https://design-guidelines.web.cern.ch/logo-0

https://en.wikipedia.org/wiki/German_Physical_Society

Simulation of Radiofrequency Accelerators

by **Alexander Müller** and **Isabelle Strecker**

Supervisor:

Hermann Pommerenke

17.05.2019

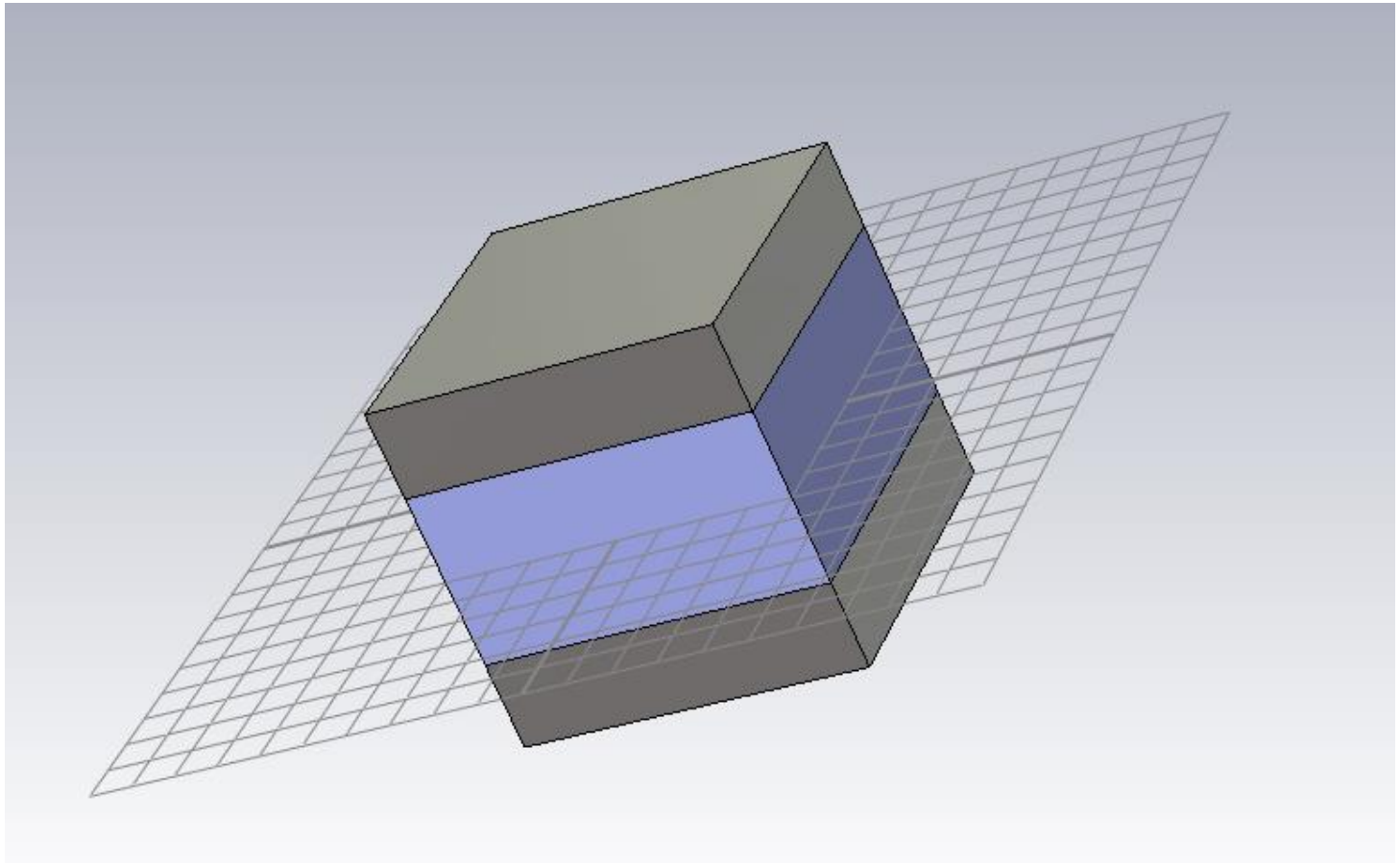
HSSIP 2019

Structure

- 1.) Step by Step modelling of an electrostatic accelerator
- 2.) Optimizing the electrostatic accelerator
- 3.) Modelling of a RF Cavity
- 4.) Experiment with soup can

Step by Step modelling of an electrostatic accelerator

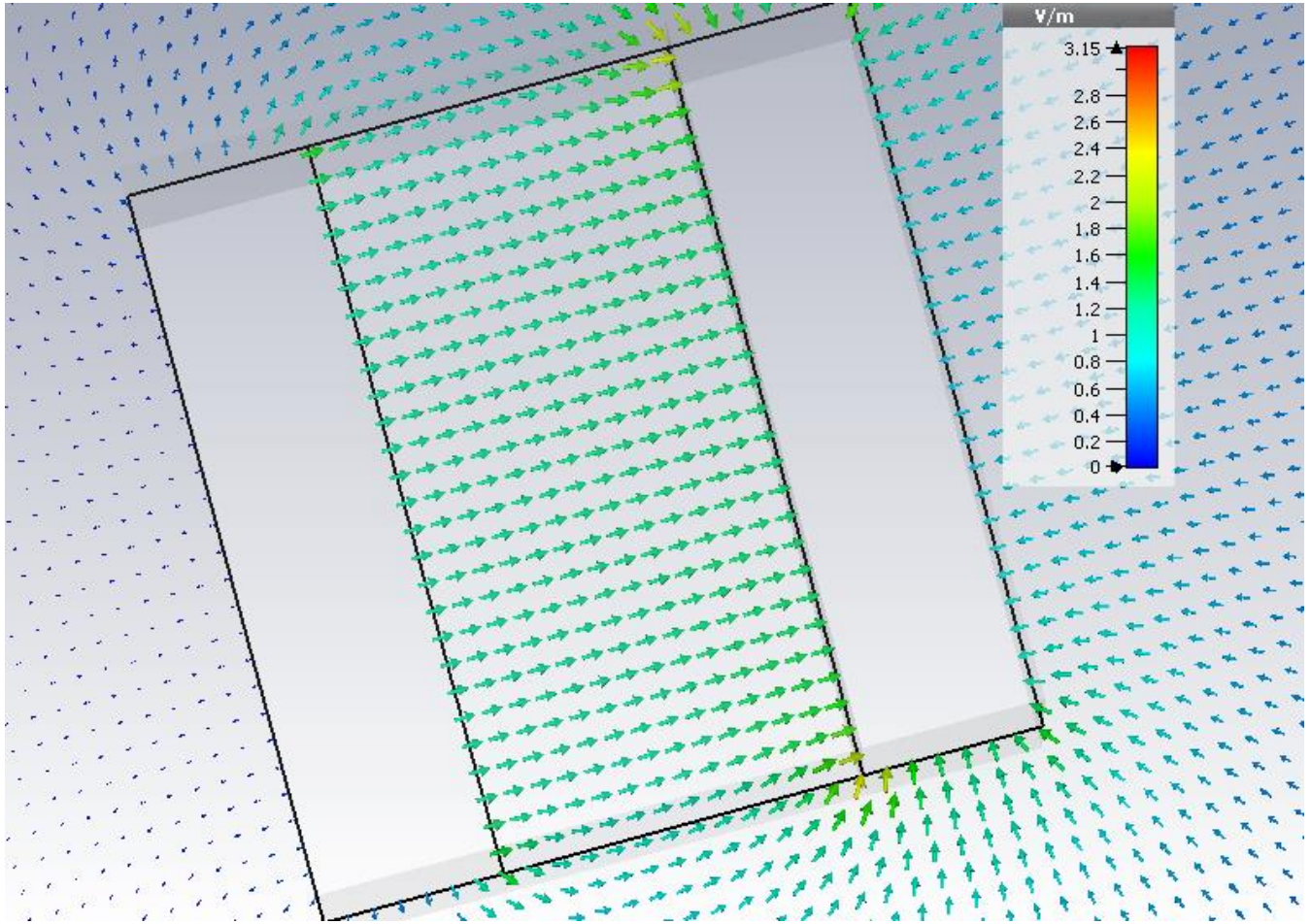
- All simulations are made with CST microwave studio
- Two PEC_1 plates are constructed opposite towards each other
- A Vacuum is put in between of them
- To one plate a voltage of -5V is applied



