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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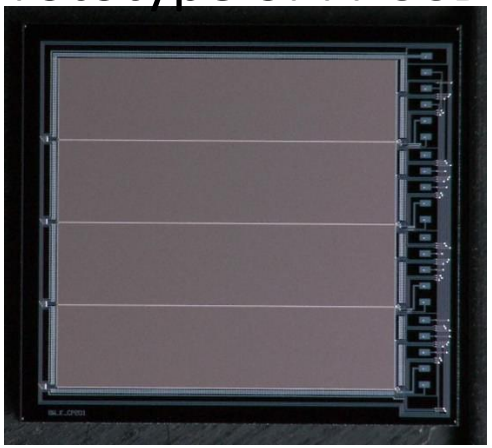
FPCCD vertex detector

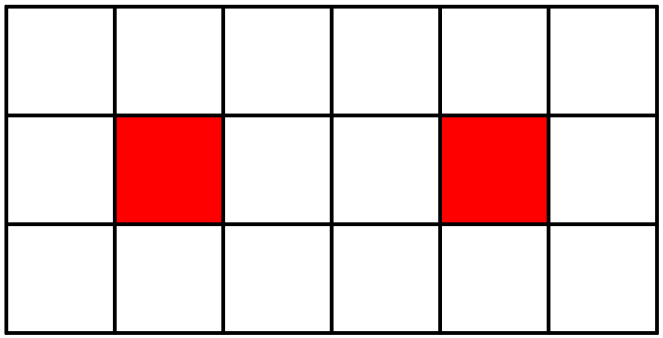
FPCCD vertex detector

Prototype of FPCCD

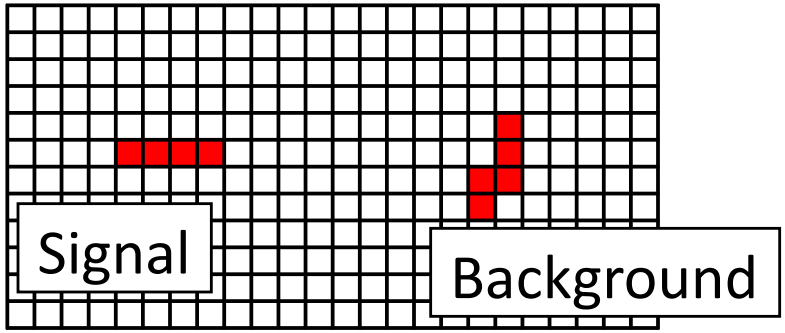


- FPCCD(Fine Pixel CCD)
  - Pixel size : 5μm x 5μm
  - Sensitive thickness : 15μm
- The number of pixels : ~10^{10} pixels
- Read out time : Inter-train

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



Large pixel size



FPCCD

Software for FPCCD vertex detector

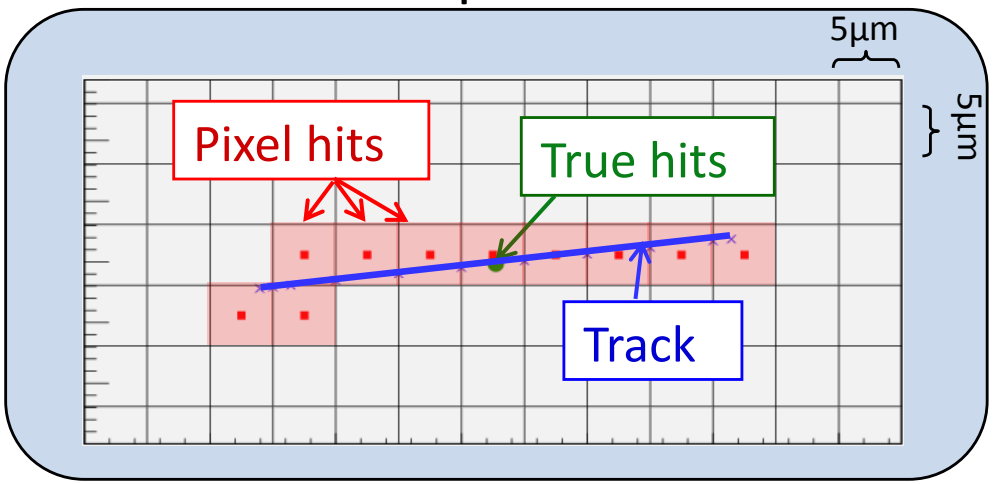
Software for FPCCD vertex detector is developed.

