Vertex Layout Simulation and Optimization
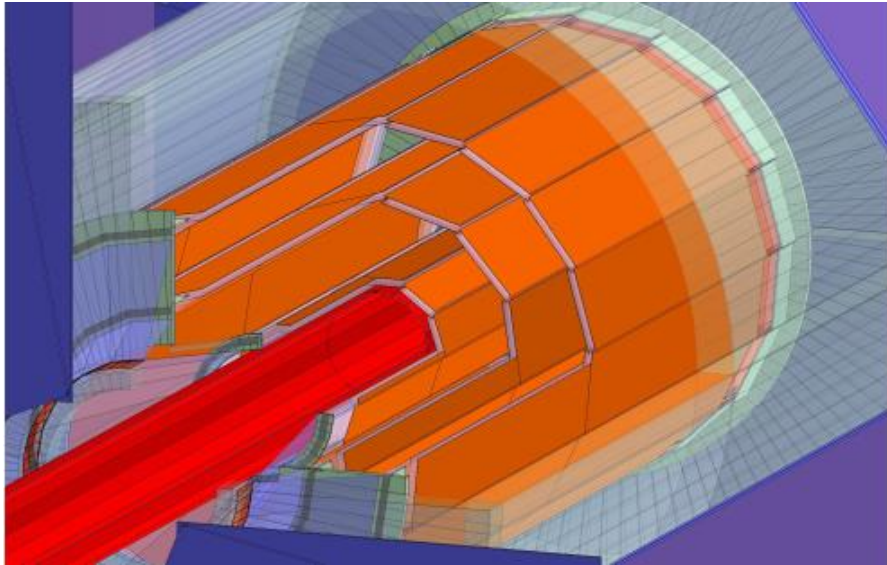
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IHEP

2019/11/28

Outline

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

Motivation

CDR vertex detector concept

Vertex detector prototype

+ mechanics

+ electronics

+ cooling system

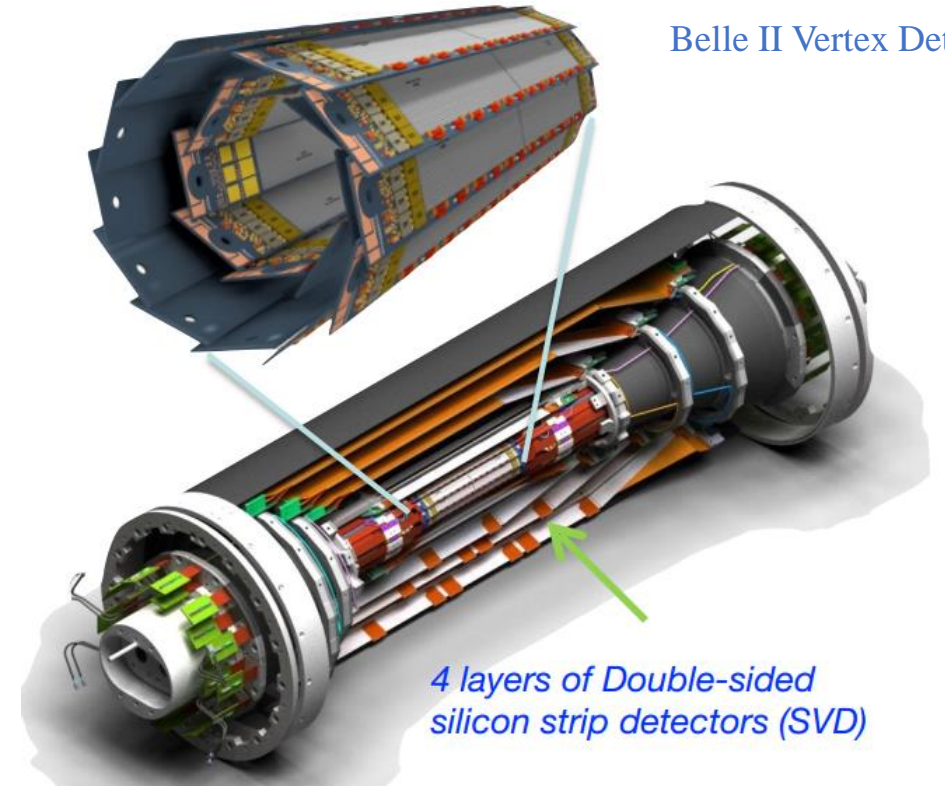+ cable

2 layers of DEPFET pixel detector (PXD)

