

What is Brilliant About Synchrotron Science

Professor Michael James



Asia Oceania Forum for Synchrotron Radiation Research





Asia Oceania Forum for
Synchrotron Radiation Research

Members:

- Australia
- China
- India
- Japan
- South Korea
- Singapore
- Taiwan
- Thailand

Associate Members:

- Indonesia
- Malaysia
- New Zealand
- Philippines
- Vietnam

Australian
Synchrotron

ANSTO

Australian Nuclear Science & Technology Organisation

A leader in nuclear science
and technology

Operating safely
for over 70 years

Over 1400
skilled employees

Managing over \$1.5 billion
in scientific infrastructure

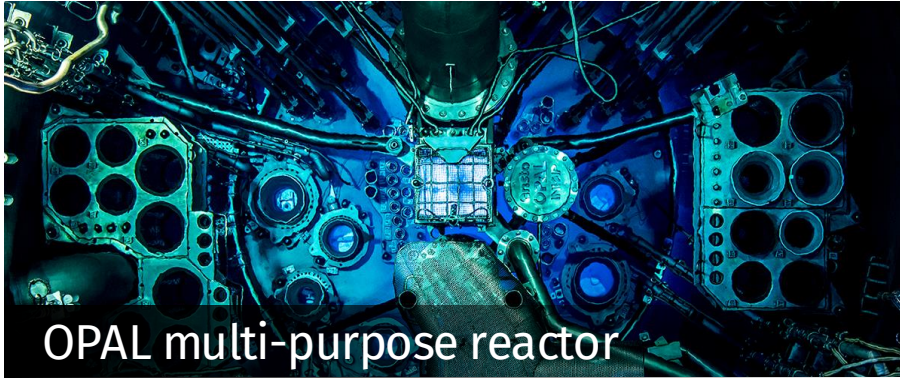
ANSTO's Lucas Heights campus

TWO LOCATIONS



1000 km between offices

ANSTO's National Research Infrastructure



OPAL multi-purpose reactor



Australian Centre for Neutron Scattering



Centre for Accelerator Science



Australian Synchrotron

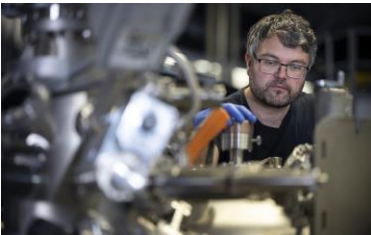
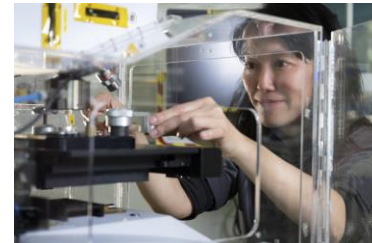
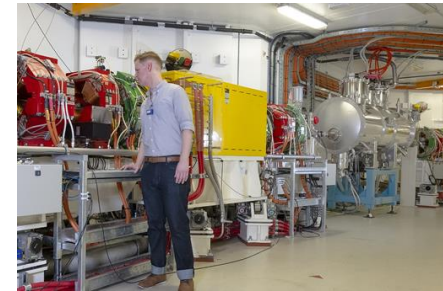
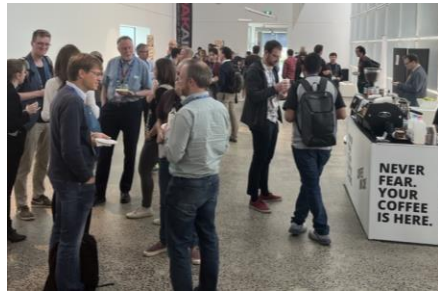
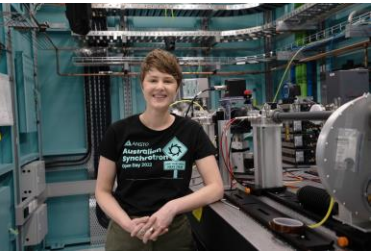
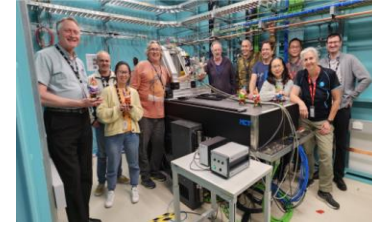
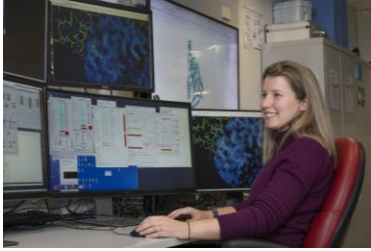


National Deuteration Facility



ANSTO Biosciences

Our Team @ The Australian Synchrotron



220 Staff

60 Scientists

55 Engineers

55 Controls & Computing

20 Accelerators Ops

**30 HR, WHS, Finance,
User Office, PMO, Quality, IT**

The Australian Synchrotron at a Glance

Operational since **2007**

~220 Staff on the Clayton Site

“24/7” User Facility

14 Operational Beamlines;

4 Beamlines Under Construction

1000 Experiments P.A

10,000 Registered Users

600 Journal Publications P.A.

300 Protein Data Bank Structures P.A.

150 Graduate Theses; **20** Patents P.A.

~\$40M Facility Refurbishment Projects

\$100M BRIGHT Beamline Program



International
User Facility

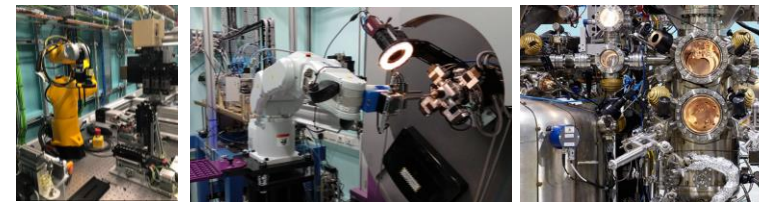
New Solar Plant



Nanoprobe Satellite
Building



3 GeV Electron
Accelerator



14 Operational
Beamlines
+ 4 to come



Operate 50 Room
Guesthouse

Research @ The Australian Synchrotron

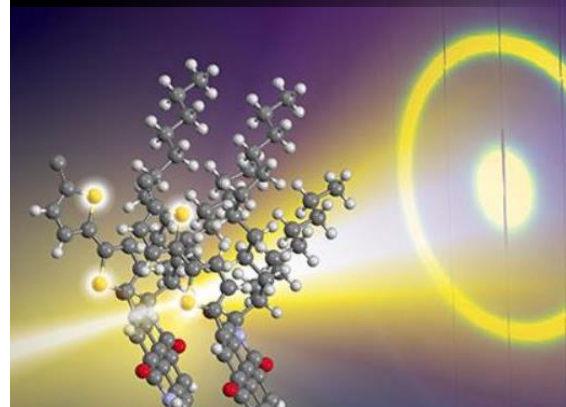
Structural Biology & Health



Environmental



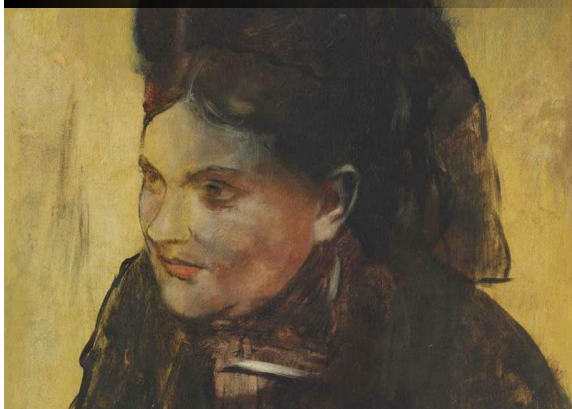
Materials



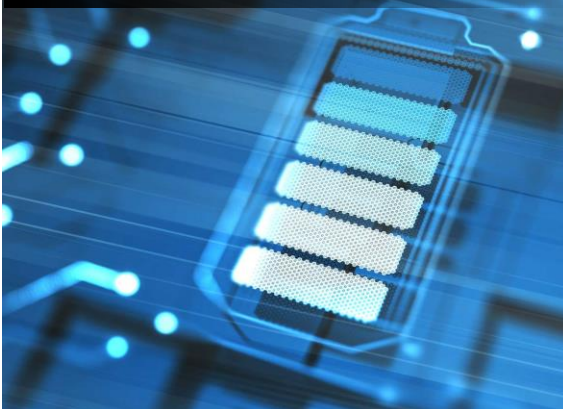
Food science



Cultural heritage



Energy



Agriculture



Planetary science

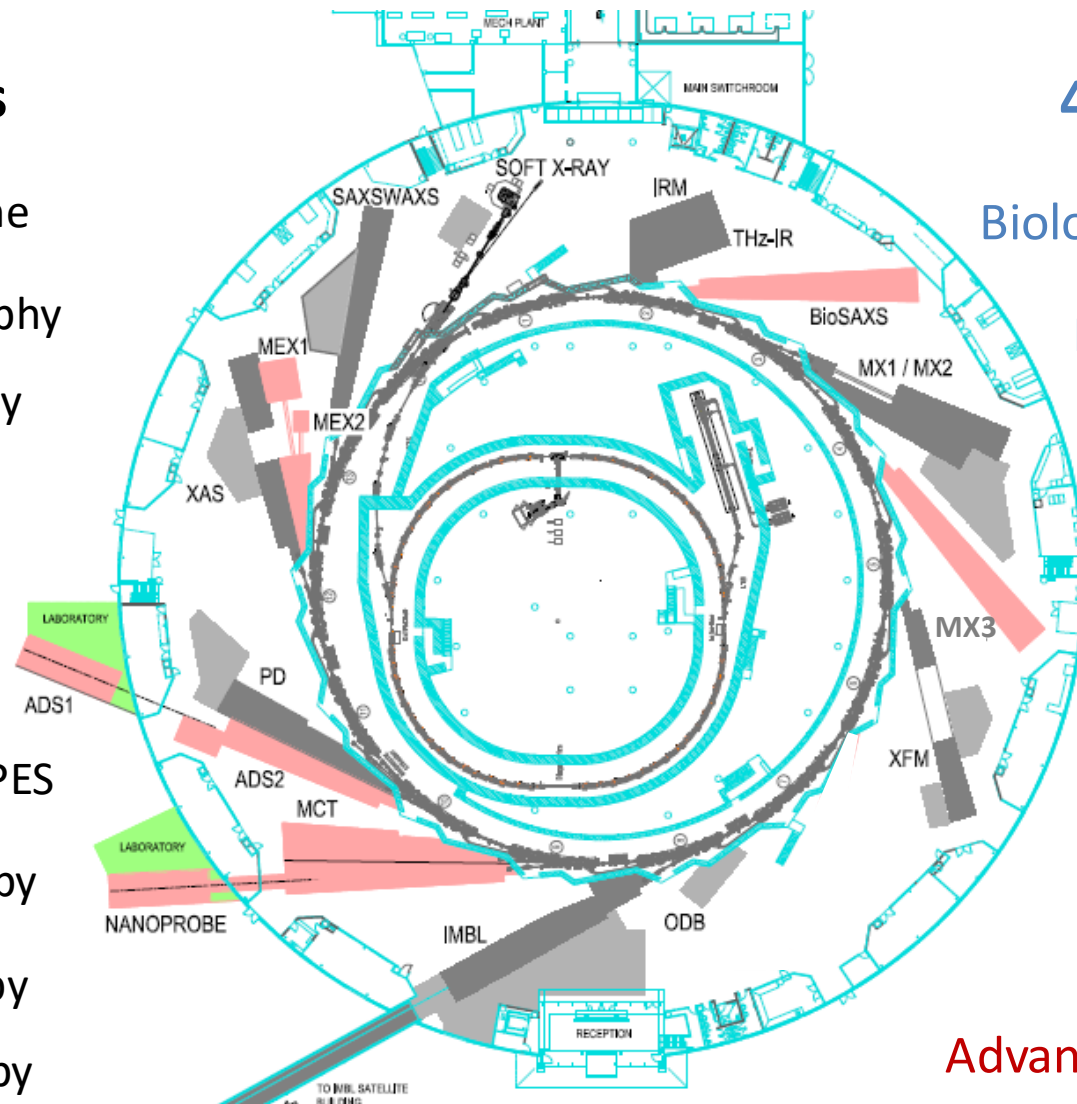


593 peer-Reviewed Publications in 2023

Australian Synchrotron Beamlines

10 Original Beamlines

Imaging and Medical Beamline
Macromolecular Crystallography
Micro-focused Crystallography
Infrared Microscopy
Powder Diffraction
SAXS / WAXS
Soft X-ray Spectroscopy / ARPES
Terahertz / Far-IR Spectroscopy
X-ray Absorption Spectroscopy
X-ray Fluorescence Microscopy



4 New BRIGHT Beamlines

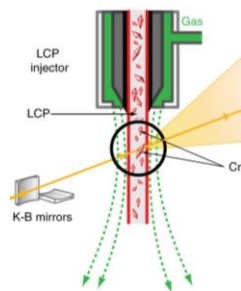
Biological Small Angle X-ray Scattering
Micro-Computed Tomography
Medium Energy XAS 1 & 2

4 BRIGHT Beamlines Under Construction

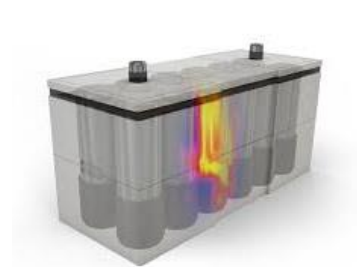
High Performance MX
X-ray Fluorescence Nanoprobe
Advanced Diffraction and Scattering 1 & 2

The BRIGHT Beamlines deliver new research capabilities

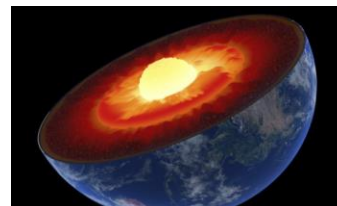
BRIGHT



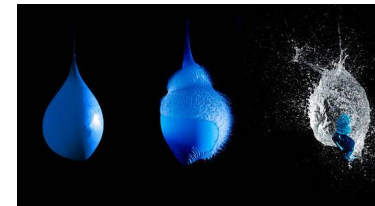
Higher
Throughput



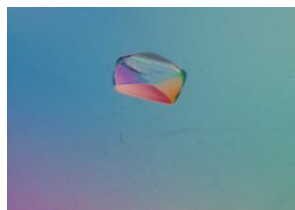
Higher
Energies



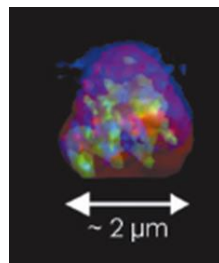
Extreme
Environments



Faster
Dynamics



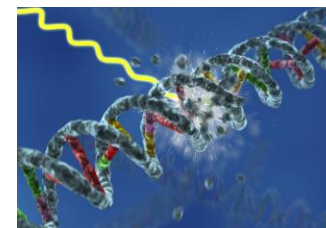
Smaller
Beams



Finer
Spatial
Resolution

																		2
																		He helium
5	6	7	8	9											10			
B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine											Ne Neon			
13	14	15	16	17											18			
Al Aluminum	Si Silicon	P Phosphorus	S Sulfur	Cl Chlorine											Ar Argon			
31	32	33	34	35											36			
Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine											Kr Krypton			
49	50	51	52	53											54			
In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine											Xe Xenon			
81	82	83	84	85											86			
Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium	At Astatine											Rn Radon			

