A_N measurement in the CNI region, at $\sqrt{s} = 200 GeV$ in polarized pp elastic scattering

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Abstract. We describe the first measurement of the single spin analysing power (A_N) at $\sqrt{s} = 200$ GeV in the four momentum transfer t range $0.01 \leq |t| \leq 0.03$ (GeV$/c)^2$, obtained by the pp2pp experiment using polarized proton beams at the Relativistic Heavy Ion Collider (RHIC). The results presented are preliminary.

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THE EXPERIMENT

The layout of the experiment is shown in Fig. 1. More details can be found in [2, 3]. The identification of elastic events is based on the collinearity criterion, which requires the simultaneous detection of the scattered protons in the pair of Roman Pot (RP) detectors [4] on either side of the IP.

The silicon strip detectors (SSD) in the RPs were used to record the x, y coordinates of the scattered protons. They are made of 0.40 mm thick n-type silicon with p^+-type implanted strips of 0.07 mm width and a strip pitch of 0.10 mm. Each strip is capacitively coupled to an input channel of a SVXIIe [5].

The elastic trigger scintillators are 8 mm thick, 80×50 mm^2 in area, and each is viewed by two photomultiplier tubes. The elastic event trigger is a coincidence between signals in the RP's scintillators, belonging either to arm A or arm B, see Fig. 1. For each arm two closest to the collision point RP's were used: RP1 and RP3. The overall trigger was a logical OR of a coincidence between up and down pots: (RP3U and RP1D) OR (RP3D and RP1U) in coincidence with the beam crossing signal derived from the RHIC master clock. For each event, TDC and ADC information for the trigger scintillation counters was recorded.

SELECTION OF ELASTIC EVENTS

The detectors in RP1 and RP3 were used for elastic event reconstruction, as this provided the highest acceptance for the experiment. Particle hits in the silicon detector were identified for each strip requiring that the energy deposited (ΔE) was $\Delta E \geq 5\sigma$ of

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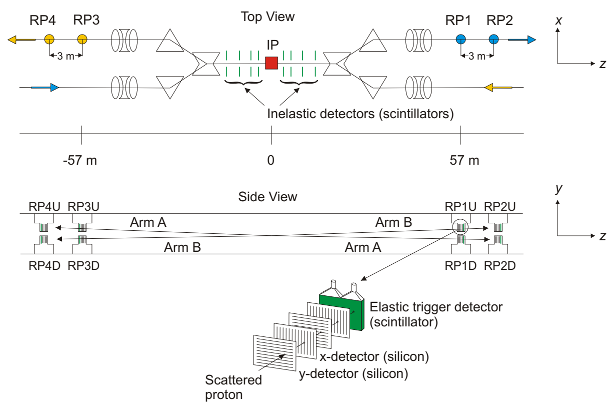

FIGURE 1. Layout of the pp2pp experiment. Note the detector pairs RP1, RP2 and RP3, RP4 lie in different RHIC rings. Scattering is detected in either one of two arms: Arm A is formed from RP3U and RP1D. Conversely, Arm B is formed from RP3D and RP1U.

its pedestal value. From those hits a cluster of consecutive strips was formed and the coordinate for that cluster was calculated as an energy-weighted average of the positions of the strips. The cluster size was limited to no more than five consecutive strips and its ΔE required to be larger than 20 ADC counts, where one ADC count is about 700 electrons of charge. The average silicon detector plane efficiency was better than 0.98, and the signal-to-noise ratio was better than 22.

The collinearity of the scattered protons results in correlation between coordinates measured on each side of the IP. Hence the main criterion to select the elastic scattering events was the hit coordinate correlation in the corresponding silicon detectors on the opposite sides of the IP.

DETERMINATION OF ANALYZING POWER A_N

After the cuts, the sample of 1.14 million events in the t-interval $0.010 \leq -t < 0.030$, subdivided into three intervals $0.010 \leq -t < 0.015$, $0.015 \leq -t < 0.020$, $0.020 \leq -t < 0.030$, was used to determine A_N. In each t-interval the asymmetry was calculated as a function of azimuthal angle ϕ using 5°-bins. Azimuthal angle dependence of the cross section for the elastic collision of the vertically polarized protons is given by

$$2\pi \frac{d^2\sigma}{dt d\phi} = \frac{d\sigma}{dt} \cdot \left(1 + (P_B + P_Y) A_N \cos\phi + P_B P_Y \left(A_{NN}\cos^2\phi + A_{SS}\sin^2\phi\right)\right), \qquad (1)$$

where P_B and P_Y are the beam polarizations and A_{NN}, A_{SS} are double spin asymmetries (see Ref.[6] for definitions). Given beam poalrizations, see below, an upper constraint is 0.028 for the term $P_B P_Y \left(A_{NN}\cos^2\phi + A_{SS}\sin^2\phi\right)$, even if both double-spin asymmetries

A_{NN} and A_{SS} were as large as 0.15. This term is small in comparison to the systematic errors on A_N and was therefore neglected in Eq. (1) but included in the systematic error, as described below.

