Australian Synchrotron
Annual Report 2012

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

Australian Synchrotron

Supported by

Australian Government

State Government Victoria AUSTRALIA

About this Annual Report

The 2012 Australian Synchrotron Annual Report provides the reader with a view of the Australian Synchrotron's science priorities, core activity and scientific achievements. It is a public document and can be read or downloaded by visiting www.synchrotron.org.au/news/publications. Requests for copies of the report can be forwarded to the Administrative Officer, Australian Synchrotron, 800 Blackburn Road, Clayton 3168 Australia or via email to info@synchrotron.org.au

Contents

About the Australian Synchrotron

The Australian Synchrotron is a world class science and research facility that provides researchers with a powerful suite of tools for investigating and analysing materials in a way that cannot be achieved using conventional technologies.

These tools use x-ray and infrared light generated by the Australian Synchrotron to support advances in science and technology across a range of fields from medicine and manufacturing to mineral exploration and nanotechnology.

Discoveries made at the Australian Synchrotron are contributing to an improved understanding of our world and lead to exciting new technologies, processes and products, which deliver a range of health, social and economic benefits.

Vision

The Australian Synchrotron's vision is to be the catalyst for the best scientific research and innovation in Australasia. The focus for the facility is to provide a thriving scientific research environment that is conducive to creating and nurturing the best scientific outcomes for Users and the staff of the facility.

Mission

The Australian Synchrotron's mission is to develop a world-class synchrotron facility, maximising the quality, breadth and impact of scientific output.

Core values

The facility is driven by the core values of passion, respect, collaboration, innovation and continuous improvement.

Our research capabilities

The Australian Synchrotron's high performance technologies and techniques can be applied to a range of academic and industrial research areas including:

- Biomedicine: researchers can take advantage of new world class diagnostic, imaging and therapeutic techniques and high-throughput structural biology capabilities.
- Defence: the facility allows the defence researcher to study the atomic nature of materials, sensors and heavy metals.
- Environmental technologies and services: the facility's beamlines can be used to support environmental remediation work and the analysis of soil samples, the quality and composition of fresh and salt water, air and atmospheric samples, pollutants and toxins and contaminants.
- Food technology: food technologists and other food specialists can use the facility to analyse ingredients, the processes used in food manufacturing and the nutritional impact of foods.
- Forensics: using the facility's world class instrumentation and scientific techniques researchers can refine and or develop new forensic processes, techniques and applications.
- Manufacturing: researchers within the manufacturing sector can use the facility to investigate the structure and characterisation of alloys, catalysts, fibres and textiles, adhesives, polymers and plastics, surfaces, interfaces and coatings. It can also be used for stress analysis of engineered components.
- Minerals: the facility's beamlines can be used to support all aspects of mineral exploration and mineral processing.
- Nanotechnology and microtechnology: the synchrotron can be used by researchers to study ways to manufacture highly advanced nano and micro-devices, micro-circuits and micro-sensors.
- Oil and gas: researchers can use a number of synchrotron techniques to support the development of exploration processes, pipeline reactions, fuel processing and the development of fuel cells.
- Pharmaceuticals: researchers can use the facility to analyse proteins, nucleic acids, viruses and also bio-memetic materials (artificial skin and organs) and to conduct cell imaging, quality control monitoring, drug target identification work and the assessment of drug targets.
- Scientific instruments: researchers can use the facility and its beamlines to develop detector technologies, measurement techniques, medical implants and delivery systems.

Chairman's Report

The past year has been immensely significant for the Australian Synchrotron – marking the completion of its first five year operational cycle, the negotiation of new funding for the next four years and the prospect of new governance arrangements.

The achievement of new funding from the Australian, Victorian and New Zealand Governments and Australian universities came at a challenging time for scientific institutions around the world in which governments were cutting back spending on science and major scientific facilities.

The Company is grateful to the governments and universities for their support and their confidence.

The proposed new funding is a recognition of the Australian Synchrotron's outstanding achievements, made possible by the excellence of its staff who have ensured that Users can access one of the world's most reliable synchrotrons and some of the world's finest beamlines. These achievements have fostered intellectual enquiry, world-class research, and educational opportunities and have contributed to Australia's economic, social and health well-being.

We are proud to report that there has been a continuing growth in refereed journal publications with more than 300 for the year. In particular there has been a strong growth in high impact factor publications in world leading journals including Nature and Proceedings of the National Academy of Sciences.

The Board of Directors and the Australian Synchrotron management team – particularly Director, Professor Keith Nugent, and Chief Operating Officer, Dr George Borg – have coped with immense demands around providing information to governments and others while being involved in extensive consultation and negotiation with governments and stakeholders. I also particularly would like to thank the scientific and engineering teams for their dedication to the facility during uncertain funding times.

They were supported by the many organisations and committees which form part of the wider Australian Synchrotron Community. There was outstanding work and support for the facility from the National Science Colloquium, Scientific Advisory Committee, Machinery Advisory Group and the many other scientific panels who are essential to ensuring that the Australian Synchrotron remains aligned with world's best practice.

The commissioning in early 2012 of the National Centre for Synchrotron Science and Guest Accommodation facility at the Australian Synchrotron have greatly improved and enhanced User experience at the Australian Synchrotron.

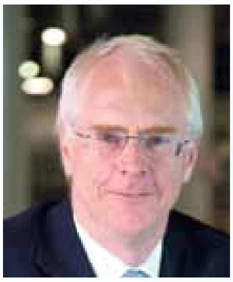
When the Board commissioned extensive modelling work on 2nd October 2009 to identify future financial needs, it aimed to produce a strong business and scientific case for increased operational and capital funding which would, over the next five year funding period until 2017, enable the Australian Synchrotron to fulfil the potential envisaged when it was first mooted. The Board also sought to ensure the facility's compliance standards with funding agreements and regulatory requirements gave funders confidence in the facility.

It was gratifying in this context that, as part of the process for securing future funding, ANSTO and CSIRO, acting as technical advisors to the Commonwealth, undertook a detailed due diligence process of the facility which concluded that the Australian Synchrotron was being well managed and achieving significant scientific outputs.

The $100m funding package secured for the Australian Synchrotron to June 2016 will ensure the facility operates to its full scientific capability for the benefit of Australian and New Zealand scientific communities.

Mrs Catherine Walter AM
Australian Synchrotron Chairman

Director's Report



As the individual responsible for managing the Australian Synchrotron's scientific leadership and strategic direction, I am happy to report that significant milestones were reached in 2011-2012.

The facility provided world-class scientific facilities and user support services. Its domestic and international user base continued to grow and a user accommodation building was constructed to meet the needs of our user community.

We achieved a high level of performance across a number of important science and research criteria including machine performance, the user experience and the quality and number of published scientific papers. In fact, it was the most productive year ever for scientific outputs.

Clearly one of our key milestones involved securing funding for the ongoing operation of the Australian Synchrotron (AS). In achieving this goal, we have taken a significant step. The announcement made by the Australian Government and Victorian State Government on 28 March 2012 means we now have a firm base on which to develop plans for capital funding.

Importantly, our science contributed to state and national research priorities and subsequently the health, social and economic well being of all Australians. Research undertaken at the facility focused on an unlimited range of fields from environmental management, health and the development of new technologies, to scientific research aimed at safeguarding Australia's physical borders.

The Australian Synchrotron also made a significant contribution to industry by providing SMEs (small to medium enterprises) and larger scale businesses with access to a unique and highly flexible research tool; a tool far superior to conventional laboratory equipment.

As a measure of its success, the Australian Synchrotron engaged directly and indirectly with over 100 private companies representing a cross section of industries ranging from mining and biotechnology to manufacturing and forensics.

The facility also made contributions to our scientific community through the International Synchrotron Access Program (ISAP), the Post Graduate Awards and the AS Thesis Medal. We nurtured existing partnerships and developed new ones with organisations such as South East Melbourne Innovation Precinct, the Victorian eResearch Strategic Initiative, Australian Collaboration for Accelerator Science, the Melbourne Centre for Nanofabrication, the Characterisation Council, Plastics and Chemicals Industries Association, universities and research groups such as CSIRO and ANSTO.

Our desire to improve the facility's scientific capabilities was again a high priority. Beamlines were the focus of continuous scrutiny and improvement, with this activity being further supported by the use of new technologies such as the super computer MASSIVE, and TARDIS, a high-end data management solution. The result of this hard work and a culture of continuous improvement also resulted in several of our beamlines being classified as world leading.

The Imaging and Medical beamline is a clear example. It is the facility's largest and most complex beamline. After commissioning, it will see its first users in 2013 – a remarkable and timely outcome when compared to other similar synchrotron projects. This NHMRC-funded upgrade, we are excited to say, will deliver a number of innovative services including: high resolution x-ray imaging, tomosynthesis and computed tomography, and microbeam radiation therapy.

All these activities across the facility were due to the dedication of our employees and our user community.

Importantly, I would like to thank the Australian and New Zealand Governments, the Victorian State Government and the education and scientific community for their collective vision and support. Their commitment has quite literally ensured the operation of what is a world-class science and research facility.

I am particularly grateful for the ongoing dedication, support and hard work of Professor Andrew Peele as Head of Science. Indeed, I would also like to thank all of our employees, the management team, the Board and our Science and User Advisory Committees, Machine Advisory Groups and the National Science Colloquium who continue to support excellence in Australian science.

