FPCCD software

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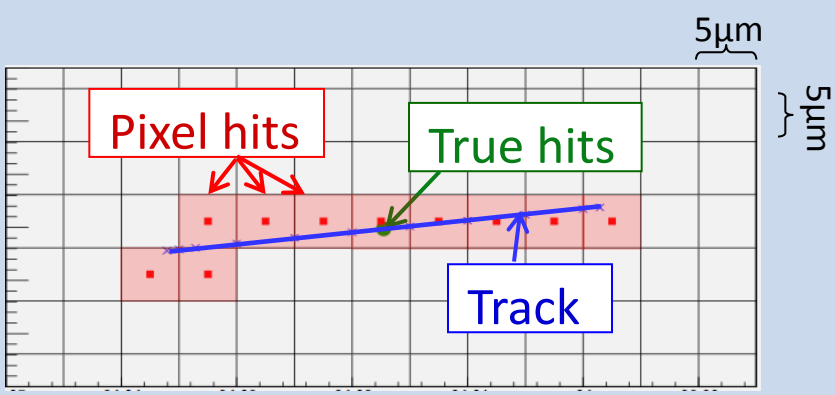
Outline

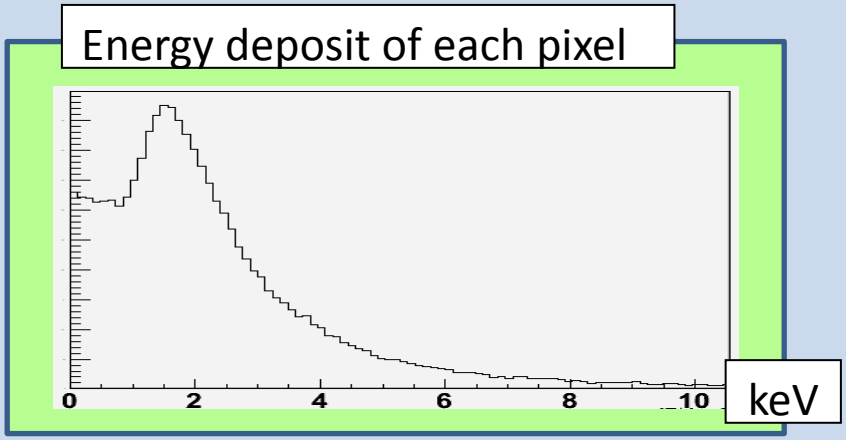
- FPCCD software.
  - FPCCD Digitizer
  - FPCCD Clustering

  (in FPCCDDigi of MarlinReco package)
  - FPCCD OverlayBX (in Overlay package)
- How to use FPCCD software
- Some results of simulation
  - Resolution
  - Background occupancy
  - Range cut determination
- Requirements for FPCCD simulation
- Summary & Plan

