Introduction to $c \to u\nu\bar{\nu}$ decays

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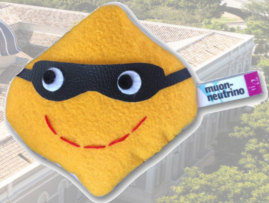


Belle II Physics week, October 6–10, 2025, KEK (Japan)

Universidad Europea VALENCIA

The "myth" of charm physics

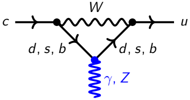
1. Hadronic effects dominate – large uncertainties.
2. Energy scale $\sim 1\,\mathrm{GeV}$ – perturbative expansion in $1/m_c$ breaks down.
3. Strong GIM suppression.

$$\boxed{1 + 2 + 3 = \text{Not a promising place to search for NP}}$$

But is this really true?

Rare charm decays are special!

1. **A unique window to probe FCNCs in the up sector!**
2. **Strong non-perturbative dynamics** $\rightarrow$ **"Null tests"** $\mathcal{O} \pm \delta\mathcal{O}$
   - Use SM symmetries: $\mathcal{O}_{\mathrm{SM}} = \mathbf{0}$,
   - Small uncertainties: $\delta\mathcal{O}_{\mathrm{SM}} \ll \mathcal{O}_{\mathrm{SM}}$,
   - Use large hadronic effects to enhance NP contributions,
   - Construct $\mathcal{O}$ to be sensitive to specific NP,
3. **Very efficient GIM mechanism:** $\sum_i \lambda_i = 0$ with $\lambda_i \equiv V_{ci}^* V_{ui}$.



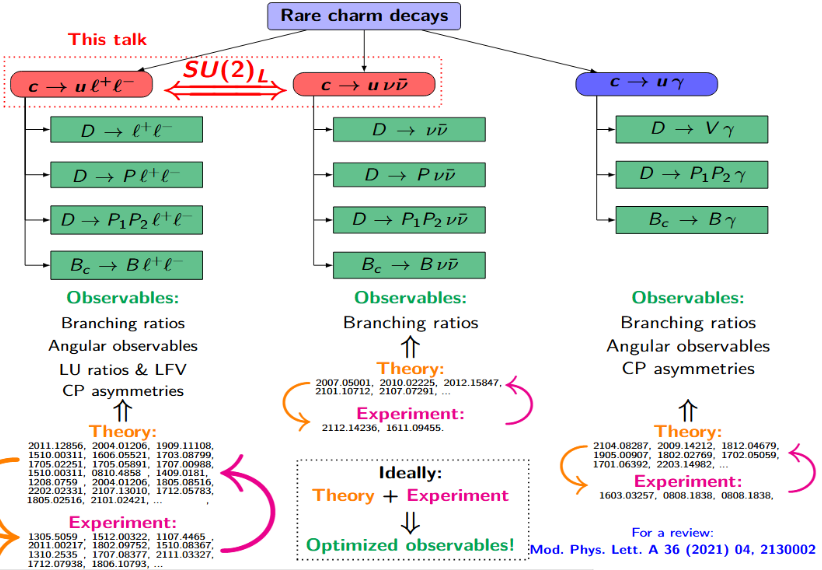
$$= \sum_{i=d,s,b} \lambda_i f_i = \lambda_s \left[(f_s - f_d) + \frac{\lambda_b}{\lambda_s} (f_b - f_d) \right]$$

$f_i \sim \frac{m_i^2}{(4\pi)^2 M_W^2}$, $\mathrm{Im}(\lambda_b/\lambda_s) \sim 10^{-3}$

BRs (A_{CP}) are loop-(CKM-) suppressed!

An excellent place to search for BSM physics!

Plenty of opportunities!



