FPCCD reconstruction

Daisuke Kamai (Tohoku university)

Y.Sugimoto, K.Fujii, A.Miyamoto,
Y.takubo, H.Sato, H.Yamamoto

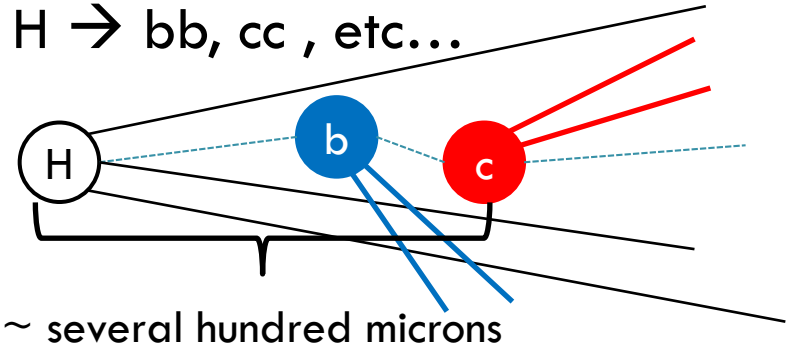
2011/9/14

Kick-Off Meeting 2011 at Tohoku university

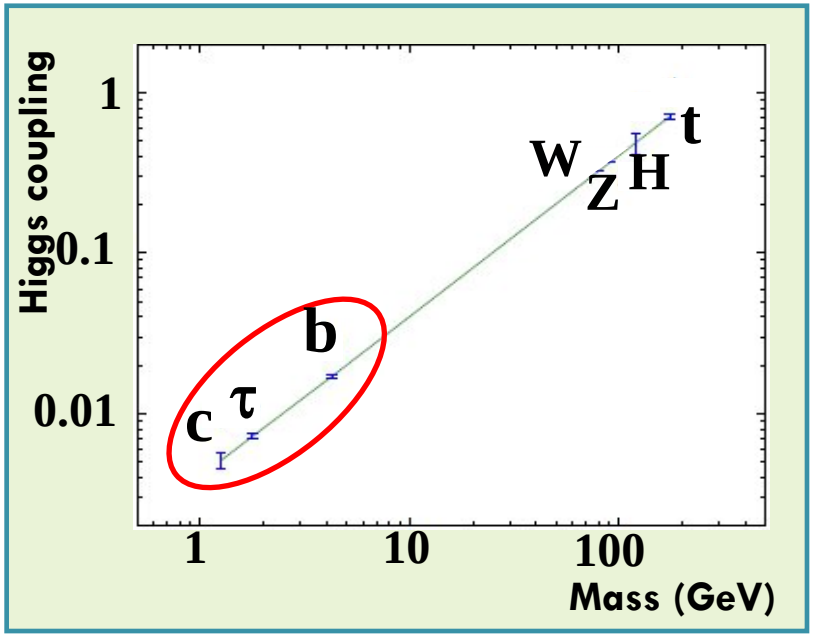
Vertex detector for ILC

1

- The physics aim of ILC
  - Validation of new physics
  - Precision measurement of Higgs
    - H → bb, cc , etc…



~ several hundred microns



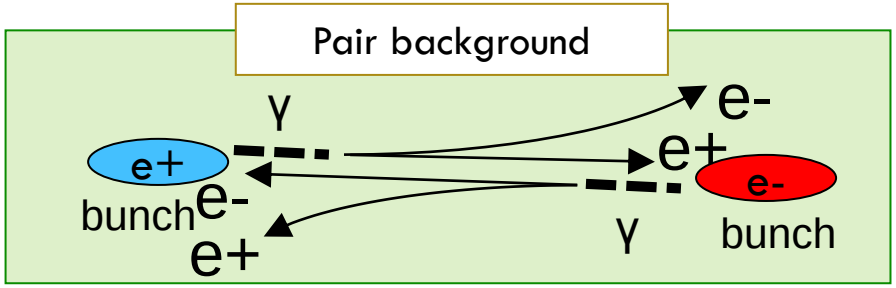
Identify b, c quark correctly.

Required impact parameter resolution

$$\sigma = 5 \oplus \frac{10}{p\beta \sin^{3/2}\theta} (\mu m)$$

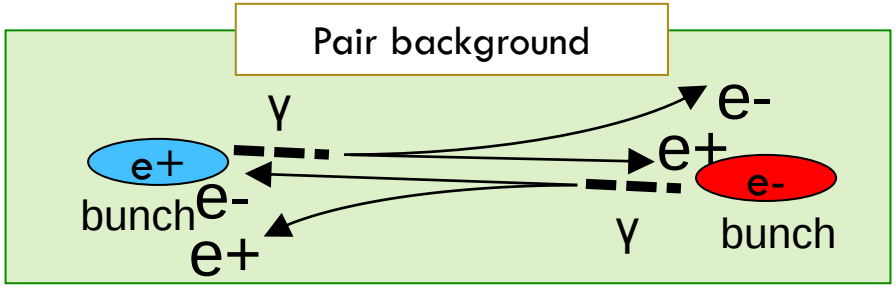
Challenge for Vertex detector

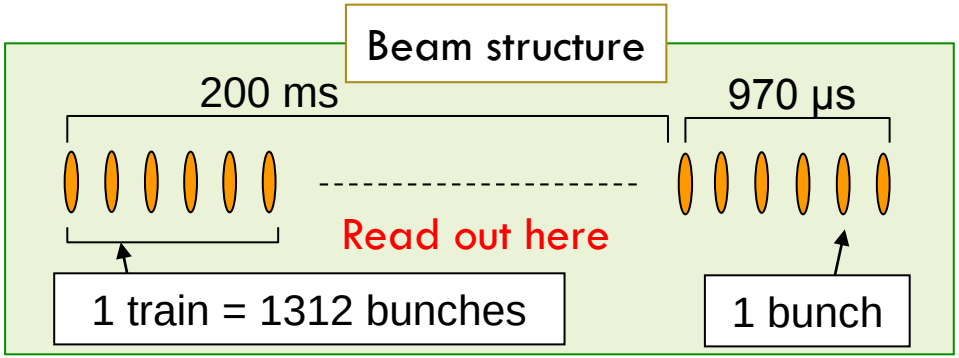
- The challenge for vertex detector
  - The vertex detector is installed in the nearest point by IP.(R=1.6cm)



Challenge for Vertex detector

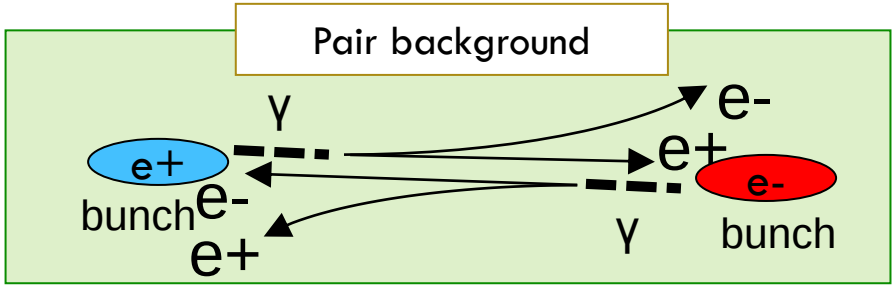
- The challenge for vertex detector
  - The vertex detector is installed in the nearest point by IP.(R=1.6cm)
  - The data for 1 train is accumulated and read out.

