BERKELEY LAB
Bringing Science Solutions to the World

U.S. DEPARTMENT OF ENERGY
Office of Science

ATHENA-Acts Tracking Updates

Shujie Li
Oct 25, 2021

1. Acts Material map

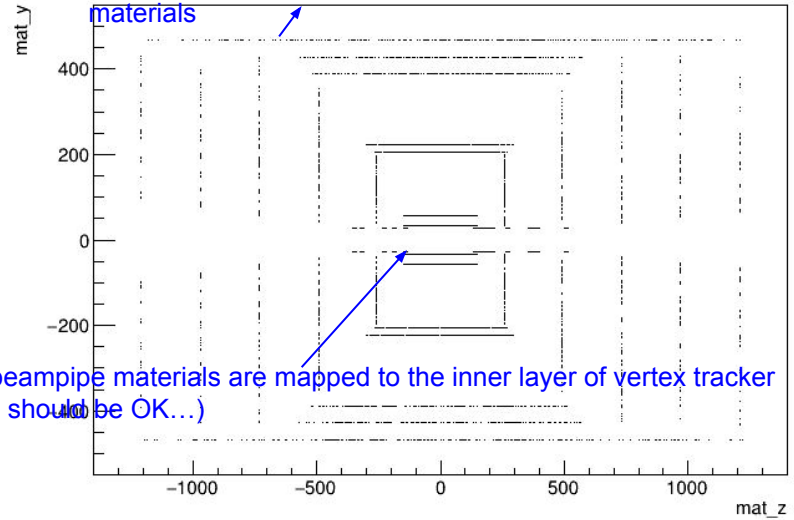
Many thanks to Wouter, Sylvester, and Corentin Allaire from the Acts developer group

- To generate a json file to provide material mapping information to ACTS (Tutorial), otherwise ACTS wouldn't consider material effect in track reconstruction
- Use Geantino scan to get materials info along projective tracks
- Need to manually enable mapping. 2 options:
  - 1. Map materials to (closest) surface along the propagation path
  - 2. Map materials to a 3D or 2D grid associated with a volume

One track from material map validation (length in mm):

event ID	instance	sqrt(x**2+y**2)	z	X0	X/X0 (%)
153	0	28.250699	1.6192829	171.10745	0.0112418
153	1	32.999999	1.8915048	197.16177	0.4074067
153	2	55.999998	3.2098264	215.1452	0.2029441
153	3	205	11.750257	133.27182	0.7623741
153	4	221.8	12.713206	138.17269	0.6613224
153	5	387.99999	22.239513	128.402	0.6153358
153	6	427.29999	24.492122	128.18264	0.6141611

