Australian Synchrotron

The Australian Synchrotron: where are we now?

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Australian use of synchrotrons

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The Australian Synchrotron

- 3 GeV storage ring
- 200 mA stored current
- 216 m circumference
- 12 available straight sections
- 6.98 nm rad natural emittance
- Capable of producing photons from IR to 120 keV
- 8 beamlines with user programs
- Possibility of going to top-up mode in the future

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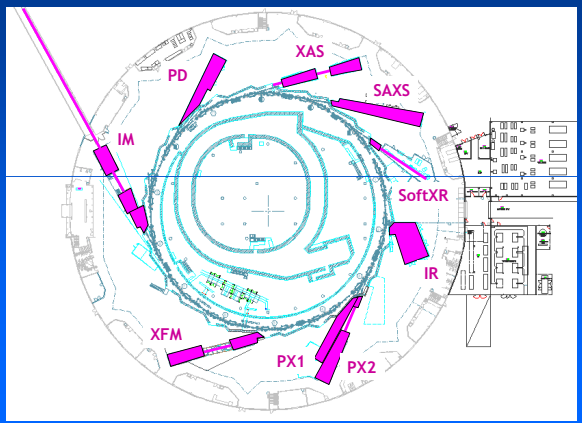
Current beamlines



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FTIR Microscope - Bruker V80v FTIR spectrometer with Hyperion microscope

Synchrotron just behind wall

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High Resolution FTIR - Gas phase studies 0.001 cm^{-1} resolution

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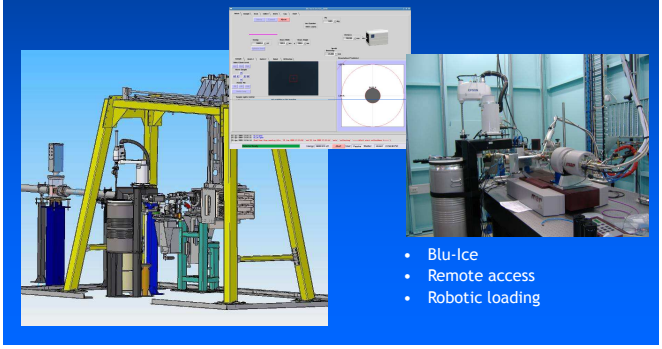
PX1 Protein Crystallography Beamline (5 – 20 keV)

250 x 200 µm beam size
>10^{11} ph/s in 100 x 100µm



- Blu-Ice
- Remote access
- Robotic loading

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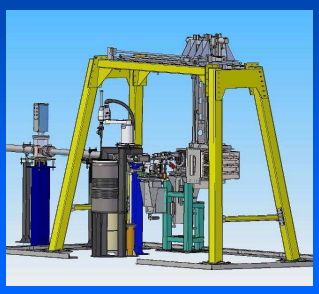
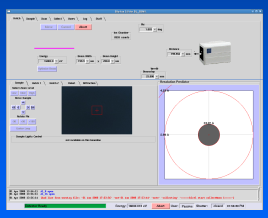
PX2 Protein Undulator Beamline (5.5 – 28 keV)

20 x 10 µm beam size
10^{13} ph/s in 100 x 100 µm





- Blu-Ice
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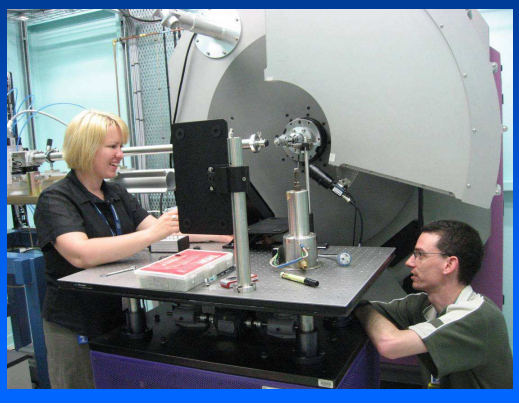
Powder Diffraction Beamline (4 – 37 keV)



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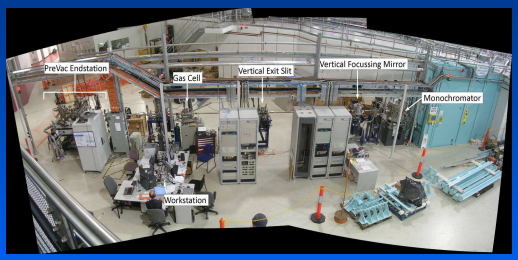
Soft X-ray Beamline (90 – 2500 eV)



- 90 - 2500 eV Beamline energy range
- 150 – 2000 eV Delivered beam energy range (K edges of C, O and N)
- Linear or circularly polarized light (100-1000 eV)
- Primarily for XAS of low atomic number elements and X-ray photoelectron spectroscopy (XPS).

