SESAME

SYNCHROTRON LIGHT FOR **E**XPERIMENTAL **S**CIENCE AND **A**PPLICATIONS IN THE **M**IDDLE **E**AST

SESAME

An international centre for research and advanced technology under the auspices of UNESCO

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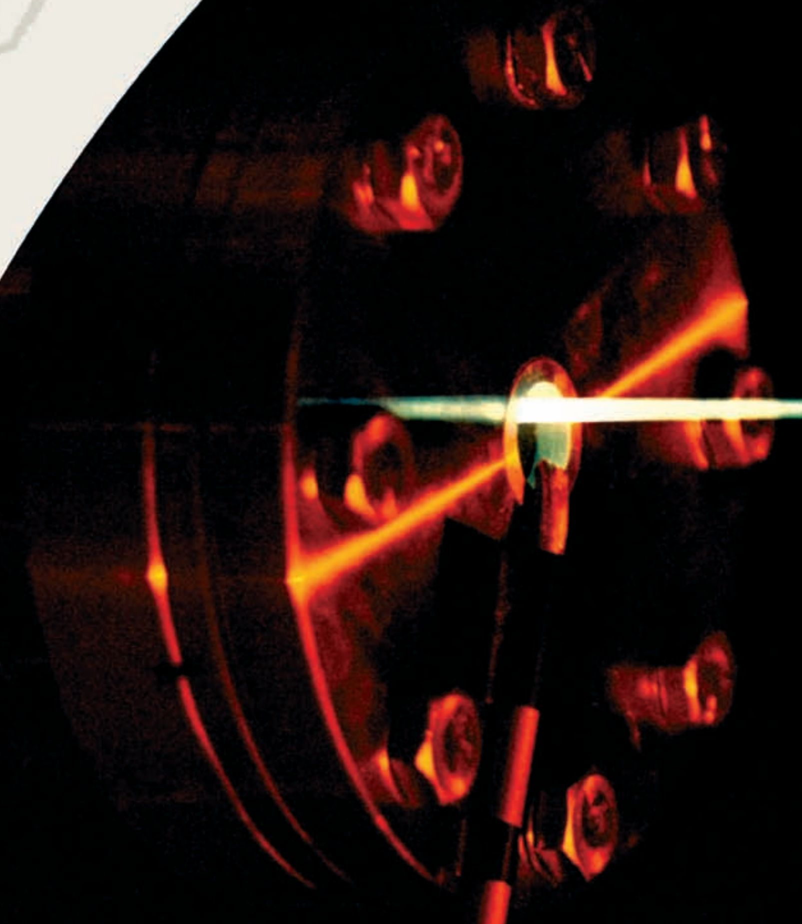


Photo:Royal photographer, Jordan

At the groundbreaking ceremony for SESAME at Al-Balqa' Applied University (Jordan) on 6 January 2003, the then Director-General of UNESCO, Koïchiro Matsuura, unveils the commemorative plaque together with HM King Abdullah II of Jordan, who has just laid the cornerstone for the future SESAME building.

AN INTERNATIONAL CENTRE FOR RESEARCH AND ADVANCED TECHNOLOGY under the auspices of UNESCO

Irina Bokova,

Director-General of UNESCO

From the outset, UNESCO has been a crucial player in establishing SESAME, thanks to the commitment of my predecessors, Federico Mayor and Koïchiro Matsuura. It is now my honour and responsibility to bring what they have established to fruition, so that the Middle East and neighbouring countries may have a centre of excellence through which they may build their capacity and excellence in science, promote fundamental research and the application of its fruits, and foster solidarity and a culture of peace.

Over the coming years, UNESCO will encourage the participation of Member countries in SESAME and help the Centre develop the outreach of its activity through UNESCO's International Basic Sciences Programme (IBSP). At the same time, it will count on SESAME to be one of its major partners in science, in common with the European Organization for Nuclear Research (CERN), the Abdus Salam International Centre for Theoretical Physics (ICTP) and the International Centre for Genetic Engineering and Biotechnology (ICGEB).

Moreover, UNESCO will promote the activity of SESAME as an instrument to empower countries to enhance their basic and applied scientific knowledge, harness science and technology for sustainable development and construct the defences of peace in the minds of people through cooperation in the sciences, education and intercultural dialogue. In view of the unique opportunities offered by SESAME for cooperation in the region, UNESCO calls on the international community for solidarity and joint actions with the Centre.

Chris Llewellyn Smith,

President, SESAME Council

The SESAME project aims to foster outstanding science and technology in the Middle East and neighbouring countries and it is doing this with steadfast support from UNESCO. It will build scientific and technical capacity and facilitate collaboration between the region's scientists and engineers.

My role as President of the Council is to help ensure that SESAME becomes a world-class laboratory which will attract scientists working in fields ranging from archaeology through biology, chemistry and physics to medicine. Collaboration at SESAME involving leading scientists from across the region is expected to produce first-class science and raise scientific standards. SESAME will stimulate local industry, and produce results of importance for local agriculture and the environment.

An extensive training programme, involving schools, meetings and fellowships, is already building the technical and scientific capacity needed to construct and then use SESAME. This programme, which has an annual value approaching US$1 million, is largely funded by outside bodies. These include the International Atomic Energy Agency (IAEA) and many of the world's leading synchrotron radiation laboratories, demonstrating their support for - and confidence in - the project.

SESAME will foster closer links between peoples with different traditions, political systems and beliefs, in a region where better mutual understanding is much needed. Some were initially sceptical that a project such as SESAME could succeed. But the growth of collaborations between scientists from across the region who are preparing to work at SESAME, and the excellent technical progress that has been made, have proved them wrong.

