GTS gun COMSOL simulations

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Summary

- Solidworks
  - How I modified the original step file to make it work with COMSOL.
- COMSOL
  - Details of simulation to show some progress and as a record of what I did in case I forget.
- Future steps

Solidworks model.

- Used the step file provided by Carlos.
- The original file has lots of detail so I removed the perforations for bolts, all the back plate that has connections behind the anode. Removed all the perforations and flanges around the chamber except for the upper flange, leaving only the chamber "shell".
- I removed the inner geometry of the cathode sphere and ~~the photocathode holder~~, as well as the photocathode. Also I kept the metal parts that correspond to the HV cable, the cathode sphere and the metal part that connects the sphere with the insulator making them all one piece.
- I simplified the geometry near the upper flange where the insulator meets its flange.
- Remade the insulator to remove small details.
- Made a rubber plug with a perforation for the HV cable.
- Performed interference tests between parts to prevent overlapping and obtained an assembly.
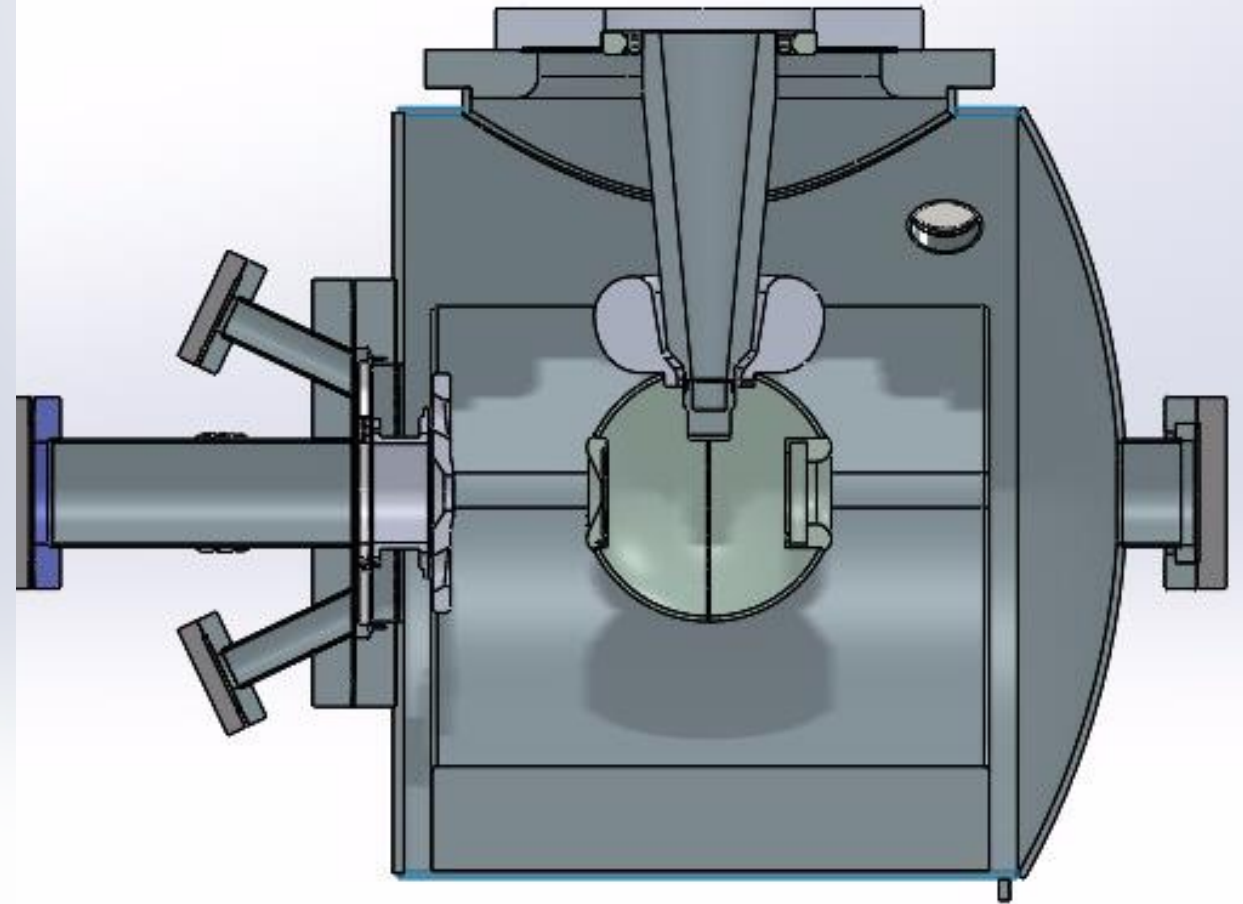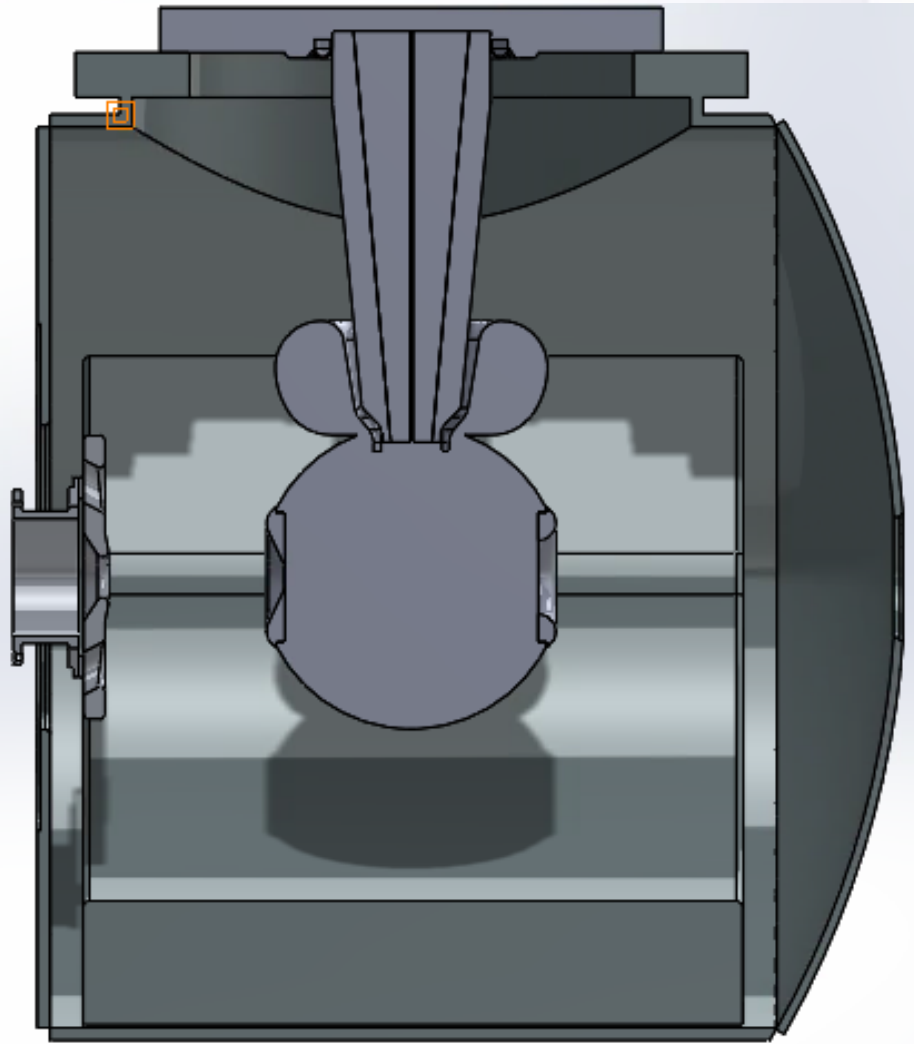
Geometry modifications: ISO
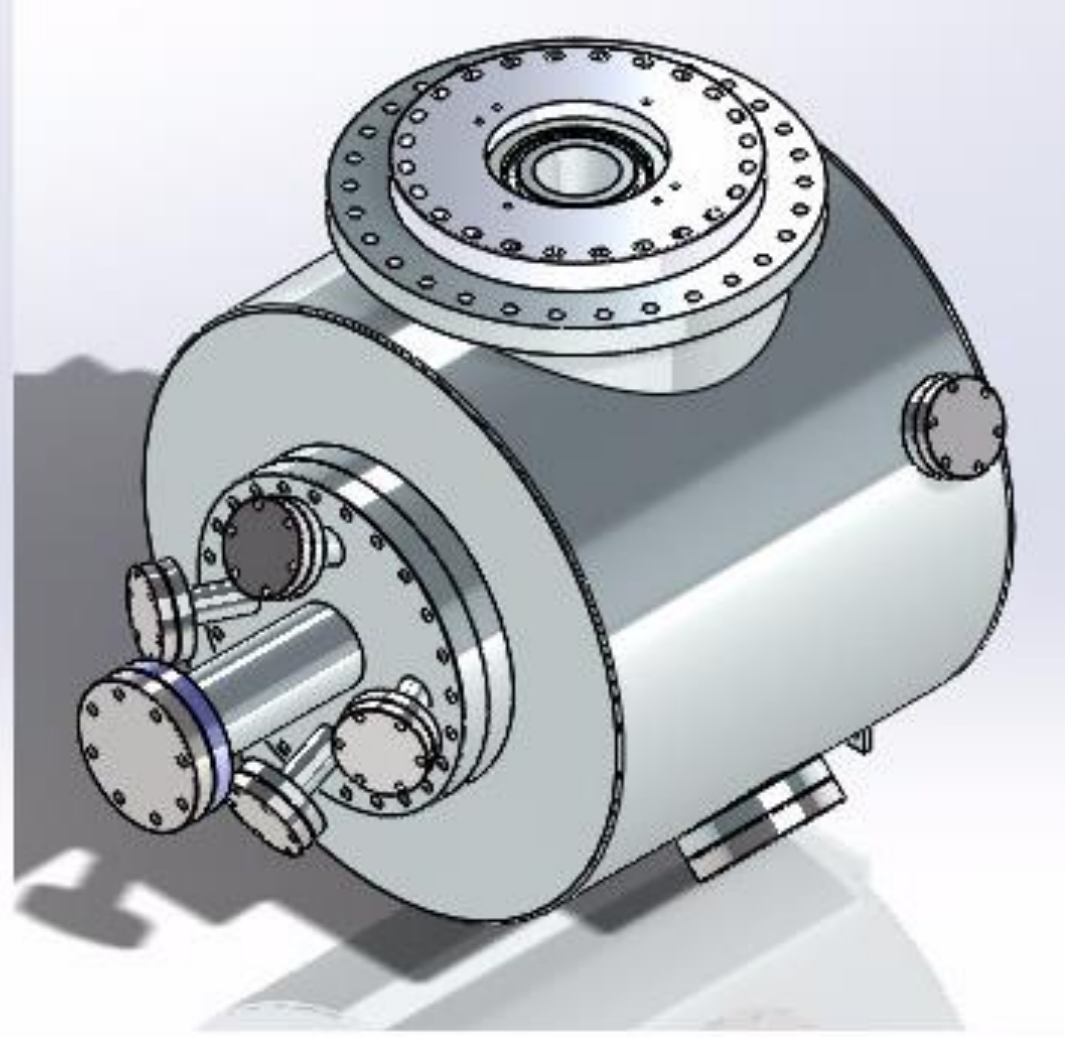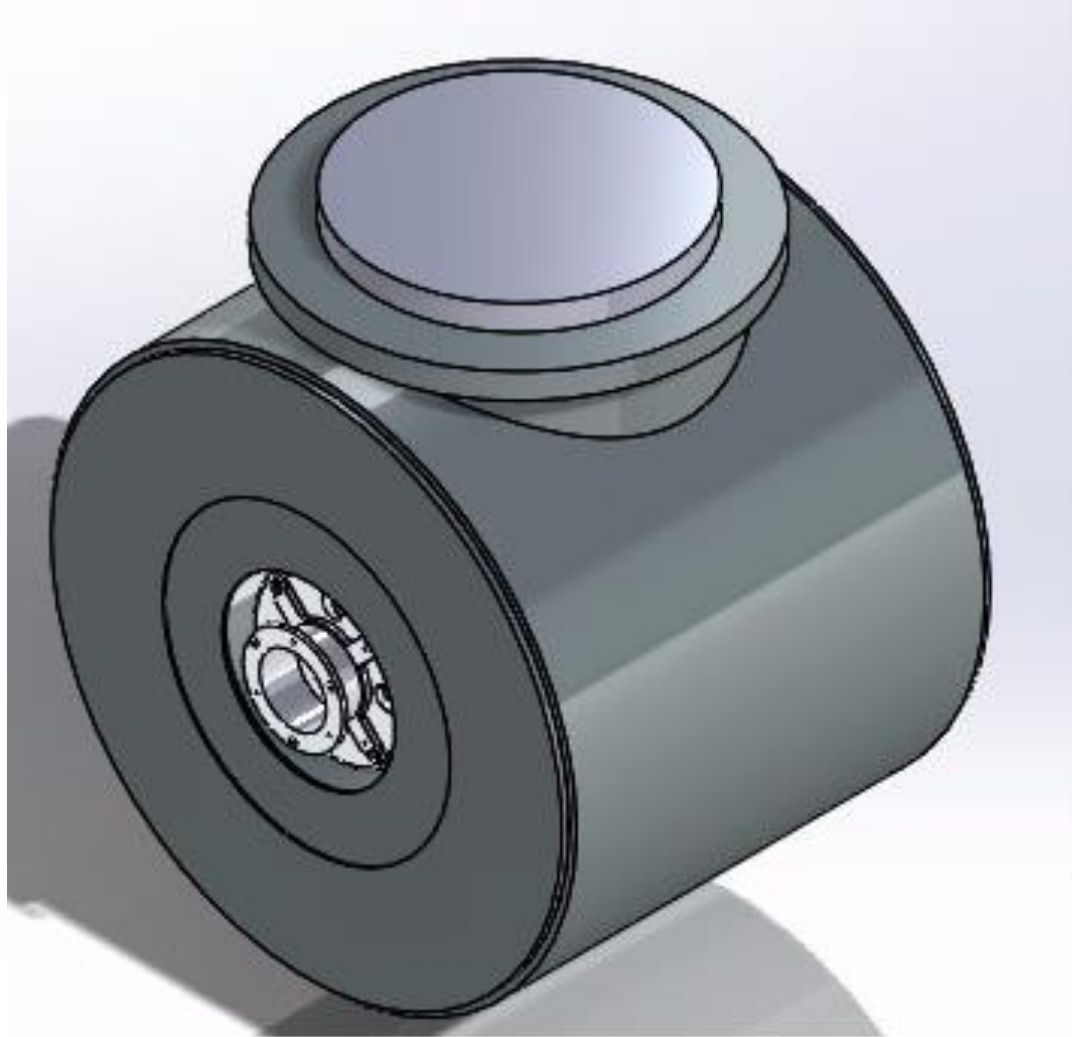
Geometry modifications: Chamber
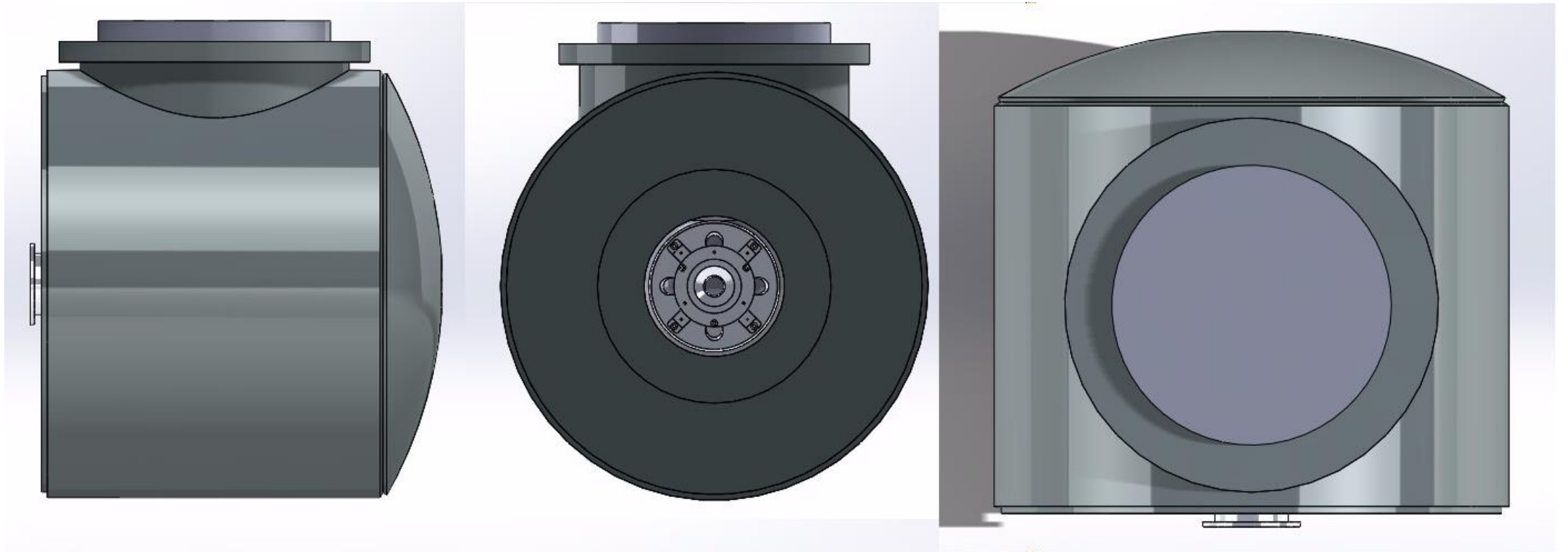
Geometry modifications: Chamber inside

