DIS kinematics in LAB frame

\[ k'' = (E', k') \]
\[ p'' = (m, \theta) \]
\[ \rightarrow \]

\[ k.k' = EE' - k.k' \]
\[ = EE' - 1|E||E'| \cos \theta \]
\[ \rightarrow \]
\[ EE'(1 - \cos \theta) \]
\[ = 2EE' \sin^2(\theta/2) \]

\[ k.p = EM \]
\[ k'.p = E'M \]

Alternate form can be obtained by invariance:

\[ s - q^2 + u = 2m^2 + m^2 + W^2 \]

\[ s - q^2 + u = \left( \begin{array}{c} 2m^2 + m^2 + W^2 \end{array} \right) \]

\[ S = (k + p)^2 = k^2 + p^2 + 2k.p \]
\[ = m^2 + M^2 + 2EM \]

\[ -t = Q^2 = -(k - k')^2 = -2m^2 + 2k.k' \]
\[ = -2m^2 + 2(EE' - 1|E||E'| \cos \theta) \]
\[ = (m^2 + M^2 + 2EM) \]
\[ + (m^2 + M^2 - 2E'M) \]
\[ - 2m^2 - M^2 - W^2 \]

\[ Q^2 = s - u - 2m^2 - M^2 - W^2 \]

If \( m = 0 \), simplify:

\[ = +4EE' \sin^2(\theta/2) \]

\[ u = (k' - p)^2 = (k')^2 + p^2 - 2k'.p \]
\[ = m^2 + M^2 - 2E'M \]

Conservation of energy:

Set the forms of \( Q^2 \) equal:

\[ -2m^2 + 2(EE' - |E'||E'| \cos \theta) = 2M(E - E') + M^2 - W^2 \]

Very complicated for \( m \neq 0 \).
Put $m = 0$

\[
4EE' \sin^2(\theta/2) = 2M(E-E') + M^2 - W^2
\]

\[
= 2ME - 2ME' + M^2 - W^2
\]

\[
(4E \sin^2(\theta/2) + 2M) E' = 2ME + M^2 - W^2
\]

\[
E' = \frac{2ME}{4E \sin^2(\theta/2) + 2M} + \frac{M^2 - W^2}{4E \sin^2(\theta/2) + 2M}
\]

\[
= \frac{1}{1 + \frac{2E \sin^2 \theta}{M^2}} + \frac{1}{2} \left( \frac{M^2 - W^2}{2E \sin^2 \theta + M} \right)
\]

... recoil factor due to non-static scattering center... contribution due to inelasticity...