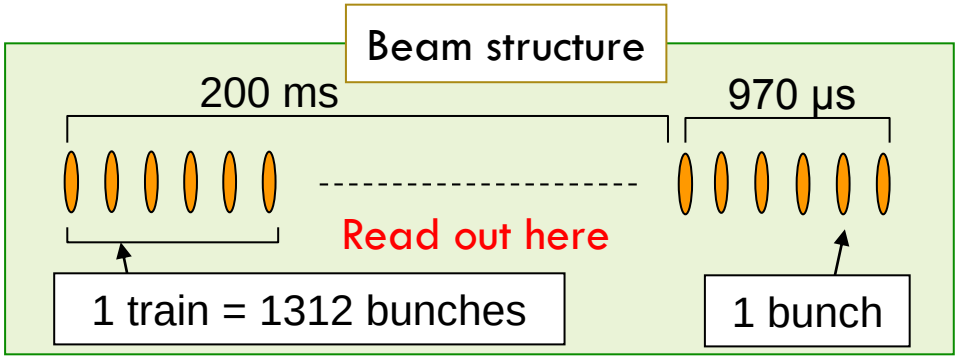




Challenge for Vertex detector

- The challenge for vertex detector
  - The vertex detector is installed in the nearest point by IP.(R=1.6cm)
  - The data for 1 train is accumulated and read out.



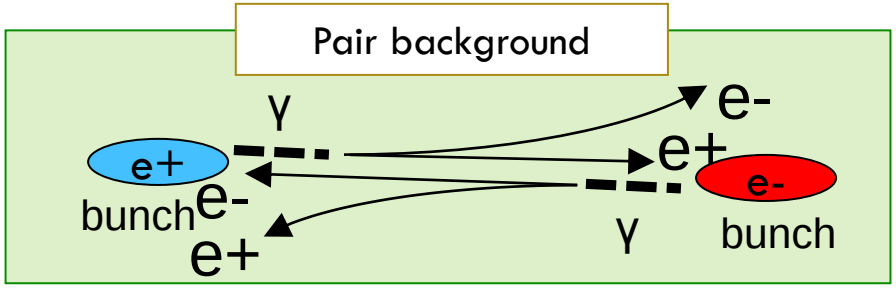


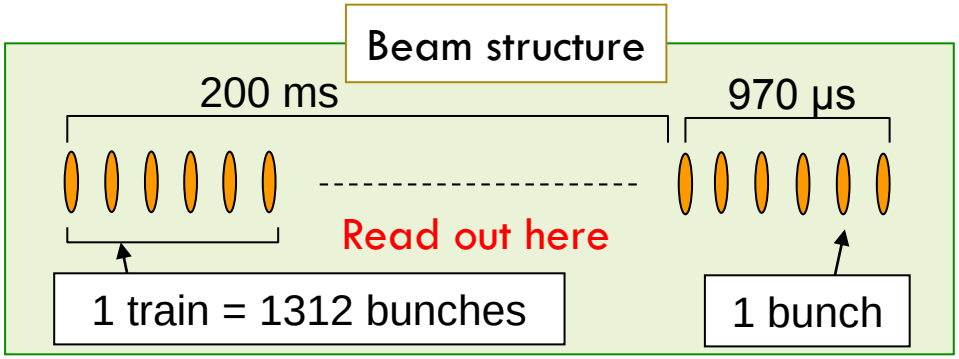
→ The pixel occupancy of pair background becomes problem.

- 20 x 20 um^2 CCD : > 40% → ~ 1% is required.

Challenge for Vertex detector

- The challenge for vertex detector
  - The vertex detector is installed in the nearest point by IP.(R=1.6cm)
  - The data for 1 train is accumulated and read out.





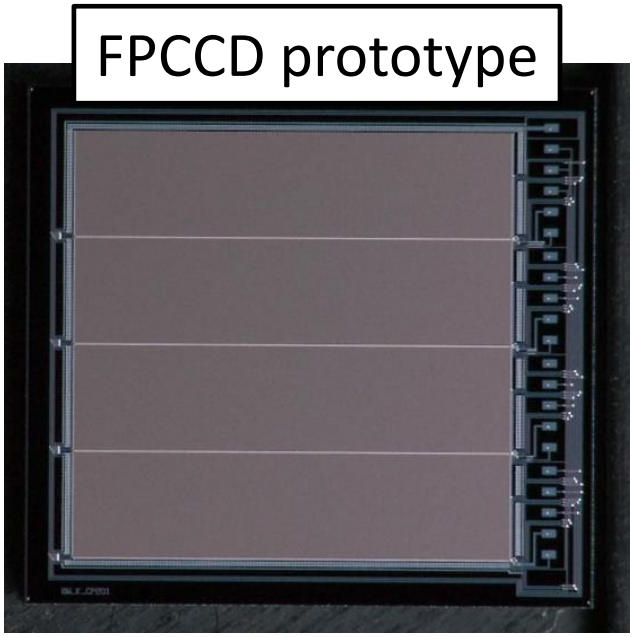
→ The pixel occupancy of pair background becomes problem.

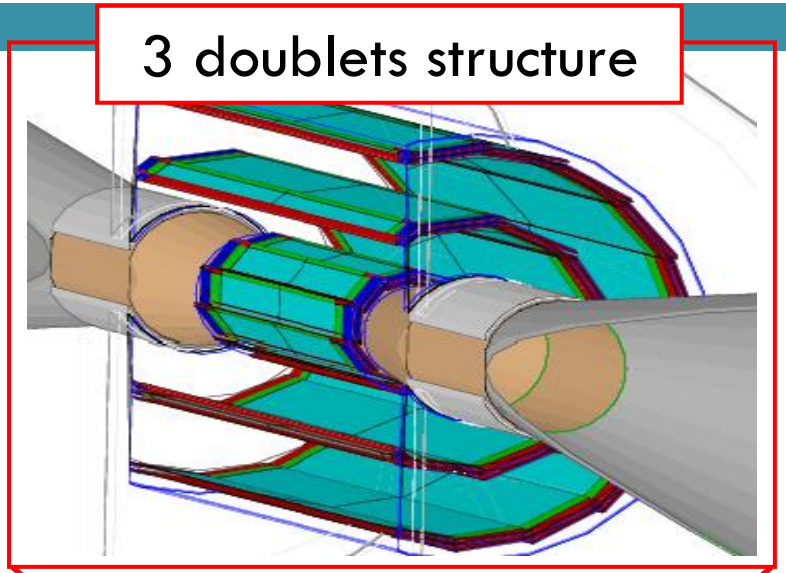
- 20 x 20 um^2 CCD : > 40% → ~ 1% is required.

