HISOR-II, FUTURE PLAN OF HIROSHIMA SYNCHROTRON RADIATION CENTER

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Abstract

The HSRC, Hiroshima University that was established in 1996 has a compact SR source 'HiSOR'. We are planning to construct a compact storage ring, 'HiSOR-II' in which undulators are dominant light sources. We refer to the electron storage ring MAX-III as the best models to design HiSOR-II lattice. It has several straight sections for undulators, and its natural emittance is about 14 nmrad. A booster ring aiming for the top-up injection is planned to construct on the inside basement of a storage ring. This layout brings advantages in radiation shielding and prevention of magnetic field interference between two rings.

INTRODUCTION

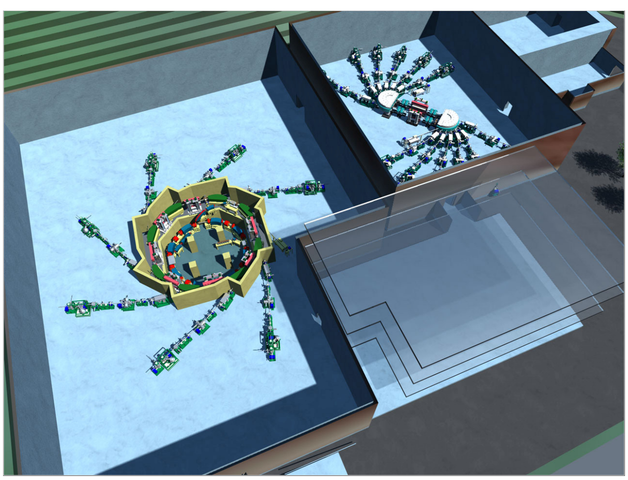

Figure 1: Layout of Accelerator complex of HSRC

The HiSOR [1] is a compact synchrotron radiation source of Hiroshima Synchrotron Radiation Center (HSRC) constructed in 1996 as a typical VUV ~ soft X-ray source. Because of a compact racetrack-type ring, its natural emittance 400 π nmrad is not so small as the other standard-sized rings. There are two undulators, one linear for 26-300 eV range and the other helical/linear for 4-40 eV. The most outstanding feature of the facility lies in the good combination with beamlines to attain high-resolution (below 1 meV) for photoemission spectroscopy. HiSOR has been running over 10 years, thus, it is time to consider the future improvements of the facility. The motivation is to pursue the leading position in the field of materials science (solid state physics) using SR for high-resolution photoemission spectroscopy. Therefore construction of the low emittance compact SR source ring HiSOR-II is planned. The accelerator complex of HSRC is shown in Figure 1.

STORAGE RING

HiSOR-II storage ring is designed in reference to MAX-III [2] (MAX-Lab., Sweden), and it has eight straight sections, and circumference of this ring is about 40 m. Though this ring is compact, its natural emittance is 13.6 nmrad, several insertion devices work as main light sources for VUV-SX ranges. It has a booster ring and injector linac for top-up operation inside of a storage ring. Therefore we can operate HiSOR-II with HiSOR independently.

A storage ring and a booster ring of HiSOR-II are shown in Figure 2, and Table 1 shows main parameters of a storage ring.

Figure 2: Layout of HiSOR-II storage ring and booster

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Table 1: Main parameters of HiSOR-II storage ring

Beam energy	700 [MeV], Bρ=2.335 [Tm]
Circumference	40.079 [m]
Maximum field	1.400 [T]
Bending radius	1.667 [m]
Betatron tune	3.761, 2.846
Natural emittance	13.57 [nmrad]
Momentum compaction	0.0319
Chromaticity	+1.00, +1.00
Bunch length	37.0 [mm]
Harmonic number	27
RF frequency	201.962 [MHz]
RF voltage	200 [kV]
Momentum spread	5.79e-04
Touschek lifetime	40.7 [min]
Straight sections	3.4 [m] ×4, 2.0 [m] ×4

Lattice and Magnet Units

Lattice of a storage ring is designed for low emittance with finite dispersion at straight sections similar to other compact 3rd generation SR rings. Figure 3 shows beta and dispersion functions of a unit cell equivalent to 1/4 of a storage ring.

