

Heavy Flavor Averaging Group

April 2006

Compilation of B^+ Semi-leptonic and Radiative Branching Fractions

All branching fractions are in units of 10^{-6}

In PDG2004 **New since PDG2004 (preliminary)** **New since PDG2004 (published)**

RPP#	Mode	PDG2004 Avg.	BABAR	Belle	CLEO	New Avg.
160	$K^*(892)^+\gamma$	38 ± 5	$38.7 \pm 2.8 \pm 2.6$	$42.5 \pm 3.1 \pm 2.4$	$37.6^{+8.9}_{-8.3} \pm 2.8$	40.3 ± 2.6
161	$K_1(1270)^+\gamma$	< 99		$43 \pm 9 \pm 9$		43 ± 12
162	$K^+\phi\gamma$	3.4 ± 1.0		$3.4 \pm 0.9 \pm 0.4$		3.4 ± 1.0
163	$K^+\pi^-\pi^+\gamma$ §	24^{+6}_{-5}	$29.5 \pm 1.3 \pm 1.9$	$25.0 \pm 1.8 \pm 2.2$		27.7 ± 1.8
–	$K^0\pi^+\pi^0\gamma$ §	New	$45.6 \pm 4.2 \pm 3.1$			45.6 ± 5.2
164	$K^{*0}\pi^+\gamma$ §	20^{+7}_{-6}		$20^{+7}_{-6} \pm 2$		20^{+7}_{-6}
165	$K^+\rho^0\gamma$ §	< 20		< 20		< 20
166	$K^+\pi^-\pi^+\gamma$ (N.R.) §	< 9.2		< 9.2		< 9.2
167	$K_1(1400)^+\gamma$	< 50		< 15		< 15
168	$K_2^*(1430)^+\gamma$	< 1400	$14.5 \pm 4.0 \pm 1.5$			14.5 ± 4.3
172	$\rho^+\gamma$	< 2.1	$0.9^{+0.6}_{-0.5} \pm 0.1$	$0.55^{+0.43+0.12}_{-0.37-0.11}$	< 13	$0.68^{+0.36}_{-0.31}$
–	$K^+\eta\gamma$	New	$10.0 \pm 1.3 \pm 0.5$	$8.4^{+1.5}_{-1.1} \pm 0.9$		9.3 ± 1.1
–	$K^+\eta'\gamma$	New	< 4.2			< 4.2
207	$p\bar{\Lambda}\gamma$	New		$2.16^{+0.58}_{-0.53} \pm 0.20$		$2.16^{+0.61}_{-0.57}$
208	$p\bar{\Sigma}^0\gamma$	New		< 3.3		< 3.3
–	$\pi^+\nu\bar{\nu}$	New	< 100			< 100
226	$K^+e^+e^-$	$0.63^{+0.19}_{-0.17}$	$0.42^{+0.12}_{-0.11} \pm 0.02$	$0.640^{+0.150+0.029}_{-0.134-0.031}$	< 2.4	$0.515^{+0.093}_{-0.090}$
227	$K^+\mu^+\mu^-$	$0.45^{+0.14}_{-0.12}$	$0.31^{+0.15}_{-0.12} \pm 0.03$	$0.628^{+0.110}_{-0.108} \pm 0.033$	< 3.68	0.516 ± 0.091
228	$K^+l^+l^-$	$0.53^{+0.11}_{-0.10} \pm 0.3$	$0.38^{+0.09}_{-0.08} \pm 0.02$	$0.632^{+0.092}_{-0.088} \pm 0.030$		0.505 ± 0.065
229	$K^+\nu\bar{\nu}$	< 240	< 52	< 36	< 240	< 36
230	$K^*(892)^+e^+e^-$	< 4.6	$0.75^{+0.76}_{-0.65} \pm 0.38$	$1.60^{+1.04+0.14}_{-0.87-0.19}$		$1.12^{+0.65}_{-0.58}$
231	$K^*(892)^+\mu^+\mu^-$	< 2.2	$0.97^{+0.94}_{-0.69} \pm 0.14$	$1.63^{+0.64+0.10}_{-0.54-0.13}$		$1.43^{+0.54}_{-0.45}$
232	$K^*(892)^+l^+l^-$	< 2.2	$0.73^{+0.50}_{-0.42} \pm 0.21$	$1.34^{+0.48+0.09}_{-0.40-0.10}$		$1.10^{+0.35}_{-0.31}$
235	$K^+e^+\mu^-$	< 0.8	< 0.09			< 0.09
236	$K^+e^-\mu^+$	< 6400	< 0.13			< 0.13
237	$K^{*+}e^\pm\mu^\mp$	< 7.9	< 1.4			< 1.4
238	$\pi^-e^+e^+$	< 1.6			< 1.6	< 1.6
239	$\pi^-\mu^+\mu^+$	< 1.4			< 1.4	< 1.4
240	$\pi^-e^+\mu^+$	< 1.3			< 1.3	< 1.3
241	$\rho^-e^+e^+$	< 2.6			< 2.6	< 2.6
242	$\rho^-\mu^+\mu^+$	< 5.0			< 5.0	< 5.0
243	$\rho^-e^+\mu^+$	< 3.3			< 3.3	< 3.3
244	$K^-e^+e^+$	< 1.0			< 1.0	< 1.0
245	$K^-\mu^+\mu^+$	< 1.8			< 1.8	< 1.8
246	$K^-e^+\mu^+$	< 2.0			< 2.0	< 2.0
247	$K^{*-}e^+e^+$	< 2.8			< 2.8	< 2.8
248	$K^{*-}\mu^+\mu^+$	< 8.3			< 8.3	< 8.3
249	$K^{*-}e^+\mu^+$	< 4.4			< 4.4	< 4.4

