Precision Measurements of Electron-Proton Elastic Cross Sections at Large Q^2

I. INTRODUCTION

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II. EXPERIMENTAL SETUP

A. Hall A Beamline

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B. Target

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C. High Resolution Spectrometer

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In order to obtain knowledge about the absolute uncertainty in the VDC reconstruction efficiency, one of the front straw chambers from the focal plane polarimeter was installed in the detector package of each HRS. As shown in Fig. 1, the straw chamber was located in front of the Gas Cherenkov detector, about 1.5 m away from the center of the bottom VDC. The active area of straw chamber was oriented perpendicular to the nominal particle trajectory at the focal plane. The chamber consisted of a total of six planes of parallel cylindrical straw tubes of radius 0.5 cm, which were divided into V and U groups, with the V group at a distance of about 7 cm upstream of the U group. The V straws were oriented at 45° relative to the dispersive direction of HRS and the U straws at 135°. An anode wire ran along the central axis of each tube and was kept at a voltage of about 1.8 kV. Each tube is supplied with a gas mixture of argon (62%) and ethane (38%).

D. Data Acquisition

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III. DATA ANALYSIS

A. Beam Energy

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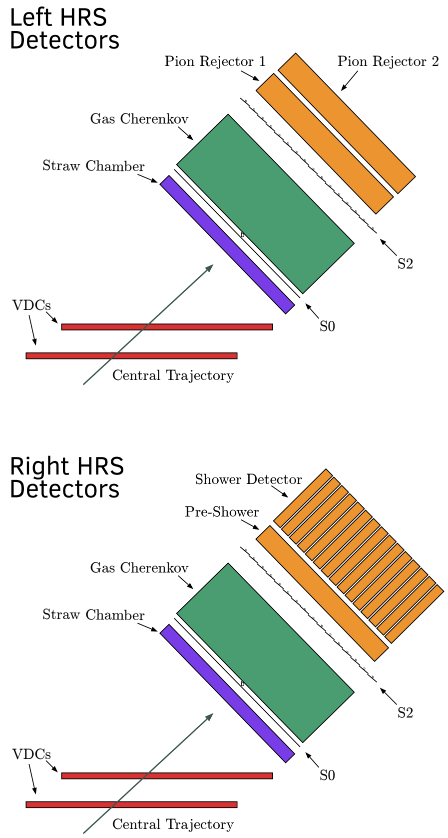

FIG. 1. Configuration of HRS detectors as used in Experiment E12-07-108.

B. Luminosity

1. Incident Charge

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2. Target Densities

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C. Event Reconstruction and Selection

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D. Efficiencies and Live Time

1. VDC Reconstruction Efficiency

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The one-cluster-only cut described above eliminated about 10% of total number of events for all E12-07-108 kinematics. The events with multiple clusters may occur due to noise from the electronics, comsmics, or radiation background. They can also result from spurious tracks caused by delta rays that are produced before or in the wire chamber by actual tracks. We applied the VDC reconstruction efficiency in Eq. **??** to the raw yield to recover those elastic electron events dropped by the one-cluster-only cut. This procedure essentially assumes that the fraction of elastic events in the multiple cluster events is the same as that in the one cluster events. The added straw chamber in HRS was used to test this assumption and estimate the uncertainty in VDC reconstruction efficiency.

The straw chamber provides an effective third readout plane for the HRS tracking system. Each straw in the straw chamber constitutes an independent drift unit. When a charged particle traverses a straw, it ionizes the gas atoms and the liberated electrons drift toward the anode wire, generating analog signals which are then processed by the electronics. From the pattern of fired straws, one can reconstruct the intercept of particle trajectory with straw planes in either the V or U direction. This additional information allows for determination of the track parameters for events where multple clusters are only present in only one of the two vertical drift chambers.

Using inelastic electron scattering data, a software alignment was first performed to find the accurate position of the straw chamber relative to the VDCs. This procedure made use of the "golden" tracks which had a single cluster in all of the four VDC readout planes. It was believed that such events were always reconstructed correctly in the VDCs. The position and orientation of the straw chamber were then adjusted so that the track projections onto the straw planes were close to the positions of the fired straws. The result of alignment is shown in Fig. **??**.

When a charged particle passes through the active area of straw chamber, a cluster in its U and V planes will be formed, which enables us to determine the track parameters even when multiple clusters are present in one of the two VDCs and lead to ambiguity in recosntructing the cross-point there. We only used the position of fired straws to determine the cluster position to avoid the problem of determining whether the particles pass to the left or right side of the anode. This procedure results in a resolution in the reconstructed track parameters that is only slightly worse than those given by the VDCs due to the relative long distance between VDCs and straw chamber.

Using straw chamber, we analyzed the multi-cluster events where more than one cluster are present in one of the two VDCs. We also request that a single cluster is identified in both the U and V planes of the straw chamber. The track parameters of such events are then reconstructed with the positions of the single clusters in the VDC and straw chamber. The scattering angle and particle momentum at the target can then be calculated by applying the HRS optics matrices to the track parameters in the TRANSPORT coordinates. In addition to the single-cluster events that are reconstruted by the VDCs alone, a significant amount (about 50%) of multi-cluster events are analyzed with the combined information in the VDC and straw chamber, boosting the overall reconstruction efficiency to about 95%. The total number of elastic events in all the analyzed sample are then corrected by this reconstruction efficiency. On the other hand, we used the same sample of events and counted the number of elastic events in the one-cluster events, corrected by the VDC reconstruction efficiency. The results are shown in Table. ?. The corrected yields of the two approaches agree within 0.2%.

2. PID Efficiencies

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3. Live Time

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E. Spectrometer Optics

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F. Simulation

1. Spectrometer Optics and Acceptance

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2. Implementation of Radiative Processes

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G. Corrections for Saturated Magnets

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H. Extraction of Cross Sections

1. Data to MC Ratio Method

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2. Acceptance Correction Method

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I. Summary of Uncertainties

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IV. RESULTS

V. CONCLUSIONS