STUDY OF BEAM LONGITUDINAL MOTION FOR SSC

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Abstract

The injection, acceleration and extraction of Separate Sector Cyclotron (SSC) is analyzed and simulated to get the longitudinal acceptance, using the typical ion $^{238}U^{36+}$ with energy 9.7 MeV/u. In order to study the actual longitudinal acceptance of SSC, the isochronous magnetic field model in coincidence with the real one is established by Kr-Kb and Lagrange methods based on the actual measurement. Under the isochronous magnetic field, the longitudinal acceptance at the injection, acceleration and extraction is calculated. From the simulation results the transmission efficiency is very low in SSC because of the large phase width of the beam from the injector Sector Focus Cyclotron (SFC). In the machine commissioning, the phase width of the beam line from SFC to SSC is measured by the phase probes, the results show that the actual phase width is larger than the acceptance of SSC.

INTRUDUCTION

Presently higher beam intensity and quality are required to perform higher level experiments. In the view of existing conditions, the accelerator system needs to be upgraded to satisfy physical requirements, where the key issue is the separate sector cyclotron (SSC) of HIRFL. The low beam transmission efficiency of SSC and the existing beam intensity of SSC's injector - sector focusing cyclotron (SFC) limited the beam intensity of SSC. In this paper, the longitudinal acceptance is calculated under the real isochronous magnetic field model. It provides important parameters for machine commissioning by particle tracking simulation of SSC. In addition, we discovered the main reason of low efficiency and acceptances of SSC depend on the simulation. The simulation results will help in machine commissioning and the upgrade of HIRFL.

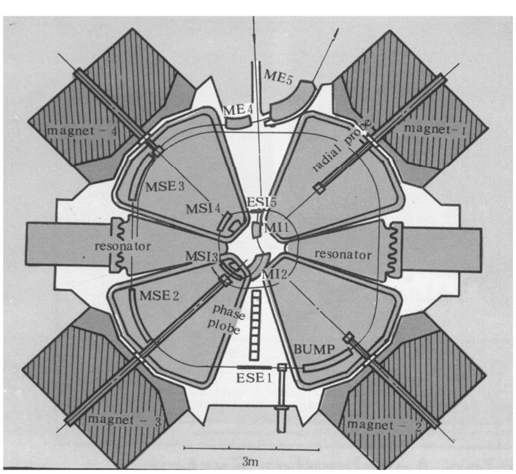

Figure1: The overall layout of SSC

Figure 1 is the overall layout of SSC. As shown, Mi1, Mi2, MSi3, MSi4, ESi5 is the injection system of SSC, and ESe1, MSe2, MSe3, Me4, Me5 is the extraction system.

BEAM DYNAMICS SIMULATION

The accelerator SSC was constructed twenty years ago. Now we can not measure the real isochronous magnetic field, but build it with the existing magnetic field parameter. Here, the method of Kr-Kb [1] and Lagrange linear interpolation is used to build the real isochronous magnetic field.

Figure 2 and 3 are the theoretical isochronous magnetic field model and the real isochronous magnetic field model respectively.

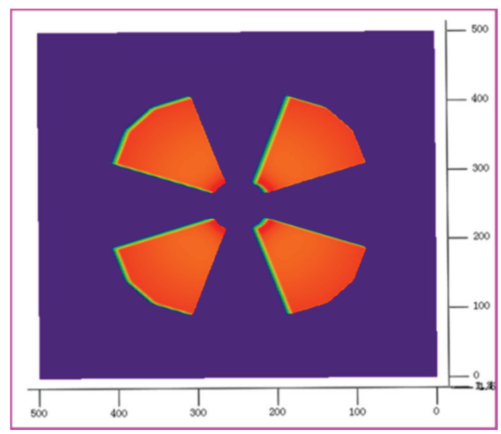

Figure 2: The theoretical magnetic field built by the sub-program ISO.

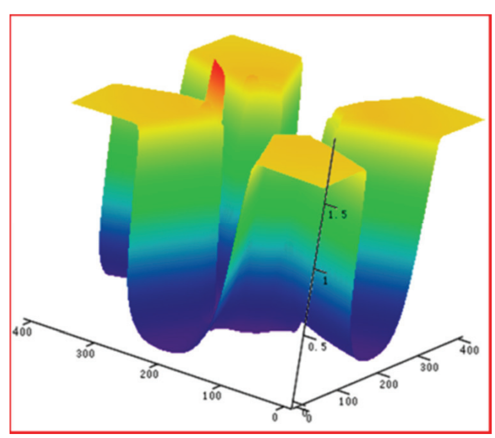

Figure 3: The real magnetic field established by Kr-Kb and Lagrange methods based on the actual measurement.

