SESAME, a 2.5 GeV Synchrotron Light Source for the Middle East Region

D.Einfeld1, R.H.Sarraf2, M.Attal3, K.Tavakoli3, H.Hashemi4, H.Hassanzadegan4, E. Al-Dmour1, B.Kalantari5, A.Aladwan5, H.Tarawneh5, S.Varnasery7

Abstract

Developed under the auspices of UNESCO, SESAME (Synchrotron light for Experimental Science and Application in the Middle East) will be a major international research center in the Middle East and Mediterranean region where most of the applications require hard x-rays up to 20 KeV photons. At the 6th of January 2003 the official foundation of SESAME as well as the ground breaking for the building took place. The accelerator SESAME is based upon the synchrotron light source BESSY I, which was, with the operation of BESSY II, devoted to SESAME. The original plan was to upgrade BESSY I to an energy of 1 GeV and use super conducting wigglers to reach 20 keV photons. According to the present design SESAME will be a 2.5GeV 3rd Generation light source with an emittance of 24.6 nm.rad and up to 13 places for the installation of insertion devices with an average length of 3.1 meters. The circumference of the machine will be 124.8 m. As injector the 800 MeV Booster Synchrotron of BESSY I will be used with minor changes. At SESAME around 39.7% of the circumference can be used for the installation of insertion devices. At the beginning of operation 6 beam lines should be installed.

INTRODUCTION

According to the workshops held in the Middle East Region the scientific case for SESAME includes structural molecular biology, molecular environmental science, surface and interface science, micro mechanical devices, x-ray imaging, archaeological microanalysis, material characterization, and medical applications. Most of this applications require hard x-rays up to 20 KeV photons. Within the "Green Book"-design [1] this 20 KeV can be reached by upgrading BESSY I from 0.8 to 1 GeV and use 7.5 T super conducting wigglers. In order to increase the number of hard X-ray

NEW LATTICE

For the new lattice a so called "TME-Optic" [3] was chosen, which gives the smallest emittance and it should give the highest percentage of the circumference, dedicated to the installation of the insertion devices. The basic elements of the lattice are a combined function bending magnets, with a set of quadrupoles and sextupoles on each side. The combined bending magnets perform the deflection and the focusing in the vertical direction, the quadrupoles make only the horizontal focusing.

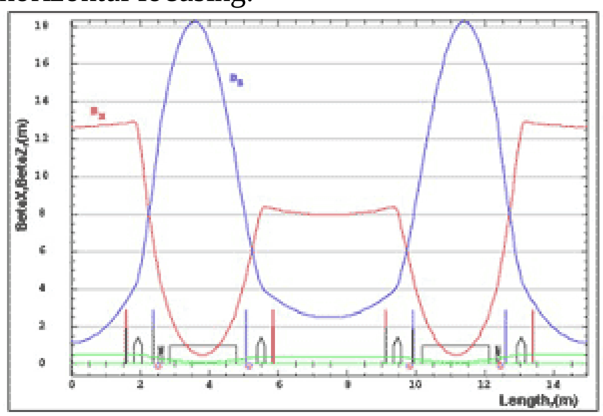


Figure 1: Optical functions of SESAME lattice, The green line represents dispersion, the pink circles represent the BPMs, while the correctors will be inside the sextupoles.

Table 1: Main parameters of the new SESAME upgrade

Parameters	Values
E (GeV), No. of BMs	2.5 , 16
C (m), ∑(Str.Sec.) / C	124.8 , 39.7%
ε_x (nm.rad)	24.6
Qx , Qz	7.217 , 5.192
ζx , ξz	- 13.1 , - 13.8
βx , βz , ηx (m)	11.12, 1.89, 0.453 (8 sec.) 10.9, 1.73, 0.534

beam lines it was decided to upgrade the SESAME to 2.0 GeV and to optimize the design for a higher brilliance with a larger number of straight sections (White Book) [2]. According to the "1st User Workshop of SESAMA" in Amman, October 2002, it should be possible to reach the selenium K-edge with in-vacuum undulators. This is only possible by increasing the energy to 2.5 GeV. The proposed upgrade to this energy is presented in this paper.

