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SESAME - An Extended Spectral Range Synchrotron Radiation Facility in the Middle East Based on an Upgrade to BESSY I *

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Abstract: The SESAME (*S*ynchrotron-light for *E*xperimental *S*cience and *A*pplications in the *M*iddle *E*ast) project is described.

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Keywords: synchrotron, storage ring, x-ray, insertion device

[1] M. Abo-Bakr et al ; "SESAME - A Proposal for a Synchrotron Radiation Source in the Middle East". October 1999.
[2] M. Abo-Bakr et al; Proc. 1999 IEEE Particle Accel. Conf. (PAC99), New York, NY.

I. Introduction: Developed under the umbrella of UNESCO, SESAME will be a major international research center in the Middle East/Mediterranean region (see www.sesame.org.jo). Its centerpiece is a synchrotron radiation source based on an anticipated gift from Germany of the 0.8 GeV BESSY I storage ring and injector system which stopped operation in November 1999. As an international scientific and technological center of excellence open to all qualified scientists, SESAME will be a propeller for the regional economy while promoting the peaceful development of science and technology in the Middle East.

BESSY I will be upgraded by raising the ring and injector energies to 1.0 GeV and enlarging the ring circumference to 101m to accommodate six straight sections The spectral range will be extended to ~20 keV with two to four 7.5 Tesla, 13 pole superconducting wigglers (ε_c=5.0 keV). With the small electron beam source size and high stored current these wigglers will provide flux density at hard x-ray wavelengths that is comparable to higher energy rings (section III). Undulators will provide relatively high brightness at photon energies up to ~1 keV. Twelve bending magnets will provide intense radiation with ε_c=1.25 keV. Programs planned include structural molecular biology, molecular environmental science, LIGA, x-ray imaging, archeological microanalysis, material science, and medical applications.

II. Project Status: After the initial suggestion by H. Winick in September 1997 that Germany offer the gift of BESSY I, a technical design was developed under the leadership of G.-A. Voss [1,2] . Support for the concept came in April 1998 from the Middle East Scientific Cooperation (MESC) group at CERN and then from UNESCO. In June 1999 the then Director-General of UNESCO, Federico Major, called a consultative meeting at which the project was strongly endorsed by scientists representing nine

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governments from the region. UNESCO continues its interest and support for SESAME under its new Director-General, Koichiro Matsuura.

The present governing body of SESAME is the International (Interim) Council with Herwig Schopper (CERN) as President and Siegbert Raither (UNESCO) as secretary. Voting members of the Council now include representatives of 11 governments from the region: Armenia, Cyprus, Egypt, Greece, Iran, Israel, Jordan, Morocco, Oman, the Palestinian Authority, and Turkey. Observer countries to this Council include Germany, Italy, Japan, Russia, Sweden, and the US. Four working committees (Technical, Scientific, Training and Finance) report to the Council. The Technical Committee is developing the design of the upgraded facility and works with the Training Committee and others to develop a scientific and technical team to operate, maintain, and upgrade the accelerators. The Scientific Committee is developing the scientific program for SESAME, including defining the beam lines, user-support facilities, and scientific and technical user-support staff. Workshops are being held in structural molecular biology and materials research and are planned for other areas. Additionally, several laboratories worldwide are providing training opportunities to interested scientists and engineers from member nations.

A call for site proposals in June 1999 resulted in offers of 18 sites by 7 governments. A process culminating in June 2000 resulted in selection of a site in Jordan in the town of Allaan, 30 km northwest of Amman and 30 km from the King Hussein/Allenby Bridge. Efforts are now intensifying to secure funding, select a director, and form a project team. It is anticipated that funds will come from member countries (e.g., Jordan has pledged $1M per year towards the operations expenses) plus outside sources. With funds provided by SESAME member countries and UNESCO, and with assistance from accelerator specialists from Russia and Armenia, a controlled and documented dismantling of BESSY I was begun in early 2000 with completion expected by September 2000. After upgrading, these components will be reassembled in Jordan as shown in figure 1.

