Australian Synchrotron
lighting the path to innovation

Imaging and Medical Therapy

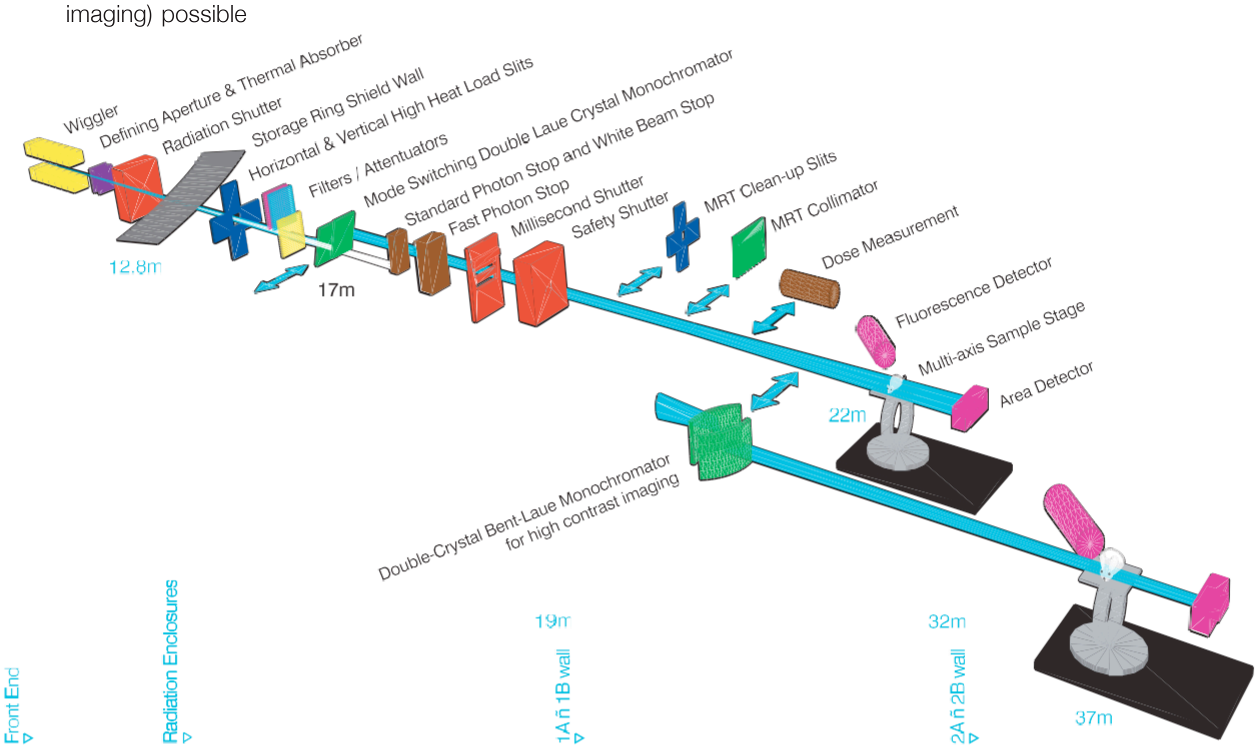
The imaging and medical therapy beamline will offer high-resolution, phase-contrast x-ray imaging of biomedical samples and a wide range of engineering materials. It will also enable research into new cancer treatments. The beamline will be 150 metres long, with a satellite building which will later include a medical suite for clinical research as well as extensive support facilities for biomedical and clinical research programs. All experiment enclosures will eventually have near-beam surgery facilities for fast preparation-to-measurement transfers. The first phase of this 'long beamline' program will begin commissioning in 2009. It will cater for high-resolution phase contrast imaging of medium-sized samples.

Features

ï phase-contrast and analyser based x-ray imaging, which allows much greater contrast from weakly absorbing materials such as soft tissue than is possible using conventional methods
ï two and three-dimensional imaging at high resolution
ï lower tissue doses than conventional x-ray methods, making longitudinal studies (serial imaging) possible
ï tuneable beam energy, which enables the imaging of specific elements with very high sensitivity, possibly down to submicron scales
ï one of only three beamlines in the world configured for work with a wide range of bioclinical research subjects.

Applications

Synchrotron x-ray imaging techniques are particularly suited to the study of living processes, as well as *in-situ* materials processes, such as alloy solidification and precipitation phenomena. The techniques have numerous biomedical, materials science and industrial applications. The capability for *in-vivo* imaging of small animals will enable longitudinal studies to be undertaken and may reduce the number of animals used for biomedical research purposes. The beamline will be used for research into the physics and biophysics of cancer therapy techniques, and may lead to commercially-valuable advances in medical, industrial and biomedical imaging technologies.



