Simulation of FPCCD Vertex Detector

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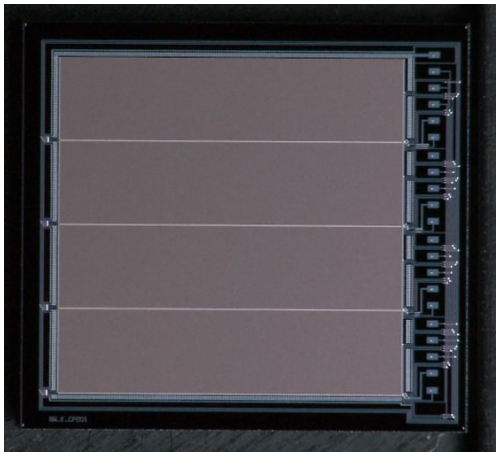
FPCCD Vertex Detector

FPCCD Vertex Detector

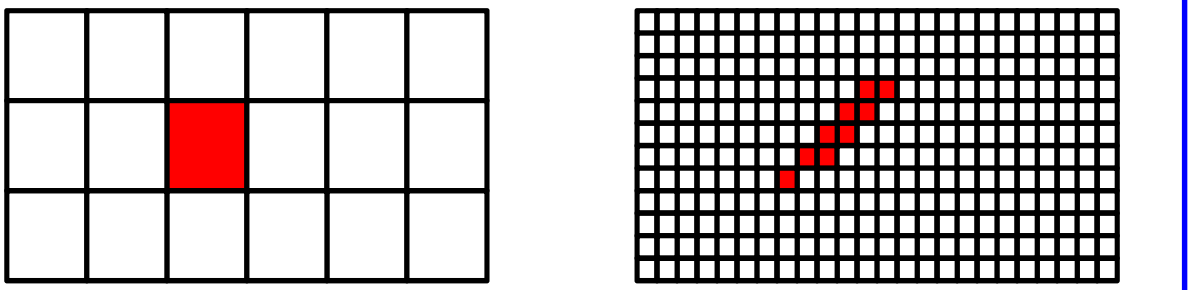
- FPCCD(Fine Pixel CCD)
  - Pixel size: 5μm × 5μm × 15μm
  - full well depletion
- #Pixels: ~10^{10} pixels
  - some pixels hit in the same layer

Prototype of FPCCD



→pair background can be rejected by pattern recognition.

Same hit on a layer with different size CCD



CCD(~20μm × 20μm)　　FPCCD

Simulation study

Simulation study for FPCCD Vertex Detector

To do

- develop dedicated software for FPCCD Vertex Detector
  - FPCCD digitizer
- develop algorithm to reduce background hits based on cluster shape
- evaluate tracking and vertexing performance

→Current status of this study will be presented.

