CONSTRUCTION OF DISK-LOADED BUNCHER FOR S-BAND LOW ENERGY TW ELECTRON LINAC

F.Ghasemi, F.Abbasi Davani, S. Ahmadiannamini, M.Shafiee Shahid Beheshti University (SBU), Radiation Application Department, Tehran, Iran
M.Lamehi Rashti, S. H. Shaker, School of Particles and Accelerators, IPM, Tehran, Iran

Abstract

The project of design and construction of Traveling linear electron accelerator is being performed by the Institute for Research in Fundamental Sciences (IPM) and Shahid Beheshti University in Iran. By using the results of the calculations and by dynamic simulation of electron beam in the designed buncher, the dimensions of the designed sample have been obtained. This paper discusses construction of this buncher.

INTRODUCTION

Fig. 1 represents a simple model of a typical TW electron Linac. The main parts of an electron linear accelerator are: RF Generator System, Electron Gun and Accelerating Structure.

The project of design and construction of linear electron accelerator is being performed by the Ministry of Science, Research and Technology and school of particles and accelerators, Institute for Research in Fundamental Sciences (IPM). The aim of the current research is to achieve the knowledge and the technology of manufacturing the components of linear accelerator.

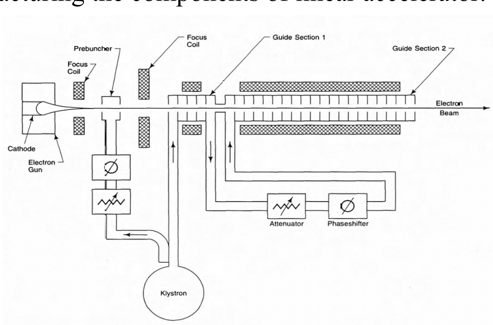

Figure 1: Simple model of a typical TW electron Linac [1].

In our design, the thermionic electron gun produces a continuous beam with 45 keV (βe =0.39) kinetic energy and 1 mA current. Inside the buncher, the beam is bunched and accelerated up to 1.4 MeV and 68% of the beam is captured. Then inside the accelerating structure, the electrons are accelerated up to 8.25 MeV. Both structures are electrical-coupling disk-loaded waveguide structures [2].

In this project, the RF generator is Twystron with 2 MW peak power which its drivers are in the construction stage.

ACCELERATING STRUCTURE

In electrical-coupling disk-loaded structure, a cylindrical tube in which there are disks with certain distances is used. The distance, thickness and substance of the disks and also their interior and exterior diameter are chosen based on the mode [3].

The frequency of the RF wave, the quality factor (Q), the shunt impedance, and the easiest way to fabricate them are measured and evaluated. The accelerating structure is a constant-impedance structure. The cell to cell phase advance is 90°. The length of accelerating structure is 120 cm that consists of two 60 cm structures with 24 cells (23 cells + two half cells on both sides) [2].

The main dimensions of cavity are illustrated in Figure 2 Considering all respects and using HFSS and SUPERFISH software, the final cavity dimensions are obtained and showed in Table 1 [2]. Figure.3 shows one main accelerator tube.

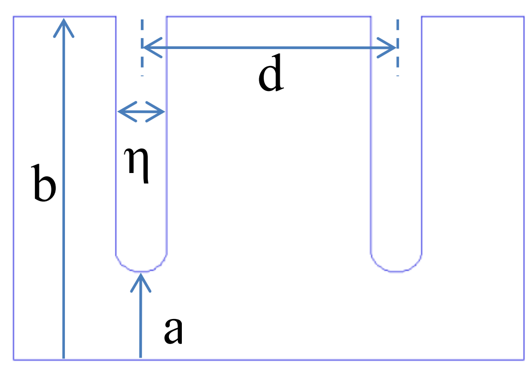

Figure 2: Disk loaded structure.

Table 1: Obtained Dimensions for Frequency 2998MHz

Parameter	A	b	d	ηd	Frequency
Value	1 cm	3.933 cm	2.5 cm	0.5 cm	2997.92 MHz

Figure 3: main accelerator tube.

