LP2019

XXIX International Symposium on Lepton Photon Interactions at High Energies

5-10 August 2019 - Toronto , Canada

B lifetime and mixing results from early Belle II data

Reem Rasheed
On behalf of the Belle II collaboration

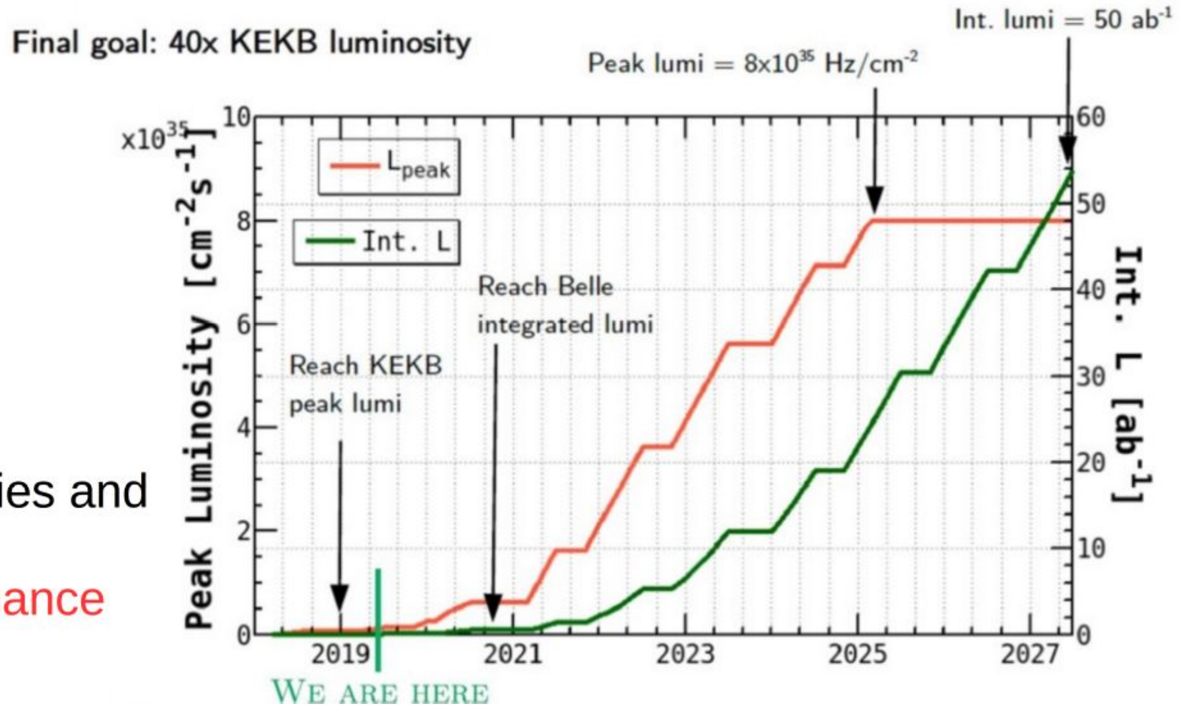
SuperKEKB

- Physics run :

  started 25 March 2019

Data on June 30th :
6.5 fb^{-1} @ Y(4S) of which
0.83 fb^{-1} off-resonance

- This talk presents performance studies and initial cross checks for data of
- → 2.66 fb^{-1} Y(4S) , 0.83 fb^{-1} off-resonance



