Development of software for FPCCD vertex detector

- FPCCD vertex detector
- Software for FPCCD vertex detector
- Simulation study of FPCCD vertex detector
- Summary

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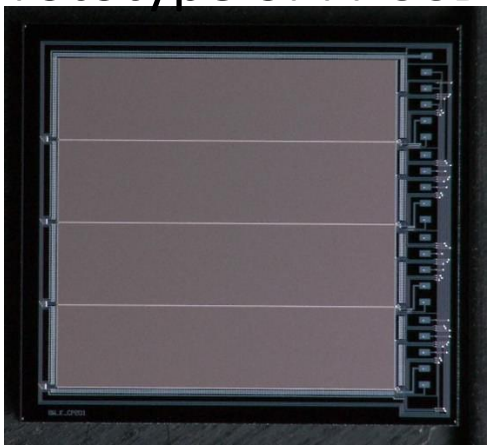
FPCCD vertex detector

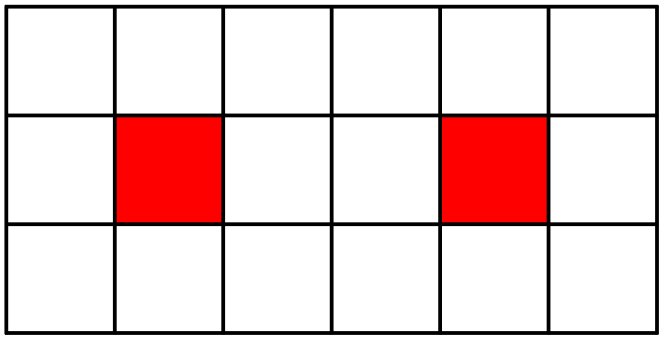
FPCCD vertex detector

Prototype of FPCCD

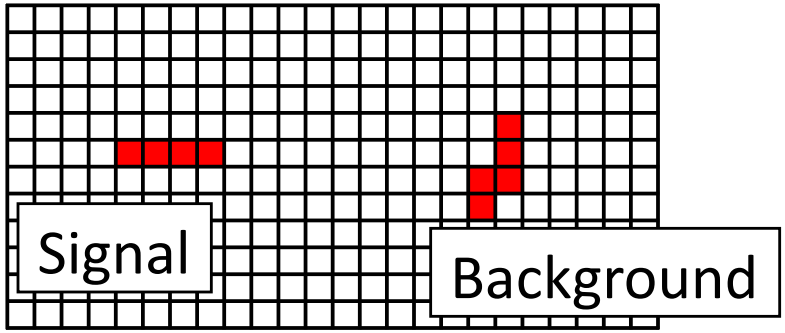


- FPCCD(Fine Pixel CCD)
  - Pixel size : 5μm x 5μm
  - Sensitive thickness : 15μm
- Read out time : Inter-train
- The number of pixels : ~10^{10} pixels

→The small pixel size enables to reject background hits by using the cluster shapes.



Large pixel size



FPCCD

Software for FPCCD

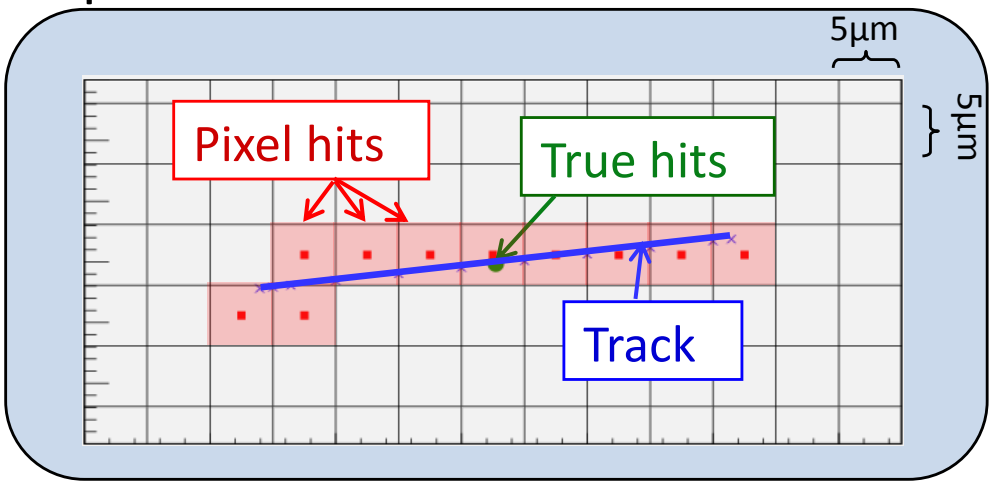
Software for FPCCD vertex detector is developed.