- FPCCD digitizer
- Pair-background rejection
- Effective pixel occupancy

Simulation condition

Simulation condition

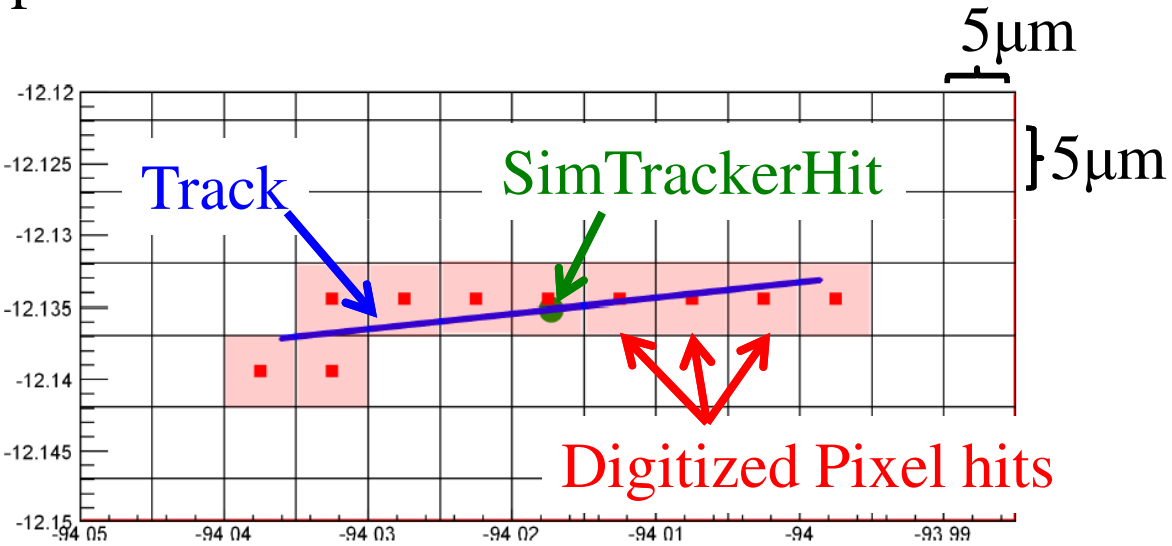
- Detector model: ILD00_fwp01
- Signal
  - Single electron events (statistics: 5000 events)
  - emitted all direction(θ,φ) by particle-gun
  - Momentum: 50 MeV, 100 MeV, 500MeV, 1GeV
- Background
  - Ecm: 500 GeV
  - Beam parameter

	BX/train	MC statistics (BX)
RDR-Nominal	2625	168
RDR-LowP	1312	63
SB2009wTF	1312	59

FPCCD digitizer

FPCCD digitizer

- special digitizer for FPCCD vertex detector
- role: make pixel hits from “SimTrackerHits”



Note

- No threshold to create pixel hits
  - Hit is created when particle shaves pixel.

→We try to estimate pixel occupancy with FPCCD digitizer.

Pixel occupancy

The pixel occupancy was estimated.

- 2nd or 3rd layer : < 0.2%
- 1st layer : 2~6% ← so large

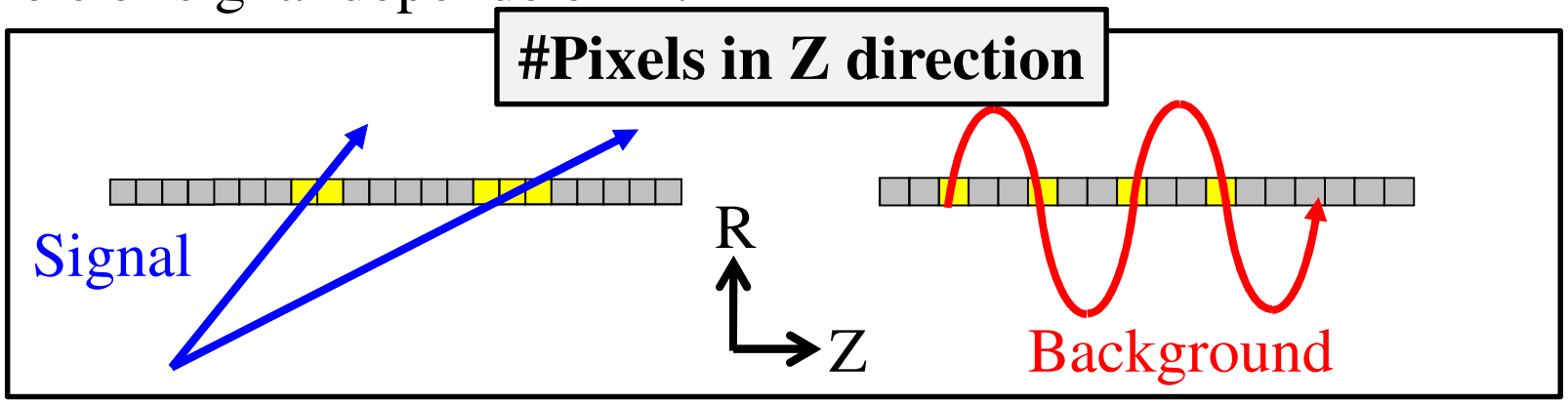
→Background should be rejected.

