Hall C Møller MC

- Based on Monte Carlo from SLAC SLC-linac Møller polarimeter
  – M . Swartz et al, NIMA 363 (1995) 526-537
- Standalone FORTRAN based simulation (not GEANT3)
- Does not include particle interactions – just checks apertures
- Generator includes
  – Internal radiative effects via electron structure function technique
  – Levchuk effect
- Cross section and asymmetry applied as weights to generated events

Event Generation

1. Z-position of scatter picked randomly along length of target
2. Incoming beam electron undergoes multiple scattering, Bremsstrahlung energy loss on the way to vertex
3. Møller scattering event generated (more next slide slides)
4. Both outgoing electrons undergo MS/Bremsstrahlung energy loss

Møller event generation w/Levchuk

Møller scattering generated flat in $\cos\theta_{CM}$, ϕ_{CM}

$$p_{\mathrm{lab}} = p_{\mathrm{beam}}(1 + \cos\theta^*)$$

$$s_0 = 2p_{\mathrm{beam}} m_e$$

(CM energy)^2

$$\theta^2_{\mathrm{lab}} = \frac{1}{p_{\mathrm{beam}} p_{\mathrm{lab}}} \frac{s_0}{2}(1 - \cos\theta^*) = 2m_e\left(\frac{1}{p_{\mathrm{lab}}} - \frac{1}{p_{\mathrm{beam}}}\right)$$

Small angle approximation

Add Levchuk effect (moving target electron)

Beam directon

$$s_1 = s_0\left(1 - \frac{\vec{p}_{\mathrm{target}} \cdot \hat{n}}{m_e}\right)$$

$$p_{\mathrm{lab}} = \frac{p_{\mathrm{beam}}}{\sqrt{s_1}} \frac{\sqrt{s_1}}{2}(1 + \cos\theta^*) = \frac{p_{\mathrm{beam}}}{2}(1 + \cos\theta^*)$$

$$\theta^2_{\mathrm{lab}} = \frac{1}{p_{\mathrm{beam}} p_{\mathrm{lab}}} \frac{s_1}{2}(1 - \cos\theta^*) = 2m_e\left(\frac{1}{p_{\mathrm{lab}}} - \frac{1}{p_{\mathrm{beam}}}\right)\left(1 - \frac{\vec{p}_{\mathrm{target}} \cdot \hat{n}}{m_e}\right)$$

Correction factor

Møller event generation – Levchuk Effect

Levchuk effect results in correction to lab scattering angle in event generator – easy to apply

Need to generate momentum for target electron
→ Event generator uses screened hydrogen atom wave functions
→ Works well for K-L shell, where the smearing is significant

Hall C generator has 2 momentum distributions
→ Polarized electrons (M shell)
→ Unpolarized electrons (K,L, shells)

Picks whether electron is polarized/unpolarized based on input target polarization
→ Also generates target momentum direction

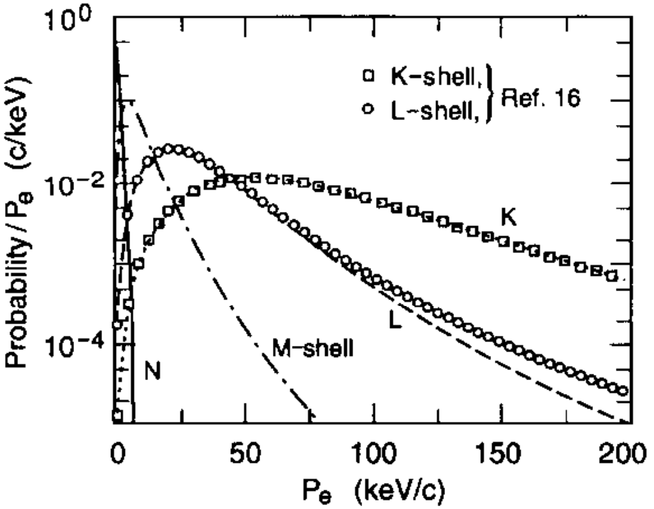

Fig. 9. The modelled K-, L-, M-, and N-shell momentum distributions for the iron atom are shown as continuous curves. The K- and L-shell parameterizations of Ref. [16] are shown as boxes and circles, respectively.

Radiative Effects (Internal)

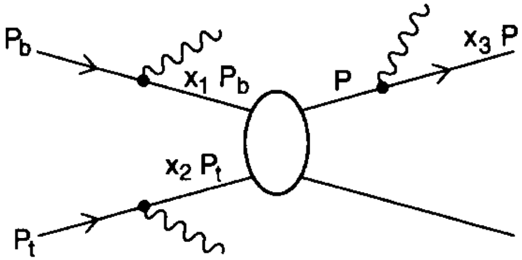

Fig. 8. A diagram of the simple collinear radiation model used to simulate the effect of internal radiation upon the Møller scattering process.

Initial (final) state electrons can radiate fraction 1-x1 and 1-x2 (1-x3 and 1-x4) of their energies

Cross section becomes:

$$\sigma(s_0) \to \sigma(x_1 x_2 s_1) D(x_1, T) D(x_2, T) D(x_3, T) D(x_4, T)$$

D(x,T): electron structure functions at momentum scale T

$$p_{\text{lab}} = \frac{p_{\text{beam}} x_1 x_3}{2}(1 + \cos\theta^*) \qquad \theta^2_{\text{lab}} = 2 m_e x_2 \left(\frac{x_3}{p_{\text{lab}}} - \frac{1}{x_1 p_{\text{beam}}} \right)$$

Event Generation Flow

→ Generate $\cos\theta_{CM}$, ϕ_{CM}
→ Generate target electron momentum
→ Generate initial state radiation according to approximate distribution

Calculate vertex kinematics

```
P1=0.5*PBEAM*X1*(1.+COSTAR)
P2=0.5*PBEAM*X1*(1.-COSTAR)
THETA1=SQRT(CORFAC*TWOELM*X2*(1./P1-1./(X1*PBEAM)))
THETA2=SQRT(CORFAC*TWOELM*X2*(1./P2-1./(X1*PBEAM)))
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Levchuk

Initial state, internal radiation

→ Generate final state radiation –apply kinematic correction to outgoing electrons (P1→ x_3P1, P2→ x_4P2)
→ Calculate event weight: cross section + radiative correction (also correcting for approximate form used in generation), and analyzing power