ePIC MPGD Simulation

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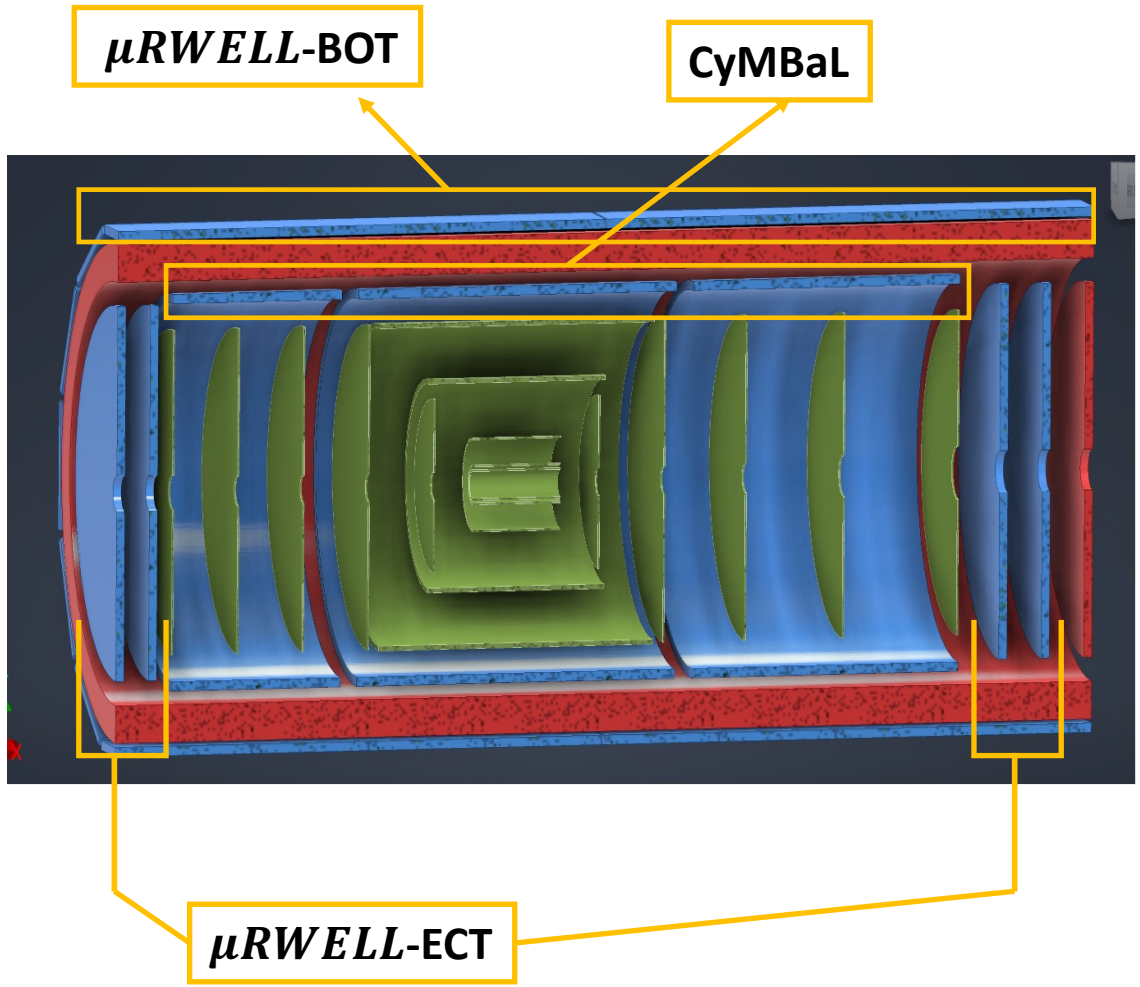
Additional information: Trk. WGM 12/14/22

ePIC MPGD Detectors

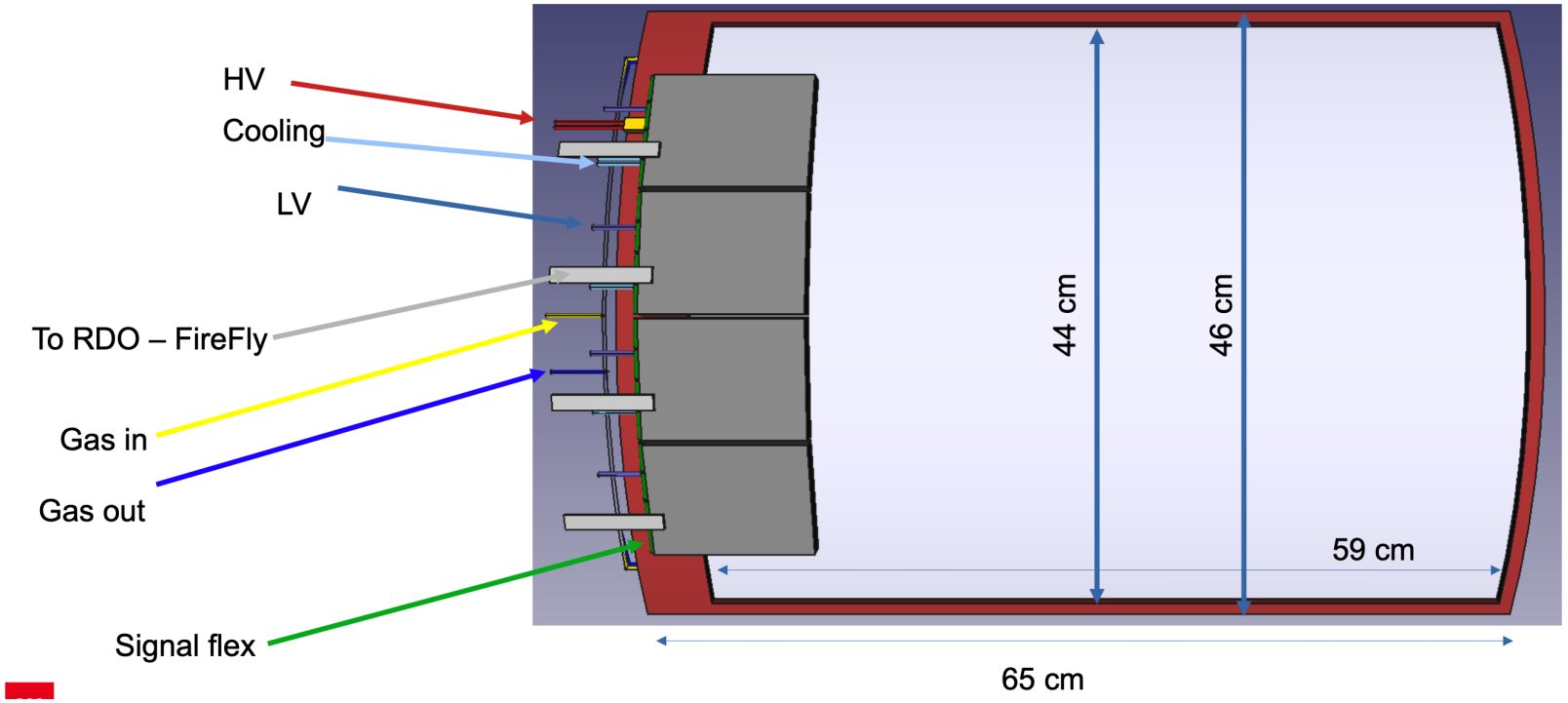
- MPGD detectors based on two technologies:
  - $\mu Megas$ (curved layers)
    - **Cy**lindrical **M**icromegas **B**arrel **L**ayer (CyMBaL)
  - $\mu RWELL$ (planar layers)
    - **μRWELL B**arrel **O**uter **T**racker (μRWELL-BOT)
    - **μRWELL** End**C**ap **T**racker (μRWELL-ECT)

