

PROGRESS REPORT OF SESAME PROJECT

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Abstract

This paper reports on the progress which has been made on the construction of SESAME. This concerns the results of the Microtron commissioning, the tests of the existing Booster subsystems, the update of the storage ring vacuum system and the 3D mechanical design of the magnets and vacuum chambers. The progress of the shielding wall construction will also be shown.

INTRODUCTION

SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East) is the first international 3rd generation synchrotron light source in the Middle East region, under construction in Jordan [1]. It will promote peace and understanding through scientific cooperation and bring new scientific fields to the region. As of January 2010, members of SESAME are Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine Authority, and Turkey. The injector of the facility consists of a 22.5 MeV Microtron and 800 MeV Booster, from BESSY I [2]. The 2.5 GeV main Storage Ring (SR) is completely new. The beam emittance is 26 nm.rad and 12 straight sections are available for Insertion Devices. The Phase I scientific program has been finalized and it foresees 7 beamlines from IR to hard X-rays.

MICROTRON STATUS

Last July 2009, the Microtron has been successfully commissioned at low energy (see Fig. 1.a). The beam was extracted from the first 8 orbits, with a maximum energy of 9.1 MeV according to our Microtron specifications. This intentional limitation was due to the delay in the construction of the final shielding while the Microtron was ready to be commissioned. A temporary ordinary concrete shielding wall of 0.5 m thickness and 3 m height has then been constructed (see Fig. 1.b). This was enough to protect the control room from direct radiations at low energy. In addition to the passive dosimeters and TLDs, two gamma and neutron monitors were used to measure the dose rate and accumulated dose. The monitors were connected to the Microtron control PLC in order to interlock the Microtron in case of high doses.

The reproducibility of the Microtron beam was verified and the behavior of the system was highly understood in the several commissioning sessions carried out. This gained experience is expected to make things easier in the full energy (22.5 MeV) commissioning which will start as soon as the final shielding wall construction is terminated. For better performance and more reliable operation in the future, the present Thyatron-based modulator of the Microtron will be replaced by solid state one. Moreover,

the old electronic circuits are intended to be replaced by modern and easy accessible ones.

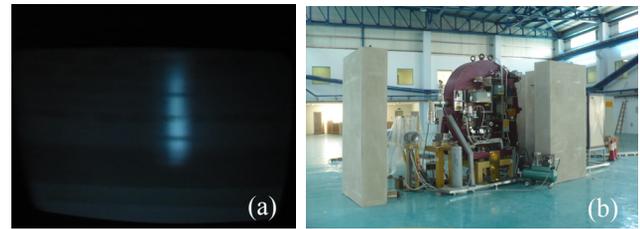


Figure 1: (a) The first beam from SESAME Microtron, (b) The temporary shielding wall around the Microtron.

BOOSTER STATUS

Booster Injection and Extraction Processes and Pulsed Magnet System Tests

The Microtron 22.5 MeV beam is injected into the Booster using an electrostatic septum. In order to maximize the injection efficiency a stainless steel septum sheet of 0.1 mm is used. In the injection process the closed orbit is moved horizontally towards the septum sheet using a 4 μ s-pulse kicker [3] placed in the opposite straight section. The kicker magnet has been designed to give a maximum displacement of 25 mm at the septum sheet. Fig. 2 shows the horizontal phase space for one particle injected at 27.5 mm and tracked for 60 turns.

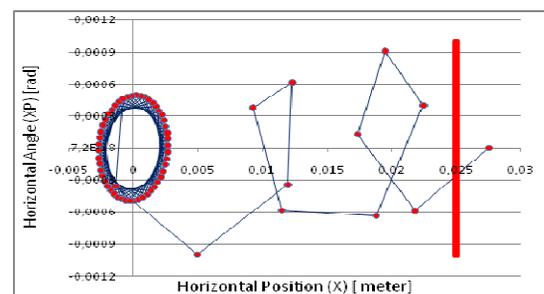


Figure 2: Phase space after tracking one particle for 60 turns at the injection point (septum sheet in red).

The in-vacuum injection septum is energized with a sinusoidal 500 μ s voltage pulse of 100 kV amplitude while the injection kicker is a one-turn current loop coil with a nominal current of 200 A [3]. The nominal values of both have been reached during the tests.

