Use of Material Volumes for a TPC Electrostatic Simulation

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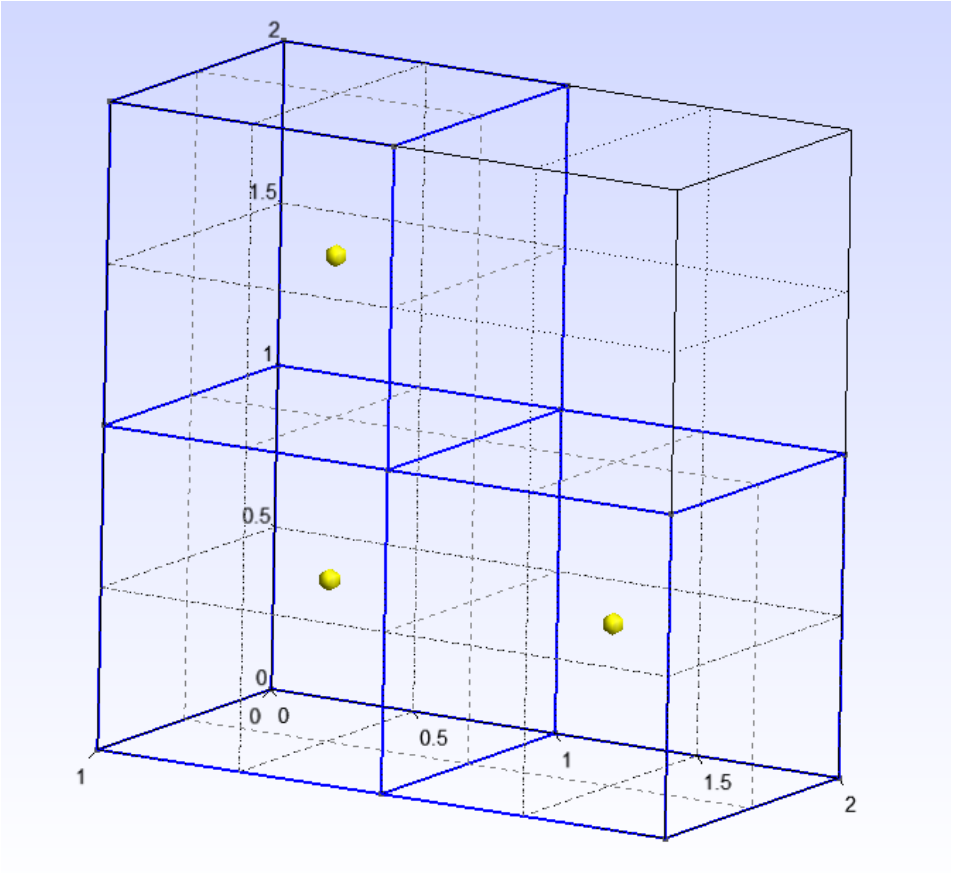
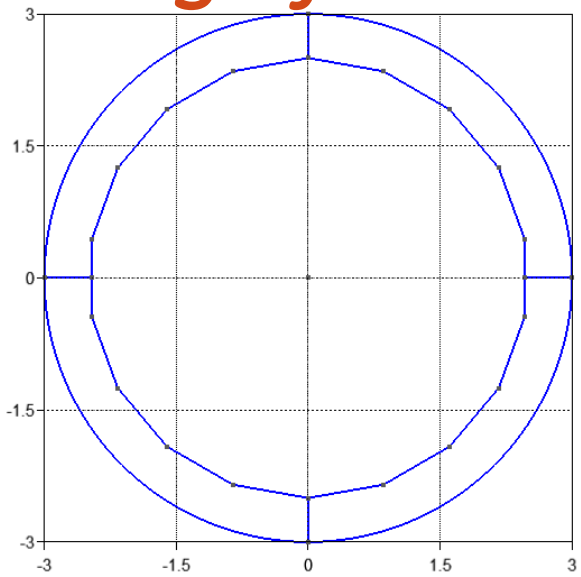
Use of Material Volumes in Gmsh and Elmer

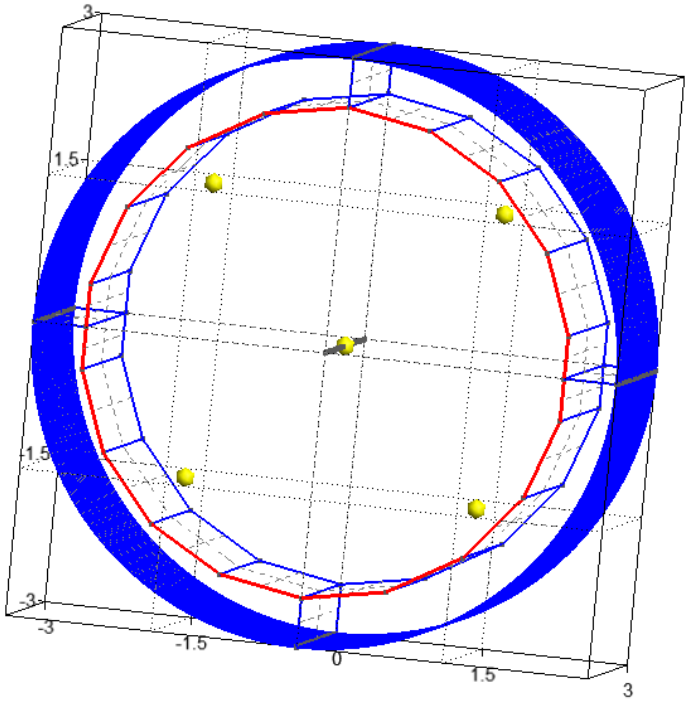
- ***Materials***
  - ***Conductors: Copper, Silver, Aluminum,***
  - ***Dielectrics: PVC, Silicon, Glass, Fused Quartz***
  - ***Vacuum***
- ***Material Properties:***
  - ***Density, Dielectric Constant, Conductivity, Viscosity Specific Heat, Thermal Expansion Coefficient***
- ***Elmer GUI has programmable menus***
  - ***Insert materials of choice with your own material properties***