Geometry modifications: Upper flange
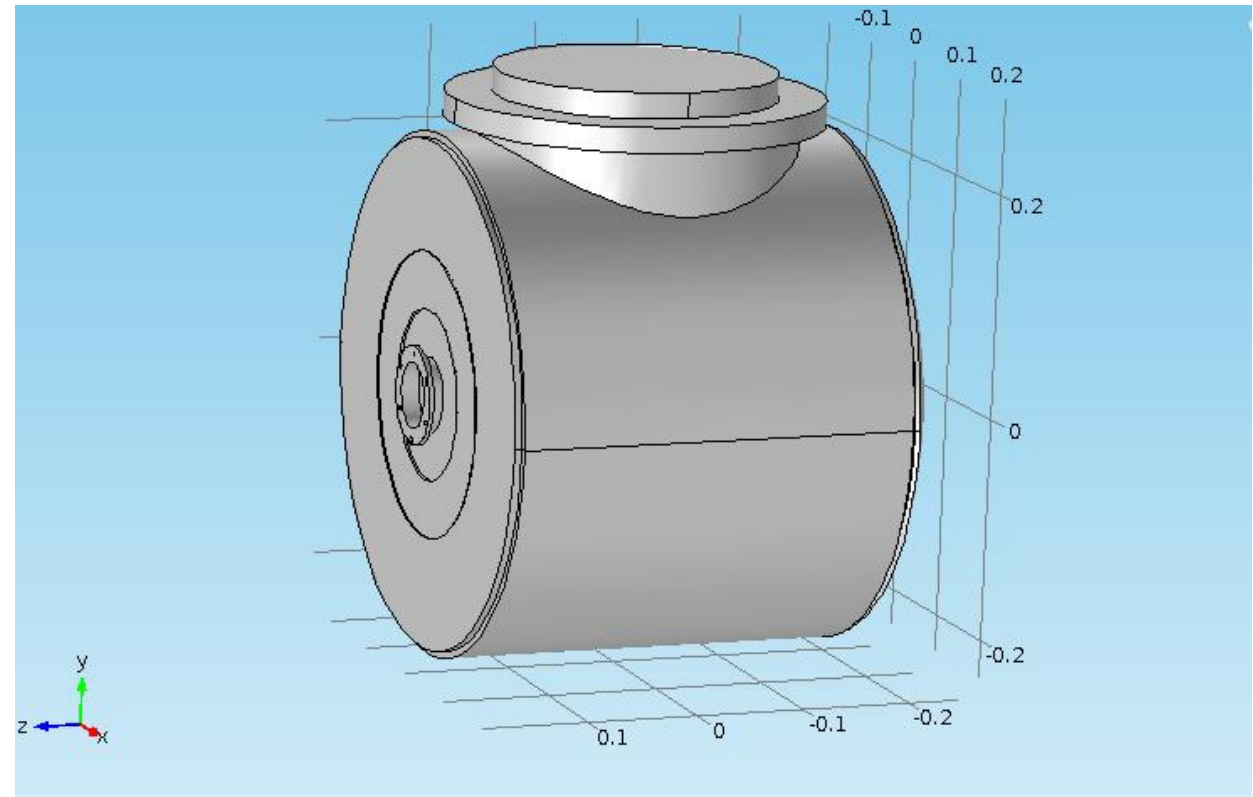

Flange

Insulator

Rubber plug

HV cable

Both drawings are at different scale, that is why they seem to be different sizes, but they have the same dimensions.

COMSOL simulations: Geometry

Performed simulations at -300kV for my Solidworks assembly of the GTS gun.

- Imported the model using the CAD import module, performed repair operations to cover the front and back holes left in the model. Created a sphere of air around everything and created a union of all materials.

COMSOL simulations: materials and physics

I defined the materials to be High-strength alloy steal (ε_r = 1) for the cathode assembly (including the HV cable), flanges and chamber (including anode).
Air (ε_r = 1) for the surrounding sphere.

Alumina for the insulator (εr = 8.4) ~~no doping~~ included resistivity of 1.7×10^{11}.

Rubber (ε_r = 7) <u>not vulcanized (?)</u>.

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.

▽ ▦ Materials

  ▷ ▦ High-strength alloy steel *(mat1)*

  ▷ ▦ Air *(mat2)*

  ▷ ▦ Alumina *(mat3)*

  ▷ ▦ Rubber *(mat4)*

▽ ⚡ Electrostatics *(es)*

  ▣ Charge Conservation 1

  ▣ Zero Charge 1

  ▣ Initial Values 1

  ▬ Electric Potential 1

COMSOL simulations: Mesh

When meshing, small details are really problematic. Parts where meshed independently from each other since doing everything in one run produced several errors. The union operation performed before ensures continuity across boundaries.

Just as a side note, the mesh was set as super fine, resulting in over 7 million domains, which took the high performance cluster just a couple minutes to compute. ☺

Version 1

Version 2
With cathode details
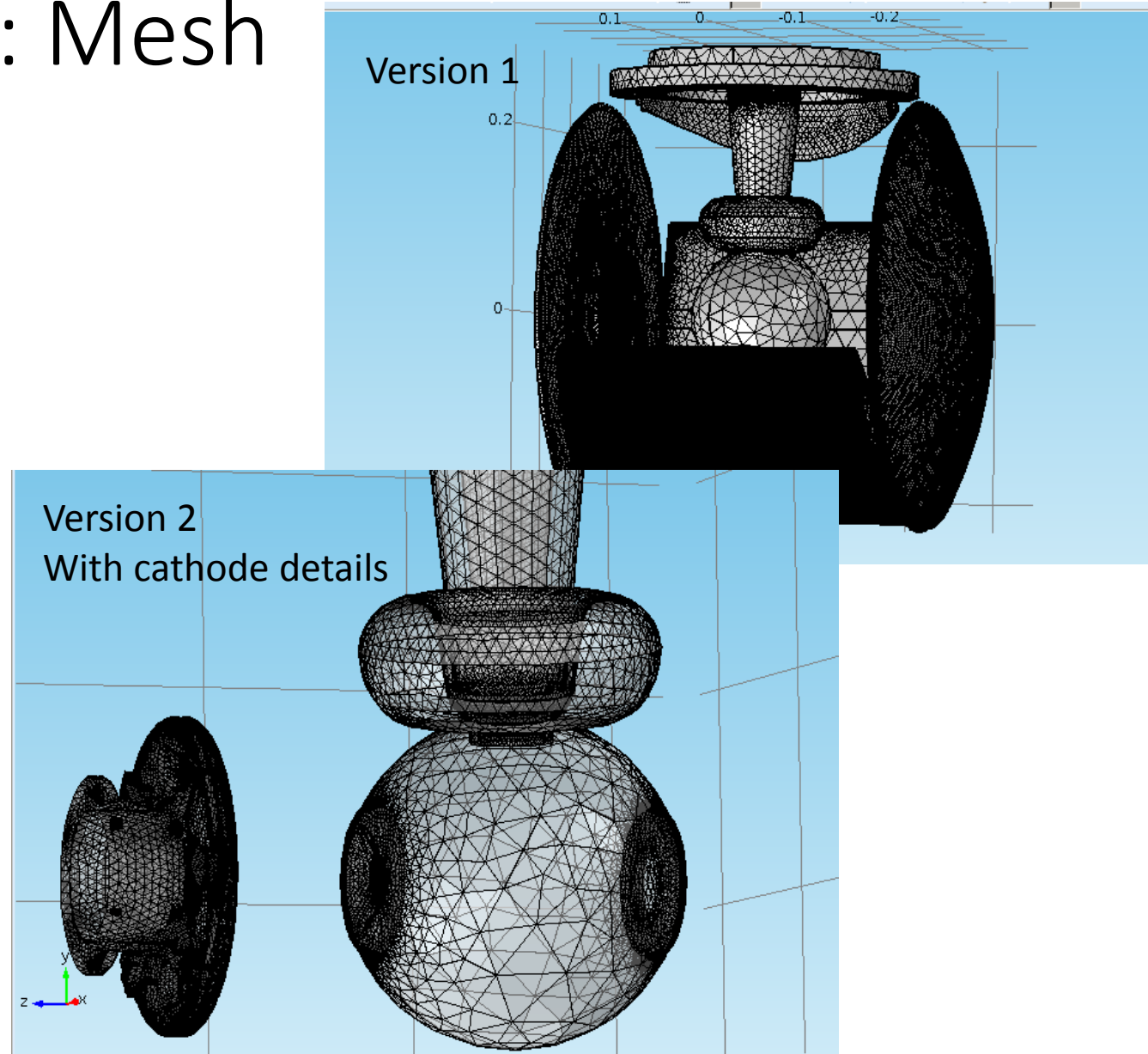
COMSOL simulations: Study and plots.

