Probing the neutrino mass through semileptonic meson decays

Lovre Pavičić

Brda 2026



UNIVERZA V LJUBLJANI | FMF Fakulteta za matematiko in fiziko

Jožef Stefan Institute
Ljubljana, Slovenia

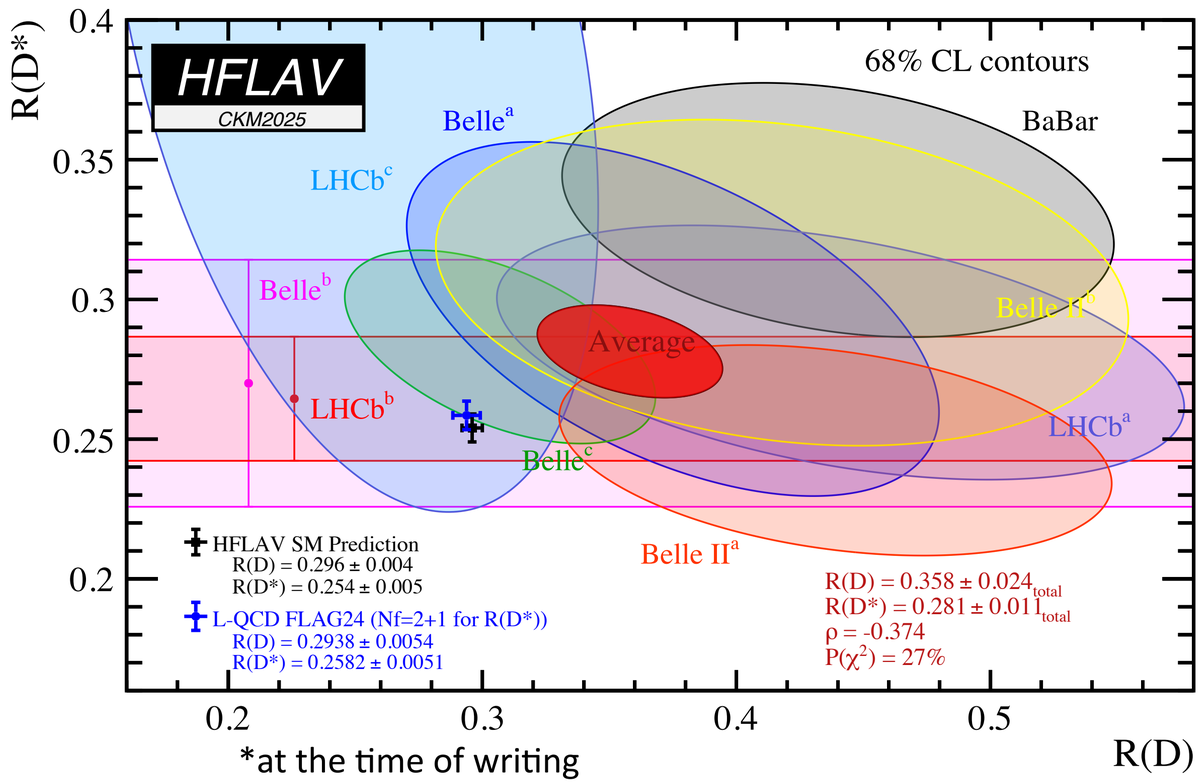
(based on 2603.15461 with C. Chevallier, D. Bečirević, S. Fajfer and N. Košnik)

15.10.2026

Observables in $b \to c\ell\nu$

$$R_{D^{(*)}} = \frac{\Gamma(B \to D^{(*)}\tau\nu)}{\Gamma(B \to D^{(*)}\ell\nu)}, \quad \ell = e, \mu$$

- Test of lepton flavour universality
- Theoretically clean; **hadronic uncertainties cancel** in the ratio
- SM predictions significantly smaller than experiment, **combined deviation*:** $\sim 3.3\,\sigma$



⇒ Violation of LFU? **New Physics** coupled to b and τ?

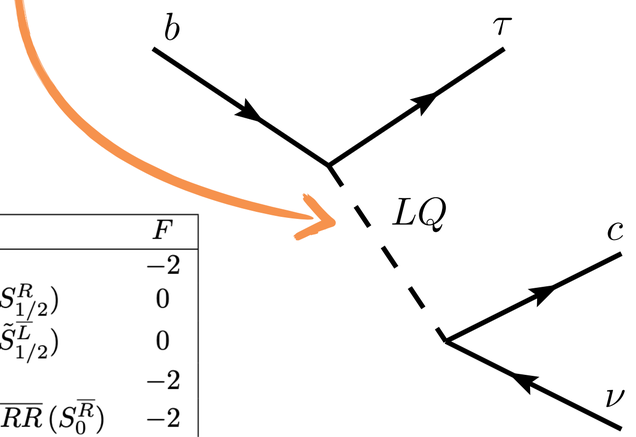
Possible explanations

$$\mathcal{L}_{b\to c\tau\nu} = -2\sqrt{2}G_F V_{cb}\Big[(1+g_{V_L})(\bar{c}_L\gamma^\mu b_L)(\bar{\tau}_L\gamma_\mu\nu_{\tau L}) + g_{V_R}(\bar{c}_R\gamma^\mu b_R)(\bar{\tau}_L\gamma_\mu\nu_{\tau L}) + g_{S_L}(\bar{c}_R b_L)(\bar{\tau}_R\nu_{\tau L}) + g_T(\bar{c}_R\sigma^{\mu\nu}b_L)(\bar{\tau}_R\sigma_{\mu\nu}\nu_{\tau L})\Big]$$

EFT study - $\Lambda_{NP} \simeq m_{NP}/C_{NP} \sim \mathcal{O}(1-3)\text{TeV}$

- Possible NP solutions: W', Charged Higgses, Exotic neutrino interactions...

