Multipacting Simulation for the PITZ RF Photo Gun

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HELMHOLTZ
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DESY

RF Photo Gun

The RF photo gun operates with a standing wave regime in the π-mode with resonant frequency of 1.3 GHz

The gun consists of:

- normal-conducting cavity (1.6 copper cells)
- exchangeable molybdenum cathode with contact spring
- pair of focusing solenoids

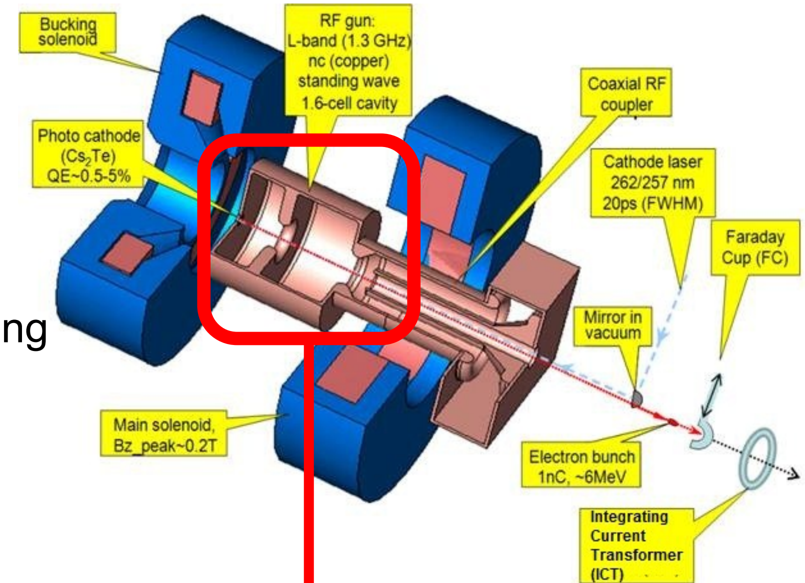
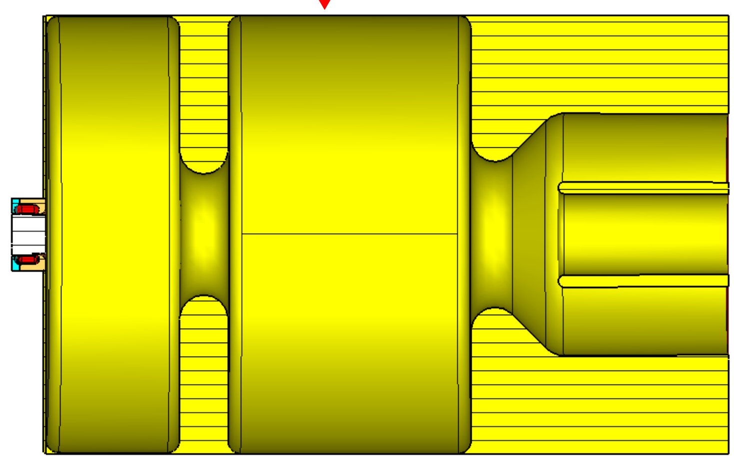


Table 1: Main parameters

Accelerating gradient at the cathode, MV/m	60
Beam energy after gun, MeV	1..7
Full RF power, MW	8
Number of bunches	1..800
RF pulse, ms	1
Repetition rate, Hz	10



Motivation

Field emission is the release of charged particles from a surface due to local electromagnetic fields.

Dark current is the flow of these particles through the cavity into which they were released. They accelerate according to the RF fields, so they could end up virtually anywhere on the accelerator walls with a large range of energies.

During the gun operation dark current measurements were performed. Significant dark current growth was observed at certain operational conditions. One of the reasons for this growth can be the multipacting effect.

The aim of the simulations is to obtain power levels on which multipacting occurs and to define the area of the cathode where stable discharge electron trajectories can be present.

