Systematic Studies On Track Reconstruction Efficiency At Belle II

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Outline

- Overview on the Belle II experiment
- Bhabha kinematics at Belle II
- Preparation for calculating the tracking efficiency
- Phase2 tracking efficiency
- Phase3 tracking efficiency
- Comparing phase2 with phase3
- Conclusion

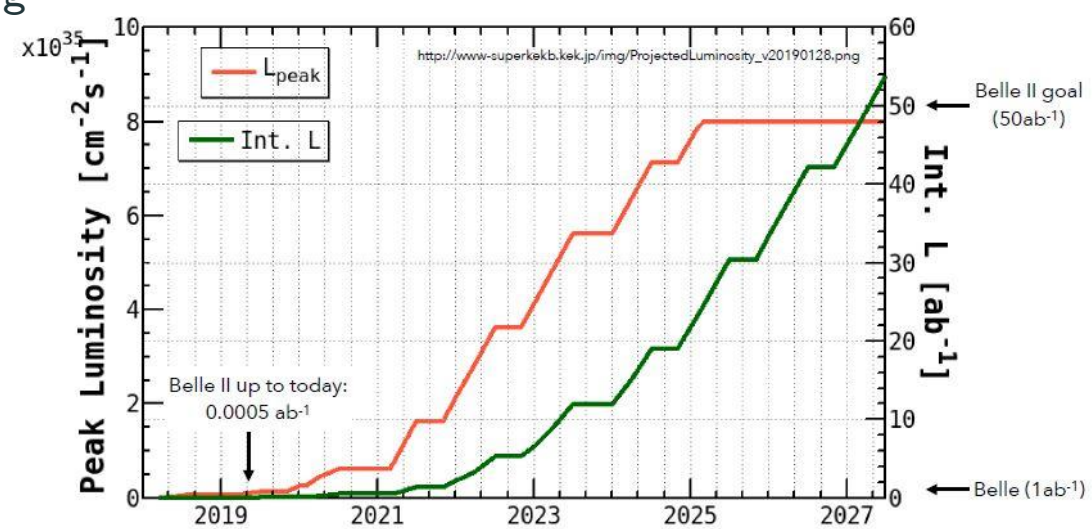
Motivation

- At an electron-positron accelerator most outgoing particles are again electrons and positrons (these events are called Bhabha events)
- These events can be used to estimate the performance of the tracking detectors
- If the *tag* particle in a Bhabha event has a track than the *probe* particle also should have a track associated
  $\rightarrow$ a tracking efficiency can be calculated

