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LETTER TO THE EDITOR

EVIDENCE OF BIMODAL PION MULTIPLICITY DISTRIBUTION IN »COLD« EVENTS PRODUCED IN SYMMETRIC HEAVY ION COLLISION AT 4.5 A GeV/c

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The letter presents a study of the multiplicity distribution of the secondary particles (pions) produced in those events where the temperature of the fragmentation region of the projectile alpha particles is 10 MeV in the ^{12}C-emulsion interaction at 4.5 GeV/c per nucleon. This 10 MeV temperature was obtained by comparing the transverse momentum distribution of the projectile alpha particles with double Maxwell-Boltzmann distribution. It was found that the two temperatures (10 MeV and 40 MeV) belonged to different events having different reaction mechanisms and the events having 10 MeV temperature were classified as QGP events. The multiplicity distribution of the pions from the events having 10 MeV temperature in their fragmentation region (cold events) shows two peaks thereby depicting a bimodal process.

Quantum chromodynamics (QCD) predicts that strongly interacting matter will form a weakly interacting plasma of unconfined quarks and gluons at high temperatures or high baryon densities. Though it is said that this prediction will be tested in ultrarelativistic nucleus-nucleus collision[1)] still some authors argue that phase transition to a quark-gluon plasma might occur even at moderately incident energies (2—10 GeV)[2)]. Gyulassi[3)] made a more differential study of compression and energy deposition in the nuclear fireballs and stated that since nuclear transparency increases with energy, it is conceivable that maximum energy deposition and maximum compression in the nuclear fireballs would occur at rather moderate incident energies.

Till now a lot of conjectures relating to the signals of quark matter formation have been brought forward which include: a) photon and lepton pair yields, b) abundance ratios of final hadrons, c) multiplicity distributions and d) high transverse momentum fragments, but the main theme that seemed to emerge is that no single observable would suffice to prove the existence of a plasma state[4]. Most likely a large variety of circumstantial evidence will have to be accumulated in searching this phase. One such evidence has been provided by Raha et al.[5] in relativistic heavy ion collision in terms of emission spectra in the fragmentation region on the basis of participant-spectator concept[6]. According to them, during the separation of the spectator from the participants due to excitation, there is some intercommunication, which results in the excitation of the spectators. This communication strongly depends whether or not the participants form a quark gluon plasma. Therefore the energy imparted in terms of temperature to the spectator may carry characteristic information about the formation of a quark gluon plasma in the participant region: so the observation of two distinctly different temperature in the fragmentation region with a ratio of four among them may be interpreted as a possible signal for the production of a quark gluon plasma. This ratio of four among them would imply a decrease in the effective friction coefficient of an order of magnitude in agreement with their model speculations based on hydrodynamical viewpoint for the formation of quark gluon plasma phase. Therefore to have an idea about the fragmentation mechanisms, it is required to study the relativistic alpha particles which are expected to be emitted due to the fragmentation process of a projectile or a projectile spectator, according to the participant-spectator concept[6].

Our earlier work with relativistic alpha particles[7] (emitted as projectile fragments in the ^{12}C-emulsion interaction at 4.5 GeV/c per nucleon) has revealed that the projectile fragmentation region is characterised by two distinctly different temperatures viz., 10 MeV and 40 MeV with differing reaction mechanisms, i. e., there exists two different class of events with these two temperatures. According to the model of Raha et al.[5] the 10 MeV temperature belongs to the events where a quark gluon plasma is formed in the participant region; therefore we call them as QGP events.

Here in this letter we have observed the multiplicity distribution of the show for those 60% events which have a temperature of 10 MeV in the fragmentation region for the ^{12}C-emulsion interaction at 4.5 GeV/c per nucleon and compared the total multiplicity distribution for all events. The result shows some interesting features such as the appearance of two peaks in the multiplicity distribution of the special events and the violation of KNO scaling.

Stacks of NIKFI-Br2 emulsion plates of dimensions 10 cm $\times$ 20 cm $\times$ 100 μm with printed grid was exposed to ^{12}C beam of 4.5 A GeV/c at Dubna Synchrophasotron. In all 1200 ^{12}C events were measured without any discrimination. The scanning of the plates was done using Leitz Ortholux microscopes using 100$\times$ objective and 20$\times$ occular. All charged secondaries in these events were classified in accordance with the conventional emulsion terminology into the following types:

a) black (B) particles with a range $l < 3$ mm,

b) grey (G) particles with $l > 3$ mm and ionization $g > 1.4g°$ where $g°$ is the plateau grain density for singly charged particles, except the particles of type (d),

(c) relativistic (S) particles with $g < g^{\circ}$,

(d) doubly charged fragments of the projectile with a constant $g \approx 4 g^{\circ}$ along the track length of 2 cm ionisation and $\Theta < 5^{\circ}$ (Θ is the emission angle in the laboratory frame).

