Homework Exercises for
QCD and Collider Physics IV
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summer term 2007

Exercises for Lecture 3 (14. May 2007)

- leftover from last week:

  • show that a four-vector can be expressed in terms of $m_t = \sqrt{p+t^2+m^2}$ and rapidity $y = \frac{1}{2}\log\frac{E+p_z}{E-p_z}$ as:

$$p^\mu = (p_x, p_y, p_z, E) = (p_t \sin\phi, p_t \cos\phi, m_t \sinh y, m_t \cosh y)$$

  • show that for massless parton we have:

$$p_t^2 = \frac{\hat{u}\hat{t}}{\hat{s}}$$

  • calculate the Matrix element for
  $q\bar{q} \to q\bar{q}$
  $q\bar{q}' \to q\bar{q}'$
  $gg \to q\bar{q}$

  • show that the cross section for jet production in hadron collision can be written as:

$$\frac{d^2\sigma}{dyd^2P_T} = \frac{1}{16\pi^2 s}\sum\int\frac{dx_1}{x_1}\frac{dx_2}{x_2}f_i(x_1,\mu^2)f_j(x_2,\mu^2)\overline{\sum}|\mathcal{M}(ij\to kl)|^2\frac{1}{1+\delta_{kl}}\delta(\hat{s}+\hat{t}+\hat{u})$$

  express phase space in terms of y and p_t.
  Show that using the laboratory rapidites of the outgoing partons y_3, y_4 we obtain:

$$\frac{d^2\sigma}{dy_3dy_4d^2P_T} = \frac{1}{16\pi^2 s}\sum\int\frac{1}{x_1}\frac{1}{x_2}f_i(x_1,\mu^2)f_j(x_2,\mu^2)\overline{\sum}|\mathcal{M}(ij\to kl)|^2\frac{1}{1+\delta_{kl}}$$

- Multiparton Interactions: use $p(x_t) = \frac{1}{\sigma_{nd}}\frac{d\sigma}{dx_t}$ and

$$P_1 = p(x_{t1})\exp\left(-\int_{x_{t1}}^1 p(x')dx'\right)$$

  to show that

$$P_N = p(x_{tN})\frac{1}{(N-1)!}\left(\int_{x_{tn}}^1 p(x')dx'\right)^{N-1}\exp\left(-\int_{x_{t2}}^{x_{t1}} p(x')dx'\right)$$