PROGRESS STATUS OF THE IRANIAN LIGHT SOURCE FACILITY

J. Rahighi, M. Lamehi, R. Eghbali, M. Jafarzadeh, Kh. Sarhadi, J. Dehghani, H. Khosroabadi, E. Yousefi, A. Sadeghipanah, F. Saeidi, S. Fatehi, E. Ahmadi, M.A. Rahimi, E. Salimi, A. Shahveh, Z. Shahveh, O. Seify, A. Gholampour, S. Amiri, S. Pirani, M. Shafiee, H. Ajam, R. Safian, V. Moradi, A. Iraji, B. Kamkari, P. Khodadoost, D. Shirangi, Sh. Kashani, M. Razazian, M. Akbari, H. Oveisi, A. Shahverdi, M. Fereidani, N. Ranjbar, M.Rasoli

Iranian Light Source Facility, ILSF, IPM, Tehran, Iran, P.O. Box 19395-5746

Dieter Einfeld, CELLS-ALBA Synchrotron Cerdanyola del Vallès, Spain

H. Ghasem, School of Particles and Accelerators, IPM, Tehran, Iran

Abstract

The Iranian Light Source Facility Project (ILSF) is a 3 GeV third generation light source with a current of 400 mA which will be built on a land of 50 hectares area in the city of Qazvin, located 150 km West of Tehran. The ILSF storage ring has been designed to be competitive in the future operation years. Some prototype accelerator components such as high power solid state radio frequency amplifiers, LLRF system, thermionic RF gun, storage ring H-type dipole and quadruple magnets, Hall probe system for magnetic measurement and highly stable magnet power supplies have been constructed in ILSF R&D laboratory.

INTRODUCTION

The ILSF project is the first Iranian synchrotron radiation source which will be built in Qazvin Science & Technology Park placed at 150 km in west of Tehran [1]. 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 a significant impetus for multidisciplinary collaborations between scientists from different institutions. General layout of the ILSF is depicted in Fig. 1.

The ILSF accelerators are composed of a pre-injector system, Linac to booster (LTB) transfer line, booster synchrotron, booster to storage ring (BTS) transfer line and storage ring. The bunched electrons are generated by a thermionic RF the electron gun, then compressed and accelerated with use of alpha magnet and three Linac sections respectively. Each Linac section accelerates the bunched electrons to the energy of 50 MeV. The 150 MeV electrons move through the LTB transfer line and enter into the booster. The booster synchrotron accelerates the electrons to the target energy of 3 GeV and then they are guided to the BTS and injected to the ring. In this paper we briefly give the status report of the whole ILSF project.

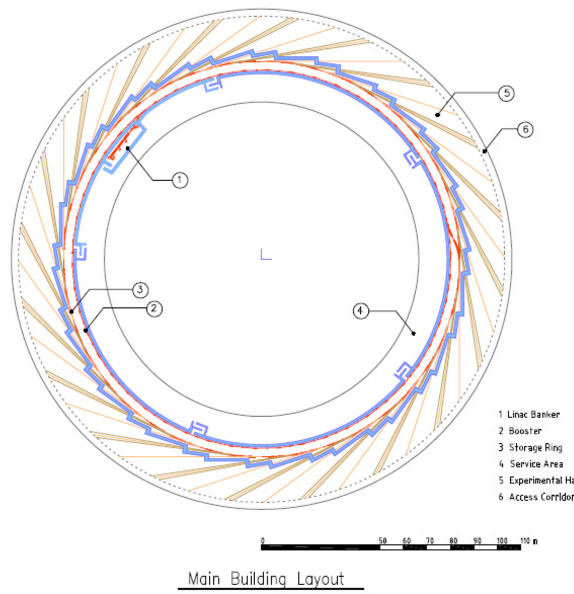


Figure 1: General layout of the Iranian Light Source Facility.

STORAGE RING

Several lattices have been designed for the ILSF ring. Main parameters of the ILSF storage ring which will be approved by the advisory committee are given by Table 1. [2].

Table 1: Main Parameters of the ILSF Ring

Parameter	Unit	Value
Circumference	m	528
Lattice structure	-	5BA
Number of super period	-	20
Length of straight sections	m	5.110
Natural emittance	nm.rad	0.477
No. dipoles/quad./sext.	-	100/320/320

BOOSTER SYNCHROTRON

A share tunnel booster synchrotron has been considered for ILSF storage ring. The booster's lattice is composed of 50 combined FODO structure. The main magnets of the lattice are one family of focusing quadrupole and one family dipole. The circumference of the booster is 504m and its natural emittance is 3.5 nm-rad. In order to decrease the number of quadrupoles, defocusing quadruple and sextuple components have been embedded in the dipoles. The main parameters of the booster are given in Table 2.

