SESAME

Synchrotron-light for Experimental Science
and Applications in the Middle East

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2003
Ground Breaking
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JOIN US ON THIS UNIQUE ADVENTURE IN SCIENCE AND TECHNOLOGY

On 16 May 2017, His Majesty King Abdullah II inaugurated the Middle East and neighbouring regions' first synchrotron light source in Allan, Jordan. Known as SESAME, which stands for Synchrotron-light for Experimental Science and Applications in the Middle East, the Laboratory is a unique facility and true international centre of excellence developed under the auspices of UNESCO and modelled after CERN. Its aim is to foster scientific and technological excellence as well as international cooperation amongst its Members, which are currently Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine and Turkey. As a user facility, SESAME is open to scientists from all of its Members and around the world to carry out research in fields ranging from medicine and biology, through materials science, physics and chemistry to healthcare, the environment, agriculture and archaeology.

The existence and success of SESAME is largely thanks to the continued enthusiasm, support and generosity of all involved, especially its Staff and Directors, and the Members, particularly Jordan, Israel and Turkey, which each made a voluntary contribution of US$5 million, and in the case of Jordan provided much more than this. Other important actors, including UNESCO, Germany, the IAEA, the European Union, CERN, Italy, the UK and numerous other international and national organisations and laboratories, have proven to be staunch partners over the years. Furthermore, the Laboratory has benefited from support from scientists in the countries holding the status of Observers in the SESAME Council, making it a truly global endeavour.

Ever since its inception, SESAME has been providing considerable benefit to the Middle East and neighbouring regions through training programmes to develop human capacity there. With the opening of SESAME's first two beamlines in November 2017 and April 2018 a new era of scientific research was launched. The first user experiments got underway in July 2018, allowing scientists to study matters of vital importance to the region such as the environment, earth sciences, cultural heritage, and public health.

The third beamline that comes on stream in 2020 will further expand the opportunities SESAME offers its users.

As a light source, SESAME joins the ranks of a global research community. With a proven track record in stimulating regional economies, light sources are efficient in spinning out new companies. Such success tends to result from the development of a knowledge-based economy in which the region's best scientists and technologists remain or return to the region. This retention of knowledge has a domino effect, encouraging many talented young people into scientific higher education, thereby securing a solid scientific future. SESAME is no exception, and is already contributing to reversing the brain drain in the Middle East and neighbouring regions, and to establishing itself on the international stage as a world-class facility for scientific excellence.

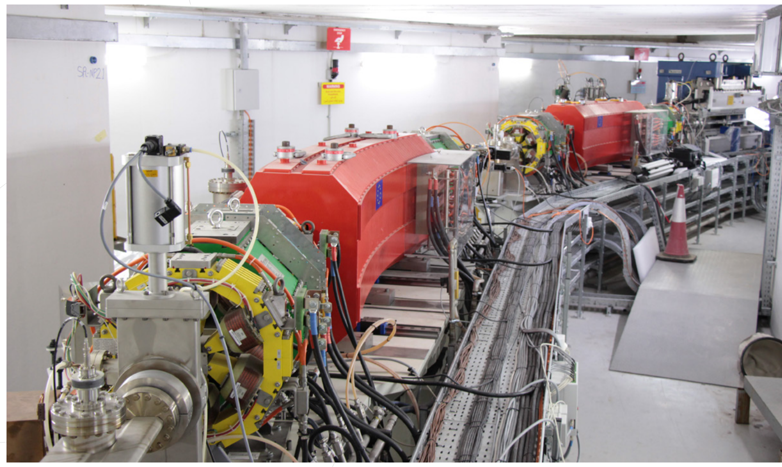
SESAME is a pioneer for science in the Middle East and neighbouring regions. In the coming years, we hope to see the Laboratory grow with new Members, expand its user community, and anchor itself as a valued member of the global scientific community. Until then we invite you to join us on this unique scientific adventure.

Rolf Heuer
President of the SESAME Council

Khaled Toukan
Director of SESAME

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. This has had an immense impact in fields that include archaeology, biology, chemistry, environmental science, geology, medicine and physics.



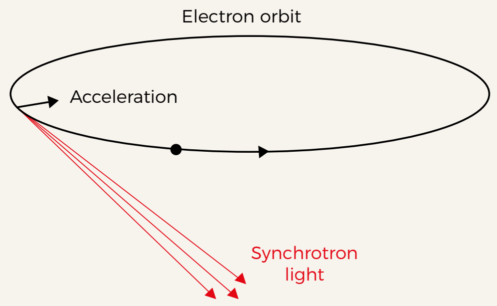
Synchrotron light sources were initially built exclusively in the developed world. Recognising their broad scientific and technical impact, many emerging economies, including Brazil, India, the Republic of Korea, Singapore, and Thailand, have however now built their own sources. There are now some 50 light sources in operation in more than 20 countries serving around 50,000 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 in the case of light sources) 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.

In third generation light sources, such as SESAME, devices (called wrigglers or undulators) can be inserted in straight sections of the accelerator which put magnetic "bumps in the road"; radiation from successive bumps adds to make a much more intense beam of light.

- 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.

The first beamlines

Beamlines contain optical elements that focus synchrotron light on sample materials that scientists wish to study. They also include the set-up for controlling the sample's environment and for data collection. Each beamline is designed to produce light with characteristics that are suited for certain types of investigation. Seven beamlines are planned for SESAME's 'Phase 1'. Two of these are currently operational, and one will be coming into operation in mid-2020. More are to follow in the coming years. SESAME will ultimately be exploited in up to 20 or more experiments operating simultaneously on independent beamlines.