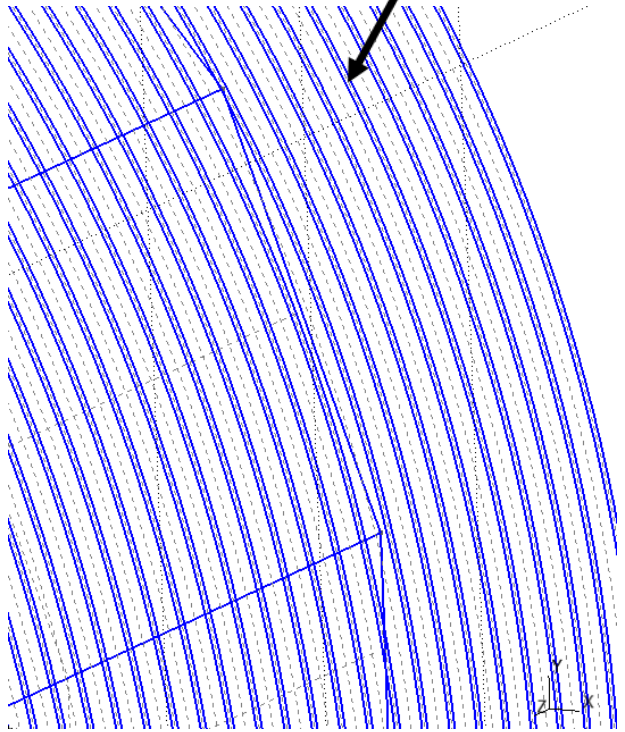
Gmsh geometry showing three independent volumes

Gmsh Design for a TPC





Physical surfaces
Width = 8.0 cm
Spacing: 2.0 cm



- ***Design composed of 5 independent volumes***
  - ***4 outer quadrants***
  - ***Central 18-sided volume***
- ***TPC has length of 2.5 m and diameter of 6.0 m.***
- ***Cylindrical Surface has 24 strips (physical surfaces) to which appropriate voltages can be applied***

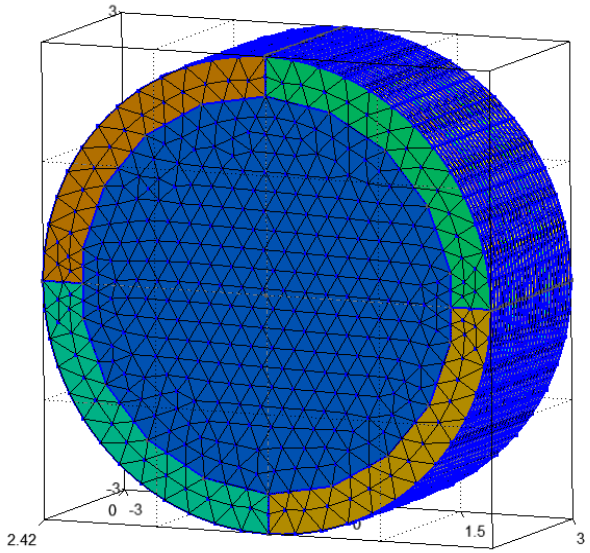
Meshing Capabilities of Gmsh

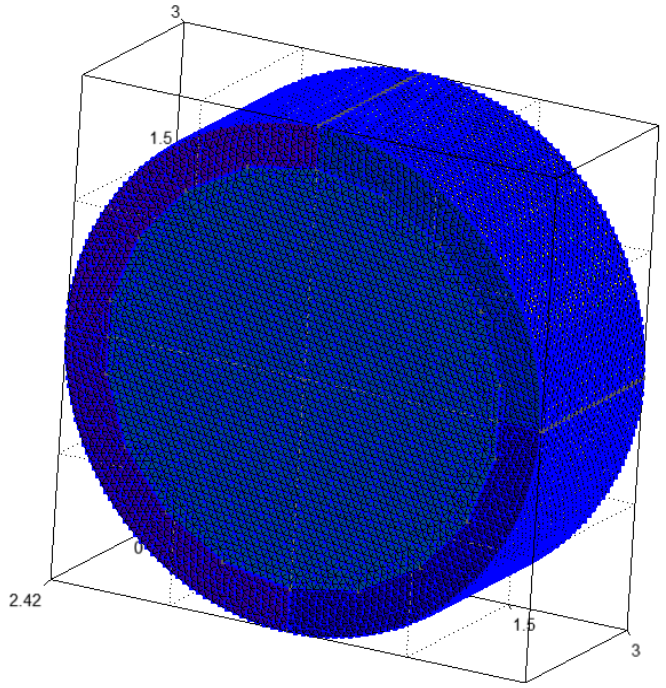
- ***Powerful mesh generator creates meshes with:***

Triangles	***Prisms***
Quadrangles	***Hexahedra***
Tetrahedra	***Pyramids***

- ***Ability to control the mesh density at points inside the volume***

- ***Can create coarse mesh files from a few KiloBytes to dense (fine) mesh files of many MegaBytes.***





5-Volume TPC uploaded to Elmer GUI

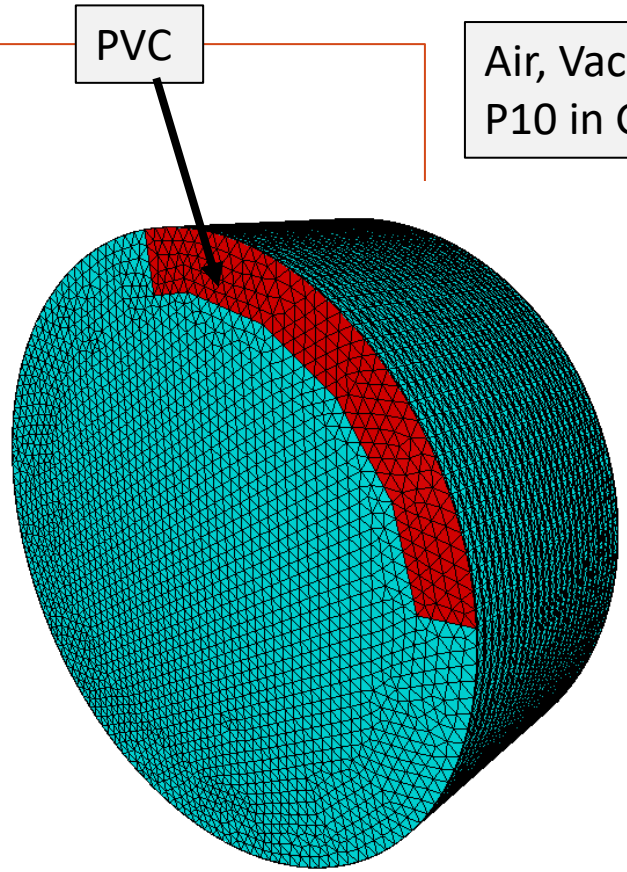
1. *Set up Elmer to solve the electrostatic equation*