Overview Of The Belle II Experiment

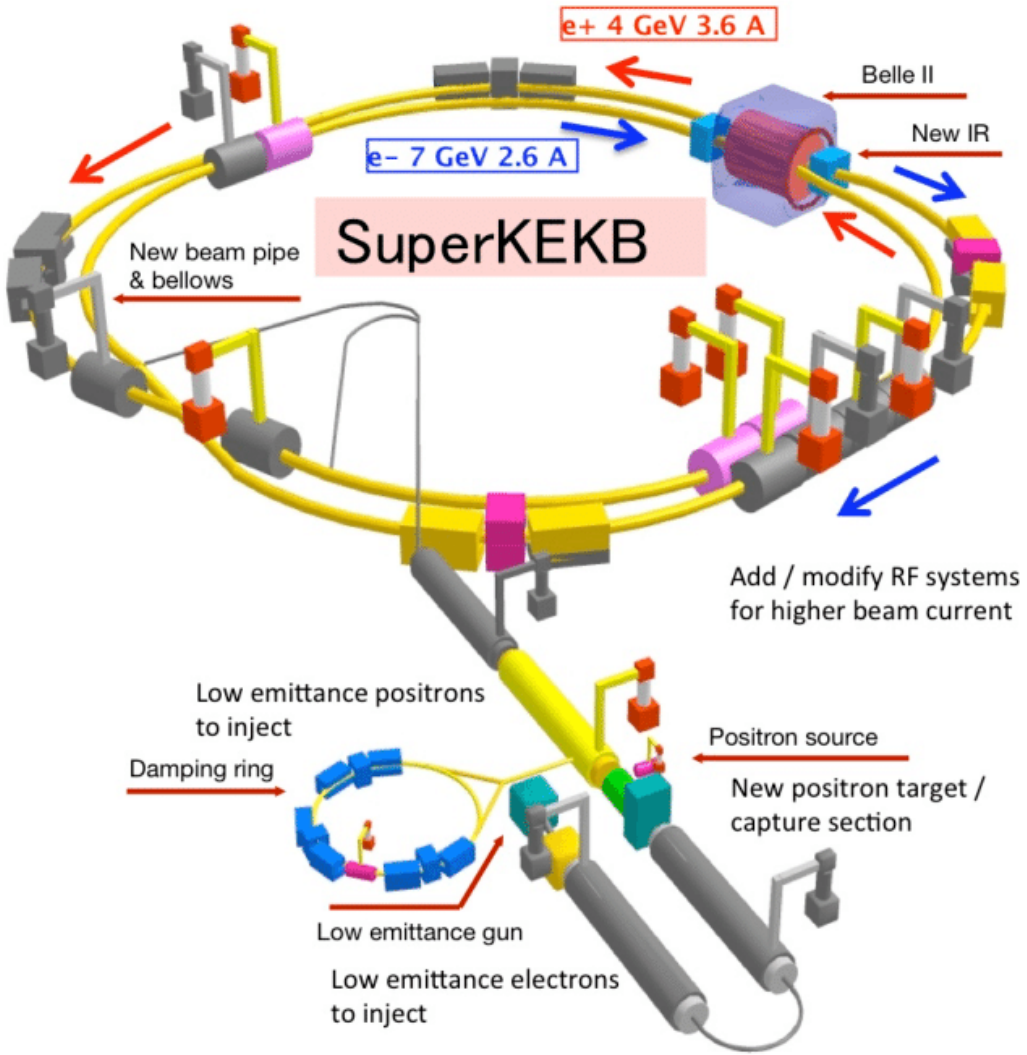
Belle II Schedule And Luminosity Goals

- Phase1: accelerator commissioning and background estimation (completed in 2016)
- Phase2: collision runs and background studies with partially installed detector (completed in 2018)
- Phase3: data taking with the whole detector (started in April 2019)



The SuperKEKB e^+e^- collider

- Asymmetric *B*-factory
- Center-of-mass close to $\Upsilon(4S)$ $\sim 10.5\,\mathrm{GeV}$
- Upgrade of the KEKB collider:
  - Larger beam current
  - Reduced beam size



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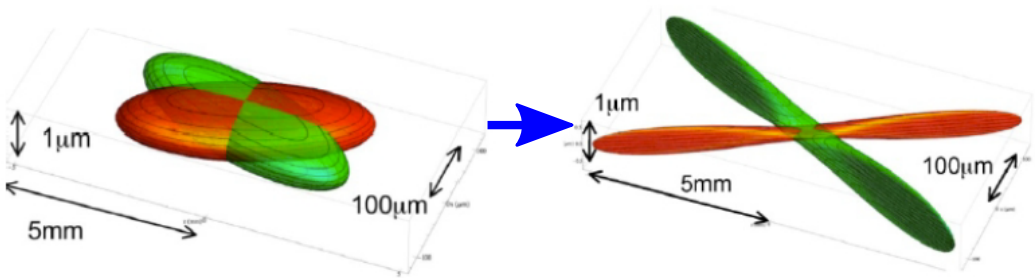

