# FPCCD software
# For ILD_WS pre

Physics and Software meeting

2010/11/19
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# Outline

■ FPCCD software were uploaded.

- — 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

■ Requirements for FPCCD simulation

■ Summary

# 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

After modified
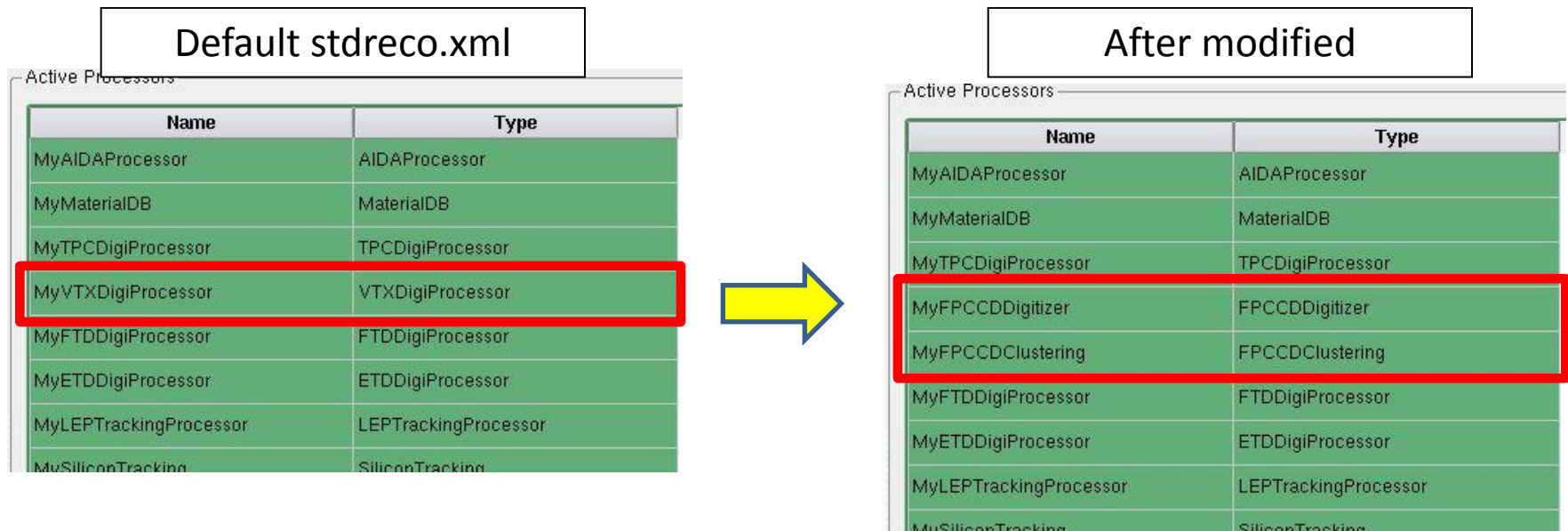


■ Background simulation of FPCCD

— merge pixel hits of background before clustering using by FPCCDOverlayBX.

