Estimation of initial temperature of high multiplicity pp event at 7 TeV in the light of Color String Percolation Model (CSPM)

Pranjal Sarma
Department of Physics,
Gauhati University

With
Nur Hussain (GU), B. Bhattacharjee (GU),
B.K. Srivastava (Purdue University)

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Outline

- Introduction
- Physics Motivation: Temperature estimation using Color String Percolation Model (CSPM)
- Analysis details
- Results
  - >> Determination of color suppression factor F(ξ)
- Summary and outlook

Introduction

- The main goal of relativistic heavy ion collision is to study the de-confined matter, called Quark Gluon Plasma (QGP)

- Percolation theory can be used to describe the transtition from hadronic to QGP state[1].

- Several objects can form a cluster of communication.

- At a certain density of the object a spanning cluster appears, which marks percolation phase transition.

- This is defined by percoaltion density parameter.

[1] T. Celik, F. Karsch, H, Satz, Phys. Lett. B (1980) 128

Color string percolation model (CSPM)

- The CSPM describes the initial collision of two nucleon in terms of color string stretched between the projectile and the target.

- In the transverse plane, the color string may be viewed as a small disk filled with the color field created by the colliding partons (Fig.1).

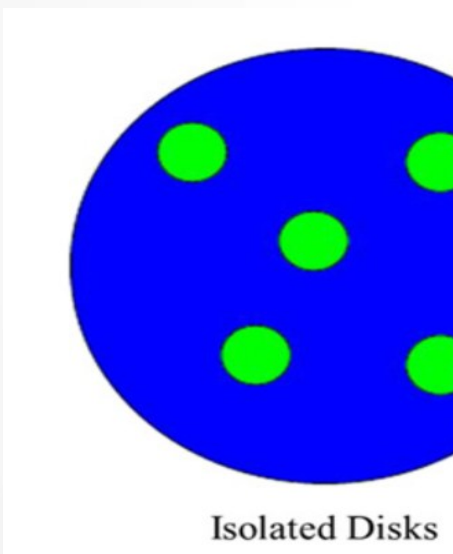


Fig.1

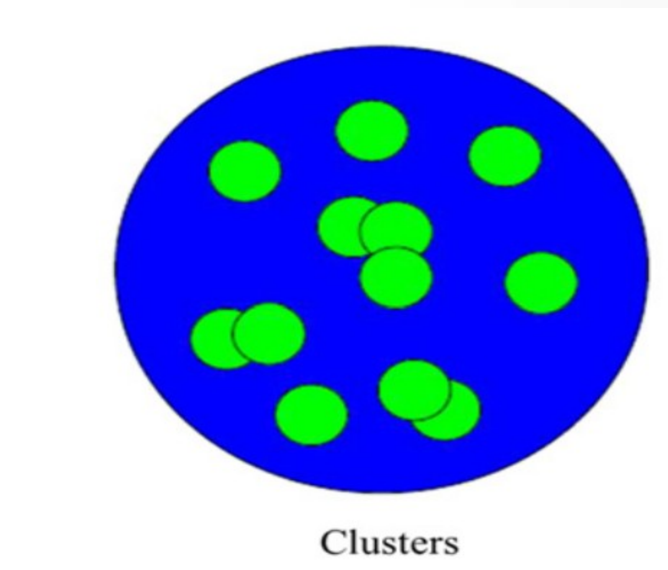


Fig.2

- With the growing energy and size, the number of string grows and start to overlap to form clusters (Fig.2).

- At a certain critical density, a macroscopic cluster appears that marks the percolation phase transition (Fig.3).

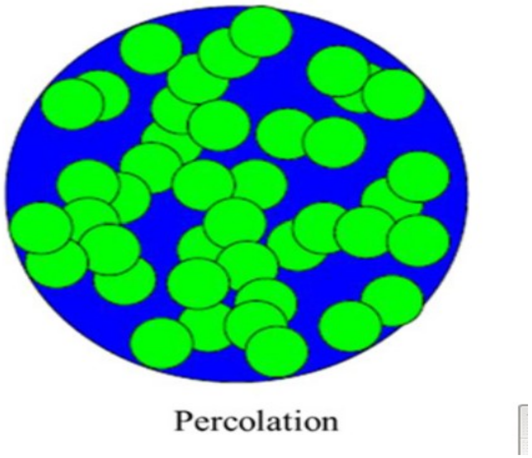


Fig.3

- The onset of percolation is given by the percolation density (ξ) parameter,

$$\xi = \frac{NS_1}{S}$$

Where N = number of stringed formed in the collision,

S_1 = transverse area of a single string,

S = transverse nuclear overlap area.

- Cluster of n strings behaves as a single stirgs with energy momentum that corresponds to the sum of the energy momentum of the overlapping strings.

- The color charge (Q_n) of such strings, which cover the same area S_n as the area of single string S_1 is

$$Q_n^2 = nQ_1^2 => Q_n = \sqrt{n}Q_1$$

which reduces the color charge by factor a of √n

- In general, $S_n > S_1$ hence the reduction factor becomes $\sqrt{\frac{nS_n}{S_1}}$

- In the framework of SM for color fileld, the multiplicity (μ_n) is proportional to color charge (Q_n) hence,

$$\mu_n = \sqrt{\frac{nS_n}{S_1}}\mu_1$$

- The average transverse momentum squared ($<p^2_T>$) is proportional to the string tension (σ_n). Again,

$$Q_n \sim S_n \sigma n$$

- Thus the transverse momentum squared ($<p^2_T>$) produced by cluster of n strings having single string transverse momentum squared $<p^2_T>_1$ is,

$$<p_T^2> = \sqrt{\frac{nS_1}{S_n}} <p_T^2>_1$$

- At high string density,

$$< \frac{nS_1}{S_n} >= \frac{1}{F(\xi)^2}$$

Where F(ξ), is the color suppresion factor (due to ovelapping of the strings) and is given by,

$$F(\xi) = \sqrt{\frac{1-e^{-\xi}}{\xi}}$$

- The net effect of F(ξ) is the reduction of multiplicity (μ_n) and increase in the transverse momentum squared ($<p^2_T>$).

$$\mu_n = nF(\xi)\mu_1$$ and $$< p_T^2 >= \frac{< p_T^2 >_1}{F(\xi)}$$

Determination of temperature

- The Schwinger mechanism for mass less particles can be expressed in terms of p^2_T

$$\frac{dN}{dp_T^2} \sim e^{-\pi p_T^2/x^2}$$

Where $<x^2>$ is the average string tension.

