Search for $B \to D^* \eta\pi$ Decays

BAW

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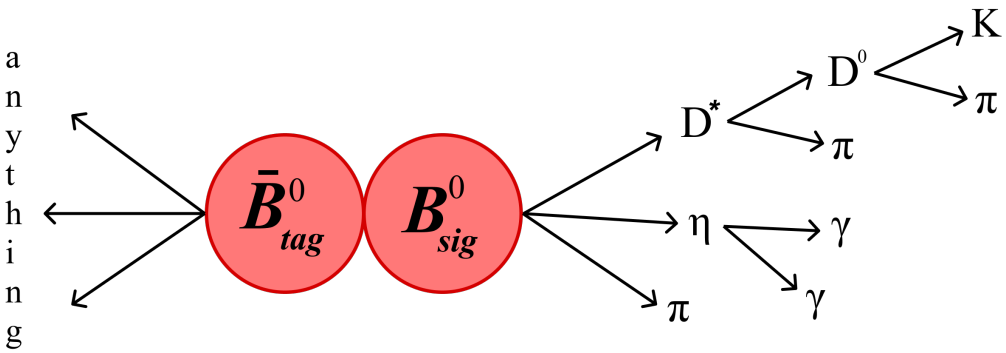
Why do we study $B \to D^* \eta\pi$ decay?

- We are searching for the decay $B \to D^* \eta\pi$, the study shown here in the Belle II generic MC samples.



- Better understanding of Semi-Leptonic (SL) gap*.
- Improve the reconstruction efficiency of tag side B (hadronic B-tagging).
- First Observation.

*(F. U. Bernlochner, Z. Ligeti, and S. Turczyk, 'A Proposal to solve some puzzles in semileptonic B decays',PRD 85, 094033, 2012])

Introduction

- Recent measurements of B to charm semileptonic decays show a difference between the branching ratio of the sum of exclusive decay rates and the inclusive $b \to c\ell\nu$ decay rate (the so-called Semi-Leptonic (SL) gap).

- Contributions from not-yet measured $B \to D^*\eta\ell\nu$ decays could be the explanation of such difference.

- Our contribution to the hadronic B - tagging : to study modes which are not very well known.

- Eventually enhance the sensitivity for searching rare B decays with missing energy.

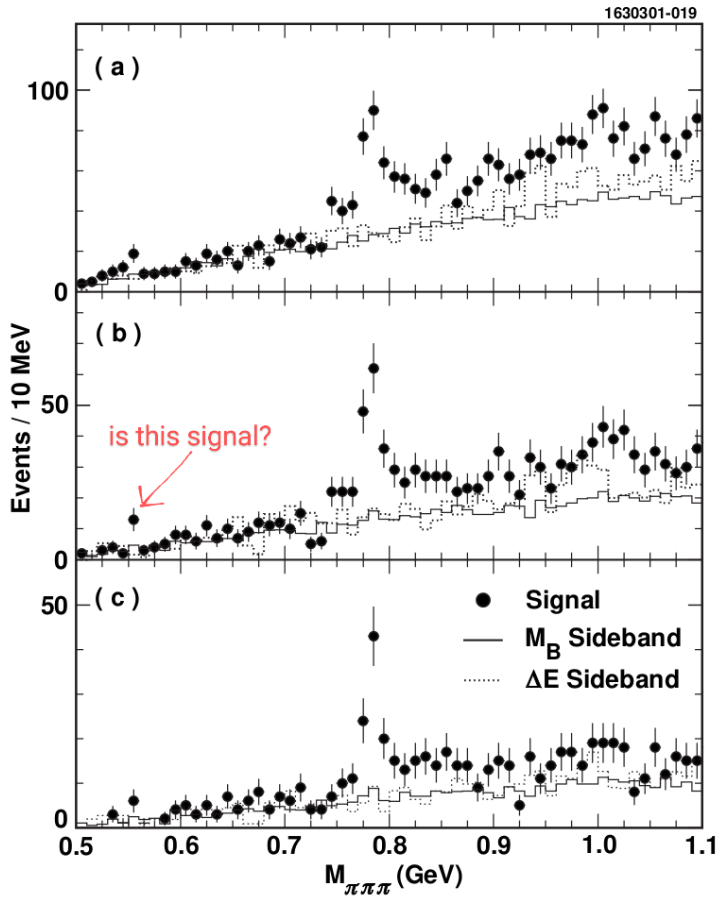
- The branching fraction (BF) prediction in our generic MC samples for the corresponding decay is $\to$ 0.34%