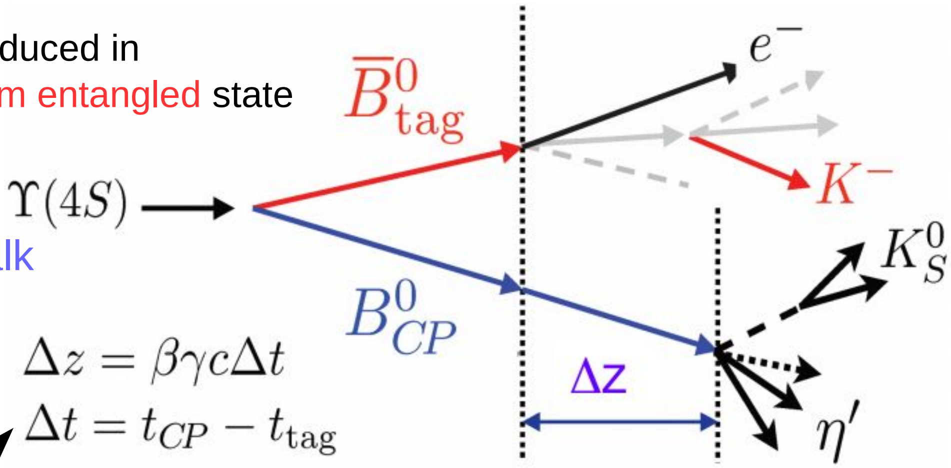
Max peak lumi: 1.2×10^{34} cm^{-2} s^{-1}

Time dependent CP violation measurements at Belle II

- $\Phi_1 = \beta$, $\Phi_2 = \alpha$ can be accessed by TDCPV analysis

$B\,\bar{B}$ produced in quantum entangled state

See Daniel Cervenkov talk



$$\mathcal{P}(\Delta t, q) = \frac{e^{-|\Delta t|/\tau_{B^0}}}{4\tau_{B^0}}\left[1 + q\left(\mathcal{A}_{CP} \cos \Delta m_d \Delta t + \mathcal{S}_{CP} \sin \Delta m_d \Delta t\right)\right]$$

q: flavor of B_{tag}

- Keys of this measurement : Vertexing , Flavor tagger

Challenges :

→ Higher background

→ reduced boost βγ to 0.28

Belle II detector Improvements :

→ New extended vertex detector

* 1 pixel layer

* 4 layers covering radius ~ 135 mm

→ New PID detector for K/pi seperation

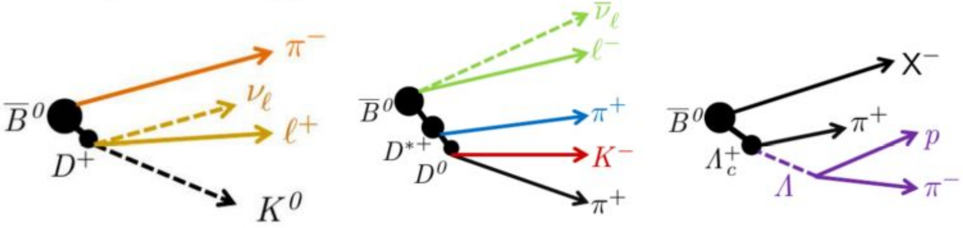
→ CDC with larger level arm and smaller cells

→ improved KLM (K_L^0 , μ) electronics

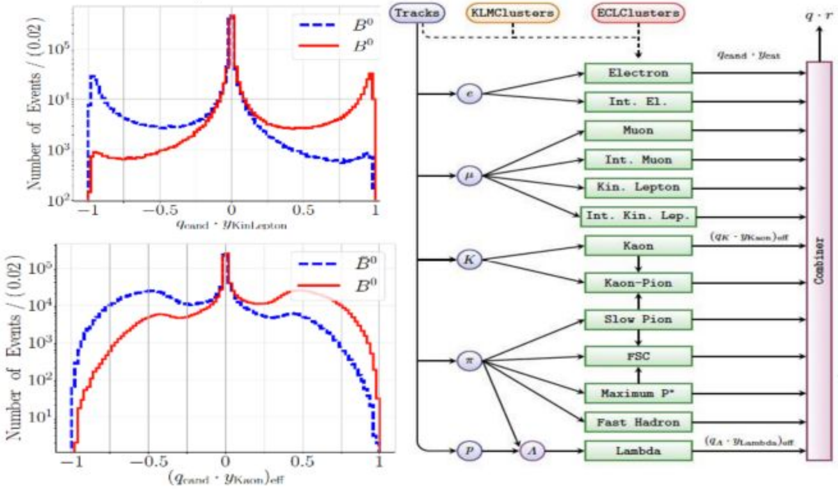
Flavor Tagger

MVA – based tagger :

