# Probing CP-violation in $b \to s\nu\bar{\nu}$ decays

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*Based on work with S. Descotes-Genon, S. Fajfer, J.F. Kamenik*


*arXiv:2208.10880*

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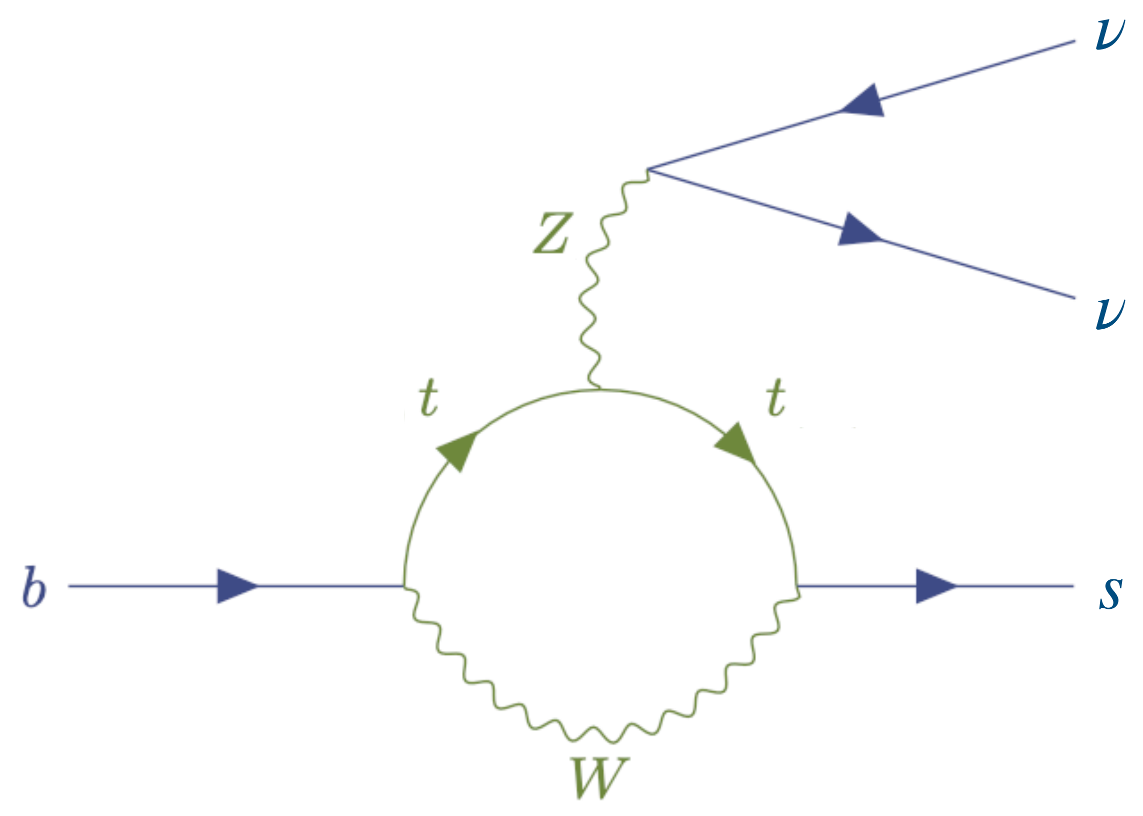
# Motivation



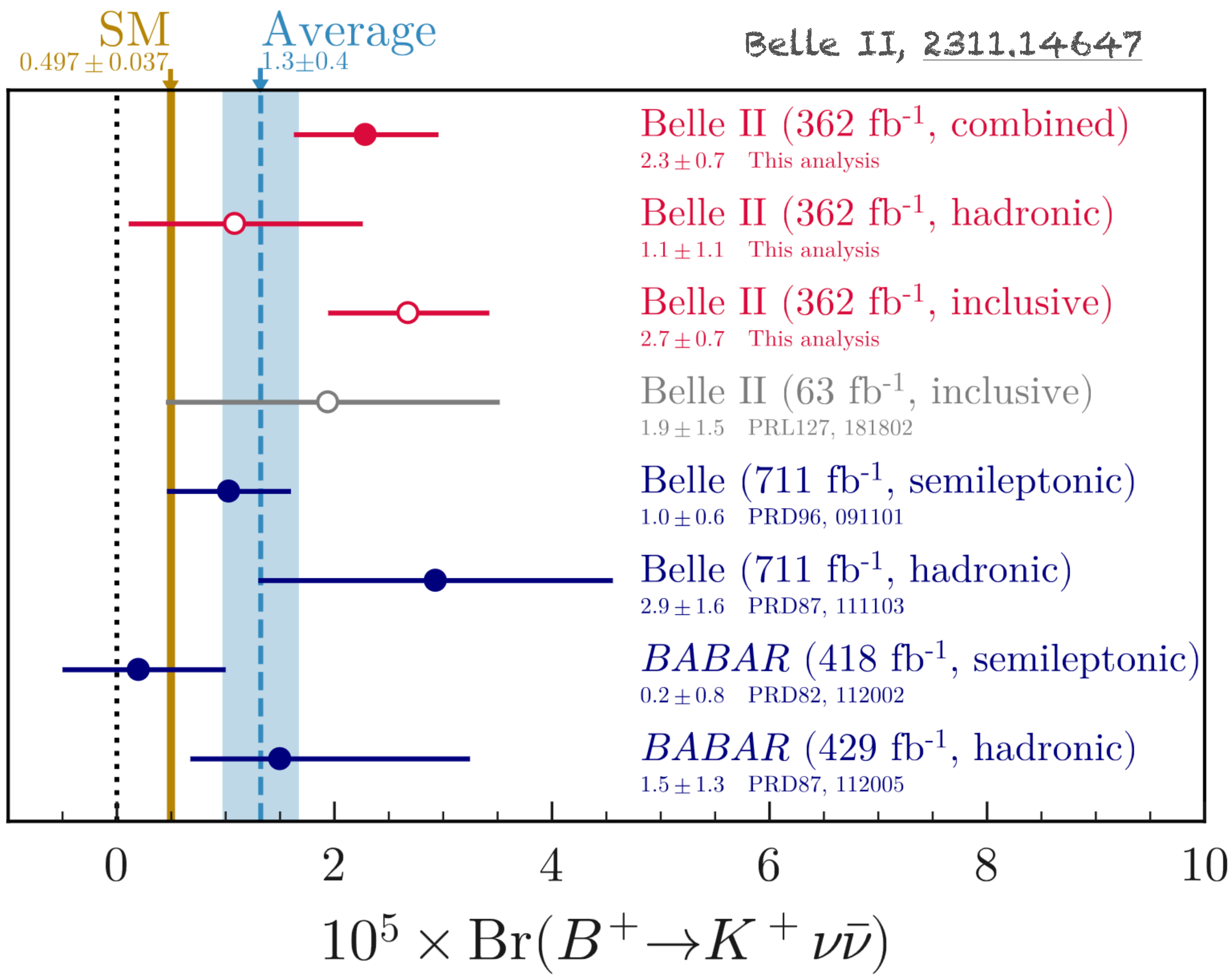

- Rare b-decays are excellent probes of NP
  - Loop and CKM suppression (GIM mechanism broken by large top mass)
  - Sensitive to virtual contributions from heavy NP states
- Hints of NP in several semileptonic decays ($b \to s\ell\ell$, $b \to s\nu\bar{\nu}$, $b \to c\ell\nu$)
- Neutrino modes are theoretically clean – they are free from long-distance, non-local hadronic effects.
- CP-violation in the SM is very small

$$\arg\left(V_{tb}V_{ts}^*\right) \simeq \frac{\mathrm{Im}(V_{tb}V_{ts}^*)}{\mathrm{Re}(V_{tb}V_{ts}^*)} \sim \eta\lambda^2 \approx 1^\circ$$

# Experimental picture

- Until recently, sensitivity was far from detecting SM signals
- $Br(B^0 \to K^{*0} \nu \bar{\nu}) < 1.8 \times 10^{-5}$ Belle, 1702.03224
- Evidence for $B \to K \nu \bar{\nu}$ decay by the 2023 Belle II analysis ($3.9\sigma$ inclusive tag, $3.3\sigma$ world average)
- Inclusive tag measurement in substantial tension with the SM:
  - Signal is almost 5 x SM
  - $3.1\sigma$ inclusive tag
  - $2\sigma$ world average

Belle II, 2311.14647



# $b \to s\nu\bar{\nu}$ in the SM

Local operator effective theory at $\mu < \Lambda_{\text{EW}}$

$$\mathscr{H}_{\text{eff}} = \frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \left( \sum_{X=L,R} \mathscr{C}_X \mathscr{O}_X \right) + \text{h.c.}$$

Short Distance WC

Local operator

Hadronic Matrix Element and Form Factors

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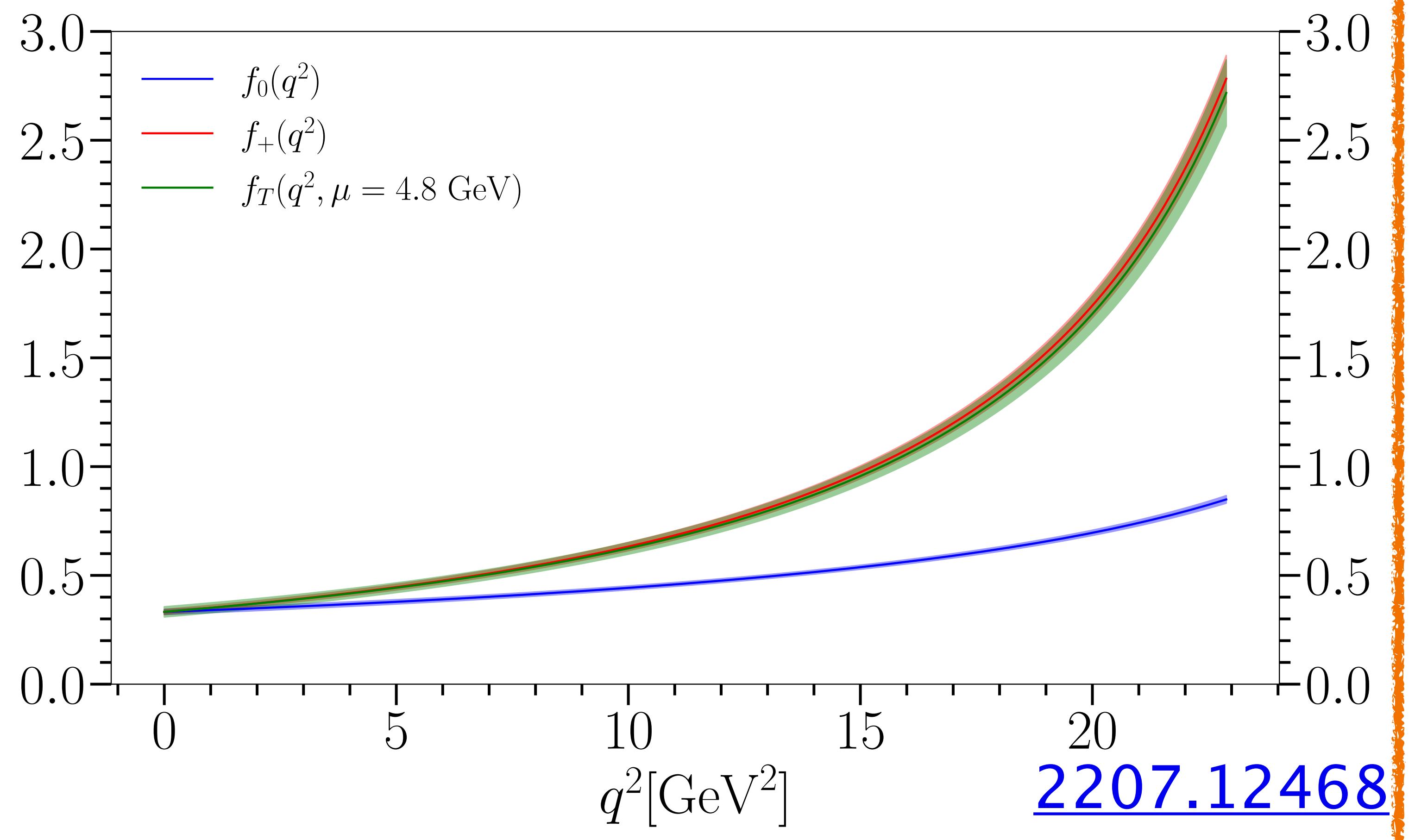


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$$\langle K(k)|\bar{s}_L\gamma^\mu b_L|B(p)\rangle = \left[(p+k)^\mu - \frac{m_B^2 - m_K^2}{q^2}q^\mu\right] f_+(q^2) + q^\mu \frac{m_B^2 - m_K^2}{q^2} f_0(q^2),$$

