Heavy FLavor AVeraging group (HFLAV) - May 2018

Compilation of B^+ Semi-leptonic and Radiative Branching Fractions ($\times 10^{-6}$) - UL at 90% CL

Preliminary Updated results not included in PDG Live as of Dec. 31, 2017

RPP#	Mode	PDG2017 Avg.	*BABAR*		Belle		LHCb		Our Avg.
428	$K^{*+}\gamma$	42.1 ± 1.8	$42.2 \pm 1.4 \pm 1.6$	[1]	$37.6 \pm 1.0 \pm 1.2$	[2]			39.2 ± 1.3
429	$K_1^+(1270)\gamma$	44^{+7}_{-6}	$44.1^{+6.3}_{-4.4} \pm 5.8$ †	[3]	$43 \pm 9 \pm 9$	[4]			$43.8^{+7.1}_{-6.3}$
430	$K^+\eta\gamma$	7.9 ± 0.9	$7.7 \pm 1.0 \pm 0.4$	[5]	$8.4 \pm 1.5^{+1.2}_{-0.9}$	[6]			7.9 ± 0.9
431	$K^+\eta'\gamma$	$2.9^{+1.0}_{-0.9}$	$1.9^{+1.5}_{-1.2} \pm 0.1$	[7]	$3.6 \pm 1.2 \pm 0.4$	[8]			$2.9^{+1.0}_{-0.9}$
432	$K^+\phi\gamma$	2.7 ± 0.4	$3.5 \pm 0.6 \pm 0.4$	[9]	$2.48 \pm 0.30 \pm 0.24$	[10]			2.71 ± 0.34
433	$K^+\pi^-\pi^+\gamma$	25.8 ± 1.5	$25.9 \pm 0.7 \pm 1.0$ †¶	[3,11]	$25.0 \pm 1.8 \pm 2.2$ ‡	[4]			25.8 ± 1.1
434	$K^{*0}\pi^+\gamma$ §	23.3 ± 1.2	$23.4 \pm 0.9^{+0.8}_{-0.7}$ †	[3]	$20^{+7}_{-6} \pm 2$	[12]			$23.3^{+1.2}_{-1.1}$
435	$K^+\rho^0\gamma$ §	$8.2 \pm 0.4 \pm 0.8$ †	$8.2 \pm 0.4 \pm 0.8$ †	[3]	< 20	[12]			8.2 ± 0.9
	$(K\pi)_0^{*0}\pi^+\gamma$		$10.3^{+0.7+1.5}_{-0.8-2.0}$ †	[3]					$10.3^{+1.7}_{-2.2}$
436	$K^+\pi^-\pi^+\gamma$ (N.R.) §	< 9.2	$9.9 \pm 0.7^{+1.5}_{-1.9}$ †	[3]	< 9.2	[12]			$9.9^{+1.7}_{-2.0}$
440	$K_0^*(1430)\pi^+\gamma$	$1.32^{+0.09+0.24}_{-0.10-0.30}$ †	$1.32^{+0.09+0.24}_{-0.10-0.30}$ †	[3]					$1.32^{+0.26}_{-0.32}$
437	$K^0\pi^+\pi^0\gamma$	46 ± 5	$45.6 \pm 4.2 \pm 3.1$ †	[11]					45.6 ± 5.2
438	$K_1^+(1400)\gamma$	$9.7^{+4.6+2.9}_{-2.9-2.4}$ †	$9.7^{+4.6+2.9}_{-2.9-2.4}$ †	[3]	< 15	[4]			$9.7^{+5.4}_{-3.8}$
439	$K^{*+}(1410)\gamma$	$27.1^{+5.4+5.9}_{-4.8-3.7}$ †	$27.1^{+5.4+5.9}_{-4.8-3.7}$ †	[3]					$27.1^{+8.0}_{-6.1}$
441	$K_2^*(1430)^+\gamma$	14 ± 4	$13.8^{+3.5+1.5}_{-3.2-1.0}$ †◇	[3,13]					$13.8^{+3.8}_{-3.4}$
442	$K^{*+}(1680)\gamma$	$66.7^{+9.3+14.4}_{-7.8-11.4}$ †	$66.7^{+9.3+14.4}_{-7.8-11.4}$ †	[3]					$66.7^{+17.1}_{-13.8}$
443	$K_3^*(1780)^+\gamma$	< 39			< 39	[6]			< 39