Use outer volume boundary as mapping surface to absorb supporting materials

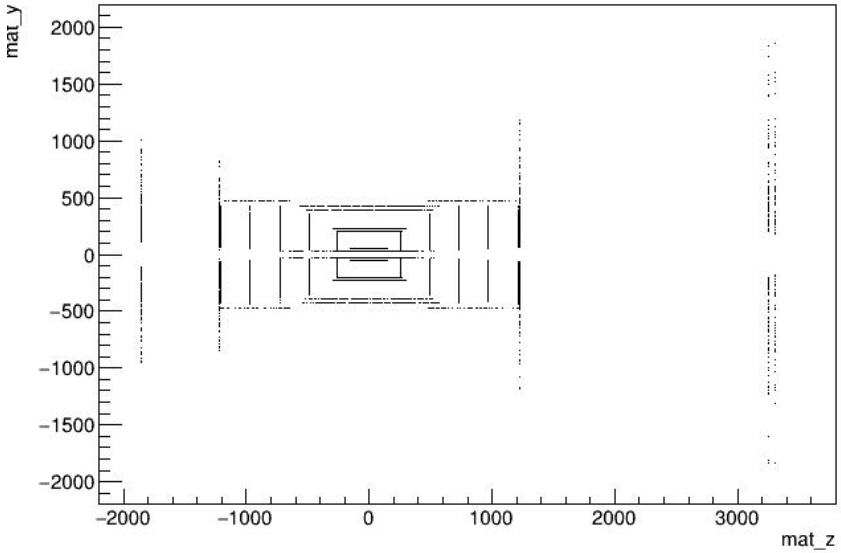


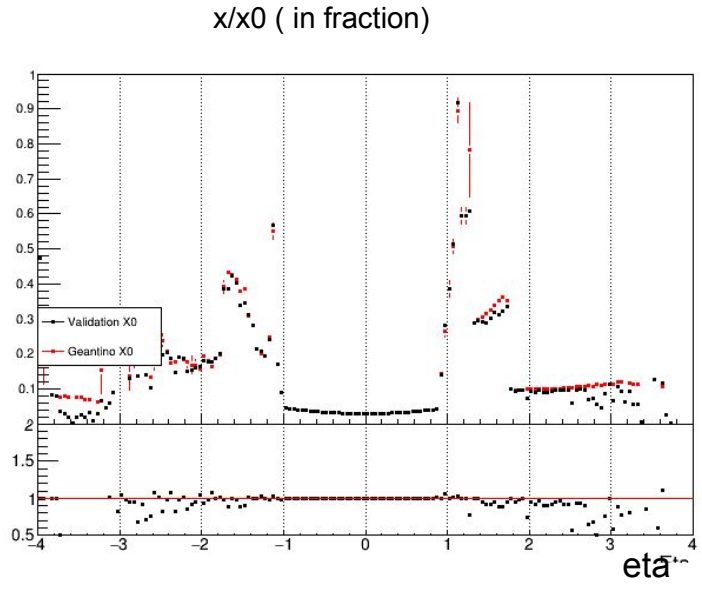
Most beampipe materials are mapped to the inner layer of vertex tracker (which should be OK…)

- Default map shipped with the latest version of container (`${DETECTOR_PATH}/calibrations`).
- To load the map in reconstruction option file:

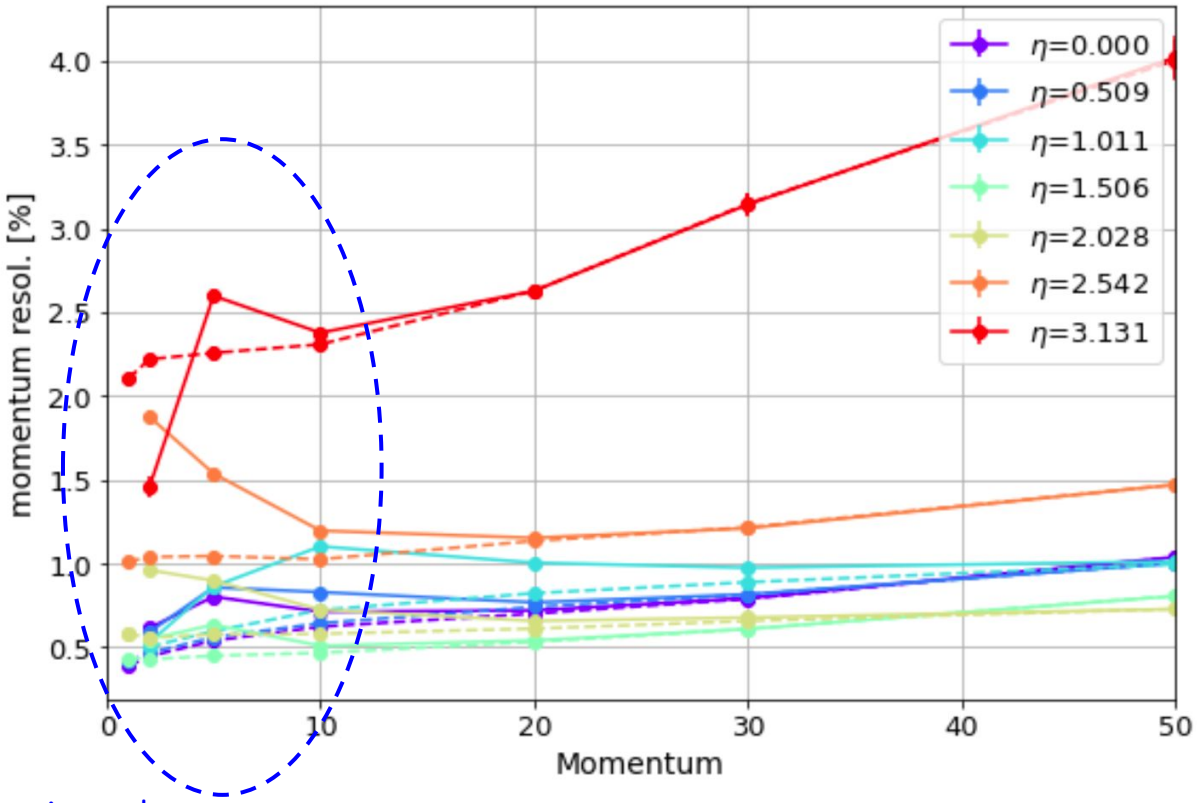
* Material map needs to be updated once volume id changed.

```
geo_service  = GeoSvc("GeoSvc",
detectors=["{}/{}.xml".format(detector_path,detector_name)], materials="config/material-maps.json",
OutputLevel=WARNING)
```





