STATE RESEARCH CENTER OF RUSSIA

INSTITUTE FOR HIGH ENERGY PHYSICS

IHEP 2001-45

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SINGLE-SPIN ASYMMETRY OF INCLUSIVE γ-PRODUCTION IN $P_{\uparrow}P$ INTERACTIONS AT 200 GEV/C

Protvino 2001

UDK 539.12.142 M–24

Abstract

Kharlov Y.V. et al. Single-spin Asymmetry of Inclusive γ-Production in $p_{\uparrow}p$ Interactions at 200 GeV/c: IHEP Preprint 2001-45. – Protvino, 2001. – p. 13, figs. 6, tables 8, refs.: 11.

From the data of Fermilab polarization experiment E704 the analyzing power A_N^{γ} of inclusively produced photons was extracted. It is small, of order 2 to 4%. The analyzing power of “leading” photons (fastest in $\pi^0 \to \gamma\gamma$ decay) is twice higher than A_N^{γ}. The Monte Carlo simulation is performed in order to see effects at higher statistics than in E704 experiment. This simulation showed that photons may be used as a basis for future polarimetry at polarized colliders.

Аннотация

Харлов Ю.В. и др. Односпиновая асимметрия инклюзивного рождения фотонов во взаимодействии $p_{\uparrow}$p при 200 ГэВ/с.: Препринт ИФВЭ 2001-45. – Протвино, 2001. – 13 с., 6 рис., 8 табл., библиогр.: 11.

Из данных поляризованного эксперимента E704 в Фермилабе была получена анализирующая способность A_N^{γ} в инклюзивном образовании фотонов. Она мала (порядка $2 \div 4\%$). Анализирующая способность “лидирующих” фотонов (наиболее энергетичных в распаде $\pi^0 \to \gamma\gamma$) в два раза больше, чем A_N^{γ}. Чтобы получить эффект на большей статистике, чем в эксперименте E704, был сделан розыгрыш событий методом Монте Карло. Этот розыгрыш показал, что фотоны могут быть использованы как основа будущей поляриметрии на поляризованных коллайдерах.

Introduction

The powerfuly polarized RHIC will soon become available for Spin physics study in the highest ever reached beam energy range ($50 \leq \sqrt{s}$ (GeV) ≤ 500) [1]. One of the important problems in making RHIC efficient is to build a local polarimeter for measuring the beam polarization at the interaction region. There are several proposals to use for such a goal the inclusive neutral pion polarimeter [2,3,4]. But space limitation and several other experimental environment features may require a polarimeter placement a long way from the interaction point. In this case the inclusive photon production becomes attractive and it is proposed in paper [5]. Because the inclusive γ-production analyzing power $A_N^\gamma(x_F^\gamma, p_T^\gamma)$ was never measured, the authors of [5] used the phenomenological model for estimation of $A_N^\gamma(x_F^\gamma, p_T^\gamma)$. In the present work we aim to reconstruct $A_N^\gamma(x_F^\gamma, p_T^\gamma)$ from the Fermilab polarization experiment E704 [6,7] making use of experimental data and the Monte Carlo simulation. The consistency of two such approaches is also considered.

This paper is organized in the following way. Section 1 is dedicated to analysis of experimental data in E704 and offers the extracted asymmetries $A_N^\gamma(x_F^\gamma, p_T^\gamma)$. Section 2 describes a simulation procedure by the Monte Carlo technique and presents the restored values of $A_N^\gamma(x_F^\gamma, p_T^\gamma)$. Section 3 is devoted to a photon polarimeter in E704 environment at 200 GeV. In conclusion the main results of our study are summarized.

1. Extraction of $A_N^\gamma(x_F^\gamma, p_F^\gamma)$ from E704 data

In the previous papers [6,7] the analyzing power for inclusive π^0-production $A_N^{\pi^0}(x_F, p_T)$ in the reaction

$$p_\uparrow + p \to \pi^0 + X \tag{1}$$

was extracted at 200 GeV/c initial momentum by detecting both photons from π^0 decay. In present paper we have a goal to perform an extraction of the photon analyzing power $A_N^\gamma(x_F^\gamma, p_T^\gamma)$ in reaction

$$p_\uparrow + p \to \gamma + X \tag{2}$$

in different conditions.

First of all, we are interested in knowing the analyzing power of all inclusively produced photons. The Table 1 contains the reconstructed analyzing power $A_N^\gamma(x_F^\gamma, p_T^\gamma)$ for such photons (with threshold $p_T^c = 0.5$ GeV/c), the false asymmetries as well as a useful statistics. As a photon we selected the electromagnetic shower and required the minimum of function

$$\chi^2 = \frac{(\Sigma(E_{exp} - E_0))^2}{\Sigma E_{exp}}, \tag{3}$$

where the sum is given over all cells of the calorimeter, E_{exp} is a measured deposited energy in each counter, and E_0 is the predicted deposited energy in each cell based on the average shower shape. The minimization was similar to [8], but in order to gain statistics we put a limit $\chi^2 \leq 1.0$ GeV for useful events. Fig. 1a shows that there are small but nonzero asymmetries of order 2 to 4% at $x_F^\gamma = 0.3$ to 0.5 ($\bullet$). The false asymmetries were calculated for three cases: 1) on the base of the same statistics which was used for $A_N^\gamma(x_F^\gamma, p_T^\gamma)$ estimates mixing all directions of the beam polarizations ($A_N^{F^1}$ in Table 1, $\circ$ in Fig. 1a); 2) using the unpolarized beam ($A_N^{F^0}$ in Table 1, $\triangle$ in Fig. 1a) and 3) for a whole statistics ($A_N^{F^2}$ in Table 1, $\star$ in Fig. 1a). There is an indication that the inclusively produced photons might have some small but nonzero analyzing power. The statistics of E704 is poor for making a more stringent statement.

