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A Study of Events From Si^{28} With Emulsion at 4.5 A GeV/c Without Target Fragmentation

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Abstract

Atotal sample of 1000 inelastic interactions of Si^{28} in emulsion at 4.5 A GeV/c has been used characteristics of projectile fragments. This paper is therefore to devoted to the study of projectile fragments, with special attention to the class of events n_h=0, in which the traget nucleus is unwounded. This paper include the multiplicity distributinon and angular distributions of projectile fragments.

Key word: Multiplicity and angular distributions of projectile fragments.

Introduction

The nucleus-nucleus interactions are interesting because they provide information about the elemantary nucleon-nucleon process than do hadron nucleus coeffisions. In the collision of two nuclei, the elementary interaction is more amplified than in the case of hadron-nucleus interaction. At such high energy 4.5 GeV/nucleon the rapidity gap between the projectile and target fragmentation region is quite wide, which provides us with a good possibility for testing the limiting fragmentation hypothesis Ref. [1], [2] implying that no corelations exist between the projectile and target fragments. These results were obtained from the study of single particle inclusive experiments where the degree of traget fragmentation can take any value. It is interesting to compare these results with those of projectile fragments angular distributions from the special class of events n_h=0, where there is no traget fragmentation but only a projectile fragmentation. This paper is therefore devoted to the study of projectile fragments, with special attention to the class of events n_h=0 in which the target nucleus is unwounded.

Experiment

Stacks consisting of pellicles of Br-2 nuclear emulsions were exposed to a 4.5 A Gev/c for Si^{28} beam at the Dubna synchrophasotron (ussr).. The pellicles dimension is 10×20 cm×.06 cm (undeveloped emulsions pellicles). The intensity of irradiation was 10^4 particle/cm^2. along the track double scanning was carried out, fast in the forward and slow in the backward direction. A charged particle with charge Z_i, emitted at an angle $\Theta \leq 3^\circ$, with respect to the direction of the incident nucleus, and of momentum per nucleon nealy equal to that of the beam, is regarded as a projectile fragment of which did not interact with the target nucleus. The one-prong events with an emission angle of secondary particle track less than three degree and without visible tracks from excitation or disintegration of the target nucleus were excluded.

The secondary particles in each event are classified according to traditional emulsion terminology to:

(i) Black particle tracks (b), having ranges $\leq$ 3mm in emulsion which corresponds to a proton kinetic energy of $\leq$ 26 MeV. (ii) Grey particle tracks (g), having ranges greater than 3 mm and relative ionization I/I_o $\geq$1.4, where I_o is the ionization of a shower track in the narrow forward cone of an opening angle of $\leq 3\circ$. These tracks are mostly due to recoil target protons with kinetic energy in the range 26-400 MeV.

(iii) The b and/or g particle tracks are called heavy ionizing particle tracks (h) and their multiplicity is denoted by (n_h).

(iv) Shower particle tracks (s) with relative ionization I/$I_o \leq$ 1.4, corresponding to pion energies above 70 MeV and proton above energies 400 MeV.

To distinguish between the secondary particles and projectile fragment we introduce the following definations concering the charged fragments:

(1) Single charged projectile fragment are considered in the present work as all shower-particles tracks lying within the forward narrow cone arround the beam direction with an angle of emission $\Theta \leq 3^\circ$. (2) Double charged projectile fragment are those tracks with I/$I_o \simeq$4 and $\Theta \leq 3^\circ$, without charge in ionization over a length of at least 2 cm from the point of interaction. (3) The multicharged projectile fragment Z$\geq$3 are considered as those tracks with an emission angle $\Theta \leq 3^\circ$ and having I/$I_o \geq$6.

Their ionization should not be charged over at least 1 cm from the point of interaction. In each interaction the highest charge of projectile fragments is denoted by Z_{max} and the total charge of these fragments is denoted by $Z^\star$.

Multiplicity Distributions of Projectile Fragments

In this paper 1000 Si^{28} inelastic interactions with emulsion were measured; 885 events were observed to have emitted projectile fragments; i.e. 89%. This percentage is about two larger than the corresponding one in interaction of alpha-particle with emulsion [3] at the same energy per nucleon. The multiplicity distributions of the emitted charged projectile fragments are showen in figures 1(a,b,c) for a class of events without target fragmentation as well as for the total sample. It can be seen that there is no great difference between these distributions.

