AINSE

The Australian Institute of Nuclear Science and Engineering

Researchers' Guide

2016

Managing Director: Dr Paul Di Pietro

(Ph: 02 9717 3388; p.dipietro@ainse.edu.au)

Last Updated: 28th July 2015

For further information about AINSE Research Awards contact: Michelle Durant, Administration Manager

(Ph: 02 9717 3436; mdt@ainse.edu.au)

Table of Contents

Environmental Research & Geosciences

1110 Near Surface and Depth Profiling Analysis Facility (SIBA2)

XYZ Target Manipulator - UHV target chamber with charged particle detectors for depth profile measurements of light elements such as hydrogen, carbon and oxygen, using forward recoil and nuclear reaction techniques. This has a target positioning stage with precise 3D X, Y and Z movement. These are used for study of water turnover in desert lizards using O^{18} as a biological tracer, depth profiling of ion implanted species, metallised contacts on semiconductors near surface hydrogen profiling in solar cells. The number of running days required to successfully complete each project should be discussed with the ANSTO contact officer or collaborator before the project is submitted to AINSE.

ANSTO Contact Scientists: Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu

1120 Multiple Surface Analysis Facility (SIBA1)

Target chamber and data collection facility for simultaneous PIXE (proton-induced X-ray emission), PIGE (proton-induced gamma-ray emission) and RBS (Rutherford backscattering). Samples are measured in vacuum and measurement of samples is can also be automated. The number of running days required to successfully complete each project should be discussed with the ANSTO contact officer or collaborator before the project is submitted to AINSE. These techniques allow bulk element determinations to the parts per million concentrations, and the depth profiling of surface layers. The range of analyses possible covers elements from hydrogen to uranium. Applications include pigment composition of paintings; studies of Aboriginal and Polynesian artefacts to identify the origin of samples and migratory history; composition of geological samples as an aid to mineral ore prospecting. This service includes spectrum evaluation and data interpretation.

ANSTO Contact Scientists: Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu

1130 Aerosol Measurement Facility (SIBA1)

Determination of environmental pollutants by PIXE analysis of particulate matter on filter papers from air samples. A complete service is provided, including PIXE analysis using the STAR Tandedron facility, and data evaluation. The number of running days required to successfully complete each project should be discussed with the ANSTO contact officer or collaborator before the project is submitted to AINSE.

ANSTO Contact Scientists: Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu

1200 10MV Tandem Accelerator - General

The 10MV Tandem Accelerator was commissioned in 1991. It provides ion beams with energies in the range of approximately 5 to 100 MeV, depending on the ion species, with beam intensities up to a few microamps. Virtually any naturally occurring isotope can be produced as a beam, free from contamination by other elements, isotopes or molecular ion species. A range of experimental facilities and analytical services are under continual enhancement on this facility and are described in the next three sections.

Operation of facility, construction and arrangement of experimental equipment, data acquisition and analysis, sample preparation.

Accelerator mass spectrometry, including high precision C^{14} dating; studies of basic nuclear, atomic and solid state processes; high sensitivity elemental composition analysis; high resolution depth profiling. Heavy ion microprobe applications.

Accelerator time is shared with other users, and requests for use must be made well in advance. Availability is normally between 8am – 8pm, however, upon request, consideration will be given to operations outside these hours. The number of running days required to successfully complete each project should be discussed with the ANSTO contact officer or collaborator before the project is submitted to AINSE.

ANSTO Contact Scientists: **Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu**

1300 Tandem Accelerator Analysis Facilities

The Ion Beam Analysis group has a variety of beamlines on the ANTARES Tandem Accelerator for the study of solid state, atomic and nuclear processes. Ion beams of almost all elemental isotopes can be produced and accelerated to high energies. Signals from target chamber charged particle, gamma and X-ray detectors are collected and sorted by a multi-parameter data acquisition system, and analysed off-line by graphical interface software permitting display and analysis of data in either one, two or three dimensions. The Tandem Accelerator, ancillary facilities and data acquisition system are computer controlled, permitting a variety of automatic irradiation and measurement cycles to be pre-programmed and a broad range of analysis methods to be applied to a range of problems.

Operation of facility, data acquisition and analysis, sample preparation.

Microanalysis of the first few microns of the surface region of materials by ion beam analysis can provide good elemental sensitivity and depth resolution. The quantitative determination and localisation of elements in modern high technology materials and devices such as semiconductors, optoelectronics and sensors, critically depends on the composition and interactions of multi-layer thin film coatings. The use of high energy, heavy ion beam techniques permits analysis of these structures, which are often impossible to characterise satisfactorily by other, low energy methods. Examples include metal-polymer, metal-ceramic adhesion studies, optical coatings on glass, high speed semiconductor memory chips and the characterisation of surface modified materials produced by plasma processing, chemical or ion implantation. The use of high energy light ion beams permits a wide range of nuclear reactions and techniques to be used for element specific studies, such as hydrogen and oxygen in corrosion, lithium in aluminium-lithium alloy materials, carbon from lubricants in wear, and nitrogen in nitrided cutting tools.

Accelerator time is shared with other users, and requests for time must be made well in advance. Availability is normally between 8am - 8pm, however, upon request, consideration will be given to operations outside these hours. The number of running days required to successfully complete each project should be discussed with the ANSTO contact scientist or collaborator before the project is submitted to AINSE.

ANSTO Contact Scientists: **Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu**

1310 Heavy Ion Time-Of-Flight Spectrometer and Surface Analysis Facility

Simultaneous element depth profiling of the composition of multi-layered thin films, and of the near surface region of bulk materials using high energy, heavy ion forward recoil spectrometry. A heavy ion beam incident on a target material ejects atoms from the surface region, which are subsequently mass identified by a measurement of particle energy and velocity. Mass separated particle yield vs energy profiles are obtained which are translated to concentration vs depth profiles. Applications include interfacial stoichiometry in semiconductor devices, solar cells, optical coatings and metallised polymers. Facilities include ultra high vacuum chamber (UHV) with XYZ target manipulator, cryogenic vacuum pumping, multiparameter data acquisition system and graphical analysis software and data interpretation. The number of running days required to successfully complete each project should be discussed with the ANSTO contact officer or collaborator before the project is submitted to AINSE.

ANSTO Contact Scientists: Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu

1320 Ion Beam Analysis Facility

Ion beams from protons to gold are available for materials analysis, nuclear and atomic physics studies. Ion beam energies up to 100 MeV are available, with atoms having either partially or fully stripped electron shells. Ion energy and charge state depends on ion species and accelerator terminal voltage. Facilities include UHV vacuum chamber with 3D XYZ target manipulator, ability to cool and heat targets during analysis, range of charge particle detectors, and gamma and X-ray spectrometers. Applications include measurement of carbon, nitrogen and oxygen by inelastic proton scattering, near surface profiling, hydrogen depth profiling and nuclear structure studies. The number of running days required to successfully complete each project should be discussed with the ANSTO contact officer or collaborator before the project is submitted to AINSE.

ANSTO Contact Scientists: Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu

1330 Ion Beam Irradiations

Facilities are available for high energy and heavy ion implantations, charged particle surface activations for wear and corrosion studies, and the production of some neutron deficient radioisotopes using (p,xn) reactions. The number of running days required to successfully complete each project should be discussed with the ANSTO contact officer or collaborator before the project is submitted to AINSE.

ANSTO Contact Scientists: Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu

1340 High Energy Heavy Ion Microprobe Analysis Facility

This microanalysis tool employing various IBA techniques for materials, environmental and geological analysis is available on the tandem accelerator. Microanalysis with spot sizes down to a few µm is readily available. With the heavy ion microprobe ions from hydrogen up to iodine can be focused and used for analysis as well as ion irradiation. This allows the use of a wide range of ion beam techniques from Rutherford Back Scattering (RBS), Particle Induced X-Ray Emission (PIXE) to Elastic Recoil Detector Analysis (ERDA). This service includes spectrum evaluation and data interpretation. The number of running days required to successfully complete each project should be discussed with the ANSTO contact officer or collaborator before the project is submitted to AINSE.

ANSTO Contact Scientists: Dr David Cohen, Dr Rainer Siegele and Dr Mihail Ionescu

1500-1550 AMS Facilities

Accelerator Mass Spectrometry (AMS) is an ultra-sensitive analytical technique based on the use of an ion accelerator as a powerful mass spectrometer. The element of interest is chemically separated from the original material and loaded as a target in the ion source of the tandem accelerator. The ion beam produced from it is accelerated and isotopically analysed. Selected isotopes are identified and counted individually with ion detectors. Isotopic concentrations at the level of 1 part in 10^{15} can be measured for long-lived radioisotopes such as ^{14}C, ^{10}Be, ^{26}Al, ^{129}I, ^{236}U and Pu isotopes, which have extensive applications as chronometers and tracers in a wide range of disciplines.

Only small quantities of the specific element are needed, often less than 1mg. The AMS facilities are designed for multi-isotope analysis with high precision and are being utilised to analyse the above isotopes in unknown samples from a variety of projects in quaternary science, global climate change, nuclear safeguards and other applications.

The AMS group provides assistance in sample selection and treatment, data interpretation, radiocarbon calibration and development of new applications of long-lived radioisotopes (in geomorphology, biomedicine and other disciplines).

The sample preparation section is an integral part of the AMS facility and includes three laboratories for ^{14}C sample preparation – a pre-treatment laboratory, a carbon dioxide/stable isotopes laboratory and a graphitisation/target pressing laboratory. Sample preparation for the cosmogenic isotopes (^{10}Be, ^{26}Al) is performed in two laboratories with a special dedicated laboratory for the actinide/^{129}I sample preparation.

Radiocarbon dating is performed on a variety of sample types, optimum sample sizes are listed in Table 1.

Table 1. Optimum sample sizes for AMS Radiocarbon analysis

Material	Quantity	Material	Quantity
Charcoal	10 – 50 mg	Bone [a]	1-2 g
Wood	20 – 30 mg	Paper, textiles	20 – 30 mg
Cellulose from wood	50-100 mg	Seeds, leaves	20 – 40 mg
Carbonates (shell, coral, stalagmites)	20 – 30 mg	Water	0.5 – 1 litre

[a] - The sample size depends on the degree of preservation.