III. Spectral Characteristics: Figures 2 and 3 plot the calculated flux and brightness for a SESAME bend, superconducting wiggler, and undulator in comparison to several multi-GeV bend/wiggler sources (table 1). Since many synchrotron experiments do not fall neatly into flux or brightness limited categories, a sample phase space acceptance merit function is employed to characterize SESAME for this intermediate class of applications. This merit function maps the source phase space onto the sample acceptance phase space, assuming appropriate optics are employed in the transformation. Consider, for example, a typical macromolecular crystallography sample with 0.1-0.3 mm transverse dimensions and a 3 mrad (0.2°) or larger mosaic spread. Such a sample has approximately an $(0.5\ \text{mm-mrad})^2$ acceptance phase space. As depicted in figure 4, integrating the source phase space over this sample acceptance phase space yields the flux that can be imaged onto the sample with ideal optics.

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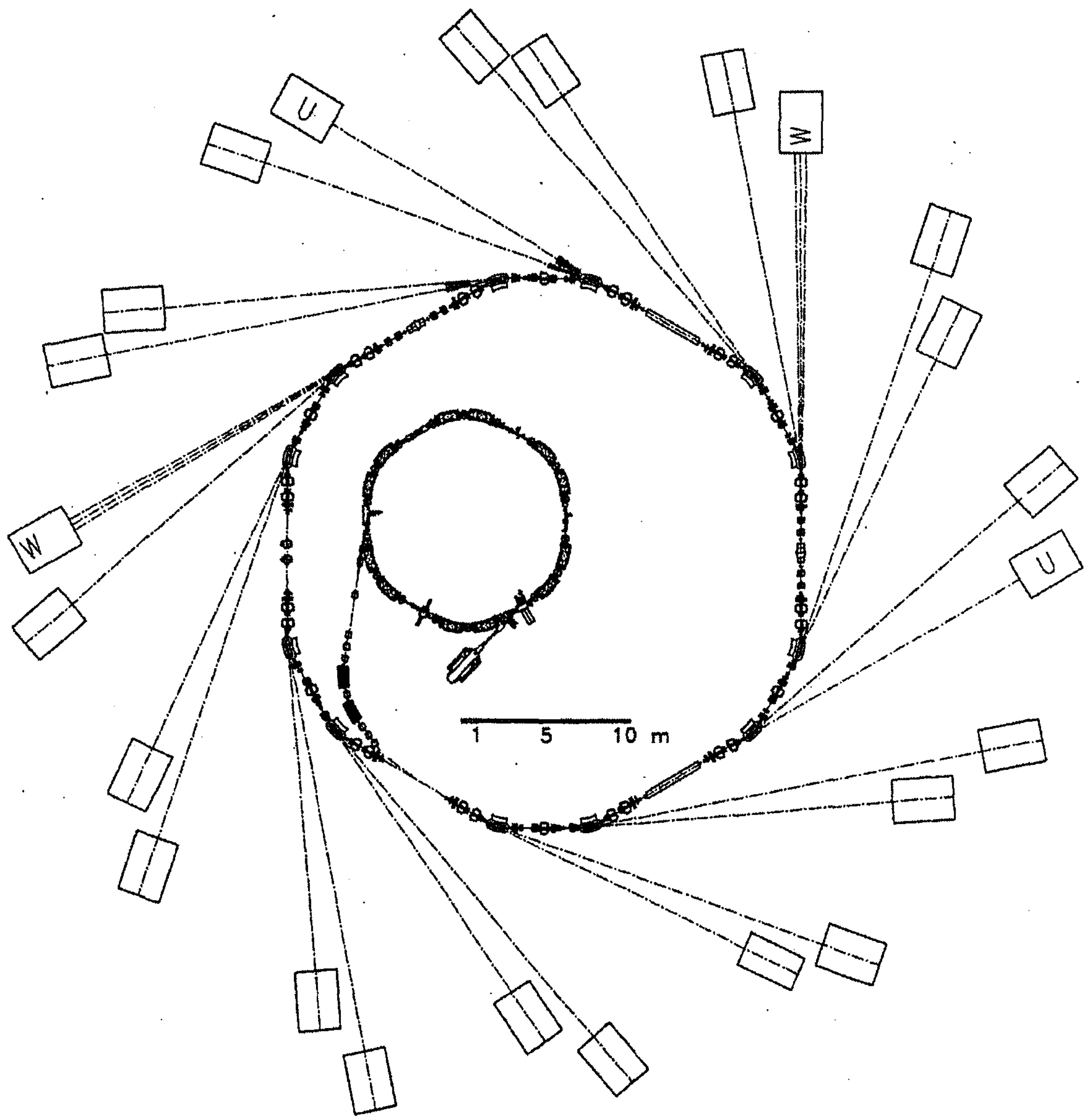

