

Heavy Flavor Averaging Group

April 2009

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

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

In PDG2008 New since PDG2008 (preliminary) New since PDG2008 (published)

RPP#	Mode	PDG2008 Avg.	BABAR	Belle	CLEO	CDF	New Avg.
276	$K^{*+}\gamma$	40.3 ± 2.6	$47.3 \pm 1.5 \pm 1.7$	$42.5 \pm 3.1 \pm 2.4$	$37.6^{+8.9}_{-8.3} \pm 2.8$		45.7 ± 1.9
277	$K_1^+(1270)\gamma$	43 ± 13		$43 \pm 9 \pm 9$			43 ± 12
278	$K^+\eta\gamma$	9.4 ± 1.1	$7.7 \pm 1.0 \pm 0.4$	$8.4^{+1.5}_{-1.2} \pm 0.9$			7.9 ± 0.9
279	$K^+\eta'\gamma$	< 4.2	$1.9^{+1.5}_{-1.2} \pm 0.1$	$3.2^{+1.2}_{-1.1} \pm 0.3$			$2.7^{+1.0}_{-0.9}$
280	$K^+\phi\gamma$	3.5 ± 0.6	$3.5 \pm 0.6 \pm 0.4$	$3.4 \pm 0.9 \pm 0.4$			3.5 ± 0.6
281	$K^+\pi^-\pi^+\gamma$	27.6 ± 2.2	$29.5 \pm 1.3 \pm 2.0$ †	$25.0 \pm 1.8 \pm 2.2$ ‡			27.6 ± 1.8
282	$K^{*0}\pi^+\gamma$ §	20^{+7}_{-6}		$20^{+7}_{-6} \pm 2$			20^{+7}_{-6}
283	$K^+\rho^0\gamma$ §	< 20		< 20			< 20
284	$K^+\pi^-\pi^+\gamma$ (N.R.) §	< 9.2		< 9.2			< 9.2
285	$K^0\pi^+\pi^0\gamma$	46 ± 5	$45.6 \pm 4.2 \pm 3.1$ †				45.6 ± 5.2
286	$K_1^+(1400)\gamma$	< 15		< 15			< 15
287	$K_2^*(1430)^+\gamma$	14 ± 4	$14.5 \pm 4.0 \pm 1.5$				14.5 ± 4.3
289	$K_3^*(1780)^+\gamma$	< 39		< 39			< 39
291	$\rho^+\gamma$	$0.98^{+0.25}_{-0.24}$	$1.20^{+0.42}_{-0.37} \pm 0.20$	$0.87^{+0.29+0.09}_{-0.27-0.11}$	< 13		$0.98^{+0.25}_{-0.24}$
338	$p\bar{\Lambda}\gamma$	$2.5^{+0.5}_{-0.4}$		$2.45^{+0.44}_{-0.38} \pm 0.22$			$2.45^{+0.49}_{-0.44}$
342	$p\bar{\Sigma}^0\gamma$	< 4.6		< 4.6			< 4.6
367	$\pi^+\ell^+\ell^-$	< 0.12	< 0.12	< 0.049			< 0.049
368	$\pi^+e^+e^-$	< 0.18	< 0.18	< 0.080			< 0.080
369	$\pi^+\mu^+\mu^-$	< 0.28	< 0.28	< 0.069			< 0.069
