# Model building for flavour anomalies

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## Outline:

1. The problem of flavour and recent developments
2. A model building solution: potential of Froggatt-Nielsen mechanism for low-energy phenomenology

# Introduction

The Standard Model: theory that better describes interactions among elementary particles.

Is the SM complete?

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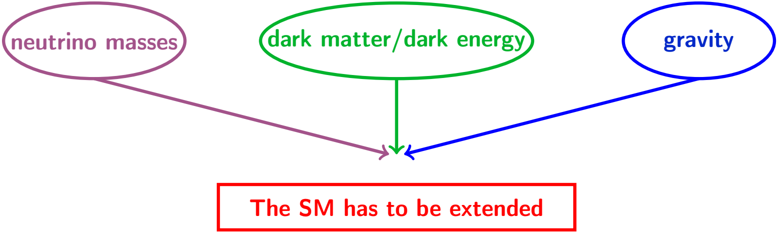

# Introduction

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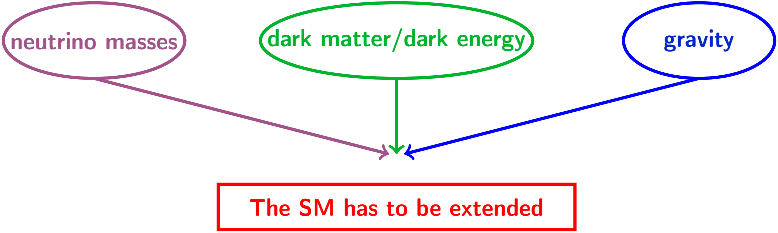
Is the SM complete?




- The SM can be regarded as a low energy realisation of a more complete theory living above the electroweak scale
- Is there any part of the SM that can be affected by NP?

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- Strong hierarchy among the Yukawa couplings
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**1) Why is the flavour sector so special?**

**2) Is there space for NP?**

# The flavour problem

## 1) The SM flavour problem

- The study of a deeper reason behind the peculiar structure of Yukawa couplings.

## 2) The NP flavour problem

- Why don't we observe any NP in flavour processes yet?
- What is the flavour structure of the physics beyond the SM?
- What energy scales?
  No absolute energy scale, strongly dependent on the NP couplings.

# What is new?

Recently, Babar, Belle and LHCb provided interesting results in $B$-physics.

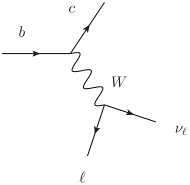
They see a few hints of **L**epton **F**lavour **U**niversality **V**iolation: channels with different lepton species in the final state behave differently

The channels explored so far are semileptonic decays of $B$-meson

- Flavour changing neutral currents $b \to s$: $\mu$ vs $e$
- Charged currents $b \to c$: $\tau$ vs $\mu/e$

# $b \to c$ semileptonic transitions

Tree-level process within the SM



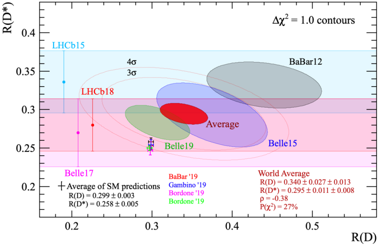

Effective hamiltonian description

$$\mathcal{H}_{\text{eff}} = -\frac{4G_F}{\sqrt{2}} V_{cb} \left(\bar{c}_L \gamma_\mu b_L\right) \left(\bar{\tau}_L \gamma_\mu \nu_L\right)$$

- Clean observables: careful treatment of $m_\tau$ dependent terms

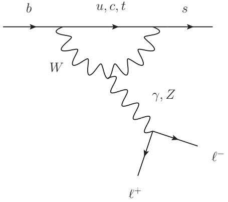
$$R_{D^{(*)}} = \frac{\mathcal{B}(B \to D^{(*)} \tau \bar{\nu}_\tau)}{\mathcal{B}(B \to D^{(*)} \ell \bar{\nu}_\ell)}$$

- Deviation of $\sim$ **10%-15%** with respect to the SM predictions
- Combined significance $\sim \boldsymbol{3.x\,\sigma}$



