

Heavy Flavor Averaging Group

March 2007

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

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

In PDG2006 New since PDG2006 (preliminary) New since PDG2006 (published)

RPP#	Mode	PDG2006 Avg.	BABAR	Belle	CLEO	CDF	New Avg.
240	$K^*(892)^+\gamma$	40.3 ± 2.6	$38.7 \pm 2.8 \pm 2.6$	$42.5 \pm 3.1 \pm 2.4$	$37.6^{+8.9}_{-8.3} \pm 2.8$		40.3 ± 2.6
241	$K_1(1270)^+\gamma$	$43 \pm 9 \pm 9$		$43 \pm 9 \pm 9$			43 ± 12
242	$K^+\eta\gamma$	$8.4^{+1.5}_{-1.2} \pm 0.9$	$10.0 \pm 1.3 \pm 0.5$	$8.4^{+1.5}_{-1.2} \pm 0.9$			9.4 ± 1.1
–	$K^+\eta'\gamma$	New	< 4.2				< 4.2
243	$K^+\phi\gamma$	$3.4 \pm 0.9 \pm 0.4$	$3.5 \pm 0.6 \pm 0.4$	$3.4 \pm 0.9 \pm 0.4$			3.5 ± 0.6
244	$K^+\pi^-\pi^+\gamma$ §	$25.0 \pm 1.8 \pm 2.2$	$29.5 \pm 1.3 \pm 1.9$	$25.0 \pm 1.8 \pm 2.2$			27.7 ± 1.8
–	$K^0\pi^+\pi^0\gamma$ §	New	$45.6 \pm 4.2 \pm 3.1$				45.6 ± 5.2
245	$K^{*0}\pi^+\gamma$ §	20^{+7}_{-6}		$20^{+7}_{-6} \pm 2$			20^{+7}_{-6}
245	$K^+\rho^0\gamma$ §	< 20		< 20			< 20
247	$K^+\pi^-\pi^+\gamma$ (N.R.) §	< 9.2		< 9.2			< 9.2
248	$K_1(1400)^+\gamma$	< 50		< 15			< 15
249	$K_2^*(1430)^+\gamma$	$14.5 \pm 4.0 \pm 1.5$	$14.5 \pm 4.0 \pm 1.5$				14.5 ± 4.3
251	$K_3^*(1780)^+\gamma$	< 39		< 39			< 39
253	$\rho^+\gamma$	< 1.8	$1.10^{+0.37}_{-0.33} \pm 0.09$	$0.55^{+0.42+0.09}_{-0.36-0.08}$	< 13		$0.88^{+0.28}_{-0.26}$
296	$p\bar{\Lambda}\gamma$	$2.16^{+0.58}_{-0.53} \pm 0.20$		$2.16^{+0.58}_{-0.53} \pm 0.20$			$2.16^{+0.61}_{-0.57}$
297	$p\Sigma^0\gamma$	< 4.6		< 4.6			< 4.6
317	$\pi^+\nu\bar{\nu}$	< 100	< 100				< 100
318	$K^+e^+e^-$	$0.80^{+0.22}_{-0.19}$	$0.42^{+0.12}_{-0.11} \pm 0.02$	$0.63^{+0.19}_{-0.17} \pm 0.03$	< 2.4		0.49 ± 0.10
319	$K^+\mu^+\mu^-$	$0.34^{+0.19}_{-0.14}$	$0.31^{+0.15}_{-0.12} \pm 0.03$	$0.45^{+0.14}_{-0.12} \pm 0.03$	< 3.68	$0.60 \pm 0.15 \pm 0.04$	$0.45^{+0.09}_{-0.08}$
320	$K^+l^+l^-$	$0.53^{+0.11}_{-0.10} \pm 0.3$	$0.38^{+0.09}_{-0.08} \pm 0.02$				$0.38^{+0.09}_{-0.08}$
321	$K^+\nu\bar{\nu}$	< 52	< 52	< 36	< 240		< 36
322	$K^*(892)^+e^+e^-$	< 4.6	$0.75^{+0.76}_{-0.65} \pm 0.38$	$2.02^{+1.27+0.23}_{-1.01-0.24}$			$1.23^{+0.69}_{-0.62}$
323	$K^*(892)^+\mu^+\mu^-$	< 2.2	$0.97^{+0.94}_{-0.69} \pm 0.14$	$0.65^{+0.69+0.14}_{-0.53-0.15}$			$0.78^{+0.56}_{-0.44}$
324	$K^*(892)^+l^+l^-$	< 2.2	$0.73^{+0.50}_{-0.42} \pm 0.21$				$0.73^{+0.54}_{-0.47}$
327	$K^+e^+\mu^-$	< 0.8	< 0.09				< 0.09
328	$K^+e^-\mu^+$	< 6400	< 0.13				< 0.13
329	$K^{*+}e^\pm\mu^\mp$	< 7.9	< 1.4				< 1.4
330	$\pi^-e^+e^+$	< 1.6			< 1.6		< 1.6
331	$\pi^-\mu^+\mu^+$	< 1.4			< 1.4		< 1.4
332	$\pi^-e^+\mu^+$	< 1.3			< 1.3		< 1.3
333	$\rho^-e^+e^+$	< 2.6			< 2.6		< 2.6
334	$\rho^-\mu^+\mu^+$	< 5.0			< 5.0		< 5.0
335	$\rho^-e^+\mu^+$	< 3.3			< 3.3		< 3.3
336	$K^-e^+e^+$	< 1.0			< 1.0		< 1.0
337	$K^-\mu^+\mu^+$	< 1.8			< 1.8		< 1.8
338	$K^-e^+\mu^+$	< 2.0			< 2.0		< 2.0
339	$K^{*-}e^+e^+$	< 2.8			< 2.8		< 2.8
340	$K^{*-}\mu^+\mu^+$	< 8.3			< 8.3		< 8.3
341	$K^{*-}e^+\mu^+$	< 4.4			< 4.4		< 4.4
–	$\pi^+l^+l^-$	New	< 0.11				< 0.11