Belle II Vertex Detector

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

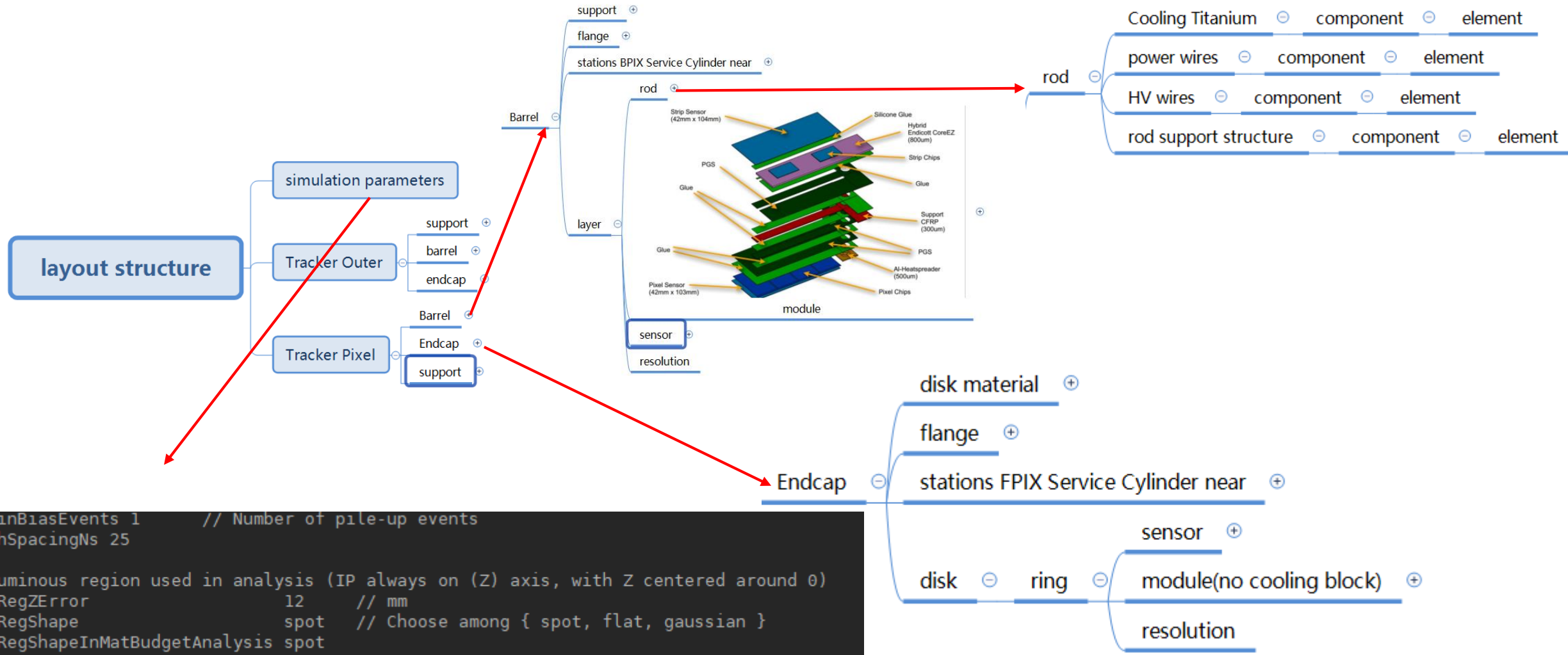|	R (mm)	$|z|$ (mm)	$|\cos\theta|$	σ (μm)
Layer 1	16	62.5	0.97	2.8
Layer 2	18	62.5	0.96	6
Layer 3	37	125.0	0.96	4
Layer 4	39	125.0	0.95	4
Layer 5	58	125.0	0.91	4
Layer 6	60	125.0	0.90	4

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:

Introduction of tkLayout

- Output webpage:

Introduction of tkLayout

- Output webpage:

Pixel geometry simulation results

- CDR vertex detector geometry
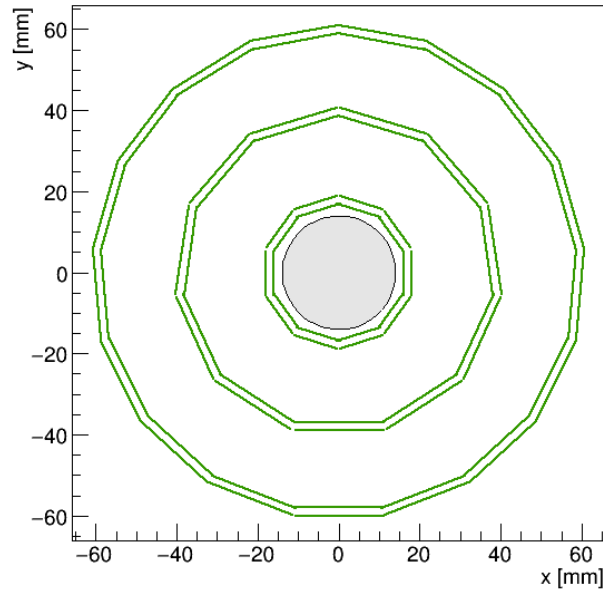
XY Section of the tracker barrel. - (png) - (pdf) - (root)
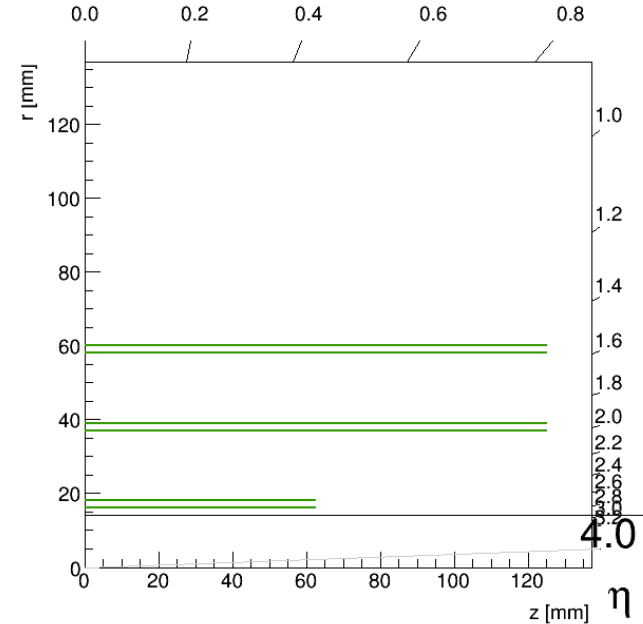
RZ positions of the barrel modules. - (png) - (pdf) - (root)