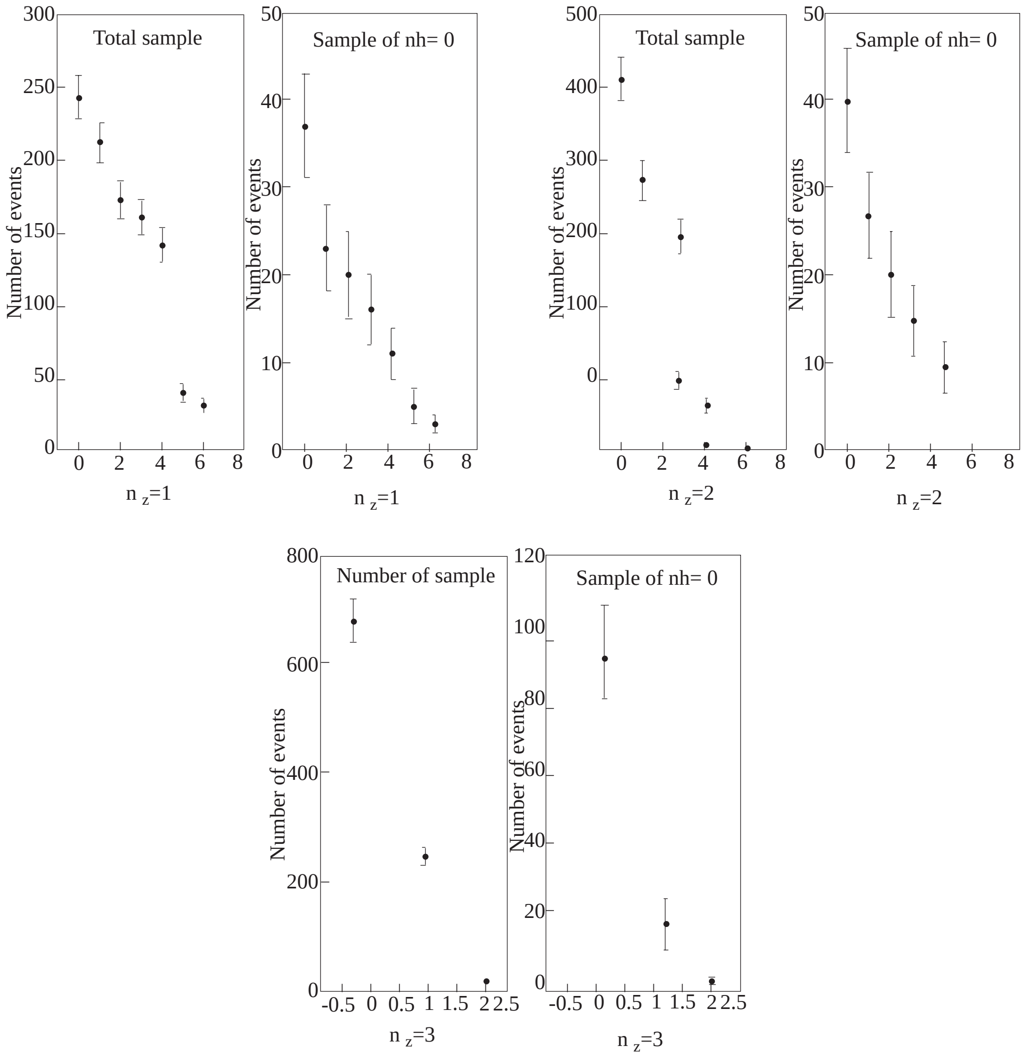

Figure 1. (a) The multiplicity distribution of charged projectile fragments n_z=1. (b) The multiplicity distribution of charged projectile fragments n_z=2. (c) The multiplicity distribution of charged projectile fragments n_z=3.

Angular Distributions of Projectile Fragments

Figure 2 represents the angular distributions (in terms of cos Θ, where Θ is the space angle between the emitted projectile fragments and the beam direction) for Z=1,2 an Z≥3 projectile fragments emitted from quasi-peripheral collision (total sample) as well as from peripheral collisions (events n_h=0), ıt can be seen clearly that the angular distributions of projectile fragments are independent of the number of traget fragments. The angular distribution of a charged projectiel fragment becomes narrower with the increase of fragment charge Z. In all these distributions there are pronounced peaks at cos Θ=1.