FPCCD digitizer

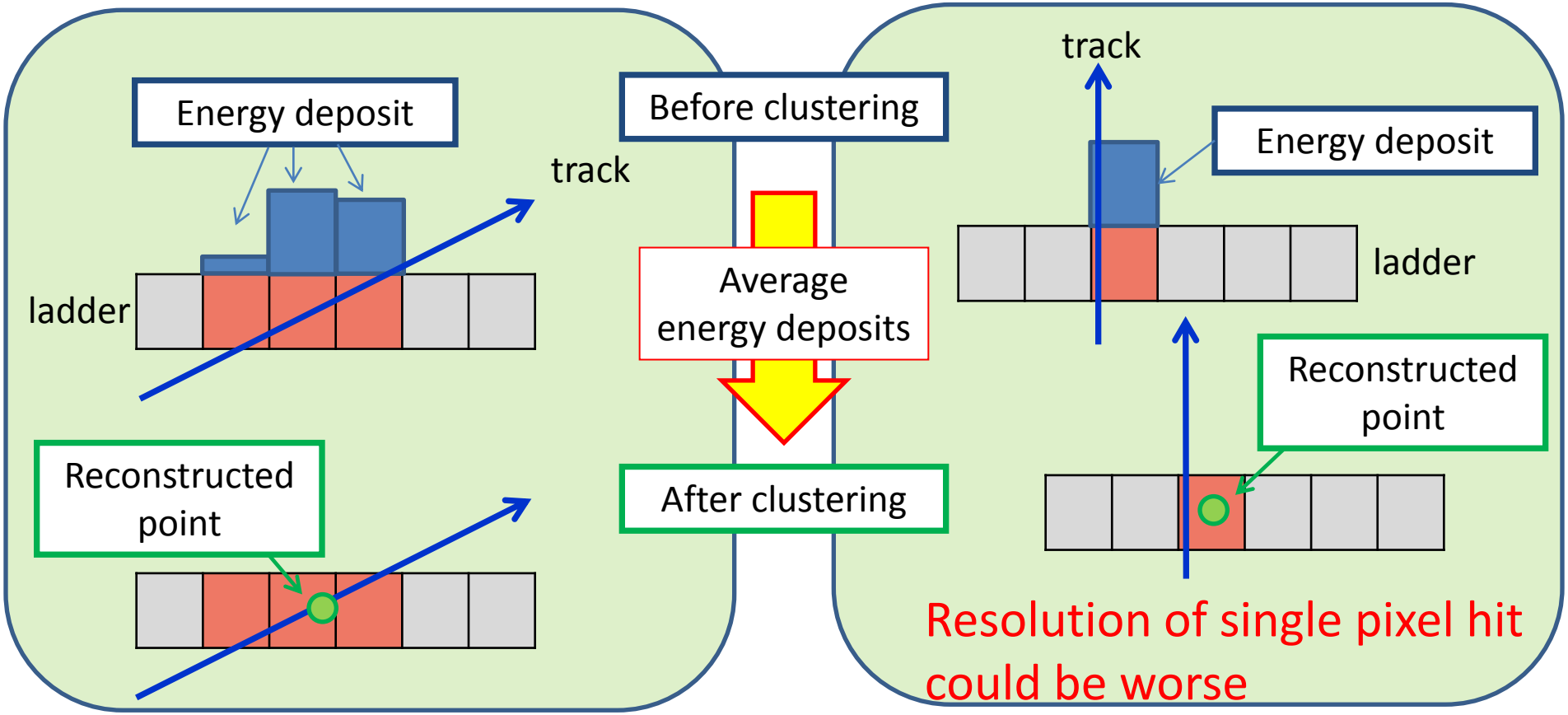
- The hit points and track momenta are obtained from Mokka.
- The trajectory is calculated by the hit point and momentum.
- The pixel hit is identified by the intersections of track and boundaries of pixels.
- The energy deposit of hit is divided into pixels as proportional to path length then smeared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





FPCCD clustering

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

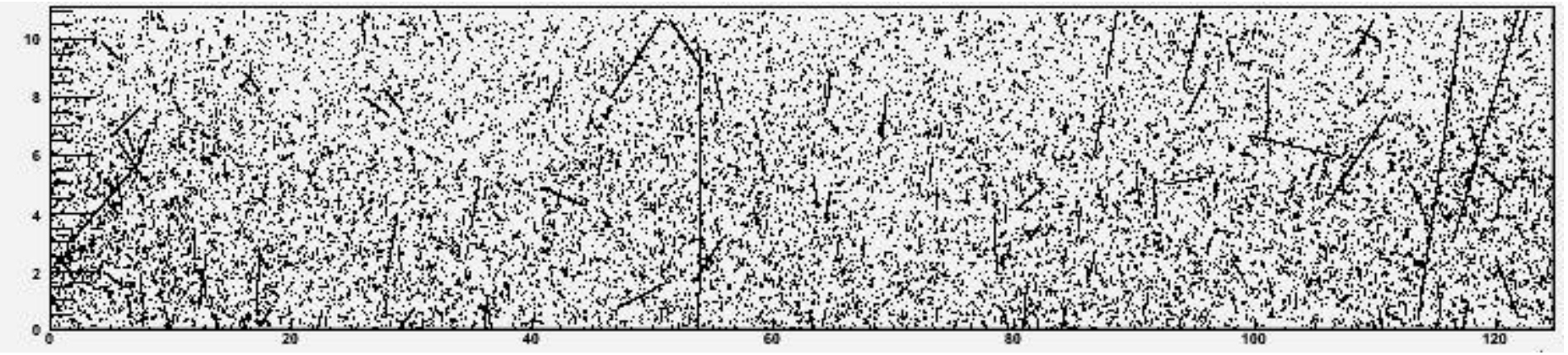


FPCCD OverlayBX

- If there are more than 2 hits in the same pixel, the processor adds the energy deposit.
- Data pool made by FPCCD digitizer is needed.

