Australian Synchrotron
Turning bright ideas into brilliant outcomes

2016 ANNUAL REPORT

VICTORIA State Government
Australian Government
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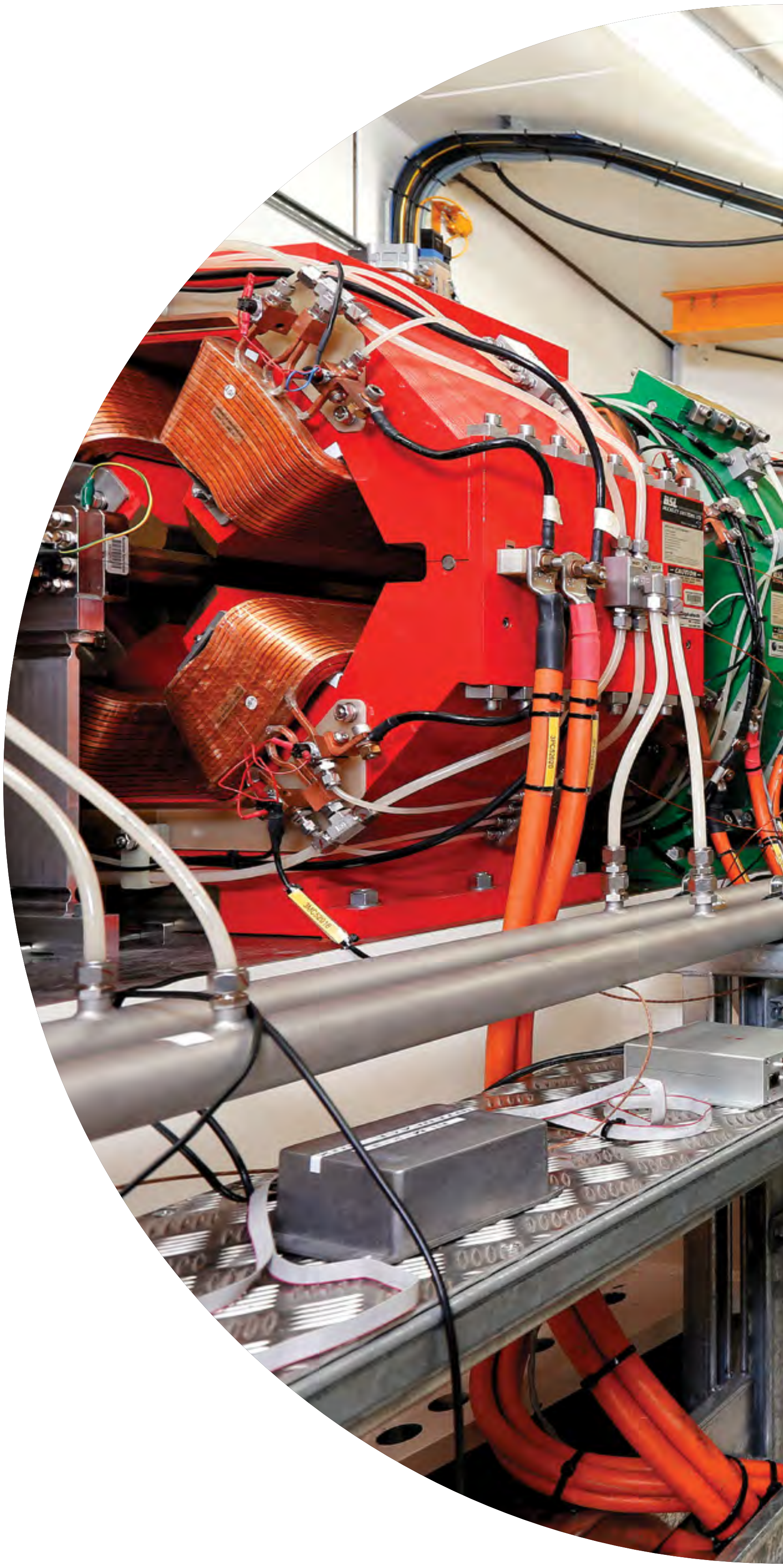


Madeline Chalmers at the intersection of the Australian Synchrotron's booster and storage rings.

CONTENTS

CHAIR'S REPORT

The 2015-16 financial year was a year like no other at the Australian Synchrotron. It was a year when the Australian Government, through the National Innovation and Science Agenda, demonstrated an unprecedented commitment to science and technology-led prosperity.

With the December announcement of a 10-year, $520 million funding package from July 2016, the Australian Synchrotron's future will be guaranteed as it takes its place as a truly national asset, a federally-owned facility within ANSTO's portfolio of landmark research infrastructure. As a scientist and Chair of an organisation that continually delivers undeniable benefits for the people of Australia, New Zealand, and the world over, I am keener to demonstrate causality, as opposed to indulging the notion that the Australian Synchrotron 'got lucky'.

It is clear that the year's positive outcomes were the result of more than ten years of hard work, commitment and achievement by current and past team members at the Australian Synchrotron and ANSTO. They were a result of the strong relationships we have with our partners in the research community as well as state and Australian governments.

For a decade, the Australian Synchrotron has been a nexus of some of the world's most talented people and world-class research infrastructure. In a time when we are often awed by hi-tech in its own right, it is worth emphasising that it has been *our people* who have sustained the vision, expertise, resilience and creativity to design, build and continuously improve one of the world's best and most research-productive synchrotron facilities.

Ten years after "First Light" (see pg 10), the Australian Synchrotron's team, and the thousands of researchers they empower, have been instrumental in, among other achievements, the development of new life-saving drugs, discovery and development of advanced manufacturing techniques and materials, and the publication of thousands of high-impact papers. This is unambiguous evidence that the Australian Synchrotron is a vital link in a chain connected directly to increased knowledge, prosperity and wellbeing for Australia and beyond.

The opportunities for the Australian Synchrotron as it joins ANSTO are many, reciprocal, and have wider significance. This union is a *win-win-win* outcome for science, for new colleagues and researcher clients, and for Australia. I am confident that the Australian Synchrotron's value – its people, its special reputation and goodwill, as well as its physical infrastructure – will grow within and for a greater ANSTO.

The Synchrotron Light Source Australia Board will disband in the second half of 2016, as the Australian Synchrotron's integration into ANSTO is formalised. It has been an honour to serve such a high-achieving organisation. I wish the team and the facility future success as a light that shines brightly into the future for innovation and science in Australia.

Dr Greg Storr
Chair, Board of Directors
Synchrotron Light Source Australia Pty Ltd

ANSTO OPERATIONS REPORT

The Australian Government's decision to support the transfer of ownership to ANSTO and the associated commitment of operational funding for 10 years heralds a new era for innovation and science in Australia and our region.

The December announcement was the culmination of collaborative work guided by ANSTO among many diverse interested parties to achieve this shared and most significant outcome for the benefit of science and innovation in Australia and our region.

The Australian Government's decision in December 2015 was a vote of confidence in the important role the Australian Synchrotron plays in meeting Australia's research priorities, and its potential to do much more. It also confirmed the Synchrotron's position as one of Australia's landmark and national research facilities: multi-disciplinary, multi-user and multi-decadal platforms that serve both research and industry and are essential for ensuring our country's competitive advantage and position in the international community.

The awarding of operational funding was contingent on Commonwealth ownership of the Synchrotron. ANSTO subsequently worked with the Department of Industry, Innovation and Science and other stakeholders in Canberra, the Victorian Government and other ASHCo shareholders; the Science Advisory Committee; the Funding Committee and the research community to effect that ownership transition. In March 2016, then-Minister for Industry, Innovation and Science Christopher Pyne announced that the Australian Government had agreed to ANSTO taking ownership of the Synchrotron.

I would like to thank all those stakeholders who believed in a brighter future for the Australian Synchrotron and who were instrumental in bringing that future forward. Also, the many people who worked behind the scenes at ANSTO, at the Synchrotron, in Canberra and in Melbourne to make this all happen. Importantly, I would like to take this opportunity to thank and acknowledge the ASHCo and the Synchrotron Light Source Australia Boards for their guidance and support and helping to secure a more certain future for the Australian Synchrotron.

We will collectively look back on this achievement and know that it was thanks to the shared vision, belief and determination of many people working together, that ensured that the Australian Synchrotron had predictable operations and could plan strategically for the future. .

The unprecedented operational funding certainty the Australian Synchrotron has now secured means it is now better placed than it has ever been before to secure the partnerships and funding to realise the $100 million capital funding required for its greater utilisation – the Bright beamline investment program – and commit to longer-term research priorities with benefits for all.

Dr Adi Paterson
Chief Executive Officer
ANSTO


NATIONAL
CENTRE FOR
SYNCHROTRON
SCIENCE

DIRECTOR'S REPORT

In 2015-16, thanks to the Australian Government's National Innovation and Science Agenda (NISA), the Australian Synchrotron secured $520 million in operational funding – ending a four-year period of interim funding arrangements.

This new funding settlement, secured through the demonstration of clear benefit for the community, has delivered unprecedented long-term financial certainty, enabling the Synchrotron team to focus more fully on empowering science for the benefit of the community, economy, and environment. It is a testament to the quality and commitment of the Australian Synchrotron's people that, even amid uncertainty about the facility's future, research outcomes and systems quality remained world-class.

This was a year of exciting progress and partnership, working towards completion of the Australian Synchrotron's transition from multiple shareholder and majority Victorian Government ownership to a nationally-held asset as an essential part of ANSTO – a milestone achieved just outside the 2015-16 financial year in July 2016.

Research and capability was boosted with the announcement of a $2 million Australian Cancer Research Foundation grant. This was supplemented by significant contributions from the Australian and New Zealand biomolecular research community. Together, this funding enabled the purchase of a state-of-the-art X-ray detector to enhance researchers' ability to solve protein structures; work which has become essential for the development of life-saving drugs and the treatment of cancer.

The Australian Synchrotron consolidated its position as one of Australia's premier national research facilities, experiencing another year of strong demand with more than 5,700 researcher visits involving more than 900 experiments spanning advanced manufacturing, agribusiness and food, biotech and health, energy, environment, resources, and transport and defence.