1 Perfect Electric Conductor

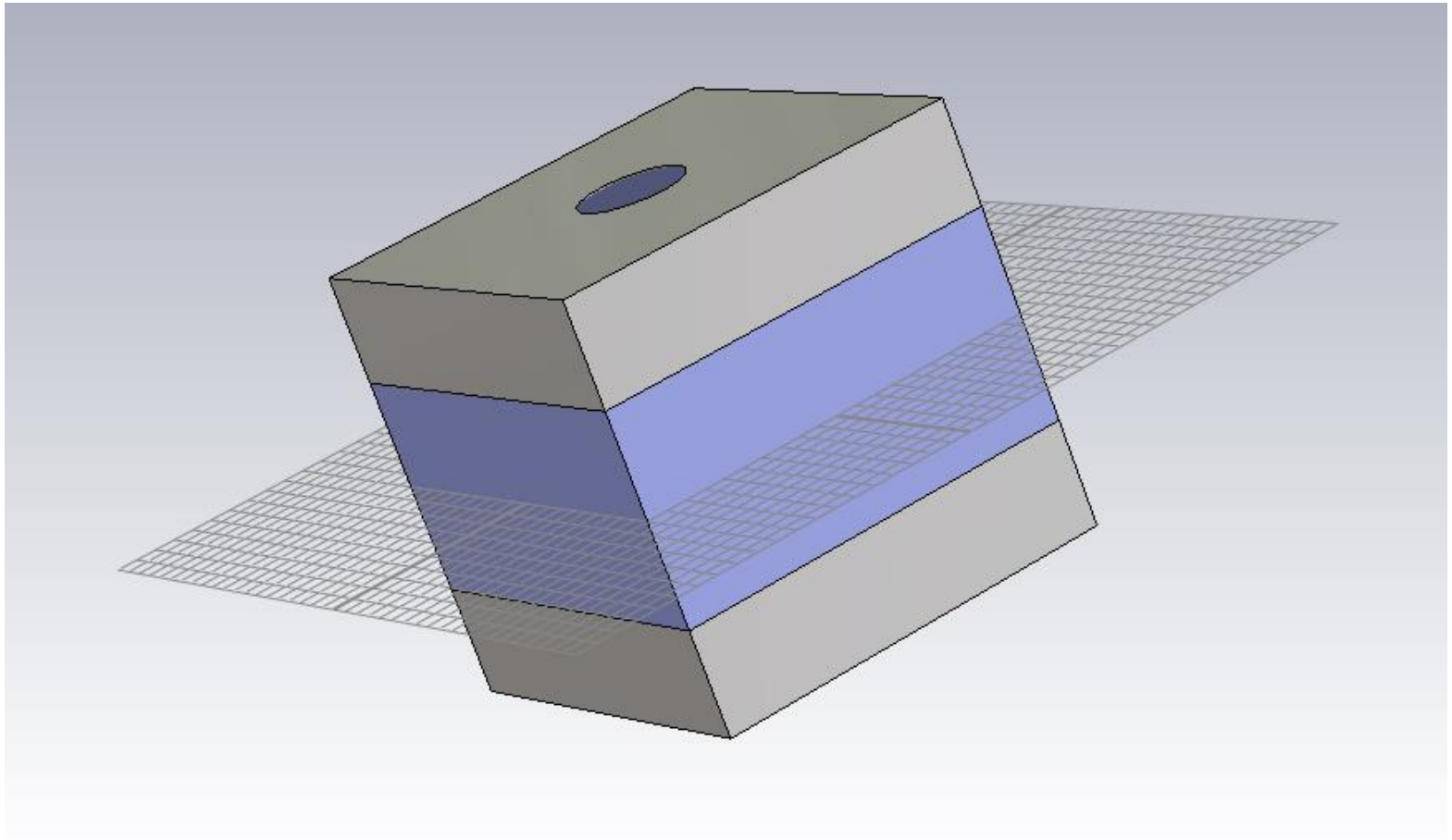
Step by Step modelling of an electrostatic accelerator

- Electric field
- Two opposite plates



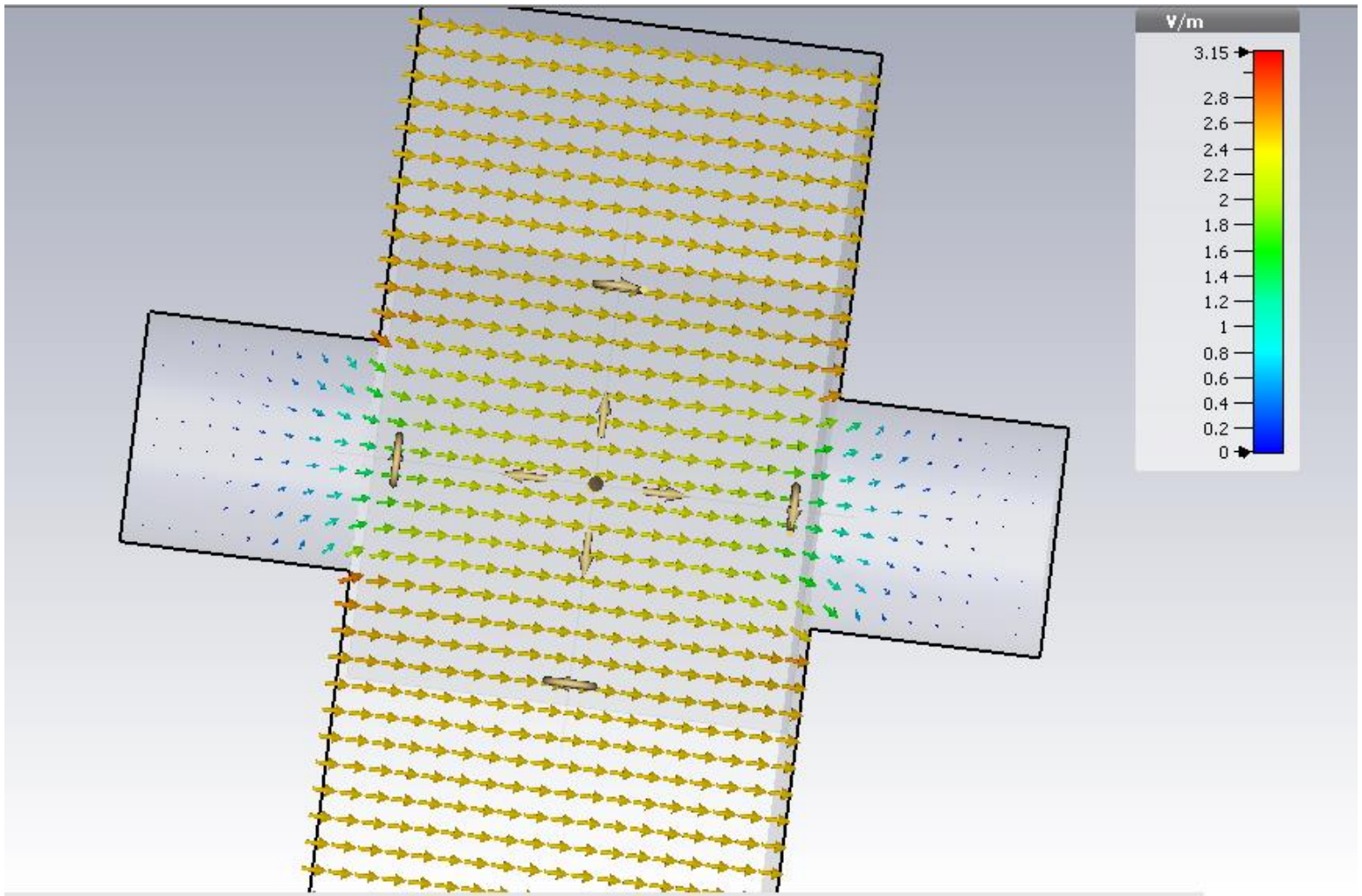
Step by Step modelling of an electrostatic accelerator

- A circle is cut into the plates
- Particles now have a way to get through



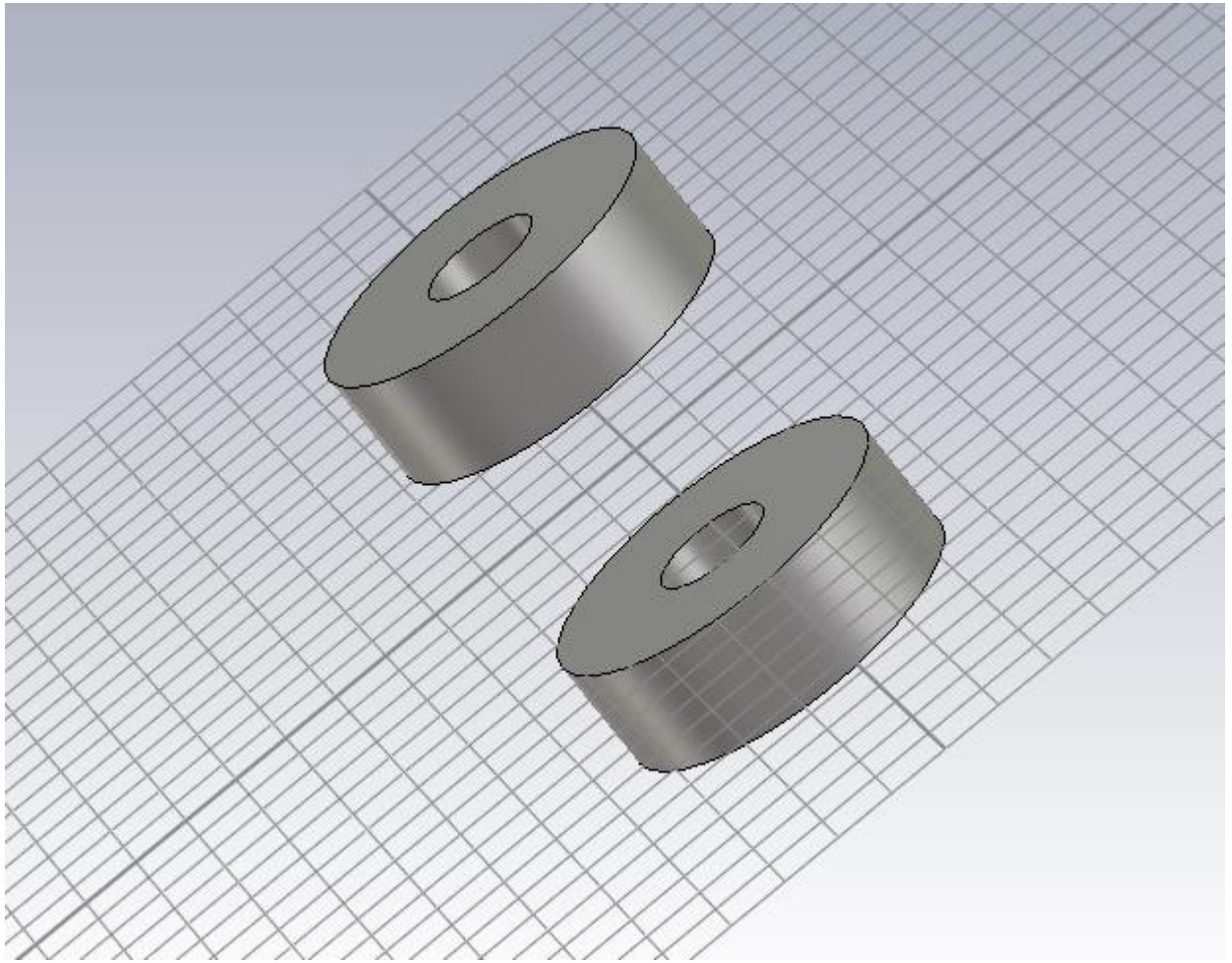
Step by Step modelling of an electrostatic accelerator

