ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E13-2002-136

L. S. Azhgirey, V. P. Ladygin, F. Lehar[1], A. N. Prokofiev[2], G. D. Stoletov, A. A. Zhdanov[2], V. N. Zhmyrov

INTERMEDIATE-ENERGY POLARIMETER FOR THE MEASUREMENT OF THE DEUTERON AND PROTON BEAM POLARIZATION AT THE JINR SYNCHROPHASOTRON

Submitted to «Nuclear Instruments and Methods A»

[1]DAPNIA, CEA/Saclay, 91191 Gif-sur-Yvette Cedex, France
[2]PNPI, 188350 Gatchina, Russia

2002

1 Introduction

The experimental investigation of spin effects in the Laboratory of High Energies (LHE) of JINR requires a good knowledge and a continuous monitoring of the vector polarization of the deuteron beam $\vec{P}_B(d)$ [1]-[7]. For these purposes a polarimeter measuring the asymmetry of the quasi-elastic pp scattering on hydrogen in a polyethylene (CH_2) and carbon targets has been developed and installed in the LHE experimental hall [8]. No magnetic analysis of outgoing particles has been performed.

This classical method of the nucleon beam polarization measurement at intermediate energies has been used earlier e.g. at SATURNE II [9]. The comparison of the elastic and quasi-elastic pp analyzing powers shows no difference between these quantities in a very large energy range [10]. Using this property, the LHE polarimeter measures $\vec{P}_B(d)$ of deuterons provided by the ion source POLARIS [11]. The polarizations of protons and neutrons produced by the deuteron breakup reaction in the forward direction are equal to each other. They are related to the vector polarization of the deuteron beam, depending on the polarimeter acceptance. The same polarimeter was used to measure the polarization of proton beam.

The aim of this paper is to summarize the results of the deuteron beam polarimeter operation during the last few years, to present the values of the beam polarization, the effective analyzing power of the target used, and to estimate possible systematic errors of the measurements.

A brief description of the on-line beam polarimeter is given in Section 2. Section 3 describes the procedure of the polarimeter calibration. The results of the vector deuteron beam polarization measurements and of the effective analyzing power are given in Section 4. The use of the beam polarimeter to determine the polarization of protons, outgoing from the polarized deuterons fragmentation, is shown in Section 5. The conclusions are drawn in the last section.

2 On-line beam polarimeter

The polarimeter for the measurement of the deuteron beam vector polarization was installed close to the focal point of the beam line at LHE, JINR. The details of the polarimeter were discussed in ref.[8]. Here we refer briefly the main items. The layout of the polarimeter is given in Fig. 1. Here S_{1-8} are the scintillation counters, IC is an ionization chamber, T is the target.

The polarimeter measures the left-right (L-R) asymmetry of pp quasi-elastic scattering, detecting both scattered and recoil particles. It consists of two pairs of arms in the horizontal plane installed at the angles corresponding to pp - elastic scattering kinematics. Each arm is equipped by two scintillation counters. The four-fold coincidence of counter signals from each pair of conjugated arms S1 to S4 and S5 to S8 define L or R scattering events, respectively. The size of the determining counters is 5×5 cm^2 and their distance from the target center is 188 cm. Therefore the solid angle subtended by the L or R counters is $\Delta\Omega = 7 \cdot 10^{-4}$ sr.

An ionization chamber placed about 2 meters downstream from the target is used as a beam intensity monitor. Coincidence counts of the polarimeter arms and monitor informations were recorded for each beam polarization direction and stored by a PC data acquisition system after the end of each beam burst.

The polarization of the extracted beam was oriented along the vertical axis (perpendicularly to the beam momentum direction) and flipped every accelerator spill.

Then the numbers of the protons scattered to the left and right are related with the beam polarization and the analyzing power as follows

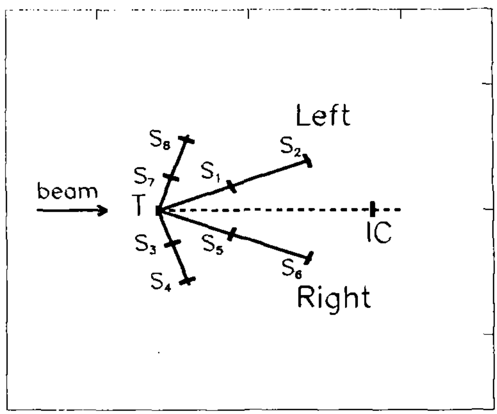

Fig.1. The layout of the *pp* polarimeter. S_{1-8} are the scintillation counters, IC is an ionization chamber and T is the target.

