Australian Synchrotron
Annual Report 2008

The Australian Synchrotron vision – to be the catalyst for the best scientific research and innovation in Australasia

Australian Synchrotron

Highlights

- The Australian Synchrotron building, machine and initial beamlines are completed on time and on budget
- Opening of the Australian Synchrotron by the Premier of Victoria, the Hon John Brumby, and then Federal Minister for Education, Science and Training, the Hon Julie Bishop
- The core facility operates at the capacity of a mature facility in its first full year of operation – exceeding the schedule by nearly two years
- The Australian Synchrotron assets are transferred to ASHCo and ASCo assumes operating control of the synchrotron from 1 November 2007
- Four beamlines are now fully operational with full user programs in place, and four of the five remaining beamlines will move through the experienced user, then open access cycle in early 2009
- Productive relationships established with key partners including consortia members, international agencies and the international science community
- Extensive use of the facility by the scientific community and use of the beamlines continues to grow with 600 user visits (325 unique users) from 32 institutions in Australian and NZ to 30 June 2008 (with less than 30 per cent of the initial beamlines available)
- The Science Advisory Committee and Machine Advisory Group are established
- Vision and mission statements are developed with a strong focus on service to users and the promotion of science excellence
- Staff transfer from Major Projects Victoria to ASCo on 1 May 2008

About this Annual Report

The Australian Synchrotron Company is pleased to publish its first Annual Report. This document covers 2007–08, the first full year of operation of the Australian Synchrotron.

The Australian Synchrotron is managed under a dual entity structure of two companies:

- Australian Synchrotron Holding Company Proprietary Limited (ASHCo) holds the Australian Synchrotron assets
- Australian Synchrotron Company Limited (ASCo) has the exclusive right to manage and operate the Australian Synchrotron assets.

Detailed financial reports have been prepared for these companies and are presented in associated documents included with this Annual Report. These documents are also available from the Australian Synchrotron Company at 800 Blackburn Road, Clayton, Victoria.

This Report details the role, vision and mission of the Australian Synchrotron, as well as the organisation's main 2007–08 achievements and activities. The Report is an important component of the Australian Synchrotron's commitment to keep the public, user communities, Foundation Investors and others informed about the progress and achievements of the Australian Synchrotron.

The Australian Synchrotron seeks to be the catalyst for the best scientific research and innovation in Australasia. The Report sets out the facility's focus on providing a thriving scientific research environment, conducive to creating and nurturing the best scientific outcomes for its users.

In its first full year of operation the Australian Synchrotron has achieved a stable machine and beamlines already producing world class scientific data. The early acheivement of the operating performance criteria for the machine, as reported in the Operations and Accelerator Science section illustrates a facility that is ready to be the catalyst for scientific excellence in the Australasian region.

The Report acknowledges:

- The ongoing commitment and collaborative effort of individuals and organisations in the growing Australasian synchrotron community
- The excellent contribution of our international counterparts to produce a vibrant and efficient Australasian synchrotron
- The expertise and skill of the people who manage and operate the technical facilities that make up the Australian Synchrotron.

This Annual Report is written with a broad readership in mind. It includes a glossary to assist non-scientific readers with the terminology and concepts used in the Report. The Australian Synchrotron welcomes your interest in the facility.

Readers are encouraged to comment on this Report by emailing info@synchrotron.org.au. This Report is a public document and is freely available on the Australian Synchrotron web site www.synchrotron.org.au or by calling +61 3 8540 4100

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"At the Australian Synchrotron we are turning bright ideas into brilliant outcomes."

Year in review

"We believe that the Australian Synchrotron is a damn good machine".

(International Machine Advisory Group)

We are delighted to present to you this first Annual Report of the Australian Synchrotron. The 2007-08 year has been one of great change at the Australian Synchrotron, marked by the progress from construction and commissioning to the commencement of operations. This Report recognises with pride the contribution of those who designed, built and commissioned the facility and charts the course of what has turned out to be an outstandingly successful initial period of operation. We look forward to reporting to you in future years on what has been done to build on this auspicious start.

The 'Stakeholder' section of this Report outlines the financial contribution made by the many partners in this enterprise. Our grateful thanks go to all those who contributed capital funds to the national partnership, initiated by Victoria and in this first year of operations, we particularly recognise the role of the Commonwealth and Victorian Governments which have each contributed $50 million to fund the initial five years of the facility's operations.

The Australian Synchrotron formally entered the scientific world on 31 July 2007, being officially opened by the Premier of Victoria, The Hon John Brumby, and the then Federal Minister for Education, Science and Training, The Hon Julie Bishop.

This launch followed a highly successful project, marked by a record breaking 'construction' phase coupled with broad national financial support. It has been a year of rapid change, with the Australian Synchrotron moving from a Victorian managed project to a national operating science facility, managed on behalf of the Australian and New Zealand stakeholders under a corporate governance structure.

As set out in the Corporate structure and governance section, the two companies established on behalf of the stakeholders to hold the synchrotron assets (ASHCo) and operate the facility (ASCo), came into being in July 2007. Following a period of due diligence, control of the facility passed from the Victorian Government to the companies on 1 November 2007. As the final step in this changeover the staff of the Australian Synchrotron transferred to ASCo on 1 May 2008.

Significantly, the Australian Synchrotron was finished on budget and the core facility has operated at the capacity of a mature facility in its first full year of operation, ahead of schedule by nearly two years. The Australian Synchrotron is now one of fifteen third generation instruments operating across the globe and its performance has proved to be exceptional by world standards. The accelerator, the heart of the instrument, now consistently generates more than 98% light beam availability and places the facility in the top five performing machines worldwide.

Among the main beneficiaries of this excellent performance are the scientists and engineers who utilise the quality light through the nine beamlines that have been, or are being, constructed around the ring. Formerly, these scientists had to endure the rigours of 'suitcase science' to carry out their synchrotron experiments. While excellent science was done in short one to three day international trips to overseas synchrotrons, the limited access to the synchrotrons and the pressure on, and sometimes loss of, delicate experimental samples meant that this approach under the Australian Synchrotron Research Programme (ASRP) could not continue to satisfy demand. Now the Australian Synchrotron allows them to undertake more scientific work and be close to home.

Four beamlines are now fully operational with full user programs in place and a further five beamlines will run through the experienced user cycle before moving to open access. This will bring the total number to nine beamlines by 2009, providing an excellent platform to service the needs of the scientific community and to engage with industry.

Use of the facility by the scientific community continues to grow with consistently more applications for beamtime than is available. As at 30 June 2008 over 325 scientists from 32 institutions in Australia and New Zealand had accessed the facility through 600 user visits, even while the facility was operating at only 15% capacity during the construction and commissioning phases. An exceptionally broad range of users from chemists through to mineralogists and physicists to biomedical scientists and forensic investigators have been engaged with this facility. Cross-disciplinary research has become a reality at the Australian Synchrotron.

Outstanding science is already taking place at the Australian Synchrotron. Examples of this are set out later in this Report in the Scientific Overview and Turning Bright Ideas into Brilliant Outcomes sections. A key to the future development of science at the facility is the 'Decadal Plan' developed in 2007 with the science community. The experience gained from 15 years under the ASRP has been used as a foundation for guiding the development of the facility.

Productive relationships have been established with key partners, including consortia members, international agencies and the community of world scientists. Scientists now come from every state of Australia and New Zealand to use the synchrotron. A number of initiatives have been undertaken this financial year to ensure that scientific partnerships, user interactions and community and industry engagement remain at the forefront of activity.

These initiatives include:

- The Science Advisory Committee to the Board, which includes four synchrotron facility directors, was established to provide strategic advice on current and proposed scientific programs
- International research groups began to access the Australian Synchrotron facilities in April 2008
- A number of memorandums of understanding (MOU) have been signed with international agencies. These facilitate the exchange of personnel and scientific and technical collaboration with international synchrotrons and major science facilities
- Community engagement was encouraged, with approximately 600 visits per month
- An open day for the community and friends of the Australian Synchrotron was held in August 2007 to thank workers and others for their contribution to the completion of the project
- In December 2007 more than 350 people attended the annual meeting of synchrotron users and took the opportunity to tour the facility and meet with staff
- The Australian Synchrotron was also the launching point for the Victorian Government's Community Cabinet in April 2008, with the Australian Synchrotron hosting a tour of the facility for State Ministers
- Major educational initiatives for 2007–08 have included:

  An Accelerator Science School and workshop was hosted in March 2008 with invited lecturers from Stanford, Shanghai and CERN

  The bilateral Australian Shanghai Synchrotron Workshop held in May 2008
- A virtual beamline has been developed to give school students web access to experiments designed and operated at Australian Synchrotron.

Most significantly, in its short history, the Australian Synchrotron and its staff have already received awards, including:

- The Australian Synchrotron Research Program Thesis Medal for research excellence was awarded in 2007 to Australian Synchrotron scientist Martin de Jonge for the most outstanding thesis under the auspices of an Australian University
- Gold Medal status, awarded in June 2008, for its approach to risk management following an independent survey of onsite risks at this facility conducted by the Victorian Managed Insurance Authority (VMIA)
- The Safety Scheme of the Year Award presented at the 5th annual national Manufacturers' Monthly Endeavour Awards ceremony for its Personnel Safety System (PSS).

These are just a few key highlights. What follows in the Report is a more detailed overview of the the 'start up' phase for the Australian Synchrotron. Without doubt, the Australian Synchrotron is rapidly becoming a recognised centre for national multi-disciplinary scientific research providing excellent facilities to lead us into the future.

Professor Robert Lamb, Facility Director

Catherine Walter AM, Chairman

The Australian Synchrotron's vision and mission

Underpinning Australian scientific research

The construction of Australia's own synchrotron provides a vital catalyst to important scientific research, with many applications for health, science and industry. The facility opens up a wide range of new avenues for research and will help Australia to remain internationally competitive and a leader in the conduct of scientific research utilising synchrotron light.

Vision:

To be the catalyst for the best scientific research and innovation in Australasia.

The key focus of the facility is on providing a thriving scientific research environment that is conducive to creating and nurturing the best scientific outcomes for the users and the staff of the facility.

Mission:

Develop a world-class synchrotron facility, maximising the quality, breadth and impact of scientific output.

Core values of the Australian Synchrotron

- Passion
- Respect
- Collaboration
- Innovation
- Continuous Improvement

Committed to supporting leading edge research that will advance:

- An environmentally sustainable Australia
- Promoting and maintaining good health
- Frontier technologies for building and transforming Australian industries
- Safeguarding Australia

"The construction of Australia's own synchrotron provides a vital catalyst to important scientific research."

Stakeholders

The Australian Synchrotron owes its existence to the development of a strategic national partnership instituted by the Victorian Government but ultimately involving the Australian Government, New Zealand Government and state governments, research institutes and universities. The Victorian Government made an initial commitment of $157 million in development funds to build the national synchrotron facility.

The Foundation Investors in turn played a crucial role in the establishment of the Synchrotron through the funding of the beamlines program, with each contributing a minimum of $5 million. The Australian Government subsequently committed $14 million through the National Collaborative Research Infrastructure Strategy.

The Australian and Victorian governments have since each contributed $50 million, a total of $100 million for the operating expenses of the Australian Synchrotron for the period 1 July 2007 to 30 June 2012. The New Zealand Synchrotron Group Limited has agreed to contribute $375,000 in 2007–08 and $750,000 per annum for the four years to 2011–12.

The Foundation Investors are set out below. The individual and consortia partners include: the Government of New Zealand; five Australian State Governments; six publicly funded research institutes (four from New Zealand and two from Australia); 33 Universities from Australia and New Zealand; and 36 medical research institutes from the Association of Australian Medical Research Institutes.

Foundation Investors

AAMRI	ANSTO	Victorian Government
CSIRO	Monash University	University of Melbourne

New Zealand consortium:

New Zealand Government	Victoria University of Wellington	University of Auckland	University of Otago	University of Canterbury	Crop Grains Science Limited
University of Waikato	Massey University	Lincoln University	IRL (Industrial Research Limited)	Agresearch	

AUSyn14 consortium:

NSW Government	University of Western Sydney	University of New England	Southern Cross University	Charles Darwin University NT	Charles Stuart University
University of Technology Sydney	University of Canberra	University of NSW	University of Newcastle	University of Wollongong	University of Sydney
University of Tasmania	Macquarie University				

Queensland consortium:

QLD Government	Griffith University	James Cook University	Queensland University of Technology	University of Queensland

South Australian and La Trobe University consortium:

Government of South Australia	Flinders University	University of Adelaide	La Trobe University	University of South Australia

Western Australian consortium:

Government of Western Australia	University of Western Australia	Curtin University

Australian Synchrotron people

It's the people who make the difference

The Australian Synchrotron is justifiably proud of the world class performance of its machine and beamlines however without the commitment, technical expertise and support provided by its dedicated people this would amount to little. The scientists, engineers, technical and corporate support people working at the Australian Synchrotron all contribute to making this one of the best facilities of its type in the world.

The positive strategy of attracting the best minds in the scientific community to continue the development of the facility and to undertake world class research in their own right is vitally important to the ongoing success of the Australian Synchrotron.

The Australian Synchrotron team at 30 June numbered 75 but has subsequently increased to over 100 committed people from 20 nations. The Australian Synchrotron building was constructed by people from 14 different countries. Many languages are spoken at the facility, reinforcing the global flavour of the facility and making the visitors from our user community feel more at home.

The international context has created a distinct culture at the Australian Synchrotron, one that is focused on user support and continues to strengthen as the facility grows.

People development

The Australian Synchrotron's focus on developing intellectual capital drives learning and career development programs, with 40 per cent of staff holding PhDs.