- Electric field
- Two opposite plates
- With holes



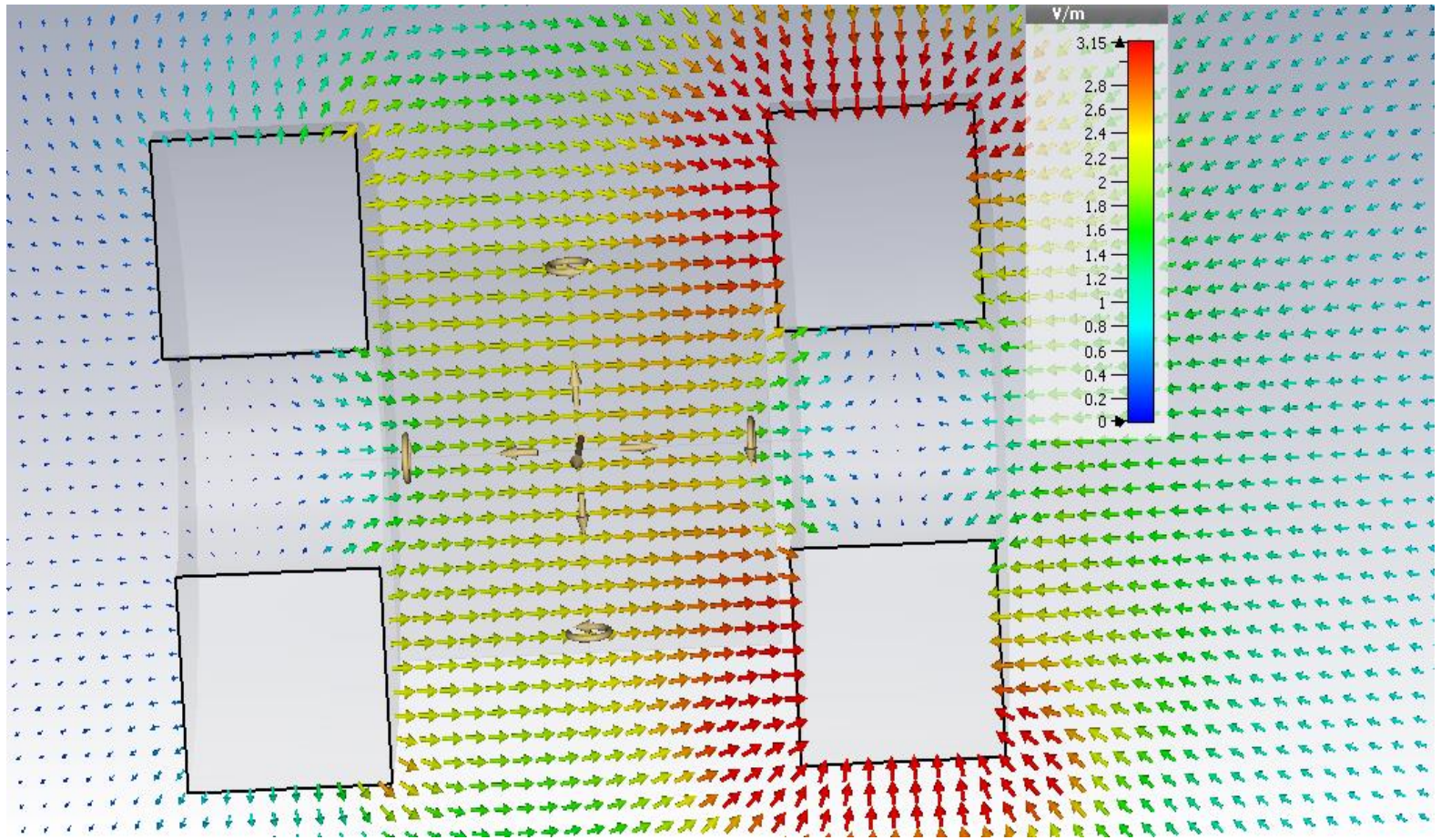
Step by Step modelling of an electrostatic accelerator

- Cutting out rings



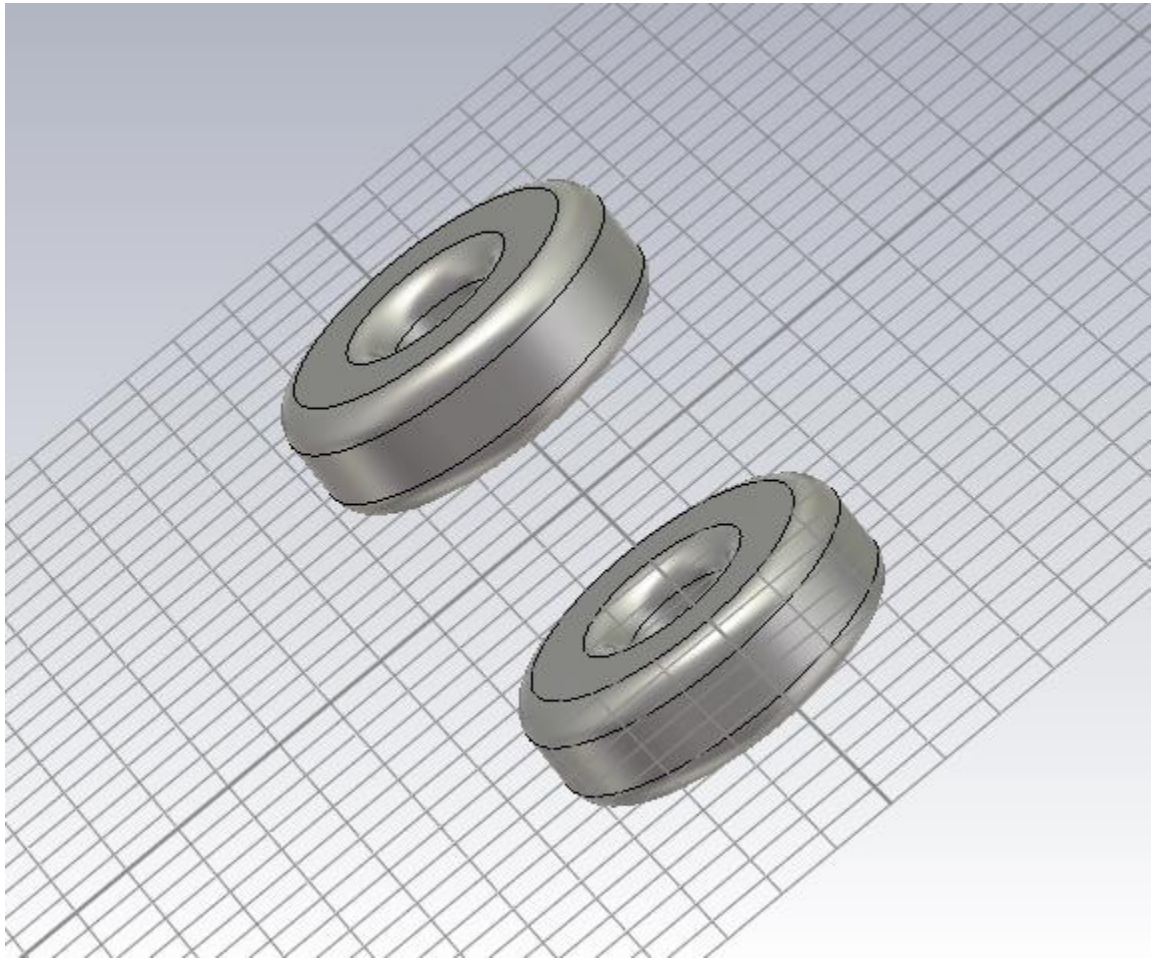
Step by Step modelling of an electrostatic accelerator

- Electric field
- Two opposite ring plates



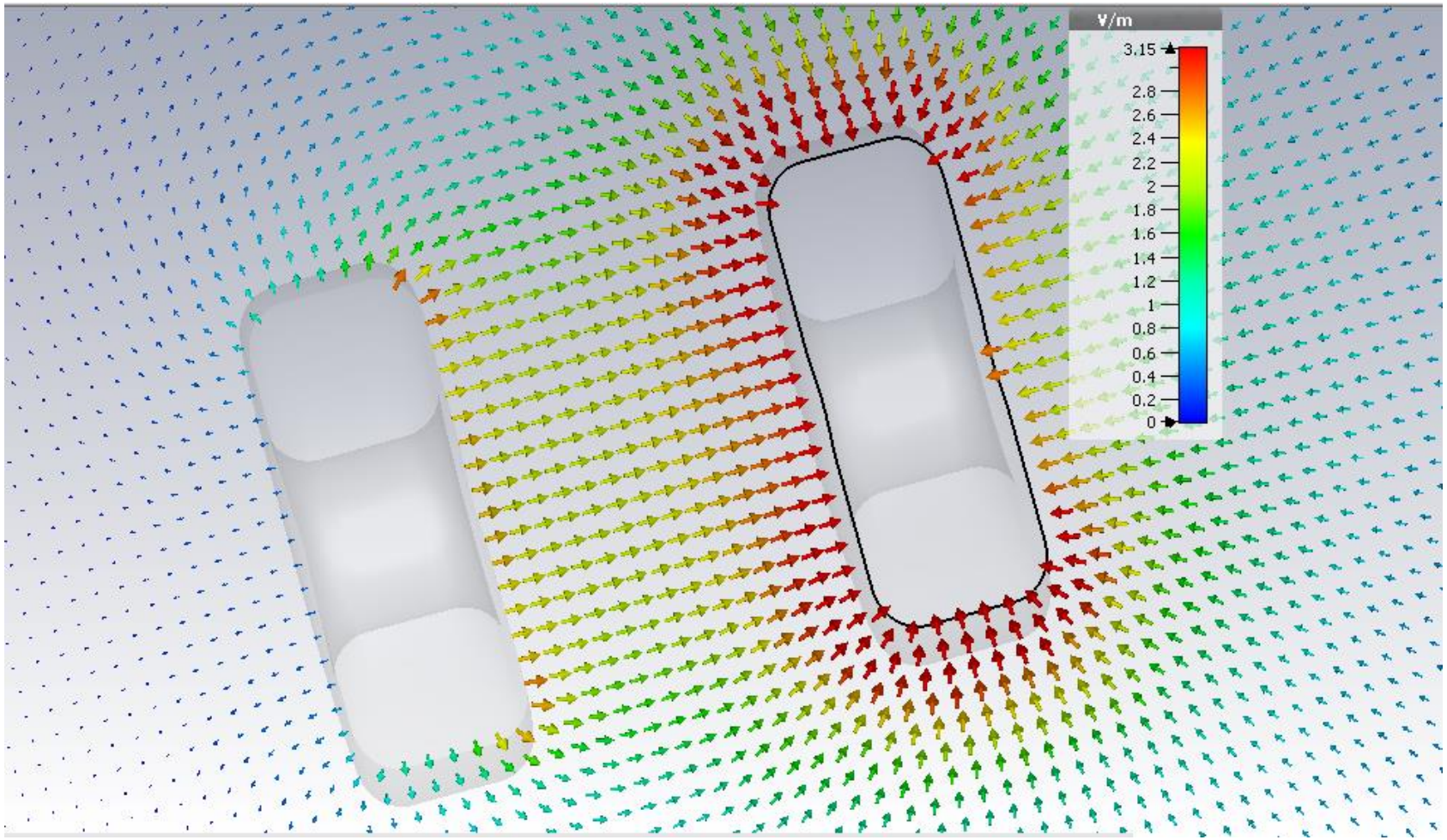
Step by Step modelling of an electrostatic accelerator

