STATUS REPORT OF THE TOHOKU CYCLOTRON

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Abstract

Tohoku-cyclotron is a type of the variable energy and multi-particle acceleration. The cyclotron beams have regularly been used for many experiments by the users of Tohoku University since July 1979. Some results of the measured beam characteristics and developed instruments are described.

1. Introduction

Tohoku cyclotron and its related facilities were funded by the Ministry of Education in 1974 and intended for wide applications in various research fields. The fundamental design of this cyclotron is that of CGR-MeV, France, and the machine was mainly constructed by Sumitomo Heavy Industries. The first internal beam was obtained in October 1977 and the extracted beam was transported to the experimental area in August 1978. After the performance tests of the cyclotron and the beam transport system were completed, the machine was opened to the users of Tohoku University in July 1979. The total machine time of 2022 hours were used for various experiments in the period from July 1979 to June 1980. The general layout of the machine and the experimental area is shown in fig. 1. Main characteristics of the cyclotron are summarized in table 1.

2. Cyclotron Operation and Partition of Machine Time

The cyclotron has been in operation on the regular schedule of 87 hours/week. The regular maintenance of the cyclotron and beam transport system has been scheduled every Monday. The partition of machine time in 1979 is listed in table 2. In normal operation, the beam energy and accelerated particle can be changed within 30 minutes.

Several machine troubles occurred during the first year of the regular operation. The serious troubles were the leakage of water from the cone of the ion source, the cracks on the flexible plate connecting between the earth plate and the movable panel in the cavity and the damage of stainless-steel framework in the dee due to a beam divergence in the z-direction. The shut down time of the machine, however, was not longer than one week for each trouble.

3. Machine Research and Development

Tohoku cyclotron needs about 40 acceleration parameters in actual operation. These parameters were equipped for each energy and particle, together with operation training. For investigating the beam quality, the properties of the internal beam were measured. They are (1) loss of the beam during acceleration, (2) radial amplitude and frequencies of oscillation, (3) phase of the beam relative to RF and (4) time width of the beam pulse. Fig. 2 shows the representative Δr-profile obtained by using the differential probe. Especially, we obtained the minimum pulse width as small as 350 psec due to the rather high frequency range of the RF system (20-40 MeV). This value indicates that this cyclotron is powerful for TOF experiments etc.. A new phase slit with a variable gap width was installed to improve the beam quality at the central region.

In order to investigate the feasibility of heavy ion acceleration $^{12}C^{3+}$ and $^{14}N^{4+}$ beam were accelerated by using the ordinary ion source of P.I.G. hot-cathode type. In the acceleration of the $^{12}C^{3+}$ 36 MeV beam, the beam current of 100 nA was obtained at the external beam stopper. We are preparing for the use of the heavy ion source of P.I.G. cold-cathode type.

For efficiently transporting the accelerated particle, an emittance measurement system was developed and installed at the entrance of the beam transport system. This system works on the principle of the one slit-multi-detectors method and being controlled by a micro-computer. It takes only one minute to obtain the phase space contours of the emittances. Fig. 3 shows the results of an emittance measurement for 40 MeV protons.