§ $M_{K\pi\pi} < 2.4 \text{ GeV}/c^2$

Heavy Flavor Averaging Group
April 2006

Compilation of B^0 Semi-leptonic and Radiative Branching Fractions
All branching fractions are in units of 10^{-6}

In PDG2004 New since PDG2004 (preliminary) New since PDG2004 (published)

RPP#	Mode	PDG2004 Avg.	BABAR	Belle	CLEO	New Avg.
162	$K^*(892)^0\gamma$	43 ± 4	$39.2 \pm 2.0 \pm 2.4$	$40.1 \pm 2.1 \pm 1.7$	$45.5^{+7.2}_{-6.8} \pm 3.4$	40.1 ± 2.0
163	$K^0\phi\gamma$	< 8.3		< 8.3		< 8.3
164	$K^+\pi^-\gamma$ †	4.6 ± 1.4		$4.6^{+1.3+0.5}_{-1.2-0.7}$		4.6 ± 1.4
–	$K^0\pi^+\pi^-\gamma$	New	$18.5 \pm 2.1 \pm 1.2$	$24 \pm 4 \pm 3$		19.5 ± 2.2
–	$K^+\pi^-\pi^0\gamma$	New	$40.7 \pm 2.2 \pm 3.1$			40.7 ± 3.8
165	$K^*(1410)^0\gamma$	< 130		< 130		< 130
166	$K^+\pi^-\gamma$ (N.R.) †	< 2.6		< 2.6		< 2.6
167	$K_1(1270)^0\gamma$	< 7000		< 58		< 58
168	$K_1(1400)^0\gamma$	< 4300		< 12		< 12
169	$K_2^*(1430)^0\gamma$	13 ± 5	$12.2 \pm 2.5 \pm 1.0$	$13 \pm 5 \pm 1$		12.4 ± 2.4
–	$K^0\eta\gamma$	New	$11.3^{+2.8}_{-2.6} \pm 0.6$	$8.7^{+3.1+1.9}_{-2.7-1.6}$		$10.3^{+2.3}_{-2.1}$
–	$K^0\eta'\gamma$	New	< 6.6			< 6.6
173	$\rho^0\gamma$	< 1.2	$0.0 \pm 0.2 \pm 0.1$	$1.17^{+0.35+0.09}_{-0.31-0.08}$	< 17	0.38 ± 0.18
174	$\omega\gamma$	< 1.0	$0.5 \pm 0.3 \pm 0.1$	$0.58^{+0.35+0.07}_{-0.27-0.08}$	< 9.2	$0.54^{+0.23}_{-0.21}$
175	$\phi\gamma$	< 3.3	< 0.85		< 3.3	< 0.85
237	$K^0e^+e^-$	< 0.54	$0.13^{+0.16}_{-0.11} \pm 0.02$	$-0.070^{+0.129+0.014}_{-0.082-0.028}$	< 8.45	$0.038^{+0.091}_{-0.079}$
238	$K^0\mu^+\mu^-$	$0.56^{+0.29}_{-0.24}$	$0.59^{+0.33}_{-0.26} \pm 0.07$	$0.626^{+0.217+0.038}_{-0.181-0.041}$	< 6.64	$0.615^{+0.184}_{-0.153}$
239	$K^0l^+l^-$	< 0.68	$0.29^{+0.16}_{-0.13} \pm 0.03$	$0.328^{+0.134+0.022}_{-0.113-0.026}$		$0.312^{+0.105}_{-0.088}$
240	$K^*(892)^0e^+e^-$	< 2.4	$1.04^{+0.33}_{-0.29} \pm 0.11$	$1.85^{+0.55}_{-0.49} \pm 0.19$		$1.28^{+0.30}_{-0.28}$
241	$K^*(892)^0\mu^+\mu^-$	1.3 ± 0.4	$0.87^{+0.38}_{-0.33} \pm 0.12$	$1.85^{+0.35}_{-0.31} \pm 0.10$		1.46 ± 0.25
243	$K^*(892)^0l^+l^-$	1.17 ± 0.30	$0.81^{+0.21}_{-0.19} \pm 0.09$	$1.69^{+0.26}_{-0.24} \pm 0.11$		1.19 ± 0.17
245	$K^0e^\pm\mu^\pm$	< 4.0	< 0.27			< 0.27
246	$K(892)^0e^\pm\mu^\pm$	< 3.4	< 0.58			< 0.58