EFT approach to charm physics

1. **Dynamical fields ϕ_i at $\mu_{\rm EW}$:** $\phi_i^{\rm SM} = q_i,\ \ell_i,\ A_\mu,\ \ldots$

2. **Symmetries to build all O_i up to the desired dimension ($D = 6$):**

$$\mathcal{H}_{\rm eff} \sim \frac{4\,G_F}{\sqrt{2}} \frac{\alpha_e}{4\pi} \sum_i C_i\, O_i$$

$$O_1^q = (\bar{u}_L \gamma_\mu T^a q_L)(\bar{q}_L \gamma^\mu T^a c_L)\,, \qquad O_2^q = (\bar{u}_L \gamma_\mu q_L)(\bar{q}_L \gamma^\mu c_L)\,, \quad q = d, s\,,$$

$$O_7^{(\prime)} = \frac{m_c}{e} (\bar{u}_{L\,(R)} \sigma_{\mu\nu} c_{R\,(L)})\, F^{\mu\nu}\,, \qquad O_{9\,(10)}{}^{(\prime)} = (\bar{u}_{L\,(R)} \gamma_\mu c_{L\,(R)})(\bar{\ell}\, \gamma^\mu (\gamma_5)\, \ell)\,,$$

$$O_{S\,(P)}{}^{(\prime)} = (\bar{u}_{L\,(R)} c_{R\,(L)})(\bar{\ell} (\gamma_5)\, \ell)\,, \qquad O_{T\,(T5)} = \tfrac{1}{2} (\bar{u} \sigma_{\mu\nu} c)(\bar{\ell} \sigma^{\mu\nu} (\gamma_5)\, \ell)\,.$$

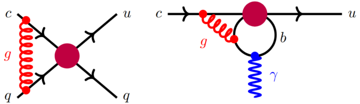
3. **Compute $C_i(\mu_{\rm EW})$ to avoid large $\alpha_s(\mu_{\rm low}) \log(\mu_{\rm low}^2/\mu_{\rm EW}^2)$.**

$$m_{q_{\rm light}} = 0 + \text{GIM mechanism} \Longrightarrow \boxed{C^{\rm SM}_{7,9,10}(\mu_{\rm EW}) = 0}$$

EFT approach to charm physics

1. **RGEs to run down to $\mu_{\rm low} \approx m_c$ (matching at $\mu_{\rm EW}$ and m_b).**

- **Penguins generated at $\mu = m_b$.**
- **$O_{7,9}$ mix with $O_{1,2}$:**



$$|C_7^{\rm eff}(\mu_c)| \lesssim 0.004\,, \qquad |C_9^{\rm eff}(\mu_c)| \lesssim 0.01$$

- **But note: the other SM WCs vanish:**

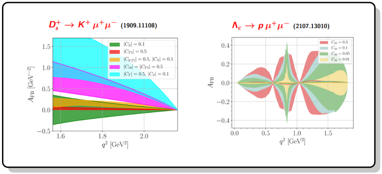
$$C_i'^{\,\rm SM} = C_S^{\rm SM} = C_T^{\rm SM} = C_{T5}^{\rm SM} = C_{10}^{\rm SM} = 0$$

Rock stars of charm physics!
Any observable proportional to these WCs is a null test.

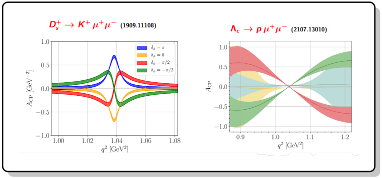
2. **$\langle O_i(\mu_{\rm low})\rangle$ non-perturbative techniques (lattice, LCSR, etc).**

3. **Include resonances: Breit–Wigner distributions + exp. data.**

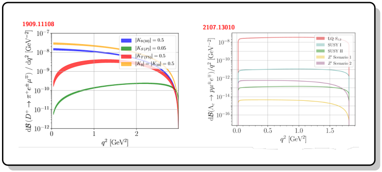
1, 2, 3, null tests!