- **Or Leptoquarks!**



$(SU(3), SU(2), U(1))$	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	$LL\,(S_0^L)$, $RR\,(S_0^R)$, $\overline{RR}\,(S_0^{\bar{R}})$	-2
$(\bar{\mathbf{3}}, \mathbf{1}, -2/3)$	0	$\bar{S}_1$	$\overline{RR}\,(\bar{S}_0^{\bar{R}})$	-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	$\tilde{V}_2$	$RL\,(\tilde{V}_{1/2}^L)$, $\overline{LR}\,(\tilde{V}_{1/2}^{\bar{R}})$	-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	$LL\,(V_0^L)$, $RR\,(V_0^R)$, $\overline{RR}\,(V_0^{\bar{R}})$	0
$(\mathbf{3}, \mathbf{1}, -1/3)$	1	$\bar{U}_1$	$\overline{RR}\,(\bar{V}_0^{\bar{R}})$	0

(1603.04993)

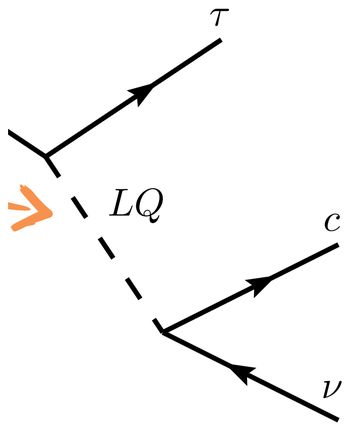
Possible explanations

$$\mathcal{L}_{b\to c\tau\nu} = -2\sqrt{2}G_F V_{cb}\Big[(1+g_{V_L})(\bar{c}_L\gamma^\mu b_L)(\bar{\tau}_L\gamma_\mu\nu_{\tau L}) + g_{V_R}(\bar{c}_R\gamma^\mu b_R)(\bar{\tau}_L\gamma_\mu\nu_{\tau L}) + g_{S_L}(\bar{c}_R b_L)(\bar{\tau}_R\nu_{\tau L}) + g_T(\bar{c}_R\sigma^{\mu\nu}b_L)(\bar{\tau}_R\sigma_{\mu\nu}\nu_{\tau L})\Big]$$

EFT study - $\Lambda_{NP} \simeq m_{NP}/C_{NP} \sim \mathcal{O}(1-3)\text{TeV}$

- Possible NP solutions: W', Charged Higgses, Exotic neutrino interactions
- **Or Leptoquarks**

$(SU(3), SU(2), U(1))$	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	$\tilde{R}_2$	$RL\,(\tilde{S}_{1/2}^L)$, $\overline{LR}\,(\tilde{S}_{1/2}^{\overline{L}})$	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	$\bar{S}_1$	$\overline{RR}\,(S_0^R)$	-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	$\tilde{V}_2$	$RL\,(\tilde{V}_{1/2}^L)$, $\overline{LR}\,(\tilde{V}_{1/2}^{\overline{R}})$	-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	$\bar{U}_1$	$\overline{RR}\,(\bar{V}_0^{\overline{R}})$	0



(1603.04993)

Inert S_1 (right-handed)

- Consider minimal coupling texture

- Right-handed interactions

  $\Rightarrow$ no **CKM mixing**

  $\Rightarrow$ evading a lot of constraints from flavour observables

- Model with **only right-handed interactions?**

$$\mathcal{L}_{S_1} = y^R_{ij}\overline{u^C_i} e_j S_1 + \tilde{y}^R_{iN}\overline{d^C_i} N_R \; S_1$$

Inert S_1 (right-handed)

- Consider minimal coupling texture

- Right-handed interactions

  $\Rightarrow$ no **CKM mixing**

  $\Rightarrow$ evading a lot of constraints from flavour observables

- Model with **only right-handed interactions?**

$$\mathcal{L}_{S_1} = y^R_{ij}\overline{u^C_i} e_j S_1 + \tilde{y}^R_{iN}\overline{d^C_i} N_R \; S_1$$

$N_R = (\mathbf{1}, \mathbf{1}, 0)$

"right-handed neutrino"

Inert S_1 (right-handed)

- Consider minimal coupling texture

- Right-handed interactions

  $\Rightarrow$no **CKM mixing**

  $\Rightarrow$ evading a lot of constraints from flavour observables

- Model with **only right-handed interactions?**

$$\mathcal{L}_{S_1} = y^R_{c\tau}\overline{c^C}\tau S_1 + \tilde{y}^R_{bN}\overline{b^C}N_R\ S_1$$

