Search for new physics signals via doubly weak B decays

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In collaboration with Y. Li, F. Munir, Q.Qin and Y.H. Xie

Search for new particle or new phenomena is our major task in particle physics

- There are two ways to achieve that: direct search or indirect search
- Accordingly we have two directions in high energy physics experiments: high energy and high intensity ...

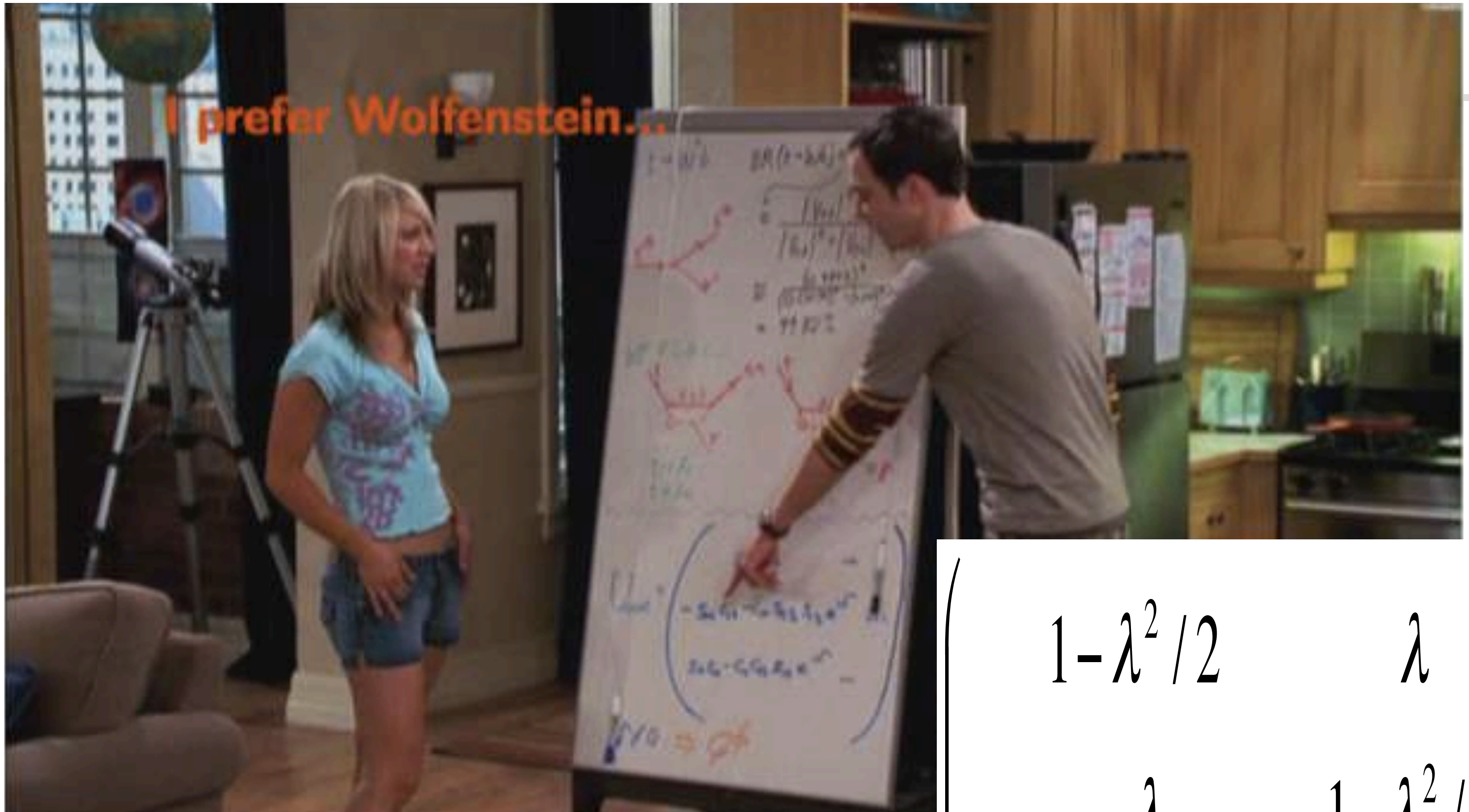
There are many high intensity experiments:

- Beijing electron position collider (BEPC)
- Many neutrino experiment etc.
- B-factories (two machines)
- LHCb
- There is even a super B-factory（Belle II）

Heavy flavor physics is a very important hot topic in particle physics recently

- People expect the new physics signal from the heaviest particle --- top quark, since it is very close to the electroweak breaking scale
- But there are too few data of top quark production
- Therefore beauty quark is our best chance for new physics signals, since they both belong to the third family

Another important topic in heavy flavor is CP violation, which is related to the CKM matrix



$$\begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho-i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

Large CP violation is the key point for Baryon number asymmetry

The key point of CP violation

- **If we found another world of civilization, we have to make sure whether they are made of anti-matter, before we travel to them**
- **This is very important (Annihilation)**
- **Since the definition of matter/anti-matter, left/right is arbitrary, unless we have CP violation:**

$$\frac{\Gamma(K_L \to \pi^- \mu^+ \nu) - \Gamma(K_L \to \pi^+ \mu^- \bar{\nu})}{\Gamma(K_L \to \pi^- \mu^+ \nu) + \Gamma(K_L \to \pi^+ \mu^- \bar{\nu})} = (0.64 \pm 0.08)\%$$

Flavor physics is important

The origin of flavour is one of the big, unsolved mysteries of fundamental physics!

While the Standard Model (SM) ***describes*** flavour physics very accurately, it does not ***explain*** its mysteries:

- ✓ Why are there 3 generations in nature?
- ✓ What determines the extreme hierarchy of fermion masses?
- ✓ What determines the elements of the CKM matrix?
- ✓ What is the origin of the matter-antimatter asymmetry (CP violation)?

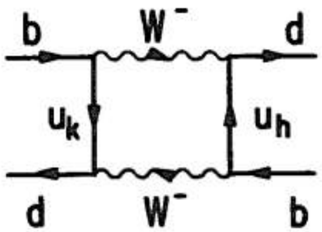
The SM CP-violation is insufficient to explain the matter/antimatter asymmetry
→ progress in flavour physics may help understand open questions in cosmology

History has shown that flavour physics often gives first evidence for new discoveries:

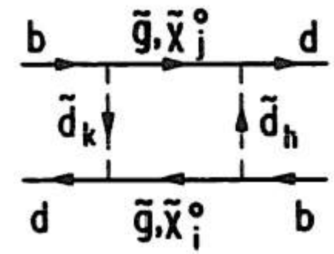
- Kaon mixing, BR($K^0_L \to \mu\mu$) & GIM → prediction of charm
- CP violation → prediction of third quark family
- B mixing → mass of top is very heavy
- rare B-decays → SUSY parameter space constrained

New Physics in FCNC processes

- Mixing

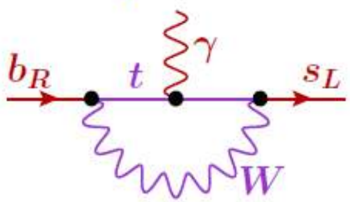


~~OR~~ $\Rightarrow$ AND?



Simple parameterization for each neutral meson: $M_{12} = M_{12}^{\rm SM}\,(1 + h e^{2i\sigma})$

- Penguin decays



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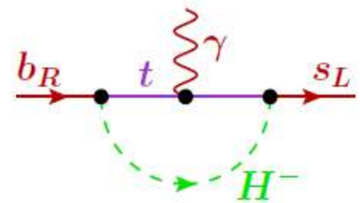


