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ATHENA-Acts Tracking Updates

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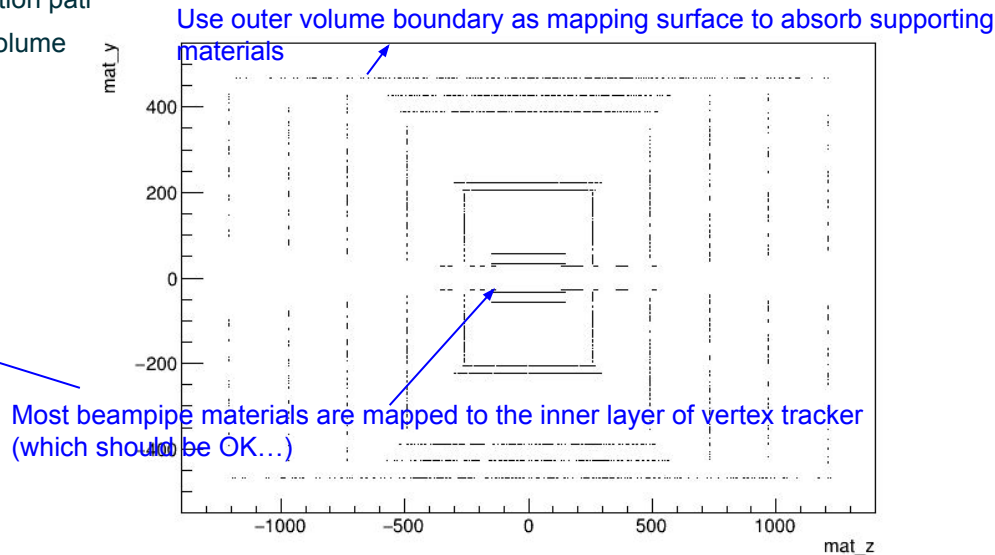
1. Acts Material map

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):

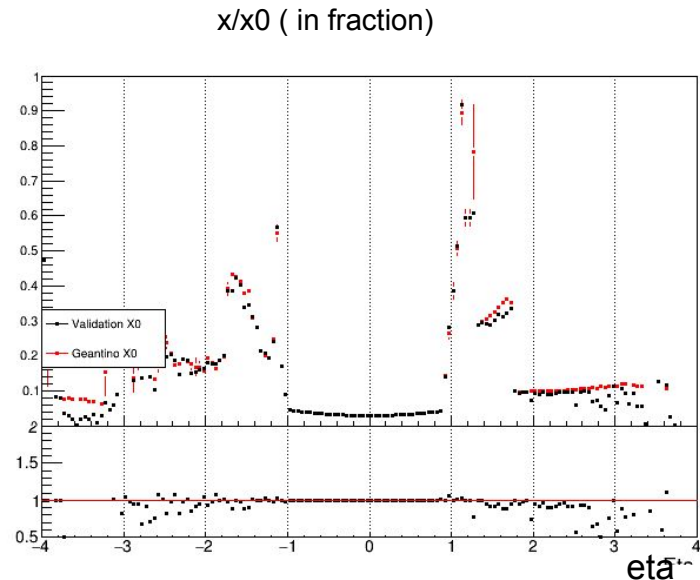
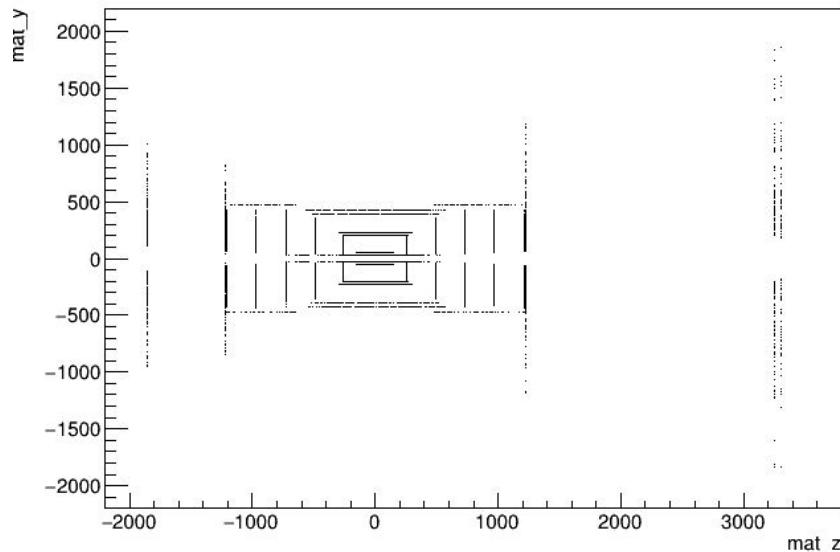
event ID	instance	$\sqrt{x^2+y^2}$	z	X0	X/X0 (%)
153	0	28.250699	1.6192829	171.10745	0.0112418
153	1	32.999999	1.8915048	197.16177	0.4074067
153	2	55.999998	3.2098264	215.1452	0.2029441
153	3	205	11.750257	133.27182	0.7623741
153	4	221.8	12.713206	138.17269	0.6613224
153	5	387.99999	22.239513	128.402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



