Development of rapid emittance measurement system

Keita Kamakura[1], K. Hatanaka[1], M. Fukuda[1], T. Yorita[1], H. Ueda[1], S. Morinobu[1], T. Saito[1], K. Nagayama,[1] H. Tamura[1], Y. Yasuda[1]

[1]*Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka 567-0047, Japan*

At RCNP cyclotron facility, high intensity secondary particle production and intensification of high quality beam have been under development. We are aiming to enlarge proton beam current up to 10 μA at downstream of existing K400 ring cyclotron at the request of ultra-cold neutron and muon experiments. Until today we have been using K140 AVF cyclotron as an injector for K400 ring cyclotron. However for the sake of injection and extraction performance of the injector, it is difficult to attain the objective. Therefore we are planning to develop a new injector that replaces existing K140 injector [1]. As a new injector (hereinafter referred to as simply "the Injector") we are planning to construct a separated sector cyclotron and to use high temperature superconducting (HTS) magnet as a sector magnet. HTS magnets are remarked as next generation cyclotron magnet, because they can operate stably and reliably against quenching compared with low temperature superconducting magnets. The injector will be the first "High Temperature Superconducting Injector Cyclotron" in the world, and this project is the first step to small-sized high energy cyclotron in the future.

Firstly the Injector should have parameters such as extraction energy, orbit frequency and harmonic numbers that match with those of K400 ring cyclotron downstream. Moreover, number of sector magnets, sector angle, extraction radius, magnetic field strength, etc. have been determined by specification required.

For magnetic analysis of sector magnets, finite element method is used. We made a three dimensional model that consists of a yoke, pole tips main coils and trim coils (Figure 1). To keep isochronicity between rotational frequency of the beam and RF electric field of accelerating cavities, magnetic field must increase its strength along the beam accelerated because of the relativistic effect. Trim coils are implemented for this reason. In our current design, it has 36 trim coils are mounted on one pole tip. We can excite each coil separately. Optimization for excitation current of trim coils is now in progress.

Runge-Kutta method is used for beam orbit analysis. To begin with, we developed orbit simulation program by C, and examined a hard-edge model (Figure 2). Hard-edge model is an ideal condition of magnetic field that has no fringing field around the pole edge. The next step will be interpolation of the magnetic field that will be calculated on the sector magnet model. The result of the orbit analysis will feed back excitation currents, then analyze the orbit again, and so on. In this way, magnet design will be made up.

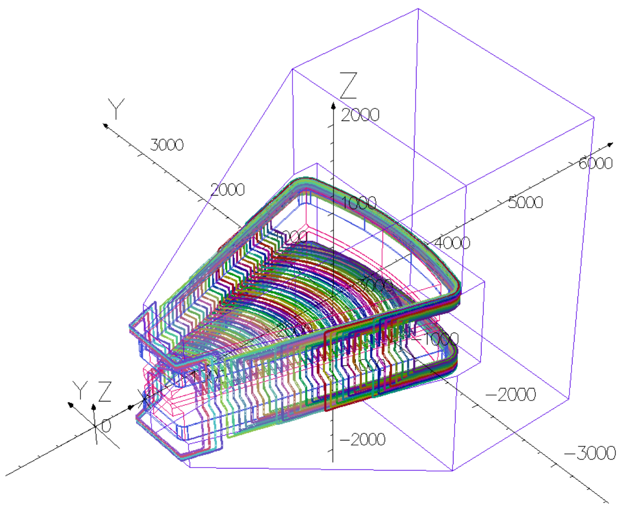

Figure 1: 3D model of a sector magnet.

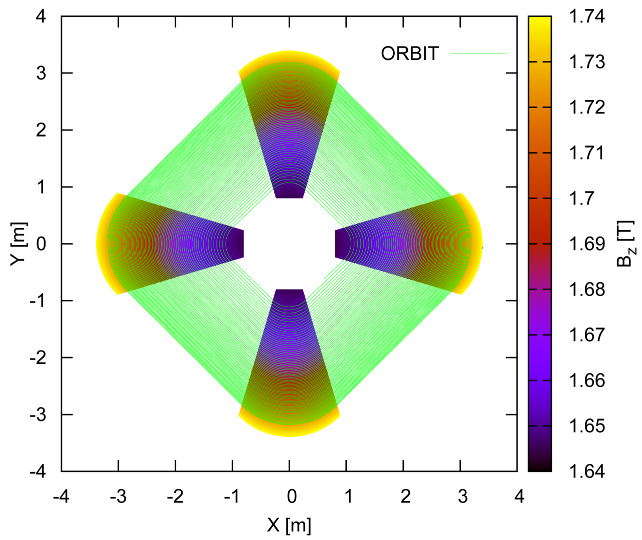

Figure 2: Orbit analysis on hard-edge model. Beam: $^4He^{2+}$, 200 MeV

References

[1] Kamakura, et al., "Challenge for the High Temperature Superconducting Injector Cyclotron", Proceedings of the 10th Annual Meeting of Particle Accelerator Society of Japan (August, 2013, Aomori, Japan)