$$N_L^{\pm} = N_L^0(1 + P^{\pm} \cdot A), \quad (1)$$
$$N_R^{\pm} = N_R^0(1 - P^{\pm} \cdot A), \quad (2)$$

where $N_L^{\pm,0}$ and $N_R^{\pm,0}$ correspond to the numbers of particles scattered leftward and rightward for " + ", " − " and "0" states of polarization, normalized to monitor counts; $P^{\pm}$ are the values of the beam polarization for states " + " and " − ". For the scattering on a hydrogen target $A = A_{oono}$ is the analyzing power of *pp* elastic scattering [12]. If the solid angles and detection efficiencies for the both arms are the same, then $N_L^0 = N_R^0$. In this case the expression (1) can be rewritten in the form [8]

$$N^{\pm} = N^0(1 + \vec{P} \cdot \vec{A}). \quad (3)$$

The values of the beam polarization can be easily obtained from asymmetries $\epsilon^{\pm}$ taking into account the instrumental asymmetry, which is evaluated using unpolarized beam (state "0"):

$$\epsilon^{\pm} = \frac{N_L^{\pm}/N_R^{\pm} - N_L^0/N_R^0}{N_L^{\pm}/N_R^{\pm} + N_L^0/N_R^0} = P^{\pm} \cdot A \quad (4)$$

Ion source POLARIS [11] can operate in the vector and tensor modes. The ideal values of polarization (P_z, P_{zz}) are $(\pm 2/3, 0)$ and $(1/3, \pm 1)$ for the vector and tensor modes, respectively.

In the case of a vector polarized deuteron beam with only two spin states " + " and " − " used in an experiment, the stability of polarization can be checked up by the calculating of so-called "up-down" asymmetry

$$\epsilon_V = \frac{N_L^+ N_R^- - N_L^- N_R^+}{(N_L^+ + N_L^-)(N_R^+ + N_R^-)}, \tag{5}$$

averaged over these beam spin states.

In the case of a tensor polarized deuteron beam, as the spin state of beam changes, the vector component of polarization does not change its sign. Therefore the expression for the up-down asymmetry has the following form

$$\epsilon_T = \frac{N_L^+ N_R^+ - N_L^- N_R^-}{(N_L^+ + N_L^-)(N_R^+ + N_R^-)}, \tag{6}$$

Due to the equality of the proton and neutron polarizations from the breakup reaction, this polarimeter was successfully used to determine the neutron beam polarization during the $\Delta\sigma_L(np)$ transmission experiment [1, 2]. It was also used to monitor the vector polarization admixture in the tensor polarized deuteron beam [11], during the measurements of the tensor analyzing power A_{yy} in deuteron inclusive breakup at 9 GeV/c [3, 4] and in deuteron inelastic scattering at 4.5 GeV/c [5]. The polarimeter has been used to measure the polarization of free protons obtained by the fragmentation of the vector polarized deuteron beam [7].

3 Calibration of the polarimeter

Since no magnetic analysis of outgoing particles was used, the recorded events contain contributions from scattering on hydrogen and on carbon. The analyzing power for scattering on the polyethylene target $A(CH_2)$ differs from $A_{oono}(pp)$. This is mainly due to the carbon content in CH_2. Moreover, the $A(CH_2)$ asymmetry depends on a choice of the counter acceptance. At small scattering angles the analyzing power $A(pC)$ of the reaction

$$p + C \to p + p + X \tag{7}$$

is smaller than $A_{oono}(pp)$. Consequently, in our energy and angular region, the carbon content decreases the measured $\epsilon(CH_2)$ with respect to that for hydrogen.

The $P_B(d)$ value can be obtained from the asymmetry measurements using both CH_2 and C targets and the known $A_{oono}(pp)$ value. Such measurements have been performed at the vector polarized deuteron beam with the momentum $p_d = 2.96\ GeV/c$ (corresponding kinetic energy of protons $T_{kin}(p) = 0.81$ GeV). The pp scattering angle of the polarimeter arms was set to $\theta_{lab} = 14^\circ$.

A preliminary calibration of the polarimeter was made before [13]. Here we give refined results based on more recent data on analyzing power of the elastic pp-scattering.

The empirical fit of the pp data available in the database [14] and in refs.[15, 16] over the energy range 1.3 and 3.25 GeV/c provides the following energy dependence of $A_{oono}(pp)$ at $\theta_{\ell ab} = 14°$ [17]:

$$A_{oono}(pp) = 0.6015 - 0.1638 \cdot T - 0.0031 \cdot T^2, \qquad (8)$$

where T is the proton kinetic energy. The result of this fit is shown in Fig.2. by the solid line along with the $A_{oono}(pp)$ data [14, 15, 16]. The value $A_{oono}(pp) = 0.466$ at $T_p = 0.8$ GeV was taken as the calibration constant. The details can be found in the paper [17].