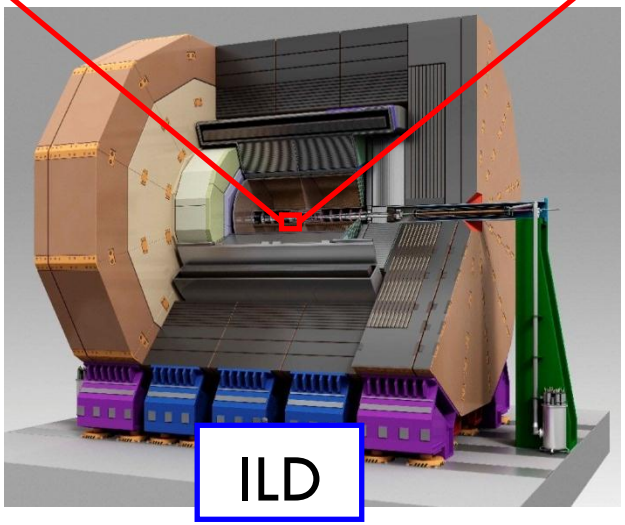
The solution : Smaller pixel → FinePixelCCD!!

FPCCD vertex detector

- FinePixelCCD vertex detector
  - Pixel size : 5 x 5 um^2
  - Number of pixels : ~10^{10}
  - Read out time : Inter-train
  - Fully depleted sensor



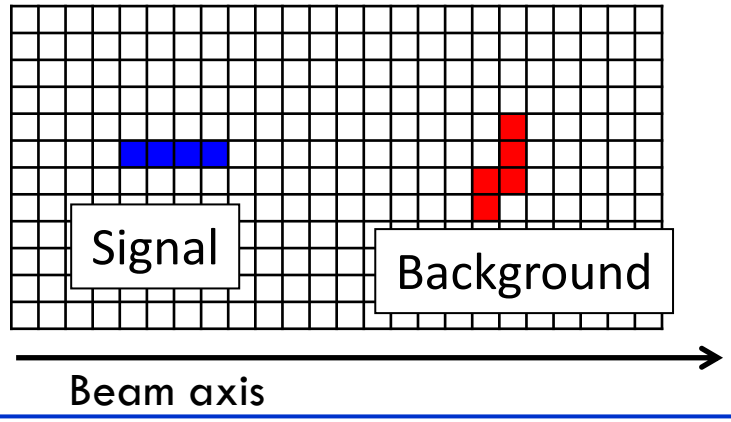


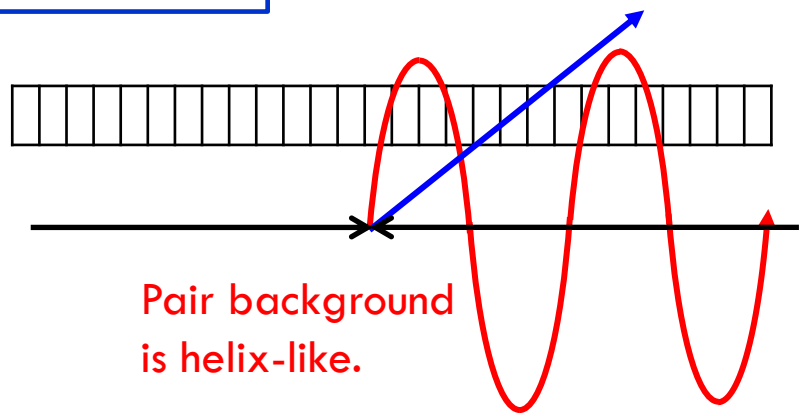


Advantage of FPCCD vertex detector

- FinePixelCCD vertex detector
  - Pixel size : 5 x 5 um^2 → High spatial resolution, High IP resolution
  - Number of pixels : ~10^{10} → Low pixel occupancy
  - Read out time : Inter-train → Not affected by RF noise
  - Fully depleted sensor → High 2track separation capability

Background rejection by using cluster shapes





Software for FPCCD

- To evaluate the performance of FPCCD vertex detector, FPCCD software were developed.

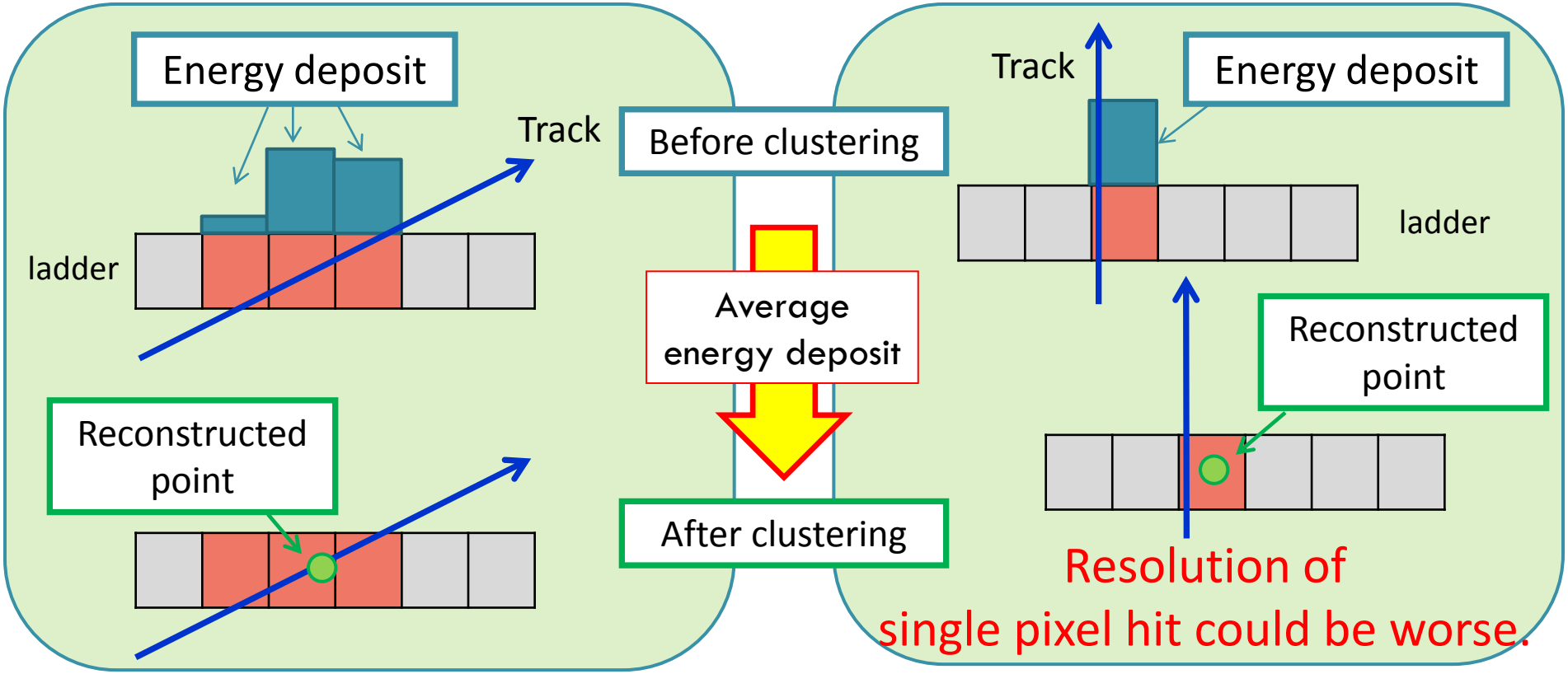
- Software for FPCCD simulation
  - FPCCD Digitizer (generate signals)
  - FPCCD Clustering (reconstruct the hit point from signal)
  - FPCCD Overlay (merge background into physics event)

  These software were developed and installed in MarlinReco.

