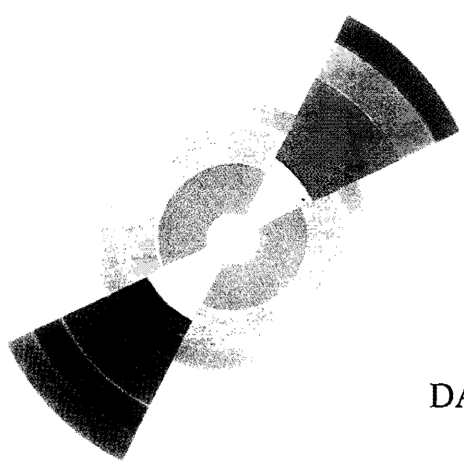
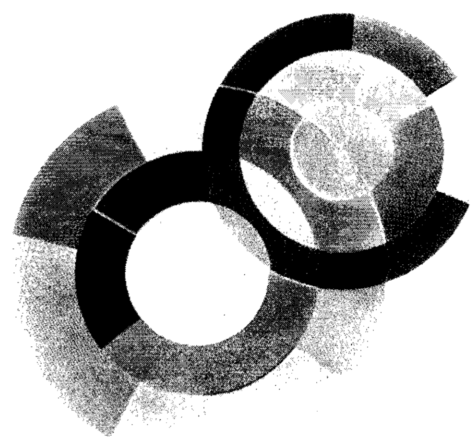
cea

DAPNIA





DAPNIA-03-631 07/2004

Polarimeter ALPOM: Results and Perspectives

V. A. Arefiev et al (E. Tomasi-Gustafsson)

Talk given at the 10th International Workshop on High Energy Spin Physics (SPIN 03), Dubna (Russia), September 16-20, 2003

Département d'**A**strophysique, de Physique des **P**articules, de Physique **N**ucléaire et de l'**I**nstrumentation **A**ssociée
DSM/DAPNIA, CEA/Saclay F - 91191 Gif-sur-Yvette Cédex
Tél : (1) 69 08 24 02 Fax : (1) 69 08 99 89
http : //www-dapnia.cea.fr

POLARIMETER ALPOM: RESULTS AND PERSPECTIVES

V.A. Arefiev[1], I. Atanasov[2], L.S. Azhgirey[1], S.N. Basilev[1], Yu.P. Bushuev[1], V.V. Glagolev[1], M.K. Jones[3], D.A. Kirillov[1], P.P. Korovin[1], G.F. Kumbartzki[4], P.K. Manyakov[1], J. Mušinský[1,5], L. Pentchev[6], C.F. Perdrisat[6], N.M. Piskunov,[1†], V. Punjabi[7], I.M. Sitink[1], V.M. Slepnev[1], I.V. Slepnev[1], and E. Tomasi-Gustafsson[8]

(1) *Joint Institute for Nuclear Research, Dubna, Moscow region, Russia*
(2) *Institute of Nuclear Research and Nuclear Energy BAS, Sofia, Bulgaria*
(3) *TJNAF, Newport News, USA*
(4) *Rutgers University, Piscataway, USA*
(5) *P.J. Šafarik University, Košice, Slovakia*
(6) *College of William and Mary, Williamsburg, USA*
(7) *Norfolk State University, Norfolk, USA*
(8) *DAPNIA/SPhN Saclay, Gif-sur-Yvette Cedex, France*
† *E-mail: piskunov@sunhe.jinr.ru*

Abstract

We report the results recently obtained at the accelerator complex of the JINR-LHE (Dubna), concerning the analyzing powers for the reaction $\vec{p} + CH_2 \to$ one charged particle $+X$, at proton momenta of 1.75, 3.8, 4.5 and 5.3 GeV/c. These results extend the existing data basis, necessary for proton polarimetry at intermediate energy, and confirm the feasibility of a large acceptance polarimeter based on this process. The polarimeter ALPOM is operational and can be installed on different beam lines. The plans of future measurements are also discussed.