The facility to choose depends on the sample type, or the form in which you wish to send the sample. There is an additional charge for high precision analysis; this is also listed as a separate facility and is added to the selected facility (e.g. for high precision tree-ring dating the facilities to choose are 1508 and 1510).

ANSTO Contact Scientists: Dr Geraldine Jacobsen, Dr Quan Hua and Dr Vladimir Levchenko

1502 C-14 AMS analysis - graphite

To be used when you wish to pre-treat and process the sample yourself, and send the graphite target to ANSTO for AMS analysis.

ANSTO Contact Scientists: Dr Geraldine Jacobsen, Dr Quan Hua and Dr Vladimir Levchenko

1504 C-14 AMS analysis - carbon dioxide

Carbon dioxide is sent to ANSTO for conversion to graphite and subsequent AMS analysis.

ANSTO Contact Scientists: Dr Geraldine Jacobsen, Dr Quan Hua and Dr Vladimir Levchenko

1506 C-14 AMS analysis - pre-treated

To be used when you wish to pre-treat the sample yourself, and send the cleaned sample for us to isolate and purify the carbon dioxide, convert it to graphite and perform AMS analysis.

ANSTO Contact Scientists: Dr Geraldine Jacobsen, Dr Quan Hua and Dr Vladimir Levchenko

1508 C-14 AMS analysis - standard treatment

This is for routine samples that require simple pre-treatment (e.g. the AAA treatment). Sample such as charcoal, wood, shell and corals, water, peat, sediment and fabrics are included as requiring standard treatments. We will pre-treat the samples, isolate the carbon dioxide and convert it to graphite prior to AMS measurement.

ANSTO Contact Scientists: **Dr Geraldine Jacobsen, Dr Quan Hua and Dr Vladimir Levchenko**

1510 C-14 AMS analysis - complex treatment

Samples needing isolation of pollen from sediments, collagen from bone and cellulose from tree-rings require a more extensive pre-treatment. Collagen from bone also includes stable isotope analysis to ascertain the quality of the bone and of the collagen isolated from the bone. These results are also reported with the final AMS measurement. Bone samples which are deemed to be too degraded for analysis will be returned without further processing.

ANSTO Contact Scientists: **Dr Geraldine Jacobsen, Dr Quan Hua and Dr Vladimir Levchenko**

1512 C-14 high precision analysis (<0.3% precision)

Requests for high precision measurements must also include this facility in addition to any of the above facilities.

Note: All AMS analyses include stable isotope analysis on the graphite (if sufficient sample is available) as this is used as a correction in the data analysis.

ANSTO Contact Scientists: **Dr Geraldine Jacobsen, Dr Quan Hua and Dr Vladimir Levchenko**

1513 C-14 AMS Analysis –small sample charge

Samples which yield ≤200 μg of carbon after processing will have an additional charge which will cover the extra costs involved in the preparation and measurement of these small targets. If it is known that your samples will yield ≤200 μg of carbon, add this facility to your request.

ANSTO Contact Scientists: **Dr Geraldine Jacobsen, Dr Quan Hua and Dr Vladimir Levchenko**

1514, 1545 – 1549 AMS Lab- Stable Isotope Analysis

The Elemental Analyser/Isotope Ratio Mass Spectrometer (EA/IRMS) in the AMS laboratory is also available to analyse $\delta^{13}C$, $\delta^{15}N$ and CN% on a range of solid sample types (eg. vegetation, soils, organic matter, samples with enriched δ13C or δ15N and collagen extracted from bone).

We offer advice regarding sample collection, handling and pre-treatment. If requested, we can perform sample pre-treatment to remove carbonates from sediments and soils prior to $\delta^{13}C$ analysis, or extract collagen from bone for $\delta^{13}C$, $\delta^{15}N$ and C:N ratio analyses. We request that contact is made with the facility prior to any sample pre-treatment, and if possible, prior to sample collection to ensure that the samples are suitable for measurement. For experiments requiring analysis of enriched stable isotopes, please contact us to discuss experimental design.

Samples must be dry, finely ground and well homogenised. For each analysis replicate samples are analysed as this is an indication of the homogeneity of the sample. Sample loading is included in the cost of analyses.

Choices for stable isotope analysis are:

1514 AMS Lab-Stable isotope, C%, N% or C:N ratio analysis

1545 AMS Lab-Stable isotope, $\delta^{13}C$ analysis

1546 AMS Lab-Stable isotope, $\delta^{15}N$ analysis

1547 AMS Lab-Stable isotope, $\delta^{13}C$ analysis with treatment

1548 AMS Lab-Stable isotope, bone (collagen) analysis with collagen extraction (includes N%, $\delta^{13}C$, $\delta^{15}N$ and C:N ratio)

1549 AMS Lab-Stable isotope, enriched samples, $\delta^{13}C$ or $\delta^{15}N$ analysis

Note:

1. The instrument cannot simultaneously analyse $\delta^{13}C$ and $\delta^{15}N$, these must be requested separately.
2. There are two stable isotope facilities in IER, when selecting this facility in your application please make sure you select the analysis beginning 'AMS Lab- Stable Isotope'.

ANSTO Contact Scientist: **Ms Linda Barry**

1516-1528 Cosmogenic Isotope Dating

The longer lived isotopes of ^{10}Be and ^{26}Al are now used extensively for determining the exposure history of geomorphic formations and surfaces and applications to landscape evolution. Dating can be performed on quartz bearing rocks, sediments or ice. The facility to choose depends on the sample type and the isotope(s) of interest.

ANSTO Contact Scientist: **Dr David Fink**

1518 Be-10 target preparation, ancillary & AMS analysis - ice, snow, filters

ANSTO Contact Scientist: **Dr Andrew Smith**

1530-1538 AMS analysis of actinides and other heavy elements

The ANSTO AMS Facilities have the capability to analyse higher mass isotopes such as ^{129}I, platinum group elements, ^{236}U and Pu isotopes.

^{129}I, ^{236}U and Pu isotopes are routinely measured. These are of interest in nuclear monitoring and dating applications. Plutonium in particular has great potential for dating recent sediments and soil erosion. In the past ^{137}Cs has been used for this purpose, but it is becoming rarer due to decay, while Pu is long-lived and AMS provides very high measurement sensitivity. The AMS system can also be used to measure a range of other radioisotopes, including the full range of uranium isotopes, thorium isotopes and ^{231}Pa with sensitivity of around 100,000 to 1 million atoms. Stable isotope analysis, for example for platinum group elements, has also been performed.

ANSTO Contact Scientist: **Dr Mike Hotchkis**

1600 Environmental Radiochemistry - Geochronology

The centre specialises in low level measurement of radioactivity in environmental samples. Sensitive radioanalytical techniques have been developed to measure a range of radioisotopes including those in the natural uranium and thorium decay series to the lowest levels of radiometric detection. Sensitive radioanalytical instrumentations are used and dedicated to measure only low level activities to avoid cross contaminations. The facility has assisted numerous AINSE collaborators in 210Pb and 137Cs sediment dating by alpha and/or gamma spectrometry.

Applications are in the areas of Late Quaternary geochronology, sedimentology and biochronology.

ANSTO Contact Scientists: **Ms Atun Zawadzki, Dr Henk Heijnis**

1620 – Pb-210 dating by alpha spectrometry

The geochronology of a sediment core can be determined by the ^{210}Pb dating method. The technique uses the decay of excess ^{210}Pb activity (half life = 22 years) to determine the rate of sediment accumulation. About 5 g of dried sample, from various depths of the sediment core, is required. The samples are processed to prepare ^{210}Po and ^{226}Ra alpha sources. The activities of these sources are determined by alpha spectrometry to calculate excess ^{210}Pb activities. This technique is more sensitive than gamma spectrometry, suitable when small quantity of sample is available for analysis. However, the method is destructive and other radionuclides such as ^{137}Cs will need to be analysed by a different technique such as gamma spectrometry. ^{137}Cs activities in sediment cores are analysed to verify ^{210}Pb chronologies.

ANSTO Contact Scientists: **Ms Atun Zawadzki, Dr Henk Heijnis**

1630 – Pb-210 dating by gamma spectrometry

^{210}Pb dating can be undertaken by gamma spectrometry technique. 30-50 g of dried sample is required. There is no radiochemical processing required with this technique. The samples are simply packed into petri dishes, left to equilibrate for 3 weeks and then counted on a High Purity Germanium (HP-Ge) gamma spectrometry system. Radionuclides such as ^{210}Pb, ^{226}Ra, ^{137}Cs, ^{7}Be, ^{228}Ra, ^{228}Th, ^{238}U and ^{40}K can be measured simultaneously. This technique is non-destructive.

ANSTO Contact Scientists: **Ms Atun Zawadzki, Dr Henk Heijnis**

1610 – Uranium and Thorium Isotopes in soil and water

This analysis is offered to assess soils and waters for their Uranium and or Thorium isotopes. Applications of this type of analysis are in the areas of "naturally occurring radioactivity in materials" and fingerprinting of soils and sediments.

ANSTO Contact Scientists: **Ms Atun Zawadzki, Dr Henk Heijnis**

1640 – Grain size analysis

It has been shown that preferential adsorption of radionuclides such as ^{137}Cs and ^{210}Pb to finer grain size can occur in sediment samples. For this reason, the grain size distribution of sediment samples for ^{210}Pb dating should be investigated. Grain size analysis is performed on an instrument which uses laser diffraction to determine the particle size distribution of solid materials. About 1 cm^3 of wet sample is required to perform the analysis.

ANSTO Contact Scientists: **Ms Atun Zawadzki, Dr Henk Heijnis**

1645 – ITRAX Core Scanner

The ITRAX XRF core scanner will provide much-needed high-resolution physical and geochemical measurements from an extensive suite of environmental archives, greatly enhancing Australia's capacity to produce world-class palaeoclimate data. Research results will make important contributions to climate models, thus improving future climate predictions. This facility enables researchers to obtain high-resolution geochemical profiles in the study of environmental change and climate variability. It will provide data on the variation of density and chemical element composition along sediment and soil cores, rock cores, wood samples, speleothems and corals. These archives contain important information such as human activity, climate variability, water quality changes, pollution histories, recent geomorphological change, land use change, introduction of invasive species and the occurrence of bushfires. A better understanding of the occurrence and timing of these major environmental issues is of national and regional importance.