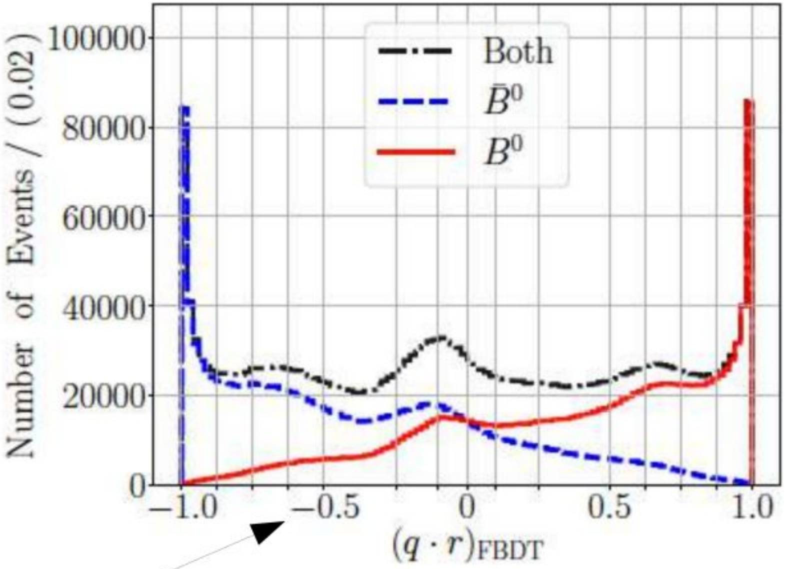
many sub-taggers with many input variables



Belle II Physics Book – arXiv:180810567



Belle II Physics Book – arXiv:180810567



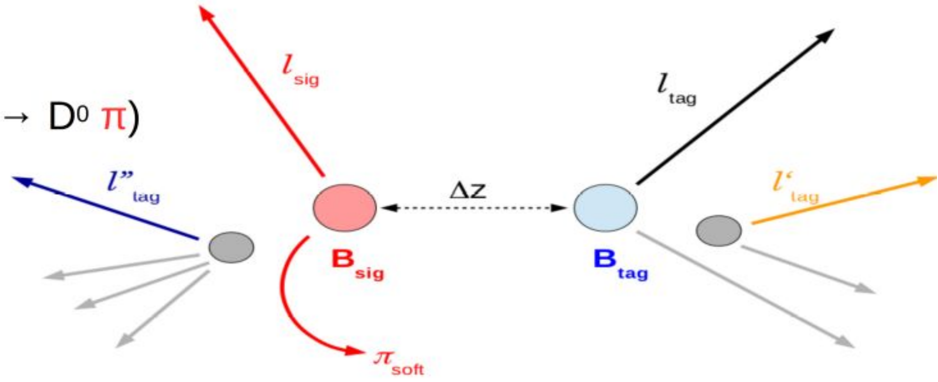
Total expected effective tagging efficiency :

37.2 % (Belle II MC)

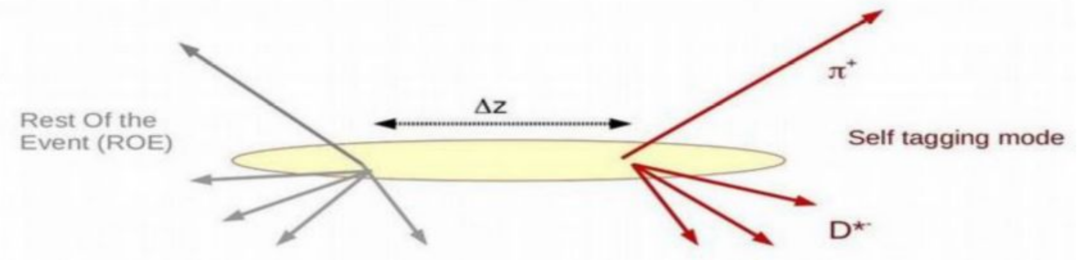
to be compared with 30 – 33 % in BaBar and Belle