  - VTracking processor ← Being developed.
    (utilizing the features of FPCCD)

FPCCD Clustering

- The neighboring pixels are recognized as a cluster.
- The hit coordinate is calculated by an energy weighted average.



The simulation results

Existing tracking processor was used.

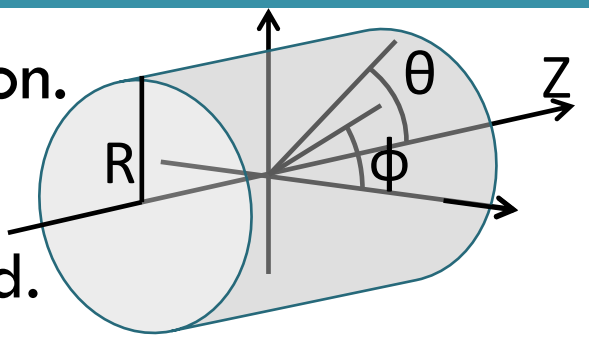
Spatial resolution

Impact parameter resolution

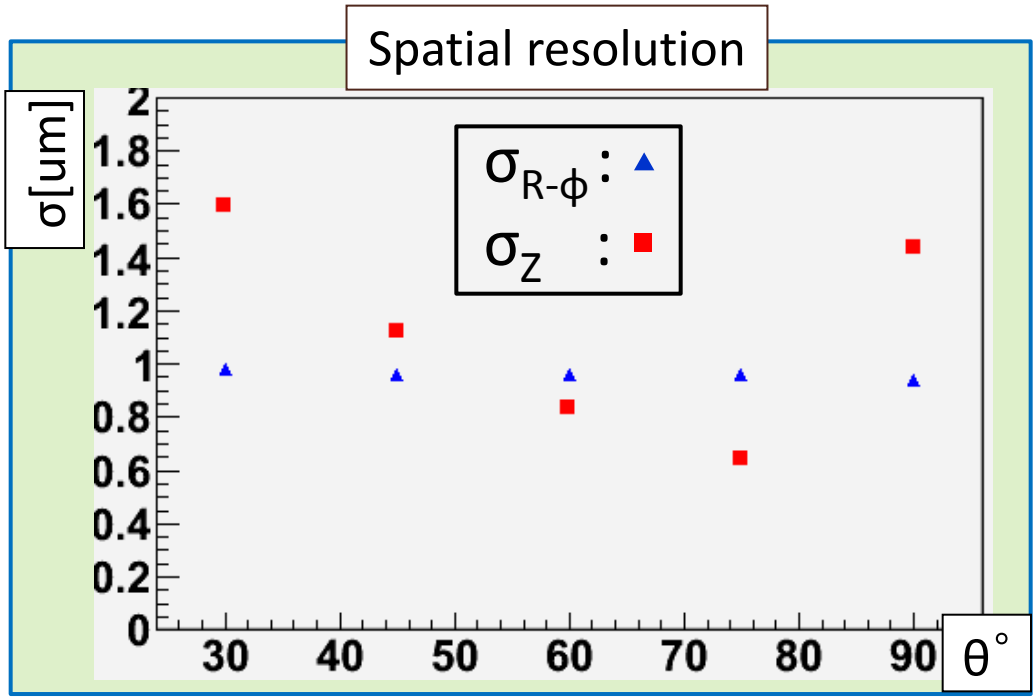
Pixel occupancy

Spatial resolution

- The θ dependency of the spatial resolution.
  - The Z resolution is worse at forward.
  - The Z resolution of the vertical track is bad.
  - The R-Φ resolution is better than 1um.



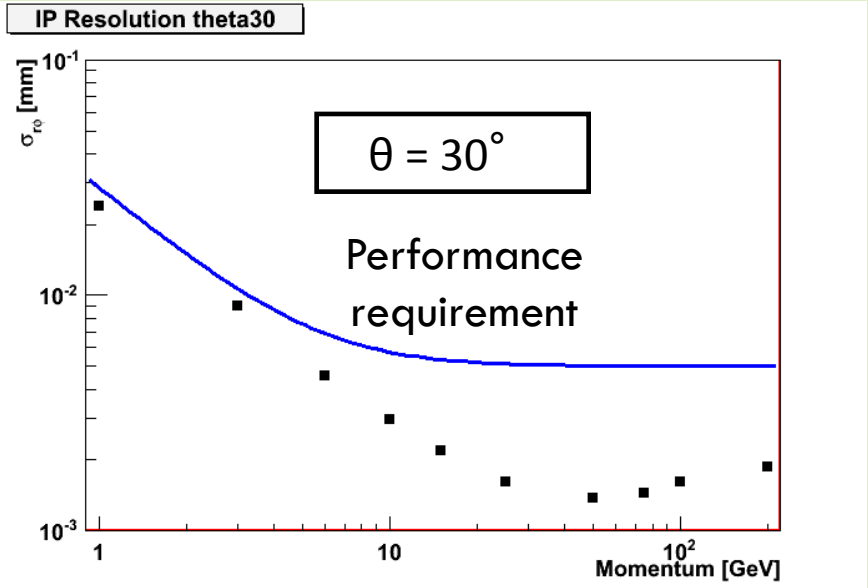
θ	σ_Z	$\sigma_{R\text{-}\phi}$
90°	1.5 um	0.94 um
75°	0.64 um	0.96 um
60°	0.83 um	0.96 um
45°	1.2 um	0.96 um
30°	1.6 um	0.98 um
LOI	2.8 um	2.8 um

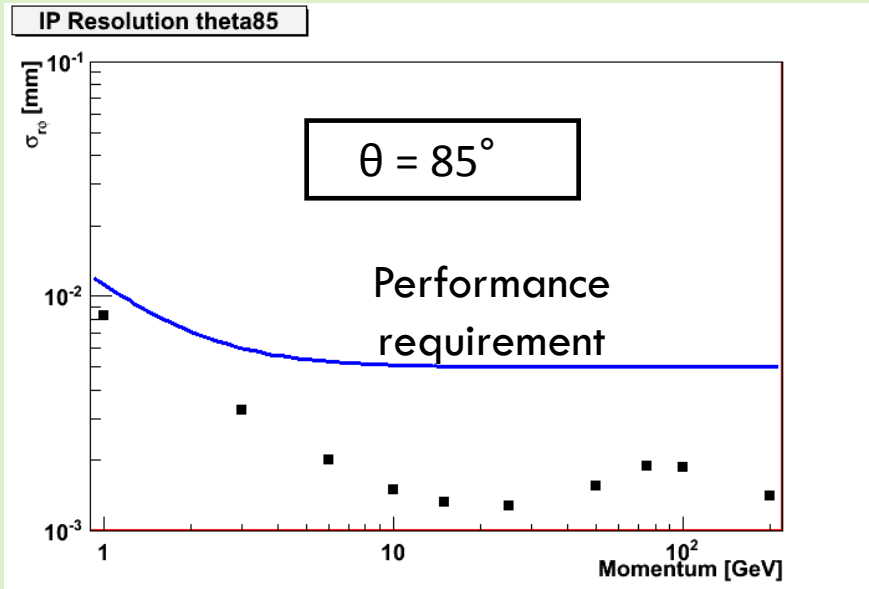


Impact parameter resolution

- Impact parameter resolution in R-Φ direction.
  - FPCCD can satisfy the performance requirements.