Table 1. The analyzing power of reaction $p_\uparrow + p \to \gamma + X$ at 200 GeV/c

x_F	A_N (%)	$A_N^{F_1}$ (%)	N_{stat} $(\cdot 10^4)$	$A_N^{F_0}$ (%)	N_{stat} $(\cdot 10^4)$	$A_N^{F_2}$ (%)	N_{stat} $(\cdot 10^4)$
$0.0 \div 0.1$	-1.0 ± 0.4	0.2 ± 0.4	38.6	-0.2 ± 0.4	50.3	0.0 ± 0.3	88.9
$0.1 \div 0.2$	-0.7 ± 0.4	0.5 ± 0.4	56.7	-0.8 ± 0.3	73.8	-0.2 ± 0.2	130.5
$0.2 \div 0.3$	0.8 ± 0.5	0.1 ± 0.5	33.8	-1.3 ± 0.4	44.4	-0.7 ± 0.3	78.1
$0.3 \div 0.4$	2.4 ± 0.8	-0.7 ± 0.8	11.1	-1.2 ± 0.7	14.7	-1.0 ± 0.5	25.9
$0.4 \div 0.5$	4.6 ± 1.7	-2.5 ± 1.7	2.6	-1.9 ± 1.5	3.5	-2.2 ± 1.1	6.1
$0.5 \div 0.6$	2.9 ± 3.1	-0.9 ± 3.2	0.7	-1.5 ± 2.8	0.9	-1.2 ± 2.1	1.7
$0.6 \div 1.0$	-4.9 ± 4.8	-2.2 ± 4.9	0.3	-3.3 ± 4.3	0.4	-2.8 ± 3.3	6.4

Keeping in mind that the reaction (1) shows $A_N^{\pi^0}$ much bigger than estimated above A_N^γ for inclusively produced photons we decided to restrict sources of photons pairs to the mass region $0.07 < m_{\gamma\gamma}$ (GeV/c^2) < 0.2. At the moment we are not able to identify decay photons from π^0. We called such source of photons pairs as "raw" π^0's. The analyzing power of such a "raw" neutral pions is presented in Table 2. The false asymmetries calculated in a similar way as Table 1 are included along with statistics. The same data is presented in Fig. 1b. Asymmetry $A_N^{\pi^0}(x_F, p_T)$ in this case is a little bit higher than in Fig. 1a for $A_N^\gamma(x_F, p_T)$ but approximately twice smaller than for true π^0 [7]. Since in our case we are not able to subtract backgrounds, we may assume that the dilution factor might be of order $d = 0.5$ in order to explain the dilution of the "raw" π^0 asymmetry.

Table 2. The analyzing power of reaction $p_\uparrow + p \to$ "raw" $\pi^0 + X$ at 200 GeV/c

x_F	A_N (%)	$A_N^{F_1}$ (%)	N_{stat} $(\cdot 10^4)$	$A_N^{F_0}$ (%)	N_{stat} $(\cdot 10^4)$	$A_N^{F_2}$ (%)	N_{stat} $(\cdot 10^4)$
$0.0 \div 0.1$	-1.6 ± 0.5	0.3 ± 0.5	24.8	0.0 ± 0.5	32.5	0.1 ± 0.4	57.3
$0.1 \div 0.2$	-1.0 ± 0.4	0.1 ± 0.4	52.8	-0.2 ± 0.3	68.7	0.0 ± 0.3	121.4
$0.2 \div 0.3$	0.3 ± 0.4	0.5 ± 0.5	36.1	-0.4 ± 0.4	47.0	0.0 ± 0.3	83.1
$0.3 \div 0.4$	1.1 ± 0.7	1.2 ± 0.7	16.1	-0.3 ± 0.6	21.2	0.3 ± 0.4	37.3
$0.4 \div 0.5$	2.1 ± 0.9	1.6 ± 1.0	8.0	-2.0 ± 0.8	10.6	-0.5 ± 0.6	18.7
$0.5 \div 0.6$	4.7 ± 1.4	1.4 ± 1.4	3.7	-3.8 ± 1.2	4.9	-1.5 ± 0.9	8.6
$0.6 \div 0.8$	7.1 ± 2.2	-4.4 ± 2.3	1.5	-2.1 ± 1.9	2.1	-3.0 ± 1.5	3.5

To improve the situation, we selected the leading photons (i.e. the photons with a higher energy) for each π^0 decay. The corresponding analyzing power for leading photons are presented in Table 3 and in Fig. 1c. Analyzing power of leading photons is approximately twice higher that of inclusive photons (see Table 1 and 3 at $x_F = 0.2$ to 0.3 and $x_F = 0.3$ to 0.4 intervals).

Table 3. The analyzing power of reaction $p_\uparrow + p \to$ "leading" $\gamma + X$ at 200 GeV/c

x_F	A_N (%)	$A_N^{F_1}$ (%)	N_{stat} ($\cdot 10^4$)	$A_N^{F_0}$ (%)	N_{stat} ($\cdot 10^4$)	$A_N^{F_2}$ (%)	N_{stat} ($\cdot 10^4$)
$0.0 \div 0.1$	-0.9 ± 0.4	0.3 ± 0.4	49.0	-0.1 ± 0.3	64.0	0.1 ± 0.3	112.9
$0.1 \div 0.2$	-0.7 ± 0.3	0.3 ± 0.4	61.9	-0.1 ± 0.3	80.4	0.1 ± 0.2	142.3
$0.2 \div 0.3$	1.4 ± 0.5	1.0 ± 0.5	25.8	-1.4 ± 0.5	34.1	-0.4 ± 0.4	60.0
$0.3 \div 0.4$	4.6 ± 1.2	-0.4 ± 1.2	5.1	-2.1 ± 1.0	6.8	-1.4 ± 0.8	12.0
$0.4 \div 1.0$	0.7 ± 3.1	-3.0 ± 3.1	0.8	-3.6 ± 2.7	1.0	-3.3 ± 2.0	1.8

So somehow our expectation is justified. The conclusions from analysis of E704 data are following:

- the inclusively produced photons show an asymmetry of order 2% at $x_F = 0.35$ and of order 4% at $x_F = 0.45$;
- the leading photons show asymmetry of order 4% at $x_F = 0.35$;
- asymmetry of photons are smaller than asymmetry for π^0 (approximately $2-3$ times) but in the case of photons one can work at smaller x_F^γ.

The statistics of E704 experiment are scarce for more detailed comparison. For this reason, in the following sections we make a Monte Carlo simulation in order to see asymmetries at much higher statistics.

2. Simulation of events

In E704 experiment the single spin asymmetry of π^0-mesons in the reaction $p_\uparrow p \to \pi^0 X$ was studied [6,7]. Expecting that the decay photons (from $\pi^0 \to \gamma\gamma$) have nonzero asymmetry we have analyzed the following dependencies:

- $A_N^\gamma(x_F^\gamma)$ for leading photon at decay $\pi^0 \to \gamma\gamma$ (it means that x_F^γ of this photon is higher than x_F^γ of the conjugated one) for every π^0 having nonzero asymmetry ("useful" pion [5]);
- $A_N^\gamma(x_F^\gamma)$ for all photons produced by interaction $p_\uparrow p$ versus cuts in p_T^γ : 0.3, 0.4, 0.5, 0.6 and 0.7 GeV/c.

2.1. Event generation algorithm

In E704 experiment the following results for single spin π^0 asymmetry were obtained (see Table 4 borrowed from paper [6]).

