18,$$

$s_{23} > 0$ & **$0 < \delta_{23} < 2\pi$**

B_s system in LHS1 scenario



Blue regions come from the constraint on $S_{\psi\phi}$
Red ones from the constraint on ΔM_s

Four allowed oases:
two *big* ones & two *small* ones

	$\tilde{s}_{23}$	δ_{23}	
$A_1(S1)$	$0.0016 - 0.0061$	$49° - 129°$	Big
$A_2(S1)$	$0.0176 - 0.0181$	$87° - 92°$	Small
$A_3(S1)$	$0.0016 - 0.0061$	$229° - 309°$	Big
$A_4(S1)$	$0.0176 - 0.0181$	$267° - 272°$	Small

How to find the optimal oasis?

The decay $B_s \to \mu^+ \mu^-$

SM effective hamiltonian $\rightarrow$ one master function $Y_0(x_t)$

$$x_t = m_t^2/M_W^2$$

$$Y_0(x_t) = \frac{x_t}{8}\left(\frac{x_t-4}{x_t-1} + \frac{3x_t \log x_t}{(x_t-1)^2}\right)$$

$\rightarrow$ independent on the decaying meson and on the lepton flavour

Z' contribution modifies this function to:

$$Y_A(B_q) = \eta_Y Y_0(x_t) + \frac{[\Delta_A^{\mu\bar{\mu}}(Z')]}{M_{Z'}^2 g_{SM}^2}\left[\frac{\Delta_L^{qb}(Z') - \Delta_R^{qb}(Z')}{V_{tq}^* V_{tb}}\right] \equiv |Y_A(B_q)| e^{i\theta_Y^{B_q}}$$

The various scenarios predict different results

a new phase

Theoretically clean observable:

$$S_{\mu^+\mu^-}^s = \sin(2\theta_Y^{B_s} - 2\varphi_{B_s})$$

phase of the function S entering in the box diagram vanishes in SM

the new phase involved

LHCb 1211.2674

$$\mathcal{B}(B_s \to \mu^+\mu^-) = (3.2^{+1.5}_{-1.2}) \times 10^{-9}$$

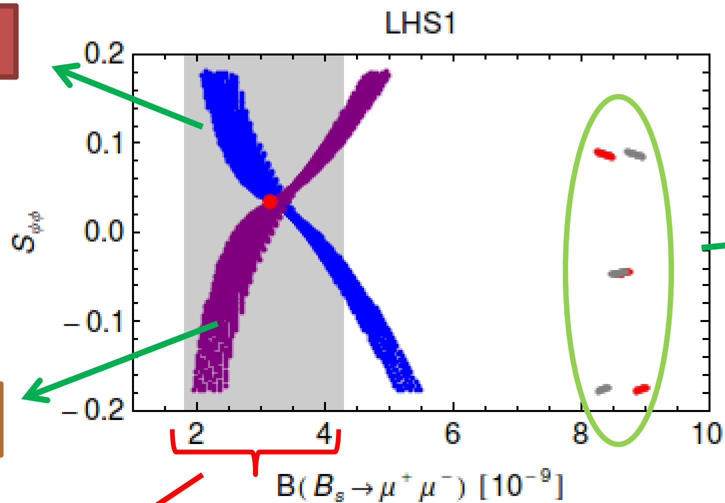
SM

$$\mathcal{B}(B_s \to \mu^+\mu^-)^{SM} = (3.23 \pm 0.27) \times 10^{-9}$$

The decay $B_s \to \mu^+ \mu^-$

A1

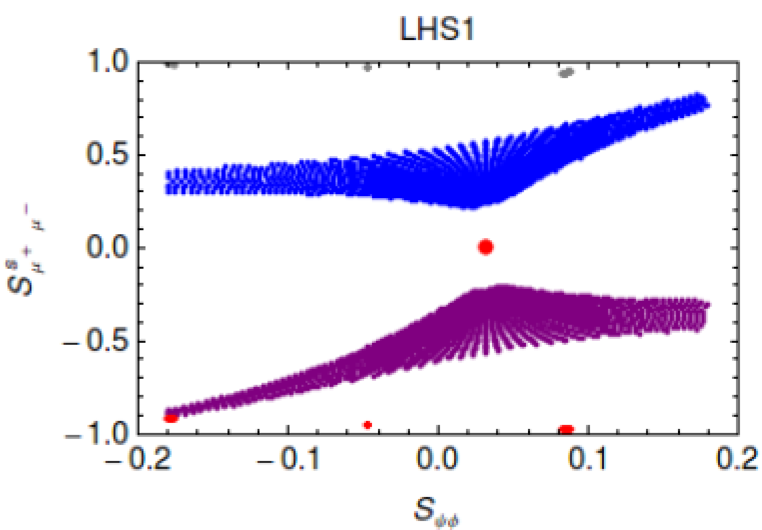
A3



small oases

exp 1 σ range

Excludes the small oases



$S_{\mu+\mu-}$ >0 would choose A1
$S_{\mu+\mu-}$ <0 would choose A3

No differences found in LHS2

Anatomy of Z' with FCNC in the FPE: the B_d system

We consider the four observables:

$$\Delta M_d, \quad S_{\psi K_S}, \quad \mathcal{B}(B_d \to \mu^+\mu^-), \quad S^d_{\mu^+\mu^-}$$

