

A photograph of the UC Berkeley tower at sunset. The sun is low on the horizon, creating a bright orange and yellow glow. The tower is silhouetted against the sky. In the background, there are trees and a building.

ePIC single-particle tracking performance

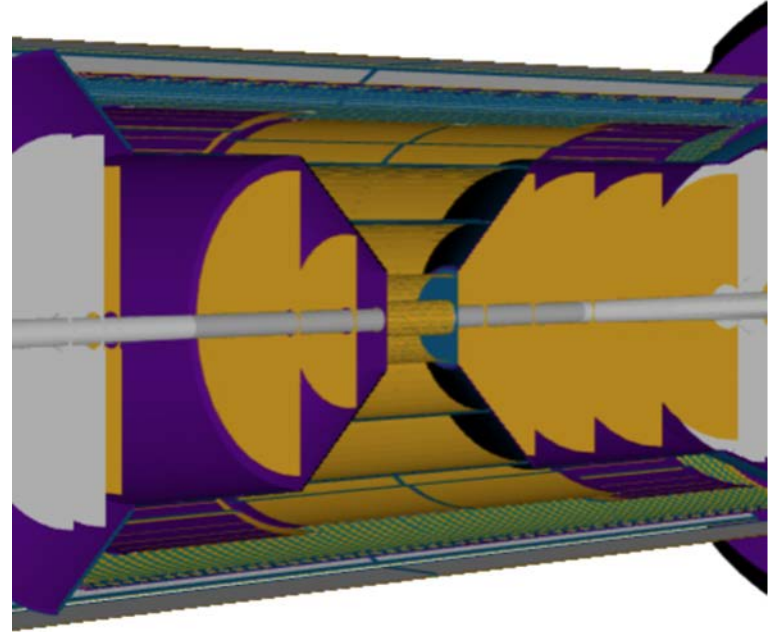
Amir Abdou, Shujie Li

12/03/2024 - LBL EIC Group Meeting

UC Berkeley

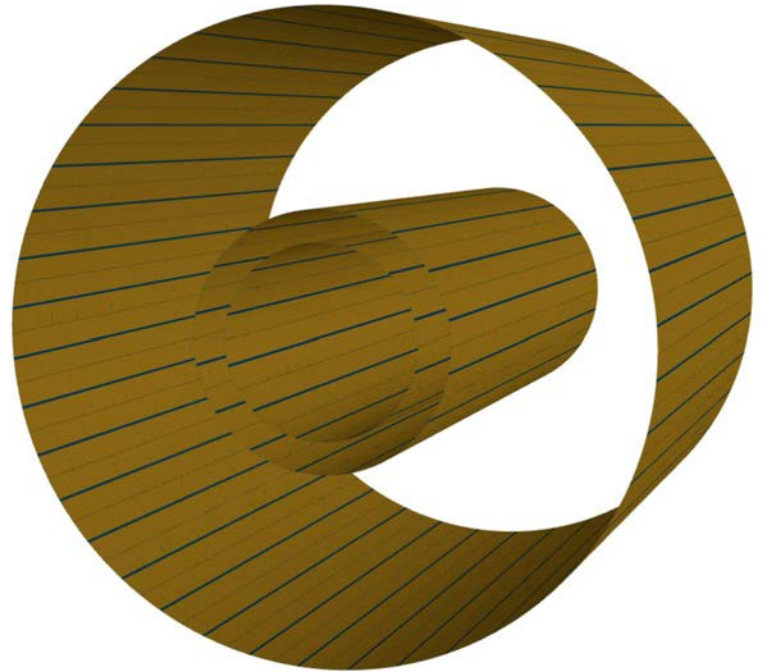
Objectives

1. Analyze the performance of the new, curved description of the Silicon Vertex Tracker Geometry
2. Analyze the performance of the Silicon Barrel under 2 conditions:
 - ❖ The Sagitta Silicon Barrel is disabled
 - ❖ The Outer Silicon Barrel is disabled
3. Analyze the Performance of the Vertex Tracking Barrel under 3 conditions:
 - ❖ Module 1 (closest to beam) is disabled
 - ❖ Module 2 (intermediate) is disabled
 - ❖ Module 3 (furthest from the beam) is disabled



