FPCCD Vertex Detector Performance Estimation

ILC年次会

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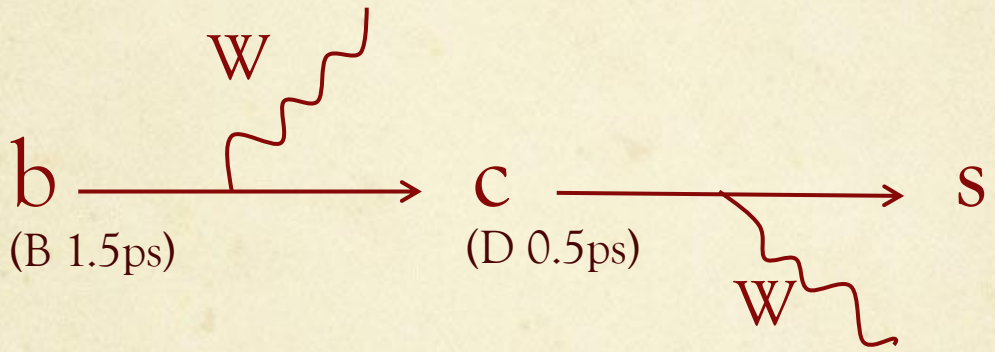
Introduction to FPCCD Performance Estimation

Motivation

- One of the goals in ILC is to measure the coupling constant of Higgs.
  - For this, we need to see the following process.



To see this process precisely, high flavor tagging resolution is required.

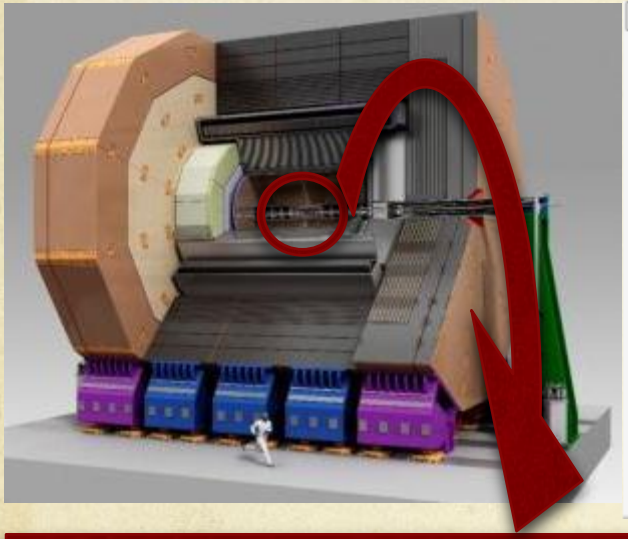
Vertex Detector Requirement

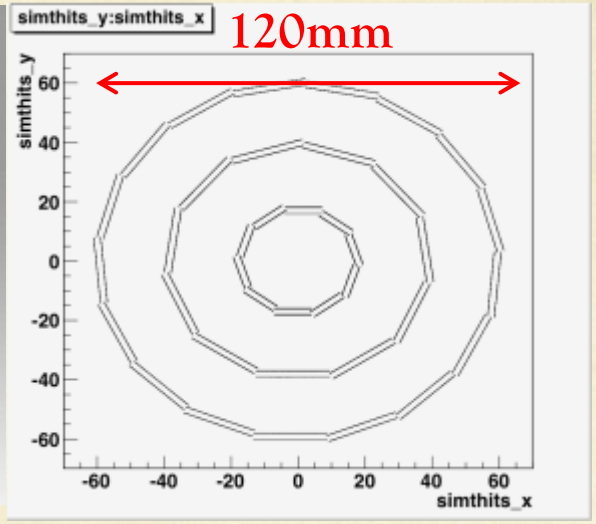
At first, High flavor tagging resolution requires the followings.