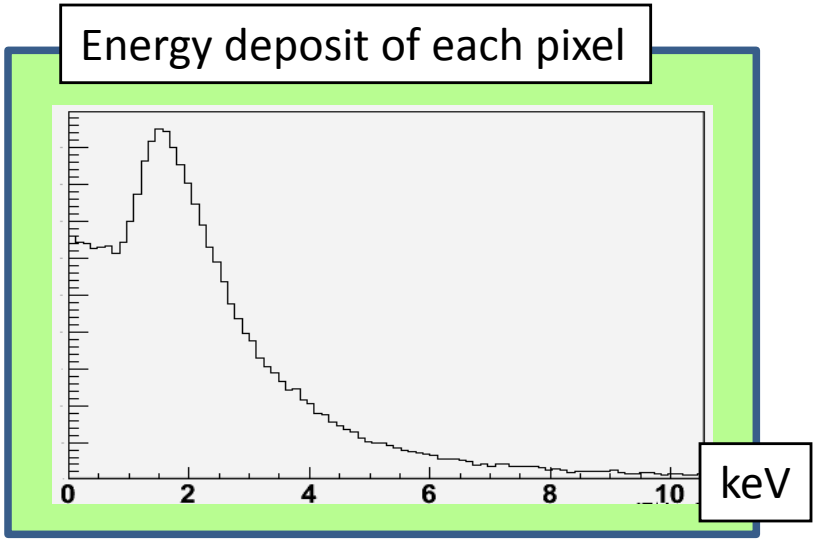
- FPCCD digitizer
  - — generates the signal of FPCCD by using the information of event simulater.
- FPCCD clustering
  - — reconstructs the hit point of the particle by using the information of the signal of FPCCD.

These software work as a part of iLCsoft MarlinReco package.

FPCCD digitizer

- The hit points and track momenta are obtained from SimTrackerHit.
- The track is calculated by the hit point and momentum.
- The pixel hit is identified by intersection of track and boundaries of pixels.





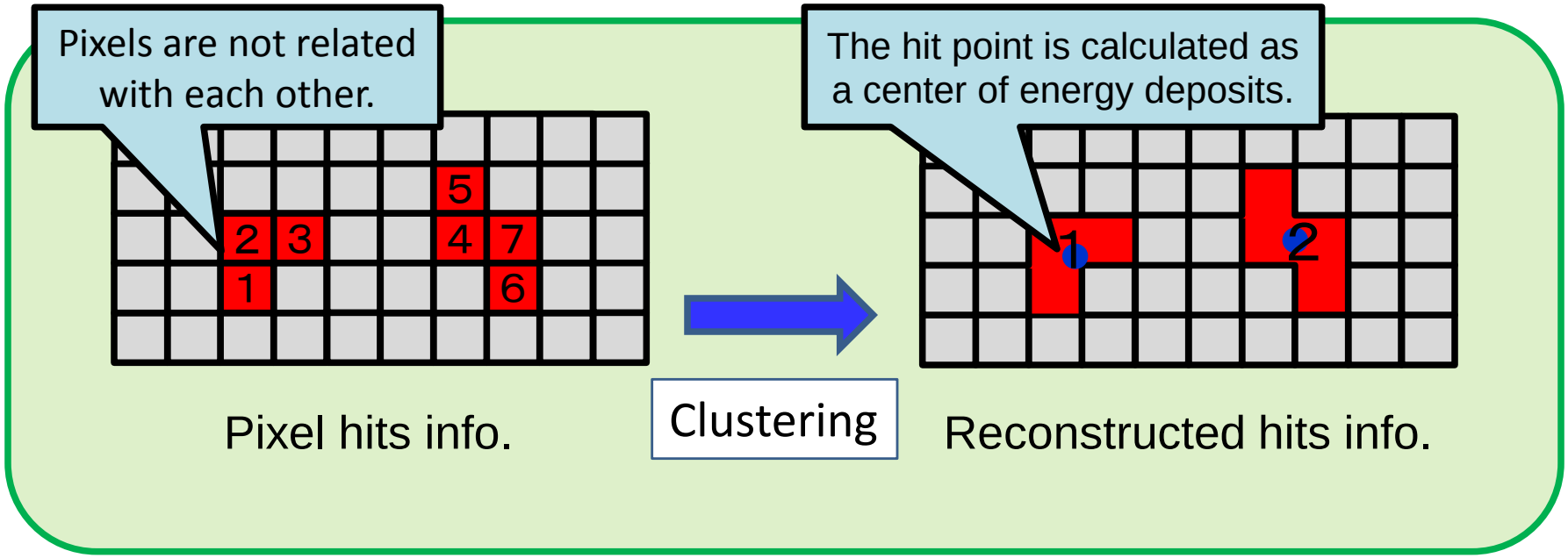
- The energy deposit of SimTrackerHit is divided into pixels proportional to path length and these are approximated by Landau distribution.
- The noise is put on to each pixel hit.