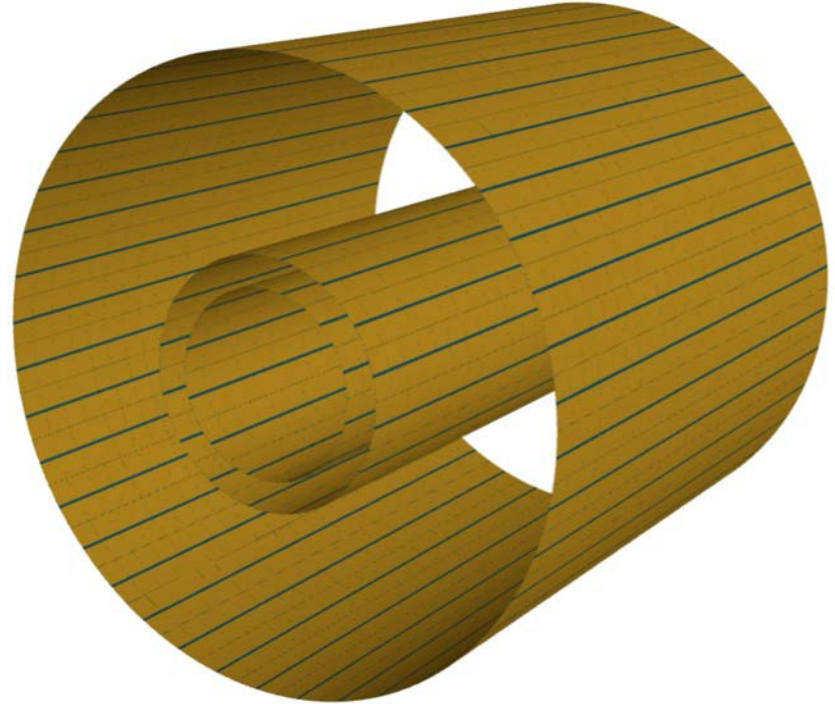
Curved Silicon Vertex Tracker

- ❖ New geometry description uses smooth cylindrical surface instead of modelling the cylinder with staves.
- ❖ The curved surface is representative of the of the current SVT design, based on the Alice ITS3 detector.
- ❖ New geometry now includes inactive regions between curved surfaces.
- ❖ Both changes to the geometry are potentially significant to the detector's performance.
- Requires new simulations to assess performance and compare to ePIC requirements.



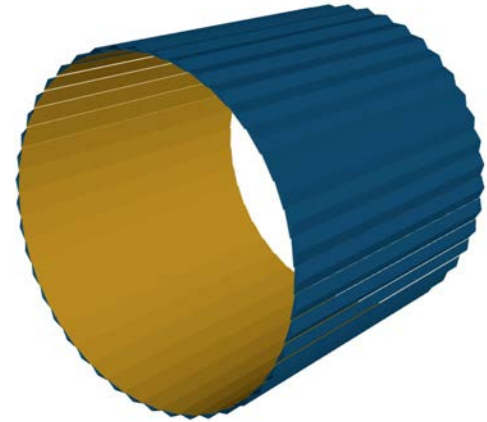
Vertex Barrel

- ❖ 3 layers are not equidistant from the beam pipe.
- ❖ Performance of reconstruction via kalman filter on resolution and efficiency may have significant dependence on which layer is disabled, especially due to non-uniformity in theta and ranges.
- ❖ A disabled layer is representative of 2 real events:
 - Particle doesn't interact with the highly granular sensors, but instead interacts with inactive areas
 - Real life is prone to error, albeit small with improvements in reliability.
- ❖ Event of particular interest is module 1 and module 3 being disabled (individually)
- Requires new simulations to assess performance and compare to ePIC requirements.

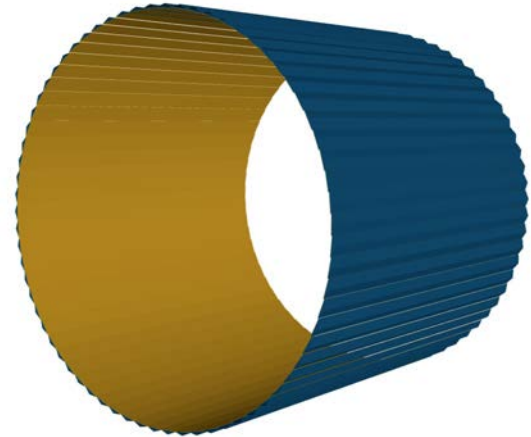


Silicon Barrel

- ❖ Comprised of 2 barrels
- ❖ Sagitta Barrel:
 - Closer to the beam pipe, larger eta range.
- ❖ Outer Silicon Barrel:
 - Further from beam pipe, less capability for forward / backward tracking and similar ability for central tracking.
- ❖ Uniform in theta, but not in eta.
- Requires new simulations to assess performance and compare to ePIC requirements.



Sagitta Silicon Barrel



Outer Silicon Barrel

Workflow Solution



Parsl

- Nercs promoted Workflow tool fully operated on python.
- In-built slurm provider to interact with perlmutter slurm scheduler
- In-built srun launcher for inter-node parallelism.
- Tested to be scalable up to thousands of nodes on Perlmutter

My custom benchmark environment.

