GTS gun COMSOL simulations

Upper shield prototypes

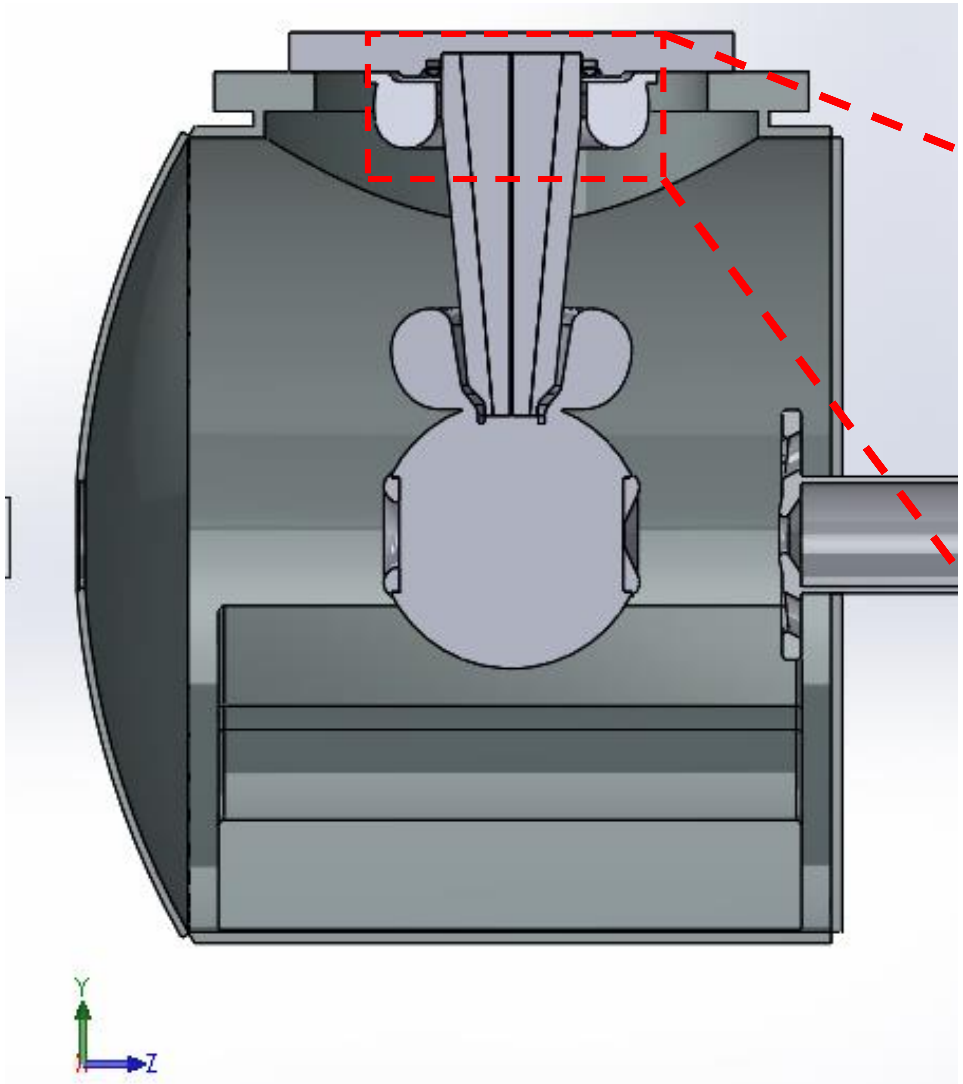
Gabriel Palacios

gpala001@odu.edu
05/10/17

Summary

- Solidworks
  - Geometry modifications
- COMSOL
  - Details of simulation
  - Electric field plots
- Additional slides

Solidworks geometry modifications:



Gabriel's suggestion. *too much heavy metal* Not machine friendly.

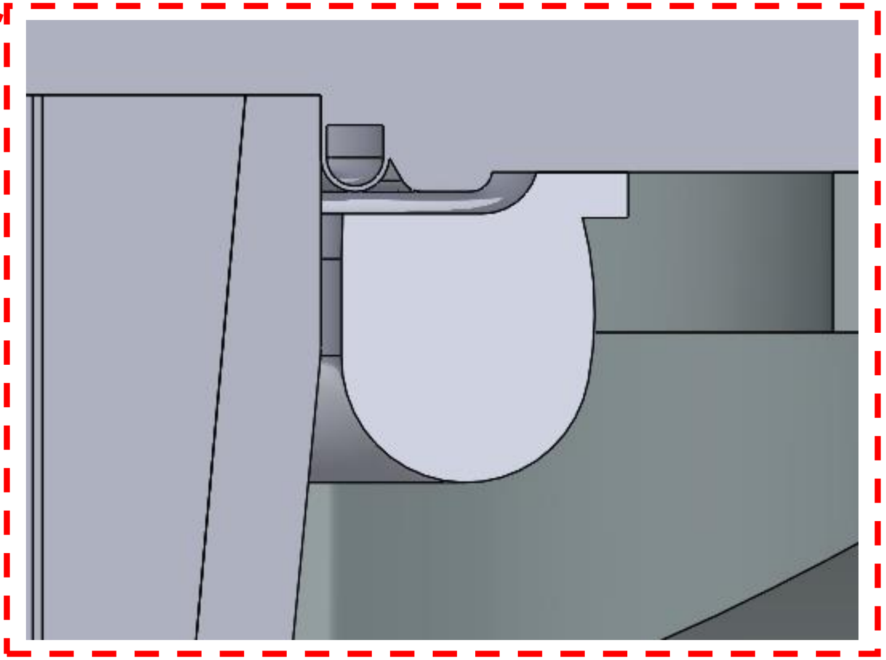
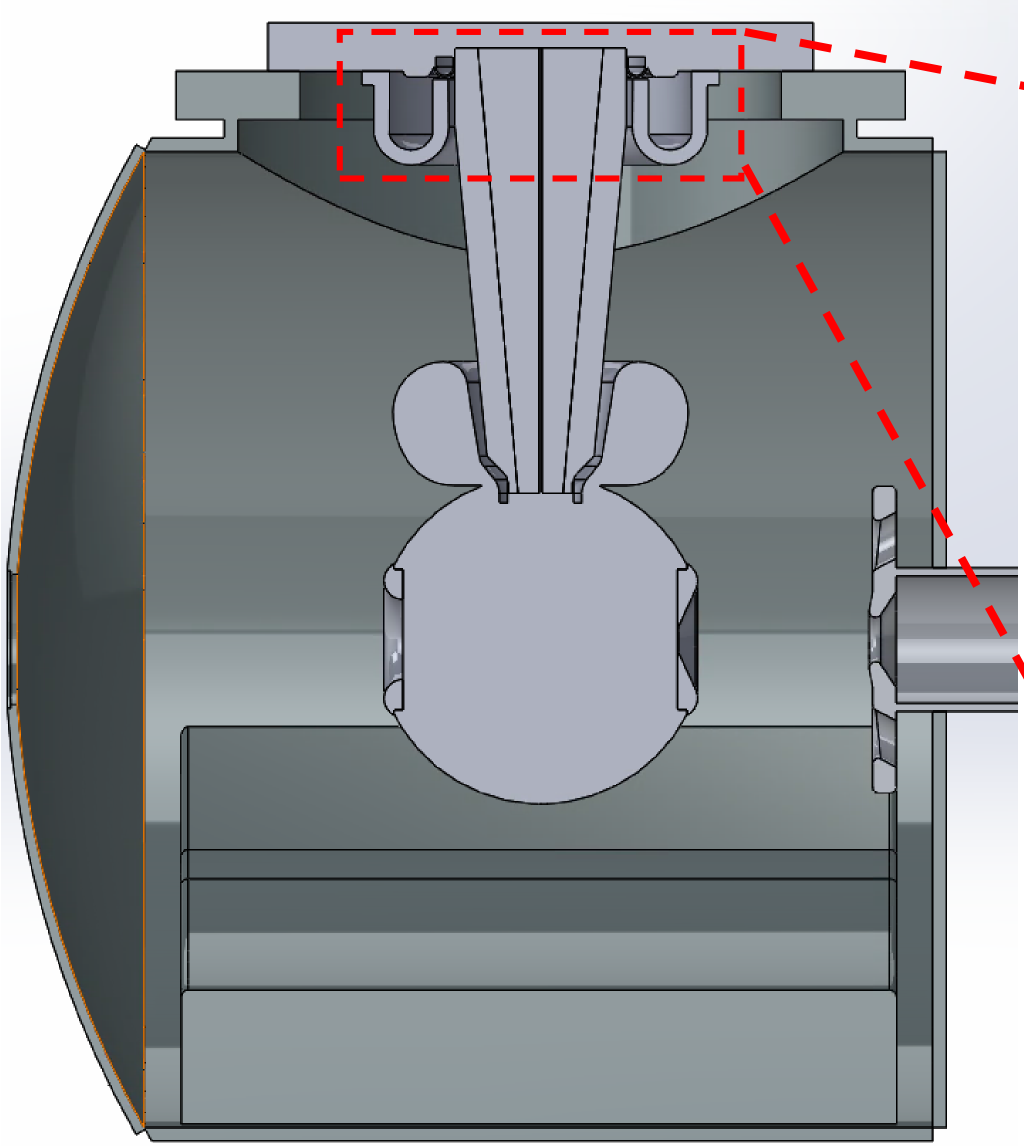


Image on the left not to scale

Solidworks geometry modifications:



Danny's suggestion. Light! Vacuum problems?

