Non-collectivity bound in p-p collisions to the RHIC and LHC energies.

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Introduction

The aim of this work is to present a study of the pion, kaon and proton particle production on high multiplicity pp collisions at LHC energies, over the transverse momentum spectra corresponding to the energy density of a dilute system in the framework of clustering of color sources to describe the suppression due to initial state effects.

The model

The String Percolation Model (SPM) is a bidimensional continuous percolation model, which infers the color fields created in a collision are strings that if projected onto the impact parameter plane form discs.

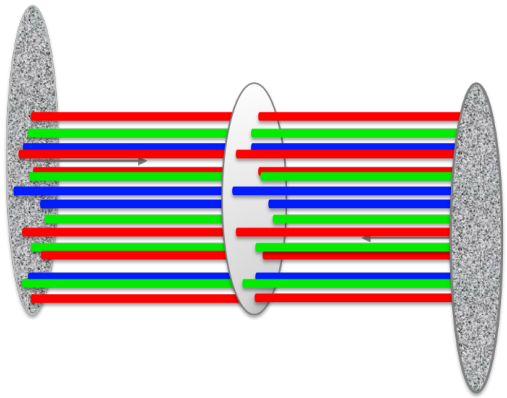


Figure: Strings

The number of strings that are formed depends on the energy of the collision, as they are created the density per unit area increases which leads to getting a critical density and a macroscopic cluster of strings is formed giving place to a geometrical phase transition.

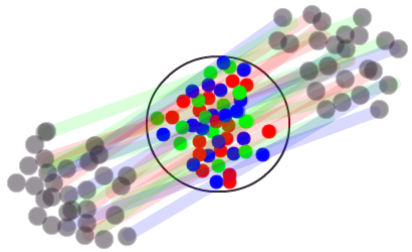


Figure: Cluster of strings

An important parameter in SPM is the transverse impact parameter density of strings which can be defined as $\zeta^t \equiv \left(\frac{S_0}{S}\right)\overline{N}^s$ where the average number of strings in a cluster is

$\overline{N}^s = 2 + 4\left(\frac{S_0}{S}\right)\left(\frac{\sqrt{s}}{m_p}\right)^{2\lambda}$

Other important quantity is the Color Suppression Factor, $F(\zeta^t)$, which is related to the particle density dN/dy and the number $\overline{N}^s$

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

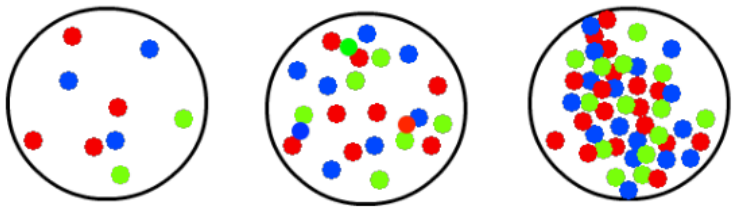


Figure: String density

Transverse momentum

Note that for pp collisions minimum bias the transverse momentum distribution can be denoted as:

$$\frac{1}{N}\frac{d^2N}{d_\eta d_{pT}} = \frac{a{p_0}^{\alpha-2}}{\left(p_0 + pT\right)^{\alpha-1}} \tag{1}$$

To obtain a, p0, α we perform a fit to the transverse momentum distributions of charged particles from minimum bias pp events at the energies in table 1

$\sqrt{s}$ (TeV)	a	p_0	α
13	30.77 ± 1.23	2.478 ± 1.862	9.98 ± 0.297
7	33.12 ± 9.30	2.32 ± 0.88	9.78 ± 2.53
2.76	27 ± 1.08	2.032 ± 0.074	9.448 ± 0.147
0.9	23 ± 0.92	1.785 ± 0.071	$9,287 \pm 0.165$

Table: 1 Parameters of the transverse momentum distribution in pp collisions.

