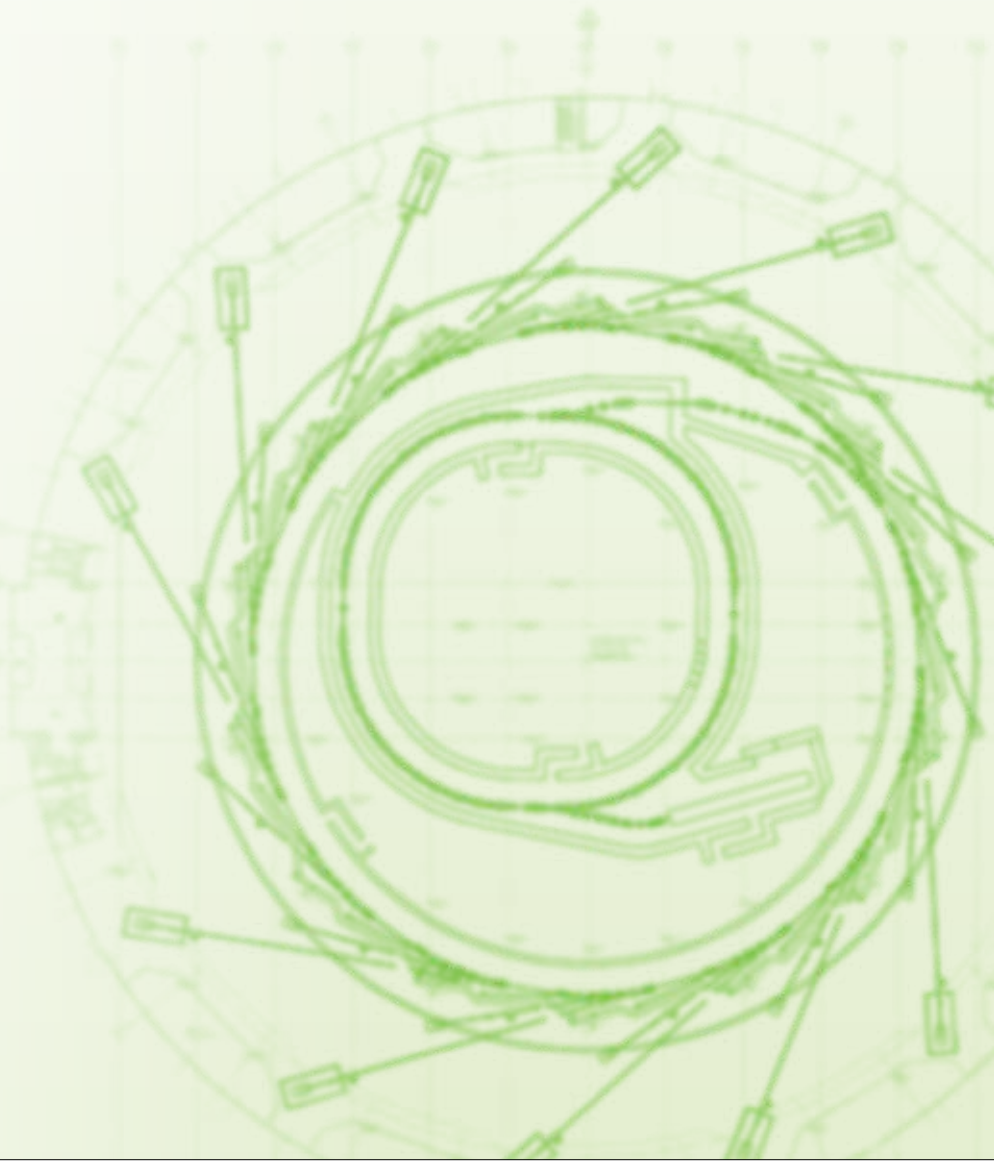
Australian Government

Ansto

BRIGHT

World-class beamlines for Australian science



In just 11 years of operation, the Australian Synchrotron has emerged as one of Australia's most important pieces of landmark scientific infrastructure. The unique properties of synchrotron light provide researchers and industry with results that are greater in accuracy, clarity, specificity and timeliness than those that could be obtained using conventional laboratory equipment.