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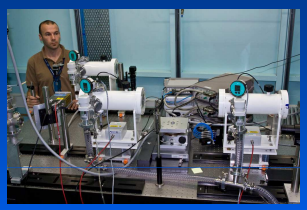
XAFS Beamline (4 to 50 keV)



- 100 x 500 µm beam size
- >10^{12} ph/s in 100 x 100 µm
- Choice of Si(111) or (311)

- Wiggler = smooth energy spectrum
- Like 40 bending magnet sources with better beam collimation
- 100 element fluorescence detector

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SAXS / WAXS Beamline (6 – 20 keV)

- 220 x 60 µm beam
- Simultaneous SAXS and WAXS
- Minimum q of < 0.001 $Å^{-1}$
- 10^{13} photons / s

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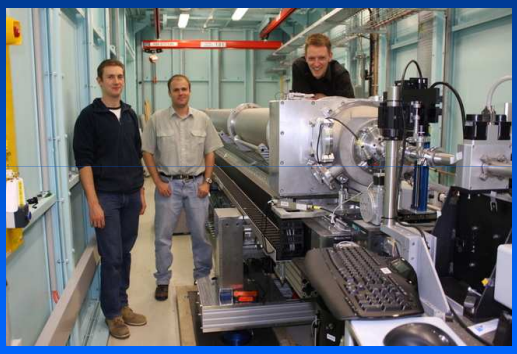

The team with the variable length SAXS camera

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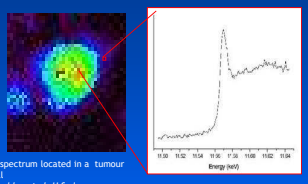
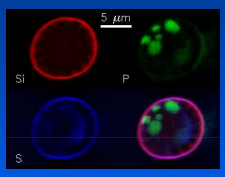
X-ray Fluorescence Microspectroscopy (XFM) beamline (4.5 – 25 keV)

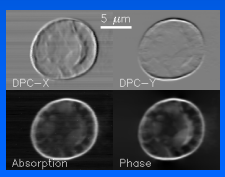


Pt spectrum located in a tumour cell
Hambley et al, U Sydney



Fluorescence mapping

- Spot size down to 50 nm
- X-ray fluorescence mapping (XRF)
- X-ray absorption spectra (XAS, μXANES, μEXAFS)



Quantitative DPC imaging

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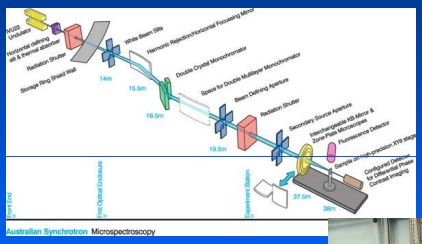
XFM beamline optics



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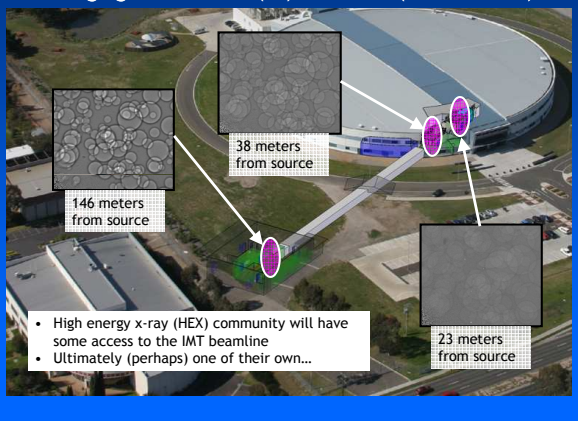
Imaging and Medical (IM) beamline (30 – 120 keV)



- High energy x-ray (HEX) community will have some access to the IMT beamline
- Ultimately (perhaps) one of their own…

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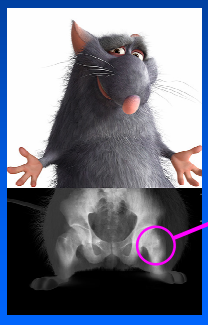
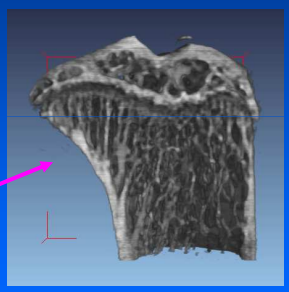
Imaging and Medical Beam Line
First light then tomography two weeks later!