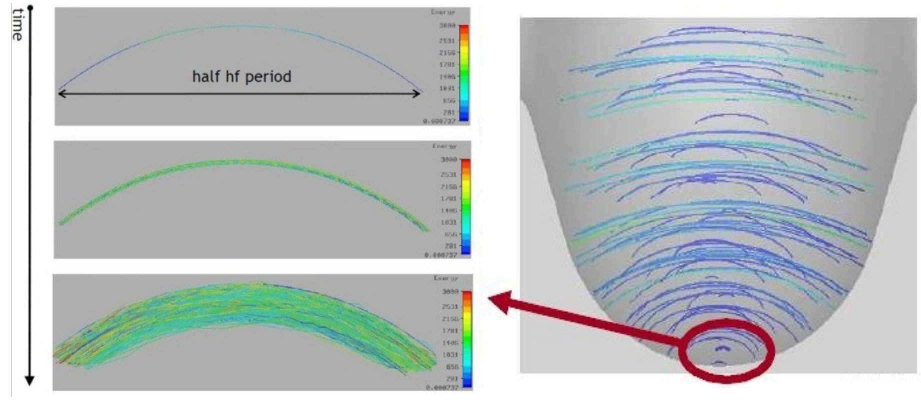
Multipacting

Multipactor discharge (multipacting) is the phenomenon of undesirable resonant secondary electron emission which occurs at certain conditions.

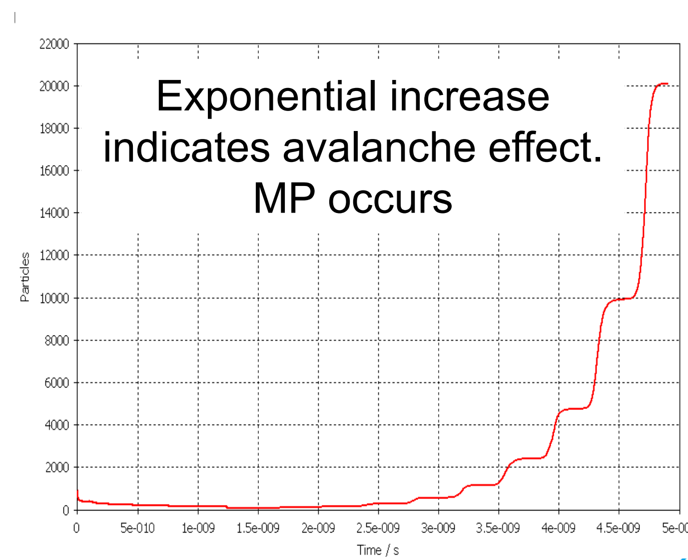
Multipacting depends on:

- The field configuration
- The cavity geometry
- The secondary electron yield (SEY)

SEY is the common parameter to describe the secondary electron emission, it is defined as the ratio of the incident over the secondary or emitted current.



Example of multipactor trajectories



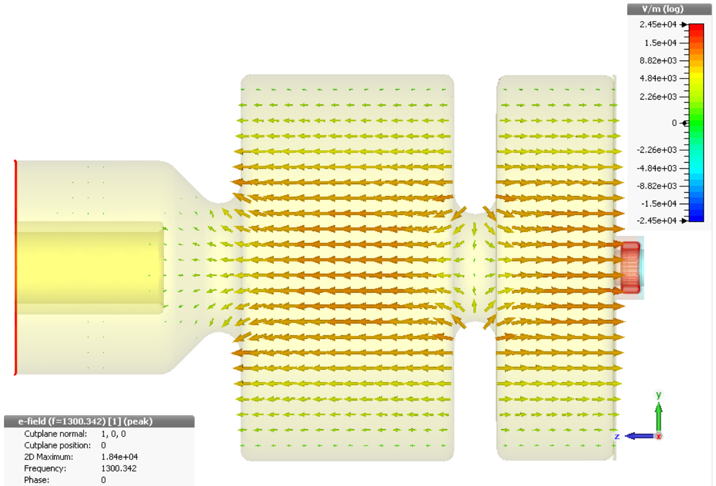
Multipacting may lead to:

- Vacuum breakdown
- Power losses
- Overheating and damage of RF components
- Quench effect (for the superconducting structures)

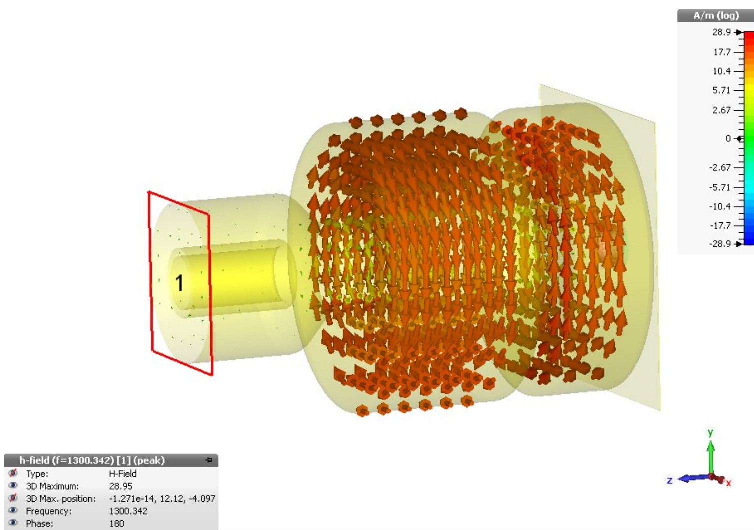
RF and external magnetic fields simulation

