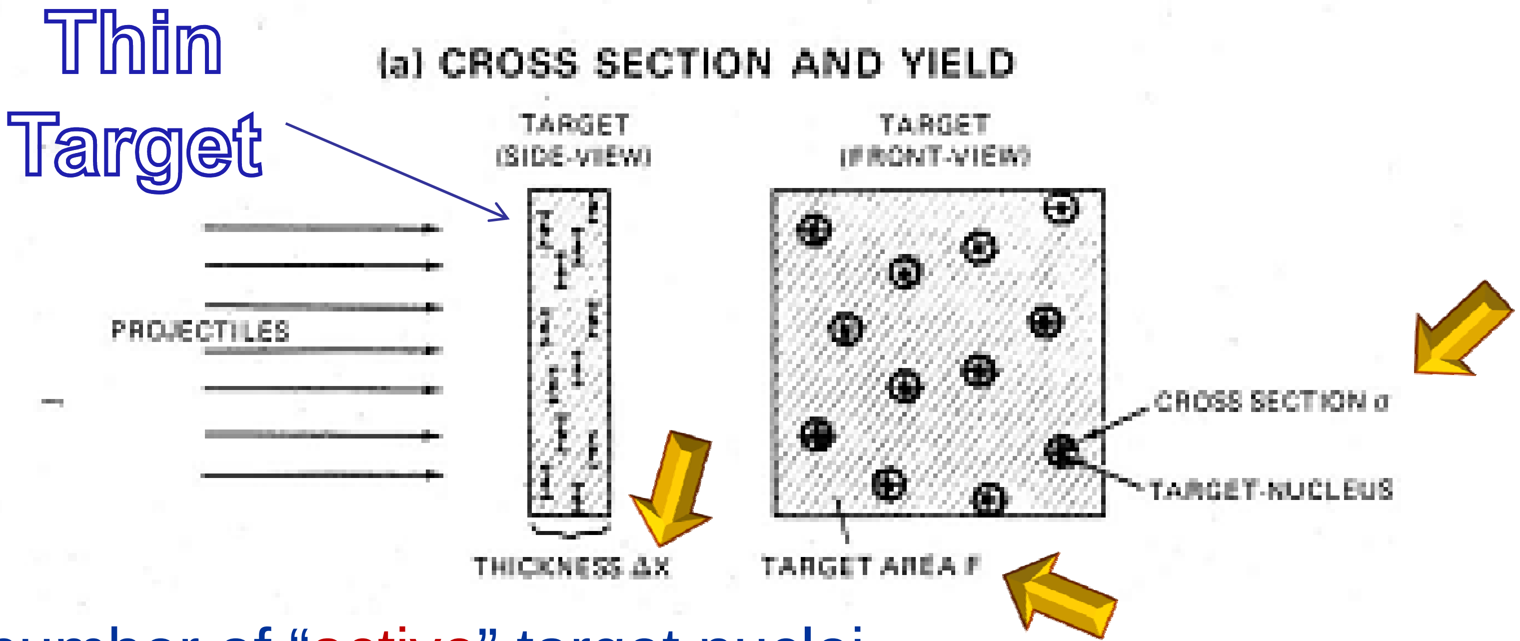
Target Properties and Reaction Yield



- n_0 = number of "active" target nuclei.
- $F_{act} = n_0 \sigma$
- $n_a = n_0 / F \Delta X$ = number of active target nuclei per unit volume.
- Reaction yield per incident particle $Y = F_{act} / F = n_0 \sigma / F = \sigma n_a \Delta X$
- $n_a \Delta X \equiv N_a$, number of active nuclei per unit area.
- For a **solid target** containing **only** active nuclei $n_a = \nu \rho N_A / A$
- ν = number of atoms per molecule.

Gas target?

