GTS gun COMSOL simulations

Flange shed

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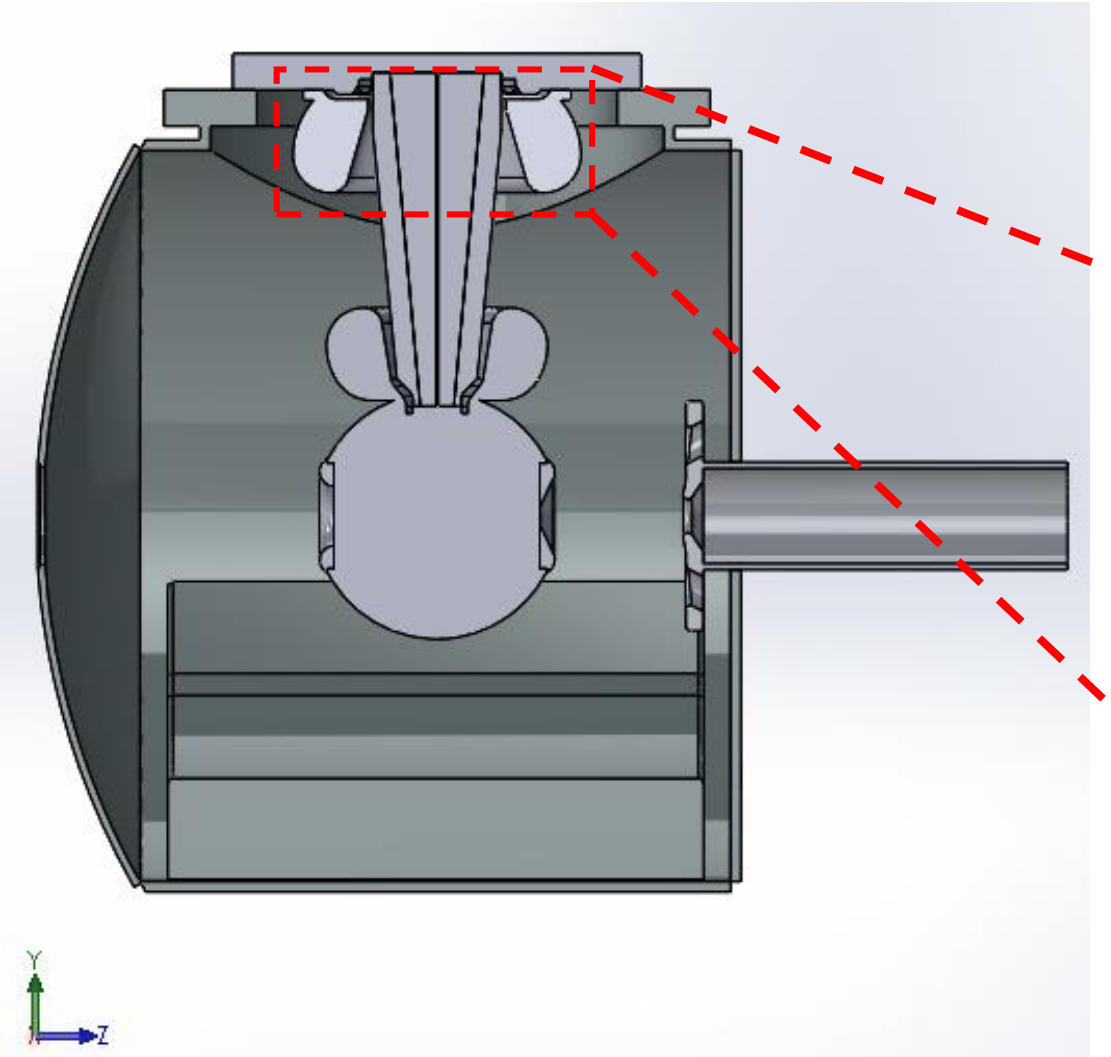
Summary

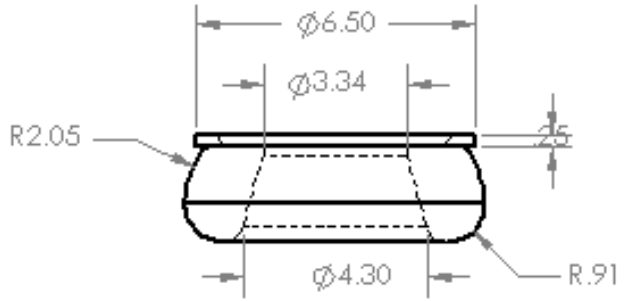
- Solidworks
  - Geometry modifications
- COMSOL
  - Details of simulation
  - PLOTS

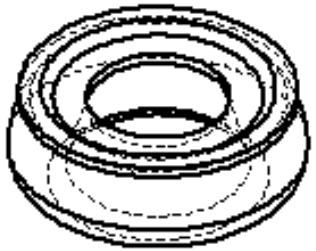
Solidworks geometry modifications:

Modeled an upper shed that attaches to the flange.
Used the bottom one as a model.

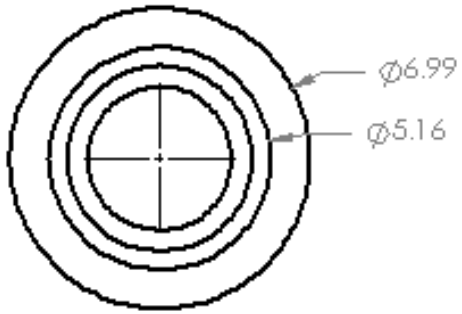


Solidworks geometry modifications:





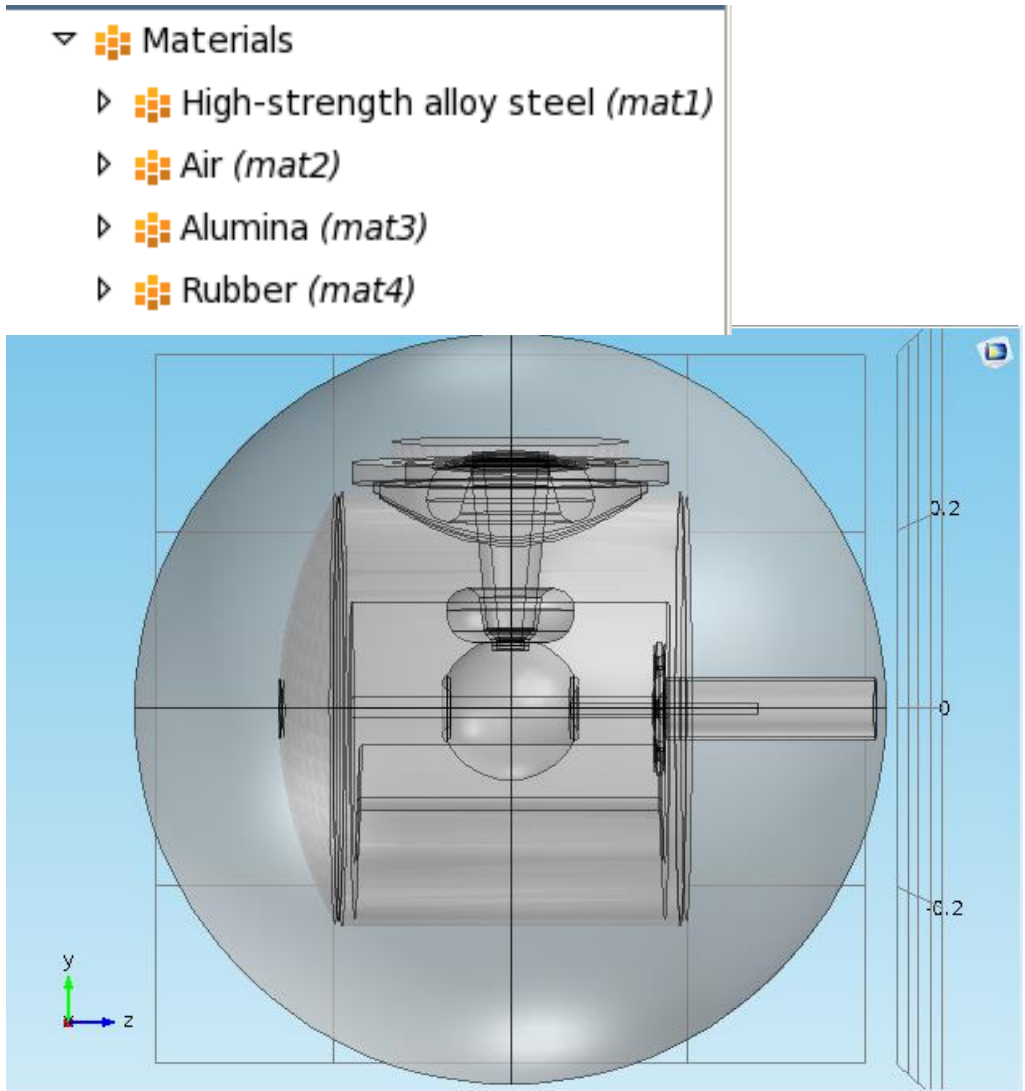
Dimensions in inches.



