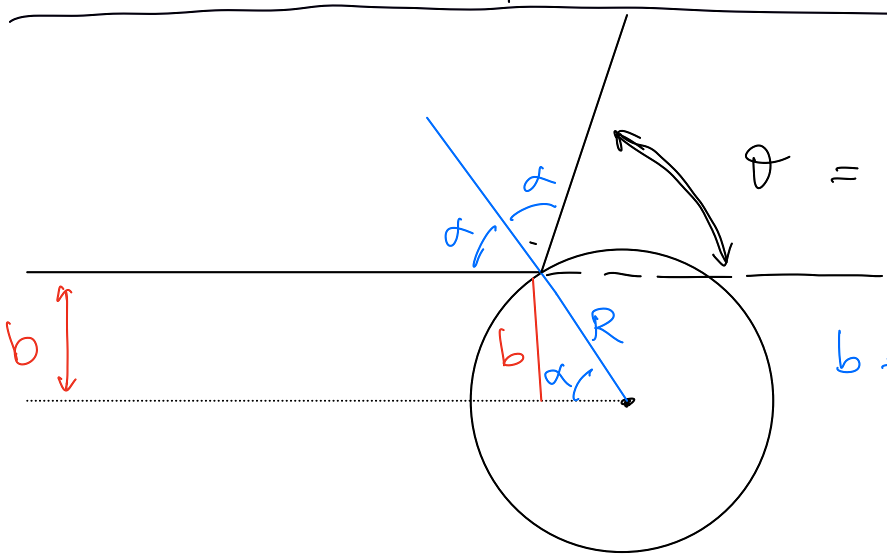
Token 989 256

Sezione d'urto per la sfera rigida



$\theta = \pi - 2\alpha$ . .

$\alpha = \frac{\pi - \theta}{2} = \frac{\pi}{2} - \frac{\theta}{2}$

$b = R . \sin\alpha .$

$\sin\alpha = \cos\frac{\theta}{2}$

$b \longleftrightarrow \theta$

$$\frac{d\sigma(\theta,\varphi)}{d\Omega} = \left|\frac{db}{d\theta}\right| \frac{b}{\sin\theta}$$

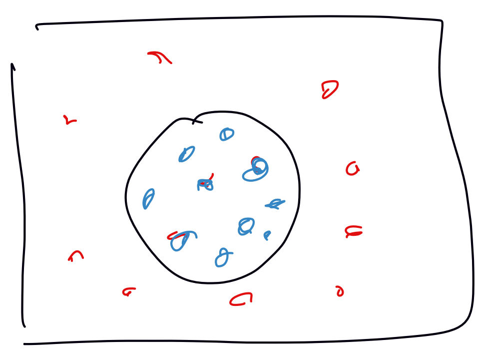
$$b = R\cos\frac{\theta}{2}$$

$$\frac{db}{d\theta} = -\frac{R}{2}\sin\frac{\theta}{2} \qquad \sin\theta = \sin\left(2\,\frac{\theta}{2}\right) = 2\sin\frac{\theta}{2}\cos\frac{\theta}{2}$$

$$\frac{d\sigma}{d\Omega} = \frac{R}{2}\cancel{\sin\frac{\theta}{2}}\;\frac{R\cancel{\cos\frac{\theta}{2}}}{2\cancel{\sin\frac{\theta}{2}}\cancel{\cos\frac{\theta}{2}}} = \frac{R^2}{4}$$

$$\sigma_{tot} = \int \frac{d\sigma}{d\Omega}\,d\Omega = \int_0^{\pi} \frac{R^2}{4}\sin\theta\, d\theta \int_0^{2\pi} d\varphi = \frac{R^2}{4}\,4\pi$$