The first two operational beamlines

for additional information and technical details see:
http://www.sesame.org.jo/sesame_2018/machine-and-beamlines/beamlines

The X-ray Absorption Fine Structure and X-ray Fluorescence Spectroscopy (XAFS/XFS) Beamline

The XAFS/XRF beamline is based on the donated Helmholtz Zentrum Dresden-Rossendorf beamline, originally installed at the European Synchrotron Radiation Facility (ESRF) in Grenoble (France), and adapted to the characteristics of SESAME. It is optimized for X-ray spectroscopic studies in all fields of science including in situ studies of functional materials. It can be used in materials and environmental science, in designing new materials and improving catalysts, and to identify the chemical composition of objects, including fossils and valuable paintings, in a non-invasive manner. It is equipped with a new state-of-the art silicon detector, funded by Italy, that has a sensitivity that is at least 50 times higher than any other currently available. The beamline came into operation in mid-July 2018.

An example of a project carried out on the XAFS/XRF beamline is that which studies soil contamination in the Jordan River valley, which was started at the Elettra light source in Italy by SESAME's beamline scientist Messaoud Harfouche and his collaborators from Egypt and Jordan, and was later brought to this beamline. X-ray spectroscopic measurements made on samples collected in the river valley were used to characterize the distribution of Chromium and Zinc. Together with knowledge of possible sources of contamination, the results obtained help to establish appropriate measures to reduce exposure to Chromium which is toxic for humans.

SESAME's first peer-reviewed paper to be published is that of a group from Turkey having worked on the XAFS/XRF beamline. The Turkish researchers looked at novel nanomaterials that can convert the waste products CO2 and glycerol into CO and H2, which are used in industry. The paper was published in June 2019.

Emrah Özensoy, Turkey

"The high-quality X-ray beams at SESAME were of paramount importance for us, allowing us to elucidate the molecular level origins of the catalytic activity and stability of novel nanomaterials that can convert an atmospheric waste, CO^{2}, and a biomass waste, glycerol, into the industrially valuable products CO and H^{2}.

We are thrilled that these experiments led to the very first peer-reviewed paper of SESAME. It is a great opportunity to have such a high-calibre facility in the region."

Bilkent University

The Infrared (IR) Beamline

The IR beamline is completely new and was designed and built in collaboration with the French light source, SOLEIL. It came into operation in November 2018. This beamline allows the application of infrared microspectroscopy and imaging in a wide range of fields, including surface and materials science, for example the characterization of new nanomaterials for solar cell fabrication and for drug delivery mechanisms. It also has capacity in biochemistry, microanalysis, polymers, archaeology, geology, cell biology, biomedical diagnostics, pharmaceuticals, drug design, environmental science and forensic investigations.

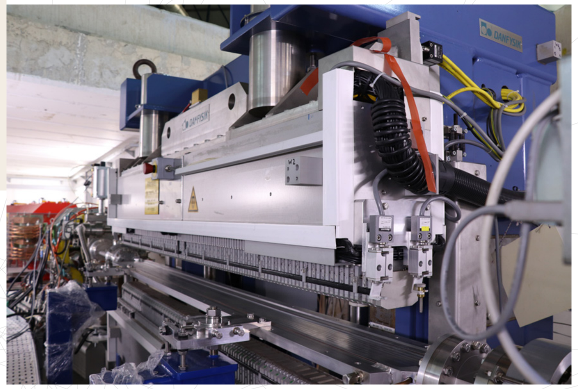
Another focus at the IR beamline is cultural heritage. Non-invasive analyses can be carried out on manuscripts and papyri, and on human remains.

The first user-led experiment conducted at SESAME was carried out by scientists from The Cyprus Institute in collaboration with SESAME's IR beamline scientist Gihan Kamel. They studied ancient human remains from the dawn of metalworking in order to understand the uptake of elements such as copper into human bodies. This work not only allows us to understand our ancestors better, it also has relevance to human health issues today.

Three beamlines under construction to host their first users in 2020-2022

The Materials Science (MS) Beamline

The MS beamline will be used in applications of the X-ray powder diffraction (XRD) technique in materials science. It will provide a powerful tool for studying microcrystalline or disordered/amorphous material on the atomic scale, the evolution of nano-scale structures and materials in various environmental conditions, and for developing and characterising new smart materials. The beamline is based on components donated by the Swiss Paul Scherrer Institute (PSI), with modifications to match the characteristics of the SESAME storage ring. It is the first beamline at SESAME to be equipped with an insertion device - a wiggler, also donated by PSI - which enhances the brightness of the synchrotron light, reducing the time needed to make measurements, and making it possible to follow fast processes. A powerful PILATUS 300K area detector, donated by DECTRIS (Switzerland), will provide the fast read-out time that is required to investigate the evolution of nano-scale structures and materials in extreme conditions of heating and cooling under gas flows. In December 2019, the first X-ray monochromatic beam was delivered to the experimental station of the beamline. This beamline is being developed by Mahmoud Abdellatief and will be hosting its first users in 2020.