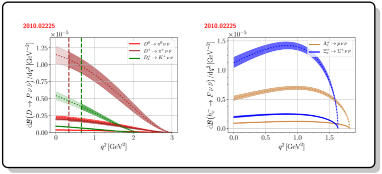
Angular



CPV



LFV



$\nu\bar{\nu}$

$1+2+3 \neq$ not a promising place to search for NP

A different way of thinking is required for charm: we target observables with $\mathcal{O}_{\rm SM} = 0$ to avoid large hadronic uncertainties.

$$\Delta\mathcal{O} = \left(\mathcal{O}_{\rm exp} - \cancel{\mathcal{O}_{\rm SM}}\right) \pm \sqrt{\cancel{(\delta\mathcal{O}_{\rm SM})^2} + (\delta\mathcal{O}_{\rm exp})^2}$$

How large can NP be in charm?

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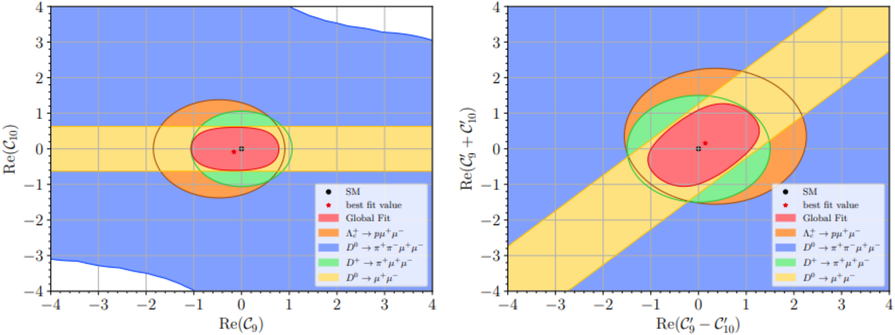

Constraints mainly set by $D^0 \to \mu^+\mu^-$ and $D^+ \to \pi^+\mu^+\mu^-$

Plenty of room for NP!

One WC at a time

fit parameter	best fit	1σ
$\mathrm{Re}\,\mathcal{C}_7$	0.01	[-0.26,+0.18]
$\mathrm{Re}\,\mathcal{C}_9$	-0.21	[-0.85,+0.55]
$\mathrm{Re}\,\mathcal{C}_{10}$	-0.09	[-0.50,+0.50]
$\mathrm{Re}\,\mathcal{C}_7'$	0.05	[-0.18,+0.25]
$\mathrm{Re}\,\mathcal{C}_9'$	0.15	[-0.61,+0.82]
$\mathrm{Re}\,\mathcal{C}_{10}'$	0.00	[-0.45,+0.45]
$\mathrm{Im}\,\mathcal{C}_7$	0.09	[-0.20,+0.24]
$\mathrm{Im}\,\mathcal{C}_9$	0.32	[-0.76,+0.85]
$\mathrm{Im}\,\mathcal{C}_{10}$	0.06	[-0.47,+0.47]
$\mathrm{Im}\,\mathcal{C}_7'$	-0.09	[-0.22,+0.21]
$\mathrm{Im}\,\mathcal{C}_9'$	-0.28	[-0.82,+0.80]
$\mathrm{Im}\,\mathcal{C}_{10}'$	-0.03	[-0.46,+0.46]

Dineutrino modes $c \to u\,\nu\bar{\nu}$

- **Extremely GIM-suppressed in the SM** (hep-ph/0112235, 0908.1174)

$$\mathcal{B}(D \to \pi\nu\bar{\nu})_{\text{SM}} \sim 10^{-16}$$

- **Only experimental information (90% C.L.)** (1611.09455, 2112.14236)

$$\mathcal{B}(D^0 \to \nu\bar{\nu}) < 9.4 \times 10^{-5}, \qquad \mathcal{B}(D^0 \to \pi^0\nu\bar{\nu}) < 2.1 \times 10^{-4}$$

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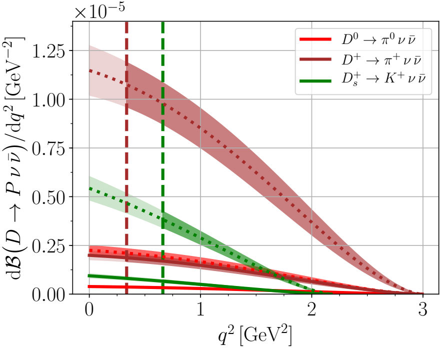