	1a	**1b**	**2a**	**2b**	**3a**	**3b**
RDR-Nominal	4.07%	2.33%	0.13%	0.10%	0.02%	0.02%
RDR-LowP	5.79%	3.05%	0.19%	0.13%	0.03%	0.03%
SB2009wTF	5.39%	3.02%	0.16%	0.15%	0.03%	0.03%

Strategy of background rejection

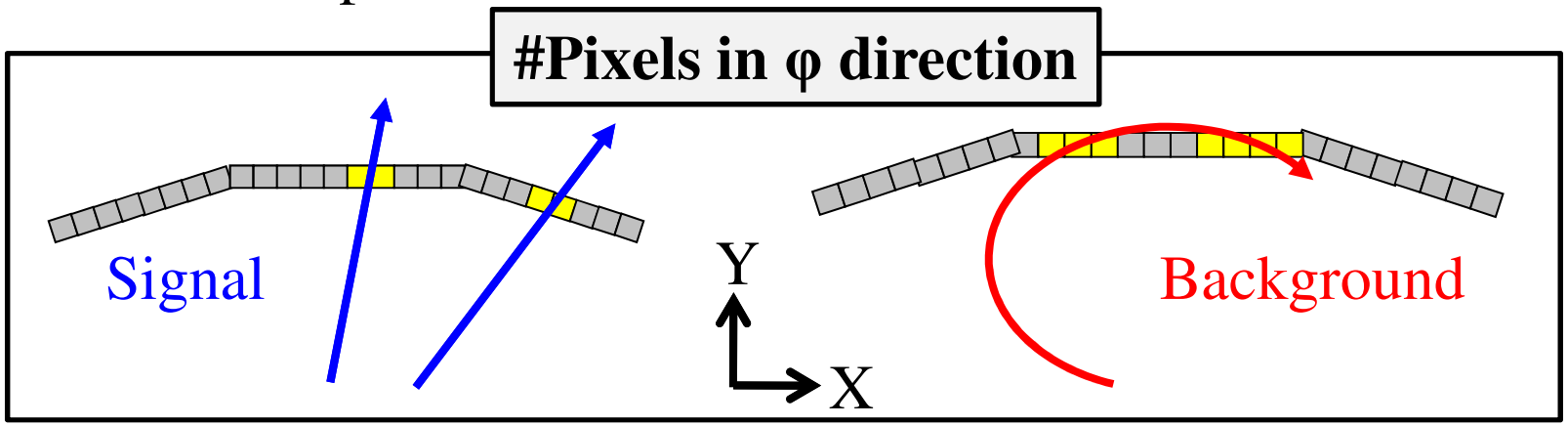
Z dependence of #Pixels in Z direction

- #Pixels of signal depends on Z.



#Pixels in φ direction

- Signal hits a few pixels.