The wiggler installed on the MS beamline

The Tomography Beamline

SESAME's Tomography Beamline, also known as BEATS (BEAmline for Tomography at SESAME), is being built under a European Union grant in a partnership with eight European institutes led by the ESRF Laboratory in Grenoble. It responds to a need first expressed at a 2014 meeting of SESAME's Scientific Advisory Committee, and subsequently discussed at the Laboratory's Users' meetings. It is to be a fully new beamline and is expected to receive its first users in 2022. Many areas of research involving material samples can benefit from high-resolution tomography. This makes BEATS particularly versatile. It will be used for studies ranging from archaeology, cultural heritage and palaeontology, to health and biomedical research, geology, chemical and industrial engineering, fuel cells and battery research, materials and nano-science. One important application is the detailed characterisation of the microstructure of rock samples. The SESAME region has large stakes in oil and gas. At the same time, it suffers from a lack of water. The recovery of oil, gas or water from underground reservoirs depends critically on the fine-structure of the pores in the rock.

The Soft X-ray Beamline

The Soft X-ray beamline, a state-of-the art beamline in the soft X-ray energy range, is also known as HESEB (HElmholtz-SEsame Beamline), a contraction of Helmholtz-SESAME-Beamline. It is being built by the Helmholtz Association of German Research Centres and is expected to receive its first users in 2022. Soft X-rays offer the possibility to investigate scientific issues in disciplines ranging from solid state interface and surface physics, to physical chemistry, biological systems, and earth and environmental sciences. The HESEB beamline will also be valuable for cultural heritage applications by investigating the distribution of oxygen and transition metals in the kind of archaeological samples in which the Middle East is rich. Scientists from the Technical University of Berlin and the University of Jordan have already made a proposal to use the beamline to analyse archaeological objects from the Nabatean culture in Petra (Jordan).

A beamline at the design stage

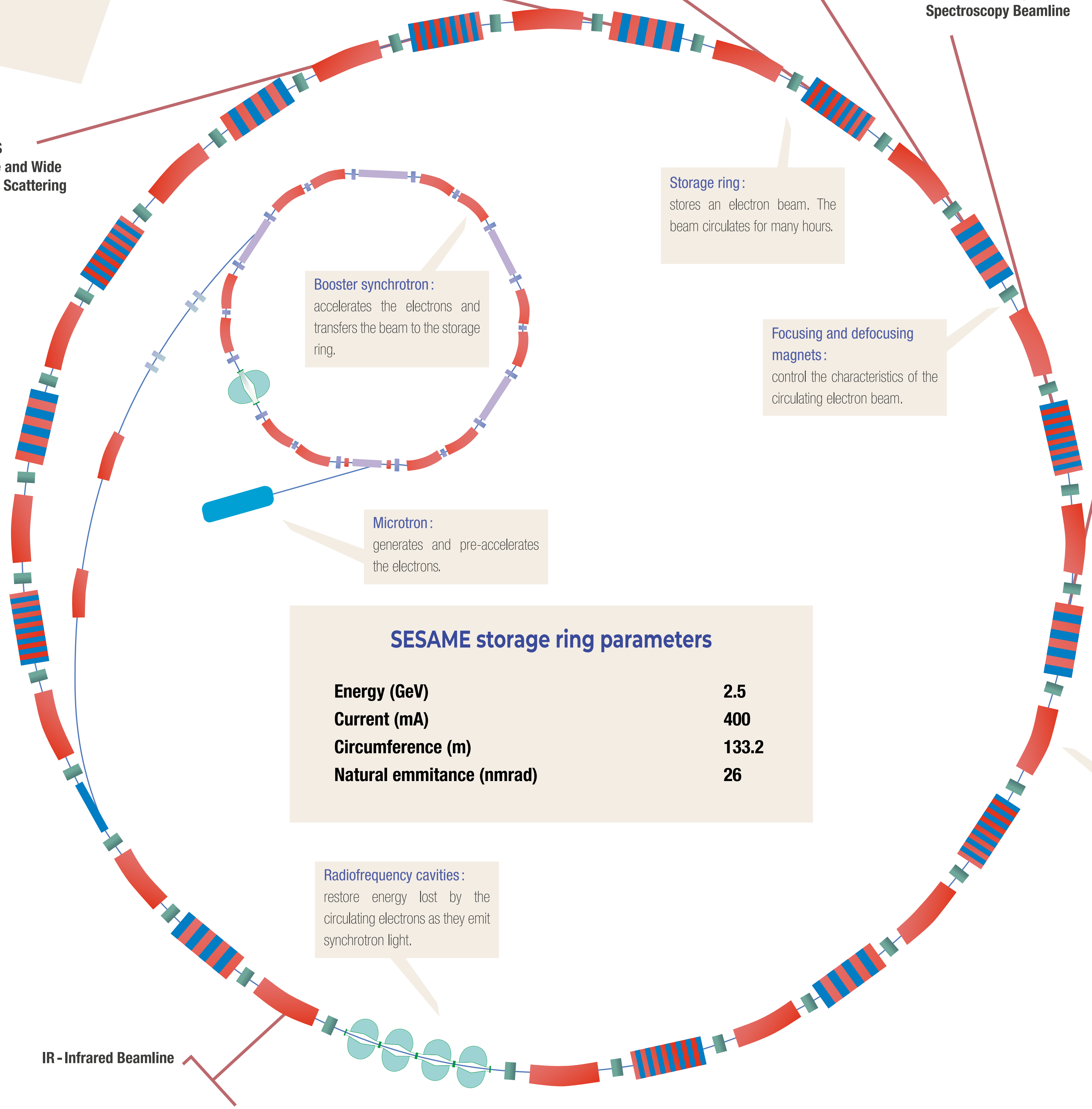
The Macromolecular Crystallography (MX) Beamline

