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BEAM TRANSPORT SYSTEM FOR THE IPCR SSC

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Abstract.- The beam transport system for the IPCR SSC is designed. The IPCR accelerator complex has a heavy-ion linac and an AVF cyclotron as preaccelerators. The beam lines of accelerators are not on the same horizontal plane and a three dimensional layout is taken into account. This system is divided into small independent subsystems with symmetry.

1. Introduction.- A separated-sector cyclotron with K-number of about 540 MeV is under construction[1]. A heavy-ion linac and an AVF cyclotron will be preaccelerators to the SSC. The linac injects heavy-ions (A≳20) and the AVF cyclotron injects light heavy-ions such as p, d , ^{3}He, α, ^{12}C, ^{16}O and ^{20}Ne. The present report describes a beam transport system from the preaccelerators to the entrance of the beam injection system for the SSC[2] and from the SSC to experimental areas.

The beam transport system from the preaccelerators to the SSC has to perform the following functions: (1) to guide efficiently the beam; (2) to match the beam ellipses in transverse and longitudinal phase spaces with the eigen ellipses of the first equilibrium orbit.

The following beam preparation modes between the SSC and the targets must be possible: (1) doubly dispersive, doubly telescopic, momentum resolution up to 20000; (2) achromatic, doubly telescopic, momentum resolution up to 10000; (3) doubly telescopic, variable time-of-flight resolution below 500 ps.

Plan view of the accelerators is shown in figure 1. The beam lines of the accelerators are not on the same horizontal plane and a three dimensional layout is taken into account. The difference of beam level between the linac and the SSC, and between the AVF cyclotron and the SSC is 11.9 m and 4 m, respectively.

2. Physical layout and calculated properties of the beam transport system

(i) The beam transport system between the linac to the SSC.- The three dimensional layout is shown in figure 2. The starting point of the transport system (SL0) is to be placed about 15 m downstream from the exit of the linac. A beam preparation system that consists of two quadrupole doublets and a slit system makes 2 x 12.5π mm·mrad upright beam ellipses in both horizontal and vertical phase spaces at SL0.

The beam transport system is composed of two kinds of subsystems. One is an achromatic beam bending section and the other is a straight beam guiding section with some quadrupole magnets.

The first subsystem from SL0 to SL3 is not only an achromatic beam transport system but a momentum analyzing system. Energy resolution at SL1 reaches uo to 0.3 % with the object slit width of 4 mm. The ion-optical calculations were made using the program TRANSPORT[3]. A charge stripping device is placed at SL0 and charge selection is carried out at SL1. Two dipoles (DL1 and DL2) have their bends in the opposite senses (S-shape), so that the system is naturally double-dispersive if two quadrupole doublets (QDL1 and QDL2) are not used. In order to change double-dispersive mode to double-achromatic mode, the sense of the second dispersive bend relative to that of the first one must be changed. This can be achieved by inserting two anti-symmetric (translational symmetric) quadrupole doublets which operate in telescopic mode ($R_{11}= R_{22}= R_{33}= R_{44}= -1$ and $R_{12}= R_{21}= R_{34}= R_{43}= 0$ in TRANSPORT nomenclature).

A beam buncher is installed at SL3 and makes a waist in ℓ-δ space at the beam injection point. The section between SL3 and SL4 converts the shape of beam ellipses so as not to diverge the beam in the subsequent sections.

The section between SL4 and SL5 forms an achromatic and a double-telescopic transport system with 80° bend. Dispersion matching is basically performed in the beam injection system after BM2[2], but this system dose not have an element that varies the dispersion functions (R_{16} and R_{26}). The R_{16} and R_{26} are to change over a certain range in this section. Consequently complete dispersion matching is carried out using combination of this section and the beam injection system.

The transverse phase-space matching is executed with four quadrupole magnets between SL5 and SL6, and is controlled with an emittance measuring system installed at SL6. The second-order calculations are also carried out to estimate the beam aberrations are negligibly small. The beam envelope in the horizontal and vertical directions is shown in figure 3.

