Heavy Flavor Averaging Group - October 2016

Compilation of B_s^0 Branching Fractions ($\times 10^{-6}$) - UL at 90% CL

In PDG2014 New since PDG2014 (preliminary) New since PDG2014 (published)

RPP#	Mode	PDG2014 Avg.	Belle	CDF	D0	LHCb	CMS	ATLAS	Our Avg.
45	$\pi^+\pi^-$	0.76 ± 0.19	< 12	$0.60 \pm 0.17 \pm 0.04$ ‡		$0.691 \pm 0.083 \pm 0.044$ ‡			0.671 ± 0.083
51	$\phi\phi$	19.1 ± 3.1		$19.1 \pm 2.6 \pm 1.6$ ‡		$18.4 \pm 0.5 \pm 1.8$ *			18.6 ± 1.6
52	π^+K^-	5.5 ± 0.6	< 26	$5.3 \pm 0.9 \pm 0.3$ ‡		$5.6 \pm 0.6 \pm 0.3$ ‡			5.5 ± 0.5
53	K^+K^-	24.9 ± 1.7	$38^{+10}_{-9} \pm 7$	$25.9 \pm 2.2 \pm 1.7$ ‡		$23.7 \pm 1.6 \pm 1.5$ ‡			24.8 ± 1.7
54	$K^0\overline{K}^0$	< 66	$19.6^{+5.8}_{-5.1} \pm 1.0 \pm 2.0$ ◇						$19.6^{+9.7}_{-9.3}$
55	$K^0\pi^+\pi^-$	19 ± 5				$19 \pm 5 \pm 2$ ‡			19 ± 5
56	$K^0K^-\pi^+$ ¶	97 ± 17				$97 \pm 12 \pm 12$ ‡			97 ± 16
57	$K^0K^+K^-$	< 4				< 4 ‡			< 4 ‡
–	$K^{*\pm}K^{\mp}$	New				$12.7 \pm 1.9 \pm 1.9$ †			12.7 ± 2.7
–	$K^{*-}\pi^+$	New				$3.3 \pm 1.1 \pm 0.5$ †			3.3 ± 1.2
59	$K^{*0}\overline{K}^{*0}$	$28.1 \pm 4.6 \pm 5.6$				$10.8 \pm 1.4 \pm 1.5$ *†			10.8 ± 2.1
60	$\phi\overline{K}^{*0}$	1.13 ± 0.3				$1.13 \pm 0.29 \pm 0.06$ ‡			1.13 ± 0.30
61	$p\overline{p}$	$0.028^{+0.022}_{-0.017}$				$0.0284^{+0.0203+0.0085}_{-0.0168-0.0018}$ †			$0.0280^{+0.0220}_{-0.0170}$
63	$\gamma\gamma$	< 8.7	< 3.1						< 3.1
64	$\phi\gamma$	36 ± 4	$36 \pm 5 \pm 7$			$35.1 \pm 3.5 \pm 1.2$ ‡			35.2 ± 3.4
65	$\mu^+\mu^-$	0.0031 ± 0.0007		$0.013^{+0.009}_{-0.007}$ †	< 0.012 †	$0.0029^{+0.0011+0.0003}_{-0.0010-0.0001}$	$0.0030^{+0.0010}_{-0.0009}$	< 0.003 †1	$0.0029^{+0.0007}_{-0.0006}$ 3
66	e^+e^-	< 0.28		< 0.28					< 0.28
67	$e^\pm\mu^\mp$	< 0.011		< 0.20		< 0.011 †			< 0.011 †
68	$\mu^+\mu^-\mu^+\mu^-$	< 0.012				< 0.012			< 0.012
70	$\phi\mu^+\mu^-$	0.76 ± 0.15			< 3.2 †	$0.797^{+0.045}_{-0.043} \pm 0.068$ †			$0.797^{+0.082}_{-0.080}$
	$\eta'\eta'$					$33.1 \pm 7.0 \pm 1.2$ ‡			33.1 ± 7.1
	$\pi^+\pi^-\mu^+\mu^-$					$0.086 \pm 0.015 \pm 0.010$ 2			0.086 ± 0.018
	$K^0\overline{K}^{*0}$ ¶					$16.4 \pm 3.4 \pm 2.3$ †			16.4 ± 4.1
	$\phi\pi^+\pi^-$					$3.48 \pm 0.29 \pm 0.35$ 4†			3.48 ± 0.46
	$\phi f_0(980), f_0(980) \to \pi^+\pi^-$					$1.12 \pm 0.18 \pm 0.11$†			1.12 ± 0.21
	$\phi f_2(1270), f_2(1270) \to \pi^+\pi^-$					$0.61^{+0.18}_{-0.14} \pm 0.06$†			$0.61^{+0.19}_{-0.15}$
	$\phi\rho^0(770)$					$0.27 \pm 0.07 \pm 0.02$†			0.27 ± 0.07

‡ The first error is experimental, the second is from reference BF.

