Study of X(3872) and X(3915)

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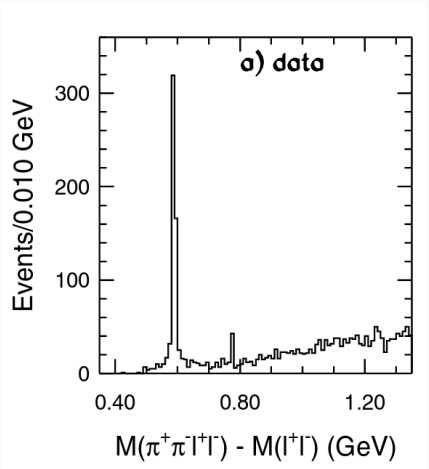
Motivation

- By 1960s hundreds of particles were known and considered them to be distinct elementary particles.
- In 1964 Gell-Mann and Zweig independently developed quark model and explained it as the fundamental elementary particles[Phys.Lett. 8(1964)].
- All the hadrons we observed were either mesons $[q\bar{q}]$ or baryons $[qqq]$.
- In the last decade, states which does not fit into this conventional model have been observed. In 2003 Belle observed X(3872) as a narrow peak in the $J/\psi\pi^+\pi^-$ invariant mass in $B^+ \to J/\psi\pi^+\pi^- K^+$ decay[PhysRevLett.91.262001(2003)].



Motivation

- X(3872) decayed as ψ'.
  - Is it just a charmonium?
- Its mass is very close to the $D^0\bar{D}^{*0}$ threshold. No $c\bar{c}$ is expected to be of this mass.
- Theoretical predictions for the nature of X(3872) are
  - Charmonium hybrid state
  - $D^0\bar{D}^{*0}$ molecule
  - Tetraquark
  - Admixture of charmonium and $D^0\bar{D}^{*0}$ molecule

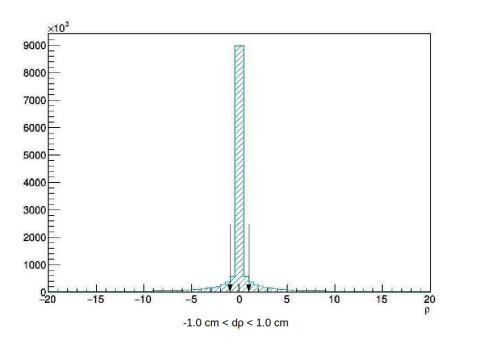
$X(3872) \to J/\psi\omega$ was first seen in $B \to (J/\psi\omega)K$ by Belle [arXiv:hep-ex/0505037] and later confirmed by BaBar[arXiv:1005.5190]. This decay mode is crucial in understanding the nature of $X(3872)$. We are performing this study with the full Belle $\Upsilon(4S)$ data (which is almost twice of BaBar).
Further $X(3915) \to J/\psi\omega$ can also be studied along with $X(3872)$ [arXiv:1207.2651].

Reconstruction

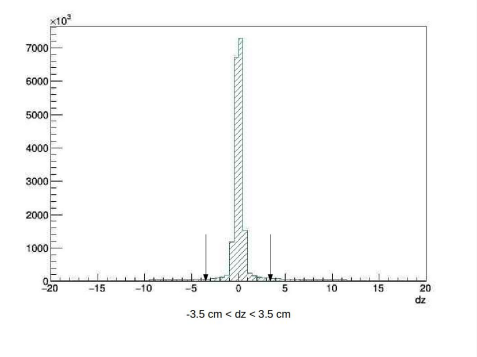
- Generated 1 million events for
  - $B \to J/\psi\omega K$
  - $B \to X(3872)K$
  - $B \to X(3915)K$
- Reconstruction of B is done from $l^+, l^-, \pi^+, \pi^-, \gamma, \gamma, K$.
  - $B \to J/\psi\omega K$ and $J/\psi \to l^+l^-$, $\omega \to \pi^+\pi^-\pi^0$, $\pi^0 \to \gamma\gamma$.
- Cuts and criterions
  - $R_2 < 0.5$
  - $|dr| < 1.0cm$
  - $|dz| < 3.5cm$
  - $Kid > 0.6$
  - $\pi id > 0.6$