B^0 lifetime and mixing in Belle II

- Two analyses on Belle II 2019 data of $\int L = 2.7\ fb^{-1}$ demonstrates vertexing and tagging capabilities
- B^0 lifetime and mixing in B^0 to semileptonic decays
  - $B_{sig} \rightarrow D^{*+}\, l\, \nu$ (l_{sig} = e , μ) : partially using π in ($D^* \rightarrow D^0\, \pi$)
  - B_{tag} vertex from l_{tag}



- B^0 lifetime and mixing in B^0 to hadronic decays (Ongoing)
  - Exclusively reconstruct B_{sig} ($B \rightarrow D\, X$) ,
  - Reconstruct (B_{tag}) from all other particles

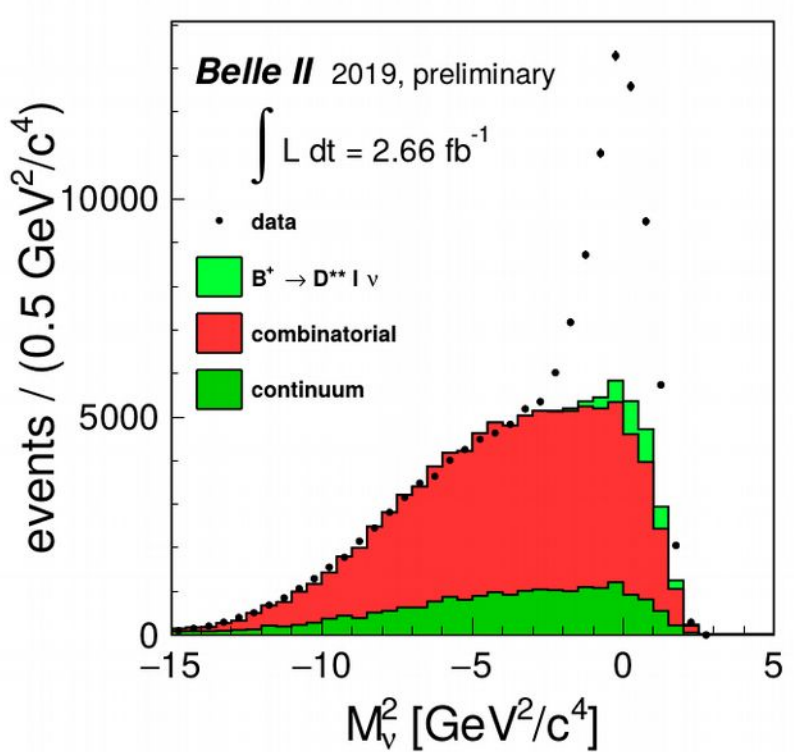


Semileptonic recon and untagged result

- Untagged events :
  - Only $B_{sig} \rightarrow D^{*+}\, l\, \nu$ (l_{sig} = e , μ) candidate is required in the event
  - Yields for signal component in 2019 data

