Monte Carlo studies of Lepton Flavor Violating (LFV) $B \to K\tau l$ decays at *Belle* and *Belle II*

Junaid Ur Rehman, *Belle/Belle II* Collaboration

11 January 2024

The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences

BELLE

Belle II

Outline

- Motivation
- Experimental setup
- Signal B and tag B meson reconstruction
- Initial results
- Summary

Motivation

- Lepton Flavor (LF) conservation is challenged in various measurements [1], and some extensions of the Standard Model (SM) predict LF violation.

- Its violation in the neutral lepton sector is confirmed.

- Decays which we are searching violates it

$$B^{\pm} \rightarrow K^{\pm} \tau^{\pm} l^{\mp}$$

$$\tau^{\pm} \rightarrow \pi^{\pm} \nu_{\tau}$$

- Upper limit on branching ratios for them, is 2.45×10^{-5} (main contributions by the τ leptonic decay modes) [2].

- Any evidence for such decays will be a direct evidence of physics beyond SM.

1. D. London and J. Matias, B Flavour Anomalies: 2021 Theoretical Status Report, Ann. Rev. Nucl. Part. Sci. 72 (2022) 37–68, [2110.13270].

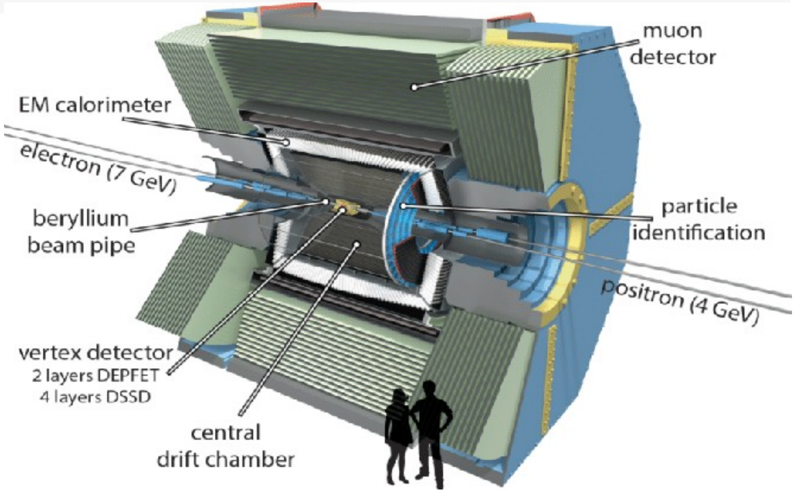
2. S. Watanuki et al.(Belle Collaboration),Search for the Lepton Flavor Violating Decays $B^{+} \rightarrow K^{+}\tau^{\pm}\ell^{\mp}$ (ℓ = e,μ) at Belle PhysRevLett.130.261802

Belle II Experimental setup

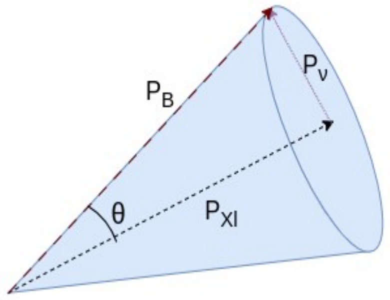
- Asymmetric e^+e^- collider.

$$e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\overline{B}$$

- One B is named as signal B (B_{sig}) and the other as tag B (B_{tag}).
- Upgraded Belle detector and clean environment makes it an ideal place to study B physics.
- Well defined kinematical constraints to study the produced B mesons.
- Belle has collected 1 ab^{-1} data and Belle II has collected 362 fb^{-1} data so far.
- Belle II has achieved the peak luminosity of 4.7 x 10^{34} cm^{-2} s^{-1} which is current world record.