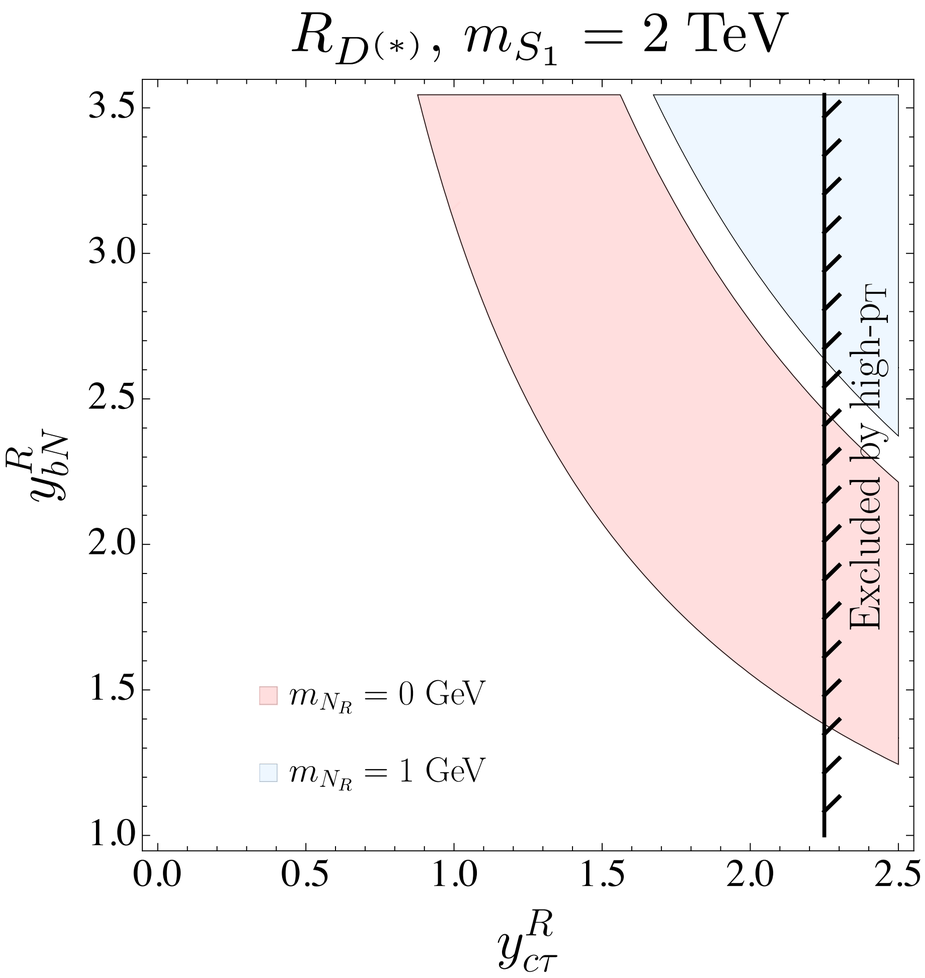
Create desired effect in $R_{D^{(*)}}$

Inert S_1 (right-handed)

- $R_{D^{(*)}}$ can be accommodated :)

  $\Rightarrow$ up to masses of RHN up to $\sim$1 GeV

- Very few other observables affected



*2σ allowed regions

Inert S_1 (right-handed) - predictions

- For example: $B_c \to \tau$'inv', $B_c \to J/\psi\,\tau$ 'inv'

- Particularly interesting:

$\Rightarrow$ Angular observables in $B \to D^{(*)}\tau\nu$ decays, example:

Quantity	SM	$m_{N_R} = 0$ GeV
$P_\tau^{D^*}$	$-0.51(2)$	$-0.39(4)$
$F_L^{D^*}$	$0.46(1)$	$0.46(1)$

Inert S_1 (right-handed) - predictions

- For example: $B_c \to \tau$'inv', $B_c \to J/\psi\,\tau$ 'inv'

Exp.
$0.71(25)$
$0.49(25)$
$0.51(14)$

- Particularly interesting:

$\Rightarrow$ Angular observables in $B \to D^{(*)}\tau\nu$ decays, example:

Quantity	SM	$m_{N_R} = 0$ GeV	Exp.
$P_\tau^{D^*}$	$-0.51(2)$	$-0.39(4)$	$-0.37(54)$
$F_L^{D^*}$	$0.46(1)$	$0.46(1)$	$0.60(9)$ $0.43(7)$

$\Rightarrow$ Very few predictions experimentally measured

Inert S_1 (right-handed) -predictions

- For example: $B_c \to \tau$'inv', $B_c \to J/\psi\,\tau$ 'inv'

- Particularly interesting:

$\Rightarrow$ Angular observables in $B \to D^{(*)}\tau\nu$ decays, example:

Quantity	SM	$m_{N_R} = 0$ GeV
$P_\tau^{D^*}$	$-0.51(2)$	$-0.39(4)$
$F_L^{D^*}$	$0.46(1)$	$0.46(1)$

Change drastically in the presence of **RHN**

Left almost unchanged

Probing the nature of invisible particle in semileptonic decays

Quantity	SM	$m_{N_R} = 0$ GeV
$P_\tau^{D^*}$	$-0.51(2)$	$-0.39(4)$
$F_L^{D^*}$	$0.46(1)$	$0.46(1)$

The difference?

Probing the nature of invisible particle in semileptonic decays

Quantity	SM	$m_{N_R} = 0$ GeV
$P_\tau^{D^*}$	$-0.51(2)$	$-0.39(4)$
$F_L^{D^*}$	$0.46(1)$	$0.46(1)$

D^* - vector meson

The difference?

Quantity	SM	$m_{N_R} = 0$ GeV
P_τ^{D}	$0.325(3)$	$0.25(2)$
$A_{\rm fb}^{D}$	$0.360(0)$	$0.360(0)$

D - pseudoscalar meson

Probing the nature of invisible particle in semileptonic decays

Quantity	SM	$m_{N_R} = 0$ GeV
$P_\tau^{D^*}$	$-0.51(2)$	$-0.39(4)$
$F_L^{D^*}$	$0.46(1)$	$0.46(1)$

The difference?