Channel	Data
Untagged e or μ	35492 ± 2239

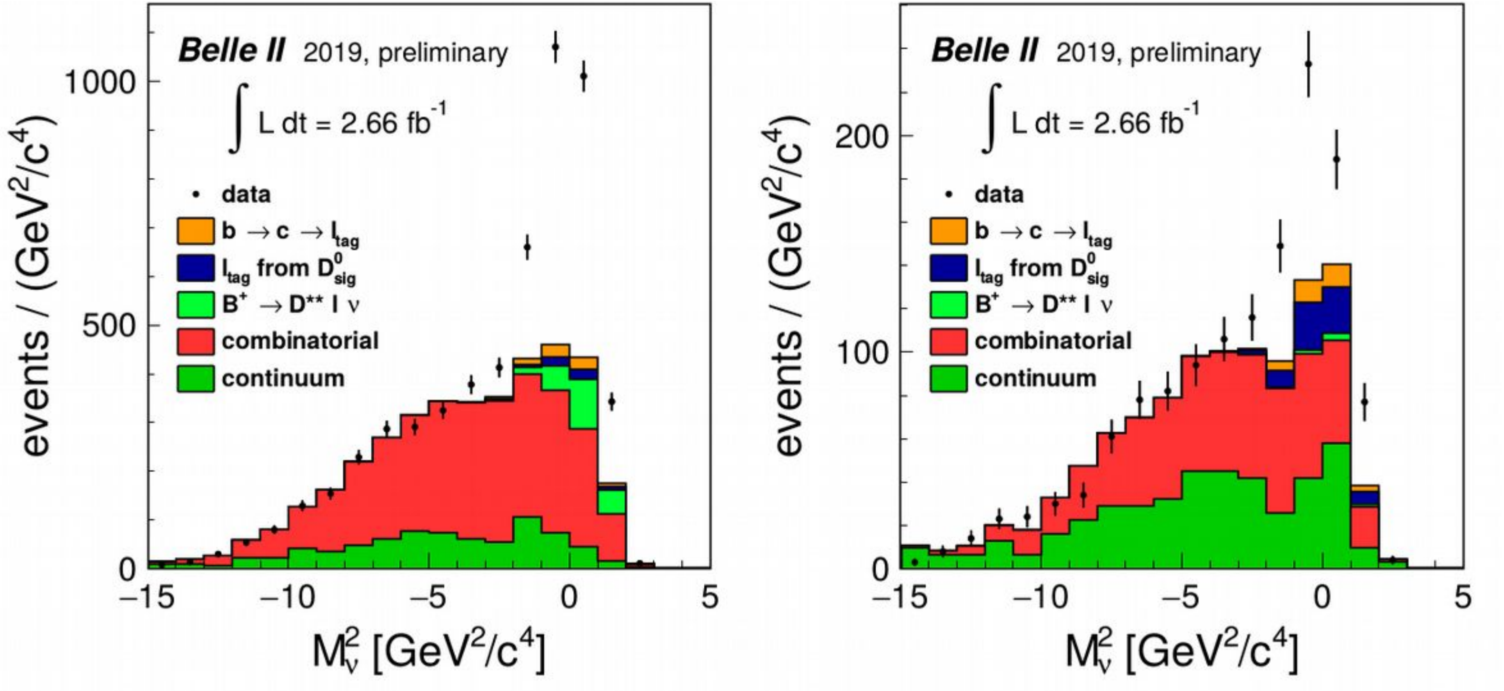
Continuum and combinatorial background : taken from data control sample



Tagged time integrated

Unmixed events — Opposite charge sign $l_{sig}\ l_{tag}$

Mixed events — Same charge sign $l_{sig}\ l_{tag}$



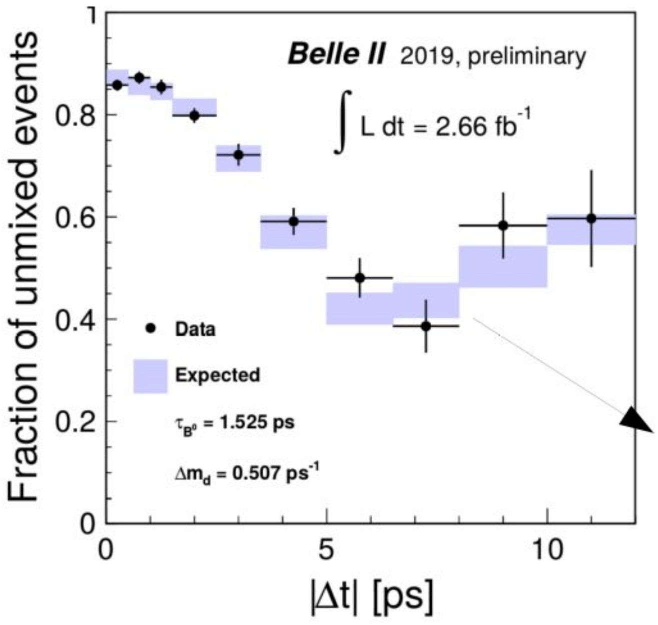
χ_d (fraction of mixed events) = 17.3 ± 3.6 % ⟶ World average: 18 .6 %

