Athena Tracking Discussion Questions

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Bi-Weekly Meeting

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Simulation Frameworks

Two simulation frameworks

1. **Fun4All**
   - Carried over from Yellow Report
   - Currently used by tracking working group
     - Framework known from Yellow Report
     - Quick studies could be performed
     - Uses truth seeding with hit smearing
     - Mainly only tracking sub detectors
   - Now migrating over to official Athena simulation framework

2. **Athena simulation framework**
   - Being actively developed
   - DD4Hep – Geometry
   - ACTS – Track/vertex reconstruction
   - GAUDI– Clustering/digitization
   - Implement full simulation (all sub detectors)
     - Accurate material budget

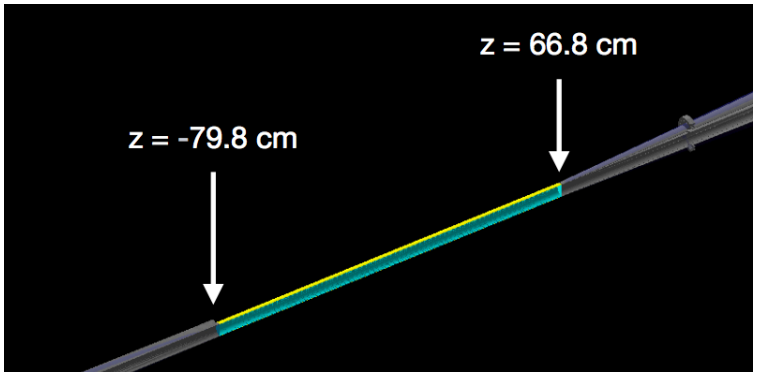
Detector Configurations: Simulation Setup

To start two minimal detector concepts were studied in Fun4All

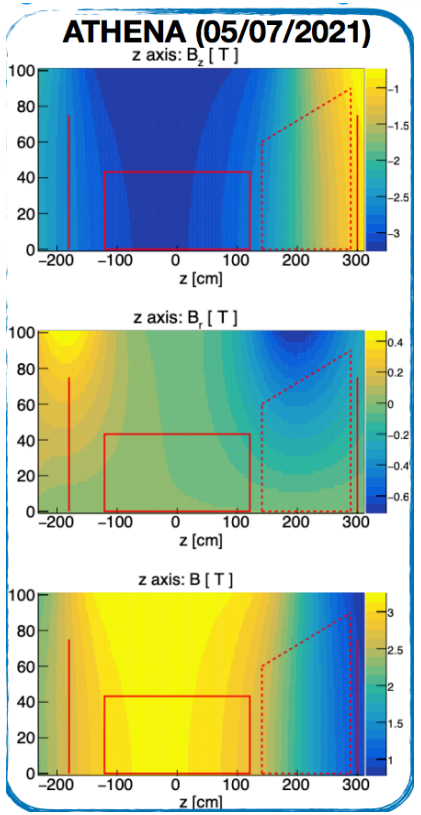
- Simulation details (Fun4All)
  - Athena solenoidal field (07 May 2021) was used
  - No background was implemented
  - Used truth seeding with hit smearing (detector resolution)
  - Detector material and details in next slides

Beam Pipe (details here)

- Central
  - Vacuum inside
  - Beryllium
    - r = 3.1 cm, t = 760 μm
  - 2 μm Au coating
- Al Forward and Backward pipe

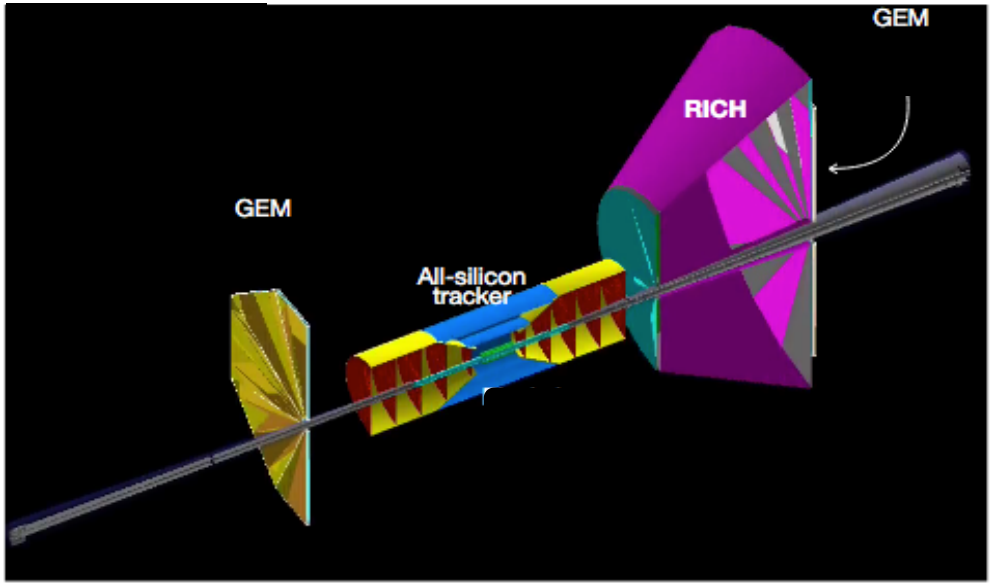


Rey et. al.



