Feasibility Study of $\phi(1020)$ Production at NICA

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Abstract. The goal of this article is to provide overview of the new accelerator complex NICA at JINR and to present the current results of the Multi-Purpose Detector (MPD) performance for ϕ-meson production. In our study we use the channel decay $\Phi \rightarrow K^+K^-$ to detect the formation of the ϕ-meson. UrQMD event generator is used and central events at $\sqrt{s} = 11$ GeV are analyzed. The obtained values of the parameters from the invariant mass distribution are consistent with the PDG values. This study shows that the measurement of ϕ-meson is feasible at NICA/MPD.

1. Introduction

The Nuclotron-based Ion Collider fAcility (NICA) is a new accelerator complex being constructed at JINR. The global scientific goal of the NICA/MPD project is to explore the phase diagram of strongly interacting matter in the region of highly compressed baryonic matter. NICA's aim is to provide collisions of heavy ions over a wide range of atomic masses, from Au+Au collisions at $\sqrt{s_{NN}} = 11$ GeV (for Au^{79+}) and an average luminosity of L = 10^{27} cm^{-2} s^{-1} to proton-proton collisions with $\sqrt{s_{pp}} = 20$ GeV and L $\sim 10^{32}$ cm^{-2} s^{-1}. [1]

2. Overview of the MPD detector

The MPD experimental program includes simultaneous measurements of observables that are presumably sensitive to high nuclear density effects and phase transitions. MPD covers a large phase space, comprises high efficiency and excellent particle identification capabilities. The main tracker is the time projection chamber (TPC) supplemented by the inner tracker (IT). IT and TPC provide precise tracking, momentum determination and vertex reconstruction. The high performance time of flight (TOF) system should identify charged hadrons and nuclear clusters in a broad pseudorapidity range. The electromagnetic calorimeter (ECAL) should identify electrons, photons and measure their energy. The zero degree calorimeter (ZDC) should provide event centrality and event plane determination. [2]

3. Motivation for study of ϕ-meson

The ϕ vector meson is the lightest bound state of hidden strangeness. It is expected to have a very small cross-section for interactions with non-strange hadrons. Its observables should remain largely undisturbed by the hadronic rescattering phase of the system's evolution. Previous experimental measurements of the ϕ/K- ratio as a function of centrality showed the possibility of ϕ production via $K^+ + K^-$ coalescence in the hadronic stage. The observed ratios are flat as

a function of centrality. These properties make the ϕ-meson an excellent probe of the hot and dense medium created in nucleus-nucleus collisions. [3, 4, 5, 6]

4. Data set

In this study the channel decay $\Phi \rightarrow K^+K^-$ is chosen to detect the formation of the ϕ-meson. UrQMD event generator is used and Au-Au collisions are generated. The number of the analyzed central events is 300 000 at $\sqrt{s} = 11$ GeV. The detector configuration used in the study includes TPC and TOF for track reconstruction and particle identification.

5. Reconstruction of ϕ-meson

The kaon daughter particles are identified through their ionisation energy loss (dE/dx) in TPC and also measurements in TOF. A selection of kaon pairs by track quality cuts and particle identification (PID) is performed. The invariant mass is calculated by combination of all K^+ and K^- pairs of the same event. Since not all charged kaons in each event originate from ϕ-meson decays, the ϕ-meson extracted signal is above a large combinatorial background of uncorrelated pairs. The mixed-event background distribution is estimated, scaled and subtracted from the signal distribution. The obtained peak from the invariant mass distribution is fitted by a Breit-Wigner function and the characteristics of the ϕ-meson such as its mass and its width are found.

6. Results

The recent results of the ϕ-meson study are shown in Figure 1.The values of the parameters obtained by the Breit-Wigner fit (Width = 4.956 ± 0.245 MeV/c^2 and $M_{inv} = 1019.030 \pm 0.118$ MeV/c^2) are consistent with the values given in literature. All these preliminary results show that the measurement of ϕ-meson is feasible at NICA/MPD.
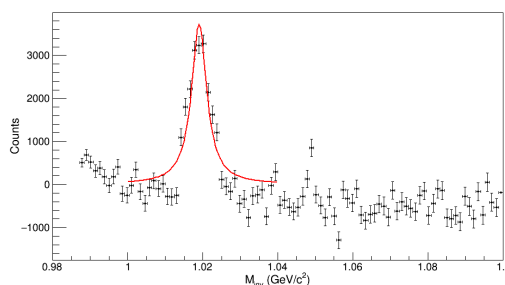

Figure 1. ϕ-meson invariant mass

7. Summary

The current results show that the study of the ϕ-meson is feasible and it can be used to probe the properties of the medium created at NICA/MPD. NICA facilities provide unique capabilities for studying fundamental properties of the theory of strong interactions (QCD).

References

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