Our team delivered a range of new or world-first experimental capabilities, including the ability to rapidly measure metal compositions in biological tissue and cellular samples with micron-precision and an innovative method for measuring solution-based protein samples with unprecedented speed. Productivity and research-user experience was further enhanced by the team's development of new automated sample delivery systems.

Of course, great research facilities aren't delivered without quality systems and reliable availability. The Synchrotron's decade-long, year-on-year improvement or consolidation of beam stability, quality and uptime performance has been an annual feature of this report. This year is no exception.

The Australian Synchrotron is very much in the business of empowering the provision of community benefits and driving innovation and employment, economic and community benefits that our work makes possible. Just two examples from the Research highlights section of this report include: mapping of micronutrients, which will have a very real impact on tackling malnutrition for millions of people; and the development of 'stainless magnesium' that is ideal for lighter, more fuel-efficient vehicles.

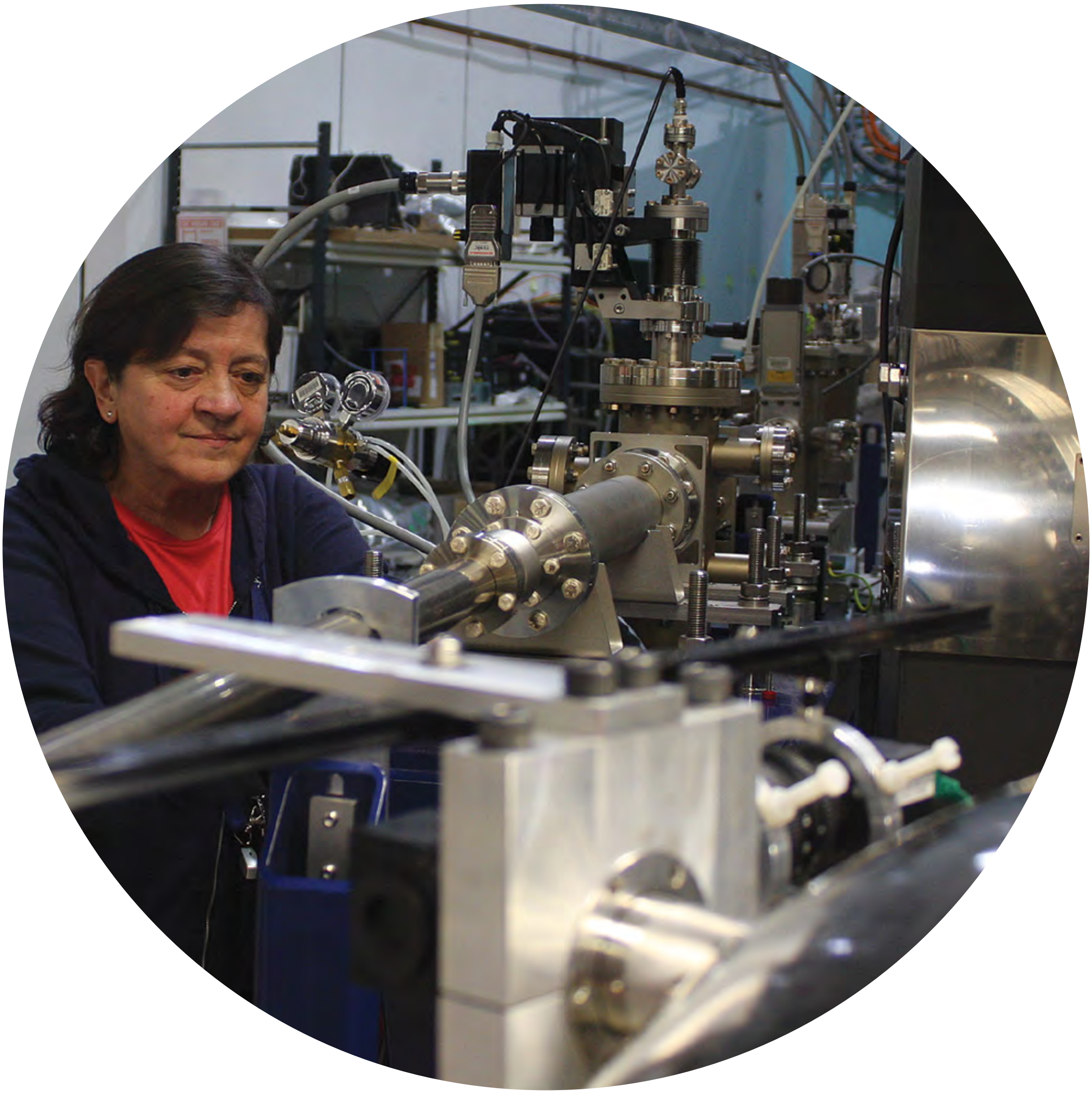
While focusing on such tangible and practical outcomes, the Australian Synchrotron continued to provide the world's research community with high-quality research. Published papers since opening in 2007 have exceeded 2,500 including more than 470 this year.

The Australian Synchrotron is just as much about people and community as it is about heavy-hitting research infrastructure. In 2015-16 the facility emphasised society-wide stakeholder engagement. More than 1,500 visitors attended the 2015 Open Day returning overwhelmingly positive feedback. The International Beam Instrumentation Conference and the International Conference in Accelerator and Large Experimental Physics Control Systems Conference met and networked at the Synchrotron. Dr Leonie Walsh, then Lead Scientist for Victoria, opened the ninth annual Asia Oceania Forum for Synchrotron Radiation Research and the 2015 Australian Synchrotron User Meeting. Dr Adi Paterson, ANSTO CEO, joined Australian Synchrotron employees in March to welcome then Minister for Industry, Innovation and Science, the Hon Christopher Pyne MP and his announcement of Australian Government support for the transfer of the Australian Synchrotron to ANSTO.

On behalf of the best team that I have had the privilege to work with, I commend this report to you and thank you for your continued support.

Professor Andrew Peele
Director
Australian Synchrotron

AUSTRALIAN SYNCHROTRON: NATIONAL LANDMARK INFRASTRUCTURE



The Australian Synchrotron is a world-class research facility that empowers researchers and industry from across Australia and New Zealand to problem-solve and innovate, by revealing how matter fits together, moves, interacts and changes – on scales ranging from the atomic to the macroscopic – in ways that outshine what can be achieved in a conventional laboratory.

Discovery begins with powerful light, a million times brighter than the sun. The Australian Synchrotron uses accelerator technology to produce a beam of high energy electrons that circulate around a 216-metre ring at nearly the speed of light, creating synchrotron light ranging from X-rays to infrared radiation that is channelled down linear beamlines to individual experiments.

At the experiment end-stations, expert scientists manipulate, refocus and adapt the light to enable a range of cutting-edge research applications, producing vast volumes of data for analysis, which reveal new understanding of the fundamental structure, composition and behaviour of materials with an unprecedented level of detail and accuracy.

The landmark research infrastructure, which is now operated by ANSTO, has more than 5,500 registered users. In 2015-16, researchers visited on more than 5,700 occasions; in June 2016, the Australian Synchrotron had recorded more than 33,000 visits since opening in 2007. The facility welcomes and supports researchers from research institutions, universities and industry across the country, the region and around the globe.

The Australian Synchrotron supports a broad range of high-quality research with applications in sectors including medicine, agriculture, environment, defence, transport, advanced manufacturing and mining. Our highly-advanced techniques and passionate staff contribute to scientific advances and industrial innovations that deliver real-life societal and economic benefits for all Australians and, through an ongoing partnership, New Zealanders.

Over page: Vesna Samardzic-Boban at the SXR beamline.

VISION

Revealing unprecedented detail, we empower researchers and clients to think outside the box, attack problems and seize opportunities to deliver world-leading scientific breakthroughs that improve the way we live.

MISSION

We provide world-class synchrotron tools and expertise. Through strong relationships, we share our knowledge to advance science and innovation, delivering benefits to Australia, New Zealand and the world.

OUR RESEARCH CAPABILITIES

The Australian Synchrotron's sophisticated scientific techniques provide benefits for diverse research and industrial fields and purposes, aligning with the Australian Government's Science and Research Priorities, including:

Advanced manufacturing: investigating the structure and characterisation of alloys, catalysts, fibres, textiles, adhesives, polymers, plastics, surfaces, interfaces and coatings; and analysing stresses in engineered components.

Energy: providing insight into geological material microstructures and novel catalysts to improve the extraction and conversion of energy and novel material characterisation to safely improve energy storage and transportation.

Environmental change: analysing environmental conditions; analysing toxic and heavy metals in existing waste and supporting environmental remediation work; characterising and analysing environmentally-friendly, recycled products.

Food: analysing the composition of ingredients, assessing the effectiveness of food processing, determining the nutritional impact of foods, monitoring and optimising the effects of selective breeding and solid state analysis.

Health: analysing proteins, nucleic acids, bacteria and viruses that are fundamental to healthy biological function or disease; quality control monitoring, identification and assessment of the effectiveness of drug targets; developing detector technologies, measurement techniques, medical implants and delivery systems.

Resources: supporting the development of exploration and processing, fuel processes, and fuel cell innovations.

Soil and water: monitoring soil for the presence and chemical state of pollutants; understanding chemistry of metals and heavier elements in soils, sediments, water and wetlands to control contaminant mobility and manage toxicity and bioavailability.

Transport: enabling study of the atomic structure of materials, sensors and specialty alloys, characterising novel materials used for safe storage and transportation of energy and additive manufacturing.