Table 4. The asymmetry parameter A_N for inclusive π^0-production by 200 GeV polarized protons

Items	x_F	p_T (GeV/c)	$\langle p_T \rangle$ (GeV/c)	$A_N^{\pi^0}(x_F)$ (%)
1	$0.0 \div 0.1$	$0.5 \div 2.0$	0.7	-0.1 ± 1.2
2	$0.1 \div 0.2$	$0.5 \div 2.0$	0.7	0.8 ± 0.8
3	$0.2 \div 0.3$	$0.5 \div 2.0$	0.8	0.7 ± 1.0
4	$0.3 \div 0.4$	$0.6 \div 2.0$	0.8	4.1 ± 1.1
5	$0.4 \div 0.5$	$0.7 \div 2.0$	0.9	6.1 ± 1.2
6	$0.5 \div 0.6$	$0.8 \div 2.0$	1.0	12.1 ± 1.7
7	$0.6 \div 0.8$	$0.8 \div 2.0$	1.1	15.0 ± 2.7

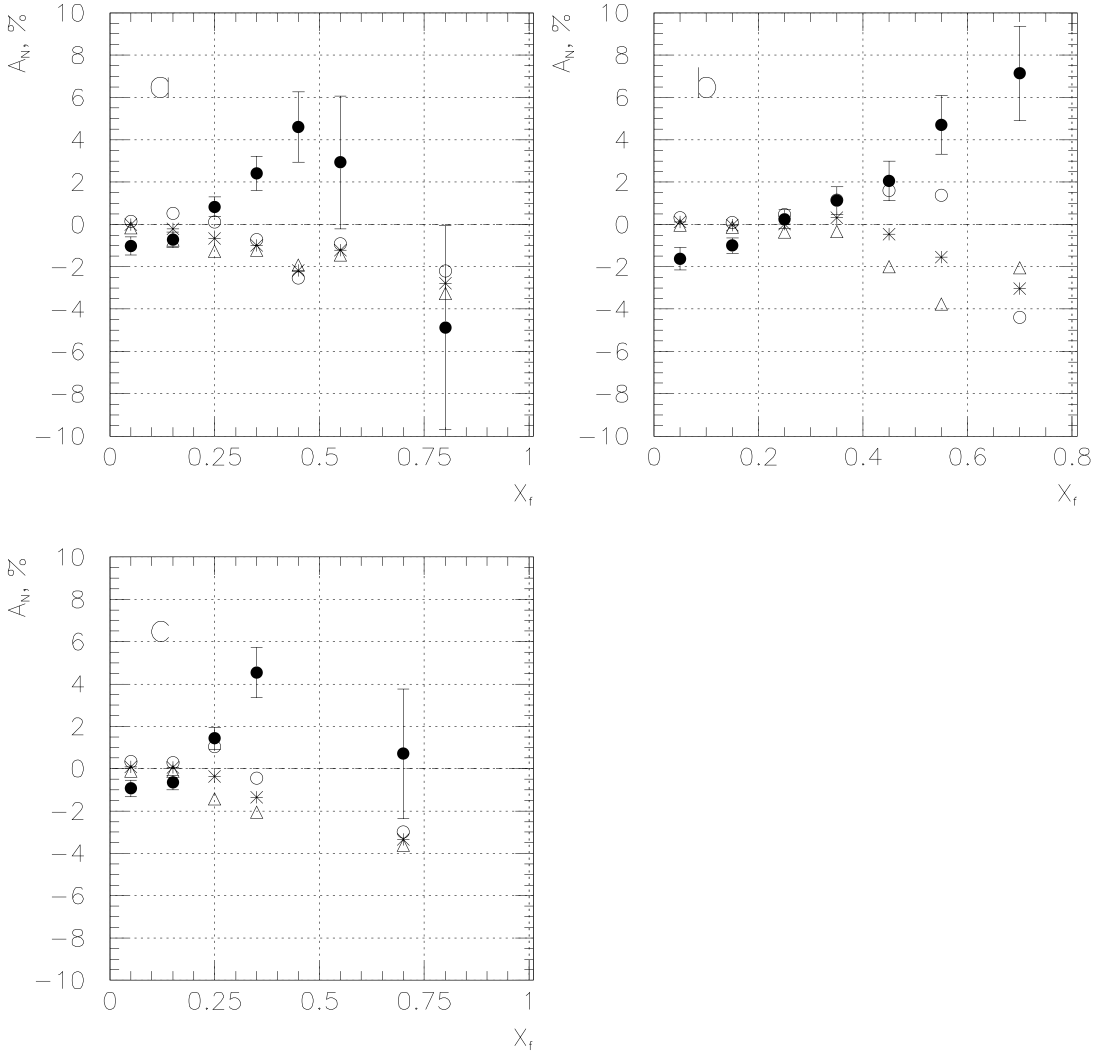

Fig. 1. The analyzing power in E704 experiment for *a*) all inclusively produced photons; *b*) "raw" neutral pions; *c*) "leading" photons. $\bullet$ — true asymmetry, false asymmetry using: $\circ$ — the same statistics as for true asymmetry, $\triangle$ — the unpolarized beam, $\star$ — the whole statistics. The error bars were omitted for background.

The following algorithm was built for generation of such events for reaction $p_\uparrow p \to aX$ at $E(p_\uparrow)$=200 GeV where

$$a = \begin{cases} \text{“useful” } \pi^0, \\ \gamma \text{ from “useful” } \pi^0, \\ \gamma \text{ from all sources.} \end{cases} \tag{4}$$

1. Minumum bias pp events are generated by $PYTHIA-5.72$ [11]. The decay $\pi^0 \to \gamma\gamma$ is forbidden.

2. From the whole set of π^0's only "useful" mesons have been chosen (in correspondence with Table 4)[1].

3. Assuming that $A_N(x_F)$ depends on x_F linearly (from Table 4):

$$A_N = b + c \cdot x_F, \tag{5}$$

the factors b and c are determined: $b = -0.082 \pm 0.032$, $c = 0.341 \pm 0.070$ with $\chi^2/ndf = 1.76/2$.

4. For each generated π^0-meson the $A_N(x_F)$ value was assigned according to relation (5).

5. The azimutal angle was drawn by the following dependence of the π^0 yield:

$$I(x_F, p_T) = I_0(x_F, p_T) \cdot (1 + A_N(x_F, p_T) \cdot P_b \cdot \cos\phi), \tag{6}$$

where I — invariant cross section of π^0-production, I_0 — the same cross section averaged over spin, $P_b = 0.456$ — beam polarization in E704.

6. All π^0 decays are allowed.

After proceeding through this algorithm we have the same set of events as in E704 with only difference that polarization asymmetry (spin $\uparrow$ and $\downarrow$) is changed to space asymmetry (left–right), and we assume an absence of asymmetry in all other channels in $p_\uparrow p$ interaction.

2.2. An approach to asymmetry estimate

The asymmetry of inclusively produced particle a (see eq. 4) in the interaction of interest was calculated in the following way.

