EXPERIMENT 00-107

Proton Polarization in Deuteron Photodisintegration
to $E_\gamma > 3$ GeV at $\theta_{cm} = 90^\circ$

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At low momentum transfer, the deuteron is well understood by the use of meson – baryon theories. As the momentum transfer increases, corresponding to improved sensitivity to the short range structure of the deuteron, one expects that quark – gluon degrees of freedom will become of increasing importance. At some sufficiently high momentum transfer, a satisfactory extension of meson–baryon theories may be either impossible, or merely less efficient, than understanding reactions in terms of quarks and gluons.

The $D(\gamma, p)n$ reaction has been a focus for recent experimental searches for such a transition in the underlying physics. Both meson–baryon and quark models reproduce some of the cross section data, which extend up to 4 GeV for $\theta_{cm} = 37^\circ$ to $90^\circ$. For example, the small-angle cross sections agree with the Regge-theory quark-gluon string model, while the data above about 2 GeV are qualitatively reproduced by the QCD rescattering model, which relates photodisintegration to nucleon-nucleon scattering.

Hall A experiment 89-019 measured recoil proton polarization in $D(\gamma, p)n$ at high energies, at $90^\circ_{cm}$ for $E_\gamma \approx 0.5$ to 2.5 GeV. The induced polarization $p_y$ disagrees dramatically with the highest-energy old data, for $E_\gamma \approx 0.8 – 1.0$ GeV, and with the Bonn meson-exchange calculation. The polarization transfers $C_x$ and $C_z$ had not previously been either measured or calculated.

The Bonn calculation is the most complete existing meson-exchange calculation, including $\pi$, $\rho$, $\eta$, and $\omega$ exchange, plus all well-established nucleon and $\Delta$ resonances with $m < 2$ GeV and $J \leq 5/2$. The calculation qualitatively reproduces cross section data up to 1.6 GeV, and previous polarization data up to nearly 1 GeV. Comparison with E89-019 shows that the description of $p_y$ totally breaks down above several hundred MeV. Indeed, above 1 GeV $p_y$ seems entirely consistent with the pQCD prediction of vanishing. While $C_x$ and $C_z$ do not vanish, and thus are inconsistent with pQCD, they are small and consistent with monotonically decreasing.

Given these surprising results, we have proposed to continue the $\theta_{cm} = 90^\circ$ excitation function to higher energies. By improving the polarimeter, reducing backgrounds, and increasing the luminosity, it is possible to measure polarizations for energies up to $\approx 3$ GeV.