ANSTO Contact Scientists: Ms Patricia Gadd, Dr Henk Heijnis

1650 Environmental Chemistry - Tritium

The facility is dedicated to the determination of environmental levels of tritium.

Applications are in the areas of water resource management and planning, and tracing of groundwater flows. The laboratory is equipped with large and small volume distillation apparatus, 32 electrolysis units and 3 liquid scintillation counters (LSC). Quantification of tritium in water down to 0.006 Bq/kg (0.05TU) is available.

ANSTO Contact Scientist: Mr Robert Chisari

1670-1695 Radon/Thoron/Radium in gases, liquids and solids

The Radon Analytical Laboratory operates a comprehensive suite of instrumentation for the monitoring and analysis of an extended range of radon and radon progeny concentrations in indoor or outdoor air, as well as radon emanation and exhalation rates from gaseous, liquid, solid and mixed phase samples (including indoor, industrial or environmental water samples). The laboratory-based instrumentation includes: a radon rig, liquid scintillation counter and a gamma spectrometer. A range of field instrumentation is also available for *in situ* continuous, or spot, measurement of radon concentration in air; the lower limits of detection of which range from 0.03 to 2 Bq m^{-3}, depending on the chosen instrument. A flux chamber ("emanometer") is also available for simultaneously determining radon and thoron flux density at environmental levels.

Field instrumentation is a very important component of the Radon Analytical Laboratory's facilities since many of the detectors have been designed and built at ANSTO, including a series of dual flow loop, two-filter radon detectors, a charcoal trap sampler, and a radon/thoron emanometer. The ANSTO-built detectors for continuous operation have been designed to monitor hourly radon concentration in air in harsh environments, with little maintenance, for prolonged periods. The highest sensitivity portable model of these detectors has a lower limit of detection of ~30 mBq m^{-3}. The single-trap sampler is designed for spot measurements of radon in air, or performing radon assays on process gas. The emanometer (or flux chamber) is designed to determine the radon and thoron flux density directly from soil and rock surfaces.

Instrument	Measurement	Medium	Analysis rate	Comments
Liquid Scintillation (small samples)	Concentration (sample)	Gas / liquid / mixed	30 min per run	20 mL samples; LLD 200 Bq m^{-3}; up to 300 samples per run.
Liquid Scintillation (Rn in water)	Concentration (sample)	Water only (via oil extraction)	30 per day	Quantification limit of ≤ 0.5 Bq/L for 600 mL samples.
Single-trap sampler	Concentration (*in situ*)	Gas	20 per day	1 L min^{-1} sampling; 60 traps available; analysis performed on radon rig
AlphaGuard	Concentration (*in situ*)	Gas	10-60 min per measurement	LLD 2 Bq m^{-3}
700/1500L Rn detectors	Concentration (*in situ*)	Gas	Hourly measurements	LLD 0.03-0.04 Bq m^{-3}
Radon Rig	Concentration Emanation (sample)	Solid / liquid / gas	20 per day	Instrumental BG <0.5 cpm; LLD depends on volume sampled
γ-spectrometer	Emanation (sample)	Solid	30 days per analysis*	0.5 kg sample, grainsize <5mm.
Rn Emanometer	Emanation (*in situ*)	Solid	30 min per measurement	LLD = 4 mBq m^{-2} s^{-1}; typically 10% measurement error.

* Numerous samples can be counted sequentially and then left for their 30-day equilibration time.

1670 Continuous *in situ* radon measurements in outdoor air
(semi-portable 700L and 1500L radon detectors)

1673 Continuous *in situ* radon measurements in indoor or outdoor air
(portable Alphaguard detectors)

1676 Sample-based *in situ* radon measurements in air and process gases

(single-trap sampler)

1680 *In situ* spot measurements of radon/thoron emanation from rocks and soils

(radon/thoron emanometer – flux chamber)

1685 Sample-based radon/radium γ-spectrometry measurements of rocks and soils

(γ-spectrometer)

1690 Sample-based radon/radium direct liquid scintillation for small gas/liquid/mixed phase samples

(liquid scintillometer)

1695 Sample-based radon in water via mineral oil extraction and liquid scintillation counting

(liquid scintillometer)

ANSTO Contact Scientist: Dr Alastair Williams

1810 Chemical analysis

The analytical laboratory provides a range of analytical services. It is equipped with sophisticated instrumentation such as quadrupole inductively coupled plasma - mass spectrometer (ICPMS); a simultaneous inductively coupled plasma atomic emission spectrometer (ICPAES); anion & cation chromatographs (IC).

Laser Ablation ICPMS

The facility is equipped with the Resonetic M50 laser ablation unit coupled to the qICPMS for chemical and isotopic composition of solid samples. This technique is particularly useful for in-situ analyses of samples requiring understanding of the elemental variation within a sample. The instrument utilises a 193 nm ArF excimer laser and a dual volume sample cell design for fast uptake and washout time. This state of the art unit can provide high resolution measurements of many banded samples such as corals, speleothems, teeth and otoliths.

ANSTO Contact Scientist**: Mr Henri Wong**

1820 ANSTO Environmental Isotope Laboratory

The ANSTO Environmental Isotope Laboratory (AEIL) is equipped with modern isotope ratio mass spectrometers (IRMS) [*Thermo Delta V Plus and Thermo Delta V Advantage*], a *Picarro* Cavity Ring-Down Spectrometer (CRDS), and a range of sample preparation devices. We also operate a well-equipped sample processing laboratory, and these facilities are complemented by the broad range of environmental research expertise within the ANSTO Institute for Environmental Research.

AEIL can analyse carbon ($\delta^{13}C$), nitrogen ($\delta^{15}N$), oxygen ($\delta^{18}O$), and hydrogen ($\delta^{2}H$) isotopes in a range of environmental samples. Most commonly we handle waters (groundwater, rainfall, river, lakes, etc), and organics (soils and biota).

IRMS can be used for a wide range of samples as the AEIL has 5 different peripherals connected to our 2 mass spectrometers. Solid, liquid and gas samples are converted to gaseous species suitable for IRMS via a range of physical and chemical processes utilised in the peripherals. The CRDS provides faster turn-around for lower conductivity water samples by examining very specific spectroscopic features of a laser beam passed through water vapour over a long path length. The amount of each isotope present is reflected in the intensity of light detected.

The AEIL resides within the Institute for Environmental Science; stable isotope analysis in conjunction with tritium and carbon-14 analysis are utilised to conduct research which includes (amongst many):

- Groundwater-Surface Water Interactions
- Groundwater residence times (dating)
- Ecohydrology
- Aquatic food web studies
- Palaeo-climate and palaeo-hydrology

Other areas of environmental research are also welcome. IER research/technical staff can provide assistance with sample selection and treatment, data interpretation, and technique development.

Analyses Available from the AEIL

Analytical reports provided by the AEIL contain determinations of relative difference of isotope ratios, δ, of ($^{13}C/^{12}C$), ($^{15}N/^{14}N$), ($^{18}O/^{16}O$) and ($^{2}H/^{1}H$), herein referred to as $\delta^{13}C$, $\delta^{15}N$, $\delta^{18/16}O$ and $\delta^{2}H$ respectively. The values will be reported as parts per thousand (‰ or per mil).

AINSE Code	Sample Type	Isotope ratio	Standard amount of sample required
AEIL 1821a	water	$\delta^{2}H$	30 mL
AEIL 1821b	water	$\delta^{18/16}O$	30 mL
AEIL 1821c	Fresh water	$\delta^{2}H$ & $\delta^{18/16}O$	30 mL
AEIL 1822b	DIC (water)	$\delta^{13}C$	12 mL
AEIL 1823a	Organic (solid)	$\delta^{13}C$ + C%	No more than 1 g
AEIL 1823b	Organic (solid)	$\delta^{15}N$ + N%	No more than 1 g
AEIL 1823c	Organic (solid)	$\delta^{13}C$ + C% and $\delta^{15}N$ + N%	No more than 1 g
AEIL 1824a	POM-glass fibre filter	$\delta^{13}C$	one 47 mm GFF
AEIL 1824b	POM-glass fibre filter	$\delta^{15}N$	one 47 mm GFF
AEIL 1824c	POM-glass fibre filter	$\delta^{13}C$ & $\delta^{15}N$	one 47 mm GFF
1695	water	^{222}Rn	600 mL

Please note:

1. Specific sampling and preservation requirements must be met, details of these will be provided upon request.
2. Solid samples must be weighed into tin cups (provided upon request) by the applicant or at ANSTO by prior arrangement only.
3. If less than the standard amount of sample is available, analysis may still be possible though precision may be lower. Please contact AEIL to discuss before sample submission.

ANSTO Contact Scientist: Dr Suzanne Hollins

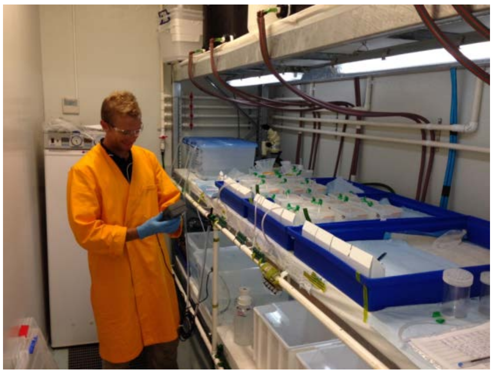
1830 Environmental Radiotracer Facility

ANSTO's Institute for Environmental Research can use radioisotope tracer techniques to study the movement of fluids, particulates and contaminants in aquatic and terrestrial environments. ANSTO can apply radiotracers to study the fate and behaviour of water, contaminants and particulates in groundwater, rivers, estuaries and coasts with the objective of validating numerical transport models. Radiotracers may also be applied in field and laboratory environments to study the uptake and transfer of contaminants and nutrients by plants and aquatic organisms. These radiotracer studies are highly specialised and are tailored to each application.