Time dependent asymmetry

$$A(|\Delta t|) = \frac{N_U(|\Delta t|)}{N_U(|\Delta t|) + N_M(|\Delta t|)}$$

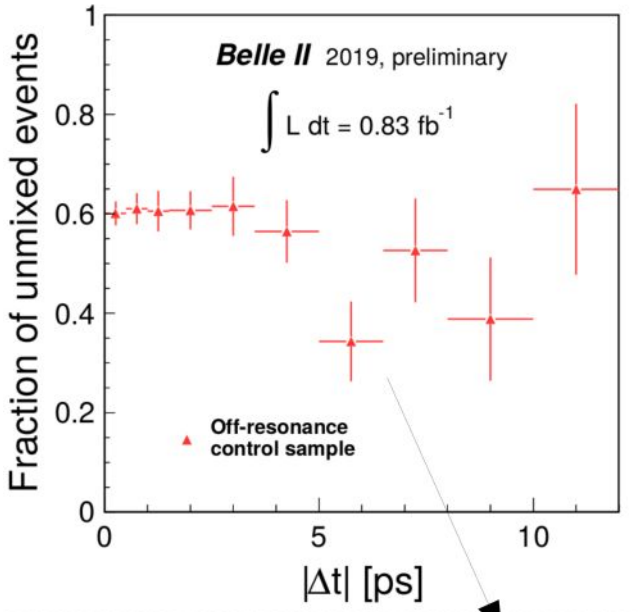
N_u : Unmixed yield , N_M : Mixed yield

A(|Δt|) - M^2_ν > -3 GeV²



Evidence of mixing

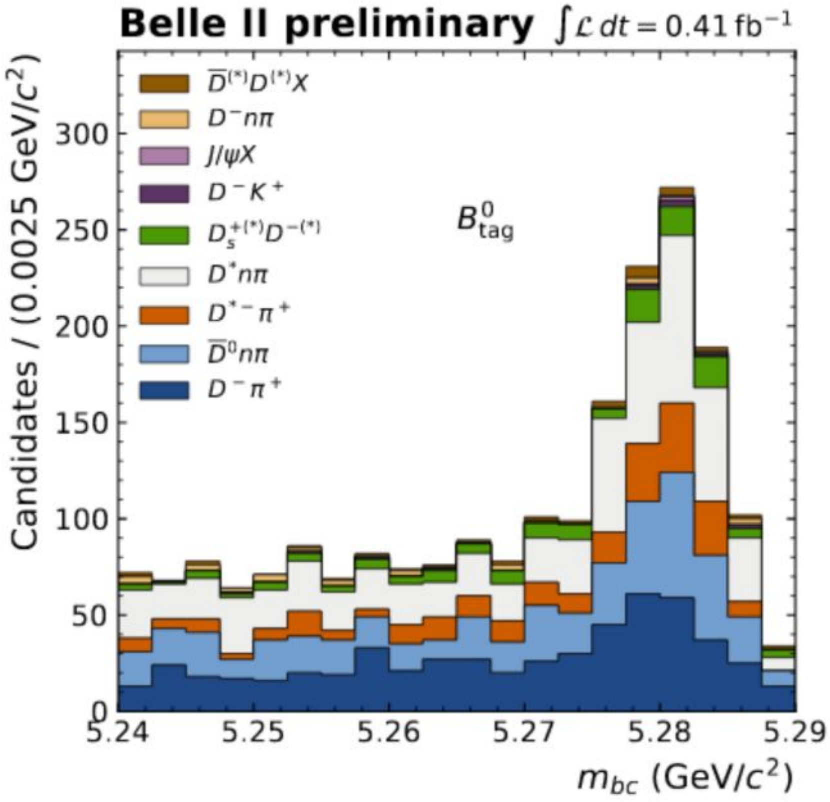
A(|Δt|) - off-resonance



Flat behavior with statistical uncertainty

Preliminary results from B^0 to hadronic decays analysis

$$mbc = \sqrt{(E_{beam}^2 - p_B^2)}$$



Exclusively reconstruct B_{sig} ($B \rightarrow D\ X$)

