

RESEARCH ON ACCEPTANCE OF SSC

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Abstract

The injection, acceleration and extraction of SSC (Separate Sector Cyclotron) is analyzed and simulated to get the transverse and longitudinal acceptance, using two typical ions $^{238}\text{U}^{36+}$ and $^{70}\text{Zn}^{10+}$ with energy 9.7MeV/u and 5.62MeV/u respectively. In order to study the actual 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. The transverse and longitudinal acceptance is calculated under the above isochronous magnetic field model. From the simulation results, one of the major reason of low efficiency and acceptance of SSC is the defaults in the design of MSI3. The simulation results show that the actual efficiency and acceptance of SSC can be improved by redesign the curvature of MSI3 or shim in MSI3 to change the distribution of inner magnetic field.

INTRODUCTION

SSC is the main accelerator of HIRFL (Heavy Ion Research Facility in Lanzhou). 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 SSC of HIRFL. The low beam transmission efficiency of SSC and the existing beam intensity of SSC's injector - Sector Focused Cyclotron (SFC)[1,2] limited the beam intensity of SSC. As a result from the above reasons, Institute of Modern Physics, CAS planned to build a new linear injector (SSC-LINAC) to get higher intensity beam for heavier elements.

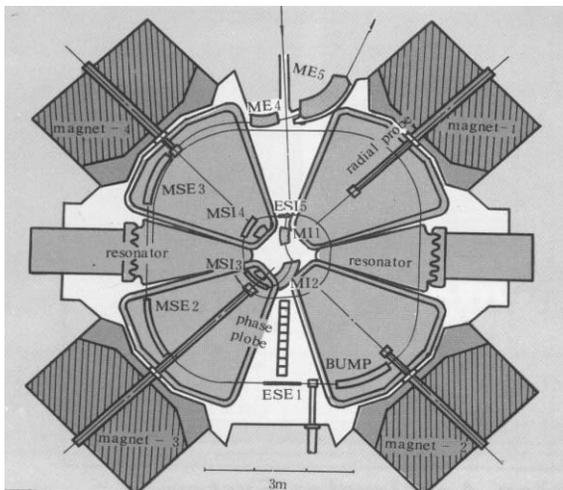
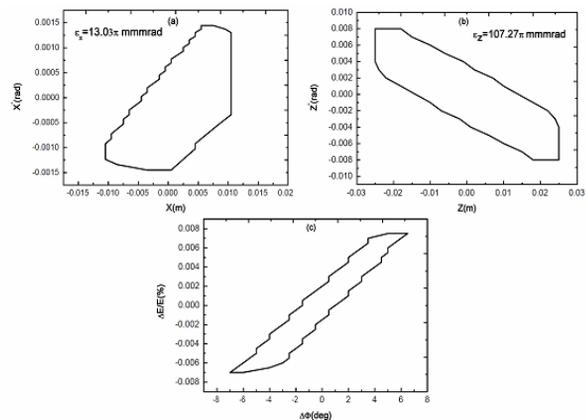


Figure 1: The overall layout of SSC.

In this paper, the transverse and longitudinal acceptance is calculated under the theoretical isochronous magnetic field model and the real one. It will provide important parameters for SSC-LINAC. In addition, the simulation results will help in machine commissioning and the upgrade of HIRFL by discussing the acceptance of SSC. Fig.1 gives the overall layout of SSC. It shows four sector magnets and the injection and extraction system of SSC, and two RF cavities.

SIMULATION RESULTS UNDER THE THEORETICAL ISOCHRONOUS MAGNETIC FIELD MODEL

The theoretical isochronous magnetic field distribution [3-5] is the hyperbola secant function. In present paper, the acceptance of SSC (the point of the injection orbit, which is 4.08m far from the centre of SSC) is calculated by tracking particles. Fig.2 and Fig.3 show the results of ions $^{238}\text{U}^{36+}$ with energy 9.7MeV/u, and $^{70}\text{Zn}^{10+}$ with energy 5.62MeV/u respectively. In Fig.2, (a), (b), (c) are radial acceptance of 13.03π -mm-mrad, axial acceptance of 107.27π -mm-mrad and longitudinal acceptance respectively. The energy spread is $\pm 0.7\%$ and the phase is from -6 to 6° . In Fig.3, (a), (b), (c) are radial acceptance of 16.43π -mm-mrad, axial acceptance of 208.34π -mm-mrad and longitudinal acceptance respectively. The energy spread is $\pm 0.6\%$ and the phase is from -10 to 10° .

Figure 2: The results of ion $^{238}\text{U}^{36+}$ with energy 9.7MeV/u, acceptance of SSC in theoretical magnetic field (a) radial acceptance (b) axial acceptance (c) longitudinal acceptance.

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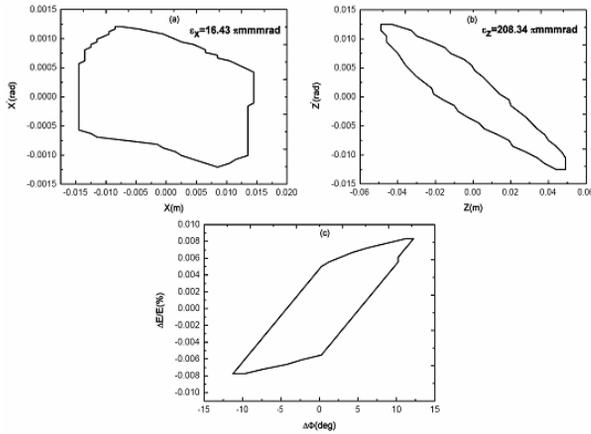


Figure 3: The results of ion $^{70}\text{Zn}^{10+}$ with energy 9.7MeV/u, acceptance of SSC in theoretical magnetic field (a) radial acceptance (b) axial acceptance (c) longitudinal acceptance.