B decay	B^+ BF (%)		B^0 BF (%)	
	Belle	Belle II	Belle	Belle II
$B \to D^*\eta\pi^-$	0.65	0.27	0.76	0.34
$B \to D\eta\pi^-$	0.23	0.29	0.28	0.34

Motivation

4 Potential modes :

- $B^0 \to D^{*-}\eta\pi^+$; $\eta \to \pi^+\pi^-\pi^0$
- $B^0 \to D^{*-}\eta\pi^+$; $\eta \to \gamma\gamma$
- $B^+ \to \bar{D}^{*0}\eta\pi^+$; $\eta \to \pi^+\pi^-\pi^0$
- $B^+ \to \bar{D}^{*0}\eta\pi^+$; $\eta \to \gamma\gamma$
- Where, $D^{(*)} \to D^0\pi$; $D^0 \to K\pi$



- BF for $\bar{B}^0 \to D^{*+}\omega\pi^-$: $(2.3 \pm 0.11 \pm 0.14)\times 10^{-3}$ [Belle, PRD 92, 012013, 2015].
- CLEO observed the decay, $B^0 \to D^{*-}\omega\pi^+$ where $\omega \to \pi^+\pi^-\pi^0$, same final state as one of our "η"decays [CLEO, PRD 64, 092001, 2001].

$B \to D^{*-}\eta\pi^+$ decay

Signal generation and initial cuts

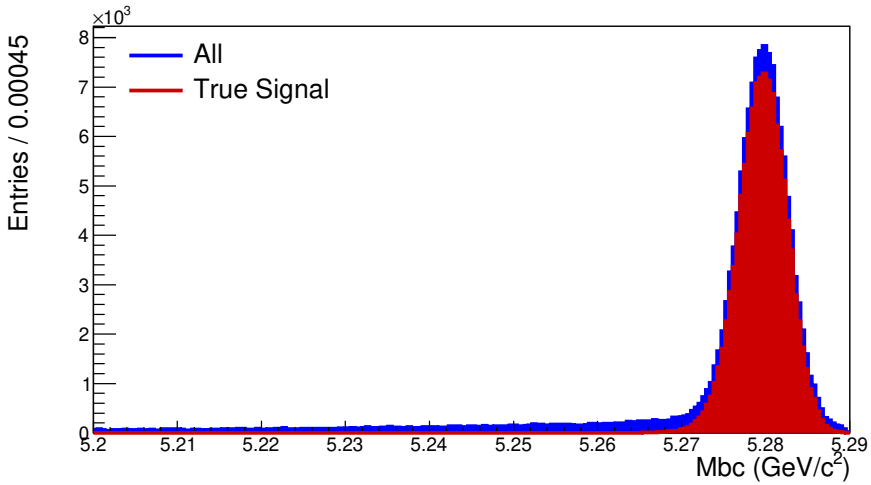
- 1M signal MC events are generated using basf2 framework for $B^0 \to D^{*-}\eta\pi^+$ decay where D^* decays to $D^0[K\pi]\pi$ and η decays to 2 photons.
- We have applied impact parameter cuts on all the charged particles and Kaons are selected with $R[K/\pi]$ >0.6.

Variables	Selection Criteria
$E_{\gamma 1,2}$	$> 80 MeV$
M_η	[0.52,0.56] GeV/c^2
$\lvert\cos helicity\rvert$	< 0.75
M_{D^0}	[1.8495, 1.8795] GeV/c^2
ΔM	[0.1435, 0.1475] GeV/c^2
ΔE	[-0.2, 0.2] GeV
M_{bc}	$> 5.2 GeV/c^2$