# Variable parameters

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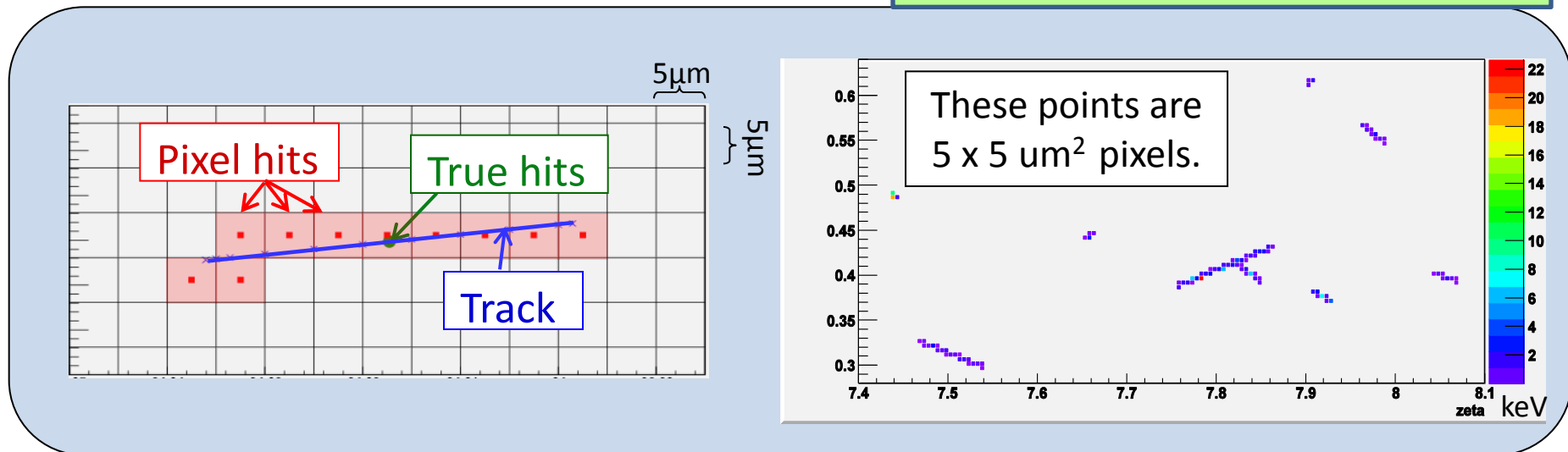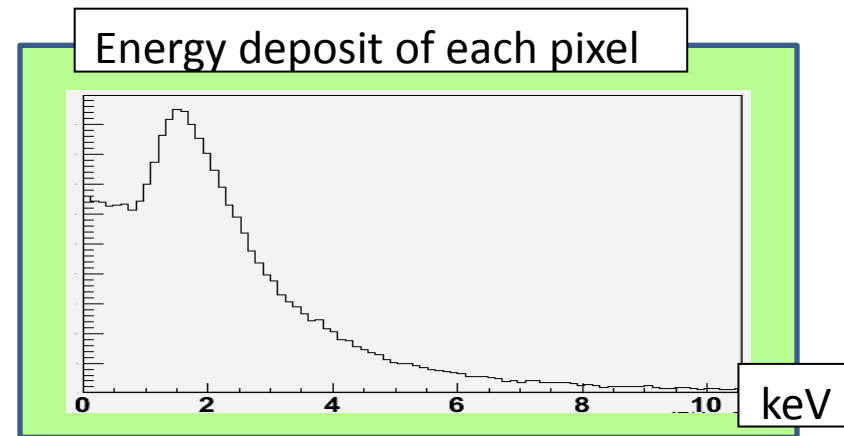- **FPCCD Clustering**
  - — variables : # bit for read out, dynamic range, noise rate, threshold
- **FPCCD OverlayBX**
  - — variables : read out time (# BX), Background file names

# FPCCD digitizer

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

- 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 hit is divided into pixels as proportional to path length and these are approximated by Landau distribution.

Energy deposit of each pixel

keV

5μm

5μm

Pixel hits

True hits

Track

These points are 5 x 5 um² pixels.