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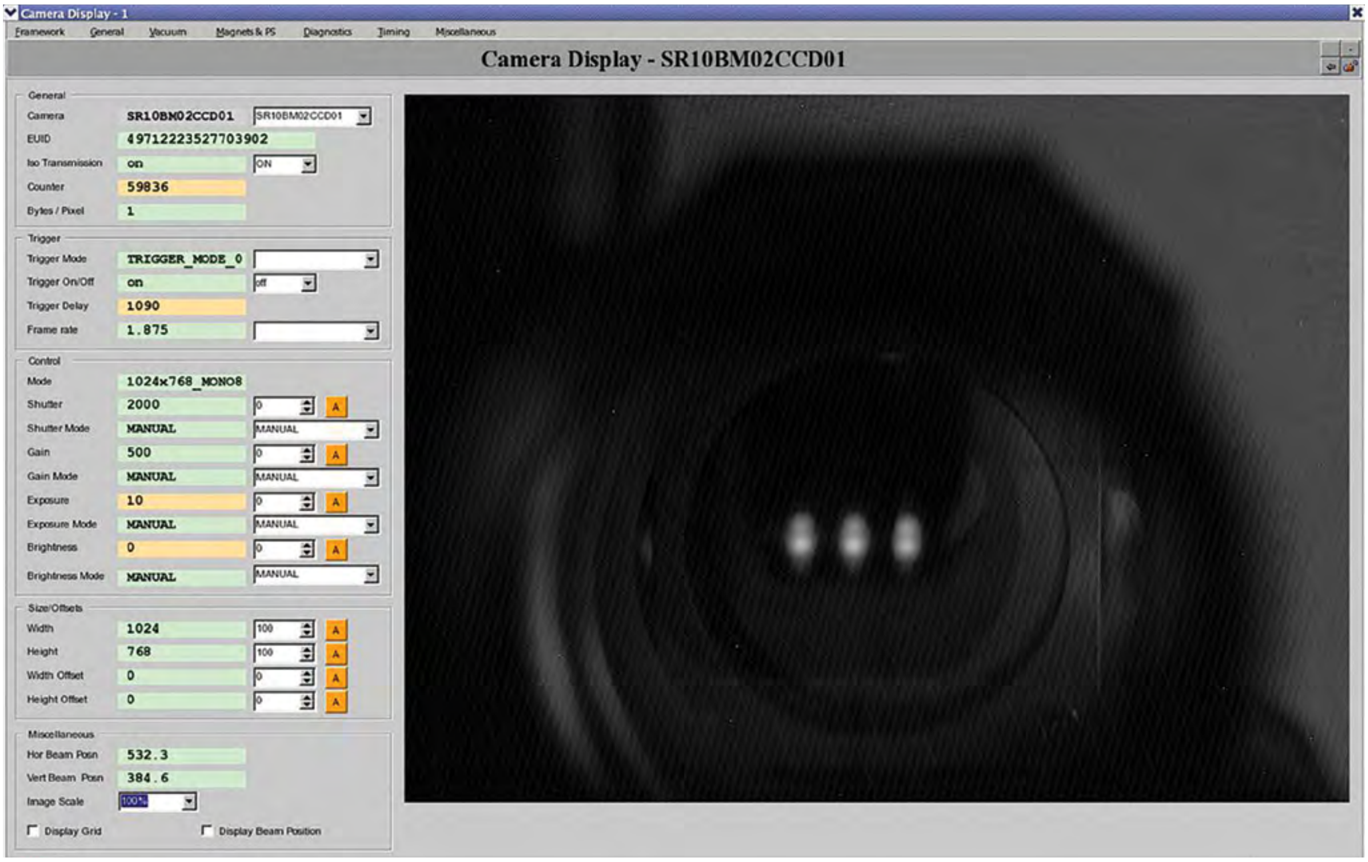


'First Light' was the exciting moment when a beam of electrons, accelerated to nearly the speed of light, was first sustained in the Australian Synchrotron's storage ring. It heralded the beginning of the facility's first decade of discovery and was one of the most important milestones on the road to delivering a fully-operational, world-class synchrotron.

At 3.15am on the morning of Friday 14 July 2006, a small group from the wider Australian Synchrotron team – *First-Lighters* – reached this milestone together (pictured above). Ten years later, present and former Australian Synchrotron staff and stakeholders came together to celebrate and to look forward to the next ten years of opportunity and innovation.

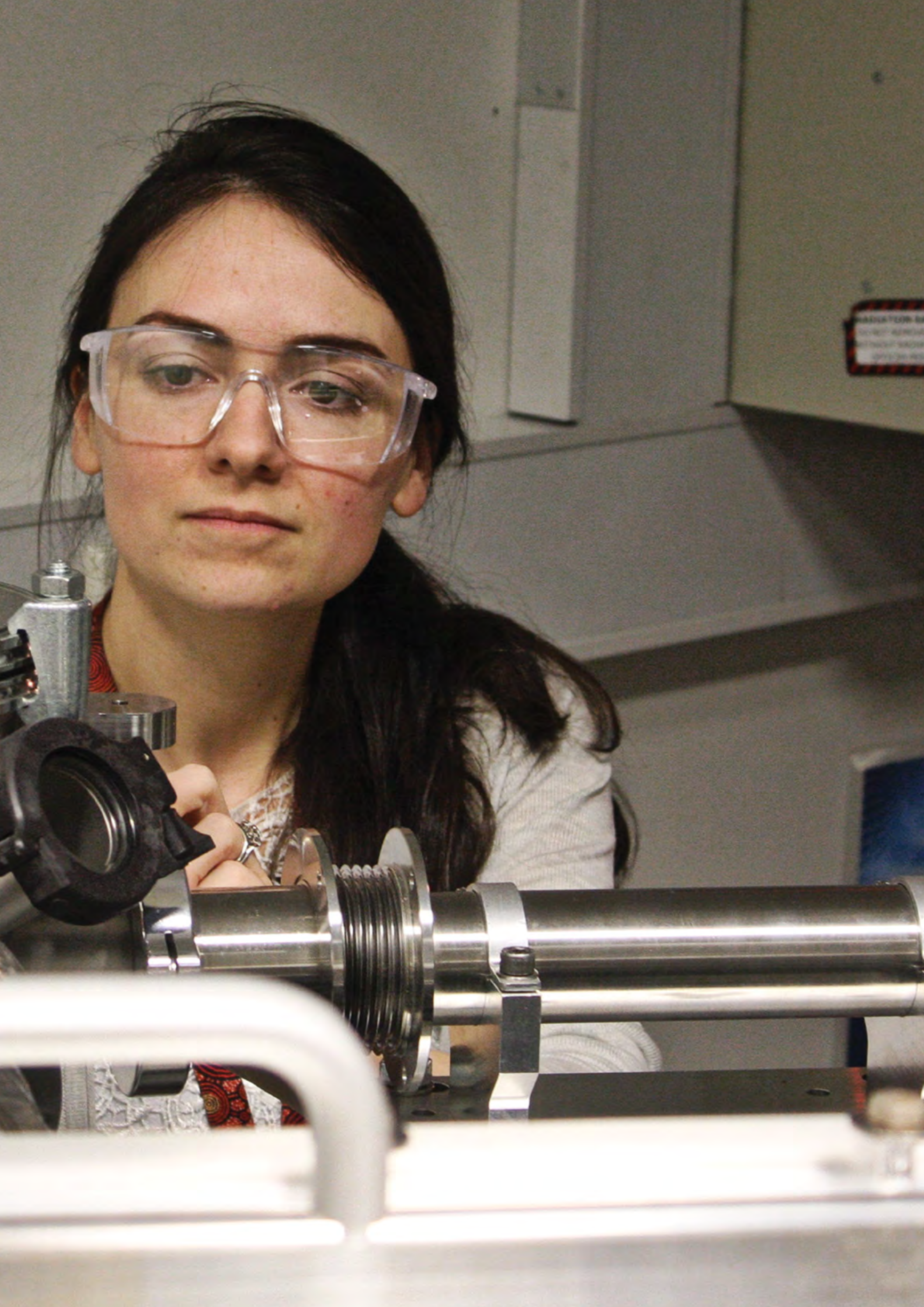
A stakeholder event hosted by Australian Synchrotron Director, Professor Andrew Peele, and ANSTO CEO, Dr Adi Paterson was attended by more than 100 guests from across Australia and overseas. Dignitaries included members of the original Victorian Government project team and current Members of Parliament.

Special guest, former Treasurer and Premier of Victoria the Hon. John Brumby, recounted 'cabinet meeting after cabinet meeting' when he, and then-Premier Steve Bracks, decided to fund Australia's synchrotron in Victoria. It was a visionary decision that marked the end of the era of 'suitcase scientists'; a time when researchers had no choice but to travel internationally – esoteric samples in their hand luggage – to access synchrotron facilities. In the years since, less travel-weary researchers have conducted more than 24,000 experiments at the world-class Australian Synchrotron.

At an earlier Australian Synchrotron staff event, Professor Peele congratulated the team of First-Lighters, led by long-term Head of Accelerator Science and Operations, Greg LeBlanc. Professor Peele underlined some of the life and game-changing outcomes achieved during the Synchrotron's first decade, before being joined in a panel discussion by soon-to-be ANSTO colleagues, exploring exciting opportunities in the coming decade as the Australian Synchrotron becomes part of ANSTO'S portfolio of landmark research infrastructure.

Although visually uneventful to the untrained eye, this image shows the first light coming from the x-ray diagnostic beamline at the Australian Synchrotron, comprising three images of the electron beam collected by passing electrons through a pinhole array, on Friday 14 July 2006.

RESEARCH HIGHLIGHTS



REMOVING BARRIERS TO PRODUCE DURABLE, RAPIDLY-PRINTABLE ELECTRONICS

Modern technology is based around semiconductor devices – including integrated circuits in computers and photovoltaic cells in solar panels – which are typically made from brittle, inorganic semiconductors, such as silicon, that are expensive and time-consuming to process.

Researchers from Monash University and the Center for Nano Science and Technology in Milan, Italy, have used the Australian Synchrotron to produce the most effective and highest frequency printable polymer transistor in the world, potentially paving the way for the rapid mass-production of cheaper and more versatile green energy sources and electronics.

After working at the Australian Synchrotron's Soft X-ray Spectroscopy (SXR) and Small and Wide Angle X-ray Scattering (SAXS/WAXS) beamlines, in September researchers defined the optimal molecular structure of the polymer in Nature Communications. The findings enabled Italian research partners to rapidly print a transistor that is not only much larger than any predecessor, but is capable of a commercially-competitive frequency of 3.3 megahertz.

Associate Professor Chris McNeill from the Department of Materials Science and Engineering at Monash University said that while many research teams have attempted to realise industry-ready printed polymer electronics, they had not matched high-throughput printing with high performance.