- ❖ Conda environment with custom built python package - 'eic-benchmark-env'
- ❖ Object Oriented structure for defining benchmark configurations. Including:
 - Simulation configurations
 - Detector description configurations
 - ePIC repository configurations
 - Workflow manager
 - Sbatch configuration

```
In [ ]: from eicbenchmarks.ParslAppConfig, BenchmarkSuiteConfig, DetectorConfig, SimulationConfig, SimulationCommonConfig
from eicbenchmarks.ParslApp.workflow_manager import ParslWorkflowManager
from eicbenchmarks.ParslApp.run import WorkflowExecutor
from eicbenchmarks.ParslApp.run import *

ETA_MIN = -1
ETA_MAX = 1
NUM_EVENTS = 50000
MOMENTUMS = ["100MeV", "200MeV", "500MeV", "1GeV", "2GeV", "5GeV", "10GeV", "20GeV"]
DETECTOR = "epic_craterlake_tracking_only.xml"
DETECTOR_FILE = "tracking/silicon_barrel.xml"
DISTRIBUTION = "eta"
SIM_PARTICLE = "pi+"
BRANCH = "main"
CONTAINER = "eicweb/jug_xl:24.10.1-stable"
CONTAINER_ENTRY = "/opt/local/bin/eic-shell"

def setup_benchmark_suite():

    benchmark_suite = BenchmarkSuiteConfig(name="Silicon_Barrel", file_path="Silicon_Barrel.yml")

    common_simulation_config = SimulationCommonConfig(use_eta=True)
    common_simulation_config.set_params(
        num_events=NUM_EVENTS, detector_path=DETECTOR,
        gun_distribution=DISTRIBUTION, particle=SIM_PARTICLE,
        min_eta=ETA_MIN, max_eta=ETA_MAX, enable_gun=True
    )
    sagitta_barrel_detector_cfg = DetectorConfig(
        detector_file_name=DETECTOR_FILE,
        config_type="set",
        detector_element_name="SagittaSiBarrel",
        module_name="Module1",
        module_component_name="ITS3",
        attribute="sensitive",
        value="false"
    )
    sagitta_bm = BenchmarkConfig(benchmark_name="Sagitta_Barrel_Disabled", repo_branch=BRANCH)
    sagitta_bm.set_common_simulation_config(common_simulation_config)
    sagitta_bm.add_detector_config(sagitta_barrel_detector_cfg)

    for mom in MOMENTUMS:
        sim_config = SimulationConfig(simulation_name=str(mom), use_eta=True)
        sim_config.set_params(max_momentum=mom, min_momentum=mom)
        sagitta_bm.add_simulation_config(sim_config)

    benchmark_suite.add_benchmark(sagitta_bm)
    return benchmark_suite

In [ ]: silicon_barrel_suite = setup_benchmark_suite()

executor = WorkflowExecutor(
    name="Silicon_Barrel_Missing_Layers",
    benchmark_suite_config=silicon_barrel_suite,
    container_img=CONTAINER,
    container_entry_command=CONTAINER_ENTRY,
    overwrite=False,
    debug=False
)

executor.set_slurm_provider_config(
    num_nodes=1, cores_per_node=8, charge_account="m3763",
    cores_per_worker=2, walltime_minutes=20, qos='debug'
)

In [ ]: executor.run_benchmarks()
```


Github Repository

<https://github.com/amirkas/ePIC-Benchmark-lib>

Benchmark Configurations

Curved Silicon Vertex Tracker

- ❖ 20000 events
- ❖ Particle: π^+
- ❖ 16 Eta bins from -4 to 4
 - Step Size of 0.5
- ❖ Momentums (single):
 - 100MeV
 - 200MeV
 - 500MeV
 - 1MeV
 - 2MeV
 - 5MeV
 - 10MeV
 - 20MeV

Vertex Barrel:

For each disabled module:

- ❖ 50000 events
- ❖ Particle: π^+
- ❖ 1 Eta Bin from -2 to 2
- ❖ Momentums (single):
 - 100MeV
 - 200MeV
 - 500MeV
 - 1MeV
 - 2MeV
 - 5MeV
 - 10MeV
 - 20MeV

Silicon Barrel:

For each disabled barrel:

- ❖ 50000 events
- ❖ Particle : π^+
- ❖ 1 Eta Bin from -1 to 1
- ❖ Momentums (single):
 - 100MeV
 - 200MeV
 - 500MeV
 - 1MeV
 - 2MeV
 - 5MeV
 - 10MeV
 - 20MeV

Current Performance Results

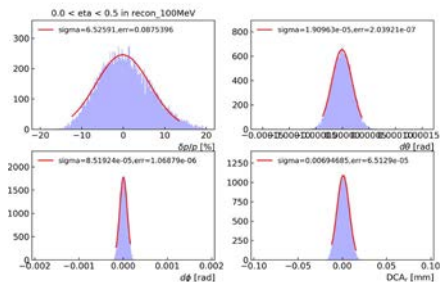
A faint, light-colored illustration in the background depicts an open book with wavy lines representing text on its pages. Above the book is a five-pointed star with radiating lines, suggesting a theme of achievement or excellence.

