$Understanding \quad B_s \to \mu\mu?$

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- naïve estimate
- BR calculation in SM & SUSY
- some example SUSY graphs

SM Bs decays

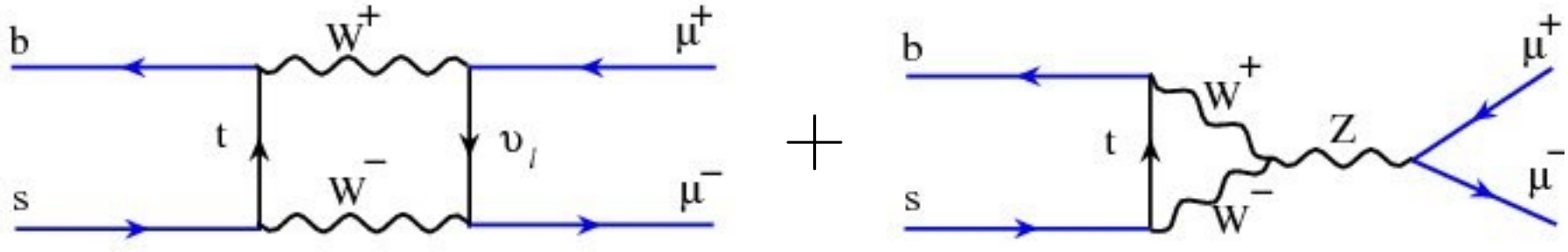
B_s^0 DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
D_s^- anything		(94 ±30) %		–
$D_s^- \ell^+ \nu_\ell$ anything	[a]	(7.9 ± 2.4) %		–
$D_s^- \pi^+$		< 13 %		2321
$D_s^{(*)+} D_s^{(*)-}$		(23 $^{+21}_{-13}$) %		–
$J/\psi(1S)\phi$		(9.3 ± 3.3) $\times 10^{-4}$		1588
$J/\psi(1S)\pi^0$		< 1.2 $\times 10^{-3}$	90%	1787
$J/\psi(1S)\eta$		< 3.8 $\times 10^{-3}$	90%	1734
•••				
$K^*(892)^- \rho^+$		< 7.67 $\times 10^{-3}$	90%	2550
$\overline{K}^*(892)^0 K^*(892)^0$		< 1.681 $\times 10^{-3}$	90%	2531
$\phi K^*(892)^0$		< 1.013 $\times 10^{-3}$	90%	2507
$p\overline{p}$		< 5.9 $\times 10^{-5}$	90%	2514
$\gamma\gamma$	*B1*	< 1.48 $\times 10^{-4}$	90%	2684
$\phi\gamma$		< 1.2 $\times 10^{-4}$	90%	2587
Lepton Family number (*LF*) violating modes or $\Delta B \equiv 1$ weak neutral current (*B1*) modes				
$\mu^+\mu^-$	*B1*	< 1.5 $\times 10^{-7}$	90%	2682
e^+e^-	*B1*	< 5.4 $\times 10^{-5}$	90%	2684
$e^\pm\mu^\mp$	*LF*	[b] < 6.1 $\times 10^{-6}$	90%	2683
$\phi(1020)\mu^+\mu^-$	*B1*	< 4.7 $\times 10^{-5}$	90%	2582
$\phi\nu\overline{\nu}$	*B1*	< 5.4 $\times 10^{-3}$	90%	2587

PDG 06

$SM : 3.42 \cdot 10^{-9}$

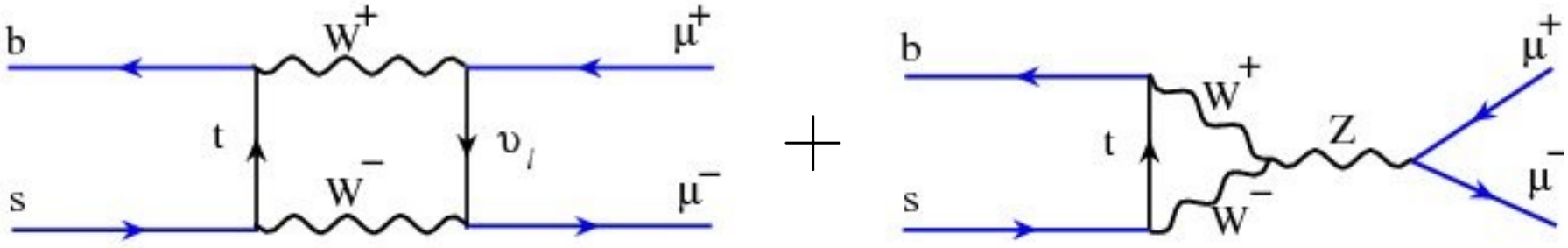
why so small?

