A PROTON RECOIL POLARIMETER FOR THE ZGS

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ABSTRACT

A crude double-arm spectrometer using coincidence and pulse-height threshold techniques to identify elastic recoil protons from a polyethylene target has been constructed and used as a monitor of external beam polarization at the ZGS. After initial calibration against the ZGS absolute polarimeter this device was used for machine tuning and machine experiments. The measurement speed was 30 times greater than that of the absolute polarimeter and the calibration was shown to be stable to $\pm 3\%$ over a period of a few days.

INTRODUCTION

The polarization of high energy beams at the ZGS is measured in the external proton beam line. A simple high-rate polarimeter uses coincidence techniques to measure the left-right asymmetry in the inclusive scattering from a polyethylene target at a lab. angle near to 90° . This so-called "fast" polarimeter is calibrated against the double-arm spectrometer described by Khoe et al¹. This report describes a similar polarimeter built at CERN and tested at the ZGS.

THE POLARIMETER

A good working point for proton recoil measurements at 6 GeV/c is in the region of $|t| = 0.1 \text{ (GeV/c)}^2$. The figure of merit for best statistics, the square of the analysing power multiplied by the p-p differential elastic scattering cross section, is close to its maximum value and yet the recoil kinetic energy, E , of around 50 MeV is high enough to permit the use of triple-coincidence telescopes with two 3 mm scintillators to measure dE/dx and a third one of 15 mm in which the protons are ranged out to give a signal depending on E . In this way good discrimination against low energy particles and pions can be achieved. Wedge absorbers are mounted in front of the 15 mm scintillators to attenuate the energy of the protons in the more forward directions.

TUNING AND STABILITY

In setting up this type of polarimeter the aim is to obtain a high event rate at large analysing power with the counter thresholds tuned so that the telescopes accept only protons within a certain range of energies around 50 MeV. Unfortunately these requirements conflict and in cleaning up the signal to exclude pions we also throw away some protons, thus reducing the rate. The maximum measured

asymmetry is only achieved at the expense of event rate.

Tuning consists of varying the tube voltages, discriminator thresholds, coincidence timing and wedge filter geometry. The first two have the effect of raising or lowering the overall thresholds. The relative levels between the first two counters and the third counter in each arm are important as well as the absolute values. The timing plays two parts. Firstly, one has to be sure of having a coincidence plateau, and then by setting the No. 3 counters towards the front end of this plateau some time-of-flight discrimination

Fig. 1. Tune curves at 6 GeV/c.

against the faster particles is achieved. Finally the use of wedge absorbers increases the energy acceptance of the telescopes, but each change of absorber has to be followed by a complete retune of the other parameters.

Typical tune curves obtained by varying the overall voltage supplied to the photomultipliers are presented in Fig. 1. Two working points are identified. The fast tune, at V_2 , gives 30 times the speed of the absolute polarimeter. At the "cleanest" setting, V_1 , we have 80% of the p-p elastic analysing power but at one half or less of the above speed.

As we rely on pulse height discrimination to get the high asymmetry, the event rates and right-left balance, R/L, are very sensitive to photomultiplier gain variations. However, this sensitivity depends on the choice of working point becoming greater as one moves to higher asymmetry. However, the asymmetry itself becomes less dependent upon voltage, which is encouraging as this is the quantity that we measure. At a typical operational setting a one-volt drift in the high voltage power supply produced a 1% to 3% change in rate but only a 0.3% change in asymmetry. Since the voltage stability over a few days was found to be good to ± 1 V this situation seems to be tolerable, although longer term drifts in photomultiplier tube gains will require that recalibration be made on, say, a weekly basis.

R. Diebold² has suggested a simple modification that would permit this polarimeter to operate with more stable calibration but somewhat reduced speed.

REFERENCES

1. T. Khoe et al, Acceleration of Polarized Protons to 8.5 GeV/c, Particle Accelerators 6, p213, 1975.
2. R. Diebold, A New Polarimeter Design, ANL-RD-30, October 1975.