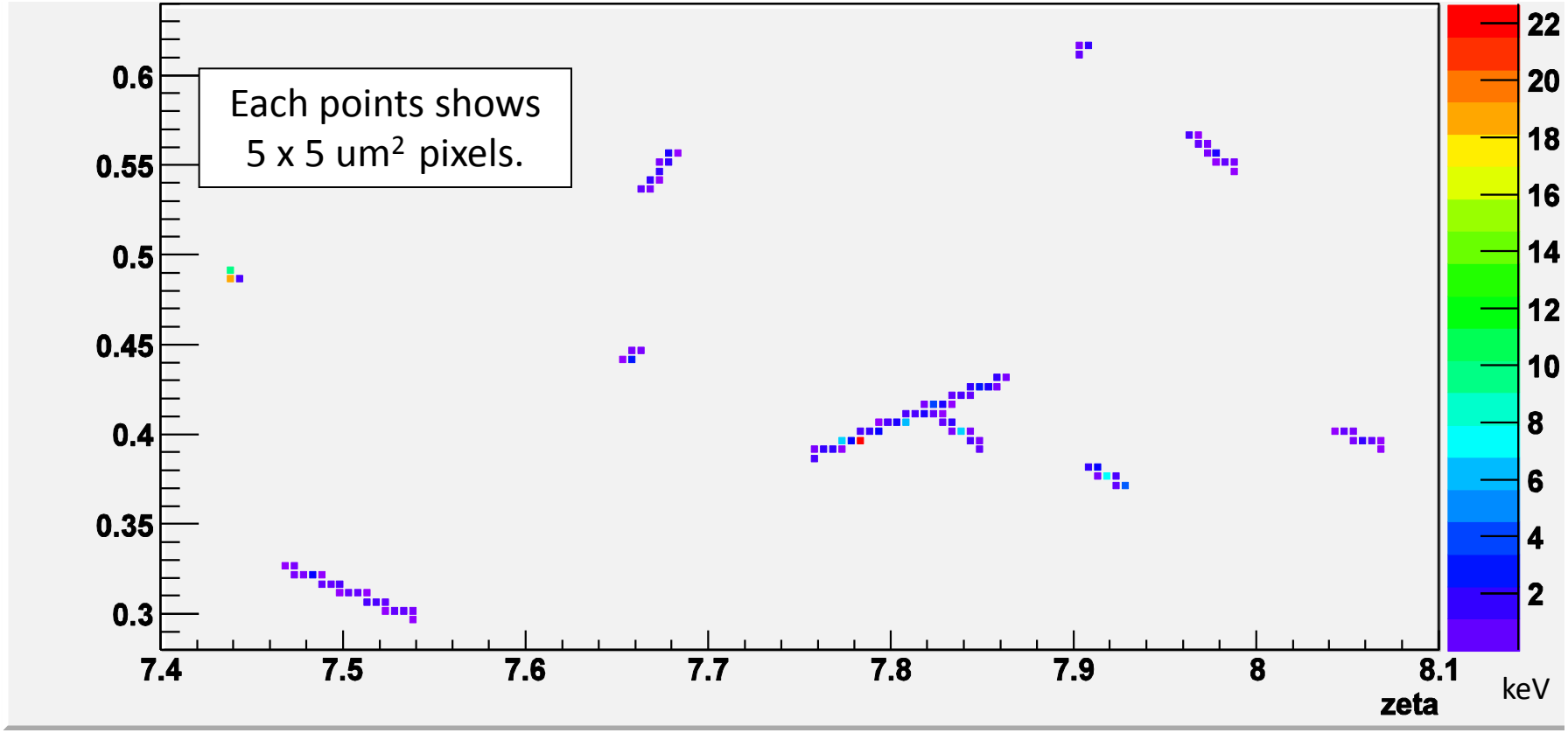
  (1500BX is prepared.)

- Pixel hits of 100BX pair background
  at small region of innermost layer



FPCCD OverlayBX

- The closeup of a part of a ladder.

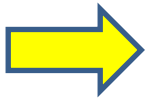


How to use FPCCD software

- Full simulation with FPCCD
  - FPCCD software perform as processor of Marlin.
  - In steering file of Marlin, replace VTXDigiProcessor with FPCCDDigitizer & FPCCDClustering.

Default stdreco.xml

Name	Type
MyAIDAProcessor	AIDAProcessor
MyMaterialDB	MaterialDB
MyTPCDigiProcessor	TPCDigiProcessor
MyVTXDigiProcessor	VTXDigiProcessor
MyFTDDigiProcessor	FTDDigiProcessor
MyETDDigiProcessor	ETDDigiProcessor
MyLEPTrackingProcessor	LEPTrackingProcessor



