



# Vertex Layout Simulation and Optimization

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IHEP

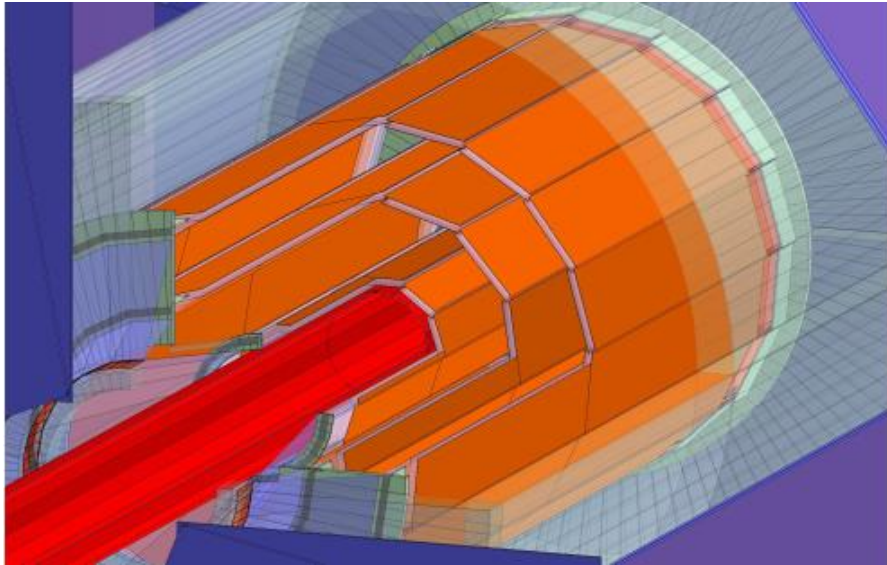
2019/11/28

# Outline

- Motivation
- Introduction of tkLayout
- Pixel geometry simulation results
- Preliminary resolution simulation results
- Plan

# Motivation

CDR vertex detector concept



+ mechanics



+ electronics



+ cooling system



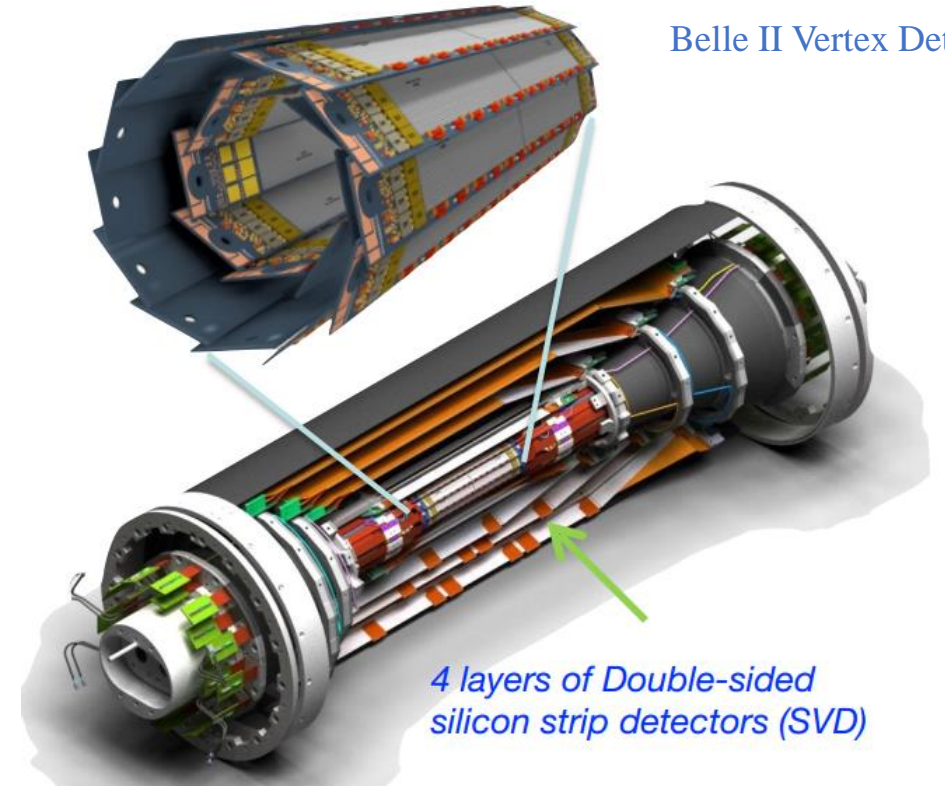
+ cable



Vertex detector prototype

2 layers of DEPFET pixel detector (PXD)

Belle II Vertex Detector



4 layers of Double-sided silicon strip detectors (SVD)

	$R$ (mm)	$ z $ (mm)	$ \cos \theta $	$\sigma$ ( $\mu\text{m}$ )
Layer 1	16	62.5	0.97	2.8
Layer 2	18	62.5	0.96	6
Layer 3	37	125.0	0.96	4
Layer 4	39	125.0	0.95	4
Layer 5	58	125.0	0.91	4
Layer 6	60	125.0	0.90	4

