ePIC MPGD Simulation Status and Needs

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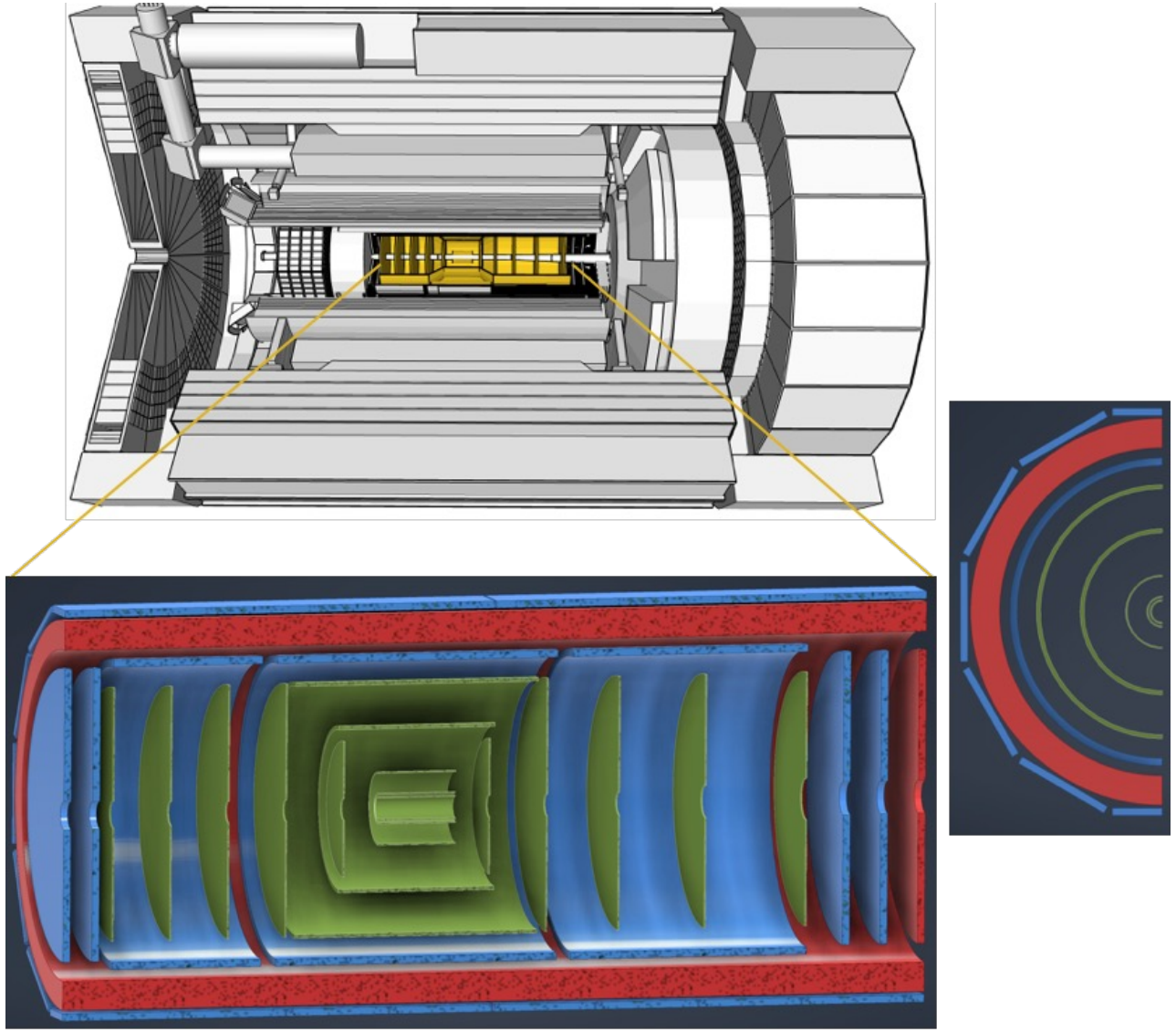
Outline

- **Overview of Current Simulation**
  - Geometry
  - Material
  - Digitization/Reconstruction
- **Ongoing Work**
  - Geometry
  - Angular resolution
- **Simulation Needs**
  - Geometry/Services
  - Digitization/Reconstruction
  - Studies

ePIC Central Tracking Layout Overview: Crater Lake



MAPS Barrel + Disks MPGD Barrels + Disks AC-LGAD based ToF

- ePIC tracking system is a hybrid of silicon and gaseous technologies

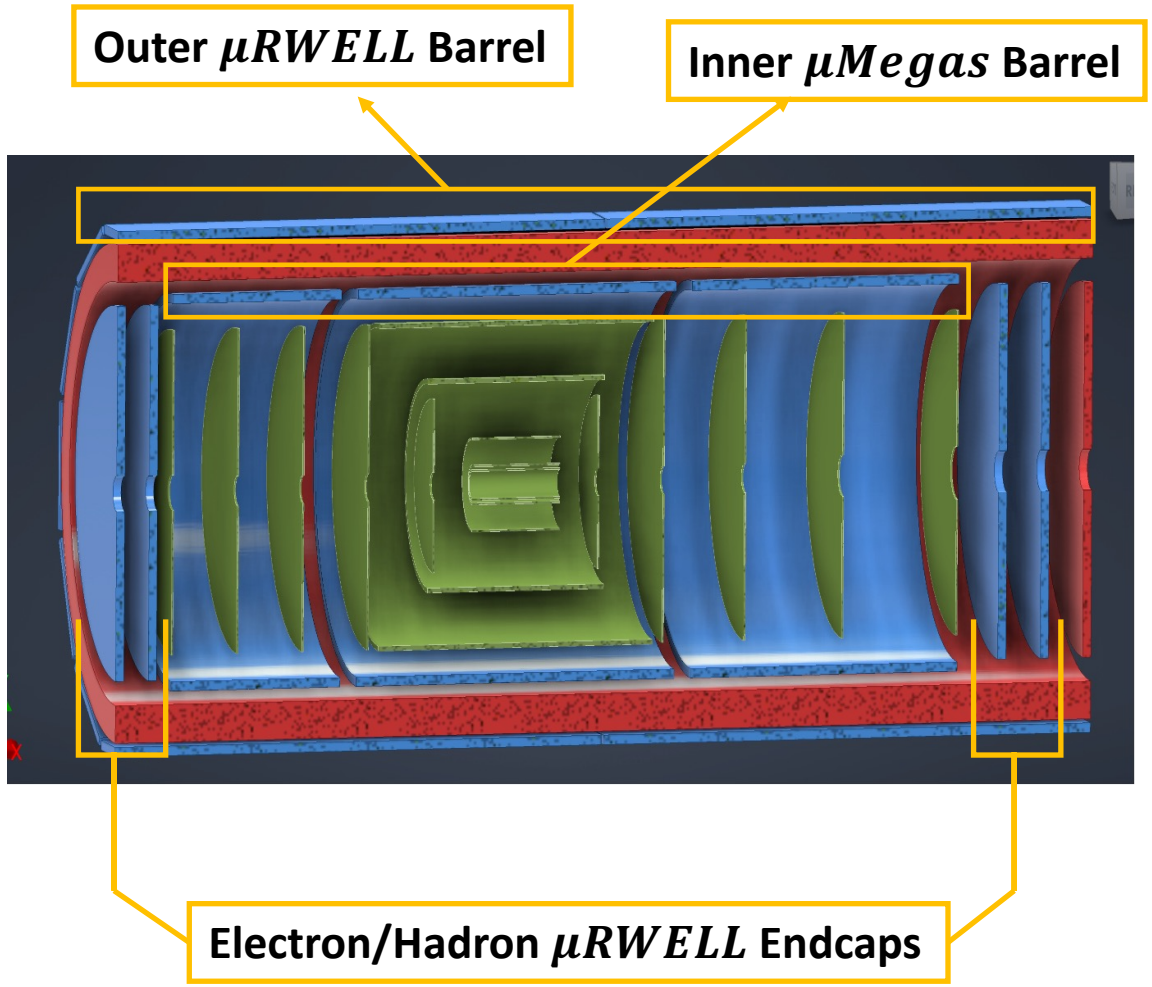
- **MAPS Layers**
  - Make up inner tracking volume
  - Highly granular and low mass layers to provide excellent momentum resolution and precision pointing resolution

- **MPGD Layers**
  - Large area detectors are instrumented in the outer tracking volume
  - Provide timing and pattern recognition
  - Planar detectors can provide impact point and direction for PID seeding

- **AC-LGAD**
  - Fast detector to provide low momentum PID.
  - Can provide an additional space point for pattern recognition/redundancy

