BEAM TRANSFER PROBLEMS ON GANIL

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Abstract

A structure for a beam line is proposed, which matches not only the transverse emittance, but also the longitudinal one. It corrects the usually strong geometric and chromatic non-isochronism of the injection and ejection systems of the cyclotrons, in order to avoid an increase of the beam length. These corrections are necessary to obtain the excellent quality (especially the small energy spread) of the final beam of GANIL.

The GANIL project aims to rather high beam characteristics [1]. In order to achieve them, special care must be taken for the beam-transfer from one cyclotron to the other.

As it is well known, the main purpose of a beam-line is to match the emittance of the beam in the six-dimensional phase space, in order to avoid further beam losses. In the GANIL project, the longitudinal matching in the transfer-line from the Injector Cyclotron C0, to the first Separated Sector Cyclotron SSC1, is very important, because the extraction channel of C0, as well as the injection device of the SSC1, are strongly non-isochronous, even for a monochromatic beam. The increase l of the path-length comes from two different effects.

The first one, which can be called geometric non-isochronism, is due to the radial dimension x_0 and the radial angular width x'_0 of the beam

$$l_1 = Ax_0 + Bx'_0$$

Without any compensation, the length of the beam, which is $\pm$ 7.5° R.F. on the final orbit of C0, would increase by 60 % in the extraction channel of C0 and by 40 % in the injection device of SSC1. The compensation, obviously based on path-length considerations, can be achieved in theory by two quadrupole lenses Q_1 and Q_2 and a dipole D, as seen on figure 1, which concerns the compensation of the geometric non-isochronism of the extraction channel of C0. Other quadrupoles can be necessary to give additional focusing parameters.

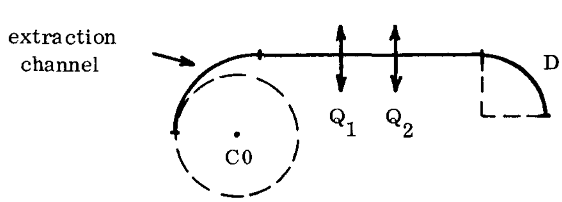


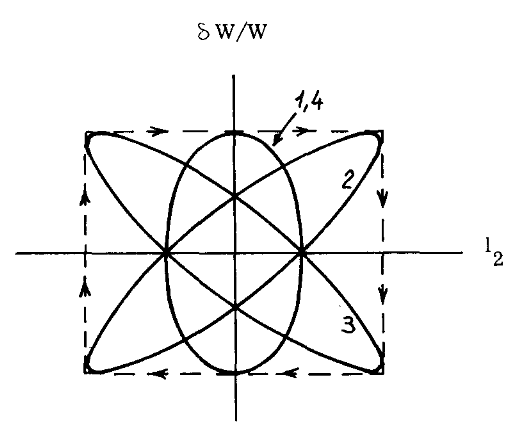
Fig. 1

It must be emphasized that in an usual beam-line, where the energy of the beam remains unchanged, the two terms (A and B) of the geometric non-isochronism and the two chromatic dispersion terms of the transfer matrix, are bound by the symplectic conditions [2], because with the actual variables the motion is hamiltonian. These relations show that complete geometric isochronism gives, in such a beam-line, complete achromatism, and vice versa. But if there is an energy variation in the beam-line (given for instance by a buncher, or by the space charge), the complete geometric isochronism and the complete achromatism cannot <u>in general</u> be obtained simultaneously.

The second effect, which can be called chromatic non-isochronism, is due to the energy spread $\delta W/W$ in the beam

$$l_2 = C \; \delta W/W$$

It is roughly proportional to the length of the beam-line. In the transfer-line from C0 to SSC1, the increase of the beam length is in the order of 20 % per meter beam-line length and per 1 % in $\delta W/W$. The chromatic path-length increase can be compensated by a buncher located about in the middle of the transfer-line. The buncher works as shown by figure 2.



Longitudinal emittance :

1. at the entrance of the beam-line
2. in the middle (before the buncher)
3. in the middle (after the buncher)
4. at the exit of the beam-line.

Fig. 2

Proc. 7th Int. Conf. on Cyclotrons and their Applications (Birkhäuser, Basel, 1975), p. 297-298

So the transfer-line from C0 to SSC1 has to fulfil many optical conditions and furthermore must be easy to tune. For those reasons, a structure with separated functions, as seen on figure 3, seems to be adequate.

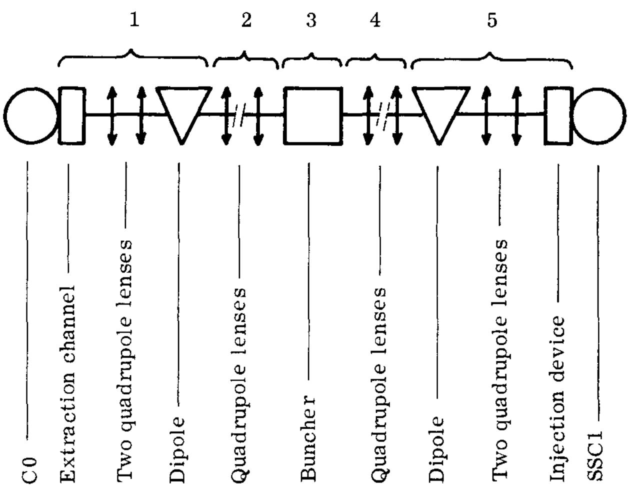


Fig. 3

Part 1, as well as part 5, give both total geometric isochronism and total achromatism. Parts 2 and 4 provide the transverse beam matching without destroying the properties of the other parts. Part 3 gets the chromatic isochronism, without destroying the properties of the other parts. So, if the space charge effects are neglected, the structure proposed on figure 3 gives both total isochronism and total achromatism, though the beam-line contains a buncher, because these properties are achieved in the section before the buncher, as well as in the section after the buncher.

Similar problems, though less critical, exist in the other beam-lines of the GANIL project.

References

1) This Conference, GANIL : a proposal for a french heavy ion laboratory.

2) R. Beck, Optique corpusculaire (2e édition), 1970, p 73.