# Multipacting Simulation

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DESY

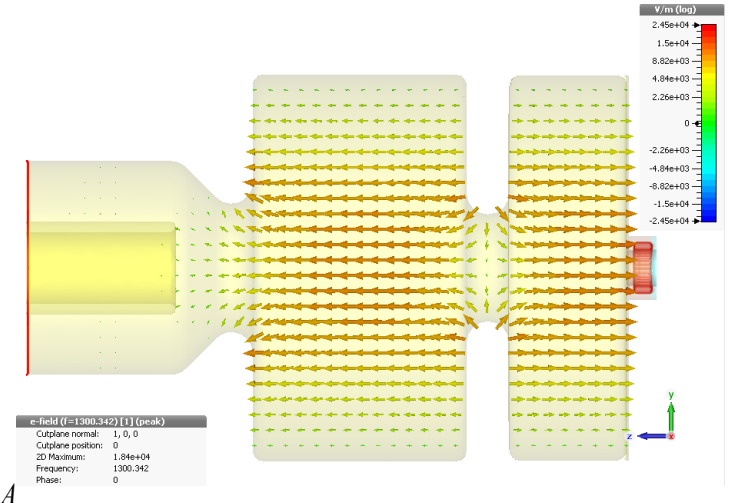
# Tasks

- Gun 4 : cathode area
- CDS booster : ½ of accelerating cell + coupling cell + ½ of accelerating cell
- Gun 5 : whole structure

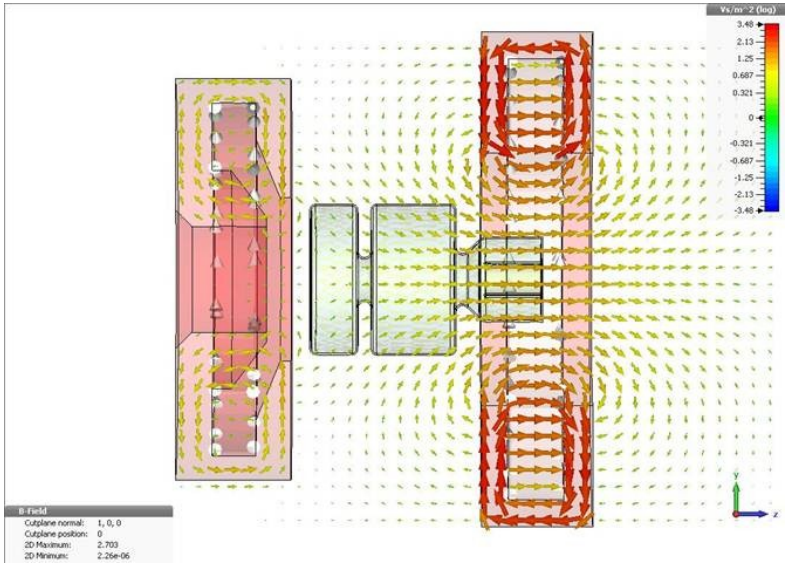
# RF and external magnetic fields simulation

1. RF field simulations (CST MWS):
   - F-solver
   - Tetrahedral mesh (max. step width 0.3 mm)
   - Symmetry ½
   - Frequency: 1300.342 MHz

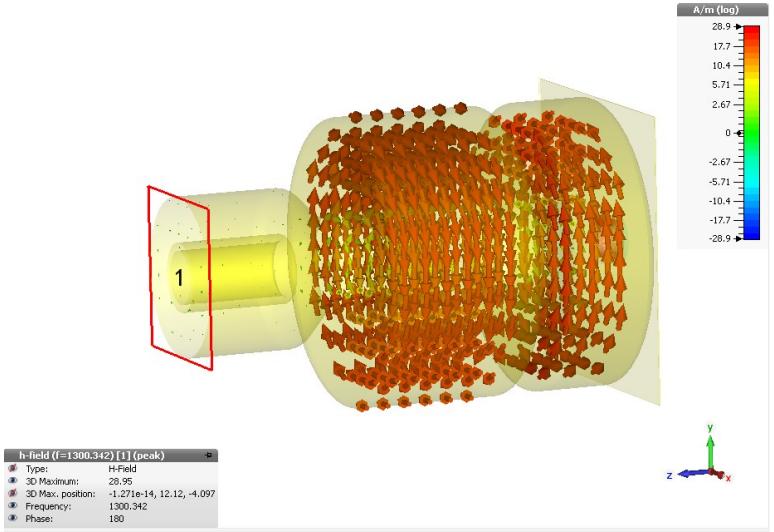
2. External magnetostatic fields (CST EM):
   - Ms-solver
   - Hexahedral mesh (2 600 000 per ¼)
   - Symmetry ¼
   - Currents: $I_{main} = 370\ A, I_{buck\_1} = -0.7\ A, I_{buck\_2} = -00\ A$