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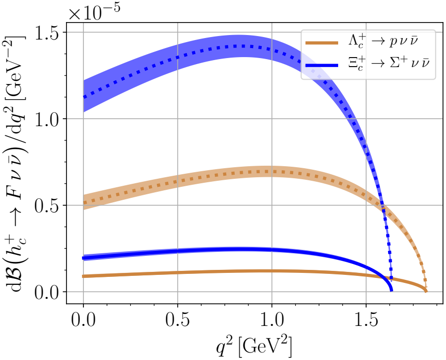
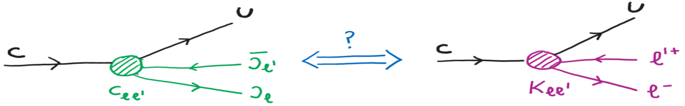


Can we get information from dineutrino modes?

ℓ and ν_ℓ (with $\ell = e, \mu, \tau$) belong to the same **SU(2)$_L$ doublet** in the SM.



$$\begin{pmatrix} c_{ee} & c_{e\mu} & c_{e\tau} \\ c_{\mu e} & c_{\mu\mu} & c_{\mu\tau} \\ c_{\tau e} & c_{\tau\mu} & c_{\tau\tau} \end{pmatrix} \Longleftrightarrow \begin{pmatrix} k_{ee} & k_{e\mu} & k_{e\tau} \\ k_{\mu e} & k_{\mu\mu} & k_{\mu\tau} \\ k_{\tau e} & k_{\tau\mu} & k_{\tau\tau} \end{pmatrix}$$

Neutrino flavour not tagged!

$$\mathcal{B}(c \to u\,\nu\bar{\nu}) = \sum_{\ell,\ell'} \mathcal{B}(c \to u\,\nu_\ell \bar{\nu}_{\ell'})$$

LU, cLFC, or general:

$$\mathcal{B}(c \to u\,\nu\bar{\nu}) \sim \tfrac{1}{3} \sum_{\ell,\ell'} c_{\ell\ell'}$$

Charged leptons tagged!

LU:

$$R_H \sim \frac{\mathcal{B}(c \to u\,\mu^+\mu^-)}{\mathcal{B}(c \to u\,e^+e^-)} \sim 1 + (k_{\mu\mu} - k_{ee})$$

cLFC or general:

$$\mathcal{B}(c \to u\,\ell'^+\ell^-) \sim k_{\ell\ell'}$$

Is there a link between $c_{\ell\ell'}$ and $k_{\ell\ell'}$?

Low-energy $|\Delta c| = |\Delta u| = 1$ EFT description

$c \to u\,\nu_\ell \bar{\nu}_{\ell'}$ $\overset{?}{\Longleftrightarrow}$ $c \to u\,\ell^- \ell'^+$

$$\mathcal{H}_{\text{eff}}^{\nu_\ell \bar{\nu}_{\ell'}} = -\frac{4\,G_F}{\sqrt{2}} \frac{\alpha}{4\pi} \sum_k \mathcal{C}_k^{U\ell\ell'}\, Q_k^{U\ell\ell'}$$

$$\mathcal{H}_{\text{eff}}^{\ell^- \ell'^+} = -\frac{4\,G_F}{\sqrt{2}} \frac{\alpha}{4\pi} \sum_k \mathcal{K}_k^{U\ell\ell'}\, O_k^{U\ell\ell'}$$

Only two operators (no RH neutrinos, as in the SM).

$$Q_{\mathrm{L\,(R)}}^{U\ell\ell'} = (\bar{u}_{L\,(R)} \gamma_\mu c_{L\,(R)})(\bar{\nu}_{\ell' L} \gamma^\mu \nu_{\ell L})$$

Additional operators are not connected.

$$O_{\mathrm{L\,(R)}}^{U\ell\ell'} = (\bar{u}_{L\,(R)} \gamma_\mu c_{L\,(R)})(\bar{\ell}'_L \gamma^\mu \ell_L),\ \ldots$$

Dineutrino BR is obtained via an incoherent neutrino flavour sum:

$$\mathcal{B}(c \to u\,\nu\bar{\nu}) = \sum_{\ell,\ell'} \mathcal{B}(c \to u\,\nu_\ell \bar{\nu}_{\ell'}) \sim \sum_{\ell,\ell'} \left| \mathcal{C}_L^{U\ell\ell'} \pm \mathcal{C}_R^{U\ell\ell'} \right|^2$$

$\mathcal{C}^P$ and $\mathcal{K}^P$ are in the mass basis. $P = D$ ($P = U$) $\to$ down-quark sector (up-quark sector).