⇒ The output is the position of pixel hit and its energy deposit.

FPCCD clustering processor

- The position of pixel hit and its energy deposit is obtained from FPCCD digitizer.
- The neighboring pixels are recognized as a cluster.
- The hit point is reconstructed as an energy weighted position.

⇒ The output is TrackerHit collection.



Simulation study of FPCCD vertex detector

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

Purpose of this study

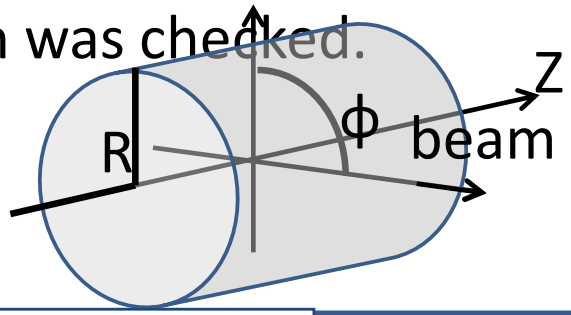
To check the performance of FPCCD vertex detector with background.

Today's talk

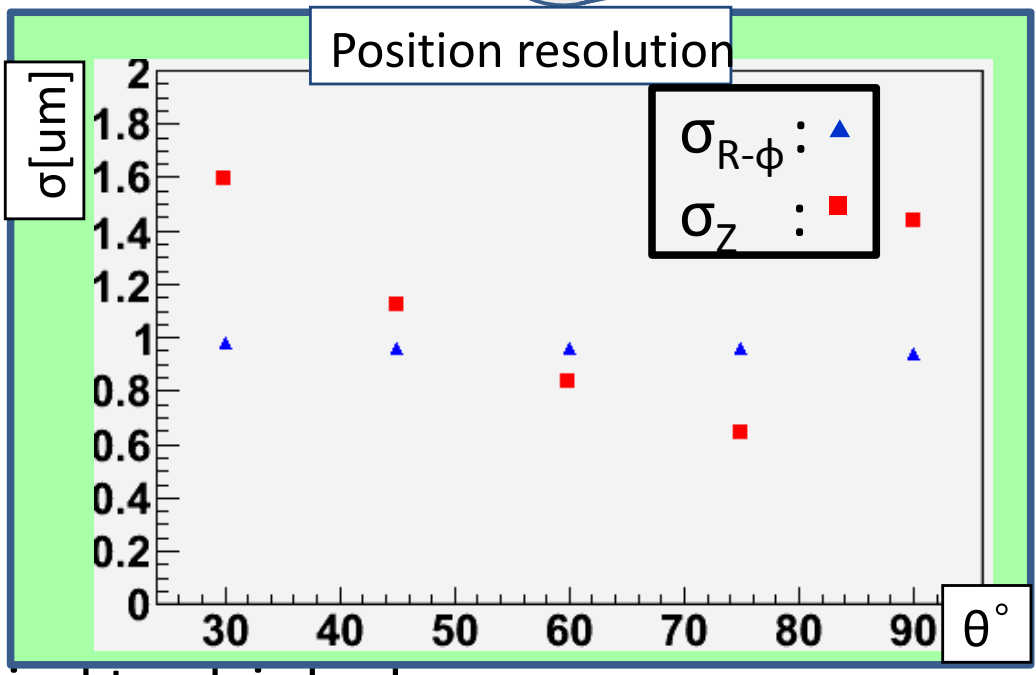
- The position and impact parameter resolution. (without background)
- The pixel occupancy of pair background.
- An algorithm to reject pair background.