We discovered that molecules in the polymer must be precisely aligned, leading to a new "bar-coating" approach, an improved approach to "roll-out"printing, in which the polymer solution is spread into a thin film, much like a mound of dough is rolled flat by a rolling pin.

The trick to achieving high performance was tightly wrapping a wire around the "rolling pin" bar, creating a coat of microscopic grooves 50 microns wide – one twentieth of a millimetre – which forces the molecules of the polymer into an organised pattern during printing, for much greater electron mobility.'

Associate Professor McNeill said printable, durable semiconductor sheets could make possible inexpensive home windows doubling as solar panels and TV screens.

The ability to mould and shape solar panels to any surface, including skyscrapers and stadiums, is a very attractive prospect as Australia works towards a sustainable energy mix that maintains output and reliability while lowering carbon emissions.

Drs Anton Tadich and Bruce Cowie; SXR beamline.

Previous page: Dr Danielle Martin at the THz/Far-IR beamline.

TAMING TRANSPORTER PROTEINS TO GROW HARDIER CROPS

In very small quantities, boron is essential for crop growth and development. While the precise role of boron in plants is not fully known, evidence suggests boron is important for cell division, the production of nucleic acids such as DNA, the movement of sugars across membranes and the development of reproductive structures such as pollen tubes, fruit and grain. However soils with high concentrations of boron affects crop yields in Australia and around the world, and results in significant revenue losses.

In *Plant Cell* in January, researchers from The University of Adelaide revealed how plants protect themselves from minerals such as boric acid, leading to a better understanding of how to protect vulnerable vegetation to secure higher yields of edible crops and improve their nutritional properties.

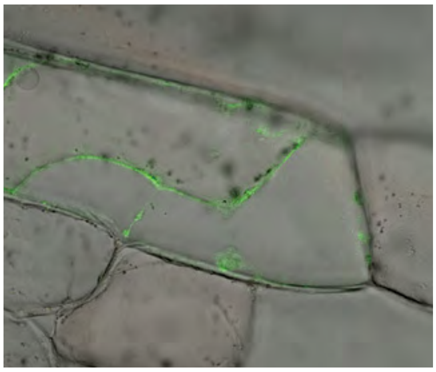
The research team, led by Professor Maria Hrmova from the University's School of Agriculture, Food and Wine and the Australian Centre for Plant Functional Genomics, used the Australian Synchrotron's Small and Wide Angle X-ray Scattering (SAXS/WAXS) beamline to investigate the plant anion efflux transport protein, responsible for directing the flow of borate anions (a form of boric acid), to understand how they are exported from plant cells.

Professor Hrmova said, until now, only a handful of the 'transporter' proteins that make this happen have been characterised, and researchers don't know how the majority of these proteins function.

We discovered the function of the transporter protein behind boric acid toxicity tolerance relies on the presence of sodium – which is ever-present in soils – and the kick-starting of the process to expunge boric acid from a plant is related to the presence of hydrated sodium in a particular location of the transporter.

In the right circumstances, this creates an energy barrier that permits an efficient exclusion of boric acid from plant cells back to soil – it is these circumstances we will now work to emulate in other cereal varieties and plants species.

Professor Hrmova said now researchers know how to influence the transport of boric acid in plants, they can start developing crops that have improved nutritional properties and higher yields in a variety of sub-optimal soil conditions.



Top: Boric acid toxicity symptoms in a leaf of boric acid-intolerant barley (image courtesy of Dr Mahmood Hassan, CSIRO); middle: Confocal image of a chimeric transporter protein expressed in onion cells; bottom: Three-dimensional representation of a predicted structure of a transporter protein (middle and bottom images courtesy of Professor Maria Hrmova).

TESTING NON-INVASIVE BRAIN ELECTRODES TO HELP OVERCOME PARALYSIS

Limb failure occurs in a variety of conditions, including stroke and spinal cord injury, causing paralysis in over 60,000 Australians each year. Fortunately, in the majority of cases, the region of the brain responsible for movement remains intact. This means an electronic brain-machine interface has the potential to restore lost motor function by enabling thought control of prosthetic limbs, computers, wheelchairs or exoskeletons.

A stentrode is a small, malleable electrode that is relatively non-invasive and can be navigated into blood vessels in the brain, from where electrical impulses from thoughts can control external mobility aids. Development of this device is the result of close collaboration between The University of Melbourne, the Royal Melbourne Hospital and the Florey Institute of Neuroscience and Mental Health.

Researchers at The University of Melbourne used the Australian Synchrotron's Imaging and Medical Beamline (IMBL) for critical assessment, publishing new findings in Nature Biotechnology in February.

The research team, led by Dr Nicholas Opie, Dr Thomas Oxley and Professor Terry O'Brien, used IMBL to investigate the essential process of endothelialisation, in which the stentrode is overgrown by host cells, ensuring it is not rejected by the immune system.

Dr Oxley, Department of Medicine (Royal Melbourne Hospital) at The University of Melbourne, said endothelialisation is not clearly visible using conventional imaging modalities such as hospital or laboratory-based computed tomography.

With stentrodes sitting inside arteries for prolonged periods of time, it is essential to see the subtle contrasts on scanned images that reveal the difference between the stentrode metal and the newly-forming endothelial cells that create a protective film around it.

Using IMBL we can see the subtle contrasts that reveal the difference between the stentrode metal and the endothelial cells because of the beam's high-powered precision and tuneable energy, which minimises interference and maximises the quality of images.

In late-2017 it is anticipated a select group of paralysed patients from the Royal Melbourne and Austin hospitals in Melbourne will be implanted with the stentrode in a clinical trial; if the trial succeeds, the technology could become commercially available within six years.

Dr Chris Hall; IMBL.

DEVELOPING NEXT-GENERATION BATTERIES THAT RUN ON SEA WATER

Lithium-ion batteries are as ubiquitous as the billions of mobile devices around the world they power, however, due to safety concerns about damaged or faulty lithium batteries and their relatively expensive cost, they are deemed impractical for community-scale storage of renewable energy. Traditional alternatives, meanwhile, such as lead acid batteries, can be cumbersome and inefficient.

Dr Neeraj Sharma. Image courtesy of Quentin Jones/UNSW Australia.

A team of researchers from UNSW Australia, led by Dr Neeraj Sharma, School of Chemistry, is working on replacing lithium with sodium, with the ultimate goal of running batteries using readily available salt water.

Using intense X-rays generated by the Australian Synchrotron's Powder Diffraction (PD) beamline, Dr Sharma's team can visualise the battery's operation at extreme resolution, enabling the team to assess atomic level structural changes and allowing them to rationally modify electrodes.

Dr Sharma said the team has seen significant progress in the battery's positive electrode – the cathode.

In experiments to date, our sodium cathode has performed on par with a modern lithium-ion battery – it's visualising this process that's our area of expertise, and why the synchrotron is vital to our work.

If successful, Dr Sharma said sodium batteries may finally make large-scale battery storage for renewable energy practical and affordable.

You can have the best solar cell in the world, but if the Sun's not shining, it's not going to produce any energy – if you couple that solar cell with the right battery, you can produce a constant energy output.

UNDERSTANDING ENVIRONMENTAL RISK OF SILVER NANOPARTICLES

Silver nanoparticles are widely and safely used in many household products but, after accumulating in wastewater treatment plants, they can be released back into the natural environment and into the agricultural soils used to grow our food.

Researchers from The University of Queensland (UQ) have used the X-Ray Absorption Spectroscopy (XAS) beamline at the Australian Synchrotron to investigate the risk posed by silver nanoparticles in agricultural soils.

Dr Peter Kopittke from the School of Agriculture and Food Sciences at UQ said silver nanoparticles generally pose a low risk to food production, however testing in certain soil conditions led to an unexpected finding.

We found the risk posed by silver nanoparticles increased substantially in saline soils and in soils irrigated with poor-quality water.

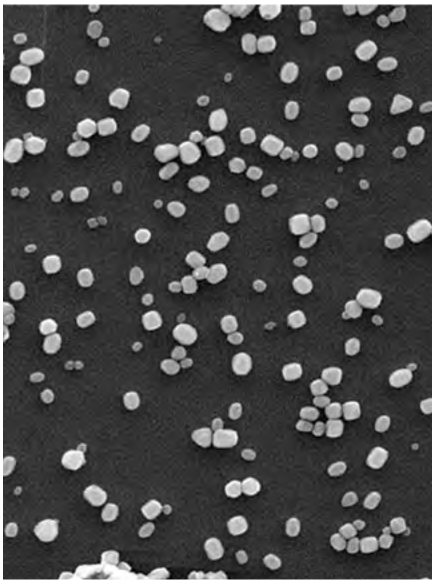
Unfortunately, unlike most other countries around the world, this applies to many of Australia's soils – soil salinity in Australia is becoming substantially worse over time.

Due to their antimicrobial properties, silver nanoparticles are used in products ranging from detergents, textiles and home appliances, to socks, toothpastes, air filters and nutritional supplements.

Dr Kopittke said the research, which also involved researchers from the University of South Australian and CSIRO Land and Water, and was published in *Environmental Science & Technology*, will now focus on exploring whether nanoparticles can move from agricultural soils into plants and food.

There are concerns regarding the release of silver nanoparticles into the broader environment, particularly into the agricultural soils from which we obtain the food we eat.

Our research could help in the development of better risk-assessment frameworks for silver nanoparticles, which are important given their widespread production and use, and the likely continued growth of nanoparticle technologies.



Silver nanoparticles viewed at 100,000x magnification; image courtesy of Dr Peter Kopittke.

STUDYING STONEFISH VENOM MAY HELP COMBAT TRANSPLANT REJECTION

The stonefish is one of the world's most dangerous fish, protecting itself with 13 razor sharp venom-filled spines capable of inflicting crippling pain on humans that can last for days and lead to limb amputation, or even death.

Image provided by Monash University.

Researchers at Monash University have used the Australian Synchrotron to determine the 3D molecular structure of the lethal factor present in stonefish venom, stonustoxin. Their results yield unexpected insight into how the immune system destroys targets and it is anticipated the work will lead to the development of new therapeutics to help prevent transplant rejection.