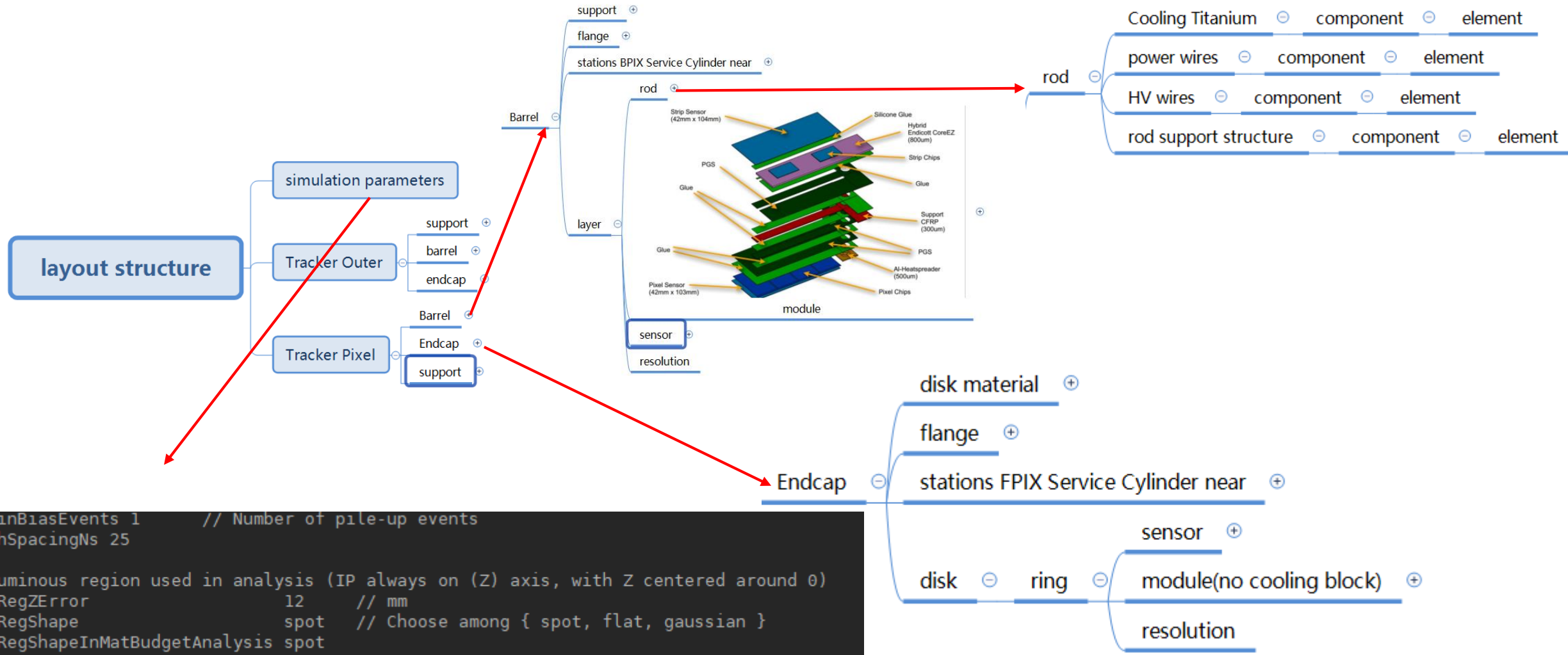
# Motivation

- Simulation tools
  - Full simulation
    - Geant4(more details, spend more time, as final simulation tool)
  - Fast simulation
    - LiC Detector Toy(LDT)(easy, fast, but less detector details, consider detector as cylindrical material layers)
    - tkLayout(fast, include more detector details)

tkLayout is what we really need!

# Introduction of tkLayout

- Layout Configuration Structure



# Introduction of tkLayout

- Output webpage:

OT\_V4\_100\_IT\_V4\_0\_0\_0  
layouts

info geometry **geometry (pixel)** bandwidth trigger cpus irradiation (outer) irradiation (pixels) material (outer) material (pixel) material (total) weights (outer) weights (pixel) resolution (pixel) resolution (tracker)  
resolution (trigger) patternreco trigger **log page**

### layers and disks

Barrel : PXB1							Total
Layer	1	2	3	4	5	6	
r	16.004	18.004	37.003	38.995	57.989	59.995	
z_max	62.500	62.500	125.000	125.000	125.000	125.000	
# rods	10	10	11	11	17	17	
# mods	40	40	88	88	136	136	528

Endcap : Total  
Disk  
z  
# rings  
# mods 0

### endcaps : additional info

### modules

### plots

layer coverage (hit)  
layer coverage (1 stub <-> (>= 2 hits))  
layer coverage (1 stub <-> (>= 3 hits))

# Introduction of tkLayout

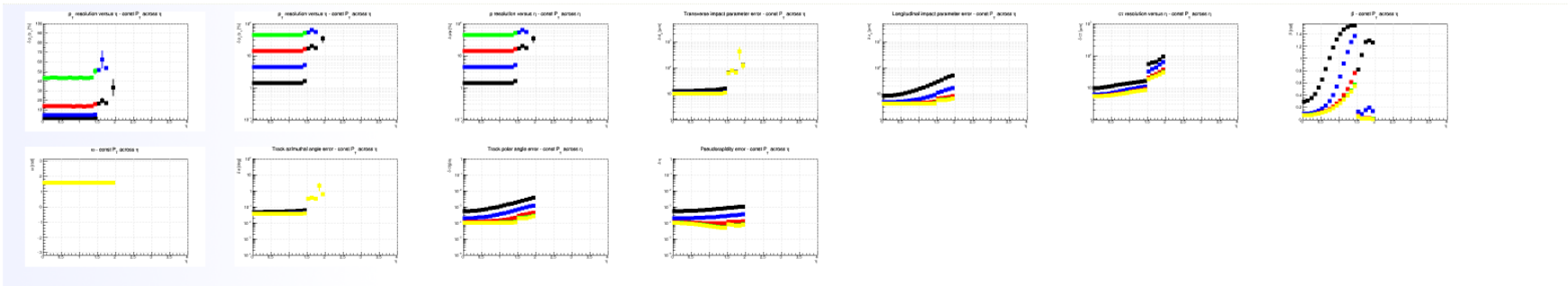
- Output webpage:

OT\_V4\_100\_IT\_V4\_0\_0\_0  
layouts

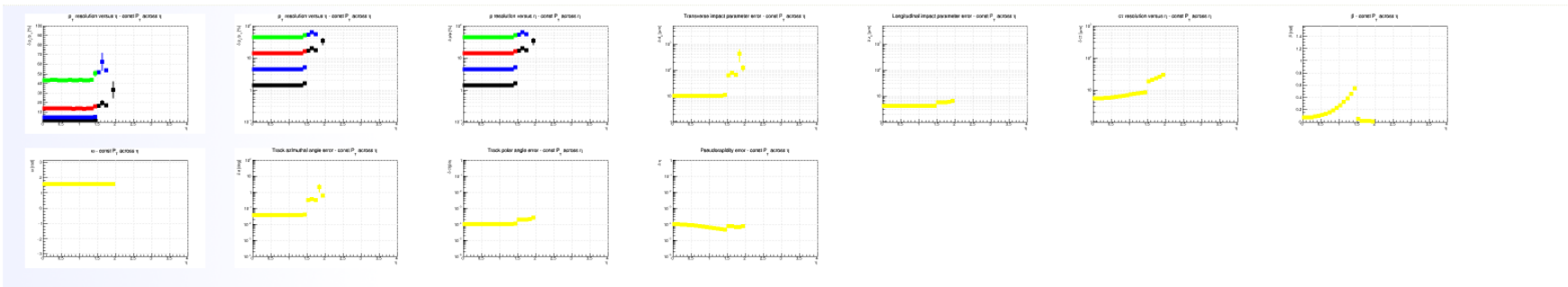
info geometry geometry (pixel) bandwidth trigger cpus irradiation (outer) irradiation (pixels) material (outer) material (pixel) material (total) weights (outer) weights (pixel) resolution (pixel) resolution (tracker)

resolution (trigger) patternreco trigger **log page**

track resolution for const pt across  $\eta$  (material)



track resolution for const pt across  $\eta$  (no material)



track resolution for const p across  $\eta$  (material)

track resolution for const p across  $\eta$  (no material)

summary - const pt across  $\eta$

Region: C | F VF VV  
Min n: 0.001 0.8 1.6 2.4 3.2

# Introduction of tkLayout

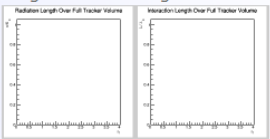
- Output webpage:

OT\_V4\_100\_IT\_V4\_0\_0\_0  
layouts

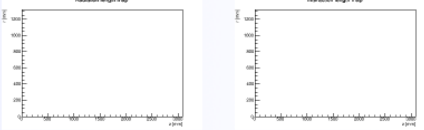
info geometry geometry (pixel) bandwidth trigger cpus irradiation (outer) irradiation (pixels) material (outer) **material (pixel)** material (total) weights (outer) weights (pixel) resolution (pixel) resolution (tracker)  
resolution (trigger) patternreco trigger **log page**

overview (full volume)

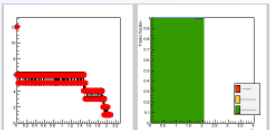
Average radiation length in full volume (eta = [0, 4.0]) 0.00000  
Average interaction length in full volume (eta = [0, 4.0]) 0.00000  
Bill of materials: [materials\\_pixel.csv](#)



categories details (full volume)  
components details (full volume)  
services details (full volume)  
1d overview (tracking volume)  
components details (tracking volume)  
services details (tracking volume)  
material distribution



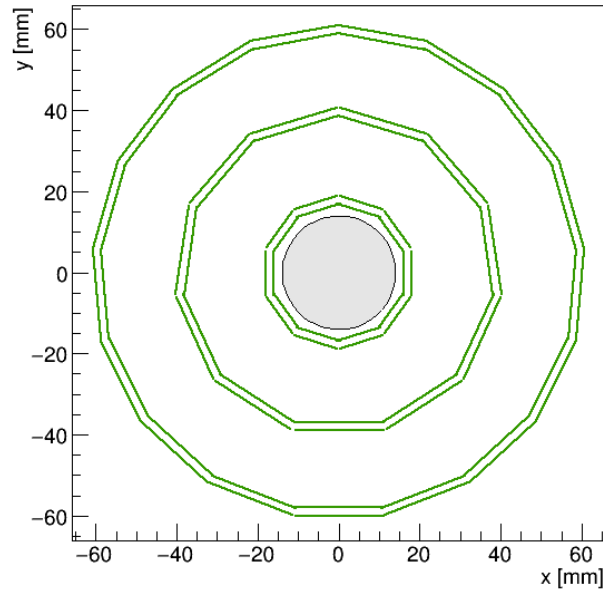
nuclear interactions



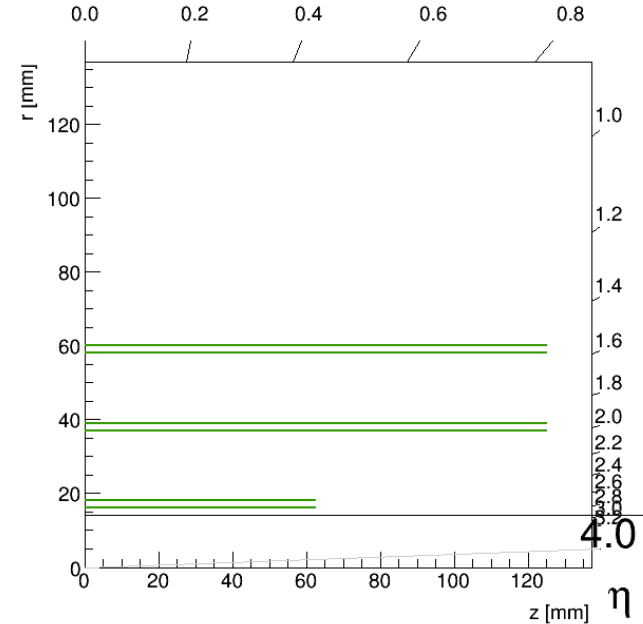


# Pixel geometry simulation results

- CDR vertex detector geometry



XY Section of the tracker barrel. - ([png](#)) - ([pdf](#)) - ([root](#))



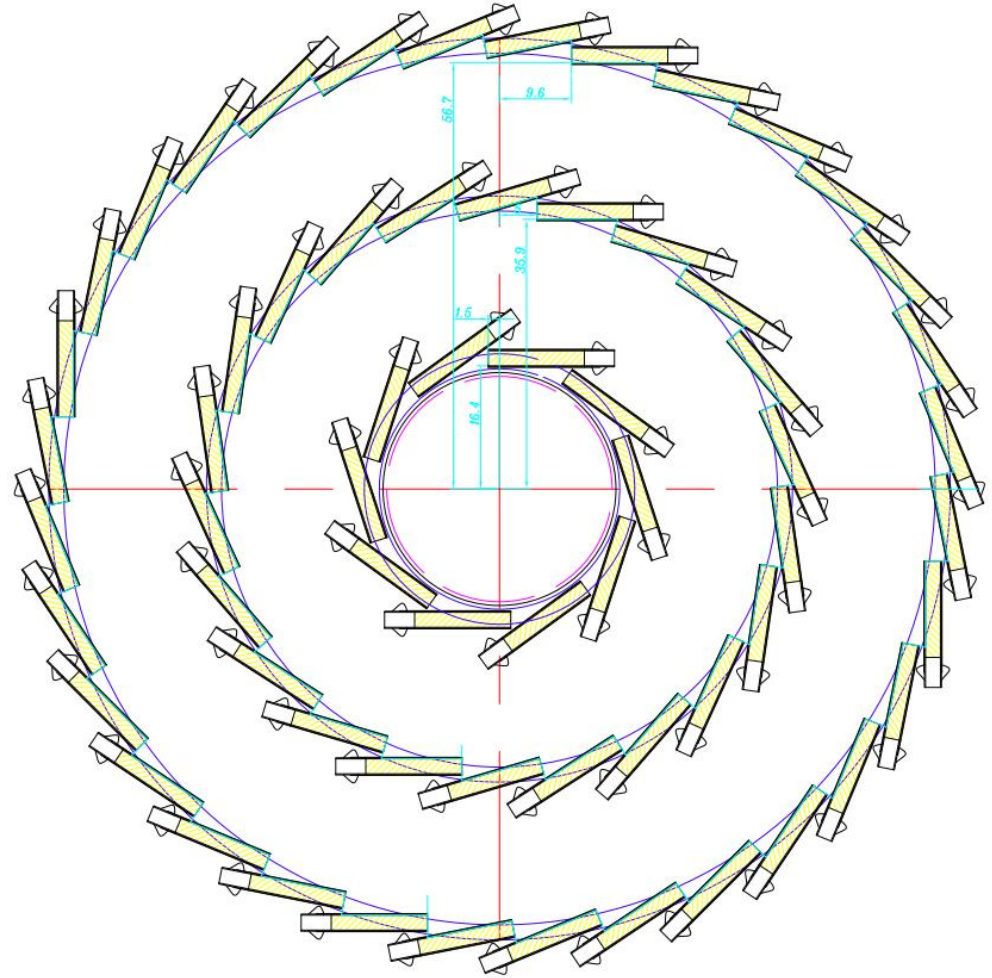
RZ positions of the barrel modules. - ([png](#)) - ([pdf](#)) - ([root](#))