Correlating neutrinos and charged leptons with $\mathrm{SU(2)_L}$

Lowest order $\mathrm{SU}(2)_L \times \mathrm{U}(1)_Y$–invariant effective theory (1008.4884)

$$\mathcal{L}^{\mathrm{LO}}_{\mathrm{SMEFT}} \supset \frac{C^{(1)}_{\ell q}}{v^2}\,\bar{Q}\gamma_\mu Q\,\bar{L}\gamma^\mu L + \frac{C^{(3)}_{\ell q}}{v^2}\,\bar{Q}\gamma_\mu \tau^a Q\,\bar{L}\gamma^\mu \tau^a L + \frac{C_{\ell u}}{v^2}\,\bar{U}\gamma_\mu U\,\bar{L}\gamma^\mu L + \frac{C_{\ell d}}{v^2}\,\bar{D}\gamma_\mu D\,\bar{L}\gamma^\mu L\,.$$

1. **Writing in $\mathrm{SU(2)_L}$ components:** ($C \to$ dineutrinos and $K \to$ dileptons in the gauge basis)

$$C_L^U = K_L^D = \frac{2\pi}{\alpha}\left(C^{(1)}_{\ell q} + C^{(3)}_{\ell q}\right), \qquad C_R^U = K_R^U = \frac{2\pi}{\alpha}\,C_{\ell u}\,.$$

2. **Mass basis:**

$$\boxed{\mathcal{C}_L^U = W^\dagger\,\mathcal{K}_L^D\,W + \mathcal{O}(\lambda), \qquad \mathcal{C}_R^U = W^\dagger\,\mathcal{K}_R^U\,W}$$

3. **BRs are independent of the PMNS matrix! (field redefinition of ν_L)**

$$\begin{aligned}\mathcal{B}(c\to u\,\nu\bar{\nu}) &\sim \sum_{\ell,\ell'}\left|\mathcal{C}_L^{U\,\ell\ell'} \pm \mathcal{C}_R^{U\,\ell\ell'}\right|^2 = \mathrm{Tr}\left[(\mathcal{C}_L^U \pm \mathcal{C}_R^U)(\mathcal{C}_L^U \pm \mathcal{C}_R^U)^\dagger\right]\\ &= \mathrm{Tr}\left[W^\dagger(\mathcal{K}_L^D \pm \mathcal{K}_R^U)W\,W^\dagger(\mathcal{K}_L^D \pm \mathcal{K}_R^U)^\dagger W\right]\\ &= \sum_{\ell,\ell'}\left|\mathcal{K}_L^{D\,\ell\ell'} \pm \mathcal{K}_R^{U\,\ell\ell'}\right|^2 + \mathcal{O}(\lambda)\,.\end{aligned}$$

Predictions for dineutrino rates with different leptonic flavour structures $\mathcal{K}^{\ell\ell'}_{L,R}$ can be probed with lepton-specific measurements!