The work, published in December in *PNAS* (Proceedings of the National Academy of Sciences of the United States of America), revealed the lethal component of stonustoxin is an ancient relative of the human immune protein perforin, which is an essential weapon unleashed by the body to destroy virally infected and cancerous cells. Unwanted perforin function is furthermore important in immune driven disease, particularly in the context of bone marrow transplantation therapy to treat leukaemia.

Professor James Whisstock said the structural insights obtained from stonustoxin are now being used to develop immunosuppressants to improve the success rate of transplant therapies.

The power of the Macromolecular and Micro Crystallography (MX1 and MX2) beamlines at the Australian Synchrotron revealed unprecedented detail of this toxin, showing us stonustoxin contains two perforin-like proteins stuck together.

By seeing how these two proteins first interact, we can better understand how perforin is assembled by the immune system to destroy targets. Accordingly, we can use this information to start to develop molecules to prevent unwanted perforin function in a wide variety of disease situations.

HARNESSING HYPERACCUMULATOR PLANTS FOR NICKEL EXTRACTION

Nickel is essential to modern life, used in transport, construction, food preparation and medical equipment, power generation and mobile phones.

The tree *Rinorea bengalensis* is a rare hyperaccumulator plant that grows across Asia and in northern Queensland; when fully grown at 25 metres tall, each tree can contain up to five kilograms of nickel. Researchers from Queensland and South Australia are investigating hyperaccumulator plants to understand how harvesting, drying and extracting this biomass could generate a high-grade bio-ore – a process called phytomining or 'metal farming'.

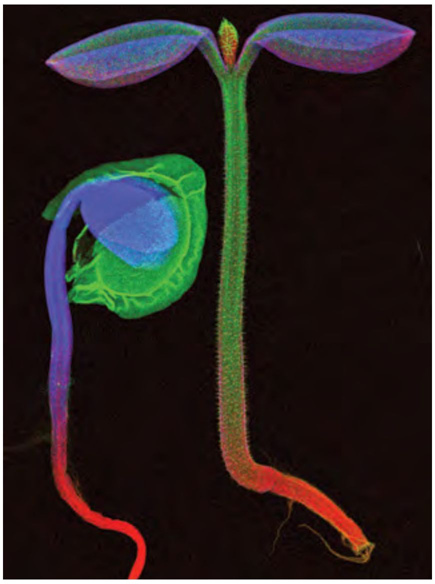
Using the X-ray Fluorescence Microscopy (XFM) beamline at the Australian Synchrotron, the research team, led by Dr Antony van der Ent from The University of Queensland and Professor Hugh Harris from The University of Adelaide, unravelled the ways in which hyperaccumulator plants are able to take up nickel from the soil and transport it to their leaves, accumulating up to six per cent of the metal in their biomass.

Professor Harris said, in addition to gaining potentially powerful insight to increase nickel extraction capacity, the research could bring benefits to metal prospecting, local economies and environmental health.

Phytomining may be undertaken on the overburden of nickel deposits and as part of progressive rehabilitation following resource extraction.

As an economic activity, phytomining can generate income for local communities, while soils rehabilitated by phytomining can be used for other types of agriculture such as food crops.

Following smaller field trials that yielded 100–160 kg nickel per hectare per year, the researchers have partnered with mining companies from France and the Asia-Pacific region to develop the first large-scale phytomining demonstrations in Indonesia.



This composite elemental map, produced by the XFM beamline, shows potassium (red), calcium (green) and nickel (blue) in live seedlings of a hyperaccumulator plant species.

Image courtesy of Antony van der Ent, Hugh Harris, Martin de Jonge, Peter Erskine, Rachel Mak, Jolanta Mesjasz-Przybylowicz and Wojciech Przybylowicz.

‘STAINLESS MAGNESIUM’ COULD HERALD TRANSPORT REVOLUTION

Magnesium-based metal alloys are under development for use across all modes of physical transport, from cars and buses to aeroplanes and spacecraft. To date, efforts to improve transport efficiency by creating lighter magnesium-based alloys using lithium, one of the lightest elements in the universe, have failed due to prohibitive corrosion when exposed to water.

In October, a research team led by scientists from UNSW Australia described how they used the Australian Synchrotron to turn the discovery of an ultra-low density, corrosion-resistant magnesium alloy into the first step toward mass-producing ‘stainless magnesium’.

The UNSW team, in collaboration with researchers from Monash University, detailed in the journal *Nature Materials* how the innovative magnesium-lithium alloy – which weighs half as much as aluminium and is 30 per cent lighter than magnesium – develops a protective carbonate-rich film when exposed to air, making it immune to corrosion in laboratory experiments.

Professor Michael Ferry, from UNSW's School of Materials Science and Engineering, said the team discovered this excellent corrosion resistance by chance after they noticed a heat-treated sample sitting, inert, in a beaker of water.

To see no corroded surface was perplexing and, by partnering with scientists on the Powder Diffraction (PD) beamline at the Australian Synchrotron, we discovered the alloy contains a unique nanostructure that enables the formation of the protective surface film – similar to how a chromium oxide layer protects stainless steel.

Professor Ferry said attention has now turned to understanding the molecular composition of both the underlying alloy and carbonate-rich surface film, by partnering with scientists on the Small and Wide Angle X-ray Scattering (SAXS/WAXS) beamline.

Questions on the precise chemistry and structure can only be answered by the powerful analytical infrastructure of the Australian Synchrotron, through which we can gain unprecedented structural detail, enabling us to work toward commercialising this alloy into manufacturing and revolutionising industrial and commercial transport.

IN FOCUS:
ENABLING
INNOVATION
ACROSS
INDUSTRY

IN FOCUS: ENABLING INNOVATION ACROSS INDUSTRY

In 2015-16 companies from across Australian industry continued to benefit from the Australian Synchrotron's commercial access program, which empowers industry clients to problem-solve and innovate by giving them timely access to world-class synchrotron tools and expertise while their intellectual property remains fully protected.

We partner with industry to overcome challenges at every stage of the value chain, from supporting the development of effective treatments for disease through protein crystallography to supporting proof-of-concept for new materials, said Ms Kerry Hayes, Group Leader, Industry Engagement.

Our group works with companies from across all sectors to solve problems with the precision and speed only a world-class synchrotron can provide.

INNOVATION IN NEW SOUTH WALES

In June 2016, a dedicated access program for New South Wales (NSW) companies, the NSW Industry Synchrotron Access (NISA) scheme, drew to a close. The NISA scheme provided more than 300 beamtime shifts and hundreds of hours of scientific analysis and reporting to NSW-based companies; work and data that helped clients make empowering discoveries.

The NISA scheme was funded in 2012 by the former Department of Trade and Investment, Regional Infrastructure and Services. Its objective was to encourage NSW-based companies and industry-university collaborations within the state to actively engage with synchrotron techniques for innovation and problem-solving that they may not otherwise have considered. Its outcomes have boosted innovation and driven future business and research directions, helping to change for the better the way people from NSW, across Australia, and around the globe, eat, work and live.

In one NISA scheme highlight reported in March, researchers from the NSW Department of Primary Industries used the Australian Synchrotron to outline an optimal approach to parboiling, a necessary preparatory step in the production of white rice that maximises the retention of valuable nutrients.

Using the Australian Synchrotron's X-ray Fluorescence Microscopy (XFM) beamline, the research team could track the migration of nutrients from the outer layer to the starchy core of rice grains during parboiling, at sub-micron resolution levels and without damaging the grain's internal structure.

The researchers found soaking in water at 90°C followed by steaming was the most effective technique for retaining nutrients, a processing approach that could boost the nutritional value of white rice for billions of people around the globe, while helping producers reduce risk of grain breakage during milling which decreases crop value.

Dr Rob Acres, left, with industry clients outside a beamline end-station.

SCIENCE OVERVIEW

FACILITY PERFORMANCE

Previous page: Dr Adrian Hawley and
Dr Katie Sizeland above the SAXS/WAXS beamline.

The Australian Synchrotron's scientific output continued to consolidate its outstanding track record for both quality and quantity of discovery and innovation. Concurrently, activities to advance the facility's investigative capabilities have increased substantially in the reporting period.

Major developments during the year have further demonstrated the Australian Synchrotron's performance and capabilities. Investigations using X-rays have led to improvements in the treatment of cancer, biomedical and nanoscale imaging, and the study of the electronic properties of materials, which reflect the breadth, quality and volume of industry and academic synchrotron research.

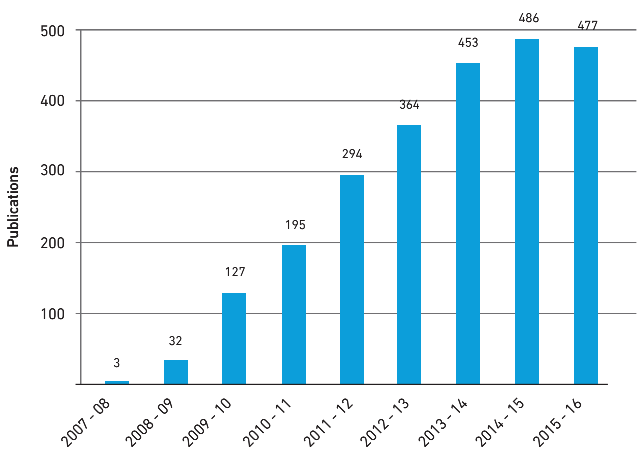
More than 5,700 researcher visits from across Australia, New Zealand and internationally took place in 2015-16, with particular areas of strength in medical and life sciences, advanced materials, earth and environmental sciences.

Publication output in 2015-16 was again outstanding, with the publication of 477 peer-reviewed scientific articles (see graph, below left). The quality of these publications was high; 16 per cent of all articles published appeared in high-impact scientific journals. The average impact factor of publications from the facility was an all-time high of 5.35. For the second consecutive year, the Small and Wide Angle X-Ray Scattering (SAXS/WAXS) beamline led the world in scientific productivity for like instruments with more than 100 peer-reviewed papers generated by users and employees.