Reconstruction of B_{sig}



- In B factories, when we have a single missing particle, we can constrain the momentum of the missing particle on a cone. e.g

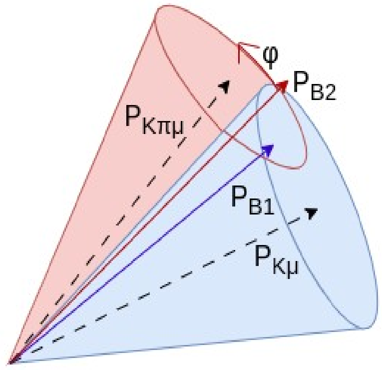
  $B^+ \rightarrow Xl^+\nu_l$ $\qquad E_{miss} = E_B - E_{Xl}$

- In our case

  $B^+ \rightarrow K^+ \tau^- \mu^+$

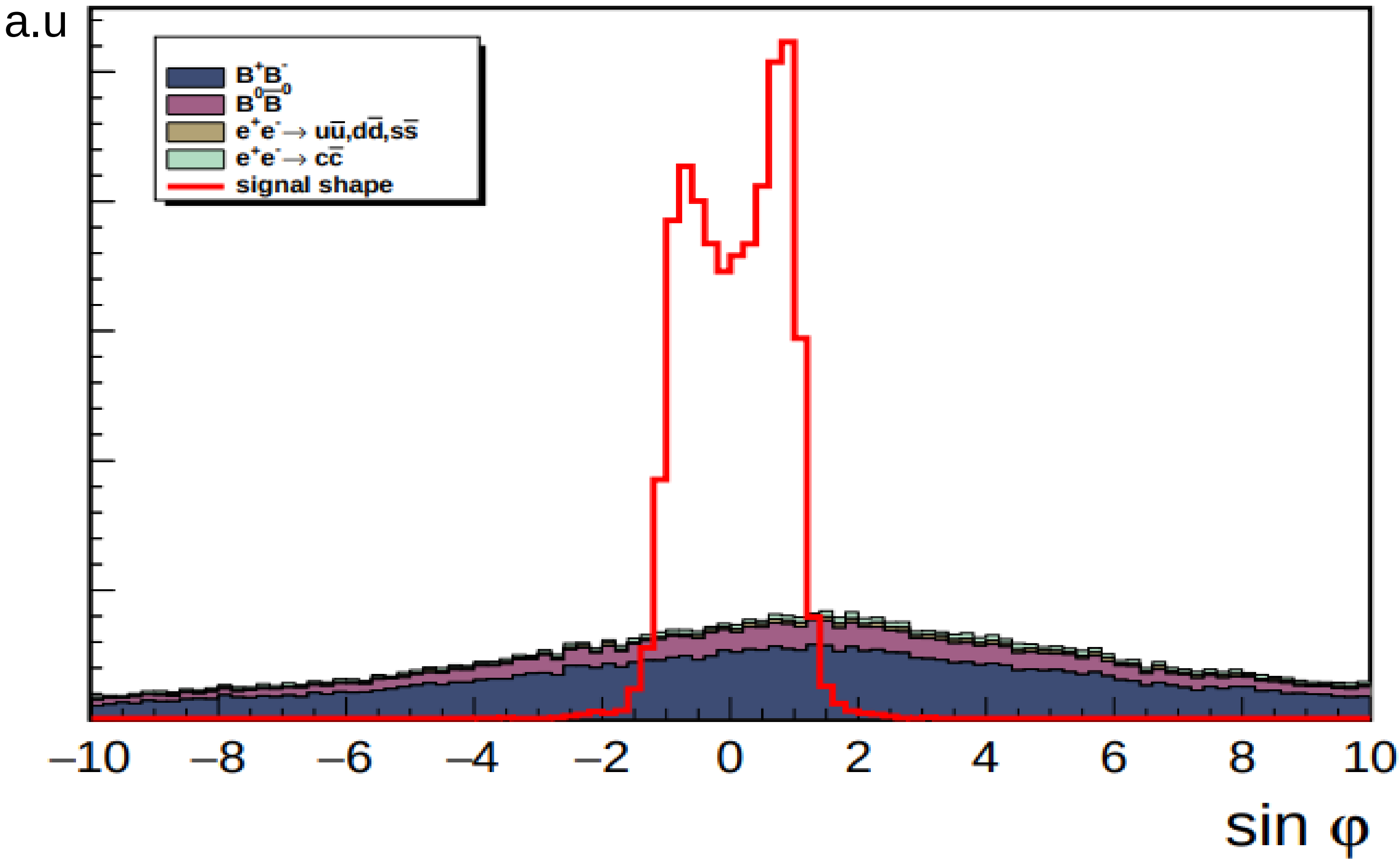
  $\tau^- \rightarrow \pi^- \nu_\tau$ (single missing neutrino)

