CYCLOTRON PROJECT OF HIROSHIMA UNIVERSITY

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Abstract: Plan of the research center at Hiroshima University is described. Design study of the separated sector cyclotron to be coupled with a commercially available cyclotron is reported.

A cyclotron research center is planned to be placed at the new campus of Hiroshima University. Purpose of the center is to perform researches in various fields of physics, chemistry biology, engineering, agriculture and medicine, and also to supply short-lived radioisotopes. Two cyclotrons are proposed to be installed at the center. The first one is a commercially available AVF cyclotron of K=100 MeV and the second one is a separated sector cyclotron of K=300 MeV. Main characteristics of these cyclotrons are listed in Table 1. Facilities of the center will be open to users in various fields of science at Hiroshima University and also other Universities.

The AVF cyclotron is to be used in two ways, first to serve as an injector for the separated sector cyclotron and, second, to provide a variety of beams from protons to light ions for researches. The beam energies are sufficiently high to be useful for extensive applications such as study of very short-lived nuclides, in-beam study of solid materials, trace analysis of environmental samples, proton therapy of cancers and routine production of short-lived radioisotopes.

Table 1. Characteristics of the cyclotrons

Item	First cyclotron	Second cyclotron
Type of cyclotron	Ordinary AVF	Separated Sector
Proton energy	80 MeV	250 MeV
Alpha particle energy	100 MeV	300 MeV
Number of sector	4	4
Sector angle	-	42° - 46°
Spiral angle	-	0° - 25°
Injection radius	-	186 cm
Extraction radius	93 cm	312 cm
Magnetic field	18 kG	16 kG
Magnetic wieght	200 ton	250x4 ton
Main coil power	300 kW	120x4 kW
Number of RF cavity	2	2
RF range	11-22 MHz	22-44 MHz
Dee angle	86°	35°
Acceleration mode	1, 2, 3	4, 6, 8

The separated sector cyclotron is expected to accelerate mainly protons of variable energy up to 250 MeV, but it is also designed to accelerate other light ions. The proton energy is suitable for studies of very neutron-deficient nuclides and pion producing reactions, and for applications to radiotherapy and tomography with proton beam.

Main parameters of the separated sector cyclotrons are chosen to be fit for the acceleration of protons from the injection energy of 70 MeV to the extraction energy of 250 MeV. The sector angle of the four sector magnets is allowed to be about 45° from the matching condition with the injector, available magnetic field strength and the range of betatron frequencies. In order to reduce trim coil currents, the sector angle is chosen to change from 42° to 46° for the mean radius from 186 cm to 312 cm. The reduction of the focusing force due to the increasing sector angle is compensated by adopting the spiral angle from 0° to 25°. The horizontal section of the separated sector cyclotron and the betatron frequencies for several ions calculated by using the modified Spy-Ring code are shown in Fig. 1 and Fig. 2, respectively. A 1/7 scale model of this sector magnet is now under fabrication.

Two RF systems are located at opposite valleys. The resonator consists of a delta-shaped dee, two vertical stems and a cavity containing them, and covers the frequency range of 22 to 44 MHz. The relation between resonance frequency and stem length and the distribution of electric field strength along the acceleration gaps were measured for a 1/10 scale model resonator.

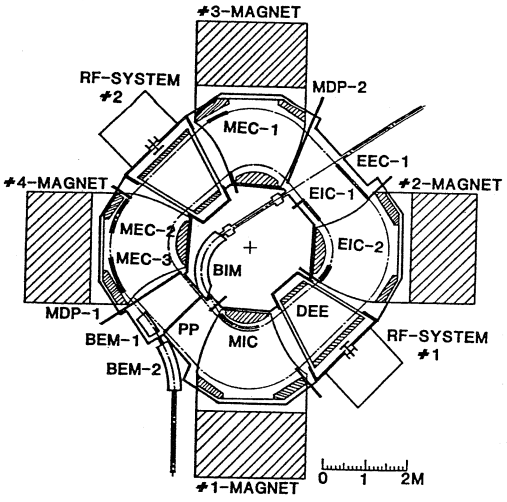

Fig. 1 Horizontal section of the proposed separated sector cyclotron

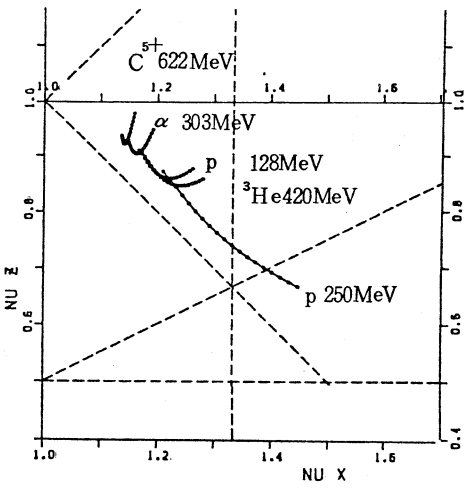

Fig. 2 Betatron frequencies for several ions