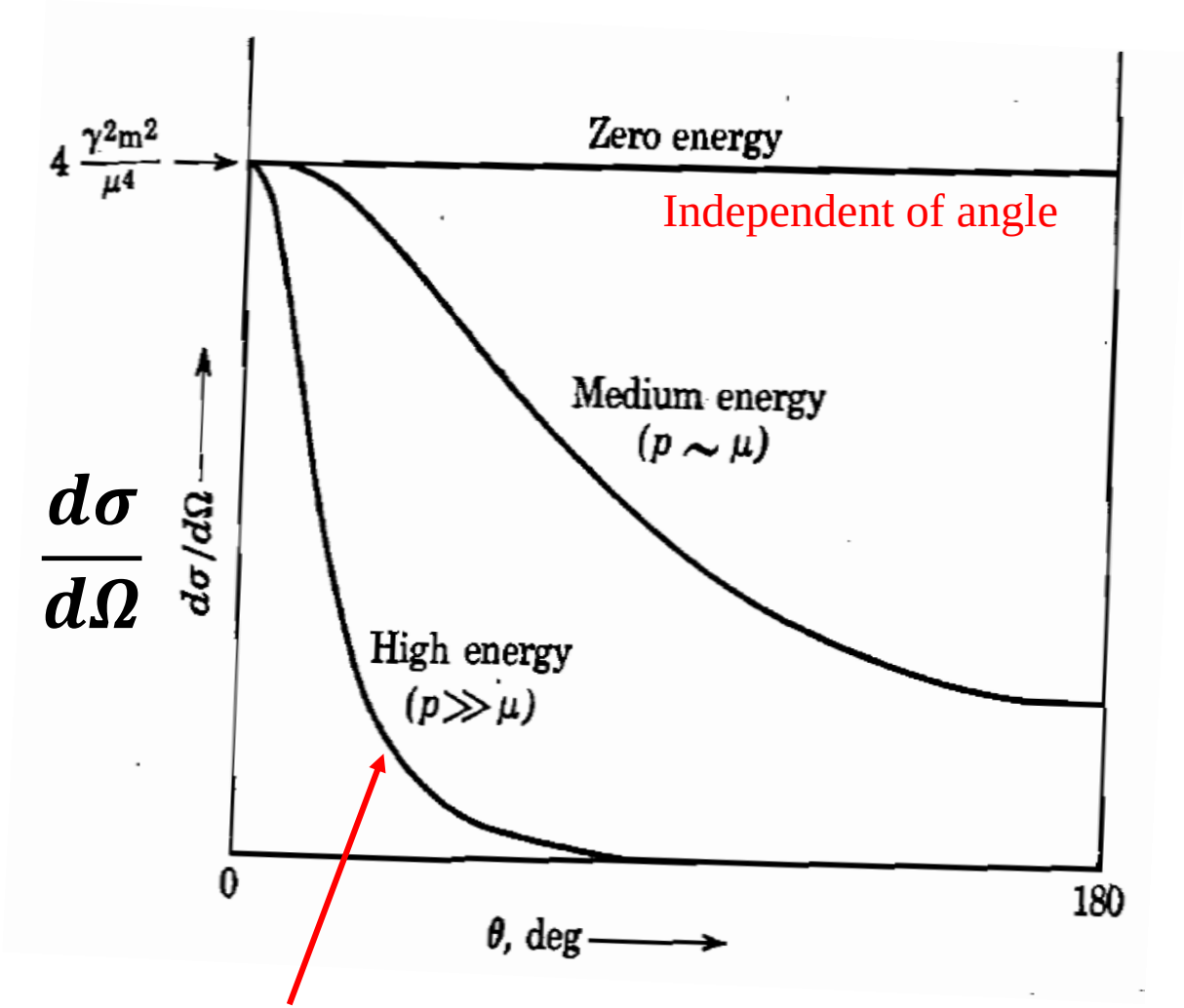
Yukawa Potential for Nucleon Interactions

$$V(r) = \gamma \frac{e^{-\mu r}}{r}$$

$\mu = 140\ MeV/c$ for Pion

$$\gamma = -\frac{2}{3}c$$

$$\frac{d\sigma}{d\Omega} = \frac{4\gamma^2 m^2}{(\mu^2 + 4p^2 \sin^2 \theta/2)^2}$$



