Simulations of a GArTPC

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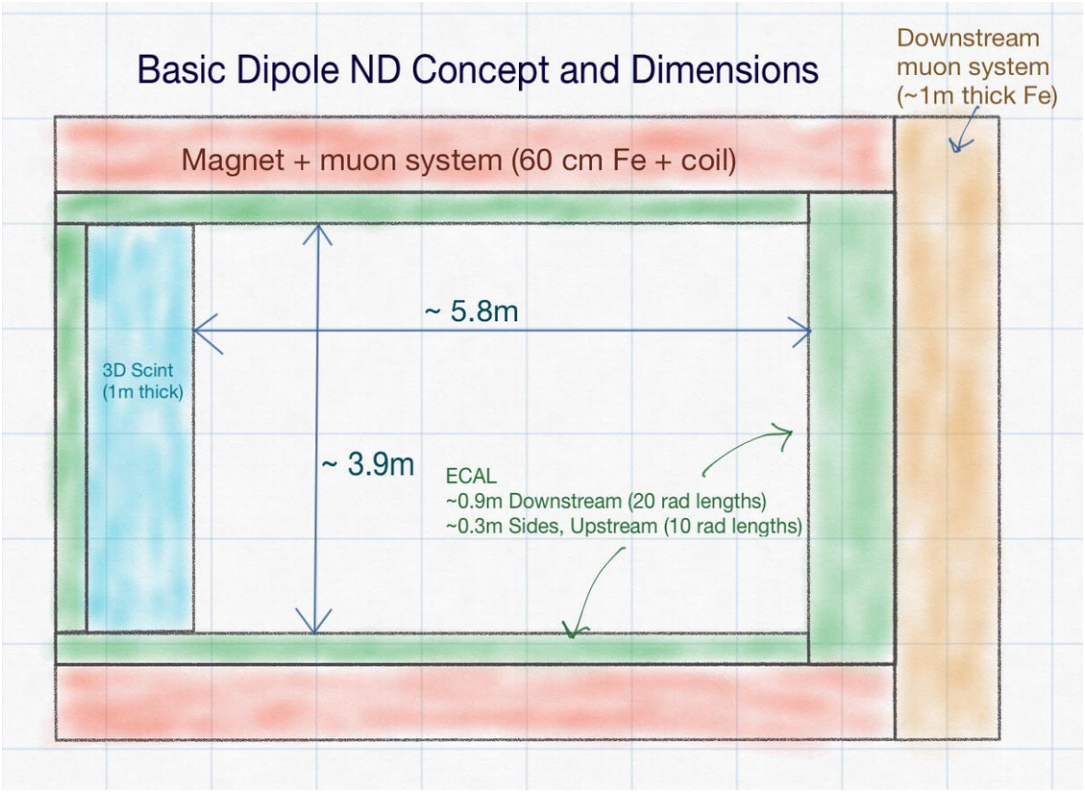
DUNE ND Workshop
11/6/2017