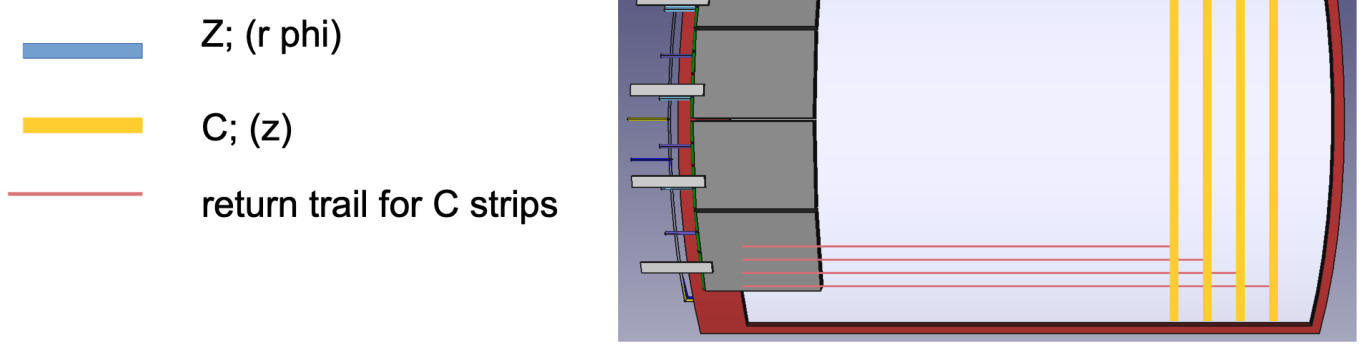


CyMBaL: Active Preliminary Design

CyMBaL Tile

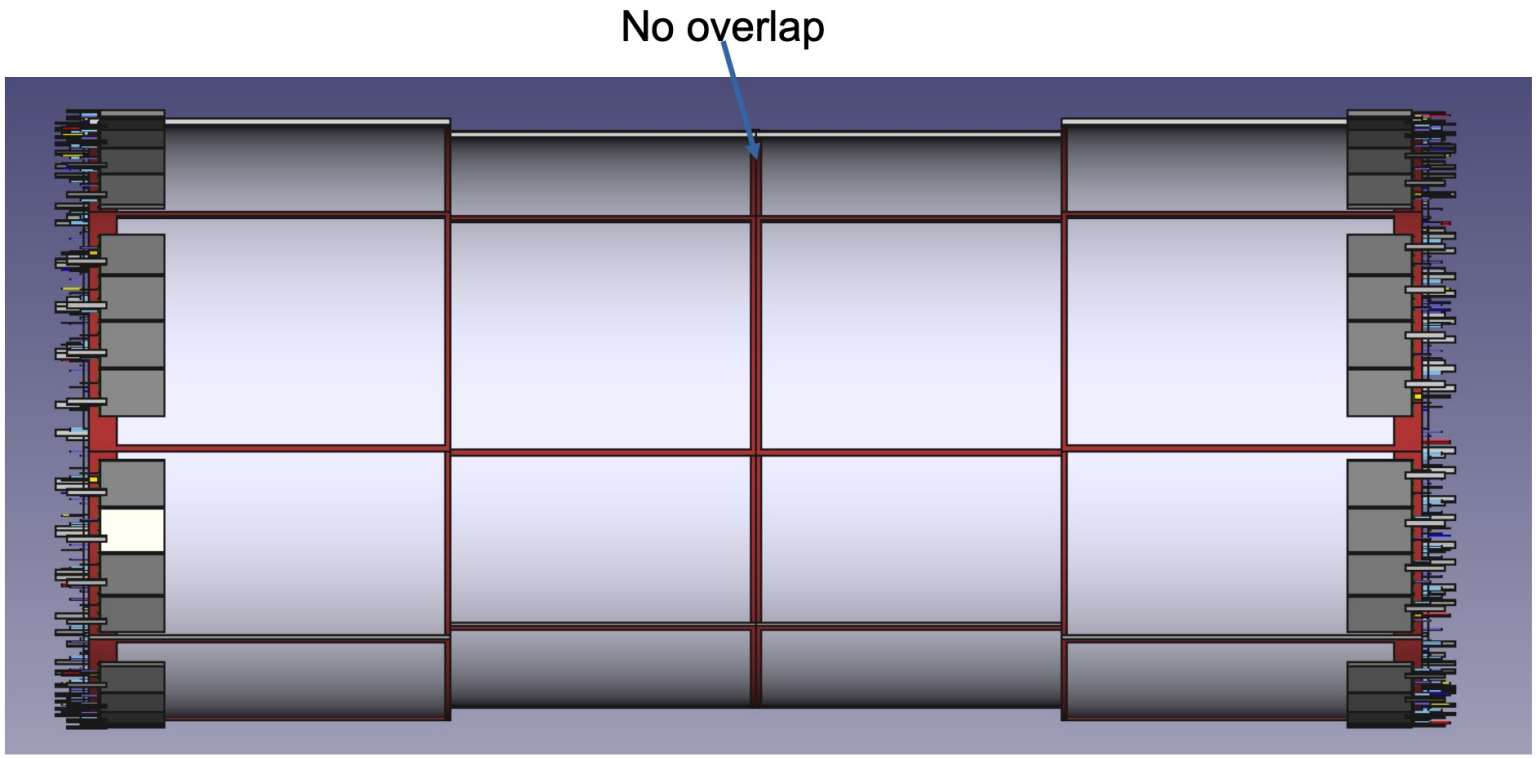
- ❑ Design is not final
- ❑ ~1 mm pitch in each direction
- ❑ 1024 strips per tile
- ❑ 4 FEBs pef tile
- ❑ 4 ASICS per FEB → 256 chan
- ❑ Z-C strips

