Design of an Ultra Compact Cyclotron

S.Wakasa, K.Fukuda, T.Takagi
Fukuda Engineering Research
Hakodate-shi Hokkai-do,041,Japan

and

N.Nakanishi
The Institute of Physical and Chemical Research (RIKEN)
Waco-shi, Saitama, 351-01, Japan

Abstract

An ultra compact cyclotron used constructed for ion analyses. The cyclotron accelerates proton and alpha beams up to fixed energy of 3MeV. The size of the magnet is $85^{cm} \times 85^{cm} \times 60^{cm}$, Characteristics of the cyclotron are presented.

INTRODUCTION

In recent years, ion beam analyses such as PIXE and RBS have become active. Analysis techniques have also establish and put to practical use. However, there are problems of the size, operation, and price of accelerators which are ion sources. As a result, the accelerator is one of obstruction factors of the practical use of the ion analyses. We developed an ultra compact cyclotron which suitable for ion analyses in order to promote the practical use and popularization of the analyses.

The proton beams are used for PIXE (Particle Induced X-rays Emission). The generation efficiency of characteristic X-rays from samples is high in the energy ranges from 2 to 3MeV for heavy elements, and from 3 to 4MeV for light elements. Therefore, 3MeV proton beams are used for PIXE.

Alpha particles of energy from 2 to 3MeV are used in RBS (Rutherford Backscattering Spectrometry).

From these reasons, we developed a handy, small, low-priced cyclotron in order to contribute to the popularization of the ion beam analyses

Figure 1 shows the front view of the cyclotron which was manufactured based on the above-mentioned design considerations. Figure 2 shows the bird's-eye view of the cyclotron in which high frequency devices are built in the

