ADJUSTMENT OF 120 CM CYCLOTRON

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Summary

The paper briefly outlines some main data and features on shimming the magnetic field and adjusting the beam of a 120 cm cyclotron (fixed energy). At present, the machine accelerates H_2^+ and D up to 13.5 MeV, and α-particles up to 27 MeV. The internal beam is about 30 A and the external beam is 5-6 μA when the FM is 10 Hz/s and the width is 1 ms. An energy resolution of about 0.1% and an external beam of 0.01 μA have been obtained when the beam passes through a 93° analyzing magnet and ϕ4 mm aperture.

Introduction

A 120 cm cyclotron (fixed energy) has been in operation at Sichuan University for three years. The machine was installed in 1978-1979, thereafter, produced its first beam at the end of 1980. The variable-energy cyclotron has been in operation at most laboratories in the world for many years. Nevertheless, we have set up the 120 cm cyclotron (Fig. 1) in order to make use of the machine to do research experiments. Of course, we hope to reconstruct it into the sector-focused cyclotron if possible.

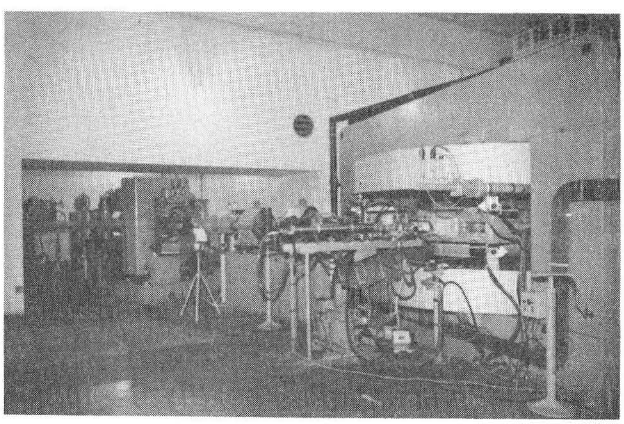

Fig. 1 A view of the 120 cm cyclotron

Magnetic field shimming and adjusting

It is necessary to adjust and shim the main magnetic field in order to get a satisfactory field distribution. For our cyclotron, we had to insert thin disk shims of various radii into the gaps between the outside surfaces of the lids of the vacuum chamber and the pole faces. Then, into these gaps were also placed symmetrical iron ring shims at the edges of the lids, with ring shims of two sizes also mounted on the inner periphery of the pole faces. After performing experiments for 18 different programs by using various sizes of shims, we finally obtained a suitable dropping curve of the field. (Fig. 2)

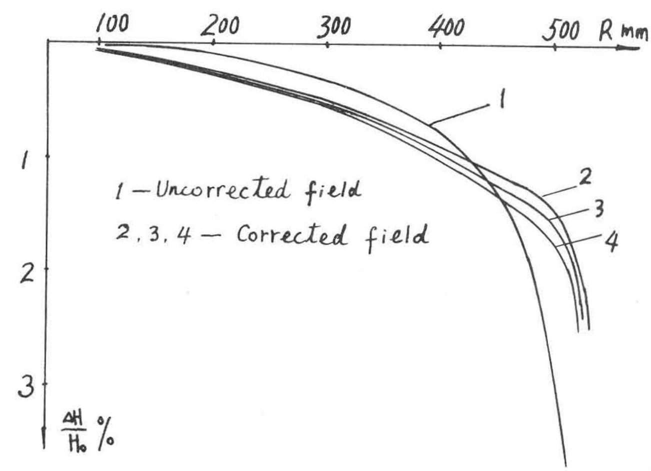

Fig. 2. The dropping curve of the magnetic field.

When the excitation current is 390 A, the field strength at the geometric center of the magnet is 14.6 KG, the radial dropping rate of the field at the entrance of the septum (R=525 mm) is 1.97%, and from R=200 mm to R=525 mm, the dropping gradient of the field $\Delta H/\Delta R > 3$-5 G/cm.

A non-parallel error of only 0.05 mm between the upper and lower lids of the chamber has been obtained, therefore, the amplitude of the first harmonic of the field errors is 3.8 G at R=525 mm without any shimming. Thus, the conditions obtained are quite suitable for the study of ion motion, and many of the problems for the fixing frame may be avoided.

The field strength, the dropping rate of the field, and the azimuthal distribution of the field were measured by using Hall Effect and voltage-frequency transformation (a small coil matched with a digital voltmeter). The measuring results of the field strength were calibrated by employing a nuclear magnetic resonance with accuracy of 0.01%.

Beam adjustment

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The main parameters of the internal beam obtained are as follows:

the excitation current	390 A
the field strength	14.6 KG
the RF	11 MHz/s
the dee-voltage	53 kV
the FM	10 Hz/s
the width	1 ms
the flow of hydrogen	3 ml/min
tge atmospheric pressure	1×10^{-5} mmHg.

When the filament current and the arc power were adjusted to the optimum value, the pulse beam of 3 mA at the internal target (R=510 mm) was obtained, which was about 3 times as much as the value originally designed. In this case, H_2^+ and D energy are 13.5 MeV.