Calculated the results and plotted the potential and (absolute value) electric field for two views (COMSOL obtains the fields on planes, but I can get as many as I want and I can also produce stream lines in 3D...I think).
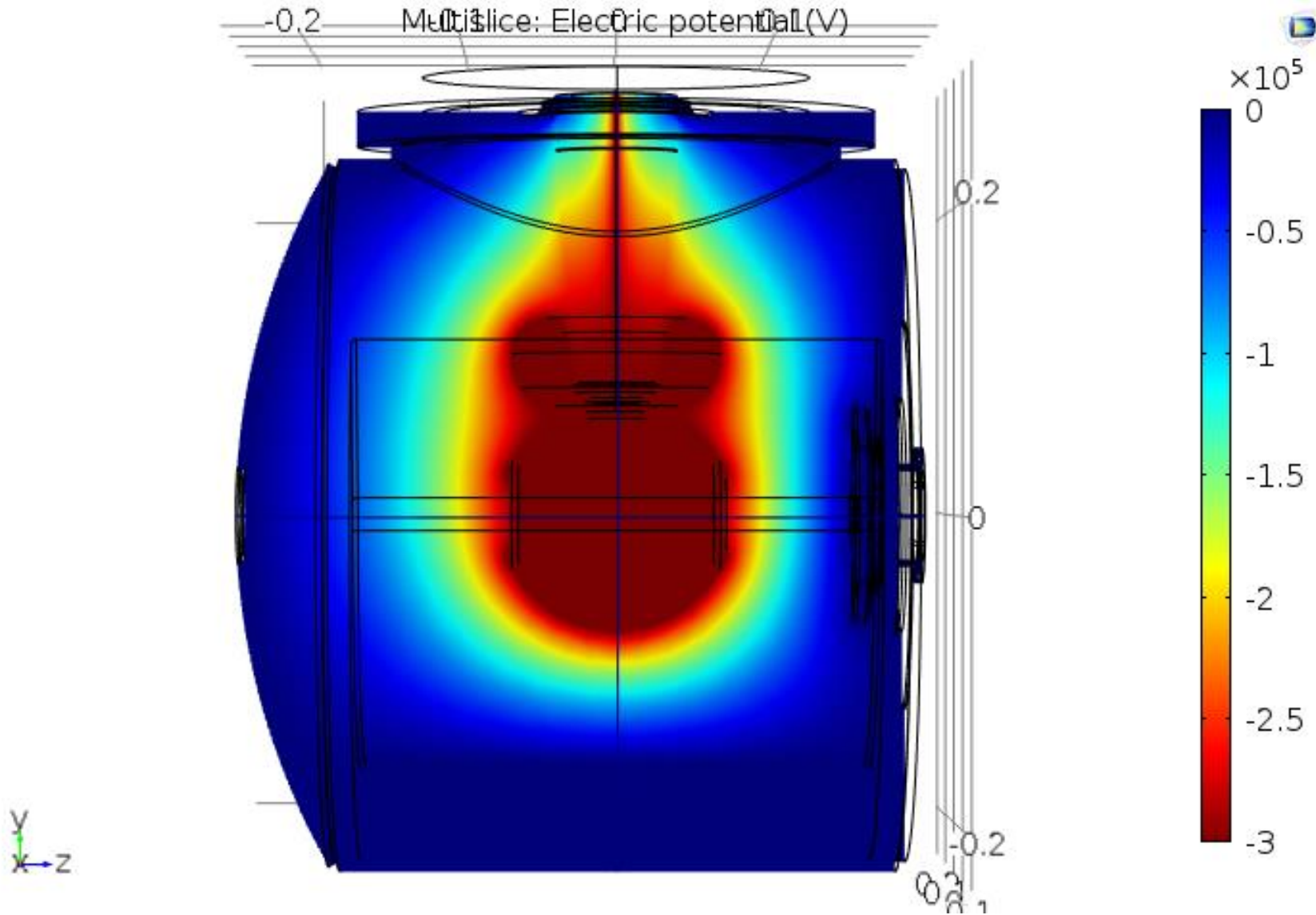
Notes on this:

- ~~The study gave me back two warnings about how I did the mesh, this needs attention.~~ **Solved (kind of...)**

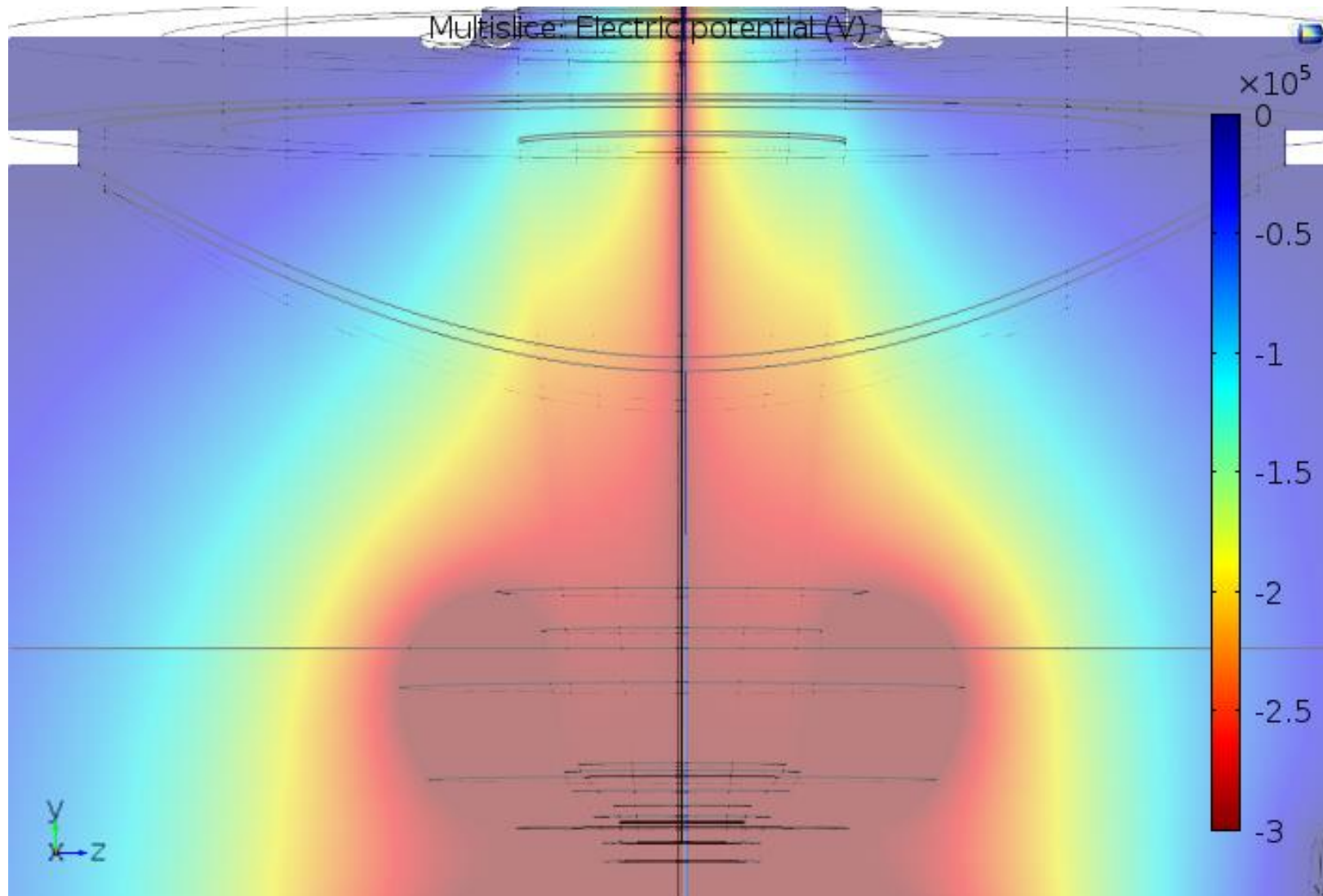- ~~The final plots show a skewed contour of the cathode assembly (still trying to find out why), ignore that.~~
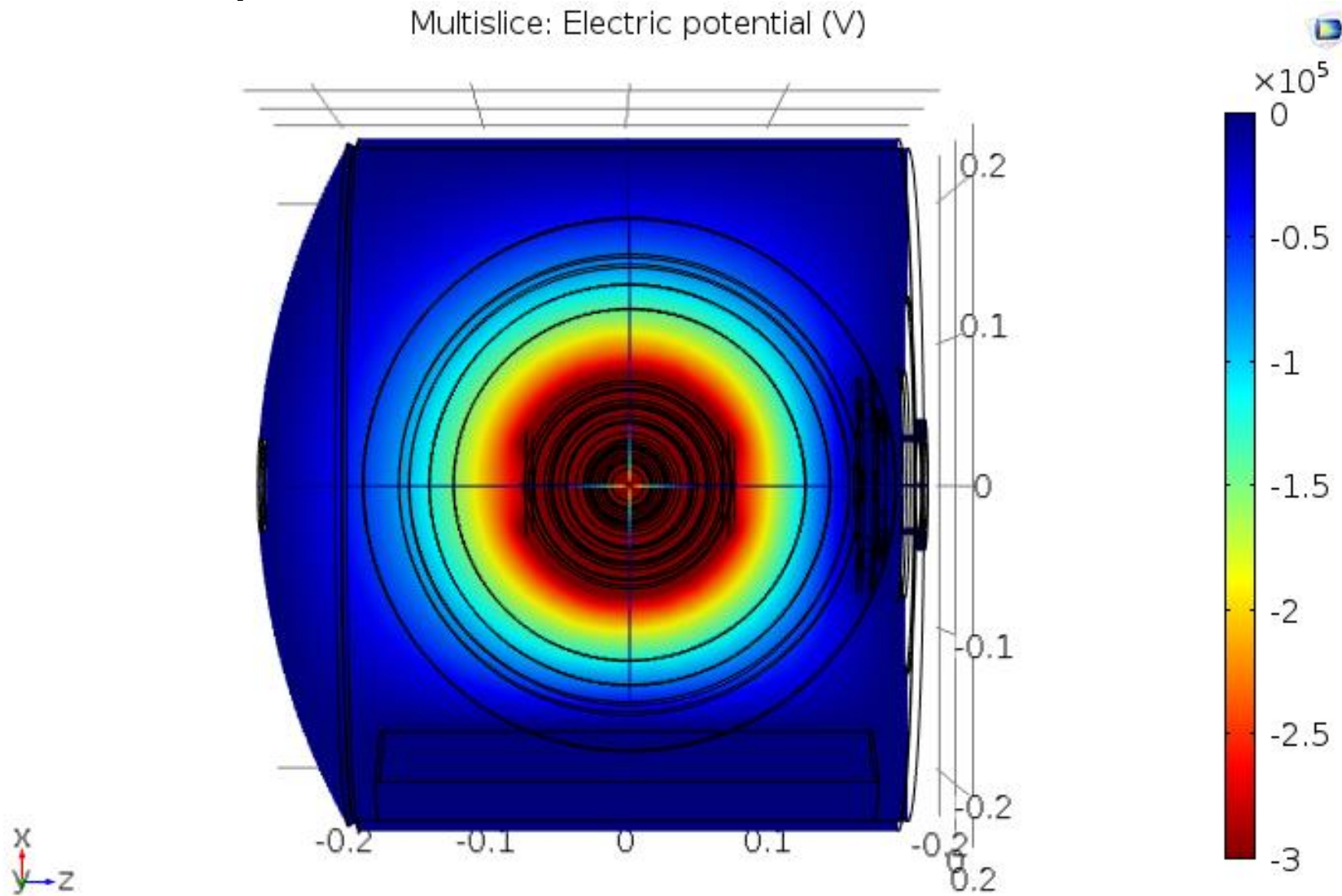
Enjoy! ☺