444	$K_3^*(2045)^+\gamma$	< 9900	< 9900 [2]	[14]					< 9900 [2]
445	$\rho^+\gamma$	0.98 ± 0.25	$1.20^{+0.42}_{-0.37} \pm 0.20$	[15]	$0.87^{+0.29+0.09}_{-0.27-0.11}$	[16]			$0.98^{+0.25}_{-0.24}$
495	$p\overline{\Lambda}\gamma$	$2.4^{+0.5}_{-0.4}$			$2.45^{+0.44}_{-0.38} \pm 0.22$	[17]			$2.45^{+0.49}_{-0.44}$
499	$p\overline{\Sigma^0}\gamma$	< 4.6			< 4.6	[18]			< 4.6
534	$\pi^+\ell^+\ell^-$	< 0.049	< 0.066	[19]	< 0.049	[20]			< 0.049
535	$\pi^+e^+e^-$	< 0.080	< 0.125	[19]	< 0.080	[20]			< 0.080
536	$\pi^+\mu^+\mu^-$	$0.0179 \pm 0.0022 \pm 0.0005$	< 0.055	[19]	< 0.069	[20]	$0.0179 \pm 0.0022 \pm 0.0005$	[21]	0.0180 ± 0.0020
537	$\pi^+\nu\overline{\nu}$	< 98	< 100	[22]	< 98	[23]			< 98
538	$K^+\ell^+\ell^-$	0.451 ± 0.023	$0.48 \pm 0.09 \pm 0.02$	[24]	$0.53^{+0.06}_{-0.05} \pm 0.03$	[25]			0.51 ± 0.05
539	$K^+e^+e^-$	0.55 ± 0.07	$0.51^{+0.12}_{-0.11} \pm 0.02$	[24]	$0.57^{+0.09}_{-0.08} \pm 0.03$	[25]			0.55 ± 0.07
540	$K^+\mu^+\mu^-$	0.443 ± 0.024	$0.41^{+0.16}_{-0.15} \pm 0.02$	[24]	$0.53 \pm 0.08^{+0.07}_{-0.03}$	[25]	$0.429 \pm 0.007 \pm 0.021$	[26]	0.435 ± 0.021
541	$K^+\tau^+\tau^-$	< 2250	< 2250	[27]					< 2250
542	$K^+\nu\overline{\nu}$	< 16	< 16	[28]	< 16	[29]			< 16
543	$\rho^+\nu\overline{\nu}$	< 213			< 30	[29]			< 30
	$\pi^+\nu\overline{\nu}$				< 14	[29]			< 14
544	$K^{*+}\ell^+\ell^-$	1.01 ± 0.11	$1.40^{+0.40}_{-0.37} \pm 0.09$	[24]	$1.24^{+0.23}_{-0.21} \pm 0.13$	[25]	$0.924 \pm 0.093 \pm 0.067$	[30]	$1.009^{+0.101}_{-0.100}$
545	$K^{*+}e^+e^-$	$1.55^{+0.40}_{-0.31}$	$1.38^{+0.47}_{-0.42} \pm 0.08$	[24]	$1.73^{+0.50}_{-0.42} \pm 0.20$	[25]			$1.55^{+0.35}_{-0.32}$
546	$K^{*+}\mu^+\mu^-$	0.96 ± 0.10	$1.46^{+0.79}_{-0.75} \pm 0.12$	[24]	$1.11^{+0.32}_{-0.27} \pm 0.10$	[25]	$0.924 \pm 0.093 \pm 0.067$	[30]	$0.958^{+0.107}_{-0.104}$
547	$K^{*+}\nu\overline{\nu}$	< 40	< 64	[28]	< 40	[23]			< 40
548	$K^+\pi^+\pi^-\mu^+\mu^-$	0.44 ± 0.04					$0.436^{+0.029}_{-0.027} \pm 0.028$ [1]	[31]	$0.436^{+0.040}_{-0.039}$
549	$K^+\phi\mu^+\mu^-$	$0.079^{+0.021}_{-0.017}$					$0.082^{+0.019+0.029}_{-0.017-0.027}$	[31]	$0.082^{+0.035}_{-0.032}$