Professor Keith Nugent
Director of the Australian Synchrotron

Chief Operating Officer's Report

As acknowledged in the Chairman's report, 2011-2012 has been an extremely busy year across the many aspects of the facility. Work has been ongoing to secure the future viability of the Australian Synchrotron, whilst also ensuring the facility continues to play a leading role in science and operations for its Australian and international users.

It is of note that the Australian Synchrotron machine reliability is amongst the highest in the world. Throughout the year, we achieved a rolling beam availability of 99.6%. This outstanding result is due in part to the huge impact of the Uninterruptible Power Supply (UPS) that was operational in early 2012 together with the great efforts of our physicists, operators and engineers. Of further note, the facility moved to Top-Up mode which has enabled users to conduct experiments faster, using a more stable beam.

The Australian Synchrotron's Triennial Re-certification Audit was successfully held in 2012 and involved a detailed review by external auditors across the many functions of the organisation. This successful audit enables the Australian Synchrotron to retain its important ISO9001:2008 certification to 30 June 2015.

The 2011 Australian Synchrotron Open Day was held in November 2011. Approximately 3,000 guests attended the event, and overall, Open Day was a resounding success. This key event on the Australian Synchrotron's calendar increased public awareness of the facility and achieved its objective of showcasing the work that is done here to the broader community.

With the assistance of the User Advisory Committee (UAC), a successful Australian Synchrotron User Meeting was hosted in December 2011. The Meeting, attended by 250 scientists, provided a forum for Australian Synchrotron users to discuss their work and network with colleagues from many diverse disciplines.

On the building and infrastructure side, considerable efforts were expended in the construction and completion of a number of buildings under the Education Investment Fund (EIF) program. The Australian Synchrotron Guesthouse was successfully launched and is proving to be of great benefit to our users. The National Centre for Synchrotron Science now houses the organisation's corporate functions, and together with the other buildings in the EIF program, contributes significantly to the wellbeing of employees and facility operations.

Throughout the year, the Australian Synchrotron was privileged to host a number of notable visitors including the Hon Chris Evans, Federal Minister for Tertiary Education, Skills, Science and Research; the Hon Simon Crean MP, Minister for Regional Development and member for Hotham; Ms Anna Burke MP, Deputy Speaker and member for Chisholm; Mr Hong Lim MP, member for Clayton; Mr Adem Somyurek, MLC for South Eastern Metro and Labor Shadow Minister for Technology and Manufacturing; Professor Douglas Hilton, Director of the Walter & Eliza Hall Institute of Medical Research; and Professor Lyn Beazley, Western Australian Chief Scientist.

None of these achievements would have been possible without the tireless efforts and commitment of our dedicated employees and our energetic user community. Together, we have met the ambitious expectations established when the Australian Synchrotron first opened in 2007. I commend all the individuals, committees and organisations who have contributed to the achievements of the Australian Synchrotron.

Dr George Borg
Chief Operating Officer of the Australian Synchrotron

Australian Synchrotron Highlights 2011-2012

The Australian Synchrotron capped off an exciting year of scientific results with the welcome news, announced by the Federal and Victorian State Governments, of a funding package that will provide for the operating costs of the facility from 2012 – 2016. Facility and research outcomes in the 2011-2012 financial period include:

- Continuing growth in refereed journal publications with more than 300 for the year; more than 600 since the facility commenced user operations; and, when programs funded or administered by the Australian Synchrotron are taken into account, more than 1,000 publications in total.
- Strong growth in high impact factor outcomes with more than 20 publications with an impact factor of 9 or higher; the average impact factor for all publications of 3.5 is comparable with the best research groups in Australia.
- Researchers working with AS staff used a combination of information from the small and wide angle x-ray scattering and the micro and macro-molecular crystallography beamlines to understand how enzymes dissolve blood clots and clean up damaged tissue – a finding that could ultimately lead to a reduction in the number of heart disease-related deaths.
- Research using the powder diffraction beamline demonstrated the potential for certain compounds to be used as solid storage for new hydrogen energy delivery systems.
- Researchers using the x-ray fluorescence microscopy and the x-ray absorption spectroscopy beamlines showed how to create crops that exhibit improved nutrient uptake. Such developments could have a huge impact in improving nutrition delivery, which is a major cause of infant mortality in the third world.
- Spectroscopy at the infra-red beamline was used to assist researchers in understanding the natural bactericidal properties of cicada wings, while spectroscopy using the soft x-ray beamline was used to demonstrate ways that diamond materials could form the basis of the next generation of electronics.
- The Australian Synchrotron directly assisted many companies, particularly in the mining and pharmaceutical sectors. For example, Hospira Global Pharma R&D called on the expertise of the Australian Synchrotron to help confirm the structure of a complex molecule as part of a comprehensive structural characterisation program.
- The reliability of the facility in delivering light to experiments was enhanced by the delivery of an uninterruptable power supply and beam availability hit unprecedented levels of greater than 99% during the year and unbroken periods greater than 500 hours without incurring an unscheduled loss of beam.
- Major building projects funded under the Commonwealth Government's Education Investment Fund were delivered during the year and are now greatly enhancing the operations of the facility:
    - A 50 room guesthouse provides convenience and comfort for users and visitors.
    - The National Centre for Synchrotron Science houses the main administrative functions of the facility, a 400 seat lecture theatre and display space.
    - The technical support and laboratories building provides the space and capacity for much of the technical services required for the continued operation of the facility.
- The facility received significant funding totalling more than $600,000 through the National eResearch Collaboration Tools and Resources program, which is funded through the Commonwealth Government's Education Investment Fund. This program will streamline the access to data and computational methods associated with several beamlines.
- Education and outreach activities saw more than 1,500 students visit the synchrotron. This, together with a well attended Open Day resulted in a total of more than 3,000 visitors to the facility during the year.

Scientific Overview

Introduction

The scientific work generated by the Australian Synchrotron made a positive contribution to Australia's National Research Priorities including: creating an environmentally sustainable Australia; promoting and maintaining good health; developing frontier technologies for building and transforming Australian industries; and safeguarding Australia.

Today, many of the facility's significant research outcomes focus not only on our strengths as a facility, but on research that is closely aligned with national priorities and policy. Whether working towards creating a sustainable Australia or the creation of technologies to support a vibrant small technologies sector, this world-class facility continues to deliver results.

Local and international research community

With respect to the number and composition of our user community, the Australian Synchrotron continued to diversify and grow. Its user base included a mix of government, industrial and academic scientists from across the world. Some in this group have already experienced the value of synchrotron science while others are just starting to see the potential of the facility.

Students and early career researchers featured prominently among the members of our user community. This illustrates the important and ongoing role the Australian Synchrotron plays in the development of our national and international synchrotron science community.

The facility also supported international synchrotron developments during the 2011-2012 period. In addition to servicing the needs of scientists in over 3,000 user visits at the facility itself, the Australian Synchrotron participated in a series of international work programs and collaborative ventures. These projects were designed to further nurture the development of synchrotron science across the world.

The facility invested time and resources in its International Synchrotron Access Program (ISAP) and in activity aimed at providing Australian scientists with access to the mature X-ray Absorption Spectroscopy (XAS) beamline in Japan. The Australian Synchrotron believes these initiatives improve the skills and expertise of our scientists by providing them with direct access to other leading synchrotrons. Importantly, the increased knowledge and skills that come from such experiences can then be applied to the Australian Synchrotron and the important work it does.

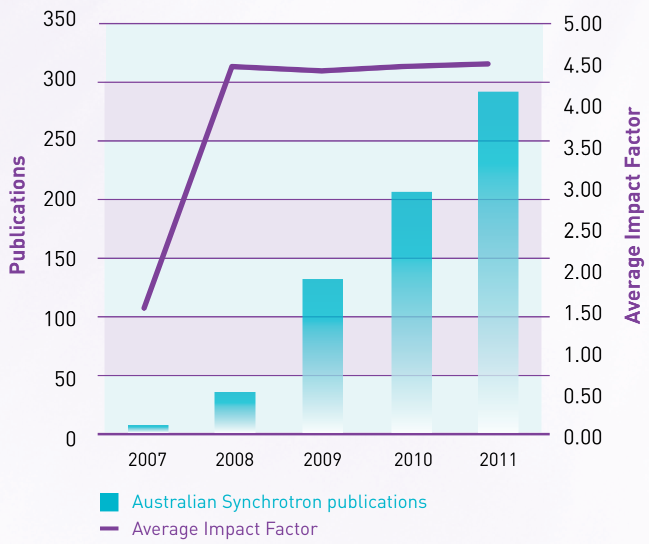
The Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS) and associated grants scheme also provided Australian scientists with the capacity to explore research avenues and collaboration. The Australian Synchrotron strongly believes that these and other initiatives will continue to support the development, growth and expertise of Australian scientists.

Performance statistics: total number of users, number of papers, quality rating and sectors

Since its establishment in 2007, the Australian Synchrotron (AS) has demonstrated that it is Australia's largest and arguably most successful User scientific facility. In its short life, it has attracted over 10,000 user visits from the research and industrial community and been directly involved in the generation of over 600 scientific publications in refereed literature, with many of these occurring in the highest impact journals in their respective fields.

