Introduction

• In the Standard Model, the FCNC decay of $B \rightarrow \mu^+\mu^-$ is heavily suppressed

$$BR(B_s \rightarrow \mu^+\mu^-) = (3.5 \pm 0.9) \times 10^{-9}$$


• $B_d \rightarrow \mu\mu$ is further suppressed by CKM coupling $(v_{td}/v_{ts})^2$

• SM prediction is below the sensitivity of current experiments (CDF+D0): SM → Expect to see 0 events at the Tevatron

Any signal would indicate new physics!!

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BEYOND STANDARD MODEL

• In many SUSY models, the BR could be enhanced by many orders of magnitude:

For example:
- MSSM: $\text{Br}(B \rightarrow \mu \mu)$ is proportional to $\tan^6 \beta$
- $\text{Br}(B \rightarrow \mu \mu)$ also enhanced at high $\tan \beta$ in GUT SO(10) models

  – BR could be as large as 10-1000 times the SM prediction

Would be observable at the Tevatron
• Another example: R-Parity violating SUSY

- Tree level diagram is allowed in R-parity violating (RPV) SUSY models.

- Possible to observe decay even for low value of $\tan\beta$

- Enhancement depends strongly on coupling constants ($\lambda, \lambda'$)

Would also be observable at the Tevatron
PROBE OF NEW PHYSICS

• New physics may enhance Bs and Bd→μμ differently

• Minimal-flavor-violation (MFV) assumption in SUSY yields SM relations between Bs and Bd→μμ decays

• Can observe both Bs and Bd: unique to Tevatron

• CDF has the mass resolution to distinguish two decays, σ(Mμμ)~23MeV: unique to CDF

• Either observation or null search, results will provide important clues about possible scenarios of new physics beyond SM
Limits Summary

Bs: we observed 0 events which yields a combined limit of:
- \( 1.6 \times 10^{-7} \) at 90% CL
- \( 2.1 \times 10^{-7} \) at 95% CL

Bd: we observed 0 events which yields a combined limit of:
- \( 3.9 \times 10^{-8} \) at 90% CL
- \( 5.1 \times 10^{-8} \) at 95% CL

\[
\begin{align*}
\text{Br}(\text{Bs} \rightarrow \mu \mu) &< 4.1 \times 10^{-7} \text{ @ 90}\% \text{ CL} ; \quad \text{D0 PRL 94 (2005) 042001} \\
\text{Br}(\text{Bs} \rightarrow \mu \mu) &< 5.8 \times 10^{-7} \text{ @ 90}\% \text{ CL} ; \quad \text{CDF PRL 93 (2003) 032001} \\
\text{Br}(\text{Bd} \rightarrow \mu \mu) &< 3.0 \times 10^{-7} \text{ @ 90}\% \text{ CL} ; \quad \text{D0 Preliminary 4733} \\
\text{Br}(\text{Bd} \rightarrow \mu \mu) &< 8.0 \times 10^{-8} \text{ @ 90}\% \text{ CL} ; \quad \text{(BaBar PRL 94 (2005) 221803)}
\end{align*}
\]

Both CDF Bs and Bd results are x2 better than the best published result!!!
RPV SUSY EXCLUSION

B. Dutta, U. Regina

- Possible to exclude phase space even for small $\tan(\beta)$
- Exclusion strongly depends on the coupling.

\[ A_0 = 0, \mu > 0, \tan(\beta) = 10 \]
\[ \text{Br}[B^0_d \to \mu^+ \mu^-] = 2.1 \times 10^{-7} \]
- We are beginning to carve into mSUGRA space
- For $m_h \sim 115$GeV implies $10^{-8} < \text{Br}(B_s \rightarrow \mu \mu) < 3 \times 10^{-7}$

Solid red = excluded by theory or experiment
Dashed red line = light Higgs mass ($m_h$)
Dashed green line = $(\delta a_\mu)_{\text{susy}}$ (in units of $10^{-10}$)
Black line = Br($B_s \rightarrow \mu \mu$)
• We are beginning to carve into mSUGRA space

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SO(10) Unification Model

- \( \tan(\beta) \approx 50 \) constrained by unification of Yukawa coupling
- White region is not excluded
- Unification valid for small \( M_{1/2} \) (~500GeV)

Red regions are excluded by either theory or experiments
Green region is the WMAP preferred region
Blue dashed line is the \( \text{Br}(B_s \rightarrow \mu\mu) \) contour
Light blue region excluded by old \( B_s \rightarrow \mu\mu \) analysis

\[ \Omega \chi^2 > 0.13 \]
\[ m_\chi^+ < 10^4 \text{GeV} \]
\[ m_\chi^- < 104 \text{GeV} \]
\[ m_h < 111 \text{GeV} \]
SO(10) Unification Model

- $\tan(\beta) \approx 50$ constrained by unification of Yukawa coupling
- All previously allowed regions (white) are excluded by this new measurement
- Unification valid for small $M_{1/2}$ ($\sim 500 \text{ GeV}$)
- New $\text{Br}(B_s \rightarrow \mu\mu)$ limit strongly disfavors this solution for $m_A = 500 \text{ GeV}$

Red regions are excluded by either theory or experiments
Green region is the WMAP preferred region
Blue dashed line is the $\text{Br}(B_s \rightarrow \mu\mu)$ contour
Light blue region excluded by old $B_s \rightarrow \mu\mu$ analysis

Excluded by this new result
**Bs→μμ Limit Projection**

- Extrapolate based on the current analysis which was optimized for 1/fb
- Assume background scales linearly with luminosity
- Will need to re-optimize the analysis for > 3/fb

CDF Projection
\[ \text{BR}(B_s \rightarrow \mu^+ \mu^-) \]

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