370	$\pi^+\nu\bar{\nu}$	< 100	< 100	< 170			< 100
371	$K^+\ell^+\ell^-$	$0.44^{+0.08}_{-0.07}$	$0.38^{+0.09}_{-0.08} \pm 0.02$	$0.53^{+0.06}_{-0.05} \pm 0.03$			0.49 ± 0.05
372	$K^+e^+e^-$	0.49 ± 0.1	$0.42^{+0.12}_{-0.11} \pm 0.02$	$0.57^{+0.09}_{-0.08} \pm 0.03$	< 2.4		0.52 ± 0.07
373	$K^+\mu^+\mu^-$	$0.39^{+0.10}_{-0.09}$	$0.31^{+0.15}_{-0.12} \pm 0.03$	$0.53 \pm 0.08^{+0.07}_{-0.03}$	< 3.68	$0.59 \pm 0.15 \pm 0.04$	$0.50^{+0.07}_{-0.06}$
374	$K^+\nu\bar{\nu}$	< 14	< 52	< 14	< 240		< 14
375	$\rho^+\nu\bar{\nu}$	< 150		< 150			< 150
376	$K^{*+}\ell^+\ell^-$	0.7 ± 0.5	$0.73^{+0.50}_{-0.42} \pm 0.21$	$1.24^{+0.23}_{-0.20} \pm 0.12$			$1.15^{+0.23}_{-0.21}$
377	$K^{*+}\nu\bar{\nu}$	< 140	< 80	< 140			< 80
378	$K^{*+}e^+e^-$	0.8 ± 0.8	$0.75^{+0.76}_{-0.65} \pm 0.38$	$1.64^{+0.50}_{-0.42} \pm 0.18$			$1.42^{+0.43}_{-0.39}$
379	$K^{*+}\mu^+\mu^-$	$0.8^{+0.6}_{-0.4}$	$0.97^{+0.94}_{-0.69} \pm 0.14$	$1.14^{+0.32}_{-0.27} \pm 0.10$			$1.12^{+0.32}_{-0.27}$
382	$\pi^+e^\pm\mu^\mp$	< 0.17	< 0.17				< 0.17
383	$K^+e^+\mu^-$	< 0.091	< 0.09				< 0.09
384	$K^+e^-\mu^+$	< 0.13	< 0.13				< 0.13
386	$K^+\tau^\pm\mu^\mp$	< 77	< 77				< 77
389	$K^{*+}e^\pm\mu^\mp$	< 1.4	< 1.4				< 1.4
390	$\pi^-e^+e^+$	< 1.6			< 1.6		< 1.6
391	$\pi^-\mu^+\mu^+$	< 1.4			< 1.4		< 1.4
392	$\pi^-e^+\mu^+$	< 1.3			< 1.3		< 1.3
393	$\rho^-e^+e^+$	< 2.6			< 2.6		< 2.6
394	$\rho^-\mu^+\mu^+$	< 5.0			< 5.0		< 5.0
395	$\rho^-e^+\mu^+$	< 3.3			< 3.3		< 3.3
396	$K^-e^+e^+$	< 1.0			< 1.0		< 1.0
397	$K^-\mu^+\mu^+$	< 1.8			< 1.8		< 1.8
398	$K^-e^+\mu^+$	< 2.0			< 2.0		< 2.0
399	$K^{*-}e^+e^+$	< 2.8			< 2.8		< 2.8
400	$K^{*-}\mu^+\mu^+$	< 8.3			< 8.3		< 8.3
401	$K^{*-}e^+\mu^+$	< 4.4			< 4.4		< 4.4

