Weekly Report

Precision measurement of Branching fraction of the $J/\psi \to \phi\pi^0$, $\phi \to K^+K^-$, and $\pi^0 \to \gamma\gamma$

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Introduction

- Report the first observation of $J/\psi \to \phi\pi^0$ based on a sample $(1.31 \pm 0.011) \times 10^9$ J/ψ events accumulated with BESIII Detector located in BEPC, which is a double ring e^+e^- collider with a design peak luminosity of $10^{33} cm^{-2}s^{-1}$ at the c.m. energy of 3.773 GeV..

$$\begin{cases} e^+e^- \to J/\psi \to K^+K^-\pi^0, \text{(Signal)} \\ e^+e^- \to \gamma^* \to K^+K^-\pi^0. \text{(Background)} \end{cases}$$

  - These final state already studied in DOI 10.1103/PhysicsRevD.91.112001,
  - Measured values of the branching fraction of $J/\psi \to \phi\pi^0$, $[2.94 \pm 0.16(\text{stat}) \pm 0.16(\text{sys})] \times 10^{-6}$ and $[1.24 \pm 0.33(\text{stat}) \pm 0.30(\text{sys})] \times 10^{-7}$.
- Motivation
  - To study this final state with including more statistics, and adding more backgrounds $\psi'(2S) \to \pi^+\pi^- J/\psi$ (2S: state of $c\bar{c}$ quark pair).
  - Expect to get precise measurement of this branching fraction.

Data and MC samples

=> In the decay chain, $\psi(3686) \to \pi^+\pi^- J/\psi, \phi \to K^+K^-, \pi^0 \to \gamma\gamma$

- DST files of $\psi(3686)$ 2009, 2012, and 2021, with BOSS version 709,
- Inclusive MC simulated data of $\psi(3686)$ (2009, 2012, and 2021).
- Generate signal sample data using BesEvent.

=> 2009: 0.225×10^9 J/ψ at $Ecm = 3.097, 0.106 \times 10^9$ $\psi(3686)$ at $Ecm = 3.686\,\text{GeV}$

=> 2012: 1.3×10^9 J/ψ at $Ecm = 3.097, 2009(0.225 \times 10^9), 0.5 \times 10^9 \psi(3686)$ at $Ecm = 3.686 GeV, 2009(0.106 \times 10^9)$,

Event selection

- Each charged particle with opposite charge (MDC): $|cos\theta| < 0.93, |R_{xy}| \leq 1\,\text{cm}, |R_z| \leq 10\,\text{cm}$.
- PID: Prob(π) > Prob(K),
- Each photon

$$\begin{cases} E_{emc} \geq 0.025\,\text{GeV}, |cos\theta| < 0.8\,\text{or}, \\ E_{emc} \geq 0.050\,\text{GeV}, 0.86 < |cos\theta| < 0.92. \end{cases}$$

- Isolated showers: $\theta_r \geq 20^\circ$.
- a good pair of pions ($\pi^+\pi^-$):

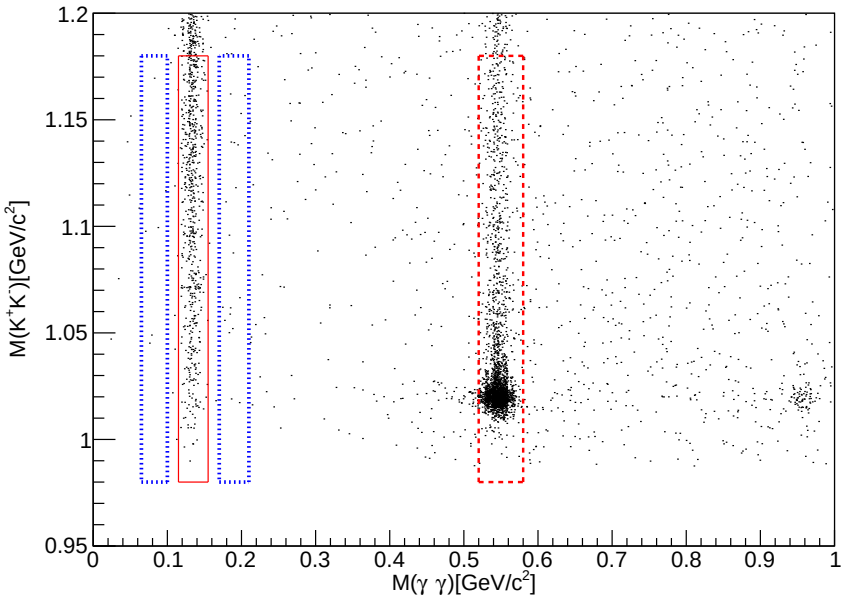
$$\begin{cases} cos\theta_{\pi^+\pi^-} < 0.8 \\ 3.0 \leq M^{\text{Rec}}_{\pi^+\pi^-} \leq 3.2\,\text{GeV}/c^2 \text{ where, } M^{\text{Rec}}_{\pi^+\pi^-} = \sqrt{[P_{\text{emc}} - (p_{\pi^+} + p_{\pi^-})]^2} \end{cases}$$