The MX beamline, which will be completely new, will be used to elucidate the mechanisms of proteins and nucleic acids at molecular level and provide guidelines for developing new drugs and therapies. It will be a state-of-the art beamline, based on an in vacuum undulator. It will have robotic sample handling and will utilize a high-performance photon counting detector. Protein crystallography studies at synchrotrons have contributed to the award of five Nobel prizes, the first in 1997 and the latest in 2012. Pharmaceutical and biotech companies use these beamlines heavily to test new lead compounds with the aim of reducing the time and cost of developing new drugs. Atomic-scale information on biological macromolecules provides insights into functional mechanisms of biological macromolecules, including membrane proteins, protein-DNA and protein-RNA complexes. It is envisaged that in the early stages there will be strong collaborations with recombinant protein production and crystallization laboratories in the region, e.g. Jordan University, Cairo University and the Israel Structural Proteomics Center (ISPC), which is a centre of the European Union's Integrated Structural Biology Infrastructure project, Instruct. The design of this beamline has been completed.

The beamline to complete 'Phase 1'

Current plans (which are being reviewed and discussed with the user community) regarding the seventh in the suite of SESAME's 'Phase 1' beamlines are focusing on a Small Angle and Wide Angle X-ray Scattering (SAXS/WAXS) beamline for life and materials sciences.

SCHEMATIC OVERVIEW OF SESAME

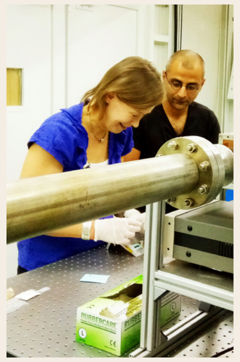


Synchrotron light is emitted by circulating electrons as their trajectories are deflected. It can be used to carry out research in fields ranging from medicine and biology, through materials science, physics and chemistry to healthcare, the environment and archaeology.

SESAME storage ring parameters

Energy (GeV)	2.5
Current (mA)	400
Circumference (m)	133.2
Natural emmitance (nmrad)	26

SESAME USERS



The Cyprus Institute, Cyprus

Kirsi LORENTZ

"Archaeological remains of humans who lived in the Middle East, the cradle of civilization as we know it, are being studied at SESAME. Ancient bone, dental tissues, and hair are being analysed by teams I am leading at The Cyprus Institute. Our research employs synchrotron radiation to throw light on key questions for the archaeology of the region, including exploring evidence for human heavy metal exposure using a variety of techniques, as well as the preservation status of bone, dental tissues and hair at micrometre scales. We look forward to using the tomography beamline being constructed at SESAME for further data collection on these unique human remains."

National Research Center, Egypt

Gehan AHMED

"Dramatic changes in the brain's biochemical composition are associated with Alzheimer's disease, which gradually leads to memory loss and brain damage. In our research, we induced Alzheimer's disease in a rat model and monitored the effect of a specific medicinal plant water extract in treating the brain tissues. The measurement was done using the IR beamline at SESAME, which was able to detect detailed structural information from very small biological materials very accurately and with much higher resolution than conventional techniques."

Department of Chemistry, Isfahan University of Technology, Iran

Maedeh DARZI

"Manuscripts in ancient cultures use inks from natural resources, such as earth minerals, plants, insects and animals, and their chemical composition sheds light on the prevailing culture and trade routes. Our joint study with the Soleil Synchrotron aims to identify the chemical composition of the inks on a Quranic paper-manuscript from the Qajar dynasty, Iran, from around 18-20 AD. SESAME's IR beamline served to identify the chemical composition of the black, blue, red and golden inks on the paper. This is a versatile technique enabling minimally-invasive investigation of the wide range of materials present in the manuscript."

Department of Materials Science and Engineering, Tel Aviv University, Israel

Brian A. ROSEN

"Fuel cells are devices that can convert chemical energy into electrical energy with the aid of electrodes made from catalytic materials. Degradation of these materials negatively impacts the performance of the cell and limits its lifetime. My group is developing new catalytic materials for fuel cells based on transition metal carbides with enhanced stability and activity. X-ray adsorption techniques at SESAME assist us in learning the electronic configuration of these materials to reveal the origin of their improved performance."

The number of users registered at SESAME now exceeds 770 scientists. They work in areas including physical and material sciences, life sciences and medicine, earth sciences and the environment, food sciences, information and communication technologies, engineering, energy, archaeology and cultural heritage. This community has grown through 17 Users' Meetings organised by SESAME since 2002 and a training programme (page 12). As more beamlines are built, the number of users is expected to rise substantially.

A first call for experimental proposals resulted in 55 applications for beam time on SESAME's XAFS/XRF and IR beamlines. Many were from the SESAME Members, but some came from further afield: Colombia, France, Italy, Kenya and Sweden. The second call resulted in 103 proposals from the SESAME region and beyond: Germany, Italy and Mexico. This impressive number demonstrates the need for a synchrotron light facility in the region, and the broad international interest in using SESAME's advanced capabilities.

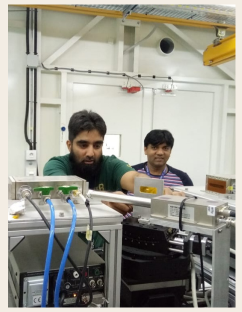
Following review by the international Proposal Review Committee, beam time was allocated to 28 of the proposals received in the first call. These came from teams from Colombia, Cyprus, Egypt, France, Iran, Italy, Jordan, Pakistan and Turkey. The first users arrived at SESAME on 17 July 2018. Beam time was granted to 57 proposals resulting from the second call. These came from Cyprus, Egypt, Germany, Iran, Israel, Italy, Jordan, Mexico, Pakistan and Turkey. From 17 July 2018 to 31 December 2019, 62 experiments involving 43 groups of users from ten countries have been carried out at SESAME, and peer-reviewed papers are beginning to appear.

