

Development of software for FPCCD vertex detector

Physics & software meeting
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Tohoku University
Daisuke Kamai

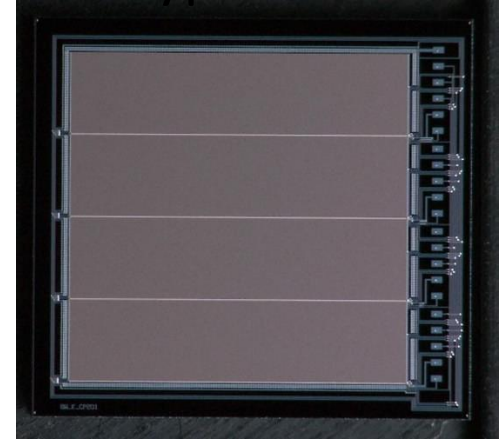
FPCCD vertex detector

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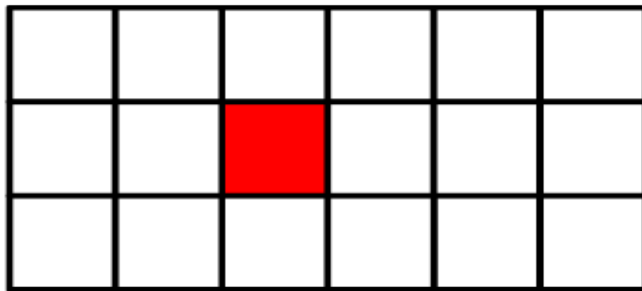
- FPCCD(Fine Pixel CCD)
 - Pixel size : $5\mu\text{m} \times 5\mu\text{m} \times 15\mu\text{m}$
 - Full well depletion
- The number of pixels : $\sim 10^{10}$ pixels
 - Some pixels hit in the same layer

→ Pair-background can be rejected by pattern recognition.

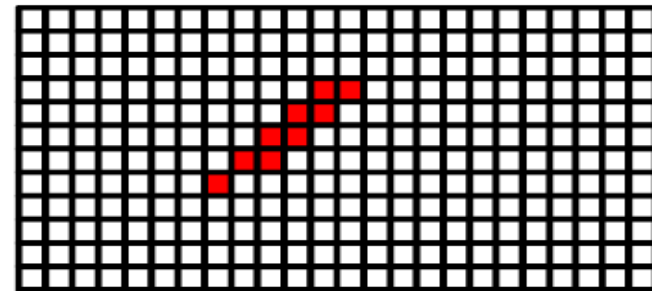
Prototype of FPCCD



Same hit on a layer with different size CCD



CCD($\sim 20\mu\text{m} \times 20\mu\text{m}$)



FPCCD

Software for FPCCD

Purpose of this study

- Estimation of the pixel occupancy by pair-background.
- Development of an algorithm to reject background hits based on the cluster shapes.
- Evaluation of the tracking and vertexing performance.