New
Chemistry



Less
Damage

Seeing into the Nanoscale



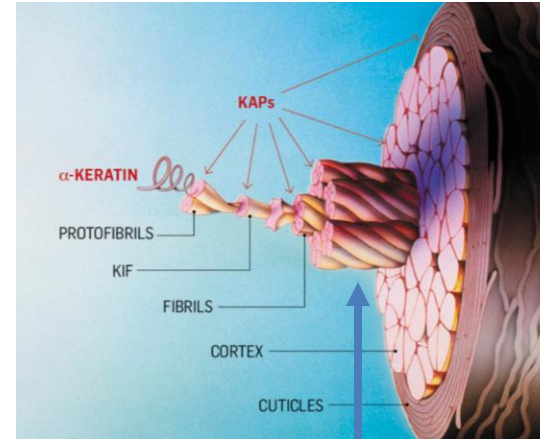
1.8 m

An Australian
Synchrotron User

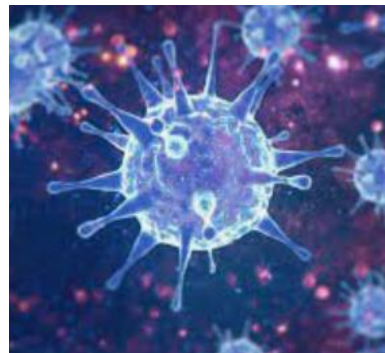


100 μm

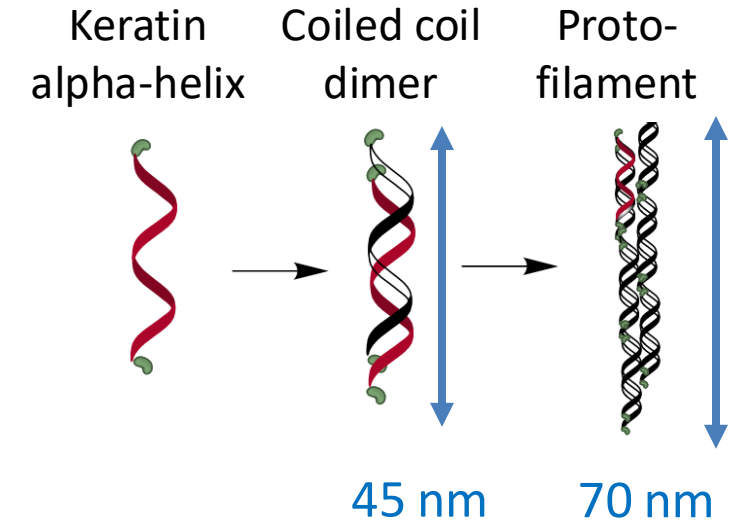
Width of a human hair



Made-up of hierarchical
fibrils of alpha-Keratin



SARS-CoV-2 Virus
80 nm



Which are composed of
protofibrils of Keratin
alpha-helix polypeptides

It Will Be Over Before You Can Blink



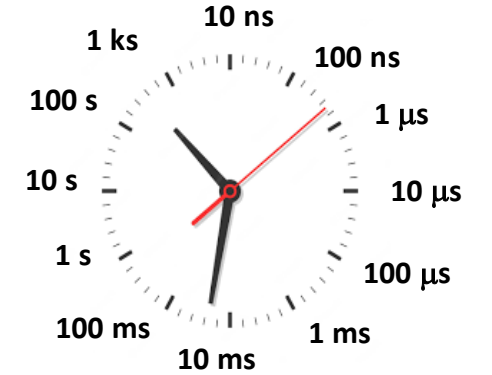
100 ms

In the blink
of an eye



1 ms

The time it takes a
camera to flash

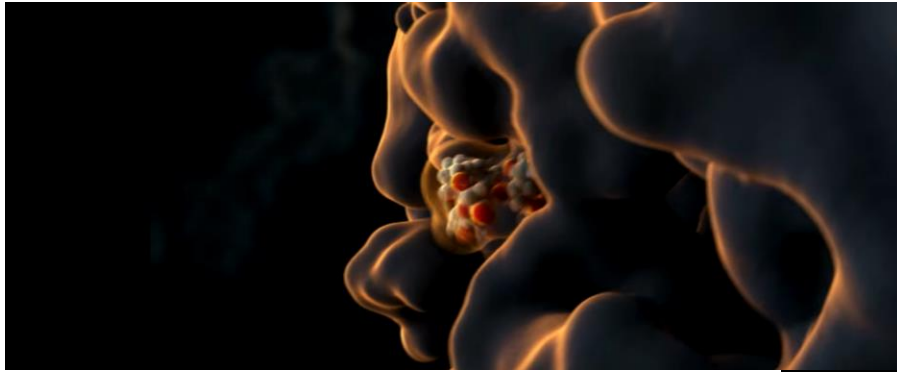


25 μs

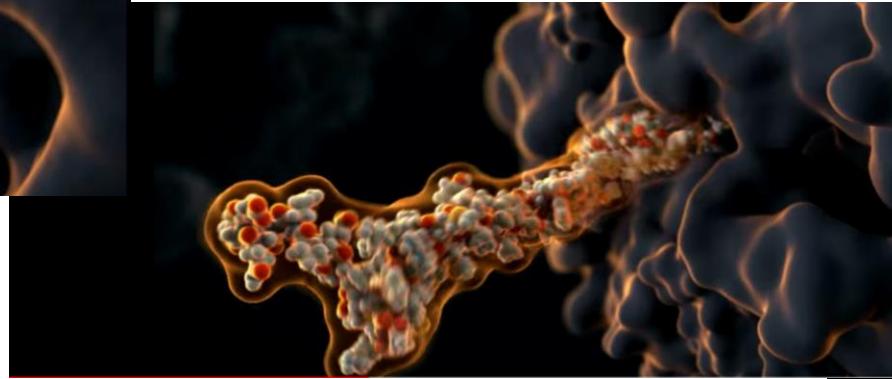
The time it takes a stick
of dynamite to explode



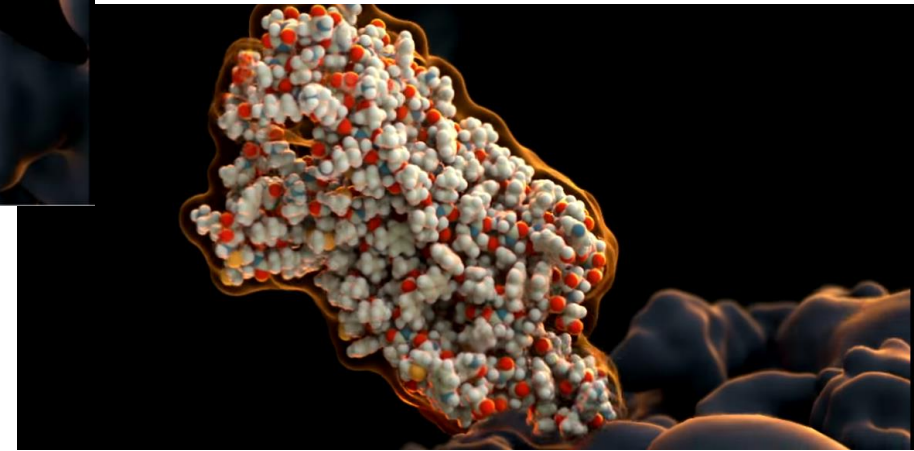
Proteins Reactions & Motions Occur on ms Timescales



22 Amino Acids



78 Amino Acids



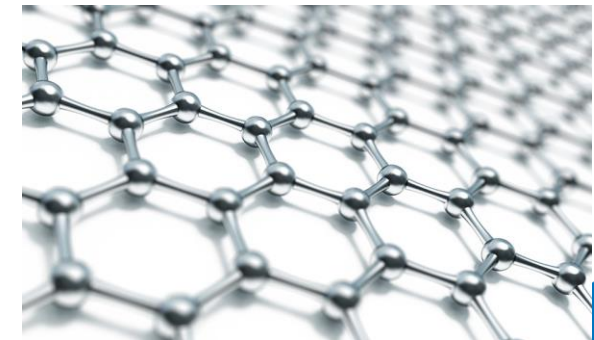
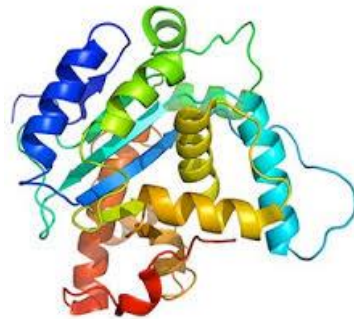
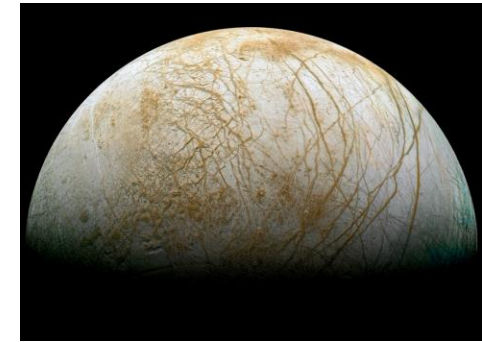
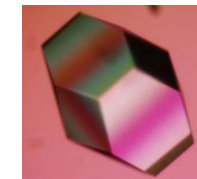
325 Amino Acids

Protein synthesis and protein folding take place on millisecond timescales and will be visible using high-speed data acquisition on BioSAXS

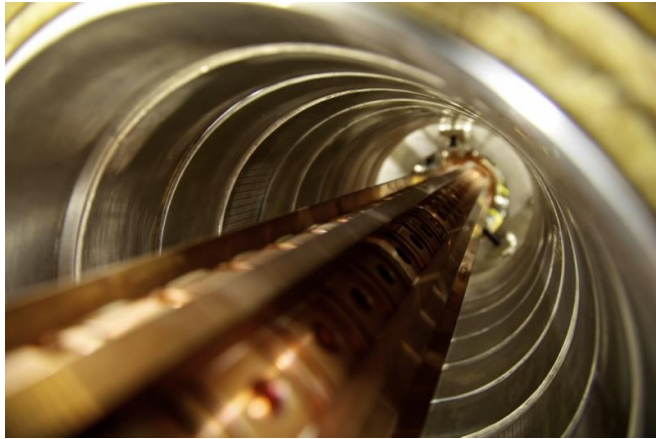
A 'Typical' Synchrotron Sample

(There's no such thing...)

- From a few microns to $\sim 1 \text{ m}^2$
- A single layer of atoms to $\sim 100 \text{ kg}$
- $10 \text{ K} - 2300 \text{ }^\circ\text{C}$
- Pressures up to 30,000 atmospheres
- Parts per billion
- $< 0.005 \text{ mg/mL}$



The Australian Synchrotron – Accelerator Systems



Storage Ring Circumference: 216 m

Electron Energy: 3 Billion eV (GeV)

Electron Velocity: 99.9999985% Speed of Light
(1.4 million laps per second)

Beam Current: 200 mA; 1.25×10^{18} e-

Electron Beam Size: ~60 microns

Vacuum Pressure: 10^{-11} mbar

Magnetic fields: up to 4 T



The Australian Synchrotron – Solar Powered...



New Solar Plant – January 2024

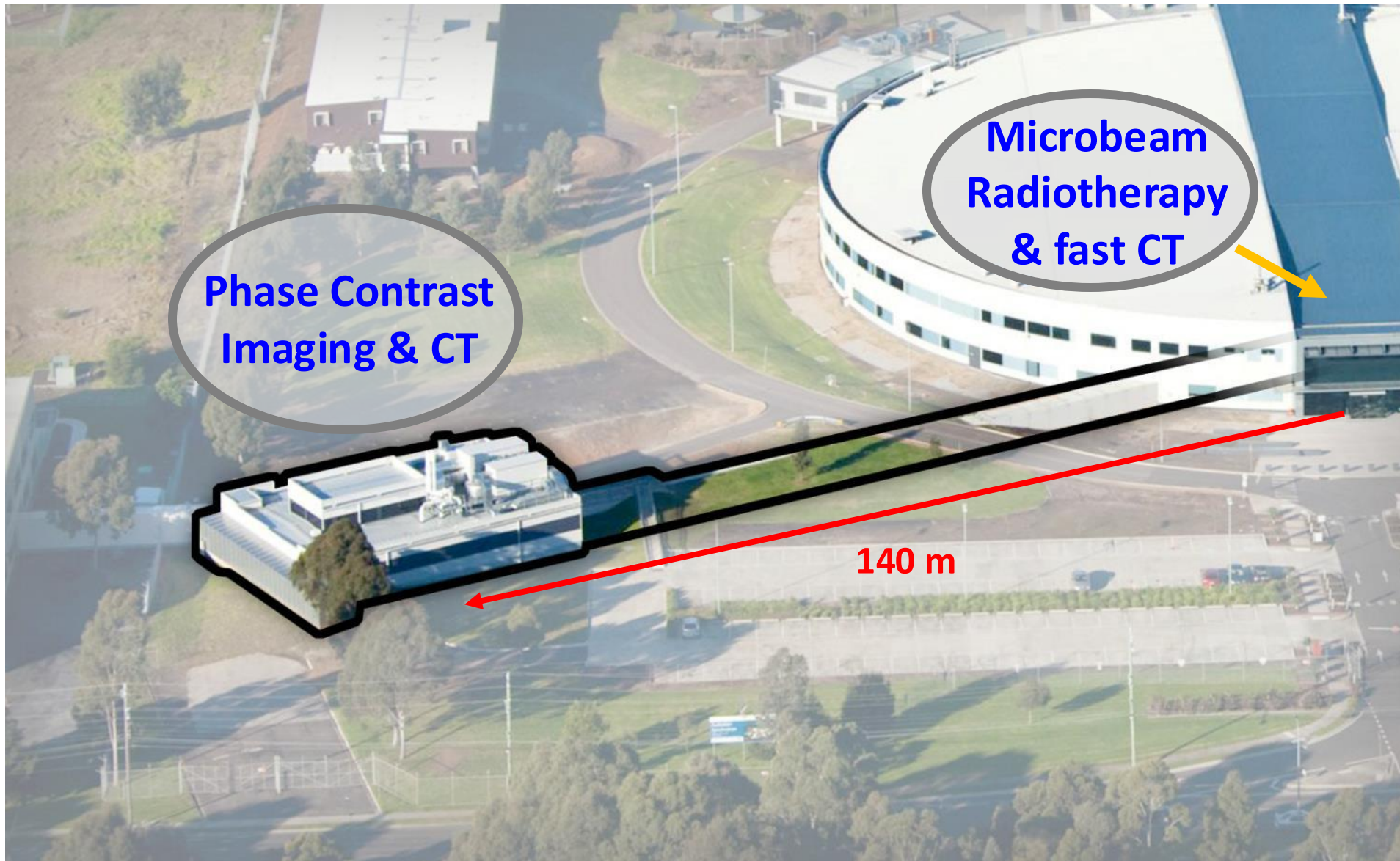
3,200 new solar panels

Generate over two million kWh and
reduce our carbon footprint by over
2,300 tonnes of CO₂ per year.



Light from the sun generates electricity,
that is used to generate *synchrotron light*,
that is used to develop new solar cell
technologies, that can be used to
generate electricity...

The Imaging and Medical Beamline (AS)



Imaging & Medical Beamline (AS)



Phase Contrast CT and Radiography of heavy (~ 100 kg) and large (> 1 m) objects

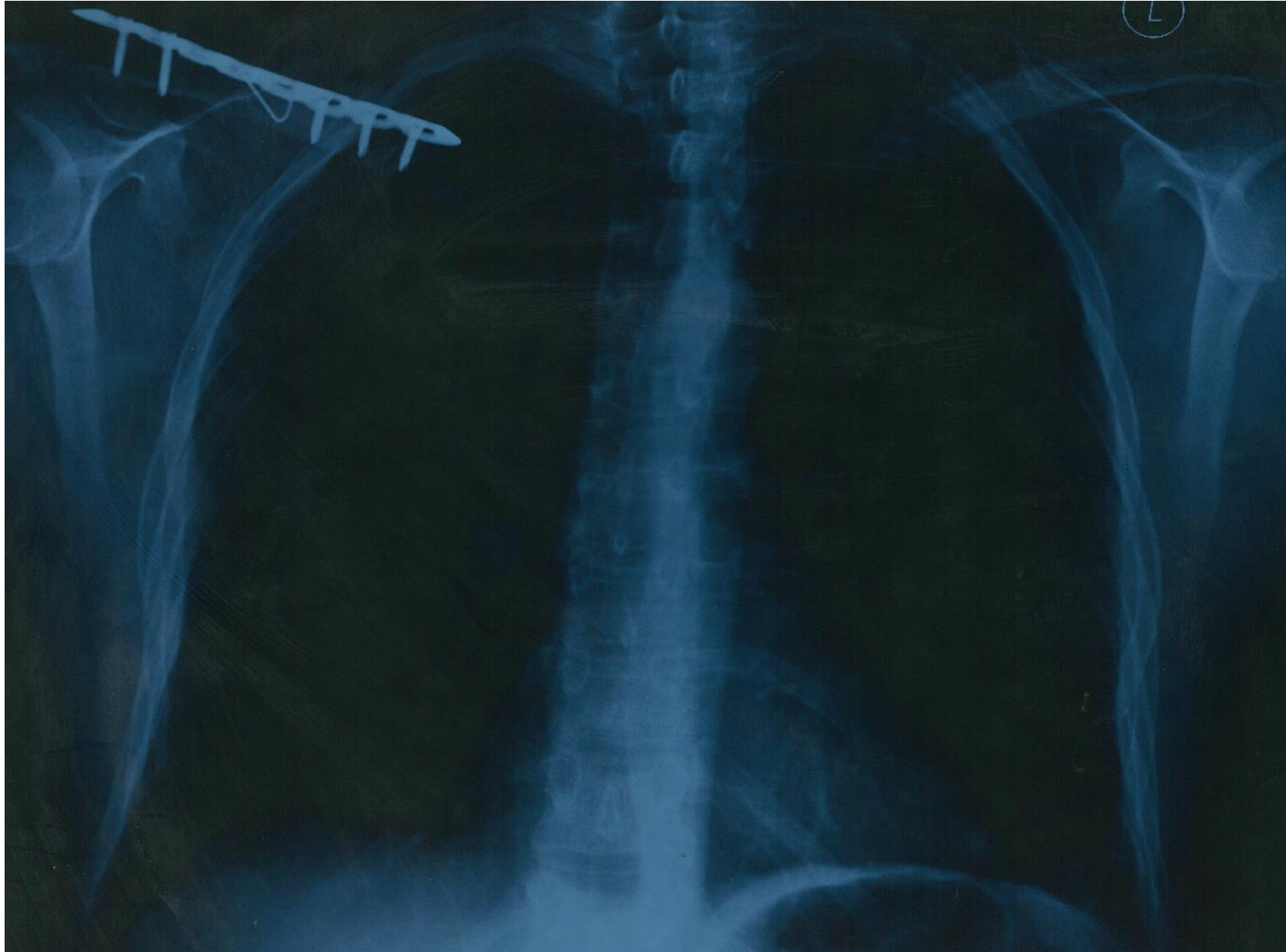
Photon Energy: Up to 300 keV

**Beam Dimensions: 300 mm x 20 mm, or
80 mm x 80 mm**

Resolution: 10-20 μm

Human “patients” coming in 2025...

Conventional (Adsorption) X-ray Imaging



Helping Babies Breathe Easier



Finding better ways to deliver air to pre-term infants in the first vital minutes of life.

- 23% of babies in Australia (~71,000 P.A.) need assistance at birth.
- Many experience neurodevelopmental, respiratory and cardiovascular complications due to a failure to adequately transition to natural breathing.
- Research on understanding the critical processes regulating the cardiorespiratory transition at birth and how best to assist in delivering improved outcomes.

Fighting Cardiorespiratory Diseases in Pre-Term Infants

Testing specific inflammatory signalling molecules is critical to understanding and treatment of diseases such as *Paediatric Bronchopulmonary Dysplasia* and *Pulmonary Hypertension*.

