A feasibility study of hypernuclei reconstruction at NICA/MPD

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Abstract. One of the main tasks of the NICA/MPD physics program is a study of the strangeness production in nuclear collisions. Heavy strange objects (including hypernuclei) could provide essential signatures of the excited and compressed baryonic matter.

Study of hypernuclei is important for: understanding the strangeness degrees of freedom in hadronic systems; study of all populated regions in the three-dimensional chart of the nuclides; study of hyperon-nucleus and hyperon-hyperon interactions.

The Monte Carlo simulation results presented show that the start version of the MPD detector will provide good conditions for hypernuclei reconstruction in Au+Au collisions at NICA.

1. Detector performance

The main goal of MPD detector is to explore the properties of nuclear matter under extreme density and temperature conditions. To reach this goal, the detector is designed as a 4π spectrometer capable of detecting charged hadrons, electrons and photons in heavy-ion collisions in the energy range of the NICA collider. The detailed description of the MPD geometry can be found in Ref. [1].

The present analysis is based on the detectors covering the mid-rapidity region (|η| < 1.3): the main tracker Time Projection Chamber (TPC) and barrel Time-Of-Flight system (TOF).

The track reconstruction method is based on the Kalman filtering technique and the number of TPC points per track is required to be greater than 10 to ensure a good precision of momentum and dE/dx measurements.

Particle identification (PID) in the MPD experiment will be achieved by combining specific energy loss (dE/dx) and time-of-flight measurements. The basic detector parameters, namely, dE/dx and TOF resolutions σ_{dE/dx} ≈ 6% and σ_{TOF} ≈ 100 ps provide a high degree of selectivity for hadrons at momenta below 2 GeV/c.

2. Event generator and data sets

The MPD software framework MpdRoot[2] is based on FairRoot and provides a powerful tool for detector performance studies, development of algorithms for reconstruction and physics analysis of the data.

The event samples for the present studies have been produced with the DCM-QGSM generator[3] at √s = 5A GeV. The analyzed statistics was 5 · 10^5 and 6 · 10^7 central events (0 − 3 fm) for studies of 3ΛH and 4ΛHe, respectively, corresponding to about 30 minutes and 60
hours of running time at the NICA collision rate of 6 kHz [1]. Produced by the event generators particles have been transported through the detector using the GEANT3 transport package (describing particle decays, secondary interactions, etc.).

3. Results

ΛH and ΛHe hypernuclei were reconstructed using their decay modes into two (2-prong ΛH) or three (3-prong ΛH and ΛHe) charged tracks. The signal event topology (Fig. 1) defines the selection criteria: relatively large distance of the closest approach DCA to the primary vertex of decay products \((dca_{1,2})\), small track-to-track separation in the decay vertex \((dca_{12})\), relatively large decay length of the mother particle \((path)\). Both the DCA and two-track separation cuts are more efficient if applied in \(\chi^2\) - space, i.e if normalized to their respective errors. The reconstruction results are presented in Figs. 2 – 4, where the invariant mass distributions are shown for 2-prong \((\Lambda H \rightarrow ^3\text{He} + \pi^-)\) and 3-prong \((\Lambda H \rightarrow p + d + \pi^-, \Lambda H \rightarrow ^3\text{He} + p + \pi^-)\) decay modes. One can see narrow peaks (\(\sigma\) of the Gaussian fit \(\approx 2\ \text{MeV}/c^2\)) with quite high significance and signal-to-background ratio.

From the results presented (see also [4]) one can conclude that MPD offers good opportunities for studies of heavy strange probes at the NICA collider.

References

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