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

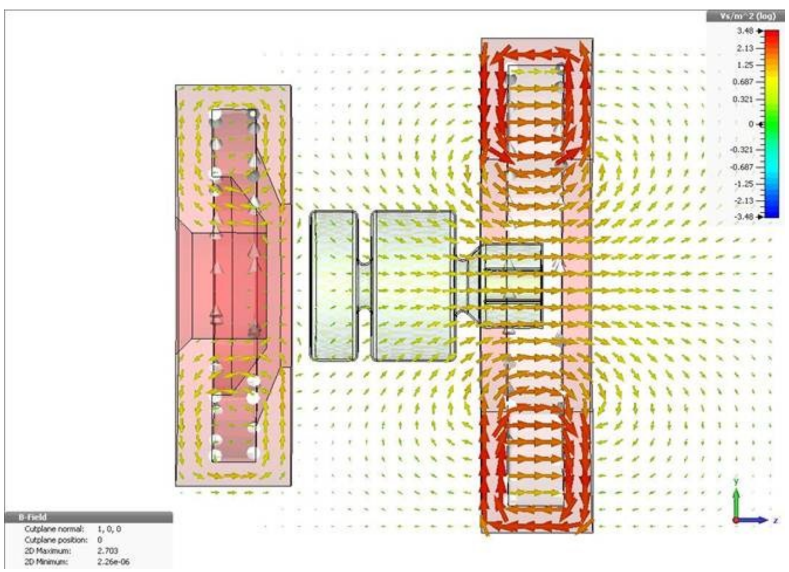
2. External magnetostatic fields (CST EM):
   - Ms-solver
   - Hexahedral mesh (2 600 000 per ¼)
   - Currents: $I_{main} = 370\ A, I_{buck\_1} = -30.7\ A, I_{buck\_2} = -200\ \ A$



