DESIGN OF INJECTION SYSTEM FOR THE IPCR SSC (I)

Y. Yano, A. Goto, T. Wada, H. Takebe, Y. Obana, N. Kishida, N. Nakanishi, S. Motonaga and H. Kamitsubo

The Institute of Physical and Chemical Research

Besides a principal role to guide a beam transported from the injectors onto the first equilibrium orbit in the SSC, the injection system must possess functions to satisfy some conditions imposed upon the beam at the position where it enters the first equilibrium orbit. These functions are indispensable for one to get well-centered accelerated orbits for particles with wide range of mass and energy, and to accelerate the beam efficiently. The conditions of the beam to be adjusted are a position and direction, dispersion in radial direction, and beam ellipse in six dimensional phase space. The third condition is met by the transporting preceding the system described here. The injection system should be designed so that these matching procedure may be done as easily as possible.

Having investigated three different types of injection method (i.e. radial injection, axial injection and injection by charge stripping), we decided to employ the method of axial injection as shown in fig. 1. In this method, firstly the beam which is injected vertically down into the open valley is inflected onto the median plane by two 45° bending magnets and secondly it is led to the first equilibrium orbit by means of a bending magnet (BM1), two magnetic inflection channels (MIC1,MIC2) and an electrostatic inflection channel (EIC). The MIC's are inserted between the magnetic poles of the sector magnets to add the necessary bending power to the sector field. The characteristics of these injection elements are listed in table 1. Face angles of BM1 are determined to match the dispersion in radial direction. The Q magnet between the 45° bending magnets makes the achromatic transportation of beam in vertical direction possible. The advantage of the present method is that the beam focusing elements can be arranged down to the central region. In the radial case, no such elements can be arranged along the injection trajectory through the long valley region because the accelerated beam exists. The circumstance that the beam line of linac as the injector is about 14m higher than the median plane of SSC is also one of primary factors for our decision. A considerable effort was devoted to the feasible design of the injection equipments, since they must be capable of bending particle of large magnetic rigidity up to about 800 kG-cm and be located in the limited available space of the SSC central region.

Fig. 2. shows the cross section of bending magnet (BM1) designed. This magnet is of modified window-frame type with the ends having the unsaturated (Rogowski) profile. The material of the yoke and pole is pure iron. A 1/1-scale model of this magnet whose bending angle is 50° has been built. The map of the magnetic field produced by this magnet was measured at excitations of 7, 12, 15 and 18 kG. The measurement of the field strength was made with Hall elements which was moved in azimuthal direction automatically by computer controlled driving system. Fig. 3. shows magnetic field distribution along radial direction measured at the position inner enough from the magnet edge when the clearance $\delta$ between the coils underneath the pole and the pole was taken to be 2.5 mm. Using the measured data, the beam passing through the magnet was traced by numerical calculations (see "Design of Injection System (II)").

The MIC's were designed to consist of a iron shim and coils, a model of which is now under construction. The EIC is of conventional structure.

Through the present study, it has been concluded that the proposed method of beam injection is feasible for the IPCR SSC.

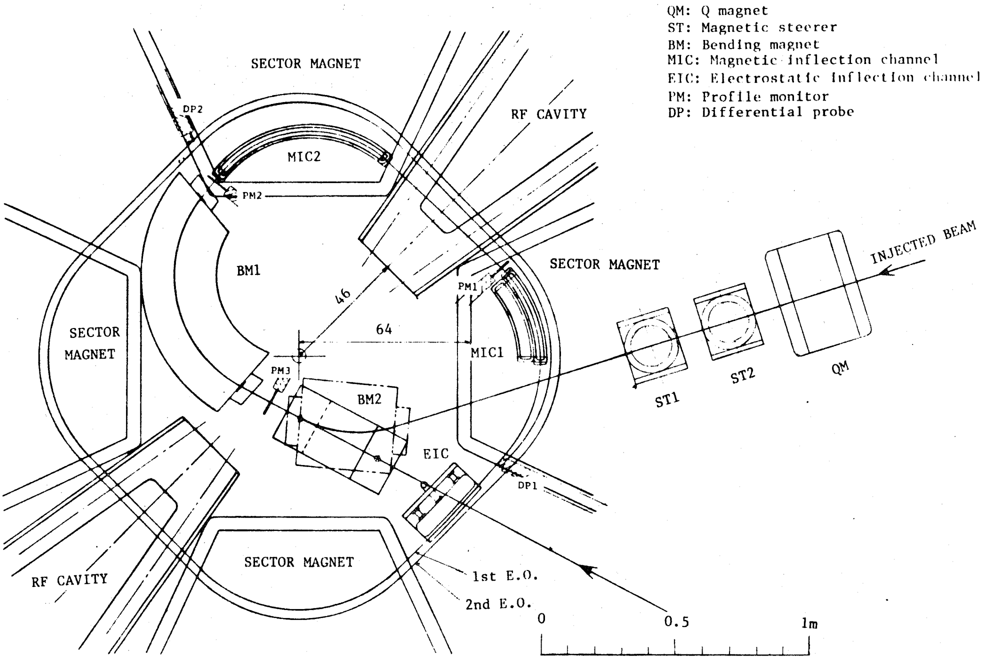


Fig. 1. Layout of central region of the IPCR separated sector cyclotron. The injection trajectory drawn through ST1, ST2 and QM is in the plane perpendicular to the median plane.

Table 1. Characteristics of injection elements.

| Element | Bend angle | Aperture(cm) (H) | (V) | Radius(cm) | Maximum field | | Face angle (entrance)/(exit) |
|---|---|---|---|---|---|---|---|
| BM2 | 45° | 10 | 4.4 | 46 | 17.1 | kG | 22.5/22.5 |
| BM1 | 110° | 6 | 4.4 | 46 | 17.1 | kG | 14/-13 |
| MIC2 | 86.9° | 3 | 4 | 43 | (15.2)+3 | kG | 0/0 |
| MIC1 | 37.2° | 3 | 4 | 48 | (15.2)+1.2 | kG | 0/0 |
| EIC | 3.6° | 2 | | 450 | 62 | kV/cm | |

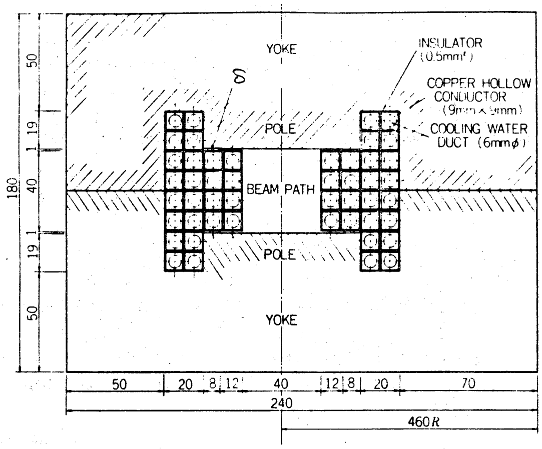


Fig. 2 Cross section of the bending magnet (BM1).

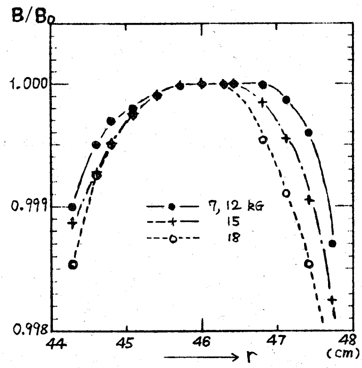


Fig. 3. Magnetic field distribution along radial direction measured at the position inner enough from the magnet edge.