AN UPDATE ON SESAME LIGHT SOURCE

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Abstract

SESAME• is a 3rd generation light source, which will provide the Middle East Region with synchrotron radiation. This machine is based upon BESSY I and meanwhile the energy is upgraded to 2.5 GeV. The layout of the machine is determined by the size of the building, which leads to a maximum circumference of 130 m. For such a machine a detailed conceptual design report has been finished. The layout of the machine has to meet the requirements of the users. The scientific program for SESAME has not been finalized. During the last meetings of the users, some longer straight sections should be included, what means a redesign of the machine has to be made. This new redesign will be described within this paper, on which a detailed engineering design is just started. Furthermore a little bit more complicated 4-fold lattice option has been investigated, which yields to 4 straight sections with a length of 5 m.

INTRODUCTION

SESAME has gone trough an evolution process [1÷7] ranging from the reinstallation, in the Middle East, of Bessy I to this final version based on a 2.5 GeV 3rd generation Light Source. The specifications of this machine are summarized in the conceptual design report, the Yellow Book. The layout of this concept is also described within the references [4] to [7]. The main parameters are given in Tab. 1.

For SESAME a Double Bend Achromat (DBA) lattice has been adopted. In order to save space vertical defocusing gradient inside the dipoles and dispersion distribution in the straights are used. This design leads to an emittance of ~25 nm.rad and up to 40% of the circumference can be used for the installation of insertion devices. The design is quite relaxed respect to the Theoretical Minimum Emittance (TME) type [8], with an emittance larger by a factor ~ 3.5. The storage ring is composed of 8 super periods with 16 dipoles and 16 straight sections of 3m length from iron to iron. With these lengths it is possible to install insertion devices with a length of ~2.5 m.

The construction of the SESAME building, located in Allan (Jordan), started in 2003 and the beneficial occupancy is expected by the end of 2005. The sizes of the experimental hall are 60x60 m^2. These fixed dimensions together with a target of ~30m for the Beamlines length put a limit on the maximum ring circumference of ~130m.

• Synchrotron-light for Experimental Science and Application in the Middle East is an Independent Intergovernmental Organization developed under the auspices of UNESCO.

THE UPGRADED LATTICE

In order to meet the requirements of the users for longer straight sections, the length of the straight sections have been changed to a long straight of 4.48 m and a short straight of 2.02 m, by keeping the tunes constant. The long straight sections (one is dedicated to the injection) will allow to host up to 7 Insertion Devices (ID) with a maximum length of ~ 4m, while the short ones can accommodate up to 4 ID with a length of ~ 1.5 m (4 straights are allocated for RF cavities, diagnostic and bunch-to-bunch longitudinal feedback). Each dipole vacuum chamber will be equipped with a port, to collect the synchrotron light, centered at 7.15^o from the dipole end, allowing to install up to 16 Beamlines. At this angle the beam sizes increase by 10%, relatively to the minimum beam size angle (11.25^o), but it is possible using a quadrupole/sextupoles design.

Table 1: Main SESAME parameters.

	Old Version	*Upgraded One*
Energy (GeV)	2.5	2.5
C (m)	128.4	129
B_0 (T)	1.4	1.455
Gradient (T/m)	-2.377	-2.794
Q_x, Q_z	7.23, 5.19	7.23, 5.19
ε (nm.rad)	26	26
ξ_x, ξ_z	-14.62, -13.65	-14.64, -14.81
U_0 (keV/turn)	590.74	589.7
τ_s, τ_x, τ_z (ms)	2.52, 2.32, 3.62	2.71, 2.21, 3.65
Quadrupoles	48 (3 families)	64 (2 families)
Sextupoles	64 (4 families)	64 (2 families)
RF freq. (MHz)	499.643	499.654
Design current	400 (mA)	400 (mA)

with non-split yoke in the horizontal plane.

The main storage ring parameters are listed in Tab. 1, while the cell layout and the optical functions are shown in Fig. 1. At each end of the dipoles there is a short QD trimming quadrupole followed by a QF quadrupole. This quadrupole choice will allow compensating locally the optical perturbation of the ID. Since in the bare SESAME lattice there are only 2 families of q-poles the compensation, depending upon the strength of the ID, will be performed by current shunts or dedicated power supplies.

Let us also point out that the adopted QD-QF solution allows quite large β-tunes variation as well as compensation up to ±4% discrepancy, from the design value, in the integrated dipole gradient, without affecting substantially the main lattice properties.

