$Y_b \to \phi\eta_b$ Analysis

L.Nayak[1] **R.Dhamija**[1] **S.Nishida**[2] **A.Giri**[1]

IIT, Hyderabad[1]
KEK[2]

Belle Analysis Workshop

December 16, 2022

Introduction

Search for $Y_b \to \phi\eta_b$:

- Belle measured $\mathcal{B}(\Upsilon(4S) \to h_b(1P)\eta) = (2.18 \pm 0.21) \times 10^{-3}$ which is the unexpectedly large as compared to $\Upsilon(4S) \to \Upsilon(1S, 2S)\pi\pi$ decay $\mathcal{B}$ ($\mathcal{O}(10^{-5})$).
- Belle has set an upper limit on $\Upsilon(4S, 5S) \to \omega\eta_b$ decay mode at 90% CL as follows;
  - $\mathcal{B}(\Upsilon(4S) \to \omega\eta_b(1S)) < 3.1 \times 10^{-4}$
  - $\mathcal{B}(\Upsilon(5S) \to \omega\eta_b(1S)) < 1.5 \times 10^{-3}$
  - $\mathcal{B}(\Upsilon(5S) \to \omega\eta_b(2S)) < 4.6 \times 10^{-3}$
- This result is seven times lower than the value for $\Upsilon(4S) \to h_b(1P)\eta$.
- $\Upsilon(4S, 5S) \to \omega\eta_b$ decay mode is predicted in some tetra-quark predictions but, there is no theory prediction of $Y_b \to \phi\eta_b$ yet. We might be able to give some information to these $\Upsilon(4S, 5S) \to \omega\eta_b$ predictions as well as related to the large BF of $\Upsilon(4S) \to h_b(1P)\eta$ decay mode.

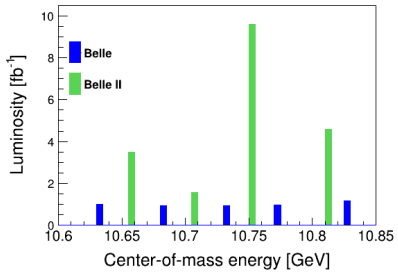
Analysis Plan:

- $Y_b \to \phi\eta_b$ with scan data - Lopa, Rashmi
- $\Upsilon(4S) \to \phi\eta_b$ with Belle II data - Jittapan
- $\Upsilon(4S, 5S) \to \phi\eta_b$ with Belle data - (optional)

$$Y_b \to \phi\eta_b$$

Data Sample

- 1M signalMC events generated using Pokhara-EvtGen generator in Basf2.
- MC14_ri_d sample is used for the background study at 10.75 GeV CM energy (9.58 /fb).



- $e^+e^- \to q\bar{q}(q = u, d, s, c)$, $e^+e^- \to B^0\bar{B}^0, B^+B^-, B\bar{B}^*, B^*\bar{B}^*$ and $e^+e^- \to \tau^+\tau^-, \mu^+\mu^-$
- **Global tag used for non $\Upsilon(4S)$ energy:** mc_nominal_beam_config_10751
- Basf2 release used: 06-00-03

Decay Table

```
Decay vpho
1.0 phi eta_b HELAMP 1.0 0.0 0.0 0.0 -1.0 0.0;
Enddecay

End
```

We set the beam energy as below to make ϕ η_b are produced from e^+e^- collisions at $\sqrt{s} = 10.75$ GeV.

```
ecms = 10.751
beamparameters.add_beamparameters(main, name="Yb10775", E_cms = ecms)
```

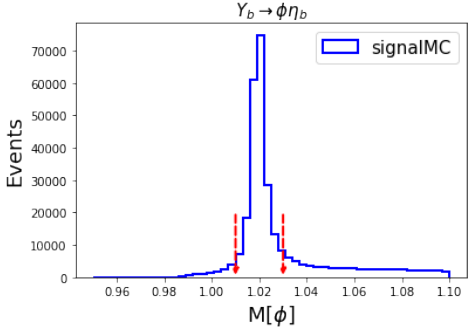
Analysis Method

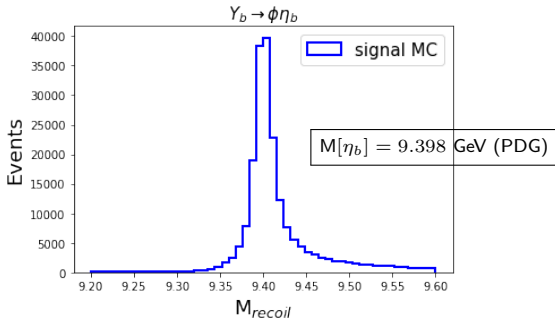
Reconstruction:

- $Y_b \to \phi$; $\phi \to K^+K^-$
- Since the decay of η_b is not known, we reconstruct ϕ and look at the recoil mass (M_{recoil}).
- $M_{recoil} = \sqrt{(\sqrt{s} - E^*_\phi)^2 - (p^*_\phi)^2}$

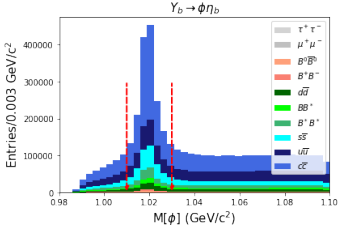
Pre-selections:

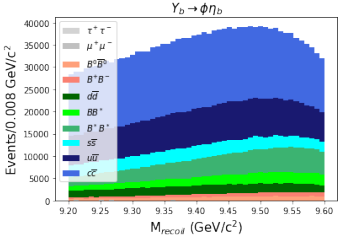
- abs(d0)<0.5cm, abs(z0)<2cm
- kaonID_noSVD>0.6
- M[ϕ] $\in$ [1.01,1.03] GeV/c^2
- $M_{recoil} \in [9.2, 9.6]$ GeV/c^2
- vertex treefit is performed.

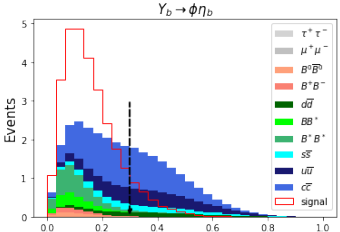




Distributions in GenericMC





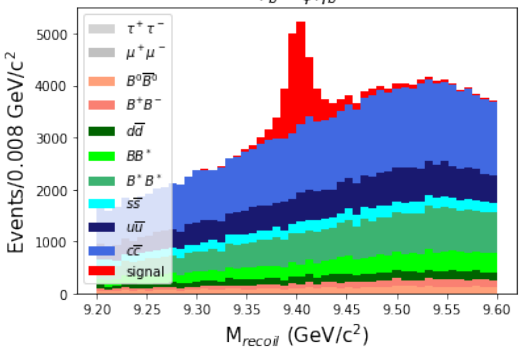


Applied cuts:
M[ϕ] $\in$ [1.01,1.03] GeV/c^2
M$_{\text{recoil}}$ $\in [9.2, 9.6]$ GeV/c^2
R2 <0.3 (7% signal loss, 34.8% background rejection)

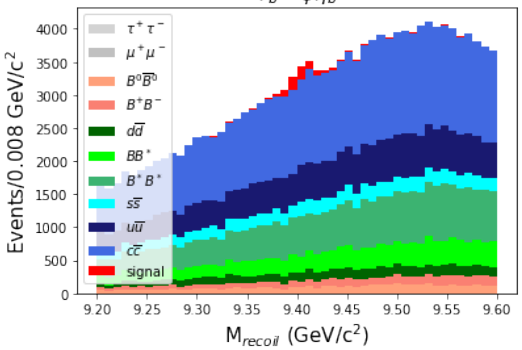
Recoil Mass Distributions

Assumed $\Upsilon(4S)$ cross-section and some $\mathcal{B}$ to scale the signal MC.

