DESCRIPTION OF SESAME (H.Winick, Sept. 17, 2009)

Developed under the auspices of UNESCO and modelled on CERN, SESAME (***S***ynchrotron-light for ***E***xperimental ***S***cience & ***A***pplications in the ***M***iddle ***E***ast) is a major international research centre now in construction in Jordan. It will enable world class research by scientists from across the Middle East and the Mediterranean region, in subjects ranging from biology and medical sciences through materials science and physics to archaeology. SESAME will both

- Foster excellent science and technology in the Middle East and the Mediterranean region (and prevent or reverse the brain drain), and
- Build bridges between diverse societies and contribute to a culture of peace through international cooperation in science.

Furthermore, it is hoped that the SESAME building will be used to host high-level Arab-Israeli meetings and Middle-Eastern scientific meetings.

The centrepiece of SESAME is a third-generation synchrotron light source, originating from the decommissioned BESSY I facility, a gift from Germany. A synchrotron light source is an electron storage ring (an evacuated, donut-shaped tube, threading through magnets) in which a slender stream of high-energy electrons, bent by magnetic fields, orbits in a closed circular path. As their path is bent by ring magnets (or special "insertion device" magnets) electrons emit tangential beams of extremely intense, concentrated radiation over a broad span of wavelengths, ranging from the infra-red to ultra-violet to x-rays. These machines have had a revolutionary impact on many areas of basic and applied research by providing radiation that is more than one million times brighter, or more intense, than conventional sources, such as medical or industrial x-ray machines.

Around the world there are now more than 60 synchrotron light research facilities in operation, serving about 30,000 scientists in basic and applied research in many disciplines, including important studies addressing local biomedical and environmental issues and concerns. In addition to facilities in many technologically developed countries, facilities were started about 25 years ago in countries such as Brazil, China, India, the Republic of Korea, Singapore, Taiwan and Thailand. Over the past decade or so these facilities have trained hundreds of graduate students and attracted dozens of mid-career scientists to return from research abroad.

Many third-generation light sources are in operation, construction, and planning around the world, ranging in electron energy from 1-8 GeV. The highest performance hard x-ray facilities are the ESRF (France, 6 GeV), APS (US, 7 GeV) and Spring-8 (Japan, 8 GeV). These have a circumference of about 1km and cost about $1B. Developments in accelerator and insertion device technology have made it possible for smaller, intermediate-energy (2.4-3.5 GeV) machines to come close to the performance of the high energy rings at lower cost. SESAME is in this class. Eight high-performance intermediate-energy machines are now in operation (Australia, Canada, China, France, Italy, Switzerland, UK, and US). In addition to SESAME, more are in construction or advanced stages of planning in Brazil, Sweden, Taiwan, and the US (to add to or replace present facilities), and a first facility in Spain. See www.lightsources.org

In SESAME, an intense (400 mA) hair-like stream of high energy (2.5 GeV) electrons will circulate in a vacuum tube with a circumference of 133 meters. The facility is being constructed in a 75m x 75m building which was completed in 2008. The site in Allaan (about 30km North-West of Amman) and funds for the main and auxiliary buildings were provided by Jordan, which won out in a competition with 18 proposals from 7 countries. A staff of 20 is now engaged in the installation of the BESSY I 0.8 GeV injection system. The pre-injector, a 22 MeV microtron, acclerated its first beam at SESAME on July 14, 2009. The facility will have the capacity to serve 30 or more experiments operating simultaneously on beamlines emerging tangentially from the ring. Twelve of these beamlines will originate from wiggler and undulator insertion devices, which provide even higher intensity than the sixteen possible beamlines originating from the ring bending magnets. An initial six beamlines will be ready when operation starts in 2012.

SESAME is governed by a Council which meets twice each year and presently has nine Members (Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestinian Authority, and Turkey). Negotiations are underway with Iraq and more are expected to join. Members have collective responsibility for the project and provide the annual operations budget (~$1.5M in 2009 and expected to grow to ~$5M when research operation starts in 2012). The President of the Council from 1999 to 2008 was Herwig Schopper, a former Director-General of CERN. In November 2008 Chris Llewellyn-Smith, also a former Director-General of CERN, took over as Council President. Observers of the Council include France, Germany, Greece, Italy, Japan, Kuwait, Portugal, Russia, Sweden, UK, and US.

Decommissioned beamlines have been provided by the Daresbury SRS in the UK, the Swiss Light Source, and LURE in France, plus beamline equipment from LBNL and SLAC in the US. Pakistan is building a soft x-ray beamline. Other Council Members are expected to do the same, as well as providing in-kind contributions, as is common for international projects. With the upgrading of donated equipment, the suite of beamlines needed at the start is essentially complete.

