

## POLARIMETERS FOR THE AGS POLARIZED-PROTON BEAM

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Summary

This report describes the three polarimeters which will be used to measure the beam polarization at the AGS polarized beam facility.<sup>1</sup> The beam polarization will be measured before injection into the AGS, during acceleration, and after extraction from the AGS. The 200-MeV polarimeter uses scintillation-counter telescopes to measure the asymmetry in p-carbon inclusive scattering. The internal polarimeter can measure the beam polarization at up to five selected times during acceleration. A continuously spooled nylon filament is swung into the beam at the appropriate time and the asymmetry in pp elastic scattering measured by two scintillation-counter telescopes. This is a relative polarimeter which can be calibrated by the absolute external polarimeter located in the "D" extracted-beam line. This polarimeter uses scintillation counters in two double-arm magnetic spectrometers to measure clearly the asymmetry in pp elastic scattering from a liquid hydrogen target. The specific features and operation of each polarimeter will be discussed.

Polarimetry

The three polarimeters described in this report are similar in that they all measure a left-right scattering asymmetry, at a given scattering angle, in a horizontal plane normal to the beam polarization direction. If the analyzing power, A, is known for the reaction the beam polarization can be measured.

Here A is defined as the left-right scattering asymmetry observed when either beam or target particles are 100% polarized where

$$A = \frac{1}{P} \frac{L-R}{L+R} = \frac{1}{P} \frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow}}$$

and where L(R) is the number of particles scattered to the left (right),  $N^{\uparrow}$  ( $N^{\downarrow}$ ) is the number scattered to the left when the polarization is up (down) and P is the actual polarization.

Inverting the above relations gives the beam polarization when A is known.

200 MeV Polarimeter

The 200 MeV polarimeter will be placed at the end of the AGS' 200 MeV linac and will measure the beam polarization before injection into the AGS.

The polarimeter is shown in Fig. 1 and consists of two pairs of two scintillation counter telescopes which measure p-carbon inclusive scattering from a carbon filament target. Two telescopes measure left and right scattering at  $12^{\circ}$  while the other two measure at  $16^{\circ}$ . In addition two other telescopes (not shown) measure the scattering in the plane of the beam polarization and thus are not sensitive to polarization direction. These telescopes are used for monitoring.

Three different size carbon targets can be placed at the instrument's scattering center or removed from the beam. The target thickness along the beam is chosen to obtain suitable count rates, while the width is adjusted to keep beam destruction (by stripping of the  $H^{-}$  ions) to a few percent.

The apparatus has been calibrated at the Indiana University Cyclotron Facility and the analyzing power at  $12^{\circ}$  and  $16^{\circ}$ , respectively, was found to be 0.62 and  $0.511 \pm .004$ .

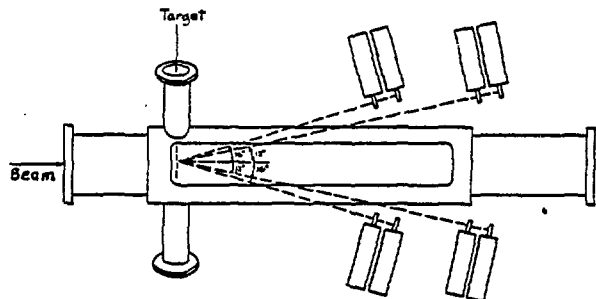


Fig. 1. Layout of 200 MeV polarimeter

Internal Polarimeter

It is desirable to measure the beam polarization at various times during acceleration. In this way the beam can be tuned through depolarizing resonances with minimum polarization loss by measuring the polarization before and after the resonance.

The apparatus to be installed in the AGS ring is shown in Fig. 2. The target consists of a nylon filament which can be swung in and out of the beam on command. Various quantities such as nuclear losses, emittance growth, radiation damage to the target and target heating placed severe constraints on the target and insertion mechanism. To keep these quantities at reasonable levels, with  $10^{11}$  circulating protons, required that the target consist of 1.2 km of .003" nylon

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filament being spooled at 100 cm/sec with the capability of being inserted into the beam envelope at 100 cm/sec and be stationary during the scattering measurement.

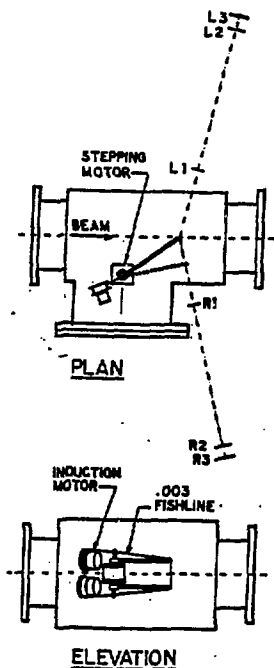


Fig. 2. Layout of internal polarimeter

Because of the problem of emittance growth, particularly at lower momenta, the dwell time is limited and the target cannot be left in for the complete acceleration cycle. So the normal procedure will be to swing the target in to study a set of depolarizing resonances with the detector being electronically gated to study a particular resonance. The apparatus is now undergoing testing and is being readied for installation.