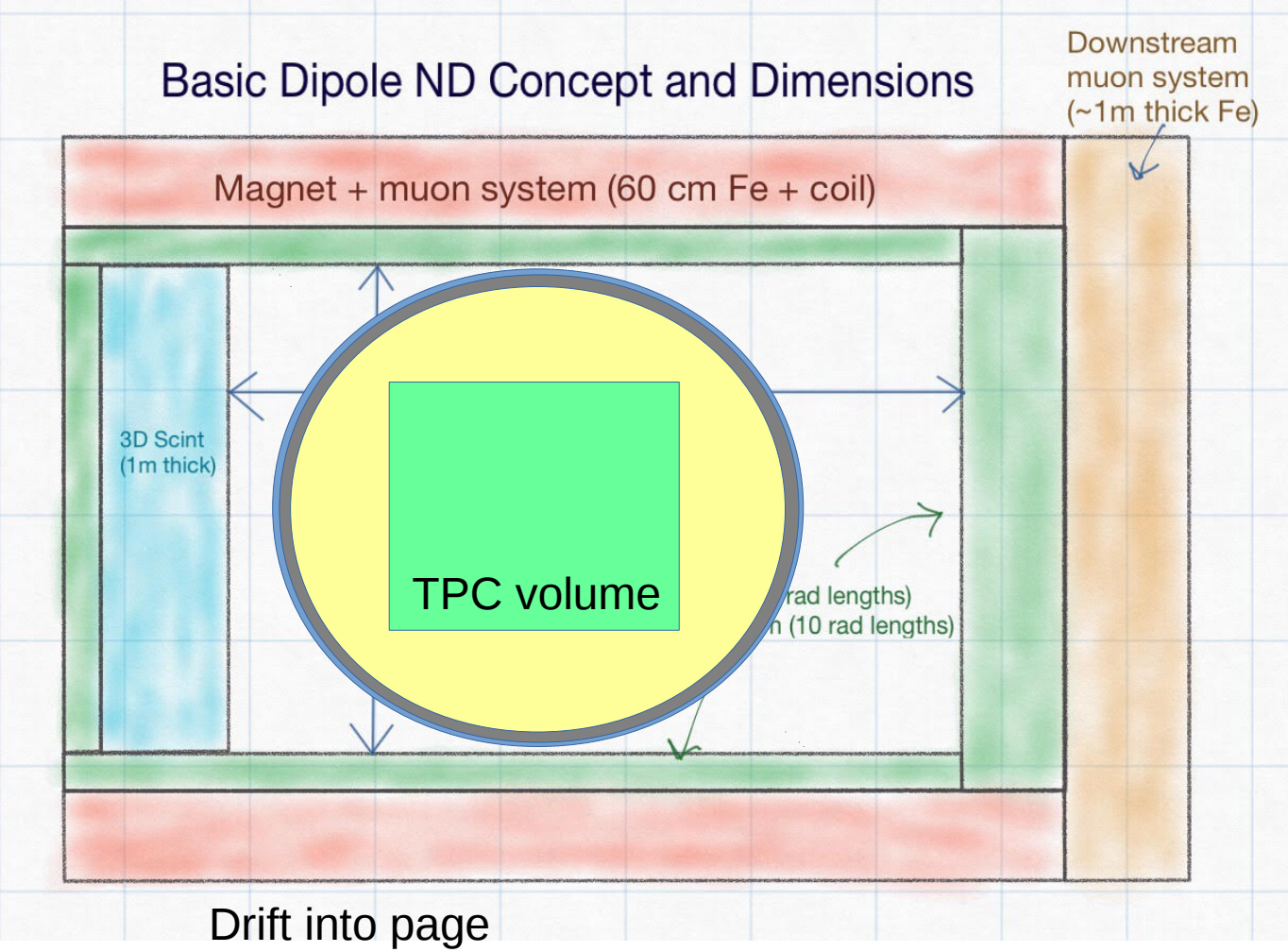
Basic Idea



From M. Kordosky

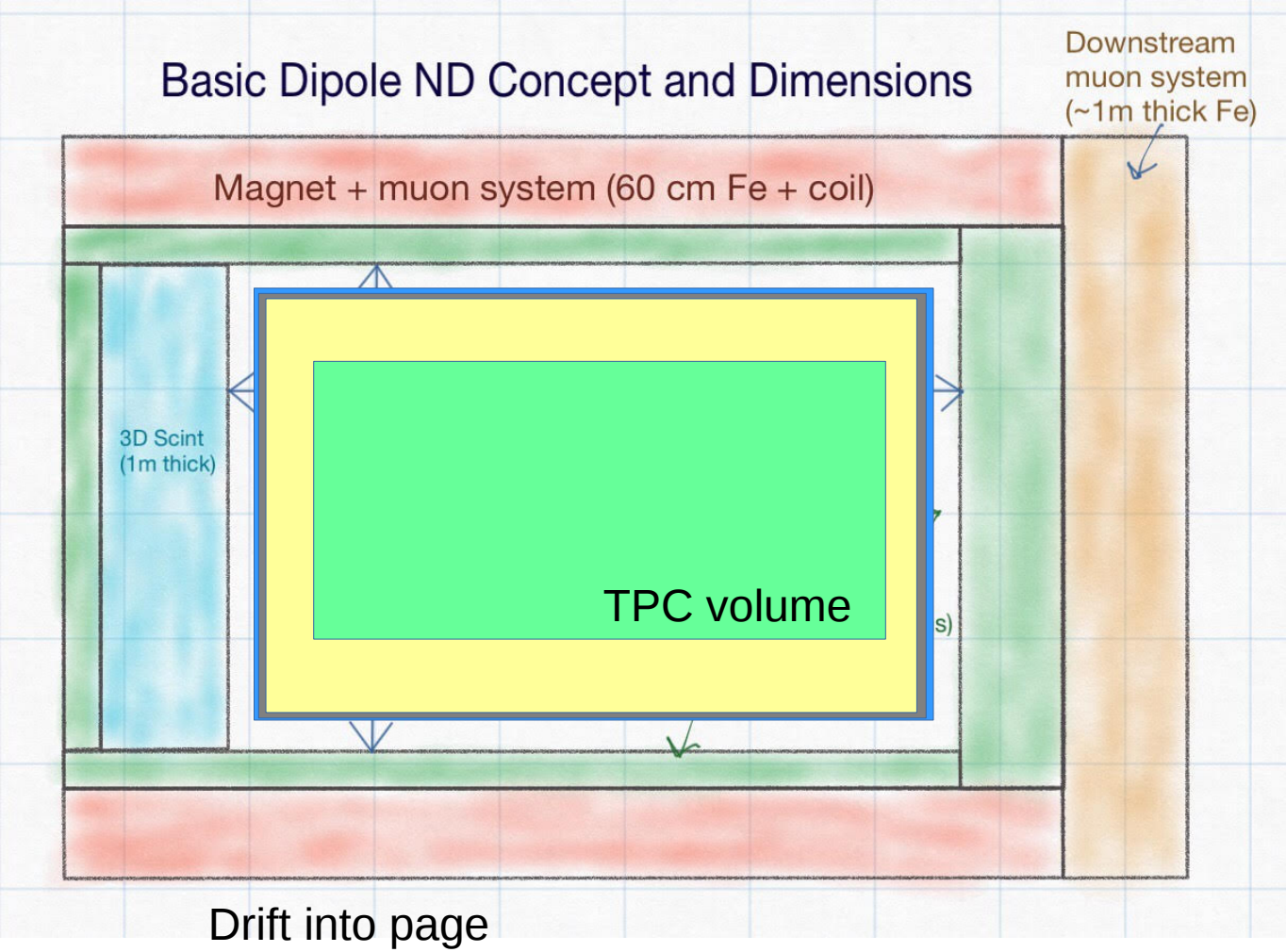
- Put cylindrical high-pressure vessel inside magnet
- Build two TPCs inside vessel, drift along magnetic field
- Can imagine 2 basic geometries

Geometry Option 1



- Not most efficient use of space, but room for other detectors
- Two rectangular TPCs, around 2.2x2.2x1.5 m each
- Could increase size if field cage support structure can be close to chamber wall without sparking
- Here: a few tens of cm between active volume and wall.