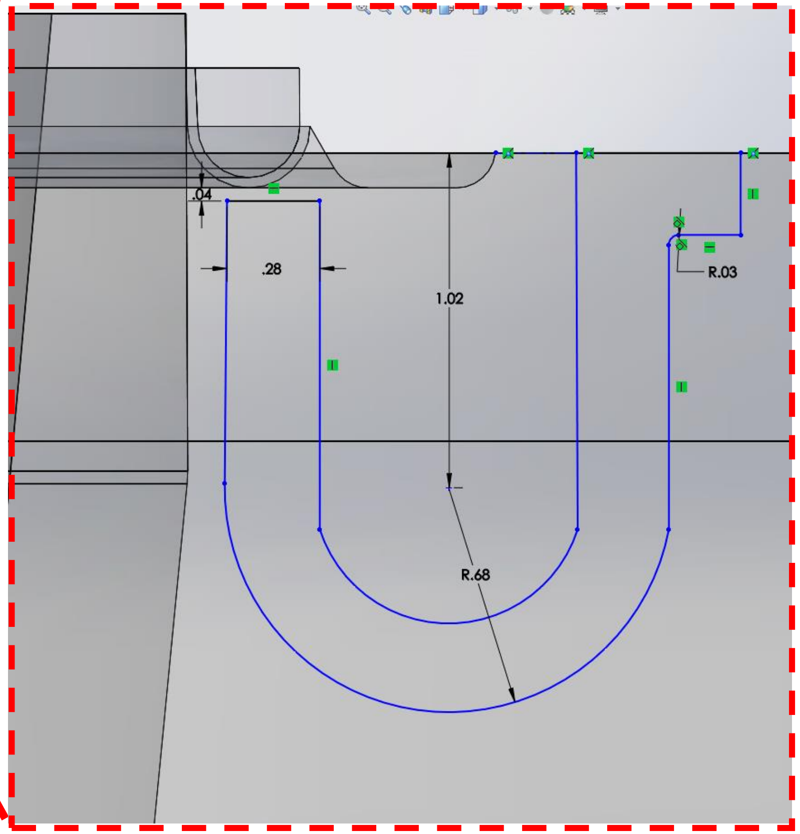
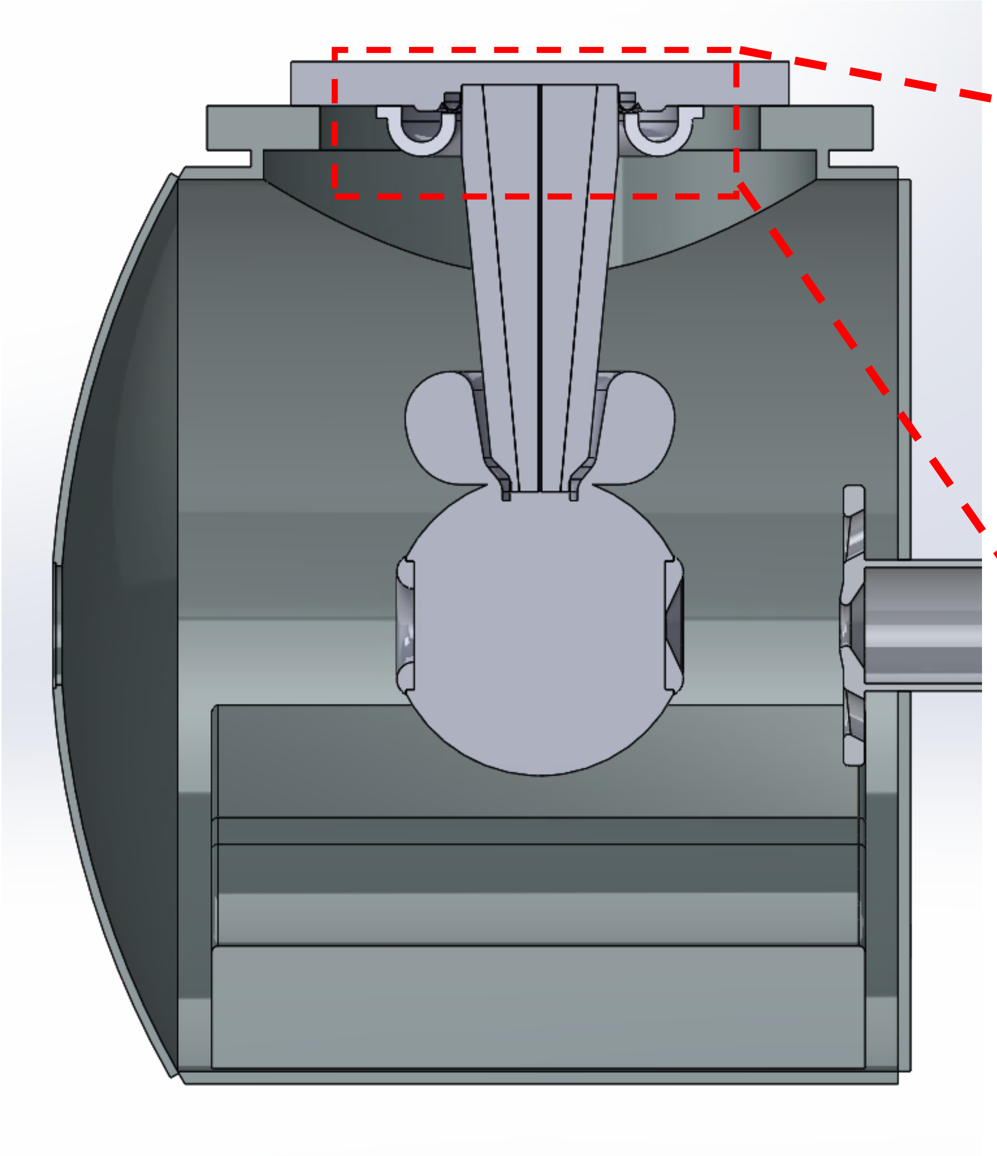


Image on the left not to scale

Solidworks geometry modifications:



Danny’s suggestion, but smaller.

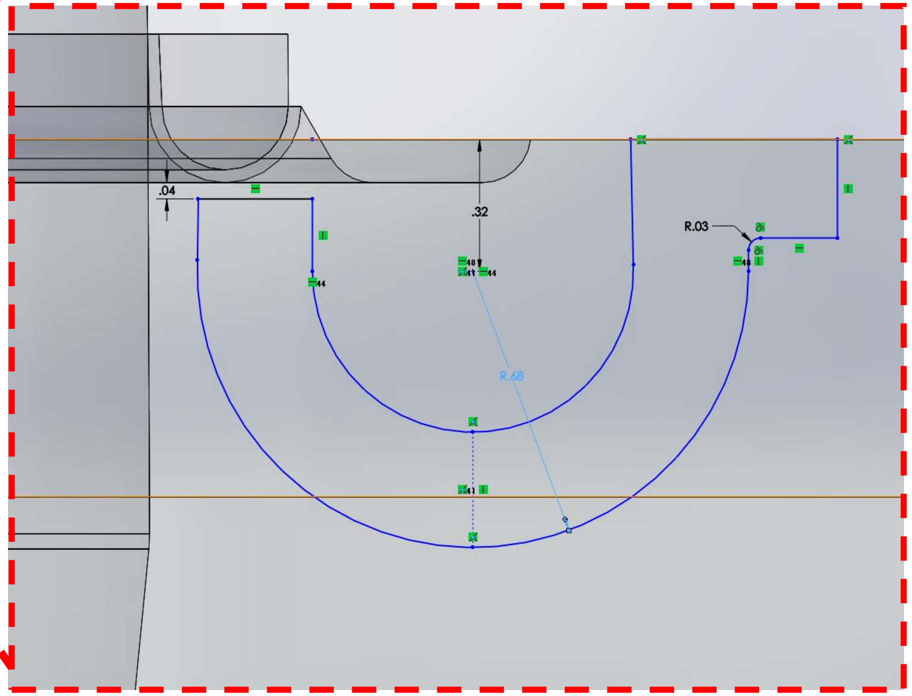


Image on the left not to scale

Solidworks geometry modifications:

Gabriel's suggestion, but hollow. Vacuum problems?

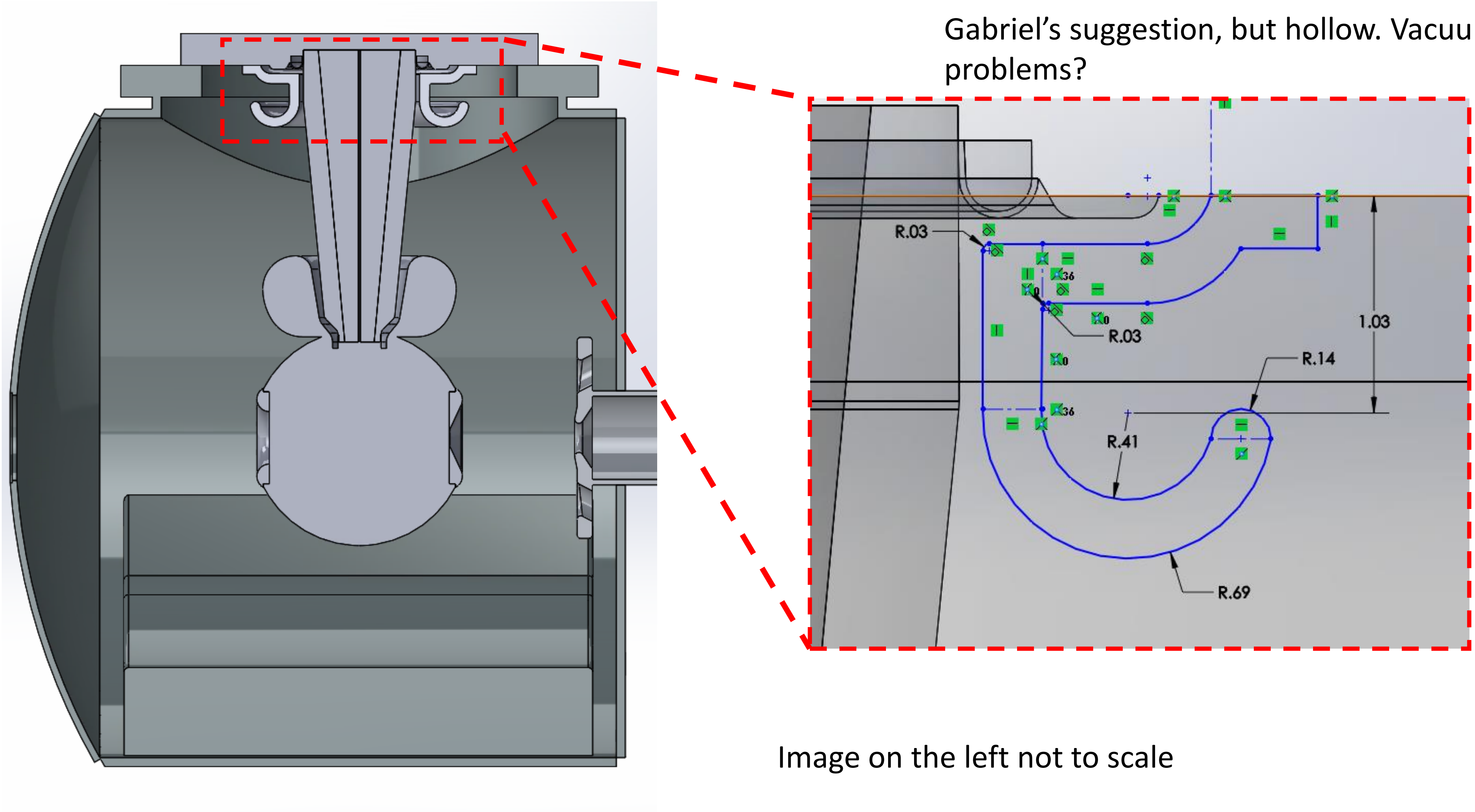
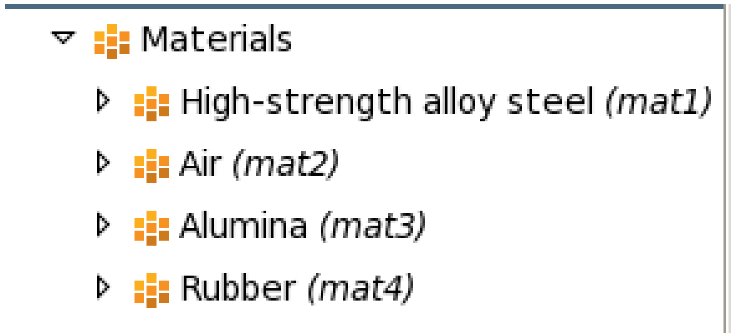