SEEING BETTER WITH SYNCHROTRON LIGHT

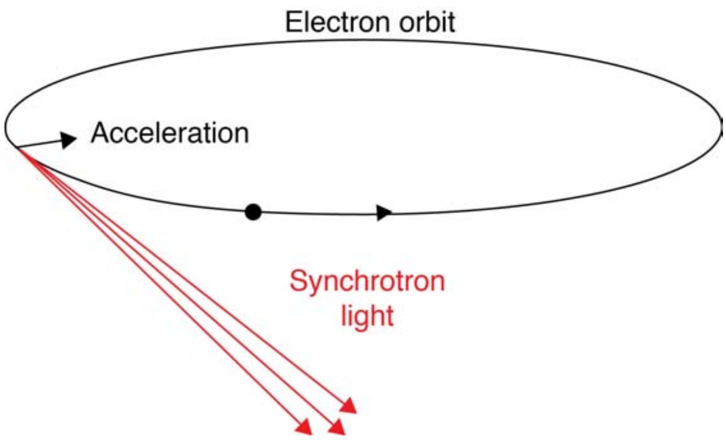
As in everyday life, in advanced scientific research we learn by 'seeing' things using light – except that scientists use light that ranges beyond the visible, in the infrared and the ultraviolet, to X-rays and beyond. Advanced sources of light (like lasers and synchrotrons) have become prime factors in promoting scientific and technological progress. In recent decades, the extraordinary power of synchrotron light has made it an essential tool for studying matter on scales ranging from biological cells to atoms, using radiation from the infrared to X-rays. It has had an immense impact in fields that include archaeology, biology, chemistry, environmental science, geology, medicine and physics.

Synchrotron light sources were initially built exclusively in the developed world. Owing to their wide impact across the scientific spectrum with quite often 'near-market' benefits, many of the rapidly emerging economies, including Brazil, India, Republic of Korea, Singapore, Taiwan and Thailand have built their own sources. There are now more than 60 synchrotron light sources in operation in 19 countries serving some 30,000 scientists. More are under construction or in various stages of planning. Even taking into account the new sources under development, the rapid growth of the user community and ever-increasing range of applications will outpace the available supply of synchrotron light for the foreseeable future.

How is synchrotron radiation produced?

In a synchrotron, bunches of charged particles – electrons – circulate at nearly the speed of light for several hours inside a long ring-shaped tube under vacuum. As magnets surrounding the tube bend their trajectories, the electrons emit 'synchrotron light', with wavelengths that range from infrared radiation to X-rays. The emitted light is collected by different 'beamlines' (optical systems) connected to the ring; thus, many experiments can be run simultaneously.

- When electrons are accelerated (e.g. in a radio transmitter antenna), part of the energy in the electromagnetic force field that surrounds them is 'shaken off' and emitted as electromagnetic radiation (e.g. radio waves).
- As their trajectories are deflected, electrons in circular motion in a synchrotron also undergo acceleration, directed towards the centre of the circle, and emit radiation.



The electromagnetic field surrounding the electrons is unable to respond instantaneously when the electrons are deflected; some of the energy in the field keeps going, producing a tangential cone of synchrotron radiation. As the electrons' energy increases, the cone of radiation narrows, and the radiated power goes up dramatically.

Nobel Prizes based on discoveries through X-ray work

Since 1901, work that used X-rays has led to 20 Nobel Prizes, in Physics, Chemistry, and Physiology and Medicine. The latest four, in Chemistry, which all used synchrotron radiation, were awarded to Paul D. Boyer and John E. Walker (1997), Peter Agre and Roderick Mackinnon (2003), Roger Kornberg (2006), and Venkatrim Ramakrishnan, Thomas Steitz and Ada Yonath (2009).

In a joint declaration in June 2008, 45 Nobel laureates from physics, chemistry, medicine, economics, literature, and peace declared that "SESAME, as well as producing educational and economic benefits, will serve as a beacon, demonstrating how shared scientific initiatives can help light the way towards peace". SESAME has also been endorsed by the Executive Board of UNESCO (May 2002), the International Union of Pure and Applied Physics (IUPAP - October 2008), the US Liaison Committee of IUPAP (June 2009), and the International Union of Biochemistry and Molecular Biology (IUBMB - September 2009).

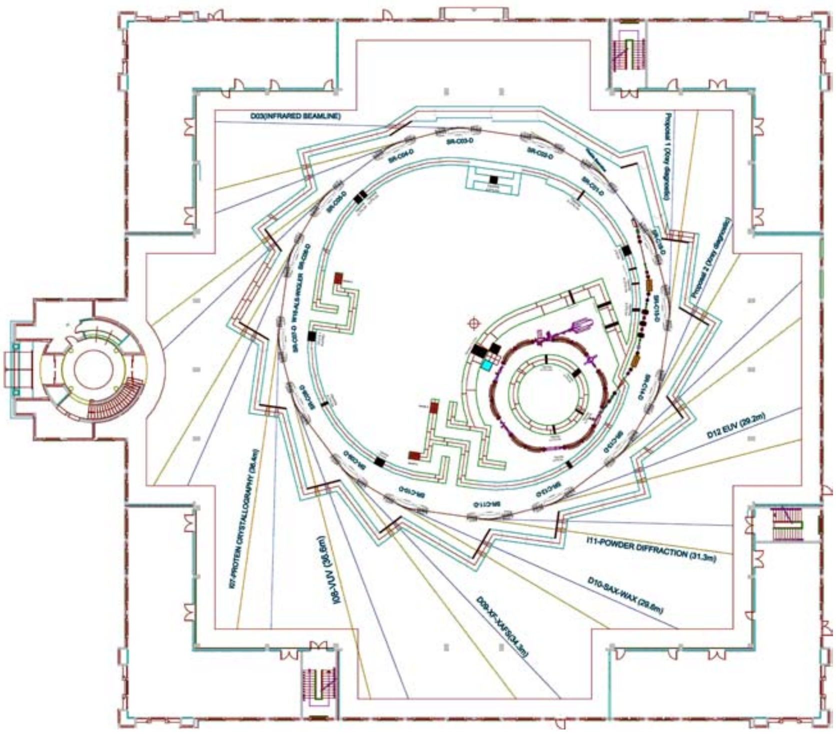
THE SESAME SYNCHROTRON LIGHT SOURCE

The decision to build SESAME, which is destined to become a major centre of excellence, was triggered by the gift from Germany of the 0.8 GeV BESSY I storage ring and its injector, which consist of a 22 MeV microtron and an 0.8 GeV booster synchrotron. The refurbished microtron has been installed at SESAME, and successfully produced an electron beam on 14 July 2009. The booster synchrotron is currently being upgraded and installed. To meet the users' demands, a completely new 2.5 GeV storage ring with a circumference of 133 m and an emittance of 26 nmrad has been designed by the SESAME staff. This compact ring provides twelve straight sections for wiggler and undulator insertion devices, which will produce highly collimated and intense beams of synchrotron light, a feature which puts SESAME in the class of modern 'third generation' intermediate-energy storage rings.