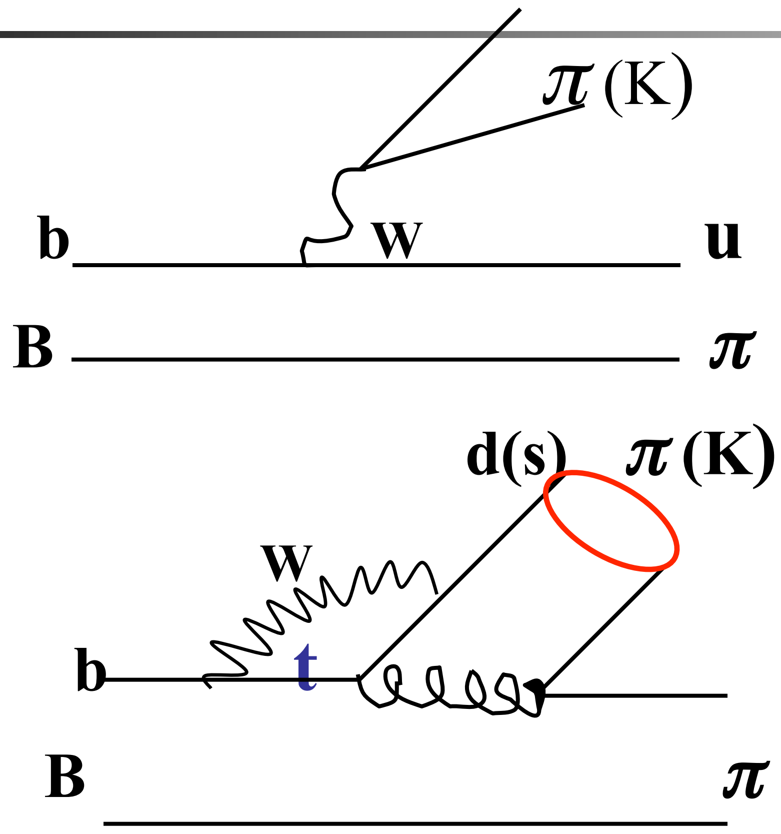
Many operators for $b \to s$ transitions — no simple parameterization of NP

- $V_{td,\,ts}$ only measurable in loops; likely also subleading couplings of new particles

Current Flavor Anomalies

$\sim 3.5\sigma$	$(g-2)_\mu$ anomaly	
$\sim 3.5\sigma$	non-standard like-sign dimuon charge asymmetry	
$\sim 3.5\sigma$	enhanced $B \to D^{(*)}\tau\nu$ rates	$R_{D^{(*)}}$
$\sim 3.5\sigma$	suppressed branching ratio of $B_s \to \phi\mu^+\mu^-$	
$\sim 3\sigma$	tension between inclusive and exclusive determination of $\lvert V_{ub}\rvert$	
$\sim 3\sigma$	tension between inclusive and exclusive determination of $\lvert V_{cb}\rvert$	
$2-3\sigma$	anomaly in $B \to K^*\mu^+\mu^-$ angular distributions	P_5'
$2-3\sigma$	SM prediction for ϵ'/ϵ below experimental result	
$\sim 2.5\sigma$	lepton flavor non-universality in $B \to K\mu^+\mu^-$ vs. $B \to Ke^+e^-$	R_K
$\sim 2.5\sigma$	non-zero $h \to \tau\mu$	

Search for new physics in hadronic B decays



*The B→ pi pi, pi K decays have both contributions **from tree and penguin** amplitudes, which can give direct CP violation by interference.*

*They have been well studied by exp. and theory at the **BRs level of 10^{-6}***

There is another chance of the doubly weak decay

$b \to ss\bar{d}$ and $b \to dd\bar{s}$ transitions in the SM

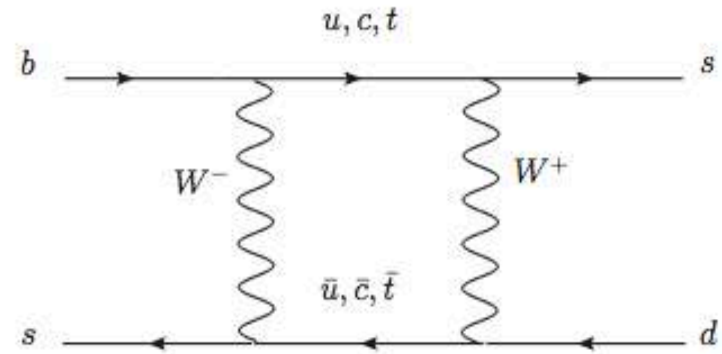
- Local $\Delta S = 2$ SM effective Hamiltonian for $b \to ss\bar{d}$ transition

$$\mathcal{H}_{\text{eff}}^{\Delta S=2} = \frac{G_F^2 m_W^2}{4\pi^2}\left(V_{td}V_{ts}^* V_{tb}V_{ts}^* S_0\left(\frac{m_t^2}{m_W^2}\right) + V_{cd}V_{cs}^* V_{tb}V_{ts}^* S_0\left(\frac{m_c^2}{m_W^2}, \frac{m_t^2}{m_W^2}\right)\right)\left[(\bar{s}_L^i \gamma^\mu b_L^i)(\bar{s}_L^j \gamma_\mu d_L^j)\right]$$

- Local $\Delta S = -1$ SM effective Hamiltonian for $b \to dd\bar{s}$ transition $s \leftrightarrow d$

$$\mathcal{B}(b \to ss\bar{d})_{\text{SM}} = (2.19 \pm 0.38) \times 10^{-12}$$

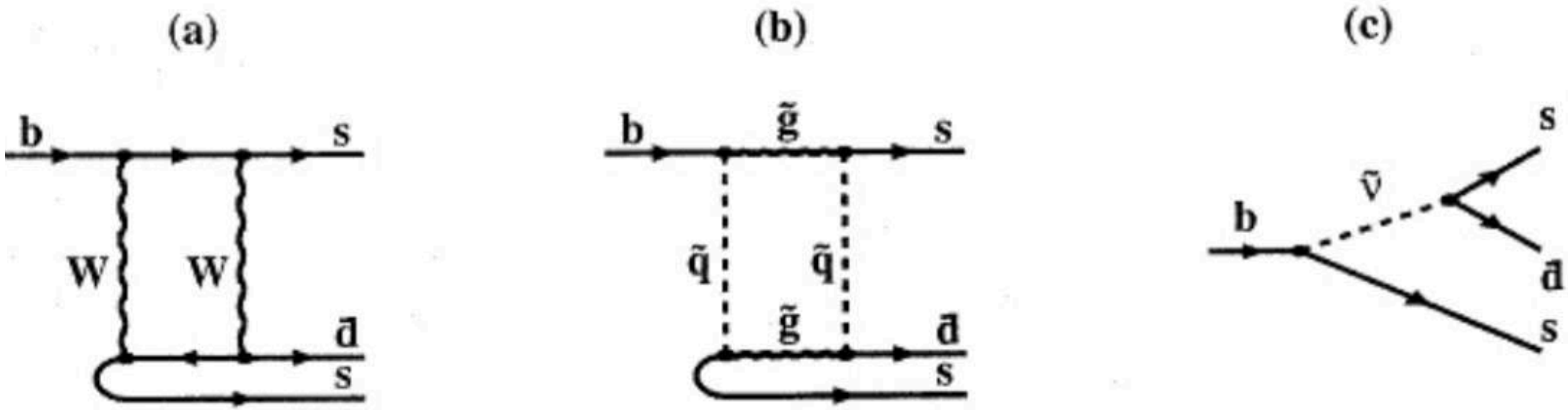
$$\mathcal{B}(b \to dd\bar{s})_{\text{SM}} = (2.24 \pm 0.41) \times 10^{-14}$$



- $b \to ss\bar{d}$ and $b \to dd\bar{s}$ decays with very small strengths in the SM serve as a sensitive probe for new physics searches.

This was first proposed 20 years ago

K. Huitu, C.D. Lü, P. Singer D.X. Zhang, **Phys. Rev. Lett. 81, 4313 (1998), hep-ph/9809566.**

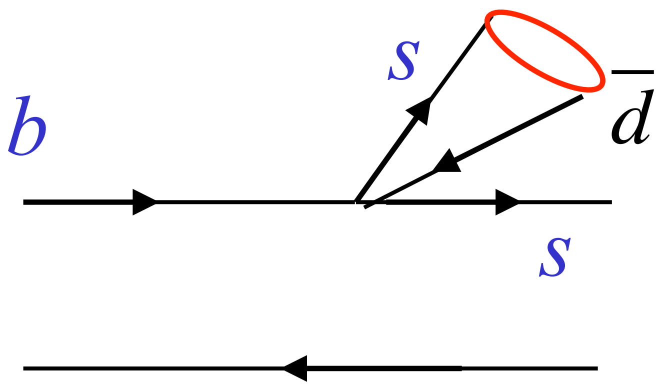


$b \to ss\bar{d}$ transition (a) SM, (b) MSSM, (c) MSSM with R-parity violating coupling

SM BRs: ~ 10 $^{-14}$,

Some New physics can reach 10 $^{-6}$

Experimentally it is difficult to search for this doubly weak decay



- $s\bar{d}$ makes a $\bar{K}^0$, which mix with K^0, not experimental distinguishable. The experiments only observe their mass eigenstate K_S.
- Unless we make two charged K meson final states, by additional up quark pair produce from sea