- Rounding off the edges



Step by Step modelling of an electrostatic accelerator

- Electric field
- Two opposite ring plates
- Rounded edges

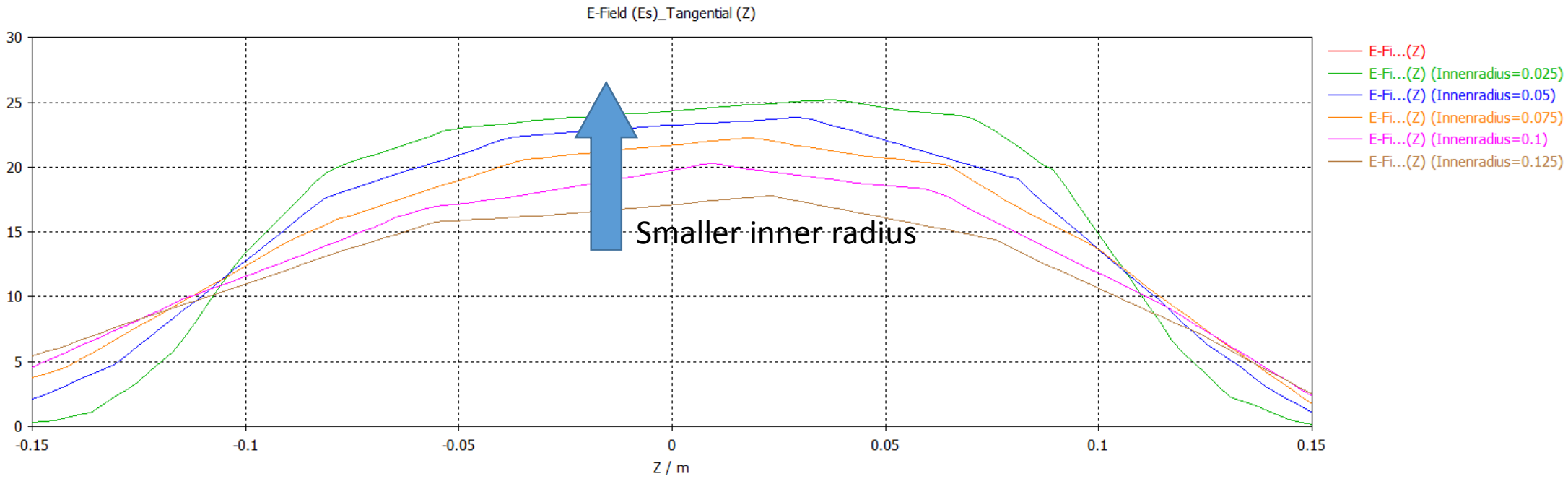


Optimizing the electrostatic accelerator

(Adjustment of the previous to realistic Numbers)

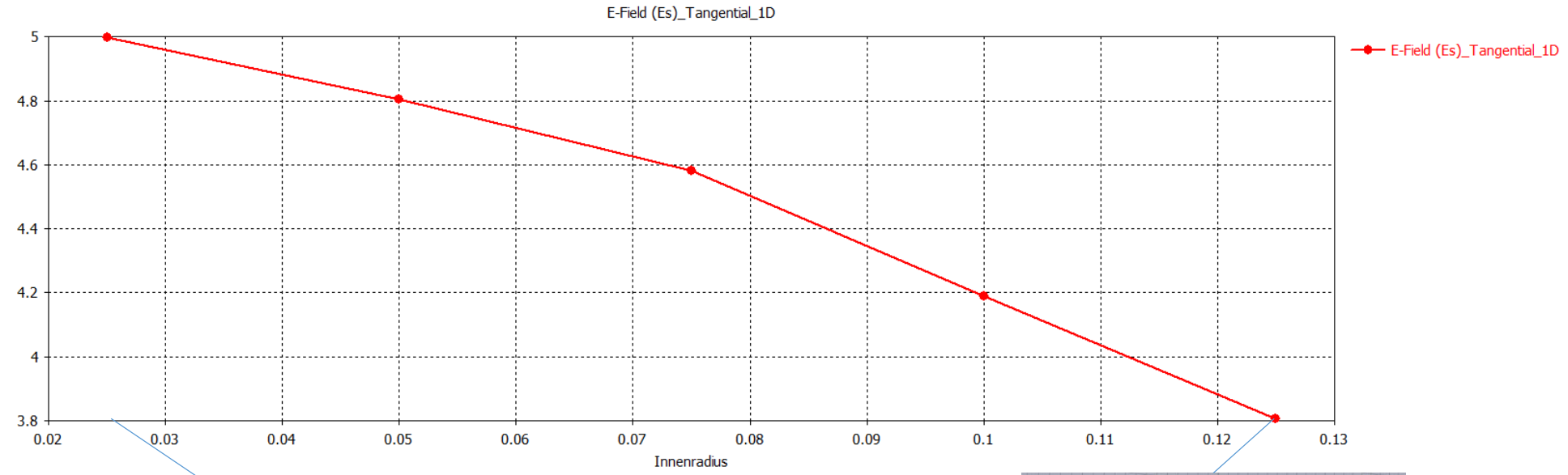
- Changing the inner radius
- Inner radii values from 2.5cm to 12.5cm

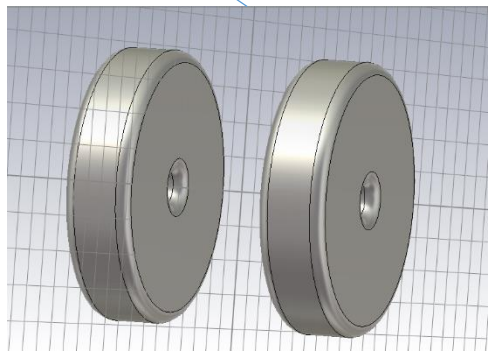
Optimizing the electrostatic accelerator



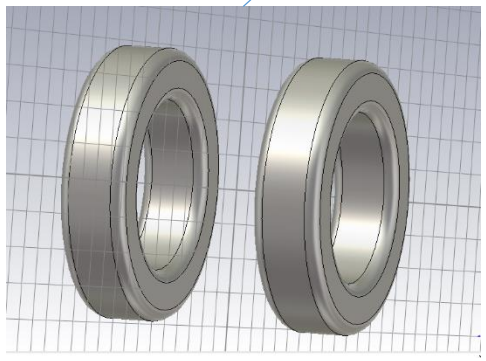
With a decreasing inner radius, the electric field gets stronger in the accelerating gap

