

A Feasibility Study of Hyperon and Hypernuclei Reconstruction at NICA with BM@N Detector

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Abstract. Heavy strange objects (hyperons and hypernuclei) could provide essential signatures of the excited and compressed baryonic matter. Their reconstruction and identification should be one of the most important tasks of any experiment with heavy ions. At NICA, it is planned to study hyperons both in the collider mode (MPD detector) and the fixed-target one (BM@N setup). The results on Λ , Ξ^- hyperon and ${}^3_\Lambda\text{H}$ hypernuclei reconstruction in Monte Carlo simulated event samples of gold-gold collisions with the BM@N detector are presented.

1. Introduction

At sufficiently high temperature and/or baryon density, which could be realized in heavy ion collisions, the existence of a new phase of matter, the Quark-Gluon Plasma (QGP) is predicted. At these temperatures and densities the excitation of the QCD vacuum can lead to the restoration of chiral symmetry and deconfinement of color charges. These phenomena are the goals for the project Nuclotron-based Ion Collider fAcility (NICA) [1] which is being developed at JINR, Dubna. The project includes design and construction of a heavy ion collider for the energy range $\sqrt{s} = 4\text{--}11$ GeV.

2. BM@N detector

A successful operation of the NICA complex will require the existing machine Nuclotron to be upgraded in order to accelerate Au nuclei. After that, the improved Nuclotron beams will also be used to run a fixed target experiment BM@N [2]. The detector will allow to study A+A collisions by measuring a variety of observables. Particle yields, ratios, transverse momentum spectra, rapidity and angular distributions, as well as fluctuations and correlations of hadrons will be studied as a function of the collision energy and centrality.

A sketch of the proposed experimental set-up is shown in Fig. 1. It combines high precision track measurements with time-of-flight information for particle identification and total energy measurements for event characterization. The charged track momenta and multiplicity will be measured with the set of GEM (Gas Electron Multipliers) detectors located downstream of the target inside the analyzing magnet of 0.8 T and drift chambers (Straw, DCH) situated outside the magnetic field. Design parameters of the time-of-flight detectors based on multigap Resistive Plate Chambers (mRPC-1, -2) with a strip read-out allow efficient discrimination between particle species with momentum up to a few GeV/c. The Zero Degree Calorimeter



(ZDC) is designed for the collision centrality analysis by measuring the energy of forward going particles.

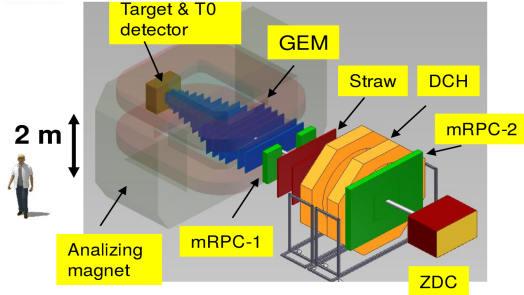


Figure 1. BM@N detector.

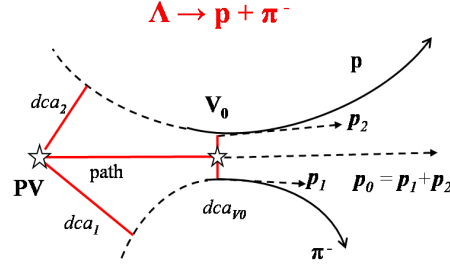


Figure 2. Event topology of a neutral particle two-prong decay.

3. Event samples and results

The study was done for central Au-Au collisions at beam kinetic energy $T_0 = 4.5$ GeV/nucleon ($\sqrt{s} = 3.5A$ GeV). The event samples were produced with the UrQMD [3] and DCM-QGSM (Dubna Cascade Model - Quark-Gluon String Model) [4] generators for hyperon and hypernuclei studies, respectively. Λ hyperons and ${}^3\Lambda\text{H}$ hypernuclei were reconstructed using their decay modes into two charged tracks, while for Ξ^- -hyperons their cascade decay chain into $\Lambda + \pi^-$ ($\Lambda \rightarrow p + \pi^-$) was used. The signal event topology (decay of a relatively long-lived particle into two or more tracks - Fig. 2) defines the selection criteria: relatively large distance of the closest approach ($dca_{1,2}$) to the primary vertex of decay products, small track-to-track separation in the decay vertex (dca_{V0}) and relatively large decay length of the mother particle ($path$).

Figures 3 – 5 illustrate the quality of hyperon and hypernuclei reconstruction in the BM@N detector with the GEM tracker. The results on Λ , Ξ^- and ${}^3\Lambda\text{H}$ reconstruction have been obtained for 10 thousand, 900 thousand and 2.6 million central events, respectively.

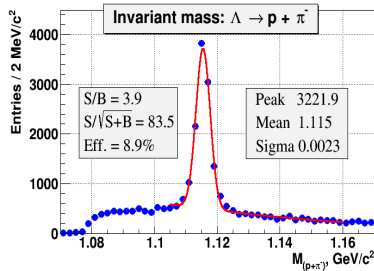


Figure 3. Reconstructed invariant mass of proton and π^- .

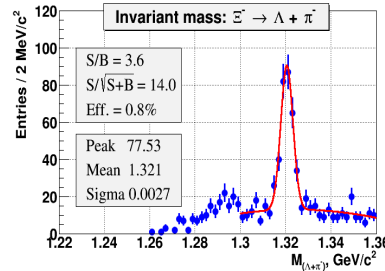


Figure 4. Reconstructed invariant mass of Λ candidate and π^- .

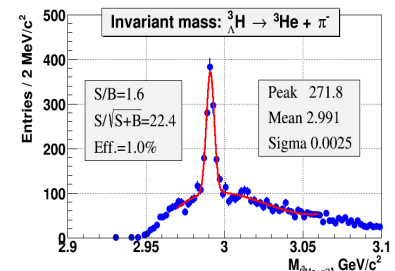


Figure 5. Reconstructed invariant mass of ${}^3\text{He}$ and π^- .

4. Conclusions

It has been demonstrated that the BM@N start version will provide a good opportunity to reconstruct hyperons and hypernuclei with high enough yields.

References

- [1] <http://nica.jinr.ru>
- [2] http://nica.jinr.ru/files/BM@N/BMN_CDR.pdf
- [3] <http://urqmd.org/>
- [4] A. S. Botvina *et al.*, Rhys. Rev. C **84**, 064904 (2011).