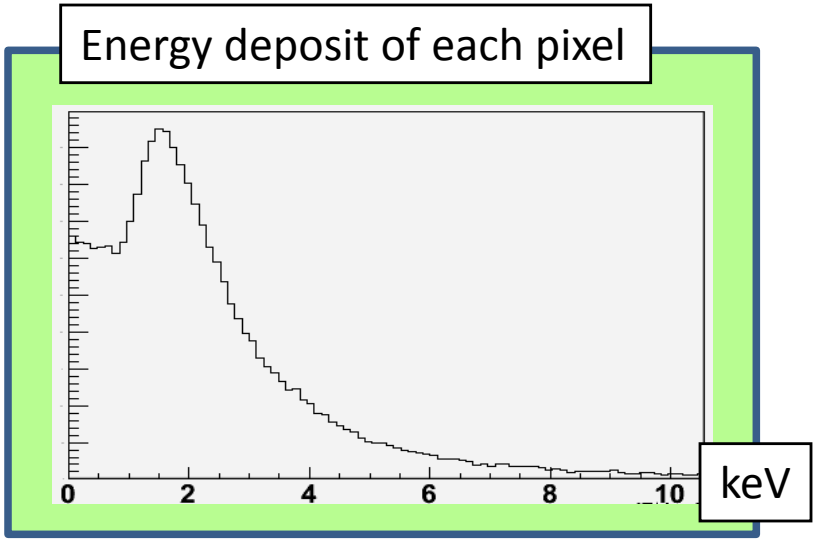
- FPCCD digitizer
- FPCCD clustering processor

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 the intersections of track and boundaries of pixels.





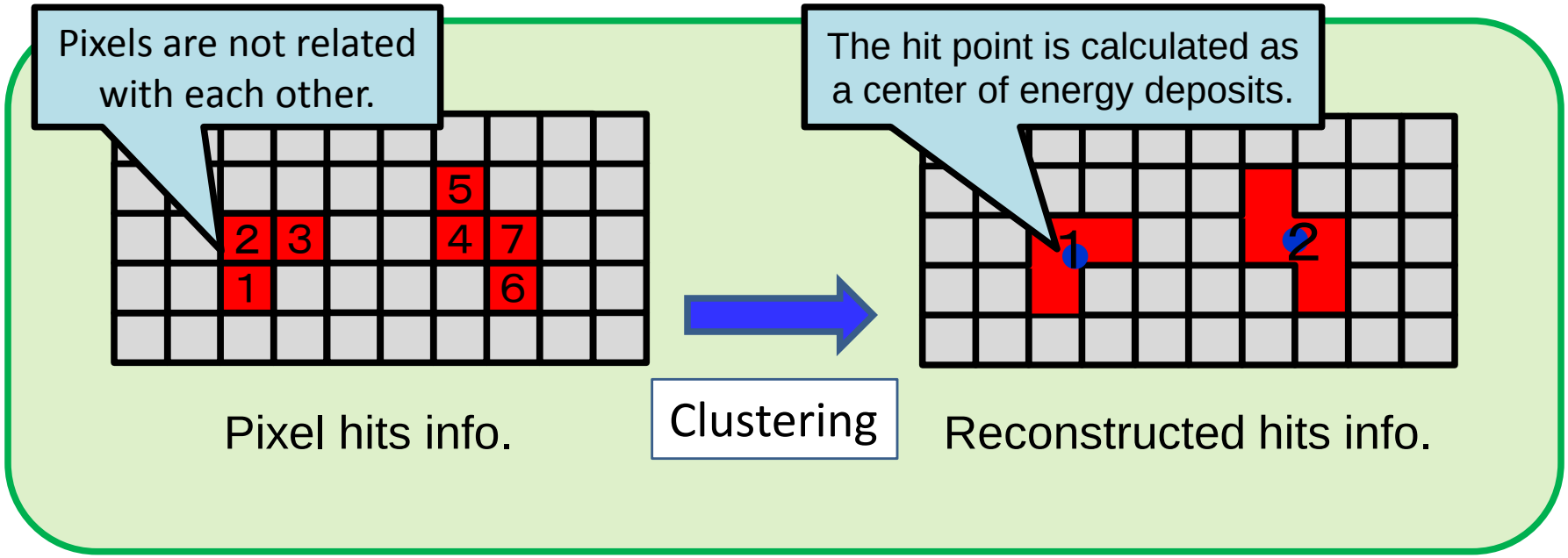
- The energy deposit of SimTrackerHit is divided into pixels as proportional to path length and these are approximated by Landau distribution.
- The noise is put on to each pixel hit.

