Recent Results from Design Study on HiSOR-2

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HiSOR, a low energy and compact synchrotron light source in Hiroshima University, has two straight sections and is capable of producing high-brightness light in the vacuum ultraviolet range from two undulators. It has two normal conducting bending magnets, which have high field strength of 2.7 T and are capable of producing synchrotron radiation in a wide range including tender X-rays even with the low electron energy, 700MeV. Since no major upgrade has been made on the accelerator since its construction in 90's, the operation of HiSOR is well established and stable in these years. On the other hand, after 25 years from its construction, the hardware has been being aged and its competitiveness in terms of light source performance are being lowered among the newly constructed light sources over the world. Some of the light sources in Japan, such as Photon Factory [1] or UVSOR [2], have been upgraded with some major modifications of the hardware. SPring-8 also has an upgrade plan [3]. In case of HiSOR, it was designed and manufactured by a single company. It has a rational design without redundancy. Therefore, it is difficult to make a major modification to improve the performance or introduce new technologies to the present machine. Therefore, we have been designing a completely new ring for the future plan of the facility [4].

The latest version of the design [4] is as follows; the circumference is about 50 m and the electron energy is 500 MeV. The emittance, which is the most important parameter to achieve high brightness, is around 10nm, which is smaller by two orders of magnitudes than the present value, 400nm. It has six straight sections and four of them can be used for installing undulators. It would have a full energy injector for the top-up operation, which consists of a linear accelerator and a booster synchrotron. We believe such a new facility is ideal for further developing the research activities which have been carried out at HiSOR for over twenty years. On the other hand, this plan requires a significant budget, which may not be easy to be approved. In addition, the feasibility of this plan also depends largely on the trends of the future plans of other synchrotron light sources in Japan. Therefore, as leaving this plan as one candidate, we have started designing alternative plan, which might be realized with less budget.

To reduce the construction cost as keeping the high performance as possible, we have designed a compact storage ring as shown in Fig. 1. The circumference is about 30 m and the electron energy is 500 MeV. The emittance is 17 nm. The ring has six 2.2 m straight sections, four of which can be used for undulators. The diameter of the ring is almost same as the major axis of the present HiSOR ring. This compactness may reduce the construction cost of the accelerator. One interesting possibility is to install this ring in the present experimental hall. If this is the case, the total construction cost would be reduced significantly.

The magnetic lattice of the new design is very simple, which may be realized with combined-function magnets. The bending magnets should produce quadrupole and sextupole fields and the quadrupole magnets sextupole fields as well as dipole fields for beam steering. It was proved that, after compensating the linear chromaticity with two families of sextupoles, the dynamic aperture is sufficiently large. The beam injection may be realized with a pulsed multipole magnet [5].

In adding to making the storage ring compact, one interesting possibility to further reduce the construction cost is utilizing the present HiSOR storage ring as an injector. We can find several examples of such utilization of older storage rings as injectors for new rings, even though they were not capable of rapid cycling of acceleration [6, 7]. In our case, the electron beam from the existing 150 MeV microtron is injected to the present HiSOR ring and is accelerated up to 500 MeV, then is extracted and transferred to the new ring. Since it is expected that the construction cost of a full energy injector is almost as high as that of the new storage ring, the recycling of old accelerator is effective to reduce the cost. An interesting possibility for further reduction of the cost is moving the present HiSOR to the injector room and constructing new storage ring in the present storage ring room.

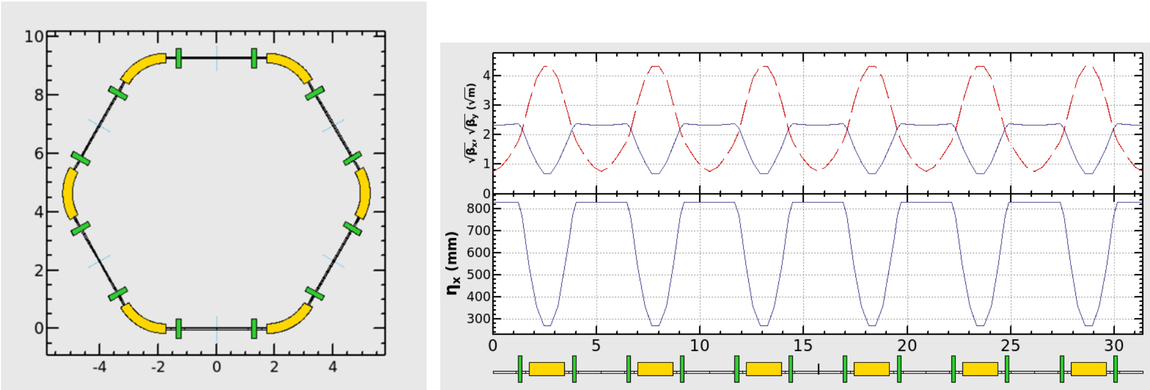

FIGURE 1. Magnetic lattice (left) and optical functions (right) of the new lattice design for HiSOR-2.

The typical synchrotron radiation spectra are shown in Fig. 2. For comparison with the present ring, we calculated the spectra for the undulators which are currently operational in the present HiSOR. The brightness is improved by more than one order of magnitudes. Since the electron energy of HiSOR-2 is lower than the present value, the spectral ranges shift to the lower photon energy. Shorter period undulators may be installed to cover the higher energy range.

In the present HiSOR, the photon energy range up to the tender X-rays is covered with the bending radiation from the high field normal conducting bending magnets. In HiSOR-2, the bending magnets will be normal conducting and have ordinary field strengths such as around 1 T. In addition, the electron energy is lower. Therefore, the bending radiation cannot cover the X-ray range. If there are strong demands for the X-rays, one idea is to replace two or three bending magnets with superconducting ones of 5 T. In this case, even with the lower electron energy, the ring can cover almost same photon energy range. The electron beam optics should be designed carefully not enlarging the emittance so much.

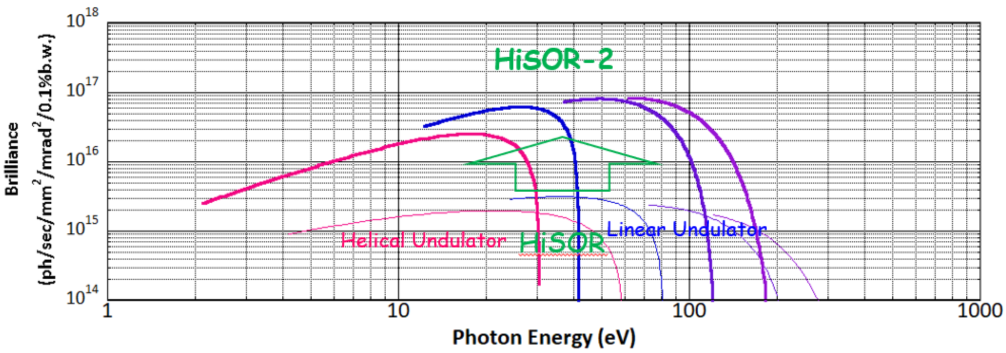

FIGURE 1. Synchrotron radiation spectra on the alternative design of HiSOR-2. The undulator parameters are same as the present HiSOR.

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