Figure 1: Publications and Impact Factor 2007 – 04/2012

The columns refer to publication numbers and the purple line to the average impact factor of these publications.



Sectors

As a scientific facility, a synchrotron is, in its most basic form, a very bright source of light. At the AS, that light is mainly delivered in the form of x-rays, although one beamline uses infrared light. Currently, the AS operates nine beamlines that provide key capabilities across a wide spread of scientific techniques.

Traditionally, certain synchrotron-based techniques have tended to serve specific disciplines – some concentrate on the medical and life sciences while others contribute more to engineering, chemistry and physics. Increasingly, however, a number of beamlines are branching out from their traditional user base, creating a wealth of new science at the point where different disciplines meet. The AS Powder Diffraction and Small and Wide Angle Scattering beamlines provide excellent examples of this.

Broadly speaking, the Australian Synchrotron studies atomic and molecular structure in two ways – using diffraction or spectroscopy. Diffraction tells us a lot about how atoms arrange themselves, while spectroscopy tells us how they are bonded together. The high-intensity light available at the AS can be focused down to microscopic regions, at times allowing both types of measurement to be applied at many closely-placed points on a given sample. This enables detailed mapping of specimens revealing granularity in elemental composition, atomic arrangement and chemical state.

It also demonstrates that both types of measurement form strong components of imaging. A standard x-ray image is actually a map of electronic density – but useful images can also be derived by mapping other measureable qualities.

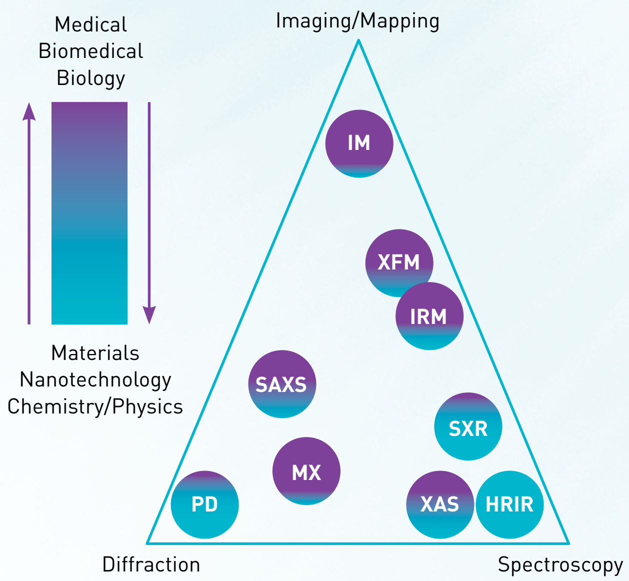
The colours displayed in Figure 2 demonstrate that most techniques at the AS contribute in varying degrees to both life sciences (purple), and physical sciences (blue). As can be seen from studying this diagram, the spread of disciplines is well balanced at this facility.

Due to this underlying capability, the Australian Synchrotron epitomises scientific research excellence in Australasia and brings together a host of sophisticated techniques that span, and can be used by, nearly every research sector and industry in Australia and New Zealand. The AS provides the ability to undertake investigations that were simply not possible in the region before 2007.

The result has been impressive growth in research outputs and impact including:

- high-quality publications as shown in Fig. 1.
- a series of outstanding research highlights and high-impact outcomes (following pages).
- strong rates of subscription, as shown in Fig. 3, ensuring that the competition for access is strong and that the AS supports only the best research.

Figure 2: shows where the techniques available at the AS fall in respect to the different measurement techniques of diffraction and spectroscopy.



HRIR - High Resolution Infrared
IM - Imaging and Medical
IRM - Infra-Red Microscopy
MX - Micro and Macro-molecular Crystallography
PD - Powder Diffraction
SAXS - Small and Wide Angle Scattering
SXR - Soft X-Ray
XAS - X-ray Absorption Spectroscopy
XFM - X-Ray Fluorescence Microscopy

- significant uptake by students and early career researchers, creating the next generation of scientific leaders. Fig. 4 shows cumulative numbers of students and early career researchers accessing the facility.
- administration of an international access program that keeps Australian researchers at the leading edge of those techniques not yet available at the AS.
- development of technical capabilities that place the AS at world-class and, in some areas, world-leading standard.

Figure 3: Subscription rates by beamline

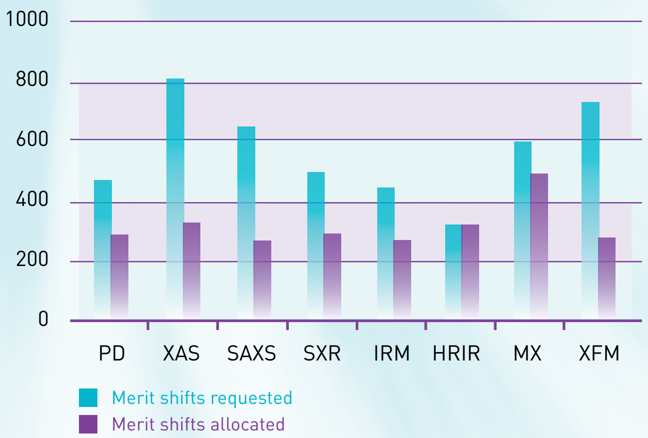
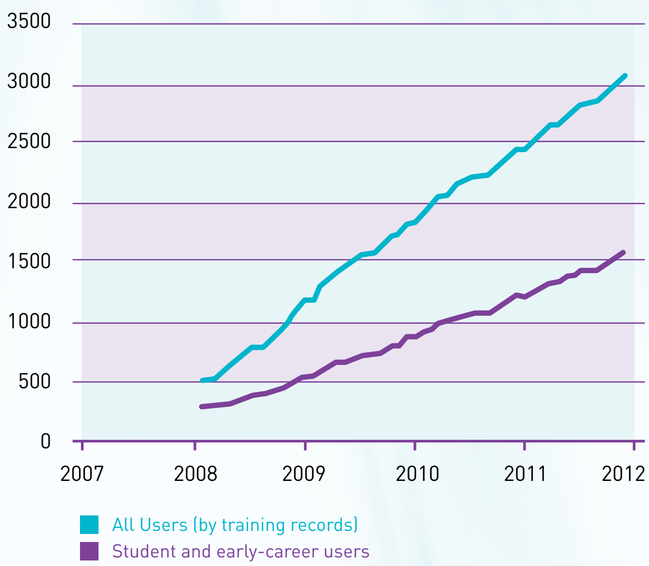


Figure 4: Students and Early Career Resarchers



Research sector concentration at the AS, as shown in Fig. 5, is reflective of the research strengths across the country and can be broadly categorised as follows:

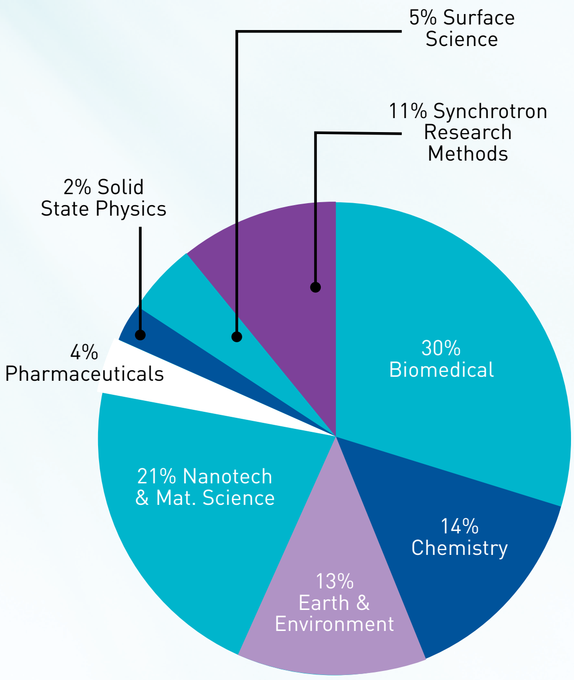
- Medical and Life Sciences: structural biology; cellular imaging and biochemistry; medical imaging and therapies.
- Advanced Materials and Engineering Science: polymers, ceramics and composite materials; magneto, optical and molecular electronics; nanoscale materials.
- Earth and Environmental Sciences: mining technology and mineralogy; environmental systems; energy technologies.

In addition, two areas of research expertise have emerged in Australia as a direct outcome of the establishment of the AS:

- Synchrotron research methods.
- Accelerator science.

