Australian Government

ANSTO

Neutron Scattering at OPAL Research Reactor

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Science. Ingenuity. Sustainability.

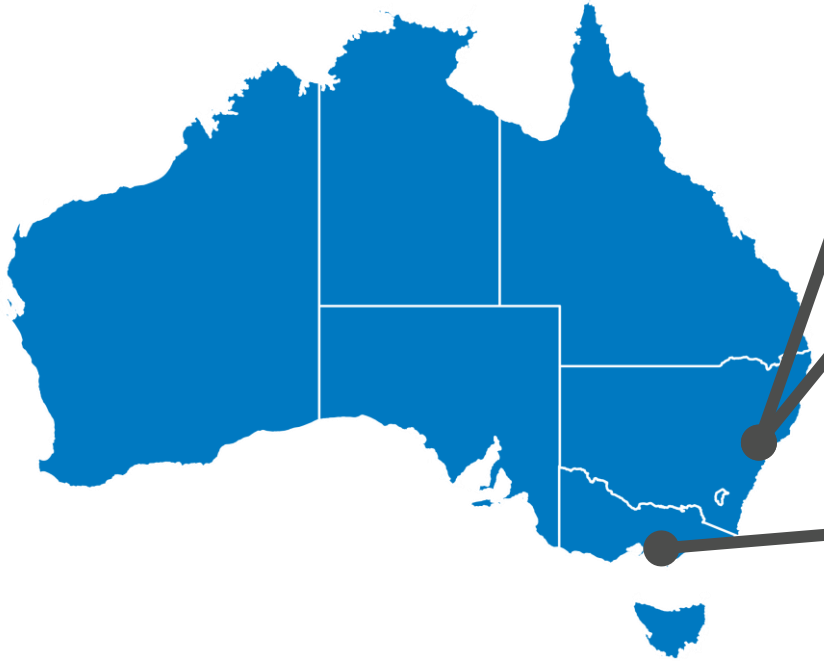

10 Years of Neutron Beams
100 Operating Cycles of OPAL
1000 Scientific Research Papers

Outline

1. Introduction to ANSTO
2. OPAL Reactor & Neutron Beam Facilities
3. Australian Centre for Neutron Scattering
4. Why Neutrons?
5. User Access
6. Closing Remarks

ANSTO

Australian Nuclear Science & Technology Organisation



Camperdown
Cyclotron

NSW

Main site
Lucas Heights

NSW

Clayton
Australian
Synchrotron

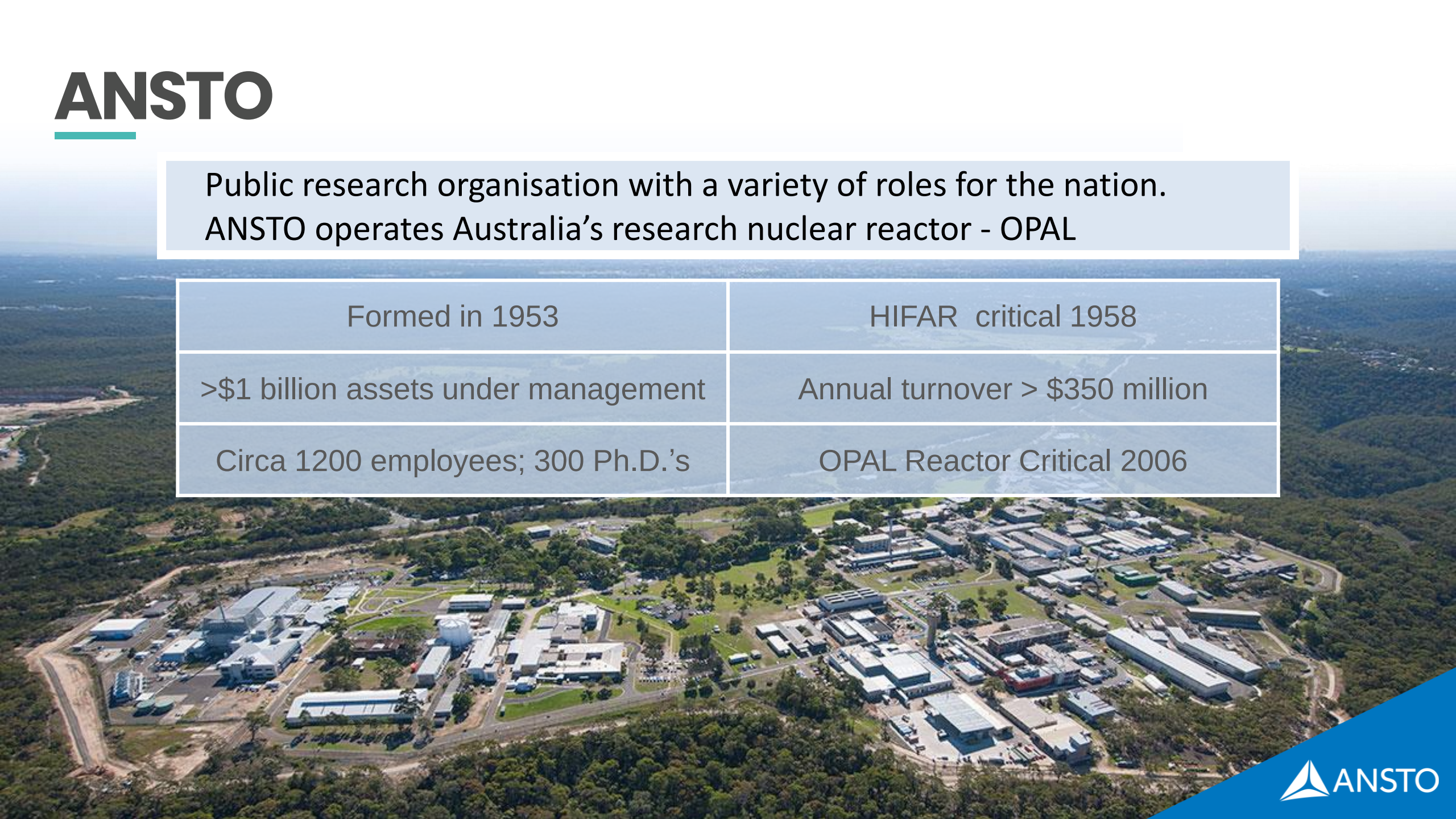
VIC

ANSTO

ANSTO

Public research organisation with a variety of roles for the nation.
ANSTO operates Australia's research nuclear reactor - OPAL

Formed in 1953	HIFAR critical 1958
>$1 billion assets under management	Annual turnover > $350 million
Circa 1200 employees; 300 Ph.D.'s	OPAL Reactor Critical 2006



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ANSTO Research Infrastructure for Users and Industry