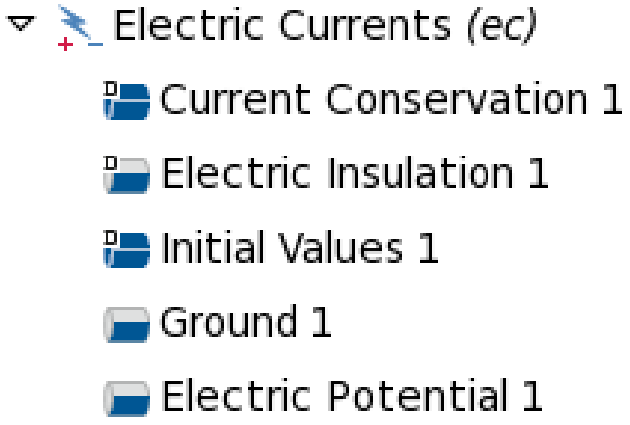
COMSOL materials:

- 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.
- Ground 1 at vacuum chamber, NEGs, anode, flanges, upper shed.
- Electric potential at -300kV at the cathode, cathode shed and HV cable.

Equation

Equation form:

Study controlled

Show equation assuming:

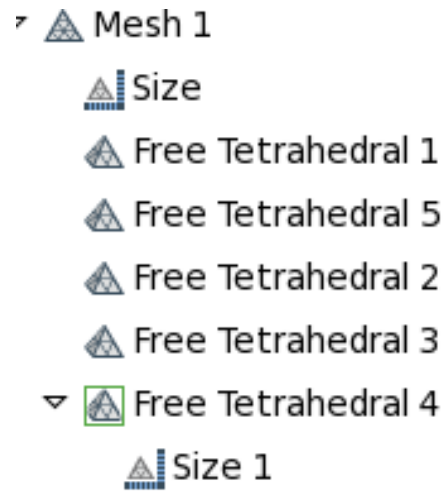
Study 1, Stationary

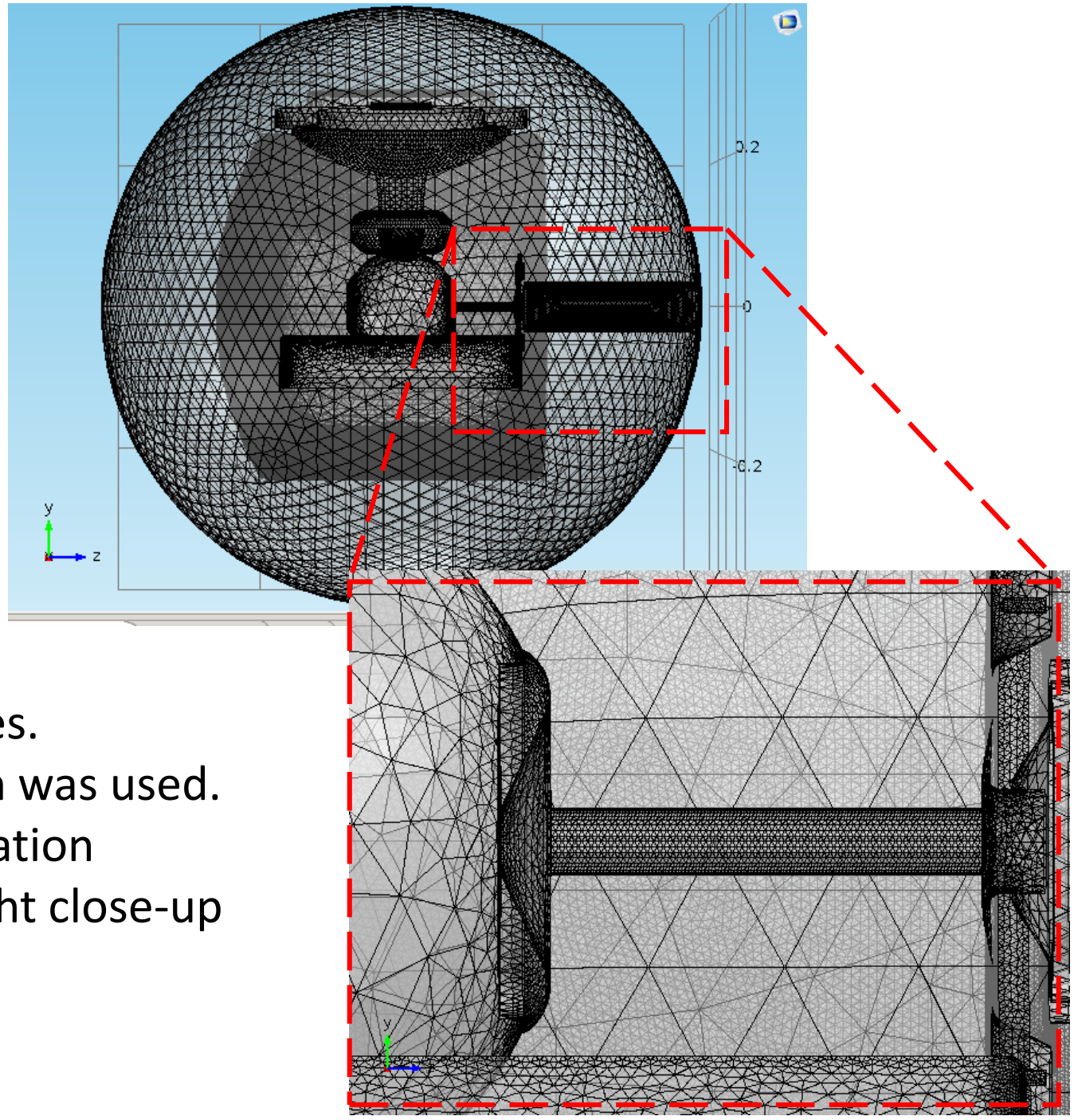
$$\nabla \cdot \mathbf{J} = Q_j$$

$$\mathbf{J} = \sigma \mathbf{E} + \mathbf{J}_e$$

$$\mathbf{E} = -\nabla V$$

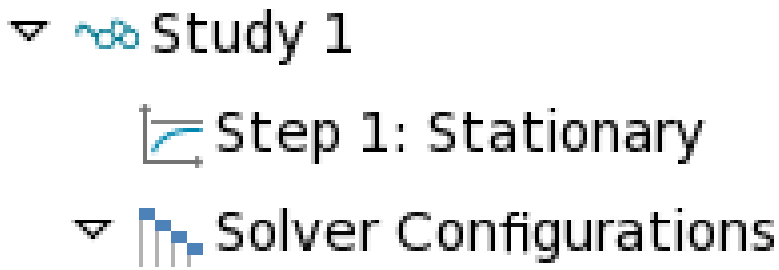
COMSOL mesh:



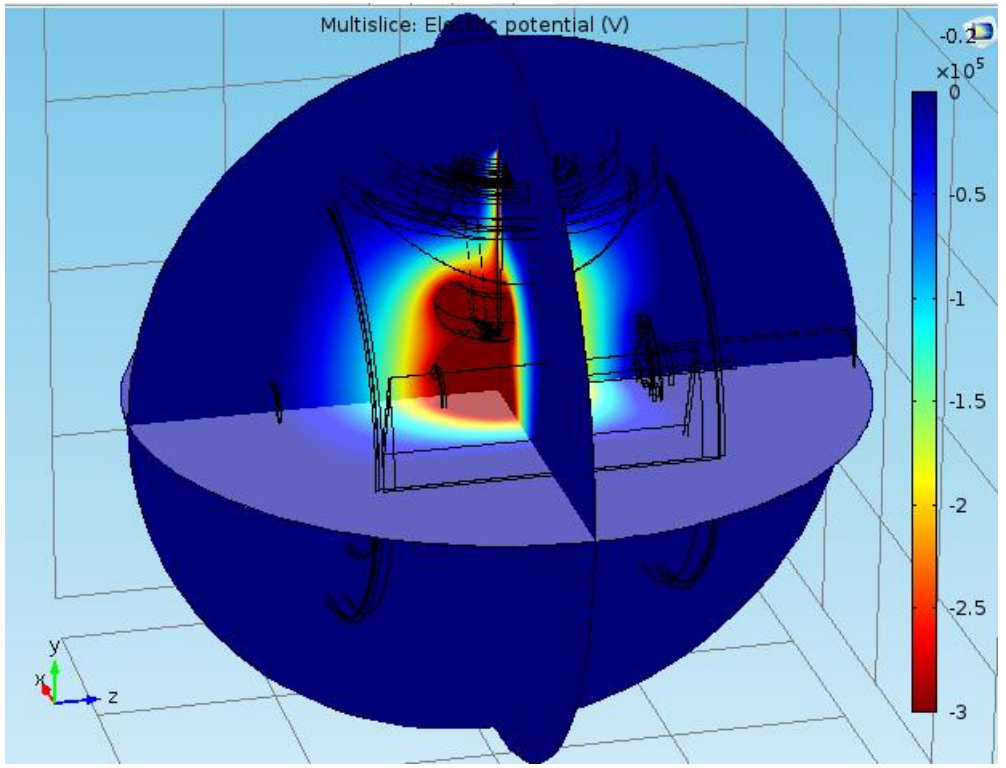


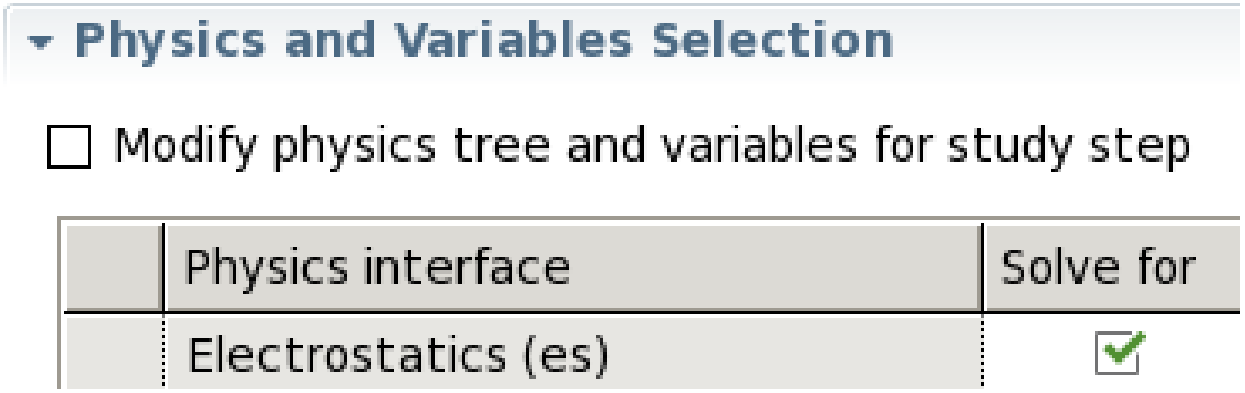
- The mesh was separated into 5 pieces.
  - A general physics extra fine mesh was used.
  - Except for the field map interpolation cylinder shown in the bottom right close-up image, where an extremely fine semiconductor mesh was used.

COMSOL Study:



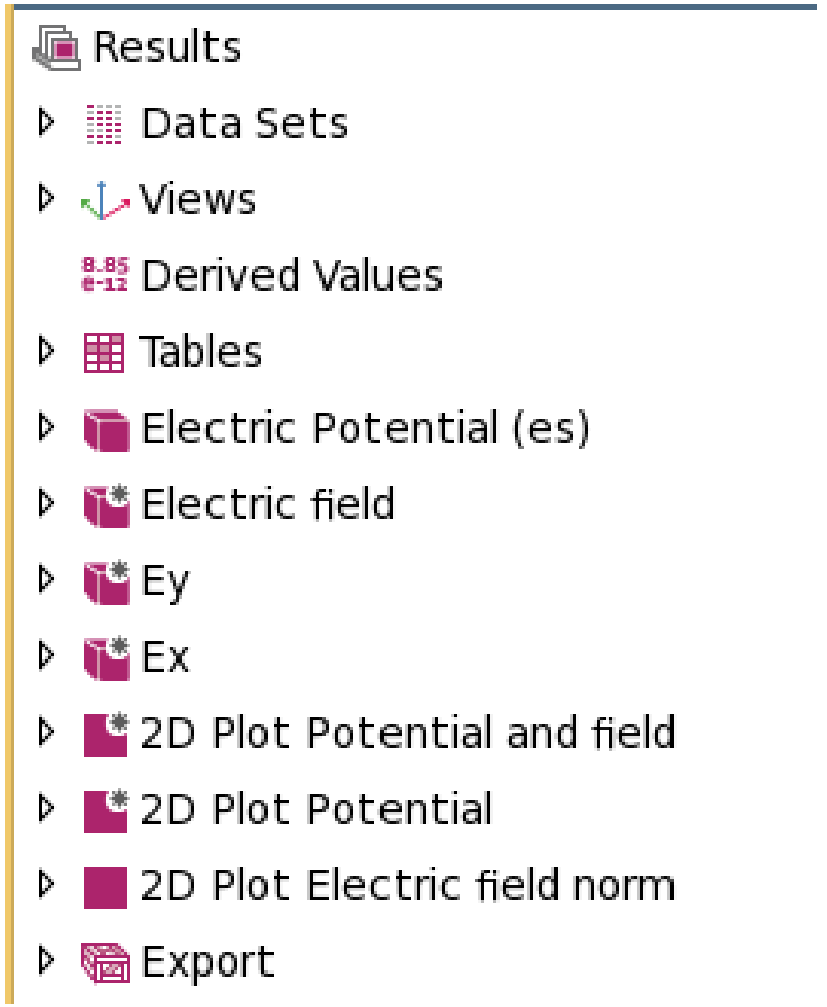
- The study solves for the electric field and potential including the effect of the conductivity of the materials using the currents module.





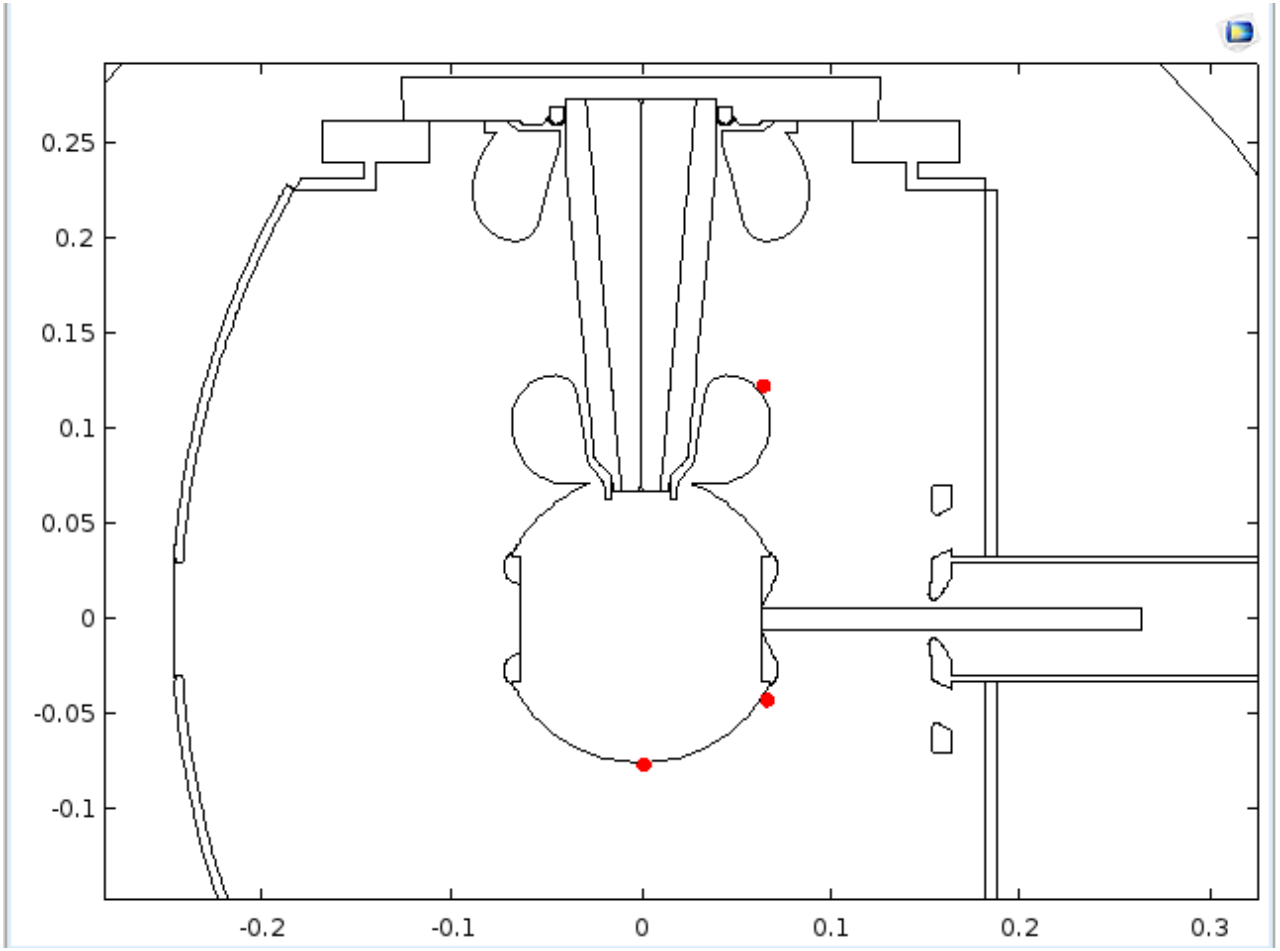
COMSOL results:

- Plotted the potential and electric fields.
- The results shown up next are comparisons between the gun with **only** a cathode shed versus the gun with **both** a cathode and upper flange sheds.



