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Resolving the Proton Form Factor Problem with Positron-Proton Scattering

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The proton electromagnetic form factors are essential pieces of our knowledge of nucleon structure. However, Rosenbluth separation measurements of the proton electric form factor, $G_E(Q^2)$, differ from polarization transfer measurements by a factor of three at $Q^2 = 5.6$ $(\mathrm{GeV}/c)^2$. This discrepancy must be resolved. One possible resolution is to include the contribution of hard two-photon exchange (TPE) contributions. These contributions are very difficult to calculate. However, we can directly determine the TPE effect by measuring the ratio of the positron-proton to electron-proton elastic scattering cross sections, $R = \sigma(e^+p)/\sigma(e^-p)$, because the TPE amplitude has the same sign as the e^+p born amplitude and the opposite sign as the e^-p born amplitude. We have measured R over a wide range of momentum transfer, $0.2 \leq Q^2 \leq 2$ GeV^2, and virtual photon polarization, $0.1 \leq \epsilon \leq 0.9$, using a mixed identical beam of electrons and positrons in Hall B at Jefferson Lab. This talk will describe the experimental techniques used to produce this beam, the analysis techniques to identify elastic scattering events, and some preliminary results.