

## THE SESAME PROJECT

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### Abstract

SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East) is a third-generation synchrotron light source under construction near Amman (Jordan), which is expected to become operational in 2015. SESAME will foster scientific and technological excellence in the Middle East and the Mediterranean region, build scientific bridges between neighbouring countries, and foster mutual understanding through international co-operation. The current members of SESAME are Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. An overview about the progress of the facility and the general plan will be given in this paper. We will then focus on the control system by explaining how this aspect is managed: the technical choices, the principal deadlines, the local staff, the international virtual control team, and the first results.

### INTRODUCTION

Developed under the auspices of UNESCO and modelled on CERN, SESAME (Synchrotron-light for Experimental Science & Applications in the Middle East) is an international research centre under construction in Jordan [1].

It will enable world-class research by scientists from across the Middle East/Mediterranean region (in subjects ranging from biology and medical sciences through materials and environmental science and physics to archaeology), preventing or reversing the brain drain. It will also build bridges between diverse societies, contributing to a culture of peace through international cooperation in science. It will help foster closer links between people with different traditions, political systems and beliefs. The centrepiece of SESAME is a new 2.5 GeV third-generation light source which will provide very intense light from infra-red to hard X-rays for a wide range of studies. The microtron and the booster constituting the injector section were originally used at the former BESSY I synchrotron but have been greatly upgraded and refurbished. The energy of the microtron is 22.5 MeV whilst the electrons will be accelerated to 800 MeV in the booster. The storage ring will have an emittance of 26 nm.rad and 12 straight sections are available for insertion devices. The phase I scientific program has been finalized and foresees 7 beamlines

providing wavelengths from infra-red to hard X-rays. The project is governed by a SESAME Council currently having nine members (Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority, and Turkey), whilst France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russia, Sweden, Switzerland, the UK, and the USA are observers. The project is benefitting enormously from help and advice provided by various synchrotron laboratories around the world (SOLEIL in France, ALBA in Spain, ELETTRA in Italy, the Swiss Light Source, Diamond in the UK and the Canadian Light Source). The capital funding needed to complete the construction of SESAME is being sought from the members and from various external sources.

Recent progress has included a growth in the number of technical and scientific staff to about 25 people [1]. The radiation shielding wall was completed in April 2011. Extraction of the first beam from the microtron has now been achieved at low energy (10 MeV) [2].

The current progress concerns tests of the booster equipment; the booster will shortly be installed in the tunnel, and preparation is under way for commissioning the booster with beam. In addition all the storage ring equipment has been designed, and the call for tenders is waiting for funding [2].



Figure 1: SESAME radiation shielding wall.

### A SPECIAL PROJECT

SESAME is a wonderful project for the idea it conveys, but is very challenging because the budget is not secured in its entirety and arrives in small portions. The technical team is young and inexperienced in accelerator design and construction. The local industry also does not have direct experience in supporting such a project. As a result, the technical management of such a project cannot be conducted in a conventional way. The project leader must have a lot of imagination in order to overcome these challenges.

Thanks mainly to the International Atomic Energy Agency (IAEA) but also to other institutions [1], a programme of training has been underway since 2000. Most members of the SESAME team have spent several months in one of the world's synchrotron radiation facilities and learned about several areas of synchrotron light source construction and operation. Experts from these laboratories have also visited SESAME and this has had a positive impact on the local team. In the case of the control system, a virtual international group has been created.

This has all helped to achieve some important milestones such as the successful commissioning with beam at low energy of the microtron, testing of all of the booster subsystems (RF, vacuum, and cooling systems, diagnostics, and so on), and providing new booster power supplies and new booster dipole vacuum chambers after an international call for tenders. Good news is foreseen concerning the budget. Commitments and offers announced and confirmed by Members in May 2011 look set to provide most of the remaining \$35 million needed for the storage ring and the three beamlines that will be in operation from day 1.