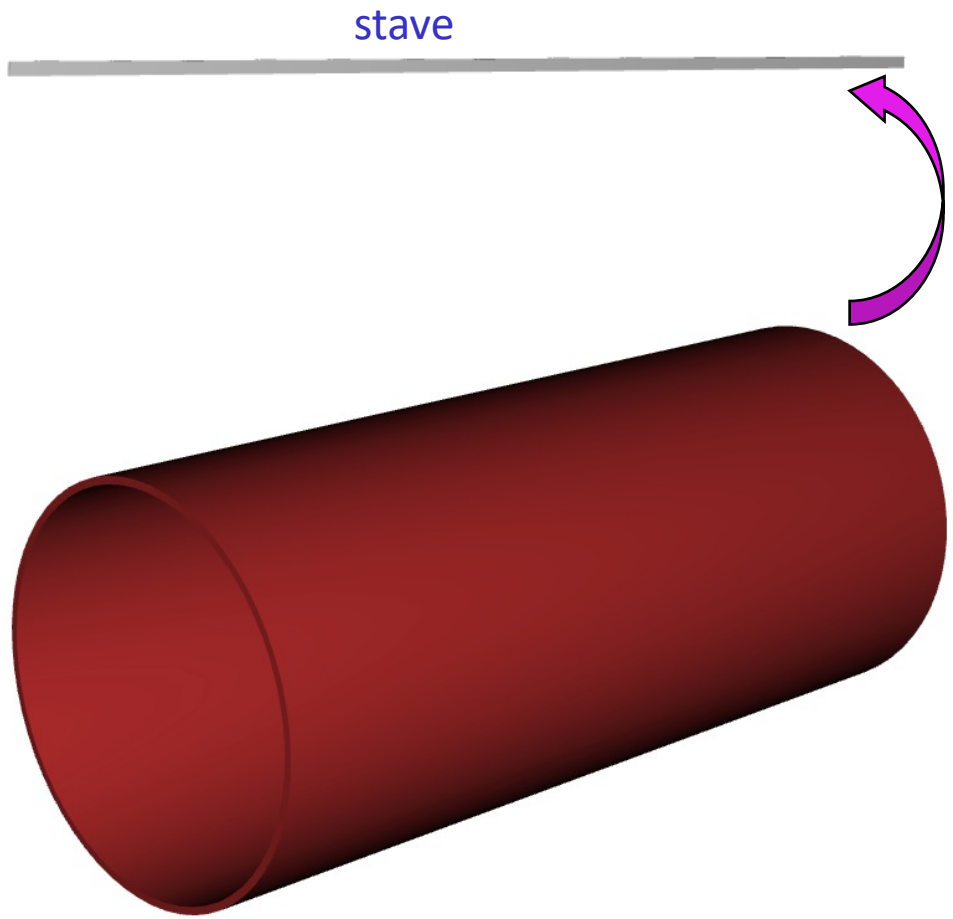
Crater Lake MPGD Detectors

- MPGD detectors based on two technologies:
  - $\mu Megas$ (curved layers) and
  - $\mu RWELL$ (planar layers)



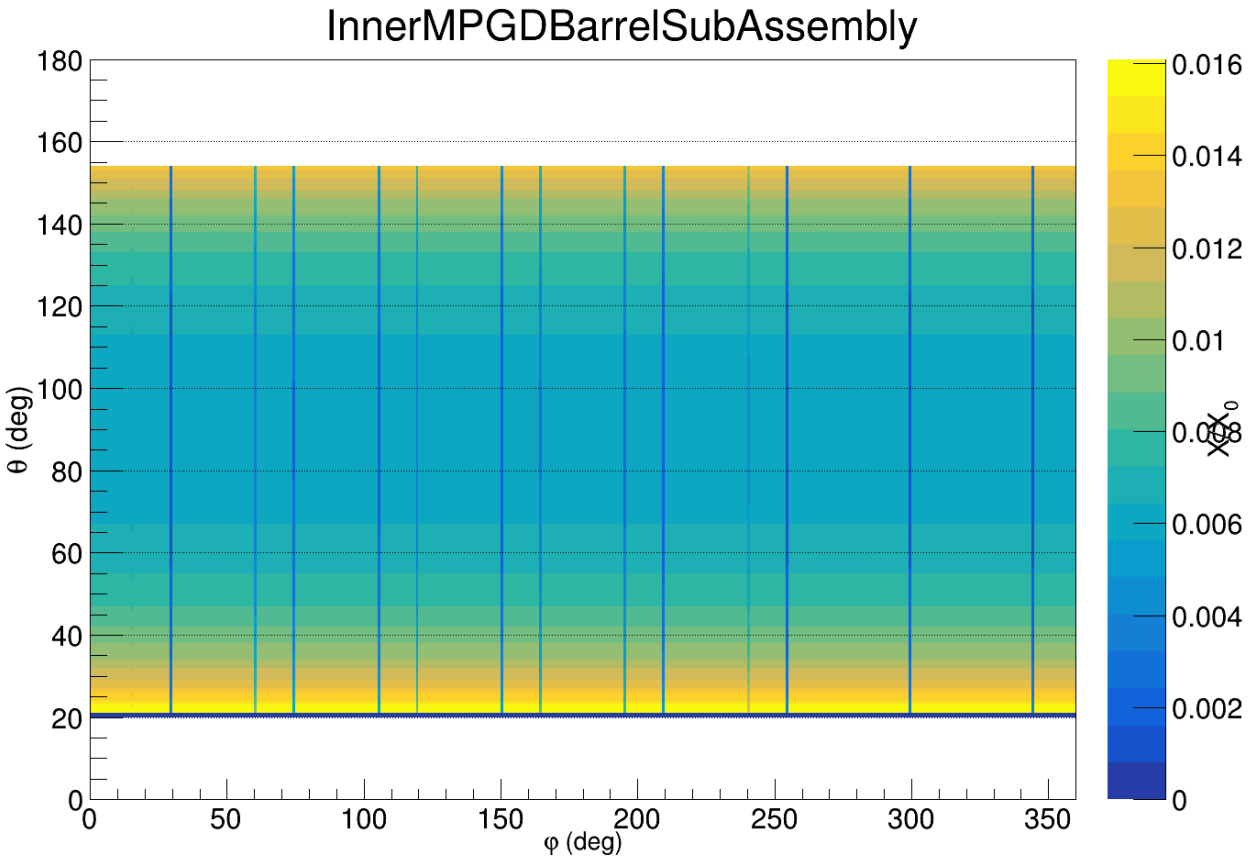
Current Status: MicroMegas Barrel

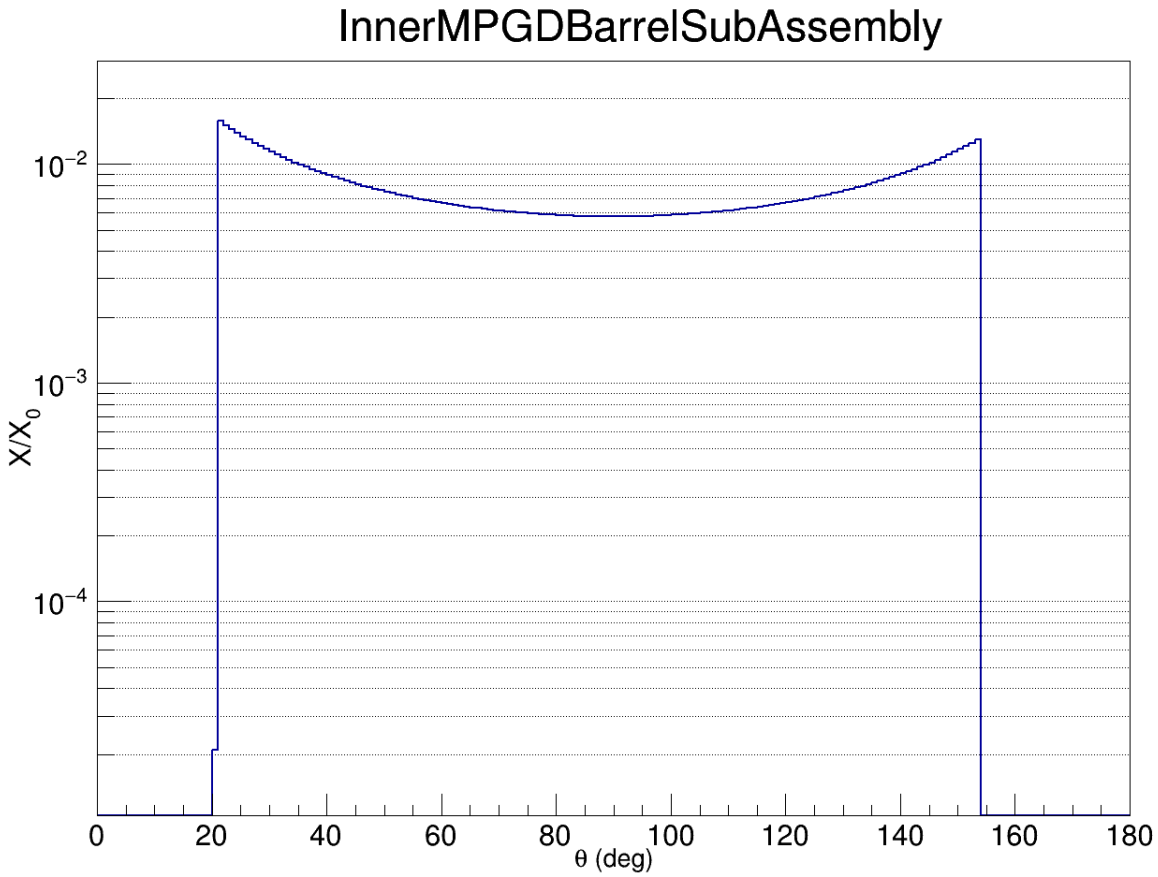
- Curved layer based on MicroMegas technology
- Approximate cylinder using 128 staves
  - Width = 2.47cm
- Barrel:
  - L = 240 cm
  - R = 51.25 cm



