THREE ELECTRODE ELECTRON GUN WITH THE DECREASED ANODE VOLTAGE GEOMETRY OPTIMIZATION

S.V. Matsievskiy, E.A. Savin, National Research Nuclear University MEPhI
(Moscow Engineering Physics Institute), Moscow, Russia

Abstract

With the rapid growth of demand for compact particle accelerators, used in number of different fields (medicine, security, etc.), there is a need for more compact and simple in production particle accelerator parts. One of such parts, electron gun injector for linear accelerator, is considered in this paper.

Modifications to the initial design, such as anode potential decrease and change of geometrical properties of cathode are described, optimal operating mode is calculated.

INITIAL MODEL CALCULATION

On figure 1 an existing electron gun with buncher cell are shown. In this case, buncher cell has an electric potential and acting as anode. Potential difference between anode and heated cathode forces electrons to emit from cathode. Control electrode is used to focus electron beam from cathode and to control electron emission intensity by altering electric field value near the cathode surface.

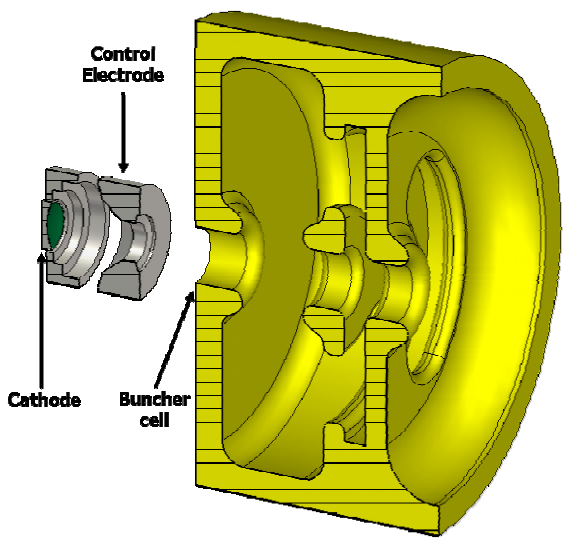

Figure 1: Cross-section of electron gun with buncher cell.

To validate the calculation method of electron gun, model of existing one was built. It consisted of spherical cathode with potential set to zero, control electrode with potential of 12.9 kV and 50 kV anode. On the figure 2 calculation output data is presented. Purple lines represent equipotential lines of electric field inside of the gun. Green lines are the electron trajectories.

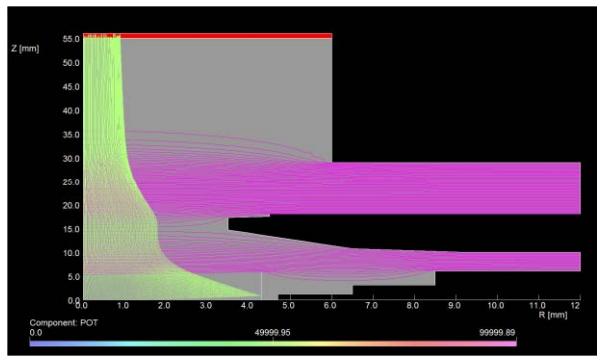

Figure 2: Initial model output data.

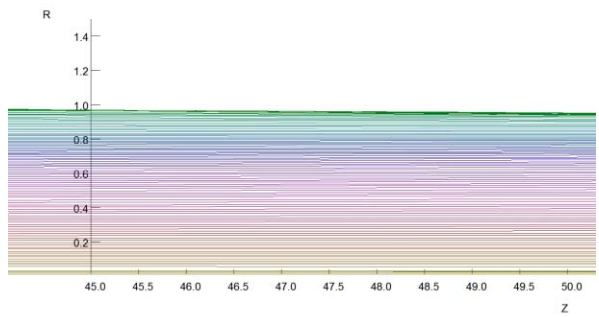

Figure 3: Electron trajectories near crossover.

