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SEPARATION OF CLUSTERS IN THE Mg-Mg REACTION

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1 Introduction

At the beginning of the 80-th A.M.Baldin et al. [1-4] founded the relativistic description of the multiple particle production in nucleus-nucleus interactions.

We used this method to describe the data obtained in the irradiation of the streamer chamber on the synchrophasotron beams in Dubna.

In this paper we discuss a new algorithm for separation of clusters of particles and try to clear up their nature.

The experimenal material we used was obtained from the reaction Mg-Mg at a beam momentum of 4.5 GeV/c per nucleon. 1390 events were registered. Only negative secondary tracks (π^-) were measured. 10606 π^- were found.

For comparison of data at different energies, we used to an.extent the experimental material from the bubble chamber [5].

2 The algorithm for clusters separation

There are two main algorithms which are used to separate clusters now. The first one is the clusterization of particles according to their cumulative numbers [1]. The second algorithm uses the functional [4] :

$$A_2 = min[-\sum_i (V_\alpha - u^i_\alpha)^2 - \sum_j (V_\beta - u^j_\beta)^2]$$

for creating clusters of particles.

We offer an algorithm for clusters separation which is based on the nearness of tracks in the four-velocities space u_i [1]. According to [4] we introduce some values which we will often use in this paper.

For a cluster consisting of n particles with four-velocities u_1, u_2, ...,u_n we can define the axis of the cluster:

$$V = \frac{\sum_i u_i}{\sqrt{(\sum_i u_i)^2}}$$

V is a unitary vector as well as u_i. For each particle belonging to the cluster we can define the quantity

$$b_k = -(V - u_k)^2$$

The b_k distribution shows us how narrow are the clusters we have obtained. Considering two clusters with axes V_α and V_β we can define their relative invariant velocity:

$$b_{\alpha\beta} = -(V_\alpha - V_\beta)^2$$

The distribution of this value shows whether the clusters differ from one another. We see a clear division of secondary particles into clusters when the mean value of $b_{\alpha\beta}$ is significantly greater than b_k. The cumulative coefficients for fragmentation of the beam (x_I) and of the target (x_{II}) can be defined for each particle and each cluster as follows:

Fragmentation of projectile		Fragmentation of target
	for particles	
$x_I = \frac{m_I \cdot u_i \cdot u_{II}}{m_i \cdot u_I \cdot u_{II}}$		$x_{II} = \frac{m_{II} \cdot u_i \cdot u_I}{m_i \cdot u_I \cdot u_{II}}$
	for clusters	
$x_{IS} = \frac{m_I \cdot V \cdot u_{II}}{m_S \cdot u_I \cdot u_{II}}$		$x_{IIS} = \frac{m_{II} \cdot V \cdot u_I}{m_S \cdot u_I \cdot u_{II}}$

A limiting value for x_o divides the x_I - x_{II} plot into four regions :

1) $x_I > x_o$ and $x_{II} < x_o$ beam fragmentation region
2) $x_I < x_o$ and $x_{II} > x_o$ target fragmentation region
3) $x_I < x_o$ and $x_{II} < x_o$ non cumulative region
4) $x_I > x_o$ and $x_{II} > x_o$ undefined region

If we find at least two particles in the beam fragmentation region we consider them as a cluster in the given region. Similarly we define a cluster belonging to the target fragmentation region . We also take into consideration groups of particles in the non cumulative (3) and undefined (4) regions.

To separate clusters we suggest a method that can reveal multi-cluster events and, on the other hand, it doesn't exclude from the analysis the particles which are in the undefined region ($x_I > x_o$ and $x_{II} > x_o$); in our material the weight of such particles is significant.

- In our approach we define a cluster as a group of particles contained in a sphere with a given radius in b_{ik} space. As it was suggested in papers [6] we'll look for clusters with $< b_k > \cong 1$.

The clusters selection algorithm is quite simple. To construct a cluster we take every secondary particle and then attach to it all particles that satisfy the condition $b_{ik} < b_0$ where b_0 is the radius of the sphere in b_{ik} space. The clusters we have obtained in this way are not the final clusters, because they contain common tracks (the cluster containing the particles i and j appears twice). We must keep only one cluster from a group containing common tracks. The selection criterion is that the cluster containing the largest number of particles will be kept. After this last step the final clusters were obtained.

3 Some results on Mg - Mg

For the calculation of physical results, we used different programs to analyse experimental data:

ALFA1 - algorithm using the fragmentation regions of the primary particles
ALFA2 - program using our algorithm
ALFA3 - algorithm using minimization of the A_2 functional.