Using equation (1) we can describe the general equation that relates the high multiplicity with string density ζ_{HM} and min bias distributions

$$\frac{1}{N}\frac{d^2N_{ch}}{d\eta dpT^2}\Big|_{\eta=0} = a\frac{(p_0 b)^{\alpha-2}}{(pT+p_0 b)^{\alpha-1}} \tag{2}$$

applying the thermodynamic limit with a vectorial color sum $b \to \sqrt{F(\zeta)/F(\zeta_{HM})}$

The transverse momentum distribution can be denoted as:

$$\frac{1}{N}\frac{d^2N}{d_\eta d_{pT}} = \frac{a\left(p_0\sqrt{\frac{F(\zeta_{pp})}{F(\zeta HM)}}\right)^{\alpha-2}}{\left(p_0\sqrt{\frac{F(\zeta_{pp})}{F(\zeta HM)}}+pT\right)^{\alpha-1}} \tag{3}$$

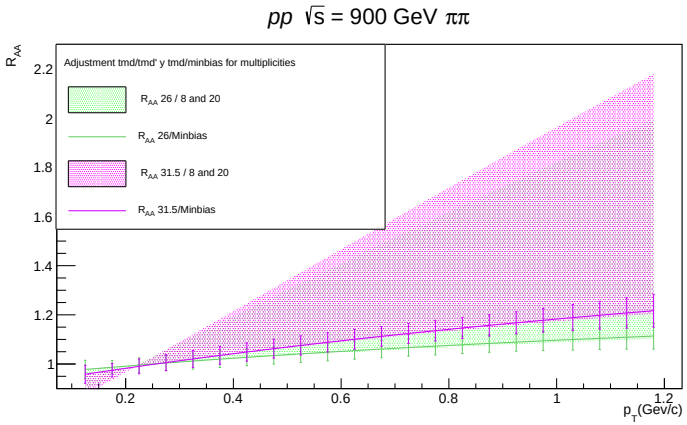
where $F(\zeta HM)$ is a free parameter that need to be determined.To obtain it, fits with experimental data from CMS were made using a, p_0 and α from Table 1 and the following values for $F(\zeta pp)$

$\sqrt{s}$ (TeV)	$F(\zeta pp)$
13	0.725553409
7	0.763683588
2.6	0.811749464
0.9	0.855821043

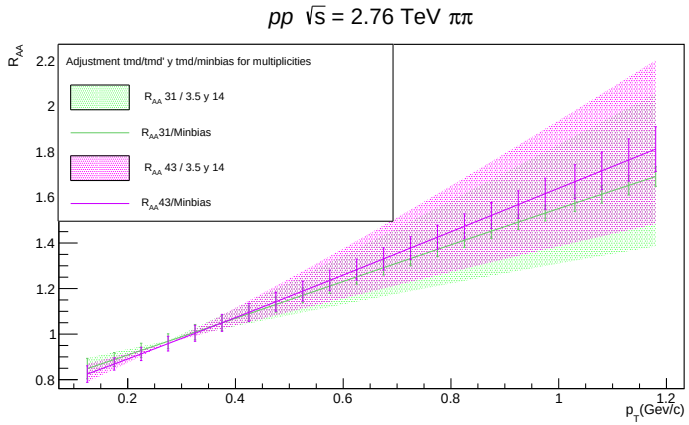
Table: 2 Parameters

Results

We show the differences for the diluted state and multiplicities



(a) 900 GeV



(b) 2.76 TeV

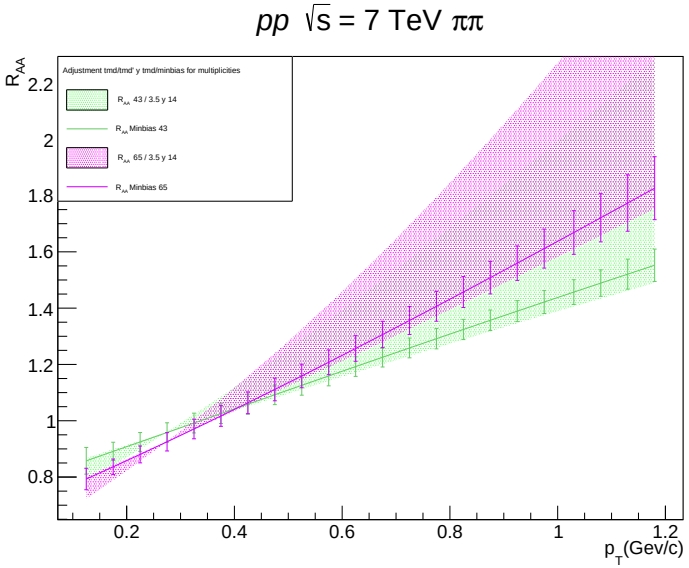


Figure: Diluted state for pions.