Geometry Option 2

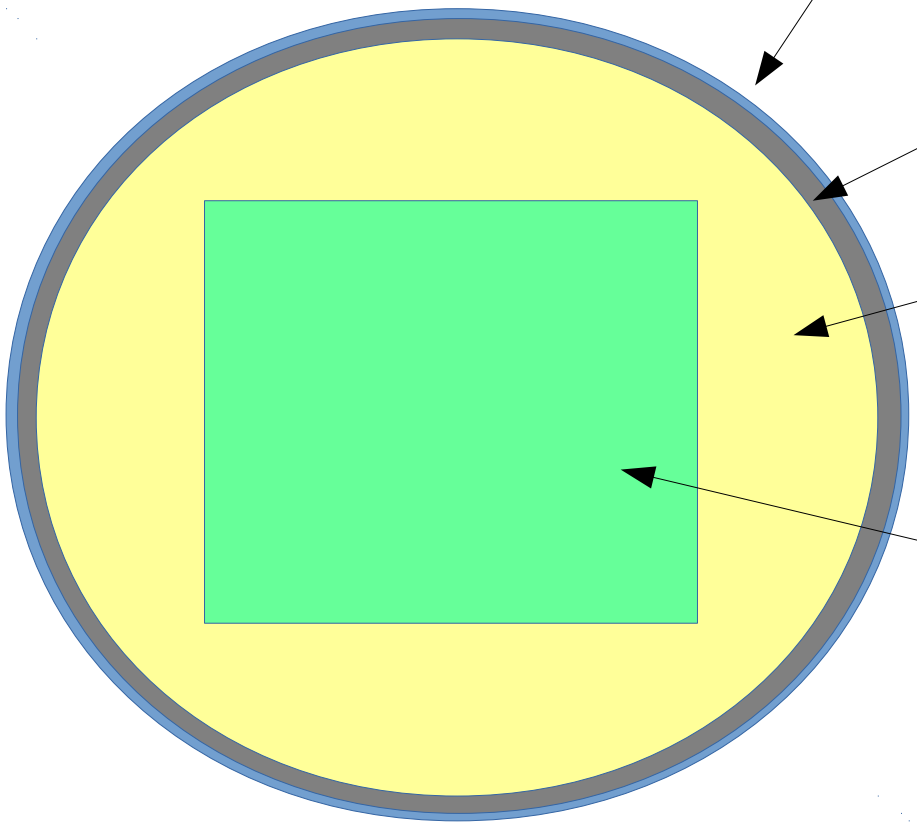


- More efficient use of space
- Two rectangular TPCs, around 2.2x5x1.1 m each
- Short drift: need to cover a lot of area with readout planes
- Somewhat smaller cross section area w.r.t. beam than in geometry 1 but much more overall volume

Implementing in GeGeDe

- Based on ALICE TPC paper/design report
  - Large volume TPC made of light materials
- For us:
  - Cylindrical high pressure chamber
  - Argon-based gas
  - Rectangular TPCs
  - Lightweight field cage, central electrode
- Many customizable options (drift direction/TPC orientation, gas, etc)

Endcap View (“Option 1”)



Thin layer of air as main LV (optional?)

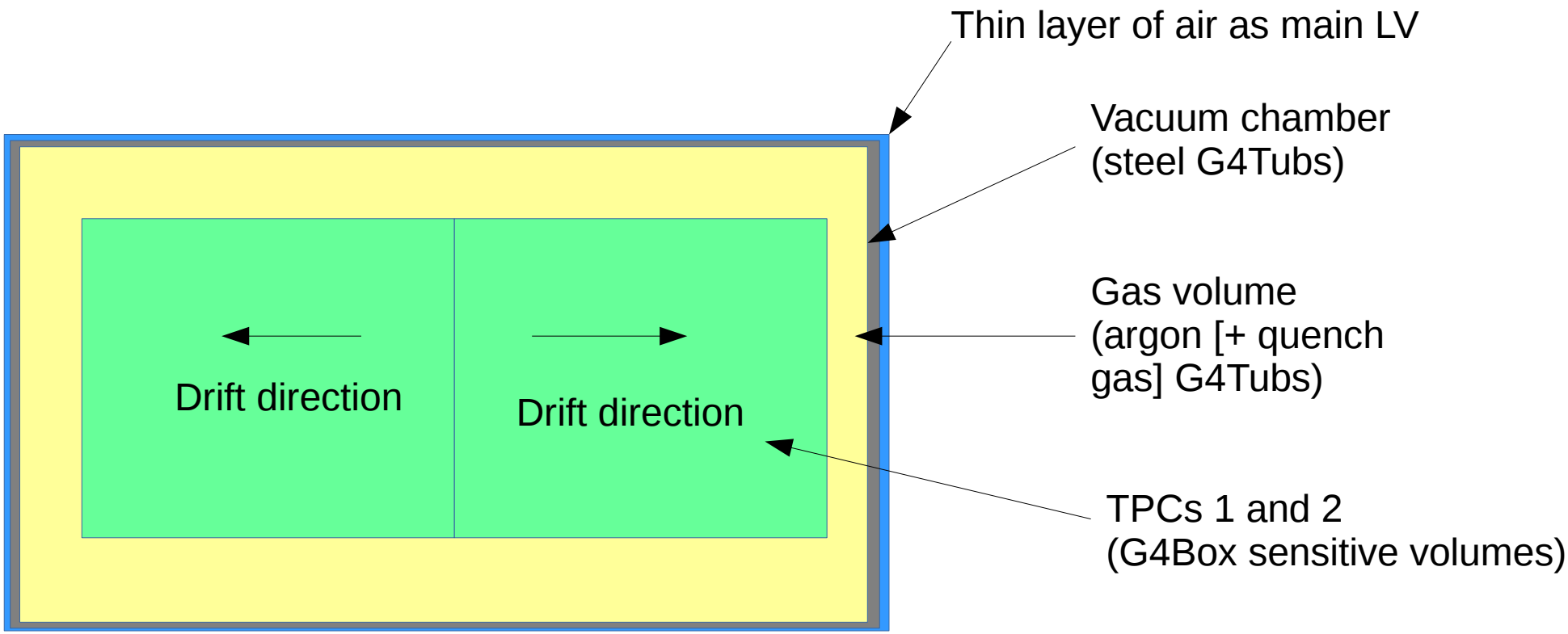
Vacuum chamber
(steel G4Tubs)

Gas volume
(argon [+ quench
gas] G4Tubs)

