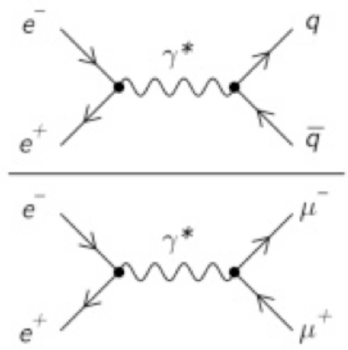
Hadron-to-muon branching ratio for e^-e^+ annihilation:

$$R = \frac{\sigma(e^-e^+ \to \text{hadrons})}{\sigma(e^-e^+ \to \mu^-\mu^+)} \approx$$



$$\approx \frac{\sum_i AQ_i^2}{AQ_\mu^2}$$

The e^-e^+ annihilation will produce a particle-antiparticle pair of either leptons or quarks. The probability or cross-section for each type of pair can be computed using QED (with the dominant contribution coming from the lowest order Feynman diagrams shown above). In general, these cross-sections σ are a function of total collision energy E, however, for sufficiently large E (well above the production threshold $2M_ic^2$) $\sigma_i \approx AQ_i^2$. Thus, the ratio R provides a measure of the number of different types of quarks. The original quark model predicted 3 quarks with charges 2/3, −1/3, and −1/3 which should give R = 2/3. The observed value of R ≈ 2 when total energy < 3 GeV is experimental evidence for the 3 distinct versions (i.e., colors) for each quark type. (The J/ψ peak marks the appearance of a fourth quark).