Examples

- studies of lung function and development are assisting the development of better asthma treatments and improved clinical practice options for neonatal care
- measurements of bone density and porosity, enhanced mammography techniques, and studies of nerve cell regrowth to assist the development of biopolymers to treat spinal injuries
- the contrast mechanisms used to visualise soft tissues can also be used to study structures inside plants, and are of particular interest for investigating drought- and salt-tolerant plants to develop more efficient crops for Australian conditions
- materials science applications include the study of membranes for use in advanced fuel cells, investigation by micro-CT (computer tomography) of micro- and nano-structured devices for use in automotive applications, and examination of advanced materials during and after exposure to mechanical and environmental stresses
- geoscience applications include characterisation of CO_2 sequestration performance and investigation by micro-CT of porosity in oil-bearing rocks and oil release rates from reservoirs
- potential radiotherapy applications include microbeam radiation therapies that deliver much higher radiation doses than conventional therapies but without adverse effects—and could revolutionise the treatment of some currently untreatable cancers.

Case study 1

In-vivo imaging in physiology

Phase contrast x-ray imaging (PCI) techniques have shown great promise for improving image quality in mammography and, more recently, for lung imaging. Professors Rob Lewis and Stuart Hooper of Monash University are combining physics and physiology to understand factors affecting pre-term infants at birth. PCI is being used to observe lung aeration in small animals in vivo at very high spatial and temporal resolution, and will be extended to larger animals as models of human lung physiology. Observing lung behaviour in healthy animals will enable the development of better ventilation strategies at birth and prevent ventilation-induced lung injuries in hospital. Techniques are also being developed for early detection of lung diseases.