$13.2M NH&MRC grant announced in April

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Future: - clinical facilities for mammography and cardiography research
- second floor of satellite building for reception and offices
- small animal holding
- near beam surgery facilities

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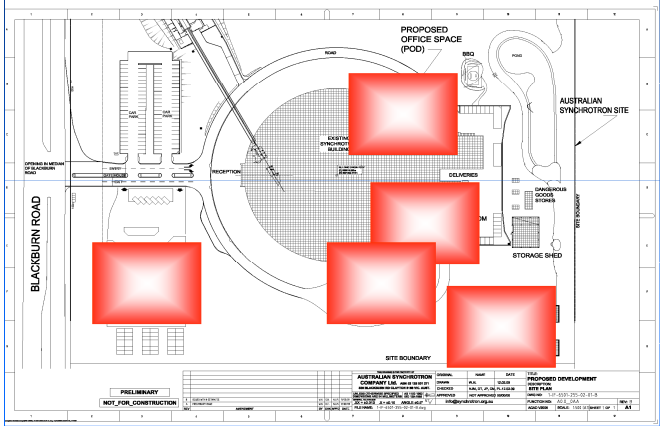

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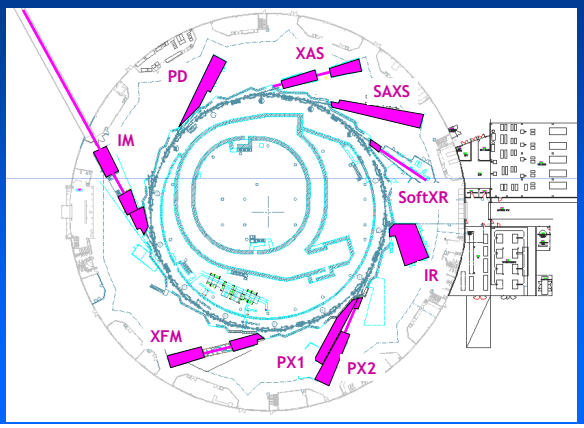
Current beamlines



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How did we get here?

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The National Science Case for the Initial Suite of Beamlines

Presented by
the Australian Synchrotron National Scientific Advisory Committee
on behalf of the Australian Science Community

DECEMBER 2003

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The initial list

10. Beamline summaries

Beamlines 1 & 2:	Crystallography of macro- and small molecules
Beamline 3:	Powder diffraction
Beamline 4:	Small and wide angle scattering
Beamline 5:	X-ray absorption spectroscopy
Beamline 6:	Soft x-ray spectroscopy
Beamline 7:	Vacuum ultraviolet spectroscopy
Beamline 8:	Infrared spectroscopy
Beamline 9:	Microspectroscopy
Beamline 10:	Imaging and medical therapy
Beamline 11:	Microdiffraction and fluorescence probe
Beamline 12:	Circular dichroism
Beamline 13:	Lithography

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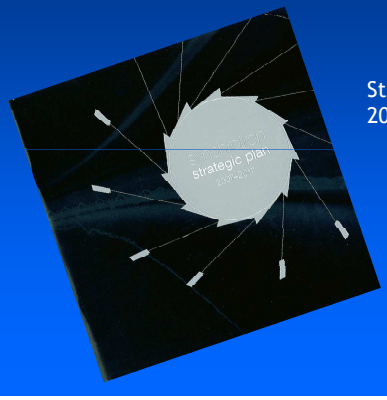
Subsequent planning



Strategic Plan for
2007-2017

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Research Trends

1. **Medical imaging and therapy**
2. **Structural biology**
3. **Structural genomics**
4. **Pharmaceuticals**
5. **Cellular imaging**
6. **Manufacturing**
7. **Environmental science**
8. **Energy science**