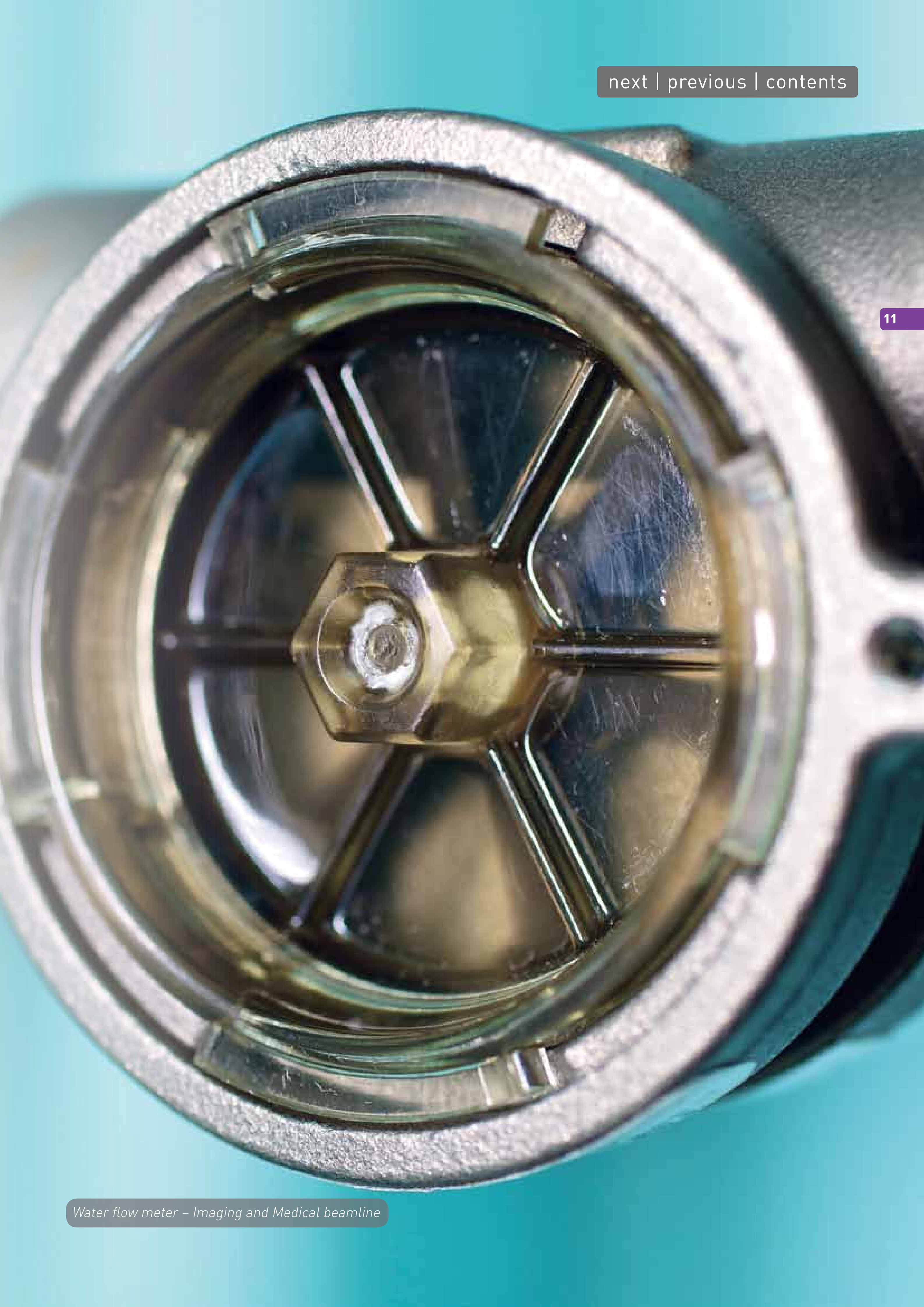
All five of these research areas are discussed in depth in the following pages.

Figure 5: Proposals by research sector



Overview of Beamlines

- High Throughput Macromolecular Crystallography (MX1): dedicated to determining the structure of protein crystals and the initial assessment of more complex crystals, this beamline also provides rapid and detailed crystal structure information in addition to supporting the rapid determination of large numbers of protein structures.
- Micro Crystallography (MX2): uses multiple wavelengths of light to evaluate high-resolution crystal structures and allows characterisation of structures that were previously difficult to determine, particularly for small, weakly diffracting crystals.
- Imaging and Medical (IM): will provide high-resolution x-ray imaging, tomosynthesis and computed tomography of biomedical samples and materials, as well as enable micro-beam radiation therapy research. The upgrade program will allow even greater resolution in phase contrast imaging and associated applications than is possible using conventional methods, and will deliver an unprecedented wide field-of-view for synchrotron-based x-ray imaging and therapy. It is one of few beamlines in the world configured for a wide range of bio-clinical and materials research applications, which will enable research into areas such as cancer and diagnostics.
- Small and Wide Angle x-ray Scattering (SAXS/WAXS): provides information on the structure and dynamics of complex samples and allows the collection of dynamic process data that cannot be collected by any other means.
- X-ray Fluorescence Microscopy (XFM): provides very high-definition maps of elemental distributions across a diverse range of samples and sample environments with sub-micronmetre resolution. XFM can be tuned to probe and analyse a single element providing valuable additional information about the oxidation state or chemical bonds. The ultrafast Maia detector system enables 3D fluorescence tomography and chemical speciation mapping with real time output.
- X-ray Absorption Spectroscopy (XAS): provides structure or chemical information about a sample including data about chemical bond lengths, local atomic geometry, nearest neighbour atoms, disorder and oxidation state. This information can be obtained for crystalline as well as amorphous, liquid and gaseous systems.
- Powder Diffraction (PD): supports a range of experiments on multi-component samples that provide data on their structure, strain, phase, texture and composition. The beamline allows rapid data collection with high-resolution and can produce two-dimensional maps of data. This is the optimal technique for investigating atomic structures in materials that do not form a single large crystal.
- Far infrared, high-resolution spectroscopy and infrared microspectroscopy (IR): the Australian Synchrotron has two infrared beamlines that operate independently of one another. The technique allows for high spatial resolution chemical images and high-resolution characterisation of gas samples.
- Far infrared, high-resolution spectroscopy is widely used in research, analytical and industrial laboratories. In contrast, the infrared microspectroscopy beamline extends the scope of this popular technique, and can locate and analyse individual components in samples with dimensions of only a few microns, producing high spatial resolution chemical images.
- Soft X-ray (SXR): Synchrotron soft x-ray spectroscopy provides distinctive information for numerous research areas ranging from fundamental studies in solid state physics and nanotechnology to applied chemical problems in catalysis and coal combustion and is well suited to characterising surfaces and near-surface interfacial layers.



Water flow meter – Imaging and Medical beamline

Medical and Life Sciences

This and the following sections describe areas of research, with work ongoing or published during the 2011-2012 period using data collected at the AS. Due to limited space, only a brief description of selected projects, representing work from more than 30 institutions from the Australian and New Zealand user community with collaborators from more than 20 overseas institutions, is given here with references to relevant publications. During this period, over 600 experiments were conducted at the AS.

Structural biology

Understanding the structure and function of the building blocks of life is core business at nearly every synchrotron facility worldwide. The overwhelming majority of protein structures deposited in the Protein Data Bank (a worldwide primary source for solved structures), now come from beamlines like the MX beamlines at the AS. These beamlines directly serve more than 20 structural biology groups around the country; by the end of 2011, more than 170 publications and 180 Protein Data Bank deposits had been produced. When coupled with the ability of the SAXS/WAXS beamline to resolve structural detail for proteins in solution, some of the most difficult structural biology experimental challenges can be overcome using the Australian Synchrotron. Beamlines such as XAS also provide information on configuration and speciation, particularly where metal interactions are involved.

Highlights from the financial year 2011-2012 included potential drug candidates for microbiological and human proteins that relate to immune recognition[1, 2]* and bacterial pathology.[3]* Specific targets have included a malarial protein that could have its function disrupted to starve the parasite, thereby inhibiting the development of the disease.[4]* Other work included the development of a method for analysing complexes of proteins from paraspeckles,[5]* which are regions of mammalian cell nuclei that regulate protein function.

The high quantity of output was matched with high quality research leading to two publications in Nature, two in Nature Immunology, one in Immunity and five in the Proceedings of the National Academy of Sciences in FY 2011-2012 alone. Several projects have also received considerable media attention. One ongoing study that has already achieved major success is the work that has been done on the molecular structure of plasminogen.[6]* Plasminogen is a precursor of the enzyme plasmin, which assists in dissolving blood clots and is also implicated in some cancers. Previously, the biochemistry of drugs that activate plasminogen and that lead to the creation of the enzyme plasmin had not been fully understood.

Researchers working with AS scientists used a combination of information from the SAXS/WAXS and MX beamlines to understand how the enzyme dissolves blood clots and cleans up damaged tissue. The findings could ultimately lead to a reduction in the number of heart disease-related deaths. With this work, the next generation of anti-clotting and "clot busting" drugs can also be designed for use in treatment of strokes, heart attack and cancers.

Ongoing investigations include identifying further suitable structures that can activate plasminogen and which may become candidates for drug therapies.