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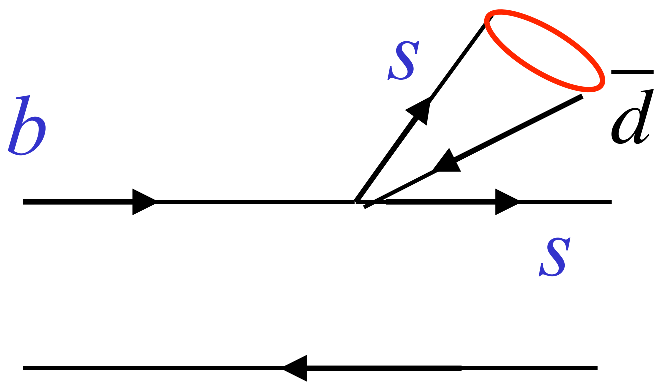

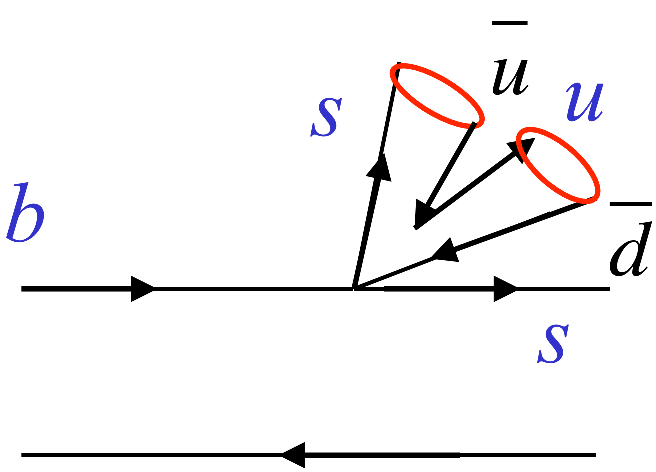

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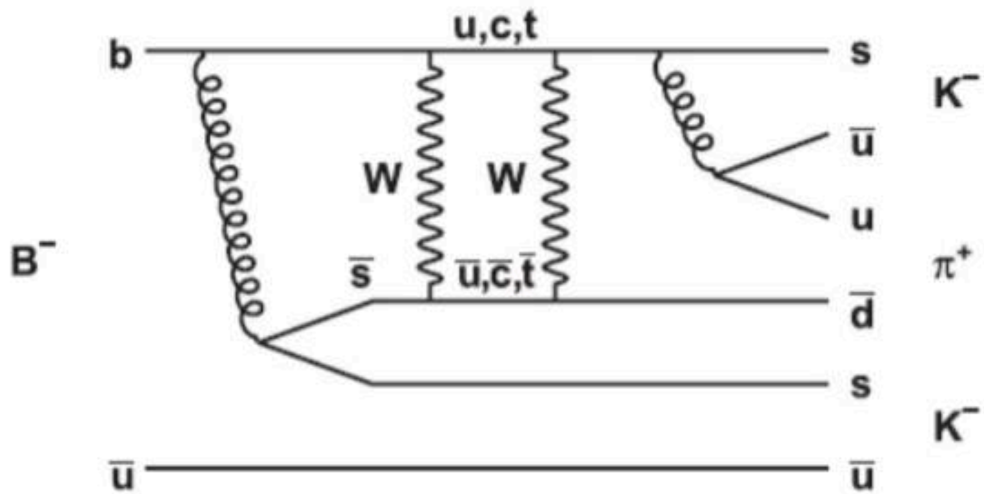
Experimental search starting from OPAL @ LEP, phys. Lett. B 476 (2000) 233, later searched also by Belle/Babar

BABAR collaboration, Phys. Rev. D 78 (2008) 091102 [arXiv:0808.0900]

A search for the decay $B^- \to K^- K^- \pi^+$, Using a sample of $(467 \pm 5) \times 10^6$ $B\overline{B}$ pairs collected with the BABAR detector.



Result : No evidence for these decays was found and a upper limit was set as

$$\mathcal{B}(B^- \to K^- K^- \pi^+) < 1.6 \times 10^{-7}$$

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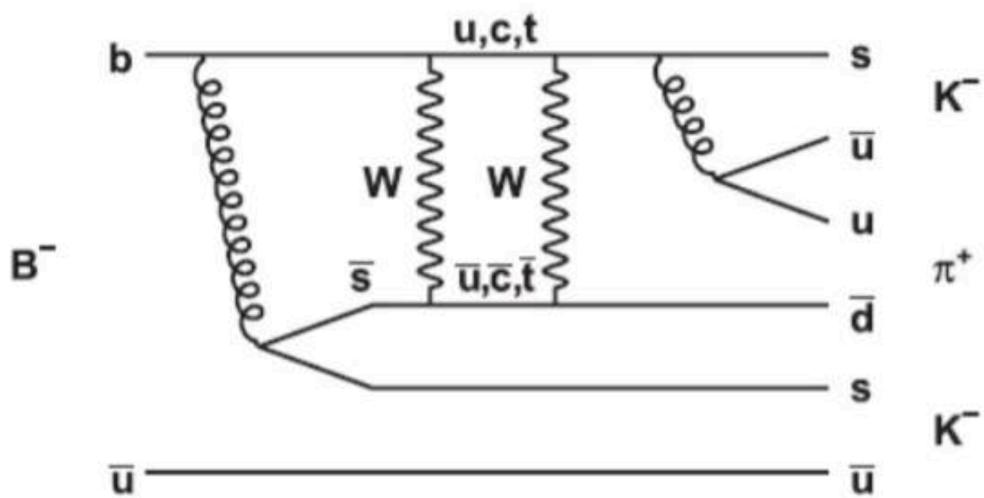

Similar channel $B^- \to \pi^- \pi^- K^+$

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Recent LHCb result:

Physics Letters B 765 (2017) 307–316

$$\mathcal{B}(B^+ \to K^+K^+\pi^-) < 1.1 \times 10^{-8}$$

$$\mathcal{B}(B^+ \to \pi^+\pi^+K^-) < 4.6 \times 10^{-8}.$$

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Recent theoretical results in Randall-Sundrum model:

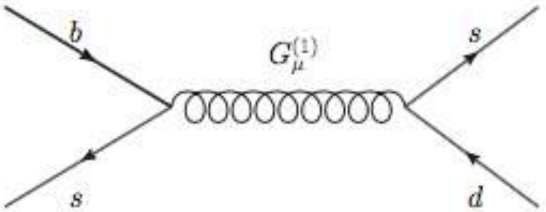
CDL, F. Munir, Q. Qin, Chinese Physics C41 (2017) 053106

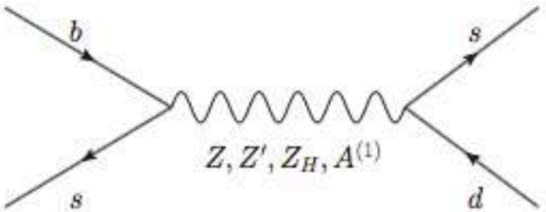
Br(b→ss d-bar) can reach to 10 $^{-10}$

$b \to ss\bar{d}$ decay in the RS$_c$ model

- $b \to ss\bar{d}$ decay receives **tree level contributions** from the Kaluza-Klein (KK) gluons, the heavy KK photons, new heavy electroweak (EW) gauge bosons Z_H and Z', and in principle the Z boson.

  $M_{\mathcal{G}^{(1)}} = M_{Z_H} = M_{Z'} = M_{A^{(1)}} \equiv M_{g^{(1)}} \approx 2.45\, M_{\text{KK}}$





- Custodial protection of the $Zb_L\bar{b}_L$ coupling through the discrete P_{LR} symmetry renders tree-level Z contributions negligible.
- The effective Hamiltonian for the $\Delta S = 2$ $b \to ss\bar{d}$ decay with the Wilson coefficients corresponding to $\mu = \mathcal{O}(M_{g^{(1)}})$

$$[\mathcal{H}_{\text{eff}}^{\Delta S=2}]_{\text{KK}} = \frac{1}{(M_{g^{(1)}})^2}[C_1^{VLL}Q_1^{VLL} + C_1^{VRR}Q_1^{VRR} + C_1^{LR}Q_1^{LR} + C_2^{LR}Q_2^{LR} + C_1^{RL}Q_1^{RL} + C_2^{RL}Q_2^{RL}].$$

$$Q_1^{VLL} = (\bar{s}\gamma_\mu P_L b)(\bar{s}\gamma^\mu P_L d), \qquad Q_1^{VRR} = (\bar{s}\gamma_\mu P_R b)(\bar{s}\gamma^\mu P_R d),$$

$$Q_1^{LR} = (\bar{s}\gamma_\mu P_L b)(\bar{s}\gamma^\mu P_R d), \qquad Q_1^{RL} = (\bar{s}\gamma_\mu P_R b)(\bar{s}\gamma^\mu P_L d),$$

$$Q_2^{LR} = (\bar{s}P_L b)(\bar{s}P_R d), \qquad Q_2^{RL} = (\bar{s}P_R b)(\bar{s}P_L d).$$