Three pulsed magnetic elements will be used to extract the 800 MeV electron beam from the Booster, the extraction slow bumper (170 A peak current /2.5 ms pulse duration), the extraction active septum (4000A/500 μ s) and the extraction kicker (25kV/190ns). The slow bumper, placed diametrically opposed to the extraction septum, will move the beam out close to the septum

before extraction. The kicker magnet is designed to produce a kick of 1.5 mrad. Its fast rise time of 40 ns is essential to obtain an efficient one-turn extraction from the Booster. The tests of the extraction system are finished also successfully to their nominal values (Fig 3).

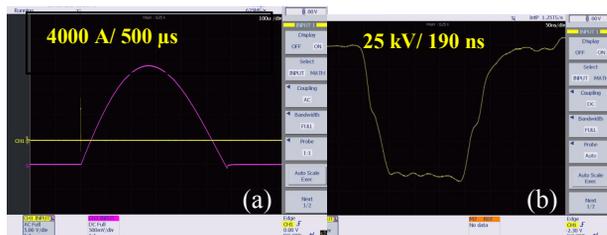


Figure 3: (a) Extraction septum magnet current waveform. (b) Extraction kicker magnet pulser waveform.

Booster Main Magnet Power Supplies

The repetition rate of the Booster is decreased from 10 Hz to 1 Hz. The old white circuits from BESSY I then can't be used and new ramping magnets power supplies are being manufactured by Bruker. The 12 dipole magnets power converter (see Fig. 4) is composed of 6 modules, connected in parallel, with 12 pulse rectification topology. Each module has the 4Q regulation in order to have good tracking even at low currents. During each cycle, an energy transfer occurs between the power converters and their magnets circuit. To avoid huge reactive power on the electrical mains, the DC-link capacitors with total capacity of 1 Farad are employed. For the quadrupoles (12 focusing quadrupoles and 6 defocusing ones), the power supply of each family is composed of a 12 pulse bridge rectifier and 4Q regulation with a DC-link capacitor in a small size compare to the dipole PS. The required stability of the output current is 100 ppm and the tracking between different families is better than 0.2%, [3]. The factory tests are scheduled early July 2010.



Figure 4: The dipole power converter under construction.

Booster RF System

SESAME Booster RF system consists of a 500 MHz DORIS type cavity, 2 kW solid-state transmitter, low level electronics and digital control system. Vacuum conditioning was done for the cavity and its plunger in SESAME RF lab in July 2009 by 1.7 kW CW RF power within 2 days with help of computer and in-house-developed program for automated conditioning. The complete Booster RF system has been set up in RF lab including new 2 kW solid state transmitter as replacement

for the old klystron which was used to feed the cavity at BESSY I. Therefore many of control/monitoring and interlocks had to be changed to satisfy requirements of the new configuration. A cPCI module with analog and digital I/Os has been adopted for this purpose and Graphical User Interface (GUI) has been prepared for better control/monitoring on Booster RF system, both locally and remotely through Ethernet connection. The complete Booster RF system has been tested and commissioned in the RF lab and is ready to be installed in its final location in the Booster area (see Fig 5).



Figure 5: Booster RF cavity under test.

Booster Vacuum and Hydraulic Tests

The hydraulic test of magnets conductors, headers and flow switches were carried out. A complete setup was designed and fabricated to check tightness of conductors and flow switches. As a result, all magnets conductors are tight up to continuous pressure of 7 bars and all existing flow switches are working according to name plate rate. Concerning the vacuum test, two procedures were adopted. First, the pressure test of vacuum chamber with helium leak detector was used in sniffer mode. The result of which, five dipole vacuum chambers have presented micro-leakages. These were repaired using a commercial cold welding named DEVICON. Second, in order to check the overall behavior of the chambers under high vacuum conditions, they were connected cell by cell surrounded by 2 valves. Two cells out of three gave a very good vacuum reading of $1.5 \cdot 10^{-8}$ mbar which is the required vacuum range for the Booster. The vacuum reading for the third cell was very low, in the atmosphere range, which indicates a high leak rate. The chambers of this cell have been dismantled and after investigation in the vacuum lab, holes of 1 to 3 cm in length were discovered in two dipole chambers. Up to now, the reason of the presence of such holes is unknown. These vacuum chambers are corrugated and have a thickness of 0.3 mm since the Booster at BESSY I was running at 10 Hz. Welding using silver, under Argon shield, has been applied and gave a good result. All the other chambers have been dismantled and investigated. They don't present any visible hole. Nevertheless, it is essential to understand the reason behind these holes before the Booster installation.