Detector Configurations: Minimal Configuration (1)

1. B-0.0,P-0.0,N-0.0 (all-silicon + 1+1 GEMs)



Silicon

- 2 vertex layers, 0.05% X/X_0
- 2 + 2 barrel layers, 0.55% X/X_0
- 5 disks per side, 0.24% X/X_0
- All with 10 μm pixel pitch

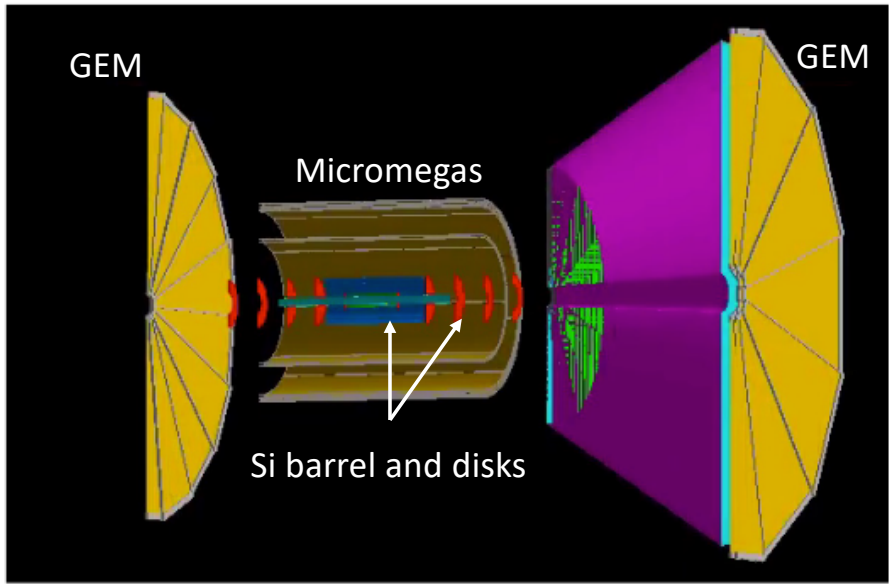
GEM

- 1 on N and 1 on P
- 0.7% X/X_0
- 250 μm in R
- 50 μm in Rϕ

- Full presentation from Rey: https://indico.bnl.gov/event/12293/contributions/51959/attachments/35876/58721/210713_performance_update.pdf

Detector Configurations: Minimal Configuration (2)

2. B-1.0, P-1.0, N-1.0 (Si + Micromegas barrel + 1+2 GEMs)



Silicon

- 3 vertex layers, 0.05% X/X_0
- 2 barrel layers, 0.55% X/X_0
- 5 disks per side, 0.24% X/X_0
- All with 10 μm pixel pitch

Micromegas

- 2+4 layers, 0.4% X/X_0
- 150 μm in z
- 150 μm in Rϕ

GEM

- 1 on N and 2 on P
- 0.4% X/X_0
- 250 μm in R
- 50 μm in Rϕ

- Full presentation from Nick and Athira:
  https://indico.bnl.gov/event/12293/contributions/51958/attachments/35871/58751/2021_07_13_HybridUpdate_1.1.pdf

Detector Configurations: Detector Specs

- Reference detector details on integration wiki:

  https://wiki.bnl.gov/athena/index.php/Tracking

- Easy reference to baseline detector configuration info via Integration page:

  https://wiki.bnl.gov/athena/index.php/Integration

On integration page

Current Configurations [edit]

Explanation of configuration labels can be fo

- Baseline (B-0.0, P-0.0, N-0.0)
- Baseline+ (B-1.0, P-1.0, N-1.0)

Barrel B-1.0 [edit]

- Silicon Tracker
- MPGD (cylindrical)
- HP-DIRC
- EMCAL
- HCAL (Fe/Sc)

Forward P-1.0 [edit]

- GEM/MMG Layer
- Silicon Disks
- The rest same as in Baseline_Configuration

Backward N-1.0 [edit]

- GEM/MMG Layer
- Silicon Disks
- The rest same as in Baseline_Configuration

MPGD Trackers (B-1.0) [edit]

Micromegas Barrel (2 + 4 barrel layers)

R (cm)	Length (cm)	Resolution	Active Area Material (X/X0 %)
47.715	188.0	150 um (r-phi) x 150 um (z)	0.4
49.57	188.0	150 um (r-phi) x 150 um (z)	0.4
71.89	188.0	150 um (r-phi) x 150 um (z)	0.4
73.75	188.0	150 um (r-phi) x 150 um (z)	0.4
75.61	188.0	150 um (r-phi) x 150 um (z)	0.4
77.47	188.0	150 um (r-phi) x 150 um (z)	0.4

Detector Configurations: Material

1) *What is the full material budget for the all-silicon tracker, both in the barrel and also in each endcap? For the hybrid tracker? How realistic is their description in the full simulation so far?*

Detector Configurations: Material

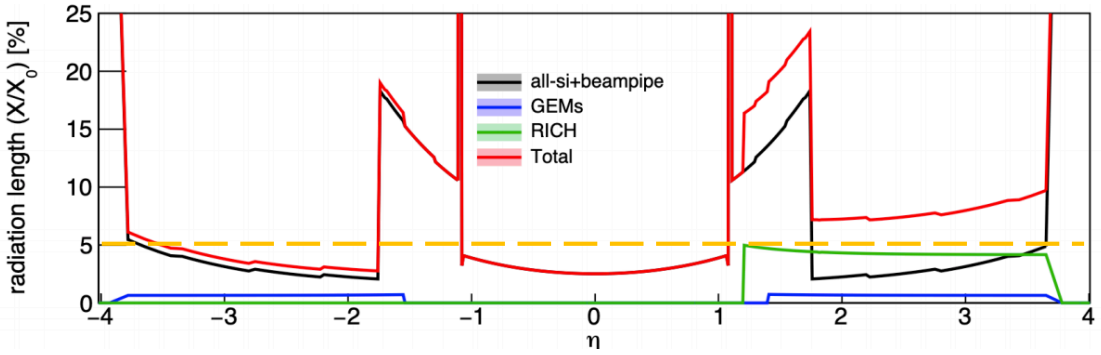
- Material in Silicon active area is estimated from extrapolation of ITS2 material budget using the ITS3 sensor power consumption (https://indico.bnl.gov/event/8231/contributions/37955/)
  - Applies to both baselines

❑ B-0.0, P-0.0, N-0.0 (All-Si)
  - **Silicon Detectors**
    - Has some support and service material estimate (e.g. the cone), but not realistic (simplified)
  - **GEMs**
    - Missing dead area material (GEM support frames)
    - Missing GEM disk support wheel and services

