Production of Λ and $\overline{\Lambda}$ in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV at RHIC

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Introduction

The early production of $\Lambda(\overline{\Lambda})$ in heavy-ion collisions provides valuable insight into the properties of the medium created in these collisions [1]. Measurements from the RHIC Beam Energy Scan (BES) program phase-I have already shown some hints for increasing dominance of hadronic interactions and the turn-off of the signatures of quark-gluon plasma at low energies. However, the data precision during BES-I is not high enough to draw definite conclusions [2]. The BES-II program, with high statistics sample and detector upgrades, allows us to improve the measurements in the energy range of $\sqrt{s_{NN}} \leq$ 19.6 GeV. In particular, the upgrade of the inner sectors of the Time Projection Chamber (iTPC) [3] provides a wider rapidity coverage, lower p_T cutoff, better momentum and dE/dx resolution. The improved acceptance of the iTPC at low momentum and the enhanced tracking efficiency are of particular interest for the reconstruction of strange and multi-strange baryons.

Analysis details and techniques

A successful run of Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV was carried out in 2019. A total of $\sim$ 770 M good events have been selected for the reconstruction of Λ and $\overline{\Lambda}$. $\Lambda(\overline{\Lambda})$ is a weakly decaying particle. It travels a certain distance (cτ = 7.89 cm) and then decays into stable daughter particles like protons and π ($\Lambda \longrightarrow$ p π, 63.9 %). The decay topology of Λ and $\overline{\Lambda}$ can be used for their reconstruction by cutting on topological variables to suppress the background.

We use a double Gaussian and second order polynomial function to determine the mean and the width of the invariant mass peak of $\Lambda(\overline{\Lambda})$. The residual background left after applying the topological cuts is estimated by the polynomial fit function and the raw yield is determined using the signal counting method under the mass window of $\pm3\sigma$, where σ is the width. Figure 1 shows the invariant mass distribution of Λ along with the fitting results at $\sqrt{s_{NN}}$ = 19.6 GeV in Au+Au collisions at mid-rapidity (|y| < 0.5).

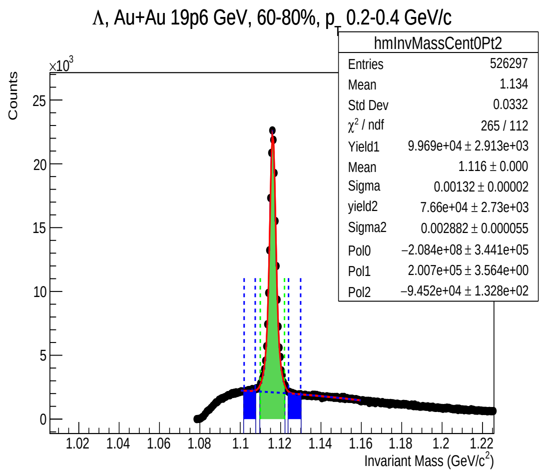

FIG. 1: Λ invariant mass distribution for the p_T bin of [0.2,0.4] GeV/c in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV. The combinatorial background is fit with a polynomial function. The vertical green lines and the green area represent the signal peak region under the mass window of $\pm3\sigma$ while the blue lines and blue area on both sides define the side-band regions.

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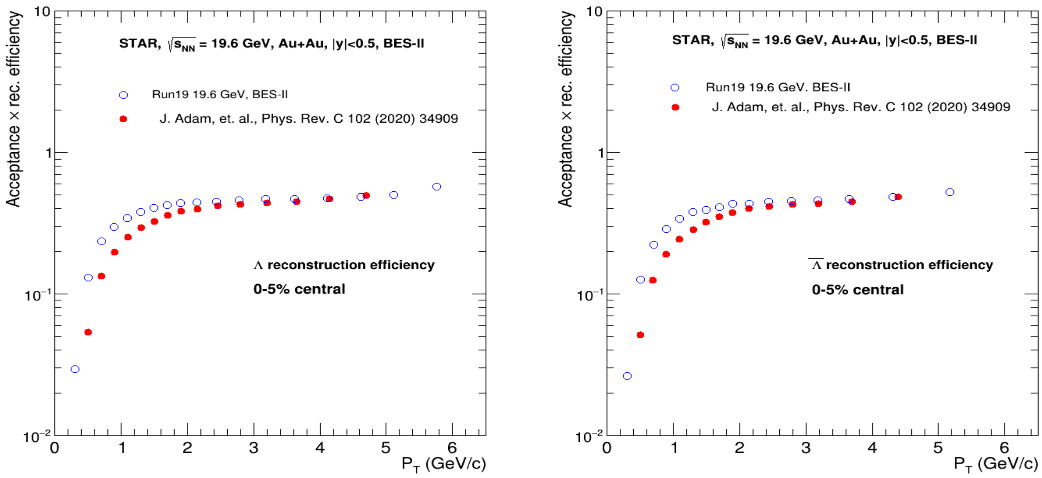

FIG. 2: The acceptance × reconstruction efficiencies of Λ (left panel) and $\overline{\Lambda}$ (right panel) at mid-rapidity (|y| < 0.5) in 0-5% most central Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV. The open circles in both panels represent reconstruction efficiencies of $\Lambda(\overline{\Lambda})$ from BES-II analysis and the solid red circles represent the reconstruction efficiencies of $\Lambda(\overline{\Lambda})$ from BES-I analysis. The iTPC upgrade significantly enhances the reconstruction efficiency at low p_T region in BES-II.

$\Lambda(\overline{\Lambda})$ reconstruction efficiency

To study the tracking efficiency, embedding data are used in the STAR experiment where simulated particles are embedded into real data. The acceptance and reconstruction efficiency of Λ and $\overline{\Lambda}$ are calculated by diving the number of reconstructed Monte Carlo (MC) $\Lambda(\overline{\Lambda})$ by that of input MC ones. The same event and track selection cuts are applied to the embedding data as those used in data analysis. Figure 2 shows the acceptance × reconstruction efficiencies of Λ and $\overline{\Lambda}$ plotted against p_T (in GeV/c) in the most central Au+Au collisions at mid-rapidity (|y| < 0.5). It also shows a comparision of the reconstruction efficiencies of Λ and $\overline{\Lambda}$ with that of BES-I analysis [2]. The iTPC upgrade significantly improves the reconstruction efficiency towards the low p_T region.

Conclusion

The invariant mass distribution and the reconstruction efficiencies of Λ and $\overline{\Lambda}$ at mid-rapidity (|y| < 0.5) in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 GeV (BES-II) are presented. It is observed that thanks to the iTPC, the reconstruction efficiency of Λ and $\overline{\Lambda}$ increases by a significant amount towards the low p_T region in comparision to the previous BES-I analysis.

Acknowledgment

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References

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