The machine functions of one unit cell are given in figure 1. and the main parameters of the ring are summarized in table 1. For operational purposes it must be possible to change the vertical tuning. For SESAME the gradient in the bending magnets must be varied by ±6% in order to change the tune by ±0.5. Using pole-face windings that will be introduced into the bending magnets will do this. To reach a sufficient dynamic aperture and an energy acceptance of 4%, chromatic and harmonic sextupoles have to be used. The arrangements of the magnets within one cell are given in figure 2 and the magnets with the quadrupoles and sextupoles are located around it. The average length of the straight sections is 3.1 meters. It is foreseen to extract two beam lines (6° & 14.5°) from each bending magnet in addition to one zero-degree line which comes from upstream insertion device. The layout of the whole storage ring with the 800 MeV BESSY I booster synchrotron is shown in figure 3.

	(other 8 sec.)
B_0 (T) ,n (strength)	1.4 , 12.9 (k = -0.3636 m-2)
No., Gr. of Quads	32 (2 families) 19 T/m
No., Gr. of Sext.	64 , 116 T/m2
No. of Str. Sec.	16 (8 x 3 m + 8 x 3.19 m)

layout of the whole storage ring is given in figure 3. It should be noted here that the above optics is the original one from paper [2] and it could be changed a bit to get the optimum optics for high brilliance due to different insertion devices number and types according to the requirements of the users.

LAYOUT OF THE MACHINE

The layout of one cell is given in figure 2. The main elements are the 22.5 degrees vertical focusing bending

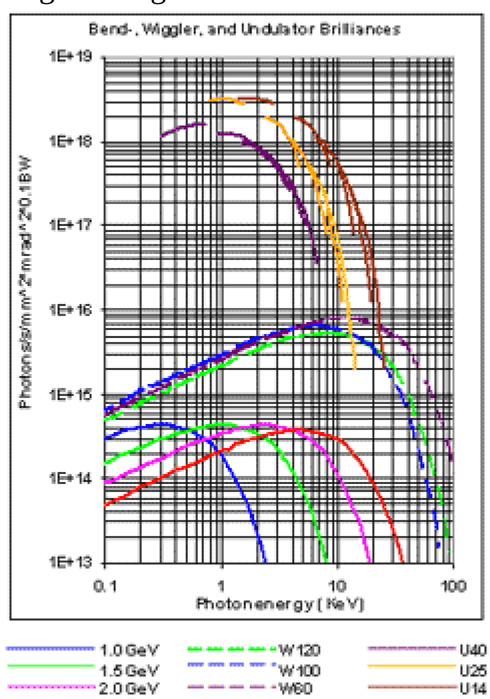


Figure 4: Brilliance of the synchrotron radiation emitted from the stored beam in the bending, wigglers and undulators.

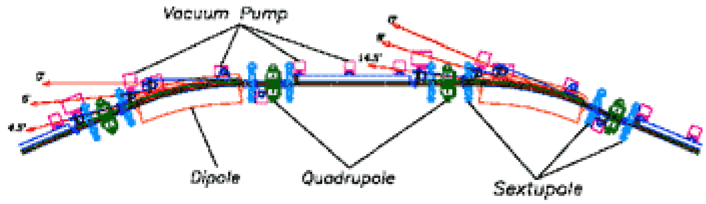
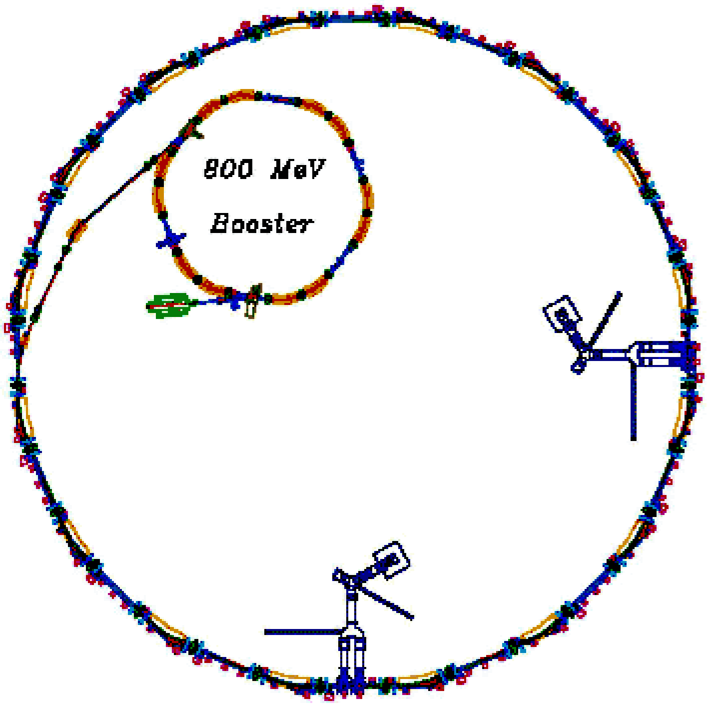