Multislice: Electric potential (V)
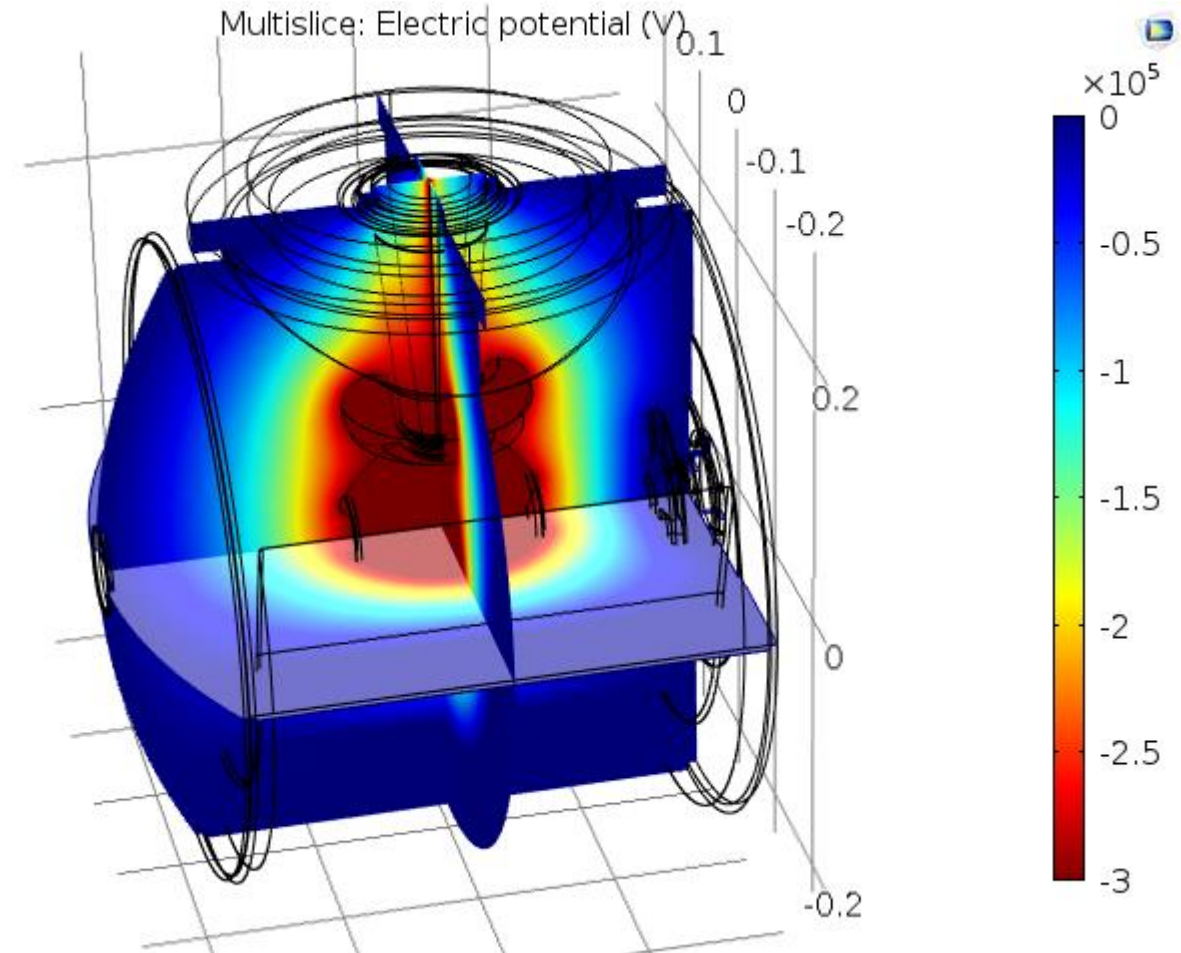
Potential. Side view.

Potential. Side view. Close up

Potential. front view.
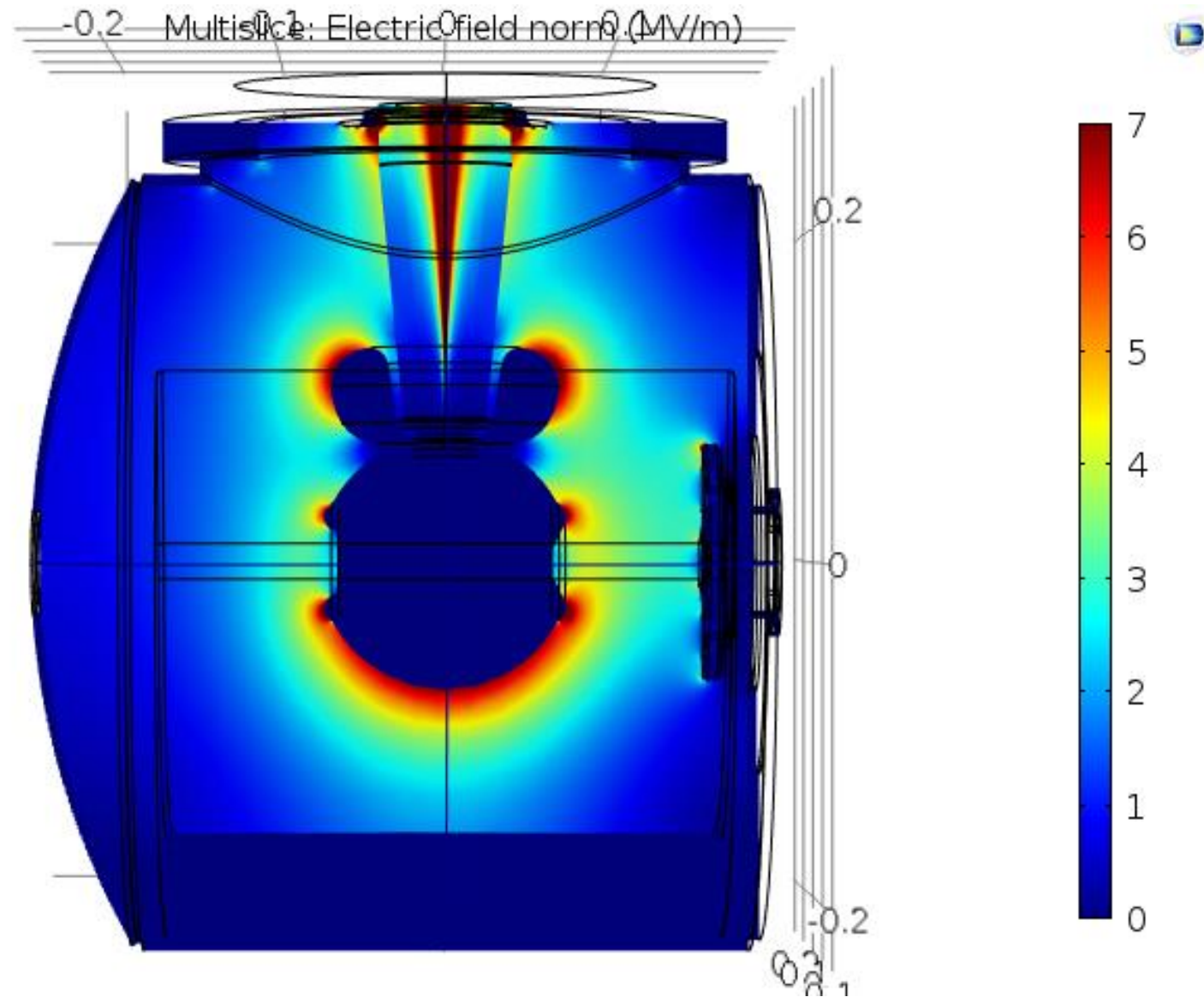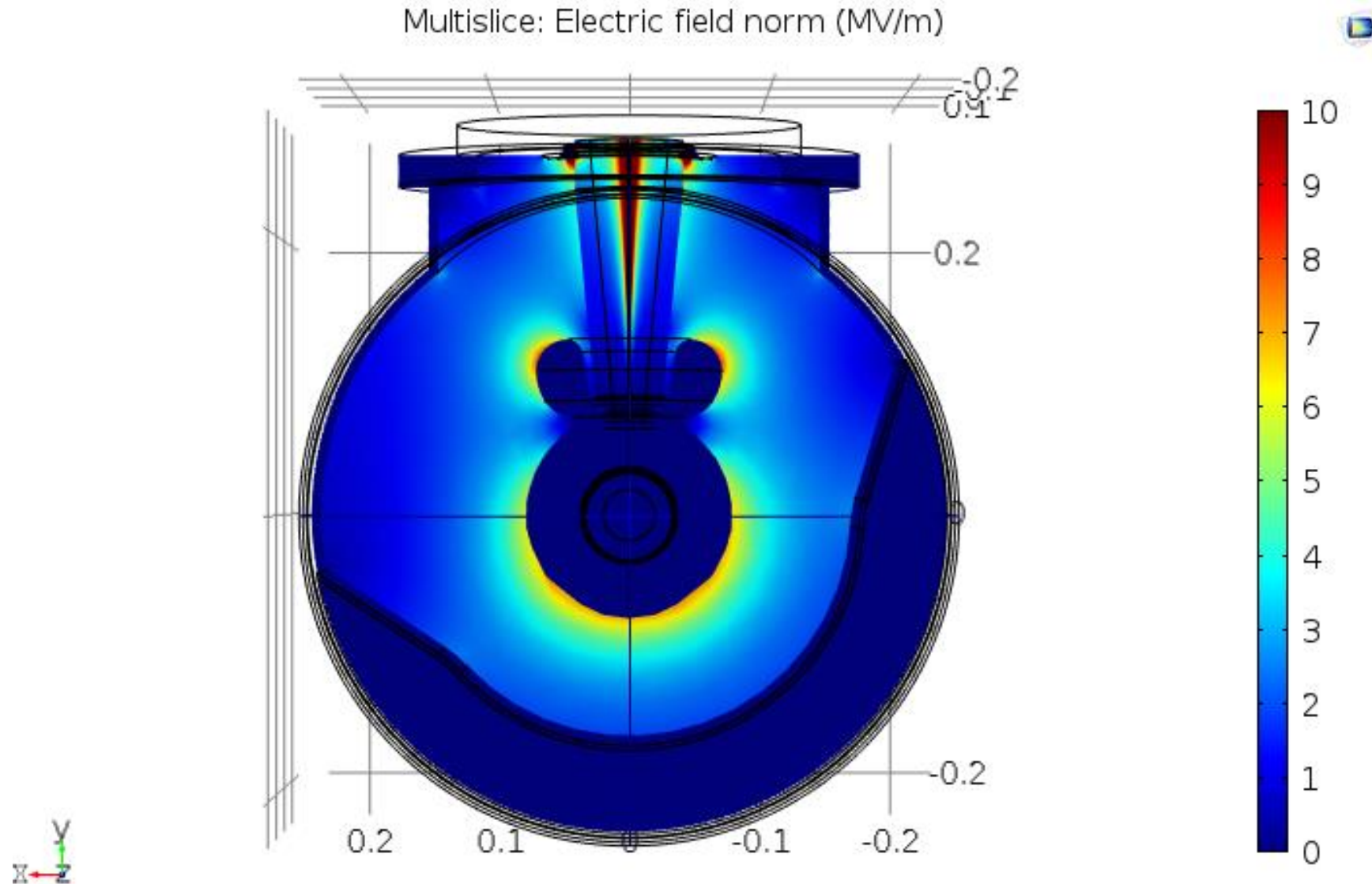

Multislice: Electric potential (V)

Potential. Up view

Multislice: Electric potential (V)

Electric field. Side view.