Quantity	SM	$m_{N_R} = 0$ GeV
P_τ^{D}	$0.325(3)$	$0.25(2)$
$A_{\rm fb}^{D}$	$0.360(0)$	$0.360(0)$

- $P_\tau^{D^{(*)}}$ - tau polarization asymmetry

  $\Rightarrow$ Encapsulates the information on τ-**helicity**

- F_L^{D*} - longitudinal polarization of vector meson
- $A_{\rm fb}^{D}$ - forward-backward asymmetry

  $\Rightarrow$ Sum over the τ-helicities

Probing the nature of invisible particle in semileptonic decays

Quantity	SM	$m_{N_R} = 0$ GeV
$P_\tau^{D^*}$	$-0.51(2)$	$-0.39(4)$
$F_L^{D^*}$	$0.46(1)$	$0.46(1)$

The difference?

Quantity	SM	$m_{N_R} = 0$ GeV
P_τ^{D}	$0.325(3)$	$0.25(2)$
$A_{\rm fb}^{D}$	$0.360(0)$	$0.360(0)$

- $P_\tau^{D^{(*)}}$ - tau polarization asymmetry
  - $\Rightarrow$ Encapsulates the information on τ-**helicity**
- F_L^{D*} - longitudinal polarization of vector meson
- $A_{\rm fb}^{D}$ - forward-backward asymmetry
  - $\Rightarrow$ Sum over the τ-helicities
- Are there more such observables that are sensitive to **chirality** of the **invisible particle**?

Probing the nature of invisible particle in semileptonic decays

- Pseudoscalar case $B \to D\tau$'inv'

$$\frac{d^2\Gamma^{\pm}(B \to D\tau N)}{dq^2 d\cos\theta_\tau} = a_{\pm}(q^2) + b_{\pm}(q^2)\cos\theta_\tau + c_{\pm}(q^2)\cos^2\theta_\tau$$

Probing the nature of invisible particle in semileptonic decays

- Pseudoscalar case $B \to D\tau$'inv'

Helicity of τ lepton

$$\frac{d^2\Gamma^{\pm}(B \to D\tau N)}{dq^2 d\cos\theta_\tau} = a_\pm(q^2) + b_\pm(q^2)\cos\theta_\tau + c_\pm(q^2)\cos^2\theta_\tau$$

- An interesting peculiarity is $b_-(q^2) = 0$, for $N = \nu_L$

$\Rightarrow$ even in the presence of generic NP coupled to ν_L!

Probing the nature of invisible particle in semileptonic decays

- Pseudoscalar case $B \to D\tau$'inv'

Helicity of τ lepton

$$\frac{d^2\Gamma^{\pm}(B \to D\tau N)}{dq^2 d\cos\theta_\tau} = a_\pm(q^2) + b_\pm(q^2)\cos\theta_\tau + c_\pm(q^2)\cos^2\theta_\tau$$

- An interesting peculiarity is $b_-(q^2) = 0$, for $N = \nu_L$

$\Rightarrow$ even in the presence of **generic NP coupled to ν_L!**

$$\mathcal{L}_{b\to c\tau\nu} = -2\sqrt{2}G_F V_{cb}\Big[(1+g_{V_L})(\bar{c}_L\gamma^\mu b_L)(\bar{\tau}_L\gamma_\mu\nu_{\tau L}) + g_{V_R}(\bar{c}_R\gamma^\mu b_R)(\bar{\tau}_L\gamma_\mu\nu_{\tau L}) + g_{S_L}(\bar{c}_R b_L)(\bar{\tau}_R\nu_{\tau L}) + g_T(\bar{c}_R\sigma^{\mu\nu}b_L)(\bar{\tau}_R\sigma_{\mu\nu}\nu_{\tau L})\Big]$$

Probing the nature of invisible particle in semileptonic decays

- Pseudoscalar case $B \to D\tau$'inv'

Helicity of τ lepton

$$\frac{d^2\Gamma^{\pm}(B \to D\tau N)}{dq^2 d\cos\theta_\tau} = a_\pm(q^2) + b_\pm(q^2)\cos\theta_\tau + c_\pm(q^2)\cos^2\theta_\tau$$

- An interesting peculiarity is $b_-(q^2) = 0$, for $N = \nu_L$

$\Rightarrow$ even in the presence of **generic NP coupled to ν_L!**

$$\mathcal{L}_{b\to c\tau\nu} = -2\sqrt{2}G_F V_{cb}\Big[(1+g_{V_L})(\bar{c}_L\gamma^\mu b_L)(\bar{\tau}_L\gamma_\mu\nu_{\tau L}) + g_{V_R}(\bar{c}_R\gamma^\mu b_R)(\bar{\tau}_L\gamma_\mu\nu_{\tau L}) + g_{S_L}(\bar{c}_R b_L)(\bar{\tau}_R\nu_{\tau L}) + g_T(\bar{c}_R\sigma^{\mu\nu}b_L)(\bar{\tau}_R\sigma_{\mu\nu}\nu_{\tau L})\Big]$$

- Therefore, we define the **polarized** forward-backward asymmetry:

$$A_{\rm fb}^- = \frac{1}{\Gamma}\int dq^2\, b_-(q^2)$$

Probing the nature of invisible particle in semileptonic decays

- Pseudoscalar case $B \to D\tau$'inv'