	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)	$|\cos\theta|$	σ (μm)
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
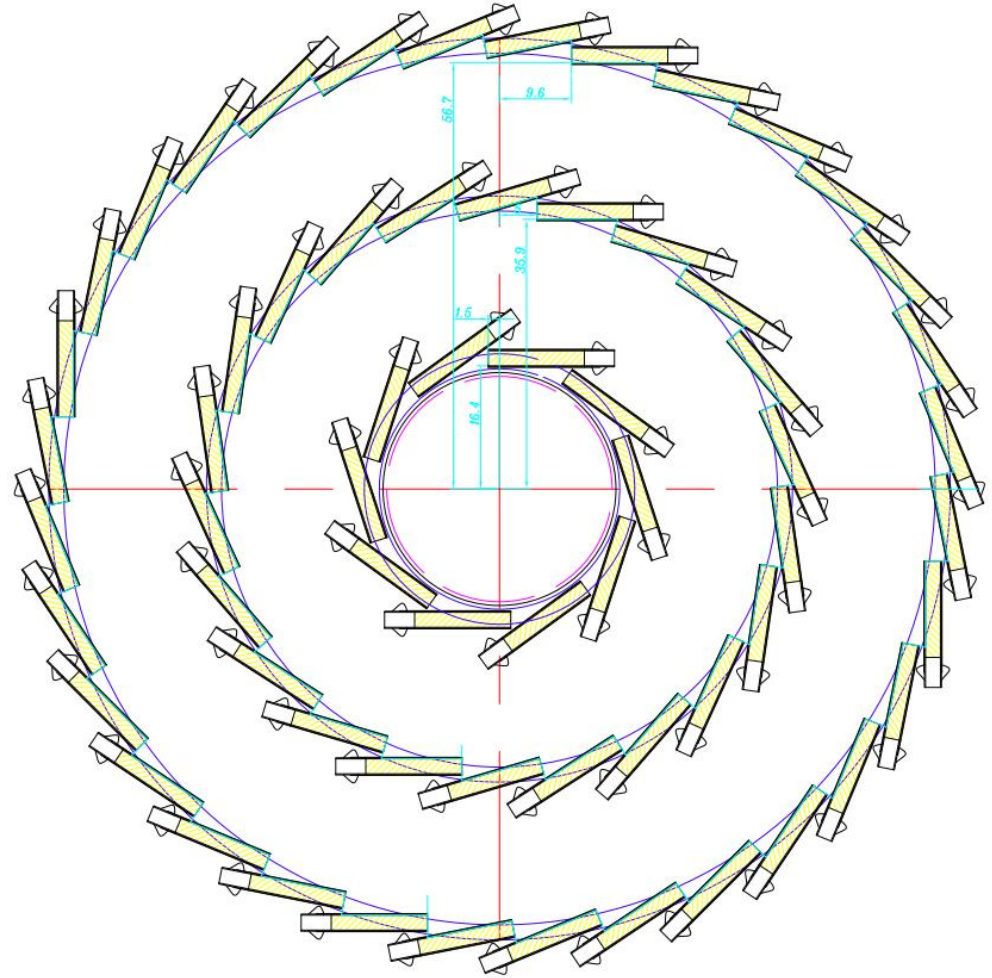
Pixel geometry simulation results