Occupancy	A few percent at each layer.
Impact Parameter Resolution	$\sigma_{r\phi} = 5\mu\mathrm{m} \oplus \frac{10\mathrm{GeV/c}}{\mathrm{p} \cdot \sin^{3/2}\theta}\mu\mathrm{m}$

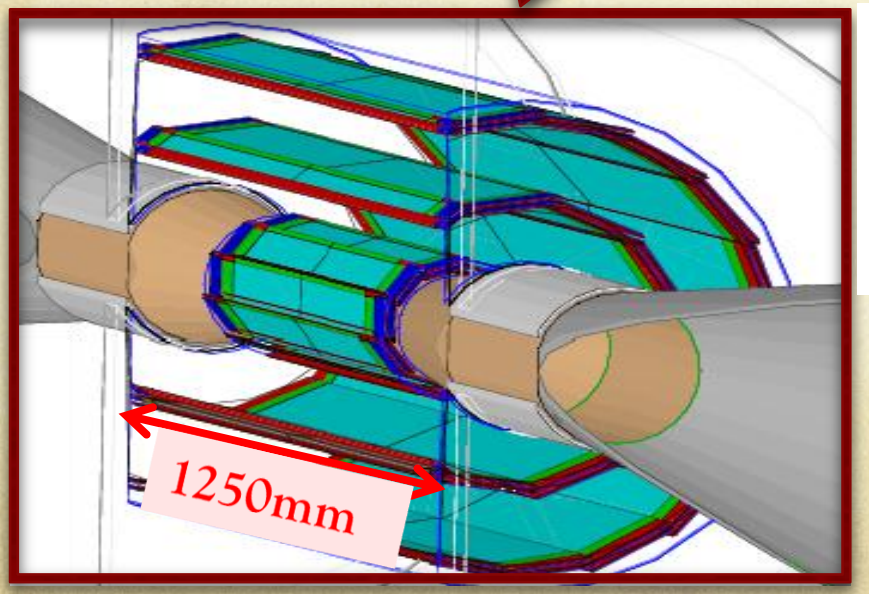
➡ FPCCD Vertex Detector will satisfy this requirement.
(Fine Pixel CCD)

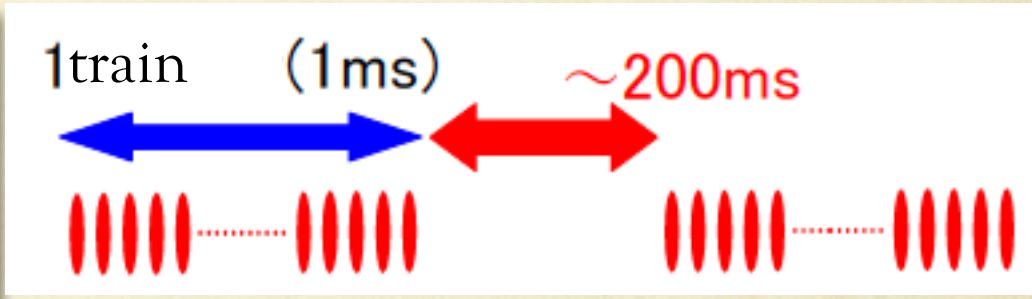
FPCCD Vertex Detector





- Diameter: 120mm
- Length: 1250mm
- 6 layers(3×2)
  - **Pixel Size** : 5μm×5μm
  - **# of pixels** : 1billion
  - Completely-depleted
  - Readout at every 1 train





Simulation Setup

①Occupancy on each layer

- BG data：eepair, backscatter at Ecm = 500GeV and 1TeV.
- Pixel size：
  1. 5um on all layer
  2. 10um on all layer

②Impact Parameter Resolution

- event：Single μ^+ from the origin of the coordinate.
- BG data：non
- Pixel size：
  1. 5um on all layer
  2. 5um on innermost and 2nd innermost layer, and 10um on the others

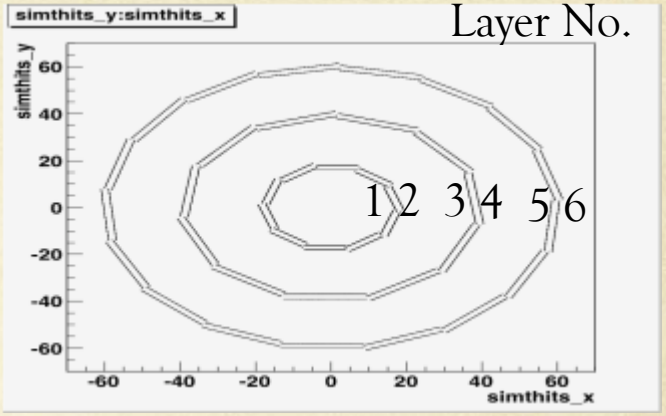
Occupancy Estimation in FPCCD

Occupancy (pixel size 5um)

500 GeV

Layer No.	Occupancy(%)		
	all	eepair	backscatter
1(inner)	2.772	1.083	1.689
2	1.557	0.684	0.874
3	0.047	0.042	0.005
4	0.040	0.032	0.008
5	0.009	0.007	0.002
6(outer)	0.008	0.005	0.003

500GeV may be OK.