❑ B-1.0, P-1.0, N-1.0 (Hybrid)
  - **Silicon Detectors**
    - Missing support and service material
  - **Micromegas**
    - Includes dead area material (MM supports)
    - Missing barrel support (holds barrel in space) and services
  - **GEMs**
    - Includes dead area material (GEM support frames)
    - Missing GEM disk support wheel (holds disk in space) and services

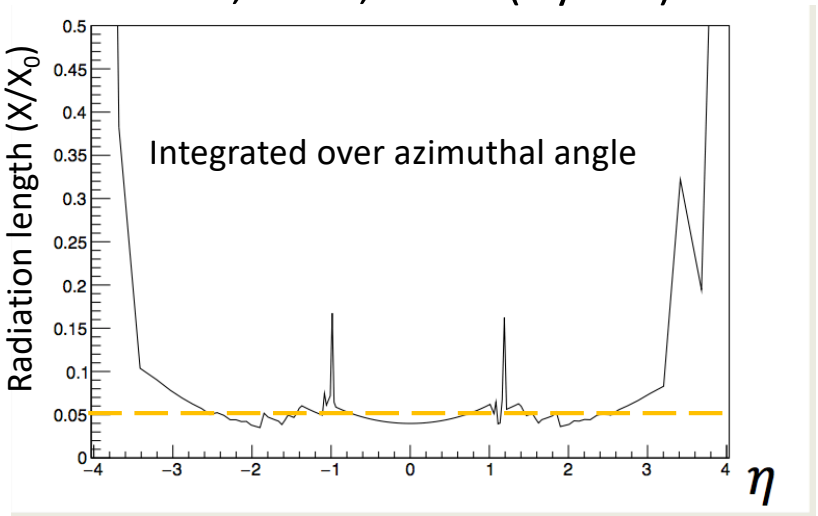
Detector Configurations: Material

B-0.0, P-0.0, N-0.0 (All-Si)



Missing Si support estimate included (not final)

B-1.0, P-1.0, N-1.0 (Hybrid)

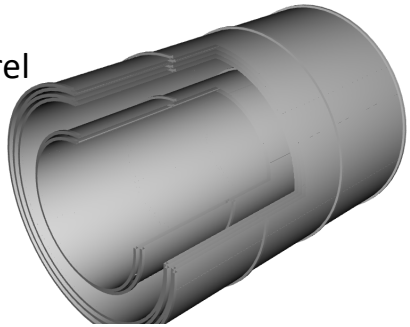


Does not include RICH material in scan
Missing Si support

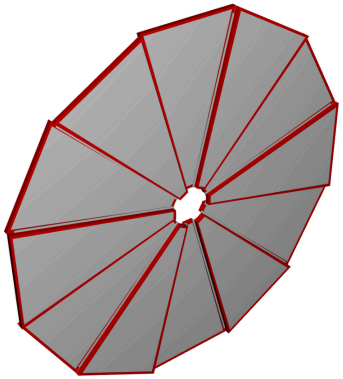
Detector Configurations: Material

1) *What is the full material budget for the all-silicon tracker, both in the barrel and also in each endcap? For the hybrid tracker? How realistic is their description in the full simulation so far?*

Micromegas Barrel
DD4Hep



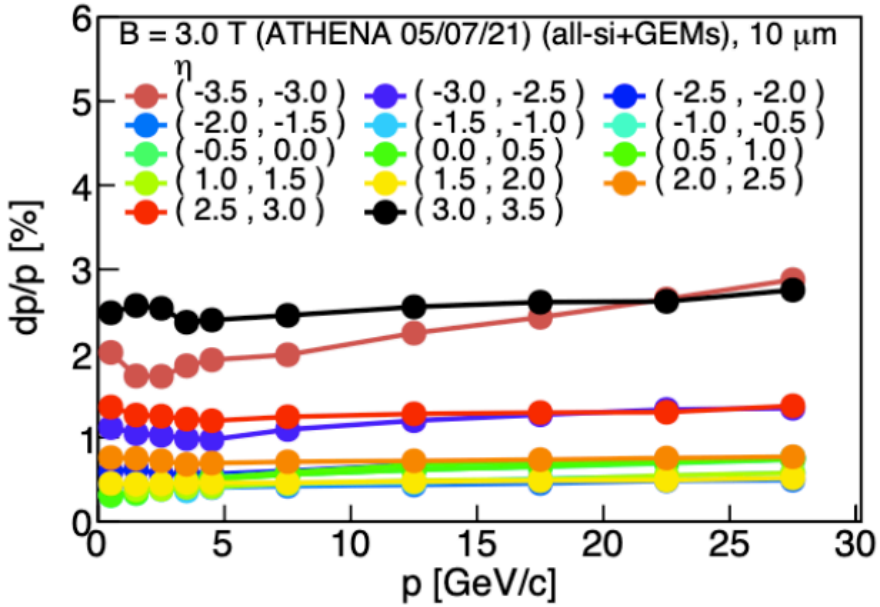
- Work is needed in DD4Hep to implement proper geometries
  - Silicon disk geometry and support material → currently working with project
  - Silicon barrel material → currently working with project
  - Micromegas barrel description implemented → being verified
  - GEM support ring and Micromegas barrel supports need to be implemented
- Accurate GEM tracker including active and dead (frames) areas are in DD4Hep