SESAME's users are mainly based in universities and research institutes. They visit the Laboratory periodically to carry out experiments, often in collaboration with scientists from other countries. At SESAME, they are exposed to the highest scientific standards in a stimulating environment for international collaboration. SESAME's scientific and technical facilities are available for users, while the Laboratory's scientific, technical and administrative staff help ensure the success of both experienced and inexperienced users. While performing experiments, users are accommodated on SESAME's campus at a Guest House constructed with funds generously donated by Italy.

Funds from a generous grant from the Lounsbery Foundation, as well as from professional societies (page 13) and the IAEA, will support scientists from the SESAME Members visiting SESAME to carry out experiments. Those of the IAEA will also be used for users from developing countries that are not Members of SESAME. In 2020-2021, a grant from the European Union's CALIPSOplus activity will cover the expenses of those scientists visiting SESAME for their experiments who work in some EU and associated countries in the Middle East.

Tayel EL-HASAN

"We used SESAME's XAFS/XRF beamline in an applied environmental study related to toxic element speciation and mobility within solidified mixtures composed of oil shale ash and various natural materials. We measured the leachability and the nature of the hosting matrix for these elements. Moreover, we also recorded the effect of ageing on oxidation states, particularly the reduction of Cr^{+6} to Cr^{+3}."



Department of Chemistry, Faculty of Science, Mutah University, Jordan

Muhammad YOUNAS

"Understanding the fundamental physics of so-called colossal dielectric constant, CDC, materials is important from an application viewpoint. Transparent zinc oxide thin film-based CDC materials have special applications in transparent displays, super capacitors and radar absorbing materials. Knowledge of the local structure of CDC materials is essential for device fabrication. The data collected by Pakistani scientists at SESAME's XAFS/XRF beamline was of great help in solving scientific problems for transparent thin film systems."

Electronic and Magnetic Materials Group, NPD, PINSTECH, Pakistan

Ahmed BASSALAT

"Palestine is very fortunate to have SESAME on its doorstep. It is a window to international collaboration in science of a very high level and I have used the facility for the training of a number of the students in my laboratory. We are actively preparing our community to use the beamlines available at SESAME, which is why in April this year I organized the *2nd International Workshop on Synchrotron Radiation and Applications: SESAME* in Palestine at An-Najah National University in Nablus."

An-Najah National University, Palestine

Mehmet YESILTAS

"We study the molecular content of meteorites, rocks that are pieces and fragments of larger rocks such as asteroids and planets, to understand the origin of our solar system and the history of planetary objects. The molecular content of meteorites contains signatures of previous chemical reactions and events. Infrared spectroscopy at SESAME allows us to identify minerals and organics in our samples and helps us unravel such signatures."

Kirklareli University, Turkey

ADVANCED TRAINING, ANOTHER STRING TO SESAME'S BOW

The process of training scientists and engineers from the region in the use of synchrotron radiation and the relevant accelerator technology began soon after SESAME came into existence. It was extended shortly after to include the installation and operation of beamlines, and now also embraces:

- Training SESAME staff in storage ring and beamline instrumentation technology, research techniques and administration for optimal use of a modern light source facility.
- Building up human capacity in the Middle East and neighbouring regions to optimally exploit SESAME's infrastructure.

SESAME has organised some 34 workshops and schools in the Middle East and elsewhere. These meetings, which have attracted more than 1,000 scientists and engineers, have focussed on applications of synchrotron radiation in biology, materials science, environmental and medical sciences, culture, science administration and other fields, as well as on informatics (in six meetings organised with The Cyprus Institute in the framework of the EU-funded LinkSCEEM project) and accelerator technology.

In addition, the training programme has allowed approximately 185 young men and women, including staff members, to spend periods of up to two years working at synchrotron radiation facilities and other centres (mostly in Observer countries) in Europe, the USA, Asia and Latin America. This has provided them with first-hand experience and further swollen the ranks of scientists in the Middle East and neighbouring regions with experience in operating and using synchrotron radiation sources.

This training programme has been made possible thanks to generous support from various international organizations (the IAEA, the European Union, UNESCO and ICPT), national agencies (in particular, the UK Department for Business, Energy and Industrial Strategy (BEIS) through the Rutherford Fund, the US Department of Energy, the US National Academy of Science, and the Foundation for Science and Technology (FCT) of Portugal), numerous synchrotron laboratories, professional scientific societies and small charities,

On-going support for training from the IAEA and others will further strengthen SESAME's training programme.

Image courtesy Diamond Light Source

PARTNERSHIPS

SESAME enjoys partnerships that stretch from the Americas in the West to Japan in the East.

It is the first Associate of LEAPS (League of European Accelerator-Based Photon Sources). It is an Honorary Member of lightsources.org. It is one of the signatories of the UN's Climate Neutral Now initiative.