⇒ 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 using the software for FPCCD vertex detector.

Purpose of this study

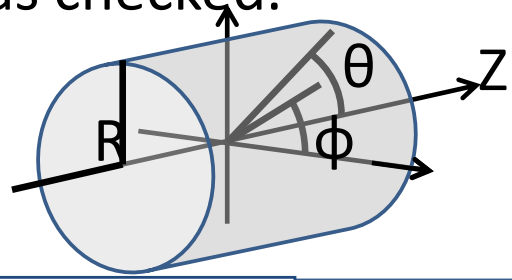
To check the performance of FPCCD vertex detector with background.

Today's talk

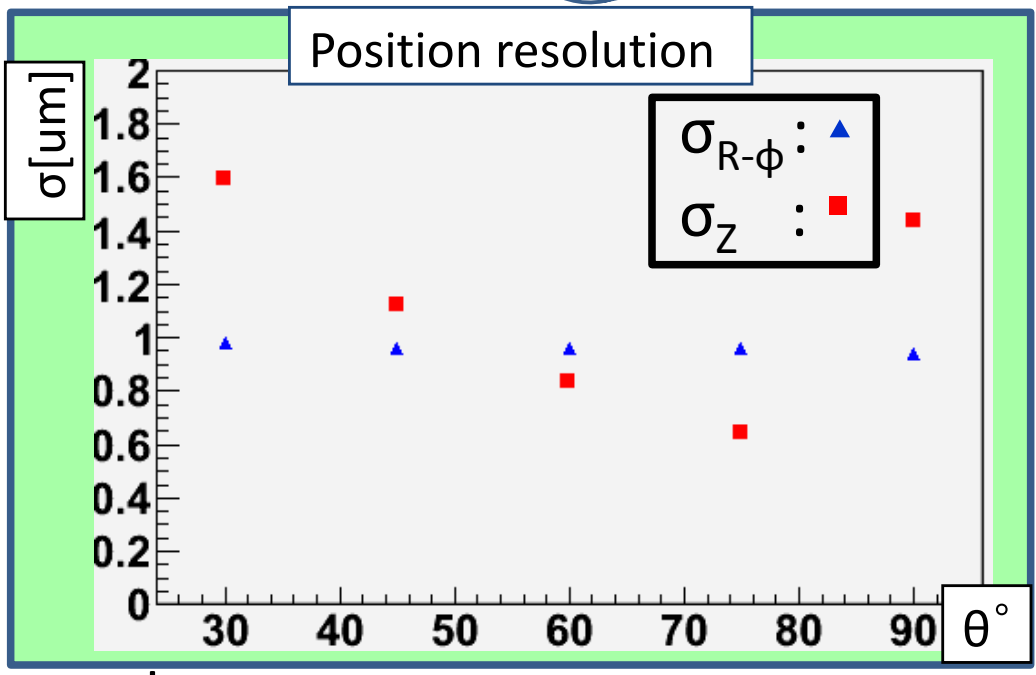
- The position resolution and the impact parameter resolution. (without background)
- The pixel occupancy of pair background.
- Pair background rejection by using the cluster shapes.

