STUDY OF IH TYPE LINEAR ACCELERATOR FOR RADIO-ISOTOPES PRODUCTION

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Abstract

We are studying an IH type linear accelerator for application as international cooperative research. Acceleration of deuteron and triton by the IH linac were planed for product of useful radio-isotopes. First plan is accelerate deuteron to 3.2 MeV by an IH linac for PET (Positron-Emission Tomograph). The linac was designed to accelerate deuteron from 0.2 MeV to 3.2 MeV by T.U.M. and T.I.T. The accelerator cavity was manufactured in Rumania. Beam-test facility was constructed at Research Laboratory for Nuclear Reactors, T.I.T. in Japan. Second plan is to accelerate triton to 7 MeV by two IH linacs at Institute for Atomic Physics in Rumania.

Introduction

In Japan[1~5)] and Germany[6~8)], the IH linear acceleration structure has been proved high shunt impedance from medium to high (maximum 6 MeV/u) energy region. The IH linear accelerator was accomplished for elementary research use. A subject of our project is that the IH linac possible acceleration of high-intensity beam is improved to practical use for medical science, semiconductor production and so on. For its purpose, the system of the IH linac should be compact and high reliable.

As the symbols of utility model, acceleration of deuteron and triton by the IH linac were planed for product of useful radio-isotopes for medical science. The linac and beam-test facility were designed and constructed. Characteristic of the linac is being studied by acceleration test as international cooperative research.

Design of IH Linac

The IH linac for PET[9~10)] was designed to accelerate deuteron from 0.2 MeV to 3.2 MeV. The operating frequency was determined to 96 MHz for stocked an amplifier. The particle trajectory was analyzed by mean of a matrix method. Calculated results of the phase and energy are shown in Fig.1 and Fig.2 as a function of the cell number. Designed parameters of the IH linac are given in Table-1.

Table-1
Design Parameters of Deuteron IH Linac for PET

Charge-to-Mass Ratio	≥1/2
Energy Input (MeV/u)	0.1
Output (MeV/u)	1.6
Cavity Inner D. (cm)	56,64,70
L. (cm)	189
Wall Thickness (mm)	5
Frame Thickness (mm)	30
Number of Drift Tube	27
Stem Thickness (mm)	18
Drift Tube Inner Radius (mm)	12~22
Thickness (mm)	4,5
Operation Frequency (MHz)	96
Synchronous Phase	~0°
Shunt Impedance (MΩ/m)	300
RF Power (wall loss) (kW)	14

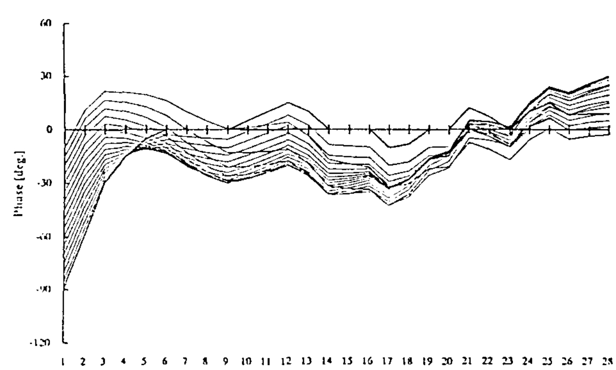

Fig.-1 Phase oscillation as a function of cell number

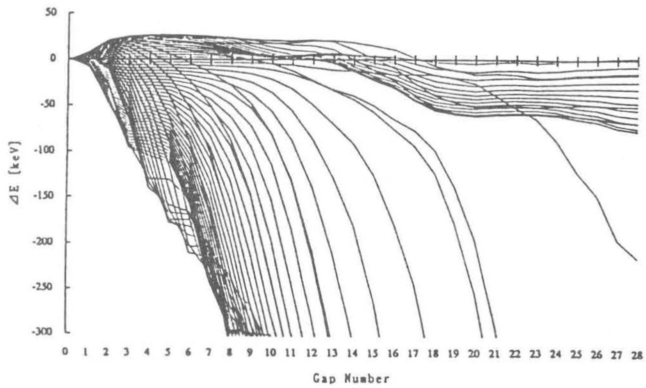

Fig.-2 Energy Spread as a function of cell number

Design and Manufacturing of Accelerator Cavity

With reference to model test of the triton accelerator, the diameter of cavity was determined to change three diameters (56, 64, 70cm) for flat-distribution of acceleration-voltage. The accelerator cavity was manufactured by TURBO-MECANICA Ltd. of jet engine maker in Rumania. The cavity tanks and connected ridges are made of copper plated mild steel. The drift tubes and the stem are made of oxygen free copper.

The manufactured cavity was transported by air from Rumania to Japan. Four tanks connected drift tubes and stems have constructed to a cavity. Fig.3 shows a photograph of fabricated the cavity. The field distribution was measured by mean of the well-known perturbing ball method. Fig.4 shows voltage distribution at 103.5 MHz after field tuning.