It has close links with a very great number of forefront light sources and research laboratories in the world (ALS,[1] CELLS-ALBA, CLS, CyI, Daresbury Laboratory, DESY, Diamond, Elettra, ESRF, FZJ, HZB, HZDR, INFN, Jagiellonian University, KEK, KIT, MAX-IV, NCP, NSRRC, SLS, Soleil, UC Berkeley, University of Liverpool…….) whether it be in partnerships for the design, construction and commissioning of some of its beamlines (e.g. its BEATS, HESEB and IR beamlines), or expertise, training opportunities, support, and in some cases the donation of equipment of which it has been the recipient.

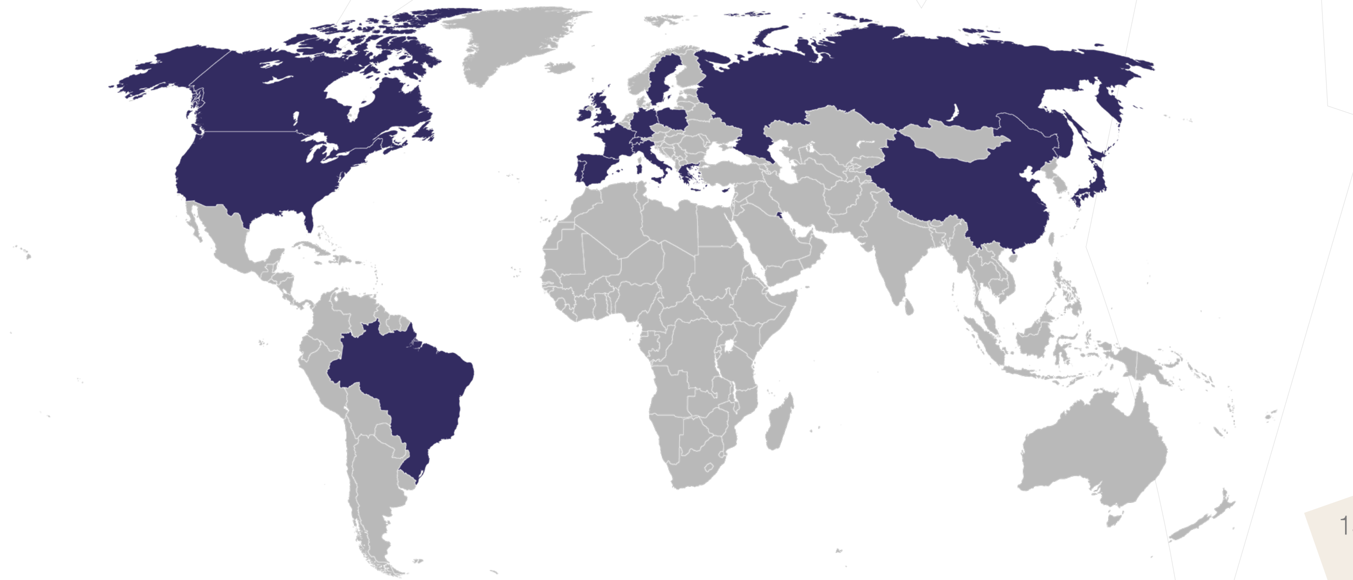
CERN (European Organization for Nuclear Research), which like SESAME is an intergovernmental science organization set up under the auspices of UNESCO, is one of the Observers to the SESAME Council. It has played a pivotal role in construction of the magnets and power supplies of SESAME's main storage ring and constantly puts its expertise at the service of SESAME. The third and current President of the SESAME Council is a former Director General of CERN as were his two predecessors.

UNESCO (United Nations Educational, Scientific and Cultural Organization), the IAEA (International Atomic Energy Agency) and the EU (European Union) are particularly important partners. In the case of UNESCO, it was vital in getting the SESAME project started, and it has been providing unfailing support thereafter, particularly in integrating SESAME in international infrastructures and promoting SESAME within its Member States. It is the depository of the Statutes of SESAME and may serve on the SESAME Council. Through long-standing support it has been granting for training of SESAME's staff and potential users in the region, the IAEA is a *backbone* partner in SESAME's capacity building programme related to the construction, safe operation and use of SESAME. The EU, through its support for construction of the magnets and power supplies of SESAME's storage ring and the BEATS beamline now being built, as well as training and outreach, holds a specially-important place as a partner. It is one of the Observers to the SESAME Council.

The Observer countries to the SESAME Council (Brazil, Canada, China, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, the Russian Federation, Spain, Sweden, Switzerland, the UK and the USA) are unfailing in their moral, scientific and political support and encouragement. Either directly or through their national institutions they provide sizeable, very tangible support for all spheres of SESAME's activity.

SESAME has long-standing ties with ICTP (Abdus Salam International Centre for Theoretical Physics), IUPAP (International Union of Pure and Applied Physics), professional societies (the American, French and German Chemical Societies, the German Mathematical Society, and the American, European, French, German, Italian and UK Physical Societies) and private foundations (the Lounsbery Foundation) and they partner with SESAME in its efforts to further expand the user community in the region and to assist users to travel to SESAME to carry out experiments using the Centre's facilities.

