Vol. 14 (2021) *Acta Physica Polonica B Proceedings Supplement* No 3

PERFORMANCE OF THE MPD DETECTOR FOR THE STUDY OF MULTI-STRANGE BARYON PRODUCTION IN HEAVY-ION COLLISIONS AT THE NUCLOTRON-BASED ION COLLIDER FACILITY (NICA)*

N. Geraksiev[a,b], V. Kolesnikov[a], V. Vasendina[a], A. Zinchenko[a]

on behalf of the MPD Collaboration

[a]VBLHEP, Joint Institute for Nuclear Research, Dubna, Russia
[b]FPT, Plovdiv University "Paisii Hilendarski", Plovdiv, Bulgaria

(Received February 1, 2021)

Presented are selected results of the Multi-Purpose Detector (MPD) for reconstruction of Λ and Ξ-baryons and K^0-mesons in a Monte Carlo simulation of heavy-ion collisions at the Nuclotron-based Ion Collider fAcility (NICA). The results were obtained from the full MPD simulation and reconstruction chain, and include yields, spectra, and anisotropy coefficients from the centrality selected Au+Au collisions.

DOI:10.5506/APhysPolBSupp.14.529

1. Introduction

The Nuclotron-based Ion Collider Facility (NICA) is a new facility under construction at the Joint Institute for Nuclear Research (JINR) in Dubna, Russia. Heavy-ion collisions at NICA are well suited to investigate fundamental problems of strongly interacting matter such as its equation of state (EOS), bulk properties, and the QCD phase diagram at a region of maximum baryon density [1].

The Multi-Purpose Detector (MPD) is a spectrometer with a large uniform acceptance capable of detecting and identifying hadrons, electrons, and photons at the very high event rate achieved at NICA. The MPD will occupy one of NICA's interaction points and is currently in the development and mass-production stage. Event reconstruction in MPD is expected to provide a high accuracy tracking and particle identification, as well as precise vertexing, collision centrality, and event plane determination [2].

* Presented at NICA Days 2019 and IV MPD Collaboration Meeting, Warsaw, Poland, October 21–25, 2019.

2. Reconstruction of hyperons at MPD

The production of (anti)hyperons is sensitive to the early stage of the collision, thus the degree of partonic collectivity can be tested by means of multi-strange baryon yields, spectra, and anisotropic flow coefficients. Multi-strange baryons can be a valuable probe to test multiple stages of the evolution of a heavy-ion collision [3].

For the study of hyperon decays, a total of 8 million minimum bias events of Au+Au collisions with the energy of $\sqrt{s_{NN}} = 11$ GeV generated by the Parton–Hadron-String Dynamics (PHSD v4) model were used. The realistic simulation was performed with the TPC and TOF sub-detectors. The track acceptance criteria were $|\eta| < 1.3$, $N_{\text{hits}} > 10$, and particle identification was performed by using energy loss in TPC and time-of-flight measurements in TOF as described in [4].

Secondary vertexes are reconstructed using a Kalman filtering algorithm based on the MpdParticle paradigm by combining identified decay products. A set of topological cuts is used to select particles and to optimize them based on signal significance. After an efficiency correction was applied, the transverse momentum distribution for the realistically reconstructed particles was in a very good agreement with the one for true simulated particles as shown in Fig. 1.