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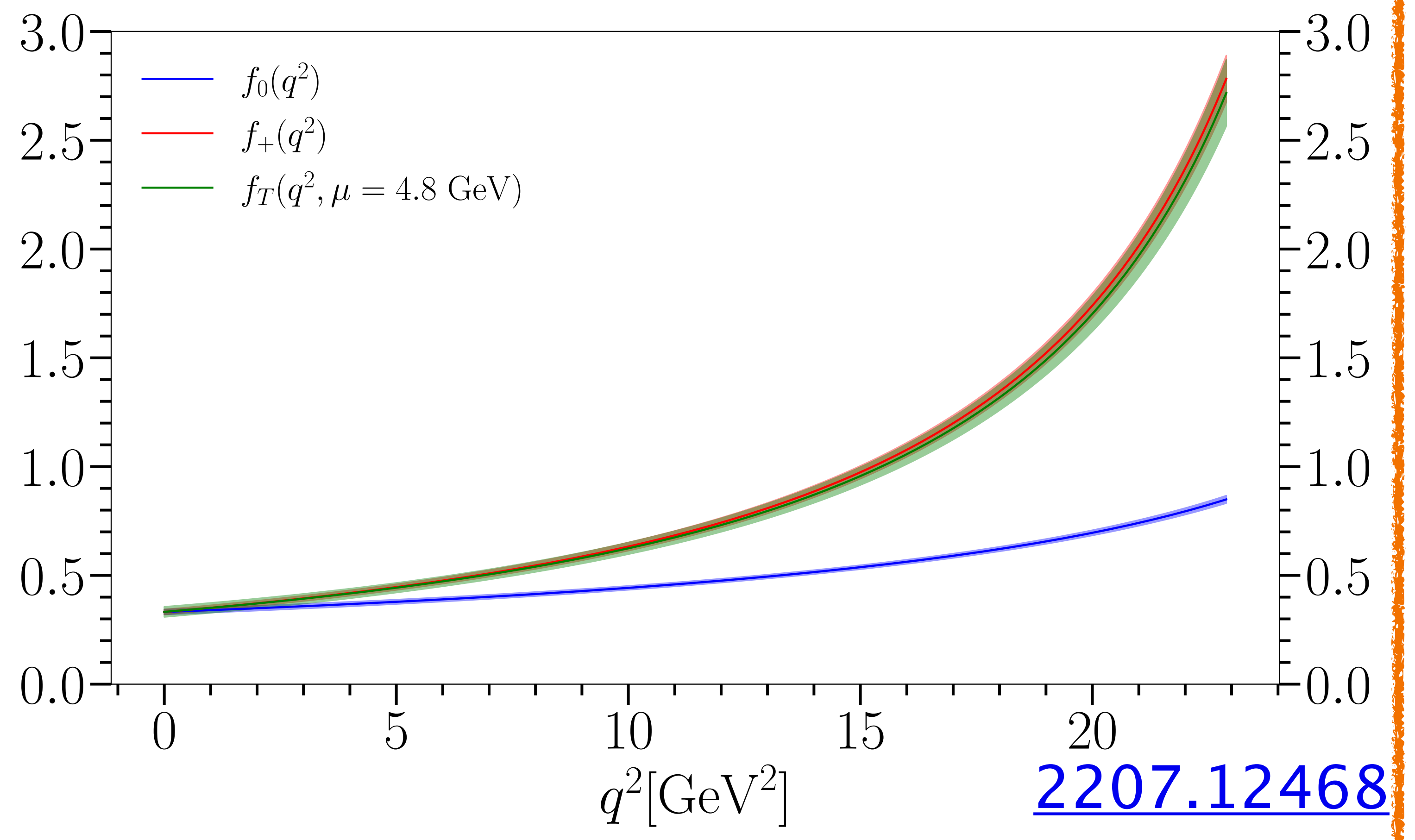


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Short distance WC well known up to NNLO in QCD and NLO in EW

Only one operator is present in the SM:

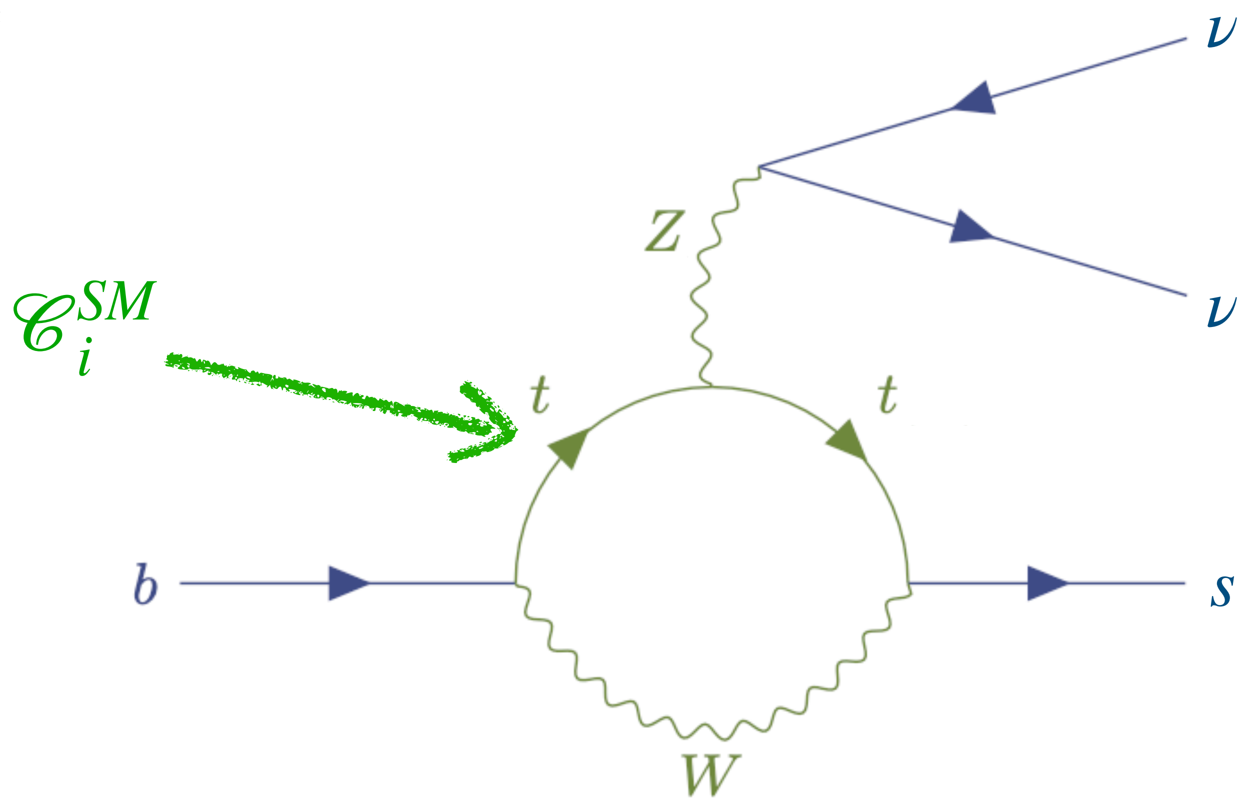
$$\mathcal{O}_L = \frac{e^2}{16\pi^2} (\bar{s}\gamma_\mu P_L b)(\bar{\nu}\gamma^\mu(1-\gamma_5)\nu)$$

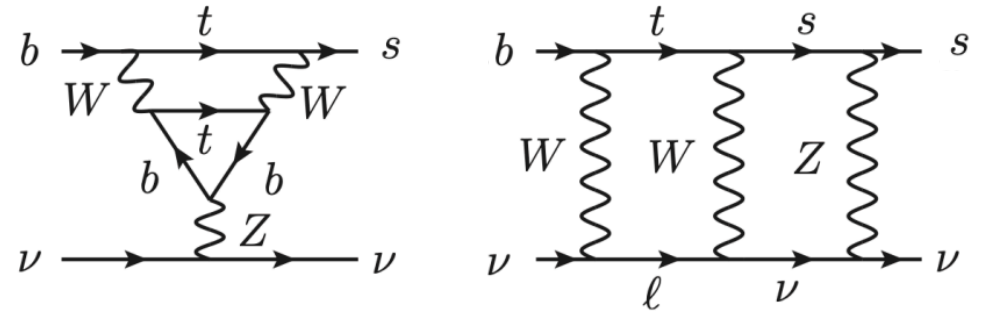
$$\mathcal{C}_L^{\rm SM} = -\frac{X_t}{\sin^2\theta_W} = -6.322$$

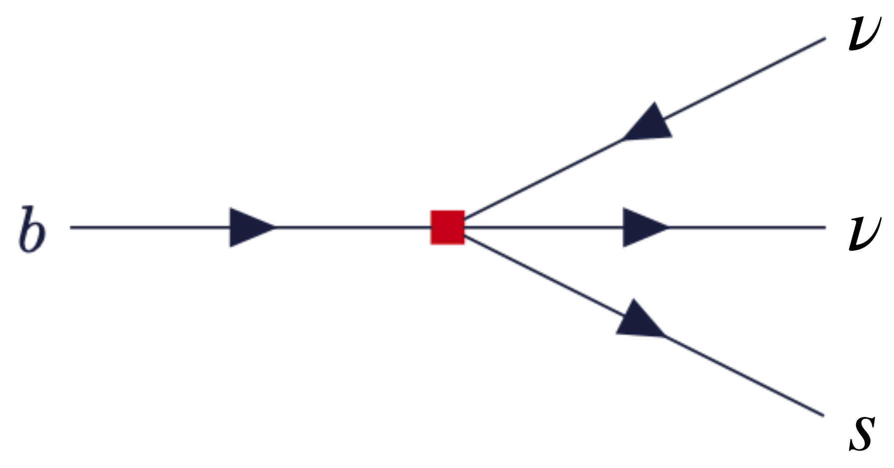
$$X_t = 1.462(17)(2)$$

$$\mathcal{O}_R = \frac{e^2}{16\pi^2} (\bar{s}\gamma_\mu P_R b)(\bar{\nu}\gamma^\mu(1-\gamma_5)\nu)$$

$$\mathcal{C}_R^{\rm SM} = 0$$




SM contributions dominated by factorizable contributions -> Absence of non-local hadronic effects

# How do you describe $b \to s\nu\bar{\nu}$ decays

## Heavy NP EFT vs Light NP

### Heavy New Physics

Heavy NP would modify the Wilson Coefficients (effective contact interactions)

Additional Right Handed Currents not present in the SM

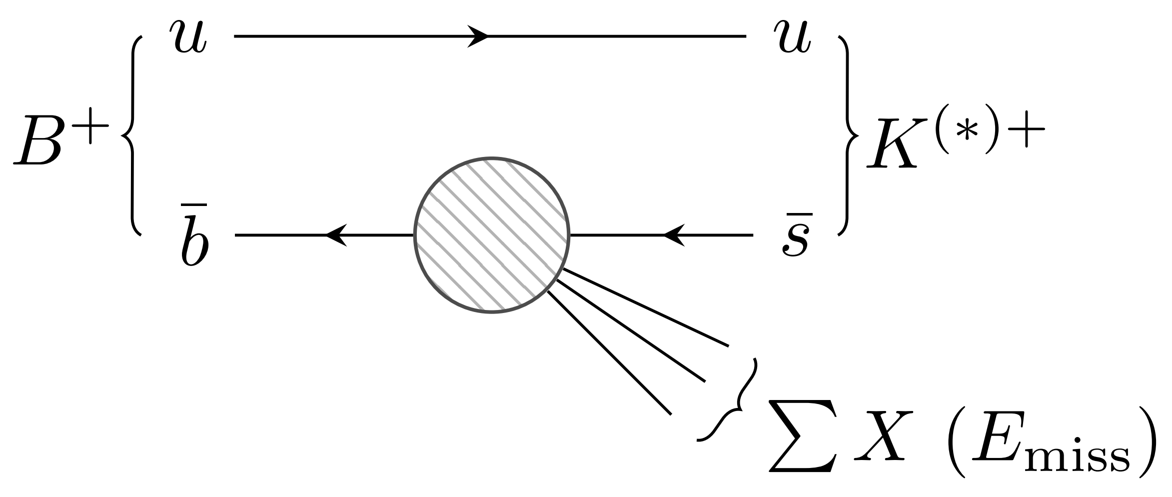
$$\mathscr{C}_L = \mathscr{C}_L^{SM} + \mathscr{C}_L^{NP} \qquad \mathscr{C}_R = \mathscr{C}_R^{NP}$$

$$\mathscr{O}_X = \frac{e^2}{16\pi^2}(\bar{s}\gamma_\mu P_X b)(\bar{\nu}\gamma^\mu(1-\gamma_5)\nu)$$

See talks by Olcyr Sumensari and David Marzocca

### Light New Physics

Light NP -> New invisible light states could be hidden in $E_{miss}$




$$Br(b \to s\, E_{miss}) = Br(b \to s\nu\bar{\nu}) + Br(b \to sX)$$

See talk by Patrick Bolton later on

We will mainly focus on this approach

# Heavy NP: Observables in $b \to s\nu\bar{\nu}$

$$\mathcal{H}_{\text{eff}} = \frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \left( (\mathscr{C}_L^{\text{SM}} + \mathscr{C}_L^{\text{NP}}) \mathcal{O}_L + \mathscr{C}_R^{\text{NP}} \mathcal{O}_L \right) + \text{h.c.}$$

$$\mathcal{O}_L = \frac{e^2}{16\pi^2} (\bar{s}\gamma_\mu P_L b)(\bar{\nu}\gamma^\mu(1-\gamma_5)\nu)$$

$$\mathcal{O}_R = \frac{e^2}{16\pi^2} (\bar{s}\gamma_\mu P_R b)(\bar{\nu}\gamma^\mu(1-\gamma_5)\nu)$$

$$\mathscr{M}(B \to K\nu\bar{\nu}) = \mathscr{N}\,(C_L + C_R)\, L_\mu \,\langle K(k)\,|\,\bar{s}\gamma^\mu b\,|\,B(p)\rangle$$

$$\mathscr{M}(B \to K^*\nu\bar{\nu}) = \mathscr{N}\, L_\mu \Big[ (C_L + C_R)\,\langle K^*(k,\varepsilon^*)\,|\,\bar{s}\gamma^\mu b\,|\,B(p)\rangle - (C_L - C_R)\,\langle K^*(k,\varepsilon^*)\,|\,\bar{s}\gamma^\mu\gamma_5 b\,|\,B(p)\rangle \Big]$$

We get two combinations: $C_L + C_R$ and $C_L - C_R$

No Interference between them (Different Helicity Amplitudes)

# Heavy NP: Observables in $b \to s\nu\bar{\nu}$

Br and $F_L$ in B->K(*) and $B_s$->phi depend only on two parameters ($\varepsilon_\nu$, $\eta_\nu$)