## TEAM BUILDING

### *The International Control System Virtual Team*

The recruitment of the control system group and its management was particularly difficult. The potential candidates are young and unfamiliar with accelerator control. There is also a limited budget which prevents the hiring of a significant number of staff or the outsourcing of work to specialized companies. SESAME has found very good candidates who have electronics or software skills, but who are new to accelerator or light source control systems. Each newly-hired engineer has therefore been trained in one of the following laboratories: SOLEIL, SLS, CLS, and/or DLS; and coached in order to be operational as soon as possible. Although SESAME, in common with other light sources, has advisory committees which meet once or twice a year, a need for senior experts who can follow the work more closely was essential.

At the end of 2010, the SESAME project leader decided to set up an international "virtual" control system group. This group is composed of experts and managers in the field of accelerator control from the Canadian Light Source (CLS), Diamond Light Source (DLS), the Institute of Research into the Fundamental Laws of the Universe (IRFU) of the CEA, Synchrotron SOLEIL, the Swiss Light Source (SLS), and of course from SESAME itself. The idea is to have close coaching of the SESAME control system team.

### *A Cross-Over Management*

Inside the virtual group management task and responsibilities are defined for better efficiency. The coordination of the virtual group is handled by Pascale Betinelli from SOLEIL. The main reason for this choice

is to make the contact between SESAME and the virtual group easier; the part time Technical Director of SESAME (until the end of this year) is the current Director of SOLEIL Sources and Accelerators Division. Moreover Mark Heron, the DLS member of the virtual control group, is present on the Technical Advisory Committee (TAC) of SESAME and on the Computing Advisory Committee (CAC) of SOLEIL. Whilst each local engineer is in charge of a part of the control system, each expert member is responsible for following that part closely and teaching the local engineer particular technical aspects of control.



Figure 2: Members of the SESAME International "Virtual" Control System group.

### *Recruitment*

The coaching starts with recruitment: the members of the virtual group guide SESAME's leaders by finding the right technical skills in the CVs. SESAME's leaders then conduct each job interview and select the person who fits with the technical requirements and the motivation of the project. Today the local control system team is composed of three engineers: Saed Abu Ghannam from Palestine, Ibrahim Saleh from Jordan, Zia-ul-Haque Qazi from Pakistan.

### *Training*

Each engineer had good electronics or software skills but needed to be trained on accelerator control systems. First they went around the world to learn the basics of instrumentation and control: EPICS, VME and Timing System. Saed Abu Ghannam spent one month at CLS, attended the PCaPAC 2010 workshop then spent two months at SLS, one week at SOLEIL and visited IRFU. He was trained in EPICS and discovered the different aspects of a synchrotron radiation facility. Similarly, Ibrahim Saleh has been invited to ICALEPCS 2011 as a member from an industrially emerging nation and will take this opportunity to spend a few weeks at DLS to learn EPICS and interlocks, and at SOLEIL, where he will stay two weeks working on PLC aspects and the installation process. The third member of the SESAME control system group, Zia-ul-Haque Qazi, should soon undertake similar training.

### Coaching

Day by day the virtual group guides the control team in the development process. They explain each step to them, providing examples and a work plan. To help the local team, the virtual group has provided a list so that they can easily find who to contact for each type of problem or for advice. On a regular basis the virtual group organizes video conference meetings with all the members, in order to validate technical choices or to review sub-projects such as power supply control, vacuum control, etc. The local engineer who is in charge of a particular task prepare the work with the person responsible for SESAME subsystems and then discuss it with the virtual group in a dedicated video conference meeting. The requirements and the control architecture are then discussed during the review.

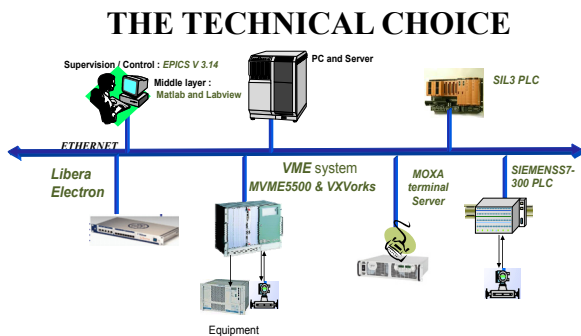


Figure 3: Control Architecture.