Then the square root formula [7] for the single spin raw asymmetry $\varepsilon(\phi)$ can be written as Eq. (2). A cosine fit to the raw asymmetry $\varepsilon(\phi)$ was used to determine values of A_N.

$$\varepsilon(\phi) \approx (P_B + P_Y) A_N \cos\phi = \frac{\sqrt{N^{\uparrow\uparrow}(\phi) N^{\downarrow\downarrow}(\pi-\phi)} - \sqrt{N^{\downarrow\downarrow}(\phi) N^{\uparrow\uparrow}(\pi-\phi)}}{\sqrt{N^{\uparrow\uparrow}(\phi) N^{\downarrow\downarrow}(\pi-\phi)} + \sqrt{N^{\downarrow\downarrow}(\phi) N^{\uparrow\uparrow}(\pi-\phi)}} \tag{2}$$

Equation (2), from which the asymmetry is calculated has important features; namely, luminosities of the differently polarized proton beam bunches cancel as do the relative detection efficiencies, including geometrical acceptance, for each t and ϕ. Two other contributions to the systematic error were considered: backgrounds, which affect the asymmetry value, and sensitivity to the transport matrix parameters and to the beam position with respect to the detectors that affect the determination of t and ϕ.

The error in A_N due to uncertainty in the transport is 1.4%. The systematic error due to an uncertainty of beam positions at the detectors is 1.8% and due to the variation in L_{eff} was also studied and estimated to be 6.4%. the upper limit of the systematic error due to the background is 4.5%. Since all the above errors are not correlated adding them in quadrature results in the systematic error of $\Delta A_N / A_N = 8.4\%$. This error is smaller than the statistical errors of the measurement.

The polarization values of the proton beams was obtained from the Collider–Accelerator Department (C–AD). For our running period the beam polarizations were $P_Y = 0.346 \pm 0.0731$ and $P_B = 0.532 \pm 0.0988$. The errors include the contribution of the systematic part of the error due to the calibration of pC polarimeter of 13%, which is correlated for both beams and the statistical errors of the measurement. This results in the sum of the polarizations and its error $P_Y + P_B = 0.877 \pm 0.146$.

The total systematic error is comprised of A_N scale error of 16.6.% mostly due to the systematic error of the polarization measurement, and 8.4% error due to the experimental systematic effects as described above.

RESULTS AND CONCLUSIONS

The values of A_N obtained in this experiment and their statistical errors are shown in Fig. 2 for the three t-intervals.

The solid curve in Fig. 2 corresponds to the calculation without hadronic spin flip. Recent measurements of A_N at substantially lower cms energies than the one reported here indicate small but significantly different from zero contribution of spin-flip amplitude in case of proton-carbon scattering and are consistent with no spin-flip contribution for proton-proton scattering at $\sqrt{s}$ = 13.7 GeV [8].

Our results, as well as A_N measurements at lower energies, provide the much needed input for the theoretical calculations of the exchange process. They also underline a need for further measurements to be able to reconcile the differences for a more complete picture to emerge and also to extend the measurements to higher energies. In addition,

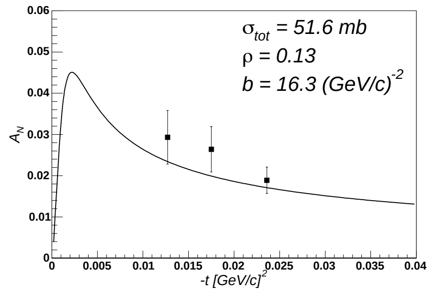

FIGURE 2. The single spin analyzing power A_N for three t intervals. Vertical error bars show statistical errors. The solid curve corresponds to theoretical calculations without hadronic spin flip.

an extension of the t-range will allow us to constrain both the magnitude and the shape of the analyzing power as a function of t, and higher statistics will permit measurements of A_{NN} and A_{SS}. This will help establish the role of multigluon exchanges in near–forward polarized proton-proton scattering.

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