2MeV/u APF-IH Linac for plactical use

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Abstract

We are studying an APF-IH type linac for plactical uses. The compact(L=1.5m) linac accelerate particle from 40 keV/amu to 2.0 MeV/amu. This Alternating-Phase-Focus (APF) system can not focus so high intense beam, but beam of several 100 μA is focused by combination of Focus-Defocus sequence. From particle orbit calculation, this compact linac can accept transverse emittance of 113 πmm•mrad, longitudinal phase of 35° and beam intensity of several 100 μA. For example, the compact-size linac can accelerate proton to 2.0 MeV by RF power of about 10kW. We designed the compact IH linear accelerator by particle-orbit calculation. For example, all PIXE and RBS analisis system occupy only 2m×3m. A half-model cavity was designed. The model is manufacturing now for measurement of RF characteristics.

1.Introduction

An IH (Interdigital H) type linac is used for the basic study. The effective shunt impedance of the structure is five to 10 times higher comparing to other acceleration structures [1-3]. Fig.1 show the effective shunt impedance of various types linac.

PIXE method is possible to analyze not destruct the matter of environmental pollution and the waste. It is possible to measure the element analysis in short time, it is high resolution [4]. Therefore it is assigned to analyze the concentration of element of the regulated material to release in short time. The present statistic accelerator and cyclotron that is used for the PIXE analysis are large enough to product the proton and every expensive, so it is not popular yet. The studies of practical linac for 2 MeV proton of PIXE and RBS analysis, 4 MeV Duteron of Positron Emission Tomoguraphy (PET) and 2 MeV/amu $C^{4,5+}$ of cancer therapy test-injector were started with method of high-gradient acceleration-structure. We designed IH type linear accelerator with Alternating Phase Focus (APF). The result is reported as follows.

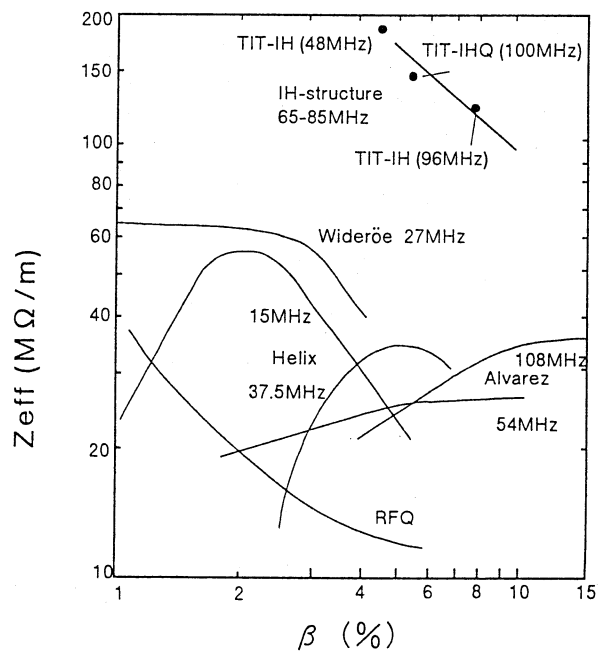

Fig.1 The effective shunt impedance of various type linac.

2. Approach to the compact linac

In the case of general linac, beam intensity is large; beam is defocused with force of space charge effect between particles on the condition of low energy. Therefore in the case of Alvarez and IH type, quadrupole magnet is inserted in drift tube because of the transverse focus.

While the amount of beam current of particle that is necessary for practical uses are enough to be several 100 μA. For PIXE analysis current of proton is lower than 1μA enough. Therefore space charge effect gets to have no problem. It was thought that the acceleration with APF having weak focus is available. We examined the acceleration with IH structure of APF. In consequence it is declared that we can accelerate particle from 40 keV/amu to 2.0MeV/amu.

3. Design of compact IH linac

Small linac that can accelerate paticle from 40keV/amu to 2MeV/amu was designed in the same way of design as high-gradient acceleration linac [5-7]. The linac structure is studying at Tokyo Institute of Technology for medical use and Heavy Ion Fusion driver [8-12].

The way of design:

a) Particles orbit was calculated various phases using APF.

b) Distribution of acceleration voltage was adopted the gradient voltage type which voltages between drift tubes increase as the energy of particles increases.

Figure 2 shows relation between transverse acceptance and injection energy of particle with various phase sequence. Figure 3 shows relation between transverse acceptance and drift-tube bore-radius. According to these calculation, phase acceptance is 35°, transverse acceptance is 113πmm•mrad. If normalized emittance of ion source is 0.6 πmm•mrad, the beam emmitance is 65 πmm•mrad and the linac can accept enough. And install the bouncer, it is possible to raise enough longitudinal acceptance(higher than 65%). Main parameters are shown in table-1. It is supposed that the practical acceleration cavity is 65 cm in diameter and 1.5 m in length.

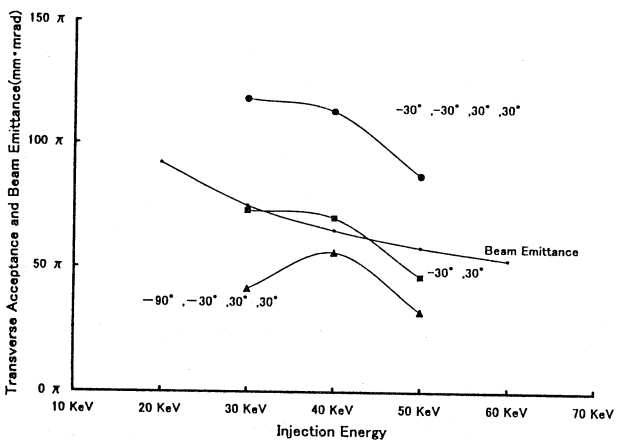

Fig.2 Relation between transverse acceptance and injection energy of paticle with various phase sequence.