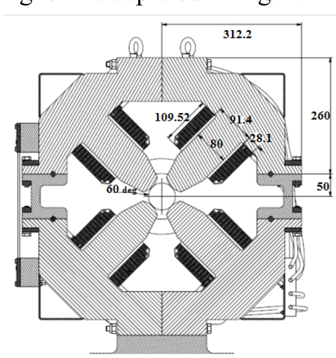
Table 2: Main Parameters of the ILSF Booster

Parameter	Unit	Value
Energy at injection	GeV	0.150
Energy at extraction	GeV	3
Circumference	m	504
Hor. Emittance	nm.rad	3.503
Rep. rate	Hz	
RF frequency	MHz	500

MAGNETS

The ILSF storage ring consists of 100 bending magnets of 2 types, one with a field of 0.747 T and another with a high field insert with a field of 1.745 T, 320 quadrupoles in 8 families with a maximum gradient of 24.78 T/m and also 320 sextupoles in 8 families with a maximum sextupole component of 1162 T/m^2

After constructing a pure H-type dipole magnet with central field of 0.5 T and length of 500mm, a 233 mm quadrupole prototype with gradient of 18T/m has been fabricated [3-4]. The design overview and the fabricated quadrupole magnet are depicted in Fig. 2.



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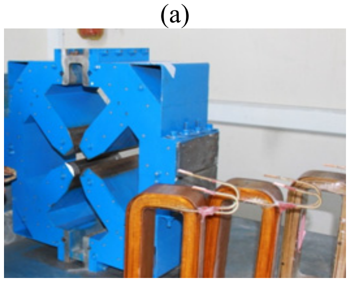
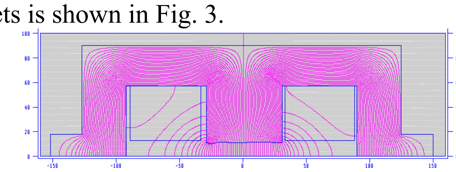


(b)

Figure 2: (a) Design overview of the quadrupole and (b) corresponding fabricated one.

The booster ring includes of 50 H-type dipole magnets with length of 1.3 m, injection field of 480 Gauus and extraction field of 0.97 T. These dipoles will have a field gradient of -0.18 T/m and sextupole component of -39.75 T/m^2. There are 55 pure quadrupoles in 2 families of 0.1 m and 0.15 m in length and both with maximum gradient of 12.33 T/m. Sextupoles also have 1 family with the same cross section, core lengths and maximum sextupole component of 246 T/m^2. Design overview of the booster magnets is shown in Fig. 3.



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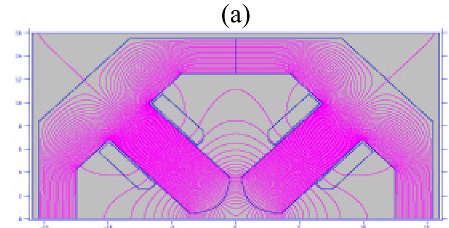

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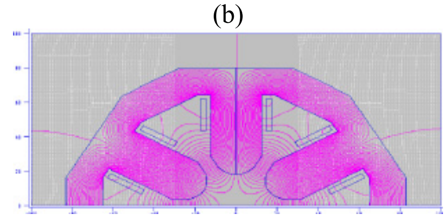

(c)

Figure 3: Design overview of the booster magnets.

MAGNETIC MEASURMENT LABORATORY

The ILSF magnetic measurements laboratory is being constructed at ILSF to test all the magnets prototypes. As the first measurement system, a Hall probe system has been designed and fabricated which includes of a very precise Hall sensor with active area of magnitude 150 μm^2. This sensor is calibrated with a NMR at reference field. An automatic 3-axes bench is moving the probe very smooth and precise. Linear encoders with resolution of 1 μm report the probe position respect to the certain reference point [3-4]. The reproducibility of the positioning is better than ±25 μm, see Fig. 4.

Figure 4: Hall probe system in the ILSF magnetic measurement laboratory.

PRE INJECTOR SYSTEM

The ILSF pre-injector consists of three TW Linac sections, each one increase the beam energy by 50 MeV.

