Average Hadron Multiplicities in Hadronic e^+e^- Annihilation Events

Table 37.1: Average hadronic multiplicities per hadronic e^+e^- annihilation event at $\sqrt{s} \approx 10$, 29–35, and 91 GeV. The rates given include decay products from resonances with $c\tau < 10$ cm, and include charge conjugated states. (Updated July 1999 by O. Biebel.)

Particle	$\sqrt{s} \approx 10$ GeV		$\sqrt{s} = 29$–35 GeV		$\sqrt{s} = 91$ GeV	
Pseudoscalar mesons:						
π^+	6.6	$\pm$ 0.2	10.3	$\pm$ 0.4	16.99	$\pm$ 0.27
π^0	3.2	$\pm$ 0.3	5.83	$\pm$ 0.28	9.45	$\pm$ 0.53
K^+	0.90	$\pm$ 0.04	1.48	$\pm$ 0.09	2.242	$\pm$ 0.063
K^0	0.91	$\pm$ 0.05	1.48	$\pm$ 0.07	2.013	$\pm$ 0.033
η	0.20	$\pm$ 0.04	0.61	$\pm$ 0.07	0.971	$\pm$ 0.030
$\eta\prime(958)$	0.03	$\pm$ 0.01	0.26	$\pm$ 0.10	0.156	$\pm$ 0.021
D^+	0.16	$\pm$ 0.03	0.17	$\pm$ 0.03	0.175	$\pm$ 0.016
D^0	0.37	$\pm$ 0.06	0.45	$\pm$ 0.07	0.454	$\pm$ 0.030
D_s^+	0.13	$\pm$ 0.02	0.45	$\pm$ 0.20 [a]	0.131	$\pm$ 0.021
B^+, B_d^0		—		—	0.165	$\pm$ 0.026 [b]
B_s^0		—		—	0.057	$\pm$ 0.013 [b]
Scalar mesons:						
$f_0(980)$	0.024	$\pm$ 0.006	0.05	$\pm$ 0.02 [c]	0.146	$\pm$ 0.012
$a_0(980)^\pm$		—		—	0.27	$\pm$ 0.11 [d]
Vector mesons:						
$\rho(770)^0$	0.35	$\pm$ 0.04	0.81	$\pm$ 0.08	1.231	$\pm$ 0.098
$\rho(770)^\pm$		—		—	2.40	$\pm$ 0.43 [d]
$\omega(782)$	0.30	$\pm$ 0.08		—	1.08	$\pm$ 0.12
$K^*(892)^+$	0.27	$\pm$ 0.03	0.64	$\pm$ 0.05	0.715	$\pm$ 0.059
$K^*(892)^0$	0.29	$\pm$ 0.03	0.56	$\pm$ 0.06	0.738	$\pm$ 0.024
$\phi(1020)$	0.044	$\pm$ 0.003	0.085	$\pm$ 0.011	0.0963	$\pm$ 0.0032
$D^*(2010)^+$	0.22	$\pm$ 0.04	0.43	$\pm$ 0.07	0.183	$\pm$ 0.010
$D^*(2007)^0$	0.23	$\pm$ 0.06	0.27	$\pm$ 0.11		—
$D_s^*(2112)^+$		—		—	0.101	$\pm$ 0.048 [f]
B^* [e]		—		—	0.288	$\pm$ 0.026
$J/\psi(1S)$		—		—	0.0052	$\pm$ 0.0004 [g]
$\psi(2S)$		—		—	0.0023	$\pm$ 0.0004 [g]
$\Upsilon(1S)$		—		—	0.00014	$\pm$ 0.00007 [g]
Pseudovector mesons:						
$\chi_{c1}(3510)$		—		—	0.0041	$\pm$ 0.0011 [g]
Tensor mesons:						
$f_2(1270)$	0.09	$\pm$ 0.02	0.14	$\pm$ 0.04	0.166	$\pm$ 0.020
$f_2'(1525)$		—		—	0.012	$\pm$ 0.006
$K_2^*(1430)^+$		—	0.09	$\pm$ 0.03		—
$K_2^*(1430)^0$		—	0.12	$\pm$ 0.06	0.084	$\pm$ 0.022 [g]
B^{**} [h]		—		—	0.118	$\pm$ 0.024
Baryons:						
p	0.253	$\pm$ 0.016	0.640	$\pm$ 0.050	1.048	$\pm$ 0.045
Λ	0.080	$\pm$ 0.007	0.205	$\pm$ 0.010	0.374	$\pm$ 0.009
Σ^0	0.023	$\pm$ 0.008		—	0.070	$\pm$ 0.012
Σ^-		—		—	0.083	$\pm$ 0.018
Σ^+		—		—	0.099	$\pm$ 0.015
$\Sigma^\pm$		—		—	0.174	$\pm$ 0.009
Ξ^-	0.0059	$\pm$ 0.0007	0.0176	$\pm$ 0.0027	0.0258	$\pm$ 0.0010
$\Delta(1232)^{++}$	0.040	$\pm$ 0.010		—	0.085	$\pm$ 0.014
$\Sigma(1385)^-$	0.006	$\pm$ 0.002	0.017	$\pm$ 0.004	0.0240	$\pm$ 0.0017
$\Sigma(1385)^+$	0.005	$\pm$ 0.001	0.017	$\pm$ 0.004	0.0239	$\pm$ 0.0015
$\Sigma(1385)^\pm$	0.0106	$\pm$ 0.0020	0.033	$\pm$ 0.008	0.0462	$\pm$ 0.0028
$\Xi(1530)^0$	0.0015	$\pm$ 0.0006		—	0.0055	$\pm$ 0.0005
Ω^-	0.0007	$\pm$ 0.0004	0.014	$\pm$ 0.007	0.0016	$\pm$ 0.0003
Λ_c^+	0.100	$\pm$ 0.030 [i]	0.110	$\pm$ 0.050	0.078	$\pm$ 0.017
Λ_b^0		—		—	0.031	$\pm$ 0.016
$\Sigma_c^{++}, \Sigma_c^0$	0.014	$\pm$ 0.007		—		—
$\Lambda(1520)$	0.008	$\pm$ 0.002		—	0.0213	$\pm$ 0.0028

All average multiplicites are per hadronic e^+e^- annihilation event.