Figure 1: Injector and storage ring layout.

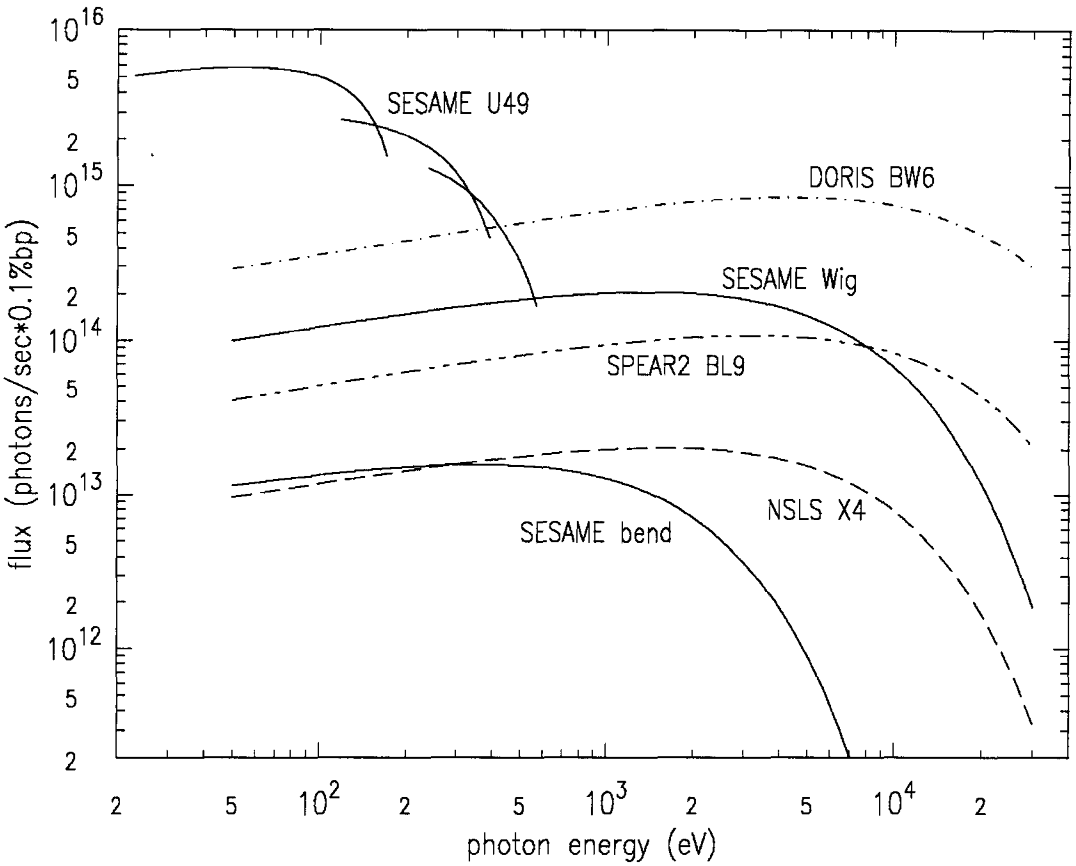

Figure 2: Calculated flux from the six sources listed in Table 1. The U49 spectrum is integrated over the central cone. The other spectra are integrated over 1 mrad horizontal acceptance.