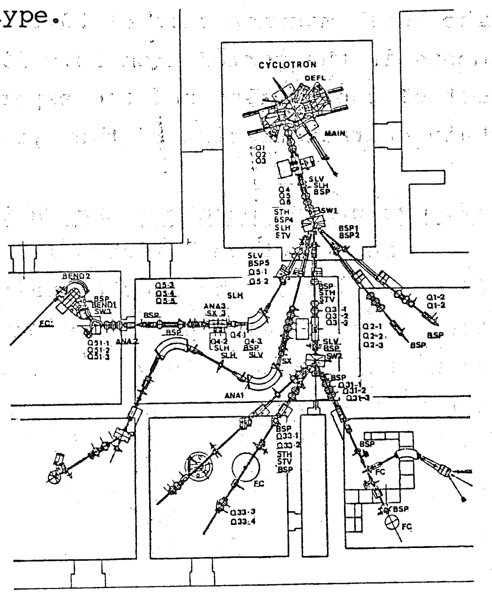

Fig. 1; Layout of the AVF cyclotron, beam lines and the experimental area

Table 1. Main characteristics of the Tohoku cyclotron

Magnet	
Weight	110(tons)
H×W×L	2.3×1.7×3.72(m^3)
Pole diameter	1600(mm)
Number of circular coils	8
Number of harmonic coils	4
Maximum average field at extraction radius	15(kG)
Ion source	
Hot cathode type of Livingston-Jones	
Radiofrequency system	
Number of dees	2
Number of cavities	2
Dee angle	60(°)
Maximum dee voltage	50(kV)
RF power dissipation	2×55(kW)
Extraction system	
Electrostatic deflector	1 set
; Maximum field	130(kV/cm)
; Angular span	55(°)
Magnetic channels	passive

Characteristics of beams

particle	p	d	^{4}He	^{3}He
energy(MeV)	3-40	5-25	10-50	7-65
current at maximum energy(μA)	40	50	30	30

Table 2. Partition of machine time and accelerated particles from July 1979 to June 1980

1)	Nuclear physics	918 hr
2)	Atomic and solid state physics	244
3)	Material irradiation	200
4)	R.I. production	201
5)	Biological study and health physics	181
6)	Element analysis and other applications	278
		2022

p (3-40 MeV)	938 hr
d (5-25)	27
^{4}He(10-50)	705
^{3}He(7-65)	352
	2022

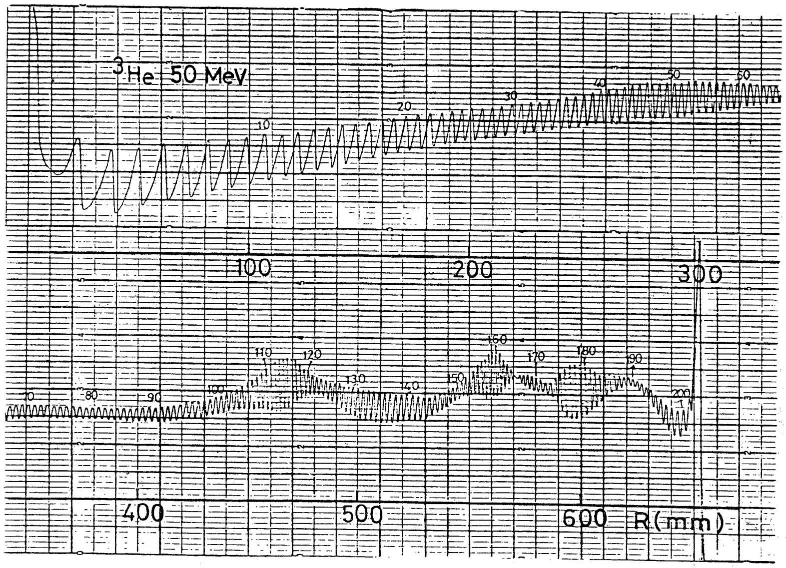

Fig. 2; The differential beam profile for ^{3}He at 50 MeV

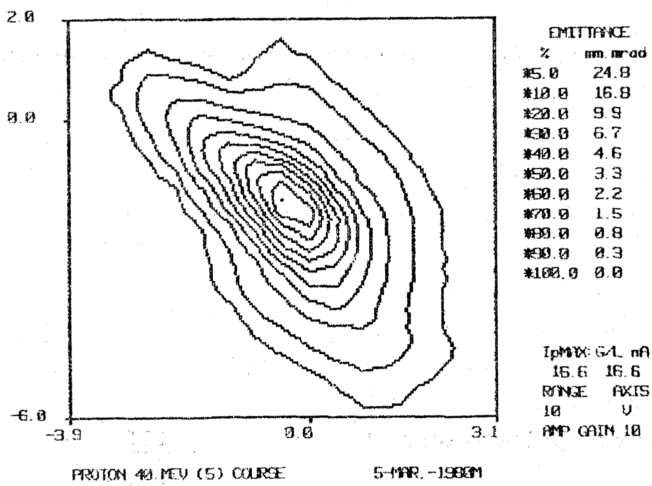

Fig. 3; Horizontal emittance for 30 MeV proton, measured by the emittance system of the one slit-multi-detectors method