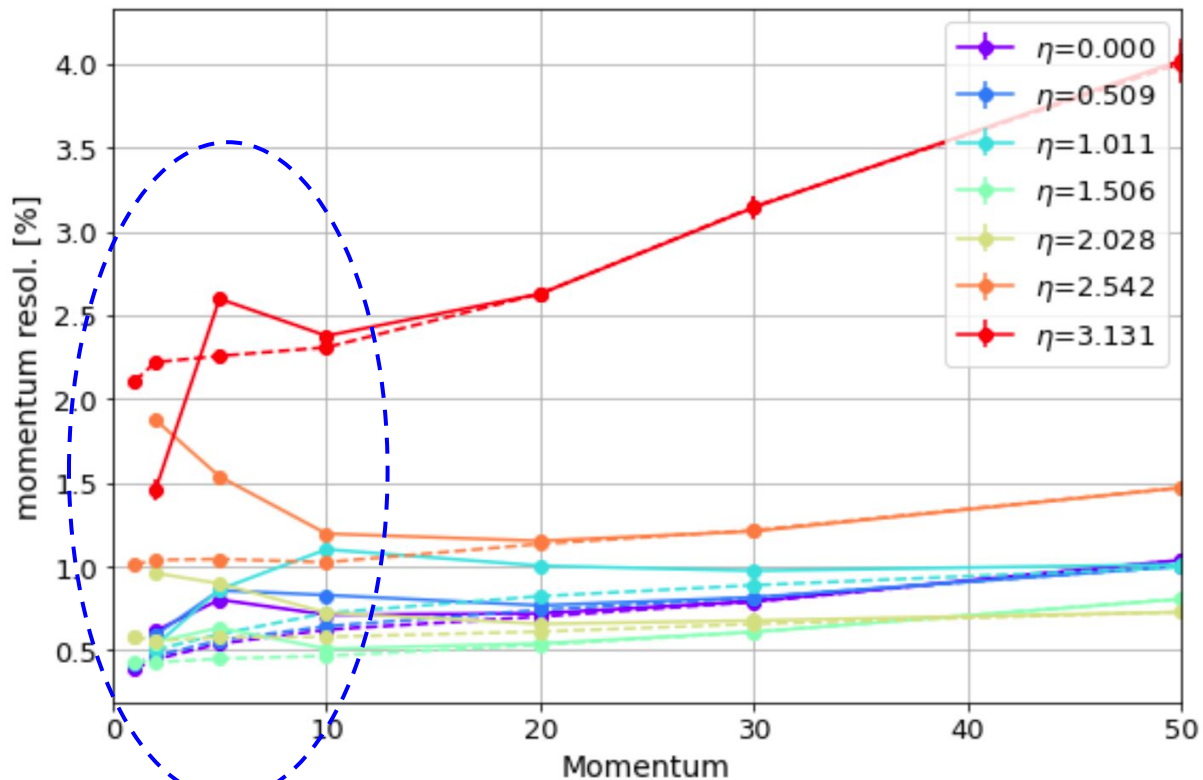
- Default map shipped with the latest version of container
(`${DETECTOR_PATH}/calibrations`).
- To load the map in reconstruction option file:

* 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

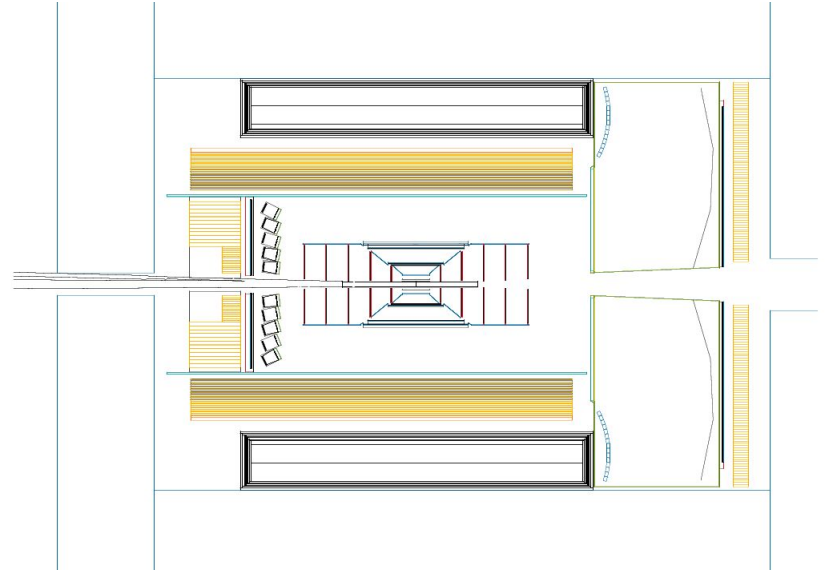
2. Tracking Performance Benchmarks

Configurations:

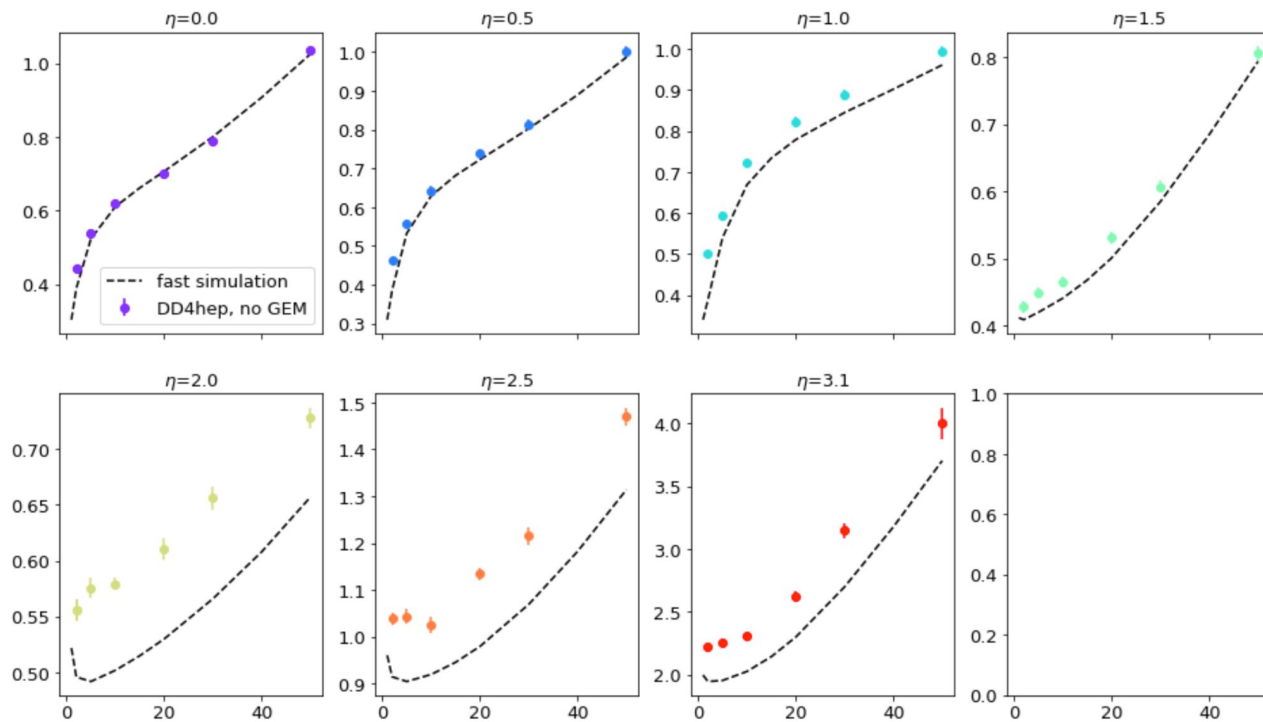
- Baseline 0 geometry
- Only beampipe + silicon trackers
- Truth seeding
- Combinatorial Kalman filter (track finding + fitting)
- WITH material map

For each set of simulation:

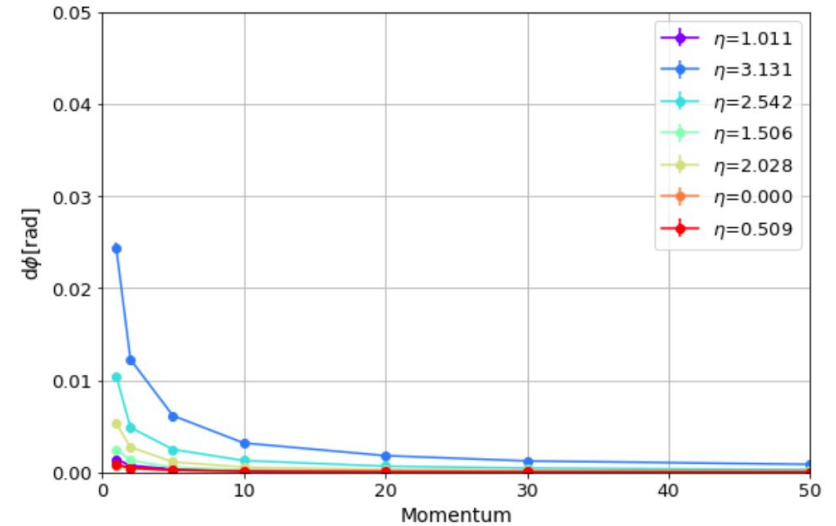
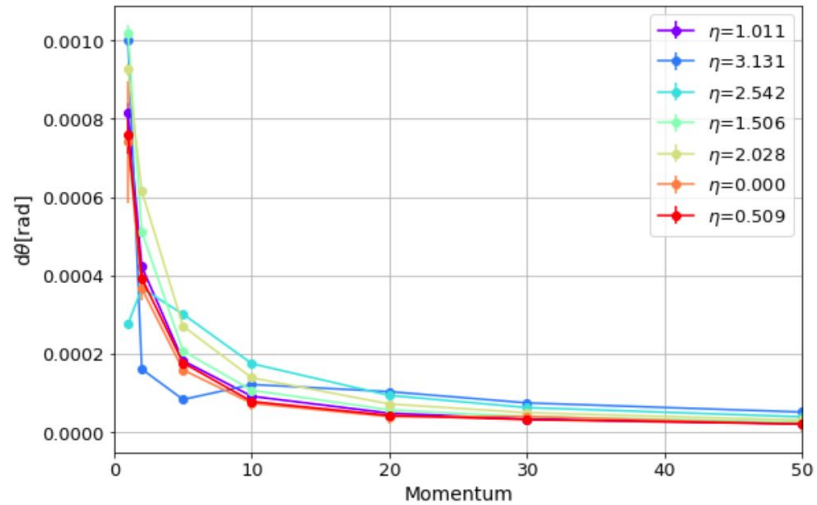
- Used single particle pion
- Fixed theta and p, evenly distributed phi (0 to 2π)
- 10000 events



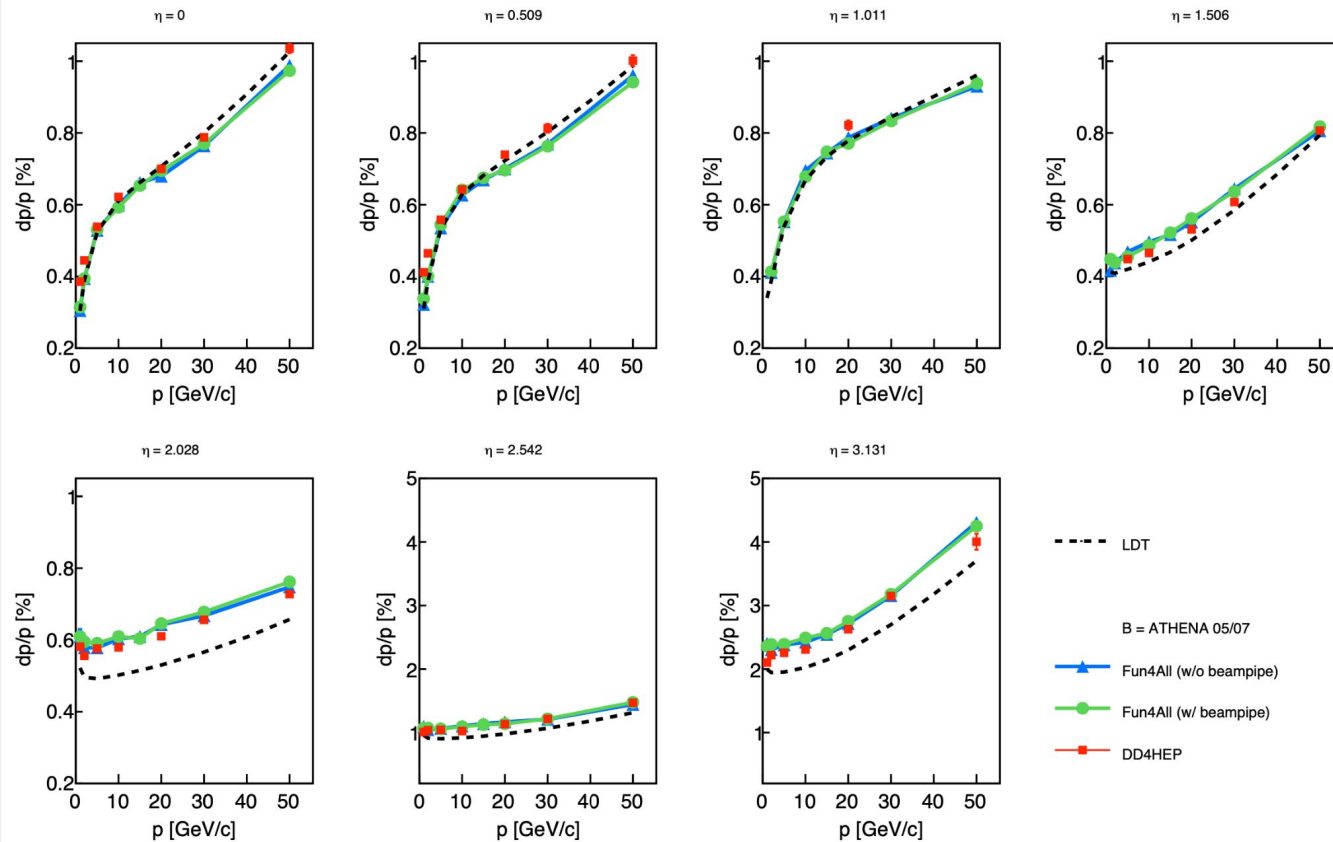
Momentum Resolution (markers: Acts, dashed line: fast simulation from Ernst)