SM FCNC: Bs --> mu mu



$$|\frac{M_{fi}(B_s \to \mu\mu)}{M_{fi}(B_s \to D^- X)}|^2 \propto \frac{\alpha^4}{\alpha^2} * propagator * helicity * \frac{|V_{tb}V_{ts}|}{|V_{ud}V_{cb}|}$$

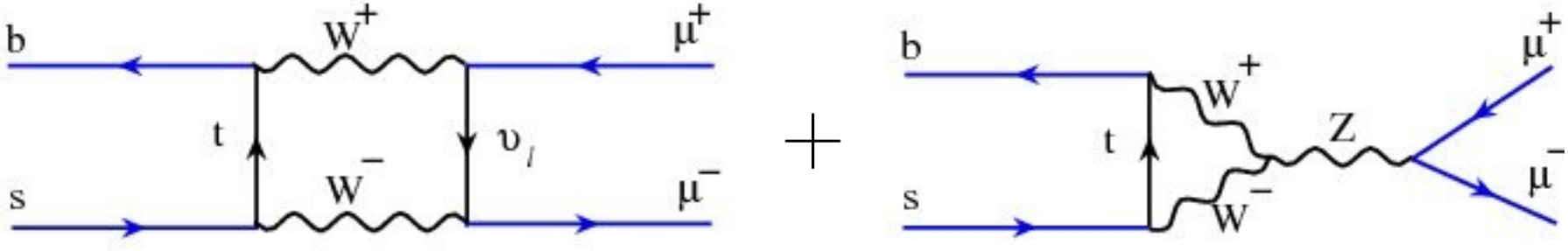
SM FCNC: Bs --> mu mu



$$\left|\frac{M_{fi}(B_s \to \mu\mu)}{M_{fi}(B_s \to D^- X)}\right|^2 \propto \frac{\alpha^4}{\alpha^2} * propagator * helicity * \frac{|V_{tb}V_{ts}|}{|V_{ud}V_{cb}|}$$

$$\propto \frac{m_t^2}{m_W^2} \approx 1$$

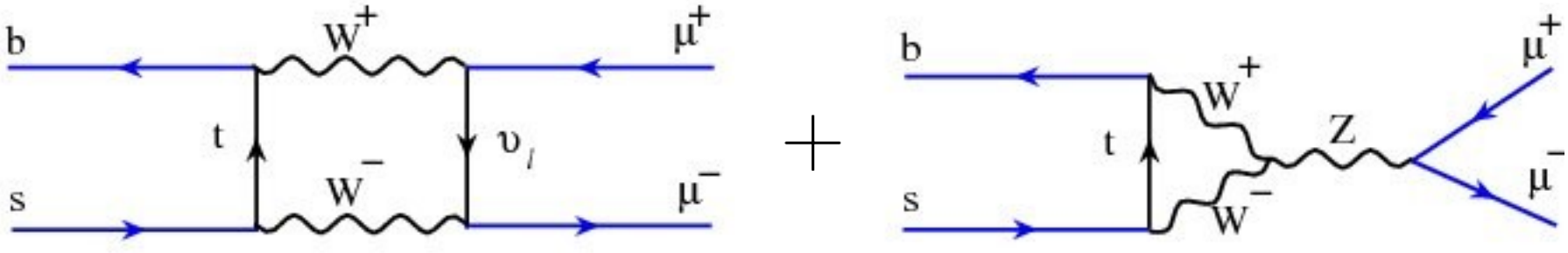
SM FCNC: Bs --> mu mu



$$|\frac{M_{fi}(B_s \to \mu\mu)}{M_{fi}(B_s \to D^- X)}|^2 \propto \frac{\alpha^4}{\alpha^2} * propagator * helicity * \frac{|V_{tb}V_{ts}|}{|V_{ud}V_{cb}|}$$