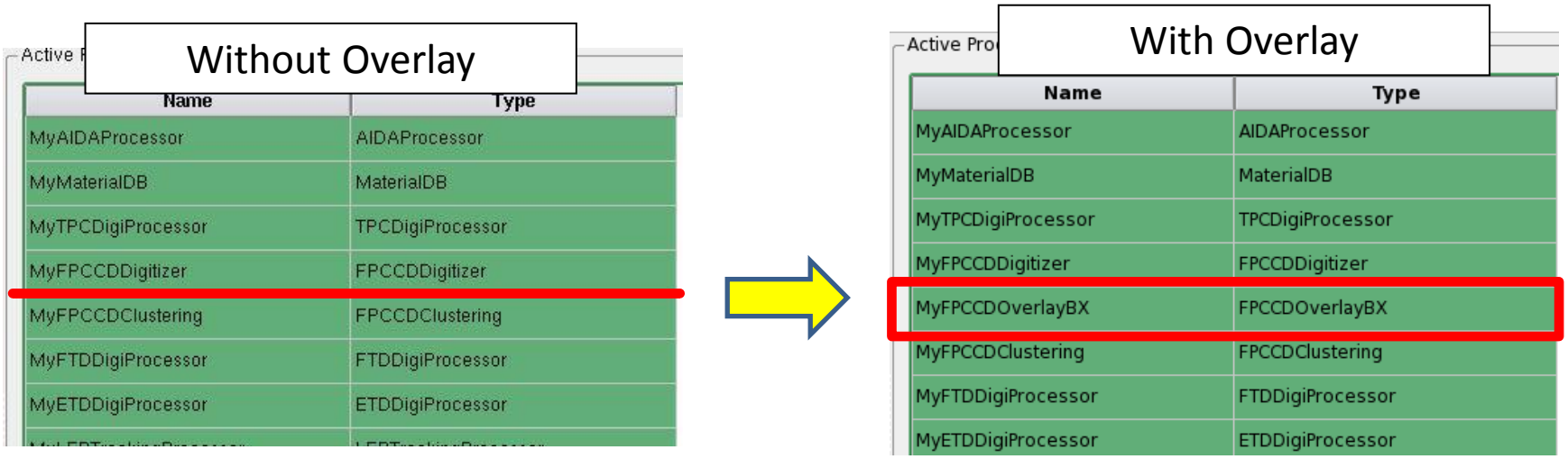
After modified

Name	Type
MyAIDAProcessor	AIDAProcessor
MyMaterialDB	MaterialDB
MyTPCDigiProcessor	TPCDigiProcessor
MyFPCCDDigitizer	FPCCDDigitizer
MyFPCCDClustering	FPCCDClustering
MyFTDDigiProcessor	FTDDigiProcessor
MyETDDigiProcessor	ETDDigiProcessor

  - FPCCDDigitizer digitizes also SIT and SET hits similar to VTXDigiProcessor.
  - It would be better to prepare digitizers separately.

How to use FPCCD software(2)

- Background simulation of FPCCD
  - FPCCDOverlayBX merges digitized hits before clustering.



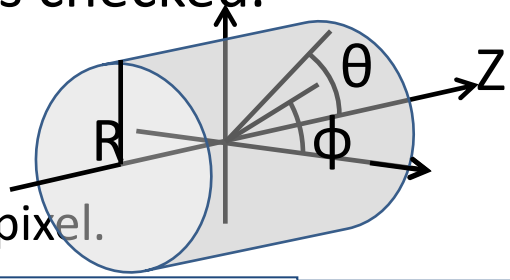
  - Data pool made by FPCCD digitizer is needed.
    Many background file names will be written in steering file.
  - ~ 4GB memory is used for 800 BX pair background.

Variable parameters

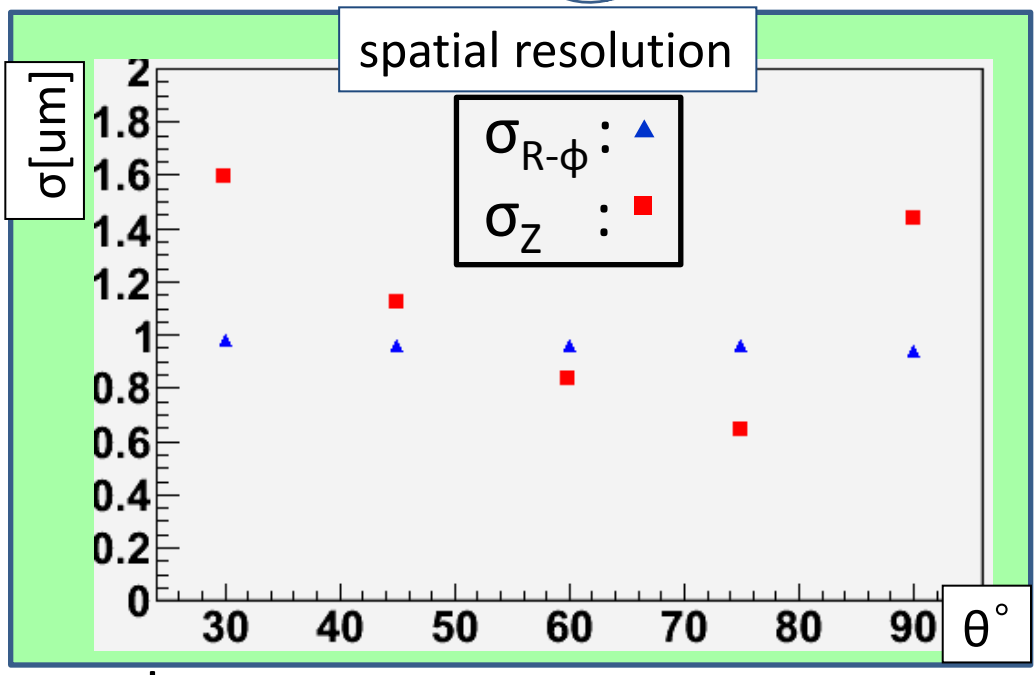
- FPCCD Digitizer
  - — variables : pixel size, pixel height
- FPCCD Clustering
  - — variables : # bit for read out, dynamic range, noise rate, threshold
- FPCCD OverlayBX
  - — variables : read out time (# BX), Background file names

