PRESENT STATUS AND FUTURE PLANS

FOR SYNCHROTRON LIGHT SOURCE ISI-800

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Abstract. The Synchrotron Light Source ISI-800 at the Ukrainian National Synchrotron Center (Kiev) will be used a 200 mA, 1 GeV electron storage ring to produce high brilliance bending magnet (conventional and superconducting - a combined magnet lattice with TBA cells) and insertion device VUV and X-rays for up 24 ray beamlines. It is 46.73 meters in circumference, including four 3.3 m-long dispersion-free straight sections, and has a beam lifetime designed to exceed more than 3 hours with 5 nTorr average ring vacuum at 200 mA. The harmonic number will be 109 and the corresponding RF frequency will be 699.3 MHz. The critical X-ray wavelength from eight conventional bending magnets will be 2.2 nm and from four superconducting magnets will be 0.3 nm. Further optimization of the storage ring lattice in progress. The major features of the light source ISI-800 are described.

1 INTRODUCTION

The design of a relatively cheap and compact source with the above-mentioned photon beam parameters is a complicated task, since the compactness of the source sets limits, first of all, on the electron energy, and hence, on the energy of emitted photons. This, in turn, necessitates the mounting, arrangement of special devices such as superconducting wigglers with limiting magnetic-field values of about 10 T. However, this insert exerts a strong effect on the focusing of the storage ring. This makes necessary long straight sections in the lattice to accommodate the matching elements, and also imposes special requirements on the wiggler design. Furthermore, in consequence of a great distortion of the reference orbit in the wiggler (Δx ~ 5 cm at an electron energy of 0.8 GeV and a field of 10 T in the wiggler), there arise essential technological difficulties. This paper describes the concept of a SR source which can form the basis of creating the National Centre of SR [1-3]. Ways of realizing this concept are discussed.

2 MAIN STORAGE RING PARAMETERS

The upper limit of the magnetic-field strength range, at which the magnetic materials can ensure a high-quality field, is about 1.5T. Besides the radiation from bending magnets, the modern SR sources incorporate superconducting wigglers (with the field up to 10 T) to increase the energy of the photons produced. The electron beam energy of about 1 GeV allows the generation of photon beams complying with the requirements of most applications.

We came to conclusion that SR source would be a 1 GeV compact electron storage ring. Injecting energy was chosen to be 120 MeV. The traveling wave linac is intended to employ as an injector. The injector is placed below the ring to provide room for more beamlines.

One of the principal SR beam parameters, i.e., brightness, is proportional to the transverse electron-beam density in the region of radiation. Therefore, it is necessary to have a beam with a minimal cross-sectional area; the lattice must ensure the minimal beam emittance and a low value of the vertical betatron function in bending magnets. The latter allows one to diminish the magnet gap, thereby reducing the cost of magnet manufacture and operation.

We have chosen the TBA lattice as providing low emittance. It consists of four superperiods. Tables 1 gives the structure of half superperiod. The curvilinear part of the trajectory includes: 3 magnets, each with the curvature radius R=2.005 m (B=1.34 T at an electron energy E=0.8 GeV), the field index n=3 and 2 quadrupoles.

Table 1.

Element	Length, m	Strength, m^{-2}
D0(1/2)	1.6162	
Q1	0.2	4.4765
D1	0.15	
Q2	0.2	-2.6920
D2	0.7	
RB	1.05	30°, -0.7453
D3	0.6	
Q3	0.2	7.520
D4	0.6	
RB(1/2)	0.525	15°, -0.7453

The straight-line part of the trajectory comprises four quadrupole magnets which ensure the stability of radial and vertical motion in combination with two quadrupole magnets and vertically focusing dipole magnets. Fig. 1 shows the lattice configuration of the superperiod.