† Relative BF converted to absolute BF.

¶ Sum of charge conjugate states.

* Last error takes into account $BF(B^0 \to \phi K^{*0})$ and $\frac{f_d}{f_s}$

◇ Last error represents the uncertainty due to the total number of $B_s^0\bar{B}_s^0$ pairs.

1 Limit at 95% C.L

2 Muon pairs do not originate from resonances and $0.5 < m(\pi^+\pi-) < 1.3$ GeV/c.

3 The average is done between the combined LHCb and CMS result, $0.0028^{+0.0007}_{-0.0006}$ (Ref. [45]) and CDF.

4 In the mass range $400 < m(\pi^+\pi^-) < 1600$ GeV/c.

Heavy Flavor Averaging Group - October 2016

Compilation of B_s^0 Relative Branching Fractions

In PDG2014 New since PDG2014 (preliminary) New since PDG2014 (published)

RPP#	Mode	PDG2014 Avg.	CDF	LHCb	Our Avg.
45	$f_s\mathcal{B}(B_s^0 \to \pi^+\pi^-)/f_d\mathcal{B}(B^0 \to K^+\pi^-)$		$0.008 \pm 0.002 \pm 0.001$	$(9.15 \pm 0.71 \pm 0.83) \times 10^{-3}$	0.008 ± 0.002
45	$f_s\mathcal{B}(B_s^0 \to \pi^+\pi^-)/f_d\mathcal{B}(B^0 \to \pi^+\pi^-)$			$0.050^{+0.011}_{-0.009} \pm 0.004$	$0.050^{+0.012}_{-0.010}$
51	$\mathcal{B}(B_s^0 \to \phi\phi)/\mathcal{B}(B_s^0 \to J/\psi\phi)$		$0.0178 \pm 0.0014 \pm 0.0020$		0.0180 ± 0.0020
	$\mathcal{B}(B_s^0 \to \phi\phi)/\mathcal{B}(B^0 \to \phi K^*)$			$1.84 \pm 0.05 \pm 0.13$	1.84 ± 0.14
52	$f_s\mathcal{B}(B_s^0 \to K^+\pi^-)/f_d\mathcal{B}(B_d^0 \to K^+\pi^-)$		$0.071 \pm 0.010 \pm 0.007$	$0.074 \pm 0.006 \pm 0.006$	0.073 ± 0.007
53	$f_s\mathcal{B}(B_s^0 \to K^+K^-)/f_d\mathcal{B}(B_d^0 \to K^+\pi^-)$		$0.347 \pm 0.020 \pm 0.021$	$0.316 \pm 0.009 \pm 0.019$	0.327 ± 0.017
55	$f_s\mathcal{B}(B_s^0 \to K^0\pi^+\pi^-)/f_d\mathcal{B}(B^0 \to K^0\pi^+\pi^-)$			$0.29 \pm 0.06 \pm 0.04$	0.29 ± 0.07
56	$f_s\mathcal{B}(B_s^0 \to K^0K^-\pi^+)/f_d\mathcal{B}(B^0 \to K^0K^-\pi^+)$ ¶			$1.48 \pm 0.12 \pm 0.14$	1.48 ± 0.18
57	$f_s\mathcal{B}(B_s^0 \to K^0K^+K^-)/f_d\mathcal{B}(B^0 \to K^0K^+K^-)$			< 0.068	< 0.068
–	$\mathcal{B}(B_s^0 \to K^{*-}K^+)/\mathcal{B}(B^0 \to K^{*+}\pi^-)$	New		$1.49 \pm 0.22 \pm 0.18$	1.49 ± 0.28
–	$\mathcal{B}(B_s^0 \to K^{*-}\pi^+)/\mathcal{B}(B^0 \to K^{*+}\pi^-)$	New		$0.39 \pm 0.13 \pm 0.05$	0.39 ± 0.14
59	$\mathcal{B}(B_s^0 \to K^{*0}\overline{K}^{*0})/\mathcal{B}(B^0 \to K^{*+}\pi^-)$	New		$1.11 \pm 0.22 \pm 0.13$	1.11 ± 0.26
60	$\mathcal{B}(B_s^0 \to \phi\overline{K}^{*0})/\mathcal{B}(B^0 \to \phi K^{*0})$			$0.113 \pm 0.024 \pm 0.016$	0.113 ± 0.029
64	$\mathcal{B}(B_s^0 \to \phi\gamma)/\mathcal{B}(B^0 \to K^{*0}\gamma)$			$0.81 \pm 0.04 \pm 0.07$	0.81 ± 0.08
70	$\mathcal{B}(B_s^0 \to \phi\mu^+\mu^-)/\mathcal{B}(B_s^0 \to J/\psi\phi) \times 10^4$	7.1 ± 1.3		$7.41^{+0.42}_{-0.40} \pm 0.29$	$7.41^{+0.51}_{-0.49}$
–	$\mathcal{B}(B_s^0 \to K_S^0K^{*0})/\mathcal{B}(B^0 \to K_S^0\pi^+\pi^-)$			$0.33 \pm 0.07 \pm 0.04^\dagger$	0.33 ± 0.08

¶ Sum of charge conjugate states in the numerator.