Channels with no RPP# are not reported by PDG.
Results for LHCb are relative BFs converted to absolute BFs.
CLEO upper limits that have been greatly superseded are not shown.
† $M_{K\pi\pi} < 1.8$ GeV/c^2.
‡ $1.0 < M_{K\pi\pi} < 2.0$ GeV/c^2.
§ $M_{K\pi\pi} < 2.4$ GeV/c^2.
¶ Average of *BABAR* results from [3] and [11].
◇ Average of *BABAR* results from [3] and [13].
[1] Differential BF in bins of $m(\mu^+\mu^-)$ is also available.
[2] Result from ARGUS. Cited in the *BABAR* column to avoid adding a column to the table.

Heavy FLavor AVeraging group (HFLAV) - May 2018

Compilation of B^0 Semi-leptonic and Radiative Branching Fractions ($\times 10^{-6}$) - UL at 90% CL

Preliminary Updated results not included in PDG Live as of Dec. 31, 2017

RPP#	Mode	PDG2017 Avg.	*BABAR*		Belle		LHCb		Our Avg.
367	$K^0\eta\gamma$	7.6 ± 1.8	$7.1^{+2.1}_{-2.0} \pm 0.4$	[5]	$8.7^{+3.1+1.9}_{-2.7-1.6}$	[6]			$7.6^{+1.8}_{-1.7}$
368	$K^0\eta'\gamma$	< 6.4	< 6.6	[7]	< 6.4	[8]			< 6.4
369	$K^0\phi\gamma$	2.7 ± 0.7	< 2.7	[9]	$2.74 \pm 0.60 \pm 0.32$	[10]			2.74 ± 0.68
370	$K^+\pi^-\gamma$ §	4.6 ± 1.4			$4.6^{+1.3+0.5}_{-1.2-0.7}$	[12]			4.6 ± 1.4
371	$K^{*0}\gamma$	43.3 ± 1.5	$44.7 \pm 1.0 \pm 1.6$	[1]	$39.6 \pm 0.7 \pm 1.4$	[2]			41.7 ± 1.2
372	$K^*(1410)^0\gamma$	< 130			< 130	[12]			< 130
373	$K^+\pi^-\gamma$ (N.R.) †	< 2.6			< 2.6	[12]			< 2.6
374	$K^{*0}X(214), X(214) \to \mu^+\mu^-$	< 0.0226			< 0.0226	[32]			< 0.0226
375	$K^0\pi^+\pi^-\gamma$	19.9 ± 1.8	$19.2 \pm 1.4 \pm 1.1$ ‡§	[3, 11]	$24 \pm 4 \pm 3$ ¶	[4]			19.7 ± 1.7
376	$K^+\pi^-\pi^0\gamma$	41 ± 4	$40.7 \pm 2.2 \pm 3.1$ ‡	[11]					40.7 ± 3.8
377	$K_1^0(1270)\gamma$	< 58			< 58	[4]			< 58
378	$K_1^0(1400)\gamma$	< 12			< 12	[4]			< 12
379	$K_2^*(1430)^0\gamma$	12.4 ± 2.4	$12.2 \pm 2.5 \pm 1.0$	[13]	$13 \pm 5 \pm 1$	[12]			12.4 ± 2.4
381	$K_3^*(1780)^0\gamma$	< 83			< 83	[6]			< 83
383	$\rho^0\gamma$	0.86 ± 0.15	$0.97^{+0.24}_{-0.22} \pm 0.06$	[15]	$0.78^{+0.17+0.09}_{-0.16-0.10}$	[16]			$0.86^{+0.15}_{-0.14}$
384	$\rho^0X(214), X(214) \to \mu^+\mu^-$	< 0.0173			< 0.0173	[32]			< 0.0173
385	$\omega\gamma$	$0.44^{+0.18}_{-0.16}$	$0.50^{+0.27}_{-0.23} \pm 0.09$	[15]	$0.40^{+0.19}_{-0.17} \pm 0.13$	[16]			$0.44^{+0.18}_{-0.16}$