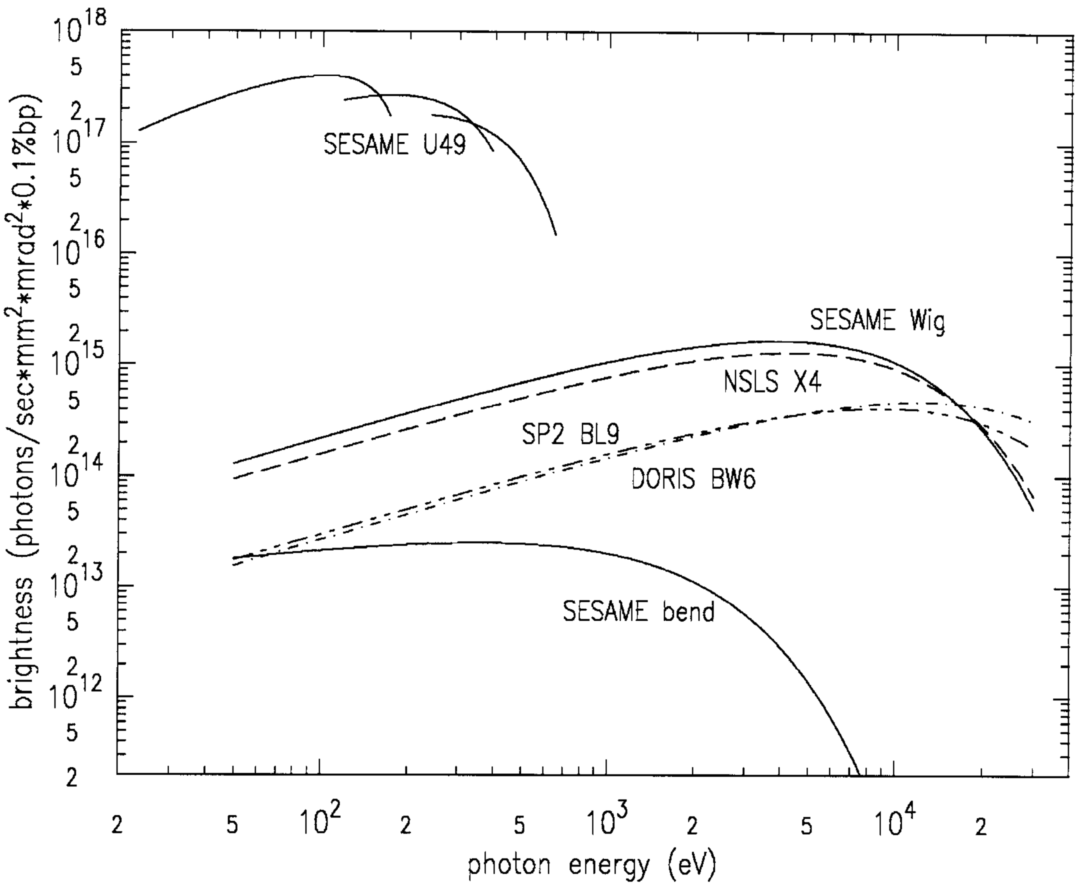

Figure 3: Calculated brightness of the sources in Table 1. The large electron orbit excursion through the SESAME wiggler results in a double-lobed source. Consequently, the brightness calculation for this source employs only 7 poles which is equivalent to assuming the focused x-ray beam will be apertured at the focus to accept only one lobe.