1 TeV

有感層No.	Occupancy(%)		
	all	eepair	backscatter
1(inner)	19.626	5.144	14.482
2	10.446	3.141	7.305
3	0.241	0.180	0.060
4	0.204	0.148	0.056
5	0.047	0.033	0.014
6(outer)	0.046	0.029	0.017

1TeV is a problem.

→At 1 TeV, this shows that backscatter is dominant.

Occupancy (pixel size 10um)

1TeV

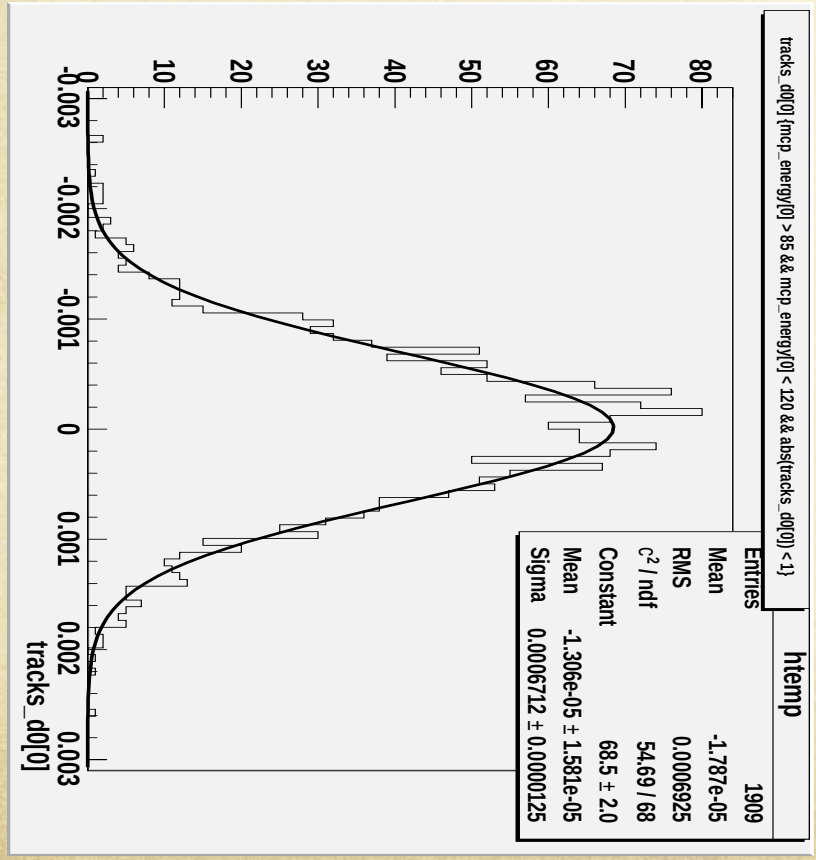
Layer No.	Occupancy(%)		
	all	eepair	backscatter
1(inner)	44.061	11.564	32.497
2	23.568	7.089	16.479
3	0.546	0.406	0.140
4	0.460	0.332	0.129
5	0.107	0.075	0.032
6(outer)	0.104	0.064	0.039

Regardless of 1TeV, layers from No3 to No6 are good. So in the perspective of occupancy, we may not need to set 5um pixel on layers from No3 to No6. 10um pixel setting makes power consumption lower than 5um pixel setting.