Multislice: Electric field norm (MV/m)

Electric field. Side view.

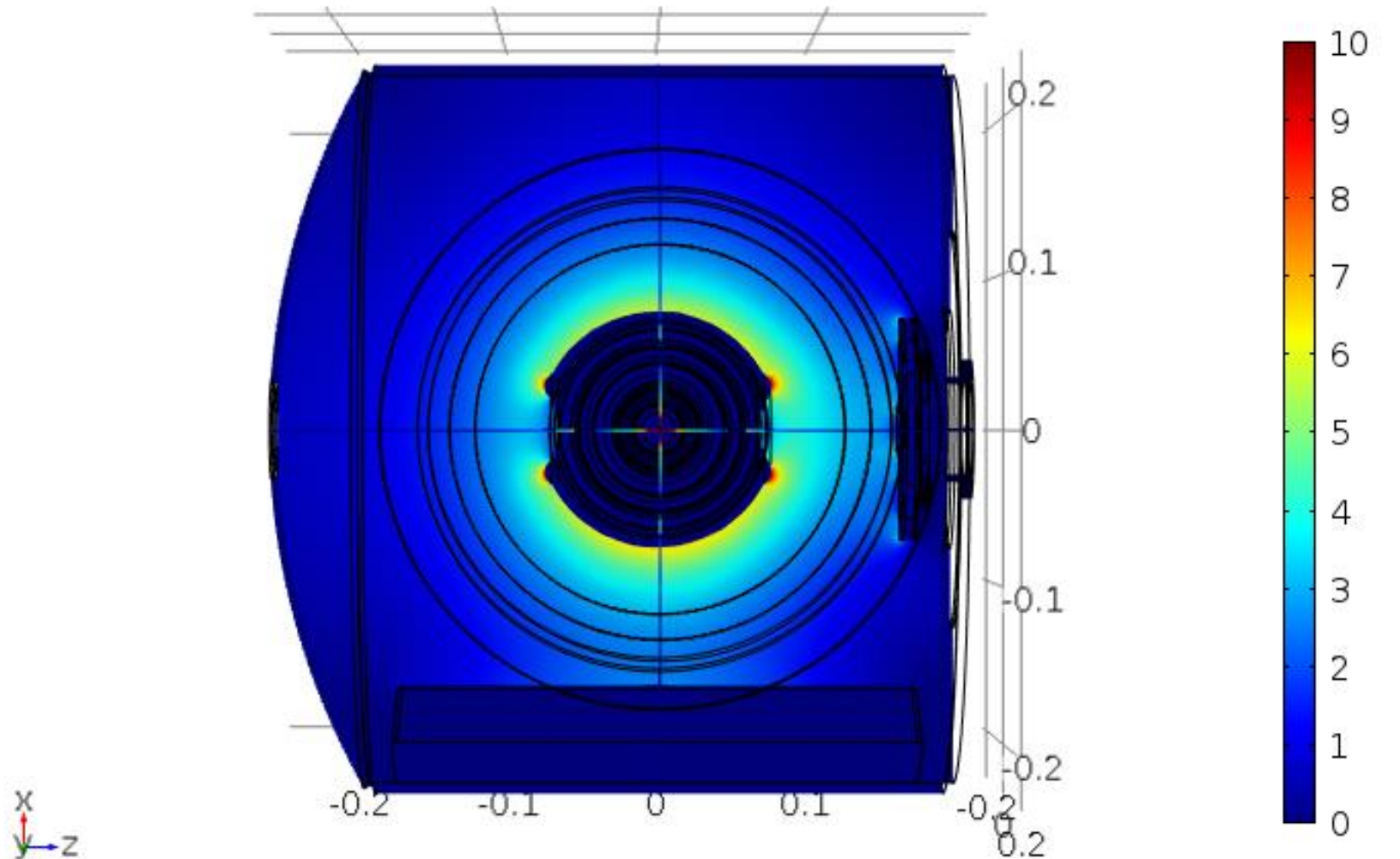Multislice: Electric field norm (MV/m)
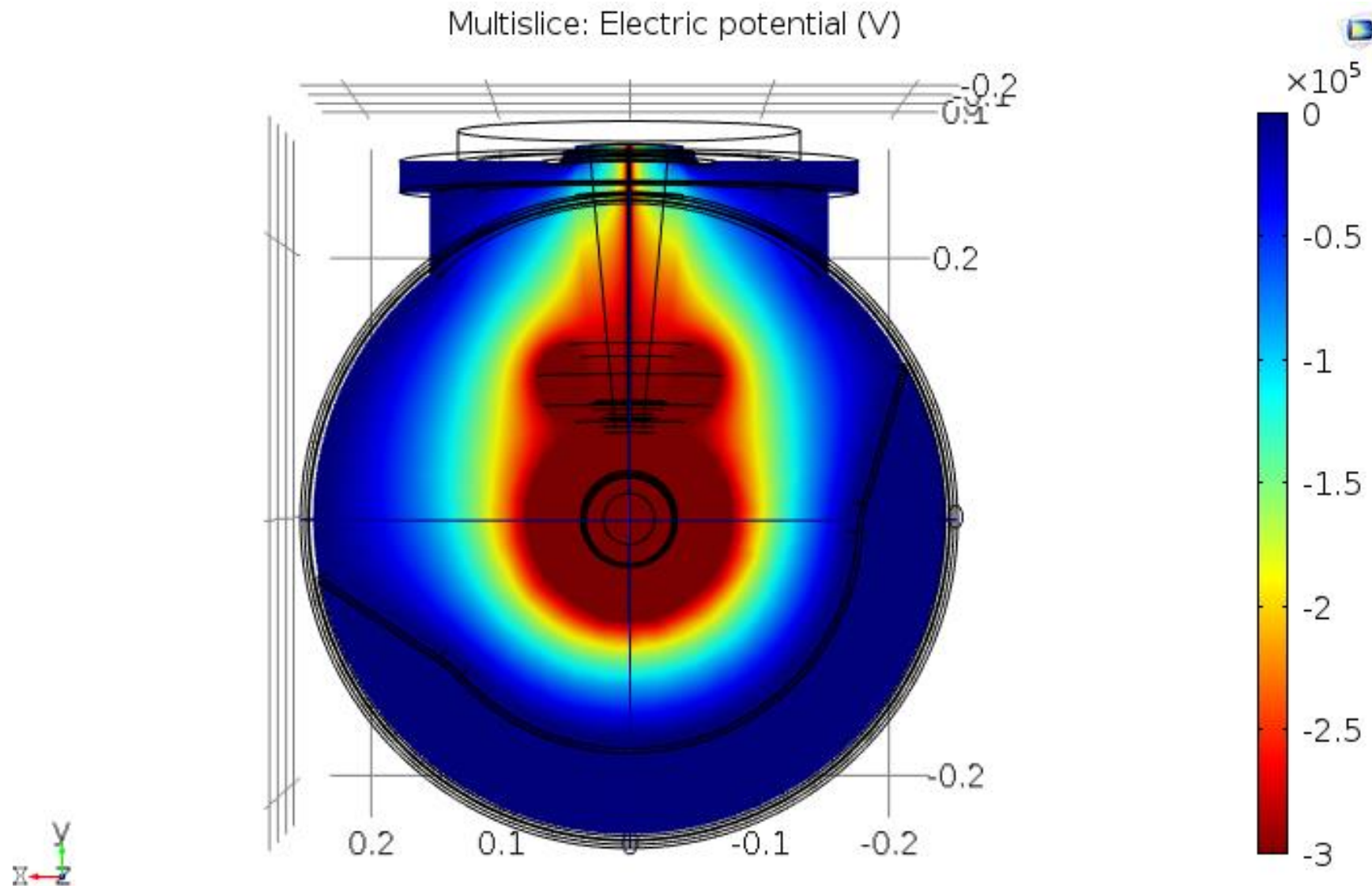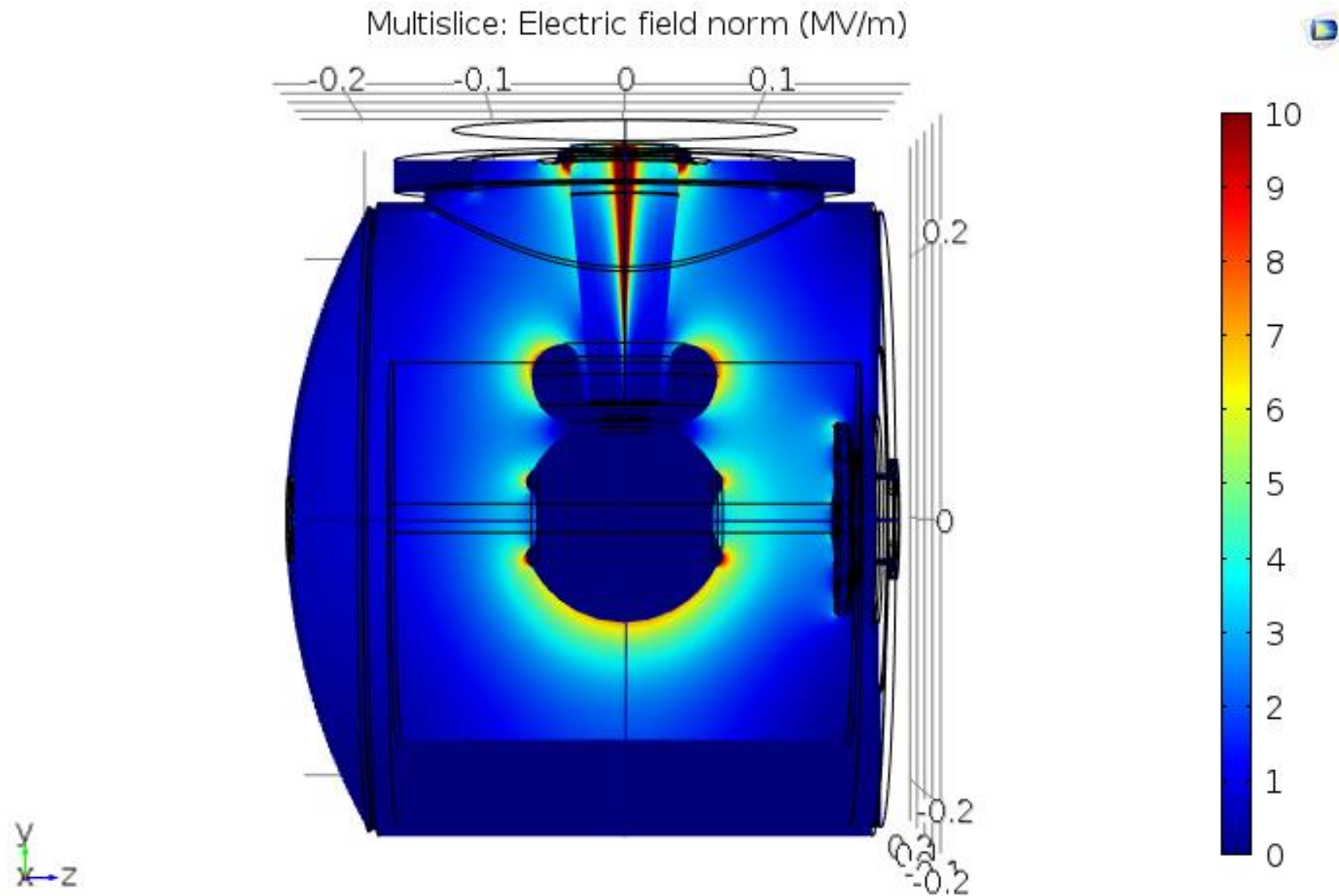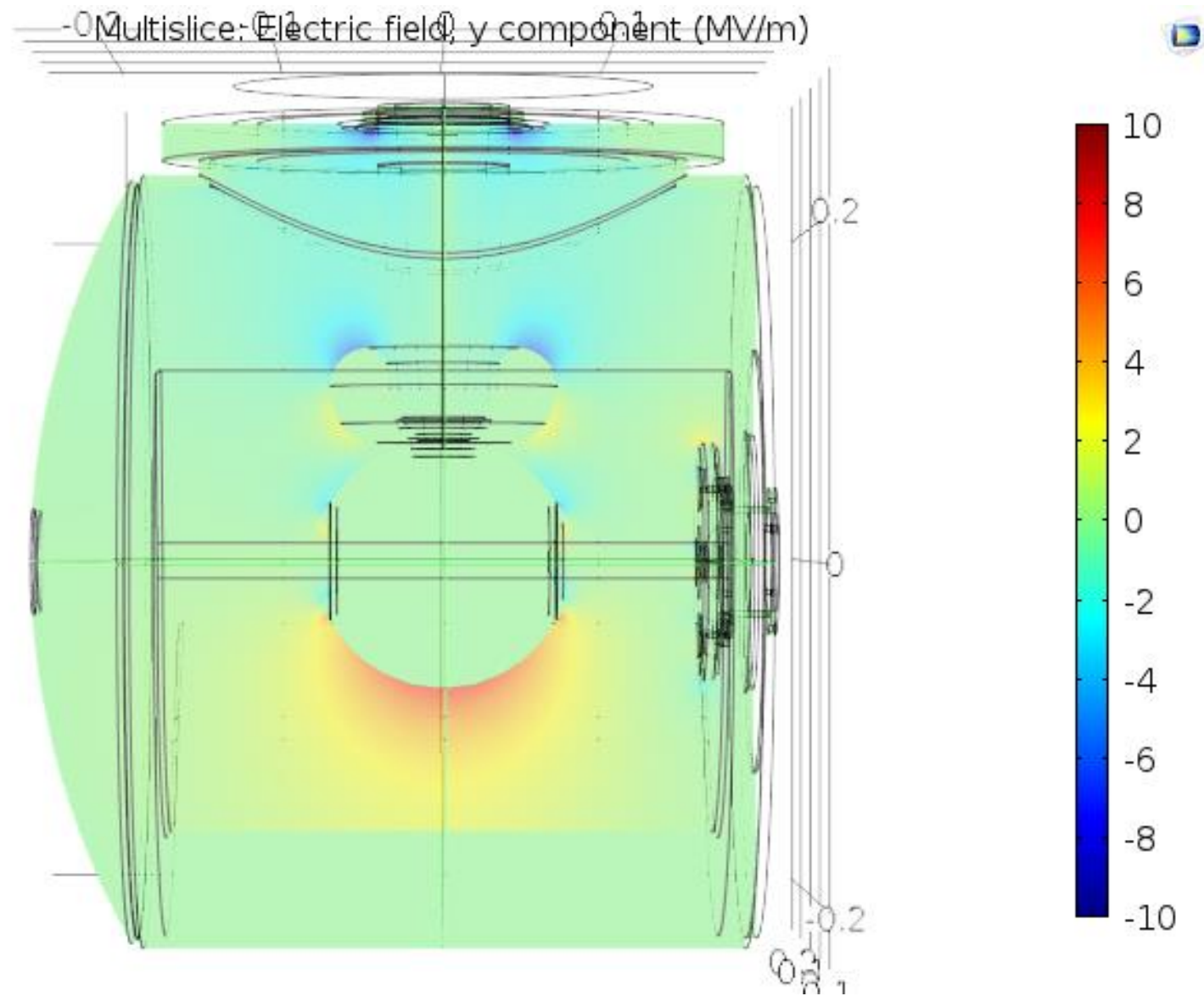
Electric field. front view.
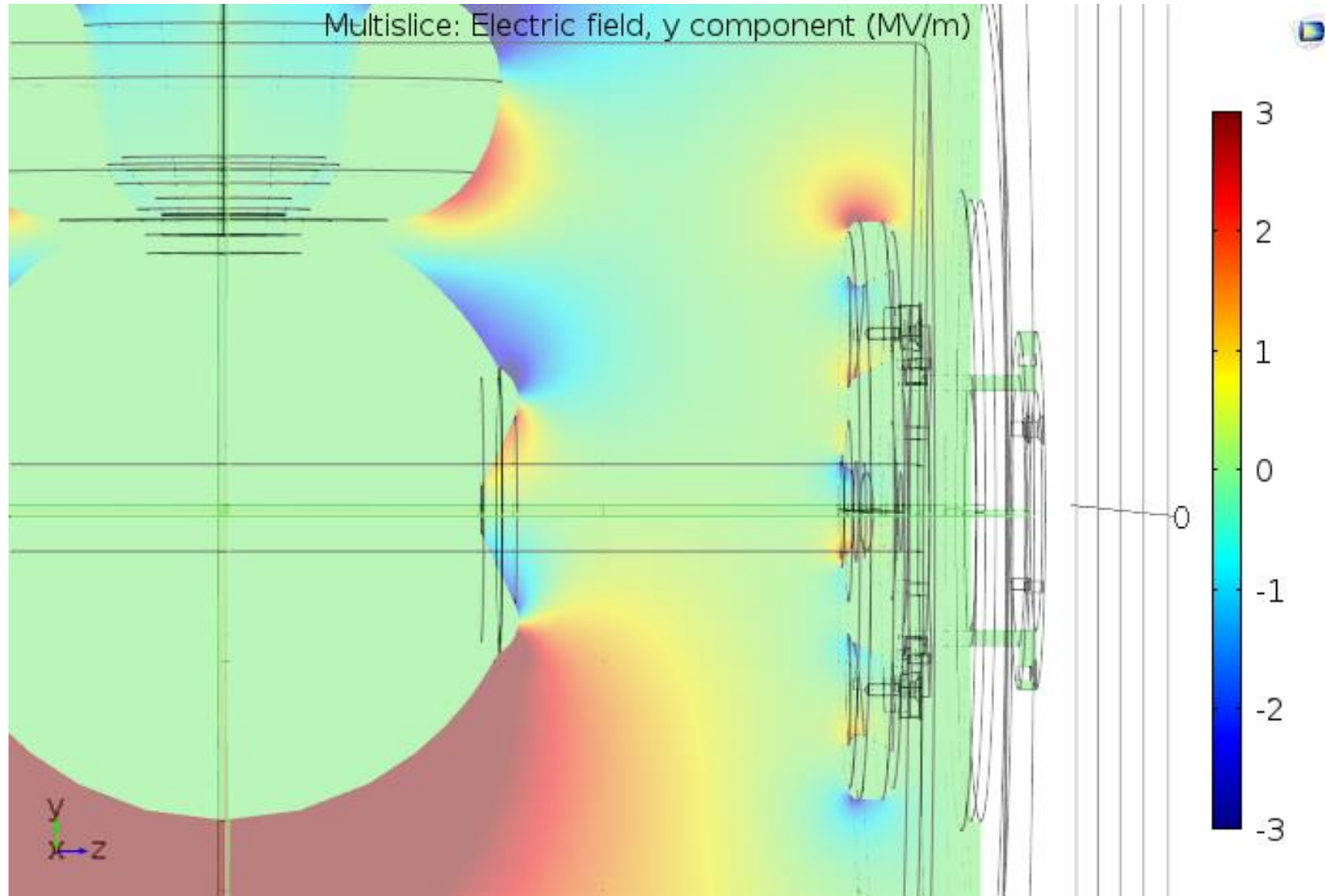
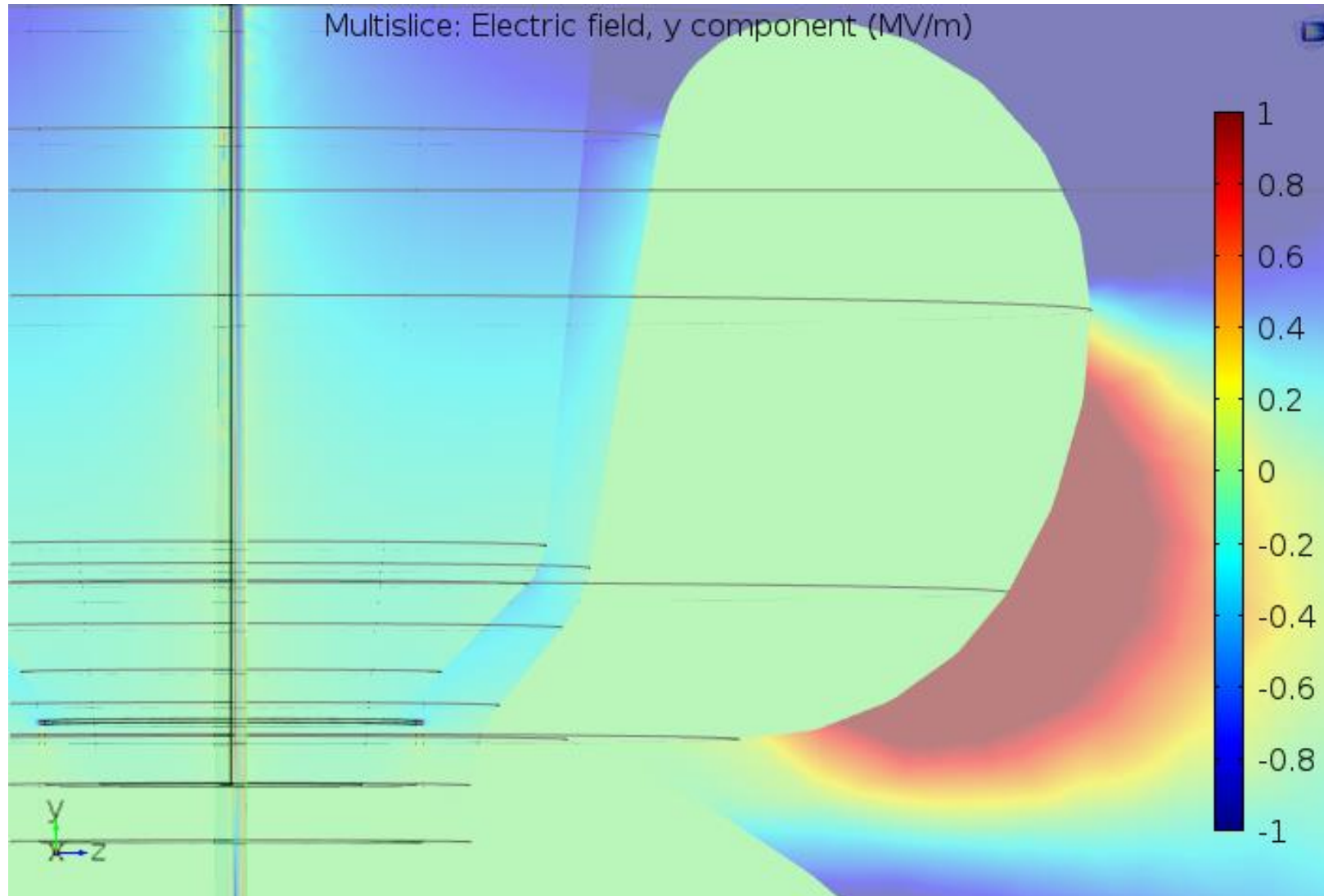# Electric field. Up view

