Exercises Physics VI (Nuclei and Particles)
Summer Semester 2009

Exercise sheet Nr. 2   Work out until 07.05.2008

Exercise 1: Lorentz transformation and Compton scattering   (Points: 3)

The polarization of the electron beam in the HERA storage ring is measured using Compton scattering of photons from a laser. The photons used in the measurement have energy $E_\gamma = 2.41$ eV and are emitted head-on to the electrons of energy $E_e = 27.5$ GeV.

a) How large is the photon energy in the electron rest frame?

b) What is the energy in the electron rest frame for photons which are emitted at 90° and 180°?

c) What are the energies and angles of those photons in the laboratory system?

Exercise 2: Energy loss and multiple scattering   (Points: 2)

Electrons with momentum of 1 GeV/c hit a lead foil ($\rho = 11.35$ g/cm³, A = 207 g/Mol) at 90°. The foil is 0.05 radiation lenghts thick ($X_0 = 0.56$ cm).

a) How large is the mean deflection angle θ_{rms} of electrons due to multiple scattering after traversing the foil? What is the amount of energy which is lost by an electron due to Bremsstrahlung?

b) Compare the energy loss of electrons due to the Bremsstrahlung with the loss due to ionisation. Neglect density corrections in calculations.

Exercise 3: Cross section   (Points: 2)

Draw a sketch of elastic scattering of a point-like particles on a sphere. Demonstrate that due to angular momentum conservation the incoming and outcoming angle are of the same size. Calculate the differential cross section using the formula

$$\frac{d\sigma}{d\Omega} = \frac{b}{\sin\theta} \cdot \left| \frac{db}{d\theta} \right|,$$

where b is the impact parameter and θ is the scattering angle defined between the momenta of incoming and outcoming particles.

From the differential cross section determine also total cross section. What is the geometrical meaning of this result?

Exercise 4: Luminosity (Points: 1)

The *pp* collider LHC is currently coming into operation at CERN in Geneva. In the 26.7 km long ring there are 2808 bunches protons in both directions. Each bunch contains $1.1 \cdot 10^{11}$ protons. Bunches collide with a center of mass energy of 14 TeV, the overlap area has an effective radius of 33 μm. What is the luminosity of collider? How many events per day are expected for a process with a cross section of 30 pb (expected cross section for the production of alow mass Higgs)?