$$= \pi R^2$$



Fine 800

nuovi tipi di radiazione

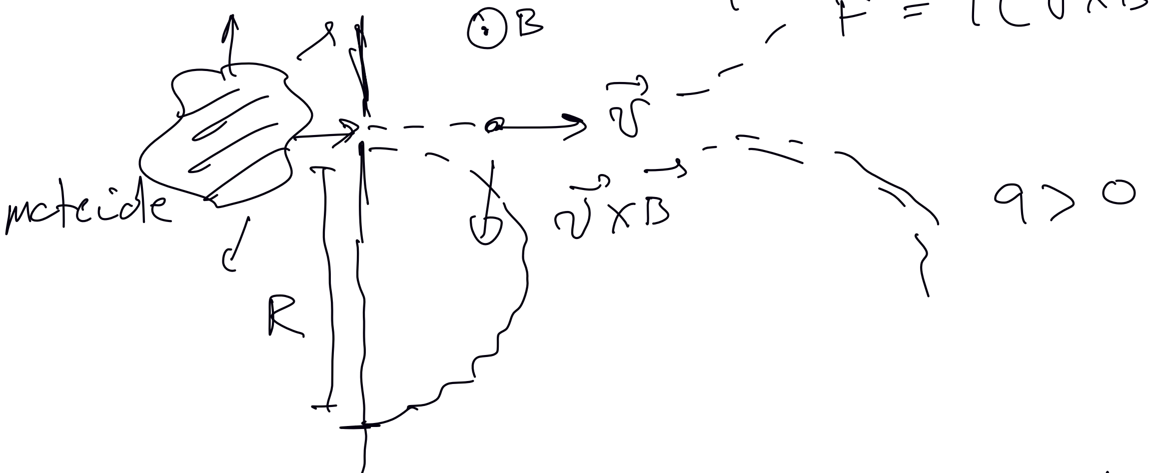
- raggi X   fotoni   KeV
- raggi β elettroni
- raggi γ fotoni   MeV
- raggi α particelle molto penetranti

$K = 3-7$ MeV   particelle cariche

$m \simeq 3.7$ GeV $\alpha = {}^{4}_{2}He$

Bromuro di Radio

$q<0$ $\vec{F} = q(\vec{v}\times\vec{B}) = ma$



Uranio	Z = 92		$\tau_{1/2}$	A − Z
U_{238}		99% in natura	4.5×10^{9} anni	146
U_{235}		1% in natura	700×10^{6} anni	143

Radio	Z = 88	$\tau_{1/2}$
	A = 223	11.4 gg
	224	3.6 gg

$\tau_{SS} \simeq 5\times10^{9}$ anni

$m = 3.7$ GeV $\qquad K \simeq 5$ MeV

$K = E - m = (\gamma - 1) m \quad \Rightarrow \quad \gamma = 1 + \frac{K}{m} = 1 + \frac{5}{3.7 \times 10^3}$

$\simeq 1 + 1.3 \times 10^{-3}$

$\gamma = \frac{1}{\sqrt{1-\beta^2}} \simeq 1 + \frac{1}{2}\beta^2$

$\Rightarrow \quad \beta \simeq 0.05$

$E \simeq \frac{p^2}{2m} \simeq K \quad \Rightarrow$

$\Rightarrow \quad p^2 = 2mK = 2 \times 3.7 \times 10^3 \times 5 \ \mathrm{MeV}^2$