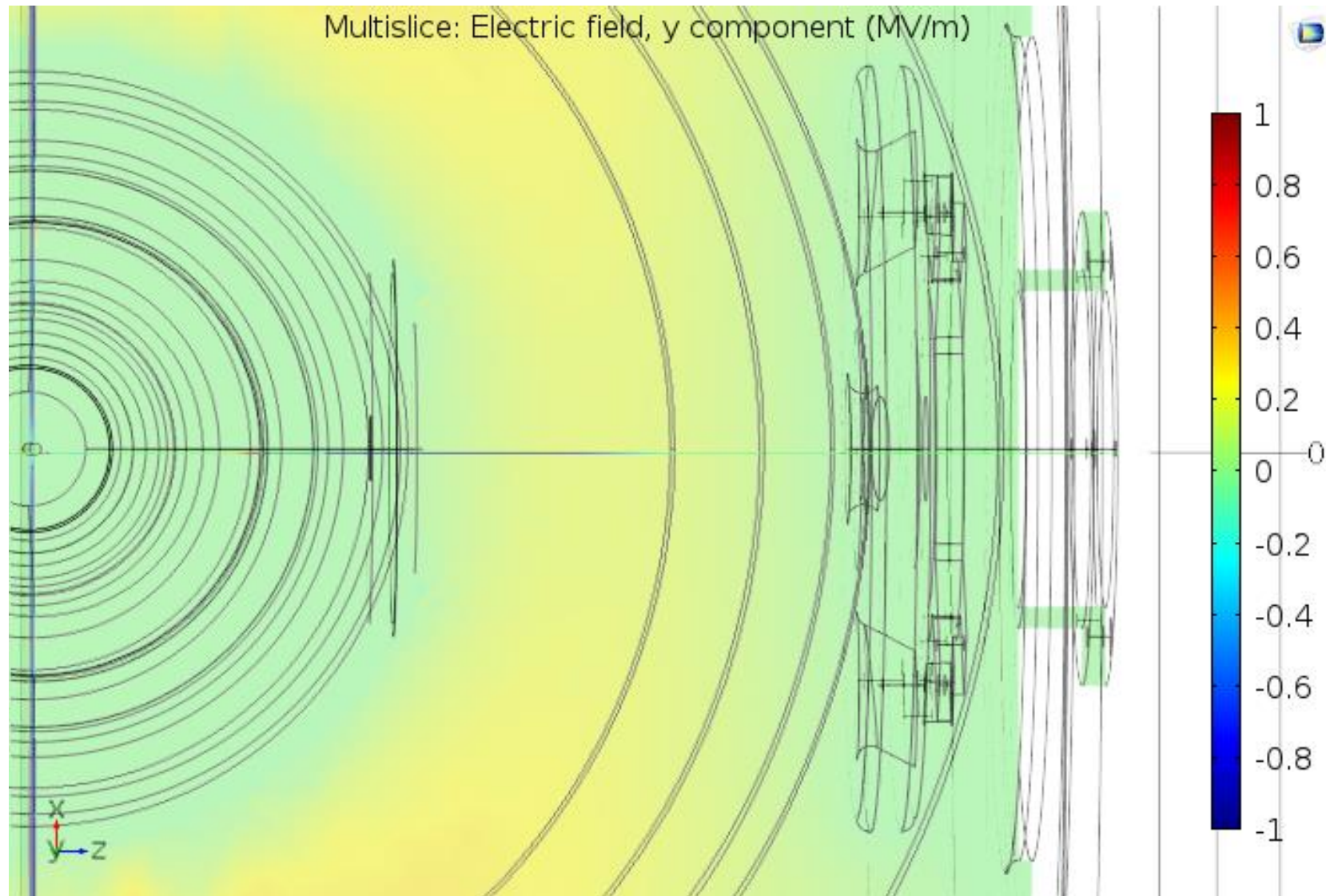
Multislice: Electric field norm (MV/m)
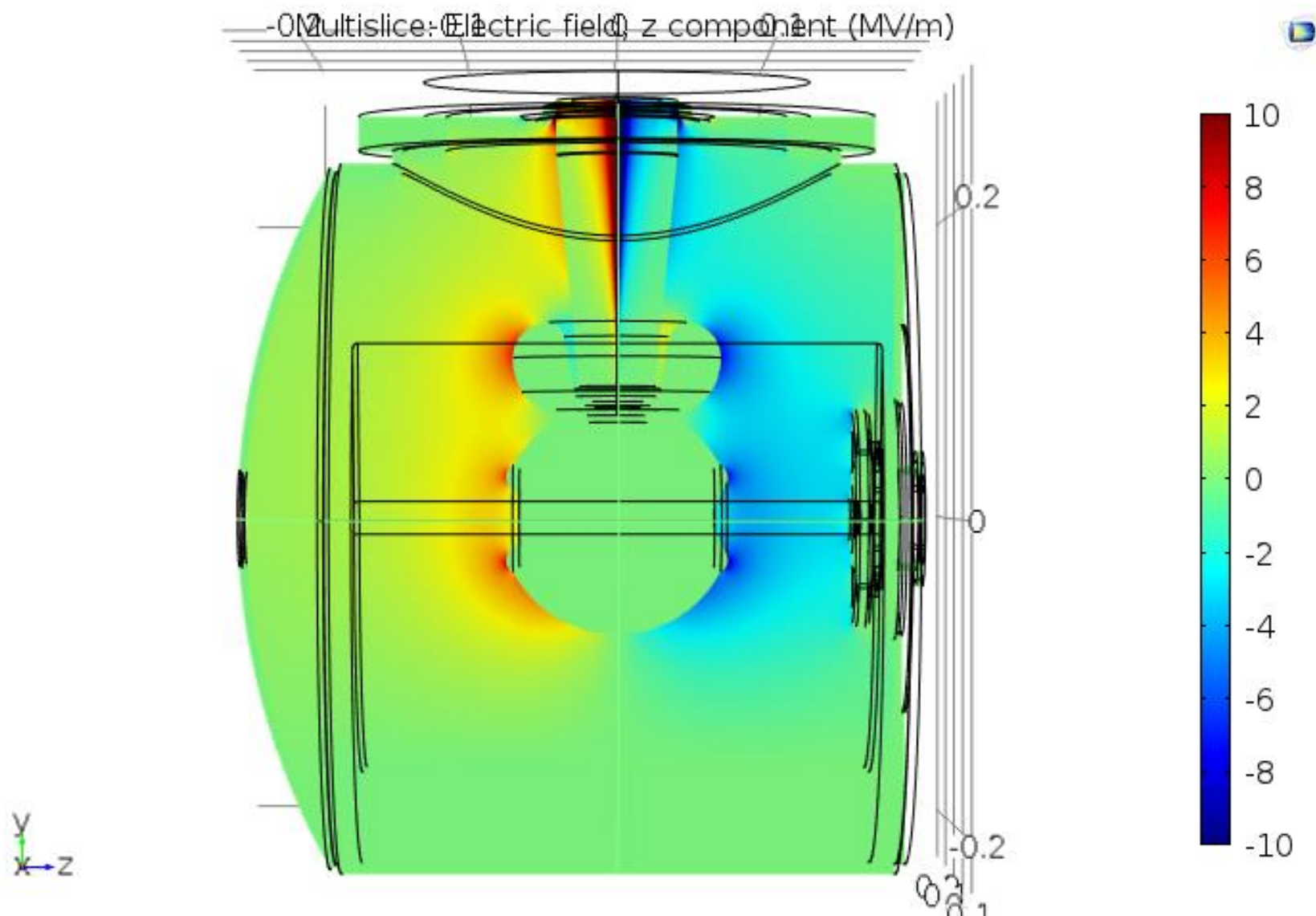
Ey field. Side view.