Distribution of RF electric field




Distribution of external magnetic field

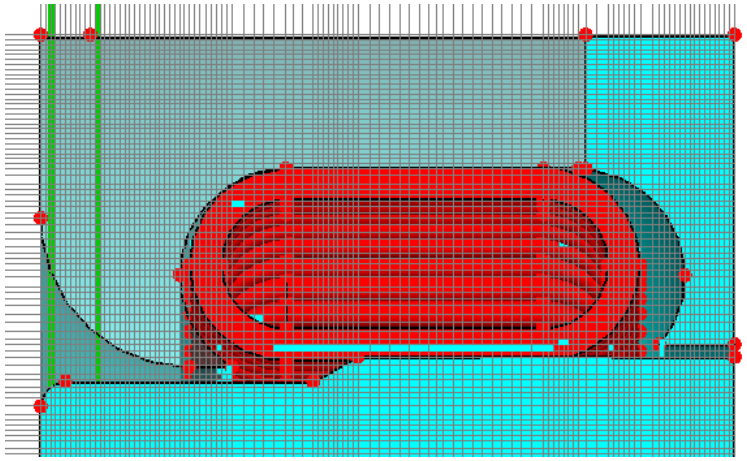



Distribution of RF magnetic field

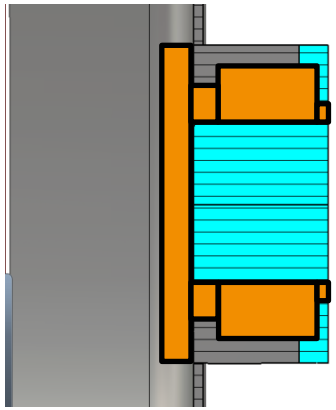
# The simplified model

1. The extraction of fields

The special script for the field extraction was developed with CST Visual basic for Applications (VBA). It provides the possibility to extract the electromagnetic fields from the desirable area:



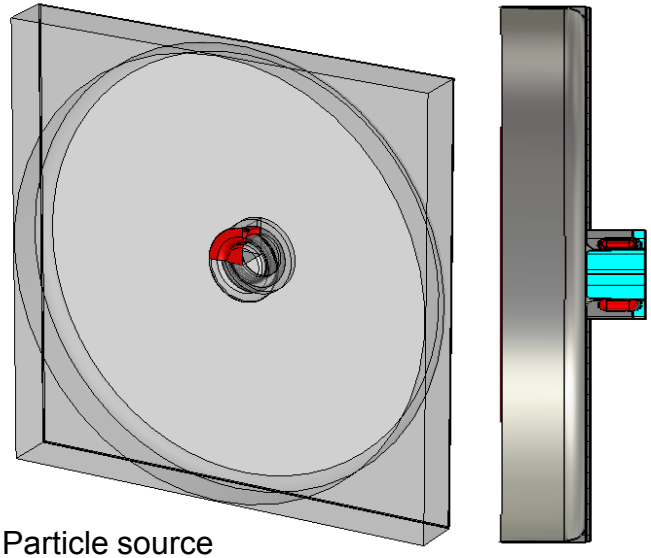
Hexahedral mesh in the cathode area



Model for the script

2. The electron source definition

The electron source is chosen at ¼ of the cathode area in order to save memory and reduce computational time. Such simplification is valid due to the symmetry of the fields.