$= 40 \times 10^3 \ \mathrm{MeV}^2$

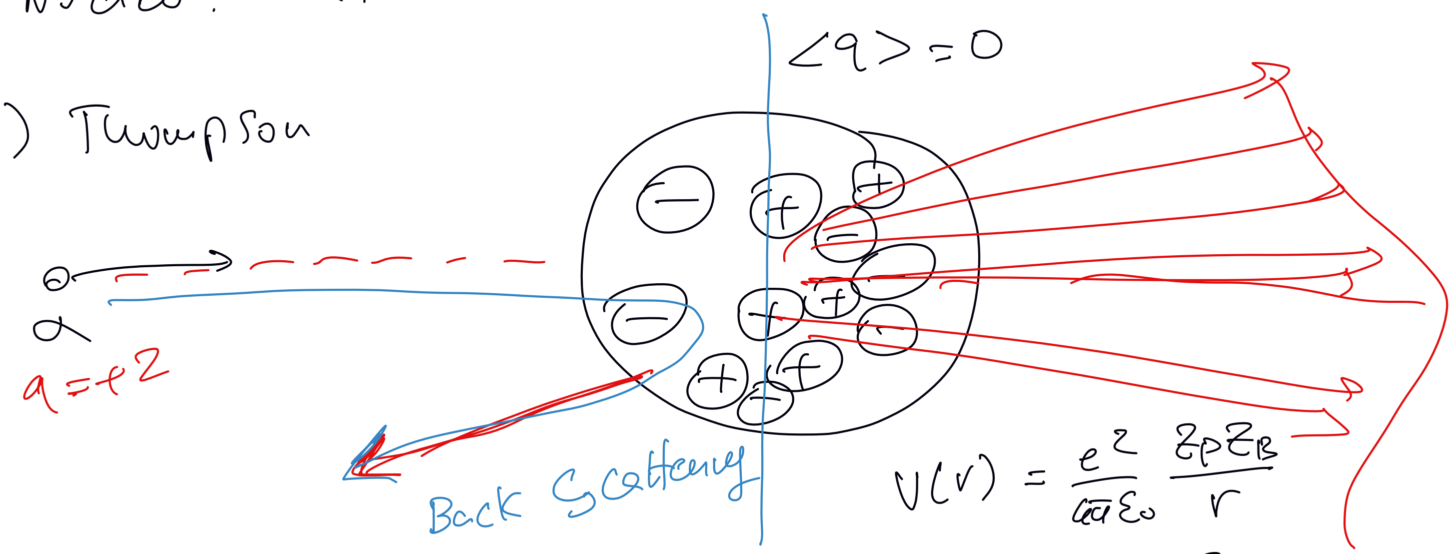
$p = 2 \times 10^2$ MeV

$m = 3.7 \times 10^3$ MeV

$p = 200$ MeV

Nucleo? Atomo?

