Status of FPCCD software

ILD software meeting

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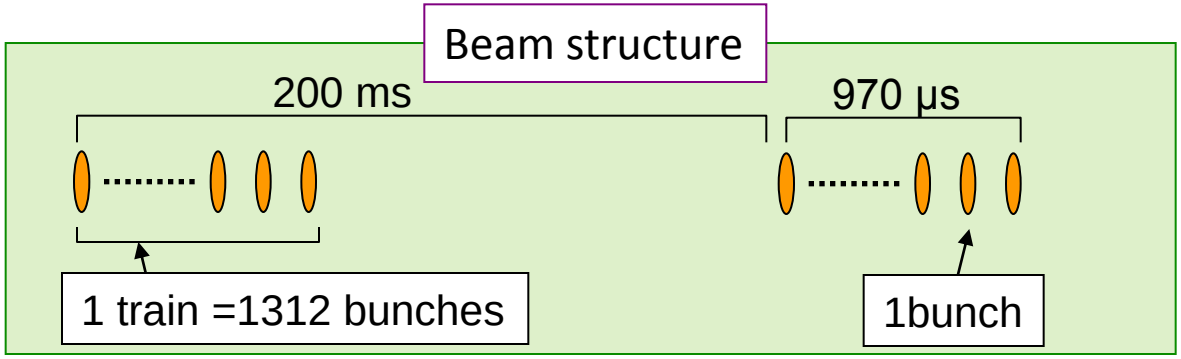
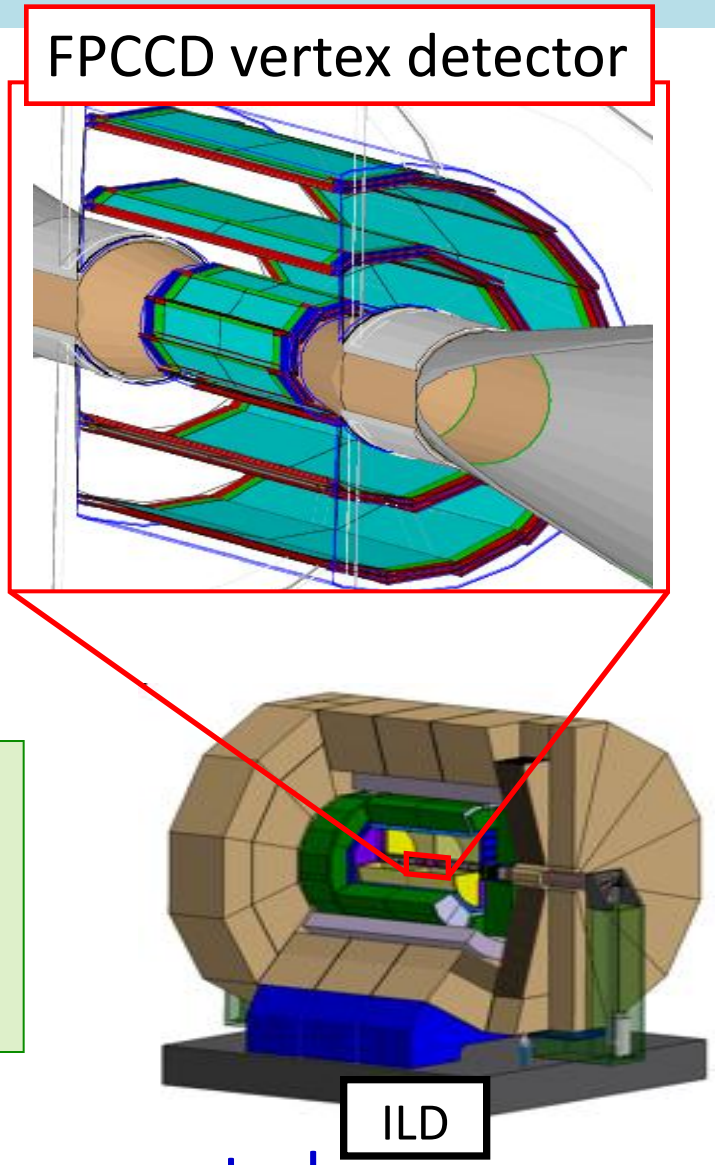
FPCCD vertex detector