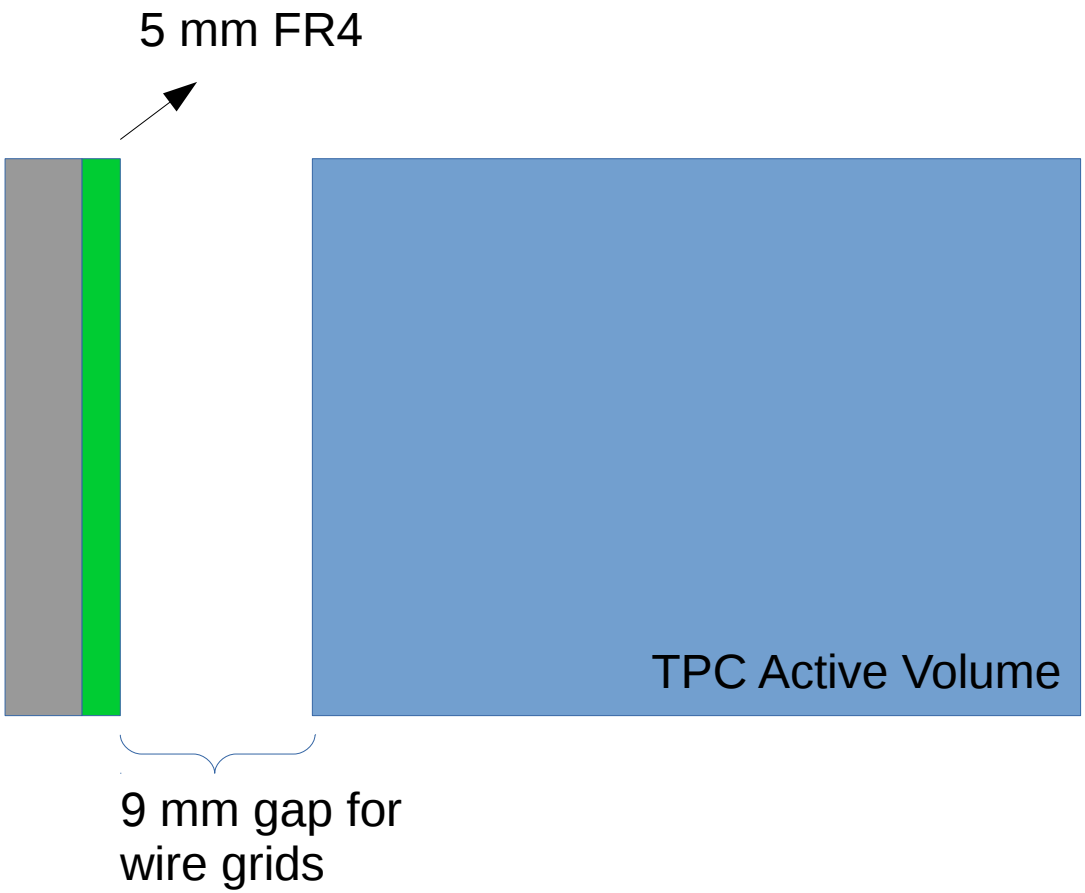
TPCs 1 and 2
(G4Box sensitive volumes)

- B-field along cylinder axis: need to rotate vessel with respect to the beam

Side View (“Option 1”)



Readout Planes



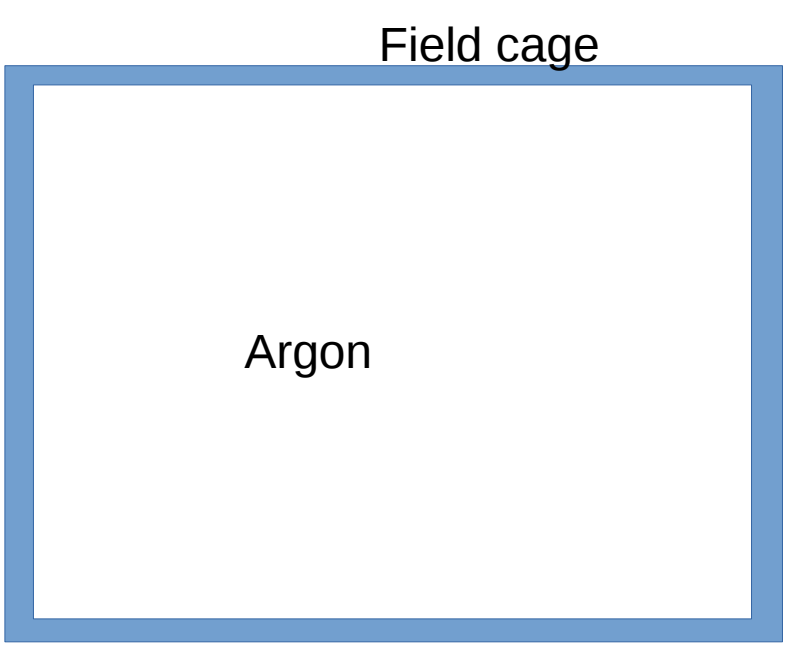
Gap & PCB size from ALICE outer chambers

