Study of Transverse momentum Distribution OF Charged Particles In 4.5 GeV/c Proton-Emulsion Interactions

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Abstract. The emission of charged particles in 4.5 GeV/c proton-emulsion interactions were investigated. The emulsion plates have been irradiated at Dubna Synchrophasotron.. The experimental data were obtained at the Laboratory of High Energy Physics (LHEP) at Cairo University. Transverse momentum technique has been used to check the sideward flow of charged particles in the considered reactions. The reaction plane has been determined in each event and the transverse momentum (the momentum component in the azimuthal plane) was projected onto the reaction plane. The dependence of the average-oriented transverse momentum per charged particles, projected onto the reaction plane, on the pseudorapidity were studied. The present work shows a significant sideward flow of charged particles in the region of large pseudorapidity i.e. small values of the space angle (forward cone). The side ward flow of nuclear matter seems to be as a result of the interaction between any two composite particles. A correlation is seen between the direction of flow of the charged particles and the emitted heavy ionized target fragments in proton-emulsion interactions at 4.5 GeV/c.

1. Introduction

The physics of high energy heavy ion collisions attract strong attention of the physics community as creation of a new type of matter, the quark gluon plasma (QGP), is expected in such collisions. Ultra-relativistic heavy ion collisions may provide conditions sufficient for the formation of deconfined QGP[1]. Experimental results from RHIC indicate that a strongly-interacting partonic matter has been created in the early stage of central Au + Au collisions at $\sqrt{s_{NN}}$ = 200 GeV at RHIC [2]. There is a variety of correlations observed in proton–proton or proton–antiproton interactions at high energies. In particular, it has been found that the average particle transverse momentum depends on the particle multiplicity in a given collision [3-4]. These correlations should be also present in nucleus–nucleus (A–A) collisions, if such a collision is a superposition of nucleon–nucleon (N–N) interactions. However, there is no straightforward method to observe them since the final state particles in A–A collisions originate from the various N–N interactions, while the correlated particles come only from the same N–N interaction. Many works have been devoted to study the collective sideward flow of the nuclear matter in (A-A) interactions in the momentum range from a few hundreds MeV/c to a few GeV/c per incidence [1-9]. Nuclear emulsions and Ag/CI nuclear track detectors have been used for the first time to search for the collective sideward flow of nuclear matter in central $^{12}C + {}^{108}Ag$ collisions . It has been shown that the angular distribution of alpha particle target fragments, emitted from these interactions, peaks at an angle predicted by the shock wave calculations [4-5]. A series of subsequent experiments has shown either less evidence for this peaking or its absence [6-7]. Signatures for a bounce off effect were observed, a few years later. Experimental results, concerning the collective sideward flow, have been obtained by the 4π plastic ball detectors [8-10] and by nuclear emulsion [11-16]. The collective sideward flow of the nuclear matter affects the emission of the projectile fragments, target fragments and pions [17-19]. Almost, all these experiments were restricted to the study of the projectile and or target fragments, since these particles are easier to be measured. The aim of the present work is to deals with the collective flow analysis for the produced shower

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particles in proton-emulsion collisions at 4.5 GeV/c. The transverse momentum technique was used to investigate such collisions. The significance of the determination of the reaction plane has been studied. The correlation, between the emitted shower particles and target figments, has been investigated.

2. Results and discussion:

2.1. Transverse momentum calculations:

In the present analysis, the momentum per nucleon of the incident Proton is P_L = 4500 MeV/c. Assuming that the momentum per nucleon of a projectile fragment after collision is $\vec{P}_L$, then the transverse momentum per nucleon of the i<u>th</u> fragment $P_i = P_L \tan\theta_i$ where θ_i is the emission angle of the i<u>th</u> fragment. The direction of the vector P_i is the azimuthal direction of this fragment. The reaction plane is the plane, which contains the directions of the incidence and the vector R_μ, which is given by the formula [15].

$$R_\mu = \sum_{\substack{i=1 \\ i\neq\mu}}^{N_f} w_i M_i P_i, \quad \mu = 1,2,3,......., N_f \tag{1}$$

$$\text{Where}, w_i = \begin{cases} 0 & P_i > 240 MeV/c \\ 1 & P_i \le 240 MeV/c \end{cases}$$

The coefficients w_i are introduced to exclude fragments of very large transverse momentum. The quantity M_i is given by $M_i = \sum_K W_{i,k} A_{i,k}$, where $A_{i,k}$ is the mass number of the kth isotope and the ith fragment and $W_{i,k}$ is the corresponding fractional abundance of the isotope [18]. The projection of the transverse momentum (P_μ) on the vector $\vec{R}_\mu$ is (P^*_μ), and is given by :

$$P^*_\mu = \vec{P}_\mu \cdot \vec{R}_\mu / |\vec{R}_\mu|, \quad \mu = 1,2,.....\eta_f \tag{2}$$

