SESAME IN JORDAN

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Abstract

An overview of the status of SESAME• is presented. SESAME will become a major international research center in the Middle East, located in Allan, Jordan. The machine design is based on a 2.5 GeV 3rd generation Light Source with an emittance of ~26 nm.rad and 12 straights for insertion devices. The conceptual design of the accelerator complex has been frozen and the engineering design is started. The Phase I scientific program for SESAME has also been finalized and it foresees 6 Beamlines, including 2 IR ports. The construction of SESAME building is in progress and the beneficial occupancy is expected by the first half of 2006. The completion of the accelerators complex construction is scheduled for the end of 2009.

INTRODUCTION

SESAME has gone through an evolution process [1÷8] 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 Building that will house SESAME is under construction (see Fig. 1), under the supervision of Eng. R. Al Sarraf, from Al-Balqa University, Jordan. Its completion, including a 6.0 MVA dedicated Electrical Power Station, is scheduled by the first half of 2006.

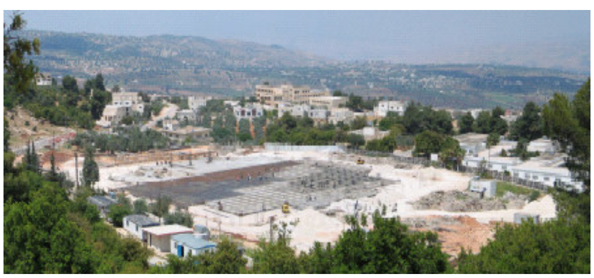

Figure 1: A panoramic view of SESAME building during construction (April 2005). In the picture is clearly visible the floor of the experimental hall.

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. Moreover the storage ring is 5 meters off center in order to have few Beamlines with a length of ~36m.

In Fig. 2 is shown the layout of the accelerator complex and the Beamlines in the experimental hall. The injector complex (800 MeV booster synchrotron and 22.5 MeV Microtron) is the one already used in Bessy I [9], with new power supplies and vacuum pumps. The 2.5 GeV Main Storage Ring, whose principal subsystems will be described in more details in this article, is completely new.

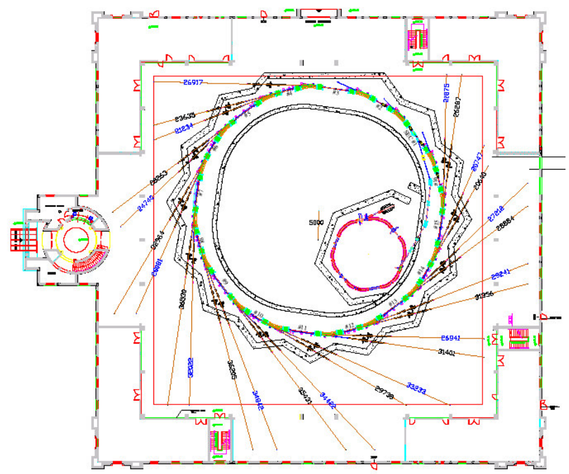

Figure 2: SESAME layout in the experimental hall.

The injection at 800 MeV is a clear limitation to the performance of a 3rd generation Light Source. For this reason we have designed a full energy injection scheme [10] which implies the replacement of the Bessy I injector with a 100 MeV Linac and a 2.5 GeV Booster Synchrotron with a circumference of 118.87m (see Fig. 3).

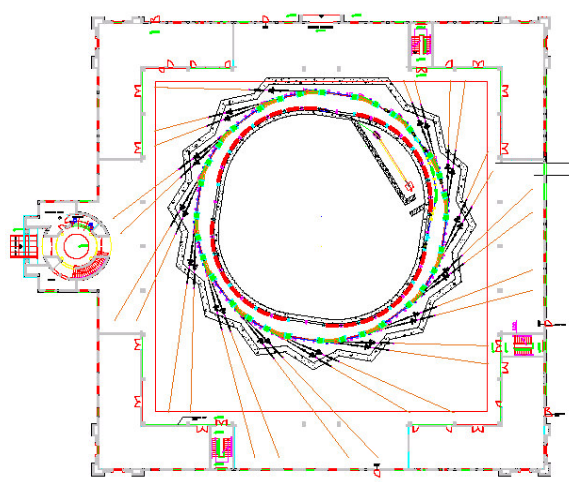

Figure 3: SESAME layout with full-energy injector.