386	$\phi\gamma$	< 0.1	< 0.85	[33]	< 0.1	[34]			< 0.1
447	$p\bar{\Lambda}\pi^-\gamma$				< 0.65	[35]			< 0.65
503	$\pi^0\ell^+\ell^-$	< 0.053	< 0.053	[19]	< 0.154	[20]			< 0.053
504	$\pi^0e^+e^-$	< 0.084	< 0.084	[19]	< 0.227	[20]			< 0.084
505	$\pi^0\mu^+\mu^-$	< 0.069	< 0.069	[19]	< 0.184	[20]			< 0.069
506	$\eta\ell^+\ell^-$	< 0.064	< 0.064	[19]					< 0.064
507	ηe^+e^-	< 0.108	< 0.108	[19]					< 0.108
508	$\eta\mu^+\mu^-$	< 0.112	< 0.112	[19]					< 0.112
509	$\pi^0\nu\bar{\nu}$	< 69			< 9	[29]			< 9
510	$K^0\ell^+\ell^-$	$0.31^{+0.08}_{-0.07}$	$0.21^{+0.15}_{-0.13} \pm 0.02$	[24]	$0.34^{+0.09}_{-0.08} \pm 0.02$	[25]			$0.31^{+0.08}_{-0.07}$
511	$K^0e^+e^-$	$0.16^{+0.10}_{-0.08}$	$0.08^{+0.15}_{-0.12} \pm 0.01$	[24]	$0.20^{+0.14}_{-0.10} \pm 0.01$	[25]			$0.16^{+0.10}_{-0.08}$
512	$K^0\mu^+\mu^-$	0.339 ± 0.034	$0.49^{+0.29}_{-0.25} \pm 0.03$	[24]	$0.44^{+0.13}_{-0.10} \pm 0.03$	[25]	$0.327 \pm 0.034 \pm 0.017$	[30]	$0.343^{+0.036}_{-0.035}$
513	$K^0\nu\bar{\nu}$	< 49	< 49	[28]	< 26	[29]			< 26
514	$\rho^0\nu\bar{\nu}$	< 208			< 40	[29]			< 40
515	$K^{*0}\ell^+\ell^-$	$0.99^{+0.12}_{-0.11}$	$1.03^{+0.22}_{-0.21} \pm 0.07$	[24]	$0.97^{+0.13}_{-0.11} \pm 0.07$	[25]			$0.99^{+0.13}_{-0.11}$
516	$K^{*0}e^+e^-$	$1.03^{+0.19}_{-0.17}$	$0.86^{+0.26}_{-0.24} \pm 0.05$	[24]	$1.18^{+0.27}_{-0.22} \pm 0.09$	[25]			$1.03^{+0.19}_{-0.17}$
517	$K^{*0}\mu^+\mu^-$	1.03 ± 0.06	$1.35^{+0.40}_{-0.37} \pm 0.10$	[24]	$1.06^{+0.19}_{-0.14} \pm 0.07$	[25]	$1.036^{+0.018}_{-0.017} \pm 0.071$ [1]	[36]	$1.049^{+0.067}_{-0.065}$
518	$K^{*0}X(214), X(214) \to \mu^+\mu^-$	< 0.001					< 0.001	[37]	< 0.001
519	$\pi^+\pi^-\mu^+\mu^-$	$0.021 \pm 0.005 \pm 0.001$					$0.0211 \pm 0.0051 \pm 0.0022$ ◇	[38]	0.0210 ± 0.0060
520	$K^{*0}\nu\bar{\nu}$	< 55	< 120	[28]	< 55	[23]			< 55
523	$\phi\nu\bar{\nu}$	< 127			< 127	[23]			< 127
525	$\pi^0e^\pm\mu^\mp$	< 0.14	< 0.14	[39]					< 0.14
526	$K^0e^\pm\mu^\mp$	< 0.27	< 0.27	[40]					< 0.27
527	$K^{*0}e^+\mu^-$	< 0.53	< 0.53	[40]					< 0.53
528	$K^{*0}e^-\mu^+$	< 0.34	< 0.34	[40]					< 0.34
529	$K^{*0}e^\pm\mu^\mp$	< 0.58	< 0.58	[40]					< 0.58
532	$\Lambda_c^+\mu^-$	< 1.4	< 1.4	[41]					< 1.4
533	$\Lambda_c^+e^-$	< 4	< 4	[41]					< 4

