Monte Carlo Simulation of Y(4260) State Using PANDAROOT

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Introduction

The P̄ANDA (antiProton ANnihilation at DArmstadt) experiment is a next generation hadron physics detector under design for the Facility for Antiproton and Ion Research (FAIR) at Darmstadt, Germany. In P̄ANDA experiment $\bar{p}$ with energies 1.5 to 15 GeV will interact with a liquid hydrogen target in a storage ring (HESR) with high luminosity. The charge and neutral decay products will be detected in a 4π-P̄ANDA detector [1]. The experiment is focusing on hadron spectroscopy search for exotic states in the charmonium region like X(3872), Y(4140), Y(4260) etc, the $\bar{p}$ beam momentum range is suitable for it. In $p\bar{p}$ interactions, direct formation is possible for all the states with different quantum numbers through coherent annihilation of the three quarks of the protons with the three antiquarks of the antiproton. P̄ANDA will be able to obtain high precision data on charmonium states and measure their masses, widths and excitation curves with high precision.

The charmonium like state Y(4260) was found by the BABAR Collaboration in a study of the $e^+e^- \rightarrow \pi^+\pi^- J/\psi$ process using initial state radiation, here assuming that a resonance with 4.26 GeV of mass and 50 to 90 MeV of width [2]. It was confirmed by the CLEO Collaboration. A interpretation of this state is not clear, many suggestions have been made for it like a tetra - quark state, a hadronic molecule of D_1D, D_0D^*, hybrid charmonium or charm baryonium etc. [3]. We have studied this state using Monte Carlo simulation tools for P̄ANDA experiment and presented here some preliminary results.

Simulation Details

PANDAROOT is an offline framework based on EVTGEN, ROOT, GEANT3 and GEANT4 for P̄ANDA Detector [4], which is useful for large scale simulation and analysis. There are also different implemented subdetectors like Time Projection Chamber (TPC), Micro Vertex Detector (MVD), Electromagnetic Calorimeter (EMC) etc. [1].

Using these tools we have simulated 20000 events for $p\bar{p} \rightarrow J/\psi\pi^+\pi^-$ with the centre of mass energy corresponding to Y(4260) resonance, where J/ψ further decay to $\mu^+\mu^-$. Here, charged $\pi^\pm$ and $\mu^\pm$ are identified by mass hypothesis (the energy component of all particles in the list will be set to a value corresponding particle mass). Here, J/ψ is reconstructed using invariant mass of $\mu^\pm$ pair. By adding J/ψ and $\pi^\pm$ mass we have reconstructed Y(4260) resonance state. We have applied following kinematic fitting algorithms to improve the quality of the reconstructed objects which are used to reject some background:

[1] 4-Constraint Fit: A constraint to the energy-momentum conservation between the mother resonance and final state particles.

[2] Mass Constraint Fit: The invariant mass candidates to find out which and how many candidates are rejected and how many are accepted under this hypothesis.

Results

The reconstructed $\mu^+\mu^-$ invariant mass is shown in Fig 1. It is also fitted with 4 - Constraint (4-C) fit as shown in Fig. 2. By adding J/ψ mass and $\pi^\pm$ mass we get Y(4260) state mass, which is shown in Fig. 3 and it is fitted with Mass constraint fit as shown in Fig. 4.

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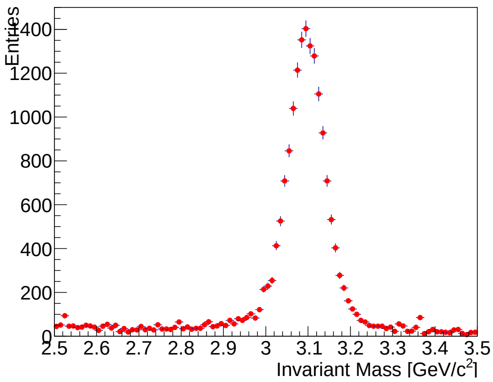

FIG. 1: Invariant mass of J/ψ state [W/O Fit].

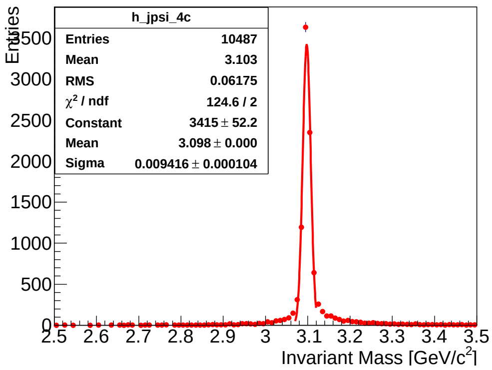

FIG. 2: Invariant mass of J/ψ state [4-C Fit].

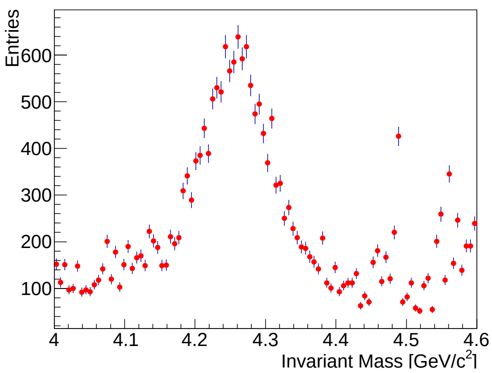

FIG. 3: Invariant mass of Y(4260) state [W/O Fit].

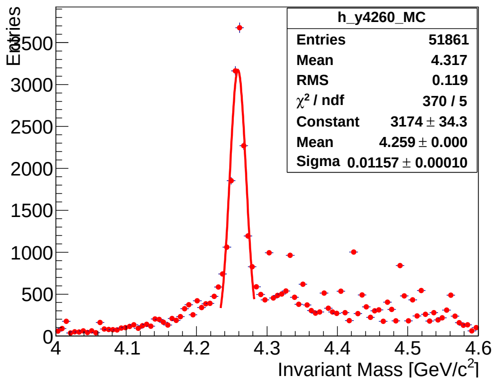

FIG. 4: Invariant mass of Y(4260) state [Mass Constraint Fit].

Conclusion

Using the PANDAROOT framework we have studied Monte Carlo simulation for Y(4260) state with corresponding decay channels and obtained invariant mass of the decay particle and final state. Similarly we can also simulate it for different decay channels and study different properties of states like decay width, branching ratio etc.

References

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