(ii) The beam transport system between the AVF cyclotron and the SSC.- The beam extracted from the AVF cyclotron is made to form a double-waist at SC0 using a quadrupole triplet (QTC1). We regard the position SC0 as the starting point of the beam transport system between the AVF cyclotron and the SSC (see figure 2). The section from SC0 to SC2 transforms a dispersive beam extracted from the AVF cyclotron into an achromatic beam ($r_{16}= r_{26}= 0$). A charge stripping and charge selecting slit are installed at SC0 and SC1, respectively. Energy resolution at SC1 reaches up to 0.14 % with the object slit width of 3 mm and this resolution is good enough to select the charge state of the ions.

The section between SC2 and SL5 composes an achromatic transport system with 90° bend. A beam buncher is installed at SC2. This transport line is joined to the beam line at the switching magnet DL4.

(iii) The beam transport system between the SSC and the target areas.- As is shown in figure 1, we decide to adopt double-monochromator systems with the 90°-bending magnets to fulfil the condition stated in the introduction. These systems operate as doubly telescopic systems with mirror or antimirror symmetry depending on the target areas. The ion-optical calculations are carried out using the eigen-ellipsoid of the last equilibrium orbit.

References

1) H. Kamitsubo, IPCR SSC with K=540, this conference.
2) Y. Yano et al., Beam injection and extraction system for the IPCR SSC, this conference.
3) K. L. Brown et al., SLAC Report , No 91 (1974).