Under the real isochronous magnetic field model, the injection, acceleration and extraction of Separate Sector

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Cyclotron (SSC) is analyzed and simulated to get the longitudinal acceptance, using the typical ion $^{238}U^{36+}$ with energy 9.7 MeV/u. In Fig. 4 the simulation results are shown. The simulation results under the real isochronous magnetic field model are not good, the longitudinal acceptance of SSC at the end extraction system is very small, the phase width is only ±5°. So the most particles can be injected into SSC and accelerated, but can be not extracted.

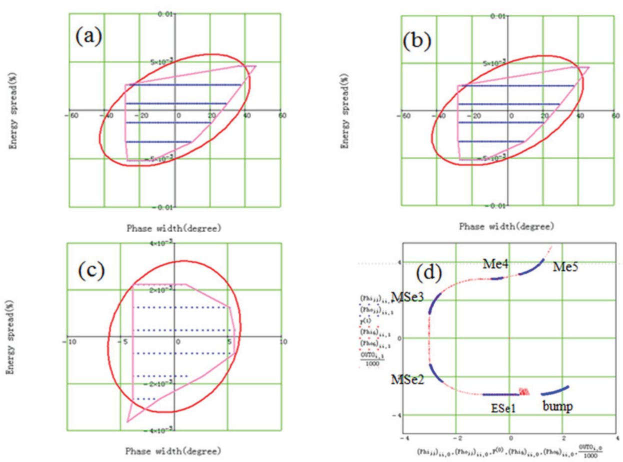

Figure 4: The simulation results under the real isochronous magnetic field model, the ion $^{238}U^{36+}$ with energy 9.7 MeV/u. (a) The longitudinal acceptance of SSC at the injection point. (b) The longitudinal acceptance of SSC at the end of acceleration (R=3200 mm). (c) The longitudinal acceptance of SSC at the end extraction system. (d) The particles orbit in the extraction system of SSC.

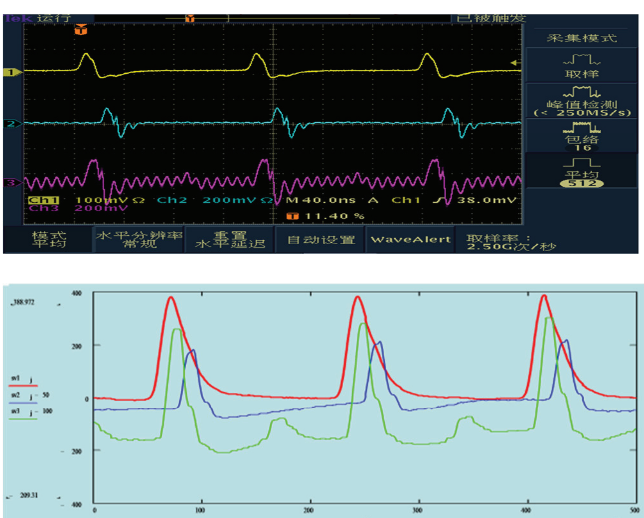

Figure 5: The measured phase spread, the ion is $^{40}Ar^{12+\sim16+}$ with energy 6.17 MeV/u, F_{rf}=7.286 MHz.

In Fig. 5, the result is that the phase spread is about 80°, it is mean that the phase spread of the beam injected into SSC is very width.

SUMMARY

Because of large phase spread the radial width of the beam is larger than the width of the extraction deflector. Then most particles lost at the extraction system. The longitudinal transmission efficiency of SSC is also low in the machine commissioning. So it necessary to measure the phase spread of the beam injected into SSC by the phase probe in the beam line. The result is that the bunch efficiency is low and the phase spread of the beam injected into SSC is large.

ACKNOWLEGEMENT

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REFERENCES

[1] K. Ziegler, "Running in of VICKSI and First Operating Experience," IEEE Trans. Nucl. Sci. No.2 (1978) NS-26.

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