

Hand-in exercises in the course QCD@Colliders, HT 2006

3. QCD in electron-positron annihilation

A*. **Calculate** the differential cross-section $\frac{d\sigma}{dx_1 dx_2}(e^+e^- \rightarrow q\bar{q}g)$ at tree-level using Feynman gauge. See the final project in part I of Peskin and Schröder, page 259, for more hints. For the trace-calculations you may use a computer-algebra program such as FORM or REDUCE.

B. **Show that** in the limit where the gluon momentum k is soft or collinear with the anti-quark p_2 such that $m^2 = (p_2 + k)^2 \rightarrow 0$ the cross-section for $e^+e^- \rightarrow q\bar{q}g$ becomes

$$\frac{d\sigma}{dm^2 dx_2}(e^+e^- \rightarrow q\bar{q}g) \propto \frac{1 + x_2^2}{m^2(1 - x_2)}$$

C. **Show that** the BLM scale for the total e^+e^- cross-section at NLO is given by

$$\mu_{\text{BLM}} = \sqrt{s} \exp\left(2\zeta_3 - \frac{11}{4}\right)$$

D. **Plot** how the boundaries between the 2- and 3-jet regions looks in the k_{\perp} -algorithm for $y = 0.1$ and compare to the JADE algorithm assuming that the three initial jets are massless.

E. **What is** the minimal thrust value with three massless partons?