# $b \to s$ semileptonic transitions

Induced at **loop** level in the SM




Effective Hamiltonian description

$$\mathcal{H}_{\text{eff}} = -4\frac{G_F}{\sqrt{2}} V_{tb} V_{ts}^* \left[\cdots + C_9 \mathcal{O}_9 + C_{10} \mathcal{O}_{10}\right]$$

$$\mathcal{O}_9 = (\bar{s}\gamma^\mu P_L b)\,(\bar{\ell}\gamma_\mu \ell)$$
$$\mathcal{O}_{10} = (\bar{s}\gamma^\mu P_L b)\,(\bar{\ell}\gamma_\mu \gamma_5 \ell)$$

- Lepton Flavour Universality ratios

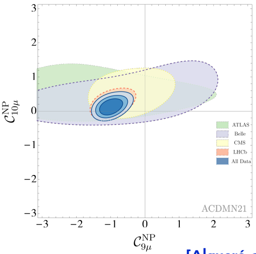
$$R_{K^{(*)}} = \frac{\mathcal{B}(B \to K^{(*)}\mu^+\mu^-)}{\mathcal{B}(B \to K^{(*)}e^+e^-)} \qquad \sim \mathbf{2.1\text{-}3.1}\boldsymbol{\sigma}$$

- Angular Observables in $B \to K^*\mu^+\mu^-$

$$P_5' = \frac{S_5}{\sqrt{F_L(1-F_L)}} \qquad \sim \mathbf{3}\boldsymbol{\sigma}$$

- LFU in $\Lambda_b \to pK\ell^+\ell^-$ decays

$$R_{pK}^{-1} = 1.17^{+0.18}_{-0.16} \pm 0.17$$




**[Algueró at al, '21]**

$$\boldsymbol{\Delta C_9 \neq 0 \quad \Delta C_{10} \neq 0}$$

# Approach to the anomalies

**SM predictions:**

- investigate SM predictions for the observables of interest
- provide predictions for new channels/observables to get complementary information

**Model building:**

- the effective scale of NP which could explain FCNC and CC anomalies is rather different

$$\Lambda \sim \begin{cases} \text{few} \times \mathrm{TeV} & \text{for CC} \\ \text{few} \times 10\ \mathrm{TeV} & \text{for FCNC} \end{cases}$$

- from EFT analysis we see that [MB, Isidori, Trifinopoulos Buttazzo,Greljo,Isidori,Marzocca]
  - FCNC and CC anomalies are addressed as a coherent pattern where NP is mainly coupled to the 3rd generation
  - a mechanism is required to suppress the couplings with light generations
  - possible links to the structure of Yukawa couplings

**Non-trivial flavour structure needed**

# Are these signals of NP?

- LHCb strengthened the significance in $R_K$ with full Run 2 statistics
- Updates for other observables are expected this year
- New $g - 2$ results also hint to some discrepancies concerning muons
- Belle II is taking data
- Both ATLAS and CMS are building an interesting $B$-physics program

**We need to keep looking**

# *A Froggatt-Nielsen based idea*

# EFT for New Physics

Let's take the following example:

$$\frac{1}{\Lambda^2}[\mathcal{C}_{ql}^{(1)}]^{ij\alpha\beta}(\bar{Q}_i\gamma_\mu Q_j)(\bar{L}_\alpha\gamma^\mu L_\beta)$$

How large can $[\mathcal{C}_{ql}^{(1)}]^{ij\alpha\beta}$ be?

