8.4.3 Q^2 Dependence

The spin structure functions g_1 and g_2 in general depend on Q^2, which result in d_2 also depending on Q^2. Thus a proper evaluation of d_2 should be performed by integrating the spin structure functions over the entire x range at a constant Q^2 value. However, E06-014 only took data at two beam energies, which made a proper interpolation to constant Q^2 impossible. As a result, three approaches were used to estimate the size of the polarized structure functions' Q^2 dependence; which in all cases was found to be small relative to the measured precision of g_1 and g_2.

One way in which to gauge the polarized structure functions' dependence on Q^2 is to compare their measured values at fixed x. Using the ^{3}He data from E06-014's two beam energies (E = 4.74 GeV and E = 5.89 GeV), E99-117 [3, 57], and E142 [50] at $\langle x \rangle = 0.33$, g_1 and g_2 were plotted against Q^2 (Figure 8.70). Taking into account the precision of the measurements in Figure 8.70, the Q^2 dependence appears to be minimal.

In addition to comparing with experimental data, one could also use models and fits to world data to investigate the Q^2 dependence of the polarized structure functions. The global analysis fits to polarized parton densities from DSSV [164] were used to evaluate

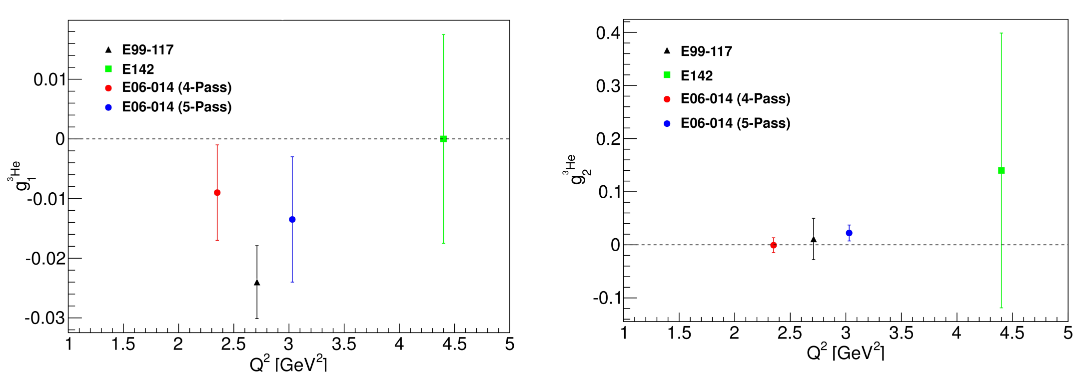

Figure 8.70: Polarized structure functions g_1 (left panel) and g_2 (right panel) on ^{3}He at mean x of 0.33 as a function of Q^2.