In the paper [2] $A_{oono}(pp)$ value for this kinematics was taken from two fixed energy phase shift analyses (PSA). The George Washington University and Virginia Polytechnic Institute (GW/VPI) PSA gives $A_{oono}(pp) = 0.4872 \pm 0.0034$ [18] and the Saclay-Geneva (SG) PSA provides 0.4821 ± 0.0009 [19], with the unweighted average of 0.4846 ± 0.0017 [2]. The value from ref.[17] is consistent also with the one obtained from the recent GW/VPI PSA ($A_{oono}(pp) = 0.4760$) [20]. Moreover, the systematic error due to the uncertainy of the analyzing power $A_{oono}(pp)$ is about 4%.

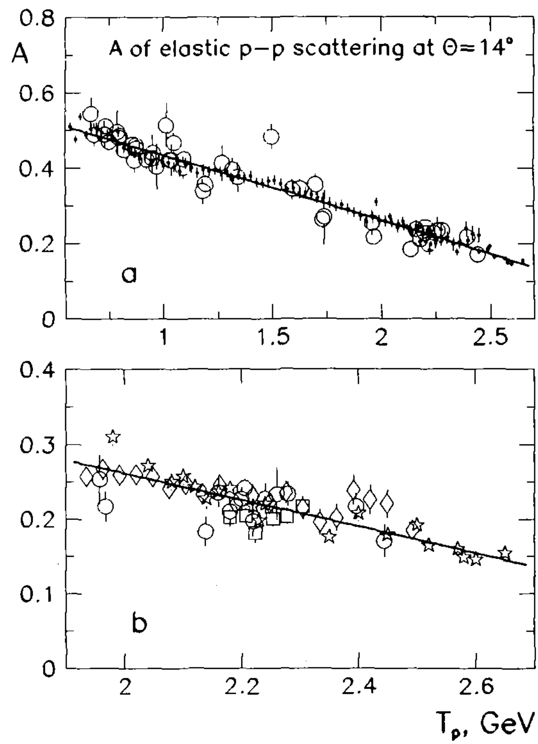

Fig.2. The analyzing power $A_{oono}(pp)$ at $\theta_{\ell ab} = 14°$ [14]-[16]. The solid line is the result of the quadratic fit [17].

The polyethylene (1.0 and 0.5 cm thick) and carbon (0.3 cm) targets have been used to evaluate the effect from hydrogen in CH_2. The number of counts $N(pp)$ corresponding to pp scattering can be written as

$$N(pp) = N(CH_2) - k \cdot N(C), \qquad (9)$$

where $N(CH_2)$ and $N(C)$ are the number of counts from CH_2 and C targets, normalized to the monitor numbers, and k is the ratio of the carbon atoms in these two targets.

The absolute value of the pp asymmetry, averaged over the opposite beam polarizations, obtained from the difference of CH_2 and C targets was $\epsilon(pp) = 0.273 \pm 0.008$. This value gives the vector polarization of the beam $P_B(d) = 0.586 \pm 0.017$. Asymmetry obtained on the polyethylene target was $\epsilon(CH_2) = 0.2314 \pm 0.0054$, which provides $A(CH_2) = 0.395 \pm 0.008$.

Assuming that the present ratio of $\epsilon(pp)/\epsilon(CH_2) = 1.18$ does not change from $T_p = 0.81$ up to $T_p = 0.83$ GeV and the mean value of $A_{oono}(pp) = 0.463$ at $T_p = 0.83$ GeV from the expression (8), one can obtain the effective analyzing power value $A(CH_2) = 0.393 \pm 0.008$ at $T_p = 0.83$ GeV.

The measured analyzing power $A(CH_2)$ and asymmetry obtained during the $\Delta\sigma_L$- experiment [1], gives the beam polarization value of 0.626 ± 0.041. This value differs slightly from the one given in ref.[8] since we are using now more accurate calculated value of the effective analyzing power. The further data on the polarimeter calibration can be found in the paper [17].

Typical rate from carbon target of 3 mm thick was about 10% of the rates from the 5 mm polyethylene target, while the rate without target was only $\simeq 2\%$. It could increase up to $\simeq 20\%$ from the CH_2 rate under bad operating conditions.

4 Monitoring of the beam polarization

The deuteron beam polarimeter was used to monitor the vector component of the tensor polarized beam during the measurements of A_{yy} in deuteron inclusive breakup at large transverse momenta [3, 4]. The results of the measurements at $p_d = 3$ GeV/c and 14° are shown in Fig.3. The full and empty symbols are the asymmetry values, obtained either during the polarization measurements, or monitoring the stability of the polarization, respectively. They are in good agreement and provide the values 0.111 ± 0.007 and 0.117 ± 0.007 for " + " and " − " spin states of the beam, respectively. Taking $A(CH_2) = 0.393 \pm 0.008$, determined above, one obtains $P_B^+(d) = 0.282 \pm 0.018$ and $P_B^-(d) = 0.298 \pm 0.018$.