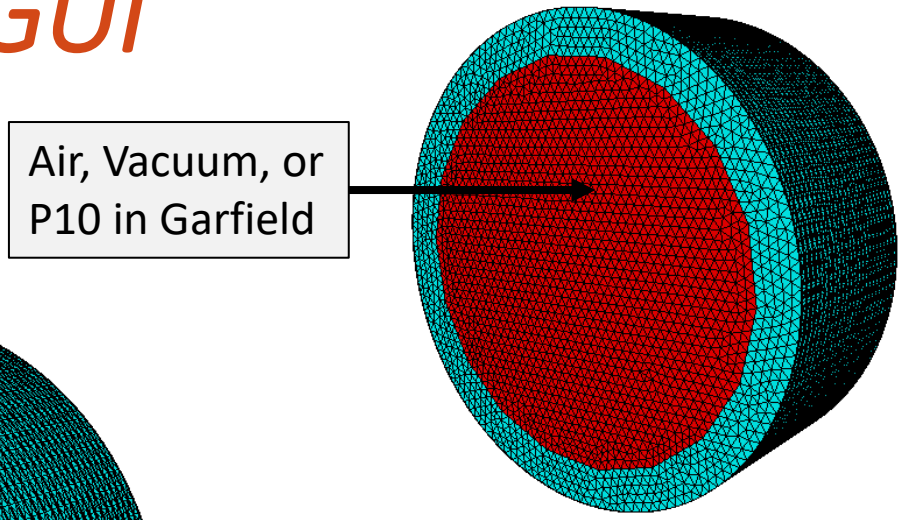
2. *Select materials for each physical volume:*
   - *Outer quadrants 1-4: PVC*
   - *18-sided inner volume: Air*

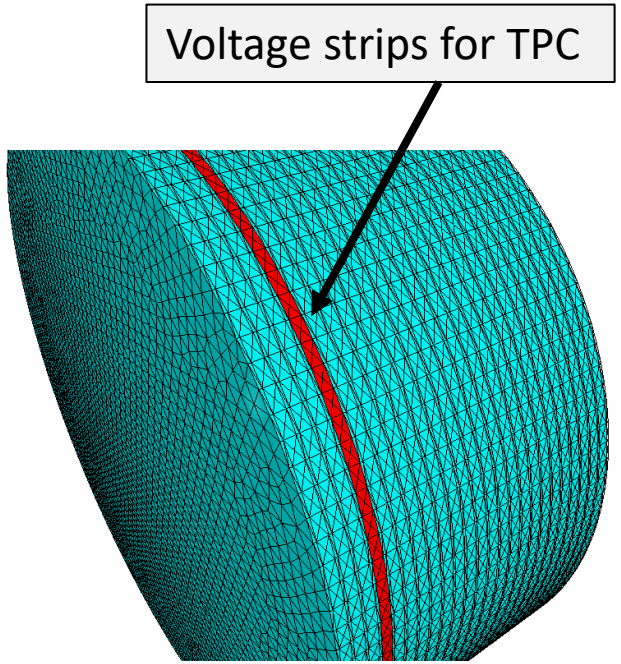
3. *Apply boundary conditions:*
   - *100 kV at back face*
   - *0 kV at front face*
   - *Each of 24 strips (s1, s2, …., s24) (4000 V, 8000 V, ..., 96,0000 V)*

