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E735

# Mass Identified Particle Production and Bose Einstein Correlations at 1800 GeV

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## Disclaimer

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**Abstract**

Results were shown on transverse momentum distributions of $\pi$, k and p from Fermilab experiment E735. This experiment, related to the search for quark gluon plasma, was run at the Fermilab Tevatron collider with $\bar{p}p$ collisions at $\sqrt{s} = 1800$ GeV. Dependence of particle ratios on transverse momentum and center of mass energies was shown. Results were also shown on Bose Einstein correlations between pairs of identical pions and a measure of size and lifetime of the source.

## 1 Introduction

The physics goal for experiment E735 was to study the properties of hadrons in high multiplicity events and search for a quark gluon plasma phase. The chief measurements made in this experiment were the total multiplicity of events, the momentum spectra of centrally produced particles and the identification of these particles. The apparatus and various details of performance have been reported elsewhere[1],[2],[3], [4]. This experiment collected 15 million events in the 1988-89 run. After background subtraction and track quality cuts 4.2 million events remained. Most of the data was taken at $\sqrt{s} = 1800$ GeV, but some data was taken at lower energies to make comparison w.r.t. increasing center of mass energies.

## 2 Mass identified particle properties

From the measured mass-squared ($M^2$) distributions, the individual $\pi^{\pm}$, $K^{\pm}$ and p/$\bar{p}$ contributions have been extracted. These quantities have been determined as a function of $p_t$ for several $p_t$ intervals.

