A Precision Measurement of d_2^n: Color Field Response to Nucleon Polarization

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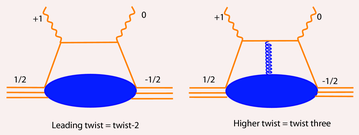
Nucleon Spin Structure Functions and d_2^n

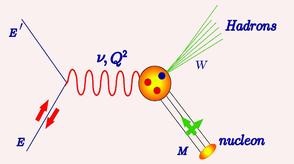
- g_1 and g_2 are spin dependent structure functions of the nucleon.
- g_1 describes scattering in terms of incoherent parton scattering.
- g_2 describes parton scattering in which more than one parton takes place in the interaction.
- From the optical theorem g_2 is the imaginary part of Virtual Compton Scattering.



- The matrix element d_2^n can be expressed in terms of measurable structure functions

$$d_2^n = \int_0^1 x^2 \left[2g_1\left(x,Q^2\right) + 3g_2\left(x,Q^2\right)\right] dx = \int_0^1 \overline{d_2^n} dx$$

where Q^2 is the momentum transfer and $x = \frac{Q^2}{2m(E-E_{scattered})}$



- g_1 and g_2 can be expressed in terms of the absolute cross section and asymmetries of ^3He

$$g_1 = \frac{MQ^2}{4\alpha^2}\frac{y^2}{2(1-y)(2-y)}2\sigma_0\left(A_\parallel + tan\frac{\theta}{2}A_\perp\right)$$

$$g_2 = \frac{MQ^2}{4\alpha^2}\frac{y^2}{2(1-y)(2-y)}2\sigma_0\left(-A_\parallel + \frac{1+(1-y)cos\theta}{(1-y)\,sin\theta}A_\perp\right)$$

What is d_2^n

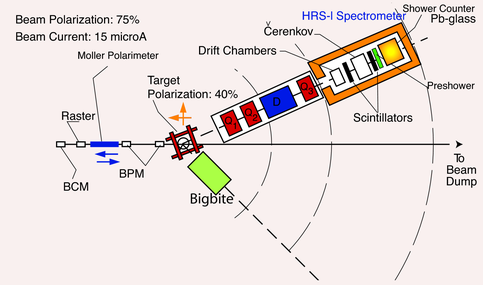
- d_2^n has the physical interpretation of being the averaged transverse (Lorentz) force acting on the struck quark immediately after being struck by a virtual photon.

- Decomposing this Lorentz color force into it's electric and magnetic components, d_2^n can be expressed as the so called "color polarizabilites":

$$d_2^n = \frac{1}{8}\left(\chi_E + 2\chi_B\right).$$

- Such a representation give information about the color field response to the polarized nucleon

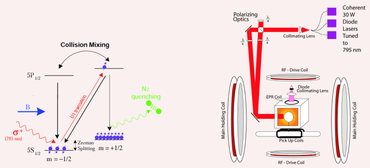
Experimental Setup



- The source is a CW polarized electron beam with an average ploarization of 75%.
- Target is polarized ^3He
- LHRS is used to measure absolute cross section $\sigma_0{}^3He$.
- Big Bite is used to measure the asymmetries $A_\perp^{^3He}, A_\parallel^{^3He}$.

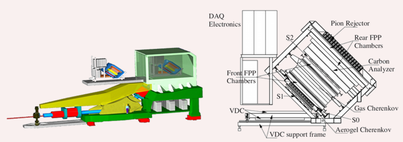
Target

- Target is polarized by spin exchange between optically pumped Rb-K gas and ^3He nuclei.
- Rb electrons accumulate in the $(5S_{1/2}, m = +1/2)$ sub level, via the D1 transition.
- Rb polarization is then transfered to ^3He nuclei through spin exchange interactions.