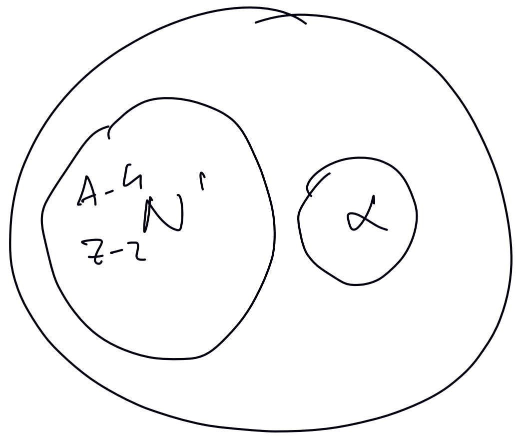
1) Thompson

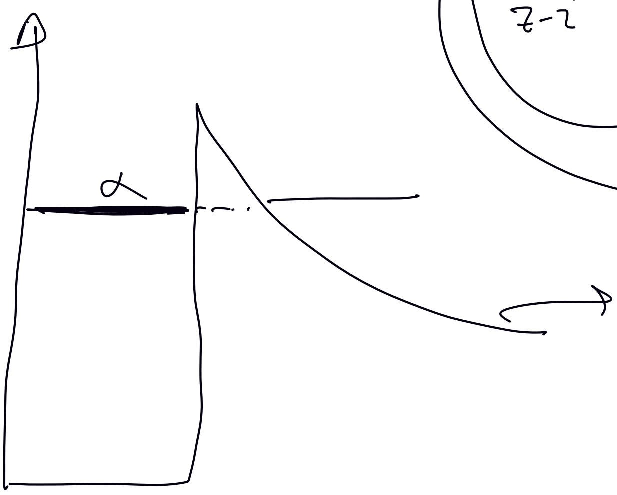


$V(r) = \frac{e^2}{4\pi\varepsilon_0} \frac{Z_p Z_B}{r}$

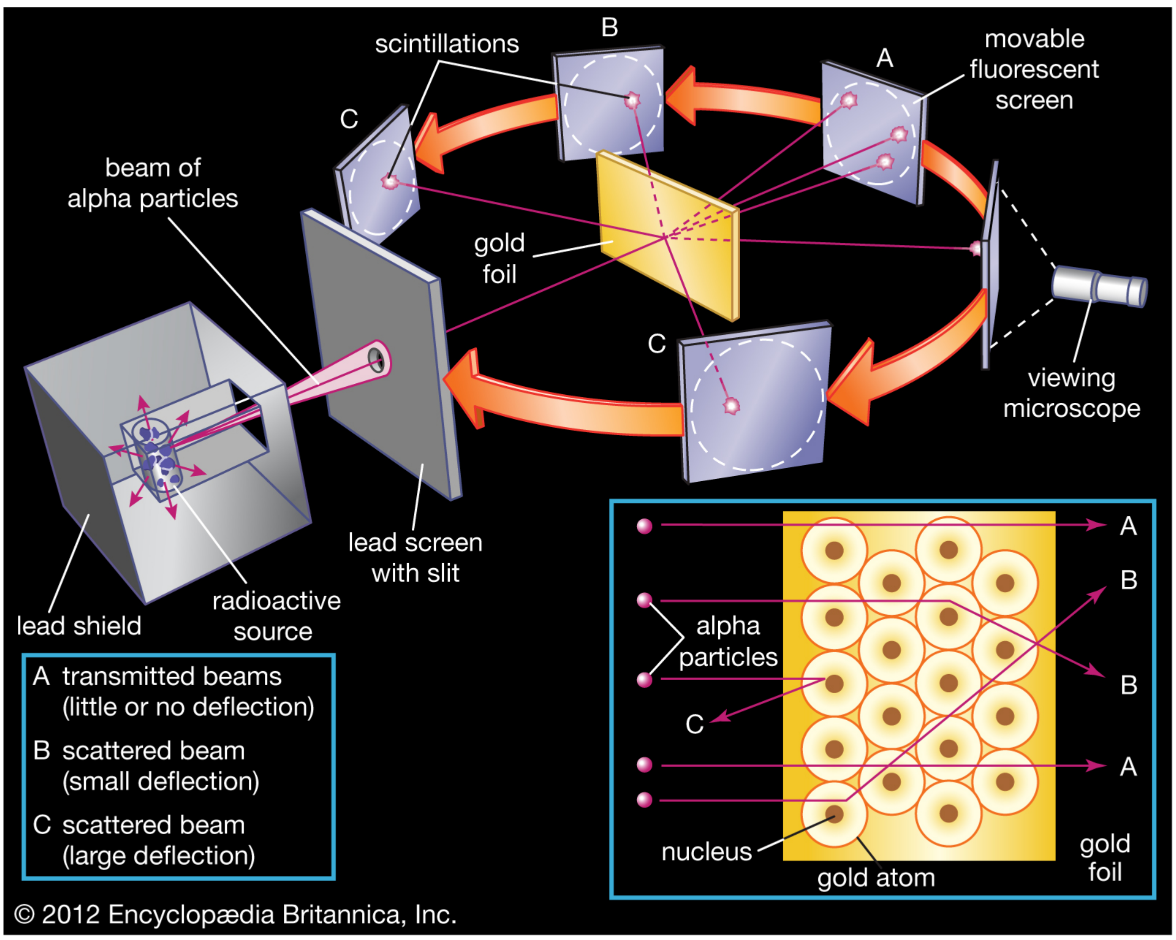
$= \frac{\alpha Z_p Z_B}{r}$

$${}^{A}_{Z}N \longrightarrow {}^{A-4}_{Z-2}N' + \alpha$$





potenziale generato da ${}^{A-4}_{Z-2}N'$

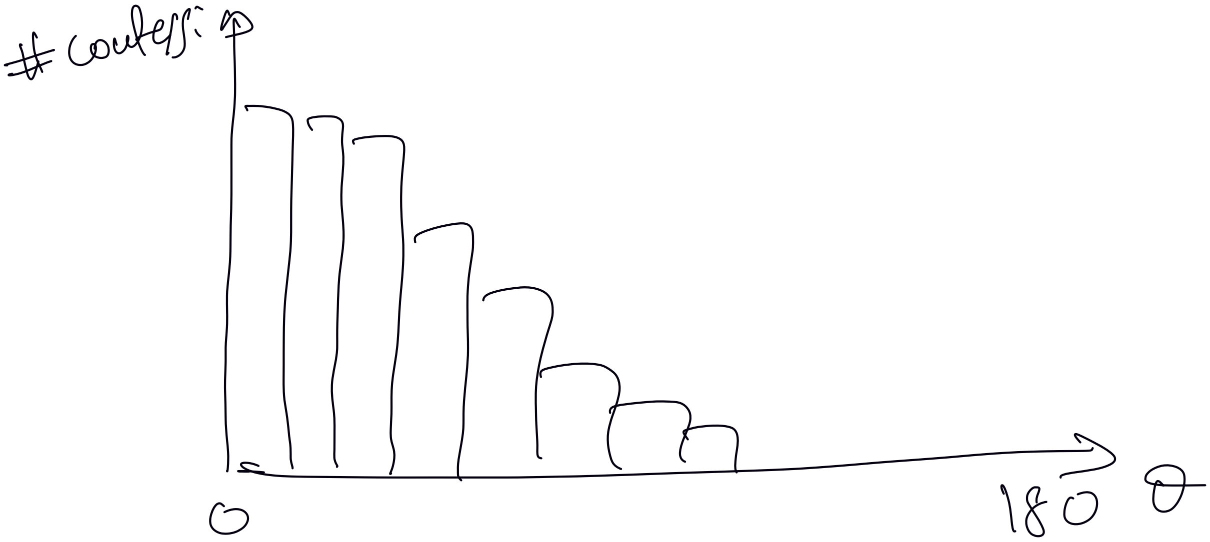


Au

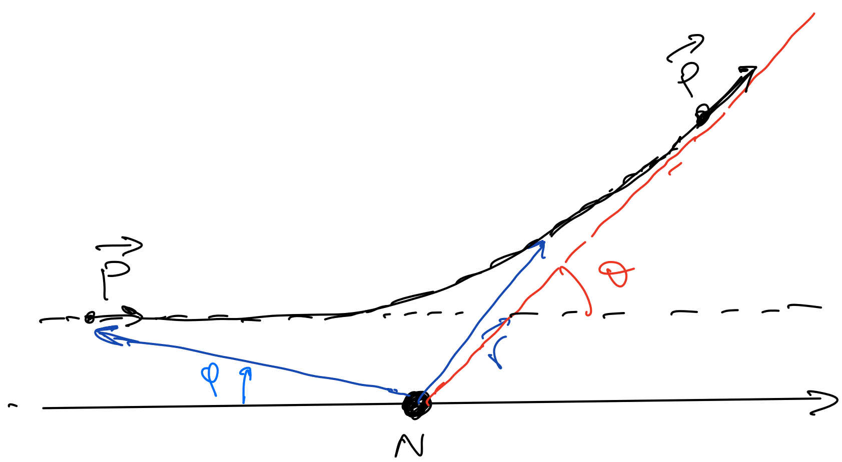
$Z = 79$

spessore

$0.4\ \mu m$



misure di $\frac{d\sigma(\theta,\varphi)}{d\Omega}$



- legge del moto del proiettile $r(t), \varphi(t)$
- traiettoria del proiettile. $r = r(\varphi)$
- ricavare la relazione $b \longleftrightarrow \theta$
- ricavare $\frac{d\sigma}{d\Omega} = \left|\frac{db}{d\theta}\right| \frac{b}{\sin\theta}$

$$U(r) = \alpha Z_p Z_B \frac{1}{r} \qquad Z_p = 2, \; Z_B = 79$$

$$= \frac{2 \times 79}{137} \frac{1}{r} \qquad A = \alpha Z_p Z_N = \frac{158}{137}$$

$$L = K - U = \frac{1}{2} m v^2 - U = \frac{1}{2} m \left(\dot{r}^2 + r^2 \dot{\varphi}^2 \right) - \frac{\alpha Z_p Z_N}{r}$$

$$\frac{\partial L}{\partial \varphi} = 0 \Rightarrow \frac{d}{dt} \frac{\partial L}{\partial \dot{\varphi}} = 0 \qquad \frac{\partial L}{\partial \dot{\varphi}} = p_\varphi = \frac{1}{\cancel{2}} m \cdot \cancel{2} r^2 \dot{\varphi} = m r^2 \dot{\varphi}$$

