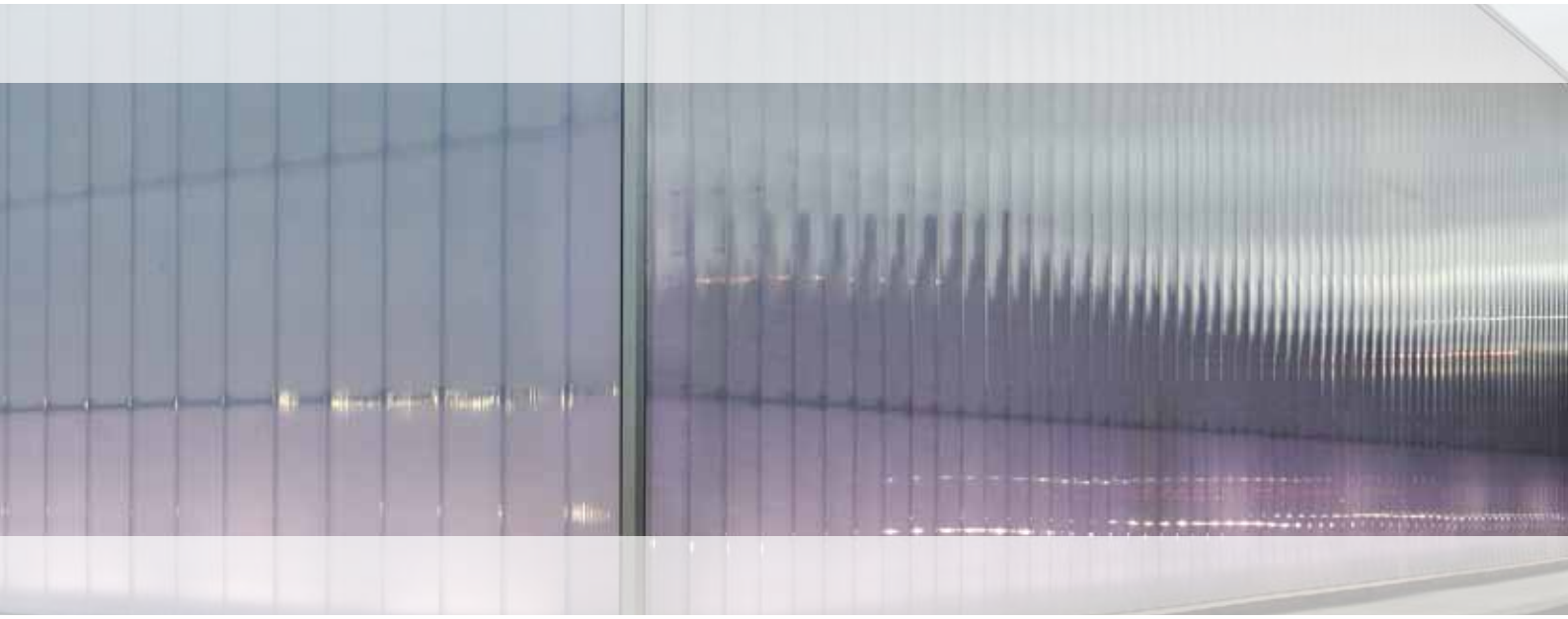
Australian Synchrotron
Annual Report 2013



Australian Synchrotron

Australian Government

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About this Annual Report

The Australian Synchrotron 2013 Annual Report provides an overview of the Australian Synchrotron's science priorities, core activities and scientific achievements.

It is a public document and can be read or downloaded by visiting www.synchrotron.org.au/news/publications.

To request printed copies of the report, email info@synchrotron.org.au or call (03) 8540 4100.

Cover and design theme – National Centre for Synchrotron Science

The design of the Australian Synchrotron 2013 Annual Report is based on imagery of the light-inspired, 5-star Green Star, National Centre for Synchrotron Science (NCSS), located next to the synchrotron building in the Melbourne suburb of Clayton.

The NCSS houses management and administration teams as well as the User Office of the Australian Synchrotron. It provides significant meeting, function and exhibition spaces, an auditorium, and an Interactive Learning Centre.

In June architects Bates Smart won the 2013 Victorian Commercial Architecture Award for the NCSS. It also achieved a commendation for interior architecture.

The NCSS cover image was provided by architectural photographer, Peter Bennetts.

Contents

About the Australian Synchrotron

The Australian Synchrotron is a world-class research facility that uses accelerator technology to produce a powerful source of light – x-rays and infrared radiation, many times brighter than the sun.

The facility has nine different experimental stations, or beamlines, which harness that light so researchers can see the fundamental structure and composition of materials, on scales ranging from the atomic to the macroscopic – with a level of detail, speed and accuracy not possible in conventional laboratories.

The Australian Synchrotron supports a broad range of high quality research, with applications in sectors from medicine and nanotechnology to manufacturing and mineral exploration. Our highly advanced techniques and passionate staff are contributing directly and demonstrably to scientific advances and industrial innovations with medical, social and economic benefits for all Australians.

Vision

The Australian Synchrotron's vision is to be the catalyst for the best research and innovation in Australia and New Zealand. The focus for the facility is to provide a thriving environment that is conducive to creating, inspiring and nurturing the best outcomes, enabled by scientific excellence, for users and staff of the facility.

Mission

The Australian Synchrotron's mission is to enable science for the benefit of the community, by providing world-class synchrotron expertise and facilities.

Core values

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

Our research capabilities

The Australian Synchrotron's sophisticated scientific techniques provide benefits for diverse scientific and industrial fields and purposes, including:

- **Biomedicine:** offering new world-class diagnostic, imaging and therapeutic techniques and high-throughput structural biology capabilities.
- **Defence:** enabling study of the sub-atomic nature of materials, sensors and heavy metals.
- **Environmental technologies and services:** supporting environmental remediation work and analysing soil samples, the quality and composition of fresh and salt water, air and atmospheric samples, pollutants, toxins and contaminants.
- **Food technology:** analysing the composition of ingredients, assessing the effectiveness of food processes and determining the nutritional impact of foods in the body.
- **Forensics:** refining or developing new forensic processes, techniques and applications.
- **Manufacturing:** investigating the structure and characterisation of alloys, catalysts, fibres, textiles, adhesives, polymers, plastics, surfaces, interfaces and coatings; and analysing stresses in engineered components.
- **Minerals:** supporting all aspects of mineral exploration and mineral processing.
- **Natural resources:** supporting the development of exploration and fuel processes, the reduction of pipeline scale formation, and fuel cell innovations.
- **Pharmaceuticals:** analysing proteins, nucleic acids, viruses and biomimetic materials (such as artificial skin and organs) as well as conducting cell imaging, quality control monitoring, identification and assessment of the effectiveness of drug targets.
- **Scientific instruments:** developing detector technologies, measurement techniques, medical implants and delivery systems.

Chairman's Report

The Australian Synchrotron is a landmark scientific facility which is realising tangible benefits for Australian knowledge and innovation. With around one thousand publications attributed to more than three thousand scientific users the Australian Synchrotron has, via the dedication of its staff and supporters, been positioned amongst the top-level of international synchrotron light sources.

Operating large and complex scientific infrastructure for the benefit of those that utilise the capabilities of such machines is an enriching and rewarding experience. The Australian Synchrotron illuminates samples, structures and specimens with light of a range of energies that help unlock fundamental scientific questions, the answers to which advance human understanding and thereby assist in driving innovation.

Scientific research and discovery relies on the ability to form strong partnerships, and this year marks the first in which the operation of the Australian Synchrotron is funded by a new arrangement, which includes contributions from Australian universities, the Australian Research Council, the National Health and Medical Research Council, the Science and Industry Endowment Fund, the New Zealand Government and universities, the Australian Nuclear Science and Technology Organisation (ANSTO) and the State Government of Victoria. Funding partners are represented by the Funders' Committee, a key component to the new governance structure for the Australian Synchrotron. The Synchrotron Light Source Australia (SLSA) Board complements the Funders' Committee by providing governance of the operation and management of the facility.

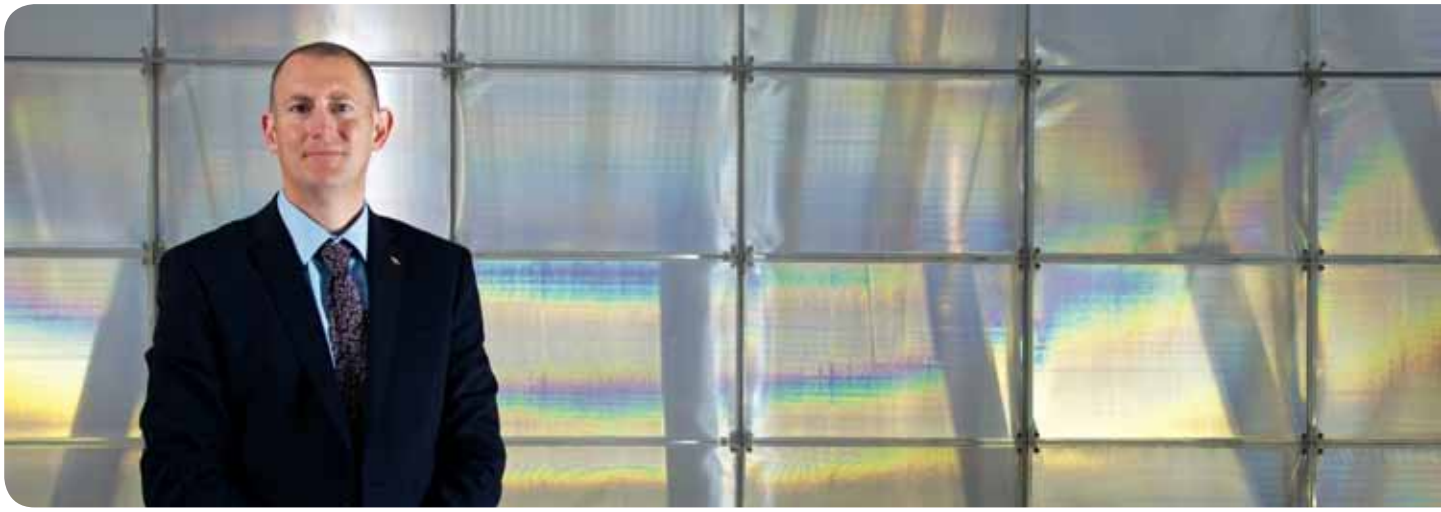
The new funding, governance and operational arrangements provide a stable platform from which to build relationships with new stakeholders and to secure the long-term future for the Australian Synchrotron. These new structures are already creating new opportunities; such as the NSW government pledging, through ANSTO, $1.4 million towards enabling an access scheme for NSW researchers.

On behalf of the operating organisation, the SLSA Board of Directors, I thank the staff, management, funders and users of the Australian Synchrotron for their vision, dedication and support. I look forward to seeing more great scientific discoveries being generated from the Australian Synchrotron over the coming years. Those discoveries will enhance Australia's knowledge, capabilities and ultimately our economy through innovation that will drive our future.

Dr Greg Storr

Chair, Board of Directors, Synchrotron Light Source Australia,
Operator, Australian Synchrotron

Director's Report



In a busy year for the Australian Synchrotron, I am pleased to report that the facility continued to excel in its delivery of science for the benefit of the community.

The year saw an important transition to a new operational funding arrangement, including direct interaction with the majority of our research partners as funding stakeholders. This interaction is mediated through the Funders' Committee, which provides an important conduit between the operations of the facility and our synchrotron 'users'.

Another important transition involved the Australian Nuclear Science and Technology Organisation (ANSTO) assuming responsibility for operations of the Australian Synchrotron. This, I believe, is a vital step in the evolution of the Australian Synchrotron becoming a part of the national asset portfolio and securing long-term operational funding.

That these transitions have been effected smoothly has been greatly assisted by ANSTO's support of the mission of the Australian Synchrotron – enabling science for the benefit of the community, by providing world-class synchrotron expertise and facilities.

It is particularly pleasing that, in the midst of all these changes, the outputs and achievements of the facility have continued to increase.

New high-water marks for number and quality of publications were set. Even more pleasing was the impressive number of publications in the world's top science journals and the number of outcomes reported in the media. The diversity of topics addressed by this high-quality research is also impressive, including forensics, energy, health, mining, environment, nanotechnology and many others – clearly demonstrating our ability to provide benefits for the community.

These results are achieved using facilities that, thanks to our pursuit of excellence, are consistently rated as world-class and, in several cases, world-leading. This year saw the first full year of operations in 'top-up' mode, which provides a more stable photon beam for experiments and has become the standard mode of operation.

The year also saw the initial commissioning of the Imaging and Medical Beamline, with users commencing in 2012 and the new superconducting multipole wiggler source successfully installed and commissioned in early 2013. The beamline will continue significant in-house commissioning and development while taking on a user program as part of its roadmap towards undertaking clinical experiments.

As well as great equipment and excellent staff support, the Australian Synchrotron facilitates the process of turning raw data into scientific outcomes by easing the process of analysis. Scientific computing initiatives funded under the Federal Government NeCTAR scheme and implemented during the year included tools that provide 'quick-look' data products, assist with remote analysis and enable access to high-performance computing resources. Those high-performance resources were also enhanced with a substantial upgrade to the processing and storage capability of the 'multi-modal Australian sciences imaging and visualisation environment' (MASSIVE) high-performance computing clusters.

Support for the research community was also provided through focused beamline workshops that offer training in data acquisition and analysis techniques. The 2012 User Meeting, held for the first time in the National Centre for Synchrotron Science, gave researchers an overview of research capabilities and outcomes from the facility as a whole.

The User Meeting also held a special session celebrating 20 years of the Australian National Beamline Facility (ANBF), which closed operations at Japan's Photon Factory in Japan in March 2013. This facility is an important part of Australia's synchrotron research history and along with the International Synchrotron Access Program, which continues to be administered by the Australian Synchrotron, has been a significant source of scientific outcomes and training in methods unavailable in Australia. The 'Big Diff' and other ANBF equipment will be reused or displayed at the Australian Synchrotron as a reminder of Australia's spirit of scientific enterprise.

The Australian Synchrotron Thesis Medal, which is presented at the User Meeting, will in future be known as the Australian Synchrotron Stephen Wilkins Medal. This honours Steve Wilkins, a stalwart of the Australian Synchrotron and synchrotron science who sadly passed away in March.

Along with growth in research outcomes, the facility saw excellent growth in industry engagement. The number of companies engaging with the facility, whether through a research provider or directly, exceeded previous years and, for the first time, the facility exceeded its target for industry revenue. As part of the facility's strategy to grow its direct engagement with industry, an Industry Advisory Committee has been appointed, with key company and government representatives.

Our direct engagement with stakeholders and the general community continued to grow. More than 1000 students undertook interactive laboratory sessions; around 40 events were hosted onsite; and guided tours were conducted for 1725 people, including almost 400 senior government, science and industry representatives. In October, around 3000 members of the community expressed their interest in and support for the Synchrotron by attending the annual Open Day.

These outcomes are only possible due to the dedication and hard work of our users, staff and the many volunteer committees that assist the facility. These include the Funders' Committee, the National Science Colloquium, the Scientific Advisory Committee, the Machine Advisory Group, the User Advisory Committee, the Program Advisory Committees, the International Program Advisory Committee, the Animal Ethics Committee and the Industry Advisory Committee. I am grateful to all for their input and passion.

I am also pleased to acknowledge and thank the efforts of ANSTO and its senior management in providing and implementing a strong vision of supporting the Australian Synchrotron.