ANSTO Contact Scientist: Dr Cath Hughes

1840 Aquatic Monitoring

The aquatic monitoring capability in ANSTO's Institute for Environmental Research uses a range of divisional facilities as well as collaborative links with external researchers. The Isotopes for Water Project, Aquatic Ecosystem Task, samples and identifies biota including aquatic plants, macro-invertebrates and fish, as well as measuring a variety of water quality parameters for the detailed determination of stable and radioactive isotopes and general water chemistry. Application of stable carbon and nitrogen isotopes ($\delta^{13}C$, $\delta^{15}N$) and enriched carbon and nitrogen isotope tracers can be used to trace the movement of energy and nutrients (i.e. sewerage) through aquatic food webs. Laboratory facilities are available at ANSTO for undertaking controlled stable- and radioisotope experiments in aquatic ecosystems to evaluate biokinetics, biodistribution, ecotoxicity, and isotope fractionation as they are influenced by a range of environmental parameters. Our recent research has targeted the health of wetland systems with particular focus on food webs and ecological structure during drought- and flood-induced hydrological changes as well as carbon dynamics and sequestration. We have also conducted studies on the bioaccumulation of metals and metal nanoparticles by aquatic invertebrates.



Top Left: Fish/invertebrate tanks in the temperature and light-controlled Aquatic Monitoring Facility

Top Right: Aquatic radiotracing lab within the Aquatic Monitoring Facility

Bottom Left: Zebtech zebrafish rearing system in the Aquatic Monitoring Facility

ANSTO Contact Scientist: **Dr Debashish Mazumder**

1850 Aqueous Radionuclide Geochemistry laboratory

The facility measures interactions between dissolved pollutants and solids such as soils, clays and barrier materials. Typical applications would be:

(a) studies of pollutant uptake on harbour sediments by radiotracer techniques,

(b) measurement of radionuclide distribution coefficients (Kd value) on soils, oxides and clays for radioactive waste disposal and water treatment studies.

Specialised apparatus such as autotitration equipment, surface charge determination are available for use in these types of experiments as required.

ANSTO Contact Scientist: **Dr Josick Comarmond**

1890 Greenhouse Facility for Environmental Research

This recently-built facility features 138 square meters of temperature controlled greenhouse. Temperature is regulated automatically via the large twin ridge roof ventilation and five evaporative coolers. Light, temperature and humidity can also be automatically adjusted through the use of aluminum screens that run the length of the building and internal air circulation can be automatically regulated through the use of two heavy duty vortex fans. The facility can be used for the uptake of radionuclide tracers to quantify nutrient, metal or environmental radionuclide biokinetics. Stable-isotopic studies of nutrients and energy flow can also be accommodated. Recent research within the facility include the uptake of nutrients by flora under differing drought scenarios (using the radioisotope tracer ^{32}P and stable isotope tracer ^{15}N) as well as use of $\delta^{2}H$ and $\delta^{18}O$ to study how eucalyptus trees use water under certain stressors such as increased salinity and reduced water availability. This facility can be used in conjunction with 1840 Aquatic Monitoring to study nutrient, metal and radionuclide cycling of both flora and fauna, affording insights into whole-ecosystem functioning.

Figure: Panorama of the inside of the Greenhouse Facility for Environmental Research

Figure: Radiation working area within the Greenhouse Facility for Environmental Research

ANSTO Contact Scientist: Dr Tom Cresswell

1900 Neutron Activation Analysis

Instrumental neutron activation analysis (INAA) is a very sensitive method of quantitative elemental analysis based on the nuclear activation of the chemical elements present in a sample. Around 65 elements may be measured using the technique. Activation is achieved by placing the sample in the neutron flux of the OPAL reactor, using the facilities described in the OPAL section of the AINSE User Guide. The specific activity of each radionuclide may be determined by measuring the characteristic gamma radiation emitted from the sample after it has been removed from the reactor. Two methods of standardisation are available, the relative (comparator) method and the k0-method. The irradiation time can be selected to optimise the detection limit for particular elements, making use of the short residence time (SRT) and long residence time

(LRT) facilities, as indicated below. A complete elemental analysis requires sub-samples to be irradiated in both the SRT and LRT facilities.

Delayed neutron activation analysis (DNAA) can measure the uranium content of a sample at concentrations from 0.5 to 100,000 ppm. The technique determines the concentration of the isotope 235U by measuring the rate of emission of delayed neutrons from the sample after it has been irradiated in the OPAL neutron flux.

There are strict requirements on the handling and nature of samples that are to be irradiated in OPAL facilities. In some cases samples will need to be analysed by XRF prior to irradiation, for an additional fee. Samples can only be loaded into approved polythene irradiation containers at the Lucas Heights site by authorised ANSTO staff. Please contact ANSTO early in the process of project development to discuss target and canning aspects as there may be a delay of up to two months to gain approval for the irradiation of a new type of material. Samples should be dry, powdered and homogeneous.

Unused samples will be stored for 6 months prior to disposal. If requested, this unused material can be returned at the client's cost.

In certain circumstances, it may be possible to return irradiated samples to the client, subject to ARPANSA regulations.

1910 NAA – short irradiation facility

A selection of elements that are best measured in the short residence time facility are Al, Cl, Cs, I, La, Mg, Mn, Ti, and V. Around 150 mg of sample will typically be required for each measurement.

Results from this facility can be provided within two weeks of irradiation.

ANSTO Contact Scientist: Dr John Bennett

1920 NAA – long irradiation facility

A selection of elements that are best measured in the long residence time facility are: As, Co, Cr, Fe, Na, Ni, Sb, Se, Th and Zn,

Results from this facility can be provided within six weeks of irradiation.

ANSTO Contact Scientist: Dr John Bennett

1930 DNAA - uranium analysis

Subject to initial review by ANSTO, the uranium concentration of any dry, stable, non-corrosive powder may be determined using this method.

The uncertainty of the analysis is around 3% (one sigma) of the stated uranium concentration above 5 ppm and about 10% below 5 ppm.

ANSTO Contact Scientist: Dr John Bennett

Irradiations

3700 Neutron Irradiations

There is a wide range of potential applications for neutron irradiations. They vary from irradiating minerals to determining yields to irradiating tracer substances for various research, environmental, and industrial processes and applications. A total of 55 irradiation facilities are available at 7 levels of thermal neutron flux to perform a wide range of irradiations.

Facilities are available for canning of samples for irradiation, post irradiation handling and quick return of the irradiated sample in a suitable shielded container. Technical advice on the usage and methods to minimise radiation levels are also available.

The availability of this service is dependent on reactor scheduling. Prior contact with ANSTO is required to ensure correct scheduling is achieved.

3711a Low Thermal Flux Irradiation (3E12 up to 1E13 ncm^{-2}s^{-1})

3711b Low Thermal Flux Irradiation per 24 hours thereafter

3712a Medium Thermal Flux Irradiation (1E13 up to 6E13 ncm^{-2}s^{-1})

3712b Medium Thermal Flux Irradiation per 24 hours thereafter

3713a High Thermal Flux Irradiation (6E13 up to 1.4E14 ncm^{-2}s^{-1})

3713b High Thermal Flux Irradiation per 24 hours thereafter

3714a Fast Flux Rigs Irradiation (approx 1E13 ncm^{-2}s^{-1}, at greater than 1MeV)

3714b Fast Flux Rigs Irradiation per 24 hours thereafter

ANSTO Contact Scientist: Mr Kith Mendis (Reactor Operations)

Irradiation services: Radiation (Biology, Chemistry and Physics)

Please note other irradiation facilities are covered in the **Life Sciences** section (page 23) and the **Materials Engineering** section (page 28)

Nuclear Analysis Facilities – General

8200 Computer Evaluation of Reactor Operation and Safety, Neutronics and Shielding Calculations

Nuclear Analysis Section develops and maintains computer software and associated data libraries with which neutron and/or gamma ray fluxes can be calculated for proposed experimental assemblies. These assemblies may be free standing or form part of rigs for insertion in OPAL. In the latter case the effect on OPAL can be calculated, if necessary, to determine the implications of the rig insertion on the safety of the reactor.

For assemblies containing fissile materials criticality certificates would need to be issued before the experiments begin. The results of the appropriate calculations can be provided to users.

Where the assemblies produce radiation fields of consequence to users and others, assessment of the necessary shielding can be provided.

For projects that involve computer simulation of neutron and/or gamma ray populations in target materials or assemblies, advice and assistance are available in using the bank of software and data maintained on ANSTO computers. These include multigroup SN and neutron diffusion codes, codes to prepare multigroup data from a master library of 200 neutron and 37 photon groups, the ENDF/B-VI cross section file and Monte Carlo based neutron and gamma transport codes.

ANSTO Contact Scientist: **Dr George Braoudakis (Nuclear Analysis Section)**

8300 Water Tunnel Flow Facility

The Nuclear Analysis Section Water Tunnel is a closed loop flow rig of 3000L capacity, used for velocity measurements, pressure loss measurements and flow visualisation in flow fields surrounding immersed bodies, or within hydraulic components. Water is circulated by a double suction pump driven by a 75 kW AC motor and variable speed controller, to achieve flow control up to 230 Ls^{-1}. The pipes range from 230mm to 690mm in diameter.

Models of the flow components, usually manufactured from highly polished acrylic, are positioned in the test section of the loop. Reflective particulate additives are used as flow tracers which are illuminated by a double pulsed Nd-YAG laser or a continuous wave Argon laser system. The resulting images of the flow patterns are captured digitally and processed to provide flow velocity and direction information.

The WTFF has also undertaken performance tests on hydraulic fittings, eg. valves, to Australian Standards. These tests include flow/pressure characteristic tests and endurance testing.

Support Services and Facilities

- Laser PIV and LDV systems
- Workshop machinery available for model manufacture and development
- Computing facilities

Flow analysis in hydraulic systems using PIV and LDV measurement techniques and flow visualisation.

Hydraulic testing of fittings to Australian Standards, determining flow loss and endurance characteristics.

The Water Tunnel is available on an advance booking basis and subject to ANSTO needs.

