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A Polarimeter for Protons Between 300 and 800 MeV*

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ABSTRACT

A polarimeter for protons between 300 and 800 MeV has been constructed. It uses a carbon block analyzer of variable thickness and 6 drift chambers for particle tracking.

DISCUSSION

As part of a program for measuring spin transfer parameters in the pp and np systems, a proton polarimeter has been constructed at LAMPF. A schematic of the polarimeter is shown in Fig. 1. S1 and S2 are scintillators, each consisting of two 3/16" x 12" x 24" scintillators. W1 - W6 are drift chambers. Each chamber has one x-plane and one y-plane. The planes are a nominal 60 cm by 60 cm, with an anode wire spacing of .8128 cm. Each anode wire is connected to a 200 ns delay line, with a 2.8 ns delay per wire.

The left-right ambiguity associated with drift chambers was solved by use of an effect observed by Walenta and others.¹ Cathode wires are placed half-way between the anode wires as shown in Fig. 2. The pulses from the "odd" and "even" buses are added and subtracted. The subtracted pulse output is fed into a charge sensitive ADC and integrated over the first 100 ns of the pulse. The resulting spectrum consists of two peaks which correspond to events occurring on the opposite sides of the anode wire. The summed pulse output is used to stop a TDC which is started by an S1-S2 trigger. This gives the drift time, which can be related to the distance of the event from the anode wire. The chamber efficiency was typically greater than 99%.

The use of 3 chambers to determine a ray provides a consistency check. A line is fit to the 3 points for each event. A residual, the fit minus the position in the middle chamber, is calculated. The residual spectrum is sharply peaked, with a FWHM of ~.2 mm for 800 MeV protons, indicating a chamber resolution of ~.1 mm. The peak does broaden at lower energies (>400 MeV), presumably due to multiple scattering between chambers.

The carbon is commercial grade HLM with a density of 1.86 and purity >99.5%. Thicknesses ranged from 3.2 cm to 25.4 cm, depending on the proton energy.

To enhance the percentage of events scattering at angles >3° in the carbon, a hardware "fast reject" system was designed. A schematic of the system is shown in Fig. 3. A rough anode position

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is calculated using TACs. Summing (T6-T4) - (T3-T1) gives a rough projected scattering angle in the x or y plane. If both x and y pulse heights are within certain limits the event is rejected. At 800 MeV, with 25.4 cm carbon, use of the fast reject system increased the percentage of scatters $>3^\circ$ written to tape from 20% to 33%. The system is adjusted such that no events scattering $>4^\circ$ are rejected.

The scattering angle, θ , and azimuthal angle, ϕ , are calculated using the distribution $P(\theta, \phi) = 1/2\pi(1 + \epsilon \cos(\phi) + \epsilon' \sin(\phi))$. ϵ and ϵ' are equal to $A(\theta)\sigma_\perp$ and $A(\theta)\sigma_\parallel$ where $A(\theta)$ is the carbon analyzing power and $\sigma_\perp$, $\sigma_\parallel$ are the proton polarizations perpendicular to the momentum. Methods of extracting these asymmetries and correcting for instrumental asymmetries are described in Ref. 2-4.

Instrumental asymmetries for the system were found to be small. The net efficiency for the system for 800 MeV protons with 25.4 cm carbon was ~20%.

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Figure 1. Polarimeter schematic.

Figure 2. Chamber schematic.

Figure 3. "Fast reject" schematic.