- A flavour symmetry enhances/suppresses the various entries
  - an example is the $U(2)^5$ flavour symmetry

    **[R. Barbieri, G. Isidori, J. Jones-Perez, P. Lodone, and D. M. Straub, 2011]**

- Make assumption on how flavour is broken for the NP
  - Minimal Flavour Violation: the Yukawa are the only source of flavour breaking

    **[G. D'Ambrosio, G. F. Giudice, G. Isidori, and A. Strumia, 2002]**

**How to generalise the MFV idea?**

# Our approach

- No assumption about how flavour is broken in the NP sector
- We start from bilinears constructed with SM fermion fields only
- We list all the possible spurions according to
  - the SM gauge group
  - the SM (unbroken) flavour symmetry
  - tree level exchange only

| Dirac bilinear | $SU(3)\times SU(2)\times U(1)$ | Flavour spurion | $\mathcal{G}_f$ | $(\Delta B;\Delta L)$ |
|---|---|---|---|---|
| $\bar{Q}\gamma^\mu L$ | $(3,1\oplus 3,\frac{2}{3})$ | $\Delta_{QL}$ | $(3,1,1)(\bar{3},1)$ | $\left(\frac{1}{3};-1\right)$ |
| $\bar{d}\gamma^\mu e$ | $(3,1,\frac{2}{3})$ | $\Delta_{DE}$ | $(1,1,3)(1,\bar{3})$ | $\left(\frac{1}{3};-1\right)$ |
| $\bar{Q}^c L$ | $(\bar{3},1\oplus 3,\frac{1}{3})$ | $S_{QL}$ | $(\bar{3},1,1)(\bar{3},1)$ | $\left(-\frac{1}{3};-1\right)$ |
| $\bar{u}^c e$ | $(\bar{3},1,\frac{1}{3})$ | $S_{UE}$ | $(1,\bar{3},1)(1,\bar{3})$ | $\left(-\frac{1}{3};-1\right)$ |

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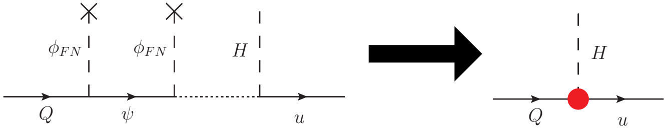
**How do we consistently introduce a power counting?**

# The Froggatt-Nielsen mechanism

**[Froggatt, Nielesen, '79]**

- The main goal of FN mechanism is to explain the mass hierarchies between quarks
- The main point is enlarging the gauge group adding an additional $U(1)$ and extra heavy fermions
- The SM fermions are charged under the $U(1)$, and the charges are generation dependent
- The $U(1)$ is spontaneously broken by a new scalar field $\phi_{\mathsf{FN}}$
- The Yukawa scale as the parameter $\lambda = \langle \phi_{FN} \rangle / \Lambda_{FN} \ll 1$



# Froggatt-Nielsen power counting

SM fields charges

$$Q^i : b_Q^i \qquad L^i : b_L^i$$

$$u_R^i : b_U^i \qquad d_R^i : b_D^i \qquad e_R^i : b_E^i$$

According to the assignment of charges of the SM fields, we have:

$$(Y_U)_{ij} \sim \lambda^{|b_Q^i - b_U^j|}$$

$$(Y_D)_{ij} \sim \lambda^{|b_Q^i - b_D^j|}$$

$$(Y_E)_{ij} \sim \lambda^{|b_L^i - b_E^j|}$$

In order to reproduce the CKM

$$(V_{\mathsf{CKM}})_{ij} = (V_{U_L}^\dagger V_{D_L})_{ij} \sim \lambda^{|b_Q^i - b_Q^j|} \qquad \lambda = \sin^2\theta_c \sim 0.2$$

# Constraining FN charges

There is no first principle which determines the FN charges.

**Quarks**

- CKM $\Rightarrow$ set the charges of the left-handed doublets
- quark masses $\Rightarrow$ we reduce the number of possible charges to two values for each right-handed quark

**Lepton**

- lepton masses $\Rightarrow$ constraining only differences of left-handed and right-handed charges

**More pheno constraints are needed**

- Using low energy pheno implies choosing a particular set of spurions to describe data
- A driving role is played by $B$ anomalies

# Which model to choose?

## 1) Colourless Mediators

- $W' + Z'$: tension with high-$p_T$ searches with $\tau_L \tau_L$ or $b_L b_L$ final states

[Greljo,Isidori,Marzocca,'15]