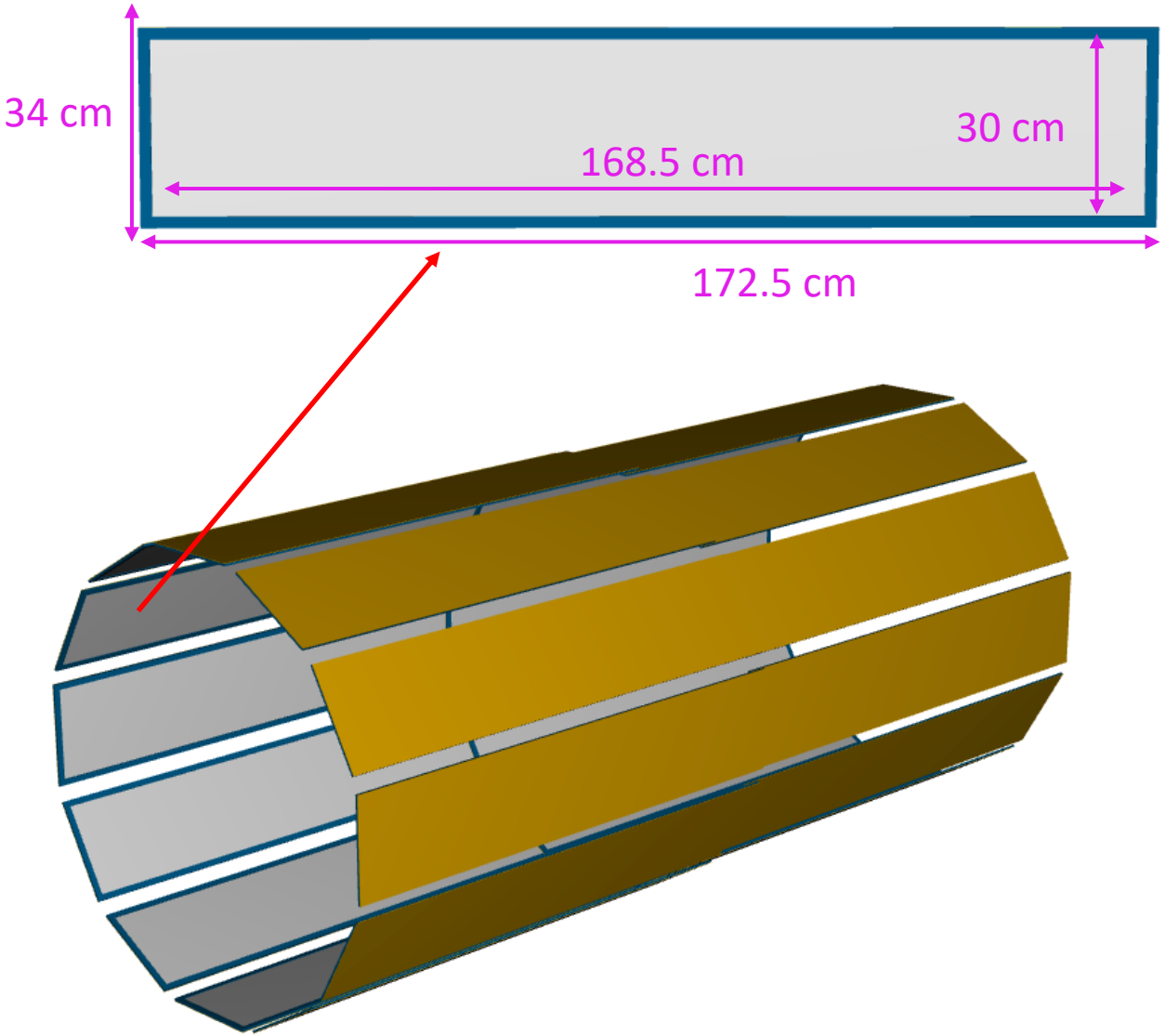
Current Status: MicroMegas Barrel

❑ Material Budget





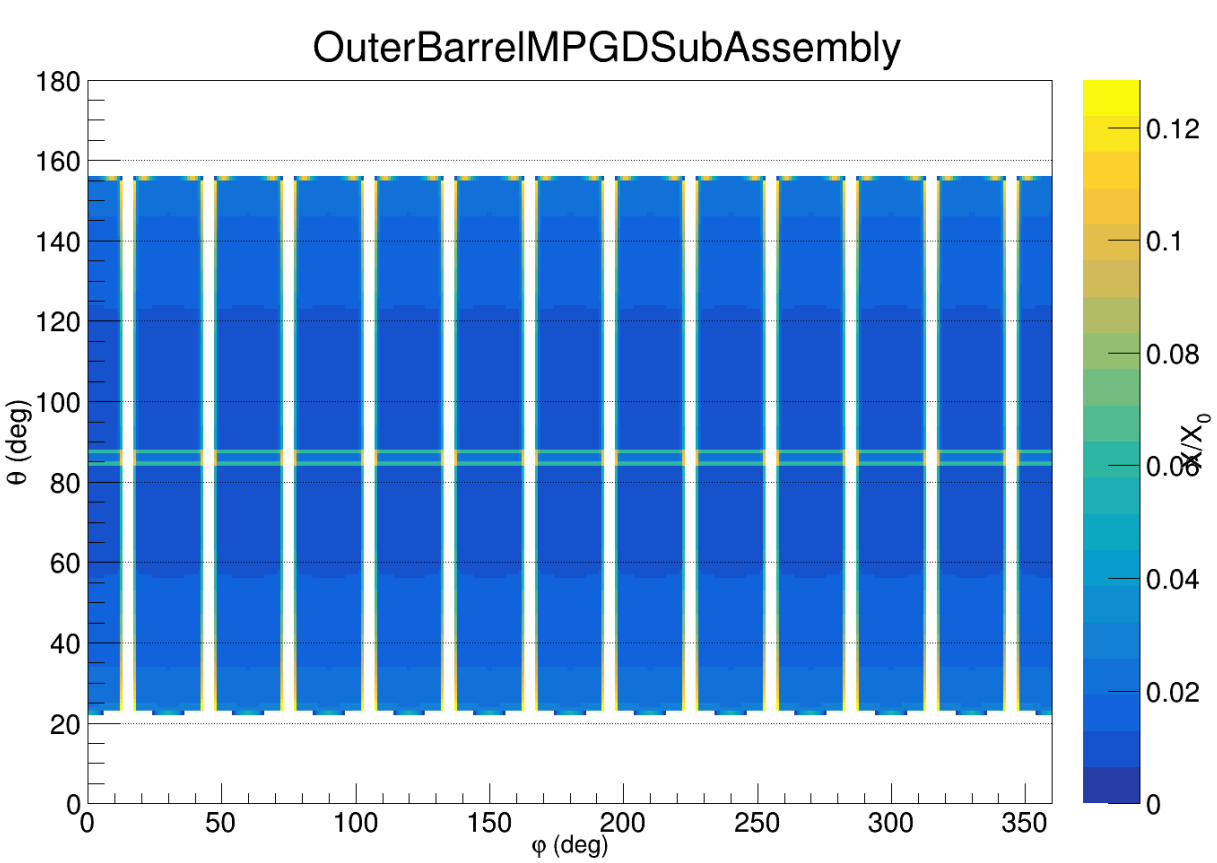
Current Status: μRWELL Outer Barrel

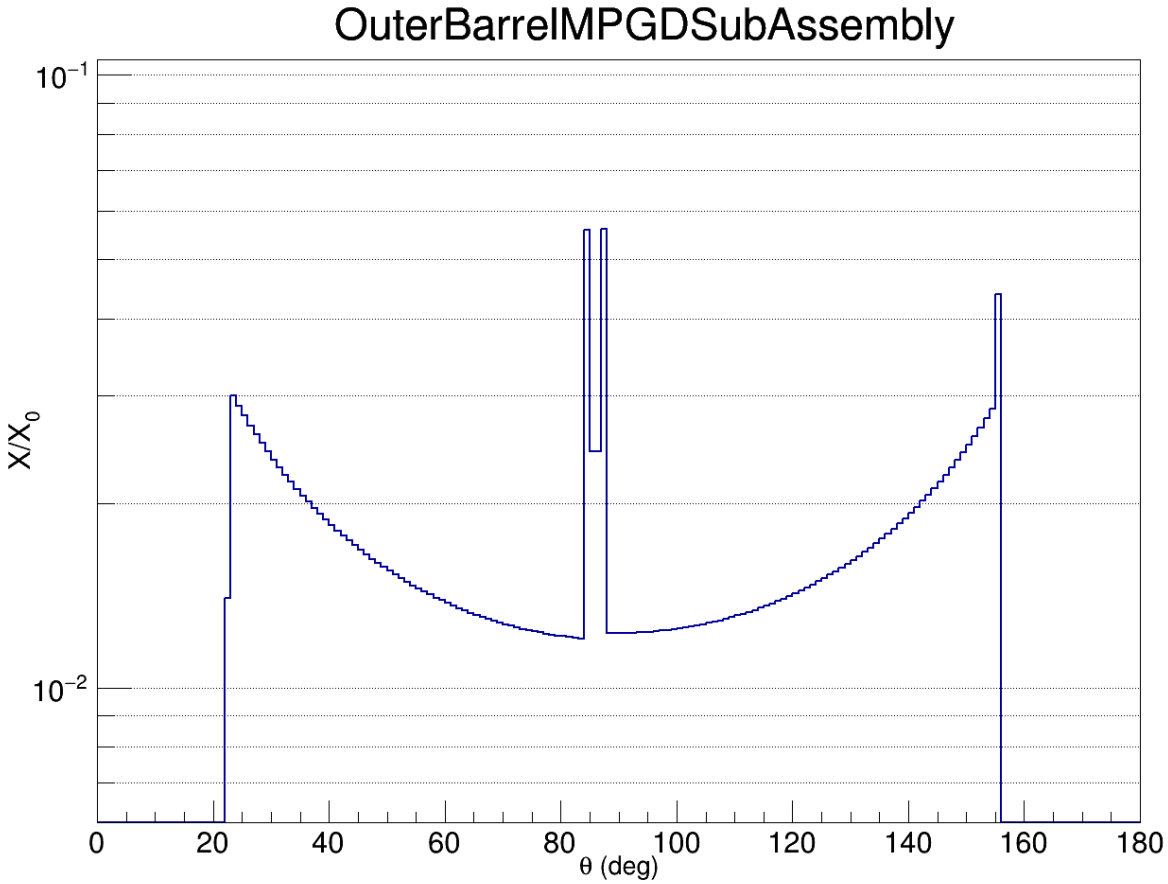


- Planar layers based on μRWELL technology
- Two panels needed for full length
- Panels arranged around azimuth
- Frame width =20 mm, thickness = 7 mm
- Barrel:
  - L = 339 cm ($-164.5\ cm \leq Z \leq 174.5\ cm$)
  - R = ~72.5 cm / 73.5 cm
  - Overlap in R = 1.2 cm/2 = 6 mm