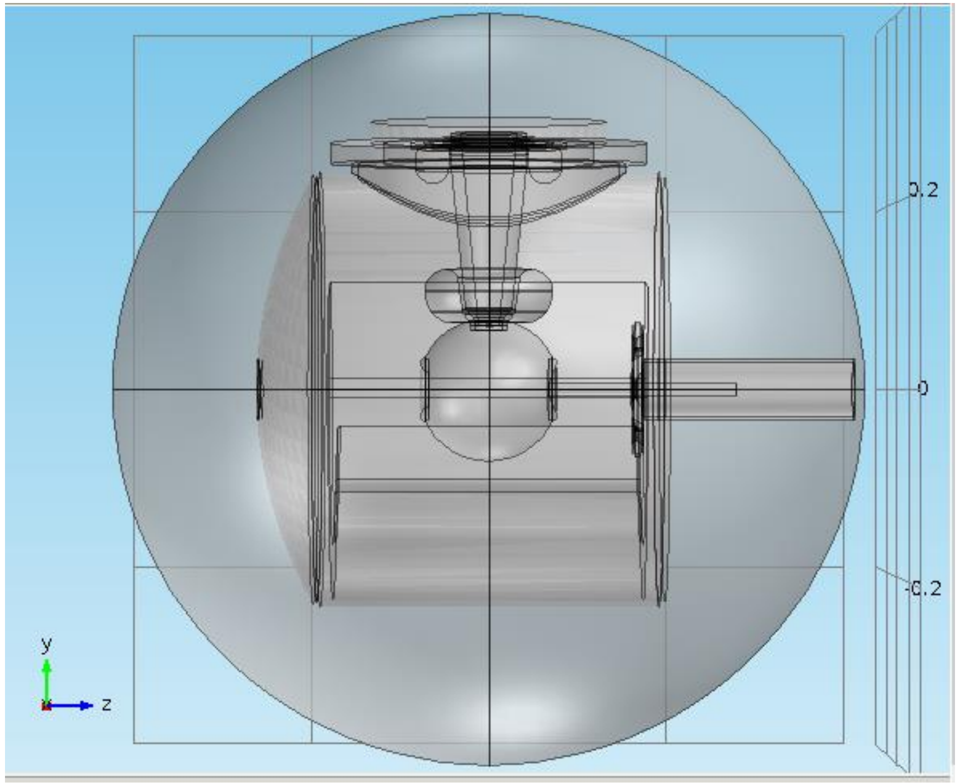
Image on the left not to scale

COMSOL materials:

- Stainless steel for all metal components with ε_r=1 and σ of 1.1E6 S/m
- Air for the vacuum surroundings.
- Alumina for the ceramic.
  - ε_r=8.4 and σ of 2E-12 S/m for the black.
- Rubber for the HV cable plug with ε_r=2.37 and σ of 1E-14 S/m .

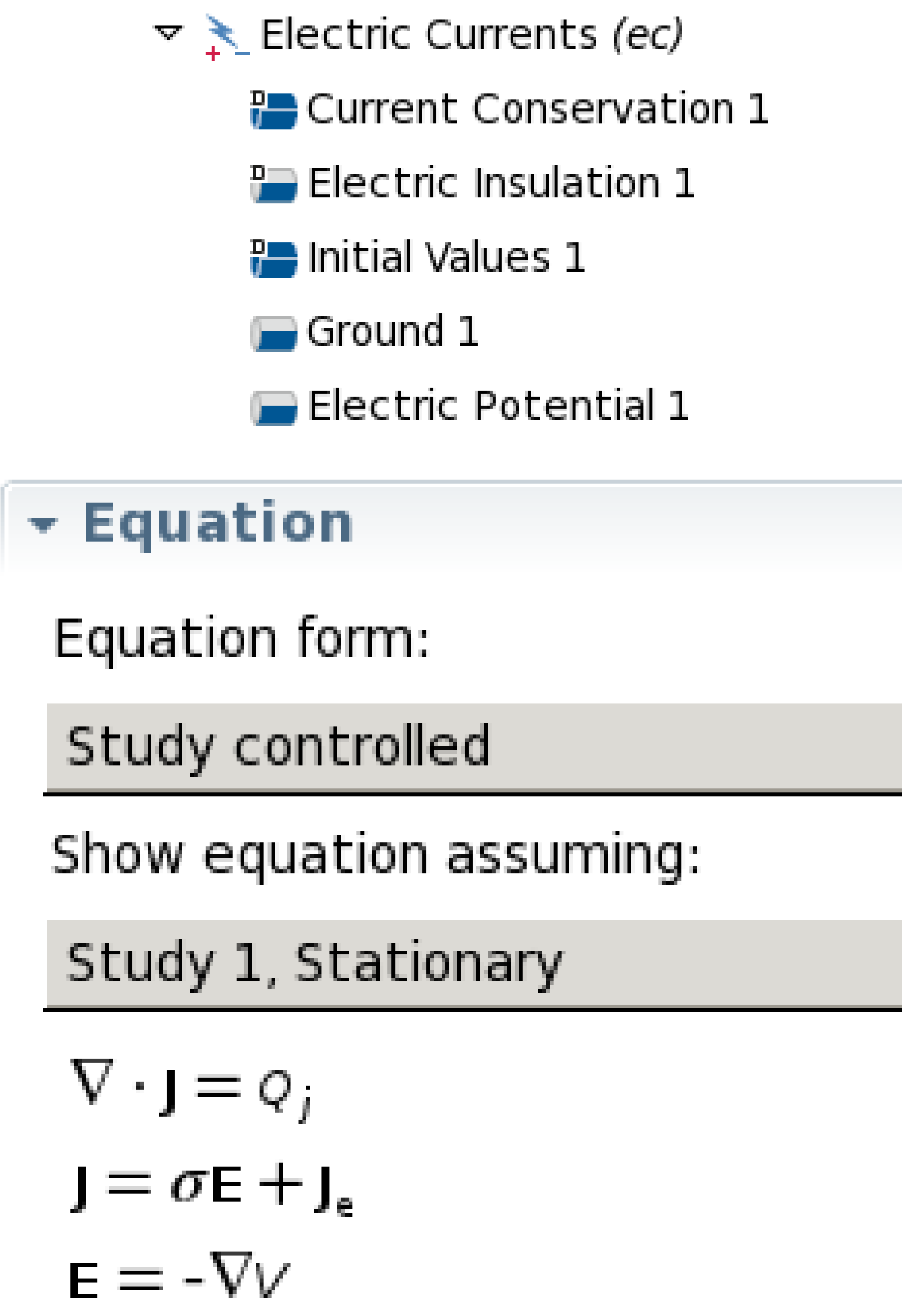
Used the Physics AC/DC module to implement electrostatics: Grounded the chamber, anode, flanges and V=-300kV to the cathode assembly. The rest of the options are automatically setup by COMSOL.





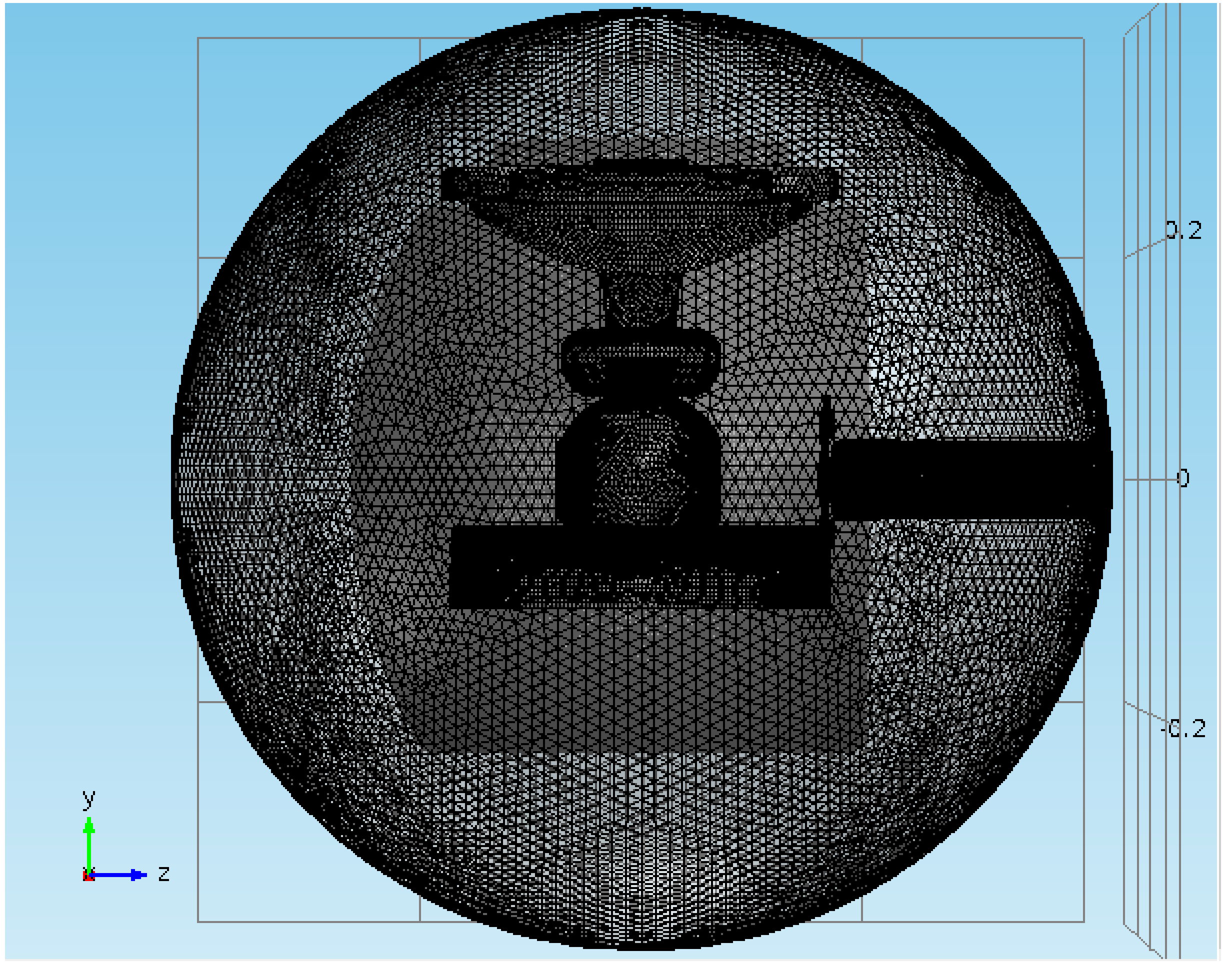
COMSOL electric currents:

- Current conservation in all domains.
- Electric insulation at the outer air boundary.
- Initial value (of potential) set to zero by default.
- Ground1 at vacuum chamber, NEGs, anode, flanges, upper shield.
- Electric potential at -300kV at the cathode, cathode shed and HV cable.