	R(mm)	module width(mm)	numRods	phioverlap
Layer 1	16	11	10	0.60257
Layer 2	18	11	10	-0.69711
Layer 3	37	22	11	0.27164
Layer 4	39	22	11	-0.90287
Layer 5	58	22	17	0.315842
Layer 6	60	22	17	-0.43189

	$R$ (mm)	$ z $ (mm)	$ \cos \theta $	$\sigma$ ( $\mu\text{m}$ )
Layer 1	16	62.5	0.97	2.8
Layer 2	18	62.5	0.96	6
Layer 3	37	125.0	0.96	4
Layer 4	39	125.0	0.95	4
Layer 5	58	125.0	0.91	4
Layer 6	60	125.0	0.90	4

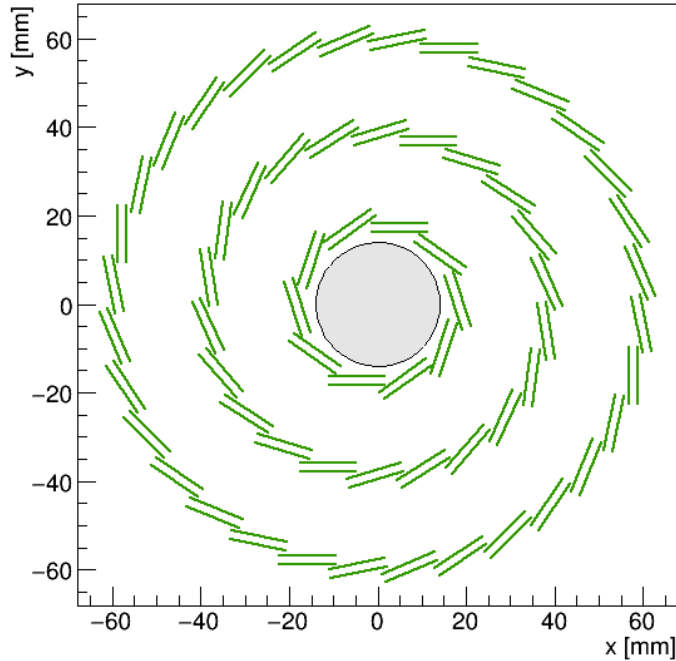
# Pixel geometry simulation results

- Prototype V1 design:
  - Come from Fu Jinyu
  - three layers with double-sided ladder
  - Only need to rotate one ladder around Z axis at a fixed angle to cover the whole barrel
  - Sensors are on both sides of the yellow slash region



# Pixel geometry simulation results

- Prototype V1 geometry

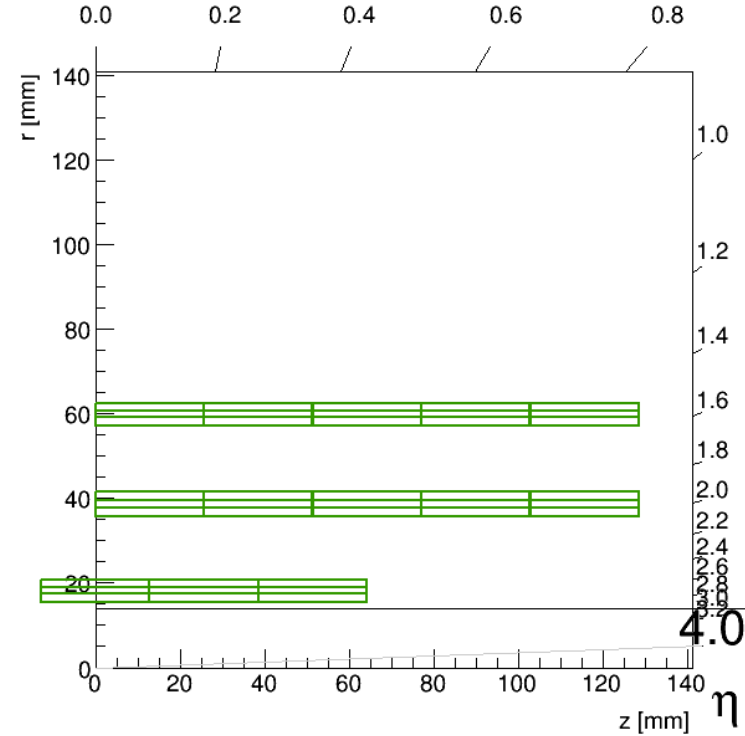


XY Section of the tracker barrel. - (png) - (pdf) - (root)

	numRods	R(mm)	skewAngle(rad)	module width(mm)
Layer 1	10	17.11637	0.290338	12.8
Layer 2	10	19.04127	0.260264	12.8
Layer 3	22	37.66656	0.307478	12.8
Layer 4	22	39.57739	0.292183	12.8
Layer 5	32	58.91426	0.275036	12.8
Layer 6	32	60.84152	0.266108	12.8