Possible leptonic flavour structures for $\mathcal{K}_{L,R}^{\ell\ell'}$

$$\mathcal{B}(c \to u\,\nu\bar{\nu}) \sim \sum_{\ell,\ell'} \left|\mathcal{K}_L^{D\ell\ell'} \pm \mathcal{K}_R^{U\ell\ell'}\right|^2$$

i) ***Lepton-universality* (LU).**

$$\begin{pmatrix} k & 0 & 0 \\ 0 & k & 0 \\ 0 & 0 & k \end{pmatrix}$$

ii) ***Charged lepton flavour conservation* (cLFC).**

$$\begin{pmatrix} k_{ee} & 0 & 0 \\ 0 & k_{\mu\mu} & 0 \\ 0 & 0 & k_{\tau\tau} \end{pmatrix}$$

iii) $\mathcal{K}_{L,R}^{\ell\ell'}$ **arbitrary.**

$$\begin{pmatrix} k_{ee} & k_{e\mu} & k_{e\tau} \\ k_{\mu e} & k_{\mu\mu} & k_{\mu\tau} \\ k_{\tau e} & k_{\tau\mu} & k_{\tau\tau} \end{pmatrix}$$

Dineutrino branching ratios

$$\mathcal{B} = A_+ \, x^+ + A_- \, x^-, \qquad x^\pm = \sum_{\ell,\ell'} \left| \mathcal{C}_L^{U\,\ell\ell'} \pm \mathcal{C}_R^{U\,\ell\ell'} \right|^2$$

→ **Long-distance dynamics & kinematics $A_\pm$: LCSR (low q^2) + Lattice (high q^2)**

→ **Short-distance dynamics $x^\pm$: Wilson coefficients (BSM)**

→ **Excellent complementarity of $\mathcal{B}$:**

- **$A_- = 0$ in $D \to P\,\nu\bar{\nu}$ decays.**
- **$A_- > A_+$ in $D \to P_1 P_2\,\nu\bar{\nu}$ decays.**
- **$A_- = A_+$ in inclusive D decays.**

$D \to F$	A_+ $[10^{-8}]$	A_- $[10^{-8}]$
$D^0 \to \pi^0$	0.9	0
$D^+ \to \pi^+$	3.6	0
$D^0 \to \pi^0\pi^0$	0	0.2
$D^0 \to \pi^+\pi^-$(*)	0	0.4
$D^0 \to X$	2.2	2.2
$D^+ \to X$	5.6	5.6

(*) heavy hadron chiral perturbation theory; new results data-driven from $D^+ \to \pi^+\pi^- e^+\nu_e$ (2509.10447): $A_+^{D^0\pi^+\pi^-} = 0.1 \cdot 10^{-8}$ and $A_-^{D^0\pi^+\pi^-} = 0.5 \cdot 10^{-8}$.

Correlations between different dineutrino modes

- The **excellent complementarity between dineutrino modes** provides a **formidable environment for NP searches!**

$$\mathcal{B}(h_c \to F\,\nu\bar{\nu}) = A_+^{h_c F}\,x_+ + A_-^{h_c F}\,x_-$$

- **Correlations test the completeness of the EFT:**

$$\boxed{\mathcal{B}(h_c \to F\,\nu\bar{\nu}) = r_+^{h_c F}\,\mathcal{B}(D \to P\nu\bar{\nu}) + r_-^{h_c F}\,\mathcal{B}(D' \to P_1 P_2\,\nu\bar{\nu})}$$

where $r_+^{h_c F} = A_+^{h_c F} / A_+^{DP}$ and $r_-^{h_c F} = A_-^{h_c F} / A_-^{DP_1 P_2}$.

- $x^{\pm}$**-independent! Model-independent correlations!**
- **All dineutrino branching ratios can be inferred from two experimental measurements.**
- **Measurements of *a priori* disconnected modes can hint at missing information in the EFT**, *i.e.*, light fields.

Upper limits on dineutrino modes can probe LU!

- **Limits from high-p_T and charged-dilepton D and K decays (†):**[1]

	$\lvert\mathcal{K}_A^{P\ell\ell'}\rvert$	ee	$\mu\mu$	$\tau\tau$	$e\mu$	$e\tau$	$\mu\tau$
$s\,d$	$\lvert\mathcal{K}_L^{D\ell\ell'}\rvert$	$5\times10^{-2\dagger}$	$1.6\times10^{-2\dagger}$	6.7	$6.6\times10^{-4\dagger}$	6.1	6.6
$c\,u$	$\lvert\mathcal{K}_R^{U\ell\ell'}\rvert$	2.9	$0.9^{\dagger}$	5.6	1.6	4.7	5.1

$$x^{\pm} < 2\,x, \qquad x = \sum_{\ell,\ell'}\left(\lvert\mathcal{K}_L^{D\ell\ell'}\rvert^2 + \lvert\mathcal{K}_R^{U\ell\ell'}\rvert^2\right) + \mathcal{O}(\lambda) = \sum_{\ell,\ell'} R^{\ell\ell'} + \mathcal{O}(\lambda)$$