Figure 2: Arrangements of magnets within one unit cell of the storage ring SESAME.



Storage Ring SESAME
Energy: 2.5 GeV
Circumference: 124.8 m
Emittance: 24.6 nm.rad
No. of Straights: 16

Figure 3: Layout of the 2.5 GeV storage ring of SESAME

COMPONENTS OF THE MACHINE

The original BESSY I injector will be used with some modifications. Instead of the 10 Hz white circuits, 1 to 3 Hz fast power supplies will be used. Hence all power supplies have to be replaced. With this transaction the current for all power supplies will be increased in order to upgrade the energy of the injector from 0.8 to 1 GeV. At this energy the flux in the bendings is 1.25 T. Perhaps in a later stage the 20 MeV Microtron as pre-injector will be replaced by a 50 MeV linac or racetrack microtron. According to the upgrading of 2.5 GeV, the bending magnets with a flux of 1.4 Tesla and a gradient of 3 T/m must be new. This is also true for the quadrupoles and sextupoles. With the changes of the circumference from 64 to 124.8 m the vacuum system must be new. It will be an antechamber system like SLS or the CLS. All photons will be stopped at lump absorbers. Overall a pumping speed of 32000 L/s will be installed in order to get after one year of operation an average pressure of 1 nTorr. The RF-system will be build up in steps too, which are determined by the donations of other laboratories. DESY will donate to the project some 250 kW klystrons and ELETTRA a cavity and the low level electronics. The layout of the RF-system will be the same as for ANKA. All the power supplies for the project will be build in a collaboration between SESAME and the Yerevan Physics Institute (Yerphi). The intention is to use the higher power parts of the old power supplies and replace the electronics. For the control system we expect some donations from the Swiss Light Source. The concept is based upon EPICS but for graphical user interface we take the ANKA approach. The same control system will be used for both, the machine and the beam lines. The whole diagnostics system for the SESAME storage ring will be new.

BRILLIANCE OF RADIATION

The brilliance of the emitted radiation of a 400 mA stored beam from the different sources are presented in figure 4. For the bending magnet it is given for the energies 1.0, 1.5, 2.0, and 2.50 GeV. For the wigglers with the maximum flux density of 2.0 T (W100), 2.5 T (W120) and 3.5 T(W80). For the undulators with the period length of 40 mm (U40), 25 mm (U25) and 14 mm (U14). U25 is an in-vacuum undulator and U14 is an super conducting mini undulator.

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REFERENCES

1. Green Book, Conceptual Design Report for SESAME, OCT 99, BESSY, Berlin.
2. Whitw Book, Conceptual Design for the Upgrading of SESAME to 2 GeV, UNESCO-Office, Amman, July 2002
3. A. ROPERT, Lattices and Emittances, CAS, 1996, CERN 98-04.
4. First operation of the Swiss Light Source, EPAC02, 3-7 June 2002, Paris.
5. Gradient Dipole Magnets for the Canadian light Source, EPAC02, 3-7 June 2002, Paris.

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1 UNESCO office Amman, Jordan. 2 Al-Balqua Applied University, Alt-Salt, Jordan. 3 LURE, Orsay, France. 4 DESY Hamburg, Germany. 5 Swiss Light Source, Villingen, Switzerland. 6 MAX-Lab, University Lund, Lund, Sweden. . 7 Daresbury Laboratory, Daresbury, United Kingdom.