Results for LHCb are relative BFs converted to absolute BFs.
CLEO upper limits that have been greatly superseded are not shown.
† $1.25\ \text{GeV}/c^2 < M_{K\pi} < 1.6\ \text{GeV}/c^2$.
‡ $M_{K\pi\pi} < 1.8\ \text{GeV}/c^2$.
§ Average of *BABAR* results from [3] and [11].
¶ $1.0 < M_{K\pi\pi} < 2.0\ \text{GeV}/c^2$.
◇ This result takes into account the S-wave fraction in the $K\pi$ system.
[1] Muon pairs do not originate from resonances and $0.5 < m(\pi^+\pi^-) < 1.3\ \text{GeV}/c^2$.

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Preliminary Updated results not included in PDG Live as of Dec. 31, 2017

RPP#	Mode	PDG2017 Avg.	*BABAR*		Belle		CLEO		CDF	Our Avg.
67	$K\eta\gamma$	$8.5^{+1.8}_{-1.6}$			$8.5^{+1.3}_{-1.2} \pm 0.9$	[6]				$8.5^{+1.6}_{-1.5}$
68	$K_1(1400)\gamma$	< 1.27					< 1.27	[42]		< 1.27
69	$K_2^*(1430)\gamma$	17^{+6}_{-5}					$17 \pm 6 \pm 1$	[42]		17 ± 6
71	$K_3^*(1780)\gamma$	< 37			< 37 §	[6]				< 37 §
78	$s\gamma$ †	349 ± 19	341^{+28}_{-28} ¶	[43–45]	328^{+20}_{-20} ¶	[46–48]	$329 \pm 44 \pm 29$	[49]		332 ± 15
78	$s\gamma$ ◇		308 ± 22 ¶	[43–45]	305^{+16}_{-16} ¶	[47, 48]				306 ± 12
79	$d\gamma$	9.2 ± 3.0	$9.2 \pm 2.0 \pm 2.3$	[50]						9.2 ± 3.0
85	$\rho\gamma$	1.39 ± 0.25	$1.73^{+0.34}_{-0.32} \pm 0.17$	[15]	$1.21^{+0.24}_{-0.22} \pm 0.12$	[16]				$1.39^{+0.22}_{-0.21}$
86	$\rho/\omega\gamma$	1.30 ± 0.23	$1.63^{+0.30}_{-0.28} \pm 0.16$	[15]	$1.14 \pm 0.20^{+0.10}_{-0.12}$	[16]				$1.30^{+0.18}_{-0.19}$
121	se^+e^- ‡	6.7 ± 1.7	$7.69^{+0.82+0.71}_{-0.77-0.60}$	[51]	$4.05 \pm 1.30^{+0.87}_{-0.83}$	[52]				6.67 ± 0.82
120	$s\mu^+\mu^-$ ‡	4.3 ± 1.0	$4.41^{+1.31+0.63}_{-1.17-0.50}$	[51]	$4.13 \pm 1.05^{+0.85}_{-0.81}$	[52]				$4.27^{+0.98}_{-0.91}$
123	$s\ell^+\ell^-$ ‡	5.8 ± 1.3	$6.73^{+0.70+0.60}_{-0.64-0.56}$	[51]	$4.11 \pm 0.83^{+0.85}_{-0.81}$	[52]				5.84 ± 0.69
124	$\pi\ell^+\ell^-$	< 0.059	< 0.059	[19]	< 0.062	[20]				< 0.059
125	πe^+e^-	< 0.110	< 0.110	[19]						< 0.110
126	$\pi\mu^+\mu^-$	< 0.050	< 0.050	[19]						< 0.050
127	Ke^+e^-	0.44 ± 0.06	$0.39^{+0.09}_{-0.08} \pm 0.02$	[24]	$0.48^{+0.08}_{-0.07} \pm 0.03$	[25]				0.44 ± 0.06
128	$K^*e^+e^-$	1.19 ± 0.20	$0.99^{+0.23}_{-0.21} \pm 0.06$	[24]	$1.39^{+0.23}_{-0.20} \pm 0.12$	[25]				$1.19^{+0.17}_{-0.16}$
129	$K\mu^+\mu^-$	0.44 ± 0.04	$0.41^{+0.13}_{-0.12} \pm 0.02$	[24]	$0.50 \pm 0.06 \pm 0.03$	[25]			$0.42 \pm 0.04 \pm 0.02$	[53] 0.44 ± 0.04
130	$K^*\mu^+\mu^-$	1.06 ± 0.09	$1.35^{+0.35}_{-0.33} \pm 0.10$	[24]	$1.10^{+0.16}_{-0.14} \pm 0.08$	[25]			$1.01 \pm 0.10 \pm 0.05$	[53] 1.06 ± 0.09
131	$K\ell^+\ell^-$	0.48 ± 0.04	$0.47 \pm 0.06 \pm 0.02$	[54]	$0.48^{+0.05}_{-0.04} \pm 0.03$	[25]				0.48 ± 0.04
132	$K^*\ell^+\ell^-$	1.05 ± 0.10	$1.02^{+0.14}_{-0.13} \pm 0.05$	[54]	$1.07^{+0.11}_{-0.10} \pm 0.09$	[25]				1.05 ± 0.10
133	$K\nu\overline{\nu}$	< 17	< 17	[28]	< 16	[29]				< 16
134	$K^*\nu\overline{\nu}$	< 76	< 76	[28]	< 27	[29]				< 27
	$\pi\nu\overline{\nu}$				< 9	[29]				< 9
	$\rho\nu\overline{\nu}$				< 30	[29]				< 30
136	$\pi e^\pm\mu^\mp$	< 0.092	< 0.092	[39]						< 0.092
137	$\rho e^\pm\mu^\mp$	< 3.2					< 3.2	[55]		< 3.2
138	$Ke^\pm\mu^\mp$	< 0.038	< 0.038	[40]						< 0.038
139	$K^*e^\pm\mu^\mp$	< 0.51	< 0.51	[40]						< 0.51

Channels with no RPP# are not reported by PDG.
Results for CDF are relative BFs converted to absolute BFs.
CLEO upper limits that have been greatly superseded are not shown.

† Results extrapolated to $E_\gamma > 1.6$ GeV, using the method of Ref. [56].

‡ Belle: $m(\ell^+\ell^-) > 0.2$ GeV/c^2, *BABAR*: $m^2(\ell^+\ell^-) > 0.1$ GeV$^2/c^4$.

§ The value quoted is $\mathcal{B}(B \to K_3^*\gamma) \times \mathcal{B}(K_3^* \to K\eta)$. PDG gives the BF assuming $\mathcal{B}(K_3^* \to K\eta) = 11^{+5}_{-4}\%$.

¶ Average of several results, obtained with different methods.

◇ Only results originally measured in the interval $E_\gamma > 1.9$ GeV (also taken into account in the previous line).