Position resolution

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



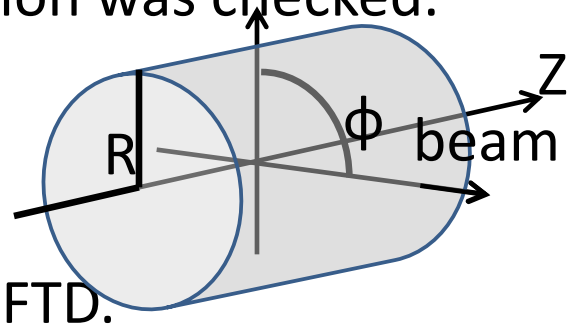
θ	σ_Z	$\sigma_{R\text{-}\phi}$
90°	1.5 um	0.94 um
75°	0.64 um	0.96 um
60°	0.83 um	0.96 um
45°	1.2 um	0.96 um
30°	1.6 um	0.98 um
LOI value	2.8 um	2.8 um



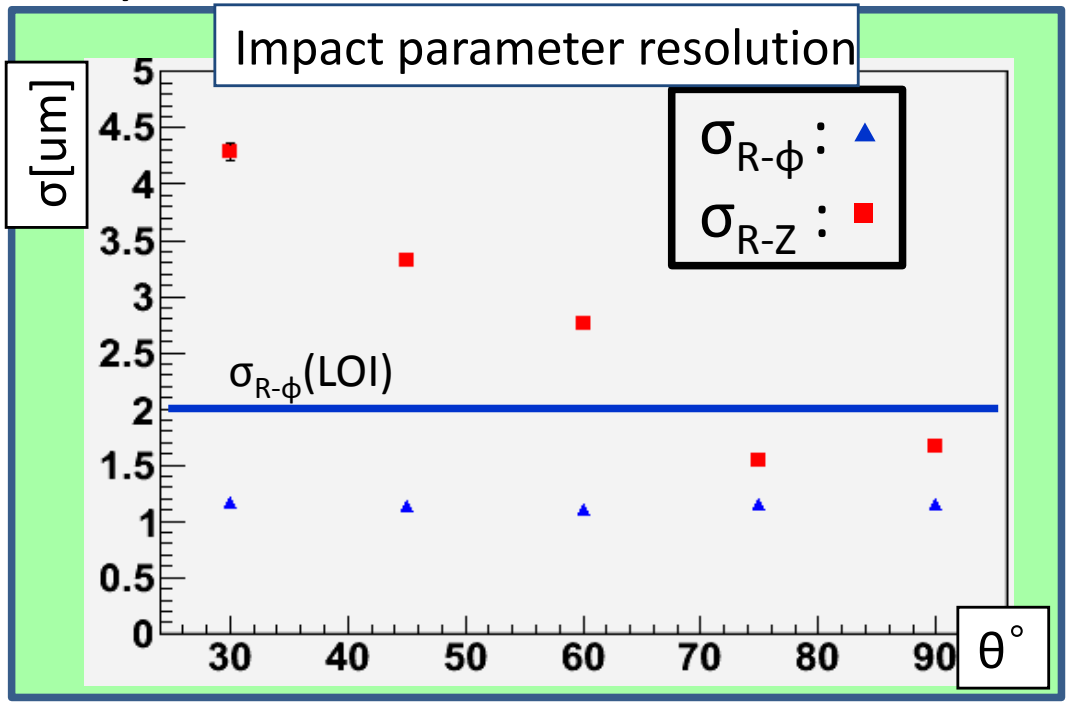
- The Z resolution of the vertical track is bad.
- The Z resolution is worse at forward.
- The R-ϕ resolution is not depends on θ.