No wires

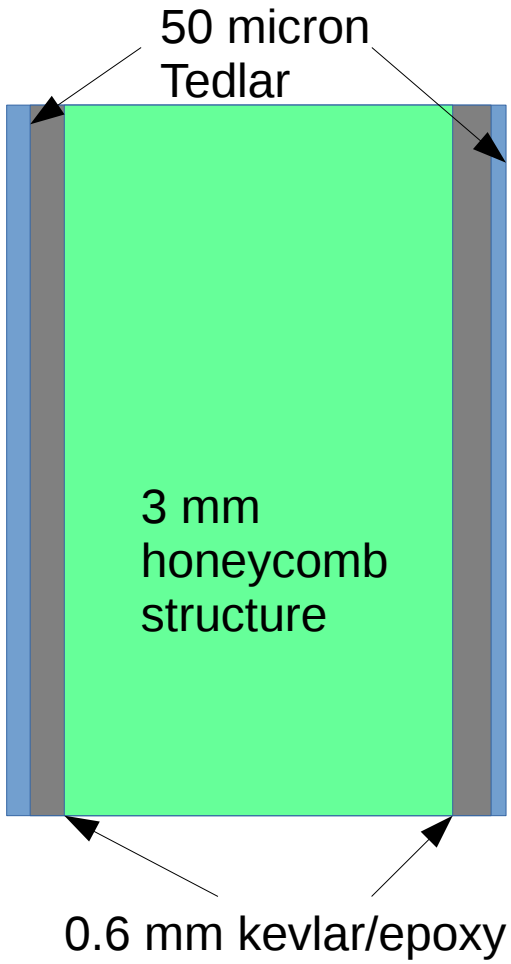
No complicated shapes right now

Field Cage

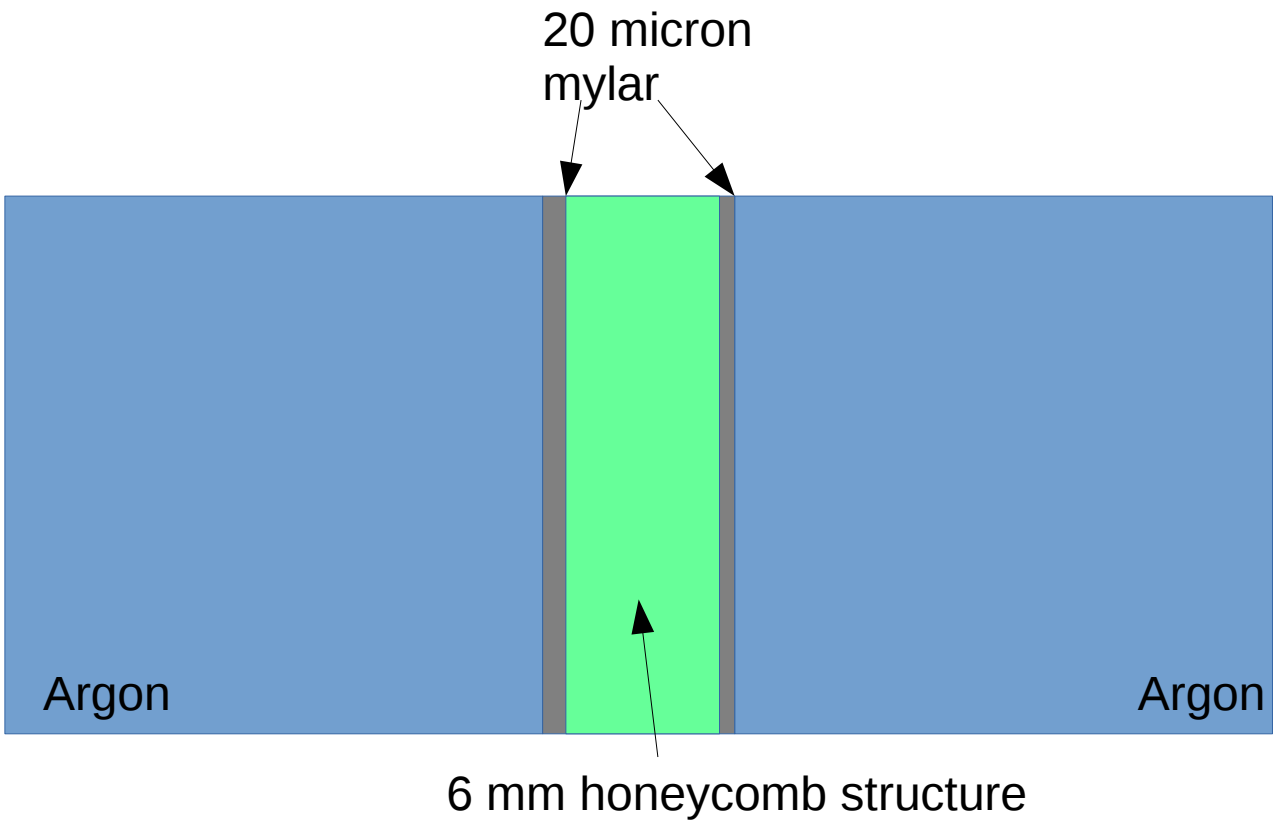
- Boolean solid surrounding active volume



Not included yet:
Field cage posts & conductive strips
(go inside field cage structure here)