A thermionic cathode RF electron gun is chosen for generation of electrons in the pre-injector and is currently under development at ILSF. It contains a full and a half cell accelerating cavities operating in 2856 MHz, $\pi/2$ mode, with a side cavity for coupling the RF wave between them. The structure is powered by 4 MW of RF input power, producing a bunched beam of electrons with 300 mA peak current and 2.5 MeV energy. Mechanical drawings of the alpha magnet are prepared and it will be manufactured in the near future. Figure 5 shows the general layout of the ILSF pre-injector lattice. As seen, an Alpha magnet is designed for longitudinal compression of bunches.

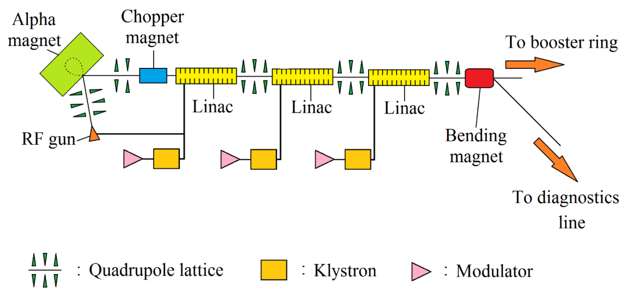

Figure 5: ILSF pre-injector system.

RF SYSTEM

The Iranian Light Source Facility (ILSF) RF system was conceptually designed in accordance with the requirements for ILSF 3GeV storage ring with 400 mA beam current at 500 MHz RF frequency. Development of the solid state amplifiers initiated with the design and fabrication of two amplifier modules based on BLF578 and MRFE6VP1K25HR6 transistors and 690W and 630W stable RF power were delivered respectively. Combining of 8 such modules is under test to achieve 4 kW output power as the first stage of the conceptually designed combining network. Motivated by the development of HOM damped cavity with simpler structure at 100 MHz at MAX Lab., 100 MHz RF system is under exploration as an alternative to 500 MHz at ILSF. In addition to thorough study of the frequency change effects on the beam and machine parameters, the design of a 100 MHz cavity based on MAX Lab. design has also been performed. Fabrication of a prototype cavity is planned in order to conclude the possibility of the cavity development in house. Cavity preliminary mechanical design and cavity parameters are respectively illustrated in Fig. 6 and Table 3 respectively.

A semi-digital LLRF system is also developed and under test. The functionality of the amplitude, phase and frequency loops have been tested using an aluminium pillbox cavity built at ILSF. The work is progressing to measure the delays, optimize the loops' speed and define the system start up procedure. Finally, a digital LLRF system is envisaged in order to have higher flexibility.

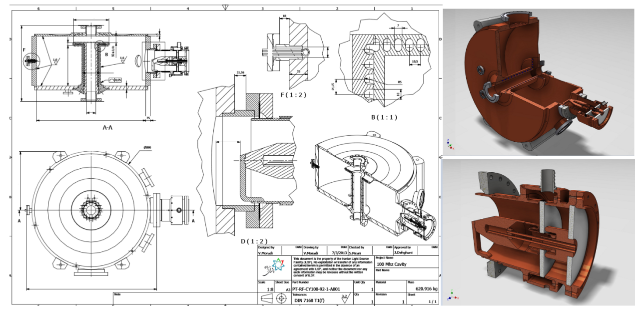

Figure 6: Mechanical drawing of designed cavity.

Table 3: Designed 100 MHz Cavity Parameters

Parameter	**Value**
Frequency (MHz)	100
Q-factor	21000
Shunt Impedance (MΩ)	1.6
Insertion Length (m)	0.5

DIAGNOSTIC SYSTEMS

As diagnostic component, a button BPMs for Storage ring and booster of ILSF is designed based on the different possibilities for dimension with less power dissipation. Software written by C# was developed which calculates capacitance, sensitivity, intrinsic resolution and induced charge on buttons based on vacuum chamber and BPM dimensions. By using this code, primary design of BPMs for storage ring and booster were performed. The high order modes (HOM's) and beam impedance were modelled using MAFIA and CST. Power dissipation was found around 0.8 Watt. Temperature and stress distributions were analyzed with this power loading with ANSYS. To validate BPMs construction, one test stand and for reading out induced voltages on buttons and achieving beam position, electrical circuit with central frequency 485MHz and 35 MHz as bandwidth were designed. Fig. 7 shows schematic of drawing for ILSF button BPM and test stand.

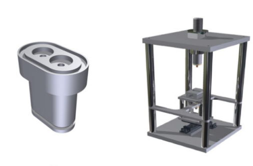

Figure 6: Mechanical drawing of designed cavity.

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