Table 1: Branching fraction upper limits @90% confidence level for $B_s \to \mu^+\mu^-$ from different experiments

Experiment	**Year**	**Limit** $[10^{-9}]$	Process	**Reference**
D0	2007	75	$p\bar{p}$ at 1.96 TeV	[4]
CDF	2006	80	$p\bar{p}$ at 1.96 TeV	[5]
CDF	2005	150	$p\bar{p}$ at 1.96 TeV	[6]
D0	2005	410	$p\bar{p}$ at 1.96 TeV	[7]
CDF	2004	580	$p\bar{p}$ at 1.96 TeV	[8]
CDF	1998	2,000	$p\bar{p}$ at 1.8 TeV	[11]
L3	1997	38,000	$e^+e^- \to Z$	[13]

1 Present Experimental Status of $B \to \ell^+\ell^-$ Decays

The decays $B^0_{d(s)} \to \ell^+\ell^-$ proceed via weak penguin loop and box diagram processes, where the dileptons are e^+e^-, $\mu^+\mu^-$, and $\tau^+\tau^-$. In the Standard Model these processes are helicity suppressed. Thus, decay rates are proportional to the lepton mass squared. They receive an additional suppression from the electromagnetic coupling and the B decay constant, both entering squared resulting in tiny branching fractions. For example, for $B_s \to \mu^+\mu^-$ the Standard Model prediction yields $\mathcal{B}(B^0_s \to \mu^+\mu^-) = (3.35 \pm 0.32) \times 10^{-9}$ [1]. The corresponding B_d decays are further suppressed by $\mid V_{td}/V_{ts} \mid^2$, yielding $\mathcal{B}(B^0_d \to \mu^+\mu^-) = (0.103 \pm 0.009) \times 10^{-9}$ [1]. In physics beyond the Standard Model, scalar and pseudoscalar interactions yields additional contributions that may increase the branching fractions by one to three orders of magnitude [2]. These interactions would also contribute to $B \to K\ell^+\ell^-$.

Experimentally, the searches focus on $B^0_s \to \mu^+\mu^-$ and $B^0_d \to \mu^+\mu^-$. For the e^+e^- final states, the branching fractions are suppressed with respect to $\mathcal{B}(B \to \mu^+\mu^-)$ by $m_e^2/m_\mu^2 = 2.3 \times 10^{-5}$. Experimentally, the best limit has been set by BABAR yielding $\mathcal{B}(B \to e^+e^-) < 61 \times 10^{-9}$ @ 90% confidence level (CL) [3]. Though the branching fraction of the $\tau^+\tau^-$ mode is enhanced by a factor of 28 with respect to that of the $\mu^+\mu^-$ mode, no experiment has reported any search so far. Due to at least two missing neutrinos in the decays of the two τs the reconstruction of this mode is rather difficult, since no kinematic constraint can be employed to eliminate backgrounds. At an e^+e^- super B factory the $B^0_d \to \tau^+\tau^-$ mode may be observable by reconstructing one B meson fully in a hadronic mode and then searching for $B^0_d \to \tau^+\tau^-$ in the recoil.

Thus, $B^0_{d(s)} \to \mu^+\mu^-$ are the most promising modes to test the Standard Model. Table 1 summarizes the searches for $B^0_s \to \mu^+\mu^-$ by different experiments in the past two decades. The 90% CL upper limits in comparison to the SM prediction are shown in Figure 1. The lowest limit of $\mathcal{B}(B^0_s \to \mu^+\mu^-) < 93\times10^{-9}$ @ 95% CL is obtained by the D0 experiment using about2 fb^{-1} of $p\bar{p}$ data [4]. Using 780 pb^{-1} of $p\bar{p}$ data CDF achieved an upper limit branching fraction of $\mathcal{B}(B^0_s \to \mu^+\mu^-) < 100 \times 10^{-9}$ @ 95% CL [5]. The corresponding searches for $B^0_d \to \mu^+\mu^-$ are summarized in table 2. Here, the lowest limit of $\mathcal{B}(B^0_d \to \mu^+\mu^-) < 30 \times 10^{-9}$ @ 95% CL is obtained by the CDF experiment using 780 pb^{-1} of $p\bar{p}$ data [5]. The 90% CL upper limits in comparison to the SM prediction are shown in Figure 2. Figures 1 and 2 indicate that the B^0_s mode is the most promising one to find at the LHC.