DZ AND DR

- dr and dz

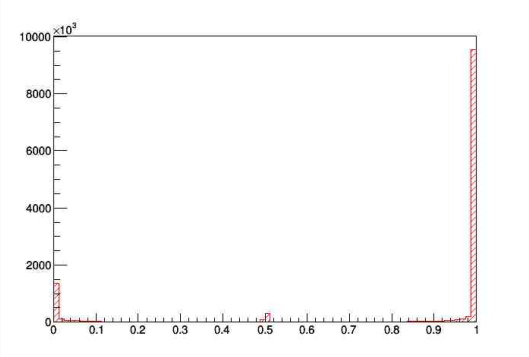


(a) -1.0 cm < dr < 1.0 cm

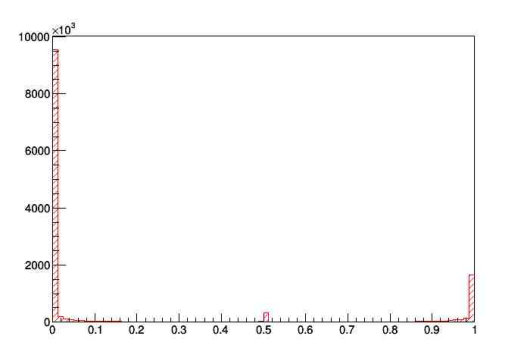


(b) -3.5 cm < dz < 3.5 cm

- π/K selection
  Tracks with $R_\pi > 0.6$ are identified as π candidates. Tracks with $R_K > 0.6$ are selected as K candidates



(c) R_π



(d) R_K

B candidate identification

- Energy difference

$$\Delta E = E_{beam} - E_B \tag{1}$$

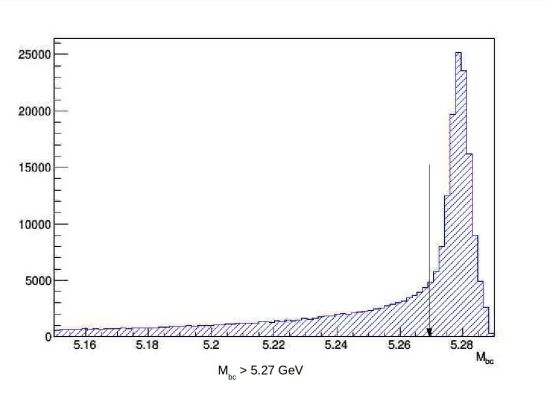
  At $\Upsilon(4S)$, $B\bar{B}$ mesons are produced with no accompanying particles. So each B meson has a total CMS energy equals to E_{beam}.

- Beam constrained mass, M_{bc}
  We identify B meson using the beam constrained mass

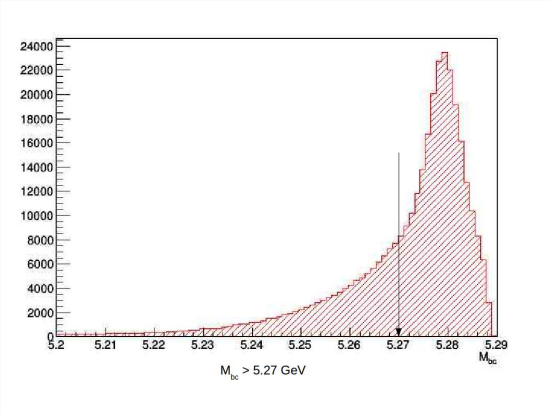
$$M_{\mathrm{bc}} = \sqrt{E^2{}_{beam} - p^2{}_B} \tag{2}$$

- Best candidate selection
  We expect one B candidate of interest per event. However due to fake combinations, we are getting multiple candidates. In case of multiple candidates, we select the best candidate having the M_{bc} closest to the nominal B mass (5.279 GeV/c^2)