Optimizing the electrostatic accelerator





Inner radius 0.025

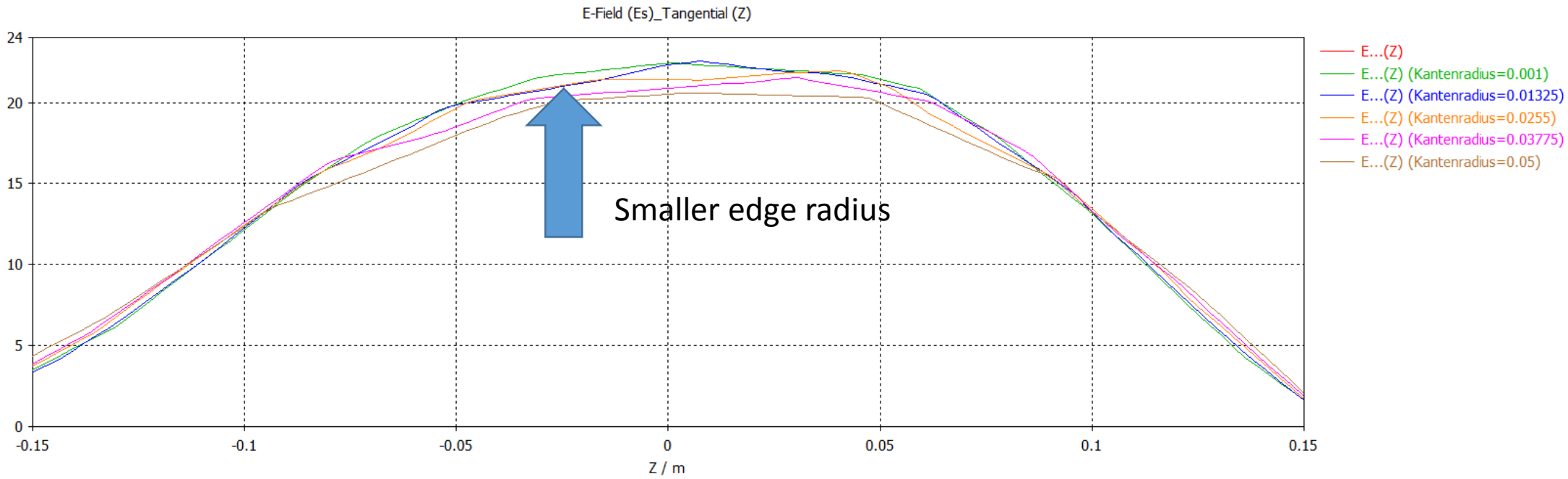


Inner radius 0.125

Optimizing the electrostatic accelerator

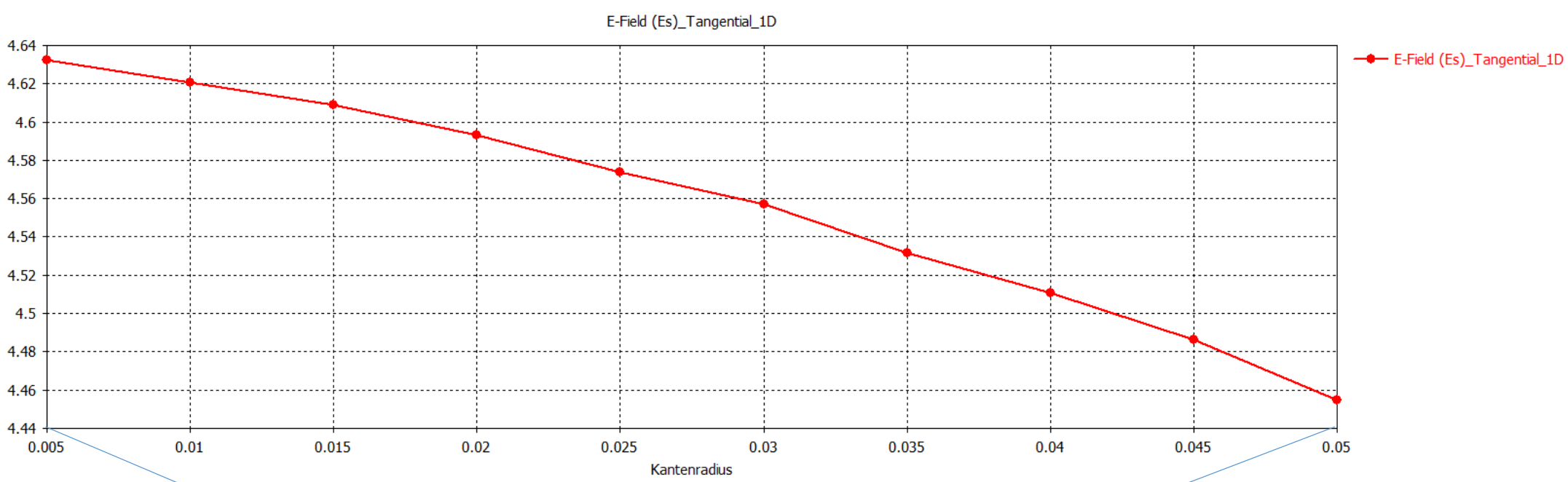
- Changing the edge radius
- Edge radii values from 0.1cm to 5cm

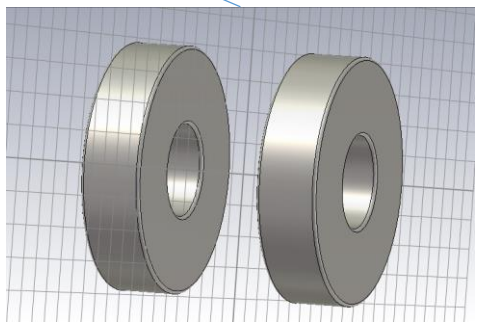
Optimizing the electrostatic accelerator



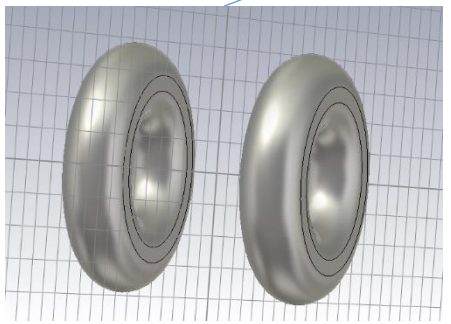
With a decreasing edge radius, the electric field in the accelerating gap gets stronger

Optimizing the electrostatic accelerator





Edge radius 0.005

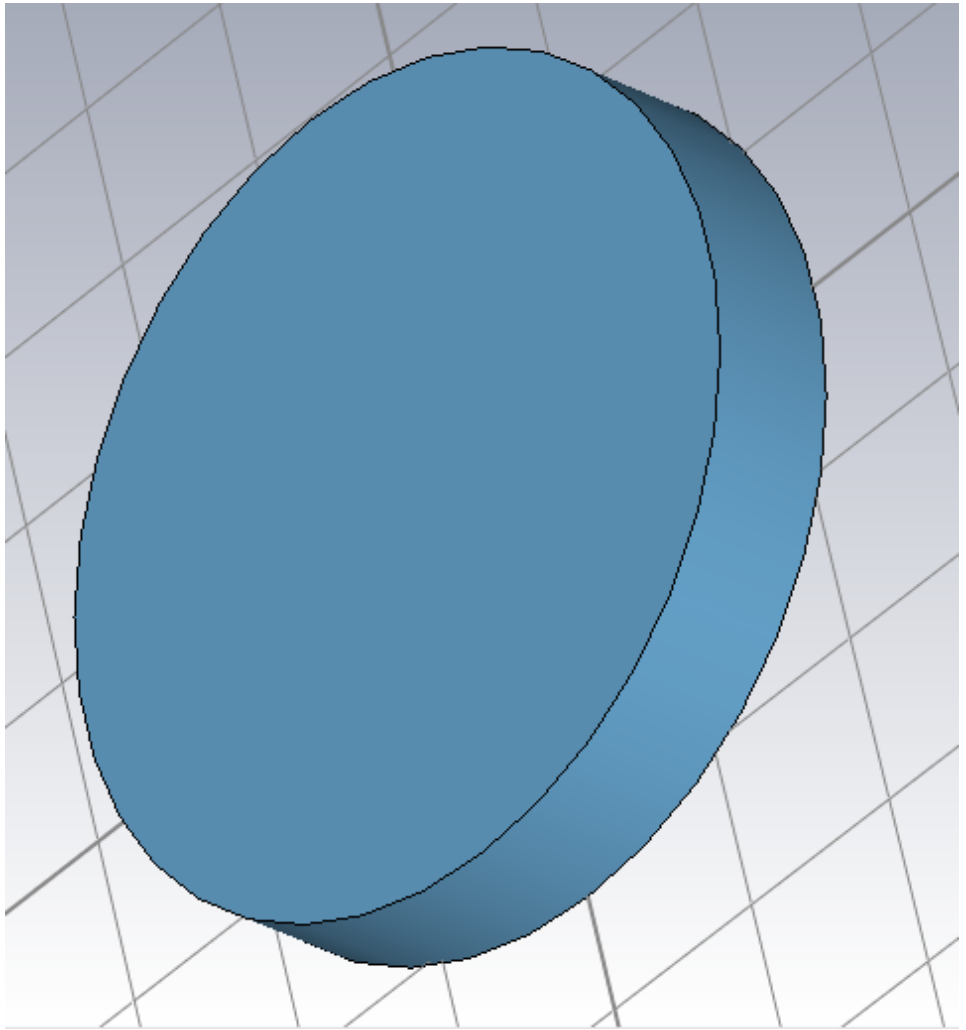


Edge radius 0.05

Modelling of a RF Cavity

- Creating a cylinder made of copper
- Inner domain is made of vacuum
- Radius of the cylinder is adjusted to a frequency of 1GHz

