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Physics Letters B 632 (2006) 167–172
PHYSICS LETTERS B
www.elsevier.com/locate/physletb

# First measurement of $A_N$ at $\sqrt{s} = 200$ GeV in polarized proton–proton elastic scattering at RHIC

PP2PP Collaboration

S. Bültmann, I.H. Chiang, R.E. Chrien, A. Drees, R.L. Gill, W. Guryn *, J. Landgraf, T.A. Ljubičič, D. Lynn, C. Pearson, P. Pile, A. Rusek, M. Sakitt, S. Tepikian, K. Yip

*Brookhaven National Laboratory, Upton, NY 11973, USA*

J. Chwastowski, B. Pawlik

*Institute of Nuclear Physics, Cracow, Poland*

M. Haguenauer

*Ecole Polytechnique, 91128 Palaiseau Cedex, France*

A.A. Bogdanov, S.B. Nurushev, M.F. Runtzo, M.N. Strikhanov

*Moscow Engineering Physics Institute, Moscow, Russia*

I.G. Alekseev, V.P. Kanavets, L.I. Koroleva, B.V. Morozov, D.N. Svirida

*Institute for Theoretical and Experimental Physics, Moscow, Russia*

A. Khodinov, M. Rijssenbeek, L. Whitehead, S. Yeung

*Stony Brook University, Stony Brook, NY 11794, USA*

K. De, N. Guler, J. Li, N. Öztürk

*University of Texas at Arlington, Arlington, TX 76019, USA*

A. Sandacz

*Sołtan Institute for Nuclear Studies, Warsaw, Poland*

Received 28 July 2005; received in revised form 10 October 2005; accepted 18 October 2005

Available online 27 October 2005

Editor: H. Weerts

* Corresponding author.
*E-mail address:* guryn@bnl.gov (W. Guryn).

0370-2693/$ – see front matter 
doi:10.1016/j.physletb.2005.10.041

**Abstract**

We report on the first measurement of the single spin analyzing power ($A_N$) at $\sqrt{s} = 200$ GeV, obtained by the PP2PP experiment using polarized proton beams at the Relativistic Heavy Ion Collider (RHIC). Data points were measured in the four momentum transfer $t$ range $0.01 \leqslant |t| \leqslant 0.03$ $(\text{GeV}/c)^2$. Our result, averaged over the whole $|t|$ interval is about one standard deviation above the calculation, which uses interference between electromagnetic spin-flip amplitude and hadronic non-flip amplitude, the source of $A_N$. The difference could be explained by an additional contribution of a hadronic spin-flip amplitude to $A_N$.


*PACS:* 13.85.Dz; 13.88.+e

*Keywords:* Polarization; Elastic scattering

## 1. Introduction

The PP2PP experiment [1–3] at RHIC is designed to systematically study polarized proton–proton (pp) elastic scattering from $\sqrt{s} = 60$ GeV to $\sqrt{s} = 500$ GeV, covering the $|t|$-range from the region of Coulomb–Nuclear Interference (CNI) to 1.5 $(\text{GeV}/c)^2$. Studies of spin dependence of pp scattering at small momentum transfers and at the highest energies presently available at RHIC offer an opportunity to reveal important information on the nature of exchanged mediators of the interaction, the pomeron and the hypothetical odderon (see Refs. [4,5] and references therein). The theoretical treatment of small-$t$ scattering is still being developed, hence the experimental data are expected to provide significant constraints for various theoretical approaches and models (see Ref. [6] and references therein).

In this Letter we present the first measurement of the analyzing power $A_N$ in pp elastic scattering of polarized protons at RHIC at $\sqrt{s} = 200$ GeV and $0.01 \leqslant |t| \leqslant 0.03$ $(\text{GeV}/c)^2$. $A_N$ is defined as the left–right cross section asymmetry with respect to the transversely polarized proton beam. In this range of $t$, $A_N$ originates mainly from the interference between electromagnetic (Coulomb) spin-flip and hadronic (nuclear) non-flip amplitudes [6]. However, it was realized that $A_N$ in the Coulomb–Nuclear Interference (CNI) region is a sensitive probe of the hadronic spin-flip amplitude [7]. A possible hadronic single spin-flip amplitude would alter $A_N$ and its effect would depend on the ratio of the single spin-flip amplitude ($\phi_5$) to non-flip amplitudes ($\phi_1$ and $\phi_3$):

$$r_5 = \frac{m\phi_5}{\sqrt{-t}\,\text{Im}(\phi_1 + \phi_3)/2}, \qquad (1)$$

where $m$ is the nucleon mass (see Ref. [6] for definitions).

Other measurements of $A_N$ performed at small $t$ have been obtained at significantly lower energies, by at least a factor of 10, than the present experiment. These measurements include recent high precision results from the RHIC polarimeters obtained at $\sqrt{s} = 13.7$ GeV for elastic pp [8,9] and pC [8,10] scattering, as well as earlier results from BNL AGS for pC scattering [11] at $\sqrt{s} = 6.4$ GeV and from FNAL E704 for pp scattering [12] at $\sqrt{s} = 19.7$ GeV.

The combined analysis of the present result with the earlier ones, especially with the very accurate results of Refs. [9, 10], will help to disentangle contributions of various exchange mechanisms involved in elastic scattering in the forward region [13]. In particular, such analysis will allow us to extract information on the spin dependence of the diffractive mechanism dominating at high energies.

## 2. The experiment

The two protons collide at the interaction point (IP), and since the scattering angles are small, scattered protons stay within the beam pipe of the accelerator. They follow trajectories determined by the accelerator magnets until they reach the detectors, which measure the $x$, $y$ coordinates in the plane perpendicular to the beam axis. Those coordinates are measured by Si detectors in the Roman Pots, which are positioned at the location that satisfy so-called "parallel to point focusing". More details on the experiment and the technique used can be found in [1,2]. The layout of the experiment is shown in Fig. 1. The identification of elastic events is based on the collinearity criterion, hence it requires the simultaneous detection of the scattered protons in the pair of Roman Pot (RP) detectors [14] on either side of the IP.

The elastic event trigger required a coincidence between signals in the RPs scintillators, belonging either to arm A or arm B, see Fig. 1. For each arm the trigger counters in RP1 and RP3 were used. The overall trigger was the logical OR of a coinci-

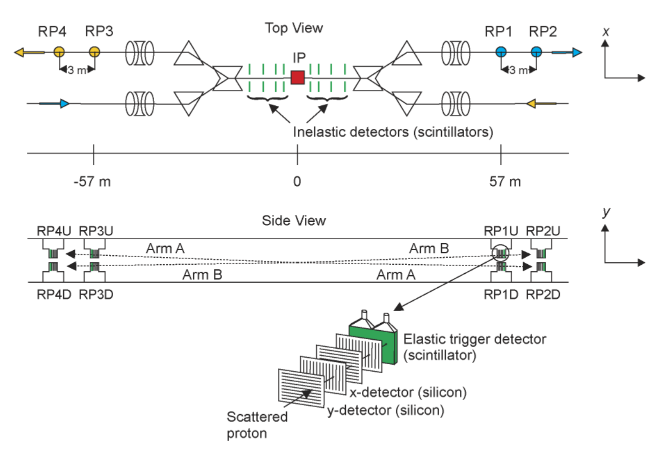


Fig. 1. Layout of the PP2PP experiment. Note the detector pairs RP1, RP2 and RP3, RP4 lie in different RHIC rings. Scattering is detected in either one of two arms: arm A is formed from RP3U and RP1D. Conversely, arm B is formed from RP3D and RP1U. The coordinate system is also shown.