Status of SESAME Synchrotron Light Source

H. Tarawneh
Outlines

• Introduction

• SESAME Accelerator Complex
  1- SESAME Storage Ring
  2- SESAME Injector

• Scientific Programme and Beamlines
SESAME STORY

SESAME

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

1997: Original idea (Voss from DESY, Winick from SLAC); Upgrade/rebuild BESSY 1 (0.8 GeV) in the Middle East, as centerpiece for a new international research center.
1998: The UNESCO agrees to support the project
1999: CDR for BESSY Ia with an extended spectral range, SESAME proposal (Green Book)
1999: Site decision: Jordan, Al-Balqa Applied University
2000: Training Program initiated
2001: Jordan will provide the Land, Building and Conventional facilities.
2002: Shipment of BESSY I to Jordan
2002: Decision to build a new 2.5 GeV ring (still using BESSY injector). Yellow Book.
2004: SESAME Centre formal creation.
2008: Building completion.

SESAME Member States:
Jordan, Israel, Egypt, Turkey, Pakistan, Cyprus, Iran, Bahrain and Palestine
2012: Major Capital Funding

- Jordan, Israel, Iran, Turkey: Each country for 5 year: 1.25 M$/Y
  total: 25.00 M$

- EU/CERN (dedicated for storage ring magnets): 5 M$

- Will allow to finalize the storage-ring and Day-One-Beam-Lines
Main Ring Parameters:
Energy = 2.5 GeV
Circumference = 133.2 m
Emitt. = 26.0 nm.rad
16 Straights sections
{8 x 4.44 m + 8 x 2.38 m}
Up to 28 Beamlines:
12 Insertion Devices
16 Dipole ports.

Beamlines length range from 21 m – 36.7 m

BESSY storage ring will not be used.

2.5 GeV Main Storage Ring

Injectors
Storage Ring Girder_One Cell

16 girders
16 Bending Magnets
64 Quadrupoles
64 Sextupoles
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>GeV</td>
<td>2.5</td>
</tr>
<tr>
<td>Circumference</td>
<td>m</td>
<td>133.2</td>
</tr>
<tr>
<td>Maximum Current</td>
<td>mA</td>
<td>400</td>
</tr>
<tr>
<td>Bending Dipole field; gradient</td>
<td>T; T/m</td>
<td>1.45545; -2.794</td>
</tr>
<tr>
<td>Emittance x / z</td>
<td>nm.rad</td>
<td>26 / 0.26</td>
</tr>
<tr>
<td>RF frequency; peak voltage</td>
<td>MHz; kV</td>
<td>499.564; 2.4</td>
</tr>
<tr>
<td>Natural bunch length</td>
<td>cm</td>
<td>1.16</td>
</tr>
<tr>
<td>Expected Beam Lifetime</td>
<td>h</td>
<td>18</td>
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</table>
## Beam Sizes and Angular Divergences

<table>
<thead>
<tr>
<th></th>
<th>Long straight / Short straight / Dipole</th>
<th>µm</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Horizontal Beam Size (σₓ):</strong></td>
<td></td>
<td></td>
<td>794.8 / 789.7 / 232.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>µm</td>
<td></td>
</tr>
<tr>
<td><strong>Vertical Beam Size (σ₂):</strong></td>
<td></td>
<td></td>
<td>28.1 / 16.6 / 71.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>µrad</td>
<td></td>
</tr>
<tr>
<td><strong>Horizontal Beam Divergence (σₓ′):</strong></td>
<td></td>
<td></td>
<td>45.3 / 45.9 / 260.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>µrad</td>
<td></td>
</tr>
<tr>
<td><strong>Vertical Beam Divergence (σ₂′):</strong></td>
<td></td>
<td></td>
<td>9.0 / 15.2 / 12.1</td>
</tr>
</tbody>
</table>
Radiation from Bending Magnets, Wigglers and Undulators