§ $M_{K\pi\pi} < 2.4 \text{ GeV}/c^2$

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In PDG2006 New since PDG2006 (preliminary) New since PDG2006 (published)

RPP#	Mode	PDG2006 Avg.	BABAR	Belle	CLEO	CDF	New Avg.
213	$K^*(892)^0\gamma$	40.1 ± 2.0	$39.2 \pm 2.0 \pm 2.4$	$40.1 \pm 2.1 \pm 1.7$	$45.5^{+7.2}_{-6.8} \pm 3.4$		40.1 ± 2.0
214	$K^0\eta\gamma$	$8.7^{+3.1+1.9}_{-2.7-1.6}$	$11.3^{+2.8}_{-2.6} \pm 0.6$	$8.7^{+3.1+1.9}_{-2.7-1.6}$			$10.3^{+2.3}_{-2.1}$
–	$K^0\eta'\gamma$	New	< 6.6				< 6.6
215	$K^0\phi\gamma$	< 8.3	< 2.7	< 8.3			< 2.7
216	$K^+\pi^-\gamma$ †	4.6 ± 1.4		$4.6^{+1.3+0.5}_{-1.2-0.7}$			4.6 ± 1.4
217	$K^*(1410)^0\gamma$	< 130		< 130			< 130
218	$K^+\pi^-\gamma$ (N.R.) †	< 2.6		< 2.6			< 2.6
219	$K^0\pi^+\pi^-\gamma$	$24 \pm 4 \pm 3$	$18.5 \pm 2.1 \pm 1.2$	$24 \pm 4 \pm 3$			19.5 ± 2.2
–	$K^+\pi^-\pi^0\gamma$	New	$40.7 \pm 2.2 \pm 3.1$				40.7 ± 3.8
220	$K_1(1270)^0\gamma$	< 58		< 58			< 58
221	$K_1(1400)^0\gamma$	< 15		< 15			< 15
222	$K_2^*(1430)^0\gamma$	12.4 ± 2.4	$12.2 \pm 2.5 \pm 1.0$	$13 \pm 5 \pm 1$			12.4 ± 2.4
224	$K_3^*(1780)^0\gamma$	< 83		< 83			< 83
226	$\rho^0\gamma$	< 0.4	$0.79^{+0.22}_{-0.20} \pm 0.06$	$1.25^{+0.37+0.07}_{-0.33-0.06}$	< 17		$0.93^{+0.19}_{-0.18}$
227	$\omega\gamma$	< 0.8	$0.40^{+0.24}_{-0.20} \pm 0.05$	$0.56^{+0.34+0.05}_{-0.27-0.10}$	< 9.2		$0.46^{+0.20}_{-0.17}$
228	$\phi\gamma$	< 0.85	< 0.85		< 3.3		< 0.85
293	$K^0e^+e^-$	< 0.54	$0.13^{+0.16}_{-0.11} \pm 0.02$	$0.00^{+0.20+0.02}_{-0.12-0.05}$	< 8.45		$0.09^{+0.12}_{-0.09}$
294	$K^0\mu^+\mu^-$	$0.20^{+0.13}_{-0.10}$	$0.59^{+0.33}_{-0.26} \pm 0.07$	$0.56^{+0.29}_{-0.23} \pm 0.05$	< 6.64		$0.57^{+0.22}_{-0.18}$
295	$K^0l^+l^-$	< 0.68	$0.29^{+0.16}_{-0.13} \pm 0.03$				$0.29^{+0.16}_{-0.13}$
296	$K^*(892)^0e^+e^-$	< 2.4	$1.04^{+0.33}_{-0.29} \pm 0.11$	$1.29^{+0.57+0.13}_{-0.49-0.10}$			$1.11^{+0.30}_{-0.26}$
297	$K^*(892)^0\mu^+\mu^-$	$1.22^{+0.38}_{-0.32}$	$0.87^{+0.38}_{-0.33} \pm 0.12$	$1.33^{+0.42}_{-0.37} \pm 0.11$		$0.82 \pm 0.31 \pm 0.10$	$0.98^{+0.22}_{-0.21}$
298	$K^*(892)^0\nu\bar{\nu}$	< 1000		< 360			< 360
299	$K^*(892)^0l^+l^-$	1.17 ± 0.30	$0.81^{+0.21}_{-0.19} \pm 0.09$				$0.81^{+0.23}_{-0.21}$
301	$K^0e^\pm\mu^\pm$	< 4.0	< 0.27				< 0.27
302	$K(892)^0e^\pm\mu^\pm$	< 3.4	< 0.58				< 0.58
–	$\pi^0\ell^+\ell^-$	New	< 0.10				< 0.10