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

- FPCCD digitizer
- Overlay processor
- FPCCD clustering
- FPCCD track finder

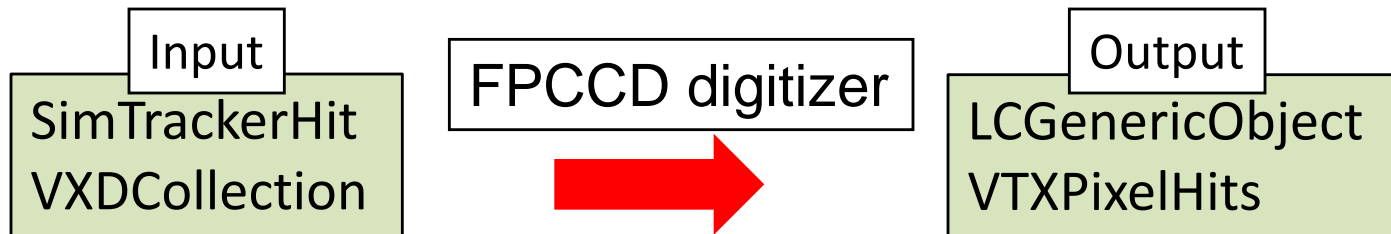


Today's talk

FPCCD digitizer

FPCCD digitizer

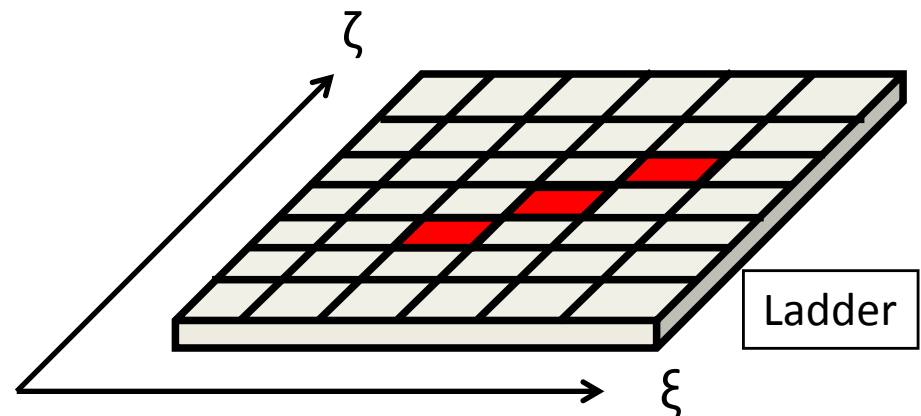
- FPCCD has a large number of pixels.
- The digitizer specialized for FPCCD is necessary.



- The hit information of a ladder of FPCCD vertex detector is packed in one element.

Members of VTXPixelHits

- Layer number (0~5)
- Ladder number (0~16)
- ID of ξ (0~4400)
- ID of ζ (0~50000)
- Energy deposit (float)
- Hit quality (0~3)

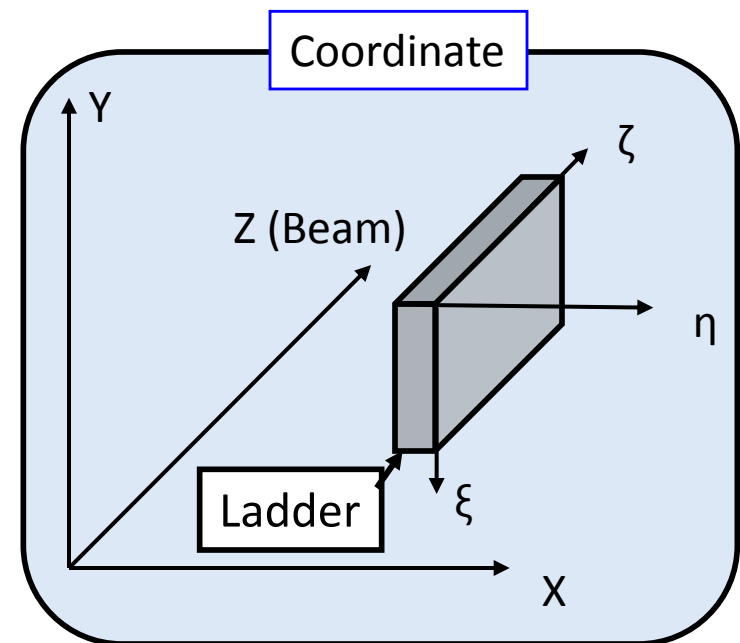
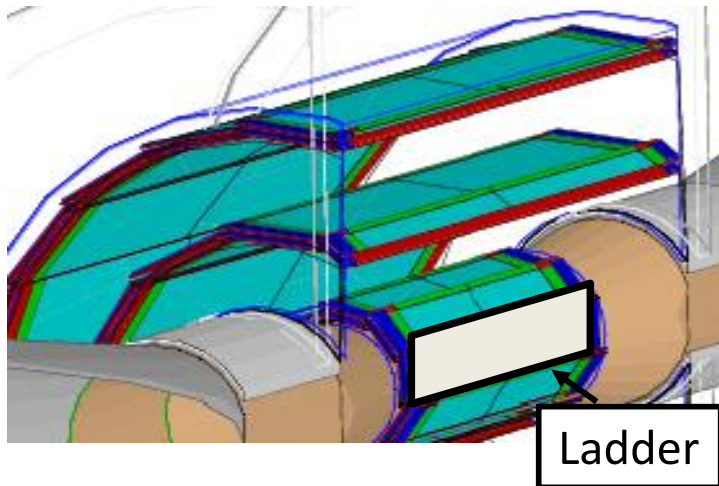


Algorithm of FPCCD digitizer (1)

- The hit points and track momenta are obtained from SimTrackerHit.