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Research Trends

9. **Materials science**
   - **Including nano- / nanobiotechnology**
10. **Extreme conditions science**
11. **Textile science**
12. **Geological science**
13. **Minerals processing**
14. **Ultra-fast science**
15. **Measurement trends**
    - **Including ultra-fast, ultra-sensitive and ultra-small measurements**

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Emerging capabilities

- Accelerators
  - Pulse compression and pump-probe experiments
  - Coherent control
  - Laser slicing
  - Laser-plasma acceleration techniques
  - Insertion devices
- Methods
  - Phase-contrast, single particle and single molecule imaging
  - Experimental stages
  - Combining techniques on some beamlines
- eResearch

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Recommendations

1. Developments across synchrotron-based science should be monitored and this plan amended accordingly in coming years.

2. Investment in eResearch modes should be regarded as essential in the near future for scientific experimentation and communication.

3. The initial suite of beamlines should be completed to world-class standards

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Recommendations

4. Resources should be made available for Australian researchers to continue to access overseas synchrotrons until beamlines are available locally, and for capabilities not available at the Australian Synchrotron, including access to fourth generation sources. Resources should also be provided for travel and subsistence costs associated with users accessing the Australian Synchrotron.

5. Access will best be provided under a single framework that includes the allocation of access to the Australian Synchrotron as well as access internationally.

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Recommendations

6. The Australian Synchrotron should be continually upgraded and evolve in its capabilities.
   - In the near term this would be with the addition of
     - circular dichroism,
     - combined micro X-ray diffraction and fluorescence,
     - medical imaging and extended-capability X-ray absorption spectroscopy.
     - high energy X-ray diffraction,
     - high-throughput micro computed tomography,
     - a long, high coherence beamline,
     - quick-scanning X-ray absorption spectroscopy and
     - time-resolved reflectometry.
   - Areas that require scoping or are emerging are
     - micro lithography,
     - nano lithography,
     - photoemission electron microscopy,
     - resonant inelastic X-ray scattering,
     - small molecule crystallography,
     - a THz beamline,
     - a protein crystallography beamline that would be the third at the Australian Synchrotron,
     - a vacuum ultraviolet beamline and X-ray microscopy / scanning transmission X-ray microscopy.

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Recommendations

7. Suitable convenient accommodation should be provided for scientists visiting the Australian Synchrotron.

8. Developments in accelerators, detectors, robotics for remote access and X-ray optics should also be introduced in collaboration with research partners. Ongoing funding for the Australian Synchrotron should include a commitment to new instrumentation and refurbishments.

9. Australia's X-ray optics and detector development communities should be nurtured.

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Recommendations

10. The capabilities proposed in this strategic plan should be accompanied by complementary development of skills among users, training of additional beamline scientists and technicians and development of the absorptive capacity required for future enhancement of the Australian Synchrotron.

11. The synchrotron community should actively engage with governments, the broader scientific community and the wider public.

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Recommendations

12. Industry-related programs should include:
    - a demonstration project program,
    - further development of capabilities attractive to industry,
    - rapid and timely access,
    - appropriate IP protocols,
    - quality assurance,
    - integrated safety practices and
    - technical consulting and support.
    - A successor to the National Industry Advisory Committee should be established.

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Available Beam Ports

ID	BM1	BM2	IR	Comments
Injection	Blocked			BM1 blocked by IR cabin and LCW pipes
			IR	Short straight - injection kicker
PX2	PX1			
XFM				
				Short straight - RF
	Optical diagnostic			Short straight - RF
IMT				
	PD	X-ray diagnostic		
				Short straight -Diagnostics
XAS				
SAXS/WAXS				
Soft x-ray				Short straight - injection kicker

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AS Development Plan

- To rationalise and justify future funding for the Australian Synchrotron on a sound scientific basis.
- To identify the most effective combination of projects going forward, in order to maximise benefit to, and satisfy identified demand in, the Australian and New Zealand scientific communities.
- To identify leading edge projects in which local scientists can become, or continue to be, world leading.
- To effectively engage the scientific community in the process of moving forward.

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AS Development Plan

Timeline

- Consultation (Roadshows) Aug, Sept 2009
- Submissions due 12 October 2009
- Publication of ASDP March 2010

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Selection Criteria

Projects should meet as many as possible of the following:

- Meet the demands of an identified group of researchers for new techniques.
- Take advantage of the existing third generation light source.
- Will position Australasian scientists at the leading edge of their field.
- Can be demonstrated to be feasibly constructed within a 3 year timeframe