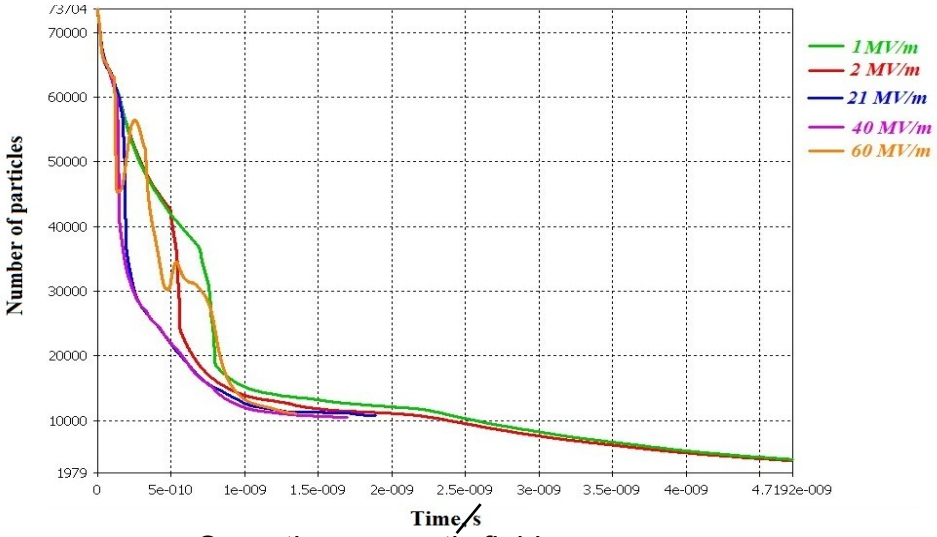
Particle source

Table 1. Simulation parameters

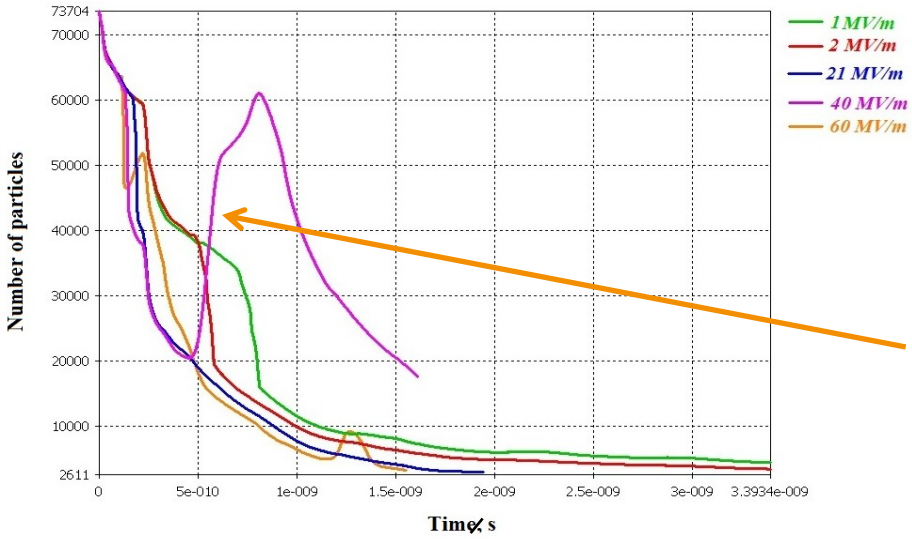
| Tracking mesh: max. step width, mm | 0.1 |
|---|---|
| Emission energy, eV | 0-5 |
| Max. generations | 25 |
| Max. secondaries per impact | 10 |

