Bethe - Bloch ionization formula

$$-\frac{dE}{dx} = 4\pi N_A r_e^2 m_e c^2 z^2 \frac{Z}{A}\frac{1}{\beta^2}\left[\ln\left(\frac{2m_e c^2\beta^2}{I\cdot(1-\beta^2)}\right) - \beta^2 - \frac{\delta}{2}\right],$$

N_A = Avogadro number = $6.022\cdot 10^{23}$ mol^{-1}

r_e = classical electron radius = 2.818×10^{-15} m

m_e = elecztron mass = $0.511\ \mathrm{MeV/c}^2$

z = charge number of penetrating particle

Z = atomic mass of absorber

A = atomic number of absorber ($\mathrm{g}\cdot\mathrm{mol}^{-1}$)

δ = density effect correction

I = mean ionization energy ~ $16\cdot \mathrm{Z}^{0.9}$ eV