- Prototype V1 geomety

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

Skewed layer

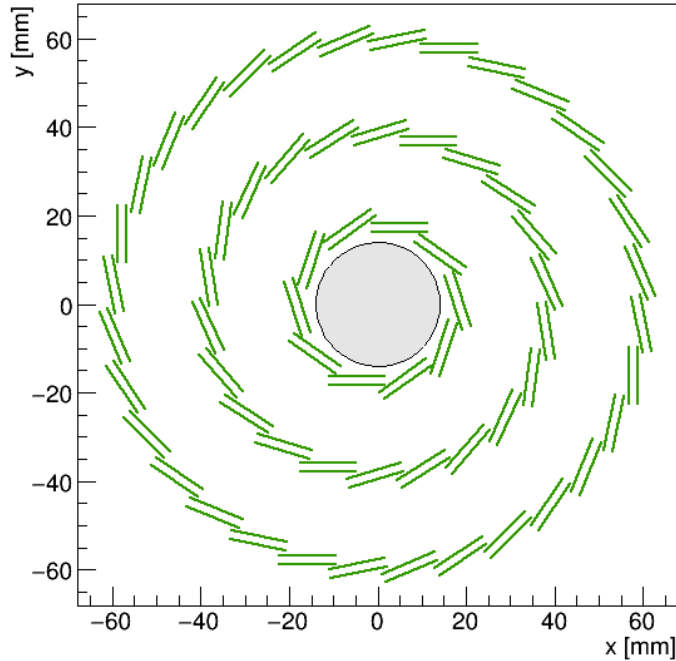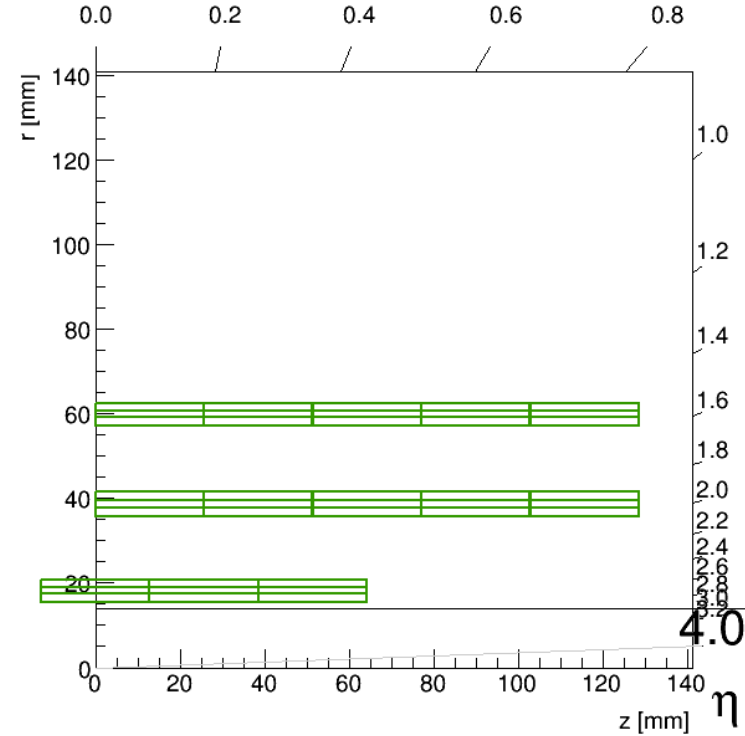RZ positions of the barrel modules. - (png) - (pdf) - (root)

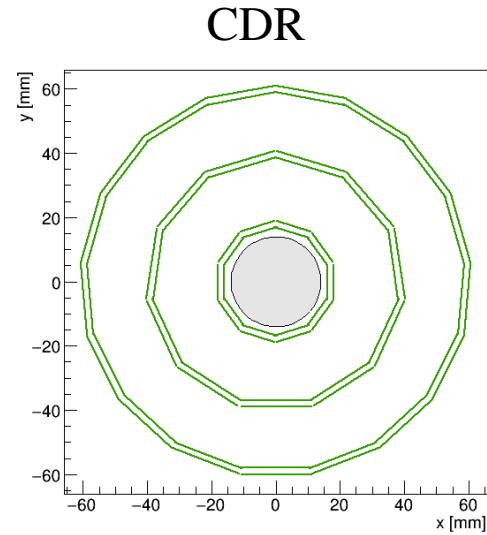|	numRods	R(mm)	skewAngle(rad)	module width(mm)
Layer 1	10	17.11637	0.290338	12.8
Layer 2	10	19.04127	0.260264	12.8
Layer 3	22	37.66656	0.307478	12.8
Layer 4	22	39.57739	0.292183	12.8
Layer 5	32	58.91426	0.275036	12.8
Layer 6	32	60.84152	0.266108	12.8

Calculated value

Barrel : PXB1

Layer	1	2	3	4	5	6	Total
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

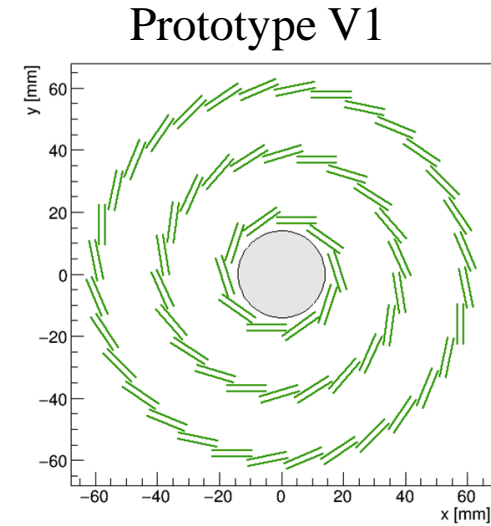Output value of tkLayout
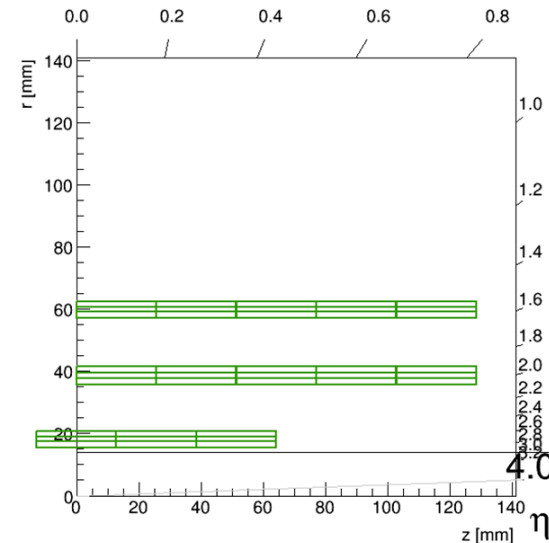
Pixel geometry simulation results