# Particle tracking simulations

The number of particles as a function of time



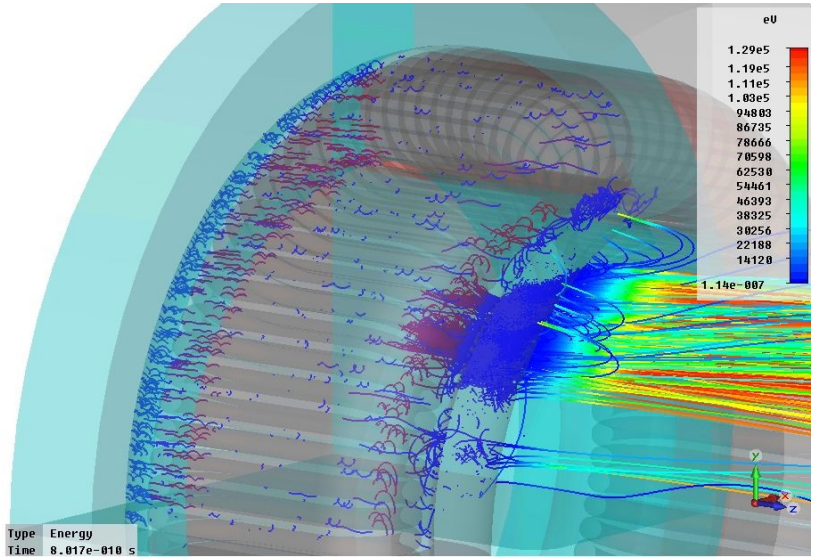

Operating magnetic fields




Special magnetic fields for multipacting investigation

The gradual decrease in the number of electrons

No multipacting

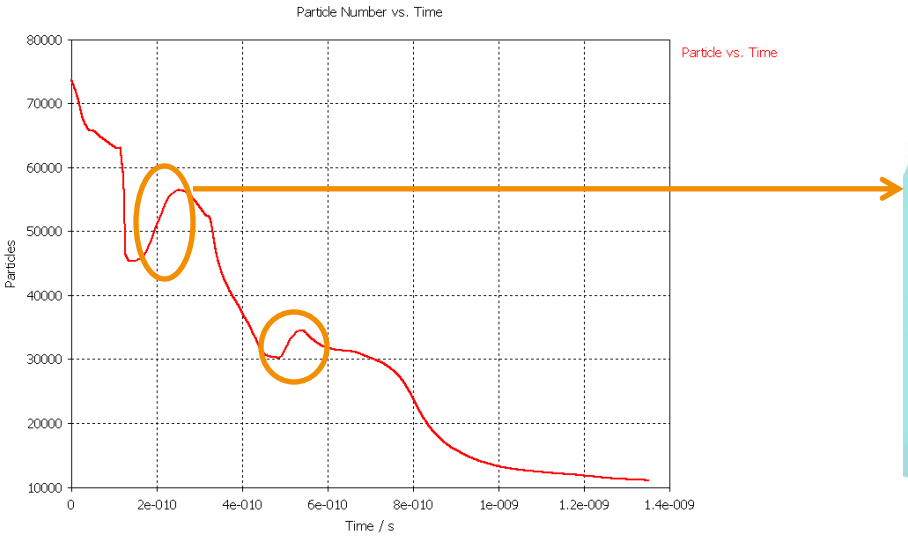



Secondary electrons in the cathode area

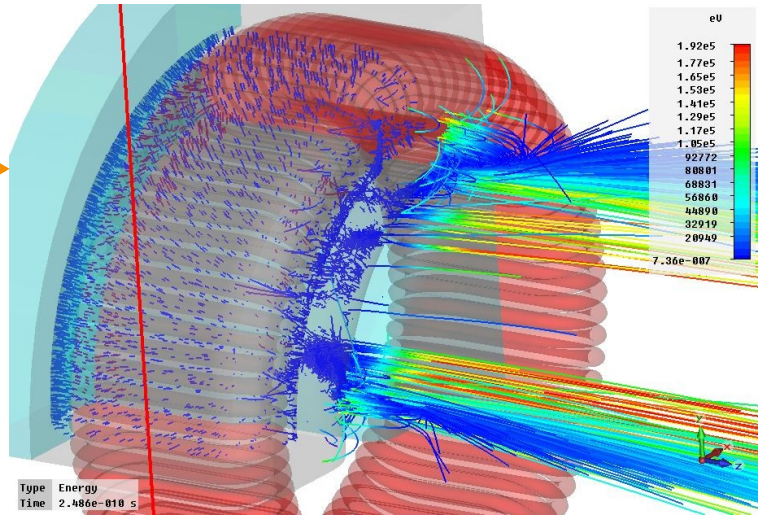
The resonant conditions for secondary electron emission appear but there is no synchronization between the field and particles. Such growth does not lead to multipacting.

# Simulations for operating regime

- 60 MV/m accelerating gradient at the cathode
- Operating magnetic fields




The number of particles as a function of time for operating regime




Secondary electrons in the cathode area

High probability for the secondary electron emission between the cathode and the blending part of the outer cylinder

There is no possibility of multipactor discharge!

# Multipacting in the CDS booster cavity

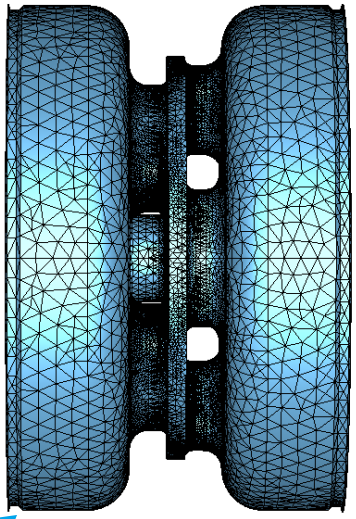
RF field simulations (CST MWS):