Since the present branching fraction upper limit @ 90% CL for $B^0_s \to \mu^+\mu^-$ is about a factor of 20 above the SM prediction, the CDF background level needs to be reduced significantly to achieve an experimental sensitivity for branching fractions of the order of 10^{-9}. In an earlier study for the run II performance CDF presented sensitivities of $S(B^0_d \to \mu^+\mu^- = 3.5 \times 10^{-9} \times (2\mathrm{fb}^{-1}/\int \mathcal{L}\mathrm{dt})$ and $S(B^0_s \to \mu^+\mu^- = 10 \times 10^{-9} \times (2\mathrm{fb}^{-1}/\int \mathcal{L}\mathrm{dt})$ [19]. These extrapolations are slightly optimistic compared to the limits obtained for 780 fb^{-1}. Using the present limit and just scaling it to 10 fb^{-1}, yields sensitivities of 6.2×10^{-9} for the B^0_s and 1.8×10^{-9} for the B^0_d. For BABARa simply scaling to 1 ab^{-1} yields 9×10^{-9}.

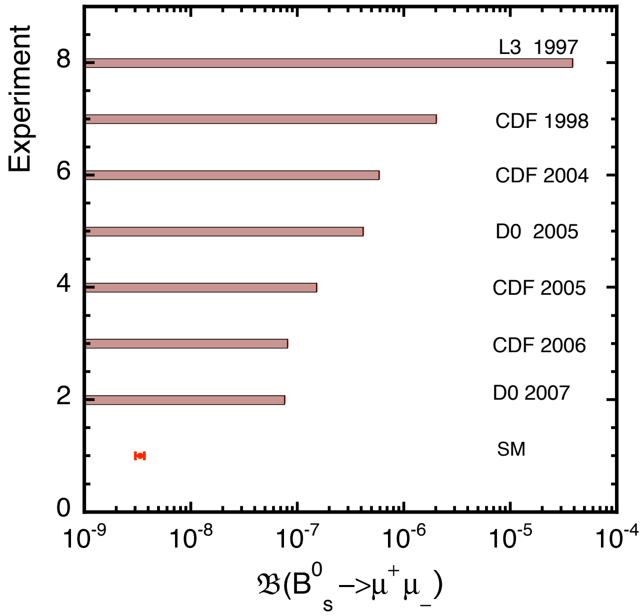

Fig. 1: Compilation of 90% confidence level upper limits for $\mathcal{B}(B_s^0 \to \mu^+\mu^-)$ from different experiments in comparison to the SM prediction.

Table 2: Branching fraction upper limits @90% confidence level for $B_d \to \mu^+\mu^-$ from different experiments

Experiment	**Year**	**Limit** $[10^{-9}]$	Process	**Reference**
CDF	2006	23	$p\bar{p}$ at 1.96 TeV	[5]
CDF	2005	39	$p\bar{p}$ at 1.96 TeV	[6]
BaBar	2005	83	$e^+e^- \to \Upsilon(4S)$	[3]
CDF	2004	150	$p\bar{p}$ at 1.96 TeV	[8]
Belle	2003	160	$e^+e^- \to \Upsilon(4S)$	[9]
CLEO	2000	610	$e^+e^- \to \Upsilon(4S)$	[10]
CDF	1998	680	$p\bar{p}$ at 1.8 TeV	[11]
D0	1998	40,000	$p\bar{p}$ at 1.8 TeV	[12]
L3	1997	10,000	$e^+e^- \to Z$	[13]
CLEO	1994	5,900	$e^+e^- \to \Upsilon(4S)$	[14]
UA1	1991	8,300	$p\bar{p}$ at 630 GeV	[15]
CLEO	1989	43,000	$e^+e^- \to \Upsilon(4S)$	[16]
ARGUS	1987	45,000	$e^+e^- \to \Upsilon(4S)$	[17]
CLEO	1987	77,000	$e^+e^- \to \Upsilon(4S)$	[18]

References

[1] M. Blanke et al., JHEP 0610, 003 (2006); A.J.Buras, Phys.Lett. B566, 115 (2003).

[2] A. J. Buras et al., Nucl. Phys. B 619, 434 (2001); Phys. Lett. B 546, 96 (2002); Nucl. Phys. B 659, 3 (2003); G. Isidori and A. Retico, JHEP 0111, 001 (2001); G. DÕAmbrosio et al., Nucl. Phys. B 645, 155 (2002); M. Carena et al., Phys. Rev. D 74, 015009 (2006).G. Isidori and P. Paradisi, Phys. Lett. B 639, 499 (2006); E. Lunghi, W. Porod and O. Vives, Phys. Rev. D 74, 075003 (2006); C. Hamzaoui, M. Pospelov and M. Toharia, Phys. Rev. D 59, 095005 (1999); C. S. Huang et al., Phys. Rev. D 63, 114021 (2001) [Erratum-ibid. D 64, 059902 (2001)]; P. H. Chankowski and L. Slawianowska, Phys. Rev. D 63, 054012 (2001); C. Bobeth et al., Phys. Rev. D 64, 074014 (2001); A. Dedes, H. K.