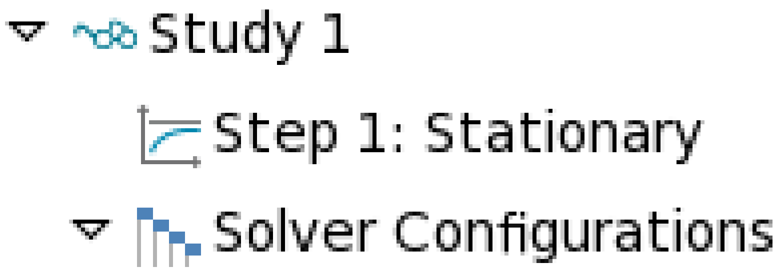
COMSOL mesh:

- Mesh 1
  - Size
  - Free Tetrahedral 1
  - Free Tetrahedral 5
  - Free Tetrahedral 2
  - Free Tetrahedral 3
  - Free Tetrahedral 4
    - Size 1

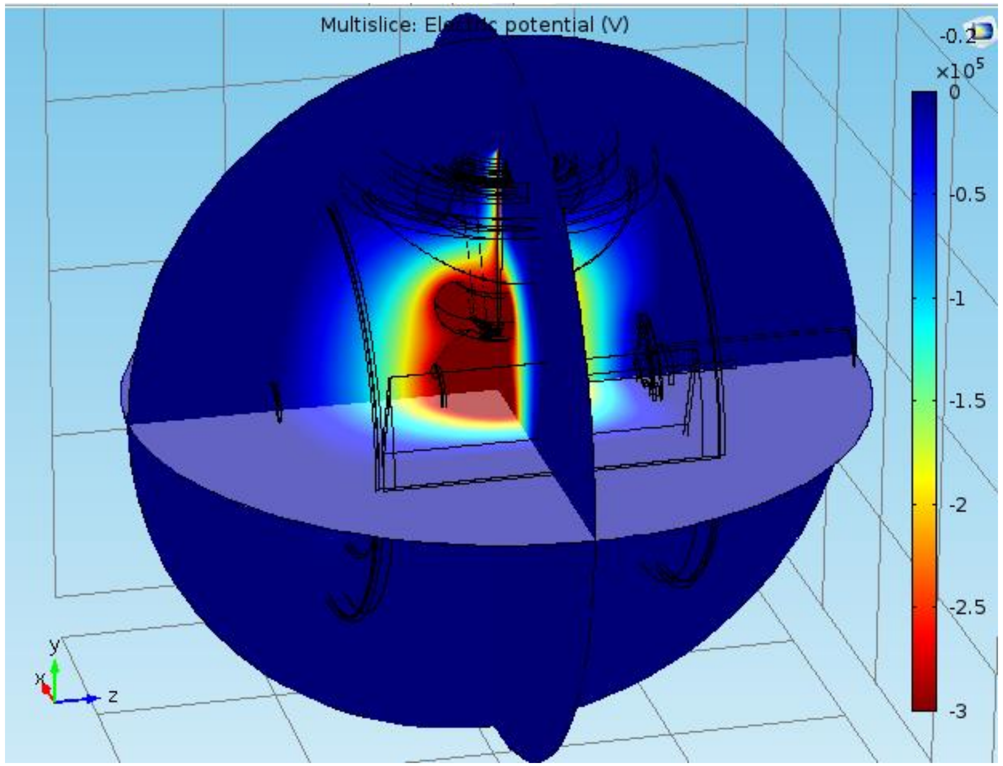


- The mesh was separated into pieces.
  - A general physics extra fine mesh was used. (min element size 1.2mm)

COMSOL Study:

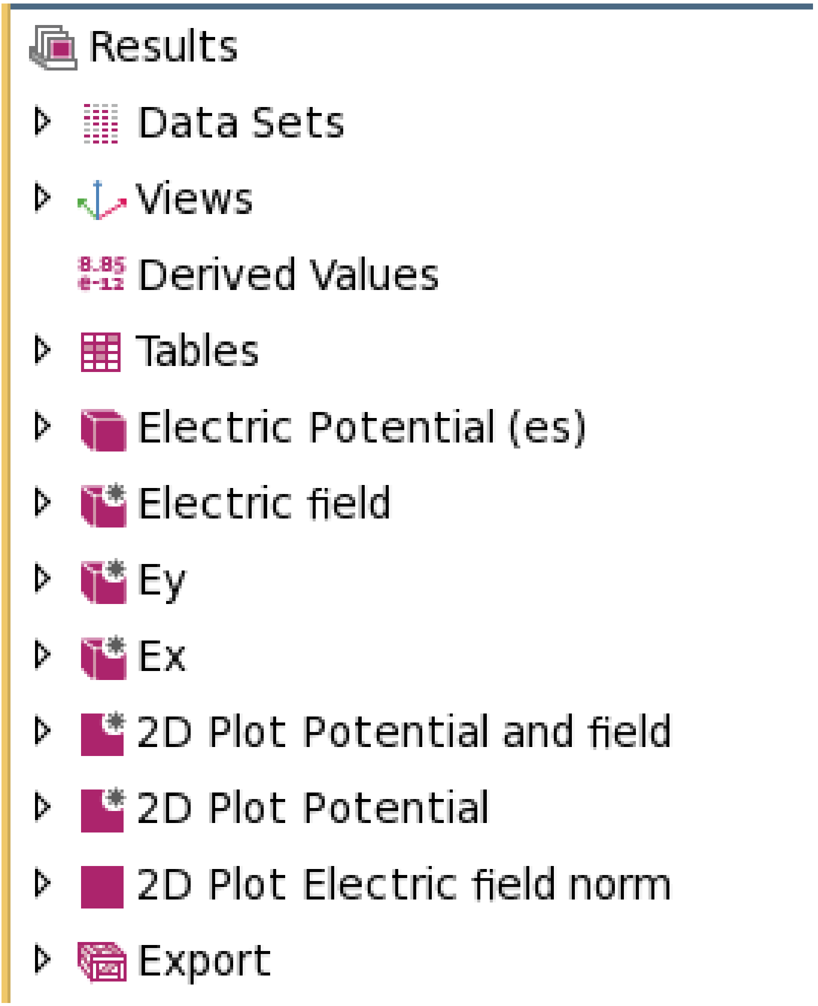


- The study solves for the electric field and potential including the effect of the conductivity of the materials using the currents module.



COMSOL results:

- The results for the transversal electric field component potential and Ey where plotted along a line along the rubber plug-insulator interface as a function of **y-coordinate.** Also COMSOL false color maps of |E| are shown.

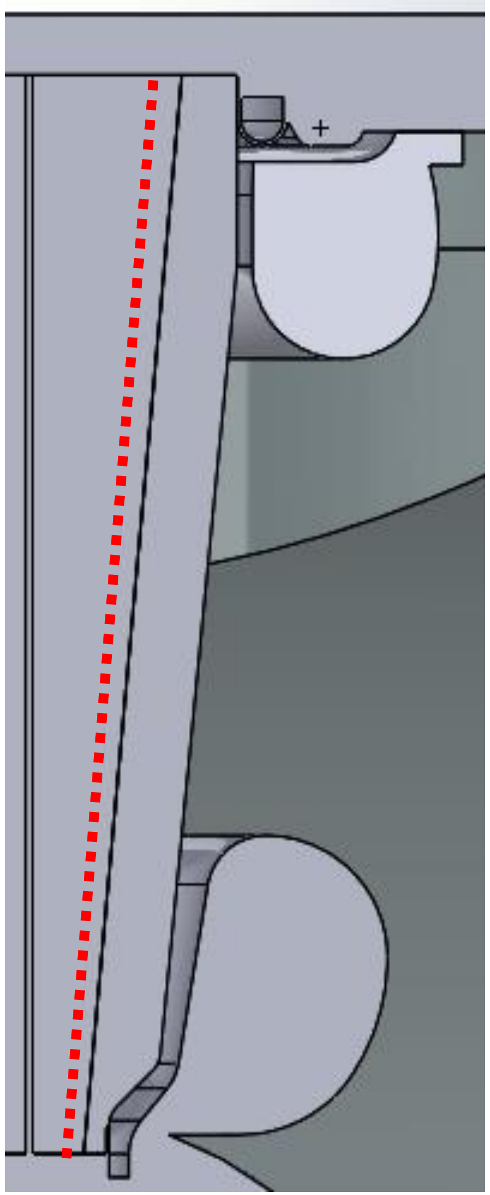


Rubber plug-insulator interface:

- The potential and electric field along the rubber plug – ceramic insulator interface were obtained (as shown in the image as a red dotted line), plotted as a function of the height (y-coordinate).
- Since the **E**=-ΔV, then the plots of Ex, Ey, Ez represent the respective gradients:

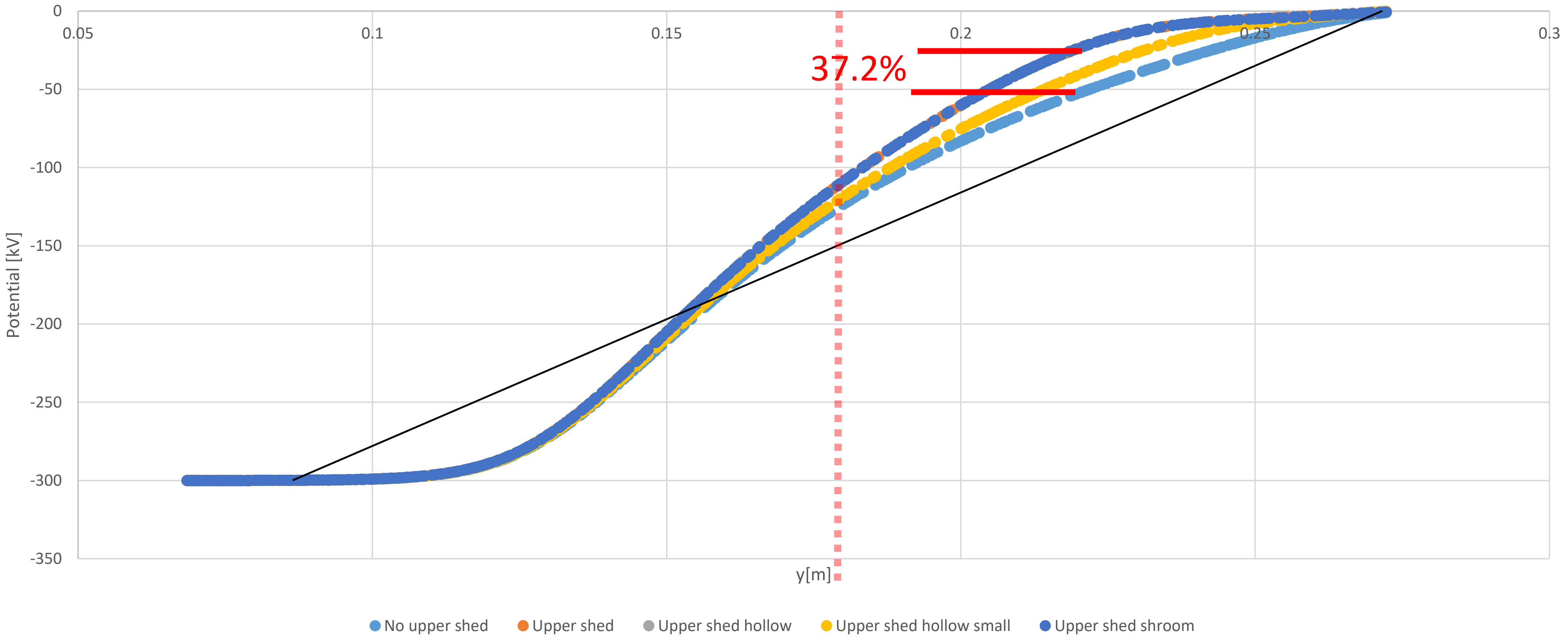
$$\text{Ex}= -\frac{\partial V}{\partial x}, \text{E}y = -\frac{\partial V}{\partial y}, \text{E}z = -\frac{\partial V}{\partial z}$$

- The norm of electric field |E| is also presented.



