

# HIGH POWER 10 MeV, 25 kW ELECTRON LINAC FOR IRRADIATION APPLICATIONS

Y.J.Pe<sup>1,2</sup>, Y.L.Hong<sup>1,2</sup>, S.K.Lu<sup>1,2</sup>, J.G.Zhang<sup>2</sup>, L.Shang<sup>1</sup>,  
G.Y.Feng<sup>1</sup>, K.Jin<sup>1</sup>, Z.M.Wang<sup>2</sup>, K.Xuan<sup>1</sup>, B.Xu<sup>1</sup>, D.C.Jia<sup>1</sup>

<sup>1</sup>National Synchrotron Radiation laboratory, University of Science & Technology of China, China

<sup>2</sup>Anhui Gray Electronic Technology Lit. Co., China

## Abstract

Using the electron beam to sterilize medical products and cosmetics, and food preservation and so on, has become important and efficient manners recently in number and variety. This paper described the design, construction, and commissioning of a high power electron LINAC which can provide beam energy of 10 MeV, beam power of 25 kW. The paper also given beam dynamic simulation results which beam loading effect was taken into account, and testing parameters.

## INTRODUCTION

In recent years, radiation processing has been rapidly growing in various fields of industrial production and scientific research [1-3]. In particular, several applications, such as polymers chemistry, sterilization, or food irradiation, electron treatment represents a very powerful alternative to other industrial techniques. Especially, food safe has become an important task concerning person health etc., and food irradiation is a powerful tool to keep food safe. As an irradiation source, electron beam from a high power electron LINAC of 10 MeV will be a main irradiation source [4-6].

Design, constructing and test of LINAC of 25 kW, 10 MeV which will be used for food irradiation and other applications, were described in this paper. Preliminary testing results shown that the machine has a good performance which coordinate to design value.

## DESIGN OF THE ELECTRON LINAC OF 25 kW, 10 MeV

Fig. 1 is the payout of the electron irradiation accelerator of 25kW, 10MeV. It consists of an electron gun, travelling wave accelerator tube of  $2\pi/3$  mode, klystron and its modulator, scanning magnet, vacuum system and control system etc.

The bunching cavities and accelerating cavities were designed as a combined type so that length of accelerator tube was reduced. The dimension of cavities and couplers were calculated by means of MAFIA, CST code. Beam dynamic simulation which including beam loading effect has done. When gun anode voltage is 50 kV, beam current is of 300 mA, accelerator tube will be composed of 4 bunching cavities, 47 accelerator cavities and tow couplers. The phase velocities in these cavities were respectively: 0.56c of one cavity, 0.92c of three cavities and 0.999c of 47 cavities. Fig. 2 shown the beam energy

gain curve and its phase trajectory, when beam current is of 300 mA and origin phase of electron is different. The microwave power loss in distance of 1 mm along the accelerator tube for  $I_b=0$  and  $I_b=300$  mA were shown in Fig. 4. The energy spread simulated was shown in Fig. 4. When beam current increasing from 300 mA to 411 mA, the beam energy reduce from 10 MeV down to 8 MeV (see Fig. 5). Fig. 6 is beam envelope calculated.

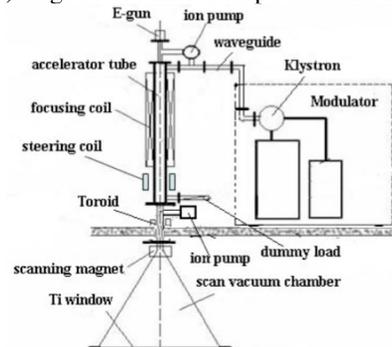


Figure 1: Layout of electron LINAC of 25 kW, 10 MeV.

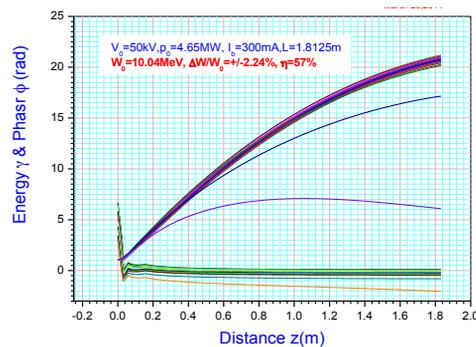


Figure 2:  $I_b=300$ mA, energy gain curve and phase trajectory.

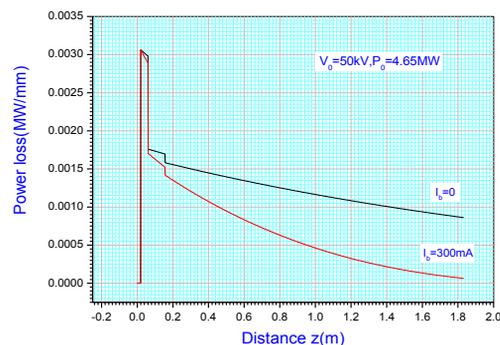


Figure 3: Power loss along the accelerator.