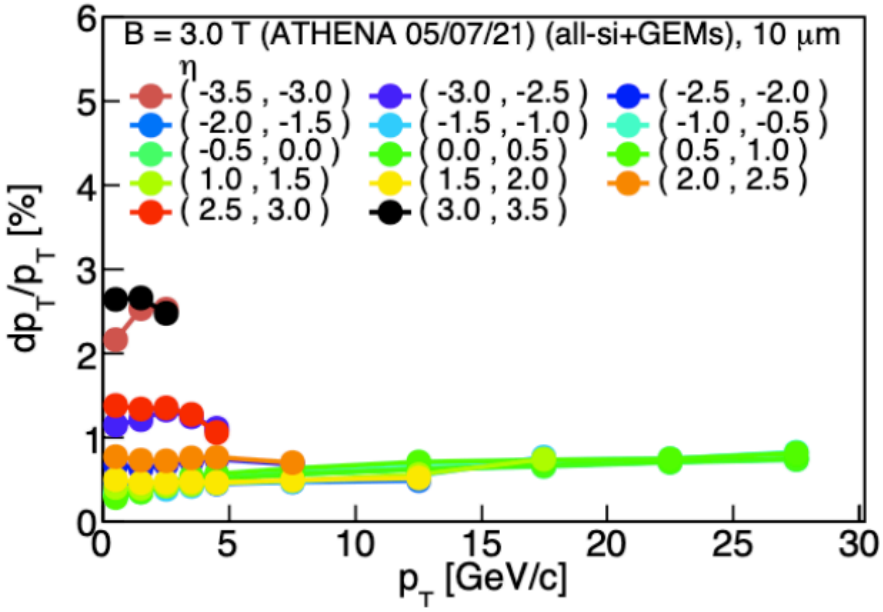


GEM Disks
DD4Hep

B-0.0,P-0.0,N-0.0: Momentum and p_T

2) What is the resolution in p and pT as a function of η?





B-1.0,P-1.0,N-1.0: Momentum

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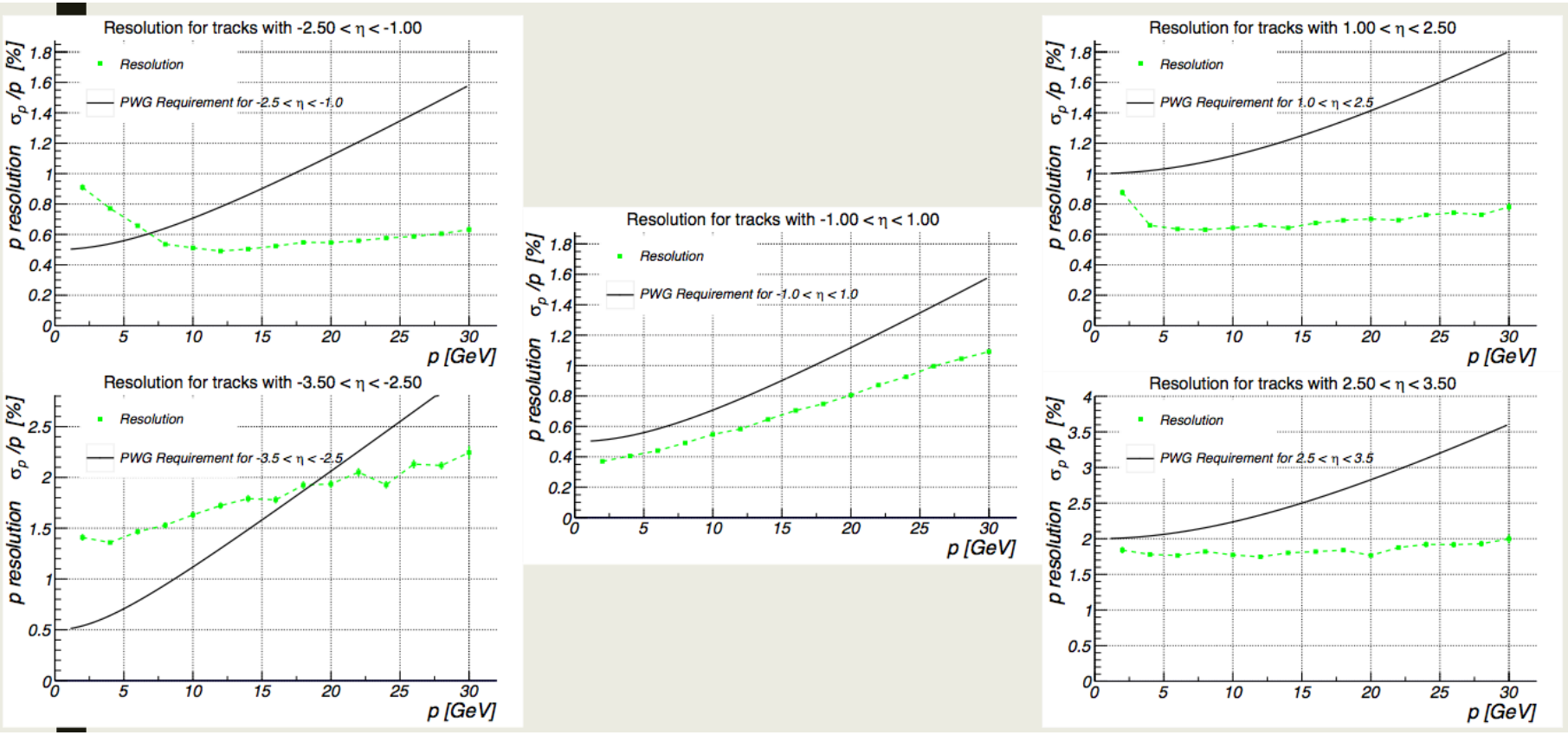
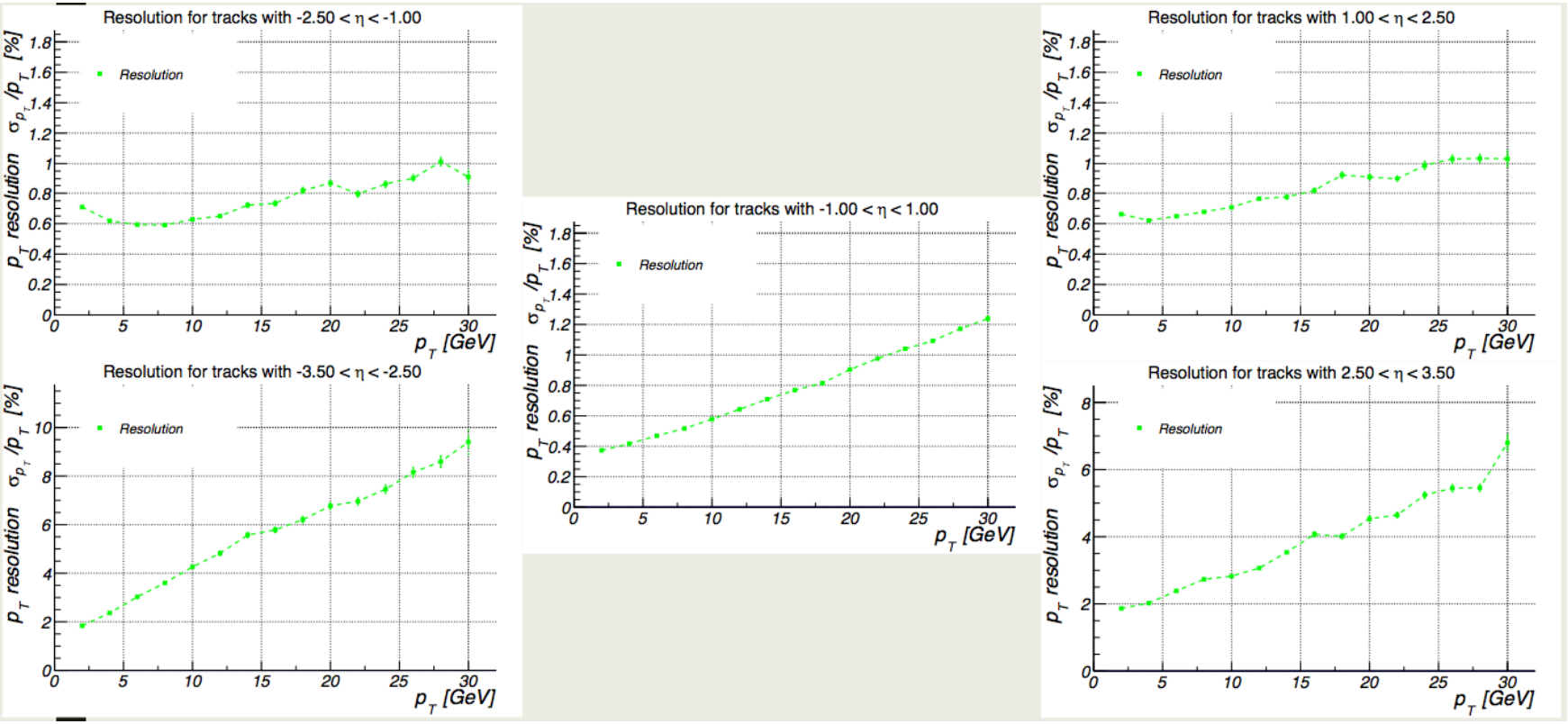