† $1.25 \text{ GeV}/c^2 < M_{K\pi} < 1.6 \text{ GeV}/c^2$

Heavy Flavor Averaging Group
April 2006

Compilation of B Semi-leptonic and Radiative Branching Fractions
All branching fractions are in units of 10^{-6}

In PDG2004 New since PDG2004 (preliminary) New since PDG2004 (published)

RPP#	Mode	PDG2004 Avg.	BABAR	Belle	CLEO	New Avg.
60	$K_3^*(1780)\gamma$	< 3000		< 2.8		< 2.8
67	$s\gamma$	330 ± 40	$338 \pm 19_{-42}^{+64}$	$355 \pm 32_{-31-7}^{+30+11}$	$321 \pm 43_{-29}^{+32}$	$355 \pm 24_{-10}^{+9} \pm 3$
–	$s\gamma$ with baryons	New			< 38 †	< 38 †
71	$\rho\gamma$	< 1.9	$0.6 \pm 0.3 \pm 0.1$	$1.34_{-0.31-0.10}^{+0.34+0.14}$	< 14	0.96 ± 0.23
–	$K\eta\gamma$	New		$8.5_{-1.2}^{+1.3} \pm 0.9$		$8.5_{-1.5}^{+1.6}$
101	$se^+e^- \ddagger$	5.0 ± 2.6	$6.0 \pm 1.7 \pm 1.3$	$4.04 \pm 1.30_{-0.83}^{+0.87}$	< 57	$4.72_{-1.25}^{+1.26}$
102	$s\mu^+\mu^-$	$7.9_{-2.6}^{+3.0}$	$5.0 \pm 2.8 \pm 1.2$	$4.13 \pm 1.05_{-0.81}^{+0.85}$	< 58	$4.27_{-1.22}^{+1.23}$
103	$s\ell^+\ell^- \ddagger$	$6.1_{-1.8}^{+2.0}$	$5.6 \pm 1.5 \pm 1.3$	$4.11 \pm 0.83_{-0.81}^{+0.85}$	< 42	$4.50_{-1.01}^{+1.03}$
104	Ke^+e^-	$0.48_{-0.13}^{+0.15}$	$0.33_{-0.08}^{+0.09} \pm 0.02$	$0.454_{-0.104-0.025}^{+0.116+0.023}$		$0.380_{-0.067}^{+0.073}$
105	$K^*(892)e^+e^-$	1.5 ± 0.5	$0.97_{-0.27}^{+0.30} \pm 0.14$	$1.84_{-0.44}^{+0.48} \pm 0.17$		1.25 ± 0.27
106	$K\mu^+\mu^-$	0.48 ± 0.12	$0.35_{-0.11}^{+0.13} \pm 0.03$	$0.626_{-0.064-0.034}^{+0.103+0.033}$		$0.561_{-0.061}^{+0.066}$
107	$K^*(892)\mu^+\mu^-$	$1.17_{-0.33}^{+0.37}$	$0.88_{-0.30}^{+0.35} \pm 0.12$	$1.81_{-0.28}^{+0.30} \pm 0.11$		1.44 ± 0.23
108	$K\ell^+\ell^-$	0.54 ± 0.08	$0.34 \pm 0.07 \pm 0.02$	$0.550_{-0.070}^{+0.075} \pm 0.027$	< 1.7	0.442 ± 0.052
109	$K^*(892)\ell^+\ell^-$	1.05 ± 0.20	$0.78_{-0.17}^{+0.19} \pm 0.11$	$1.65_{-0.22}^{+0.23} \pm 0.11$	< 3.3	1.17 ± 0.16
111	$\pi e^\pm\mu^\mp$	< 1.6			< 1.6	< 1.6
112	$\rho e^\pm\mu^\mp$	< 3.2			< 3.2	< 3.2
113	$Ke^\pm\mu^\mp$	< 1.6	< 0.038		< 1.6	< 0.038
114	$K^*e^\pm\mu^\mp$	< 6.2	< 0.51		< 6.2	< 0.51