Target Properties and Reaction Yield

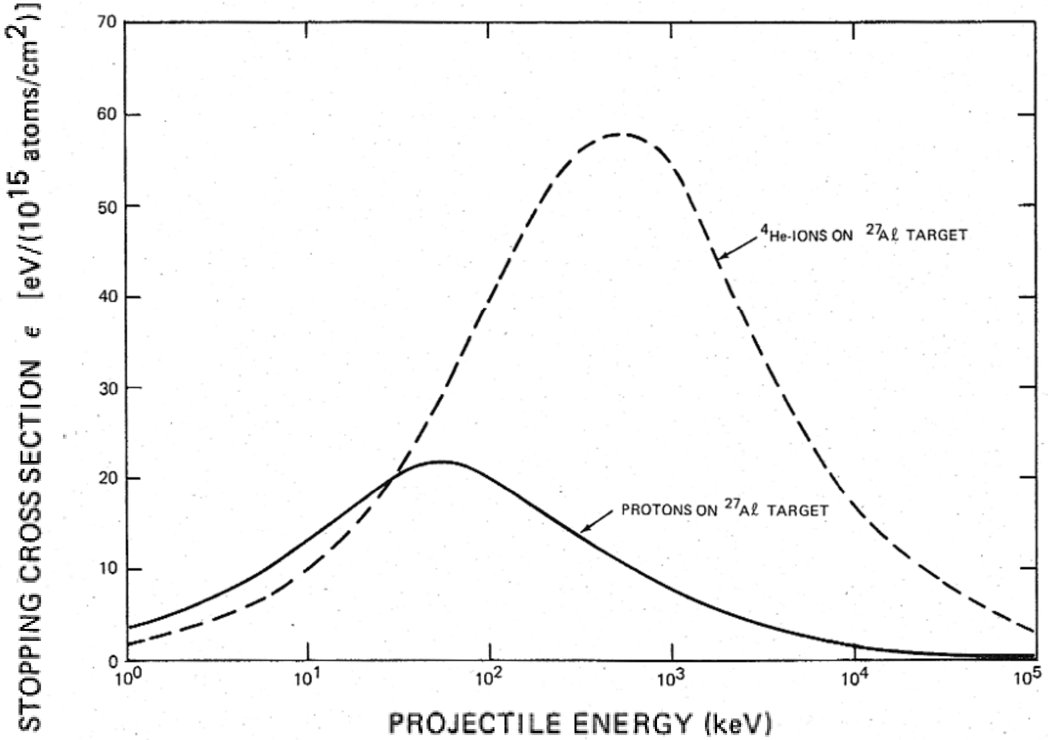
- Stopping power $S(E) = -\,dE/dX$ $(\mathrm{keV/cm}$ or $\mathrm{keV\ cm^2/g})$
- Stopping cross section $\varepsilon = dE/(n\,dX)$ $(\mathrm{keV\ cm^2/atoms})$

$$\epsilon = 1.66 \times 10^{-24} A S(E) \quad \mathrm{eV\ atoms^{-1}\ cm^2}$$

- Or simply take dX in units of cm, g/cm^2 or $atoms/cm^2$.

- Or consider Δ, the target thickness in energy units.

Compare SRIM



Target Properties and Reaction Yield

Compound $X_a Y_b$

Stoichiometry

$$\varepsilon = a\varepsilon(X) + b\varepsilon(Y)$$

$$S(E) = w_a S_x(E) + w_b S_y(E)$$

$$w_a = \frac{aA_x}{aA_x + bA_y}, \qquad w_b = \frac{bA_y}{aA_x + bA_y}$$

Bragg's rule is an approximation which neglects binding effects.

Compare SRIM

Target Properties and Reaction Yield

- *Thin target Yield* $= \sigma n_a \Delta X = \sigma \Delta / \varepsilon$ for "pure active" target.
- If the target contains active and inactive (inert) nuclei:

$$Y = \sigma \frac{\Delta_{\mathrm{eff}}}{\epsilon_{\mathrm{eff}}}$$

$$\Delta_{\mathrm{eff}} = N_a \epsilon_a + \Sigma_i N_i \epsilon_i$$

$$\epsilon_{\mathrm{eff}} = \epsilon_a + \frac{1}{N_a} \Sigma_i N_i \epsilon_i = \frac{\Delta_{\mathrm{eff}}}{N_a}$$

Active

$$\mathrm{Ta_2O_5}$$

$$\epsilon_{\mathrm{eff}} = \epsilon_{\mathrm{O}} + \tfrac{2}{5}\epsilon_{\mathrm{Ta}}$$

$$N_a = n_a \Delta X = \frac{\nu_a \rho N_A \Delta X}{A} = \nu_a N_{molecules}$$

$$N_i = \nu_i N_{molecules}$$

$$\varepsilon = \frac{N_a}{N_{molecules}} \varepsilon_a + \sum_i \frac{N_i}{N_{molecules}} \varepsilon_i$$

$$\varepsilon_{eff} = \varepsilon \frac{N_{molecules}}{N_a} = \frac{\Delta_{eff}}{N_a}$$