(16.1) In a small linear accelerator containing 30 stages, He^{2+} ions are accelerated by a 150 kV, 100 MHz RF source. The ions are used to bombard a metal target to induce a specific reaction. (a) What is the proper length of the last drift tube? (b) What is the maximum projectile energy achieved? (c) What is the heaviest target in which a nuclear transformation can be induced (no tunneling)?

Basic definitions of units and constants:

$q_e := 1.6021773 \cdot 10^{-19} \cdot coul$ $\quad c_{light} := 299792458 \cdot m \cdot sec^{-1}$ $\quad MeV := 1.60217733 \cdot 10^{-13} \cdot joule$

$amu := 1.6605402 \cdot 10^{-27} \cdot kg$ $\quad N_A := 6.0221367 \cdot 10^{23} \cdot mole^{-1}$

$M_e := 5.485799 \cdot 10^{-4} \cdot \frac{gm}{mole}$ $\quad M_{He} := 4.002603 \cdot \frac{gm}{mole}$

Data for the accellerator:

$E_{acc} := 150 \cdot KV$ $\quad n_{stages} := 30$ $\quad z := 2$ $\quad f_{RF} := 100 \cdot MHz$

$\lambda := \frac{c_{light}}{f_{RF}}$ $\quad m_0 := \frac{M_{He} - z \cdot M_e}{N_A}$ $\quad m_0 = 6.645 \cdot 10^{-27} \cdot kg$

Calculations:

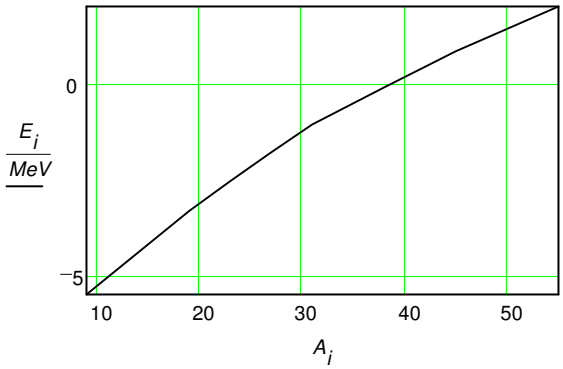
(a) $k_x := \frac{q_e \cdot z \cdot E_{acc}}{m_0 \cdot c_{light}^2}$ $\quad L_{30} := \frac{\lambda}{2} \cdot \sqrt{1 - \left(n_{stages} \cdot k_x + 1\right)^{-2}}$ $\quad L_{30} = 10.398 \cdot cm$

(b) $E_{proj} := n_{stages} \cdot E_{acc} \cdot z \cdot q_e$ $\quad E_{proj} = 9 \cdot MeV$

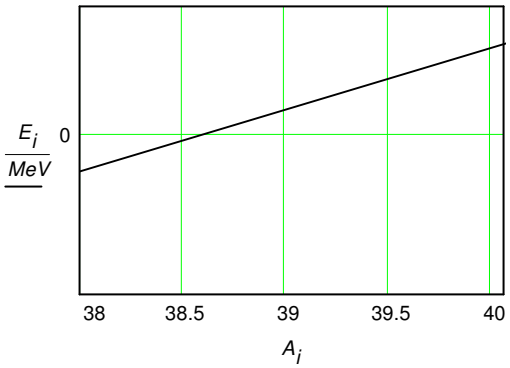
(c) $A_1 := 4$ $\quad Z_1 := 2$ $\quad i := 1..8$ Make a Table of possible targets and test each value:

$A_i :=$	$Z_i :=$
9	4
19	9
23	11
27	13
31	15
38	18
45	21
55	25

eqn.(12.14) $E_i := \left[1.109 \cdot \left(A_1 + A_i\right) \cdot \frac{Z_1 \cdot Z_i}{A_i \cdot \left[A_1^{\frac{1}{3}} + \left(A_i\right)^{\frac{1}{3}} \right]} - 9 \right] \cdot MeV$



Heaviest target about ^{38}Ar (Z for A from Table above)


$\frac{E_i}{MeV}$
0
38
38.5
39
39.5
40
A_i