$b \to s s \bar{d}$ decay in the bulk-Higgs RS model

$$(\widetilde{\Delta}_D)_{23} \otimes (\widetilde{\Delta}_d)_{21} \to (U_d^\dagger)_{2i}(U_d)_{i3}(\widetilde{\Delta}_{Dd})_{ij}(W_d^\dagger)_{2j}(W_d)_{j1},$$

$$(\widetilde{\Delta}_{Dd})_{ij} = \frac{F^2(c_{Q_i})}{3+2c_{Q_i}} \frac{3+c_{Q_i}+c_{d_j}}{2(2+c_{Q_i}+c_{d_j})} \frac{F^2(c_{d_j})}{3+2c_{d_j}},$$

$$(\widetilde{\Omega}_D)_{23} \otimes (\widetilde{\Omega}_d)_{21} \to (U_d^\dagger)_{2i}(W_d)_{j3}(\widetilde{\Omega}_{Dd})_{ijkl}(W_d^\dagger)_{2k}(U_d)_{l1},$$

$$(\widetilde{\Omega}_{Dd})_{ijkl} = \frac{\pi(1+\beta)}{4L} \frac{F(c_{Q_i})F(c_{d_j})}{2+\beta+c_{Q_i}+c_{d_j}} \frac{(Y_d)_{ij}(Y_d^\dagger)_{kl}}{1} \times \frac{(4+2\beta+c_{Q_i}+c_{d_j}+c_{d_k}+c_{Q_l})}{4+c_{Q_i}+c_{d_j}+c_{d_k}+c_{Q_l}} \frac{F(c_{d_k})F(c_{Q_l})}{2+\beta+c_{d_k}+c_{Q_l}}.$$

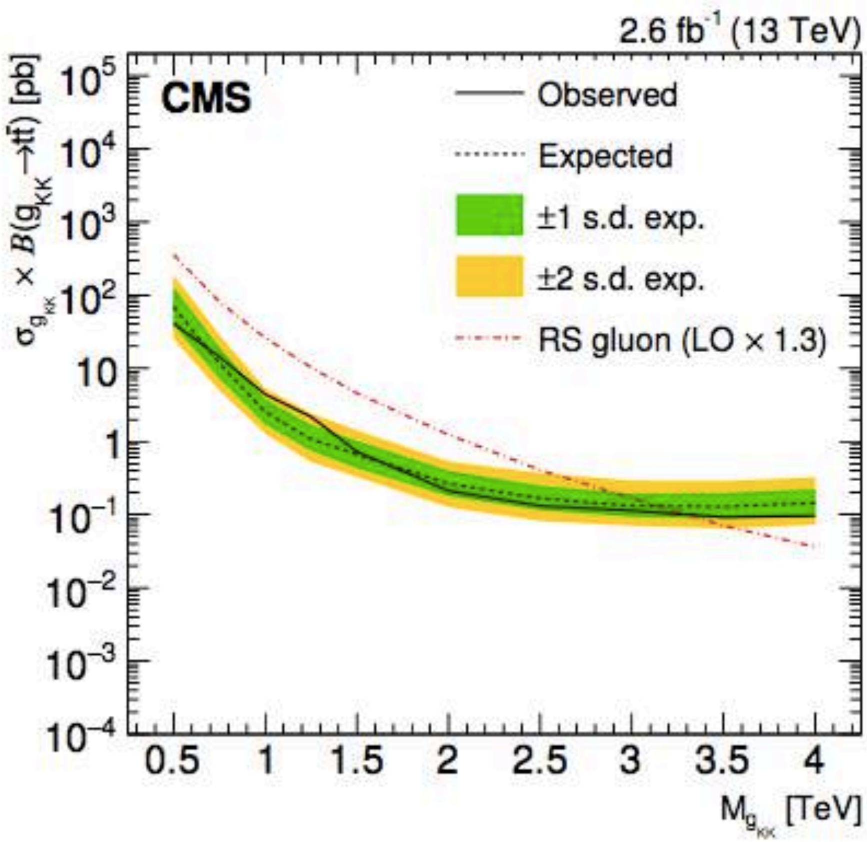
- The decay width in the bulk-Higgs RS model

$$\begin{aligned}\Gamma_{\text{KK}} = \frac{m_b^5}{3072(2\pi)^3}&[64(|C_1(\mu_b)|^2+|\widetilde{C}_1(\mu_b)|^2)\\ &+12(|C_4(\mu_b)|^2+|\widetilde{C}_4(\mu_b)|^2+|C_5(\mu_b)|^2+|\widetilde{C}_5(\mu_b)|^2)\\ &+4\mathcal{R}e(C_4(\mu_b)C_5^*(\mu_b)+C_4^*(\mu_b)C_5(\mu_b)\\ &+\widetilde{C}_4(\mu_b)\widetilde{C}_5^*(\mu_b)+\widetilde{C}_4^*(\mu_b)\widetilde{C}_5(\mu_b))].\end{aligned}$$

Constraints on the RS Parameter space

Direct Searches

[A. M. Sirunyan *et al.* (CMS), JHEP 07 (2017) 001]



$M_{g^{(1)}} > 3.3$ TeV (95% CL).

More Constraints

- The RS$_c$ model
  - Constraint from tree-level analysis of the S and T parameters

[Malm, Neubert, Novotny, Schmell, JHEP 01 (2014) 173]

$$M_{g^{(1)}} > 4.8 \text{ TeV} \qquad (95\% \text{ CL}).$$

- The bulk-Higgs RS model

$$S = \frac{2\pi v^2}{M_{KK}^2}\left(1 - \frac{1}{(2+\beta)^2} - \frac{1}{2L}\right)$$

$$T = \frac{\pi v^2}{2c_W^2 M_{KK}^2}\,\frac{2L(1+\beta)^2}{(2+\beta)(3+2\beta)}$$

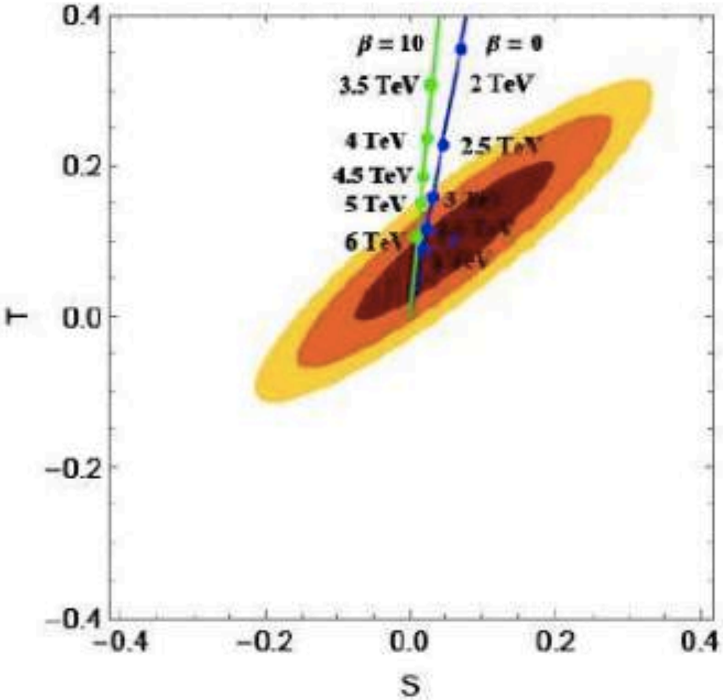
$$U = 0.$$

[M. Baak *et al.* (Gfitter), Eur. Phys. J. C74 (2014) 3046]