$$\propto (\frac{m_\mu}{m_B})^2 \approx 4 \cdot 10^{-4}$$

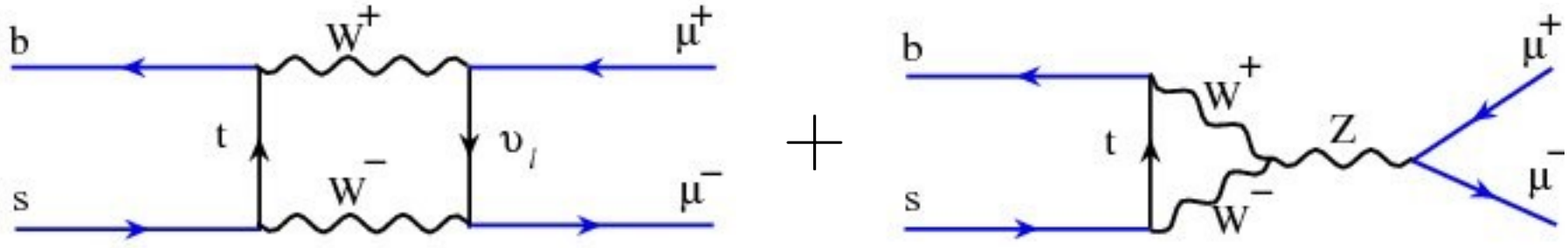
SM FCNC: Bs --> mu mu



$$\left|\frac{M_{fi}(B_s \to \mu\mu)}{M_{fi}(B_s \to D^- X)}\right|^2 \propto \frac{\alpha^4}{\alpha^2} * propagator * helicity * \frac{|V_{tb}V_{ts}|}{|V_{ud}V_{cb}|}$$

$$\approx 1$$

SM FCNC: Bs --> mu mu

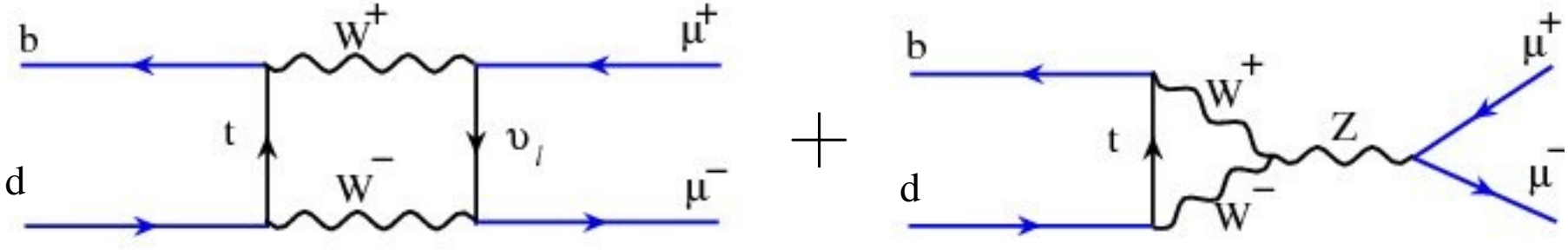


$$|\frac{M_{fi}(B_s \to \mu\mu)}{M_{fi}(B_s \to D^- X)}|^2 \propto \frac{\alpha^4}{\alpha^2} * propagator * helicity * \frac{|V_{tb}V_{ts}|}{|V_{ud}V_{cb}|}$$

$$\approx 6 \cdot 10^{-5} * 1 * 10^{-4} * 1$$

$$\approx 10^{-9}$$

SM FCNC: Bd --> mu mu



$$\left|\frac{M_{fi}(B_d \to \mu\mu)}{M_{fi}(B_d \to D^* X)}\right|^2 \propto \frac{\alpha^4}{\alpha^2} * propagator * helicity * \left|\frac{V_{tb}V_{td}}{V_{ud}V_{cb}}\right|^2$$

$$\approx 10^{-10}$$

$$\approx 1 \cdot 10^{-2}$$

Calculate BR(Bs -> mumu): SM

$$\mathcal{B}(B_s \to \mu^+\mu^-) =$$

$$6.0 \cdot 10^{-7} \left(\frac{|V_{ts}|}{0.040}\right)^2 \left(\frac{f_{B_s}}{230\,\mathrm{MeV}}\right)^2 \frac{m_\mu^2}{m_{B_s}^2} \sqrt{1 - \frac{4m_\mu^2}{m_{B_s}^2}}$$