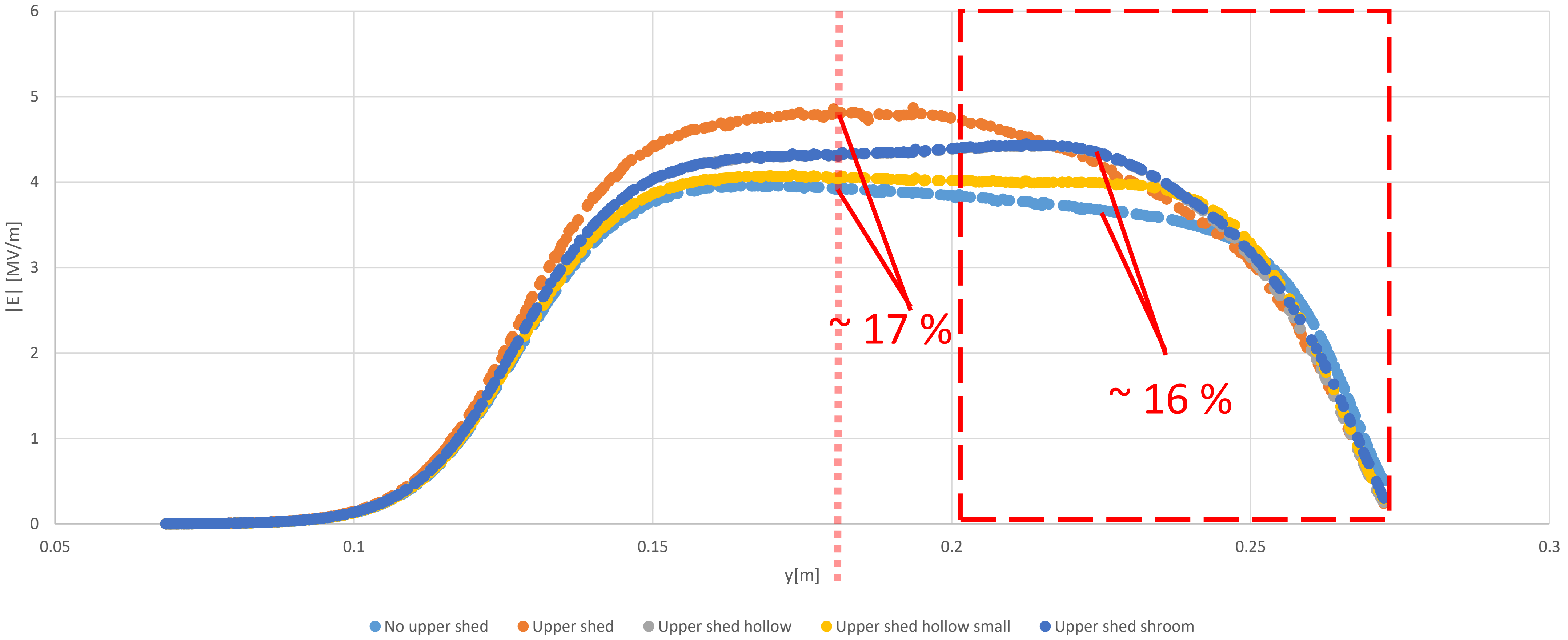
Potential:

The red dotted line represents the middle of the insulator, the black line represents the linear case. The **(solid) upper shield, hollow upper shield** and **upper shield shroom** cases <u>overlap</u> and are separate from the linear case as much as 37.2%. The **small hollow shield** is closer to the linear case.



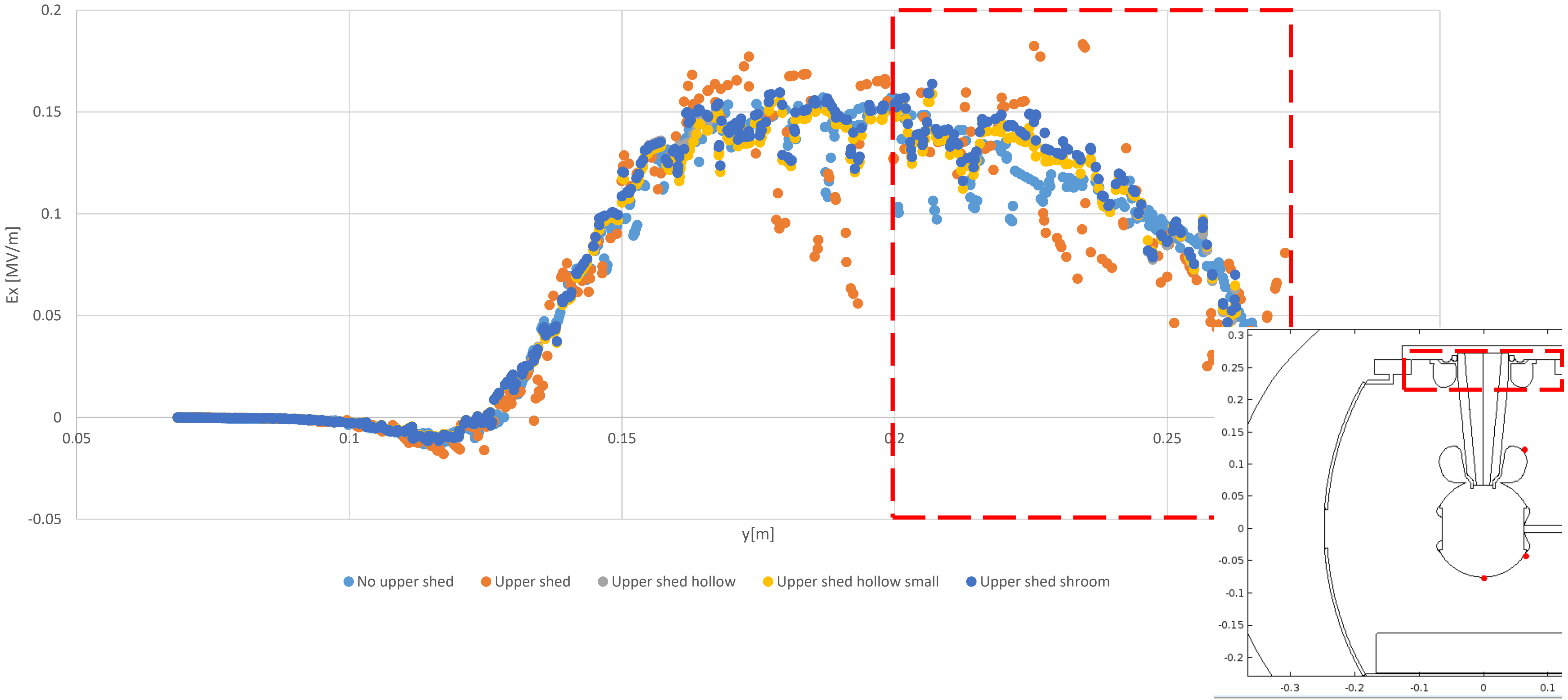
Electric field:

For the |E| field, near the middle of the insulator the **hollow small shield** seems better since its closer to the **no upper shield** curve, but in the region near the Kovar ring (red discontinuous square) the **(solid) shield, hollow shield** and the **shroom shield <u>overlap</u>** and seem to diminish the transversal field much more.



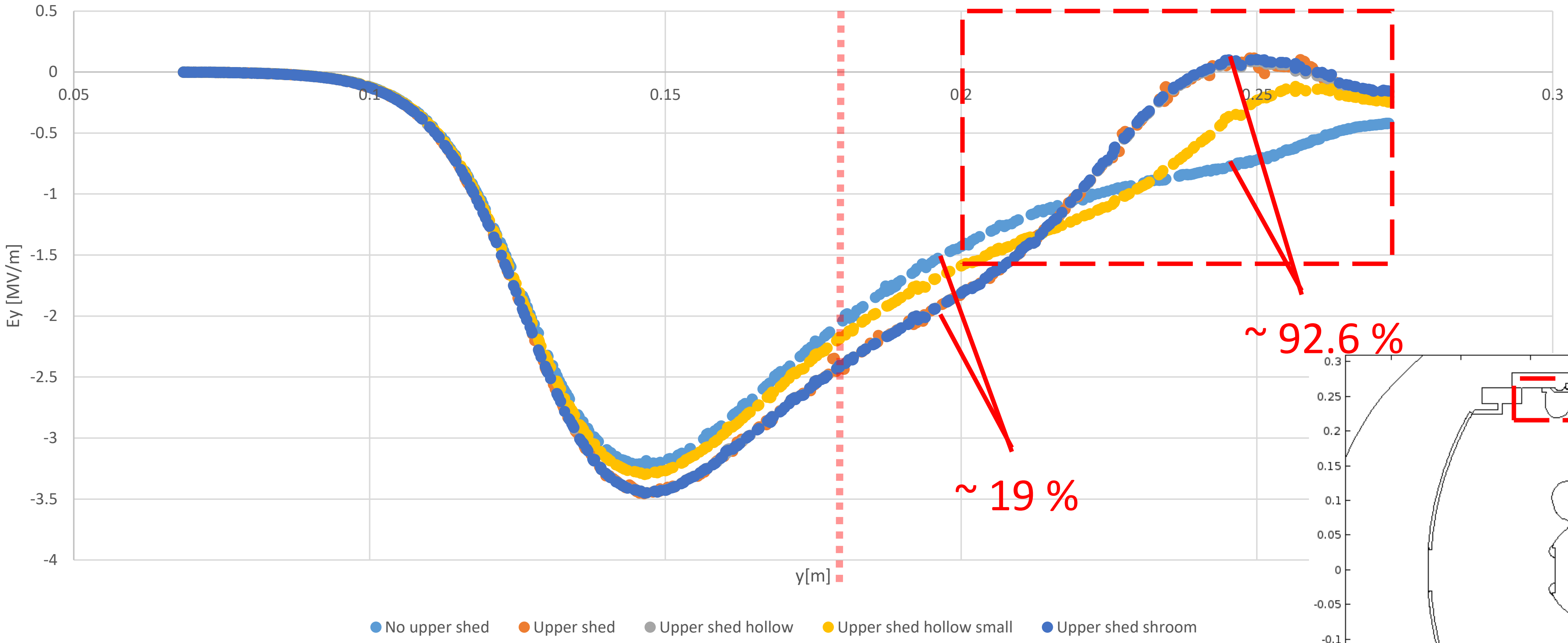
Ex electric field:

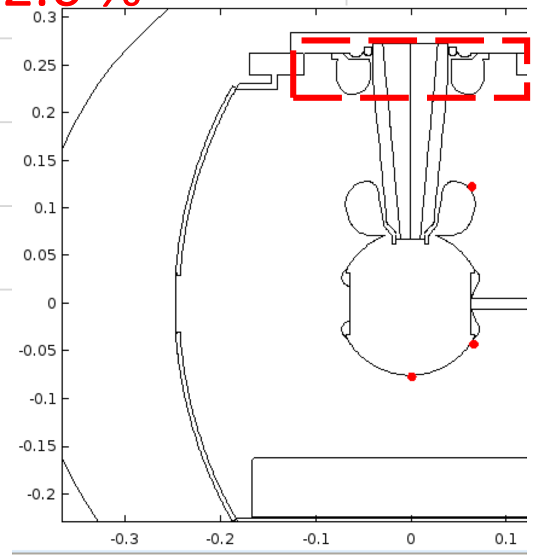
Along the rubber plug-insulator interface. What about the distribution of points?



Transversal electric field:

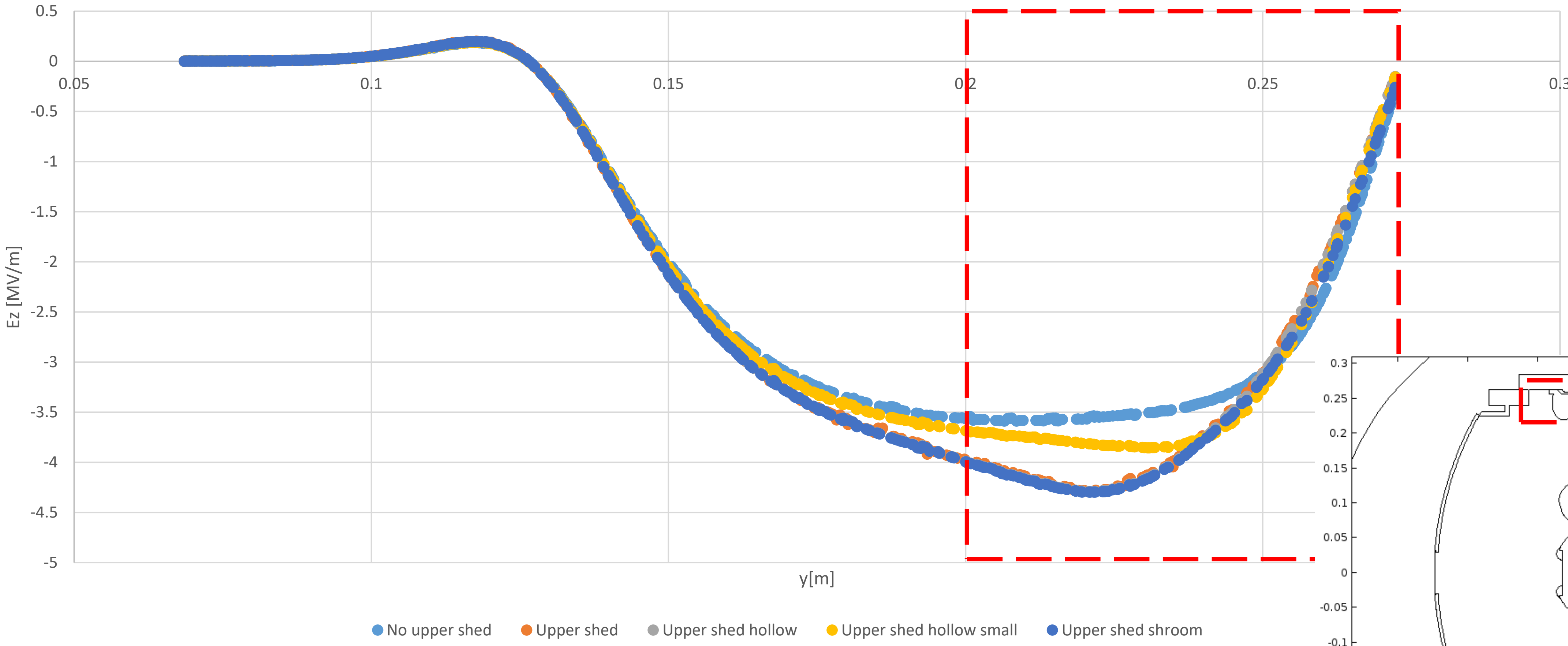
For the transversal field, near the middle of the insulator the **hollow small shield** seems better since the Ey field is closer to the **no upper shield**, but in the region near the Kovar ring the **(solid) shield, hollow shield** and the **shroom shield** **overlap** and seem to diminish the transversal field much more.

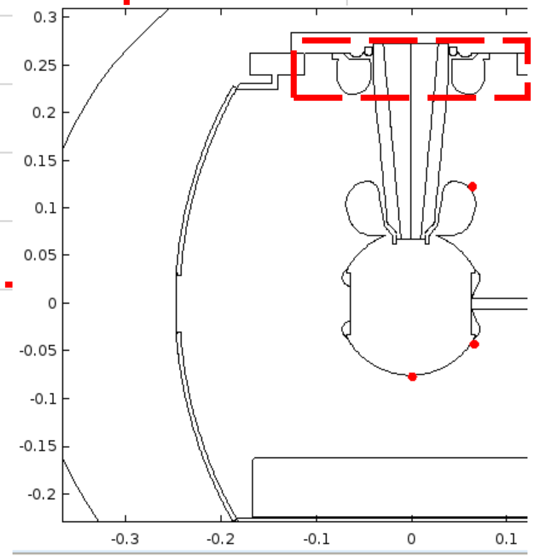




Ez electric field:

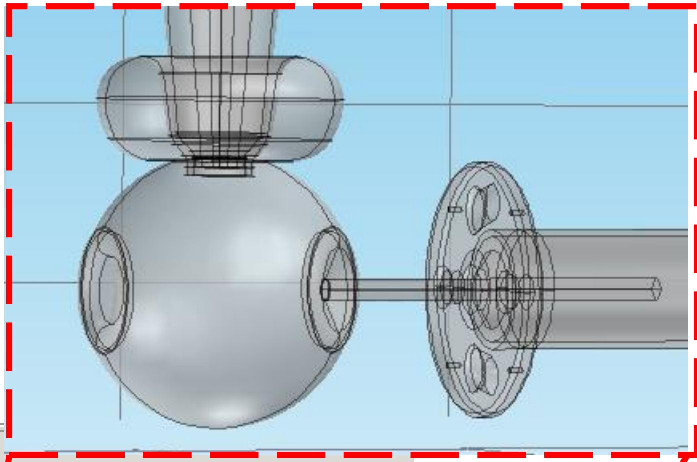
Along the rubber plug-insulator interface

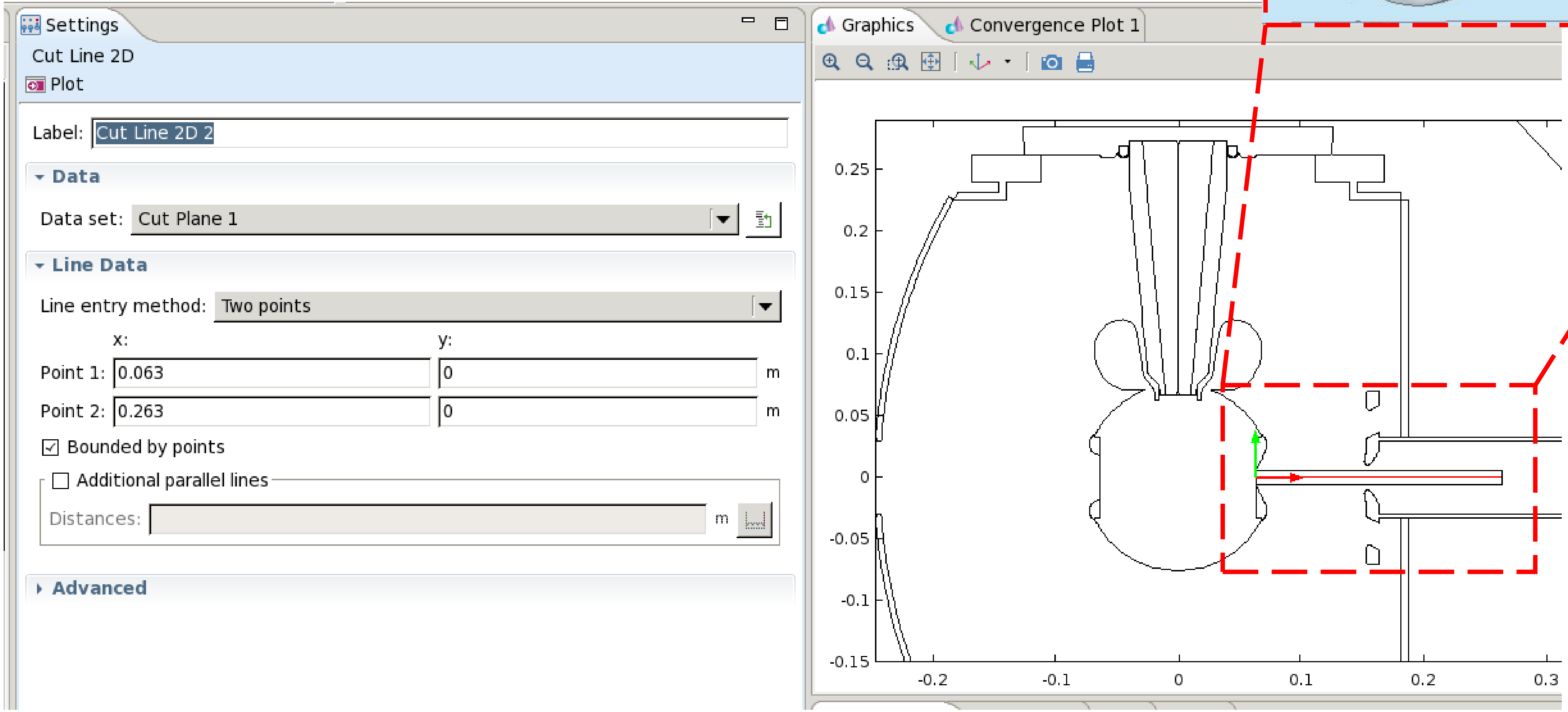




Photocathode-anode line:

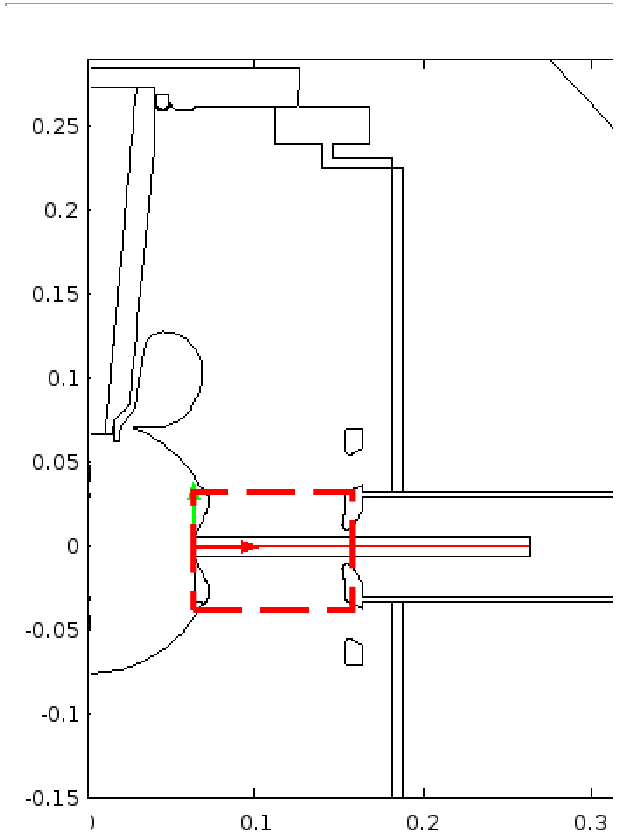
The data for the following plots was taken along a horizontal line from the center of the photocathode to the back of the chamber passing through the anode center as shown in the red line

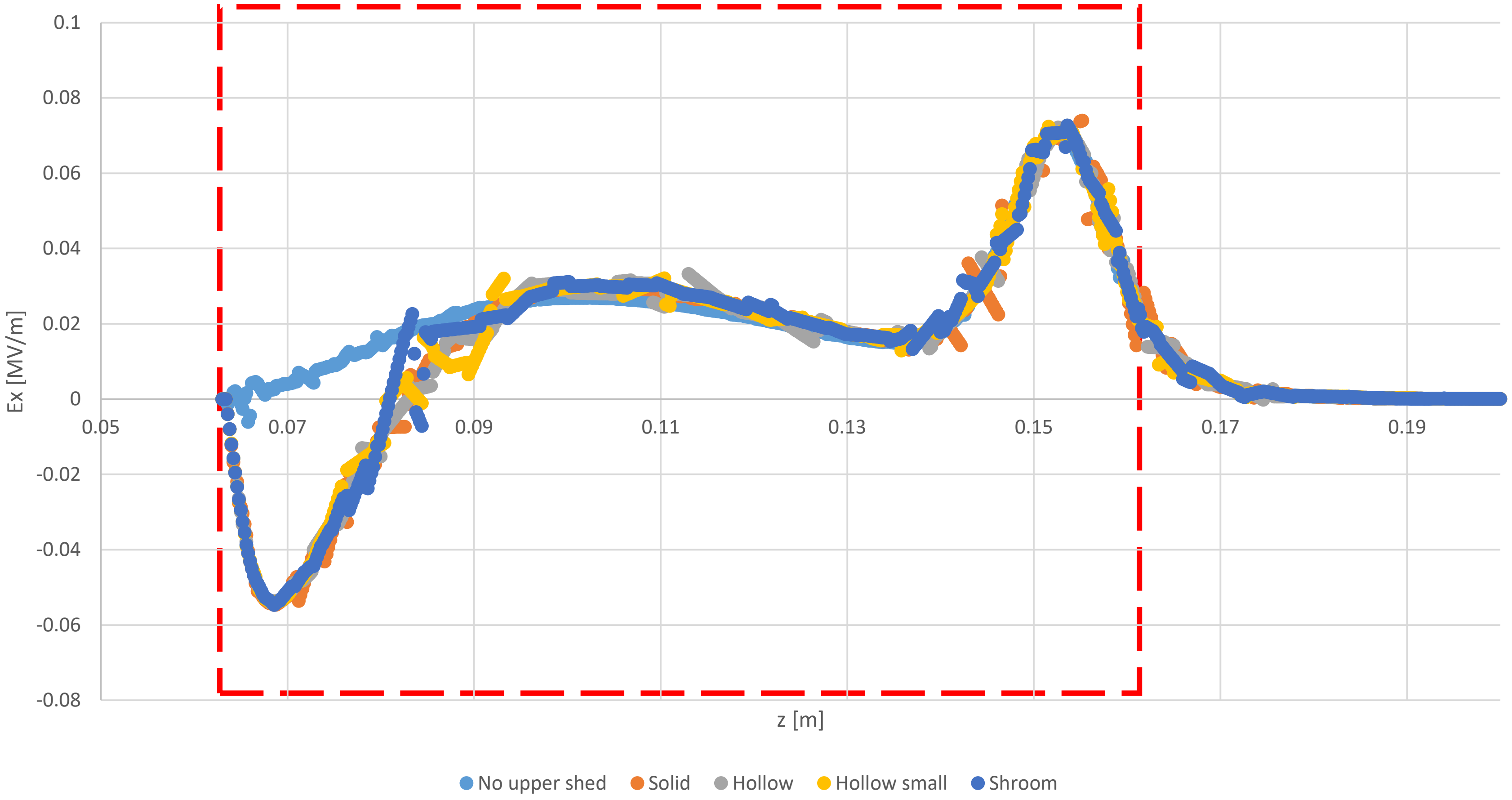




Photocathode-anode line :

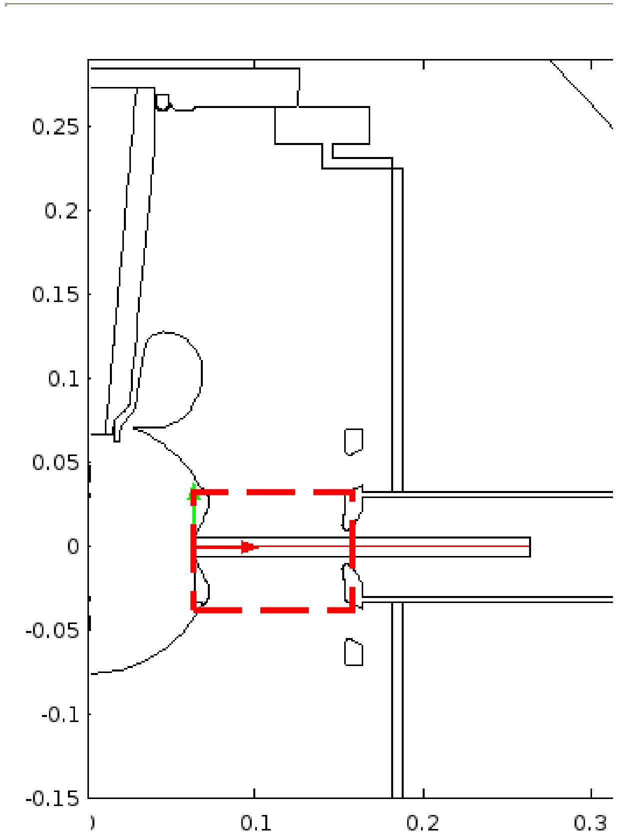
- This image shows the electric field Ex component in MV/m as a function of position on the z axis.

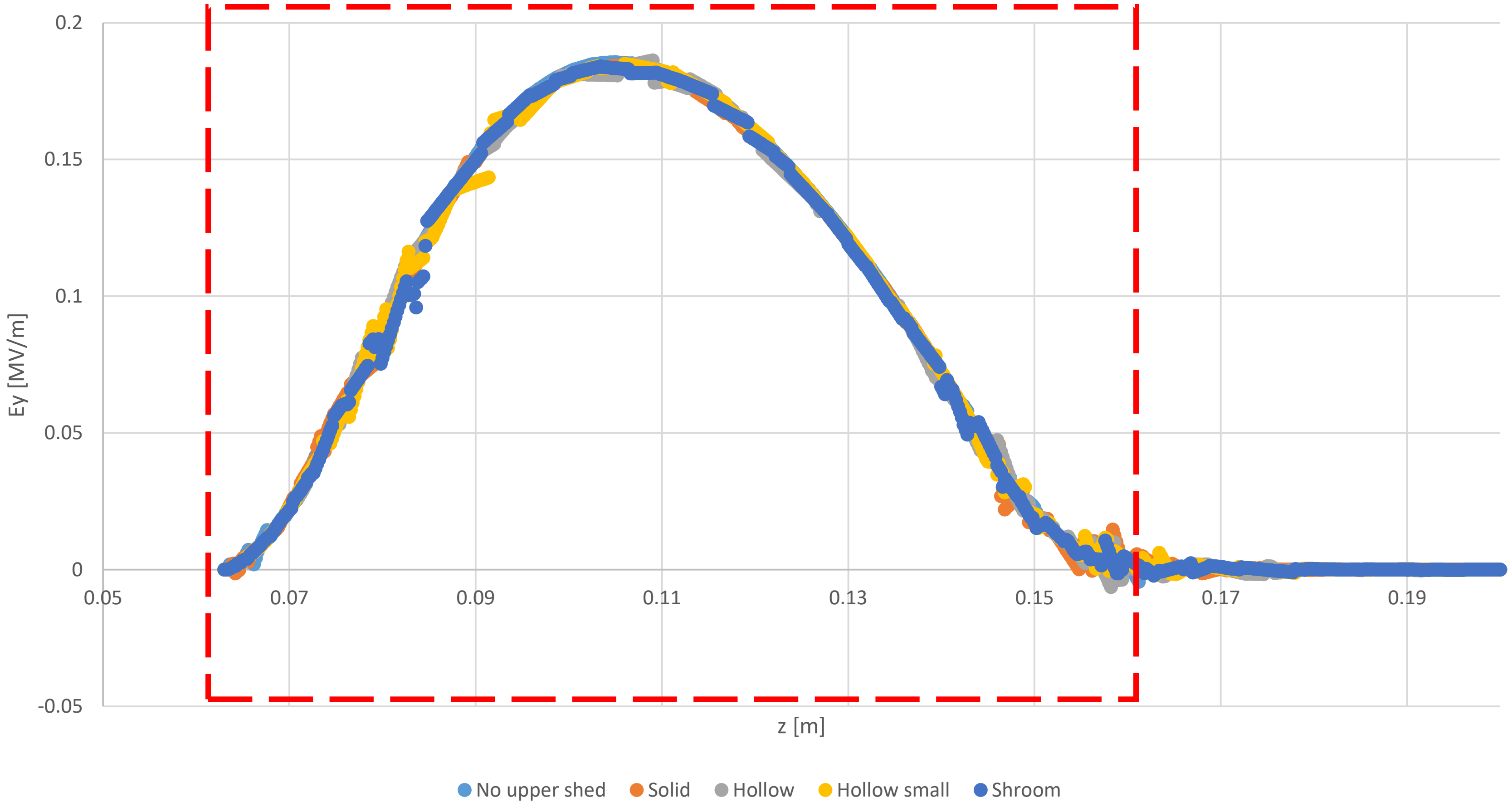




Photocathode-anode line :