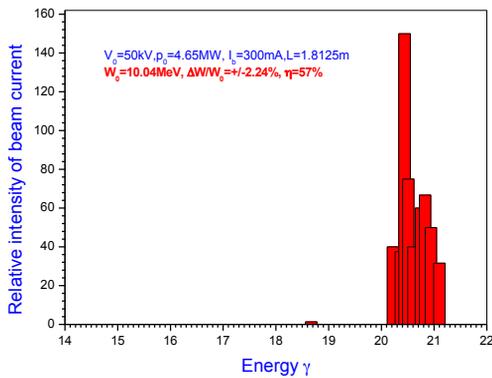


Figure 4:  $I_0=300\text{mA}$ , energy spread of beam.

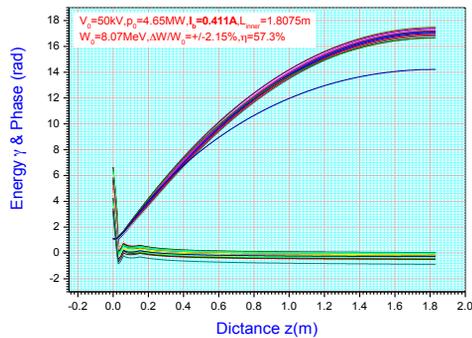


Figure 5:  $I=411\text{ mA}$ , energy gain curve and its phase trajectory.

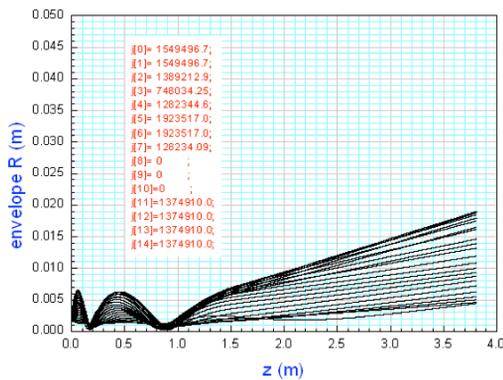


Figure 6: Beam envelope of the facility.

According to simulation results as mentioned above, designed and constructed an electron LINAC for irradiation applications. Table 1 is main design parameters of the facility. Fig. 7 is a photo of the LINAC and Fig. 8 is a photo of scanning vacuum chamber and transport belt which is used for transport goods irradiated.



Figure 7: Photo of LINAC of 10 MeV.

Table 1: Main Design Parameters of the LINAC of 10 MeV, 25 kW

Energy (MeV)	8-10
Beam Current (mA)	300-410
Pulse Width (us)	15.6
Repeat Frequency (pps)	537
Microwave Power (MW)	5.0
Pulse Beam Power (MW)	3.0-3.2
Average Beam Power (kW)	20-25
Energy Spread (%)	±2.7
Beam Size (at window) (mm)	~30
Scanning Width (cm)	60-80
Gun Voltage (kV)	45-50

## TEST AND COMMISSIONING

Recently the electron LINAC was installed and start to test and commissioning. When input microwave power is 5 MW, frequency is of 2856.4 MHz, we have got the preliminary results tested as following: beam current is 320 mA, energy is of 10 MeV, average beam power is 11 kW, when repeat frequency is of 291 pps, beam pulse width of 12  $\mu\text{s}$ . Energy measurement is employed a range method, Fig. 9 shown the range of electron measured in glass. Because of vacuum condition is not so good, so far it difficult to increase the repeat frequency, so average beam power have not reached the design value.



Figure 8: Photo of scan vacuum chamber and transport belt.

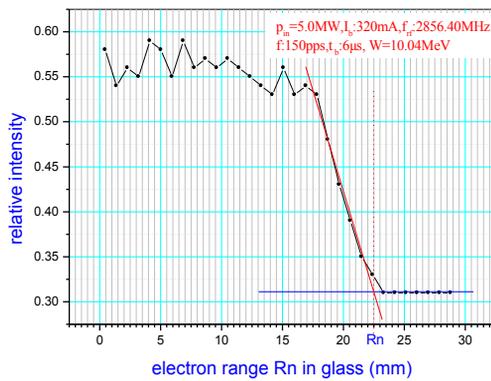


Figure 9: Electron range in glass measured.

## CONCLUSION

Preliminary test results shown that the beam of 25 kW, 10 MeV can get and will be running well, after conditioning and vacuum getting more better.

## REFERENCES

- [1] J. Coth Smith and Suresh Pillai, "Food Safety", Food Technology 58(11), (2004) 48.
- [2] O.P. Snyder and D.M. Poland, "Food Irradiation Today", <http://www.hi-tm.com/Documents/Irrad.html>
- [3] Zhou Ruimin, Liu Zhaomin, and Wang Jinghua, "Radiation Vulcanization of Rubber", Nuclear Techniques 23(6), (2000) 427.
- [4] M. Tiunov, V. Auslender, V. Cheskidov et al., "5-10 MeV Industrial High Power Accelerator", Proc. of EPAC 2002, pp. 2813-2815 (2002).
- [5] V.V. Tarnetsky et al., "Status of Work on 5 MeV 300kW Industrial Electron Accelerator Prototype", Proc. of RuPAC 2006, pp. 351-353 (2006).
- [6] R.C. Sethi, "Electron Beam Accelerators for Material Processing: a BARC Scenario", Proc. of APAC 2004, pp. 708-710 (2004).