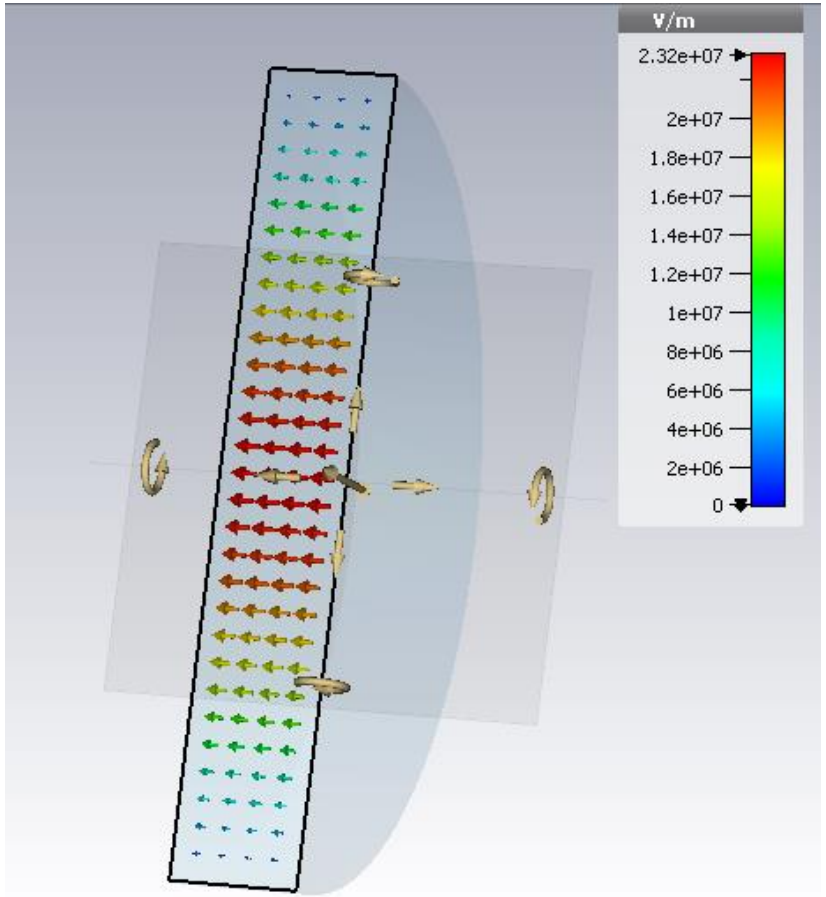
→$f_0 = c * \chi_{01} / 2\pi r$



χ is the first null of the Bessel function

Modelling of a RF Cavity

- Electric field
- Cavity with copper shell and vacuum

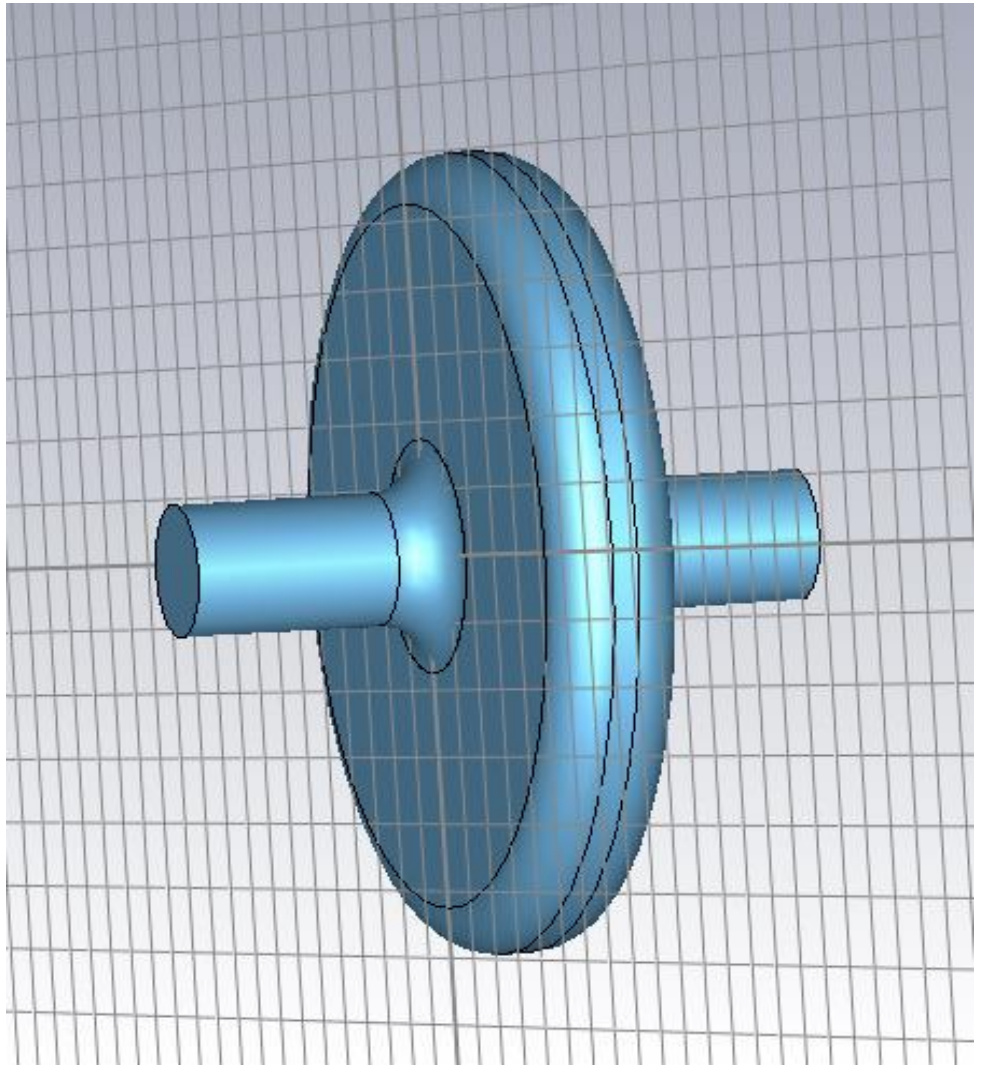


Modelling of a RF Cavity

- Creating a thinner, longer cylinder

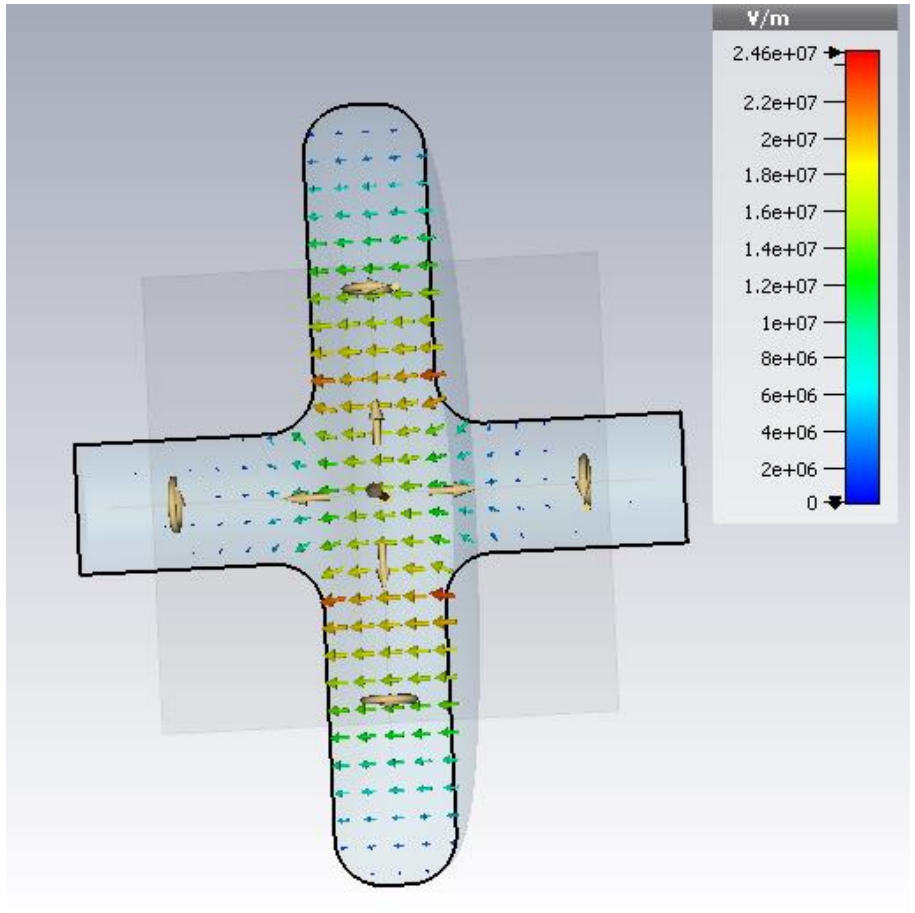
→ Acting as beam pipe

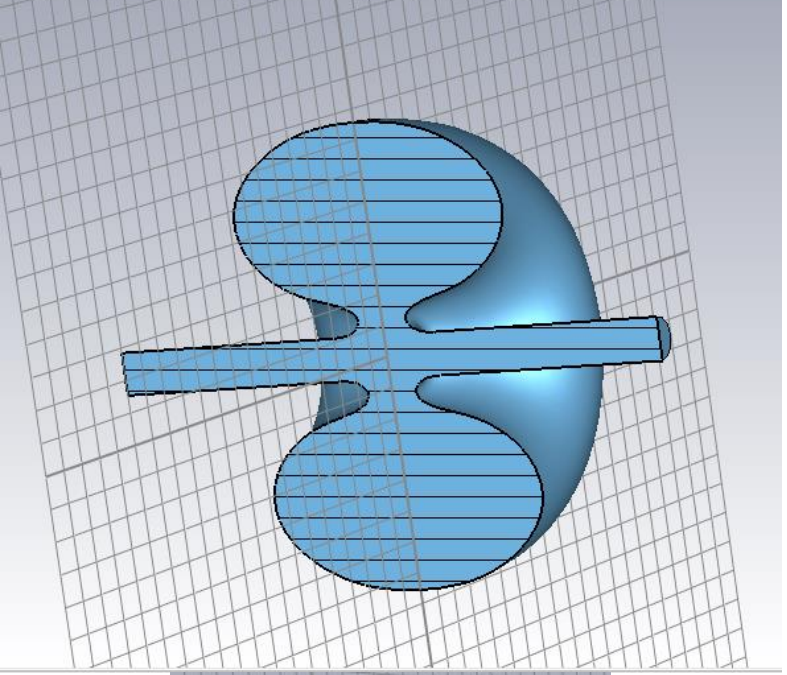
- Edges are rounded off

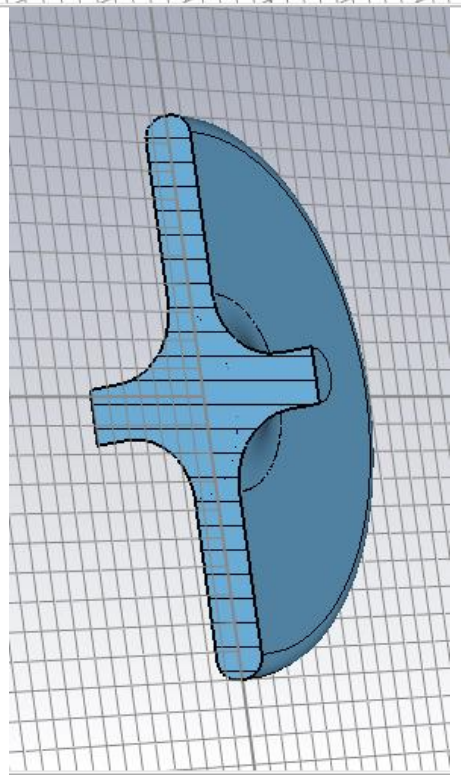


Modelling of a RF Cavity

- Electric field
- Cavity with cylinder through middle







Comparison of different aspects between a flat and an elliptic cavity

	Flat Cavity	Elliptic Cavity
R over Q (Ohm)	60.418	286.096
Q-Factor	12000	17000
Frequency GHz	0.6	1
Surface Emission (E_{max}/E_{acc})	1.91	3.79
Magnetic quench (mT/(MV/m))	4.125	2.27