Sensitive to the Magnitude of the WC

$$\epsilon_\nu = \frac{\sqrt{|C_L^\nu|^2 + |C_R^\nu|^2}}{|C_L^{\nu,\mathrm{SM}}|} \qquad \epsilon_\nu > 0$$

$$\eta_\nu = \frac{-\mathrm{Re}(C_L^\nu C_R^{\nu *})}{|C_L^\nu|^2 + |C_R^\nu|^2} \qquad |\eta_\nu| < 1/2$$

Sensitive to the presence of Right Handed Currents and the relative phase between CL and CR

$$\mathscr{B}(B \to K\nu\bar{\nu}) = (4.5 \pm 0.7) \times 10^{-6}\,\frac{1}{3}\sum_\nu (1 - 2\eta_\nu)\,\epsilon_\nu^2$$

$$\mathscr{B}(B \to K^*\nu\bar{\nu}) = (6.8 \pm 1.1) \times 10^{-6}\,\frac{1}{3}\sum_\nu (1 + 1.31\eta_\nu)\,\epsilon_\nu^2$$

$$\mathscr{B}(B \to X_s\nu\bar{\nu}) = (2.7 \pm 0.2) \times 10^{-5}\,\frac{1}{3}\sum_\nu (1 + 0.09\eta_\nu)\,\epsilon_\nu^2$$

$$\langle F_L \rangle = (0.54 \pm 0.01)\,\frac{\sum_\nu (1 + 2\eta_\nu)\,\epsilon_\nu^2}{\sum_\nu (1 + 1.31\eta_\nu)\,\epsilon_\nu^2}$$

# How Big can $\mathscr{C}_L^{\nu,\,\mathrm{NP}}$ and $\mathscr{C}_R^{\nu,\,\mathrm{NP}}$ be?

- Let's assume NP only affecting the tau neutrino (Avoid constrains from $b \to s\mu\mu$)

- Fit to Upper limits for $B \to K^*\nu\bar{\nu}$ and Belle II $B \to K\nu\bar{\nu}$ evidence

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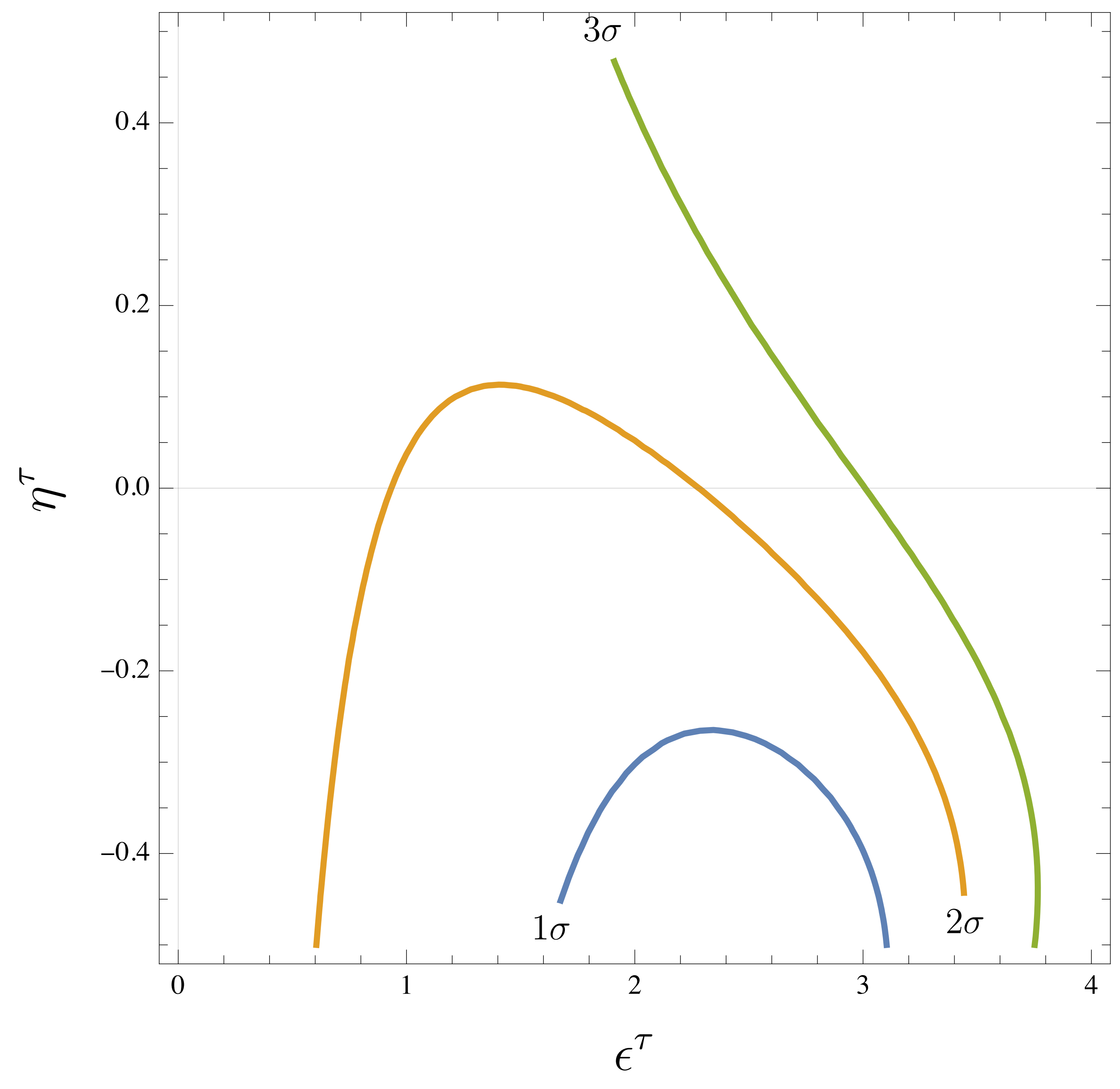


- Let's assume NP only affecting the tau neutrino (Avoid constrains from $b \to s\mu\mu$)
- Fit to Upper limits for $B \to K^*\nu\bar{\nu}$ and Belle II $B \to K\nu\bar{\nu}$ evidence
- Prefers maximal magnitude of $\eta = -1/2$ to minimise $Br(B \to K^*\nu\bar{\nu})$ while enhancing $Br(B \to K\nu\bar{\nu})$

$$\mathscr{B}(B \to K\nu\bar{\nu}) = (4.5 \pm 0.7) \times 10^{-6}\, \frac{1}{3} \sum_\nu (1 - 2\eta_\nu)\, \epsilon_\nu^2 \qquad \epsilon_\nu = \frac{\sqrt{|C_L^\nu|^2 + |C_R^\nu|^2}}{|C_L^{\nu,\mathrm{SM}}|}$$

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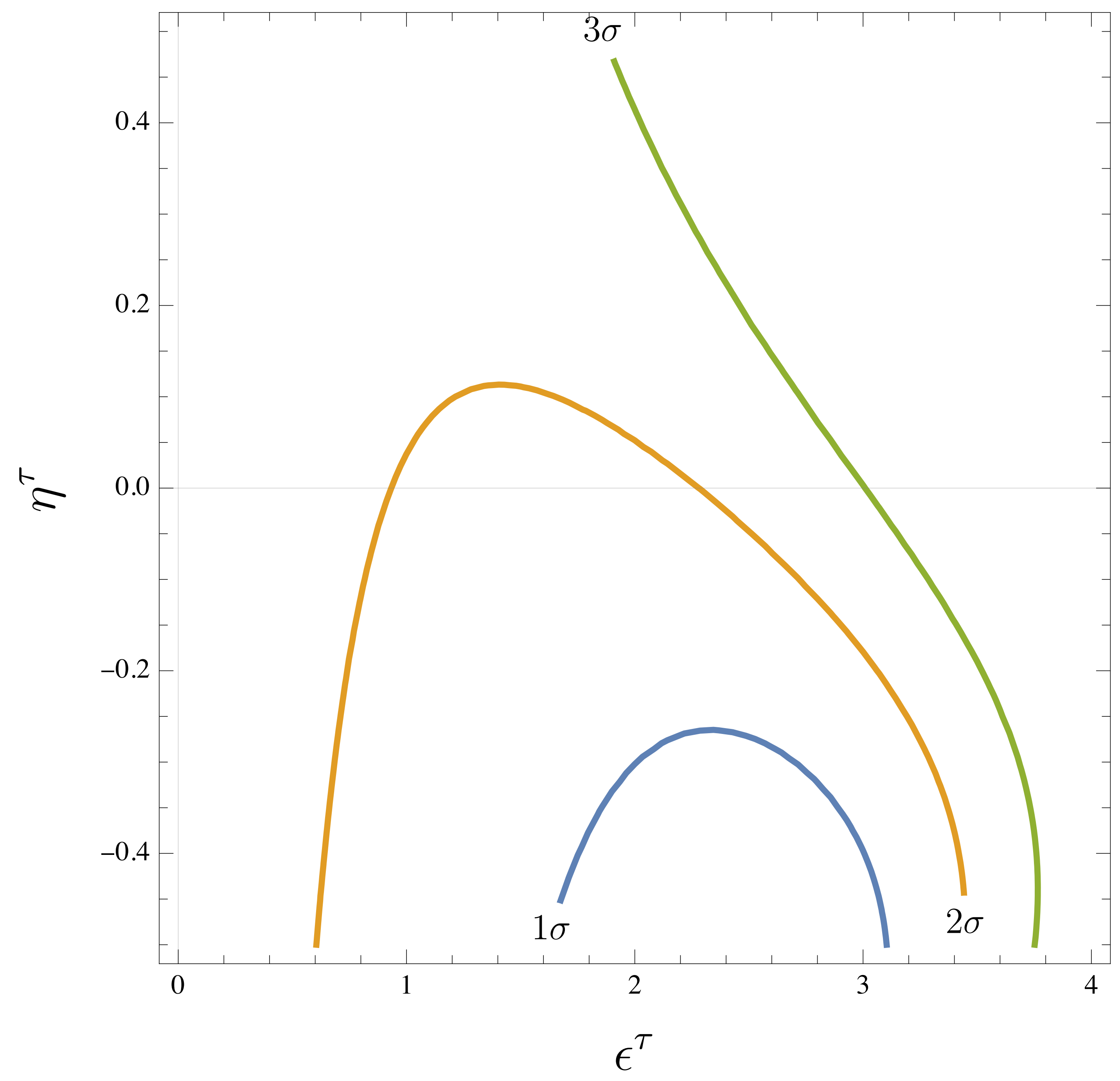
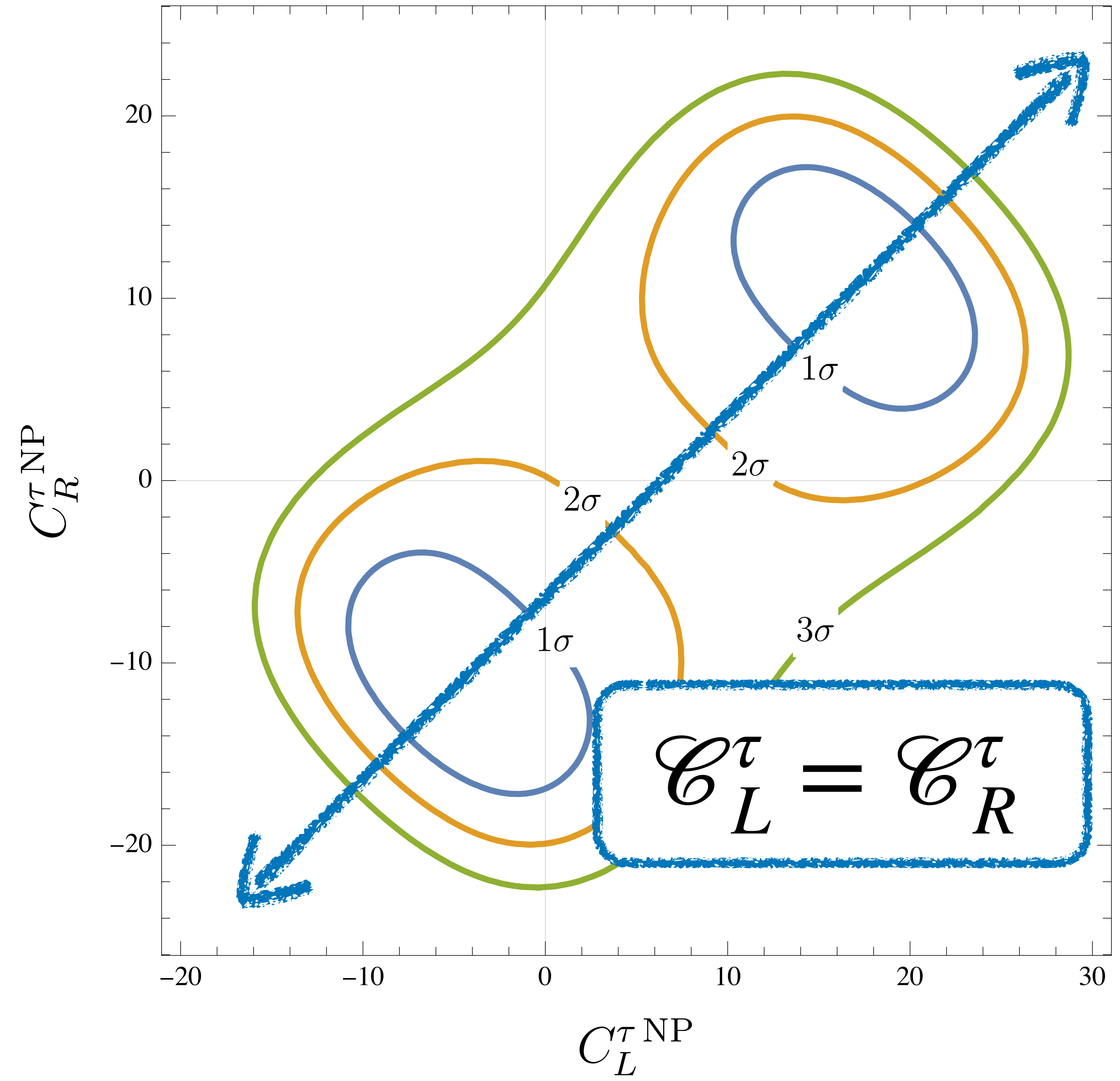
- Prefers maximal magnitude of $\eta = -1/2$ to minimise $Br(B \to K^*\nu\bar{\nu})$ while enhancing $Br(B \to K\nu\bar{\nu})$

