

BNL-104593-2014-TECH

AGS/AD/Tech Note No. 165;BNL-104593-2014-IR

SENSITIVITY REQUIREMENT OF THE HIGH ENERGY POLARIMETER

Y. Y. Lee

May 1980

Collider Accelerator Department Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.DE-AC02-76CH00016 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Accelerator Department BROOKHAVEN NATIONAL LABORATORY Associated Universities, Inc. Upton, New York 11973

AGS DIVISION TECHNICAL NOTE

No. 165

SENSITIVITY REQUIREMENT OF THE HIGH ENERGY POLARIMETER

Y.Y. Lee

May 30, 1980

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 $X = AP_{B}$

$$\frac{\delta_{\mathrm{X}}}{\mathrm{x}} = \frac{1 - \mathrm{x}^{2}}{2\mathrm{x}} \left[\left(\frac{\delta \mathrm{N}_{\mathrm{L}}}{\mathrm{N}_{\mathrm{L}}} \right)^{2} + \left(\frac{\delta \mathrm{N}_{\mathrm{R}}}{\mathrm{N}_{\mathrm{R}}} \right)^{2} \right]^{1/2}$$
Assuming $\left| \frac{\delta \mathrm{N}_{\mathrm{L}}}{\mathrm{N}_{\mathrm{L}}} \right| \sim \left| \frac{\delta \mathrm{N}_{\mathrm{R}}}{\mathrm{N}_{\mathrm{R}}} \right| = \left| \frac{\delta \mathrm{N}}{\mathrm{N}} \right|$

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

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

$$\frac{\delta N}{N} \sim \sqrt{2} \times \frac{\delta A}{A}$$

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

$$\frac{\delta N}{N}$$
 ~ 5 · 10⁻² · $\frac{\delta A}{A}$

In other words, if $\frac{\delta A}{A}$ is say 5 x 10⁻² then

$$\frac{\delta N}{N}$$
 $\stackrel{<}{\sim}$ 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

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

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.

REFERENCE

1. D. Crab, private communication.

mn

Distribution: Dept. Adm. AD S&P Staff