The Australian Synchrotron features ten world-class beamlines, covering a broad range of applications including health and biological sciences, earth and environmental sciences, advanced materials, engineering and manufacturing, energy and sustainability science, cultural heritage and archaeology as well as fundamental physics, chemistry and accelerator science.

Such is the value of the facility to Australia's science and innovation ecosystem, that each of the existing beamlines is oversubscribed. Furthermore, with constant advances in scientific methods, researchers and industry partners require access to a broader suite of techniques than those currently available.

Following the Federal Government's substantial $520 million contribution to secure the future of the facility to 2027, ANSTO has been working in earnest to secure capital investment for the Australian Synchrotron. This investment will facilitate the design and installation of eight additional beamlines, enabling the facility to meet the needs of Australian researchers and industry partners and continue enabling ground-breaking research well into the future.

To date, ANSTO has received $80.2 million of capital funding from 20 contributors. This overwhelming support for the Australian Synchrotron is testament to the value of the research it enables.

However, the job is far from over; we are still seeking additional funding commitments to ensure all eight additional beamlines can be constructed. This document outlines remaining opportunities for investment, and highlights the research and industrial benefits of each of the proposed new beamlines. We encourage you to consider how an investment could benefit your organisation, and contact us to discuss further.

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First tranche beamlines

From the funding secured to date, and consultation with contributors, design will commence shortly on the first two beamlines to be constructed.

BEAMLINE

Micro-Computed Tomography

MCT

MCT opens a window on the micron-scale 3D structure of a wide range of samples relevant to many areas of science including life sciences, materials engineering, anthropology, palaeontology and geology. Employing a 8-40 keV bending magnet, the MCT Beamline will enable high throughput and dynamic micro-CT down to submicron resolution.

A key feature will be speed of data collection, focusing both on applications where many samples are imaged and experiments where a single specimen is imaged many times to observe dynamic responses to temperature, pressure, strain or other changing environmental conditions.

The high brightness and high intensity monochromatic X-ray beam produced by the MCT Beamline will provide significant advantages in spatial resolution, speed and contrast compared to conventional laboratory micro-CT instruments, including capabilities such as phase contrast. The MCT beamline can measure 3 dimensional structures of organs, tissue samples and other biological structures and then allow researchers to virtually cut and separate the sample using computer modelling. This technique avoids the need to stain samples with dyes or markers or physically change the object which may distort the features of interest.

NATIONAL RESEARCH APPLICATIONS

Biological and health science

Creating virtual microscopic anatomy of tissues and organisms to help understand disease pathology and healthy biological function

Materials science

Development of new battery technologies

Palaeontology

Research into toxic organochlorine and organophosphate pollutants and their impact on the environment and human health

Earth science

Research into sulphur-based minerals to understand the formation, location and extraction of metals from new ore bodies

INDUSTRY APPLICATIONS

- Analysing the microstructure of coal and coke for the mining and energy industries
- Development of high-grade medical implants and 3D printing

- Complementary to the Imaging and Medical Beamline (IMBL), by allowing 3D structures to be studied in close detail; down to 0.7 µm resolution
- Utilises a 8-40 keV bending magnet

BEAMLINE

Medium Energy X-ray Absorption Spectroscopy

MEX

The MEX Beamline will provide medium energy absorption spectroscopy on a bending magnet, optimised for cutting-edge applications in biological, agricultural and environmental science. It will cover an energy range not currently available to Australian and New Zealand researchers, allowing X-ray absorption spectroscopy measurements of radiation sensitive elements, including sulphur, phosphorus, silicon and chlorine. Focusing optics will add microprobe capabilities to this energy range.

MEX is an excellent beamline for biology as it will have a lower X-ray energy and lower power density than many of our other beamlines (like XAS and our MX beamlines where we have to freeze samples to inhibit radiation damaged while they are being measured).