Curved SVT

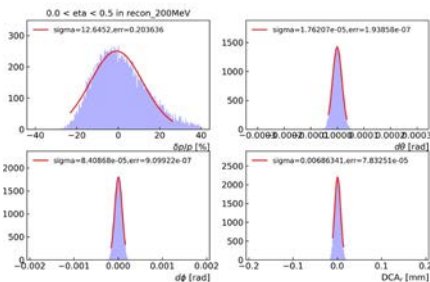


Curved SVT Resolution example (Eta from 0 to 0.5)

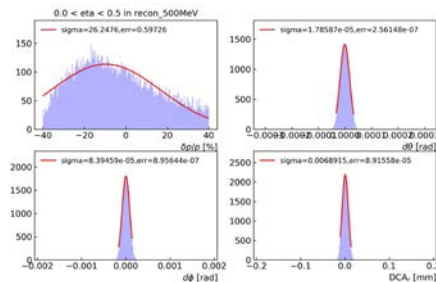
100MeV



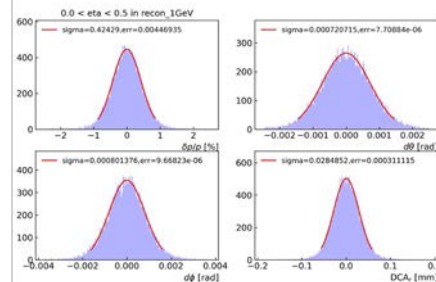
200MeV



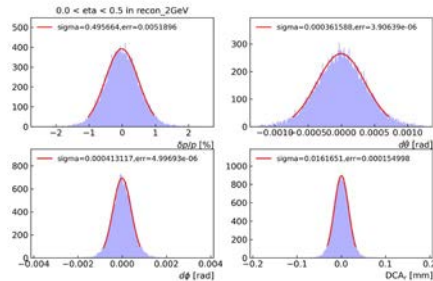
500MeV



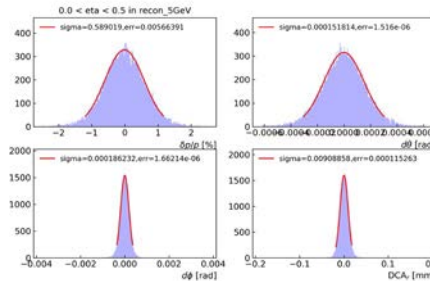
1GeV



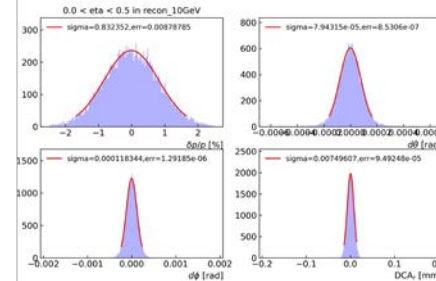
2GeV



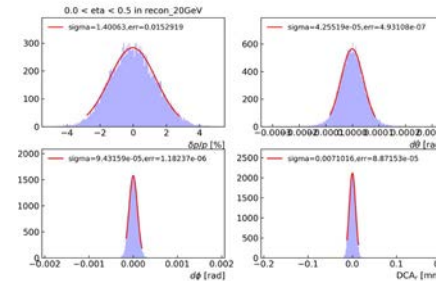
5GeV



10GeV

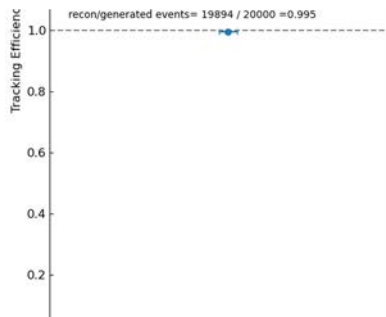


20GeV

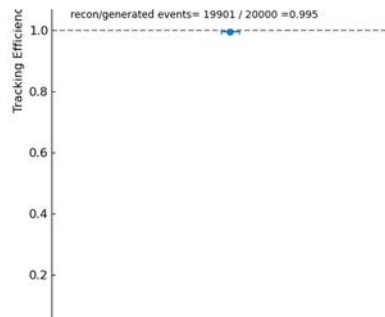


Curved SVT Efficiency example (Eta from 0 to 0.5)