keV

# FPCCD clustering

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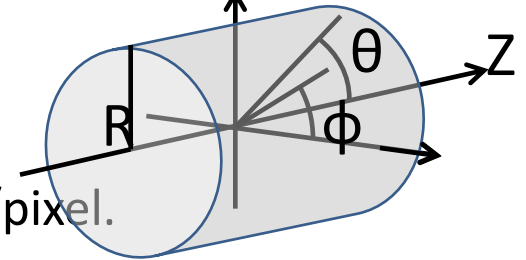- The hit point is reconstructed as an energy weighted position.
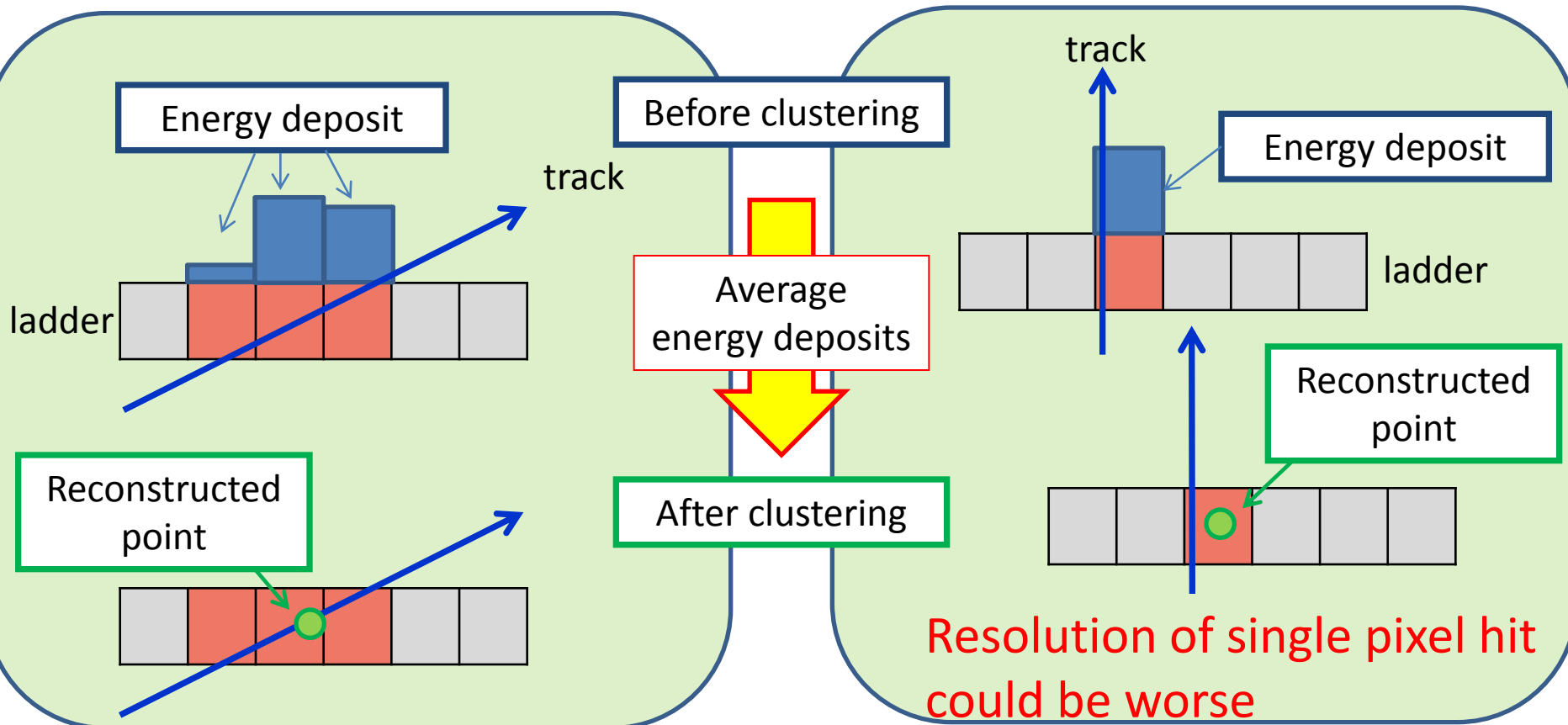
# FPCCD OverlayBX

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

■ Data pool made by FPCCD digitizer is needed.

　　(1500BX is prepared.)