FPCCD vertex detector

- FPCCD(Fine Pixel CCD)
  - Pixel size : 5μm x 5μm
  - Sensitive thickness : 15μm
  - The number of pixels : ~10^{10} pixels
  - Fully depleted sensor
  - Read out time : Inter-train

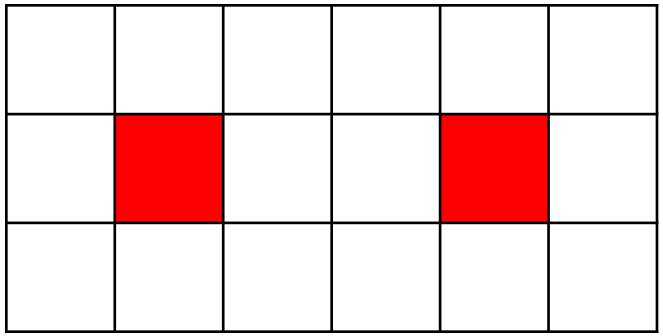




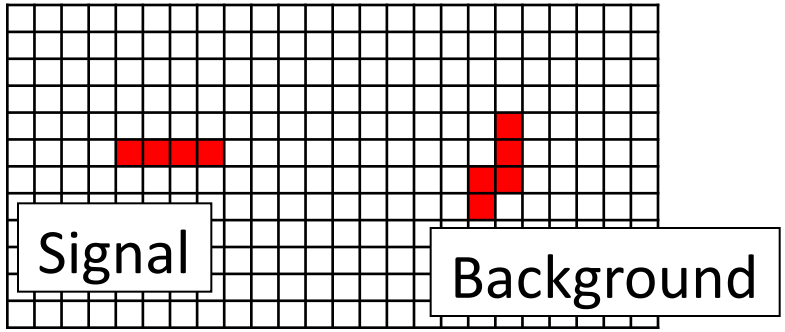
By using FPCCD, many advantages are expected.

Advantage of FPCCD

- High spatial resolution because of very small pixel size.
  → High impact parameter resolution is also expected.
- High two-track separation capability because of fully depleted sensor.
- Low pixel occupancy because of a large number of pixels.
- Not affected by RF noise produced by the beam because the signal is read out in the interval between train and train.
- Background rejection by using the cluster shapes.



Large pixel size



FPCCD

Software for FPCCD vertex detector

Purpose

- Evaluation of the tracking and vertexing performance.
- Evaluation of the background effect.
- Estimation of the flavor tagging and charge ID performance.

→ For this purpose, software for FPCCD vertex detector was developed.

- FPCCD digitizer (generate signals)
- Overlay processor (merge background into physics event)
- FPCCD clustering (reconstruct the hit point from pixel hits)

These software operate as a part of MarlinReco package.

Simulation study of FPCCD under background is available.

Simulation study of FPCCD vertex detector

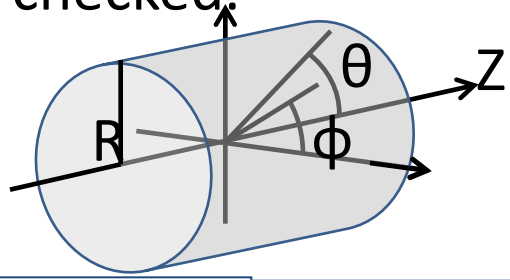
The performance of FPCCD vertex detector was checked by using the software for FPCCD vertex detector.