The SESAME building at Allan (Jordan), some 35 km northwest of Amman, where installation of the accelerator complex has begun. Financed by Jordan, the building has been designed by civil engineers from Al-Balqa' Applied University. It was officially inaugurated on 3 November 2008.

SESAME is expected to begin operations in 2014/15. Seven beamlines are envisaged in Phase I, with three available at the start-up of the new ring. Complete beamlines from decommissioned synchrotrons at Daresbury (UK) and LURE (Laboratoire pour l'Utilisation du Rayonnement Electromagnétique - France) have been donated, as has additional equipment from laboratories in Switzerland and the USA. Some of the Phase I beamlines will make use of this donated equipment and some will be newly built by teams from the region. In the longer-term, up to 18 further beamlines can be added.

The microtron in the SESAME experimental hall. The first electron beam was produced on 14 July 2009.



SESAME 'Beamline Clock' showing the location of the seven Phase I beamlines on the storage ring.

SESAME USERS

The users of SESAME will mostly be based in universities and research institutes in the Middle East and neighbouring region. They will visit the laboratory periodically to carry out experiments, often in collaboration with scientists from other countries, where they will be exposed to the highest scientific standards in a stimulating environment for international collaboration. SESAME's well-equipped beamlines, experimental end stations, laboratories, and other support facilities will be available to users, and a highly trained scientific, technical and administrative staff will ensure that both experienced and inexperienced users of the Centre are successful in their experiments.

Several hundred scientists, working in disciplines ranging from the biological and medical sciences to archaeology, are expected to use SESAME from day-one. This will make SESAME a unique multidisciplinary centre in the region. As more beamlines are built, the number of users is expected to grow to 1000 or more.

Advanced training, another string to SESAME's bow

SESAME will make important contributions to building scientific and technological capacity in the Middle East and neighbouring region. Experienced scientists will be encouraged to remain in, or return to, their 'home' region to pursue their research interests at SESAME and graduate students and young researchers will no longer have to go abroad for advanced training.

The process of training scientists and engineers from the region in the uses of synchrotron radiation and the relevant accelerator technology is well under way. During the last decade, more than 400 scientists and engineers participated in seventeen SESAME workshops and schools in the Middle East and elsewhere on applications in biology, materials science and other fields, as well as on accelerator technology.

Approximately 65 of these men and women have spent periods of up to two years working at synchrotron radiation facilities in Europe, the USA, Asia and Latin America. The majority of these facilities are situated in countries that are Observers to the SESAME Council. This has given scientists from the SESAME Members the opportunity to use existing light sources while SESAME is under construction, thereby providing them with first-hand experience and further swelling the ranks of Middle Eastern scientists with experience in using synchrotron radiation sources. European, American and Japanese centres are also contributing valuable assistance and advice in designing, constructing and utilizing SESAME. This training programme has been made possible thanks to generous support from various organizations (in particularly IAEA), national agencies (such as the US Department of Energy), professional scientific societies, synchrotron laboratories and small charities.

A research centre modelled on CERN

A CERN-inspired international laboratory, SESAME is much more than an advanced scientific facility. Past experience of national and multi-national synchrotron light centres in different parts of the world, and other laboratories that house accelerators such as CERN, shows the substantial and practical benefits for the host region:

- The region's best scientists and technologists are motivated to stay in the region or return if they have emigrated;
- The members' brightest young talent is attracted to scientific higher education and thus contributes to the development of a knowledge-based economy;
- By stimulating the regional economy, synchrotron centres create jobs well beyond those of the centres' own staff. They create business for local and regional operators in the areas of travel, accommodation, restaurants, logistics and technical support needs;
- Frequently, enterprises involved in research and development acquire additional know-how, thus enhancing their competitiveness and scope;
- New synchrotron-based technologies like structural genomics, materials science and microanalysis can lead to spin-off enterprises;
- Scientists from the region can use synchrotron radiation to address important societal problems, including local biomedical and environmental issues and concerns;
- Mutual understanding between people from different traditions, religions, races and political systems is fostered.

NEW OPPORTUNITIES

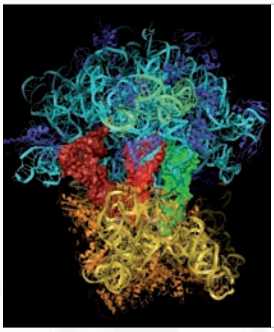
Chemistry | Biological / Medical sciences | Materials Science

SESAME beamlines that will be ready in the first phase of operation (protein crystallography, X-ray absorption fine structure/X-ray fluorescence spectroscopy, infrared spectromicroscopy, powder diffraction, small- and wide-angle X-ray scattering, extreme ultraviolet spectroscopy, and soft X-Ray spectroscopy) have been selected on the basis of requests from scientists in the region. The following examples of applications based on techniques offered by these beamlines demonstrate their effective use at other synchrotron sources around the world.

Exploring biological structures

Intense synchrotron light is a unique source for detailed studies of biological systems at scales from molecules up to the level of organs. Several techniques, including macromolecular crystallography, infrared spectromicroscopy and imaging are being used to study biological functions and disorders that occur under disease conditions.

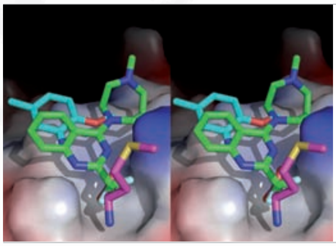
Thanks to synchrotron-based X-ray protein crystallography, the positions of thousands of atoms in huge biological molecules can be located and structures of extremely large and complex molecules, such as the ribosome, can be determined. Knowledge of structures has far-reaching implications, including for healthcare: it helps to speed up, and reduce the cost of, searches for new drugs, and to increase the effectiveness of those already on the market.