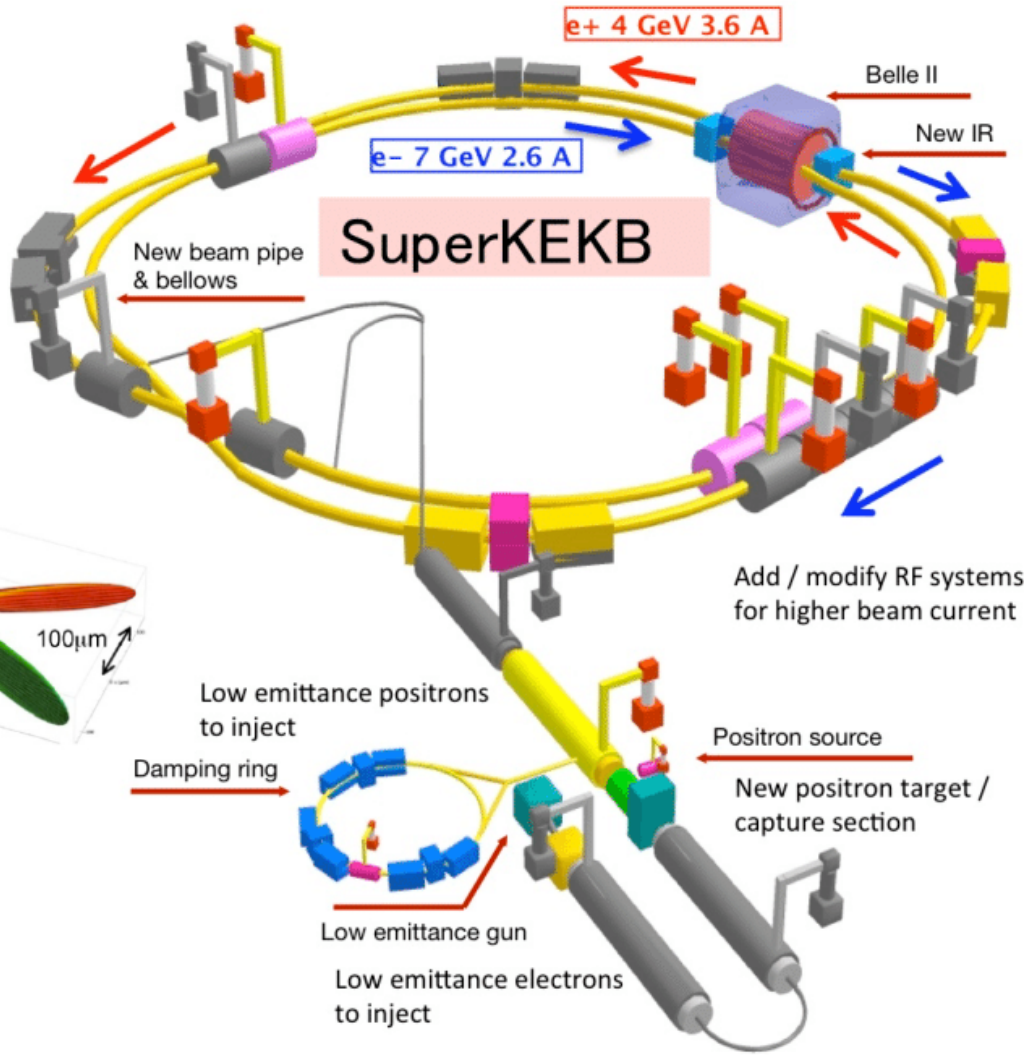

The SuperKEKB $\mathrm{e^+e^-}$ collider

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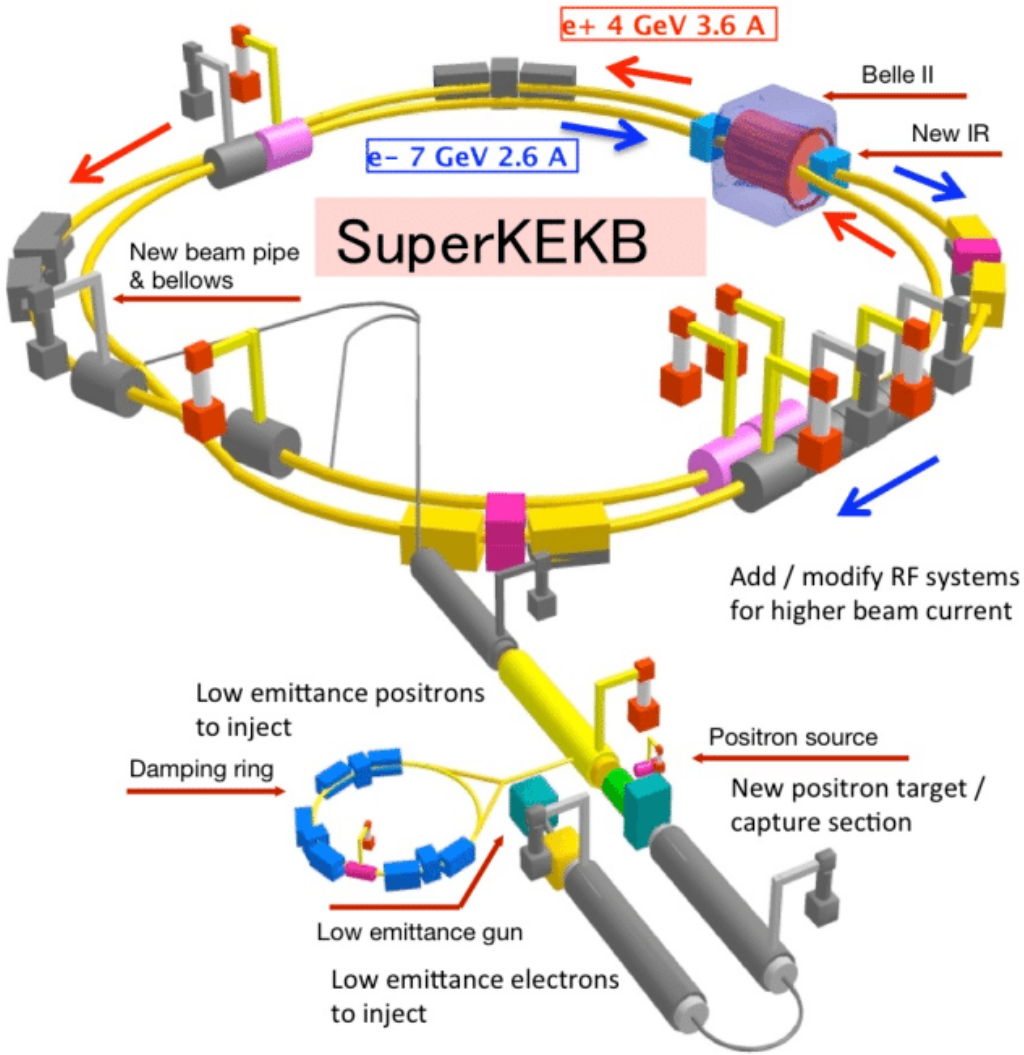
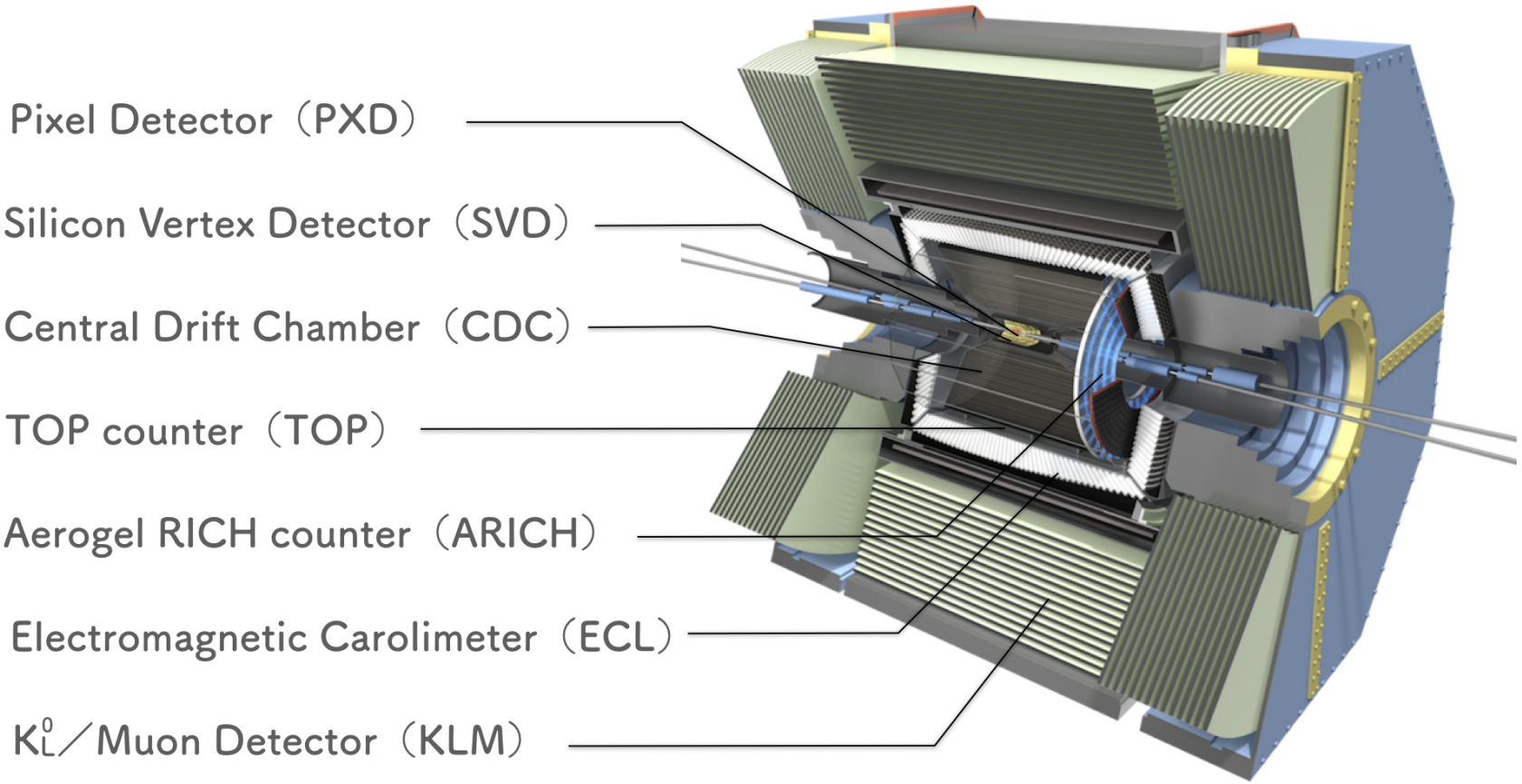
- Center-of-mass close to $\Upsilon(4\mathrm{S})$ $\sim 10.5\,\mathrm{GeV}$
- Upgrade of the KEKB collider:
  - Larger beam current
  - Reduced beam size
- $\rightarrow$ Luminosity increase x40
- Designed peak luminosity of $8 \cdot 10^{35}\,\mathrm{cm^{-2}s^{-1}}$
- Planned data sample corresponding to a recorded integrated luminosity of $\sim 50\,\mathrm{ab^{-1}}$