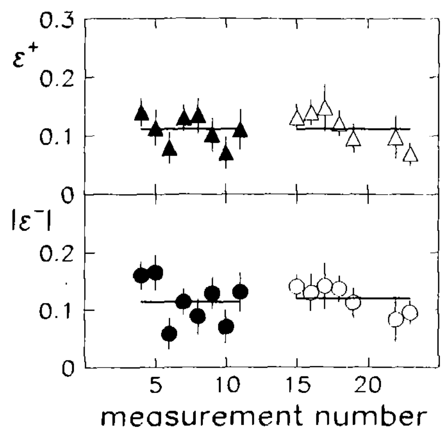

Fig.3. The left-right asymmetry at 0.83 GeV/nucleon and at $\theta_{lab} = 14°$, at tensor polarized deuteron beam. The full and empty symbols are the asymmetry values obtained during the polarization measurements and monitoring the polarization stability, respectively.

Fig. 4 demonstrates the stability of the asymmetries during the experiment [3, 4]. The open and full symbols represent the values of asymmetries $\epsilon^{\pm}$ obtained at 3.66 GeV and θ_{lab} = 8° during the beam polarization measurements and the data taking, respectively. The averaged values of asymmetries obtained during the test measurements were 0.033 ± 0.004 and 0.035 ± 0.004 for "+" and "-" polarization states. The corresponding averaged values of asymmetries obtained simultaneously with the data taking were 0.029 ± 0.004 and 0.031 ± 0.004. Both results are in good agreement [4]. If we assume that the polarization of the deuteron beam was stable during the run, one can obtain the analyzing power $A(CH_2)$ of the scattering of protons in deuterons with the momentum of a 9 GeV/c at 8°.

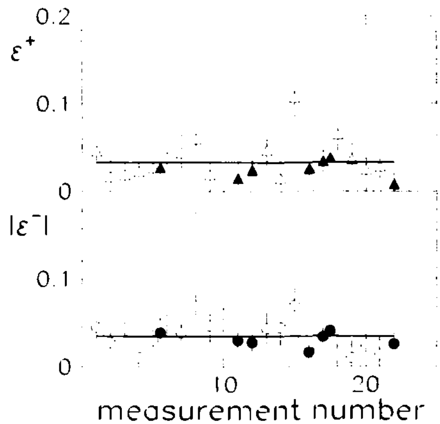

Fig.4. The left-right asymmetries $\epsilon^{\pm}$ from polarimeter. The open and full symbols are the values of asymmetries $\epsilon^{\pm}$ obtained at tensor polarized deuteron beam during the beam polarization measurements and the data acquisition, respectively [4].

This value was equal to 0.117 which is in agreement with the result obtained in refs.[1, 8]. The averaged value of $A(CH_2)$ is 0.123 ± 0.006.

Table 1. The renormalized (in comparison with [13]) values of the vector polarization of the deuteron beam from the polarimeter measurements. The experiments [1, 2] and [3, 6] have been performed using vector and tensor spin modes of POLARIS [11], respectively.

p_d, GeV/c	T_p, GeV/c	θ^o_{lab}	$P_B^+ \pm dP_B^+$	$P_B^- \pm dP_B^-$	$P_B \pm dP_B$	year	exp.
3.00	0.83	14			0.626 ± 0.041	1995	[1]
2.96	0.81	14	0.707 ± 0.022	-0.465 ± 0.024	0.586 ± 0.017	1997	[2]
3.00	0.83	14	0.282 ± 0.018	0.298 ± 0.018	0.290 ± 0.013	1997	[3]
9.00	3.66	8	0.275 ± 0.016	0.287 ± 0.016	0.281 ± 0.011	1998	[6]

The measurements of the tensor analyzing power A_{yy} in inclusive breakup and inelastic scattering of the 9 GeV/c and 4.5 GeV/c deuterons have been continued [5, 6]. The results of the left - right asymmetries at 9 GeV/c and 8° are shown in Fig. 5. The averaged values of the asymmetries are 0.0338 ± 0.0009 and 0.0353 ± 0.0009 for "+" and "−" states of the beam polarization, respectively. Using the value of the analyzing power determined above $A(CH_2) = 0.123 \pm 0.006$ one can obtain the values of the beam polarization as $P_B^+(d) = 0.275 \pm 0.016$ and $P_B^-(d) = 0.287 \pm 0.016$ which is in agreement with the values obtained eariler [3, 4].