Latest Nobel prize for Synchrotron Radiation work

The 2009 Nobel prize for Chemistry was awarded to three crystallographers (V. Ramakrishnan, T. Steitz and A. Yonath) for studies of the structure and function of the ribosome - the cell's protein factory - in which synchrotron light played an essential role. Ribosomes use the genetic code to make proteins - which are the building blocks of all living organisms.

The ribosome structure consists of a large subunit and a small subunit whose structure (left) is shown in ribbon representation. It is composed of ribosomal RNA (light blue, light green and yellow) and about 20 different proteins (the remaining colours). Analysis of the structure of a subunit provides insights into how ribosomes synthesize proteins and how drugs like antibiotics selectively kill bacteria but not human cells.

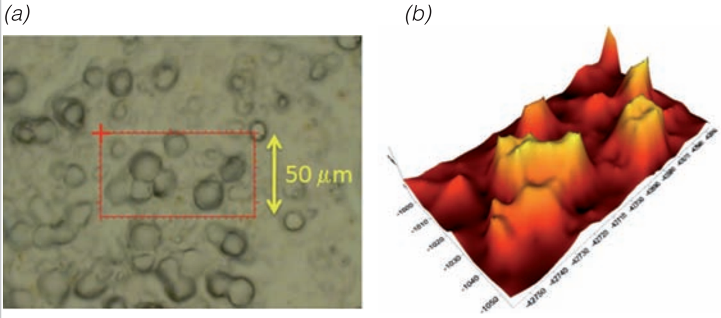


Structural Biology is used for designing drugs

A significant proportion of cases of motor neuron disease are caused by mutations in the essential enzyme superoxide dismutase (SOD). Protein crystallography has helped to understand the mechanism of the disease and is now being used to discover ('druggable') sites in SOD and help design promising drug compounds. The stereo images (left) show three small molecules bound in the same druggable site. [Images courtesy of S.S. Hasnain; Antonyuk, S. et al., J. Med. Chem. 53(3): 1402-6 (2010)]

Infrared (IR) spectroscopy is another area that has benefited tremendously from the availability of synchrotron sources. Fourier transform IR (FTIR) microspectroscopy helps to develop maps of the chemical composition of healthy and diseased tissues and provides insights into mechanisms of disease development.

(a) *(b)*



Infrared imaging of liver disease

Fatty liver (steatosis) is a frequent pathological condition that may progress to cirrhosis, and in some cases to hepatocellular carcinoma (a primary malignant cancer of the liver). Sections of fatty liver often display vesicles (sacs) as shown in the microscope image (a). High resolution FTIR infrared spectra obtained using a synchrotron beam show the presence of different species of lipids (groups of molecules which include fat) inside and outside the vesicles. The 3D chemical image in (b), which corresponds to the area inside the red rectangle in (a), demonstrates selective accumulation of specific lipids inside the vesicles (peaks) and provides clues about how the condition arises. [Images courtesy of P. Dumas; Le Naour, F. et al., Inserm U602 Villejuif, and SOLEIL synchrotron, France]

Materials science

Materials science has seen dramatic growth with the advent of advanced manufacturing methods and the ability to probe the structures of these materials while they are being made. Synchrotron sources provide several techniques at micron resolution for noninvasive analyses of engineered materials.

Ancient pigment technology revealed by synchrotron X-rays

Techniques originally developed for materials science have recently been used in archaeology with remarkable results. This is due mainly to the high intensity and tunability of X-rays from a synchrotron source.

The pictures show opaque coloured glass of the 18th Egyptian dynasty in the Louvre Museum. On the left, small amphorae [inventory number AF2622; © C2RMF/D. Bagault], on the right, broken pieces of glass [inventory numbers: AF12707 and AF13175; © C2RMF/D. Vigears]. Recent studies combining X-ray absorption spectroscopy, diffraction and electron microscopy showed that the Egyptians developed a new technology for obtaining opaque glass. This work necessitates reassessment not only of studies of ancient Egyptian glass, but more generally of studies of high-temperature technologies used throughout antiquity. [Lahlil, S. et al., Appl. Phys A, 98:1 (2010)]

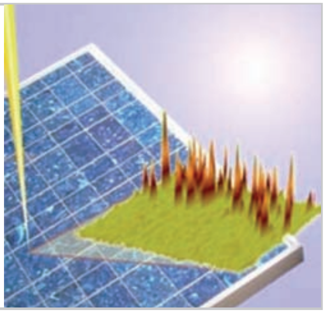
Energy

Diminishing fossil-fuel reserves and environmental concerns are leading to intensified research on alternative methods of energy production. Synchrotron sources offer tools for understanding the electronic and atomic structure of materials that are needed for producing environment-friendly and renewable energy.

Sun to Electricity

Scientists use synchrotron-based techniques (X-ray-beam-induced-current techniques combined with fluorescence and absorption spectroscopy) to improve the properties of multicrystalline photovoltaic solar cells. They discovered that instead of trying to remove transition metal impurities, that degrade efficiency, these can be manipulated in a way ('defect engineering') that reduces their detrimental impact.

Artist's depiction (right) of an intense beam of synchrotron light striking a photovoltaic solar cell and the resulting fluorescence image of the distribution of iron impurities. [Depiction courtesy of Z. Hussain; Buonassisi, T. et al., Nature Materials 4: 676 (2005)]



Environmental applications

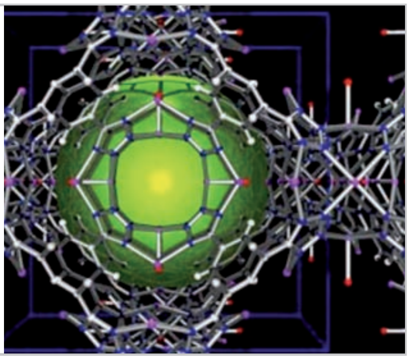
In the 21st century, environmental pollutants have become a serious threat to biodiversity and human health and are having adverse effects on the climate. Synchrotron-based techniques help not only to analyse and identify pollutants, but also to develop materials for capturing and storing carbon dioxide (CO_2).