With fixed value of x_F the asymmetry $A_N(p_T)$ is determinated from (6) through equation

$$A_N(p_T) = \frac{1}{P_b} \cdot \frac{[I^L(p_T) - I^R(p_T)]}{[I^L(p_T) + I^R(p_T)]} = \frac{1}{P_b} \cdot \frac{[N^L(p_T) - N^R(p_T)]}{[N^L(p_T) + N^R(p_T)]}, \tag{7}$$

where $N^L(p_T)$, $N^R(p_T)$ — the numbers of particles a (see (4)) with positive and negative directions of beam polarization (i.e. in our terminology flying respectively to the left and to the right) normalized by the flux of incident protons hitting the target and having in average a zero polarization.

For normalized events one may write

$$N^{L,R}(p_T, \phi) = N^0(p_T) \cdot (1 + \epsilon(p_T) \cdot \cos\phi), \tag{8}$$

where N^0 means the averaging over spin.

Raw asymmetry $\epsilon(p_T)$ was determinated as a result of a fit over $\cos\phi$, the right part of the correlation

$$\epsilon(p_T) \cdot \cos\phi = \frac{[N^L(p_T) - N^R(p_T)]}{[N^L(p_T) + N^R(p_T)]}. \tag{9}$$

After raw asymmetry $\epsilon(p_T)$ calculation unknown quantity $A_N(p_T)$ was reconstructed as

$$A_N(p_T) = \frac{\epsilon(p_T)}{P_b}. \tag{10}$$

[1] For rows $5-7$ the region of p_T was expanded to $0.6 \div 2.0$ GeV/c for smoothing the x_F and p_T distributions. One may do this because the values of A_N are not changed in such expansion.

2.3. Results of asymmetry estimate

As a test of algorithm the results for $A_N(x_F)$ for π^0-mesons (the acceptance of E704 calorimeter was taken into account) are presented in Table 5 and compared to their experimental values.

Table 5. The MC values of A_N for inclusive π^0 production

Item	x_F	p_T (GeV/c)	A_N (%)	Num. of π^0 generated
1	$0.3 \div 0.4$	$0.6 \div 2.0$	3.74 ± 0.40	604385
2	$0.4 \div 0.5$	$0.6 \div 2.0$	6.54 ± 0.52	356108
3	$0.5 \div 0.6$	$0.6 \div 2.0$	9.62 ± 0.68	209779
4	$0.6 \div 0.8$	$0.6 \div 2.0$	14.42 ± 0.73	182064

There is a good consistency between the simulated $A_N(x_F)$ given in Table 5 and their experimental values presented in Table 4: $\chi^2/ndf = 2.3/4$. Kinematical variables of "useful" π^0-mesons are shown at Fig. 2. These results convinced us that this algorithm may be applied to study $A_N^\gamma(x_F)$ of inclusive γ production.

Firstly we assume that the only source of γ production is a π^0 decay. It's known that η-mesons may add around 10% of additional photons. Since A_N for η-production is the same as A_N for π^0 [8] we can regard η source as an π^0 source. In this case only "useful" π^0 were chosen i.e. in some sense this is the ideal variant for our polarimeter which may not be reached at the experiment. Photon distribution over x_F, p_T and $A_N^\gamma(x_F^\gamma)$ are shown in Table 6 and Fig. 3.

Table 6. The MC parameter A_N for "leading" γ from π^0 decay

Items	x_F	A_N (%)	Num. of γ generated
1	$0.1 \div 0.2$	2.23 ± 0.97	103127
2	$0.2 \div 0.3$	5.16 ± 0.44	497706
3	$0.3 \div 0.4$	5.98 ± 0.48	422430
4	$0.4 \div 0.5$	10.94 ± 0.70	200535
5	$0.5 \div 0.6$	12.48 ± 1.06	87698
6	$0.6 \div 0.8$	14.75 ± 1.57	39614

Fig. 2a reflects the distribution (6) for approximate value of $\epsilon = A_N \cdot P_B \simeq 0.07$. Since the electromagnetic calorimeter has a full azimutal acceptance one does not need to make corrections for the detector acceptance. Fig. 2b illustrates the limited acceptance of the electromagnetic calorimeter used in E704 experiment. Fig. 2c demonstrates the importance of making cut at $x_F = 0.3$ in order to suppress a contribution of the "harmful" π^0-mesons to the analyzing power. Fig. 2d stems out from distribution presented in Fig. 2b and Fig. 2c. For example, taking position of the distribution maxima $\theta = 0.5^0$, $x_F = 0.4$ one gets an expected position of the maximum in p_T distribution, $p_T = 8.5 \cdot 10^{-3} \cdot 0.4 \cdot 200$ GeV/c=0.7 GeV/c which is consistent with Fig. 2d. Table 6 shows that $A_N^\gamma(x_F)$ (column 3) is higher than $A_N^{\pi^0}(x_F)$ at lower x_F values. This can be easily understood in the following way. The photons with low x_F^γ are produced by π^0 of higher $x_F^{\pi^0}$. Since these π^0 have a higher analyzing power $A_N^{\pi^0}(x_F)$, they transfer them to photons with lower x_F^γ (in average $x_F^\gamma \simeq \frac{1}{2} \cdot x_F^{\pi^0}$).

The Fig. 3a presents the energy spectrum of the "leading" photons coming from π^0 decays. As expected this spectrum is softer than the spectrum of the parents π^0 (see Fig. 2c). According to Fig.3a one must put a cut at the $x_F^\gamma \simeq 0.2$ in order to select practically all "useful" photons (having nonzero analyzing power) and at the same time to suppress essentially backgrounds. The p_T^γ distribution presented in Fig. 3b gives a hint to the necessary p_T-threshold for keeping the "useful" photons and decreasing the background contributions. Fig. 3c is our main goal. It demonstrates that the $A_N^\gamma(x_F)$ for leading photons behaves practically in the same way as $A_N^{\pi^0}(x_F)$ does. Therefore assuming that backgrounds may be essentially suppressed one can use the "leading" photon production as a base of a new type of polarimeter.

