Monte-Carlo simulation of Y(4260) state using PANDAROOT

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Introduction

The exotic charmonium like state Y(4260) was first time observed by the BABAR Collaboration in the initial state radiation process: $e^+e^- \to \gamma_{ISR}\pi^+\pi^- J/\psi$ [1]. It was confirmed by the CLEO and BELLE Collaboration. Many suggestions have been made for its structure likes a tetra-quark state, a hadronic molecule, hybrid charmonium or charm baryonium etc. Interestingly BESIII collaboration has given preliminary experimental evidence of this state containing more quarks than just a charm and anticharm quark [2]. For the proper understanding of the Y (4260) state, it would be necessary to study other possible decay mode and determine its properties in detail.

The $\bar{\text{P}}$ANDA (antiProton ANnihilation at DArmstadt) is a future experiment design for the Facility for Antiprotron and Ion Research (FAIR) at Darmstadt, Germany. In $\bar{\text{P}}$ANDA experiment the antiprotron beam with energy 1.5 to 15 GeV will interact with a liquid hydrogen target [3]. The antiprotron beam momentum range is suitable for study of Y(4260) state. The $\bar{\text{P}}$ANDA detector is a fixed target multipurpose detector designed to obtain nearly 4π solid angle coverage with high particle tracking and identification capacity. There are also different implemented subdetectors like Electromagnetic Calorimeter (EMC), Micro Vertex Detector (MVD) etc.

PANDAROOT is offline framework for $\bar{\text{P}}$ANDA experiment which is based on virtual Monte-Carlo concept, the object oriented data analysis framework ROOT, transport models GEANT3/GEANT4 and event generators EvtGen/DPM, which are used for simulation and analysis [4]. Using these tools $\bar{\text{P}}$ANDA experiment will be able to obtain high precision data on charmonium like states and measure their masses, widths and excitation curves with high precision. We have studied Y(4260) state using Monte-Carlo simulation technique for the $\bar{\text{P}}$ANDA experiment and some preliminary results are presented here.

Simulation and Analysis

We have studied two decay channel for Y(4260) resonance:
$\bar{p}p \to Y(4260) \to J/\psi\pi^+\pi^- \to e^+e^-\pi^+\pi^-$
$\bar{p}p \to Y(4260) \to J/\psi K^+K^- \to e^+e^-K^+K^-$
For each decay channel we have simulated 10,000 Monte-Carlo events using PANDAROOT framework. The centre mass energy is corresponding to Y(4260) resonance. The events are generated with an event generator *EvtGen*, the generated particles are transported through $\bar{\text{P}}$ANDA detector using the transport model GEANT3 and get detector response (hits-interaction points). These hits are converted to digital form (xyz-coordinate) in digitization step, after that we perform reconstruction and identification of the particle candidates for the physics analysis.

Final stage particles $e^\pm$, $\pi^\pm$ and $K^\pm$ are identify from likelihood based selection algorithm, which use information of the MVD, STT, DIRC, EMC and muon detector. We have applied electron/pion discrimination to classify all $e^\pm$ and $\pi^\pm$ present in the events. All combinations of one electron and one positron candidate in the same event were used to calculate the two particle invariant mass. From $e^\pm$ pair we reconstruct J/ψ mass and apply mass cut from 2.6 GeV to 3.4 GeV to remove the background as shown in Fig.1.

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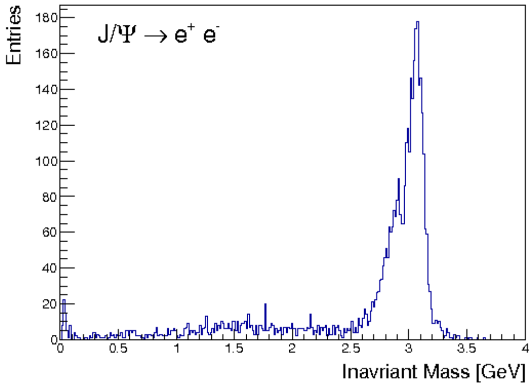

FIG. 1: Invariant mass spectrum for J/ψ

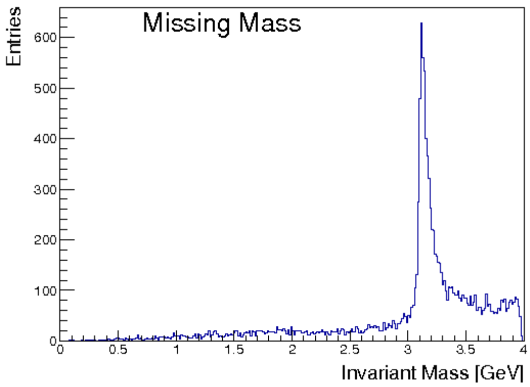

FIG. 2: Invariant mass spectrum for Missing Mass

We have calculated missing mass for $\pi^{\pm}$ and if this value falls in J/ψ mass region with mass range from 2.95 GeV to 3.35 GeV than it is selected as pion candidate as shown in Fig.2. If the event contained one or more suitable J/ψ candidates and at least one possible $\pi^+\pi^-$ pair with a missing mass than this event is used to construct Y(4260) candidate which is shown in Fig.3. The mean invariant mass value determined from above is 4.149±0.004 GeV.

Similarly we have done analysis for second decay channel: $\bar{p}p \rightarrow Y(4260) \rightarrow J/\psi K^+K^- \rightarrow e^+e^-K^+K^-$ using the same method and reconstruct Y(4260) candidates for that channel, which is shown in Fig.4. The mean invariant mass value determined from above is 4.060±0.000 GeV.

Conclusion

We have performed Monte-Carlo simulation for the Y (4260) resonance state using PANDAROOT framework and reconstructed the intermediate and final state particles. The background studies for this state are in progress. The signal and background results can be used for width and branching fraction study.

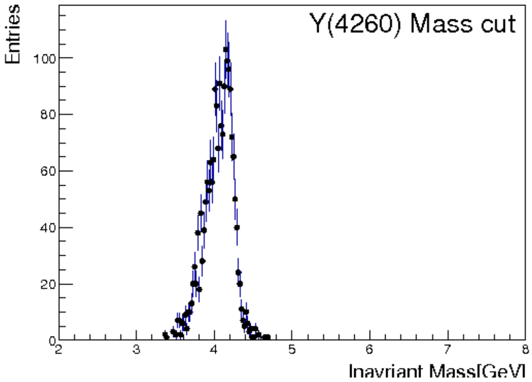

FIG. 3: Invariant mass spectrum for $Y(4260) \rightarrow J/\psi\pi^+\pi^-$

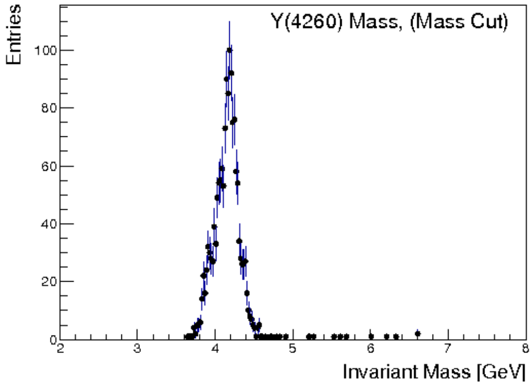

FIG. 4: Invariant mass spectrum for $Y(4260) \rightarrow J/\psi K^+K^-$

References

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