Mouse lung in model of PBD.
Feature resolution in the blood-gas exchange interface below 50µm.

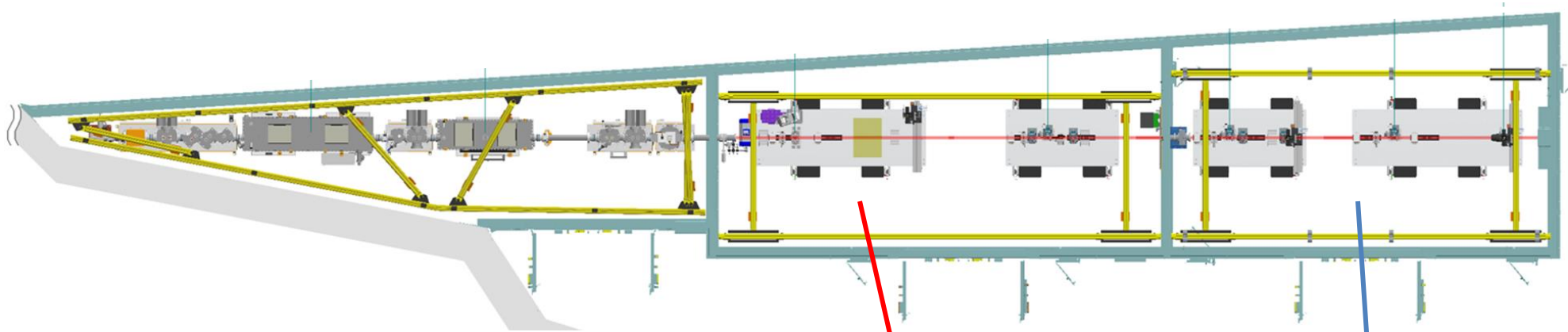
A/Prof Marcel Nold and Dr Claudia Nold,
(Hudson Institute of Medical Research)



Christine B. Bui, et al.,
Frontiers in Immunology, **10**, 1480 (2019).

Jason C. Lao, et al.,
Science Translational Medicine, **14**, 639 (2022).

Micro-Computed Tomography



BR—GHT



Now in Operation

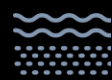
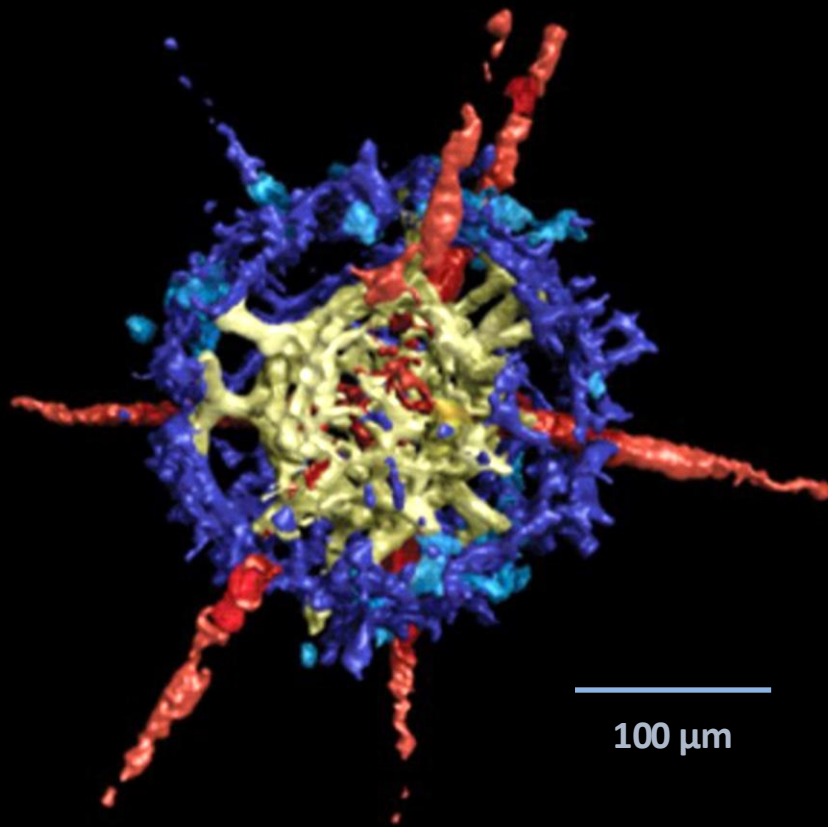


Sample Table &
Sample Robot

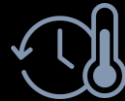
“Nano-CT” and
special modalities
in 2025

Managing Climate Change

Data from the past informs the future



Analysis of *Radiolarian* microfossils
preserved in marine sediments



Helps reconstruct the palaeo-climate
of the Southern Oceans



Necessary resolution and throughput
available only at MCT



Better understanding and management of
modern climate change

20+

Radiolarians
across eight species
were characterised

Shale core size



Rice grain



**Micro-Computed
Tomography
Beamline
(MCT)**

Unicellular marine protozoans from the mid-Cambrian

Image courtesy of Prof. Jonathan Aitchison (UQ) and Dr Sarah Kachovich (ANU).

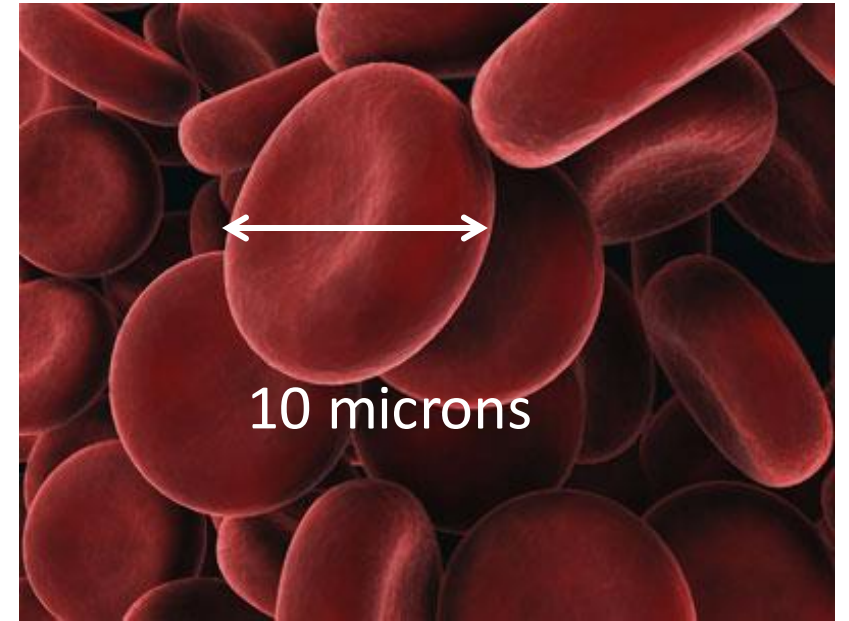
Infrared Microscopy (IRM)

Ideally suited for small particles and thin layers within complex samples, or thin coatings on surfaces

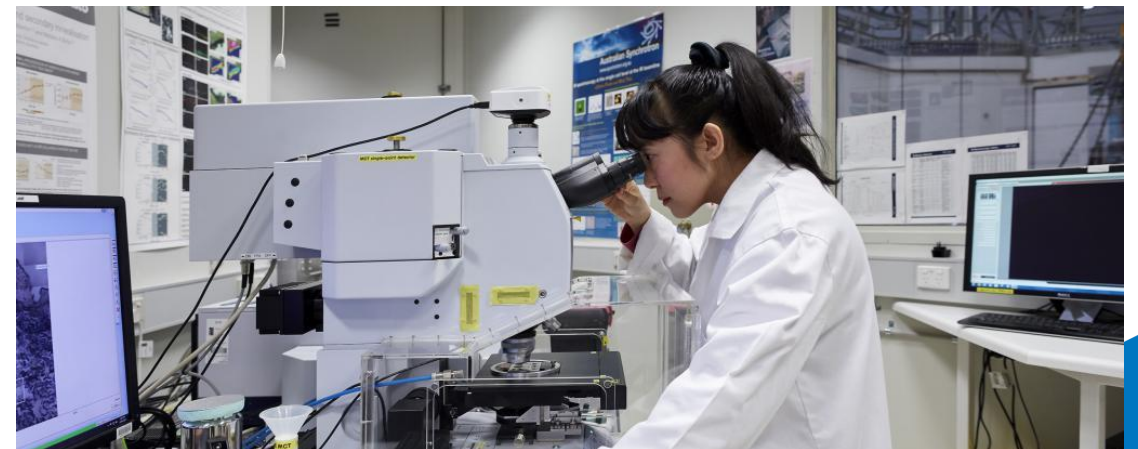
Molecular and chemical analysis at high spatial resolutions, $600 - 6000 \text{ cm}^{-1}$

**Diffraction limited spot size $3\text{-}5 \text{ }\mu\text{m}$,
step size $1 \text{ }\mu\text{m}$**

Multiple sample mounts available



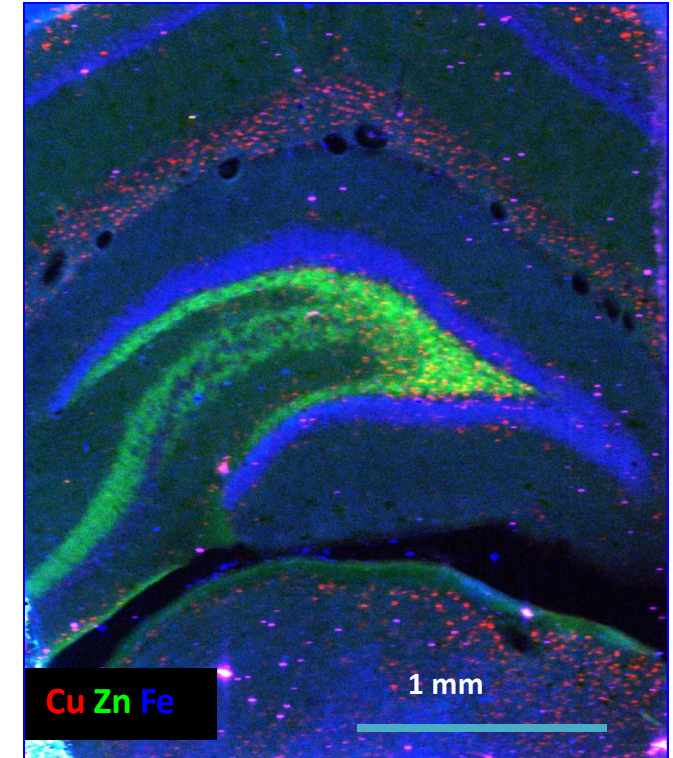
Human red blood cells



X-ray Fluorescence Microspectroscopy (XFM)

- **Simultaneous** access to **10⁺ elements** $Z > 14 \sim \text{Si}$
- **High sensitivity** - sub-ppm
- **Resolution** – **down to 1 micron** (*mapping*)
– **down to 50 nm** (*structure*)
- Native contrast - no dyes or contrast agents
- Quantitative
- Non-destructive / minor damage
- Extended penetration & Depth of Field
- Sensitive to chemical speciation via XANES

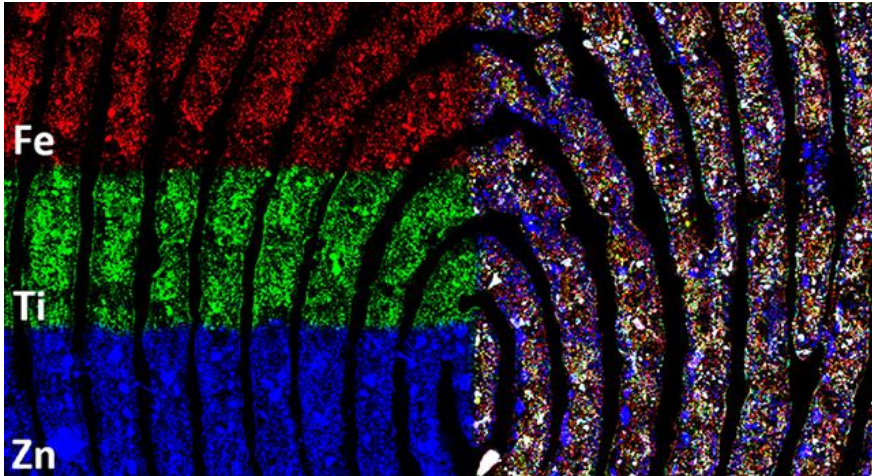
Applications: Biosciences & Health, Earth Sciences, Mining & Mineral Extraction, Agriculture, Environmental Science & Climate Change, Cultural Heritage,...



Mark Hackett et al.,
ACS Chemical Neuroscience,
10, 2533 (2019).

Forensic Analysis of Fingermarks

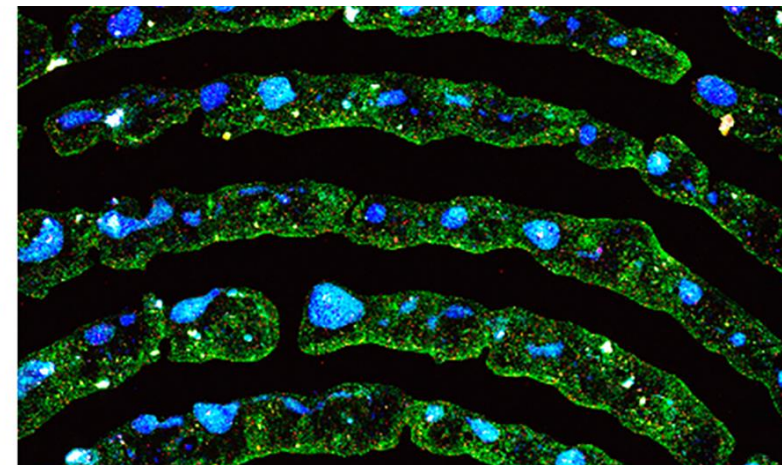
(IRM and XFM)



Fingermarks contain important trace information for forensic analysis.

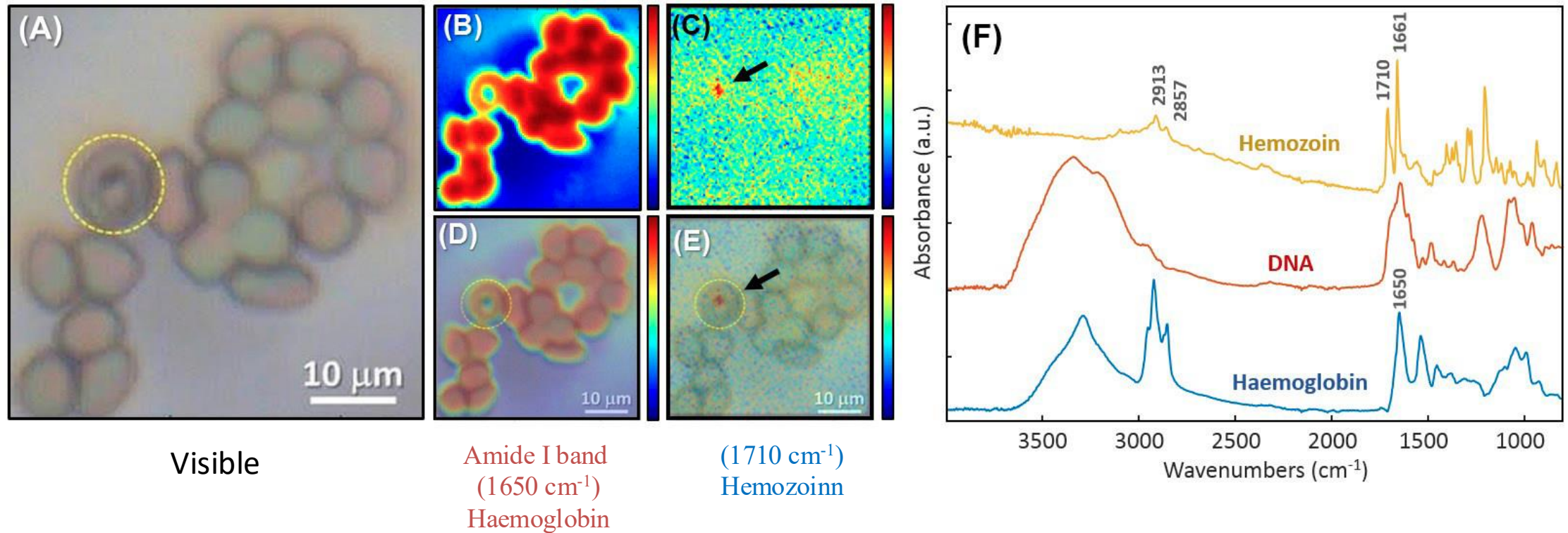
Understanding the chemical contributions from organic and inorganic components provide new detection capabilities.

A multimodal study using **X-ray Fluorescence Microscopy** and **Infrared Microspectroscopy** gives colocalization of endogenous metals within the hydrophilic organic components.



Rhiannon E. Boseley, *et al.*,
Analytical Chemistry, **81**, 10622 (2019).
Analyst, **147**, 387 (2022).

