CHARACTERISTICS OF CENTRAL COLLISION EVENTS IN FE-NUCLEUS INTERACTIONS FROM 20 TO 60 GEV/NUCLEON

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ABSTRACT

Fe nucleus interactions with per-nucleon energies 20 to 60 GeV in JACEE-3 seem to suggest the existence of compression and of collective flow in nuclear matter.

1. Introduction

A counter-emulsion hybrid chamber in JACEE-3[1] was flown on a balloon at the altitude (5.4 g/cm^2) in 1982 with objective of probing the heavy nuclear collisions above 20 GeV per nucleon. In the energy region, it is suggested that nucleus-nucleus collisions provide dense collision complex through compression and secondary particle production[2]. In the lower energy region, an evidence of collective flow has been reported[3]. And also, at higher energy region, it has been argued that nucleus has rather large stopping power[4]. In this paper, the high multiplicity characteristics of Fe-nucleus central collisions with energies 20 to 60 GeV/nucleon will be presented. This is considered to be relevant to compressibility and collective flow of nuclear matter.

2. Results and Discussions

In the energy region 20 to 60 GeV/nucleon, events induced by nuclei with primary charge around Z=26 have been sampled and analyzed selectively. Inclusive characteristics will be described separately elsewhere[5]. Multiplicity (Nsh) in forward cone is given by number of secondary produced charged tracks in forward hemisphere, $\sum_{\theta_i<\theta_h} Z_i - Z_p$, where θ_h is half angle defined by $\tan \theta h = 2m/(m(m+Ec))^{1/2}$.

The scattering plot between multiplicity and incident energy/nucleon is shown in Fig. 1. Average values of multiplicity in Fe-CHO collisions are represented by crosses. These values are consistent with factor 8.8 times of average forward multiplicities in proton-proton collisions as presented by a dotted curve in the figure.

The high multiplicity events of Fe-nucleus collisions are summarized in Table 1.

Table 1

List of High Multiplicity Events

Event	Nsh	Ec	Zp	Mode	Non-sp	dN/dy	aF
< CHO Target >							
#6- 869	101	55.	Fe	128ch+3He	37	40.	0.9
#5- 393	60	45.	Cr	108ch+ He+Be	33	35.	1.3
#1-1214	57	28.	Fe	104ch+ He	41	40.	1.2
#5-1834	55	37.	Cr	87ch+2He	37	35.	1.8
#6-1596	51	51.	Fe	90ch+2He	41	25.	1.0
#7-1357	51	46.	Ti	73ch+2He	37	35.	1.1
#2- 191	46	40.	Fe	84ch+5He	24	30.	1.2
#5-1215	40	22.	Fe	75ch+ He	43	25.	1.2
#7-1689	36	55.	Fe	56ch+ He+N+Li	17	25.	1.3
#6-1114	36	30.	Cr	58ch+ He	30	25.	1.9
#6-1409	35	58.	Fe	59ch+2He+O	15	25.	1.3
#5- 607	34	22.	Fe	57ch+ He+B	26	25.	2.0
#6- 141	34	22.	Fe	62ch+3He	44	25.	1.5
#4- 876	34	35.	Fe	66ch+ Be	37	20.	1.0
#6- 733	35	30.	Cr	62ch+2He+Li	28	20.	.
#2- 497	30	38.	Ti	53ch+3He	26	15.	1.0
< Pb Target >							
#7- 642	134	41.	Ti	267ch	48	125.	2.0
#8- 378	105	33.	Fe	160ch	54	100.	2.0
#1-1542	93	51.	Fe	123ch+ He	43	50.	1.3
#6-1927	82	24.	Fe	164ch	56	60.	1.8
#4-2006	52	25.	Cr	90ch+3He+Li	30	50.	2.0
#1- 308	41	34.	Fe	68ch+3He	28	25.	1.3
#4- 400	36	48.	Cr	56ch+5He	15	20.	1.3
< AgBr Target >							
#4- 749	150	26.	Ti	265ch	48	95.	1.8
#8-1063	38	23.	Fe	77ch+ He+Si	38	25.	1.8
#1-1004	39	27.	Fe	70ch+ He+C	24	25.	1.4

Notes : Ec:primary energy(GeV/nucleon), Zp:incident charge
Non-sp:number of non-spectator nucleons
dN/dy:max of rapidity density, aF:slope of F-plot;
$F/(1-F)=(\tan(\theta))^{aF}$

In Fig. 2, pseudo-rapidity distributions of Ti(41 GeV/nucleon)/Pb and Ti(26 GeV/nucleon)/Em are shown. In the figure, curves are calculations of multi-chain model(MCM)[6]. Both events have more tracks in the central region in comparison with the model calculation. The forward multiplicity (Nsh) of these events are 134 and 150,

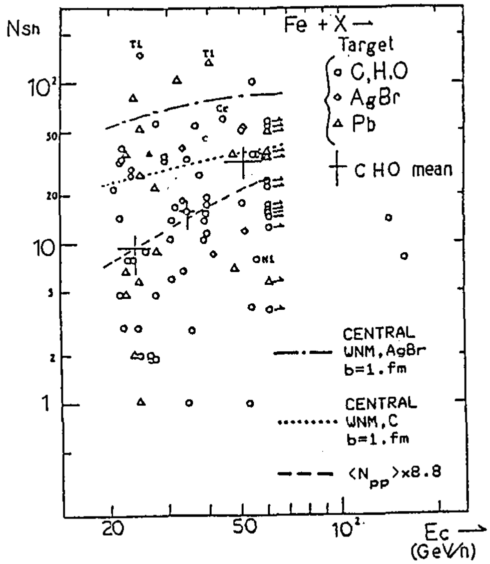

Fig. 1
Scatter Plots between Energy (Ec GeV/n) and Multiplicity (Nsh)

