PR12-13-009: *Wide–angle Compton Scattering at 8 and 10 GeV photon energies*

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The proposed experiment would measure wide–angle real Compton scattering (RCS), $\gamma p \to \gamma p$, in the region of large squared CM energy $s = 16 - 20\,\mathrm{GeV}^2$ and large invariant momentum transfer $|t| = 2 - 13\,\mathrm{GeV}^2$, corresponding to CM scattering angles in the range $\theta_{\mathrm{CM}} = 60 - 120\,\mathrm{deg}$. The experiment is to be carried out in Hall C, where the recoil proton would be detected with the HMS spectrometer, and the produced γ with a new neutral particle spectrometer (NPS). It builds on and extends the successful 6 GeV RCS experiments E99-114 (Hall A) and E07-002 (Hall C).

RCS at large s and $|t|$ is the simplest hard exclusive process on the nucleon, and its physics interpretation is closely related to that of the high–$|t|$ elastic nucleon form factors. It probes short–range nucleon structure (at the smallest distances accessible with 12 GeV), the nature of interquark forces in QCD, and the role of polarization in the nucleon's valence quark component. The basic question explored in RCS is how the struck quark radiates the photon and transfers its multi-GeV momentum to the other constituents. Two mechanisms have been proposed and widely discussed in the literature: (a) the Hard Scattering Mechanism, where three valence quarks rescatter through perturbative gluon exchange; (b) the Soft Mechanism (or handbag diagram), where the photon is radiated by the struck quark, and the momentum transfer to the spectators happens through non-perturbative interactions. The Hall A E99-114 measurement of the $\gamma \to p$ polarization transfer was able to clearly distinguish hard and soft mechanisms (at a single kinematic point) and had major impact on the theoretical understanding of hard processes.

Recent theoretical developments have further heightened the interest in RCS and strengthened the framework for its theoretical analysis. A comprehensive study of RCS within Soft–Collinear Effective Theory (SCET) systematically classified the corrections to the QCD hard scattering mechanism and established an interesting connection with two-photon exchange in elastic ep scattering [Vanderhaeghen, Kivel 12]. An update of the soft mechanism predictions now allows for a quantitative assessment of the uncertainties and the role of helicity-flip generalized parton distributions [Diehl, Kroll 13].

An extension of RCS measurements to 8 and 10 GeV photon energy would clearly be very interesting. It would penetrate further into the short-

distance regime, observe the kinematic dependencies, and allow one to test the quantitative predictions of the proposed mechanisms. The new information on short–range nucleon structure and polarization effects would complement that obtained with the approved 12 GeV elastic nucleon form factor measurements. In the context of SCET the RCS measurement would also provide input for the theory of two–photon exchange in elastic form factors.

The γp RCS signal will have a large background of photons from exclusive π^0 production, which is expected to have a different kinematic dependence and reach 10-30 times the RCS rate at the highest $|t|$ values. The π^0 background will be measured and simulated independently to enable accurate subtraction. Given the kinematic constraints (initial photon momentum direction, exclusive final state) this looks feasible, and the proponents have demonstrated the technique in the earlier 6 GeV RCS measurements. The exclusive π^0 cross section would be of independent physical interest and provide input for future theoretical studies of high–$|t|$ meson production (e.g., using the SCET approach).