Angle Resolution

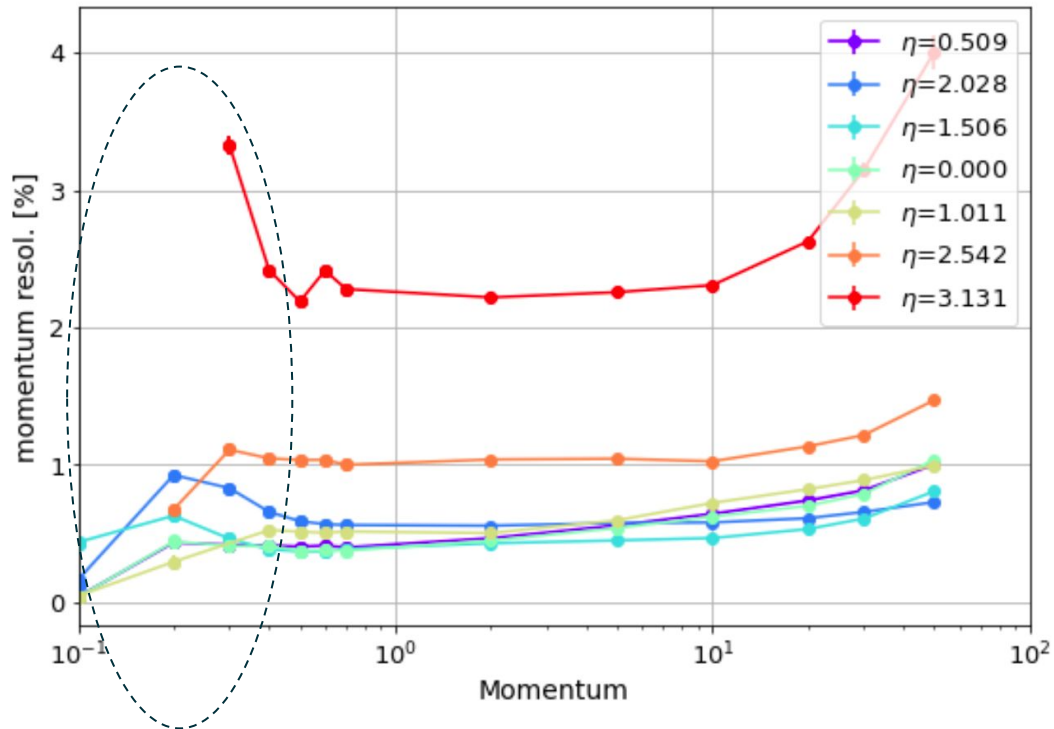


Momentum Resolution benchmarks (courtesy of Rey)



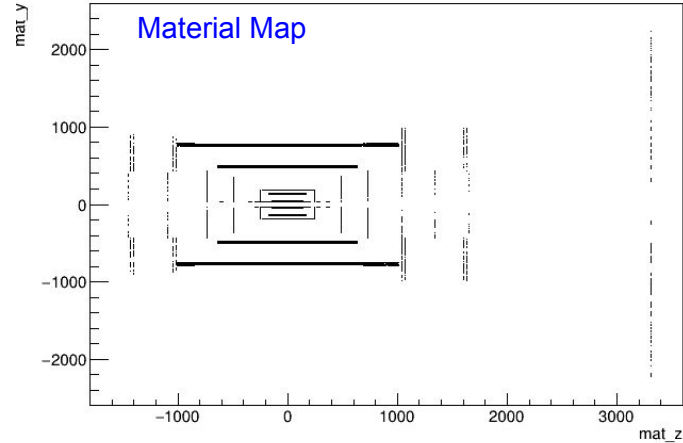
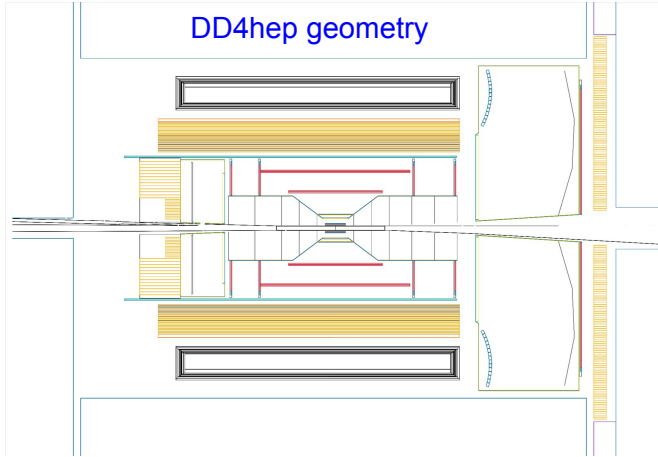
Low momentum reconstruction