I am grateful to previous management, in particular Professor Keith Nugent, Director, and Dr George Borg, Chief Operations Officer, for their efforts in securing a new operations package and for facilitating the transition to new management.

The achievements of the Australian Synchrotron in the short time since it commenced operations in 2007 have been nothing short of remarkable. That the facility has been able to expand on those achievements this year while undertaking a fundamental change in its funding, governance and operations is exceptional and is a validation of the vision and commitment provided by all our funding partners and our staff, users and supporters.

Professor Andrew Peele

Interim Director, Australian Synchrotron

ANSTO Integration Update

Dr Richard Garrett

Mr Michael Beckett

The Australian Nuclear Science Technology Organisation (ANSTO) has had an association with the development of synchrotron science capabilities in Australia since the early 1990s. This role complimented our function as the long-term custodian and operator of landmark infrastructure such as the OPAL reactor, the Bragg Institute and the National Imaging Facility Research Cyclotron and associated facilities in Camperdown. ANSTO is proud to operate the Australian Synchrotron Light Source Australia (SLSA), which is a wholly-owned subsidiary of ANSTO.

This relationship with the Australian Synchrotron is fundamental to ensure the continued development and financial security of the facility. Importantly, it also enhances the capacity of both organisations to deliver important research and innovation benefiting Australian and New Zealand communities and industries.

Securing the future of the Synchrotron would not have been possible without the support of the Commonwealth and Victorian governments and those of New Zealand, in crafting a new way forward. Support from the CSIRO and Australian universities has also developed a partnership that leveraged significant support from the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC).

The ongoing commitment of the funders is testament to the very high quality of the facility itself, its scientific achievements and its importance to modern science and innovation. We will continue to work with our committed partners to ensure that the Synchrotron remains a truly world class facility and is a catalyst for high impact and excellent scientific research and innovation in Australia, New Zealand and beyond.

As this process of finalising the new operation came to fruition, I requested Prof Andrew Peele to take on responsibility for overall leadership as Interim Director. He has done a great job working with the SLSA Board chaired by Dr Greg Storr, ANSTO's Group Executive for Nuclear Science and Technology, to ensure a solid start for the new model, continuity of operations and effective integration. Mr Michael Beckett, General Manager Operations, anchored the integration plan and with Prof Michael James, who stepped into Andrew's shoes as Head of Science, has ensured that establishing connections and synergies with ANSTO have been successful.

There are many others who have played an important part in getting us to this point. Prof Ian Smith, Pro Vice-Chancellor, Research and Research Infrastructure, at Monash University, was a key player in crafting the successful ARC Special Research Initiative and chairs the Funders' Committee which is playing an important part in ensuring that access arrangements are both merit based and transparent to our funders.

I would like to thank Prof Keith Nugent (Director at the time) and Dr George Borg (COO) of the Synchrotron, and Dr Richard Garrett, Chair of the User Advisory Committee who provided wise counsel and undertook a range of roles as we constructed the funding model and the access arrangements. The successive Chairs of Australian Synchrotron Company (ASCo), Mrs Catherine Walter and Prof Richard Larkins, and their board have been crucial to a successful outcome. The various Commonwealth and Victorian government representatives, and ANSTO staff dedicated to achieving this solution, are included in this heartfelt thank you.

ANSTO is closely tied to the Australian Synchrotron operationally, scientifically and historically, and for all these reasons, we are very pleased to take on the role as operator of the facility and to steer it to further success.

Dr Adi Paterson
Chief Executive Officer, ANSTO

Australian Synchrotron Highlights 2012-2013

The Australian Synchrotron has cemented its place as one of the nation's premier research facilities by concluding a year of strong facility and research outcomes including:

Publication Metrics

- A new high in publication outputs with more than 340 peer-reviewed publications using Australian Synchrotron data.
- Exceptional publication quality: an average impact factor of 4.71; publications in Nature, Science, Cell and Immunity and more than 30 papers published in journals with an impact factor greater than 9.

Facility Upgrades

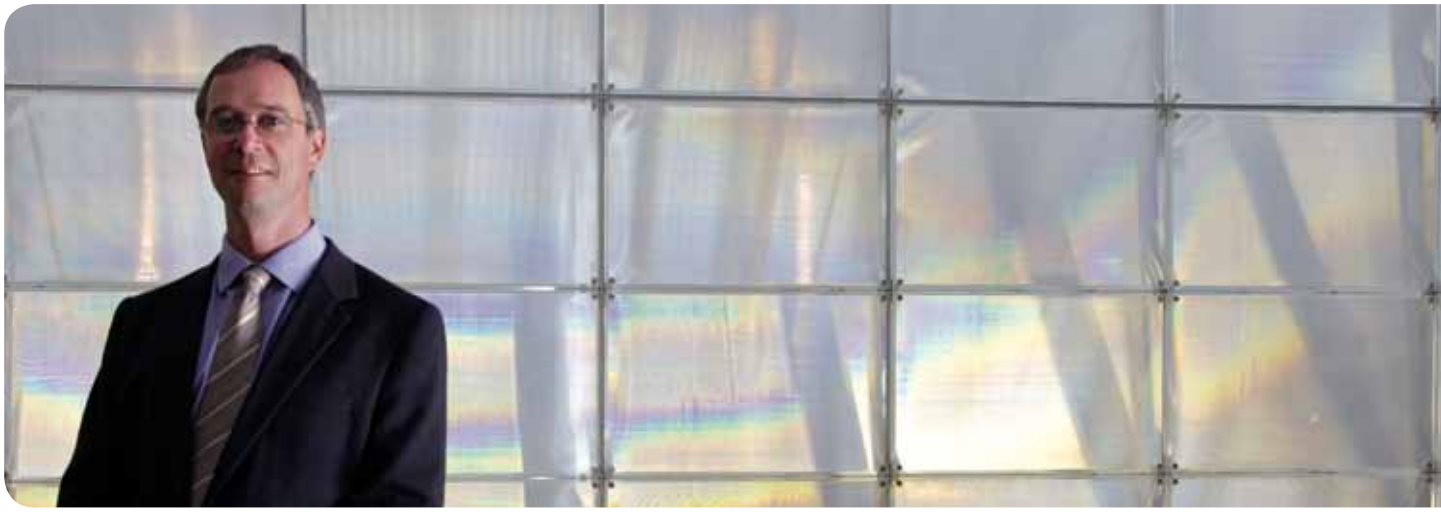
- A full year in top-up mode providing injections every three-four minutes and high reliability of stable photon supply.
- Commencement of partial user operations including pre-clinical microbeam radiation therapy (MRT), and computed tomography imaging studies of vascular and lung function on the Imaging and Medical Beamline (IMBL). A new superconducting multipole wiggler was installed.
- Substantial upgrade in the 'multi-modal Australian sciences imaging and visualisation environment' (MASSIVE) high-performance computing clusters, necessary to enable the transfer and processing of enormous volumes of data.
- Installation of scientific computing tools enabling users to obtain quick-look data products from their experiments, remote access and access to MASSIVE.
- Soft x-ray imaging branchline installation: commissioning studies undertaken demonstrating capability in coherent diffractive imaging.

Research Outcomes

- Leading results from the Accelerator Science and Operations team, including a method for measuring small vertical beam emittance using a horizontal undulator, contributing to a worldwide collaboration with CERN – damping ring studies for the Compact Linear Collider (CLIC).
- World's first 3D pictures of insulin in the process of binding to its receptor, captured using the micro-crystallography beamline (MX2), and published in Nature.
- The development of a potential drug which could quickly bring future flu outbreaks under control, using MX2, and published in Science.
- The use of infrared analysis to study tumour sections irradiated using synchrotron x-ray MRT, which suggests a mechanism by which it can kill the whole tumour despite only a small percentage receiving peak irradiation.
- The use of x-ray powder diffraction (PD) to investigate hydrogen storage and release from a borohydride compound which exceeds the US Department of Energy storage target for 2015 by 50 percent.
- The use of PD to examine gas interactions with metal-organic frameworks with possible applications in carbon sequestration, or low cost natural gas purification.
- Using the Maia detector, x-ray fluorescence microscopy (XFM) obtained a detailed 3D distribution of physiologically important metal elements in an anesthetised, hydrated adult nematode – a valuable model system for biomedical research.
- XFM investigated a pewter plate engraved by Dutch explorers in 1697. The de Vlamingh plate is the earliest written record of European contact in Australia, and reveals corrosion effects and other details of its history on the coast of Western Australia.
- X-ray absorption spectroscopy (XAS) used to examine groundwater – contributing to understanding bioremediation by microbial sulfate reduction in arsenic-contaminated subsurface environments.
- The small and wide angle x-ray scattering (SAXS/WAXS) beamline generated numerous outcomes in structural biology and studies of surfactant mesophases for drug delivery, including using time-resolved SAXS to follow the photo-switching of a light-activated liquid crystalline matrix.
- Soft x-ray spectroscopy (SXR) was used to study molecular orientation and structure in semiconducting organic thin films, and how this relates to charge carrier mobility, which might aid the development of these novel materials for new electronics.

Science at the Australian Synchrotron

Overview



Since opening in 2007, the Australian Synchrotron has continued to improve its capabilities, output and breadth of scientific contribution, in line with national research priorities. Choose any field of scientific endeavour, and there is a solid chance that the Synchrotron can demonstrate a relevant and significant contribution to it.

The facility has maintained the breadth and quality of research, with increasing production of research papers and demand for beamtime. This has been effected through merit-based allocations of beamtime for each of the year's three rounds, and strong collaboration with the local and international user community, both scientific and industrial. Focussed research continues to grow at the Australian Synchrotron, either through direct engagement with local and international companies, or through supporting universities and other research providers. For example, one of the Synchrotron's largest user groups the CSIRO, has indicated that 10 percent of their beamtime either directly or indirectly benefits industrial research and applications.

The facility's outcomes are testament to maintaining a high standard of capabilities by an outstanding Accelerator Science and Operations team. And equally, dedicated beamline teams focussed on the adaptation of techniques in response to a stream of diverse challenges put to them by hundreds of new researchers each year.

Scientific merit is the key driver behind the allocation of beamtime to users, and the high quality of research produced. Beamtime proposals are reviewed by local and international experts for potential scientific impact and the need for synchrotron radiation to support the research.

The track record of applicants is a key consideration, ensuring the highest quality of outcomes and the most effective use of highly-coveted beamtime. Consideration is also given to novice synchrotron radiation users to ensure the development of the user community, and the broadening of the fields of research undertaken at the Australian Synchrotron.

Beamline capabilities

The past 12 months have seen the implementation of a number of new beamline capabilities. These include major technical developments on the Imaging and Medical beamline (IMBL) such as installing and commissioning the new superconducting multipole wiggler, allowing the delivery of experiments in one of three modes of operation: microbeam radiation therapy, computed tomography imaging and phase contrast imaging.

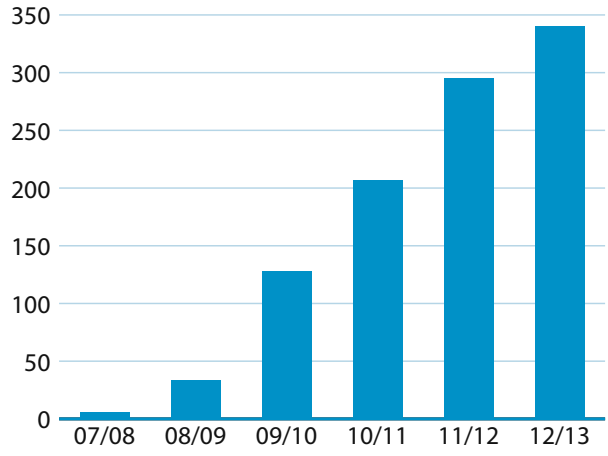
New sample preparation methods and ancillary devices for *in situ* measurements have been introduced by staff and colleagues, and made available for users. Investment in a suite of new software tools, in conjunction with the MASSIVE high-performance computing cluster, has enabled more efficient use of limited beamtime, with near real time data reduction and visualisation tools for a number of beamlines, along with new remotely accessible data processing portals and data analysis tools.

Facility outcomes

This year's scientific output has been exceptional, with the production of 340 peer reviewed scientific publications containing data from the Australian Synchrotron. A further 77 papers were either produced by Australian Synchrotron staff, or generated by our user community using funds administered by the Australian Synchrotron to access international synchrotron facilities.

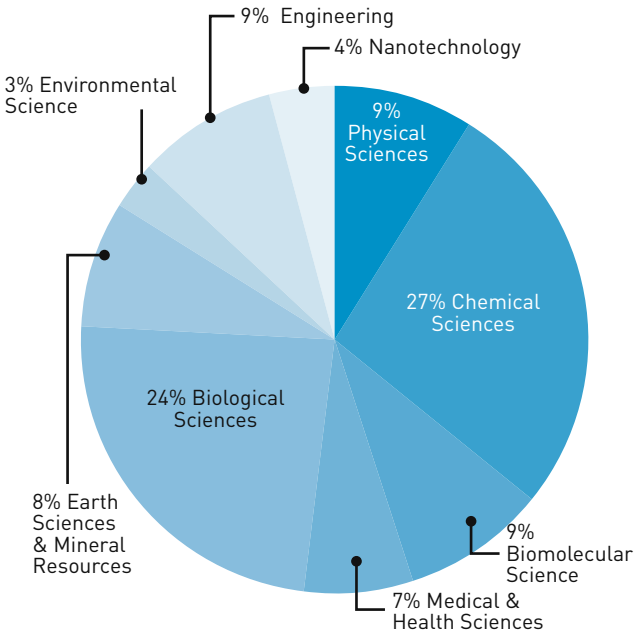
The quality of published work remains high with an average impact factor of 4.71. Several papers were published in the highest quality journals such as *Nature*, *Science*, *Cell* and *Immunity*, with more than 10 percent of publications appearing in journals with impact factors above 9.

Publications (FY)



Compared to previous years, 2013 has seen increases in the proportion of chemical and biomedical research carried out at the facility, and a relative decrease in effort devoted to synchrotron research methods. This reflects the facility's transition from its developmental years to a more mature user research platform.

Experiments by field of research (FOR) codes (FY13)



It is also notable that the Australian Synchrotron user community is becoming increasingly adept at using multiple synchrotron techniques, with six percent of published studies from the past year containing data from two or more beamlines. The structural biology community has shown significant interest in combining micro-crystallography and small angle x-ray scattering (SAXS) data in their studies, while soft x-ray spectroscopy and SAXS have been used in complementary studies of organic semiconducting materials. X-ray absorption spectroscopy is being increasingly used in concert with x-ray fluorescence microscopy in studies of metal distribution in the environment, and with powder diffraction to probe local structural order within crystalline materials of technological interest.

Publication research trends by beamline

Macro- and Micro-crystallography (MX1 and MX2)

Across the fields of research on the MX1 and MX2 beamlines, two-thirds of publications over the past 12 months related to studies of protein and biomolecular structure and function, with most of the remainder associated with small molecule systems and crystal engineering, and several attributed to mineralogical systems.

Powder Diffraction (PD)

Publications on the PD beamline were equally split approximately one-third each between structural studies of magnetic or electronic materials, and materials for new energy technologies (hydrogen storage, gas separation, batteries, catalysis and fuel cells). The remainder were associated with mineral formation or processing, metallic alloys and intermetallic systems.

Small- and Wide-angle X-ray Scattering (SAXS/WAXS)

Around one-third of papers published with data from the SAXS/WAXS beamline were associated with studies of biomolecular structure and function, a field that has shown strong increasing demand in recent years. A further quarter of the papers from this beamline were associated with mesoporous and liquid crystalline materials used for drug-delivery vehicles, with the remainder relating to nanostructures and nano-materials, studies of organic semiconductors, or materials modified by radiation damage.