Landmark

OPAL
Multipurpose Reactor

Australian Centre for Neutron Scattering

Australian Synchrotron

National

National Deuteration Facility

Centre for Accelerator Science

Medical Research Cyclotron

Institutional

Local with national impact

Isotope Tracing and Dating

Nuclear Forensics

Activity Standards

Neutron Activation and Irradiations

Radiotracers and Bioimaging

Materials Characterisation







ANSTO

ANSTO businesses

Ansto Health

ANM ANSTO Nuclear Medicine

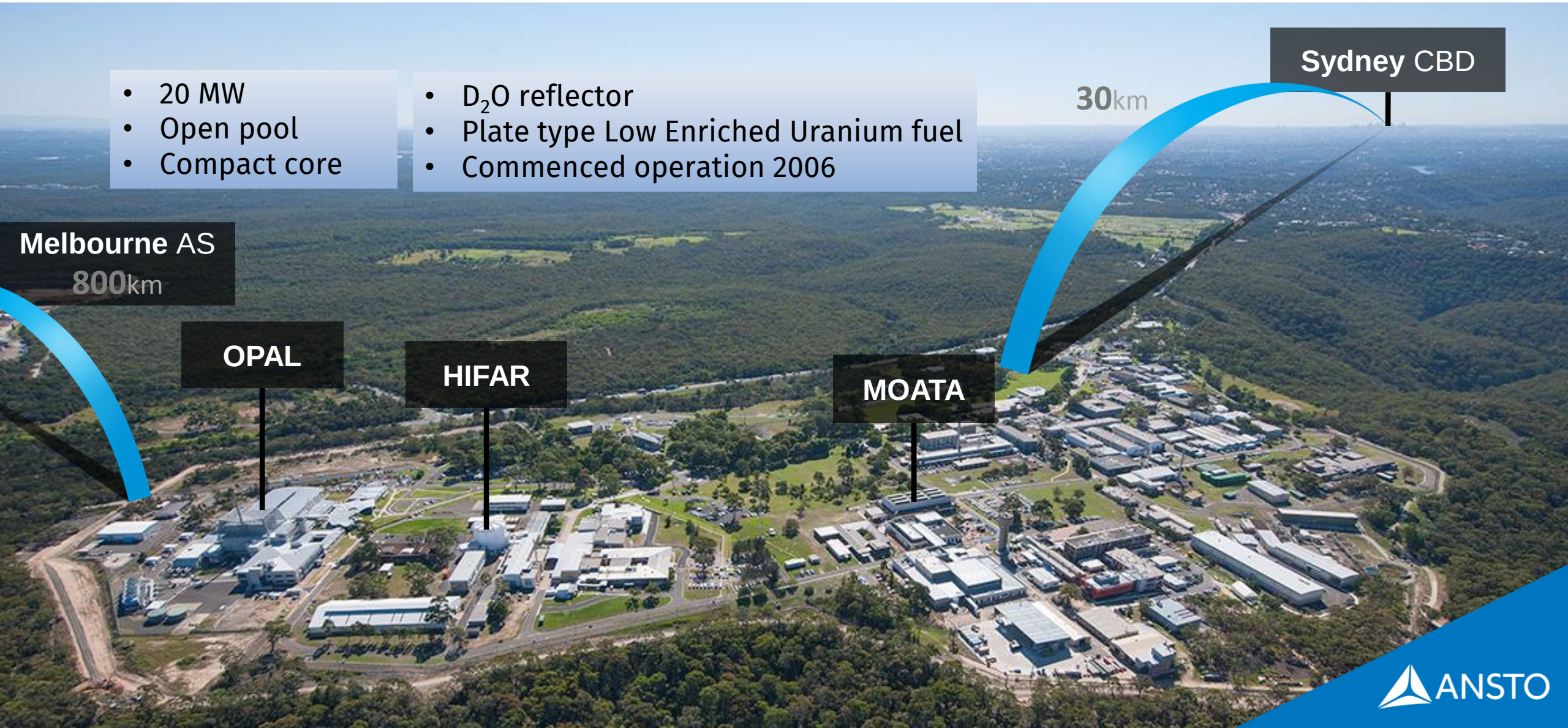
Ansto Minerals

Ansto Silicon

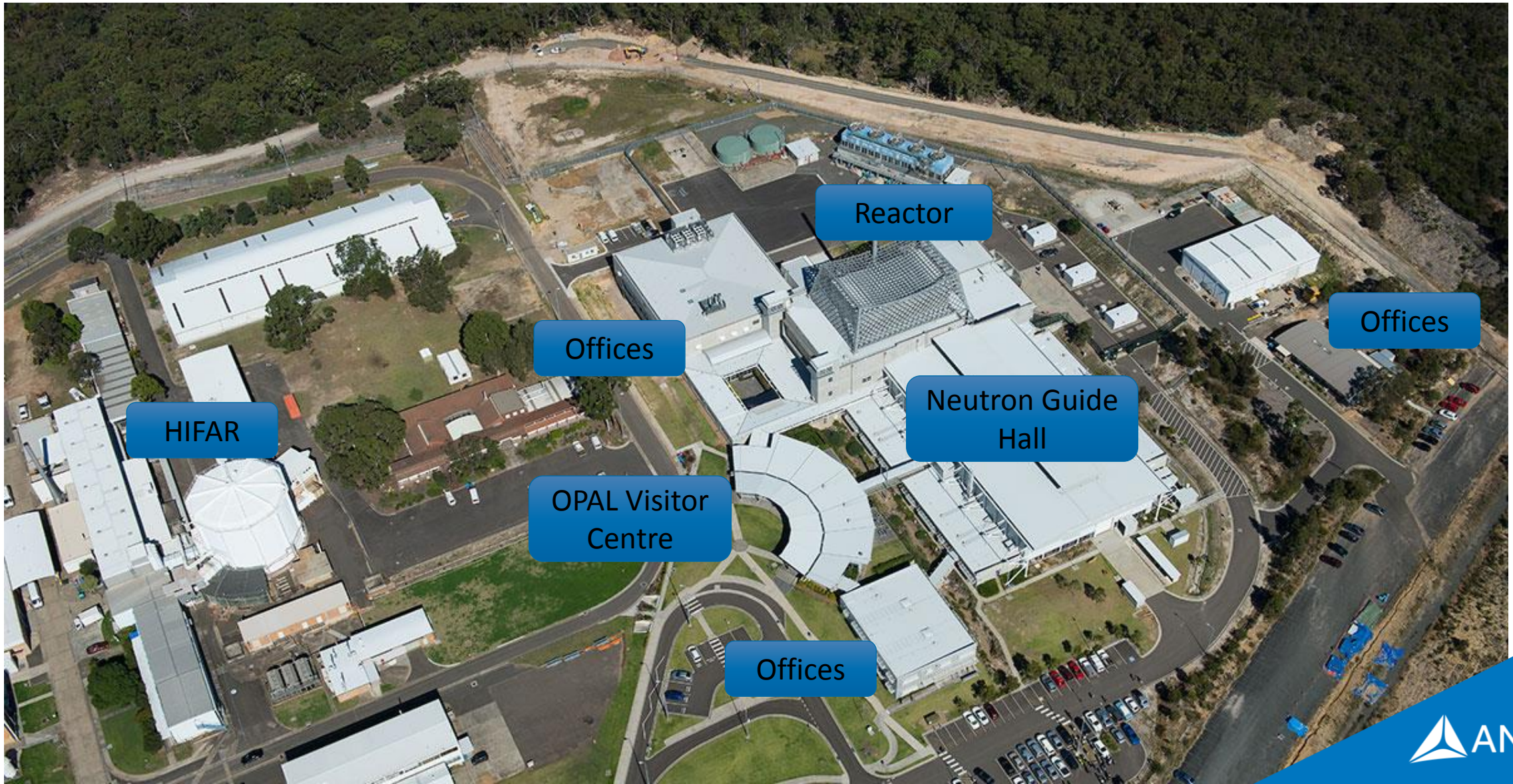
Ansto Synroc

Ansto Radiation Services

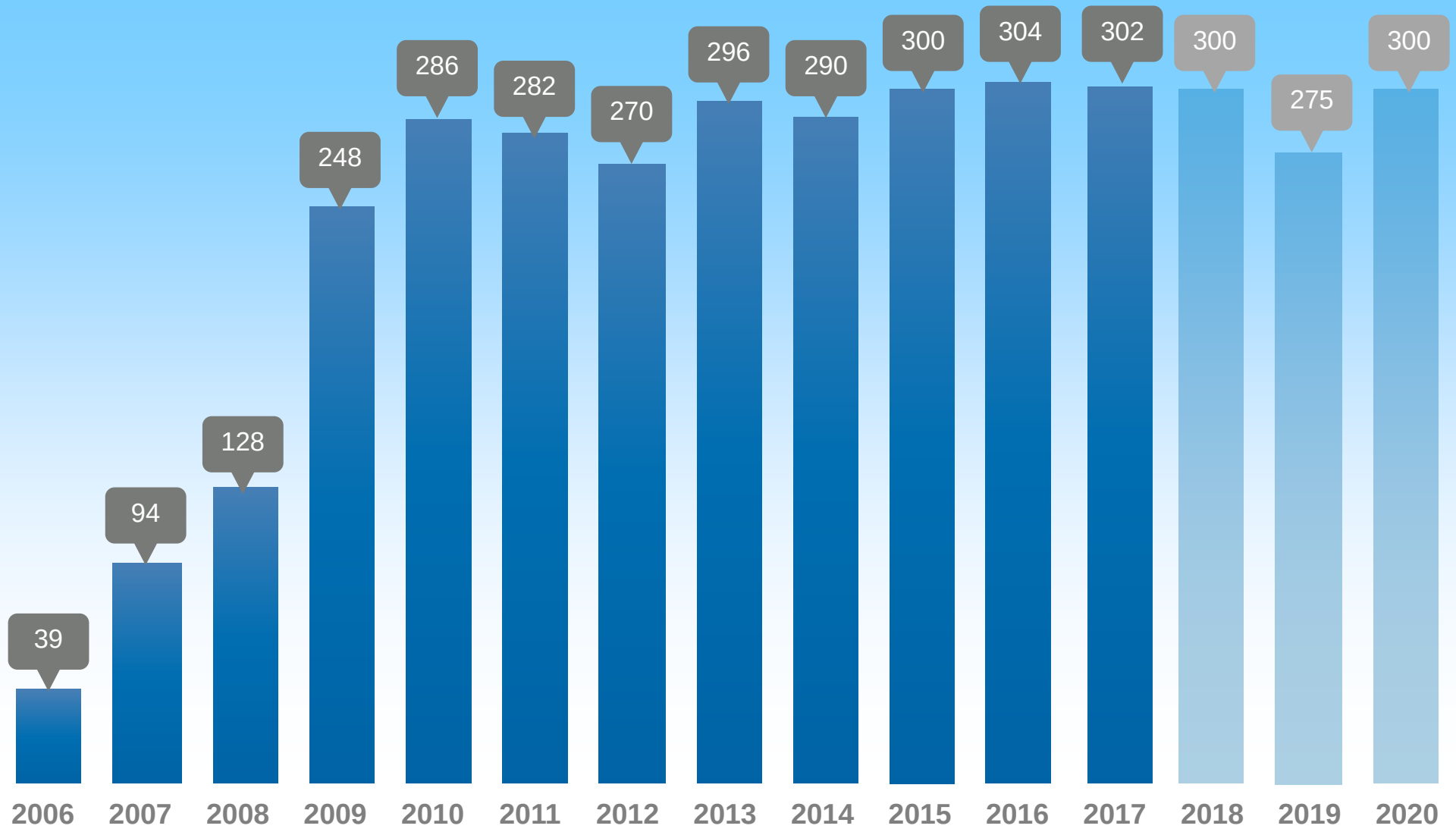
ANSTO Lucas Heights Campus & OPAL Reactor



OPAL Facility



OPAL Operating Days



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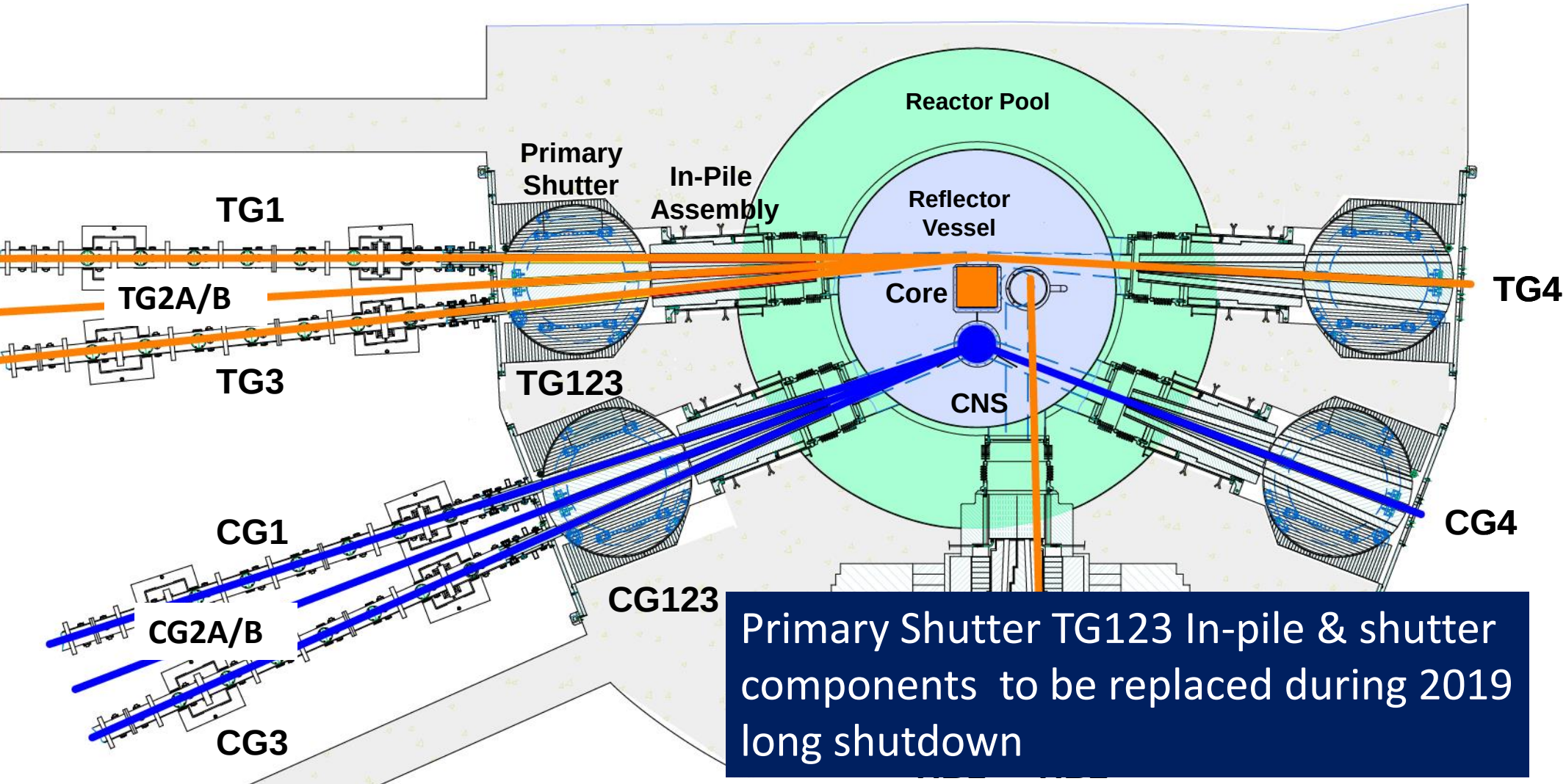
OPAL's Neutron Beam Facilities



Primary Shutter TG123 In-pile & shutter components to be replaced during 2019 long shutdown

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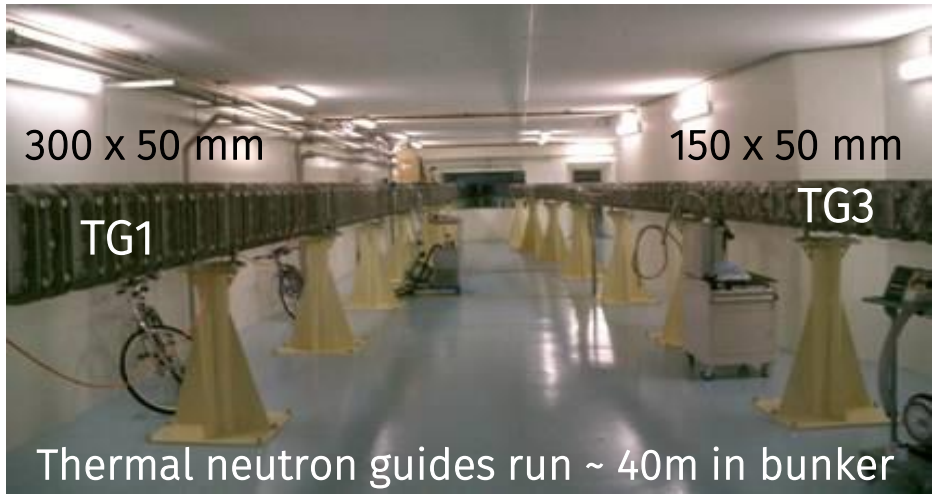
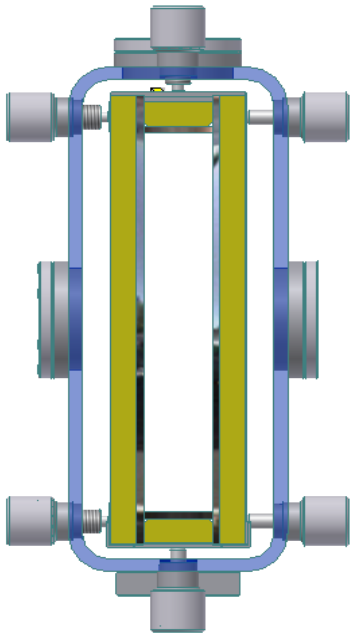
Reactor Face, Neutron Guides & Bunker





Supermirror neutron guides transmit up to ~80 m from the core

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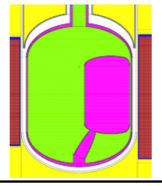
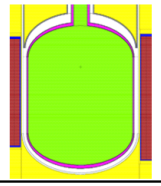
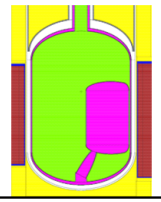
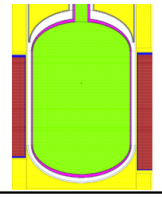
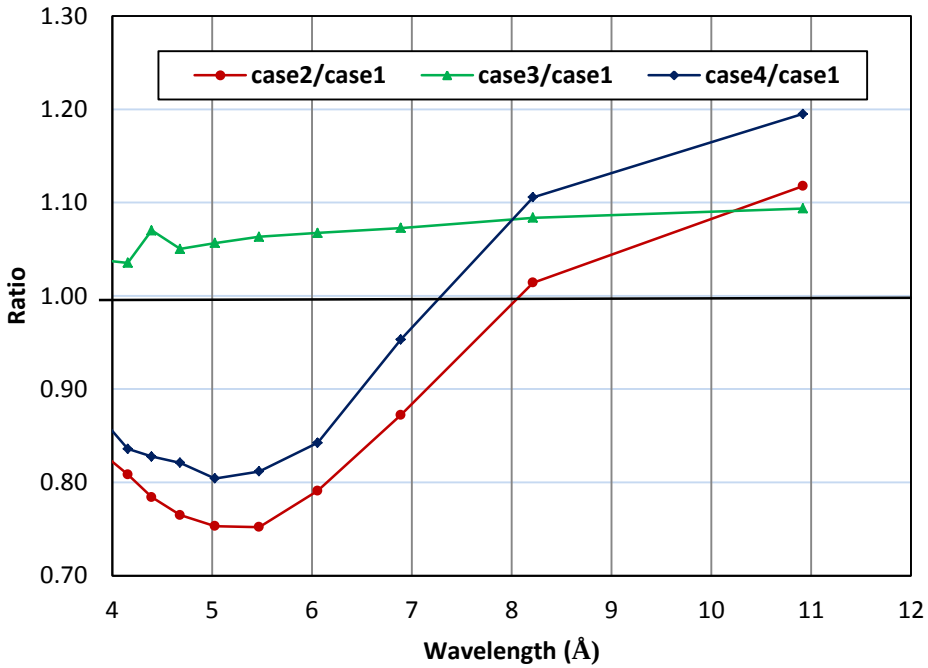
Cold Neutron Source Mk2