Baseline 0



Bad fitting quality, distributions not Gaussian

3. Material map for Baseline 2

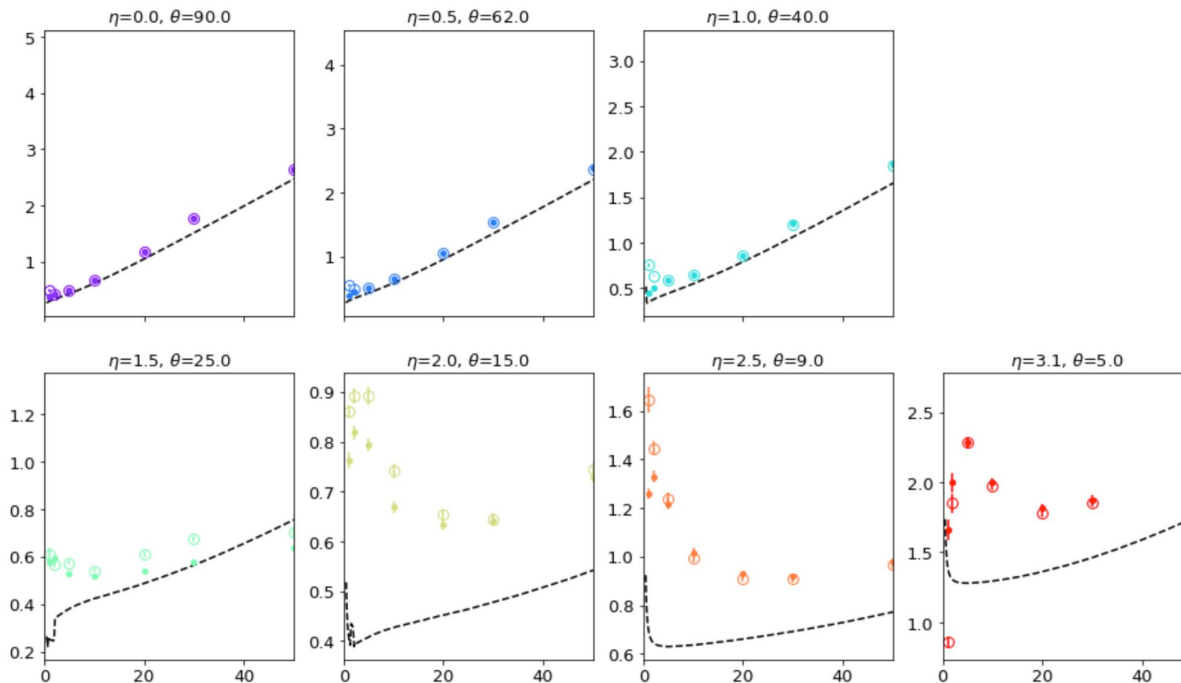


- Project materials along the Geantino trajectory (fixed eta) to the nearest entrance/exit tracker surfaces as well as the central beampipe
- 36 bins in phi and 50 bins in R and Z
- Shipped with the latest ATHENA simulation (thanks to Wouter!)

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:

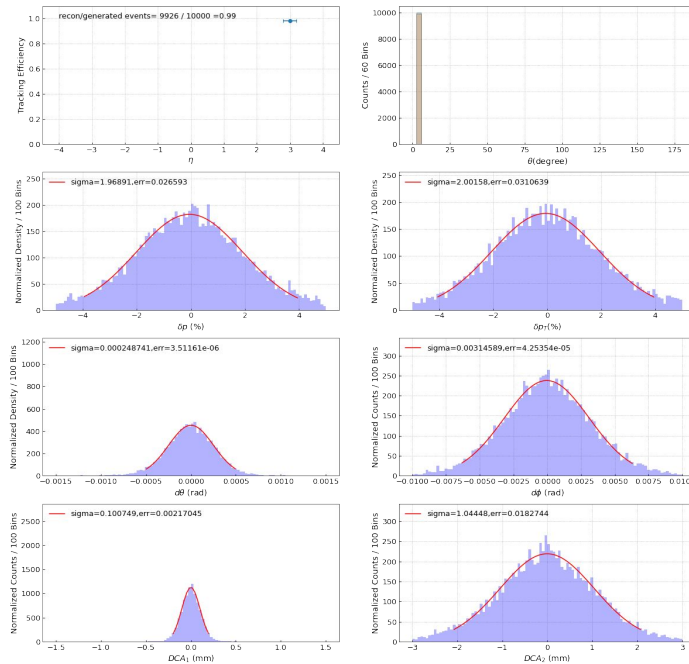
p=10 GeV, theta=5 degree

Tracking performance (Truth Init.)

