

# Life of a Particle : Passage of Particles Through Matter

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## 1 Why do we see muons on Earth?

Cosmic rays colliding with air in the upper atmosphere (10,000 km) produce muons. The lifetime of the muon is  $\tau_\mu = 2.2 \times 10^{-6}$  s.

A rough estimation on their average distance would be in the order of 600 m.

**Question A:** Accounting for relativistic effects, what is the average distance a muon of kinetic energy  $E_\mu = 2$  GeV will cover?

**Question B:** What would be this distance for pions?

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*Data:*

The total kinetic energy of a particle of rest mass  $m_0$  and velocity  $v$  is given by:

$$E = mc^2 = \sqrt{pc^2 + m_0^2 c^4} \quad (1)$$

with  $p$  the momentum of the particle,  $p = m_0 v \gamma$

The relativistic factor  $\gamma$  is defined by:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (2)$$

where  $c$  is the speed of light.

The muon has a rest mass of  $m_\mu = 105$  MeV.

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## 2 Stopping power

Calculate the stopping power of 5 MeV  $\alpha$ -particles in air.