Tracking performance with (dashed) / without (solid) material map

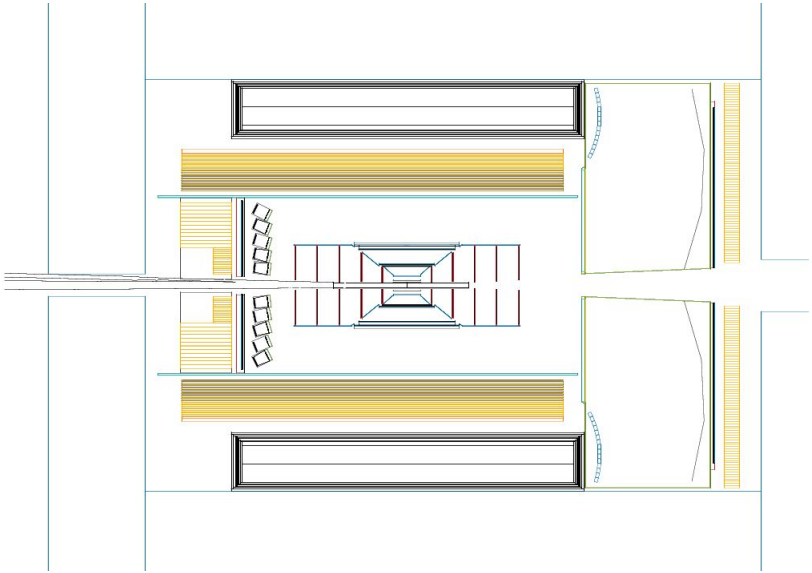


Improved reconstruction at low p

2. Tracking Performance Benchmarks

Configurations:

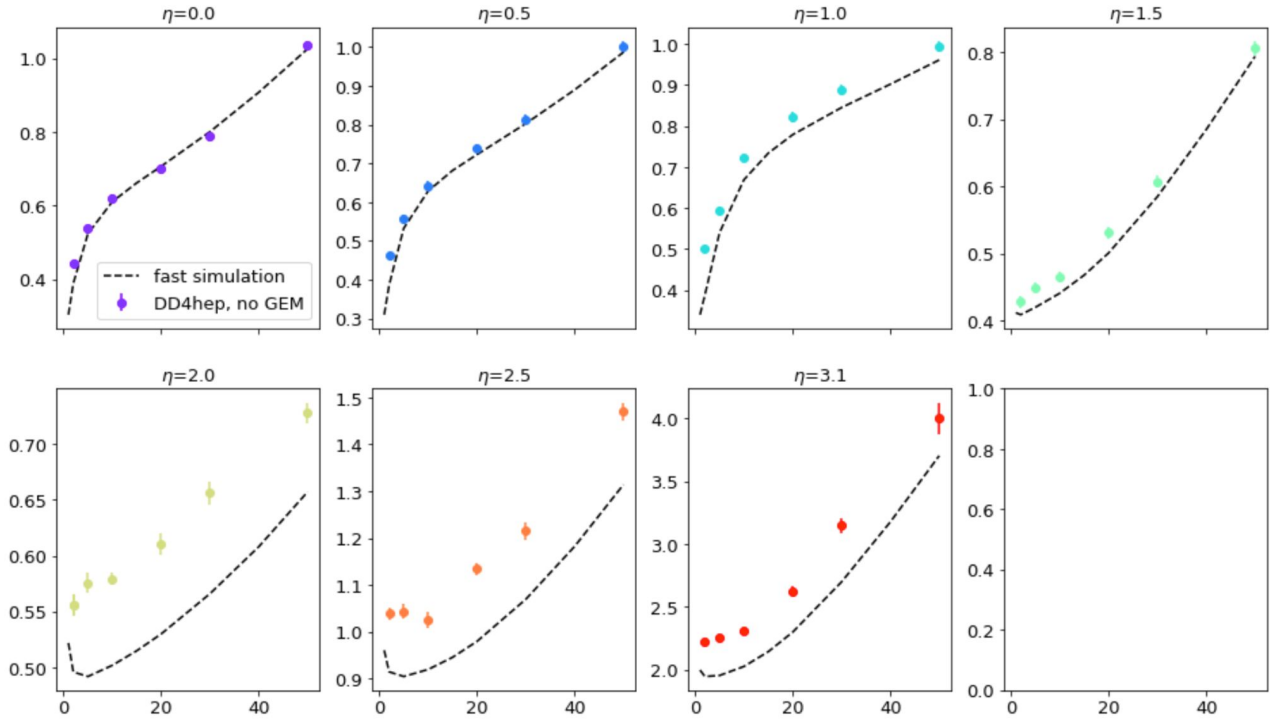
- Baseline 0 geometry
- Only beampipe + silicon trackers
- Truth seeding
- Combinatorial Kalman filter (track finding + fitting)
- WITH material map



