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

**Table 38.1:** 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 September 1997 by O. Biebel.)

| Particle | $\sqrt{s} \approx 10$ GeV | | $\sqrt{s} = 29$–$35$ GeV | | $\sqrt{s} = 91$ GeV | |
|---|---|---|---|---|---|---|
| **Pseudoscalar mesons:** | | | | | | |
| $\pi^+$ | 6.6 | ± 0.2 | 10.3 | ± 0.4 | 17.1 | ± 0.4 |
| $\pi^0$ | 3.2 | ± 0.3 | 5.83 | ± 0.28 | 9.42 | ± 0.56 |
| $K^+$ | 0.90 | ± 0.04 | 1.48 | ± 0.09 | 2.39 | ± 0.12 |
| $K^0$ | 0.91 | ± 0.05 | 1.48 | ± 0.07 | 2.013 | ± 0.033 |
| $\eta$ | 0.20 | ± 0.04 | 0.61 | ± 0.07 | 0.97 | ± 0.10 |
| $\eta'(958)$ | 0.03 | ± 0.01 | 0.26 | ± 0.10 | 0.222 | ± 0.040 |
| $D^+$ | 0.16 | ± 0.03 | 0.17 | ± 0.03 | 0.175 | ± 0.016 |
| $D^0$ | 0.37 | ± 0.06 | 0.45 | ± 0.07 | 0.454 | ± 0.030 |
| $D_s^+$ | 0.13 | ± 0.02 | 0.45 | ± 0.20 [a] | 0.131 | ± 0.021 |
| $B^+, B_d^0$ | | — | | — | 0.165 | ± 0.026 [b] |
| $B_s^0$ | | — | | — | 0.057 | ± 0.013 [b] |
| **Scalar mesons:** | | | | | | |
| $f_0(980)$ | 0.024 | ± 0.006 | 0.05 | ± 0.02 [c] | 0.14 | ± 0.06 [d] |
| **Vector mesons:** | | | | | | |
| $\rho(770)^0$ | 0.35 | ± 0.04 | 0.81 | ± 0.08 | 1.28 | ± 0.14 |
| $\omega(782)$ | 0.30 | ± 0.08 | | — | 1.10 | ± 0.13 |
| $K^*(892)^+$ | 0.27 | ± 0.03 | 0.64 | ± 0.05 | 0.715 | ± 0.059 |
| $K^*(892)^0$ | 0.29 | ± 0.03 | 0.56 | ± 0.06 | 0.747 | ± 0.028 |
| $\phi(1020)$ | 0.044 | ± 0.003 | 0.085 | ± 0.011 | 0.109 | ± 0.007 |
| $D^*(2010)^+$ | 0.22 | ± 0.04 | 0.43 | ± 0.07 | 0.183 | ± 0.010 |
| $D^*(2007)^0$ | 0.23 | ± 0.06 | 0.27 | ± 0.11 | | — |
| $B^*$ [e] | | — | | — | 0.288 | ± 0.026 |
| $J/\psi(1S)$ | | — | | — | 0.0053 | ± 0.0004 [f] |
| $\psi(2S)$ | | — | | — | 0.0023 | ± 0.0004 [f] |
| $\Upsilon(1S)$ | | — | | — | 0.00014 | ± 0.00007 [f] |
| **Pseudovector mesons:** | | | | | | |
| $\chi_{c1}(1P)$ | | — | | — | 0.0041 | ± 0.0011 [f] |
| **Tensor mesons:** | | | | | | |
| $f_2(1270)$ | 0.09 | ± 0.02 | 0.14 | ± 0.04 | 0.31 | ± 0.12 |
| $f_2'(1525)$ | | — | | — | 0.020 | ± 0.008 |
| $K_2^*(1430)^+$ | | — | 0.09 | ± 0.03 | | — |
| $K_2^*(1430)^0$ | | — | 0.12 | ± 0.06 | 0.19 | ± 0.07 [g] |
| $B^{**}$ [h] | | — | | — | 0.118 | ± 0.024 |
| **Baryons:** | | | | | | |
| $p$ | 0.253 | ± 0.016 | 0.640 | ± 0.050 | 0.964 | ± 0.102 |
| $\Lambda$ | 0.080 | ± 0.007 | 0.205 | ± 0.010 | 0.372 | ± 0.009 |
| $\Sigma^0$ | 0.023 | ± 0.008 | | — | 0.070 | ± 0.012 |
| $\Sigma^-$ | | — | | — | 0.071 | ± 0.018 |
| $\Sigma^+$ | | — | | — | 0.099 | ± 0.015 |
| $\Sigma^\pm$ | | — | | — | 0.174 | ± 0.009 |
| $\Xi^-$ | 0.0059 | ± 0.0007 | 0.0176 | ± 0.0027 | 0.0258 | ± 0.0010 |
| $\Delta(1232)^{++}$ | 0.040 | ± 0.010 | | — | 0.085 | ± 0.014 |
| $\Sigma(1385)^-$ | 0.006 | ± 0.002 | 0.017 | ± 0.004 | 0.0240 | ± 0.0017 |
| $\Sigma(1385)^+$ | 0.005 | ± 0.001 | 0.017 | ± 0.004 | 0.0239 | ± 0.0015 |
| $\Sigma(1385)^\pm$ | 0.0106 | ± 0.0020 | 0.033 | ± 0.008 | 0.0462 | ± 0.0028 |
| $\Xi(1530)^0$ | 0.0015 | ± 0.0006 | | — | 0.0055 | ± 0.0005 |
| $\Omega^-$ | 0.0007 | ± 0.0004 | 0.014 | ± 0.007 | 0.0016 | ± 0.0003 |
| $\Lambda_c^+$ | 0.100 | ± 0.030 [i] | 0.110 | ± 0.050 | 0.078 | ± 0.017 |
| $\Lambda_b^0$ | | — | | — | 0.031 | ± 0.016 |
| $\Sigma_c^{++}, \Sigma_c^0$ | 0.014 | ± 0.007 | | — | | — |
| $\Lambda(1520)$ | 0.008 | ± 0.002 | | — | | — |

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

(a) B($D_s \to \eta\pi,\ \eta'\pi$) has been used (RPP 1994).

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

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

(d) Extrapolation to the unobserved region using the shape predicted by JETSET.

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

(f) B($Z \to$ hadrons) = 0.699 has been used (RPP 1994).

(g) $x_E = E[K_2^*(1430)^0]/E_{\rm beam} < 0.3$ only.

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

(i) The value was taken from the cross section of the $\Lambda_c^+ \to p\pi K$, assuming the branching fraction to be (3.2 ± 0.7)% (RPP 1992).

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