Central Electrode

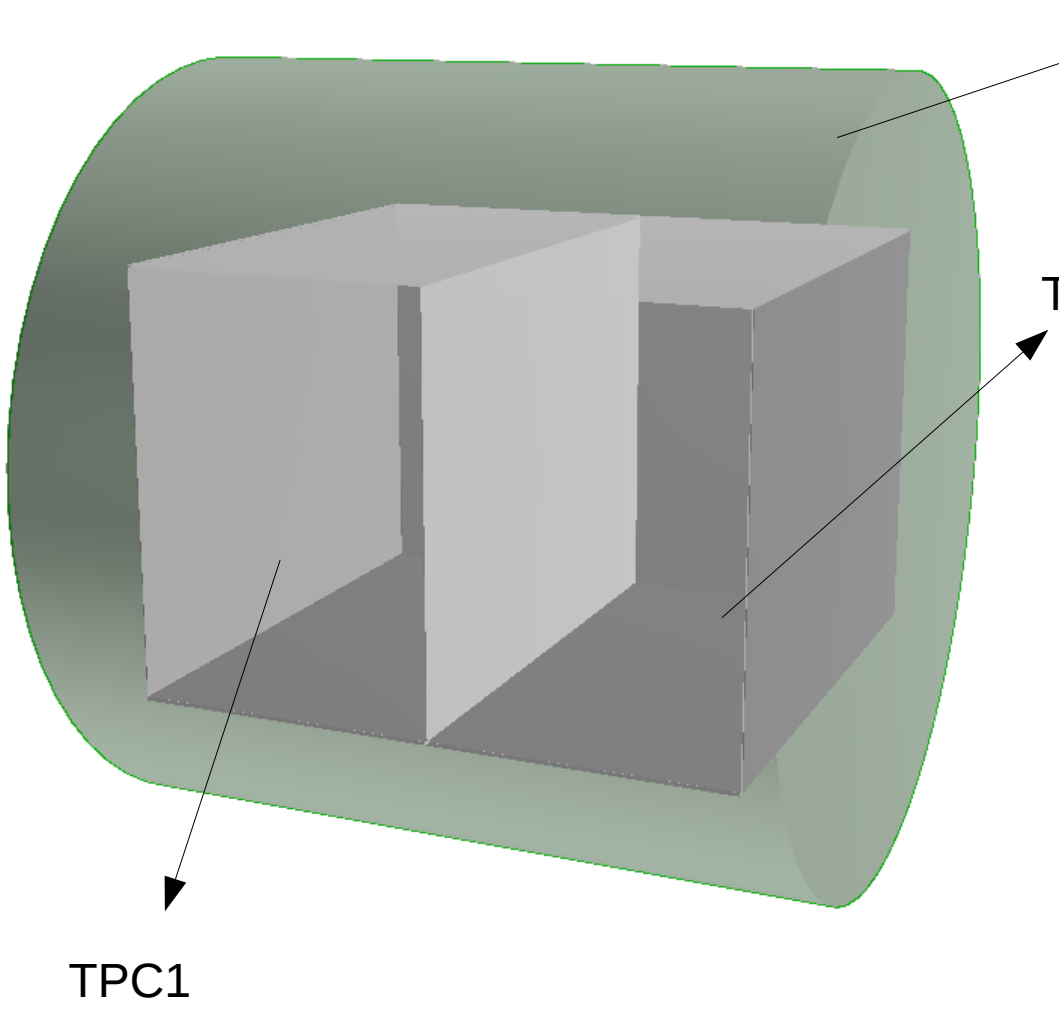


I picked 20 micron just to have something. Need more realistic number

In geometry, did not add aluminum to mylar

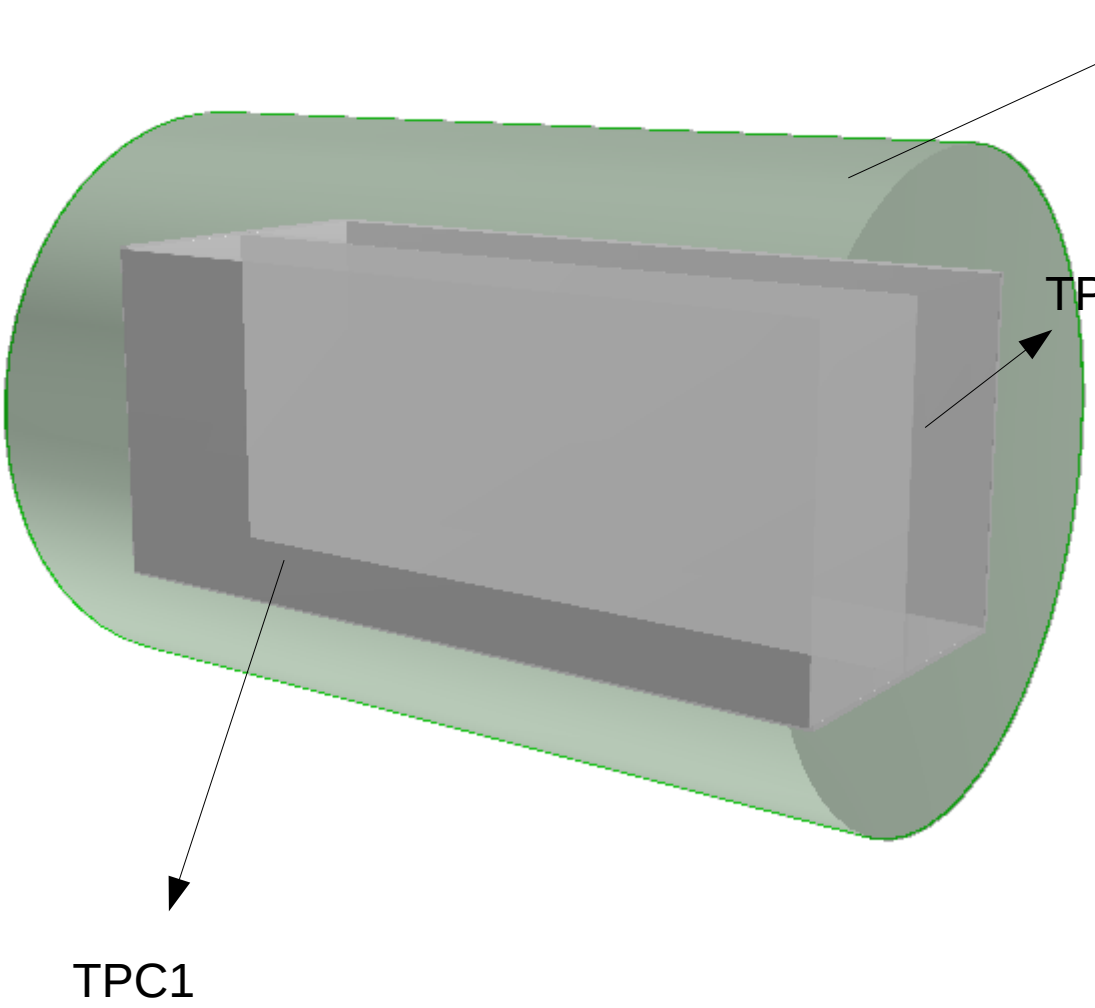
- For ALICE, similar design concerns as for field cage
- For both, we probably aren't as sensitive to material choices