ANSTO Contact Scientist: **Mr David Wassink (Nuclear Analysis Section)**

Other Facilities

9010 Cemented Waste Facilities

Cement Waste Forms Laboratory is for
- the characterisation of cement and cemented waste forms eg. shrinkage at different relative humidities
- sample preparation for SEM, XRD
- preparing hydrated cement compounds eg milling, shear mixing and glove boxes
- examining conditioned cemented wastes (eg leach testing)

For characterisation of cement and cemented waste forms.

ANSTO Contact Scientist: **Dr Kapila Fernando**

9020 Health and Safety: Gamma Irradiation Suite (GIS) – irradiation only

ANSTO Contact Scientist: Mr Haider Meriaty

9021 Health and Safety: Gamma Irradiation Suite (GIS) – irradiation and biology rooms

The gamma irradiation suite (GIS) is utilised in radiobiology research. It consists of two main sections: the irradiation room and the animal/biology rooms.

The irradiation room is equipped with a Cobalt-60 collimated beam (Theratron). Different gamma dose rates can be obtain by changing the Source to Sample Distance, however, the field size is function of the SSD. A number of beam attenuators are also available. They can be used to reduce the dose rates with little change to the field size however, the scattered radiation is proportional to the attenuator thickness. The Irradiation period can run from seconds to days.

The suite has a dedicated room to hold small animals e.g. mice over days to a few weeks. It has also an adjacent room to perform animal dissection and CO2 euthanasia if required. The biology lab is classified as PC1. Biological supporting staff may available to limited tasks.

The temperature, humidity and light of the suite are controlled.

ANSTO Contact Scientist: Mr Haider Meriaty

9030 Health and Safety: in vivo gamma spectrometry (IVGS)

Generally not applicable to AINSE users but grants have been awarded for whole body monitoring.

The Internal Radiation Dosimetry (IRD) provides a qualitative and quantitative measurement of radioactivity in living samples eg. the human body. The investigated radionuclide must be a photon emitter of energy greater than 14KeV ie. gamma radiation or x-ray. The measurements are usually performed in a graded shielded room to provide a low radiation background environment. The detection system utilises NaI, HPGe or Phoswitch large crystals as a detector.

Applications

- whole body gamma spectrometry
- thyroid gamma spectrometry
- lungs gamma spectrometry
- K-40 body content
- gamma spectroscopy on bulk samples in a low radiation background environment

ANSTO Contact Scientist: Mr Haider Meriaty

Secondary Standard Dosimetry laboratory (SSDL)

Other services include Sr-90 stability checks, dosimeter or material irradiation, dose linearity (dose vs time), referenced absorbed dose to water, dose rate linearity (dose rate vs distance) and charge sensitivity of electrometer.

ANSTO Contact Scientist: Mr Haider Meriaty

9200 Heavy Water

Specifications of the heavy water available is normally as follows

- isotopic purity - nominally 99.92% by mass
- conductivity - less than 1 mS/m
- turbidity - less than 2 NTU
- $KMnO_4$ demand - Less than 10 mg/kg
- tritium content - less than 5 µCi/kg
- oxygen-18 content - approximately 0.22 atom per cent

The heavy water is normally supplied in 500g or 1000g quantities in stainless steel transport containers dispensed under dry nitrogen. On receipt the heavy water should be transferred to the consignee's own container and the transport container returned to ANSTO at the expense of the consignee. On occasions larger quantities may be supplied in similar, larger, returnable transport containers, when available.

ANSTO Contact Scientist: Nuclear Safeguards Officer – Campus Services

9210 Heavy Water Dispensing Fee

Please note that a prerequisite of supply of heavy water is the receipt by ANSTO of information on proposed end use and regulatory approval.

Limited quantities of heavy water may be made available to academic organisations. Although the heavy water is subject to the Nuclear Non-Proliferation (Safeguards) Act 1987, no Permits are required for small quantities used for research purposes, however, supply is contingent upon regulatory (ASNO) approval for the transfer.

ANSTO Contact Scientist: Nuclear Safeguards Officer – Campus Services

External Facilities

9910 Linear Accelerator / Pulse Radiolysis Facility –University of Auckland

A Dynaray 4 linear accelerator converted to deliver electrons in single pulses of up to 180 mA current. Pulse lengths available are 200 ns, 750 ns, 1.5 μs and 3 μs. Beam energy can be varied between 0.5 and 5 MeV but normal operation is at 4 MeV. Radiation dose per pulse can be set between 1 and 30 Gy. A range of optical cell path lengths between 0.5 cm and 3.0 cm as well as combined optical and AC conductivity detection cells of 1.0 cm and 2.0 cm are available for pulse radiolysis studies. Transient spectrophotometric detection is over 210 nm – 2000 nm using photomultipliers and photodiode detectors. Conductivity measurements are made using a 250 kHz AC system capable of handling up to 0.01 Ω^{-1}. Optical and conductivity detection cells, combined with temperature control (4-90 ^{o}C), are also available, as well as a pre-pulse rapid-mix facility (under development). Both xenon (for uv-vis detection) and tungsten lamps (vis-red detection, and for long observation times, up to seconds) are available.

The modern, PC-driven, optical and conductivity radical detection system is operated in a LabView environment. Data is harvested/displayed by a 300 MHz digitizer/scope and full kinetic, spectral and conductance analysis is carried out using dedicated modern software. Data analysis can also be carried out off-line using stand-alone software as well as data sent to home institutions via the internet. Gas mixing lines (N_2, N_2O, O_2, AIR) are installed for saturating samples prior to pulse radiolysis and samples changed remotely between electron pulses.

The purpose built facility is located in the School of Chemical Sciences, at the University of Auckland. The full range of research facilities on site includes a ^{137}Cs gamma source providing a dose rate of up to 2.5 Gy min^{-1} for complementary steady-state radiolysis studies. A fully equipped laboratory is available for sample preparation and analysis. Experienced radiation chemists are on the staff and can assist with experimental design and supervision of student research projects.

Pulse radiolysis experiments are used to identify radical intermediates and to study reaction mechanisms in solution by measuring time-resolved spectra and conductance changes. Electron transfer reactions between donors and acceptors are studied in real time. Conductivity measurements can be used to identify and study charged species that do not have accessible absorption spectra and to confirm the protonation state of species. Studies on complex organic and inorganic molecules as well as biological systems can be carried out. Temperature-dependent kinetic studies are used to obtain thermodynamic parameters for the studied reactions. Thermodynamic redox potentials of compounds and their radical intermediates are determined from radical equilibrium measurements with reference compounds.

Cumulative electron pulses for material science and sterilization studies are also available.

The University of Auckland Contact:

Associate Professor Bob Anderson - School of Chemical Sciences, University of Auckland.

9930 National Plasma Fusion Research Facility - Australian National University.

The Australian Plasma Fusion Research Facility is designed to perform research into the basic properties of magnetically confined, high-temperature plasma as the Australian centrepiece of an international program, whose ultimate aim is environmentally sustainable power generation by the controlled fusion of hydrogen isotopes. This facility is built around the existing H-1 Heliac experimental confinement device at the Australian National University, established under the Commonwealth Major National Research Facilities program, and recently upgraded as part of the Super Science Initiative. The research aims to build upon Australia's internationally recognised position of excellence in basic plasma physics and applications such as plasma diagnostics and plasma processing, and to enable Australian scientists, engineers and industry to tackle the "grand challenge" problems presented by fusion research; this provides excellent postgraduate training and generates spin-offs with commercial potential.

The Facility is integral to the strategy for Australian fusion science and engineering, developed by the Australian ITER Forum, an association of over 160 scientists, engineers, students and others interested in the development of plasma fusion energy. The upgrades to heating, vacuum and diagnostics enable the facility to support the key elements of this strategy such as building Australia's capability, and developing advanced instrumentation for fusion reactor prototypes, and ultimately ITER.

A new line of research into the interaction of fusion reactor materials with plasma was enabled by this upgrade, building on Australian expertise in extreme materials in Universities and ANSTO. The MAGPIE prototype linear plasma device uses Facility heating, magnet and diagnostic infrastructure to produce plasma approaching conditions at the edge of fusion reactors, and analyse interaction of plasma with candidate wall materials.

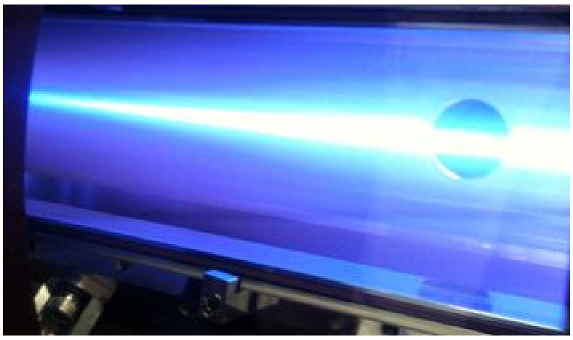


Figure 1: Argon plasma in the MAGPIE device showing magnetic compression of the plasma which produces high density and high heat flux

Research Fields

Physics and technology of magnetically confined plasma, including its generation, heating, confinement, stability, interactions with materials, remote measurement systems and numerical modelling.

Research Outcomes

- A detailed understanding of the behaviour of hot plasma which is magnetically confined in the helical axis stellarator configuration, under the recently renewed IEA Implementing Agreement on Research into the Stellarator Concept.
- The development of advanced measurement systems ("diagnostics"), integrating optical and microwave detectors, real-time processing and multi-dimensional visualisation of data on large scale computer networks, and theoretical modelling.
- Fundamental studies of confinement, turbulence and transport of particles and energy in confined plasmas.
- Significant contributions to the global fusion research effort and an increased Australian presence in the field of plasma fusion power.
- Furthering knowledge of basic plasma physics and technologies for applications such as plasma processing of semiconductors, and plasma-material interaction.
- Improvements in skills of Australian industry in the areas of materials, modern power engineering, and communications and control.

Description

H-1 is a type of stellarator in which the plasma twists helically three times before closing back on itself to form a torus. The magnetic configuration of H-1 can be seen in Figure 2. By adjusting the relative currents in the coils, the H-1 configuration can be made to vary its shape and confinement properties; hence it is called a flexible heliac.