Case study 2

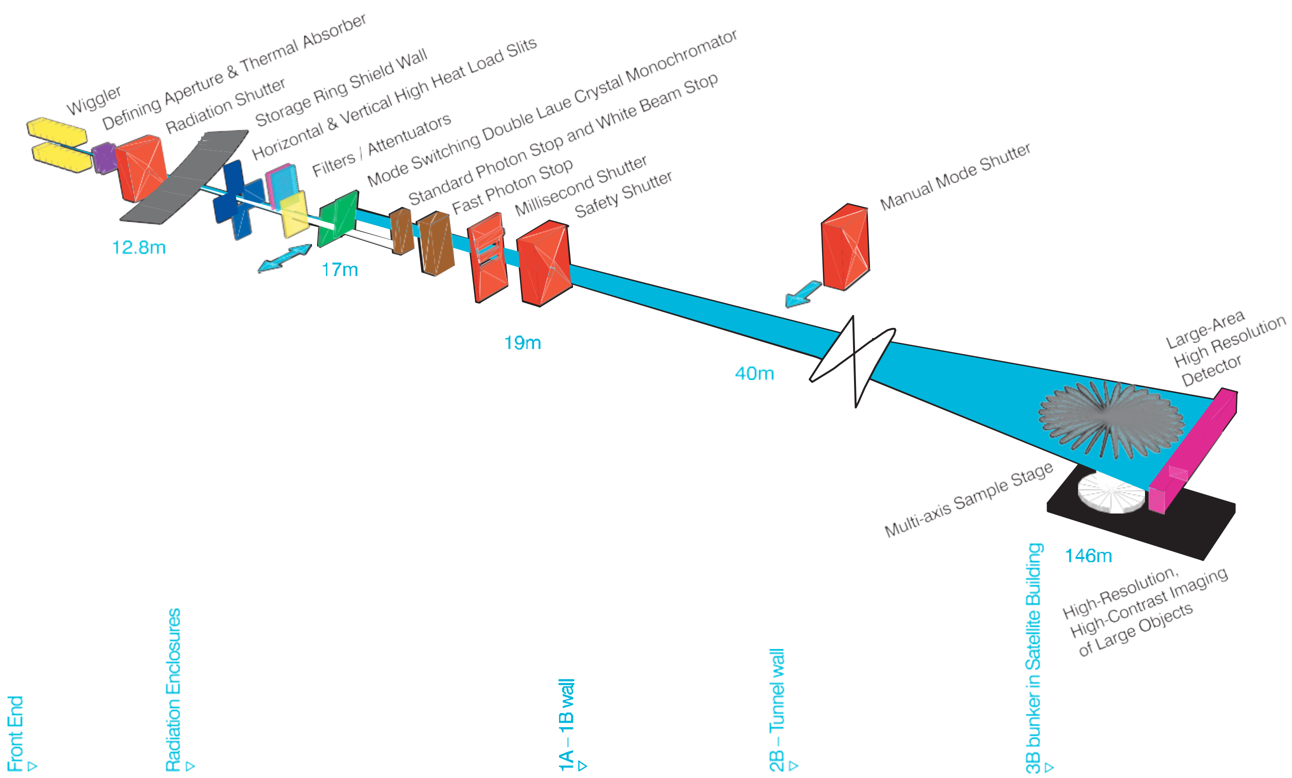
Microbeam radiation therapy

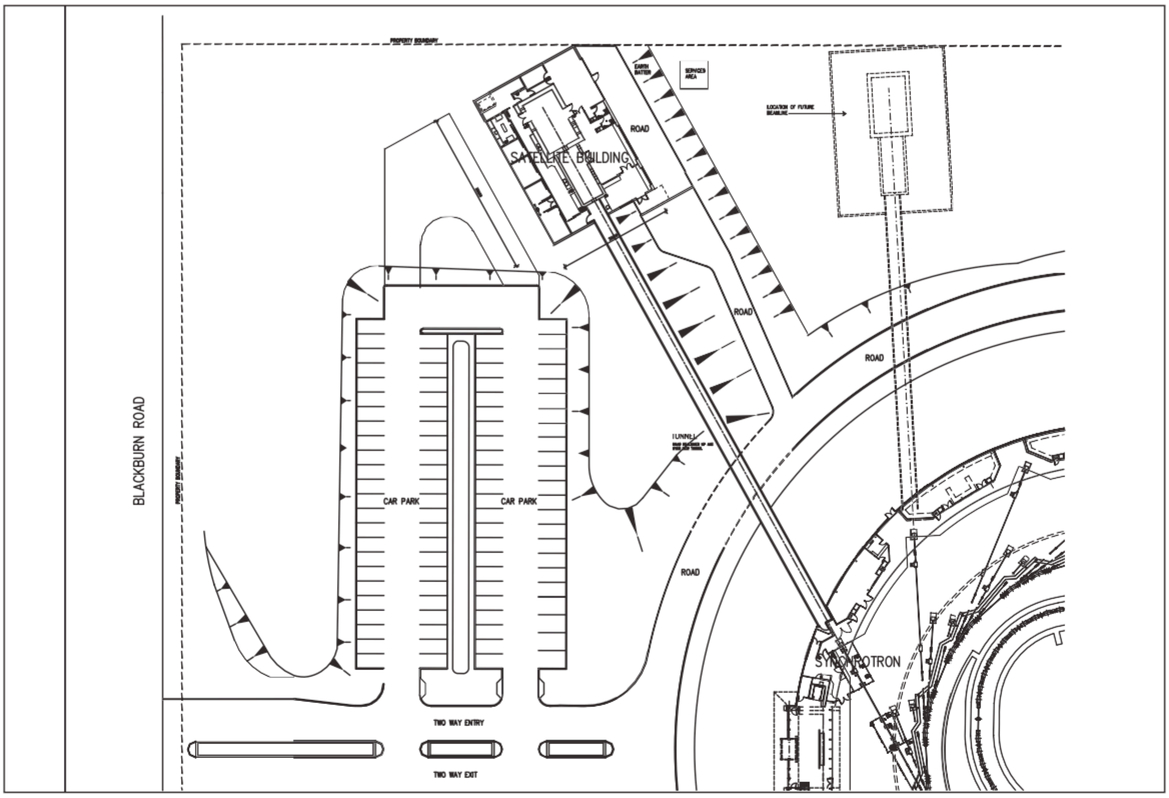
The observation that normal tissue has remarkable resistance to necrosis when irradiated with very thin X-ray beams has led to the development of microbeam radiation therapy (MRT). Dr Peter Rogers and colleagues from the Monash Medical Centre and Monash Centre for Synchrotron Science have found that normal tissue tolerates doses up to 100 times greater than those permitted in treatments using conventional methods, and that entire tumours ablate when only 10 per cent of their volume has been irradiated. The work challenges many preconceived ideas in radiotherapy. Continuing work aims to better understand whole-organ tissue responses and to define the physical parameters of MRT that maximise tumour cell kill while minimising normal tissue damage.

Case study 3

Soil–root interactions

Phase contrast imaging techniques will provide major insights into the soil–root interactions that occur in Australia's complex and often fragile agricultural soils. Dr Peter Fisher and his team from the Victorian Department of Primary Industries are conducting innovative proof-of-concept experiments in this area. The work could be extended to investigate the different root mechanisms employed by agricultural crops and native plants in hostile conditions, and to assist the development of crop models that can more accurately predict water and nutrient use efficiency and the design of better subsurface irrigation techniques.





Beamline specifications

	Stage 1: 2008	Stage 1: 2010
Source	1.4 T wiggler	4 T superconducting multipole wiggler
Available energy range	up to 60 keV	up to 180 keV
Optimal energy range	20 - 40 keV	20 - 120 keV
Total power	5.2 kW	29.5 kW
Maximum useable beam width at sample	120 mm at 40 m	200 mm at 40 m 600 mm at 150 m
Flux at 20m	10^{12} ph/s/mm^2/0.1% (at 30keV)	10^{12} ph/s/mm^2/0.1% (at 100 keV)

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