

# MULTIPACTING SIMULATION IN INPUT POWER COUPLERS OF ELECTRON LINEAR ACCELERATOR

M.A. Gusarova, V.L. Zvyagintsev\*, I.I. Petrushina  
National Research Nuclear University "MEPhI";

\*Canada's National Laboratory for Particle and Nuclear Physics, Vancouver, Canada

This paper concerns the results of multipacting prediction for the feeding waveguide section of the eLINAC accelerator. The threshold values of the input power, at which the discharge may occur in this structure, were obtained. Simulations were carried out analytically and numerically with various codes. The results of simulation were compared to each other.

PACS: 29.20.Ej

## INTRODUCTION

TRIUMF has recently embarked on the construction of ARIEL [1], the Advanced Rare Isotope Laboratory, with the goal to significantly expand the Rare Isotope Beam (RIB) program for Nuclear Physics and Astrophysics, Nuclear Medicine and Materials Science. This project comprises a new superconducting 50 MeV, 10 mA CW electron linear accelerator (eLINAC) as a driver for photo-fission of actinide targets to produce rare isotope beams. Flowchart of the accelerator with phases of construction is shown in Fig. 1.

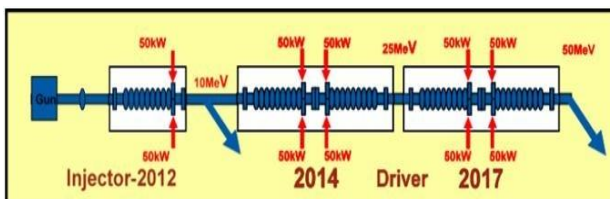


Fig. 1. Flowchart of the TRIUMF eLINAC

The electron beam is generated in a 300 kV DC thermionic gun, bunched in a room temperature 1.3 GHz buncher cavity, and accelerated by five 1.3 GHz superconducting cavities. The eLINAC accelerating cavities are TTF-type 9-cell niobium cavities based on well-known TESLA geometry [3] which was developed in TRIUMF [2]. Superconducting cavities are housed in three cryomodules: one in the injector cryomodule, and the others are housed in two accelerator cryomodules, with two cavities each. The cavity will accelerate 10 mA current up to energy of 10 MeV. Two input CPI couplers [4] with an average operating power of about 60 kW are used for each cavity. Each 9-cell cavity will operate with an acceleration gradient of  $E_a = 10$  MV/m.

Design of accelerating cavities, input power couplers and other RF devices for the charged particle accelerators should provide the conditions of multipactor discharge elimination or suppression.

Multipactor discharge (secondary electron discharge) is undesirable resonant particle growth in the vacuum area of the RF structure which leads to various negative effects. The electron avalanche appearing in the vacuum region of the cavity can absorb RF power, limiting thereby the required level of the accelerating field. Also, electron bombardment can lead to overheating of the structure, which in turn can lead to quench – the cavity goes from superconductive state to normal state that is unacceptable for the accelerator operation. The study of multipactor discharge should be done at

the RF structure design stage to avoid such kind of problems.

Investigations were done for the eLINAC TRIUMF coupler, operating range of the input power for this device is up to 60 kW. CST PS and MultP-M 3D codes were used to obtain the threshold values of the input power, at which the discharge may occur.

Geometry of the input coupler is shown in Fig. 2: it consists of warm part which comprises the rectangular waveguide, warm ceramic window and part of the coaxial line, and cold part which consists of two parts of the coaxial line and conical section with cold ceramic window between them.

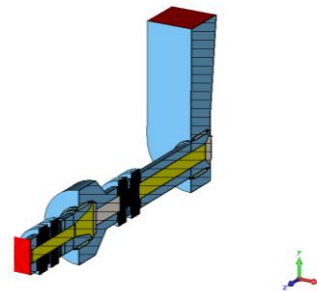


Fig. 2. Input coupler

The first stage of the work was a detailed study of the cold ceramic window. Analytical estimations were done for segments of the coaxial lines and numerical simulations were carried out for the whole cold part of the structure directly using special code for multipacting prediction MultP-M [5]. Fig. 3 shows the percentage increase in the number of particles in the cold ceramic window at different levels of the transmitted power.

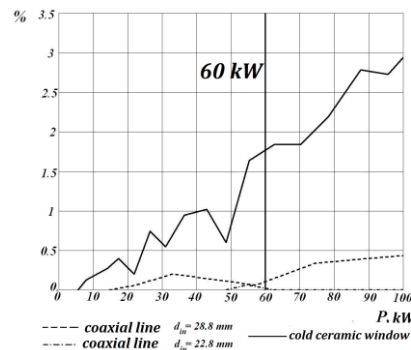


Fig. 3. Particle growth vs. input power for the cold ceramic window

Simulation of multipacting for the full structure of the input coupler was the second stage of these investigations. CST PS and MultP-M codes were used for these simulations.