A wide variety of training is undertaken, including technical skills development, support for ongoing formal education and cross-organisational training in project management and occupational health and safety certification.

Since its inception, the Synchrotron has attracted the best of local and overseas talent, with approximately twenty nationalities represented amongst its staff. The last year has also witnessed more than a doubling of staff numbers.

People are supported to undertake professional development opportunities and frequently accept invitations to address Australian and international conferences to share their knowledge with the broader scientific community. Scientists working on beamlines undertake their own research projects within the facility.

Organisation

The Australian Synchrotron brings together a number of highly technical specialist roles that have previously been developed in only a small number of centres around the world. The science, operations and technical support must be tailored to the specialist requirements of a world class synchrotron.

In recognition of this, and considering the overarching requirement for teamwork between the specialist areas, the organisation has been structured to give a high degree of research and development freedom within the specialist areas, while ensuring communication and cooperation among the specialist groups.

In mid 2007 Professor Robert Lamb was appointed as Science Director and subsequently also took on the role of Facility Director. Peter Dawson was appointed Chief Financial Officer in late June 2008. Both officers report to the Board.

Profiles

Richard Farnsworth
Head of Controls and Information Technology

As Head of Controls and Information Technology, Richard Farnsworth is responsible for managing the applications and instrumentation for all the computers that are utilised to make the beamlines work.

But this is not his only passion involving fast moving particles. Richard took particle acceleration to another level when he formed a cycling group at the Australian Synchrotron and led a team of executives on the ride around Port Phillip Bay, a journey of 215 kilometres – the third time a group from the synchrotron participated.

Richard's involvement with the Australian Synchrotron began in 2003 when there was just an old car park, that once was a drive-in movie site, for the facility. "We had a party in a tent to start things off," Richard recalls. Since then he has been working to find the best information technology solutions and software to ensure the facility works efficiently and optimally.

The Australian Synchrotron has overcome many challenges and is now operating at a very high capacity, Richard says.

"One of our first challenges was to find out what software and applications were available and suitable for the synchrotron and what we needed to develop. We were successful in being able to use software that was primarily developed by other synchrotrons from overseas, then integrate that to meet our needs; but we also developed a small number of applications ourselves," Richard said.

"Finding this software also gave us a fast entry into the close community of other people in synchrotrons around the world, doing the same thing – instant friends, colleagues and support groups," Richard said.

"The Australian Synchrotron software control and information systems are among the most sophisticated of their type in the world. All who were involved in setting them up were thrilled when they worked well and came in on time and on budget."

"More than 65 per cent of all software projects fail by being late or too costly. It's a testament to both the dedication and skill of everyone who worked on the Controls and IT side of things including our international collaborators, that the Australian Synchrotron's applications work so well and so reliably," Richard says.

Sergio Costantin, Radiation Safety Officer

The Australian Synchrotron has a range of physical and operational safety systems to make sure that the Australian Synchrotron is safe and that everyone who works there: staff, users and visitors are completely safe.

Sergio is often asked whether the Australian Synchrotron is dangerous. "The radiation levels, most of the time, are very low and not much different from levels outside the facility. It's only in the accelerator equipment tunnels and the beamline enclosures where there may be significant radiation levels."

Sergio has a degree in Physics and came to the Australian Synchrotron from the Victorian Radiation Regulator. His role requires him to liaise with the Regulator to ensure that all regulatory requirements and safety standards are being met or exceeded. He was involved with the establishment of the Australian Synchrotron and says there are still issues ahead to ensure that the radiation levels continue to be as low as possible.

"We also face challenges outside of radiation; standard workplace hazards such as falls and electrocution also need to be addressed," Sergio said. "So the occupational health and safety team is continuously monitoring and reviewing safety performance. Safety is and must be seen to be everyone's responsibility," Sergio concluded.

Dr Kia Wallwork, Principal Scientist Powder Diffraction Beamline

Dr Kia Wallwork is Principal Scientist for the powder diffraction beamline. Her job involves overseeing the original design for the beamline, managing the installation phase and now supervising the operations of the beamline.

"My job involves supervising and assisting the many groups of scientists who are granted access to the beamline," she explains.

"I may help the scientists by instructing them on how to use the beamline or I may be able to assist them in modifying their experiments so that the will get the best possible results."

Dr Wallwork loves a challenge and says that one of the best parts of her job is solving difficult problems.

"I love it when there is a challenging problem concerning an experiment with the beamline that we need to solve, and we can work out different ways of achieving desired results."

The recruitment of suitably qualified and skilled staff has been an important step in establishing the synchrotron.

"Because there are not many scientists in Australia who have the extensive training needed, we have also had to recruit some scientists from overseas to work here. It has not been too difficult to find the right people, as working at the Australian Synchrotron is a wonderful opportunity for many scientists interested in this field of research," Dr Wallwork said.

The brightest light in the Southern Hemisphere

What is a synchrotron?

A synchrotron is a machine that produces intense light. Infra-red, visible, ultra-violet and x-ray wavelengths are generated by electrons orbiting a large ring in a hollow airless tube at speeds close to that of light. Strong magnetic fields keep these electrons in a stable orbit and high-power microwaves stop them from slowing down with each successive lap.

At each place around the ring where the electrons are steered by a magnet, a beam of light is produced. Beamlines placed in these positions allow researchers to make use of the light's properties. On different beamlines, separate groups of scientists can simultaneously perform different measurements, each selecting a wavelength of light tailored to their specific experiment. The resulting measurements are vastly superior to those obtained from lab-based infrared, ultraviolet and x-ray sources.

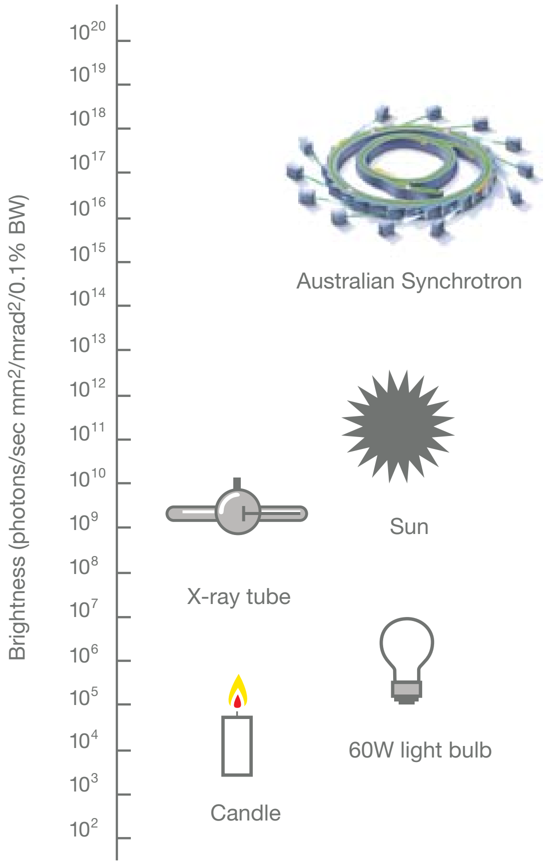


Figure 1:
This diagram compares the light brightness from a synchrotron with other sources of light.

Opening up a wide range of possibilities

In addition to the bending magnets that steer the electrons there are other magnetic devices known as undulators and wigglers. These insertion devices are what makes this a third-generation synchrotron – giving some of the most intense beams of light available in the world.

The intense light beams generated by the Australian Synchrotron offer a wide range of new research possibilities across many sectors ranging from fundamental science to industry applications. The facility's advanced instrumentation provides for rapid throughput and real-time analysis of chemical, mineral and biological samples under a wide range of experimental conditions. While most users of these laboratories perform their experiments on-site, there is also a growing capability for remote access where users in another state or country can control experiments from their home facility.

It is expected that, once fully developed, the techniques available from the initial suite of beamlines will meet more than 90 per cent of the needs of the Australian and New Zealand research community for synchrotron science.

Benefits for Australian scientists

Although these techniques are available at a number of synchrotrons overseas, the competitive advantages of the Australian Synchrotron are:

- World-class capability available within short travel times
- Australian researchers are able to bring samples to the Australian Synchrotron without the complication of customs clearance requirements
- Availability of skilled staff at the Australian Synchrotron beamlines to ensure successful experimental work
- Support provided for travel and accommodation arrangements and costs.

The Australian Synchrotron is benefiting researchers through:

- Significantly higher quality data than is available with conventional laboratory techniques, resulting in more accurate, reliable solutions
- Significantly faster, cheaper, easier, and more reliable access for researchers from Australasia wanting to use a synchrotron
- Providing a wider choice of techniques than previous access to overseas beamlines provided
- Using the best techniques to explore industry questions results in faster, cheaper and more reliable answers
- Fast, local access to the Australian Synchrotron, thereby accelerating the development and improvement of new technologies and products.

The leaps of knowledge made possible by synchrotron science will support the emergence and growth of new industries.

The making of the Australian Synchrotron

As synchrotron science revolutionised experimental techniques in the UK, Europe and the USA in the late 1970s, Australia's science leaders saw the potential for a national light source to spur scientific investigation and industrial innovation in this country. In 1989 the Australian Academy of Science first proposed that a national synchrotron facility be made available for Australia.

For 16 years Australian scientists used overseas synchrotrons for groundbreaking research, but demand for beamtime far outstripped supply and it was clear that for Australia to remain internationally competitive, Australian researchers needed much easier access to a light source closer to home.

In 1993 the Australian Science and Technology Council (ASTEC) recommended Australia build its own synchrotron. Two years later, funding was granted for a feasibility study into an Australian Synchrotron and the study was completed in 1997.

In 1999 a detailed proposal was submitted to the Federal Government and this became the basis for the Australian Synchrotron.

In June 2001 the Victorian Government announced its decision to build a national synchrotron facility on land adjacent to Monash University. The Victorian Government committed to funding the synchrotron machine and building to house the facility. Beamline capital funding came from partners such as research institutions and state governments. State agencies were given carriage of the task of building a national partnership and constructing the most significant addition to Australia's research and development infrastructure in decades.

In 2002 the National Science Advisory Committee (NSAC), comprising experienced synchrotron users in Australia and New Zealand and two international advisory committees – the International Science Advisory Committee (ISAC) and the International Machine Advisory Committee (IMAC) – were established to help guide design and development of Australia's first synchrotron light source.

After extensive site preparation, construction of the Australian Synchrotron began in 2003. The project was scheduled to take five years to complete.

In January 2004 the then Minister for Innovation and Acting Premier, The Honourable John Brumby, announced the University of Melbourne, Monash University, Australian Nuclear Science and Technology Organisation (ANSTO) and CSIRO would each provide $5 million towards nine initial beamlines planned for the Australian Synchrotron project. These nine beamlines had been chosen through a rigorous consultation process and were planned to cater for current and emerging demand for synchrotron techniques Australia-wide. Later in 2004 New Zealand announced it would join the beamline funding partnership.

In 2005 the Association of Australian Medical Research Institutes (AAMRI) joined the beamline funding partnership, and Queensland became the first Australian state to join the beamline partnership, in what was now emerging as a new collaborative capital funding model for major national science facilities.

The first beamline contract was awarded in October 2005 to supply a high-throughput protein crystallography beamline that would help develop new treatments for diseases such as Alzheimer's, arthritis and malaria.

In June 2006 the Australian Synchrotron project reached a major milestone with engineers and scientists achieving 'first light', confirming that the machine was working as planned.

Contracts to supply soft x-ray and infrared beamlines for the Australian Synchrotron were signed, and by the end of 2006 funding commitments for the initial nine beam-lines had reached $50 million after consortia from New South Wales, Western Australian and South Australian/ La Trobe University joined the partnership. The Commonwealth Government also came on board with a $14 million contribution from National Collaborative Research Infrastructure Strategy funds, underlining a major shift towards greater collaboration to meet national research requirements.

Experiments begin in 2007

Experiments at the synchrotron began in April 2007 to prepare for the official opening in July.

By the end of June the Commonwealth and Victorian Governments finalised an agreement under which each would provide $50 million in operating funds, to a total of $100 million for the period to 2011–12. The New Zealand Government has also committed to contribute operating funds.

Australian Synchrotron operations commenced in July 2007 with five beamlines in operation; two with a full user programme and three with expert users. A further four beamlines were under construction to be commissioned progressively in 2008.

The Australian Synchrotron – for all Australians and open to international synchrotron scientists

On 31 July 2007, the Premier of Victoria, and the then Federal Minister for Education, Science and Training, officially opened the Australian Synchrotron. Mr Brumby emphasised that although the Victorian Government had provided $157 million of the $221 million in capital dedicated to building it, the Australian Synchrotron was not just for Victoria but for all Australians and open to international synchrotron scientists.

This crucial platform for national and international science was delivered on time and on budget, a testament to the foresight, ingenuity and expertise of all the many individuals and groups who had planned and built this leading light source.

The Australian Synchrotron is now serving the needs of all its partners and the wider research community and providing a platform for leading edge research and development across the whole spectrum, from medicine to manufacturing.

On 31 July 2007, the Premier of Victoria, the Hon. John Brumby, and the then Australian Minister for Education, Science and Training, the Hon. Julie Bishop, officially opened the Australian Synchrotron.

