The Commission of A 2MeV X-Band SW Accelerating Guide

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Abstract

A 2MeV, X-band, on-axis coupled, standing wave electron linear accelerator guide is described and the experimental performance is given in this paper.

1 INTRODUCTION

The many advantages of using higher RF frequencies for eleratron linear accelerators include smaller size, higher shunt impedance, higher breakdown threshold level and short fill time. In addition, increasing the RF frequency increases the accelerated beam energy for a fixed input RF power. An extremely small accelerator structure with high shunt impedance is needed for medical and industrial application. The Accelerator Laboratory at Tsinghua University, which has extensive experience with S-band elerctron linacs, having studied X-band SW electron linacs since 1991, is currently developing a prototype 2 MeV, x-band SW accelerating guide. Work is also proceeding on the development of a portable 6 MeV X-band accelerating structure.

The design parameters of a 2MeV, X-band, on-axis coupled, SW accelerating guide operated in the $\pi/2$ mode is as following. The power soruce is a 0.8MW tunable coaxial magnetron at 9.3GHz. It is a 1.48mm long and consists of 21 cells including 9 cells of bunder. To minimize the size and weight of structure and to improve the beam spot as well as the transmission, the phase-focusing technique was used without a bulky, externalmagnetic focusing device. By choosing the right phase velocity taper and tapering the magnitude of the buncher field levels from cavity to cavity, the field in the buncherregion provides transverse focusing as well as longitudinal bunching and acceleration. Fig.1 shows schematic illustration for the on-axis structure. The phase orbitsand energy spectra are shown in Fig.2 and Fig.3. They are under the case of 16KV injection voltage and 0.6MW of RF power.

2 COLD TEST

The guide tuning results are: The frequency uniformity is ±1.5MHz for the accelerating cavities and ±2.0 MHz for the coupling cavities. The stop band is less than 2.0 MHz. The nearest neighbor coupling, K for accelerating section, is 3.7%. The nearest neighbor coupling factors for the buncher section were adjusted to meet the requirement of the field configuration. The bead pull data is shown in Fig.4. The passband characteristic of the guide is shown in Fig.5. The brazing was done in collaboration with BIEVT. When the overall structure was brazed, evacuated and sealed, no post-braze tuning of the guide was done. Fig.6 is a photograph of the 2 MeV On-axis SW Guide.

3 HIGH POWER TEST

The device of the high power test has been completed by Tsinghua University Accelerator Laboratory in cooperation with BIEVT and the China Institute of Atomic Energy. A coaxial magnetron made by BIEVT is adopted as the RF system power source. Its output peak power is 0.8 MW with the operating frequency range from 9305Mhz to 9325.

A four-port circulator is used in the system as a isolator between power source and the guide. It has 0.3db forward loss and 30db isolation. The guide is installed at port 1 and the magnetron at port 4. Two absorb-loades are connected respectively to port 2 and port 3, and their VSWR are less than 1.05. The insertion loss of the whole RF transmission system is less than 0.5db. In order to prevent the RF breakdown ,the system is pressurized with SF_6 at 2 atm. Fig.7 and Fig.8 are two photographs of the four-port circulator and the coaxial magnetron. Fig.9 is a photograph of the total set-up system for the commissioning. A Line-type modulator provides a pulsed voltage to RF power source at -36KV and to electron gun at -17KV via a bifilar pulse transformer. The transformer ratios are 1:3.74 and 1:1.93 respectively. The PFN used in the modulator has 10 sections and a characteristic impedance of 50Ω. A Flat-topped pulse is obtained by tuning the compact 10 sections respectively. Fig.10 shows a pulsed voltage waveform of modulator for magnetron. Fig.11 shows a microwave envelop to be tested at port 4 of the circulator. Fig. 12 shows the beam energy curve with the method of the Half-Value Layer (HVL). Fig.13 shows x-ray intensity angle distribution.