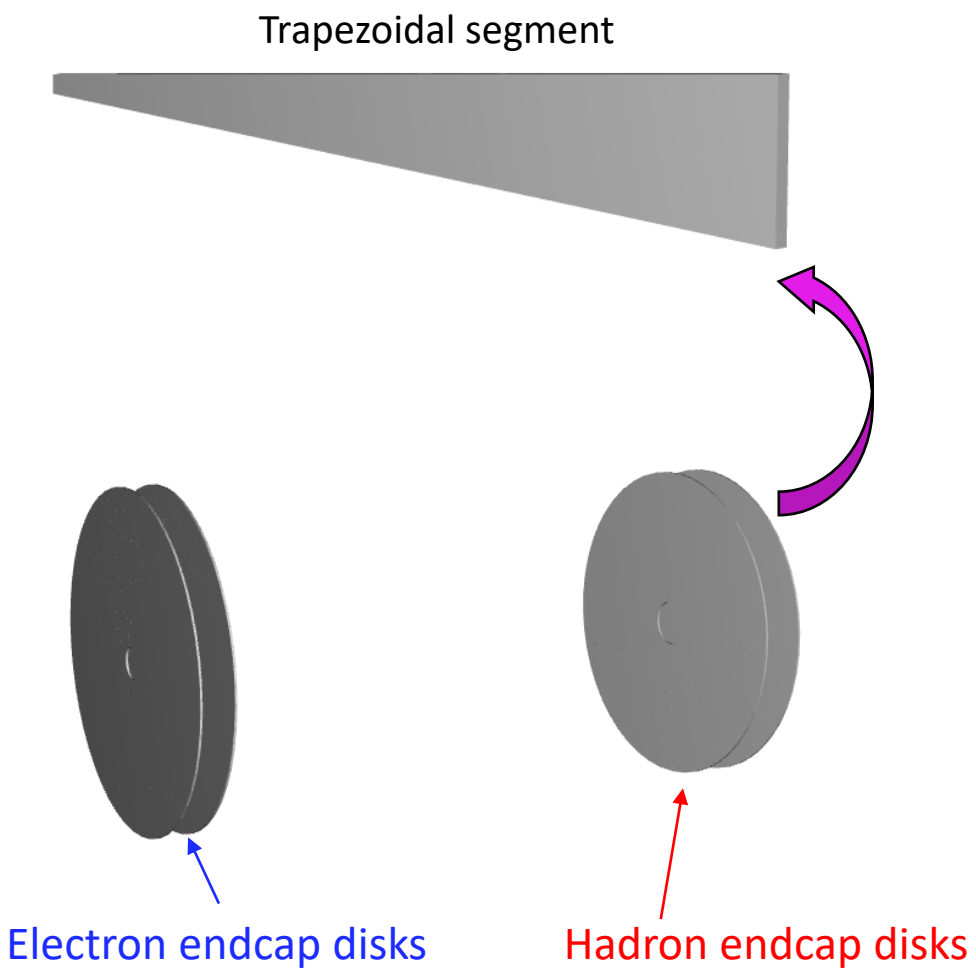
Current Status: μRWELL Outer Barrel

❑ Material Budget



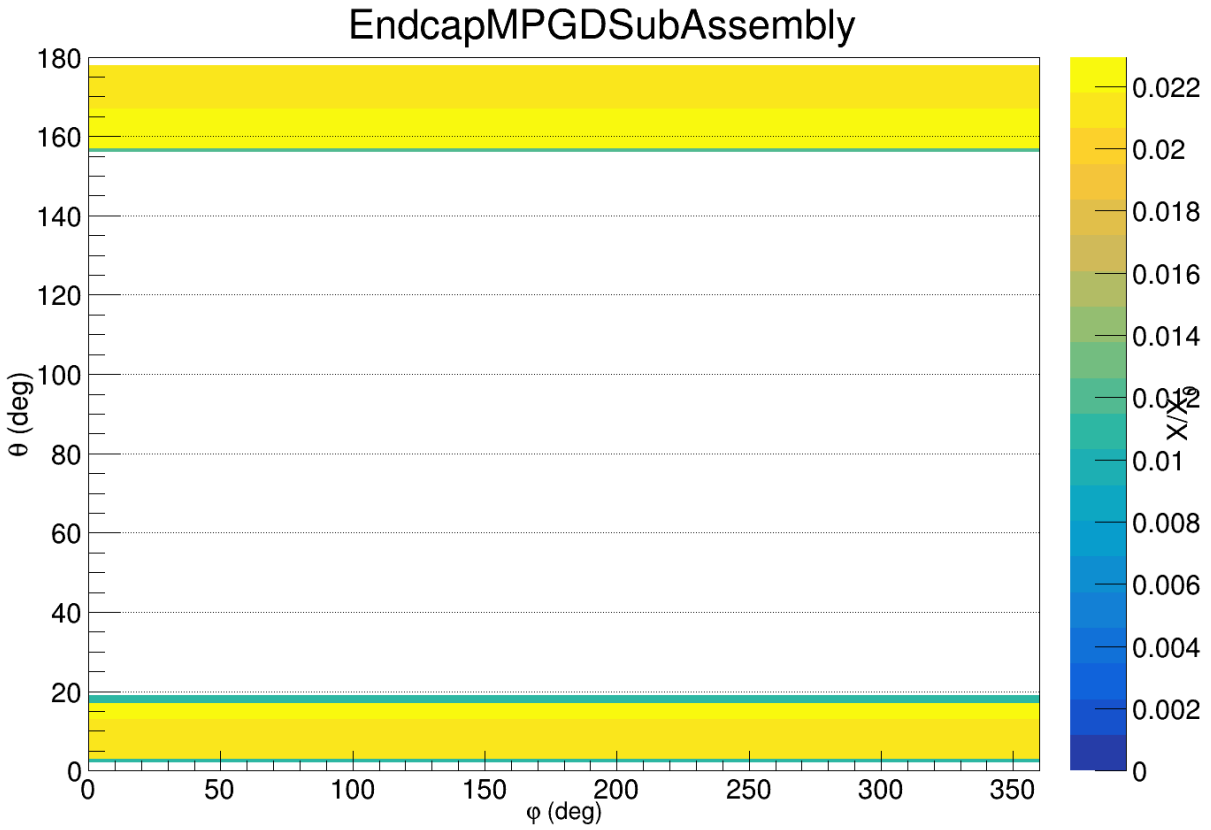


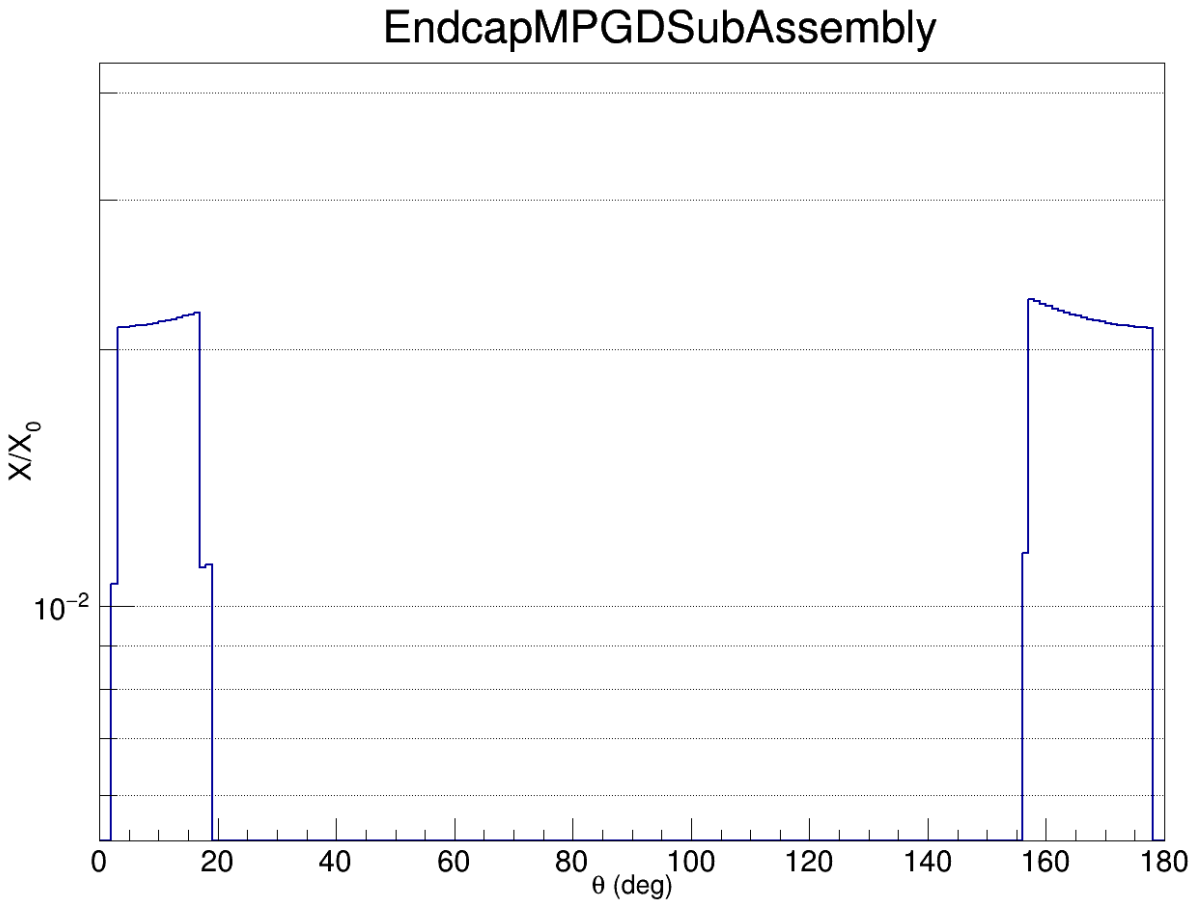
Current Status: μRWELL Disks



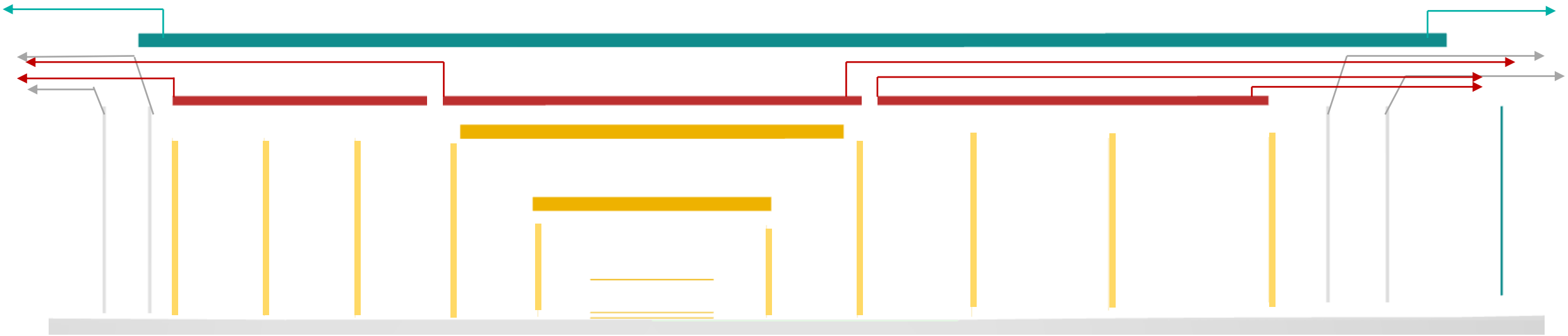
- Pairs of disks in electron and hadron endcaps based on $\mu RWELL$ technology
- Approximate disk using 48 trapezoid shapes
- Currently no overlaps or module segmentations
- Electron Endcap Disk:
  - $R_{in} = 4.65\ cm, R_{out} = 50\ cm$
  - $Z = -110\ cm, -112\ cm$
- Hadron Endcap Disk:
  - $R_{in} = 7\ cm, R_{out} = 50\ cm$
  - $Z = 148\ cm, 161\ cm$

Current Status: μRWELL Disks





Current Status: MPGD Services



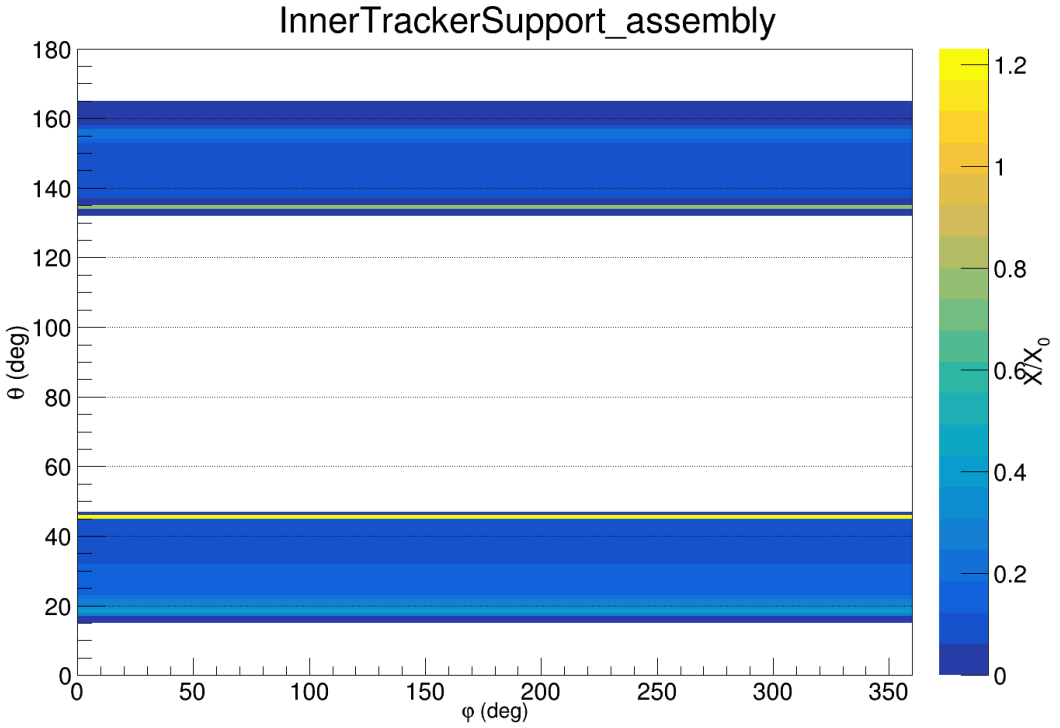
- Assumptions:
  - 1 mm pitch
  - 64 chan/ASIC
  - 8 ASIC/FEB
- Takes into account
  - HV (0.0773)
  - LV (0.0791)
  - FEE Power (0.0887)
  - Cooling (0.0032)
  - Gas (0.0013)
  - Optical Fiber (0.0223)