Today's talk

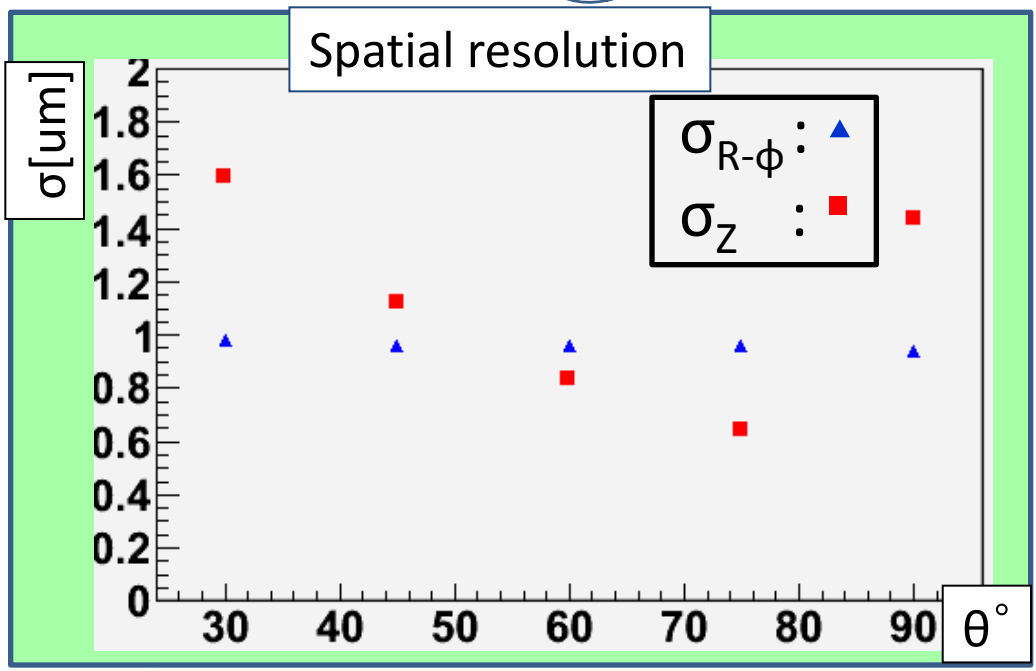
- The spatial resolution and the impact parameter resolution.
- The pixel occupancy of pair background.
- The flavor tagging.

Spatial resolution

- The θ dependency of the spatial resolution was checked.
  - μ-（Momentum 100GeV)
  - σ_{noise} : 50 electrons /pixel.
  - Threshold : 200 electrons /pixel.



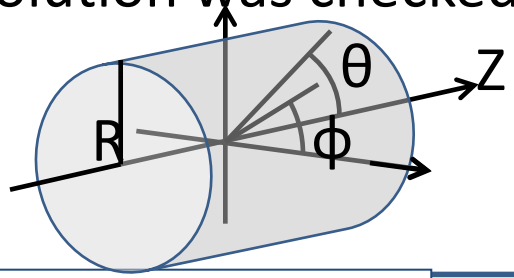
θ	σ_Z	$\sigma_{R\text{-}\phi}$
90°	1.5 um	0.94 um
75°	0.64 um	0.96 um
60°	0.83 um	0.96 um
45°	1.2 um	0.96 um
30°	1.6 um	0.98 um
LOI value	2.8 um	2.8 um



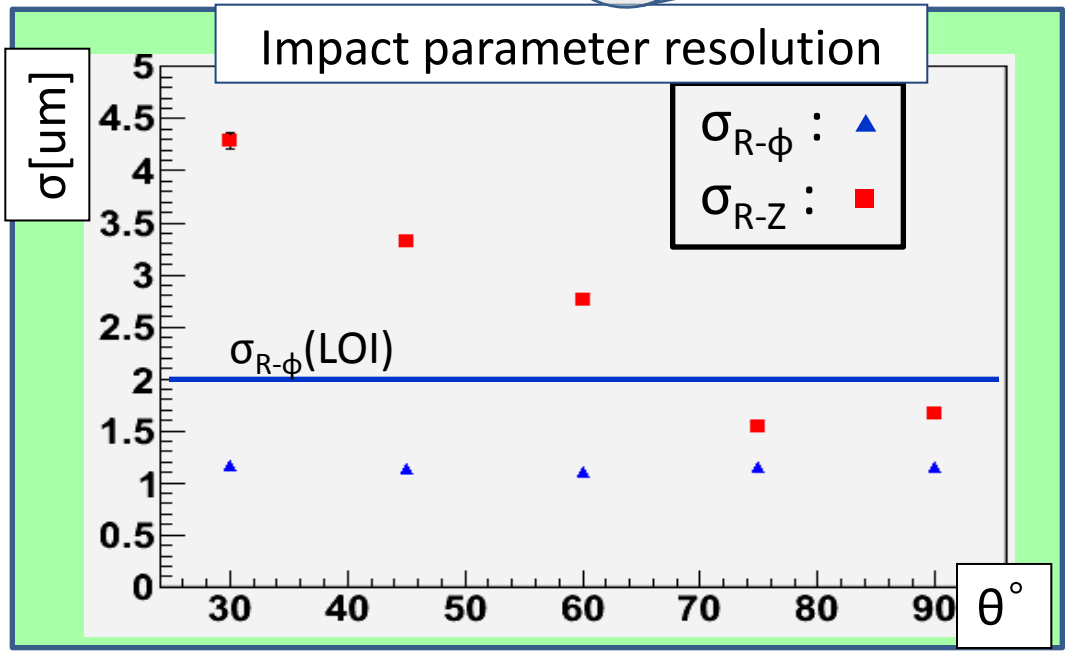
- The Z resolution is worse at forward.
- The R-ϕ resolution does not depends on θ.
- The Z resolution of the vertical track is bad.