[1] **ALS:** Advanced Light Source; **CELLS-ALBA:** Consorci per a la Construcció Equipament i Explotació del Laboratori de Llum de Sincrotró; **CLS:** Canadian Light Source; **CyI:** The Cyprus Institute; **DESY:** Deutsches Elektronen-Synchrotron; **Diamond:** Diamond Light Source Ltd.; **Elettra:** Elettra-Sincrotrone Trieste S.C.p.A.; **ESRF:** European Synchrotron Radiation Facility; **FZJ:** Forschungszentrum Jülich; **HZB:** Helmholtz-Zentrum Berlin; **HZDR:** Helmholtz-Zentrum Dresden-Rossendorf; **INFN:** Instituto Nazionale di Fisica Nucleare; **KEK:** High Energy Accelerator Research Organization; **KIT:** Karlsruher Institut für Technologie; **MAX-IV:** MAX-IV Laboratory; **NCP:** National Centre for Physics; **NSRRC:** National Synchrotron Radiation Research Center; **SLS:** Swiss Light Source; **Soleil:** Soleil Synchrotron; **UC Berkeley:** University of California, Berkeley



THE SESAME STORY

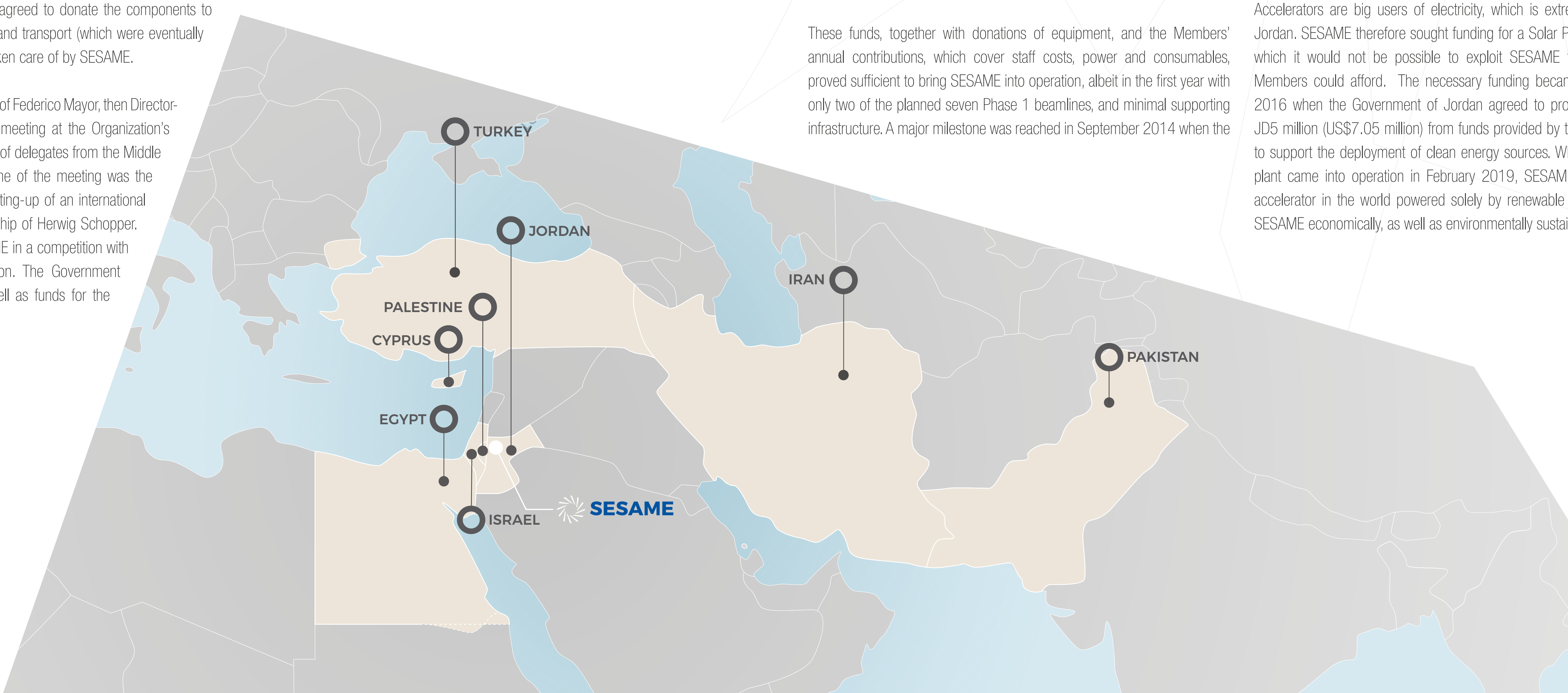
The need for an international synchrotron light source in the Middle East, which SESAME will satisfy, was recognized by eminent scientists such as the Pakistani Nobel Laureate Professor Abdus Salam some 30 years ago. This need was also felt by the CERN and Middle-East based MESC (Middle East Scientific 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 in 1997 and Sweden in 1998 by MESC (which adopted the proposal) and Tord Ekelof (MESC and Uppsala University, Sweden). At the request of Sergio Fubini and Herwig Schopper, a former Director General of CERN, the German Government agreed to donate the components to SESAME, provided the dismantling and transport (which were eventually largely 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 SESAME in a competition with five other countries from the region. The Government of Jordan 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 the auspices of UNESCO, which is the depository of SESAME's Statutes. The Centre formally came into existence in April 2004 when the required number of Members had informed the Director-General of UNESCO of their decision to join.

Meanwhile, in 2002 the idea of re-building and upgrading BESSY I was abandoned in favour of building a completely new 2.5 GeV main storage ring, with straight sections that can accommodate insertion devices (wigglers and undulators), thereby making SESAME a third generation light source, while retaining the microtron and the booster synchrotron, which provide the first two stages of acceleration. A ground-breaking ceremony was held in January 2003 in the presence of HM King Abdullah II of Jordan and Koïchiro Matsuura, then Director-General of UNESCO. The SESAME building was formally opened on 3 November 2008 in a ceremony held under the auspices of King Abdullah, and with the participation of HRH Prince Ghazi Ben Mohammed of Jordan and Koïchiro Matsuura.