B-1.0,P-1.0,N-1.0: p_T

2) *What is the resolution in p and pT as a function of η?*



Detector Optimizations

3. *How wide is the dead area in eta arising from mechanical supports, rails, and cable connectors?*
   - Not known yet. We do not have this level of detail (see question 1)
4. *How does tracking work near the interface between barrel and disks?*
   - See Ernst's presentation
5. *How is the disk placement and number optimized?*
   - See Ernst's presentation

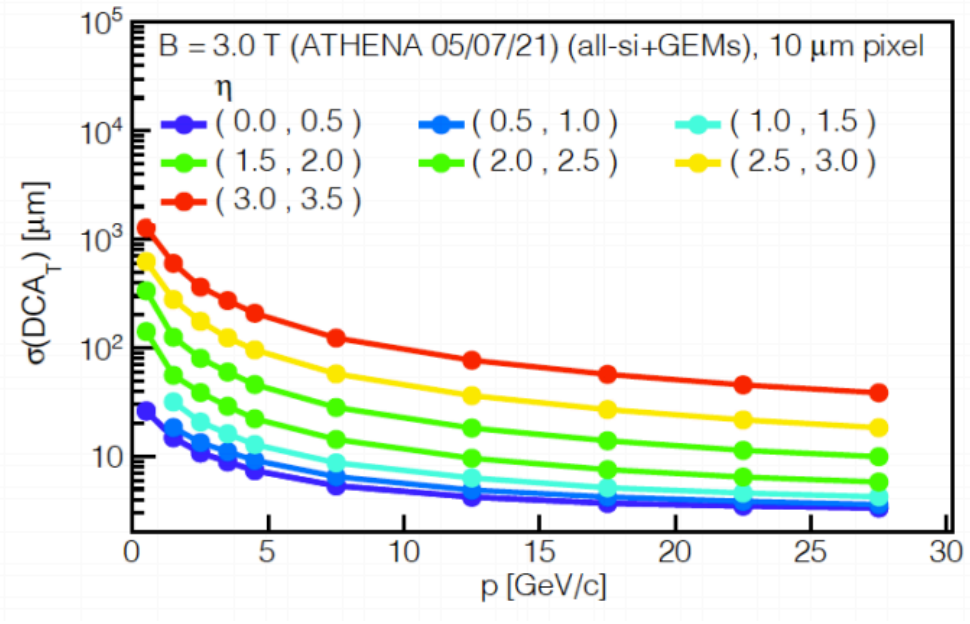
Pointing Resolution

6) What is the collision vertex resolution?