The plasma in H-1 is heated by 50-400 kW of rf power at 4-20 MHz and a 200 kW, 28 GHz gyrotron microwave source from Kyoto University and the National Institute of Fusion Science in Japan. A large number (>100) of ports provide access for diagnostics, and many gate valves of various sizes allow convenient connection of user's instruments.

Figure 2: Plasma in the H-1 Heliac. The vertical toroidal coils confine the plasma, and the horizontal ring coil creates the helical twist.

A number of internationally unique diagnostic systems are being developed on the Facility. These include:

- 21 channel millimetre-wave tomographic interferometry for electron density imaging;
- electrical probes to measure particle energies and fluxes, and several magnetic probe arrays for investigation of MHD/Alfvén instabilities;
- Coherence imaging spectroscopic systems for two dimensional measurements plasma temperatures, flows, and fluctuations;
- Supersonic helium beams for local spectroscopic measurement of electron temperature and density.

Applications

The Facility upgrades build on a major investment by the ANU, allowing Australia to capitalise on the current resurgence of interest in magnetic fusion configurations of the stellarator type. The flexibility of H-1 provides access to a wide range of configurations, including some with the promising "reversed shear" characteristic of advanced tokamaks, but without the drawback of multi-megampere plasma currents and associated instabilities. This allows H-1 and the MAGPIE facility to be used for basic studies or as a test-bed for divertor and edge diagnostics for ultimate application to the international fusion experiment, ITER.

H-1 is Australia's main experimental contact with the international fusion community and is the largest plasma facility in the Southern Hemisphere. The Facility offers many diplomatically important opportunities for academic and technological exchange. Significant collaborative activities with Japan, Korea, China and Europe and the US are already under way, with exchanges of personnel and scientific equipment.

Availability

The Facility is available to all Australian physicists and engineers and is affiliated with AINSE. Scientists outside of the ANU are involved in all aspects of experimental program of the Facility, The data acquisition and analysis is readily conducted over the AARNET computer network, enabling data mining, remote access via metadata portals and grid computing.

Proposals may be made at any time by contacting the Director, and scheduling of experimental time will be arranged between the applicant and the Facility Management Committee. Typical projects include development of new diagnostics, or use of the many existing diagnostics for studying wave, turbulence or confinement physics, or materials interaction, possibly leading to further experimentation on international devices.

Contact Scientist: Dr Boyd Blackwell, Associate Director

9940 The Australian Positron Beamline Facility at the Research School of Physical Sciences and Engineering, ANU

The Australian Positron Beamline Facility (*APBF*) provides a unique national facility for scientists to study fundamental interactions of positrons with matter and to use positrons as a diagnostic tool for materials and bioscience activities. It was initially supported by the ARC through LIEF and Centre of Excellence grants. Participants include the ANU, Flinders, Griffith, Murdoch, Curtin, Adelaide, UWA, James Cook and Charles Darwin Universities, ANSTO, and the CSIRO. The *APBF* provides the only variable energy, positron beam lines in Australia. Positrons emitted from a 50 mCi ^{22}Na source are moderated using solid neon and then loaded into a Penning-Malmberg trap, where they are accumulated and cooled, using gas-collision techniques, to form a positron cloud at room temperature (~30 meV). By modulating the well depth of the trap, pulses of positrons several usec wide are produced, with a 100-4000 Hz repetition rate, and these are then used in two experimental beamlines.

The two positron beamlines are available for both high and low energy studies:

(i) The low energy (0.1-200 eV), high-energy-resolution (~30 meV) beamline is being used to investigate positron interactions with atoms and molecules, including measurements of ionization, annihilation and positronium formation. Important bio-molecules, and the fundamental interactions with them that underpin medical imaging processes such as Positron Emission Tomography (PET), will be studied.

(ii) The second, high energy (0.1-20 keV) beamline is dedicated to materials science and bioscience studies. The pulsed beam will be further bunched to form a sub-nanosecond, positron pulse that can be injected at high energies into the surface of the material under study. The positrons quickly thermalise and many of them combine with an electron in the material to form positronium – a mutually orbiting electron-positron pair. When this exotic ‘atom’ decays, it produces gamma rays that are detected in time coincidence, allowing the lifetime of the positronium to be determined. The lifetime depends critically on the free space in the material, and it is thus an excellent probe of voids and defects in materials, on the nano-scale, and at depths up to several microns. The *APBF* will enable, for the first time in Australia, the study using a variable energy positron beam, of new and exotic materials that are designed to have certain characteristics such as porosity or conductivity, or the controlled release of embedded agents such as drugs.

Contact Scientist: Dr James Sullivan

ANSTO LifeSciences

This section of the Facilities Guide identifies the research themes and programmes in ANSTO LifeSciences. Access to the LifeSciences facilities is through collaborative research within these programmes. The contact details for staff can be found in pages 36-37.

ANSTO LifeSciences utilises nuclear and isotopic techniques to probe the fundamental properties of living matter to gain insights that will benefit individuals and society. LifeSciences operates in spheres of activity in interdisciplinary teams using a range of technology platforms to investigate intractable biological issues such as patho-physiological processes, including disease prevention and treatment. This includes the optimization of nuclear probes and the understanding of the impact of radiation on living matter.

LifeSciences Access Procedure

Identify the LifeSciences research programme which might incorporate your project and discuss your project with the relevant contact scientist(s).

Your research contact scientist(s) will

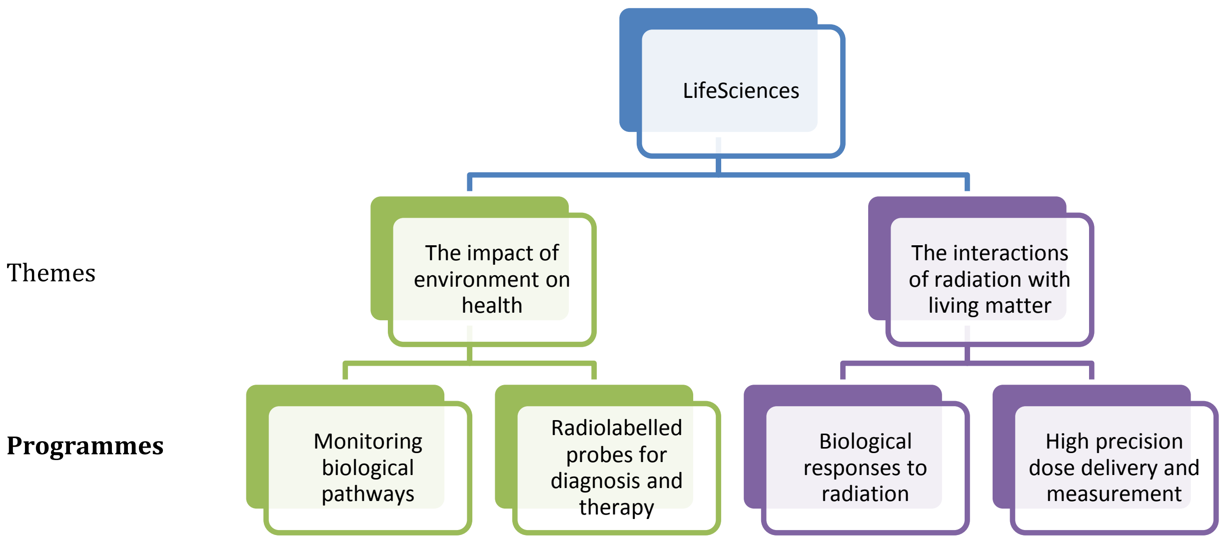
- work with you to develop both your AINSE application and your LifeSciences proposal,
- advise on LifeSciences capability selection and costs.
- help you optimise the use of our capabilities

The parallel preparation of a LifeSciences proposal is essential. For more information see How do I collaborate with LifeSciences?

Studies involving use of living animals at Lucas Heights must obtain an approval from the ANSTO Animal Care and Ethics Committee. Studies involving the use of genetically modified material must obtain approval from the ANSTO IBC (Institutional Biosafety Committee).

Programmes in LifeSciences

Two themes drive our research and within each theme are two programmes:



Monitoring biological pathways from health to disease

This programme is designed to help understand the *pathways from health to disease,* which are triggered by environmental factors whether biological, societal or environmental.

Our research focuses on the development and optimisation of tools such as radio-tracers and imaging methods to enable the longitudinal monitoring of selected biological pathways and elements during the period of challenge.

Monitoring biological response contributes strongly to research in patho-physiology and therapeutic strategy, and to improving patient management in fields such as neurosciences, oncology (for example, melanoma) and other diseases such as Alzheimer's or diabetes.

Radiolabelled probes for diagnosis and therapy

This programme is primarily focussed on the development of radioactive probes and imaging techniques which optimise the assessment of a functional state of a disease, and tailoring radio-ligands that enable the evaluation of the best therapeutic plan for patients.

There are three main research directions:

- Development of novel radiochemistry methodology and radiolabelling techniques to improve radiolabelling efficiency, and to decrease radiolabelling time through microwave, macro- and micro-fluidic technologies
- Development of novel radio-ligands (small molecules, peptides, proteins, cells or particles for imaging (PET, SPECT) and targeted radio-isotope therapy
- Optimising imaging and quantification techniques for new radio-isotopes and various organs of interest.

Biological responses to radiation

This programme focuses on understanding the impact of radiation (ranging from environmental to therapeutic levels) on living systems. The major biological component we are investigating is mitochondria.

Research is being developed in

- Understanding low dose radiation effects on whole animals, cells and cellular compartments
- Understanding adaptive mechanisms in response to low levels of radiation.

High-precision dose delivery and measurement

This programme focuses on developing and refining the tools that enable research especially that investigating adaptive responses to radiation.