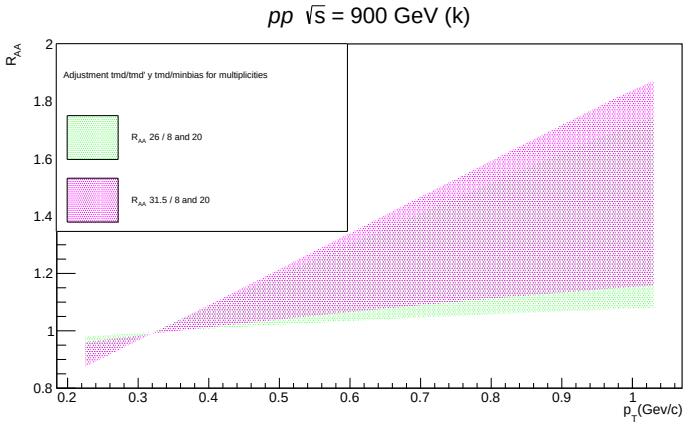
For kaons and protons the transverse momentum distribution is given by:

$$\frac{1}{N}\frac{d^2N}{d_\eta d_{pT}} = \beta exp(-\frac{m^2_{meson,baryon}F(\zeta_{pp})}{< p_t >^2 + < p_{meson,bayion} >^2})\frac{1}{N}\frac{d^2N}{d_\eta d_{pT}}|_\pi (N_S)^{0.09} \quad (4)$$

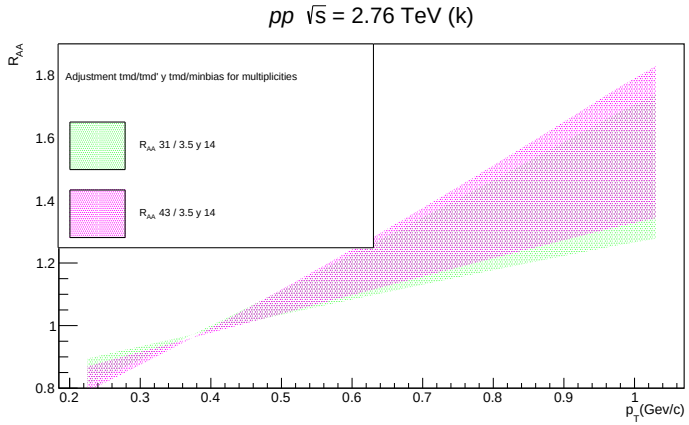
Were β is a parameter that only depends of energy

$\sqrt{s}$ (TeV)	β	N_s
7	0.5$\pm$.02	5.95
2.6	0.3$\pm$.01	4.5
0.9	0.31$\pm$.02	3.55