- We can reconstruct the B_{sig} momentum from the two cones and their intersection leads to two possible solutions.
- By this approach, **we can recover the B_{sig} momentum without reconstructing the B_{tag} .**
- Intersection of two cones, gives us a discriminator variable which can be used for background suppression((0.5-0.7)% background, signal eff:77%)[4].



4. M. Kaleta, M.S thesis, Belle Collaboration.

$B^+ \to K^+ \tau^-(\to \pi^- \nu_\tau)\mu^+$



M. Kaleta, M.S thesis, Belle Collaboration.

Signal Vs Hadronic tag side

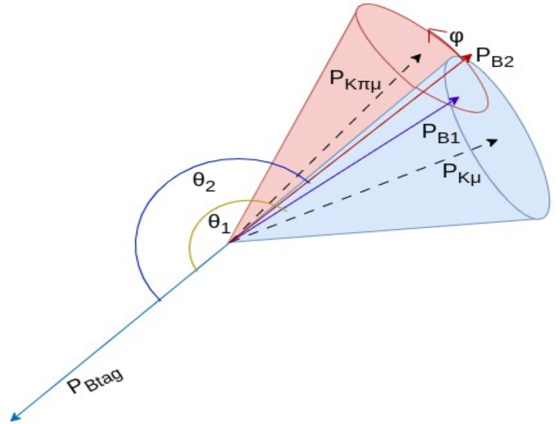
- In this case, B_{sig} is reconstructed first and then we combine all the remaining tracks and clusters (rest of events (ROE)) to form the B_{tag} candidate.

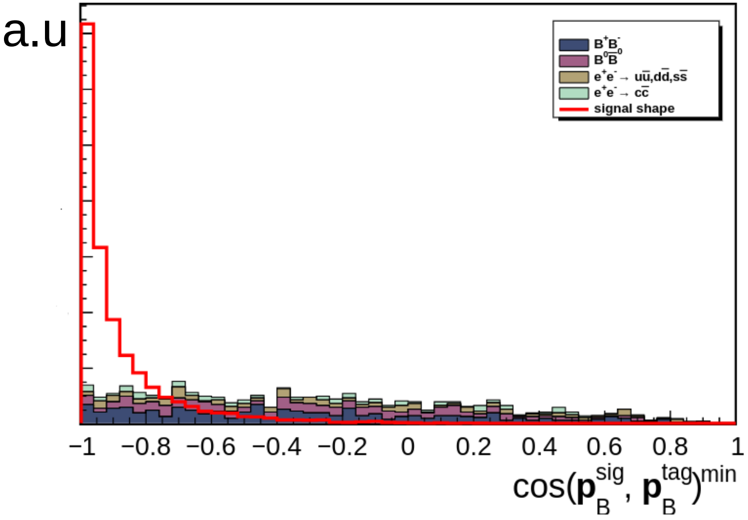
$$B^+ \rightarrow K^+\tau^-(\rightarrow \pi^- \nu_\tau)\,\mu^+$$

$$B^- \rightarrow \text{all possible final states(ROE)}$$

- When B_{tag} decays hadronically, we have the complete information about the B_{tag} momentum.

- Based on the best cosine angle distribution for θ_1 and θ_2, we can further suppress the background events.