Position resolution

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



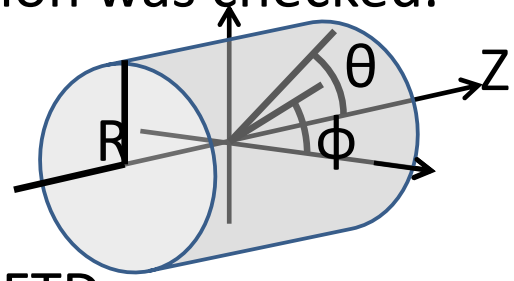
θ	σ_Z	$\sigma_{R\text{-}\phi}$
90°	1.5 um	0.94 um
75°	0.64 um	0.96 um
60°	0.83 um	0.96 um
45°	1.2 um	0.96 um
30°	1.6 um	0.98 um
LOI value	2.8 um	2.8 um



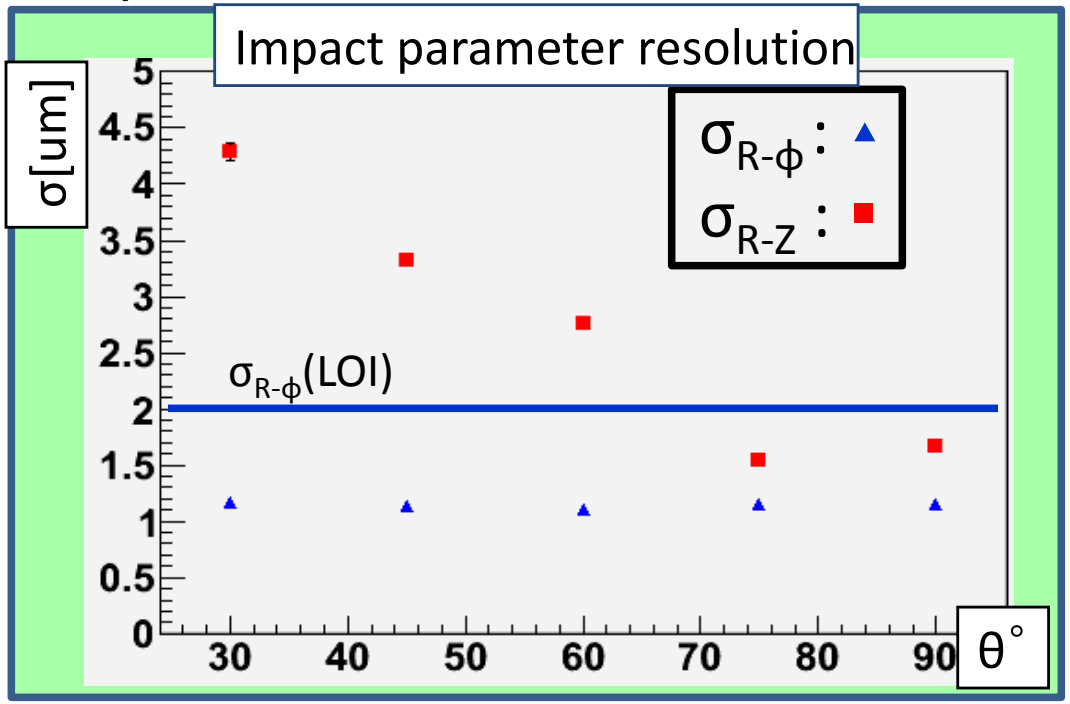
- The Z resolution is worse at forward.
- The R-ϕ resolution is not depends on θ.
- The Z resolution of the vertical track is bad.