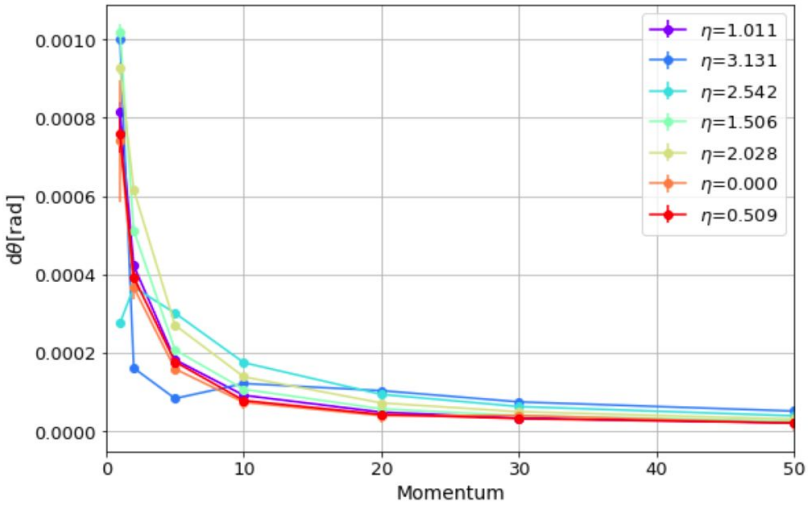
For each set of simulation:

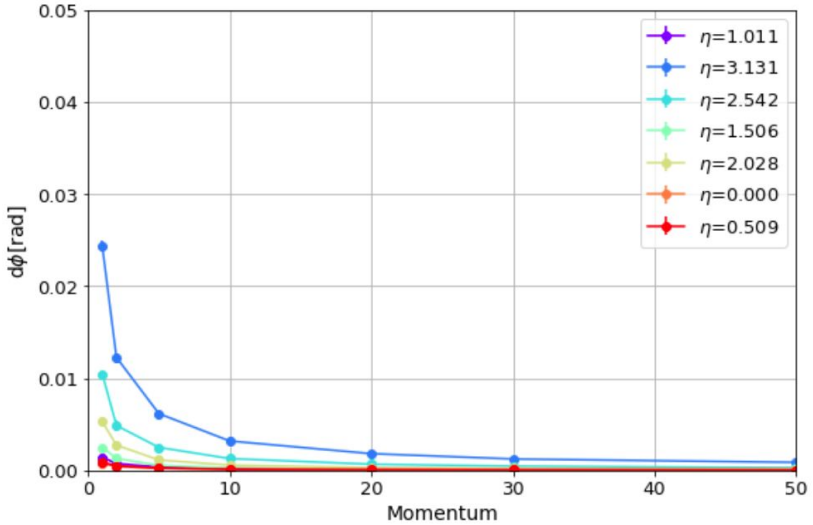
- Used single particle pion
- Fixed theta and p, evenly distributed phi (0 to 2pi)
- 10000 events

Momentum Resolution (markers: Acts, dashed line: fast simulation from Ernst)