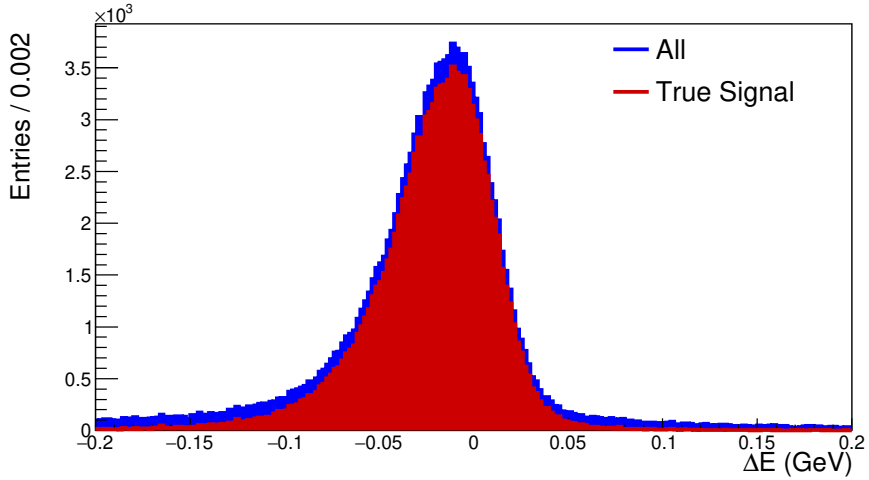
- ΔM is the difference between mass of D^{*+} to D^0.

Mbc and ΔE distribution

Mbc with $-0.15 < \Delta E < 0.05$



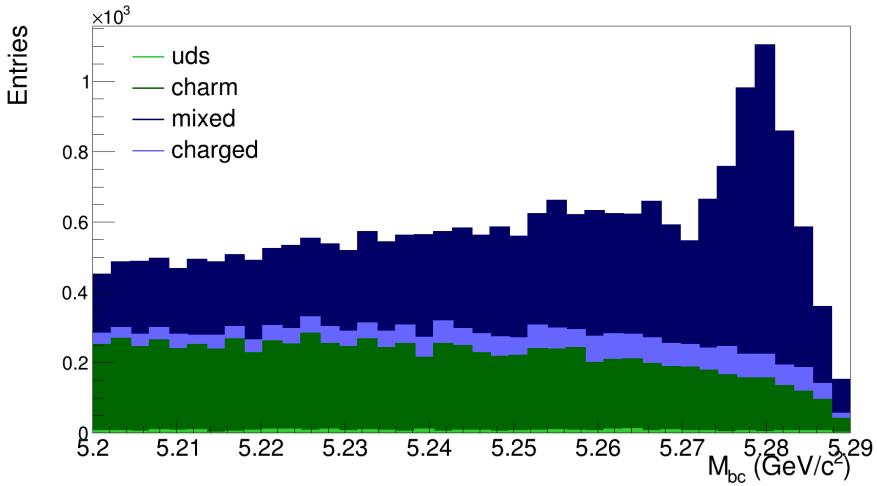
ΔE with Mbc > 5.27



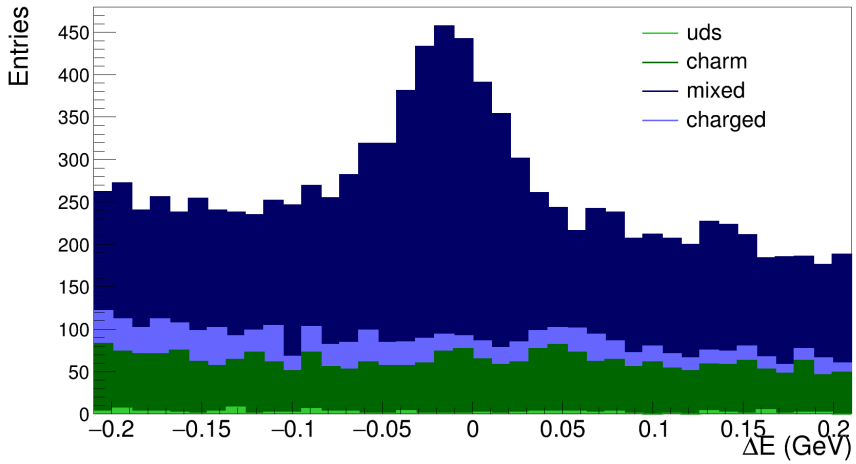
Generic MC study

- Our next step is to study the background, so we used 300 fb^{-1} of Belle II generic MC which includes $q\bar{q}$, B^+B^- and $B\bar{B}$ samples.

