

## Exercises 3 (20. March 2024)

8. Calculate  $\sigma(p + p \rightarrow h)$  (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:

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

with  $G_F = 1.166 \cdot 10^{-5} \text{ GeV}^{-2}$  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  $t = 10000 \text{ GeV}^2$ . 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.