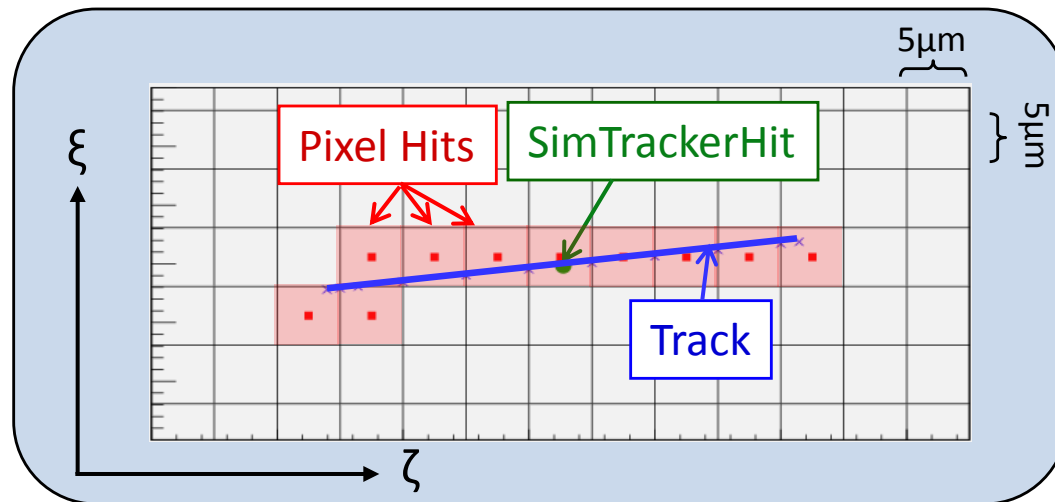
- `posX = SimTrackerHit->getPosition()[0];`
- `momX = SimTrackerHit->getMomentum()[0];`

- The hit points and momenta are transformed to the local coordinate on a ladder.



Algorithm of FPCCD digitizer (2)

- The track is calculated by the local point and local momentum.
 - Large momentum \rightarrow Approximated by a linear track.
 - Low momentum \rightarrow Calculated as a helical track.



- The energy deposit in SimTrackerHit is calculated by the path length in each pixel.

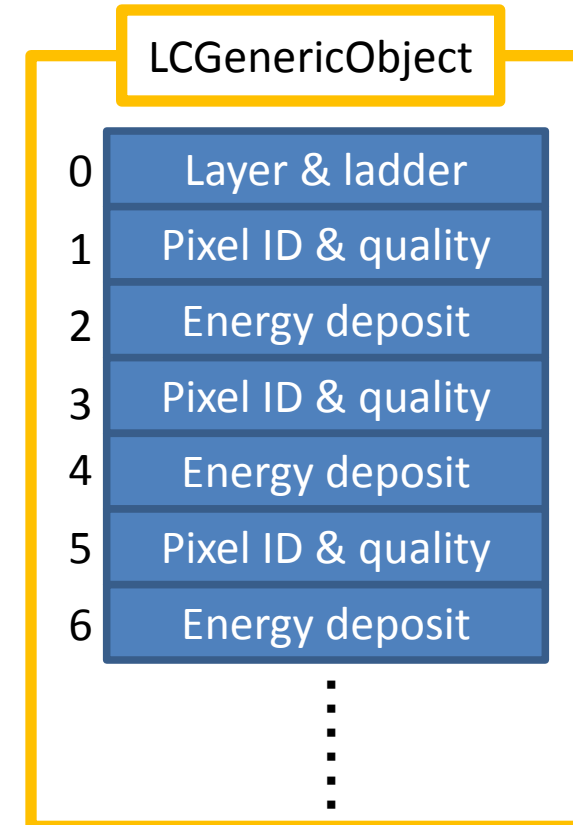
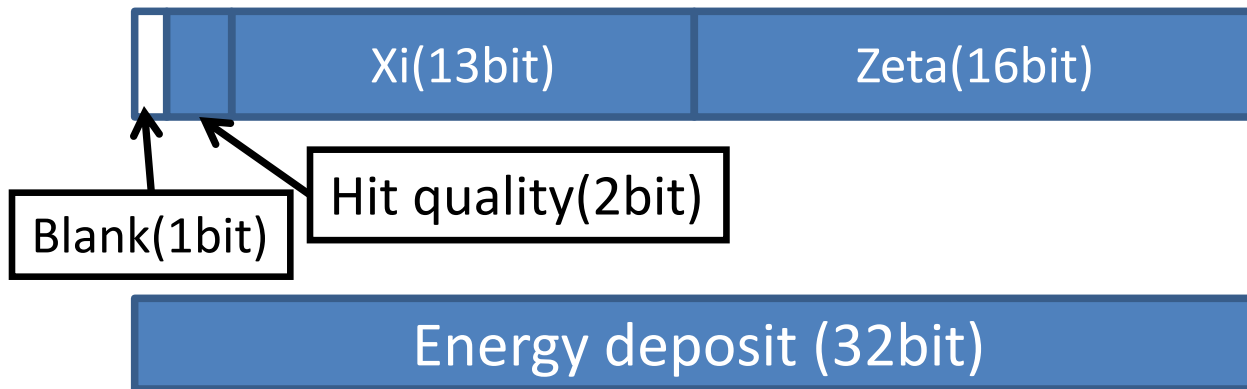
Output collection from FPCCD digitizer