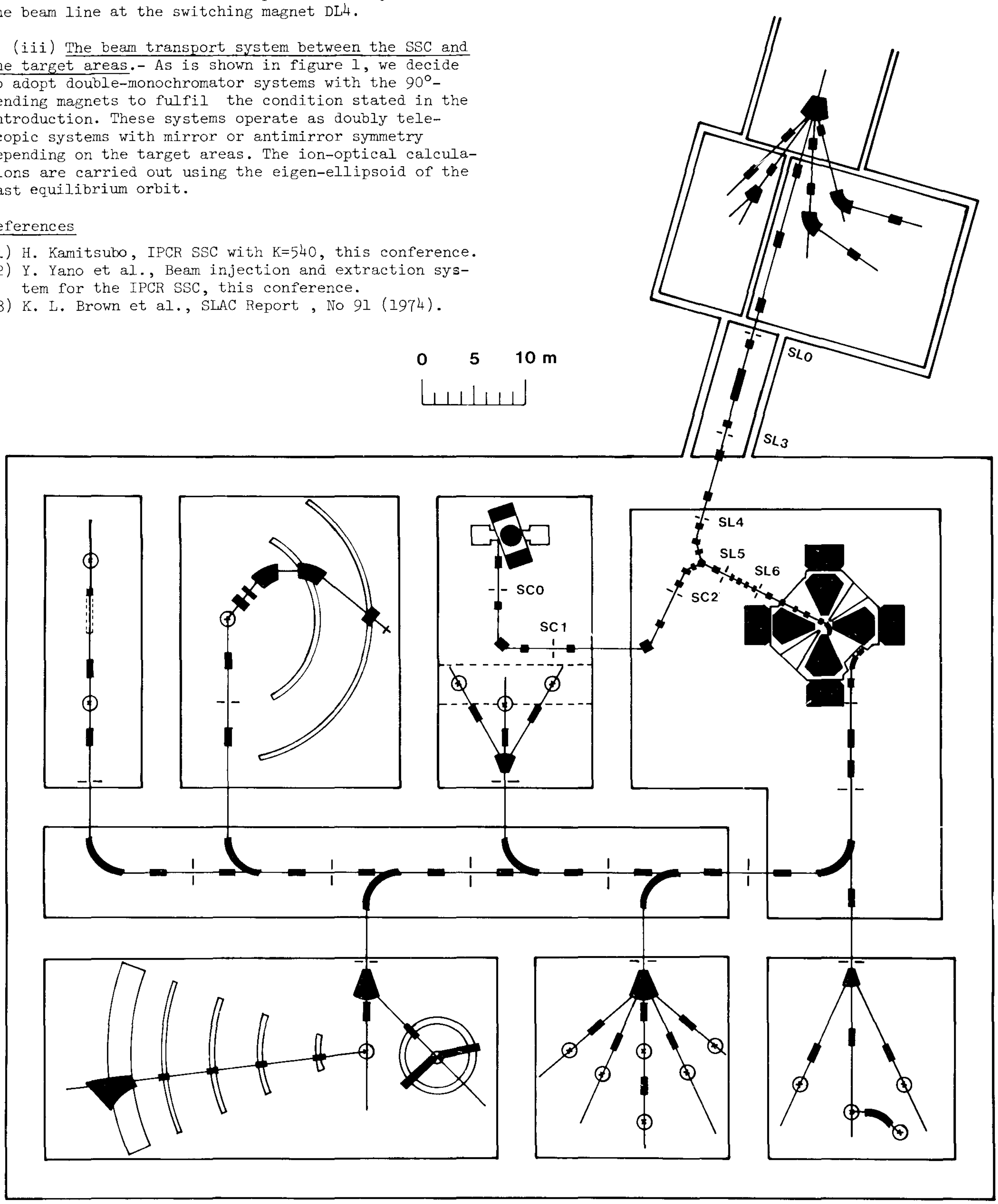

Fig. 1 : The plan view of the beam transport system for the IPCR SSC. The beam levels of the SSC, the linac and the AVF cyclotron are not on the same horizontal plane.

