THE RESEARCH OF A NOVEL SW ACCELERATING STRUCTURE WITH SMALL BEAM SPOT

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Abstract

A new kind of on-axis coupled biperiodic standing-wave (SW) accelerating structure has been built for a 9MeV accelerator. The research progress was introduced in this paper; it includes the choice of the accelerating structure, the analysis of electron beam dynamics, the tuning of the cavity, the measurement of the accelerating tube and the powered test. The small beam spot is the most interesting feature of this accelerating structure, the diameter of the beam spot is 1.4mm.This accelerator has been used for the x photons generation and the x-ray dose rate is about 3400rad/min/m.

INTRODUCTION

The high energy industrial computed tomography (ICT) which uses accelerator as the driving source has important applications in the fields of aerospace, non-destructive inspection, precise machining etc, the result of the ICT was determined by the performance of the accelerator which used for the generation of x photons, so the accelerating structure with small beam spot is the key of obtaining high space solution and density solution. Usually in order to increasing the transit-time factor and so the effective shunt impedance, nose cone was set in the accelerating cells[1], but the transverse electric field was increased at the same time, so in order to decreasing the beam spot ,we attempt to take out of the nose of the accelerating cell .

DESIGN OF THE ACCELERATING STRUCTURE

This accelerating structure was an on-axis coupled biperiodic SW structure and was made of 11 accelerating cells and 10 coupling cells, illustrated in Figure 1.

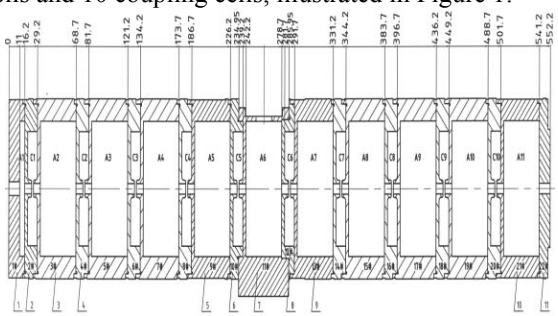

Figure 1: The accelerating tube

There are no nose cones in the accelerating cells and in order to making the electric field cutting off, the nose cones were set in the coupling cell. Adjacent cells are coupled magnetically, through slots cut in the outer walls and so the accelerating structure is a resonant system. In order to decreasing the secondary coupling. The SUPERFISH code was used in the design and optimised of the cavity; the distribution, the stored energy and the power dissipation of the wall were calculated. The electric field in the cells were illustrated in Figure 2 and electric field on the axis was illustrated in Figure 3.

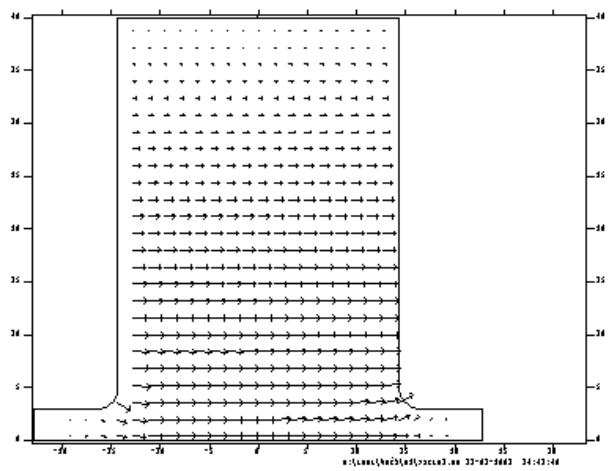

Figure 2: The electric field in the cell

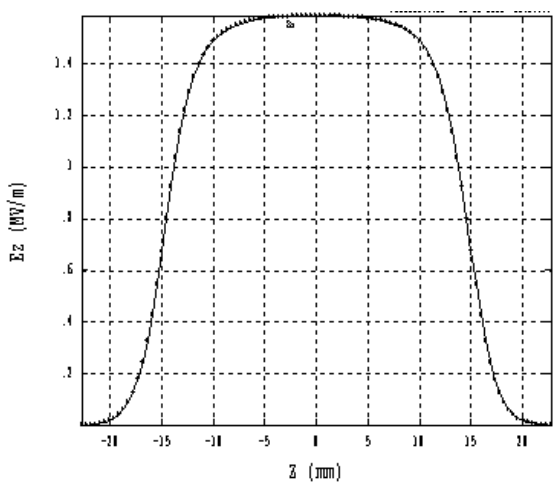

Figure 3: The on-axis electric field

There are no nose cone in the accelerating cells, this makes the longitudinal electric field much smooth, and

the transverse electric field was depressed, so the transverse defocusing forces is small, it contributes to obtain a small beam spot. The GPT code was used to analysis the behavior of the electron beam in the accelerating tube and several designs were check in order to get an small beam spot. It can getting a better transverse focusing by adjusting the ration of electric field in the first cell and the second cell, when optimising the ratio of the electric field to 1：2.3：2.5, the small beam spot was obtained, the diameter of the beam spot is about 1.0mm(FWHM) at the end of the accelerating tube without the external focusing, and it satisfied our need. Figure 4 shows the electrons trajectory. Figure 5 shows the electrons transverse distribution on the target. Figure 6 shows the electrons distribution at the exit of the accelerating tube.