- This translate to $\mathscr{C}_L^\tau = \mathscr{C}_R^\tau$, but a pure $\mathscr{C}_R^{\tau,\,\mathrm{NP}}$ contribution gives a good fit

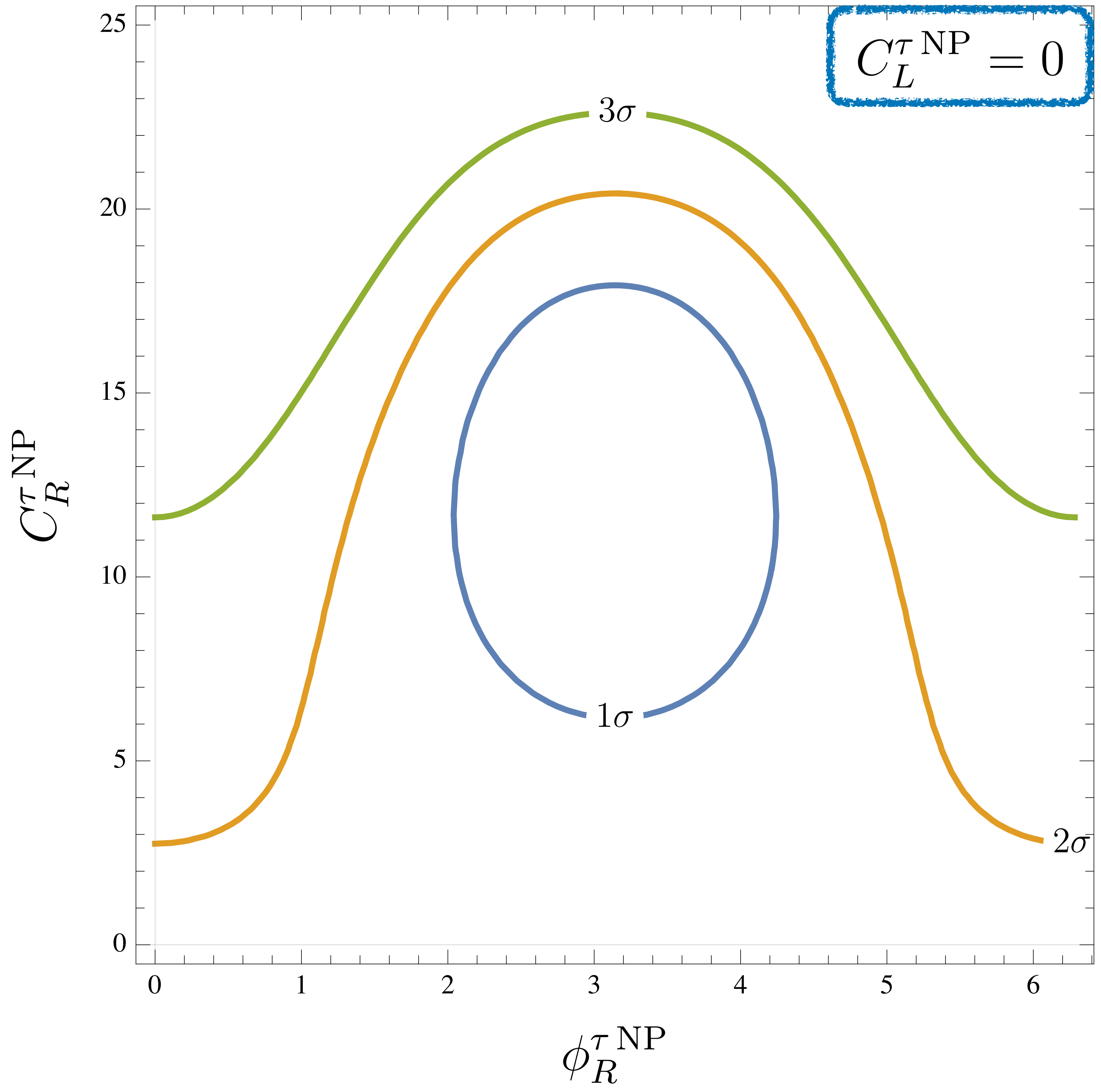


# What about CP phases?

Limits of Current observables

- Br and FL cannot fully disentangle RHC from relative CL/CR phase
- Only partial control over the relative phase
- Thanks to the maximal value for eta relative phase is partially constrained



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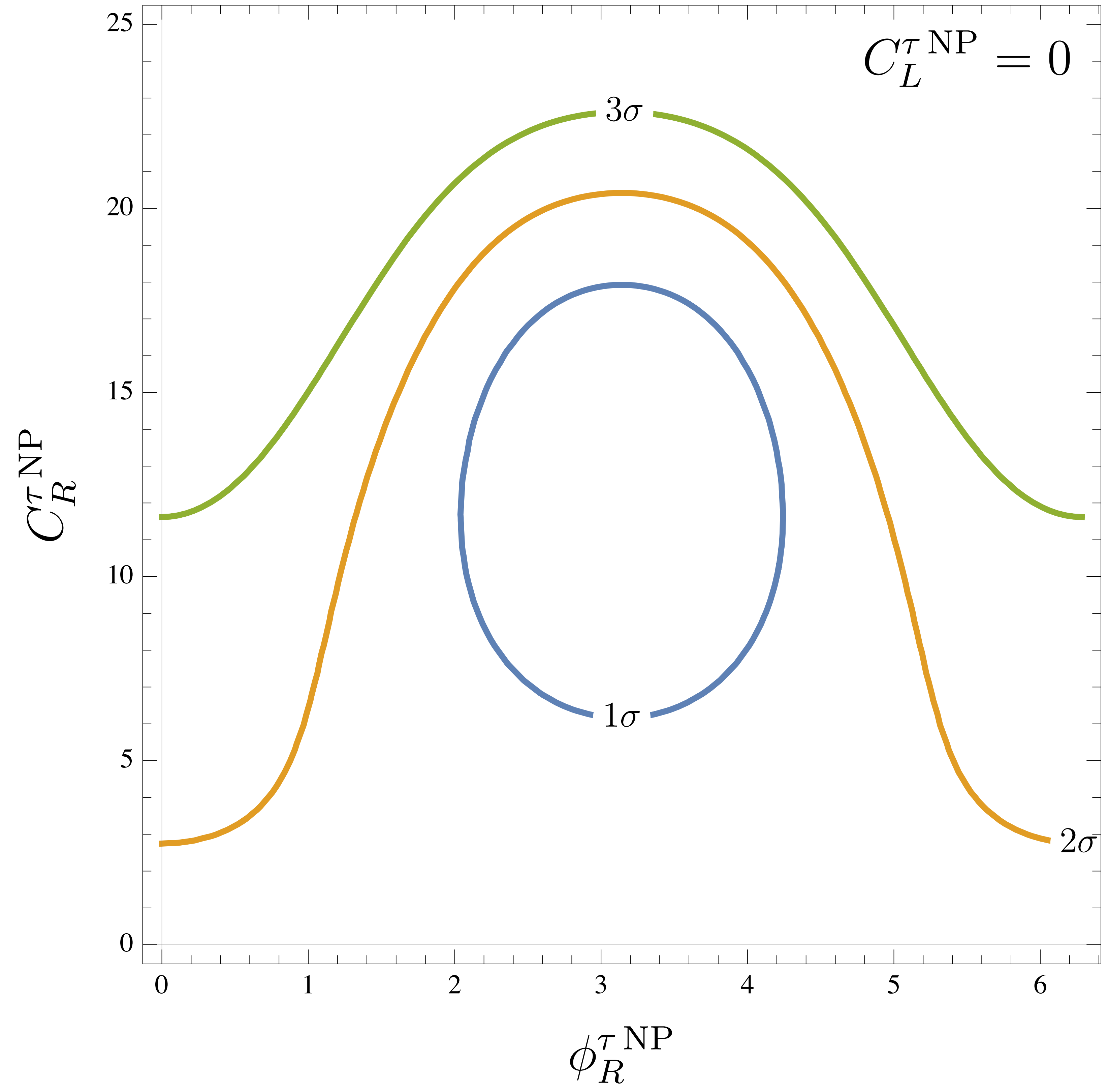


Direct CP-Asymmetries

Due to lack of strong phases $\mathscr{A}_{\mathrm{CP}}^{\mathrm{dir}} = 0$

(Neutrinos couple to Z, only short distance)

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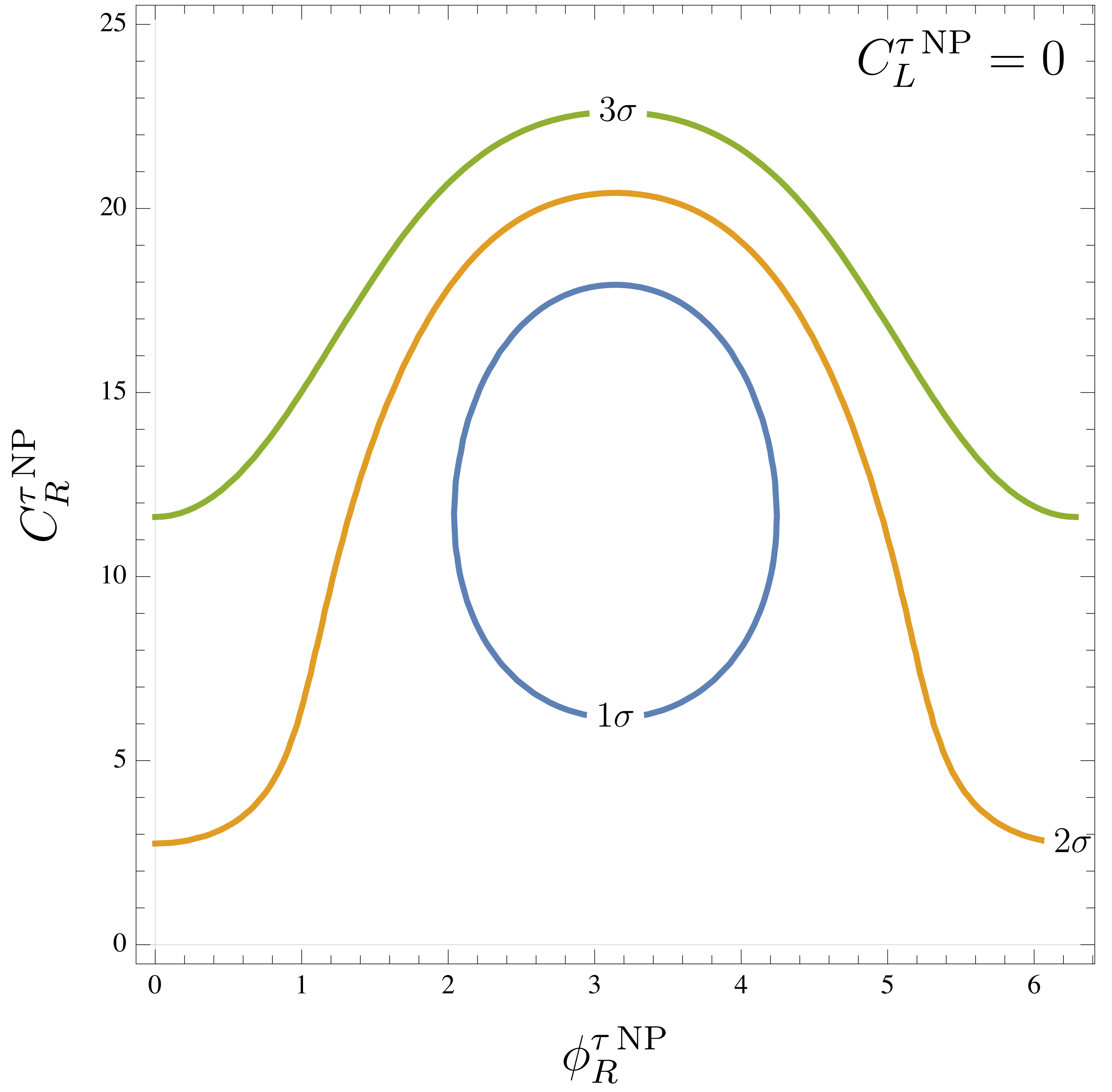


What about $\Lambda_b \to \Lambda \nu \bar{\nu}$ ?