Mass difference in the $\bar{B}_d - B_d$ system

CP asymmetry in $B_d \to J/\psi K_s$

CP asymmetry in $B_d \to \mu^+\mu^-$

They depend all on

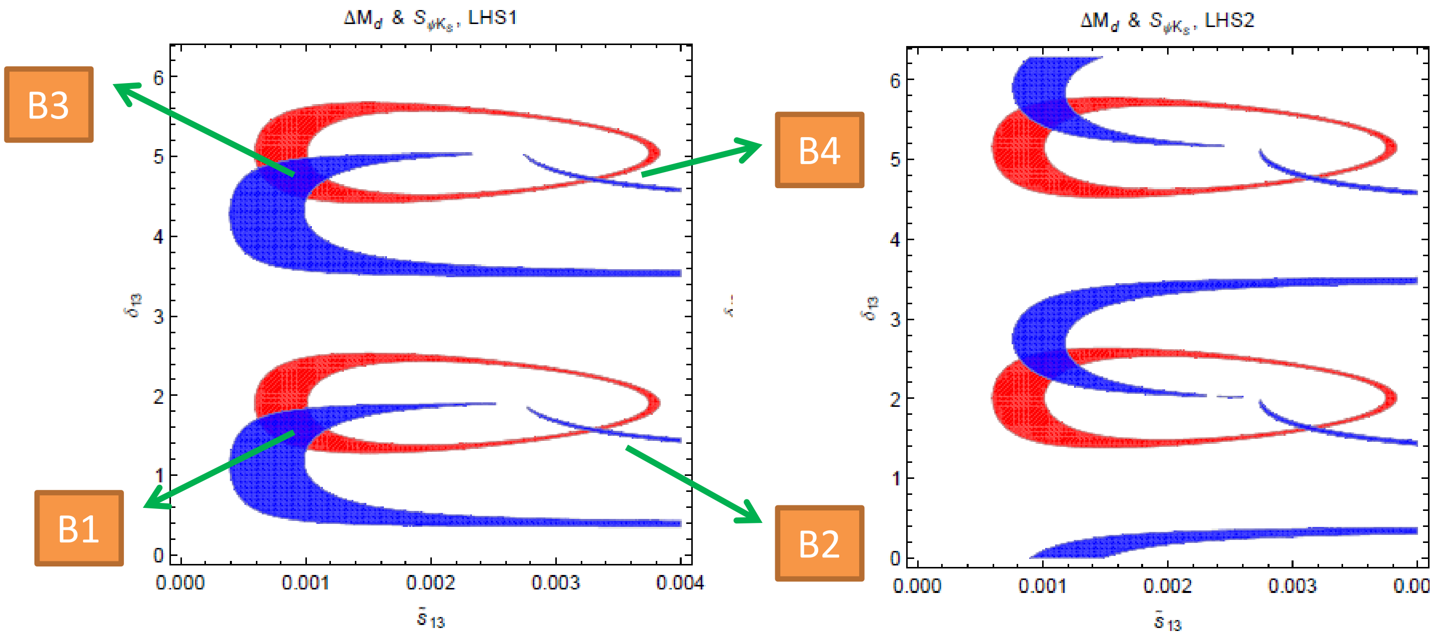
$$\frac{\Delta_L^{bd}(Z')}{M_{Z'}} = \frac{\tilde{s}_{13}}{M_{Z'}} e^{-i\delta_{13}}$$

Imposing the experimental constraints:
we find allowed ranges for the parameters

$$0.48/\mathrm{ps} \le \Delta M_d \le 0.53/\mathrm{ps}, \quad 0.64 \le S_{\psi K_S} \le 0.72.$$

$s_{13} > 0$ & **$0 < \delta_{13} < 2\pi$**

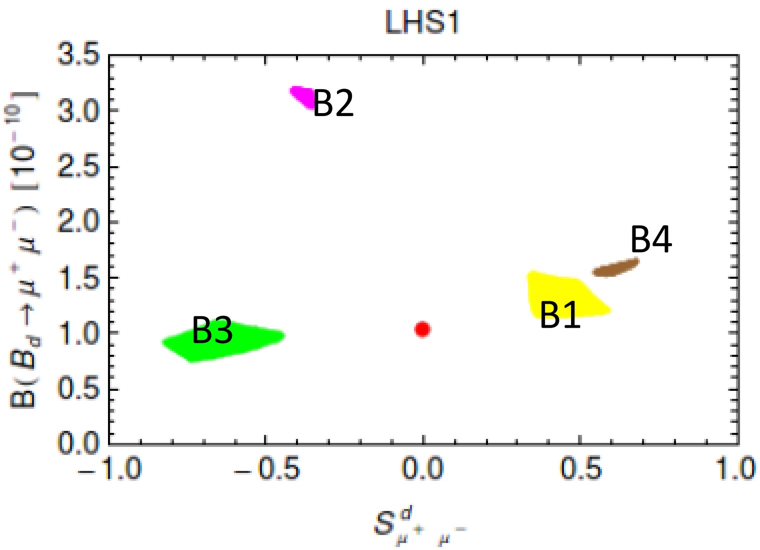
B_d system in LHS1 & LHS2 scenarios

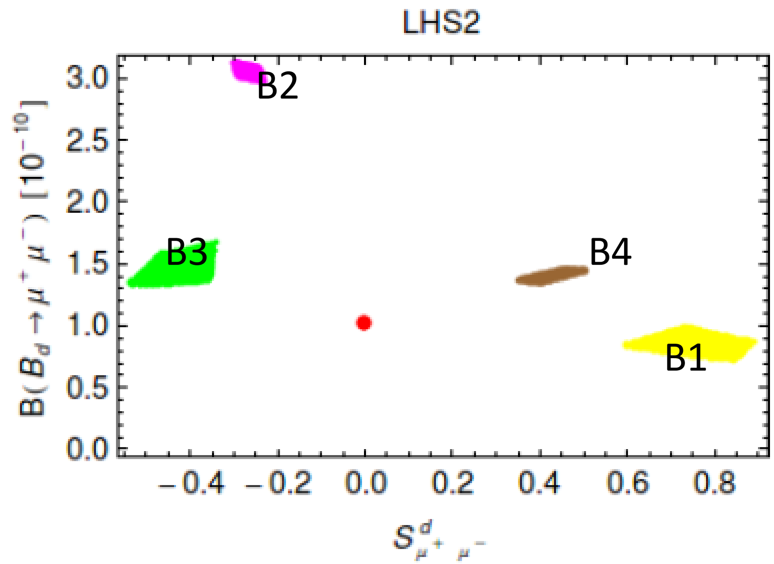


Blue regions $\rightarrow S_{\psi Ks}$
Red ones $\rightarrow \Delta M_d$

	$\tilde{s}_{13}$	δ_{13}
$B_1(S1)$	$0.00062 - 0.00117$	$76° - 105°$
$B_2(S1)$	$0.00322 - 0.00337$	$89° - 91°$
$B_3(S1)$	$0.00062 - 0.00117$	$256° - 285°$
$B_4(S1)$	$0.00322 - 0.00337$	$269° - 271°$
$B_1(S2)$	$0.00081 - 0.00128$	$128° - 150°$
$B_2(S2)$	$0.00306 - 0.00322$	$92° - 95°$
$B_3(S2)$	$0.00081 - 0.00128$	$308 - 330°$
$B_4(S2)$	$0.00306 - 0.00322$	$272° - 275°$