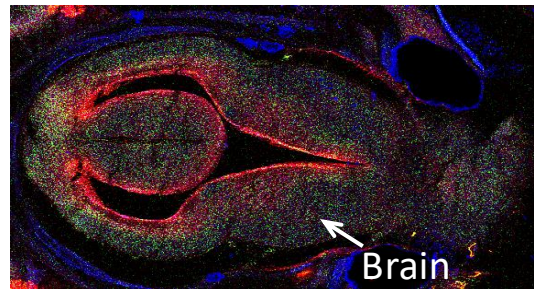
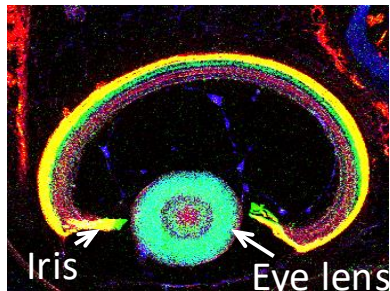
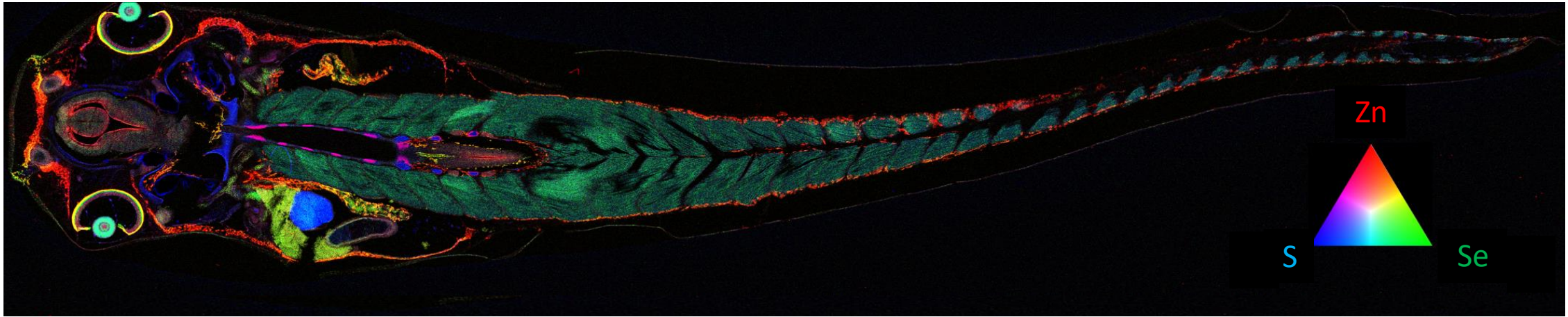
Improved Imaging of Malarial Cells Using Attenuated Total Reflectance FTIR



Macro ATR delivers superior spatial resolution ($\sim 2\text{ }\mu\text{m}$),
Without damaging or distorting soft samples

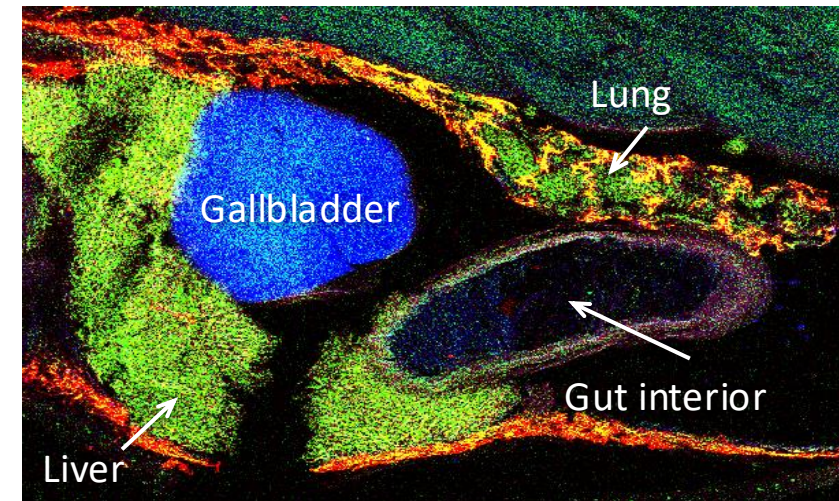
Jitraporn Vongsvivut, et al.,
Analyst, **144**, 3226 (2019).

Selenium Bioaccumulation on the Micron Scale



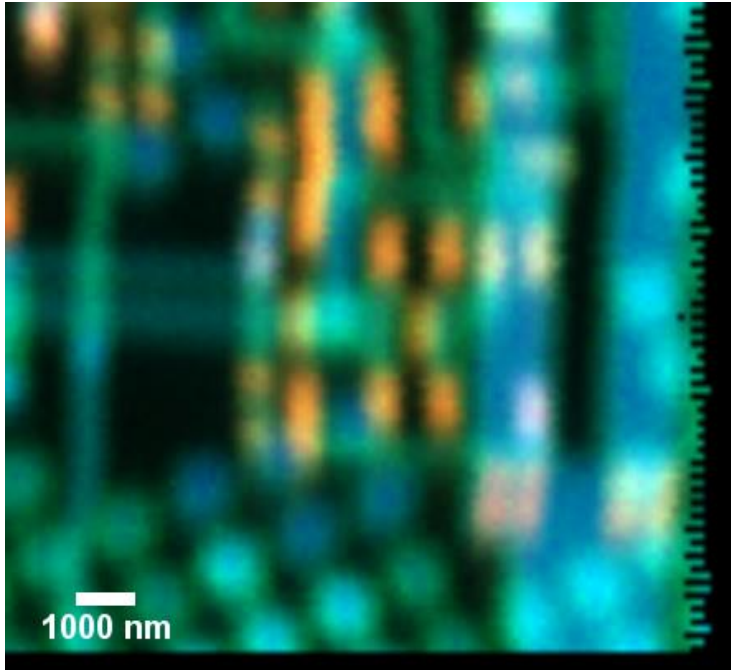
Tadpole exposed to Se(IV) (30 $\mu\text{g/L}$)

- Exposed tadpoles to Se for 7 days followed by 3 days depuration
- Observed bioaccumulation in the liver, iris, eye lens, brain, retained through metamorphosis



XFM – Ptychography Imaging on the Nanoscale

- ❖ *Scanning X-ray Diffraction Microscopy* → providing high spatial resolution and high sensitivity
- ❖ Automated algorithms to reconstruct image

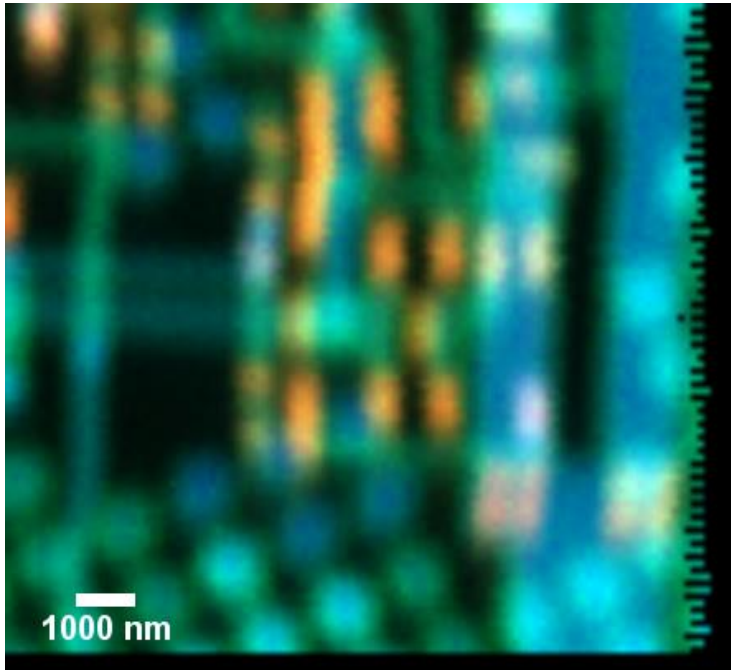


X-ray fluorescence map:
orange - tungsten, green - tantalum,
blue - copper.

Features resolved significantly
better than the probe size of $\sim 1\ \mu\text{m}$.

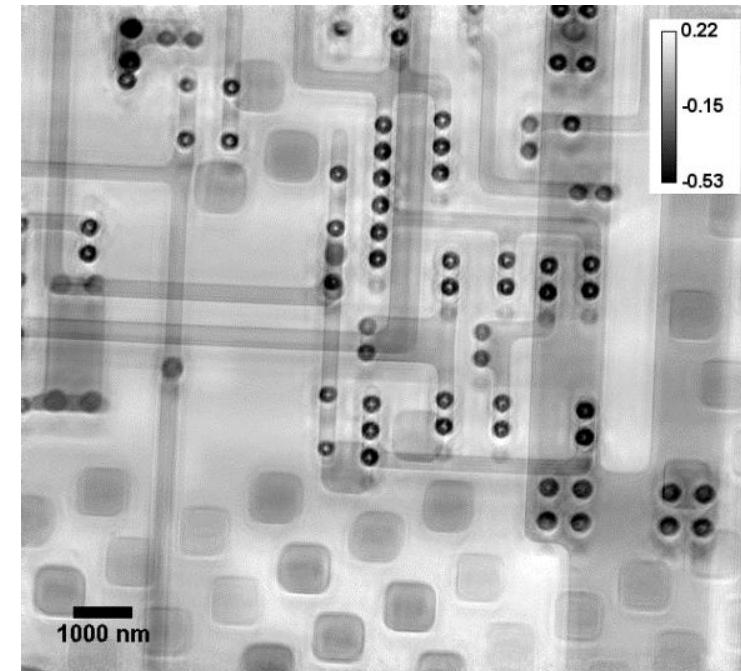
XFM – Ptychography Imaging on the Nanoscale

- ❖ *Scanning X-ray Diffraction Microscopy* → providing high spatial resolution and high sensitivity
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X-ray fluorescence map:
orange - tungsten, green - tantalum,
blue - copper.

Features resolved significantly better than the probe size of $\sim 1 \mu\text{m}$.



Ptychographic phase reconstruction
of an integrated circuit at
 $\sim 50 \text{ nm}$ resolution.

X-ray Fluorescence Nanoprobe

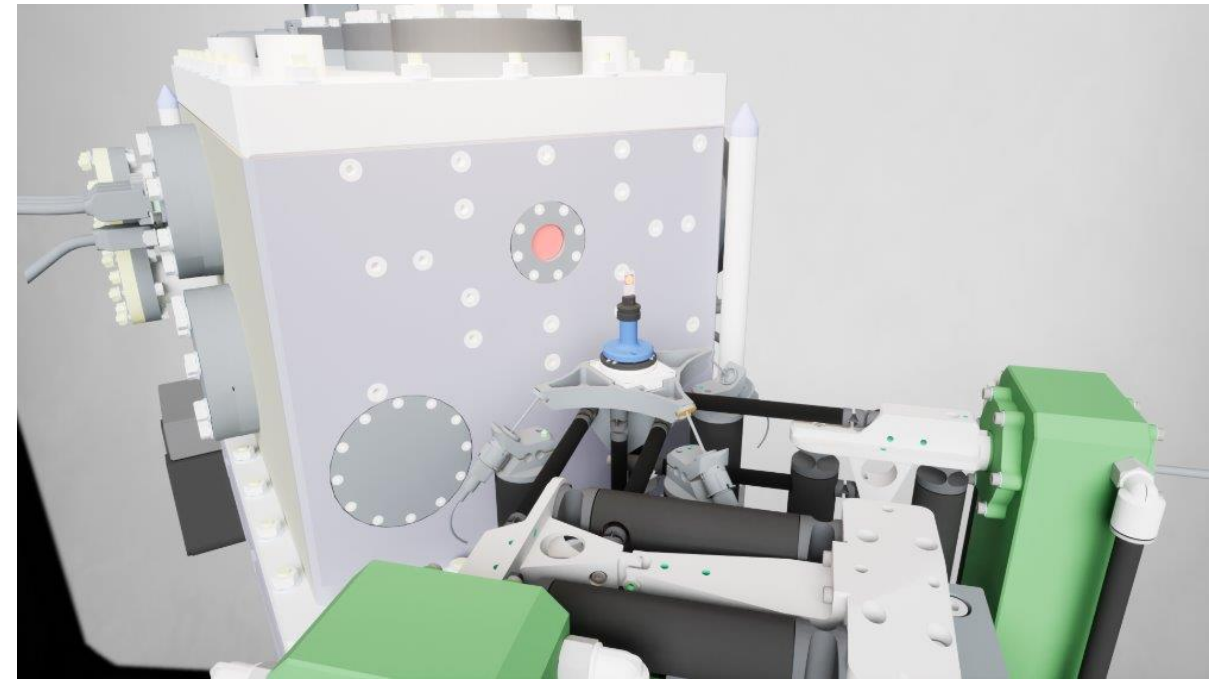


Ultra-stable NANO Satellite Building

- Minimal Vibrations
- Temperature stability

Commencing operations in 2026

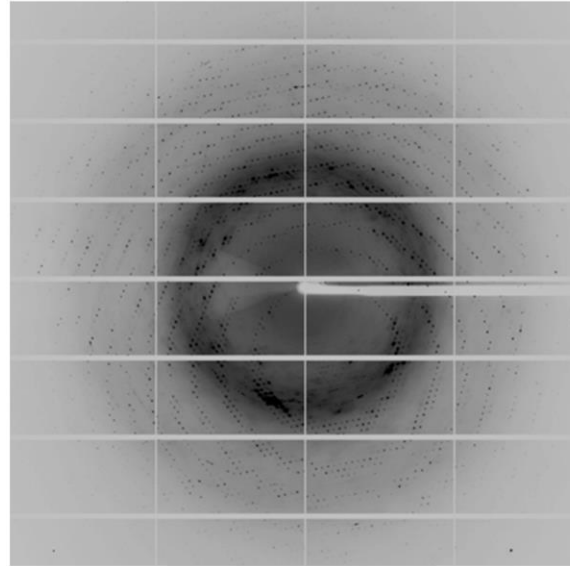
- 60 nm Elemental mapping
- 10 nm Structural mapping
- Nano-diffraction & Nano-SAXS



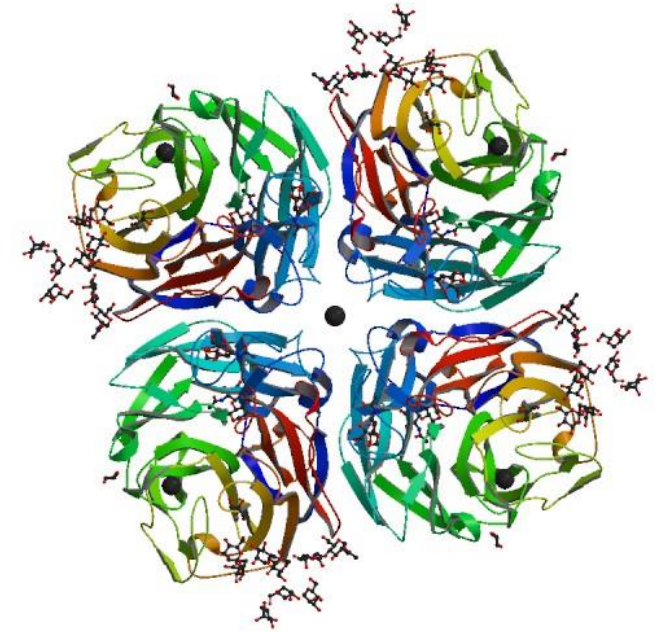
Macromolecular Crystallography (MX1 & MX2)



Tiny, weakly diffracting
protein crystals



MX1 / MX2
(100 K)



Complex biomolecular
structures

~1 Tb per Experiment

Life Saving Pharmaceutical Break Throughs

Venetoclax (Venclexta™) is now being used to treat *Chronic Lymphocytic Leukaemia* in the USA, Europe and Australia

There have been very few effective treatments for this Leukaemia for the past 50 years.

Venetoclax blocks the **B-cell lymphoma-2 (Bcl-2) protein**, leading to programmed cell death of CLL cells.



Global sales in 2022: US\$2.01 billion

> 500 Clinical Trials for Venetoclax worldwide

abbvie

Genentech

A Member of the Roche Group



Walter+
Eliza Hall

Institute of Medical Research

ANSTO

Putting Cancer Cells to Sleep

Researchers from Melbourne have discovered a new type of drug that puts cancer cells to "sleep".

By screening ~250,000 compounds, researchers have developed a drug to target proteins responsible for driving several types of cancer (KAT6A and KAT6B).

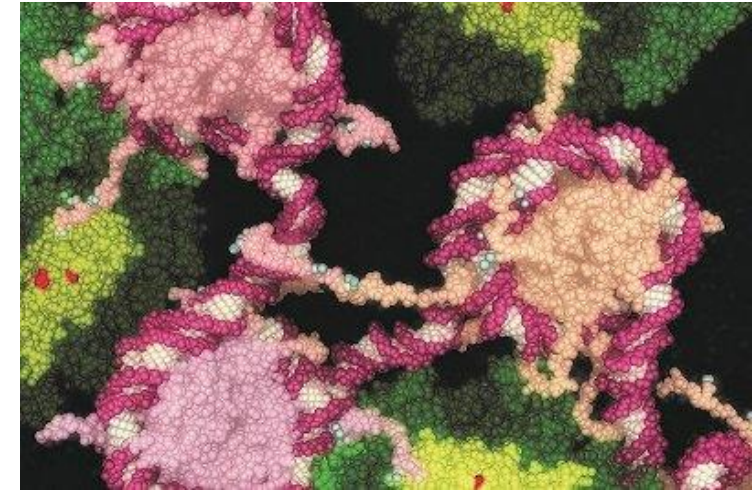
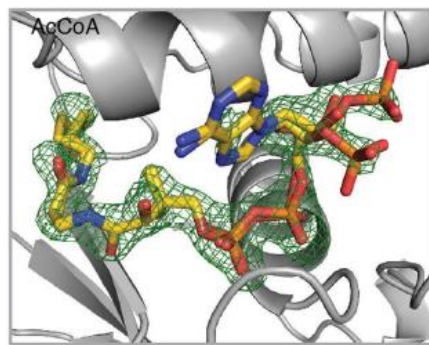
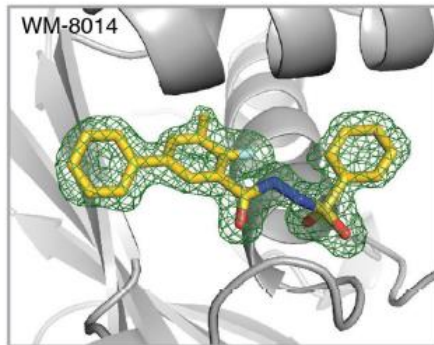


Image courtesy of Ms Etsuko Uno,
Walter and Eliza Hall Institute

Could give cancer patients an alternative
to radiotherapy and chemotherapy.