- Licence application – CNS life 10 years (2018)
  - Conservative due to limited data on AlMg5
  - Life extension now to 15 years (2024)
- 2 x CNS currently being fabricated by HNFT
  - Increased height and volume

Case 1 (current)	Case 2 (no cavity)	Case 3 (increased height)	Case 4 (no cavity and increased height)
			



Australian Centre for Neutron Scattering

- 80 staff support 300 reactor days
  - 225 days to user service
- 14 (+1) neutron beam instruments
- 4,300 registered users
- 450 user experiments per year
- 500 individual users visit per year
  - 1,400 user visits per year
- 1061 journal publications with neutron data from users & staff (2007-2018)
  - 184 in 2017
  - 127 in 2018

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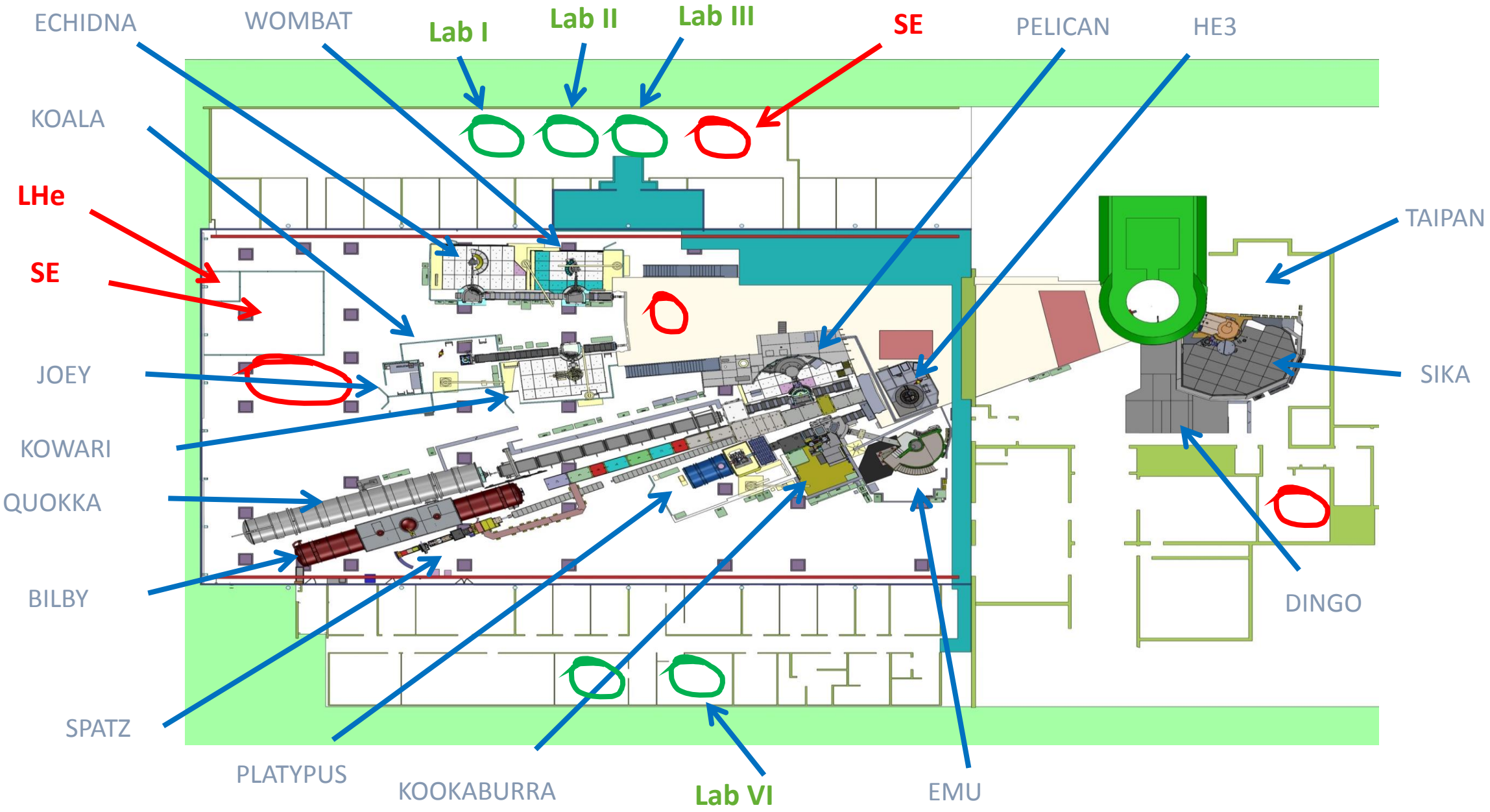
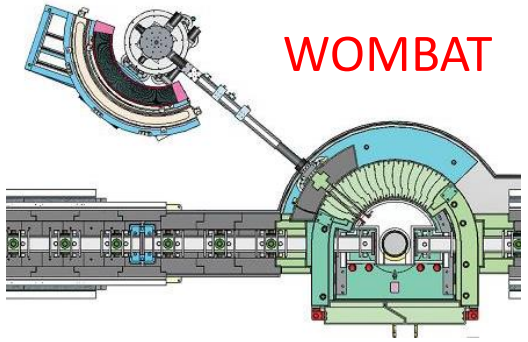

ECHIDNA
WOMBAT
Lab I
Lab II
Lab III
SE
PELICAN
HE3
KOALA
LHe
SE
TAIPAN
JOEY
SIKA
KOWARI
QUOKKA
BILBY
DINGO
SPATZ
PLATYPUS
KOOKABURRA
Lab VI
EMU

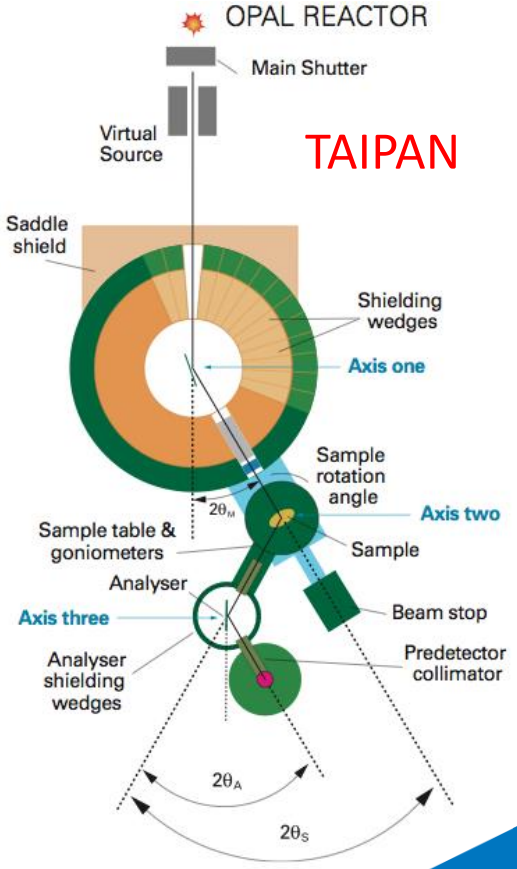
ACNS Instruments

Diffractometers:	
ECHIDNA	high-resolution powder diffractometer
WOMBAT	high-intensity diffractometer
KOALA	single-crystal Laue diffractometer
KOWARI	strain scanner
JOEY	crystal-alignment Laue diffractometer
Small-angle Spectrometers:	
QUOKKA	monochromatic SANS
BILBY	time-of-flight SANS
KOOKABURRA	ultra-SANS
Imaging & Reflectometry:	
DINGO	radiography/tomography/imaging station
PLATYPUS	reflectometer
SPATZ	reflectometer (under construction)
Inelastic Spectrometers:	
TAIPAN	thermal-neutron three-axis spectrometer, with Be-filter option
SIKA	cold-neutron three-axis spectrometer
PELICAN	cold-neutron time-of-flight spectrometer
EMU	high-resolution back-scattering spectrometer

WOMBAT



TAIPAN



ACNS Operations Teams

Scientific Operations (Scott Olsen 9): Mechanical workshops, neutron delivery systems, chopper systems, vacuum systems and shielding

Sample Environment (Rachel White 8): sample environments and laboratories support; key interface with users and support for specific experiments

Computing & Electronics (Nick Hauser 12): software and electronic engineering, data-acquisition and data-analysis software and hardware, detectors and technical support for ACNS user portal

Electrical Engineering (Frank Darmann 8): motion controls, encoding, safety interlocks, pneumatics, control systems, power distribution and signal earthing

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SE Equipment and Instrumentation

- More than 60 individual pieces of Sample Environment equipment, including:
  - 14 cryostats or cryofurnaces + dilution insert + 3He one-shot
  - 4 magnets
  - 8 multi-sample changers
  - 3 Robots one (6 axis) dedicated to texture measurements
  - 5 furnaces
  - + pressure cells, Eulerian cradles, gas/vapour delivery, electric field, differential scanning calorimeter, rapid viscosity analyser, rheometer, solid-liquid and stopped-flow cells + more!

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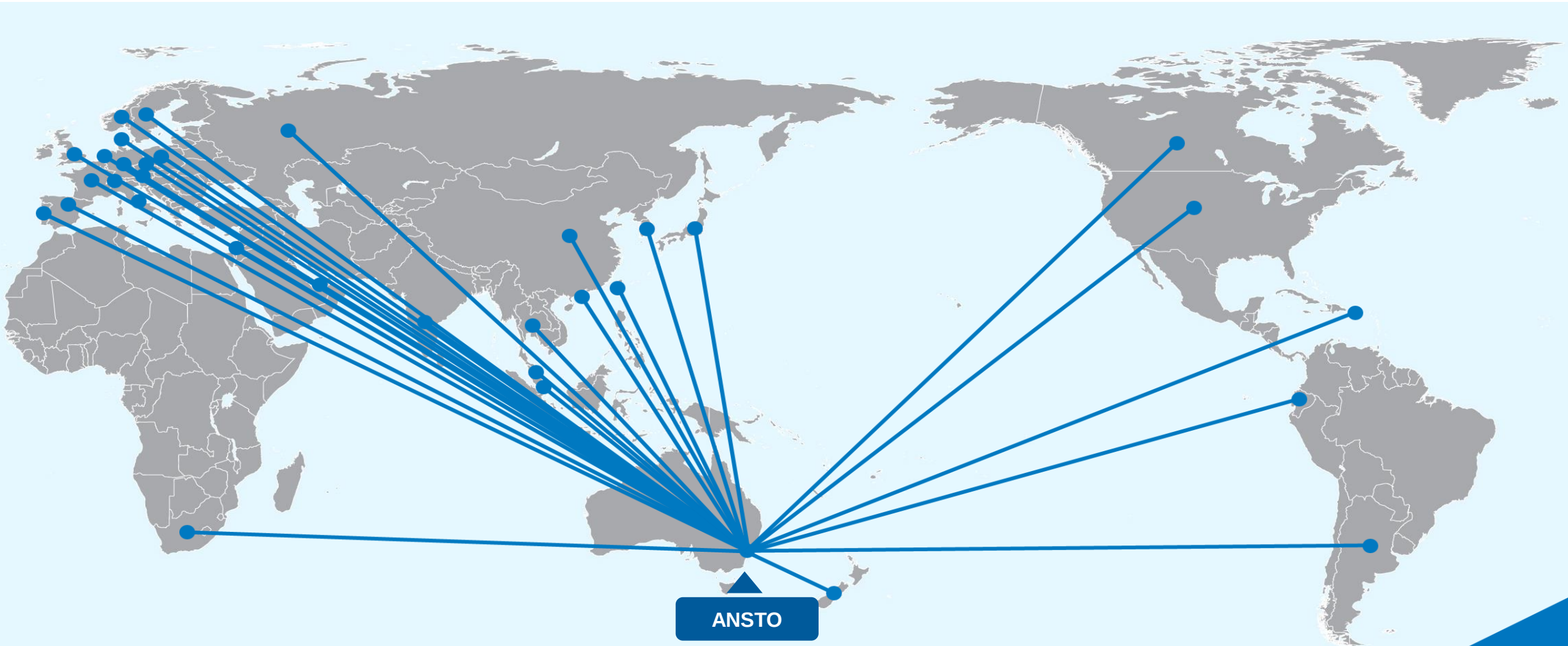
Lab and Main SE Work Area

ACNS Partnerships

- Strategic Partnerships
  - National Synchrotron Radiation Research Center (NSRRC)
  - Helmholtz-Zentrum Berlin
  - University of Tokyo
  - National Collaborative Research Infrastructure Strategy
- Joint Appointments
  - Adjunct Positions with Universities

- Joint Research
  - Universities & Industry
  - Students, Post-docs
  - Australian Research Council Discovery, Linkage, LIEF, Centres of Excellence, Industrial Transformation Training Centres
- Facilities & Associations
  - J-PARC, PSI, CIAE, BATAN, KAERI
  - ANBUG & AONSA

Where do the users come from?