Soft X-ray Spectroscopy and Imaging (SXR)

The largest fraction of publications from the SXR beamline related to the study of nanostructured materials, with the remaining papers in the fields of surface chemistry, organic semiconductors and photonic devices, and surface coatings.

Terahertz/Far-IR and Infrared Microscopy (IRM)

The Terahertz/Far-IR and IRM beamlines have a wide-ranging and reasonably even spread of research conducted across the fields of molecular spectroscopy, mineral systems, energy technologies and environmental studies, forensics, tissue and cellular systems, and naturally-occurring nanostructures associated with insect wings.

X-ray Absorption Spectroscopy (XAS)

Approximately one-third of the published studies from XAS were associated with earth sciences, with the remainder relating to nuclear waste forms catalytic materials, and studies of environmental pollution. XAS measurements were also conducted at the Australian National Beamline Facility (Photon Factory, Tsukuba Japan), resulting in 13 publications associated with environmental science, electronic and magnetic materials, and studies of anti-cancer drugs.

X-ray Fluorescence Microscopy (XFM)

The past year saw a significant increase in the proportion of biological studies published containing XFM data (approximately half the output of the beamline), with the other major areas of research being the characterisation of heavy metals in the environment, and earth sciences.

Research Impact

The following pages provide an outline of the Australian Synchrotron user community, beamline capabilities and support staff, which have combined to produce the impressive range of high quality research achieved over the course of the year.

In the following pages we describe a small number of the best of the 417 papers published over the past 12 months to demonstrate the impact of the Australian Synchrotron in diverse research areas such as Medical and Life Sciences, Advanced Materials and Engineering Science, Earth and Environmental Sciences, and Accelerator Sciences.

Professor Michael James

Head of Science, Australian Synchrotron

Science at the Australian Synchrotron

User Community

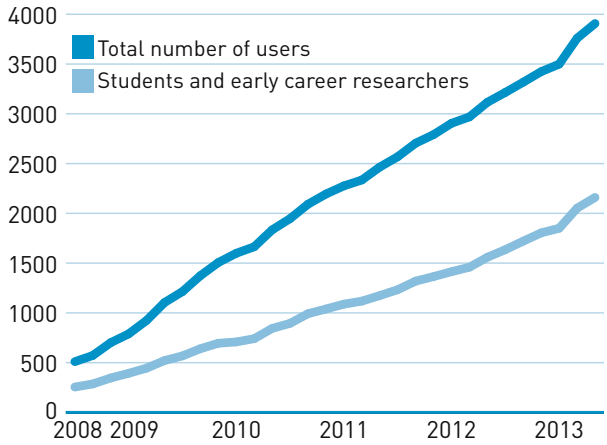
Along with the passion and expertise of Australian Synchrotron staff, it is the creativity, drive and energy that the user community brings to the facility that keeps the Synchrotron dynamic, flexible and engaged in cutting-edge science and innovation. In addition to the excellent productivity, the breadth of research across individual beamlines continues to be a feature of the operation and output of the facility, challenging staff on a daily basis to develop new instrumental capabilities, tackle new scientific fields, and speak the various languages of biologist, chemist, geologist, material scientist, art historian and engineer.

The User Office team serve on the front line of user community relations, and importantly facilitate interactions with the user committees that support scientific excellence. Aside from managing the merit proposal system, inductions and access to the facility, they're also committed to managing the new guesthouse and numerous other areas of user amenity.

The facility's collaborations with the user community are substantial, with 597 investigations approved during the past year giving rise to more than 800 experiments and 3736 user visits. Strong, ongoing growth in facility demand saw 688 new users conducting investigations at the Australian Synchrotron in FY13, which is well above the year-on-year trend of approximately 600 new users per year since 2008.

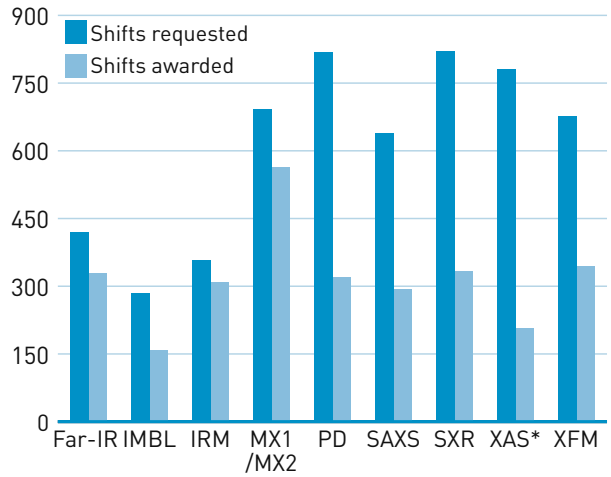
The user community has continued to expand. Of the total of 3759 registered users, more than 1500 users came to the facility over the past year to conduct experiments. On average, half of the user community are students or early career researchers, reflecting the facility's commitment to training and developing the next generation of synchrotron scientists in Australia.

Australian Synchrotron Users



Subscription rates across beamlines continue to be strong with demand for merit beamtime shifts exceeding the number available for all instruments — in some cases by more than 200 percent — and supporting the case for the development of new instrumentation and capabilities at the Australian Synchrotron. For PD, SAXS, SXR, XFM and XAS, there has been particularly high demand, with the latter also experiencing increased demand since the closure of the Australian National Beamline Facility in Japan.

Subscription rates per beamline



*includes XAS at the Synchrotron and ANBF at the Photon Factory.

Science at the Australian Synchrotron

Beamline Capabilities & Updates

Imaging and Medical Beamline (IMBL)

The upgraded Imaging and Medical beamline (IMBL) began limited operations in November 2012. It caters for very high dose micro-beam radiotherapy (MRT) research, and fast, medium-resolution computed tomography imaging. High-resolution phase-contrast imaging (PCI) and slower computed tomography with PCI are available in a satellite building that accommodates preclinical research.

A new superconducting multipole wiggler system supplies very high energy x-rays to the beamline, either in the form of a wide energy 'white beam', or as a monochromatic beam after reflecting from a high-stability double crystal monochromator. Delivering this very large x-ray beam (500mm x 40mm) to the satellite building 136 metres from the wiggler, involved designing and installing a large vacuum transfer pipeline.

Bone, cardiovascular, heart, lung and radiotherapy research streams have been formed in consultation with clinicians, biomedical and clinical researchers. Bone research concentrates on in-vivo high-resolution imaging and MRT for musculoskeletal diseases.

Infrared Microspectroscopy Beamline (IRM)

The Infrared Microspectroscopy beamline (IRM) is a mature facility with a strong user base. Regular workshops introduce users to data analysis tools such as advanced multivariate statistical methods.

Using the high-performance MASSIVE high-performance computing cluster, researchers can correct data from biological samples 100 times faster than by personal computer. Data analysis software is available through the Remote Access to Infrared Data Analysis Resource (RAIDAR).

Integrating a focal plane array imaging detector with the synchrotron beam will further improve spatial resolution and reduce collection times.

Terahertz/Far-Infrared Beamline (THz/Far-IR)

The Terahertz/Far-Infrared beamline (THz/Far-IR) users have diverse interests that include biological, atmospheric, astrophysical, renewable energy, and materials research and applications. For example, users are studying protein-water interactions, water ice particles which play important roles in interstellar and atmospheric photochemical processes, catalytic properties of ligand-stabilised gold clusters, hydrogen release from new hydrogen storage materials, and new cathode materials for non-aqueous lithium ion batteries.

New instrumentation is increasing the scientific capabilities at the beamline and offering more techniques to condensed-phase and gas-phase users.

Macromolecular and Micro-crystallography Beamlines (MX1 and MX2)

The Macromolecular Crystallography beamline (MX1) performs standard experiments with high throughput. The Micro-crystallography beamline (MX2) has a micro-focussed beam for tackling more challenging problems. These mature and productive facilities have a large user base.

Addressing the needs of chemical and macromolecular crystallographers is challenging but enriching. The beamlines also service the needs of commercial users.

Automated data processing gives users near real time feedback on data quality. AutoRickshaw can automatically solve structures where data have sufficient information content. Beamline development is ongoing.

The Australian structural biology community regularly produces internationally significant research using Australian Synchrotron MX data and crystal structures. Recent highlights include insights into the regulation of blood clotting and cancer cell metastasis, and discoveries that could lead to more effective treatments for some cancers and neurodegenerative diseases.

Powder Diffraction Beamline (PD)

Powder Diffraction beamline (PD) staff are extending the beamline's sample environments and supporting users to more effectively process their data for publication.

A high-pressure diamond anvil cell exposes samples to pressures found in the Earth's deep mantle or on other planetary bodies. A high-temperature furnace enables data collection up to 1500°C.

New user support features include in-house data visualisation, processing and reporting software (PDViPeR). Web-based tutorials are available to help new users refine synchrotron powder diffraction data.

Current projects will enhance beamline capabilities for experiments on polycrystalline solids and films, and improve operation of the Mythen microstrip detector. Forward plans include a faster auto-alignment spinner for sample capillaries and a sample-loading robot to improve throughput.

Small and Wide Angle X-ray Scattering Beamline (SAX/WAXS)

The Small and Wide Angle X-ray Scattering beamline (SAXS/WAXS) is a world-class facility for protein solution scattering, which accounts for almost half of beamline use. The beamline is fully automated for running solution samples and *in situ* size exclusion chromatography, and caters for exceptionally dilute samples. Users have full control of optics performance. Automatic data processing outputs include an initial 3D shape reconstruction.

High-performance software includes: AreaVision for high-speed sample alignment; and ScatterBrain for data acquisition, processing, and analysis. Beamline staff have developed a comprehensive wiki of beamline documentation and troubleshooting.

Recent user highlights include new structural insights into the body's cellular defences against viral pathogens, discovered by examining protein conformational changes in solution, which are not accessible to crystallography.

Soft X-ray Spectroscopy and Imaging Beamline (SXR)

The Soft X-ray Spectroscopy beamline (SXR) has a new branchline and imaging endstation. Internationally-recognised experts in coherent diffraction imaging from the Centre of Excellence for Coherent X-ray Science recommissioned an instrument they designed and operated at Chicago's Advanced Photon Source.

The original beamline supports diverse users, mainly for soft x-ray spectroscopy and surface preparation under ultra-high vacuum. The beamline offers sample heating to 1000 °C, cooling to -130 °C, argon ion beam etching, and limited reactive ion etching. Thermal sources for *in situ* sample preparation allow evaporation from 50 to 1400 °C.

The past year has seen notable scientific outcomes in diamond-based electronics, organic solar cells and semiconductors.

X-ray Absorption Spectroscopy Beamline (XAS)

The X-ray Absorption Spectroscopy beamline (XAS) supports diverse users from biology to materials science, specialising in ultra-dilute, *in situ* and extreme environment investigations. XAS is facing increasing demand following closure of the Australian National Beamline Facility (ANBF).

XAS beamline refurbishments will enhance delivery of the highest quality data from transmission and fluorescence measurements at room and low temperatures. Synchrotron staff are overhauling the second experimental station to accommodate large roll-in, roll-out equipment for extreme chemistry, high temperature and high pressure measurements.

X-ray Fluorescence Microscopy Beamline (XFM)

The X-ray Fluorescence Microscopy beamline (XFM) accommodates users from biological, geological and environmental sciences, with significant cultural heritage and materials science program. It offers elemental mapping, spectroscopy and tomography with 120 nm to 200 µm resolution.

The beamline's popularity is largely due to the Maia detector system, being further developed in collaboration with CSIRO and Brookhaven National Laboratory. Maia offers an order-of-magnitude improvement in experimental efficiency, with extremely short dwells for high definition investigations. Users can inspect images during acquisition: high quality analysis is supplied within minutes of scan completion using the GeoPIXE software on MASSIVE.

Staff are implementing cryogenic capabilities to improve microprobe mapping, spectroscopy and tomography through reduced radiation damage. Maia upgrades will enhance transmission imaging quality.

Science at the Australian Synchrotron

Medical & Life Sciences

Medical and life sciences play a vital role in improving human health and increasing the benefits we derive from plant and animal products. This year the Australian Synchrotron has helped researchers to better understand how our immune system protects us against harmful bacteria, and develop more effective ways to diagnose, treat and prevent diseases and health problems such as various types of cancer, diabetes, malaria, leukaemia, influenza, bone and musculoskeletal conditions, cardiovascular disease and lung health. Other groups investigated how plants transport and store trace minerals that can accumulate in the food chain.

Synchrotron x-ray diffraction in particular is an essential tool for medical and life scientists, with the macromolecular (MX1) and micro-crystallography (MX2) beamlines accounting for more than two-thirds of Australian Synchrotron papers published in the medical and life sciences area. The MX beamlines are mature and highly productive facilities that also service a growing number of commercial clients directly.

Other examples of new applications of synchrotron science can be found on pages 20 and 21.

Understanding disease

World's first 3D images of insulin

The world's first 3D images of insulin in the process of binding to cell surfaces to allow the cells to take up sugar from the blood have been produced by an Australian-led research team using MX2 data. The work will enable better forms of synthetic insulin to be developed for type 1 and type 2 diabetes.[1]

Potential leukaemia drug candidate

A potential drug candidate identified by Japanese researchers who used x-ray crystallography at the Australian Synchrotron could help to improve outcomes for sufferers of acute myeloid leukaemia, a type of cancer that affects the blood and bone marrow.[2]

Apoptosis imaging to improve treatment of cancer and neurodegenerative diseases

A new research discovery could lead to improved treatments for some types of cancer and neurodegenerative diseases. Australian medical researchers used MX to obtain highly detailed pictures of a key part of the process of programmed cell death (apoptosis), which governs the turnover of cells in our body.[3]

High resolution imaging of blood microcirculation of kidneys, lungs and brain

Australian Synchrotron staff along with researchers at the universities of Otago and Osaka, and the Japanese synchrotron SPring-8 are undertaking pre-clinical research into aspects of heart and lung health and kidney disease. Following successful experiments in Japan, studies of the blood microcirculation of the kidneys, lungs and brain have begun at the Australian Synchrotron's Imaging and Medical Beamline (see images on page 23).[4]

Light-activated drug delivery for macular degeneration

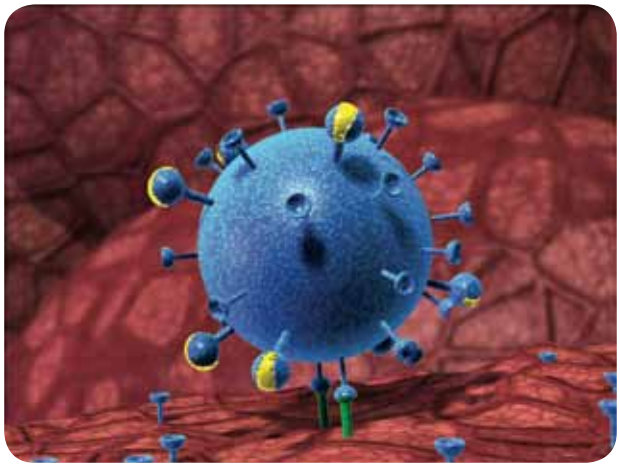
Australian researchers have used the Small Angle X-ray Scattering (SAXS) beamline to develop a new switchable drug-delivery implant that can be activated by laser light to provide a more effective treatment for macular degeneration, reducing the need for frequent injections of medication into the eye.[5]