Calculation results of existing gun model coincided with beam parameters measurement. Calculation method is suitable for modified gun calculations.

MODEL WITH DECREASED ANODE VOLTAGE

Beam width in the crossover dependence of anode potential was investigated. The plot of beam radius r over anode potential U_1 is shown on the figure 4.

As shown on figure 4, beam width is decreasing in reverse ratio to anode potential. For simplification of electron gun design due to the isolation requirement reduction, compromise potential of 30 kV on the anode was chosen.

ISBN 978-3-95450-170-0

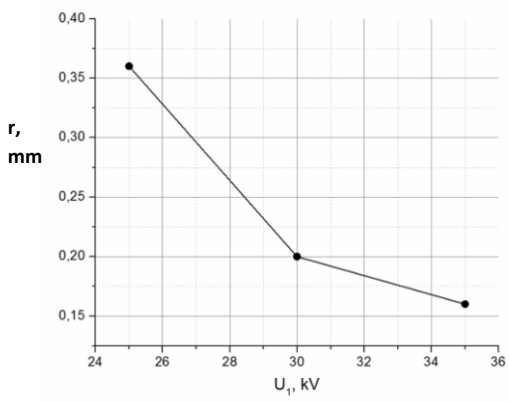

Figure 4: Beam radius over anode potential.

On the figure 5 plot of beam width in the center of the cell over control electrode potential is presented.

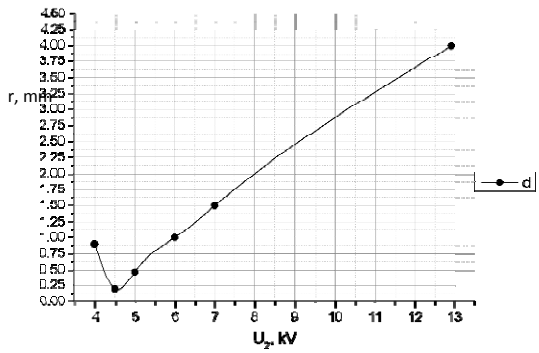

Figure 5: Beam width over control electrode potential for model with decreased anode potential.

Set of electrode potentials, corresponded to the smallest width of beam, is shown in the table 1.

Table 1: Electrode potentials for model with decreased anode potential .

Cathode	0
Anode	30 kV
Control electrode	3.5 kV

Equipotential lines of electric field and electron trajectories for model with decreased anode potential (electrode potential values are presented in table 1) are shown on the figure 6.

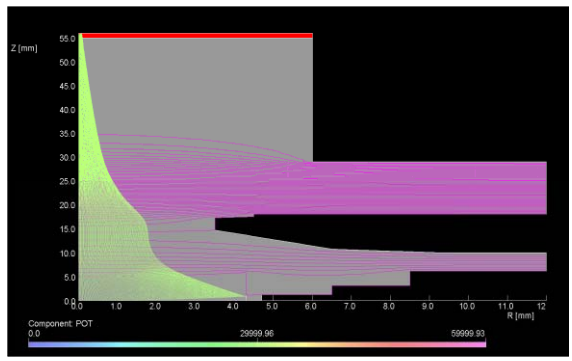

Figure 6: Electric field equipotential lines and electron trajectories for model with decreased anode potential.

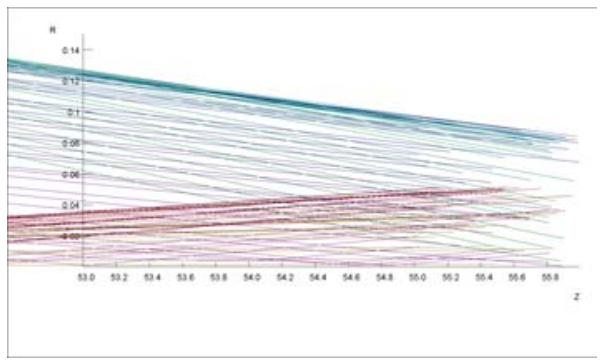

Figure 7: Electron trajectories near crossover.