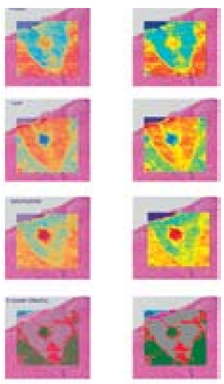
Turning bright ideas into brilliant outcomes

The Synchrotron's benefits reach across a diverse range of fields

The Australian Synchrotron's facilities enable a wide range of new research and development possibilities across a diverse range of sciences. These include:

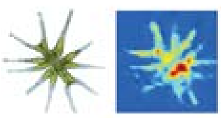
- Biosciences: protein crystallography and cell biology
- Medical research: microbiology, disease mechanisms, high-resolution imaging and cancer radiation therapy
- Environmental sciences: toxicology, atmospheric research, clean combustion and cleaner industrial production technologies
- Agriculture: plant genomics, soil studies, animal and plant imaging
- Minerals exploration: rapid analysis of drill core samples, comprehensive characterisation of ores for ease of mineral processing
- Advanced materials: nano-structured materials, intelligent polymers, ceramics, light metals and alloys, electronic and magnetic materials
- Engineering: imaging of industrial processes in real time, high-resolution imaging of cracks and defects in structures, the operation of catalysts in large chemical engineering processes
- Defence industries, forensics: identification of suspects from extremely small and dilute samples, new materials, sensors, heavy metal analysis
- Pharmaceuticals: analysis of proteins, nucleic acids and viruses; cell imaging, quality control monitoring, bio-mimetic materials

Current projects



Inflammatory Diseases Research – University of Queensland

Chronic inflammatory diseases represent one of the greatest health problems in the developed world, and macrophages play a central role in the inflammation process. Researchers from the University of Queensland are using synchrotron protein crystallography to investigate macrophage proteins from mice. The work is contributing to a better understanding of the inflammation process in arthritis and other chronic inflammatory diseases and helping to identify targets for the development of new anti-inflammatory therapeutics.



The Ocean Climate and Change – Monash University

Scientists from Monash University are using the synchrotron to investigate how phytoplankton could react to the environmental conditions likely to accompany climate change. For example, if changing environmental conditions reduce the nutrient supply available for phytoplankton, this could have a big impact on global carbon cycles. These tiny aquatic organisms fix around 65 thousand million tonnes of atmospheric carbon each year. The research team is looking at the impact of changes in temperature, pH (level of acidity), carbon dioxide levels and ultraviolet light.

Forensic Collaboration – University of South Australia and Museum of Victoria

Researchers from the University of South Australia used a US synchrotron to develop new methods to determine whether lead found in hair had been deposited as dust on the outside of the hair, or had first been absorbed into the bloodstream. The latter could of course have much more serious health consequences. Researchers from Museum Victoria and the University of South Australia used similar techniques to confirm their preliminary findings that the untimely demise of famous racehorse Phar Lap was due to arsenic poisoning. Similar work will be possible in Australia when the microspectroscopy beamline comes online.

Tuberculosis Research – New Zealand

Tuberculosis (TB) is an infectious disease that causes more than two million deaths a year worldwide. Now a more virulent form of the disease has emerged, one that is virtually untreatable by available drugs. This is known as extreme drug-resistant tuberculosis (XDR-TB). New Zealand researchers seeking potential new drugs to treat TB are using synchrotron protein crystallography to determine the three-dimensional structures of proteins necessary to the survival of *Mycobacterium tuberculosis*, the bacterium that causes TB. They have already turned up several potential candidates. The next step will be to find ways to block, alter or otherwise inhibit the action of these proteins, thus killing the bacterium.

Aluminium Refining – CSIRO

CSIRO scientists are using synchrotron powder diffraction to investigate the reactions that lead to scale formation in the giant pressure cookers used to turn bauxite into alumina. When bauxite is cooked in caustic soda at high temperature and pressure to create alumina, clays and quartz in the bauxite also react to form scale deposits. The problem is similar to scale build-up in a kitchen kettle, but much bigger and much more expensive to clean. The next step will be to find ways to inhibit scale formation. Even a small improvement in production efficiency would be good news for Australia's $12 billion aluminium export industry.

Mineral Processing – Universities of New South Wales and South Australia

Researchers from the University of New South Wales and the University of South Australia used the soft x-ray spectroscopy beamline to investigate the surface chemistry of cuprite, a valuable copper ore, under conditions similar to those encountered during mineral processing. The team was particularly interested in how freshly-exposed cuprite surfaces interact with the flotation chemicals used to help extract copper from copper ores. The synchrotron findings will assist the development of improved industrial methods for processing copper ores.

Preventing Leaching from Landfill Sites – Monash University

Monash University engineering staff are using the soft x-ray beamline to study the finer details of the structure of different clay minerals, and how metals such as calcium, caesium, zinc or cadmium actually stick to the clay. The aim is to improve the processing of bentonites, which are used to make 'geosynthetic' clay barriers to stop metals leaching out of municipal and industrial landfill sites. Australia is one of the top three countries in the world working on geosynthetic clay containment barriers.

Operating beamlines

In the 2007–08 financial year a total of five beamlines were accessed by merit-based users from Australia and overseas.

During the reporting period, the Australian Synchrotron operated the following beamlines:

PX1 – Protein Crystallography (bending magnet source)

This beamline has been generating world-class data, almost from the day that it was switched on. Most of Australia's structural biochemistry groups now regularly use the facility, which allows them to map, atom by atom, highly complex biomolecules. A recent highlight is the commissioning of a high-capacity robot, which can load and unload sensitive protein crystal samples in a fraction of the time required by human hands. One of the earliest outcomes of this activity has been published work on an enzyme used by *Staphylococcus aureus* to grow and reproduce. This bacterium, also known as Golden Staph is a leading cause of infection at hospitals and is currently resistant to even the strongest antibiotics. Understanding the detailed biochemistry of this organism gives us the best chance of developing the next generation of medicines.

PD – Powder Diffraction (bending magnet source)

This beamline now provides high-quality data for tiny powder samples in Australia. Any crystalline material may be studied at an atomic scale under a range of pressures and temperatures. A wide range of scientific disciplines have now been making use of this beamline, with the mineral processing community standing out as one of the heavier users. Nickel as an example, is difficult to refine and requires pressure acid-leaching. Studies done on this beamline should help make this process more profitable with less environmental impact.

SXR – Soft X-ray Spectroscopy (undulator source)

Australia now has a facility ideal for studying light elements such as carbon, nitrogen and oxygen. This tool also allows scientists to focus on the outermost atomic layers of a solid sample. These layers determine the fundamental nature of a material surface that dictates its susceptibility to corrosion or its usefulness as a catalyst that could make an industrial process more efficient.

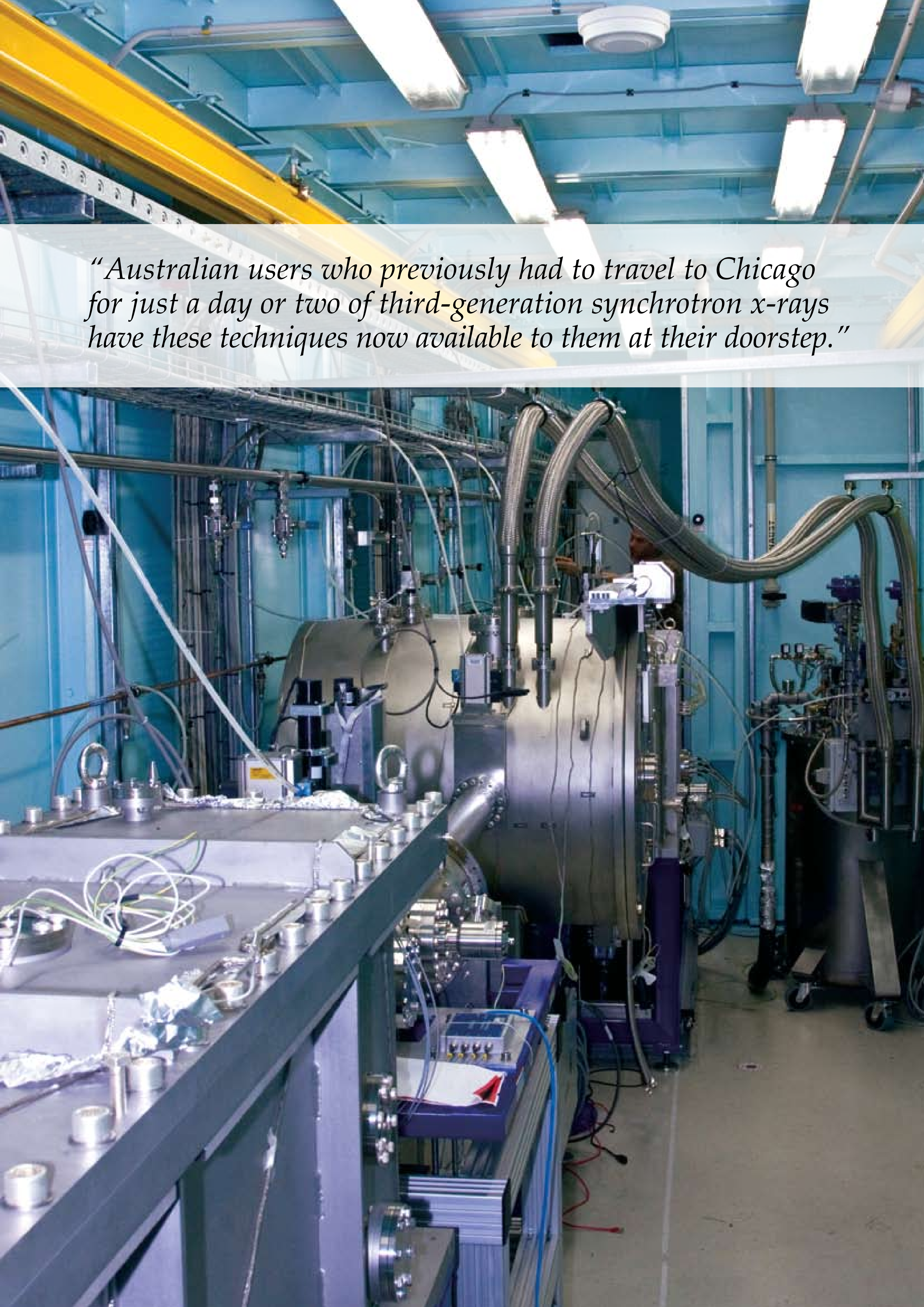
IR – Infra-red Spectroscopy

After only a few months of operation, the mid-IR microscopy is one of the best instruments of its kind in the world. The number of users mainly working in the area of cell biology has prompted the purchase of a second mid-IR microscope. Early studies have shown that this could be an excellent way of determining when mammalian eggs are ready for in-vitro fertilisation and implantation.

XAFS – X-ray Absorption Fluorescence Spectroscope

The XAFS beamline was made operational to the expert user level by its scheduled date in 2007. Faults that were subsequently detected have been addressed by staff with the original supplier. It is anticipated to recommence operation in the second half of 2008. Expert users have been assisting the accreditation of this facility in preparation for full Foundation Investors and merit-based user operation.

"Australian users who previously had to travel to Chicago for just a day or two of third-generation synchrotron x-rays have these techniques now available to them at their doorstep."



The beamlines

Beamlines under construction or accreditation

All the beamlines currently under construction require insertion device hard x-ray sources. These provide x-ray beams thousands of times more intense than those from bending magnets but are also more complex to construct and operate.

While previous beamline enclosures had been fully imported from overseas, a decision was made to source a substantial part of the new enclosures locally, saving money and building local expertise.

XFM – X-ray Fluorescence Microscopy

The mystery of Phar Lap's untimely death was solved on a beamline with similar capabilities to the Australian Synchrotron's XFM beamline. The ability to pinpoint the distribution of heavy metals within a single hair (horse or human) is just one of the many things Australian users will be able to do for forensics, environmental science, biology and different facets of nanotechnology.

IMT – Imaging and Medical Therapy

The most ambitious of all the laboratories to be built at the Australian Synchrotron, the Imaging and Medical Therapy facility will ultimately allow the highest quality medical imaging possible. Construction of the satellite building started in early 2008. In addition to medical imaging, a range of new medical x-ray therapies will be developed at this facility allowing scientists to build on and extend Australia's world-leading medical research infrastructure.