The Optics optimization

Our target has been to define a basic lattice (without ID's) which is very simple, has only 2 families of q-poles and 2 of sextupoles, flexible enough to be easily retuned, to eliminate the perturbation of the ID's, and with acceptable dynamic aperture.

Due to the choice to have straight sections with 2 different lengths and only 2 families of quadrupoles, the vertical defocusing gradient inside the dipoles has been slightly changed, respect to the old one, in order to minimize the relative beating in the horizontal β (for symmetry there is no beating in the dispersion function).

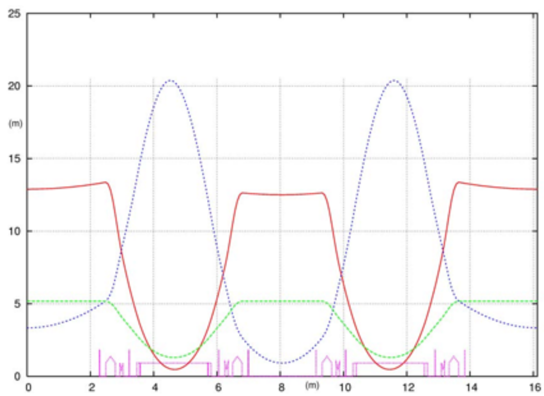

Figure 1: SESAME optical functions for a full period: β_x is in red; β_z is in blue while the dispersion function (x10) is in green.

The lattice optimization procedure has demonstrated to be effective in order to obtain a lattice with good dynamical behavior. Fig.2 shows the dynamical aperture, with chromaticity corrected to zero value in both planes by using only 2 families of sextupoles. Correcting the chromaticity values to +2 in both planes does not drastically reduce the dynamical aperture.

The influence of the higher multipoles errors of all magnets however, is expected to reduce the dynamic aperture.

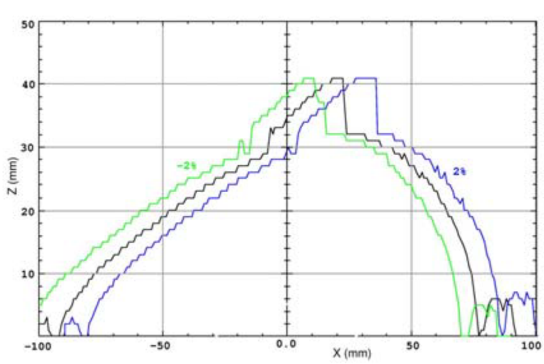

Figure 2: SESAME dynamic aperture for 1000 turns (the on-momentum is in black while the 2% and –2% off-momentum ones are in blue and green respectively).

By inspecting the off-momentum dynamic apertures (Fig. 2) and the tune shift vs. energy deviation (±6%) shown in Fig. 3, one deduces that the lattice has an acceptable off-momentum behavior.

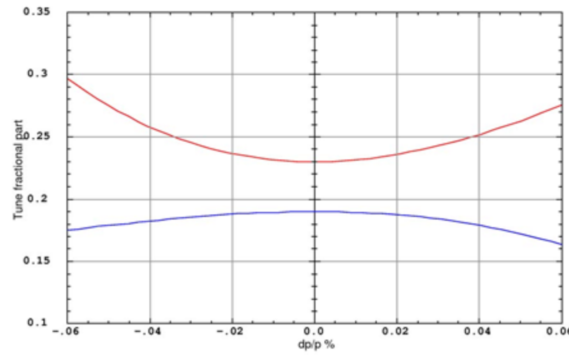

Figure 3: The horizontal (red) and the vertical (blue) tune shifts vs. energy deviation.

THE 4-FOLD LATTICE OPTION

Longer straight sections, keeping the ring circumference ~ 130 m, can only be obtained by the reduction of the symmetry to 4. In this configuration the ring is composed of 4 periods with the following straight section lengths: 1x5m, 2x3.5m, 1x1.9m. In order to keep the circumference of the storage ring close to ~ 130m, we decided to eliminate the QD trimming quadrupole in all the short straight sections. Moreover to get $_x$ = 0 in the 3.5m section was paid by an emittance increase of ~10%. The elimination of this QD quadrupoles also prevents the possibility to compensate for ID perturbation, but one can think to use these short straights for RF cavities, diagnostic and bunch-to-bunch longitudinal feedback.

