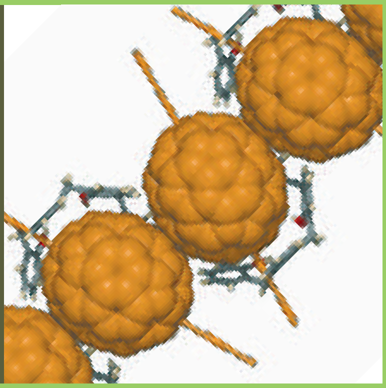
04



Proposed initial suite of beamlines and cost estimates

IMAGE: Fullerenes

Structure of a complex between fullerene C70 and a cavitand molecule, calix[5]arene.

A recent example of the capability of a synchrotron source is the determination of the structure of a complex between fullerene C70 and a cavitand molecule, calix[5]arene, which is important in understanding molecular recognition/purification of the fullerene, and also in building up new material with novel function. Data was collected at the SRS facility, UK, with the small crystals (10 microns) too weakly diffracting for data collection from conventional x-ray sources.

Chapter 04

Proposed initial suite of beamlines and cost estimates

The versatility of synchrotron light enables many different experimental techniques to be used, each technique requiring a separate dedicated beamline.

It is proposed that the Australian Synchrotron should commence with a core suite of between nine and thirteen world class beamlines. As the user community grows and as new techniques are developed (synchrotron science is moving rapidly) further lines will be established. In the long term the lattice has the potential to accommodate in excess of 30 different beamlines.

In some American synchrotrons (notably the Advanced Photon Source in Chicago and the Advanced Light Source in San Francisco) the beamlines have been funded and constructed by groups separate from the core synchrotron operators. Experience has shown however that this results in unnecessary duplication, and also that many of the beamlines have been designed to perform too many functions, which adds extra complication and expense. To avoid this, it is proposed to construct a comprehensive and complementary range of specialist beamlines for the Australian Synchrotron and to provide scientific and technical support for the broad community of users. Wherever possible common equipment should be used – particularly vacuum equipment, electronic controls and data handling software and hardware – to simplify and reduce maintenance costs. In deciding the beamlines to establish initially the objective is to create a suite of techniques that would cover 95% of the Australian scientific community's anticipated needs.

A National Scientific Advisory Committee (NSAC) and an International Scientific Advisory Committee (ISAC) – comprising senior scientists experienced in synchrotron research – have guided the selection, and the research groups currently working through the Australian Synchrotron Research Program (ASRP) have been extensively consulted. NSAC has met on six occasions, ISAC has had two major meetings, and members of both committees participated in a large workshop attended by 350 delegates in January 2003. Resulting from all of these discussions, the thirteen beamlines listed in table 4.1 have been recommended as the optimum configuration for Australia's scientific and industrial needs. Page vi lists the members of the advisory committees. Beamlines 3, 5, and 10 will require wigglers and 2, 4, 6, 7, and 9 will require undulators for their radiation source. These insertion devices add significant expense and need to be individually commissioned, so their beamlines are likely to be introduced progressively in the construction schedule. At 'first light' it would be expected to have beamlines 1, 3, 5, 8, 9, 11 and 13 operating (High-throughput Protein Crystallography, Powder X-Ray Diffraction, X-ray Absorption Spectroscopy, Infrared Spectroscopy, Microspectroscopy, Microdiffraction and Fluorescence Probe and Lithography), with beamlines 2, 4, 6 and 10 (Protein Microcrystal and Small Molecule X-ray Diffraction, Small and Wide Angle X-Ray Scattering, Soft X-ray Spectroscopy, and Imaging and Medical Therapy) under construction and progressively introduced during 2007 and 2008.

Once these core beamlines are commissioned, it is planned that beamlines 1 and 3 will be upgraded to operate from an in-vacuum undulator and wiggler respectively, beamline 10 will be extended and beamlines 7 (Vacuum Ultraviolet) and 12 (Circular Dichroism) will be established.

Table 4.1. Proposed initial suite of beamlines for the Australian Synchrotron

No	Category	Beamline Description	Source	Energy Range
		Crystallography & Diffraction		
1	A	High-throughput Protein Crystallography	Bending magnet	2–23 keV
2	A	Protein Microcrystal & Small Molecule X-ray Diffraction	In-vacuum undulator (22 mm period)	5.5–20 keV
3	A	Powder X-ray Diffraction	Stage 1: Bending magnet Stage 2: Wiggler	4–60 keV
4	A	Small and Wide Angle X-ray Scattering	In-vacuum undulator (22 mm period)	5.5–20 keV
		Spectroscopy		
5	A	X-ray Absorption Spectroscopy	Wiggler (2T)	4–65 keV
6	A	Soft X-ray Spectroscopy	Undulator (75 mm period)	0.1–2.5 keV
7	B	Vacuum Ultraviolet (VUV)	Undulator (185 mm period)	10–350 eV
8	A	Infrared Spectroscopy	Bending magnet	0.001–1 eV (2–10,000 cm^{-1})
9	A	Microspectroscopy (submicron-XAS, XANES, & XRF)	In-vacuum undulator (22 mm period)	5–20 keV
		Imaging		
10	A, B	Imaging & Medical Therapy	Wiggler (4T)	10–120 keV
11	C	Microdiffraction and Fluorescence Probe (XRD & XRF mapping)	Bending magnet	4–37 keV
		Polarimetry		
12	B	Circular Dichroism	Bending magnet	2–10 eV
		Advanced Manufacturing		
13	C	Lithography	Bending magnet	2–25 keV

Category A: Nine general purpose beamlines are considered to be essential to be available or under construction at the commissioning of the synchrotron in 2007. This suite is selected to ensure access by the widest possible discipline groupings to photons from low energies (infrared) to high energies (x-rays) to achieve balance between physical and biological scientific investigations.