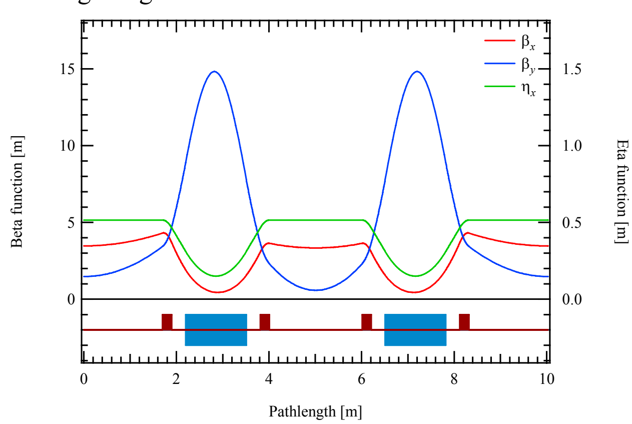

Figure 3: Optical functions of HiSOR-II storage ring

Magnets of this storage ring [3] are combined function type magnets with complicated 3-dimensional shape to realize miniaturization. Bending magnets have dipole, quadrupole and sextupole field components, quadrupole magnets have quadrupole and sextupole components. Further, the suppression of the alignment error between the magnets is expected because two quadrupoles of both ends and one central bending magnet share the same return yoke.

Insertion Devices and Radiation Spectra

We are considering about the insertion devices installed into HiSOR-II storage ring, and APPLE-2 type undulator [4] is one of the most desired candidates. Figure 4 shows expected radiation spectra from APPLE-2 type undulator and bending section calculated by SPECTRA [5]. The distortion of optical functions to occur by changing gap of undulator is corrected by strip lines installed on a beam duct and quadrupole magnets added to the undulator both ends. Optical functions can be kept always unchanged without depending on a gap of undulator by using these correction magnets.

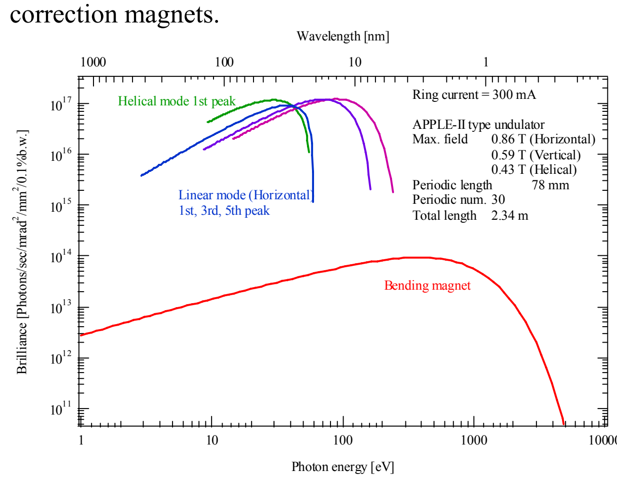

Figure 4: Radiation spectra of HiSOR-II

BOOSTER RING

HiSOR-II has a very compact booster ring for top-up injection to a storage ring. Because low emittance is not needed to a booster ring so much, FODO lattice is adopted, it consists of simple rectangular bends and quadrupole magnets unlike a storage ring. This booster ring is constructed on the inside basement of a booster ring, this layout brings advantages in radiation shielding and prevention of magnetic field interference between two rings.

RF frequency of a booster ring is unified with it of a storage ring to be easy to operate two rings synchronized. Figure 5 and Table 2 show optical functions of a unit cell of a booster ring and main parameters.