COMSOL Electric field Norm at 3 points:

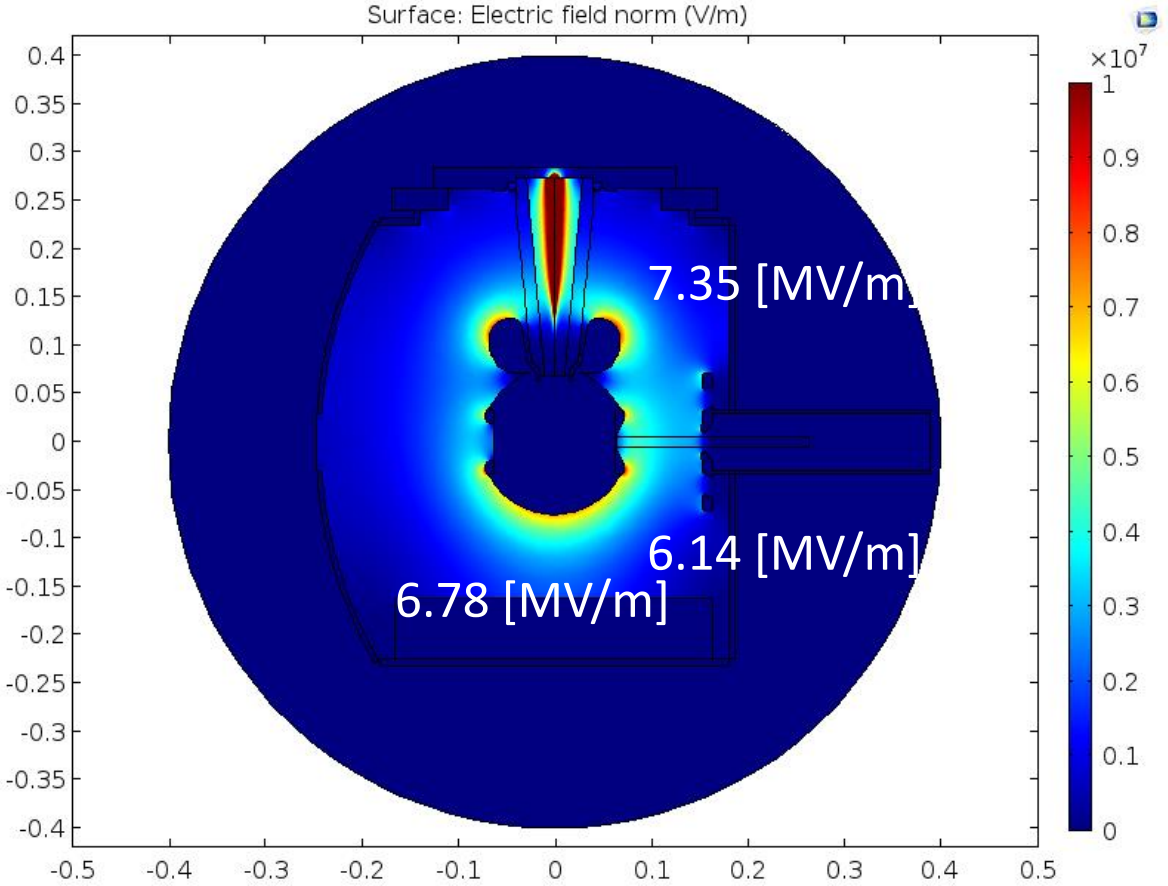
- The simulations show a lateral cross section. The electric field norm was obtained at three points around the cathode electrode for both cases.



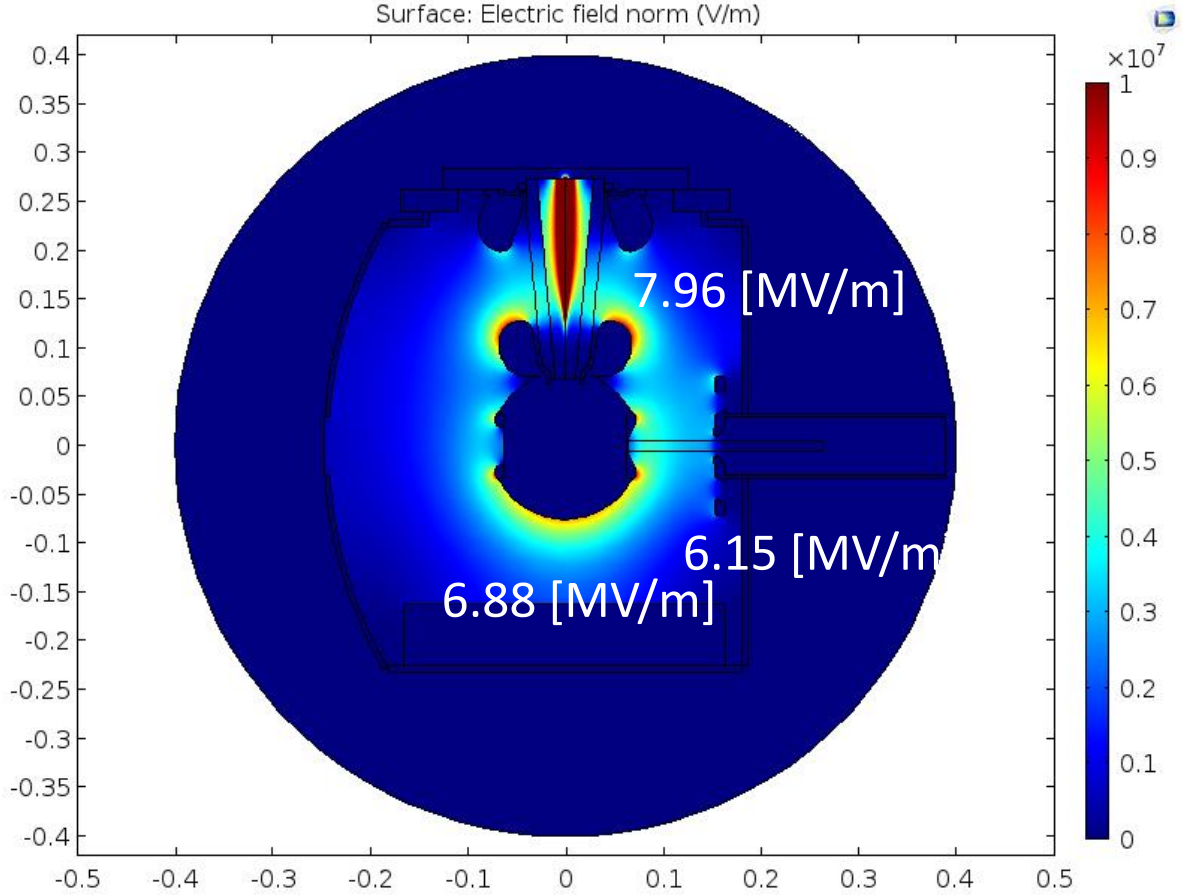
COMSOL Electric field Norm :

- For the lowest point the electric field norm remains around ~6.8 MV/m for both. At the top right corner the presence of the shed produced a value around ~7.6% smaller than the no-upper-shed model.