4. *Generate SIF file*

5. *Run the Solver (output field map is a .vtu file)*



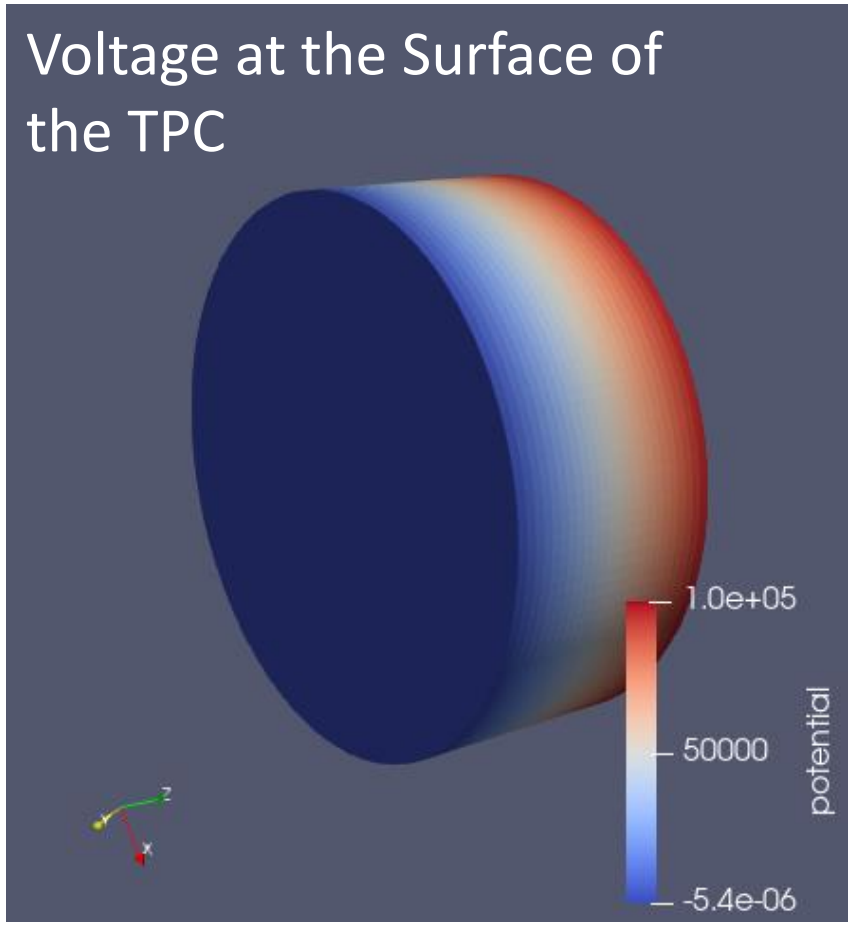


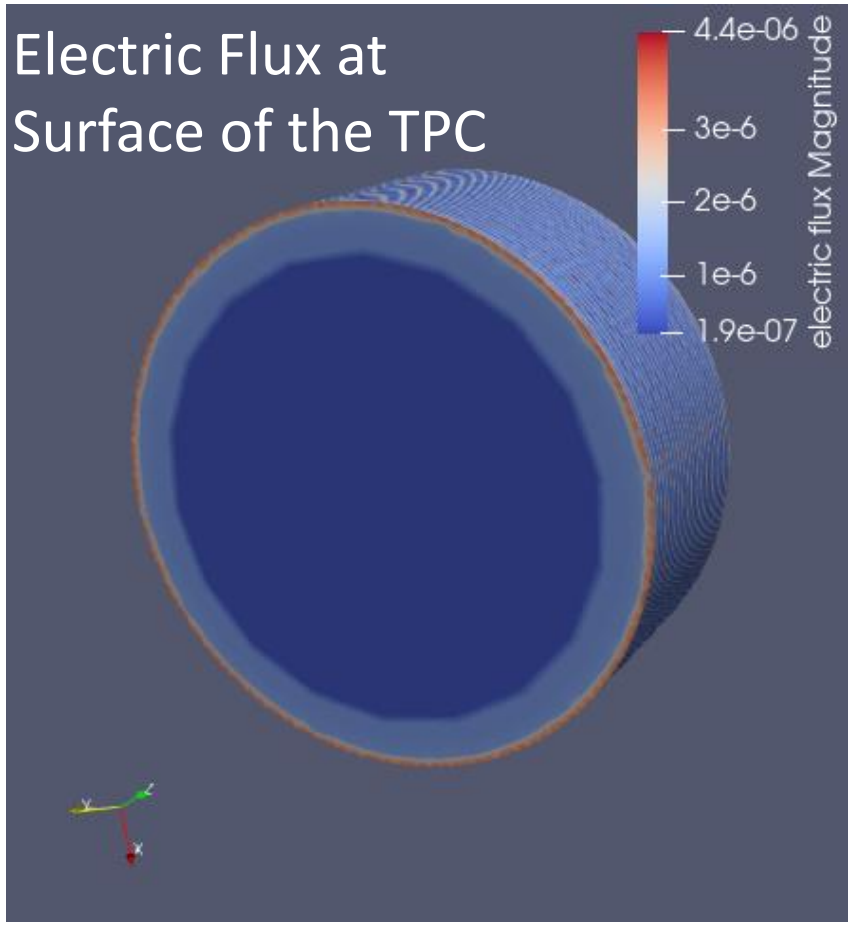


Elmer Results for the TPC Design using ParaView Visualization Software

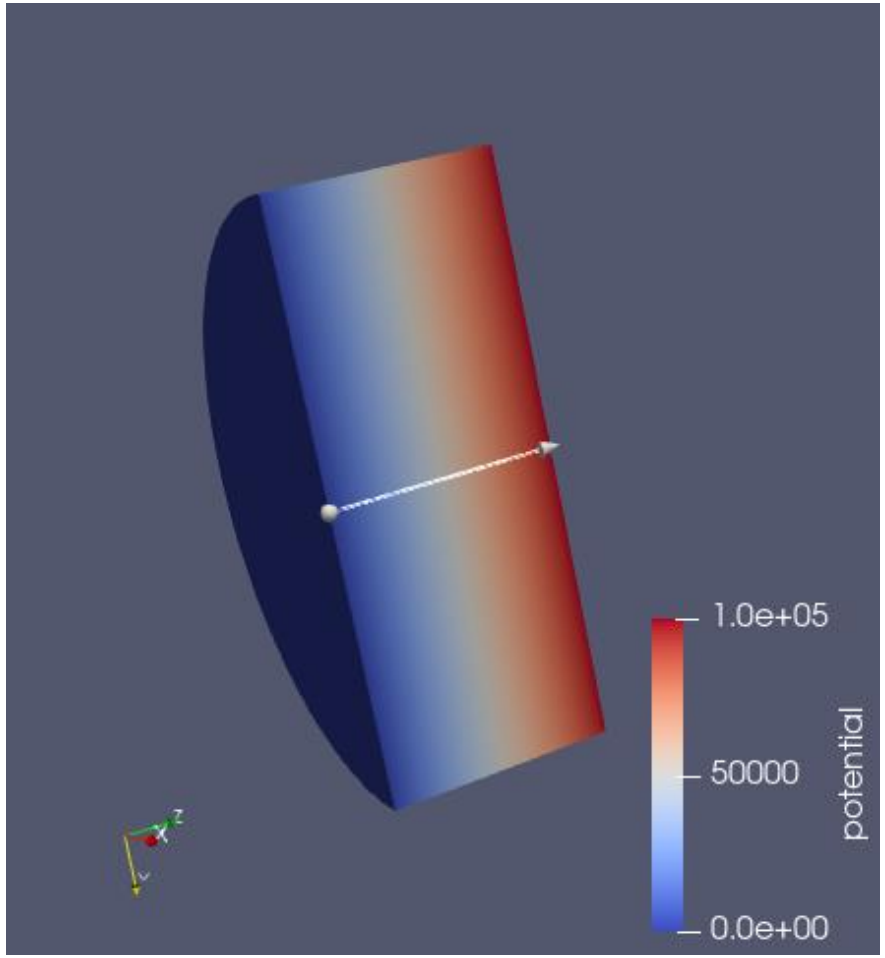
ParaView:

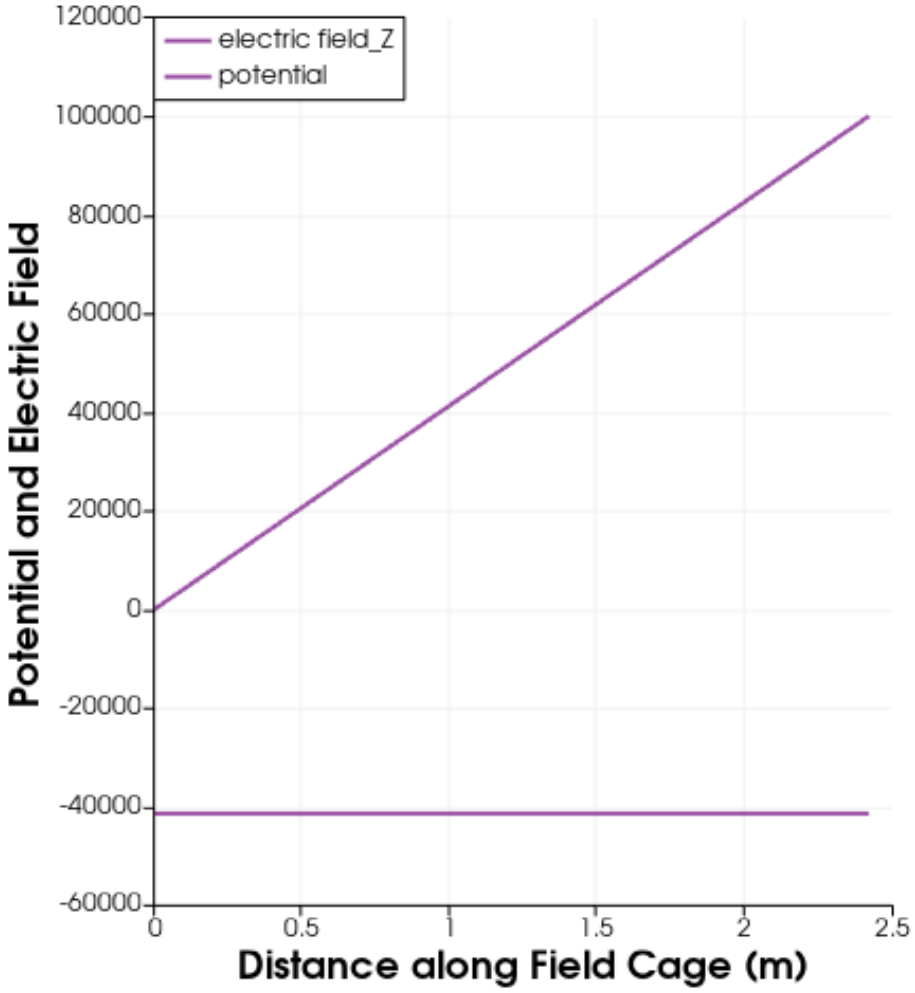
- ***Open source software***
- ***Visualization of 2D and 3D data sets***
- ***Capabilities***
  - ✓ ***Multi-View***
  - ✓ ***Plotting***
  - ✓ ***Animation***
  - ✓ ***Streamlines***
  - ✓ ***Etc.***