Polarized $Br(\Lambda_b \to \Lambda \nu \bar{\nu})$ @ FCCee help disentangle

$$A_{FB} \propto P_{\Lambda_b} |\mathscr{C}_R|^2 - |\mathscr{C}_L|^2$$

Breakes the degeneracy of Meson decays ($\varepsilon_\nu$, $\eta_\nu$)

(See Wolfgang Altmannshofer Talk)

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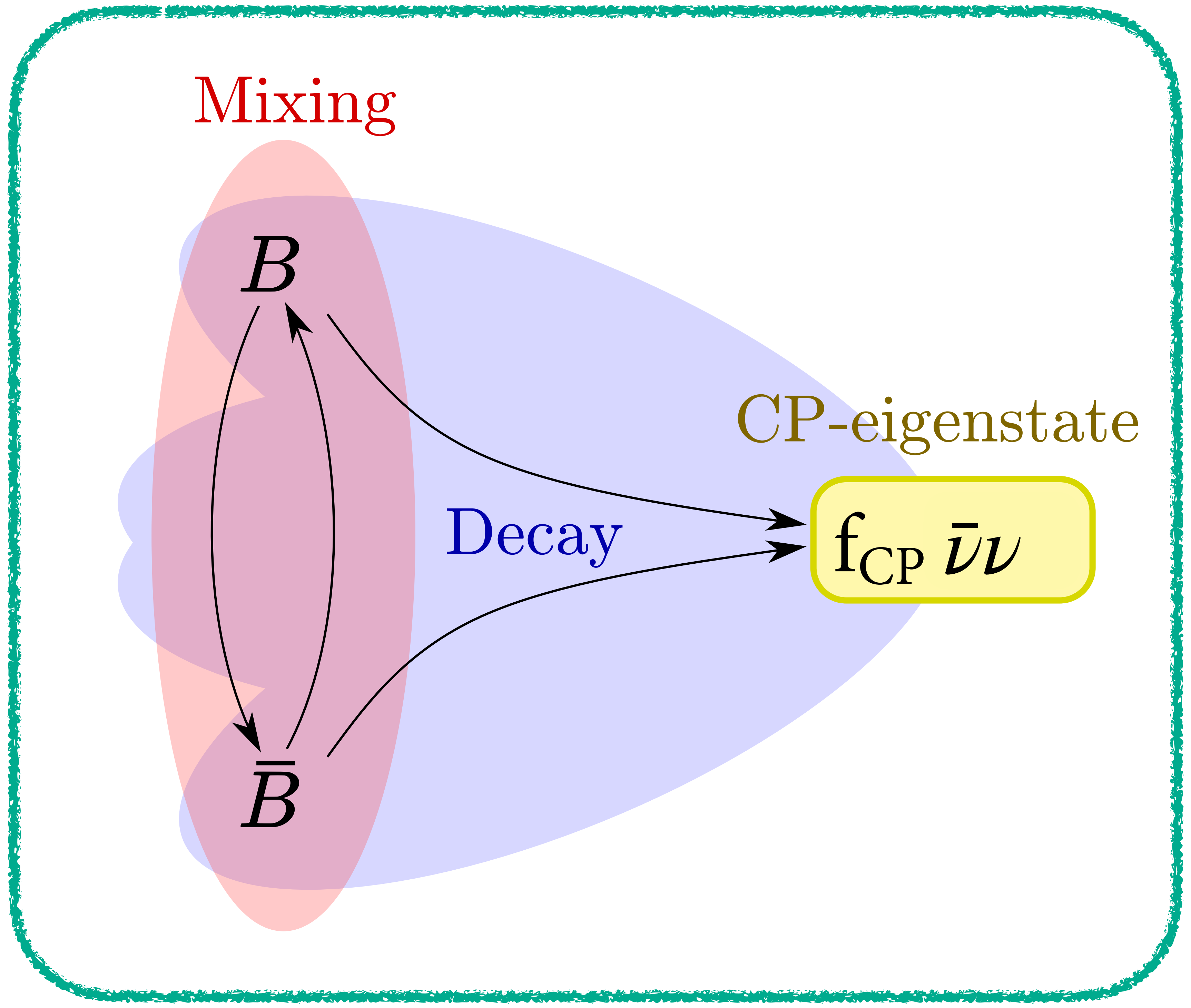
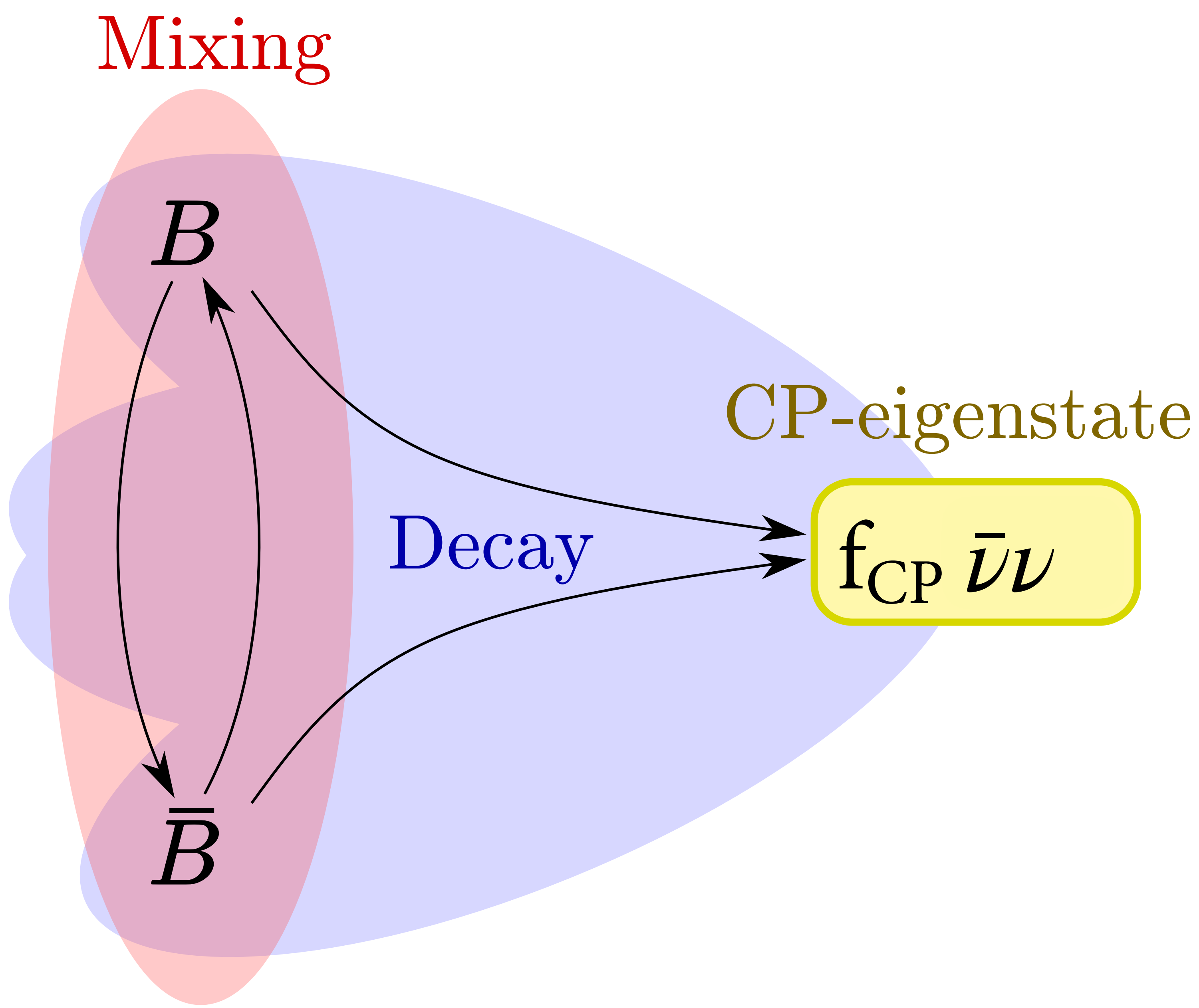
# Indirect CP-Asymmetries



# Indirect CP-Asymmetries

## What are they?

- Occur in neutral mesons that mix and decay to the same CP eigenstate
    - Interference between the decay amplitude and the mixing amplitude
- Measure CP-violating phases coming from mixing (q/p) and from the decay – even when there are no strong (hadronic) phases
- In the SM: Precisely predicted→ clean tests for NP.



# Neutral Meson Mixing (General Framework)

Time evolution of the $B-\bar{B}$ system

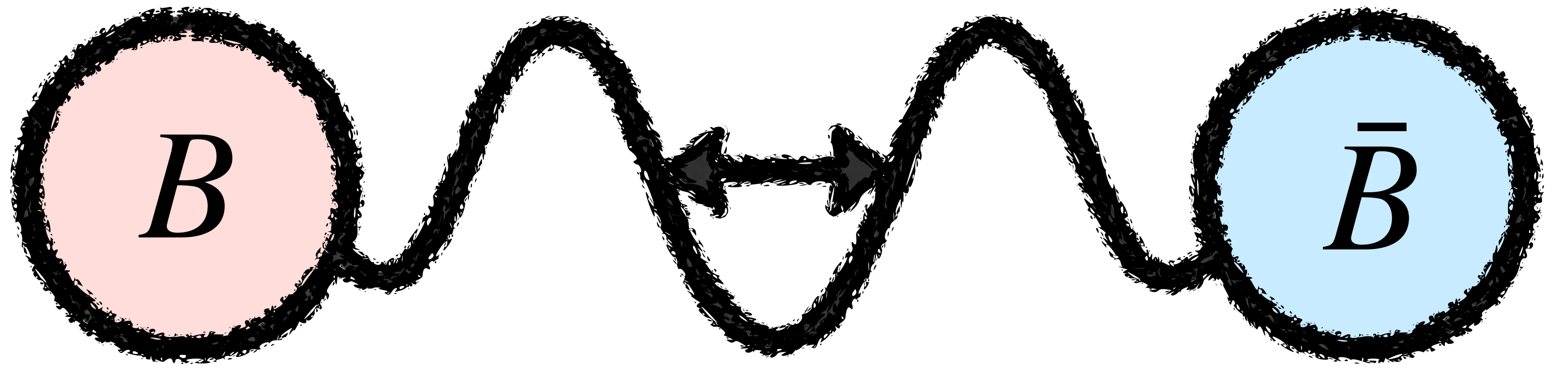
$$i\frac{d}{dt}\begin{pmatrix}|B(t)\rangle \\ |\bar{B}(t)\rangle\end{pmatrix} = \left(M - \frac{i}{2}\Gamma\right)\begin{pmatrix}|B(t)\rangle \\ |\bar{B}(t)\rangle\end{pmatrix}$$

$$\frac{q}{p} = \sqrt{\frac{M_{12}^* - \frac{i}{2}\Gamma_{12}^*}{M_{12} - \frac{i}{2}\Gamma_{12}}}$$

$$M = M^\dagger \quad \Gamma = \Gamma^\dagger$$

$$M_{12}, \Gamma_{12} \neq 0 \;\Rightarrow\; |B_{H,L}\rangle = p\,|B\rangle \mp q\,|\bar{B}\rangle, \quad |p|^2 + |q|^2 = 1$$

Mixing comes from off-diagonal elements



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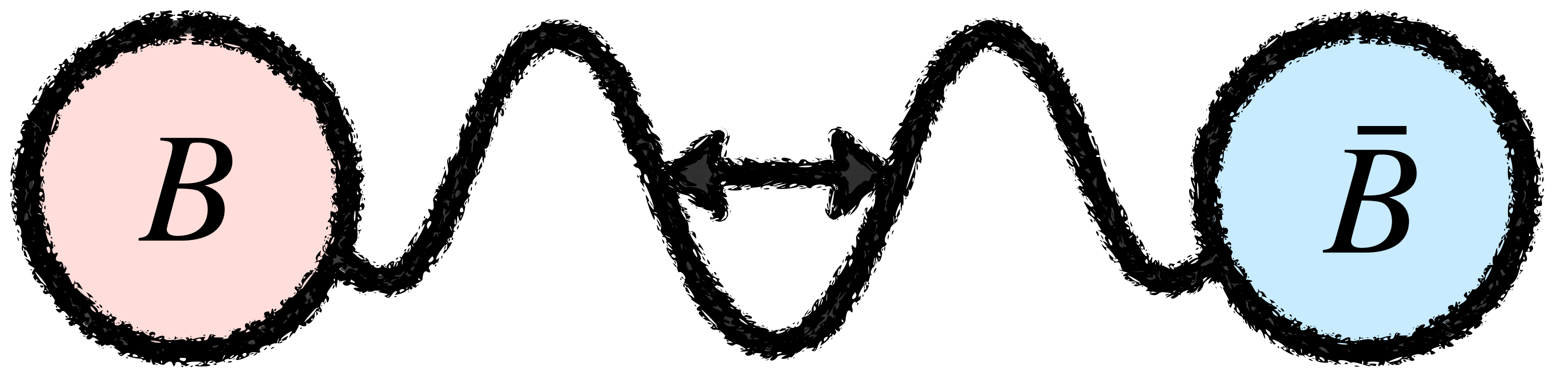


Oscillating solutions

$$|B(t)\rangle=g_{+}(t)\,|B\rangle+\frac{q}{p}\,g_{-}(t)\,|\bar{B}\rangle\qquad |\bar{B}(t)\rangle=\frac{p}{q}\,g_{-}(t)\,|B\rangle+g_{+}(t)\,|\bar{B}\rangle$$

$$g_{\pm}(t)=\frac{1}{2}\left(e^{-im_H t-\frac{1}{2}\Gamma_H t}\;\pm\;e^{-im_L t-\frac{1}{2}\Gamma_L t}\right)$$

$$|g_{\pm}(t)|^2=\frac{e^{-\Gamma_q t}}{2}\left[\cosh\left(\frac{\Delta\Gamma_q}{2}t\right)\pm\cos(\Delta m_q\,t)\right]$$