- Rediscovery of these decays
- Channels are self tagged

Conclusion and outlooks

- Belle II physics run started
- Commissioning of **vertexing and flavor tagging tools** is ongoing
- Expected experimental performances often improve w.r.t Belle
- B^0 lifetime and mixing in **B^0 to semileptonic decays** :
  - X_d (fraction of mixed events) is in agreement with world average
- B^0 lifetime and mixing in **B^0 to hadronic decays :** (Preliminary and ongoing)
- Data set of 50 ab^{-1} will provide better room for TDCPV studies
- Looking forward to the next decade of exciting Belle II results ! **Stay Tuned**

Backups

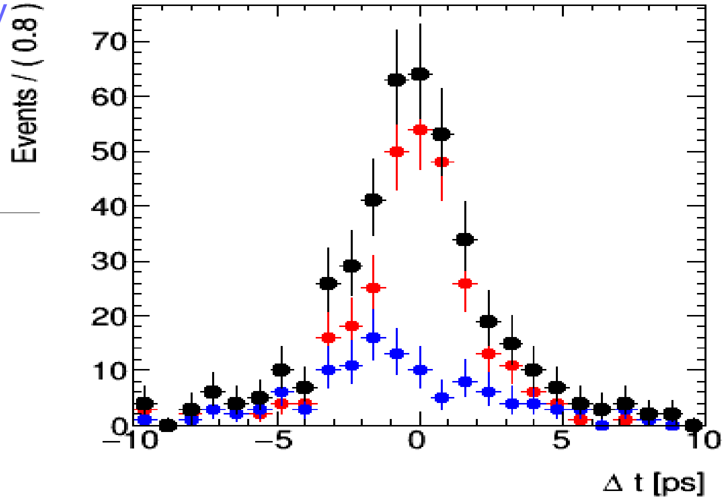
Mixing in B^0 to hadronic decays

- Mixing Rediscovery in a time-integrated way :
  - Plot on the right shows the Δt distribution on 2019 data
  - The mixed events are shown in blue and the unmixed events are in red
  - Δt observable for mixed and unmixed events has the following probability

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

$P(\Delta t) = e^{-\Delta t/\tau} \cdot (1 \pm \cos(\Delta m_d \Delta t))$, where Δm_d : mixing frequency

Evidence of B-meson mixing



Δt in $M_{bc} > 5.27$, $-0.5 < \Delta E < 0.5$ region

Yields

TABLE I: Yields for the signal component in the `proc9` data. For both the untagged and the lepton tagged sample, at most one candidate per event has been selected. The fraction of mixed events (last row) has been computed taking into account the correction factor $\varepsilon_U/\varepsilon_M = 1.35 \pm 0.10$, where ε_U (ε_M) is the efficiency for selecting a correctly reconstructed unmixed (mixed) signal event.

Channel	Data
Untagged e only	18514 ± 1128
Untagged μ only	16625 ± 1111
Untagged (e or μ)	35492 ± 2209
Tagged unmixed (N_U)	1642 ± 133
Tagged mixed (N_M)	253 ± 45
($\varepsilon_U/\varepsilon_M$) correction factor	1.35 ± 0.10
χ_d (fraction of mixed events)	$(17.2 \pm 3.6)\%$

$$\chi_d = \frac{N_M/\varepsilon_M}{N_U/\varepsilon_U + N_M/\varepsilon_M} = \frac{N_M \cdot \left(\frac{\varepsilon_U}{\varepsilon_M}\right)}{N_U + N_M \cdot \left(\frac{\varepsilon_U}{\varepsilon_M}\right)} \tag{1}$$