ϕ meson yield using PHSD model at FAIR energies

B. Waseem[1],* M. Farooq[1], S. Ahmad[1], B. Towseef[1], and Arshad. Ahmad[1]
[1] *University Of Kashmir , Srinagar - 190006, INDIA*

Introduction

Heavy ion physics goal is to study nuclear matter under two extreme conditions, one is temperature and the other is density, which could ultimately form the new state of matter, i.e., the Quark Gluon Plasma (QGP). This state of matter is thought to have existed in the first few microseconds after the Big Bang and possibly exists in the cores of heavy neutron stars. Different experiments at high energy produce heavy ion collisions like Large Hadron Collider (LHC) and Relativistic Heavy Ion Collider (RHIC) which leads to an extremely hot but almost net-baryon free reaction zone. CBM experiment at Facility for Anti-Proton and Ion Research (FAIR) is a fixed target experiment aiming at exploring the properties of strongly interacting matter in the high net baryon density regime, which is yet to be explored in detail. The energy range for CBM is from 2 A GeV to 35 A GeV lab energies for gold gold collisions.

Strangeness enhancement is one of the important signatures of the QGP which can be studied through ϕ-meson containing ($s\bar{s}$). ϕ meson can be extracted through di-leptonic channel (branching ratio for e^+ e^- = 2.97 $\times 10^{-4}$ and $\mu+$ $\mu-$ = 2.86 $\times$ 10^{-4}) or di-hadronic channel K^+K^- with a branching ratio of 49.2%. ϕ (s$\bar{s}$) meson has small cross-section of interaction with non-strange hadrons and long lifetime which allows it to decouple from the strongly interacting medium, produced in heavy ion collisions, early in time and hence escapes the medium before decaying, thereby preserving information about the conditions in which the mesons were produced.

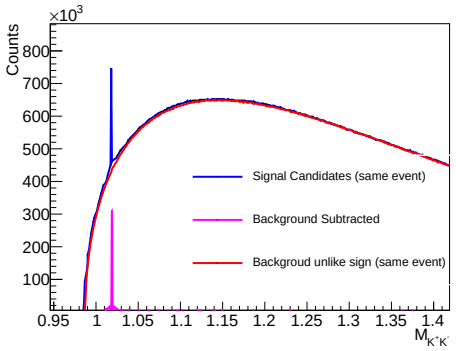

FIG. 1: Invariant mass of ϕ meson reconstructed from K^+K^- in central Au + Au collisions at 25 A GeV Lab energy.

In this paper we have studied ϕ meson using the Parton Hadron String Dynamics (PHSD) transport model. PHSD is a microscopic off-shell transport approach that describes the strongly interacting partonic and hadronic matter in and out-of equilibrium [1] The self generated scaler mean-field potential is developed in QGP phase between the partonic degrees of freedom in which quarks , antiquarks and gluons scatter and propagate [2]. Massive colored off-shell quarks and antiquarks hadronize to colorless off-shell mesons and baryons once the local energy density becomes lower than $\epsilon_c = 0.5\ GeV/fm^3$. PHSD includes the 0^- and 1^- meson nonets and baryon octet and decouplet, as well as higher resonances as in the Hadron String Dynamics (HSD) approach [3].

We have simulated 1 million events of central Au + Au collisions from PHSD model at E_{lab} 6 - 25 A GeV . We have reconstructed the ϕ mesons from K^+K^- decay channel within the mid-rapidity ($|Y| < 1$). As we cannot distinguish kaons track-by-track from ϕ decay , so we have used same-event technique for sig-

*Electronic address: W.Bhat@gsi.de

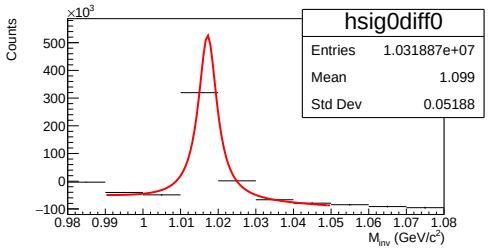

FIG. 2: Subtracted ϕ meson signal fitted with Breit Wigner function at $|Y| < 1$ for central Au+Au collisions at 25 A GeV .

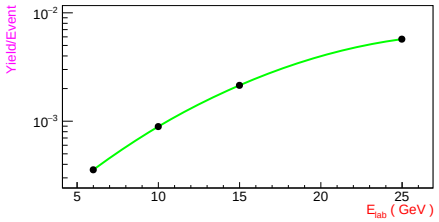

FIG. 3: Energy dependance of yield at various FAIR energies within the rapidity cut of $|Y| < 1$ in central Au + Au collisions.

nal extraction in which kaon from each event are combined into unlike sign kaon of same event. The combinatorial background formed from uncorrelated K^+K^- kaon pairs is done by same-event technique where like sign kaon pairs from each event are combined. Fig. 1 shows unlike sign signal candidates over like sign background after proper normalization, with ϕ meson signal on the top. Then the ϕ meson signal extraction is done by subtracting the combinatorial background and fitted with Breit Wigner as shown in Fig. 2 .

ϕ-meson yield have been extracted from the Breit Wigner fit and then plotted with different energies and shown in Fig. 3. Increase in the ϕ-meson yield with energy can be seen clearly, as expected. We also studied the effect of p_T on the ϕ meson yield as shown in Fig. 4. Yield of ϕ meson is maximum around 0.5 GeV/c.

We can conclude that at FAIR energies,

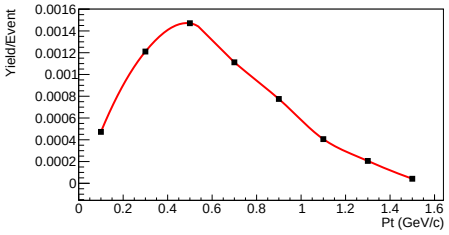

FIG. 4: The invariant yield of ϕ mesons as a function of P_t measured within the rapidity cut of $|Y| < 1$ for central Au+Au collisions at 25 A GeV.

where net-baryonic density is expected to be high, ϕ-meson can be reconstructed from the K^+K^- very well and hence can be examined for QGP effects.

References

[1] V. Kireyeu et.al., Eur. Phys. J. A **56**, 223 (2020)

[2] W. Cassing, E.L. Bratkovskaya, Nucl. Phys. A **831**, 215 (2009).

[3] W. Cassing, E.L. Bratkovskaya, Phys. Rep. **308**, 65 (1999).