⇒ The observable $A_{\rm fb}^-$ presents a **null-test** for the SM

⇒ Measuring $A_{\rm fb}^- \neq 0$ can mean two things

an additional **left-handed** invisible particle N_L

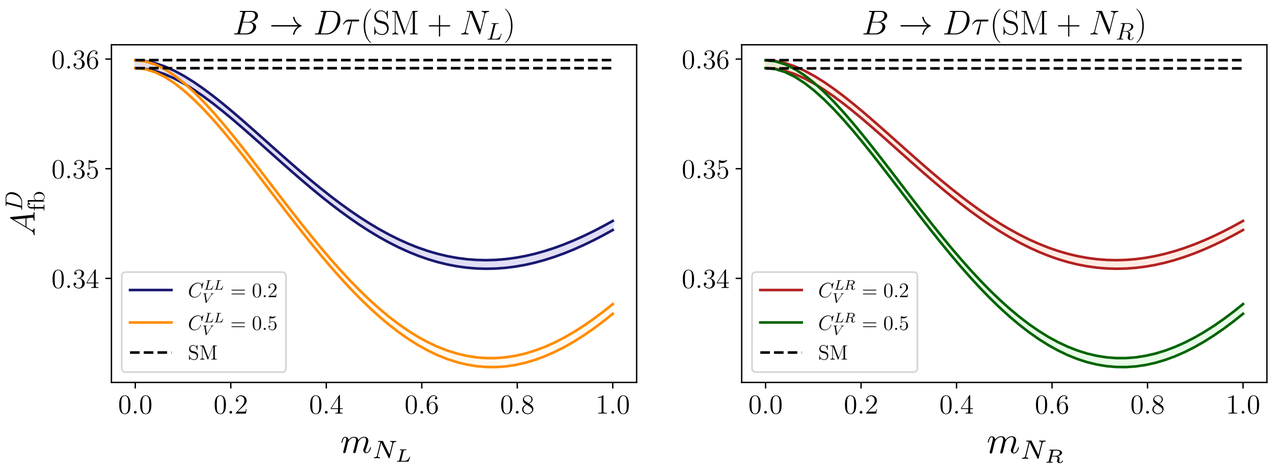
⇒ only if **massive**

an additional **right-handed** invisible particle N_R

⇒ possibly **massless**

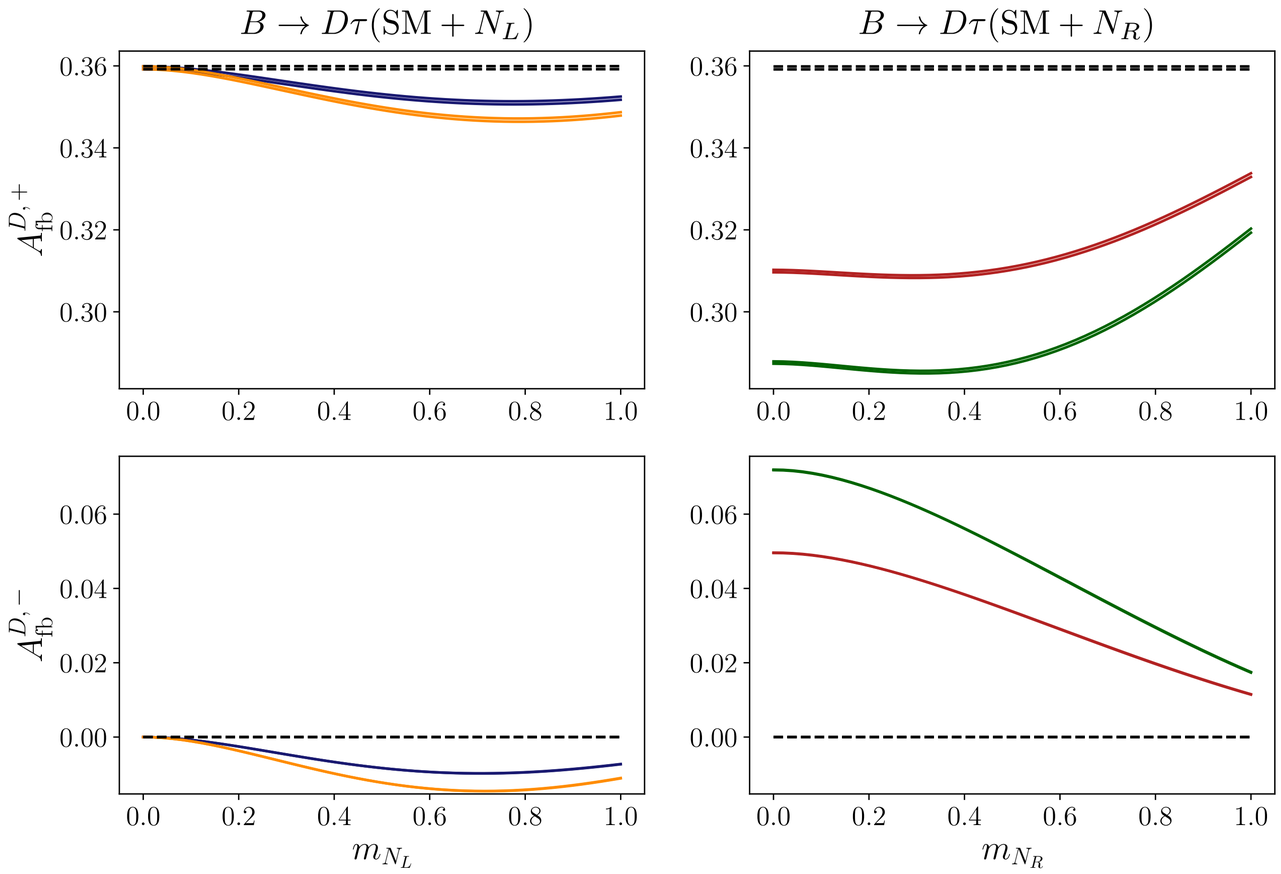
Probing the nature of invisible particle in semileptonic decays

- Pseudoscalar case $B \to D\tau$'inv'



Probing the nature of invisible particle in semileptonic decays

- Pseudoscalar case $B \to D\tau$'inv'