No upper shed



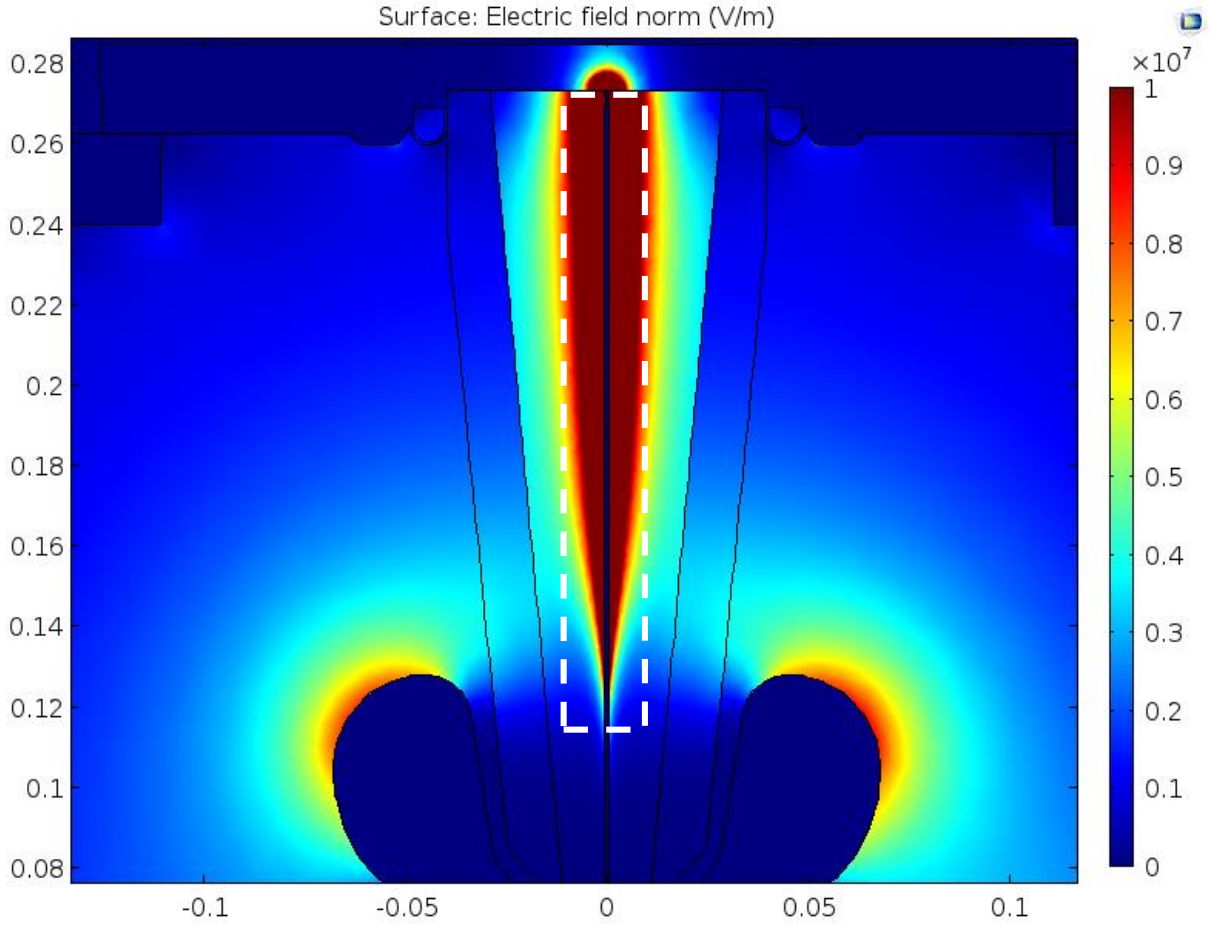
With upper shed



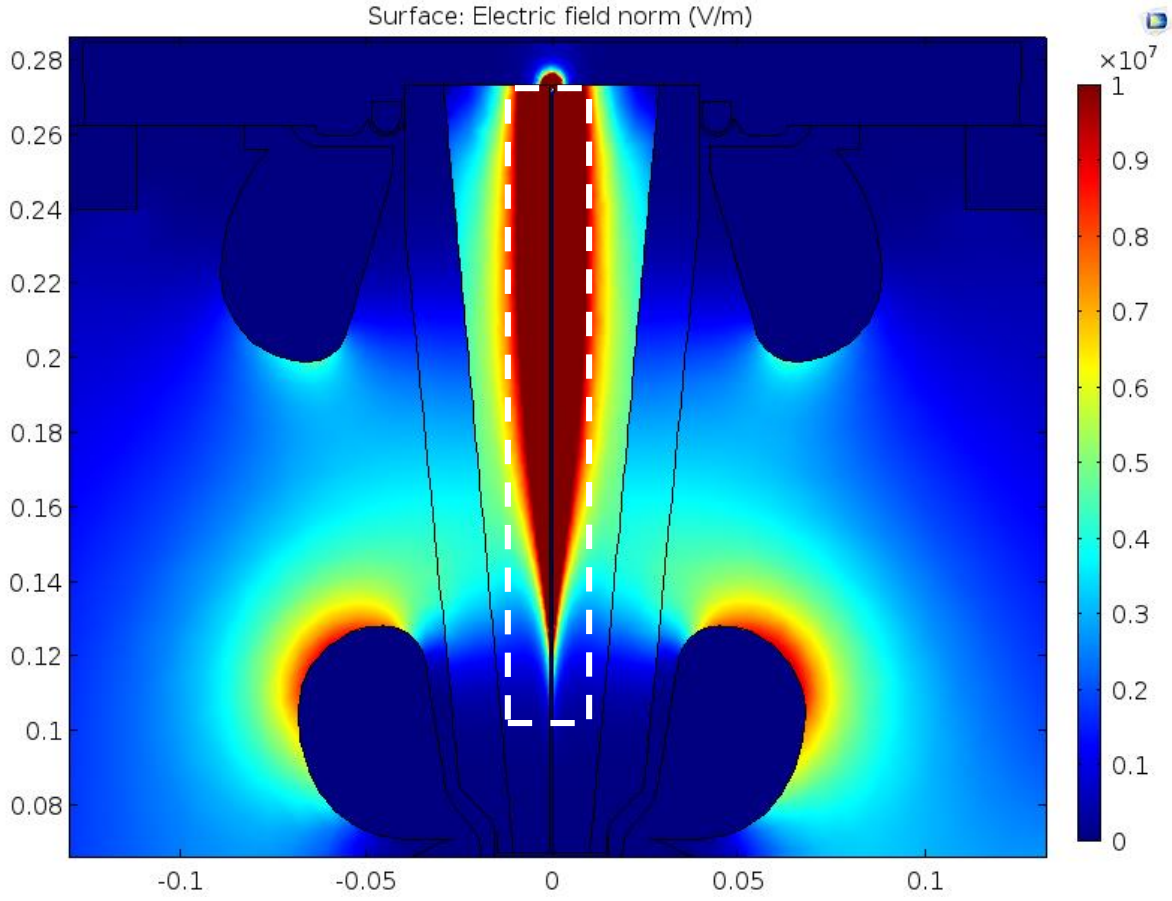
COMSOL Electric field Norm :

- The effect of the shed on the gradient of the electric field norm |E| close to the upper flange.

No upper shed

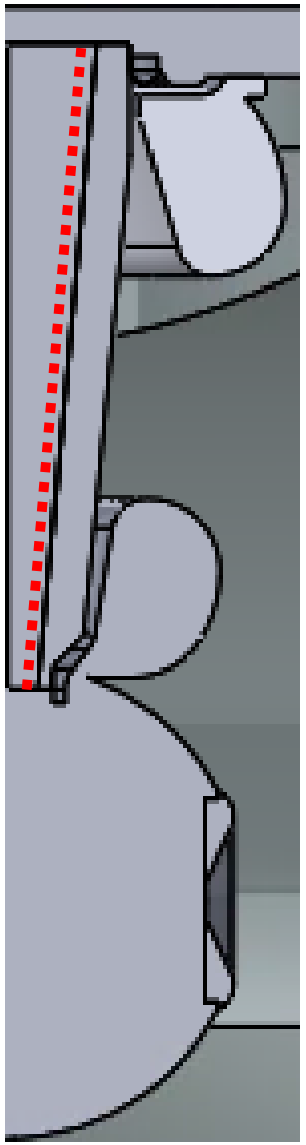


With upper shed.



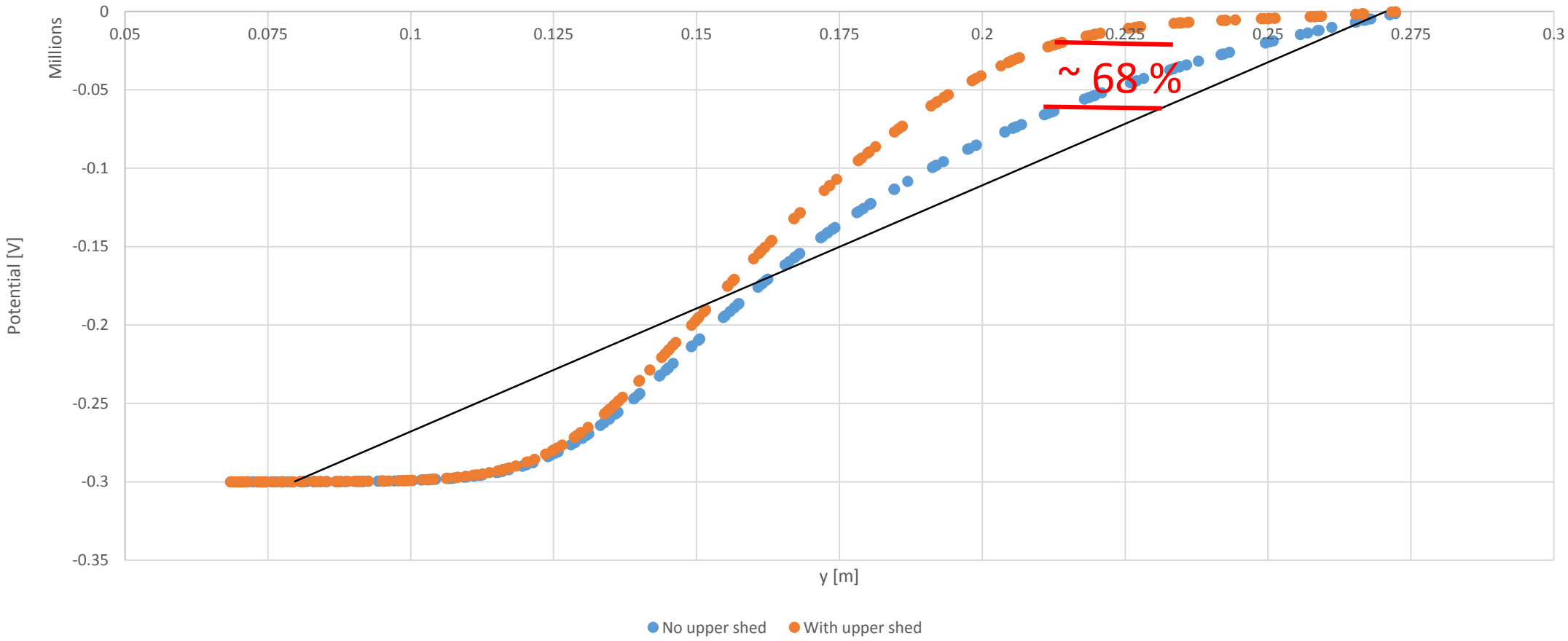
Rubber plug-insulator interface:

- The potential and electric field along the rubber plug – ceramic insulator interface was obtained (as shown in the image as a red dotted line), plotted as a function of the height (y-coordinate) and compared for between the two models.



Potential:

The interpolated fields along the rubber plug-insulator interface shows that the presence of the upper shed decrease the linearity of the potential along the interface. The black line represents the ideal case.