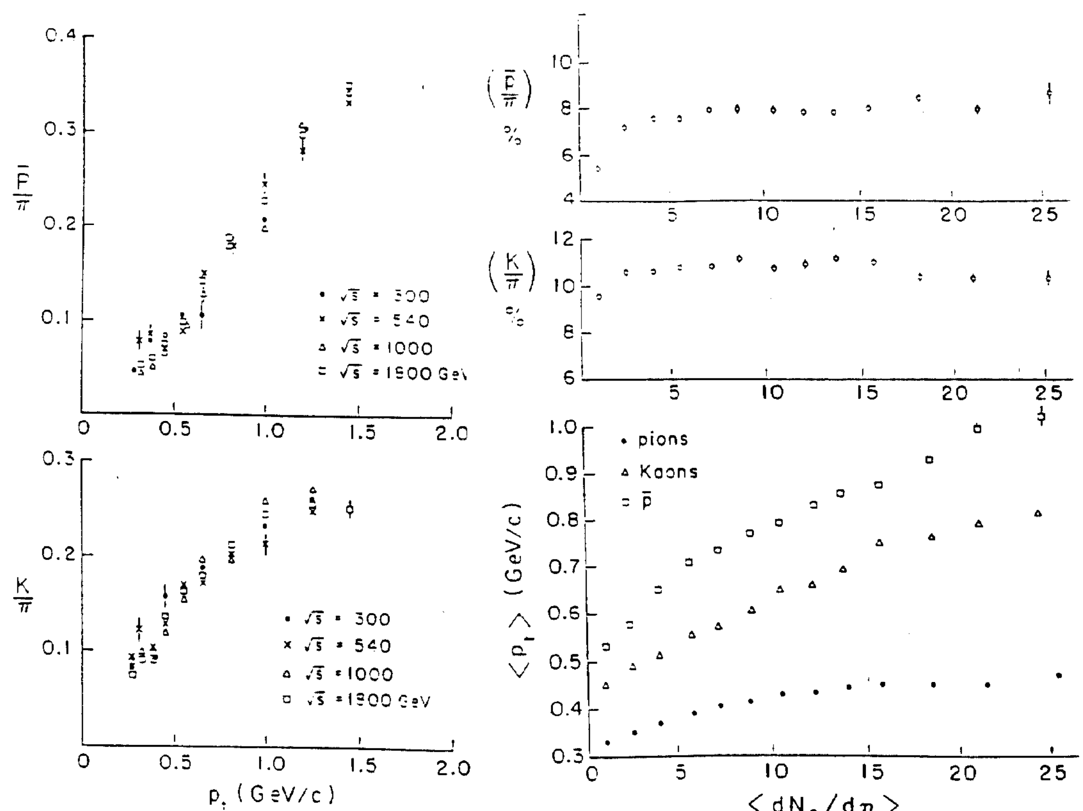


**Figure 1: a) The ratios of $\bar{p}/\pi$ and $K/\pi$ as a function of $p_t$ for four center of mass energies (300, 540, 1000 and 1800 GeV) b) Average transverse momentum $< p_t >$ and $K/\pi$ and $\bar{p}/\pi$ ratios as a function of charged particle density $dN_c/d\eta$**

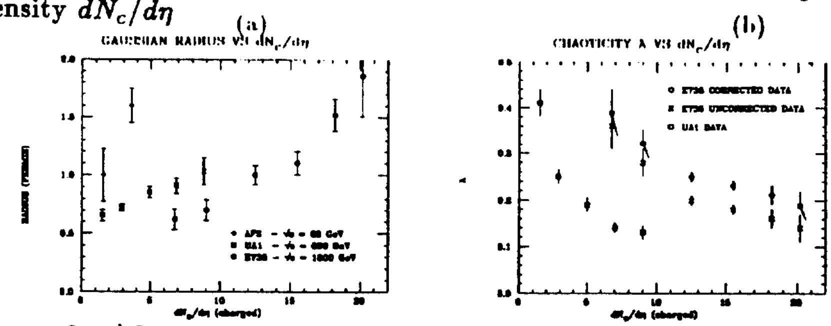


Figure 2: a) Interaction radius vs. $dN_c/d\eta$, charged particle multiplicity per unit pseudorapidity b) Chaoticity factor $\lambda$ as a function of $dN_c/d\eta$

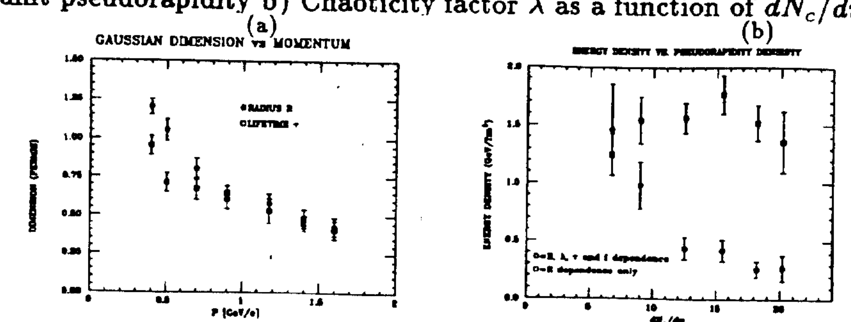


Figure 3: a) Interaction radius and lifetime as a function of the total momentum of the pion pair b) Open squares are estimates of energy density of R, without taking into account pahase correlated pion pairs

### 2.1 *Energy dependence*

The invariant distributions $d^2N/(dydp_t^2)$ as a function of $p_t$ for K and p̄ can be fitted by the form $ae^{-\alpha p_t}$. The pion data has to be fitted with $b(p_t + p_0)^{-n}$[5], with $p_0 = 1.0$ GeV/c. Integrating these expressions from 0 to $\infty$ we get $< p_t >= 2/\alpha$, $N = a/(\alpha^2)$ and $< p_t >= 2p_0/(n-3)$, $N = bp_0^{2-n}/[(n-1)(n-2)]$ for exponential and power law functions respectively. Values of a, $\alpha$, b and n are obtained from the fits and $< p_t >$ and N can be determined from the above expressions. $< p_t >$ increase linearly with $ln(\sqrt{s})$ for the pions and increases at a faster rate for K and p̄, i.e. the rate of increase is larger for particles with larger mass. The particle ratios (k/$\pi$ and p̄/$\pi$) show a definite increase from the ISR to the Tevatron energy regime. It is not possible to conclude however, whether the ratios have attained constant values at the Tevatron energies. Fig. 1 shows the data for the particle ratios as a function of $p_t$. No definite energy dependence is observed in this figure. k/$\pi$ ratio shows a trend of flattening out at a value of $\sim$0.25 for $< p_t >$=0.9 GeV/c.