- Gaussian fluctuation of the string tension for the cluster gives rise to the thermal distribution.

$$\frac{dN}{dp_T^2} \sim e^{-p_T\sqrt{\frac{2\pi}{<x^2>}}}$$

with $$< x^2 > = \pi < p_T^2 > / F(\xi)$$

- The temperature can be expressed as

$$T(\xi) = \sqrt{\frac{< p_T^2 >_1}{2F(\xi)}}$$

where $<p^2_T>_1$ is calculated using above equation at ξ=1.2 with universal freeze out temperature T_f=167.7 ± 2.6 MeV which gives

$$\sqrt{< p_T^2 >_1} = 207.2 \pm 3.3 MeV$$

Analysis Details :

- $0.25 < p_T < 1.3$ (GeV/c)
- $|eta| < 0.5$
- Detector used : TPC
- Z Vertex cut : 10. cm
- Range used to fit $<p^2_T>$ distribution = 0.145 – 1.5 $(GeV/c)^2$
- ALICE data: p-p at $\sqrt{S_{NN}}$ = 7 TeV

LHC10d, pass2, ESD data

Run Number : 125085, 126007, 126082, 126097

- MC data : p-p at $\sqrt{S_{NN}}$ =7 TeV

LHC10f6a, ESD data

Run Number : 126097, 126007, 126082, 126088

- Multiplicity cut : V0A multiplicity cut

ALICE detector

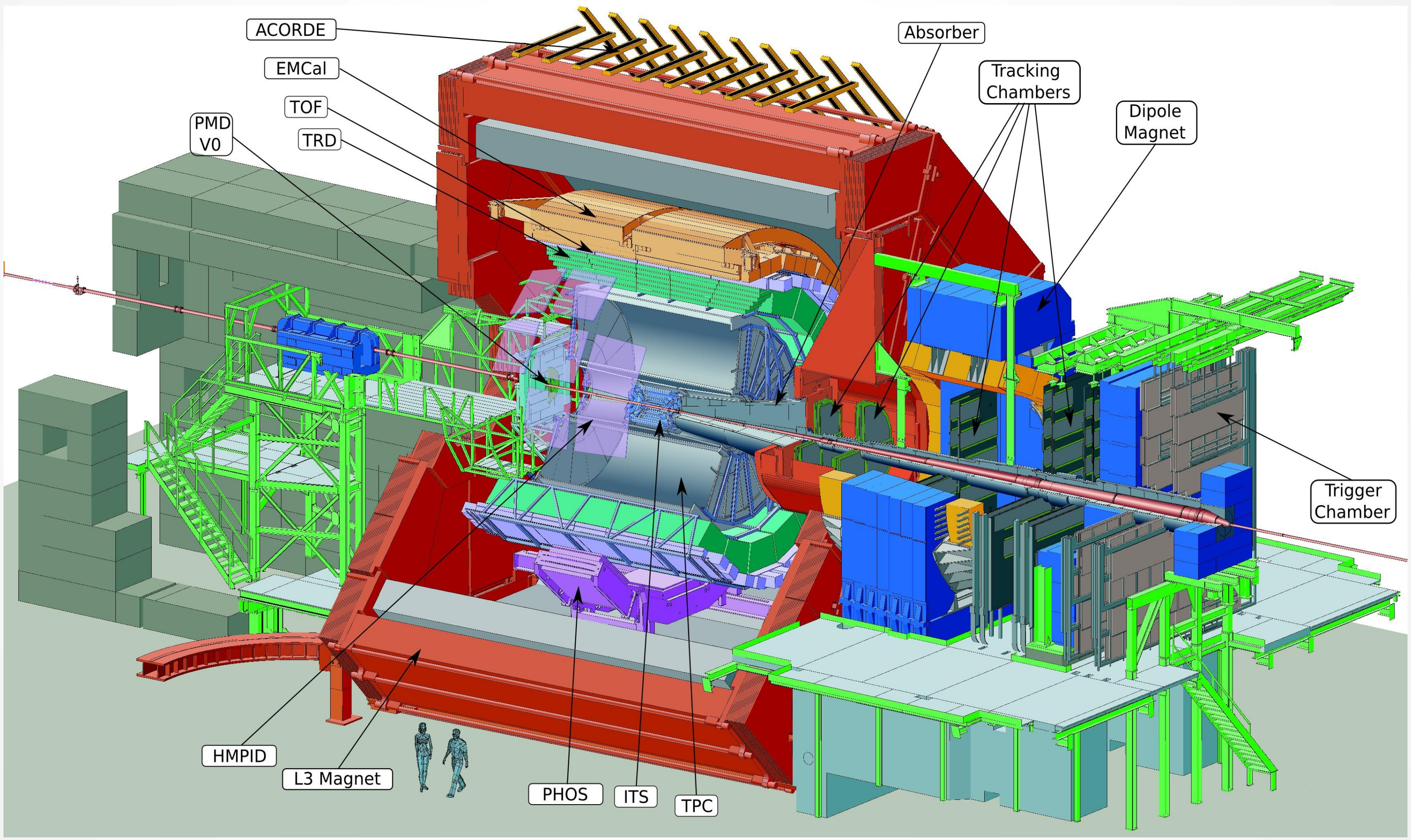


Fig. 1. ALICE detector system

Particles Identification

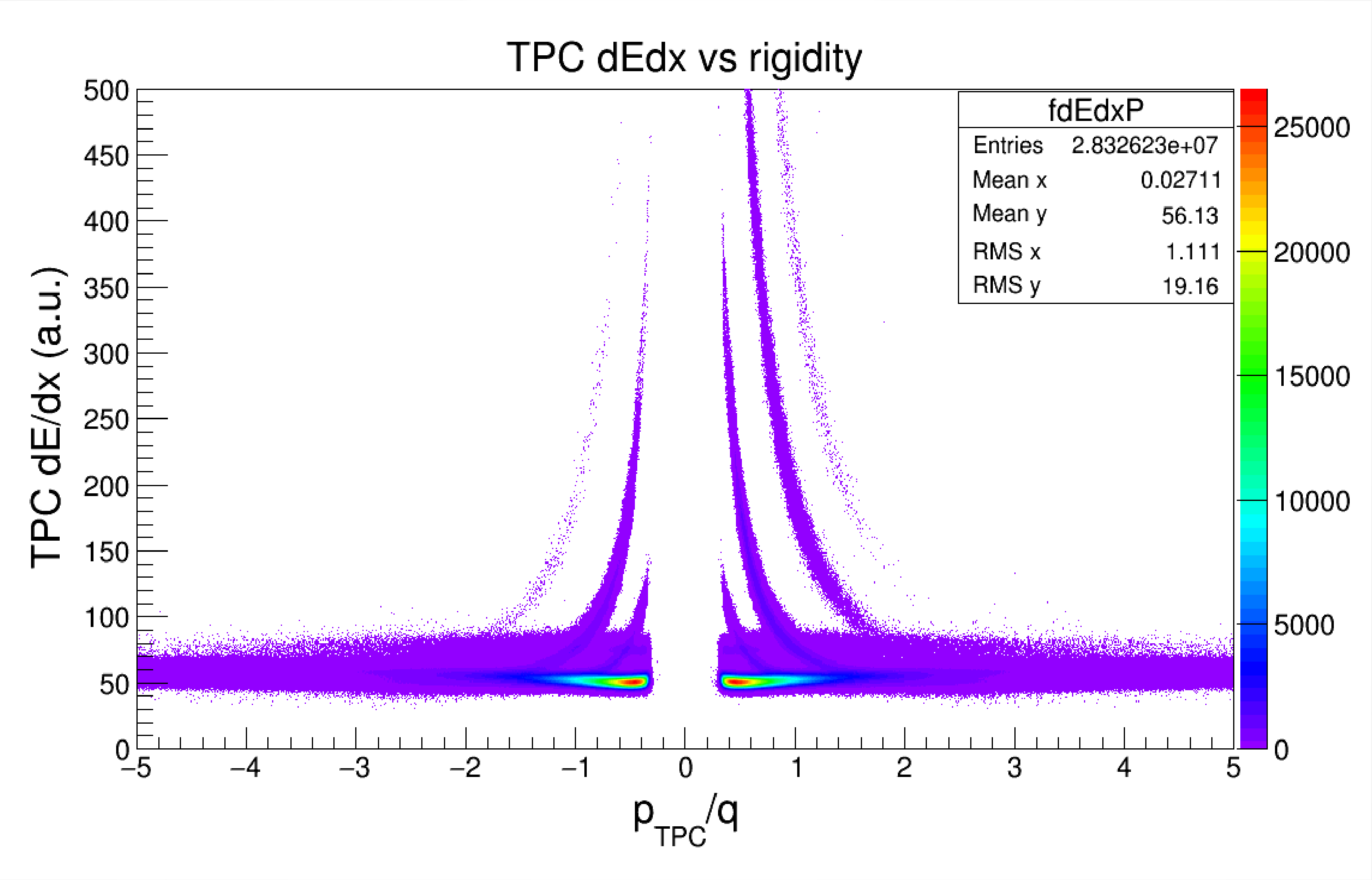
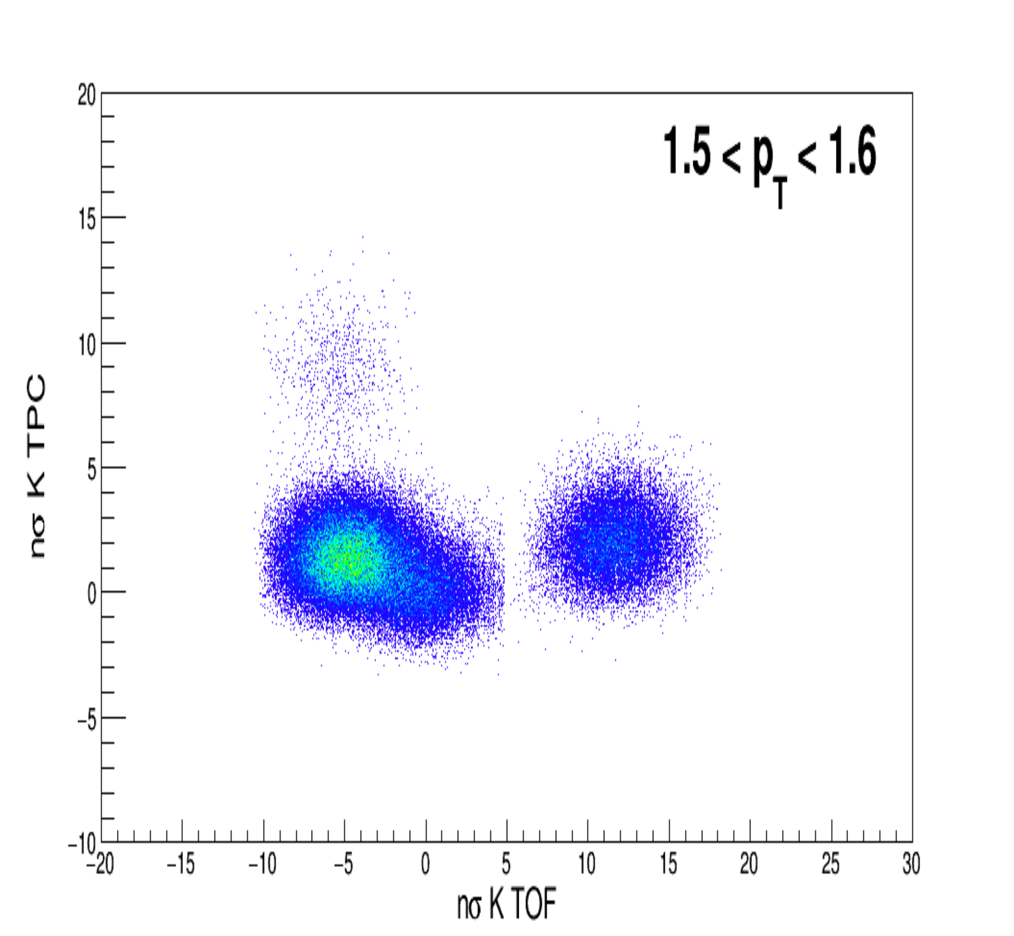