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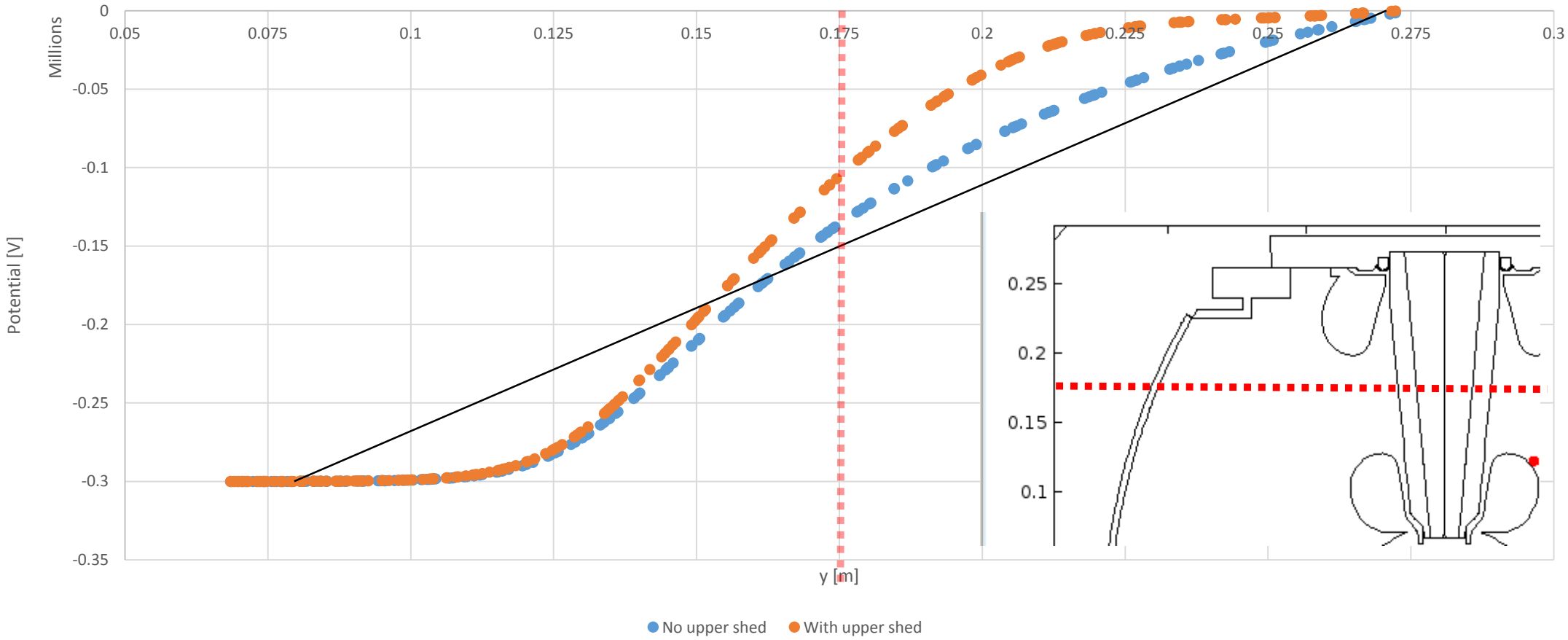
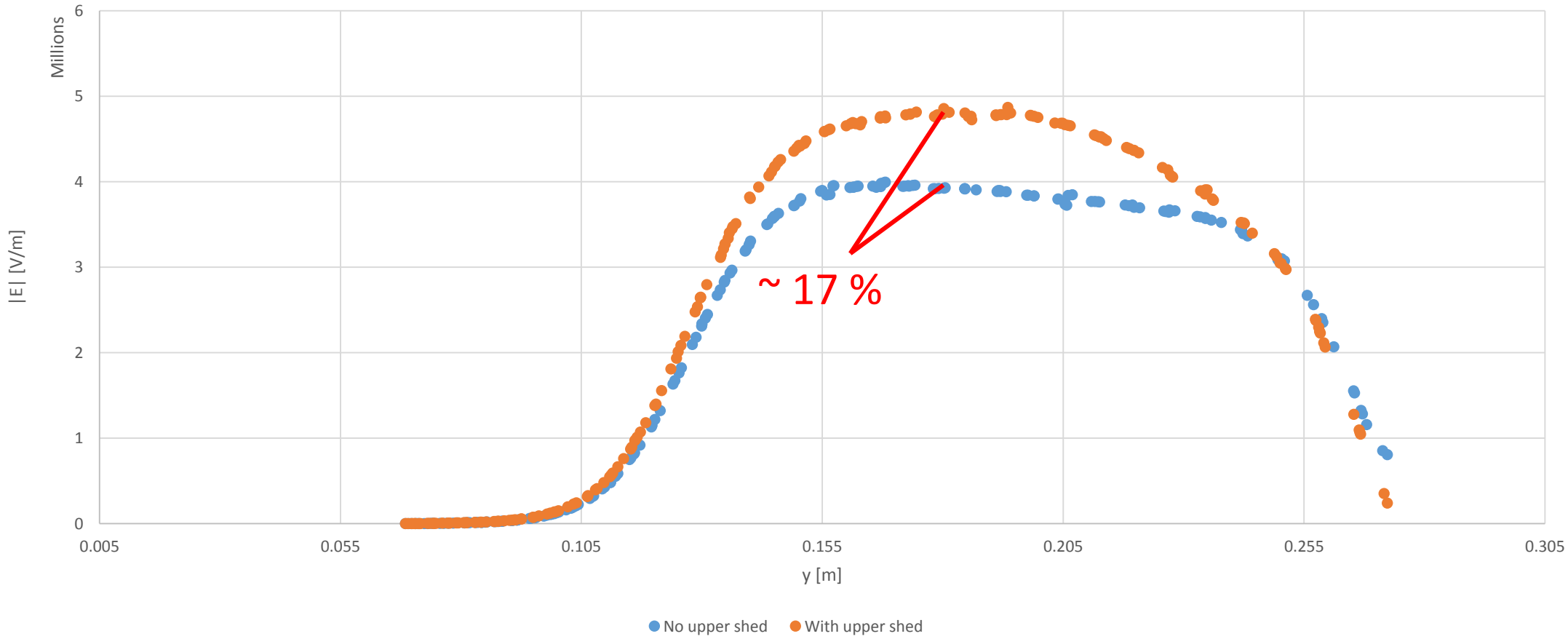


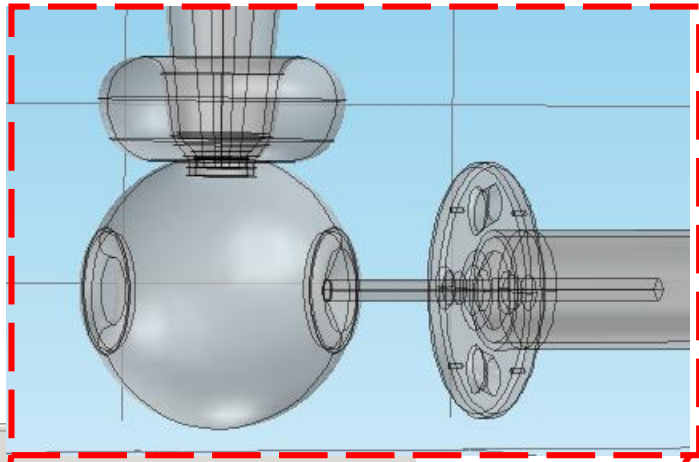
Electric field norm:

The interpolated fields along the rubber plug-insulator interface shows that the presence of the upper shed. The black line represents the ideal case.



