ABSTRACT

We propose a study of the off-shell electron-proton vertex through a measurement of the virtual Compton scattering cross section and polarization transfer coefficients in the reaction $^1\mathrm{H}(\vec{e},e'\vec{p})\gamma$. Our proposed measurement will determine the dependence of these observables both as a function of the four-momentum transfer, over the range of 0.28 to 1.00 $(\mathrm{GeV/c})^2$, and as a function of invariant mass of the intermediate state in the range of 938 to about 1150 MeV. The experiment exploits the 100 % duty factor electron beam at CEBAF in combination with the proton polarimeter, which is presently being developed for Hall A by a collaboration of the College of William and Mary, and Rutgers University. The combined knowledge of electron and proton spin enables a precise structure-function separation. The proposed experimental method allows a separation with small systematic error, as for each such measurement only one electron beam energy is used and the kinematical configuration is fixed.

Recent calculations using microscopic models for the nucleon predict that the form factors of the off-shell proton differ significantly from the on-shell form factors. In addition, a correct description of the vertex requires the existence of additional vertex operators and associated form factors, beyond $\mathrm{F_1(Q^2)}$ and $\mathrm{F_2(Q^2)}$. The proposed experimental method allows one to test models for the off-shell behavior under very clean circumstances. This is in contrast to the situation for electron scattering from off-shell nucleons bound in a nucleus, where one is faced with obscurance due to e.g. nuclear-structure, final-state interaction and meson-exchange currents effects.

Using a separable model, we present estimates for the cross section and the polarization transfer coefficients, D_{lt} and D_{ll}, including contributions from electron and proton radiation, as well as the interference contribution. For the measurements probing the dependence of the cross section as a function of the four-momentum transfer, we expect better than 2 % statistical precision within 80 hours of beam time. It is shown that the coefficients D_{ll} and D_{lt} can be determined to an accuracy better than 0.03 within 350 hours of beam time. This experiment requires forward electron scattering angles in order to enhance the $^1\mathrm{H(e,e'p)}\gamma$ cross section. The excellent resolution of the Hall A spectrometer setup is necessary in order to cleanly select virtual Compton scattering events.