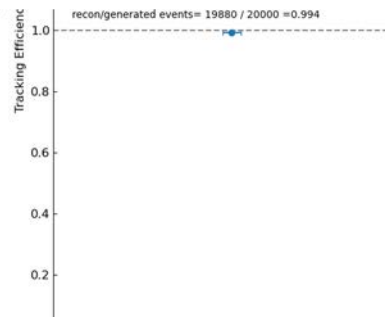
100MeV



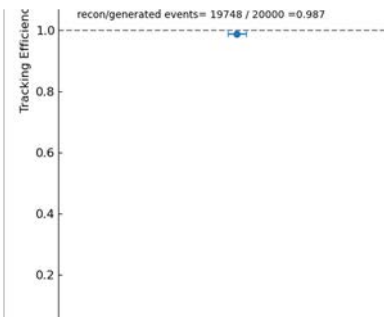
200MeV



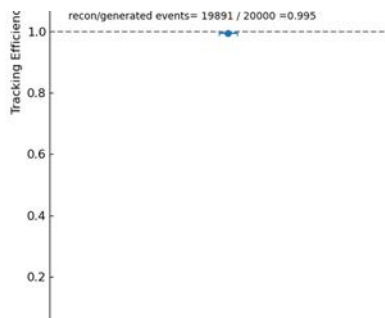
500MeV



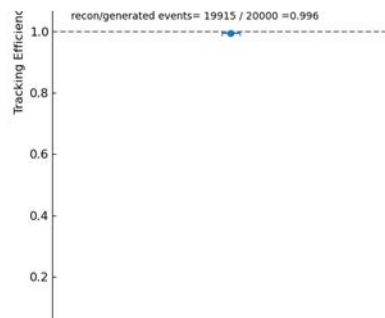
1GeV



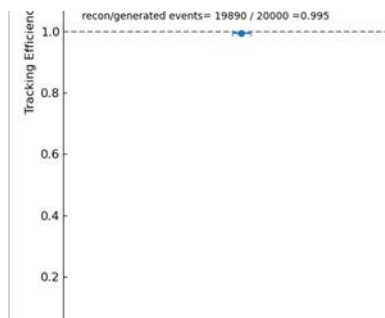
2GeV



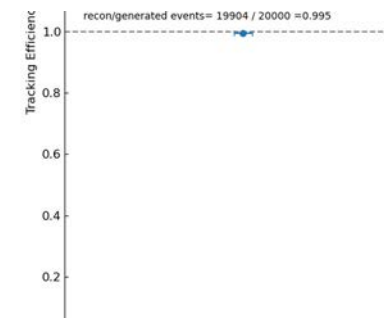
5GeV



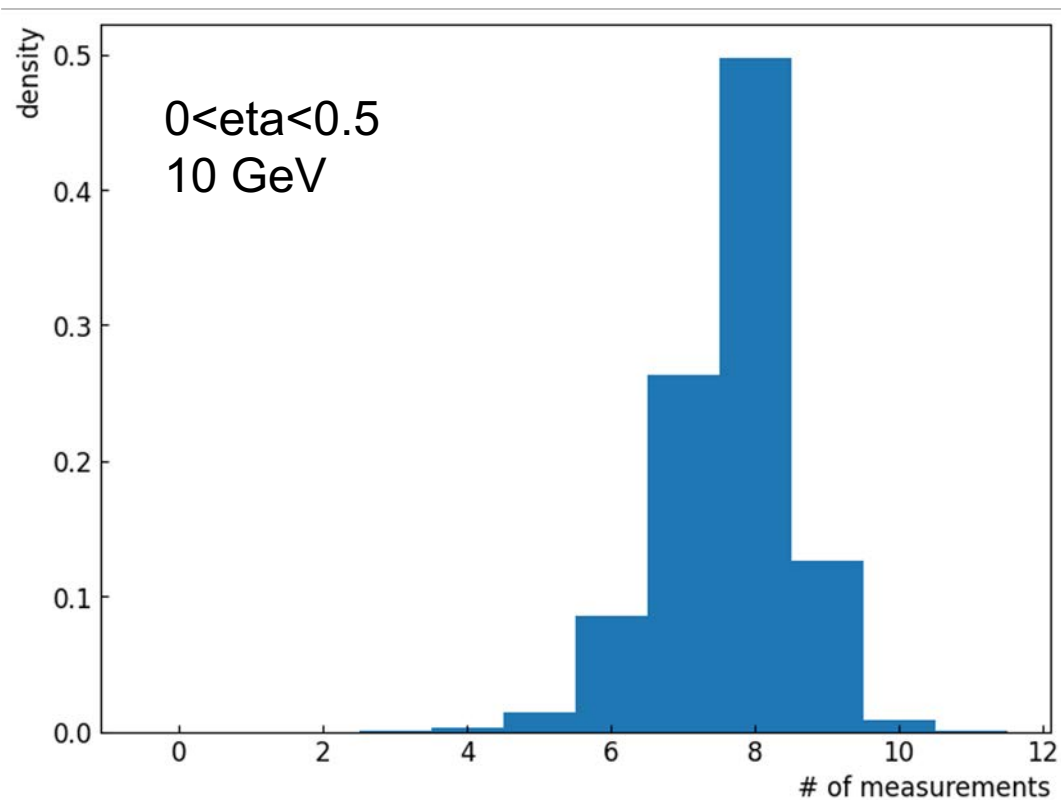
10GeV



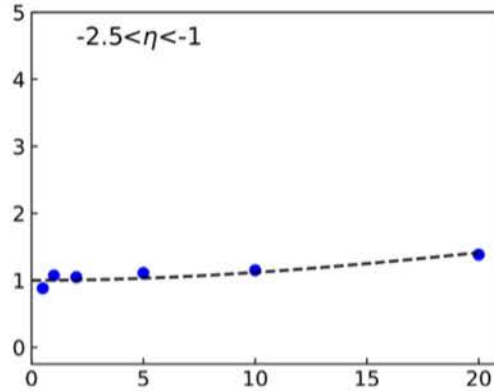
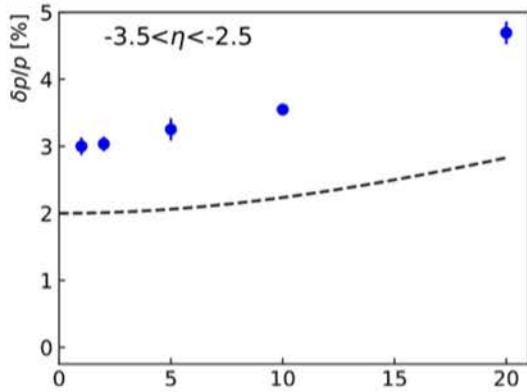
20GeV