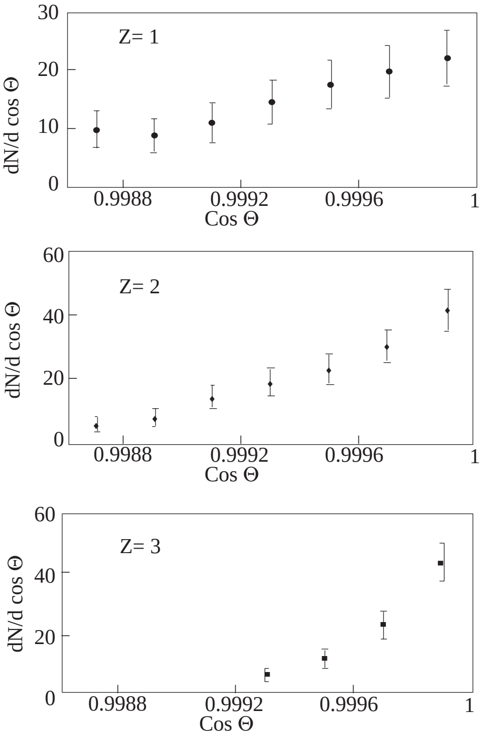

Figure 2. The angular distributions of Z=1(⊕), Z=2(△) and Z=3(⊓) for a class of events with n_h=0.

Topological Features of Events With Projectile Fragmentation Only (n_h=0.)

The motivation for choosing n_h=0 events for detailed study is to compare the angular distributions of the rapied projectile fragments with the results of the single particle inclusive data [4-6] where there were no restrictions on the fragmentation of the target. This comparison provides a more stringent test of the limiting fragmentation hypothesis.

In the 115 events satisfying the criterion n_h=0 from our sample of 1000 inelastic interactions, the projectile fragments are divided into Z=1,2,3,...,14. No experimental trail was made to separate isotopes of Z=1 fragments. In table 1 we explicity list all the reaction products observed in these 115 events which are orderd according to the value of $Z^\star$, the total charge of the emitted projectile fragments. It is to be kept in mind that neutrons and neutral pions may be emitted all these reactinos.

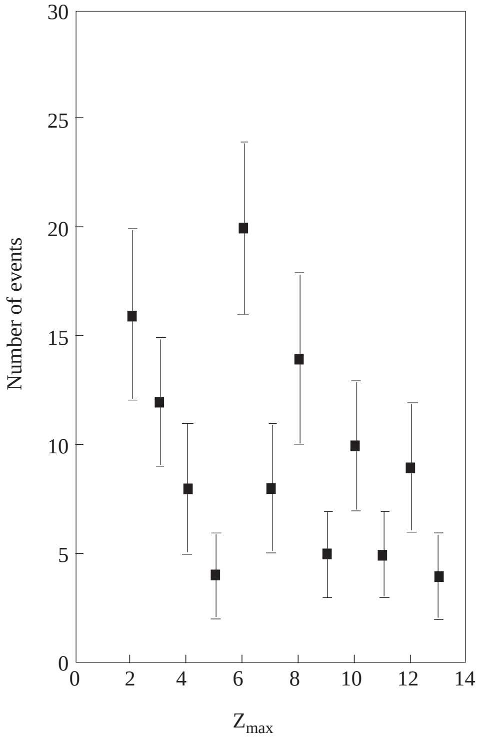

Figure 3. The production frequency of n_h=0 events as a function of Z_{max} the highest charge of projectile fragment in an event.

From table 1, we can extract various features of the fragmentation process. The production frequency of events in Si^{28}- emulsion interactions as a function of Z_{max}, the highest charged projectile fragment emitted in the interaction, is shown in figure 3. It should be noted that the fragmentation probability is higher for events with Z_{max}=2,6 and 8. This is interpreted as due to the structure of Si^{28} nucleus, which is an even-even nucleus of total spin I=0. This means that the nuclear structure of the projectile may play an important role in the fragmentation process. Table 2 gives the percentage frequencies of production of Z_{max}=1,2,3 and $\geq$ 4 in this class of events, n_h=0, from interactions of C^{12} with emulsion at 2.1 GeV/nucleon [7], 4.2 GeV/nucleon [8] and Si^{28} with emulsion at 4.5 GeV/nucleon [7], 4.2 GeV/nucleon [8] and Si^{28} with emulsion at 4.5 GeV/nucleon. The values in the first and second raws, within the large statistical errors, are in agreement, which indicates the energy independence of the distribution in the range of energy.

