An investigation on the mass/species type behavior of produced particles at FAIR energies - A different approach

Kalyan Dey* and B. Bhattacharjee†
Nuclear and Radiation Physics Research Laboratory,
Department of Physics, Gauhati University, Guwahati - 781014, India

Introduction

It is believed that a study of the relation of particle production to its intrinsic property may reveal its production mechanism. To ascertain if the nature of particle production is mass or type (meson/baryon) dependent, a number of observables such as R_{AA}, R_{CP}, v_2 have been studied both at SPS and RHIC energies. From these results it is inferred that at RHIC energy the particle production mechanism is species (meson/baryon) rather than mass dependent.

The proposed Compressed Baryonic Matter (CBM) experiment at FAIR is planned to explore the properties of nuclear matter at moderate temperature and high baryon density. Its large acceptance will give the CBM experiment access to almost the entire forward rapidity hemisphere. Thus, the evolution of the width of the rapidity distribution with beam energy and centrality will be experimentally addressed. This evolution is believed to be sensitive to the final state re-scattering which in turn is dependent on the mass of the produced particle. Strangeness enhancement, on the other hand, is considered to be one of the traditional signatures of formation of QGP which is found to be strongly dependent on the number of strange quark content of various strange particles.

As the width of the rapidity distribution and the strangeness enhancement factor respectively depends on the mass of the produced particles and the strange quark content, in this work an attempt has been made, with UrQMD-3.3p1 generated Au+Au events at 10, 20, 30 and 40 AGeV, to investigate the mass/species type behavior of produced particles from a measurement on the width of the rapidity distribution and the rapidity dependent strangeness enhancement factor of mesons and baryons.

Results and discussion

Figure 1 represents the width of the rapidity distributions as a function of beam rapidity for studied mesons and baryons both for UrQMD generated central Au+Au collision and available experimental data (AGS and SPS). As expected, the lighter particles have larger width. From this plot, a scaling behavior of the type, $\sigma \propto (Y_{beam})^{\tau}$ of the width of the rapidity distribution on beam rapidity is readily evident. Friese *et al.* [1] have reported similar results for Pb+Pb collision with NA49 data. The variation of the power law exponent with the mass of the produced particles is shown in figure 1(**d**). The exponent values are found to increase linearly with the mass of the produced particles irrespective of their type (meson/baryon), indicating the mass dependent nature of the exponent. It is interesting to note both from the upper and lower panel of figure 1(**a** and **b**) that though mesons and baryons separately follow mass ordering, such mass ordering is violated if the studied hadrons are taken together (figure 1**c**) indicating that the mass ordering of the width of the rapidity distribution of produced particles is particle type dependent.

In this report the strangeness enhancement factor E_S is defined as [2]

$$E_S = \left[\frac{(Yield)_{AA}}{<N_{\pi^-}>}\right]_{central} / \left[\frac{(Yield)_{AA}}{<N_{\pi^-}>}\right]_{peripheral}$$

E_S has been estimated, using UrQMD generated events, as a function of rapidity for both strange mesons (k^- and ϕ) and strange baryons (Λ, Ξ^- and Ω^-) at the incident beam

*Electronic address: kalyn.dey@gmail.com
†Electronic address: bb_22@rediffmail.com

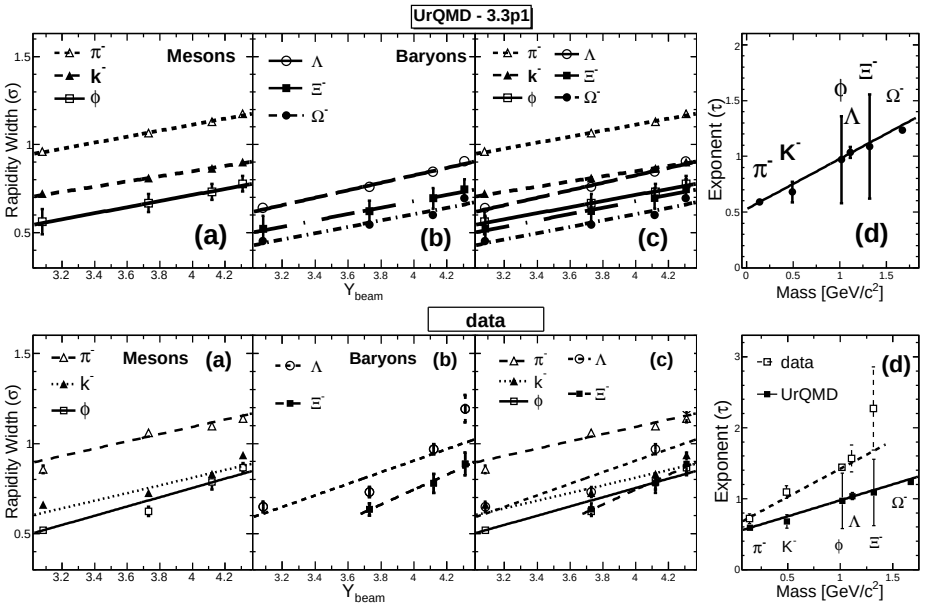

FIG. 1: Variation of width of the rapidity distribution calculated from UrQMD (upper panel) and from data (lower panel) of (a) mesons (b) baryons (c) all studied hadrons as a function of beam rapidity in the lab system. In the panel (d) the power law exponents has been plotted as a function of mass of the produced particles. The solid lines (and the dashed line as shown in panel d) correspond to the best fitted lines. The error bars shown here corresponds to the statistical error.

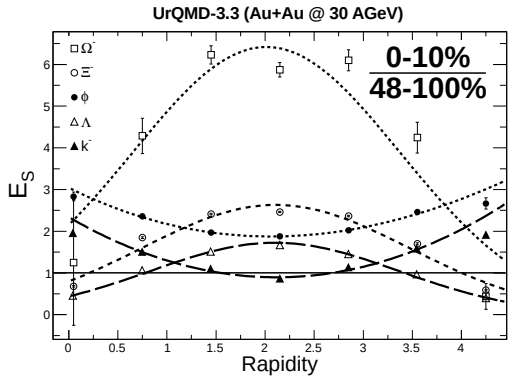

FIG. 2: Strangeness enhancement factor E_S as a function of rapidity for Ω^-, Ξ^-, ϕ, Λ and k^- at 30 AGeV. The baryons and mesons are respectively fitted by a Gaussian and a polynomial of 3rd order.

energy 30 AGeV and is shown in figure 2. From this figure it can be readily seen that both for mesons and baryons the strangeness enhancement at mid-rapidity increases with the strange quark content. Though E_S of mesons and baryons separately follow mass ordering, it is violated if both mesons and baryons are taken together. Further, it is interesting to note that even though the enhancement factor $E_S > 1$ almost at all rapidities for both mesons and baryons, the patterns of variation of enhancement factor E_S for the studied mesons and baryons are completely different. For baryons, E_S is maximum at mid-rapidity and minimum at beam and target rapidities while for mesons, the situation is otherwise. Similar behavior has been observed at other FAIR energies viz. 10, 20 and 40 AGeV as well. Thus the rapidity distribution of enhancement factor may be considered yet another tool to discriminate the mass/species type behavior produced particles.

Acknowledgments

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References

[1] V. Friese (NA49 collaboration), Pos(CPOD 2009)005.

[2] S. Soff *et al.* Phys. Lett. B 471 (1999) 89-96.