Status of the Australian Synchrotron Project

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Facility Overview

Accelerator Systems

Initial Beamlines

Accelerator Commissioning

Storage Ring Performance

Conclusions
The Australian Synchrotron is a synchrotron light facility based on a 3-G electron storage ring.

Located in metropolitan Melbourne.

Built by a project team from Major Projects Victoria (MPV), a part of the Victorian State Government.

The funding for the building and accelerators has been provided by the Victorian State Government.

The initial nine beamlines are being funded by a group of interested parties, including universities, research organisations, other state governments, and New Zealand.

Storage ring commissioning, and beamline installation and commissioning continue through March 2007, after which the facility will become operational.
Relatively small staff of 54 people.

Specialist contractors and consultants used.

Design and project management responsibility has been placed on suppliers with turn-key contracts.

Contracts for the following systems included installation and commissioning:

- Injection system
- Storage ring RF system
- Storage ring vacuum vessels
- Beamline photon delivery systems
- Storage ring girders
- Front ends
<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design announced</td>
<td>January 2003</td>
</tr>
<tr>
<td>Building contract placed</td>
<td>July 2003</td>
</tr>
<tr>
<td>Building complete</td>
<td>February 2005</td>
</tr>
<tr>
<td>Staff move into building</td>
<td>March 2005</td>
</tr>
<tr>
<td>Installation begins</td>
<td>April 2005</td>
</tr>
<tr>
<td>Injection system commissioning begins</td>
<td>October 2005</td>
</tr>
<tr>
<td>Storage ring installation complete</td>
<td>May 2006</td>
</tr>
<tr>
<td>Storage ring commissioning begins</td>
<td>June 2006</td>
</tr>
<tr>
<td>First turns in the storage ring</td>
<td>June 2006</td>
</tr>
<tr>
<td>Samline installation begins</td>
<td>September 2006</td>
</tr>
<tr>
<td>Samline commissioning begins</td>
<td>February 2007</td>
</tr>
<tr>
<td>Transition to operations</td>
<td>April 2007</td>
</tr>
<tr>
<td>Classification</td>
<td>Value</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Electron Source</td>
<td>Linac</td>
</tr>
<tr>
<td>Energy (keV)</td>
<td>90</td>
</tr>
<tr>
<td>Frequency</td>
<td>0.1 [GeV]</td>
</tr>
<tr>
<td>Harmonic Pre-buncher Frequency</td>
<td>2997.92 [MHz]</td>
</tr>
<tr>
<td>Injection rate</td>
<td>1-5 [Hz]</td>
</tr>
<tr>
<td>Normalised Emittance &lt;50π [mm·mrad]</td>
<td></td>
</tr>
<tr>
<td>Charge (short/long)</td>
<td>&gt;0.31/&gt;3.1 [nC]</td>
</tr>
</tbody>
</table>
Booster Function Lattice

Energy $0.1 \rightarrow 3.0[\text{GeV}]$

Length 130.2[m]

Frequency 499.654[MHz]

Chromatic Number 217

Bunch Current $>0.5[\text{mA}]$

Bunch Train $>5.0[\text{mA}]$

Proton Tune (h/v) 9.2/3.25

Long Chrom. (h/v) -8.8/-11.5

Energy Spread (3GeV) 0.094[%]

Transverse Emittance 33[nm rad]
<table>
<thead>
<tr>
<th><strong>Parameter</strong></th>
<th><strong>Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>3[GeV]</td>
</tr>
<tr>
<td>Circumference</td>
<td>216[m]</td>
</tr>
<tr>
<td>RF Frequency</td>
<td>499.654[MHz]</td>
</tr>
<tr>
<td>Harmonic Number</td>
<td>360</td>
</tr>
<tr>
<td>Peak RF Voltage</td>
<td>3.0[MV]</td>
</tr>
<tr>
<td>Current</td>
<td>200[mA]</td>
</tr>
<tr>
<td>Critical Photon Energy</td>
<td>7.8[keV]</td>
</tr>
<tr>
<td>Storage Ring Tune (h/v)</td>
<td>13.3/5.2</td>
</tr>
<tr>
<td>Momentum Compaction</td>
<td>0.002</td>
</tr>
<tr>
<td>Natural Chromaticity (h/v)</td>
<td>-28/-27</td>
</tr>
<tr>
<td>Radiation Damping (h/v/l)</td>
<td>3/5/3[ms]</td>
</tr>
<tr>
<td>Energy Spread</td>
<td>0.1[%]</td>
</tr>
<tr>
<td>Radiation Loss Per Turn</td>
<td>932[keV]</td>
</tr>
<tr>
<td>Horizontal Emittance</td>
<td>7-16[nm·rad]</td>
</tr>
</tbody>
</table>
combined function dipoles
variable emittance with dispersion
electro-coils on sextupoles
Controls