- E-solver
- Tetrahedral mesh
- Symmetry ¼
- Frequency: 1300.719MHz
- π-mode

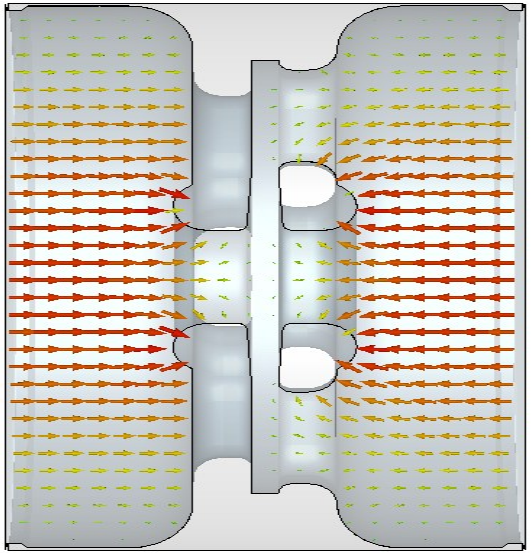
$$T = \frac{\left| \int_0^l E_z(z) e^{ik_z z} dz \right|}{\int_0^l \left| E_z(z) \right| dz}$$

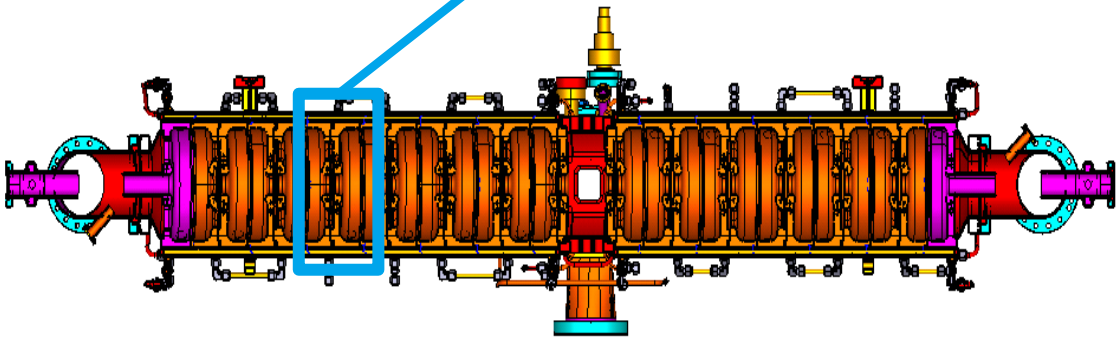
$$E_{acc} = E_{z\_\max} \cdot T$$

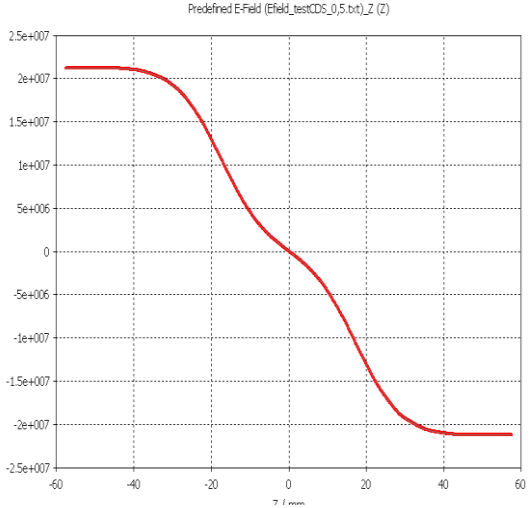
$$E_{acc} = 13.14 \ MV/m$$



Tetrahedral mesh



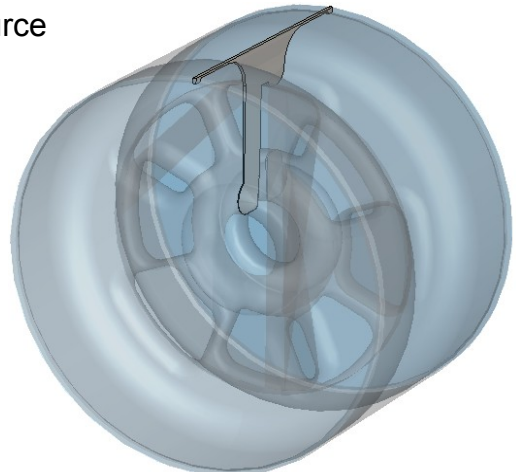





Distribution of RF electric field

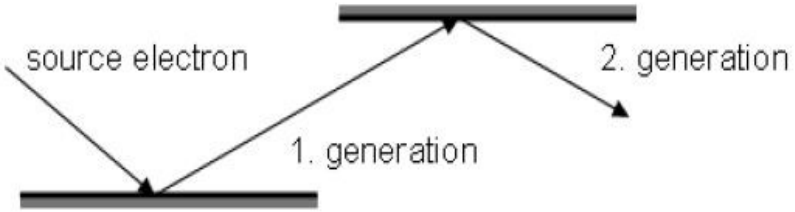
# Multipacting in the CDS booster cavity