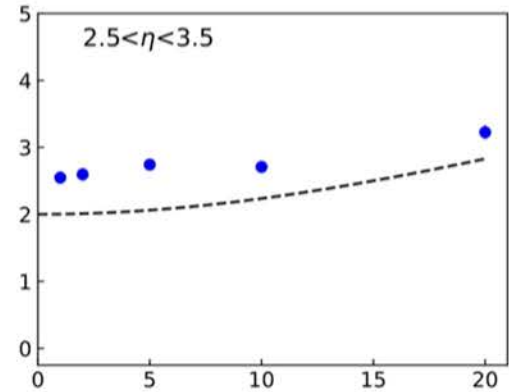
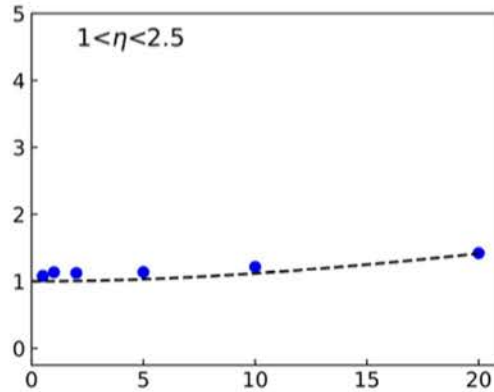
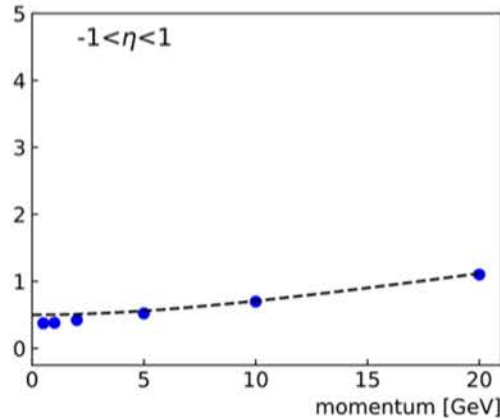
Curved SVT: # of measurements



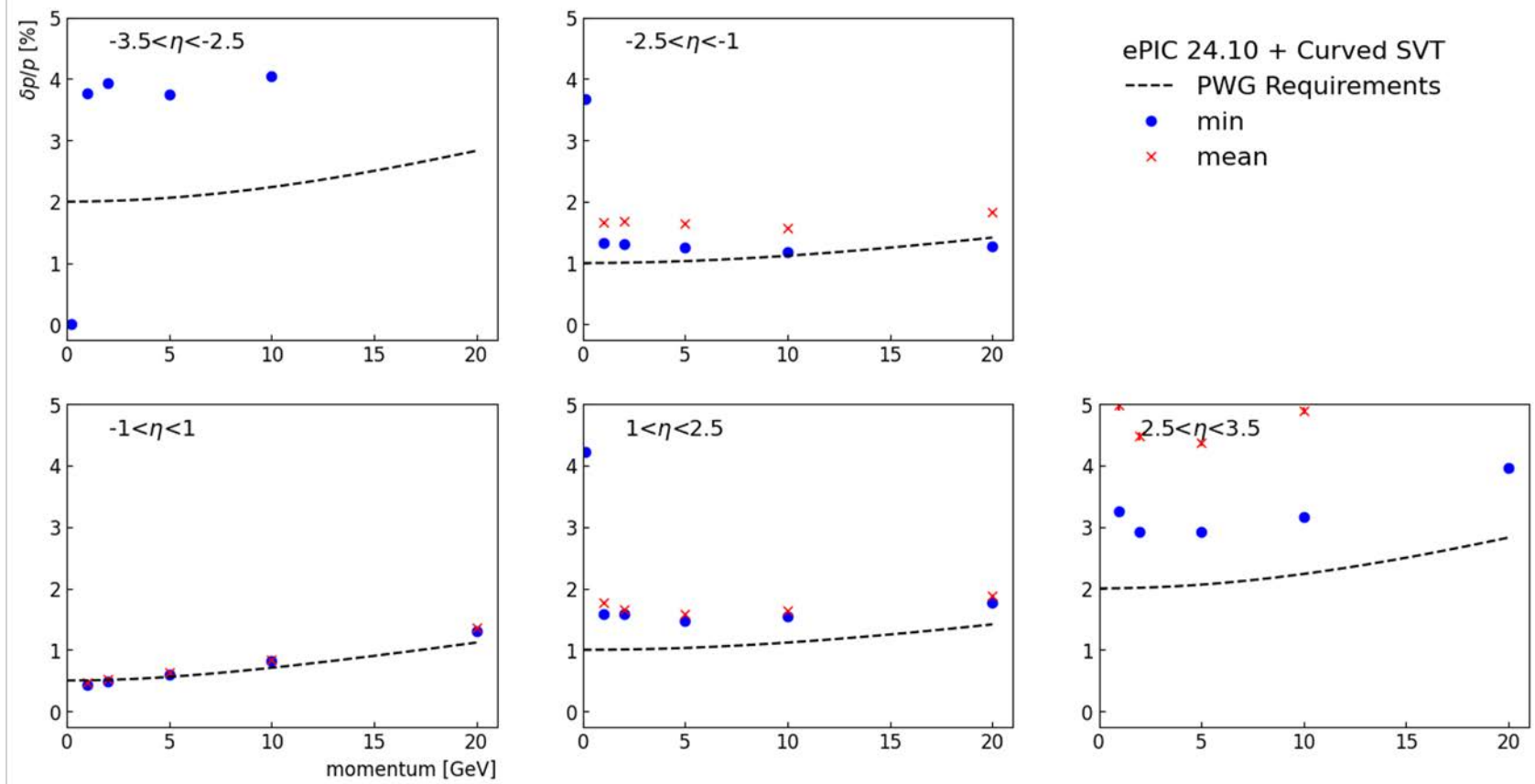
Momentum resolution (old stave SVT)