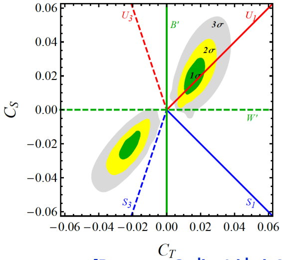
- Solutions with right-handed neutrino are motivated and help to ease the tension with $b \to c\tau\nu$ data but they are most likely to be excluded from high-$p_T$

[Greljo, Camalich,Ruiz-Álvarez,'18]

## 2) Leptoquark Mediators

| Model | $R_{K^{(*)}}$ | $R_{D^{(*)}}$ | $R_{K^{(*)}}$ & $R_{D^{(*)}}$ |
|---|---|---|---|
| $S_1$ | ✗* | ✓ | ✗* |
| $R_2$ | ✗* | ✓ | ✗ |
| $\widetilde{R}_2$ | ✗ | ✗ | ✗ |
| $S_3$ | ✓ | ✗ | ✗ |
| $U_1$ | ✓ | ✓ | ✓ |
| $U_3$ | ✓ | ✗ | ✗ |

[Angelescu, Bečirević, Faroughy , Sumensari, '18]




[Buttazzo, Greljo, Isidori, Marzocca, '17]

- $U_1$ vector leptoquark is the favoured, but requires UV completion
- $S_1$+$S_3$ scenario is also viable

# A $U_1$ simplified model

$$\mathcal{L}_{U_1} = \Delta^{i\alpha}_{QL}\bar{Q}^i\gamma_\mu L^\alpha U_1^\mu + \Delta^{i\alpha}_{DE}\bar{d}^i_R\gamma_\mu e^\alpha_R U_1^\mu + \text{h.c.}$$

$$\Delta^{i\alpha}_{QL} \leftarrow c^{i\alpha}_{QL}\lambda^{|b^i_Q - b^\alpha_L|} \qquad \Delta^{i\alpha}_{DE} \leftarrow c^{i\alpha}_{DE}\lambda^{|b^i_D - b^\alpha_E|}$$

$$\mathcal{L}_{\text{eff}} = \mathcal{L}_{\text{SM}} - \frac{1}{\Lambda^2}\Big\{[\mathcal{C}^{(3)}_{lq}]^{ij\alpha\beta}(\bar{Q}^i\gamma^\mu\sigma^a Q^j)(\bar{L}^\alpha\gamma_\mu\sigma^a L^\beta) + [\mathcal{C}^{(1)}_{lq}]^{ij\alpha\beta}(\bar{Q}^i\gamma^\mu Q^j)(\bar{L}^\alpha\gamma_\mu L^\beta)$$
$$+[\mathcal{C}_{ed}]^{ij\alpha\beta}(\bar{d}^i_R\gamma^\mu d^j_R)(\bar{e}^\alpha_R\gamma_\mu e^\beta_R) + [\mathcal{C}_{ledq}]^{ij\alpha\beta}(\bar{Q}^i_L d^j_R)(\bar{e}^\alpha_R L^\beta) + \text{h.c.}\Big\},$$

Tree-level matching

$$[\mathcal{C}^{(1)}_{lq}]^{ij\alpha\beta} = [\mathcal{C}^{(3)}_{lq}]^{ij\alpha\beta} = +\,\Delta^{i\alpha}_{QL}\Delta^{*j\beta}_{QL}\,, \quad \longleftarrow$$
$$[\mathcal{C}_{leqd}]^{ij\alpha\beta} = -\,2\,\Delta^{i\alpha}_{QL}\Delta^{*j\beta}_{DE}\,,$$
$$[\mathcal{C}_{ed}]^{ij\alpha\beta} = +\,\Delta^{i\alpha}_{DE}\Delta^{*j\beta}_{DE}\,.$$

avoids tree-level contraints from $d_i \to d_j\nu\bar{\nu}$ modes

# Fit results

[MB, Catà, Feldmann, JHEP 2001 (2020) 067]