Category B: Beamlines 7 and 12 are considered to be highly desirable in order to have a balanced set of capabilities for the synchrotron. In addition it is planned that, after beamline 10 is fully established and proven, it should be extended out to a separate building equipped for full-body medical imaging research and that beamline 1 should be up-graded to be sourced from an in-vacuum undulator. Mechanisms to fund these lines will be sought once funding for the first nine beamlines is achieved.

Category C: These two beamlines are viewed as high throughput facilities, principally to service the diagnostic and production needs of industry. A funding plan is being developed for these beamlines based upon a combination of capital contributions and cost recovery fees.

Capital cost estimates for the beamlines

Preliminary cost estimates for the design, construction and commissioning of the beamlines are given in Table 4.2.

Work is continuing on the specifications for each beamline, and as details are finalised these cost estimates will be refined. Appendix 1 contains costing breakdowns for each beamline.

Cost estimate assumptions

Items that are included in the budget for the machine and as such are not included in Table 4.2:

- the 'front end' equipment (i.e. vacuum equipment, interlocks, controls and electronic equipment on the inner side of the shielding wall)
- a distributed liquid nitrogen system
- the labour costs of the beamlines manager and corporate technical staff. (However, an allowance has been included for labour for design, construction and commissioning of each beamline.)
- costs for survey and alignments, vacuum and control interfacing with the machine and radiation monitoring.

Prices quoted are in current Australian dollars. Conversion rates used:

$A1 = $US0.65

$A1 = $CAN0.90

$A1 = GBP 0.385

$A1 = Euro 0.58

$A1 = Yen 75

Table 4.2 Preliminary cost estimate for the initial suite of beamlines

BL	Title	Category A	Category B	Category C
		$(A)	$(A)	$(A)
1	High throughput Protein Crystallography	5,823,000	1,655,000	
2	Protein Microcrystal & Small Molecule Diffraction	7,983,000		
3	Powder Diffraction	5,300,000		
4	Small & Wide Angle Scattering	4,785,000		
5	X-ray Absorption Spectroscopy	5,110,000		
6	Soft X-ray	4,939,000		
7	Vacuum UV		4,990,000	
8	Infrared Spectroscopy	2,600,000		
9	Microspectroscopy	5,339,000		
10	Imaging & Medical Therapy	7,610,000	5,120,000	
11	Microdiffraction and Fluorescence Probe			3,442,000
12	Circular Dichroism		3,100,000	
13	Lithography			4,240,000
Total		**49,489,000**	**14,865,000**	**7,682,000**

Contingency

No contingency has been made for currency fluctuation or uncertainties of the cost of components. Synchrotron technology is evolving rapidly and it is possible that by 2006 some devices may be of lower cost; however this is impossible to predict at present.

Operating Costs

The annual operating costs of a synchrotron comprise the fixed costs to maintain and operate the machine and associated infrastructure as a leading-edge facility and costs associated directly with the functioning beamlines. The cost of operating the total facility has been estimated as being around $15 million per year (real 2003) on commencement of operations in 2007 rising to around $17 million per year (real 2003) in the more mature operating phase.

Operating costs associated with the mature synchrotron can be considered in two broad categories:

- scientific, technical and management staff; and
- general operating costs.

The approximate full-time employee requirement for the Australian Synchrotron with 12 to 13 beamlines is around 80 staff. The majority will be employed directly on the storage ring or the beamlines.

General operating cost categories include:

- administration and consumables
- computing and office equipment
- workforce support (non-salary items: recruitment, training, security, safety etc)
- communication and conferences
- engineering and maintenance
- utilities.

Within the general operating costs a major variable is the level of electricity consumed during operation. This will be determined by the operating approach and the equipment selection, which will in turn affect the conditions for the purchase of electricity.

The development and finalisation with key stakeholders of the coverage of operating costs, and the methods by which these are met will be an important element of future stakeholder discussions. It is expected that the bulk of operating funds, at least in the initial years after commissioning, will be provided predominantly from national science funding sources, with possible contributions from other governments (State and overseas), some research institutions, and the private sector.

Further discussion of possible approaches to financing and management of the facility are contained in chapter 9.

Access to Ancillary Services

The synchrotron will be sited next to Monash University and the Monash cluster, which includes the CSIRO Clayton facilities and the Monash Health Sciences precinct, and not far from the Baker Institute, Melbourne University and the 'Parkville Strip' of research institutes. It is anticipated that ready access can be provided to ancillary services by these institutions and this will enable capital and operating costs to be kept to a minimum.

For example, access will be available to:

- the sample preparation facilities (including growing of protein crystals) at Monash and CSIRO
- the confocal microscopy, electron microscopy and NMR suites at Monash and CSIRO
- the Scanning Nuclear Microprobe facility of the CSIRO, which will be relocated to Melbourne in 2004
- the animal breeding and housing facilities of Monash and Melbourne Universities, and
- several specialised instrument-making workshops.