Spatial resolution

- The θ dependency of the position resolution was checked.
  - μ-
  - 7 bits read out
  - σ_{noise} : 50 electrons /pixel, Threshold : 200 electrons /pixel.



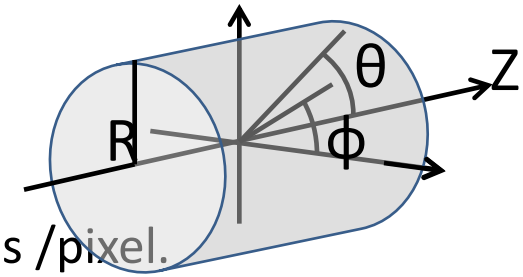
θ	σ_Z	$\sigma_{R\text{-}\phi}$
90°	1.5 um	0.94 um
75°	0.64 um	0.96 um
60°	0.83 um	0.96 um
45°	1.2 um	0.96 um
30°	1.6 um	0.98 um
LOI value	2.8 um	2.8 um



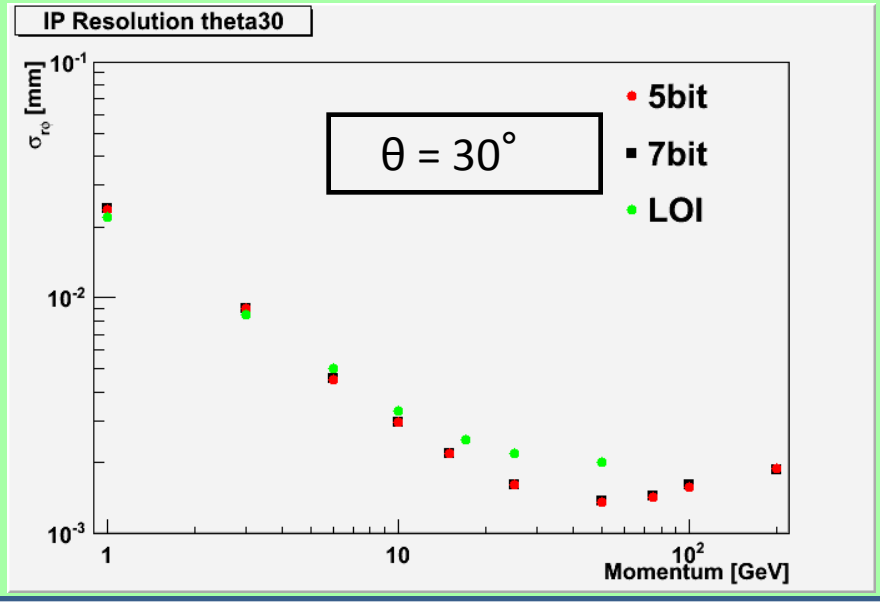
- The Z resolution is worse at forward.
- The R-ϕ resolution is not depends on θ.
- The Z resolution of the vertical track is bad because of single pixel hit.