Mbc



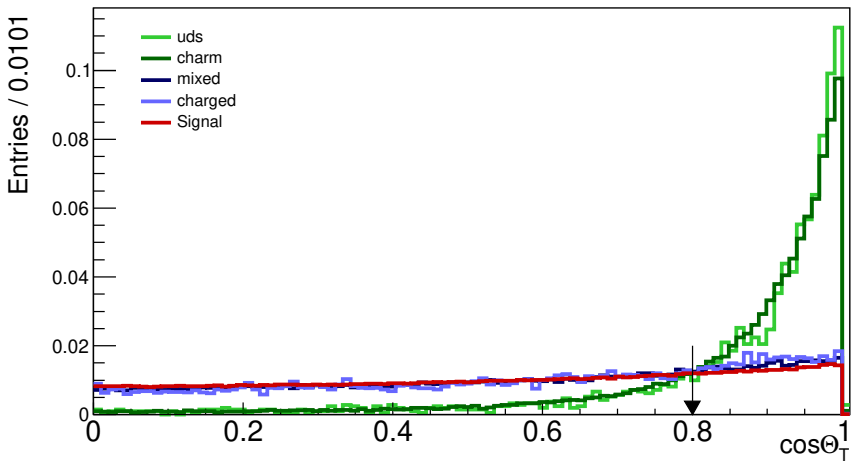
ΔE



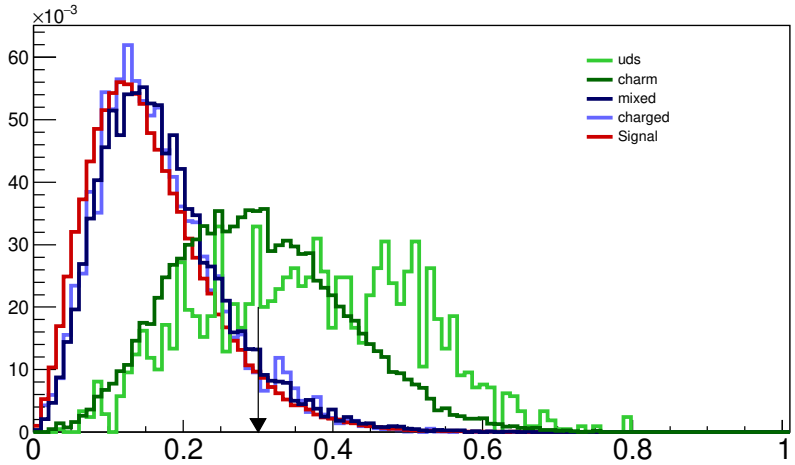
Continuum Suppression

- $\cos\theta_T < 0.8$ and $R2 < 0.3$ gives a good suppression to continuum background.