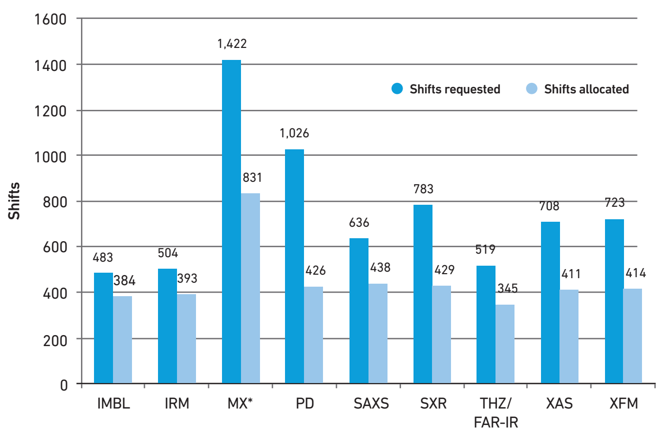
A further 62 publications were produced by Australian Synchrotron employees, or by Australian researchers accessing international synchrotron facilities, supported by funding administered by the Australian Synchrotron through the International Synchrotron Access Program. This demand for access to international facilities is further evidence of the sophistication of the Australian user community. It provides a way to grow expertise and demonstrate the need for instrumentation that is not yet available at the Australian Synchrotron – instrumentation that will be delivered under the landmark infrastructure's plan for capital expansion.

All of the Australian Synchrotron's beamlines were over-subscribed during the reporting period, with demand for beamtime hours exceeding available time, which was at near-optimal capacity (see graph, below right).

PUBLICATIONS PER YEAR FROM AUSTRALIAN SYNCHROTRON BEAMLINES



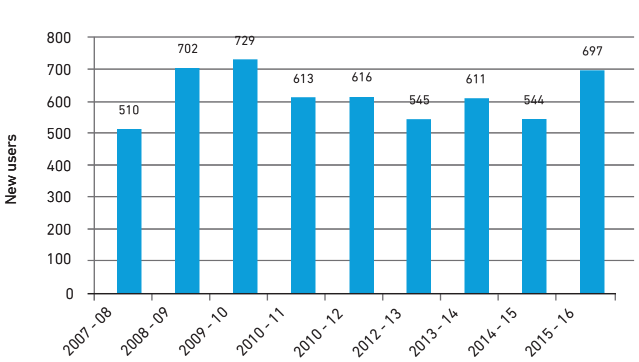
SUBSCRIPTION RATES PER BEAMLINE – NUMBER OF REQUESTED AND ALLOCATED EIGHT HOUR SHIFTS



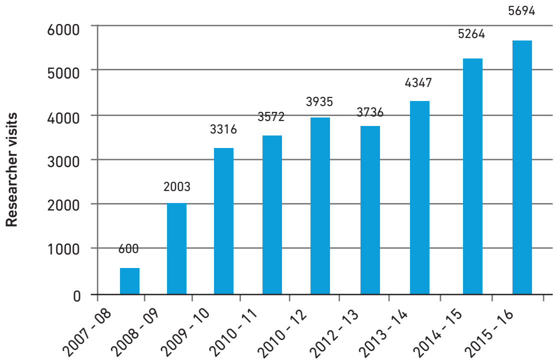
OUR COMMUNITY

The number of registered users has climbed to more than 5,500 since opening in 2007, with almost 700 new researchers registering in 2015-16.

NEW REGISTERED USERS BY YEAR



TOTAL RESEARCHER VISITS BY YEAR



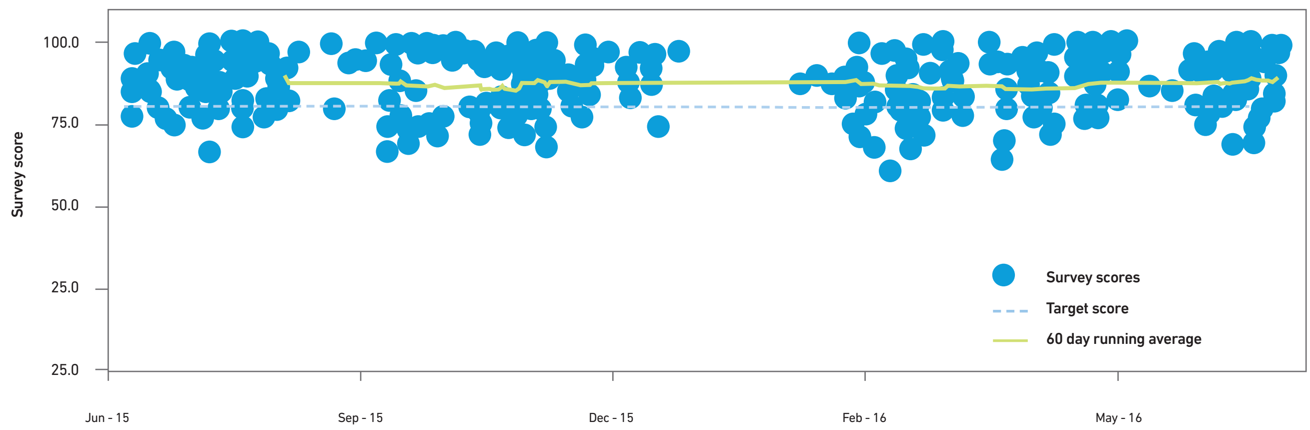
Poster sessions at the combined User Meeting and Asia Oceania Forum for Synchrotron Radiation Research in November.

New users continue to be attracted to the Australian Synchrotron and its unique techniques.

The number of visits by researchers to the Australian Synchrotron has continued to climb from a base of 2,000 user visits in 2008-09 to more than 5,700 visits in 2015-16.

THE EXPERIENCE OF THOSE WHO USE THE AUSTRALIAN SYNCHROTRON IS TRACKED THROUGH A SURVEY AND BY USER REPRESENTATIONS TO THE USER ADVISORY COMMITTEE. SURVEY DATA IS SHOWN BELOW WITH OVERALL USER SATISFACTION CONSISTENTLY ABOVE THE TARGET OF 80 PER CENT.

USER SURVEY RESULTS



ACCOMMODATING USERS ON SITE

As unique landmark infrastructure in the region, the Australian Synchrotron attracts scientists from all Australian states and New Zealand, as well as from Asia, Europe and North America, and a dedicated Guest-house was built in 2012 to provide conveni-ent, high quality, on-site accommodation. In 2015-16 the Australian Synchrotron Guesthouse took more than 1,365 bookings from more than 900 unique guests; 70 per cent of bookings were for users attending beam time, with the remaining 30 per cent for guests attending meetings, conferences and workshops.

A FOCUS ON ASIA-OCEANIA

In November 2015, the Australian Synchrotron hosted the facility's annual User Meeting in conjunction with the Asia Oceania Forum for Synchrotron Radiation Research, a three day event at the National Centre for Synchrotron Science. More than 260 delegates from our domestic community and across the globe gave more than 220 presentations, including more than 70 contributed talks and several plenary presentations.

Professor Brendan Kennedy from The University of Sydney spoke about structural transformations in radioactive oxides under extreme conditions; Professor Jenny Martin from The University of Queensland described the molecular biology of cellular membrane fusion, while Associate Professor Chris McNeill from Monash University gave a presentation on the microstructure of high-performance polymer electronics. Dr Sakura Pascarelli from the European Synchrotron Radiation Facility highlighted investigations of extreme states of matter using X-ray absorption spectroscopy. Dr In Soo Ko, from the Pohang Accelerator Laboratory, described the status of the Korean X-ray Free Electron Laser project, and Dr Gwo-Huei Luo, from the National Synchrotron Radiation Research Center, provided an update on the Development of TPS Light Source in Taiwan.

In addition to the formal program at the meeting, 142 student posters were presented over two sessions – with Nicholas Anthony from La Trobe University receiving the Student Poster Prize: a travel grant to attend a conference, to the value of AU$3,000. Many students vied to best promote their posters using one slide in 60 seconds in the entertaining 'Poster Slam', won by Patrick Capon from The University of Adelaide (see pg 34).

The Australian Synchrotron also hosted the following international conferences in 2015-16:

- *The International Beam Instrumentation Conference in September, which explored the physics and engineering challenges of beam diagnostic and measurement techniques for charged particle accelerators worldwide.*
- *The 15th International Conference on Accelerator and Large Experimental Control Systems (ICALEPCS 2015) at the Melbourne Convention and Exhibition Centre in October; this meeting, jointly hosted by the Australian Synchrotron and ANSTO, attracted more than 360 delegates from around the globe.*

RESEARCH TRENDS BY BEAMLINE

Two important themes characterised beamline-specific research trends in 2015-16, one of which was an increase in cross-beamline or complementary beamline use to produce data and insights; of this year's 477 industry and research user-generated publications, 23 were complementary studies. The second theme was that beamline demand consistently exceeded available hours, even in the context of near-maximal capacity due to world-class beam availability and uptime.

IMAGING AND MEDICAL BEAMLINE (IMBL)

Significant areas of published work from IMBL related to developments in microbeam radiation therapy and associated dosimetry measurements, as well as a range of high energy X-ray imaging studies contributing unique insights to the fields of vulcanology and geology.

INFRARED MICROSPECTROSCOPY (IRM) BEAMLINE

Use of the IRM beamline was reported in publications relating to biology and biomaterials, nanomaterials, and polymers.

MACROMOLECULAR AND MICRO CRYSTALLOGRAPHY (MX1 AND MX2) BEAMLINES

The MX1 and MX2 beamlines generated important research outcomes relating to biological processes, disease and pharmaceutical development. Areas of special focus were the human immune system, cancer, and bacterial-based disease. MX1 also produced significant results in chemistry and advanced materials.

POWDER DIFFRACTION (PD) BEAMLINE

Publications from the PD beamline focused on advancing knowledge and applications in cleaner or more sustainable energy materials, including papers addressing hydrogen storage, frameworks for carbon dioxide capture, and innovative new battery technologies.

SMALL AND WIDE-ANGLE X-RAY SCATTERING (SAXS/WAXS) BEAMLINE

The SAXS/WAXS beamline continued to deliver a wide and impressive variety of research outcomes; major themes related to solution-based structural biology, polymers, as well as surfactant, lipid and liquid crystalline based nanomaterials for technological and advanced drug delivery systems.

SOFT X-RAY SPECTROSCOPY (SXR) BEAMLINE

Outcomes using the SXR beamline advanced insights in the fields of polymer electronics and solar cells, diamond and other advanced electronics. Significant results were also obtained in the field of advanced catalytic systems.