Impact parameter resolution

- The θ dependency of impact parameter resolution was checked.
  - μ-（Momentum 100GeV)
  - σ_{noise} : 50 electrons /pixel
  - Threshold : 200 electrons /pixel.
  - Tracks were reconstructed by VTX, SIT and FTD.



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

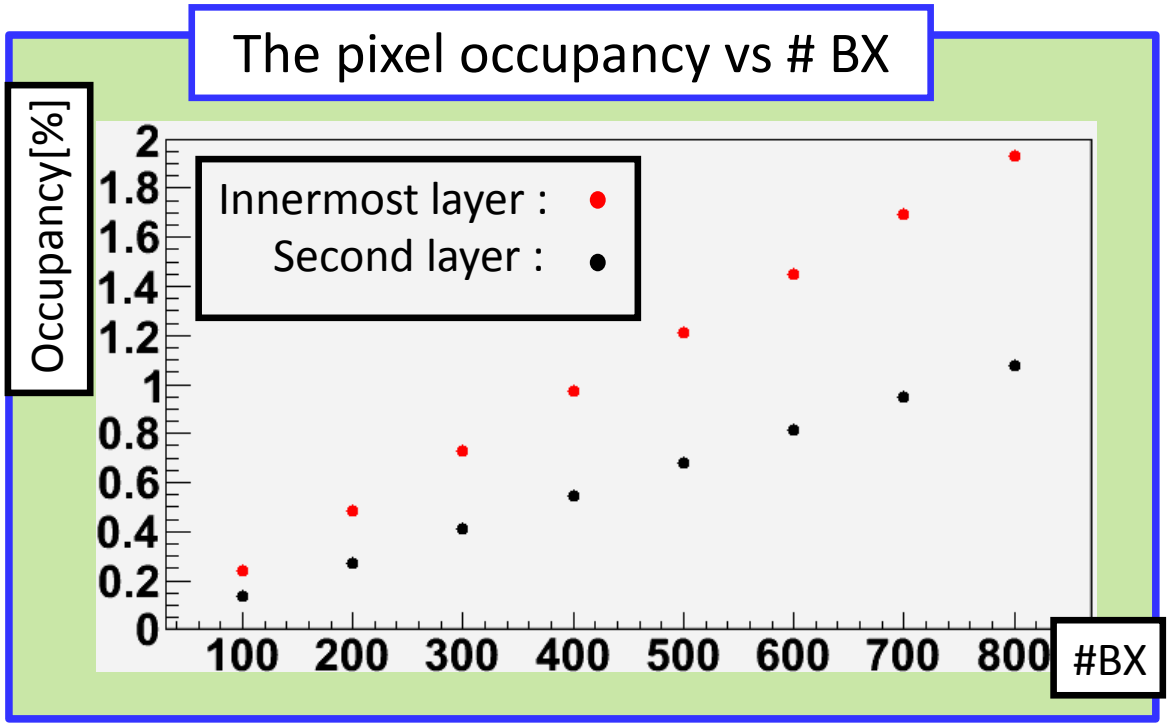


- The impact parameter resolution is roughly proportional to the position resolution.

Pair-background occupancy

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

Background conditions
— Generator : Guinea Pig
— Beam parameter : SB2009w/TF
— CM energy : 500 GeV
— Range cut : 0.1 mm



Expected pixel occupancy for 1train(1312 BX)

- Innermost layer : 3.17%
- Second layer : 1.77%

Lower occupancy is required.

→ background rejection algorithm was developed.

Background rejection

- The μ- hits and pair background hits were separated by using the cluster shapes.

Efficiency

	innermost	second
μ-(100GeV)	99.2%	99.7%
Pair background	8.53%	9.37%

- The background hit decreased to 1/10, keeping 99% μ- efficiency.
- The challenge is to increase the efficiency of low-energy signals keeping background hits low.

Summary

The software for FPCCD vertex detector were developed.

- FPCCD digitizer
- FPCCD clustering

The result of simulation study of FPCCD vertex detector

- Position 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°)
- Pixel occupancy of pair background
  - Innermost layer : 3.17%, second layer: 1.77% (for1312BX)
- Background rejection algorithm
  - μ^- (momentum 100GeV) and pair background were well separated by the difference of the cluster shapes.