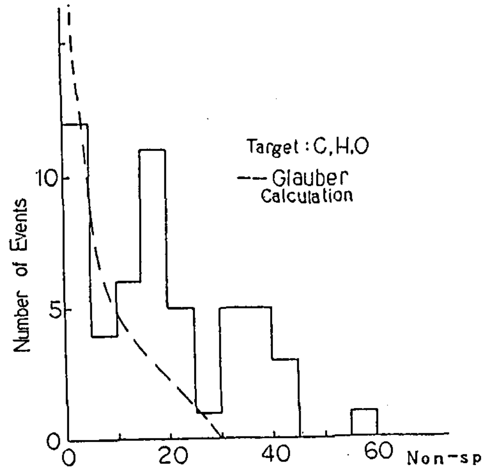

Fig. 3
Number Distribution of Non-spectator Nucleons

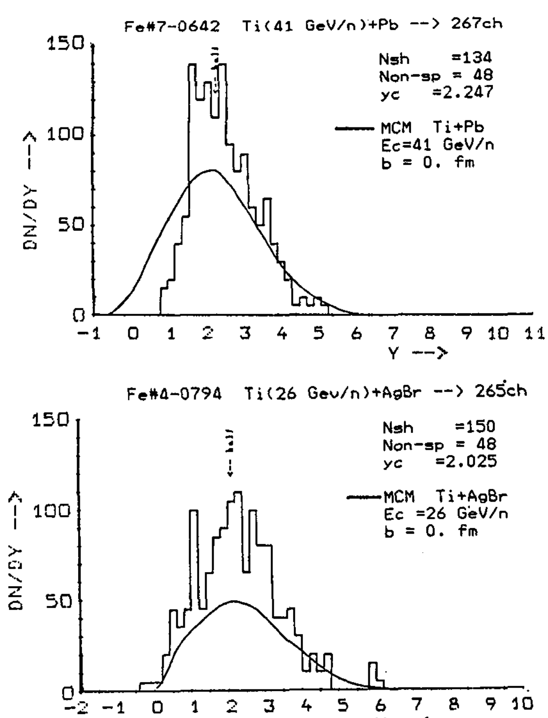

Fig. 2
Pseudo Rapidity Distributions of High Multiplicity Events

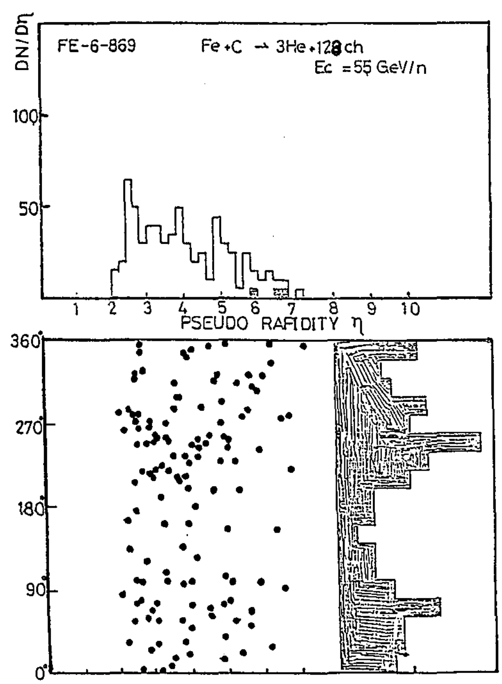

Fig. 4
Azimuth Angle and Pseudo Rapidity

respectively, which are three standard deviation from average value. The maximum heights of pseudo-rapidity densities are 125 and 95, respectively. These values are comparable with the maximum height in high multiplicity events above TeV /nucleon region[7].

In the iron collisions with CHO-target, number of spectator protons was obtained by comsecutively adding all relativistic singly charged tracks starting with the most forward until mean value of tan θi coincides with that of evapolation formula of Goldhaber[8] boosted by projectile velocity (evapolation temperature was assumed as 10 MeV). Number of non-spectator projectile protons (which may or may not be 'wounded') are defined by Zp (projectile charge)-ΣZf(fragment)-Nsp(number of spectator protons). The number of non-spectator nucleon (Non-sp) is estimated by (Zp - ΣZf - Nsp) x Ap/Zp, where Ap is mass number of projectile. The distribution of the non-spectator nucleon number(Non-sp) is shown in Fig. 3. The curve in the figure is a calculation of Glauber's model[9]. Thus, we find a lump of events (12 events) in the region 25 < Non-sp < 56. We can define such events as central collisions. Six events of them have more tracks at the central region in comparison with multi-chain model assuming head on collision. This feature may be interesting in connection with the stopping power problem[4].

One of them, event Fe(55 GeV/nucleon)/CHO has very large multiplicity and dipole type azimuthal distribution as shown in Fig. 4. And also the slope of F-plot in this event is 0.9. The existence of such event is considered to be suggestive for collectiveness of nucleus-nucleus collision in the energy region. However, high multiplicity events Ti(41 GeV/nucleon)/Pb and Ti(26 GeV/nucleon)/Em show isotropical distributions of azimuthal angles and their slopes of F-plot are 2.0 and 1.8, respectively.

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