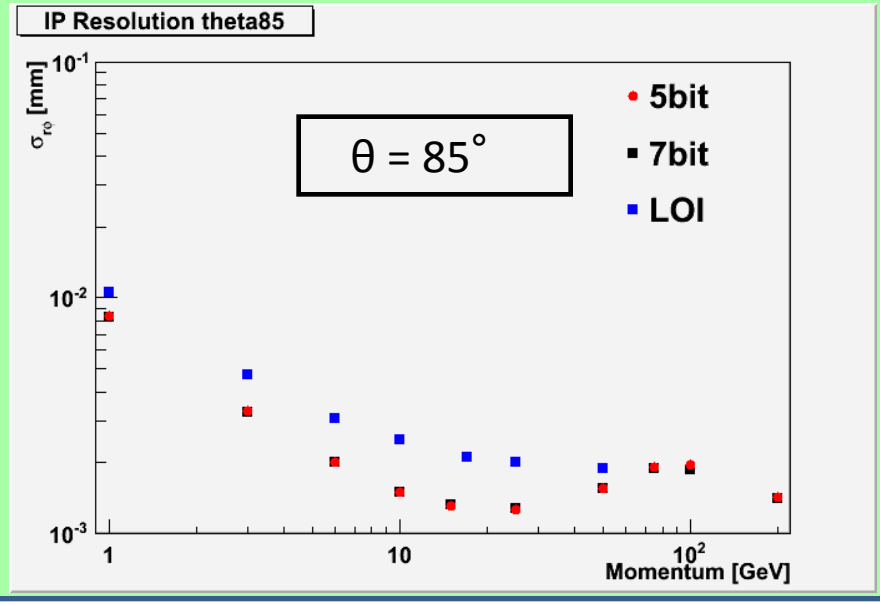
Impact parameter resolution

- The momentum dependency of the impact parameter resolution was checked.
  - μ-
  - 7 bits & 5bits read out
  - σ_{noise} : 50 electrons /pixel, Threshold : 200 electrons /pixel.



Impact parameter resolution

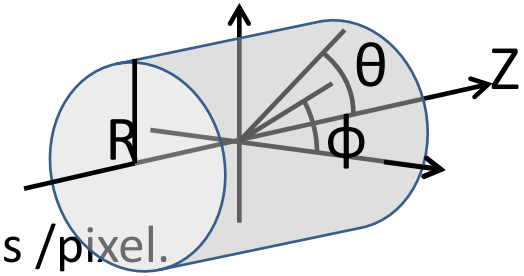




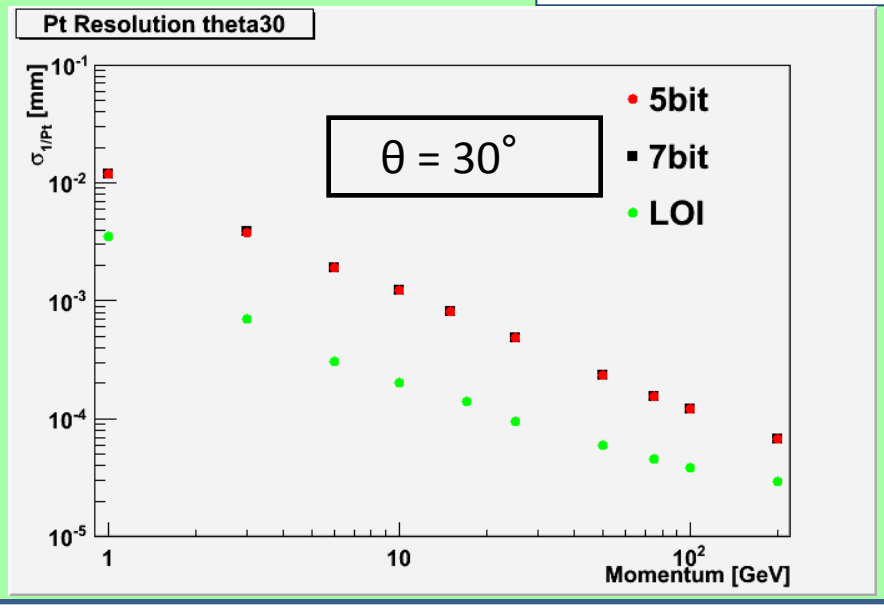
- There are no significant difference between 7bits & 5 bits read out.
- $\sigma_{r\phi}$ is better at P_T = 25 GeV.