The main storage ring parameters are listed in Tab. 2, while the cell layout and the optical functions are shown in Fig. 4.

Table 2: Main parameters for the 4-fold option.

Circumference (m)	131.81
Dipole field (T)	1.46
Dipole gradient (T/m)	-2.44
Betatron tunes; Q_x, Q_z	6.84, 4.82
Emittance (nm.rad)	28.5
Nat. chromaticity; ξ_x, ξ_z	-9.57, -16.3
Damp.times; τ_s, τ_x, τ_z(ms)	2.64, 2.24, 3.63
No. of straight sections	4x5m+8x3.5m+4x1.9m
Quadrupole families	5
Sextupole families	6

The Optics behavior

In order to ensure β-tunes variability is now necessary to adopt 5 families of independent q-poles, complicating in some way the tuning and the commissioning of the bare lattice, but this is an unavoidable price to pay. The compensation for the perturbation of the ID's can be made locally as already described.

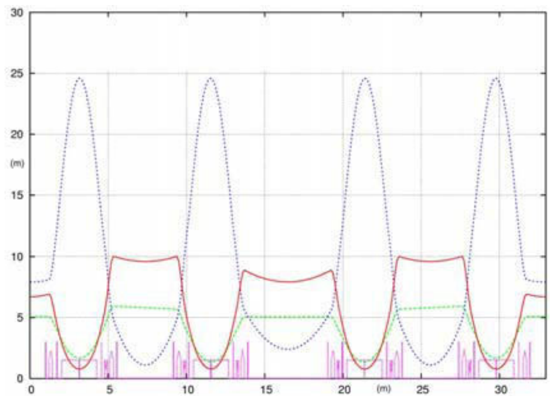

Figure 4: Optical functions of the 4-fold ring lattice: β_x is in red; β_z is in blue while the dispersion function (x10) is in green.

The β-tune working point (Q_x= 6.84, Q_z= 4.82) has been chosen to meet the same conditions of the upgraded lattice. In order to achieve acceptable dynamic aperture 2 families of sextupoles are now not enough, but using 6 families of independent sextupoles it is possible to achieve good results (see Fig. 5). How critical is the dynamical aperture to magnetic errors has not been investigated.

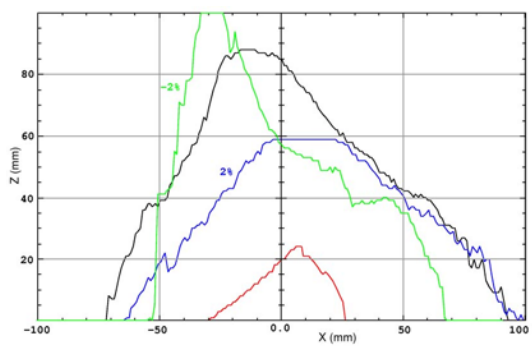

Figure 5: Dynamic aperture for 1000 turns. Black, blue and green lines are for 6 families of sextupoles, while the red line refers to 2 families configuration (the on-momentum dynamic aperture is in black while the 2% and –2% off-momentum ones are in blue and green respectively).

The off-momentum dynamical behavior is acceptable and stable for large energy deviations even though the practical energy deviations are limited to ±2%. An indication of this stability can be seen by inspecting the off-momentum dynamic apertures (Fig. 5) and the tune shift vs. energy plotted in Fig. 6.

The dynamic aperture and the other nonlinear calculations were done for chromaticity values corrected to zero value in both planes.

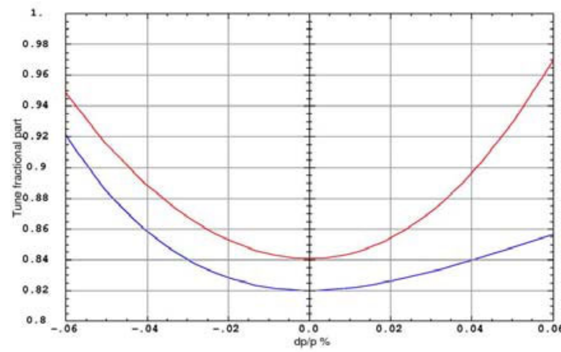

Figure 6: The horizontal (red) and the vertical (blue) tune shifts vs. energy deviation for 6 families of sextupoles configuration.

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