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

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RPP#	Mode	PDG2006 Avg.	BABAR	Belle	CLEO	New Avg.
61	$K_2^*(1430)\gamma$	$1.7 \pm 0.6 \pm 0.1$			$1.7 \pm 0.6 \pm 0.1$	1.7 ± 0.6
63	$K_3^*(1780)\gamma$	< 37		< 2.8		< 2.8
70	$s\gamma$	343 ± 29	$327 \pm 18^{+55}_{-41}$	$355 \pm 32^{+30+11}_{-31-7}$	$321 \pm 43^{+32}_{-29}$	$355 \pm 24^{+9}_{-10} \pm 3$
–	$s\gamma$ with baryons	New			$< 38 \dagger$	$< 38 \dagger$
74	ρ/γ	< 1.9	$1.36^{+0.29}_{-0.27} \pm 0.10$		< 14	$1.36^{+0.31}_{-0.29}$
75	$\rho/\omega\gamma$	< 1.2	$1.25 \pm 0.25 \pm 0.09$	$1.32^{+0.34+0.10}_{-0.31-0.09}$	< 14	$1.28^{+0.21}_{-0.20}$
–	$K\eta\gamma$	New		$8.5^{+1.3}_{-1.2} \pm 0.9$		$8.5^{+1.6}_{-1.5}$
105	$se^+e^- \ddagger$	4.7 ± 1.3	$6.0 \pm 1.7 \pm 1.3$	$4.0 \pm 1.3^{+0.9}_{-0.8}$	< 57	4.7 ± 1.3
106	$s\mu^+\mu^-$	4.3 ± 1.2	$5.0 \pm 2.8 \pm 1.2$	$4.1 \pm 1.1^{+0.9}_{-0.8}$	< 58	$4.3^{+1.3}_{-1.2}$
107	$sl^+\ell^- \ddagger$	4.5 ± 1.0	$5.6 \pm 1.5 \pm 1.3$	$4.11 \pm 0.83^{+0.85}_{-0.81}$	< 42	$4.50^{+1.03}_{-1.01}$
108	Ke^+e^-	$0.60^{+0.14}_{-0.12}$	$0.33^{+0.09}_{-0.08} \pm 0.02$	$0.48^{+0.15}_{-0.13} \pm 0.03$		$0.38^{+0.08}_{-0.07}$
109	$K^*(892)e^+e^-$	$1.24^{+0.37}_{-0.32}$	$0.97^{+0.30}_{-0.27} \pm 0.14$	$1.49^{+0.52+0.11}_{-0.46-0.13}$		$1.13^{+0.28}_{-0.26}$
110	$K\mu^+\mu^-$	$0.47^{+0.11}_{-0.10}$	$0.35^{+0.13}_{-0.11} \pm 0.03$	$0.48^{+0.13}_{-0.11} \pm 0.04$		$0.42^{+0.09}_{-0.08}$
111	$K^*(892)\mu^+\mu^-$	$1.19^{+0.34}_{-0.29}$	$0.88^{+0.35}_{-0.30} \pm 0.12$	$1.17^{+0.36}_{-0.31} \pm 0.10$		$1.03^{+0.26}_{-0.23}$
112	$K\ell^+\ell^-$	0.54 ± 0.08	$0.34 \pm 0.07 \pm 0.02$	$0.48^{+0.10}_{-0.09} \pm 0.03$	< 1.7	0.39 ± 0.06
113	$K^*(892)\ell^+\ell^-$	1.05 ± 0.20	$0.78^{+0.19}_{-0.17} \pm 0.11$	$1.15^{+0.26}_{-0.24} \pm 0.08$	< 3.3	$0.94^{+0.17}_{-0.16}$
115	$\pi e^\pm\mu^\mp$	< 1.6			< 1.6	< 1.6
116	$\rho e^\pm\mu^\mp$	< 3.2			< 3.2	< 3.2
117	$Ke^\pm\mu^\mp$	< 1.6	< 0.038		< 1.6	< 0.038
118	$K^*e^\pm\mu^\mp$	< 6.2	< 0.51		< 6.2	< 0.51
–	$\pi\ell^+\ell^-$	New	< 0.08			< 0.08