$$\left\{ \left(1 - \frac{4m_\mu^2}{M_{B_s}^2}\right) \left| \frac{m_{B_s}^2 C_S}{m_\mu} \right|^2 + \left| \frac{m_{B_s}^2 C_P}{m_\mu} - 2C_A \right|^2 \right\}. \qquad (1)$$

$$within \quad StandardModel : C_S, C_P \approx 0 \quad and \quad C_A \approx 1$$

$$\mathfrak{B}(B_s \to \mu\mu) \approx 3.42 \cdot 10^{-9}$$

hadronic uncertainty dominates: $\sigma(f_B) \sim 25\%$

Calculate BR(Bs -> mumu): SUSY

$$\mathcal{B}(B_s \to \mu^+\mu^-) =$$

$$6.0 \cdot 10^{-7} \left(\frac{|V_{ts}|}{0.040}\right)^2 \left(\frac{f_{B_s}}{230\,\mathrm{MeV}}\right)^2 \frac{m_\mu^2}{m_{B_s}^2} \sqrt{1 - \frac{4m_\mu^2}{m_{B_s}^2}}$$

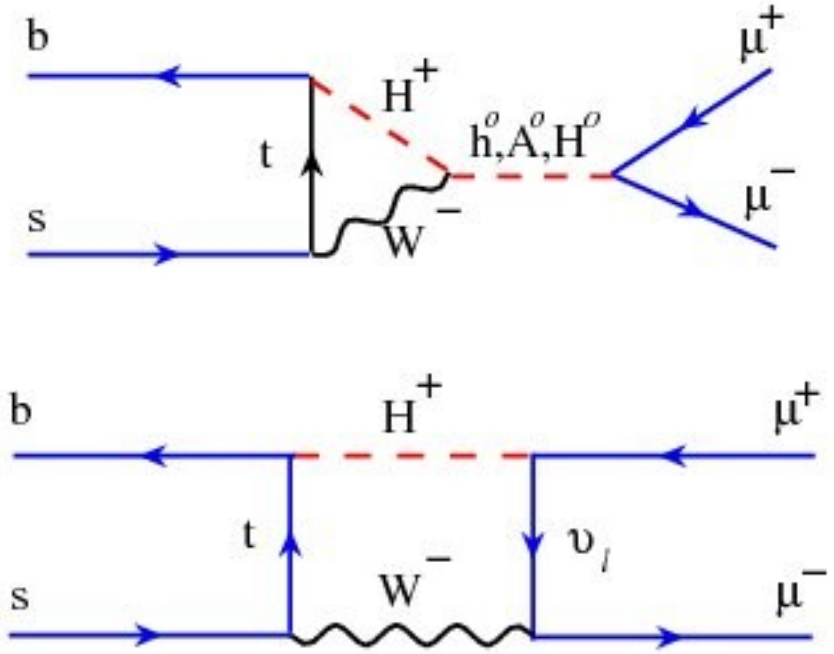
$$\left\{ \left(1 - \frac{4m_\mu^2}{M_{B_s}^2}\right) \left| \frac{m_{B_s}^2 C_S}{m_\mu} \right|^2 + \left| \frac{m_{B_s}^2 C_P}{m_\mu} - 2C_A \right|^2 \right\}. \qquad (1)$$

$$with A_0 \approx 0 \quad and M_0, M_{1/2} \lesssim 500 GeV$$

$$\mathfrak{B}(B_s \to \mu\mu) \approx \frac{10^{-6} \cdot tan^6\beta \cdot M_{1/2}^2 \cdot GeV^4}{(M_{1/2}^2 + M_0^2)^3}$$

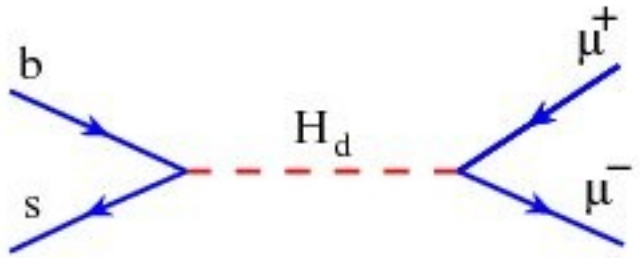
Example SUSY Feynman Graphs I

- **SUSY model: 2 Higgs doublets:**
  - **graphs as SM with different propagators**



Example SUSY Feynman Graphs II

- **SUSY model: Flavor changing Higgs**



- **R parity violation:**
  - **Bd not necessarily suppressed**