† $M_{K\pi\pi} < 1.8 \text{ GeV}/c^2$; ‡ $1.0 < M_{K\pi\pi} < 2.0 \text{ GeV}/c^2$; § $M_{K\pi\pi} < 2.4 \text{ GeV}/c^2$

Heavy Flavor Averaging Group

April 2009

Compilation of B^0 Semi-leptonic and Radiative Branching Fractions

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

In PDG2008

New since PDG2008 (preliminary)

New since PDG2008 (published)

RPP#	Mode	PDG2008 Avg.	BABAR	Belle	CLEO	CDF	New Avg.
266	$K^{*0}\gamma$	40.1 ± 2.0	$45.8 \pm 1.0 \pm 1.6$	$40.1 \pm 2.1 \pm 1.7$	$45.5^{+7.2}_{-6.8} \pm 3.4$		44.0 ± 1.5
267	$K^0\eta\gamma$	$10.7^{+2.2}_{-1.5}$	$7.1^{+2.1}_{-2.0} \pm 0.4$	$8.7^{+3.1+1.9}_{-2.7-1.6}$			$7.6^{+1.8}_{-1.7}$
268	$K^0\eta'\gamma$	< 6.6	< 6.6	< 6.3			< 6.3
269	$K^0\phi\gamma$	< 2.7	< 2.7	< 8.3			< 2.7
270	$K^+\pi^-\gamma$ §	4.6 ± 1.4		$4.6^{+1.3+0.5}_{-1.2-0.7}$			4.6 ± 1.4
271	$K^*(1410)^0\gamma$	< 130		< 130			< 130
272	$K^+\pi^-\gamma$ (N.R.) §	< 2.6		< 2.6			< 2.6
273	$K^0\pi^+\pi^-\gamma$	19.5 ± 2.2	$18.5 \pm 2.1 \pm 1.2$ †	$24 \pm 4 \pm 3$ ‡			19.5 ± 2.2
274	$K^+\pi^-\pi^0\gamma$	41 ± 4	$40.7 \pm 2.2 \pm 3.1$ †				40.7 ± 3.8
275	$K_1^0(1270)\gamma$	< 58		< 58			< 58
276	$K_1^0(1400)\gamma$	< 15		< 15			< 15
277	$K_2^*(1430)^0\gamma$	12.4 ± 2.4	$12.2 \pm 2.5 \pm 1.0$	$13 \pm 5 \pm 1$			12.4 ± 2.4
279	$K_3^*(1780)^0\gamma$	< 83		< 83			< 83
281	$\rho^0\gamma$	0.93 ± 0.21	$0.97^{+0.24}_{-0.22} \pm 0.06$	$0.78^{+0.17+0.09}_{-0.16-0.10}$	< 17		$0.86^{+0.15}_{-0.14}$
282	$\omega\gamma$	$0.46^{+0.20}_{-0.17}$	$0.50^{+0.27}_{-0.23} \pm 0.09$	$0.40^{+0.19}_{-0.17} \pm 0.13$	< 9.2		$0.44^{+0.18}_{-0.16}$
283	$\phi\gamma$	< 0.85	< 0.85		< 3.3		< 0.85
372	$\pi^0\ell^+\ell^-$	< 0.12	< 0.12	< 0.154			< 0.12
373	$\pi^0\nu\bar{\nu}$	< 220		< 220			< 220
374	$\pi^0e^+e^-$	< 0.14	< 0.14	< 0.227			< 0.14
375	$\pi^0\mu^+\mu^-$	< 0.51	< 0.51	< 0.184			< 0.184
376	$K^0\ell^+\ell^-$	$0.29^{+0.16}_{-0.13}$	$0.29^{+0.16}_{-0.13} \pm 0.03$	$0.33^{+0.09}_{-0.07} \pm 0.02$			$0.32^{+0.08}_{-0.06}$
377	$K^0\nu\bar{\nu}$	< 160		< 160			< 160
378	$\rho^0\nu\bar{\nu}$	< 440		< 440			< 440
379	$K^0e^+e^-$	$0.13^{+0.16}_{-0.11}$	$0.13^{+0.16}_{-0.11} \pm 0.02$	$0.20^{+0.14}_{-0.10} \pm 0.01$	< 8.45		$0.17^{+0.11}_{-0.08}$
380	$K^0\mu^+\mu^-$	$0.57^{+0.22}_{-0.18}$	$0.59^{+0.33}_{-0.26} \pm 0.07$	$0.43^{+0.13}_{-0.10} \pm 0.02$	< 6.64		$0.45^{+0.13}_{-0.10}$
381	$K^{*0}\ell^+\ell^-$	0.95 ± 0.18	$0.81^{+0.21}_{-0.19} \pm 0.09$	$0.98^{+0.13}_{-0.11} \pm 0.07$			$0.93^{+0.12}_{-0.11}$
382	$K^{*0}e^+e^-$	$1.04^{+0.35}_{-0.31}$	$1.04^{+0.33}_{-0.29} \pm 0.11$	$1.18^{+0.26}_{-0.21} \pm 0.09$			$1.13^{+0.21}_{-0.18}$
383	$K^{*0}\mu^+\mu^-$	$1.10^{+0.29}_{-0.26}$	$0.87^{+0.38}_{-0.33} \pm 0.12$	$1.08^{+0.19}_{-0.15} \pm 0.07$		$0.81 \pm 0.30 \pm 0.10$	$1.00^{+0.15}_{-0.13}$
384	$K^{*0}\nu\bar{\nu}$	< 340	< 120	< 340			< 120
385	$\phi\nu\bar{\nu}$	< 58		< 58			< 58
387	$\pi^0e^\pm\mu^\mp$	< 0.14	< 0.14				< 0.14
388	$K^0e^\pm\mu^\pm$	< 0.27	< 0.27				< 0.27
391	$K^{*0}e^\pm\mu^\pm$	< 3.4	< 0.58				< 0.58