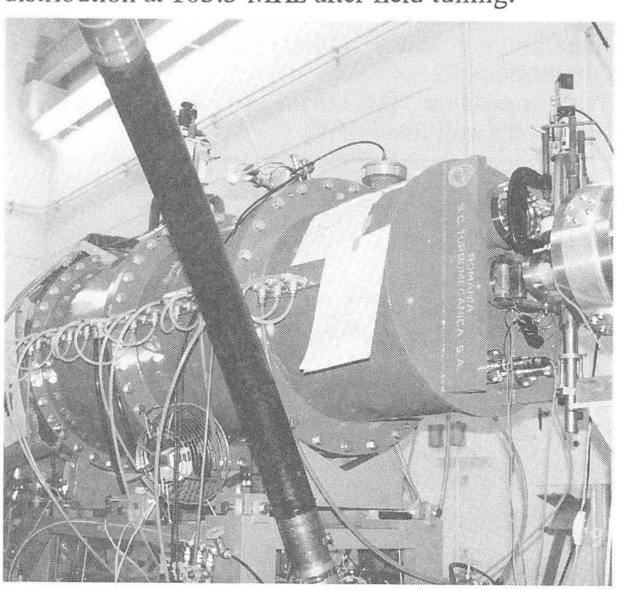

Fig.-3 Photograph of fabricated IH cavity

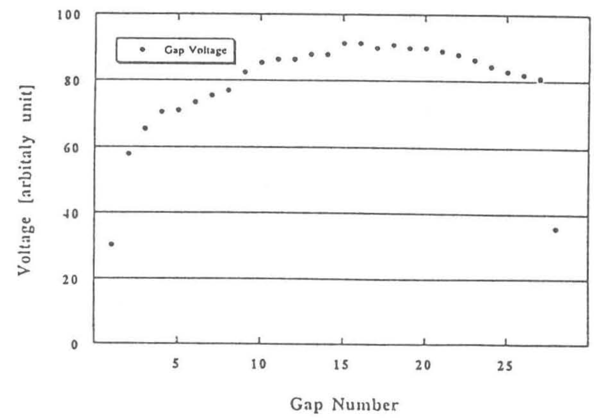

Fig.-4 Acceleration Voltage Distribution

Acceleration Test Facility

The RF power is supplied from a power amplifier system (TV broadcasting system) connected with a master oscillator. A tetrad tube 8F supplies CW power up to 10 kW. The resonance frequency of the cavity was measured to be 103.5 MHz for the TE111 mode. The frequency was higher than the design value of 96 MHz. Therefore, the power amplifier system was tuned up 103 MHz. The RF power is fed through a coaxial line wx-77D to the cavity with the loop coupler.

A compact 2.45 GHz ECR type ion source on a high-voltage terminal of 100kV was used to produce beam of proton. The extracted proton beam at 100 keV is transported through two sets of einzel lenses. The beam is focused with the last einzel lens into a phase space that matches to the acceptance of the IH linac. The accelerated beam is measured by a SSD in a scattering chamber. Figure 5 shows layout of the acceleration test facility. A photograph of the constructed facility is shown in Fig.-8.

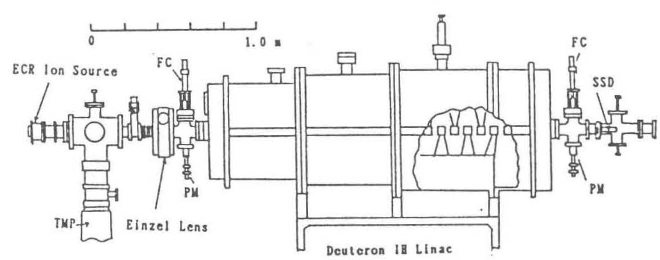

Fig.-5 Layout of the Acceleration Test Facility

Preliminary Acceleration Test

Beam test has been performed using proton beam produced by the compact ECR ion source. Energy spectra of accelerated proton beam have been measured by means of Rutherford Scattering on gold target. The protons were detected by the SSD at back ward. The transmission of accelerated proton is shown in Fig.-6 as a function of the RF power. Figure 7 shows energy spectra of accelerated protons in condition of input power 2.4 and 3.3 kW. The effective shunt impedance of the deuteron IH linac for PET was estimated to be about 337 MΩ/m from RF power.

