Physics at the LHC

1 Introduction: Exercises for the 1st lecture.

1. a) Estimate the minimum energy for the new particles production, with mass M, at the collider with proton beams, with energy E, and in the collisions with a stationary target, with mass m. (We assume \( M \gg m \)).

   b) The collision energy in the center-of-mass frame of protons at the LHC is 13 TeV. What should be the energy of the proton beam for equivalent collision on an accelerator with a stationary target?

2. How long does it take for a proton and an electron with the kinetic energy, \( E_k \), of 5 MeV to cover 3m distance?

3. In Tevatron, protons and antiprotons collide with the energies of 1 TeV. What is the number of their interactions per 1s, if the total cross-section of proton-antiproton for these energies is 75 mb. The luminosity is \( 5 \times 10^{31} \text{sm}^{-2}\text{s}^{-1} \).

   The luminosity of the LHC is \( 10^{34} \text{sm}^{-2}\text{s}^{-1} \), some process has the production cross-section 20 fb. How many events are produced for 4 months?

4. (Discussion) The collisions should be going in 8 points in the collider ring with constant frequency. What is the minimum number of injected bunches needed to resolve the requirement? And how they should be injected.

2 Physics basics: Exercises for the 2nd lecture.

1. Show, that for highly relativistic particles rapidity \( \approx \) pseudorapidity.