David Leaver, et al.,
J. Medicinal Chemistry, **62**, 7146 (2019).

Jonathan B. Baell, *et al.*,
Nature, **560**, 253–257 (2018).

Development of New Antibody-Based Therapies

The *SARS-CoV-2 Viral Spike Protein* is the key that enables the virus to infect our cells and replicate.

Binding an anti-viral inhibitor molecule to the Viral Spike Protein can prevent the virus from entering our cells.

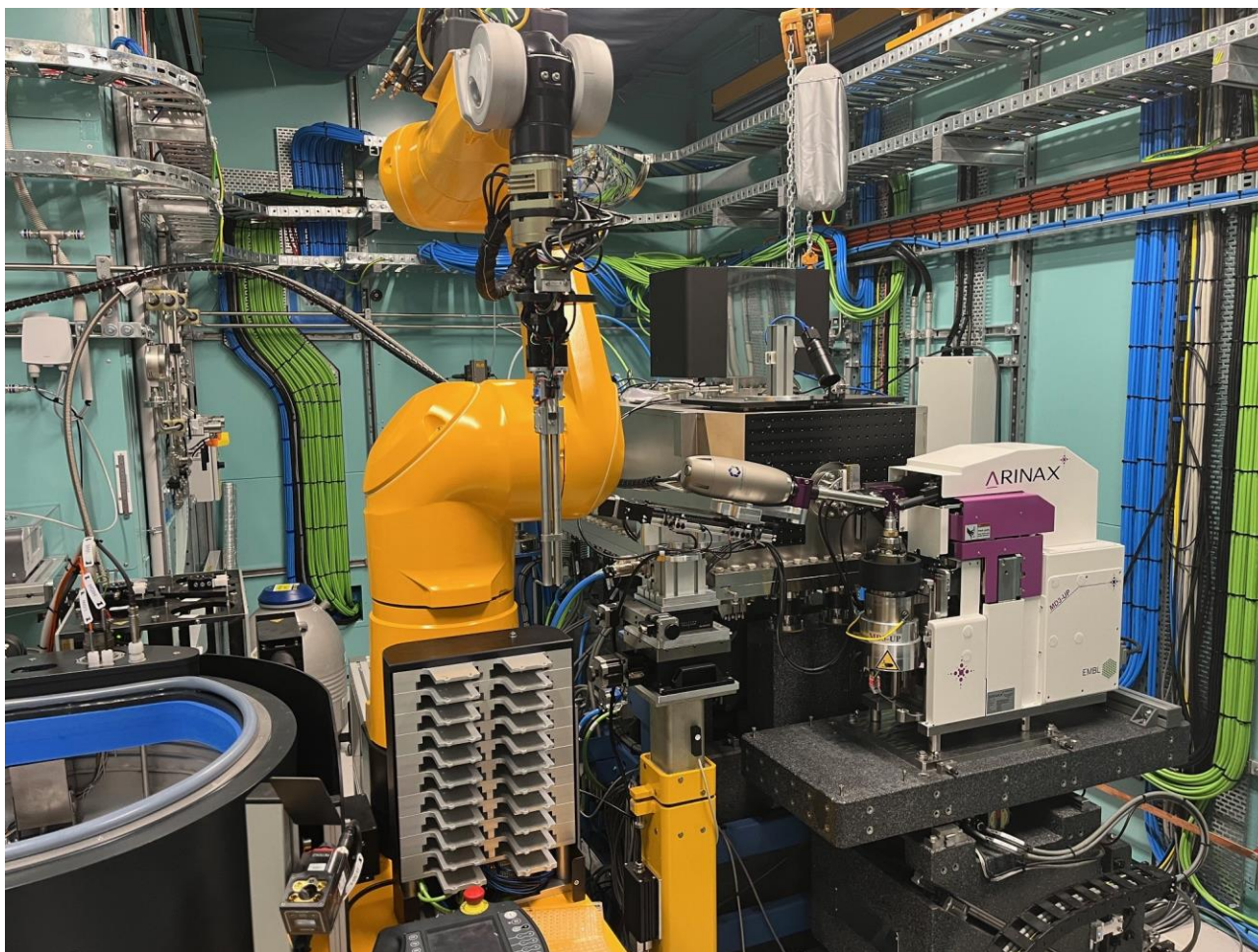


Alpacas inoculated with the Viral Spike Protein produce “Nanobodies” that are being studied as a new anti-viral therapy.

Phillip Pymm, et al., *PNAS*, 118, e2101918118 (2021)
Adam K. Wheatley, et al., *Cell Reports*, 37, 109822 (2021)

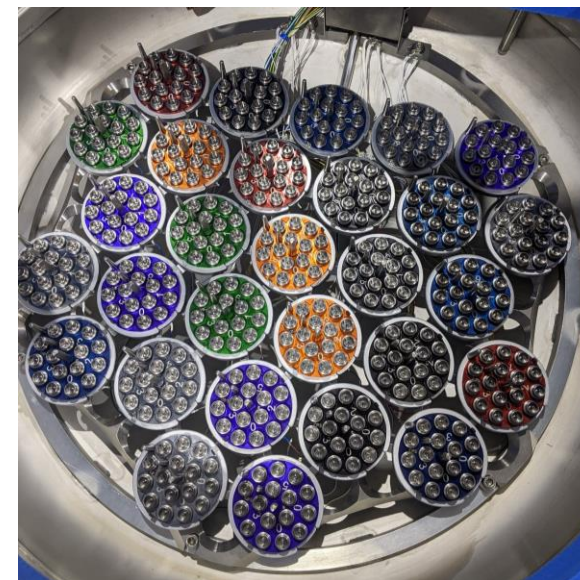
MX3 – Smaller, Brighter, Faster,...

BR—GHT



MX1 – 50 μm beam, 10^7 ph/ $\mu\text{m}^2/\text{s}$
MX2 – 10 μm beam, 10^{10} ph/ $\mu\text{m}^2/\text{s}$
MX3 – 2 μm beam, 5×10^{12} ph/ $\mu\text{m}^2/\text{s}$

Goniometer mode
Tray Screening
Serial Crystallography

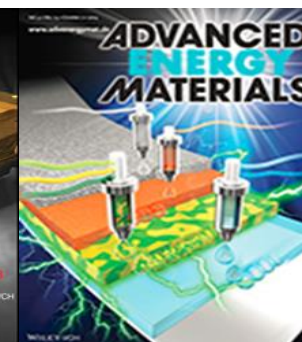
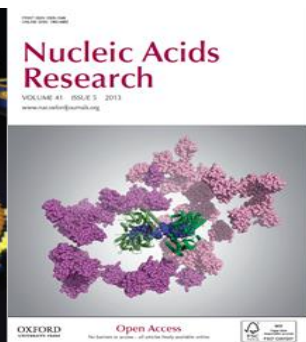
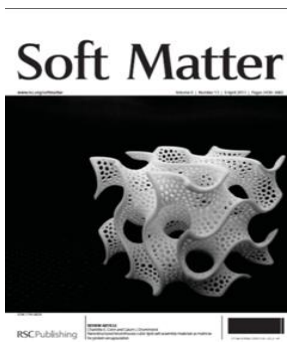


Double the sample
capacity of MX2

Small and Wide Angle X-ray Scattering

(*Structural Studies on the Nanoscale*)

Food and Agricultural products
Biomaterials and Medical implants
Polymers, Organic solar cells and electronics
Advanced drug delivery systems
Catalysis & Metal Organic Frameworks
Surfactants, and Liquid Crystal systems
Carbon Fibres, Nanomaterials
Protein structures and complexes



Small Angle and Wide Angle X-ray scattering (SAXS/WAXS)



Information about the shape and size of macromolecules & nanoparticles

Transmission SAXS and vertical dispersion WAXS

Glancing Incidence Wide Angle X-ray Scattering (GIWAX)

Solution analysis, particularly biomacromolecules

Min. protein conc. < 0.005 mg/mL

How Treat Malaria with Milk

Instead of putting an antimalarial drug in milk...

Put it in a simplified formulation made from milk derivatives

- Cheap & readily available
- Known to be human compatible
- Already have FDA approval



Prof. Ben Boyd and colleagues from ANSTO have developed an effective *single-dose* anti-malarial treatment



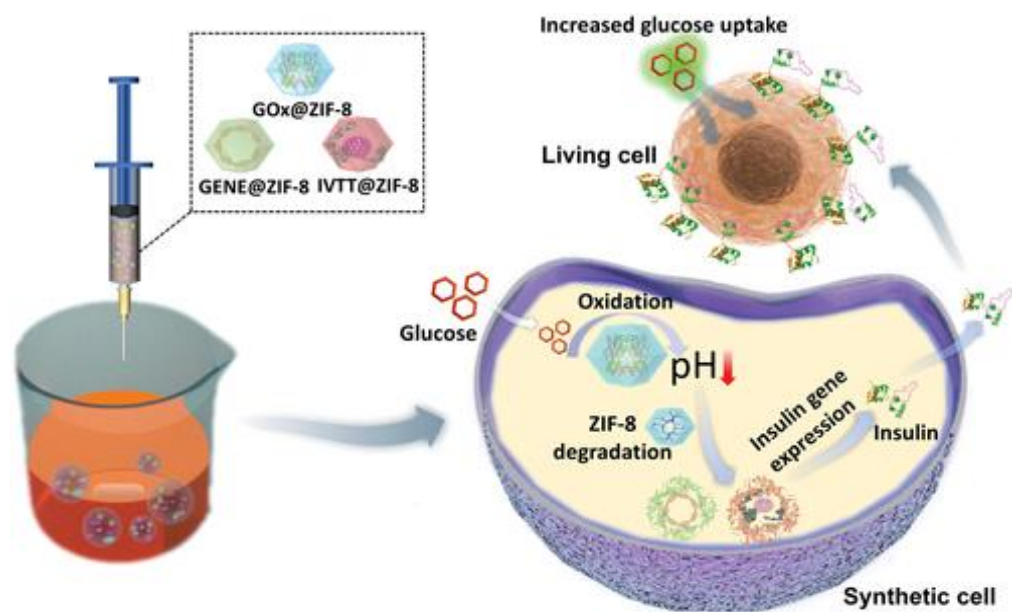
Eureka Prize 2020

Ben J. Boyd, et al., *Journal of Controlled Release*, **292**, 13 (2018)

Syaza Y. Binte Abu Bakar, et al., *International Journal of Pharmaceutics*, **554**, 179 (2019)

Malinda Salim, et al., *Molecular Pharm.* **17**, 885 (2020); **20**, 2256 (2023)

Genetically Encoded Synthetic Beta Cells for Insulin Biosynthesis and Release



Researchers developed a genetically encoded synthetic beta cell made out of MOFs, which can sense hyperglycemic conditions to initiate programmed biosynthesis and secretion of insulin.

Different MOF-based artificial organelles with can undergo glucose sensing, initiation of insulin gene transcription and translation, and excretion of functional insulin.

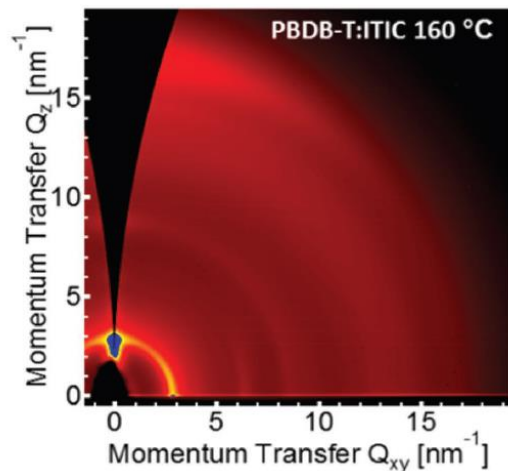
Jian Liu, et al.,
Advanced Functional Materials
32, 2111271 (2022).

Powder Diffraction; SAXS/WAXS; Terahertz / Far-IR

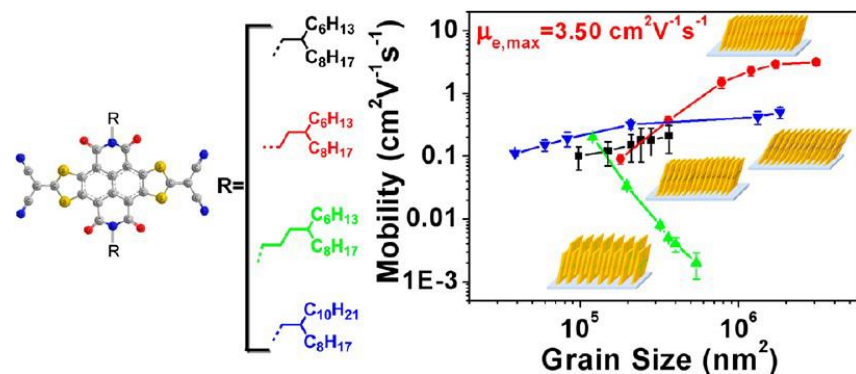
Red Hot Organic Electronics & Photovoltaics

Prof. Chris McNeill and colleagues (Monash Uni.)

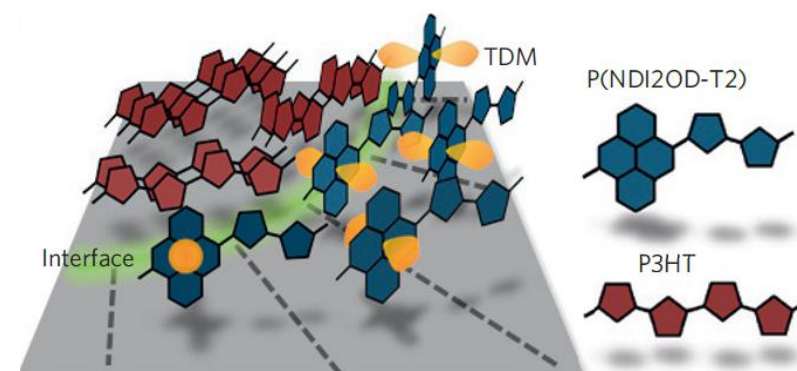
GIWAXS
Soft X-ray Spectroscopy



Zhuping Fei, et al.,
An Alkylated Indacenodithieno
[3,2-*b*] thiophene-Based Nonfullerene
Acceptor with High Crystallinity
Exhibiting **Single Junction Solar Cell**
Efficiencies Greater than 13% with Low
Voltage Losses,
Advanced Materials,
30, 1705209 (2014).
550 Citations



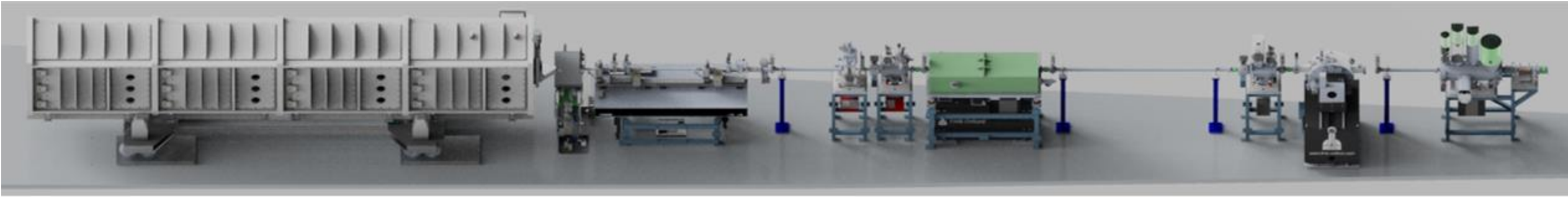
Fengjiao Zhang, et al.,
Critical Role of Alkyl Chain Branching of Organic
Semiconductors in Enabling Solution-Processed
N-Channel **Organic Thin-Film Transistors** with
Mobility of up to $3.50 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$,
JACS, 135, 2338 (2013).
450 Citations



B. A. Collins, et al.,
Polarized X-ray scattering reveals
non-crystalline **orientational**
ordering in organic films,
Nature Materials, 11, 536 (2012).
350 Citations

> 20 journal publications with > 100 citations

Biological Small Angle X-ray Scattering (BioSAXS)



BR—GHT



- Highly automated
- Very high flux
(Superconducting Undulator)
- Optimised for solution scattering
and Biological samples (*CoFlow*)

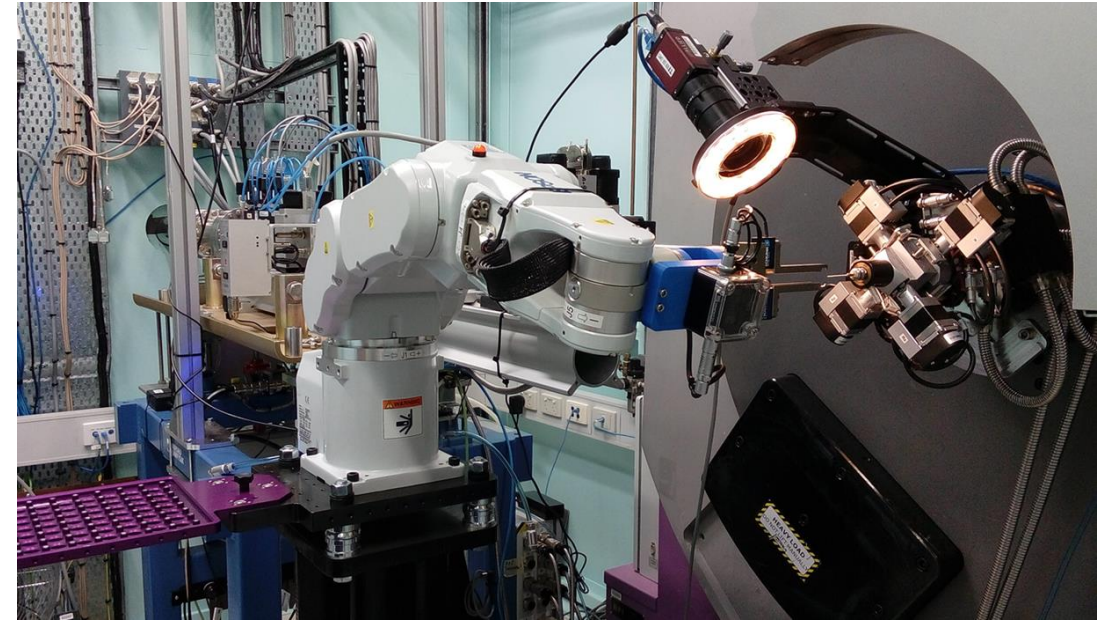


Operational since October 2023

Powder Diffraction (PD)

In situ, *In operando*, and time-resolved structural characterisation of atomic structures

- Powder or microcrystalline samples
- Tunable, monochromatic X-rays
- Fast data collection (seconds to minutes)
- Able to detect crystalline phases to $\sim 0.5\text{wt}\%$
- Tiny quantities of samples needed: minimum $\sim 3\text{mg}$
- Automated sample exchange
- Radioactive samples can be measured



Applications: Energy Technologies, Catalysts, Gas Separations, Planetary Sciences, Mineral Extraction, Advanced Manufacturing, Corrosion, Forensics, Cultural Heritage,...