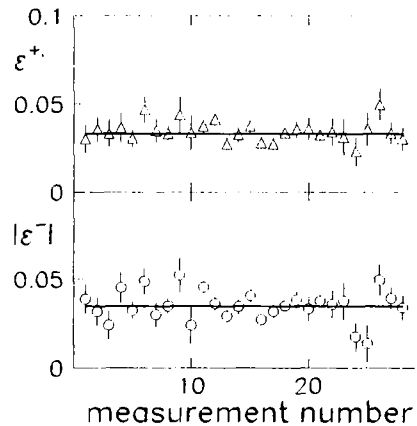

Fig.5. The left-right asymmetries $\epsilon^{\pm}$ from polarimeter [8] obtained at 3.66 GeV and at $\theta_{\ell ab} = 8°$ with tensor polarized deuteron beam, during the experiment [5, 6].

The statistical errors are small, however, the systematic error due to $CH_2 - C$ substraction is $\sim$ 5 %. The values of polarization and analyzing powers $A(CH_2)$ obtained by polarimeter [8] since 1995 are listed in Tables 1 and 2.

Table 2. The asymmetries ϵ and renormalized values of analyzing powers $A(CH_2)$ from the polarimeter measurements.

p_d, GeV/c	T_p, GeV	Θ°_{lab}	ϵ	$A(CH_2)$	ref.
2.96	0.81	14	0.2314 ± 0.0054	0.395 ± 0.008	[2]
3.00	0.83	14	0.1140 ± 0.0050	0.393 ± 0.008	[3, 4]
3.00	0.83	14	0.2460 ± 0.0160	0.393 ± 0.008	[1, 8]
3.84	1.20	14	0.2214 ± 0.0015	0.354 ± 0.024	[1, 8]
4.72	1.60	14	0.1680 ± 0.0030	0.286 ± 0.009	[2]
5.14	1.80	14	0.1440 ± 0.0040	0.246 ± 0.009	[2]
6.00	2.20	14	0.0860 ± 0.0030	0.147 ± 0.007	[2]
6.64	2.51	8	0.1434 ± 0.0015	0.229 ± 0.016	[1, 8]
9.00	3.66	8	0.0807 ± 0.0020	0.129 ± 0.009	[1, 8]
9.00	3.66	8	0.0339 ± 0.0020	0.117 ± 0.009	[3, 4]

The measurements of $\Delta\sigma_L$ in np transmission have been performed at the deuteron momenta of 3.00, 3.84, 6.64 and 9.0 GeV/c [1] and at 2.96, 4.72, 5.14 and 6.0 GeV/c [2]. The measurements at 2.96 and 3.00 GeV/c have been devoted to obtain the value of the beam polarization. The asymmetry, averaged over different spin states, obtained during the measurements of $\Delta\sigma_L$ [2] is shown in Fig. 6 as a function of time. The measurements of the asymmetry values at p_d = 5.14 and 6.0 GeV/c were made twice during the run, while the measurements at p_d = 4.72 GeV/c was performed only once. The dotted lines in Fig.6 are the averaged values of the asymmetries during the run. The asymmetries values and corresponding analyzing powers $A(CH_2)$ at p_d = 4.72, 5.14 and 6.0 GeV/c are given in Table 2.

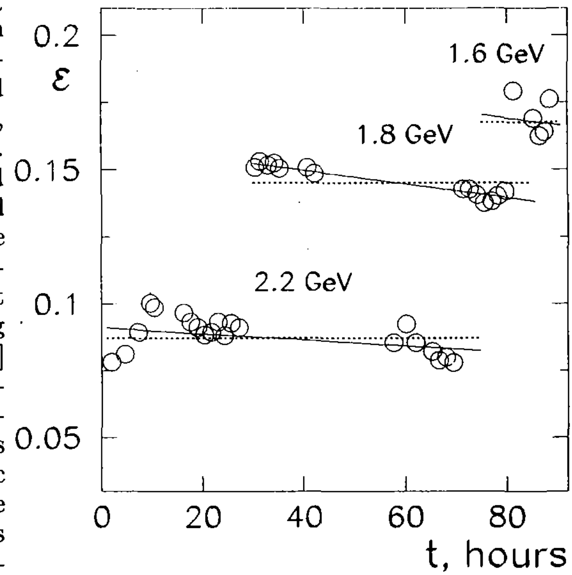

Fig.6. The asymmetries ϵ from the polarimeter, averaged over different spin states, obtained during $\Delta\sigma_L$ experiment [2] with vector polarized deuteron beam at 1.6, 1.8 and 2.2 GeV.