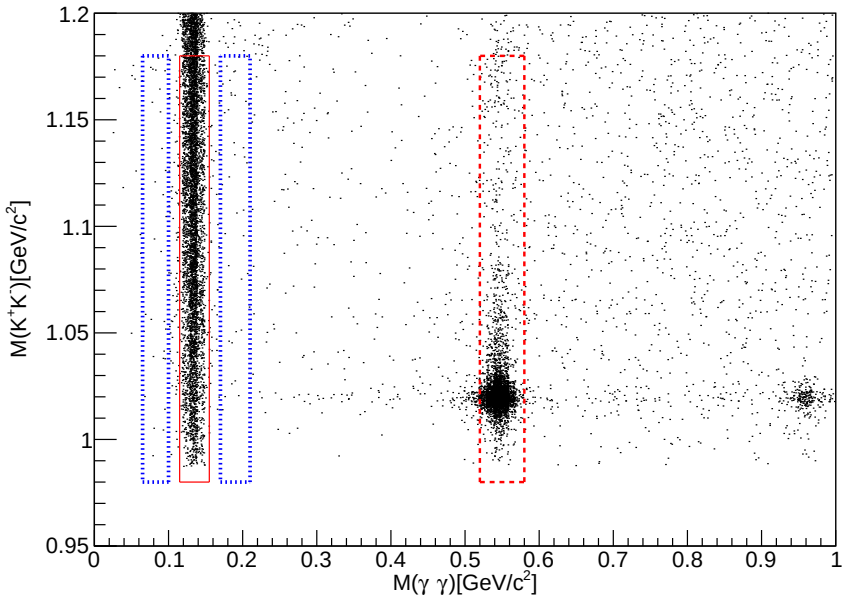
- Prob: $\begin{cases} TkProb(K^\pm) < 0.001 \\ TkProb(K^\pm) < TkProb(p) \\ TkProb(K^\pm) < TkProb(\pi) \end{cases}$

Results

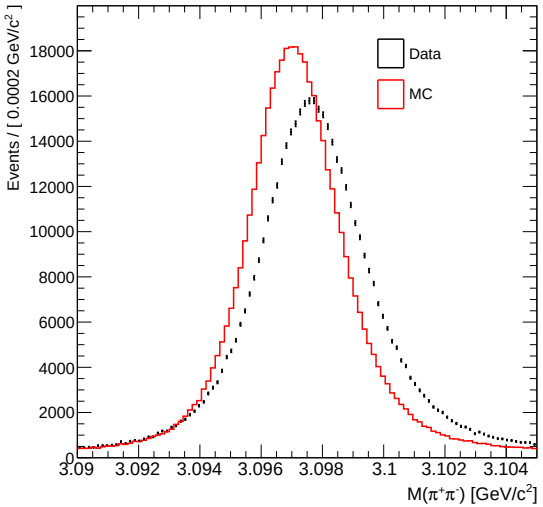
MC vs Data (Distribution)