$$\vec{L} = \vec{r} \times \vec{p}$$

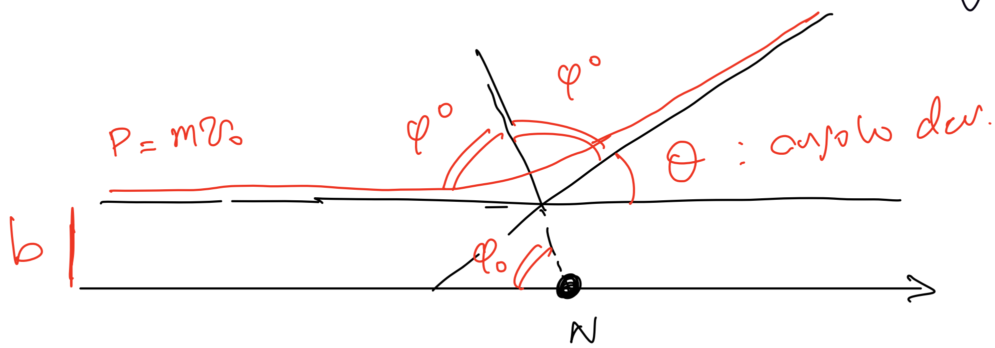
$$\parallel$$

$$\text{cost} \Rightarrow m r^2 \dot{\varphi} = \text{cost}$$

si conserva mom. angolare.

$$\frac{d\varphi}{dt} m r^2 = \text{cost.}$$

$$\theta = \pi - 2\varphi_0$$



$$L_0 = b m v_0$$

$$m r^2 \frac{d\varphi}{dt} = \underbrace{b m v_0}_{L_0 \text{ mom ang iniziale.}} \Rightarrow dt \propto d\varphi$$

stato iniziale: $r = \infty$, $\varphi = 0$

stato intermedio: φ_0, r_{min}.

stato fin.: $r \to \infty$, $2\varphi_0$

$$E = \frac{1}{2} m \dot{r}^2 + \underbrace{\frac{1}{2} m r^2 \dot{\varphi}^2}_{} + V = \text{cost} = \frac{1}{2} m v_0^2$$

$$= \frac{1}{2} m \dot{r}^2 + \frac{L^2}{2 m r^2} + V(r) = \text{cost}$$

$$\left(\frac{dr}{dt} \right)^2 = \left(E_0 - \frac{L^2}{2 m r^2} - \frac{A}{r} \right) \frac{2}{m}$$

$$\frac{dr}{dt} = \sqrt{\left(E_0 - \frac{L^2}{2mr^2} - \frac{A}{r}\right)\frac{2}{m}}$$

$$m r^2 \dot{\varphi} = \text{cost} = L \rightarrow \frac{d\varphi}{dt} = \frac{L}{mr^2}$$

$$\frac{1}{dt} = \frac{L}{mr^2}\frac{1}{d\varphi}$$

$$\frac{dr}{d\varphi}\frac{L}{mr^2} = \sqrt{}$$

$$\frac{dr}{\sqrt{(\text{---}\ \text{---})}}\frac{L}{mr^2} = d\varphi$$

$$\int_{\infty}^{r_{min}} \frac{dr}{\sqrt{}}\frac{L}{mr^2} = \int_0^{\varphi_0} d\varphi$$

$$= \varphi_0 - (\underset{0}{\underset{\shortparallel}{\varphi_{in}}})$$

$$\varphi_0 = \int_{r_{min}}^{\infty} \frac{b/r^2}{\sqrt{1 - \frac{b^2}{r^2} - \frac{A}{E_0}\frac{1}{r}}}\,dr \qquad U(r) = \frac{A}{r}$$

$$= \arccos \frac{\frac{A}{2E_0 b}}{\sqrt{1 + \left(\frac{A}{2E_0 b}\right)^2}}$$

$$\theta = \pi - 2\varphi_0 \Rightarrow \theta = \theta(b)$$

$$b = \frac{A}{2E_0} \frac{1}{tg \frac{\theta}{2}}$$

$$\frac{d\sigma}{d\Omega} = \left|\frac{db}{d\theta}\right| \frac{b}{\sin\theta}$$

$$= \left(\frac{A}{4E_0}\right)^2 \frac{1}{\sin^4\frac{\theta}{2}} = \left(\frac{\alpha Z_\alpha Z_B}{4E_0}\right)^2 \frac{1}{\sin^4\frac{\theta}{2}}$$

