INJECTOR CYCLOTRON CONCEPTS

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Abstract

Concepts of an injector cyclotron for the ring cyclotron have been studied. A solid pole cyclotron, a connected sector magnet cyclotron and a separated sector cyclotron with a Cockcroft-Walton preinjector have been compared.

1. Introduction

An accelerator complex composed of two ring cyclotrons has been proposed as a new project of the RCNP, Osaka[1]. A general progress of the project will be reported in this symposium. It will be able to accelerate both light and heavy ions up to medium energy. An injector cyclotron and eventually a heavy ion linear accelarator will be added in this system. The injector is important to decide beam intensity and qualities. In the first phase a compact cyclotron has been proposed as a light ion injector. To improve beam qualities, however, external ion sources are useful. In this study, a connected sector magnet cyclotron with an axial injection and a separated sector cyclotron with a Cockcroft-Walton preinjector have been examined.

2. Condition for the injector

The proposed injector should be able to accelerate protons up to 25 MeV and heavy ions up to 70 q^2/A MeV, where q is charge of an ion and A is particle mass number. As an injection radius of the next stage cyclotron is 135 cm, the extraction radius of the injector has to be 67.5 cm, 135 cm or 270 cm.

3. Solid pole cyclotron

A small cyclotron is commercially available. For example, the SUMITOMO-CGR-MeV Model 680 cyclotron is suitable for our injector. But the maximum magnetic field should be increased for heavy ions and the central region should be modified for heavy ion sources. The two resonators with 72° dee electrodes are good for matching with a ring cyclotron in which particles are accelerated in harmonic mode of 4,6,8 and 12.

4. Connected sector cyclotron

The external ion source is useful for heavy ions and essential for polarized ions. An ordinary solid pole cyclotron is acceptable for an axial injection system. But the injection energy should be as low as 10 keV for beam centering in the cyclotron. It is desirable to increase the injection energy to 50 keV or more especially for heavy ions as a space charge effect is large at a low energy. To accept such a high energy beam it is necessary to decrease magnetic fields. An inflecter electrode in the magnetic field may be useful for axial injection system. It becomes larger as the injection energy becomes higher. In case of a moderate gap magnet a large inflecter could not be situated in the magnetic field. The proton injection energy of 50 keV has been chosen in our case. On the other hand the extraction system should be located in a field free region to improve extraction efficiency and beam qualities. Therefore a connected sector cyclotron has been designed to realize a rather flat low field at a central region and a four symmetry sector field at a larger radius. A plan view of this injector cyclotron is shown in fig. 1. Except for the connecting part of the central region it resembles to the VICKSI cyclotron.[3].

5. Separated sector cyclotron

A Cockcroft-Walton preinjector for the separated sector cyclotron is desirable to get high intensity light ion beams and heavy ion beams. For proton beam the SIN injector II is very powerful to accelerate more than 1 mA beams[2]. However, our accelerator does not accelerate such high intensity beams and it is a variable energy machine. Low sector fields are useful to make a variable energy injection system. A low field separated sector cyclotron has been designed as a second alternative of our injector. A 300 keV Cockcroft-Walton is used as a preinjector and a electrostatic injection system is adopted. The vertical betatron frequency is below $\nu z=1.0$. Two 18° delta electrode of the RF system is used for matching with the next cyclotron. It is similar to the SIN injector II, but has a variable plate to change a resonance frequency. The extraction efficiency is expected to be almost 100%.

6. Discussion and Conclusion

Main characteristics of the above mentioned three cyclotron as an injector are listed in table 1. As an injector of a large accelerator the separated sector cyclotron with a preinjector is most preferable but it needs large amount of steel. Choice of an injector depends on a size of total accelerator system as well as costs.

References

1) I. Miura et al., in these proceedings.
2) S. Adam et al., Proc. 7th Int. Conf. on cyclotrons and their applications (1975), 123.
3) K.H. Maier, ibid., 68.

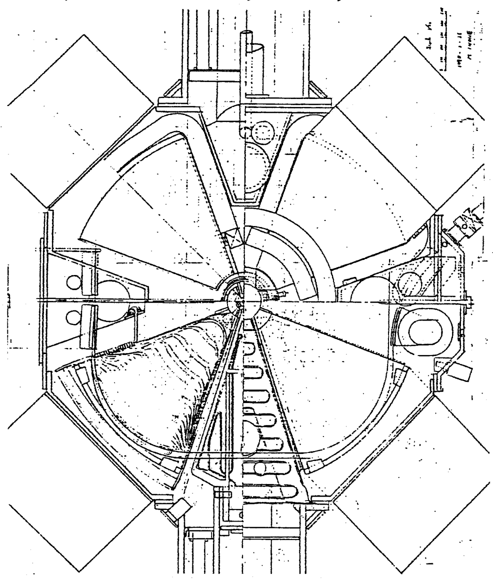

Fig. 1. A connected sector magnet cyclotron

Table 1

Injector cyclotrons K=70 for Heavy ion, 25 MeV for proton

	Solid Pole	Connected sector	Separated sector
No. of Sector		4	4
Sector angle		50°	50°
		Connected at the centor	
Extraction radius	67.5 cm	135 cm	270 cm
Magnet gap	hill 20 cm	4 cm	4 cm
	valley 35 cm		
Max. magnetic field	18 kG	16 kG	8 kG
Magnet weight	120 ton	150 ton	450 ton
Main coil power	100 kW	100 kW	100 kW
Trim coil power	50 kW	30 kW	30 kW
No. of cavity	2 (72°)	2 (36°)	2 (18°)
RF frequency	20∿32 MHz	20∿32 MHz	20∿32 MHz
Maximum voltage	50 kV	50 kV	50 kV
RF power	30 kW x 2	50 kW x 2	100 kW x 2
Ion source	internal	external 50 kV	external
			300 kV Cockcroft -Walton