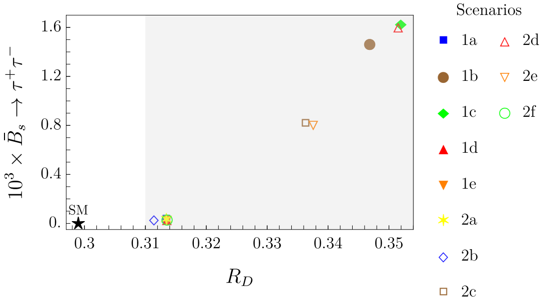
| Scenario | $b_L^1$ | $b_D^1$ | $b_D^2$ | $b_D^3$ | $b_E^1$ | $b_E^2$ | $b_E^3$ | $\mathcal{C}_{QL}$ | $\mathcal{C}_{DE}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1a | $-2$ | 10 | $-3$ | $-3$ | $-11$ | 4 | $-2$ | $1.10 \pm 0.07$ | $0.72 \pm 0.22$ |
| 1b | | 10 | 7 | $-3$ | $-11$ | $-6$ | $-2$ | $1.07 \pm 0.08$ | $6.4 \pm 1.8$ |
| 1c | | 10 | 7 | 3 | $-11$ | $-6$ | 4 | $1.07 \pm 0.08$ | $7.2 \pm 2.1$ |
| 1d | | $-4$ | $-3$ | $-3$ | $-11$ | 4 | $-2$ | $1.10 \pm 0.09$ | $0.74 \pm 0.28$ |
| 1e | | $-4$ | $-3$ | $-3$ | 7 | 4 | $-2$ | $1.10 \pm 0.09$ | $0.73 \pm 0.28$ |
| 2a | $+8$ | 10 | $-3$ | $-3$ | 17 | 4 | $-2$ | $1.10 \pm 0.10$ | $0.74 \pm 0.26$ |
| 2b | | 10 | 7 | $-3$ | $-1$ | $-6$ | $-2$ | $1.09 \pm 0.09$ | $0.42 \pm 0.25$ |
| 2c | | 10 | 7 | $-3$ | 17 | $-6$ | $-2$ | $1.08 \pm 0.09$ | $4.6 \pm 1.4$ |
| 2d | | 10 | 7 | 3 | $-1$ | $-6$ | 4 | $1.07 \pm 0.10$ | $7.1 \pm 2.0$ |
| 2e | | 10 | 7 | 3 | 17 | $-6$ | 4 | $1.08 \pm 0.09$ | $4.8 \pm 1.3$ |
| 2f | | $-4$ | $-3$ | $-3$ | 17 | 4 | $-2$ | $1.10 \pm 0.09$ | $0.74 \pm 0.28$ |

Common features:

- $b \to s\mu^+\mu^-$ dominated by left-handed operator
- $b \to se^+e^-$ is negligible
- $B_c$ lifetime is not spoiled
- $\Delta\chi^2 = \chi^2|_{\mathsf{SM}} - \chi^2|_{\mathsf{NP}} \sim 30$

# Fit results

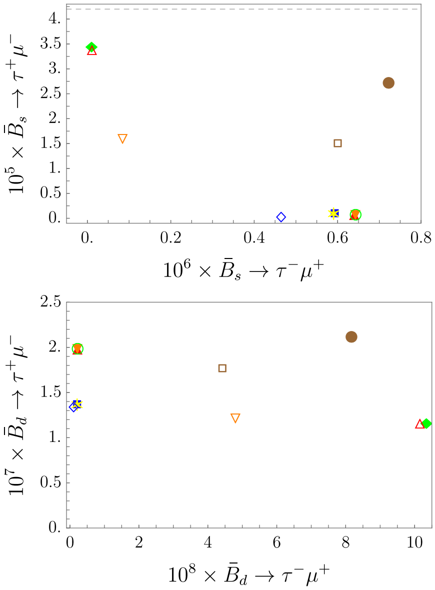
[MB, Catà, Feldmann, JHEP 2001 (2020) 067]




- **High correlation** between $R_D$ and $\bar{B}_s \to \tau^+\tau^-$ due to sizeable scalar contributions
- Better measurements of $\bar{B}_s \to \tau^+\tau^-$ provide a **strong** indication on the chirality of the NP operators in $R_{D^{(*)}}$

# Fit results

[MB, Catà, Feldmann, JHEP 2001 (2020) 067]