Probing the nature of invisible particle in semileptonic decays

- Vector case $B \to D^*(\to D\pi)\tau$'inv'

$$\begin{aligned}\frac{d^4\Gamma^{\pm}}{dq^2\, d\cos\theta_\ell\, d\cos\theta_D\, d\phi} &= (I_{1s}^{\pm} + I_{2s}^{\pm}\cos 2\theta_\ell + I_{6s}^{\pm}\cos\theta_\ell)\sin^2\theta_D \\ &+ (I_{1c}^{\pm} + I_{2c}^{\pm}\cos 2\theta_\ell + I_{6c}^{\pm}\cos\theta_\ell)\cos^2\theta_D \\ &+ (I_3^{\pm}\cos 2\phi + I_9^{\pm}\sin 2\phi)\sin^2\theta_D\sin^2\theta_\ell \\ &+ (I_4^{\pm}\cos\phi + I_8^{\pm}\sin\phi)\sin 2\theta_D\sin 2\theta_\ell \\ &+ (I_5^{\pm}\cos\phi + I_7^{\pm}\sin\phi)\sin 2\theta_D\sin\theta_\ell\end{aligned}$$

Probing the nature of invisible particle in semileptonic decays

- Vector case $B \to D^*(\to D\pi)\tau$'inv'

$$\begin{aligned}\frac{d^4\Gamma^{\pm}}{dq^2\, d\cos\theta_\ell\, d\cos\theta_D\, d\phi} &= (I_{1s}^{\pm} + I_{2s}^{\pm}\cos 2\theta_\ell + I_{6s}^{\pm}\cos\theta_\ell)\sin^2\theta_D \\ &+ (I_{1c}^{\pm} + I_{2c}^{\pm}\cos 2\theta_\ell + I_{6c}^{\pm}\cos\theta_\ell)\cos^2\theta_D \\ &+ (I_3^{\pm}\cos 2\phi + I_9^{\pm}\sin 2\phi)\sin^2\theta_D \sin^2\theta_\ell \\ &+ (I_4^{\pm}\cos\phi + I_8^{\pm}\sin\phi)\sin 2\theta_D \sin 2\theta_\ell \\ &+ (I_5^{\pm}\cos\phi + I_7^{\pm}\sin\phi)\sin 2\theta_D \sin\theta_\ell\end{aligned}$$

- Analogously to pseudoscalar case, we notice: $I_{6c}^{-} = 0$ and $I_{6s}^{+} = 0$

  $\Rightarrow$ physical meaning?

Probing the nature of invisible particle in semileptonic decays

- Vector case $B \to D^*(\to D\pi)\tau$'inv'

$$\begin{aligned}\frac{d^4\Gamma^{\pm}}{dq^2\, d\cos\theta_\ell\, d\cos\theta_D\, d\phi} &= (I_{1s}^{\pm} + I_{2s}^{\pm}\cos 2\theta_\ell + I_{6s}^{\pm}\cos\theta_\ell)\sin^2\theta_D \\ &+ (I_{1c}^{\pm} + I_{2c}^{\pm}\cos 2\theta_\ell + I_{6c}^{\pm}\cos\theta_\ell)\cos^2\theta_D \\ &+ (I_3^{\pm}\cos 2\phi + I_9^{\pm}\sin 2\phi)\sin^2\theta_D\sin^2\theta_\ell \\ &+ (I_4^{\pm}\cos\phi + I_8^{\pm}\sin\phi)\sin 2\theta_D\sin 2\theta_\ell \\ &+ (I_5^{\pm}\cos\phi + I_7^{\pm}\sin\phi)\sin 2\theta_D\sin\theta_\ell\end{aligned}$$

$\Rightarrow$ We integrate over ϕ

Probing the nature of invisible particle in semileptonic decays

- Vector case $B \to D^*(\to D\pi)\tau$'inv'

$$\frac{d^4\Gamma^{\pm}}{dq^2\, d\cos\theta_\ell\, d\cos\theta_D\, d\phi} = (I_{1s}^{\pm} + I_{2s}^{\pm}\cos 2\theta_\ell + I_{6s}^{\pm}\cos\theta_\ell)\sin^2\theta_D + (I_{1c}^{\pm} + I_{2c}^{\pm}\cos 2\theta_\ell + I_{6c}^{\pm}\cos\theta_\ell)\cos^2\theta_D + (I_3^{\pm}\cos 2\phi + I_9^{\pm}\sin 2\phi)\sin^2\theta_D\sin^2\theta_\ell + (I_4^{\pm}\cos\phi + I_8^{\pm}\sin\phi)\sin 2\theta_D\sin 2\theta_\ell + (I_5^{\pm}\cos\phi + I_7^{\pm}\sin\phi)\sin 2\theta_D\sin\theta_\ell$$

$\Rightarrow$ We integrate over ϕ

Probing the nature of invisible particle in semileptonic decays

- Vector case $B \to D^*(\to D\pi)\tau$'inv'

$$\frac{d^4\Gamma^{\pm}}{dq^2\, d\cos\theta_\ell\, d\cos\theta_D\, d\phi} = (I_{1s}^{\pm} + I_{2s}^{\pm}\cos 2\theta_\ell + I_{6s}^{\pm}\cos\theta_\ell)\sin^2\theta_D + (I_{1c}^{\pm} + I_{2c}^{\pm}\cos 2\theta_\ell + I_{6c}^{\pm}\cos\theta_\ell)\cos^2\theta_D + (I_3^{\pm}\cos 2\phi + I_9^{\pm}\sin 2\phi)\sin^2\theta_D \sin^2\theta_\ell + (I_4^{\pm}\cos\phi + I_8^{\pm}\sin\phi)\sin 2\theta_D \sin 2\theta_\ell + (I_5^{\pm}\cos\phi + I_7^{\pm}\sin\phi)\sin 2\theta_D \sin\theta_\ell$$