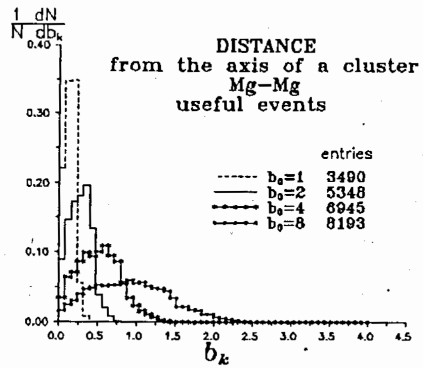

Fig.1

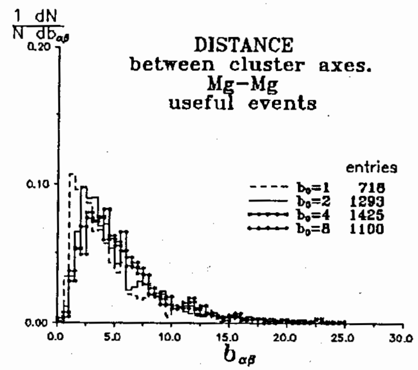

Fig.2

- Fig.1 presents distances (in b_{ik}) from the tracks to the axis of the cluster they belong to. b_0 is the cut parameter, which was used to construct the cluster. The legend indicates the numbers of entries to each histogramm. Fig.2 presents distances between clusters.

As we see average widths of the clusters are considerably less than the average distance between them. For b_0=4 only 5% of all clusters can't be distinguished one from another.

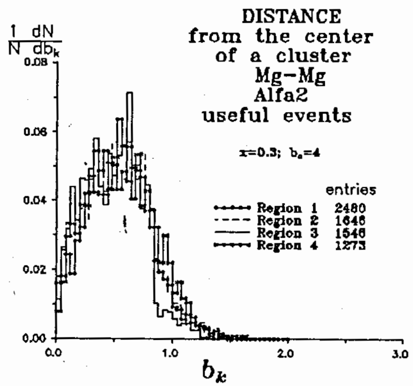

Fig.3

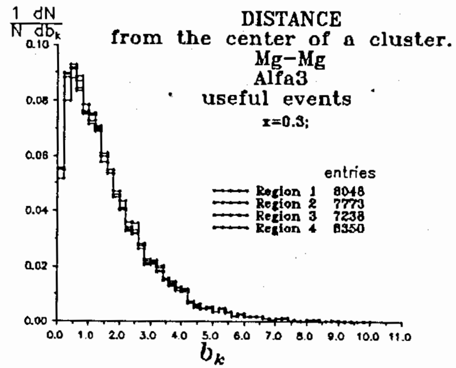

Fig.4

It is very interesting to compare the characteristic of clusters in different regions. For this purpose we have divided our data according to the cumulative numbers. In Fig.3 and Fig.4 b_k distribution of the clusters are given. They are obtained using programs ALFA2 and ALFA3.

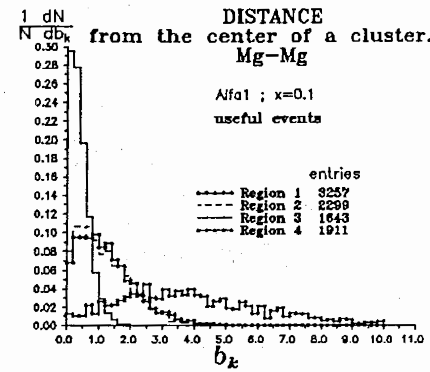

Fig.5

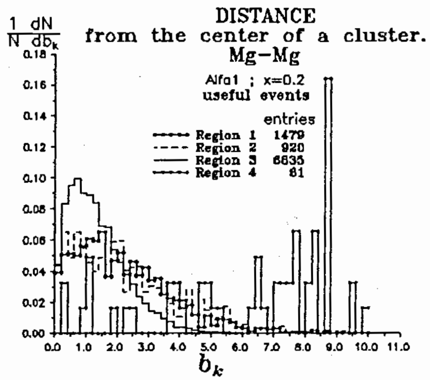

Fig.6

The results of the old definition (Alfa1 [1]) of the clusters are given in Fig.5 and Fig.6 for the same regions and different cumulative numbers x_0=0.1 and x_0=0.2.

In distinction to our definition (Alfa2) we see a clear difference in the b_k distribution for different regions. On the other hand, for the definitions Alfa1 and Alfa3 there is a difficulty connected with the nearness of b_k and $b_{\alpha\beta}$.

