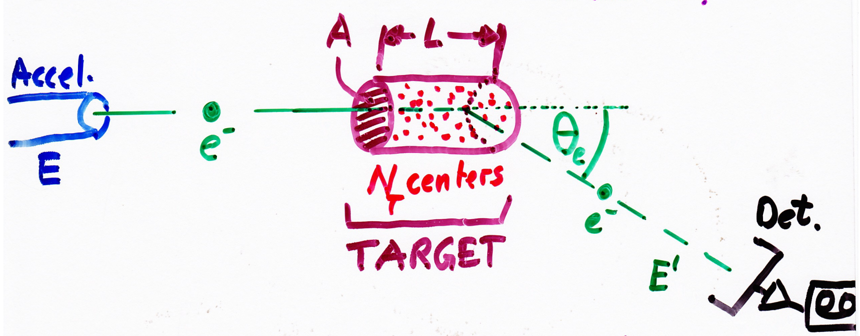
OBSERVABLES

Electron Scattering – what can we measure?



What is the likelihood to find the electron scattered into the detector?

$P \sim n_T \cdot L = \frac{N_T}{A\,L} \cdot L = \frac{N_T}{A}$ *

$\Rightarrow$ call $\Delta\sigma = P / \left(\frac{N_T}{A}\right)$ (cross section)

$\Delta\sigma$ DEPENDS on the kinematics (E, E', θ_e) and is $\approx$ proportional to SIZE of kinematic bin spanned by the detector

*Note: $\frac{N_T}{A} = \rho\left[\frac{g}{cm^3}\right] \cdot L\,[cm] \cdot \frac{\text{Avogadro}}{\text{Atomic Weight [u]}}$

Count rate (L = luminosity):

$$\dot{N} = P \cdot \dot{n}_{el} = \Delta\sigma \cdot \frac{N_T}{A}\dot{n}_{el} = \Delta\sigma \cdot \frac{N_T}{A}\frac{I}{e} = \Delta\sigma \cdot L$$

In general:

$$\Delta\sigma = \Delta\sigma\left(E'...E'+\Delta E', \theta_e...\theta_e+\Delta\theta_e, \varphi...\varphi+\Delta\varphi\right)$$

Limit of infinitesimal acceptance:

$$\Delta\sigma = \frac{d^3\sigma}{dE'\,d\theta_e\,d\varphi}\left(E', \theta_e, \varphi\right)\Delta E'\Delta\theta_e\Delta\varphi = \frac{d\sigma}{dE'\,d\Omega}\Delta E'\Delta\Omega$$

(use Jacobian to transform variables)

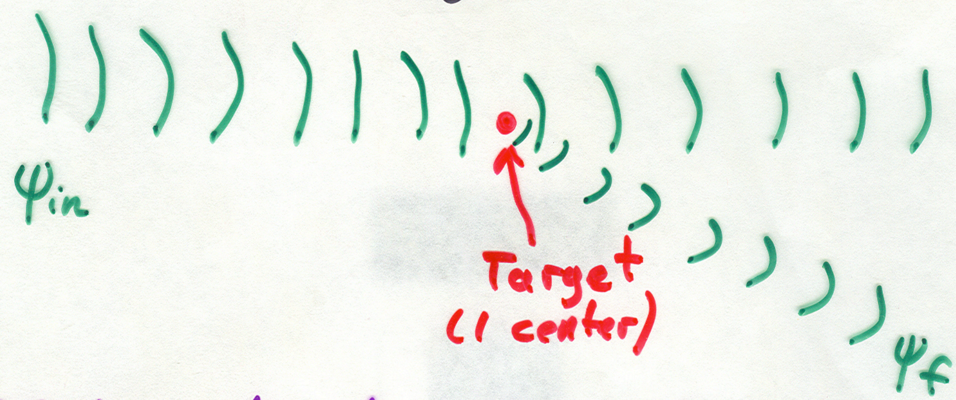
In case of more particles/observables and finite phase space:

$$\Delta\sigma = \iiint_{\substack{Phase\\Space}} \frac{d^n\sigma}{dk_1 dk_2 ... dk_n}\left(k_1...k_n\right) Acc\left(k_1...k_n\right) dk_1 dk_2 ... dk_n$$

where Acceptance is defined by detector boundaries and bin sizes as well as number of observed particles

(inclusive = only 1, semi-inclusive, exclusive)

Electron Scattering - Theorist's View



What is the transition rate $W_{i\to f}$?

$$\dot{N}_{e,f} = \dot{N}_{e,in} \cdot P(i\to f) = I_{e,in} \cdot \frac{N_T}{A} \cdot \Delta\sigma$$

$$= \frac{I_{e,in}}{A} \cdot N_T \cdot \Delta\sigma = \left(\vec{j}_{e,in}\right)_z \cdot N_T \cdot \Delta\sigma$$

$$\Rightarrow W_{i\to f} = j_{in} \cdot \Delta\sigma$$

Fermi's GOLDEN Rule:

$$W_{i\to f} = \frac{2\pi}{\hbar} \left|\mathcal{M}_{fi}\right|^2 \Delta\phi$$

Phase space spanned by detector/kinematic bin

$$\mathcal{M}_{fi} = \langle \psi_f \,|\, H_{int} \,|\, \psi_{in} \rangle$$