Electron source



**Max. secondaries per hit -** maximum number of secondary electrons, which can be emitted per incident electron.

**Max. generations -** maximum number of generations which a (primary) source electron can produce.



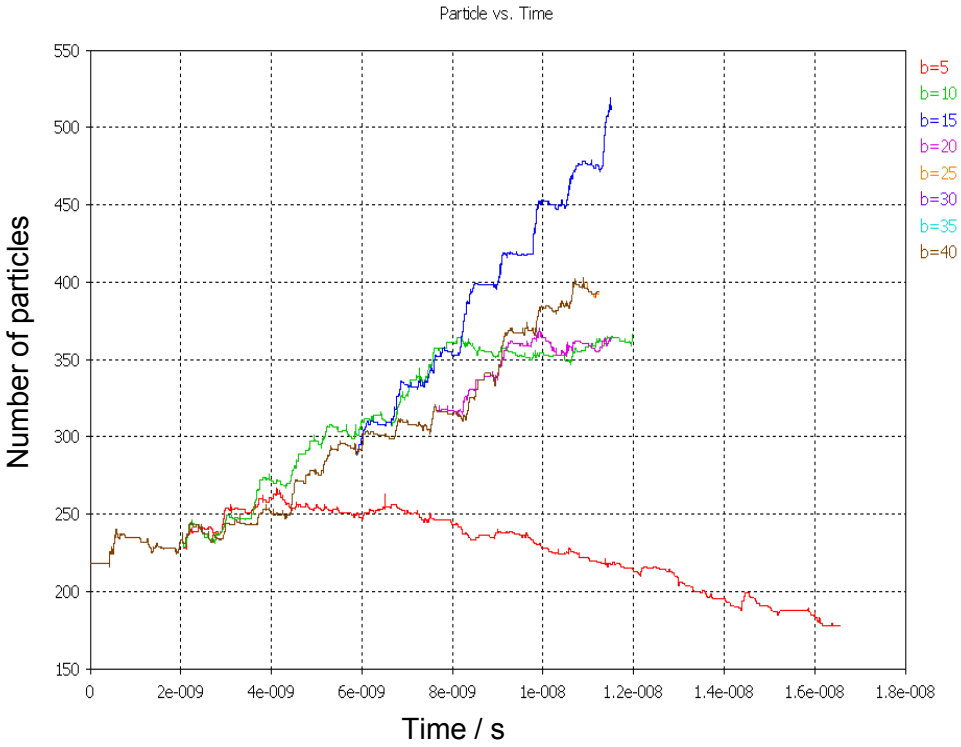
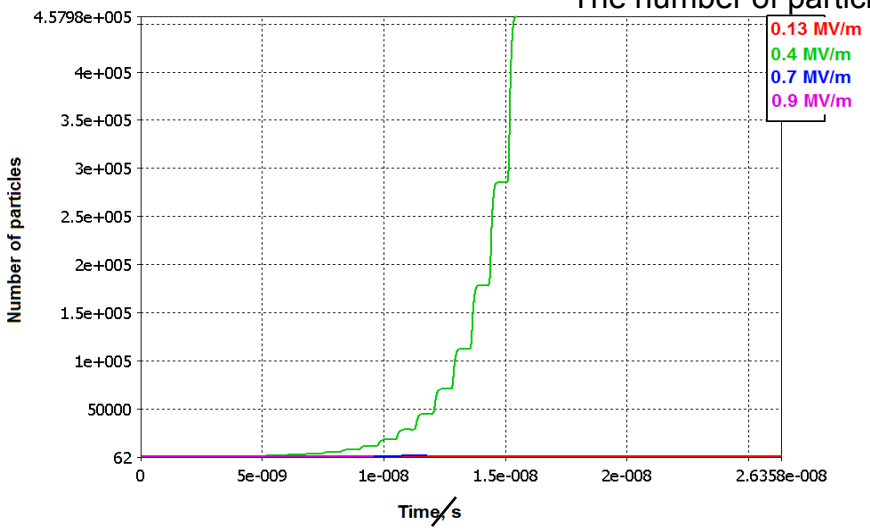