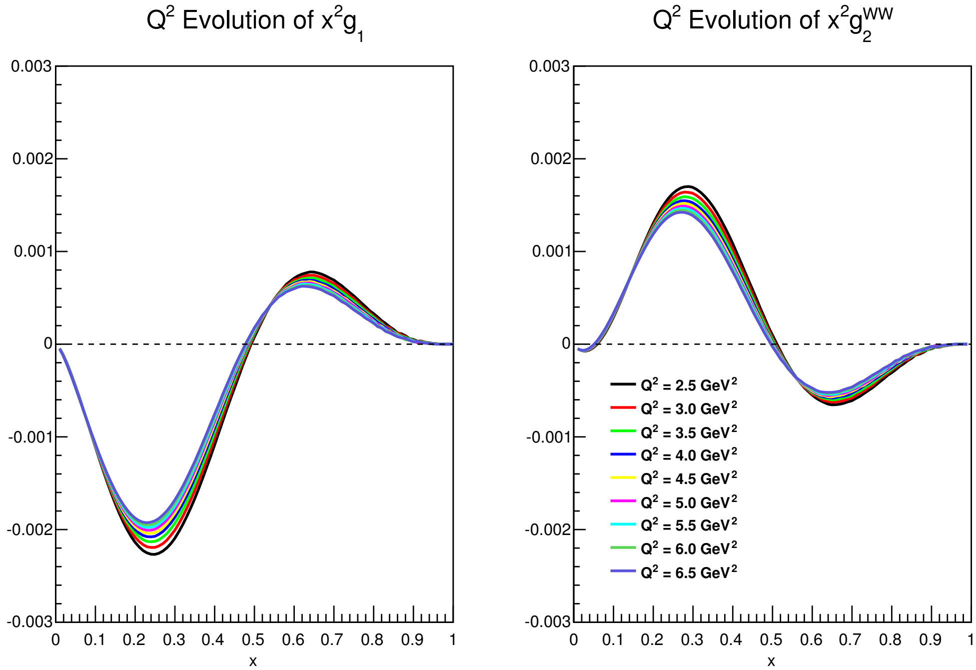

Figure 8.71: Polarized structure functions $x^2 g_1$ (left panel) and $x^2 g_2^{WW}$ (right panel) on ^{3}He evaluated from DSSV [164] plotted against x for a range of Q^2 values.

g_1 and g_2^{WW} [20] for a range of fixed Q^2 values[21]. Figure 8.71 shows $x^2 g_1$ and $x^2 g_2^{WW}$ on ^{3}He as a function of x at constant Q^2 values ranging from Q^2 = 2.5 to 6.5 GeV^2. The Q^2 dependence seen in DSSV is largest around x = 0.25 and x = 0.65. Although, compared to the precision of the g_1 and g_2 measured by E60-014, the Q^2 variation is small.

The final method used to assess the Q^2 dependence, also used by SLAC E143 [51], is to assume that g_1/F_1 is Q^2 independent. Then g_1 at a fixed Q^2 value (Q_0^2) can be determined as

[20] g_1 is formed from polarized quark distributions, whereas g_2 does not have a simple parton interpretation and can not be formed from the polarized quark distributions. As a result g_1 is used to calculate g_2^{WW} rather than g_2.

[21] Several other global analyses (BBS [165, 166], LSS [167], DNS [168], and GS [169]) were also checked and found to give similar results as DSSV.

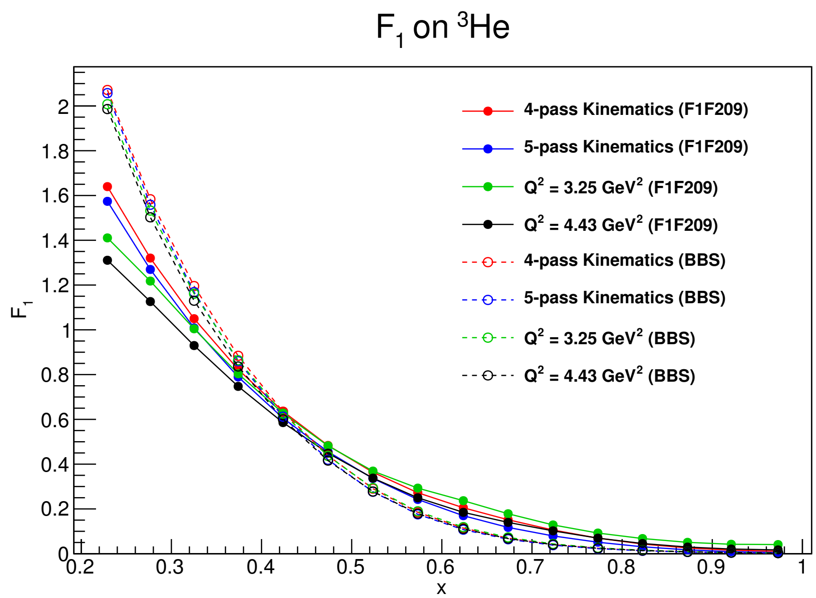

Figure 8.72: Unpolarized structure function F_1 evaluated using F1F209 [163] and BBS [165, 166] for Q^2 values matching measured E06-014 kinematics and for two constant Q^2 values on ^{3}He
.