However, if one assume that the beam polarization decreased monotonically, its time dependence can be approximated by the linear function :

$$P_B(t) = P_B(t=0)[1 - (0.00154 \pm 0.00013)t], \tag{10}$$

where "t" is in hours. The solid lines in Fig.6 represent the linear decreasing of the asymmetries values with the time. The possible time-dependence of the asymmetry values proofs the neccessity of the beam polarization monitoring during the experiment.

The $P_B(d)$ values obtained from the pp polarimeter are systematically higher than the values given by the four-arm magnetic polarimeter ALPHA [21]. The latter polarimeter measures the dp elastic scattering at 3 GeV/c, where the dp analyzing power is well known. For instance, the polarization given by the polarimeter ALPHA [21] equals 0.535 $\pm$ 0.009 [2], while pp polarimeter gives P_B = 0.586 $\pm$ 0.017. A difference between $P_B(d)$ values provided by these two polarimeters can be explained due to the precision of the dp and pp analyzing power data.

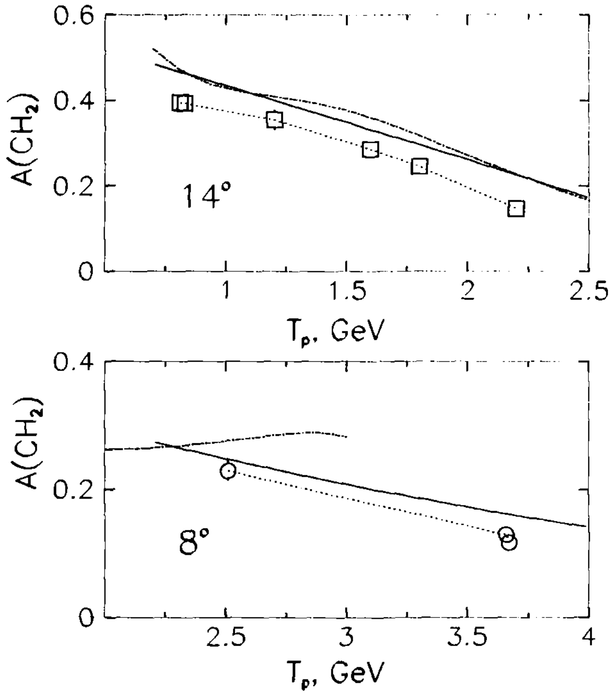

Fig.7. Effective analyzing power $A(CH_2)$ at different initial energies and at θ_{lab} of 14° and 8°. The solid lines are the results of the $A_{oono}(pp)$ fit [17, 22]. The dashed lines are the result of recent GW/VPI PSA [20].

The effective analyzing power of the polarimeter at 14° and 8° is presented versus incident proton energy in Fig.7 (upper and lower panels). One can see that for both scattering angles the analyzing power decreases with the increasing incident energy. The solid lines are the results of the *pp* analyzing power fit at 14° [17] and 8° [22], respectively. The following expression for the *pp* analyzing power at 8° has been used:

$$A_{oono}(pp) = 0.5164 - 0.130 \cdot T + 0.009056 \cdot T^2, \tag{11}$$

where T is the proton kinetic energy. The dashed lines are the behaviour of *pp* analyzing power predicted by GW/VPI PSA [20]. One can see that the values of $A(CH_2)$ are smaller than the $A_{oono}(pp)$ ones for the both angles. Also the both PSA [20] and empirical fit [17] demonstrate the same energy dependence of $A_{oono}(pp)$ near calibration point ($T_p = 0.81$ GeV and $\theta_{lab} = 14°$).

The performance of a polarimeter is expressed in terms of the figure of merit, $\mathcal{F}$. The $\mathcal{F}$ is the function of efficiency eff and analyzing power A. It is defined as

$$\mathcal{F}^2 = \int eff \cdot A^2 d\Omega, \tag{12}$$

where Ω is the solid angle, and integration is over the angular domain of the polarimeter. The figure of merit allows one to evaluate the counting rate N_{inc}, needed for a desired beam polarization accuracy ΔP

$$\Delta P \sim \frac{\sqrt{2}}{\mathcal{F}\sqrt{N_{inc}}} \tag{13}$$

Since the cross section of pp elastic scattering decreases as a function of scattering angle θ, the polarimeter figure of merit $\mathcal{F}$ also decreases versus angle. Therefore, polarimetry at smaller angles is more convenient if the analyzing power varies smoothly versus angle. It has been shown in ref.[22] that as low as at 2.2 GeV the measurement of the polarization at 8° is preferable than that at 14°.

It should also be noted that the contribution of the carbon content and inelastic channels to the effective analyzing power of the polarimeter $A(CH_2)$ is non-negligible at high energies.