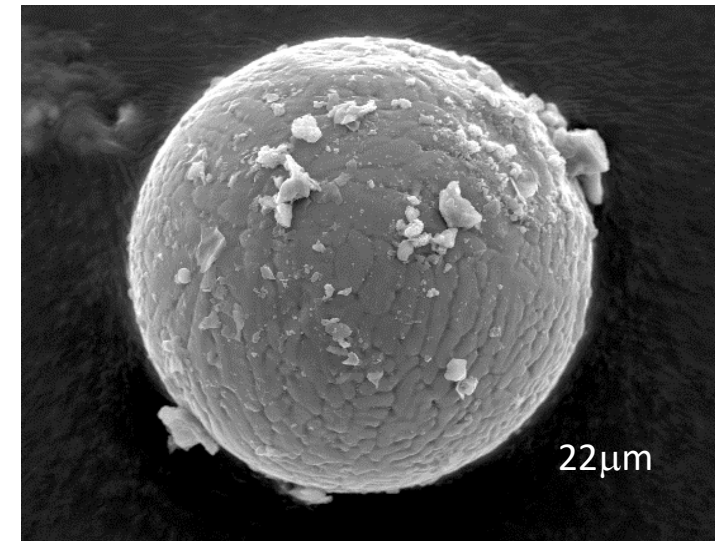
Powder Diffraction

Atomic Structure with Exquisite Sensitivity

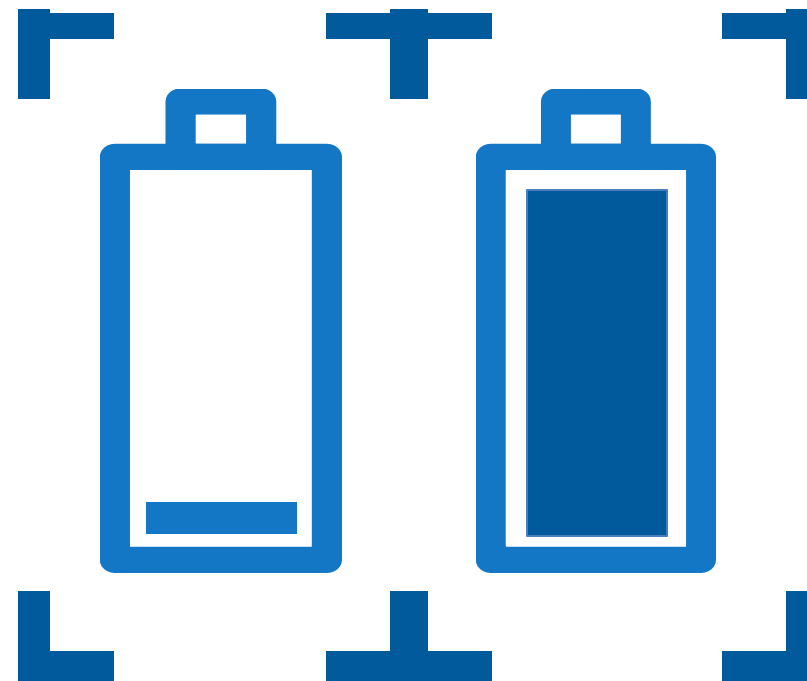
Synchrotron-based Powder X-ray Diffraction (XRD) can be used to study atomic structure from the smallest of samples

- Exquisite signal-to-noise / sensitivity
- Excellent structural resolution

PD studies of ancient iron micro-meteorites demonstrates the presence of atmospheric oxygen *2.7 billion* years ago -
~200 million years earlier than expected.



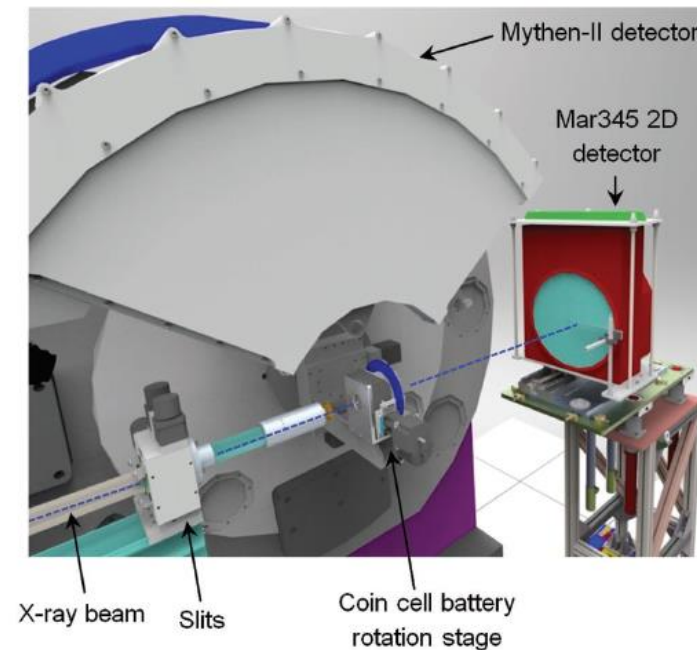
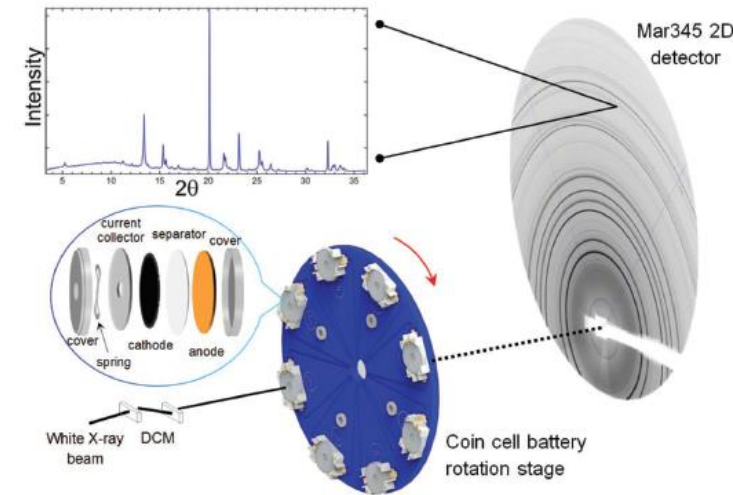
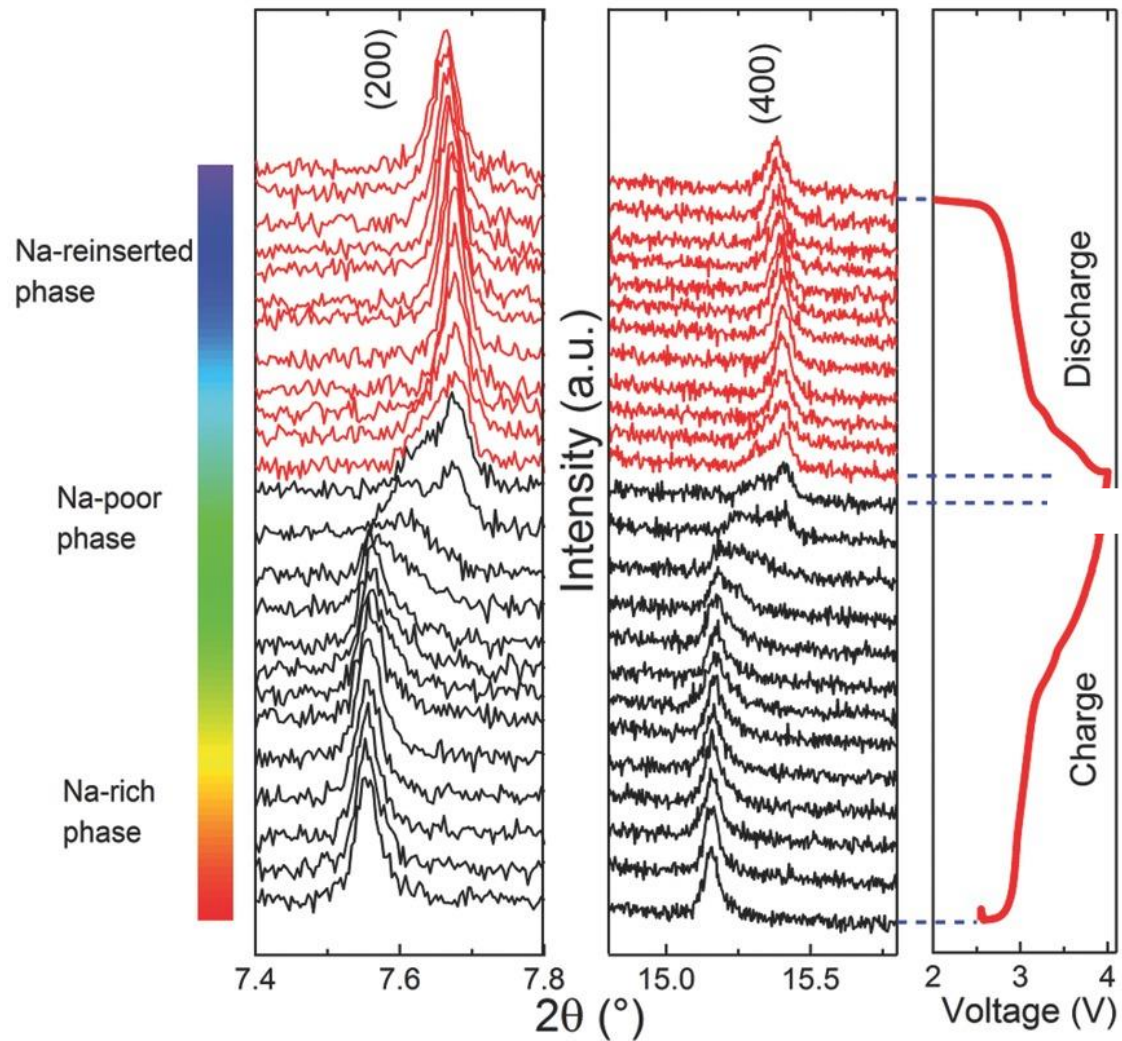
New Energy Materials



Synchrotron *Powder Diffraction* enables researchers to study the atomic structure of a huge range of energy generating and energy storing materials – *under operational conditions*.

Huge interest in Li^+ & Na^+ ion batteries

In-situ studies of Battery Materials Using Powder Diffraction



Q. Gu, et al., *Adv. Energy Mater.* 7, 1602831 (2017).

Advanced Diffraction & Scattering 1 & 2

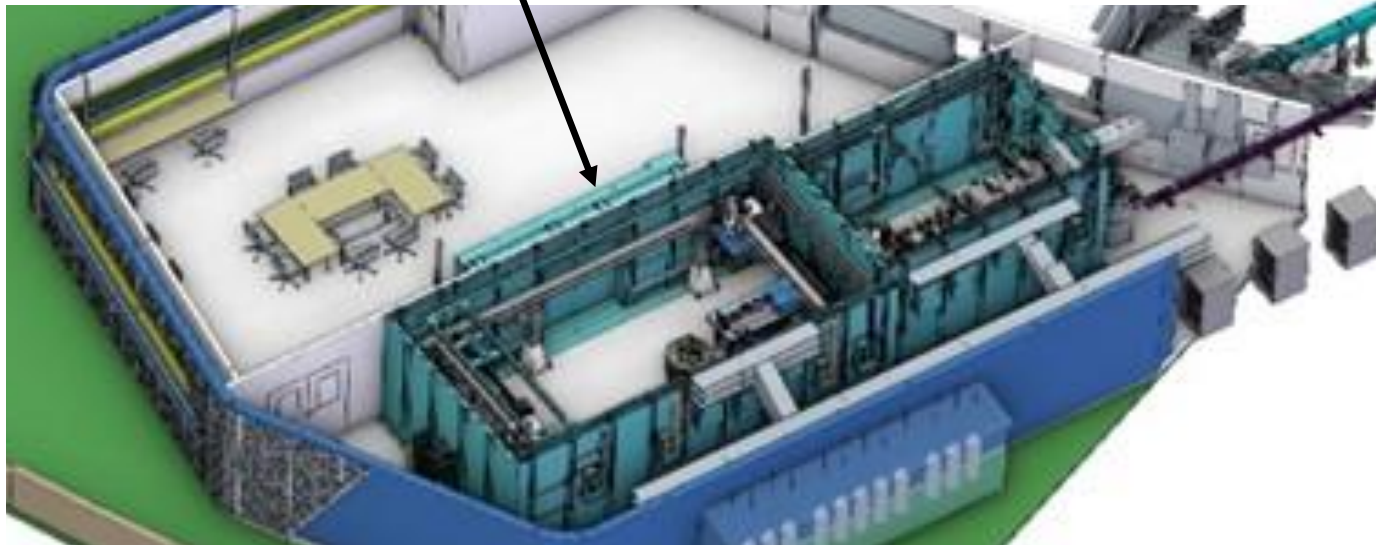
ADS-1

Modes: White & monochromatic

Energy range: 50 - 150 keV

Techniques:

- Diffraction – angle & energy dispersive
- Imaging & tomography



Samples

- Small/light (20 μ m, mg)
- Large/heavy (300 kg, 800 mm)
- Large & complex sample environments

ADS-2

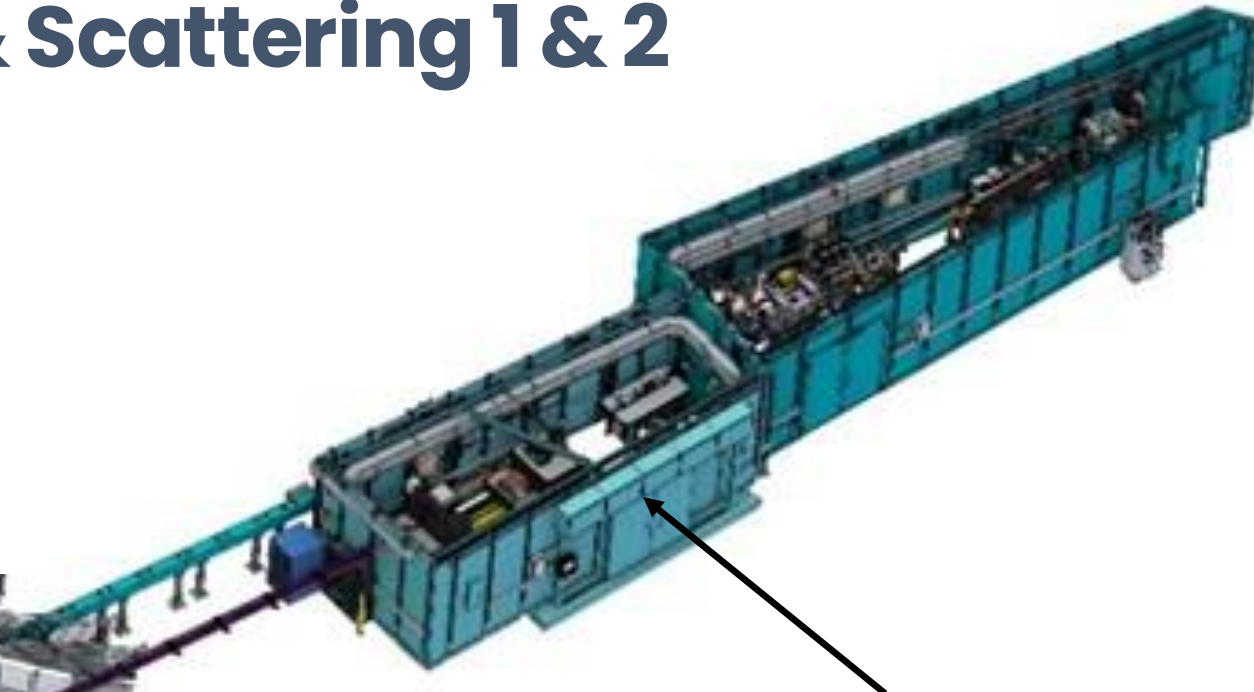
Energies: 45.3, 74.0, 86.8 keV

Techniques: Diffraction

Samples: <50 kg

Specific techniques:

- *In situ* powder diffraction
- Single crystal diffraction
- High throughput stages
- Total scattering

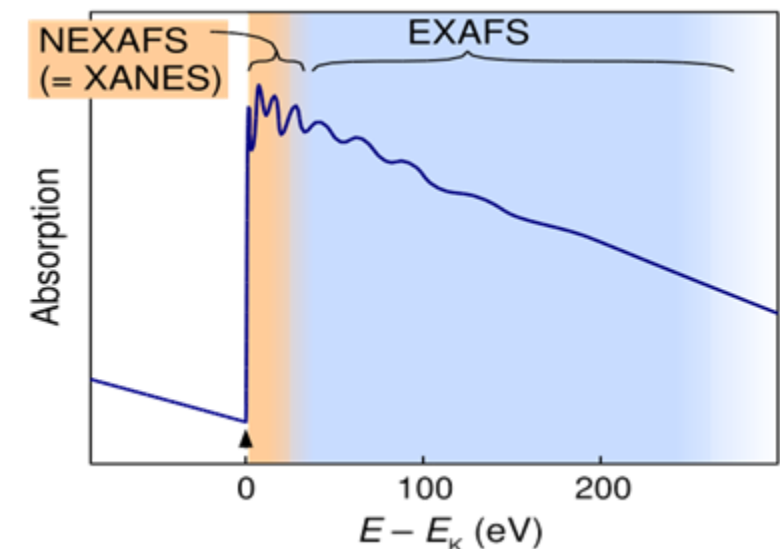


X-ray Absorption Spectroscopy (XAS)

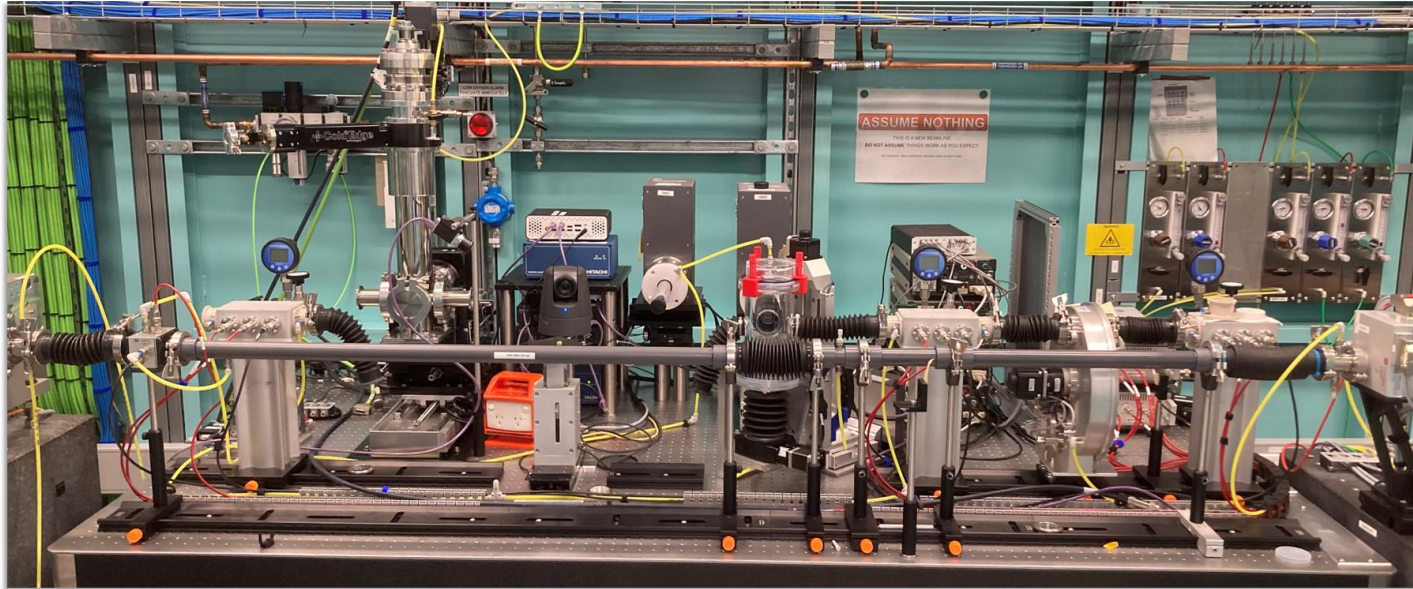
Oxidation state, symmetry and the local bonding environment around a central atom.

- Crystalline or amorphous materials
- Almost all metals and heavier elements (Ti to Pu)
- Multiple sample mounts available, including cryostat and sample heating to $\sim 1000\text{ }^{\circ}\text{C}$
- High sensitivity (low ppm); Quantitative

Applications: Biosciences & Health, Earth Sciences, Mining & Mineral Extraction, Agriculture & Food Technology, Environmental Science & Climate Change, Energy Materials



Medium Energy X-ray Absorption Spectroscopy (MEX1 / MEX2)



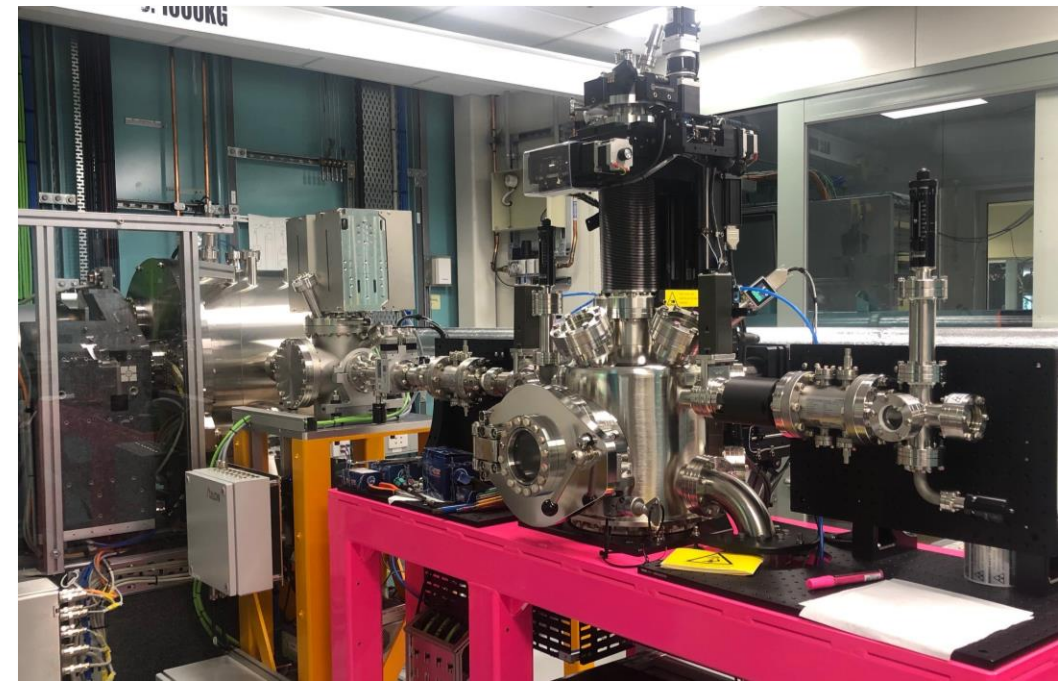
MEX1

Conventional XAS

Microspectroscopy mapping

S, Cl, K, Ca, Sc,

+ 1st Row Transition Metals



MEX2

Conventional XAS

Drain current measurements

Si, P, S, Cl, Ar

BR—GHT

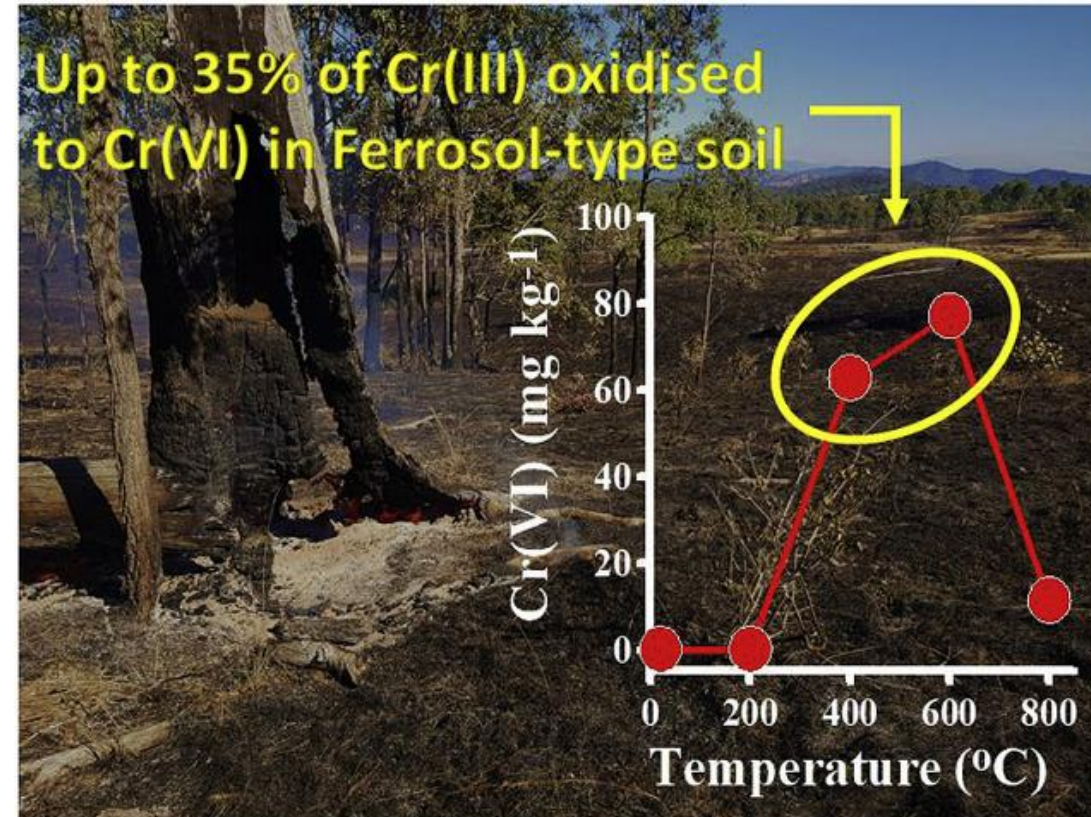
Do Bushfires Generate Hazardous Chromium In Soil?

Chromium is commonly hosted in iron oxy/hydroxide minerals in soil.

These minerals transform at high temperatures but the fate of trace metals such as chromium has not been well explored.

- At bushfire temperatures (200-700 °C), Cr^{3+} is oxidised to Cr^{6+} in soil
- Cr^{3+} is benign; Cr^{6+} is highly toxic and carcinogenic
- 30-40% of this Cr^{6+} is extractable/mobile, meaning it could be flushed into waterways with rainfall

This is a previously unrecognised environmental risk associated with bushfires.



Ed Burton, *et al.*
Environ. Pollut. **247**, 618 (2019).

Soft X-ray Spectroscopy (SXR)

Surface sensitive techniques

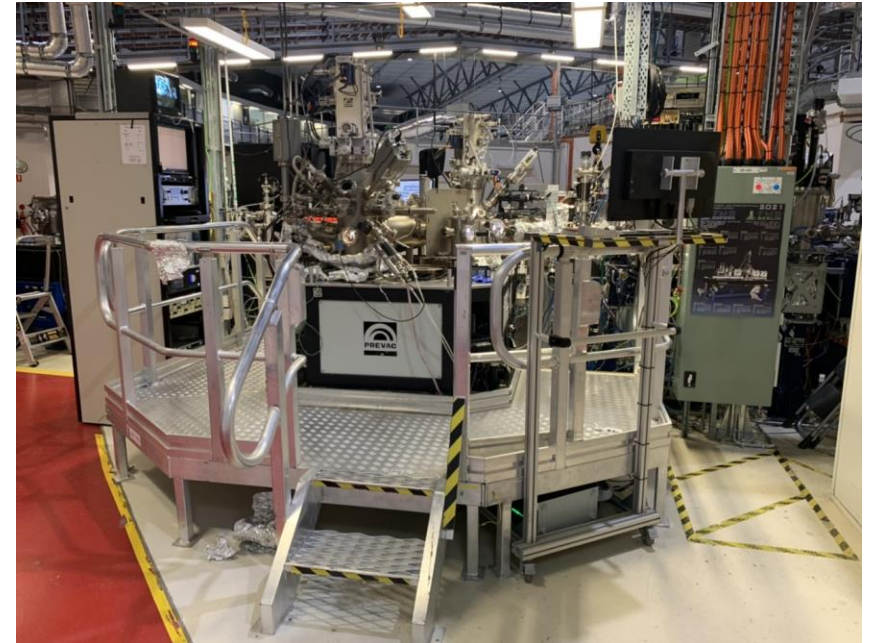
- X-ray Photoelectron Spectroscopy (XPS)
- Near Edge X-ray Absorption Fine Structure (NEXAFS)
- Angle-resolved Photo Emission Spectroscopy (ARPES)
- VUV Lithography – coming soon...

Sample requirements

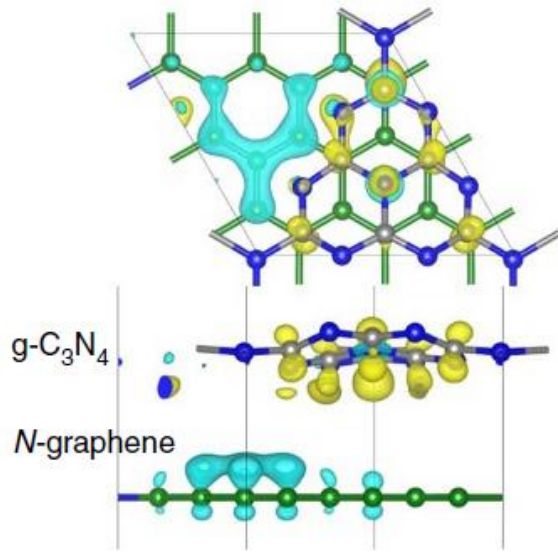
- Ultra-high vacuum compatible
- Measurement depth only a few nm

Applications

- Surface physics & chemistry; electronics; catalysts; earth sciences; environmental science

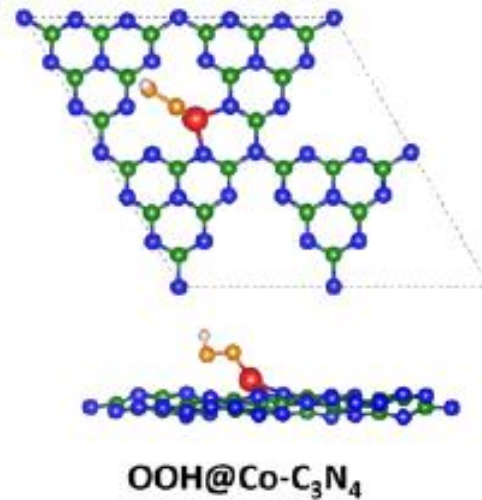


Red Hot Catalysts: Hydrogen from Seawater



Yao Zheng, et al.,
Hydrogen evolution by a
metal-free electrocatalyst,
Nature Communications,
5, 3783 (2014).

> 2100 Citations

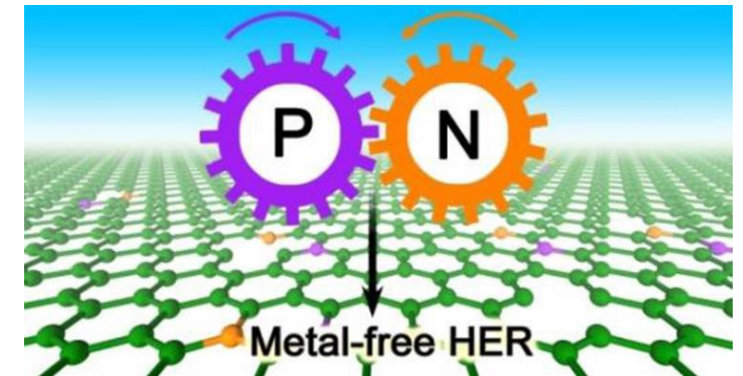


Yao Zheng, et al.,
Molecule-Level g-C₃N₄ Coordinated Transition
Metals as a New Class of Electrocatalysts for
Oxygen Electrode Reactions,
JACS, **139**, 3336 (2016).

> 1100 Citations

Fangxi Xie, et al.,
A general approach to 3D-printed single-atom catalysts,
Nature Synthesis, **2**, 129 (2023).

Soft X-ray Spectroscopy
X-ray Absorption Spectroscopy
Powder Diffraction



Yao Zheng, et al.,
Toward design of synergistically
active carbon-based catalysts for
electrocatalytic hydrogen evolution,
ACS Nano, **8**, 5290 (2014).