Distribution of RF electric field



Distribution of RF magnetic field

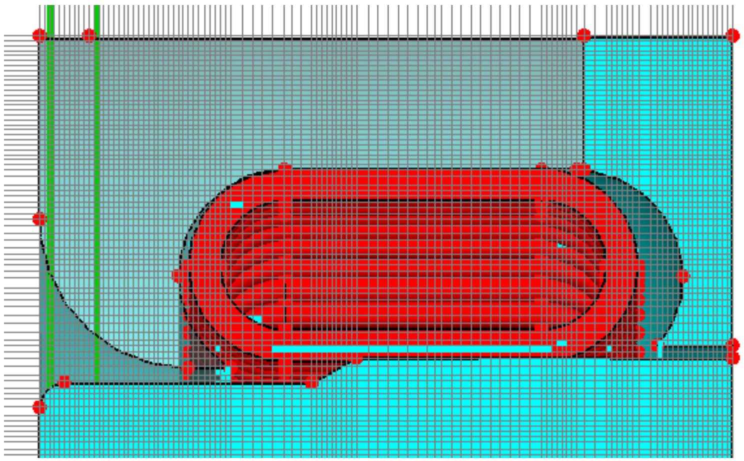


Distribution of external magnetic field

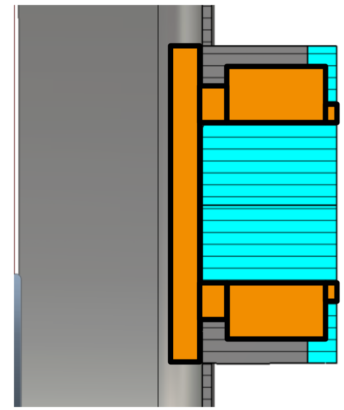
The simplified model

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



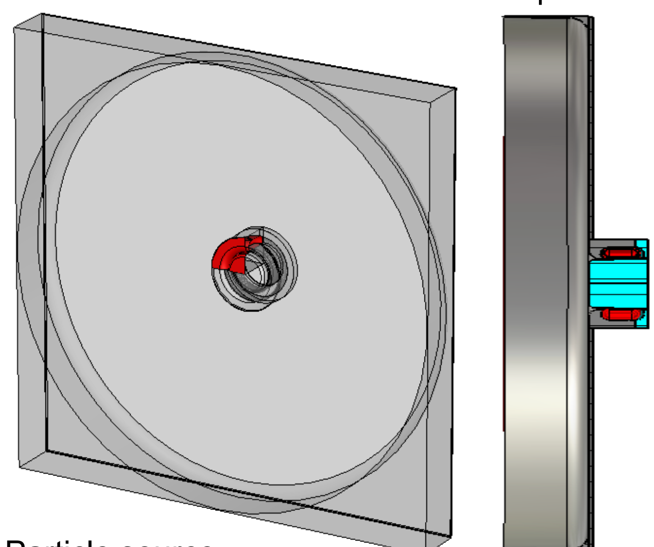
Model for the script

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.

Table 2 : Simulation parameters

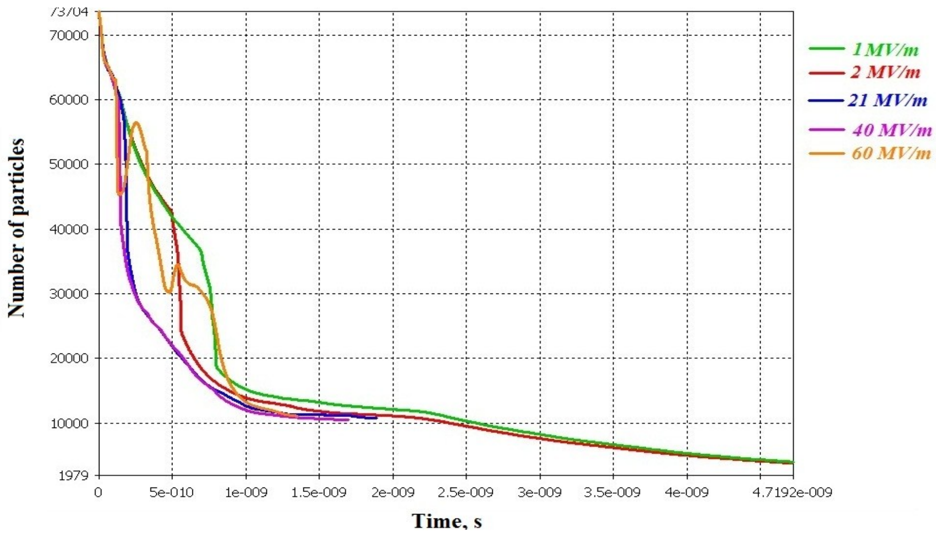
Tracking mesh, max. step width mm	0.1
Emission energy, eV	0-5
Max. generations	25
Max. secondaries per impact	10