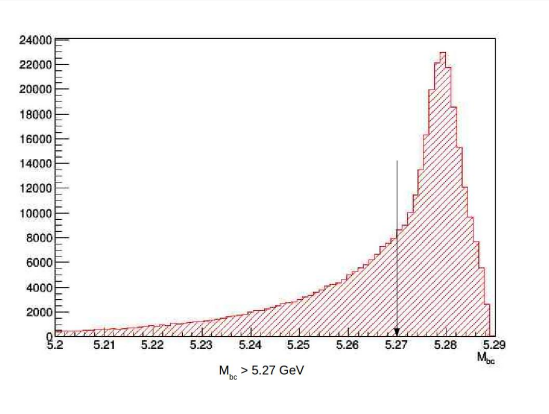
M_{bc} AND ΔE



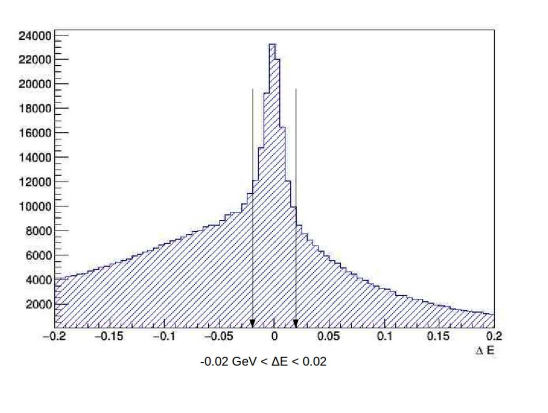
(e) $B \to J/\psi\omega K$



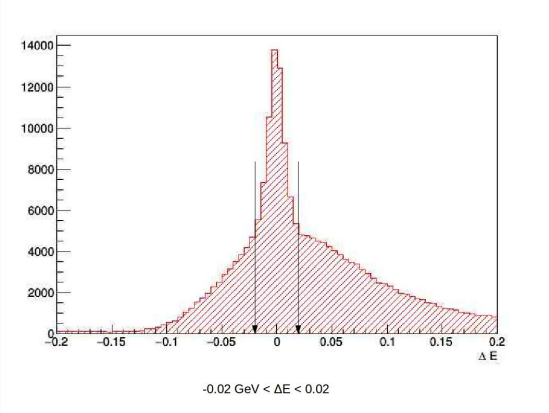
(f) $B \to X(3872)K$



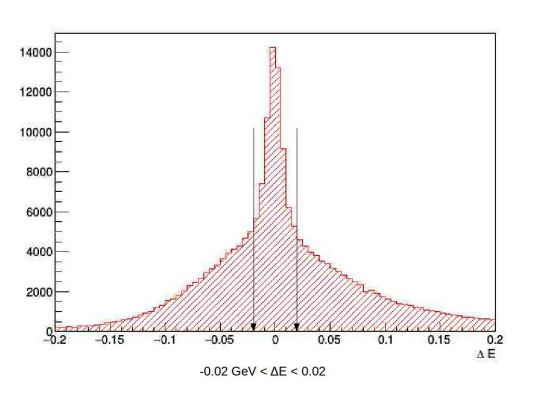
(g) $B \to X(3915)K$



(h) $B \to J/\psi\omega K$



(i) $B \to X(3872)K$



(j) $B \to X(3915)K$

Invariant mass distribution ($M_{J/\psi\omega}$)

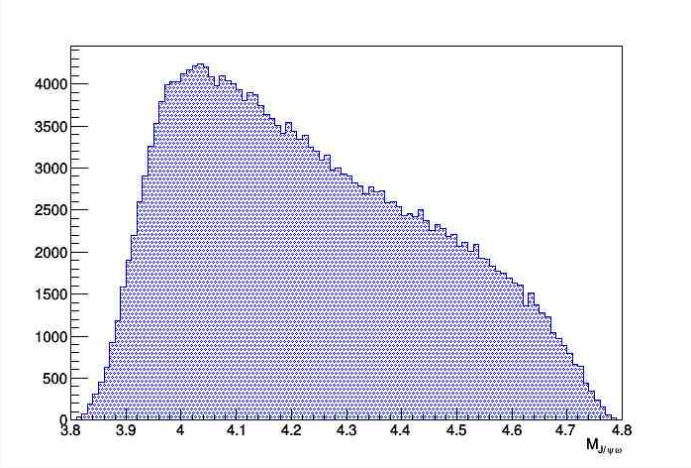
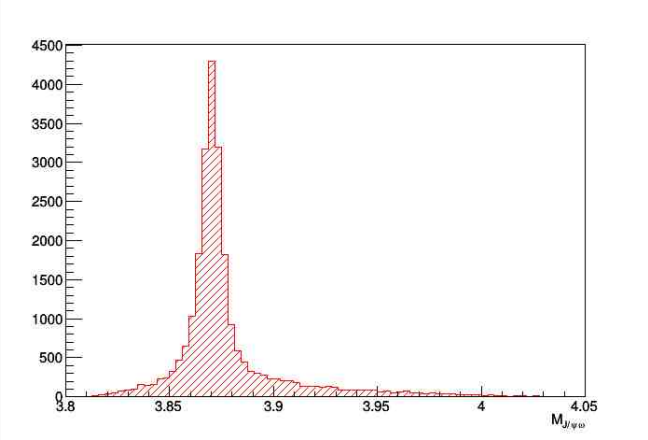
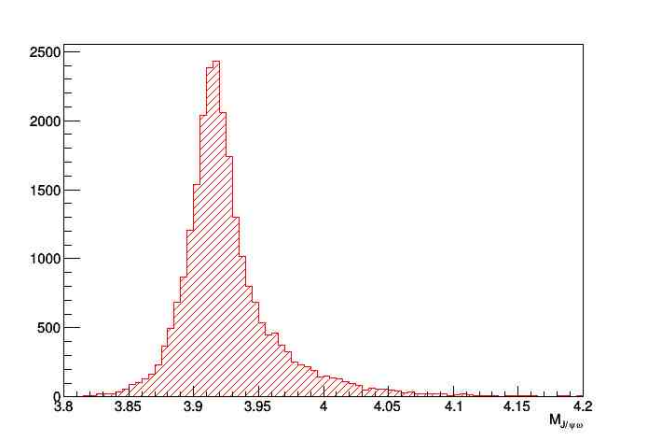