FLUX

Photon energy (KeV) vs. Photons/sec/0.1% BW for different configurations:
- In-Vacuum (6mm gap) Undulator, 25mm
- Wiggler, 3.5T, 60mm
- Wiggler, 2.5T, 120mm
- Undulator, 40mm
- Bending, 2.5GeV
BRILLIANCE

Photons/s/mm²mrad²*0.1BW

- In-Vacuum (6mm gap) Undulator, 25mm
- Undulator, 40mm
- Wiggler, 3.5T, 60mm
- Wiggler, 2.5T, 120mm
- Bending, 2.5GeV
The Radiation Shielding Wall is complete!
SESAME Storage Ring Magnet System

SESAME Storage Ring Cell (16 cells in total)
- Optimized cross section with 1.4554 T and -2.79T/m with iron Loss of 3.2 %.
- The “same” effective magnetic length along the transverse position of the electron beam within ±20mm

\[
L_{\text{eff}}(x) - L_{\text{eff}}(x=0)
\]

Horizontal position in the magnet Median Plane [ mm ]
An iron length of 100 mm for QD (10T/m) and 280 mm for QF (17T/m) with same lamina.

Power supplies ratings will be for 115% of the nominal quadrupole strength value for QF and 150% for QD.

Unsaturated up to 21T/m (20%)
Minimum iron length of 100mm SF and SD with same lamina cross section.
Chromaticity of +1 in both planes SD=220T/m² and SF=150T/m².
Max. 25% increase in power supplies rated power.
Correctors and skew quad coils integrated in both families.

Unsaturated up to 470T/m² (53%)
Conceptual Design Study: EPU for SESAME

On-axis Field

Circular Polarizing Flux

Flux Density [T]

-150 -100 50 100 150

Circular Polarization

Brilliance

[Photon/s/mm²/mrad²/0.1% BW]

Photon Energy [eV]

10 100 1000 10000
Modal Analysis

Frequency (Hz)

<table>
<thead>
<tr>
<th>Mode</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
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<tbody>
<tr>
<td></td>
<td>44.2</td>
<td>66.7</td>
<td>67.9</td>
<td>68.7</td>
</tr>
</tbody>
</table>
Crotch absorber

Arc vacuum chamber

SESAME Storage Ring Vacuum System

SR nominal pumping speed 20400 l/s
The RF system is based on ELETTRA type cavity

2 RF cavities of ELETTRA (4 is needed for nominal performances)

Storage ring RF system in phase 2, i.e. feeding 4 cavities each by 150 kW.

Collaboration with SOLIEL to build 500 MHz Solid state amplifiers.
CONTROL SYSTEM

Supervision / Control:
- EPICS V 3.14

Middle layer:
- Matlab and Labview

VME system:
- Emerson CPU
- Hytec I/O boards
  - VxWorks 6.9

IBM virtual Server with Scientific Linux

MOXA terminal Server

SIEMENS S7-300 PLC for PSS

Direct on Ethernet

Equipment:
- I-tech Libera Module...

Micro-Research Finland timing system
Total beamline length = 2 [4.2m (source-1st mirror) + 1.1m (1st-2nd mirror)+0.4m (1st mirror-lens)] =11.4 m.
Injector

Microtron & Booster Synchrotron
Microtron in Operation

Beam in the transfer line 22MeV
Sept. 2012
# Booster Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum energy, MeV</td>
<td>800</td>
</tr>
<tr>
<td>Injection energy, MeV</td>
<td>20</td>
</tr>
<tr>
<td>Circumference, m</td>
<td>38.4</td>
</tr>
<tr>
<td>Super periodicity</td>
<td>6</td>
</tr>
<tr>
<td>Number of bending magnets</td>
<td>12</td>
</tr>
<tr>
<td>No. of focusing quadrupoles</td>
<td>12</td>
</tr>
<tr>
<td>No. of defocusing quadrupoles</td>
<td>6</td>
</tr>
<tr>
<td>Repetition rate, Hz</td>
<td>1</td>
</tr>
<tr>
<td>Horizontal tune, $Q_x$</td>
<td>2.22</td>
</tr>
<tr>
<td>Vertical tune, $Q_y$</td>
<td>1.30</td>
</tr>
<tr>
<td>Momentum compaction factor $\alpha$</td>
<td>0.18</td>
</tr>
<tr>
<td>Harmonic number</td>
<td>64</td>
</tr>
<tr>
<td>RF-frequency, MHz</td>
<td>500</td>
</tr>
<tr>
<td>RF-output power, kW</td>
<td>2</td>
</tr>
<tr>
<td>Cavity shunt impedance, MΩ</td>
<td>3</td>
</tr>
<tr>
<td>Current @maximum energy, mA</td>
<td>7</td>
</tr>
<tr>
<td>Vertical emittance, mm-mrad</td>
<td>0.016</td>
</tr>
<tr>
<td>Horizontal emittance, mm-mrad</td>
<td>0.155</td>
</tr>
</tbody>
</table>