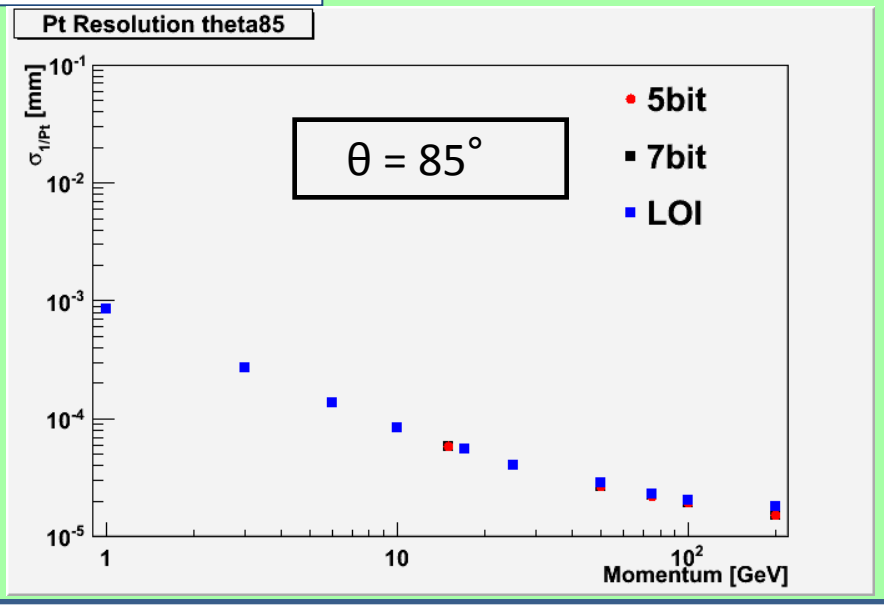
Momentum resolution

- The momentum dependency of the momentum resolution was checked.
  - μ-（Momentum 100GeV)
  - 7 bits & 5bits read out
  - σ_{noise} : 50 electrons /pixel, Threshold : 200 electrons /pixel.



Momentum resolution



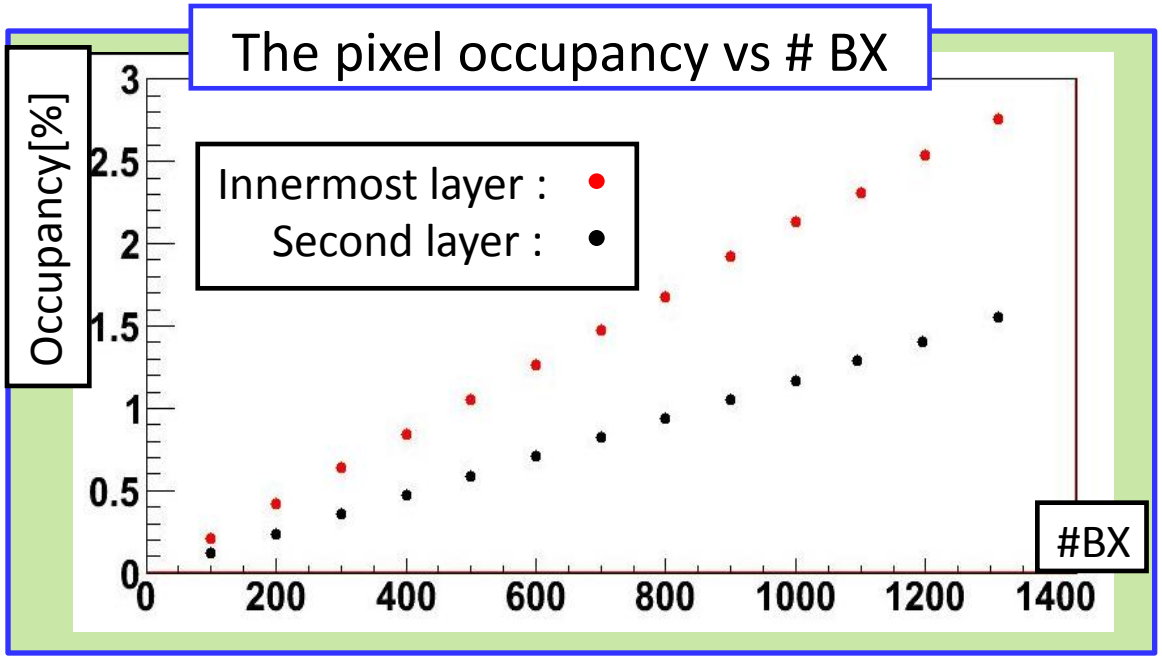


- There are no difference between 7 bits & 5 bits read out.
- The cause of bad resolution at 30 degree is not understand yet.

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%)

The γγ → hadron background

- The number of clusters from γγ → hadron background was checked.
  - SB2009 wTF
  - data statistics : 2000 γγ → hadron events
    (corresponds to ~2860 BX)

# Clusters from γγ → hadron for 1 train (1312 BX)						
Layer	1a	1b	2a	2b	3a	3b
# Clusters	2090	1700	1830	1700	1500	1430

- Rate : ~ 1.5 clusters/BX. (~ 1 / 2000 of pair background)
  - These are real tracks.
  - Almost clusters have only 1 pixel.
  - It will difficult to reject these background using cluster shapes.