SIMULATION RESULTS UNDER THE REAL ISOCHRONOUS MAGNETIC FIELD MODEL

The accelerator SSC was constructed twenty years ago, so now we can not measure the real isochronous magnetic field directly. However, we can build it with the existing magnetic field parameters. Here, the method we used is Kr-Kb[5-8] and Lagrange linear interpolation. Fig.4 and Fig.5 show the results of ions $^{238}\text{U}^{36+}$ with energy 9.7MeV/u, and $^{70}\text{Zn}^{10+}$ with energy 5.62MeV/u respectively. In Fig.4, (a), (b) and (c) are radial acceptance of $2.33\pi\text{-mm}\cdot\text{mrad}$, axial acceptance of $41.09\pi\cdot\text{mm}\cdot\text{mrad}$ and longitudinal acceptance respectively. In Fig.5, (a), (b), (c) are radial acceptance of $1.54\pi\text{-mm}\cdot\text{mrad}$, axial acceptance of $54.27\pi\text{-mm}\cdot\text{mrad}$ and longitudinal acceptance respectively.

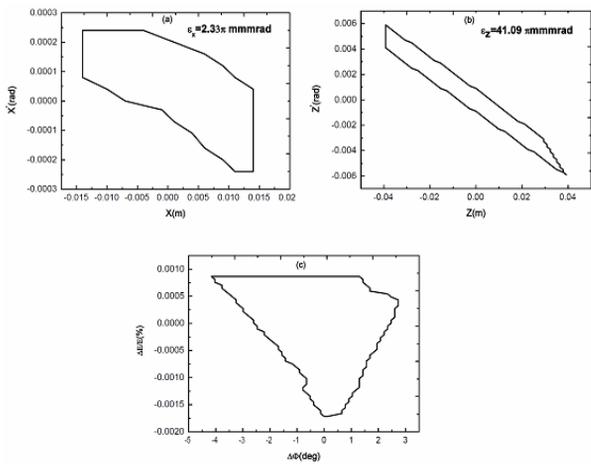


Figure 4: Acceptance of SSC in real magnetic field (a) radial acceptance (b) axial acceptance (c) longitudinal acceptance.

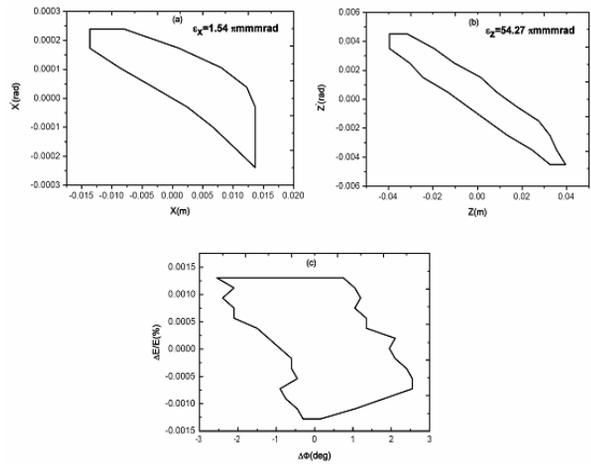


Figure 5: Acceptance of SSC in real magnetic field (a) radial acceptance (b) axial acceptance (c) longitudinal acceptance.

From the above simulation results, the acceptance under the real magnetic field model is not good. In the process of the central particle tracking, the central particle orbit in MSI3 under the real magnetic field is bad, so a lot of particles are lost in this element. Fig 6 shows the results of ion $^{238}\text{U}^{36+}$ with energy 9.7MeV/u, central particle orbit in MSI3 under the theoretical and real magnetic field.

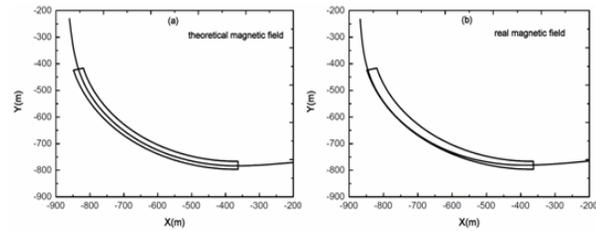


Figure 6: The results of ion $^{238}\text{U}^{36+}$ with energy 9.7MeV/u, central particle orbit in MSI3 under the theoretical and real magnetic field.

COMMISSIONING RESULTS

In the machine commissioning, the transmission efficiency is also low. Table 1 shows the transmission efficiency of three typical ions in the machine commissioning.

Table 1: The transmission efficiency of three typical ions

Particles	Matching Efficiency	Transmission Efficiency
$^{40}\text{Ar}^{14+}$ 18MeV/u	100%	12%
$^{20}\text{Ne}^{10+}$ 85.75MeV/u	50%	21%
$^{86}\text{Kr}^{26+}$ 25MeV/u	100%	23%

CONCLUSION

The simulation results under the real isochronous magnetic field model are worse than expected, and the transmission efficiency of SSC is also low in the machine commissioning. From the simulation results, the orbit of central particle in MSI3 is bad in measured field distribution. This might be one of the major reason of low efficiency and acceptance of SSC. The results show that the actual efficiency and acceptance of SSC can be improved by redesign the curvature of MSI3 or shim in MSI3 to change the distribution of inner magnetic field. Besides, more careful optimization in simulation and operation must be done to improve the transmission efficiency and acceptance.

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