Research areas include

- Adapting and improving methods for high-precision radiation dose delivery, dose measurement, and sample handling and preparation
- Developing new methods to monitor the immediate effects of radiation in living matter such as real-time live cell measurement of irradiation responses

Capabilities in LifeSciences

Radiochemistry, radio-halogen and radio-carbon probes, radio-metal chemistry

Radiotracers for preclinical investigations

LifeSciences has a range of unique radiotracers which is available to collaborative researchers for preclinical investigations. These radiotracers have been fully characterised. The range includes

^{11}C-Choline (cancer)	^{18}F-PBR111 (neuroscience)
^{11}C-Raclopride (neuroscience)	^{18}F-FSB (protein labelling)
^{11}C-Acetate (metabolism)	^{18}F-FHBG (reporter gene)
^{11}C-Methionine (cancer)	^{18}F-MEL050 (cancer)
	^{18}F-Fallypride (neuroscience)

Contact scientist: Ivan Greguric

Development of radiotracers for preclinical investigations

Our radio-halogen and radio–carbon research involves the use of ^{11}C, ^{18}F and radioiodine (^{123}I, ^{124}I, ^{125}I and ^{131}I) isotopes for radiolabelling compounds and biological reagents. This work includes the development of new radiosynthons, reagents and radiolabelling methodologies using macro and microfluidic modules and extends to radiosynthesis of radiopharmaceuticals. Predominately diagnostic radiopharmaceuticals are developed within this theme.

Contact scientists: Tien Pham, Giancarlo Pascali, Ben Fraser

Our radio-metals research accesses and utilises a diverse set of radio-isotopes in both applied and fundamental research. These radio-isotopes include ^{67}Ga/^{68}Ga, ^{64}Cu, ^{99m}Tc, ^{111}In, ^{57}Co, ^{89}Zr and ^{177}Lu. Applied activities focus on the radiolabelling of key biomolecules including proteins directly, peptides, antibodies and even cells, either directly with the radio-metal or via a metal complex. Our research involves exploration of new 'exotic' radio-metals and developing the next generation of radio- ligands for radio-metal complexation for use in diagnosis and therapeutic applications.

Contact scientists: Nigel Lengkeek, Paul Pellegrini

Activities

- Production of radiotracers for preclinical investigations
- Radiochemistry precursor synthesis
- Radiometals radiochemistry
- Radiohalogens and radiocarbon radiochemistry

Investigations with imaging

New radiotracer characterisation

Our imaging capabilities are dedicated to the characterisation and use of radiotracers for functional exploration by monitoring biological pathways. These are based on *in vitro* and *in vivo* functional evaluation techniques which are complementary. Radioligand stability studies may be conducted *in vitro* or *in vivo* - both involve activity extraction and/or analytical methodologies such as radio-HPLC, radio-TLC or appropriate chromatography methods. Through biodistribution studies in small animals %ID/g (percent of injected dose per weight of wet tissue) values are calculated to express the uptakes of radiotracers in organs of interest. Ratios of target:non-target or organ:background uptakes are often calculated to serve as indications of radiotracer selectivity/specificity and clearance. Pharmacokinetic studies may be involved if sophisticated data is required for compartmental uptakes or clearance.

Contact scientist: Vu Nguyen

Functional exploration

Many biomarkers of pathological changes are identified using histological approaches such as immunohistochemistry (for detecting proteins), in situ hybridisation (for detecting mRNA of specific proteins), and histological stains (for lipids, cell matrix, etc.). Radioreceptor binding is an ideal method for determining the specificity and selectivity of uncharacterised compounds for a wide range of receptor targets. Receptor distribution can be visualised and its density quantified using radioactive probes attached to either endogenous or synthetic ligands. When an agonist binds to its receptor and the receptor is known to couple with G protein, the process and its extent can be examined using [35S]GTPγS binding (membrane fractions or whole cells) or autoradiography (slides) studies.

Contact scientist: Arnaud Charil, Paul Callaghan

Complex dynamic imaging in PET

In vivo pre-clinical longitudinal imaging using Positron Emission Tomography (PET)/CT and Single Photon Emission tomography (SPECT)CT reveals physio-pathological changes in response to challenges. Dynamic imaging tells the story of what is happening within the subject over an extended period of time. A full dynamic study coupled with the analysis of the kinetic in each voxel or defined region of interest extracts the parameters of interest. When combined with other capabilities such as blood sampling, kinetic modelling, Monte-Carlo simulation, a comprehensive view of the processes being investigated is obtained.

Contact Scientists: Anthonin Reilhac, David Zahra

Density Structural analysis using micro CT

To obtain cross-sectional or structural information about an object, traditional techniques would include sectioning or disassembly of the object. Using our micro-CT we can non-destructively acquire low magnification/resolution scans of small rodents, up to high magnification scans with a resolution of 40um (20mm^3 field of view). The scan is reconstructed into a 3D volume which can be manipulated and viewed as virtual slices. This can be combined with various techniques such as Positron Emission Tomography, X-ray Fluorescence Microscopy or histology to add functional, chemical and biological information.

Contact scientist: David Zahra

Longitudinal studies with PET/CT and SPECT/CT

One of the great advantages of longitudinal imaging is the ability to image physiological changes within individual subjects over time. This is a unique experimental paradigm, reducing variability within the population investigated and modelling individual subject's response to treatment. LifeSciences has capacity for functional imaging of biological processes such as metabolism, proliferation, amino acid transport, hypoxia and drug clearance in cancer models and in imaging glucose metabolism and neuroinflammation in animal models of multiple sclerosis, epilepsy, psychiatric disorders and excitotoxic brain injury. The main focus of our pre-clinical program is to establish in vivo imaging biomarkers and ex vivo correlative biomarkers of response which can then be used to design clinical trials.

Contact scientists: Paul Callaghan (neuroscience studies), Arvind Parmar (cancer studies)

Quantification

Much of our research focuses on the accuracy of the quantification methods and the optimisation of investigation protocols. In nuclear medicine, the design, optimization and validation of image correction, reconstruction and analysis techniques often relies on the use of physical phantoms or software simulated phantoms whose geometry and contents are precisely known. PET-

SORTEO is a Monte Carlo-based simulator which enables fast generation of realistic PET data and is used as a tool for designing/optimizing and validating data correction/reconstruction and analysis processes such as image reconstruction, image registration, Partial Volume Effects correction, and statistical analysis. PET-SORTEO has been validated for the geometries of the Ecat Exact HR+ human scanner, the R4 and P4 pre-clinical scanners and for the Siemens Inveon pre-clinical scanners.

Contact Scientist: Dr Anthonin Reilhac

Activities

- Radiotracer characterisation and validation
- *In vivo* functional imaging
- Post mortem imaging
- Living Animal Resources

Bio-analytics

Bio-analytics activities are centred on the assessment of the biological function at the scale of the cells and organelles. Biological samples from humans, experimental animals, wildlife, food or environmental samples are investigated to assess functions and detect elements or contaminants. An important aspect of the work of the Bio-analytics team is not only to determine received dose but also to understand the actual biological impact. This extension of the dosimetry of exposure to the biometry of effect is supported by a range of molecular biological techniques that measure DNA, RNA, protein expression and membrane properties.

Contact Scientists: Jun Liu, Ryan Middleton, Nicholas Howell

Activities

- Radiation biology – molecular biology
- Radiation biology – cellular and biophysical biology
- Analytical biology - radiological and nuclear methodologies

Radiation technology - High precision dose delivery and measurement

The Radiation technology group operates 60Co irradiators for small scale irradiation studies to various doses. The group’s unique capabilities enable us to accurately deliver high doses of radiation with a precision not achievable in industrial-scale irradiators. Controlled dose rates and temperatures allow users to test ideas, develop applications and perform irradiations under non-standard conditions. The work has multiple applications in food biosecurity, agriculture, horticulture, radiobiology, radiotherapy dosimetry, material radiation hardness studies, polymer science, immunology, medical sciences and biotechnologies.

Contact scientists: Justin Davies, Connie Banos

Activities

- Gamma Technology Research Irradiator (GATRI) - materials development, sterilization techniques, dosimetry
- Gamma Irradiation Suite (GIS) - radiobiology (health, food security)

Materials Engineering at ANSTO

This section of the AINSE Researchers' Guide identifies the research topics in Materials Engineering. Access to the Materials Engineering facilities is through collaborative research.

Materials Engineering Access Procedure

1. Identify the research topic which might incorporate your project.

2. Draft applications including scientific objectives, background, and proposed method and program must be provided to the ANSTO research task leader by 15 August.

3. The research task leader will advise the facility details and any other additional information to include in your application.

Nuclear Materials Science

Australian and International Context

Research conducted under the Nuclear Materials Science programme seeks to address the emerging needs of materials and processes linked to the advanced nuclear fuel cycle. In this context, our research theme is focused on activities which can deliver benefits towards future environmentally sustainable energy production and to apply our expertise in other areas to support Australia's environmental challenges. Our programme seeks to establish collaborative research though partnerships, both national and international, that will deliver and promote the benefits of nuclear science and technology.

Research Topics

Our research group consists of a multi-disciplinary team of chemists, materials scientists, and technical staff working together to develop advanced technologies for fabricating materials and processes which are vital to the next generation nuclear fuel cycle. Recent research projects include:

- Development of selective adsorbent materials;
- Development of nano-scale materials and their structure-function relationships in nuclear applications.

Our Capabilities

The research team is building an effective capability in separations science and nano-scale synthesis with particular emphasis on the development of novel separations materials and engineering materials properties based on metal oxides; specifically modifying chemical, thermal or mechanical properties of materials using nano-scale processes. We have expertise in the synthesis of oxide and non-oxide materials using solution chemistry, vapour phase deposition and electrochemical methods. Our thin-films labs have the tools to prepare and characterise the evolution of materials prepared at several length scales. In addition, there are many investigative tools to study the structure-function relationships of materials, they include; vibrational spectroscopy (FTIR, Raman), UV-Vis spectroscopy, surface analysis by gas adsorption methods, particle size measurement and a radio-analytical chemistry lab for probing the adsorption of radionuclides with alpha and gamma spectroscopy. Instrumented micro-mechanical testing facilities (tensile, bending and indentation) are also available.

ANSTO Research Task Leader: Dr Gerry Triani

Applications of Ionising Radiation

Australian and International Context

Our research portfolio is designed to address emerging needs for new knowledge and instrumentation concerning the measurement and detection of ionising radiation, radionuclide metrology and the emerging discipline of nuclear forensics.