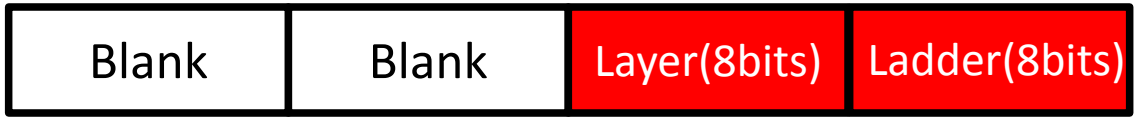
The performance of FPCCD with background will be studied.

Back up

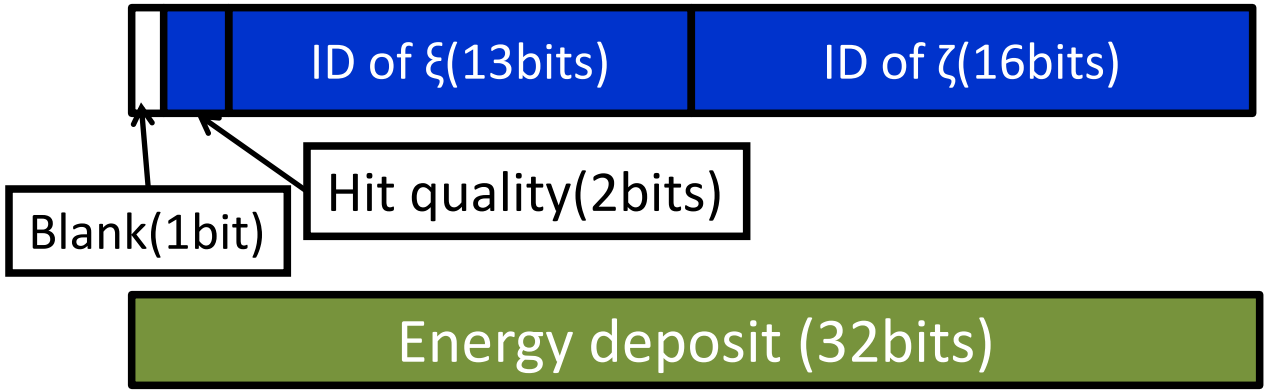
Output collection from FPCCD digitizer

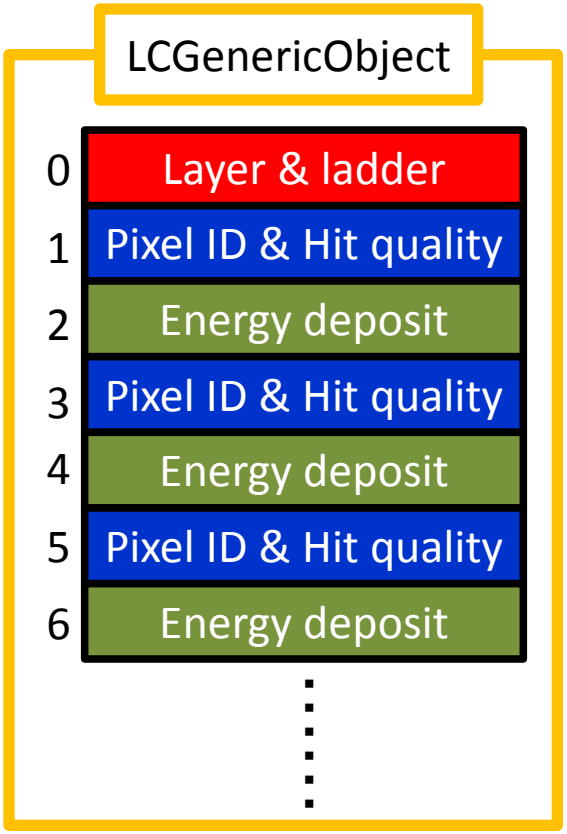
Format of LCGenericObject

- The first word(32 bits) contains layer number and ladder number of the element.



- Two words are used for each pixel hit.





— The number of elements is equal to that of the ladders with hits.