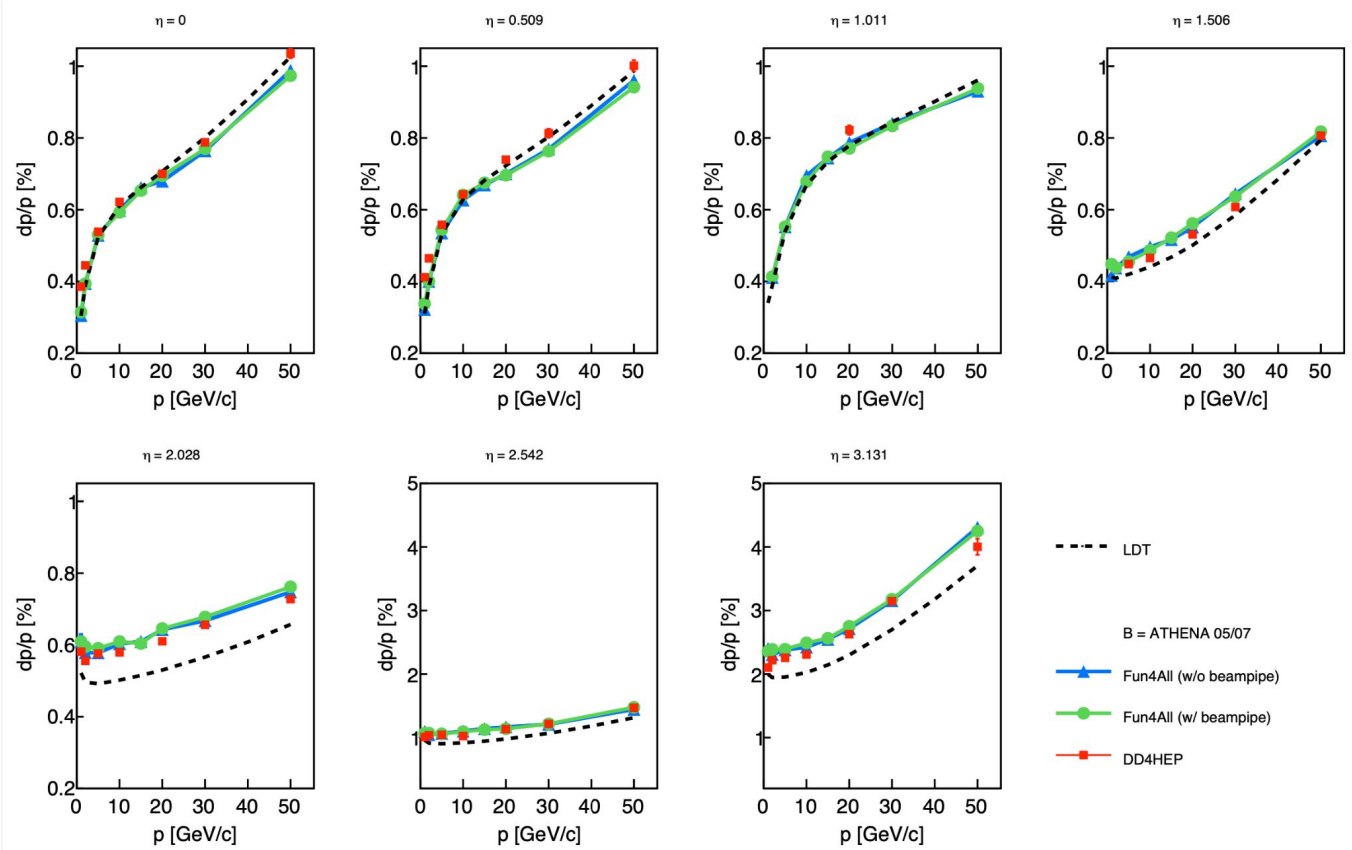


Angle Resolution



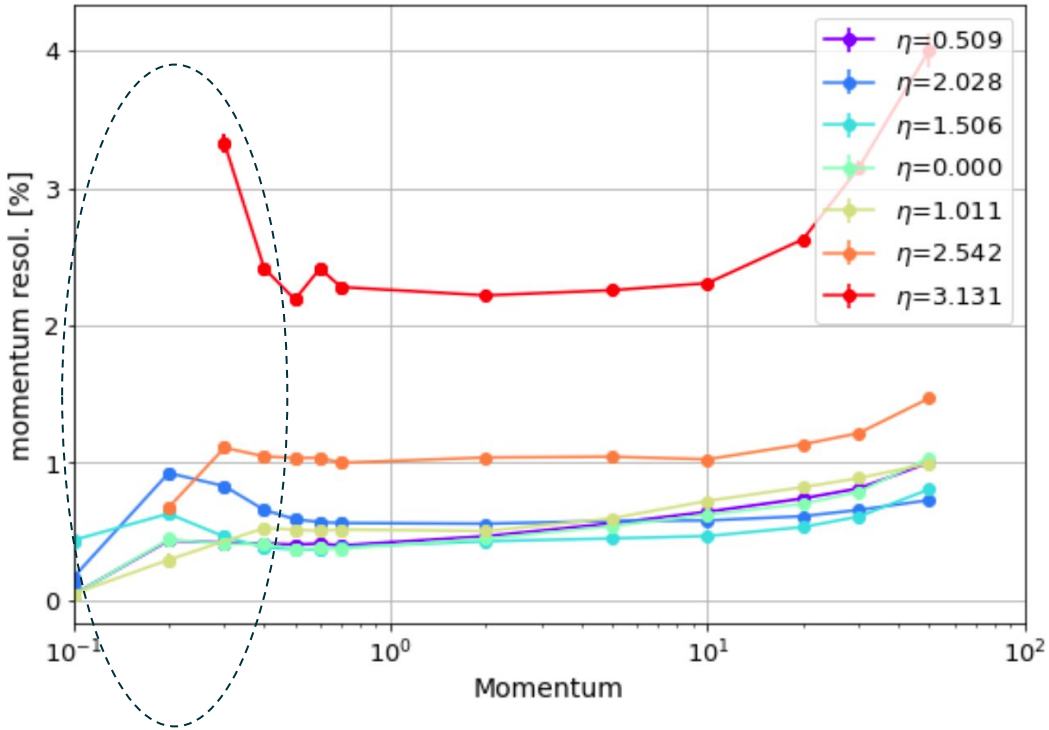


Momentum Resolution benchmarks (courtesy of Rey)