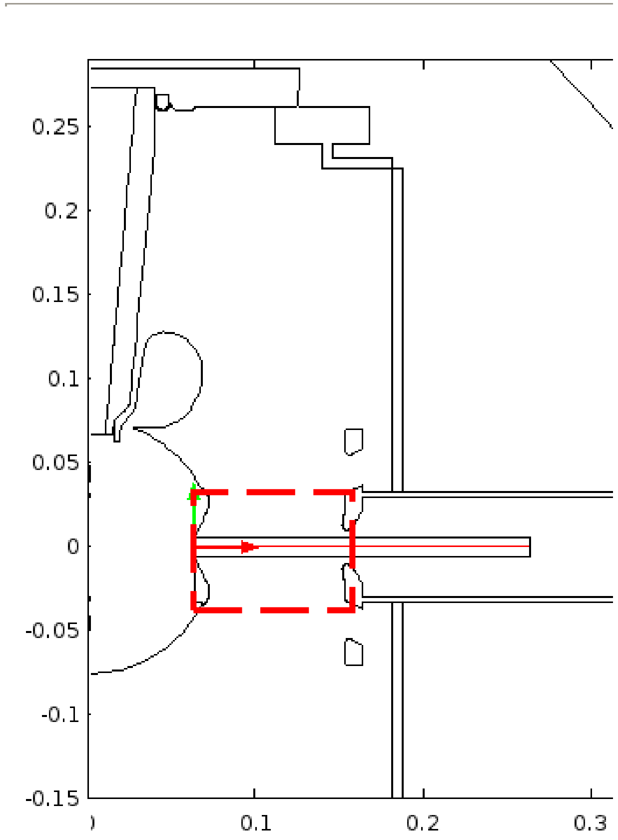
- This image shows the electric field Ey component in MV/m as a function of position on the z axis.

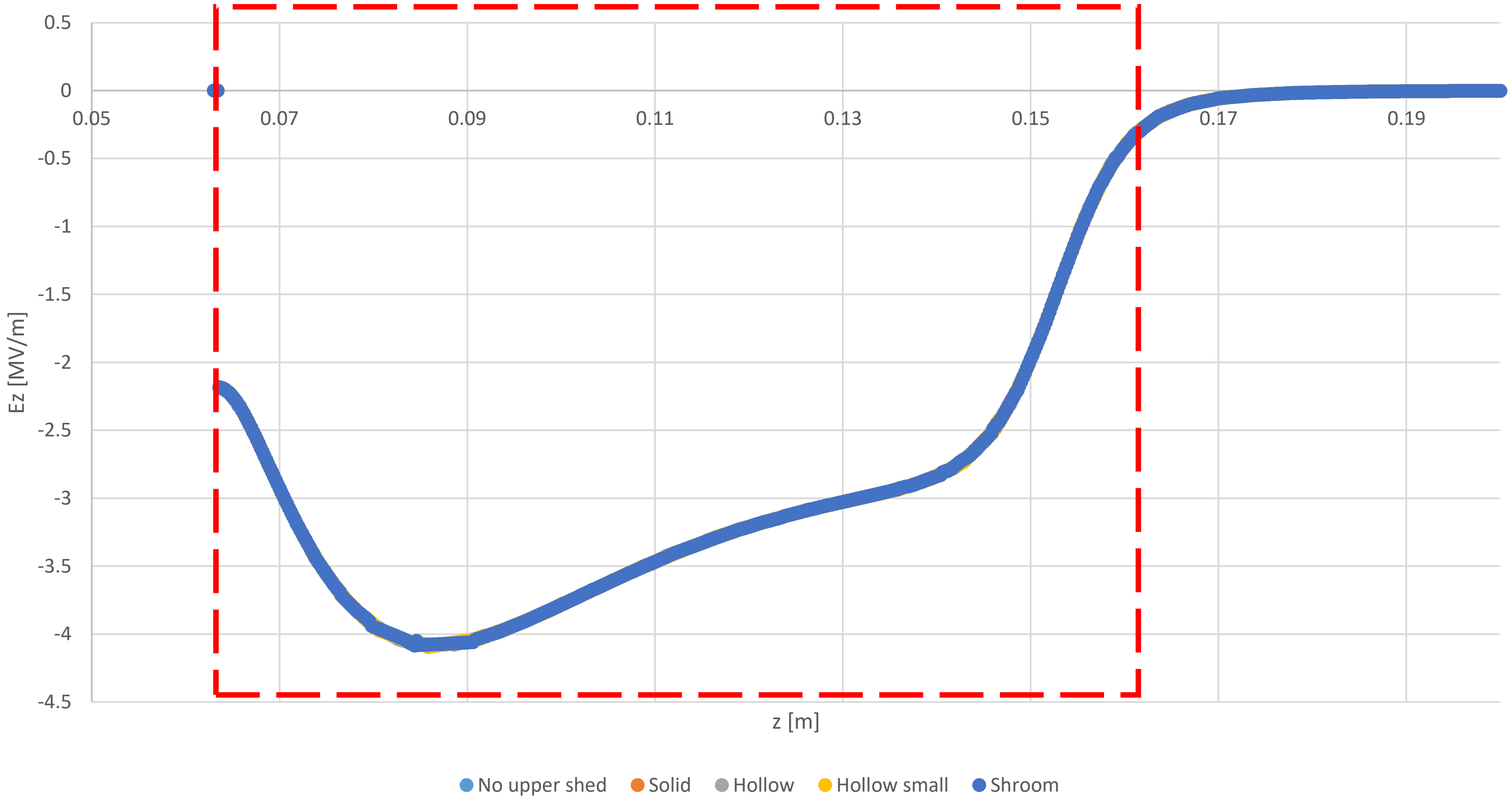




Photocathode-anode line :

- This image shows the electric field Ez component in MV/m as a function of position on the z axis.



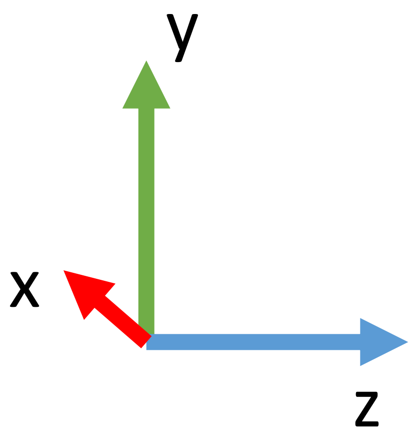


Future steps

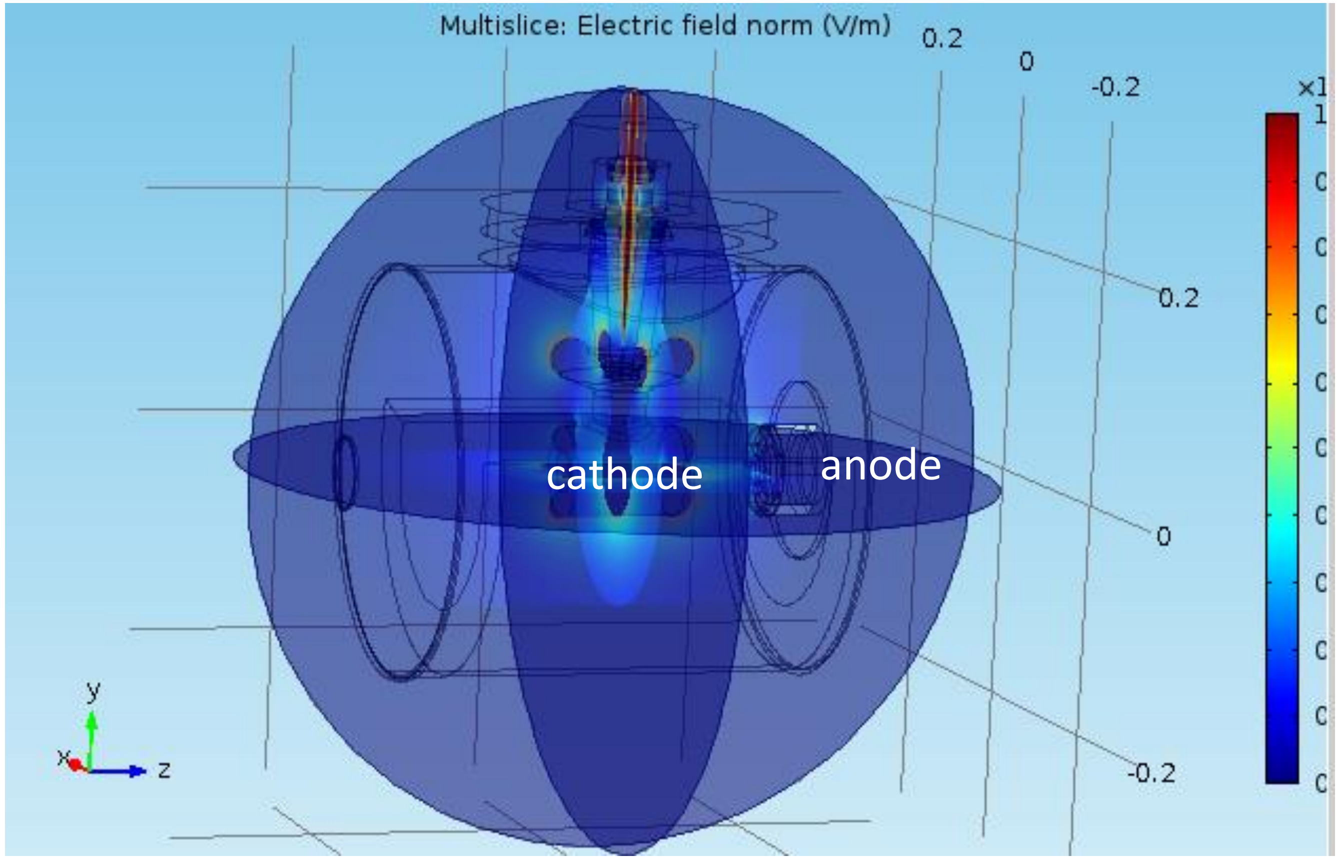
- Add COMSOL false color plots of |E| field.
- ~~Add cathode-anode gap field maps.~~

Fin.

COMSOL frame of reference:



X goes into the page.



- This image shows the electric field norm |E| in MV/m as color intensity. The coordinate system is as shown for all plots and images the origin is at the center of the cathode electrode. (The anode is at the right)