(a) B($D_s \to \eta\pi$, $\eta'\pi$) was used (RPP94).

(b) The Standard Model B($Z \to b\overline{b}$) = 0.217 was used.

(c) $x_p = p/p_{\rm beam} > 0.1$ only.

(d) Both charge states.

(e) Any charge state (*i.e.*, B_d^*, B_u^*, or B_s^*).

(f) B($D_s^* \to D_S^+\gamma$), B($D_s^+ \to \phi\pi^+$), B($\phi \to K^+K^-$) have been used (RPP98).

(g) B($Z \to$ hadrons) = 0.699 was used (RPP94).

(h) Any charge state (*i.e.*, B_d^{**}, B_u^{**}, or B_s^{**}).

(i) The value was derived from the cross section of $\Lambda_c^+ \to p\pi K$, assuming the branching fraction to be $(3.2 \pm 0.7)\%$ (RPP92).

References:

RPP92: Phys. Rev. **D45** (1992) and references therein

RPP94: Phys. Rev. **D50**, 1173 (1994) and references therein

RPP96: Phys. Rev. **D54**, 1 (1996) and references therein

RPP98: Eur. Phys. J. **C3**, 1 (1998) and references therein

R. Marshall, Rep. Prog. Phys. **52**, 1329 (1989)

A. De Angelis, J. Phys. **G19**, 1233 (1993) and references therein

ALEPH: D. Buskulic *et al.*: Phys. Lett. **B295**, 396 (1992); Z. Phys. **C64**, 361 (1994); **C69**, 15 (1996); **C69**, 379 (1996); **C73**, 409 (1997); and R. Barate *et al.*: Z. Phys. **C74**, 451 (1997); Phys. Reports **294**, 1 (1998); Eur. Phys. J. **C5**, 205 (1998)

ARGUS: H. Albrecht *et al.*: Phys. Lett. **230B**, 169 (1989); Z. Phys. **C44**, 547 (1989); **C46**, 15 (1990); **C54**, 1 (1992); **C58**, 199 (1993); **C61**, 1 (1994); Phys. Rep. **276**, 223 (1996)

CELLO: H.J. Behrend *et al.*: Z. Phys. **C46**, 397 (1990); **C47**, 1 (1990)

CLEO: D. Bortoletto *et al.*, Phys. Rev. **D37**, 1719 (1988)

Crystal Ball: Ch. Bieler *et al.*, Z. Phys. **C49**, 225 (1991)

DELPHI: P. Abreu *et al.*: Z. Phys. **C57**, 181 (1993); **C59**, 533 (1993); **C61**, 40 7(1994); **C65**, 587 (1995); **C67**, 543 (1995); **C68**, 353 (1995); **C73**, 61 (1996); Nucl. Phys. **B444**, 3 (1995); Phys. Lett. **B341**, 109 (1994); **B345**, 598 (1995); **B361**, 207 (1995); **B372**, 172 (1996); **B379**, 309 (1996); **B416**, 233 (1998); **B449**, 364 (1999); Eur. Phys. J. **C6**, 19 (1999); **C5**, 585 (1998); W. Adam *et al.*: Z. Phys. **C69**, 561 (1996); **C70**, 371 (1996)

HRS: S. Abachi *et al.*, Phys. Rev. Lett. **57**, 1990 (1986); and M. Derrick *et al.*, Phys. Rev. **D35**, 2639 (1987)

L3: M. Acciarri *et al.*: Phys. Lett. **B328**, 223 (1994); **B345**, 589 (1995); **B371**, 126 (1996); **B371**, 137 (1996); **B393**, 465 (1997); **B404**, 390 (1997); **B407**, 351 (1997); **B407**, 389 (1997), erratum ibid. **B427**, 409 (1998); **B453**, 94 (1999);

MARK II: H. Schellman *et al.*, Phys. Rev. **D31**, 3013 (1985); and G. Wormser *et al.*, Phys. Rev. Lett. **61**, 1057 (1988)

JADE: W. Bartel *et al.*, Z. Phys. **C20**, 187 (1983); and D.D. Pietzl *et al.*, Z. Phys. **C46**, 1 (1990)

OPAL: R. Akers *et al.*: Z. Phys. **C63**, 181 (1994); **C66**, 555 (1995); **C67**, 389 (1995); **C68**, 1 (1995); and G. Alexander *et al.*: Phys. Lett. **B358**, 162 (1995); Z. Phys. **C70**, 197 (1996); **C72**, 1 (1996); **C72**, 191 (1996); **C73**, 569 (1997); **C73**, 587 (1997); Phys. Lett. **B370**, 185 (1996); and K. Ackerstaff *et al.*: Z. Phys. **C75**, 192 (1997); Phys. Lett. **B412**, 210 (1997); Eur. Phys. J. **C1**, 439 (1998); **C4**, 19 (1998); **C5**, 1 (1998); **C5**, 411 (1998);

PLUTO: Ch. Berger *et al.*, Phys. Lett. **104B**, 79 (1981)

SLD: K. Abe, Phys. Rev. **D59**, 052001 (1999)

TASSO: H. Aihara *et al.*, Z. Phys. **C27**, 27 (1985)

TPC: H. Aihara *et al.*, Phys. Rev. Lett. **53**, 2378 (1984)