2008 – 2018

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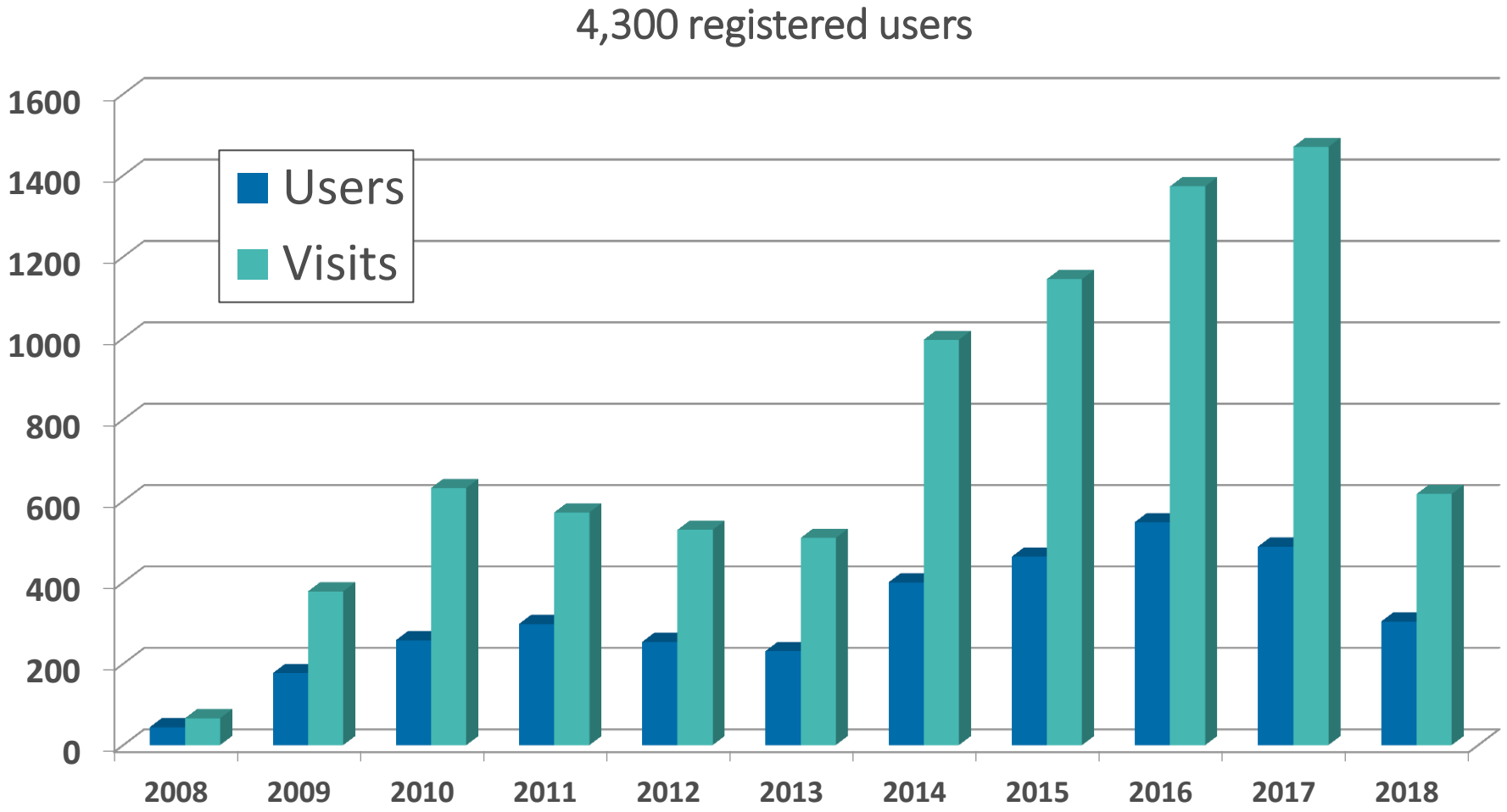
Users Visiting ACNS (June 2018)



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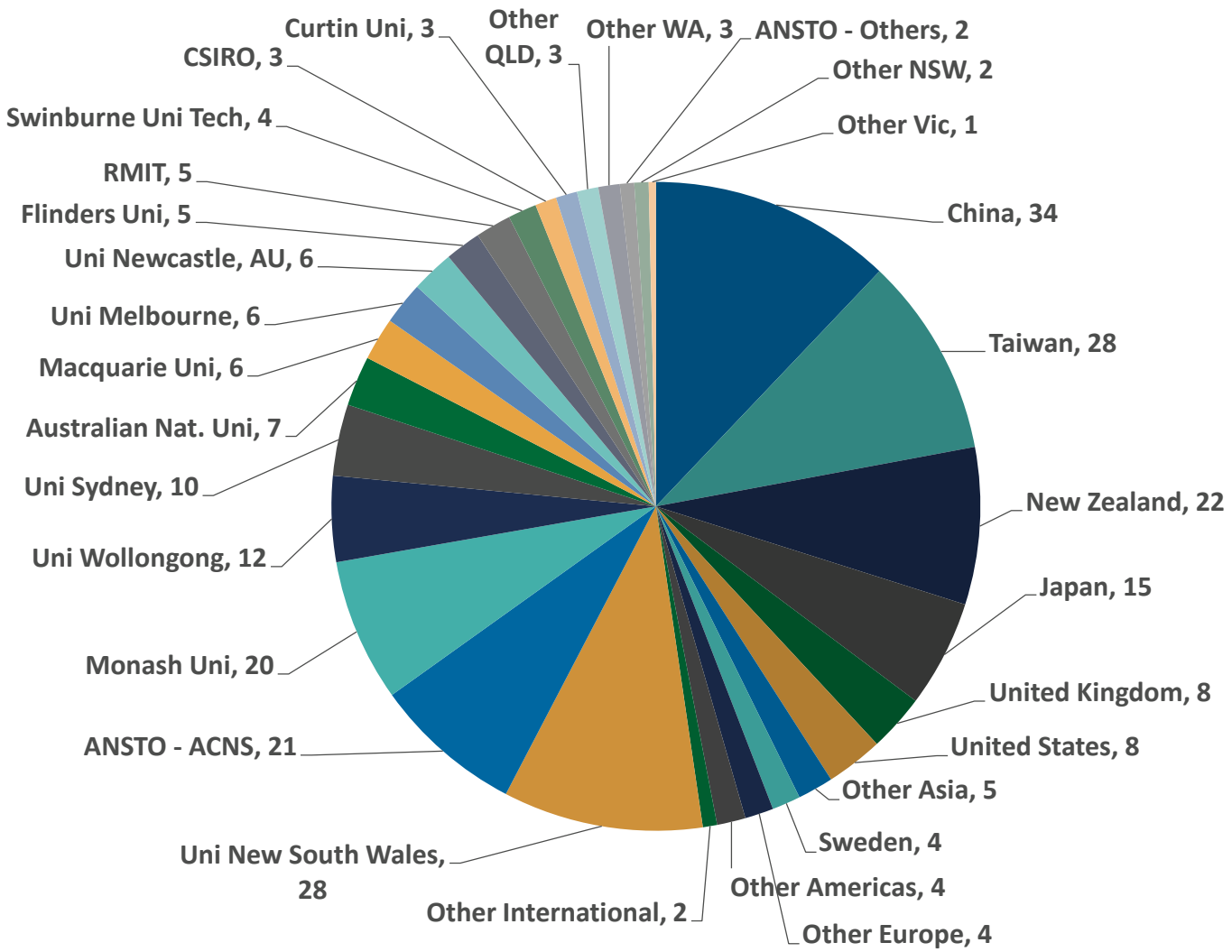
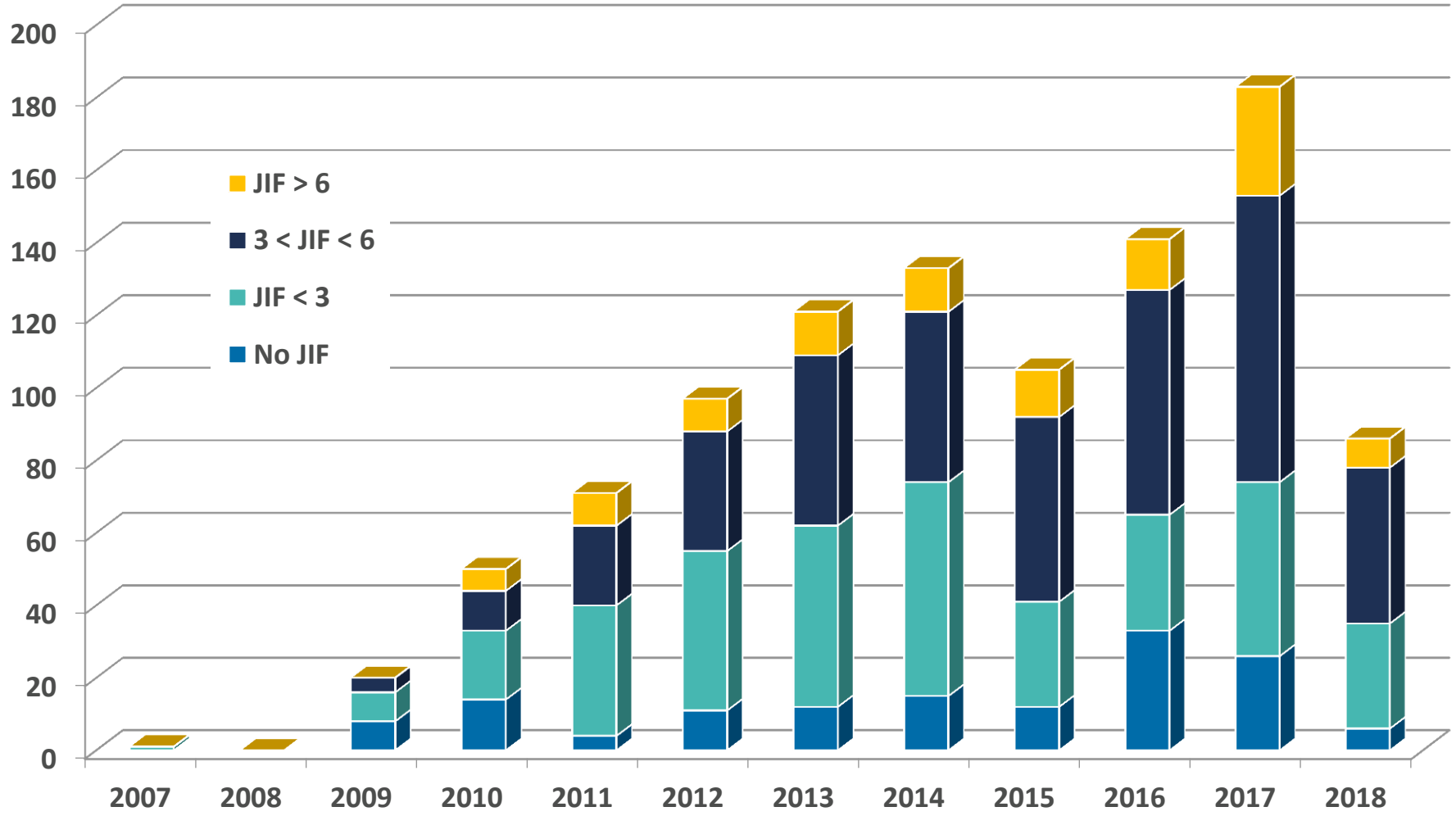
Demand from 2019 –1



- Last Round 281 Proposals

- Australia 53%
- Asia/Oceania 37%
- Europe/USA 10%

Papers from ACNS Neutron Beam Instruments (July 2018)