Impact parameter resolution





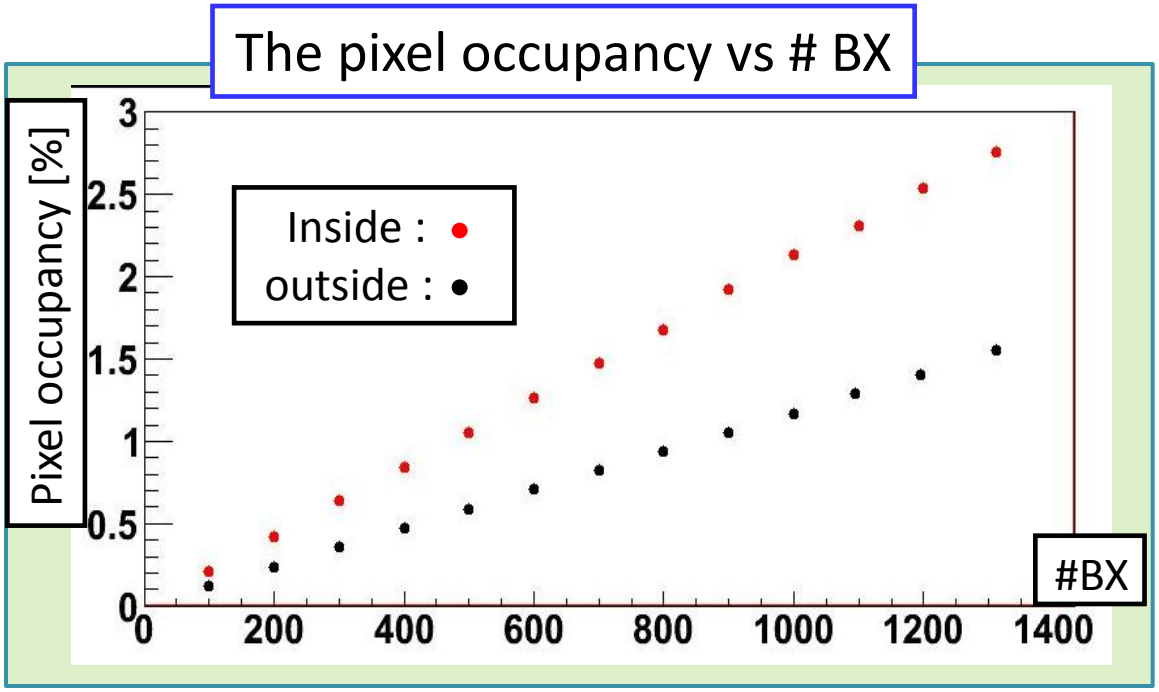
Pixel occupancy

- The Pixel occupancy of 1 train pair background.
  - Inside of innermost : 2.76 %, Outside of innermost : 1.55 %

Very low occupancy, compared with conventional CCD.

→ Check the performance under the background.

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



Software under development

Tracking software

Tracking software

- The tracking software utilizing the features of FPCCD vertex detector is being developed.
- Tracking

1 . Track finding Finding the hit points that make up the track.	2 . Track fitting Fitting the track parameter

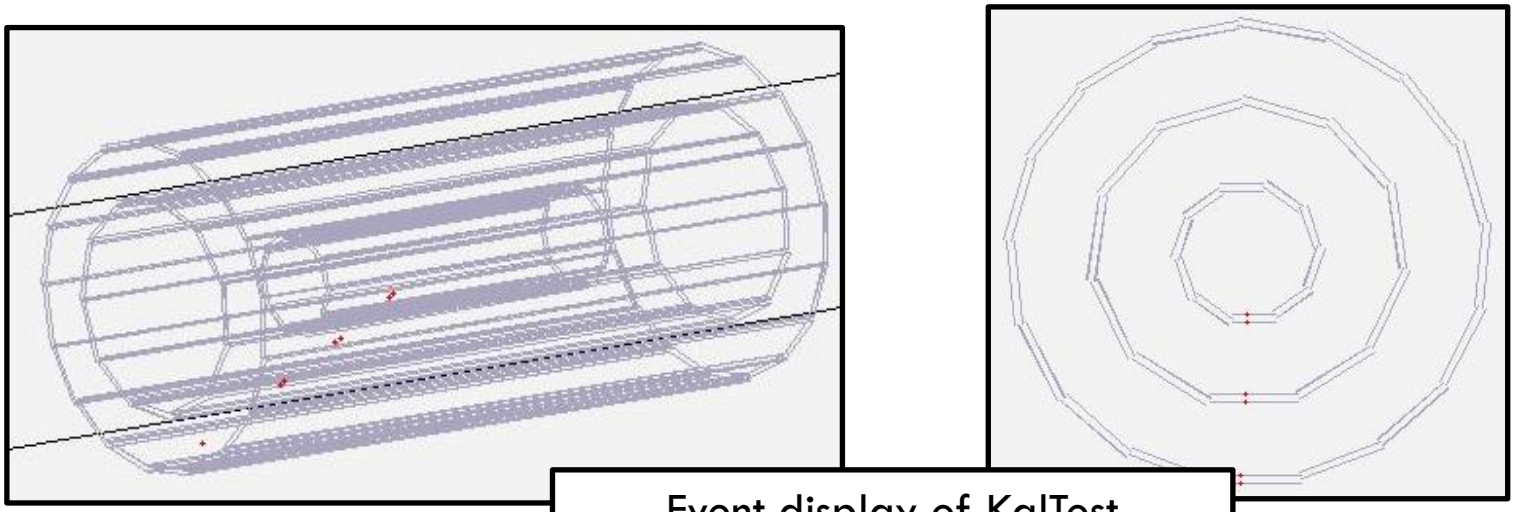
- Old : Standard track finding — χ^2 fitting
- New : Track finding utilizing the features of FPCCD — Kalman Filter

Under development

Installation is completed.

Track fitting

- The vertex detector which is 3 doublets structure is implemented into KalTest.