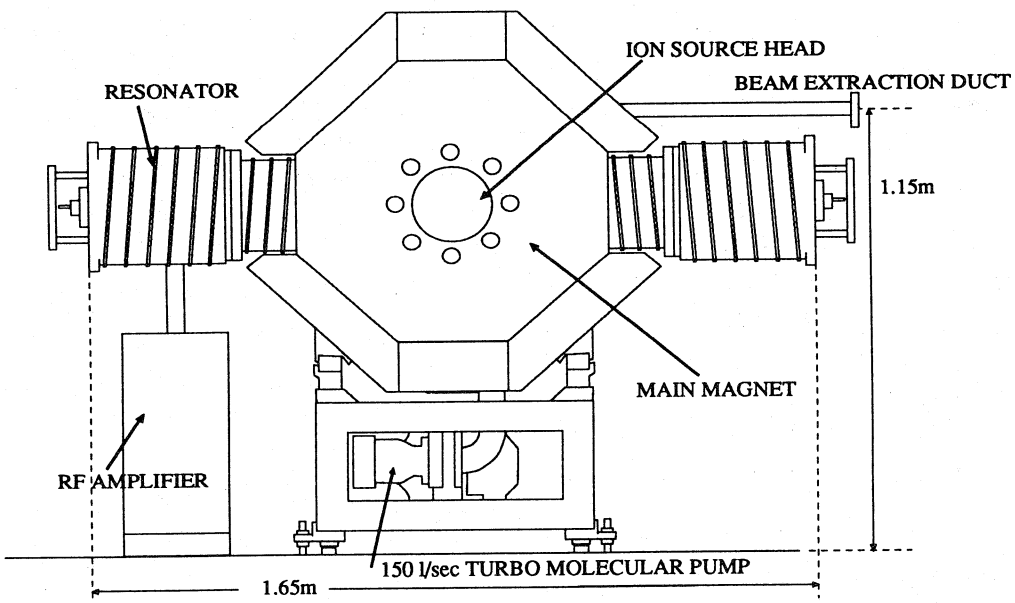

Fig.1 Front view of the ultra compact cyclotron

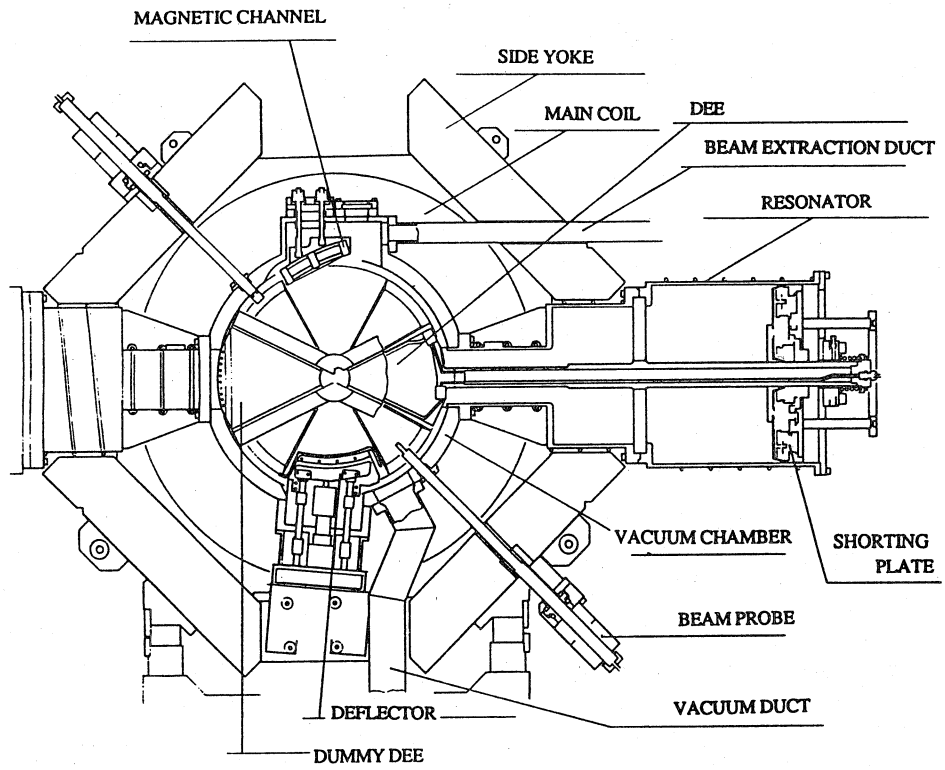

Fig.2 Cross-sectional view of the ultra compact cyclotron

electromagnet. Characteristies of the cyclotron are summarized in Table 1.

DESIGN FEATURES OF THE ULTRA COMPACT CYCLOTRON

A. Structure of Magnet

We developed the cyclotron in order to offer a handy, small, low-priced accelerator for the beam analyses. The design is focused to down sizing and low power consumption. Therefor, a high magnetic field and small radius is adopted. Pole gap is narrowed as possible as for insertin of a magnetic field measuring device so that the consumption of electric power of main coils is decreased, though a high magnetic field is adopted. We employed a radially increasing magnetic field between iscohronism field of proton and alpha beams. We selected vertical structure of the magnet as shown in Fig.1 in order to make maintenance easy and the ion source handy and simple.

B. RF System

The accelerating electrodes consist of two dees of 52 degrees and are connected of the center. The acceleration frequency is fixed to 51.7MHz. The half-wave length becomes about 150cm by adoption of a high magnetic field, and the total length of the resonator becomes about 160cm as a result. The dee voltage ranges from 20kV to 25kV. The R.F.power is 3kW.

C. Deflector

The deflector is of the electric static field type. The maximum electric field is about 25kV/cm. The septum board was made of tantalum, and the entrance part of electrode collided with beams was covered with a block of tantalum in oder to decrease neutron generation. Hence the shield in the cyclotron room is able to make a minimum.

D. Ion Source

The ion source is of a hot cathode PIG type and is introduced axially to the center of the cyclotron. The lifetime of the filament is expected to exceed about 200 hours.

E. Control

We has the plan to make PIEX and RBS analyses useing by this cyclotron . In the future , however, the cyclotron will be driven automatically as a whole system including analysis sdevices.

Table 1. Pricipal cyclotron parameters

Beam			
	Type of ions	H^+	H_e^{++}
	Energy (MeV)	3	3
	Maximum intensity (μA)	10	5
Magnet			
	Pole radius (cm)	20	
	Number of sectors	4	
	Sector angls		
	Hill	32°	
	Valley	58°	
	Average field (fixed) (T)	1.7	
	Gap (cm)		
	Hill (cm)	2.4	
	Valley (cm)	5.2	
	magnetic motive force (Amper-turns)	5×10^4	
	Coil power consumption (KW)	11	
RF-system			
	Number of dees	2	
	Dee angle	52°	
	Frequency (Mhz)	51.7	
	Dee voltage (kV)	20	
Total power consumption (kW)		21	