Format of LCGenericObject

- The first word(32 bit) contains layerID and ladderID of the element.



- Two words are used for each pixel hit.



- The number of the elements is equal to that of the ladders with hits.
- Data size for one element : $(2 \times \text{hits} + 1)$ words
 - The blank area is reserved for the future use.

Development of Overlay processors

■ OverlayEvents

The number of the pair-backgrounds for 1 BX is too large to include in data for one event.

– Divided into about 1800 events in Mokka run.

→ OverlayEvents processor was newly developed to merge these events to a single event record.

■ OverlayBX

– OverlayBX processor was modified to merge VTXPixelHits.

– If there are more than 2 hits in the same pixel, the processor adds the energy deposit and rewrites Hit quality.

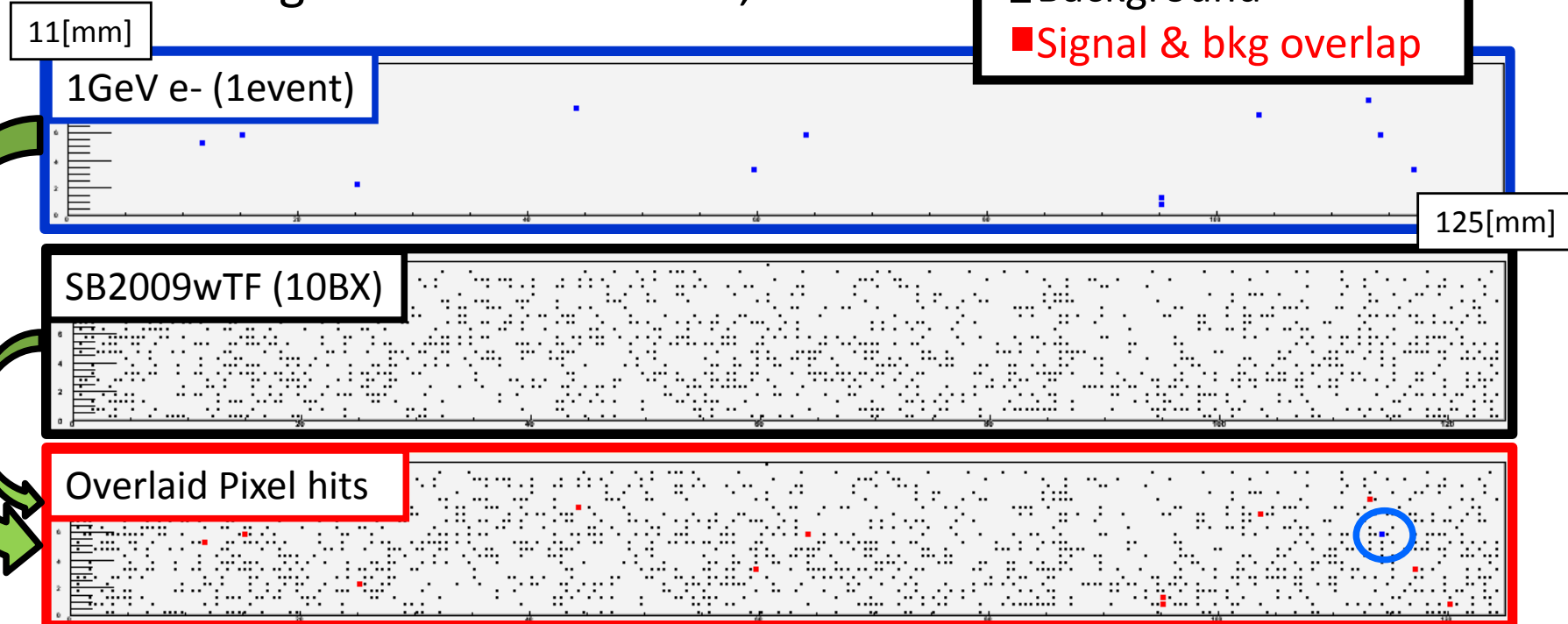
– Hit quality : A signal particle hit,
multiple signal particles hit,
a hit with signal and background overlap,
and background hit.