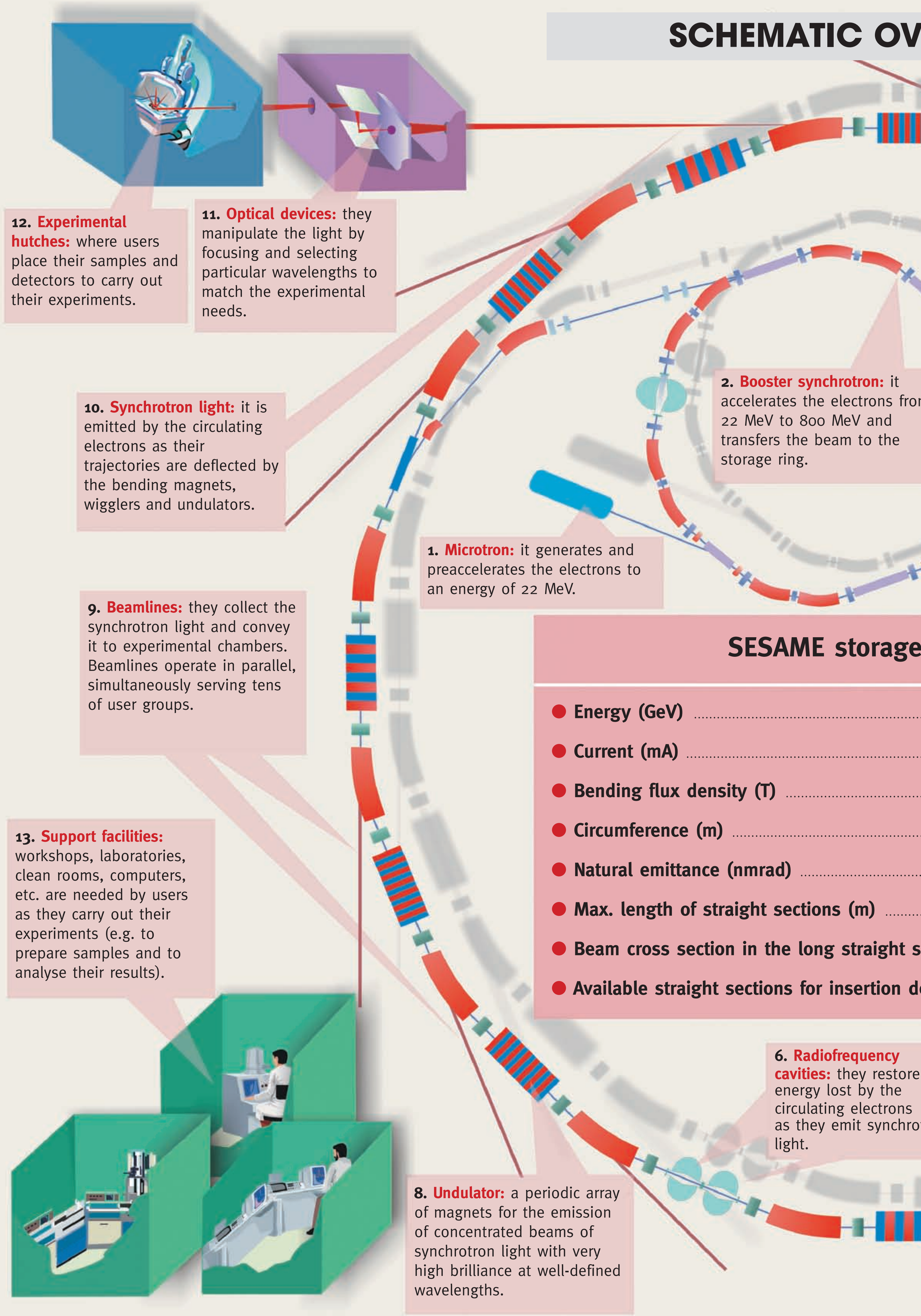
CO_2 Capture and Sequestration

Capturing CO_2 and then pumping it underground for storage in permeable rocks or depleted oil or gas wells is a possible way to reduce 'greenhouse gas' effects on the climate.

Synchrotron-based single-crystal X-ray diffraction makes it possible to study the structure of Metal-Organic Frameworks (MOFs), which are porous materials that can be used to create systems with high CO_2 storage capacity.

Illustration (right) of large voids (one shown as a yellow sphere) in a section of an MOF scaffold structure (grey sticks) that can be used to accommodate CO_2 molecules. [Illustration by C. Beavers (ALS) and courtesy of Z. Hussain; Dinca, M. et al., J. Am. Chem. Soc. 128: 16876 (2006)]




SCHEMATIC OV
12. Experimental hutches: where users place their samples and detectors to carry out their experiments.
11. Optical devices: they manipulate the light by focusing and selecting particular wavelengths to match the experimental needs.
2. Booster synchrotron: it accelerates the electrons fro
22 MeV to 800 MeV and transfers the beam to the storage ring.
10. Synchrotron light: it is emitted by the circulating electrons as their trajectories are deflected by the bending magnets, wigglers and undulators.
1. Microtron: it generates and preaccelerates the electrons to an energy of 22 MeV.
9. Beamlines: they collect the synchrotron light and convey it to experimental chambers. Beamlines operate in parallel, simultaneously serving tens of user groups.
SESAME storage
Energy (GeV)
Current (mA)
Bending flux density (T)
Circumference (m)
Natural emittance (nmrad)
Max. length of straight sections (m)
Beam cross section in the long straight s
Available straight sections for insertion d
13. Support facilities: workshops, laboratories, clean rooms, computers, etc. are needed by users as they carry out their experiments (e.g. to prepare samples and to analyse their results).
6. Radiofrequency cavities: they restore energy lost by the circulating electrons as they emit synchro light.
8. Undulator: a periodic array of magnets for the emission of concentrated beams of synchrotron light with very high brilliance at well-defined wavelengths.

ERVIEW OF SESAME

3. **Storage ring:** it stores an electron beam of 400 mA with an energy of 2.5 GeV. The beam circulates for many hours.

m

4. **Bending magnets:** they deviate the electron beam, keeping it inside the storage ring's doughnut-shaped vacuum chamber.

5. **Focusing and defocusing magnets:** they control the characteristics of the circulating electron beam.