Calculated value

Skewed layer



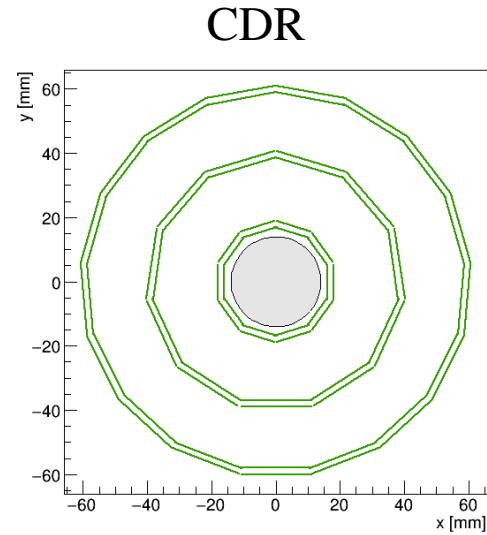
RZ positions of the barrel modules. - (png) - (pdf) - (root)

Barrel : PXB1							Total
Layer	1	2	3	4	5	6	
r	17.116	19.041	37.667	39.577	58.914	60.842	
z_max	64.200	64.200	128.450	128.450	128.450	128.450	
# rods	10	10	22	22	32	32	
# mods	50	50	220	220	320	320	1180

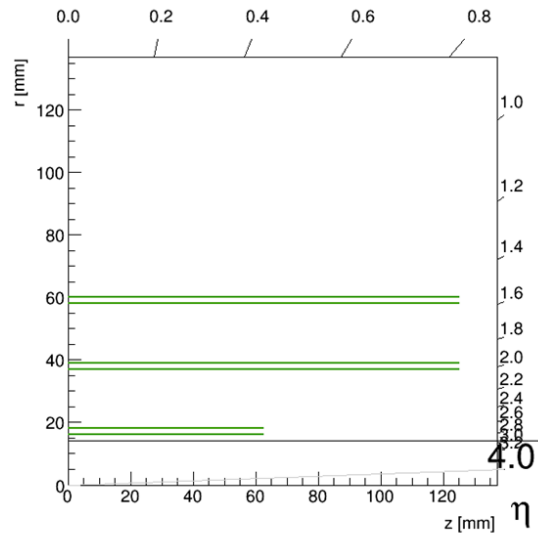
Output value of tkLayout

# Pixel geometry simulation results

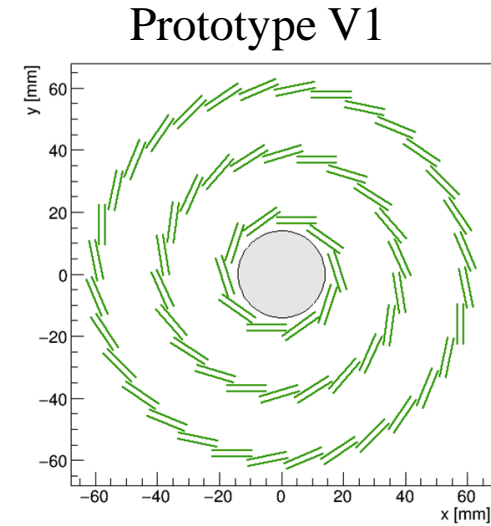
- Comparison



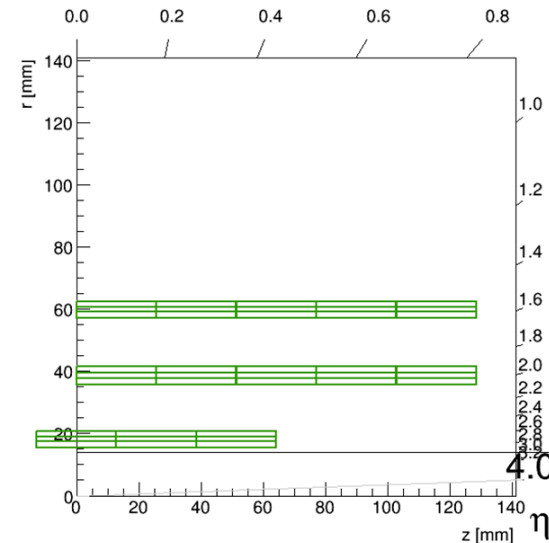
XY Section of the tracker barrel. - (png) - (pdf) - (root)



RZ positions of the barrel modules. - (png) - (pdf) - (root)



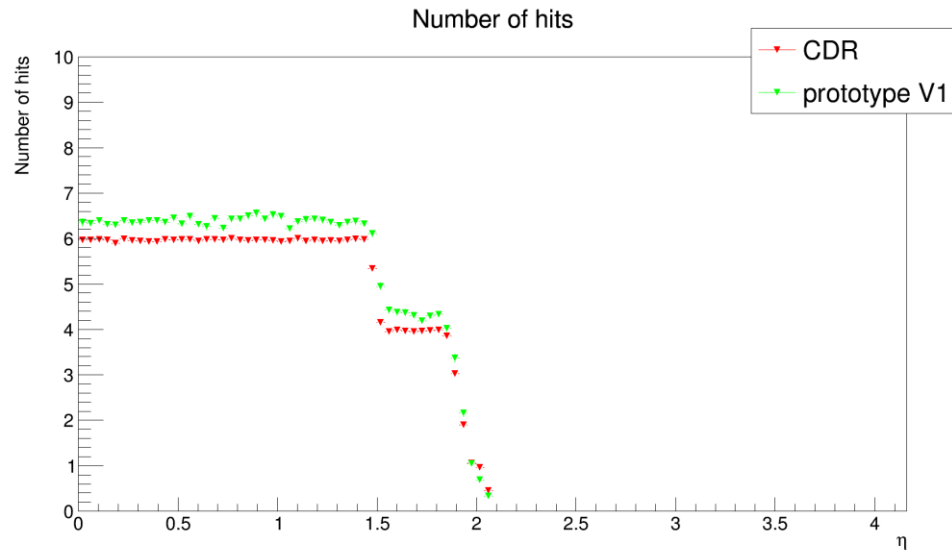
XY Section of the tracker barrel. - (png) - (pdf) - (root)