Many studies in the intermediate energy physics require the measurement of the polarization of the secondary particles. These investigations provide rich information concerning the nuclear structure and the reaction mechanism. In particular the G_{Ep} collaboration at the Jefferson Laboratory [1] plans to extend the measurement of the ratio between the electric and the magnetic form factor, G_{Ep}/G_{Mp}, up to $Q^2 = 9$ GeV^2 by the recoil proton polarization method [2]. The 3rd phase of this experiment requires the construction of a new polarimeter that will measure the polarization of the recoil proton of momentum up to 5.5 GeV/c.

Polarization experiments are, in general time consuming. Therefore a thorough optimization of the characteristics of the polarimeter is desired. This requires a careful study of the analyzing reaction, which has to have large cross section and large analyzing powers. Usually polarimeters with 2π azimuthal angular acceptances, based on inclusive scattering on a carbon target, are built for such purposes [3, 4]. The efficiency of such polarimeters can reach 40% for the inclusive reaction $p + C(CH_2) \to p + X$ on thick $C(CH_2)$ analyzers. An optimization of the nature and the thickness of the absorber as well as of the geometry of the detection system are required, and these depend strongly upon the kinematical conditions. The inclusive scattering on a C or CH$_2$ target has been used up to p_p =4 GeV/c at Jefferson Lab (JLab). The average analyzing power decreases smoothly with increasing momentum. A CH$_2$ analyzer gives a better analyzing power than C [5].

To realize the experiment that we will describe here, the POMME polarimeter, which has been widely used at Saclay, was transported to Dubna and used as a part of the detection system of the ALPHA spectrometer. A schematic view of the detection is shown in Fig. 1.

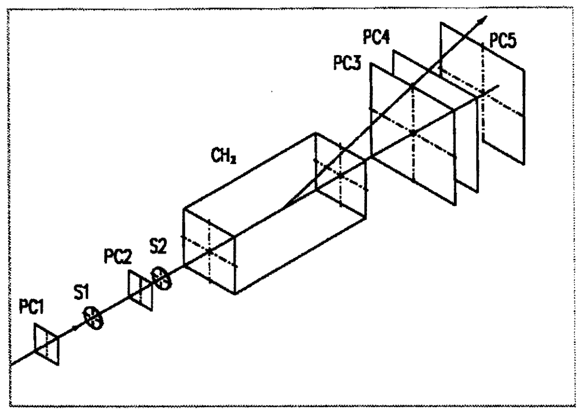


Figure 1. Schematic view of the setup. S_i – scintillator counters, PC_i – proportional chambers.

The incident protons were detected by proportional chambers PC1, PC2 (ALPHA) with sensitive area 12x12 cm^2. The three wire chambers PC3-PC5 (POMME) with sensitive area 48x48 cm^2 were used to detect the trajectory of the charged particle after the scattering on the CH_2 analyzer. Each chamber has a x- and a y-plane and wire spacing of 2 mm. The plane angular resolution achieved with this polarimeter was 2.6 mrad. The trigger was defined by the coincidence of signals from scintillation counters S1 and S2 of a diameter of 48 mm. In order to improve the data acquisition system a new module was developed, which allows us to increase number of recorded events up to 4800 per beam spill.

During two beam runs at the Synchrophasotron we measured the analyzing power for the inclusive reaction $p + CH_2 \rightarrow$ one charged particle +X, at proton momenta of 3.8, 4.5 and 5.3 GeV/c, for different thicknesses of the CH_2 target, and at proton momentum 1.75 GeV/c, with a 37.5 g/cm^2 thick target.