Estimation of "Impact Parameter Resolution" in FPCCD

The way of calculation

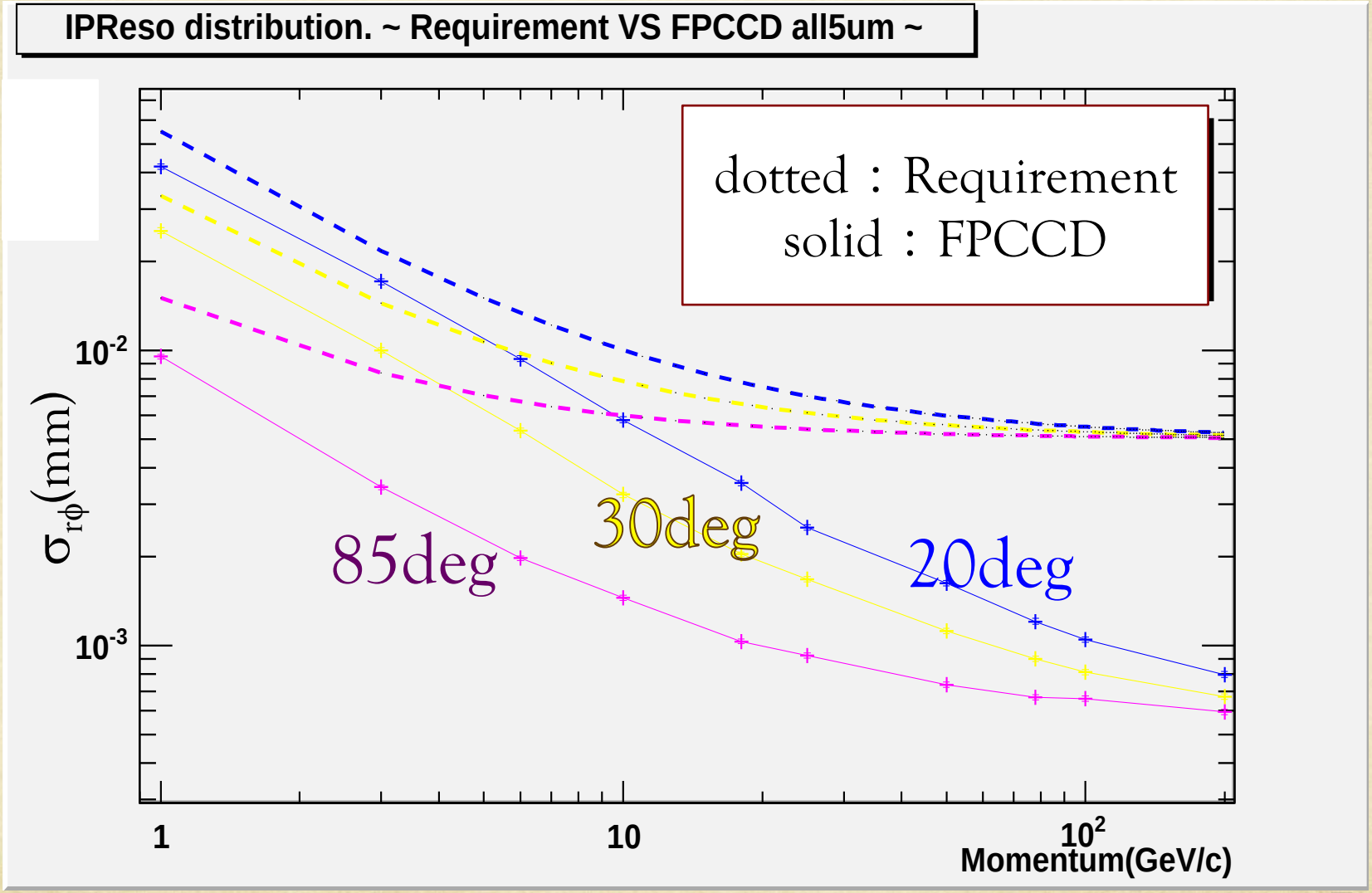
- Impact parameter, d0, of μ^+ from the center of VXD is measured. This is fitted with gaussian.



We call σ of the fitted line Impact Parameter Resolution.