† $M_{K\pi\pi} < 1.8 \text{ GeV}/c^2$; ‡ $1.0 < M_{K\pi\pi} < 2.0 \text{ GeV}/c^2$; § $1.25 \text{ GeV}/c^2 < M_{K\pi} < 1.6 \text{ GeV}/c^2$

Heavy Flavor Averaging Group
April 2009

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

In PDG208 New since PDG2008 (preliminary) New since PDG2008 (published)

RPP#	Mode	PDG2008 Avg.	BABAR	Belle	CLEO	New Avg.
63	$K\eta\gamma$	$8.5^{+1.6}_{-1.5}$		$8.5^{+1.3}_{-1.2} \pm 0.9$		$8.5^{+1.6}_{-1.5}$
65	$K_2^*(1430)\gamma$	$1.7^{+0.6}_{-0.5}$			$1.7 \pm 0.6 \pm 0.1$	1.7 ± 0.6
73	$K_3^*(1780)\gamma$	< 37		< 2.8		< 2.8
74	$s\gamma$	356 ± 25	$327 \pm 18^{+55}_{-41}$	$325 \pm 16 \pm 24$	$321 \pm 43^{+32}_{-29}$	$352 \pm 23 \pm 9$
–	$s\gamma$ with baryons	New			$< 38 \dagger$	$< 38 \dagger$
–	$d\gamma$	New	$7.2 \pm 2.7 \pm 2.3$			7.2 ± 3.5
78	$\rho\gamma$	1.36 ± 0.30	$1.73^{+0.34}_{-0.32} \pm 0.17$	$1.21^{+0.24}_{-0.22} \pm 0.12$	< 14	$1.39^{+0.22}_{-0.21}$
79	$\rho/\omega\gamma$	1.28 ± 0.21	$1.63^{+0.30}_{-0.28} \pm 0.16$	$1.14 \pm 0.20^{+0.10}_{-0.12}$	< 14	$1.30^{+0.18}_{-0.19}$
109	$se^+e^- \ddagger$	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
110	$s\mu^+\mu^-$	4.3 ± 1.2	$5.0 \pm 2.8 \pm 1.2$	$4.1 \pm 1.1^{+0.9}_{-0.8}$	< 58	$4.3^{+1.3}_{-1.2}$
111	$s\ell^+\ell^- \ddagger$	4.5 ± 1.0	$5.6 \pm 1.5 \pm 1.3$	$4.11 \pm 0.83^{+0.85}_{-0.81}$	< 42	$4.50^{+1.03}_{-1.01}$
112	$\pi\ell^+\ell^-$	< 0.091	< 0.091	< 0.062		< 0.062
113	Ke^+e^-	$0.38^{+0.08}_{-0.07}$	$0.33^{+0.09}_{-0.08} \pm 0.02$	$0.48^{+0.08}_{-0.07} \pm 0.02$		0.42 ± 0.06
114	$K^*e^+e^-$	1.13 ± 0.27	$0.97^{+0.30}_{-0.27} \pm 0.14$	$1.37^{+0.23}_{-0.18} \pm 0.12$		$1.24^{+0.19}_{-0.17}$
115	$K\mu^+\mu^-$	$0.42^{+0.09}_{-0.08}$	$0.35^{+0.13}_{-0.11} \pm 0.03$	$0.50 \pm 0.06 \pm 0.03$		0.47 ± 0.06
116	$K^*\mu^+\mu^-$	$1.03^{+0.26}_{-0.23}$	$0.88^{+0.35}_{-0.30} \pm 0.12$	$1.12^{+0.16}_{-0.14} \pm 0.08$		$1.08^{+0.16}_{-0.14}$
117	$K\ell^+\ell^-$	0.39 ± 0.07	$0.34 \pm 0.07 \pm 0.02$	$0.48^{+0.05}_{-0.04} \pm 0.03$	< 1.7	0.43 ± 0.04
118	$K^*\ell^+\ell^-$	0.94 ± 0.18	$0.78^{+0.19}_{-0.17} \pm 0.11$	$1.08 \pm 0.10 \pm 0.09$	< 3.3	1.00 ± 0.11
–	$K^*\nu\bar{\nu}$	New	< 80			< 80
120	$\pi e^\pm\mu^\mp$	< 0.092	< 0.092		< 1.6	< 0.092
121	$\rho e^\pm\mu^\mp$	< 3.2			< 3.2	< 3.2
122	$Ke^\pm\mu^\mp$	< 0.038	< 0.038		< 1.6	< 0.038
123	$K^*e^\pm\mu^\mp$	< 0.51	< 0.51		< 6.2	< 0.51