### 2.2 *Multiplicity dependence*

Dependence of $< p_t >$ and particle ratios on charged particle multiplicity density $dN_c/d\eta$ was studied. $dN_c/d\eta$ is obtained by dividing $N_c$, the number of charged particles measured by the multiplicity hodoscope in an event by 6.5, the pseudorapidity interval accepted by the hodoscope. Using the method described earlier, $< p_t >$ and particle ratios for the $p_t$ interval $0.0 < p_t < \infty$ were calculated for events with different $dN_c/d\eta$. Fig. 2 shows variations of $< p_t >$ and particle ratios w.r.t. $dN_c/d\eta$. The rate of increase of $< p_t >$ with $dN_c/d\eta$ depends on the mass of the particle.

## 3 *Bose Einstein Correlations*

E735 obtained a large pion sample, 0.52 million $\pi^+$ pairs and 0.40 million $\pi^-$ pairs. Assuming a symmetrized free particle wave function for two pions with Gaussion source density, the two particle correlation function is, $C_2 = 1 + \lambda e^{-|\vec{q}|^2 R^2 - q_0{}^2 \tau^2}$, Here $\vec{q} = \vec{q_t} + \vec{q_l}$ is the momentum difference and $q_0$ is the energy difference of the pion pair in the lab. $\vec{q_t}$ and $\vec{q_l}$ are the transverse and longitudinal components of $\vec{q}$ w.r.t. $\vec{p} = \vec{p_1} + \vec{p_2}$, momentum of the pair. $\lambda$ is the chaoticity parameter. Experimental two pion correlation function is calculated by[8]

$$C_2 = \frac{like - charged - pairs - same - event}{like - charged - pairs - different - events}$$

By fitting this value of $C_2$ with the functional form of $C_2$ given above, R is found. To get a resonable sample size, the pion pairs are required to have $q_0 < 0.2GeV$ (instead of $q_0 = 0.0$). To keep the sample bias free, the two pion tracks were required to have an opening angle $> 12^0$.

Dimension R of the source along the beam and the dimension $\tau$ in the transverse direction increase with increase in pseudorapidity density $dN_c/d\eta$. $\tau$ tends to saturate at higher values of $dN_c/d\eta$. Value of the chaoticity parameter $\lambda$ decreases with increasing $dN_c/d\eta$ for our limited aperture. These are plotted in Fig. 3a,b There is a difference between the E735 and UA1 data point at the same value of $dN_c/d\eta$. This is mainly because of the different pseudorapidity ranges covered by the two experiments and the analysis cuts[9]. The source dimensions are seen to decrease with increasing pair momentum (Fig. 4a). This could mean that pions are emitted from an expanding spherical shell. Fig. 4b shows the variation of the energy density of the source with $dN_c/d\eta$. Energy density is seen to remain constant for increasing values of pseudorapidity density.

## 4 summary

The $< p_t >$ dependence on charged particle density $dN_c/d\eta$ was studied. E735 could go to a high value of $dN_c/d\eta$ (=25). The characteristic that the rate of increase of $< p_t >$ with $dN_c/d\eta$ increases with the mass of the particle can be explained by the minijet model.[6] Also, this effect has been explained by the presence of transverse flow of hadronic matter and might be indicative of the formation of quark gluon plasma.[7] E735 also studied the characteristics of the source using Bose Einstein correlations. the transverse and longitudinal dimensions R, $\tau$ increase with multiplicity density and the chaoticity parameter $\lambda$ decreases. Energy density of the source remains constant with changing $dN_c/d\eta$.

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