Assumed BF $\sim 10^{-2}$

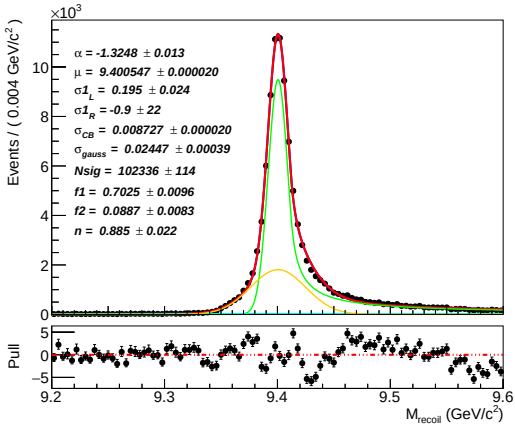


Assumed BF $\sim 10^{-3}$

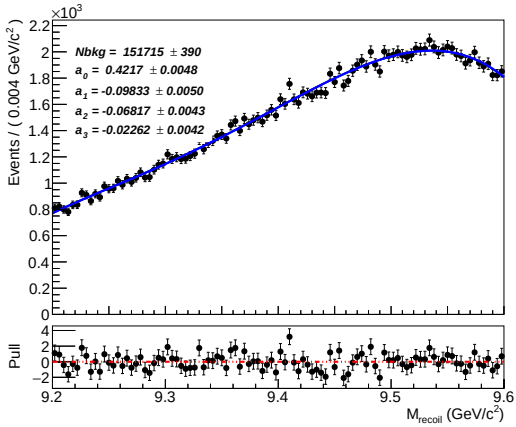


$\epsilon_{sig} = 10.23\%$

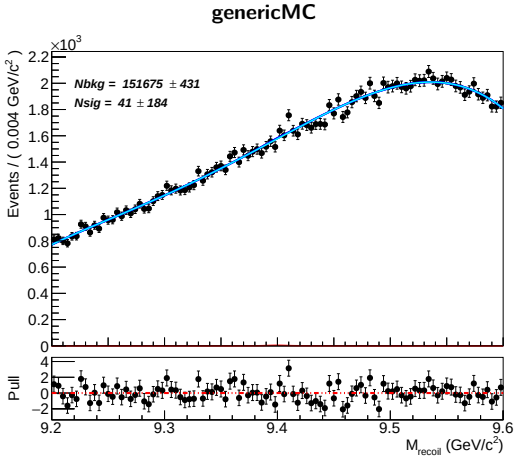
signalMC

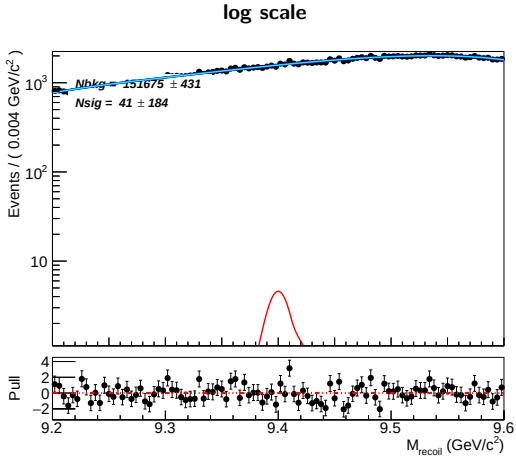


genericMC



SignalPDF: CrystalBall + Bifurcated Gaussian + Gaussian with common mean
BkgPDF: 3rd order Chebyshev Polynomial





- We fit the background distribution with signalpdf + bkgpdf. All the parameters are fixed.
- We obtained 41±184 events and estimated the upper limit by taking the value of 1.28σ.

Sensitivity

- luminosity ($\mathcal{L}_{int}$) = 9.58/fb (Y(10751) scan)
- generated signal events = 1M
- $\epsilon_{\text{sig}} = 10.23\%$
- UL @ 90% CL = 41+(184×1.28) = 276.52

$$\mathcal{B}(Y_b \to \phi\eta_b) \times \text{cross-section} = \frac{\text{UL 90\% CL}}{\mathcal{L}_{int} \times \epsilon_{sig}} = 2.82 \times 10^{-4}\ nb$$

Summary

- 1M signal MC generated.
- Analyzed MC14 sample.
- Looked at the recoil mass distribution with some selections applied.
- 1D fit performed.
- Estimated $\mathcal{B}(UL) \times$ cross-section.

Future Plans

- Will work on background suppression.

Thank You