B_d system in LHS1 & LHS2 scenarios





LHCb 1203.4493

$$\mathcal{B}(B_d \to \mu^+\mu^-) \leq 9.4 \times 10^{-10}$$

SM

$$\mathcal{B}(B_d \to \mu^+\mu^-)^{\rm SM} = (1.07 \pm 0.10) \times 10^{-10}$$

- in the small oases $B(B_d \to \mu^+ \mu^-)$ is always larger than in SM
- the sign of $S_{\mu+\mu-}$ distinguishes B1 from B3 and B2 from B4

Correlation between $S_{\mu+\mu-}$ and $B(B_d \to \mu^+ \mu^-)$: LHS1 vs LHS2

LHS1 : in B1 $S_{\mu+\mu-} > 0$ & $B(B_d \to \mu^+ \mu^-) > B(B_d \to \mu^+ \mu^-)_{SM}$

in B3 $S_{\mu+\mu-} < 0$ & $B(B_d \to \mu^+ \mu^-) < B(B_d \to \mu^+ \mu^-)_{SM}$

LHS2 : in B1 $S_{\mu+\mu-} > 0$ & $B(B_d \to \mu^+ \mu^-) < B(B_d \to \mu^+ \mu^-)_{SM}$

in B3 $S_{\mu+\mu-} < 0$ & $B(B_d \to \mu^+ \mu^-) > B(B_d \to \mu^+ \mu^-)_{SM}$

RHS1 & RHS2 scenarios

Means Z' with exclusively RH couplings to quarks

QCD is parity conserving $\Rightarrow$ hadronic matrix elements of operators with RH currents & QCD corrections remain unchanged

ΔF=2 constraints appear the same as in LHS scenarios $\Rightarrow$ **the oases remain the same**

ΔF=1 observables: decays to muons governed by the function Y

$$Y_A(B_q) = \eta_Y Y_0(x_t) + \frac{[\Delta_A^{\mu\bar\mu}(Z')]}{M_{Z'}^2 g_{\rm SM}^2}\left[\frac{\Delta_L^{qb}(Z') - \Delta_R^{qb}(Z')}{V_{tq}^\star V_{tb}}\right] \equiv |Y_A(B_q)| e^{i\theta_Y^{B_q}}$$

There is a change of sign of NP contributions in a given oasis

RHS1 & RHS2 scenarios

B_s system

LHS	RHS
$S_{\mu^+\mu^-} > 0$ would choose A1	$S_{\mu^+\mu^-} > 0$ would choose A3
$S_{\mu^+\mu^-} < 0$ would choose A3	$S_{\mu^+\mu^-} < 0$ would choose A1

B_d system

Correlation between $S_{\mu^+\mu^-}$ and $B(B_d \to \mu^+ \mu^-)$: LHS1 vs LHS2

LHS1 : in B1 $S_{\mu^+\mu^-} > 0$ & $B(B_d \to \mu^+ \mu^-) > B(B_d \to \mu^+ \mu^-)_{SM}$

in B3 $S_{\mu^+\mu^-} < 0$ & $B(B_d \to \mu^+ \mu^-) < B(B_d \to \mu^+ \mu^-)_{SM}$

LHS2 : in B1 $S_{\mu^+\mu^-} > 0$ & $B(B_d \to \mu^+ \mu^-) < B(B_d \to \mu^+ \mu^-)_{SM}$

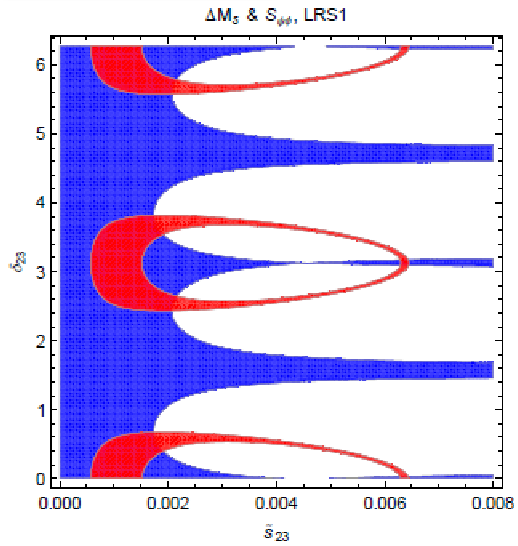
in B3 $S_{\mu^+\mu^-} < 0$ & $B(B_d \to \mu^+ \mu^-) > B(B_d \to \mu^+ \mu^-)_{SM}$