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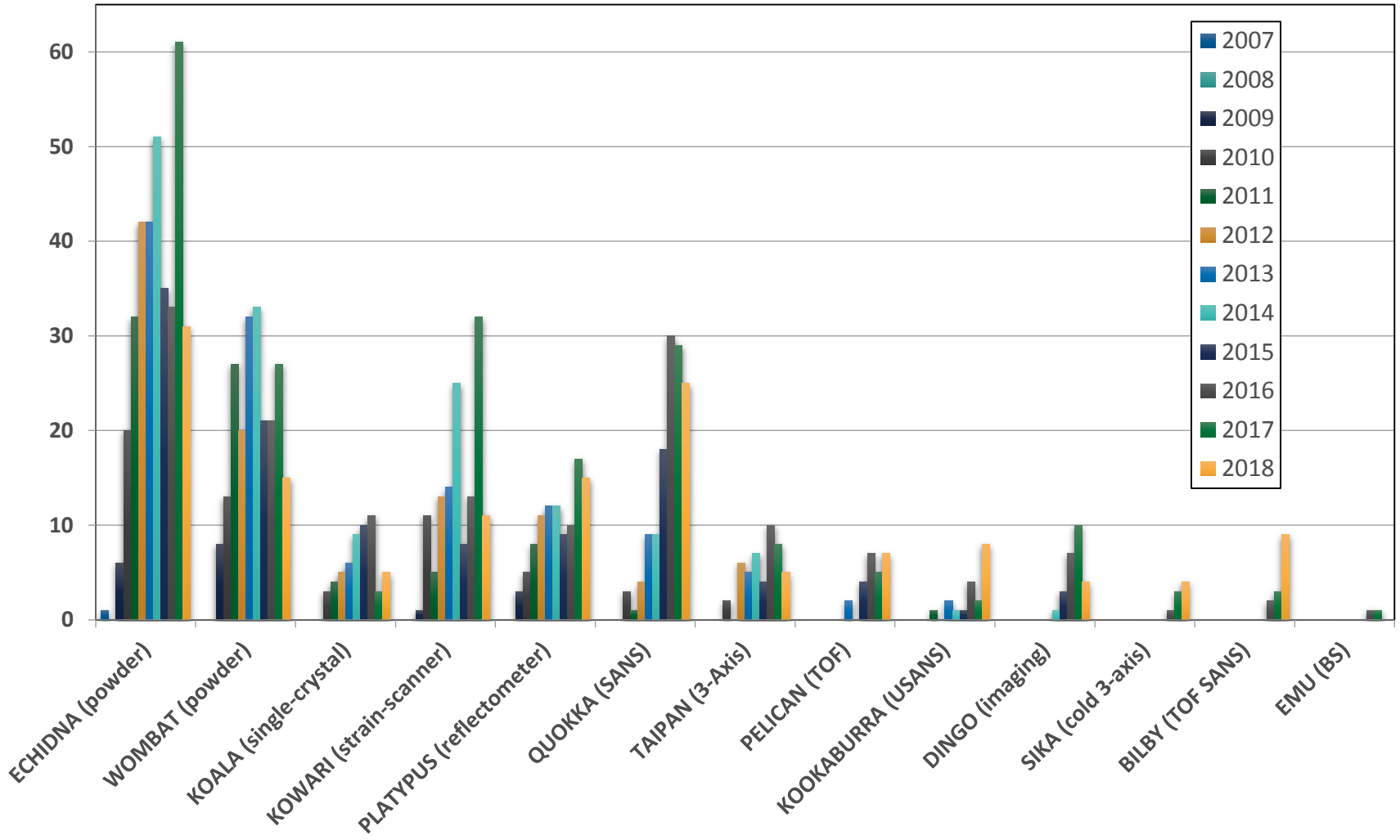
Papers from ACNS NBI (October 2018)



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ACNS Industrial Liaison Office

- Dedicated industry portal for access to ACNS:
  - Provide industrial access to neutron and X-ray instruments
  - Develop software and high-tech instrumentation
  - Collaborate or partner with industry in research and development projects
  - Provide specialised training for academic and industry users.
    - http://www.ansto.gov.au/ResearchHub/OurInfrastructure/ACNS/Industry/

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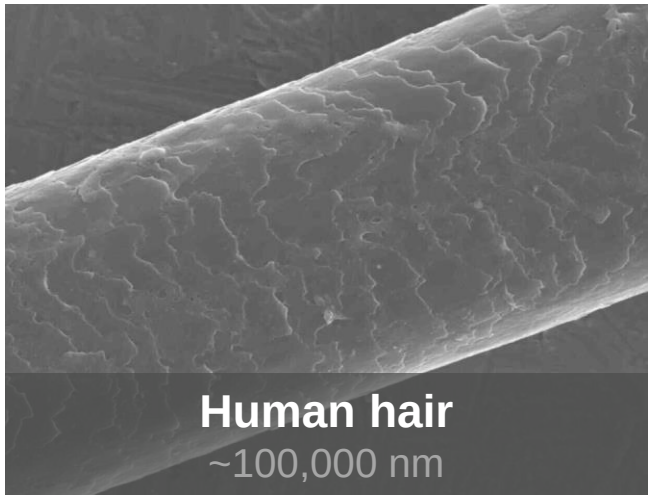
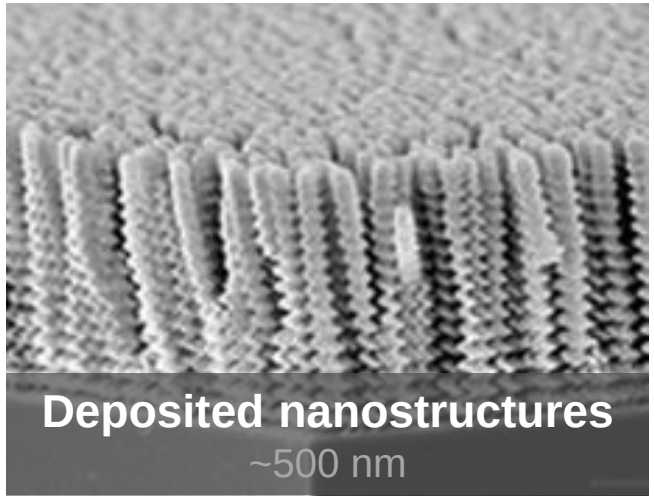
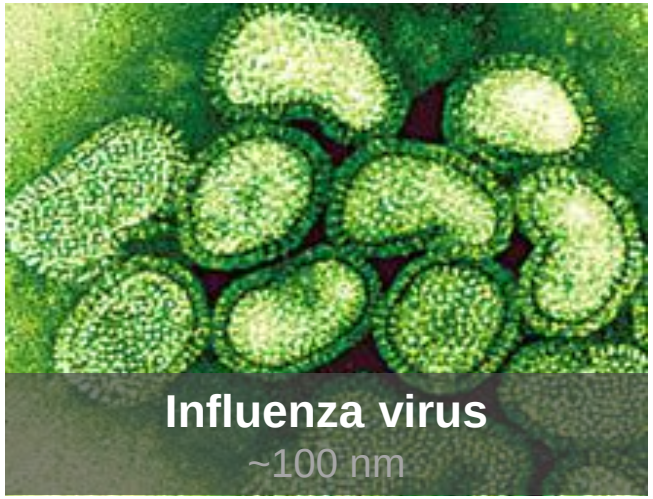
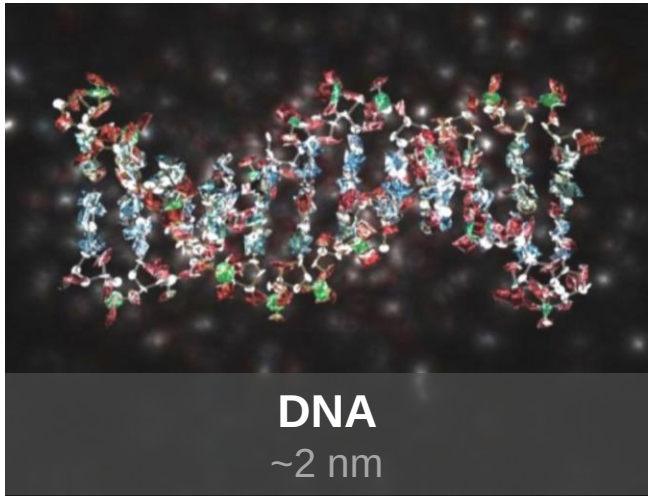
Neutrons as a Probe of Atomic and Nanoscale Structures

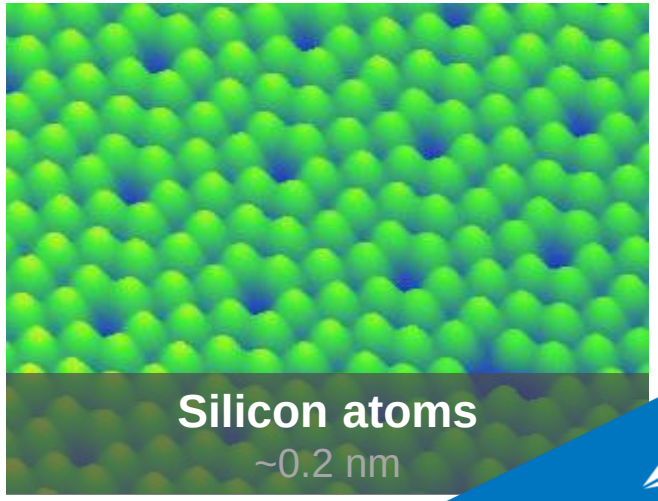
1. Have the right (tunable) wavelength











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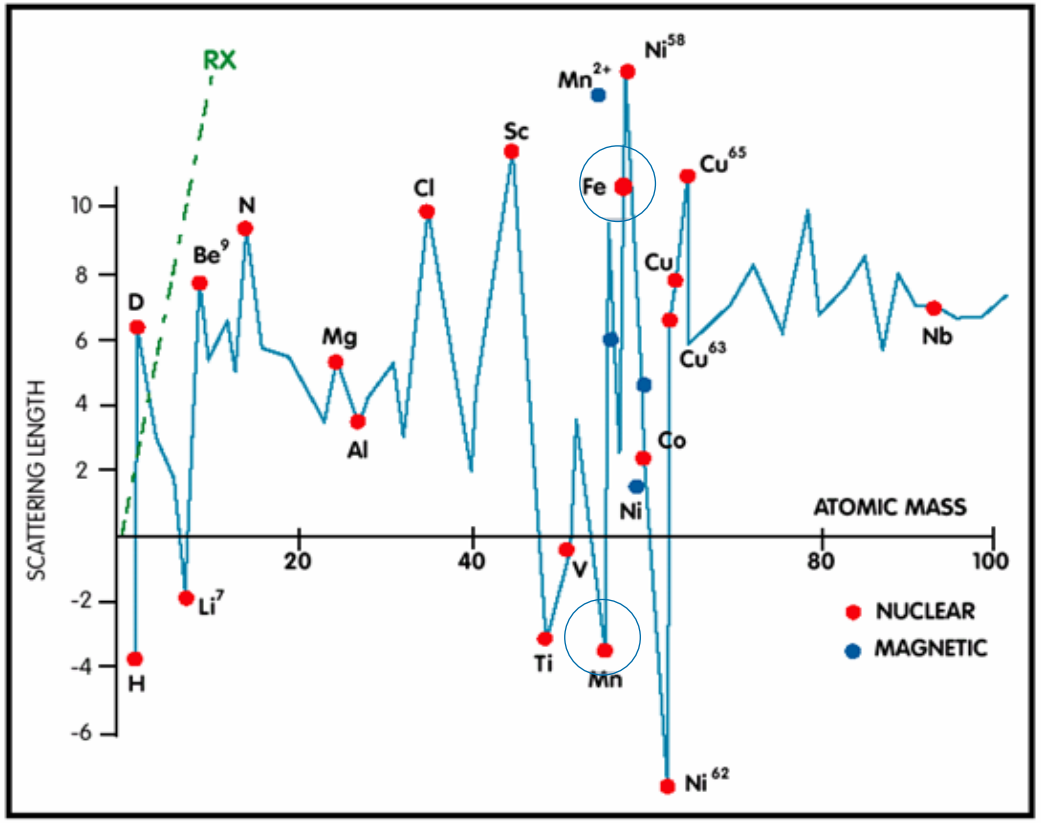
Neutrons as a Probe of Atomic and Nanoscale Structures

2. Scatter from the nucleus
   - See light atoms next to heavy ones
   - Distinguish neighbouring atoms in periodic table



chromium **24** **Cr** 52.00	manganese **25** **Mn** 54.94	iron **26** **Fe** 55.85	cobalt **27** **Co** 58.93
molybdenum **42** **Mo** 95.94	technetium **43** **Tc** 98.00	ruthenium **44** **Ru** 101.07	rhodium **45** **Rh** 102.91