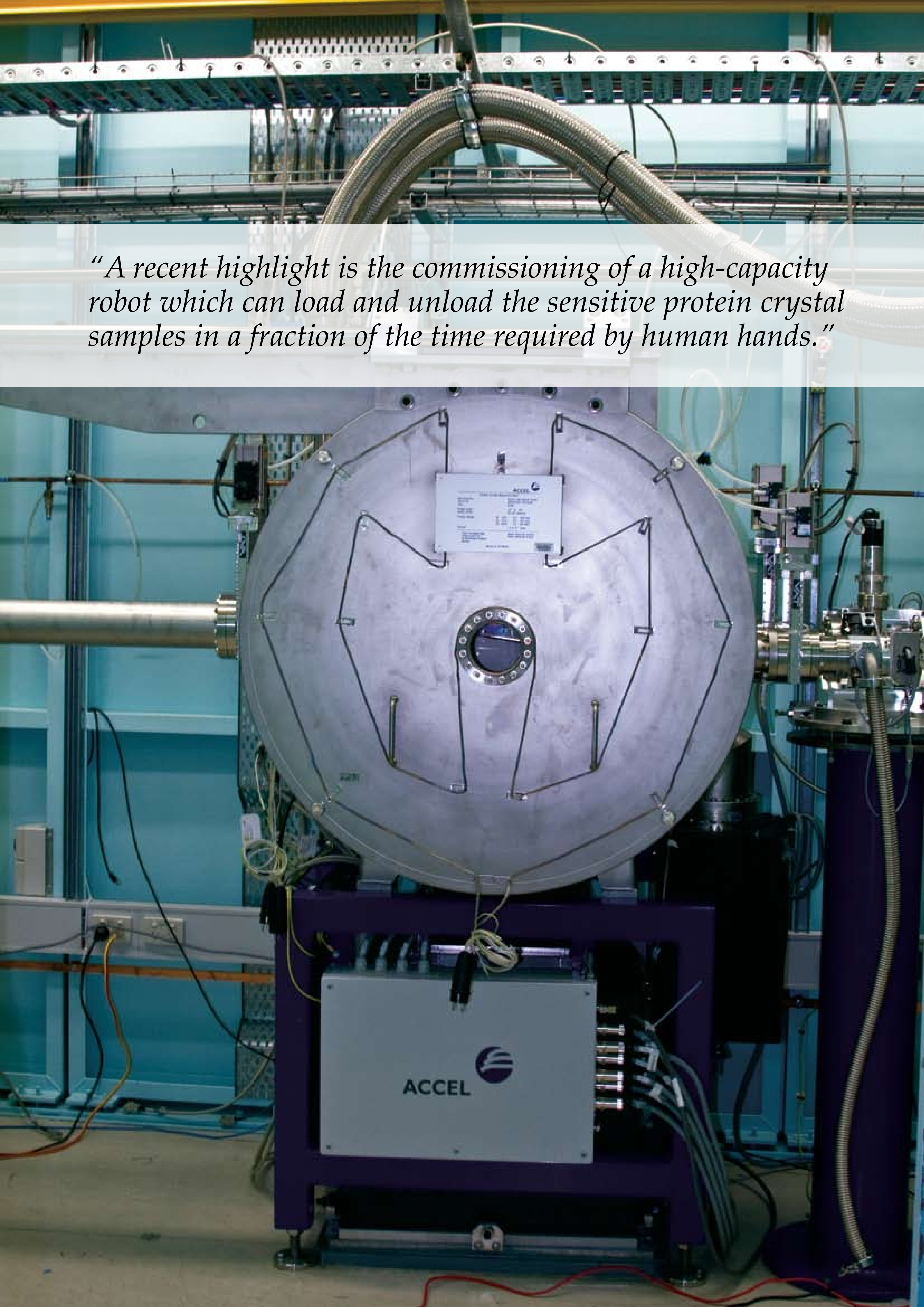
PX2 – Protein Crystallography (undulator source)

From the user's point of view, this new beamline will be just as easy to use as the PX1 facility. Its main difference is a beam that is hundreds of times more intense, which is ideal for focusing down on protein or small-molecule crystals that are too small or not sufficiently high in quality to give data on PX1. Drug companies depend on protein crystallography at facilities like this to understand the biochemistry of diseases at a molecular level and reduce the drug development time.

SAXS – Small Angle X-ray Scattering

A versatile technique used in a diverse range of disciplines, Small and Wide Angle X-ray Scattering (SAXS/WAXS) opens the window on things larger than an atom but smaller than a bacterium. Studying and then manipulating matter at this level has revolutionised what can be done with high-tech materials and biology on a molecular scale. Nano-assembled membranes used for water purification or even hydrogen fuel cells have been closely studied at similar facilities around the world.

“A recent highlight is the commissioning of a high-capacity robot which can load and unload the sensitive protein crystal samples in a fraction of the time required by human hands.”



Operations and accelerator science

Machine operation activities at the Australian Synchrotron are aimed at:

- Delivering the target number of hours of machine operation time per year
- Providing the maximum availability of beam to users in the scheduled periods
- Continued improvement in the performance of the machine
- Developing the field of accelerator science.

Substantial progress has been made during 2007–08 in achieving each of these objectives.

The medium-term goal for the facility is 5,000 user beam hours per year. This is in line with comparable yet more mature third generation synchrotrons worldwide. Scheduled user beam hours in the early years of operation of a new synchrotron are generally lower than the target level due to the time required for the installation and commissioning of beamlines and the time taken to ramp up to full staffing levels.

However, the Australian Synchrotron operations team has made very rapid progress towards this goal in the first year and by the second half of 2007–08, the machine operated at an annualised rate in excess of 4,000 hours. It is expected that the 5,000 hour target will be met or exceeded in 2008–09.

For machine operations the primary performance indicator is the availability of the operating machine. Mature synchrotron facilities can achieve operating machine availability times of 98% although 95–97% is more typical. The medium term target for availability of the Australian Synchrotron is 97% and the Operations Group has exceeded this since February 2008, in less than a year of operation.

This high level of operating performance has been made possible by the systematic and rapid achievement of the design capabilities of the machine.

To establish agreed baselines for the construction, commissioning and optimisation of the Australian Synchrotron, a two-stage evaluation program was agreed with the International Machine Advisory Committee (IMAC) in 2005. The agreed baselines were:

- Performance Acceptance Criteria (PAC), to be reached by 1 April 2007, prior to entering the initial operations phase
- Operating Performance Criteria (OPC) to be met by 1 April 2009.

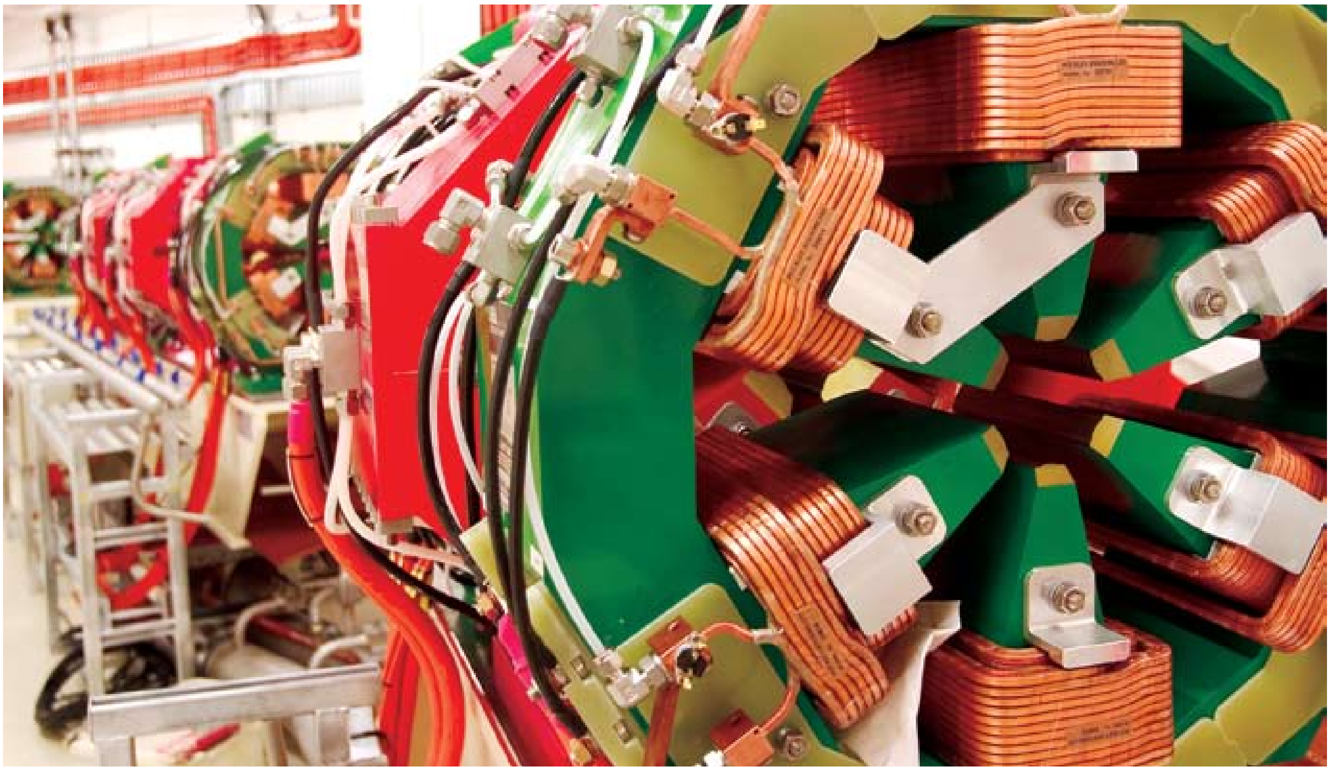
The PAC were met in full by 1 April 2007.

The OPC set for the Machine by IMAC were benchmarked on world best practice for comparable machines. These criteria have effectively been met in full during 2007–08, some nine months ahead of the scheduled date of 1 April 2009.

The Operations Group staffs the control room 24 hours a day 7 days a week. During the user runs, they monitor the accelerator systems and respond to any faults as well as working on various projects. These projects include the electrical noise investigation, beam position monitor cable matching and a bunch-by-bunch feedback system.

The storage ring now has five insertion devices installed and characterised: one elliptical undulator, one wiggler and three in-vacuum undulators.

"The Operations Group has maintained a high beam availability consistently greater than 95 per cent."



Accelerator science

The development of expertise in accelerator science, which underpins the initial progress and continuing development of the Australian Synchrotron, has been a high priority. Since the Australian Synchrotron is Australia's first synchrotron, there was limited accelerator science experience available in this country. This was addressed through the recruitment of international expertise to the staff of the Australian Synchrotron, combined with the development of 'home grown' scientists. A team of young Australian scientists has been given the opportunity to develop their expertise through a program which has included working in international synchrotrons, local training and a continuing international program of conferences.

During the year the Accelerator Science Group participated in a number of international conferences and workshops, including the European Particle Accelerator Conference. Members of the group attended the CERN Accelerator School course on beam diagnostics and the United States Particle Accelerator School. They also collaborated with Stanford Synchrotron Radiation Laboratory during machine studies shifts at their optical diagnostic beamline.

Members of the Accelerator Science Group were invited to participate in commissioning of the Shanghai Synchrotron Radiation Facility and set up the tools used to calibrate a model of the storage ring. The Accelerator Science Group and the University of Melbourne jointly ran an Accelerator Science School and Workshop in March 2007, attracting nearly 40 students for the lecture series.

Three PhD students are working with the Accelerator Science Group, among other students from a range of Australian tertiary intuitions who are undertaking additional study at the facility.

Occupational health and safety (OHS)

The Australian Synchrotron is committed to zero harm to employees, contractors, users and visitors to its facility. To live up to this commitment, the facility is establishing a safety management system to the Australian Standard, AS/NZS 4801:2001 Occupational Health and Safety Systems Standard, to replace the current OHS Management Plan.

As an integral part of its OHS program, all employees, contractors and users are required to successfully complete the OHS and radiation safety inductions before being allowed to enter the technical floor unescorted. All employees are represented on the OHS Committee that meets monthly to review the OHS performance and statistics, discuss OHS issues and consider initiatives to further improve site safety.

The Australian Synchrotron's OHS performance is measured against: Lost Time Injury Frequency Rate (LTIFR) and annual radiation dose. The LTIFR (number of injuries resulting in at least one full work day lost per 200,000 hours worked) for 2007–08 was 2.41. For 2007–08, the highest radiation dose measured was 0.16 mSv/year for one individual. All other individuals were below this level, which compares favourably with the standard of 1 mSv/year (the Public Exposure Limit).

Radiation safety has been factored into all phases of the design, construction and commissioning of the facility. This has involved a close liaison with the Victorian Radiation Regulator that is ongoing. A regular meeting is held with the Regulator to review the radiation safety management performance and practices. All employees, contractors and users are required to wear personal radiation monitoring badges while working at this facility. In addition, active radiation monitors are located around the facility to provide real-time, continuous monitoring of the radiation levels.

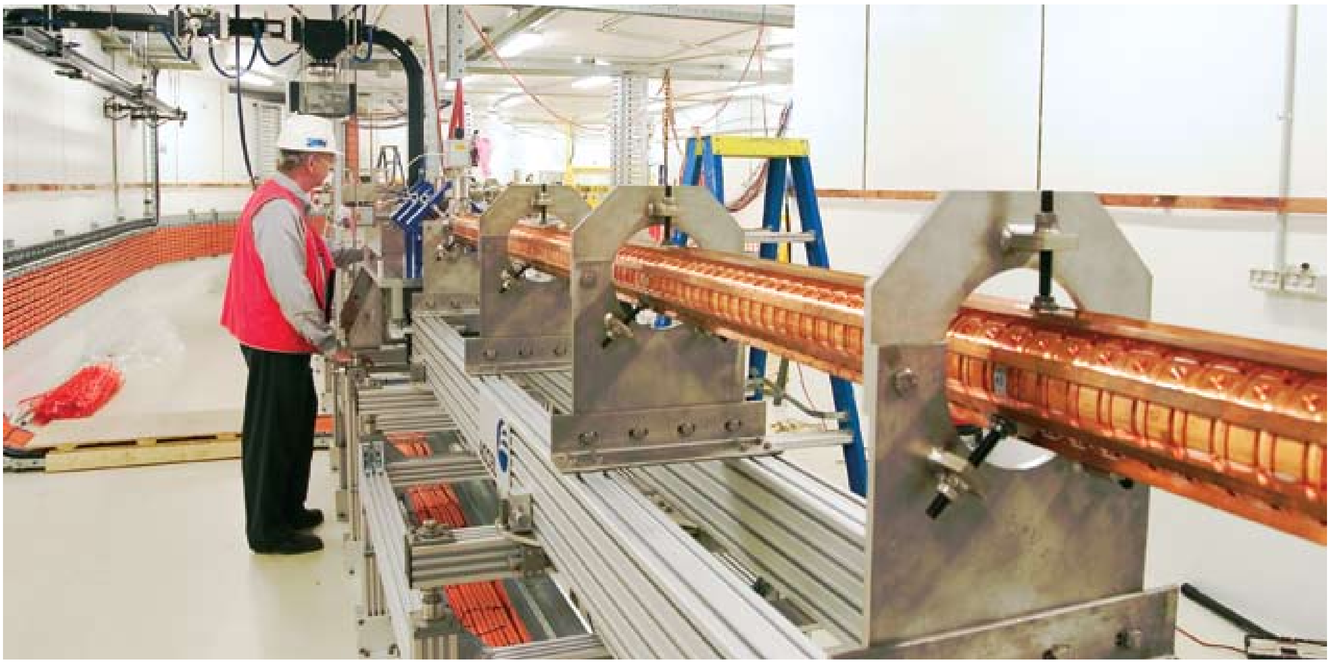
In June 2008 the Australian Synchrotron was awarded Gold Medal status for its approach to risk management following an independent survey of onsite risks at this facility. The site risk survey was conducted by the Victorian Managed Insurance Authority (VMIA).

