# Performance studies of CBM Time of Flight(TOF) detector and a few aspects of particle production at a FAIR energy

Somen Gope[1]*
[1] *Nuclear and Radiation Physics Research Laboratory, Department of Physics, Gauhati University, Guwahati-781014, India and*
[1] *Department of Physical Sciences, Bose Institute, Kolkata-700091, India*

## Introduction

Exploring the QCD phase diagram is one of the main goals of the realtivistic and ultra-relativistic heavy-ion collision programs. In such nuclear collisions, the produced nuclear matter is far away from normal nuclear density and temperature. Depending on the energy and the collision system under invetigation, it is contemplated that nuclear matter with an almost zero net-baryon density and an extremely high temperature, or alternatively, with an extremely high baryon density and at moderate temperature, is formed. The Facility for Anti-proton and Ion Research (FAIR) of GSI, Darmstadt, Germany, is a planned facility that is intended to examine nucleus-nucleus collisions from 10 AGeV to 45 AGeV and is anticipated to be operational sometime during the later part of this decade [1]. One of the four main experiments of FAIR, the proposed Compressed Baryonic Matter(CBM) experiment, is intended to investigate the critical point of phase transition in the QCD phase diagram. So, the studies of physical observables related to such physics are very necessary to find the existence of phase transitions at such beam energies. Also, particle identification is very much necessary to study such observables. One of my objectives was to identify the charged hadrons using the CBM-ToF detector tracking algorithm.

The particle number density of primary charged particles emitted in heavy-ion collisions exhibits fluctuations in various phase-spaces. It is expected that the investigation of such fluctuations will provide information related to particle production mechanisms. Such fluctuations can be broadly classified into two categories: (a) statistical fluctuations and (b) dynamical or non-statistical fluctuations [2, 3]. One of the most successful mathematical tools for separating the dynamical component of fluctuations from the mixture of these two is the scaled factorial moment (SFM) method. In this work, another attempt has been made to study multi-particle fluctuation with the SFM technique using ultra-relativistic quantum molecular dynamics (UrQMD) and hybrid UrQMD-hydro-generated data.

## Physics performance studies of CBM-ToF detector

The ToF detector, which is will be considered as one of the core detectors of the future CBM experiment and the function of ToF is identify the charged hadrons. The $n\sigma$-approach, is usual method, is adopted for this analysis for particle identification.

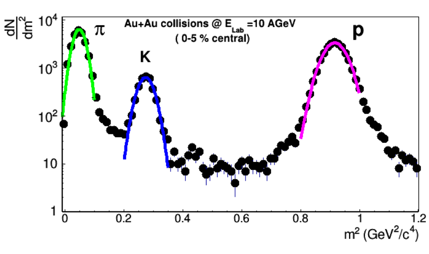


FIG. 1: $m^2$ distribution of primary charged hadrons.

In the standard approach, the flight time

*Electronic address: somengope30@gmail.com

and track length of the particles from the collision vertex, and momentum from STS track curvature can be used to measure the squared mass ($m^2$) [1]. FIG. 1 represents the $m^2$-distribution for identified pion ($\pi$), Kaon ($K$), and proton ($p$). The plot agrees well with published result of Deppner and Herrmann [4]. FIG. 2, represented the transverse mass ($m_T$) spectra of identified $\pi$, $K$, and $p$ which are fitted with Boltzamnn equation [1]. The $m_T$ spectra of mentioned particles follow the expected mass ordering. Effective temperature ($T_{eff}$) of fireball has been calculated from the fitted parameter (slope) of the $m_T$-spectra.

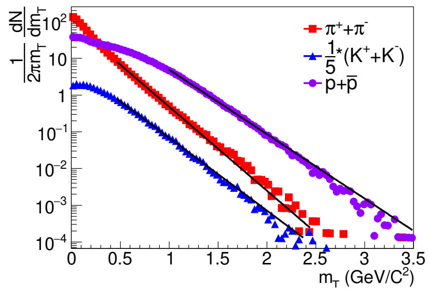


FIG. 2: $m_T$ spectra of identified light flavored hadrons $\pi^+ + \pi^-$, $K^+ + K^-$, and $p + \bar{p}$.

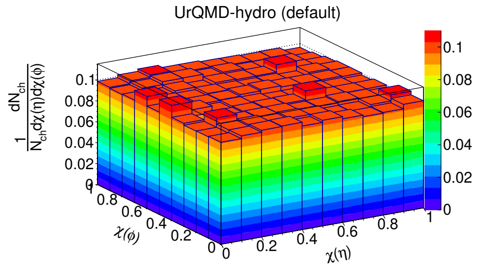


FIG. 3: Density distribution in 2D $\chi(\eta-\phi)$ spaces for all charged particle.

## Scaled factorial moment analysis of multiplicity fluctuation

In this work, the UrQMD and UrQMD-hydro event generator has been used. The detail method of SFM has already been described in our published paper [2].

FIG. 3 is represented the two dimensional density distribution spectrum of all charged particles. From FIG. 3, it is clear that the distribution, as expected, is flat in pseudorapidity($\eta$)-azimuthal($\phi$) space and devoid of any preferential emission, which reduces the possibility of error in our fluctuation studies caused by initial shape dependence of single particle spectra.

FIG. 4 represented the plot of two dimensional horizontally averaged factorial moments versus number of phase-space bins. From this figure, a clear signature of power-law behaviour of factorial moment with number of bins could be observed, confirming the presence of intermittency in UrQMD-hydro data.

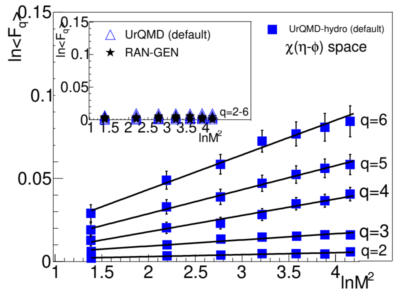


FIG. 4: Variation of $ln < F_q >$ aginst $lnM^2$ plots for different modes of UrQMD events.

## Acknowledgments

The author would like to thank thesis supervisor Prof. B. Bhattacharjee for his continiuos support and guidence. Author also thankful to Department of Science and Technology (DST), Govt. of India for providing the financial support.

## References

[1] S. Gope and B. Bhattacharjee, Acta Phy. Pol. B **53**, 9-A3 (2022).

[2] S. Gope and B. Bhattacharjee, Eur. Phys. J. A **54**, 44 (2021).

[3] B. Bhattacharjee, Nucl. Phys. A **748**, 641 (2005).

[4] I. Deppner and N. Herrmann, arXiv:2006.08510 [physics.ins-det].