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



Settings

Cut Line 2D

Plot

Label: Cut Line 2D 2

Data

Data set: Cut Plane 1

Line Data

Line entry method: Two points

	x:	y:	
Point 1:	0.063	0	m
Point 2:	0.263	0	m

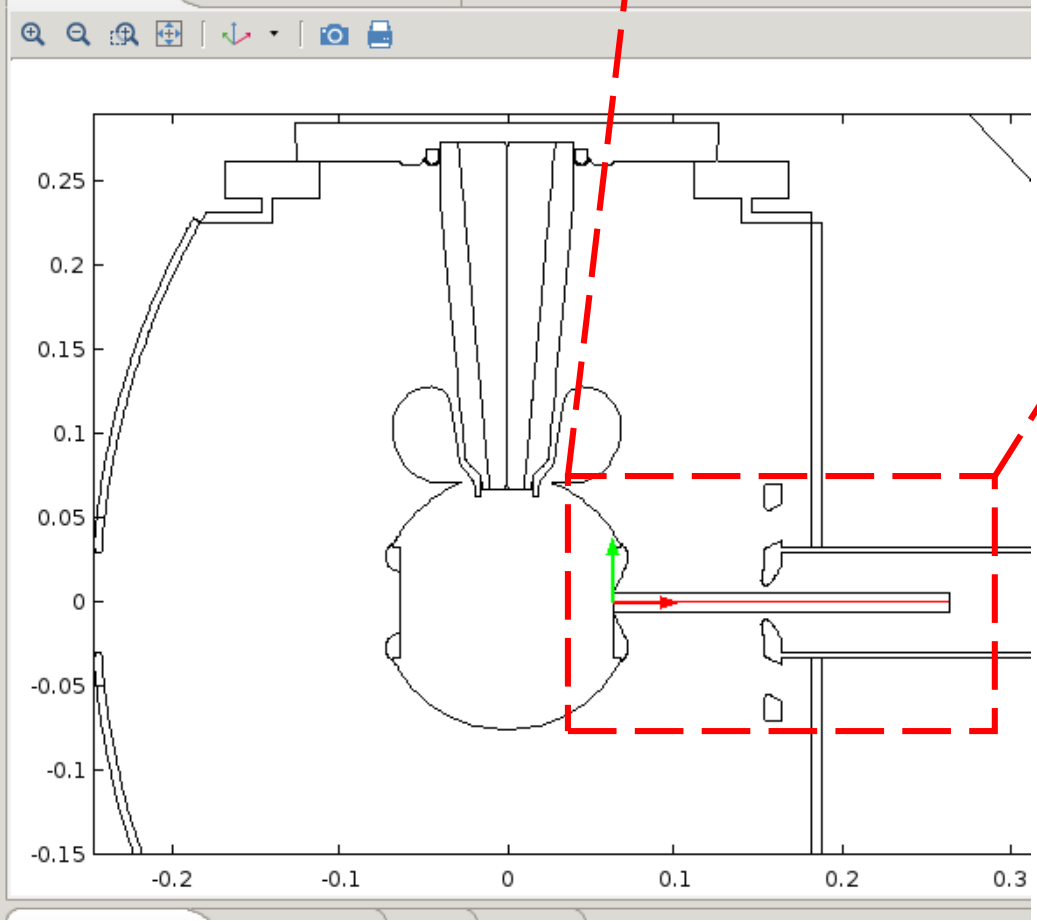
☑ Bounded by points

☐ Additional parallel lines

Distances: m

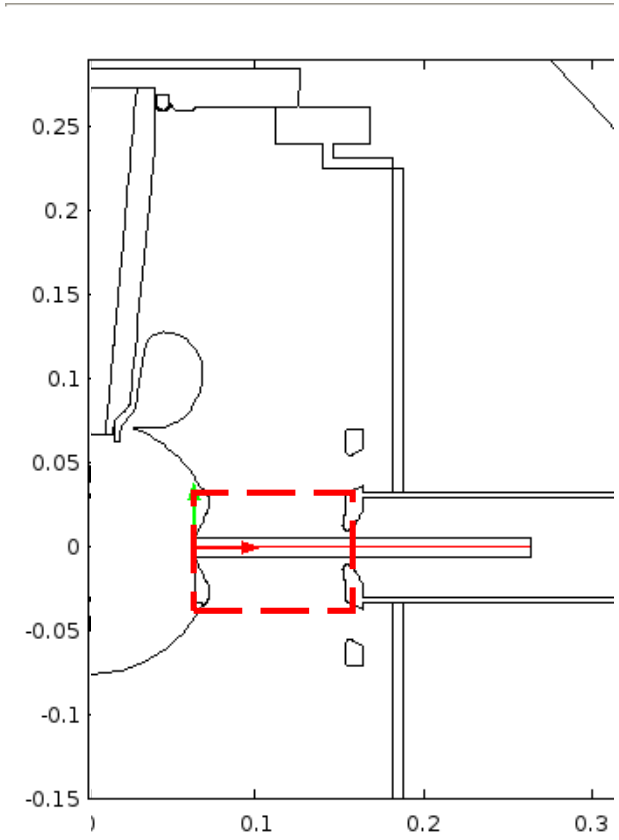
Advanced

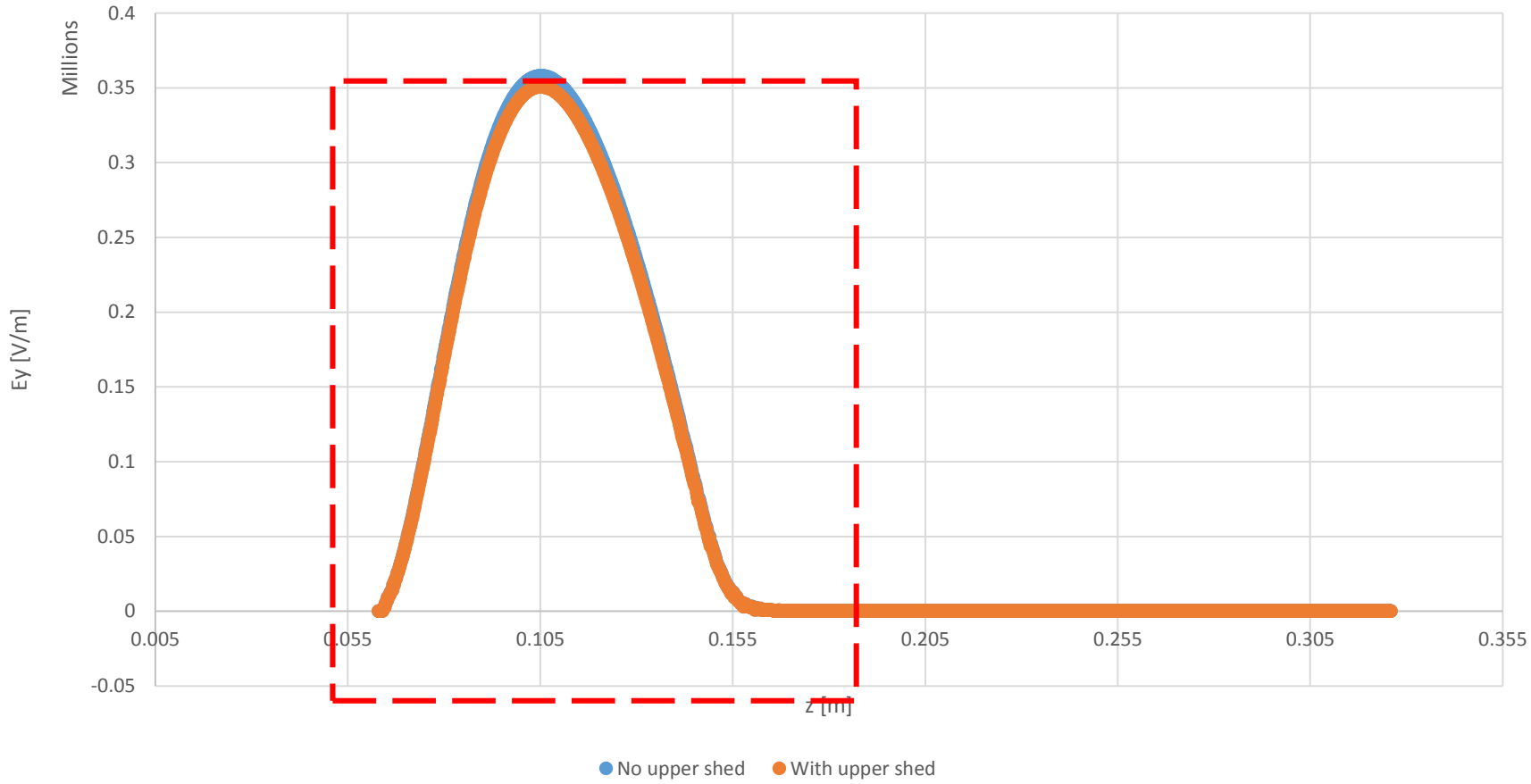
Graphics | Convergence Plot 1



Photocathode-anode line :

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





Future steps.

- The anode !?
- The top of the flange is not detailed.
- The upper flange has little effect on the field inside the

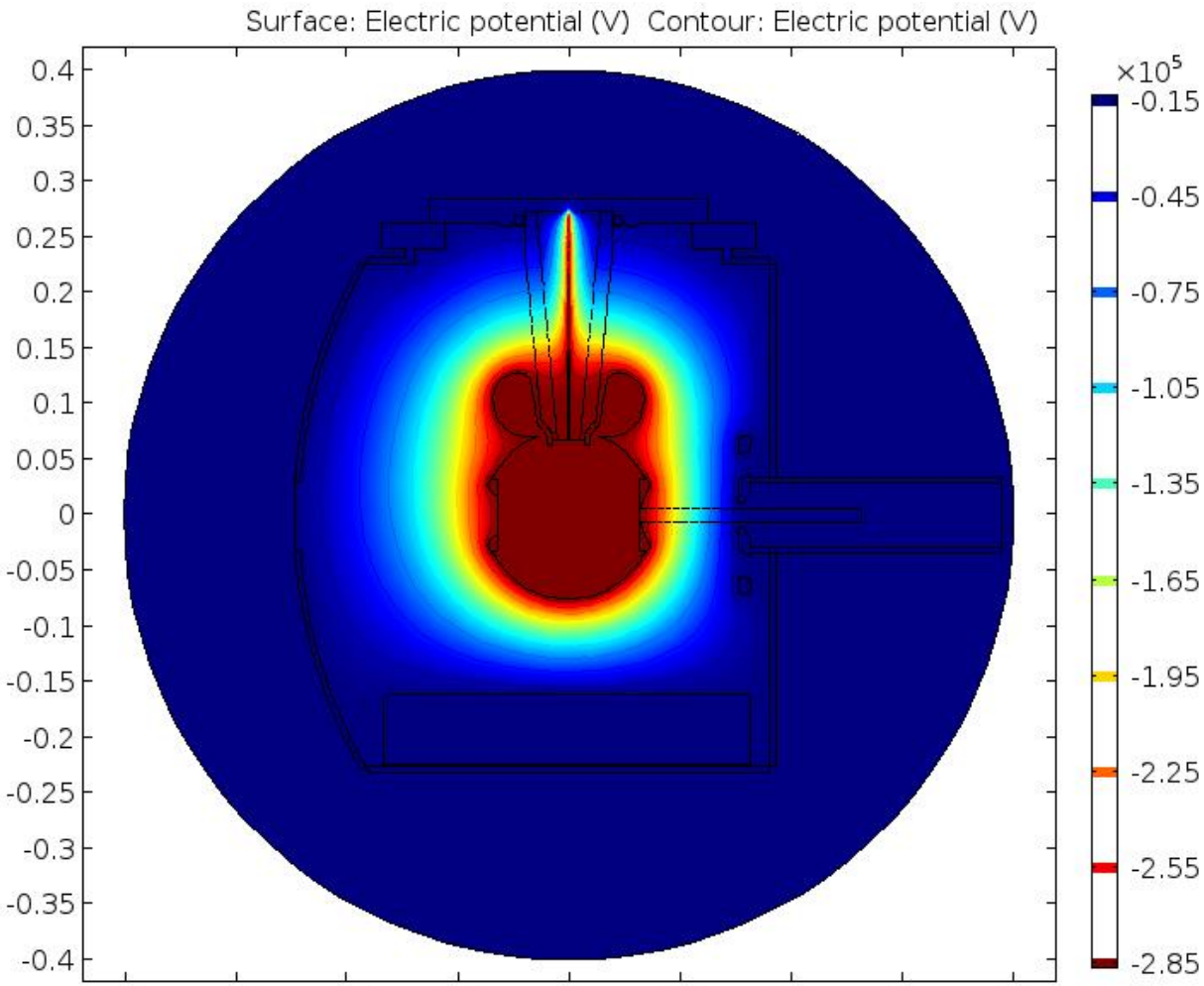
Fin.

