STATUS REPORT ON THE IRANIAN LIGHT SOURCE FACILITY PROJECT

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Abstract

The Iranian Light Source Facility Project (ILSF) is a 3rd generation light source with energy of 3 GeV, a full energy injector and a 150 MeV linac as pre-injector. This is the first large scale accelerator which will be built in Iran. For storage ring, booster synchrotron and linac including the transfer lines, a draft design will be completed soon. The storage ring has an emittance of 3.3 nm-rad, a circumference of 297.6 meters with an overall of 32 straight sections of different lengths. The booster synchrotron has a circumference of 192 meters and emittance of 35nm-rad. For the booster synchrotron a new lattice is proposed. The linac is a conventional 150 MeV accelerator. The different accelerator components, magnets, girders, power supplies, vacuum systems etc are in the design phase. State of the art design for different components is employed through international collaboration.

INTRODUCTION

In order to meet the demands of researchers in Iran, an advanced synchrotron radiation facility will be constructed by the year 2020. The facility will be built on a land of 100 hectares area in the city of Qazvin, located 150 km West of Tehran. The city is surrounded by many universities, research centers and industrial companies. The Iranian light source consists of a 3GeV storage ring, a circumference of 297.6 m and with a predicted emittance of 3.28 nm-rad. The designed beam current is 400 mA. In this paper the latest status of the Iranian Light Source Facility, ILSF is presented. In the last 2 years, various technical groups with the help from other light sources have designed: beam optics, magnets, radiofrequency components, vacuum systems, power supplies and girders. The design and construction of prototype items such as radio frequency solid state unit amplifier, dipole magnets, highly stable magnet power supplies and girders have already begun .Site selection studies, including geotechnical and seismological measurements are being performed. Conceptual Design Report, CDR, as the first milestone of the project will be completed and will be accessible on the project website by the end of July2012. The Iranian Light Source Facility is an open project fully complying with the international scientific codes and standards. All the design and progress reports have been presented at local and international conferences and published in international journals. ILSF welcomes collaboration with scientists, researchers and light source laboratories all around the world in order to share data and experiences. In the following sections we will discuss the progress made so far in designing the Iranian Light Source Facility.

STORAGE RING

The Iranian Light Source is an intermediate energy 3GeV storage ring which should cover the requirements of experimental science in several fields. The general layout of ILSF is shown in Fig. 1 and the main parameters of storage ring are given in Table 1.

Storage ring consists of four super-periods in which each super-period is composed of two matching cells at start and end of lattice and three unit cells in between.

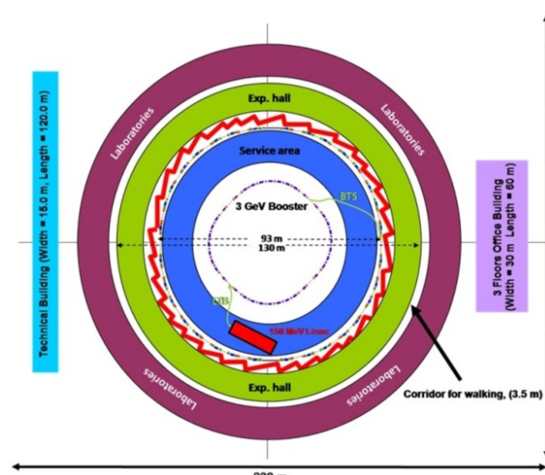

Figure 1: General layout of ILSF.

The design philosophy for the lattice was to have a large percentage of the circumference devoted to straight section, to get a minimum normalized emittance and to get small beam sizes in the medium straights, which are devoted to users. The main parameters of the storage ring are given in table1.

BOOSTER

A full energy booster synchrotron has been designed to accelerate the 150 MeV electron beam, extracted from the

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linac, to the final energy of 3GeV.The primary goal in the design of the ILSF booster is to deliver a small emittance (ε < 30 nm-rad), while keeping the construction costs as low as possible. In order to design a lattice for the booster, two alternatives have been considered. In both alternatives, the booster has a circumference of 192m which is placed concentric in a separate tunnel inside the storage ring.