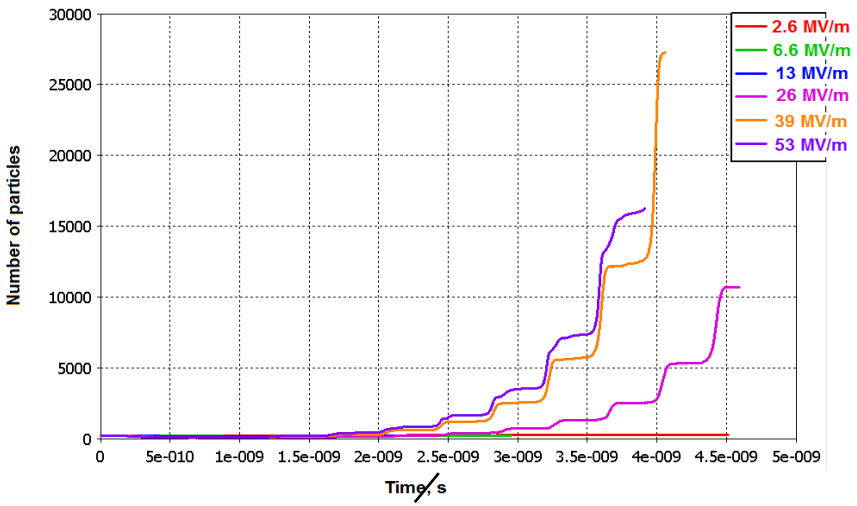

Table 1. Simulation parameters

| Tracking mesh: max. step width, mm | 0.5 |
|---|---|
| Emission energy, eV | 0-5 |
| Max. generations | 25 |
| Max. secondaries per impact | 10 |

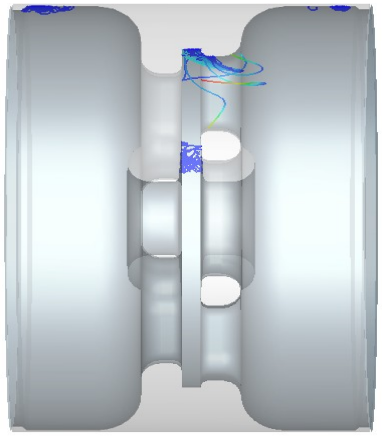
# Multipacting in the CDS booster cavity

The number of particles as a function of time

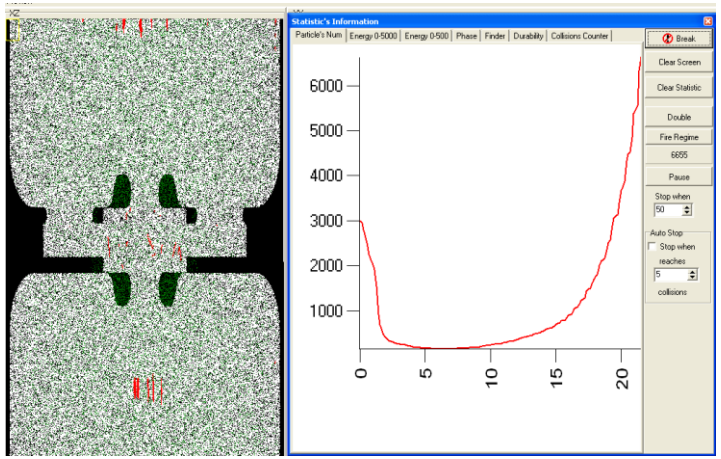



An exponential increase of the secondary electron number is obtained at ≈ 0.4 MV/m and above ≈ 20 MV/m. But the order of multipacting is not so dangerous.