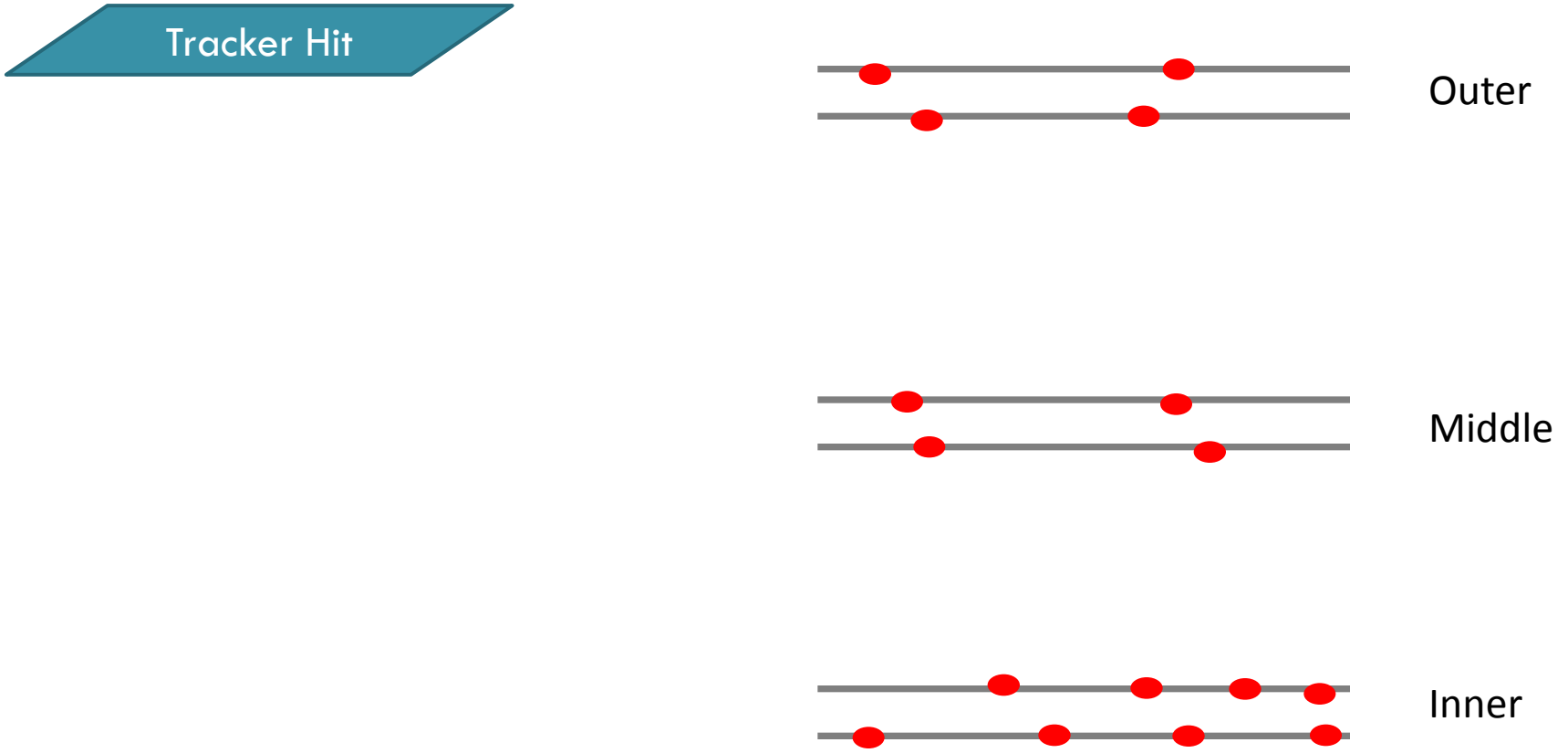


Event display of KalTest

- The Kalman filter fitting on FPCCD is available.

Track finding – Vector hit

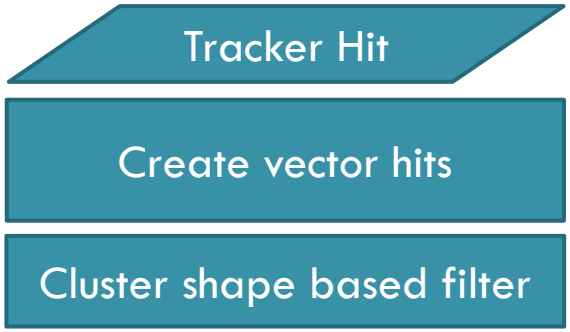
- Algorithm of track finding.
  - Find the track taking advantage of 3 doublets structure.

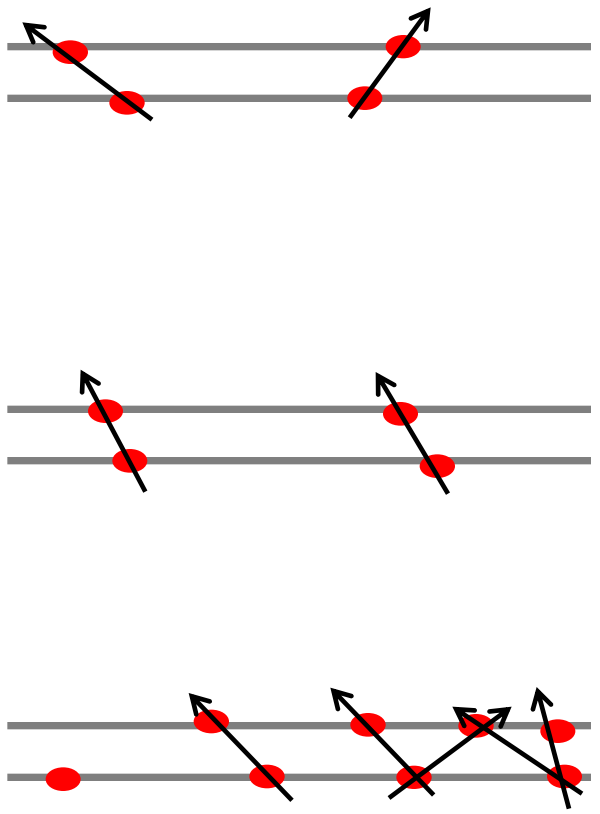


Track finding – Vector hit

- Create Vector hit by using doublet layer.
- Perform cluster shape based filter.