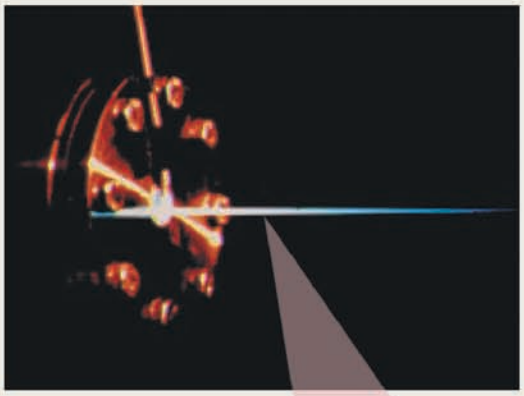


Photo of X-ray beam, courtesy of Paul Horowitz, Harvard University, USA

14. **Synchrotron light:** X-rays produce visible air fluorescence as an intense focused X-ray beam emerges from a beryllium window at the end of a beamline.

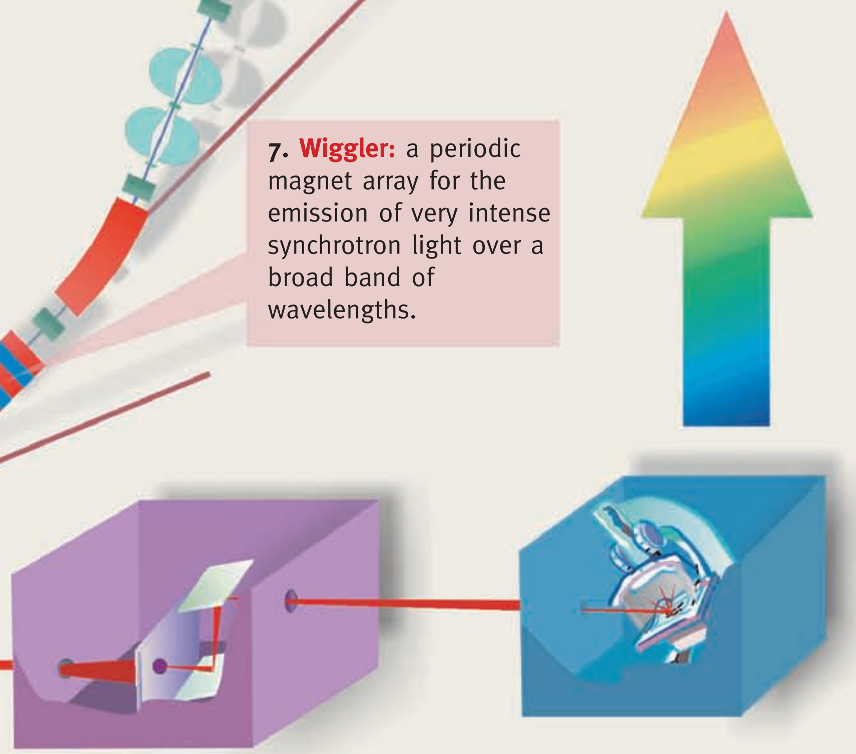
Synchrotron light is useful for a wide range of applications including spectroscopy, microscopy, crystallography and other structural techniques, radiology, many other experimental approaches, and industrial fabrication.

ring parameters

....	2.5
....	400
....	1.455
....	133.2
....	26
....	4.44
ections δx, δy (µm)	830 x 21
evices	12

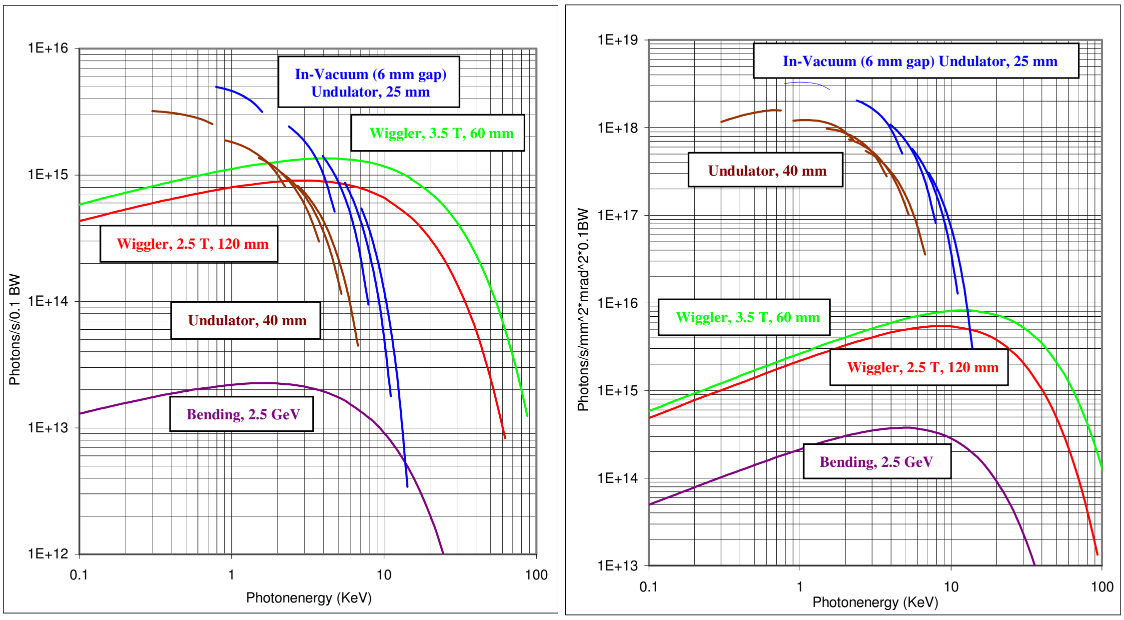
7. **Wiggler:** a periodic magnet array for the emission of very intense synchrotron light over a broad band of wavelengths.

tron



SESAME FLUX AND BRILLIANCE
A CLOSER LOOK FOR SCIENTISTS

Flux (the amount of light delivered to an experimental sample) and brilliance (a measure of the concentration of the radiation) are the key parameters that characterize the quality of synchrotron-light sources. With an electron energy of 2.5 GeV and a stored current of 400 mA, SESAME bending magnets and multipole wigglers will provide very high photon flux over the wide spectral range required for most applications, from the infrared to X-rays of 60 keV and beyond. With an in-vacuum undulator, and its emittance of 26 nmrad, SESAME will provide high brilliance reaching the K-edge of selenium (12 keV) for Multiwavelength Anomalous Dispersion (MAD) phasing, a powerful technique for protein structure determination. The SESAME design provides for 16 straight sections of which 12 can be used for wiggler and undulator insertion devices. These characteristics make SESAME competitive with other 'third generation' synchrotron light sources.