$\Rightarrow$ We integrate over ϕ

$\Rightarrow$ Then, project longitudinal and transverse D^* polarization

$\theta_D = 0$ $\theta_D = \pi/2$

Probing the nature of invisible particle in semileptonic decays

- Vector case $B \to D^*(\to D\pi)\tau$'inv'

$$\frac{d^4\Gamma^{\pm}}{dq^2\, d\cos\theta_\ell\, d\cos\theta_D\, d\phi} = (I_{1s}^{\pm} + I_{2s}^{\pm}\cos 2\theta_\ell + I_{6s}^{\pm}\cos\theta_\ell)\sin^2\theta_D + (I_{1c}^{\pm} + I_{2c}^{\pm}\cos 2\theta_\ell + I_{6c}^{\pm}\cos\theta_\ell)\cos^2\theta_D$$

$\propto \Gamma^T$

$\propto \Gamma^L$

$\Rightarrow$ We integrate over ϕ

$\Rightarrow$ Then, project longitudinal and transverse D^* polarization

$\theta_D = 0$ $\theta_D = \pi/2$

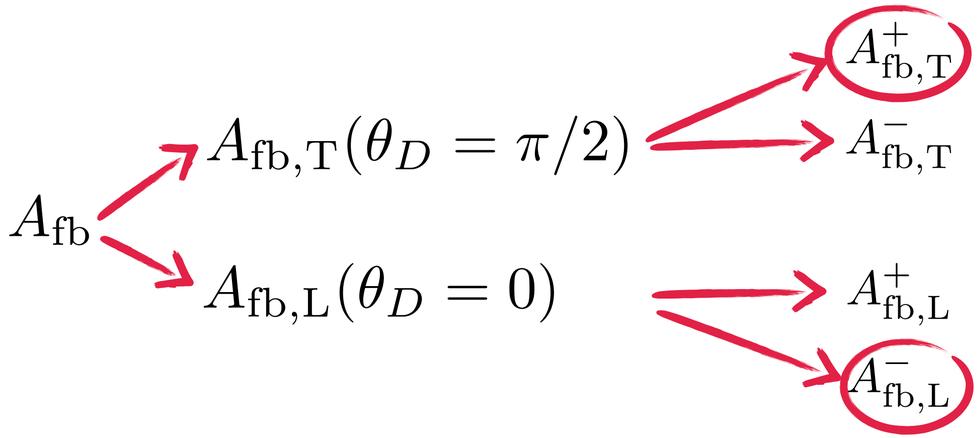
Probing the nature of invisible particle in semileptonic decays

- Vector case $B \to D^*(\to D\pi)\tau$'inv'

  $\Rightarrow$ We can isolate the term next to $\cos\theta_\ell$, and define forward-backward asymmetries analogously to pseudoscalar case

$$A^+_{\mathrm{fb,T}} = \frac{1}{\Gamma}\int dq^2 \frac{8\pi}{3} I^+_{6s} \qquad A^-_{\mathrm{fb,L}} = \frac{1}{\Gamma}\int dq^2 \frac{8\pi}{3} I^-_{6c}$$

$\Rightarrow$ Schematically:



Summary and conclusions

- Polarized angular observables in $B \to D^{(*)}\tau\nu$ discriminate the nature of inv. particle
- Separating τ-polarizations allow the following observables: $A_{\rm fb}^{D,-}$, $A_{\rm fb,L}^{D^*,-}$, $A_{\rm fb,T}^{D^*,+}$

  $\Rightarrow$ Each of them is a **null-test** for SM, and for **LHNs** in general
- Measuring any of them means either:

  $\Rightarrow$ An additional **massive** left-handed inv. particle N_L is present

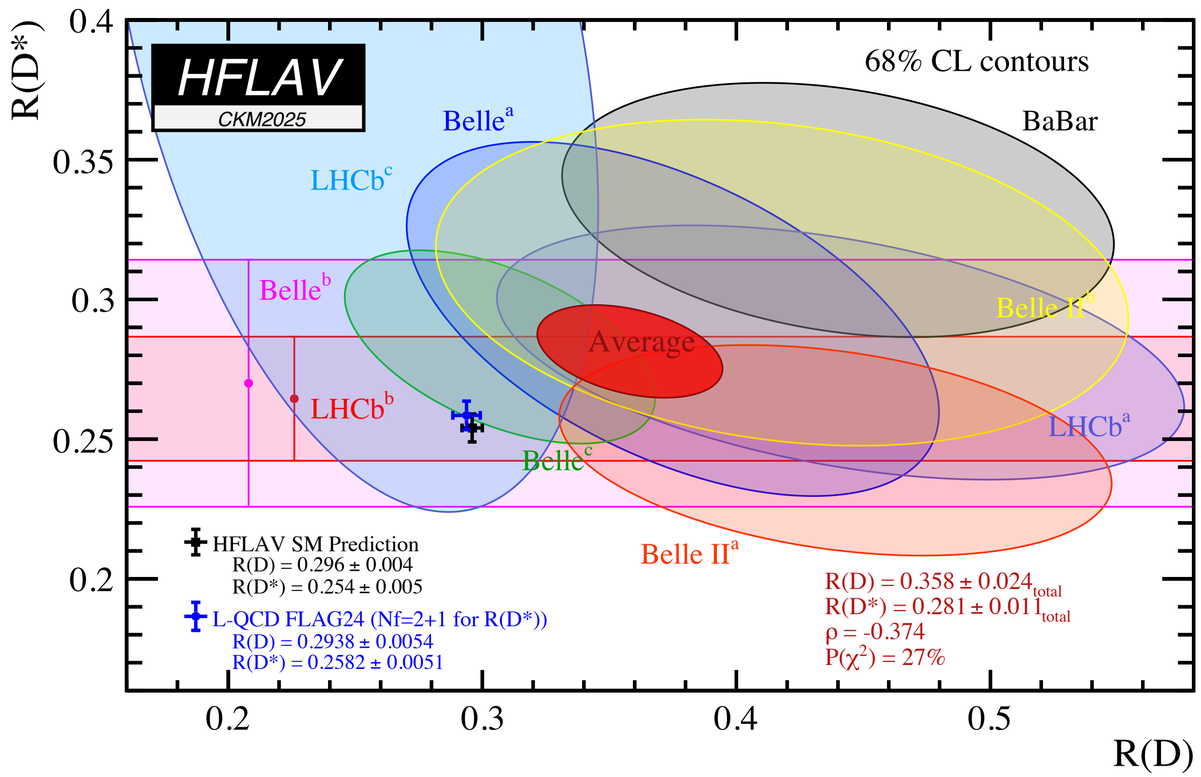
  $\Rightarrow$ An additional, possibly **massless**, right-handed inv. particle N_R is present
- All of the discussion can be extended to any $P \to P\ell\text{`inv'}$ or $P \to V\ell\text{`inv'}$ process