- LFV B decays constitute an important signature of this scenarios
- For both the $\bar{B}_{d,s}$ modes, the final state with a $\tau^+$ is enhanced with respect to final state with a $\tau^-$
- Especially for the $\bar{B}_s$ initial state, the predictions approach the current experimental limit

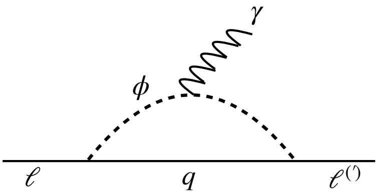
# The $S_1 + S_3$ solution [MB, Catà, Feldmann, Mandal, '20]

$$\mathcal{L}_{S_1+S_3} = S^{i\alpha}_{QL}\bar{Q}^{ci}\epsilon L^{\alpha} S_1 + \tilde{S}^{i\alpha}_{QL}\bar{Q}^{ci}\epsilon\sigma^{a} L^{\alpha} S^{a}_3 + S_{UE}\bar{u}^{ci}_R e^{\alpha}_R S_1 + \text{h.c.}$$

$$c^{i\alpha}_L \lambda^{|b^i_Q - b^\alpha_L|} \qquad \tilde{c}^{i\alpha}_L \lambda^{|b^i_Q - b^\alpha_L|} \qquad c^{i\alpha}_R \lambda^{|b^i_U - b^\alpha_E|}$$

- Scalars allow a full 1-loop analysis
- Left-handed, scalar and tensor couplings are generated
- No protection in $B \to K^{(*)}\nu\bar{\nu}$ and $K \to \pi\nu\bar{\nu}$ modes
- Viable solutions are very similar from the phenomenological point of view
  - Due to the constraining power of LFV lepton decays

# Results




- $m_q$ enhancement when $q = t$

$$\mathcal{B}(\tau \to \mu\gamma)|_{\text{exp}} < 4.4 \times 10^{-8}$$

$$\frac{\mathcal{B}(\tau \to \mu\gamma)}{(c_L^{32})^2 (c_R^{33})^2} \in [0.420, 2.38] \times 10^{-5}$$

- Tuning in $c_L^{32}$ and $c_R^{33}$ si required
- Reproducing $g-2$ would falsify the power counting scheme
  - less constraining scenarios can explain the $g-2$ [Gherardi, Marzocca, Venturini, '20]

# Summary

- Flavour physics allows to probe at high accuracy physics within and beyond the Standard Model
- Recent data show some (first?) hints of deviations with respect to the Standard Model expectations
- Model building shows that extensions based on a vector and scalar leptoquarks can indeed address the anomalies
    - Froggatt-Nielsen as a power counting gives a good description of low energy data and provides interesting predictions for LFV decays

# Appendix

# Inclusive vs Exclusive determination of $V_{cb}$

Inclusive determination of $V_{cb}$:

$$V_{cb}^{\text{incl}} = (42.00 \pm 0.65) \times 10^{-3}$$

[P. Gambino, C. Schwanda, 1307.4551
A. Alberti, P. Gambino, K. J. Healey, S. Nandi, 1411.6560
P. Gambino, K. J. Healey, S. Turczyk, 1606.06174]

Exclusive determination of $V_{cb}$: depends on the data set used and the assumptions for the hadronic parameters

- $B \to D\ell\bar{\nu}$: $V_{cb}^{\text{excl}}|_{BD} = (40.49 \pm 0.97) \times 10^{-3}$

  [P.Gambino, D.Bigi, 1606.08030, + $\cdots$]

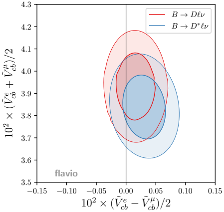
- $B \to D^*\ell\bar{\nu}$: not a general consensus yet, but systematically lower $V_{cb}^{\text{excl}}|_{BD}$

  [P.Gambino, M.Jung, S.Schacht, '19
  F.Bernlochner, Z. Ligeti, M. Papucci, D. Robinson,'17 + $\cdots$]

- $B_s \to D_s^{(*)}\ell\bar{\nu}$: new extraction by LHCb $\Rightarrow$ still large uncertainties [2001.03225]