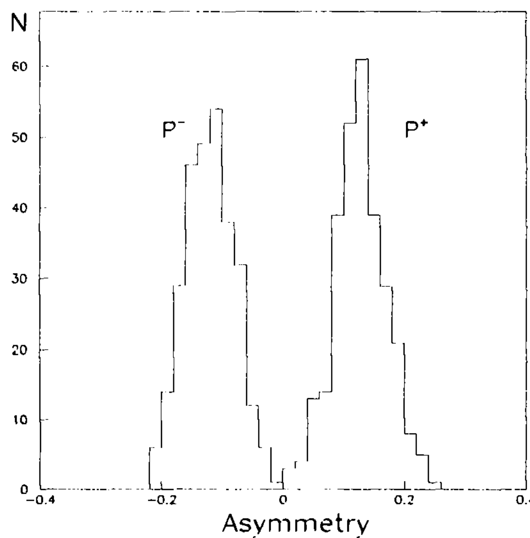

Fig.8. Raw asymmetries for different spin states at 2.51 GeV obtained with the free polarized proton beam [7].

The ratio $A(CH_2)/A_{pp}$ is equal to 0.732 ± 0.076 at 8° and 3.66 GeV [22]. This ratio is significantly smaller than that obtained at ANL [23] and KEK [24], where magnetic analysis of the scattered protons and suppression of inelastic events was applied.

5 Measurements of the proton polarization

The polarized proton beam obtained by the deuterons fragmentation on the beryllium target has been used for the measurements of the analyzing power of the

$\vec{p}C \to pX$ reaction at 2.51 GeV [7]. The typical intensity of the polarized proton beam was $2 \div 5 \cdot 10^7$ particles/cycle.

The measurement of the proton polarization has been performed using the described polarimeter. The analyzing power of the polarimeter $A(CH_2)$ was taken as 0.229 ± 0.016 (see table 2.) The left-right asymmetries of the beam in two spin modes are show in Fig.8. These asymmetries are not corrected for the false asymmetry, which is small. One can see large values of the asymmetries for both spin modes of the beam.

The stability of the beam polarization during the experiment [7] is demonstrated in Fig.9. The values of the polarization averaged over whole duration of the experiment are $P_B^+ = 0.621 \pm 0.009$ and $P_B^- = -0.446 \pm 0.009$ for "+" and "-" spin states, respectively. The absolute value of polarization averaged over different spin states is therefore $P_B = 0.533 \pm 0.006$.

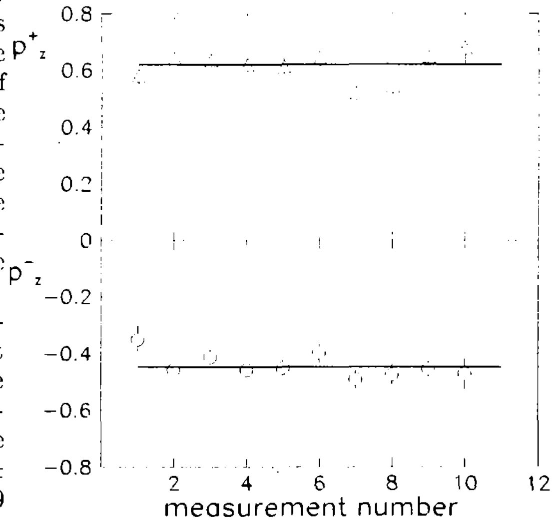

Fig.9. The polarization of the proton beam during the experiment [7].

6 Conclusions

The results of present work are:

The results of the last few years operation of the deuteron beam on-line polarimeter are summarized.

It is demonstrated that obtained values of analyzing power of the polarimeter $A(CH_2)$ allow to measure and to monitor the vector polarization of the deuteron beam over the full domain of Synchrophasotron beam energy (up to 3.66 GeV/nucleon) with a good precision.

The polarimeter can be also used to measure the polarization of free protons, produced by the fragmentation of the vector polarized deuterons on beryllium target.

Acknowledgements

The authors are grateful to L.V. Budkin for his assistance during the polarization measurements, N.M. Piskunov and V.V. Vikhrov for their help in the polarimeter installation, V.I. Sharov and L.S. Zolin for fruitful discussions.

This work was supported in part by Russian Foundation for Basic Research under grant N^o 01-02-17299.

References

[1] B.P. Adiasevich et al., Z.Phys. C71 (1996) 65.

[2] V.I. Sharov et al., Eur.Phys.J C13 (2000) 255.

[3] S.V. Afanasiev et al., Phys.Lett. B434 (1998) 21.

[4] L.S. Azhgirey et al., Yad.Fiz.62 (1999) 1796.