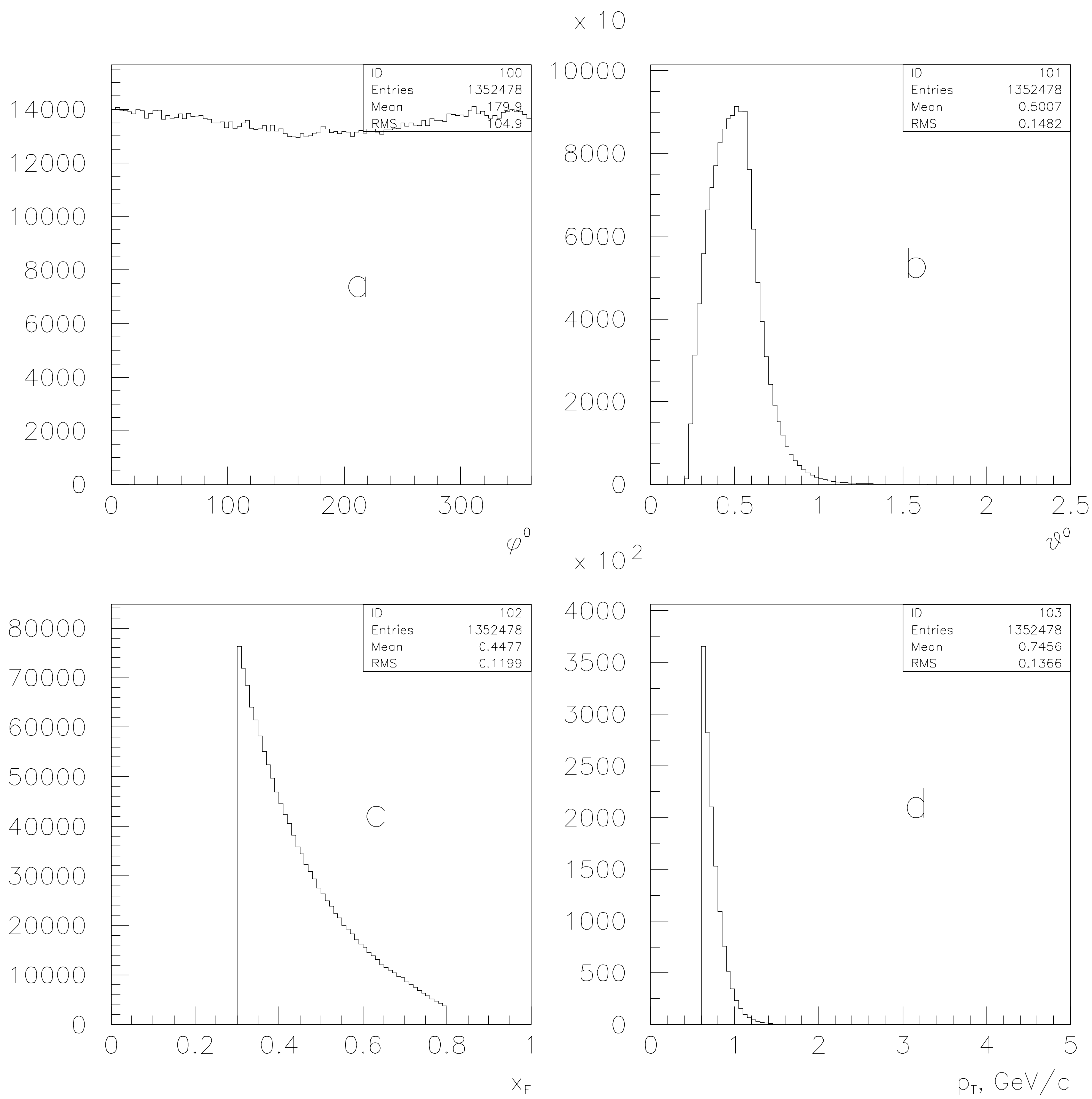

Fig. 2. The distribution of useful π^0 mesons on: *a*) the azimuthal angle ϕ; *b*) the polar angle θ; *c*) x_F and *d*) p_T.

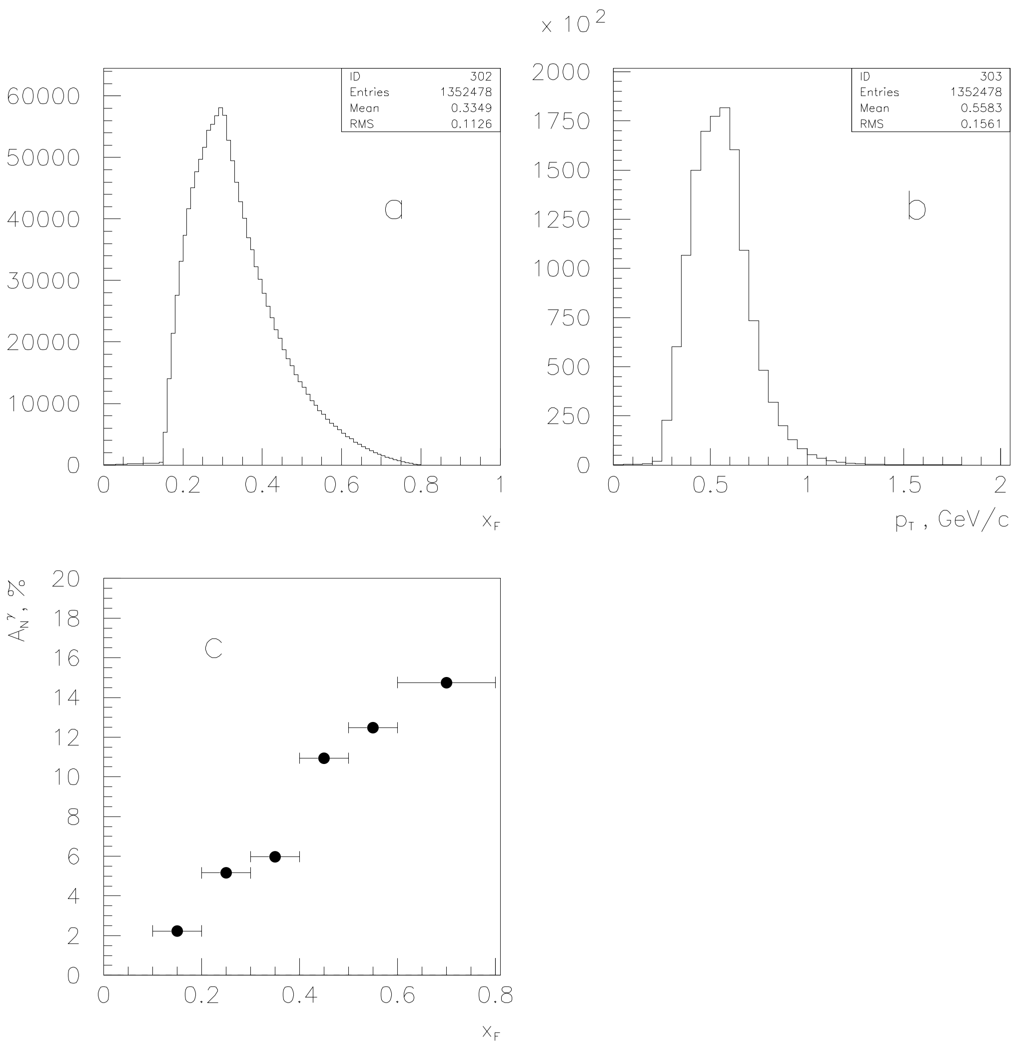

Fig. 3. The "leading" photon distributions over: *a*) x_F^γ; *b*) p_T^γ; *c*) analyzing power of the "leading" photons.