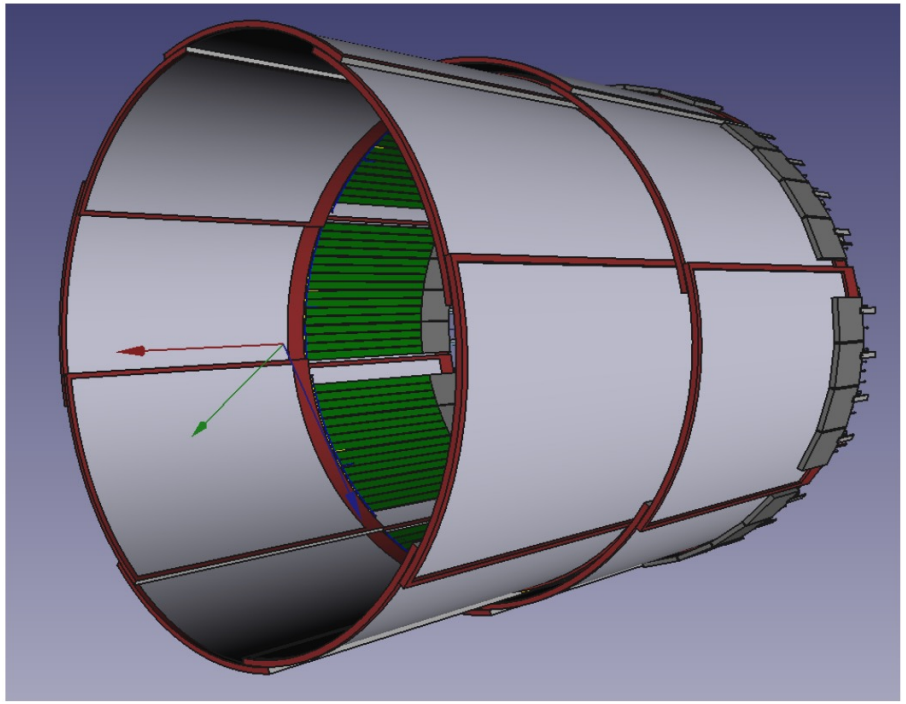




CyMBaL: Active Preliminary Design

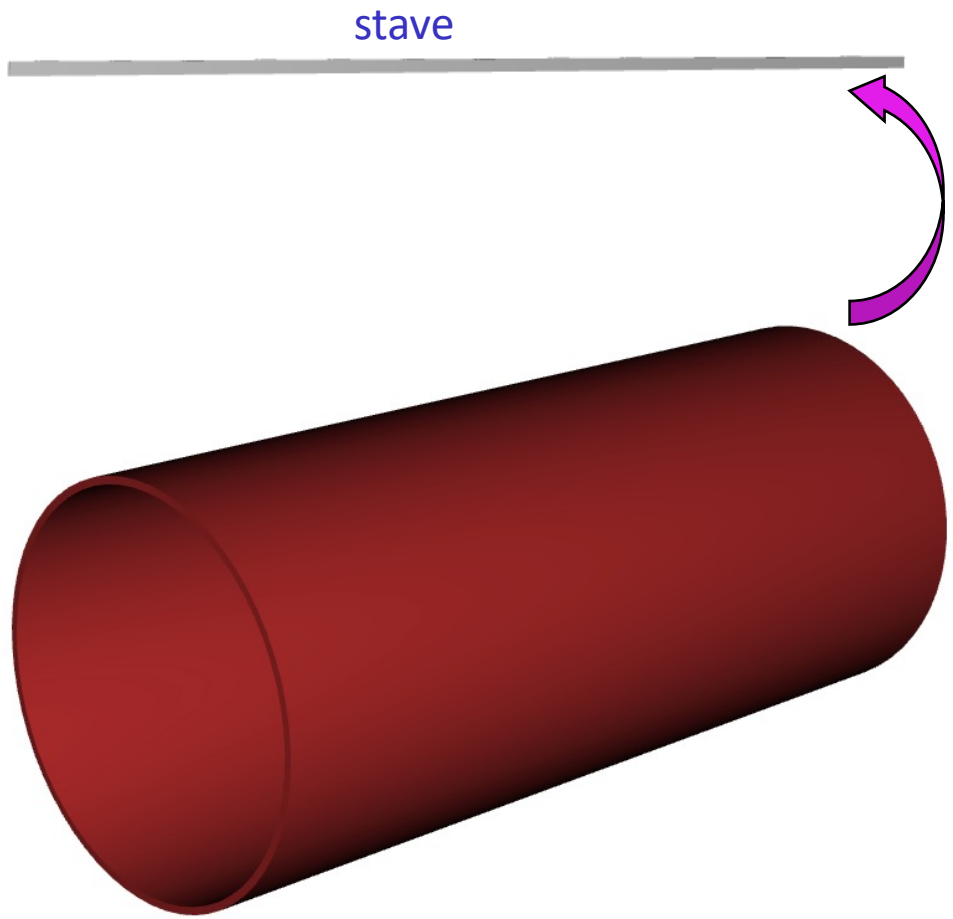
- ❑ Length in z covered by 4 modules
- ❑ Two different radii: 50 cm and 52.5 cm
- ❑ No overlap in middle
- ❑ 8 modules in azimuth
- ❑ Alternated layout with two slightly different radii





CyMBaL: Simulation Status

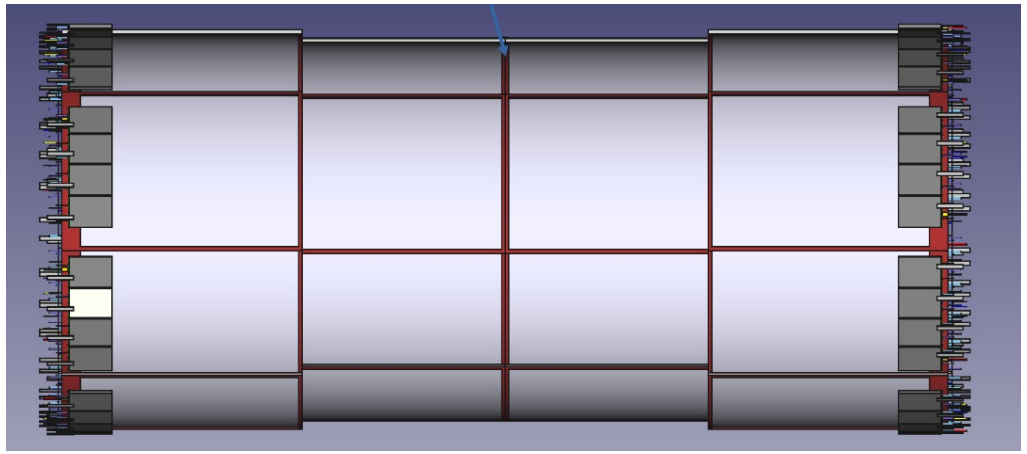
- Curved layer based on MicroMegas technology
- Approximate cylinder using 128 staves
  - Width = 2.47cm
- Barrel:
  - L = 240 cm
  - R = 51.25 cm

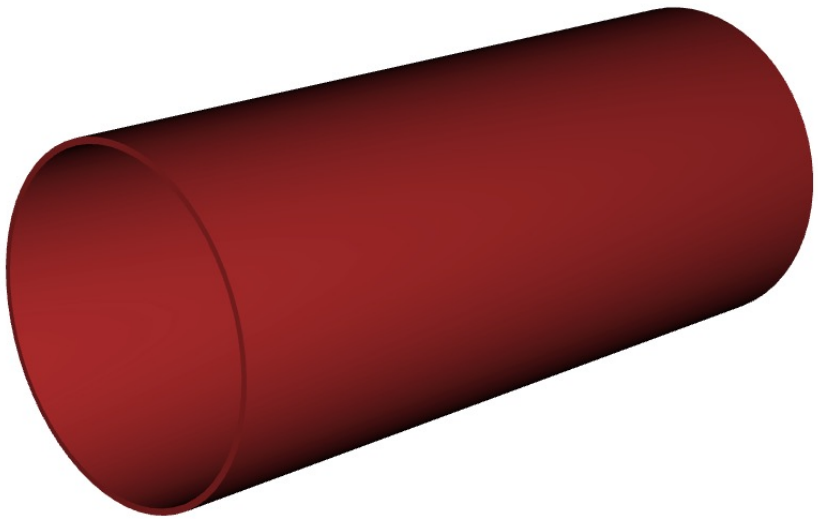


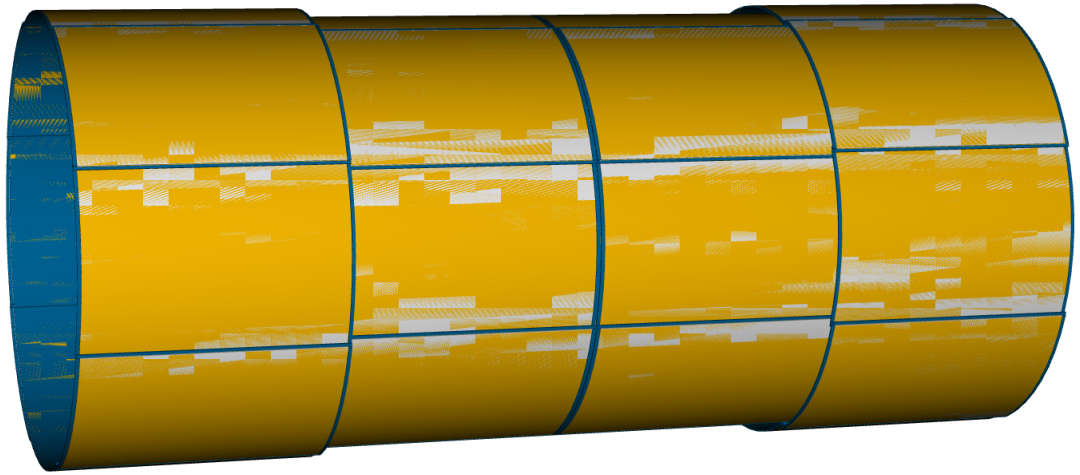
CyMBaL: Simulation Work

- 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.)

