Bveri activies on MBK RF source

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Abstract- Beijing Vacuum Electronics Research Institute (BVERI) has dedicated on high power MBK RF source recent years, C/X band MBK source has already been manufactured and applied into accelerator system for NDT. In this article, an S-band klystron using reversed permanent magnet focusing system will be shown. This klystron can work at 2998 MHz and obtain a ≥3.1 MW peak output power. Currently, this tube is applied in an accelerator for medical treatment test, further test and validation is under way.

Keywords- multi-beam klystron, radiation therapy

I. INTRODUCTION

Considering the microwave power needed by LINAC system and the application condition brought by the working system, multi-beam klystron (MBK) is a good option to provide power for the system. Lower working voltage makes it possible to operate without oil tank in the electron gun section; also with the help of electron modulation technique, MBK can give out higher power level in shorter tube length. Furthermore, rPPM is applied to make the whole system more compact and compatible in various situations.

When compared with single beam klystron and magnetron, higher output power and duty cycle can be reached with a notable increase in efficiency.[1][2]

II. TECHNICAL SPECIFICATION AND DESIGN DETAIL

Based on electron energy and microwave power needed by the radiation therapy system, this tube is designed to operating at the voltage of 48 kV and the output power of 3.1 MW. Also the dimension and weight is taken into consideration for the medical gantry system. Picture of the tube is shown in Figure 1.

The design parameters are listed in Table 1.

Figure 1. Photograph of the klystron.

Table 1. Basic technical characteristics.

1	Center frequency	2998 MHz
2	Cathode voltage	48 kV
3	Output pulse power	3.1 MW
4	Efficiency	≥50%
5	Dimension	D300*H500 (mm)
6	Weight	45 kg

This klystron adopts a coaxial cavity design. 40 electron beams can obtain a voltage of 48 kV, a peak current of 130 A, and a output power of 3.1 MW. 4 interaction cavities are used to compress the size and weight of the klystron. The overall interaction length is 170 mm.

E-gun design results are shown in Figure 2. According to the electron trajectory, the beam has good laminarity.

Focusing system adopts periodic reversed permanent magnet focusing system. Considering the length of the high-frequency interaction cavities, it is achieved by 2 reversed cycles using 3 pieces of magnets. 1/8 models of magnetic field in simulated computation is shown in Figure 3.

The focusing magnetic field is simulated and optimized for a single electron gun, so that the fluctuation period of the electron beam matches the period of the focusing magnetic field. Therefore, when the electron pass through the reversed magnetic field, the radial velocity points to the electron beam axis, which can reduce the electron divergence caused by the reversed magnetic field. The electron beams pass well in Figure 4.

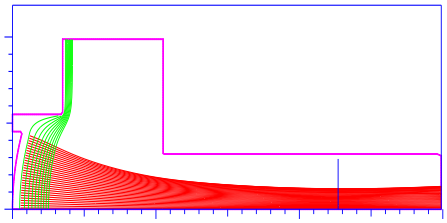

Figure 2. Single electron beam trajectory simulated by EGUN.

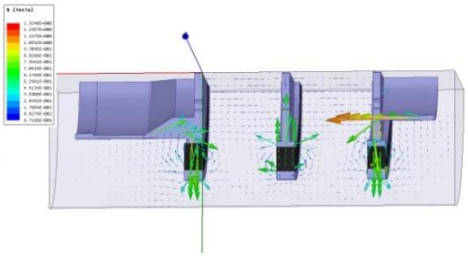

Figure 3. 1/8 models of magnetic field in simulated computation.

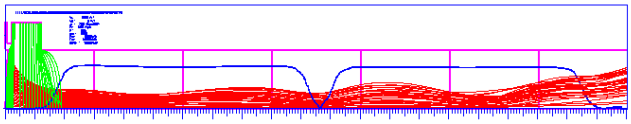

Figure 4. Electron optical trajectory of single beam simulated by EGUN.

III. TEST RESULT AND APPLICATION

Two prototypes have been manufactured and under high voltage test. 3.1 MW output power can be reached under voltage of 49 kV. With good matching of the modulator, the voltage and power waveform are quite stable compared with the magnetron system， which is shown in Figure 5. Pulse width is controllable between 2-6 μs, which is meaningful in medical accelerator system, because of the 0.5 μs time or longer to build the accelerating field.

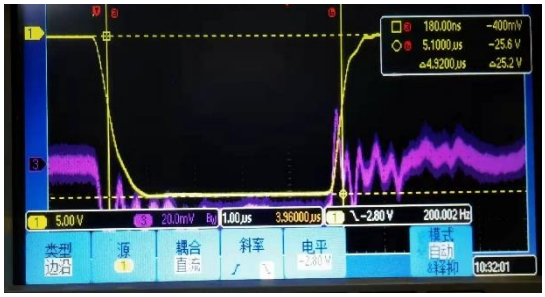

Figure 5. High voltage with shorter rise time.

Also our prototype #0 is provided to one of the top radiation therapy treatment device provider for application test, results including the stability and dose rate have met our expectation.

IV. BVERI MBK SERIES

By far, Bveri has developed and manufactured several MBK source across S/C/X band, which is shown in Figure 6.

Figure 6. S/C/X band MBK providing ≥3 MW output power.

Along with these powerful MBK source, Bveri also developed accelerator tube series matching the output power we can provide, some of these have already been deployed in industrial and medical scenario. Our product series are listed in Figure 7.

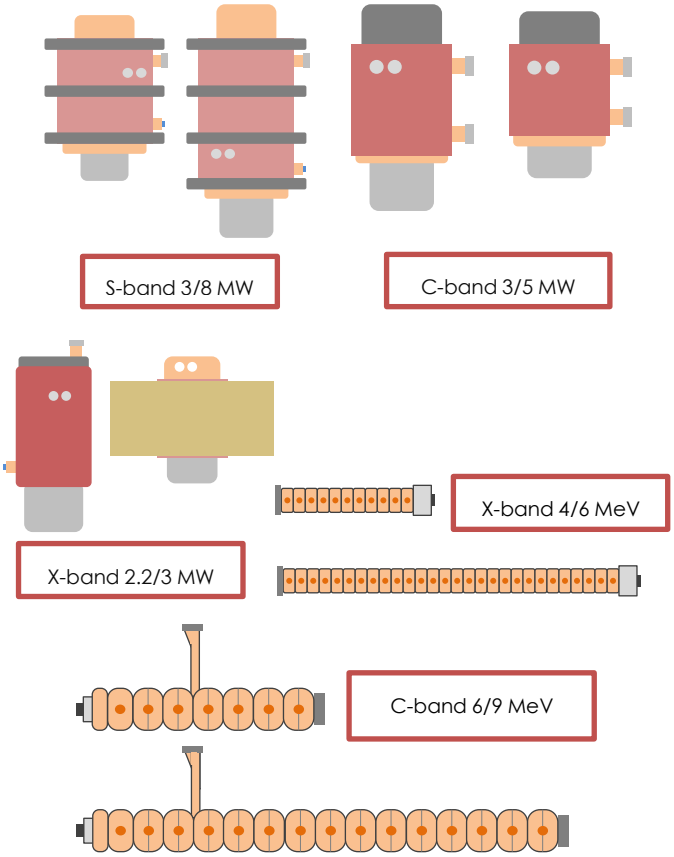

Figure 7. Product series provided by Bveri.

ACKNOWLEDGEMENTS

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