Impact parameter resolution

- The θ dependency of the impact parameter resolution was checked.
  - μ-（Momentum 100GeV)
  - σ_{noise} : 50 electrons /pixel
  - Threshold : 200 electrons /pixel.



θ	σ_{R-Z}	$\sigma_{R-\phi}$
90°	1.7 um	1.2 um
75°	1.5 um	1.2 um
60°	2.9 um	1.1 um
45°	3.4 um	1.1 um
30°	4.3 um	1.2 um
LOI value	—	2.0 um

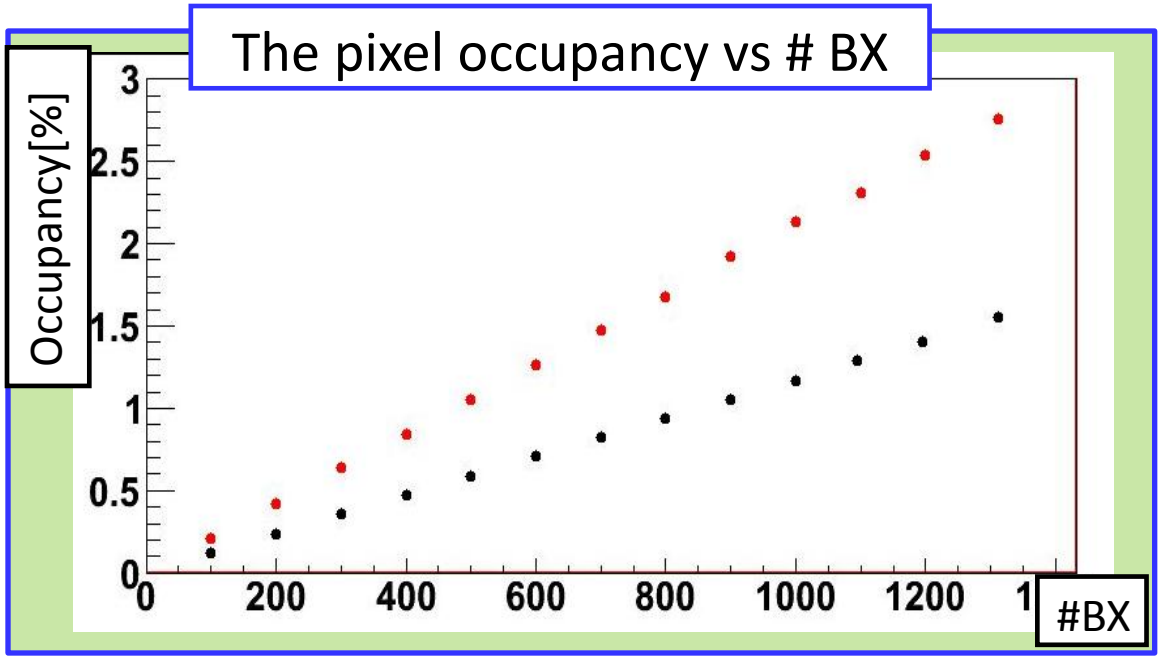


- The impact parameter resolution is roughly proportional to the spatial resolution.
- Spatial resolution and IP resolution are better than LOI value.

Pair background occupancy

- The pixel occupancy of the FPCCD VTX innermost, second layer was checked.