Details: CyMBal Design

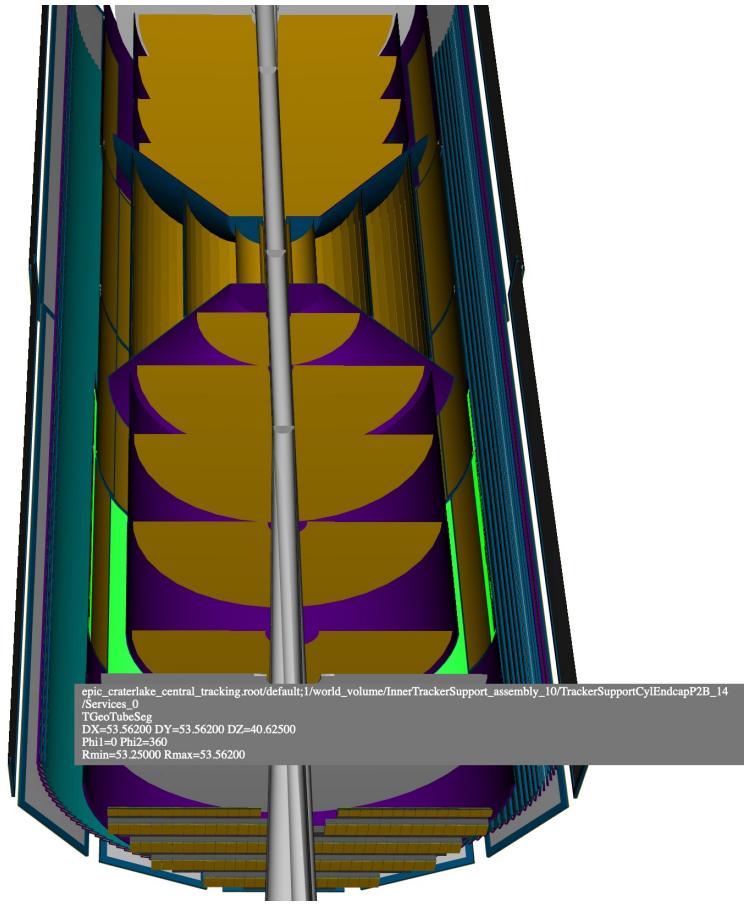






CyMBaL: Simulation Work

- Base code exists in epic branch: [inner-mpgd-barrel-geoUpdate]
  - Overlaps found in DD4HEP (tolerance = 0.001 mm)
  - Needs implementation into ACTS

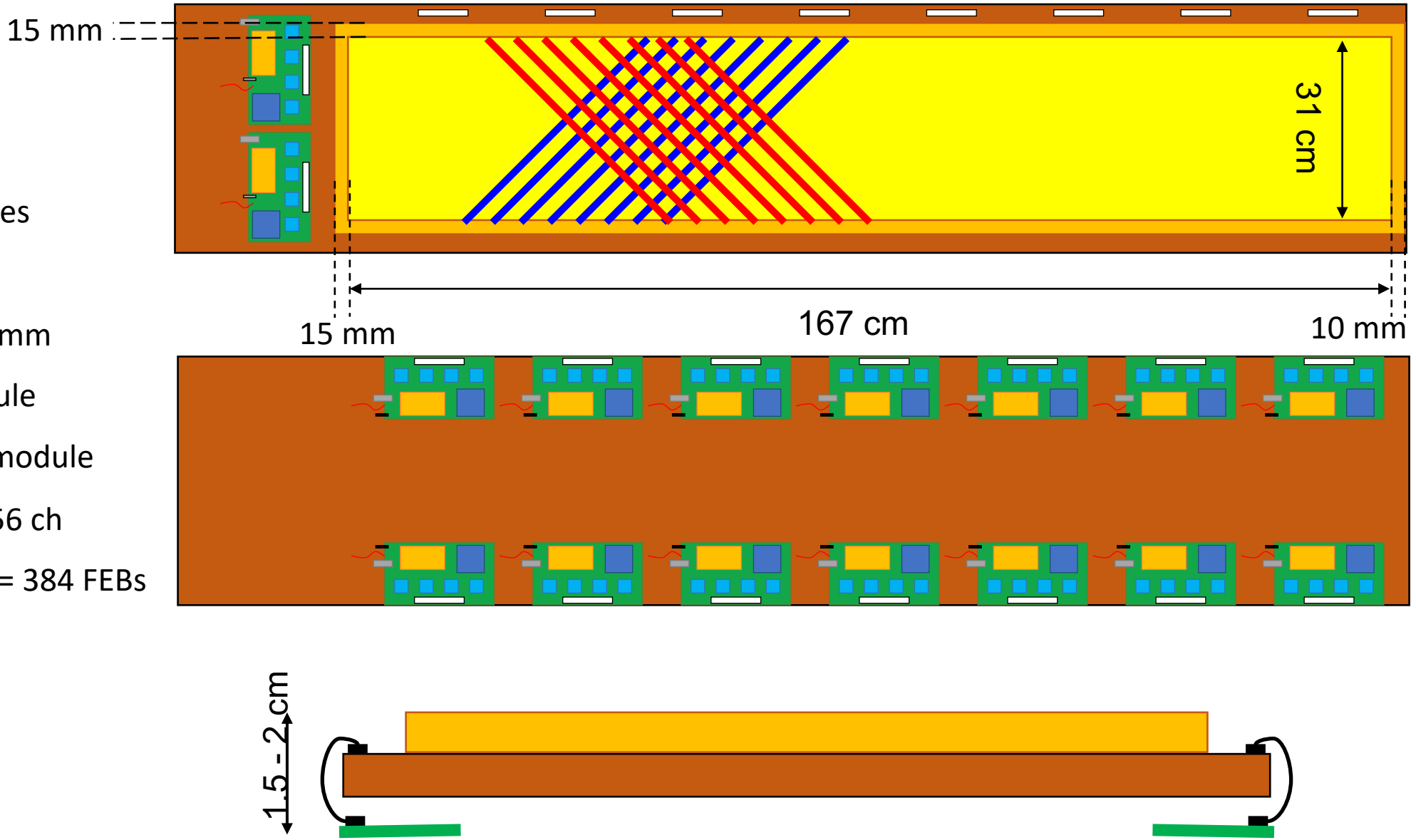



```
checkOverlaps -t 0.001 -c epic_craterlake_tracking_only.xml

Info in <TGeoNodeMatrix::CheckOverlaps>: Number of illegal overlaps/extrusions : 19

= Overlap ov00008: InnerMPGDBarrel_Mod1/component3_7 overlapping InnerMPGDBarrel_Mod1/component5_9 ovlp=0.0279066
= Overlap ov00009: InnerMPGDBarrel_Mod1/component1_5 overlapping InnerMPGDBarrel_Mod1/component3_7 ovlp=0.0263734
= Overlap ov00010: InnerMPGDBarrel_Mod1/component2_6 overlapping InnerMPGDBarrel_Mod1/component3_7 ovlp=0.0247831
= Overlap ov00011: InnerMPGDBarrel_Mod1/component3_7 overlapping InnerMPGDBarrel_Mod1/component4_8 ovlp=0.0206586
= Overlap ov00012: InnerMPGDBarrel_Mod1/component5_9 overlapping InnerMPGDBarrel_Mod1/component6_10 ovlp=0.00578146
= Overlap ov00013: InnerMPGDBarrel_Mod1/component4_8 overlapping InnerMPGDBarrel_Mod1/component5_9 ovlp=0.00487134
= Overlap ov00014: InnerMPGDBarrel_Mod1/component0_4 overlapping InnerMPGDBarrel_Mod1/component3_7 ovlp=0.00342412
= Overlap ov00015: InnerMPGDBarrel_Mod1/component0_4 overlapping InnerMPGDBarrel_Mod1/component1_5 ovlp=0.00207584
= Overlap ov00016: InnerMPGDBarrel_Mod1/component1_5 overlapping InnerMPGDBarrel_Mod1/component2_6 ovlp=0.00173648
= Overlap ov00017: InnerMPGDBarrel_Mod1/component10_14 overlapping InnerMPGDBarrel_Mod1/component12_16 ovlp=0.00111189
= Overlap ov00018: InnerMPGDBarrel_Mod1/component6_10 overlapping InnerMPGDBarrel_Mod1/component7_11 ovlp=0.00100763
```