Fig. 2. Specific energy loss dE/dx in the TPC vs rigidity

Combined PID for TPC and TOF done with,

$$n\sigma_{combined} = \sqrt{(n\sigma_{TPC}^2 + n\sigma_{TOF}^2)}$$



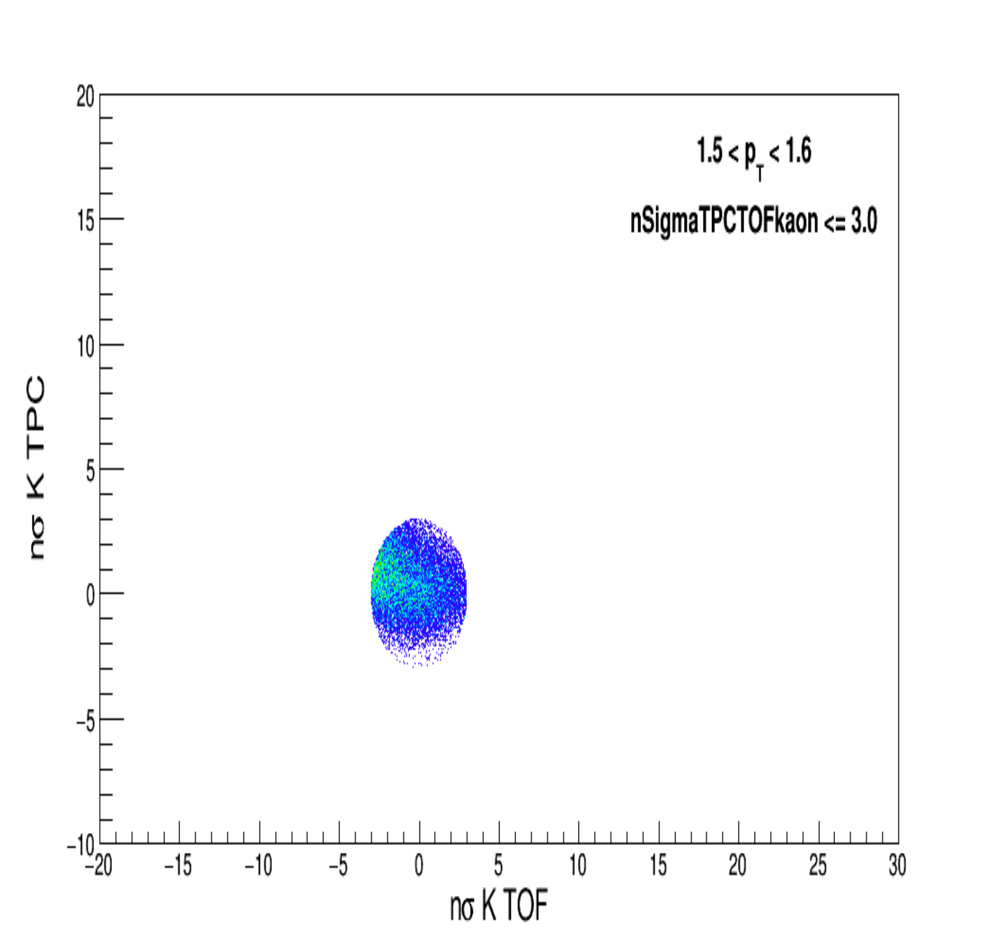


Fig. 3.PID with combined TPC and TOF detector

p_T dependent efficiency for all charged particles

Efficiency = Reconstructed / Generated

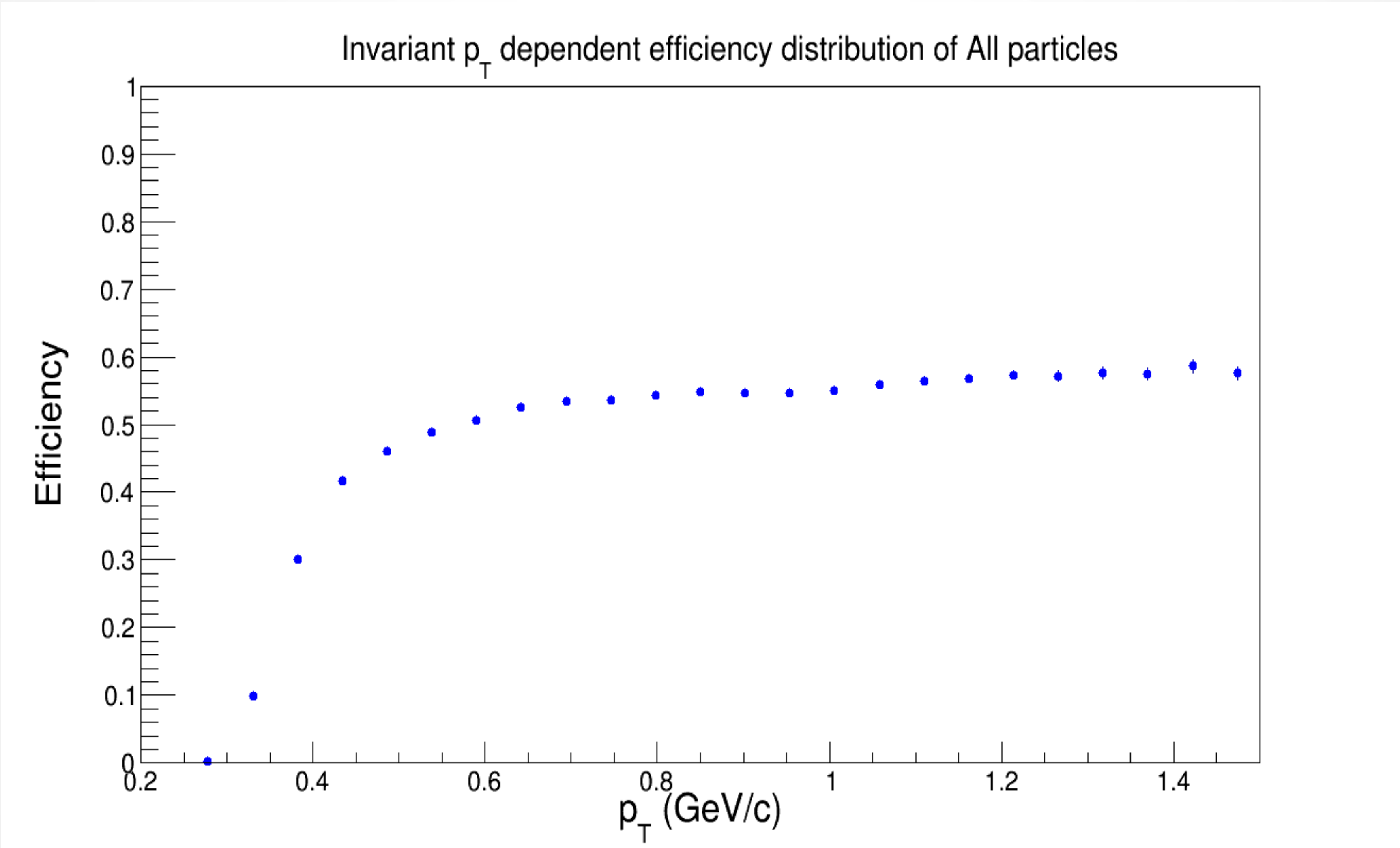


Fig. 4. p_T dependent efficiency distribution for all charged particles

p_T distribution of all charged particles

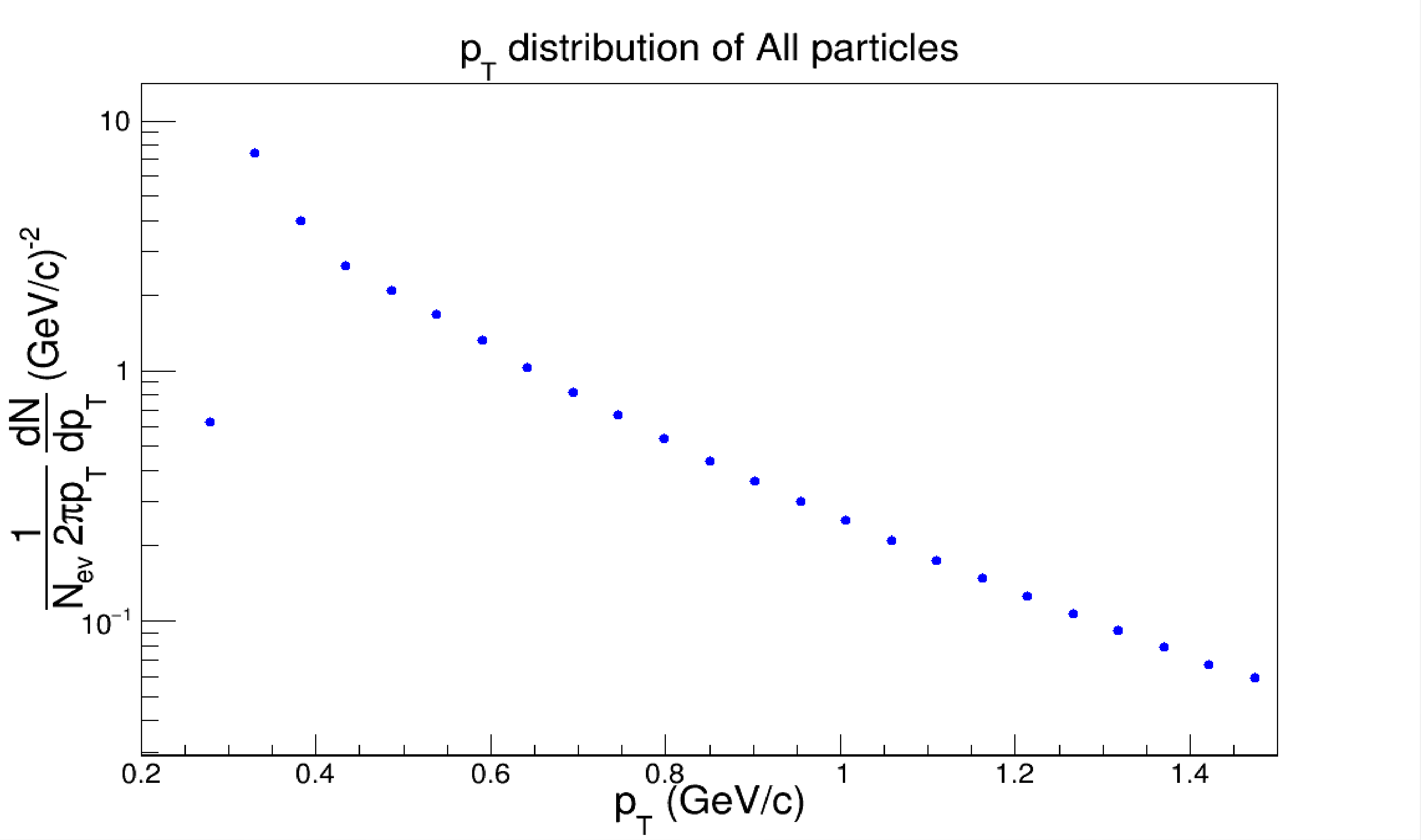


