Heavy Charged Particle Interactions

\[ \Delta E = \frac{4m}{M} K_0 \Rightarrow \text{energy transfer during a collision} \]

Small energy transfer, essentially undeflected needs millions of collisions to stop & travel a straight path

What affects atomic interactions?

Electron density \( \propto \) atomic \( \# \) \( Z \)

Charge of particle/\( \# \) of charges \( \Rightarrow \) Coulomb Force

\[ \Delta P \text{ of electron} = \text{Impulse} = \int F dt = F_{ave} \Delta t \]

\[ \Rightarrow \Delta P \Rightarrow \text{interaction time inversely proportional to } v \]

Bethe-Bloch Equation

\[ \frac{dE}{dx} = \left( \frac{e^2}{4\pi \varepsilon_0} \right) \left( \frac{4\pi Z^2 N_a e^2}{m_e v^2 A} \right) \ln \left( \frac{2m_e v^2}{I} \right) \]

\[ = C_i \frac{Z^2}{v^2} \ln(c_2 v^2) \]

Protons in water

\[ \frac{dE}{dx} = \text{rate of energy loss = Stopping Power} \]

But: Bragg peak \( \Rightarrow \) as \# of interactions increases, particle speed decreases

\( \Rightarrow \) interaction time increases \( \Rightarrow Z \text{eff} \) ?

NIST website \( \Rightarrow \) Radiation & dosimetry data \( \Rightarrow \) Stopping power tables

SRIM \( \rightarrow \) Program to calculate stopping power

Range = distance traveled through material