SESAME needs to have the most up-to-date control possible, but in doing so needs to consider how the solutions will be supported. It is therefore very important to select items corresponding to the skills of the virtual group. Sometimes SESAME has the chance to receive gifts from the international community. These generous gifts help us to reduce costs but involve some difficult upgrades due to the age of the equipment given or to technology changes. The analysis of the feasibility of integrating old technologies is a process that requires time and special skills

All the time we have to make a compromise between up-to-date technology and pragmatism.

As a result of following these guidelines, the main technical choices are very conventional and tested: EPICS and VME have become established. Figure 3 shows a schematic view of the main architecture.

### VME System

We have selected EPICS 3.14 in order to benefit from the latest improvements. For VME systems, we first analyzed the feasibility of integrating old VME 2304 CPUs. Finally we selected the boards currently used at SLS, DLS, and IRFU, namely MVME5500 from Emerson and I/O boards from Hytec Electronics. We would have liked to use the very latest EMERSON CPU technology but during the startup period we cannot accommodate the work load of adopting this new technology. On the VxWorks kernel side, we have chosen

to implement version 6.9. This allows us to take advantage of the know-how of IRFU, which is in charge of building the appropriate control system environment (VxWorks kernel with required functionalities, EPICS3.14 base, extensions and development framework).

Because VME technology is expensive and complex to implement and maintain, the international experts encourage the use of stand-alone PLC and Ethernet modules as far as possible.

### PLC Systems

SIEMENS PLCs are the de facto standard as SESAME has experience in this field. The local team has already upgraded the control of the Microtron with a CPU312. Furthermore, SOLEIL and DLS have experience with this type of PLC system.

In most cases the machine protection systems will be connected to the PLC from different subsystems (vacuum, cooling, etc.). Part of the power supply and vacuum control will be performed by PLC. In accordance with the SOLEIL specification method, an order has already been placed with SIEMENS' Jordanian supplier. In October SESAME will start to implement booster development with the help of SOLEIL.

### Ethernet Standalone Equipment

Serial links are communication interfaces that will have to be managed in large numbers. To reduce cost we have selected a MOXA terminal server with the first items ordered from a local supplier in Dubai. The terminal server was received and an implementation for the corrector power supply of TL1 has already been done. Thanks to the training already received, the implementation required very little help. Figure 4 shows the first EDM interface for the corrector power supply.

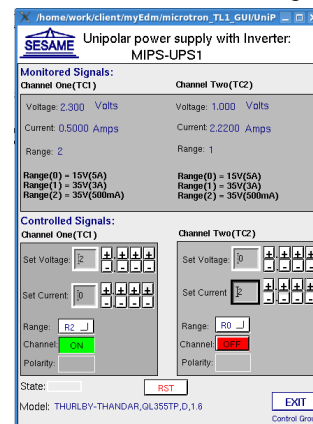


Figure 4: EDM interface for corrector power supply.

The control of diagnostics is supervised by CLS, which has provided a template and advice. Many diagnostics devices come from BESSY I. The three fluorescent screens available around the Booster have been refurbished and the cameras have been replaced by a low-cost Ethernet camera. Current measurement performed by a cavity is still under discussion to understand the

appropriate control mechanism. Whilst there was no tune measurement in the old BESSY I Booster, it is planned to have such a system at SESAME. The BPM read-out electronics is performed by I-Tech Libera Electron modules. SESAME has already received seven Libera Electron modules to be used in its booster ring. A SESAME engineer is in charge of the implementation of the embedded process. Presently EPICS IOC (from DLS) has been installed in one of these modules and the module and driver performance is being analyzed. Performance analysis is being carried out with a 500 MHz signal provided to the Libera Electron inputs through a clock splitter. However the available EPICS IOC is incompatible with latest version of Libera Electron and there is a need for modifications which are currently under way. On the other hand, GUIs have also been obtained from DLS to receive and view information from Libera Electron modules, and these are being used for the performance analysis of the EPICS driver.

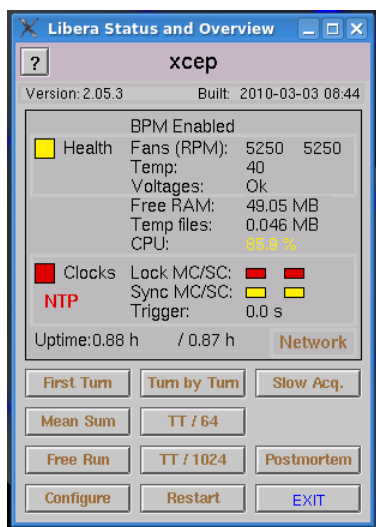


Figure 5: Main GUI for Libera Electron.

