Pheno Club
Thursday 3:30 pm ?
February Vlad ?
March Sophie Mutzel.
April
May

B anomalies

- Several anomalies in $b \to s$ and $b \to c$ transitions
- One of only signs of New Physics
- Current status pre and post Dec. 20 2022

$b \to s \ell\ell$ transitions

Calculated in effective field theory, integrating out fields above m_b.

$$\mathcal{H}_{eff} = -\frac{4 G_F}{\sqrt{2}} V_{tb} V_{ts}^* \left(C_1 O_1^c + C_2 O_2^c + \sum_{i=3,6} C_i O_i + \sum_{7,8,9,10} C_i O_i + C_i' O_i' \right)$$

$i = 7', 8', 9', 10'$

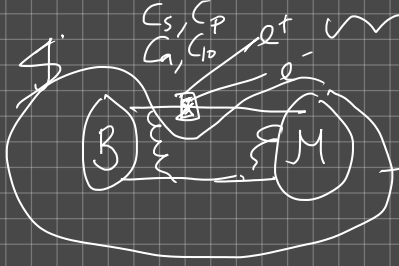
Leading contributions from:

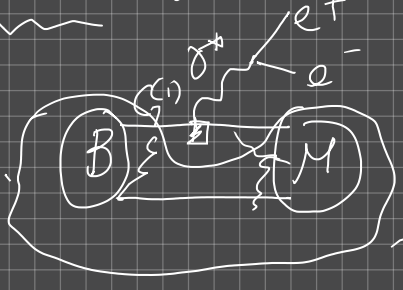
Name	W.C.	Operator
Photon penguin	$C_7^{(\prime)}$	$\frac{e}{g^2} m_b (\bar{s} \sigma_{\mu\nu} P_{R(L)} b) F^{\mu\nu}$
Gluonic penguin	$C_8^{(\prime)}$	$\frac{e}{g_s^2} m_b (\bar{s} \sigma_{\mu\nu} P_{R(L)} b) G^{\mu\nu,a}$
EW penguins (V)	$C_9^{(\prime)}$	$\frac{e^2}{g^2} (\bar{s} \gamma_\mu P_{L(R)} b)(\bar{\mu} \gamma^\mu \mu)$
" (A)	$C_{10}^{(\prime)}$	$\frac{e^2}{g^2} (\bar{s} \gamma_\mu P_{L(R)} b)(\bar{\mu} \gamma^\mu \gamma_5 \mu)$

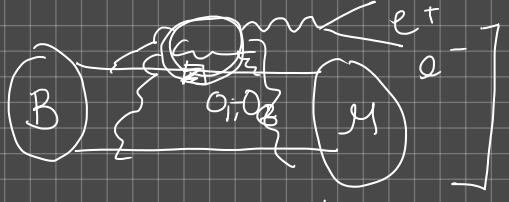
Write amplitude:

$$\mathcal{A}_{B \to \mu\ell\ell} = \langle \ell^+ \ell^- \mu | \mathcal{H}_{eff} | B \rangle = \frac{4 G_F}{\sqrt{2}} \lambda \sum_i \langle \ell^+ \ell^- \mu | C_i O_i | B \rangle$$

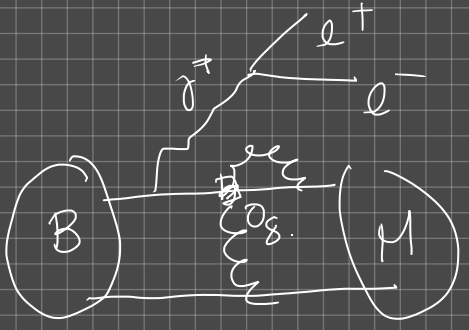
$$\mathcal{A}_{B \to \mu\ell\ell} \propto N \left(C F^V(q^2) + \frac{1}{q^2} \left(C F^T(q^2) - H_L(q^2) \right) \right) \langle \ell^+ \ell^- | j_\ell | 0 \rangle$$







⇒ Dominant uncertainty
Cannot use form factors



$\mathcal{H}$ = non-local hadronic matrix element

Lepton flavour universality ratios

$$R_K = \frac{\mathcal{B}(B \to K e^+ e^-)}{\mathcal{B}(B \to K \mu^+ \mu^-)}$$

In SM $\simeq 1$.

Update December 2022.

Anomalies disappeared due to improved treatment of misidentified hadronic background.
Tight PID cuts on electron removed background

$b \to c$.

$$R_{D^{(*)}} = \frac{\mathcal{B}(B \to D^{(*)} \tau \nu)}{\mathcal{B}(B \to D^{(*)} \mu/e \nu))}$$

Differences from $b \to s$

1) Semi-leptonic unsuppressed
2) τ in numerator therefore diff from 1 due to τ mass.
↳ more dependence on FFs than neutral.

Perform fits to fns of data to theory in q^2.
motivated parameterization. BGL preferred.