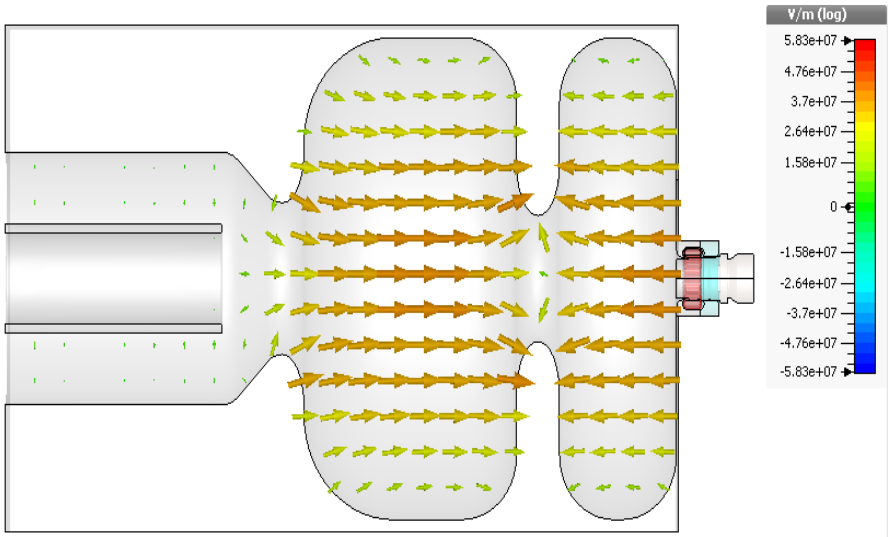


Multipacting trajectories

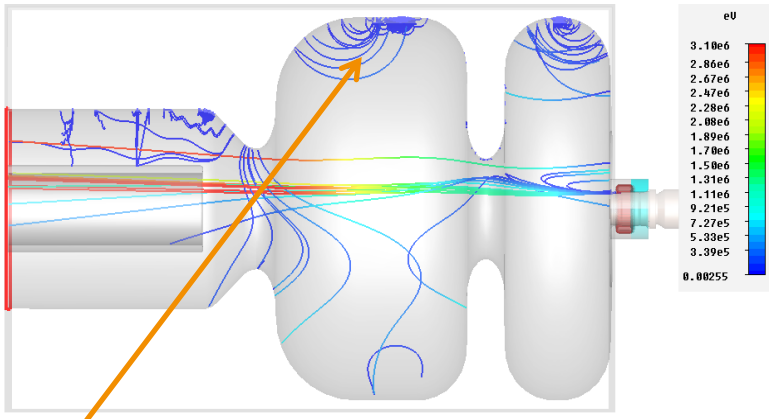



Example of the similar simulations in MultP-M

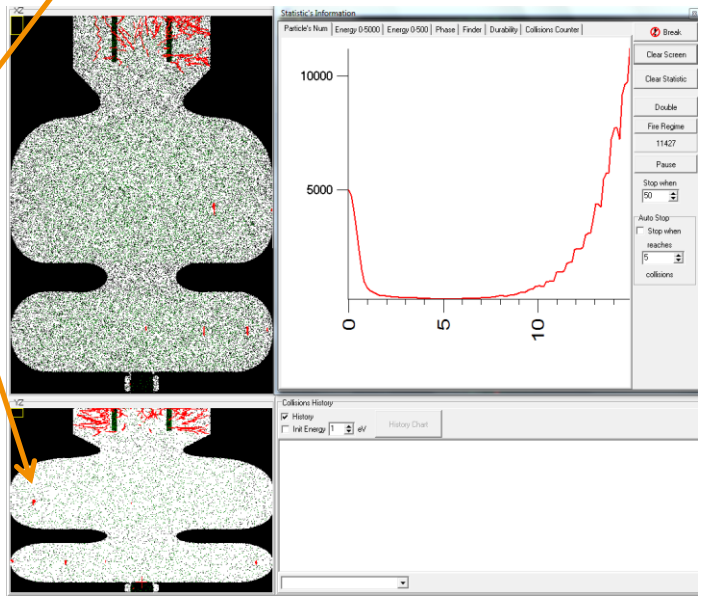
# Multipacting in the Gun 5




Distribution of RF electric field




Multipacting trajectories (8 MV/m at the cathode)




Stable multipacting trajectories are obtained at the "equatorial" parts of the cavity cells (similar to elliptical cavities).
Trajectories in the coaxial part of the structure are not dangerous.

# Conclusions

- Gun 4, the cathode area: There is no possibility of multipactor discharge. However, the area between the cathode and the blending part of the outer cylinder undergo the secondary electron emission at operating levels of the accelerating gradient of about 60 MV/m;
- CDS booster: An exponential increase of the secondary electron number is obtained at ≈ 0.4 MV/m and above ≈ 20 MV/m. But the order of multipacting is not so dangerous.
- Gun 5, whole structure: Stable multipacting trajectories are obtained at the "equatorial" parts of the cavity cells. Trajectories in the coaxial part of the structure are not dangerous. Simulations with the external magnetostatic fields are required.

Thank you for your attention.