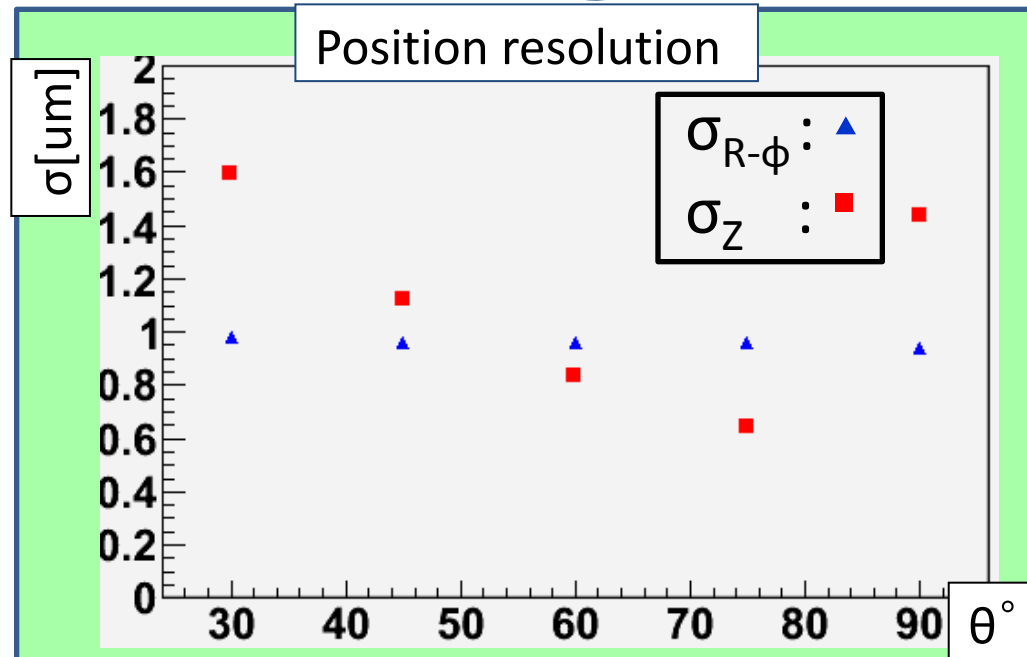• Pixel hits of 100BX pair background at a ladder of innermost layer
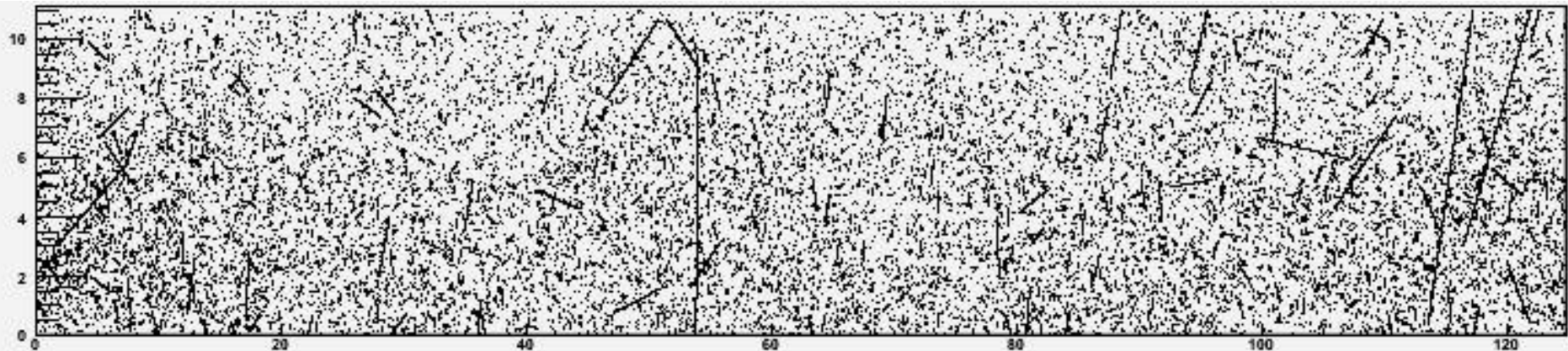
# Spatial resolution

■ The θ dependency of the position resolution was checked.