$\boldsymbol{x = 3\,R^{\mu\mu} \lesssim 2.6\,,}$ **(Lepton Universality)** **LU is fixed by muons.**

$\boldsymbol{x = R^{ee} + R^{\mu\mu} + R^{\tau\tau} \lesssim 156\,,}$ **(charged Lepton Flavor Conservation)**

$\boldsymbol{x = R^{ee} + R^{\mu\mu} + R^{\tau\tau} + 2\,(R^{e\mu} + R^{e\tau} + R^{\mu\tau}) \lesssim 655.}$

[1] 2007.05001

Upper limits on dineutrino branching ratios

2007.05001, 2010.02225

$$\mathcal{B}(h_c \to F\,\nu\bar{\nu}) = A_+^{h_c F}\, x_+ + A_-^{h_c F}\, x_-\,, \quad x_\pm = \sum_{i,j} |\mathcal{C}_L^{Uij} \pm \mathcal{C}_R^{Uij}|^2 < 2\,x\,.$$

$$N_i = \eta_{\text{eff}}\, \mathcal{B}_i\, N(h_c),\; N(c\bar{c})_{\text{Belle II}} = 65 \cdot 10^9,\text{ luminosity } 50\,\text{ab}^{-1}$$

$h_c \to F$	$\mathcal{B}^{\text{max}}_{\text{LU}}$ $[10^{-7}]$	$\mathcal{B}^{\text{max}}_{\text{cLFC}}$ $[10^{-7}]$	$\mathcal{B}^{\text{max}}$ $[10^{-7}]$	$N^{\text{Belle II}}_{\text{LU}}/\eta_{\text{eff}}$ $[10^5]$	$N^{\text{Belle II}}_{\text{cLFC}}/\eta_{\text{eff}}$ $[10^5]$	$N^{\text{Belle II}}_{\text{max}}/\eta_{\text{eff}}$ $[10^5]$
$D^0 \to \pi^0$	3.2	18	67	0.3	1.4	5.4
$D^+ \to \pi^+$	13	74	270	0.4	2.2	8.1
$D^0 \to \pi^0\pi^0$	1.5	9	32	0.1	0.7	2.6
$D^0 \to \pi^+\pi^-$	1.5	9	31	0.1	0.7	2.5
$\Lambda_c^+ \to p^+$	9.7	56	200	0.08	0.4	1.6
$\Xi_c^+ \to \Sigma^+$	19	110	400	0.2	0.9	3.2

$\mathcal{B}(D^0 \to \pi^0\,\nu\bar{\nu}) < 2.1 \times 10^{-4}$ (BESIII) is about one order of magnitude above our predictions. 2112.14236

$\delta\mathcal{B}$ vs $\mathcal{B}$: exp. projections and theo. predictions

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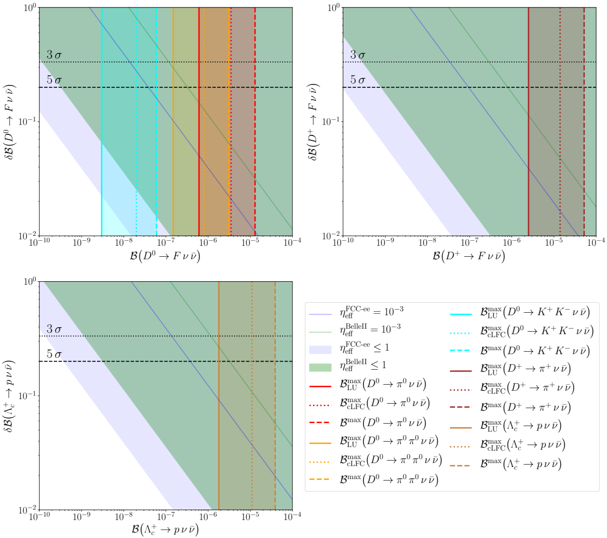