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

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

In PDG2008

New since PDG2008 (preliminary) New since PDG2008 (published)

RPP#	Mode	PDG2008 Avg.	BABAR	Belle	CLEO	New Avg.
–	$K^+ X$	New	$196^{+37+31}_{-34-30} \dagger$			196^{+48}_{-45}
–	$K^0 X$	New	$154^{+55+55}_{-48-41} \dagger$			154^{+77}_{-63}

$\dagger p^* > 2.34$ GeV

Heavy Flavor Averaging Group
April 2009

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

In PDG2008

New since PDG2008 (preliminary) New since PDG2008 (published)

RPP#	Mode	PDG2008 Avg.	BABAR	Belle	CLEO	CDF	DØ	New Avg.
24	$e^+ \nu$	< 9.8	< 5.2	< 1.0	< 15			< 1.0
25	$\mu^+ \nu$	< 1.7	< 1.3	< 1.7	< 21			< 1.3
26	$\tau^+ \nu$	140 ± 40	$120 \pm 40 \pm 36$	165^{+38+35}_{-37-37}	< 840			143 ± 37
27	$e^+ \nu e \gamma$	< 200			< 200			< 200
28	$\mu^+ \nu \mu \gamma$	< 52			< 52			< 52
366	$\gamma \gamma$	< 0.62	< 1.7	< 0.62				< 0.62
367	$e^+ e^-$	< 0.113	< 0.113	< 0.19	< 0.83	< 0.083		< 0.083
368	$e^+ e^- \gamma$	< 0.12	< 0.12					< 0.12
369	$\mu^+ \mu^-$	< 0.015	< 0.052	< 0.16	< 0.61	< 0.015		< 0.015
370	$\mu^+ \mu^- \gamma$	< 0.16	< 0.16					< 0.16
371	$\tau^+ \tau^-$	< 4100	< 4100					< 4100
386	$e^\pm \mu^\mp$	< 0.092	< 0.092	< 0.17	< 1.5	< 0.064		< 0.064
392	$e^\pm \tau^\mp$	< 110	< 28		< 110			< 28
393	$\mu^\pm \tau^\mp$	< 38	< 22		< 38			< 22
394	$\nu \bar{\nu}$	< 220	< 220					< 220
395	$\nu \bar{\nu} \gamma$	< 47	< 47					< 47

Radiative and Leptonic Decays:

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