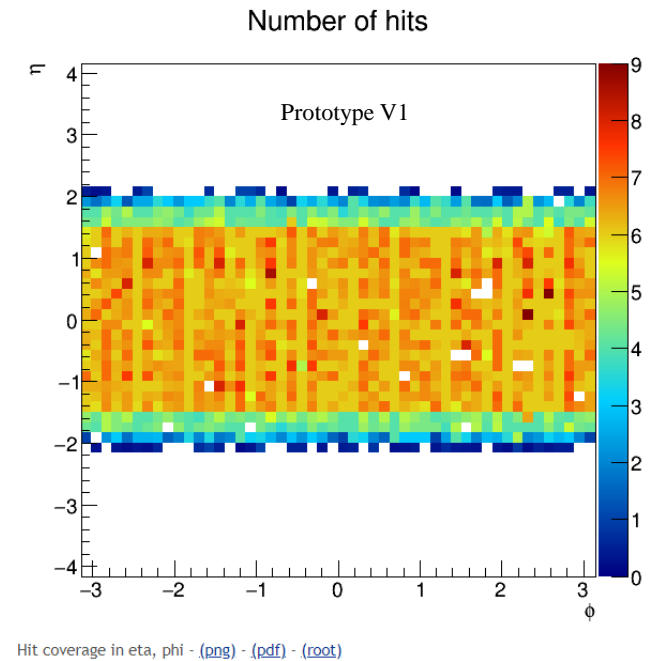
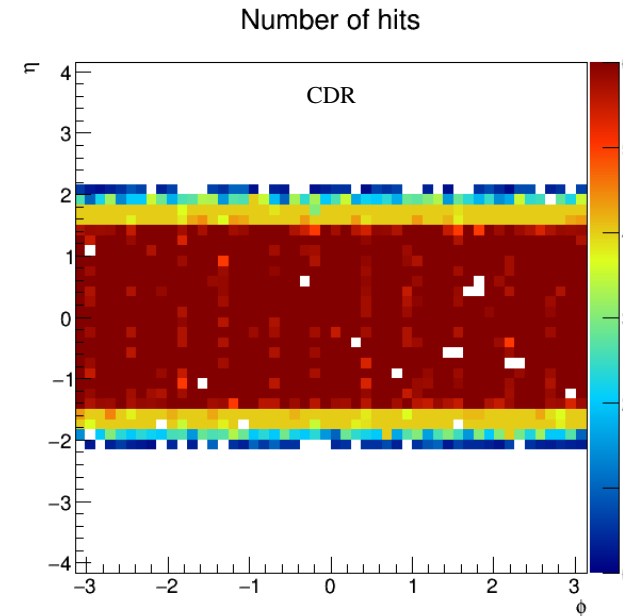
RZ positions of the barrel modules. - (png) - (pdf) - (root)

# Pixel geometry simulation results

- Hit coverage

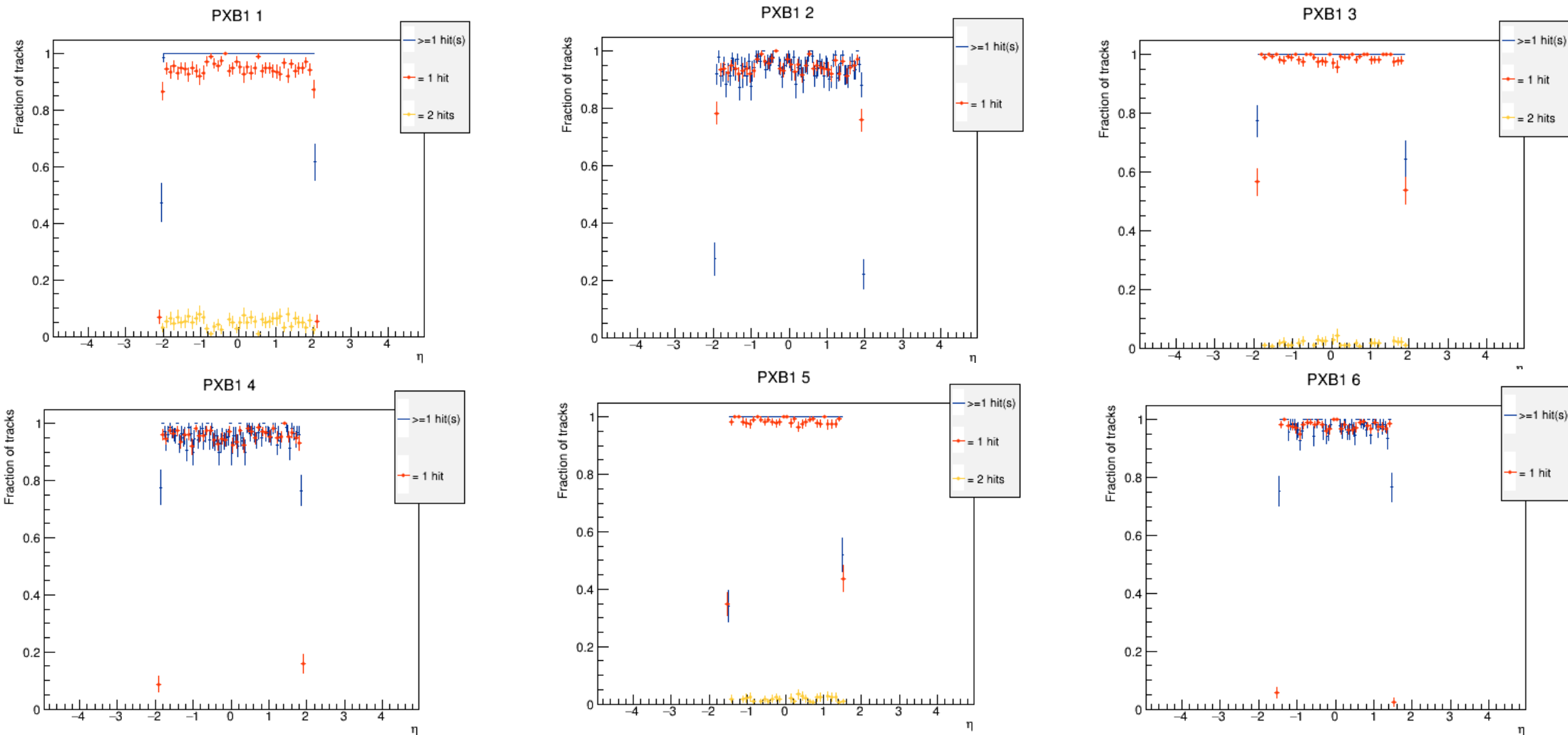


	$R$ (mm)	$ z $ (mm)	$ \cos\theta $	$\sigma$ ( $\mu\text{m}$ )	$\eta$
Layer 1	16	62.5	0.97	2.8	2.09
Layer 2	18	62.5	0.96	6	1.95
Layer 3	37	125.0	0.96	4	1.95
Layer 4	39	125.0	0.95	4	1.83
Layer 5	58	125.0	0.91	4	1.53
Layer 6	60	125.0	0.90	4	1.47