† $E_\gamma > 2.0$ GeV; ‡ $M(\ell^+\ell^-) > 0.2$ GeV/ c^2

Heavy Flavor Averaging Group
April 2006

Compilation of B Leptonic Branching Fractions
All branching fractions are in units of 10^{-6}

In PDG2004 New since PDG2004 (preliminary) New since PDG2004 (published)

RPP#	Mode	PDG2004 Avg.	BABAR	Belle	CLEO	CDF	D0	New Avg.
12	$e^+\nu$	< 15		< 5.4	< 15			< 5.4
13	$\mu^+\nu$	< 21	< 6.6	< 2.0	< 21			< 2.0
14	$\tau^+\nu$	< 570	130^{+100}_{-90}	106^{+34+24}_{-28-19}	< 840			109^{+38}_{-31}
15	$e^+\nu_e\gamma$	< 200		< 22	< 200			< 22
16	$\mu^+\nu_\mu\gamma$	< 52		< 23	< 52			< 23
234	$\gamma\gamma$	< 1.7	< 1.7	< 0.62				< 0.62
235	e^+e^-	< 0.19	< 0.061	< 0.19	< 0.83			< 0.061
236	$\mu^+\mu^-$	< 0.16	< 0.083	< 0.16	< 0.61	< 0.023		< 0.023
–	$\tau^+\tau^-$	New	< 3400					< 3400
244	$e^\pm\mu^\mp$	< 0.17	< 0.18	< 0.17	< 1.5			< 0.17
247	$e^\pm\tau^\mp$	< 530			< 110			< 110
248	$\mu^\pm\tau^\mp$	< 830			< 38			< 38
–	$\nu\bar{\nu}$	New	< 220					< 220
–	$\nu\bar{\nu}\gamma$	New	< 47					< 47

Radiative and Leptonic Decays:

BABAR References

- [1] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. D **70**, 112006 (2004).
- [2] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. Lett. **94**, 011801 (2005).
- [3] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0604007 (submitted to PRD).
- [4] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0408086 (ICHEP2004 contributed paper), 2004.
- [5] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. Lett. **94**, 221803 (2005).
- [6] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0603054 (submitted to PRL).
- [7] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. D **70**, 091105 (2004).
- [8] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. Lett. **93**, 081802 (2004).
- [9] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. D **73**, 057101 (2006).
- [10] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. Lett. **92**, 221803 (2004).
- [11] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. D **72**, 091103 (2005).
- [12] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. Lett. **93**, 091802 (2004).
- [13] J. Walsh for the *BABAR* Collaboration, talk presented at Moriond QCD, 2005.
- [14] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. Lett. **87**, 241803 (2001).
- [15] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0507031 (LepPho05 contributed paper).
- [16] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0511015 (submitted to PRL).
- [17]
- [18]
- [19]
- [20]