→ Opposite signs in RHS scenarios

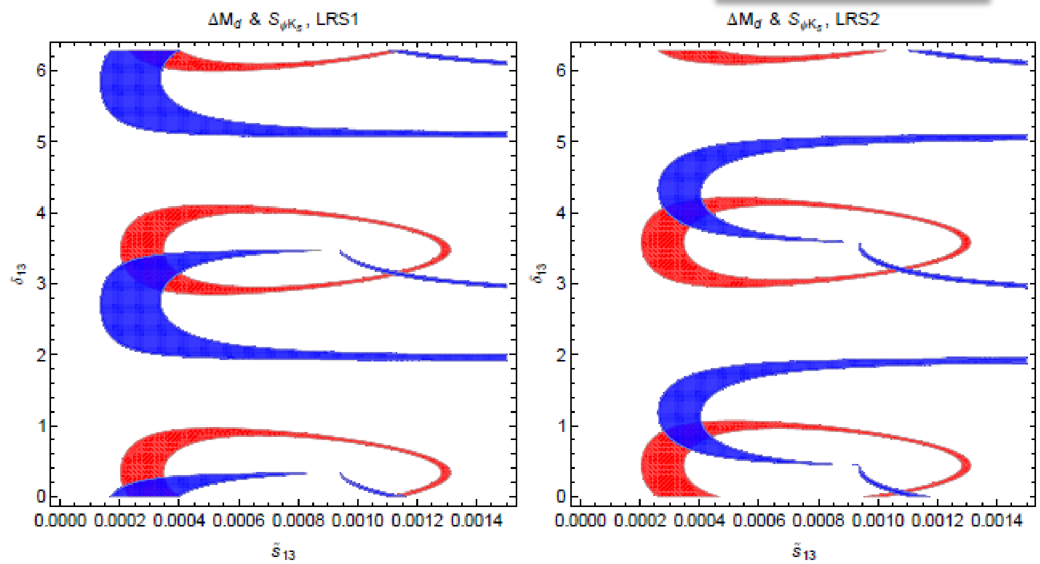
On the basis of these observables it would not be possible to know whether LHS in oases A1 (B1) is realized or RHS in oases A3 (B3)

LRS1 & LRS2 scenarios

B_s system



B_d system



Main difference with respect to the previous cases:
No NP contribution to $B_{d,s} \to \mu^+ \mu^-$
$\Rightarrow$ We cannot rely on this observable to identify the right oases

ALRS1 & ALRS2 scenarios

Similar to LHS scenario, but NP effects much smaller

Can we exploit other observables?

$b \to s\, \ell^+ \ell^-$

$$\mathcal{H}_{\text{eff}}(b \to s\ell\bar{\ell}) = \mathcal{H}_{\text{eff}}(b \to s\gamma) - \frac{4G_F}{\sqrt{2}} \frac{\alpha}{4\pi} V_{ts}^* V_{tb} \sum_{i=9,10} [C_i(\mu) Q_i(\mu) + C_i'(\mu) Q_i'(\mu)]$$

SM (C_i) NP (C_i')

operators

$$Q_9 = (\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu \ell), \qquad Q_{10} = (\bar{s}\gamma_\mu P_L b)(\bar{\ell}\gamma^\mu \gamma_5 \ell)$$

$$Q_9' = (\bar{s}\gamma_\mu P_R b)(\bar{\ell}\gamma^\mu \ell), \qquad Q_{10}' = (\bar{s}\gamma_\mu P_R b)(\bar{\ell}\gamma^\mu \gamma_5 \ell).$$

coefficients

$$\sin^2\theta_W C_9 = [\eta_Y Y_0(x_t) - 4\sin^2\theta_W Z_0(x_t)] - \frac{1}{g_{\text{SM}}^2} \frac{1}{M_{Z'}^2} \frac{\Delta_L^{sb}(Z')\Delta_V^{\mu\bar{\mu}}(Z')}{V_{ts}^* V_{tb}}$$

$$\sin^2\theta_W C_{10} = -\eta_Y Y_0(x_t) - \frac{1}{g_{\text{SM}}^2} \frac{1}{M_{Z'}^2} \frac{\Delta_L^{sb}(Z')\Delta_A^{\mu\bar{\mu}}(Z')}{V_{ts}^* V_{tb}},$$

$$\sin^2\theta_W C_9' = -\frac{1}{g_{\text{SM}}^2} \frac{1}{M_{Z'}^2} \frac{\Delta_R^{sb}(Z')\Delta_V^{\mu\bar{\mu}}(Z')}{V_{ts}^* V_{tb}},$$

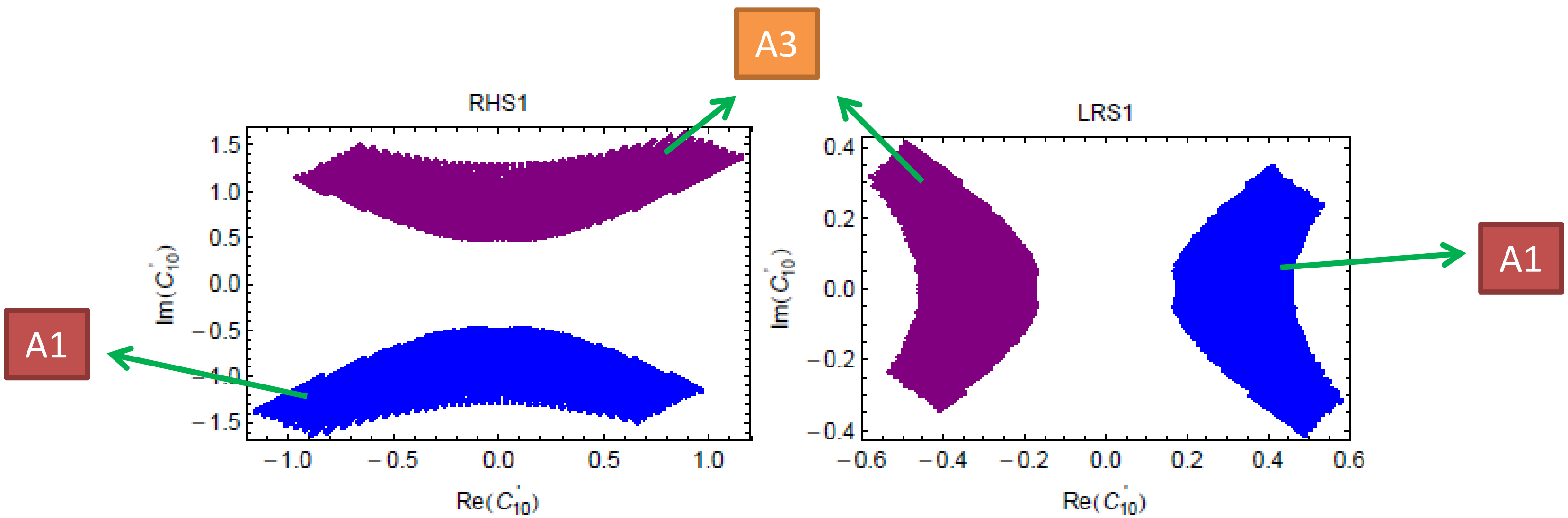
$$\sin^2\theta_W C_{10}' = -\frac{1}{g_{\text{SM}}^2} \frac{1}{M_{Z'}^2} \frac{\Delta_R^{sb}(Z')\Delta_A^{\mu\bar{\mu}}(Z')}{V_{ts}^* V_{tb}},$$