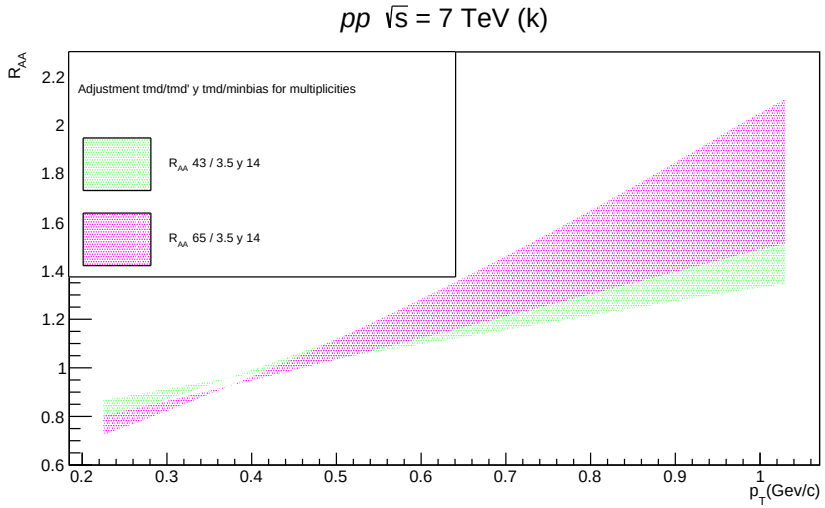
Table: 3 β Parameter and N_s



(a) 900 GeV

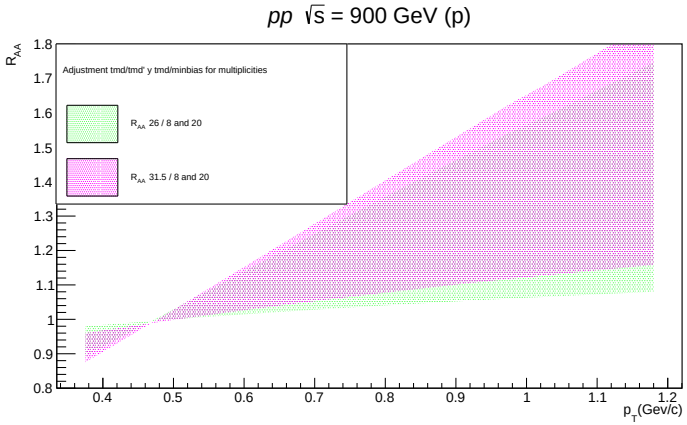


(b) 2.76 TeV

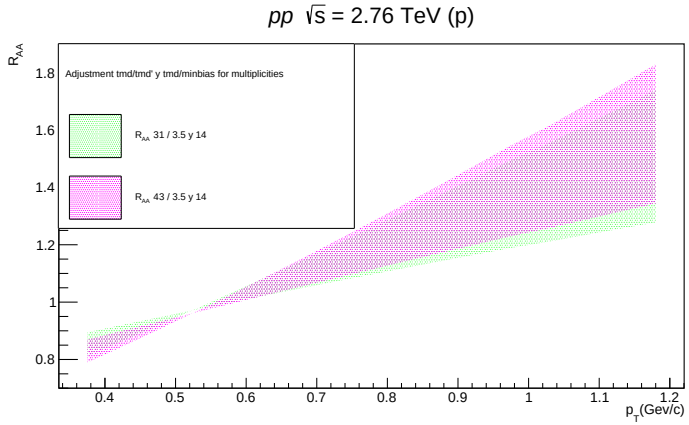


(c) 7 TeV

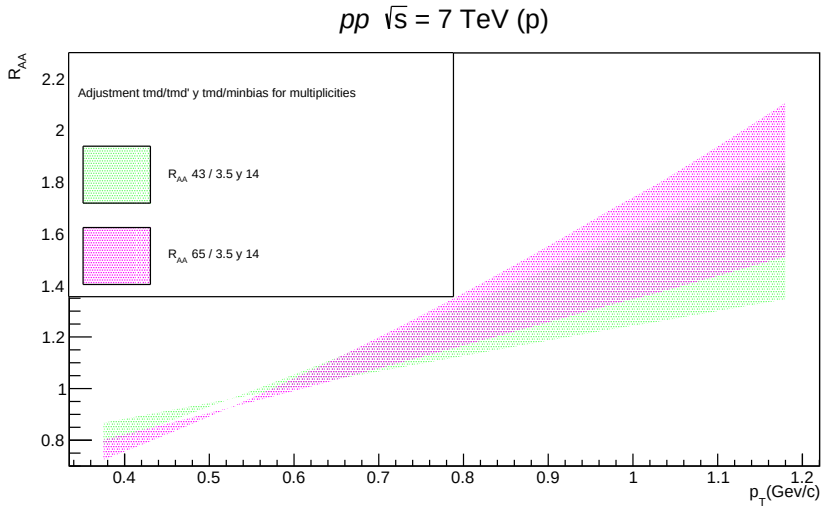
Figure: Diluted state for kaons.



(a) 900 GeV



(b) 2.76 TeV



(c) 7 TeV

Figure: Diluted state for protons.

Conclusions

We presented a study of the ratio of the pion, kaon and proton production on high multiplicity pp collisions atLHC energies, over the transverse momentum spectra corresponding to the energy densityof a dilute system.
Our results show a wide region of non-collectivity which has a large effect on the modification factor. As energy increases, a wider region suppressed for low momentum is observed, which in turn changes depending on the mass of the identified particle.

References

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