Ey field. Side view.
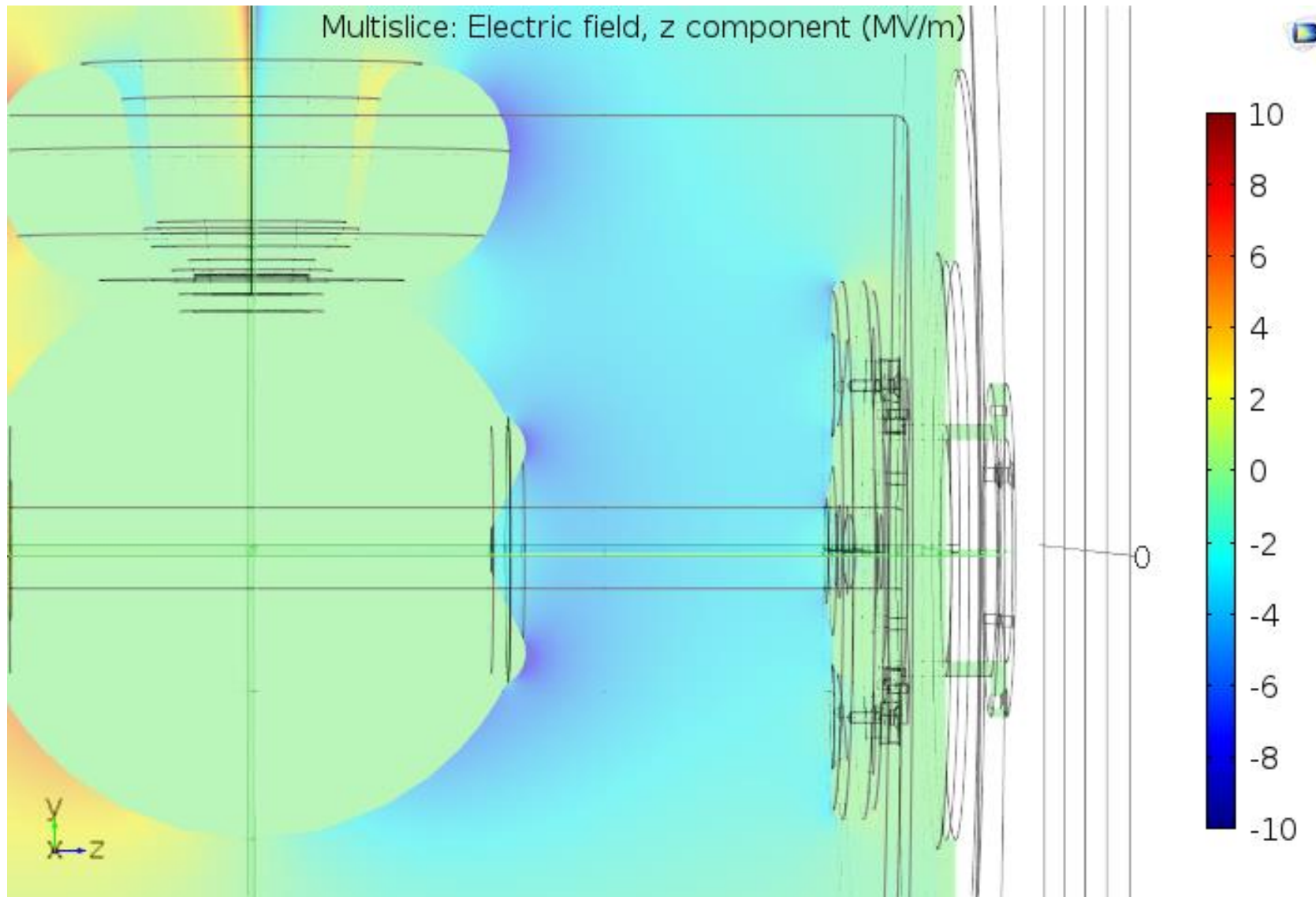
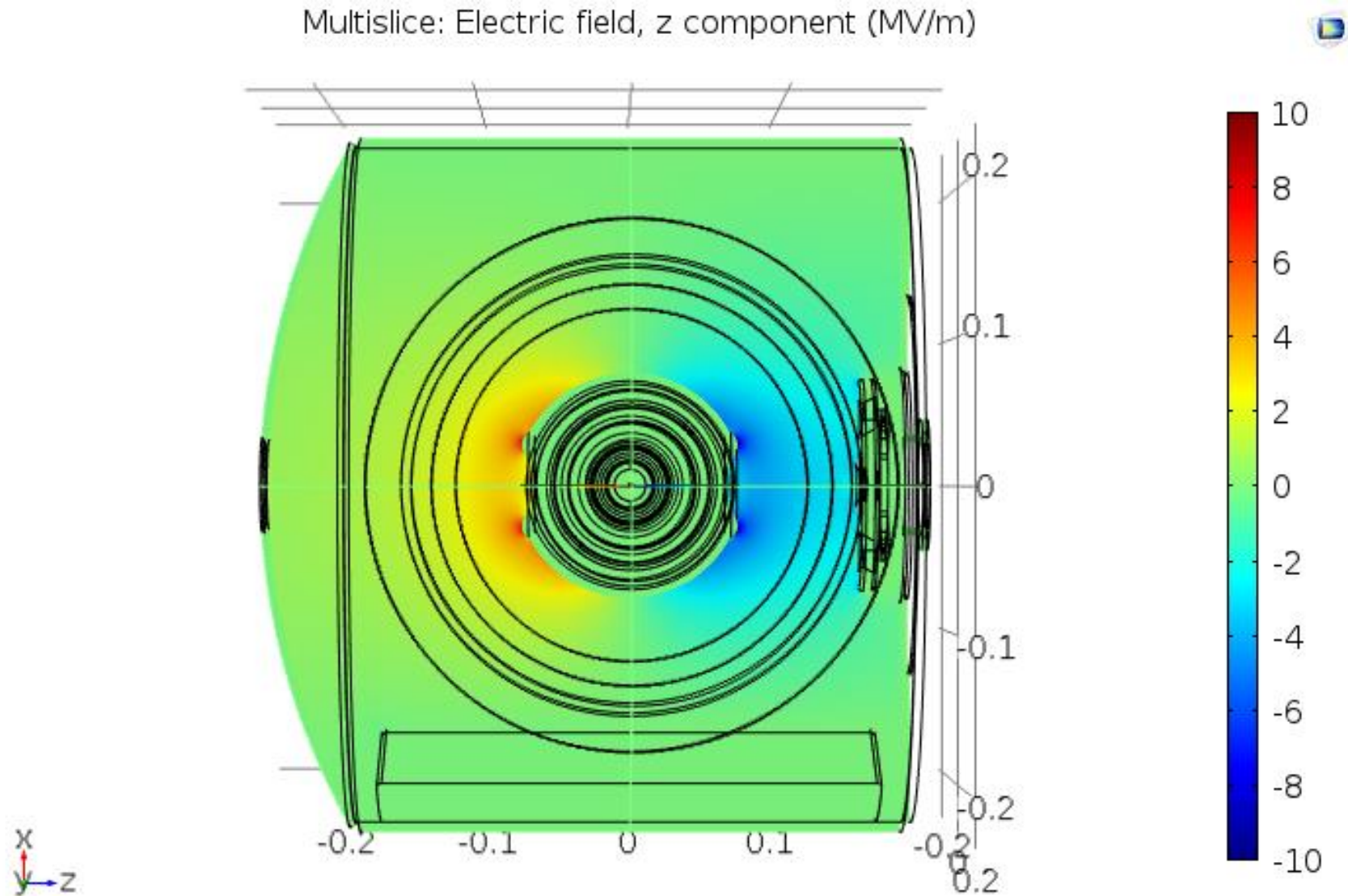# Ey field. Side view: triple point

Ey. Up view

Multislice: Electric field, y component (MV/m)

Ex field. Side view.