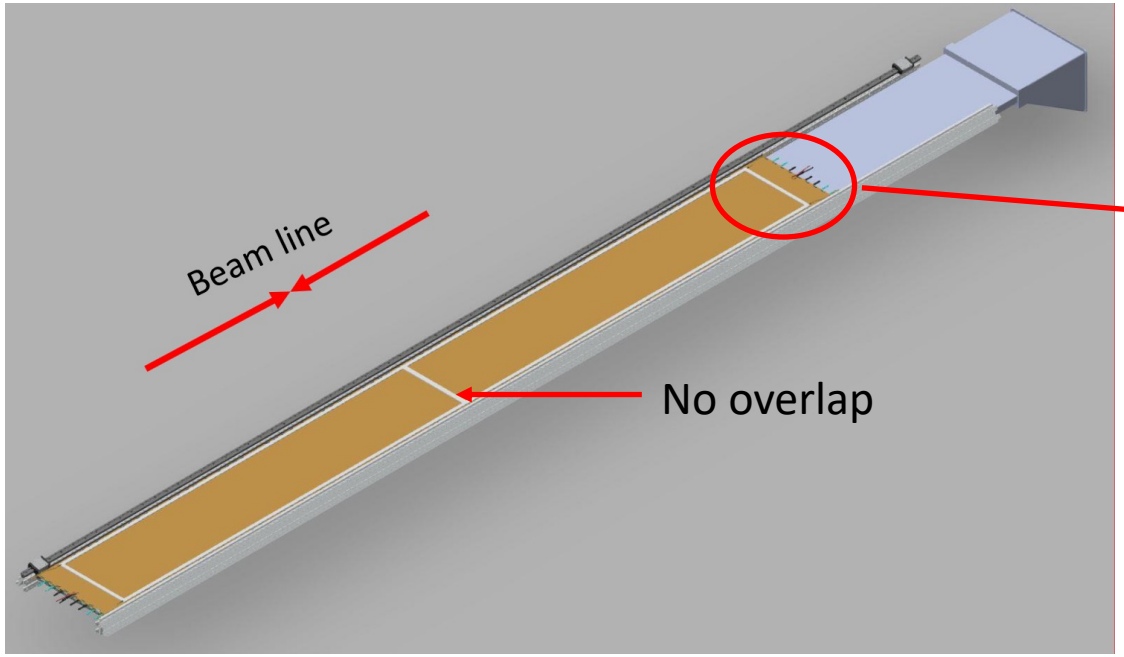
```
= Overlap ov00000: world_volume/InnerMPGDBarrelSubAssembly_5/InnerMPGDBarrel_0/InnerMPGDBarrel_layer1_0 overlapping world_volume/InnerTrackerSupport_assembly_10/TrackerSupportCylEndcapN2A_10 ovlp=0.05
= Overlap ov00001: world_volume/InnerMPGDBarrelSubAssembly_5/InnerMPGDBarrel_0/InnerMPGDBarrel_layer1_0 overlapping world_volume/InnerTrackerSupport_assembly_10/TrackerSupportCylEndcapN2B_11 ovlp=0.05
= Overlap ov00002: world_volume/InnerMPGDBarrelSubAssembly_5/InnerMPGDBarrel_0/InnerMPGDBarrel_layer1_0 overlapping world_volume/InnerTrackerSupport_assembly_10/TrackerSupportCylEndcapN2C_12 ovlp=0.05
= Overlap ov00003: world_volume/InnerMPGDBarrelSubAssembly_5/InnerMPGDBarrel_0/InnerMPGDBarrel_layer1_0 overlapping world_volume/InnerTrackerSupport_assembly_10/TrackerSupportCylEndcapP2A_13 ovlp=0.05
= Overlap ov00004: world_volume/InnerMPGDBarrelSubAssembly_5/InnerMPGDBarrel_0/InnerMPGDBarrel_layer1_0 overlapping world_volume/InnerTrackerSupport_assembly_10/TrackerSupportCylEndcapP2B_14 ovlp=0.05
= Overlap ov00005: world_volume/InnerMPGDBarrelSubAssembly_5/InnerMPGDBarrel_0/InnerMPGDBarrel_layer1_0 overlapping world_volume/InnerTrackerSupport_assembly_10/TrackerSupportCylEndcapP2C_15 ovlp=0.05
= Overlap ov00006: world_volume/InnerMPGDBarrelSubAssembly_5/InnerMPGDBarrel_0/InnerMPGDBarrel_layer1_0 overlapping world_volume/InnerTrackerSupport_assembly_10/TrackerSupportCylEndcapP2D_16 ovlp=0.05
= Overlap ov00007: world_volume/InnerMPGDBarrelSubAssembly_5/InnerMPGDBarrel_0/InnerMPGDBarrel_layer1_0 overlapping world_volume/InnerTrackerSupport_assembly_10/TrackerSupportCylEndcapP2E_17 ovlp=0.05
```