MODEL WITH MODIFIED CATHODE GEOMETRY

For increasing cathode lifetime and technological reasons original cathode was changed to the bigger and more frequently used one. To fit new cathode to the form-factor of initial gun, geometry of control cathode was altered.

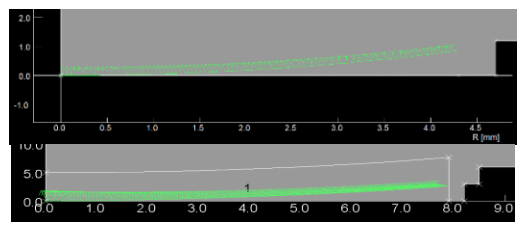

Figure 8: Emitting area for initial 8.6mm cathode model (a) and modified 15.8mm cathode model (b).

For a new gun model geometry beam width dependence on control electrode potential was investigated (Figure 9). Optimal electrode potentials are presented in table 2.

ISBN 978-3-95450-170-0

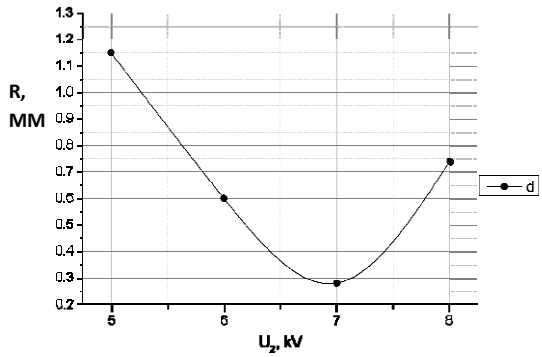

Figure 9: Beam crossover radius over control electrode potential plot.

Table 2. Electrode potentials for model with modified geometry.

Cathode	0
Anode	30 kV
Control electrode	7 kV

For modified geometry model with electrode potentials, shown in table 2, electric field and electron trajectories were calculated (Figure 9).

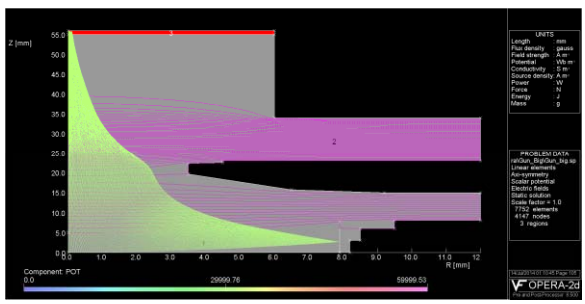

Figure 10: Electric field equipotential lines and electron trajectories for model with modified geometry.

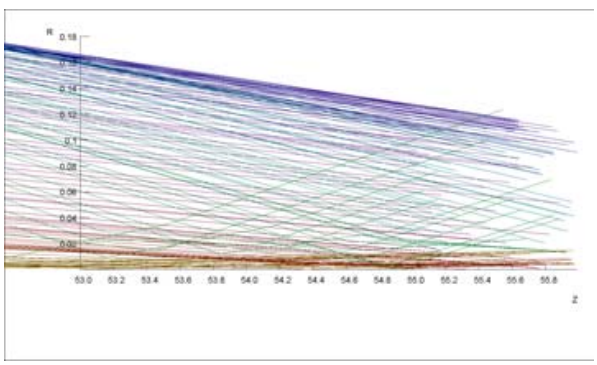

Figure 11: Electron trajectories near crossover.

CONCLUSION

Three electrode gun, consisting of spherical cathode, control electrode and anode, has been designed. Anode potential was varying between 30kV and 50kV. For the each potential the control electrode potential has been chosen to achieve the smallest beam crossover in the middle of the first accelerator cell. Calculations was based on the initial model of the already existing gun – electron injector in the linear accelerator. All calculations for the different anode voltages has been repeated for the bigger cathode, which imply different cathode electrode geometry. The result, usable in the further accelerator calculations has been achieved.

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