The number of events, for the inclusive reaction $\vec{p} + CH_2 \rightarrow$ one charged particle $+X$, is given by

$$N^{\pm}(\theta, \phi) = N_0(\theta) \left(1 + P_y^{(\pm)} A_y(\theta) \cos\phi\right), \tag{1}$$

where A_y is the analyzing power of the reaction and the sign $\pm$ refers to the spin orientation of the incident protons. The z-axis is along the beam direction, the y-axis is along the beam polarization (upwards) and the x-axis such as to form a left handed system. The polar angle θ is defined as the angle between the incident and the scattered trajectory. Due to the very narrow angular distribution of incident trajectories in the vertical plane (± 1 mrad) the y-axis can be considered as perpendicular to all incident trajectories, and ϕ is then the angle between the y-axis and the normal to the scattering plane. The convention is that $\phi = 0^o$ for left scattering and $\phi = 90^o$ for down scattering. $N_0(\theta)$ is the number of counts in some interval centered at θ for unpolarized beam.

The coordinates in the xz and yz plane allow to find the parameters of the incident and scattered trajectories. The distance of closest approach is then calculated as the distance along a line perpendicular to both trajectories. The interaction vertex is the middle point of this segment. At least two planes in the rear chambers had to fire, in order to collect events into statistics.

The results (Fig. 2), show the following interesting features.

- For protons of 3.8 GeV/c, the analyzing power is fairly independent from the amount of material in the analyzer, from 37 to 80 g/cm^2.

- Taking a target thickness above nuclear collision length and values of the polarimeter acceptance above $p_t > 0.7$ GeV/c do not improve figure of merit.

- In a wide region of momentum transfers, the analyzing power both for graphite and CH_2 targets has a maximum for $p_t = p \cdot \sin\theta \simeq 0.3$ GeV/c.
- High angular resolution of the polarimeter is very important to increase the figure of merit.
- In the momentum range investigated so far, the analyzing power is inversely proportional to the incident momentum.
- The analyzing power decreases with increasing incident momentum, but it is still sizeable at a proton momentum of 5.3 GeV/c. This validates the proposal to build a new polarimeter based on this principle, in this kinematical range at the Thomas Jefferson National Accelerator Lab...

Preliminary results were previously presented [6] and more details can be found in a forthcoming paper [7].

These studies have led to assembling a new polarimeter at the JINR, which is mobile and can be set, in principle, at different beam lines.

To continue this project to higher proton momenta we are going to change the small proportional chambers to larger planes of drift tubes, of size 16×16 cm^2. These tubes represent the contribution to the proposal from the American side of the collaboration. After this improvement the polarimeter can be installed at any place in the experimental area and used in other experiments, for example, the measurement of the transfer polarization coefficient in deuteron fragmentation. The drift tubes were successfully checked during the June 2003 run. The spatial resolution is shown in Fig. 3.

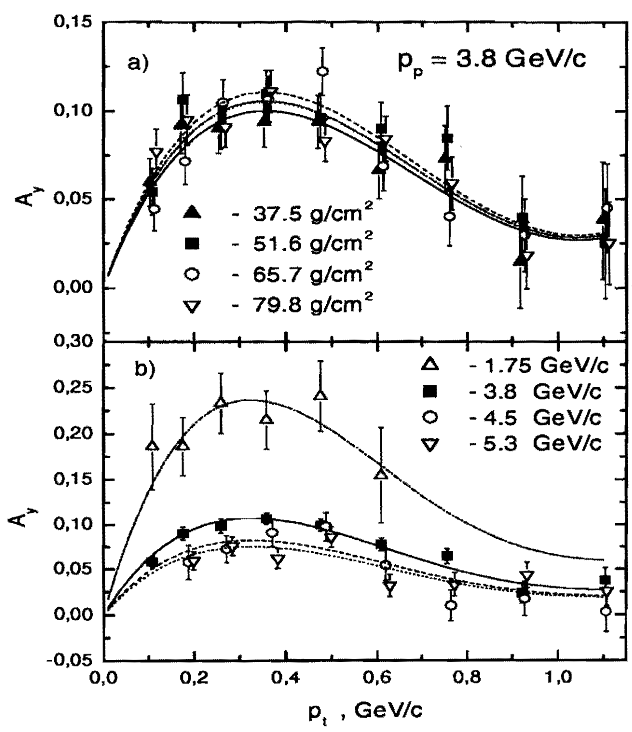


Figure 2. Analyzing powers as a function of p_t: (a) for different target thicknesses at 3.8 GeV/c; (b) for different momenta at L=51.6 g/cm^2.