Electric Field/Potential on Central Axis of TPC Using ParaView



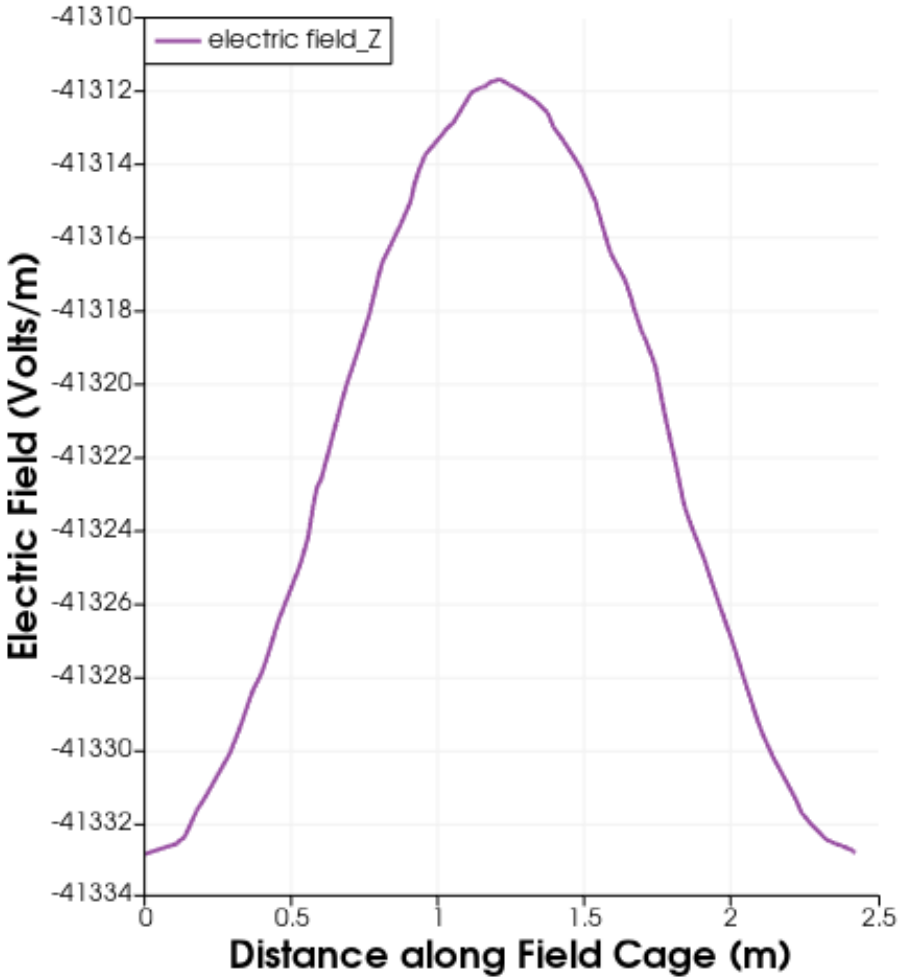


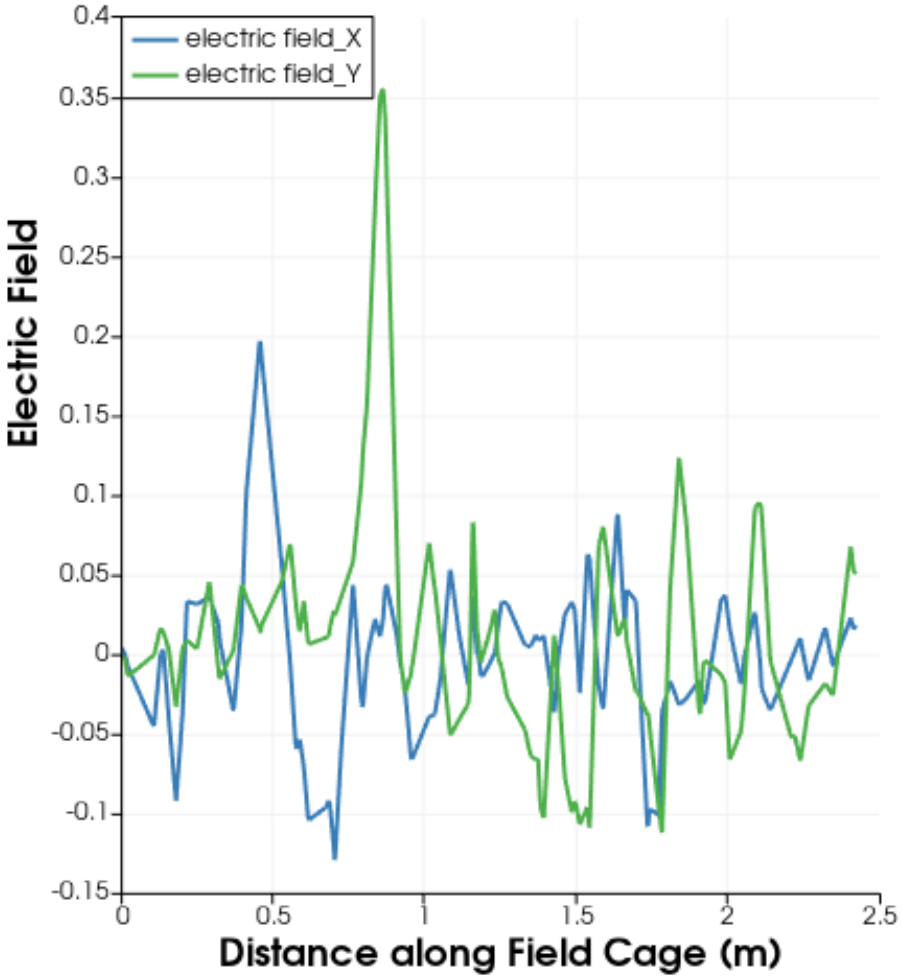
Details of Electric Field Components on Central Axis