- Comparison

CDR

Prototype V1

Pixel geometry simulation results

- Hit coverage
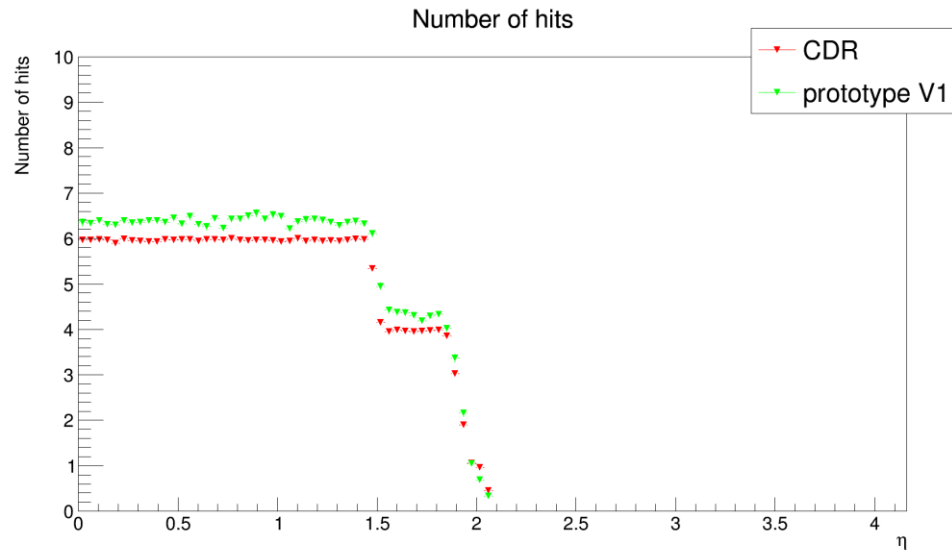
	R (mm)	$|z|$ (mm)	$|\cos\theta|$	$\sigma\,(\mu m)$	η
Layer 1	16	62.5	0.97	2.8	2.09
Layer 2	18	62.5	0.96	6	1.95
Layer 3	37	125.0	0.96	4	1.95
Layer 4	39	125.0	0.95	4	1.83
Layer 5	58	125.0	0.91	4	1.53
Layer 6	60	125.0	0.90	4	1.47

Hit coverage in eta, phi - (png) - (pdf) - (root)