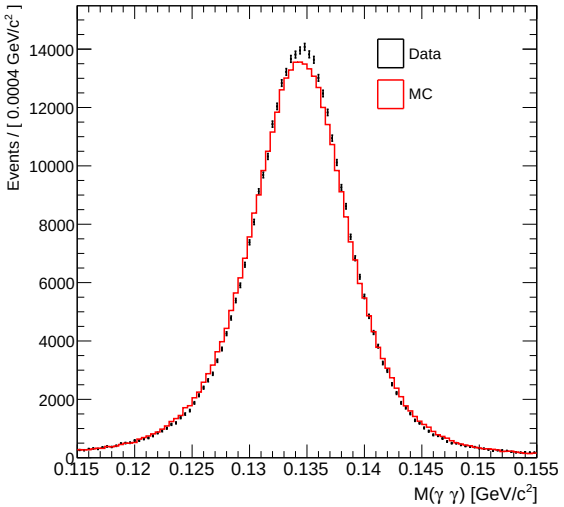
- $\psi' \to K^+K^-\pi^+\pi^-(\pi^0 \to \gamma\gamma \text{ or } \eta \to \gamma\gamma)$
  - For $J/\psi \to \phi\pi^0 \to K^+K^-\gamma\gamma$, $\chi^2_{4C} < 30$.