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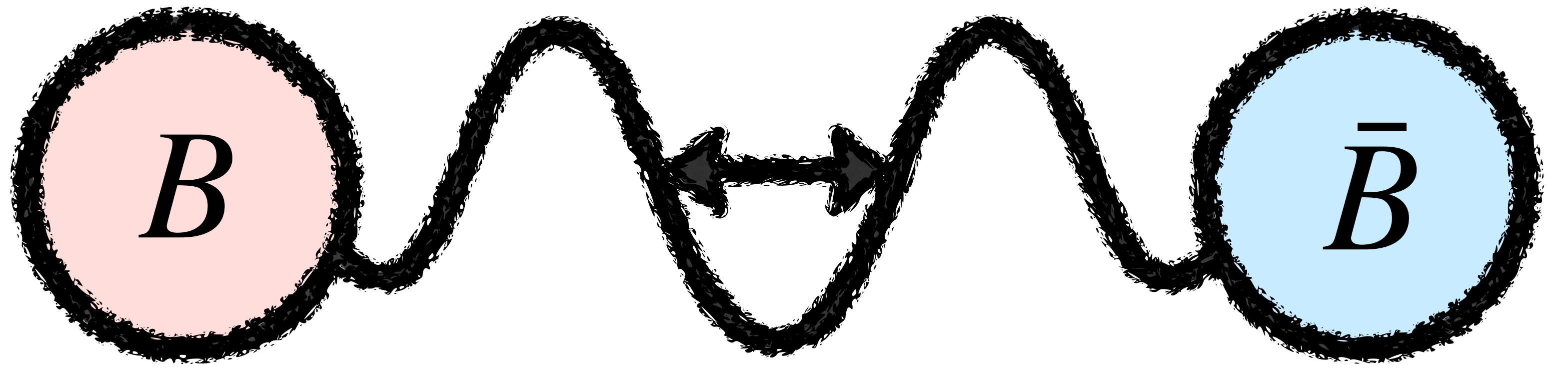


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$$g_\pm(t) = \frac{1}{2}\left(e^{-im_H t - \frac{1}{2}\Gamma_H t} \pm e^{-im_L t - \frac{1}{2}\Gamma_L t}\right)$$

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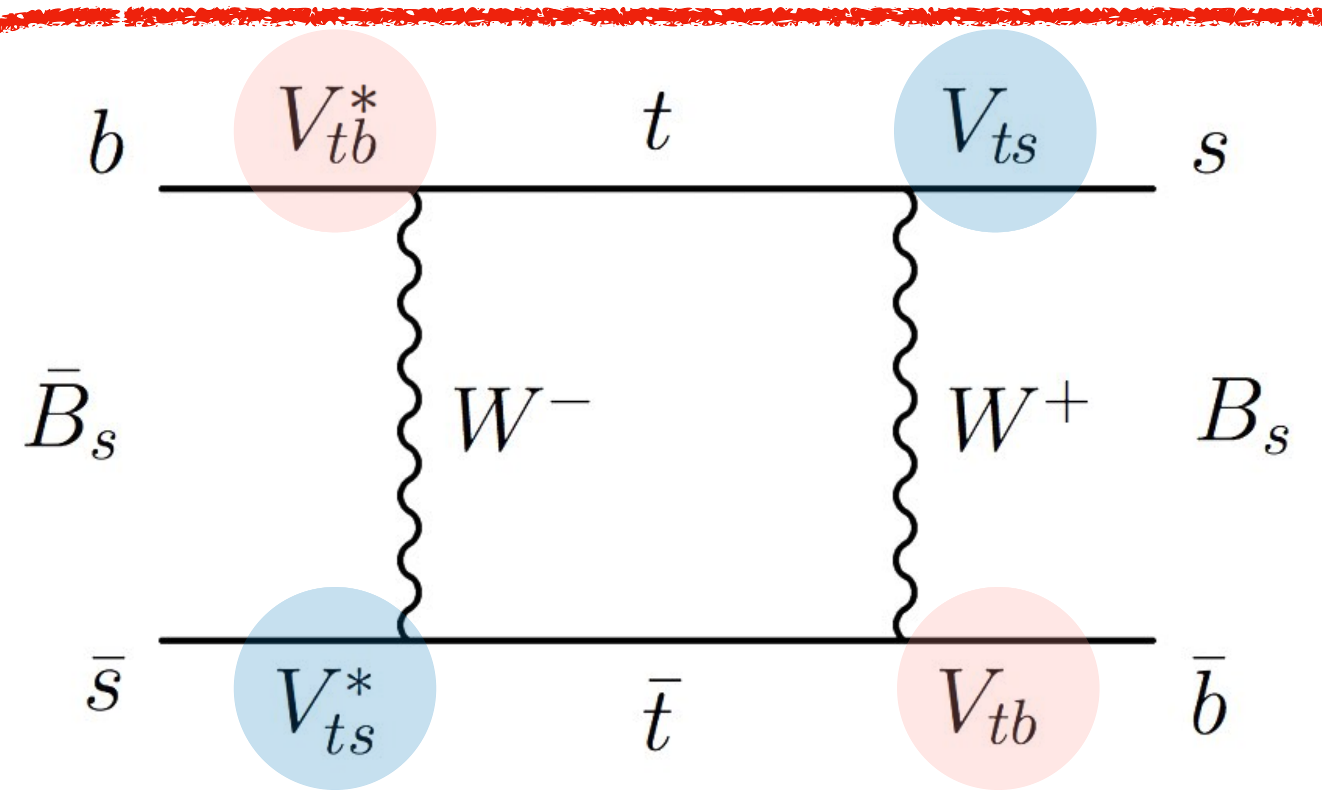
Mixing Parameters in B oscillations




$$\phi_q^{\text{mix}} \equiv \arg\left(\frac{q}{p}\right) \simeq -2\arg\left(V_{tb}^* V_{tq}\right)$$

Mixing parameter dominated by box diagram

$$\phi_d^{\text{mix}} \simeq 2\beta \qquad \phi_s^{\text{mix}} \simeq -2\beta_s$$

$$\beta \equiv \arg\left(-\frac{V_{cd}V_{cb}^*}{V_{td}V_{tb}^*}\right) \approx 23^\circ$$

$$\beta_s \equiv \arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right) \approx 1^\circ$$

$$x_q = \frac{\Delta m_q}{\Gamma_q}, \quad y_q = \frac{\Delta\Gamma_q}{2\Gamma_q}$$

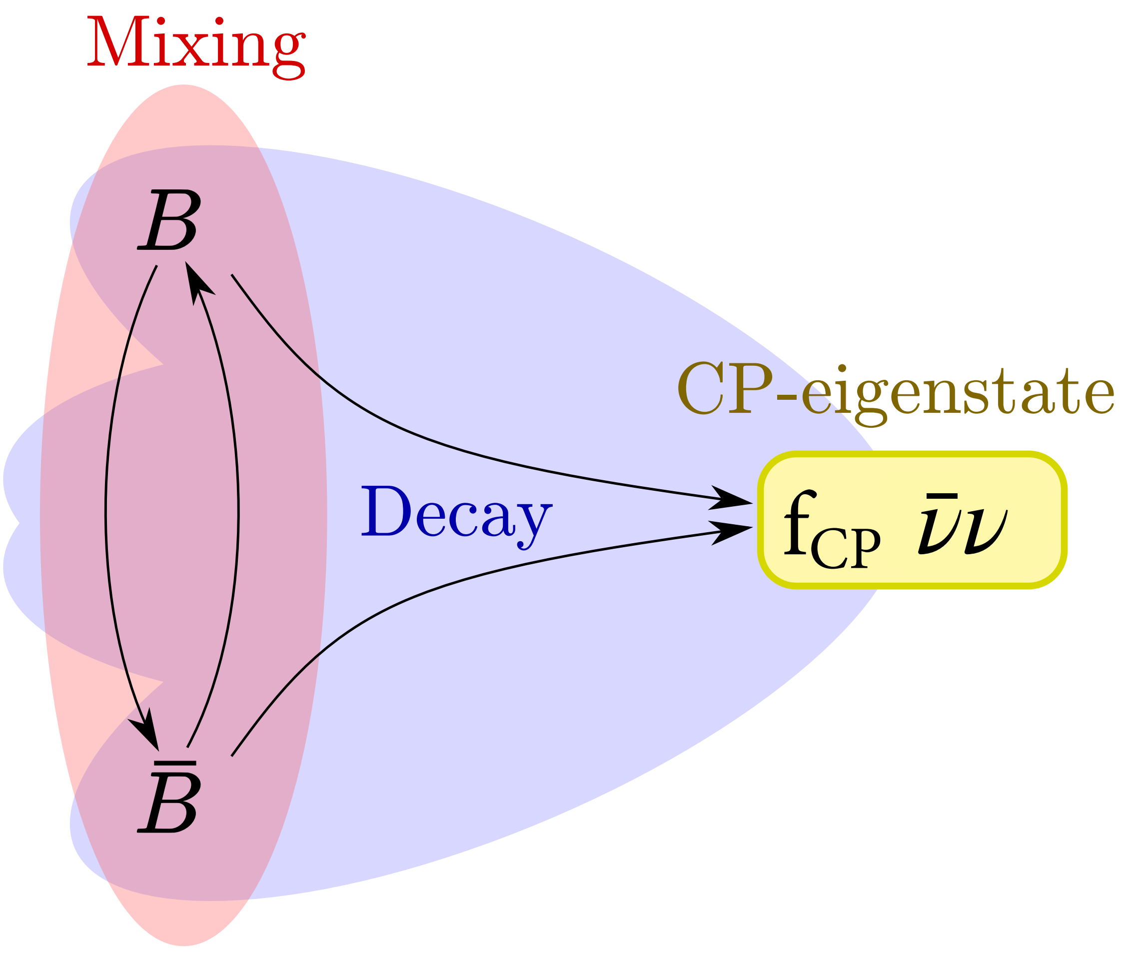
$$x_s \simeq 26.8 \qquad y_s \simeq 0.065$$

$$x_d \simeq 0.77 \qquad y_d \simeq 0$$

See Marcella's Talk

# Neutral Meson Mixing and Decay

Indirect




If the final state is a CP-eigenstate ($f_{CP}\,\nu\bar{\nu}$) there is an interference in between mixing and decay

$$A_f \equiv \langle f_{CP} | \mathscr{H} | B^0 \rangle \qquad |\bar{B}(t)\rangle = \frac{p}{q} g_-(t)\,|B\rangle + g_+(t)\,|\bar{B}\rangle$$

$$\bar{A}_f \equiv \langle f_{CP} | \mathscr{H} | \bar{B}^0 \rangle \qquad |B(t)\rangle = g_+(t)\,|B\rangle + \frac{q}{p} g_-(t)\,|\bar{B}\rangle$$

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Relevant final states

$$B_d \to K_S \nu\bar{\nu}$$
$$B_d \to K^{*0}(\to K_S \pi^0)\nu\bar{\nu}$$
$$B_s \to \phi(\to K^+K^-)\nu\nu$$

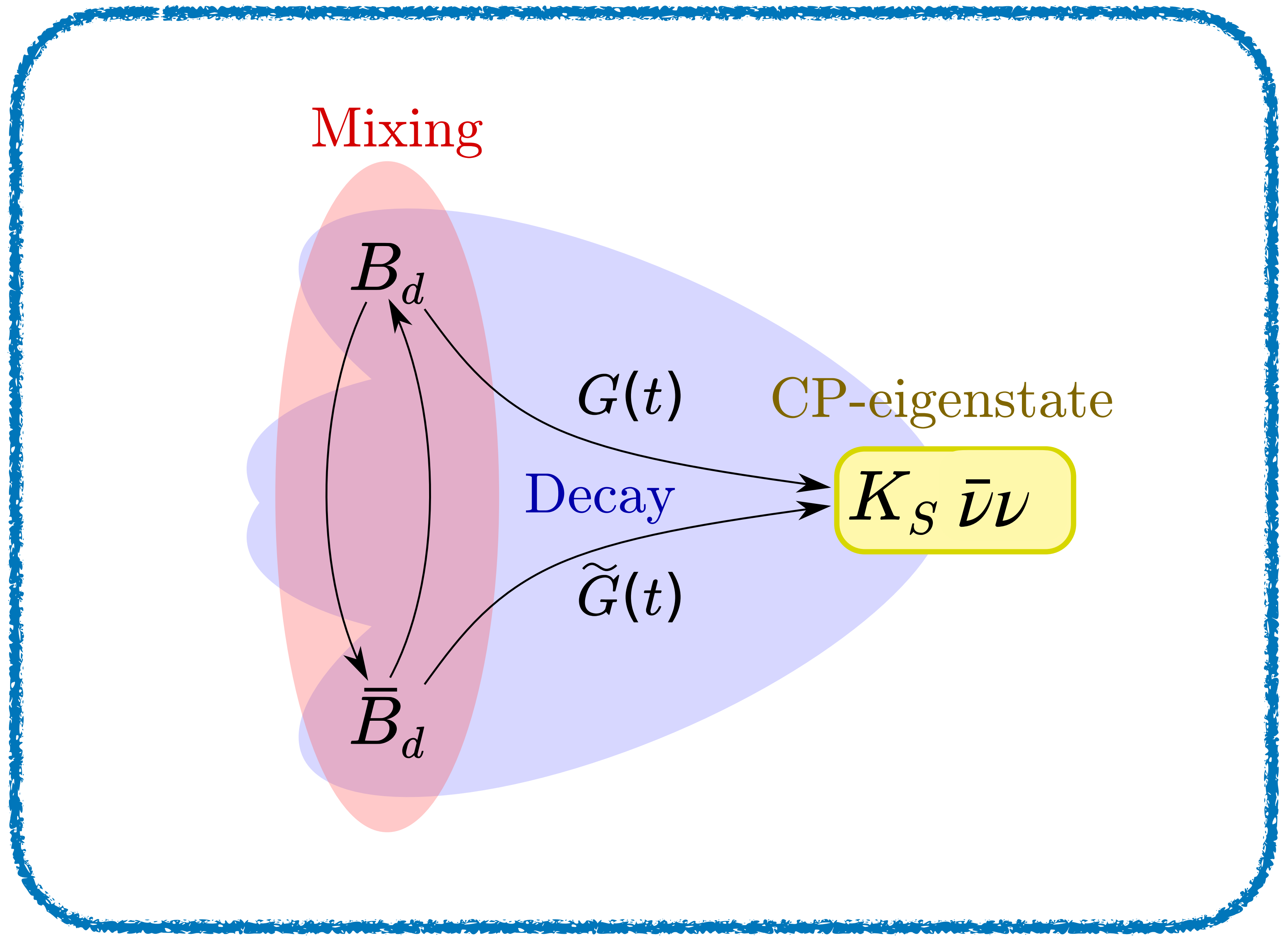
$$\langle f_{CP} | \mathscr{H} | B(t) \rangle = g_+(t)\,A_f + \frac{q}{p} g_-(t)\,\bar{A}_f$$

$$\langle f_{CP} | \mathscr{H} | \bar{B}(t) \rangle = \frac{p}{q} g_-(t)\,A_f + g_+(t)\,\bar{A}_f$$

$$\Gamma(B^0(t) \to f_{CP}) \propto e^{-\Gamma t}\left[\cosh\frac{\Delta\Gamma t}{2} + A_f^{\Delta\Gamma}\sinh\frac{\Delta\Gamma t}{2} + C_f\cos(\Delta m\, t) - S_f\sin(\Delta m\, t)\right]$$