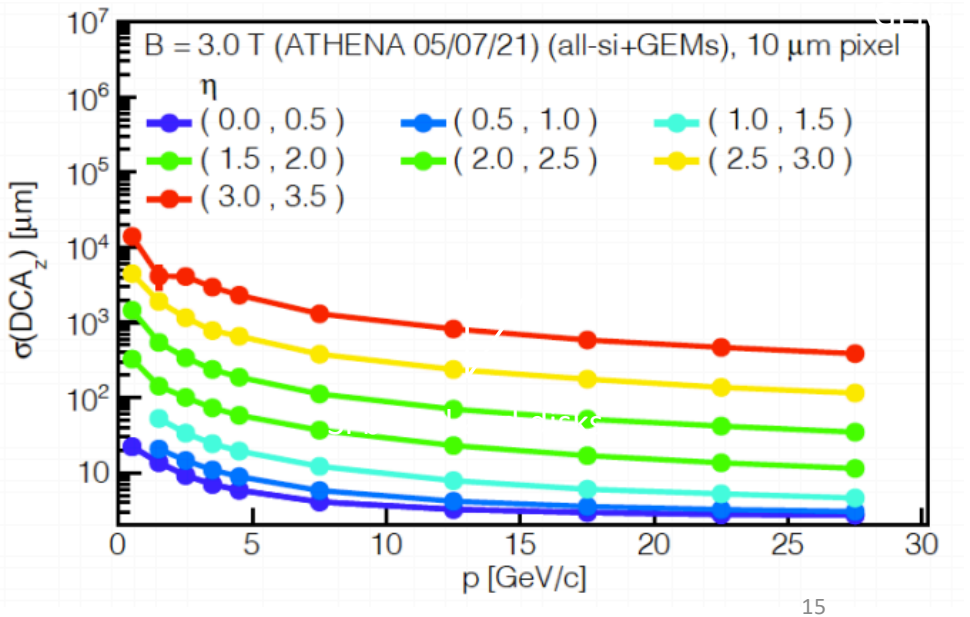
- Without vertexing algorithm and background, we can not answer this question.
- However we can look at pointing resolutions (w/o background, which uses truth seeding and hit smearing)

B-0.0, P-0.0,N-0.0

Transverse



Longitudinal



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B-1.0, P-1.0,N-1.0

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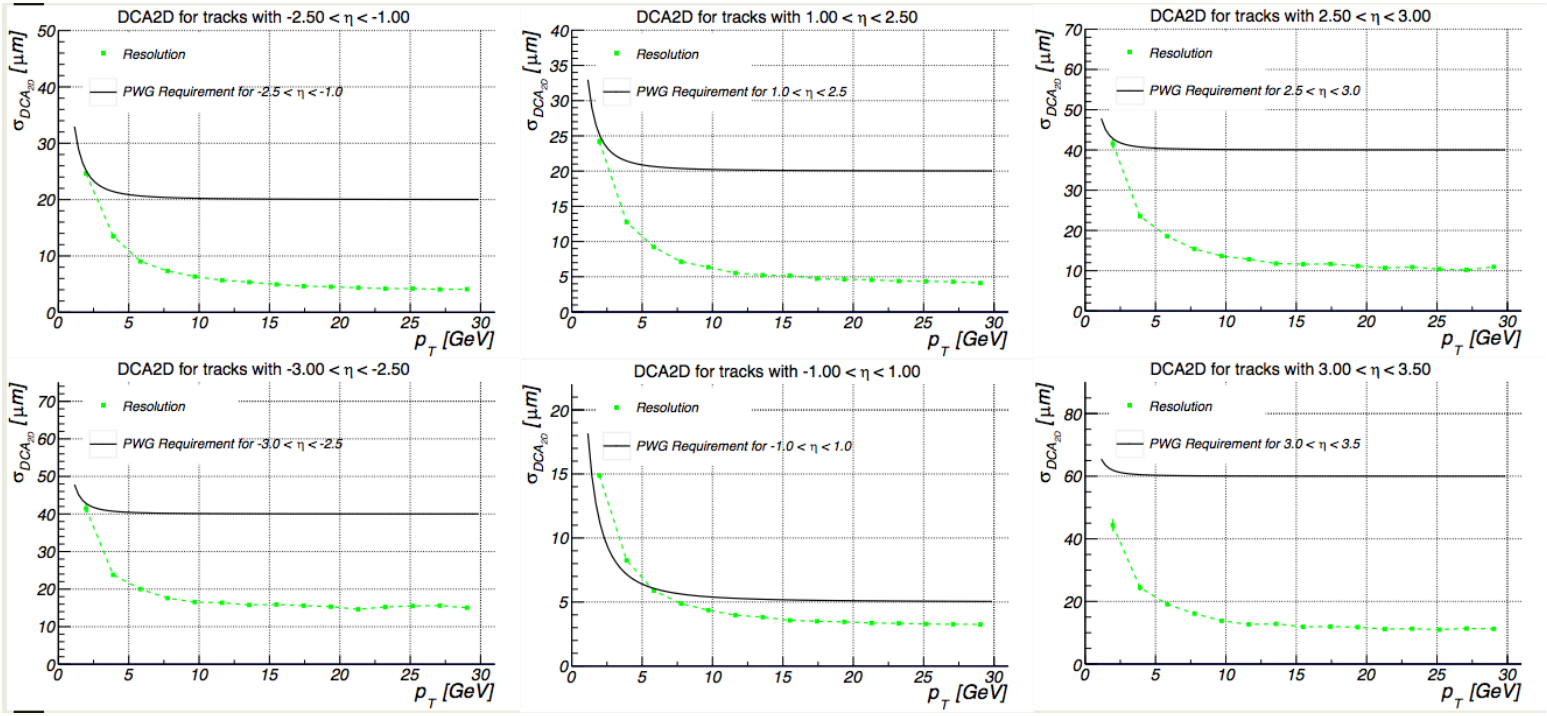