$b \to s\, \ell^+ \ell^-$

Exploiting present data constraints can be obtained:

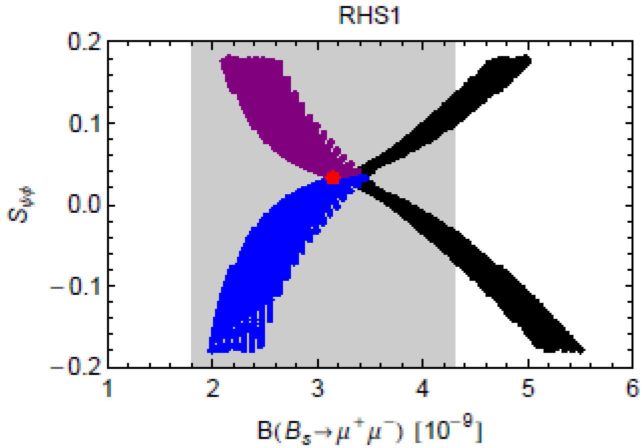
W. Altmannshofer & D. Straub, JHEP 1208 (2012) 121

$$-2 \leq \Re(C'_{10}) \leq 0\,, \quad -2.5 \leq \Im(C'_{10}) \leq 2.5\,,$$



Oasis A1 excluded in LRS

$b \to s \ell^+ \ell^-$



Black regions are excluded due to the constraint on C_{10}'

An enhancement of $B(B_s \to \mu^+ \mu^-)$ with respect to SM is excluded

$$\sin^2\theta_W C'_{10} = -\frac{1}{g_{\rm SM}^2}\frac{1}{M_{Z'}^2}\frac{\Delta_R^{sb}(Z')\Delta_A^{\mu\bar{\mu}}(Z')}{V_{ts}^* V_{tb}}$$

ONLY in RHS!!

Possibility to differentiate between LHS and RHS scenarios, but only if $B(B_s \to \mu^+ \mu^-) > B(B_s \to \mu^+ \mu^-)_{SM}$

$b \to s \bar{\nu} \nu$

SM

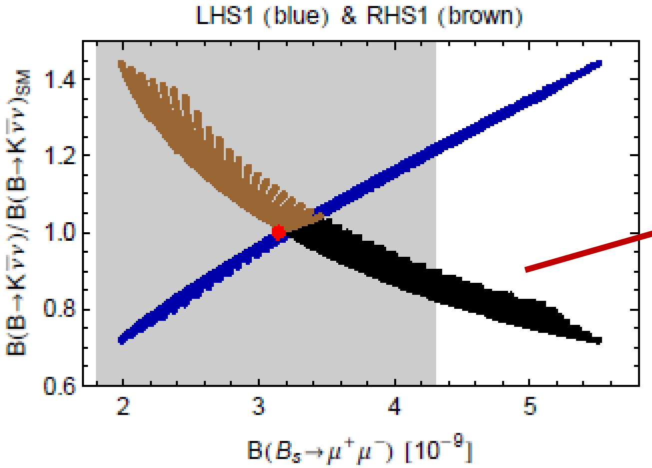
Altmannshofer et al.
JHEP 04 (2009) 022

$$\mathcal{B}(B \to K\nu\bar{\nu})_{\rm SM} = (3.64 \pm 0.47) \times 10^{-6} ,$$
$$\mathcal{B}(B \to K^*\nu\bar{\nu})_{\rm SM} = (7.2 \pm 1.1) \times 10^{-6} ,$$
$$\mathcal{B}(B \to X_s\nu\bar{\nu})_{\rm SM} = (2.7 \pm 0.2) \times 10^{-5} ,$$

EXP

$$\mathcal{B}(B \to K\nu\bar{\nu}) < 1.4 \times 10^{-5} ,$$
$$\mathcal{B}(B \to K^*\nu\bar{\nu}) < 8.0 \times 10^{-5} ,$$
$$\mathcal{B}(B \to X_s\nu\bar{\nu}) < 6.4 \times 10^{-4} .$$

Sensitive observables



excluded by $b \to s\, \ell^+ \ell^-$

Clear distinction between LHS and RHS

$B \to D^{(*)}\ \tau\ \bar{\nu}_\tau$

BaBar measurements:

BaBar, PRL 109 (2012) 101802

$$\mathcal{R}^-(D) = \frac{\mathcal{B}(B^- \to D^0\tau^-\bar{\nu}_\tau)}{\mathcal{B}(B^- \to D^0\ell^-\bar{\nu}_\ell)} = 0.429 \pm 0.082 \pm 0.052\ ,\ \mathcal{R}^-(D^*) = \frac{\mathcal{B}(B^- \to D^{*0}\tau^-\bar{\nu}_\tau)}{\mathcal{B}(B^- \to D^{*0}\ell^-\bar{\nu}_\ell)} = 0.322 \pm 0.032 \pm 0.022\ ,$$

$$\mathcal{R}^0(D) = \frac{\mathcal{B}(\bar{B}^0 \to D^+\tau^-\bar{\nu}_\tau)}{\mathcal{B}(\bar{B}^0 \to D^+\ell^-\bar{\nu}_\ell)} = 0.469 \pm 0.084 \pm 0.053\ ,\ \mathcal{R}^0(D^*) = \frac{\mathcal{B}(\bar{B}^0 \to D^{*+}\tau^-\bar{\nu}_\tau)}{\mathcal{B}(\bar{B}^0 \to D^{*+}\ell^-\bar{\nu}_\ell)} = 0.355 \pm 0.039 \pm 0.021$$