# Indirect Asymmetry: How do you describe it?

Indirect




CP-Average

Time-evolution of CP-average

Encodes the same information as si Re vs Im part

$$G_i(t) + \tilde{G}_i(t) = e^{-\Gamma t}\left[(G_i + \tilde{G}_i)\cosh\left(\frac{\Delta\Gamma t}{2}\right) - h_i \sinh\left(\frac{\Delta\Gamma t}{2}\right)\right]$$

$$G_i(t) - \tilde{G}_i(t) = e^{-\Gamma t}\left[(G_i - \tilde{G}_i)\cos(\Delta m t) - s_i \sin(\Delta m t)\right]$$

Indirect CP-Asymmetry

Direct CP-Asymmetry

$$\frac{d\Gamma(B^+ \to K^+\nu\bar{\nu})}{dq^2} = \sum_\nu 2G_0(q^2)$$

$$G_0^\nu(q^2) = -\frac{4}{3}\left(\left|h_V^\nu\right|^2 + \left|h_A^\nu\right|^2\right)$$

$$h_0^\nu = \frac{4}{3}\mathrm{Re}\left[e^{i\phi}\left[\bar{h}_V^\nu h_V^{\nu *} + \bar{h}_A^\nu h_A^{\nu *}\right]\right]$$

$$s_0^\nu = \frac{4}{3}\mathrm{Im}\left[e^{i\phi}\left[\bar{h}_V^\nu h_V^{\nu *} + \bar{h}_A^\nu h_A^{\nu *}\right]\right]$$

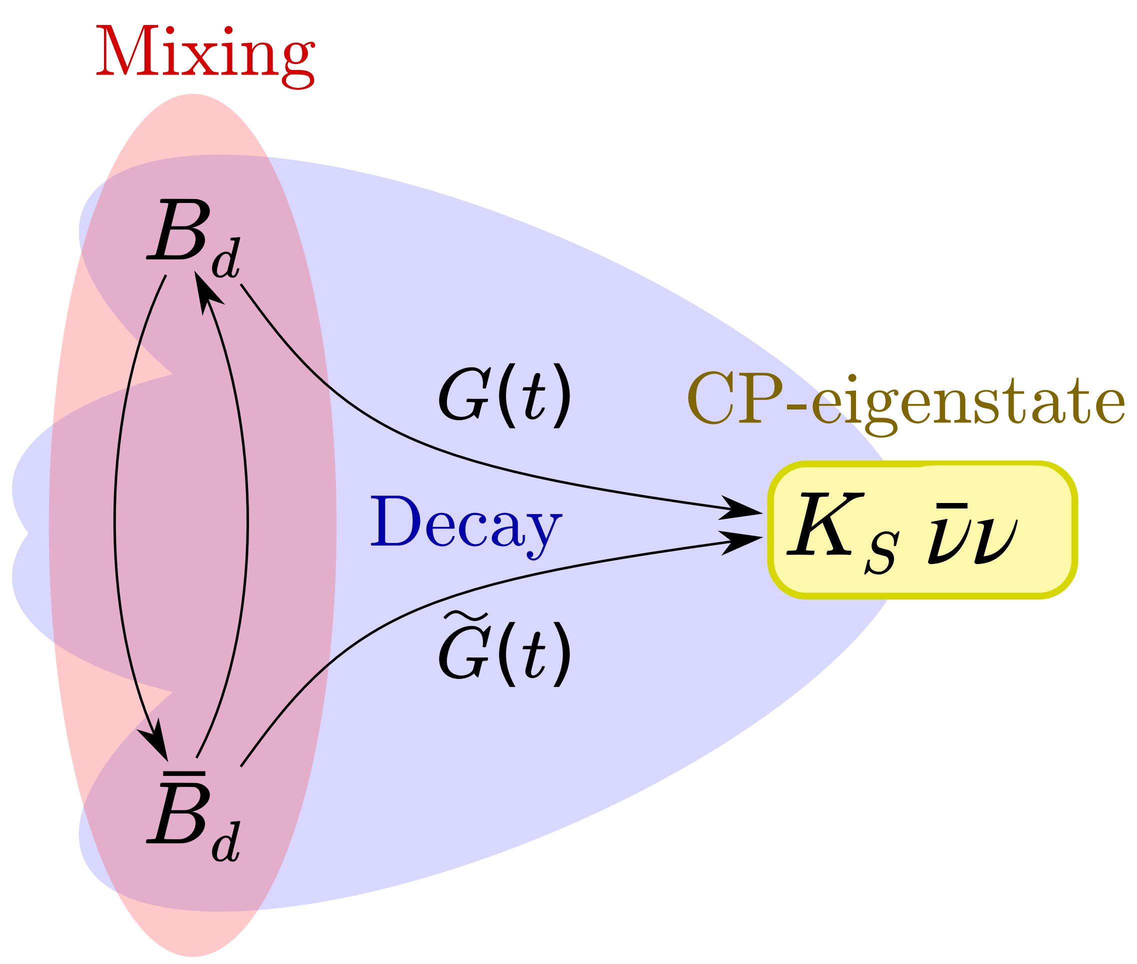
$$\bar{h}_V^\nu \to \mathcal{N}\frac{\sqrt{\lambda_B}}{2\sqrt{q^2}}(C_L^\nu + C_R^\nu)f_+\,,$$

$$\bar{h}_A^\nu \to -\mathcal{N}\frac{\sqrt{\lambda_B}}{2\sqrt{q^2}}(C_L^\nu + C_R^\nu)f_+$$

Similar description for $B_d \to K^{*0}(\to K_S\pi^0)\nu\bar{\nu}$ and $B_s \to \phi(\to K^+K^-)\nu\bar{\nu}$

# Indirect Asymmetry: What does it probe?

Indirect




CP-Average

Time-evolution of CP-average

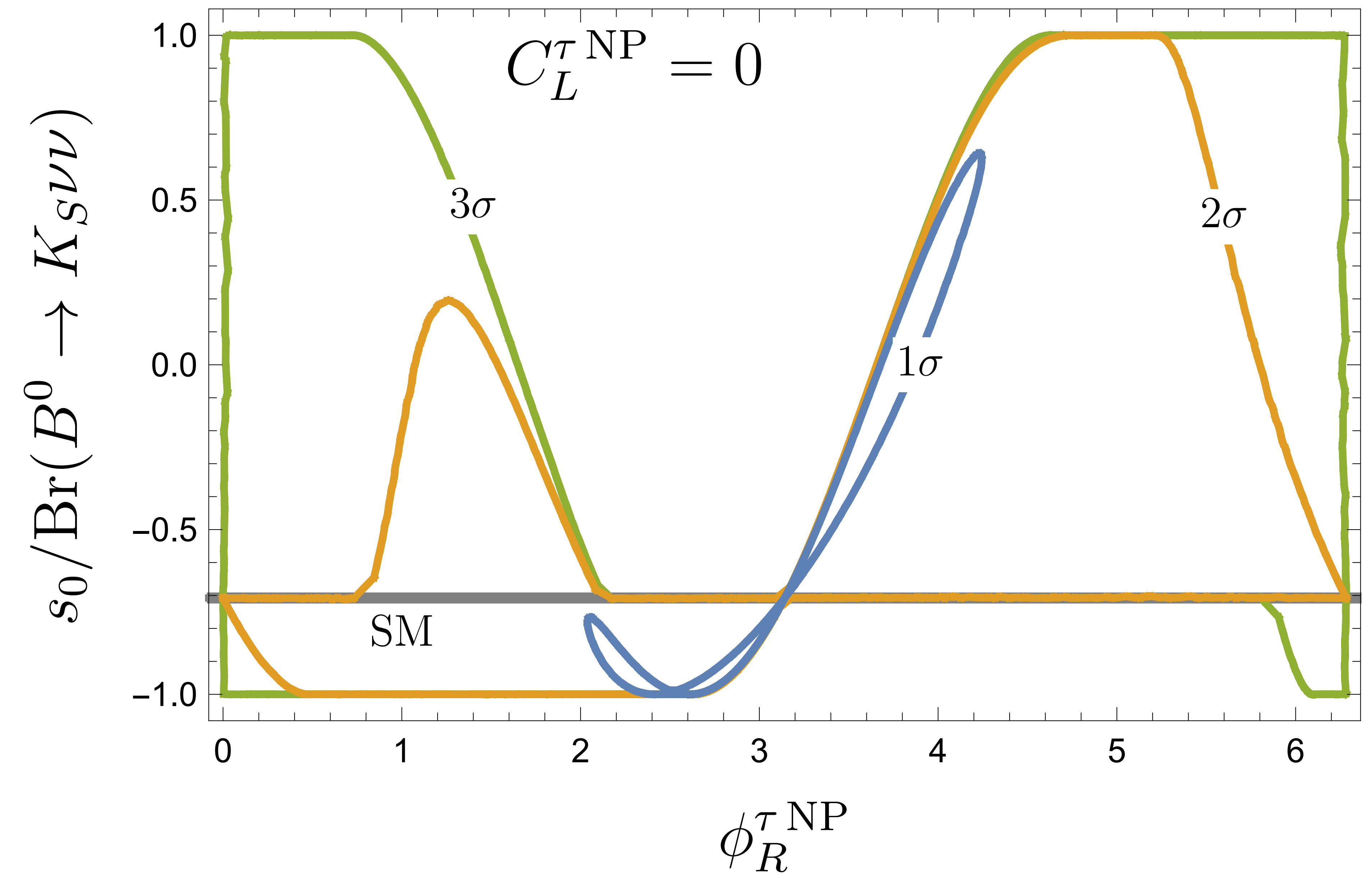
Encodes the same information as si Re vs Im part

$$G_i(t) + \tilde{G}_i(t) = e^{-\Gamma t}\left[(G_i + \tilde{G}_i)\cosh\left(\frac{\Delta\Gamma t}{2}\right) - h_i \sinh\left(\frac{\Delta\Gamma t}{2}\right)\right]$$

$$G_i(t) - \tilde{G}_i(t) = e^{-\Gamma t}\left[(G_i - \tilde{G}_i)\cos(\Delta m t) - s_i \sin(\Delta m t)\right]$$

Indirect CP-Asymmetry

Direct CP-Asymmetry




Complex NP

$$s_0 \simeq -2\sin(\phi^{\mathrm{mix}} - \phi^{\mathrm{decay}})G_0$$

Interference between weak (CP-odd) phase and mixing phases

# Indirect Asymmetry: Can you measure this?

Observables

| CP-asymmetries (si) | CP-symmetric (hi) |
|---|---|
| Accessible in both $B_d$ and $B_s$ decays | Only accessible in $B_s$ decays |
| $x = \Delta m_{B_{d,s}}/\Gamma$ large | $y_d = \Delta\Gamma_{B_d}/2\Gamma \approx 0$<br>$y_s = \Delta\Gamma_{B_s}/2\Gamma$ small |
| Higher sensitivity | Lower sensitivity |
| Require Flavour tagging | No Flavour tagging |

# Indirect Asymmetry: Can you measure this?

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Higher sensitivity

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Only accessible in $B_s$ decays

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Lower sensitivity

No Flavour tagging

Time dependence

Precise B vertex determination necessary to study time evolution

$\phi(\to K^+K^-)$ decays promptly -> Easy to identify Bs vertex

$K_S$ flies -> Hard to identify Bd vertex

$K^{*0} \to K_S\pi^0$ decays promptly -> $\pi^0$ makes hard to precisely determine the vertex

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$B_d$ a

$x =$

Hig

Requir

CP-symmetric (hi)

Only accessible in

Need for vertex determination
might be avoided at B-factories
at the cost of dilution

**Unlocking time-dependent *CP* violation without signal vertexing at *B* factories**

M. Dorigo,[1] S. Raiz,[2] D. Tonelli,[1] and R. Žlebčík[1]

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# Time Integration: Coherent vs Incoherent Production

Timing of the B decay behaves differently with incoherent and coherent production

In B-factories, entanglement implies that in coherent production the relevant quantity is
$$\Delta t = t_{tag} - t_{signal} \in [-\infty, \infty]$$

At LHC or FCCee the relevant quantity is
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$$\langle G_i + \tilde{G}_i \rangle_{\text{incoherent}} = \int_0^\infty G_i(t) + \tilde{G}_i(t)\, dt = \frac{1}{\Gamma}\left[\frac{1}{1-y^2}(G_i + \tilde{G}_i) - \frac{y}{1-y^2} h_i\right]$$

$$\langle G_i + \tilde{G}_i \rangle_{\text{coherent}} = \int_{-\infty}^\infty G_i(\Delta t) + \tilde{G}_i(\Delta t)\, d\Delta t = \frac{2}{\Gamma}\left[\frac{1}{1-y^2}(G_i + \tilde{G}_i)\right]$$

Additional term in incoherent production
No need for vertex determination at the
cost of dilution factor

$$\langle G_i - \tilde{G}_i \rangle_{\text{incoherent}} = \int_0^\infty G_i(t) - \tilde{G}_i(t)\, dt = \frac{1}{\Gamma}\left[\frac{1}{1+x^2}(G_i - \tilde{G}_i) - \frac{x}{1+x^2} s_i\right]$$