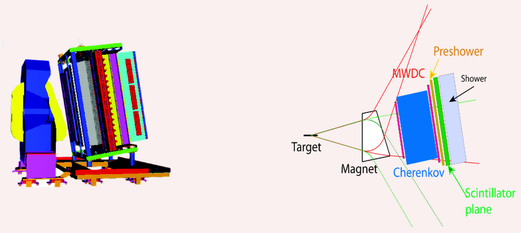
- Three 30W Coherent lasers are used to create circularly polarized light at 795nm.
- Polarization holding field is created using 25G Helmholtz coils.
- Target polarization is measured using two techniques, NMR and EPR.
- Average target polarization of 60%

LHRS

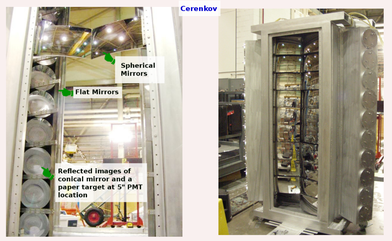


- Momentum resolution $1x10^{-4}$.
- Solid angle acceptance 6.7msr.
- Contains Vertical Drift Chamber for momentum and scattering determination.
- Gas Cerenkov and Pb-Glass Calorimeter used for pion rejection.
- Scintillators used for charged particle triggering.

Big Bite

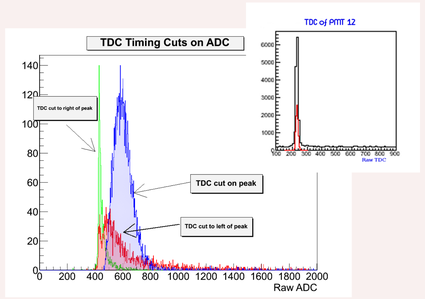


- Large acceptance non-focusing magnet.
- Solid angle 64msr.
- Contains 3 MWDC (used for track reconstruction)
- Pb-Glass Calorimeter (pre-shower, shower)
- Gas Cerenkov used as pion rejecter.

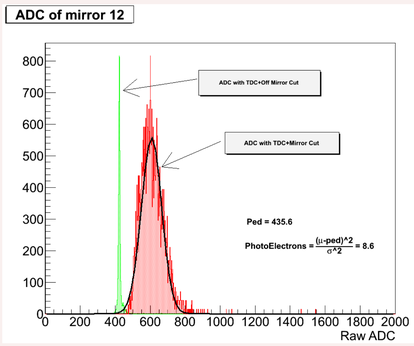


Big Bite Cerenkov Analysis

Cerenkov timing cuts were made to select good electrons.

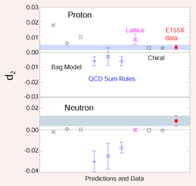


- Using TDC and Cerenkov Mirror cuts, the Photo Electron yield was found.

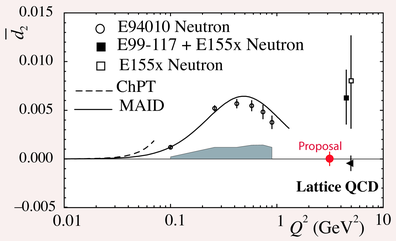


Projected Results

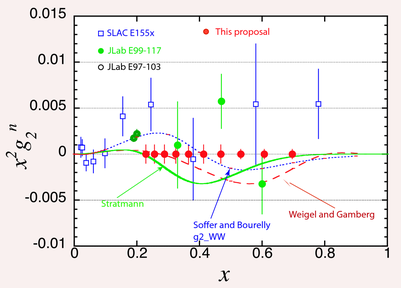
- Except for QCD Sum Rules all nucleon bag models and chiral solution models are consistent with Lattice QCD and a zero value.
- Experimental result is positive and 2σ away from zero.
- g_2^n in these models is negative at large x, so poor precision may be affecting the overall sign of the result.



- Data point for d_2^n at $Q^2 = 3GeV^2$ will be measured and added to the Q^2 evolution of d_2^n(evolution plot shown without nucleon elastic contribution).
- Measurement of d_2^n at $Q^2 = 3GeV^2$ will allow a comparison to Lattice QCD calculation.



- Precision measurement of d_2^n will provide a better test for g_2^{ww}(twist-two contribution to g_2^n) model calculations as well as quark and chiral solution models.



- Precision measurements of d_2^n along with $f_2^n = \frac{1}{3}(\chi_E - \chi_B)$ will yield measurements for χ_E and χ_B.

Acknowledgements

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References

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