8.701

Introduction to Nuclear and Particle Physics

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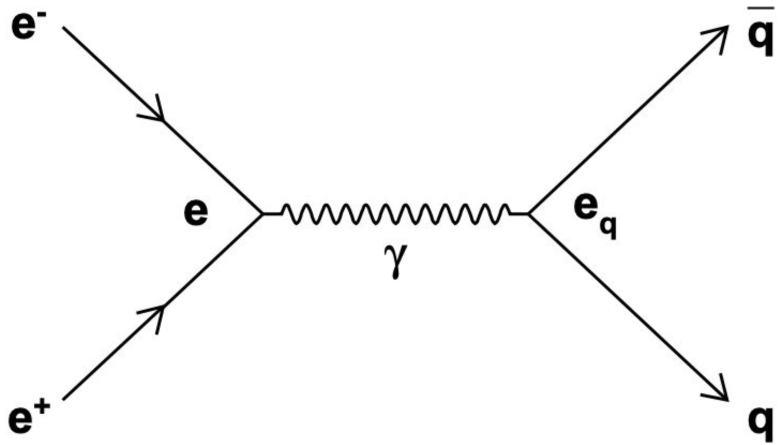
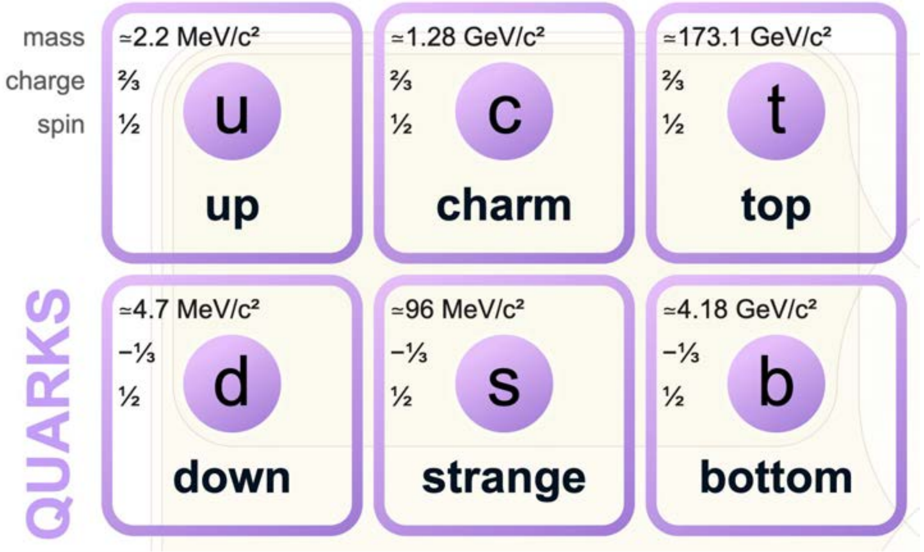
5. QCD