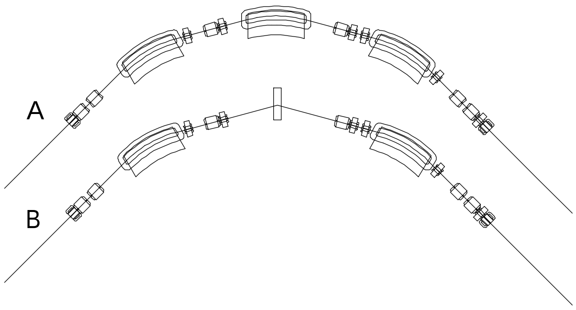

Fig.1. The lattice configuration of the ISI-800 storage ring superperiod
(A - conventional lattice, B - combined lattice)

The betatron tunes Q_X = 4.25 and Q_Z =3.20. Since the vertical focusing is mainly accomplished by gradient dipole magnets, this provides the smallest value of the betatron radial function β_X in the magnet, and hence, the minimum radial size of the beam. The radiation emittance is ε_X=2.7·10^{-8} mrad (E=0.8 GeV).

The compensation of the natural chromaticity requires the mounting of sextupole lenses. At large betatron amplitudes the presence of sextupole fields leads to the occurrence of undesirable nonlinear effects, which significantly decrease the dynamic aperture. The final choice of the sextupole strengths is based on the results of computer simulation.

To produce high-brightness photon beams with a sufficiently high energy, we also considered a compact storage ring with the lattice based on the combined TBA cell ("warm" and superconducting magnets), where the central dipole magnet of the cell is superconducting (fig.1).

The contribution of the central superconducting magnet (field is 10 T) to the emittance value at a beam energy of 0.8 GeV is ε_X =2·10^{-8} mrad.

Now we develop three-pole wiggler with a peak field of ~ 7 T in the principal pole and a field of ~ 4.5 T in the half-poles. The distribution of the quadrupole component $\partial B_z / \partial x$ and one of the highest multipole components $\partial^2 B_z / \partial z^2$ in the coordinate system following a reference trajectory is presented in Fig.2.

The simulation of the dynamic aperture of the storage ring with a modified lattice and the wiggler shows that the presence of the superconducting central magnet in the TBA lattice and wiggler exert no essential effect on the aperture value [4].

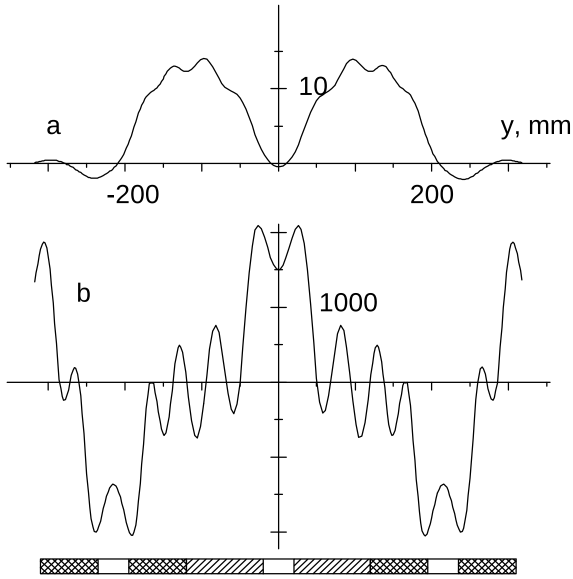

Fig.2. The distribution of the quadrupole and multipole components of the wiggler field:
a $-\partial B_z / \partial x$, b - $\partial^2 B_z / \partial z^2$

The spectral distribution of photons from the ISI-800 is shown in fig.3. We have designed the general purpose beamline. This project allows one to assemble dedicated beamline (for, e.g., photolithography, EXAFS, x-ray material analysis, etc.). The radiation from both conventional magnet dipoles and wigglers as well would be utilized through this line.