The results of the beam test are found to coincide with the design of the 2MeV guide, as shown in the table 1. The pulsed beam current is 108mA. At present, Tsinghua University Accelerator Laboratory is developing a 6MeV X-band ,on -axis coupled,SW accelerating guide in collaboration with BIEVT.The guide will be completed in this year.

4 REFERENCES

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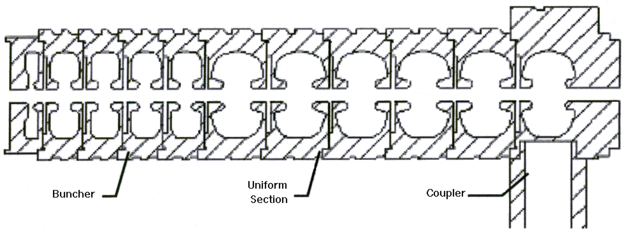

Fig. 1. Schematic Illustration for On-axis Structure

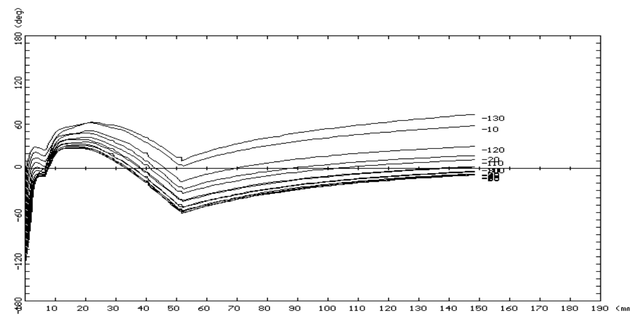

Fig. 2. Longitudinal Orbits for Various Input Phases

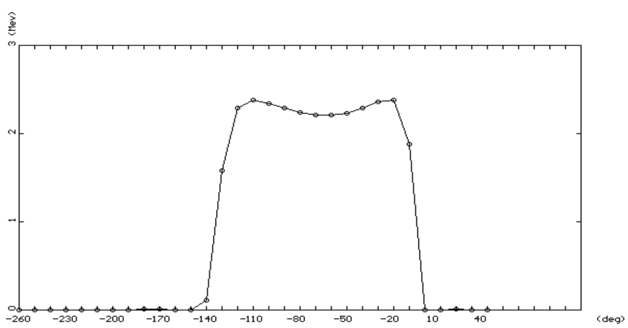

Fig. 3. Energy Spectra as a Function of Input Phase

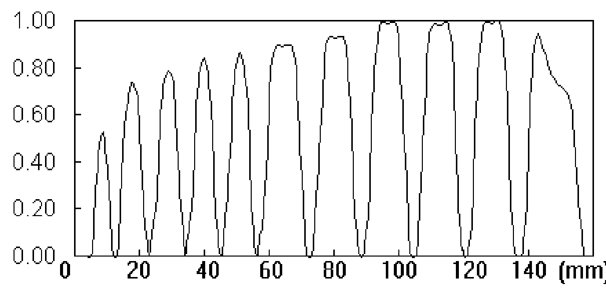

Fig. 4. On axis Bead Drop Data

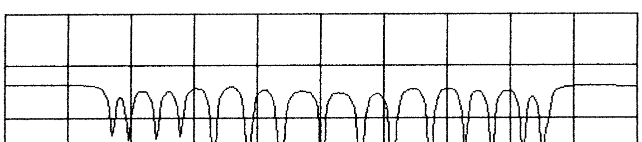

Fig. 5. Modules of Complex Reflection vs. Frequency