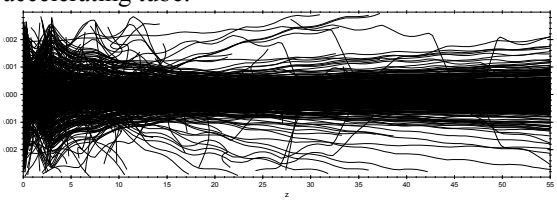

Figure 4: The trajectory of electrons

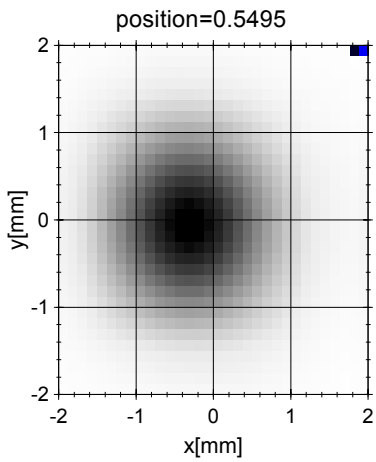

Figure 5: The transverse distribution of electrons

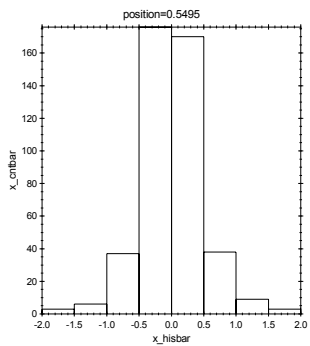

Figure 6: The relation of electrons and beam spot

THE TUNING OF THE ACCELERATING STRUCTURE

The vector net analyzer was used to measure the resonant frequency, the quality factor, and the electric field distribution. The tuning of the accelerating tube was finished by regulating the resonant frequency of each cell in the chain carefully. The adjacent coupling constant was calculated, it is about 1.8%. The secondary coupling factor was depressed by optimising arranged the cell. The jointing and cool measurement were done. The frequency of the π/2 mode is 2856MHz, the coupling factor of microwave source-to-accelerating tube is 1.3. Dispersion relation of the accelerating structure was illustrated in Figure7. The ratio of the electric field illustrated in Figure8 adjusts to 1：2.3：2.5 to satisfy the simulation condition. Figure9 is the jointed accelerating tube.

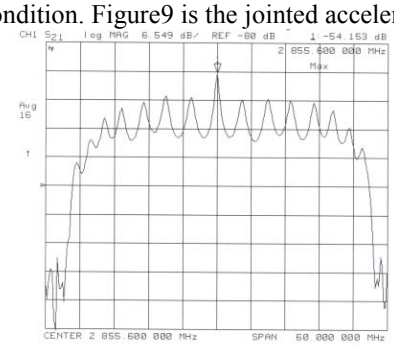

Figure 7: The dispersion relation of the tube

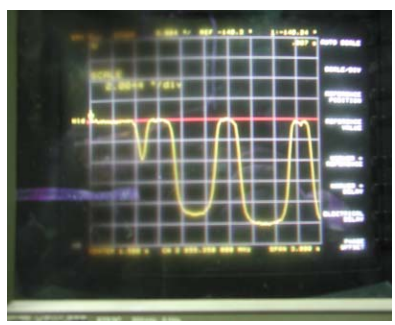

Figure 8: The electric field of the first three cells

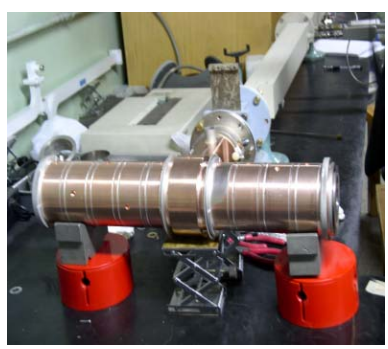

Figure 9: The accelerating tube

THE EXPERIMENT OF THE ACCELERATOR

The conditions of the accelerator experiment are: microwave power is about 7.5MW,the injected current from the electron gun is 500mA and the electron energy is 20keV. The energy of the electron at the end of the accelerating tube is 9MeV. The beam spot was measured carefully; the diameter of the beam spot is about 1.4mm(FWHM). This accelerator has been used for the x photons generation and the x-ray dose rate is about 3400rad/min/m. The 3D CT space solution is 2.5line pairs/mm, density solution is about 5‰.

SUMMARY

We use no-nose cone cells as accelerating structure, this makes the longitudinal electric field much flat, and the transverse electric field was depressed, so the transverse defocusing forces is small, it is one way of obtaining small beam spot.

REFERENCES

[1] T.P.Wangler,Principles of RF Linear Accelerators,1998