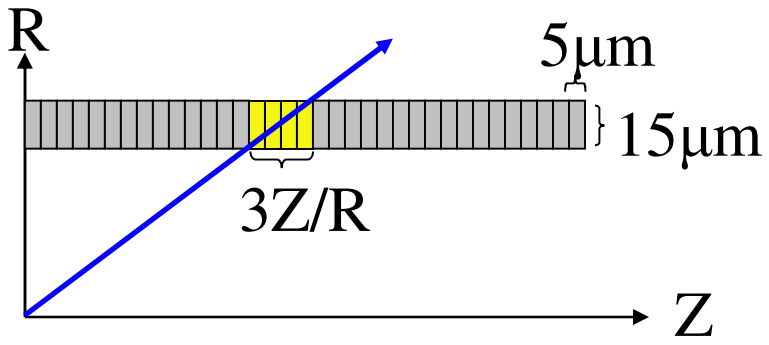


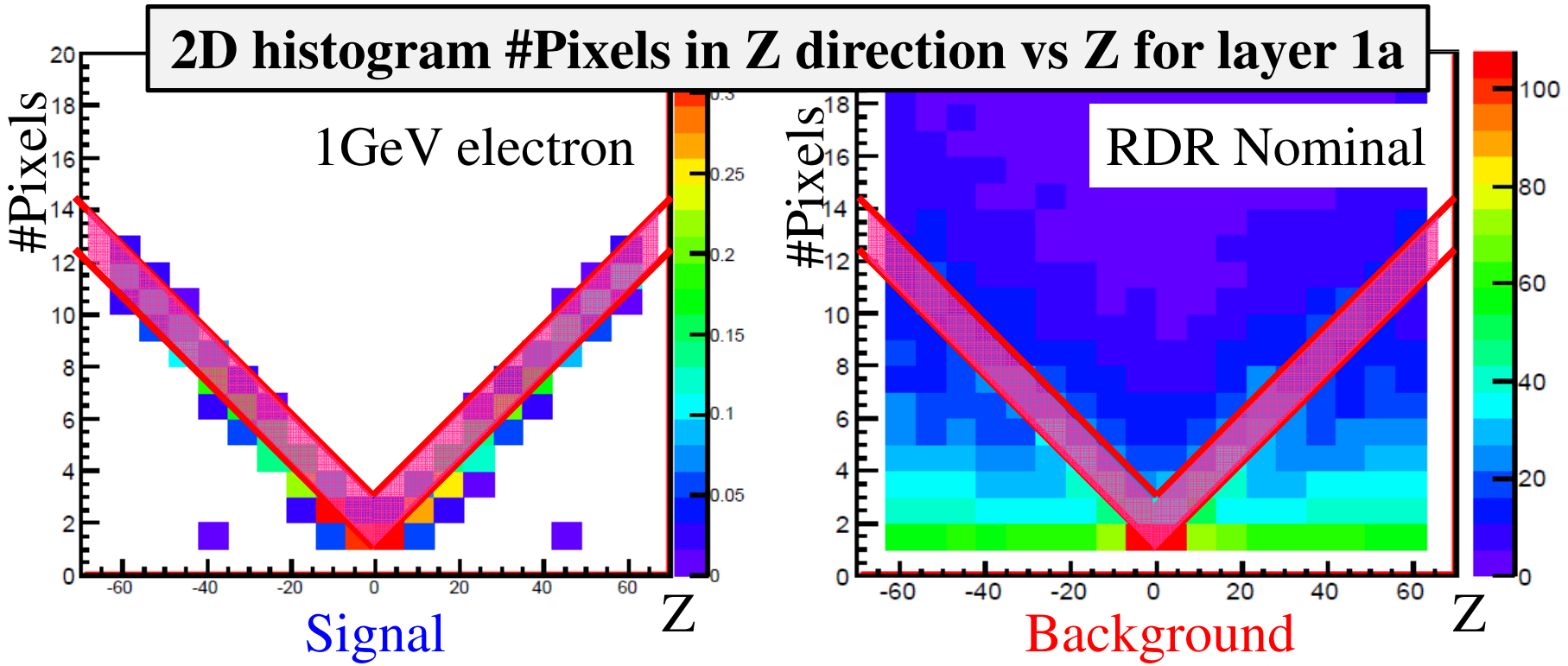
Z dependence of #Pixels in Z direction

#Pixels in Z direction was checked.

- #Pixels of signal depends on Z.
- Typical #Pixels: 3Z/R

→3Z/R < #Pixels < 3Z/R + 2 was selected.