“Option 1”-Type Geometry



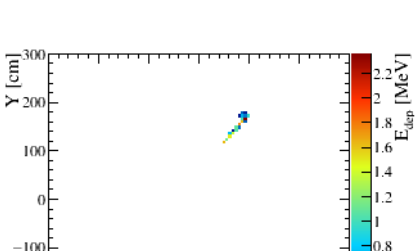
- Showing standalone geometry
- Just need to rotate to fit inside magnet
- TPC materials mostly lightweight, so not so visible with default colors

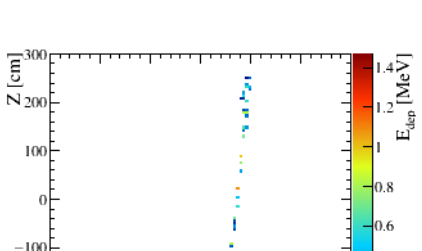
“Option 2”-Type Geometry

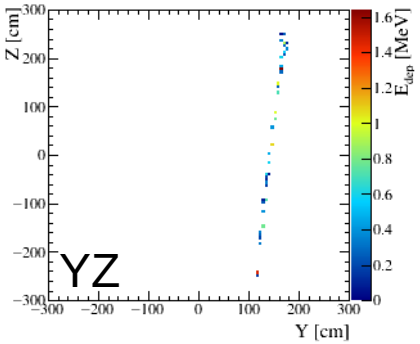


- Showing standalone geometry
- Just 1 line in configuration to change TPC orientation inside chamber

Edep-sim (Geant4) Works!

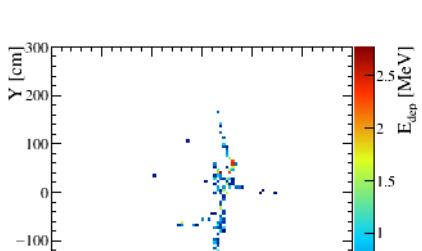


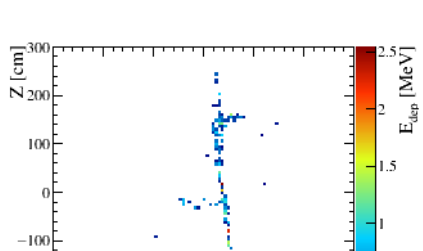


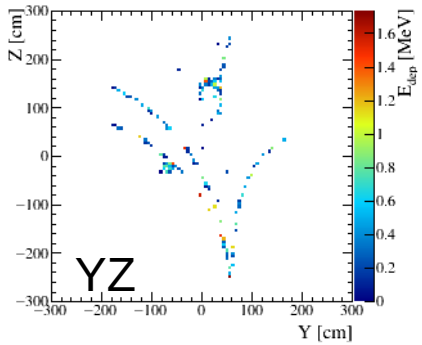


2 GeV muon, no magnetic field

Hits a bit far apart





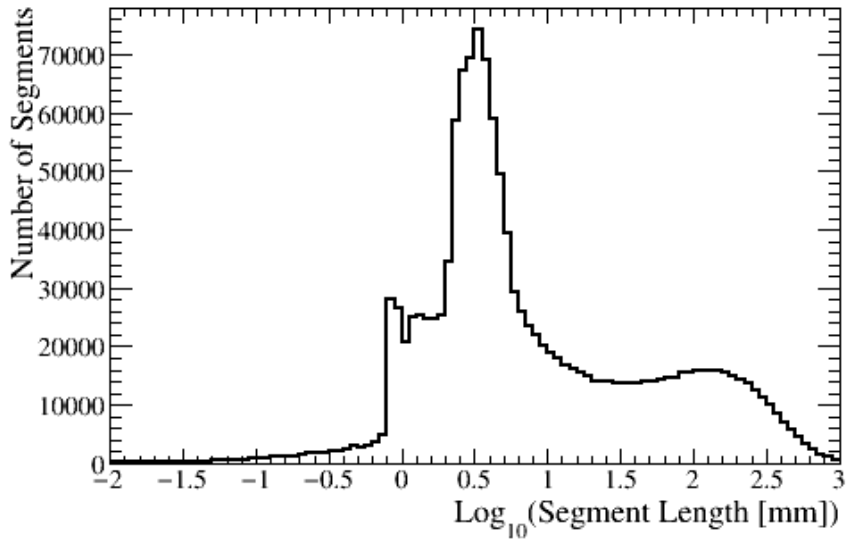


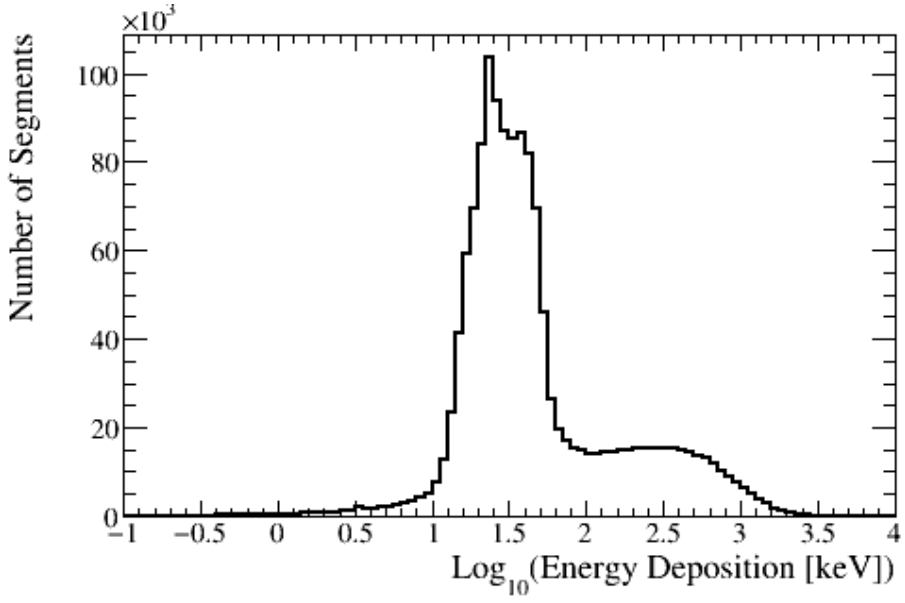
2 GeV electron, with magnetic field

Pair production near chamber wall

- Histogram of G4 hits (bin size = 6 cm), color = energy loss
- Readout would have much finer binning