The relations of the internal beam versus the dee-voltage and versus the radius of the magnet are shown in Fig. 3 and 4.

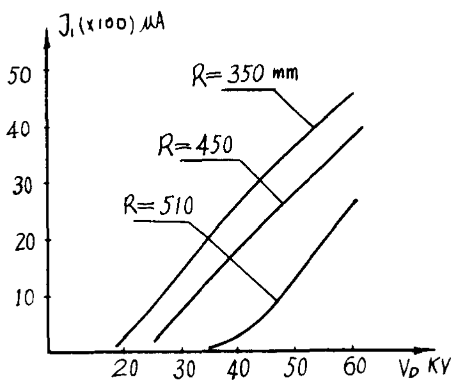

Fig. 3. Relation of the internal beam vs the dee voltage.

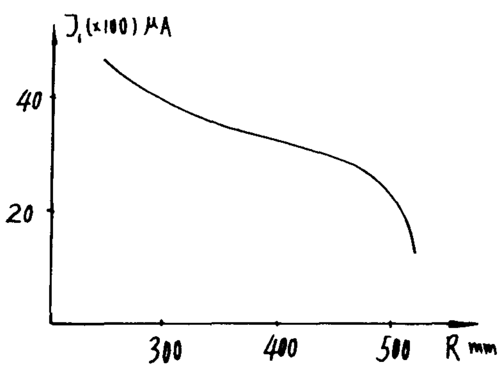

Fig. 4. Relation of the internal beam vs the radius of the magnet.

Fig. 5 shows that the internal beam depends mainly on the magnetic field. The beam vs the field relation is a resonant curve. There is a varying peak value of the field at each different radius. The beam intensity changes notably with the changing of the field strength by 10 G. The internal beam loss at large radius is influenced mainly by the phase shift of the particles accelerated. The cross-section of the beam at R=510 mm is a small ellipse of which the long axis is about 8 mm. The flatter

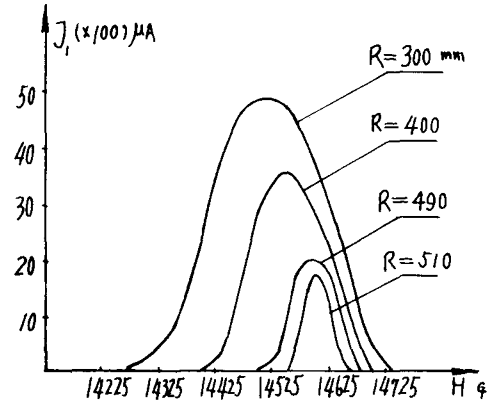

Fig. 5. Relation of the internal beam vs the field.

dropping rate curve of the field and the larger internal beam show that the shimming of the magnetic field is acceptable.

In many experiments conducted, the emergent beam has been affected by the position of the deflection system. We believe that the following geometrical sizes are more suitable: the radius of the septum entrance is 525 mm, the radius of that exit is 608 mm and the channel widths between the deflector and the septum are 5, 10 and 16 mm, respectively. It is necessary to move the position of the ion source for raising the emergent beam. The more suitable position for this machine is at the distance of 18.5 mm from the center of the pole (see Fig.6). The emergent beam changes notably if the position of the ion source is increased or decreased by 1 mm of the distance. The deflector voltage is about 50 kV. Obviously, higher or low-

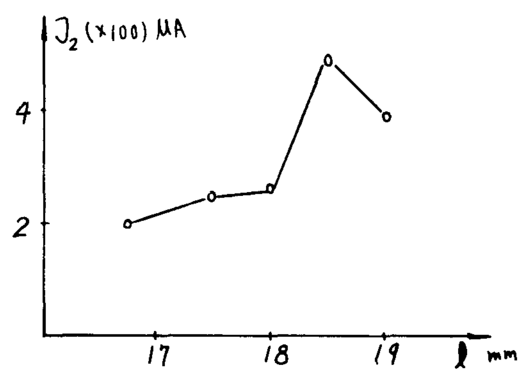

Fig. 6. Relation of the emergent beam vs the position of the ion source.

er deflector voltage would influence the beam extracting efficiency as well as its direction or cause the deflector to spark. The emergent beam near the exit of the deflector is about 5-6 μA. The efficiency of the beam transport is about 75% -- 80% in the pipe. The cross-section at the external target is about 25x25 mm^2.

A 93° analyzing magnet has been used along the 15 degree direction. When the particles accelerated pass through the magnet and then the ⌀4 mm aperture, .1 μA pulse beam intensity and energy resolution of about 0.1% have been obtained when the FM is 10 Hz/s and the width is 1 ms.

Acknowledgements

The paper is the result of a number of discussions held among the author's colleaques, but the author is responsible for its actual writing. The writer wishes to express his gratitude to the staff connected with the 120 cm cyclotron for their valuable contributions in installing, adjusting and performing the experiments. I am particularly indebted to Senior Engineer Wang Da-ji, as well as the other members of the Institute of Atomic Energy, Academia Sinica for their strong support and helpful guidance during the construction of the cyclotron.

CH1996-3/84/0000-0474 $1.00 © 1984 IEEE