# The Polarized $e^{\pm}p$ Neutral-Current Cross Section

[following M. Klein and T. Riemann, Z.Phys. C24 (1984) 151]

The double differential cross section for the scattering of $e^{\pm}$ (helicity $\lambda$) on unpolarized protons may be written (assuming the Callan-Gross relation and neglecting radiative corrections)

$$\frac{\mathrm{d}^2\sigma}{\mathrm{d}Q^2\,\mathrm{d}x}(e^{\pm}p \to e^{\pm}X) = \frac{2\pi\alpha^2}{xQ^4}\sigma^{\pm}(\lambda) = \frac{2\pi\alpha^2}{xQ^4}\left[\sigma_0 + \sigma_i^{\pm}(\lambda) + \sigma_Z^{\pm}(\lambda)\right]$$

$$\gamma:\quad \sigma_0 = \left[Y_+ \cdot \hat{F}_2(x,Q^2)\right]$$

$$\gamma/\mathrm{Z}:\ \sigma_i^{\pm}(\lambda) = \kappa(Q^2)\left[Y_+(-v \mp \lambda a)\ \hat{G}_2(x,Q^2) + Y_-(\pm a + \lambda v)\ x\hat{G}_3(x,Q^2)\right]$$

$$Z:\ \sigma_Z^{\pm}(\lambda) = \kappa^2(Q^2)\left[Y_+(v^2 + a^2 \pm 2\lambda va)\ \hat{H}_2(x,Q^2) + Y_-(\mp 2va - (v^2+a^2)\lambda)\ x\hat{H}_3(x,Q^2)\right]$$

$$\boxed{Y_{\pm} = 1 \pm (1-y)^2}$$

Propagator

$$\kappa(Q^2) = \kappa(\infty)\, Q^2/(Q^2 + M_Z^2)$$

$$\kappa(\infty) = \left[4\sin^2\theta_W \cos^2\theta_W\right]^{-1} \simeq 1.5$$

Weak neutral current couplings of $e^{\pm}$

$$a = I_3^L = -\frac{1}{2}$$

$$v = I_3^L \mp 2\sin^2\theta_W$$

## Structure Functions

$$\hat{F}_2(x,Q^2) = x\,\Sigma_q(q+\bar{q}) \cdot Q_q^2$$

$$\hat{G}_2(x,Q^2) = x\,\Sigma_q(q+\bar{q}) \cdot 2v_qQ_q$$

$$\hat{H}_2(x,Q^2) = x\,\Sigma_q(q+\bar{q}) \cdot (v_q^2 + a_q^2)$$

$$\hat{G}_3(x,Q^2) = x\,\Sigma_q(q-\bar{q}) \cdot a_qQ_q$$

$$\hat{H}_3(x,Q^2) = x\,\Sigma_q(q-\bar{q}) \cdot a_qv_q$$