Design Study of Beam Injection and Extraction at HiSOR-II Booster Synchrotron

Daisuke Fujita[a], Miho Shimada[b,a], Hiroshi Miyauchi[b,a], Masahiro Katoh[a]

[a]*Hiroshima University*
2-313 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-0046, Japan
[b]*High Energy Accelerator Research Organization (KEK)*
1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan

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Nearly 30 years have passed since the construction of the small synchrotron radiation source, HiSOR, at Hiroshima University. In these years, its aging has led to a serious decline in its availability and performance competitiveness. Therefore, the HiSOR-2 project is being proposed, which involves the construction of a new storage ring with a circumference of 44 m and a beam energy of 600 MeV, as well as an injector that will enable top-up operation. One of the options of the plan is to utilize the present HiSOR injector, 150 MeV microtron, as a pre-injector and to construct a new booster synchrotron of 600 MeV. Its circumference will be 22 m, which is exactly a half of the storage ring. The preliminary layout of the accelerator complex of HiSOR-2 is shown in Figure 1 as well as that of the present HiSOR.

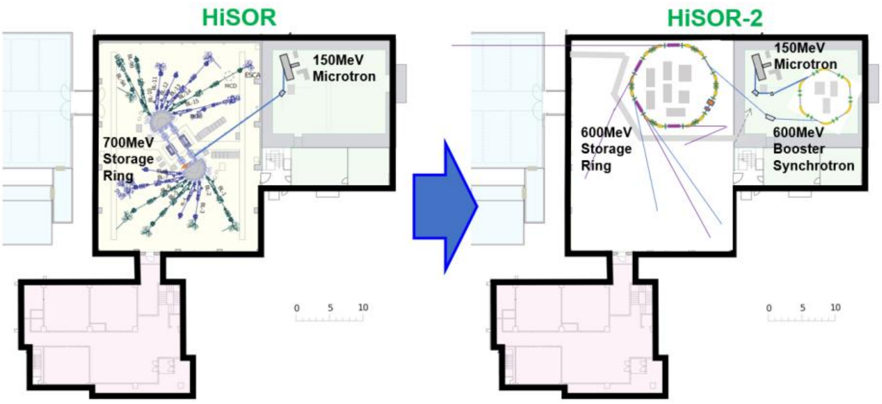

FIGURE 1. Layout of present HiSOR (left) and that of new HiSOR-2 (preliminary) (right).

In this study, we developed a simulation code on electron orbit in a synchrotron using transport matrices to design the beam injection and extraction schemes on the booster synchrotron [1]. In many cases, for the beam injection into a synchrotron, to reduce the oscillation amplitude after the injection, kicker magnets are used to shift the reference orbit of the synchrotron closer to that of the beam transport line. Usually, three or four kicker magnets are used to make a local bump orbit that the reference orbit in a small section of synchrotron is shifted and other sections are not [2]. On the other hand, a simple injection scheme using only one kicker has been applied to a small synchrotron or to early commissioning stage of a large synchrotron [3]. We examined this scheme because this scheme enables us to save the space and the construction cost.

Based on the simulation study, we demonstrated that injection was possible by placing one kicker magnet at the exact opposite side of the beam injection point. By adjusting the kicker strength properly, the injected beam circulates the synchrotron without hitting the wall of the injection septum magnet which is the most limiting the transverse acceptance. An example of the orbit of the injection beam is shown in Fig. 2. Furthermore, we confirmed that the electron beam with the pulse length as long as 0.6 microsecond can be injected, which is thought to be practical.

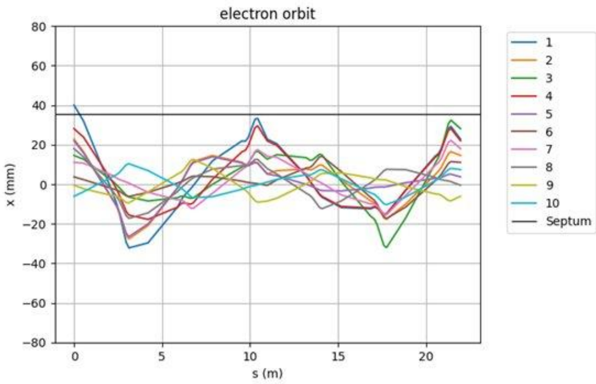

FIGURE 2. An example of the orbit of the injected beam. The horizontal axis is the distance from the injection point. The electron orbit in each turn up to 10 is shown with different colors. The origin is the injection point. The black line indicates the position of the septum wall.

We also made simulation on the beam extraction from the synchrotron. We confirmed that it is possible to extract the circulating beam with one kicker. Because the circumference of the synchrotron is so small, the rise time of the kicker magnet should be faster than about 40 nano-second, otherwise more than half of the beam cannot be extracted.

In summary, we have demonstrated that the injection into the HiSOR-2 booster synchrotron can be made by only one kicker magnet as well as the extraction by another one. The next challenge is to confirm the efficiency of the beam transport as taking into the account the effects of the spatial and energy spread of the electron beam.

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