QCD and Monte Carlos

University Antwerp 2015

Exercises for Lecture 2 (15. Oct 2015)

6. use the LHAPDF library to calculate the flavor sum rules:

$$\int_0^1 dx\ u_V(x, Q^2) = 2$$

$$\int_0^1 dx\ d_V(x, Q^2) = 1$$

use the LHAPDF library and calculate the momentum sum rule:

$$\int_0^1 dx \sum_{i=-6}^{6} x p_i(x, Q^2)$$

use the MRST (MRST2004nlo) set and the LO* (MRST2007lomod) set. How much is the momentum sum rule violated in the LO* set ? Is the momentum sum rule satisfied (or violated in the same way) for different Q^2 values (use $Q^2 = 5, 10, 100, 1000$ GeV^2).

7. use the Monte Carlo method to generate x, y and Q^2 according to the cross section in DIS: $\frac{d^2\sigma}{dydQ^2} = \frac{2\pi\alpha^2}{y\, Q^4}(1 + (1-y)^2)F_2(x)$ using $F_2 = \sum_i e_i^2 x q(x)$ with both MRST sets from above.
Use $xys = Q^2$ with $\sqrt{s} = 320$ GeV and $y_{min} = 0.001$, $y_{max} = 0.9$, $Q^2_{min} = 5$ GeV^2, $Q^2_{max} = 100$ GeV^2. Plot the differential cross section $\frac{d\sigma}{dy}$ ($\frac{d\sigma}{dQ^2}$) normalised to nb (nb/GeV^2, respectively) and integrate the cross section to obtain the total cross section within the visible range specified above.

8. Calculate $\sigma(\gamma^* g \to q\bar{q})$ using the matrix element and flux and phase space factors. Plot the differential cross section as a function of p_t of one of the outgoing quarks. Use $\sqrt{s} = 320$ GeV, $y = 0.3$, $Q^2 = 10$ GeV^2 and $|t_{min}| = 1$ GeV^2. Use 4 flavours and take $x_g = 0.01$, $|u_{min}| = 1$ GeV^2 and a fixed $\alpha_s = 0.3$ (for the formulas look in lecture writeup).

9. Calculate $\sigma(\gamma^* p \to q\bar{q} + X)$ using the results from before with a gluon density $xg(x) = 3(1-x)^5$. Calculate $x_{g\ min} = \frac{\hat{s}_{min} + Q^2}{ys}$, with $\hat{s}_{min} = 10$ GeV^2 being the minimal center of mass energy squared for the $q\bar{q}$ pair (for the formulas look in lecture writeup).

10. Plot the cross section $\frac{d\sigma}{dp_t}$ for $\gamma^* p \to q\bar{q} + X$ as a function of p_t using the full matrix element and also using the small t approximation. What is different, and where ?

11. Construct a program to calculate the cross section for $ep \to e' q\bar{q} X$. Use $0.05 < y < 0.8$ and $5 < Q^2 < 100$ GeV^2, define the photon flux and use all the other parameters as above.