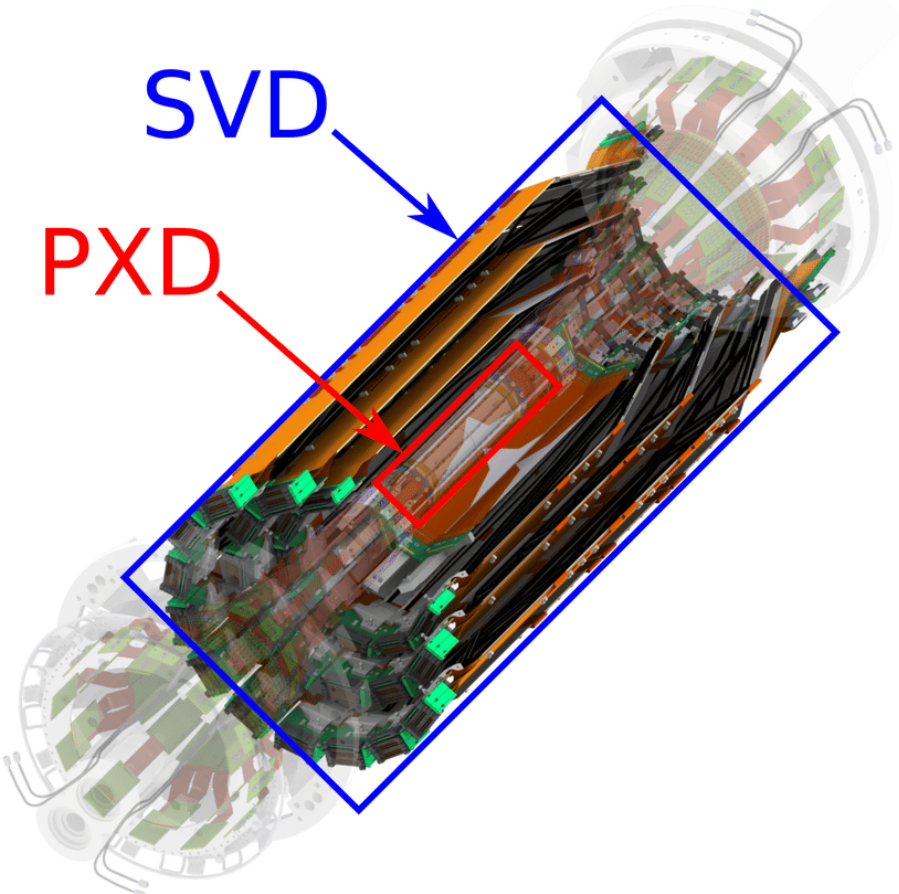
The Belle II Detector



Vertex Detectors

Vertex Detectors:

- Consist of Pixel Detector (PXD) and Silicon Vertex Detector (VXD)
- Both detectors consist of multiple ladders of strip detectors
- During phase2, only a fraction of the VXD detectors were installed
- During phase3, the complete SVD and roughly half of the PXD were installed



Central Drift Chamber

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Electromagnetic Calorimeter

content...

Motivation

- I am performing an analysis to estimate the tracking efficiency on phase 2 data
- The process I am considering is Bhabha events $\mathrm{e}^+ + \mathrm{e}^- \rightarrow \mathrm{e}^+ + \mathrm{e}^-$
- The definition of efficiency I am going to use is:

$$\epsilon = \frac{\text{Number of Bhabha events with exactly 2 tracks}}{\text{Number of Bhabha events with 1 or more tracks}}$$

- After selecting Bhabha events where at least one of the tracks was detected, one can look how many times the second one is found
- This idea comes from some plots presented by Sam Cunliffe in previous tracking and ECL meetings.

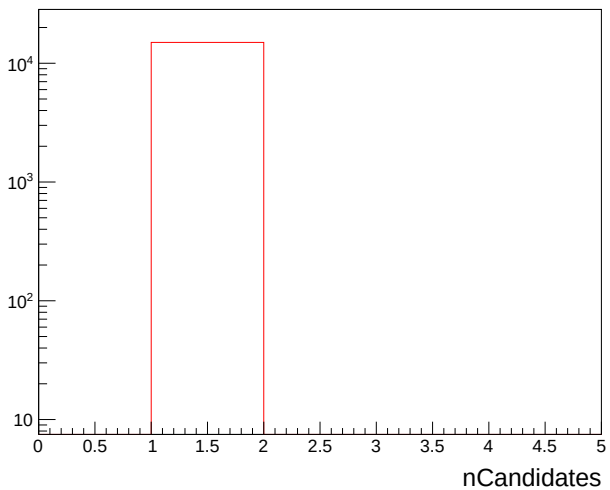
Best Candidate Selection

$$\text{vpho} \rightarrow \text{ECL-Object(HclE)} + \text{ECL-Object(LclE)}$$

HcLE: particle with the higher cluster Energy; LclE: particle with the lower cluster Energy

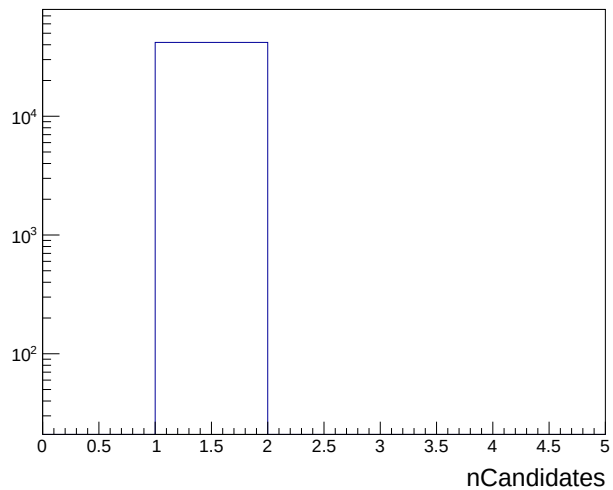
- $0.296706 < \theta_{\text{ECL Object}} < 2.61799 \rightarrow$ It has to hit the ECL
- Exactly two clusters with at least 3.5 GeV per event and one cluster has to have at least 4.5 Ge
- $8\,\text{GeV} < \text{M}_{\text{vpho}} < 12\,\text{GeV}$
- $\text{nTracks} < 7$
- $\text{Total Energy in the ECL} < 15\,\text{GeV}$

