YU ISSN 0015-3206
FZKAAA 14 (4) 313 (1982)

TWO-PARTICLE RAPIDITY AND AZIMUTHAL CORRELATION IN ^{16}O-NUCLEUS INTERACTION AT 2.1 GeV/n

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Received 12 June 1982

UDC 539.12

Original scientific paper

This paper presents a study of two-particle inclusive rapidity correlations among relativistic particles and also two-proton azimuthal angle correlation in the interaction ^{16}O nuclei with photoemulsion at 2.1 GeV per nuclei. It has been observed that there is short-range correlation among the relativistic particles. There is also some azimuthal correlation among two protons.

1. Introduction

Recently there has been great interest in studying correlation effects among secondaries produced in hadron-nucleus and nucleus-nucleus interaction at high energy since such study can provide information on the possible mechanism of production process. However, study of correlations in the case of nucleus-nucleus interaction still remains in its incipient stage[1,2]. There are little data on correlation in nucleus-nucleus collision although they are very useful discriminations between various models. Besides the usual two-particle rapidity correlations among relativistic particles, the study of two-proton azimuthal correlation is also of considerable interest in case of nucleus-nucleus collision[3].

In view of this we investigate in this paper the two-particle rapidity correlations along the relativistic particles and two-proton azimuthal correlation in the interactions of relativistic ^{16}O nuclei with nuclear emulsion at 2.1 GeV/n.

2. *Experimental*

A set of photoemulsion *Illford K5* plate exposed to a 2.1 GeV/n ^{16}O beam at the *Berkeley Bevatron* has been used in the present investigation. The scanning of the plate was done by a *Leitz-Ortholux* microscope provided with a *Brower* travelling stage. Plates were scanned using the following optics: 53-1 x oil immersion objective and 20 x ocular lens. The events were chosen utilising the criteria: a) the beam track should be $< 1^0$ to the mean beam direction of the pellicle b) interaction should not be within top of bottom 20 μm thickness of the pellicle. 480 events have been selected for analysis. According to the conventional emulsion terminology the secondaries in an event are classified into the following main types (depending on the ionisation that they produce)

a) Relativistic particles
for which $b^* < 1.4$ where b^* is the normalised blob density.

b) Grey particle
for which $b^* > 1.4$ and $g^* < 6$ where g^* is the normalised grain density.

c) Black particle
for which $g^* > 6$.

The spatial emission angles (Θ) of all charged particles in an event have been determined by measuring x, y and z coordinates of the interaction vertex, three points on the beam track and three points on the track of the produced particles. From the knowledge of Θ one can field out the rapidity (pseudorapidity) $\eta = -\ln \tan \Theta/2$.

3. *Two-particle correlation*

A general two-particle correlation function has been defined as

$$C(Y_1, Y_2, p_{T1}, p_{T2}, S, A) \equiv (1/\sigma_{in}) \frac{d^6\sigma}{dy_1\, dy_2\, d^2p_{T1}\, d^2p_{T2}} -$$

$$- (1/\sigma_{in})^2 \frac{d^3\sigma}{dY_1\, d^2p_{T1}} \frac{d^3\sigma}{dY_2\, d^2p_{T2}}$$

where Y represents the rapidity, p_T the transverse momentum, A the mass number and S the squared C. M. energy; the subscript 1 and 2 stand for the two particles considered. Integrating over p_T one gets

$$C(Y_1, Y_2, S, A) \equiv (1/\sigma_{in}) \frac{dY_1 \, dY_2}{d^2\sigma} - (1/\sigma_{in})^2 \frac{d\sigma}{dY_1} \frac{d\sigma}{dY_2}$$

where

$$(1/\sigma_{in}) \int \frac{d^2\sigma}{dY_1 \, dY_2} \, dY_1 \, dY_2 = \langle n_S (n_S - 1) \rangle$$

$$(1/\sigma_{in}) \int \frac{d\sigma}{dY} \, dY = \langle n_S \rangle$$

$$\int C \, dY_1 \, dY_2 = f_2.$$

f_2 is the multiplicity moment defined

$$f_2 = \langle n_S (n_S - 1) \rangle - \langle n_S \rangle^2.$$

We choose pseudorapidity (η) as variable where $\eta = -\ln \tan \Theta/2$. Θ is the emission angle of the produced particle with respect to the incident beam.

Since the shower particles are primarily pions with mean $p_T \sim 0.4$ GeV/c, $p_{11}^2 \gg P_T^2 \gg m^2$ for most of the particles, η closely approves the laboratory rapidity $Y = \frac{1}{2} \ln \frac{E + p_{11}}{E - p_{11}}$. The correlation function C then becomes

$$C(\eta_1, \eta_2) = \frac{1}{\sigma_{in}} \frac{d^2\sigma}{d\eta_1 \, d\eta_2} - \frac{1}{\sigma_{in}^2} \frac{d\sigma}{d\eta_1} \frac{d\sigma}{d\eta_2} = \frac{N_2}{N} (\eta_1, \eta_2) - \frac{N_1(\eta_1) \, N_1(\eta_2)}{N^2}$$

where $N_1(\eta)$ is the number of shower particles with pseudorapidity between η and $\eta + d\eta$; $N_2(\eta_1, \eta_2)$ is the number of pairs of shower particles with pseudorapidity between η_1, $\eta_1 + d\eta_1$ and η_2, $\eta_2 + d\eta_2$, in the same event and N_T is the total number of inelastic interaction in the sample.