The MEX beamline can help understand the structure and function of metalloproteins because it is sensitive to the local structure around the metals. This technique can be used to understand the structure of these proteins at the atomic level where sometimes no other alternatives are available to do so. The MEX beamline can help to reveal specific biologically relevant molecules in tissues and other biomaterials, and, also, importantly, understands the chemical state of these molecules and how they react as part of their biological function.

NATIONAL RESEARCH APPLICATIONS

Biological and health science

Investigating the role of metalloproteins in biological function and disease, the chemistry of biologically-relevant elements, and contributing to the development of anti-cancer drugs

Earth science

Research into sulphur-based minerals to understand the formation, location and extraction of metals from new ore bodies

Materials science

Development of new battery technologies

Environmental science

Research into toxic organochlorine and organophosphate pollutants and their impact on the environment and human health

INDUSTRY APPLICATIONS

Aiding the mining industry in developing improved sulphide mineral processing, especially for copper and nickel ores and 'invisible gold'

Investigating sulphur, particularly in the form of preservatives, in food and beverages

- Complementary to the X-ray Absorption Spectroscopy (XAS) and X-ray Fluorescence Microscopy (XFM) beamlines, it will enable spectroscopy and mapping of lighter elements including sulphur, phosphorus, chlorine, calcium and potassium
- The MEX beamline will also facilitate studies of radiation sensitive materials, including biological samples and those with significant cultural heritage value

MCT and MEX will closely be followed by-

BEAMLINE

Biological Small Angle X-ray Scattering

BioSAXS

The BioSAXS Beamline will be optimised for measuring small angle scattering of proteins and other biological macromolecules. It will combine a state-of-the-art small angle scattering beamline with specialised on-line protein purification and preparation techniques for high-throughput protein analysis.

The BioSAXS Beamline will accommodate the rapidly growing demand for small angle X-ray scattering investigations of biological macromolecules. Applications include great impact in the study of the structure of larger biomedical molecules involved in the critical functions of human cells, such as proteins and the nucleic acids that compose the genetic material within cells, and the study of interactions between biological molecules and new drugs.

NATIONAL RESEARCH APPLICATIONS

Health science

Understanding, preventing and treating diseases such as bacterial infections and antibiotic resistance, diabetes, autoimmune diseases, cancer, and Alzheimer's. Development of new pathology tests and biosensors. Development of new agents for biomedical imaging and therapy

Structural biology

The conformation and structure of proteins and their interactions with other biomolecules provides key understandings of biological processes

Pharmaceutical research

The structures of protein-based drug targets and rational drug design

Food science

Studies of formulations and nanostructures in food, digestion processes and nutrition

INDUSTRY APPLICATIONS

Development of controlled release and on-demand drug delivery systems

Improvements in food processing and quality control

- Complementary to the Small Angle X-ray Scattering and Wide Angle X-ray Scattering (SAXS/WAXS) Beamline and the Macromolecular and Micro Crystallography Beamlines (MX1 and MX2), by optimising the study of nanoscale biological samples, such as proteins, in close detail; down to 2 nm resolution
- Utilises an in-vacuum undulator

Other beamlines

Funding contributions are still being sought for construction of the following beamlines, in addition to another, yet-to-be specified beamline. The properties of this final beamline will be determined based on emerging research and industry demand, in addition to discussions with contributors.

BEAMLINE

Advanced Diffraction and Scattering

ADS

The ADS Beamline will be optimised for a range of leading-edge diffraction and scattering techniques including: studies of mineral formation and recovery under extreme conditions of temperature and pressure; non-destructive detection of cracking, fractures, textures, strains and deformations in large manufactured objects across the energy, automotive, transport, defence and aerospace sectors; maintenance and component failure studies of engineering infrastructure; and studies of corrosion and cracking in aluminium alloys used in aircraft and marine platforms.