Table 1. Catalogue of the observed charged particles produced in 115 events of n_h=0, ordered according to the value of $Z^{\star}$.

$Z^{\star}$	Reaction Products	frequency	$Z^{\star}$	Reaction Products	Frequency	$Z^{\star}$	Reaction Products	Frequency
3	L_i	1	4	2H+He	1	5	H+2He	1
							He+Li	1
6	3He	2	7	2He+Li	1	8	2H+3He	3
	2Li	1		H+3He	1		6H+He	1
	H+He+Li	1		He+B	2		He+c	1
							He+2Li	1
9	H+4He	1	10	H+F	1	11	2H+3He+Li	1
	H+O	2		2H+4He	1		4H+N	1
	H+He+C	2		4H+3He	1		5H+C	1
	3H+3He	2		2He+C	1		H+2He+C	2
				5H+He+Li	1		2H+He+N	1
				H+He+N	1		H+He+O	1
				2H+He+C	1		Li+O	1
				Ne	2		3H+He+C	1
							H+5He	1
							Na	2
							3H+O	1
12	2H+3He+Be	2	13	He+Li+O	1	14	He+He+Na	1
	3H+3He+Li	2		3H+Li+O	1		4He+C	
	H+He+F	1		3H+Ne	2		2H+Mg	2
	2H+O	2		H+2He+O	1		He+Mg	2
	2H+2He+C	3		Li+Ne	1		4H+He+O	2
	H+2He+Li+Be	1		H+4He+Be	1		H+Al	1
	3H+F	1		3H+2He+C	1		5H+F	2
	4H+4He	1		Al	3		H+He+B+C	1
	He+Ne	2		2H+4He+Li	1		2He+Ne	2
	4H+2He+Be	1		4H+He+N	1		3H+Na	2
	4H+O	1					H+Li+Ne	1
	5H+Li+Be	1					4H+Li+N	1
							2H+3He+C	1
							3H+4He+Li	1
							6H+ZHe+Be	1
							3H+2He+N	1
							4H+2He+C	1
							2H+2He+O	2
							2H+4He+Be	1
							3H+He+Be+B	1
							5H+2He+B	1
							6H+He+C	1

Table 2. The production in percentage of events in emulsion as a function of Z_{max}, the highest charged projectile fragment produced in an interaction.

Projectile	Energy/nucleon	Z_{max}			
		1	2	3	≥4
C^{12}	2.1 GeV	7∓2	59∓10	8∓3	26∓12
C^{12}	4.2 GeV	13∓4	62∓9	15∓4	10∓3
Si^{28}	4.5 GeV	-	14∓4	10∓3	76∓9

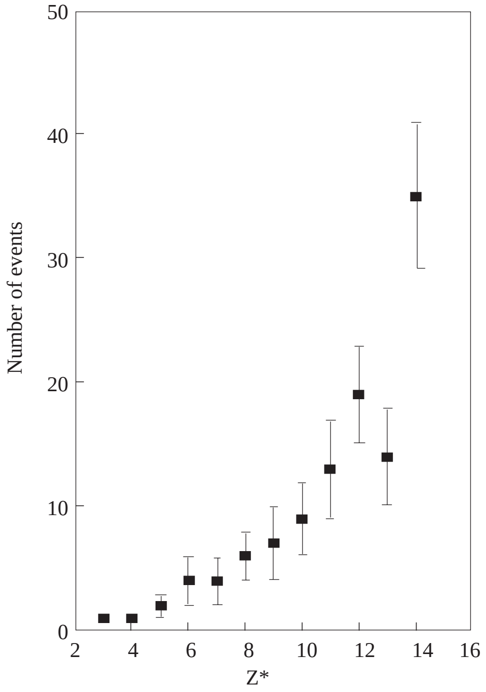

Figure 4. The production frequency of n_h=0 events as a function of $Z^\star$, the total charge of the emitted projectile fragment in an event.