1. John G. Menting et al., Nature, 493, 241–245 (2013)
2. Yoriko Saito et al., Sci. Transl. Med., 5, 181ra52 (2013)
3. Peter E. Czabotar et al., Cell, 152, 519-531 (2013)
4. Mikiyasu Shirai et al., Circulation Research, 112, 209-221 (2013)
5. Wye-Khay Fong et al., Langmuir, 28, 14450-14460 (2012)

Fighting bacteria and viruses

Potential new flu drug

A potential new flu drug is being developed by Australian and international researchers with the assistance of MX1 data as a weapon against resistant strains of the flu virus, which are notorious for their ability to mutate. The new drug could quickly bring future flu outbreaks under control, buying time for specific vaccines to be developed.[6]



The new drug (yellow) stops the flu virus detaching itself from the cell surface. Image: CSIRO and Magipics

Connection between potassium and bacterial diseases revealed

Potassium is vital for human health. It also plays a previously unsuspected, but essential role in the bacteria behind illnesses such as gastroenteritis and Legionnaires' disease. When Sydney researcher Miriam-Rose Ash used MX to examine an iron-transport protein in bacteria that helps them to infect us, she discovered that its activity was accelerated by the potassium inside our bodies. Dr Ash was awarded the 2012 Australian Synchrotron Thesis Medal for her outstanding PhD thesis on this work.[7]

Studies of cellular defence mechanisms against pathogens

Australian and German researchers gained new structural insights into an important process at the frontline of our cellular defences against viral pathogens. The researchers used SAXS to examine conformational changes to our cells' immune response proteins when they were confronted by foreign pathogens. SAXS is an essential tool to undertake these studies in solution, as such protein complexes are not accessible to protein crystallography.[8]

New insights into golden staph drug

Melbourne researchers and Synchrotron staff combined MX and SAXS techniques to obtain important new insights into an essential metabolic enzyme that is a potential target for the development of new drugs to combat antibiotic-resistant 'golden staph', Staphylococcus aureus.[9]

6. Jin-Hyo Kim et al., Science, 340, 71-75 (2013)

7. Miriam-Rose Ash et al., FEBS Lett., 586(16):2218-24 (2012)

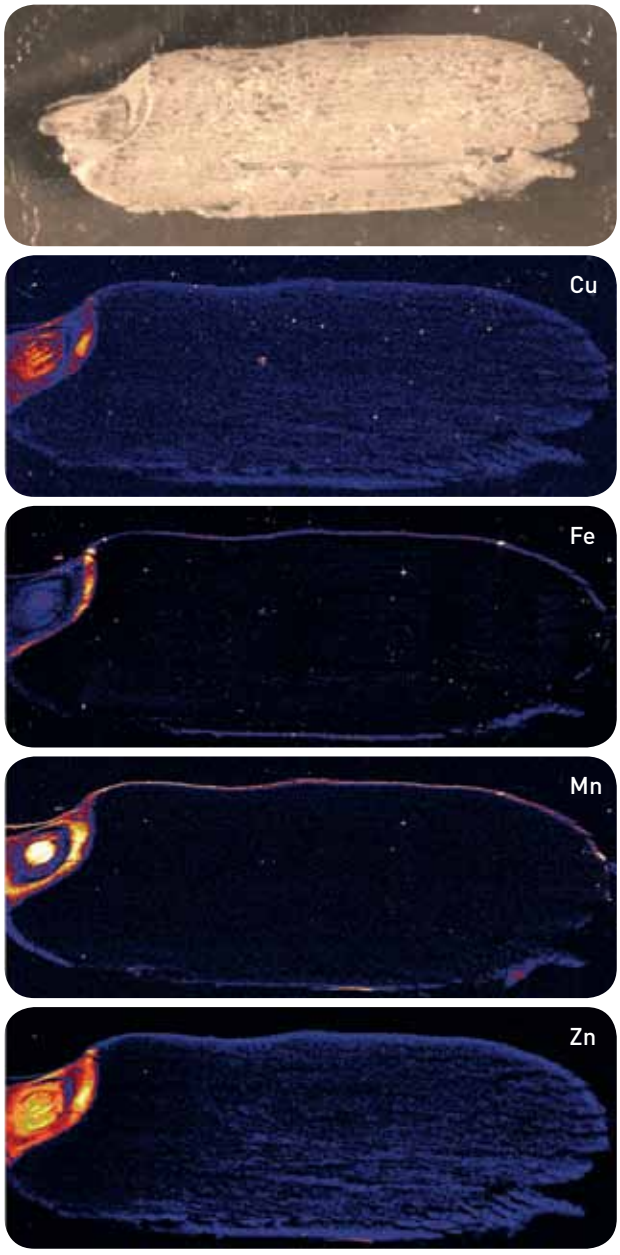
8. Simone A. Beckham et al., Nucleic Acids Research, 41, No.5, 3436-3445 (2013)

9. Nicole R. Pendini et al., Protein Sci., 22 762-73 (2013)

Food and agriculture

Distribution of micronutrients in rice after processing

Different rice varieties lose varying amounts of essential mineral elements when de-husked and polished. An international team with researchers from South Australia used X-ray Fluorescence Microscopy (XFM) to study how rice variety and polishing methods influenced the loss of iron, magnesium, zinc, calcium and other important elements. Iron is particularly susceptible to polishing losses because it is mainly found in the outer parts of the grain.[10]



Synchrotron x-ray fluorescence microscopy of Copper (Cu), Iron (Fe), Manganese (Mn) and Zinc (Zn) in a grain of rice genotype TSN1.

10. Thomas H. Hansen et al., J. Cereal Sci., 56, 307-315 (2012)

Science at the Australian Synchrotron

Advanced Materials & Engineering Science

Advanced materials are the product of engineering, science and technology. They are becoming an essential part of the daily lives of Australians, and with the assistance of synchrotron techniques, are increasingly helping to meet the challenges of sustainable energy generation and storage. This year, researchers used the Australian Synchrotron to investigate novel substances used in electronic devices such as computers, mobile phones and battery-operated appliances, in fabrics, and in power generation. Others used the Synchrotron to help them develop new materials inspired by nature.

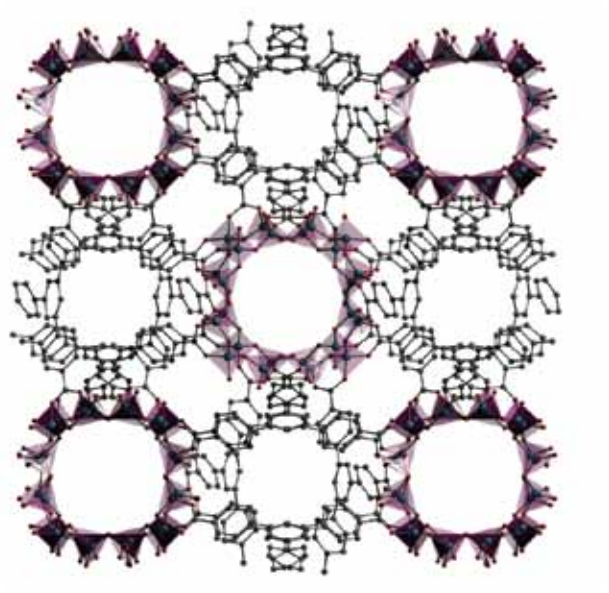
Global scientific interest in the electronic structure of novel materials is encouraging more scientists to use the soft x-ray spectroscopy (SXR) beamline. Several research groups are modifying the electronic properties of carbon, in the form of thin diamond films and atom-thick sheets of graphene, by depositing sub-monolayers of electron-donating or electron-withdrawing molecules. The SXR beamline provides precise information on the structural and electronic changes in these surfaces, and the beamline team can assist with preparation techniques that users may not have in their local laboratories.

Fuel cell development, hydrogen storage and associated technologies – such as gas separation and geosequestration – are now critical needs. Growing areas for synchrotron x-ray powder diffraction (PD) beamline users are studies of the structure and function of hydrogen storage and lithium battery technologies for mobile applications.

Alternative energy and carbon dioxide

New hydrogen storage materials

Clean and high in energy, hydrogen is widely considered a key fuel of the future. Australian and international research groups are using synchrotron PD to investigate the structures of novel hydrogen storage materials, and the associated hydrogen uptake and release processes.[11]



Metal organic frameworks (MOFs), like the one picture above, have many applications including storing and releasing CO_2 when exposed to sunlight.

A more cost-effective way to purify natural gas

A Melbourne research team may have found a way to reduce the cost of natural gas purification. The researchers used the PD beamline to investigate how a molecular sieve could let carbon dioxide into its structure but keep methane (natural gas) out. The 'trapdoor' mechanism could also be used to separate and store carbon dioxide.[12]

Using solar energy to capture and recycle carbon dioxide

A new 'solar sponge' approach to capturing and recycling carbon dioxide uses visible and UV light to switch between adsorption and release, eliminating the need to apply heat to release the carbon dioxide. Developed by CSIRO, Monash and Sydney Universities the highly porous 'metal organic framework' material can store huge volumes of carbon dioxide, hydrogen or methane.[13]

Building better solar cells with polymers

Researchers are using small angle x-ray scattering (SAXS) to study advanced polymers for use in all-polymer solar cell technology. These new materials are improving the efficiency of polymer solar cells, which are lightweight, flexible and much cheaper to manufacture than silicon-based solar cells.[14]

11. Guanglin Xia et al., J. Mater. Chem. A, 1, 250-257 (2013)

12. Jin Shang et al., J. Am. Chem. Soc., 134, 19246–19253 (2012)

13. Richelle Lyndon et al., Angew. Chem. Int. Ed., 52, 3695-3698 (2013)

14. Yaqi Tang and Chris R. McNeill, J. Polym. Sci. B 51, 403-409 (2013)

Batteries and electronic devices

Cathode materials for more efficient lithium batteries

Australian researchers are developing potential new cathode materials to improve the efficiency, safety, cost and environmental impact of aqueous rechargeable lithium batteries for large-scale energy storage. They have used far-infrared spectroscopy[15] and powder diffraction[16] to help assess the impact of different processing agents and conditions on cathode characteristics.

Smaller, more versatile and robust electronic devices

An emerging field of nanoscale electronics called 'spintronics' could mean smaller, more versatile and robust electronic devices for a market worth hundreds of billions of dollars. New Zealand researchers used soft x-ray (SXR) spectroscopy to investigate the electronic structure of nanoscale zinc oxide thin films with spintronics potential.[17]

Polymer films for low cost flexible electronic devices

Victorian and UK researchers worked with Synchrotron staff to investigate the microstructure of thin films of an organic polymer that could enable low cost flexible electronic devices to be produced by high-throughput printing. The researchers used novel SXR and small and wide angle x-ray scattering (SAXS/WAXS) techniques to examine changes in chemical structure and nanoscale morphology in these molecular films.[18]

New materials

Recycling system uses light to decompose plastics

Melbourne researchers are using the microcrystallography (MX2) beamline to help them develop a plastic recycling system in which the plastic is made from components that can later be decomposed by light. The system includes the first demonstration of a complete light-based plastic breakdown process, with the components able to be reused to make new plastic products.[19]

Tailoring silk for new medical and industrial uses

Silk is a natural, strong, light material suitable for modern biomedical applications. However, artificial silk with the required characteristics has proven surprisingly difficult to manufacture. CSIRO scientists are using SAXS/WAXS and infrared microspectroscopy (IRM) to understand silk materials and enable development of tailor-made silks for tissue engineering, drug delivery, stem cell growth, biomonitoring, catalytic materials and advanced-textiles. [20]

Useful characteristics of insect wings considered for industrial applications

Insect wings are typically very difficult to wet (superhydrophobic), with directional textured nanostructures that make it easier to shed water. Some wings also have antibacterial properties resulting from these nanostructures and their chemical make-up. An international research team used complementary synchrotron infrared techniques in Australia and the US to examine proteins and waxes on cicada wing surfaces, with the ultimate aim of reproducing these characteristics for industrial applications.[21]

This cicada's wing has not only anti-reflective, but also 'superhydrophobic' qualities - studied at the Synchrotron for their potential for industrial applications.

Gold nanoparticles improve prospects for photocatalytic materials to clean up pollution

Australian researchers are developing ways to produce improved photocatalytic materials in the form of nanofibrous titanium dioxide mats embedded with gold nanoparticles. The researchers used PD to identify the processing temperature that would optimise the properties of the resulting material. The new photocatalytic materials could potentially be used to help deal with pollution in liquid and gaseous environments.[22]

15. Sathiyaraj Kandhasamy et al., Electrochimica Acta, 82, 302-308 (2012)
16. Jiantie Xu, et al., J. Power Sources, 225, 172-178 (2013)
17. Peter.P. Murmu et al., J. Mater. Sci., 47, 1119-1126 (2012)
18. Torben Schuettfort et al., J. Am. Chem. Soc., 135, 1092 (2013)
19. Priscilla Johnston et al., Chem. Sci., 3, 2301-2306 (2012)
20. Tara D. Sutherland et al., Biopolymers, 97, 446-454 (2012)
21. Mark J. Tobin et al., J. Synchrotron Radiat., 20, 482-489 (2013)
22. Xingdong Wang et al., ChemCatChem, (2013) doi: 10.1002/cctc.201300180

Science at the Australian Synchrotron

Earth & Environmental Sciences

Earth and environmental sciences underpin many Australian consumer products, play an essential role in protecting the natural environment, and deliver additional value to the mining and mineral processing sectors. This year, researchers in these areas used the Australian Synchrotron to investigate environmental processes, determine how to minimise the harmful effects of human activity on the environment, develop better methods for locating and processing valuable mineral ore deposits, and improve our understanding of the Earth's geology.

The last 12 months have seen earth and environmental science researchers making greater use of the powder diffraction (PD) beamline's *in situ* capabilities to replicate natural conditions of high temperature and pressure and better understand mineral formation and reaction mechanisms. Beamlines are anticipating a slight shift away from minerals and mining-related projects towards increased research efforts in deep-earth geology, planetary science and human interactions with the geological environment.

Understanding the environment

How fungi break down gum leaves

A Victorian research team is using synchrotron infrared microspectroscopy to examine how eucalypt leaves degrade in wetland areas, which are a major environmental carbon sink. Their investigation of biomolecular changes in leaf tissue during fungal decomposition is the first spatially related study of how fungi separate lignified material into biodegradable and non-biodegradable forms.[23]

Revealing the location and chemistry of trace elements in plant roots

The x-ray fluorescence microscopy (XFM) beamline and its Maia detector system enable researchers to study small, delicate samples that would otherwise be damaged by the x-ray beam. Australian researchers who examined the distribution and chemistry of arsenic in fresh cowpea roots found that arsenic (V) and arsenic(III) were taken up by different parts of the root, leading to varying degrees of accumulation and damage.[24]

Is it safe to use treated sewage sludge as fertiliser?