Cellular imaging and biochemistry

The SAXS/WAXS, XAS, XFM and IR beamlines are key tools for the investigation of biochemistry and interactions at the atomic and cellular levels. Highlights from the AS included the use of the IR beamline to identify conformational changes to DNA as a response to environmental stress. These studies may provide a method to differentiate cancerous cells, while also providing insight into how some organisms, including pathogens, are able to survive extreme conditions.[7]* This work also demonstrated that the live cell research capabilities available on the IR beamline can be used to study the differentiation process in stem cells. This finding may lead to the development of infrared spectroscopy methods for screening cells, which could be applied to stem cell therapy.[8]*

An ongoing study in the cellular biochemistry sector involves XAS and XFM and the study of arsenic, chromium, platinum and selenium-based compounds, and their potential use as anti-cancer drugs. It is clear that careful study is required to understand the mechanisms that influence both the beneficial anti-cancer effect of these drugs and their acute toxicity.[9]*

Other research groups are also actively pursuing studies in this area including:

- Design, preparation and characterisation of novel MRI contrast agents.[10]*
- Effects of metal-based drugs in the cellular environment.[11]*

** References providing further information are set out on page 18.*

Rotary actuator for the robot – Macromolecular Crystallography beamline

Medical imaging and therapies

On the macroscopic scale, the IM beamline at the AS allows part and whole animal imaging that can target gene expression and drug effects. This type of technique and accompanying technology can also be used to understand the morphology of disease and anatomy. The IM beamline is highly relevant to the study of x-ray interactions with biological matter. National Health and Medical Research Council (NHMRC) funding has provided for an extension to the IM beamline. In the last year, major milestones towards the completion of the IM Beamline extension were reached. When complete and commissioned, these developments will culminate in the use of the world's widest synchrotron x-ray beam - 500 mm wide by 40 mm high.

The IM beamline will allow greater resolution in phase-contrast imaging and associated applications such as tomosynthesis and computed tomography. It will also be one of the few beamlines in the world configured to accommodate a wide range of bioclinical and materials research applications that enable studies into areas such as cancer diagnostics and treatment. The future will see instrumentation for preclinical and clinical imaging and radiotherapy programs. In the area of radiotherapy, a new microbeam collimator and a high-speed positioning system will be introduced.

In an ongoing study in this area, scientists using the Australian Synchrotron are working on the imaging of animals to assess drug delivery strategies for the treatment of cystic fibrosis. Extensive preliminary work at the AS and elsewhere has demonstrated that the phase imaging methods to be implemented at the IM beamline will greatly assist in assessing the efficacy of nasally delivered gene therapies.[12]*

Initial research into radiotherapy delivered in microcollimated beams has shown that doses delivered this way had a significant effect on cancerous tissue while leaving healthy tissue relatively undamaged.[13]* This NHMRC-funded research has already investigated methods for irradiating animals. This means that efficient trials can be conducted at the AS when the beamline upgrade is completed.

** References providing further information are set out on page 18.*

Advanced Materials and Engineering Science

Many of the techniques described previously under the category of 'Medical and Life Sciences' are equally useful when applied to the characterisation of materials – an area where the Australian scientific community has traditionally performed strongly.

The PD beamline, for example, is a highly effective tool for tracking the atomic structure of material in real time under specific chemical or physical conditions. It also allows accurate 'fingerprinting' of solids, allowing complex mixtures of compounds or minerals to be quantitatively measured. The SAXS/WAXS beamline, by contrast, performs a similar function but has the ability to extend the range of lengths scales that can be monitored from a few tenths of a nanometre to hundreds of nanometers. Understanding the different levels or 'hierarchies' of a structure from the atomic to the microscopic level in materials is key to understanding the inherent properties of many natural and man-made materials.

For both these diffraction techniques, high throughput analysis is made possible by the intense light of the synchrotron beam. Spectroscopic methods available on the XFM, XAS, SXR and IR beamlines identify different bonding information within and between molecules. Combining this intensity with the ability to focus light at a point that is smaller than the width of a human hair allows techniques such as XFM and IR microscopy to show us how much a single sample can vary in its elemental composition and chemical nature from one sample site to another. This heterogeneity is an important contributing factor in how useful complex 'real' materials can be.

Unlike other nanometre-scale analysis techniques, such as electron microscopy and atomic force microscopy, synchrotron-based techniques have a minimal effect on the material being studied and can be applied to almost any liquid, solid or mixed system under a vast range of physical and chemical conditions.

Polymers, ceramics and composite materials

There are many examples of fundamental scientific research being performed on materials at the AS.

Some highlights from the last year:

- Tracking the evolution of block co-polymer microparticles during in-situ SAXS/WAXS measurements of a novel, environmentally-friendly synthesis technique. Given the importance of high-tech polymers in almost all high-value products, reducing or even eliminating the use of harmful solvents in their production is highly desirable.
- Characterising the hydrogen capture and release capabilities of solid powders such as borohydride compounds.[14]* The PD beamline has allowed us to track atomic structure changes as a function of temperature, providing us with insights that move us ever closer to developing safe and economically-viable hydrogen storage solutions for environmentally-friendly energy usage.
- The use of the XFM and IR beamlines in providing a detailed understanding of the origins and fabrication of precious cultural artefacts. An example is paintings, where pigments and under-paintings can be identified by elemental[15]* and chemical distribution, which allows more accurate valuation of collections.
- Developing new methods for increasing the mechanical strength of animal hides such as sheep leather. Using the SAXS/WAXS beamline, a detailed understanding of the highly complex structure of leather[16]* provided AS users with a better understanding of the composition of the material and how its strength can be enhanced.

*References providing further information are set out on page 18.

Magneto, optical and molecular electronics

The silicon chip has for decades been the foundation of the world's electronics industry. However, radical innovations in the future mean we are likely to move from this material to others that provide even better information processing capabilities.

Some of the 2011- 2012 research highlights in this area from the AS provide a hint of what is to come. Work by AS scientific teams and users included:

- The study of Single Molecule Magnets (SMMs), which may hold the key to higher density information storage and the evolution of so-called 'spintronics' where magnetic spins propagate along circuit paths rather than electrons. Materials that exhibit SMM behaviour include so-called 'polynuclear metal clusters' which are strongly magnetic. Microcrystallography measurements on the MX beamline provided the structural information required to better understand how this magnetic behaviour arises.[17]*
- Using the SXR beamline to characterise modification of diamond surfaces with fluorine atoms using fluorinated 'buckyball' molecules. Diamond is normally a very good electrical insulator, but can potentially be modified in the same way as silicon to create integrated circuits.[18]* Circuits formed on diamonds would be more heat resistant, allowing them to be stacked more closely together. Circuits would also be able to run at a much faster speed when compared to current silicon wafers, leading to smaller, better-performing computing devices.
- Surface morphology studies of polymers, which can be used for thin-film transistors and all-polymer organic solar cells.[19]* The energy resolution and intensity of soft x-rays available at the SXR beamline supported detailed analysis of the critical molecular layers closest to the surface of such novel electronic devices. These devices will potentially require less power and be much cheaper to produce.

Nanoscale materials

Many well-established natural and man-made materials, and the properties they hold, come from their nanostructures. In the past two decades, nanotechnology has given us the ability to design and build small, discrete structures that have specific purposes. Some examples studied at the AS over the last year included:

- Using the SAXS/WAXS beamline to understand complex self-assembled nanoparticles incorporating paramagnetic metal ions such as magnesium and gadolinium. Particles of this type are promising contrast enhancement agents for magnetic resonance imaging– a powerful clinical tool whose sensitivity could be further enhanced to improve disease diagnostics.[20]*
- Studies with the SAXS/WAXS beamline of liquid crystal nanoparticles which can incorporate drugs for delayed time release.[21]* These particles could be used in future to provide a delivery system for drugs that would usually be too unstable if injected directly into the human body.
- The multi-technique study of self-assembling fibrous nanomaterials that support the adhesion of certain cells based on the presence of specific adhesion markers. Three beamlines - SAXS/WAXS, MX and IM – were used by researchers to illustrate how certain peptides self assemble (polymerise) into what could be highly useful bioscaffolding materials.[22]* Bioscaffolding is the use of biocompatible and bioresorbable materials to construct a three dimensional structure comparable to an implant tissue area in order to promote tissue regeneration and injury recovery.

** References providing further information are set out on page 18.*

Support Mechanism for Transfer Line – X-ray Fluorescence Microscopy beamline

Earth and Environment Sciences

Earth Sciences research places high value on the importance of in-situ characterisation methods. These methods are supported by synchrotron technology. Here, samples are subjected to a range of environmental conditions including extremes of heat and pressure, altered pH, varying hydration and changing environmental gases. Growth in the resources sector, and an increasing focus on unconventional resource extraction, make these synchrotron capabilities highly attractive to researchers in the areas of mineral exploration and processing. For this reason, these types of studies have generated increasing interest over the 2011- 2012 period.

Mining technology and mineralogy

Australia's National Research Priorities seek to, among other things, create an environmentally-sustainable Australia. Australian Synchrotron researchers are leading the way in this area through their direct involvement in ground-breaking sustainability research projects.

Users of the AS are investigating all manner of problems relating to mineral exploration, processing and the environmental issues that must be addressed to ensure a safe and sustainable future.

Some examples included:

- The use of the XFM beamline to understand the movement, transportation and oxidation state of elements in order to improve exploration techniques.[23]* Powder Diffraction is also being used to shed light on mineral crystal structures[24]* to inform our understanding of mineral formation, as well as processing practice and in situ analysis at pressures and temperatures comparable to deep earth. These investigations are revolutionising our understanding of mineral physics and geochemistry.
- Researchers who collaborated through the Australian Research Council's Linkage Infrastructure, Equipment and Facilities scheme obtained funding to build a high-pressure cell at the AS. The information obtained from experiments using such equipment informs the development of models that detail the earth's behaviour including plate tectonics, earthquakes and volcanic hazards. This type of research will be invaluable to scientists studying extra terrestrial materials and modeling planetary evolution.
- Other work being undertaken by researchers on the PD beamline sought to understand the process of scale deposition as a result of CO^2 corrosion of steel pipes in the oil and gas industry - with the aim of reducing failures that could have environmental consequences.[25]*
- The behaviour of minerals in their natural environment[26]* is also being examined by a number of research groups across Australia, including the investigation of the mineralogical impacts of bushfires.[27]*

Environmental systems

The study of the natural environment and the development of sustainable practices are vital not only to the health of Australians, but also the wider global community.