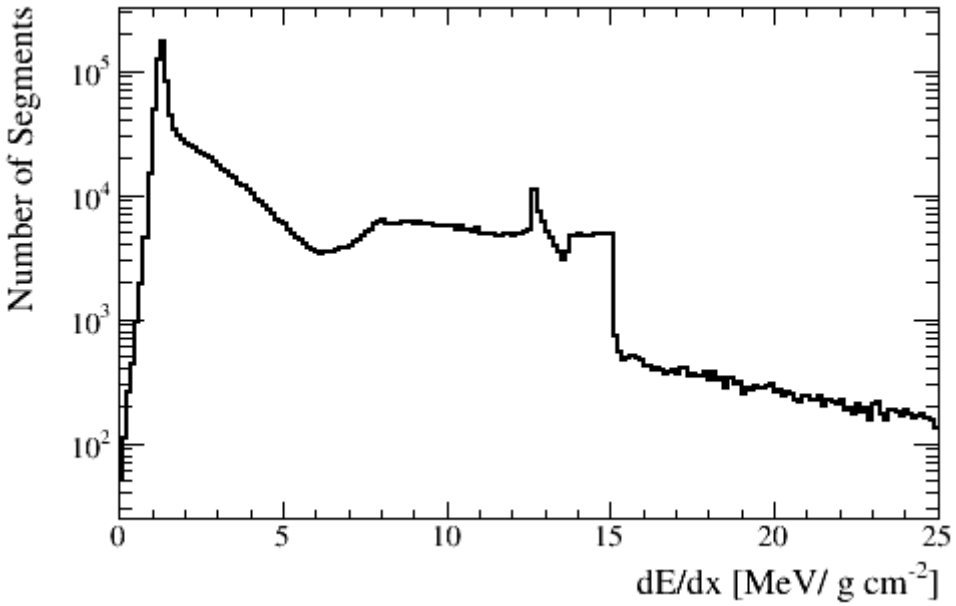
Muon Steps & Energy Loss

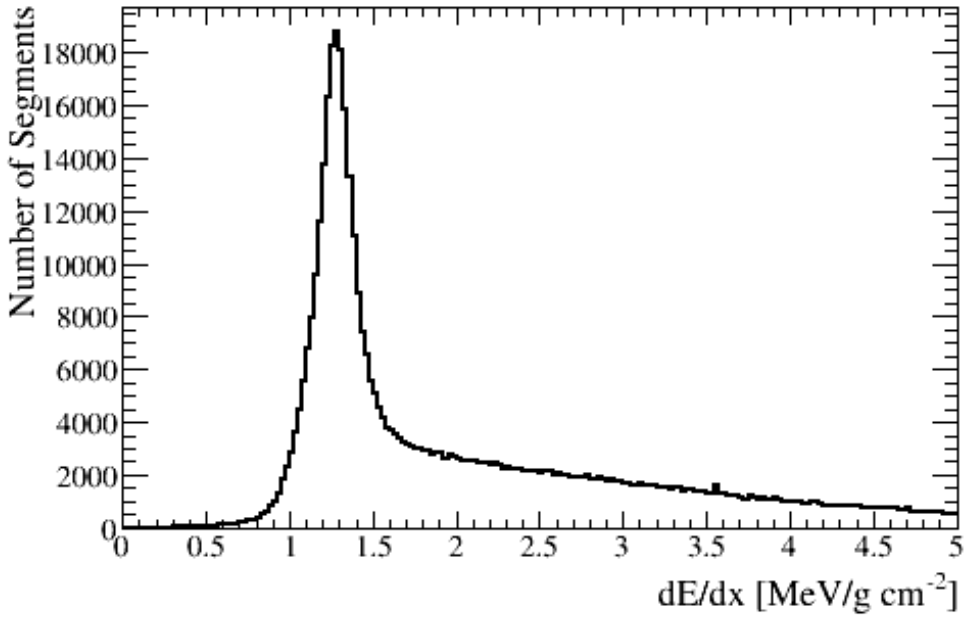




- Note plateau structure near 1 mm segment length
- Some segments are even 1 m long! Not so good for gas simulations...
- Just using default settings – need to tune settings a bit for gas detector
- Particle gun MC, 10000 muons

Muon Stopping Power





- Maybe some physics list artifacts
- Overall, looks fairly reasonable

Conclusions

- Have built an initial version of a high pressure GAr TPC geometry in GeGeDe
  - Includes vessel, gas, two TPCs, some material for the field cage, readout planes, and central electrode
  - Is well-documented: Should be easy to use, many user options available
- Initial tests show that the geometry is easy to integrate with edep-sim
  - Some tuning of Geant4 settings likely, but overall few to no changes are likely required at this point.

User Parameters in Config File

- halfDimension {rmin,rmax,dz}: Radii and half-length of bounding volume
- chamberDimension {r,dz}: Radius and length of chamber
- tpcDimension {dx,dy,dz}: Dimensions of a single TPC volume
- Material (string or {}): Material name or composition

  Optional:
- BField: (): Magnetic field (only use in standalone mode with no magnet)
- drift: x, y, or z. Drift direction. Need to validate rotations in x/y mode
- MaterialName, Density (strings): Use if Material gives the composition
- PadThickness, PadMaterial, PadOffset: Readout PCB parameters
- PadFrameThickness, PadFrameMaterial: Readout support structure parameters
- EndCapThickness, WallThickness, ChamberMaterial: Chamber parameters
- CentElectrodeThickness, CentElectrodeHCThickness: Central electrode mylar & honeycomb widths