OVERVIEW

Source
Superconducting multi-pole wiggler

Energy range
30-120 keV

Energy resolution
Monochromatic, pink and white beam

Beam size at sample
Variable– 10µm-1mm

Experimental stations
Main at 60m, side station at 40m – simultaneous operation

Major research fields
Materials science and engineering

Time to construct and commission
Four years

ADS complements the existing Powder Diffraction (PD) Beamline

BEAMLINE

Micro Materials Characterisation

MMC

Polycrystallinity, strain, grain orientation, defect structure, migration and organisation are fundamental to understanding the properties of materials. The MMC Beamline will enable these properties to be measured in 3D at sub-micron scale and will be only the second 3D diffraction facility in the world.

The MMC Beamline will offer multiple micro-focus analysis techniques for materials science – monochromatic and Laue diffraction, X-ray fluorescence microscopy and selected area X-ray absorption spectroscopy. Applications of this technique extend across a wide range of fields, including: solar cells; high-temperature and nuclear energy materials; pollutants; mining and mineral recovery processes; and biological materials.

OVERVIEW

Source
Wiggler or wavelength shifter

Energy range
5-60 keV

Bandpass
Selectable white beam; 10% bandpass; 10^{-4}

Beam size at sample
1-5 µm

Experimental stations
Single station – multiple techniques

Major research fields
Materials science and engineering; geology; environmental science

Time to construct and commission
Three years

MMC complements the existing Powder Diffraction (PD) Beamline and the X-Ray Fluorescence Microscopy (XFM) Beamline.

BEAMLINE

High Performance Macromolecular Crystallography

HMX

The most important targets for the design of novel drugs include difficult large assemblies, which rarely produce crystals of sufficient size for analysis using traditional macro or micro-molecular crystallography beamlines. The HMX Beamline will enable the study of sub-5 micrometre crystals, providing a state-of-the-art high-throughput facility for researchers to study very small, weakly diffracting crystals of protein fragments and solution studies of protein fragments.

Researchers working on medically-relevant projects for which only small, weakly diffracting crystals are achievable must currently travel to overseas facilities to collect data. Applications include: in membrane proteins and receptors; virology; and materials science. The beamline will take advantage of the latest developments in high-throughput crystallography, including robot handling of 96-well crystallisation plates.

OVERVIEW

Source
In-vacuum undulator

Energy range
6-18 keV

Beam size at sample
25 × 25 µm

Beam intensity at sample
>4e12 ph/s

Experimental stations
Single station – high throughput automated crystallography

Major research fields
Structural biology

Time to construct and commission
Three years

HMX complements the existing Macromolecular and Micro Crystallography (MX1 and MX2) Beamline.

BEAMLINE

High Coherence Nanoprobe

HCN

High coherence nanoprobe (HCN) beamline undertakes high-resolution X-ray microspectroscopy, elemental mapping and coherent diffraction imaging. The HCN Beamline will provide a unique facility capable of spectroscopic and full-field imaging at sub-30nm resolution. With a cryogenic sample mount, the system will also provide the ability to probe frozen hydrated biological samples, imaging and identifying cellular substructures that are critical components in biological machinery, but are far smaller than what current beam spots can resolve.

The HCN Beamline will use an undulator source and a very long beamline, in the order of 100m, to deliver X-rays of the highest brightness possible to an experiment. Capable of accessing the K-edges of elements from phosphorous to silver, the HCN Beamline will suit applications in chemistry, biological sciences, condensed matter physics, nanotechnology, environmental sciences and geology. The high coherence properties of the beamline will make it suitable for the development of new techniques in coherent X-ray science – an area that has been undergoing tremendous growth across the globe.

OVERVIEW

Source
In-vacuum undulator

Energy range
2-20 keV

Beam size at sample
50-500 nm

Imaging resolution
5-10 nm (CDI)

Experimental stations
Single station – imaging station at ~100m from source

Major research fields
Biology, nano-materials, environment, fundamental physics

Time to construct and commission
Four years

HCN complements the existing X-Ray Fluorescence Microscopy (XFM) Beamline.

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