TJNAF Exp. 96-002: Precision measurement of the nucleon spin structure functions in the region of the nucleon resonances

U. of Virginia, U. Basel, Florida International U., Hampton U., Kent State U., North Carolina A&T U., Norfolk State U., Old Dominion U., U. of Tel-Aviv, TJNAF, C. of William & Mary, Yerevan Physics I.
Oscar A. Rondon, spokesman

This experiment will make high precision and high resolution measurements of the spin structure of the proton and deuteron in the region of the nucleon resonances, at two values of the four-momentum transfer $Q^2\sim$ 1.3 GeV^2 and $\sim$ 5.5 GeV^2. Fundamental properties of the nucleon and QCD will be explored with adequate precision to obtain conclusive information. We plan to use TJNAF's polarized electron beam at 6 GeV, the Virginia-Basel ammonia and deuterated ammonia polarized targets and Hall C's High Momentum Spectrometer and Møller polarimeter.

At $Q^2 \sim 1.3$ GeV^2 we will concentrate on the nucleon spin asymmetries $A_1(\nu, Q^2)$ and $A_2(\nu, Q^2)$; ν is the lepton energy loss. The neutron spin asymmetries will be extracted from the measured proton and deuteron asymmetries. A_1 and A_2 describe the quarks contribution to the nucleon spin, explore the effects of quark-gluon interactions which can be represented by twist-3 matrix elements calculable in lattice QCD, and probe the extension of local duality from the unpolarized scattering regime to spin degrees of freedom. The kinematic region to be covered by the data connects very well with other polarized deep inelastic scattering (DIS) experiments. The spin structure function $g_1 = F_1(A_1 + QA_2/\nu)/(1 + (Q^2/\nu^2))$ measured in our experiment (F_1 is the transverse structure function) can be used to test the extended Gerasimov-Drell-Hearn[1] sum rules $\Gamma(Q^2) = \frac{2m^2}{Q^2}\int_0^1 g_1^{p,n}(x, Q^2)dx = \int_{Q^2/2m\nu}^{\infty} g_1^{p,n}(\nu, Q^2)\frac{d\nu}{\nu}$ with a minimum of interpolations or use of fits to the world data on g_1. We will measure the inclusive parallel and perpendicular asymmetries $A_{||}$ and $A_\perp$, to remove any model dependence when extracting the spin asymmetries $A_1 = \frac{C}{D}\left(A_{||} - dA_\perp\right)$ and $A_2 = \frac{C}{D}\left(c'A_{||} + d'A_\perp\right)$ where C, c', D, d and d' are only functions of the kinematic variables (D has an additional weak dependence on $R = \sigma_L/\sigma_T$).

At $Q^2\sim$ 5.5 GeV^2 the focus will be the transverse asymmetry $A_{TT}(\simeq A_1)$ which will provide additional information on polarized local duality and its Q^2 dependence, bridging the low Q^2 data with the 12 GeV upgrade. Higher twists will be studied by combining our data with the numerous DIS results. A_{TT} is also directly related to the resonances' form factors and our measurement will test their Q^2 evolution and the associated pQCD predictions. For this kinematics the contribution of A_2 will be minimized by aligning the target field along the direction of the momentum transfer.

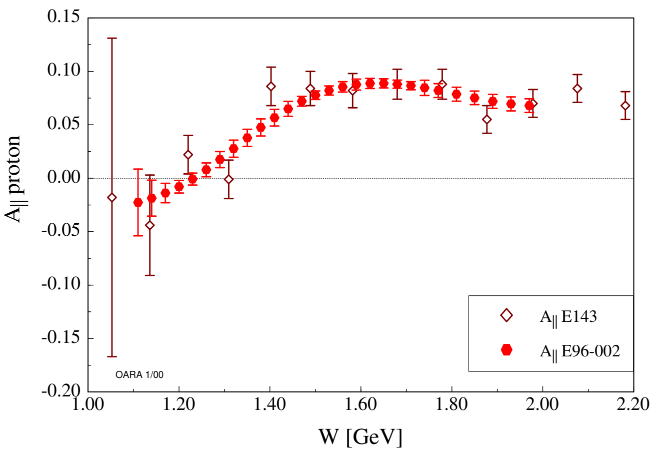

FIG. 1. Proton $A||$ in the nucleon resonances region. Diamonds: SLAC E143; hexagons: expected errors.

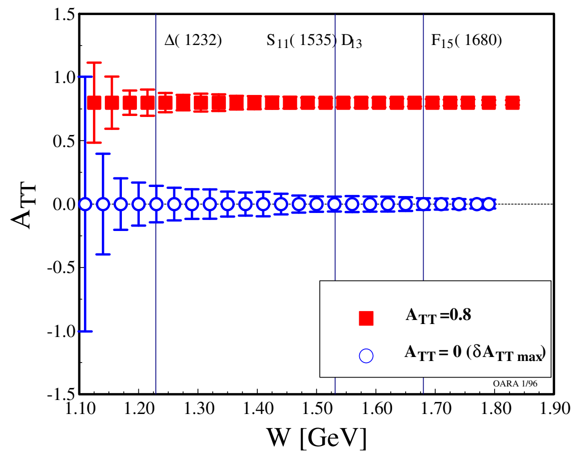

FIG. 2. Expected results for A_{TT} vs invariant mass W.

A sample of the expected precision and resolution of the data is shown in the figures, based on 100 nA, $\sim$70% polarized beams and $\sim$80% proton (30% deuteron) target polarization. The experiment is approved for 21 days of beam, divided roughly as 2/3 at low Q^2 and 1/3 at high Q^2.

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[1]V.D. Burkert and B.L. Ioffe, Phys. Lett. **B296**, 223 (1992).