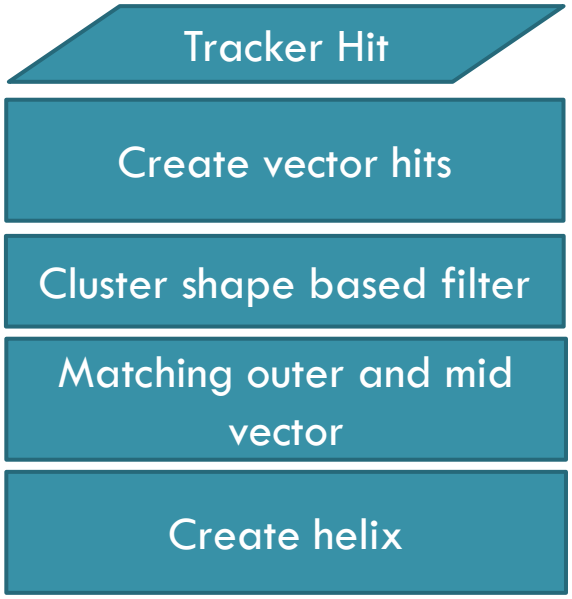
Vector hit : ↑

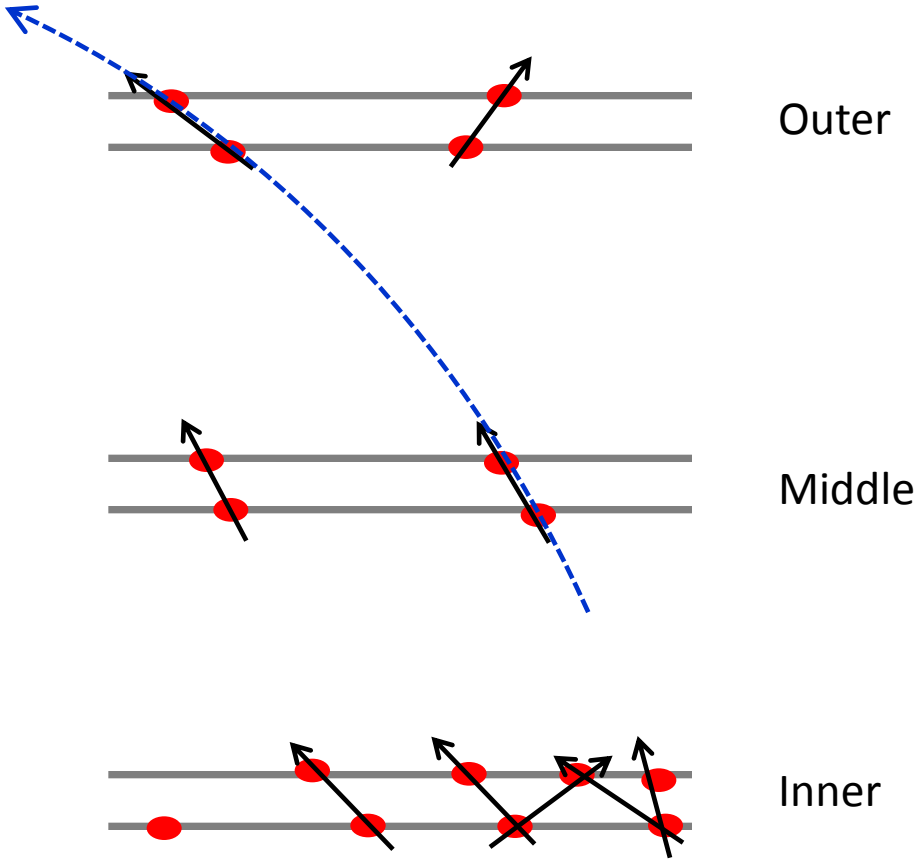




Track finding – Vector hit

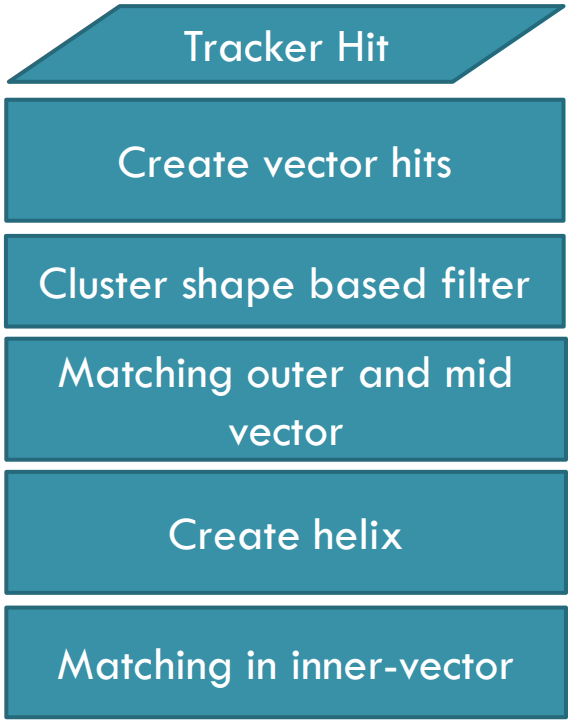
- Create helix by middle and outer layers. (Inner layers has heavy background.) → Speed-up will be expected.

