Part 1 Bethe-Bloch formula Muons in iron

$\rho := 7.87$ density in g /cm^3

$A := 55.85$

$Z := 26$

$m_{\mu} := 106$ muon mass MeV/c^2

$I := 0.0000135 \cdot Z$

$m_e := .511$ electron mass MeV/c^2

$$\beta(p) := \frac{p}{\sqrt{p^2 + m_{\mu}^2}}$$

$$\gamma(p) := \frac{1}{\sqrt{\left(1 - \beta(p)^2\right)}}$$

$$E_{ion}(p) := 0.307 \cdot \rho \cdot \left(\frac{Z}{A}\right) \cdot \left(\frac{1}{\beta(p)^2}\right) \cdot \left[ \ln\left[\frac{\left(2 \cdot m_e \cdot \beta(p)^2 \cdot \gamma(p)^2\right)}{I}\right] - \beta(p)^2 \right]$$ MeV/ cm

Some values to compare $\frac{\text{MeV}}{\text{cm}}$

$E_{ion}(30) = 81.565$

$E_{ion}(300) = 11.599$

$E_{ion}(3000) = 15.388$

$E_{ion}(10000) = 18.078$

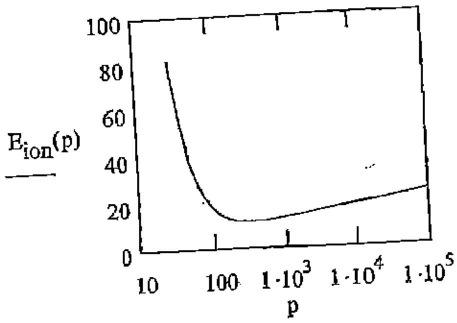
$E_{ion}(30000) = 20.547$

$E_{ion}(100000) = 23.255$

$dp := 10$ $\quad p_{start} := 30$

$p := p_{start}, p_{start} + dp .. 100000$

Energy Loss MeV/cm




muon momentum MeV/c

MCS of muons in iron    see section 10.6 and 10.7 in handout

$$X_0 := 716.4\cdot\frac{A}{\left[Z\cdot(Z+1)\cdot\ln\left(\left(\frac{287}{\sqrt{Z}}\right)\right)\right]}$$

Radiation length in g cm^-2 units (equation 10.18)

$X_0 = 14.141$ g cm^-2

$$X_a := \frac{X_0}{\rho}$$

radiation length cm

$X_a = 1.797$ cm

$Q := 1$ charge on muon units e

$t := 1.0$ Thickness of material in cms

Multiple scattering angle

$$\theta(p) := \frac{13.6}{(\beta(p)\cdot p)}\cdot Q\sqrt{\left(\frac{t}{X_a}\right)}\cdot\left(1 + \cancel{0.38}\ 0.038\cdot\ln\left(\frac{t}{X_a}\right)\right)$$

radians

$\theta(500) =$ ~~0.016~~ 0.020 radians

$\theta(1000) =$ ~~$7.93\times10^{-3}$~~ $9.98\times10^{-3}$

$\theta(3000) =$ ~~$2.63\times10^{-3}$~~ $3.31\times10^{-3}$

The quantity $\theta$ is the sigma of a gaussian distribution. We will see how to use this in later lectures.