$|\cos\theta_T|$



R_2

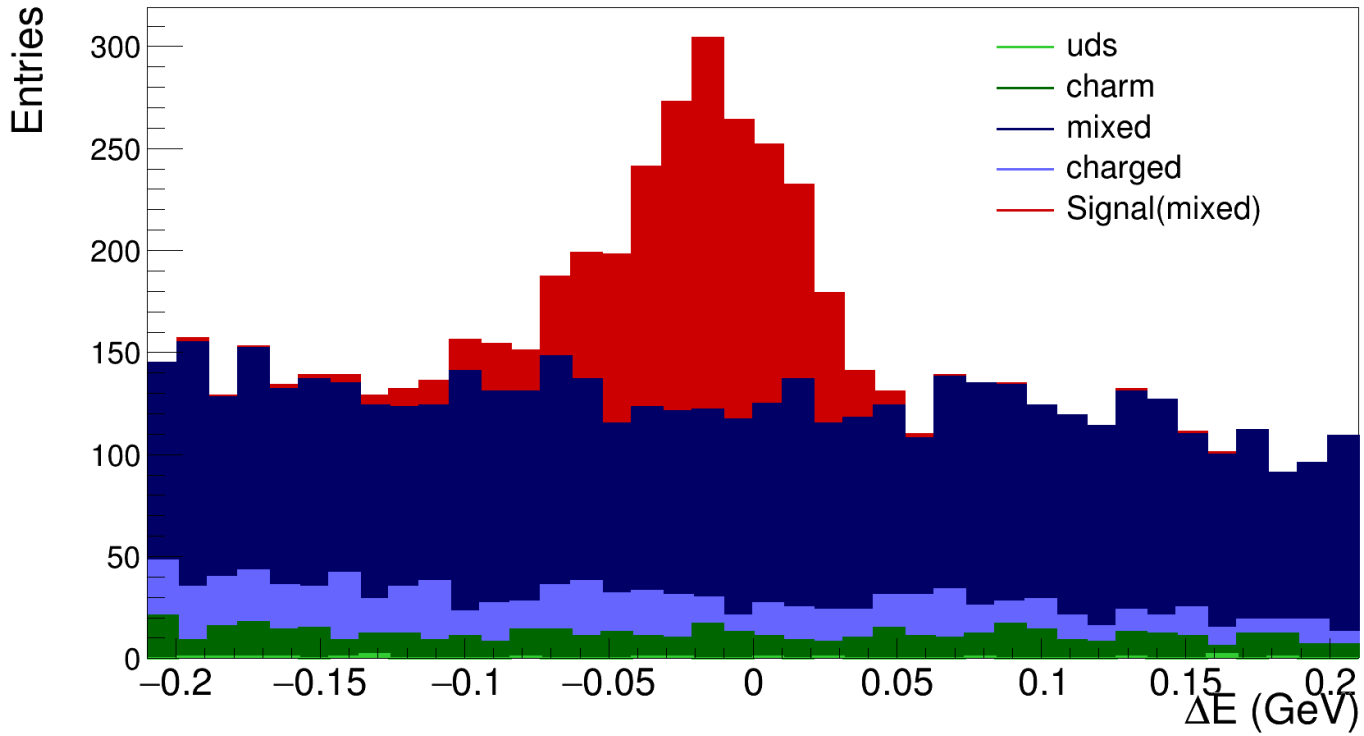


- 44% of background has reduced in the signal window of ΔE after applying this criteria.

ΔE distribution after CS

- The variable used to extract the signal events is ΔE. Here the background is listed for each sample with the signal component.