• Synchrotron-light for Experimental Science and Application in the Middle East is an Independent Intergovernmental Organization developed under the auspices of UNESCO. It involves at the present the following Member States: Bahrain, Egypt, Islamic Republic of Iran, Israel, Jordan, Pakistan, Palestinian Authority, Turkey and United Arab Emirates.

THE MAIN STORAGE RING

The main storage ring parameters are given in Tab. 1. The storage ring is composed of 8 super periods with 16 dipoles and 16 straight sections of alternate length, from steel to steel, of 4.44m and 2.38m respectively. 4 straights (2 long and 2 shorts) are allocated for injection, RF cavities, beam diagnostic and feedbacks. The injection scheme (4 kickers closed orbit bump) foresees the septum with 2 kickers in a long straight, while the other 2 kickers will be positioned in the 2 adjacent short straights. This scheme is compatible also with full energy injection.

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Table 1: SESAME design parameters.

	Q_x=7.23,Q_z=5.19	Q_x=7.23,Q_z=6.19
Energy (GeV)	2.5	
Circumference (m)	133.12	
N. of Periods	8	
N. of Dipoles	16	
Dipole field (T)	1.455	
Dipole field index	11	
Dipole Gap (mm)	40	
N. of Quadrupoles	64 (2 families)	
N. of Sextupoles	64 (2 families)	
Mom. Compaction	0.00833	0.00829
N. Emitt.(nm.rad)	25.5	26.0
H/V Chromaticity	-14.0/-13.8	-15.5/-19.0
U_0 (keV/turn)	589.7	
τ_ε, τ_x, τ_z (ms)	2.81, 2.27, 3.77	2.80, 2.28, 3.77
RF freq. (MHz)	499.564	
Harmonic Number	222	
Peak Voltage(MV)	2.4	
% RF Acceptance	1.459	1.463
Synch. Freq. (kHz)	37.28	37.18
σ_L (cm)	1.16	1.15
Current (mA)	400	
N. of bunches	200	
1/e Lifetime(hrs)	18.2	16.9

The Optics

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

For SESAME a Double Bend Achromat (DBA) lattice has been adopted. In order to save space vertical focusing gradient inside the dipoles and dispersion distribution in the straights are used. This design leads to an emittance of ~26 nm.rad and up to 31% 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 [11], with an emittance larger by a factor ~ 3.5.

In Fig. 4 and Fig.5 are shown the optical functions for 2

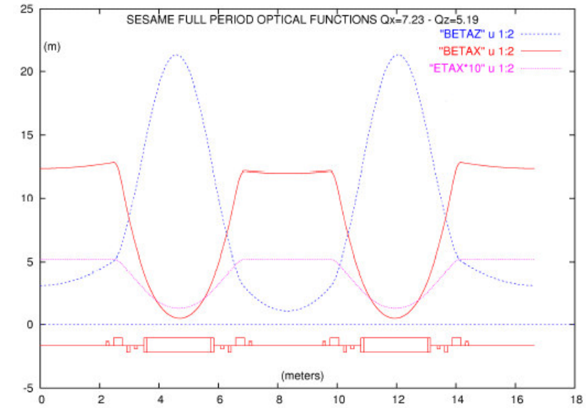

Figure 4: SESAME full period optical functions for (Q_x=7.23 - Q_z=5.19).

potential β-working points: (Q_x=7.23 - Q_z=5.19) and (Q_x =7.23 - Q_z = 6.19), while the bare dynamic apertures are shown in Fig. 6 and Fig. 7 respectively.

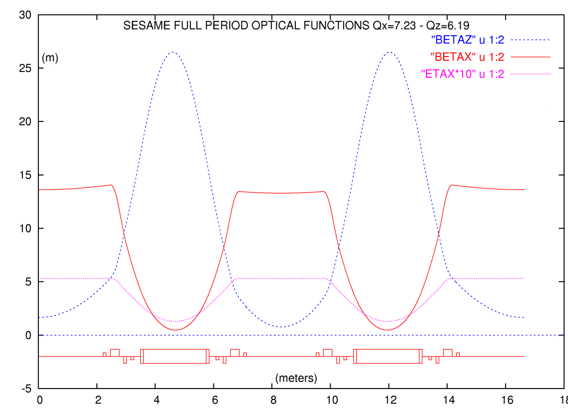

Figure 5: SESAME full period optical functions for (Q_x =7.23 - Q_z = 6.19).