> 1000 Citations

Catalysts for Hydrogen Generation

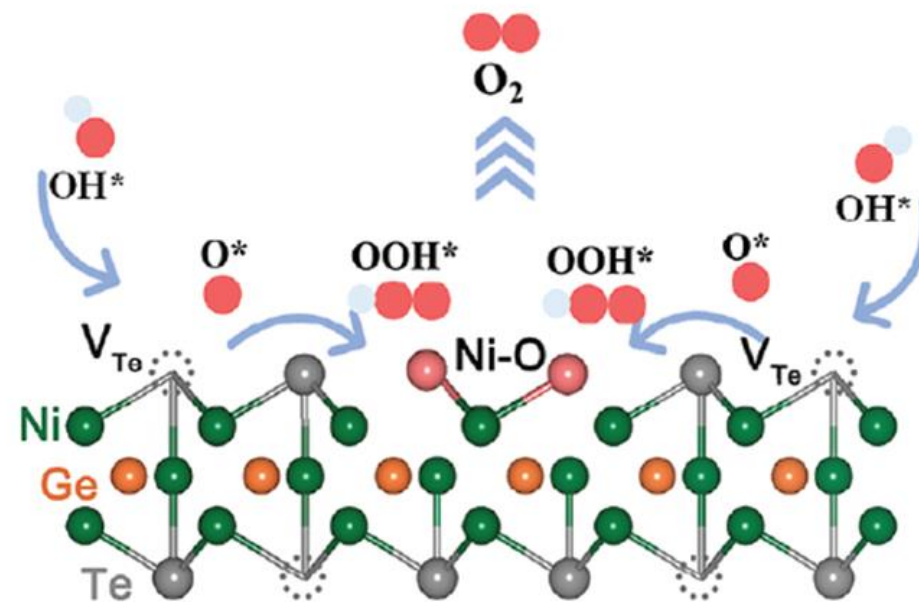
2D Ferromagnetic $M_3\text{GeTe}_2$ ($M = \text{Ni}/\text{Fe}$) for Faster Water Oxidation

This study made use of 3 synchrotron beamlines to investigate the complex chemistry of a 2D engineered electrocatalyst Ni_3GeTe_2 used in an anion-exchange membrane for water electrolysis.

SXR – Oxygen chemistry

MEX-1 – Ni & Ge Chemistry

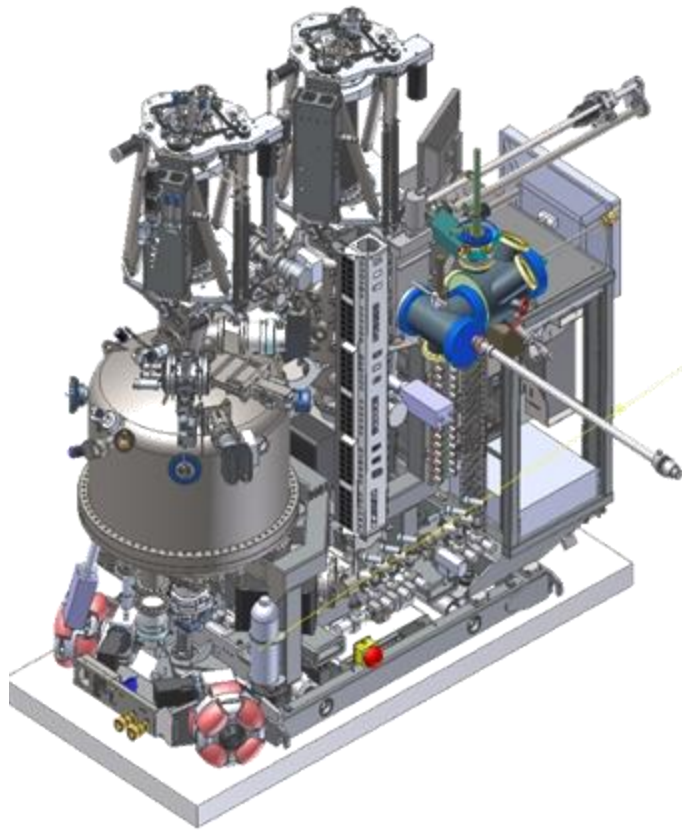
XAS – Te Chemistry



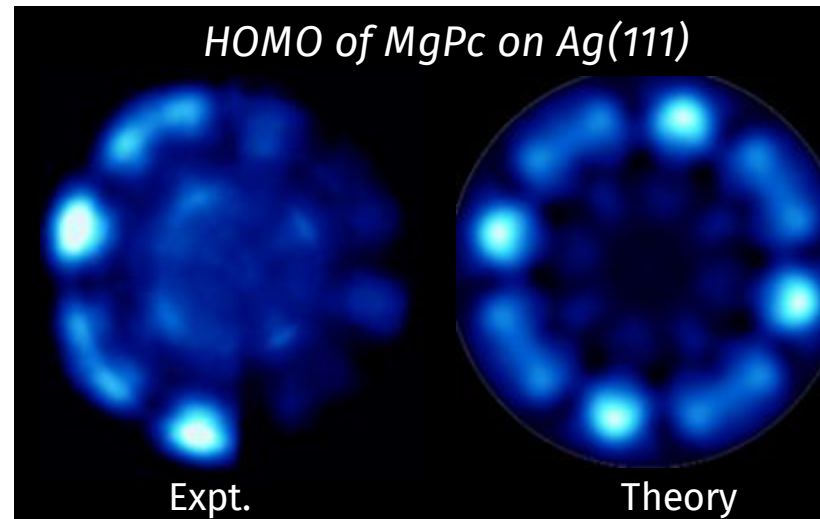
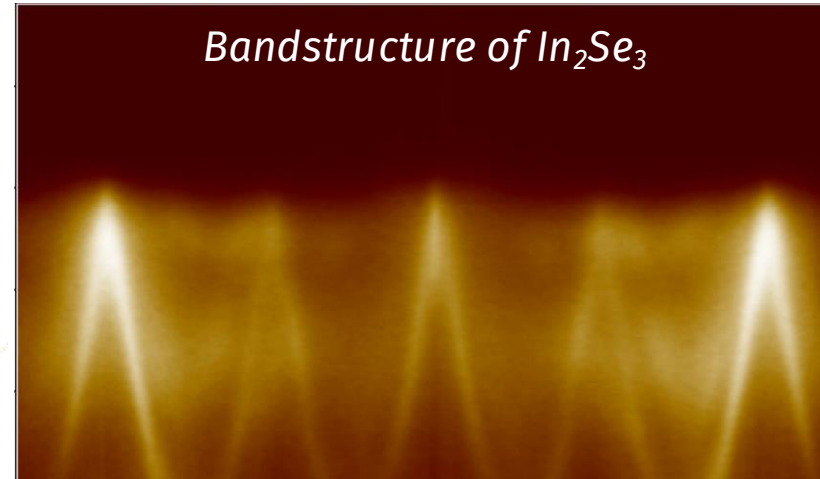
Guyue Bo, *et al.*, *Advanced Science* **11**, 2310115 (2024).

Quantum Materials Analysis

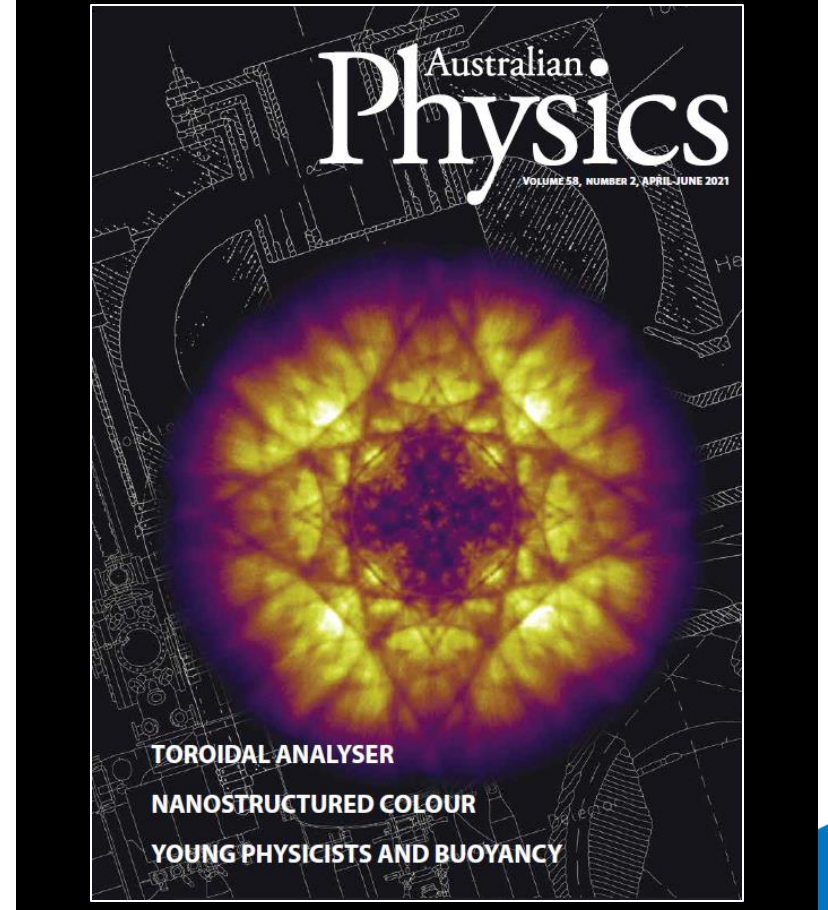
Angle-Resolved Photoemission (ARPES): Toroidal Analyser



Electronic structure (k -space),
photoelectron diffraction,
molecular tomography

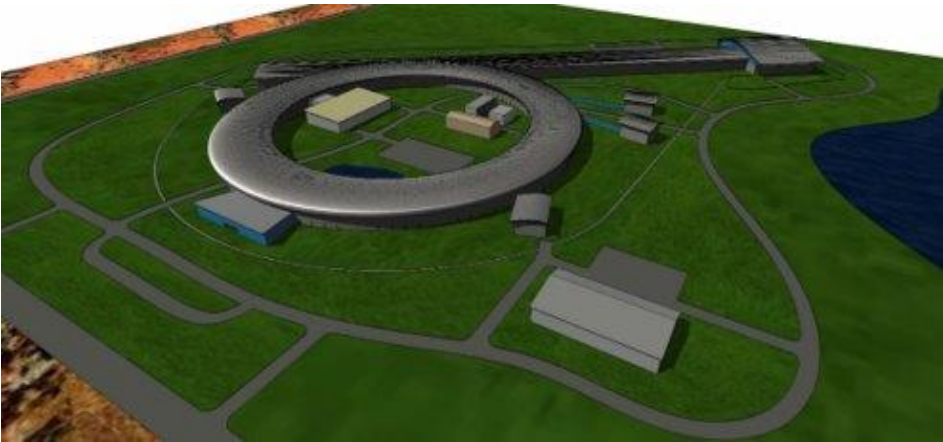


C1s photoelectron diffraction (diamond)



Jack Hellerstedt, et al., *Nanoscale Advances*, **4**, 3845 (2022).

A Future Synchrotron Light Source for Australia (AS2)

- The Australian Synchrotron has an operational life to 2037.
 - International synchrotron facilities all over the world are currently upgrading or building new 4th Generation Synchrotron facilities.
 - Synchrotron light in new facilities is $\sim 100 - 1000\times$ brighter than existing facilities.
- 
- Preliminary design and development of the business case for a new facility has commenced.
 - A 450 m circumference, 4th Gen facility is envisaged.
 - 3 GeV; 400 mA; 7 MBA Lattice; 100 pm.rad
 - Important to ensure operational overlap between the two facilities.

The Australian Synchrotron vs AS2

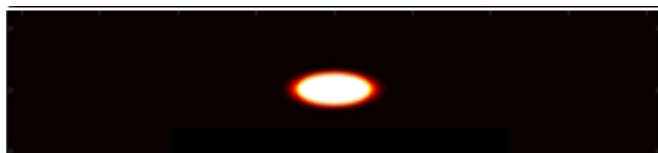
Electron Beam
(Emittance)

AS



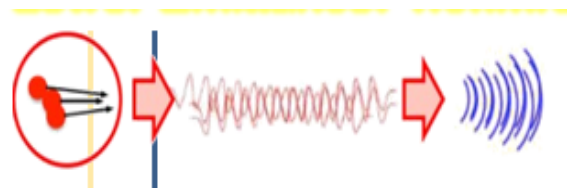
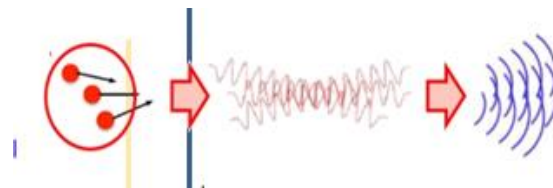
(10349 pm.rad)

AS2



(100 pm.rad)

Undulator



X-ray Beam

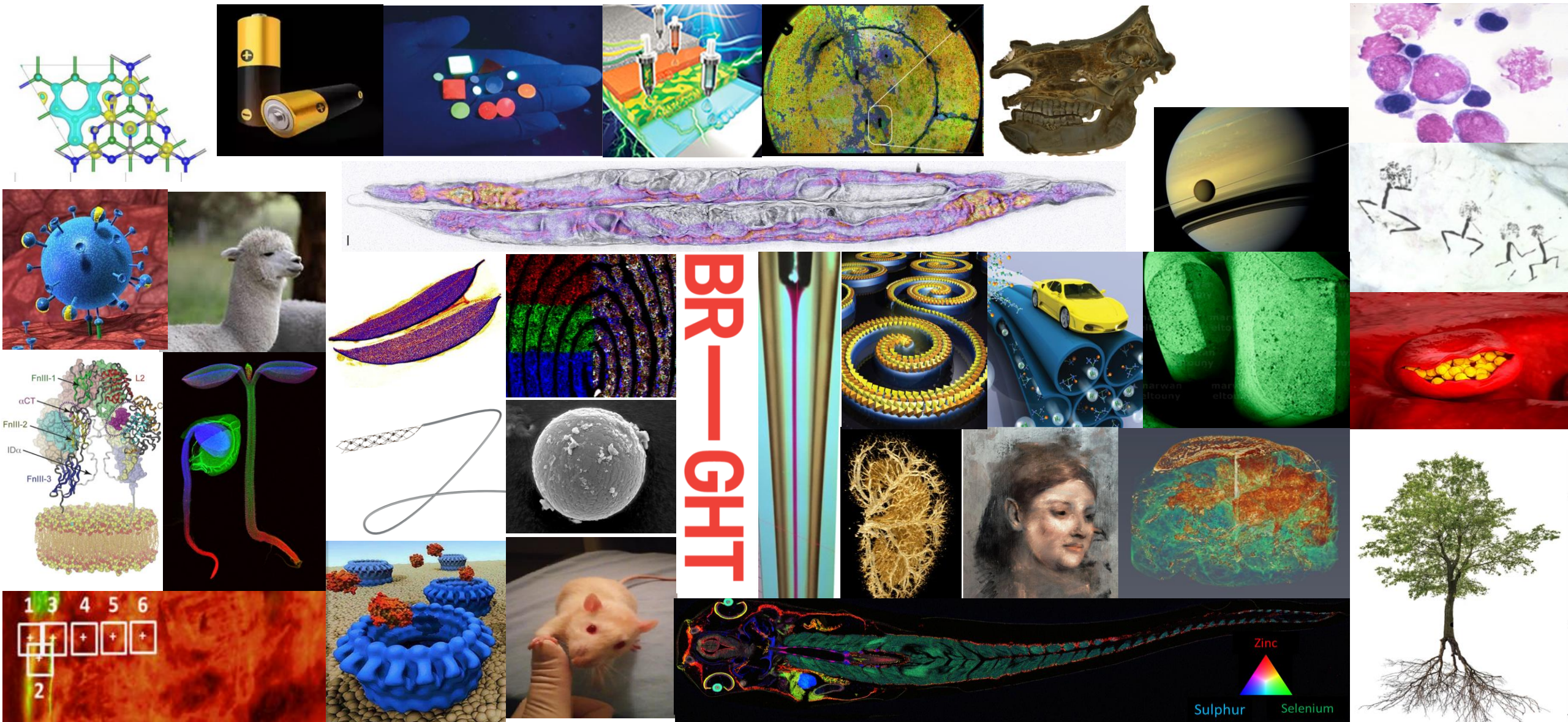


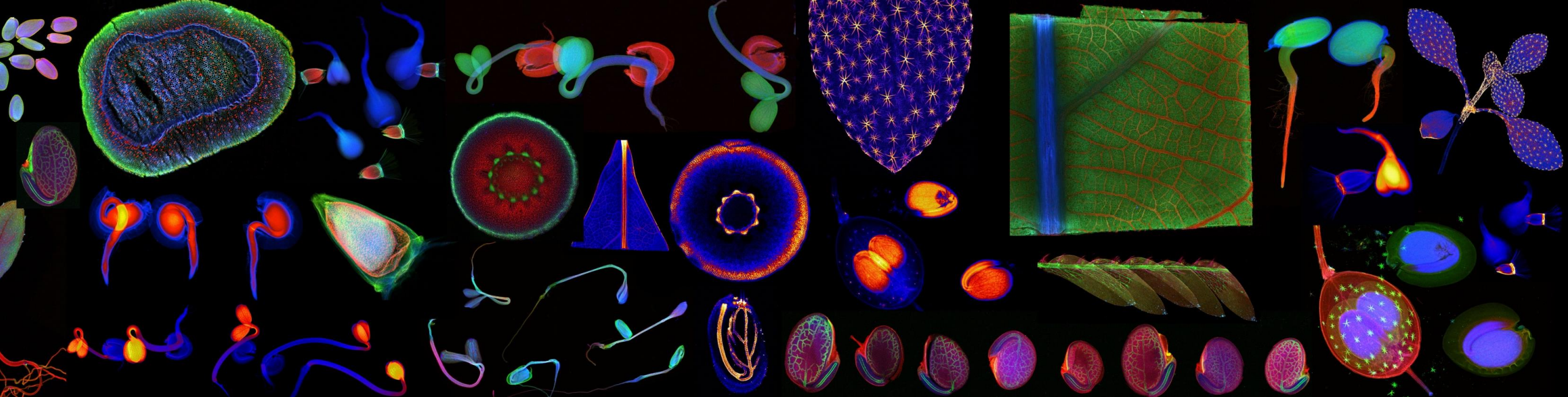
Higher
Brilliance

Higher
Coherence



17 Years of Brilliance at the Australian Synchrotron





Thank you

mja@ansto.gov.au