Fig.6. 2MeV On-axis SW Guide Braze Assembly

Fig.7. Coaxial Magnetron

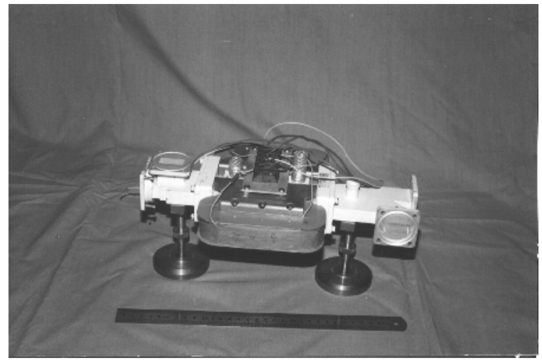

Fig.8. Four-port Circulator

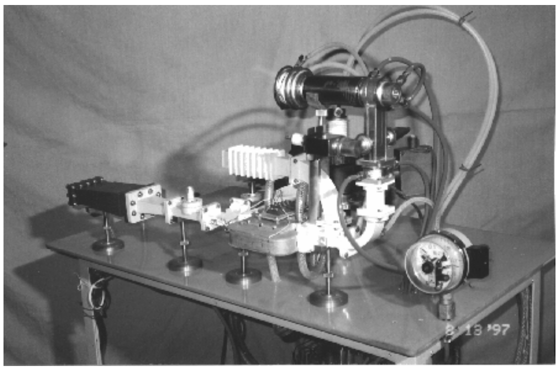

Fig.9 Setup for Beam Test

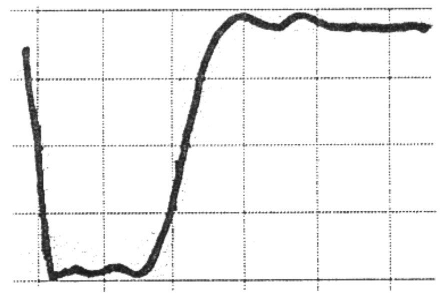

Fig.10 Waveform of the pulsed voltage

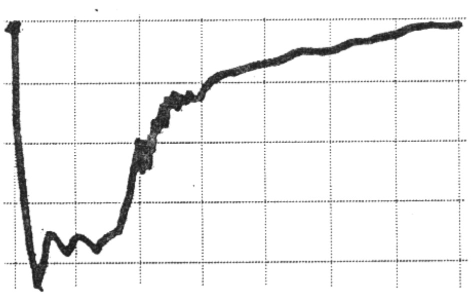

Fig.11 Waveform of microwave envelop

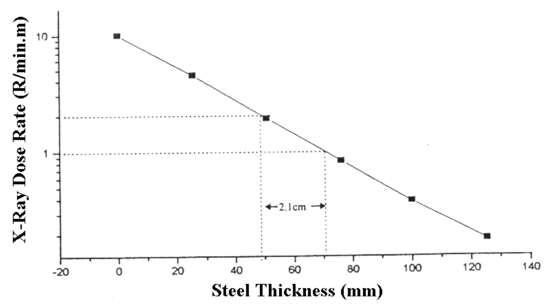

Fig.12 .Beam Energy Curve

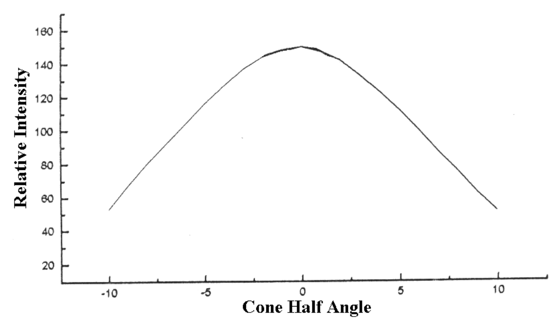

Fig.13. X-Ray intensity Angle Distribution

Table 1 guide Characteristics

Parameter	RF Input Power (MW)	Operation Frequency (MHz)	Injection Voltage (KV)	Electron Energy (MeV)	Beam Current (mA)	Beam spot size (mm)
Design	0.60	9300.0	16	2.3	75	1.5
Experiment	0.68	9316.5*	17	2.4	>90	1.4

* To meet the operation frequency range of the magnetron made by BIEVI