Chapter 1

Exercises

Exercise 1: Electromagnetic shower in calorimeters

Calculate the average number of particles in an electromagnetic shower initiated by a 50 GeV photon, after 10, 13 and 20 cm of crossed iron.
Hint: search for the radiation length of the iron on the PDG.

Searching on Particle Data Group[a], we find for e^-:

$$X_0^{\text{Fe}} = 1.757 \text{ cm} \tag{1.1}$$
$$E_C^{\text{Fe}} = 21.68 \text{ MeV} \tag{1.2}$$

So, until the energy of the product particles is lower than the critical energy E_C, we have:

$$N(x) = 2^{\frac{x}{X_0^{\text{Fe}}}} \tag{1.3}$$

We find these values:

$$N(x = 10 \text{ cm}) \approx 52 \tag{1.4}$$
$$N(x = 13 \text{ cm}) \approx 169 \tag{1.5}$$
$$N(x = 20 \text{ cm}) \approx N(x \approx 19.6 \text{ cm}) \approx 2306 \tag{1.6}$$

We note that for $x = 20$ cm, the critical energy has already been reached at $x \approx 19.6$ cm, so the number of product particles has to be computed at this distance with Eq. 1.3.

[a] `http://pdg.lbl.gov/2010/AtomicNuclearProperties/HTML_PAGES/026.html`

Exercise 2: Energy loss of muons

A muon of 100 GeV energy crosses without being absorbed a detector whose mass is mainly due to the hadronic calorimeter and to the muon detector. The thickness of the crossed material can be considered as a layer of 3 m of iron. Determine:

- **What is the dominant energy loss process.**
- **The average loss of the muon inside the detector.**

Hint: look at the energy loss picture of muons.