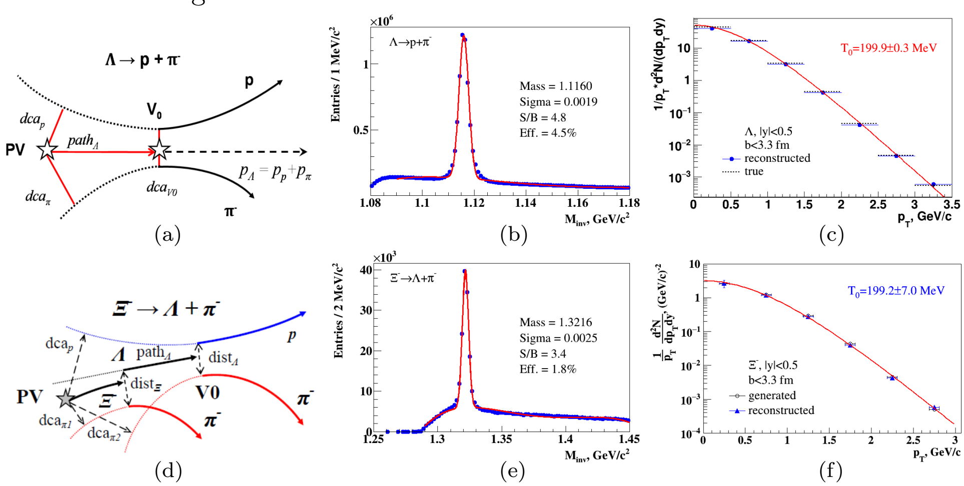

Fig. 1. (a) and (d) — decay schemes, (b) and (e) — reconstructed invariant mass distributions, (c) and (f) — transverse momentum distributions.

3. Anisotropic flow of reconstructed decays at MPD

One of the key areas of interest in heavy-ion collisions is that of the collective dynamics of the resulting system. Due to the initial spatial eccentricity and particle interactions in the formed "fireball", an anisotropy in momentum space arises. This is usually evaluated using a Fourier expansion and the flow coefficients which describe it: $\nu_n = \langle \cos(n(\phi - \Psi_{\mathrm{RP}})\rangle$, where ϕ is the angle of particle momentum and Ψ_{RP} is the reaction plane angle.

In a realistic MPD experiment, the reaction plane is unknown, and instead, an estimated event-plane is used with a resolution correction factor. In this study, the event-plane is determined by energy deposition in the two Forward Hadronic Calorimeters (FHCal), according to the procedure described in [5]. The flow coefficients take the form of $\nu_n = \langle \cos(n(\phi - \Psi_{\mathrm{EP}})\rangle / \mathrm{Res}\{\Psi_n^{\mathrm{EP}}\}$, and Fig. 2 (a) depicts the resolution correction factor applied to the flow coefficient calculation as a function of centrality.

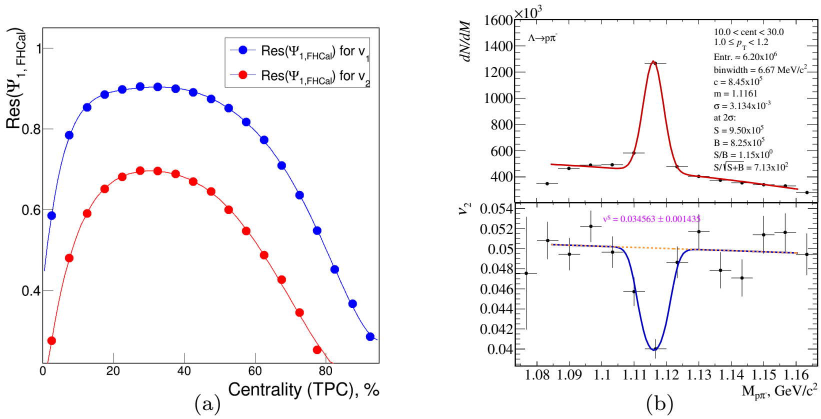

Fig. 2. (a) Resolution correction factor, (b) elliptic flow extraction in a p_{T} bin: (top) invariant mass, (bottom) fit of flow *versus* M_{inv}.

For the study of anisotropic flow of decays, a total of 25 million minimum bias events of Au+Au collisions with the energy of $\sqrt{s_{NN}} = 11$ GeV generated by the Ultra-Relativistic Quantum Molecular Dynamics (UrQMD v3.4) model were used in a non-hydrodynamic configuration, along with the MPD realistic simulation based on Geant4, including the TPC, TOF and FHCal systems. The events falling within 10 to 30 percent centrality classes window based on multiplicity in TPC were selected for the flow analysis. The realistic decay reconstruction was done as described in the previous section.