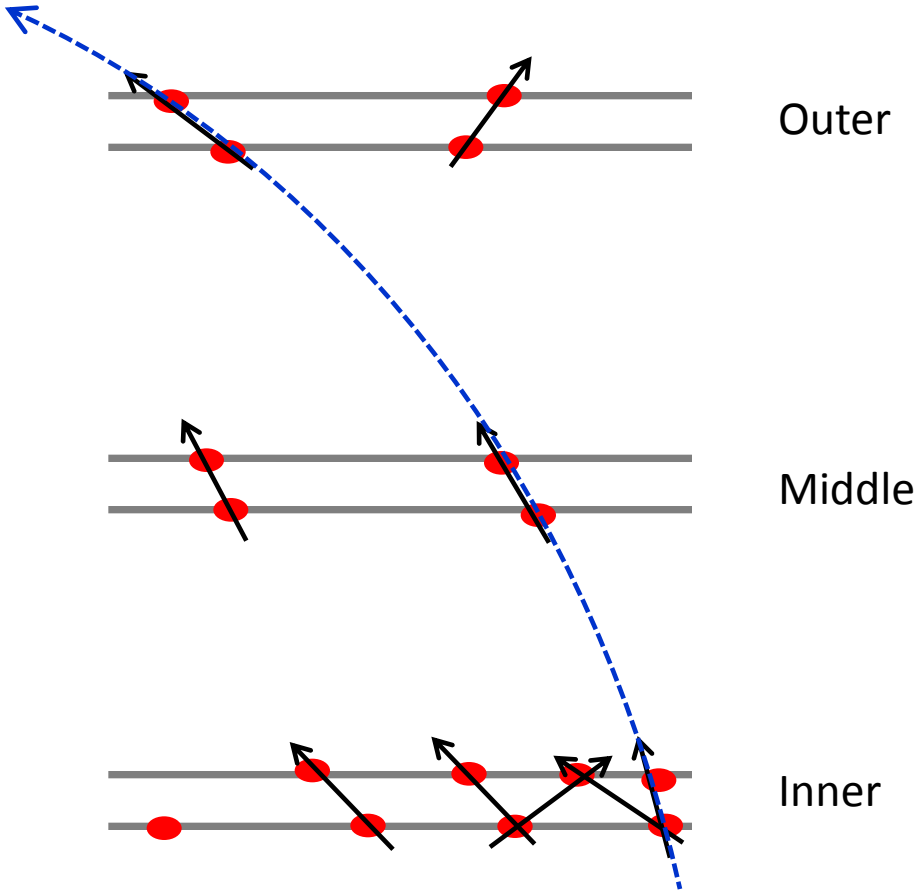




Track finding – Vector hit

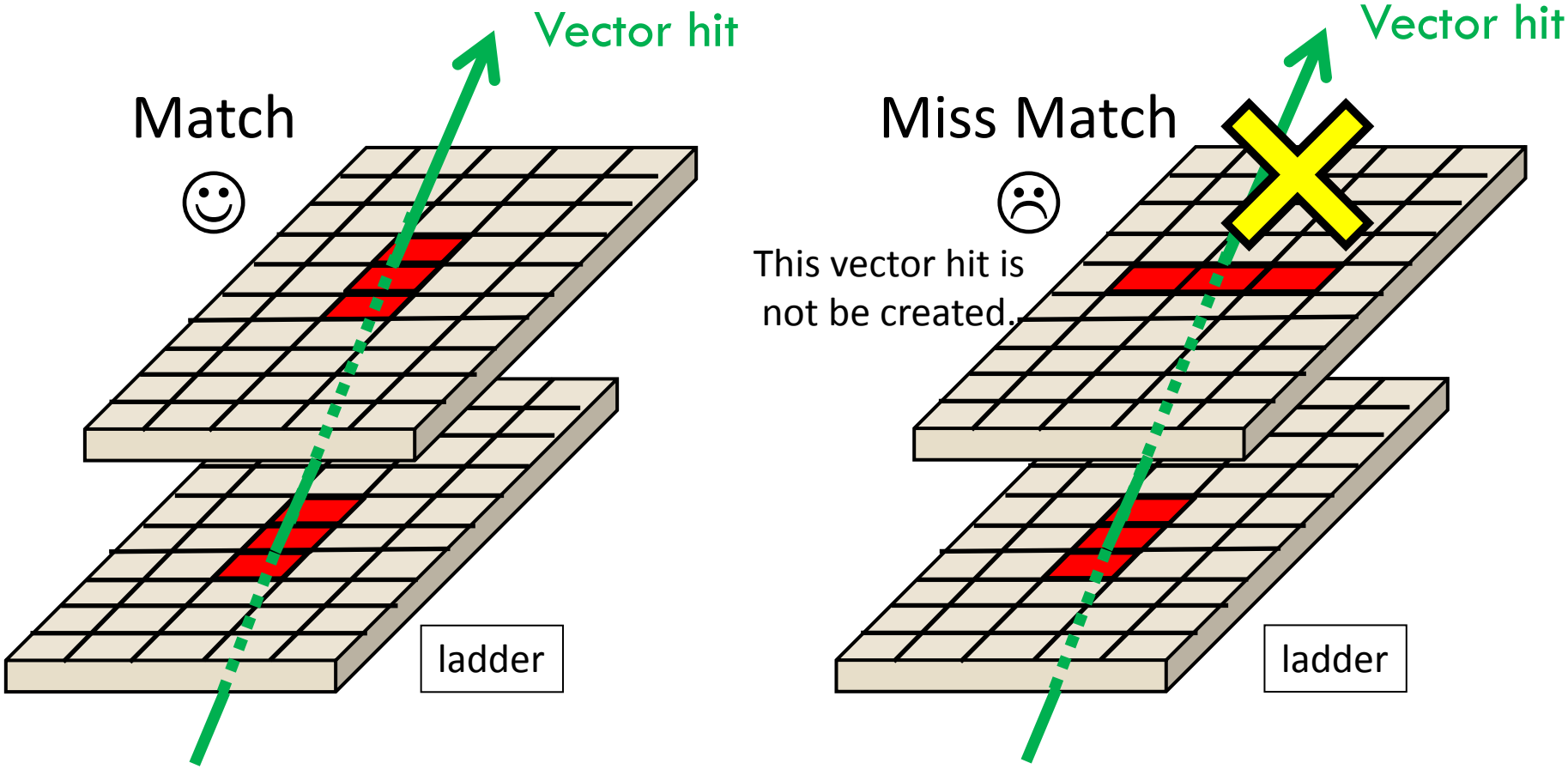
- Extrapolate the helix into inner layers and determine the track.





Track finding – Cluster shapes filtering

- Take consistency by cluster shapes in making vector hits.
  - More precise track finding can be expected.



Summery/Plan

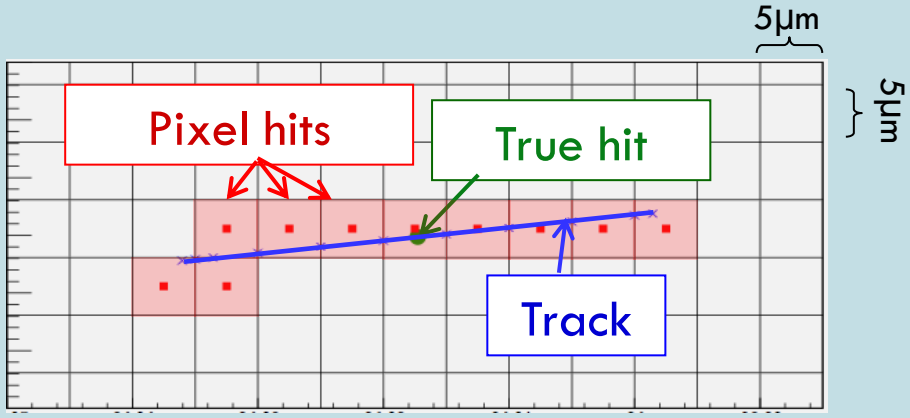
- The simulation software for the performance study of FPCCD vertex detector were developed.
- FPCCD can satisfy the IP resolution requirements.
- New tracking software is being developed.

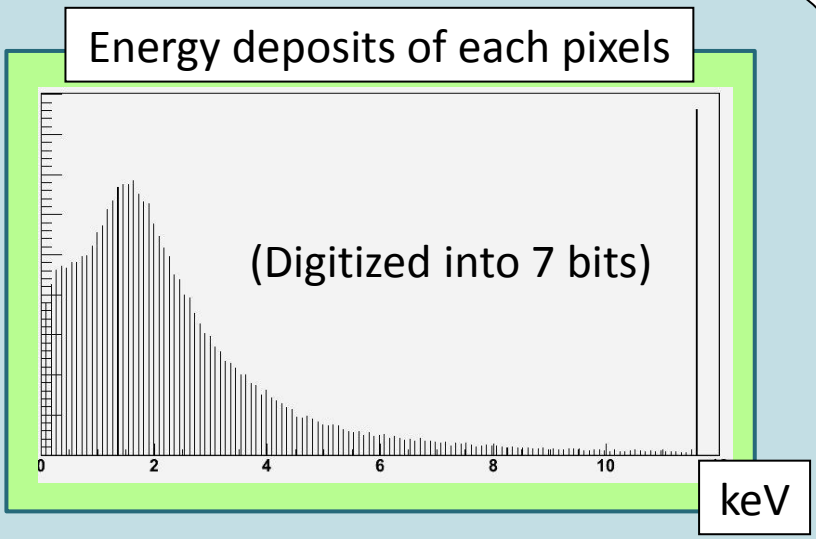
- Plan
  - Estimation of background effect.
  - Evaluate the performance of flavor tagging.

Back up

FPCCD Digitizer

- The hit point and track momentum are obtained from Mokka.
- The trajectory is calculated by hit point and momentum.
- The pixel hit is identified by the intersection of track and boundaries of pixels.
- The energy deposit of hit is divided into pixels as proportional to path length then smeared by Landau distribution.





FPCCD Overlay

- FPCCD Overlay merge the data of background event into the data of physics event.
- If there are more than 2 hits in the same pixel, the processor adds the energy deposit of both hits.

Highest density region of innermost layer