The detailed survey report concluded that: "Site management should be commended on their excellent attitude towards risk management, which is reflected by the facility achieving Gold Medal status based on the VMIA Site Risk Survey ranking structure".

At the 5th annual national Manufacturers' Monthly Endeavour Awards ceremony in May, the Australian Synchrotron won the Safety Scheme of the Year Award for its Personnel Safety System (PSS). The PSS electronic access control system is designed to ensure that a 'search and secure' procedure has been completed and everyone has left the beamline enclosure before synchrotron radiation is allowed into the enclosure. If any of the safety system locks are interrupted, the machine immediately shuts down and the area is rendered safe within about 20 milliseconds. As the PSS uses 'intelligent' safety-rated components, it cannot be defeated either accidentally or deliberately.

Australian Synchrotron Principal Controls Engineer Bryce Karnaghan (left) accepts the 'Safety scheme of the year' award in Sydney.

Environment



As a significant user of both energy and water the Australian Synchrotron is committed to the efficient use of resources and reducing and preventing environmental pollution.

In October 2007 an energy audit was commissioned to investigate the use of energy within the facility and to identify potential energy cost saving opportunities that could be applied to the facility. The energy audit found that there was little scope for energy efficiencies within the core synchrotron operation and that savings were best focused on the maintenance and management areas. To help offset the environmental impact of the energy used, a supply contract has been negotiated whereby 15% of the total electricity provided to the facility will be from ‘accredited green energy’. This was implemented on 1 April 2008. From April 2009 this percentage will rise to 20%.

The Australian Synchrotron participated in the Victorian Government funded Water Efficient Cooling Towers Program in which the water efficiency of the facility’s four cooling tower systems were assessed. Resulting from the assessments, two systems were characterised as ‘Good’ and the other two systems as ‘Excellent’. In addition, Yarra Valley Water has now committed to assist the facility to design and implement a water management plan. This Plan will incorporate large scale rainwater harvesting for this facility.

Various recycling initiatives have been implemented. Redundant computers and other electrical equipment including copying machines are collected for recycling. Arrangements are in place to collect and recycle fluorescent tubes, alkaline and lithium batteries and other consumable products such as paper, cardboard, cans, bottles and printer cartridges. The Australian Synchrotron also has a policy of using hybrid motor vehicles.

The user community

The Australian Synchrotron exists to facilitate and support scientific exploration. It is our user community that undertakes this vital work and produces the results with the potential to transform medical, industrial and other products and processes in our society. All of the staff at the Australian Synchrotron recognise the role that our users play and are focused on providing full support to their work.

Scientists and researchers who access the synchrotron are referred to as the 'user community'. The Australian Synchrotron is committed to making it as easy as possible for users to access and use the synchrotron. A broad range of services and assistance is provided to ensure that this occurs.

The user office is the first point of contact for anyone wanting to access the synchrotron. The user office advises potential users when beamtime becomes available, sending out the initial notification, providing follow-up services with user groups until beamtime has been completed. The office organises and pays for accommodation and travel for interstate users as well as safety training. The user office also issues a welcome pack that includes important information for those accessing the synchrotron.

The user lounge is provided to support the users during their time at the Australian Synchrotron. It provides daily newspapers, tea and coffee, kitchen facilities, local menu directory, computers with internet access and printing facilities, lockers for user belongings and cable television. The computer area and the general conversational area are separated, allowing for quiet study to be undertaken if necessary. Pool cars are available for users during their time at the Australian Synchrotron.

User support

Users are fully supported during their time at the facility with the following services:

- Comprehensive beamline induction training on arrival
- Hands-on support during the day shift, Monday to Friday
- Some direct support during evening shifts and during the day at weekends
- Support from machine operators out-of-hours when no beamline staff are on site
- On-call support from beamline staff at all other times.

In addition to direct support when taking data, users also have access to support laboratories for the preparation and analysis of samples. These facilities will be extended during 2008–09 to include a tissue culture laboratory and to expand the range of equipment provided as the number of operational beamlines and users increases.

User access

The allocation of user access to the beamlines is based on the following schedule:

Merit based (50 per cent)

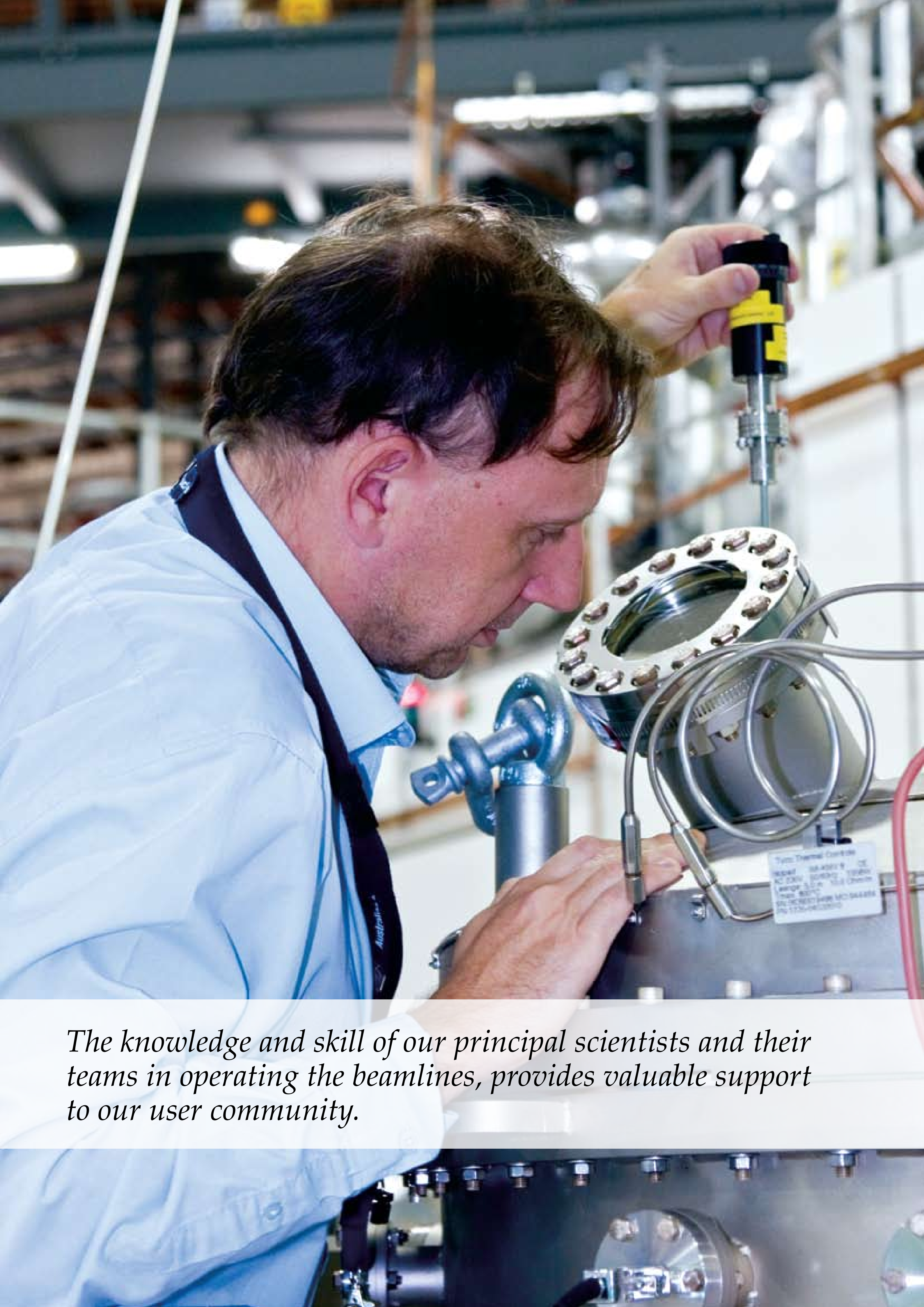
There were three open 'calls for proposals' in 2007–08 relating to three beamtime periods. Typically the call for proposals is open for one month, and closes two months ahead of the scheduling period.

Foundation Investors (30 per cent)

Foundation Investor proposals are not subject to peer review, and are guaranteed beam time subject to satisfactory safety and technical feasibility criteria. This arrangement remains in place for six years from the time of the first beamline becoming operational in September 2007.

Facility and commercial access (20 per cent)

This includes access for ASCo scientists' own projects. A commercial program will start in early 2009 and is likely to involve a mixture of facility operated programs such as full service analytical programs and subcontracted industry projects.



The knowledge and skill of our principal scientists and their teams in operating the beamlines, provides valuable support to our user community.

User demographics

Cumulative total of user visits

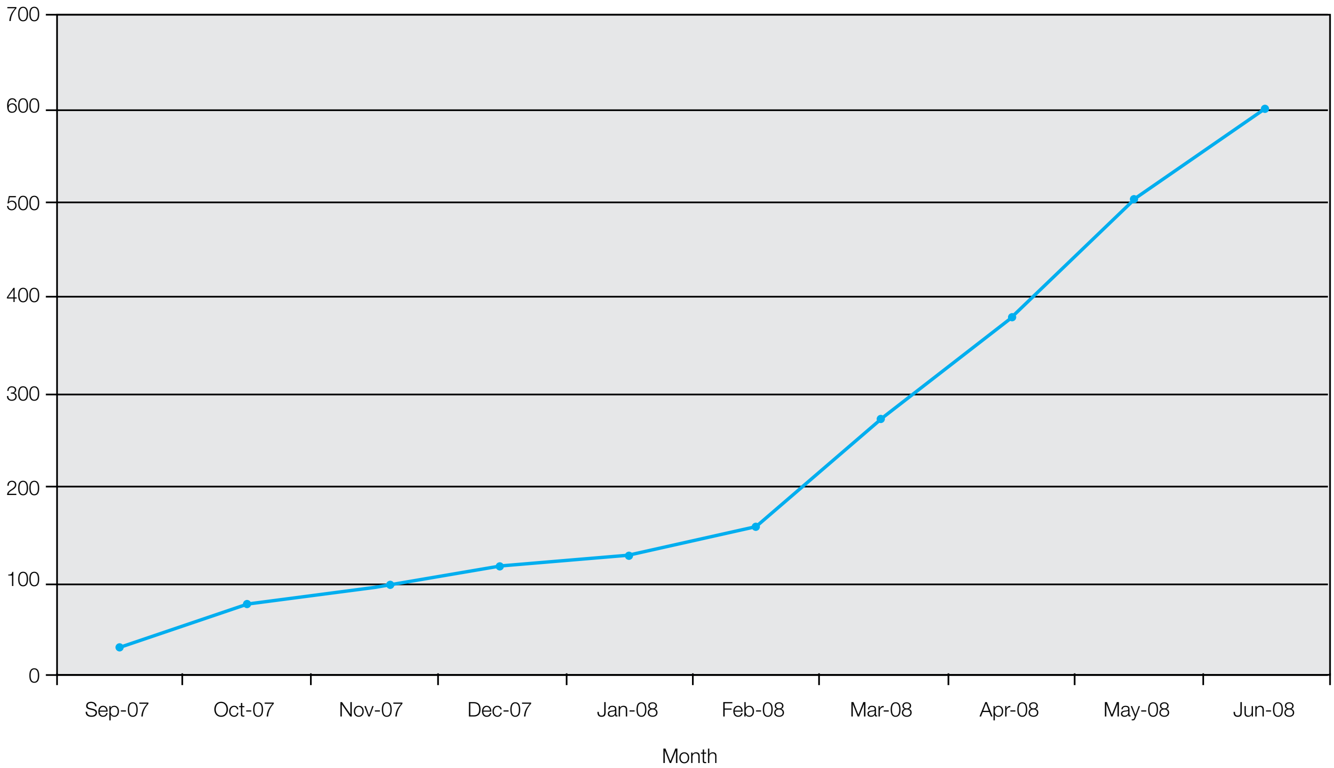
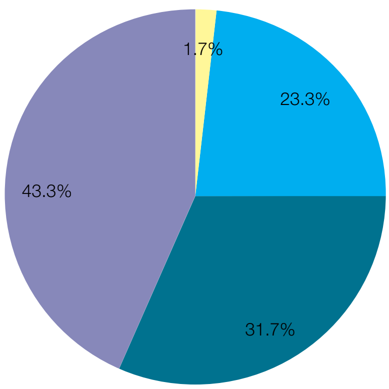


Figure 2: Cumulative total of user visits September 2007 to June 2008

The dramatic increase in March was due to the number of available beamlines increasing from 2 to 4, 30 per cent of the planned operating capacity.

