ACCELERATION TEST OF 2MeV PROTON PROTOTYPE NEW IHQ LINAC

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Abstract

Characteristics of an interdigital-H type linac structure with focusing finger electrodes (IHQ) have been studied. A prototype IHQ linac was designed to accelerate proton from 0.8 to 2.0MeV with an operation frequency of 101.5MHz. The geometrical dimension of the linac tank is 54cm in inner diameter and 92cm in length. The linac has been constructed and has successfully accelerated beams.[1~7]

Introduction

In this structure design, the RF fields is used for focusing of ions as well as for acceleration. The resent success of RFQ linacs which use the RF electric field not only for acceleration but also for focusing has solved most problems associated with the acceleration of intense low velocity ions.

On the other hand, idea of spatially uniform acceleration and focusing scheme of Kapchinsky and Teplyakov[8] who have proposed the basic idea of RFQ linac is known to be applicable only to the low energy region of 2MeV or less, because of its low effective shunt impedance. Boussard tried an RF acceleration and focusing by attaching circular fingers to the face of drift tubes[9]. A similar configuration was proposed by R.W.M ller for his split coaxial structure[10].

We have begun to study an interdigital-H type linac structure with Boussard's electrode configuration. The IH type structure is well known for its high shunt impedance at low and medium particle velocity[11]. This type linac has a high effective shunt impedance and is applicable to the medium energy region.

2MeV Proton Prototype Linac

Based on successful results of the low level RF measurements and numerical calculation of the beam orbit, a prototype IHQ linac is constructed in order to demonstrate the operational capabilities of the new structure.

For the design work of the cavity, a 1/2 scale model resonator was made of brass. The resonance frequency and the field distribution were checked by measurements on the model in term of the end cut of the ridge.

Table
Parameters of Prototype IHQ Linac

Acceleration Particle	Proton
Energy Input	0.8 MeV
Output	2.0 Mev
Operation Frequency	101.5 MHz
Synchronous Phase	- 30°
RF Power	16 kW
Effective Shunt Impedance	132 MΩ/m
Number of Cell	10
Focusing Sequence	FD
Element	RFQ with Finger
Drift Tube Bore Diameter	16 mm
Outer Diameter	48 mm
Stem Diameter	24 mm
Gap Distance	40 mm
Voltage	145 kV
Tank Inner Diameter	54 cm
Length	92 cm
Ridge Width	6.4 cm
Length	72 cm
Height	27 cm
Vacuum System	520 l/s TMP

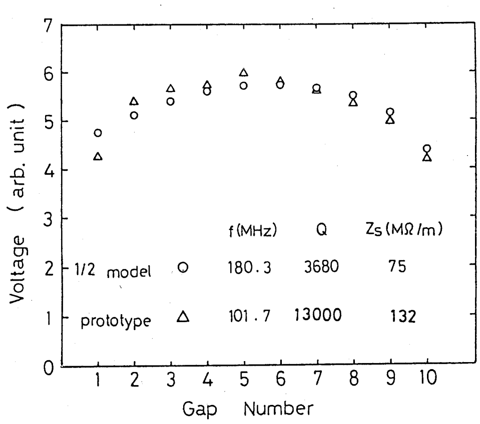

Fig.1 Voltage distribution of 1/2 scale model and prototype linac

The particle trajectory was analyzed by mean of a modified computer program (LINOR)[12] in which the most important input data were obtained from the model experiments.

The main parameters of the prototype IHQ linac are summarized in table. The linac was designed to accelerate protons from 0.8 to 2.0MeV with an operating frequency of 101.5MHz. The geometrical dimension of the linac tank is 54cm in inner diameter and 92cm in length. The voltage distribution of the 1/2 scale model and the prototype linac are shown in fig.1.

Acceleration Test Stand

A beam acceleration test stand was constructed at INS[13]. The injection is the RFQ linac "TALL"[14] which has capability accelerating up to 0.8MeV/u. The accelerated protons up to 2MeV are analyzed with an analyzer magnet having a bending angle of 90° and a momentum dispersion of 160cm. Slit systems, multiwire profile monitors and Faraday cups are placed at the object and image points of the magnet. A photograph of constructed IHQ linac and its beam acceleration test stand are shown in fig.2.

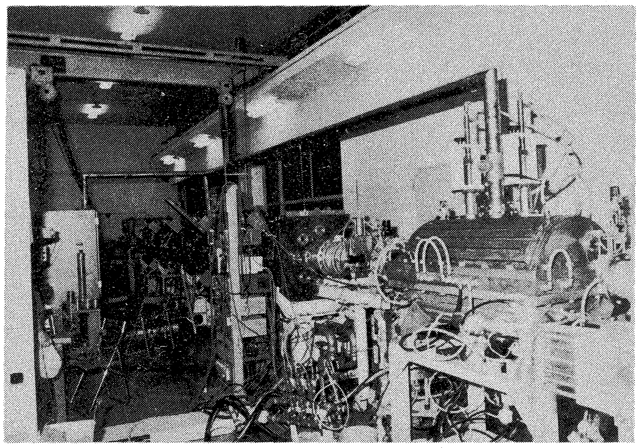

Fig.2 Photograph of constructed 2MeV IHQ linac and beam acceleration test stand

RF Sources and Control Systems of Tandem Operation

The RF power sources are supplied from two power amplifier systems connected with a master oscillater. A tetrode tube Eimac 4CW-25000A(8F) supplies to the prototype IHQ linac (injector RFQ linac) CW power up to 25kW (8kW). The RF power is fed through a coaxial line WX-77D to the IHQ linac (RFQ linac) cavity with a loop coupler. CW and pulse operations are possible in two systems.