SM

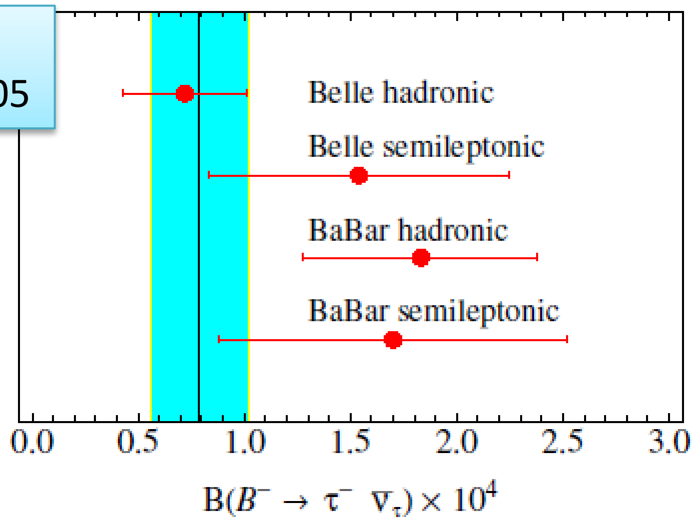
$$\mathcal{R}^0(D)\Big|_{SM} = \frac{\mathcal{B}(\bar{B}^0 \to D^+\tau^-\bar{\nu}_\tau)}{\mathcal{B}(\bar{B}^0 \to D^+\ell^-\bar{\nu}_\ell)}\Big|_{SM} = 0.324 \pm 0.022$$

$$\mathcal{R}^0(D^*)\Big|_{SM} = \frac{\mathcal{B}(\bar{B}^0 \to D^{*+}\tau^-\bar{\nu}_\tau)}{\mathcal{B}(\bar{B}^0 \to D^{*+}\ell^-\bar{\nu}_\ell)}\Big|_{SM} = 0.250 \pm 0.003$$

- BaBar quotes a 3.4 σ deviation from SM predictions
- is this related to the enhancement of $B(B \to \tau\ \nu_\tau)$?

...but...

SM prediction for
$|Vub|=0.0035 \pm 0.0005$



$B \to D^{(*)} \tau \bar{\nu}_\tau$

Most natural explanation: new scalars with couplings to leptons proportional to their mass
- would explain the enhancement of τ modes
- would enhance both semileptonic and purely leptonic modes

The simplest of such models (2HDM) has been excluded by BaBar:
No possibility to simultaneously reproduce R(D) and R(D^*)

Alternative explanations using several variants of effective hamiltonian
- S. Fajfer et al, PRD 85 (2012) 094025; PRL 109 (2012) 161801
- A. Crivellin et al., PRD 86 (2012) 054014
- A. Datta et al., PRD 86 (2012) 034027
- A. Celis et al., JHEP 1301 (2013) 054
- D. Choudhury et al, PRD 86 (2012) 114037

$B \to D^{(*)} \tau \bar{\nu}_\tau$

P. Biancofiore, P. Colangelo, FDF
1302.1042, PRD 87 (2013) 074010

A different strategy:

- consider a NP scenario that enhances semileptonic modes but not leptonic ones
- predict similar effects in other analogous modes

$$H_{eff} = H_{eff}^{SM} + H_{eff}^{NP} = \frac{G_F}{\sqrt{2}} V_{cb} \left[\bar{c}\gamma_\mu(1-\gamma_5)b\, \bar{\ell}\gamma^\mu(1-\gamma_5)\bar{\nu}_\ell + \epsilon_T^\ell\, \bar{c}\sigma_{\mu\nu}(1-\gamma_5)b\, \bar{\ell}\sigma^{\mu\nu}(1-\gamma_5)\bar{\nu}_\ell \right]$$

SM

NP

new complex coupling: $\epsilon_T^{\mu,e}=0$, $\epsilon_T^{\tau} \neq 0$

Charmed meson

$$\frac{d\Gamma}{dq^2}(B \to M_c \ell \bar{\nu}_\ell) = C(q^2) \left[\frac{d\tilde{\Gamma}}{dq^2}(B \to M_c \ell \bar{\nu}_\ell)\Big|_{SM} + \frac{d\tilde{\Gamma}}{dq^2}(B \to M_c \ell \bar{\nu}_\ell)\Big|_{NP} + \frac{d\tilde{\Gamma}}{dq^2}(B \to M_c \ell \bar{\nu}_\ell)\Big|_{INT} \right]$$

$$C(q^2) = \frac{G_F^2 |V_{cb}|^2 \lambda^{1/2}(m_B^2, m_{M_c}^2, q^2)}{192\pi^3 m_B^3} \left(1 - \frac{m_\ell^2}{q^2}\right)^2$$