† Sum of charge conjugate states in the numerator and denominator.

Charmless B_s^0 Decays: CDF References

[1] CDF Collaboration (A. Aaltonen *et al.*), Phys. Rev. Lett. **87**, 072003 (2013).

[2] CDF Collaboration, (A. Aaltonen *et al.*), Phys. Rev. Lett. **103**, 031801 (2009).

[3] CDF Collaboration (A. Aaltonen *et al.*), Phys. Rev. Lett. **102**, 201801 (2009).

[4]

[5] CDF Collaboration, (A. Aaltonen *et al.*), Phys. Rev. Lett. **107**, 261802 (2011).

[6] CDF Collaboration, (A. Aaltonen *et al.*), Phys. Rev. Lett. **108**, 211803 (2012).

[7] CDF Collaboration, (T. Aaltonen *et al.*), Phys. Rev. Lett. **106**, 181802 (2011).

[8]

[9]

DØ References

[10] DØ Collaboration (V. Abazov *et al.*), Phys. Rev. D **87**, 072006 (2013).

[11] DØ Collaboration (V. Abazov *et al.*), Phys. Rev. D **74**, 031107 (2006).

Belle References

[12] Belle Collaboration (D. Dutta *et al.*) Phys. Rev. D **91**, 011101 (2015).

[13] Belle Collaboration (C.-C. Peng *et al.*) Phys. Rev. D **82**, 072007 (2010).

[14] Belle Collaboration (B. Pal *et al.*) Phys. Rev. Lett. **116**, 161801 (2016).

[15]

[16]

[17]

[18]

[19]

LHCb References

[20] LHCb Collaboration, (R. Aaij *et al.*), Phys. Rev. Lett. **111**, 101805 (2013).

[21] LHCb Collaboration, (R. Aaij *et al.*), J. High Energ. Phys. **07**, 166 (2015).

[22] LHCb Collaboration, (R. Aaij *et al.*), J. High Energ. Phys. **1210**, 037 (2012).

[23] LHCb Collaboration, (R. Aaij *et al.*), Nucl. Phys. B **867**, 1 (2013).

[24] LHCb Collaboration, (R. Aaij *et al.*), J. High Energ. Phys. **1509**, 179 (2015).

[25] LHCb Collaboration, (R. Aaij *et al.*), Phys. Rev. Lett. **110**, 211801 (2013).

[26] LHCb Collaboration (R. Aaij *et al.*), J. High Energ. Phys. **1310**, 143 (2013).

[27] LHCb Collaboration (R. Aaij *et al.*), J. High Energ. Phys. **1311**, 092 (2013).

[28] LHCb Collaboration, (R. Aaij *et al.*), Phys. Rev. Lett. **111**, 141801 (2013).

[29] LHCb Collaboration (R. Aaij *et al.*), J. High Energ. Phys. **1310**, 005 (2013).

[30] LHCb Collaboration (R. Aaij *et al.*), New J. Phys. **16** 123001 (2014).

[31] LHCb Collaboration, (R. Aaij *et al.*), Phys. Rev. Lett. **115**, 051801 (2015).

[32] LHCb Collaboration (R. Aaij *et al.*), Phys. Lett. B **743**, 46 (2015).

[33] LHCb Collaboration (R. Aaij *et al.*), J. High Energ. Phys. **1601**, 012 (2016).

[34] LHCb Collaboration (R. Aaij *et al.*), J. High Energ. Phys. **1510**, 053 (2015).

[35] LHCb Collaboration (R. Aaij *et al.*), arXiv:1610.05187 [hep-ex] (2016).

[36] LHCb Collaboration (R. Aaij *et al.*), arXiv:1610.08288 [hep-ex].

[37] LHCb Collaboration (R. Aaij *et al.*), arXiv:1609.02032 [hep-ex].

[38]

[39]

CMS/ATLAS References

[40] CMS Collaboration (S. Chatrchyan *et al.*), Phys. Rev. Lett. **111**, 101804 (2013).

[41] ATLAS Collaboration (M. Aaboud *et al.*), arXiv:1604.04263 [hep-ex] (2016).

[42]

[43]

[44]

Combination of results from several experiments

[45] CMS and LHCb Collaborations (V. Khachatryan *et al.*), Nature **522**, 68-72 (2015).

[46]

[47]