Hit coverage in eta, phi - (png) - (pdf) - (root)
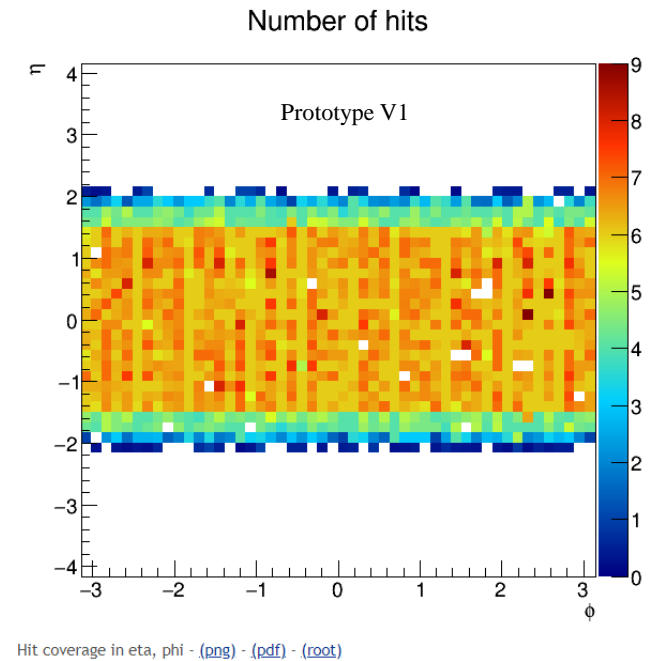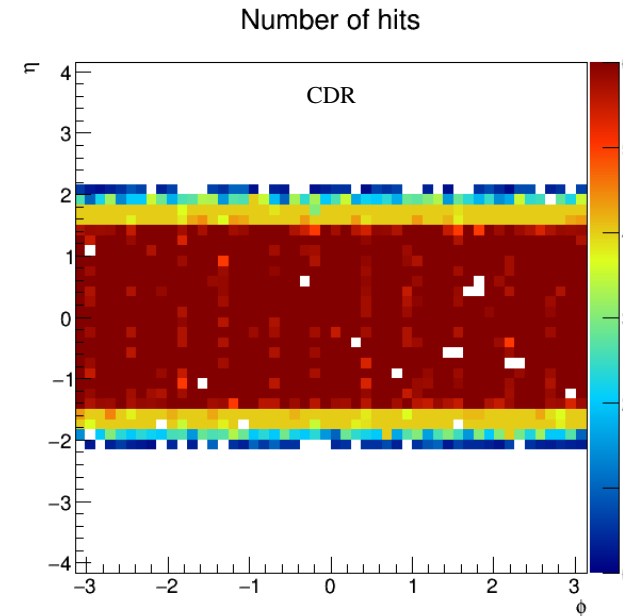
Pixel geometry simulation results
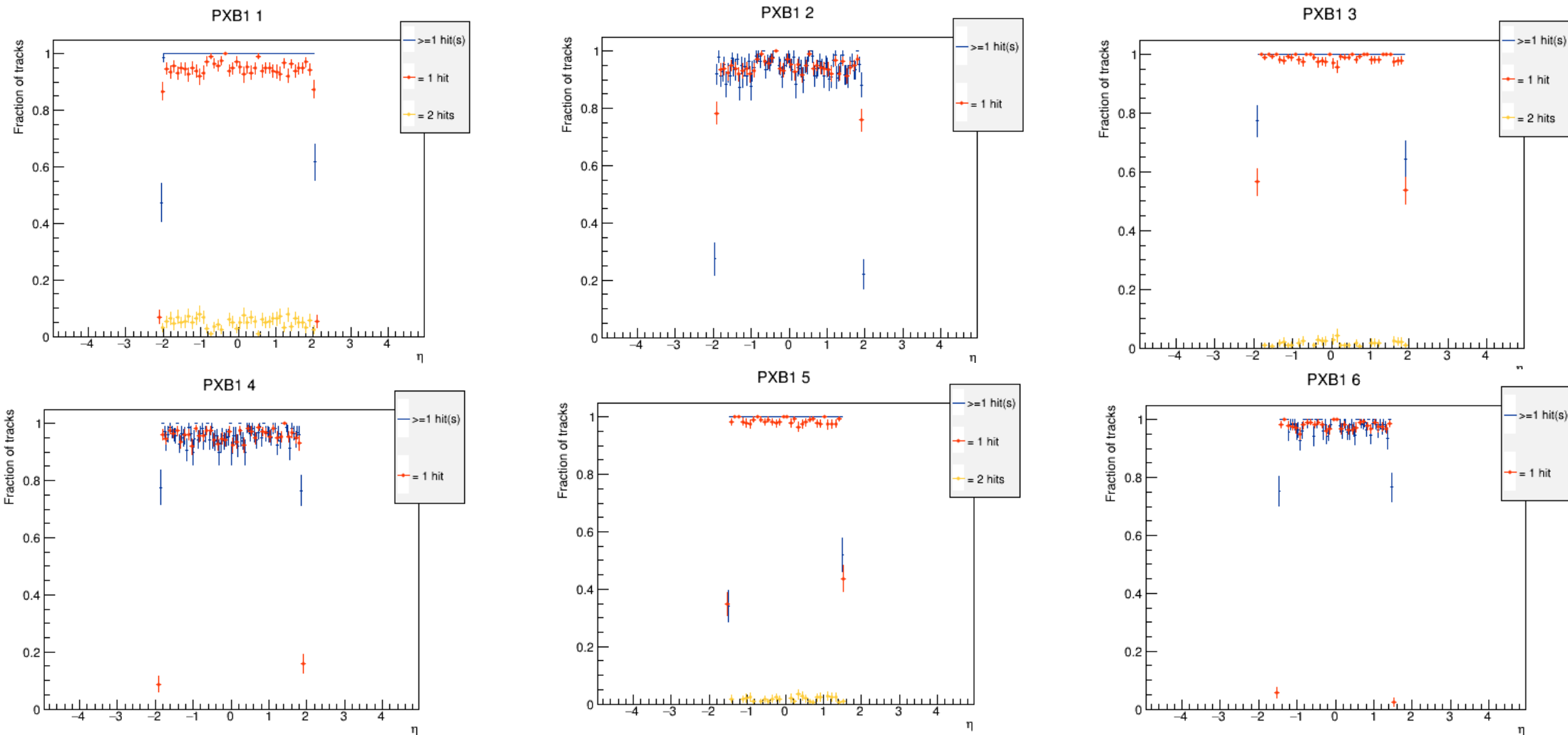
- Layer coverage(CDR)