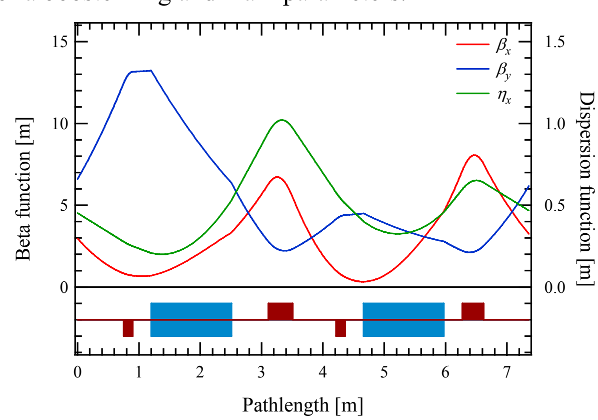

Figure 5: Optical functions of a booster ring

Table 2: Main parameters of booster ring

Lattice type	FODO
Beam energy (max.)	700 [MeV], Bρ=2.335 [Tm]
Circumference	29.688 [m]
Maximum field	1.400 [T]
Bending radius	1.667 [m]
Betatron tune	3.258, 1.169
Natural emittance	86.5 [nmrad]
Momentum compaction	0.065
Natural chromaticity	–4.518, –3.779
Harmonic number	20
RF frequency	201.962 [MHz]
Repetition rate	3 [Hz]
Operation mode	Single bunch
Straight sections	1.55 [m] ×4

Required Time for Injection and Current Stability

Table 3: Required time to inject and current stability

Accelerator	**Storage**	**Booster**	**Injector**
Harmonic num.	27	20	-
RF frequency [MHz]	202	<-	(2856?)
Injection mode			
Bunch	27	1	1
Repetition rate [Hz]	-	3	3
Current [mA]	300	0.5	50mA, 1ns
Storage (top-up inj.) mode			
Bunch	27	1	1
Repetition rate [Hz]	-	3	3
Current [mA]	300	0.055	5mA, 1ns

As for the operation of the SR ring, the required time to accumulate from 0 current should be short, therefore powerful injector is necessary. Further the stability of a stored current is determined by beam lifetime and injection frequency, of course had better be stable.

The repetition rate of a booster ring is limited by about 3 Hz due to the realistic limitation such as magnets or power supply. In this case the stability of the current of the storage ring of HiSOR-II is estimated at 0.37% for 300 mA. It will be necessary for a Landau cavity to be installed to extend beam life if we wish more stability.

Moreover, when we require the electron beam accumulation up to 300 mA within 5 minutes, it is necessary for single bunched injector linac to supply a pulsed beam with 1 ns / 50 mA. Table 3 is the parameter list of each accelerator for this estimate.

Injection Using Pulsed Sextupole Magnet

Because a storage ring and booster ring of HiSOR-II is compact, it is difficult to make enough straight sections for injection or extraction. Therefore we study a beam injection with using pulsed sextupole magnet (PSM) [6].

However, a beam is kicked for several turns even if we use short pulse power supply for PSM because the circumferences of these rings are very short. Therefore the behaviour of injected beam will strongly depend on betatron tune of the ring. Figure 6 shows the difference of behaviour of the beam on horizontal phase space cause of operating point.

We need detailed examination about searching an appropriate condition for injection that the betatron amplitude of injected beam is made small enough. The suitable operating point should be found if we can provide a sextupole that has a short enough duration time and strong enough field.

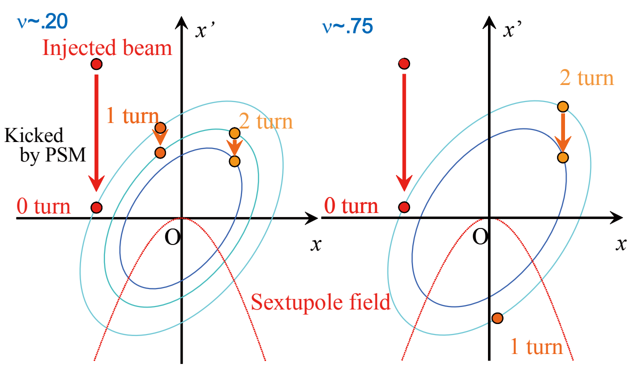

Figure 6: A behaviour of injected beam on phase space.

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