Following the opening of the building in November 2008, Chris Llewellyn Smith (Oxford University, UK), also a former Director General of CERN, took over from Herwig Schopper as President of the Council. In November 2009, the SESAME Council endorsed a Strategic Plan, which has been followed subsequently, albeit not as rapidly as hoped, and with some items postponed, because the necessary capital funding was not available.

The funding problem was partly overcome when, in March 2012, Iran, Israel, Jordan and Turkey committed to making voluntary contributions of US$5 million each to SESAME's capital budget, although as a result of sanctions Iran has so far been unable to transmit the funds. This demonstration of commitment by the SESAME Members, encouraged the European Union to decide in 2013 to provide €5 million to CERN to procure the components of the magnetic system for the SESAME main ring, which has been built in collaboration with SESAME. It also encouraged Italy to provide €1 million in 2014, which was used to procure RF (Radio Frequency) accelerating cavities; this was followed by further contributions from Italy, which has so far contributed a total of €3.6 million, of which the most recent part has been used to build a Guest House for SESAME users.

These funds, together with donations of equipment, and the Members' annual contributions, which cover staff costs, power and consumables, proved sufficient to bring SESAME into operation, albeit in the first year with only two of the planned seven Phase 1 beamlines, and minimal supporting infrastructure. A major milestone was reached in September 2014 when the booster synchrotron stored and accelerated a beam to the its full energy of 800 MeV, thus making it the highest energy accelerator in the Middle East at that time. On 11 January 2017, a beam was transferred from the booster and circulated in the main storage ring for the first time. By late February, a beam had been stored and accelerated to 2 GeV, and on 27 April the beam had been ramped up to its design energy of 2.5 GeV.

With these successes achieved, the SESAME Council fixed the date of 16 May 2017 for SESAME's formal opening held under the patronage, and in the presence, of HM King Abdullah II. On the day following the inauguration, Rolf Heuer, another former CERN Director General, took over from Chris Llewellyn Smith as President of the Council. More milestones were soon to follow. SESAME's first beamline, the XAFS/XRF beamline, came into operation on 22 November 2017, and was followed by the IR beamline on 30 April 2018. The first users came to SESAME to perform experiments using the XAFS/XRF beamline on 17 July 2018, and on 4 November it was the turn of those to use the IR beamline. SESAME's first peer-reviewed paper was published in June 2019.

Accelerators are big users of electricity, which is extremely expensive in Jordan. SESAME therefore sought funding for a Solar Power Plant, without which it would not be possible to exploit SESAME fully at a cost the Members could afford. The necessary funding became available in late 2016 when the Government of Jordan agreed to provide SESAME with JD5 million (US$7.05 million) from funds provided by the European Union to support the deployment of clean energy sources. When its solar power plant came into operation in February 2019, SESAME became the first accelerator in the world powered solely by renewable energy. This made SESAME economically, as well as environmentally sustainable.

THE SESAME COUNCIL

The Council is SESAME's governing body. The current Members are **Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestine,** and **Turkey.** The Observers are *Brazil, Canada, China, the European Organization for Nuclear Research (CERN), the European Union (EU), France, Germany, Greece, Italy, Japan, Kuwait, Portugal, the Russian Federation, Spain, Sweden, Switzerland, the UK* and *the USA.* UNESCO may serve on the Council.

President of the Council - Rolf Heuer (Germany)

Co-Vice Presidents[1] - Ioanna Cleanthous (Cyprus), Erdal Recepoğlu (Turkey)

Delegates to the Council:

Cyprus	Ioanna Cleanthous, Christos Aspris
Egypt	Atef A. Abdel-Fattah, Mahmoud Sakr
Iran	Javad Rahighi, Mahmoud Tabrizchi
Israel	Eliezer Rabinovici, Roy Beck-Barkai
Jordan	Kamal Araj, Abdul-Halim Wriekat
Pakistan	Tariq Banuri, Muhammad Masood ul Hasan
Palestine	Rezq A.S. Salimia, Muamar H.H. Shtaiwi
Turkey	Erdal Recepoğlu

The Finance Committee provides advice to, and exercises certain powers delegated by, the Council.

Chair - Najibullah Khan (Pakistan)

Secretary of the Council: Clarissa Formosa-Gauci

SESAME ADVISORY COMMITTEES

The SESAME Council is advised by two Committees: the Machine Advisory Committee for the operation of the accelerators and any upgrades that may be required during the first years of operation, and the Scientific Advisory Committee for the planning of the overall scientific management of the programme and the conceptual design of beamlines.

Machine Advisory Committee (MAC - formerly Technical Advisory Committee)
Chair - Amor Nadji (Algeria/France)

Scientific Advisory Committee (SAC)
Chair - Esen Ercan Alp (Turkey/USA)

The SESAME Director is advised by the Proposal Review Committee on the allocation of beam time to General Users following its evaluation of the scientific and technological merit of proposals and their priority using criteria based on IUPAP's Recommendations for the Use of Major Physics Users Facilities

Proposal Review Committee
Chair - Samar Hasnain (UK/Pakistan)

THE SESAME DIRECTORATE

Director, Khaled Toukan
Technical Director, Maher Attal
Scientific Director, Andrea Lausi
Administrative Director, Walid Zidan

[1]Positions that rotate among all the Members