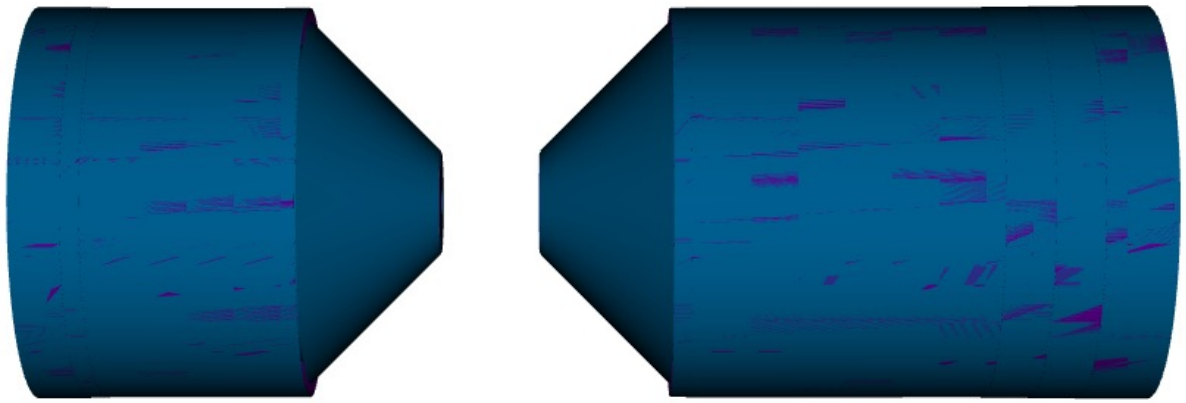
	Avg X0	Al Thickness (cm)
(BE1 + BE2 + IB1 + IB2 + OB1) z < -167.5	0.09557857	0.850362537
(BE1 + BE2 + IB1 + IB2) -167.5 < z < -120	0.064545617	0.57426235
(BE1 + IB1 +IB2) -120 < z < -110	0.049796311	0.443037781
(IB1 +IB2) -110 < z < -105	0.035047006	0.311813212
(IB2) -105 < z < -48.75	0.017523503	0.155906606
() -48.75 < z < 48.75	0	
(IB3) 48.75 < z < 53.75	0.017523503	0.155906606
(IB3 + IB4) 53.75 < z < 135	0.035047006	0.311813212
(IB3 + IB4+IB5) 135 < z < 148	0.052570509	0.467719818
(IB3 +IB4 +IB5 + FE1) 148 < z < 161	0.067319814	0.598944387
(IB3 +IB4 +IB5 + FE1 +FE2) 161 < z < 174	0.082069119	0.730168956
(IB3 +IB4 +IB5 + FE1 +FE2 + OB2) 174 < z	0.113102073	1.006269143

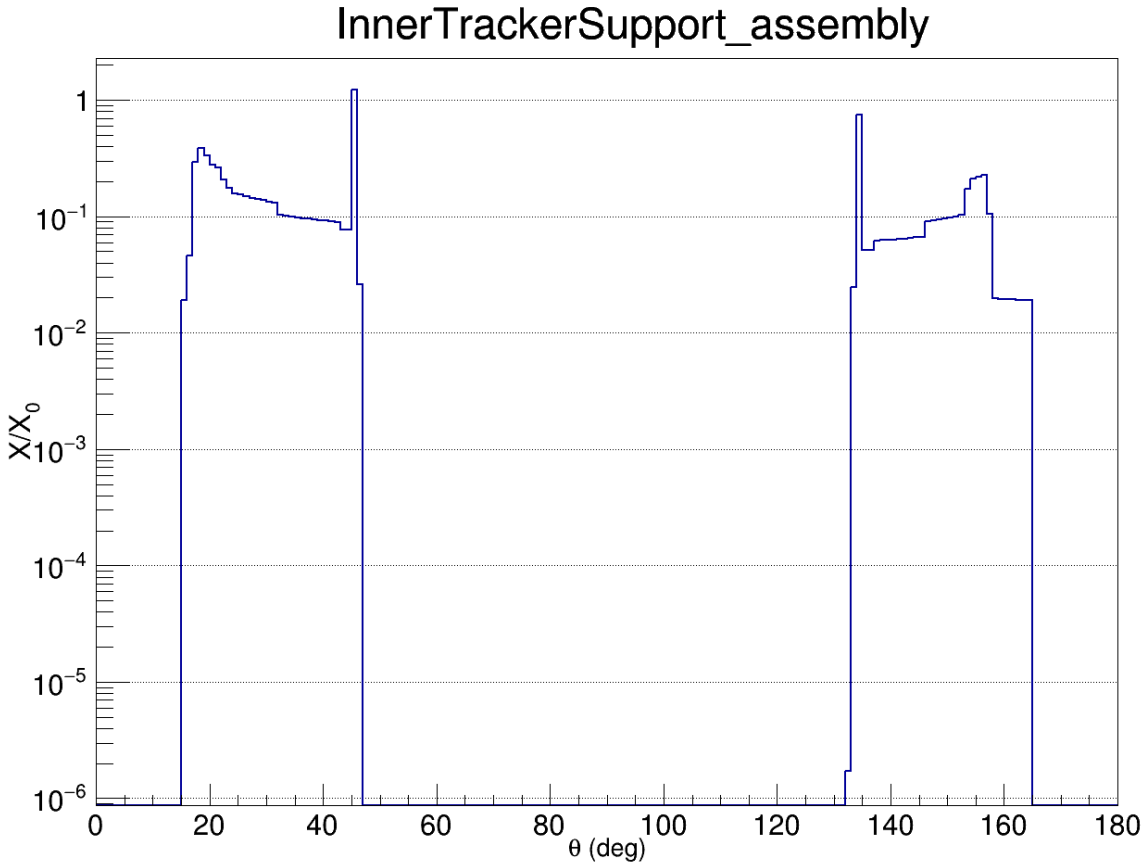
*Material averaged over area

More details

Current Status: MPGD Services



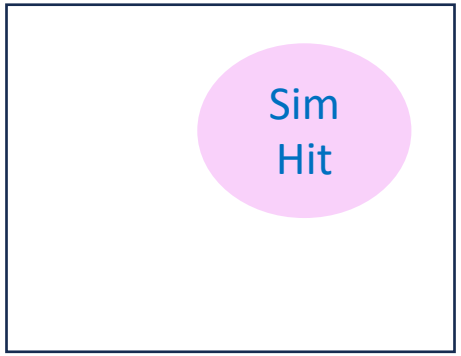


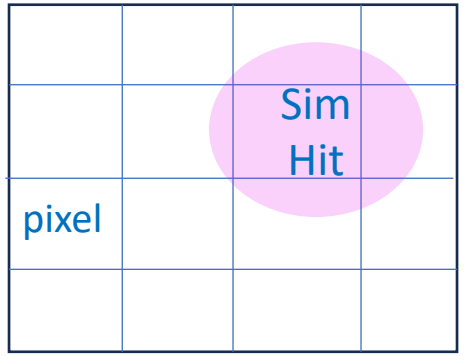


*Also includes Si services

Current Status: Digitization

- Readout Segmentation is defined in the DD4HEP (epic repo) xml files
  - Simulated hits are ”binned” following the readout segmentation
  - A minimum deposited energy is used to set a threshold
  - “pixel” charge used for ADC of reconstructed hit
- Uses digitization used by Si detectors





Segmentation Grid

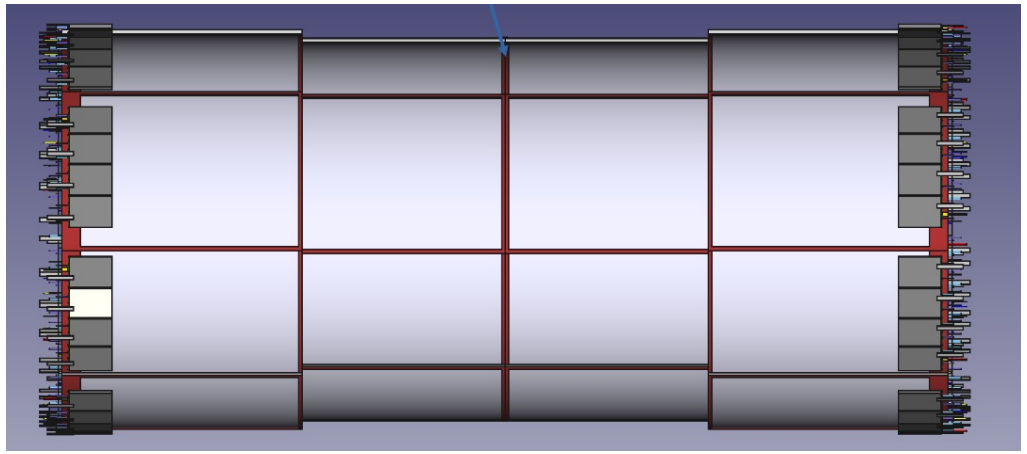
```
<readouts>
  <readout name="ForwardMPGDEndcapHits">
    <segmentation type="CartesianGridXZ" grid_size_x="sqrt(12)*150*um" grid_size_z="sqrt(12)*150*um" />
    <id>system:8,layer:2,module:6,sensor:16,x:32:-16,z:-16</id>
  </readout>
</readouts>
```