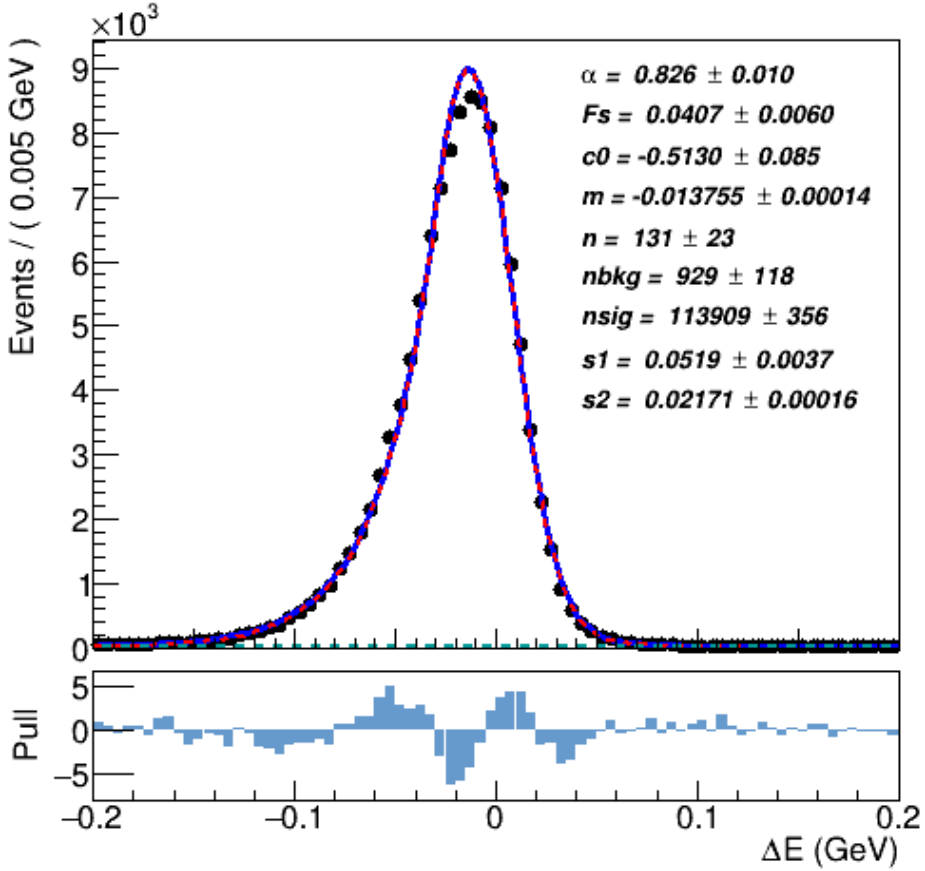
ΔE



Fit to extract signal

ΔE fit in signal MC (true signal)

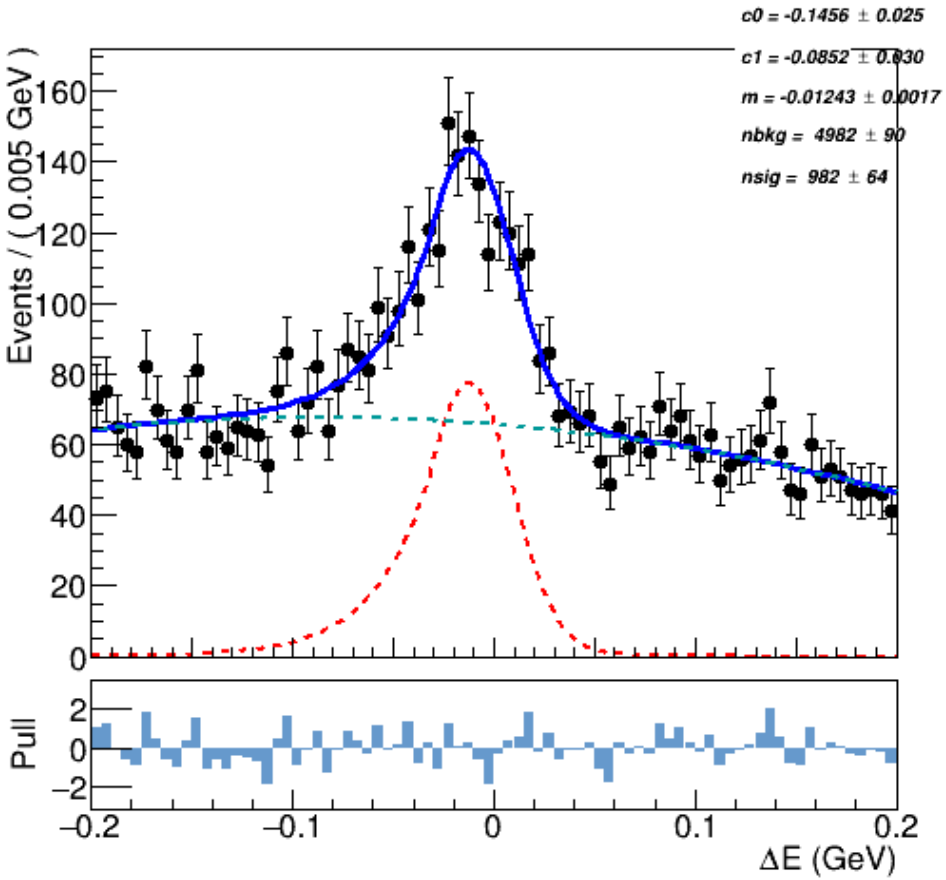
- Signal PDF = 1 Gaussian + 1 Crystal Ball and bkg PDF = 1^{st} order Chebychev polynomial. ($Mbc > 5.27$)



Fit to extract signal

ΔE fit in Generic MC

- Signal pdf = Fixed the signal shape from signal mc except mean and floated background with a 2^{nd} order Chebychev polynomial. ($Mbc > 5.27$)