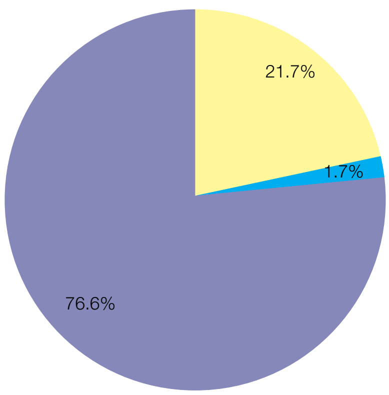
Beamline Users



Undergraduate Student	1.7%
Postgraduate Student	23.3%
Post-Doctoral Researcher	31.7%
Senior Scientists and Research Fellows	43.3%

Figure 3: Users by beamline

Affiliation



University	76.6%
Australian and New Zealand Governments - Crown Research Institutes	21.7%
Medical Research Institute	1.7%

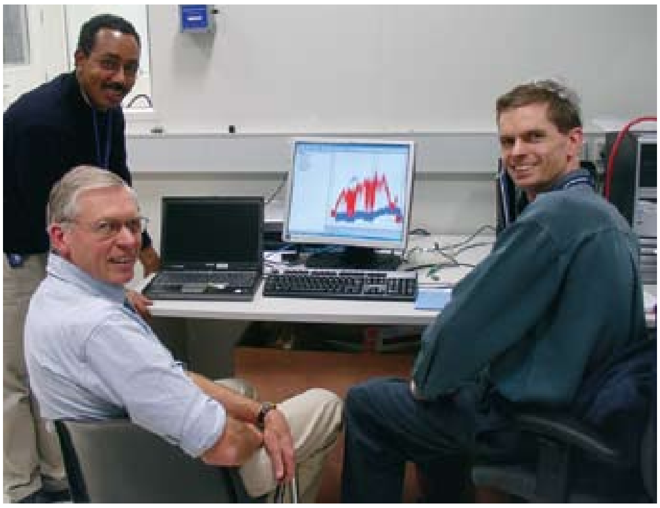
Figure 4: Users by affiliation

Note: Not all available beamlines are relevant to all potential users. As more beamlines become available therefore, we can expect quite a change in the user distribution.

Dr Kevin Jack, Centre for Microscopy and Microanalysis, The University of Queensland.

Chris Thompson, Monash University.

Sally Caine, Monash University.



First High Resolution Far IR Spectrum.

Renee Jelly and Bill Van Bronswijk, Curtin University.

Dr James Blinco, Centre for Magnetic Resonance and Australian Institute for Bioengineering and Nanotechnology.

User profiles

Award winning medical research

Beamline science leads to discovery that will help fight leukaemia – Professor Michael Parker.

Professor Michael Parker, from the St Vincent's Institute and the University of Melbourne, is using the Protein Crystallography beamline at the Australian Synchrotron to examine proteins in their crystalline state. Research facilitated by the beamline is already proving very valuable in helping scientists to understand some of the mechanisms involved in diseases including leukaemia and Alzheimer's.

According to Professor Parker, the research made possible by the facility is already proving to be a real boon for Australian researchers.

"Before we had access to the Australian Synchrotron, we had to travel to Chicago in the United States to undertake our research. This involved expensive and rather infrequent trips and unfortunately our delicate samples encountered considerable hazards associated with long journeys, customs, extensive handling and other risks," he said.

In contrast, Professor Parker continued, "It is wonderful to now be able to make regular 20 minute trips across town to conduct our research in a state-of-the-art facility and get the high-level technical access and support we need from the beamline team."

Professor Parker explained that the research his team is undertaking involves the exposure of protein crystals to x-rays which allows scientists to see the fine detail of the three-dimensional atomic structure of the protein.

Professor Parker's team was able to unravel the structure of a cell signalling receptor in the blood control system which, when damaged, is responsible for diseases such as certain forms of leukaemia. Using science made possible by synchrotrons, his team was able to develop the first 3D-image of the cell receptor involved. They will now be using this finding to develop drugs to modify the action of this receptor, and hopefully, one day be able to treat diseases such as leukaemia, as well as certain inflammatory diseases such as asthma and rheumatoid arthritis.

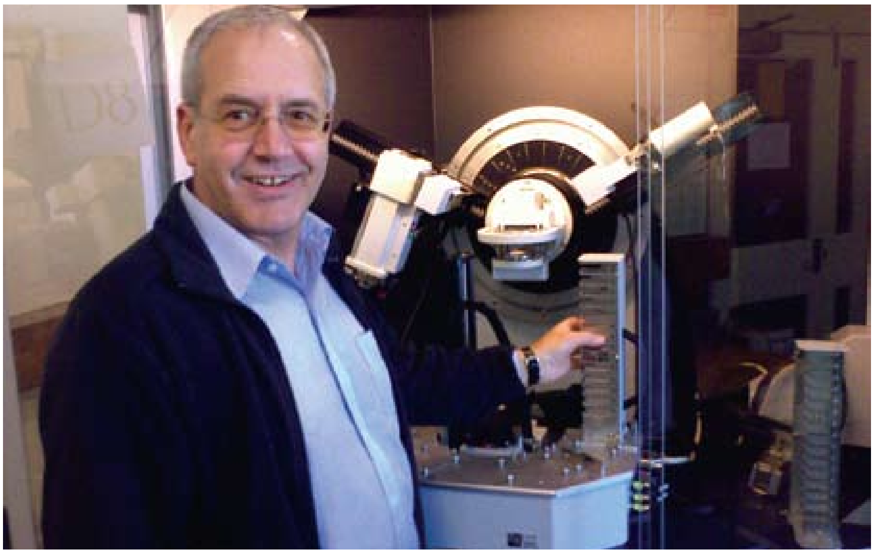
Professor Parker said: "Because our discovery shows precisely what the receptor looks like and also how it works, we can now begin to design new drugs to rein in the deadly abnormal blood cells involved in certain aggressive forms of leukaemia."

"Many leukaemias are currently treated with chemotherapy that destroys the diseased blood cells and bone marrow as well as normal cells. We hope that this discovery will lead to targeted therapies that are more specific to the malfunctioning cells," he said.

Other promising research being undertaken by Professor Parker and his team with the help of the Australian Synchrotron includes a study of toxins associated with meningitis and gangrene, as well as the study of proteins associated with Alzheimer's disease and enhanced memory function.

Professor Parker is confident that in the future the applications of science made possible by the Australian Synchrotron will provide many remarkable benefits to the treatment of major diseases that afflict many Australians.

Western Australia
producing environmentally friendly geopolymers



Using the beamline to study natural processes and to mimic them in new products from waste – Associate Professor Arie van Riessen.

Associate Professor Arie van Riessen from Curtin University is a keen user of the Australian Synchrotron. Before the Australian facility was available, Professor van Riessen and his students were compelled to undertake time-consuming and expensive trips overseas to conduct research into geopolymers and biomineralisation.

Now, the relatively short trip to Melbourne and the extensive support provided by the Australian Synchrotron makes his research not only easier, but more timely and cost-effective.

Professor van Riessen and his students are currently using the powder diffraction beamline to undertake research into geopolymers and they plan to use the facility for biomineralisation research.

Geopolymers are cement-like products made from waste produced when coal is burnt. Geopolymers have many of the building and strength properties of regular cement, but are much more environmentally friendly as they can be produced at room temperatures, using much less energy than is required to make cement. They are also made from an otherwise useless waste product.

Professor van Riessen believes that the research work being undertaken with the help of the Australian Synchrotron will enable Australia to produce geopolymers with specific properties. These properties will meet the needs of manufacturers of pipes, sleepers and construction products, while at the same time significantly reducing carbon emissions.

Biomineralisation involves the study of how nature makes calcium carbonate products. It is used to gain an understanding of the production of kidney stones and seashells. Professor van Riessen plans to use the powder diffraction beamline to understand the complex processes involved.

“Understanding how nature builds these compounds will enable scientists to mimic nature’s processes in the laboratory and then either copy the ones with superior properties or remove the ones with detrimental properties,” Professor van Riessen explains.

This science has many practical applications, including the ability to remove unwanted scale from pipes, develop new materials and remove painful kidney stones.

Australian Capital Territory conserving rare parchments

Alana Treasure, Research Associate at the University of Canberra

Like the famous character in Pulitzer Prize-winning author, Geraldine Brooks' bestselling novel, *People of the Book*, Alana Treasure is intrigued by old parchments.

Brooks' novel follows a book conservator's journey to conserve and find out about the 'life' of a rare illuminated Hebrew manuscript. Alana Treasure's work is just as fascinating and is certainly the stuff of fascinating science.

Alana works as a materials analyst in conservation science. This involves the application of instrumental analysis to items of artistic, cultural and archaeological significance for identification and studying chemical changes and or degradation.

Her work involves the use of the Australian Synchrotron's infrared beamline with the micro-FTIR instrument to analyse 19^{th} Century parchment documents written on with iron gall ink, an acidicorganometallic ink used from the Middle Ages until early 20^{th} Century.

Alana explains that use of this particular ink has caused many problems to historic items, particularly documents and artworks.

"Documents that were written or drawn in this ink are often badly corroded leaving degraded areas of parchment or paper," Alana explains.

"In extreme cases, where the ink is applied, it has effectively eaten away the support, leaving holes in the parchment," she said.

"With the help of the Australian Synchrotron we are investigating whether FTIR spectral results can give us an insight into what mechanisms of degradation are occurring in the collagen of the parchment samples as caused by the inks," she said.

Understanding how the material is degrading will enable conservation scientists to develop conservation treatments to preserve the extensive range of documents, manuscripts and artworks affected by this process throughout the world.

Alana says that it has been a joy to access the Australian Synchrotron's infrared beamline, and that it has been a real pleasure to work there.

"The staff at the IR beamline are always helpful and supportive, even after leaving the synchrotron. Users are given the opportunity to tailor experiments themselves and are trusted with the instrumentation," she said.

New Zealand characterisation of nano-materials

Dr Bridget Ingham
New Zealand characterisation of nano-materials

Dr Bridget Ingham, a New Zealand scientist, was one of the first scientists to use the powder diffraction beamline at the Australian Synchrotron. In February 2008 she undertook research exploring how the atomic arrangement of AgAu (silver-gold) foils changes during dealloying. The dealloying of AgAu foil results in a high surface area that can be used for gas sensing or catalysis.

Dr Ingham's two-year post-doctoral work from 2005 to 2007 was done at Imperial College, London and later at the Stanford Synchrotron Radiation Laboratory. During this time she gained invaluable experience and exposure to a range of techniques and light source facilities, including Advanced Proton Source (Chicago USA), National Synchrotron Light Source (USA), European Synchrotron Radiation Facility (France) and Spring-8 (Japan).

Dr Ingham returned to New Zealand in mid-2007. She is pleased to now have the Australian Synchrotron close by where she can more readily undertake her experiments and apply the skills she has learnt. She has visited four times in 2008 to perform experiments on her own projects and also assist students from New Zealand Universities.

Her research is varied but can be broadly described as the "characterisation of nano-materials". She is always on the lookout for interesting science questions that could benefit from synchrotron experiments. One such example was to use USAXS at Spring-8 in Japan to watch flocculation events during the paint drying process.

"That was certainly one of the most amusing beamtime proposals I've ever written," she said. "But at least the project is easy to talk about with members of the public, because it's something they can relate to."

This detailed understanding may lead to improvements in paint specifications and improved long-term performance of paint products.

Other areas she is working on include the study of metallic nanoparticles for use in nano-electronics, sensing, transistors, catalysis, etc., and zinc oxide electrochemically deposited nanostructures for photonic applications such as LEDs and solar cells.

Scientific engagement and collaboration

Our scientists play a significant advocacy role, on behalf of Australian Synchrotron, in the wider scientific community within Australia and internationally. Each principal scientist has an adjunct position with a major Australian University and participates in synchrotron-related activities at their host university. They also engage with their fellow scientists on campus and sharing their knowledge of the Synchrotron's services and capabilities.

Australian Synchrotron scientists are encouraged to attend a wide range of scientific conferences and workshops in Australia and overseas. This ensures that they remain in touch with scientific developments as well as share their own research. In the future this will extend into the development of partnerships with industrially based users.

Collaboration on research projects also serves to both share and acquire knowledge. An example of a recent international collaboration involves Australian Synchrotron scientists developing a new high-speed fluorescence detector in collaboration with CSIRO and the American Brookhaven National Laboratories.

In December 2007 260 people attended the joint ASRP-Australian Synchrotron Users Meeting, held from 12 to 14 December 2007 and the associated science symposium, held on 11 December 2007 which marked the facility's official Science Opening.

Synchrotron users took the opportunity to tour the facility and meet with staff. User meetings are an excellent opportunity for engagement and interaction with existing and potential users.

An inaugural New Zealand user meeting was held in Christchurch in April 2008, presenting an opportunity to provide information on the capabilities of the Australian Synchrotron to their community.

Recognising the importance of collaboration and international cooperation, a number of memorandums of understanding (MOU) have been signed with international agencies. These facilitate the exchange of personnel and scientific and technical collaboration with international synchrotrons and major science facilities. The list of current MOUs is set out below. Additional MOUs are being discussed with several other synchrotrons.

LEFT: Shri Kapil Sabil, Indian Minister for Science and Technology with Australian Synchrotron Facility Director, Professor Robert Lamb, February 2008.

RIGHT: Professeur Michel Thibier, French Scientific Attaché, French Embassy , Canberra, inspecting the protein undulator beamline (PX2) with Dr David Cookson, Head of Beamline and Science Development

The Australian Synchrotron has established partnerships with leading light sources worldwide:

- Advanced Photon Source, Chicago USA
- Beijing Synchrotron Radiation Facility, China
- Canadian Light Source, Canada
- Conseil Européen pour la Recherche Nucléaire (CERN)
- Diamond Light Source, UK
- Elettra (Syncrotrone Trieste), Italy
- European Synchrotron Radiation Facility (ESRF), Grenoble France
- National Synchrotron Radiation Research Centre, Taiwan
- Photon Factory (The Institute of Materials Structure Science of the High Energy Accelerator Research Organization), Japan
- Pohang Accelerator Laboratory, South Korea
- Shanghai Synchrotron Radiation Facility, China
- Spring-8, (Japan Synchrotron Radiation Research Institute), Japan
- Swiss Light Source, (Paul Scherrer Institute), Switzerland.