Taylor, Scattering Theory

Elastic Electron Scattering from Atoms: Hydrogen

$$V(\mathbf{x}) = -e\int d^3x' \frac{\rho(\mathbf{x}')}{|\mathbf{x} - \mathbf{x}'|}$$

Coulomb interaction between electron and atom

$\rho(x')$ is the atom charge distribution in space

nucleus **electron cloud**

For a hydrogen atom with the electron in the ground state: $\rho(\mathbf{x}) = e\{\delta_3(\mathbf{x}) - |\phi(\mathbf{x})|^2\}$

$$\phi(\mathbf{x}) = (\pi a^3)^{-1/2} e^{-r/a}$$

Electron ground state wavefunction
a = Bohr radius

$$V(r) = -e^2\left(\frac{1}{r} + \frac{1}{a}\right)e^{-2r/a}$$

This calculation of $V(r)$ takes 3 pages…

For a spherically-symmetric potential, $f(\theta) = 2a\,\frac{8 + q^2a^2}{(4 + q^2a^2)^2}$ **q = momentum transfer**

Performing the $f(\theta)$ integral in Mathematica

In[1]:=
```
Integrate[r^2 Sin[q r] / (q r) (1 / r + 1 / a) Exp[-2 r / a],
 {r, 0, ∞}]
```

Out[1]=

$$\frac{a^2\left(8+a^2 q^2\right)}{\left(4+a^2 q^2\right)^2} \quad \text{if} \quad 2\,\text{Re}\left[\frac{1}{a}\right] > \text{Im}[q] \;\&\&\; \text{Re}[a] > 0$$

Elastic Electron Scattering from Atoms: He

He atom charge density

$$\rho(\mathbf{x}) = e\left\{2\delta_3(\mathbf{x}) - \int d^3x_2\,|\phi(\mathbf{x}, \mathbf{x}_2)|^2 - \int d^3x_1\,|\phi(\mathbf{x}_1, \mathbf{x})|^2\right\}$$