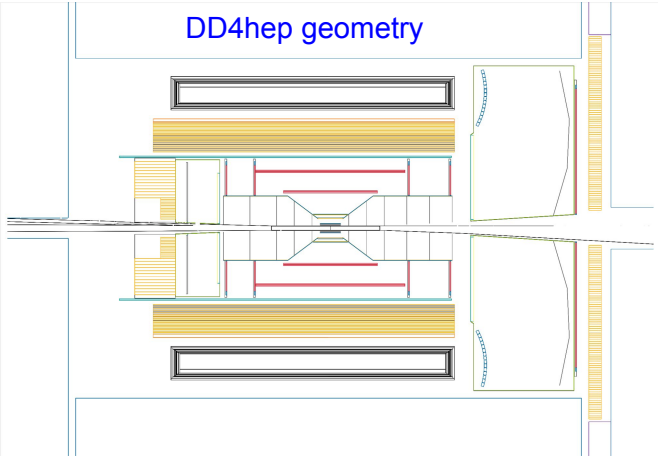
Low momentum reconstruction

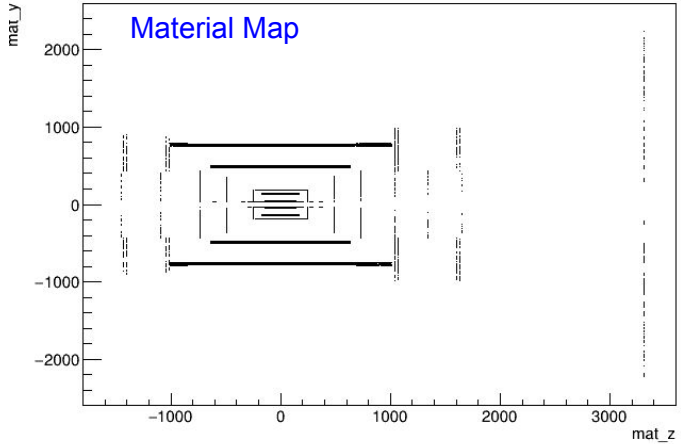
Baseline 0



Bad fitting quality, distributions not Gaussian

3. Material map for Baseline 2



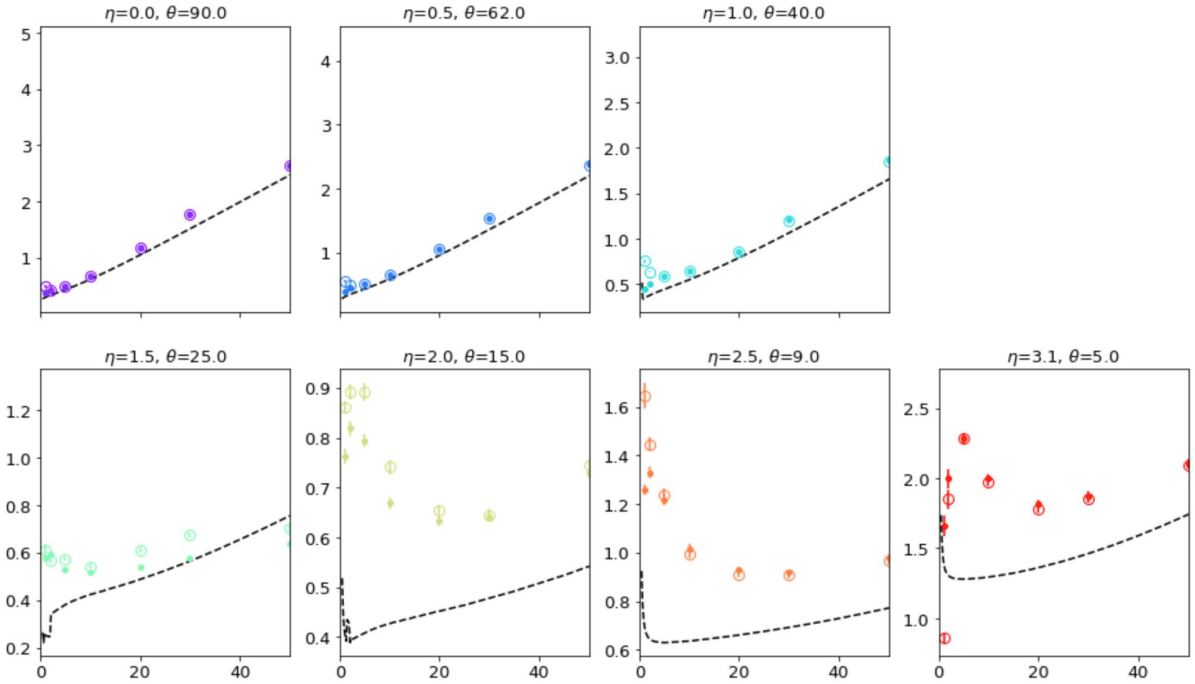


- Project materials along the Geantino trajectory (fixed eta) to the nearest entrance/exit tracker surfaces as well as the central beampipe
- 36 bins in phi and 50 bins in R and Z
- Shipped with the latest ATHENA simulation (thanks to Wouter!)

Momentum Resolution (dpp v.s. p)

Forward region:

Dashed line: fast simulation from Ernst