South Australian and overseas researchers used XFM to look into the distribution and potential bioavailability of copper and zinc in treated sewage sludge (wastewater biosolids). Biosolids add valuable macro-nutrients and organic matter to agricultural soils, but also contain mineral micronutrients that may become environmental contaminants.[25]

Understanding the processes behind environmental fish kills

Iron oxides and minerals are involved in many environmental processes. NSW researchers teamed up with Synchrotron staff to determine the key mechanisms behind the transformation from ferrihydrite to goethite, using *in situ* x-ray absorption spectroscopy (XAS) measurements. Their aim is to develop ways to turn ferrihydrite into goethite in the environment, to reduce the risk of fish kills following rainfall in acid-sulphate soils in northern NSW river systems.[26]

Learning about the atmosphere

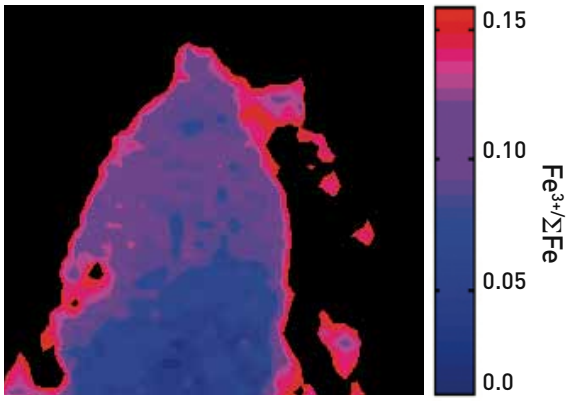
Molecular ices are important in interstellar and atmospheric chemistry because they can host chemical reactions. Australian and German researchers used mid-infrared spectroscopy to examine the characteristics of laboratory-produced water ice aerosols with particles 3 to 100 nanometres in diameter. Their findings will assist the interpretation of atmospheric measurements.[27]

23. *Janice L. Kerr et al., PLOS ONE, 8, e60857, (2013)*
24. *Peter M. Kopittke et al., Plant Physiology 159, 1149-1158 (2012)*
25. *Erica Donner et al., Environ. Pollut., 166, 57-64 (2012)*
26. *Daniel D. Boland et al., Colloid. Surf. A, 435, 2-8 (2013)*
27. *Chris Medcraft et al., Phys. Chem. Chem. Phys., 15, 3630-3639 (2013)*

Geological processes

Expanding the use of synchrotron techniques to shed light on diamond stability

Australian, UK and German researchers used XFM to reveal new information about the impact on diamond stability of particular changes in the composition of rocks in the Earth's upper mantle. A reviewer for the top-ranked journal that published this work said the work could encourage many more geoscientists to use synchrotron techniques.[28]



Map of the ratio of ferric ions to total iron (ferrous and ferric ions) in garnet from analysis of multiple XFM scans. The pink-red colours indicate areas that have more ferric ions (up to about 15 percent) than the blue areas, purple is mid-range. The image is about 600 micrometres wide.

Reproduced with permission of the Geological Society of America

The role of water migration in volcanic eruptions

Geological researchers investigating the role of water migration in explosive volcanic eruptions are increasingly using synchrotron techniques to study the gas content of micron-scale bubbles in quartz and volcanic glasses. Researchers used IRM to map water distribution in volcanic glasses from the 2008 eruption of the Chaiten volcano in Chile.[29]

Response of Jupiter's moon materials

Jupiter's moons have some surprisingly complex geological features made from icy mixtures of water, salts, methane and ammonia. Synchrotron staff recreated the environmental conditions found on Jupiter's moons and used PD to examine how such icy mixtures behave at extreme temperatures and pressures.[30]

Mineral exploration and mineralogy

Cost-effective mineral deposit exploration examined

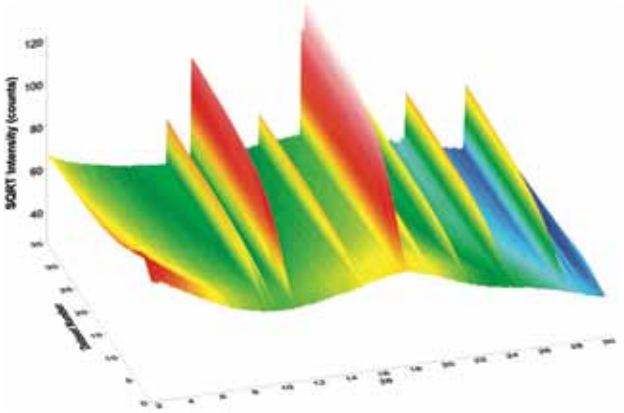
Termites can bring up buried gold, making their mounds a potentially valuable indicator of the presence of subterranean gold deposits. CSIRO researchers working in collaboration with exploration companies are using XFM to help them develop new, cost-effective and environmentally friendly ways of exploring for new mineral deposits.[31]

Investigations to improve bauxite ore processing

Australia's mineral processing industries make an important contribution to national and regional economies, as well as supplying many of the raw materials required for the manufacture or provision of consumer goods and services. Researchers who study mineral processing methods are helping the mineral sector to increase the efficiency of these processes and reduce their impact on the environment. West Australian researchers recently used *in situ* synchrotron x-ray PD to examine mineral phase changes in bauxite ore from different regions during processing.[32]

Exploration early stage jarosite crystallisation

The mineral jarosite is found in both natural and industrial settings, and can lead to groundwater problems in acid mine drainage environments. CSIRO researchers and Synchrotron staff used small and wide angle x-ray scattering (SAXS/WAXS) and PD to investigate the earliest stages of jarosite crystallisation. Their findings may be the key to controlling jarosite formation in various industrial processes.[33]



Accumulated synchrotron powder X-ray diffraction pattern showing the formation of jarosite from solution over time, and the growth of the jarosite peaks. The data are represented as a three-dimensional plot with diffraction angle along the x-axis, dataset number (which relates to elapsed time) along the y-axis and intensity along the z-axis.

28. Andrew J. Berry et al., Geology, 41, 683-686 (2013).
29. Jonathan M. Castro et al., Earth Planet. Sci. Lett., 333-334, 63-69 (2012)
30. Helen E. Maynard-Casely et al., J. Appl. Cryst., 45, 1198-1207 (2012)
31. Aaron D. Stewart et al., Geochem: Explor. Environ. Analysis, 12, 327-337 (2012)
32. Bee K. Gan et al., Int. J. Miner. Process. 123, 64–72 (2013)
33. Helen E. A. Brand et al., J. Synchrotron Rad. 20, 626-634 (2013)

Science at the Australian Synchrotron

New Applications of Synchrotron Science

The Australian Synchrotron has dramatically increased the access to synchrotron techniques for Australian researchers, and helped experienced synchrotron users to improve their research productivity. This proliferation of synchrotron activity has prompted the development of diverse techniques and applications that take advantage of the unique features of synchrotron light.

Biomedical science, cultural research and forensic science are three areas in which synchrotron techniques are playing an increasingly prominent role. Forensic science and the examination of cultural materials both draw on materials science techniques – and stimulate the development of new analytical tools. New approaches in biomedical science are being explored across several different techniques including new approaches coming online with the development of the Imaging and Medical Beamline (IMBL).

Biomedical developments

Promising new experimental radiotherapy technique

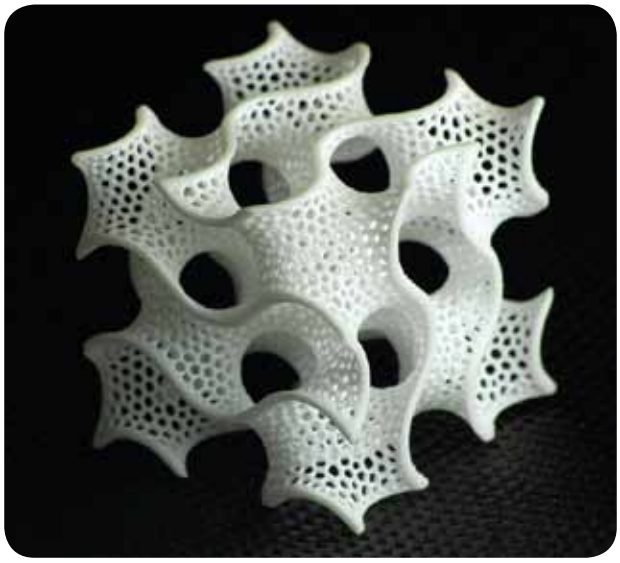
Microbeam radiation therapy (MRT) is a promising experimental radiotherapy technique to attack tumours using finely-divided synchrotron x-ray beams possible on the IMBL with regions of peak (very high dose) irradiation separated by lower dose 'valley' regions. Using infrared microspectroscopy (IRM), Melbourne researchers and Synchrotron staff have found a possible explanation for how MRT can kill a whole tumour even though only a small percentage of the tumour has received peak irradiation.[34]

Towards better cancer diagnosis

Melbourne researchers and Synchrotron staff are using IRM to examine hydrated biological samples with the aim of improving the detection and monitoring of deoxyribonucleic acid (DNA) levels. Their findings could lead to better cancer diagnosis and increase understanding of the biochemistry of disease. Hydrated samples provide more accurate information, and the team is gradually overcoming technical challenges associated with IR absorption by water molecules in the samples.[35]

Improving our knowledge of membrane proteins

Researchers are using macromolecular crystallography (MX1) and small angle x-ray scattering (SAXS) to develop advanced nanostructured materials that assemble themselves. These materials can facilitate structural studies of membrane proteins that are important in fundamental cell processes and many diseases.[36] The new materials can also encapsulate bioactive molecules – including proteins, peptides and drug molecules – for applications such as drug delivery (pictured below). Other potential applications include biosensors and biofuel cells.[37]



Pictured above is a 3D printed model of an advanced nano-structured material which assembles and encapsulates bioactive molecules (Conn and Drummond)

34. Monica Sharma et al., Int. J. Rad. Biol., 89, 79-87 (2013)

35. Donna R. Whelan et al., J. Biophotonics, (2013) DOI: 10.1002/jbio.201200112

36. Dianfan Li, et al., Nature, 497, 521-524 (2013)

37. Charlotte E. Conn and Calum J. Drummond, Soft Matter 9, 3449 – 3464 (2013)

Biomedical developments (cont.)

Hydrophilic/hydrophobic properties reveal drug delivery potential

Self-assembled materials that contain hydrophilic (water-compatible) and hydrophobic (water-incompatible) sections, have great potential for use in high-throughput drug discovery and development. CSIRO researchers used SAXS to further develop their automated preparation and structural characterisation methods.[38]

Drug delivery advances: dose and absorption findings

Melbourne researchers are using SAXS to investigate the way that pharmaceuticals dissolve when introduced into the body. This will aid in assessing the therapeutic dose of such drugs and understanding how quickly they are metabolised.[39]

Distribution of metal elements in nematodes

A simple organism widely used as a model system in biomedical research has yielded detailed information on the anatomical distribution of metal elements that play important roles in health and disease. Synchrotron staff and collaborators used x-ray fluorescence microscopy (XFM).[40]

Studying x-ray-sensitive biological materials

Sensitive biological materials, such as cells, are sometimes chemically degraded by the intense x-ray absorption spectroscopy (XAS) beams used to analyse them. Researchers are investigating the degradation mechanisms so they can find ways to study biological systems with the greater accuracy afforded by XAS – without encountering this frustrating phenomenon.[41]

Forensic and cultural materials

Better forensic analysis for automotive paint residues

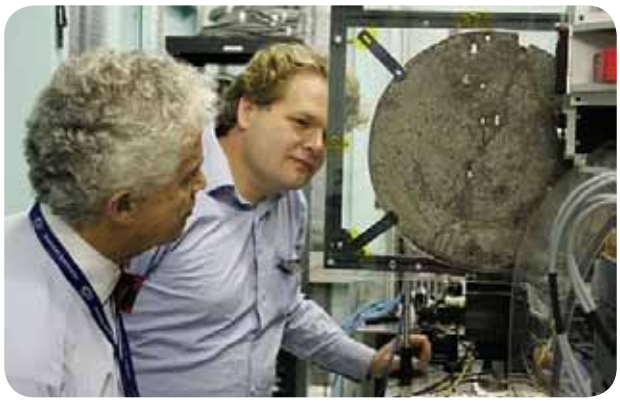
A common form of evidence in car accidents and hit-and-run incidents, automotive paint, consists of layers with different chemical characteristics that combine to create the desired finish. West Australian researchers used synchrotron IRM to examine the extent to which chemicals move between the layers. Their findings will enable forensic procedures to be modified to take account of the chemical migration processes.[42]

Protecting 20th century paintings for the future

Conservators from Queensland and New South Wales are using synchrotron IRM to study how zinc oxide, an industrial-age pigment, reacts with fatty acids in oil-based paints to form zinc soap, which can lead to lumps and cracks in 20th century paintings, particularly those aged under ambient Australian conditions. The work will inform strategies to minimise the impact of these changes, improve restoration methods and assist identification of at-risk paintings.[43]

Australia's oldest written record of European contact examined

Materials conservation experts from Western Australia and Victoria used XFM to analyse one of Australia's oldest records of European contact, the 315-year-old pewter de Vlamingh plate. The findings will assist the preservation of other metal items in historic collections and provide unique insights into the corrosion of soldered connections on circuit boards used in remote and or hostile environments.[44]



(L-R) Ian McLeod (WA Museum) and David Thoroughgood (National Gallery of Victoria) view the de Vlamingh plate on the XFM beamline.

Poison darts still active after 100 years

The poison-coated tips of wooden darts and iron arrow heads in the Melbourne Museum collections are still dangerous, more than a century after they were collected in South East Asia and Africa. Museum scientists made this discovery when they used synchrotron IRM to analyse residues attached to the tips, which were thickly coated with plant toxins. The toxins may have come from the Antiaris plant, a well-known source of arrow poisons.

38. *Xavier Mulet et al., Acc. Chem. Res., 46, 1497-1505 (2013)*
39. *Johan Boetker et al., Molecular Pharmaceutics 9, 2787-2791 (2012)*
40. *Simon A. James et al, Metallomics, 5, 627-635 (2013)*
41. *G.N. George et al., J. Synchrotron Radiat., 19, 875-886 (2012)*
42. *Mark Maric et al., Forensic Sci. Int., 228, 165-169 (2013)*
43. *Gillian Osmond et al., Appl. Spectrosc., 66, 1136-1144 (2012)*
44. *http://www.synchrotron.org.au/index.php/aussyncbeamlines/x-ray-fluorescence-microprobe-x-ray-microspectroscopy/highlights-xfm/history-on-a-plate*

Science at the Australian Synchrotron

Accelerator Science & Operations

The Accelerator Science and Operations team is a dedicated group of physicists, accelerator scientists and operators who make an essential contribution to the operation and continued improvement of the synchrotron. These specialists manage the synchrotron light source – the centrally-located machine that produces photons (x-rays and infrared light) used in research experiments – and operate the synchrotron on a daily basis from the control room.

Following full implementation of top-up mode at the Synchrotron in May 2012, photon beam characteristics have improved for beamlines. Top-up mode is a way of maintaining a stable current in the storage ring by injecting new electrons every three to four minutes. The team is continuing to improve machine set-up procedures to further boost performance.

Another key area of expertise includes coupling control studies to achieve and quantify extremely small vertical emittance, a measure of the size and collimation of the electron beam inside the synchrotron light source. Improved emittance is valuable to researchers at synchrotron facilities as it can lead to higher quality synchrotron light; it is also valuable to particle physicists as it can improve the properties of particle accelerators. As a result of its expertise, the Accelerator Science and Operations team is part of the Australian Collaboration for Accelerator Science (ACAS) and works with other Australian and overseas groups, including researchers from the Large Hadron Collider and the Compact Linear Collider (CLIC) project at CERN in Geneva.