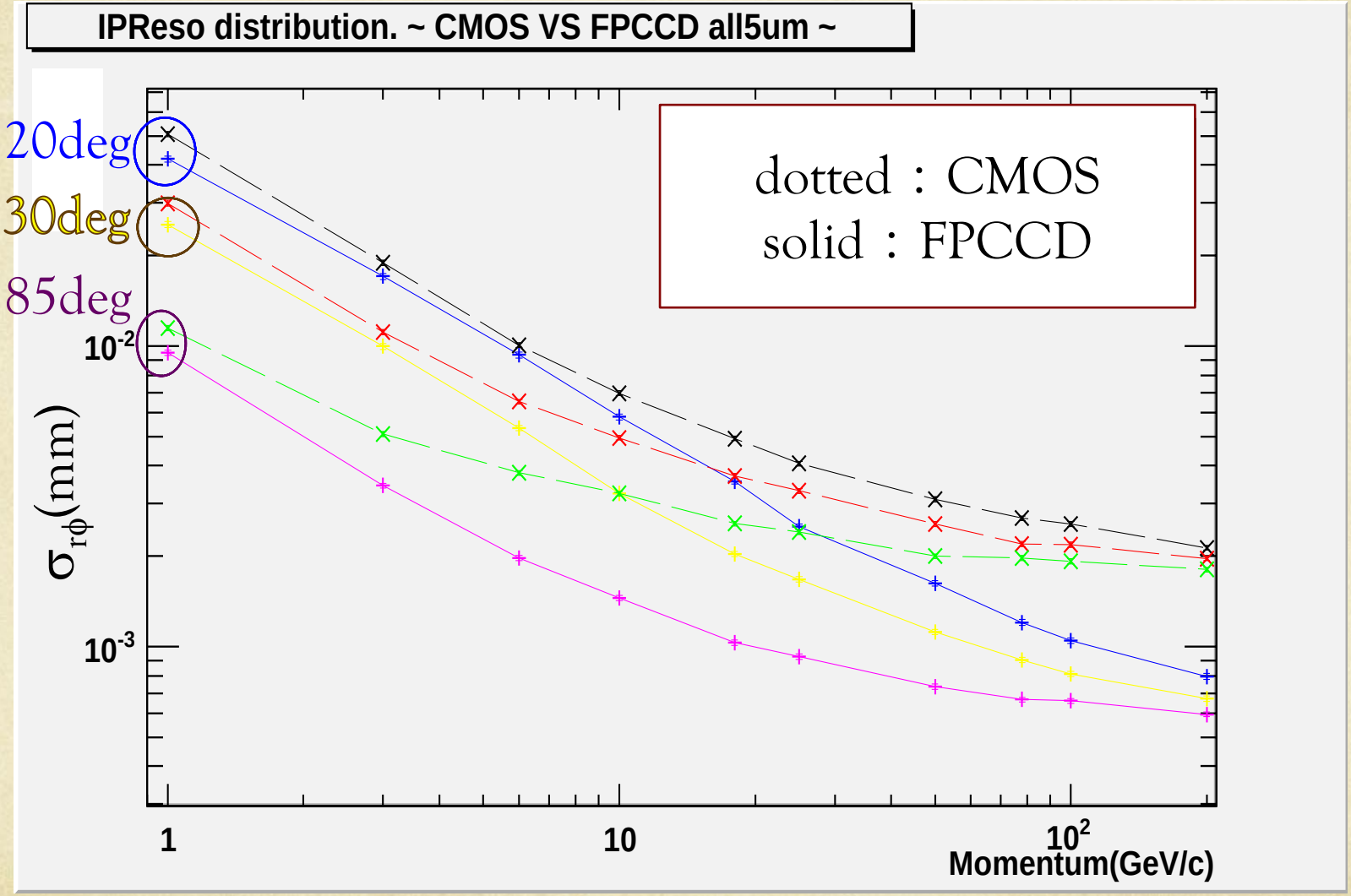
From here, this is denoted by $\sigma_{r\varphi}$

Requirement VS FPCCD



FPCCD satisfies impact parameter resolution requirement easilly.

CMOS VS FPCCD



One of strong points of FPCCD can be said to be high impact parameter resolution.

Comparison of two pixel size settings

①Occupancy on each layer

- BG data：eepair, backscatter at Ecm = 500GeV and 1TeV.
- Pixel size：
  1. 5um on all layer
  2. 10um on all layer