Experiment with soup can

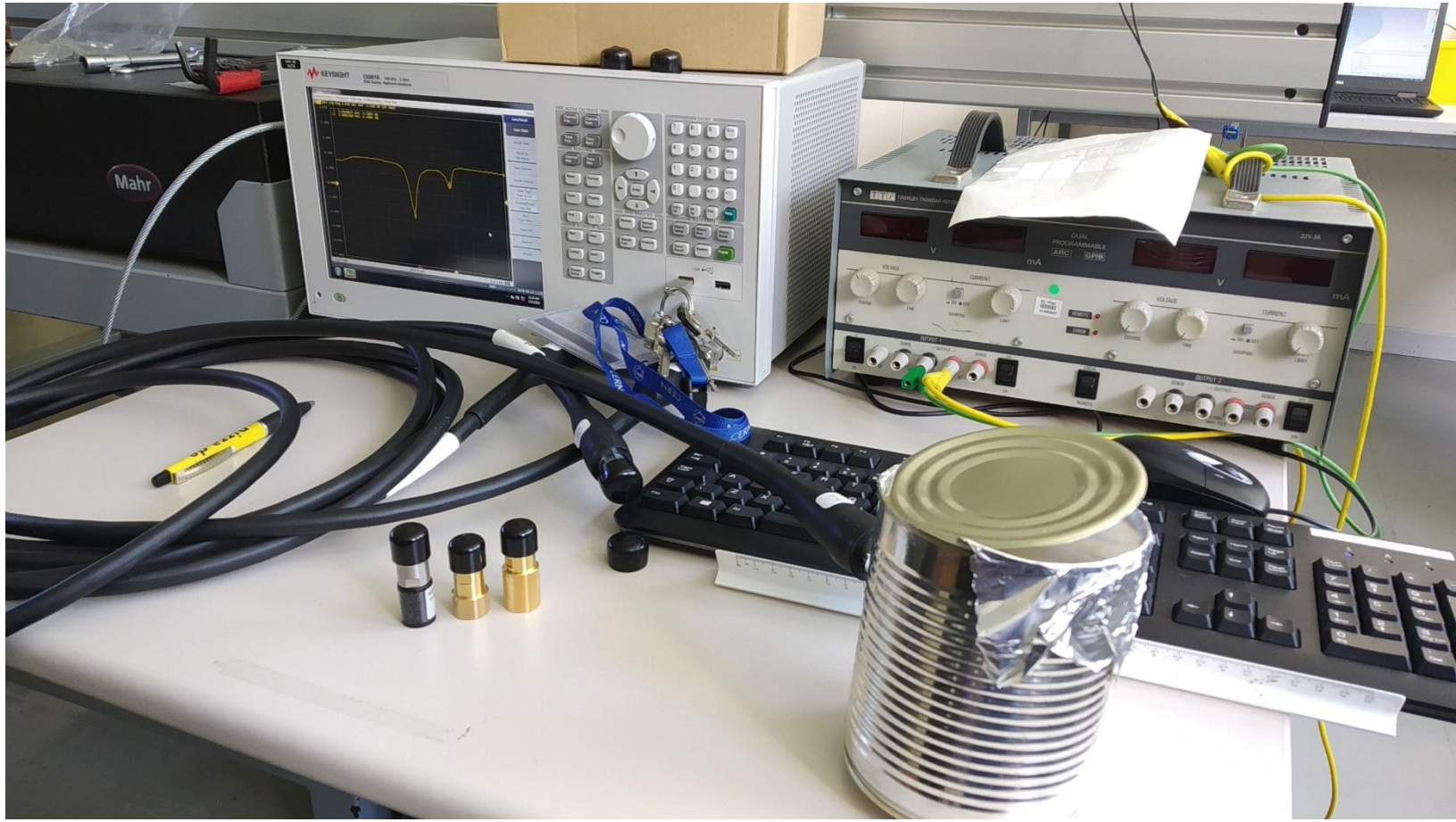
- Installation of an input coupler inside of the can

→Magnetic loop antenna

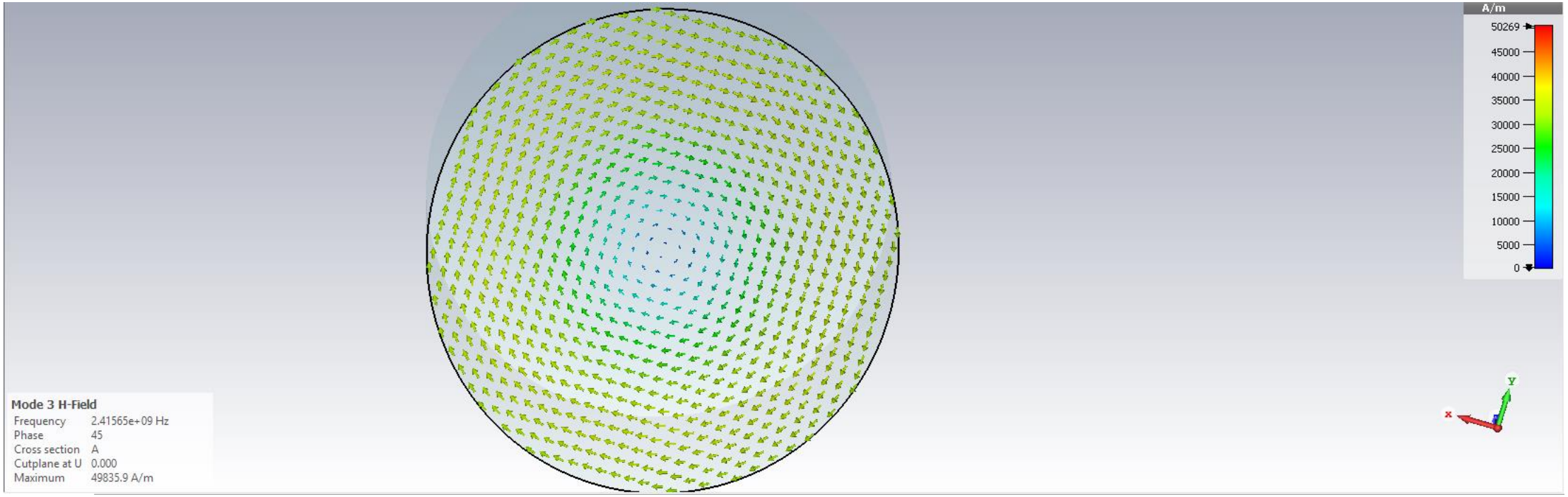
- Antenna will be aligned to the direction of the magnetic field of the desired mode

Experiment with soup can

- Open side of the can is covered with aluminium foil
- Coaxial cable is connected to the antenna



Experiment with soup can



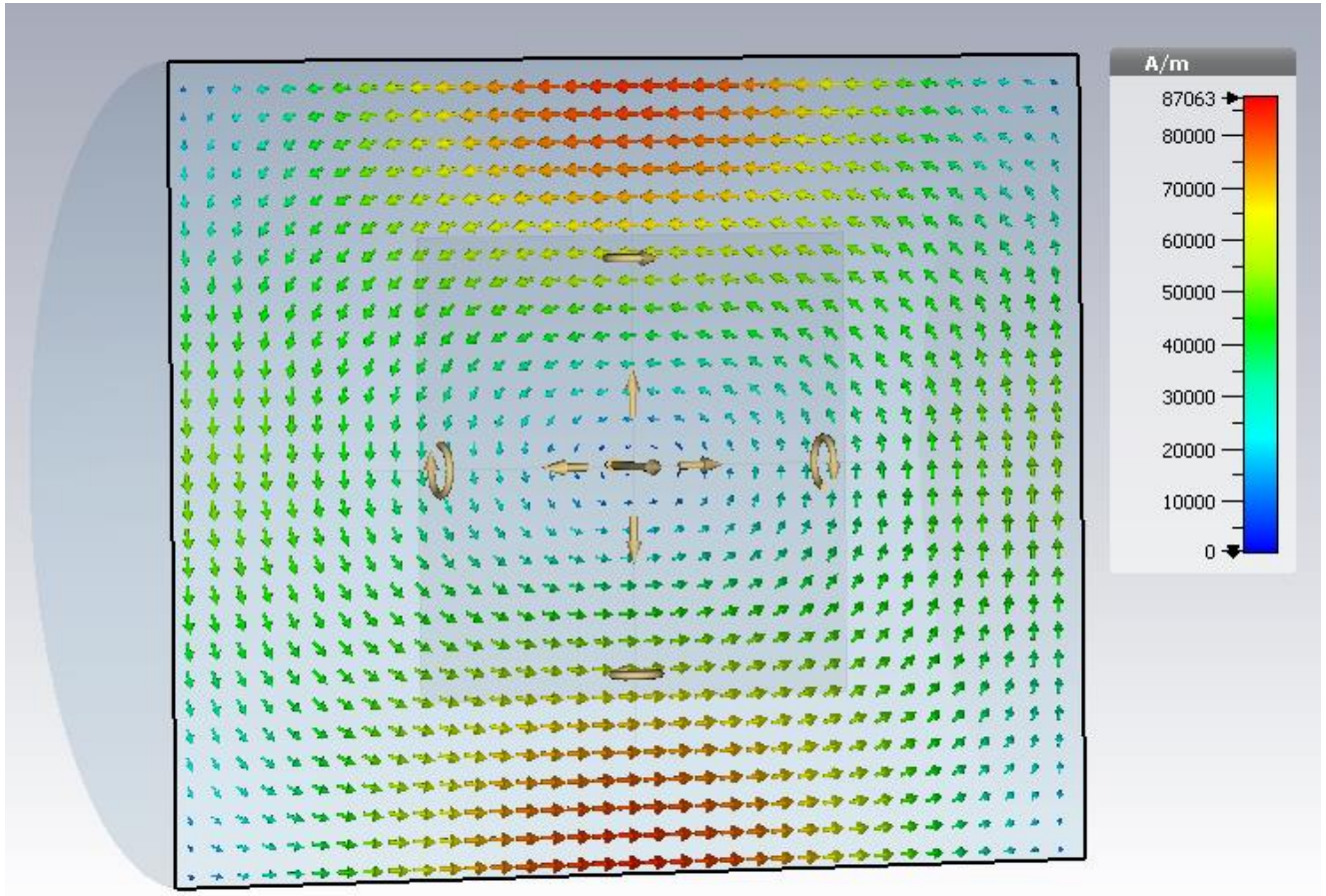
- Magnetic field has a vortex shape
- Antenna is adjusted to excite this mode