EPICS control system

Different control systems from contractors

All EPICS compatible

Accelerator Toolbox running in the Matlab environment is used

Matlab Channel Access makes process variables available in Matlab

Matlab scripts automate measurements
Diagnostics

BPMs per sector

- First-turn, turn-by-turn, and slow acquisition simultaneously
- Horizontal and vertical scrapers
- Horizontal and vertical stripline detectors

DCCT
- beam loss monitor system
- X-ray diagnostic beamline
- Optical diagnostic beamline

- Streak camera
- ICCD camera
- Fill pattern Monitor
XDB

Schematic layout of the X-Ray Diagnostic Beamline

Be window
pinholes
x-rays

filters

Kodial window
mirror

YAG

vacuum
air

CCD

beam

$d1 = 3.4 \text{ m}$

$d2 = 6.8 \text{ m}$
Schematic layout of the Optical Diagnostic Beamline
There are nine beamlines planned:

<table>
<thead>
<tr>
<th>Beamline Code</th>
<th>Description</th>
<th>Magnetic Field Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>R*</td>
<td>Infrared Spectroscopy</td>
<td>Bending Magnet</td>
</tr>
<tr>
<td>BM*</td>
<td>Protein Crystallography 1</td>
<td>Bending Magnet</td>
</tr>
<tr>
<td>ID</td>
<td>Protein Crystallography 2</td>
<td>In-vacuum undulator</td>
</tr>
<tr>
<td>ID</td>
<td>Imaging &amp; Medical Therapy</td>
<td>Superconducting wiggler</td>
</tr>
<tr>
<td>ID</td>
<td>Microspectroscopy</td>
<td>In-vacuum undulator</td>
</tr>
<tr>
<td>0BM*</td>
<td>Powder Diffraction</td>
<td>Bending Magnet</td>
</tr>
<tr>
<td>2ID*</td>
<td>X-ray Absorption Spectroscopy</td>
<td>Wiggler</td>
</tr>
<tr>
<td>3ID</td>
<td>Small &amp; Wide Angle X-ray Scattering</td>
<td>In-vacuum undulator</td>
</tr>
<tr>
<td>4ID*</td>
<td>Soft X-ray Spectroscopy</td>
<td>APPLE II Undulator</td>
</tr>
</tbody>
</table>

Beamlines under construction
Injection System

Commissioning included in contract

SP personnel actively involved

Microwave klystrons started in September 2005

First electrons from the gun October 2005.

First linac beam December 2005.

First beam into the booster February 2006

Booster ramp developed during March 2006

First 3 GeV beam April 2006.
First electrons from gun
First 100 MeV beam
First 3 GeV beam
Routine operations
Not included in the injection system commissioning
first beam in BTS in the storage ring tunnel June 1, 2006
first turn in the storage ring on June 8, 2006.
First beam was stored July 14, 2006.
Current was immediately stacked to 1 mA
Routine injections to 10 mA in first week
Diagnostics equipment commissioned and storage ring characterization began
10 mA has been stored with a lifetime of 6.5 hours (after the first of the insertion
device chambers has been installed)
The first insertion device is installed and has been run with the minimum gap of
1 mm with 100 mA in the storage ring
Second insertion device chamber installed and lifetime at 200 mA unchanged
First electrons into storage ring
First turn in the storage ring
First light 03:00 July 14 2007
Storage Ring Lifetime Conditioning

Current distributed to ~300 buckets

ID vessel installed in Sector 12

ID vessel installed in Sector 14

Dose [AmpHrs]
Optics Correction

Vertical Beta Function Comparison

- Calibrated model beta function
- Beta function measured by QDA

Vertical Beta Function After Quadrupole Correction

- Calibrated Model Vertical Beta Function
Distributed Dispersion Optics

Dispersion in \( x \) (zero dispersion lattice)

Dispersion in \( x \) (distributed dispersion lattice)
Response Matrix used to characterize wiggler

Difference between 205mm wiggler measured response matrix and 14mm wiggler measured response matrix
Emittance

horizontal sigma = 108.32 um
position = 105.48

vertical sigma = 84.28 um
position = 87.00

$\sigma_x = 108.32$ \text{ um}
$\sigma_y = 84.28$ \text{ um}
$\varepsilon_x = 17.52$ \text{ nm}
$\varepsilon_y = 0.22$ \text{ nm}
The Australian Synchrotron Project has been very successful. There is still work to be done before becoming an operational facility.

A small team of dedicated staff have done an excellent job:

- Writing the specifications for the contracts
- Working with the contractors
- Integrating all of the systems

This has led to a smooth commissioning according to the project schedule.