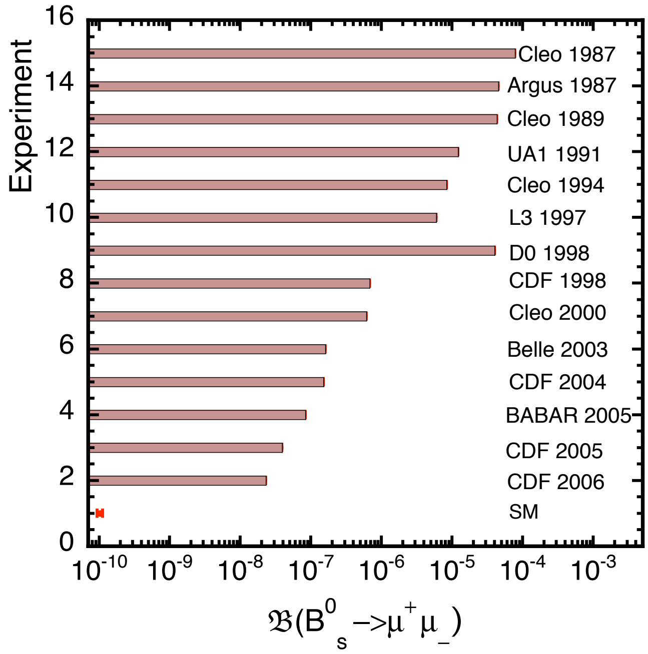

Fig. 2: Compilation of 90% confidence level upper limits for $\mathcal{B}(B^0_d \to \mu^+\mu^-)$ from different experiments in comparison to the SM prediction.

Dreiner and U. Nierste, Phys. Rev. Lett. 87, 251804 (2001); A. Dedes and A. Pilaftsis, Phys. Rev. D 67, 015012 (2003); J. Foster, K. i. Okumura and L. Roszkowski, Phys. Lett. B 609, 102 (2005); JHEP 0508, 094 (2005); Phys. Lett. B 641, 452 (2006), J.R. Ellis et al., JHEP 0605, 063 (2006). [15] R. Barbieri and M. Frigeni, Phys. Lett. B 258, 395

[3] B. Aubert et al. (BABAR Collab.), Phys.Rev.Lett. 94, 221803 (2005).

[4] V.M. Abazov et al. (D0 Collab.), http://www-d0.fnal.gov/Run2Physics/WWW/results/b.htm

[5] A. Abulencia et al. (CDF collaboration), Note 8176, www-cdf.fnal.gov/physics/new/bottom/060316.blessed-bsmumu3; R.P. Bernhard, FERMILAB-CONF-06-110-E, hep-ex/0605065 (2006).

[6] A. Abulencia et al. (CDF collaboration), Phys.Rev.Lett. 95, 221805 (2005).

[7] V.M. Abazov et al. (D0 Collab.), Phys.Rev.Lett. 94, 071802 (2005).

[8] D. Acosta et al. (CDF Collab.), Phys.Rev.Lett. 93, 032001(2004).

[9] M.-C. Chang et al. (BELLE Collab.), Phys.Rev. D68 111101R (2003).

[10] T. Bergfeld et al. (CLEO Collab.), Phys.Rev. D62 091102R (2000).

[11] F. Abe et al. (CDF Collab.), Phys.Rev. D57 R3811 (1998).

[12] B. Abbott et al. (D0 Collab.), Phys.Lett. B423, 419 (1998).

[13] M. Acciarri et al. (L3 Collab.), Phys.Lett. B391, 474 (1997).

[14] R. Ammar et al. (CLEO Collab.), Phys.Rev. D49, 5701(1994).

[15] C. Albajar et al. (UA1 Collab.), Phys.Lett. B262, 163 (1991).

[16] P. Avery et al. (CLEO Collab.), Phys.Lett. B223, 470 (1989).

[17] H. Albrecht et al. (ARGUS Collab.), Phys.Lett. B199, 451 (1987).

[18] P. Avery et al. (CLEO Collab.), Phys.Lett. B183, 429 (1987).

[19] K. Anikeev et al., 583 pp, hep-ph/0201071 (2002).