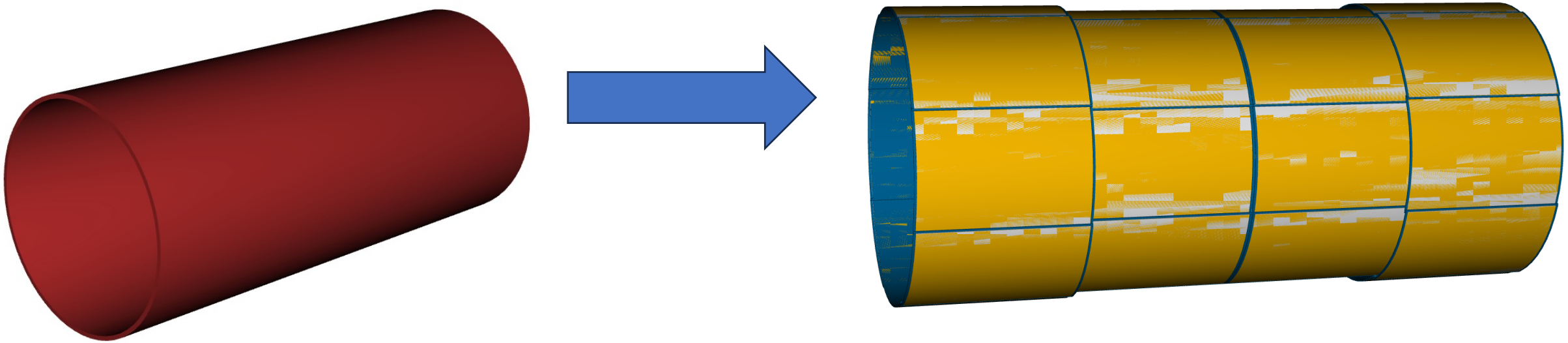
mpgd_forward_endcap.xml

On Going Work: Inner MicroMegas Barrel (CyMBal)

- Work on implementing updated inner MicroMegas Barrel into DD4HEP started by Niveditha Ramasubramanian
- Follow current CyMBal design and makes use of Tube geometry (no stave approx.)
- Will need someone to continue her work

Details: CyMBal Design



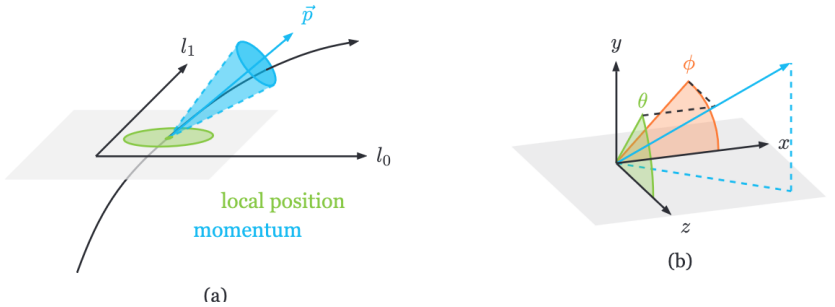


Ongoing Work: Angular Resolutions for PID

Goal: Determine spatial resolutions needed to meet PID requirements

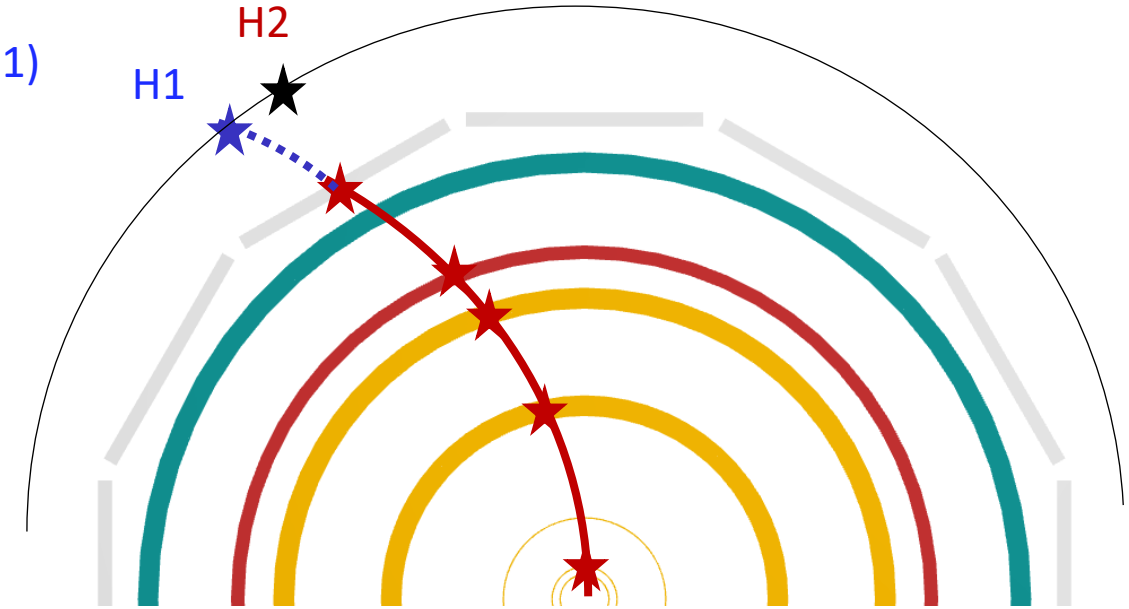
1) Use projected position point vectors of projected track point (H1) and **nearest** DIRC hit (H2) to obtain angles:
   - Projected Point (x,y,z) hits → θ_{proj} , ϕ_{proj}
   - DIRC Point (x,y,z) hits → θ_{dirc} , ϕ_{dirc}

2) Use covariance matrix from ACTS CKF algorithm



$$C = \begin{bmatrix} \sigma^2(l_0) & \mathrm{cov}(l_0,l_1) & \mathrm{cov}(l_0,\phi) & \mathrm{cov}(l_0,\theta) & \mathrm{cov}(l_0,q/p) \\ . & \sigma^2(l_1) & \mathrm{cov}(l_1,\phi) & \mathrm{cov}(l_1,\theta) & \mathrm{cov}(l_1,q/p) \\ . & . & \sigma^2(\phi) & \mathrm{cov}(\phi,\theta) & \mathrm{cov}(\phi,q/p) \\ . & . & . & \sigma^2(\theta) & \mathrm{cov}(\theta,q/p) \\ . & . & . & . & \sigma^2(q/p) \end{bmatrix}$$