1 MC ee $\rightarrow$ ee File

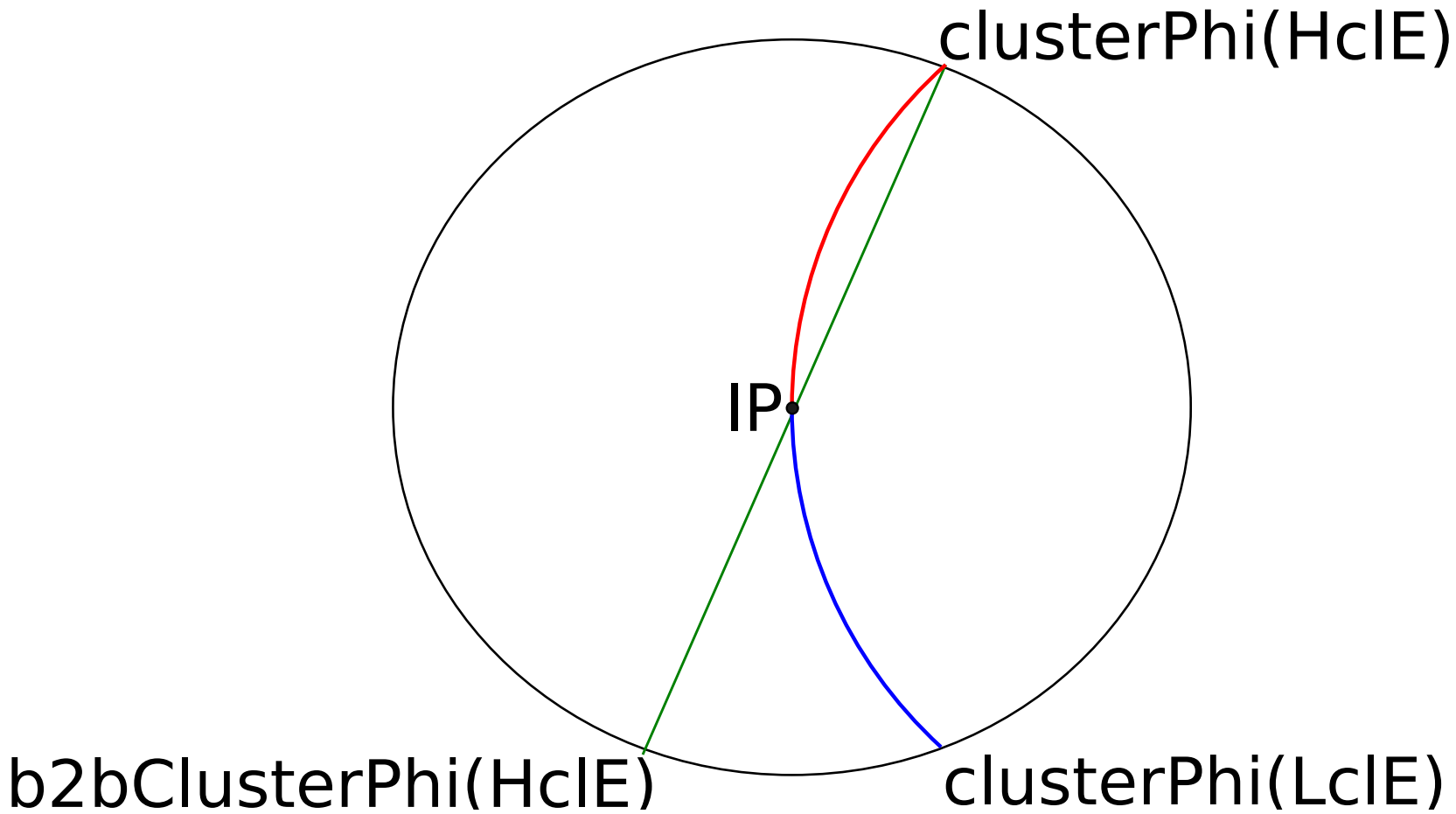


Phase 2 data

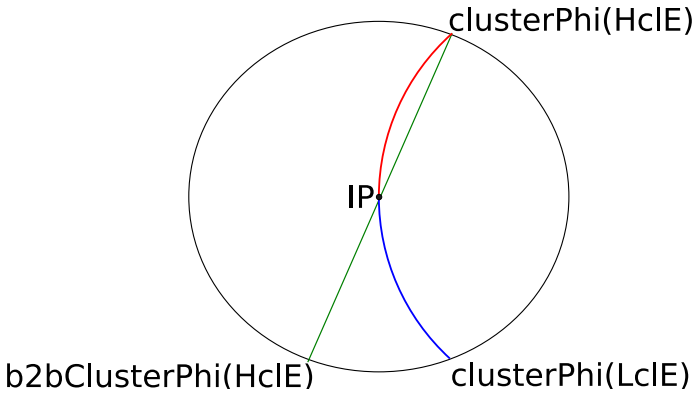
r02608/all/mdst/sub00/*.root

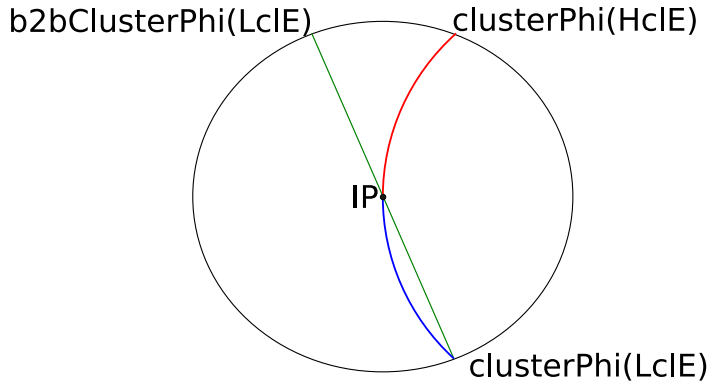


Bhabha Event Selection

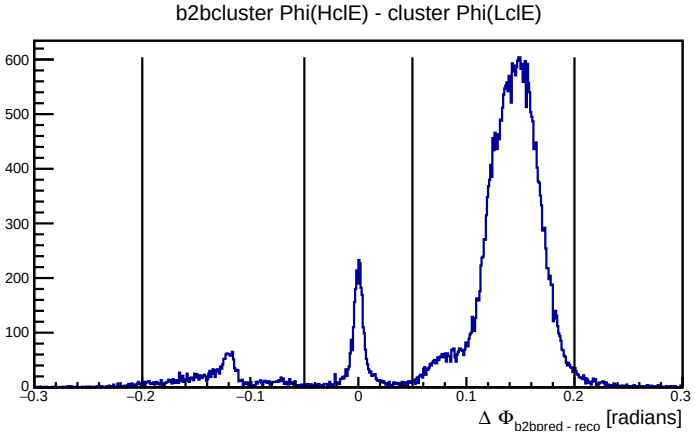