Solid marker: DD4hep with material map
Open circle: DD4hep w/o material map



- Material map Improved tracking performance at small momentum (consistent with the baseline 0 benchmarks)
- Need to understand the low p, large eta behavior

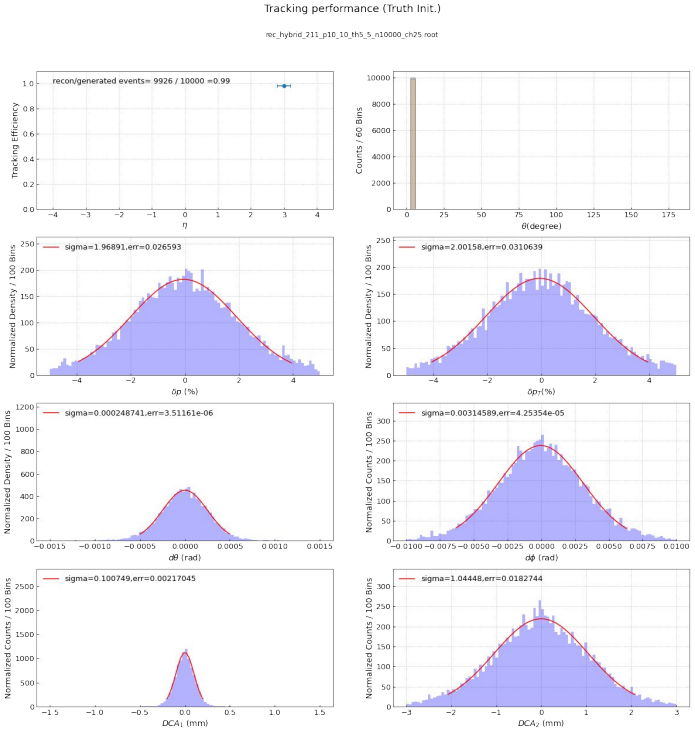
Momentum Resolution (dpp v.s. p)

Forward region:

Dashed line: fast simulation from Ernst
Solid marker: DD4hep with material map
Open circle: DD4hep w/o material map

- Material map Improved tracking performance at small momentum (consistent with the baseline 0 benchmarks)
- Need to understand the low p, large eta behavior