A polarized deuteron beam has been recently accelerated and extracted at the Nuclotron accelerator. The collaboration plans to continue the measurements of the analyzing powers for the reaction $p+CH_2(C)$ at a proton momentum up to 6.5 GeV/c. No such measurements have ever been reported; such a database is generally of great interest; in particular it may support further investigations of the proton form factors to Q^2 values larger than 10 GeV^2 after the upgrade of JLab.

At the moment it is difficult to estimate precisely the beam time necessary for the future measurements, at deuteron beam momentum close to 11 GeV/c. In order to get a statistical error of 0.01 on analyzing power, one find that 10^7 counts are necessary for each of two polarization states, with polarization at the level of 0.55. For beam intensity of $5*10^8$ at deuteron beam momentum at 11-11.5 GeV/c we need 4 days of beam time. In additional for checking the equipment of the setup during its modernization 2 or 3 days are also needed.

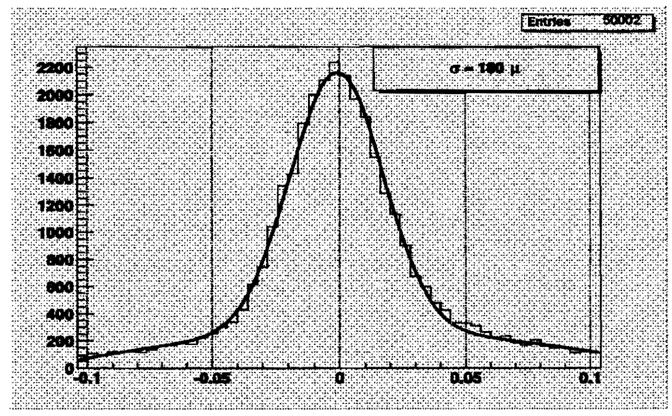


Figure 3. Spatial resolution of the drift tubes.

The transportation of POMME from Saclay to Dubna has been made possible with the help of the Donation Program of UNESCO. This work is supported in part by the Russian Foundation for Basic Research (grants 00-02-016189 and 98-02-16915), the Grant Agency for Science at the Ministry of Education of the Slovak Republic (grant 1/8041/01) ant the French Commissariat à l'Energie Atomique. The US participants are supported by the US National Science Foundation grants PHY 9901182 (CFP), PHY 0098642 (GFK) and US Department of Energy grant DE-FG05-89ER40525 (VP).

References

[1] M. K. Jones et al., Phys. Rev. Lett. **A84**, 1398 (2000), O. Gayou et al., Phys. Rev. **88**, 092301 (2002).

[2] A. Akhiezer and M. P. Rekalo, Dokl. Akad. Nauk USSR, **180**, 1081 (1968) and Sov. J. Part. Nucl. **4**, 277 (1974).

[3] B. Bonin et al., Nucl. Instr. and Meth. A **288**, 379 (1991). E. Tomasi-Gustafsson, POMME Manual, LNS/Ph/92-07.

[4] N.E. Cheung et al., Nucl. Instr. and Meth. A **363**, 561 (1995).

[5] E. Tomasi-Gustafsson et al., Nucl. Instr. and Meth. A366, 96 (1995).

[6] The ALPOM collaboration, A. Azhghirey *et al.*, IX Workshop on High Energy Spin Physics, Dubna, Aug. 2-7, 2001 and 15th International Spin Physics Symposium Brookhaven National Laboratory, Long Island, New York, September 9th-14th, 2002.

[7] The ALPOM collaboration, A. Azhghirey *et al.*, to be submitted to Nucl. Instr. and Meth. A.