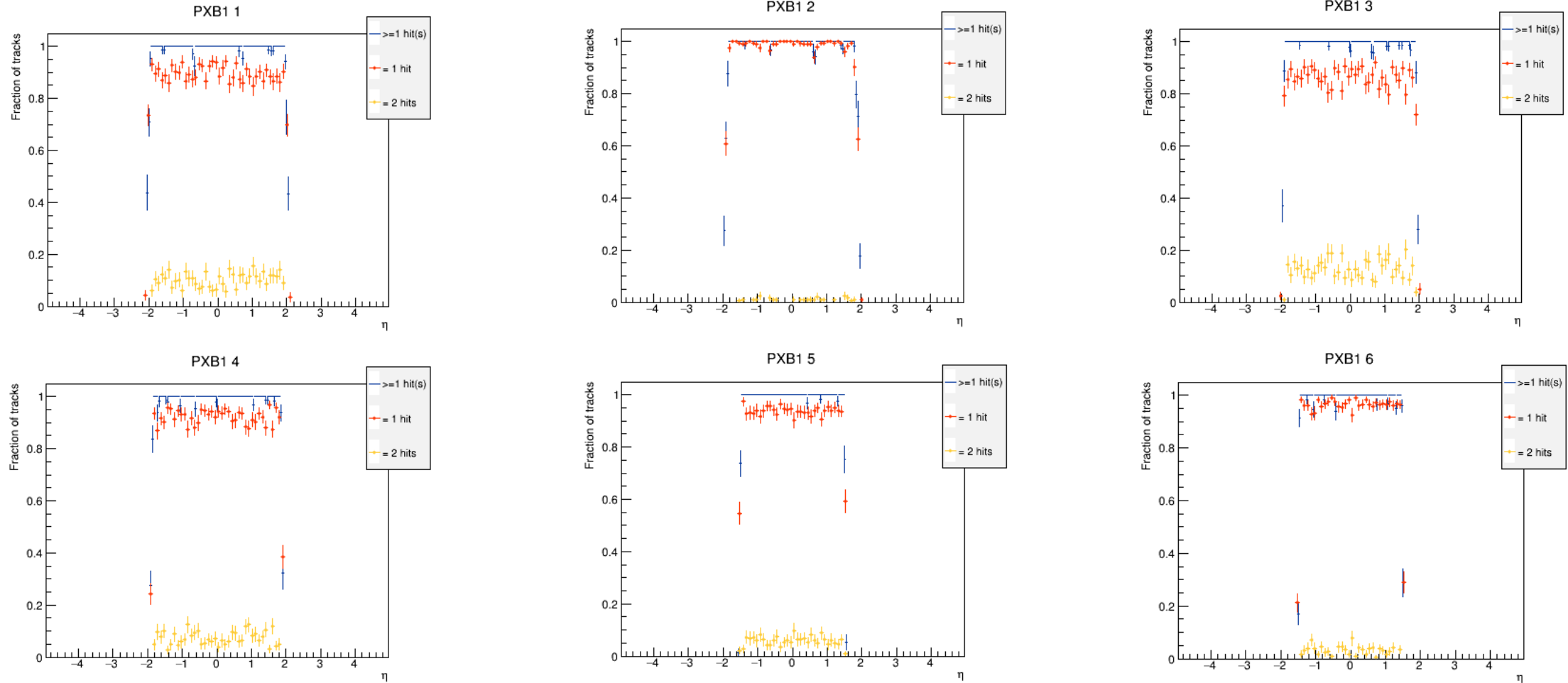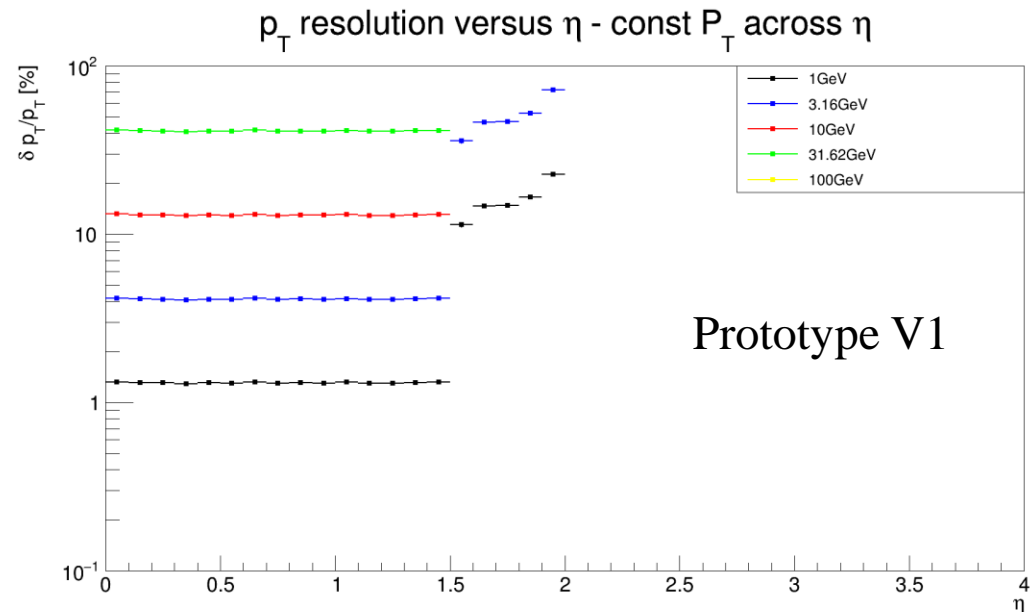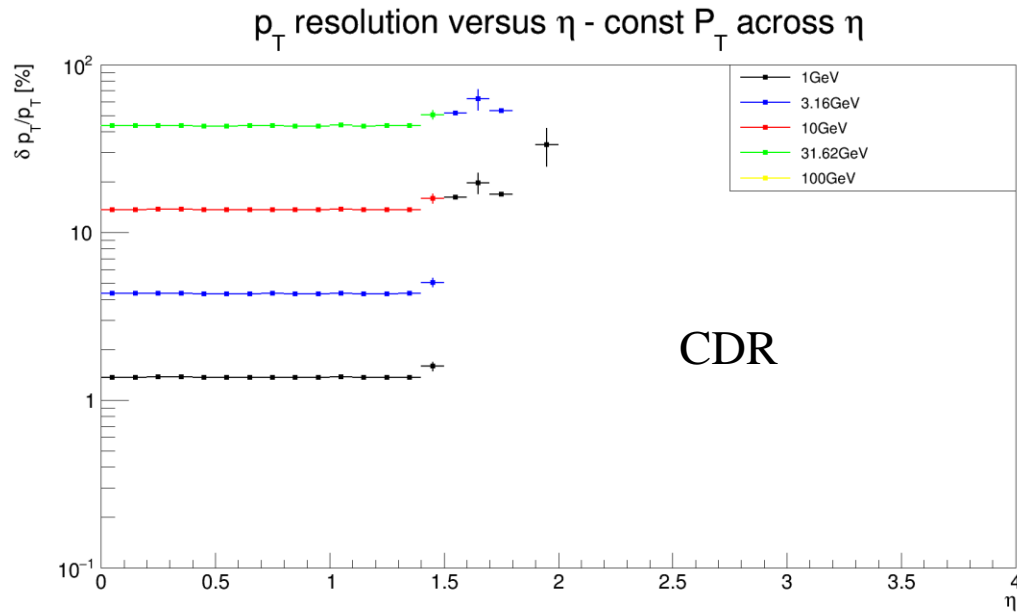# Pixel geometry simulation results