| Energy (MeV)        | 800 |
| Circumference (m)   | 38.4|
| Horizontal Emittance (nmrad) | 155 |
| Vertical Emittance  (nmrad) | 16  |
| $\alpha$            | 0.18|

800MeV BESSY I Booster Synchrotron
Booster Installation

- **Major Upgrades:**
  1. New DC & Pulsed Power supplies.
  2. New vacuum system (VC, IP, ...).
  3. Control and Timing system.
  4. New Diagnostics.

- **Installation started June 2012.**
As for the tracking QF vs Dipole, once the offset is tuned on the quadrupole power Supply, the tracking error measurement ($\pm 2.10^{-3}$) remains very stable while the power supplies are running.
New Vacuum Chamber of Booster

- Rep. Rate of 1 Hz instead of 10 Hz.
- All vacuum chambers of bending magnets are going to be changed with different wall thickness. As a result the induced sextupole field budget will be changed, i.e. chromaticity change.
- Chamber thickness of 1mm instead of 0.3mm of the old one.
Scientific Programme @ SESAME
Science with Day-One Beamlines:

- Structural Molecular Biology.
- Electronic Materials and Devices
- Energy Production, Storage and Conversion.
- Material Chemistry.
- Nanotechnology.
- Environmental Sciences.
- Archeology.
## SESAME PHASE – I BEAMLINES

<table>
<thead>
<tr>
<th>Beamline</th>
<th>Energy Range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein Crystallography <em>(PX)</em></td>
<td>4 – 14 keV</td>
<td>Bending Magnet</td>
</tr>
<tr>
<td>X-ray Absorption Fine Structure &amp; X-ray Fluorescence <em>(XAFS/XRF)</em></td>
<td>3 – 30 keV</td>
<td>Bending Magnet</td>
</tr>
<tr>
<td>Infra-red Spectro-microscopy <em>(IR)</em></td>
<td>0.01 – 1 eV</td>
<td>Bending Magnet</td>
</tr>
<tr>
<td>Powder Diffraction <em>(PD)</em></td>
<td>3 – 25 keV</td>
<td>MPW</td>
</tr>
<tr>
<td>Soft X-ray</td>
<td>0.05 – 2 keV</td>
<td>EPU</td>
</tr>
<tr>
<td>Small and Wide Angle X-ray Scattering <em>(SAXS/WAXS)</em></td>
<td>8 – 12 keV</td>
<td>Bending Magnet</td>
</tr>
<tr>
<td>Extreme Ultraviolet <em>(EUV)</em></td>
<td>10 – 200 eV</td>
<td>Bending Magnet</td>
</tr>
</tbody>
</table>
Day-One Beamlines

IR Beamline
D03 – 26.9 m

PX Beamline
D07 – 36.4 m

XRF Beamline
D09 – 34.3 m
At SESAME, IR radiation will be collected from Constant Field & Edge Radiation.

Opening of 17 mrad vertical and 39 mrad horizontal.

Note: SOLEIL is running 500 mA, and an 20 mrad V x 78 mrad H
ESRF is running 200 mA, and 8 mrad V x 15 mrad H
THANK YOU

Many thanks to A. Nadji, H. Hoorani, E. Huttel from SESAME for some materials to this presentation.