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	$\sigma_{R\text{-}Z}$	$\sigma_{R\text{-}\phi}$
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

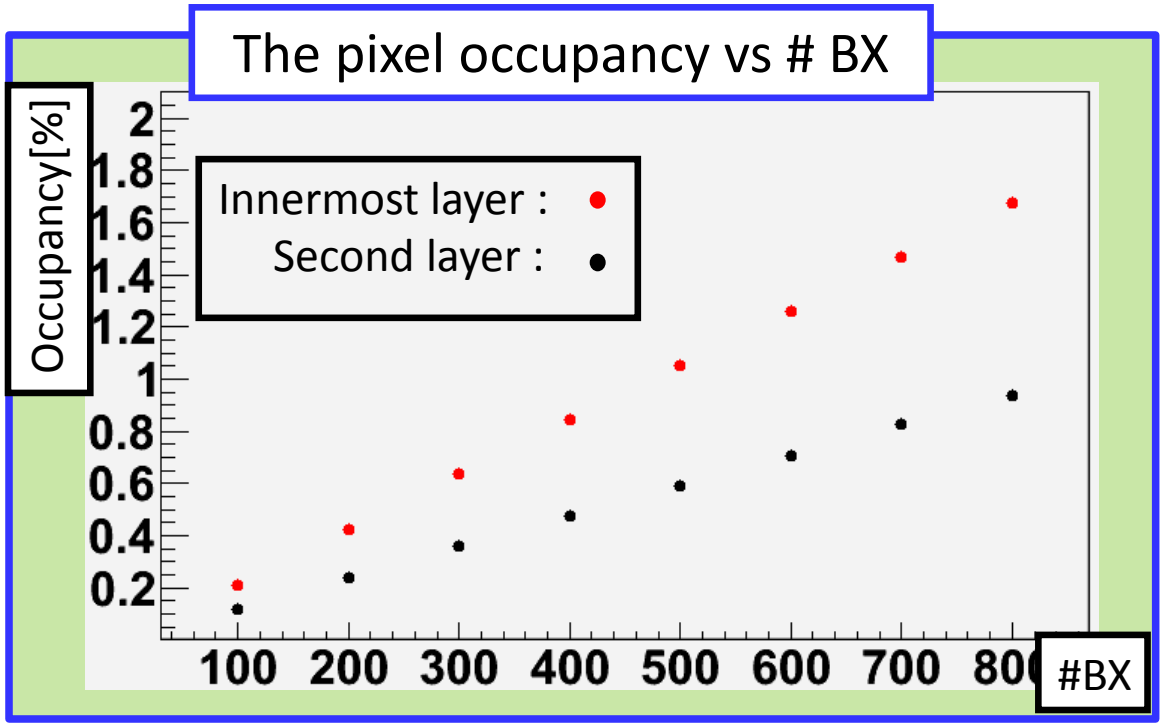


- The impact parameter resolution is roughly proportional to the position resolution.

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 : 2.76%
- Second layer : 1.55%

Lower occupancy is required.

→ background rejection algorithm was developed.

Background rejection

- The μ-(Momentum 100GeV) hits and pair background hits were separated by using the cluster shapes.

Efficiency

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

- The background hits 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 processor

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 for 1train(1312BX)
  - Innermost layer : 2.76%, second layer: 1.55%
- Background rejection algorithm
  - μ^- (momentum 100GeV) and pair background were well separated by the difference of the cluster shapes.