Variation of Ez along center:
0.05 percent

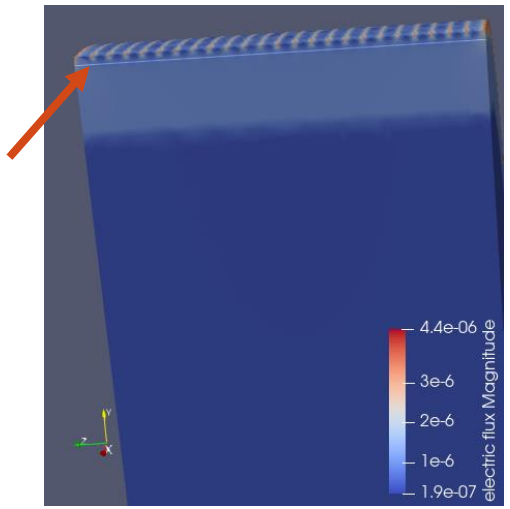
Significance of Ex and Ey is minimal:

Ex/Ez < 10E-5
Ey/Ez < 10E-5

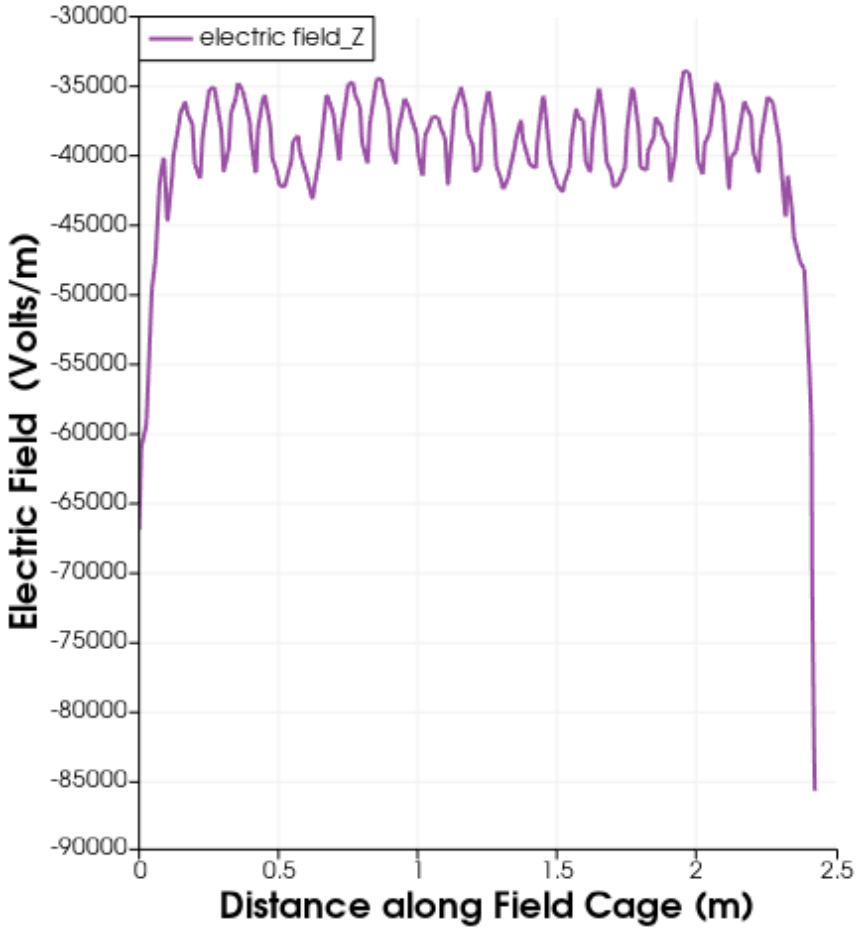


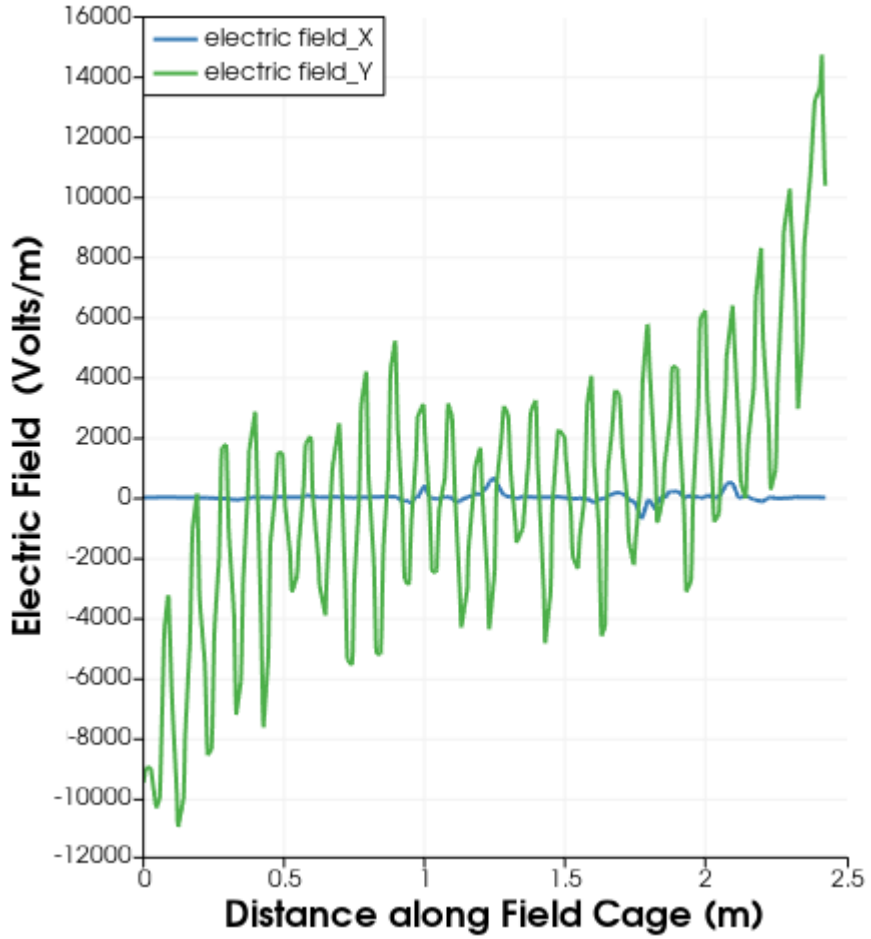


Fields near the Edge of the TPC Using ParaView

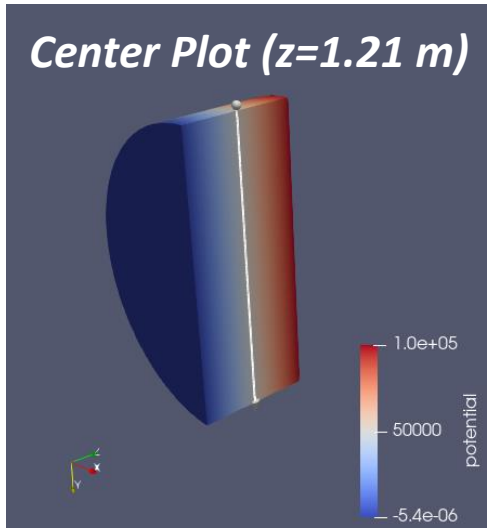


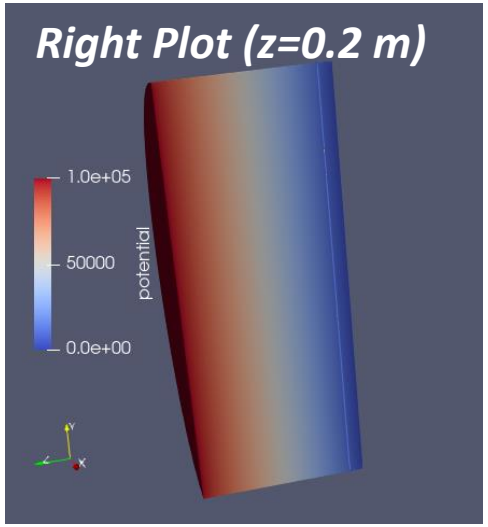
- ***Fields at y=2.95 m from center***

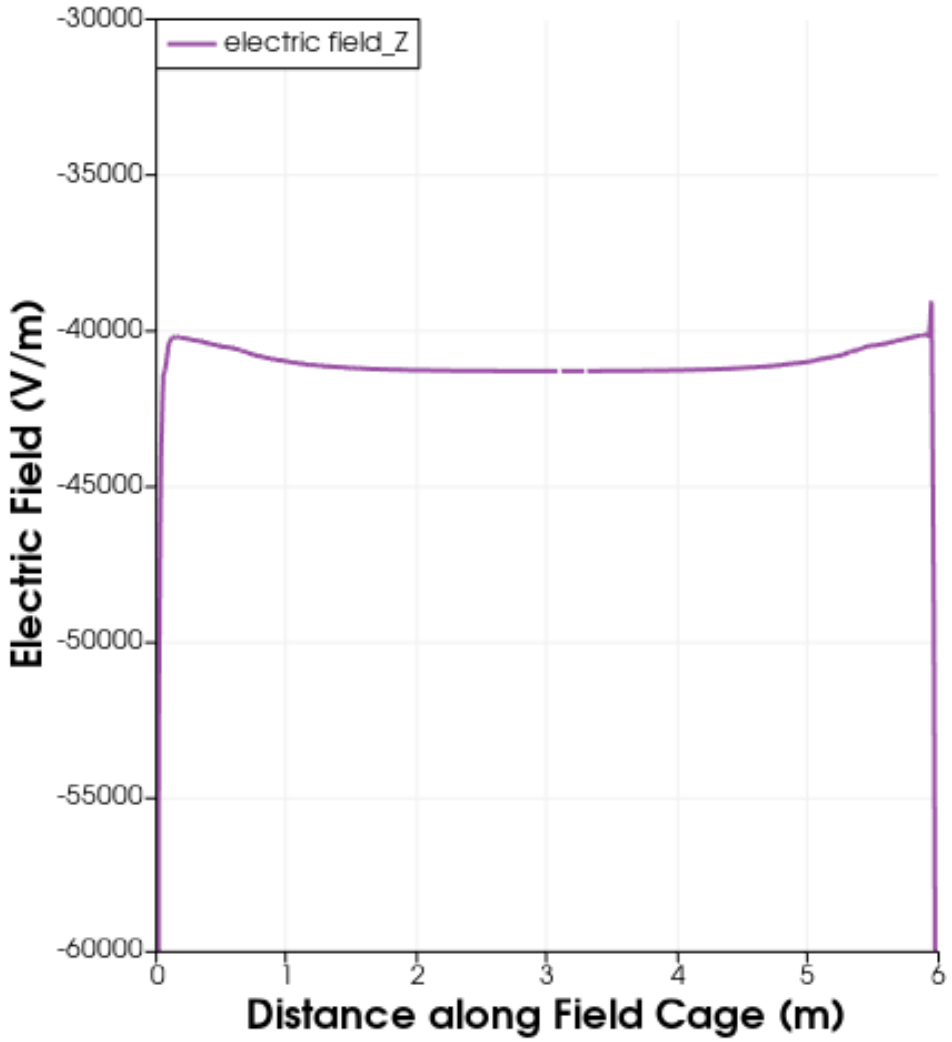


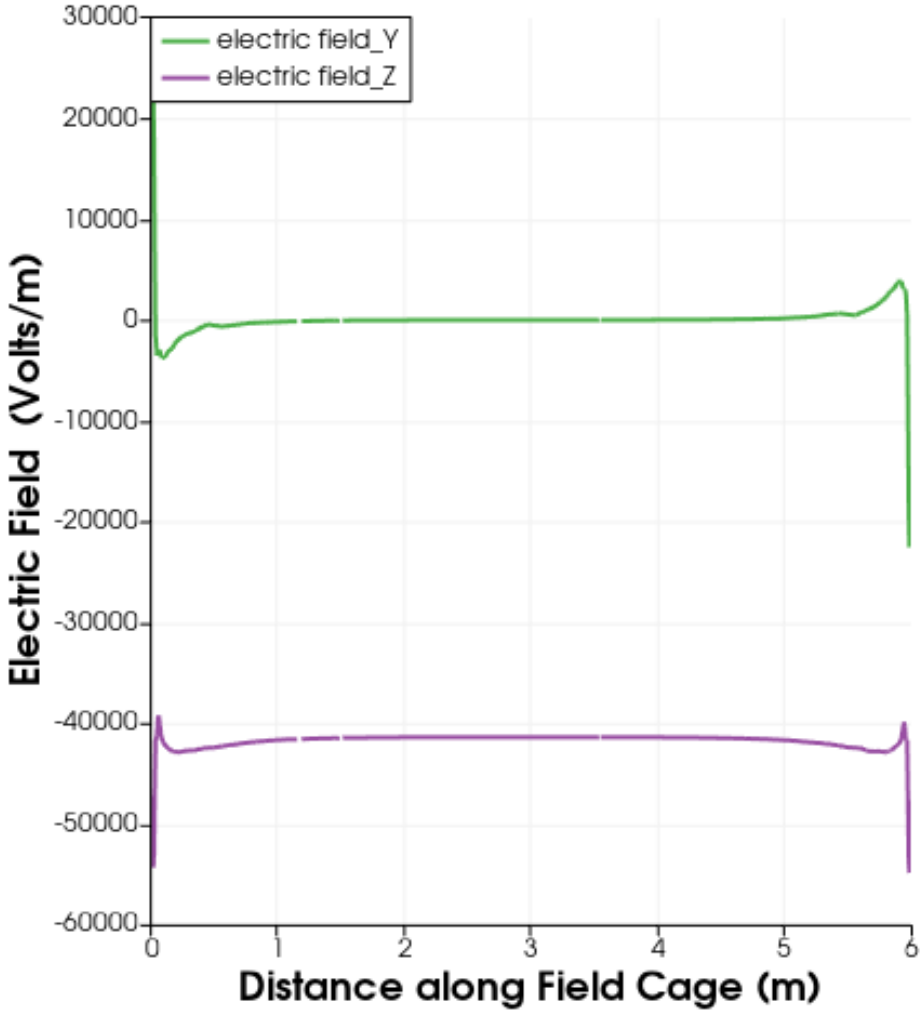


Electric field from Top to Bottom Using ParaView