— μ-（Momentum 100GeV)

— 7 bits read out

— $\sigma_{noise}$ : 50 electrons /pixel, Threshold : 200 electrons /pixel.

| θ | $\sigma_Z$ | $\sigma_{R-\phi}$ |
|---|---|---|
| 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 |



Position resolution

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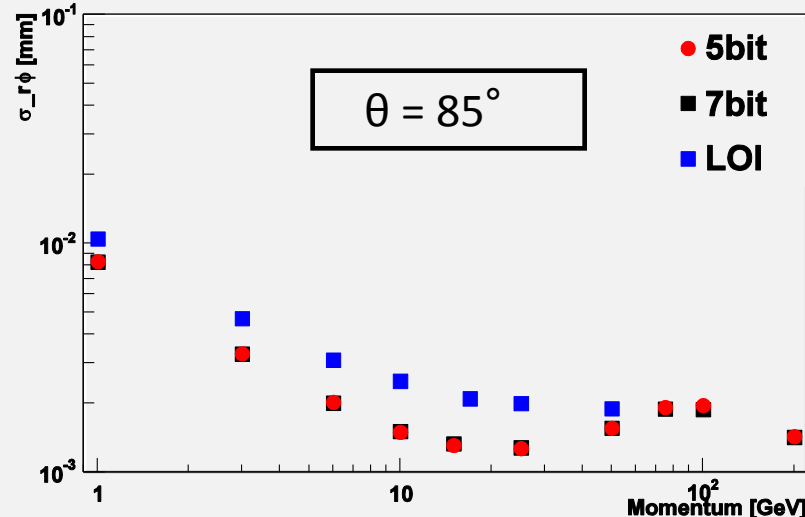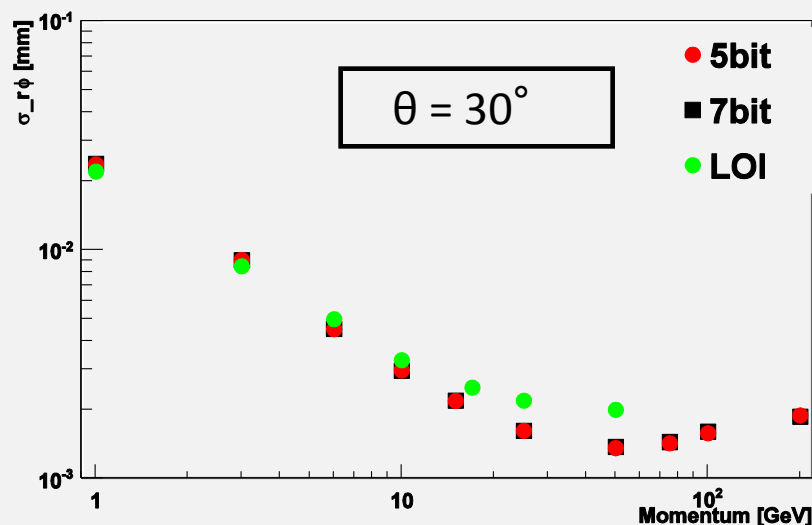- The Z resolution of the vertical track is bad because of single pixel hit.

# Impact parameter resolution

■ The momentum dependency of the impact parameter resolution was checked.