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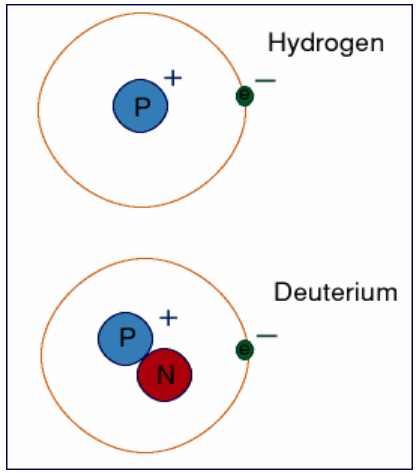
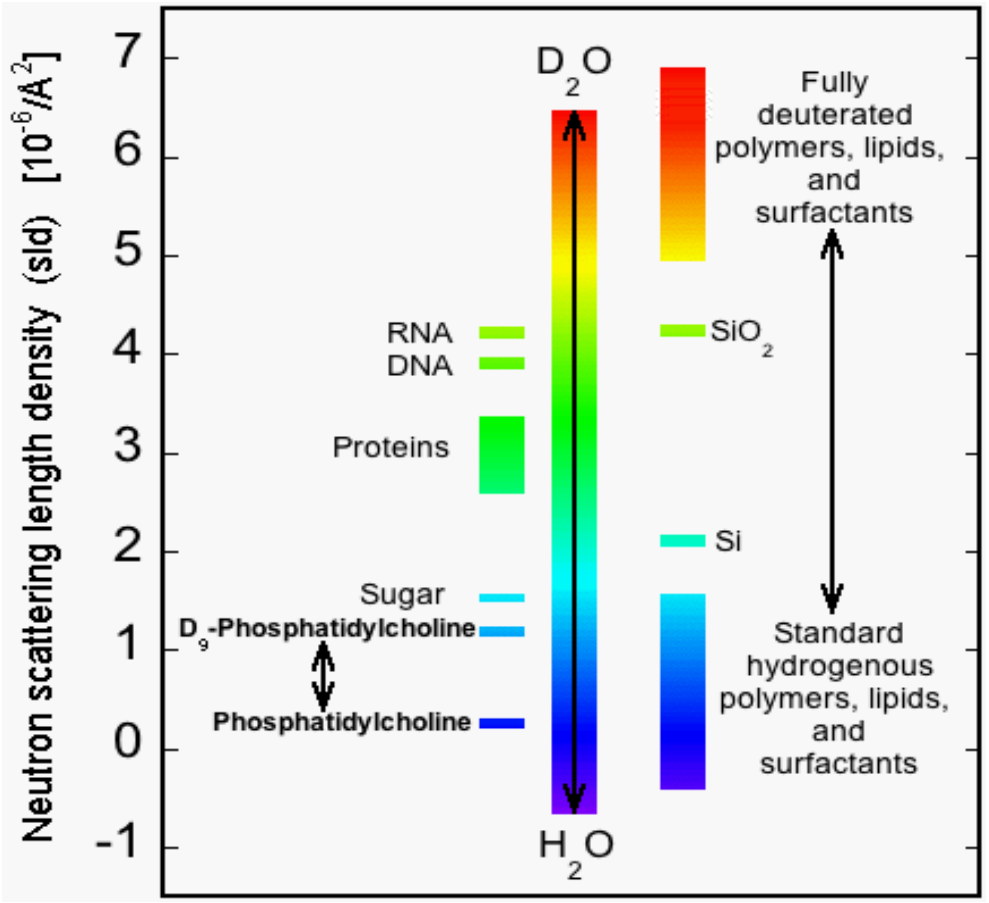
Neutrons as a Probe of Atomic and Nanoscale Structures

3. Scatter from the nucleus: isotopic sensitivity
   - isotopic sensitivity - contrast between H and D



Scattering Length / (10^{-12} cm)

	n	X-ray
H	-0.374	0.28
D	0.667	0.28



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Biological and Chemical Deuteration

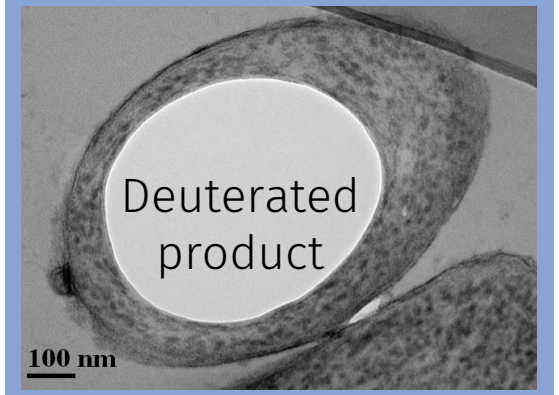
- ANSTO's National Deuteration Facility
  - User Provide access to specialised laboratory space, equipment, and expertise for deuteration
  - Merit access via proposal

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

Chemical synthesis in D_2O

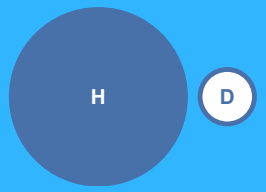
Chemical Deuteration

Growing bacteria in D_2O

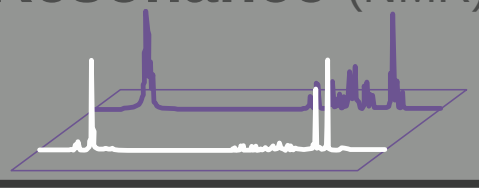


Biological Deuteration

Neutrons

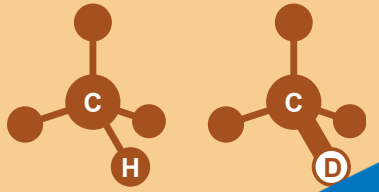


Nuclear Magnetic Resonance (NMR)



Infra Red (IR)

Kinetic Effect



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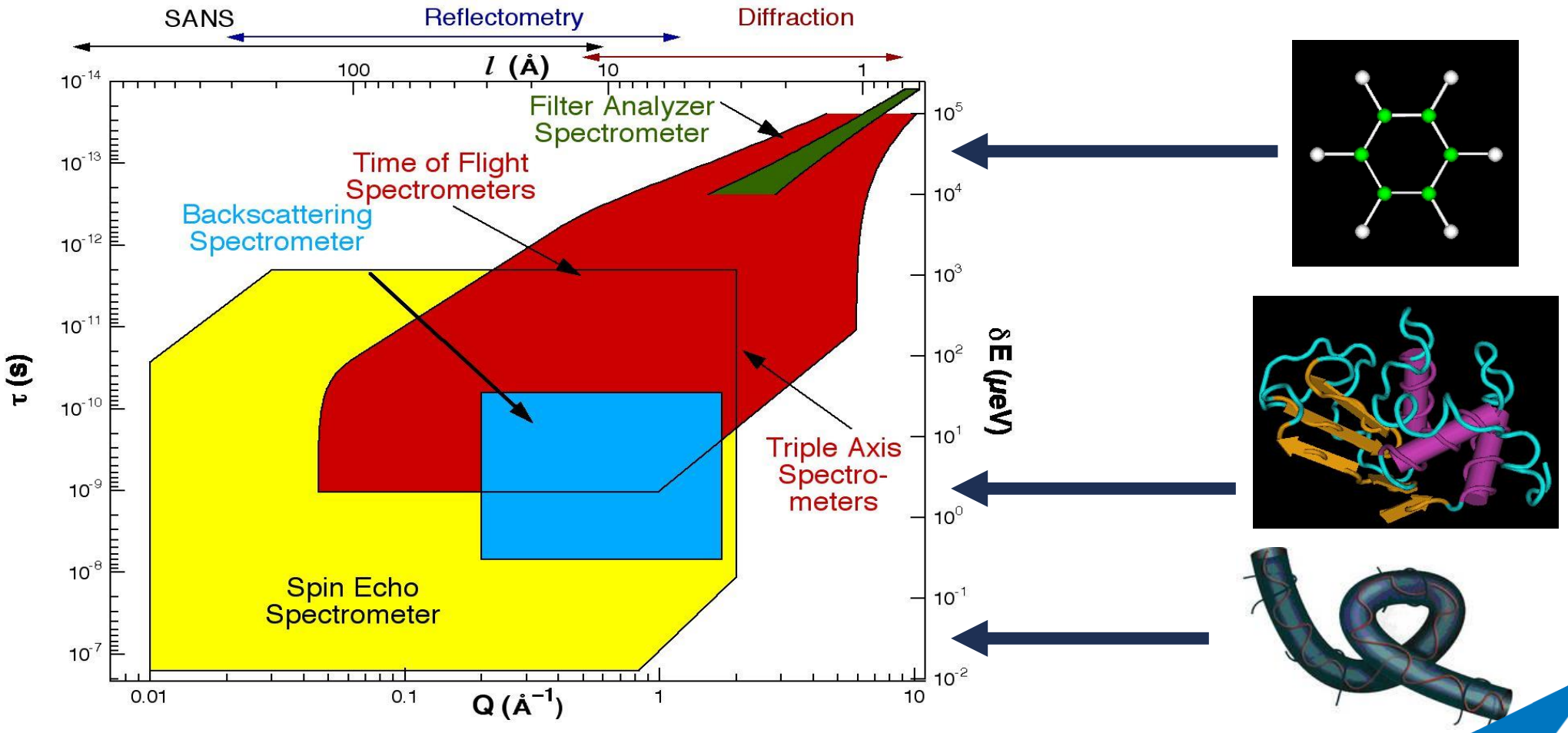
Probe of Atomic and Nanoscale Structures

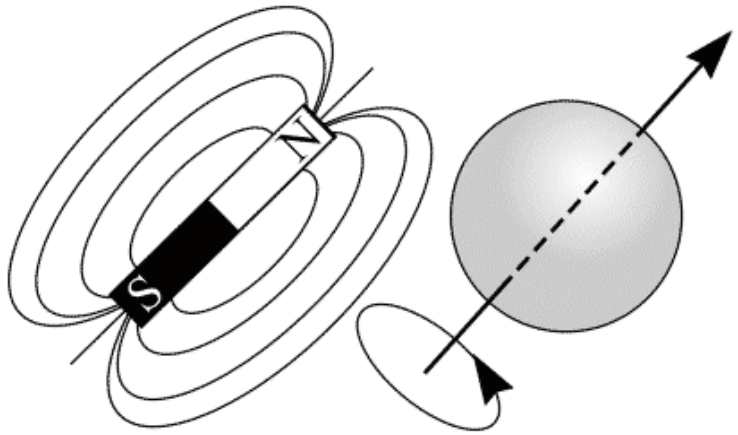
4. Energy comparable to atomic and molecular motion and dynamics



Probe of Atomic and Nanoscale Structures

5. Penetrate deeply
6. Neutrons have a magnetic moment
7. Neutrons are Fermions with spin ½

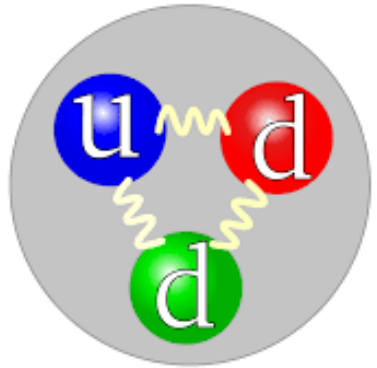
Study of magnetism at atomic level



What is the relative size?

Proton	neutron	electron
1 amu	1 amu	~1/1836 amu

- AMU = atomic mass unit = 1/12 CARBON ATOM
- (standard)