## 1. SIMULATION BY MULTP-M

The electromagnetic field simulations were carried out by CST MWS with parameters of the mesh generation:  $N_x=65$ ;  $N_y=106$ ;  $N_z=246$ ; max. width of the mesh step 7.5 mm; min width 0.8 mm.

Multipacting simulations were done for two kinds of the secondary electron yield (SEY) curves (Fig. 4): SEY CST – for the simulation by CST, SEY MultP-M – for the simulation by MultP-M.

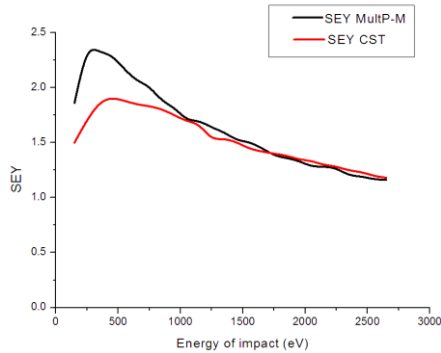


Fig. 4. Secondary electron yield curves

The dependence of the particles number in the structure against input power was obtained with MultP-M code as well as Phase/Field diagram (Fig. 5).

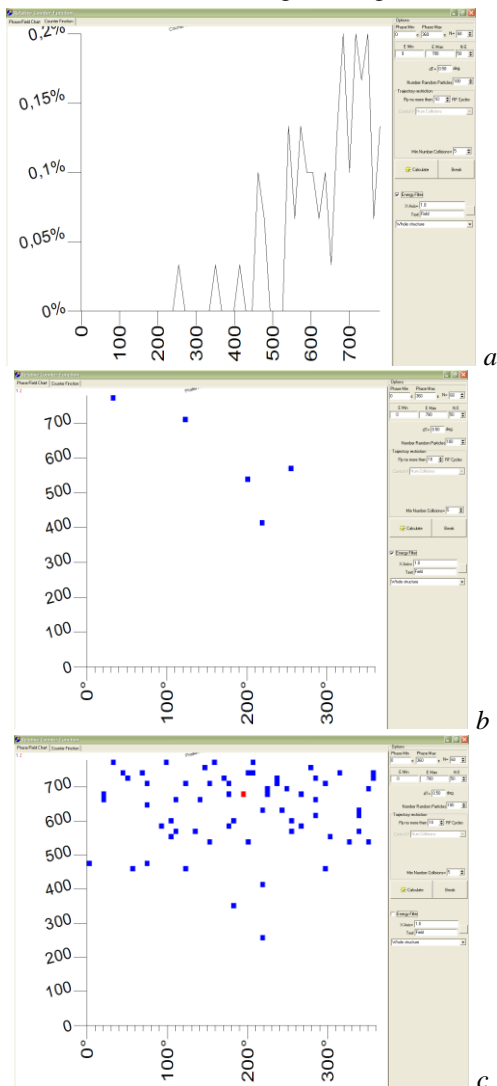


Fig. 5. Particle growth vs. Normalized electric field (a), Phase/Field diagram with (b) and without (c) energy filter  
ISSN 1562-6016. BAHT. 2013. №6(88)

The combined plot of percentage increase in particles number in the structure vs. transmitted power in the operating range is shown in Fig. 6 (normalization was taken into account).

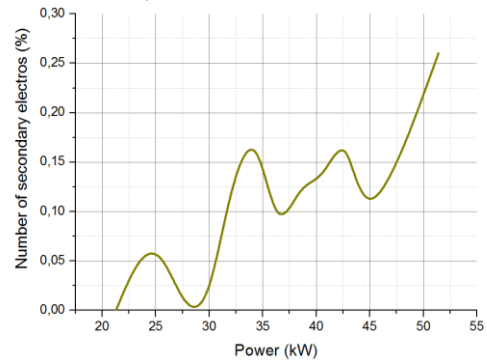


Fig. 6. The number of secondary electrons in the structure as a function of the input power

According to Fig. 6, the first trajectories which are stable for 5 RF periods appear at the input power levels of about 21 kW. The percentage increase in the particles number was observed over the entire operating range of the transmit power up to 60 kW. Stable multipacting trajectories were found on surface of the cold ceramic window at power levels of about 50 kW.

## 2. SIMULATION BY CST PS

Similar studies were carried out using the CST PS code. Results of the simulations are shown in Figs. 7, 8. Fig. 7 shows the number of secondary electrons in the structure as a function of time at different transmit power levels.