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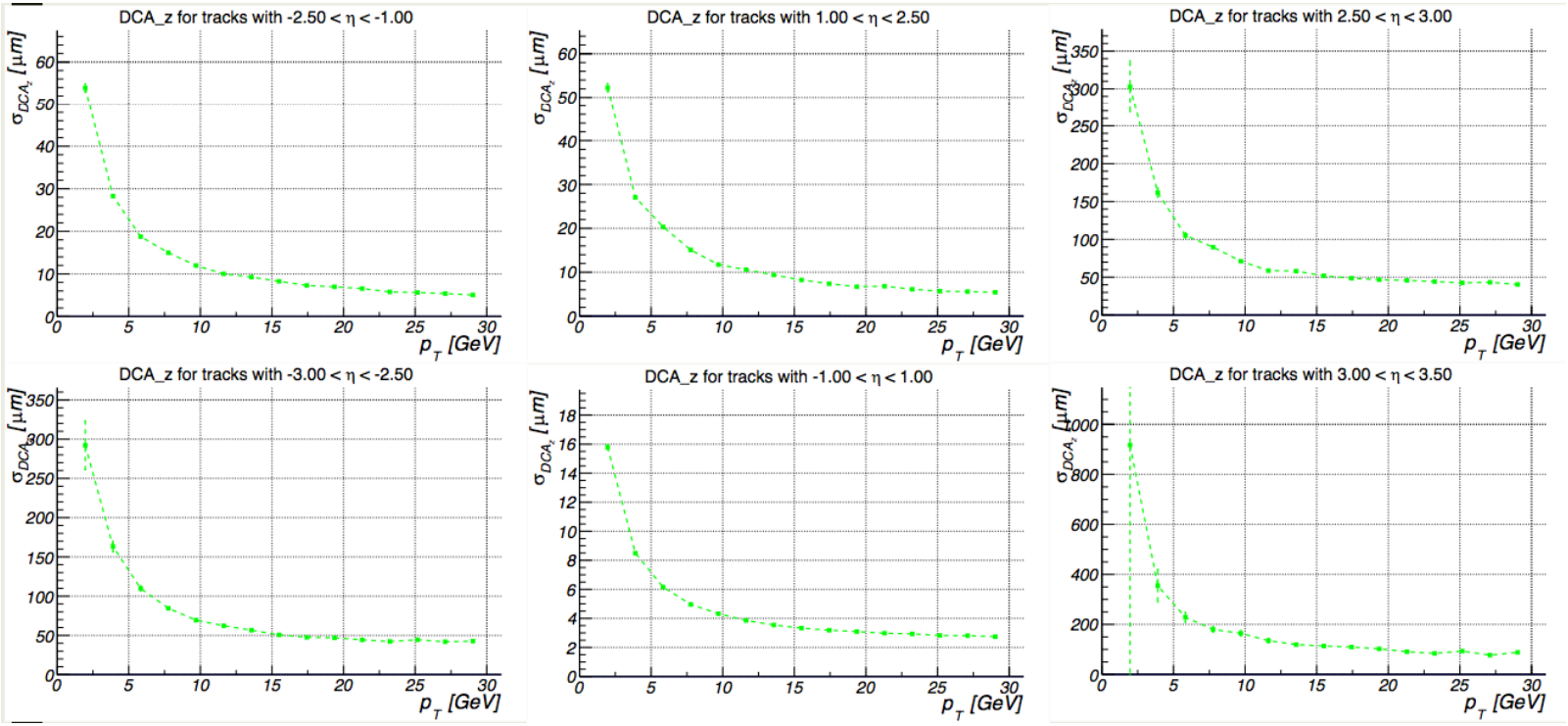
B-1.0, P-1.0,N-1.0
Longitudinal

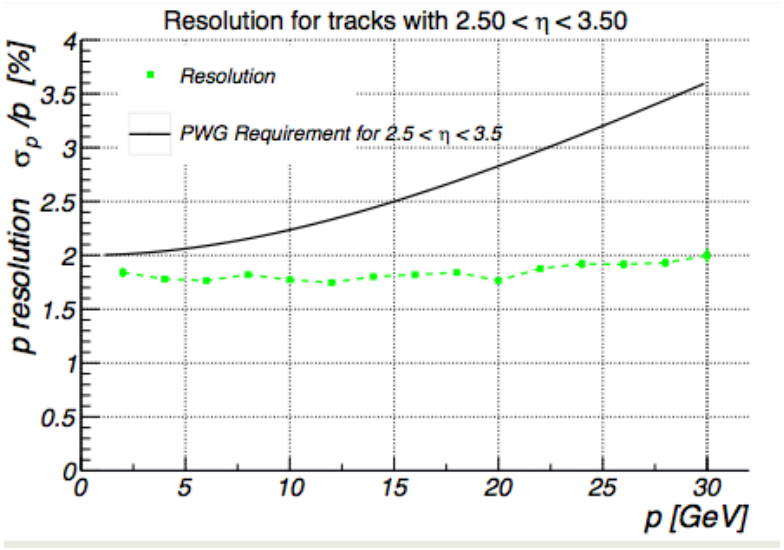


Detector Optimizations

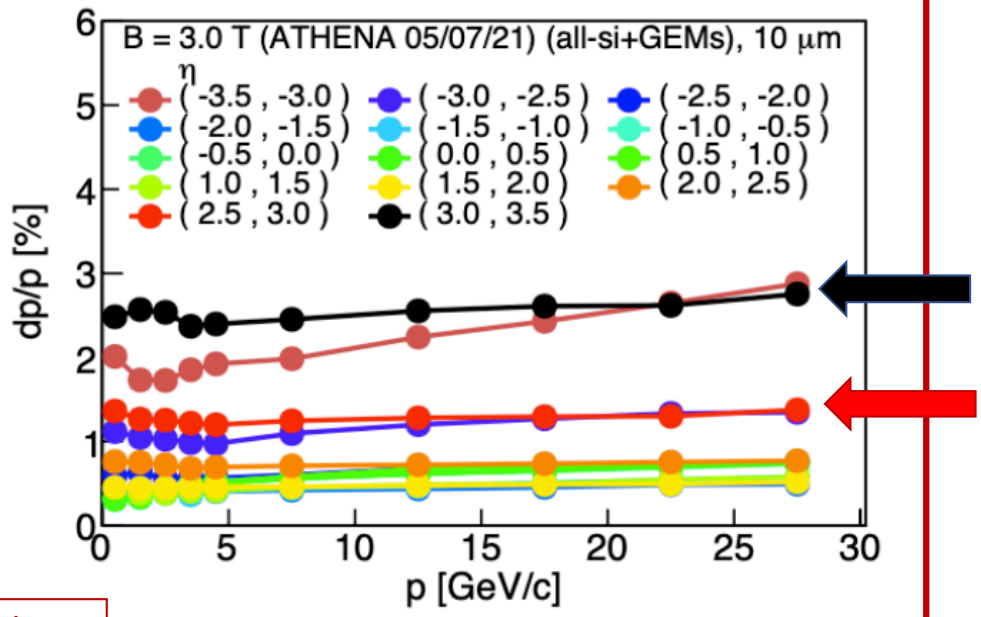
7) Should the tracker be centered around the collision vertex, or should it be offset to give more room and Bdl for high momentum particles in the hadron going direction?