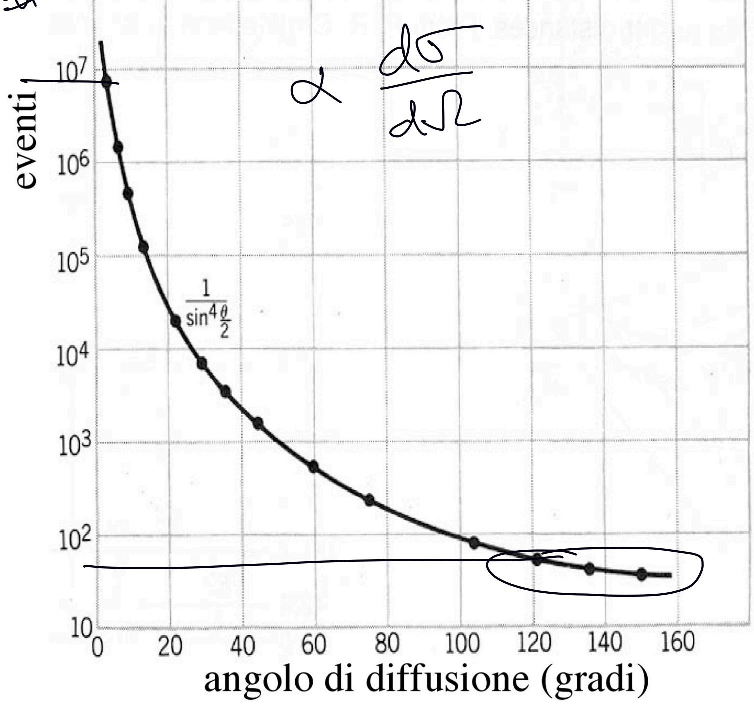
1) $\frac{d\sigma}{d\Omega} \propto A^2$

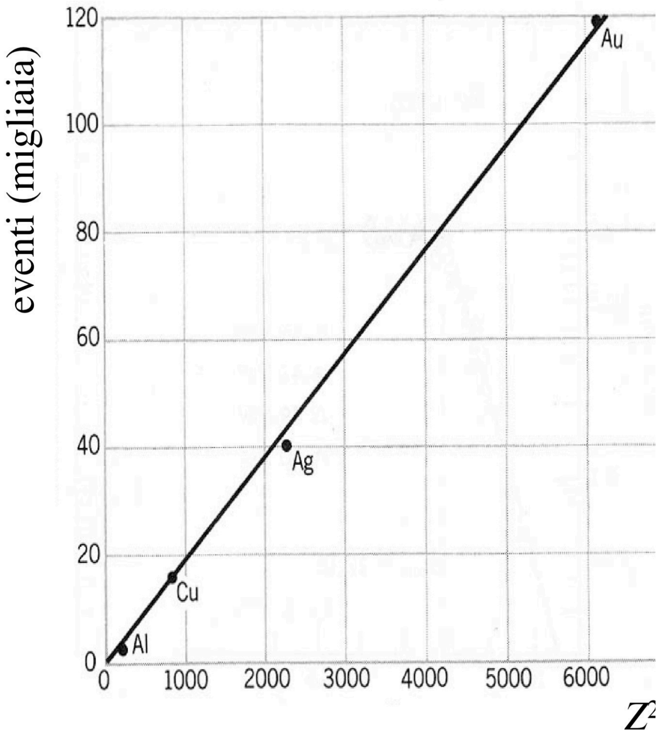
2) $\frac{d\sigma}{d\Omega} \propto Z_B^2$