Scientific training and education

The Australian Synchrotron supports collaboration with overseas scientists and institutes through in-house workshops and seminars for visiting international speakers within Australia and worldwide.

Major educational activities for 2007–08 included:

- The Accel08 School and workshop conducted by the Australian Synchrotron and the University of Melbourne in March-April 2008. Accel08 provided an introduction to accelerator science and synchrotron light sources for researchers and university students from physics, engineering and related fields.
- The bilateral Shanghai-Australian Workshop at the Australian Synchrotron in May 2008, which has strengthened ties between the Australian facility and its Shanghai counterpart.
- The 3rd Italy-Australia Workshop held at the Australian Synchrotron in April 2007, which highlighted future directions in spectroscopy and imaging with synchrotron light. Sponsors included Elettra, CSIRO, the ARC Molecular and Materials Structure Network, and the ARC Centre of Excellence for Coherent X-ray Science.

The Australian Synchrotron presents a Friday afternoon seminar session on a range of interests to scientists. The Accelerator Group ran an inaugural Accel 08 workshop in March 2008 at the University of Melbourne, as part of the group's aim to build an accelerator community in Australia.

Developing a future user community begins with education and along with the assistance of Victorian eResearch, the Australian Synchrotron has created a virtual beamline to give students school-based remote access for experiments. Victorian high school students undertaking final year physics can now elect to undertake a four-week study design on synchrotron science. The Australian Synchrotron plans to extend and develop synchrotron science programs in all state and territory school curriculums in the near future.

Virtual beamlines – sharing Australia's brightest light

To assist researchers using the protein crystallography beamline, the Victorian eResearch Strategic Initiative (VeRSI) has developed a Virtual Beamline (VBL). This is an enhanced video collaboration environment that allows off-site researchers remote access to interact with their colleagues and beamline scientists at the Australian Synchrotron using video conferencing.

Team leaders can mentor their staff and students, and scientists can workshop problems with experts and monitor experiments from their laboratory, office or home across the world. The video system is currently only fitted to the protein crystallography beamline – PX1 – but the modular design allows the videoing capability to be added to other beamlines. The VBL is available to approved scientists free of charge.

La Trobe University, a VeRSI member, is partnering with VeRSI to build a remote training laboratory and classroom to teach synchrotron science and expose students to a real synchrotron experience. The remote beamline at the La Trobe Bundoora campus is the first communal VBL node and will serve as an exemplar of the remote sharing of significant scientific infrastructure.

The VBL Storage Gateway provides a simple-to-use and effective way for researchers to move large, experimental datasets from the synchrotron to their laboratories or storage facilities elsewhere, including the VeRSI Storage Grid. The Gateway offers a range of optimised file transfer protocols which are tuned for maximum throughput. Data transfers can be immediate or scheduled to use networks when they are lightly loaded.

Taking beamlines into the classroom

The VeRSI Educational Virtual BeamLine (eVBL) is an example of science reaching out to students to excite their minds and encourage an interest in a science career. eVBL is a web accessible experiment designed and operated at the Australian Synchrotron through which teachers and students can control a real synchrotron experiment from their classroom. The next stage of this program is to roll it out to the rest of Australia.

"By bringing the Australian Synchrotron into students' own classrooms we hope to inspire the next generation of scientific researchers," Premier of Victoria, The Honorable John Brumby.

The Victorian Premier, the Hon John Brumby said at a demonstration of the eVBL at Williamstown High School, "Victoria needs bright minds to build a brilliant future. By bringing the Australian Synchrotron into students' own classrooms we hope to inspire the next generation of scientific researchers.

Cheiron School

Australia is a founding member of the Asia-Oceania Forum for Synchrotron Radiation Research. The forum was established in 2006 to promote and facilitate collaboration between the synchrotron facilities and user communities of the region. A major forum activity is the Synchrotron Summer School hosted by Spring-8 in Japan. The first school was held in September 2007 with an 11-day curriculum covering most aspects of synchrotron science. This included basic light-source physics, beamline optics and introductions to all major synchrotron science application areas. The lecturers for the school were leading international researchers, including four Australian Synchrotron scientists and two other Australian scientists, with Professor Robert Lamb delivering the opening lecture.

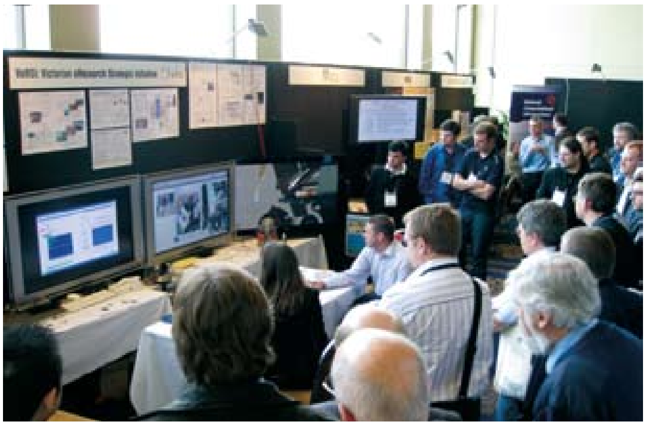
Scholarships and awards

Martin shines a light on fluorescence

Martin de Jonge was the winner of the Australian Synchrotron Research Program Thesis Medal for 2007. The medal is awarded to the PhD student undertaking research using a synchrotron light source and judged to have written the most outstanding thesis under the auspices of an Australian University.

"My research focuses on improvements to imaging methods that will enable the acquisition of more realistic three-dimensional images in the same time it takes for more common two dimensional imaging," Martin explained.

"These methods are world leading and are of general interest to the field of fluorescence microscopy. They will almost certainly be adopted by similar facilities around the globe," he concluded.



Top: The virtual beamline and remote access solution on Protein Crystallography 1 beamline, demonstrating remote data collection of insulin by Dr Rachel Williamson, at the eResearch 08 conference.

Below: Australian Synchrotron scientist Martin de Jonge – winner of Australian Thesis Medal.

Community outreach

The Australian Synchrotron undertakes a wide range of activities to actively engage and educate the Australian community and reach out to the broader community in our region and internationally.

Supported by a wide range of professional communications materials, the Australian Synchrotron is actively engaging the community at many levels. In addition to printed materials, communications are maintained with all stakeholders and users via the Australian Synchrotron's electronic newsletter *Lightspeed*, and the Australian Synchrotron website www.synchrotron.org.au.

The Australian Synchrotron hosted a wide range of events following the official opening of the facility. A Family and Friends Day, to thank workers and others for their contribution to the completion of the project, was held on 12 August 2007. The day was a huge success with a capacity crowd touring the synchrotron and gaining an understanding of the capabilities of the newly opened facility and an appreciation of the tremendous impact this facility will have on Australian research in the coming decades.

Public interest along with request for tours has increased exponentially as the facility has developed. Tours and speaker requests were initially handled by Department of Innovation, Industry and Regional Development (DIIRD) from the city offices and supported by an in-house display and educational talks at the neighbouring Monash Science Centre. When the new facility was established on-site scientists volunteered their time to conduct tours. To accommodate the increasing number of requests a part-time visits coordinator now coordinates the visits and the volunteer tour program.

The Australian Synchrotron has hosted thousands of visits by secondary and tertiary students; academic and professional organisations; delegates on conference tours; state, federal and international politicians; consular officials and international dignitaries.

The Australian Synchrotron was the launching point for the Victorian Government's 'Community Cabinet' in April 2008, with the Australian Synchrotron hosting a tour of the facility for state ministers. The Australian Synchrotron was also a sponsor of the annual 'Science meets Parliament', a federal government initiative held in Canberra in March 2008.

Bridging art and science, the Australian Synchrotron took part in an artist in residence program through the Arts Victoria; Arts Innovation program, with Melbourne artist Chris Henschke collaborating with in-house beamline and accelerator scientists to produce some outstanding images and digital media. Chris Henschke and Dr Steve Gower, Head of External Relations, were invited to present at the Adelaide Arts Festival in March 2008.

The growing public interest in the facility has corresponded with increasing interest from media organisations. A number of programs were filmed on site, including a forensic episode of the ABC *Catalyst* program, the ABC's *Can We Help* program, and a Hollywood movie *Knowing* staring Nicholas Cage, filmed on location at the Australian Synchrotron during April 2008.

The facility in the Hollywood spotlight, April 2008

A group on tour at the Australian Synchrotron for Family and Friends Day, 12 August 2007

L to R: The Hon Gavin Jennings (Victorian Minister for Innovation), Professor Tony Burgess (Ludwig Institute for Cancer Research), and the Hon David Andrews (Victorian Minister for Health) mark the start of construction of the Australian Synchrotron's Imaging and Medical Therapy Laboratory, during Community in Cabinet hosted at the Australian Synchrotron in February 2008

Visitors to the Australian Synchrotron for Family and Friends Day, 12 August 2007

Corporate structure and governance

Overview of corporate structure

The Australian Synchrotron is managed under a dual entity structure, set out in Figure 5 below, comprising two companies:

- Australian Synchrotron Holding Company Pty Limited (ASHCo) is the ownership entity and owns all the Australian Synchrotron assets
- Australian Synchrotron Company Limited (ASCo) is the management entity and has the exclusive right to operate, manage and develop the Australian Synchrotron assets under a lease with ASHCo

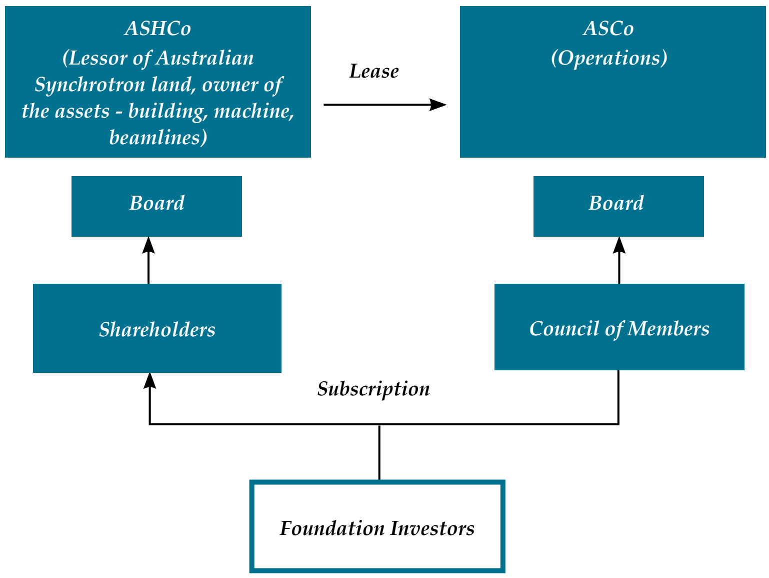


Figure 5:
Australian Synchrotron governance structure

Foundation Investors in the Australian Synchrotron receive interests in both companies in consideration of their capital investment, namely shares in ASHCo proportional to their level of capital investment (being a minimum of $5 million) and membership of ASCo.

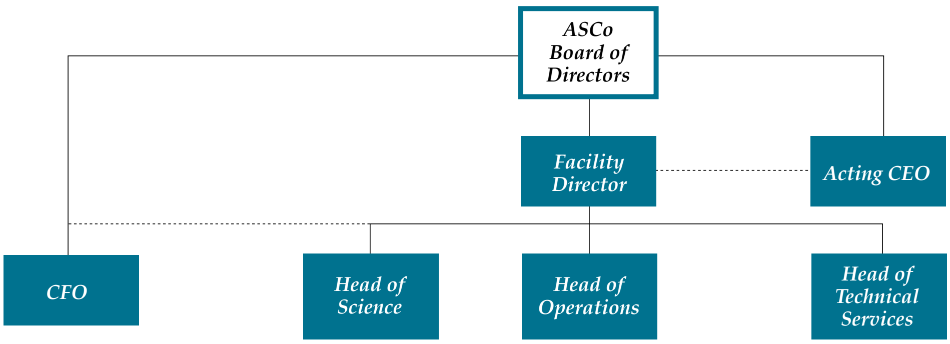


Figure 6:
Organisational Structure – 30 June 2008

Role, function and corporate structure

ASHCo's main activities are to:

- Sub-lease the Australian Synchrotron land from the State of Victoria, own the Australian Synchrotron assets and lease them to ASCo
- Ensure the Australian Synchrotron facilities are kept in good condition and proper working order (ASCo is responsible under the lease for carrying out this responsibility)
- Fulfil its other obligations under the lease with ASCo, including authorising alterations, upgrades and improvements to the Australian Synchrotron assets.

ASCo is the management entity and has the exclusive right to operate, manage and develop the Australian Synchrotron assets under a lease with ASHCo.

ASCo's objects and activities

As the operator of the Australian Synchrotron facility, ASCo is responsible for the following:

1. Objects

- To be responsible for the efficient and effective operation of the Australian Synchrotron as a national synchrotron facility that facilitates the performance of scientific, medical and industrial research
- To promote or advance scientific knowledge, particularly in relation to synchrotron science, through the facilitation of synchrotron research

2. Activities

- Operation of the Australian Synchrotron at world-class standards
- Providing researchers in the scientific, medical and industrial research fields with access to fully operational, state-of-the-art synchrotron facilities
- Providing training, technical, scientific and administrative support to users
- Conducting and facilitating awareness programs to promote the use and benefits of synchrotron science
- Maintaining the Australian Synchrotron in an excellent state of repair through a comprehensive annual maintenance program
- Developing relationships with international facilities and providing support for international collaboration in synchrotron science.

Composition of the Australian Synchrotron Boards of Directors

The Boards of Directors for ASHCo and ASCo, as at 30 June 2008 and current, are listed below.