Great care was taken in the identification of relativistic alpha particles and the contamination with singly charged particles was minimum.

In our earlier work[7] the transverse momentum distribution (P_T) of the projectile alpha particles were done utilising the formula

$$P_T = A \cdot m_0 \left(\sqrt{\gamma^2 - 1}\right) \sin \Theta$$

where A is the atomic number, m_0 the nucleon rest mass, γ the Lorentz factor of the projectile and Θ is the spatial emission angle in the laboratory frame. It was then compared with the double Maxwell-Boltzmann distribution, since a single Maxwell-Boltzmann distribution cannot fit the peak and the tail part simultaneously. This revealed two temperatures (40 MeV and 10 MeV) a hot and a cold. It was shown that the events fall into two distinctly different classes with different reaction mechanisms. Also it was found that 60% (725) of the total events (1200) belong to cold group with a temperature of 10 MeV in the fragmentation region. Fig. 1 shows the multiplicity distribution of the shower particles for the cold events. The distribution shows two peaks in the region of 3—4 and 8—9. This bimodal distribution might reflect two type of production mechanism or process in the case of cold events. The experimental points in the distribution do not lie on the universal curve which can be fitted with a KNO type scaling function as shown by Slattery[8]

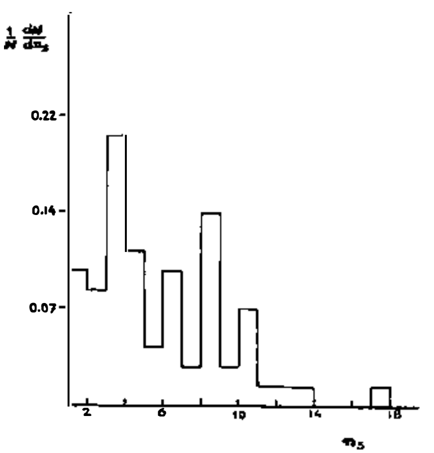

Fig. 1. Multiplicity distribution of the cold events showing two peaks.

$$\psi(z) = (3.79z + 33.7z^3 - 6.64z^5 + 0.332z^7) \exp(-3.94z).$$

It is interesting to see that the total multiplicity distribution of all the events showed a KNO type scaling behaviour[9].

Finally we can conclude that particle production process in case of so called cold events appears to be entirely different from the normal events[9] and the serious investigation of the process responsible is required.

References

1) K. Kajantie, Proceedings of the Bilefeld Workshop *Quark Matter and Heavy Ion Collision*, eds. M. Jacob. and H. Satz. (1982), p. 39;
G. Byam, ibid., p. 349;
2) L. Van Hove, ibid., p. 349;
J. J. Molitoris and H. Stocker, *Proc. Seventh High Energy Heavy Ion Study*, G S I Darmstadt (F. R. G.) 1984, p. 197;
3) M. Gyulassy, ibid., p. 435 and 81;
4) M. Gyulassy, ibid., p. 435;
5) S. Raha, R. M. Wheeler and R. M. Weiner, Phys. Rev. Lett. **53** (1984) 138;
6) J. D. Bowman, W. J. Swiatecki and C. F. Tasan, Lawrence Barkeley Laboratory Report LBL 2908 (1973);
7) D. Ghosh, J. Roy and R. Sengupta, J. Phys. G (1988) in press;
8) P. Slattery, Phys. Rev. Lett. **29** (1972) 1624;

8) P. Slattery,:Phys. Rev. Lett. **29** (1972) 1624;
9) D. Ghosh, J. Roy and R. Sengupta, Nucl. Phys. **A468** (1987) 719.

EVIDENCIJA BIMODALNE RASPODJELE PIONA U »HLADNIM« DOGAĐAJIMA PROIZVEDENIM U SIMETRIČNOM SUDARU TEŠKIH IONA KOD 4,5 A GeV/c

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Ovo pismo prikazuje studij raspodjele multipliciteta sekundarnih čestica (piona) u interakciji ^{12}C s emulzijom pri 4,5 GeV/c po nukleonu, koji su proizvedeni u događajima gdje je temperatura područja fragmentacije projektila alfa čestica 10 MeV. Ova temperatura od 10 MeV dobivena je usporedbom transverzalne raspodjele impulsa projektilnih alfa čestica s dvostrukom Maxwell-Boltzmannovom raspodjelom. Nađeno je da dvije temperature (10 MeV i 40 MeV) pripadaju različitim događajima koji imaju različiti mehanizam reakcije. Događaji s temperaturom 10 MeV klasificirani su kao QGP događaji. Raspodjela multipliciteta piona u događajima s temperaturom od 10 MeV u području fragmentacije (hladni događaji) pokazuje dva vrha ukazujući na bimodalni proces.