**No evidence so far that this tension is due to NP**

[M. Jung, D. Straub, 1801.01112]



# HQET in a nutshell

- In HQET it is convenient to work with **velocities** instead of momenta
- Instead of $q^2$ we use the dimensionless variable $w = v_B \cdot v_{D^*}$
- When the $B(b)$ decays such that the $D^*(c)$ is at rest in the $B(b)$ frame

$$v_B = v_{D^*} \qquad \Rightarrow \qquad w = 1$$

- The brown muck doesn't realise that anything changed
- At zero recoil, the leading IW function is **normalized**

$$\xi(w = 1) = 1$$

# $V_{cb}$ and NP

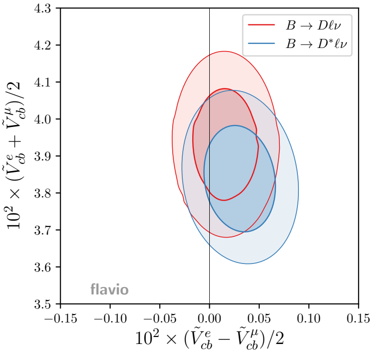
[Jung, Straub 2018]

- If we allow LFUV between $\mu$ and electrons

$$\tilde{V}_{cb}^{\ell} = V_{cb}(1 + C_{V_L}^{\ell})$$

- Fitting data from Babar and Belle

$$\frac{\tilde{V}_{cb}^{e}}{\tilde{V}_{cb}^{\mu}} = 1.011 \pm 0.012$$



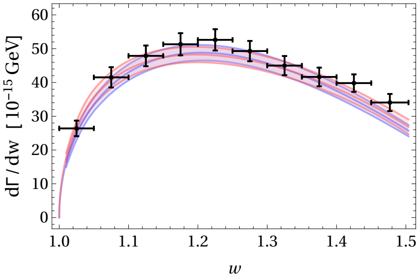

$$\frac{1}{2}(\tilde{V}_{cb}^{e} + \tilde{V}_{cb}^{\mu}) = (3.87 \pm 0.09)\%$$
$$\frac{1}{2}(\tilde{V}_{cb}^{e} - \tilde{V}_{cb}^{\mu}) = (0.022 \pm 0.023)\%$$

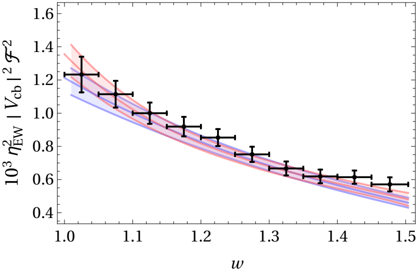
# BGL vs CLN

- Both BGL and CLN parametrisation of form factors rely on using unitarity arguments.

[Boyd, Grinstein, Lebed, '95
Caprini, Neubert, Lellouch, '98]

- CLN relies on HQET.
- Unfolded distributions from Belle allowed to repeat an independent fit.




BGL has a more conservative error

Provides better agreement with inclusive $V_{cb}$

# BGL vs CLN parametrisations

## CLN

[Caprini, Lellouch, Neubert, '97]

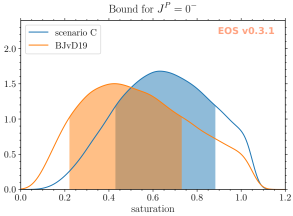
- Expansion of FFs using HQET
- $1/m_{b,c}$ corrections included
- Expansion of leading IW function up to 2nd order in $(w-1)$

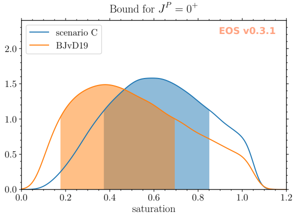
## BGL

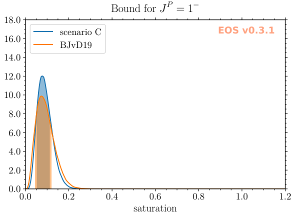
[Boyd, Grinstein, Lebed, '95]