STORAGE RING STATUS

Vacuum System

The Storage Ring layout is divided into 16 arc chambers shown in Figure 6, 8 straight sections of 3.67 m long and 8 straight sections of 1.9 m long, to house the Insertion Devices (IDs). Some modifications have been brought to the layout. The number of the BPMs has been increased from 32 to 64 in order to have in addition to two BPMs surrounding each dipole magnet, 2 BPMs in each straight section (Fig. 6). The height of the vacuum chamber in the arcs has been decreased to 28 mm in order to increase the clearance between the chambers and magnet poles to 2 mm. Another important modification was reducing the number of valves and bellows in order to reduce the cost. We end up with 17 RF shielded valves and 24 RF shielded bellows. The arc and straight section vacuum chambers are ready for call for tender.

All chambers will be made up 3 mm stainless steel sheets (316 LN). The dipole vessel will have one port at 0° for IDs beamlines and another at 6.5° for dipole beamlines. The longitudinal welds will use e-beam while the transverse joints will be TIG welded. Flat seal flanges will be used for connecting the dipole chambers within the arc section. This will allow machining of the flange faces after the welding for last tolerances and has an advantage of low impedance between flanges. Locations and speed of pumps were optimized for maximum efficiency using home written program. The total pumping speed 23600 l/s is used to achieve an average pressure of $1 \cdot 10^{-9}$ mbar required for beam lifetime of 16 hours.

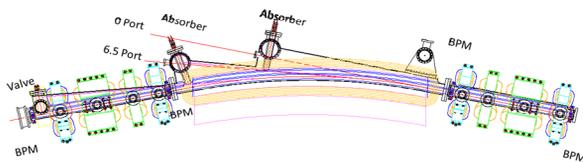


Figure 6: One Storage Ring arc chamber assembly.

Storage Ring Mechanical Subsystem Design

The mechanical design of the SR subsystems is in a good advanced status. The detailed engineering design including the cooling and electrical connections of the sextupoles and quadrupoles has been finalized. The example of the sextupole can be shown in Figure 7 (a). The stress and deformation analysis has been performed for the SR vacuum chambers. A 3D model of the arc vacuum chamber can be seen in Fig. 7 (b). The maximum deformation value is less than 0.5 mm and it is due to the vacuum and the self weight loads. For the case of the sextupole, a local machining will be applied on the chamber to reach the clearance of 2 mm as everywhere else. Using extension supports, the vacuum pumps will be rigidly fixed to the girders. The dipole radiation will be absorbed by five lumped absorbers which will cover a radiation fan of 22.5° . The same crotch absorber of SLS

will be used. The second absorber will intercept the maximum power load of 6.6 kW. Finite Element Analysis has been performed to simulate the absorber performance under the high heat load. The maximum temperature was found to be around 220°C on the absorber tip and the maximum cooling water temperature was 79°C using OFHC copper. The elastic strain value was found to be 0.13% which assures a minimum cyclic life of 10^4 thermal cycles.

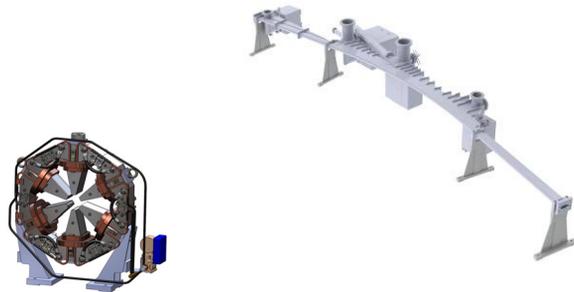


Figure 7: (a) 3D model SR sextupole. (b) 3D model SR arc vacuum chamber.

RADIATION SHIELDING WALL

The shielding wall construction has been started first of April 2010 and is expected to take six months to be finished. At this moment, about 20% of the construction has been completed (see Fig. 8).

Determination of the shielding wall thickness in each area took into account to reduce the one-year cumulated dose (2000 working hours) outside the shielding wall to less than 1 mSv or the dose rate to around $0.5\mu\text{Sv/h}$.



Figure 8: Current radiation shielding wall construction.

CONCLUSION

The Microtron has been successfully commissioned with beam at low energy. All the existing Booster subsystems have been tested and new Booster magnets power supplies are being manufactured. The shielding wall is under construction. The design of the Storage Ring equipment is finalised and technical specifications are ready for call for tender.

REFERENCES

- [1] SESAME website: "www.sesame.org.jo".
- [2] SESAME Green Book, October 1999.
- [3] S. Varnasseri, A. Nadji, Proceedings of PAC09.