LATTICE CANDIDATES FOR THE ILSF STORAGE RING*

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Abstract

Iranian Light Source Facility (ILSF) is a new 3 GeV third generation synchrotron light source which is currently in design and will be built in Iran. It will provide a high photon flux density to cover requirements of experimental science in several fields. Regarding to the proposed budget and in order to produce high quality X-ray pulses with several photon beamlines as a request of users, it has been decided to design a very low emittance (ε<5nm-rad) storage ring with a typical beam intensity of 400 mA and circumference in the range of 280 m to 320 m.

INTRODUCTION

The Iranian Light Source is an intermediate storage ring with energy of 3 GeV which is supposed to cover the requirements of experimental science in several fields. According to several submitted request proposals from the users for high quality pulsed X-ray [1], it has been decided to build a 3 GeV synchrotron light source with 24 beamlines to extend spectrum of the undulator radiation to 20 KeV. Considering the proposed budget [2], the ILSF is designed to have a very low emittance (ε < 5nm-rad) storage ring with a 400 mA beam current and a circumference in the range of 280 m to 3 20 m. The general layout of the ILSF is shown in Fig. 1. Buildings as well as accelerator systems are depicted.

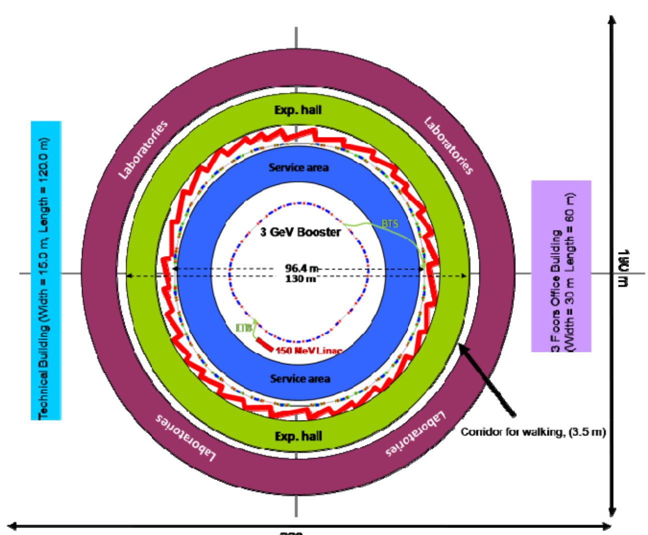

Figure 1: General overview of the ILSF.

As shown, approximate diameter of the facility will be approximately 230 m.

An electron beam produced with an electron gun, is accelerated by a travelling wave linear accelerator (linac) to the energy of 150 MeV. Then the electrons enter into the booster synchrotron via linac-to-booster transfer line (LTB). The booster accelerates the electron beam to the energy of 3 GeV using a radio frequency (RF) cavity with the frequency of 500 MHz. After reaching the target energy, the electron beam is transferred from the booster to the storage ring through almost 40 m transfer line (BTS). Several different types of magnetic lattice structures with different circumferences of the storage ring have been explored. This paper gives the optimization results of the proposed lattices as the main candidates for the storage ring of ILSF.

LATTICE CHOICES

Since we are interested in high-energy photons with high brilliance in several beamlines, we aimed to have several straight sections of different lengths to accommodate various required insertion devices. Thus a four-fold symmetric ring with 32 straight sections was a good solution for our lattice. The circumference of the storage ring in this design (1st lattice candidates) is 297.6 m and the linear lattice functions are well matched to the requirements of a small emittance and a small beam size at the radiators. In addition, a good working tune point in a stable area on the tune diagram is desirable for the ring stability. Thus the linear parts of lattice have been optimized to find a tune point far away from major resonance lines. An overview of the storage ring is shown in Fig. 2 and its major lattice parameters are listed in Table 1. The four-fold symmetric configuration provides four 7.88 m long straight sections to accommodate long insertion devices (ID) and injection elements. There are 4 straight sections of medium length in each super-period, each 4 m long, which can be used for insertion devices up to 3 m long. Moreover, 3 short straight sections in each super-period with a length of 2.82 m are reserved for placing diagnostic equipment, kickers for feedback system, RF cavities or even short IDs. The ratio of the total length of the straight sections to the circumference of the ring (percentage of storage ring) is 43.46% which is pretty good in comparison with other light sources. Lattice functions in a super-period of the ILSF storage ring are shown in Fig. 3 and the associated tune point is given in Fig. 4. As shown, each super-period is composed of two matching cells that are at the beginning and at the end of a super-period and three DBA as unit cells located between the matching cells.