Flux and brilliance of radiation from different sources (bending magnets, wigglers and undulators) at SESAME. The numbers in mm in the boxes are the corresponding period lengths.

SESAME Phase I beamlines (numbers 1-3 available at start-up)

1. **Protein crystallography** beamline (photon energy range: 4-14 keV) for structural molecular biology, aimed at elucidating the mechanisms of proteins at the atomic level and providing guidelines for developing new drugs (as done by pharmaceutical companies and biotech companies). Such studies have led to four Nobel Prizes since 1997.
2. **X-ray absorption fine structure and X-ray fluorescence spectroscopy** beamline (3-30 keV) for applications in basic materials science and environmental science on the micrometer scale, including designing new materials and improving catalysts (e.g. for the petrochemical industries), and identification of the chemical composition of fossils and of valuable paintings in a non-invasive manner.
3. **Infrared** beamline (0.01-1 eV) for molecular biology, environmental studies, materials, and archaeological sciences. Infrared spectromicroscopy is very powerful in studying cells and tissues without the need for chemical fixing. Since infrared light is non-ionizing, there is a promising future for time-resolved imaging of living cells.
4. **Powder diffraction** beamline (3-25 keV) to be used mainly for materials science. This technique is particularly powerful for studying disordered/amorphous material on the atomic scale and the evolution of nano-scale structures and materials in extreme conditions of pressure and temperature, and has become a core technique for developing and characterizing new smart materials.
5. **Small and wide angle X-ray scattering** beamline (8-12 keV) for structural molecular biology and materials science, including studying molecular properties of synthetic and biological polymers and determining parameters (e.g. strength) that improve the quality of a polymer for a particular purpose, studying large macromolecular assemblies, and providing information on protein-protein complexes.
6. **Extreme ultraviolet** beamline (10-200 eV) for atomic and molecular physics. Photoabsorption and photoionization techniques used in this spectral range provide fundamental information on the behaviour of atmospheric gases. Photoemission studies in this spectral range can also be used to characterize the electrical and mechanical properties of materials, surfaces and interfaces.
7. **Soft X-ray ultraviolet** beamline (50-2000 eV) for chemical, energy, environmental, materials and physical sciences. This multi-purpose beamline will be used for a variety of applications, including the development of new materials in experiments that allow in-situ manipulation, one example being studies of the behaviour of catalysts and how they can be tailored.

THE SESAME STORY

The need for an international synchrotron light source in the Middle East, which SESAME will satisfy, was recognized by eminent scientists such as the Pakistani Nobel Laureate Professor Abdus Salam more than 25 years ago. This need was also felt by the CERN and Middle-East based MESC (Middle East Scientific Cooperation) group, headed by Sergio Fubini. MESC's efforts to promote regional cooperation in science, and also solidarity and peace, started in 1995 with the organization in Dahab (Egypt) of a meeting at which the Egyptian Minister of Higher Education, Venice Gouda, and Eliezer Rabinovici (MESC and Hebrew University, Israel) took an official stand in support of Arab-Israeli cooperation.

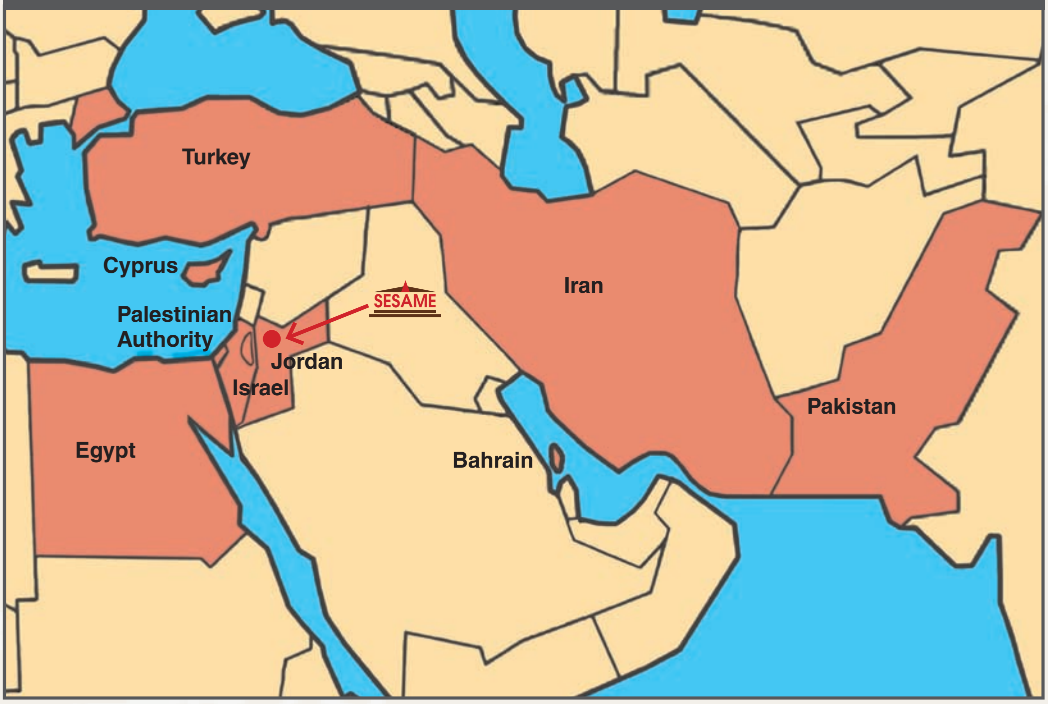
In 1997, Herman Winick (SLAC National Accelerator Laboratory, USA) and Gustav-Adolf Voss (Deutsches Elektronen Synchrotron, Germany) suggested building a light source in the Middle East using components of the soon to be decommissioned BESSY I facility in Berlin. This brilliant proposal fell on fertile ground when it was presented and pursued during workshops organized in Italy (1997) and Sweden (1998) by MESC and Tord Ekelof (MESC and Uppsala University, Sweden). At the request of Sergio Fubini and Herwig Schopper (former Director-General of CERN), the German Government agreed to donate the components to SESAME, provided the dismantling and transport (which were eventually funded by UNESCO) were taken care of by SESAME.