Experiment with soup can

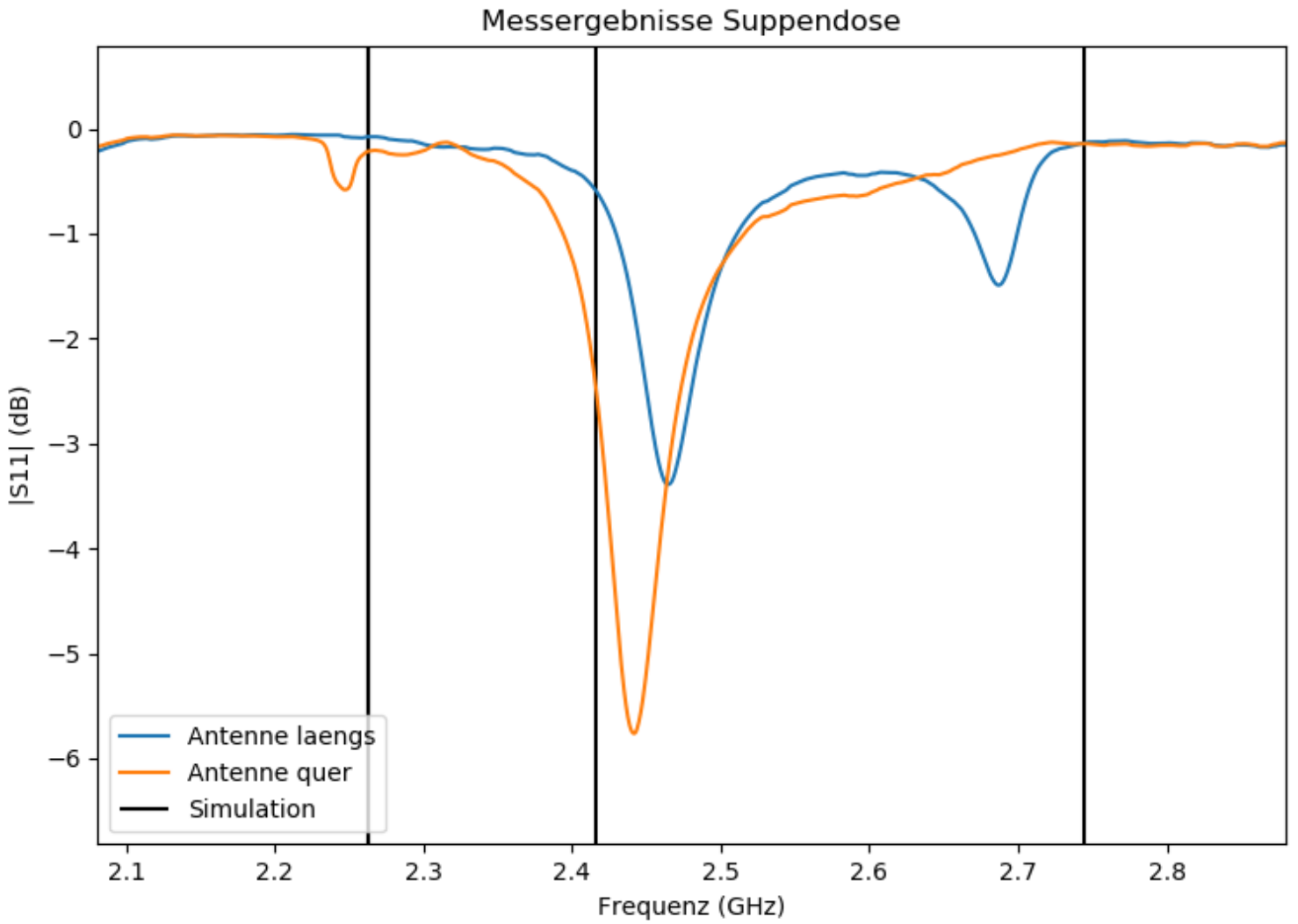
- Magnetic field of the antenna is going through the middle of the two loops

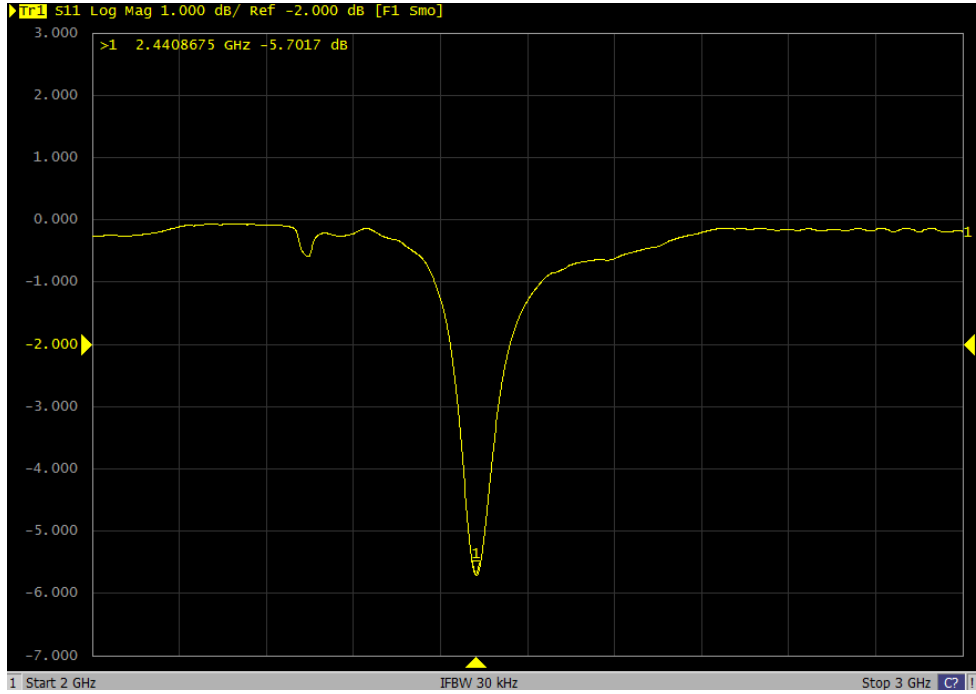
Experiment with soup can

- Repetition of the experiment
- Antenna will be rotated by 90°
- Now the antenna should excite other modes



Experiment with soup can



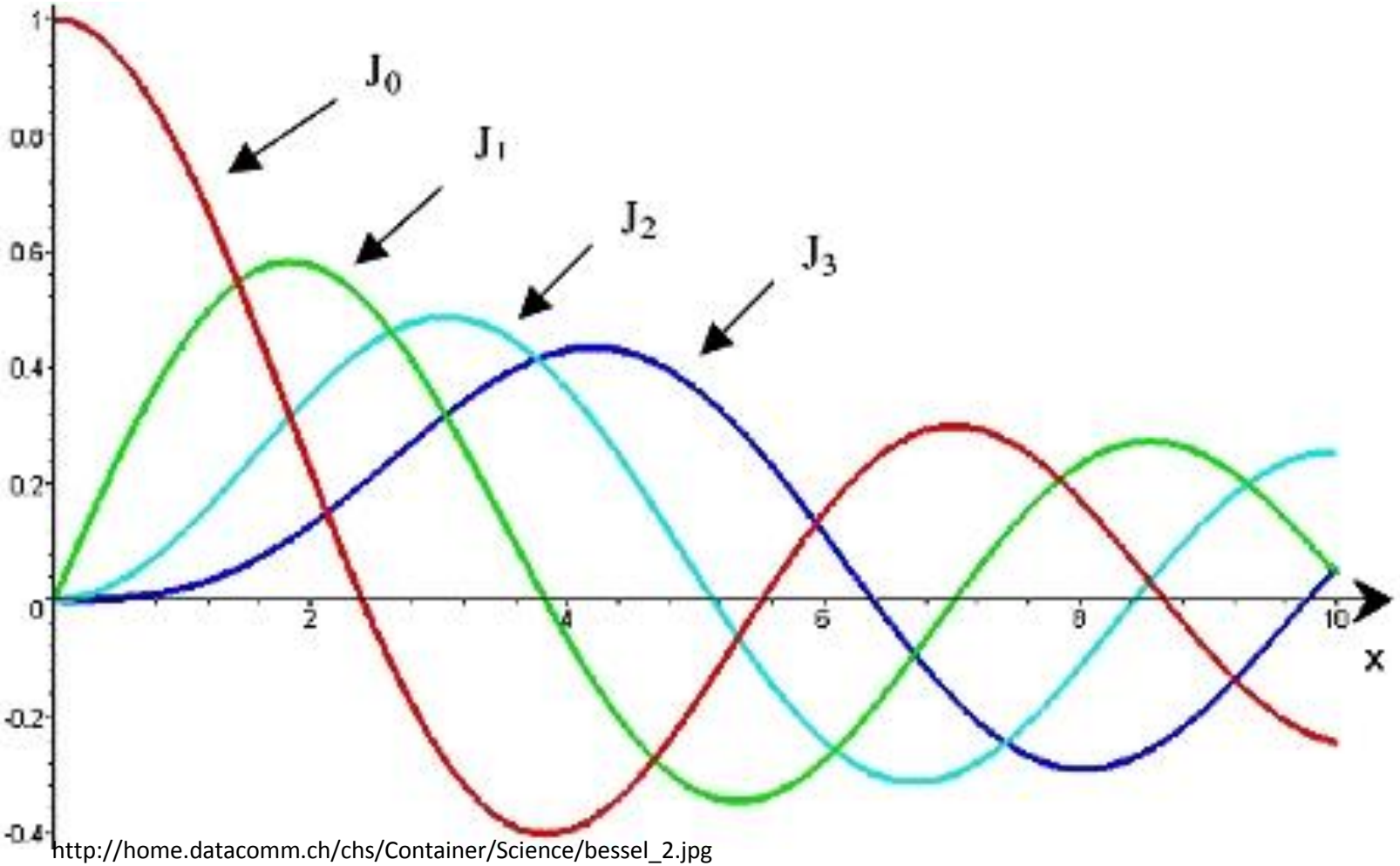


Thank you fors attention!

Quellen

- CST microwave studio

Bessel function



http://home.datacomm.ch/chs/Container/Science/bessel_2.jpg