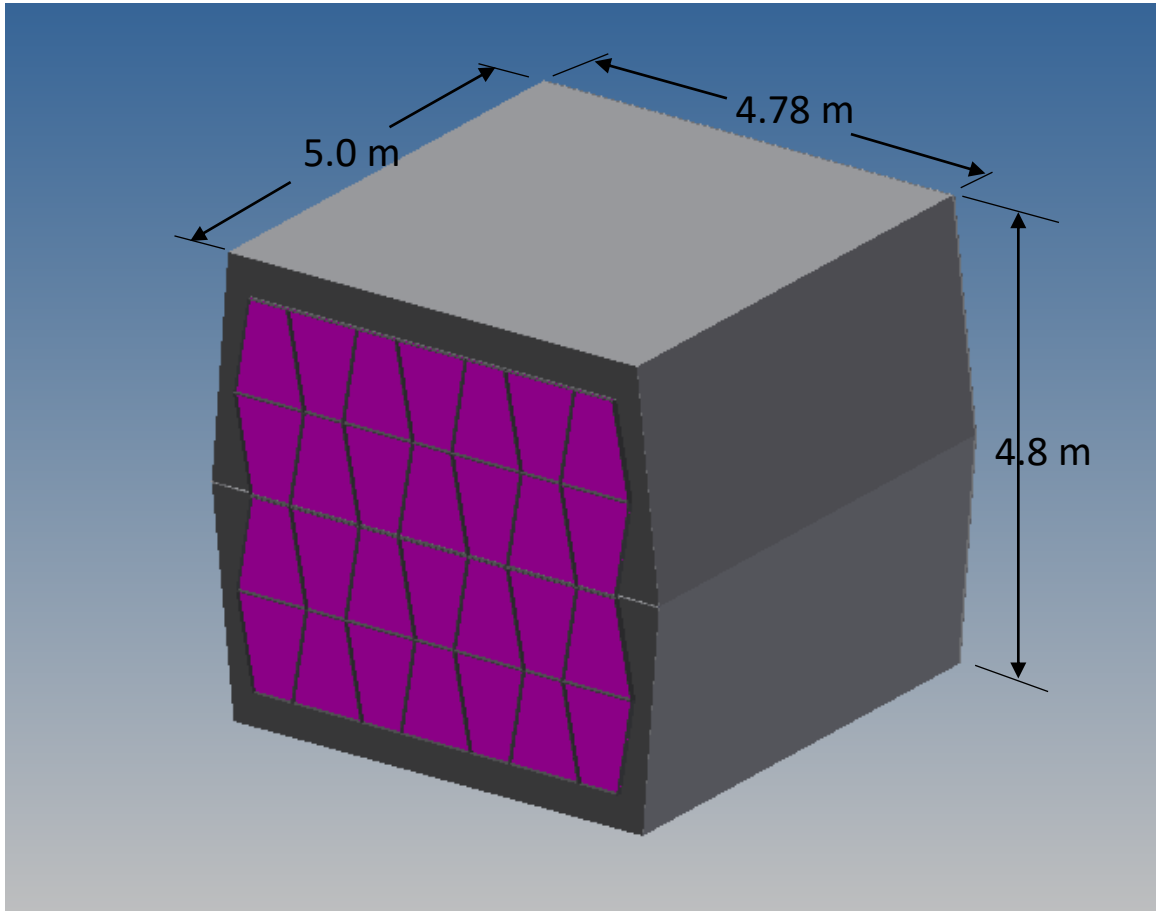


A New Design for a TPC

- ***Design based on discussions in Tuesday July 14th, 2020 gas TPC meeting***
  - ***TPC with a full 5 meter drift volume with readout electronics installed on only one end of the device***
  - ***Extra ROCs can then be used as replacements if needed***
  - ***Increase the cathode voltage considerably at the far end (Maybe 180kV)***
  - ***Cost savings for needing FEE on one side of the device***
  - ***ALICE design necessary based on CM interaction region at the center of the device. DUNE device measuring interactions from orthogonal Neutrino beam***

TPC with full 5m Drift Volume

- *Design uses 28 OROC's from the ALICE Detector (8 leftover)*
- *Total area for 28 OROCs is 17.9 m^2*
- *Compare with total area of IROCs, OROCs, and the CROC on the cylindrical ALICE design where A=17.2 m^2*
- *Can consider a similar design with Central cathode and readout chambers on both sides. For this design, need to build 20 more OROCs.*



Thank you for your time