TERAHERTZ/FAR-INFRARED (THZ/FAR-IR) BEAMLINE

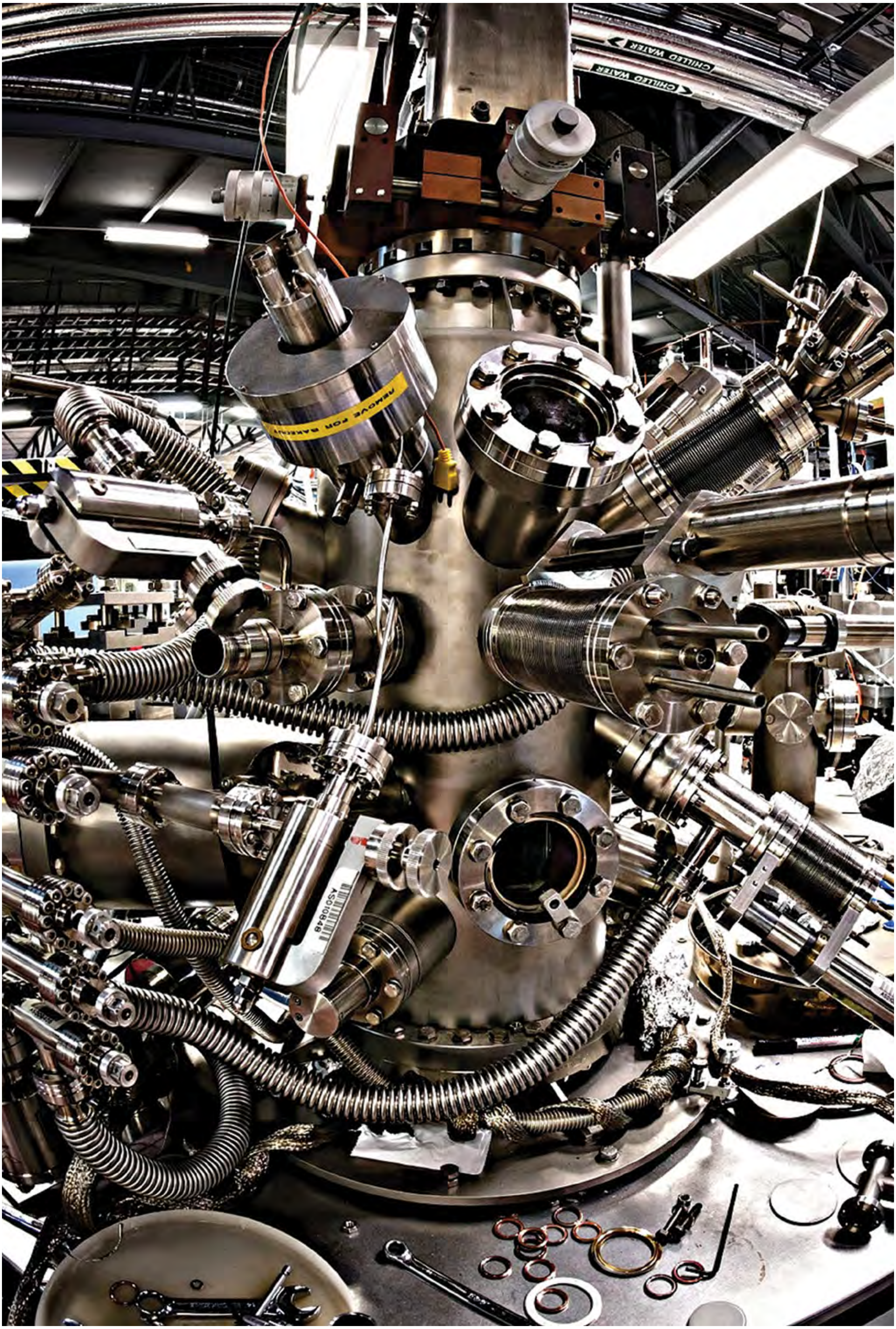
The THz/Far-IR beamline continued its valuable contribution within its traditional specialist area of expertise: gas-phase spectroscopy. This year it also demonstrated emerging prowess in the important field of biomaterials characterisation.

X-RAY ABSORPTION SPECTROSCOPY (XAS) BEAMLINE

Samples from a diverse range of scientific fields were examined by the XAS beamline, with a particular focus on nanomaterials, mineral formation and processing, catalysts, and the fate and consequences of metals in biomaterials and the environment.

X-RAY FLUORESCENCE MICROSCOPY (XFM) BEAMLINE

XFM beamline scientists and users significantly increased the number of studies providing insights in the role of metals in disease and biological processes. The XFM beamline was also the source of numerous studies adding to worldwide knowledge on mineral formation, metals in the environment, and micronutrients in food, and the beamline also continued to build on its reputation as a powerful tool for cultural heritage studies.



BEAMLINE AND MACHINE UPDATES

The Australian Synchrotron's engineering team delivered an impressive range of significant beamline enhancements during 2015-16. These developments have substantially improved the quality and breadth of capabilities delivered to the facility's research community and industry clients.

XFM: SUPER-FAST WITH SUPER-RESOLUTION

The speed and spatial resolution of the X-ray Fluorescence Microscopy (XFM) beamline, already a world-class instrument with its very fast and highly sensitive Maia detector developed by CSIRO, has been further improved this year.

New fast scanning stages for the microprobe system have cut scanning times from more than one day to less than a few hours. Further advances in scanning stage control have eliminated more than 80 per cent of time 'lost' as samples shift from line to line during scanning. Implementation of a simultaneous detection system has enabled the provision of structural data of samples down to 50 nanometres in detail, in parallel with elemental mapping at two-micron resolution.

These advances empower researchers from Australia and New Zealand by providing access to novel capabilities: confocal X-ray microscopy; XANES imaging for chemical state as well as elemental maps of samples; and fluorescence tomography for full three-dimensional elemental maps.

SAXS/WAXS: A CO-FLOW REVOLUTION

Co-Flow is an innovative new capability developed by the SAXS/WAXS beamline team that has the potential to revolutionise small angle scattering around the globe. It is a new way of delivering biological and other solution-based samples to high-intensity X-ray beamlines and overcomes a host of limitations associated with these types of experiments.

Co-Flow removes the possibility of radiation damage to sensitive biological samples: it decreases the volume of samples necessary for measurement; improves sample throughput as well as measurement statistics; and removes the need to clean sample cells after beam exposure. At very little cost, Co-Flow is poised to unlock the potential from third-generation synchrotron beamlines globally, leading to a world of new possibilities to determine biological structures.

UPGRADES

Regular upgrades and enhancements to the synchrotron echo the facility's commitment to excellence and innovation. Projects delivered or commenced in 2015-16 include:

- an upgrade of the bunch-by-bunch feedback monitoring systems delivering enhanced reliability and diagnostics;
- successful testing of the fast orbit feedback system with an interim software solution ahead of deployment of a new field-programmable gate array system;
- upgrade of a tuning plunger motor control on booster RF cavities.

MACHINE RELIABILITY

The synchrotron's reliability was consistently excellent during the 2015-16 year, with availability at 99.2 per cent, above the 97 per cent target for the year. There were 27 faults in the period – one fewer than the previous reporting period – resulting in 37.75 outage hours. Beamline-specific issues accounted for 40 per cent of all faults.

BRINGING 'BROADBAND' PROTEIN ANALYSIS TO AUSTRALIA

AUSTRALIAN CANCER RESEARCH FOUNDATION

In December 2015, the Australian Cancer Research Foundation (ACRF) awarded a $2 million grant to the Australian Synchrotron in partnership with a range of major universities and medical research institutes for the purchase of a state-of-the-art Eiger detector for the MX2 beamline. The ACRF Detector will improve data quality for macromolecular crystallography while providing a ten-fold increase in capacity, which is crucial to accelerating cancer drug development. Fast and accurate macromolecular crystallography studies are critical in modern cancer research, delivering enhanced capabilities for solving unknown protein structures – an essential tool in the understanding and combating cancer.

Over page: Dr Rachel Williamson; MX beamlines.

AWARDS AND ACHIEVEMENTS

At the Australian Synchrotron, it is the commitment, passion and expertise of all of our employees and our community that enables the maximum possible productivity from highly specialised equipment. Here we celebrate some of their achievements and successes.

PASSION ON THE JOB HONOURED

In May, Clare Scott, Laboratory Coordinator at the Australian Synchrotron (pictured), was nominated in the People's Choice category of the Australian Academy of Science's On the Job award, which celebrates the support staff who keep Australian science moving.

Clare was recognised for her tireless work ensuring the Australian Synchrotron's users can safely and effectively draw on chemistry laboratories, biosafety cabinets and other critical support services. Clare also partners with groups from leading universities and research institutes to manage quarantine permits for complex samples, negotiate the use of rare or niche equipment and prepare specific guidance to help researchers handle and manage hazardous materials.

VICTORIA PRIZE VICTORY FOR SYNCHROTRON USER

In October, Professor Calum Drummond from RMIT University was awarded a prestigious Victoria Prize for his fundamental chemistry research involving the Australian Synchrotron, which is enhancing industrial products and improving nanomedicine drug delivery for people with cancer.

By devising a new method of high-throughput analysis on the Australian Synchrotron's Small and Wide Angle X-ray Scattering (SAXS/WAXS) beamline, Professor Drummond and his team from RMIT and CSIRO were able to investigate thousands of samples a day, accelerating the hunt for molecules that can 'self-assemble' in solvents. These insights can also be used to improve offshore oil well-drilling fluids, waterproof recyclable paper coatings, and household cleaning products.

STUDENTS SHINE IN SCIENCE WITH A SLAM

At the 2015 User Meeting in November, The University of Adelaide's Patrick Capon took out the coveted Poster Slam, impressing delegates with his one-minute description of how he used synchrotron light to examine the bonding of catalytic material with metals to develop uniquely-fused structural frameworks to purify gases.

Also at the User Meeting, Nicholas Anthony from La Trobe University was the major poster prize winner. Nicholas' research aim is to build a new X-ray microscope for imaging cells using a complex approach known as ptychography.