$\dagger E_\gamma > 2.0 \text{ GeV}$; $\ddagger M(\ell^+\ell^-) > 0.2 \text{ GeV}/c^2$

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

In PDG2006

New since PDG2006 (preliminary)

New since PDG2006 (published)

RPP#	Mode	PDG2006 Avg.	BABAR	Belle	CLEO	New Avg.
–	$K^+ X$	New	196^{+37+31}_{-34-30}			196^{+48}_{-45}
–	$K^0 X$	New	154^{+55+55}_{-48-41}			154^{+77}_{-63}

† $p^* > 2.34$ GeV

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March 2007

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

In PDG2006

New since PDG2006 (preliminary)

New since PDG2006 (published)

RPP#	Mode	PDG2006 Avg.	BABAR	Belle	CLEO	CDF	D0	New Avg.
15	$e^+ \nu$	< 15	< 7.9	< 1.0	< 15			< 1.0
16	$\mu^+ \nu$	< 6.6	< 6.2	< 1.7	< 21			< 1.7
17	$\tau^+ \nu$	< 260	$88 \pm 68 \pm 11$	179^{+56+46}_{-49-51}	< 840			132 ± 49
18	$e^+ \nu_e \gamma$	< 200			< 200			< 200
19	$\mu^+ \nu_\mu \gamma$	< 52			< 52			< 52
290	$\gamma \gamma$	< 0.62	< 1.7	< 0.62				< 0.62
291	$e^+ e^-$	< 0.061	< 0.061	< 0.19	< 0.83			< 0.061
–	$e^+ e^- \gamma$	New	< 0.07					< 0.07
292	$\mu^+ \mu^-$	< 0.039	< 0.083	< 0.16	< 0.61	< 0.023		< 0.023
–	$\mu^+ \mu^- \gamma$	New	< 0.34					< 0.34
–	$\tau^+ \tau^-$	New	< 4100					< 4100
300	$e^\pm \mu^\mp$	< 0.17	< 0.18	< 0.17	< 1.5			< 0.17
303	$e^\pm \tau^\mp$	< 110			< 110			< 110
304	$\mu^\pm \tau^\mp$	< 38			< 38			< 38
305	$\nu \bar{\nu}$	< 220	< 220					< 220
306	$\nu \bar{\nu} \gamma$	< 47	< 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.*), hep-ex/0612017 (submitted to PRL), 2006.
- [3] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. D **73**, 092001 (2006).
- [4] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. Lett. **94**, 101801 (2005).
- [5] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. Lett. **94**, 221803 (2005).
- [6] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. D **74**, 031102 (2006).
- [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.*), hep-ex/0608019 (ICHEP06 contributed paper).
- [10] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0607110 (ICHEP06 contributed paper).
- [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] *BABAR* Collaboration (B. Aubert *et al.*), Phys. Rev. D **72**, 052004 (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.*), Phys. Rev. Lett. **96**, 241802 (2006).
- [17] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0611037 (submitted to PRDRC).
- [18] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0607048 (ICHEP06 contributed paper).
- [19] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0607053 (ICHEP06 contributed paper).
- [20] *BABAR* Collaboration (B. Aubert *et al.*), hep-ex/0607058 (ICHEP06 contributed paper).

Belle References

- [21] Belle Collaboration (K. Abe *et al.*), Phys. Rev. Lett. **91**, 261601 (2003).
- [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.*), Phys. Rev. Lett. **97**, 251802 (2006).
- [25] Belle Collaboration (K. Abe *et al.*), hep-ex/0611045, 2006.
- [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 (Y.-J. Lee, M.-Z. Wang *et al.*), Phys. Rev. Lett. **95**, 061802 (2005).
- [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.*), Phys. Rev. Lett. **96**, 221601 (2006).
- [35]
- [36]
- [37]
- [38] Belle Collaboration (S. Villa *et al.*), Phys. Rev. D **73**, 051107 (2006).
- [39] Belle Collaboration (K. Abe *et al.*), hep-ex/0608047 (ICHEP06 contributed paper).
- [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] CDF Collaboration, talk by M. Rescigno at CKM 2006, Nagoya, Japan, Dec. 2006.

[62]

[63]

[64]