MEDICAL ELECTRON LINEAR ACCELERATOR FOR THE PION GENERATION

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Abstract

We have been studying the conceptional design of a high power electron accelerator of small size for pion therapy. In order to realize such an accelerator, we adopt Disk and Washer accelerating structures, the overall length of which is approximately 50m with klystrons now available for energy, current 500MeV 400μA. We will use a new type of supports of the washers for DAW so that the cooling system become simpler and driving off the heat easier.

Introduction

Since the discovery of a radiobiological advantage of pions over convensional radiation e.g. γ-rays and neutrons, several laboratories have been trying to its medical applications.

At the pion factories e.g. LAMPF, TRIUMF and SIN, protons are used as a primary beam and accelerated by large accelerators. However, for an accelerator exclusively used for therapy should be compact and easily operated being compared with accelerators used for nuclear physics. Because of these reasons, an electron linac will be used for pion facility for therapy at Nihon University.

To establish a compact linac we adopt standing wave structures, especially, DAW structure. Using the standing wave structures, efficiency and energy gradient will be higher than that of the traveling wave structure, which is used for medium or high energy electron linac until now. Moreover, introduction of the DAW structure, will lead to much interest in its rf properties, because of the much larger rf coupling constant and the simplified fabricarion and assembly of accelerating structures.

Properties of DAW structure

Several parameters of the DAW cavity with resonant frequency of 2856 MHz at $\pi/2$ mode are optimized by using the computer code SUPERFISH. Dispersion relation of the optimized cavity and effective shunt impedance and quality factor are simulated.

The cooling of washer part is recognized as one of the major engineering problems of DAW structure. This problem could be simply solved by using the heat pipes which can easily remove the heat from the washer. The axial groove type of heat pipe has several advantages of removable heat quantity and fabrication, which could be made simply by drawing.

Conceptional design of electron linac

Several types of electron linacs are cosidered, and the electron energies and intensities are 800MeV for 300μA and 500MeV for 400μA. These two sets of energy and intensity contribute to almost the same pion yield, according to the calculations considering quasi-free process.

We employ klystrons of 30kW average output power which are commercially available to feed the rf power to acceleration tubes. One or two meters acceleration tube of the DAW type is fed the rf power by one klystron.

A high power isolater is inserted betweeen the klystron and acceleration tube to sweep the reflected wave to dummy load, which occers within a period of build up time.

To avoid beam break-up focusing magnets are placed between acceleration tubes biperiodicaly. Near the focusing magnet beam profile and intensity monitors are placed for automatic operation of the linac.

In table 1, several operation modes of klystrons and other conditions which can realize the above mentioned beam conditions are listed.

If the higher power klystron could be available, the higher energy gradient should be possible, then the more compact linac could be realized and also higher duty cycle attainable.

Table 1 Typical operation mode of linac.

Beam power (average)	800MeV,300μA		500MeV,400μA	
Unit length (m)	1	2	1	2
RF peak power (MW)	15	10	15	15
RF pulse width (μs)	6	9	6	6
Repetition rate (pps)	300	300	300	300
Energy gain (MeV/m)	26	15.5	24	15.5
Beam pulse width (μs)	4.0	6.7	4.2	4.4
Peak current (mA)	250	150	320	300
Number of sections	31	27	21	17
Total length (m)#	68	87	48	57
Total RF power (kW)	840	730	570	460
Efficiency (%)	29	34	36	46

With a injecter and focus system.