Unpolarized Structure Functions

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Measuring the complete set of unpolarized structure functions in inclusive electron nucleon scattering requires a separation of the cross section into longitudinal and transverse strengths. In the one photon exchange approximation, the double differential cross section can be expressed in terms of the photon helicity coupling as

$$\frac{d\sigma}{d\Omega dE'} = \Gamma\left[\sigma_T(x,Q^2) + \epsilon\sigma_L(x,Q^2)\right], \tag{1}$$

where σ_T (σ_L) is the cross section for the photo-absorption of purely transverse (longitudinal) polarized photons, and both the flux of virtual photons, Γ, and the virtual photon polarization, ϵ, depend on kinematic factors only. The photo-absorption cross sections are related to the unpolarized structure functions by

$$\sigma_T = \frac{4\pi^2\alpha}{2x(W^2-M^2)}2xF_1 \tag{2}$$

and

$$\sigma_L = \frac{4\pi^2\alpha}{2x(W^2-M^2)}\left[\left(\frac{4M^2x^2+1}{Q^2}\right)F_2 - 2xF_1\right] = \frac{4\pi^2\alpha}{2x(W^2-M^2)}F_L. \tag{3}$$

The cleanest way to do this separation experimentally is via the Rosenbluth technique [1], where the cross section is measured at multiple values of ϵ for fixed x and Q^2. Dividing the cross section by Γ and fitting linearly with ϵ yields the transverse cross section as the intercept and the longitudinal cross section as the slope.

The ratio of the photo-absorption cross sections is defined as $R = \sigma_L/\sigma_T$, and has been found to be much smaller than unity in the kinematic region for which separated cross sections have been extracted. Until recently, precision measurements [2, 3, 4, 5] have been performed predominantly at SLAC and have been mostly limited to the DIS region with $x < 0.75$. Measurements of R on the proton in the region of the resonances have recently been made in Hall C for $0.4 < Q^2 < 4.5$ (GeV/c)^2 [6] and will finally provide a survey of the separated strengths across the entire x range for large fraction of the Q^2 range measured. Extending these measurements to higher Q^2 and larger x either require, or are greatly aided by, an 11 GeV CEBAF beam.

The precision obtainable for measuring R depends on both the precision of the individual data points and the range in ϵ over which the measurements are made. Given the