From ACTS



Projected Track Point

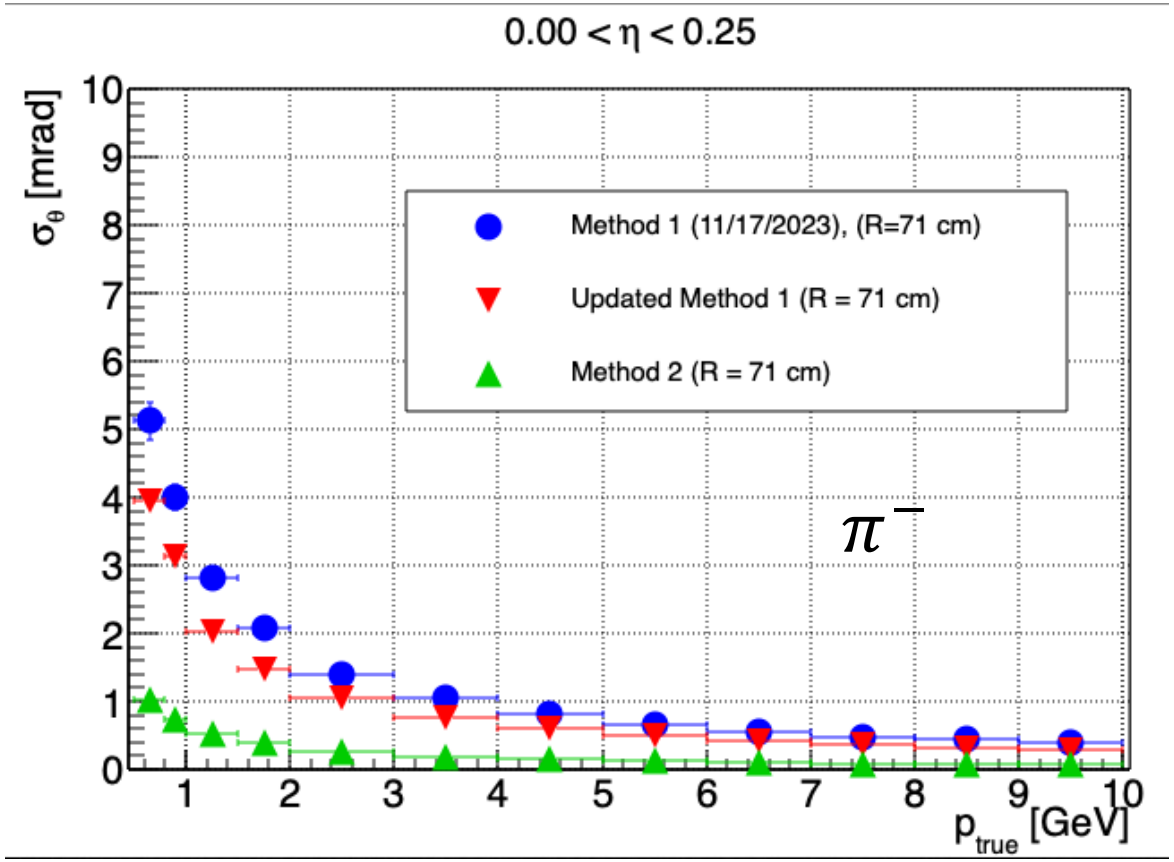
Reference (truth) Hit

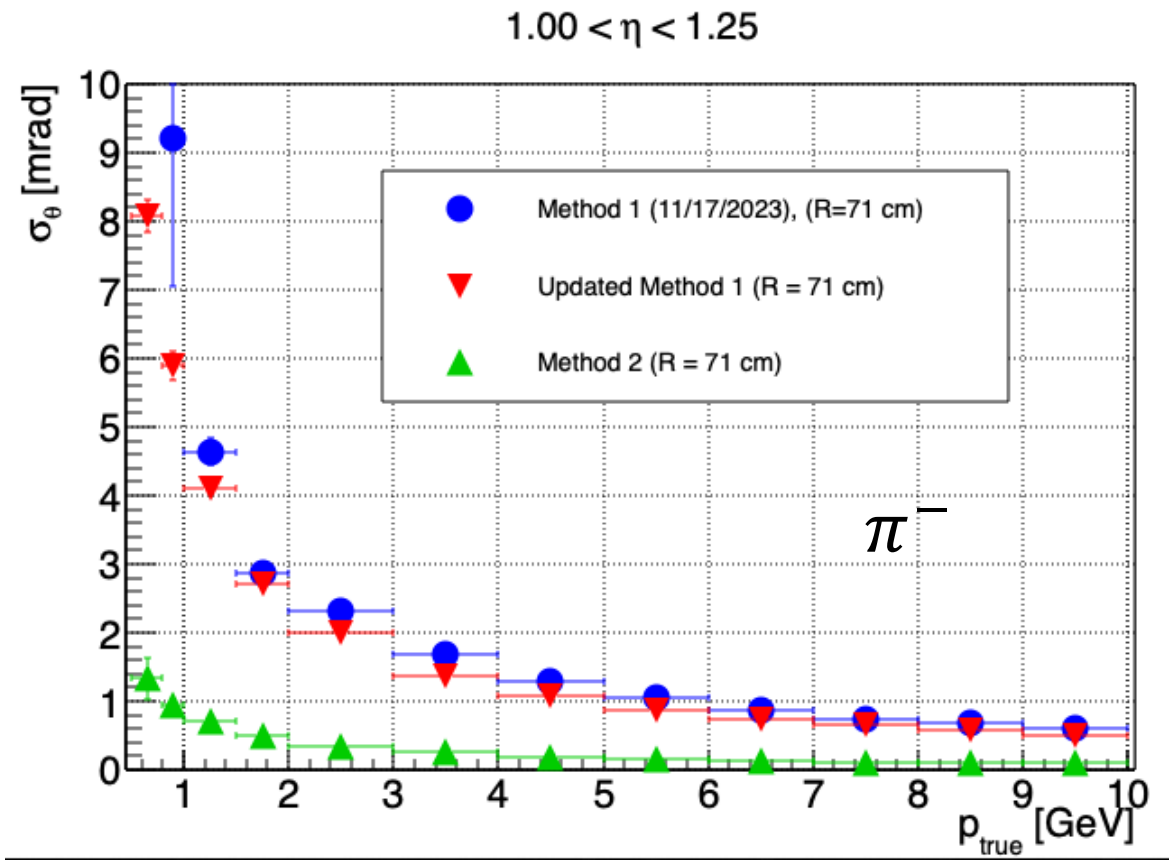
Detector Hit

Projected Track Segment

Reconstructed Track

Ongoing Work: Angular Resolutions for PID





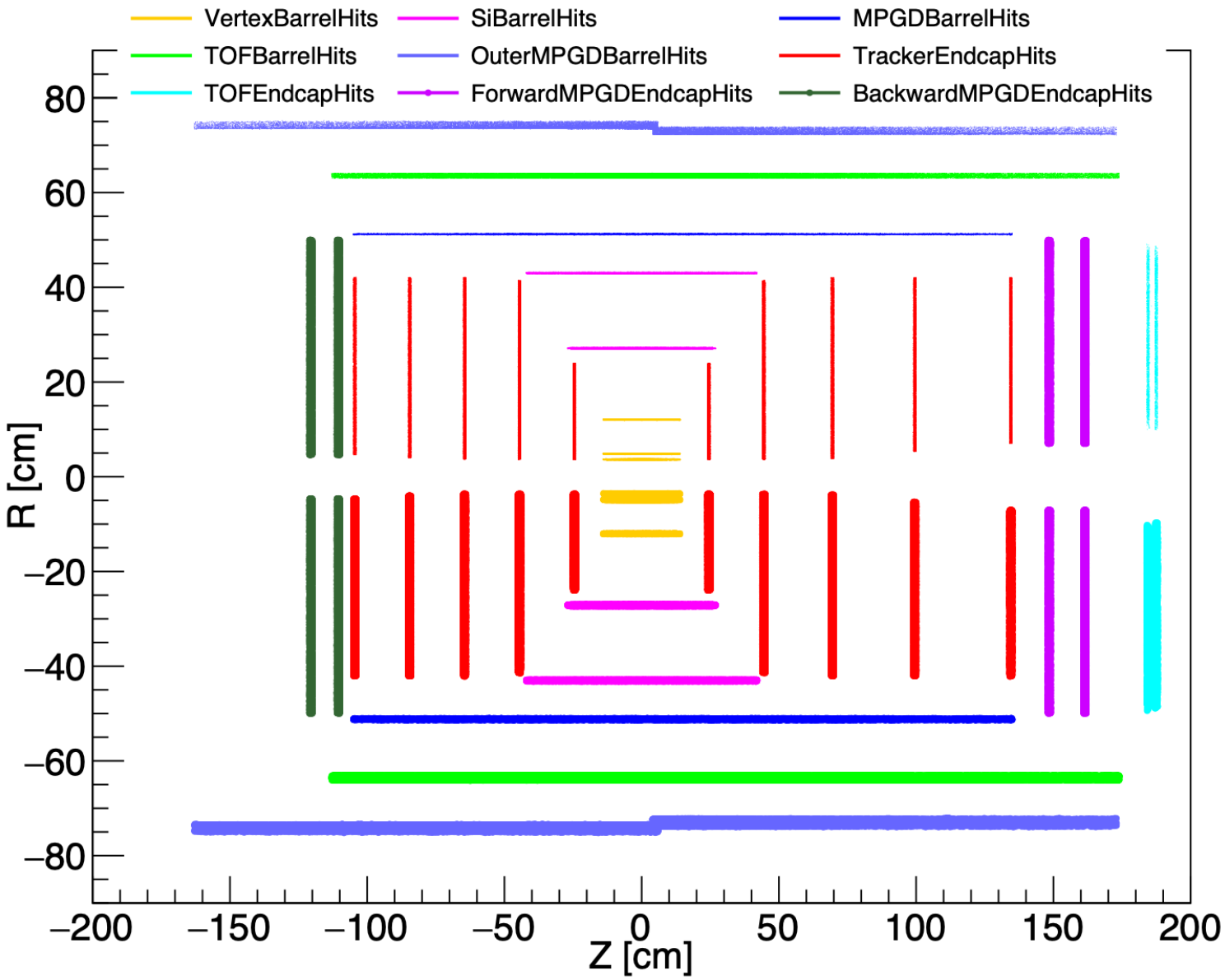
Details: PID+Tracking Meeting

Needed Simulation Tasks

- ❑ Geometry/Material
  - Implement geometry/segmentation that better matches current detector designs
    - Input will come from MPGD-DSC about dimensions and materials
- ❑ **Digitization/Reconstruction**
  - Develop MPGD digitization algorithm – use test beam data to parameterize resolution and cluster size vs. track angle
- ❑ Reconstruction of tracklets in fast detectors (MPGDs + AC-LGADs)
- ❑ Can track reconstruction go the other way?

Pattern recognition and angular resolution at PID

ePIC Central Detector Tracking: Crater Lake



ePIC Central Tracking Detectors: Crater Lake