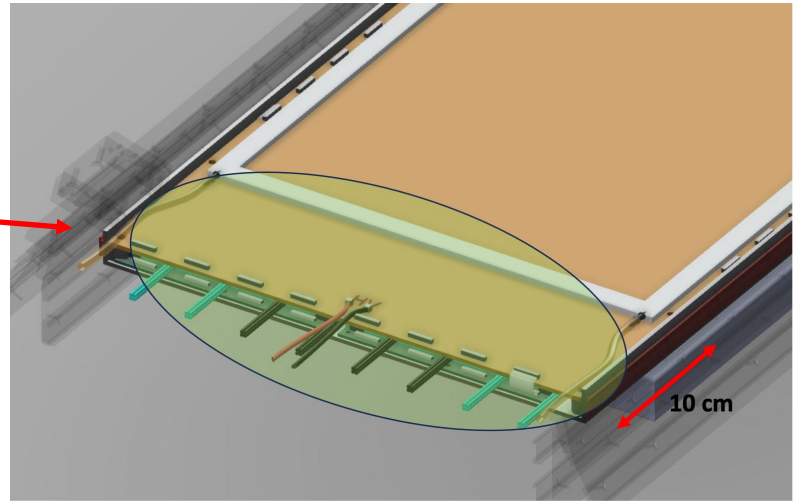
μRWELL-BOT: Active Preliminary Design

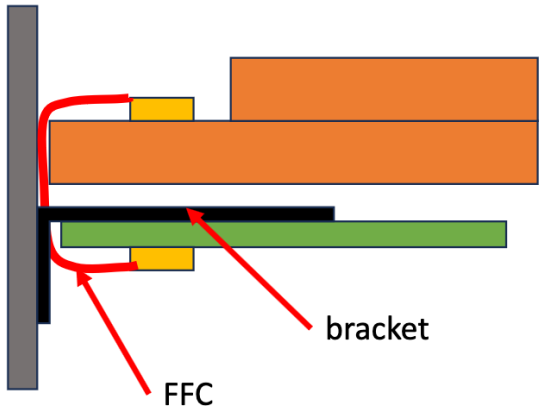
- Design is not final
- 24 μRWELL-BOT modules
  - U-V Strips
  - Pitch: 1 mm – 1.2 mm
  - ~4096 strips/module
- 16 FEBs/μRWELL-BOT module
  - 4 SALSA/FEB → 256 ch
  - Total FEBS: 24x16 = 384 FEBs