Including light right-handed neutrinos

- Light RH neutrinos admit additional $D = 6$ dineutrino operators:

$$Q^{ij}_{LR} = (\bar{u}_L \gamma_\mu c_L)(\bar{\nu}_{jR} \gamma^\mu \nu_{iR}), \qquad Q^{ij}_{S(P)} = (\bar{u}_L c_R)(\bar{\nu}_j\,(\gamma_5)\,\nu_i),$$

$$Q^{ij}_{RR} = (\bar{u}_R \gamma_\mu c_R)(\bar{\nu}_{jR} \gamma^\mu \nu_{iR}), \qquad Q^{ij}_{T(T5)} = \tfrac{1}{2}(\bar{u}\sigma_{\mu\nu} c)(\bar{\nu}_j \sigma^{\mu\nu}(\gamma_5)\nu_i)\,.$$

- $Q_{S(P)}$ are constrained by the branching ratio of $D^0 \to \nu\bar{\nu}$ (Belle, 1611.09455):

$$\mathcal{B}(D^0 \to \mathrm{inv.}) < 9.4 \times 10^{-5} \quad (90\%\ \mathrm{C.L.}).$$

- Bounds on $D \to P\,\nu\bar{\nu}$ from $D^0 \to \mathrm{inv.}$ (scalar/pseudoscalar dominance):

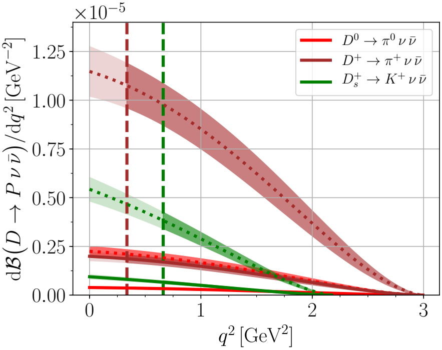
$$\mathcal{B}\left(D^0 \to \pi^0 \nu\bar{\nu}\right)_{S,P} \lesssim 2.4 \times 10^{-6}, \qquad \mathcal{B}\left(D^+ \to \pi^+ \nu\bar{\nu}\right)_{S,P} \lesssim 1.22 \times 10^{-5},$$

$$\mathcal{B}\left(D_s^+ \to K^+ \nu\bar{\nu}\right)_{S,P} \lesssim 2.3 \times 10^{-6}.$$

- Corrections of $\sim 20\%$ to the general flavour branching-ratio limits.
- $Q_{S,P}$ could become irrelevant if the bound on $\mathcal{B}(D^0 \to \mathrm{inv.})$ improves: requiring the LU impact $< 10\%$ implies $\mathcal{B}(D^0 \to \mathrm{inv.}) \lesssim 2 \times 10^{-6}$. An improvement by two orders of magnitude would exclude S and P contributions.

Two important comments

1. SM model backgrounds in charged model like $D^+ \to \tau^+(\to \pi^+\bar{\nu}_\tau)\nu_\tau$ can be removed by kinematic cuts: $q^2 > (m_\tau^2 - m_\pi^2)(m_D^2 - m_\tau^2)/m_\tau^2$.
2. Since these channels involve missing energy, the invisible final state is not necessarily neutrinos - it could be new light BSM states. To identify the underlying new physics, providing differential branching ratios is more useful than only integrated rates.



Conclusion

- ⋆ Window to explore FCNCs in the up sector.
- ⋆ Unique phenomenology (strong GIM suppression).
- ⋆ Clean null-test observables can probe NP.
- ⋆ Plenty of opportunities, not only charm decays with missing energy:
  - Angular observables
  - CP asymmetries
  - LU ratios
  - LFV
- ⋆ $c \to u\nu\bar{\nu}$ well suited to Belle II.

Thank you for your attention!