$$S = 0.06 \pm 0.09$$

$$T = 0.10 \pm 0.07$$

$$U = 0.$$

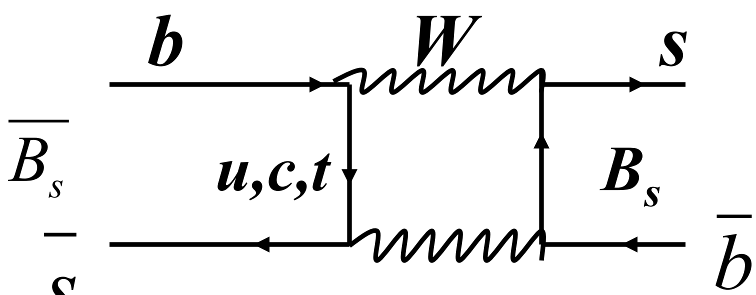


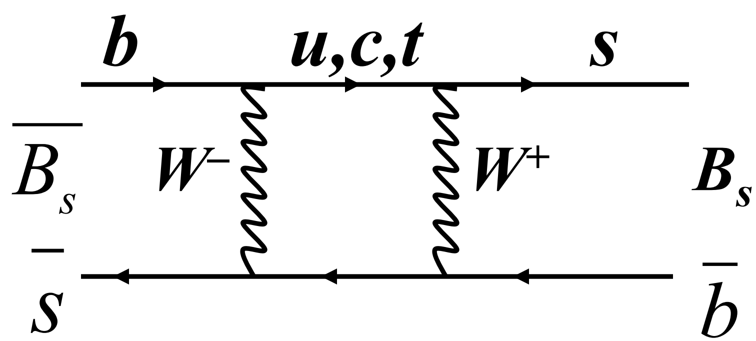
$M_{KK} > 5$ TeV, with $\beta = 10$

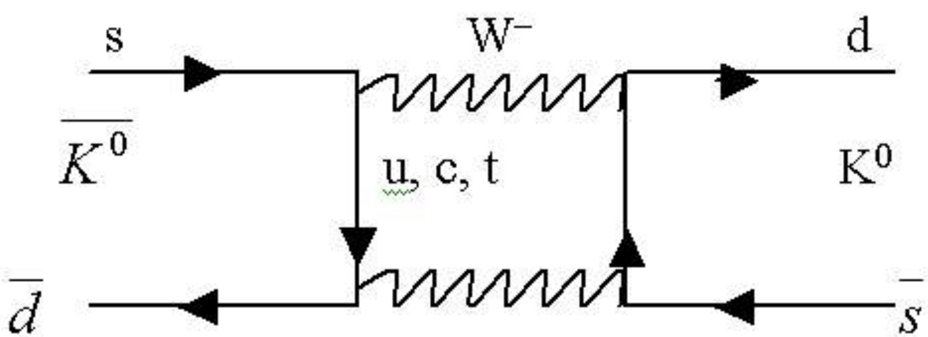
$M_{KK} > 3$ TeV, with $\beta = 0$

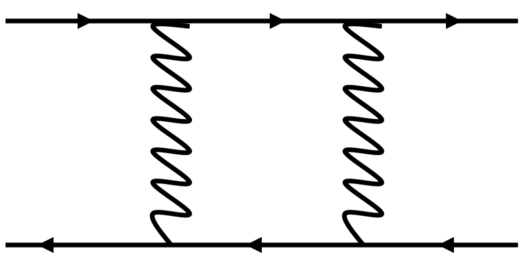
most severe constraints are from $B_s - \overline{B}_s$ and $K - \overline{K}^0$ mixing

Combined constraints of coupling and mass of new particle







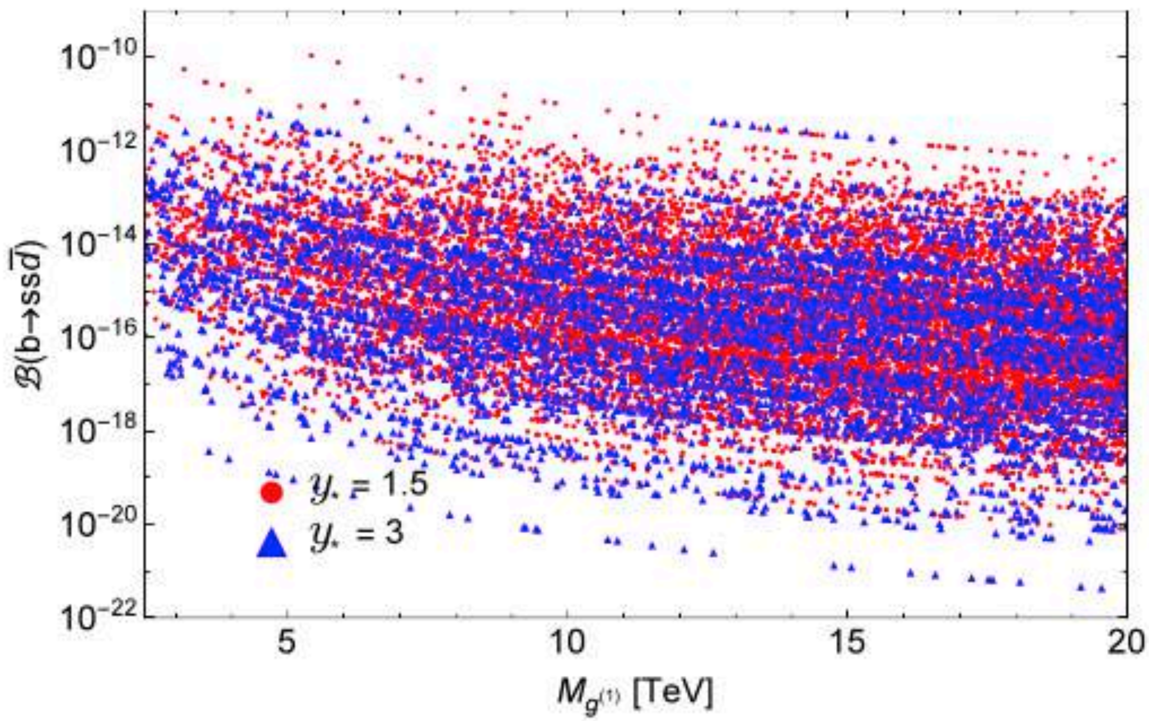


Branching ratio of $b \to ss\bar{d}$ in the RS_c model

ΔM_K, ϵ_K and ΔM_{B_s} constraints

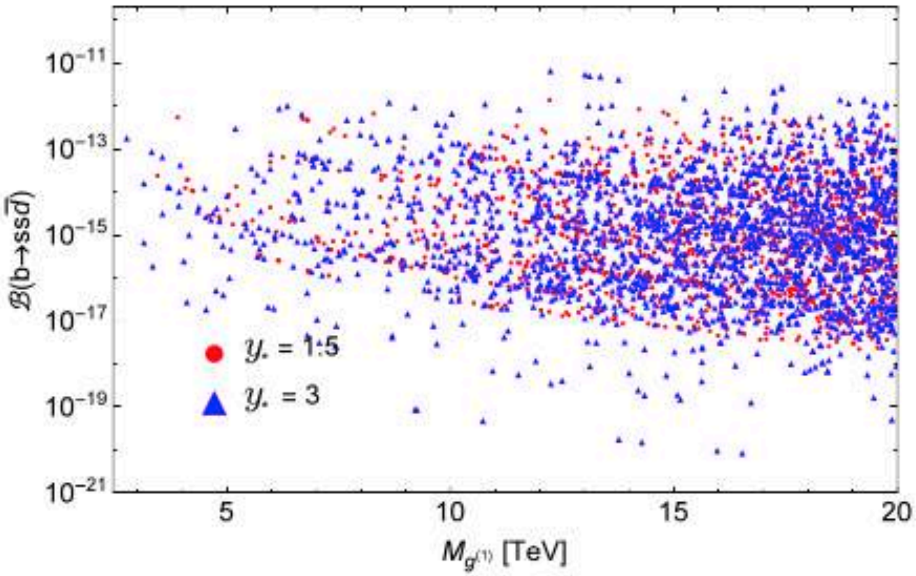
KK gluons dominant

Comparable Z_H and Z' contributions



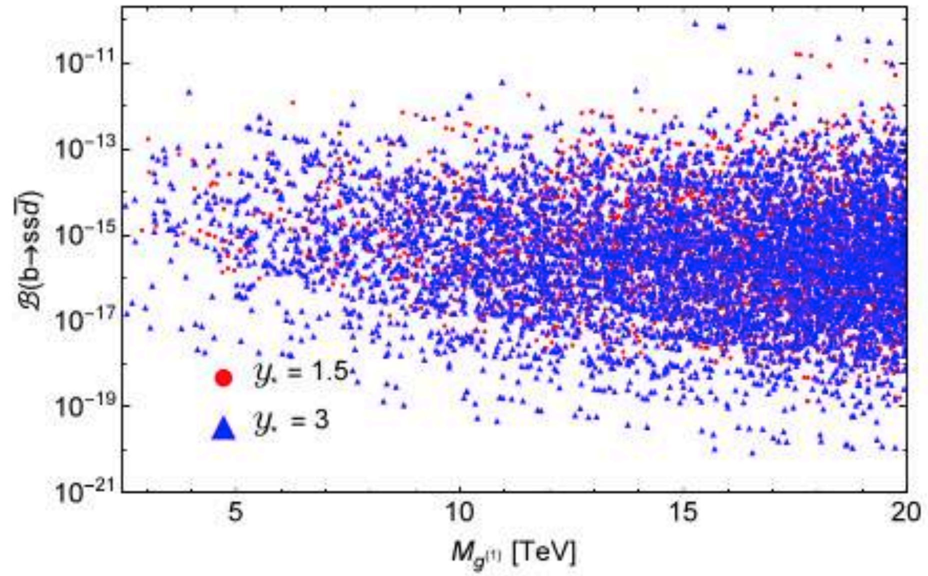
Branching ratio of $b \to ss\bar{d}$ in the bulk-Higgs RS model