mc_hybrid_711_p10_10_th5_5_n10000_ch25.root

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

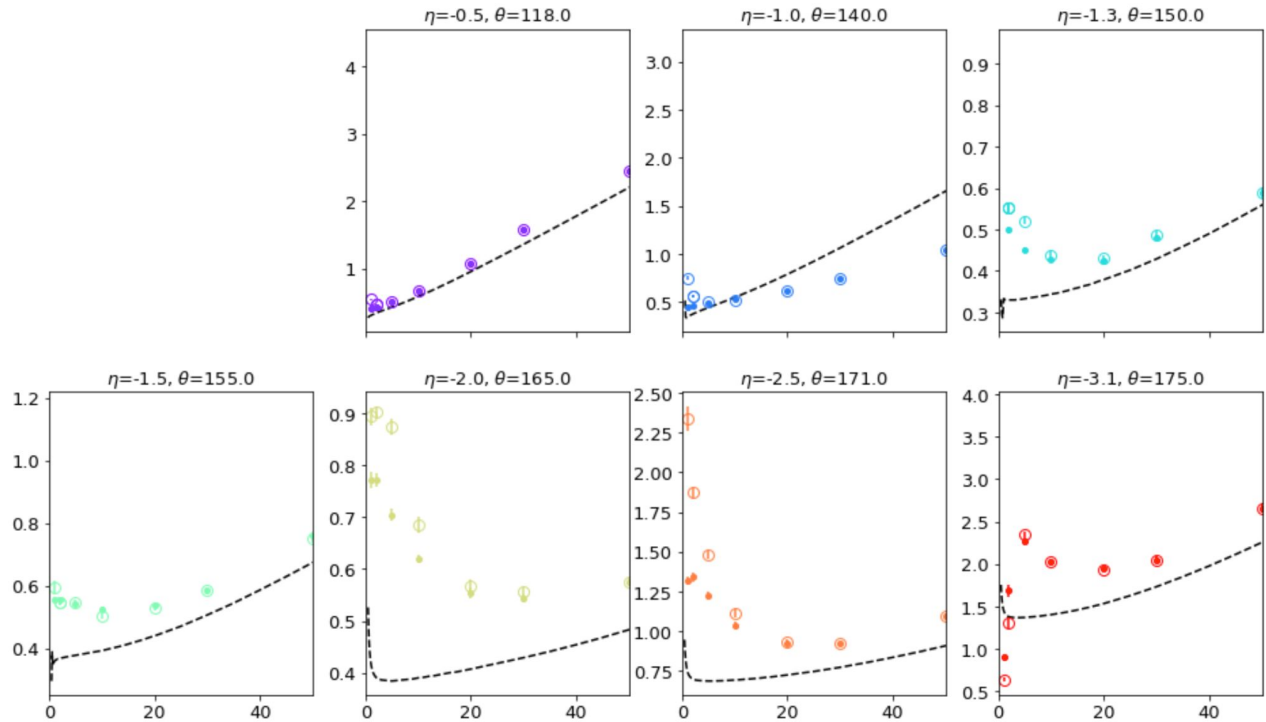
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Momentum Resolution (dpp v.s. p)

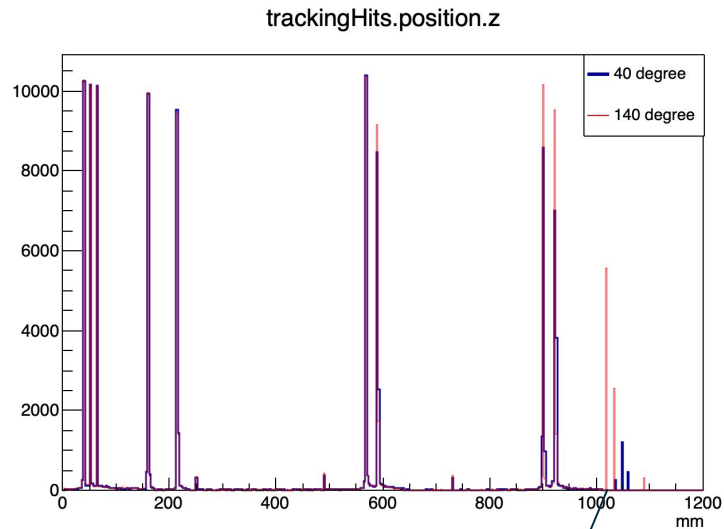
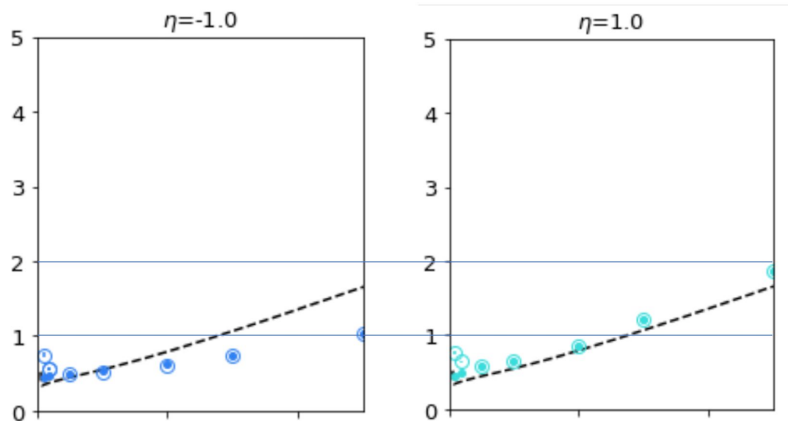
Backward region:

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



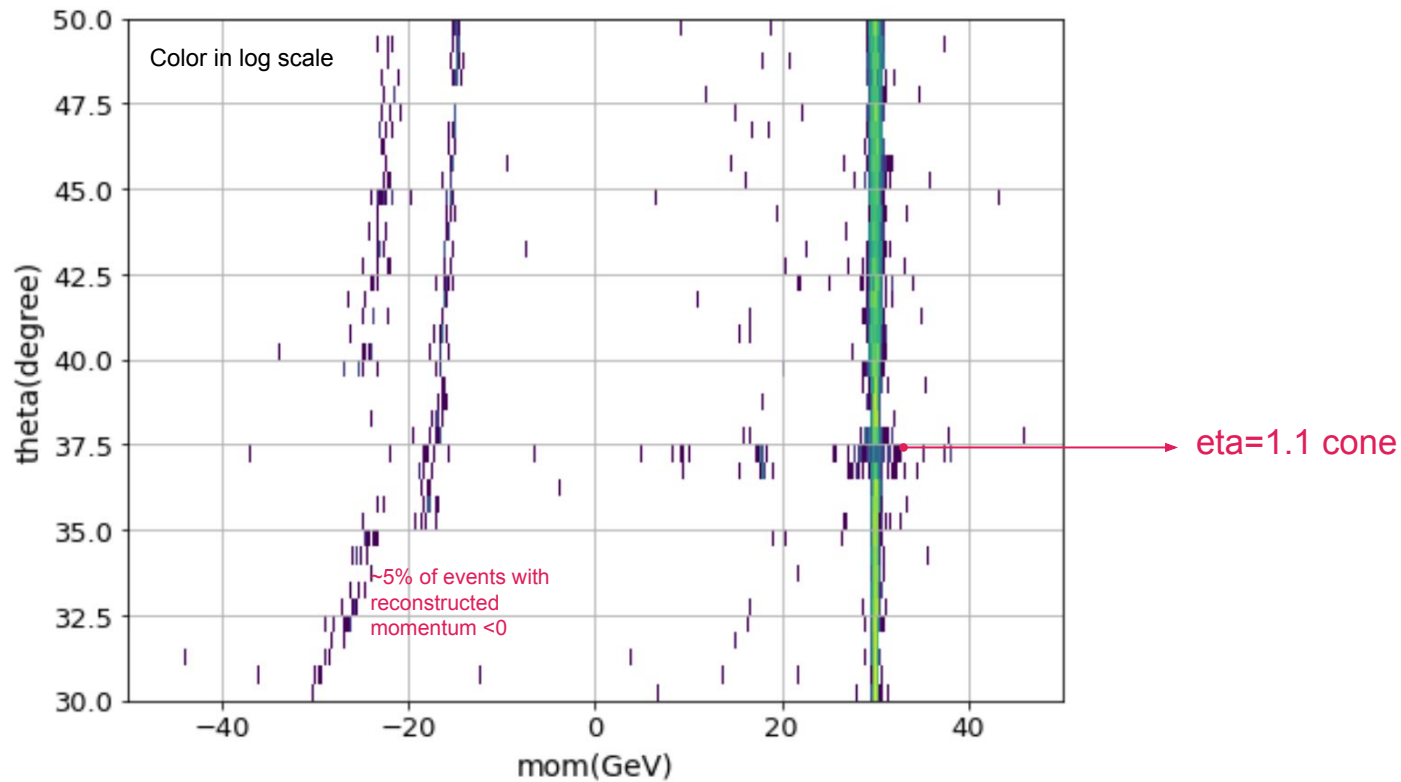
Momentum Resolution (dpp v.s. p)

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



First GEM ring at -1.03m

Reconstruction in the transition region



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