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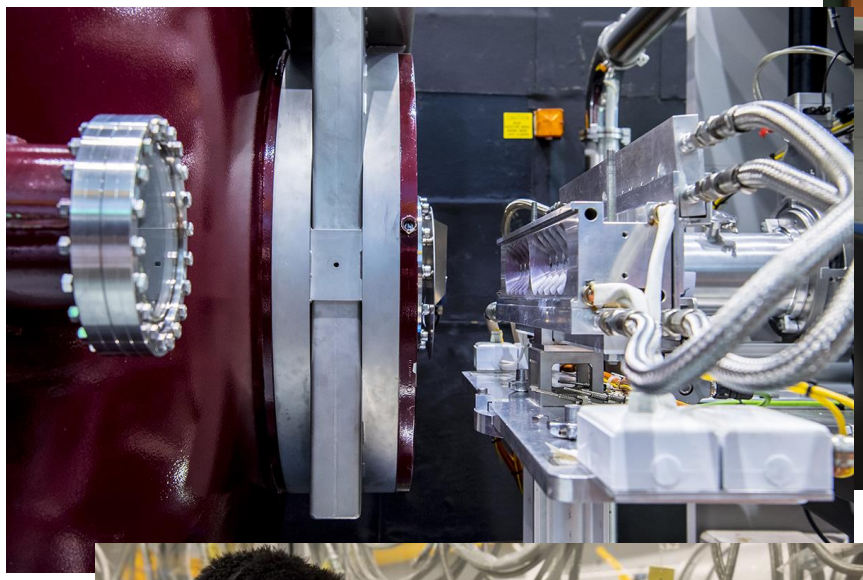
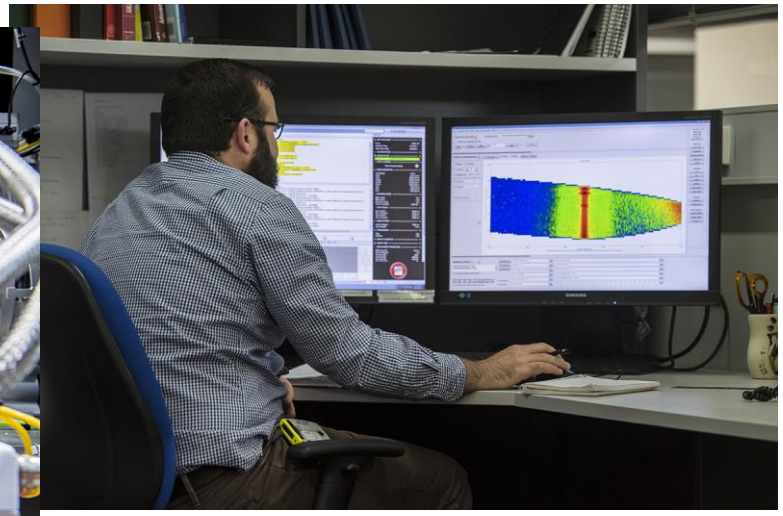
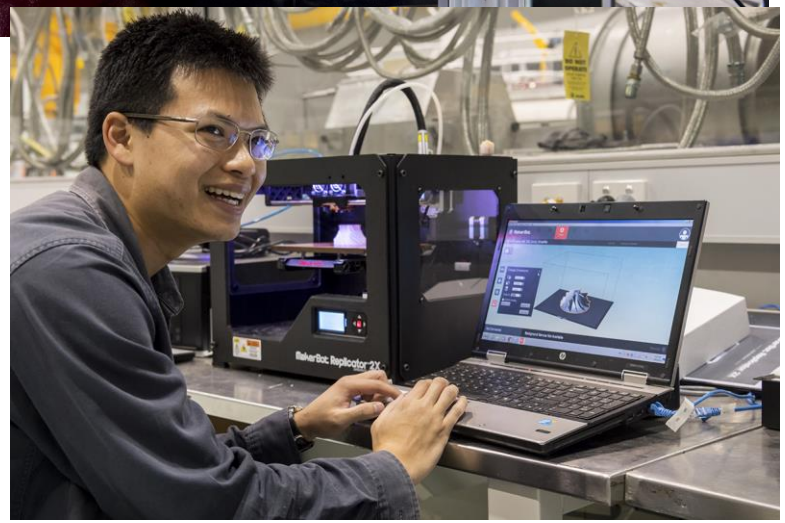
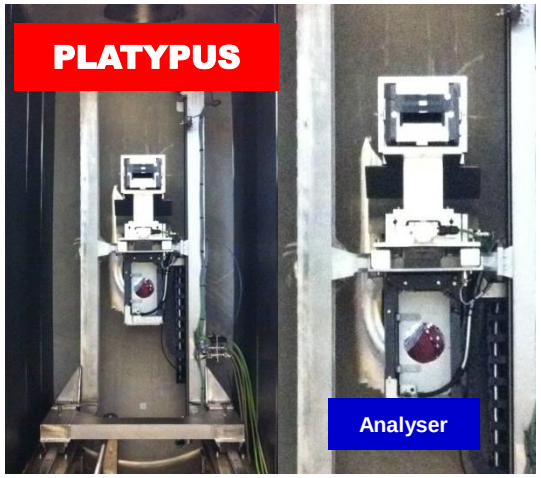
Probe of Atomic and Nanoscale Structures

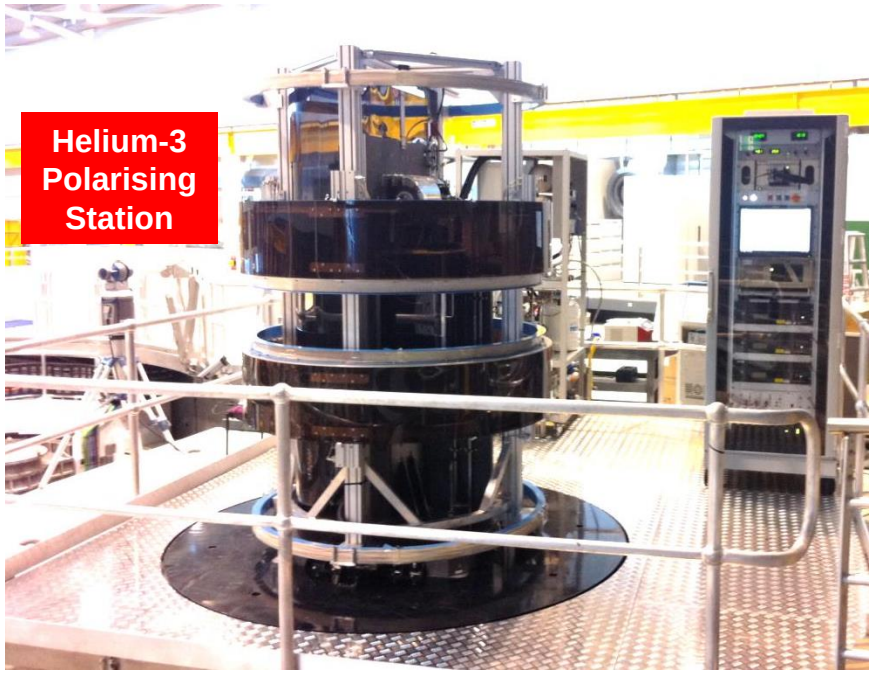


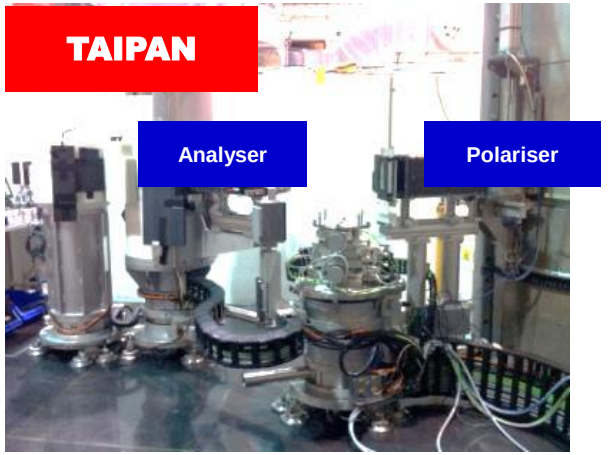


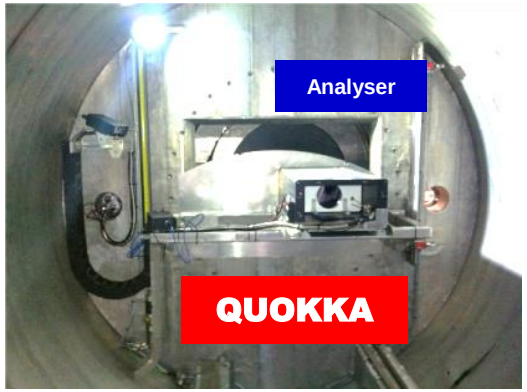


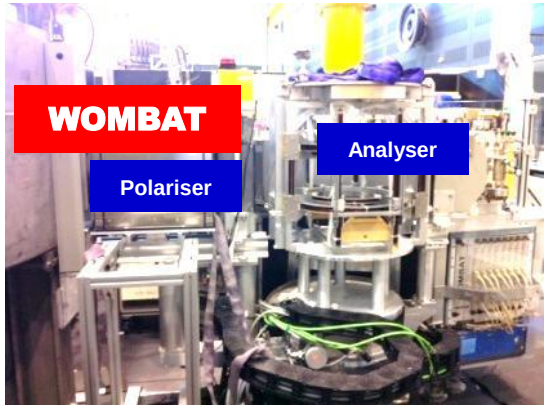
^{3}He Neutron Polarisation on 7 Instruments

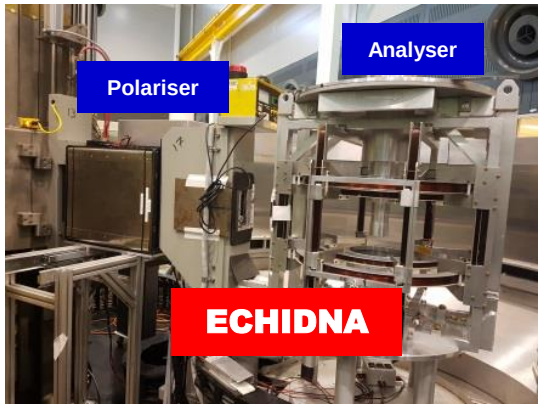


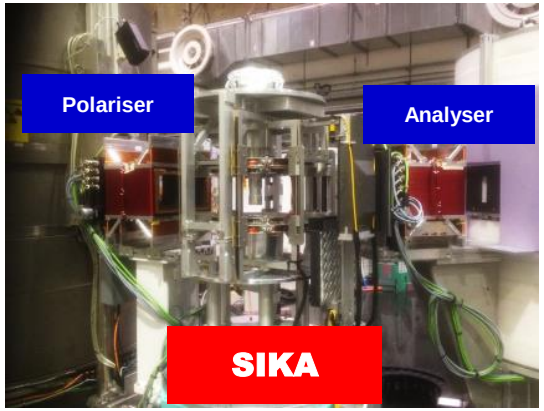








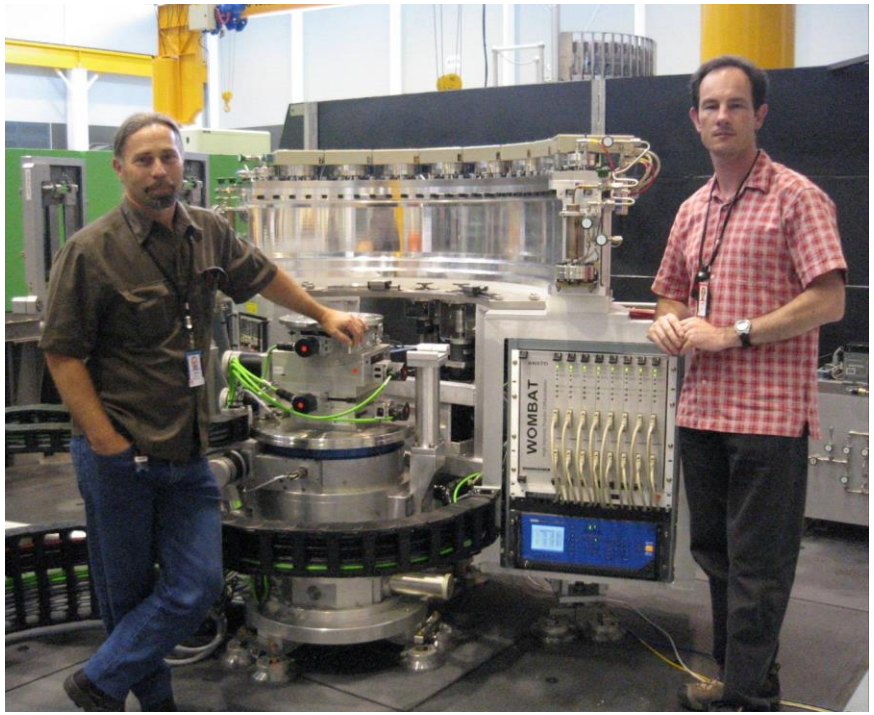


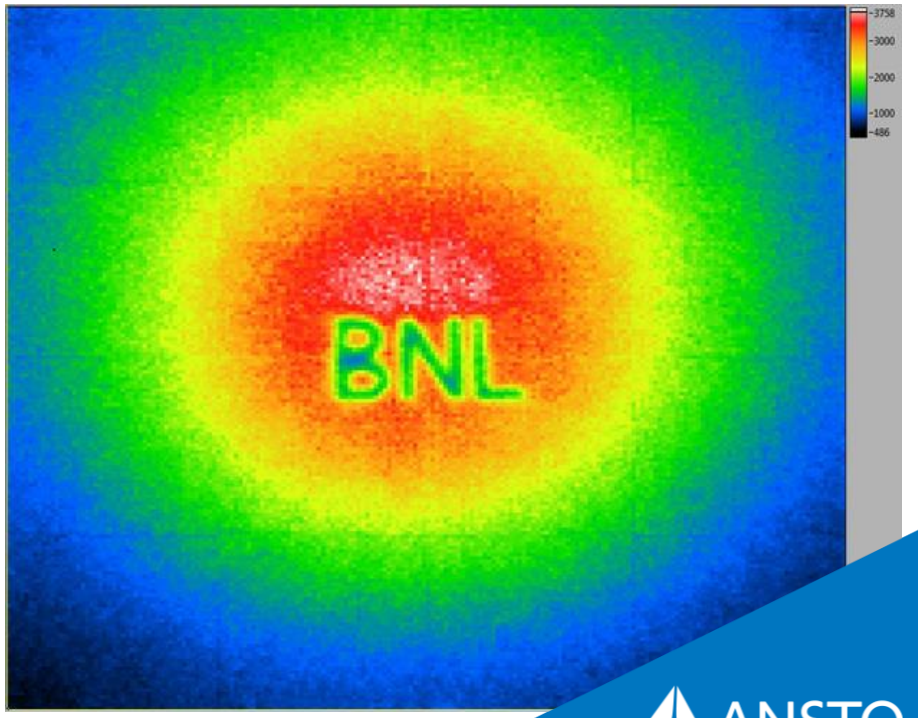


ANSTO & BROOKHAVEN NATIONAL LABORATORY

Wombat Detector
- 12 years reliable service & low maintenance cost

Quokka Detector
- High performance SANS detector
- 7k counts/second /pixel (upgradeable to 25k)
  - 250m counts/second /detector