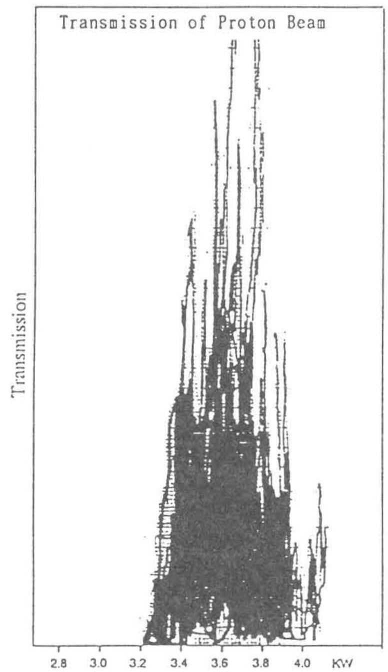

Fig.-6 Transmission of Accelerated Proton (1.55MeV) as a function of RF power

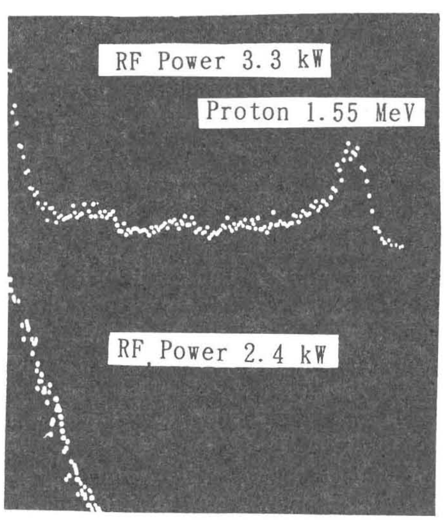

Fig.-7 Energy Spectra of Accelerated Proton

Reference

1)N.Ueda, S.Yamada, E.Tojyo, T. Hattori and K.Yoshida, IEEE Trans. Nucl. Sci. NS-28 (1981)3023.

2)S. Yamada, T. Hattori, T.Fujino, T. Fukushima, T. Morimoto, E. Tojyo, K.Yoshida and T. Murakami, Proc. Intern. Ion Engineering Congress ISIA '83 & IPAT '83 (1983)p623.

3)Y. Oguri, E. Arai and T. Hattori, Nuci. Instr. and Meth. in Phys. Res., A235(1985)7.

4)T. Hattori, K. Sato, H. Suzuki, Y. Oguri and E. Arai, Proc. 1986 Intern. Conf. of Linear Accelerator, Stanford, USA, (1986)p377-379.

5)T. Hattori, H. Suzuki, H. Muto T. Fukushima and N. Ueda, Proc. 1989 IEEE Particle Accelerator Conferance,Chicago, USA, CH2669-0(1989)944-946.

6)E. Nolte, G. Geschonke, K. Berdermann, R. Oberschmid, R. Zierl, M. Feil, A. Jahnke, M Kress and H. Morinaga, Nuci. Instr. and Meth., 158(1979)311-324.

7)U. Ratzinger, E. Nolte, R. Geier, N. Gartner and H. Morinaga, Nuci. Instr. and Meth. in Phys. Res., A263(1988)261.

8)U. Ratzinger, Proc. 1990 Intern. Conf. of Linear Accelerator, Albuquerque, USA, LA-12004-C (1990)p525-529.

9)T. Hattori, Y. Oguri, M. Okamura, Y. Shida, T.Fujisawa, S. Seki, H. Morinaga, H. Schubert, E.Ivanof and D. Dudu, Proc. 18th Linear Accelerator Meeting in Japan, 18(1993)38-40.

10)T. Hattori, H. Schubert, H. Morinaga, Y. Oguri, D. Dudu, M.Okamura, T. Ito, S. Seki, K. Furuno, Y. Shida, T. Fujisawa, E. Ivanof, V. Zoran, G.Pascovici, T.Nakamura, M. Okada and S. Yamaki, Proc. 19th Linear Accelerator Meeting in Japan,Tokai 18 (1993) 184-186.

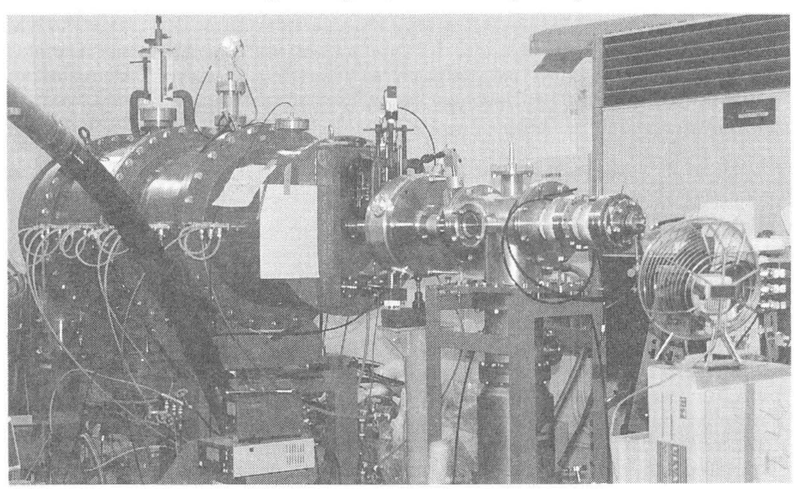

Fig.-8 Phtograph of Acceleration Test Facility