Fig. 5. Invariant p_T distribution for all charged particles

Comparision of p_T distribution with ALICE preliminary results for K^-

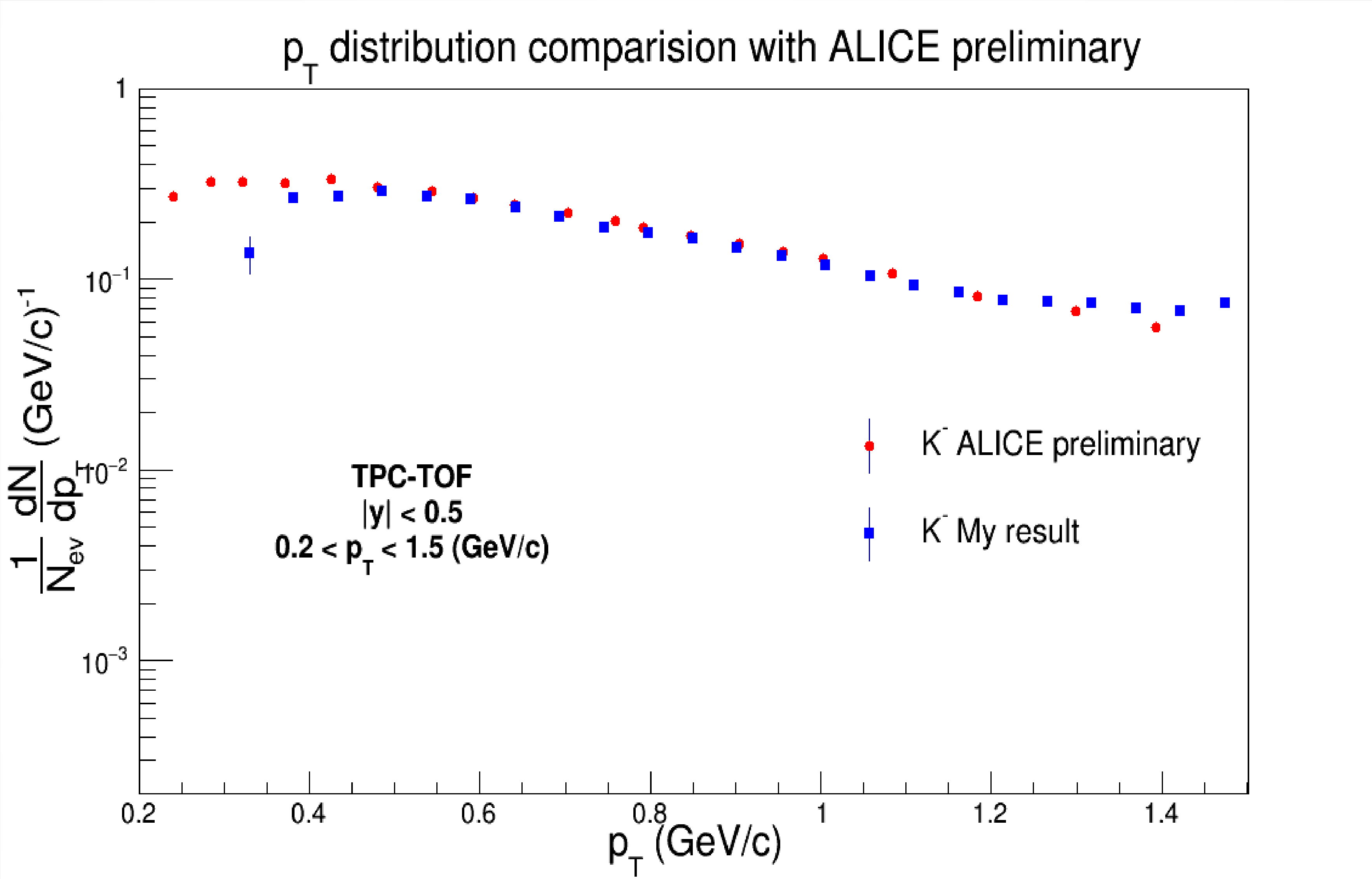


Fig. 6. Comparision of p_T distribution of K^-

Determination of color suppression factor F(ξ)

- To evaluate the initial value of ξ from data, a parameterization of pp collision at $\sqrt{s}$ = 200 GeV is used to compute the p_T distribution,

$$\frac{dN}{dp_T^2} = \frac{a}{(p_0 + p_T)^n}$$

Where a is normalization constant, p_0= 1.98 and n=12.88 are parameter used to fit the data.