broad Higgs profile



$\beta = 1$

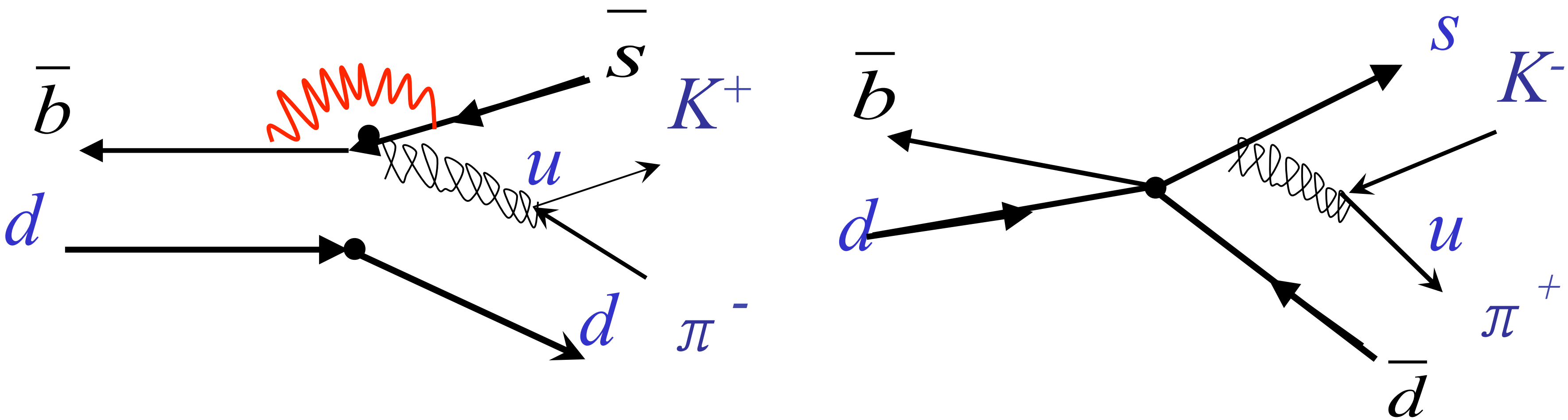
narrow Higgs profile



$\beta = 10$

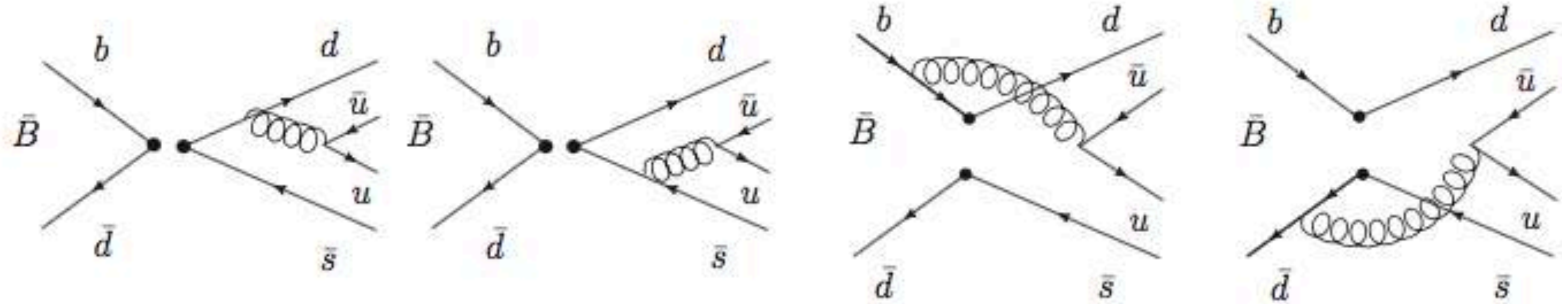
The wrong sign decay $B^0 \rightarrow K^- \pi^+$ can be extracted from the right sign decay $B^0 \rightarrow K^+ \pi^-$ by study the time dependent CP violation

In one of the new physics scenarios, the new physics can survive from the current experimental constraint, which give large branching ratio to the wrong sign $B^0 \rightarrow K^- \pi^+$ decay: F.M. Bhutta, Y. Li, CDL and Y.H. Xie, arXiv:1807.05350 [hep-ph]



$\overline{B}^0 \to K^+\pi^-$ decay in the Standard Model

$$\mathcal{H}^{\mathrm{SM}} = C^{\mathrm{SM}}[(\bar{d}_L^i \gamma^\mu b_L^i)(\bar{d}_L^j \gamma_\mu s_L^j)],$$



$$\mathcal{A} = f_B F_a^{LL}[\tfrac{4}{3}C^{\mathrm{SM}}] + \mathcal{M}_a^{LL}[C^{\mathrm{SM}}],$$

$$\begin{aligned} F_a^{LL} &= 4\pi C_F m_B^2 \int_0^1 dx_2 dx_3 \int_0^\infty b_2 db_2 b_3 db_3 \Big[\Big\{x_3 \phi_K^A(x_2)\phi_\pi^A(x_3) + 2 r_\pi r_K \phi_K^P(x_2)\Big[\Big(\phi_\pi^P(x_3) - \phi_\pi^T(x_3)\Big) \\ &+ x_3\Big(\phi_\pi^P(x_3) + \phi_\pi^T(x_3)\Big)\Big]\Big\} E_a(t_a) h_a(x_2, x_3, b_2, b_3) S_t(x_3) - \Big\{(1-x_2)\phi_K^A(x_2)\phi_\pi^A(x_3) + 4 r_\pi r_K \phi_K^P(x_2)\phi_\pi^P(x_3) \\ &- 2 r_\pi r_K x_2 \phi_\pi^P(x_3)\Big(\phi_K^P(x_2) - \phi_K^T(x_2)\Big)\Big\} E_a(t_b) h_b(x_2, x_3, b_2, b_3) S_t(x_2)\Big], \end{aligned}$$

$$\begin{aligned} \mathcal{M}_a^{LL} &= 8\pi C_F \frac{\sqrt{2N_c}}{N_c} m_B^2 \int_0^1 dx_1 dx_2 dx_3 \int_0^\infty b_1 db_1 b_3 db_3 \phi_B \Big[\Big\{(1-x_2)\phi_K^A(x_2)\phi_\pi^A(x_3) + r_\pi r_K\Big[(1-x_2)(\phi_K^P(x_2) - \phi_K^T(x_2)) \\ &\times (\phi_\pi^P(x_3) + \phi_\pi^T(x_3)) + x_3(\phi_K^P(x_2) + \phi_K^T(x_2))(\phi_\pi^P(x_3) - \phi_\pi^T(x_3))\Big]\Big\} E'_a(t_c) h_c(x_1, x_2, x_3, b_1, b_3) \\ &- \Big\{x_3 \phi_K^A(x_2)\phi_\pi^A(x_3) + r_\pi r_K\Big[4\phi_K^P(x_2)\phi_\pi^P(x_3) - (1-x_3)(\phi_K^P(x_2) - \phi_K^T(x_2))(\phi_\pi^P(x_3) + \phi_\pi^T(x_3)) \\ &- x_2(\phi_K^P(x_2) + \phi_K^T(x_2))(\phi_\pi^P(x_3) - \phi_\pi^T(x_3))\Big]\Big\} E'_a(t_d) h_d(x_1, x_2, x_3, b_1, b_3)\Big], \end{aligned}$$

$$\mathcal{B}(\overline{B}^0 \to K^+\pi^-)^{\mathrm{SM}} = 9.8 \times 10^{-20}$$

Model Independent Analysis of $\overline{B}^0 \to K^+\pi^-$ decay

- Assuming new physics contribution only to local operator $\mathcal{O}_1$

$$[\mathcal{H}_{\text{eff}}^{\Delta S=-1}] = C_1^{dd\bar{s}}(\bar{d}_L\gamma_\mu b_L)(\bar{d}_L\gamma^\mu s_L),$$