— μ-（Momentum 100GeV)
— 7 bits & 5bits read out
— $\sigma_{noise}$ : 50 electrons /pixel, Threshold : 200 electrons /pixel.
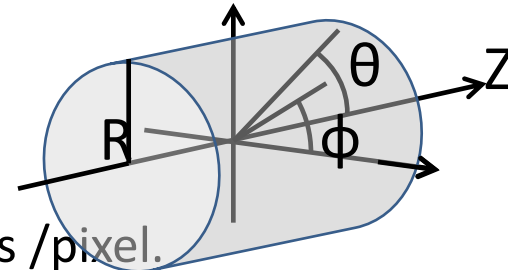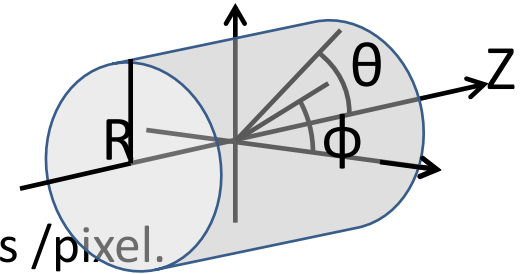
Impact parameter resolution



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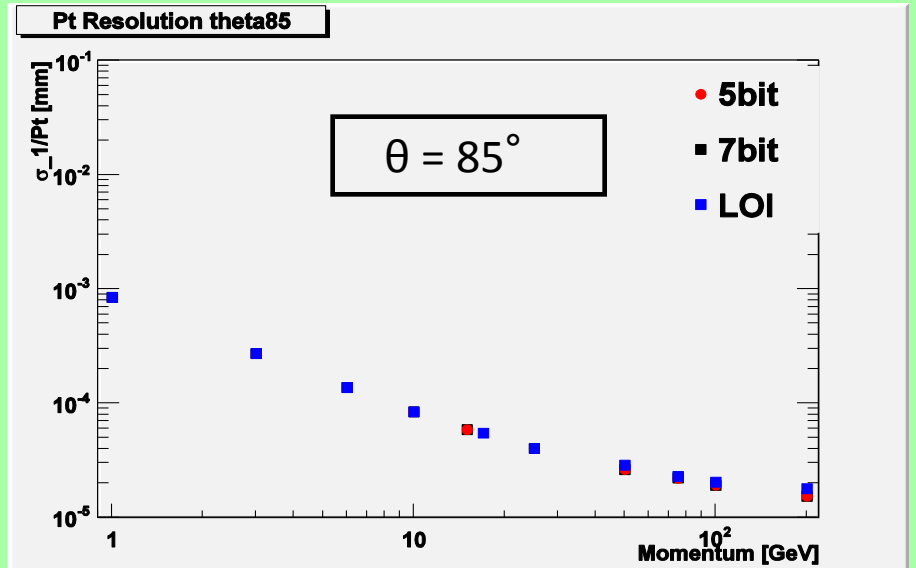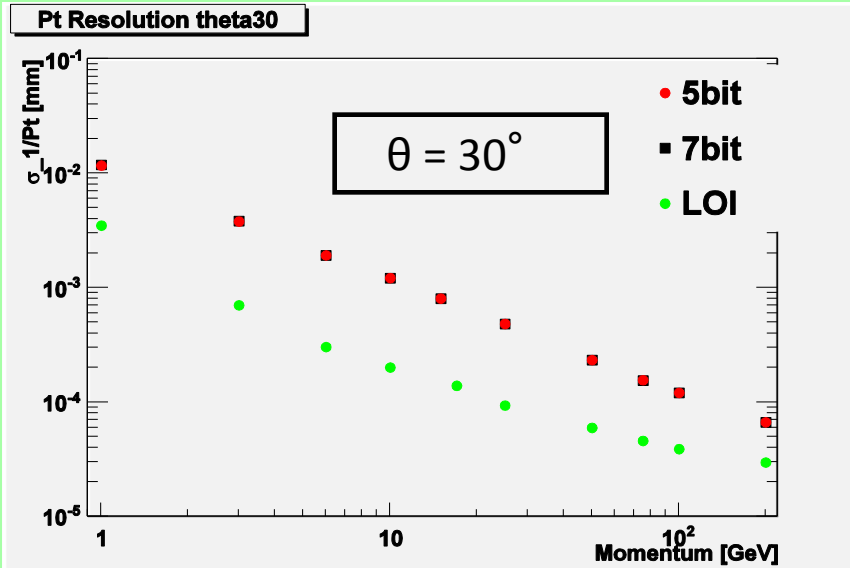● $\sigma_{r\phi}$ is better at $P_T$ = 25 GeV.

