Studies on particle production in proton-proton collisions at the LHC energies using ALICE-TOF and MC data

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Introduction

One of the motivations of studying particle production in pp collisions is that they provide a baseline measurement for the realization of a hot and dense medium of deconfined quarks and gluons in the Pb−Pb collisions. However, the unprecedented energy at the LHC for pp collisions has engendered the production of large numbers of particles. Recent studies in those high-multiplicity (HM) events have revealed several collective effects [1]. The dynamics behind such behaviors couldn't be fully realized yet. Further, all previous multiplicity-dependent studies on identified particles were performed for different colliding systems, each at a different energy. The pp collisions data at $\sqrt{s}$ = 13 TeV allows to disentangle the effect of center of mass energy from the multiplicity dependent π, K, & p production. Moreover, another important objective of nuclear collisions studies is to understand the particle production mechanisms. It has been observed that particles are ofter emitted in a correlated manner due to some underlying production mechanism, resulting fluctuations in the number density of such emitted particles in phase-space. Among various mathematical tools, the Scaled Factorial Moments (SFM) method was extensively used to study fluctuations resulting from such underlying dynamics. In this thesis, the PYTHIA Monash Monte Carlo (MC) event generated data are used to study dynamical fluctuations using the SFM method in pp collisions at $\sqrt{s}$ = 2.76, 7, and 13 TeV. Moreover, as PYTHIA also includes color reconnection (CR), which can mimic several flow-like effects in pp collisions, attempts have also been made to study the CR effect on fluctuations in HM pp events.

Multiplicity dependent π, K, and p production in pp collisions at $\sqrt{s}$ = 13 TeV

The excellent tracking and particle identification (PID) capabilities of the ALICE detector have provided scope to study the production of π, K, and p from very low to high p_{T} regions. In this work, a statistical unfolding method on the time difference between the experimental Time of Flight (TOF) of particles and the expected one, as shown in Fig. 1(a), has been applied for particle identification. Then the raw yields of particles are estimated as a function of p_{T} for various multiplicity classes. The corrected p_{T} spectra estimated with the TOF detector are combined with the results of the ITS and TPC to obtain the p_{T} spectra over a wide p_{T} range.

The p_{T} spectra of π, K, and p measured for different multiplicity classes in pp collisions at $\sqrt{s}$ = 13 TeV are shown in Figs. 1(b), 1(c), & 1(d), respectively. It could be observed that the p_{T} spectra become harder with increasing multiplicity and the effect is more pronounced for heavier particles [2]. Further, the p_{T}-differential p/π ratio suggests a depletion at low p_{T} and an enhancement at intermediate p_{T} [2], which in Pb−Pb collisions is believed to be the consequence of collective expansion of the medium or a possible quark recombination mechanism [3]. The p_{T}-integrated K/π and p/π yield ratios measured in pp collisions at $\sqrt{s}$ = 13 TeV is found to follow a common trend from pp to Pb−Pb collisions. The K/π ratio increases with increasing multiplicity for pp collisions [2], which is attributed to the enhanced production of strangeness or a reduced

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canonical suppression in larger freeze-out volume [3]. On the contrary, the p/π ratio shows no significant variation with increasing multiplicity for pp collisions. These results suggest that the hadrochemistry of particles is driven by multiplicity density, rather than colliding systems size or collisions energy.

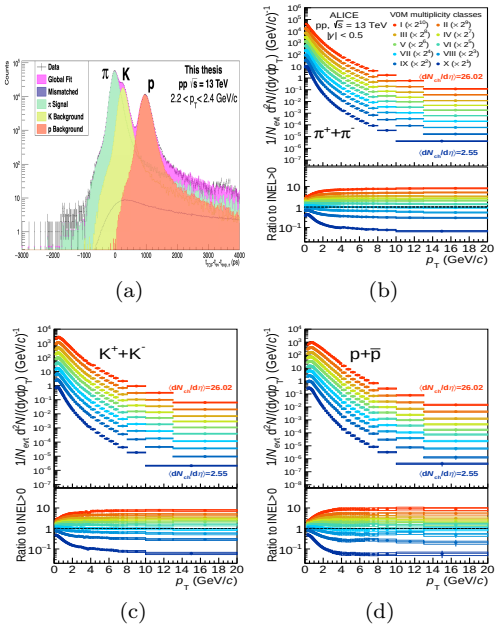

FIG. 1: (a) Example of a statistical unfolding fit and p_{T} spectra of (b) pions, (c) kaons, and (d) protons in different V0M multiplicity classes.

Dynamical fluctuations in high multiplicity pp events at the LHC

The dynamical fluctuations in charged particles emission spectra have been studied using the SFM method in both minimum bias (MB) and high-multiplicity (HM) pp events. An intermittent pattern could be observed for the HM pp events at $\sqrt{s} = 2.76$, 7, and 13 TeV for η, ϕ, and $\eta - \phi$ (Fig. 2) spaces. On the contrary, the MB pp collisions don't show such an intermittent pattern. The intermittency indices α_q increase with increasing order of the moments q in all three spaces of HM pp events. No $\sqrt{s}$ dependence evolution of α_q's could be seen for the studied systems. The anomalous dimensions d_q are found to increase with the q for HM pp events, suggesting the production of particles via cascading mechanism [4]. Studies on the exponent λ_q indicate that such events exhibit a non-thermal phase transition like behavior in $\chi(\eta - \phi)$ space for q=q_c=4. This q_c separates frequently occurring small fluctuations from rarely occurring large fluctuations. Moreover, the CR mechanism, implemented in PYTHIA, considers that final partons are color connected in such a way that the total string length becomes as short as possible, which in turn, results in correlated emission of particles. Therefore, it is very important to examine the contribution, if any, of the CR in the observed correlated emission of particles. With the variation of the CR strength, significant changes in the intermittency, as well as d_q and λ_q could be observed than the default PYTHIA results for the HM pp events [4]. Nevertheless, the CR can't solely be attributed as the origin of intermittency for the studied data.

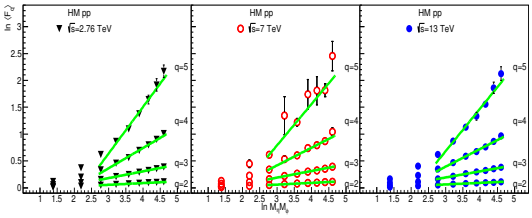

FIG. 2: $\ln\langle F_q\rangle$ vs lnM in 2D $\chi(\eta - \phi)$ space for HM pp events at $\sqrt{s} = 2.76$, 7, and 13 TeV.

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