$$[\mathcal{H}_{\text{eff}}^{\Delta S=2}] = C_1^{K}(\bar{d}_L\gamma_\mu s_L)(\bar{d}_L\gamma^\mu s_L),$$

$$[\mathcal{H}_{\text{eff}}^{\Delta B=2}] = C_1^{B_d}(\bar{d}_L\gamma_\mu b_L)(\bar{d}_L\gamma^\mu b_L).$$

$$C_1^{dd\bar{s}} \sim \sqrt{C_1^K C_1^{B_d}}$$

- Assuming NP contributions come from non standard model chiralities

$$\mathcal{A}_j^i(\overline{B}^0 \to K^+\pi^-) = f_B F_a^i\left[C_j^{dd\bar{s}}\right] + \mathcal{M}_a^i\left[C_j^{dd\bar{s}}\right]$$
$$\widetilde{\mathcal{A}}_j^i(\overline{B}^0 \to K^+\pi^-) = f_B F_a^i\left[\widetilde{C}_j^{dd\bar{s}}\right] + \mathcal{M}_a^i\left[-\widetilde{C}_j^{dd\bar{s}}\right]$$

$$\Gamma(\overline{B}^0 \to K^+\pi^-) = \frac{m_B^3}{64\pi}\left|\mathcal{A}_j^i(\overline{B}^0 \to K^+\pi^-) + \widetilde{\mathcal{A}}_j^i(\overline{B}^0 \to K^+\pi^-)\right|^2$$

$$R \equiv \frac{\mathcal{B}(\overline{B}^0 \to K^+\pi^-)}{\mathcal{B}(\overline{B}^0 \to K^-\pi^+)}$$

- For an experimental precision of $R < 0.001$

Parameter	Allowed range (GeV^{-2})
$\widetilde{C}_1$	$< 1.1 \times 10^{-7}$
C_4	$< 5.5 \times 10^{-9}$
$\widetilde{C}_4$	$< 6.8 \times 10^{-9}$
C_5	$< 2.3 \times 10^{-6}$
$\widetilde{C}_5$	$< 8.7 \times 10^{-7}$

New Physics with Conserved Charge

- NP Lagrangian of a generic form

$$\mathcal{L}_{\text{flavor}} = g_{b\to d}(\bar{d}\Gamma b)X + g_{d\to b}(\bar{b}\Gamma d)X + g_{s\to d}(\bar{d}\Gamma s)X + g_{d\to s}(\bar{s}\Gamma d)X + \text{h.c.},$$

$$\mathcal{L}_{\text{eff}} = \frac{1}{M_X^2}\Big[g_{s\to d}g^*_{d\to s}(\bar{d}\Gamma s)(\bar{d}\overline{\Gamma} s) + g_{b\to d}g^*_{d\to b}(\bar{d}\Gamma b)(\bar{d}\overline{\Gamma} b)$$
$$+g_{b\to d}g^*_{d\to s}(\bar{d}\Gamma b)(\bar{d}\overline{\Gamma} s) + g_{s\to d}g^*_{d\to b}(\bar{d}\overline{\Gamma} b)(\bar{d}\Gamma s)\Big].$$

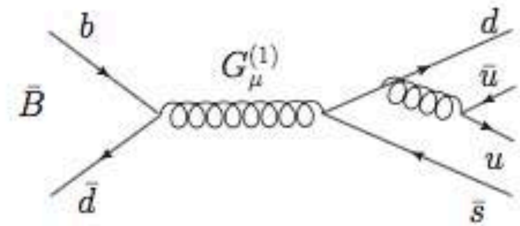
- $K^0 - \overline{K}^0$ and $B^0 - \overline{B}^0$ mixing bounds

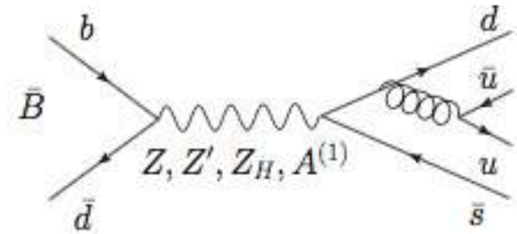
$$\frac{|g_{s\to d}g^*_{d\to s}|}{M_X^2} < \frac{1}{(\Lambda_j^K)^2}, \qquad \frac{|g_{b\to d}g^*_{d\to b}|}{M_X^2} < \frac{1}{(\Lambda_j^{B_d})^2}.$$

Scenarios	R_X				R_{SM}
	M_X (TeV)	Case-I	M_X (TeV)	Case-II	
S1	1.0		11	6.8×10^{-6}	6.7×10^{-15}
S2		0.074		6.1×10^{-6}	
S3		32	6.0	0.025	
S4		0.001	7.0	5.4×10^{-7}	

$\overline{B}^0 \to K^+\pi^-$ decay in the RS$_c$ model

$$[\mathcal{H}_{\rm eff}]_{\rm RS_c} = \frac{1}{[M_{g^{(1)}}]^2}[C_1^{VLL}\mathcal{O}_1 + C_1^{VRR}\widetilde{\mathcal{O}}_1 + C_4^{LR}\mathcal{O}_4 + C_4^{RL}\widetilde{\mathcal{O}}_4 + C_5^{LR}\mathcal{O}_5 + C_5^{RL}\widetilde{\mathcal{O}}_5].$$





$$\mathcal{O}_1 = (\bar{d}_L\gamma_\mu b_L)(\bar{d}_L\gamma^\mu s_L),$$
$$\mathcal{O}_4 = (\bar{d}_R b_L)(\bar{d}_L s_R),$$
$$\mathcal{O}_5 = (\bar{d}_R^\alpha b_L^\beta)(\bar{d}_L^\beta s_R^\alpha).$$

$$[C_1^{VLL}(M_{g^{(1)}})]^{\mathcal{G}^{(1)}} = 1/3 p_{\rm UV}{}^2 \Delta_L^{db}\Delta_L^{ds},$$
$$[C_1^{VRR}(M_{g^{(1)}})]^{\mathcal{G}^{(1)}} = 1/3 p_{\rm UV}{}^2 \Delta_R^{db}\Delta_R^{ds},$$
$$[C_4^{LR}(M_{g^{(1)}})]^{\mathcal{G}^{(1)}} = -p_{\rm UV}{}^2 \Delta_L^{db}\Delta_R^{ds},$$
$$[C_5^{LR}(M_{g^{(1)}})]^{\mathcal{G}^{(1)}} = 1/3 p_{\rm UV}{}^2 \Delta_L^{db}\Delta_R^{ds},$$
$$[C_4^{RL}(M_{g^{(1)}})]^{\mathcal{G}^{(1)}} = -p_{\rm UV}{}^2 \Delta_R^{db}\Delta_L^{ds},$$
$$[C_5^{RL}(M_{g^{(1)}})]^{\mathcal{G}^{(1)}} = 1/3 p_{\rm UV}{}^2 \Delta_R^{db}\Delta_L^{ds},$$

$$[\Delta C_1^{VLL}(M_{g^{(1)}})]^{A^{(1)}} = [\Delta_L^{db}(A^{(1)})][\Delta_L^{ds}(A^{(1)})],$$
$$[\Delta C_1^{VRR}(M_{g^{(1)}})]^{A^{(1)}} = [\Delta_R^{db}(A^{(1)})][\Delta_R^{ds}(A^{(1)})],$$
$$[\Delta C_5^{LR}(M_{g^{(1)}})]^{A^{(1)}} = -2[\Delta_L^{db}(A^{(1)})][\Delta_R^{ds}(A^{(1)})],$$
$$[\Delta C_5^{RL}(M_{g^{(1)}})]^{A^{(1)}} = -2[\Delta_R^{db}(A^{(1)})][\Delta_L^{ds}(A^{(1)})].$$