Test of OverlayBX processor

OverlayBX for VTXPixelHits was tested.

- The pixel hits on one ladder of the innermost layer are plotted.
 - Pixel size : $500\ \mu\text{m} \times 500\ \mu\text{m} \times 15\ \mu\text{m}$ (to make easily to see)
 - Signal : e-, 1 GeV, 1 event
 - Pair-background : SB2009wTF, 10BX

■ Single signal
■ Background
■ Signal & bkg overlap



The pixel hits are merged correctly.

Estimation of pixel occupancy

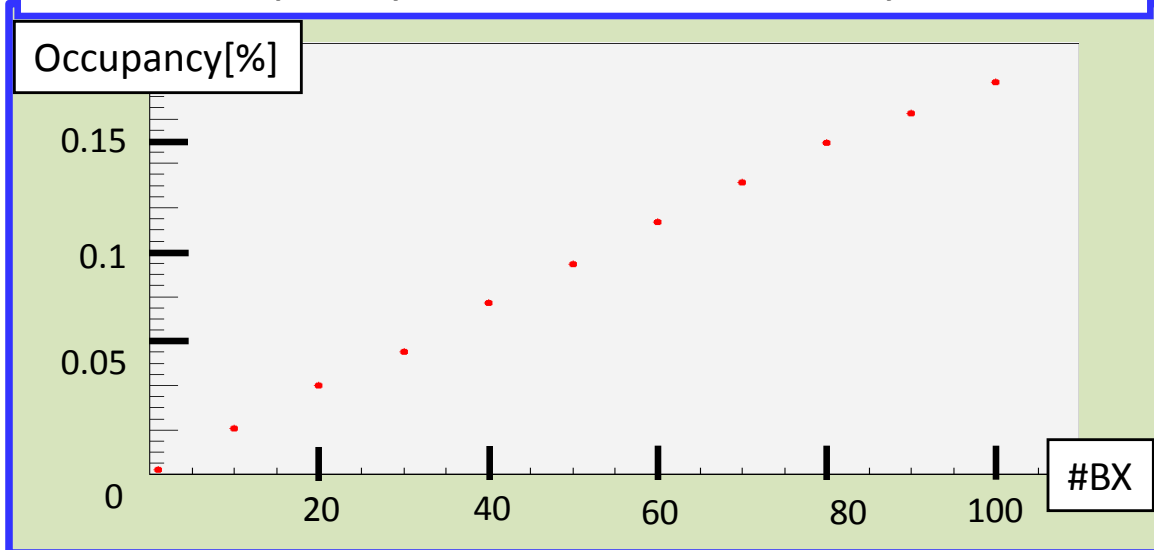
The pixel occupancy of the FPCCD VTX innermost layer was checked.

— Pixel size : $5\mu\text{m} \times 5\mu\text{m} \times 15\mu\text{m}$

Background conditions

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

Pixel occupancy of the innermost layer vs #BX



Pixel occupancy : $\sim 2.5\%$ for 1train

The occupancy is about a half of the previous result.

(In the previous study, the overlap hits were not considered.)

File size & memory usage

Data size of pair-background events

- Separated data(1800 events) : 40 MB/BX.
 - Merged data (1 event) : 25 MB/BX.
- Data size of VTXPixelHits : 130MB/1 train.

We will be able to study performance in a realistic condition.

Performance of processor

- Amount of memory used for running processor.
 - FPCCD Digitizer : 190 MB
 - OverlayEvents : 400 MB
 - OverlayBX : ~300MB for 50BX, ~400MB for 100BX,
~2GB/1 train memory is required.
- It is acceptable.

Summary / Plan

Summary

- We developed the software for the FPCCD vertex detector.
 - The FPCCD digitizer and Overlay processor were developed.
 - we can analyze the performance of the FPCCD vertex detector, including the background with these software.

Plan

- FPCCD clustering
 - Development of FPCCD clustering is getting started.
 - Algorithm to reject background hits based on the cluster shapes will be developed.
- FPCCD track finder
 - FPCCD track finder will be developed.