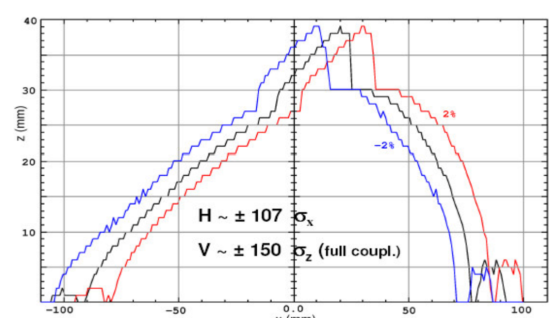

Figure 6: On energy and ±2% energy deviation dynamic aperture for (Q_x =7.23 - Q_z = 5.19).

The chromaticity is 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 dynamic aperture.

The evaluation of the influence of the higher order multipoles components for all magnets is in progress: preliminary results indicate that the reduction of the dynamic aperture is acceptable.

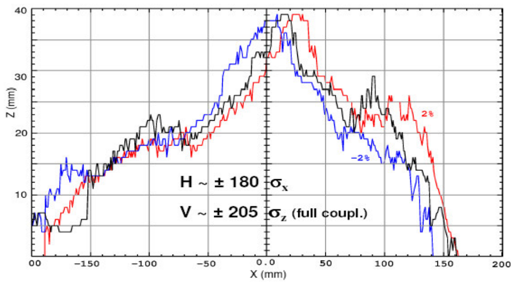

Figure 7: On energy and ±2% energy deviation dynamic aperture for (Q_x =7.23 - Q_z = 6.19).

Let us point out that the second working point has smaller vertical β-function in the straights, being more suitable for small–gap insertion devices, but the higher β_z value will increase the requirement on the dipole field quality.

The Vacuum system

The SESAME vacuum system, with a total pumping speed of ~40.000 l/s, is dimensioned to reach after adequate beam conditioning (~100 Ampere-hours of stored beam) an average operating pressure of ~ 1 nTorr with 400 mA of circulating current.

A design, similar to SLS [12], has been adopted for the stainless steel vacuum vessel: it is based on the chamber-antechamber concept with lumped cupper absorber: ~ 97% of the unused synchrotron radiation is intercepted by the absorbers system. In SESAME the antechamber will be present in the bending magnets and in the following multipoles, while the pre-dipole chamber will have no antechamber. A schematic layout for 1/16 of SESAME ring and vacuum chamber (no straights) is shown in Fig. 8.

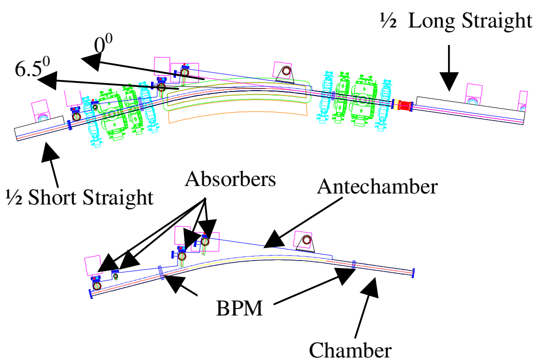

Figure 8: The unit half-cell of the storage ring.

The vacuum chamber will be equipped with 32 ESRF type capacitive BPM buttons, welded to the chamber and with a port, to collect the synchrotron light, centred at 6.5^o from the dipole beginning, allowing installing up to 16 Beamlines. At this angle the beam sizes increase by 10%, relatively to the minimum beam sizes angle (11.25^o), but this choice makes possible to adopt a quadrupole/sextupoles design with non-split yoke in the horizontal plane.

The Magnets system

In SESAME there are 16 Dipoles, 32 F-quadrupoles with magnetic length of 30 cm, 32 D-quadrupoles with magnetic length of 10 cm, 32 F-sextupole and 32 D-sextupole with magnetic length of 10 cm. For quadrupoles and sextupoles a design identical (a part the length) to the one adopted for ANKA has been chosen [13], the max gradient is 19T/m for the quadrupoles and 350 T/m^2 for the sextupoles. For the dipole magnet a design similar to the ANKA one has also been adopted, but a modification of the pole profile has been carried out to incorporate the vertical focusing gradient (see Fig. 9).