# Momentum resolution

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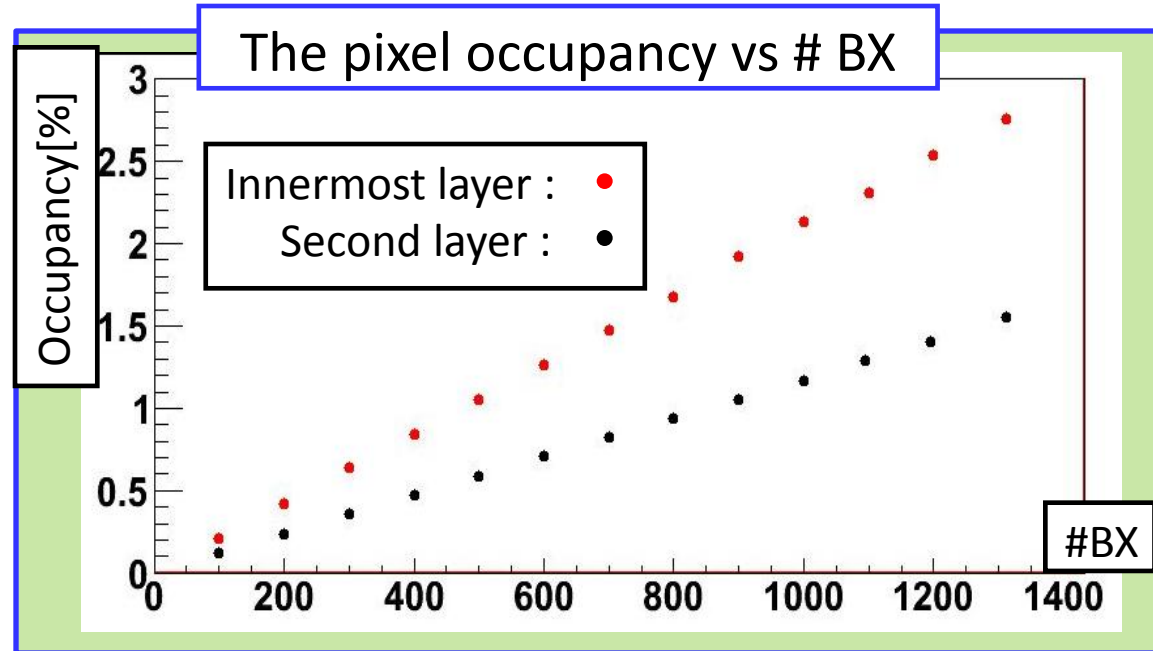
Impact parameter resolution



- There are no difference between 7 bits & 5 bits read out.
- θ = 85° is same as LOI, θ = 30° is worse than LOI.

# 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

The pixel occupancy vs # BX

Occupancy[%]

Innermost layer : •
Second layer : •

#BX

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.

   — data statistics : 2000 γγ → hadron events
(corresponds to ~<u>2860 BX</u>)

| # Clusters from γγ → hadron for 1 train | | | | | | |
|---|---|---|---|---|---|---|
| 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.

# 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.

# 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 Marlin
- **IP resolution & momentum resolution were checked.**
  - — Momentum resolution
    - $\theta = 85°$ is same as LOI, $\theta = 30°$ 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%
  - — γγ → hadron : ~ 1.5 cluster /BX
- **There are some requirements to Mokka production.**
  - — Geometry, Data format

# Plan

- Determination of short enough Range cut.

- Estimation of background effect on tracking.

- Development of Silicon track finder using Kalman filter.