BUNCHER

Studying the electrons motion in the field through the aperture of the disks and using the equations of disk-loaded waveguide theory, the dimensions of the desired buncher for this project were obtained [2].

Higher bunching factor, larger initial phase range, and smaller final phase range are favorable in the disk-loaded buncher [4].

The buncher has 15 cells (14 plus two half cells on both sides) and its length is 30.8 cm. 68% of the continuous beam (244°) produced by electron gun is captured and is focused to about 15° at the end of accelerating structure. The average kinetic energy at the end of buncher is about 1.4 MeV and at the end of accelerating structure is equal to 8.25 MeV and the energy spread is 0.26 MeV (3.1 %). The last 2.5 cells (two plus one half cells) are similar to the accelerating structure cells. The disk hole radius (a) and the disk thickness (ηd) for each cell is similar to the accelerating structure cells [2].

Figs. 4 and 5 show relative phase evolution of different particles in buncher and dimensions of buncher respectively.

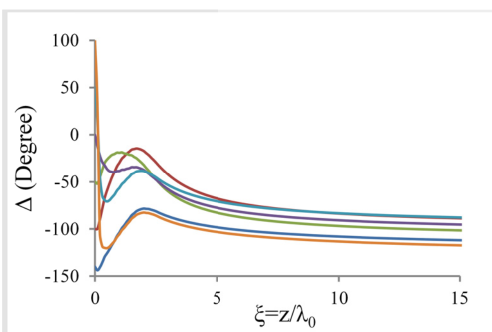

Figure 4: Relative phase evolution of different particles.

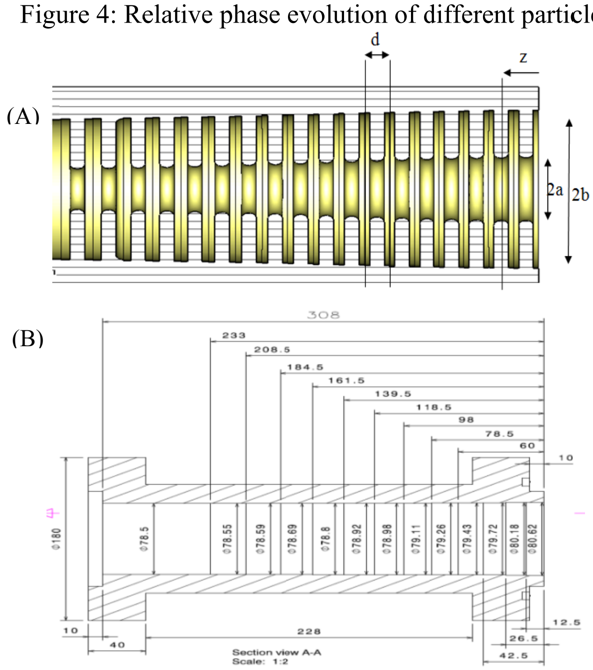

Figure 5: A) Layout and B) dimensions of buncher.

MATERIALS AND METHODS

Since the value of shunt impedance is in proportion with the square root of electric conductivity, metals such as copper, silver and gold are appropriate for making cavities [4]. Copper was used for fabricating cavities.

In our method, instead of joining the rings and separate disks, we managed to make an integrated model of the cavities of buncher, by cooling the disks in liquid nitrogen temperatures and heating the cylinder shaped tube (whose interior was carefully and appropriately cut by a lathe). To do so, after the disks were appropriately washed and set on the designed fixture, we cooled the cavity disks whose diameter was larger than the interior diameter of the cylinder-shaped tube in liquid nitrogen temperatures. The cylinder shaped tube was heated by a heater. Cooling the disks in liquid nitrogen temperature leads to their contraction and heating the tube leads to its expansion. After spending enough time, the disks which were put into the tube pressed the wall and became fixed [5].

The side figures show the buncher waveguide of an electron Linac and its fabrication by integrated method. Also this part which has been made in the Radiation Application Lab of Shahid Beheshti University consists of a set of fifteen cavities.

