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LATTICE DESIGN HISTORY OF THE IRANIAN LIGHT SOURCE FACILITY STORAGE RING

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Abstract

Several lattice alternatives have been designed for the 3 GeV storage ring of Iranian Light Source Facility (ILSF). Design of the ILSF storage ring emphasizes an ultra low electron beam emittance, great brightness, stability and reliability which make it competitive in the operation years. In this paper, we give a brief review of the main designed lattice candidates for the ILSF storage ring.

INTRODUCTION

Synchrotron radiation, as a versatile research tool, has experienced an unprecedented expansion. Nowadays, more than 50 synchrotron light sources around the world are under operation and several light sources are under design or construction [1-2]. However, in spite of innumerable applications of the synchrotron radiation, a large portion of the world namely Mid-East is unfortunately poor on modern synchrotron light source facility. After SESAME which has been dedicated by UNESCO [3], several countries of that region such as Armenia [4] and Turkey [5] have planned to have their own high technology synchrotron radiation facility. In parallel, the ILSF project [6] was initiated in 2003 and formally approved in 2008. At the end of 2009, the Institute for Research in Fundamental Sciences, IPM, has been given the go ahead to establish a major center in Iran for multi disciplinary research.

The ILSF project is a new 3 GeV synchrotron light source which is in design stage and will be built in the city of Qazvin located 150 km West of Tehran. Based on the ILSF strategy, various requirements of the modern synchrotron radiation sources cannot be totally fulfilled at this facility but it will provide super bright synchrotron radiation required for the cutting edge science in several fields and will serve as a significant impetus for multidisciplinary research.

The accelerator complex for the ILSF synchrotron light source consists of a pre injector, a booster synchrotron and the storage ring. In addition there are the transfer lines between the pre injector systems and the booster synchrotron as well the booster and the storage ring. In this pager, we give a review of the ILSF lattice design history for the ILSF storage ring from the start point till now.

LATTICE DESIGN

Design of the ILSF storage ring was commenced in June 2010. With regarding to the proposed budget and users requirements, several types of the magnetic lattice structures with the different circumferences have been explored for the ILSF storage ring.

The first lattice solution is found based on four-fold symmetry with ring circumference of 297.6 m. The storage ring is composed of four super periods and provides 32 straight sections, 4 long straight section with length of 7.88 m, 16 medium straight sections with length of 4 m and 12 short straight sections with length of 2.28 m. It can store electron beam current of 400 mA and emittance of 3.278 nm.rad. Each super period includes of three double bend achromat unit cells with two matching sections. The matching sections have been added to the unit cells to match the optical functions to the requirements of a small emittance and a small beam size at the radiators. The machine functions and according beam envelope in a period of the first ILSF lattice option are depicted in Fig. 1 and Fig. 2 respectively. As this option is based on the use of 1.42 T dipole magnets, we have called it as high field solution. It should be noted that the conceptual design report (CDR) of the ILSF is published in Oct. 2012 based on this option and more information can be found there [6].

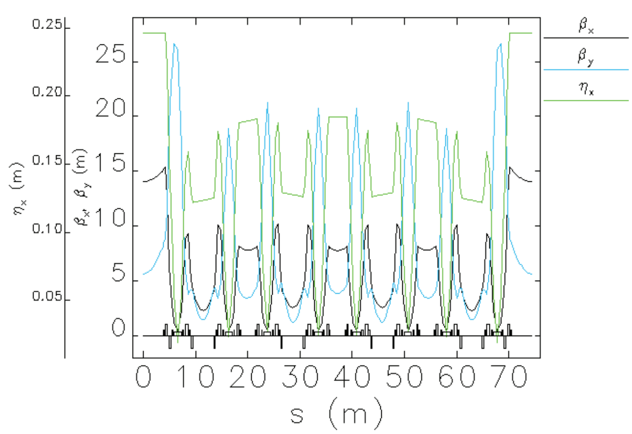

Figure 1: Optical functions in a super period of the ILSF ring, first lattice option.

