An Instrument for Precision Angle Measurement

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Introduction

The need for Hall A HRS angle measurements on the level of 10^{-4} rad (or better) was evident from the time of construction of the facility. The present technique used for HRS angle measurement relies heavily on optical surveys whose geometrical accuracy is limited to 100-200 μm. The proposed technique will result in a geometrical accuracy on the level of 5-10 μm. The physics motivation for the construction of such a device is clear. A unique set of L/T (Rosenbluth) separation experiments has been proposed whose systematic uncertainties are dominated by the knowledge of the absolute HRS angle. For example, in an L/T separation performed on a proton target at $Q^2 = 5$ (GeV/c)^2, the value of G_E^p/G_M^p changes by a full 20% for a change in recoil proton angle of 0.5 mrad. A precision study of the Coulomb sum rule also requires excellent understanding of the L/T separation systematics which depend on knowledge of the HRS angle. The precision of the proposed instrument completely solves this problem for all existing proposals, and even for investigations of two-photon effects in electron scattering through careful measurement of the angular dependence of the cross section.

Parameters of the instrument

The proposed device (see Fig. 1) will allow measurement of the absolute spectrometer angle to an accuracy of 0.05 mrad. It consists of an aluminum frame (see Fig. 1), two wire scanners, a wire target, and a silicon microstrip detector (MSD). The frame has a diameter of 90 cm which will enable it to be placed inside the Hall A scattering chamber. The 10 μm tungsten wire target will be stretched vertically (in the lab frame) on the target holder. The MSD (one or even several) will be mounted on aluminum blocks, which can be removed from the main frame without significant loss of positional accuracy.

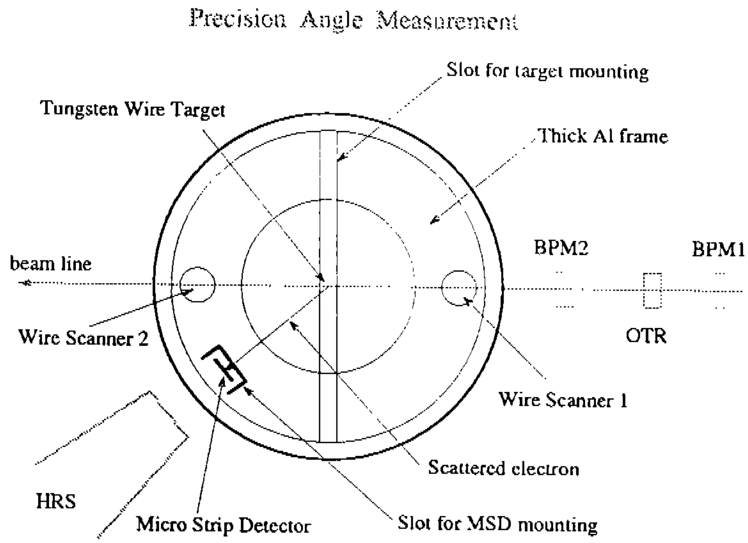

Figure 1. The layout of the PAM inside Hall A scattering chamber.

Measurement procedure

Each measurement will take about one hour of beam time. A beam current on the level of 5 μA will be required. Note that before cryogenic target runs which result in high luminosity, the scattering chamber will have to be opened, and the MSD(s) and the wire target removed. A measurement will combine information from the existing beam position monitors BPM1 and BPM2 (recall Fig. 1), as well as from additional wire scanners WS1 and WS2. BPM1/BPM2 will be used to monitor the stability of the beam both during the angle measurement and over the entire experiment. WS1 and WS2 will be used to measure the beam direction relative to the frame of the device. Electrons scattered from the tungsten wire will be detected both by the High Resolution Spectrometer whose angular position needs to be measured, and by the MSD(s) mounted on the instrument frame inside scattering chamber. Event-by-event determination of the scattering angle will be on the level of 0.05 mrad (or better). 1000 events will be needed to calibrate the angular offset of the HRS with a resolution of 1-2 mrad FWHM.

Manpower and community interest

Several groups have expressed interest in joining developmental efforts. P. Vernin has agreed to work on the conceptualization of this novel wire scanner. R. Gilman is interested in working with the MSD(s), and the design and construction of the precision frame. His new proposal will require this instrument. M. Finn and D. Armstrong are ready to take major role in this project, which will solve a problem of accurate q^2 determination for parity experiments.

Technology availability

MSD(s) have been successfully used in Hall A in the energy measurement system [1]. A subsequent MSD DAQ based on commercial electronics was recently developed for the photon polarimeter in Hall B. Wire scatter technology is well-known to JLab, and has already reached the required level of accuracy of 10 μm. P. Vernin has ideas on how to improve the precision further. Frame calibration to a few μm has already been performed for the comparable energy measurement system frame. Finally, according to A. Gavalya, the design of the proposed instrument is straightforward.

References

[1] J. Berthot and P. Vernin, Nucl. Phys. News **9**, 12 (1990).