Small Angle and Wide Angle X-ray Scattering

This beamline will collect small angle x-ray scattering (SAXS) and wide angle x-ray scattering (WAXS) data, either separately or simultaneously, on the structure and dynamics of complex materials and large molecular assemblies such as polymers, colloids, emulsions and biomolecules in solution. Synchrotron sources provide valuable information on dynamic processes that is not available by any other means.

Features

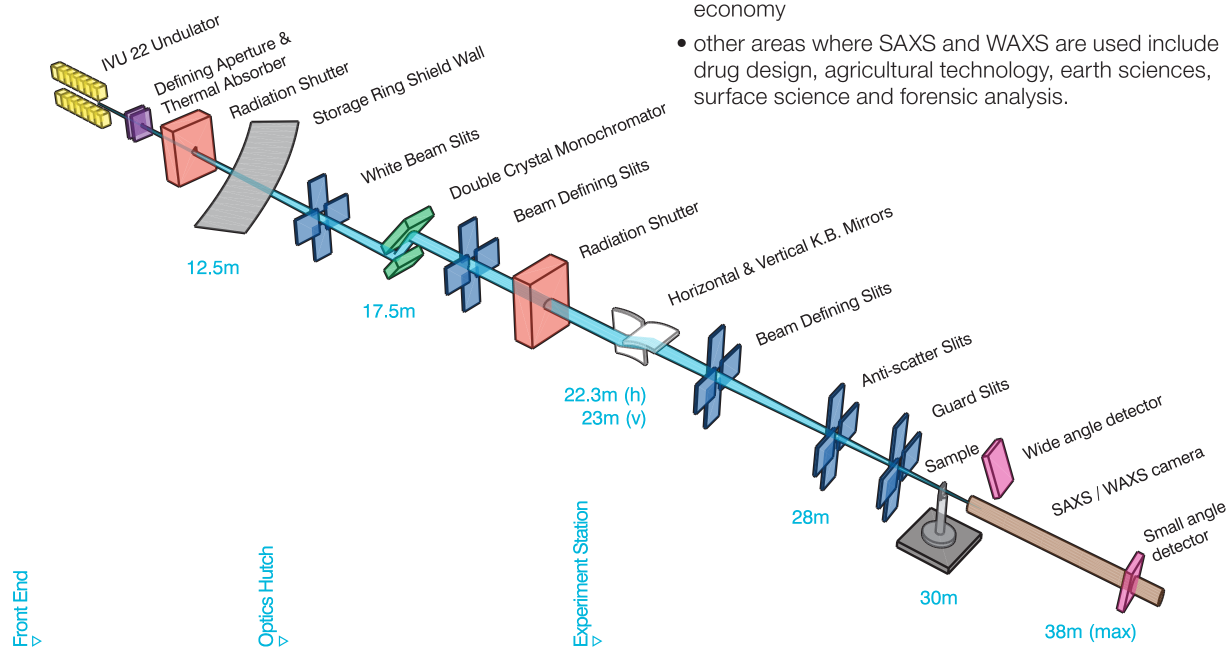
- medium energy, high flux, simultaneous SAXS and WAXS, suitable for both very weak and strong scattering samples
- rapid data collection for fast time-dependent studies
- high speed time-resolved, spatially-resolved and anomalous scattering (energy-resolved) analysis
- analysis of solid surfaces, thin films and liquid surfaces
- *in-situ* measurement of dynamic processes such as polymer processing, mineral processing and crystallisation.

Applications

SAXS provides information on long range order in complex molecules and materials, particularly for features in the size range of ~1 nm to 500 nm. WAXS provides information on the atomic scale down to ~0.1 nm similar to standard x-ray diffraction techniques. Studies of processes such as nucleation and crystallisation use SAXS and WAXS in combination. SAXS and WAXS complement NMR, electron microscopy, light scattering and small angle neutron scattering (SANS) techniques. They are used to study a wide range of samples and systems in the life sciences and physical sciences, including muscle and membrane structures, chemical reactions and catalysts, advanced materials and food components.

Examples

- insights into domain reorientation and protein-protein interactions in cellular signalling are helping to improve our understanding of biochemical regulation
- studies of protein oligomerisation during conformational transformation are helping to shed light on neurodegenerative diseases such as Alzheimer's and prion diseases such as bovine spongiform encephalopathy (BSE or mad cow disease)
- investigation of the hierarchy of interplay and the formation of complex arrays in self-assembled systems such as the clustering of C60 and higher fullerenes used in the manufacture of nanomaterials
- analysis of the solution structure of colloid-forming salts such as zirconium chloride, to improve the manufacture of ceramic solid oxide fuel cells for the hydrogen economy
- other areas where SAXS and WAXS are used include drug design, agricultural technology, earth sciences, surface science and forensic analysis.



Case study 1

Watching the heart beat in real time

Dr James Pearson and researchers at Monash University are using SAXS to study structural changes in heart muscle associated with heart conditions such as ischaemia and hypertrophy. They will use the advanced high speed capabilities of the SAXS beamline to measure tissue structure and actin-myosin interactions in real time in beating heart muscles. The work will improve our understanding of the fundamental processes of heart contractions, and help to determine new ways to reduce and prevent permanent damage and structural changes that lead to heart failure.

Case study 2

Turning gold into nano-rods

Metallic nanoparticles have many valuable uses, including biosensors, data storage, diagnostic and therapeutic medical procedures, spectrally sensitive coatings and catalysis. The world market for gold nanoparticles in biomedical, pharmaceutical and cosmetic applications is worth over $200 million.

Most nanoparticle applications depend on exotic optical properties that vary with particle size, shape and composition. Nano-rods exploit the shape dependence of optical properties, further broadening the range of possible applications.

Dr Catherine Kealley and colleagues at the University of Technology, Sydney, are using in-situ synchrotron SAXS techniques to study the formation and growth of gold nano-rods. The aim is to develop ways to synthesise nano-rods with optimal properties for specific applications. Synchrotron SAXS offers much better intensity, data quality and time resolution than laboratory SAXS equipment, allowing new areas of research to be explored.

Case study 3

Biological processes—protein kinases

Dr Jill Trewhella, a Federation Fellow based at Sydney University, is studying the global structures of large biological molecules in solution. Her aim is to investigate how these molecules work together to regulate key cellular processes that underpin specific biological responses such as a muscle twitch, particularly focusing on kinases, enzymes that modify the actions of other proteins by attaching or detaching phosphate groups. Trewhella's findings will contribute to human health through a better knowl dge of the cellular processes that underpin healthy biological functioning or are implicated in disease states.

Case study 4

Food safety, quality and nutrition

Dr Raymond Mawson and other researchers from Food Science Australia plan to use synchrotron techniques to advance their understanding of molecular food structure for a range of applications. These include managing nutrient availability, protecting and delivering 'bioactive' components in functional foods, assessing microbiological risks associated with food structures and processing and packaging surfaces, developing models and technologies for improving food texture and flavour release, and ensuring the stability of food materials during processing.

Beamline specifications

Source	in-vacuum undulator, 22mm period, 3m length, Kmax =1.56
Energy range	5.2 - 20 keV
Flux	10^{13} photons/s
Energy resolution	~10^{-4} and option for ~10^{-2} in future
Beam size at specimen (FWHM)	250 - 700 µm horizontal, 40 – 500 µm vertical with full flux. Smaller size by slitting down beam.
q-range	0.0015 - 1.5 $Å^{-1}$ for SAXS up to 12 $Å^{-1}$ for WAXS

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