Signal Vs Semi-leptonic tag side

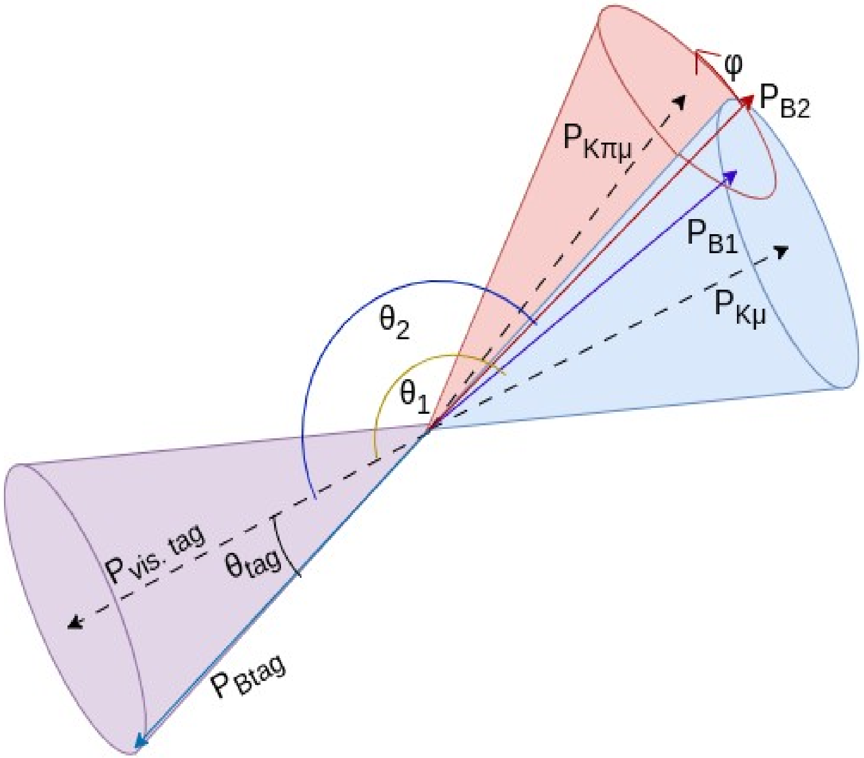
- In this case the B_{tag} decays to a hadron, lepton and a neutrino. For example