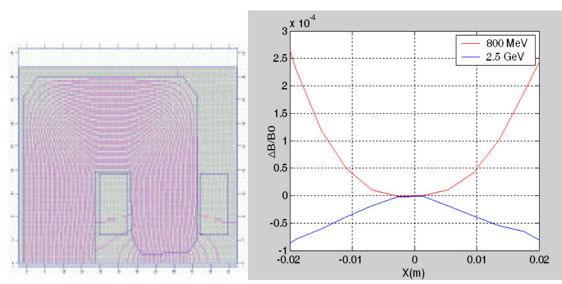

Figure 9: Dipole cross section and transverse field quality within ±2 cm at 2.5 GeV and 800 MeV.

3D calculations give a yoke length of 2.214 m for a magnetic length of 2.250 m. A total of 49.6 kAmpere turns are necessary at the nominal maximum Energy. The optimization of the design is still in progress.

2 (4) additional coils inside each SF (SD) sextupole are used as horizontal (vertical) correctors. The transverse field profile for such correctors is shown in Fig. 10. 3D calculations show that a total of 6.24 (7.23) kAmpereturns/mrad is needed for the Horizontal (Vertical) corrector at 2.5 GeV

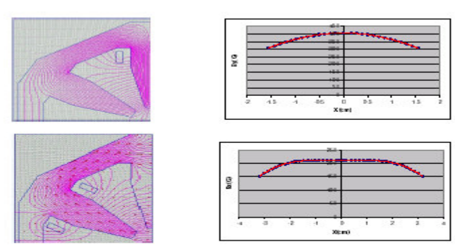

Figure 10: Transverse field profile for horizontal (top) and vertical (bottom) correctors.

The RF system

It was decided for SESAME to adopt a RF system similar to the ANKA one and based on Elettra type cavities [14]. We are now investigating also the performance of the newly developed EU HOM [15] damped cavity, in relation to the suppression of longitudinal and transverse multibunch instabilities driven by HOM's of the RF cavities.

In Fig. 11 is plotted, as function of the Energy, and for

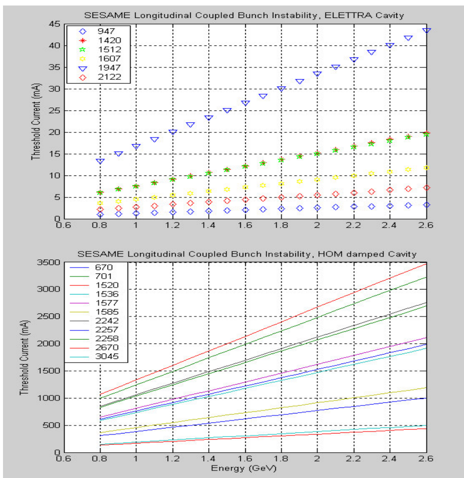

Figure11: Threshold current due to HOM's for ELETTRA type cavity (top) and EU HOM damped cavity (bottom).

constant synchrotron frequency, the threshold current of each single HOM for the 2 type of cavities, assuming the worst case scenario of 100% coupling. In Fig. 12 the resulting grow rate of the instability is plotted at the design current of 400 mA.

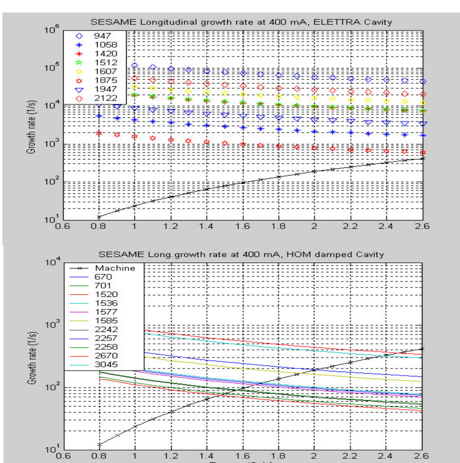

Figure12: Growth rate due to HOM's for ELETTRA type cavity (top) and EU HOM damped cavity (bottom). The continuous curve is the inverse of the synchrotron damping time.

The ELETTRA type cavities provide the possibility of temperature tuning for the HOM, which might be particularly effective since the short circumference results in the multi-bunch modes being widely spaced, but a very accurate design of the temperature HOM tuning system needs to be carried out.

The EU HOM damped cavity looks very attractive from the instability point of view, but other considerations needs to be done, including the economic aspect.

The choice of the RF cavity is still open, but it is our opinion that a feedback system might be needed for one or the other solution if we want to achieve the operating design current of 400 mA without deteriorating the quality of higher radiation harmonics from Undulators.

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