---- PWG Requirements
● ePIC 24.08



Momentum resolution (Curved SVT with RSU)

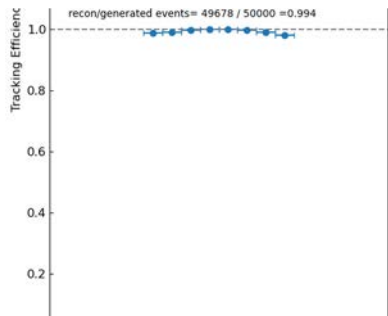


“Missing” Layers

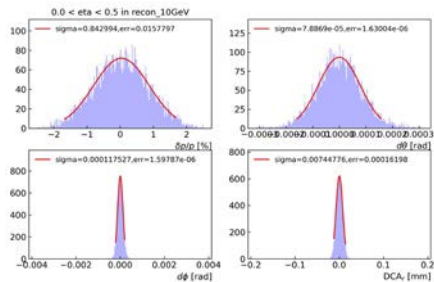


Vertex Barrel (example at 10GeV - Eta from 0 to 0.5 for resolution)

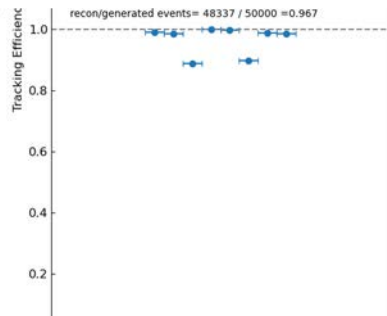
No Module Disabled Efficiency



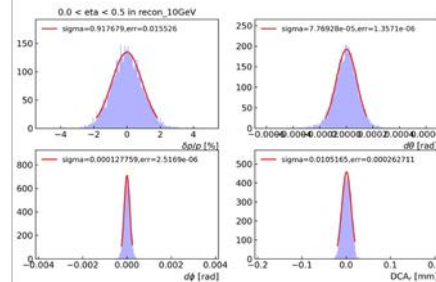
No Module Disabled Resolution



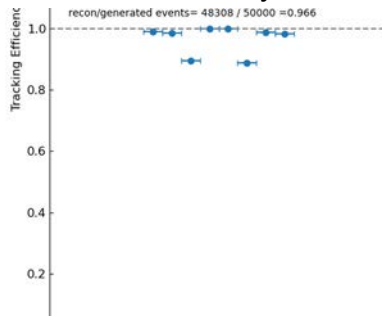
Module 1 Disabled Efficiency



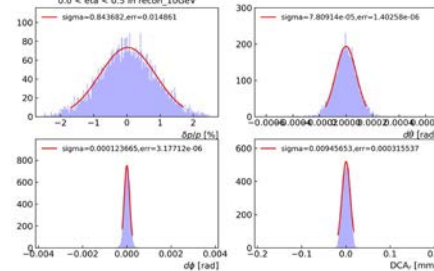
Module 1 Disabled Resolution



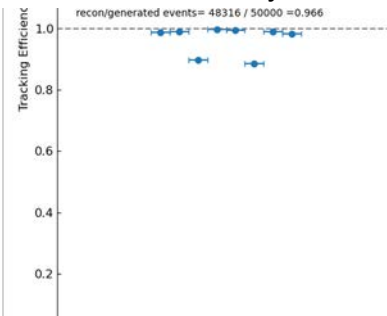
Module 2 Disabled Efficiency



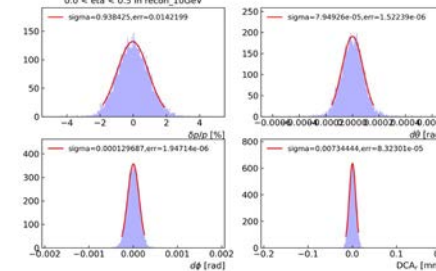
Module 2 Disabled Resolution



Module 3 Disabled Efficiency

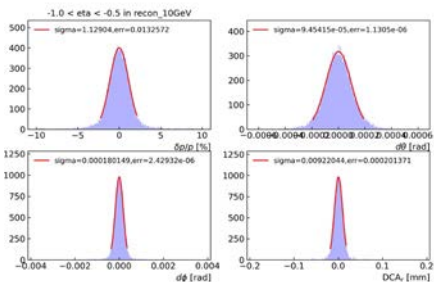


Module 3 Disabled Resolution

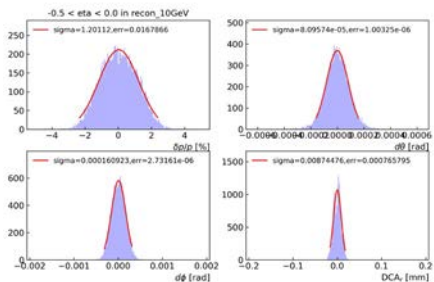


Silicon Barrel Resolution (example at 10GeV)