3. The possible photon polarimeter in the E704 experiment

In this section we make an estimation of the possible photon polarimeter in the E704 environments. We calculated the photon distributions on x_F and p_T (see Fig. 4a and b) and also analyzing power $A_N^\gamma(x_F)$ for different p_T threshold (see Fig. 5). All photons were taken into account.

The results for photon yield and analyzing power in the reaction $p_\uparrow p \to \gamma X$ at 200 GeV/c are presented in Table 7. The typical distributions are shown in Fig. 4 for cut $p_T^c = 0.3$ GeV/c. The steep decreases on x_F and p_T reflect the yeild of photons. The analyzing power $A_N^\gamma(x_F)$ increases with x_F at fixed p_T. With increasing of threshold in p_T (see Table 7) $A_N^\gamma(x_F)$ steadly increases with x_F. At the same time the increase of threshold on p_T suppresses the yield of photons so called a factor of merit

$$M = \langle A_N^\gamma \rangle^2 \cdot N, \tag{11}$$

varies with cut on p_T, where N is number of photons integrated over x_F and p_T, $\langle A_N^\gamma \rangle$ - integrated over p_T and averaged over x_F. The precision in beam polarization mesurement $\delta P_B = \frac{\Delta P_B}{P_B}$ depends on this factor in the following way

$$\delta P_B^2 = \frac{1}{M \cdot d^2}, \tag{12}$$

where d is a dilution factor defined as

$$d = \frac{S}{B+S}, \tag{13}$$

where S is a signal (number of γ from "useful" π^0), B is a background (number of γ from all other sources).

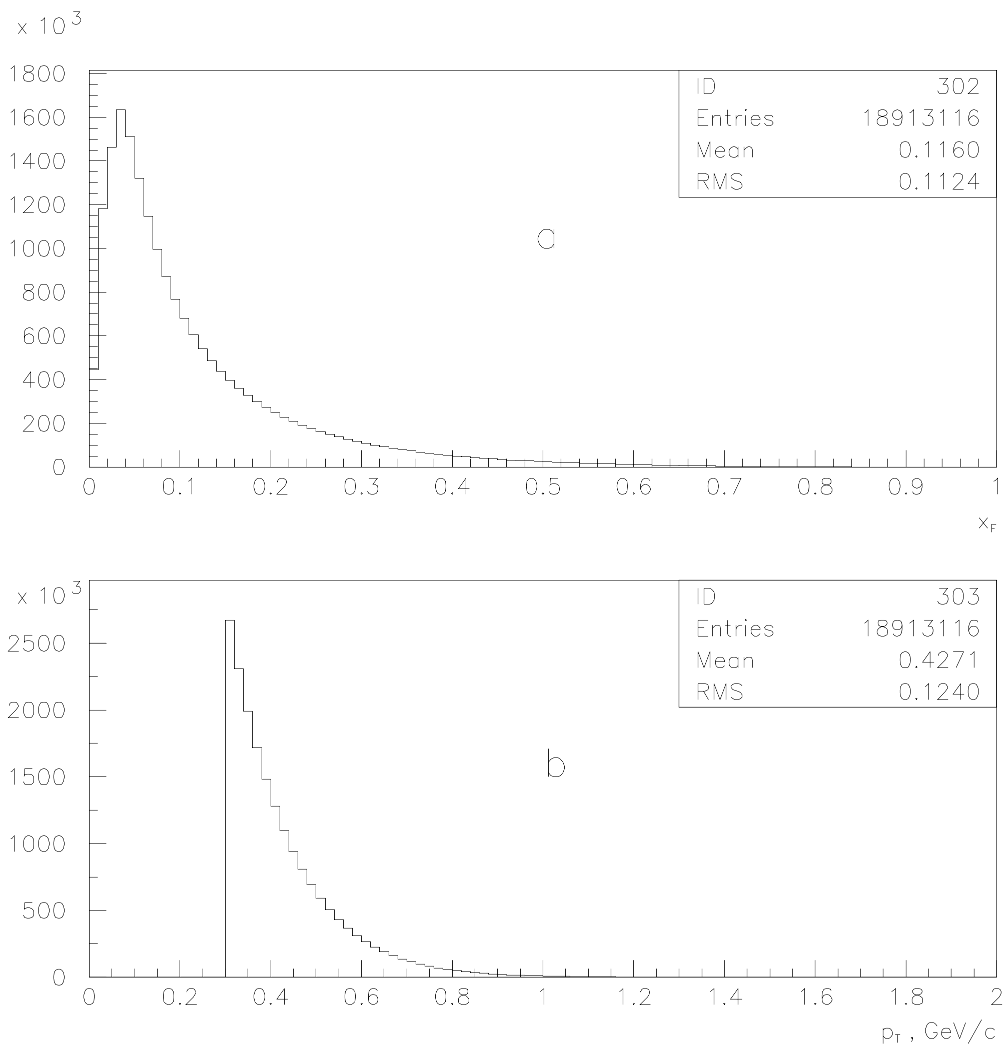

Fig. 4. Photon distributions on: a) x_F, b) p_T of photons from all sources with $p_T^c = 0.3$ GeV/c.