- The above parameter can be used for the high multiplicity pp event to take account of the interaction of the strings.

$$p_0 \rightarrow p_0 \left(\frac{<\frac{nS_1}{S_n}>_{HM}}{<\frac{nS_1}{S_n}>_{pp}} \right)^{\frac{1}{4}}$$

- Thus we get,

$$\frac{dN}{dp_T^2} = \frac{b}{\left(p_0 \sqrt{\frac{F(\xi)_{pp}}{F(\xi)_{HM}}} + p_T \right)^n}$$

Here we take ,$F(\xi)_{pp} = 1$

V0A Multiplicity

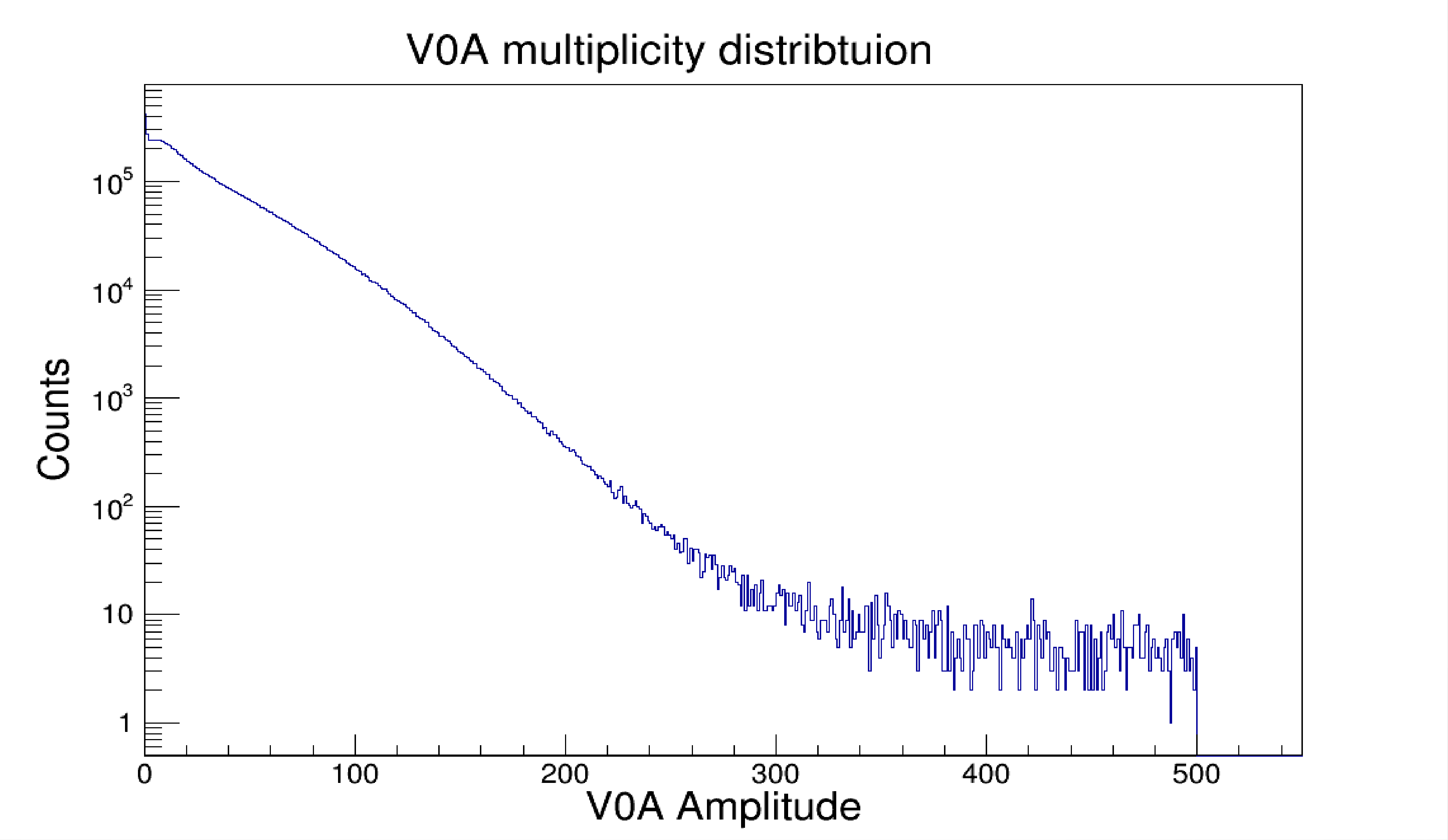


Fig. 7. V0A Multiplicity