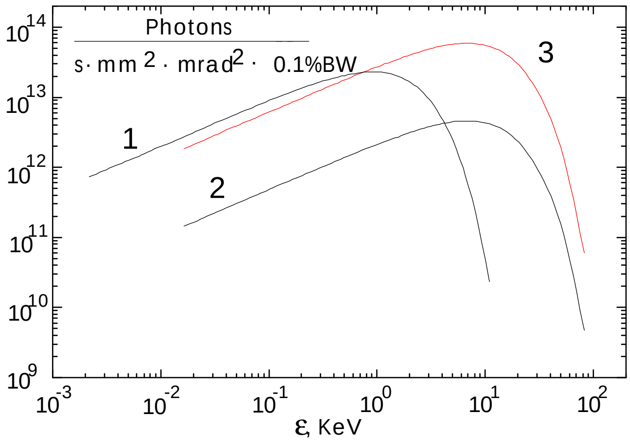

Fig.3. Spectral distribution of SR from ISI-800 dipole (*1*), and superconducting magnet (*2* and *3*).

The beamline is supposed to operate in following modes:

1. X-ray lithography beamline (comprises from no optical elements inside). Transverse beam dimensions could be achieved within the range of 0-30 mm.

2. The line with the tuneable grid will be applied for experiments in physics and chemistry. This line

comprised few optical elements covers photon frequency from VUV to the soft x-ray.

3 The toroidal grid monochromator line will be used in experiments requiring large photon flux and moderate resolution.

4. X-ray transmitting microscope.

5. The coronar angyography line.

The dipole magnet will have a conventional C type cross section. The rectangular magnet will be laminated, the laminates are 1.5 mm thick. The good-field region extends to ± 15 mm horizontally.

24 quadrupole magnets are grouped in three families with 8 in each, the lenses in a family being connected in series. The poles of all the lenses are of one and the same profile The bore diameter is 50 mm and length is 20 cm for all quadrupole magnets.

The ISI-800 magnet lattice contains 4 families of sextupoles, total 24 magnets. To compensate the negative chromaticity $\xi_{x,z}$, which is equal to -7.14, -7.36, four sextupole magnets are mounted at the curvilinear part of the trajectory of each superperiod and two sextupole magnets in the achromatic part of each superperiod correct the dynamic aperture. The aperture radius of sextupoles is 28 mm, with a pole length of 100 mm. In addition to the main coils mounted on the poles, there are six back-leg coils which, given the correct excitation, can generate vertical and horizontal dipole fields with maximum corrector strength: vertical 3 mTm, horizontal 3 mTm.

The synchrotron radiation facility ISI-800 will have a transfer line which has been designed for transporting 120 MeV electrons from the linac to the storage ring. The transfer line includes 4 dipole magnets (rectangular, C-type, bend angle is 41.5 degrees, length is 29 cm), 9 quadrupole magnets (length is 10 cm, gradient is 15 T/m) and 4 bi-directional steering magnets.

Correction of the storage ring orbit is accomplished by 8 horizontal, 8 vertical sextupole steering elements (combined with the sextupoles) in the curvilinear part of the orbit and 8 bi-directional dipole steering magnets distributed in the straight sections (length is 10 cm, field is 0.03 T).

Beam energy losses by synchrotron radiation and parasitic losses in the vacuum chamber walls are compensated with the help of a 10 kW RF (699.3 MHz) system. The accelerating voltage of 200 kV chosen in view of the Touschek lifetime, is provided by a single half-wave cavity, whose shape has been optimized against the shunt resistance at the main (operating) mode (Ω-cavity).

Based on the reasonable 6-hour lifetime of the zero-intensity beam we come to the conclusion that the residual gas pressure in the chamber should not exceed $5 \cdot 10^{-9}$ Torr throughout the range of circulating currents at an operating energy of the beam. Pumping is produced by 40 sputtering 400 l/s pumps placed on the dipole magnet chambers and by the end of the defocusing quadrupole magnets.

Sixteen pickup stations and a current transformer are used to monitoring the beam in the storage ring.

3 CONCLUSION

The design of the magnet, the vacuum, the RF and the indicating systems is completed. Also we have the project of the injector and the building.

We have got the government decision about the construction of the synchrotron radiation source ISI-800 for Ukrainian National Synchrotron Center.

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