GOVERNANCE

Synchrotron Light Source Australia Pty Ltd (SLSA), trading as the Australian Synchrotron, assumed operations of the facility on 1 January 2013, while the assets are owned by the Australian Synchrotron Holding Company Pty Ltd (ASHCo). SLSA is a wholly-owned subsidiary of the Australian Nuclear Science and Technology Organisation (ANSTO), which operates the Synchrotron under an operations services agreement with ASHCo.

SLSA BOARD OF DIRECTORS

Members of the SLSA Board of Directors for the period 1 July 2015 to 30 June 2016 were as follows:

Dr Greg Storr (Chair)
Group Executive, ANSTO

Professor Les Field
Vice President and Deputy Vice-Chancellor (Research), UNSW Australia

Ms Patricia Kelly PSM
Director General, IP Australia

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

Mr Shaun Jenkinson
Group Executive, ANSTO

Further detail of the Directors and activities of SLSA are contained in the Australian Synchrotron Financial Reports, 30 June 2016.

FUNDERS' COMMITTEE

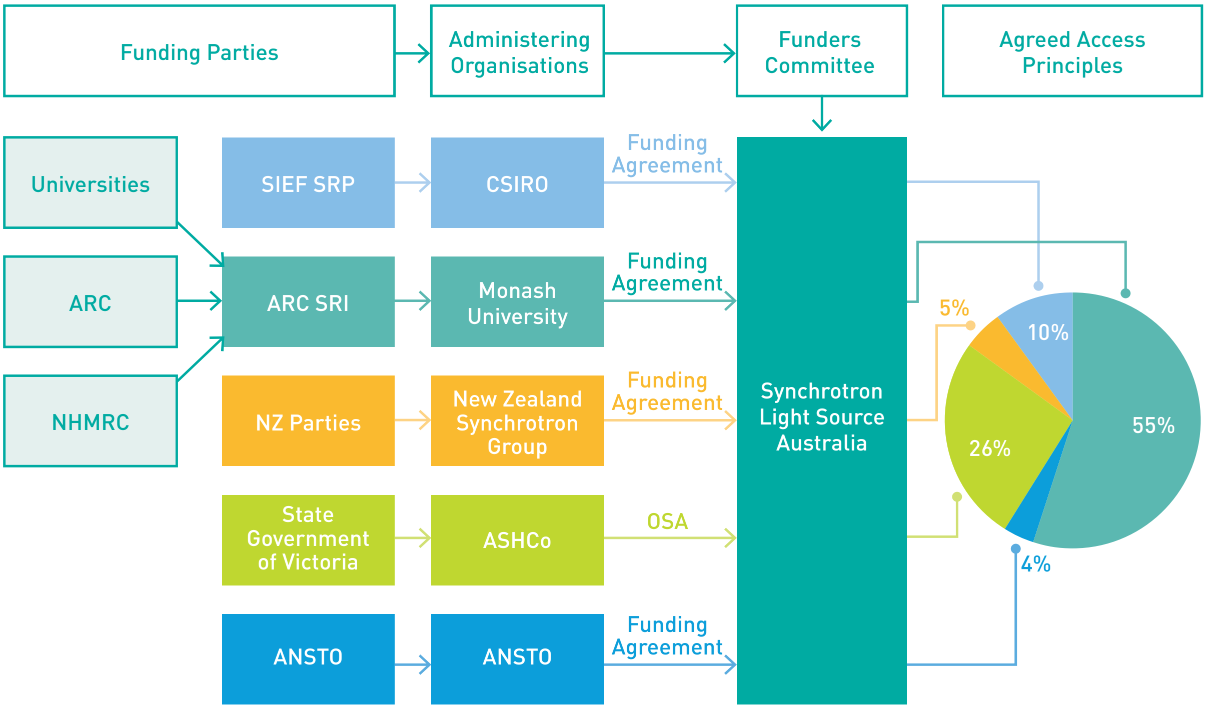
A representative committee of the Funding Parties (see Funding Framework, pg 39), the Funders' Committee has oversight of facility operations and its endorsement is required before matters, such as the operating plan and budget for SLSA, can be approved.

COMMITTEES

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

- Scientific Advisory Committee
- Animal Ethics Committee
- International Program Advisory Committee
- Machine Advisory Group
- Program Advisory Committees
- User Advisory Committee.

FUNDING



Australian Synchrotron: Funding framework.

In March 2012, the Australian and Victorian governments signed a Memorandum of Understanding, providing the framework to deliver $100 million to support operating and research costs at the Australian Synchrotron for the four years to 30 June 2016.

The funding parties and relevant funding schemes are:

- Australian Research Council Strategic Research Initiative (ARC SRI), National Health and Medical Research Council (NHMRC), and Australian universities: $55.57 million
- State Government of Victoria (managed through the Department of Economic Development, Jobs, Transport and Resources): $26 million
- Science and Industry Endowment Fund Special Research Program (SIEF SRP): $10 million
- The New Zealand Synchrotron Group Ltd, representing a consortium of the Australian Government, universities and research institutes: $5 million
- The Australian Nuclear Science and Technology Organisation (ANSTO): $4 million.

The funding parties are granted synchrotron beamtime in proportion to their funding contributions. The relationship between the funding parties, their administering organisations, the Funders Committee and the share of beamtime (Agreed Access Principles) is shown above.

As outlined at the start of this report, a significant funding and sustainability milestone for the Australian Synchrotron, one that built upon years of high performance, was the Australian Government's National Innovation and Science Agenda announcement in December. This policy announcement committed $520 million over 10 years to fund the facility's operations from 1 July 2017. This was an unprecedented guarantee of science funding for an Australian research facility.

Importantly, the announcement also came with the appointment of ANSTO as the long-term owner and operator of the Australian Synchrotron. These announcements were confirmed in the May Federal Budget, and arrangements to transfer the assets and operations of the facility to ANSTO were completed in July 2016.

FINANCIAL STATEMENTS

Professor Andrew Peele with Mr Russell R Caplan,
Board Director, Australian Cancer Research Foundation.

The Australian Cancer Research Foundation (ACRF) provided a grant of $2 million to assist in the purchase of a world-leading detector to enhance the ability of researchers to solve protein structures (pictured, over page; also see pg 32). In total, $2,095,000 of was received from ACRF and other contributing parties during the year.

Commercial revenue increased by 21.5 per cent from the previous year and included income from a variety of industry clients and from the New South Wales Industry Synchrotron Access scheme (see pg 23).

The consolidated result was a surplus of $3,728,527. This year's result is based on total revenue of $32,084,291 and total expenditure of $28,355,764, which includes $2,313,903 of assets transferred to Australian Synchrotron Holding Company Proprietary Limited (ASHCo) for zero consideration. The main source of revenue was $27,975,759 from the funding parties.

Other revenue of $851,735 consists mainly of income from international conferences held; grant funding towards the International Synchrotron Access Program, guesthouse revenue, sponsorships, conferences and workshop registrations, and postdoctoral contributions.

Operating expenditure during the year was made up of $17,107,954 for salaries and employee benefits, and $182,647 for occupational, health and safety expenditure.

$5,178,252 was spent on operating and maintaining the facility at a world-class standard, including $3,023,681 for building and technical expenditure and $2,154,571 on utilities.

A total of $2,313,903 was spent on essential operating upgrades and spare parts, while an additional $2,173,149 was committed to support local and international user access, scientific development, communications activity, business development and industry engagement.

Administrative costs for the facility were $1,399,859, including staff travel, information technology, and general administration. Further financial information is available in the 2016 annual financial statements for Synchrotron Light Source Australia (SLSA), which is available on request.

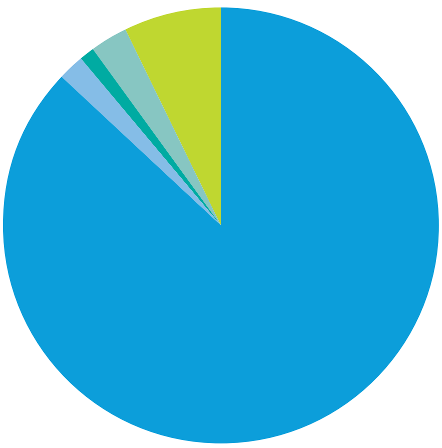
EXPENSES

Payroll and consulting	17,107,954	60.33%
Occupational health, safety and environment	182,647	0.64%
Building and engineering	5,178,252	18.26%
User support and business development	2,173,149	7.66%
Administration	1,399,859	4.94%
Transfer of assets at nil consideration	2,313,903	8.16%
Total expenses	**28,355,764**	

REVENUE

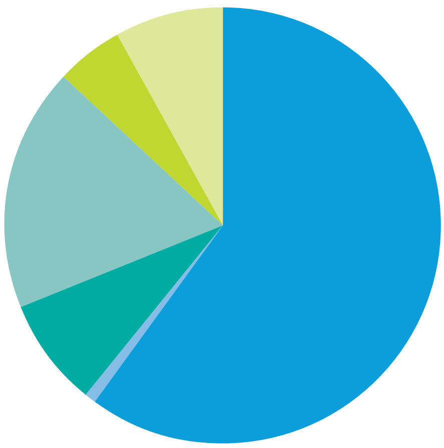
Funding parties	27,975,759	87.19%
The ACRF Detector funding & other contributing parties	2,095,000	6.53%
Other revenue	851,735	2.65%
Interest	354,951	1.11%
Commercial revenue	806,846	2.51%
Total revenue	**32,084,291**	

INCOME



- Funding parties 87%
- Commercial revenue 2%
- Interest revenue 1%
- Other revenue 3%
- ACRF & other contributing parties 7%

EXPENDITURE



- Salaries & employee benefits 60%
- OHS&E 1%
- User support & business development 8%
- Building & technical expensises 18%
- Administration expenses 5%
- Spares & essential operating upgrades 8%


DELIVERIN
REAL
BENEFITS
.IFE

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and can be downloaded at
synchrotron.org.au

Australian Synchrotron
800 Blackburn Road
Clayton, Victoria 3168
Australia

t. +61 3 8540 4100
f. +61 3 8540 4200
www.synchrotron.org.au

@aus_synchrotron

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