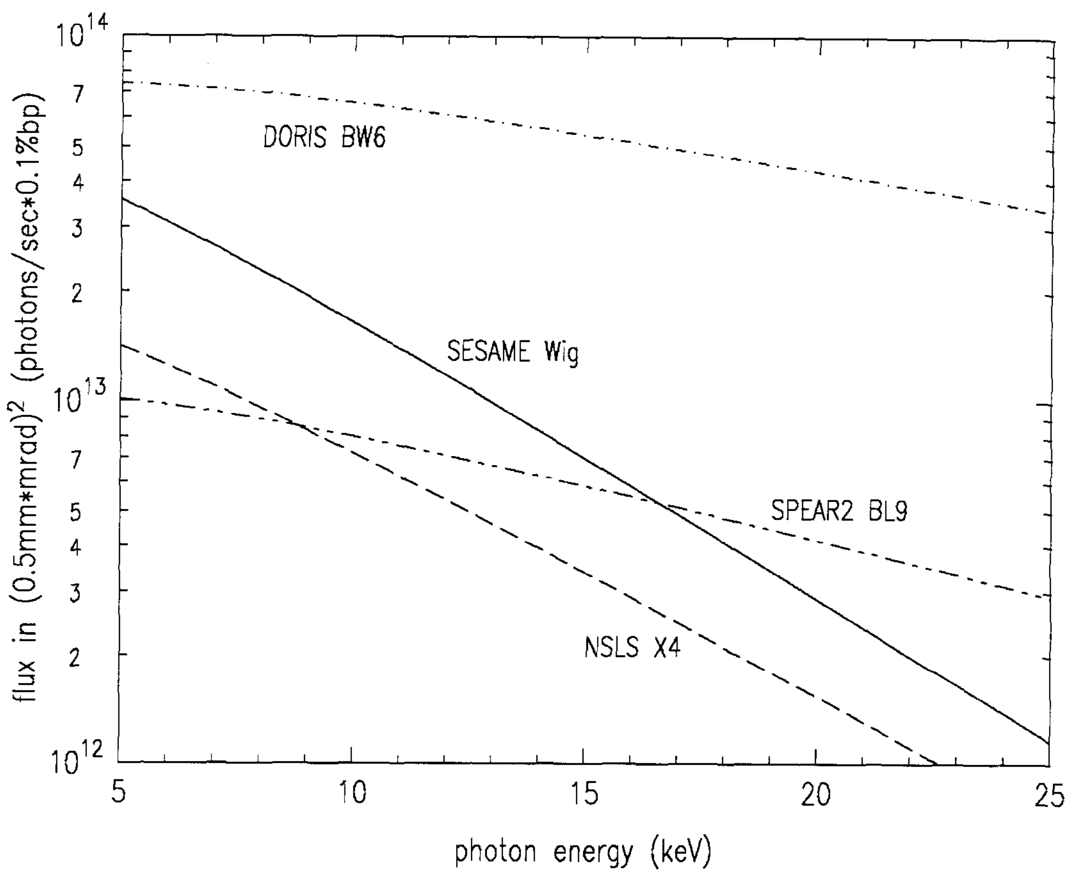

Figure 4: Calculated flux to the sample acceptance phase space of typical protein crystals. The SESAME wiggler spectrum includes contributions from only 7 poles. The apparent theoretical advantage of the DORIS BW6 wiggler is difficult to realize in practice since the beam must be strongly vertically demagnified (~6:1) to match the source vertical size to the sample size.

Table 1: Source characteristics employed in spectra calculations. The NSLS, SPEAR2, and DORIS characteristics assume the existing operating parameters. The latter three sources are representative of non-undulator x-ray sources for macromolecular crystallography.

	SESAME			NSLS X4	SPEAR2 BL9	DORIS BW6
parameter	bend	wiggler	undulator	bend	wiggler	wiggler
energy (GeV)	1			2.584	3	4.5
current (mA)	700			350	100	150
emittance (nm-rad)	50			45	160	440
coupling (%)	2			0.1	1	3
energy spread (%)	0.1			0.085	0.083	0.1
beta_x / beta_y (m)	1.2 / 24.0	4.0 / 0.5	12.0 / 8.0	0.94 / 15.9	20.9 / 1.8	2.0 / 9.2
sigma_x (mm)	0.256	0.438	0.759	0.218	2.071	2.29
sigma_y (mm)	0.155	0.022	0.089	0.027	0.054	0.507
B_peak (T)	1.875	7.5	Kmax=3.84	1.25	1.9	1.17
period (mm)	n.a.	140	49	n.a.	260	140
number periods	n.a.	7	84	n.a.	8	28