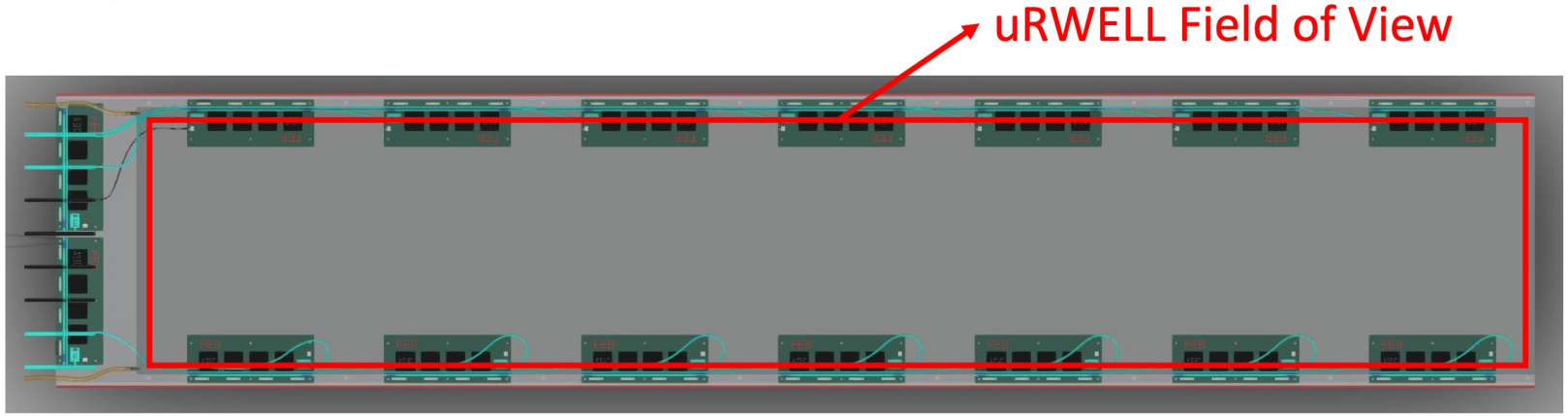


μRWELL-BOT: Active Preliminary Design

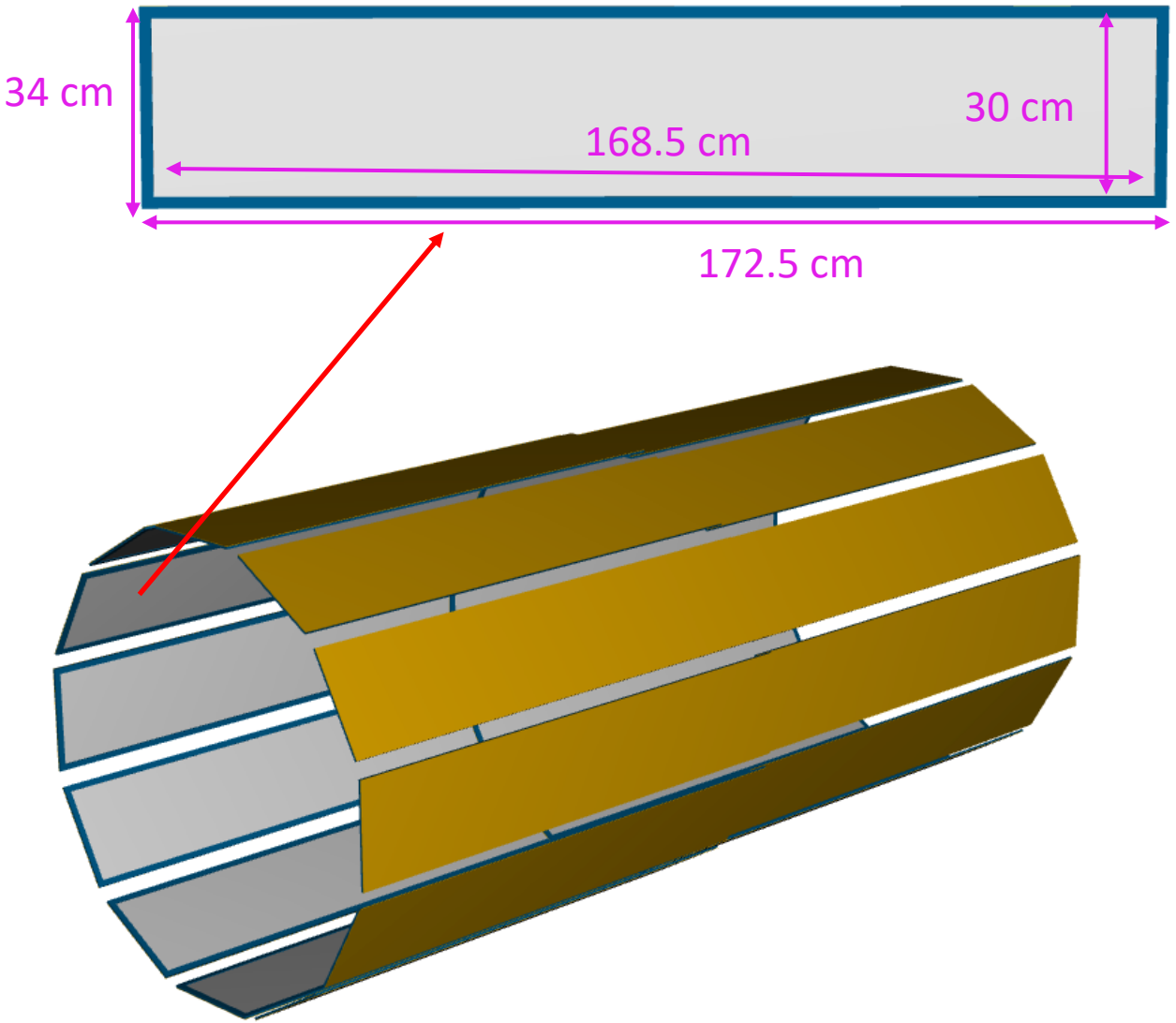








μRWELL-BOT: Simulation Status



Status

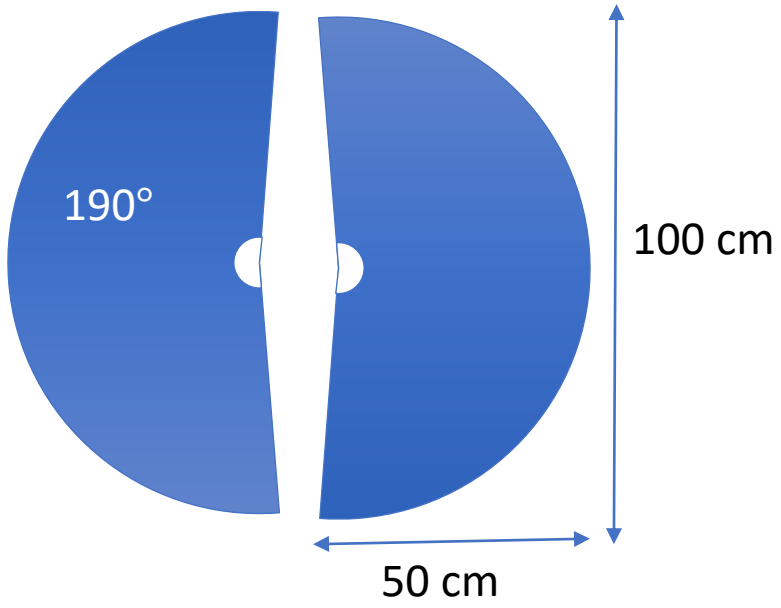
- ❑ Planar layers based on μRWELL technology
- ❑ Two panels needed for full length
- ❑ Panels arranged around azimuth
- ❑ Frame width =20 mm, thickness = 7 mm
- ❑ Barrel:
  - ➢ L = 339 cm $(-164.5\ cm \leq Z \leq 174.5\ cm)$
  - ➢ R = ~72.5 cm / 73.5 cm
  - ➢ Overlap in R = 1.2 cm/2 = 6 mm

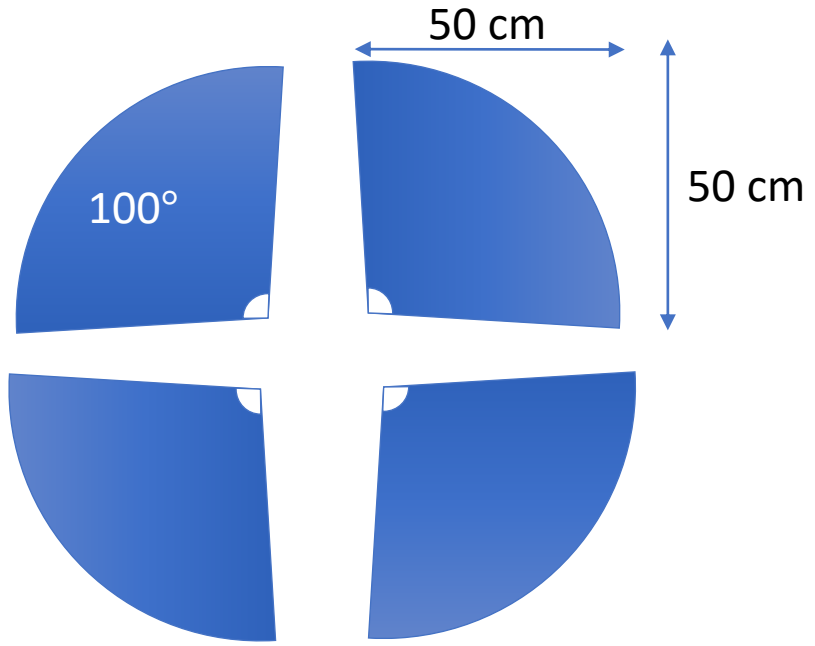
Needed Work

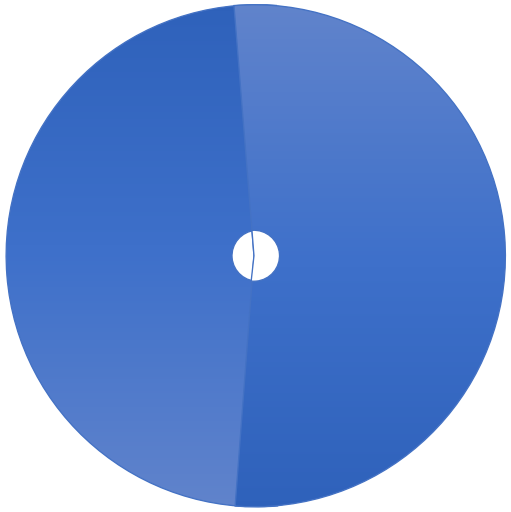
- ❑ Remove overlap in adjacent modules
- ❑ Modify support frame
- ❑ Modify module geometry

μRWELL-ECT: Design Status

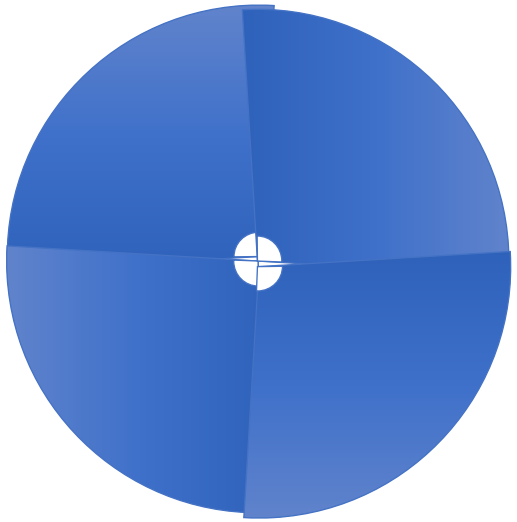
- Disk design is in initial stages
- Segmentation most likely in halves or quarters
- FEB and services most likely located around disk perimeter
- Readout strip details still under discussion, e.g. orientation, pitch





