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Measurement of $F_{\gamma^*\gamma\pi^o}$ at Low Q^2 via the Virtual Primakoff Effect

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This experiment will measure the neutral pion form factor $F_{\gamma^*\gamma\pi^o}$ in the space-like Q^2 range 0.005 to 0.04 (GeV/c^2) using small angle electroproduction of π^o's in the Coulomb field of a heavy nucleus, the so called virtual Primakoff effect. The $\gamma^*\gamma\pi^o$ interaction procedes via the Adler-Bell-Jackiw axial anomaly and represents the most fundamental electromagnetic interaction of the neutral pi meson. It has been studied theoretically from the point of view of models based on vector meson dominance as well as those involving treatments of the π^o quark substructure and is expected to be sensitive to the quark distribution inside the pion and to the constituent quark mass. The slope of the form factor at low Q^2 will provide information on the interaction radius of the $\gamma^*\gamma\pi^o$ transition. Such low Q^2 measurements are expected to be largely model independent in their extraction of this interaction radius, as they are quite insensitive to the functional form used for the form factor in its extrapolation to the photon point.

The virtual Primakoff scattering cross section is given by:

$$\frac{d^3\sigma}{d\epsilon_2 d\Omega_2 d\Omega_\pi} = \frac{Z^2\eta^2}{\pi}\sigma_M \frac{Q^4}{K^4}\frac{\beta_\pi^{-1}}{\omega_\pi}|F_N(K^2)|^2|F_{\gamma^*\gamma\pi^o}(q_\mu^2)|^2 sin^2(\frac{\theta_e}{2})sin^2(\theta_\pi)[4\epsilon_1\epsilon_2 sin^2\phi_\pi + |\vec{q}|^2/cos^2(\frac{\theta_e}{2})]$$

where σ_M is the Mott cross section, $\eta^2 = (4/\pi m^3)/\tau$, τ is the π^o lifetime, K is the (nearly real) photon four momentum from the Coulomb field, the pion four momentum is $Q = (\vec{q}, \omega_\pi)$, $\beta_\pi = \vec{q}/\omega_\pi$, and $F_N(K^2)$ is the nuclear form factor.

The Pb$(e, e'\pi^o)$Pb cross section will be measured at an electron energy loss of 4.4 GeV, an electron scattering angle of 2.7 degrees, and a pion angle of 0.1 degrees with respect to $\vec{q}$ using the small scattering angle capabilities of the TJNAF Hall A Möller polarimeter and a series of lead glass detectors to measure photons from the neutral pion decays. The Hall A Möller polarimeter is designed to measure the small electron scattering angle events using a series of quadrupole magnets and a dipole. The quadrupoles perform a selection on the angle of the scattered electrons and transform their trajectories so that they are parallel to and displaced from the beam. The scattered electrons are then momentum analyzed in a dipole magnet and detected in a detector package especially designed for this experiment. Running time for this experiment is ten days at 5μAmperes of beam current.