p^2_T dependent efficiency for all charged particles

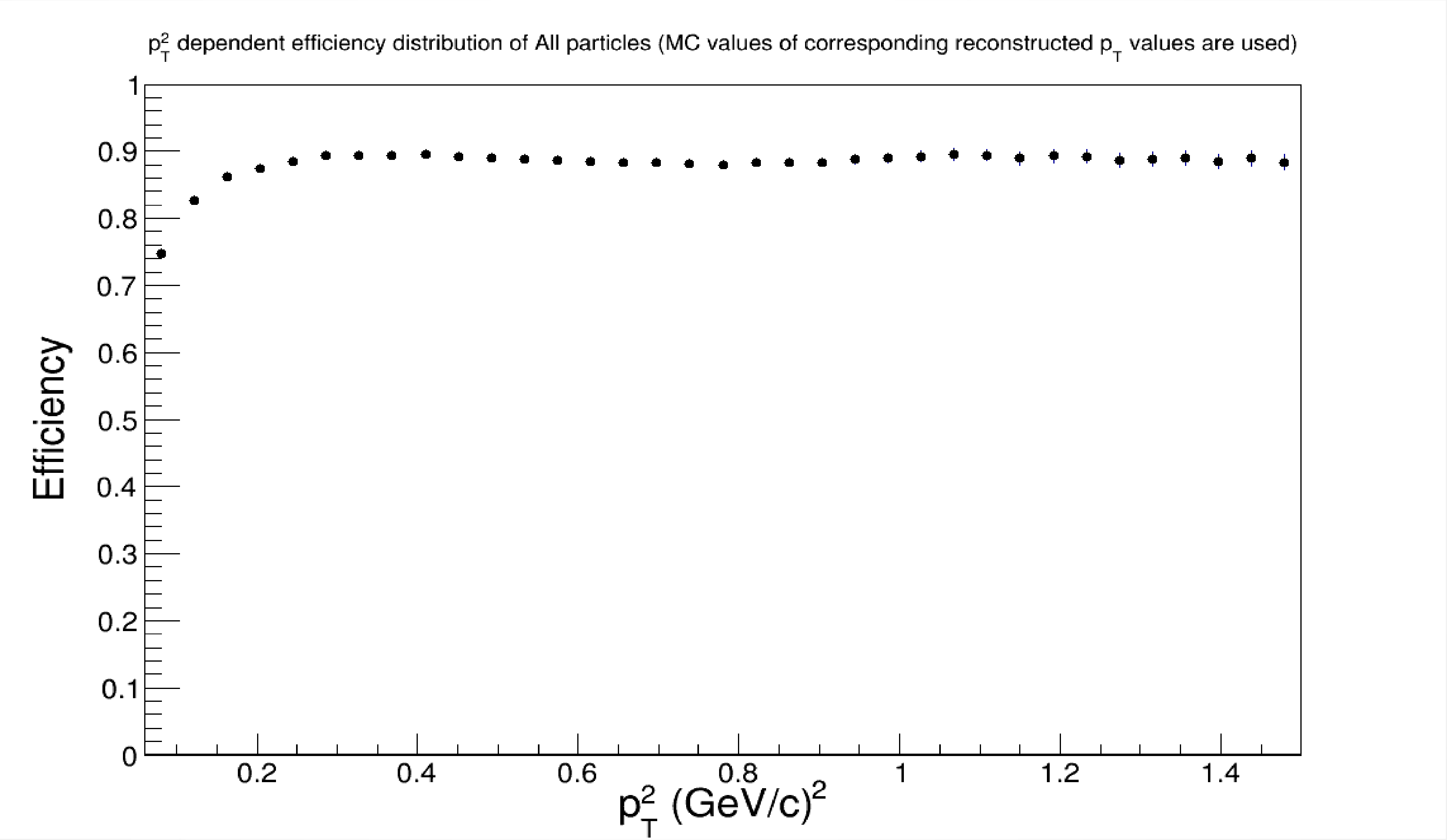


Fig. 8. p^2_T dependent efficiency distribution for all charged particles

p^2_T distribution of all charged particles for different mulitplicity cut

The fitting equation is, $$\frac{dN}{dp_T^2} = \frac{b}{\left(p_0\sqrt{\frac{F(\xi)_{pp}}{F(\xi)_{HM}}} + p_T\right)^n}$$

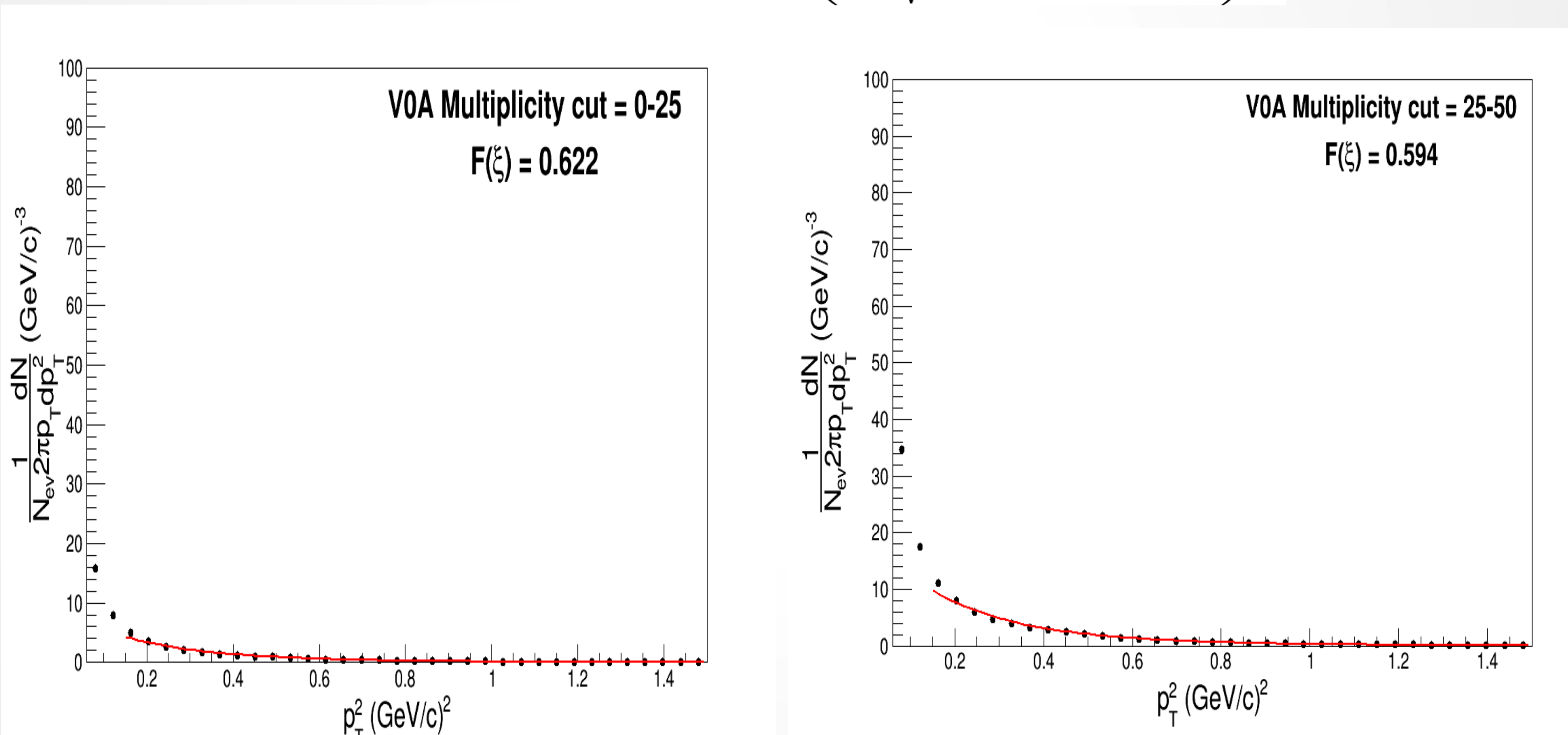


Fig. 9. Invariant p^2_T distribution for all charged particles at different multiplicity