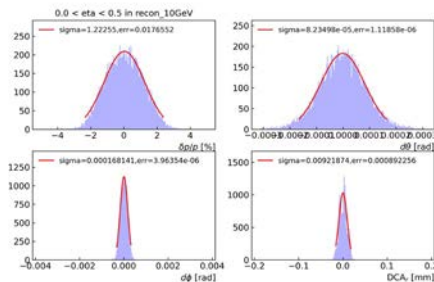
Sagitta Barrel
Disabled
Eta -1→-0.5



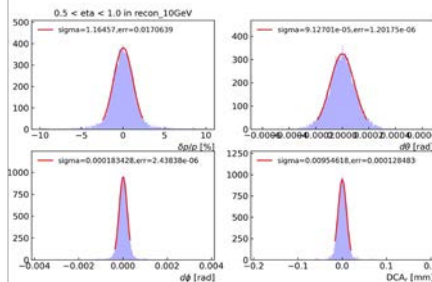
Sagitta Barrel
Disabled
Eta -0.5→0.0



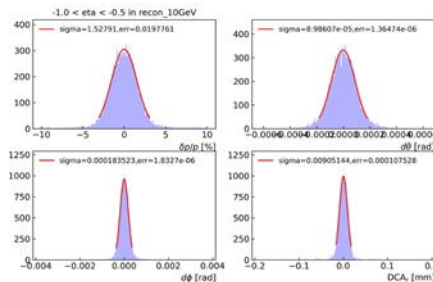
Sagitta Barrel
Disabled
Eta 0.0→0.5



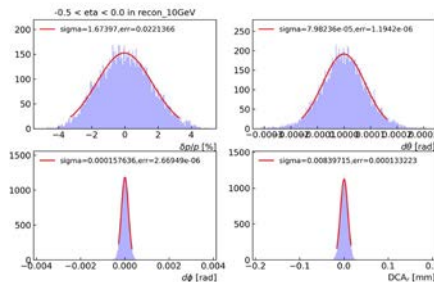
Sagitta Barrel
Disabled
Eta 0.5→1



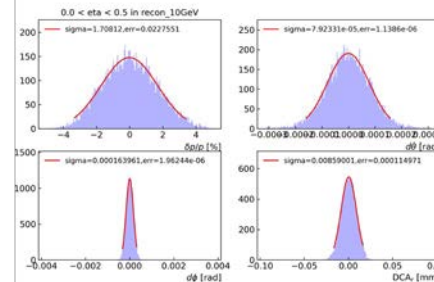
Outer Barrel
Disabled
Eta -1→-0.5



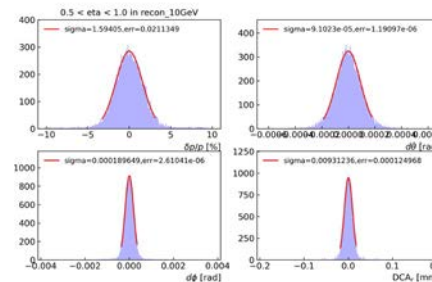
Outer Barrel
Disabled
Eta -0.5→0.0



Outer Barrel
Disabled
Eta 0.0→0.5

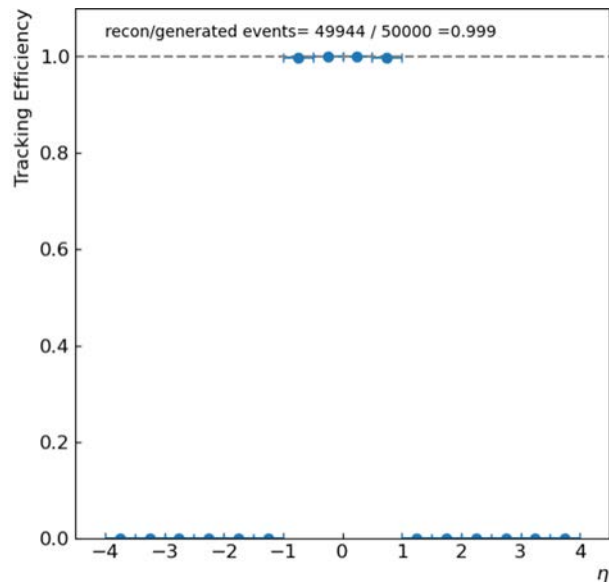


Outer Barrel
Disabled
Eta 0.5→1



Silicon Barrel Efficiency (example at 10GeV)

Sagitta Barrel Disabled



Outer Barrel Disabled