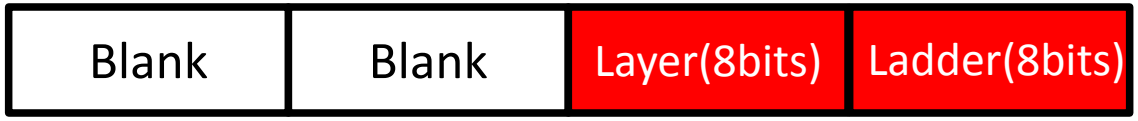
The performance of FPCCD with background will be studied.

Back up

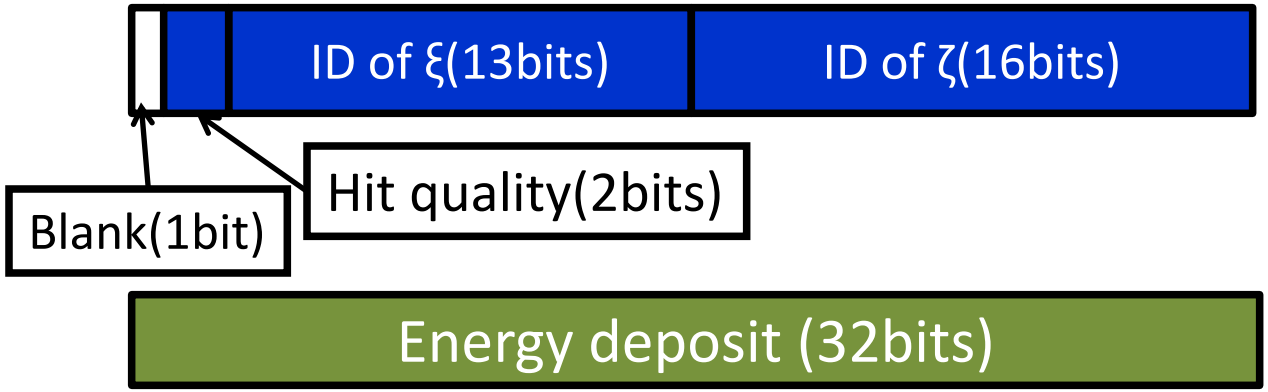
Output collection from FPCCD digitizer

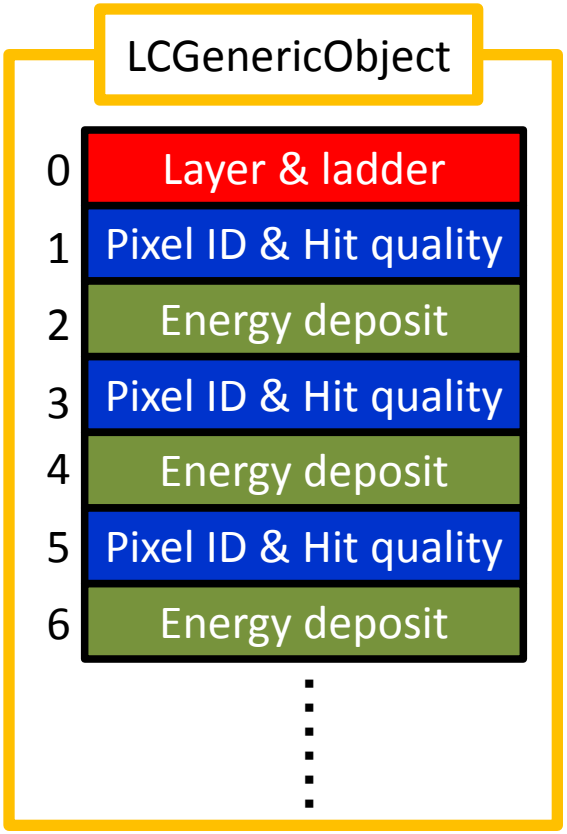
Format of LCGenericObject

- 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.