Further details of the Directors and activities of the companies are contained in the associated Financial Reports 30 June 2008 for each of ASHCo and ASCo.

ASHCo:

Mrs Catherine Walter (Chairman)

Professor Rod Hill

Dr Garth Carnaby

Dr Sean Gallagher

Professor David Siddle

ASCo:

Mrs Catherine Walter (Chairman)

Professor Rod Hill

Dr Garth Carnaby

Dr Sean Gallagher

Professor Linda Kristjanson

Professor David Siddle

Risk Management Statement

During its first year of operation, the Australian Synchrotron continued to develop its risk management systems and policies for the operation and management of the Facility and has contracted a specialist risk management expert to assist with this task. During the year, the Australian Synchrotron received a gold star pass from the Victorian Government's Victorian Managed Insurance Authority for the results of its site risk survey and a commendation that it had an "excellent attitude to risk management".

The Board of Directors and the Audit and Risk Committee fully support the development of world class standards of risk mitigation and processes to the requirement of current Australian Standard AS/NZS 4360 "Risk Management". The Australian Synchrotron has developed policies, plans and procedures to achieve compliance and management of this important function.

Advisory committees and councils

The Council of Members

The Council of Members is a representative committee of Foundation Investors. Its role is to advise the Board of ASCo on issues related to science policy committee appointments and terms of reference and overall facility development.

Membership of the Council of Members

Foundation Investor	Representative
Victorian Government	Dr Amanda Caples
Monash University	Mr David Pitt
Association of Australian Medical Research Institutes	Professor Garry Jennings
Australian Nuclear Science and Technology Organisation	Mr Doug Cubbin
Commonwealth Scientific and Industrial Research Organisation	Ms Jan Bingley
Western Australian consortium	Mr Charles Thorn
New Zealand Synchrotron Group	Dr Don Smith
University of Melbourne	Mr Allan Tait
South Australian and La Trobe University consortium	Professor Richard Russell
Queensland consortium	Professor David Siddle
AUSyn14 consortium	Dr Chris Ling

Foundation Investor Liaison Committee

The Foundation Investor Liaison Committee meets quarterly to coordinate Foundation Investor access to the synchrotron and its members are the conduit for communication with the Foundation Investors.

Foundation Investor	Representative
Victorian Government	Dr Cassandra Schefe
Australian Nuclear Science and Technology Organisation	Dr Richard Garrett
Commonwealth Scientific and Industrial Research Organisation	Dr Jose Varghese
University of Melbourne	Dr Frances Skrezenek
Monash University	Dr Karen Siu
AUSyn14 consortium	Dr Joseph Bevitt
Queensland consortium	Professor Jenny Martin
Western Australian consortium	Professor Roland De Marco
South Australian and La Trobe University consortium	Dr Hugh Harris
	Associate Professor Andrew Peele
New Zealand Synchrotron Group	Dr Bridget Ingham
Association of Australian Medical Research Institutes	Dr Mike Lawrence

Science Advisory Committee

A Science Advisory Committee (SAC), reporting directly to the Board was appointed.

The SAC provides strategic advice on current and proposed scientific programs ensuring they are aligned with world's best practice and of continuing relevance to the requirements of the Australian Scientific Community.

The SAC Terms of Reference are to:

- monitor international developments in synchrotron science and provide input to the Board on optimising the scientific and technical capability of the Australian Synchrotron
- advise on the preferred mix of beamlines and skill set of operators and the ancillary laboratories and equipment required, having regard to the direction of leading-edge scientific enquiry and national research and development priorities
- develop procedures for the evaluation of proposals for the establishment of new experimental and support facilities and to recommend mechanisms for monitoring progress towards the introduction of these facilities
- respond to the Board's requirements for advice

Membership of Science Advisory Committee

Australia/New Zealand

Professor Frank Larkins, Chair, Deputy Vice Chancellor International, University of Melbourne and Chief Scientist, Energy, Victorian Department of Primary Industry

Professor Ted Baker, Professor of Biological Sciences, University of Auckland

Professor Jenny Martin, Institute of Molecular Bioscience, University of Queensland

Professor Tony Burgess, Director of the Ludwig Institute for Cancer Research and Professor of Surgery at the Royal Melbourne Hospital

Professor Peter Lay, School of Chemistry, University of Sydney

Science Advisory Committee members at the first SAC meeting in May. Professor Baker not present. (Photo: Sandra Morrow)

International

Dr Bill Thomlinson, former Foundation Executive Director of the Canadian Light Source Synchrotron, Saskatoon, Saskatchewan, Canada

Professor Michael Grunze, Professor Applied Physical Chemistry, University of Heidelberg, Germany

Dr Kevin Prince, Head of Spectroscopy ELETTRA Synchrotron, Trieste, Italy

Professor Xu Hongjie, Director of Shanghai Synchrotron Radiation Facility, Shanghai, China

Professor Soichi Wakatsuki, Director, Photon Factory Synchrotron Radiation Facility, Tsukuba, Japan

Professor Janet Smith, University of Michigan Medical School, Life Sciences Institute, Michegan, USA

Ex officio

Professor Robert Lamb, Australian Synchrotron

Other advisory committees

Proposal advisory committees

Proposal advisory committees (PAC) comprise senior researchers with an understanding of the latest developments in synchrotron science. PACs meet to discuss the proposals submitted for access to the Australian Synchrotron and make recommendations to the Director as to which proposals should be scheduled. This process is consistent with the established peer review system of the Australian Synchrotron Research Program (ASRP).

Members of the Structural Biology and Chemistry PAC

Professor Charlie Bond	University of Western Australia
Dr Paul Carr	Australian National University
Professor Geoff Jameson	Massey University, NZ
Dr Michael Lawrence	Walter and Eliza Hall Institute (Chair)
Professor Michael Parker	St Vincent's Institute
Dr Peter Turner	University of Sydney

Members of the Powder Diffraction PAC

Associate Professor Brendan Kennedy	University of Sydney (Chair)
Dr Ian Madsen	CSIRO
Professor Alan Pring	Flinders University
Dr Michael James	ANSTO
Dr Bridget Ingham	Industrial Research Ltd, NZ

Members of the Infrared PAC

Professor Don McNaughton	Monash University (Chair)
Associate Professor Peter Fredericks	Queensland University of Technology
Associate Professor Bill van Bronswijk	Curtin University of Technology
Dr Phil Heraud	Monash University
Dr Liz Carter	University of Sydney
Professor Peter Lay	University of Sydney

Members of the Soft X-Ray PAC

Professor Alan Buckley	University of New South Wales
Professor Paul Dastoor	University of Newcastle
Associate Professor William Skinner	University of South Australia (Chair)
Professor Jim Metson	University of Auckland
Dr Will Gates	Monash University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Independent review panel

Independent review panel

Proposals for beamtime undergo independent review prior to being assessed by the proposal advisory committees. The chair of the respective PAC assigns two independent reviewers with relevant expertise to each proposal.

Machine Advisory Group

Independent monitoring and review of machine operations is critical to the continued development of the facility.

A Machine Advisory Group (MAG) has been established to replace the International Machine Advisory Committee (IMAC) that reported upon progress during the build phase of the facility. MAG membership is drawn from key machine experts from international synchrotrons and includes heads of machine groups in Sweden: Professor Mikael Eriksson, MAX Lab, the USA: Dr Jeff Corbett, Stanford Linear Accelerator Center and ANKA: Dr Erhard Huttel, Institut für Synchrotronstrahlung, Germany.

Machine Advisory Group. From L to R, Dr Jeff Corbett, Stanford Linear Accelerator Center, USA; Dr Erhard Huttel, Institut für Synchrotronstrahlung, Germany & Professor Mikael Eriksson, MAX Lab, Sweden.

Glossary

Beamline
Generic name given to the infrastructure required to take the raw beam from a synchrotron then deliver it, filtered and possibly focused, to a scientific experiment. A synchrotron can typically feed many beamlines simultaneously.

Bending magnet
See dipole magnet.

Brightness
Also known as brilliance - this term refers to how much light is generated and how well this light can be focused on to a small spot.

CERN
European Organisation for Nuclear Research. (Conseil Européen pour la Recherche Nucléaire), Geneva Switzerland. CERN is the largest particle accelerator in the world.

Control system
The hardware and software required to operate a synchrotron and its associated facilities.

CSIRO
Commonwealth Scientific and Industrial Research Organisation.

Diffraction
One of the processes by which electromagnetic radiations (such as x-rays or visible light) is scattered by a solid, liquid or gas.

Dipole magnet
A dipole magnet generates a uniform magnetic field. Dipole magnets have two poles (north and south) and are used as bending magnets to steer the electron beam in the storage ring.

Emittance
The emittance of a storage ring is a measure of the size of the electron beam and thus has a direct relationship to the size of the light beam. Designers of storage rings endeavour to make the emittance as small as possible because this increases the brightness of the light beam.

Endstation
The endstation is the part of a beamline where the sample is placed and experiments take place.

eV
The abbreviation for electron volt, which is the total energy given to a single electron when accelerated by an electric potential of one volt. A 3 GeV synchrotron accelerates electrons by an equivalent of 3,000,000,000 volts.

EXAFS or XAFS
Extended X-ray Absorption Fine Structure spectroscopy is a technique that can be tuned to a single type of atom (like copper for example), then determine the nature of its chemical bonding with its nearest atomic neighbours.

Experimental station
See endstation.

Flux
Flux is the number of photons that cross a defined area per second.

Front-end
The front-end is the first part of a beamline – usually containing all the equipment required to select a desired wavelength and safely discard the unwanted part of the raw synchrotron beam.

Hard X-rays
Hard X-rays are x-rays with wavelength less than 6 nanometers. Hard X-ray microscopes can get penetrating images of solid samples and map their chemical composition.

Injection
The electrons circulating in the ring are continuously losing and regaining energy. Occasionally electrons strike gas atoms or molecules, and are lost from the beam. New electrons are injected into the ring, typically every 4 to 24 hours, to replace these lost electrons.

Insertion device
Insertion devices are rows of dipole magnets placed in the straight sections of storage rings, and are the key devices for the generation of synchrotron light in third generation storage rings. An insertion device will typically produce light 100 to 1,000 times brighter than a bending magnet.

Lifetime
The lifetime is the time taken for the current (concentration of electrons) in a storage ring to decrease by a factor of about 2.17 – typically this can be between 4 to 24 hours.

Magnetic field
The magnetic field is the force field between the poles of a magnetic assembly.

Magnets
In addition to the insertion devices, there are four main types of magnet in a storage ring: dipole, quadrupole, sextupole and corrector. These are all required to keep the electrons circulating around the synchrotron in a controlled orbit.

Photoemission
Photoemission is the process by which an atom releases an electron after absorbing a photon of light. It can give detailed chemical information especially from the surface of a sample yielding maps of a chemical landscape.

Photon
Light (including x-rays) can behave in a wave-like or particle-like manner. When describing light as particles we call these small bundles of energy photons.

Photon energy
There is a relationship between the energy of a photon and its wavelength – the higher the energy of the photon, the shorter the wavelength.

Polarisation
One of the wave-like properties of light is its oscillating electric field. If the electric field vibrates in a well defined direction, then the light is said to be linearly polarised.

Protein crystallography
Proteins can be crystallised into an ordered array of atoms. X-ray scattering data from these crystals can be analysed to help determine the position of the atoms in the protein, and thus derive the protein structure. Most protein structures are solved by x-ray methods, and this drives much of our understanding of how organisms function as well as the development of new medicines.

Soft X-rays
Soft X-rays are x-rays of wavelengths from 6 nm to 120Nm and can be used to image cells – revealing detail down to about 20 nm (20 millionths of a millimetre).

Soft X-rays can also be combined with photoemission to image the top few atomic layers of a sample – useful for examining the fine detail on the surface of a microchip.

Storage ring
Once electrons are generated, and accelerated in the linac and/or booster ring, they are injected into the storage ring. Here they are maintained in a circular orbit at a constant speed. Synchrotron light is produced as these electrons pass through bending magnets and insertion devices.

Synchrotron
This is a generic description of a particle accelerator facility in which the particles (usually electrons) orbit the ring with their energy loss precisely compensated by a synchronized injection of powerful microwaves. The orbiting particles produce intense synchrotron light, which is used for scientific, industrial and medical applications.

Synchrotron light
Synchrotron light is the broad spectrum of light produced by a synchrotron - it ranges from infra-red light to visible light to x-rays.

Synchrotron radiation
This is another term for synchrotron light - infra-red, visible light and x-rays are all part of the electromagnetic spectrum.

Top up mode
Top up mode is the process used by some synchrotron facilities to maintain the electron current at a constant level by regular injection of additional electrons.

X-ray diffraction
See diffraction.

X-ray fluorescence
When x-rays hit an atom in a sample, they can knock electrons out in a process called photoemission. After this, an atom may emit another, lower energy x-ray in a process called fluorescence. This second x-ray has an energy that is characteristic of the atom and can be used to determine the chemical composition of a sample.

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Cover Image
By Chris Henschke

Detail: Amber Spectra

In 2007, artist Chris Henschke undertook a three month residency at the Australian Synchrotron through the Arts Victoria Arts Innovation program and the Australian Network for Art and Technology.

During his stay he conducted several experiments using the synchrotron in different ways to collect visual data. One such 'visualisation experiment' used image sequences of the infra-red and optical diagnostics beams passing through a lightbulb, composited with 360 degree video footage shot in the particle beam's accelerator and storage ring and spectral analysis of the light.

In a way that is visually analogous to the 'Fourier Transform' processes, Chris manipulated the images by separating the colour frequencies then spinning them back together into a 'frequency panorama' dubbed Amber Spectra.

Australian Synchrotron Company Limited
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