Background conditions
— Generator : Guinea Pig
— Beam parameter : SB2009w/TF
— CM energy : 500 GeV
— Range cut : 100 um



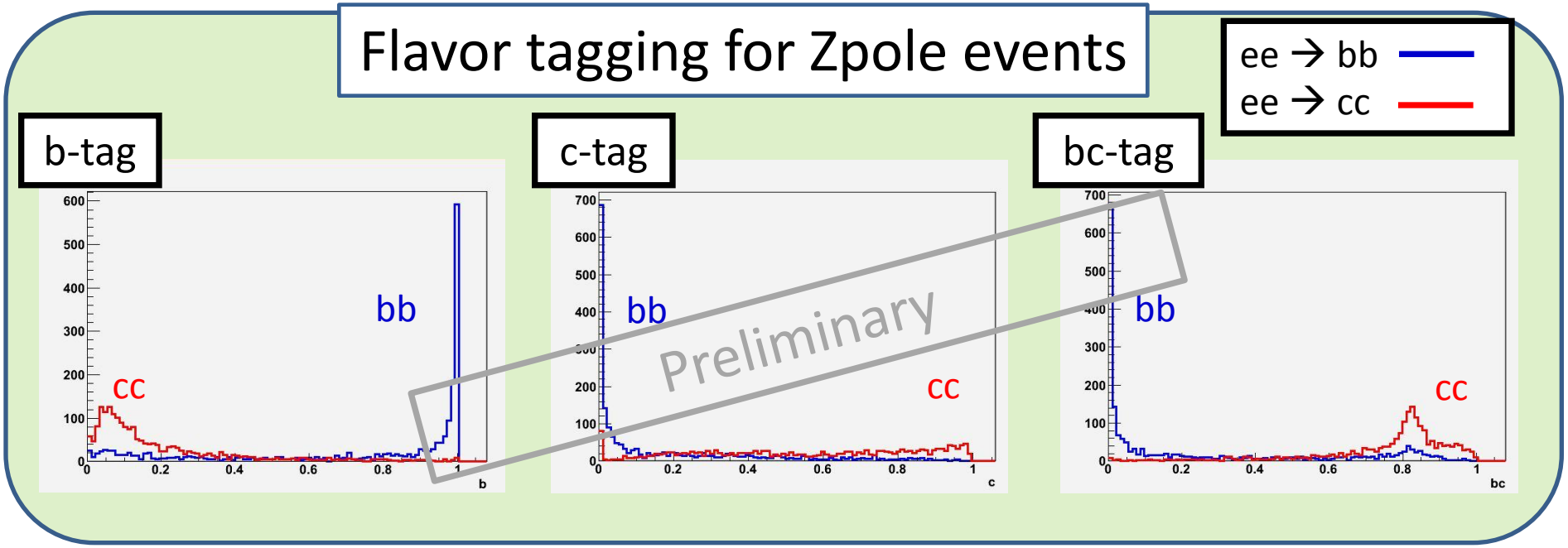
Pixel occupancy for 1train(1312 BX)

- Innermost layer : 2.76%
- Second layer : 1.55%

Very low occupancy, compared with conventional CCD.
(25um pixel >> 10%)

Flavor tagging

- Estimation of the flavor tagging performance was started.
  - $e^+e^- \rightarrow b\bar{b}$, $e^+e^- \rightarrow c\bar{c}$ event
  - CM energy : 91 GeV
  - 1000 events



- Efficiency and purity will be checked.

Summary

- FPCCD software were developed.
  - — Simulation study of FPCCD under background is available.
- FPCCD has good resolution.

- Spatial resolution
  - $\sigma_{R\text{-}\phi}$ = ~0.96 um
  - σ_z = 0.64 um (θ =75°)
- IP resolution
  - $\sigma_{R\text{-}\phi}$ = ~1.2 um
  - $\sigma_{R\text{-}Z}$ = 1.5 um (θ =75°)

- FPCCD realizes low occupancy.
  - Innermost layer : 2.76%
  - second layer : 1.55%

Plan

- Estimation of the flavor tagging and charge ID performance.
- Development of FPCCD track finder.
  - — Using information of the cluster shapes.