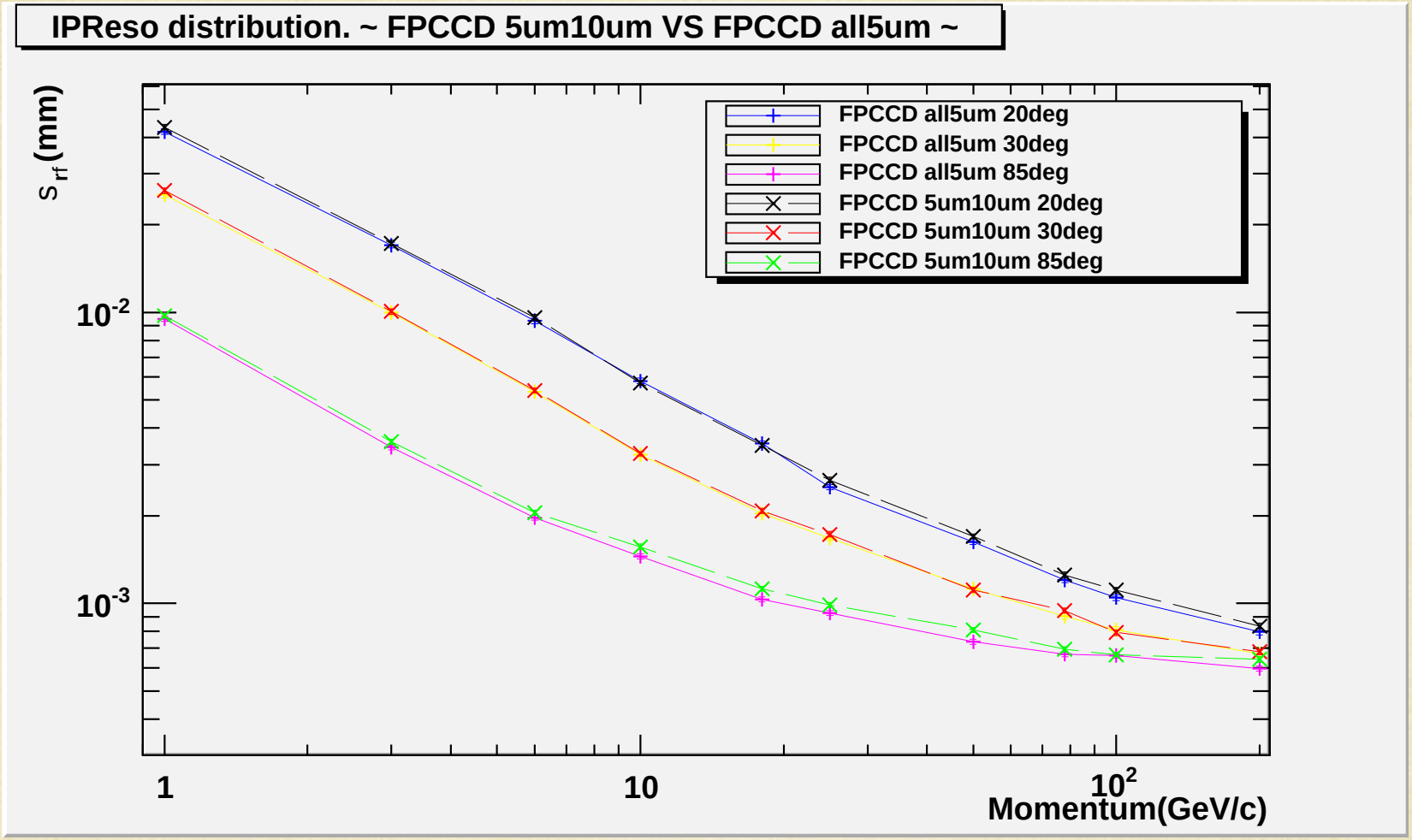
②Impact Parameter Resolution

- event：Single μ^+ from the origin of the coordinate.
- BG data：non
- Pixel size：
  1. 5um on all layer

VS

  2. 5um on innermost and 2nd innermost layer, and 10um on the others

FPCCD All5um VS 5um10um



Almost same. This shows $\sigma_{r\varphi}$ almost depends on innermost two layers.
So in the perspective of $\sigma_{r\varphi}$, we may not need to set 5um pixel on layers from No3 to No6. →power consumption lower than 5um pixel setting.

Summary and Future Plan

- Occupancy in FPCCD satisfies VXD requirement at 500GeV.
- Impact Parameter Resolution in FPCCD satisfies VXD requirement easily and is one of the strong points of FPCCD.
- From perspectives of occupancy and impact parameter resolution, setting 5um pixels on innermost and 2nd innermost layer and 10um pixels on the others doesn't become worse, and makes power consumption lower.

Future Plan:

- now I'm studying tracking efficiency in FPCCD.