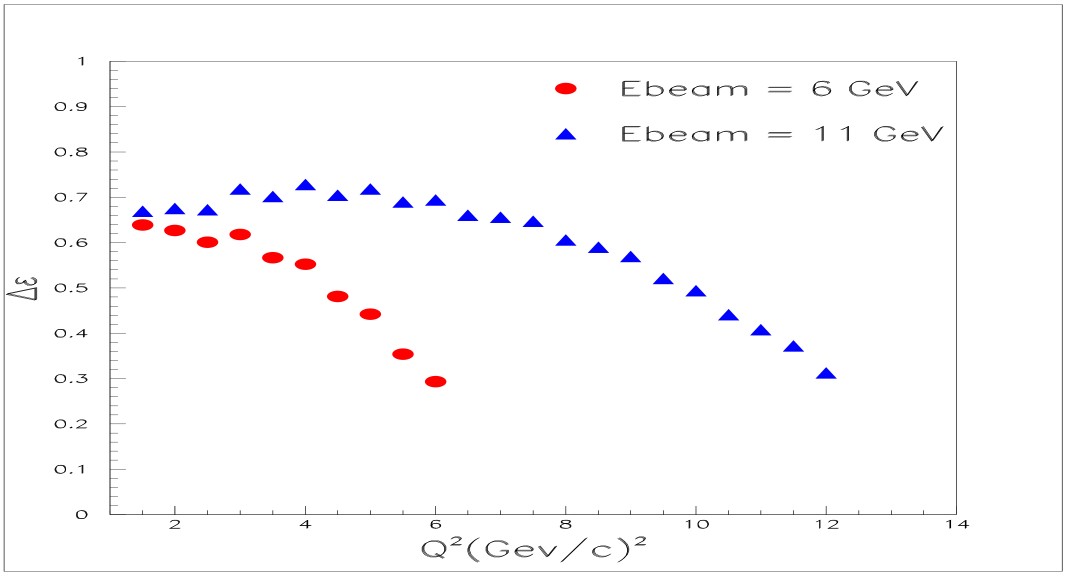

Figure 1: The $\Delta\epsilon$ range accessible at $x = 0.8$ in Hall C as a function of Q^2 for beam energies of 6 GeV (red circles), and 11 GeV (blue diamonds).

typical point-to-point systematic uncertainties on precision cross section measurements in Hall C of $\approx 1.2\%$, the minimum ϵ range required to perform a separation of the cross section is $\Delta\epsilon \approx 0.3$. Figure 1 shows the ϵ range verses Q^2 which is accessible at $x = 0.8$ for a maximum CEBAF beam energy of both 6 GeV (red squares) and 11 GeV (blue diamonds). For a 6 GeV beam, the measurement of separated structure functions is limited to $Q^2 < 6$ (GeV/c)^2, but with an 11 GeV beam this range can be doubled. In addition, with the higher beam energy, the precision possible for $4 < Q^2 < 6$ (GeV/c)^2 can be significantly improved due to the extended ϵ range which is opened up at the higher energy.

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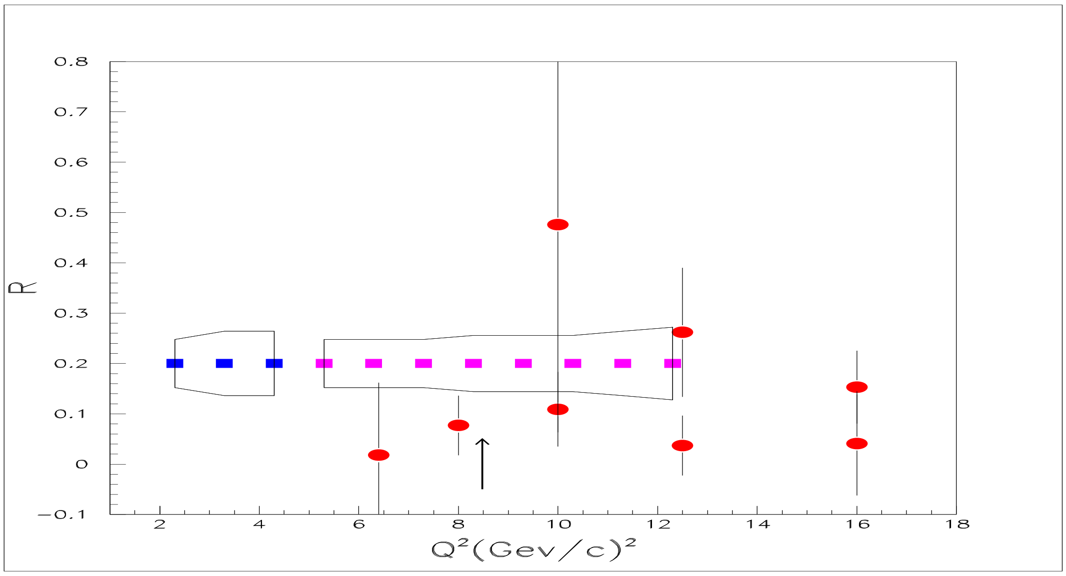

Figure 2: The current worlds data from SLAC (red circles) for R on the proton in the range $x > 0.75$. The estimated errors for measurements at $x = 0.8$ in Hall C utilizing a 6 GeV beam (blue squares) and an 11 GeV beam (pink squares) are represented by the banded areas. The vertical arrow indicates the position in Q^2 for which $W^2 = 4$ GeV^2 for $x = 0.8$.