The mean transverse momentum per nucleon projected onto the reaction plane <P*>, is obtained by averaging P^*_μ over all fragments and over all the selected interactions (hadronic or baryonic). The value of <P*> will equal zero if P^*_μ is randomly distributed in the azimuthal plane and it differs from zero if the energy flow of particles deviates from zero angle direction. figure l. shows the dependence of <P*> on the pseudorapidity, (η) of the shower produced particles in proton-emulsion collisions at 4.5 GeV/c. The dots with error bars, are the experimental points and the histogram represents the

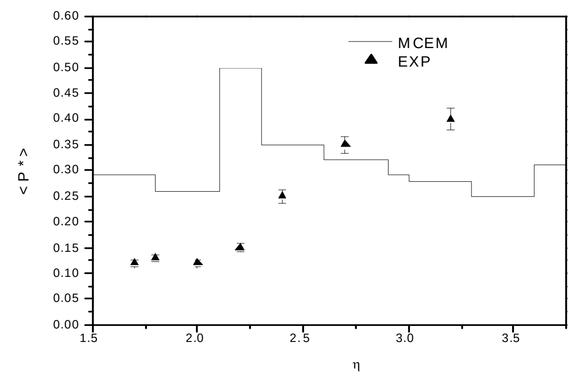

Figure 1. shows the dependence of <P*> on the pseudorapidity, (η) of the shower produced particles in proton-emulsion collisions at 4.5 GeV/c.

Modified cascade evaporation model (MCEM) simulation of events from the experimental tracks which were randomized before the simulation. The experimental data in figure. 1 reveals that $<P^*>$, differs significantly from zero. To investigate whether such observation is a true significant effect or just a statistical fluctuation, (MCEM) program was designed to regenerate events of the same multiplicity from a randomized sample of produced showers in the experiment i.e., all the shower produced were raffled and MCEM events were generated randomly from them [22]. The histogram represents the relation between $<P^*>$, and the pseudorapidity, (η), assuming a random distribution of the produced showers. A significant difference between the experimental and simulated data is seen in Fig. 1, especially in the region of large (η). This observation displays the sideward flow of the produced showers in p-Emulsion collisions at 4.5 GeV/c. The resultant vectors R together with the direction of the incident particle reconstruct the geometry of the collision and determine the reaction plane with a certain accuracy. The uncertainty in the determination of the reaction plane can be estimated by studying the difference between the reaction planes found for single event using different sets of particles ($i \neq \mu$ as defined in eq. (1)). If the difference between two reaction planes for the same event is small, either of these two planes can be viewed as being well determined. The accuracy, of the method used in the present work for the reaction plane determination, is adequate for the analysis of-high energy nuclear reactions.

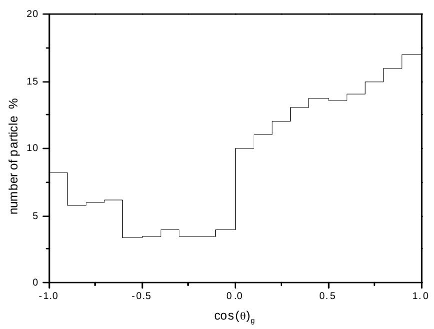

Figure 2. show the angular distribution of the grey (g) particles relative to the reaction plane.

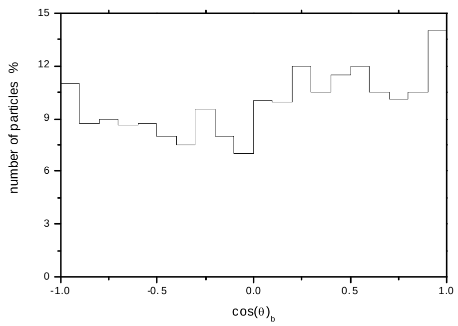

Figure 3. show the angular distribution of the black (b) particles relative to the reaction plane.

Figure (2) and figure (3) show the angular distribution of the grey (g) and black (b) particles relative to the reaction plane. It can be seen that, for black particles, in the region of cos(θ) greater than 0.2, there is an enhancement in the angular distribution. This may indicate a collective sideward flow of slow target fragments (black-particles). Such signature is difficult to be observed in the angular distribution of black particles relative to the microscope coordinates.

2.2. Correlation between the produced shower particles and target fragments:

A unit vector was assumed along the projection of the direction of flight of each particle onto the azimuthal plane. Then, the unit vectors for the produced shower particles and for the emitted target fragments, in each event, were summed separately to find the resultant vectors of the produced shower particles and the emitted target fragments. In figure (4) presents the distribution of the azimuthal angle between the resultant vectors of the shower particles and the heavy target fragments. A peak is observed at an angle $\phi_{sh} = 180^o$. This shows that the produced shower particles and target fragments indicate a back-to-back emission. This observation agrees with the sideward flow of the nuclear matter.