Two automatic gain control(AGC) are performed with an accuracy of ±1%. An inductive tuner(4tuners) is used for the automatic control of the resonance frequency which shifts due to the change of temperature of the IHQ (RFQ) cavity. Two automatic frequency control (AFC) are stable within a phase shift of 3°. A phase shift between the IHQ cavity and the injector RFQ cavity is stable by an automatic phase control (APC). A block diagram of the automatic tuning system of two linacs is shown in fig.3.

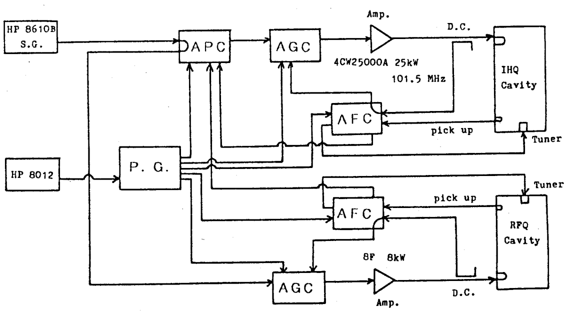

Fig.3 Block Diagram of Automatic Tuning System of Two Linacs

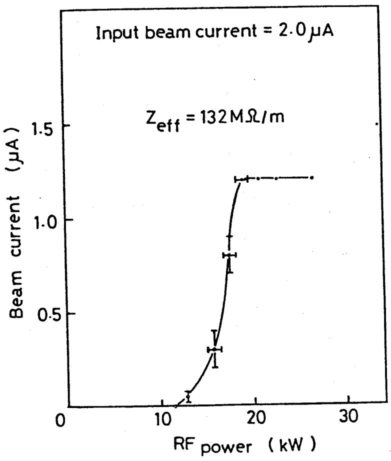

Fig.4 Intensity of 2MeV Proton vs RF power

Results of Acceleration Test[6,7]

A beam acceleration test was performed under pulse operation of two linacs having automatic tuning systems with a duty factor of 5%. The pulse width and repetition period were 1ms and 20ms, respectively. Beam test was performed by proton from a SF-ECR[15] ion source.

The intensity of 2MeV proton is shown in fig.4 as a function of the RF power. The effective shunt impedance of the IHQ linac was estimated to be about 132MΩ/m from RF power for proton (11.4kW at ψ_s=0).

The intensity of 2MeV proton is shown in fig.5 as a function of the phase shift between the IHQ linac and the injector RFQ linac. From this result, it is shown that the automatic phase control (APC) is stable and is required within the phase shift of 10°.

The momentum distribution of accelerated particles was measured as a function of the RF power as shown in fig.6. The acceleration characteristics agree well with computer simulation.

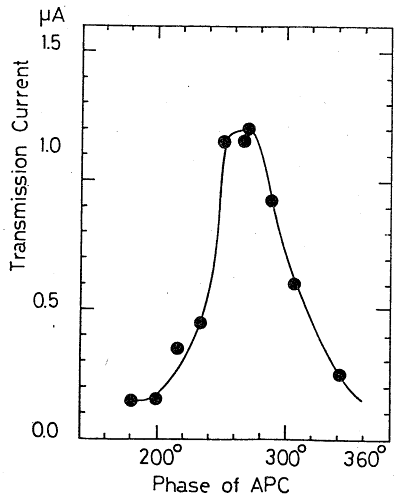

Fig.5 Intensity of 2MeV proton vs APC phase

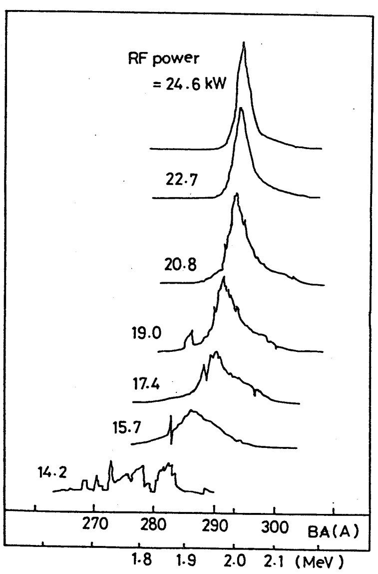

Fig.6 Energy distribution of output proton vs RF power

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