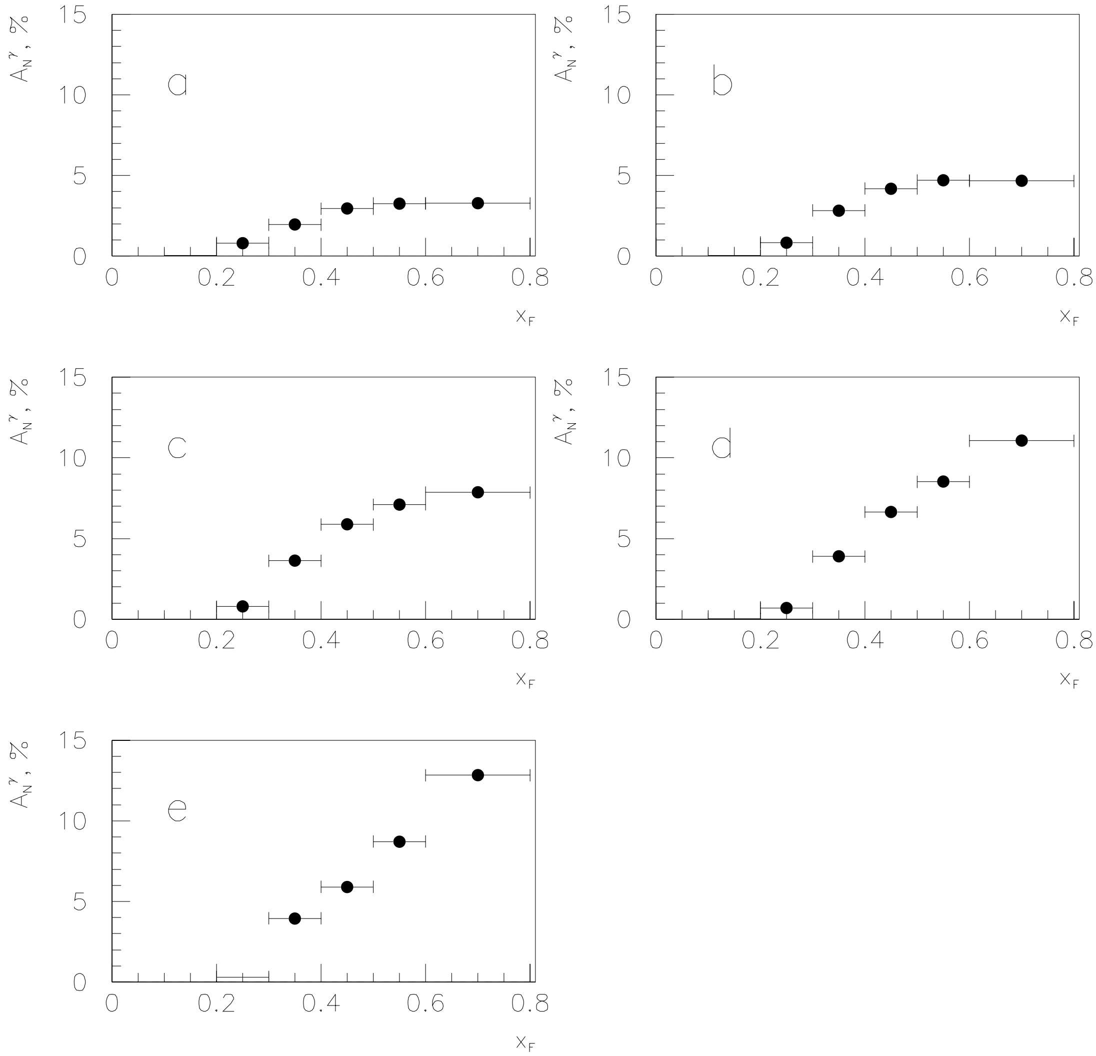

Fig. 5. Dependencies $A_N^\gamma(x_F)$ for different p_T thresholds for photons from all sources: *a*) p_T^c = 0.3 GeV/c; *b*) $p_T^c = 0.4$ GeV/c; *c*) $p_T^c = 0.5$ GeV/c; *d*) $p_T^c = 0.6$ GeV/c; *e*) $p_T^c = 0.7$ GeV/c.

Table 7. The MC estimates for $A_N^\gamma(x_F)$ taking into account all sources of photons in reaction $p_\uparrow p \to \gamma X$ at 200 GeV/c.

		p_T^c (GeV/c) $= 0.3$		p_T^c (GeV/c) $= 0.4$		p_T^c (GeV/c) $= 0.5$	
i	x_F	$A_N^\gamma, \%$	$N_\gamma \cdot 10^{-6}$	$A_N^\gamma, \%$	$N_\gamma \cdot 10^{-6}$	$A_N^\gamma, \%$	$N_\gamma \cdot 10^{-6}$
1	$0.1 \div 0.2$	0.06 ± 0.05	44.08	0.05 ± 0.07	22.02	0.00 ± 0.10	10.47
2	$0.2 \div 0.3$	0.82 ± 0.07	17.51	0.85 ± 0.10	9.56	0.78 ± 0.14	4.72
3	$0.3 \div 0.4$	1.95 ± 0.11	7.81	2.83 ± 0.14	4.64	3.62 ± 0.20	2.45
4	$0.4 \div 0.5$	2.95 ± 0.16	3.68	4.19 ± 0.20	2.32	5.87 ± 0.27	1.30
5	$0.5 \div 0.6$	3.26 ± 0.24	1.74	4.71 ± 0.29	1.14	7.10 ± 0.38	0.67
6	$0.6 \div 0.8$	3.28 ± 0.32	0.97	4.67 ± 0.38	0.66	7.85 ± 0.49	0.40

Table 7 (continuation).

i	x_F	$A_N^\gamma, \%$	$N_\gamma \cdot 10^{-6}$	$A_N^\gamma, \%$	$N_\gamma \cdot 10^{-6}$
1	$0.1 \div 0.2$	0.02 ± 0.14	4.85	-0.28 ± 0.21	2.22
2	$0.2 \div 0.3$	0.69 ± 0.21	2.18	0.31 ± 0.32	0.97
3	$0.3 \div 0.4$	3.88 ± 0.29	1.17	3.95 ± 0.43	0.52
4	$0.4 \div 0.5$	6.64 ± 0.39	0.65	5.90 ± 0.57	0.30
5	$0.5 \div 0.6$	8.51 ± 0.53	0.35	8.72 ± 0.76	0.17
6	$0.6 \div 0.8$	11.06 ± 0.66	0.22	12.83 ± 0.94	0.11

Another important parameter is a geometrical efficiency of the detector which is defined as

$$E = \frac{N_{acc\,\gamma}}{N_{events}}, \tag{14}$$

where $N_{acc\,\gamma}$ is a number of photons accepted by detector and N_{events} is a number of generated events in $p_\uparrow p$ collisions. The parameter of interest is a time T of accumulating necessary statistics N for the luminosity of experiment L is given by

$$T = \frac{N}{L \cdot \sigma \cdot E}, \tag{15}$$

where $\sigma = 40$ mb — the total cross section of pp interaction at 200 GeV/c. For E704 experiment, the luminosity was estimated in the following way. From [9] it stems that the intensity of tagged protons with polarization magnitude $> 35\%$ and average polarization 45% is $3 \cdot 10^6$ pol.prot./spill (at incident flux of 10^{12} protons per 20 sec spill). Since duty factor is 3, the intensity of polarized proton beam is $I = \frac{3 \cdot 10^6}{20 \cdot 3} = 5 \cdot 10^4$ pol.prot./sec. In E704 experiment the liquid hydrogen target was used with length $l = 100$ cm and density $\rho = 0.07$ g/cm^3. Therefore the luminosity L is: $L = I \cdot N_A \cdot \rho \cdot l = 5 \cdot 10^4 \cdot 6 \cdot 10^{23} \cdot 0.07 \cdot \cdot 100$ cm$^{-2} \cdot$ sec$^{-1} = 2.1 \cdot 10^{29}$ cm$^{-2} \cdot$sec^{-1}. This is consistent with [10]. In the Table 8 and Fig. 6 these parameters are shown for different p_T cuts.