Figure: $B^{\pm} \to J/\psi\omega K^{\pm}$



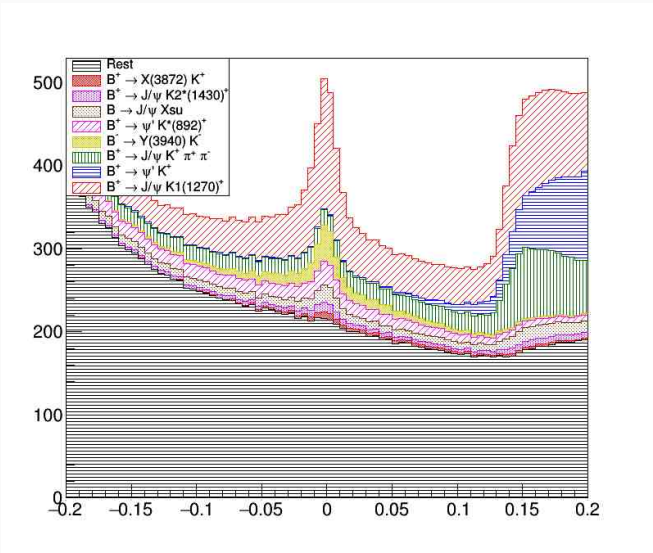
(a) $B^{\pm} \to X(3872)[\to J/\psi\omega]K^{\pm}$



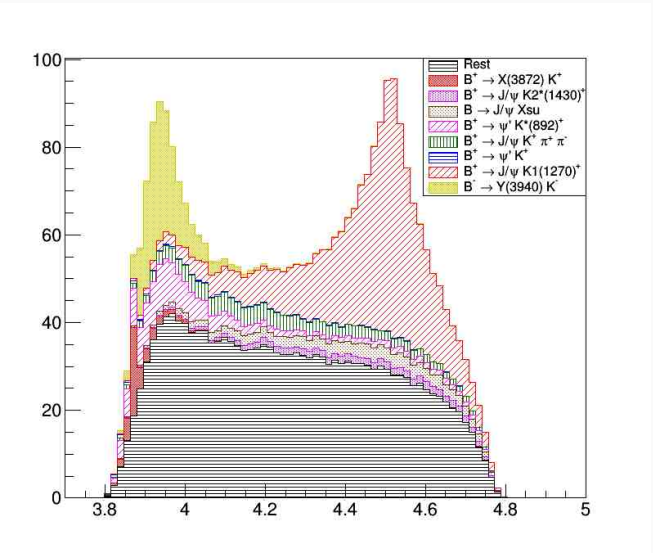
(b) $B^{\pm} \to X(3915)[\to J/\psi\omega]K^{\pm}$

J/ψ INCLUSIVE MC

- In order to understand the background, we use $B \to J/\psi X$ inclusive MC.
- This MC includes all the known B decay modes where the final states contains at least one J/ψ candidate.
  - We expect the non-J/ψ background to be very less.
- Luminosity of $B \to J/\psi X$ inclusive MC is 100 times the real data.
- We run our reconstruction code and tagged all the possible background modes.
- Following modes are found to be the major background sources .



(c) ΔE



(d) $M_{J/\psi\omega}$

SUMMARY

Summary

- Learned about Belle detector and BASF
- Generated 1 Million signal events for
  - $B^{\pm} \to J/\psi\omega K^{\pm}$
  - $B^{\pm} \to X(3872)[\to J/\psi\omega]K^{\pm}$
  - $B^{\pm} \to X(3915)[\to J/\psi\omega]K^{\pm}$
- Reconstruction module is prepared and basic cuts and criterions are applied
- Background study is done and potential backgrounds are identified
- To Do
  - Optimize cuts and criterions
  - Reduce background to improve the Signal to Noise ratio
  - Signal extraction procedure to be prepared
  - Test the procedure for any bias

Reference

- [1] A Schematic Model of Baryons and Mesons. Murray Gell-Mann, Phys.Lett. 8 (1964).
- [2] Observation of a Narrow Charmoniumlike State in Exclusive $B^{\pm} \to K^{\pm}\pi^{+}\pi^{-}J/\psi$ Decays, S.-K. Choi, S. L. Olsen et al, PhysRevLett.91.262001 (2003).
- [3] Evidence for $X(3872) \to \gamma J/\psi$ and the sub-threshold decay $X(3872) \to \omega J/\psi$. K. Abe, et al., for the Belle Collaboration, arXiv:hep-ex/0505037 (2005).
- [4] Evidence for the decay $X(3872) \to J/\psi\omega$. P. del Amo Sanchez et al. (BABAR Collaboration), arXiv:1005.5190 (2010).
- [5] Study of $X(3915) \to J/\psi\omega$ in two-photon collisions, The BABAR Collaboration, arXiv:1207.2651 (2012).