BF Calculation

- Signal efficiency (from fit) = 113909/1M x 100 = 11.4%
- Calculating the BF using the signal events from fit.

$$\mathbf{BF} = \frac{N}{Eff. \times BF(D^{*-} \to \bar{D}^0\pi^-) \times BF(\bar{D}^0 \to K^+\pi^-) \times BF(\eta \to \gamma\gamma) \times N_{B\bar{B}}}$$

$$\mathbf{BF} = \frac{982}{0.1139 \times 0.677 \times 0.039 \times 0.3931 \times 300 \times 1.05 \times 10^6}$$

$$\mathbf{BF} = \mathbf{0.0026} \pm 0.00017$$

Summary/Plans

- We have reconstructed the decay $B^0 \to D^{*-}\eta\pi^+$ and we found the BF in the generic MC for the preliminary study.
- We have started studying the control sample $B^0 \to D^{*-}\omega\pi^+$ [Belle collaboration, PRD 92, 012013 ,2015].

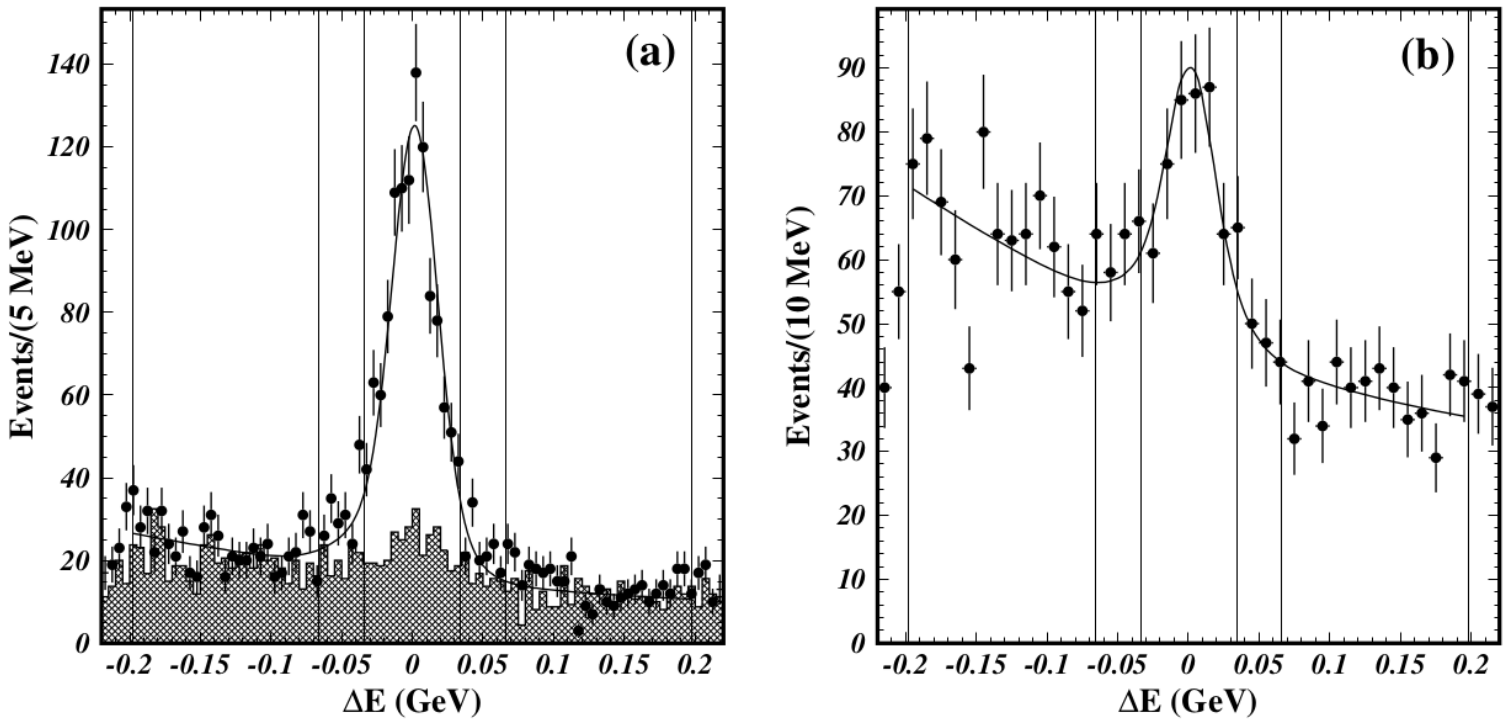
Plans :

- Proceed with the control sample study further.