Some of the research highlights in this field from the AS included studies of metal uptake in hyper-accumulating plants – potentially useful for nutrient fortification of food crops and bioremediation.[28]* The facility was also used to investigate methods for monitoring heavy metal contamination from sewage outflows[29]* and to demonstrate how radioactive technetium interacts with various materials to assist with the development of more efficient radioactive waste storage solutions.[30]*

Ongoing studies in this area are using XAS and XFM beamlines to find ways to improve the uptake of nutrients in cereal crops.[31]* In this work, the quantity and distribution of micronutrients in a single grain can be determined. This assists researchers in the design of staple crops with improved nutritional value.

Energy technologies

Australian researchers have been leading the way in energy research. In the 2011-2012 period, work undertaken in this field resulted in more than a dozen papers on this topic alone. The facilities at the AS have been used to study and demonstrate how certain materials could be used to support hydrogen storage and its use as an alternative to fossil fuel-based energy solutions.[32]* To do this, a specially constructed flow cell was built on the PD beamline. This experiment looked at how certain boron-nitrogen-hydrogen compounds may be a valuable new class of materials which can capture and later release hydrogen in a controlled manner.[33]* These studies will assist Australia in the development of safe and efficient methods for storage, transportation and use of large quantities of hydrogen.

References providing further information are set out on page 18.

Other research groups also pursued energy technology research including:

- The use of the far-IR beamline to characterise novel olivine-type electrode materials for environmentally-friendly aqueous rechargeable batteries and zinc electrodes.[34]*
- Using PD to evaluate new electrode materials for 'clean' fuel cells.[35]*
- Investigation, with PD, of magnesium hydrogen nanoparticles and other materials as additional potential platforms for economically viable hydrogen storage.[36]*

Synchrotron research methods

During the course of the year, strong collaborations between AS employees and the broader research community have resulted in the introduction and use of new research methods and new technologies. Some important examples included:

- The deployment of the R&D100 Award-winning Maia x-ray fluorescence detector built in collaboration with CSIRO and Brookhaven Laboratories on the XFM beamline at the AS. This new device has already produced some spectacular scientific results, including visualisation of hidden work by the painter, Arthur Streeton.
- Leveraging the Maia detector's ability to extend traditional element mapping to three-dimensional imaging and spectroscopy on biological samples.
- The introduction of MASSIVE (Multi-modal Australian ScienceS Imaging and Visualisation Environment) which is now accelerating the conversion of measured data to world-class scientific outcomes over all the physical and life science disciplines.

  MASSIVE is a high-performance computing cluster which allows a much faster assimilation of data to produce reconstructed models of complex biomolecules, complex materials and 3D reconstructions of animal and human anatomy with microscopic detail.

  The MASSIVE project links with other experimental facilities and will be exploited across a range of imaging modalities, including synchrotron imaging, neuroimaging, electron microscopy and microscopy.

Professor Andrew Peele
Head of Science

** References*

1. *J. P. Vivian et al., Nature, 479, 401 – 405 (2011)*
2. *P. T. Illing et al., Nature, 486, 554-558, (2012).*
3. *J.-K. Hyun et al., PLoS Pathogens, 7, e1002239, (2011).*
4. *M. B. Harbut et al., Proc. Natl. Acad. Sci., 108, E526-E534, (2011).*
5. *D.M. Passon et al., Proc Natl Acad Sci.,109, 4846-50, (2012).*
6. *R.H.P. Law et al., Cell Reports, 1, 185-190, (2012).*
7. *D. R. Whelan et al., Nucleic Acids Research, 39, 5439-5448, (2011).*
8. *L. R. Clements et al., Phys. Status Solidi A, 208, 1440-1445, (2011).*
9. *C.M. Weekley et al., J. Am. Chem. Soc., 133, 18272-18279 (2011).*
10. *B. W. Muir et al., Biomaterials, 33, 2723-2733, (2011).*
11. *A. Levina and P. A. Lay, Dalton Trans., 40, 11675-11686, (2011).*
12. *M. Donnelley et al., Gene Therapy, 19, 8–14, (2012).*
13. *J.C. Crosbie et al., International Journal of Radiation Oncology*Biology*Physics, 77, 886-894 (2010).*
14. *G. Xia et al., J. Mater. Chem., 22, 7300-7307, (2012).*
15. *D.L. Howard et al., Anal. Chem., 84, 3278-3286, (2012).*
16. *M.M. Basil-Jones et al., J. Agr. Food Chem., 59, 9972-9979, (2011).*
17. *S. K.Langley et al., Chem. Eur. J., 17, 9209-9218, (2011).*
18. *D.P. Langley et al., Appl. Phys. Lett., 100, 032103, (2012).*
19. *B.A. Collins et al., Nat. Mater., 11, 536 - 543 (2012).*
20. *M.J. Moghaddam et al., Soft Matter, 7, 10994-11005, (2011).*
21. *S. Phan et al., Int. J. Pharm, 421, 176-182, (2011).*
22. *M.N. Bongiovanni, et al., Biomaterials, 32, 6099-6110, (2011).*
23. *M. Lintern et al., J. Geochem. Explor., 112, 189-205, (2012);*
24. *I.E. Grey et al., Mineral. Mag., 75, 2775-2791, (2011).*
25. *N.A.S. Webster et al, Hydrometallurgy, 109, 72-79, (2011); Journal of Crystal Growth, 340, 112-117, (2012).*
26. *N.V.Y. Scarlett et al., Clay Clay Miner., 59, 560-567, (2011).*
27. *E. Yusiharni and R. Gilkes, Geoderma, doi:10.1016/j.geoderma.2012.01.030 (2012).*
28. *E. Donner, Anal. Bioanal. Chem., 402, 3287-3298, (2012)*
29. *A. Padovan et al., Hydrobiologia, 687, 275-288, (2012).*
30. *G. J. Thorogood et al., Dalton Transactions, 40, 10924-10926, (2011).*
31. *A.A.T. Johnson et al., PLoS One, 6, e24476-1 - e24476-11, (2011).*
32. *R. K. Hocking, et al., Aust. J. Chem., 65, 608-614, (2012).*
33. *Q. Gu, Energy Environ. Sci., 5, 7590–7600, (2012)*
34. *M. Minakshi et al., Ionics, 18, 583-590, (2012).*
35. *M.T. Dunstan et al., Journal of Solid State Chemistry, 184, 2648, (2011).*
36. *M. P. Pitt et al., J. Phys. Chem. C, 115, 22669 – 22679 (2011).*

Operations

Accelerator science

Representing a critical part of the facility's operations, the Accelerator Science and Operations groups' research activities ensured strong links were built with the Schools of Physics at both the University of Melbourne and Monash University. As a member of the Australian Collaboration for Accelerator Science (ACAS), the University of Melbourne held undergraduate laboratory classes studying the accelerators at the Australian Synchrotron. This initiative was led by one of its PhD students in accelerator physics, Kent Wootton. Tessa Charles from Monash University started her PhD with the group where she worked on the low emittance electron source project as part of the Australian Synchrotron Development Projects.

At an international level, the accelerator group continued to build links with the Asian region through collaborative research visits to Korea and Japan. Eugene Tan, for example, presented a tutorial at the Pohang Accelerator Laboratory in Korea and discussed development of a fast orbit feedback system being designed for the Australian Synchrotron storage ring. In other achievements from the group, Mark Boland was awarded a Japanese Society for the Promotion of Science travelling fellowship and spent a month at KEK in Tsukuba, Japan, with Prof Toshiyuki Mitsuhashi on developments with his invention to measure picometre beam emittances. As part of a continuing collaboration with SLAC, including postdoc Evelyne Meier's PhD work on the LCLS free electron laser, Kent Wootton took a particle detector system to SSRL and measured the storage ring electron beam energy to one part in a million.

Under a collaborative agreement between the Swiss synchrotron, CERN, and ACAS, the accelerator group is working with local industry to develop technology that will support the next generation of accelerators. In other developments, novel high-speed optical beam monitoring systems were being developed at the Australian Synchrotron. These will be used by the Swiss-based Large Hadron Collider to support a test facility at CERN and the future creation of a new linear collider.

The skills and expertise developed in this area by MSc and PhD students are being shared with local accelerator companies, such as Cyclotek, who produce radiopharmaceuticals. The aim is to offer this beam diagnostic technology to the global accelerator community.

Accelerator science and operations

Accelerator systems at the Australian Synchrotron continued to run reliably. Their overall availability remained well above the target of 97% and in some cases reached 99.26%. Improvements to the storage ring radiofrequency system, upgrades to magnet power supplies, and the installation of an uninterruptable power supply (UPS) for the storage ring contributed to a steady increase in the mean time between failures from around 70 hours to 188 hours. This activity resulted in the delivery of more than 500 hours of beam with no disruption, a record for this facility.