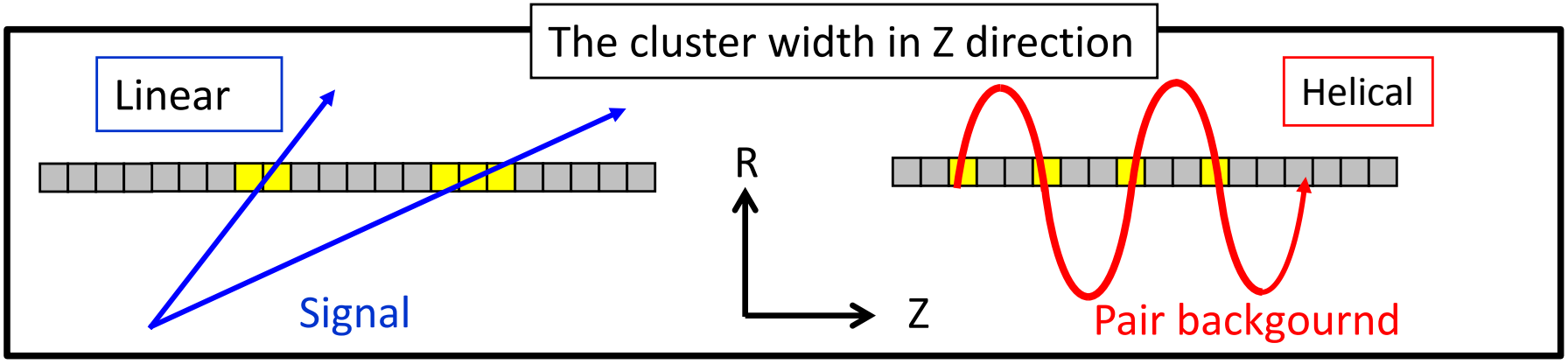
— Data size for one element : $(2 \times N_{hits} + 1)$ words

— The blank area is reserved for the future use.

Background rejection algorithm

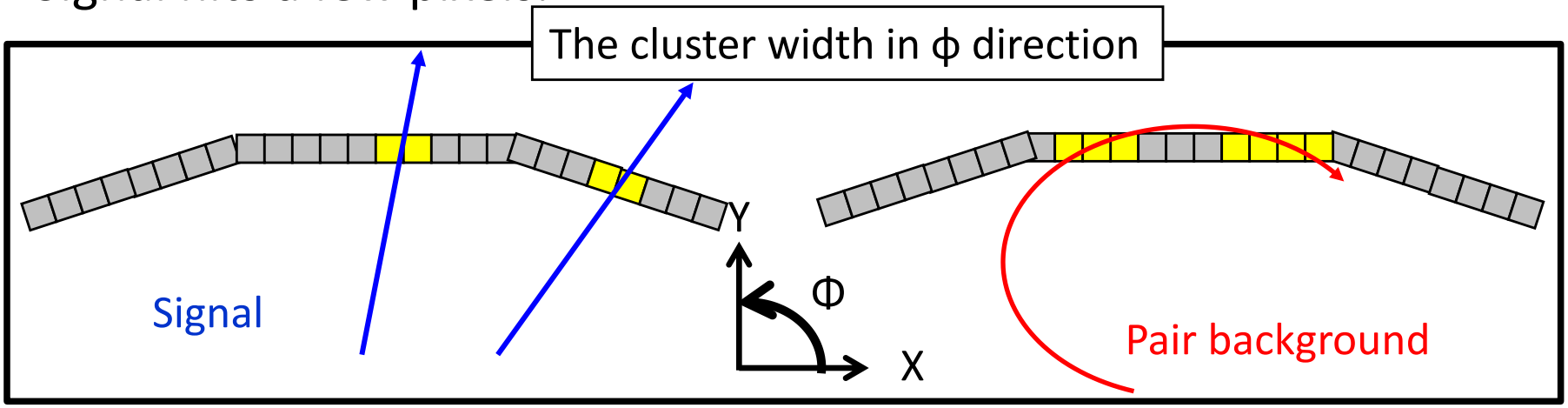
The cluster width in Z direction

- 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.