Figure 4 represents the frequency distribution of $Z^\star$, the total charge of the emitted projectile fragments in an interaction for our sample of n_h=0 events. The distribution is smooth and the frequency increases with the value of $Z^\star$. The average value of $Z^\star$ equals (9.58$\mp$0.92), and the average number of produced charged pions in these events equals (3.76$\mp$0.42). In figure 5 the averge number of interacting projectile nucleons $< v >$=(2.33$\mp$0.38); thus the average number of produced charged pions per one interacting nucleon $< n_h > / < v >$=(1.61$\mp$0.34). This results provides evidence for the inchorent production model [9] in collision of two nuclei. Figure 5 illustrates the rapidity (η=-ln tan $\Theta/2$) distribution for all shower tracks (pions and hydrogen isotopes) emerged from events stars of n_h=0 in comparison with the corresponding distribution of shower tracks from central events, i.e., events with $Z^\star$=0. A pronounced rapidity gap is observed between the two distributions. The distribution of central events extends from the target fragmentation region no the projectiel fragmentation region due to the absence of spectator and the complete dominance of actors. The distribution from n_h=0 events is dominated by the projectile fragmentation region.

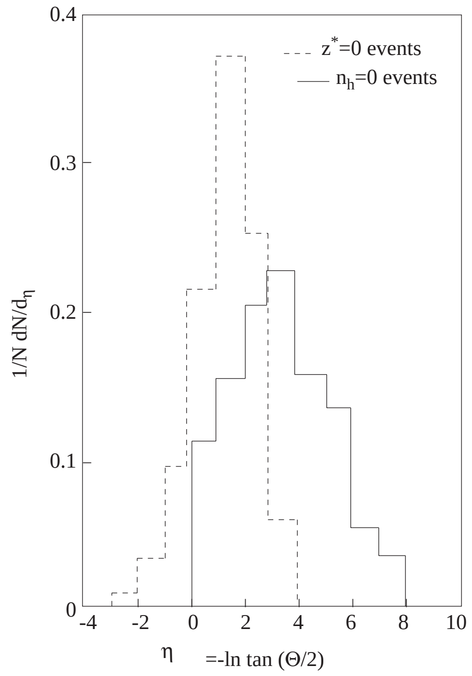

Figure 5. The rapidity ($\eta = -ln \tan \Theta/2$) distribution of shower tracks produced from events with n_h=0 and from centeral events $Z^{\star}$=0.

Conclusions

In 89% of the total inelastic events, at least one projectile charged fragment is observed to be emitted in a star. This percentage is about two times larger than the corresponding one in interactions for alpha-particle with emulsion at tha same energy per nucleon. The angular distributions of the projectile fragments are typically narrow with the increase of fragment charge Z. The fragmentation probability is higher for events with Z^{max}=2,6,8 and 10. This is interpreted as due to the structure of Si^{28} nucleus, which is an even-even nucleus of total spin I=0. This means that the nuclear structure of the projectile may play an important role in the fragmentation process. The average number of produced charged pions per interacting projectile nucleon is constant at different impact parameters and equals the corresponding value from elemantary interaction. This experimental fact supports the hypothesis of considering nucleus-nucleus interaction a super-position of nucleon-nucleus collisions. The rapidity distribution of shower tracks from n_h=0 events has its peak in the high rapidity region, i.e., the projectile fragmentation region, and it is separated by a measurable rapidity gap from the target to the limiting fragmentation hypothesis.

References

[1] A. El-Naghy: Frascati Report LNF-81/3 (1981), submitted to Nuovo Cimento.

[2] Bucharest-Dubna-Kosice-Leningrad-Moscow-Tashkent-Warsaw-Collaboration: Dubna preprints JINR, PI-687, JINR, PI-8313 (1974).

[3] G.M. Chernov, K.G. Gulamov, U.G. Gulyamov, S.Z. Nasyrov, L.N. Svechnikova: Nucl. Phys. A 280, 478 (1977).

[4] H.H. Heckman, D.E. Greiner, P.J. Lindstrom, F.S. Bieser, Phys. Rev. Lett. 28, 929 (1972).

[5] D.E. Greiner, P.J. Lindstrom, H.H. Heckman, B. Cork, F.S. Bieser, Phys. Rev. Lett. 35, 152 (1975).

[6] P.J. Lindstrom D.E. Greiner, H.H. Heckman, B. Cork, F.S. Bieser, Lawarence Berkeley Laboratory Report LBL-3650 (1975).

[7] H.H. Heckman, D.E. Greiner, P.J. Lindstrom, and H. Shwe, Phys. Rev. C17, 5 (1978) 1735.