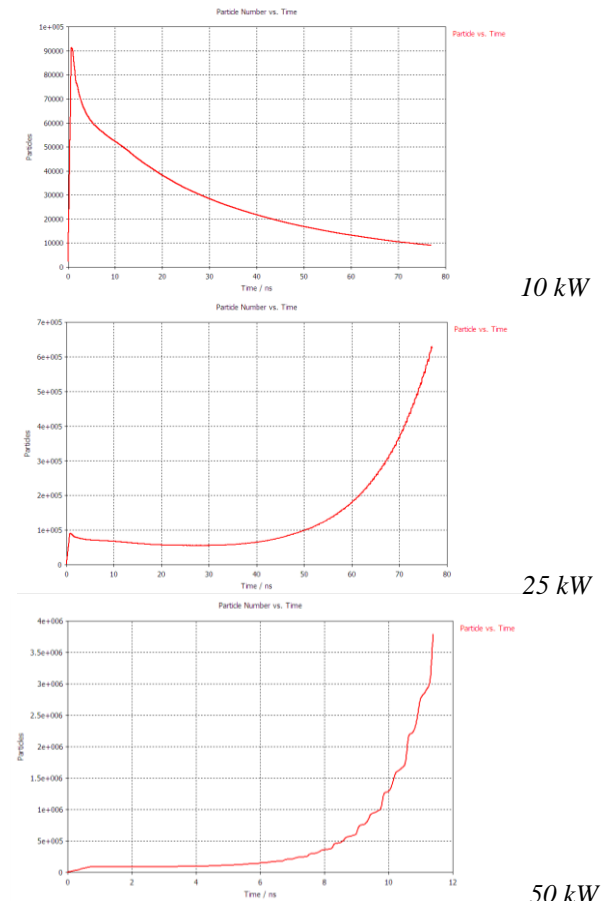


Fig. 7. Number of particles vs. time at various levels of the input power

Areas of the structure which undergo multipacting at 25 kW of the input power are shown in Fig. 8. Obviously, cold part of the coupler with cold ceramic window undergoes multipacting.

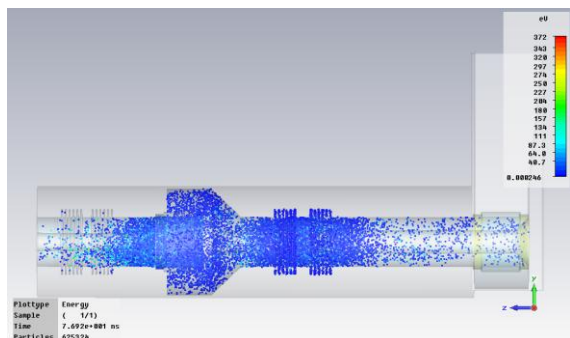


Fig. 8. The areas of the structure which undergo multipactor discharge. 25 kW of input power

According to the simulation results significant increase in the number of particles was observed in cold part of the structure at the input power levels over 25 kW.

### CONCLUSIONS

Simulations by both codes predict the particle number growth in cold part of the input coupler at power levels of about 21...25 kW and further evolution of an electron avalanche up to 60 kW. The next stage of the

investigation should be a more detailed simulation of the whole structure, as well as detailed investigations for the warm ceramic window at low levels of transmitted power. Possibly one way of the discharge preventing can be an external electric or magnetic fields using.

### REFERENCES

1. L. Merminga et al. ARIEL: TRIUMF's Advanced Rare Isotope Laboratory // *Proceedings of IPAC2011*, San Sebastian, Spain, September 4-9, WEOBA01. 2011, p. 1917-1919.
2. V. Zvyagintsev et al. Nine-Cell Elliptical Cavity Development at TRIUMF // *Proc. of SRF2011 Conference*, Chicago, USA. 2011, MOPO020.
3. B. Aune et al. Superconducting TESLA cavities // *Phys. Rev. ST Accel. Beams* 3. 2000, p. 092001.
4. V. Veshcherevich, I. Bazarov, S. Belomestnykh. A High Power CW Input Coupler for CORNELL ERL Injector Cavities // *Proc. of SRF 2009 Conference*. 2009, p. 722-725.
5. M.A. Gusarova, S.V. Kutsaev, V.I. Kaminsky. Multipacting simulation in accelerator RF structure // *Nuclear Instrument and Methods in Physics Research*. 2009, v. A599, p. 100-105.

Article received 02.10.2013

### МУЛЬТИПАКТОРНЫЙ РАЗРЯД В УСТРОЙСТВЕ ВВОДА МОЩНОСТИ В ЛИНЕЙНЫЙ УСКОРИТЕЛЬ ЭЛЕКТРОНОВ

М.А. Гусарова, В.Л. Звягинцев, И.И. Петрушина

Рассмотрены вопросы возможности возникновения мультипакторного разряда в устройстве ввода мощности eLINAC. Определены пороговые уровни передаваемой мощности, при которой возможно развитие мультипакторного разряда, и выявлены наиболее подверженные разряду области.

### МУЛЬТИПАКТОРНИЙ РОЗРЯД У ПРИБОРІ ВВЕДЕННЯ ПОТУЖНОСТІ В ЛІНІЙНОМУ ПРИСКОРЮВАЧІ ЕЛЕКТРОНІВ

М.А. Гусарова, В.Л. Звягинцев, І.І. Петрушина

Розглянуто питання можливості виникнення мультипакторного розряду в пристрої введення потужності eLINAC. Визначено порогові рівні переданої потужності, при якій можливий розвиток мультипакторного розряду, та виявлено найбільш схильні області до розряду.