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

Preliminary Updated results not included in PDG Live as of Dec. 31, 2017

RPP#	Mode	PDG2017 Avg.	*BABAR*		Belle		CDF	LHCb	CMS	ATLAS	Our Avg.
31	$e^+\nu$	< 0.98	< 1.9	[57]	< 0.98 †	[58]					< 0.98 †
32	$\mu^+\nu$	< 1.0	< 1.0	[57]	< 1.07	[59]					< 1.0
33	$\tau^+\nu$	109 ± 24	$183^{+53}_{-49} \pm 24$ ‡	[60]	$125 \pm 28 \pm 27$ ‡	[61]					144 ± 31
34	$\ell^+\nu_\ell\gamma$	< 3.5	< 15.6	[62]	< 3.5	[63]					< 3.5
35	$e^+\nu_e\gamma$	< 6.1	< 17	[62]	< 6.1	[63]					< 6.1
36	$\mu^+\nu_\mu\gamma$	< 3.4	< 24	[62]	< 3.4	[63]					< 3.4
495	$\gamma\gamma$	< 0.32	< 0.32	[64]	< 0.62	[65]					< 0.32
458	e^+e^-	< 0.083	< 0.113	[66]	< 0.19	[67]	< 0.083 [68]				< 0.083
497	$e^+e^-\gamma$	< 0.12	< 0.12	[69]							< 0.12
498	$\mu^+\mu^-$	0.00018 ± 0.00031	< 0.052	[66]	< 0.16	[67]	< 0.0038[70]	< 0.00034 ¶ [71]	< 0.00110 ¶ [72]	$-0.25^{+0.20}_{-0.20}$ ¶ [73]	$0.00039^{+0.00016}_{-0.00014}$ §
499	$\mu^+\mu^-\gamma$	< 0.16	< 0.16	[69]							< 0.16
500	$\mu^+\mu^-\mu^+\mu^-$	< 0.0053						< 0.0053 ¶ [74]			< 0.0053 ¶
501	$SP, S \to \mu^+\mu^-, P \to \mu^+\mu^-$	< 0.0051						< 0.0051 ¶ [74]			< 0.0051 ¶
502	$\tau^+\tau^-$	< 4100	< 4100	[75]				< 1600 [76]			< 1600
524	$e^\pm\mu^\mp$	< 0.0028	< 0.092	[66]	< 0.17	[67]	< 0.064 [68]	< 0.001 [77]			< 0.001
530	$e^\pm\tau^\mp$	< 28	< 28	[78]							< 28
532	$\mu^\pm\tau^\mp$	< 22	< 22	[78]							< 22
521	$\nu\bar{\nu}$	< 24	< 24	[79]	< 130	[80]					< 24
522	$\nu\bar{\nu}\gamma$	< 17	< 17	[79]							< 17

Results for CDF, LHCb, CMS and ATLAS are relative BFs converted to absolute BFs.

† More recent results exist, with hadronic tagging [81], that do not improve the limits (< 3.5 and < 2.7) for $e^+\nu$ and $\mu^+\nu$, respectively).

‡ The authors make the average with their previous results, derived from statistically independent samples [82, 83].

§ This is the combined result obtained by the LHCb and CMS collaborations [84].

¶ UL at 95% CL.

Heavy FLavor AVeraging group (HFLAV) - May 2018

Compilation of B Relative Semi-leptonic and Radiative Branching Fractions

Preliminary Updated results not included in PDG Live as of Dec. 31, 2017

RPP#	Mode	PDG2017 AVG.	Belle	*BABAR*	LHCb	Our Avg.
548/298	$10^4 \times \mathcal{B}(K^+\pi^+\pi^-\mu^+\mu^-)/\mathcal{B}(\psi(2S)K^+)$	$6.95^{+0.46}_{-0.43} \pm 0.34$			$6.95^{+0.46}_{-0.43} \pm 0.34$ [31]	$6.95^{+0.57}_{-0.55}$
549/274	$10^4 \times \mathcal{B}(K^+\phi\mu^+\mu^-)/\mathcal{B}(\psi(2S)K^+)$	$1.58^{+0.36+0.19}_{-0.32-0.07}$			$1.58^{+0.36+0.19}_{-0.32-0.07}$ [31]	$1.58^{+0.41}_{-0.33}$
536/540	$\mathcal{B}(\pi^+\mu^+\mu^-)/\mathcal{B}(K^+\mu^+\mu^-)$ †	$0.053 \pm 0.014 \pm 0.01$			$0.038 \pm 0.009 \pm 0.001$[21]	0.038 ± 0.009
	$\mathcal{B}(K^+\mu^+\mu^-)/\mathcal{B}(K^+e^+e^-)$ ‡			$1.00^{+0.31}_{-0.25} \pm 0.07$ [54]		$1.00^{+0.32}_{-0.26}$
	$\mathcal{B}(K^*\mu^+\mu^-)/\mathcal{B}(K^*e^+e^-)$ §		$0.83 \pm 0.17 \pm 0.08$ [25]			0.83 ± 0.19
	$\mathcal{B}(K^*\mu^+\mu^-)/\mathcal{B}(K^*e^+e^-)$ ¶			$1.013^{+0.34}_{-0.26} \pm 0.010$[54]		$1.013^{+0.340}_{-0.260}$
	$\mathcal{B}(K^{*0}\mu^+\mu^-)/\mathcal{B}(K^{*0}e^+e^-)$ ◇				$0.66^{+0.11}_{-0.07} \pm 0.03$ [85]	$0.66^{+0.11}_{-0.08}$
	$\mathcal{B}(K^{*0}\mu^+\mu^-)/\mathcal{B}(K^{*0}e^+e^-)$ [1]				$0.69^{+0.11}_{-0.07} \pm 0.05$ [85]	$0.69^{+0.12}_{-0.09}$
	$\mathcal{B}(B^0 \to K^{*0}\gamma)/\mathcal{B}(B_s^0 \to \phi\gamma)$		$1.10 \pm 0.16 \pm 0.09 \pm 0.18$ [2]		$1.23 \pm 0.06 \pm 0.11$ [86]	1.21 ± 0.11

Channels with no RPP# are not reported by PDG.