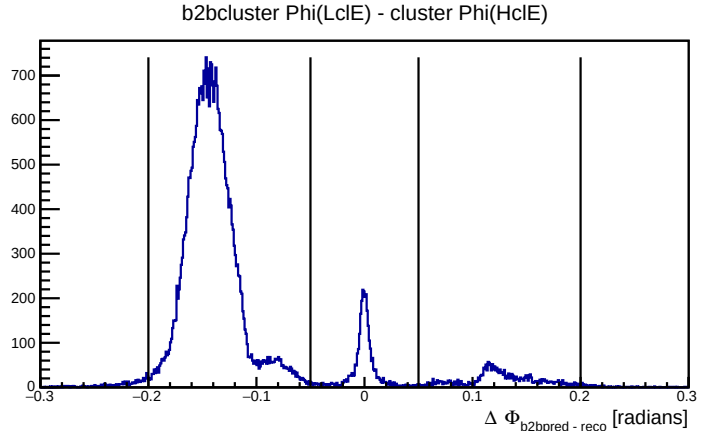
Bhabha Event Selection (Phase 2 data)



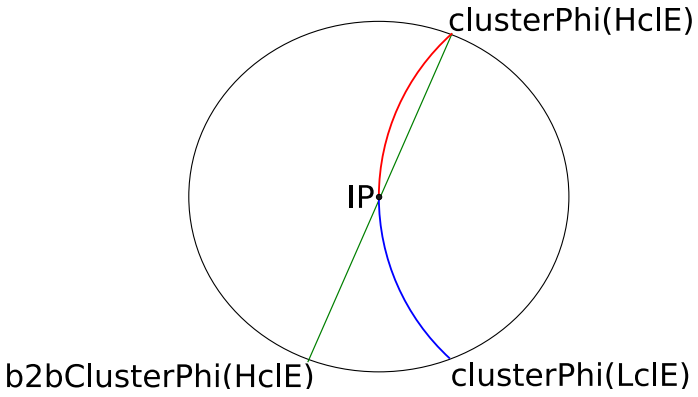


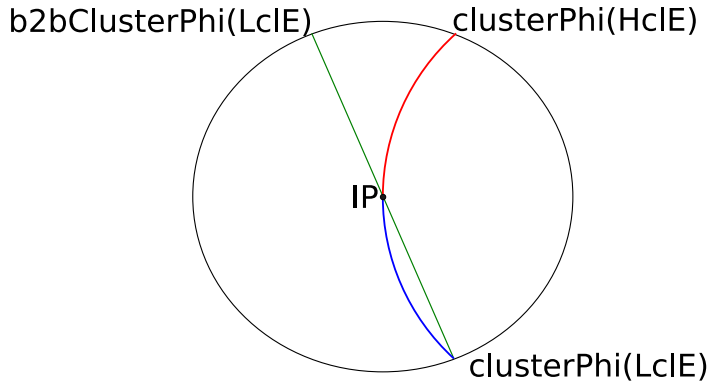
Phase 2 data r02608



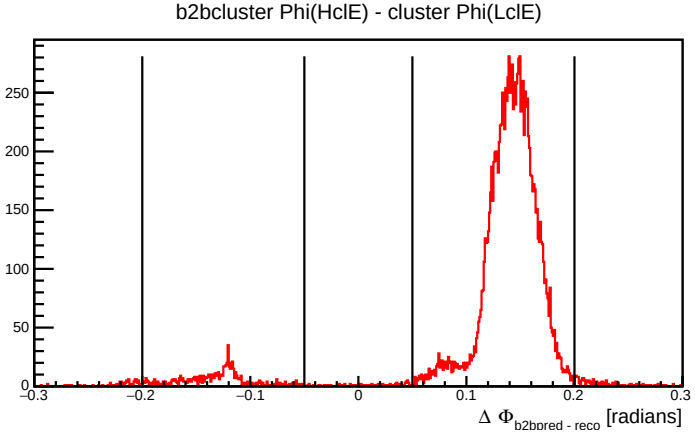


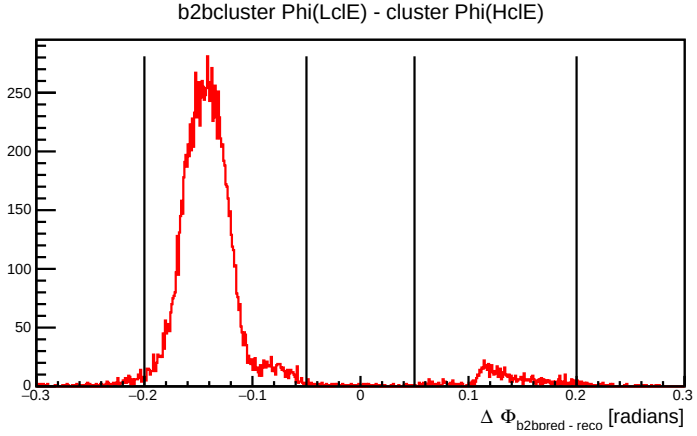
Bhabha Event Selection (MC)