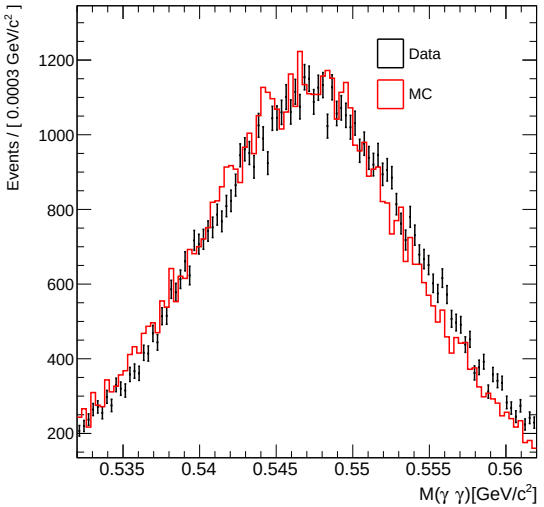




Data vs MC comparison

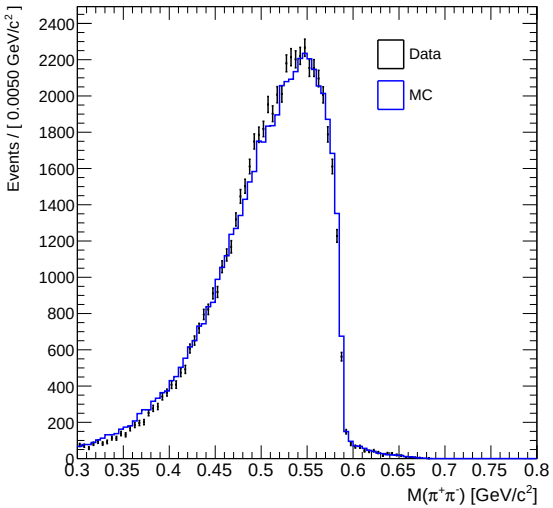


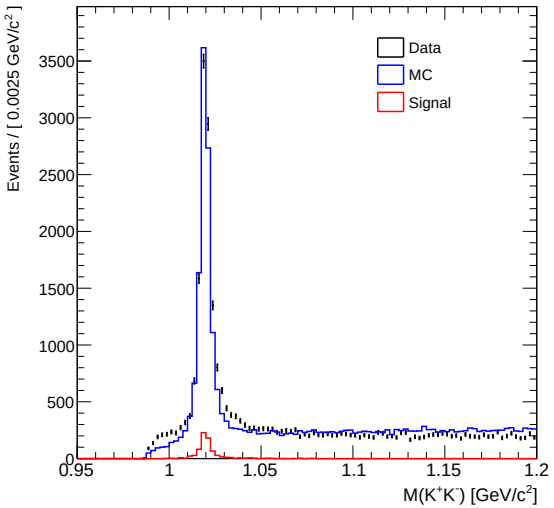


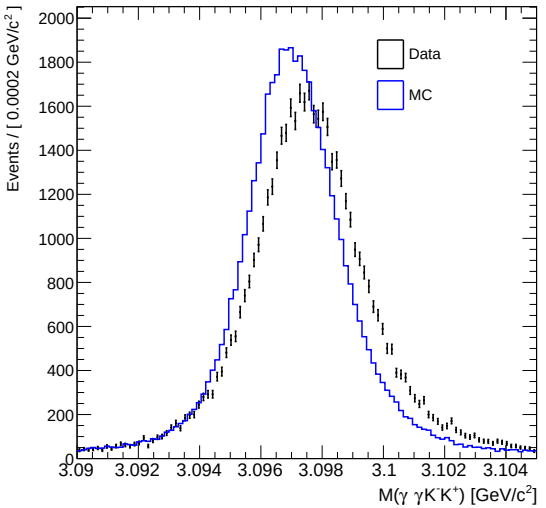


- These plots : $\psi(2S) \to K^+K^-\pi^+\pi^-\gamma\gamma$,
  - Data (black) and MC (red) curves,
  - Left: invariant mass of $\pi^+\pi^0$, $3.0 \leq M^{\text{Rec}}_{\pi^+\pi^-} \leq 3.2\,\text{GeV}/c^2$ where, $M^{\text{Rec}}_{\pi^+\pi^-} = \sqrt{[P_{\text{ecm}} - (p_{\pi^+} + p_{\pi^-})]^2}$
  - Middle: the invariant mass of $\gamma\gamma$, $(\pi^0 \to \gamma\gamma)$ where, $0.115 \leq M_{\gamma\gamma} \leq 0.155\,\text{GeV}/c^2$
  - Right: the invariant mass of $\gamma\gamma$, $(\eta \to \gamma\gamma)$ where, $0.532 \leq M_{\gamma\gamma} \leq 0.567\,\text{GeV}/c^2$

Data vs MC distribution

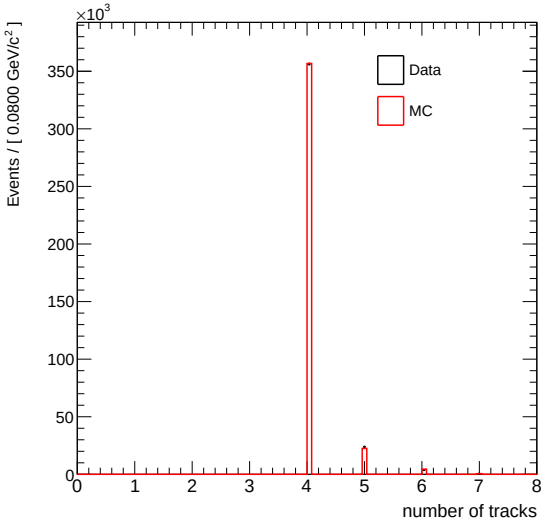


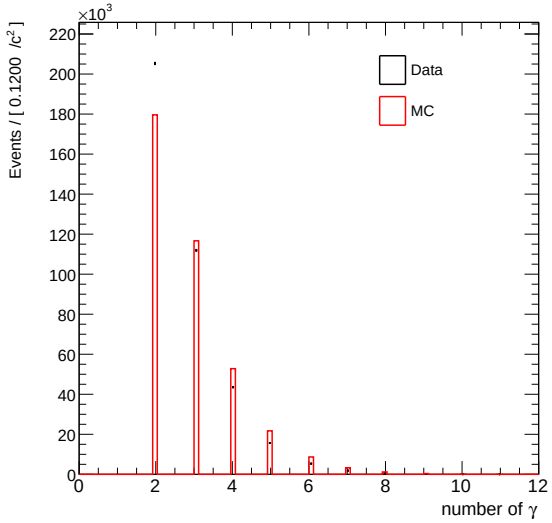




- Data (black) and MC (blue) curves,
- Left: invariant mass of a good pair of $\pi^+\pi^0$, $0.3 \leq M^{\text{Inv}}_{\pi^+\pi^-} \leq 0.6\,\text{GeV}/c^2$
- Middle: the invariant mass of K^+K^- where, $M_{K^+K^-} \leq 1.2\,\text{GeV}/c^2$
- Right: the invariant mass of $K^+K^-\gamma\gamma$, $3.09 \leq M_{K^+K^-\gamma\gamma} \leq 3.105\,\text{GeV}/c^2$,

Data vs MC distribution





Summary

=> Work is still in progress,

- Generated MC Samples,
- Encrease data sample from to get more accurancy and efficiency results needed.
- Looked in to different kinematic distribution for $\psi' \to \pi^+\pi^- J/\psi$ decays selection.
- Applied some cuts to get most validated results needed.

=> Outcomes and next plans

- Improve measurements of B($J/\psi \to \phi\pi^0$) based on this selected events.