Figure 5 shows the main screen from the GUIs for Libera Electron. It shows the health status, the clock status, controls to obtain various types of data from Libera modules such as First Turn, Turn by Turn, etc., as well as controls for Configuration and Restart. Once the performance of EPICS IOC and GUIs is finalized, they will need to be customized by SESAME according to its naming convention.

## Booster Timing System

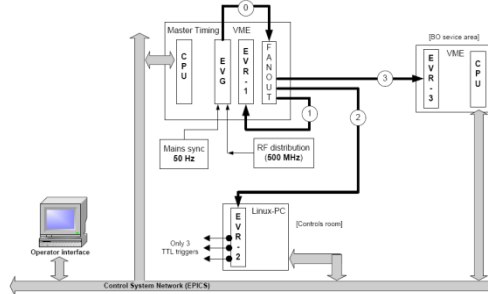


Figure 6: Booster timing system.

SESAME's booster timing system is based on the global event system, widely used in many light source facilities such as APS, SLS, DLS and others. The booster timing system has been designed and developed by SLS, and all the hardware used is from Micro-research Finland. In the SESAME booster timing system, one event generator and three event receivers will be used in order to provide and distribute all the event sequences to operate the booster. Figure 6 shows a schematic of the booster timing system. It will be delivered to the SESAME site at the end of November to be tested before its deployment.

## End User Development Environment

The main development environments used are Labview and Matlab. These two software packages are easily interfaced to the EPICS framework and offer a suitable end-user environment. Matlab middle layer physics applications [3] will be used as commissioning tools to and for a few high level control applications from the transfer line to storage ring as in similar facilities. With Labview we can directly integrate the prototype of the Booster RF control, which has already been completed using a PCI system. In a second step we will upgrade this prototype to run on a VME platform to provide consistency with the rest of the control system.

## Network and Server

In SESAME, the control servers are based on virtual machines running Scientific Linux. We currently have around 15 powerful virtual machines. Those machines will be used in making EPICS servers, development consoles, file systems and others.

## HOW TO SET UP THE RELATIONSHIP WITH MANUFACTURERS AND SUPPLIERS

Industry in the Middle East has very little experience of Synchrotron light sources. There is also a limited presence of the big companies involved in control systems, and those which are present are reluctant to get involved. From this low point, SESAME has to educate and develop relations with potential suppliers.

International support is again essential: Day by day, through discussion after discussion, companies will come

to understand the approach and objectives. Conversely, SESAME engineers must understand and adjust to the ways in which western companies and people think and work. Once mutual understanding has been established, companies are often willing to help and support the SESAME project. For instance Windriver has offered to let SESAME join their research program.

## HOW TO SET UP THE INSTALLATION PROCESS

SESAME engineers have no experience of the requirements and the complexity that they will face during installation. Like all people in similar positions, they need time to understand the necessity for and the strategic requirements of aspects such as a naming convention and a cabling database, and the need to do some tasks in advance. To tell them is not always enough: they need to acquire experience in order to appreciate every detail of the virtual team's advice. Many short discussions are necessary to compensate for the drawbacks of having a virtual team: E-mail and documents are not enough; direct contact is very important to solve problems.

Today, reviews have already been conducted for the power supply, vacuum and diagnostics areas.

## OUTCOME AND FUTURE

We should always keep in mind that SESAME is not a standard project and the context and the issues are complex. In 2009 the TAC was worried about the state of the control system. This year, after just one short year of existence of the control system virtual group and the recruitment of local engineers, control system development is going ahead at SESAME. We hope to assemble most of the booster control system by the end of the year. Some control parts like the pulsed magnet control are still critical because of the age of the equipment but we are confident that we can solve the problems.

Unfortunately we note that planning has to be flexible to handle this complex project. The booster assembly will be a true test to demonstrate to the international community the legality and viability of SESAME.

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