For the flow signal extraction of the reconstructed decays, a simultaneous fit on the flow coefficient *versus* invariant mass profile distribution was performed. The background was estimated by a linear function fitted to the sidebands region of the profile distribution. The resulting fit function $\nu_n^{\mathrm{SB}}(m, X) = \nu_n^{\mathrm{S}}(X)\frac{N^{\mathrm{S}}(m,X)}{N^{\mathrm{SB}}(m,X)} + \nu_n^{\mathrm{B}}(m, X) \times \frac{N^{\mathrm{B}}(m,X)}{N^{\mathrm{SB}}(m,X)}$ contains the flow signal ν_n^{S} as a fit parameter. This procedure was repeated in each bin of interest along X and thus, a differential dependence of the flow coefficient was extracted; Fig. 2 (b) illustrates the procedure, and the final results shown in

Fig. 3 demonstrate a good agreement between extracted flow parameters of reconstructed particles and that of the generated model.

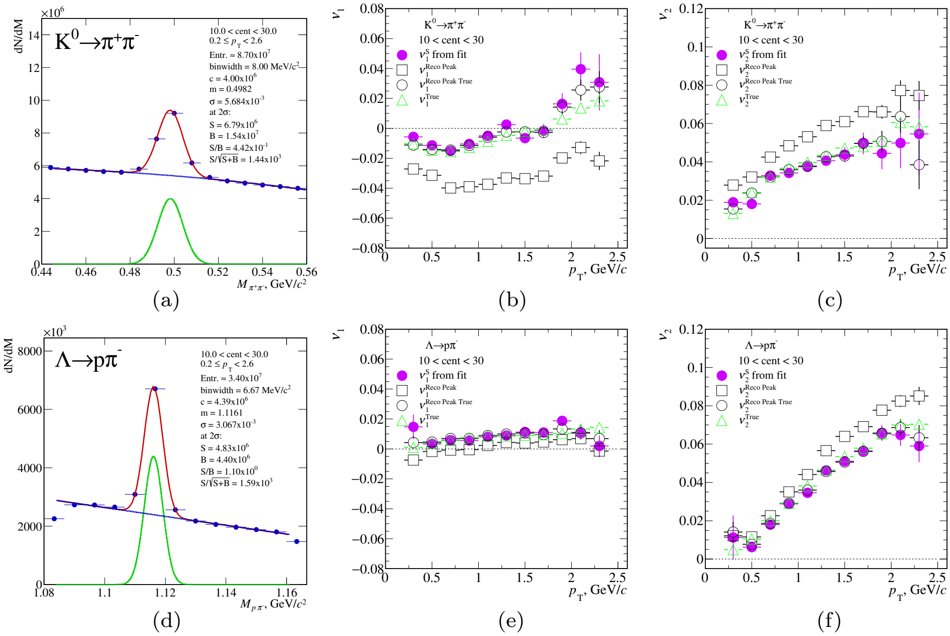

Fig. 3. (a) and (d) — reconstructed invariant mass plots in full p_{T} region under study; (b), (c), (e) and (f) — flow coefficients *versus* p_{T}. Legend: □ — reco flow at the signal peak (SP); ◦ — reco and true flow at SP; △ — true flow from model; • — extracted flow parameter.

In summary, the MPD detector provides good tracking and particle identification performance. The study of multi-strange baryon production and anisotropic flow at NICA was presented. Both the transverse momenta slope parameters and flow coefficients of the reconstructed particles were analyzed. The model-generated values were in good agreement with the reconstructed results. In order to achieve this, an efficiency and acceptance correction was applied and a flow-signal-extraction procedure was developed.

REFERENCES

[1] V.D. Kekelidze *et al.*, *JINST* **12**, C06012 (2017).

[2] V. Golovatyuk *et al.*, *Eur. Phys. J. A* **52**, 1 (2016).

[3] J. Drnoyan *et al.*, *Phys. Part. Nucl. Lett.* **17**, 32 (2020).

[4] A.A. Mudrokh, A.I. Zinchenko, *J. Phys.: Conf. Ser.* **798**, 012071 (2017).

[5] P. Parfenov *et al.*, *KnE Energy* **3**, 352 (2018).