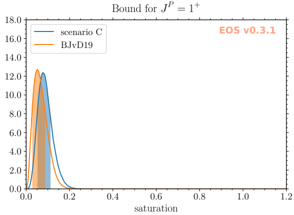
- Based on analyticity of the form factors
- Expansion of FFs using the conformal variable $z$
- Large number of free parameters

# Results: unitary bounds

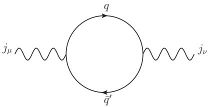


# Unitarity Bounds




$$= i \int d^4x \, e^{iqx} \langle 0 | T \left\{ j_\mu(x), j_\nu^\dagger(0) \right\} |0\rangle = (g_{\mu\nu} - q_\mu q_\nu)\Pi(q^2)$$

- If $q^2 \ll m_b^2$ we can calculate $\Pi(q^2)$ via perturbative techniques $\Rightarrow \chi(0)$
- Dispersion relations link Im $\left(\Pi(q^2)\right)$ to sum over matrix elements

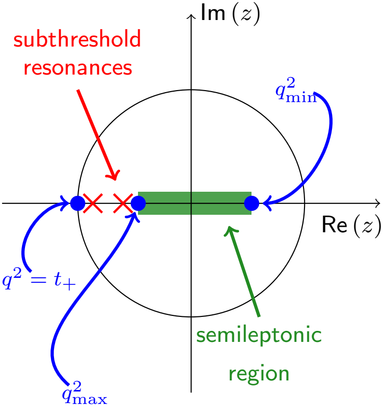
$$\sum_i |F_i(0)|^2 < \chi(0)$$

**[Boyd, Grinstein, Lebed, '95**
**Caprini, Lellouch, Neubert, '97]**

- The sum runs over <u>all</u> possible states hadronic decays mediated by a current $\bar{c}\Gamma_\mu b$
  - The unitarity bounds are more effective the most states are included in the sum
  - The unitarity bounds introduce correlations between FFs of different decays
  - $B_s \to D_s^{(*)}$ decays are expected to be of the same order of $B_{u,d} \to D_{u,d}^{(*)}$ decays due to $SU(3)_F$ simmetry

# The $z$-expansion

The continuum limit needs a parametrisation of the form factors $\Rightarrow$ $z$-expansion




- in the complex plane form factors are real analytic functions
- $q^2$ is mapped onto the conformal complex variable $z$

$$z(q^2, t_0) = \frac{\sqrt{t_+ - q^2} - \sqrt{t_+ - t_0}}{\sqrt{t_+ - q^2} + \sqrt{t_+ - t_0}}$$

  $t_+ = (m_{H_{\rm in}} + m_{H_{\rm fin}})^2$ and $t_0$ can be chosen to minimise $z_{\max}$
- $q^2$ is mapped onto a disk in the complex $z$ plane, where $|z(q^2, t_0)| < 1$
- being $z$ small, we can expand any form factor in $z$ and truncate the series at relatively low orders

# Non-leptonic $\bar{B}_s \to D_s^{+(*)}\pi$ and $\bar{B} \to D^{+(*)}K$ decays

- Non-leptonic $\bar{B}_s \to D_s^{+(*)}\pi$ and $\bar{B} \to D^{+(*)}K$ are very clean predictions in QCDF
- Updated results on $\bar{B}_q \to D_q$ form factors and $V_{cb}$ drastically reduce the uncertainties [MB, Gubernari, Huber, Jung, van Dyk, '20]
- Next-to-leading power $1/m_b$ corrections are estimated to be small [MB, Gubernari, Huber, Jung, van Dyk, '20]
- With the current experimental measurement we signal a $4.4\,\sigma$ discrepancy [MB, Gubernari, Huber, Jung, van Dyk, '20]

# Non-leptonic $\bar{B}_s \to D_s^{+(*)}\pi$ and $\bar{B} \to D^{+(*)}K$ decays

**What is responsible of this deviation?**

- QCDF predictions seem rather stable
- New Physics could be an option, but it is strongly disfavoured by flavour bounds combined with high-$p_T$ bounds **[MB, Greljo, Marzocca, 2103.10332]**