Thank you for your attention!

Observables in $b \to c\ell\nu$

$$R_{D^{(*)}} = \frac{\Gamma(B \to D^{(*)}\tau\nu)}{\Gamma(B \to D^{(*)}\ell\nu)}, \quad \ell = e, \mu$$

- Two new measurements
  (since the writing)

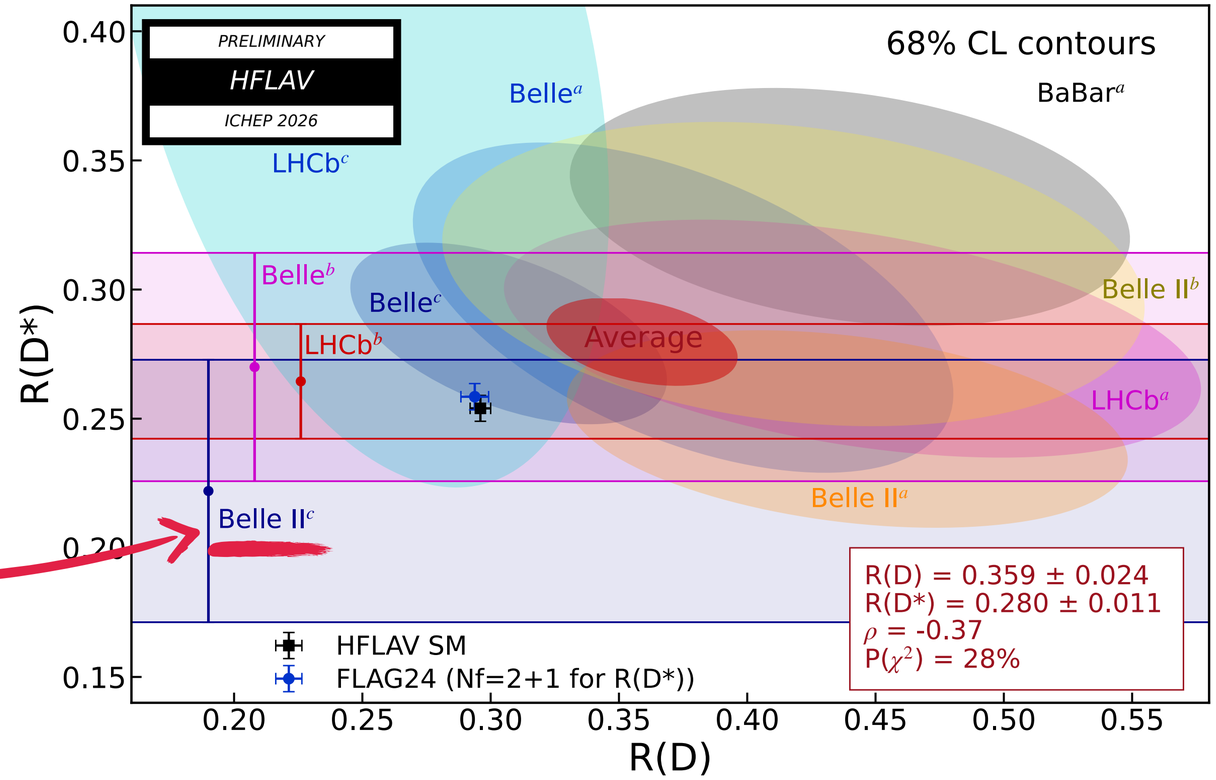


Observables in $b \to c\ell\nu$

$$R_{D^{(*)}} = \frac{\Gamma(B \to D^{(*)}\tau\nu)}{\Gamma(B \to D^{(*)}\ell\nu)}, \quad \ell = e, \mu$$

- Two new measurements
  (since the writing)

ICHEP 2026 (talk)



Observables in $b \to c\ell\nu$

$$R_{D^{(*)}} = \frac{\Gamma(B \to D^{(*)}\tau\nu)}{\Gamma(B \to D^{(*)}\ell\nu)}, \quad \ell = e, \mu$$

- Two new measurements
  (since the writing)

ICHEP 2026 (talk)

Moriond 2026 (talk)