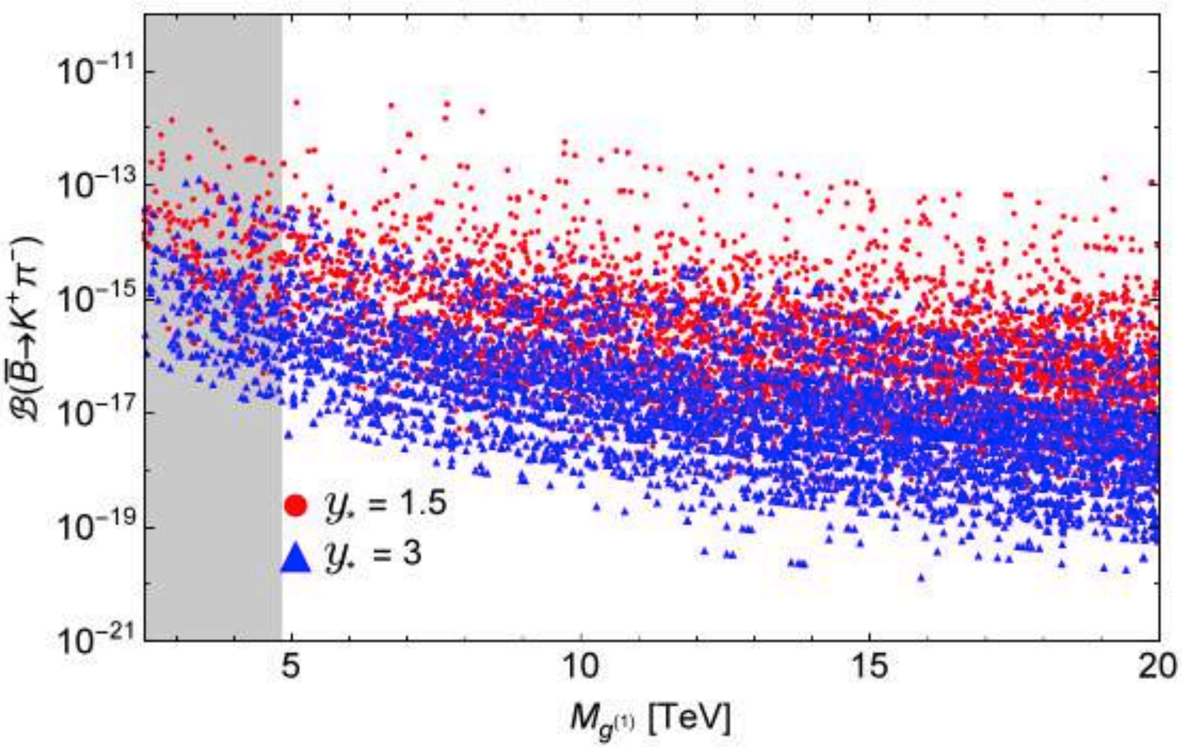
$$[\Delta C_1^{VLL}(M_{g^{(1)}})]^{Z_H,Z'} = [\Delta_L^{db}(Z^{(1)})\Delta_L^{ds}(Z^{(1)}) + \Delta_L^{db}(Z_X^{(1)})\Delta_L^{ds}(Z_X^{(1)})],$$
$$[\Delta C_1^{VRR}(M_{g^{(1)}})]^{Z_H,Z'} = [\Delta_R^{db}(Z^{(1)})\Delta_R^{ds}(Z^{(1)}) + \Delta_R^{db}(Z_X^{(1)})\Delta_R^{ds}(Z_X^{(1)})],$$
$$[\Delta C_5^{LR}(M_{g^{(1)}})]^{Z_H,Z'} = -2[\Delta_L^{db}(Z^{(1)})\Delta_R^{ds}(Z^{(1)}) + \Delta_L^{db}(Z_X^{(1)})\Delta_R^{ds}(Z_X^{(1)})],$$
$$[\Delta C_5^{RL}(M_{g^{(1)}})]^{Z_H,Z'} = -2[\Delta_R^{db}(Z^{(1)})\Delta_L^{ds}(Z^{(1)}) + \Delta_R^{db}(Z_X^{(1)})\Delta_L^{ds}(Z_X^{(1)})],$$

$$\mathcal{A} = \frac{1}{[M_{g^{(1)}}]^2}\Big[f_B\Big(F_a^{LL}\Big[\frac{4}{3}(C_1^{VLL}+C_1^{VRR})\Big] + F_a^{LR}\Big[\frac{4}{3}(C_5^{LR}+C_5^{RL})\Big] + F_a^{SP}\Big[\frac{4}{3}(C_4^{LR}+C_4^{RL})\Big]\Big)$$
$$+ \mathcal{M}_a^{LL}\Big[C_1^{VLL} - C_1^{VRR}\Big] + \mathcal{M}_a^{LR}\Big[C_5^{LR} - C_5^{RL}\Big] + \mathcal{M}_a^{SP}\Big[C_4^{LR} - C_4^{RL}\Big]\Big].$$

Branching ratio of $\overline{B}^0 \to K^+\pi^-$ decay in the RS$_c$ model

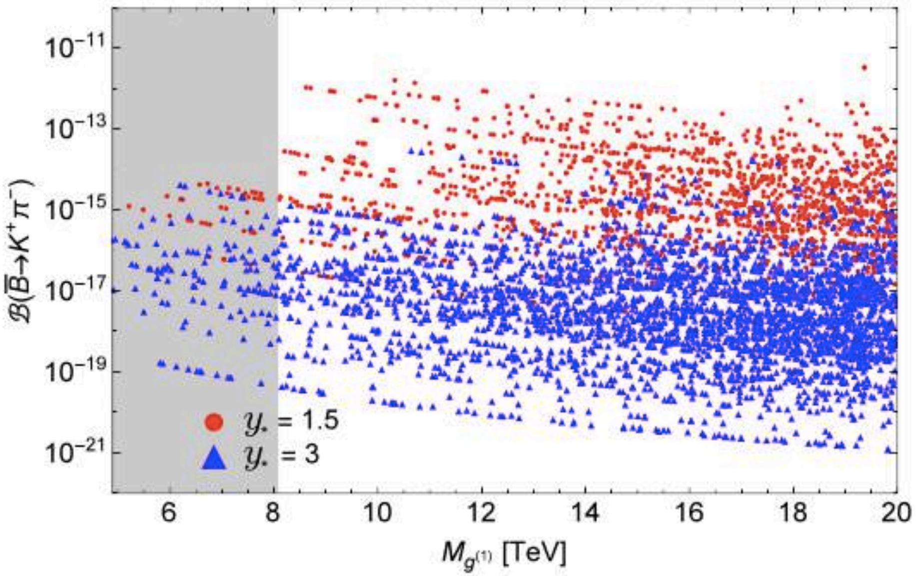
ΔM_K, ϵ_K and ΔM_{B_d} constraints

KK gluons dominant



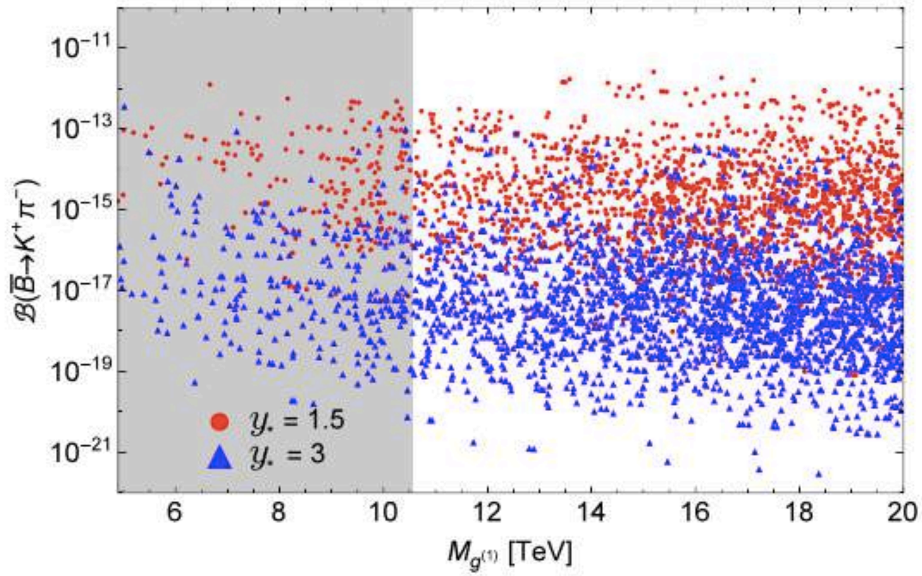
$B^0 \to K^+\pi^-$ Branching ratio in the bulk-Higgs RS model

broad Higgs profile



$\beta = 1$

narrow Higgs profile



$\beta = 10$

Summary

- **Flavor sector has only been tested at the 10% level and can be done much better**
- **The doubly weak decays of B meson is highly suppressed in the SM, which can serve as an ideal place for searching of new physics signals.**
- In the model independent analysis of $B^0 \to K^+\pi^-$ decay, it is possible to constrain the Wilson coefficients of different dimension-6 operators for a specific experimental precision.

Thanks !