INJECTION SYSTEM FOR THE 1ST RING CYCLOTRON

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Abstract

An intermediate energy particle accelerator complex is being designed as a new accelerator facility at RCNP[1]. This variable energy accelerator complex covers a wide energy range and accelerates ions from proton through uranium with high intensity and good beam quality. It consists of a injector cyclotron and/or linac and two separated-sector cyclotrons. Beam injection into the 1st separated-sector cyclotron should be designed to meet the necessities of variable energy and variable particles. Several methods for beam injection to equilibrium orbit from the injector have been considered.

1. Introduction

Injection into cyclotrons is, in many cases, the most difficult part because the magnetic field has to bend the injected beam more than the internal beam. Generally, there are three injection methods; that is, axial injection, trochoidal injection and direct injection along a valley. The last method is very suitable for the separated-sector cyclotron where the weak fringe field in the valley deflects the beam only a few degrees before it reaches the central region, where magnetic and electrostatic bending devices can guide the beam onto the 1st equilibrium orbit. The design for various magnet and electrostatic devices, should be appropriate for the injection of the particle of the maximum rigidity.

2. The Proposed Injection System

a) Most simple injection system consists of one bending magnet located in the central region and magnetic inflector channel (MIC) in sector magnet. This design is very attractive as it means lower power consumption. However, the magnetic inflector channel may disturb the field around the 2nd equilibrium orbit because the orbit separation between the 1st and 2nd equilibrium orbit is 30 mm even at the maximum acceleration gain (0.8 MeV/turn). And, the field of MIC required for the beam to be on the equilibrium orbit has to be increased by about 0.3 to 0.4 T over the range of the MIC. Moreover, one bending magnet which is positioned close to the MIC is not feasible both physically and magnetically. As a result, this method, even if it is much simple, can't be used practically.

b) The alternative system consists of two bending magnets in the central region, a magnetic inflector channel (passive + active) in the pole-tip of a sector magnet and an electrostatic inflector channel (EIC) in the next free valley. The beam from the injector cyclotron is guided by final steering magnet and focussing elements near the chamber of ring 1 and transported into the central region. The beam enters the 1st bending magnet (BM1) which produces a maximum field strength of 0.5 T and bends the beam through 23°. This directs the beam into the second bending magnet (BM2) in which maximum field of 1.4 T bends the beam through 105° and injects the beam into the MIC in the 1st sector magnet, and if necessary final adjustments can be made with an electrostatic inflector channel in the free valley of the second quadrant. By the orbit calculation, the MIC must increase the field in the gap of the pole-tip by a maximum of 0.3 T to guide the beam onto its inner most centered orbit. It only the field strength is needed, it will be obtained by the simple magnetic shims in the 1st sector magnet. However, they have disadvantage that the MIC field is always proportional to the sector magnet field and no finer field setting can be accomplished. These conditions for the MIC can be realized by active magnetic device along with floating shims to reduce the current density of the MIC. A preliminary layout of injection system is shown in fig. 1.

3. Status of Progress

In the design of the MIC, there are some problems; that is, fringing field of the 1st sector magnet around the injection orbit, effects of shims and/or floating shims, field distribution inside the MIC and positioning of the MIC on to guide for beam to the equilibrium orbit. At the first step, magnetic field measurement of effect due to shim or floating shim has been done using a 1/3.5 scale model magnet of the 1st ring. A calculation of optical properties of this injection system, especially matching condition to the 1st equilibrium orbit is under progress.

Reference

1) I. Miura et al., RCNP Annual Report 1978, p.231

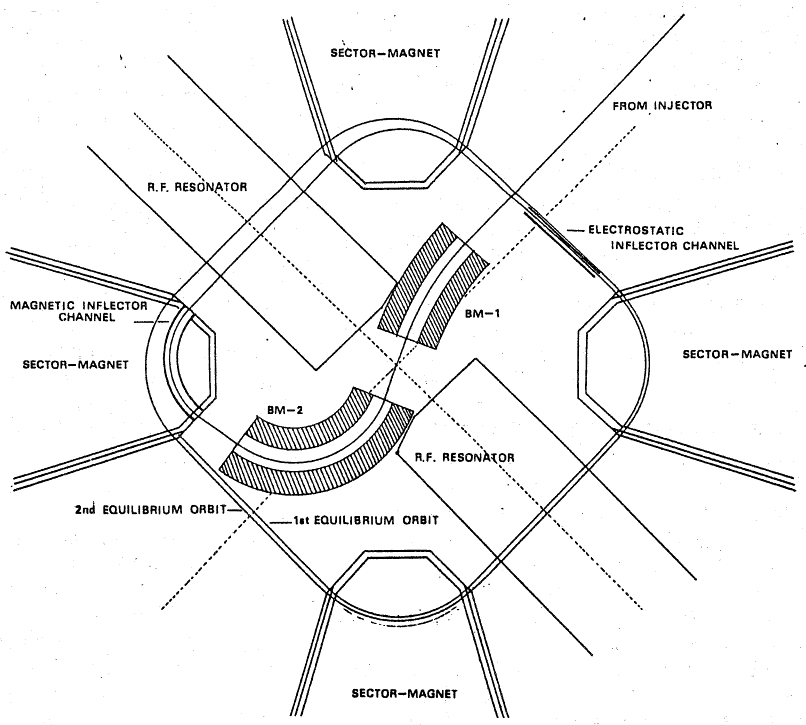

Fig. 1 Layout of injection system to the 1st ring cyclotron