Range cut

- Range cut
  - The limit of track length in Geant simulation.
  - Shorter range cut is accurate, but time consuming.
  - Default value : 100um > 5um (FPCCD pixel size)

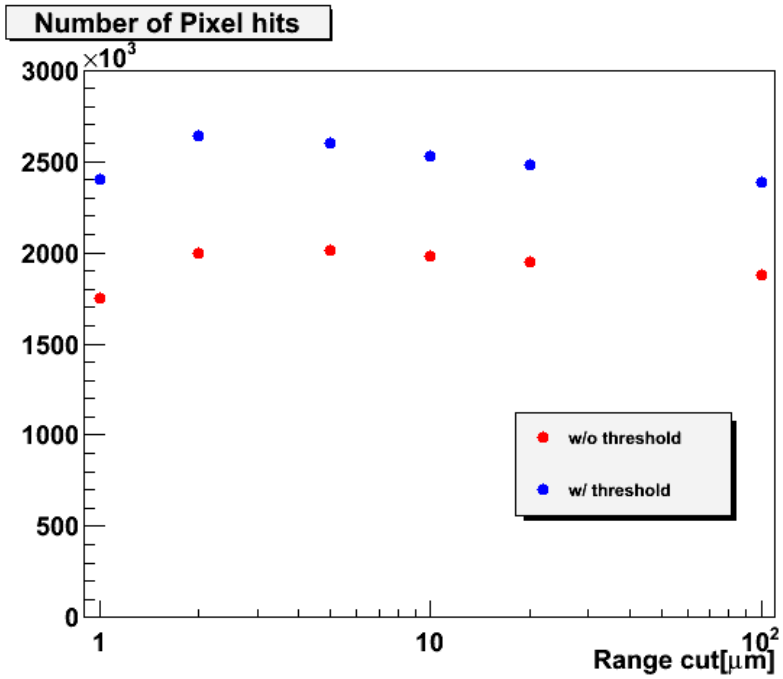
  The determination of the short enough “range cut” value for FPCCD simulation study is required.

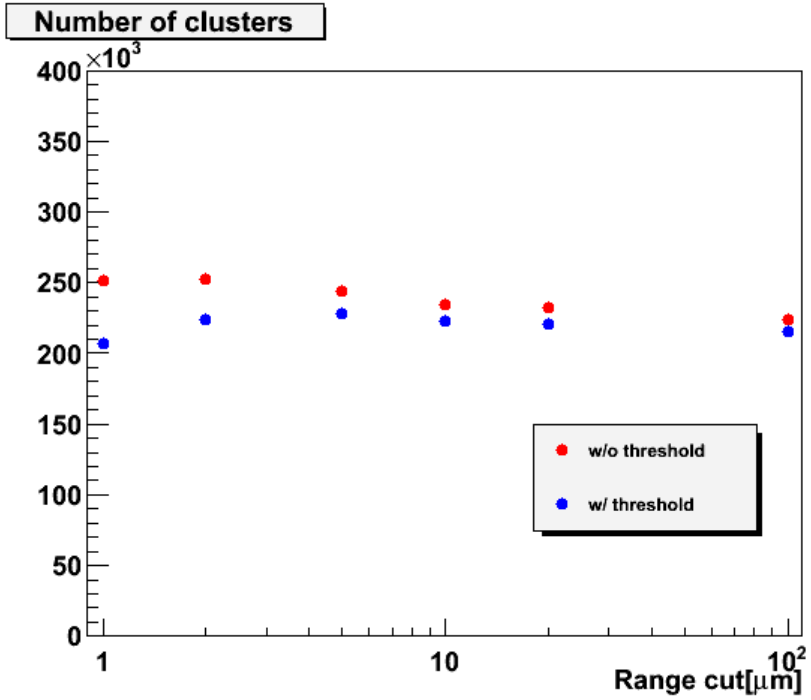
- Pair background samples with various range cut are compared.
  - range cut : 1, 2, 5, 10, 20, 100 um
  - data statistics : 100 BX

Number of pixel hits & clusters

■ # pixel hits & clusters are checked.

— the plot shows innermost layer.





- The difference due to range cut are a few %.
- 100 um range cut is acceptable.

Requirement for FPCCD simulation

- Mokka production
  - Geometry
    - Cable and services are not implemented.
    - Support structure is not implemented.
  - Data format
    - Information of momentum of particle must remain for FPCCD digitizer.
    - 100um range cut is acceptable.

Summary

- FPCCD software were uploaded.
  - svn co https://svnsrv.desy.de/public/marlinreco/MarlinReco/trunk MarlinReco
  - svn co https://svnsrv.desy.de/public/marlin/Overlay/trunk Overlay
- IP resolution & momentum resolution were checked.
  - Momentum resolution
    - $\theta = 85^\circ$ is same as LOI, $\theta = 30^\circ$ is worse than LOI.
  - IP resolution
    - Better than LOI, at $P_T = 25$ GeV.
  - There are no difference between 7 bits & 5 bits read out.
- Occupancy
  - Pair background : Innermost layer 2.76 %, second layer 1.55%
  - $\gamma\gamma \rightarrow$ hadron : ~ 1.5 cluster /BX
- There are some requirements to Mokka production.
  - Geometry, Data format

Plan

- Estimation of background effect on tracking.
- Development of Silicon track finder using Kalman filter.