† For $0.1 < m^2(\ell^+\ell^-) < 6.0$ GeV$^2/c^4$.

‡ For $1.0 < m^2(\ell^+\ell^-) < 6.0$ GeV$^2/c^4$.

§ For the full $m^2(\ell^+\ell^-)$ range.

¶ For $0.10 < m^2(\ell^+\ell^-) < 8.12$ GeV$^2/c^4$ and $m^2(\ell^+\ell^-) > 10.11$ GeV$^2/c^4$.

◇ For $0.045 < m^2(\ell^+\ell^-) < 1.1$ GeV$^2/c^4$.

[1] For $1.1 < m^2(\ell^+\ell^-) < 6.0$ GeV$^2/c^4$.

Heavy FLavor AVeraging group (HFLAV) - May 2018

Compilation of Branching Fractions of B^+/B^0 to $\bar{q}$ gluon decays ($\times 10^{-6}$) - UL at 90% CL

Preliminary Updated results not included in PDG Live as of Dec. 31, 2017

RPP#	Mode	PDG2017 Avg.	*BABAR*	Belle	CLEO	Our Avg.
81	ηX	260^{+50}_{-80}		$261 \pm 30^{+44}_{-74}$ [§][87]	< 440 [88]	261^{+53}_{-79}
82	$\eta' X$	420 ± 90	$390 \pm 80 \pm 90$ [†][89]		$460 \pm 110 \pm 60$ [†][90]	423 ± 86
83	$K^+ X$	< 187	< 187 [‡] [91]			< 187 [‡]
84	$K^0 X$	190^{+70}_{-70}	$195^{+51}_{-45} \pm 50$ [‡] [91]			195^{+71}_{-67}
95	$\pi^+ X$	370 ± 80	$372^{+50}_{-47} \pm 59$ [¶] [91]			372^{+77}_{-75}

[†] $2.0 < p^*(\eta') < 2.7$ GeV/c.
[‡] $m_X < 1.69$ GeV/c^2.
[§] $0.4 < m_X < 2.6$ GeV/c^2.
[¶] $m_X < 1.71$ GeV/c^2.

Heavy FLavor AVeraging group (HFLAV) - May 2018

Isospin Asymmetry

Preliminary Updated results not included in PDG Live as of Dec. 31, 2017

Parameter	PDG2017 Avg.	*BABAR*		Belle		LHCb	Our Avg.
$\Delta_{0^-}(X_s\gamma)$	-0.01 ± 0.06	$-0.01^{+0.06}_{-0.06}$ ‡	[43, 92]				-0.01 ± 0.06
$\Delta_{0^+}(K^*\gamma)$	0.052 ± 0.026	$0.066 \pm 0.021 \pm 0.022$	[1]	$0.062 \pm 0.015 \pm 0.006 \pm 0.012$	[2]		0.063 ± 0.017
$\Delta_{\rho\gamma}$	-0.46 ± 0.17	$-0.43^{+0.25}_{-0.22} \pm 0.10$	[15]	$-0.48^{+0.21+0.08}_{-0.19-0.09}$	[16]		$-0.46^{+0.17}_{-0.16}$
$\Delta_{0^-}(K\ell\ell)$ †	-0.13 ± 0.06	$-0.58^{+0.29}_{-0.37} \pm 0.02$	[54]	$-0.31^{+0.17}_{-0.14} \pm 0.08$	[25]	$-0.10^{+0.08}_{-0.09} \pm 0.02$ §[30]	-0.17 ± 0.08
$\Delta_{0^-}(K^*\ell\ell)$ †	-0.45 ± 0.17	$-0.64^{+0.15}_{-0.14} \pm 0.03$	[54]	$0.30^{+0.12}_{-0.11} \pm 0.08$	[25]	$0.00^{+0.12}_{-0.10} \pm 0.02$ § [30]	-0.06 ± 0.07

In some of the B-factory results it is assumed that $\mathcal{B}(\Upsilon(4S) \to B^+B^-) = \mathcal{B}(\Upsilon(4S) \to B^0\overline{B}^0)$, and in others a measured value of the ratio of branching fractions is used. See original papers for details. The averages quoted above are computed naively and should be treated with caution.