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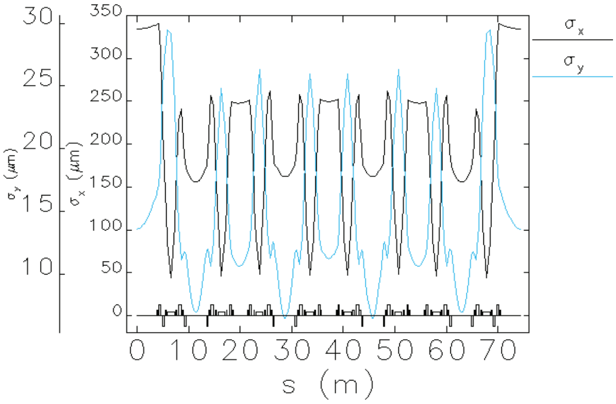

Figure 2: The beam envelope in a super period of the ILSF ring, first lattice option.

To obtain ultra low beam emittance and save energy, the storage ring of the ILSF is redesigned based on the low field dipoles in the field range of 0.5 T to 0.8 T. The photon beam energies radiated by the low field dipoles limits to 4.48 KeV critical energy at 3 GeV which is low for the experiments with high energy hard x-ray. The required radiation with higher brilliance and flux density will be achievable from the insertion devices (IDs). However, lower required RF power, less needed power supply and cooling systems are the other benefits of the using low field magnets which all results to minimize the operation cost. Moreover, the availability of the low field material for the magnets inside Iran results to reduce fabrication cost of them.

In the second lattice solution, a double bend (DB) lattice structure based on the magnetic field of 0.72 T has been designed with 2×6.428 Deg. dipoles in each half cell. The storage ring has the circumference of 489.6 m and consists of 14 super cells. It provides 14 long and 14 medium straight sections with the length of 8 m and 6 m respectively. Two of the 8 m long straight sections will be occupied with the injection equipment and the RF cavities; the rest 6 long straight sections can be used for installation of two insertion devices with the length up to 3.6 m or a long insertion device up to 7 m in each section. Since ultra low beam spot size is available at the 14 medium straight sections, they have been reserved for placing IDs up to 5 m long to provide very bright radiation for the users. Main parameters of the storage ring are given in Table 1. The optical functions and beam envelope in a super period of the storage ring are shown in Fig. 3 and Fig. 4 respectively. No gradient in the low field dipoles has been considered in the design stage of the lattice to ease alignment of them. Focusing in horizontal direction is performed in each super period with 8 focusing quadrupoles in three families and vertical focusing is done with 10 defocusing quadrupoles in four families. More information can be found in our publication [7].

Table 1: Main Parameters of the ILSF Ring Based on the Second Lattice Option

Parameter	Unit	Value
Circumference	m	489.60
Nat. emittance	nm.rad	0.93
No. super cell	-	14
Tune (Q_x/Q_y)	-	31.25/11.27
Nat. chromaticity (ξ_x/ ξ_y)	-	-84.75/-45.79
Radiation loss per turn	keV	518.64
No. dipoles/quad./sext.	-	56/252/196

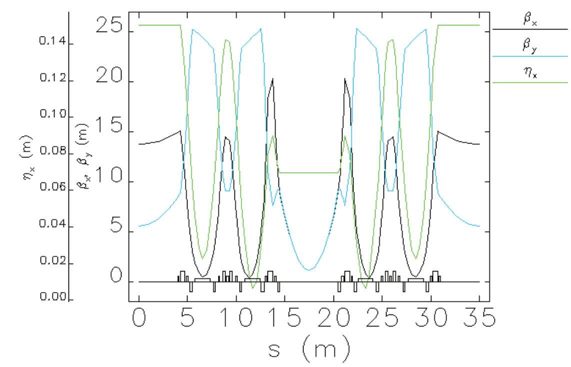

Figure 3: Optical functions in a super period of the ILSF ring, second lattice option.

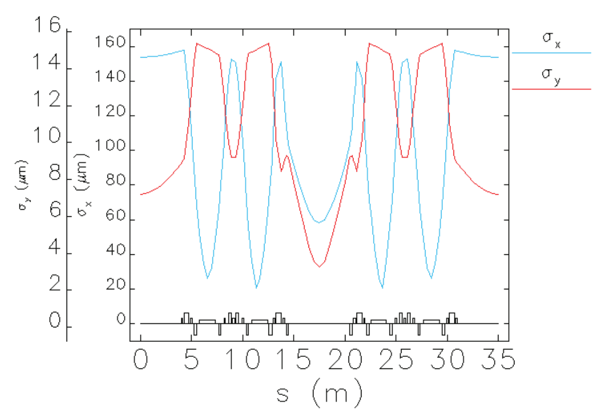

Figure 4: The beam envelope in a super period of the ILSF ring, second lattice option.