[5] V.P. Ladygin et al., Eur.Phys.J. A8 (2000) 409.

[6] V.P. Ladygin et al., Few Body Systems Suppl. 12 (2000) 240.

[7] A.A. Yershov et al., talk at XV ISHEPP, September 2000, Dubna, Russia, to be published.

[8] L.S. Azhgirey et al., Pribory i Technika Experimenta 1 (1997) 51;
transl. Instrum. and Exp.Techniques 40 (1997) 43,
A.N.Prokofiev et al., Deuteron-95 Conference proceedings, JINR, Dubna, 1996, pp.227-231,
A.N.Prokofiev et al., Cz.J.Phys.42, S2 (1999) 29.

[9] F. Lehar et al., Note CEA-N-2490 (1986) CEN Saclay, Gif-sur-Yvette.
Ch. Allgower et al., Preprint LNS/Ph/97-11 (1997) Gif-sur-Yvette.

[10] J. Ball et al., Eur.Phys.J. C11 (1999) 51. (and the references therein).

[11] N.G. Anishchenko et al., Proc. 5-th Int.Symp. on High Energy Spin Physics (Brookhaven, 1982), AIP Conf.Proc. 95 (N.Y.1983) 445.

[12] J. Bystrický, F. Lehar and P. Winternitz, J.Physique (Paris) 39 (1978) 1.

[13] L.S.Azhgirey et al., JINR Rapid Commun., 3[95]-99 (1999) 20.

[14] *http://nn-online.sci.kun.nl*

[15] J. Ball et al., Eur.Phys.J. C10 (1999) 409.

[16] M. Altmeier et al., Phys.Rev.Lett. 85 (2000) 1819.

[17] L.S. Azhgirey et al., submitted in Part. and Nucl. Lett.

[18] R.A. Arndt et al., Phys.Rev. C56 (1997) 3005;
GW- VPI Phase Shifts Analysis, 1999.

[19] J. Bystrický, C. Lechanoine-LeLuc, F. Lehar., Eur.Phys.J. C4 (1998) 607.

[20] R.A. Arndt, I.I. Strakovsky, R.L. Workman, Phys.Rev.C62 (2000) 034005.

[21] V.G. Ableev et al., Nucl.Instr. and Meth.A306 (1991) 73.

[22] V.P. Ladygin, JINR Preprint E13-99-123, Dubna, 1999.

[23] H. Spinka et al., Nucl.Instr. and Meth. 211 (1983) 239.

[24] C. Ohmori et al.., Nucl.Instr. and Meth. A278 (1989) 705.

Received on June 11, 2002.

Ажгирей Л. С. и др. E13-2002-136
Поляриметр промежуточных энергий для измерения поляризации дейтронов и протонов на синхрофазотроне ОИЯИ

С помощью *pp*-поляриметра измерялась и мониторировалась векторная поляризация пучка дейтронов ($2{,}5 \le P_d \le 9{,}0$ ГэВ/с) синхрофазотрона ОИЯИ. Асимметрия рассеяния протонов из дейтронов на тонкой полиэтиленовой и углеродной мишенях была определена в предположении, что пучок дейтронов является пучком слабосвязанных протонов и нейтронов. Дано описание поляриметра, а также приведены значения векторной поляризации пучка дейтронов и анализирующей способности полиэтиленовой мишени.

Работа выполнена в Лаборатории ядерных проблем им. В. П. Джелепова и в Лаборатории высоких энергий ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна, 2002

Azhgirey L. S. et al. E13-2002-136
Intermediate-Energy Polarimeter for the Measurement of the Deuteron and Proton Beam Polarization at the JINR Synchrophasotron

The vector polarization of the deuteron beam ($2.5 \le P_d \le 9.0$ GeV/c) of the JINR synchrophasotron was measured and monitored by the *pp* beam polarimeter. Considering the deuteron beam as a beam of weakly bound protons and neutrons, the asymmetries of scattering of protons from deuterons on thin polyethylene and carbon targets were determined. The polarimeter is described, and the values of the vector polarization of the deuteron beam and of the CH_2 analyzing power are given.

The investigation has been performed at the Dzhelepov Laboratory of Nuclear Problems and at the Laboratory of High Energies, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna, 2002

Макет *Т. Е. Попеко*

ЛР № 020579 от 23.06.97.
Подписано в печать 27.06.2002.
Формат 60 × 90/16. Бумага офсетная. Печать офсетная.
Усл. печ. л. 1,0. Уч.-изд. л. 1,6. Тираж 320 экз. Заказ № 53377.

Издательский отдел Объединенного института ядерных исследований
141980, г. Дубна, Московская обл., ул. Жолио-Кюри, 6.