Fake tracks and time rejection in Belle II

GDR-InF

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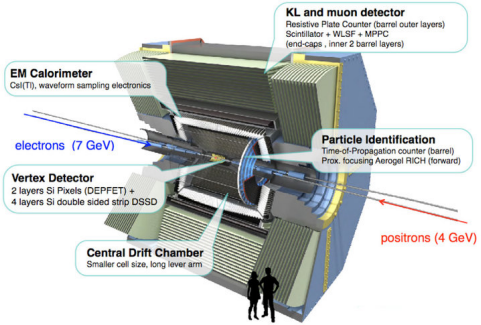
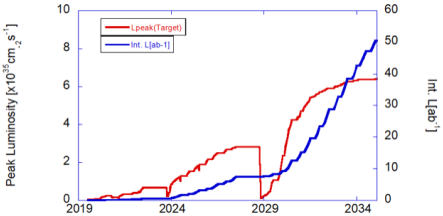
Belle II

Belle II : detector at the collision point of the e+e- collider SuperKEKB



- 50 ab^{-1} of data are expected (420 fb^{-1} has of now)
- Steady increase in instantaneous luminosity
- 4.7 x $10^{34}/cm^2/s$: Record lumi !



$\rightarrow$ High background (and even more to be expected), ie from highly collimated beams

Fake tracks

Fake tracks

- Clones
- Ghosts : wrong combination of hits
- Beam-induced background

Important to know the amount of fakes for systematic uncertainties.

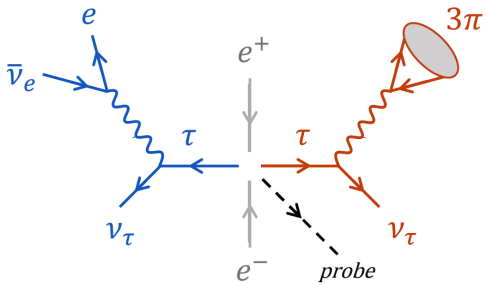
With increase in luminosity, tracking might suffer from higher backgrounds, and we don't want to spend time reconstructing fake and storing them.
$\rightarrow$ It's also important to be able to reject them.

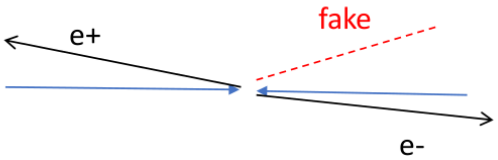
Measuring fake rate in data

Tag and probe method using bhabha or tau pairs production

Both have quite large cross section, but for tracking studies, tau pairs events are better suited : better topology, wider kinematics range.

$e^+e^- \to \tau^-(\to e\nu\nu)\tau^+(\pi^+\pi^+\pi^-\nu)$





- Reconstruct samples with and without additional track
- Fake rate = $\frac{\#\text{ of events with 1 additional track}}{\text{Total number of events}}$
  (Rate of events with a fake more than actual fake rate)

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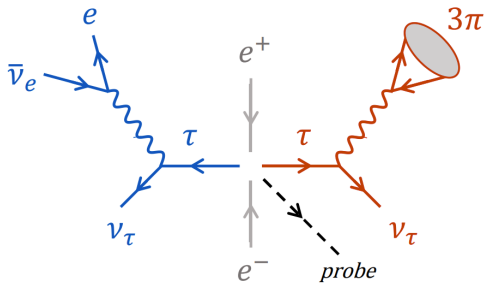
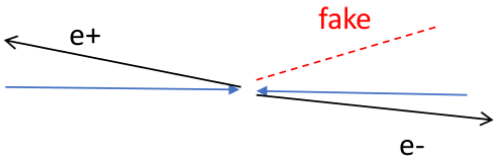




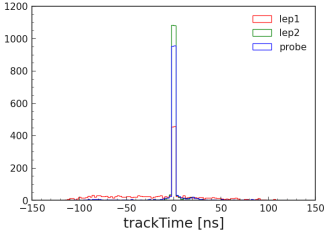
- Reconstruct samples with and without additional track
- Fake rate $= \frac{\#\text{ of events with 1 additional track}}{\text{Total number of events}}$ $\approx 1\%$
  (Rate of events with a fake more than actual fake rate)

Fakes vs timing

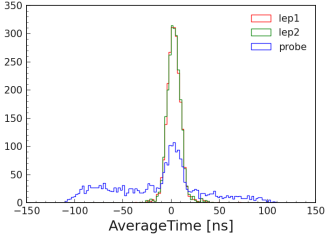
Idea

Use time information from detector (SVD) to reject fakes (beam background mainly)

- Possible thanks to really good time resolution ($\approx$ 1 ns)
- Simply look at the time of the track = the average of the time of the hits attached to the track.
- t=0 is given by the trigger, which is not very precise $\rightarrow$ correct with the event T0 = the instant of the collision



Corrected track time



Uncorrected track time

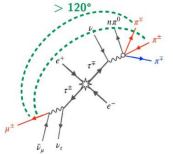
Monte Carlo bhabha events (really usefull for development purposes)
Possible to cut the fakes by a factor up to 4
No loss in tracking efficiency

Summary

- Fake rate is a tracking FOM that needs to be known
- Measure fake rate using bhabha or tau pairs
- Reject fake using time information
- Fake rate is not incredibly high... yet
- In the future : higher lumi and background, simulations are not overly optimistic.
- Upgrade : more sensitive to low pt
- Efforts are made to get an even better tracking

- $\text{cosToThrustOfEvent}\left(\pi_1^{tag}/\pi_2^{tag}/\pi_3^{tag}/probe\right) \times \text{cosToThrustOfEvent}(e^{tag}) < 0$
- $\cos\theta^{CMS}_{e^{tag}-\pi_1^{tag}/\pi_2^{tag}/\pi_3^{tag}/probe} < -0.5$

tag+probe & 1-prong back-to-back



L. Zani, Belle II Italia, 16/12/2019

- $0.2 < 2p^{CMS}_{1-prong}/\sqrt{s} < 0.8$
- Opposite charge pions: $\left|m_{\pi_1^{tag}\pi_2^{tag}} - m_\rho\right|, \left|m_{\pi_2^{tag}\pi_3^{tag}} - m_\rho\right| < 100$ MeV
- Same charge pions: $300\ \text{MeV} < m_{\pi_1^{tag}\pi_3^{tag}} < m_\tau$

reduce low-momentum & continuum

- $M_{\pi\pi\pi} < 1.3$ GeV
- $3\ \text{GeV/c} < p_T^{3-prong}$ and $1\ \text{GeV/c} < p_T^{1-prong}$
- electronID of $e^{tag} > 0.9$ and kaonID of $\pi_2^{tag} < 0.6$

reduce remaining background in N5 sample (optimised with $S/\sqrt{B}$ figure of merit in MC13a)