The plan was brought to the attention of Federico Mayor, then Director-General of UNESCO, who called a meeting at the Organization's Headquarters in Paris in June 1999 of delegates from the Middle East and other regions. The outcome of the meeting was the launching of the project and the setting-up of an International Interim Council under the chairmanship of Herwig Schopper. Jordan was selected to host the Centre in a competition with five other countries from the region. It has provided the land, as well as funds for the construction of the building.

In May 2002, the Executive Board of UNESCO unanimously approved the establishment of the Centre under UNESCO's auspices. UNESCO is the depository of the SESAME Statutes. In April 2004, the Centre formally came into existence following an exchange of correspondence between the Director-General of UNESCO and the required number of UNESCO Member States. The permanent Council was then established – replacing the International Interim Council – and the Council ratified the Statutes of the Centre and elected the President and Vice-Presidents.

Meanwhile, the groundbreaking ceremony was held in January 2003, and construction work began the following August. Since February 2008, SESAME has been working from its own premises, which were formally opened on 3 November 2008 in a ceremony held under the auspices of HM King Abdullah II of Jordan, and with the participation of HRH Prince Ghazi Ben Mohammed of Jordan and Koïchiro Matsuura, then Director-General of UNESCO. In November 2008, the first President of the Council (Herwig Schopper) stepped down and was replaced by Chris Llewellyn Smith (former Director-General of CERN, Oxford University, UK). The current Vice-President is Tarek Hussein (Cairo University, Egypt).

The SESAME Members



THE SESAME COUNCIL

The Council governs the SESAME Centre. The current Members (2010) are Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. The Observers are France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russian Federation, Sweden, Switzerland, UK and USA. In addition, Iraq has expressed interest in becoming an Observer.

Chris Llewellyn Smith (UK), President: *C.Llewellyn-Smith1@physics.ox.ac.uk*
Maciej Nalecz (UNESCO), Secretary: *m.nalecz@unesco.org*

Bahrain: a new delegate being nominated; **Cyprus:** George Georgiou; Costas Iacovou; **Egypt:** Mohamed Taha El-Kolaly; Tarek Hussein; **Iran:** Babak Shokri; *Advisors:* Javad Rahighi; Majid Shahriari; **Israel:** Moshe Paz-Pasternak; Eliezer Rabinovici; **Jordan:** Kamal Araj; Abdul-Halim Wriekat; **Pakistan:** Javaid R. Laghari; Ansar Parvez; **Palestinian Authority:** Said A. Assaf; Salman M. Salman; **Turkey:** Zafer Alper; Dincer Ülkü

THE SESAME COMMITTEES

The SESAME Council is advised by four Committees: the Beamlines Advisory Committee for the conceptual design of the beamlines; the Scientific Advisory Committee for the planning of the overall scientific management of the programme; the Technical Advisory Committee for the design and construction of the SESAME machine; and the Training Advisory Committee for the training of personnel and users. The composition of the Council and of its Committees is the best illustration of the international character and level of the project – and a guarantee of its success.

Beamlines Advisory Committee (BAC)
Zahid Hussain (USA/Pakistan), Chair
Salvador Ferrer Fabregas (Spain); Samar Hasnain (UK/Pakistan);
Engin Ozdas (Turkey); Joel L. Sussman (Israel);
Soichi Wakatsuki (Japan); Herman Winick (USA)

Scientific Advisory Committee (SAC)
Zehra Sayers (Turkey), Chair
Maged Al-Sherbiny (Egypt); Paul Dumas (France);
Thomas H. Ellis (Canada); Maya Kiskinova (Italy/Bulgaria);
Sami Mahmood (Jordan); Irit Sagi (Israel);
Mukhles Sowwan (Palestinian Authority)

Technical Advisory Committee (TAC)
Albin F. Wrulich (Switzerland), Chair
Amr Ameen Adly (Egypt); Esen Ercan Alp (Turkey/USA);
Carlo J. Bocchetta (Italy); Dieter Einfeld (Germany);
Jean-Marc Filhol (France); Salman M. Salman (Palestinian Authority);
Lothar Schulz (Switzerland); Mario Serio (Italy); Ernst Weihreter (Germany)

Training Advisory Committee (TrAC)
Javad Rahighi (Iran), Chair
Randa Mohamed Ahmed Abdel-Karim (Egypt);
Dia Eddin Arafah (Jordan); Said A. Assaf (Palestinian Authority);
Shin-ichi Kurokawa (Japan) – alternate Osamu Shimomura (Japan); Adel. M. Qabazard (Kuwait);
ICTP (Abdus Salam International Centre for Theoretical Physics); one vacancy

THE SESAME STAFF

SESAME's work is led by the Director and Technical, Scientific and Administrative Directors. Staff numbers are growing rapidly. Currently the technical team consists of 16 young experts from the region, many of whom have received training in synchrotron laboratories in Europe and the USA thanks to SESAME's training programme, and there is a nascent scientific team and a small administrative team.

THE SESAME DIRECTORATE

- Director, **Khaled Toukan** e-mail: *sonia@sesame.org.jo*
- Technical Director, **Amor Nadji** e-mail: *amor.nadji@sesame.org.jo*
- Scientific Director, **Hafeez R. Hoorani** e-mail: *Hafeez.Hoorani@sesame.org.jo*
- Administrative Director, **Mohamed Yasser Khalil** e-mail: *yasser.khalil@sesame.org.jo*

Khaled Toukan, Director of SESAME

By grouping the efforts of a number of governments, SESAME offers an extraordinarily cost-effective way of obtaining excellent wide-ranging research opportunities. SESAME is a Centre of its Members. It is governed by them and its science and training programme is determined by them, and it is they who benefit from it. Thanks to the Observers, which are virtually exclusively all at the forefront of science, they gain tremendously from very privileged scientific and technical cooperation. SESAME would welcome other countries joining this international centre of excellence.

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