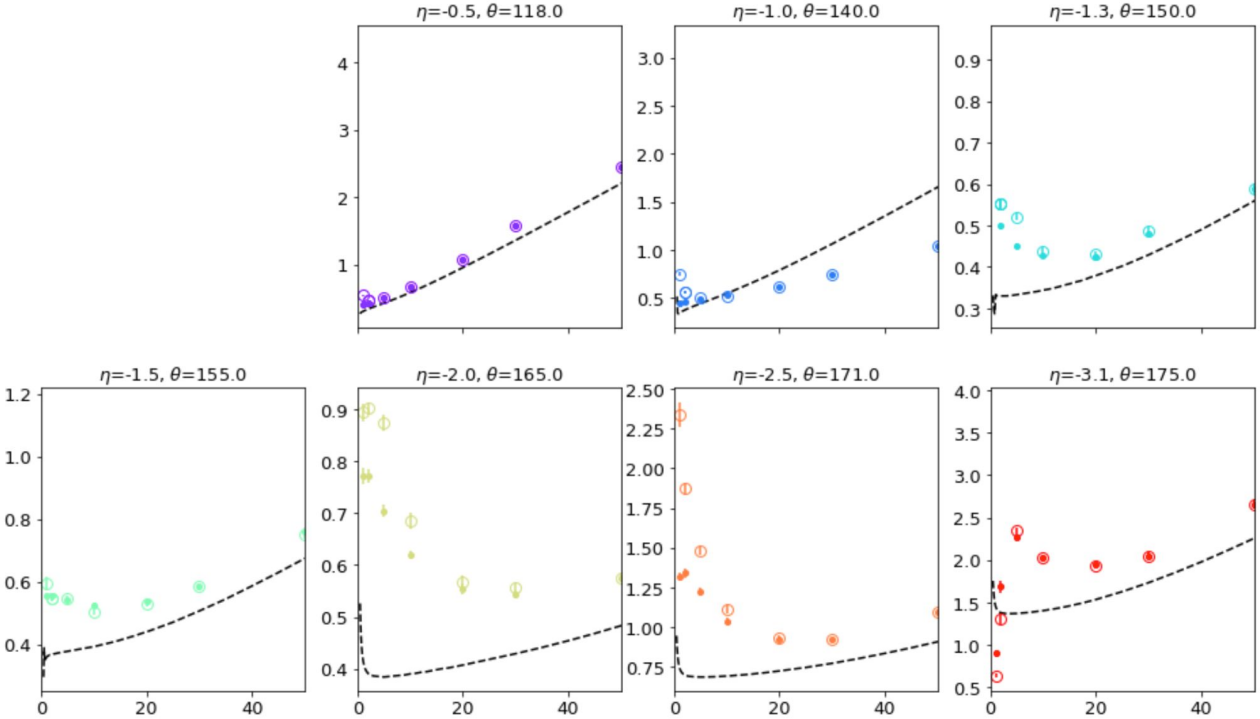
p=10 GeV, theta=5 degree



Momentum Resolution (dpp v.s. p)

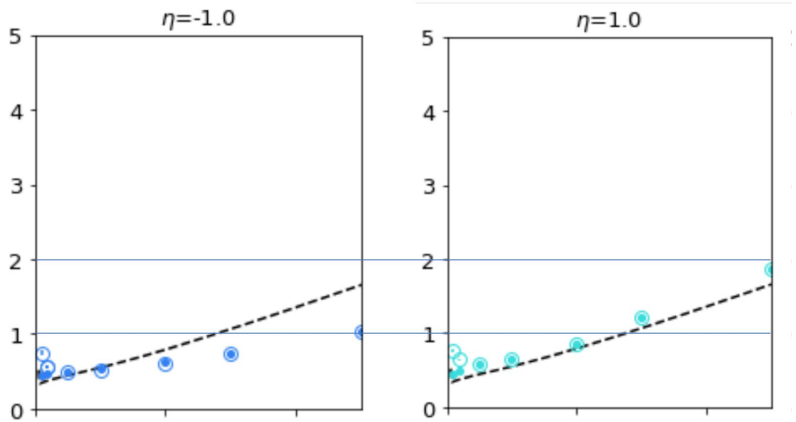
Backward region:

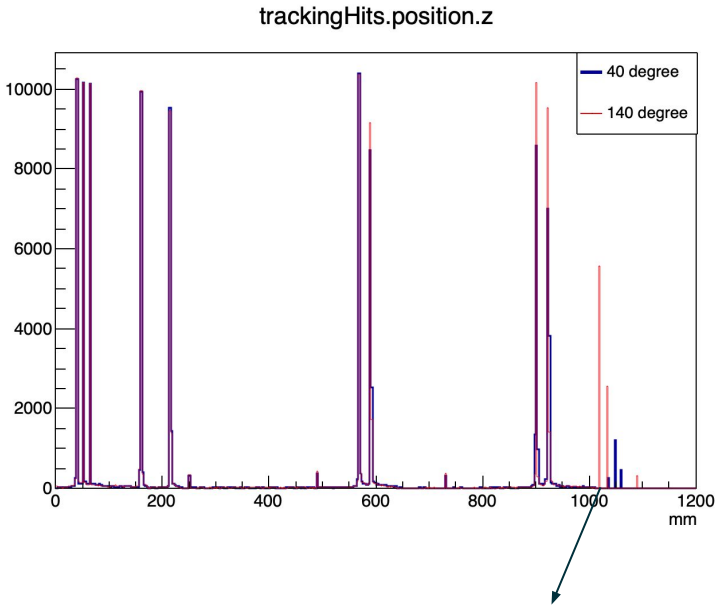
Dashed line: fast simulation from Ernst
Solid marker: DD4hep with material map
Open circle: DD4hep w/o material map



Momentum Resolution (dpp v.s. p)

- Inconsistency b/w eta = +-1 (theta = 40 and 140 degrees) from small offsets in implementation.





First GEM ring at -1.03m

4. Baseline 0 v.s. 2 Comparison (DD4hep + Acts)

Solid line: All silicon Dashed line: Hybrid