Study of $B \to D^* \omega \pi$

[Belle, PRD 92, 012013, 2015]

- The study has been carried out using a data sample containing 772 million $B\bar{B}$ events collected at the $\Upsilon(4S)$ resonance with the Belle detector.
- Here $D^* \to D^0[\to K\pi]\pi$ and $\omega \to \pi\pi\pi^0$.
- Signal is extracted by fitting ΔE in the signal window and side band region of M_ω.



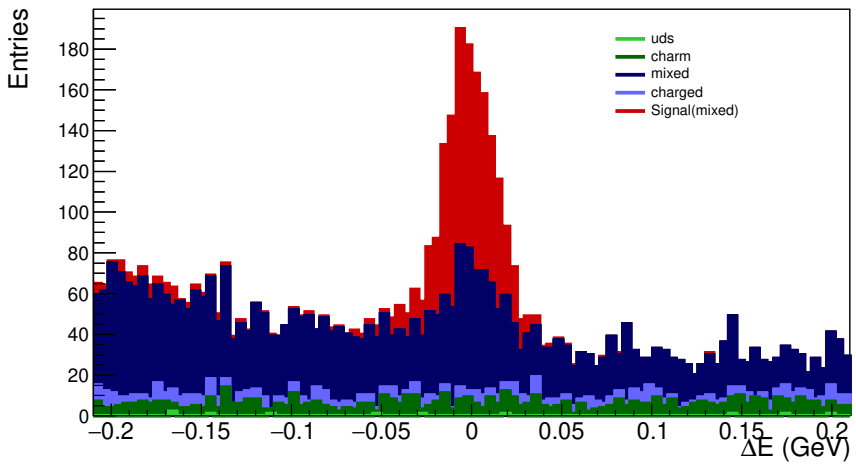
$$B = (2.31 \pm 0.11 \pm 0.14) \times 10^{-3}$$

Study of $B \to D^* \omega \pi$

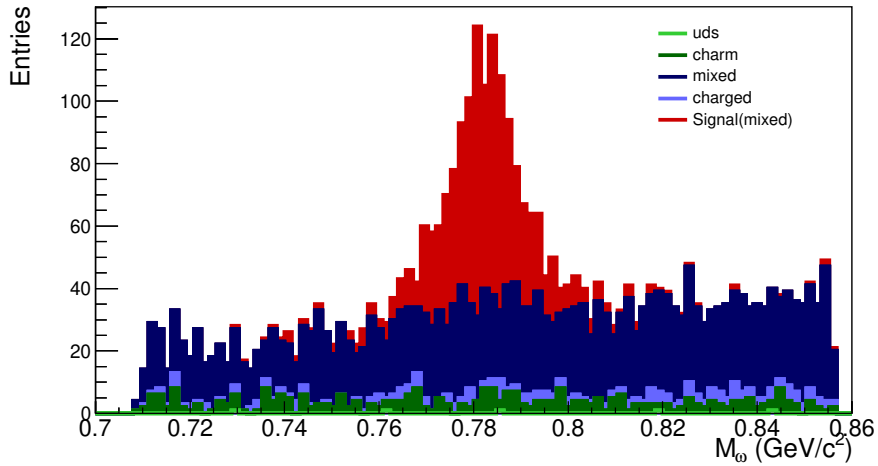
ΔE and M_ω distributions for all sample

- We have tried to recreate the study using the Belle framework by applying the criteria mentioned in this paper**.
- In the M_ω Distribution, the $|\Delta E| < 0.034$ has applied and in the ΔE distribution, M_ω has taken in the signal window [0.76135,0.80385].
- Here the red component is signal from mixed sample and all others are the background from all the samples separately.

ΔE



M_ω



[**Belle, PRD 92, 012013, 2015]