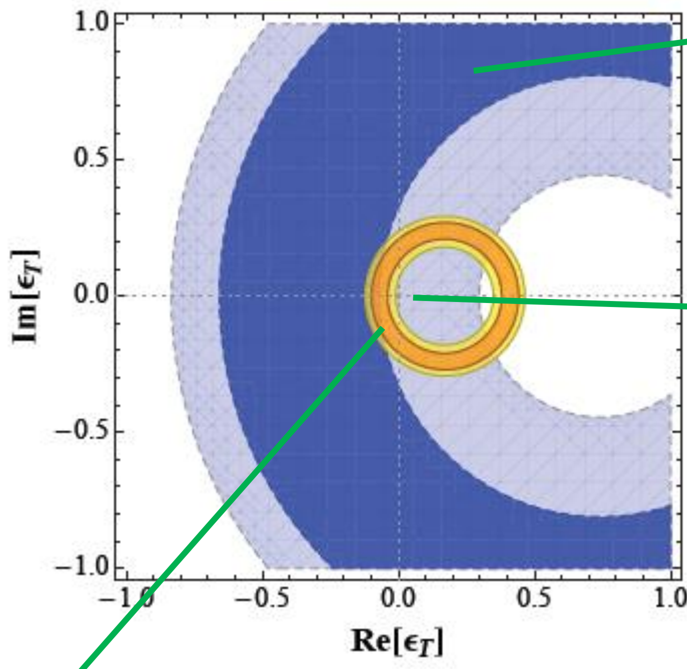
$\propto |\epsilon_T|^2$

$\propto \mathrm{Re}(\epsilon_T)$

A simlar strategy in
M. Tanaka & R. Watanabe 1212.1878

$B \to D^{(*)} \tau \bar{\nu}_\tau$

Including a new tensor operator in H_{eff} :
is it possible to reproduce both R(D) and R(D*)?



Big circle: R(D) constraint

overlap region: $\epsilon_T = |a_T| e^{i\theta} + \epsilon_{T0}$

Small circle: R(D*) constraint

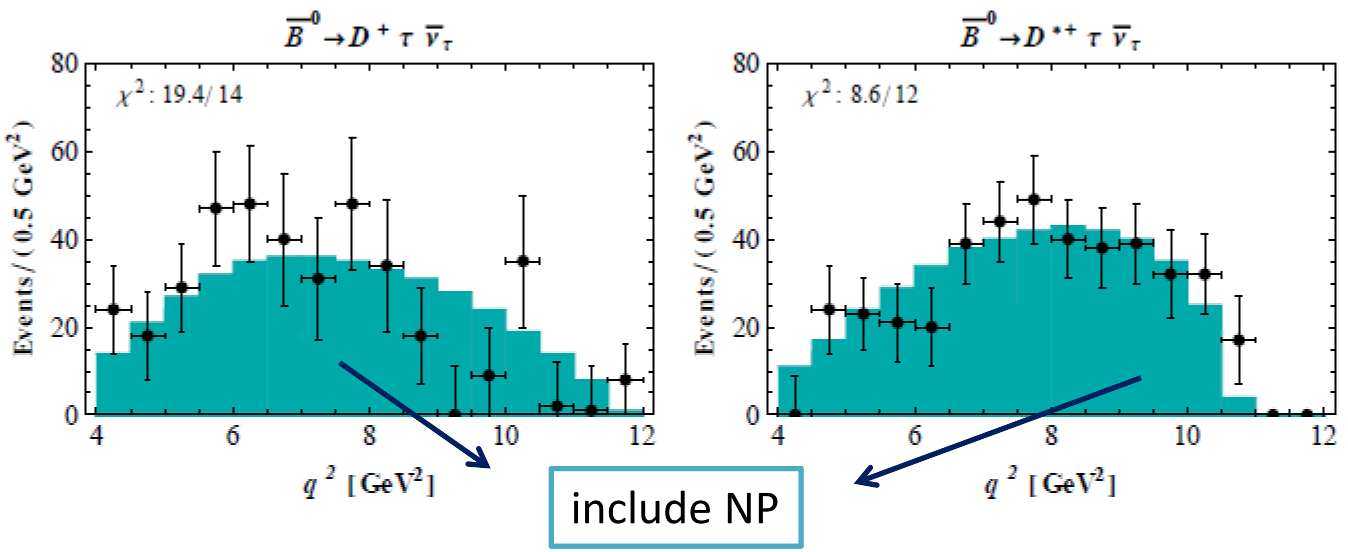
$$Re[\epsilon_{T0}] = 0.17 \quad , \; Im[\epsilon_{T0}] = 0$$
$$|a_T| \in [0.24, \; 0.27]$$
$$\theta \in [2.6, \; 3.7] \, \text{rad}$$

varying ε_T in this range predictions for several observables can be gained

$B \to D^{(*)}\ \tau\ \bar{\nu}_\tau$: which observables are the most sensitive ?

Comparison with the latest BaBar results:

BaBar Collab. 1303.0571



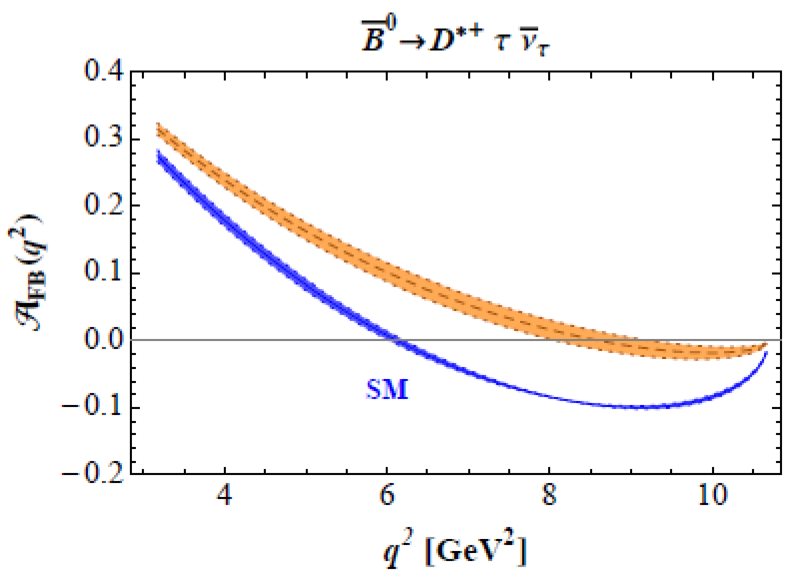
The spectra $d\Gamma/dq^2$ cannot distinguish the SM from the NP case