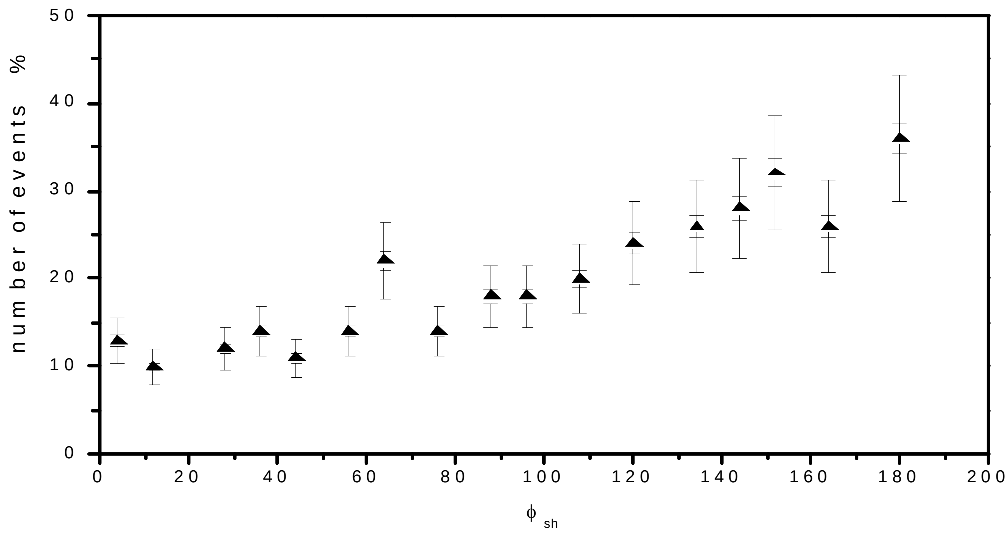

Figure 4. Illustrate the distribution of the azimuthal angle between the resultant vectors of the shower particles and the heavy target fragments.

3. Conclusions

Relativistic gray particles show an observable enhancement in angular distribution projected onto the reaction-plane. The sideward flow of the produced shower particles has been observed in proton-emulsion collisions at 4.5 GeV/c. A back-to-back emission has been seen for the produced shower particles and emitted the target fragments.

References

[1] F. Karsch, Nucl. Phys. A 698 (2002) 199c.
[2] I. Arsene, et al., BRAHMS Collaboration, Nucl. Phys. A 757 (2005) 1,
B.B. Back, et al., PHOBOS Collaboration, Nucl. Phys. A, 757 (2005) 28,
J. Adames, et al., STAR Collaboration, Nucl. Phys. A 757 (2005) 102,
S.S. Adler, et al., PHENIX Collaboration, Nucl. Phys. A, 757 (2005) 184.
[3] H.G. Baumgardt et aI., Z.Phys A, 273 (1975) 359.
[4] H.H. Hechmann et aI., Phys.Rev. C; 17 (1978) 1651.
[5] W. Scheid et al., Phys.Rev. Lett., 32 (1978) 741.
[6] B.P. Bannik et aI., Z.Phys.A, 284 (I978) 283.
[7] A. EL-Naghy, lL Nuovo Cimento, 71 (1982)245.
[8] R.Stock et aI., Phys.Rev. Lett., 44 (1980) 1243.
[9] L.P. Csemai and W. Greiner, Phys.Lett. B, 99 (1981)85.
[10] H.A. Gustafsson et aI., Phys.Rev. Lett., 52 (1984) 1590.
[11] G.Buchwald et aI., Phys.Rev.C, 52 (1984) 1594.
[12] H.H. Hechmann et aI., Phys.Rev.C, 34 (1986) 1333.
[13] B.P.Bannik et aI., Z.Phys. A, 329 (1988) 341.
[14] B.P.Bannik et aI., 1. Phys. G, 14 (1988) 949.

[15] A.EL-Naghy et aI., JINR,EI- (1987) 87472.
[16] A.EL-Naghy et aI.,Proc. Of 5th -conf. Nucl.Sc.Appl., 2 (1992) 722.
[17] M.A. Allomer et aI., Nucl . Sc. J., 32, (1995) 347.
[18] A.El-Naghy,S.S. Abdel-Aziz, S.H.Abou-Steit, And A.M.El-Shimy, Heavy Ion Physics 15/1-2(2002)131.
[19] S. S. Abdel -Aziz , Can.J.Phys (2006)925.
[20] N.G. Antoniou, F.K. Diakonos and E.N. Saridakis, Nucl Physics A, 784 (2007)536c.
[21] A.Majumder ,Nucl Physics A, 785 (2007)158c.
[22] S. S . Abdel- Aziz et al., Egypt . J. Phys (2002)193.