- Our current simulations shows a possible issue at large η (3.0—3.5)

B-1.0,P-1.0,N-1.0 (Hybrid)



B-0.0,P-0.0,N-0.0 (All-Si)



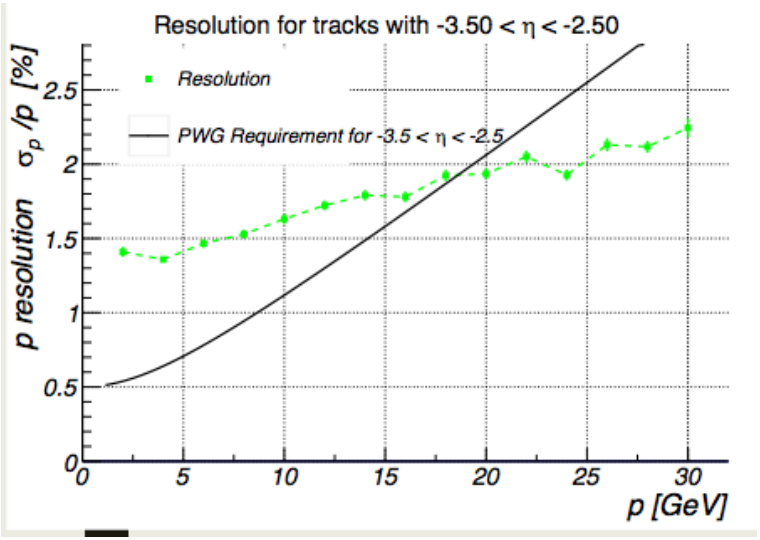
Hadron Direction

Detector Optimizations

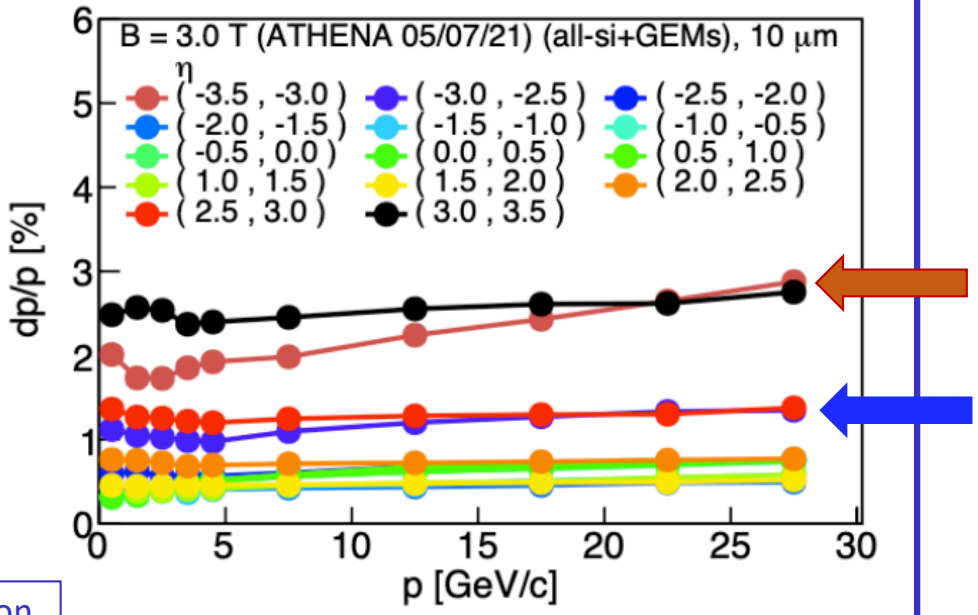
7) Should the tracker be centered around the collision vertex, or should it be offset to give more room and Bdl for high momentum particles in the hadron going direction?

- Low-mid momentum particles in electron direction at high eta are a bigger issue

B-1.0,P-1.0,N-1.0 (Hybrid)



B-0.0,P-0.0,N-0.0 (All-Si)



Electron Direction

Detector Optimizations

- Lacking person power with tracking expertise related to simulation and track reconstruction
  - Plan to involve several interested people without extensive experience once simulation is up and running

8) What are the plans to test tracking resolutions in PYTHIA events + synchrotron background? Who are the people responsible for this?

- Backgrounds needed (from project)
- Testing and assessing resolutions will be an effort between Tracking and Software WGs

9) What are the plans for testing track finding in the presence of background? What is the occupancy including noise and synchrotron radiation load?

- Effort between Tracking and Software WGs.
  - Software working group have base track finding, clustering and digitization codes they can implement – can be refined
- Occupancy including noise and synchrotron radiation load: unknown as we do not have background files

Detector Optimizations: MPGDs

10) For the hybrid tracker, how many MPGD layers are needed? Where do they go? What is full material budget (including active + services and supports)?

- MPGD location, and layer number greatly depends on other materials. It is critical to have accurate Si materials (including support) and PID materials to assess this question.
- Additional MPGD layers outperform hybrid baseline as more material is added
- Full integrated simulation with background and track finding is needed