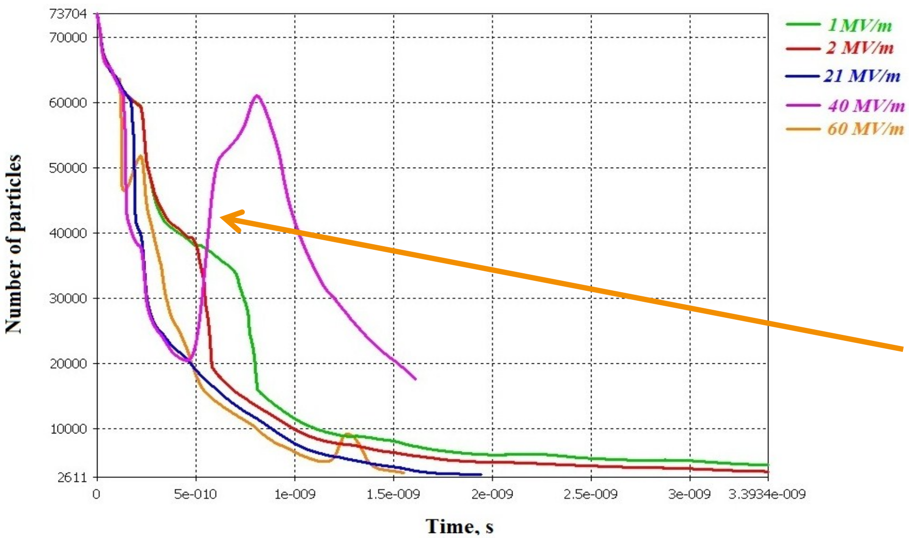
Particle source

Particle tracking simulations

The number of particles as a function of time



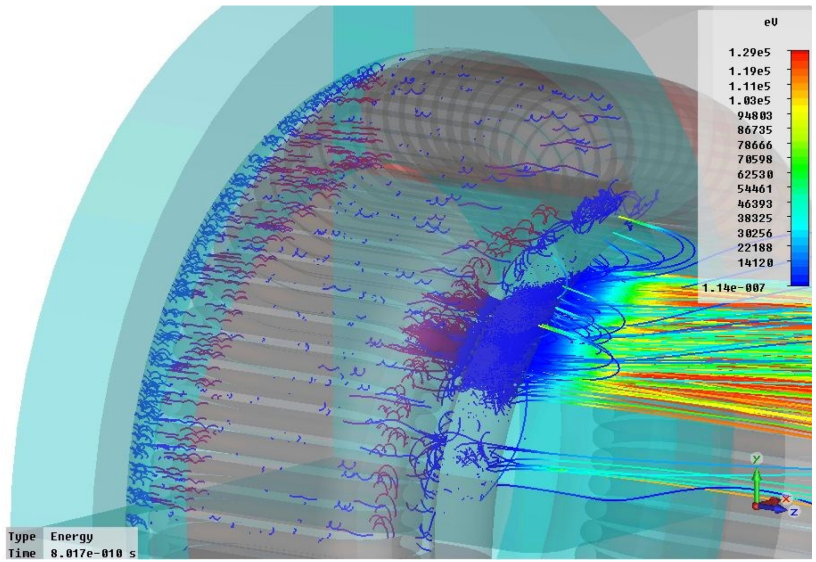
Operating magnetic fields



Special magnetic fields for multipacting investigation

The gradual decrease in the number of electrons

No multipacting

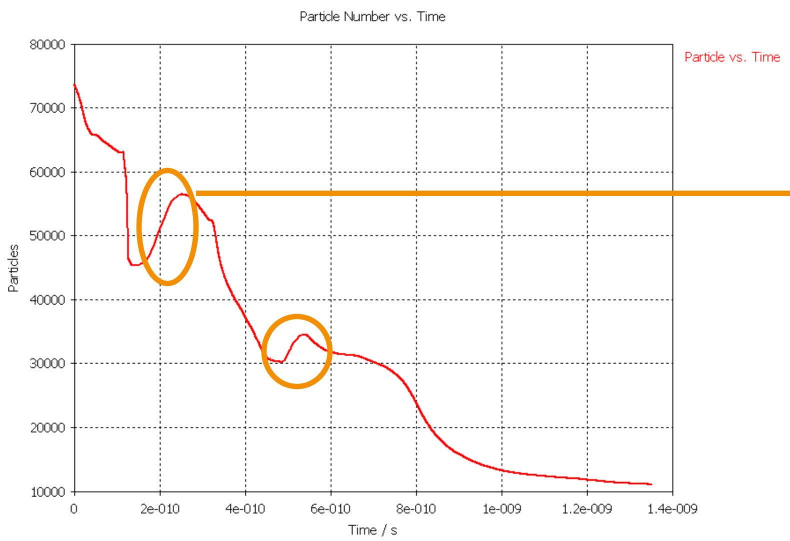


Secondary electrons in the cathode area

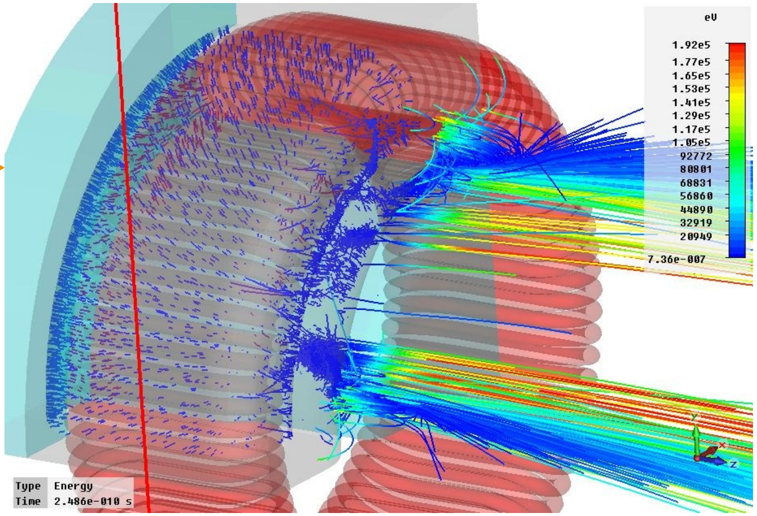
The resonant conditions for secondary electron emission appear but there is no synchronization between the field and particles. Such growth does not lead to multipacting.

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!

Conclusion

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.

Thank you for your attention.