Due to the reliability of the accelerator systems, the Accelerator Science and Operations group made significant progress in transitioning to Top-Up operations - a new mode that will deliver even better results in terms of beam reliability and near constant brightness for users.

Uninterruptible Power Supply

Engineering

The Engineering group carried out numerous projects for the science teams during the year, in addition to providing service and support to the facility's accelerator and beamline groups. The Engineering group also collaborated with the AS science and technical teams to install the UPS and ancillary equipment that needed to be safely connected to the facility's existing electrical systems. This work played a critical part in the AS move to Top-Up operations.

In addition to supporting the improvement of beamline stability, work on the Imaging and Medical (IM) Beamline dominated the Engineering group's time. Engineering was responsible for the design and build of a new imaging and medical monochromator, which involved the development of important optical components and their integration with third party equipment.

The Engineering team also designed and built the transfer line carrying the x-ray beam a distance of 140 metres from the main facility to the external IM satellite building. This tube contains the high vacuum required for the beam to pass along its length. The job required the welding of large-scale vacuum components and the integration of the control systems to produce and monitor the line's vacuum.

Quality and occupational health, safety and environment

The AS successfully passed its triennial ISO 9001 quality re-certification in March 2012, and has now held this international quality standard for more than three years. The AS is one of the few synchrotron facilities in the world to have achieved this quality standard.

The facility had only one Lost Time Injury (LTI) for the year and no major safety incidents.

Our radiation safety record continued to be excellent as a result of the facility's comprehensive radiation management program. Exposure levels for employees, users and contractors were also well below the allowable public limit of 1 mSv per year - this is only a fraction of the background levels that occurs naturally in our environment.

No notices or directives were issued pursuant to relevant sections of the Victorian OHS Act 2004, Accident Compensation Act 1985, Dangerous Goods Act 1985 and Radiation Act 2005.

In the area of environmental management, the National Greenhouse & Energy Report and the Water Management Action Plans for 2010-11 were lodged successfully. To ensure the structured and systematic management of environmental issues, ASCo's environmental management policies, procedures and documents are also in the process of being established in accordance with the Australian Standard, AS/NZS ISO 14001 Environmental Management Systems.

Major Infrastructure Projects

Education Investment Fund (EIF)

With the support of the Australian Government's Education Investment Fund (EIF), the Australian Synchrotron continued its building construction program. This program focused on the construction of a number of buildings designed to meet the needs of its growing domestic and international scientific user base.

Work under this program focused on the design and construction of the National Centre for Synchrotron Science (NCSS), the Australian Synchrotron Guesthouse Office Extension Building (OEB), Technical Support Laboratory (TSL) and Extension to Switch Room (ESR).

Construction of all buildings has now been completed, with employees moving to the OEB and TSL buildings in November 2011, the ASG in April 2012 and the NCSS in May 2012.

The future introduction of site and building signage and landscaping works will see the completion of this major building project in December 2012.

National Centre for Synchrotron Science (NCSS)

This building houses the main synchrotron user facilities, as well as the corporate functions of the organisation. The building will also act as a centre for education, outreach and community engagement. It comprises a 400 seat auditorium, seminar rooms, exhibition space, user office, cafeteria, and administrative capacity for 47 workstations and 15 offices. This building holds a 5 Star Green Star – Education Design v1 certificate rating from The Green Building Council of Australian (GBCA).

Australian Synchrotron Guesthouse (ASG)

The ASG is a new two-storey accommodation facility comprising 50 self-contained rooms, a communal kitchen and lounge facilities. International, interstate and domestic users will be accommodated in this building while visiting the Australian Synchrotron.

Office Extension Building (OEB)

This modular building is connected to the main AS building and contains workstations for the combined Australian Synchrotron science and engineering teams, as well as so-called "hot desks" for users, postgraduate students and post doctoral fellows.

Technical Support Laboratories (TSL)

The new Technical Support Laboratories building contains technical support laboratories including vacuum and controls integration and RF laboratories.


NATIONAL
CENTRE FOR
SYNCHROTRON
SCIENCE
THE AUSTRALIAN SYNCHROTRON

External Relations

In line with its strategic aims, the External Relations (ER) group continued to drive the marketing efforts of the Australian Synchrotron through its corporate communications, stakeholder relations, industry engagement and education and outreach activities.

Stakeholder relations

During the 2011-2012 period, a major focus for ER was its government relations program. Implemented with the aim of showcasing the scientific and industry value delivered by the Australian Synchrotron, this campaign resulted in significant outcomes for the AS and its scientists.

The facility hosted briefing sessions and tours (mentioned earlier by our Chief Operating Officer) for ministers and policy advisors. Among this group were the Hon Chris Evans, the Hon Louise Asher, the Hon Simon Crean, and the Hon Martin Ferguson, as well as advisors to the Prime Minister of Australia Julia Gillard MP and Victorian Premier Ted Baillieu MP. To further support stakeholder relations activities and the requirement to secure funding for operation and expansion of the facility, AS staff including Director Professor Keith Nugent, took part in roadshows hosted at universities and research centres across Australia.

Marketing and events

Over the past year, our marketing and events program assisted the facility to enhance its profile among the domestic and international user communities and general public.

Initiatives designed to support user development were managed by AS and included the 2011 User Meeting (which saw 240 participants), MX beamline CCP4 School on Advanced X-ray Crystal Structure Analysis, the IR RMieS Data Analysis Workshop and the SAXS/WAXS beamline workshop ANZSAS, (hosted in New Zealand in support of the large user community there), with all attracting large numbers and positive feedback.

In other marketing efforts, the AS was successful in presenting bids to host a number of international conferences over the coming years, including 7th International Workshop on Infrared Microscopy and Spectroscopy 2013, Accelerator Reliability Workshop 2013, International Conference on X-ray Microscopy 2014, and the International Conference on Accelerator & Large Experimental Physics Control Systems 2015.

The facility's annual Open Day also provided the AS with an additional platform on which to showcase its value to the broader community. As part of AS's Open Day celebrations in October, Radio Station Triple RRR broadcast live from the facility during its 'Radio Therapy' and 'Einstein A Go–Go' programs, with the event itself attracting around 3,000 visitors.

Media relations activities resulted in over 200 media references being made to the Australian Synchrotron and its work. While a number of these focused on issues of governance and funding, a significant level of coverage promoted the AS's critical involvement in scientific research across areas such as biomedicine, forensics and nanotechnology.

Education and outreach

The AS's education program, designed to encourage interest at school level in the fundamental sciences and to assist in developing the next generation of synchrotron users, also saw significant developments. In 2011, the laboratory program for Unit 4 physics students expanded to include a Synchrotron and its Applications component. Due to strong interest in this, over 50 schools and 650 students participated.

Industry engagement

As part of its business development activities, the ER group continued to raise awareness of the AS's capabilities directly with industry, with the purpose of supporting economic development at state, territory and national levels. This was achieved using a variety of channels including visits to relevant organisations to better explore possible research applications for industry, the hosting of industry events and workshops, and participation in sector-specific conferences.

Other highlights supported and driven by ER included AS's involvement in sponsoring and leading the South East Melbourne Innovation Precinct's (SEMIP) successful second Innovation Showcase, and its listing as a partner in the $250,000 Small Technologies Industry Uptake Program grant to Micro-X Pty Ltd, with Grey Innovation and the Melbourne Centre for Nanofabrication. This was in addition to the facility's work with industry partners in the Monash Vision Group Direct to Brain Bionic Eye project, in particular miniFAB™, which resulted in a saving of $400,000 in research and development expenses – an outcome of tests conducted on the biocompatibility of electrodes which are essential to the success of the project.

Our People

The Human Resources (HR) Group again played an important role in enabling strategy, attracting and inducting new employees and retaining and developing the facility's workforce.

Organisational effectiveness and change

The number of employee positions increased overall to 120.2 Full Time Equivalents, with the level of women working at the facility also rising from 27.2% to 29.3%. Term positions and contracts also changed to reflect HR strategy and environmental issues.

During the period, retention remained above the HR key performance indicator of 90% with a 12 month rolling average finishing in 2012 at 97.9%.

In an effort to improve organisational performance, secondments were introduced across the facility. Under this arrangement, engineering specialists were actively relocated to areas of the facility to work on critical projects that were important to the ongoing development of the Australian Synchrotron.

Culture, communications, engagement and wellbeing

As part of HR's ongoing activites, Australian Synchrotron employees were trained on the facility's diversity policy and EEO compliance program. A diversity team was also introduced to manage diversity activities across the facility.

Importantly, results from the AS 2011 Workplace Improvement Survey demonstrated significant improvements across the organisation on key indicators such as clarity, empathy, engagement and learning. The results obtained were above the national average, particularly in terms of employee commitment. To communicate ongoing change and key milestones within the facility, the Director and Chief Operating Officer delivered information updates to employees throughout the year. To complement this activity, HR also delivered monthly facility-wide HR updates, covering topics from workforce change and wellness to learning and development.

In addition to this activity, a peer nominated Employee Rewards Program was created to continue an informal program of recognising employees who perform above and beyond their prescribed roles.

Talent and resourcing

In the important areas of talent and resourcing, HR worked throughout the year with key members of the facility's management team to simplify the organisation's decision-making processes, with this activity leading to the establishment of a re-modelled Executive Management Group (EMG).