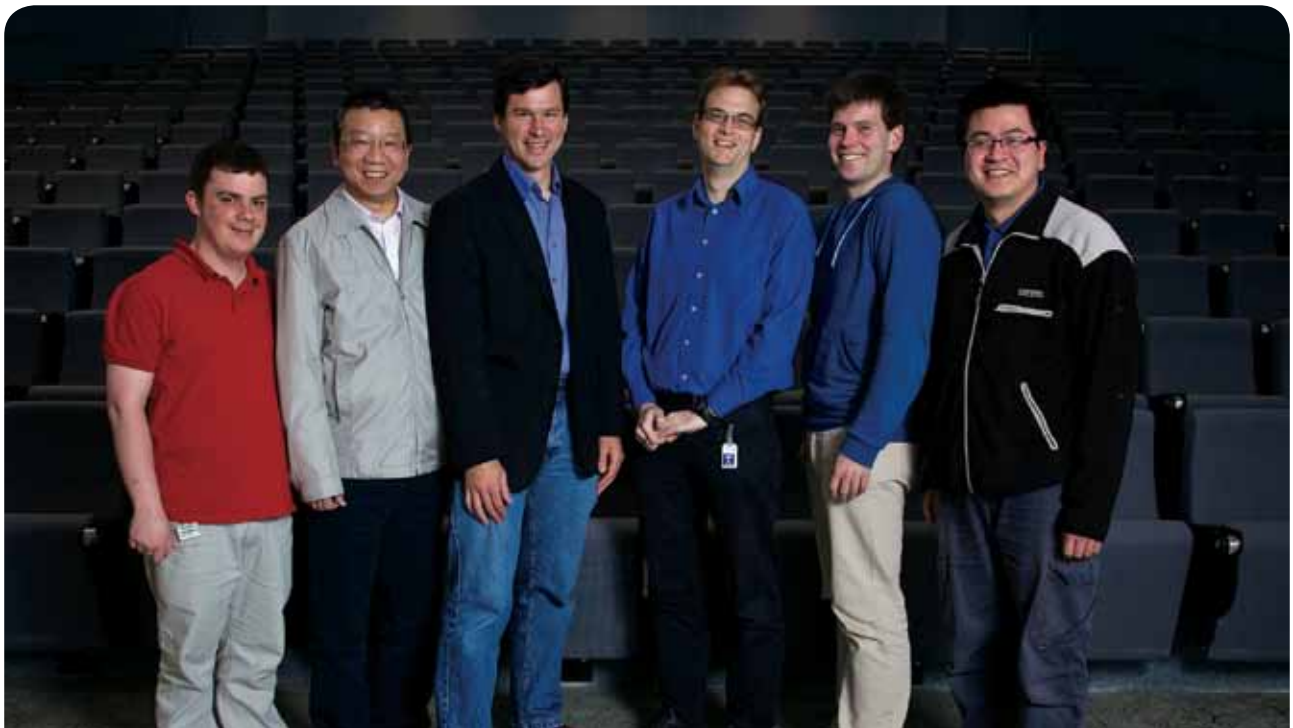
Accelerating the pace

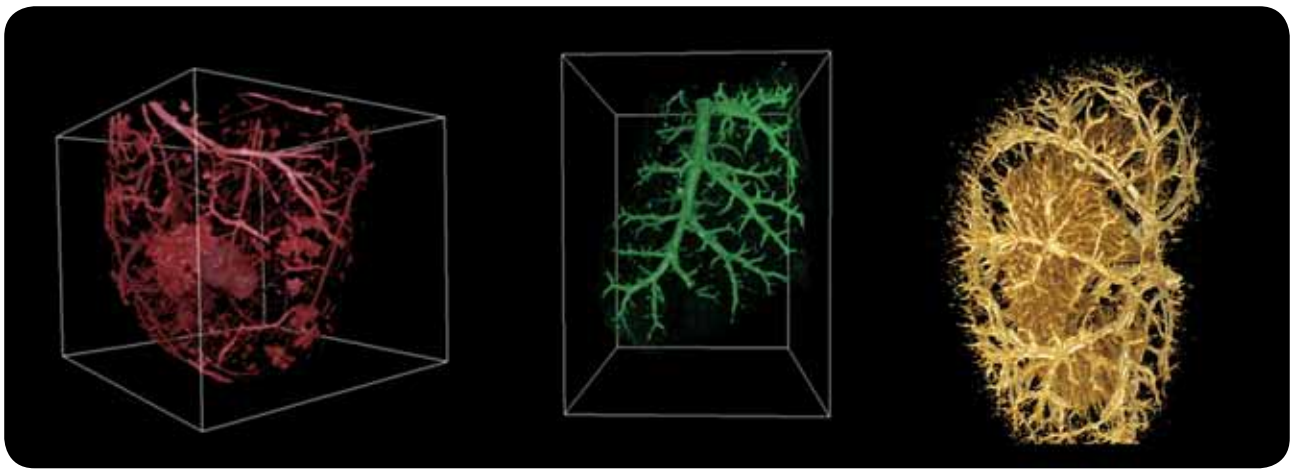
Better electron and photon beam characteristics

The Accelerator Science and Operations team also conducts research that will improve experiment conditions at the Australian Synchrotron by developing improved feedback systems. These monitor and control the characteristics of the stored electron beam, allowing it to be optimised in real time as it circulates around the ring.

Better operations

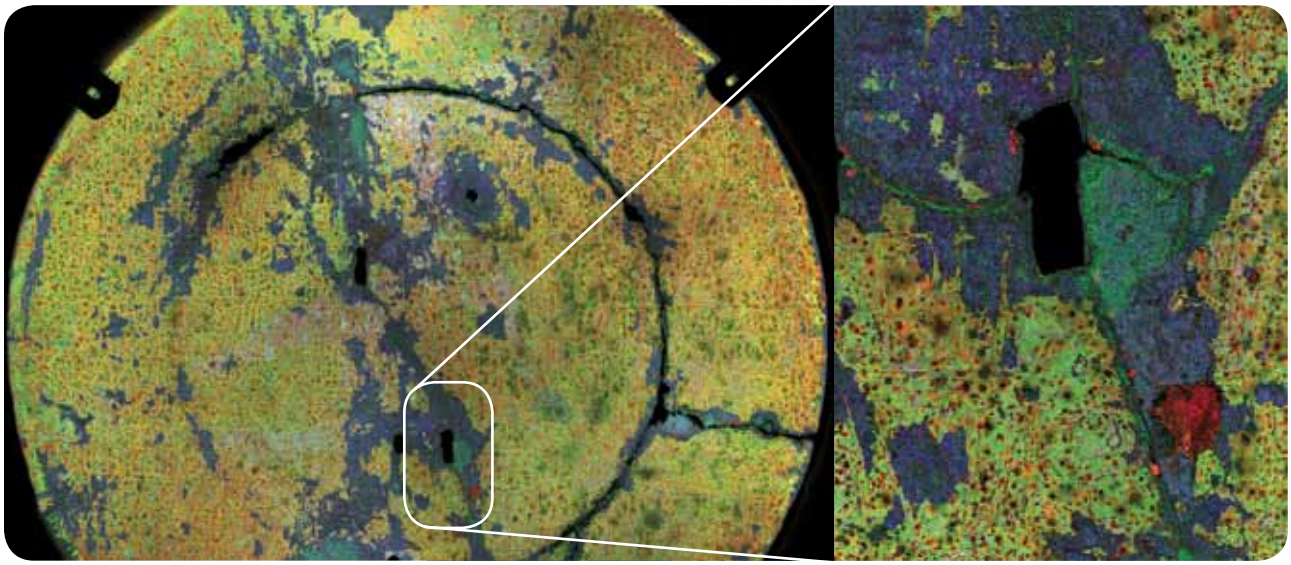
An important outcome of the efforts of the Accelerator Science and Operations team is a deeper understanding of the machine leading to reliable operations. Beam availability remained at more than 98% for the entire year and the mean time between failures remained well above the target of 50 hours.





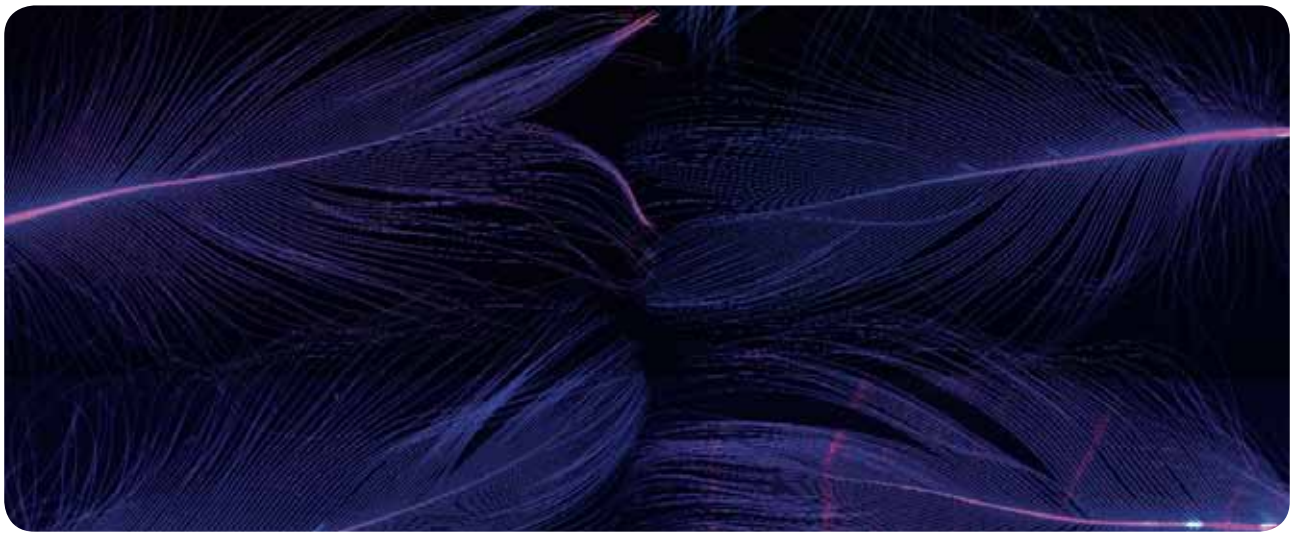
The Imaging and Medical Beamline (IMBL) has the computing power, enabled by the MASSIVE high-performance computing cluster CSIRO's X-tract software, to offer Australia unprecedented resolution, speed and detail for medical imaging. These images show 3D detail of the vascular structure of a heart (red), lung (green) and kidney (yellow).

IMBL: James Pearson, Australian Synchrotron Daryl Schwenke, Mikiyasu Shirai and Alberto Astolfo



This scan of the de Vlamingh plate – Australia's earliest written record of European contact - demonstrates the power of the x-ray fluorescence microscopy technique in mapping clearly and in high detail, numerous elements of matter. Distributions of Zinc (red), Lead (green), and Copper (blue) were mapped within the pewter plate, to assist with the development of conservation techniques.

XFM: WA Museum, National Gallery of Victoria



This image shows, with unprecedented sensitivity and resolution, the distribution of important atomic elements in seabird feathers. These distributions, such as bands of zinc - visible in pink, serve as a record of the bird's metabolism. They're also indicative of the presence of plastics and other contaminants in the food chain, and are helping scientists to understand environmental changes, and dangers to marine life.

XFM: Australian universities, ANSTO and Australian Synchrotron

Science at the Australian Synchrotron

Industry Engagement

The Australian Synchrotron has continued to increase its direct industry engagement, meeting its annual KPI for industry-derived revenue, developing an active program to promote industrial applications of synchrotron science, and implementing a number of initiatives within the Synchrotron to foster even greater support to industrial users.

Engagement efforts for the period were significant, and targeted toward: research opportunities and needs in biotechnology, pharmaceuticals and mining; and the two newly-formed federal innovation precincts, manufacturing and food technology.

Events ranged from local business leader breakfasts for 20 people, through to consultation sessions and workshops for over 130 people. Many were hosted in the award-winning National Centre for Synchrotron Science (NCSS). Event delegates have included private and government representatives from local and international entities.

Business development at the Synchrotron continues to foster significant and innovative projects with large multi-nationals and SMEs, the calibre of which are indicated by the ongoing work with Alcoa Australia Ltd, and Southern Innovation (see cases opposite).

Industry engagement highlights for FY13 include:

Service Crystallography

Promotion of Service Crystallography continued at local, national and international forums. Dr Santosh Panjikar, from the Macro-molecular and Micro-molecular Crystallography (MX) beamlines team, joined the Victorian Government's Super Trade Mission in March 2013 to India, successfully developing relationships with high-level officials in the sector. Applications are underway for similar trade missions into the Japanese and Chinese markets in 2014.

South East Melbourne Innovation Precinct (SEMIP) events

As a key member of SEMIP, the Synchrotron hosted three major events, each attracting over 100 delegates:

- 'Knowledge to Profit', co-hosted with CSIRO (October 2012)
- 'Industry Consultation Session', Australian Government's Manufacturing Industry Innovation Precinct (March 2013)
- 'Food in the Asian Century – increasing Australia's Opportunities and Impact', which featured Nicolas George, R&D Director, Kraft Foods (May, 2013).

The Synchrotron also helped develop the SEMIP Innovation Symposium 'Bridging the Gap Between Research and Innovation', in March 2013 (see page 26).

Albert Goller, Chairman of the Manufacturing Industry Innovation Precinct, addresses the Industry Consultation Session hosted at the National Centre for Synchrotron Science (NCSS).

Department of State Development, Business and Innovation (DSDBI)

DSDBI hosted delegations from China and the ASEAN nations at the NCSS, with a specific interest in the auto industry. In addition, the Synchrotron hosted a visit by a delegation from the Tomsk region of Russia, which is a special economic zone for technology research. The delegation was interested in exploring potential scientific collaborations, particularly in the agriculture sector as the region is one of Russia's largest wheat-producing areas.

Greater industrial user support

Industry Advisory Committee (IAC)

The Australian Synchrotron's Industry Advisory Committee (IAC) was formed in April 2013 to provide a consultative forum for a current and real-world understanding of the trends in industry needs for synchrotron techniques.

The committee is headed by Dr Erol Harvey, CEO of miniFAB™ located at the Small Technologies Cluster in Scoresby. miniFAB™ has a successful track record in commercialising biotech devices, and is part of the Monash Bionic Vision Team.

Committee members include senior representatives from Dulux Australia, the Department of Primary Industries, CleanTeQ Holdings Ltd, Capstone Partners, and the Australian Synchrotron.

Beamline Industry Group

An internal Beamline Industry Group (BIG) has been created with three new scientific liaison positions dedicated to commercial project delivery. The team will ensure an integrated response to the needs of industry, working across all nine facility beamlines. The team will report to the Head of Beamline Science, Dr David Cookson, and is expected to form the nucleus of an extended network that will include other facility scientists and external users of the Synchrotron.

Industrial case studies

Alcoa of Australia Limited

Australian Synchrotron scientists assisted researchers from Alcoa of Australia Limited with x-ray powder diffraction (PD) data for characterisation purposes. The work on the PD beamline was also an opportunity for the Alcoa team to evaluate the effectiveness and potential benefits of the technique for present and future applications. The Synchrotron's high-resolution capabilities enabled them to further their understanding of how raw materials behave during processing.

Improving the conversion of wood into biofuels

Torrefaction is a thermochemical process used to convert biomass materials such as wood into biofuels. New Zealand scientists used SAXS to investigate optimum torrefaction conditions for Pinus radiata wood chips.[45]

Southern Innovation

Southern Innovation (SI) developed and brought to market a patented pulse processing technology that enables energy resolution of neutron and x-ray events at extremely high count-rates. This technology has wide application in diverse areas such as airport baggage screening, oil exploration, mineral analysis and early cancer detection. Southern Innovation's SITORO® technology is sold under licence by XIA in their FalconX pulse processor. Synchrotron staff from the x-ray fluorescence microscopy (XFM) beamline assisted SI with a FalconX beta test program.

