PHYSICS AT THE TERA SCALE
Helmholtz Alliance

Exercises 3 (18. August 2020)

8. 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^{-2} 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 $\Gamma_h = 0.4$ GeV. 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.

9. 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.