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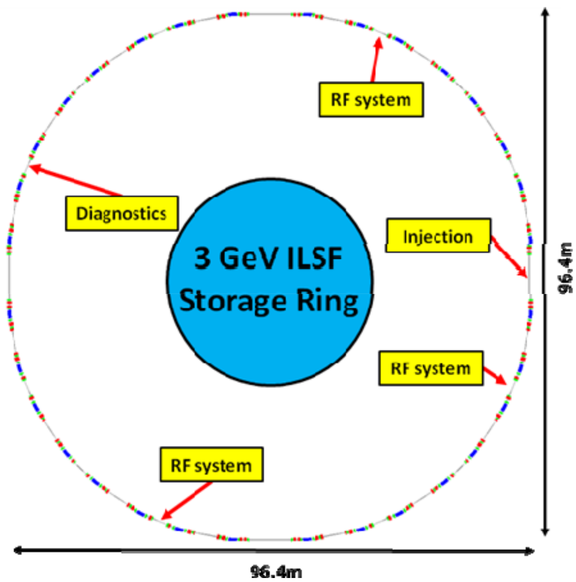

Figure 2: Layout of the ILSF storage ring (1st candidate).

Table 1: Main parameters of the ILSF storage ring (1st design).

Parameter	Value
Energy (GeV)	3
Circumference (m)	297.6
No. of super-period	4
Current (mA)	400
Emittance (nm-rad)	3.278
Harmonic number	496
RF frequency (MHz)	500
Tune [Q_x/Q_y]	18.265/11.328
Nat. energy spread	1.0108E-3
Nat. Chromaticity [ξ_x/ξ_y]	-34.56/-28.02
Momentum compaction	7.621E-4
Radiation loss per turn (MeV)	1.0167
No. of dipole	32
No. of Quadrupole	104
No. of sextupole	128
Dipole field (T)	1.42
Deflecting angle (Deg.)	11.25
Dipole gradient [Matching/Unit cell](T/m)	-3.83/-5.83

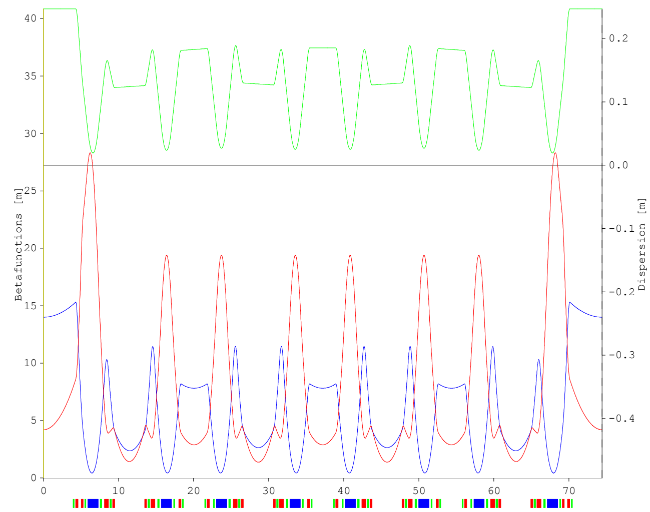

Figure 3: Optical functions in a quadrant of the ILSF storage ring (1st design). Blue and red curves represent horizontal and vertical beta functions respectively and the green curve remarks dispersion function.

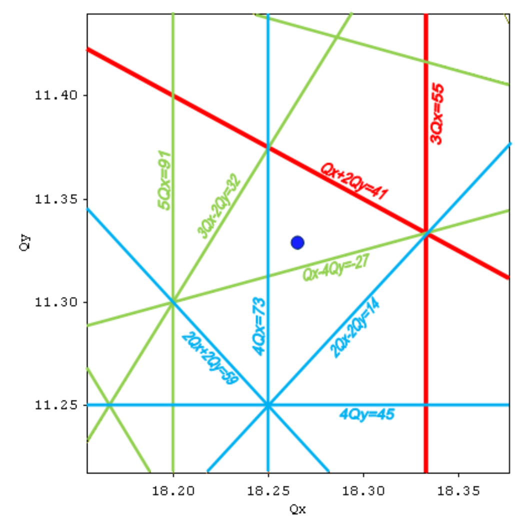

Figure 4: Tune point of the ILSF storage ring. The blue circle represents the tune point in tune diagram with 5th order of resonance line.

In the 2nd lattice candidates, the storage ring lattice has a DBA structure with a periodicity of 22. All 22 straight sections have the same length of 4.825 m which is enough for many IDs with lengths up to 4 m, feedback systems and RF modules. A general layout of the storage ring is shown in Fig. 5. Percentage of the ring is 35.67% which is significantly smaller than the previous design while the natural emittance is less than 2 nm-rad, almost 1.3 nm-rad less than 1st candidate. But the beam cross section at the radiators in first design is smaller than second design. The major parameters of this particular design for ILSF storage ring are listed in Table 2.