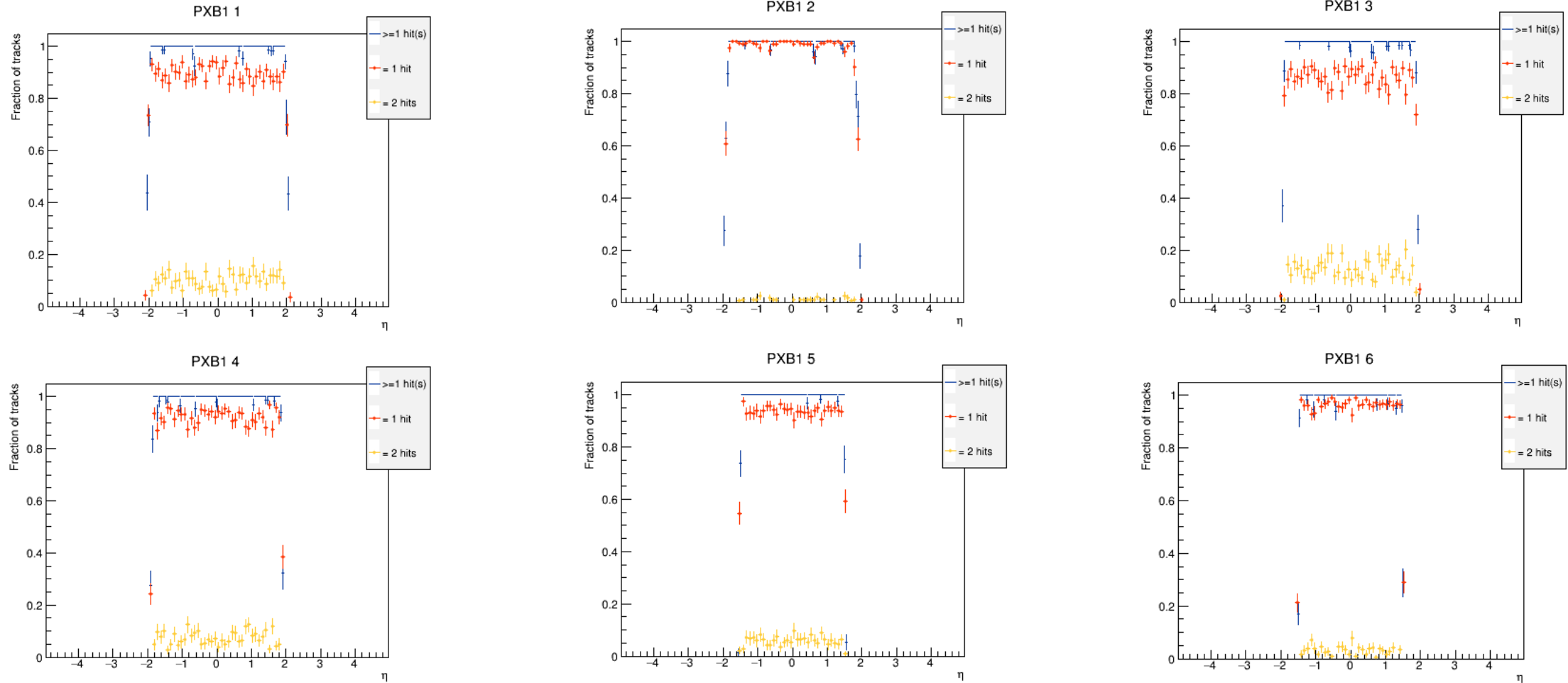
# Pixel geometry simulation results

- Layer coverage(CDR)



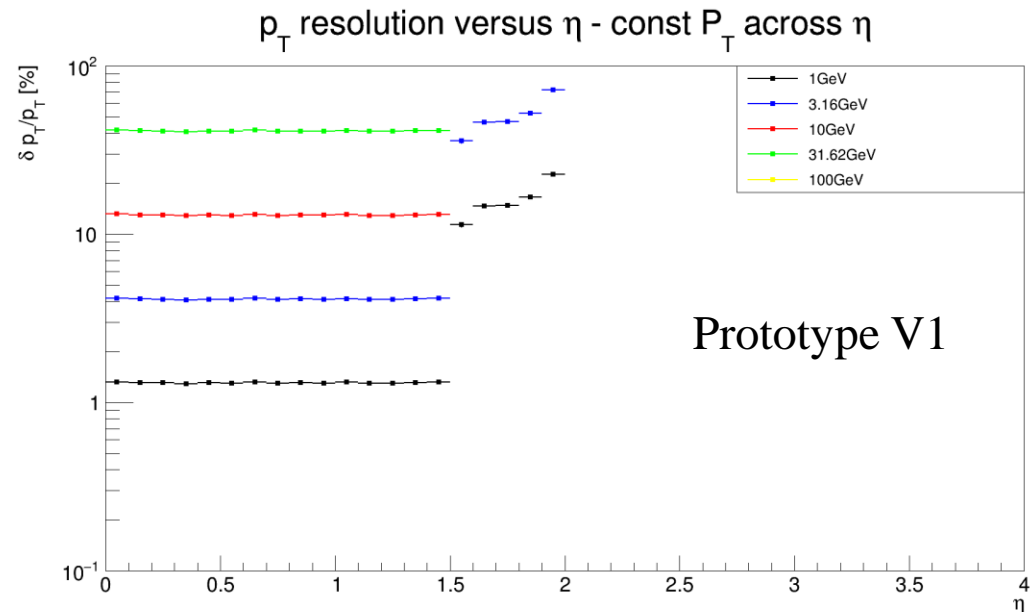
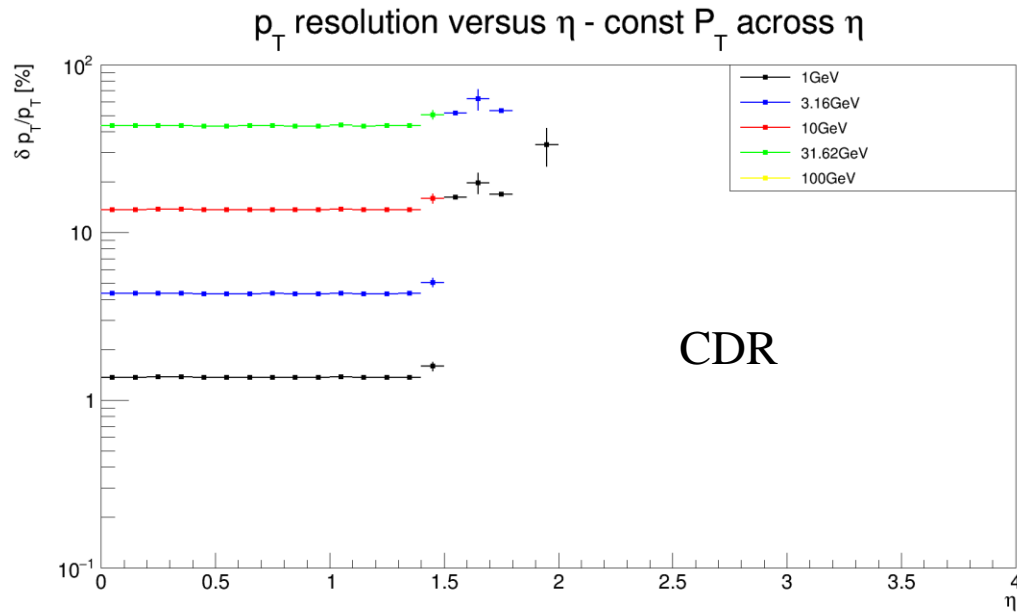
# Pixel geometry simulation results