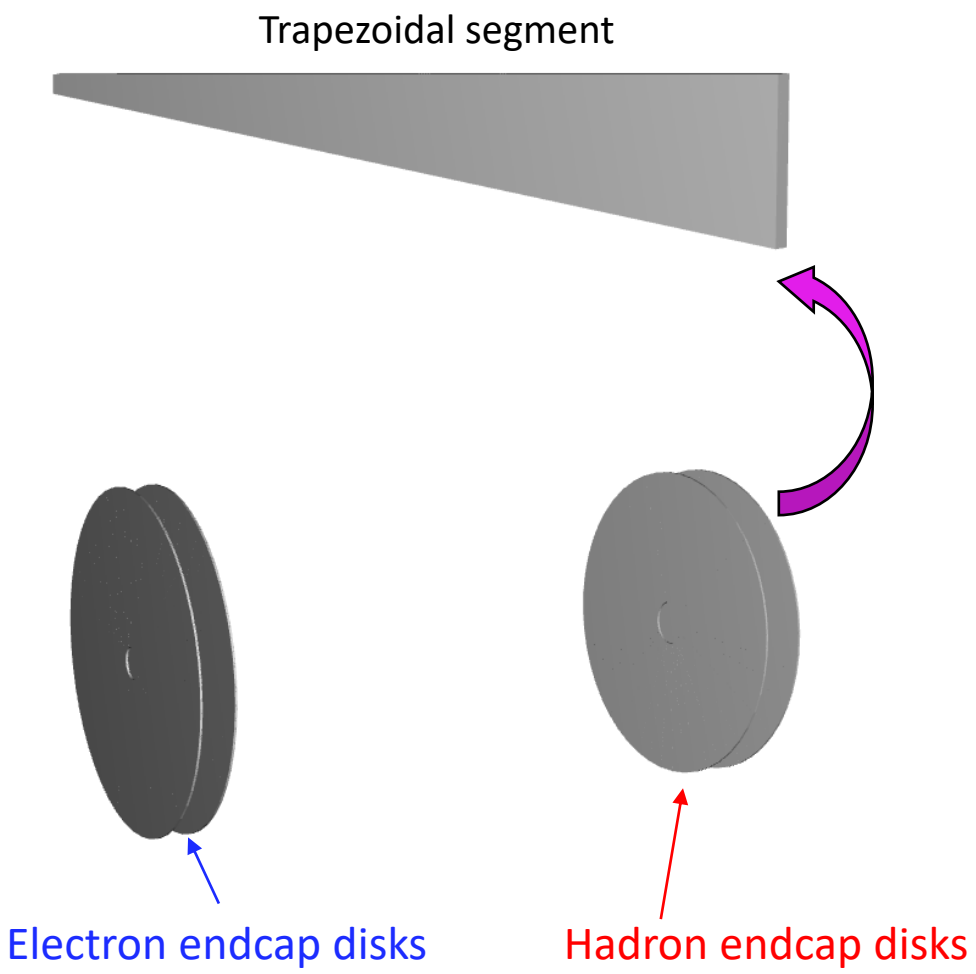


2 x 5°overlap



4 x 5°overlap

μRWELL-ECT: Simulation Status



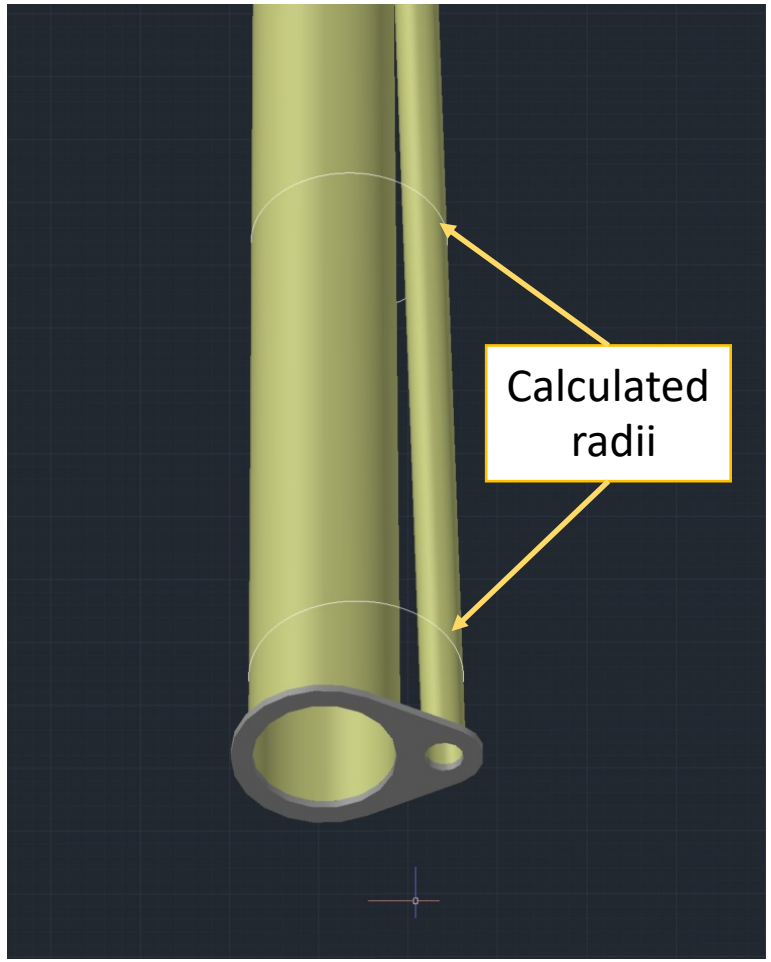
- Pairs of disks in electron and hadron endcaps based on $\mu RWELL$ technology
- Approximate disk using 48 trapezoid shapes
- Currently no overlaps or module segmentations
- Electron Endcap Disk:
  - $R_{in} = 4.65\ cm, R_{out} = 50\ cm$
  - $Z = -110\ cm, -120\ cm$
- Hadron Endcap Disk:
  - $R_{in} = 7\ cm, R_{out} = 50\ cm$
  - $Z = 150\ cm, 160\ cm$

μRWELL-ECT: Simulation Work

- ❑ Add segmentation to disks
  - Decision on detector segmentation not yet finalized
  - Allow for flexible segmentation, e.g. split disk into 2 halves or 4 quadrants
- ❑ Define detector frame around perimeter of detector segmentation
- ❑ Create off center hole in disks

MPGD Detector Layer	Max Z Position (mm)	Inner Radius (mm)	X Offset (mm)
Backward Disks 1	-1125	37.7	-3.1
Backward Disk 2	-1225	39.2	-4.1
Forward Disk 1	1505	53.1	19.9
Forward Disk 2	1610	55.8	22.5

Stephen Maple: Beampipe.C



Current Simulation Status and Needs: Digitization and Reconstruction

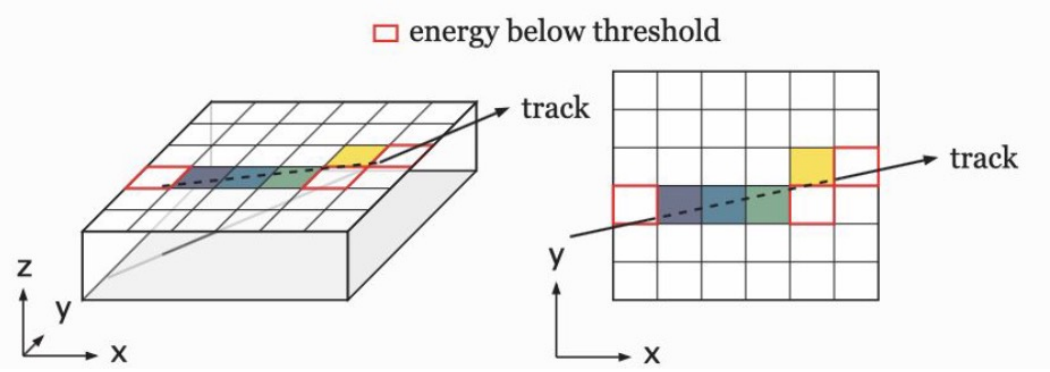
Status

- Setup segmentation in geometry xml file. Each SimHit has a cell ID on the detector surface

```
<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

- Digitization in EICrecon
  - Reads in SimHit (cell ID, edep, time)
  - Apply threshold (0.25 keV)
  - Put hit at center of each cell, resolution is grid_size/sqrt(12)
  - Digitized Hit → track measurement



To do

- Implement MPGD digitization (Babu Pokhrel beginning work)
- Track clustering
- Replace pixel segmentation with strip segmentations

Summary of Needed Simulation Tasks

- Geometry/Material
  - Implement geometry/segmentation that better matches current detector designs
- **Digitization/Reconstruction**
  - Develop MPGD digitization algorithm – use test beam data to parameterize resolution and cluster size vs. track angle
  - Track cluster algorithm
  - Switch from pixel to strip readouts
- Reconstruction of tracklets in fast detectors (MPGDs + AC-LGADs + BIC)
  - Could help pattern recognition and angular resolution of track entering PID detector