Ex field. Side view.

Ex. Up view

Multislice: Electric field, z component (MV/m)

Ex. Up view

Multislice: Electric field, z component (MV/m)
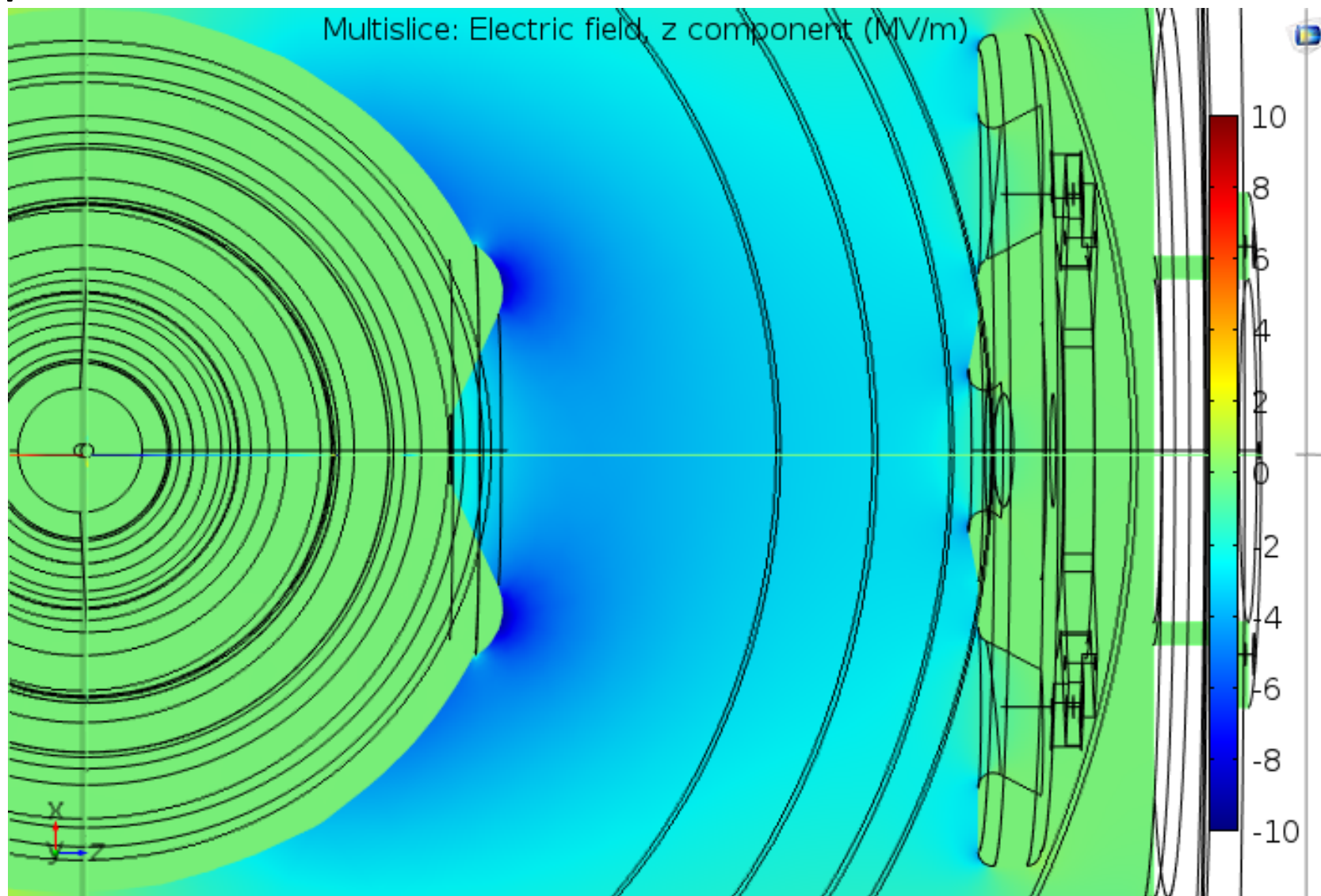
Electric field. Comparing Poisson and COMSOL. Qualitatively

~11MV/m with small current in the insulator due to doping
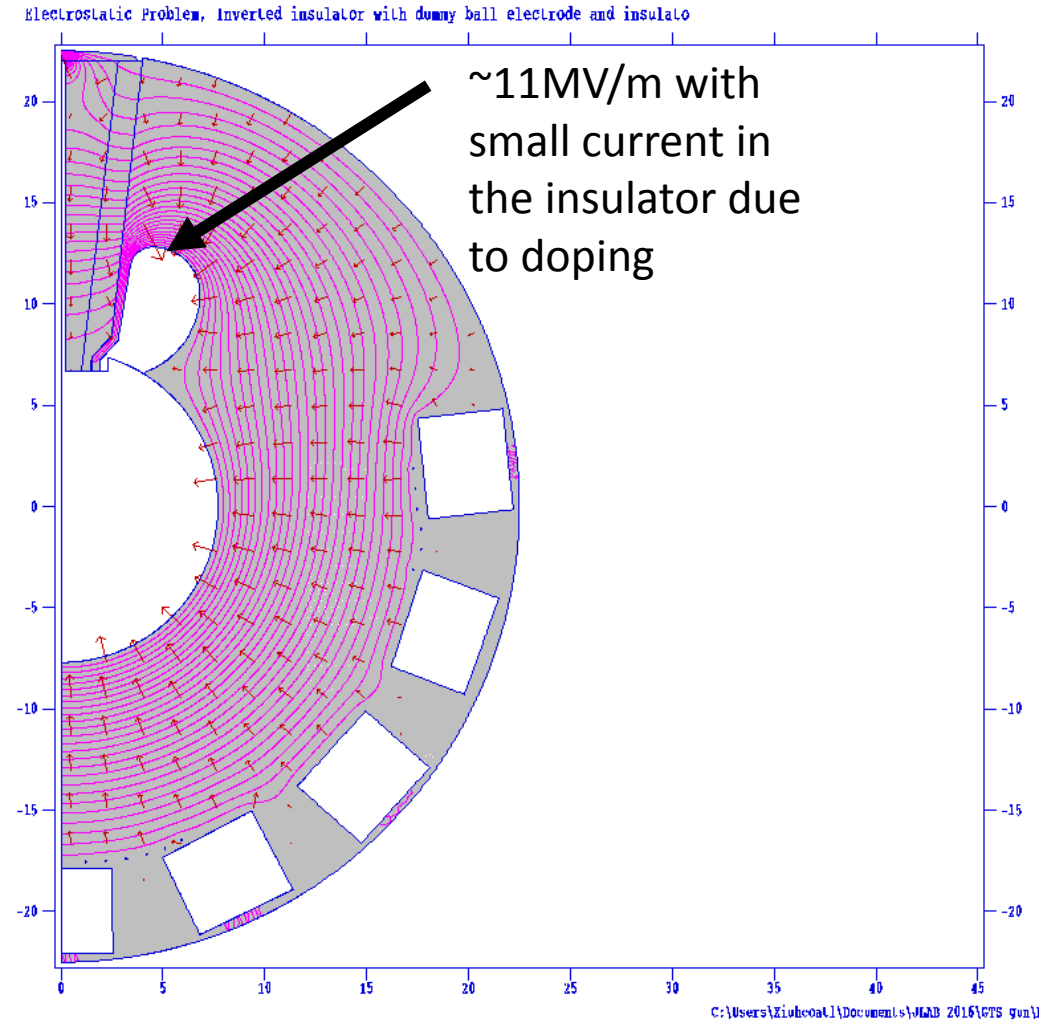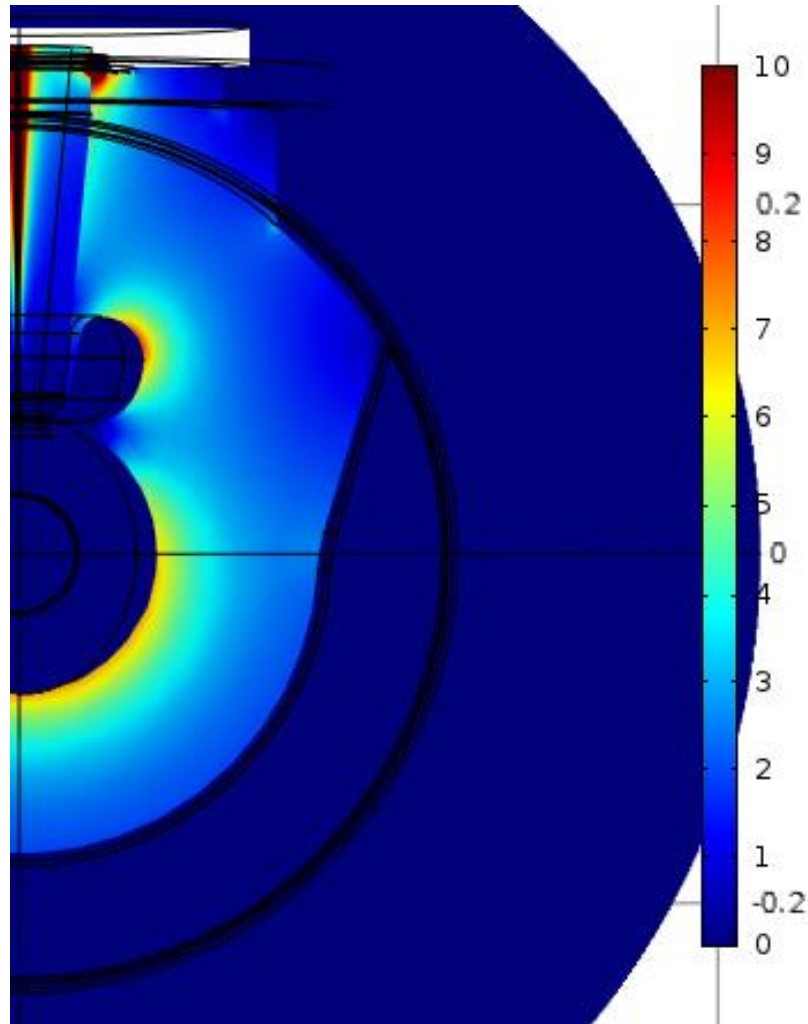
Next steps.

I have yet to unleash the full power of the Solidworks/COMSOL/HPC Turing combo. Many things come to my head but please, feel free to throw suggestions at me!

- Solidworks
  - ~~Include the details of cathode sphere and photocathode~~. Maybe even extractor gauge or other components that come into play.
- COMSOL
  - ~~Review the warnings I got for the mesh and repair them.~~
  - ~~Get the contour to show unskewed in the plots.~~
  - ~~Obtain properly aligned plots.~~
  - ~~**Include the small conductivity due to doping in the insulator (Can do!).**~~
  - **Learn how to interpolate along lines to obtain plots of V, Ey, Ex and E along the boundaries as in Poisson.**
  - Maybe include HV cable connector details.
  - Improve meshing to achieve a good calculation near small details.
  - Maybe repeat this for the small -200kV gun to double check with Poisson.

Fin.