Belle References

- [21] Belle Collaboration (K. Abe *et al.*), BELLE-CONF-0247 (ICHEP2002 contributed paper), 2002.
- [22] Belle Collaboration (M. Nakao *et al.*), Phys. Rev. D **69**, 112001 (2004).
- [23] Belle Collaboration (S. Nishida *et al.*), Phys. Rev. Lett. **89**, 231801 (2002).
- [24] Belle Collaboration (K. Ikado *et al.*), hep-ex/0604018, 2006.
- [25] Belle Collaboration (K. Abe *et al.*), BELLE-CONF-0241, (ICHEP2002 contributed paper), 2002.
- [26] Belle Collaboration (M.-C. Chang *et al.*), Phys. Rev. D **68**, 111101 (2003).
- [27] Belle Collaboration (P. Koppenburg *et al.*), Phys. Rev. Lett. **93**, 061803 (2004).
- [28] Belle Collaboration (M. Iwasaki *et al.*), Phys. Rev. D **72**, 092005 (2005).
- [29] Belle Collaboration (D. Drutskoy *et al.*), Phys. Rev. Lett. **92**, 051801 (2004).
- [30] Belle Collaboration (K. Abe *et al.*), hep-ex/0507034, 2005.
- [31] Belle Collaboration (K. Abe *et al.*), hep-ex/0409009, 2004.
- [32] Belle Collaboration (H. Yang *et al.*), Phys. Rev. Lett. **94**, 111802 (2005).
- [33] Belle Collaboration (S. Nishida *et al.*), Phys. Lett. B **610**, 23 (2005).
- [34] Belle Collaboration (K. Abe *et al.*), hep-ex/0506079, 2005.
- [35] Belle Collaboration (K. Abe *et al.*), hep-ex/0410006, 2004.
- [36] Belle Collaboration (K. Abe *et al.*), hep-ex/0408132, 2004.
- [37] Belle Collaboration (K. Abe *et al.*), hep-ex/0408144, 2004.
- [38] Belle Collaboration (S. Villa *et al.*), Phys. Rev. D **73**, 051107 (2006).
- [39]
- [40]

CLEO References

- [41] CLEO Collaboration (M. Artuso *et al.*), Phys. Rev. Lett. **75**, 785 (1995).
- [42] CLEO Collaboration (T.E. Coan *et al.*), Phys. Rev. Lett. **84**, 5283 (2000).
- [43] CLEO Collaboration (S. Anderson *et al.*), Phys. Rev. Lett. **87**, 181803 (2001).
- [44] CLEO Collaboration (T. Browder *et al.*), Phys. Rev. Lett. **86**, 2950 (2001).
- [45] CLEO Collaboration (K.W. Edwards *et al.*), Phys. Rev. D **65**, 111102R (2002).
- [46] CLEO Collaboration (T. Bergfeld *et al.*), Phys. Rev. D **62**, 091102R (2000).
- [47] CLEO Collaboration (S. Chen *et al.*), Phys. Rev. Lett. **87**, 251807 (2002).
- [48] CLEO Collaboration (S. Glenn *et al.*), Phys. Rev. Lett. **80**, 2289 (1998).
- [49] CLEO Collaboration (K.W. Edwards *et al.*), Phys. Rev. D **65**, 111102 (2002).
- [50] CLEO Collaboration (K.W. Edwards *et al.*), Phys. Rev. D **68**, 011102 (2003).
- [51] CLEO Collaboration (T. Browder *et al.*), Phys. Rev. D **56**, 11 (1997).
- [52] CLEO Collaboration (A. Bornheim *et al.*), Phys. Rev. Lett. **93**, 241802 (2004).
- [53]
- [54]
- [55]
- [56]
- [57]
- [58]
- [59]
- [60]

Tevatron References

[61] Diego Tonelli for the CDF Collaboration, talk presented at FPCP 2006.

[62]

[63]

[64]