Work by HR during the year also saw it and the EMG review leadership and strategic technical positions, which form part of a succession plan for the facility and its operations. Critically, the annual promotions process also identified and benchmarked talent on an internal and professional external basis, with this activity supporting the development of a pilot mentor program.

Learning and capability development

As it does every year, HR devoted significant resources to the professional development of AS employees, investing over 1,000 hours in training, team development, mentoring, e-learning and other professional development initiatives.

A number of organisational development programs were introduced with the aim of improving inter-group relations and performance across the facility.

Funders of the Australian Synchrotron

The Australian Synchrotron was established through a partnership between the Victorian Government and the Australian Government.

Additional investment and support came from the New Zealand Government, other Australian state governments, six publicly-funded research institutes, 33 universities and 37 medical research institutes from across New Zealand and Australia.

As Foundation Investors (FIs), these groups played a critical role in the facility's development, with each contributing a minimum of $5 million to the establishment and operation of this world-class science and research facility. Each continues to play an active part in the governance of the Australian Synchrotron as primary advisors to the Australian Synchrotron Board.

Supported by

Australian Government

State Government Victoria AUSTRALIA

Foundation Investors

AAMRI

ANSTO

CSIRO

Monash University

University of Melbourne

New Zealand Synchrotron Group Limited

New Zealand Government (Funding Partner)

University of Auckland

Massey University

University of Waikato

Victoria University of Wellington

Lincoln University

University of Canterbury

University of Otago

New Zealand Institute for Plant & Food Research Ltd

AgResearch

GNS Science Limited

IRL (Industrial Research Limited)

AUSyn14 Consortium

NSW Government

University of Western Sydney

University of New England

Southern Cross University

Charles Darwin University NT

Charles Sturt 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 Australia/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

Public space – National Centre for Synchrotron Science

Governance

Australian Synchrotron (ASHCo and ASCo)

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

- Australian Synchrotron Holding Company (ASHCo) is the ownership entity and owns all 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.

Foundation Investors in the Australian Synchrotron have 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 each) and membership of ASCo.

Composition of the Australian Synchrotron Board of Directors

The members of the Boards of Directors for ASHCo and ASCo, as at 30 June 2012, are listed below.

Further details of the Directors and activities of the Companies are contained in the Financial Reports 30 June 2012 for ASHCo and ASCo associated with this document.

ASHCo	ASCO
Mrs Catherine Walter AM	Mrs Catherine Walter AM
Professor Rod Hill	Professor Rod Hill
Dr Sean Gallagher	Dr Sean Gallagher
Prof Linda Kristjanson	Prof Linda Kristjanson
	Prof Peter Colman
	Prof Max Lu

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 scientific policy, committee appointments and terms of reference, and overall facility development.

Affilliation of Council Members

Foundation Investor	Representative
Victorian Government	Dr Amanda Caples
Monash University	Mr David Pitt
AAMRI (Association of Australian Medical Research Institutes)	Prof Julie Campbell
ANSTO (Australian Nuclear Science and Technology Organisation)	Mr Peter Arambatzis
CSIRO (Commonwealth Scientific and Industrial Research Organisation)	Ms Jan Bingley
Western Australian Consortium	Mr Anthony Tate
New Zealand Synchrotron Group Limited	Dr Don Smith
University of Melbourne	Dr Frances Skrezenek
South Australia/La Trobe University (Consortium)	Prof Richard Russell AM
Queensland Consortium	Prof Max Lu
AUSyn14 Consortium	Dr Chris Ling

Foundation Investor Liaison Group

The Foundation Investor Liaison Group meets regularly to coordinate Foundation Investor access to the Synchrotron. Its members are the conduit for communication with the Foundation Investors and relevant researchers at member organisations.

Foundation Investor	Representative
Victorian Government	Dr Gerry Roe
ANSTO (Australian Nuclear Science and Technology Organisation)	Dr Richard Garrett
CSIRO (Commonwealth Scientific and Industrial Research Organisation)	Dr Jose Varghese
University of Melbourne	Dr Frances Skrezenek
Monash University	Dr Karen Siu
AUSyn14 Consortium	Dr Chris Ling
Queensland Consortium	Prof Jenny Martin
Western Australian Consortium	Prof Charles Bond
South Australia/La Trobe University (Consortium)	Dr Peter Kappen
	Dr Hugh Harris
New Zealand Synchrotron Group Limited	Dr Don Smith
AAMRI (Association of Australian Medical Research Institutes)	Assoc Prof Mike Lawrence

Committees and advisories

A number of bodies have been set up to support the development and effective operation of the Australian Synchrotron. These bodies include the Scientific Advisory Committee, the National Science Colloquium, the Program Advisory Committees, the international Proposal Advisory Committees, the Machine Advisory Group and the User Advisory Committee.

Financial Statements

The Australian Synchrotron continued to deliver strong scientific achievements to foundation investors and the wider scientific and commercial communities during the 2011-2012 financial year.

The operating result for the year was a surplus of $34,086. This was the result of total revenue of $27,725,286 and total operating expenditure of $27,691,200. Included in the comprehensive result for the year were $1,666,116 from the accumulated reserve applied to the acquisition of an Uninterrupted Power Supply and $240,967 to fund restructuring costs.

The main source of revenue was the funding agreement between the Commonwealth and State Governments of $25,200,810 and the New Zealand Synchrotron Group of $819,783. Other revenue included grant funding towards International Synchrotron User Access and Australian National Data Services Meta Data project.

Operating expenditure during the year comprised $16,157,290 for salaries and employee benefits and $8,570,143 to operate and maintain the facility at a world class standard, including $2,243,598 for building and technical expenditure, $2,620,290 for utilities and $3,706,255 for essential operating upgrades and spare parts. An additional $2,518,076 was committed to support local and international user access, scientific development, external relations activities and business development. Administrative costs for the facility were $2,352,774 including staff travel, information technology, occupational health and safety, general administration and Board costs.

The key infrastructure project funded under the Commonwealth Government's Education Investment Fund (EIF) of $36.78 million was committed in the Federal Budget 2009-10 and construction of all buildings - National Centre for Synchrotron Science, User Accommodation and Technical Support Laboratories - was completed ahead of schedule and on budget in May 2012. The final stage of the project which involves landscape design, civil works and storm water drainage is anticipated to be completed by December 2012.

Independent valuation of the facility's assets was conducted during the year resulting in an increase in book value of $685,853.

In accordance with a Memorandum of Understanding (MoU) executed in March 2012 between the State and Commonwealth Governments, ANSTO and CSIRO, new operational funding of $100 million for the four years ending 30 June 2016 will be committed to the operation of the Australian Synchrotron. Pursuant to the MoU, funding of $25 million per annum will be provided by the following parties:

Party	$'M
ARC Special Research Initiative	55
State of Victoria	26
Science and Industry Endowment Fund	10
New Zealand Synchrotron Group Limited	5
ANSTO	4
Total funding	**100**

Further financial information is available in the 2012 annual financial statements for the Australian Synchrotron Company (ASCo) and the Australian Synchrotron Holding Company Proprietary Ltd. (ASHCo).

Figure 6: Income

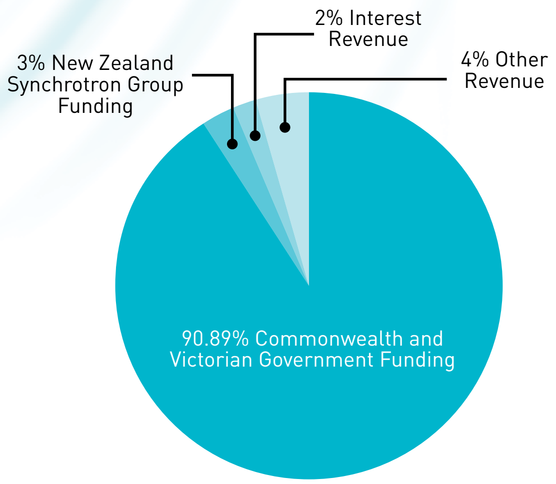
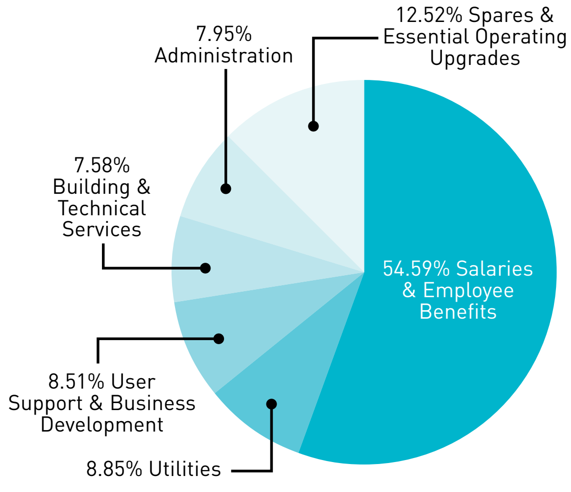


Figure 7: Expenditure



Australian Synchrotron

800 Blackburn Road
Clayton, Victoria, Australia 3168
t. +61 3 8540 4100
f. +61 3 8540 4200
www.synchrotron.org.au

Australian Synchrotron Company Limited
ACN 126 531 271

Australian Synchrotron Holding Company Pty Limited
ACN 126 506 205