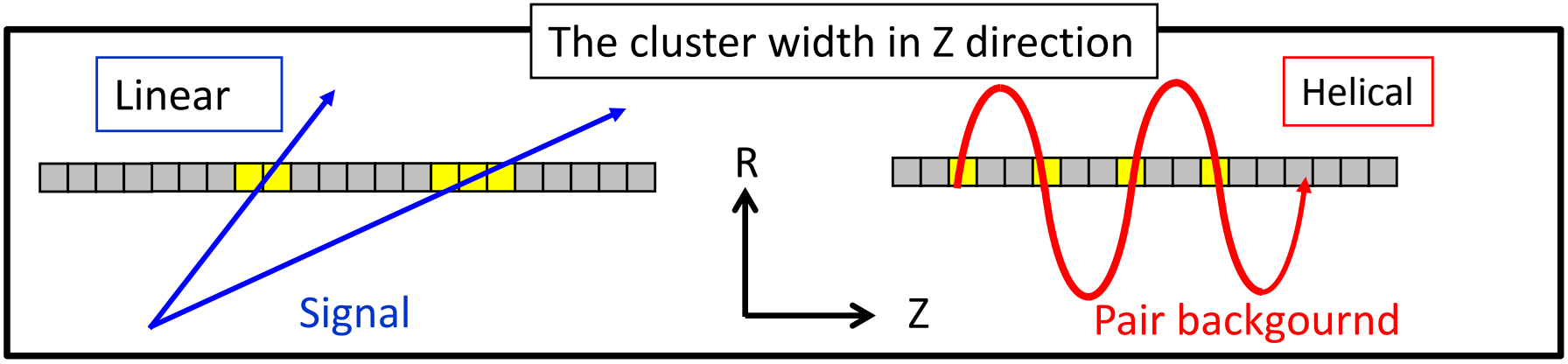
— Data size for one element : $(2 \times N_{hits} + 1)$ words

— The blank area is reserved for the future use.

Background rejection algorithm

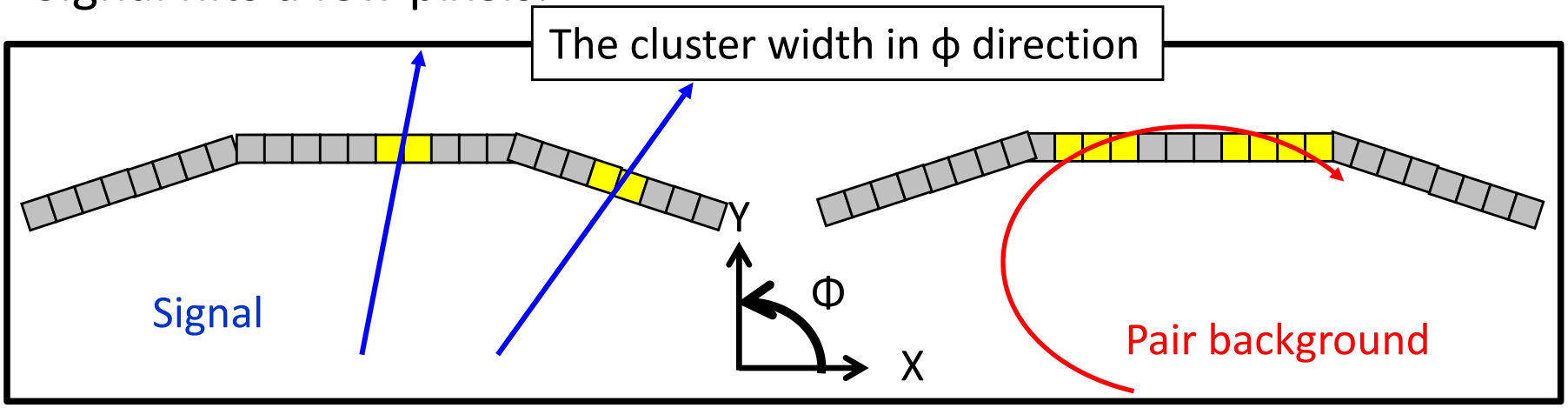
The cluster width in Z direction

- The cluster width of signal is depends on Z.



The cluster width in ϕ direction

- Signal hits a few pixels.



Cluster width cut

- The inside of green line was accepted.