MC: $ee \to ee$





More Events

MC:

- /belle/MC/release-02-00-01/DB00000411/MC11/prod00006731/s00/e1002/4S/r00000/3600520000/mdst/sub00
- 5272146 candidates selected

Phase 2 data:

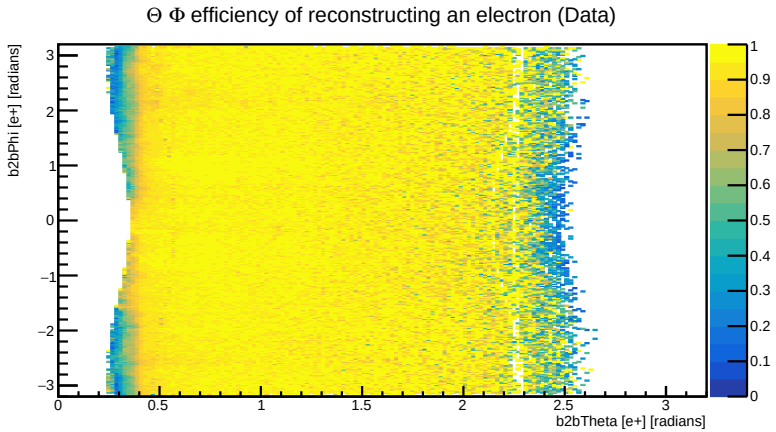
- /ghi/fs01/belle2/bdata//Data/release-03-00-03/DB00000528/proc00000008/e0003/4S/r02*/all/mdst/sub00/*.root
- proc8
- 3669759 candidates selected

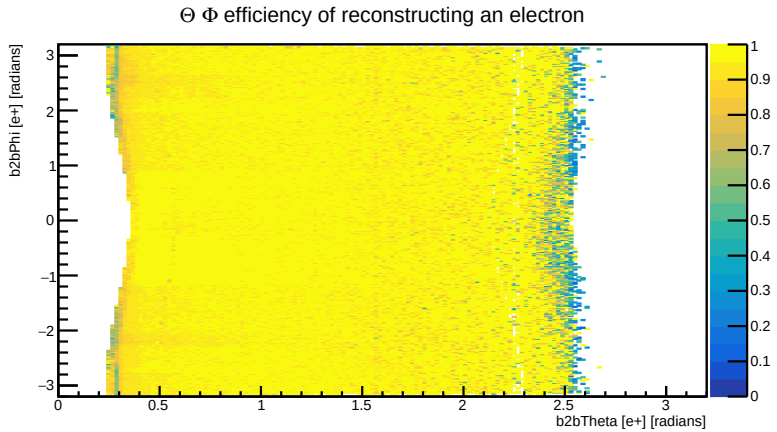
Compare MC And Phase 2 data Efficiency

Phase 2 data

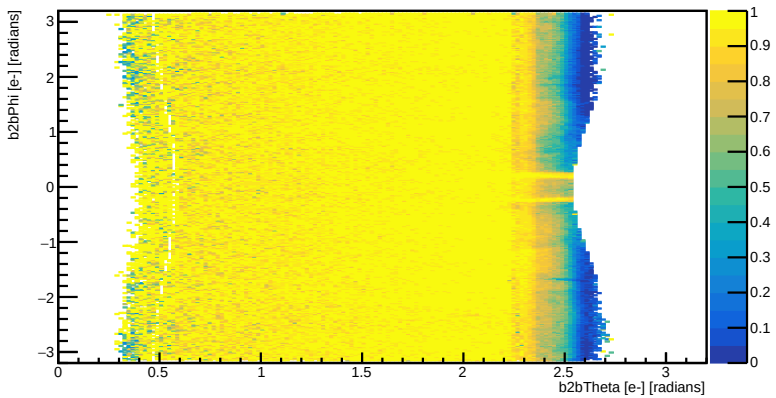
MC

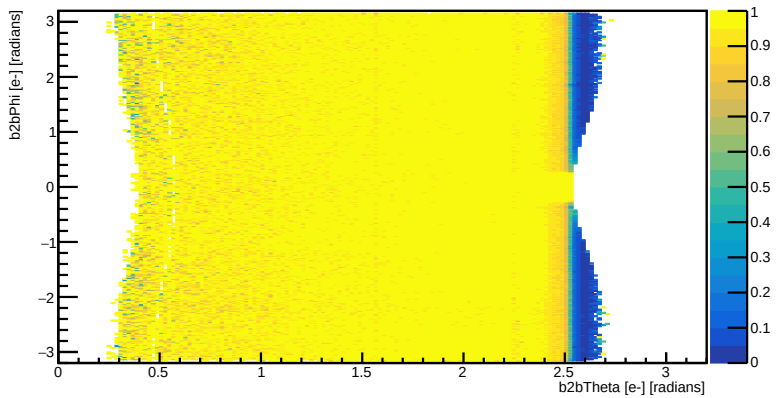
e^-





e^+





Theta And Phi Projection

Φ

Θ

e^-

e^+