- Layer coverage(prototype V1)



# Preliminary resolution simulation results

- Pt resolution(no material)



$$\sigma_{1/p_T} = a \oplus \frac{b}{p \sin^{3/2} \theta}$$

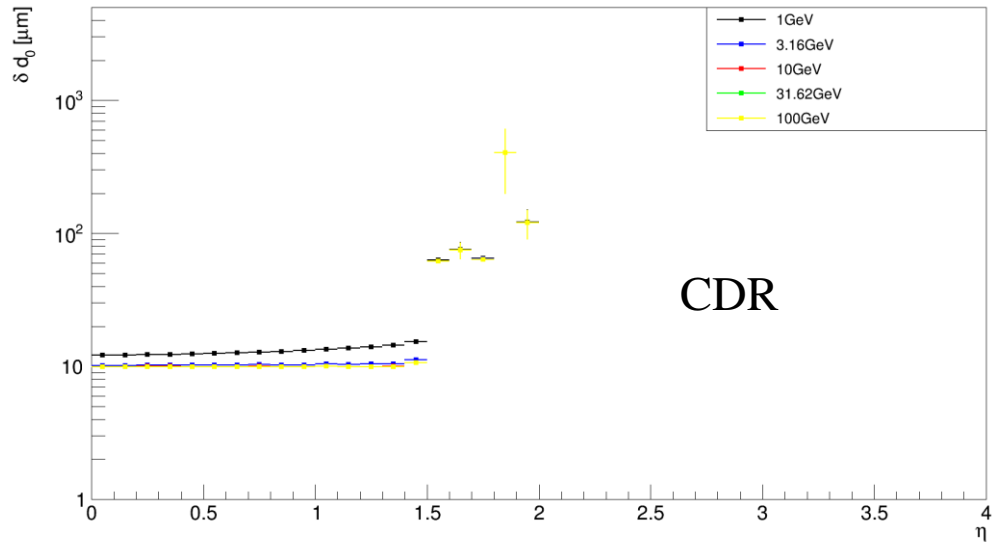
No material,  $\delta Pt/Pt$  will be constant.



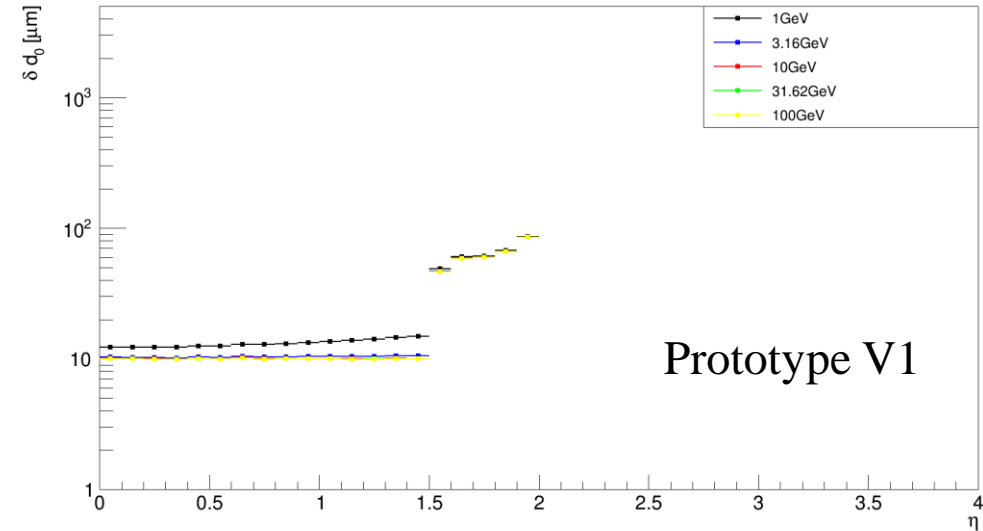
# Preliminary resolution simulation results

- Impact parameter resolution(no material)

Transverse impact parameter error - const  $P_T$  across  $\eta$

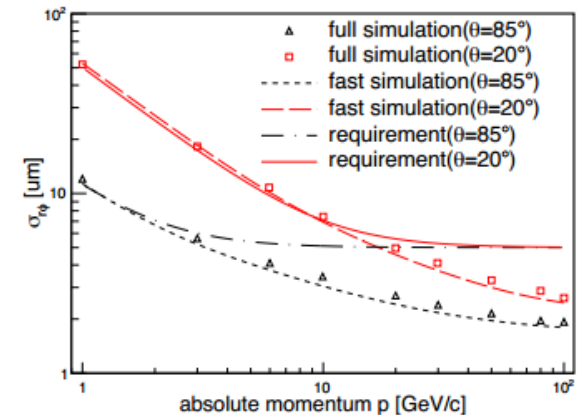


Transverse impact parameter error - const  $P_T$  across  $\eta$



pixel resolution is 4um for every layer  
but the result is inconsistent with the  
result in CDR.

$$\sigma_{r\phi} = a \oplus \frac{b}{p(\text{GeV}) \sin^{3/2} \theta}$$



# Plan

- Fix the impact parameter resolution problem
- Add material into prototype V1 layout
- Once all configurations validated, the final results only takes a few minutes
- Compare more different layouts

Thank you!