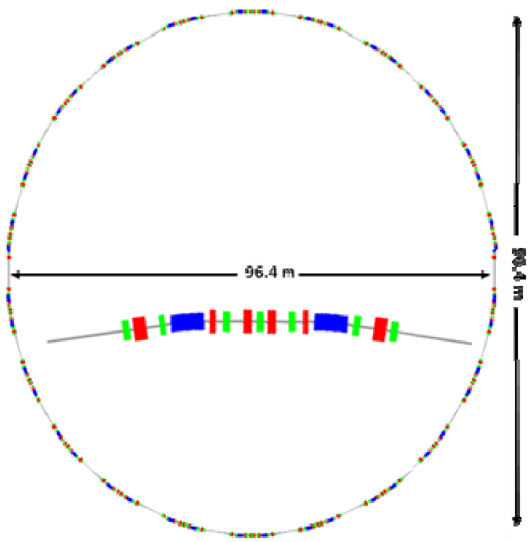

Figure 5: Layout of the ILSF storage ring (2nd candidate).

Table 2: Main parameters of the ILSF storage ring (2nd design).

Parameter	Value
Energy (GeV)	3
Circumference (m)	297.6
No. of super-period	22
Current (mA)	400
Emittance (nm-rad)	1.96
Harmonic number	496
RF frequency (MHz)	500
Tune [Q_x/Q_y]	21.170/5.134
Nat. energy spread	1.0125E-3
Nat. Chromaticity [ξ_x/ξ_y]	-56.17/-35.37
Momentum compaction	5.5156E-4
Radiation loss per turn (MeV)	1.002
No. of dipole	44
No. of Quadrupole	132
No. of sextupole	154
Dipole field (T)	1.4
Deflecting angle (Deg.)	8.182
Dipole gradient (T/m)	-5.389

As seen, the natural emittance of second designed lattice is 1.96 nm-rad. Due to lower deflecting angles and higher quadrupole strengths, resulting in a lower emittance, the natural chromaticity of this design is higher than 1st candidate (see Table 1 and Table 2) and so stronger sextupole magnets are required to compensate the chromaticity of ring. Optical functions in a super-period of the storage ring in the second design are depicted in Fig. 6 and the associated working tune points in the tune diagram with 5th order of resonance lines are shown in Fig. 7.

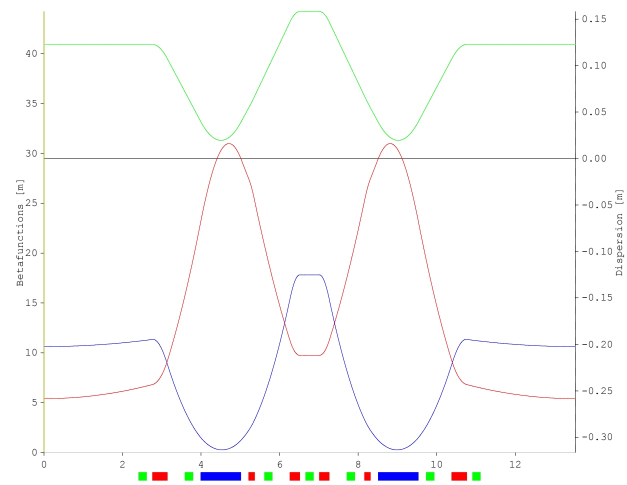

Figure 6: Optical functions in a super-period of the ILSF storage ring (2nd design). Blue and red curves represent horizontal and vertical beta functions respectively and the green curve remarks dispersion function.

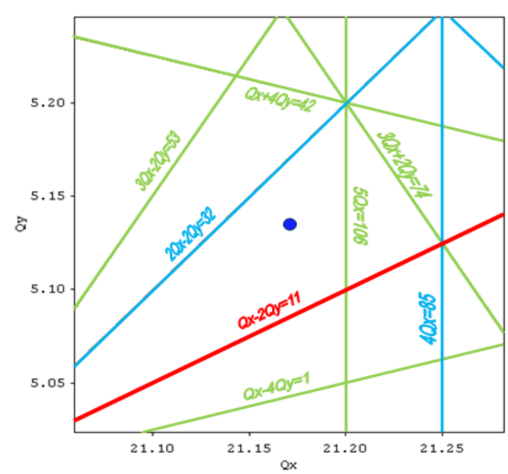

Figure 7: Tune point for the storage ring (2nd candidate).

REFERENCES

[1] J. Rahighi, *Proposal for a 3rd Generation National Iranian Synchrotron Light Source*, IPAC2010, Kyoto, Japan, WEPEA023, p. 2532 (2010).

[2] G. R. Aslani (private communication).