$$B^+ \rightarrow K^+\tau^-(\rightarrow \pi^- \nu_\tau)\mu^+$$

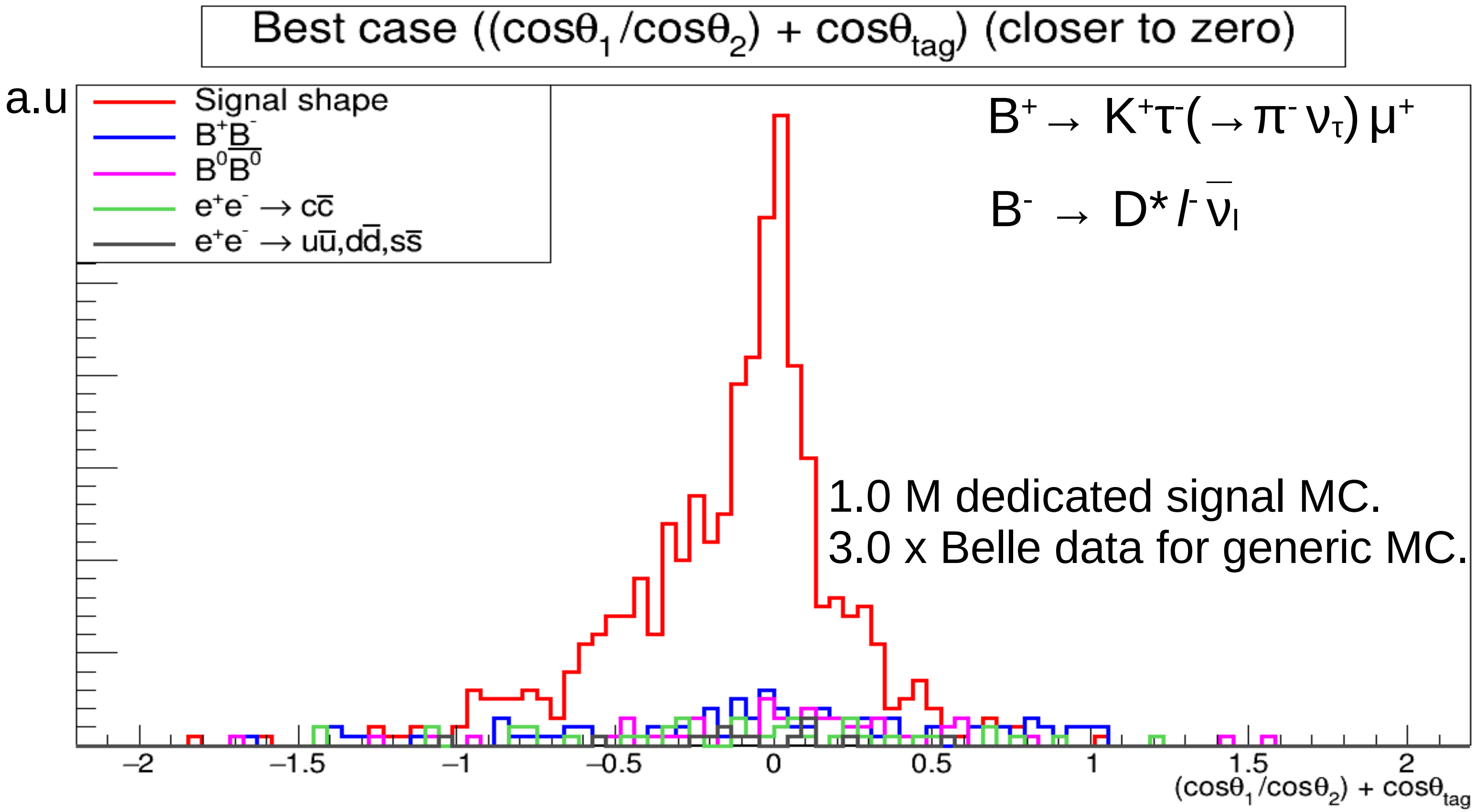
$$B^- \rightarrow D^* l^- \bar{\nu}_l$$

- Because of a missing neutrino on the tag side, we can only partially reconstruct B_{tag} momentum(cone around the visible momentum on tag side).

- Based on the sum of $\cos(\theta_1)/\cos(\theta_2)$ and $\cos\theta_{tag}$, we can extract signal over background.



Signal Vs Semi-leptonic tagging



Summary

- By using the semi-leptonic tau decay ($\tau^- \rightarrow \pi^- \nu_\tau$) mode and exploiting the kinematic conditions of the experiment,we have found the promising results for this approach in the Belle MC studies.

- We will include more decay modes in this study and validate our results on different control channel modes.

- Finally, we will apply this approach on the complete Belle and Belle II available dataset.


рахмат
ngiyabonga
આભાર
danke
格雷西
teşekkür ederim
баярлалаа
mersi
barka
welalin
tack
mahalo
tapadh leat
дзякуй
faafetai lava
vinaka
dank je
misaotra
paldies grazzi
спасибо
blagodaram
matondo
kiitos
dankie
thank you
gracias
благодаря
dhanyavad
asante
manana
bedankt
hvala
mauruuru
obrigada
enkosi
djiere dieuf
mochchakkeram
dziękuję
धन्यवाद
gratias ago
aitäh
sulpáy
go raibh maith agat
sobodi
děkuji
sukriya
kop khun krap
taiku
takk
dakujem
obrigado
mërsi
sagolun
ありがとう
tanemirt
toda
хвала
trugarez
najis tuke
terima kasih
rahmet
dhanyavadagalu
shukriya
дякуємо
kam sah hamnida
salamat
xièxie
diolch
eskerrik asko
고맙습니다
ти благодарам
ευχαριστώ
dankewol