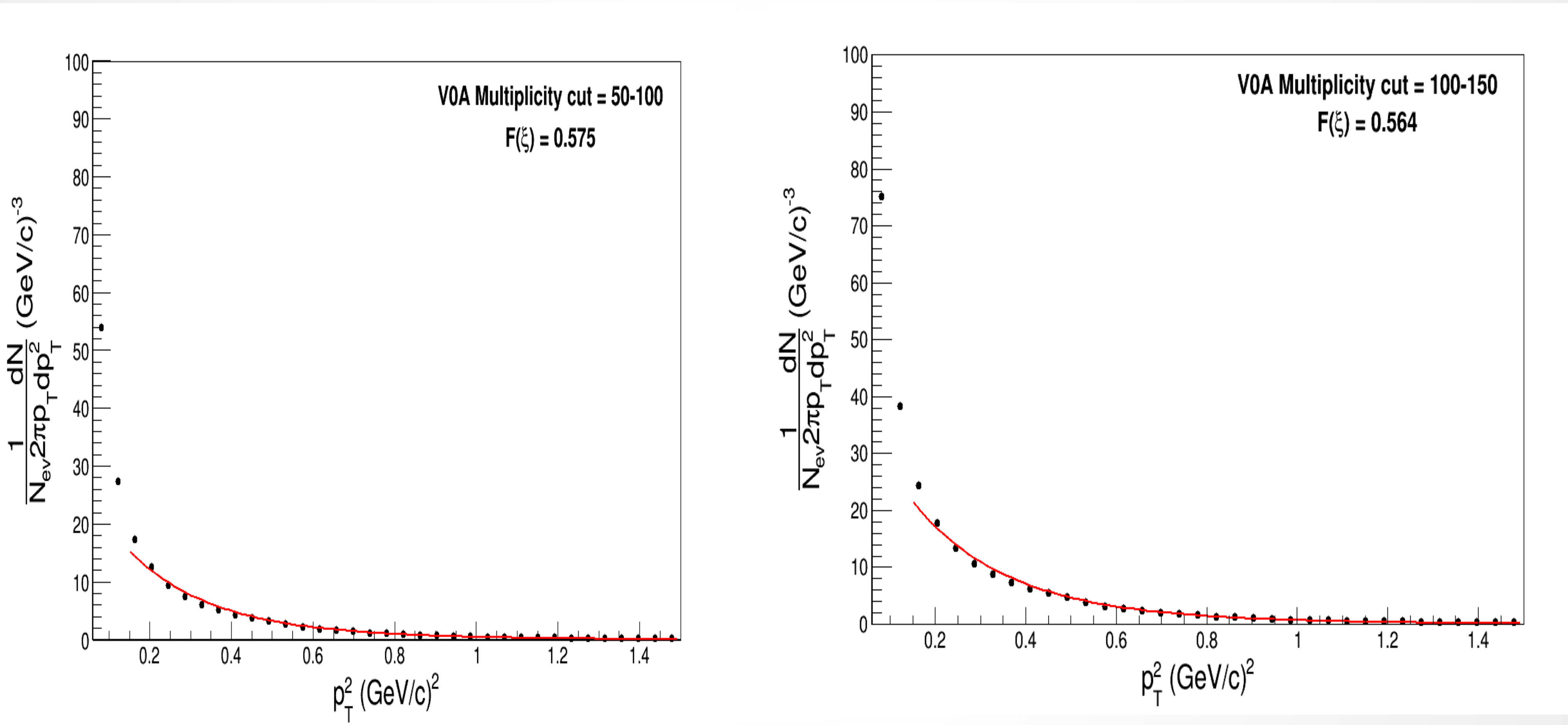


Fig. 10. Invariant p^2_T distribution for all charged particles at different multiplicity

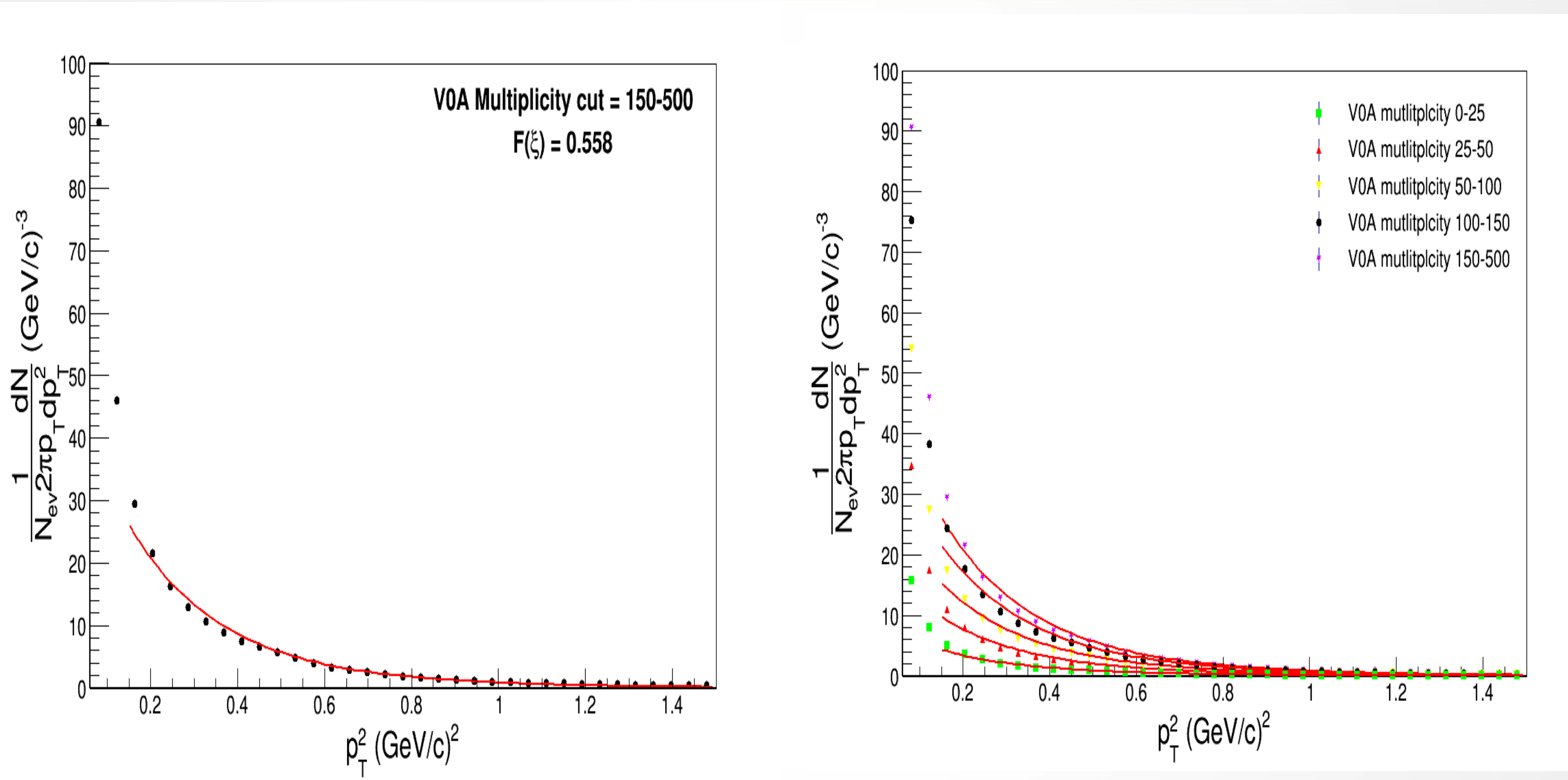


Fig. 11. Invariant p^2_T distribution for all charged particles at multiplicity 150-500 and at all multiplicity

Table 1: V0A Multiplicity cut, F(ξ), ξ and initial temperature

V0A Multiplicity cut	F(ξ)	ξ	Temperature (MeV)
0-25	0.622	2.34	185.8 ± 3.35
25-50	0.594	2.62	190.1 ± 3.44
50-100	0.575	2.85	193.2 ± 3.49
100-150	0.564	2.99	195.1 ± 3.56
150-500	0.558	3.06	196.1 ± 3.68

Table 2: Initial temperture of other system (published results)

System	Temperature (MeV)
Au+Au (0-10%) @ 200 GeV	193.6 ± 3.0
Pb+Pb (0-5%) @ 2.76 TeV (estimated)	262.2 ± 13.0

Ref: J. D. de Deus, A. S. Hirsch, C. Pajares, R. P. Scharenberg, B. K. Srivastava,Eur.Phys. J. C 72 (2012) 2123.

Summary

- Successfully extract the color suppression factor and percolation density.
- Temperature is also detemined successfully.
- The temperature obtained is much above the freeze out temperature.
- The temperature obtained from the analysis are in agreement with the published results.

Outlook

- Analyze the all avaiable energy. (2.76 TeV and 13 TeV)
- To check the variation of energy density with temperature.
- Variation of shear viscosity to entropy density ratio with temperature.

References

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- B. K. Srivastava, Nucl. Phys. A 926 (2014) 142.
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Thank you