Shutterstock: 94337242

Truly biodegradable plastic

New Zealand researchers are turning dried bloodmeal from red meat processing into a compostable plastic that breaks down without harmful byproducts. The new plastic, called Novatein, is an alternative to petrochemical-based plastics, and will be used in products such as pots, trays, containers and clips used in the horticultural industry. The researchers will soon make use of synchrotron infra-red microspectroscopy a second time, to fine-tune their processes to develop a clear and extrudable product appropriate for thin-film plastics.[46]

Hydrogen production improvements

Melbourne researchers used XAS to characterise new catalysts that oxidise water to oxygen at record energy efficiency. This process is important for the inexpensive production of hydrogen as a fuel, by 'splitting' water. The new materials and preparation processes have been patented and licensed to a local company.[47]

45. *Stefan J. Hill et al., Biomass and Bioenergy, 56, 92-98, (2013)*

46. *James M. Bier et al., J. Appl. Polym. Sci., 130, Issue 1, 359–369 (2013)*

47. *Alex Izgorodin et al., Catalysis Today, 200, 36-40 (2013)*

'Bridging the Gap Between Research and Innnovation', SEMIP Innovation Symposium, March 2013

A central theme of this well-attended event was the need for greater access to research by industry for innovation, and the event showcased the effectiveness of geographical precincts in connecting these sectors. Keynote speakers included Professor Ian Chubb, Chief Scientist of Australia, and Kees Eijkel, CEO of Kennispark Twente in Holland, both of whom made subsequent visits to the Synchrotron.

Ms Ros Hore, CSIRO (Top Left), Keese Eijkel, Kennispark Twente (Top Right), Prof Ian Chubb (Left), Innovation Symposium panel session (Below)

Support Services

Engineering

The Australian Synchrotron's Engineering team works with the science teams to design and develop new equipment for the facility as well as carrying out maintenance, repair and upgrade work on the accelerator, beamlines and supporting infrastructure. This Year FY13, the team completed the move of laboratories and workshops into a new EIF-funded building, which includes office space for 50 staff and the laboratories required for the team's work.

Approximately half the Engineering team's efforts are devoted to the critical area of beamline and accelerator reliability. Engineering has played a key role in continuing to maintain the facility's outstanding record in delivering stable beam at a world-class level of reliability.

Highlights for FY13 include:

- Major works on the experimental station of the x-ray absorption spectroscopy beamline and upgrade of motion controls for the beamline's optics
- A major upgrade of the linear accelerator's vacuum systems
- Extensive input to the preparation of the facility's ARPANSA licence application, necessary to conduct operations under the new operational arrangements with ANSTO
- Handover from builders, to the facility, of all EIF-funded buildings at the end of their warranty period.

The Engineering Team also carried out significant work on the Imaging and Medical Beamline (IMBL), including:

- Fit-out of hutches and experimental stations in the satellite building
- Design and build of x-ray slits and tables
- Design and installation of a 90m-long evacuated pipeline to deliver the x-ray beam into the satellite building, along with support equipment and personal safety systems
- Installation and commissioning of a cryogenically cooled superconducting x-ray source in the synchrotron's storage ring to provide high intensity x-rays to the beamline
- Extensive software development, including detector integration, motion controls for mechanical devices and ongoing user-interface development.

Support Services

Scientific Computing & IT

A significant development for FY13 has been the combining of the Information Technology (IT) and Scientific Computing teams into the Scientific Computing and IT team. Dr Ulrich Felzmann, formerly the Principal Computing Scientist, is the Group Leader. The merger is expected to increase the breadth of knowledge across the group, giving the scientific computing officers greater access to IT systems and aligning the work of IT more closely with the scientific goals of the Australian Synchrotron.

The integration with ANSTO has seen a number of developments in efficiency - already the team is utilising ANSTO for mail routing, software purchasing and networking expertise. New initiatives in the pipeline will further align the IT systems of the two organisations, allowing the Australian Synchrotron to benefit from ANSTO resources .

Highlights for FY13 include:

MASSIVE upgrade

The MASSIVE high-performance computing cluster went through a substantial upgrade at the end of 2012, and supports a host of activities within the facility. MASSIVE, coupled with substantial scientific computing initiatives supported by the federally-funded National eResearch Collaboration, Tools and Resources (NeCTAR) project has led to near real time data reduction at the MX and SAXS beamlines, data visualisation tools for the PD and SXR beamlines, and remotely accessible data processing portals for the IR, SAXS and XFM beamlines.

Virtualisation environment

IT at the Synchrotron has entered the world of virtual computing with the installation of a powerful 'virtualisation environment'. This allows servers to be decoupled from aging hardware while allowing greater flexibility and control. Already more than 50 physical servers have been successfully virtualised, greatly decreasing power consumption and hardware upgrade costs.

Significant purchases

A new 10GB core switch coupled with a ½ Petabyte storage array will enable far greater data outputs from the beamlines. Data from all beamlines will be able to be centrally managed and directly processed by the MASSIVE high-performance computing cluster.

Support Services

Work Health, Safety & Environment

The Work Health, Safety and Environment team protects, promotes and monitors the work health and safety of all staff, users, contractors and visitors, enforcing strict compliance standards and process expectations across the Australian Synchrotron.

They are committed to proactively managing impacts on the environment, continuously improving environmental performance, preventing pollution, and meeting and exceeding all environmental regulatory requirements.

Highlights for FY13 include:

Work Health and Safety

Australian Standards met for WHS Management System

The Australian Synchrotron's Work Health and Safety (WHS) Management System was certified in May to the Australian Standard AS/NZS 4801:2001, Occupational Health and Safety Management Systems Standard.

Audit confirms compliance with Commonwealth WHS legislation

The Synchrotron achieved seamless transition to the Commonwealth WHS legislative framework. Audits undertaken by both ANSTO and NCS International - the Australian Synchrotron 4801 certification party – confirmed that the Synchrotron's policies and procedures comply with Commonwealth WHS legislation.

No OHS notices or directives

No notices or directives were issued pursuant to relevant sections of: the Victorian Occupational Health and Safety (OHS) Act 2004, Accident Compensation Act 1985; Dangerous Goods Act 1985 and Radiation Act 2005; or the Commonwealth WHS Act 2011.

WorkSafe funding secured

The Synchrotron secured $10,000 funding from WorkSafe Victoria for implementing various employee health and wellness initiatives.

Risks reduced

The Synchrotron successfully applied for two water fountains to replace the bottled water dispensing units. This will provide clean water without the manual handling risks associated with lifting and carrying bottled water.

Radiation Safety

ARPANSA licence issued

Based on its submissions to the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), the Synchrotron was issued an interim facility radiation licence on 20 December 2012. A full licence application will be completed in 2013.

Radiation doses significantly lower than allowed limits

To date, recorded personal radiation doses to all workers, contractors and users have all been significantly less than the Public Exposure Limit of 1 mSv per year.

Workers compensation

The 2012-13 workers compensation premium and premium rate are the Synchrotron's lowest to date, demonstrating the facility's consistent employee safety record.

	2012/13	2011/12	2010/11	2009/10	2008/09
Premium Amount	*$41,596.80*	*$45,042.88*	*$48,756.49*	*$46,671.91*	*$45,448.19*
Premium Rate	*0.3211%*	*0.3359%*	*0.3671%*	*0.3922%*	*0.3424%*

Environmental Management

Action plans lodged

The National Greenhouse & Energy Report and the Water Management Action Plans for 2011-12 were successfully lodged.

Certification underway

The Synchrotron is working towards certification of its Environmental Management System to the Australian Standard AS/NZS ISO 14001 Environmental Management Systems.

Support Services

Quality Management

The Australian Synchrotron Quality Team ensures that the Quality Management System (QMS) contains approved and detailed procedures to cover business processes across all functions. Procedures are internally audited throughout the year, and externally audited twice a year, to ensure continuous improvement of the system.

In addition to the QMS, the Quality Team manages and maintains a documentation and records management system, ensuring control of all policies, procedures and associated business records, documentation and archives. The team also maintains a program of inspection and testing when major equipment is supplied and installed, and a calibration program for critical technical equipment.

The Australian Synchrotron site has maintained certification to international quality standard ISO9001:2008 since June 2009.

Highlights for FY13 include:

QMS 100 percent conformance

Zero non-conformances were raised in the October 2012 and April 2013 ISO 9001 external surveillance audit reports of the quality QMS. This was achieved during a period of significant change in processes and documentation associated with organisational restructuring and the company name changing to Synchrotron Light Source Australia on 1 January 2013.

Continuous improvement at a high level

The Australian Synchrotron achieved a high level of continuous improvement in all areas across the organisation with 23 corrective action and 80 continuous improvement/preventive action initiatives actioned and closed this financial year.

Victorian State Government standard met

The Australian Synchrotron successfully completed its first annual review of business records to identify new and expired business records and update our retention schedule, based on the Victorian State Government standard, PROS 07/01 General Retention and Disposal Authority for Records of Common Administrative Functions.

Support Services

Human Resources

The Australian Synchrotron Human Resources (HR) team provided essential support to the organisation during a period of change resulting from the Synchrotron's transfer of operation from Australian Synchrotron Company (ASCo) to Synchrotron Light Source Australia (SLSA).

In particular, the team was instrumental in the ongoing integration with ANSTO and the delivery of the new Australian Synchrotron Enterprise Agreement (EA) 2013.

Highlights for FY13 include:

ANSTO Integration

Much planning and preparation was delivered by the HR team as part of the integration with ANSTO, and the creation of the new entity SLSA.

As at 1 January 2013, all ASCo employees were offered employment with SLSA. This transfer of employment was smooth and all ASCo employees accepted SLSA's offer. The change in employer created additional HR administrative tasks to ensure effective compliance with legislation and working conditions, but did not affect the operational effectiveness of Australian Synchrotron staff.

The integration and transfer to SLSA created an opportunity to restructure senior management positions and led directly to the establishment of the Executive Management Team (EMT). The EMT comprises a cross-representation of departments across the Australian Synchrotron and has become a well-rounded decision making body.

Australian Synchrotron Enterprise Agreement 2013

Two earlier enterprise agreements expired during June 2012, which was a challenging time for the Synchrotron due to the impending transfer of employment to SLSA. However, thanks to the efforts of a collaborative Enterprise Agreement negotiation party made up of ASCo management (subsequently SLSA management), ANSTO Industrial Relations experts, Union officials and employee representatives, the Australian Synchrotron Enterprise Agreement 2013 was drafted, voted and passed through Fair Work Australia on 19 April 2013.

As a result of the successful implementation of the EA, Synchrotron staff and management are continuing to work on a number of initiatives that focus on improving processes and procedures related to effective management of performance and development, flexible working arrangements, efficient travel, and salary banding and classifications.

Support Services

External Relations

The External Relations (ER) team carries out a number of functions, including stakeholder engagement (covering government, science and public sectors), science and industrial research outreach support, media relations and education. These functions are supported by exhibition spaces and an Interactive Learning Centre in the National Centre for Synchrotron Science.

Highlights for FY13 include:

Stakeholder engagement

Science

A wide range of activities across the facility maintained relevance to and relations with a diverse group of research and academic stakeholders. This increases awareness of synchrotron capabilities and access for existing and potential users, improved operational skills, and fostered support for the Australian Synchrotron.

Conferences

The Accelerator Reliability Workshop held in April attracted 80 delegates from accelerators worldwide, including 10 delegates from CERN. Planning for a number of other Australian Synchrotron-hosted international conferences is underway. These include the International Workshop on Infrared Microscopy and Spectroscopy (WIRMS); X-ray Microscopy (XRM) 2014; Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation (MEDSI); Accelerator and Large Experimental Physics Control Systems (ICALEPCS) and the International Beam Instrumentation Conference (IBIC).

Workshops

Workshops supported by the ER team included beamline-hosted events such as the Aus BioSAXS, SXR and MX Crystallography School workshops.

User Meetings

Forums for existing and potential synchrotron users, the New Users Symposium and the 2012 User Meeting were held in the National Centre for Synchrotron Science for the first time. Each was attended by approximately 200 delegates.

Community

Open Day

The annual Open Day provided a comprehensive display of the Australian Synchrotron's research capabilities and contributions to the everyday lives of Australians.

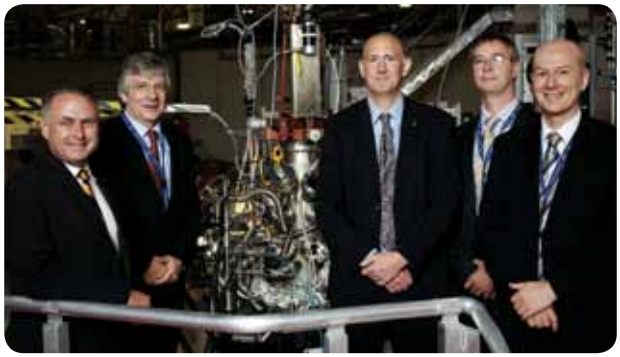
The day's program included a self-guided tour of the synchrotron, control room and beamlines, specialist tours, speaker series, entertainment, laboratory sessions and kids activities. The event attracted around 3000 visitors.

Outreach support

Other ER functions include outreach support for events, tours and media.

Approximately 40 events were supported by the ER team this year. Tours were conducted for over 1700 people, including almost 400 tours for senior government, science and industrial representatives including the Minister for Science and Research, the Honourable Don Farrell; the Chief Scientist of Australia, Professor Ian Chubb, and the Chief Executive of CSIRO, Dr Megan Clark.

A successful media reach was achieved with 170 new online and in-print mentions of the Synchrotron, including 10 in each of The Australian and The Canberra Times. The Conversation and The Age each included four articles. Over 84 percent of mentions were rated with a sentiment of 'extremely positive'.



(L - R) Minister for Science and Research, The Honorable Senator Don Farrell, Dr Adi Paterson (ANSTO), Prof Andrew Peele, Prof Mike James, Assoc Prof David Cookson

(L – R) Dr Andrew Stevenson, Dr Sherry Mayo (CSIRO), Dr Megan Clark (CSIRO), Prof Andrew Peele, Mr Gareth Moorhead (Melbourne Centre for Nanofabrication)

Education

The Australian Synchrotron is working to engage students at senior and junior, advanced and lay levels. The aim is to provide them with access to a world-class scientific facility and exposure to the potential of synchrotron science to advance scientific research, provide valuable learning experiences and offer good career prospects.

The new Interactive Learning Centre hosted a full year of synchrotron science-specific laboratory sessions. Demand for tailored tours and beamline-based learning workshops, has continued to grow.

This arm of the ER team has maintained a strong connection with syllabus-driven physics institutions, both local and international, and endeavoured to extend capabilities in teaching for greater reach of the physical sciences throughout Australia's state-based education systems.

Secondary

Lab Sessions

The engaging hands-on lab sessions developed and delivered by education and physics professional Jonathan de Booy pushed the boundaries of what is available to most students studying the VCE physics units of Light and Matter and Synchrotron and its Applications. The sessions use sophisticated equipment to simulate accelerator and beamline techniques used at the Australian Synchrotron.

A record number of schools and students attended the secondary laboratory sessions in FY13, with almost 75 schools and over 1000 students.

There has been increasing interest from regional Victorian schools for lab sessions, and the new User Guesthouse has helped make it possible for them to attend. For example, the Synchrotron hosted a group of 45 Victorian Endowment for Science Knowledge and Innovation (veski) students from schools in regional Victoria identified as having low science engagement.

Tours

Tours of the facility are offered to secondary students and tailored to each group. The aim is to create strong links between the classroom curriculum and the cutting-edge science and research undertaken at the Australian Synchrotron.

Teacher Outreach

The Synchrotron aims to empower Australian science teachers by offering sessions at the Science Teachers Association of Victoria and VCE Physics Teachers conferences. Highly positive feedback has been received from attendees at both conferences.