It was originally proposed to upgrade the BESSY I 0.8 GeV facility to 1 GeV, and expand the circumference to accommodate several superconducting wigglers to provide hard x-rays. When it became clear that more and better hard x-ray beams would be needed to serve a large hard x-ray user community, a new 2.0 GeV ring was designed. Following the recommendation of an expert European Commission panel which reviewed this design in 2002, a more ambitious 2.5 GeV ring, a truly world-class facility with much greater scientific potential, is now in construction. The BESSY I 0.8 GeV injector will be still be used as the initial injector into this larger new main storage ring.

It was hoped by Council Members that the additional cost of providing a new main ring might be provided by the European Union. However, while the EU has already provided €1.2M, and Jordan has made very generous contributions ($3.3M in addition to the land, buildings, and infrastructure), ~€15M more is now urgently needed to purchase the ring technical components and upgrade the donated beamlines. Otherwise, the major elements are in place to meet the 2012 commissioning target.

Progress is being made in securing the funds needed. An additional €2M has recently been approved by the EU and $2.5M that could be used for SESAME in FY 2010 and 2011 is being requested as an appropriation for the US State Department, Foreign Operations by Congressman Rush Holt. China has agreed to provide technical components of the new ring at less than market prices.

Based on the participation of hundreds of Middle East scientists at 7 workshops and schools (beginning in 1999), and annual Users' meetings (beginning in 2002), it is anticipated that about 500 Middle East scientists will use SESAME when it begins operation. This will grow to more than 1,000 users as additional beamlines are built.

A training program for beamlines, accelerator technology, and scientific applications has been underway for nine years, funded by IAEA, the Japanese Society for the Promotion of Science (JSPS), US/DOE, and fellowships provided by other synchrotron radiation laboratories around the world.

A Director, Administrative Director, Scientific Director and Technical Director are on board. An accelerator group has finalized the design of the storage ring. Four international Advisory Committees advise the Council and work with the staff on the technical design, beam lines, training and scientific programs.

A "soft" inauguration, marking building completion, staff occupancy, and the start of installation of the injector was held on November 3, 2008, with the Director-General of UNESCO, a representative of the King of Jordan, and many dignitaries present. See www.sesame.org.jo

Endorsements of SESAME

UNESCO Executive Board and General Assembly: ***"a quintessential UNESCO project combining capacity building with vital peace-building through science"*** *and* ***"a model project for other regions"***

IUPAP Oct. 2008 resolution**:*"The IUPAP strongly endorses SESAME and urges its national committees and Commissions to identify opportunities for continued and expanded assistance to the project, including identifying opportunities for broadening participation by scientists from the region, and raising the visibility of it's "science for peace" objectives throughout scientific and policy-making communities."***

Nobel Laureates: 45 signed a June, 2008 statement: ***"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."***

Contributions to SESAME

Jordan: Land, buildings, infrastructure (value at least $20M) plus $3M from Royal Court and $300K from the Ministry of Education.

Germany: BESSY I 0.8 GeV injection system (value ~$6-8M)

UNESCO: Since the start UNESCO has provided $945K of support. This includes $400K (which was added to $200K from Council Members and the US) to pay for the controlled dismantling of BESSY I. UNESCO is the depository of the SESAME Statutes, is present on the Council, and continues to provide significant staff support.

France, Switzerland, UK, US: Total of 6 beamlines, Insertion devices, monochromators, etc. (value ~$15-20M after upgrading)

Italy: RF cavities from the Elettra facility in Trieste (value ~$0.5M)

China: Offer to provide technical components of the storage ring at below market prices.

Spain: SESAME magnets will be measured at the ALBA light source in Barcelona

Pakistan: has said it will build a VUV/Soft X-ray beamline (value ~$3M)

EU: €1.2M already contributed through a bilateral program with Jordan. €2M recently approved.

US: DOE grants to UNESCO ($200K). DOE Cooperative Research Program for SESAME has supported ~25 Middle East scientists at US labs since 2000 (~$350K). Request by Rep. Rush Holt for $2.5M in FY2010 and 2011 for US State Dept. Foreign Operations.

IAEA: Through an interregional project especially created for SESAME over the years 2007-2011 the IAEA will have spent $950K on SESAME for human resource capacity building in accelerator physics and synchrotron radiation applications. This is in addition to about $150K provided earlier. The IAEA is represented at SESAME Council meetings.

Japan Society for the Promotion of Science (JSPS): funds to support schools and workshops in the Middle East starting in 2002 (~$500K).

American Physical Society, European Physical Society, German Physical Society, UK Institute of Physics travel fund; $20K/yr starting 2008. Electronic journal access from IoP.

Canon Foundation: funds to support costs of SESAME Users' meetings.

Fellowships: Taiwan: 9 one year Fellowships granted. **Brazil:** 3 one year Fellowships granted.
Portugal: 4 multi-year fellowships per year for three years starting in 2009. Fellowships at other labs (**APS, Diamond, Japan, Spain, China…**) are in the works.

Schools, workshops, conferences in many countries provide local support to SESAME scientists.