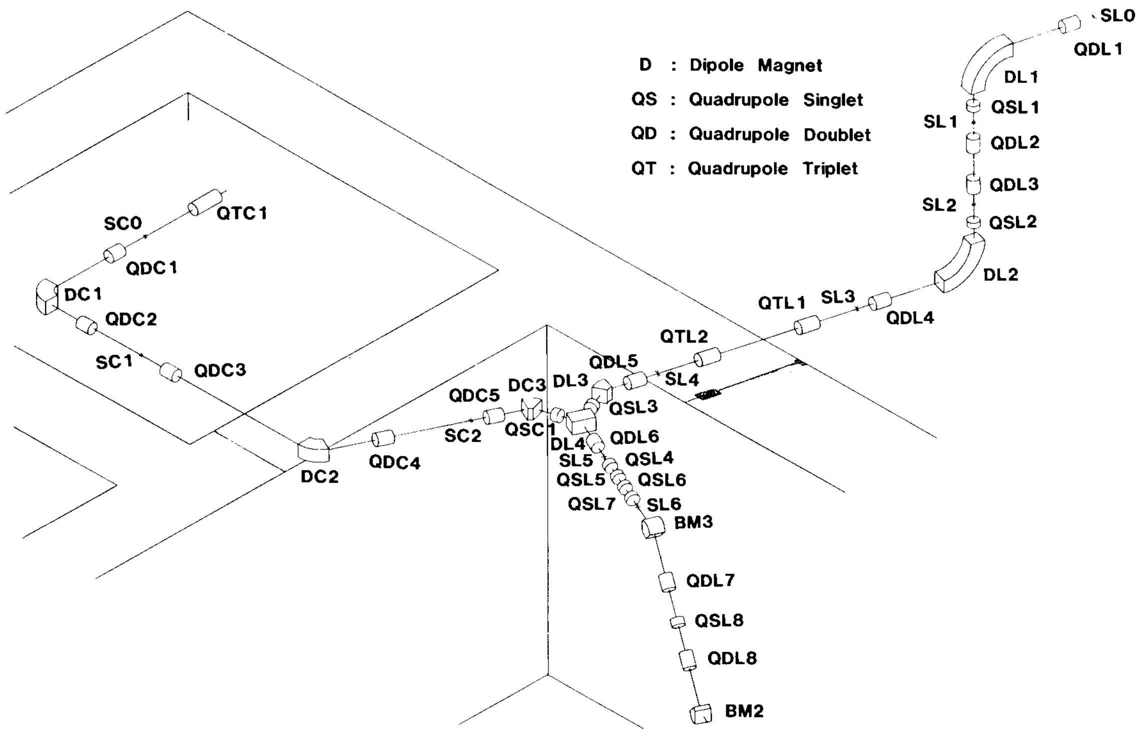

Fig. 2 : Layout of the beam transport system between the linac and the SSC, and between the AVF cyclotron and the SSC

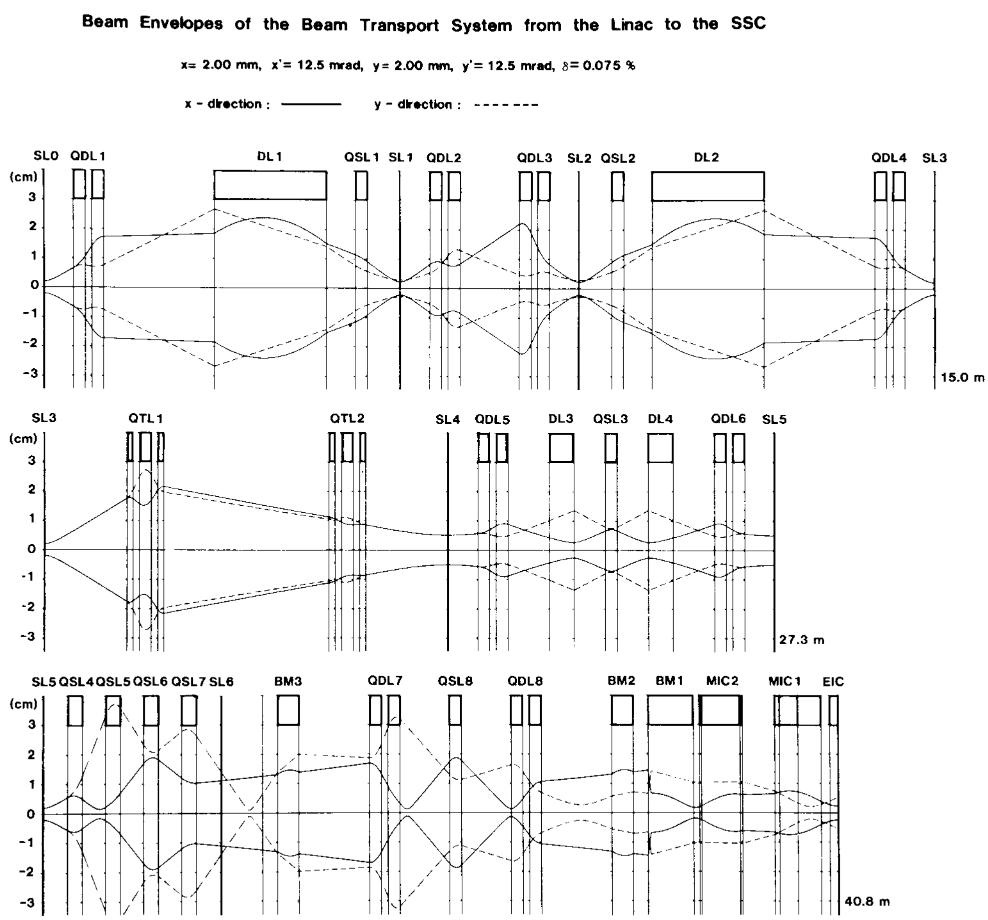

Fig. 3 : Beam envelope throughout the beam transport system from the linac to the SSC. The beam injection system starts from BM3[2].