$B \to D^* \tau \bar{\nu}_\tau$

Forward-Backward asymmetry

$$\mathcal{A}_{FB}(q^2) = \frac{\int_0^1 d\cos\theta_\ell \frac{d\Gamma}{dq^2 d\cos\theta_\ell} - \int_{-1}^0 d\cos\theta_\ell \frac{d\Gamma}{dq^2 d\cos\theta_\ell}}{\frac{d\Gamma}{dq^2}}$$

angle between the charged lepton and the D^* in the lepton pair rest-frame



The SM predicts a zero at $q^2 \approx 6.15$ GeV^2

In NP the zero is shifted to $q^2 \in [8.1, 9.3]$ GeV^2

- Uncertainty in the SM prediction is due to $1/m_Q$ corrections and to the parameters of the IW function fitted by Belle
- NP includes uncertainty on ε_T

$B \to D^{**}\ \tau\ \bar{\nu}_\tau$

D^{**}=positive parity excited charmed mesons

Two doublets:

$(D_{(s)0}^{*}, D_{(s)1}')$ with $J^P=(0^+,1^+)$ and **$(D_{(s)1}, D_{(s)2}^{*})$** with $JP=(1^+,2^+)$

Form factors for semileptonic B decays to these states can be expressed in terms of universal functions analogous to the IW

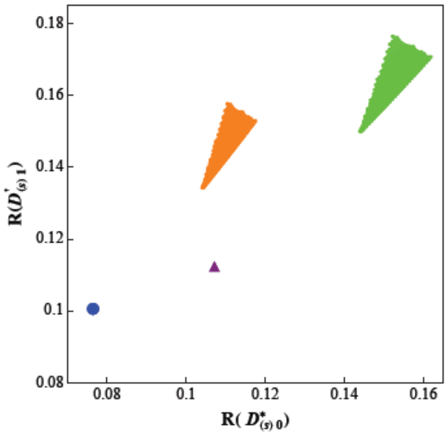
$B \to (D_{(s)0}^{*}, D_{(s)1}')$ → $\tau_{1/2}(w)$

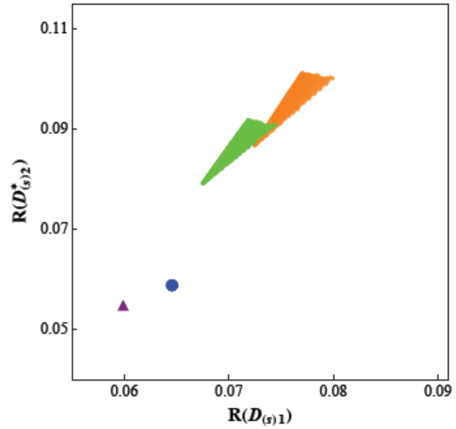
$B \to (D_{(s)1}, D_{(s)2}^{*})$ → $\tau_{3/2}(w)$

We consider again ratios in which the dependence on the model for the τ functions mostly drops out

$$\mathcal{R}(D^{**}) = \frac{\mathcal{B}(B \to D^{**}\tau\bar{\nu}_\tau)}{\mathcal{B}(B \to D^{**}\mu\bar{\nu}_\mu)}$$

$B \to D^{**} \tau \bar{\nu}_\tau$

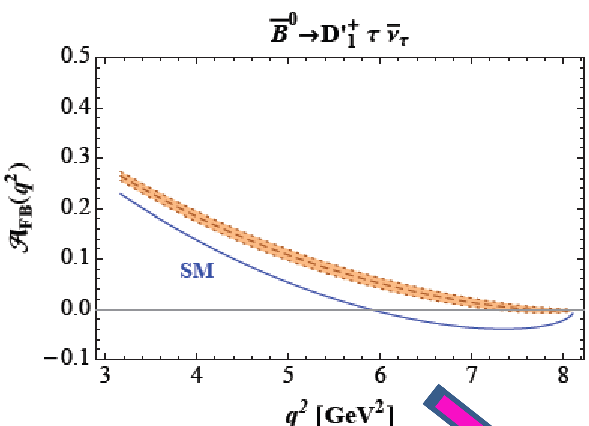


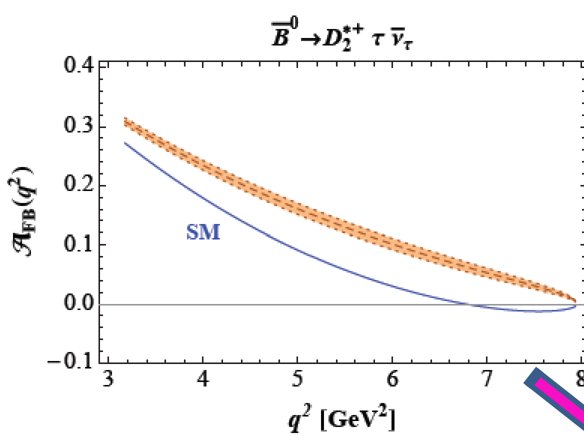


Orange= non strange
Blue circle= SM
Green= strange
Triangle= SM

The inclusion of the tensor operator produces a sizable increase in the ratios

Forward-backward asymmetries





shift in the position of the zero

the zero disappears

summary

Studying correlations between flavour observables may lead us to select the right scenario (if any) for Z' couplings to quarks for $M_{Z'}$=1 TeV
Larger masses (>5 TeV) have negligible impact on the observables considered

The most constrained system is that of B_s

- important role is played by $S_{\psi\phi}$ and $B(B_s \to \mu^+ \mu^-)$
- highest sensitivity to RHC is that of $b \to s\, \ell^+ \ell^-$ and $b \to s\, \bar{\nu}\, \nu$

Anomalous enhancement of $R(D^{(*)})$ could be explained introducing a new tensor operator in the effective hamiltonian.
Differential distributions help to discriminate this scenario from SM
Large effects forseen in $B \to D^{**}\ \tau\, \bar{\nu}_\tau$