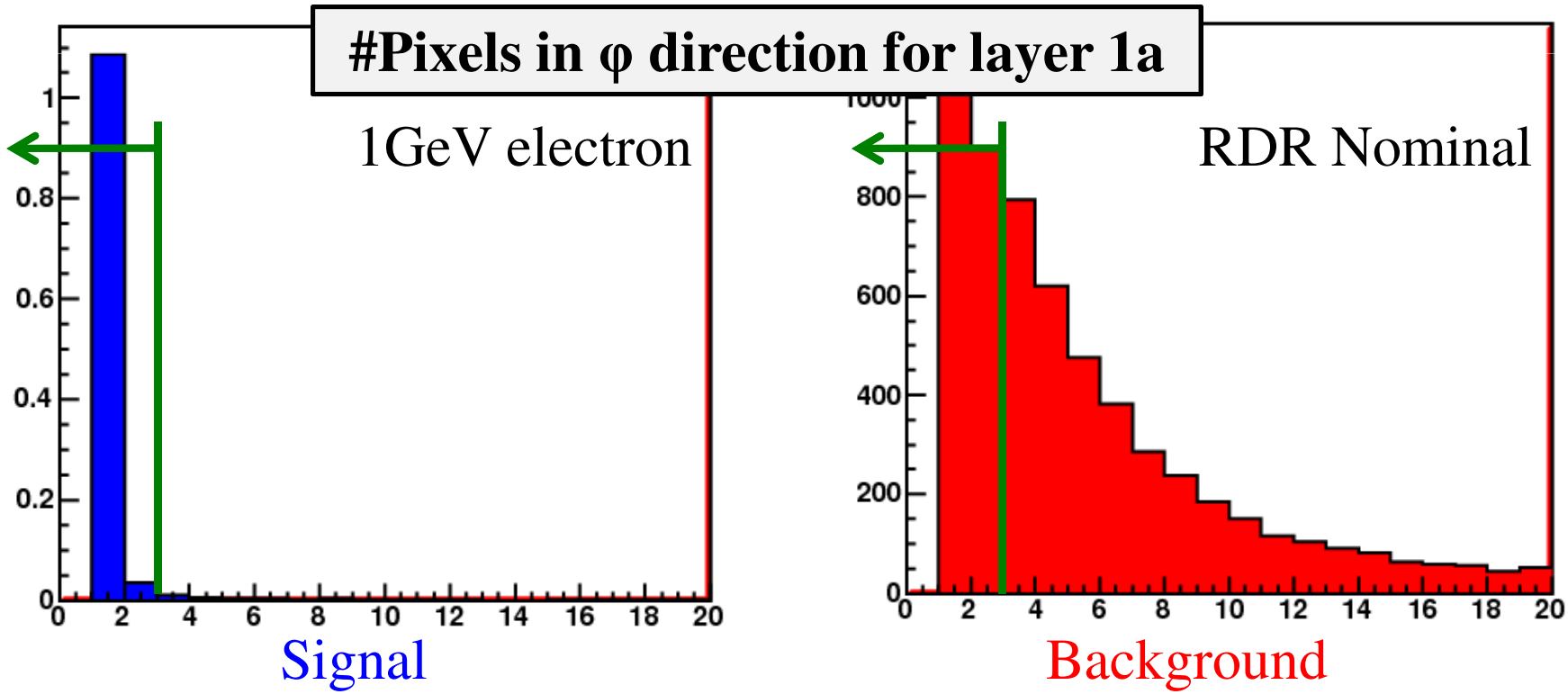


#Pixels in φ direction

#Pixels in φ direction was checked.

- Signal event hits a few pixels.

→#Pixel ≤ 2 was selected.



Reduction summary

Efficiency of signal

- Efficiency of 50 MeV electron is low. → should be improved

	1a	1b
50 MeV	46.99%	46.61%
100 MeV	89.82%	81.63%
500 MeV	96.22%	97.45%
1 GeV	97.98%	99.42%

Effective occupancy

- The occupancy was reduced sufficiently.

	1a		1b	
RDR-Nominal	4.07% →	0.13%	2.33% →	0.08%
RDR-LowP	5.79% →	0.17%	3.05% →	0.11%
SB2009wTF	5.39% →	0.17%	3.02% →	0.11%

Summary

Simulation study of FPCCD vertex detector is ongoing.

- FPCCD vertex detector can reject pair background thanks to very small pixels.
- Software to make FPCCD hits are developed.
- Backgrounds were rejected by pattern recognition.
  - Parameter: RDR-Nominal,LowP and SB2009wTF
  - Efficiency of 50 MeV single electron event should be improved.

Occupancy	1a		1b	
RDR-Nominal	4.07% →	0.13%	2.33% →	0.08%
RDR-LowP	5.79% →	0.17%	3.05% →	0.11%
SB2009wTF	5.39% →	0.17%	3.02% →	0.11%