3) $\frac{d\sigma}{d\Omega} \propto \frac{1}{E_0^2}$ $\qquad E_0 = \frac{1}{2} m v_0^2$

4) $\int_{\frac{\pi}{2}}^{\pi} \frac{d\sigma}{d\Omega} d\theta > 0$ $\qquad$ Back scattering.

conteggi





grande di eventi @ $\theta \to \pi$

r_{min}

$$K = 5\ \text{MeV} = \frac{\alpha Z_p Z_B}{r_{min}} \Rightarrow r_{min} = \frac{2\times 79}{137}\ \frac{1}{5\ \text{MeV}}$$

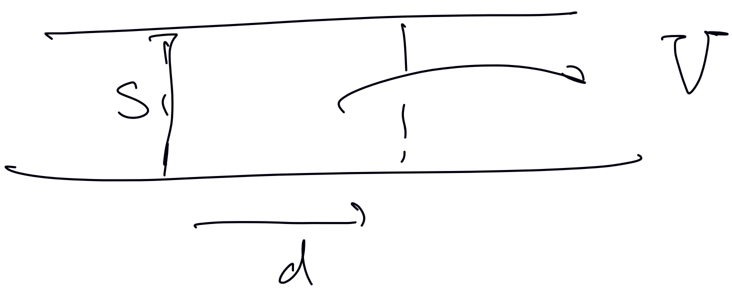
$$1\ \text{fm} = 200\ \text{MeV}^{-1} =$$

$$\text{MeV}^{-1} = \frac{1}{200}\ \text{fm}$$

$$\Rightarrow r_0 = 46\ \text{fm}$$

Rutherford: $r_N \lesssim 30\ \text{fm} \ll 1\ \text{Å}$

$$\Gamma(i\to f) = 2\pi |M_{fi}|^2 \rho(E) = \sigma \cdot \frac{v_p}{V}$$



$$M_{fi} = -i\int d^3r \; \psi_f^{*} \, H_I \, \psi_i$$

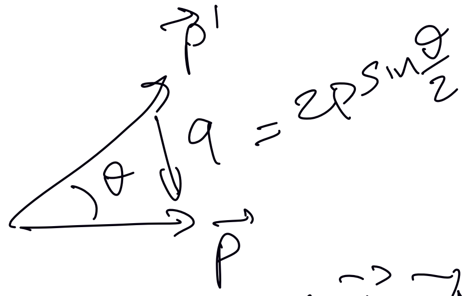
Approssimazione di Born: onde piane per particelle libere nello stato iniziale e finale.

$$\psi_i = \frac{1}{\sqrt{V}} e^{i\vec{p}\cdot\vec{r}}$$

$\vec{p}$ impulso iniziale.

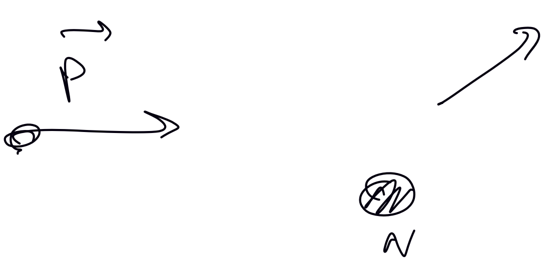
$$\psi_f = \frac{1}{\sqrt{V}} e^{i\vec{p'}\cdot\vec{r}}$$

$\vec{p'}$ impulso finale.



$$V(r) = \frac{A}{r}$$

$$M_{fi} = -i\int d^3r \; e^{-i(\vec{p'}-\vec{p})\cdot\vec{r}} \, \frac{A}{r} = -i\int d^3r \, \frac{e^{i\vec{q}\cdot\vec{r}}}{r}$$



$$M_{fi} \propto \frac{1}{q^2}$$

$$\cancel{\sigma\propto} \quad \sigma \propto |M_{fi}|^2 \propto \frac{A^2}{q^4} \propto \frac{A^2}{p^4 \sin^4\frac{\theta}{2}}$$

$$E = \frac{p^2}{2m}.$$

$$\Rightarrow \quad \sigma \propto \frac{1}{E^2}\,\frac{A^2}{\sin^4\frac{\theta}{2}}$$