Nuclear Instruments and Methods in Physics Research A 795 (2015) 228–238

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

Conceptual design and expected performance of Iranian light source facility injectors

H. Ghasem [a,b,*], E. Ahmadi [b,c]

[a] School of Particles and Accelerators, Institute for Research in Fundamental Sciences (IPM), Tehran, Iran
[b] Iranian Light Source Facility (ILSF), Institute for Research in Fundamental Sciences (IPM), Tehran, Iran
[c] Department of Physics, Iran University of Science and Technology, Tehran, Iran

ARTICLE INFO

Article history:
Received 4 April 2015
Received in revised form
13 May 2015
Accepted 16 May 2015
Available online 29 May 2015

Keywords:
Beam emittance
Injectors
Lattice
Dynamic aperture

ABSTRACT

In this paper, we present conceptual design of the Iranian Light Source Facility (ILSF) injection systems. Beam dynamics issue and expected performance of the designed injectors have been described. We introduce layout of the injection systems, give the optimized parameters of the components and discuss the injection and extraction procedures with detail.

1. Introduction

Nowadays synchrotron radiation laboratories are well known for the researcher's communities which provide versatile research tool for their experiments in various scientific disciplines. Due to the numerous applications of the synchrotron radiation and in order to cover submitted request proposals from the users, the government of Iran is persuaded to build a new third generation synchrotron light source called as Iranian Light Source Facility (ILSF) [1,2]. At the end of 2009, Institute for Research in Fundamental Sciences (IPM) was selected as executer to construct the facility. The ILSF will be built in the city of Qazvin located 150 km west of Tehran. Figure of merit of the ILSF storage ring follows modern synchrotron light sources design trend which indicates a storage ring with intermediate energy electron beam, high beam current and an ultra low electron beam emittance. Based on the Five-Bend Achromat (5BA) lattice structure, the ILSF storage ring circumference is 528 m and the electron beam emittance in the ring would be 0.48 nm rad. It will provide super bright synchrotron radiation required for the cutting-edge science in several fields and will serve as a significant impetus for the multidisciplinary researches. Further information about the storage ring can be found in Refs. [3,4].

To fill up the ILSF storage ring, several configurations of the injection systems have been investigated. There were two scenarios for the main body of the ILSF injector systems. The first one was to employ a full energy linear accelerator (Linac) and the second one was to use a booster synchrotron fed by small Linac sections. A compromise between these two scenarios revealed that use of the booster synchrotron provides higher reliability, better performance of the injection systems and additionally lower cost. Therefore a full energy booster synchrotron is chosen for ILSF. However, two approaches were studied for design of the booster. In the first approach, the booster with small circumference was designed to place in a separated tunnel as storage ring and in the second, a low emittance large booster was designed to be in the shared tunnel with storage ring. In spite of the concerns regarding the risk associated with interference in installation, testing and commissioning of both machines placed in the shared tunnel as well as future booster troubleshooting, significant higher construction cost of the additional tunnel for the case of separated tunnel booster motivated us to accept the risk and thus the choice of booster in the shared tunnel with ring is frozen. As a consequence of this decision, the booster becomes as large as storage ring but most of the booster circumference is in use with small stainless steel vacuum pipe. Based on housing both booster and storage ring in the shared tunnel, maintenance cost is expected to reduce during the ILSF operation phase. Due to the low value of beam emittance in the large booster; more efficient beam injection would be obtainable. General layout of the ILSF accelerator complex is shown in Fig. 1.

* Corresponding author at: School of Particles and Accelerators, Institute for Research in Fundamental Sciences (IPM), Tehran, Iran.
E-mail address: ghasem@ipm.ir (H. Ghasem).