Tertiary

Tours and workshops are offered to tertiary students and tailored to their specific needs. In many cases, advanced programs are hosted by science or engineering team members.

Primary

This year the Australian Synchrotron worked with G.A.T.E.WAYS (Gifted and Talented Education, Extension and Enrichment) to develop a two-day program suitable for gifted and talented primary school age students from schools across Melbourne. The students were specifically selected by their schools for their interest and competence in science and mathematics.

Governance

Australian Synchrotron

'Australian Synchrotron' is the trading name of Synchrotron Light Source Australia Pty Ltd (SLSA), which assumed operations of the facility on 1 January 2013 from the previous operator Australian Synchrotron Company (ASCo).

ASCo was formally wound up as a company on 12 April 2013.

SLSA is a wholly-owned subsidiary of the Australian Nuclear Science and Technology Organisation (ANSTO), and is the operating entity for the Synchrotron.

The ownership entity for the facility is Australian Synchrotron Holding Company Pty Ltd (ASHCo), which owns the relevant assets.

SLSA Board of Directors

The members of the Board of Directors for SLSA as at 30 June 2013 are listed below.

Further details of the Directors and activities of SLSA are contained in the Australian Synchrotron Financial Reports, 30 June 2013.

Further details of each of the SLSA Board members, can be found at: http://bit.ly/SLSABoard

SLSA Board of Directors membership

Dr Greg Storr (Chair)
Group Executive, ANSTO

Mr Peter Arambatzis
Chief Financial Officer, ANSTO

Ms Nadia Levin
General Manager, Government, International and External Relations, ANSTO

Professor Liz Sonenberg
Pro Vice-Chancellor (Research Collaboration)
The University of Melbourne

Professor Jill Trewhella
Deputy Vice-Chancellor (Research)
The University of Sydney

Committees

Several bodies continue to support the development and effective operation of the Australian Synchrotron:

- Animal Ethics Committee
- Funders' Committee
- Industry Advisory Committee (IAC)
- International Program Advisory Committees (IPAC)
- Machine Advisory Group (MAG)
- National Science Colloquium (NSC)
- Program Advisory Committees (PAC)
- Scientific Advisory Committee (SAC)
- User Advisory Committee (UAC)

Funding Framework

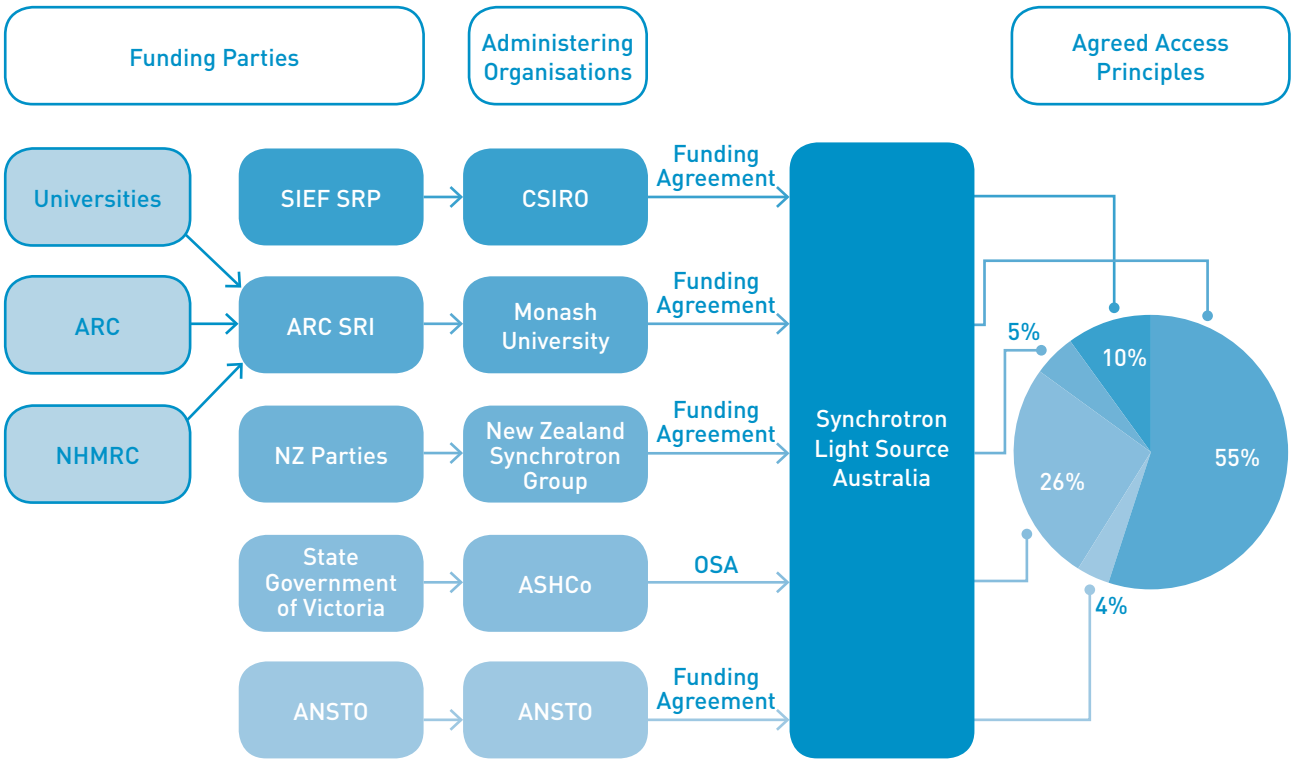
In March 2012, Commonwealth and Victorian Government parties signed a Memorandum of Understanding (MoU) that provided a framework to deliver $100 million to support operating and research costs at the Australian Synchrotron for the four years to 30 June 2016. As part of this, Australian Nuclear Science and Technology Organisation (ANSTO) were appointed the operator of the Synchrotron for the remaining three and a half years of the four-year funding period. The contributing parties and funding schemes to the operating funding through the respective administering organisations listed below are:

- Australian Research Council Strategic Research Initiative (ARC SRI), National Health and Medical Research Council (NHMRC), and Australian universities, $55M
- State Government of Victoria (managed through the Department State Development, Business and Innovation), $26M
- Science and Industry Endowment Fund Special Research Program (SIEF SRP), $10M
- A New Zealand consortium of the federal government, universities and research institutes, $5M
- ANSTO, $4M

The funding parties are granted synchrotron beamtime in proportion to their funding contributions (outlined below), according to a new access model that replaces the previous system which gave beamtime entitlements to the Foundation Investors (refer page 36).

On 1 January 2013, ANSTO assumed operational control of the Synchrotron, through its wholly-owned subsidiary Synchrotron Light Source Australia Pty Ltd (SLSA). SLSA was incorporated on 14 August. It is the management entity and has the exclusive right to operate, manage and develop the Australian Synchrotron assets under an Operations Services Agreement (OSA) with ASHCo. It has been established as a proprietary limited not-for-profit company under the Corporations Act 2001 and is limited by shares. SLSA is also regulated under the Commonwealth Authorities and Companies Act 1997. The company is income tax exempt.

ASHCo owns all the Australian Synchrotron assets, and the OSA, in effect since the 26 October 2012, outlines the terms under which SLSA operates the Synchrotron.



Foundation Support

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.

The Foundation Investors have preferred beamtime access rights until 31 August 2013, and between them and the State Government of Victoria, own all shares in Australian Synchrotron Holding Company (ASHCo).

Supported by

Australian Government

State Government Victoria AUSTRALIA

Foundation Investors

AAMRI

Australian Government ansto Nuclear-based science benefiting all Australians

CSIRO

MONASH University

New Zealand Synchrotron Group Limited

New Zealand Government (Funding Partner)

THE UNIVERSITY OF AUCKLAND NEW ZEALAND

Massey University

THE UNIVERSITY OF WAIKATO

Victoria

Lincoln University

UC UNIVERSITY OF CANTERBURY

University of Otago

Plant & Food RESEARCH RANGAHAU AHUMĀRA KAI

agresearch

GNS SCIENCE TE PŪ AO

INDUSTRIAL RESEARCH IRL

AUSyn14 Consortium

NSW Government

Queensland Consortium

South Australia/La Trobe University Consortium

Western Australian Consortium

Financial Statements

The Australian Synchrotron continued to deliver strong scientific achievements to foundation investors, operational funders and the wider scientific and commercial communities during the 2012-2013 financial year.

Synchrotron Light Source Australia Pty Ltd (SLSA) took over the operations of the Synchrotron facility from Australian Synchrotron Company Ltd (ASCo) on 1 January 2013 under the new operational funding arrangements. This funding covers four years of operations from 1 July 2012 to 30 June 2016.

Synchrotron Light Source Australia (1 January 2013 to 30 June 2013)

The surplus for the half-year was $879,614. This result is on total revenue of $14,187,496 and total expenditure of $13,307,882, which includes $1,207,734 of assets transferred to Australian Synchrotron Holding Company Pty Ltd (ASHCo) for zero consideration.

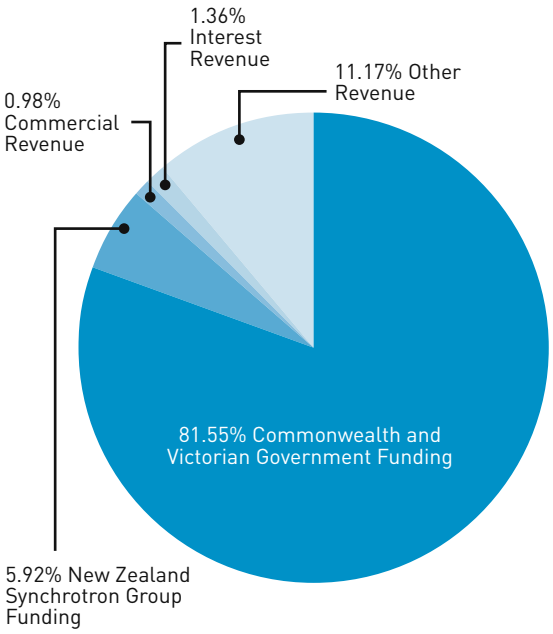
The main source of revenue was from the funders (page 35), comprising $12,409,855. In addition, $13,163,960 of revenue was received in advance and allocated into the Statement of Financial Position as a Contribution in Advance. Other revenue of $1,584,600 mainly consists of grant funding towards International Synchrotron User Access, NeCTAR grant funding, guest house revenue, conference and workshop registrations.

Operating expenditure during this period (January 2013 – June 2013), was made up of $7,529,135 for salaries and employee benefits and $97,678 for preventative measures for Work Health, Safety and Environment expenditure. $3,771,759 was spent on operating and maintaining the facility at a world-class standard, including $2,564,025 for utilities, building and technical expenditure, and $1,207,734 on essential operating upgrades and spare parts.

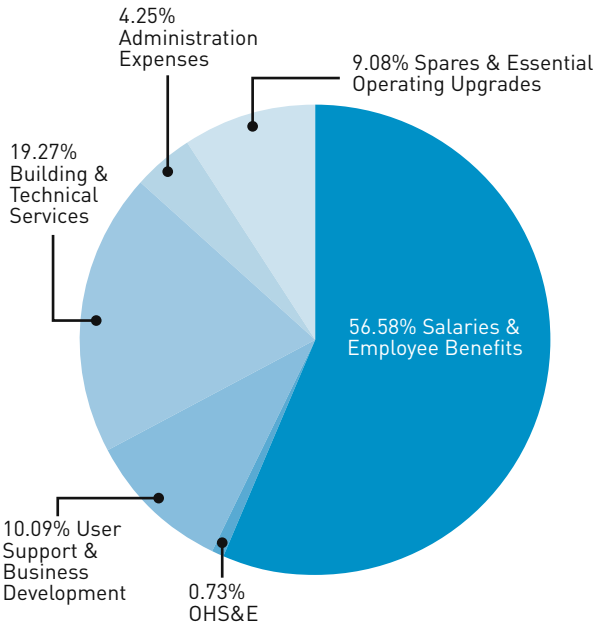
An additional $1,343,393 was committed to support local and international user access, scientific development, external relations activity and business development.

Administrative costs of the facility were $565,917 including information technology, general administration and staff travel.

Further financial information is available in the 2013 Annual Financial Statements for SLSA.



Income



Expenditure

Annual combined financial results (SLSA and ASCo) for 1 July 2012 to 30 June 2013

The surplus for the year was $1,931,905.

This result is on total revenue of $27,620,818 and total expenditure of $25,688,913, which includes $1,488,794 of assets transferred to ASHCo for zero consideration.

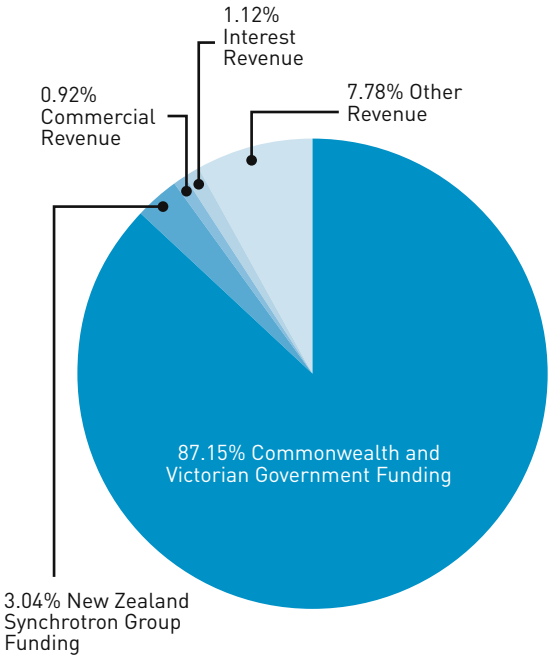
The main source of revenue was from funders (page 35), comprising $24,909,853. Other revenue totalled $2,148,067, and commercial revenue was $253,664.

Operating expenditure during the year was made up of $15,475,632 for salaries and employee benefits and $205,867 for preventative measures for Work Health, Safety and Environment.

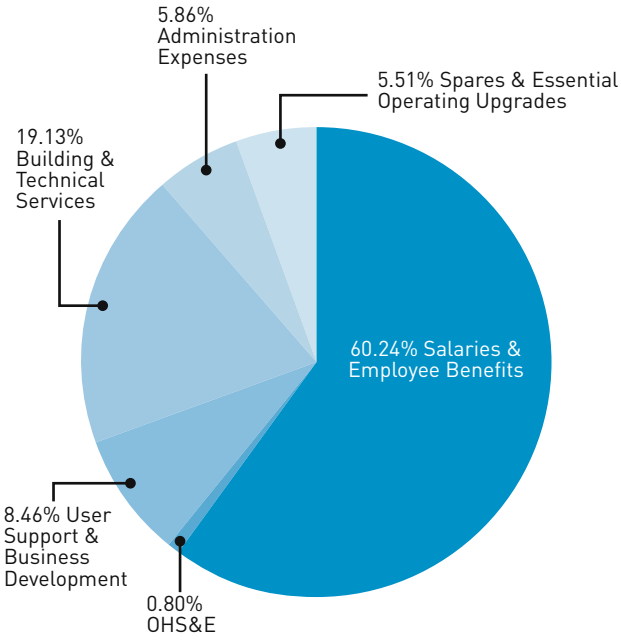
$6,329,615 was spent on operating and maintaining the facility at a world-class standard, including $4,840,821 for utilities, building and technical expenditure, and $1,488,794 on essential operating upgrades and spare parts.

An additional $2,172,596 was committed to support local and international user access, scientific development, external relations activity and business development.

Administrative costs of the facility were $1,505,204 including staff travel, information technology, and general administration and board costs.



Income



Expenditure

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