- Layer coverage(prototype V1)

Preliminary resolution simulation results

- Pt resolution(no material)

p_T resolution versus η - const P_T across η

CDR

p_T resolution versus η - const P_T across η

Prototype V1

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

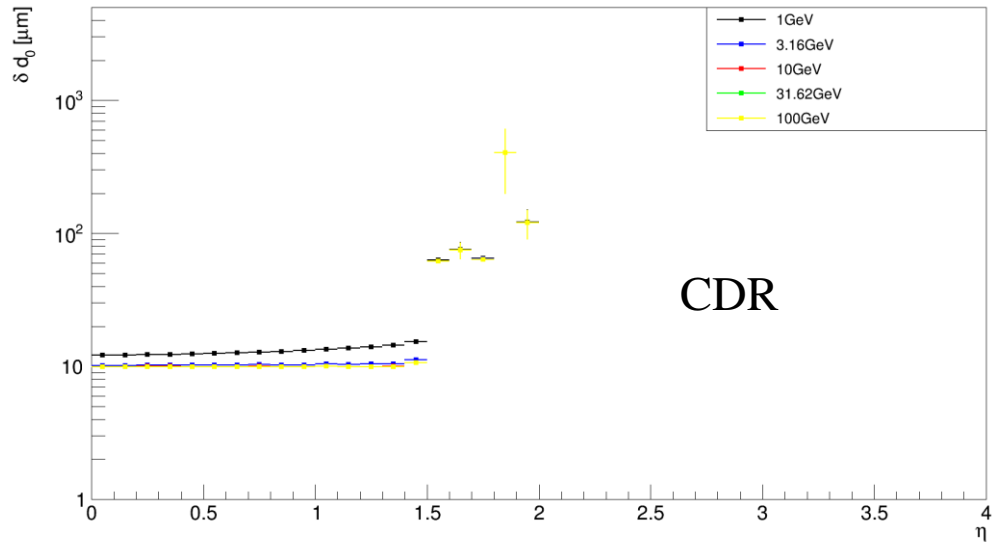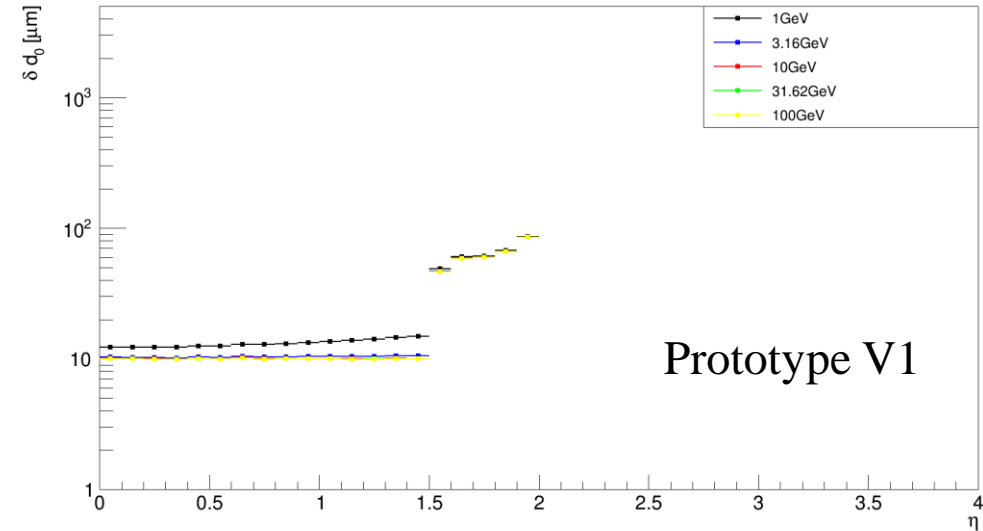No material, δPt/Pt will be constant.

Preliminary resolution simulation results

- Impact parameter resolution(no material)

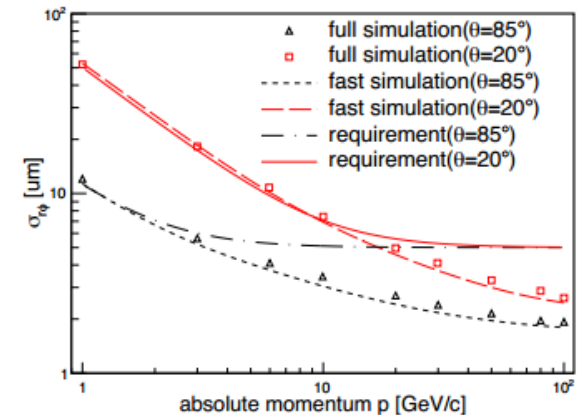Transverse impact parameter error - const P_T across η

CDR

Transverse impact parameter error - const P_T across η

Prototype V1

pixel resolution is 4um for every lay $\sigma_{r\phi} = a \oplus \dfrac{b}{p(\,\mathrm{GeV})\sin^{3/2}\theta}$ but the result is inconsistent with the result in CDR.

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!