The detectors are a pair of three scintillation counter telescopes. They measure the left and right recoil particles from pp elastic scattering at a four momentum transfer squared ( $-t$ ) of  $.15 \text{ (GeV/c)}^2$ . The elastically scattered events are identified through time of flight, ranging and energy loss. However, because the nylon target is only 9% hydrogen, protons from other reactions are likely to be detected, thus the effective analyzing power  $A_{\text{eff}}$  will be less than that from elastic scattering  $A_{\text{el}}$ . It is expected that

$$A_{\text{eff}} = \frac{2}{3} A_{\text{el}}$$

Figure 3 shows  $A_{\text{el}}$  for pp elastic scattering at  $-t = .3 \text{ (GeV/c)}^2$  as a function of beam momentum. It is not much different at  $-t = .15 \text{ (GeV/c)}^2$ , but the important points are that there is a rapid variation in  $A_{\text{el}}$  as  $P_{\text{lab}}$  increases and that at  $26 \text{ GeV/c}$   $A_{\text{el}} = .03$ . Therefore, it is important to keep  $A_{\text{eff}}$  as high as possible.

The internal polarimeter is a relative polarimeter, but can be used for measuring the polarization difference before and after a depolarizing resonance without an absolute calibration. If it is necessary

to calibrate it, an absolute polarimeter such as described in the next section can be used.

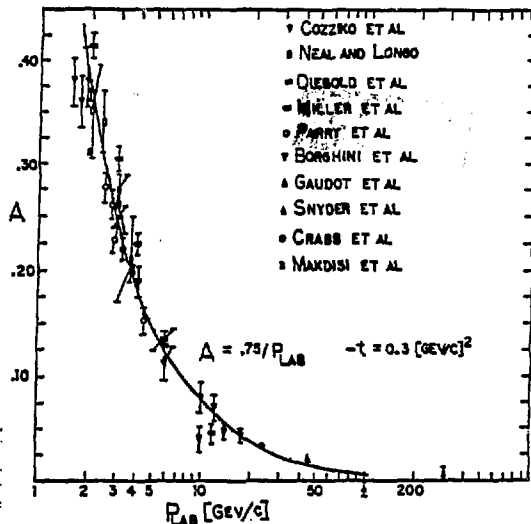


Fig. 3. Analyzing power in pp elastic scattering as a function of laboratory momentum at a four momentum transfer of  $0.3 \text{ (GeV/c)}^2$

#### High Energy Polarimeter

The high energy polarimeter is situated in the "D" extracted beam line and is used to measure the polarization of the extracted beam before the scattering experiments in the line. The polarimeter layout is shown in Fig. 4. Two double arm magnetic spectrometers measure left and right pp elastic scattering from a liquid hydrogen target. By using tight angle and momentum constraints the elastic scattering signal is clearly identified. From Fig. 3 it is seen that  $A$  has been well measured and a simple fit as shown represents the data very well.

For this  $t$  value the analyzing power at  $P_{\text{lab}} = 26 \text{ GeV/c}$  is  $-0.03$ , but the cross section is high so it will be possible to measure the beam polarization to statistical accuracy of  $\sim 1\%$  in about 15 mins. assuming a polarized beam intensity of  $10^{10}$  protons/pulse.

The polarimeter has been installed and is currently being tested.

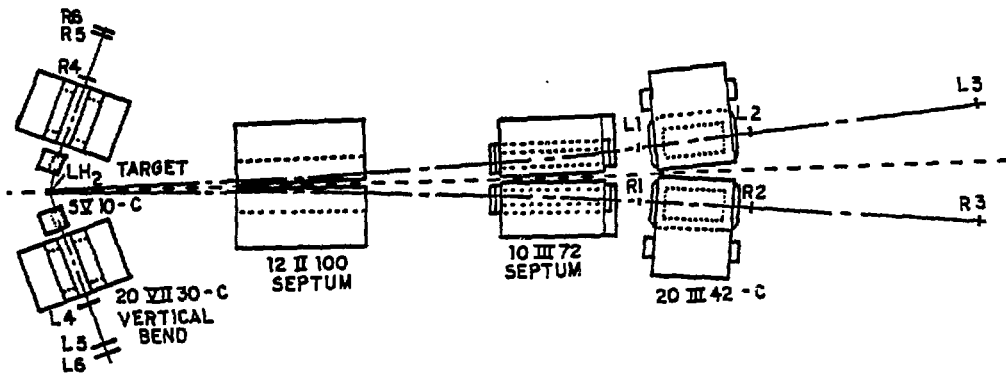


Fig. 4. Layout of the high energy polarimeter

References

1. K. M. Terwilliger et al., IEEE Trans. on Nuc. Sci. NS-28, 2031 (1981).

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