QCD and Monte Carlos

University Antwerp 2015

Exercises for Lecture 5 (17. Nov 2015)

continue with exercises from Lecture 4

14. Calculate $\sigma(p + p \to h)$ (Higgs production via gluon fusion) in lowest order. Take $\sqrt{s} =$ 7000 GeV. Calculate the total cross section, and plot x_1, x_2 and y_h. Require $120 < m_h <$ 130 GeV. Plot the transverse momenta of the incoming partons. Use for simplicity parton density of the form $xg(x) = 3(1 - x)^5$.
The Higgs cross section is:

$$\sigma(g + g \to h) = \alpha_s^2 \frac{\sqrt{2}}{\pi} \frac{G_F}{576}$$

with $G_F = 1.166 \cdot 10^{-5}$ GeV^{-1} and $\alpha_s = 0.1$.
Use a Breit-Wigner form for the Higgs:

$$P(m) = \frac{1}{2\pi} \frac{\Gamma_h}{(m - m_h)^2 + \Gamma_h^2/4}$$

with $m_h = 125$ GeV and $\Gamma_h = 0.02$ GeV (upper limit measured from CMS, the theoretical width is $\Gamma_h \sim 4$ MeV, but this is not appropriate for the simulation we use here for efficiency reasons) Calculate the cross section.
Include in the calculation a small intrinsic transverse momentum from both of the incoming partons. Assume $h(k_t) = \exp(-bk_t^2)$. Using $b = 1$ corresponds to a gauss distribution with $\mu = 0$ and $\sigma \sim 0.7$. Plot the transverse momentum k_t and the transverse momentum squared k_t^2 of both incoming partons and the resulting h.
Write the code in a modular way, such that it can be used for the last exercise.

Repeat the same for $\sigma(p + p \to \gamma^* \to l^+ l^-)$ (Drell-Yan) in lowest order. Assume 4 quark species and a $\sqrt{s} = 7000$ GeV. Require $70 < m_{\gamma^*} < 110$ GeV (around the mass of the Z_0). Plot the invariant mass distribution m_{γ^*} of the virtual photon. Plot also the transverse momenta of the incoming partons. Use for simplicity a form which is similar to a gluon $xg(x) = 3(1 - x)^5$

15. Use the evolved pdf (from previous exercise) to calculate higgs production from above. Set the scale $t = 10000$ GeV^2. Use for simplicity the a gluon density $xg(x) = 3(1-x)^5$ as a starting distribution and use P_{gg}. Calculate the transverse momentum of the incoming partons and calculate the transverse momentum of the Higgs. Plot the x-values of the incoming partons and the transverse momenta.

    Repeat the same exercise for Drell-Yan production and use P_{qq} instead of P_{gg}. What is the difference ?