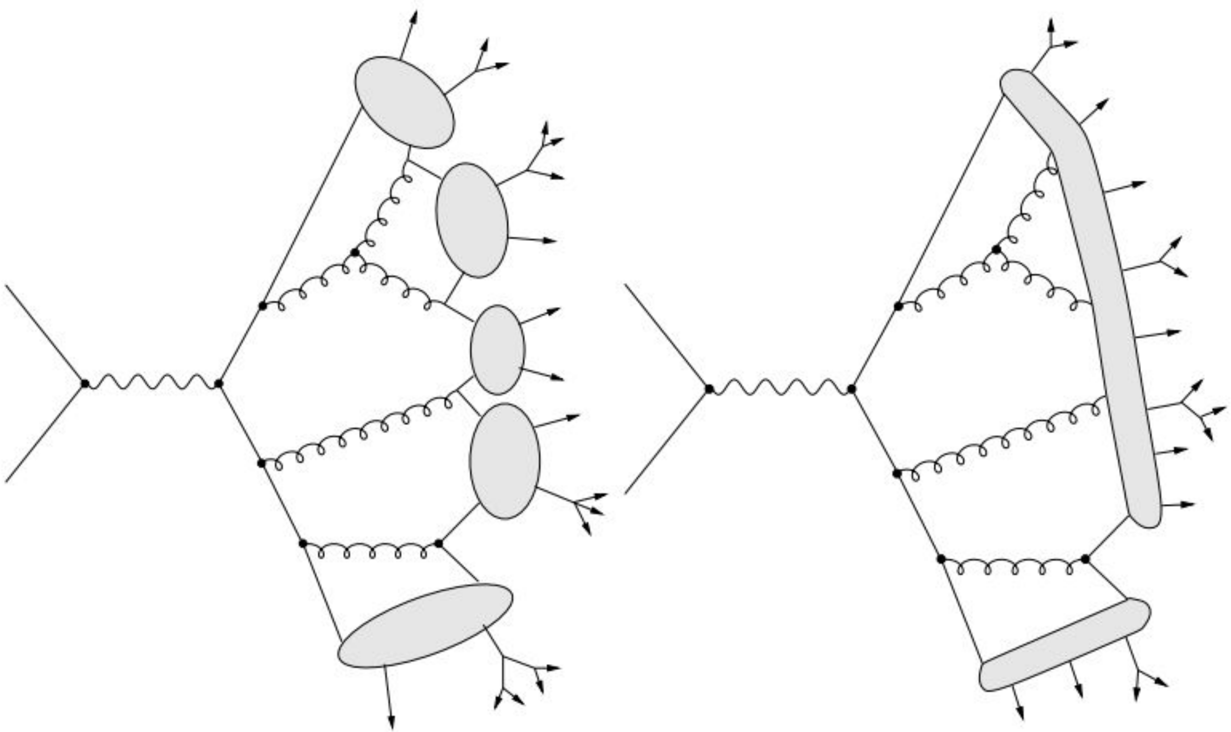
5.1 Hadron Production

Production of Quark Pairs



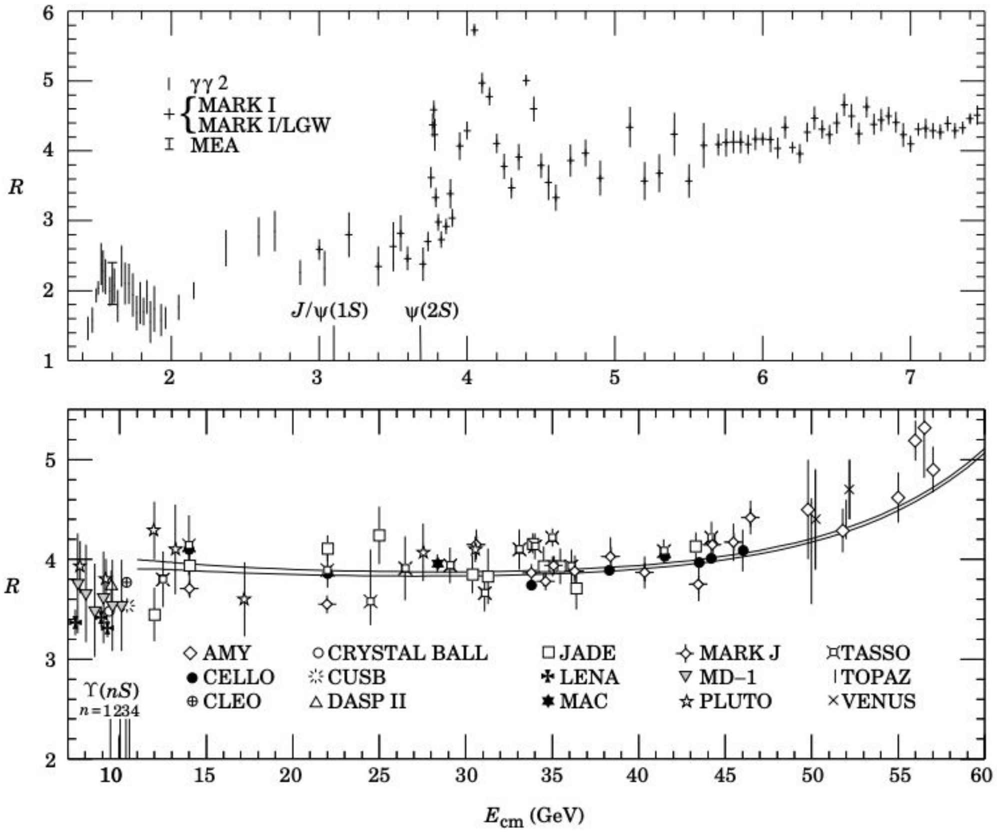


Hadronization



R-ratio

$$R = \frac{\sigma_H}{\sigma_{\mu\mu}}$$



R-ratio at leading order

Discussion of leading order cross sections

$$\sigma_0^{e^+e^-\to\mu^+\mu^-} = \frac{4\pi\alpha_{em}}{3s} \qquad \sigma_0^{e^+e^-\to q\bar{q}} = \frac{4\pi\alpha_{em}}{3s} e_q^2 N_c$$

$$R = \frac{\sigma^{e^+e^-\to\text{hadrons}}}{\sigma^{e^+e^-\to\mu^+\mu^-}} = N_c \sum_q e_q^2$$

R-ratio at leading order

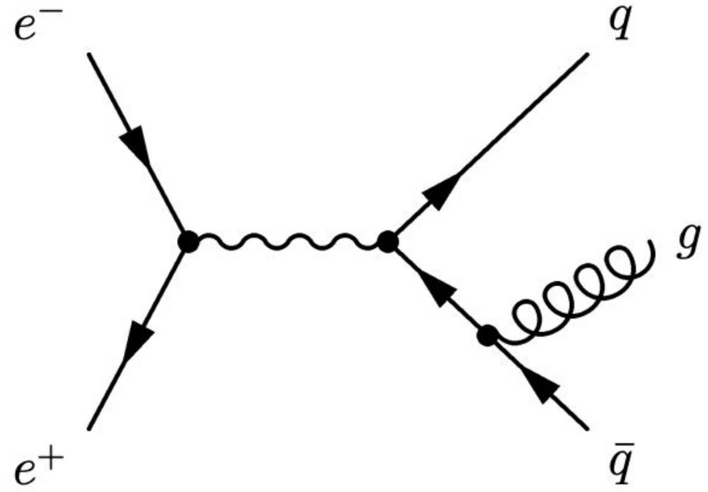
Example for center of mass energy between

$2m_bc^2 \sim 10$ GeV and $2m_tc^2 \sim 350$ GeV.

R = 3* $\frac{4}{9} + \frac{1}{9} + \frac{1}{9} + \frac{4}{9} + \frac{1}{9}$ = 11/3

Good agreement experiment and clear evidence for color.

R-ratio at higher order



$$R = R_0 + R_1^{q\bar{q}} + R_1^{q\bar{q}g} = R_0 \left(1 + \frac{\alpha_s(\mu)}{\pi}\right)$$