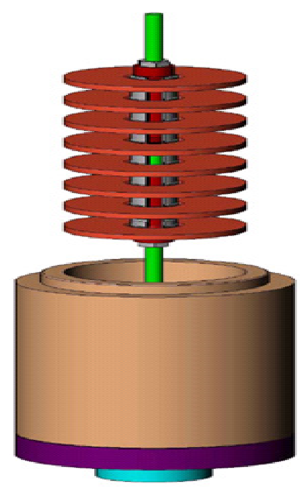

Figure 6: Fabricating of buncher by integrated cavities.

In this project for fabricating buncher, first a sample of tube of buncher was made of aluminum. Then accuracy of machining was measured by CMM. Fig. 7 shows prototype of tube of buncher that fabricate for Measurement of precision manufacturing by CMM. Its accuracy was achieved0/02 mm. Fig. 8 show the final tube of buncher and Figs. 9 and 10 show disks of buncher and Setting base for them. Fig.11 shows the final buncher. It is necessary to wash all parts before assembling the tube.

Fig.12 shows the buncher with other parts of main structure of accelerator (main accelerating tube and RF input couplers). These parts will be used to inject RF high

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power for accelerating electron after preparing cooling systems and solenoids.

DISCUSSION AND CONCLUSION

Making a prototype and measuring accurately helps to fabricate the final tube very much. The results of aluminium tube prototype represent 0.02 mm precision manufacturing.

In this paper, shrinking method was used for assembling parts of buncher. Manufacturing of proper buncher for under construction travelling wave linear accelerator is results of this paper.

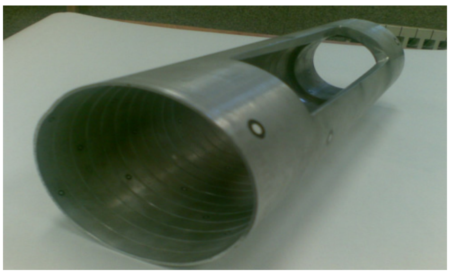

Figure 7: Aluminium buncher Prototype for measurement precision of manufacturing by CMM.

Figure 8: The final tube of buncher.

Figure 9: Disks of buncher.

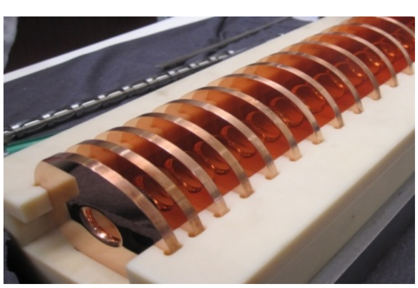

Figure 10: Setting base for disks.

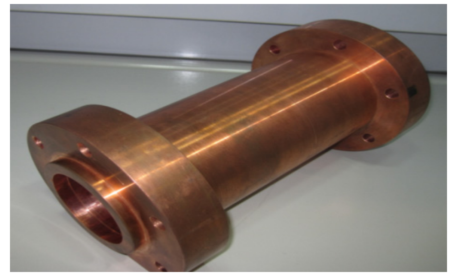

Figure 11: Final buncher.

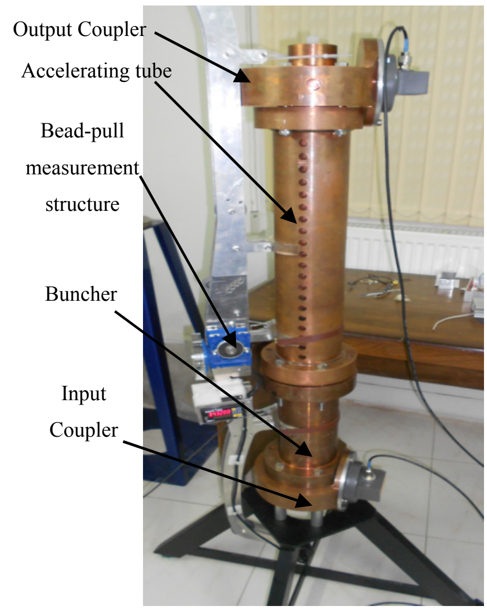

Figure 12: Buncher with other components.

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