For two-proton azimuthal angle correlation study we use

$$C(\Phi_{ij}) = \frac{2\pi}{\sigma} \frac{d^2\sigma}{d\Phi_i \, d\Phi_j} - \frac{2\pi}{\sigma^2} \frac{d\sigma}{d\Phi_i} \frac{d\sigma}{d\Phi_j}$$

where

$\Phi_{ij} = \Phi_i - \Phi_j$ (Φ is the azimuthal angle for particle).

4. Results and discussions

Fig. 1 (a) shows the correlation function $C(\eta_1, \eta_2 = \eta_1)$ along diagonal. It is evident from the graph that the experimental data reveals substantial positive correlations.

Fig. 1 (b, c, d) show the different rows of correlation matrix $C(\eta_1, \eta_2)$.

It is interesting to observe that in each case the correlation function is prominent in the central region.

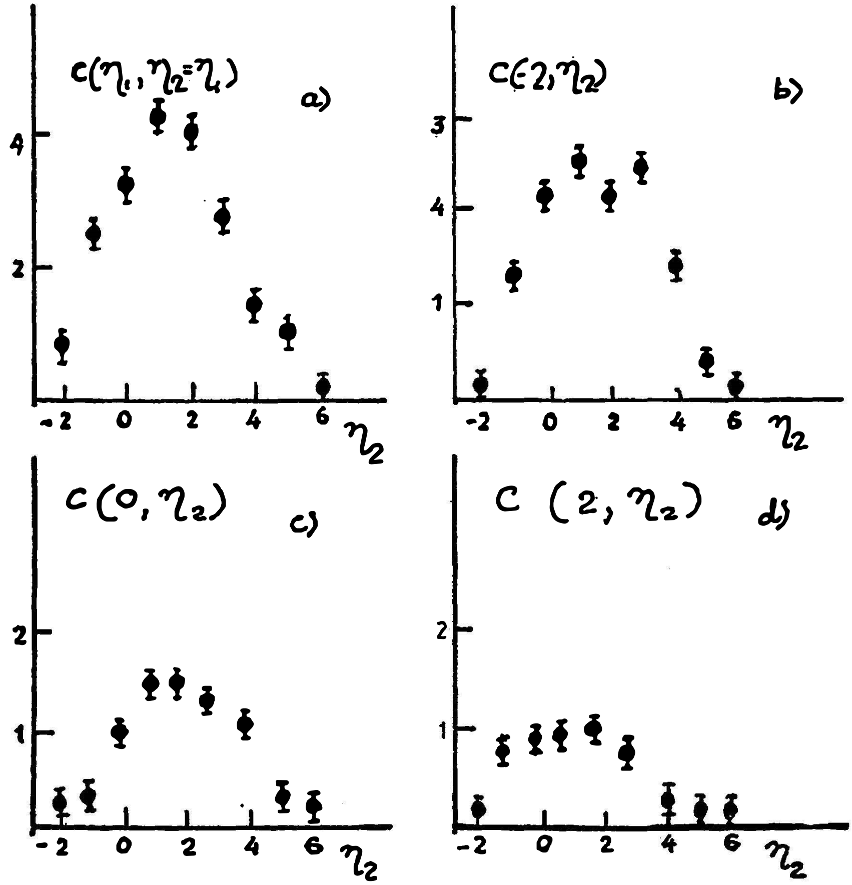

Fig. 1. Two-particle correlation functions

(a) $C(\eta_1, \eta_2 = \eta_1)$, (b) $C(-2, \eta_2)$, (c) $C(0, \eta_2)$, (d) $C(2, \eta_2)$ for relativistic particles.

Fig. 2 shows the two-proton azimuthal correlation function $C(\Phi_{ij})$. The experimental data indicates a correlation.

This interesting observation might be helpful for a detailed study required for a proper interpretation of two-proton azimuthal correlation.

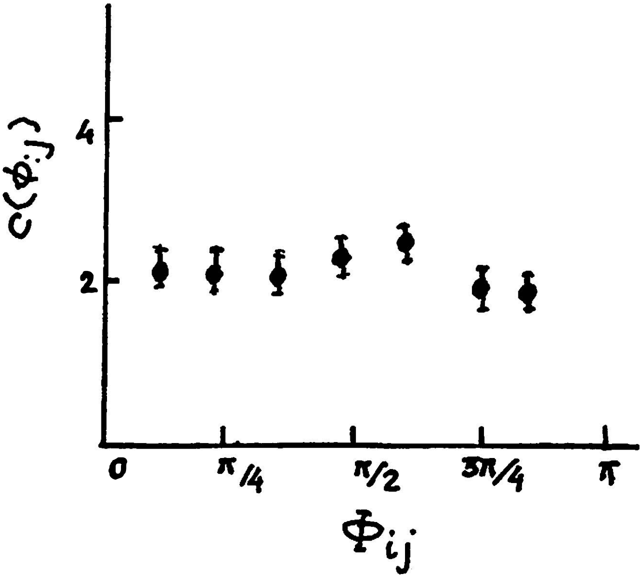

Fig. 2. Two-proton azimuthal angle correlation function $C(\Phi_{ij})$.

Acknowledgment

The authors wish to thank Prof. P. S. Young (Mississippi State University, U.S.A.) for his help.

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DVOČESTIČNI RAPIDITET I AZIMUTALNA KORELACIJA U MEĐUDJELOVANJU ^{16}O S JEZGROM EMULZIJE NA 2.1 GeV/n

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UDK 539.12

Originalni znanstveni rad

U ovom članku prikazana je studija korelacije inkluzivnog rapiditeta među relativističkim česticama, te također dvoprotonska korelacija u azimutalnom kutu pri međudjelovanju jezgre ^{16}O s fotoemulzijom na 2.1 GeV po jezgri. Opažena je korelacija kratkog dosega između relativističkih čestica.