$$\frac{d\sigma}{d\Omega}$$

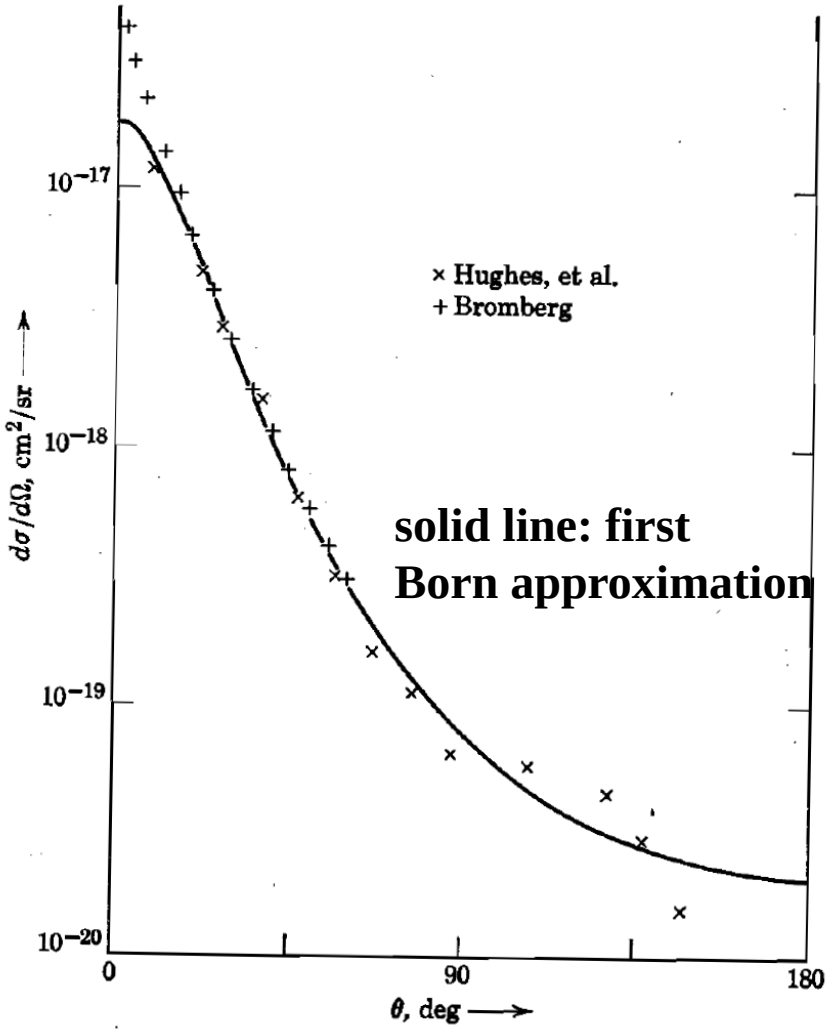


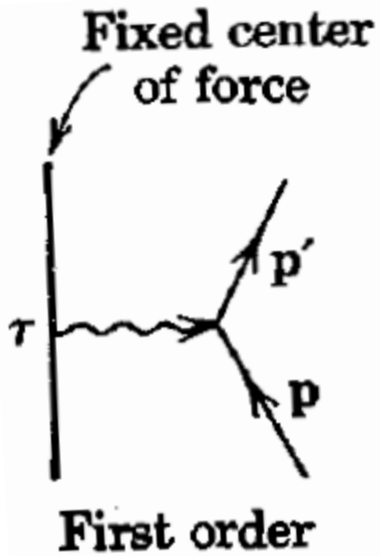
FIGURE 9.3. The electron–helium elastic cross section at 500 eV. The curve is the Born approximation (9.22), the experimental points are taken from Hughes, et al. (1932) and Bromberg (1969).

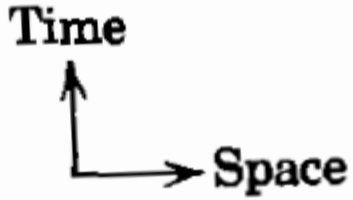
Deviation at small θ due to:

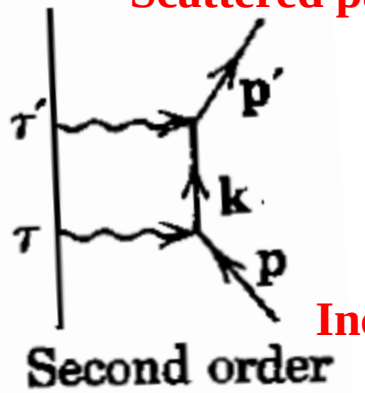
i) Distortion of atom $V(r)$ due to incident electron,

ii) Exchange (spin) interaction ignored here

Feynman Diagrams

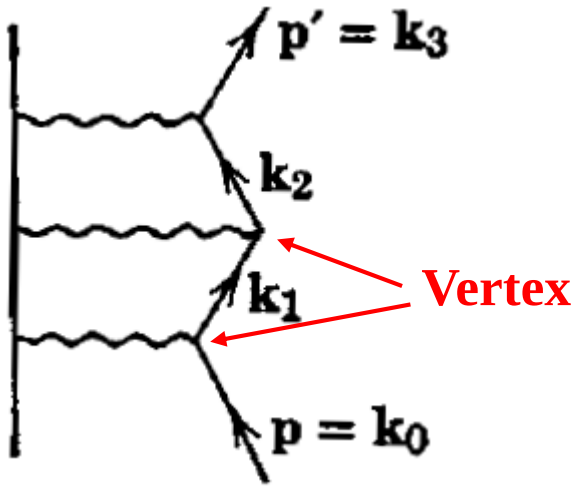






Scattered particle

Incident particle



Feynman's Van in Front of Beckman Auditorium @ Caltech