Table 1:Main Parameters of the ILSF Ring

Parameter	Unit	Value Storage ring	booster
Energy	GeV	3	3
Circumference	m	297.6	192
No. of super-periods	-	4	4
Current	mA	400	-
Horizontal Emittance	nm-rad	3.28	32.42
Harmonic number	-	496	320
RF frequency	MHz	500	500
Tune (Q_x/ Q_y)	-	18.26/11.32	11.22/4.25
Natural energy spread	-	1.04×10^{-3}	8.47×10^{-4}
Natural chromaticity (ξ_x/ξ_y)	-	-34.56/-28.02	-19.87/-10.01
Momentum compaction (α_c)	-	7.62×10^{-4}	5.90×10^{-3}
Radiation loss per turn	MeV	1.02	787.60
No. of dipoles	-	32	48
No. of quadrupoles	-	104	92
No. of sextupoles	-	128	16
Dipole magnetic field	T	1.42	1.1
Dipole field gradient	T/m	-3.83/-5.83	0

PRE-INJECTOR STRUCTURE

The pre-injector system includes a thermionic cathode RF electron gun, an alpha magnet for longitudinal bunch compression and a chopper magnet to omit the bunches which will be decelerated in the booster's cavity. The beam will then accelerate in three linac sections to gain the energy of 150 MeV. Quadrupole magnets are required between these elements to keep the beam focused while it is travelling through pre-injector system. Fig. 2 shows the layout of the proposed ILSF pre-injector.

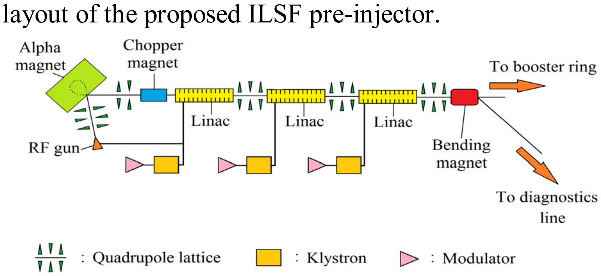

Figure 2: Lattice layout of the pre-injector at ILSF.

MAGNETS

Storage ring dipole magnets has been designed in 2 types with the field of 1.42 T and different gradients of -3.837 and -5.839 T/m. All dipole magnets have parallel ends and curved yoke to follow the beam path. The opening of the magnets is towards the outside of the ring and can be separated from the middle due to installation and fabrication reasons. Quadrupoles have 9 families with the same cross section but 3 different core lengths and a maximum gradient of 23T/m (Fig. 3). Sextupoles also have 9 families with the same cross section but 2 different core lengths and maximum sextupole component of 700 T/m^2.More details are given in the Presentation of this conference

The booster ring doesn't have any sextupole magnet but the sextupole component is inserted in both dipoles and some of the quadrupoles. All the booster dipole magnets are the same with maximum field of 1.1T and sextupole component of 16.03 T/m^2. Quadrupoles have 6 families 3 of them without sextupole component and 2 different cross sections and 2 different core lengths and a maximum gradient of 14.9 T/m and maximum sextupole component of 3.22 T/m^2.

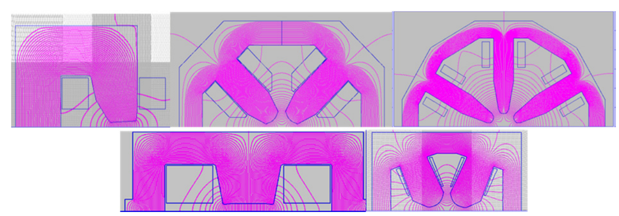

Figure 3: ILSF storage ring and booster magnets.

RF SYSTEM

As in the most of the 3rd generation light sources, RF frequency of 500MHz has been selected according to availability and practical considerations. For the cavities it was decided to have a normal conducting (NC) HOM damped one. Within HOM-damped NC cavities, ELETTRA [1], EU [2], PEP-II [3] and KEK-PF (ASP type)[4] cavities have been considered as cavity candidates for ILSF. Irrespective of the type of the selected cavity, six cavities are required to provide 3.6MV total RF voltage assuring desirable energy acceptance and lifetime except in PEP-II case which 5 cavities are sufficient. EU and PEP-II cavities HOM impedances are lower than ILSF instability threshold while for ELETTRA and ASP-type cavities, further HOM damping is needed. In addition to damping efficiency and operational complexity, cost will be a decisive factor for final selection of ILSF cavity. Table2 shows the main parameters of ILSF storage ring RF system in case EU-cavity is selected. Based on the successful experience in SOLEIL and LNLS and also existence of local expertise, ILSF RF group has started R&D on design and fabrication of solid state amplifier as the RF power amplifier. Three amplifier modules based on three LDMOS power transistors are under test. Digital low level electronics system would control RF phase and amplitude to ensure the beam stability.

