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Performance Evaluation and Software Development for FPCCD Vertex Detector in ILC

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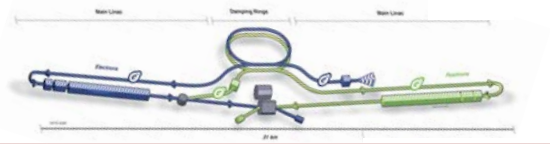
What is ILC?

ILC (International Linear Collider) is a next generation lepton collider for the high energy frontier physics.

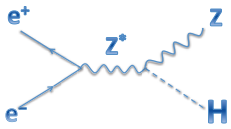
- Basic Characteristics
  - e^+e^- collider
  - total length = 31 km
  - E_{CM} = 250 ~ 500 GeV (upgrade : 1 TeV)
  - peak luminosity = $2 \times 10^{34}\ cm^{-2}s^{-1}$



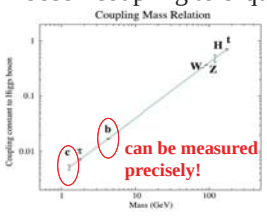
Higgs Study in ILC

One of purposes of ILC is to measure Higgs coupling constant precisely, especially to b-quark and c-quark.

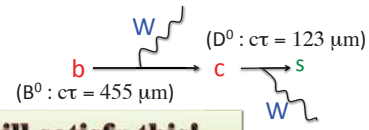
The golden mode of Higgs generation process in ILC is ee -> ZH.



ILC is a lepton collider, so precise measurement of Higgs boson coupling to b-quark and c-quark can be done.



Vertex Detector is required to see measure 100 μm scale and below.



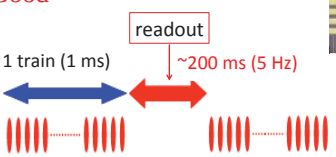
FPCCD Vertex Detector will satisfy this!

FPCCD Vertex Detector

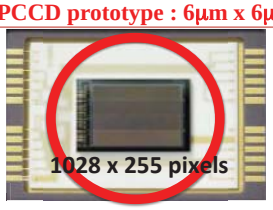
FPCCD (Fine Pixel CCD) Vertex Detector will enable precise flavor tagging.

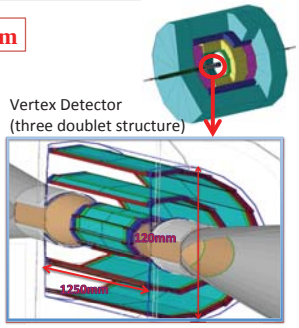
- Basic Characteristics
  - pixel size : 5μm x 5μm
  - sensor thickness : 50μm
  - number of pixels : ~10^9

  → **space resolution : Very Good**
  → **pixel occupancy of background : Good**
- fully depleted CCD → two-track separation capability : Good
- three doublet structure
  → background rejection by cluster shape : Good
- readout par one train
  → completely free from beam-induced RF noise (EMI)



FPCCD prototype : 6μm x 6μm





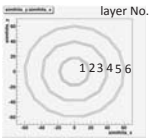
Before building FPCCD Vertex Detector, its performance should be evaluated and optimized.

Performance Evaluation and Software Development for FPCCD

Pixel Occupancy of Background

Main background in VXD is caused by electron-positron beam.

at 500 GeV		at 1 TeV	
layer No.	occupancy of B.G.(%)	layer No.	occupancy of B.G.(%)
1	2.8	1	19.6
2	1.6	2	10.4
3	0.1	3	0.2
4	0.0	4	0.2
5	0.0	5	0.0
6	0.0	6	0.0

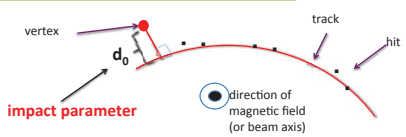


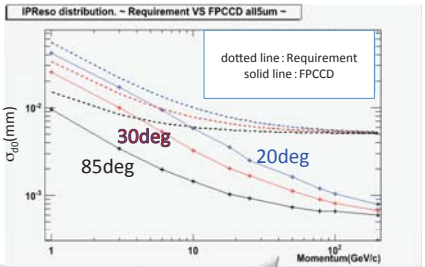
Occupancy must be lower than ~3% in each layer.

Occupancy under 500 GeV is OK!!

Impact Parameter Resolution (without B.G.)

definition: impact parameter





FPCCD provides fantastic I.P. Resolution!!

Pixel-size configuration has been optimized to reduce power consumption of readout.

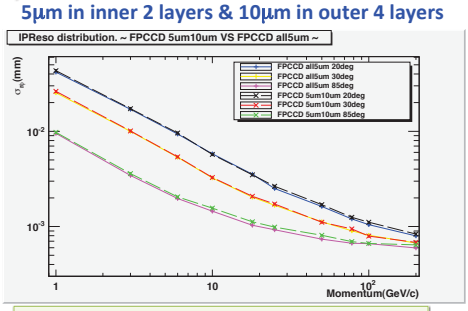
If pixel size in the outer 4 layers are 10μm x 10μm, then power consumption of readout is decreased by 70%. If both occupancy and I.P. resolution remain OK, this value is very attractive.

Check! Occupancy: 5μm VS 10μm

at 1 TeV		
	occupancy of B.G.(%)	
layer No.	5 x 5 μm²	10 x 10 μm²
1	19.6	–
2	10.4	–
3	0.2	0.5
4	0.2	0.5
5	0.0	0.1
6	0.0	0.1

Occupancy requirement cleared with 10μm x 10μm pixel configuration!

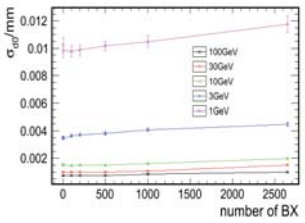
Check! I.P. resolution: all 5μm VS 5μm in inner 2 layers & 10μm in outer 4 layers



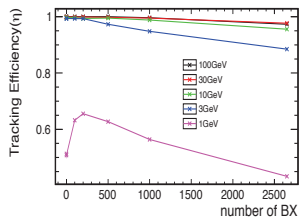
I.P. resolution remains almost same as all 5μm configuration.

From these two results, we can conclude that using 10 x 10 μm² for outer layers is an attractive configuration.

Currently, tracking efficiency and I.P. resolution with B.G. is being studied. The followings are tentative results.



This shows I.P. resolution with background. Even if number of BX increases, it doesn't increase so much.



This shows tracking efficiency with background. Definition of the efficiency is whether there are more than 5 hits used in VXD.

Problems about the efficiency:
1. Why is the efficiency at 1GeV with 0BX very low?
2. Why is the efficiency at 1GeV with 100 ~ 1000BX higher than that with 0BX?
→Now the tracking algorithm is being checked.

Summary and Plan

- **If FPCCD is used,**
  → **Occupancy : OK!** (under E_{CM} = 500 GeV)
  → **Impact parameter resolution : Very Good!**
  → **Power consumption can be reduced** with new configuration of pixel size.

- **Plan**

Tracking Algorithm: I'll check and modify it.
Beam Test: June 2013.
I'll prepare analysis code to derive FPCCD's excellent spatial resolution.