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SENSITIVITY REQUIREMENT OF THE HIGH ENERGY POLARIMETER

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AGS DIVISION TECHNICAL NOTE

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When polarized protons are accelerated, one of the important problems is measuring the polarization P_B of the accelerated proton. Although it is quite easy to measure polarization of the low energy protons, say at 200 MeV, many depolarizing resonances in the strong focusing accelerator make it impossible to deduce the polarization of the accelerated protons.

The complicity of the polarimeter depends largely on the sensitivity and stability required to measure good relative and absolute polarization. One might argue that one needs not to know absolute polarization of the beam if one knows the relative polarization of the beam well enough. However, it is necessary to know the aboslute polarization good enough to analyze the overall physics result. Let us assume one has to know the relative polarization better than one percent and absolute polarization better than 5 percent and see what kind of sensitivity and the stability is required.

In general, one measures polarization by measuring the left and right assymetry and using known analyzing power A

$$P_B = \frac{1}{A} \frac{N_R - N_L}{N_R + N_L}$$

Let's say $X = AP_B$

$$\frac{\delta x}{x} = \frac{1 - x^2}{2x} \left[\left(\frac{\delta N_L}{N_L} \right)^2 + \left(\frac{\delta N_R}{N_R} \right)^2 \right]^{1/2}$$

Assuming $\left| \frac{\delta N_L}{N_L} \right| \sim \left| \frac{\delta N_R}{N_R} \right| = \left| \frac{\delta N}{N} \right|$

$$\frac{\delta x}{x} = \frac{1 - x^2}{\sqrt{2}\, x} \frac{\delta N}{N} \sim \frac{1}{\sqrt{2}\, x} \frac{\delta N}{N}$$

And

$$\frac{\delta P_B}{P_B} = \left[\left(\frac{\delta x}{x} \right)^2 + \left(\frac{\delta A}{A} \right)^2 \right]^{1/2}$$

$$= \left[\left(\frac{1}{\sqrt{2}\, x} \frac{\delta N}{N} \right)^2 + \left(\frac{\delta A}{A} \right)^2 \right]^{1/2}$$

According to the measurements of Crab, et al,[1] the analyzing power of the proton-proton elastic scattering is small (order of 3-5%) at 24 GeV/c. The uncertainty of the measurement of analyzing power A is typically a few percent.

In the case of absolute polarization measurement, the $\frac{\delta N}{N}$ of the spectrometer should be such that

$$\frac{1}{\sqrt{2}\, x} \frac{\delta N}{N} \sim \frac{\delta A}{A}$$

And

$$\frac{\delta N}{N} \sim \sqrt{2}\, x \frac{\delta A}{A}$$

Since $x = AP_B$ is about the order 3×10^{-2} in this energy range

$$\frac{\delta N}{N} \sim 5 \cdot 10^{-2} \cdot \frac{\delta A}{A}$$

In other words, if $\frac{\delta A}{A}$ is say 5×10^{-2} then

$$\frac{\delta N}{N} \lesssim 1/4\%$$

In other words, aside from statistical error, the systematic error should be in the order of 10^{-3} and inelastic rejection should be better than 10^{-3}.

In the case of the relative polarization, assuming the analyzing power is stable in this region,

$$\frac{1}{\sqrt{2}\ x} \frac{\delta N}{N} \sim 10^{-2}$$

And

$$\frac{\delta N}{N} \sim \sqrt{2}\ x \cdot 10^{-2}$$

Again

$$\frac{\delta N}{N} \sim 5 \times 10^{-4}$$

In other words, the N should be in order 4×10^{6} events. The spectrometer should be stable, better than the order of 10^{-4} in order to have relative polarization measurements of the order of one percent.

<u>REFERENCE</u>

1. D. Crab, private communication.

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