Similar to the recently designed and upgraded light sources [8-9], in the third option, we designed lattice with multi low field dipoles per cell for the ILSF ring. It provides an ultra low beam emittance and long enough straight sections which are the main concerns from user's point of view. We used large number of the dipoles to strongly reduce the beam emittance. Moreover, to avoid large storage ring circumference and to have large number of beamlines, the designed lattice is optimized to be as compact as possible. The designed ILSF storage ring is composed of 20 cells and provides 20 straight

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sections with length of 5.11 m. One of them will be occupied with the injection equipment, two of them are reserved for the RF cavities; the rest straight sections are considered for installation of the insertion devices with the length up to 4 m. Each super period includes of five pure dipoles which each has the field of 0.75 T, length of 0.84 m and bends the beam 3.60 Deg. No any gradient in the dipoles results to lower fabrication cost of dipoles with inside industries and eases alignment of them in the ring. However, focusing in horizontal direction is performed with the use of 10 quadrupoles within 5 families and 6 quadrupoles within 3 families are used for the vertical focusing per cell. Mechanical drawing of one super period of the ring lattice is depicted in Fig. 5.

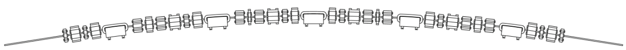

Figure 5: Magnets structure of a super period of the ILSF ring based on third option.

Minimum effective length of drift space between the magnets is 18.5 cm which allows comfortable positioning of the magnets and diagnostic systems. Four pumping stations are utilized in the components to provide ultra low vacuum pressure. The main ring parameters are given in Table 2. The optical functions and beam envelope in a period of ring are shown in Fig. 6 and Fig. 7 respectively.

Table 2: Main Parameters of the ILSF Ring Based on the Third Lattice Option

Parameter	Unit	Value
Circumference	m	528
Nat. emittance	nm.rad	0.477
No. super cell	-	20
Tune (Q_x/Q_y)	-	43.28/14.25
Nat. chromaticity (ξ_x/ ξ_y)	-	-99.43/-52.82
Radiation loss per turn	keV	535.97
No. dipoles/quad./sext.	-	100/320/320

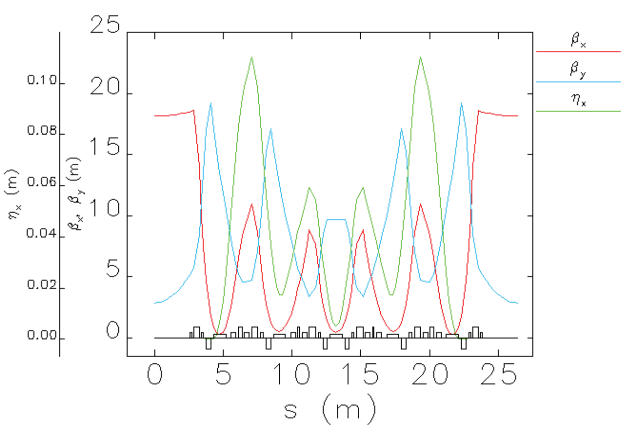

Figure 6: Optical functions in a super period of the ILSF ring, third lattice option.

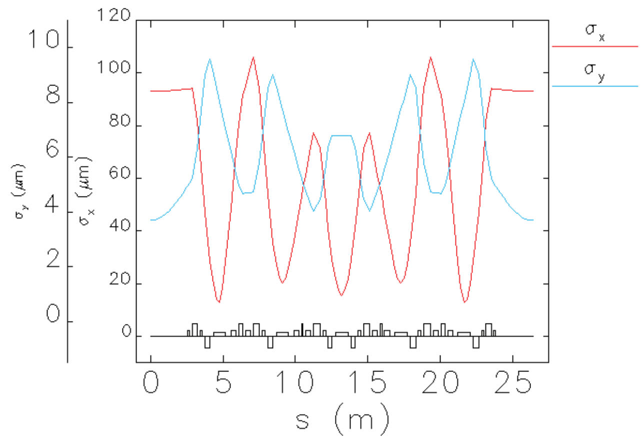

Figure 7: The beam envelope in a super period of the ILSF ring, third lattice option.

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