DESIGN STUDY OF MAGNETIC DEFLECTION CHANNELS FOR THE RIKEN SSC

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The beam extraction system for the RIKEN SSC was previously reported[1)-3)]. This system consists of an electrostatic deflection channel, two magnetic deflection channels(MDC1 and MDC2) and two uniform-field bending magnets. Required characteristics of each element were tabulated in Ref. 1. The present report describes the calculated results of the magnetic field distribution by the designed MDC systems.

A pure shim channel is more attractive than a current septum channel from the economical and mechanical points of view. But the shim channel cannot be adopted in our energy variable SSC, because it cannot adjust the field strength and causes inevitably an undershoot field problem. The maximum fields reduced by MDC1 and MDC2 are 0.05 T and 0.17 T, respectively. Finally we adopted current septum without iron shims for MDC1, but with iron shims for MDC2. The iron shims were used for MDC2 to avoid enormous increase of current density of the septum coils.

Design study of the MDC systems was performed using the least-squares method similar to Ref. 4 which minimized field disturbance outside the channels and uniformed the field distribution inside. In designing the MDC systems we assumed that these field distributions were produced by superposing the magnetic field of current cells upon the magnetic field by the sector magnet(the base field). The base field was calculated by the magnetostatic calculation program TRIM[5)]. The magnetic field generated by each current cell was obtained by subtracting the base field from the magnetic field which was calculated with a current cell inserted in an air gap of the sector magnet. The field strength produced is completely proportional to current values of the cell up to 2500 A at the base field of 1.675 T.

The overshoot field inherent to the use of a current septum channel is compensated within a distance of 6 cm from the extraction orbit(E.O.) not to affect the last accelerating orbit(L.A.O.) and not to make a harmonic field.

The configuration of MDC1 is shown in Fig. 1. The current septums were placed apart from the median plane in order to increase a field uniformity inside MDC1. But a required current became large. The field distribution near MDC1 is shown in Fig. 2. Field expansion coefficients of quadrupole and sextupole terms within a beam width(1 cm) are -1.02×10^{-3} cm^{-1} and -8.13×10^{-5} cm^{-2}, respectively. The deformation of the beam shape, therefore, is negligibly small in the beam passing through MDC1. The undershoot field was found to be almost zero(0.01 mT).

A cross section of MDC2 is shown in Fig. 3. The iron shims decreased the base field by about 0.06 T inside the channel and produced an undershoot field of about 0.003 T outside the channel. This undershoot canceled out the overshoot field by the current septums in the case of extracting $^{12}C^{6+}$ ions at 135 MeV/u, so that the compensation coils were not required. But two compensation coils were adopted to elminate an undershoot field in the case of extracting other ions. Figure 4 shows the field distribution near MDC2. The field inhomogeneity was a little larger than that of MDC1, but the deformation of beam shape was rather small in passing through MDC2.

References

1) Y. Yano *et al.*: Proc. 9th Int. Conf. on Cyclotrons and Applications, p. 473 (Caen, France, 1981).
2) A.Goto *et al.*: ibid., p. 439.
3) N. Kishida *et al.*: RIKEN Accelerator Progress Report, **15**, 183 (1981).
4) H. Braun: Proc. Int. Conf. on Magnet Technology, p. 1620 (Hanburg, Germany, 1970).
5) J. S. Colonias and J. H. Porst: Magnet Design Applications of the Magnetostatic Problem called, TRIM, UCRL-16382 (1965).

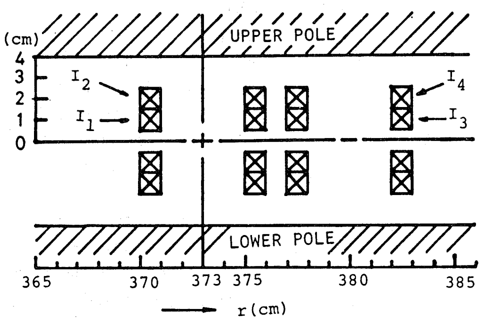

Fig. 1. Schematic drawing of MDC1. r denotes the radial distance from the center of the SSC. I_3 and I_4 indicate the currents that flow through the respective compensation coils.

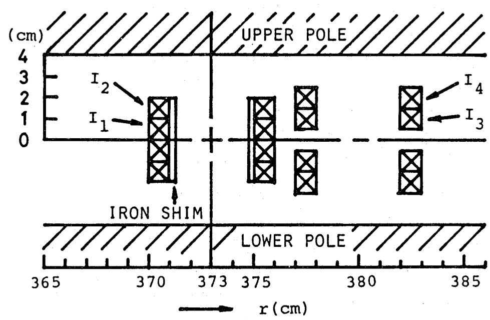

Fig. 3. Schematic drawing of MDC2. The width of iron shim is 0.25 cm.

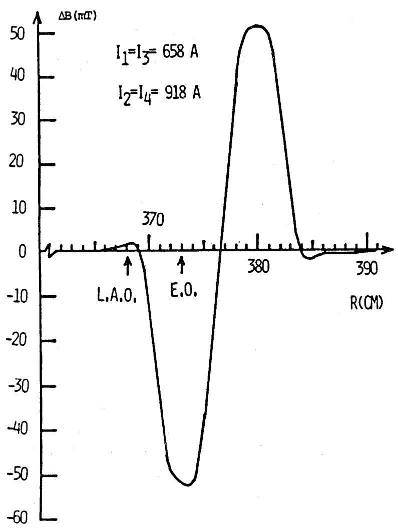

Fig. 2. Magnetic field distribution produced by MDC1 at B_{base} = 1.675 T.

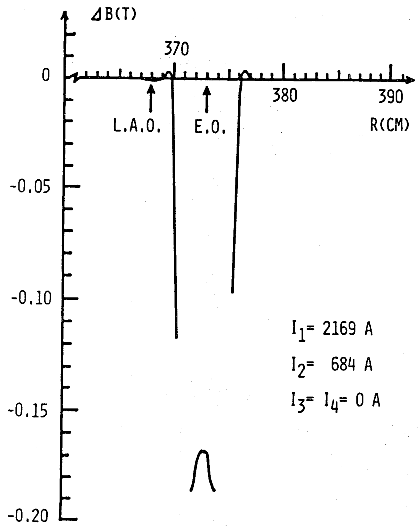

Fig. 4. Magnetic field distribution produced by MDC2 at B_{base} = 1.675 T.