$$g_1\left(x, Q_0^2\right) = \frac{g_1\left(x, Q^2\right)}{F_1\left(x, Q^2\right)} \cdot F_1\left(x, Q_0^2\right). \tag{8.65}$$

The ^{3}He polarized structure function $g_1\left(x, Q^2\right)$ are the measured E06-014 values. The ^{3}He unpolarized structure function F_1, was computed at Q^2 values matching the measured $g_1\left(x, Q^2\right)$ data, in addition to F_1 at Q_0^2 = 3.25 and 4.43 GeV^2. To evaluate F_1 two different global fits, F1F209 [163] and BBS [165, 166] were used. F1F209 uses fits to world data to determine F_1 and F_2, and BBS uses a statistical quark model to determine polarized and non-polarized parton distributions. Figure 8.72 shows the results of F_1 as a function of x for both the F1F209 (solid circles, solid lines) and BBS (open circles, dashed lines) fits. The red and blue markers give the F_1 values for x and Q^2 values matching E06-014's E = 4.74 and 5.89 GeV E06-014 datasets. The green and black markers show F_1 values calculated at a constant Q_0^2 of 3.25 and 4.43 GeV^2.

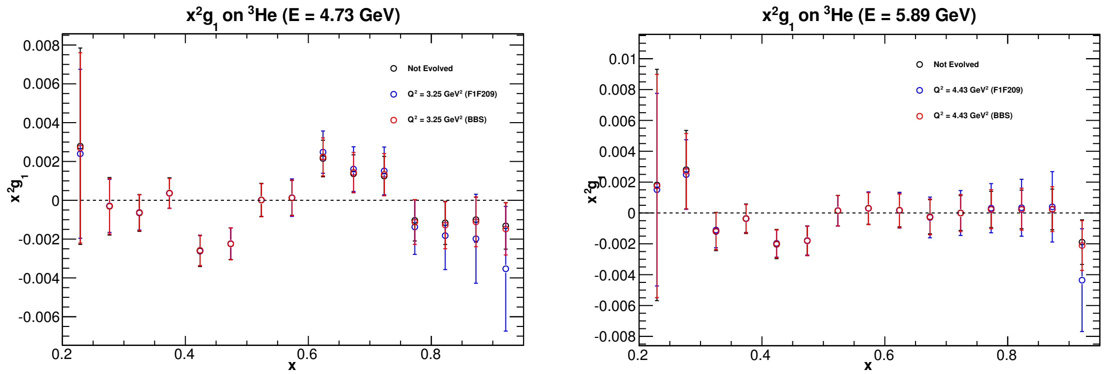

Figure 8.73: Compares the evolved $x^2 g_1$ from F1F209 [163] and BBS [165, 166] fits to the measured E06-014 $x^2 g_1$ on ^{3}He for E = 4.74 and 5.89 GeV data sets.

Applying the values of F_1 to the measured g_1, following Equation 8.65, g_1 can be evolved to a constant Q^2. A comparison of the evolved $x^2 g_1$ data using F1F209 (blue markers) and BBS (red markers) to the measured $x^2 g_1$ (black marker) can be seen in Figure 8.73, which clearly show a negligible Q^2 dependence within the experimental precision. If one assumes that the Q^2 dependence of g_2 is similar to that of g_1, then the Q^2 dependence on g_2 is also small.

Considering the size of the Q^2 dependence from the three methods presented above, the Q^2 dependence was neglected in E06-014, and a mean Q^2 value was used when computing d_2 and other Q^2 dependent quantities. While the quantities were not computed at a constant Q^2 for E06-014, the upcoming JLab experiment E12-06-121 [170, 171] will be able to compute the spin structure functions and d_2^n at constant Q^2, in addition to providing an extension of the E06-014 measured d_2^n to higher Q^2 values.

8.5 Radiative Corrections

An electron's interaction with materials before and after scattering, as well as with the target itself, will cause it to loose energy. These interactions lead to an alteration of the electron's