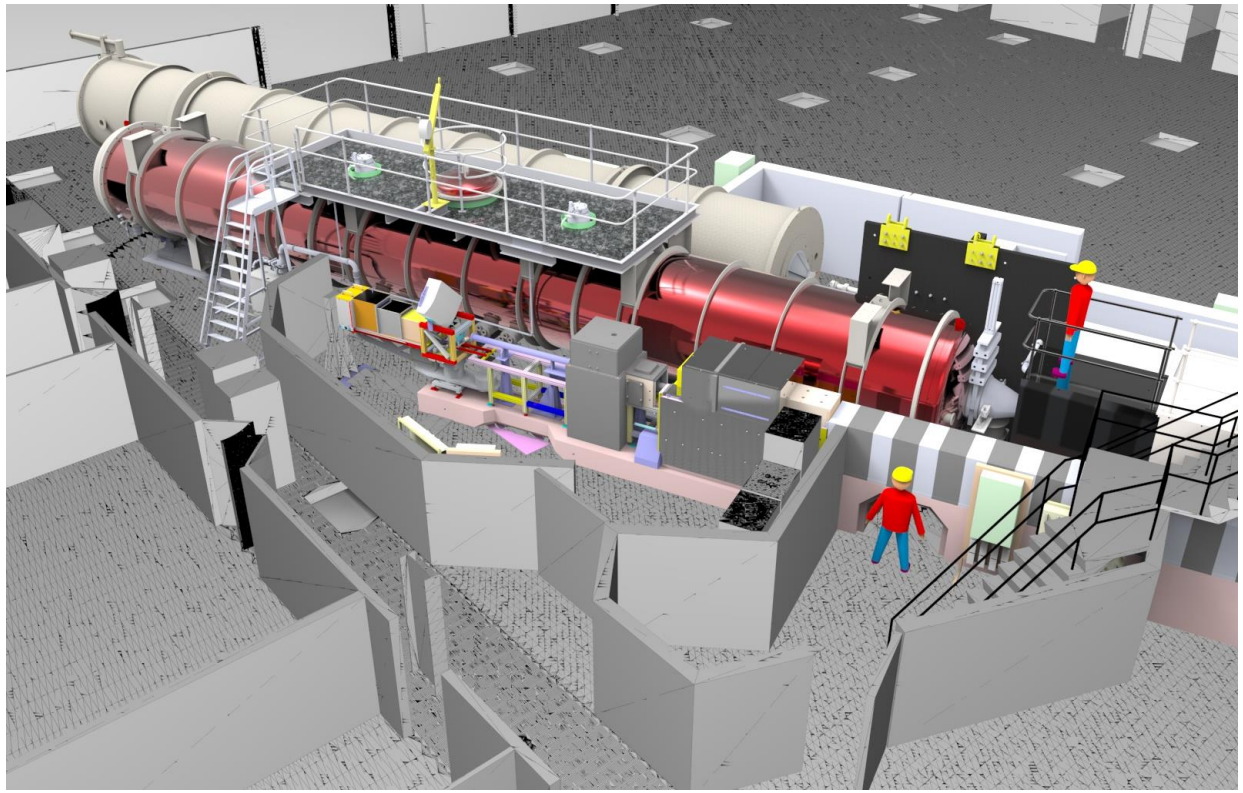


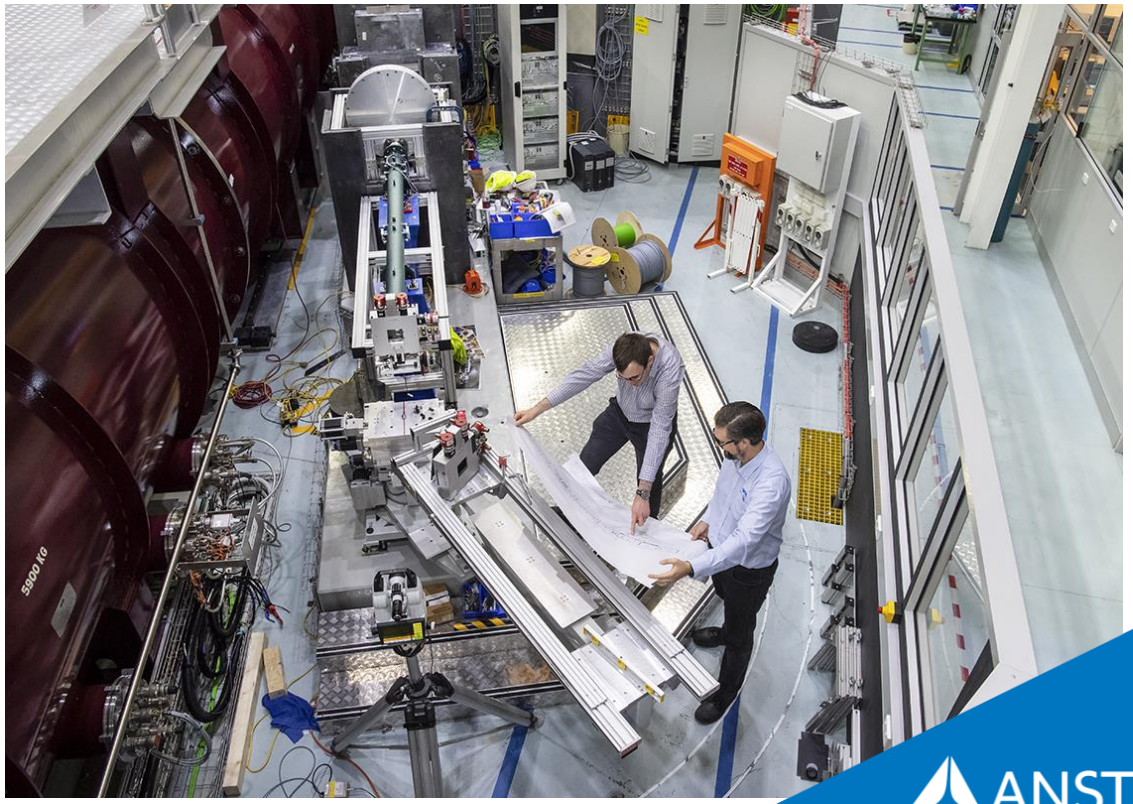


ANSTO

SPATZ Neutron Reflectometer

- BioRef Reflectometer transferred from HZB (BER-II reactor) to ANSTO in 2017
  - First neutrons in late 2018 & first users in early 2019





Access to ANSTO

1. Merit

Normal & Program (3 years) proposal rounds - 15th March & 15th September.

Mail-in for Powder Diffraction measurements on ECHIDNA

No charge but expectation to publish

2. User Pays

Sample preparation, experiment, analysis and reporting conducted by a team of specialist scientists

Timely access, minimal waiting period

IP conditions that support commercial use

3. Discretionary

High impact science, Measurements critical to students thesis or to complete a publication

Continuously open round

No charge but expectation to publish

ANSTO

Proposal Process

- Preparation
- Submission (Proposal Deadlines: 15 Sep, 15 Mar)
- Review – online through Web portal
  - Scientific – national & international experts
  - **Technical & Safety Review – instrument scientists, sample environment manager, laboratory manager**
  - Program Advisory Committee (PAC)

ANSTO

Proposal Process

- Approval
  - ACNS Director approves PAC recommendation & makes adjustments if required (may balance for institutional commitments)
- Scheduling
  - user office & instrument scientists
- Completion
  - **customer feedback requested**
- Reporting
  - brief scientific report
  - publications

Access Policy

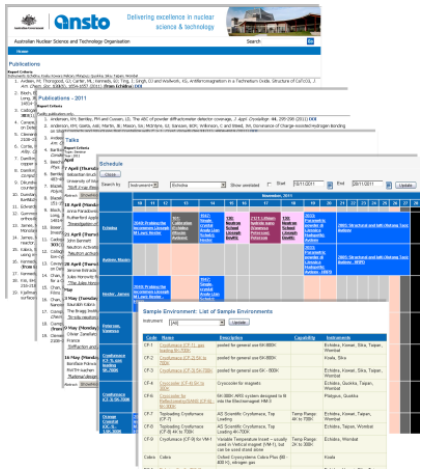
- Principal Investigator agrees to principles of non-proprietary research and takes responsibility for their team
  - Non-proprietary research (no IP)
  - Publish in open literature
  - Acknowledgment of ANSTO on publication:
    - Service – standard assistance with experiment up to and including data reduction
    - Collaboration – special sample environment/experiment, assistance with data analysis, writing papers

Access Policy

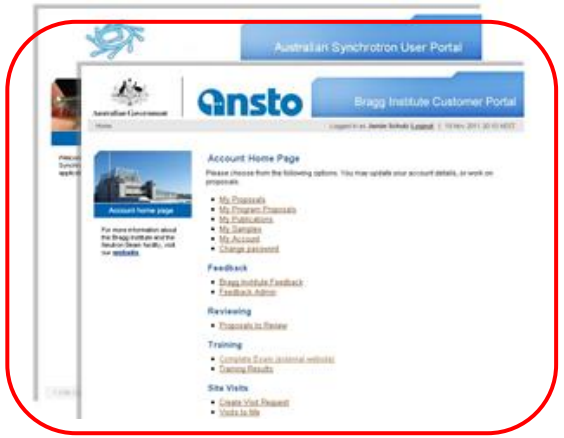
- Data policy
- Each Researcher completes a Guest Researcher agreement upon arrival
  - Safety
  - Security
  - Confidentiality
  - Has Medical Insurance/Cover (international users)

Integrated User Portal & Infrastructure

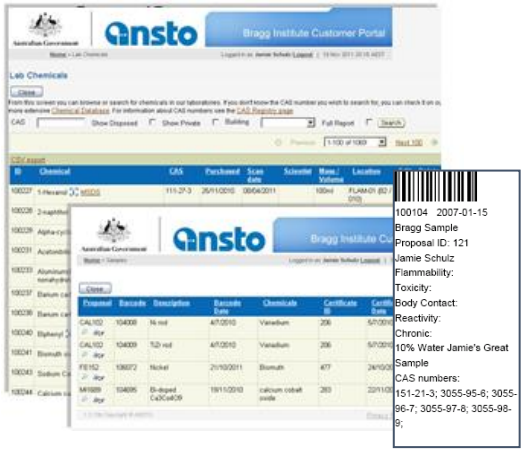
Dynamic Web Pages



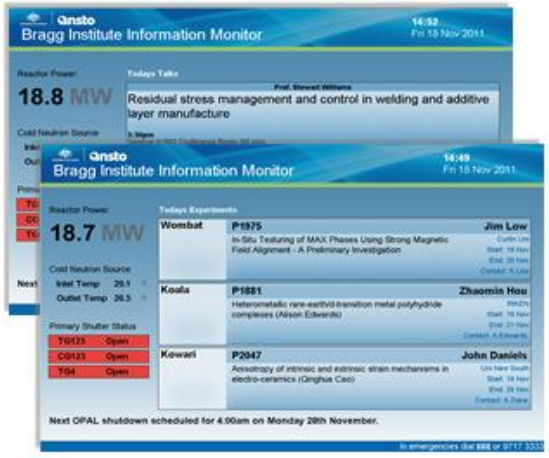
User Portal



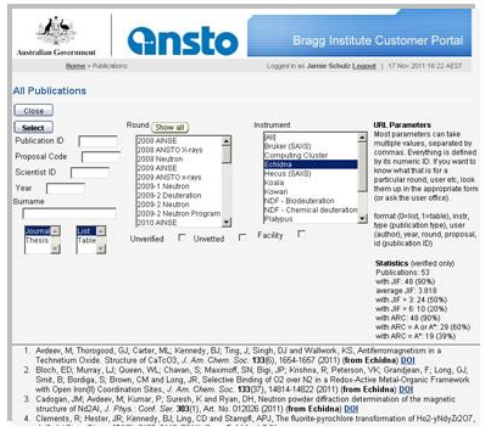
Sample management



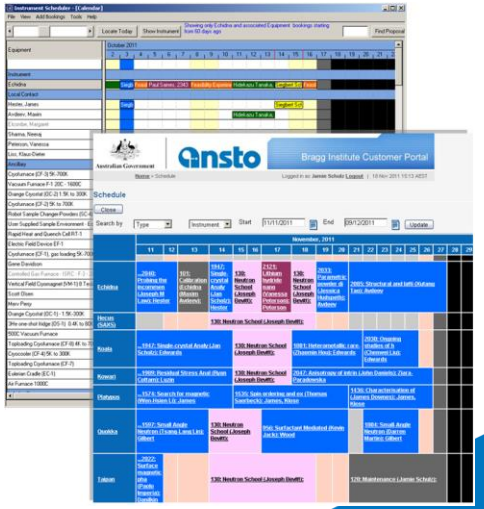
Facility Status Monitor



Publications



Instrument Schedules



ANSTO

Scholarships & Awards

- AINSE Honours Scholarships
  - Students are eligible if they are either undertaking work at ANSTO or processing prior data
  - Students receive a $5,000 stipend
- AINSE Post Graduate Research Awards
  - Students must have an Australian Postgraduate award or equivalent
  - Students receive:
    - $7,500 stipend per year
    - 2 return flights and up to four weeks accommodation at ANSTO
- https://grants.ainse.edu.au/

Thank you.

Australian Government

ANSTO