Additional slides

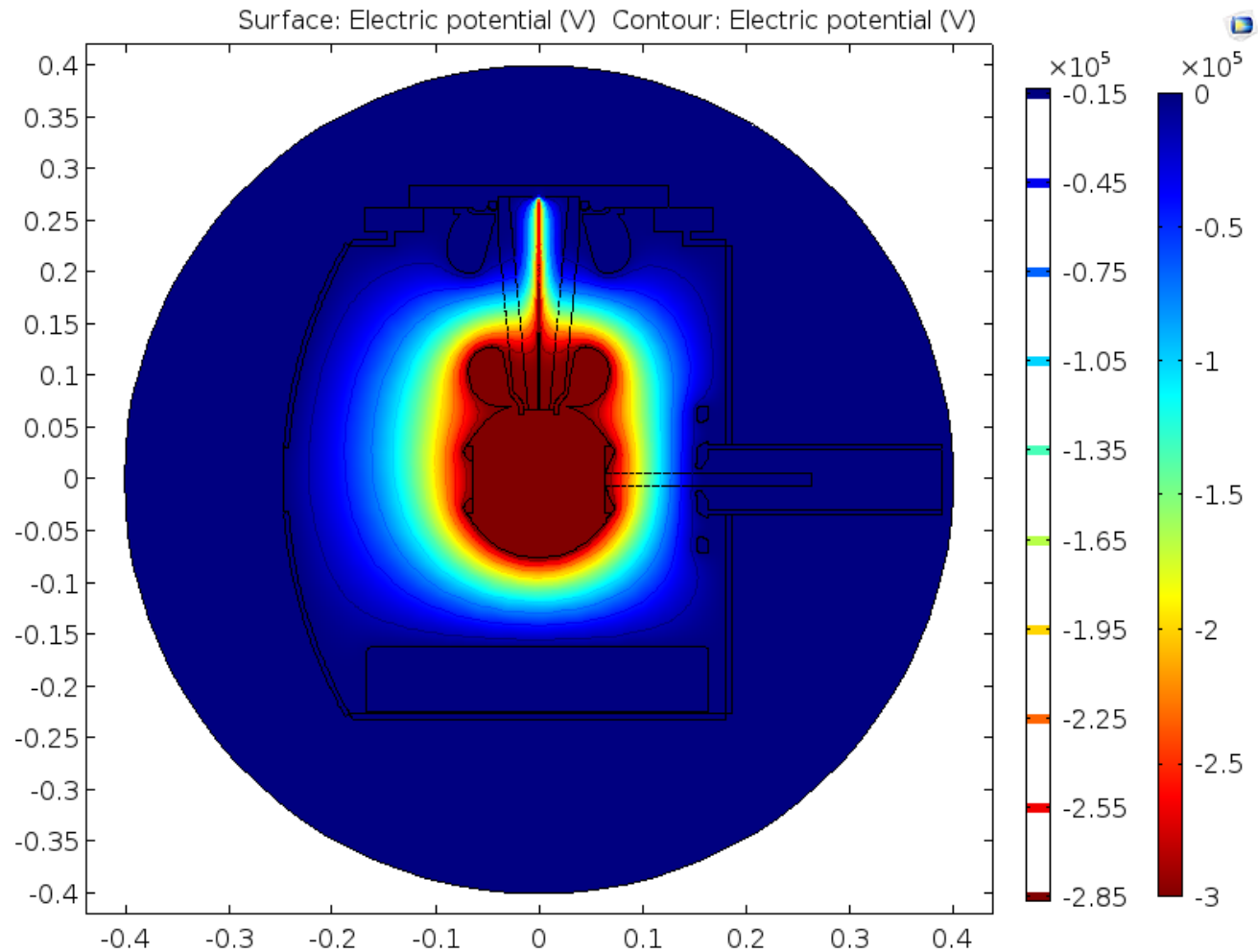
COMSOL Potential:

- This image shows the potential as color intensity (with equipotential lines). The axis are coordinates in meters.

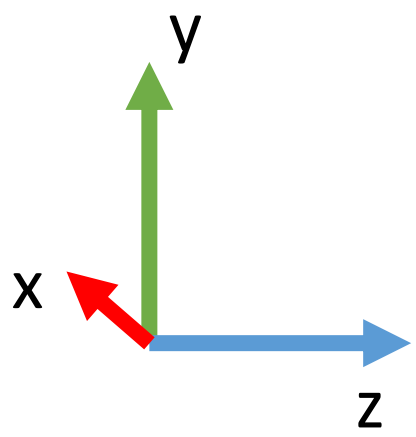
No upper shed



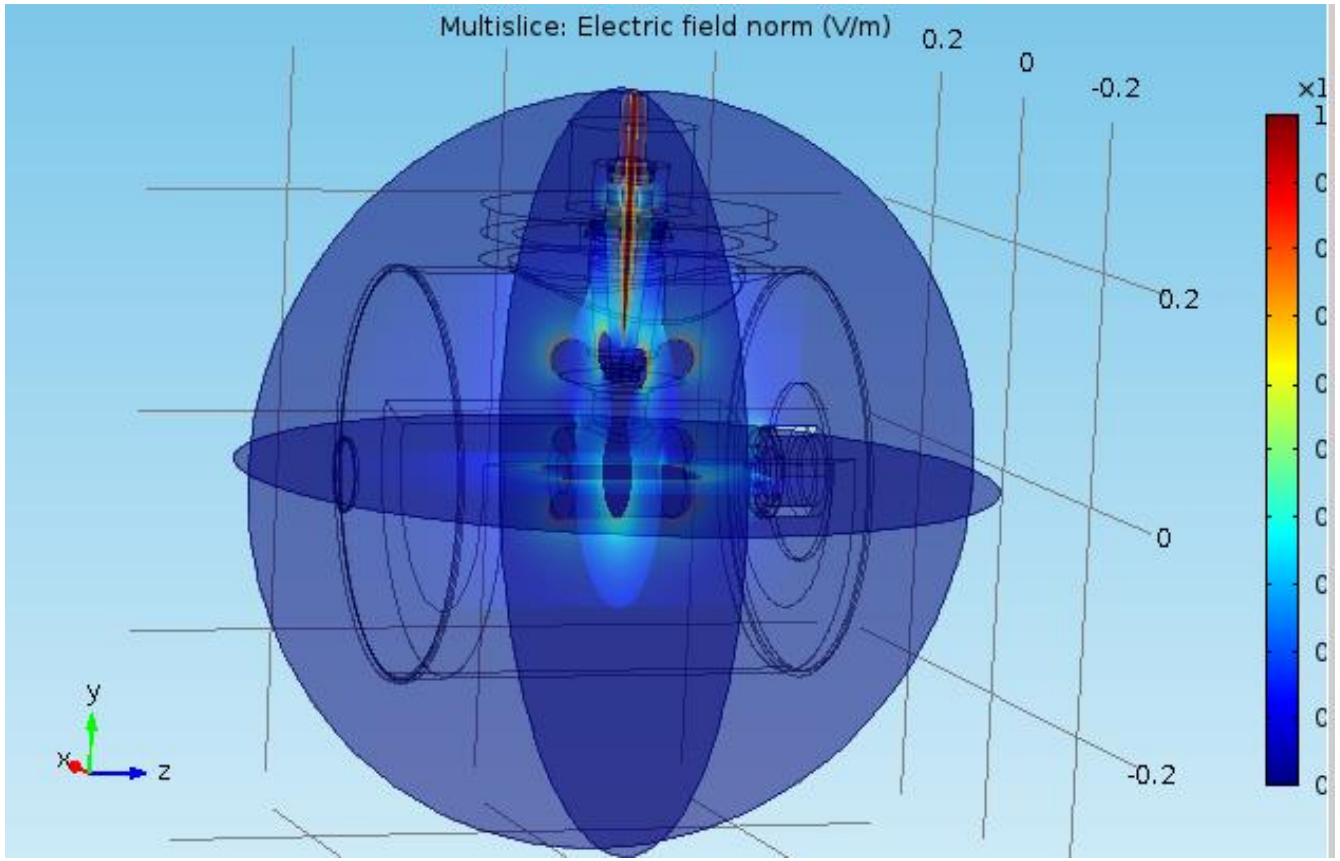
Upper shed



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)