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$$\langle G_i - \tilde{G}_i \rangle_{\text{coherent}} = \int_{-\infty}^\infty G_i(\Delta t) - \tilde{G}_i(\Delta t)\, d\Delta t = \frac{2}{\Gamma}\left[\frac{1}{1+x^2}\cancel{(G_i - \tilde{G}_i)}\right] = 0$$

Zero direct CP asymmetry in neutrino decays
$\mathcal{A}_{\text{CP}}^{\text{dir}} = 0$

# Time Integration: Coherent vs Incoherent Production

Timing of the B decay behaves differently with incoherent and coherent production

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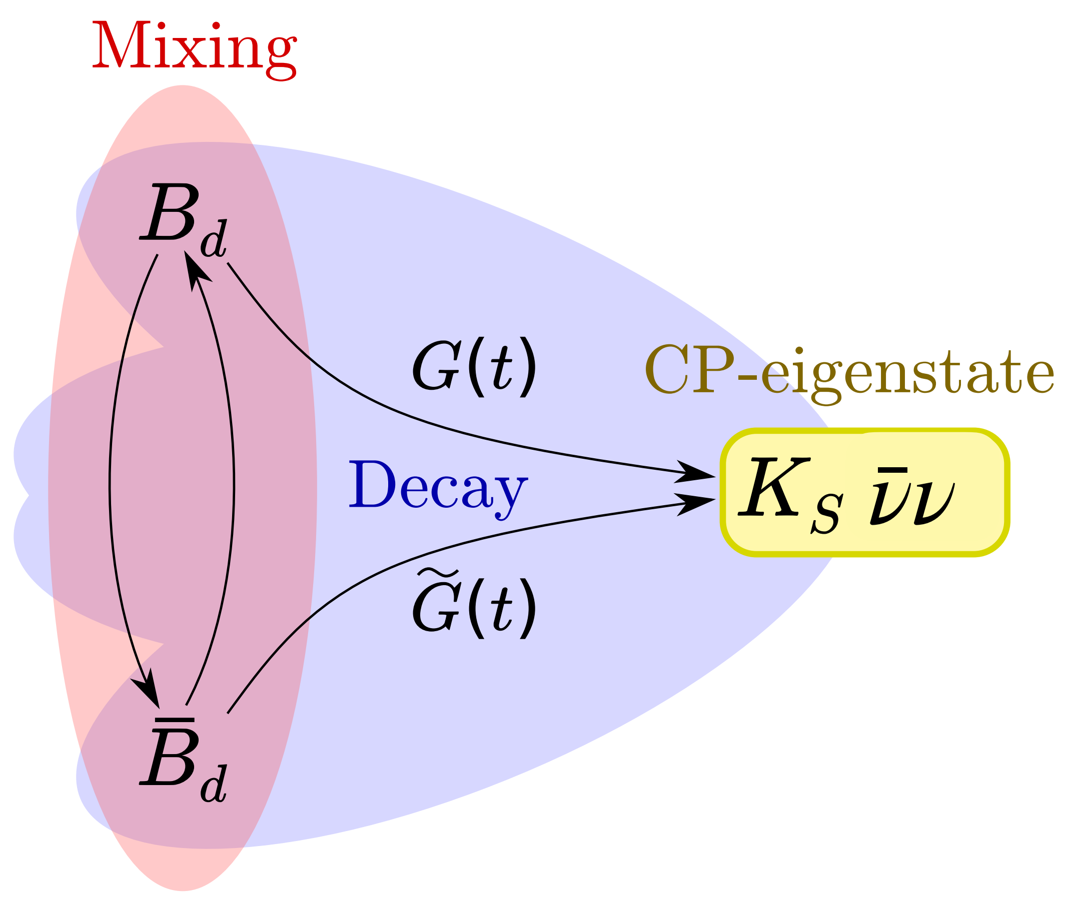
$$\langle G_i - \tilde{G}_i \rangle_{\text{coherent}} = \int_{-\infty}^{\infty} G_i(\Delta t) - \tilde{G}_i(\Delta t)\, d\Delta t = \frac{2}{\Gamma} \left[ \frac{1}{1+x^2} (G_i - \tilde{G}_i) \right] = 0$$

In B-factories an asymmetric time integration would access si and hi
Still requires vertex id, but no fit to time evolution

# Conclusions

- CP-phases in $b \to s\nu\bar{\nu}$ would be a clear indication of NP
- Only relative phases can be partially accessed in Meson decays (flat directions)
- Full handle through meson decays + $A_{FB}$ in Polarised $\Lambda_b$ decays @ FCCee
- No Direct CP-asymmetries (They require a strong phase)

Indirect




- A $B_d \to K_S\nu\bar{\nu}$, $B_d \to K^{*0}\nu\bar{\nu}$ or $B_s \to \phi\nu\bar{\nu}$ time dependent analysis could constrain CP phases in $b \to s\nu\bar{\nu}$
- Experimentally it is extremely challenging
- $B_s \to \phi\nu\bar{\nu}$ could potentially be measured at FCCee
- $B_d \to K_S\nu\bar{\nu}$ and $B_d \to K^{*0}\nu\bar{\nu}$ would probably require a tag decay method at Belle II

# Probing CP-violation in $b \to s\nu\bar{\nu}$ decays


**Martín Novoa-Brunet**

*Based on work with S. Descotes-Genon, S. Fajfer, J.F. Kamenik*
*arXiv:2208.10880*

CSIC
Consejo Superior de Investigaciones Científicas
Vniversitat de València
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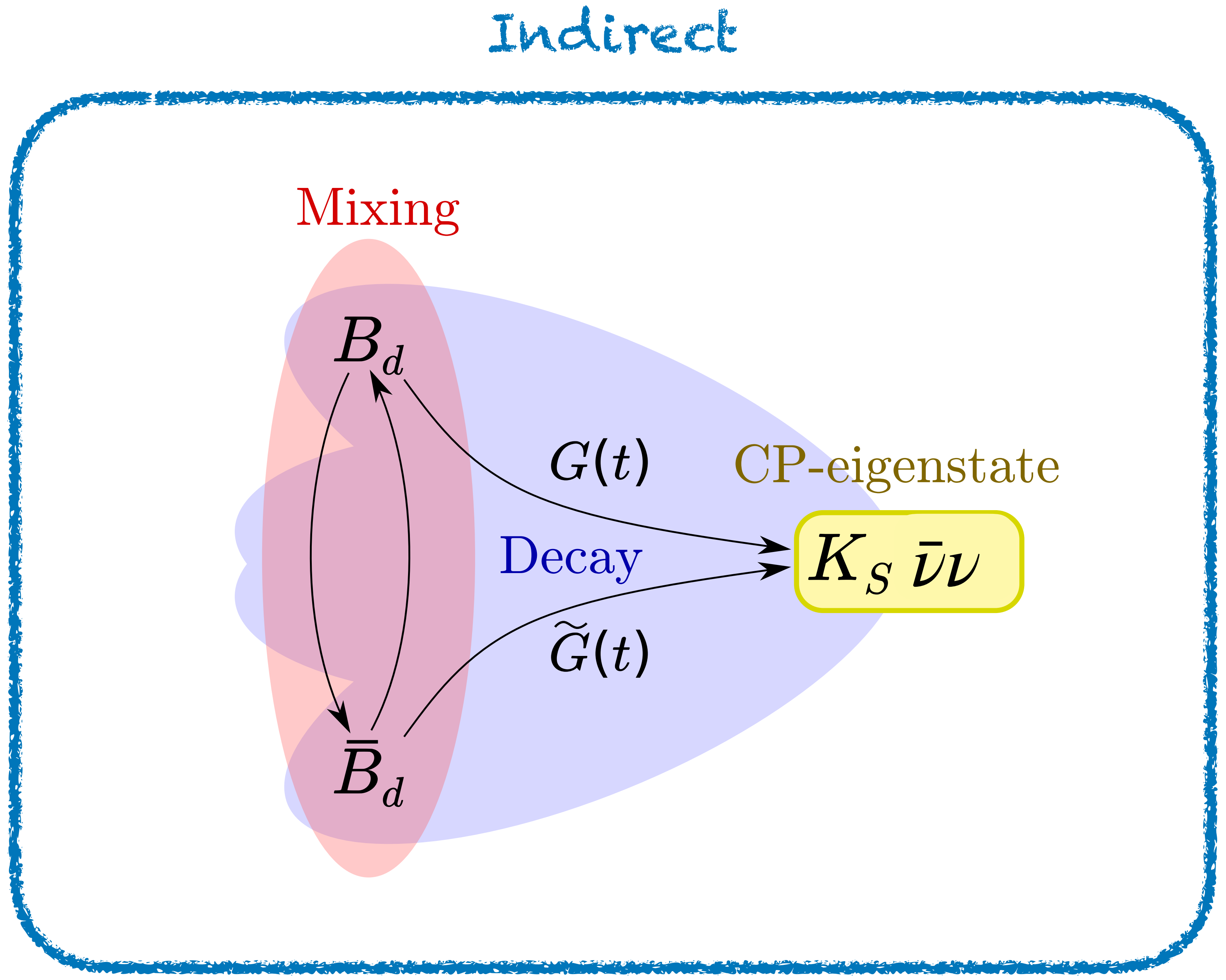
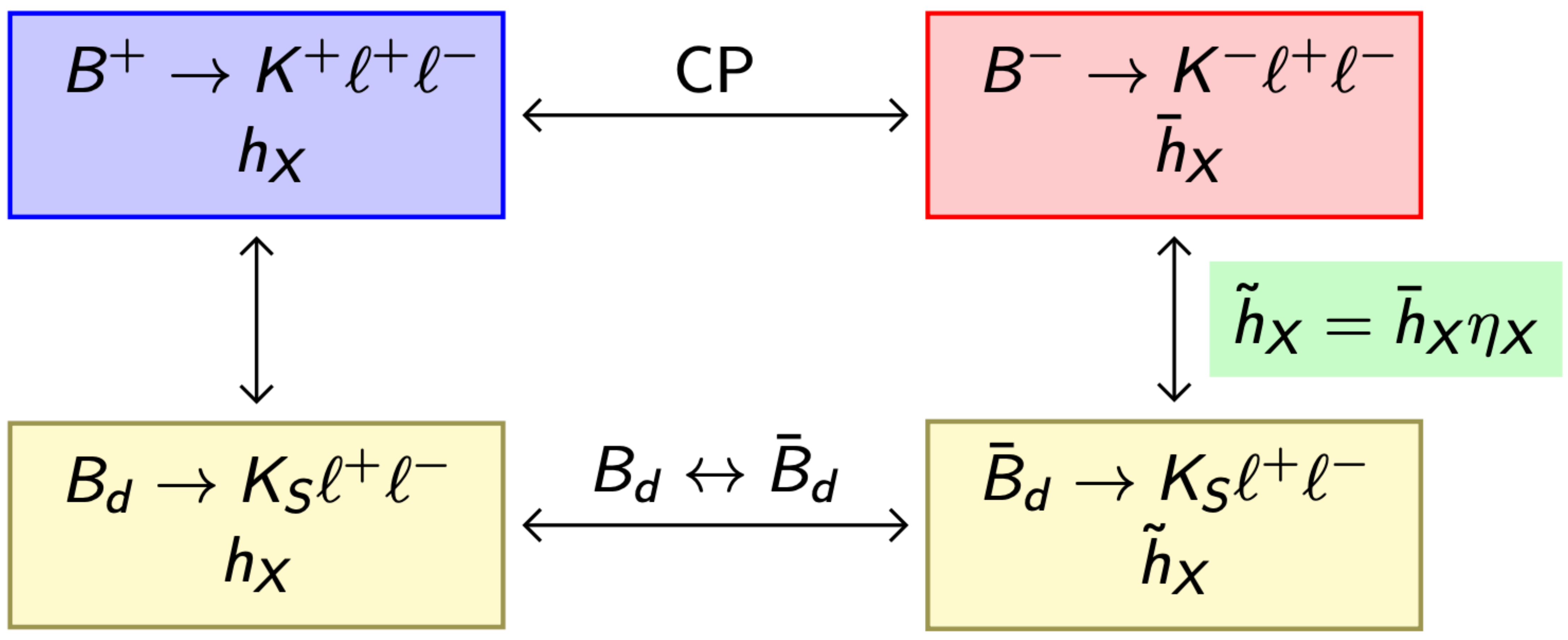
# Back Up

# Indirect Asymmetry in $b \to s\ell^+\ell^-$




$h_X$: Transversity amplitudes  $\eta_X$: CP-parity associated to $h_X$

$$\boxed{\eta_{V,A,P,T_t} = -1 \quad \text{and} \quad \eta_{S,T} = 1 \quad \Longrightarrow \quad \tilde{h}_X^{\rm SM} = -\bar{h}_X^{\rm SM}}$$

$$G_2 = -\frac{4\beta_\ell^2}{3}\left(\left|h_V\right|^2 + \left|h_A\right|^2 - 2\left|h_T\right|^2 - 4\left|h_{T_t}\right|^2\right)$$

[Dunietz et al '01, Descotes-Genon et al '15]

$$\bar{h}_A \propto (\mathscr{C}_{10} + \mathscr{C}_{10'})f_+(q^2)$$

$$\frac{d^2\Gamma(B^+ \to K^+\ell^+\ell^-)}{dq^2\,d\cos\theta_\ell} = G_0(q^2) + G_1(q^2)\cos\theta_\ell + G_2(q^2)\frac{1}{2}(3\cos^2\theta_\ell - 1)$$

# Naive Prospects and Sensitivity

- Naive prospects (only statistical errors)
- The experimental situation is substantially more complex (Vertexing and Flavour Tagging)
- Nevents = 200 -> 20%
- Nevents = 2000-> 6%
- Nevents = 20000 -> 2%