Transverse Acceptance v.s. Bore Radius of Drift Tube

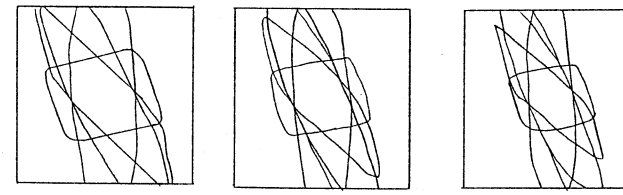

Fig.3 Relation between transverse acceptance and drift-tube bore-radius.

Table-1 **Main parameters of 2MeV APF-IH Linac**

Acceleration Particle	p, D, $C^{4,5+}$
Input Energy	40 keV/u
Output Energy	2.0 MeV/u
Operation Frequency	100 MHz
Synchronous Phase	-30°,-30°,30°,30°
Number of Cell	22
Cavity Length	1.5 m
Cavity Diameter	65cm
Focusing Sequence	-30°,-30°,30°,30°
Transverse Acceptance	113 π mm·mrad
Longitudinal Acceptance	35°
Transmission	~65 % by Buncher
Acceleration Voltage/Gap	30-180 kV at p
Acceleration Rate	1.3 MV/m at p
Effective Shunt Impedance	350 MΩ/m
RF Power	10 kW at p

4. Conclusion

The APF-IH linac was designed to accelerate particle from 40keV/amu to 2.0MeV/amu for plactical uses. It is supposed that the acceleration cavity is 65 cm in diameter, 1.5 m in length, and required RF power is about 10 kW for proton. The compact accelerator is very small and energy saving of electric power. The occupied space for PIXE and RBS analysis is in 2mx3m including some power supplies. Figure 4 shows layout of 2MeV APF-IH linac system for PIXE and RBS analysis. It will be possible to get popular, as an element analyzer, considering the occupied space of floor, needed electric power and cost.

A half scale model cavity being based on results of calculation is making now. After measuring RF characteristics of the model cavity, real machine will be designed and manufactured. After examination of acceleration test, apparatus of PIXE and RBS and

measurement system will be set, and analyze the concentration of element without radiation is supposed to be used for practical study.

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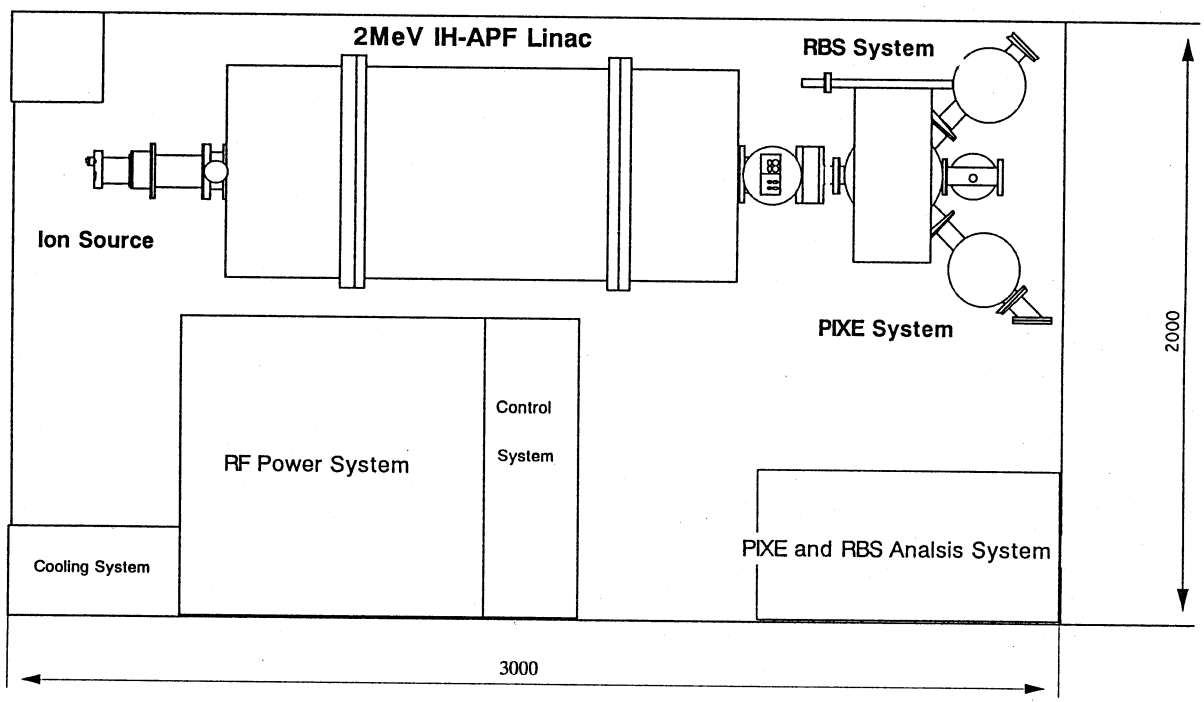

Fig.4 Layout of 2MeV APF-IH linac system for PIXE and RBS analysis.