Table2: Main ILSF Storage Ring RF Parameters in Case EU Cavity would be Selected

Parameters	RF system
RF frequency (MHz)	500
Synchrotron tune, Q_s	8.051×10^{-3}
Beam Current, I_b (mA)	400
Total beam loss per turn, V_r (MeV)	1.4
Beam power, P_b(kW)	560
Total RF voltage (MV)	3.6
Over-voltage factor, q	2.57
Shunt Impedance, R_s (MΩ)	3.3
No. of cavities, N_c	6
RF voltage per cavity (kV)	600
Power dissipation per cavity (kW)	54.5
Total RF power (kW)	887
RF Power per cavity (including 10% transfer losses) (kW)	165

MAGNET–GIRDER

The ILSF storage ring lattice is DBA/TME type, and the lattice has 4 super periods. Each of them has 2 matching cells and 3 unit cells, so there are 32 bending magnets accompanied with quadruples and sextuples in each side. For beam stability and alignment reasons, each set of sequential magnets are mounted on one girder, therefore two different type of girders will be needed for ILSF. Beam stability is affected greatly by girder static and dynamic stability. Consequently, the beam stability requirements are fulfilled using strict constraints on design of the various accelerator subsystems including girder-magnets assembly. (Fig. 4) Two first natural frequencies are 70.85Hz and 81.18Hz with mode shapes of rolling and magnets oscillation, respectively. Maximum deformation for upper and lower limit of storage ring temperature (25±0.1ºC) was calculated and is equal to 14.5 and 9.9 μm.

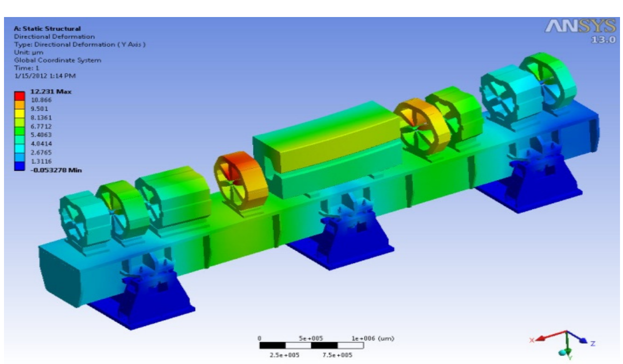

Figure 4: Static deformation of the ILSF magnet–girder assembly in vertical direction.

VACUUM SYSTEM

The concept of antechamber has been chosen for the current design and for the foreseen lumped absorbers and lumped pumps. The vacuum chambers will be made of stainless steel and will be baked out before installation (non in-situ baked). 220 ion pumps with 41000 l/s overall pumping speed have been foreseen for the storage ring. Different computational methods have been developed to help designers to achieve the necessary low pressure throughout small aperture magnet vessels. Several methods have been employed to calculate pressure profile in different working modes of storage ring. Calculations have shown that the maximum pressure in storage ring will be lower than 1.5×10^{-9} mbar (Fig. 5).

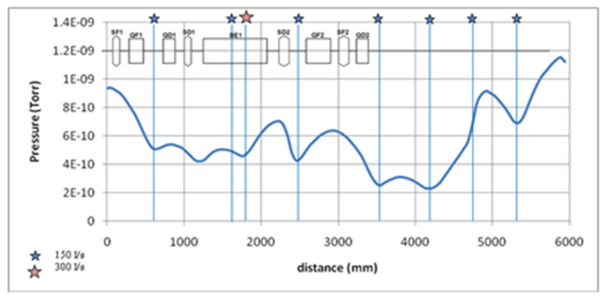

Figure 5: Base pressure of 6m of storage ring.

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