4 Combinatorial background

Description of the algorithm

The clusters we've got are supposed to be related to the nucleus- nucleus reaction mechanism. The particles belonging to the cluster go out of the event simultaneously. To estimate the background, we created a file in which events contain mixed tracks from different parts of the experimental data. The background file written in the same format as the data file could be run using the same programs. The first step in building the background file is to get a permutation of the numbers from 1 to N , where N is the full number of secondary particles (10606 for Mg-Mg and 30148 for π^-C). Using this permutation we build pseudo- events which contain tracks coming from different events.

The multiplicities of pseudo-events are identical to the multiplicities of real events. We checked that pseudo-events didn't contain tracks that come from one useful event accidentally. We verified our combinatorial background on general distributions (p,$p_\perp$, $p_\parallel$,θ, y) which must be the same as for useful events. These distributions are identical.

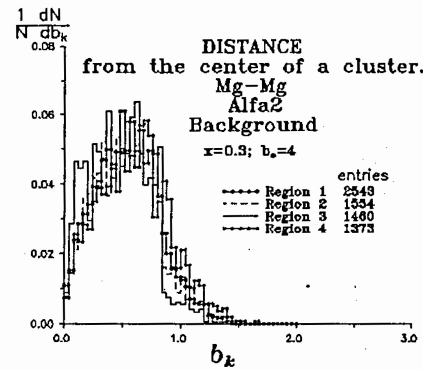

Fig.7

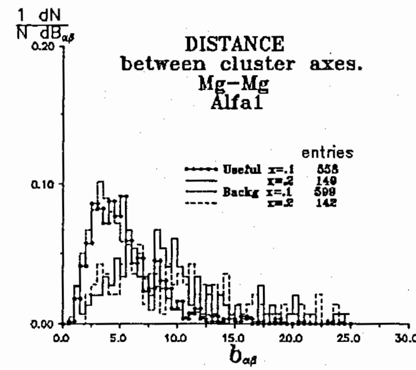

Fig.8

In Figs. 7,8,9 we have the b_k and $b_{\alpha\beta}$ distibutions for background material in Mg-Mg interactions. It is clearly seen that there is no differences between useful and background events. This conclusion doesn't depend on the program which we use to analyse the experimental data.

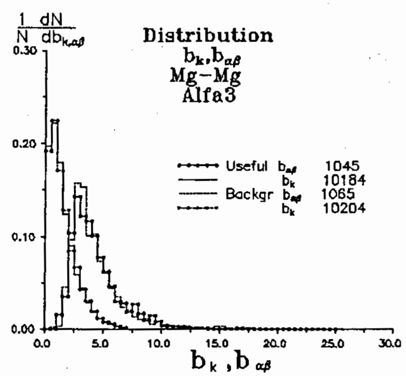

Fig.9

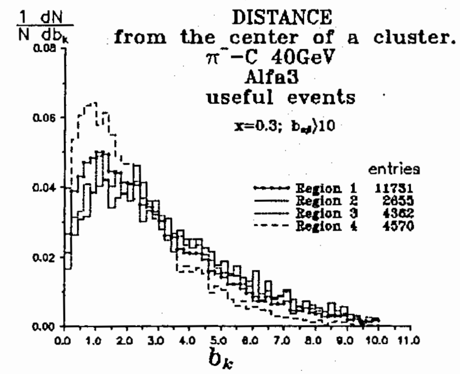

Fig.10

The same we can say about experimental material from π^{-}C interactions on E_{π}=40 GeV as it is seen from Figs. 10 and 11.

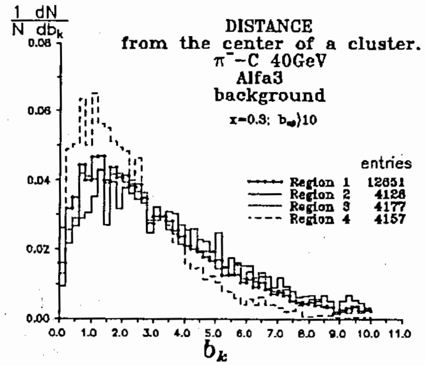

Fig.11

5 Conclusion

This paper is an analysis of the clusters obtained according to the algorithm that looks for close groups of tracks in b_{ik} space. The square distances inside jets and between jets - b_k and $b_{\alpha\beta}$ - show a clear division of secondary particles into distinct groups. The analysis has shown that the distributions for Mg-Mg interactions weakly depend on the chosen cumulative number. The comparison to the generated false events allows us to affirm that the distributions we studied characterize the reaction as a whole and for building jets it's necessary either to increase statistics or to study some other distributions.

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