† Results given for the bin $1 < m^2(\ell^+\ell^-) < 6$ GeV$^2/c^4$, see references for the other bins.

‡ Average of two independent measurements from *BABAR* [43, 92].

§ Only muons are used.

Heavy FLavor AVeraging group (HFLAV) - May 2018

Compilation of B^+ Semi-leptonic LFV & LNV Branching Fractions ($\times 10^{-6}$) - UL at 90% CL

Preliminary Updated results not included in PDG Live as of Dec. 31, 2017

RPP#	Mode	PDG2017 Avg.	*BABAR*	BELLE	LHCb	Our Avg.
552	$\pi^+ e^\pm \mu^\mp$	< 0.17	< 0.17 [39]			< 0.17
553	$\pi^+ e^+ \tau^-$	< 74	< 74 [93]			< 74
554	$\pi^+ e^- \tau^+$	< 20	< 20 [93]			< 20
555	$\pi^+ e^\pm \tau^\mp$	< 75	< 75 [93]			< 75
556	$\pi^+ \mu^+ \tau^-$	< 62	< 62 [93]			< 62
557	$\pi^+ \mu^- \tau^+$	< 45	< 45 [93]			< 45
558	$\pi^+ \mu^\pm \tau^\mp$	< 72	< 72 [93]			< 72
559	$K^+ e^+ \mu^-$	< 0.091	< 0.091 [40]			< 0.091
560	$K^+ e^- \mu^+$	< 0.13	< 0.13 [40]			< 0.13
561	$K^+ e^\pm \mu^\mp$	< 0.091	< 0.091 [40]			< 0.091
562	$K^+ e^+ \tau^-$	< 43	< 43 [93]			< 43
563	$K^+ e^- \tau^+$	< 15	< 15 [93]			< 15
564	$K^+ e^\pm \tau^\mp$	< 30	< 30 [93]			< 30
565	$K^+ \mu^+ \tau^-$	< 45	< 45 [93]			< 45
566	$K^+ \mu^- \tau^+$	< 28	< 28 [93]			< 28
567	$K^+ \mu^\pm \tau^\mp$	< 48	< 48 [93]			< 48
568	$K^{*+} e^+ \mu^-$	< 1.3	< 1.3 [40]			< 1.3
569	$K^{*+} e^- \mu^+$	< 0.99	< 0.99 [40]			< 0.99
570	$K^{*+} e^\pm \mu^\mp$	< 1.4	< 1.4 [40]			< 1.4
571	$\pi^- e^+ e^+$	< 0.023	< 0.023 [94]			< 0.023
572	$\pi^- \mu^+ \mu^+$	< 0.013	< 0.107 [94]		< 0.004 † [95]	< 0.004 †
573	$\pi^- e^+ \mu^+$	< 0.15	< 0.15 [96]			< 0.15
574	$\rho^- e^+ e^+$	< 0.17	< 0.17 [96]			< 0.17
575	$\rho^- \mu^+ \mu^+$	< 0.42	< 0.42 [96]			< 0.42
576	$\rho^- e^+ \mu^+$	< 0.47	< 0.47 [96]			< 0.47
577	$K^- e^+ e^+$	< 0.03	< 0.03 [94]			< 0.03
578	$K^- \mu^+ \mu^+$	< 0.041	< 0.067 [94]		< 0.041 [97]	< 0.041
579	$K^- e^+ \mu^+$	< 0.16	< 0.16 [96]			< 0.16
580	$K^{*-} e^+ e^+$	< 0.40	< 0.40 [96]			< 0.40
581	$K^{*-} \mu^+ \mu^+$	< 0.59	< 0.59 [96]			< 0.59
582	$K^{*-} e^+ \mu^+$	< 0.30	< 0.30 [96]			< 0.30
583	$D^- e^+ e^+$	< 2.6	< 2.6 [96]	< 2.6 [98]		< 2.6
584	$D^- e^+ \mu^+$	< 1.8	< 2.1 [96]	< 1.8 [98]		< 1.8
585	$D^- \mu^+ \mu^+$	< 0.69	< 1.7 [96]	< 1.1 [98]	< 0.69 [99]	< 0.69
586	$D_s^- \mu^+ \mu^+$	< 0.58			< 0.58 [99]	< 0.58
587	$\bar{D}^0 \pi^- \mu^+ \mu^+$	< 1.5			< 1.5 [99]	< 1.5
589	$\Lambda^0 \mu^+$	< 0.06	< 0.06 [41]			< 0.06
590	$\Lambda^0 e^+$	< 0.032	< 0.032 [41]			< 0.032
591	$\bar{\Lambda}^0 \mu^+$	< 0.06	< 0.06 [41]			< 0.06
592	$\bar{\Lambda}^0 e^+$	< 0.08	< 0.08 [41]			< 0.08

Results for LHCb are relative BFs converted to absolute BFs.
CLEO upper limits that have been greatly superseded are not shown.
† UL at 95% CL.

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