Table 8. Main parameters which characterize the efficiency of events accumulation.

p_T^c (GeV/c)	N_{ev} $(\cdot 10^8)$	S $(\cdot 10^7)$	$S+B$ $(\cdot 10^7)$	d	$\langle A_N \rangle$ (%)	N $(\cdot 10^6)$	E $(\cdot 10^{-2})$	T (sec$\cdot 10^4$)
0.3	5	3.25	7.58	0.43	2.5 ± 0.4	3.57 ± 1.11	2.84	1.50 ± 0.46
0.4	5	1.81	4.03	0.45	3.6 ± 0.7	1.52 ± 0.59	1.75	1.03 ± 0.37
0.5	5	0.98	2.00	0.48	5.1 ± 1.4	0.67 ± 0.37	0.97	0.82 ± 0.45
0.6	5	0.49	0.94	0.51	6.0 ± 2.3	0.43 ± 0.33	0.48	1.06 ± 0.81
0.7	5	0.21	0.43	0.50	6.1 ± 2.8	0.43 ± 0.40	0.22	2.33 ± 2.14

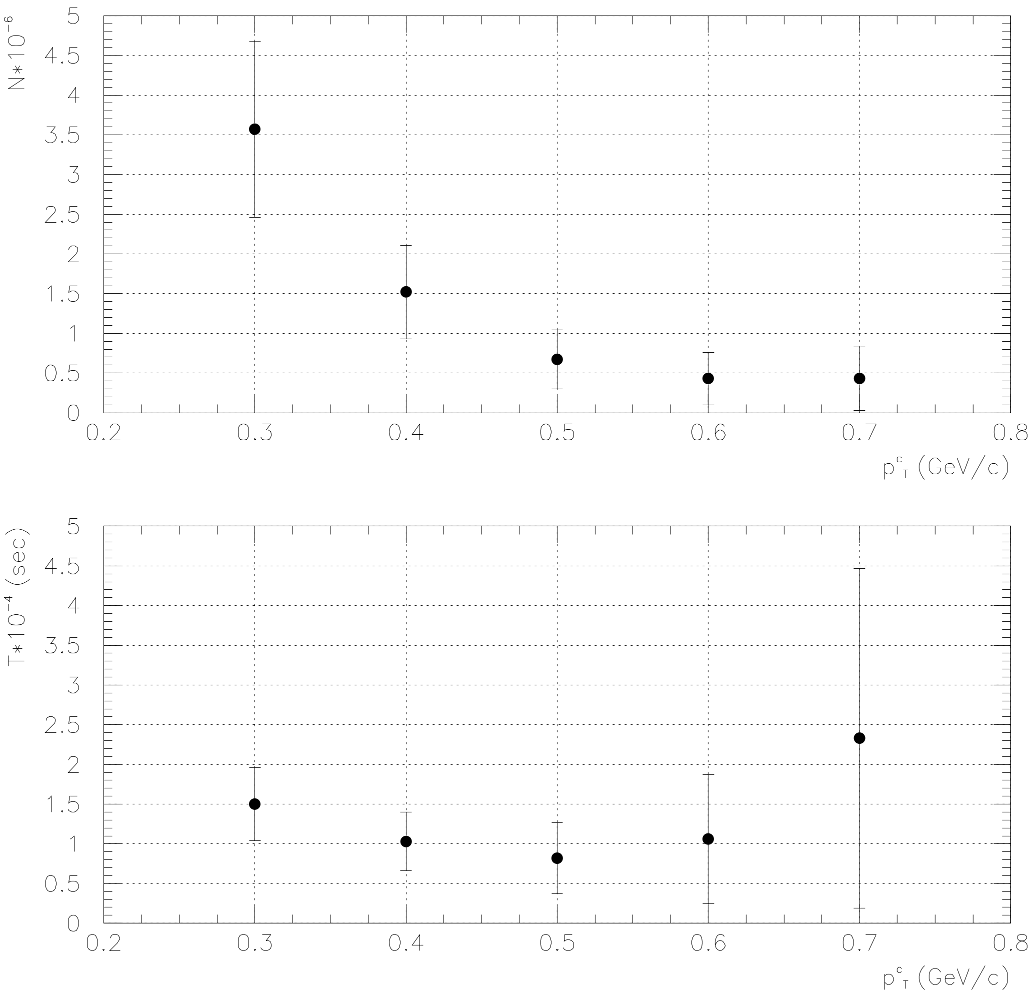

Fig. 6. Dependences $N(p_T^c)$ and $T(p_T^c)$.

Conclusions

Single spin asymmetry of inclusive photons has been obtained from the E704 experimental data. However, the statistics in the experiment was not big enough to achieve a precise accuracy in the asymmetry needed for polarimetry. A Monte Carlo algorithm based on π^0 asymmetry results from E704 [8] has been developed to compensate a lack of statistics.

In the Monte Carlo study it has been shown that the asymmetry of leading photons from decays of π^0's with Feinman variable $x_F > 0.3$ and $p_T > 0.6$ GeV/c increases linearly with x_F and approaches 15% at $x_F \simeq 0.7$. The asymmetry of all inclusive photons in $p_\uparrow p$ interactions is significant as well. It is in the range between 4 and 6% for moderate transverse momenta thresholds to select the photons. This asymmetry can be considered as an analyzing power for polarimetry.

The idea to create a polarimeter based on the analyzing power of single inclusive photons in $p_{\uparrow}p$ interactions has been established. No time consuming π^0 reconstruction is needed for this polarimeter. As an example, it is shown for the E704 environment that this polarimeter has a minimum of time needed for determination a beam polarization (2 hours approximately) with an accuracy of 5% at transverse momenta threshold $p_T^c = 0.5$ GeV/c. Now we expect to make an estimate of a time which will be needed for this type of a polarimeter to achieve the required 5% accuracy in beam polarization measurement at polarized RHIC.

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Received October 30, 2001

Препринт отпечатан с оригинала-макета, подготовленного авторами.

Ю.В. Харлов и др.
Односпиновая асимметрия инклюзивного рождения фотонов во взаимодействии $p_{\uparrow}$p при 200 ГэВ/с.

Оригинал-макет подготовлен с помощью системы LaTeX.

Подписано к печати 01.11.2001. Формат $60 \times 84/8$.
Офсетная печать. Печ.л. 1.37. Уч.-изд.л. 1.1. Тираж 160. Заказ 182.
Индекс 3649. ЛР №020498 17.04.97.

ГНЦ РФ Институт физики высоких энергий
142284, Протвино Московской обл.

Индекс 3649

П Р Е П Р И Н Т 2001-45, И Ф В Э, 2001