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Since an acceleration of heavy ions has succeeded with the model 680 cyclotron[1,2], heavy ion beams have been transported to some beam courses. One of them is the high-resolution beam course numbered (41). Sometimes, in the heavy ion reaction experiments, high beam intensity is required rather than high resolution beam on the course (41). Then achromatic beam transport is of great advantage to some experiments. That is, a beam of ions with a spread in energy must be sent through two bending magnets, yet it is desirable to do this without dispersion. This need can arise when the image on a target should be of maximum intensity, rather than of homogeneity of energy.

An examination of the fundamental first order matrix for transport through a magnet makes it evident that a radius of curvature has been assigned only to the particles of standard momentum p; ions of greater and less momentum are assumed to follow sinusoidal path about the central p orbit. On this basis, the expression for the lateral deviation from the central path was found to contain the dispersion term $C \cdot \Delta p/p$, where C is a matrix element at the distance in question, most significantly the image distance. Similarly, the expression for the path slope with respect to the central ray contained the dispersion term $f\Delta p/p$, where f is another matrix element. To the extent that this procedure gives an acceptable approximation to the truth, the lateral displacement and the slope will be achromatic lie independent of momentum, if the coefficients C and f can be made to vanish. This is the basis of first order achromatism.

In the high-resolution course (41), the beam is shifted laterally by two oppositely bending magnets of different angles, furthermore this beam course has been designed without a consideration of achromatic beam transport. Therefore it is a very difficult that find out the necessary conditions for achromatic beam transport in analytic formula. So, at first, the achromatic beam transport for proton of 10 MeV has been calculated numerically using the beam transport code OPTIC.[3] The test according to the results of the calculations has been performed on the course (41). Supposing an object is made at the slit (SLH4-1) just down stream of the first bending magnet[4] (SW1), the calculations have done. As the result of the test, about 100% of beam intensity pass through the slit (SLH4-1) was transported to the target position in the large chamber which is the terminal of the course (41). The beam spot on the target position was 5×2 mm. On the basis of this experience, the achromatic beam transport for $^{14}N^{5+}$ ions of 84 MeV has been calculated and tested. The result was similar to the proton beam transport test. The poor focus of beam on the target position is caused by a relative position of the third bending magnet (DEF) and a triplet quadrupole magnets placed on just the upper stream of the large chamber. The achromatic beam trajectories calculated for $^{14}N^{5+}$ ions of 84 MeV are drawn in Fig. 1.

References

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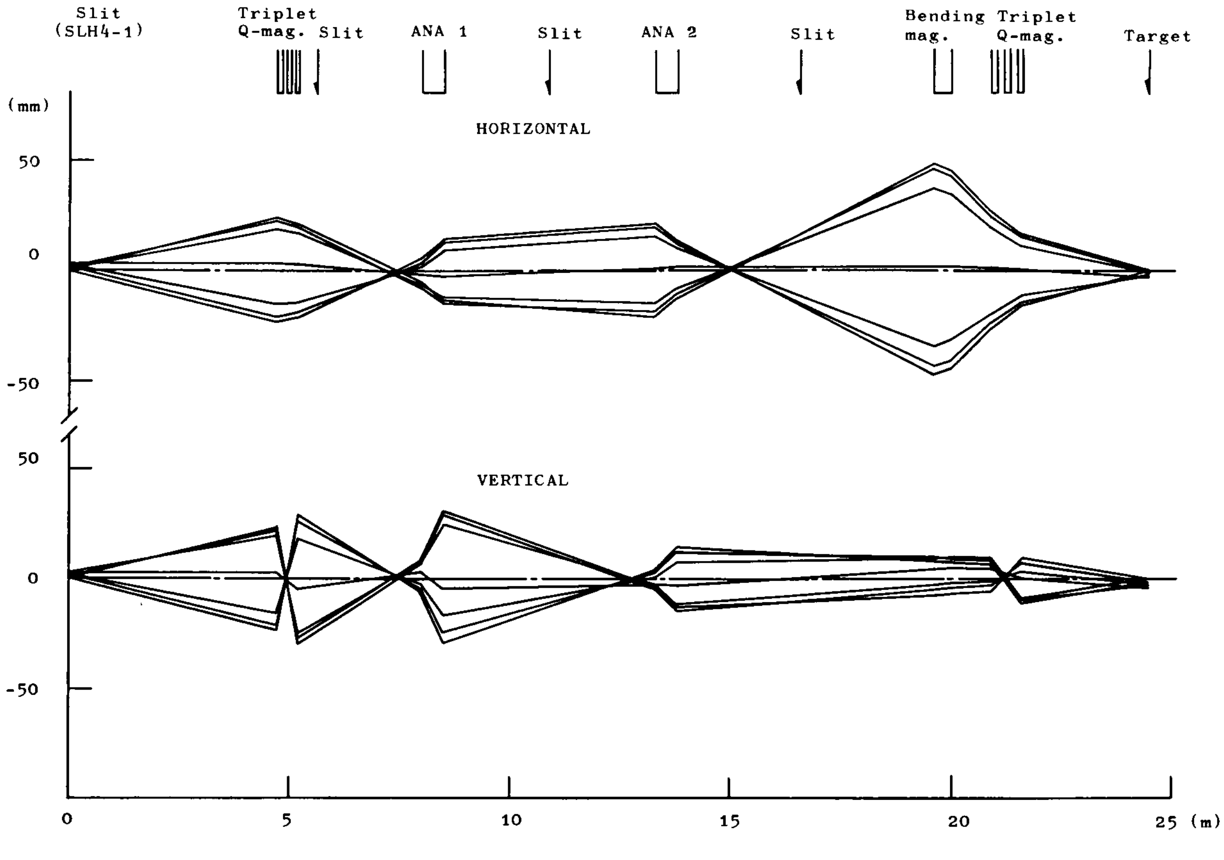

Fig. 1. Chromatic and achromatic beam trajectories of 84 MeV $^{14}N^{5+}$ ions on the course (41).