http://dx.doi.org/10.1016/j.nima.2015.05.034
0168-9002/

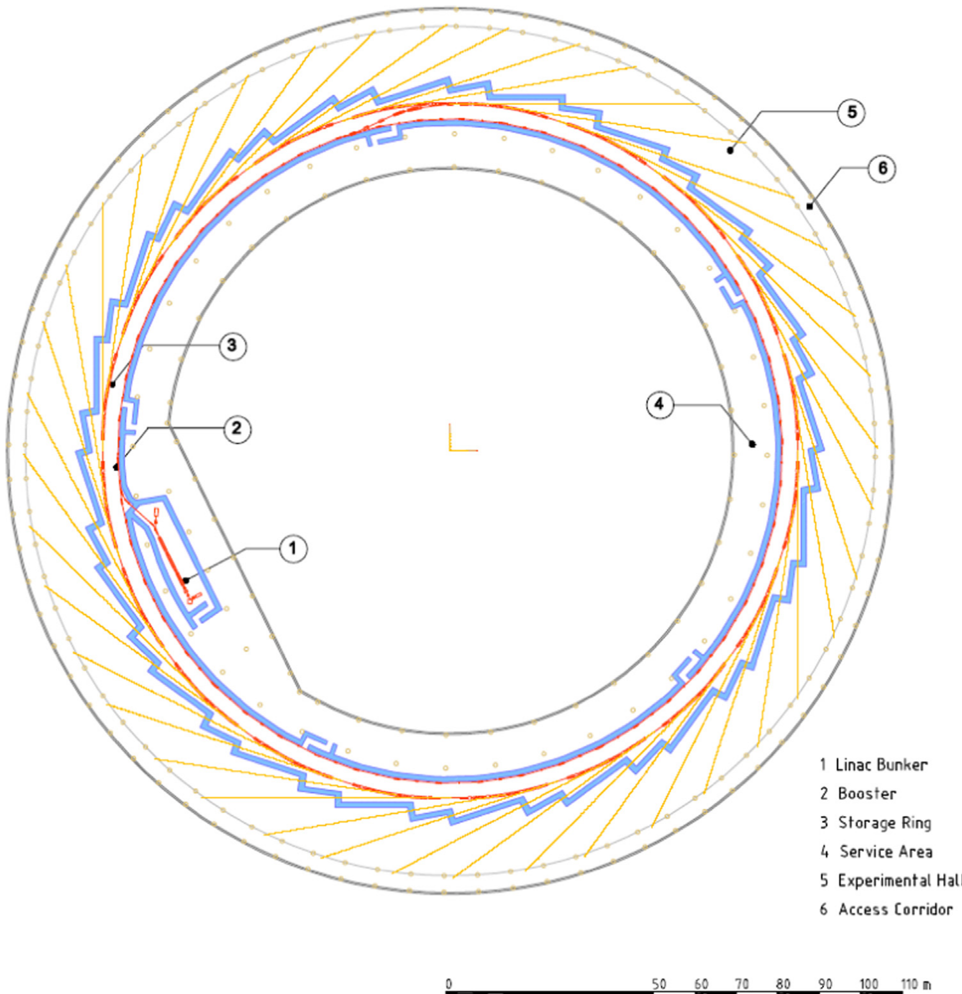

Fig. 1. The ground floor layout of the ILSF main building, taken from Ref. [5]. The accelerators are specified with red color. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

It depicts layout of the injectors where the booster and storage ring are housed in the shared tunnel. The main building consists of two floors service area, Linac bunker, shared storage ring and booster tunnel, experimental hall and access corridors. The typical width of the service area is 10 m and the experimental hall accommodates beamlines with the length up to 60 m long. Outboard of the experimental hall is the access corridor with 2.5 m width. The supplemental laboratories would be next to them.

The electron bunches are produced with a thermionic RF electron gun. They go through the alpha magnet for bunch length accumulation. As the part of the pre-injectors, three traveling wave Linac sections each with length of 3.5 m are employed to accelerate the bunched electrons. The electrons move toward the accelerating structures and reach the energy of 150 MeV at the exit of Linacs. The Linac design parameters will be specified according to the expected injection time to fill up the storage ring. Although as a separate project, a 10 MeV linear accelerator [6,7] had been designed and is now under construction by IPM, but based on the ILSF strategy, ILSF is completing the preliminary injector's design and then the major components of the injectors such as Linac will be procured from vendors. However, reliability of the Iranian Linac project may influence this strategy. The triplet quadrupoles are used in the different locations in pre-injector section for transverse beam focusing. General layout of the pre-injector system is depicted in Fig. 2. Further information can be found in Refs. [8,9].

The high energy Linacs produce beam with low energy spread and emittance, which are required for easy injection into the booster. The 150 MeV electron bunches are guided to the booster straight section via Linac to booster (LTB) transfer line. Booster accelerates the electrons to the target energy and then the electrons move to the storage ring using booster to the storage ring (BTS) transfer line.

This paper starts with the design of LTB transfer line and then is followed with design of the booster synchrotron. It ends with design of the BTS transfer line. The injection and extraction procedures at each step have been discussed and the optimized parameters of the injection components are given. The beam dynamics issue includes of the expected errors typically from alignment techniques and multipoles of the magnets have been studied. It should be noted that OPA [10] and ELEGANT [11] simulation codes are employed for design, linear/nonlinear optics optimization and particle tracking.

2. LTB transfer line

2.1. LTB lattice

The LTB transfer line guides the 150 MeV bunches to the booster synchrotron. It starts at the exit of the last Linac and ends at the exit of the injection septum. Two dipole magnets with the