Research Topics

The research group consists of physicists, chemists, materials scientists, and technical staff with diverse backgrounds, working together to form a multi-disciplinary research team. The team works across three laboratories areas consisting of Detector Lab, Activity Standards Lab and Nuclear Forensic Research Facility. Specific research areas include:

- Nuclear forensics.
- Detector science including micro- and nano-dosimetry for applications in medical physics, radiation protection and radiobiological research.
- Radionuclide metrology (techniques for the precise measurement of the activity of radionuclides)
- X-ray test pieces and algorithms that improve border security screening performance in maritime, vehicular and aviation contexts.

Our Capabilities

We have expertise invested in our people and facilities. Particular capabilities delineated by laboratory are provided below.

(1) Detector Lab
- Geant 4 radiation transport modelling.
- Semiconductor based material assessment including electrical characterisation, charge collection imaging, current pulse analyses and deep level transient spectroscopy.

(2) Activity Standards Lab
- High precision radioactivity measurements (national standard).
- Radioisotope assay of unknown radiological and nuclear materials.
- Hot Spot irradiation (C0-60 irradiations)

(3) Nuclear Forensics Research Facility
- Nuclear signature characterisation.
- Traditional forensic techniques in a radiological context.

ANSTO Research Task Leader: Dr Mark Reinhard

Nuclear Materials Modelling and Characterisation

Australian and International Context

Our strategic directions are based on the need for innovative materials for safe, environmentally friendly, reliable, and cost effective energy production to support the future wellbeing of Australians and to promote domestic and international research partnerships in nuclear science and technology. The current research profile is based on applied and discovery research on the solid state physics and chemistry of advanced materials for use in extreme environments of radiation, temperature, and pressure. These studies include materials of interest in the high technology sector, e.g., oxide based compounds with useful electronic, ionic, or magnetic properties.

Research Topics

The research group consists of physicists, chemists, materials scientists, and technical staff with diverse backgrounds, working together to form a multi-disciplinary research team. The *modus operandi* of the group involves the application of both experimental and atomistic modelling techniques in an iterative loop: providing high quality experimental data supported by validated computational models. Currently, our major research effort is devoted to a fundamental understanding of the interaction of radiation with materials. This exciting research area has several applications ranging from fission and fusion energy materials to device physics to radiation detection and human health, among others. We also have extensive expertise in the mineralogy, geochemistry, and radiation effects of Th-U minerals and conduct laboratory based studies of actinide crystal chemistry and aqueous speciation. Thus, we encourage research collaboration in the following areas:

- Fundamentals of radiation damage in oxides (e.g., fluorite, pyrochlore, spinel, and garnet structure types) and intermetallic compounds. This work involves both *in situ* irradiation of TEM samples and ion irradiation of bulk materials.
- X-ray, neutron, and electron scattering studies of the structure, bonding, and order-disorder behaviour of materials relevant to fission, fusion, and other advanced energy systems.
- Synthesis and characterisation of materials containing actinides and other radionuclides for studies of the crystal chemistry, physical properties, phase transitions, and aqueous dissolution behaviour.

Our Capabilities

We have expertise in the synthesis of materials, electron microscopy and microanalysis, X-ray and neutron diffraction, and a range of spectroscopic methods including vibrational spectroscopy (FTIR, Raman), electron energy loss spectroscopy, X-ray absorption spectroscopy, UV-Vis and Diffuse Reflectance, and X-ray photoelectron spectroscopy. For atomistic modelling approaches, we are supported by ANSTO's advanced computing facilities and currently use molecular dynamics (MD) simulations to study the energetics and migration behaviour of defects, thermal spikes, and large collision cascades in materials. We also use density functional theory (DFT) applied to structure, bonding, phase stability, mechanical properties, and the energetics of defects in materials. We manage the following ANSTO facilities:

- X-ray diffraction laboratory, with a range of detectors, sample heating and cooling.
- SEM laboratory with capabilities in high-resolution imaging, chemical microanalysis and mapping, and electron backscatter diffraction and mapping.

- TEM laboratory with STEM imaging, high-resolution imaging, chemical microanalysis, and electron energy loss spectroscopy and mapping capabilities.
- Access to DL_POLY3 for detailed MD simulations of the dynamic behaviour of materials.
- Access to DFT codes including SIESTA, Dmol3, and VASP for *ab initio* studies of energetics and electronic properties of materials.

ANSTO Research Task Leader: Dr Greg Lumpkin

Structural Integrity Program

Australian and International Context

The Structural Integrity Programme undertakes research in the area of the behaviour of material in extreme environments; principally neutron irradiation, high temperature and high pressure. A major focus is to develop an understanding and be able to predict the behaviour of materials under future Generation IV (GenIV) and fusion power reactor operating conditions and to determine the effect that property changes have on the integrity of the structures that make up the reactor systems. This includes an understanding of the effect of neutron irradiation on structural materials and how these changes affect the integrity of welds. The outcomes of the programme include fundamental knowledge on the effects of radiation on materials, and of the development of residual stresses in welds due to materials properties and weld procedures.

Research Topics

Our research team consists of a multi-disciplinary group of physicists, materials scientists, materials engineers and metallurgists with a wide range of research and industrial experiences. We have some of the most comprehensive mechanical testing capabilities in the region and specialise in the generation of high quality results from such tests. The overall objective is to understand the behaviour of materials under extreme environments, with a major focus being the future application in nuclear power generation in fission and fusion reactors. The activities are undertaken in several areas detailed below.

- Understanding the effects of neutron irradiation on the properties of materials for use in nuclear applications, particularly in GenIV fission and future fusion reactors. The materials include steels (ferritic, martensitic, austenitic etc), zirconium alloys (including Zircaloy-4, Zr-2.5Nb and Zr-3Sn), a variety of dispersion strengthened materials (such as oxide dispersion through nano-sized particles of yttrium oxide), various aluminium alloys (widely used in research reactors) and various other metallic and non-metallic materials.
- Modelling of welds in structural materials – this is required to enable the performance of structures to be understood – particularly multi-pass welds that have the potential to develop significant residual stresses. The weld modelling is supported by modelling of the development of microstructure
- Development of knowledge of materials properties at high temperature and extend current defect and structural assessment codes applicable to next generation power plants. Particular emphasis is placed on creep and creep/fatigue interactions that result from cycling of high temperature engineering plant. Contributions are being made in the development of international assessment protocols such as the R5 and ASME-EPRI codes.

Our Capabilities

Our research programmes are supported by a range of experimental facilities. Significant investment has recently been made in the development of facilities for the preparation, handling and testing of radioactive materials. An active metallography facility (for low level radioactive materials) is under construction and a suite of hot cells (for high activity materials) are currently in the design stage. Other major facilities include:

- Mechanical testing – tension, compression, fracture toughness, fatigue and creep etc. at temperatures from -196˚C to in excess of 1,500˚C, in various environments including air, argon and vacuum.
- Finite element modelling capability centred around the ABAQUS package with elastic/plastic capability.
- Capabilities for measuring residual stresses including: neutrons (KOWARI instrument on OPAL), X-ray, contour method, slitting technique and others
- SEM, TEM and FEGSEM facilities including EBSD
- Materials fabrication capability including mechanical alloying, hot isostatic pressing (HIP), cold isostatic pressing (CIP)

ANSTO Research Task Leader: Dr Bob Harrison

9800 AINSE Facilities & Staff

AINSE Facilities-for hire

Lecture Theatre

- 150 seat capacity
- Equipped with audio-visual equipment.

Conference / Seminar Room complete with audio-visual equipment; to seat up to 40 people.
In general, there is no charge to AINSE member universities or ANSTO. A hiring fee may be applicable in all other cases.

Costs

Theatre	$500 per day
Council Room	$300 per day
Foyer Area	$200 per day

The rooms are only hired out to corporate groups.

AINSE Conferences - Contribution to Travel and Accommodation

Depending upon circumstances, AINSE may provide a contribution towards travel costs for nominated participants from member universities. The extent of any such travel contribution will be determined by AINSE when all nominations have been received and the circumstances are known. Preference is given to students presenting papers and posters. Where appropriate, group leaders will be advised of the amount which can be made available for travel costs for the group, and the basis for payment. AINSE may meet bed and breakfast charges for participants from member organisations during the conference.

AINSE Awards - Travel and Accommodation

Researchers planning to use the Lucas Heights facilities are expected to take advantage of the discounted airfares. The airfares are normally calculated on the basis of advance purchase airfares plus travel to and from Sydney airport.

Car travel

AINSE interstate award holders who wish to use cars for travelling to Lucas Heights may be eligible to receive reimbursement. A tax invoice must be received from the University claiming an agreed amount and not exceeding the AINSE award.

Bookings and further information

AINSE Conferences:	**AINSE Travel & Accommodation Bookings**
Mrs Rachel Caldwell	Ms Sandra O'Connor
Ph: 02 9717 3376	Ph: 02 9717 3411
Fax: 02 9717 9268	Fax: 02 9717 9268
Email: ainse@ainse.edu.au	Email: ainse@ainse.edu.au

AINSE Staff

Dr Paul DiPietro	Managing Director
Ms Michelle Durant (Full Time)	Business Manager and Scientific Coordinator
Ms Rachel Caldwell (Full Time)	Communications and Events Coordinator
Ms Nerissa Philips (PT: Wed & Thu)	Accounts Receivable/Publications/Student Scholarships
Ms Sandy O'Connor (PT: Mon-Wed)	Travel / Accounts Payable

Ph:	**02 9717 3436**
Fax:	**02 9717 9268**
Email:	**ainse@ainse.edu.au**
Mail:	**Locked Bag 2001, Kirrawee DC NSW 2232 Australia**

Contact Information

Name	Phone	Fax	Email	Comments / Other Info.
Anderson, Prof Bob	+64 9923 8315	+64 9373 7422	r.anderson@auckland.ac.nz	
Banati, Prof Richard	02 9717 3505		rib@ansto.gov.au	
Banos, Ms Connie	02 9717 3116		connie.banos@ansto.gov.au	
Barry, Ms Linda	02 9717 3014	02 9717 9265	lib@ansto.gov.au	
Bennett, Dr John	02 9717 3743	02 9717 9669	john.bennett@ansto.gov.au	
Blackwell, Dr Boyd	02 6125 2482		Boyd.Blackwell@anu.edu.au	http://apfrf.anu.edu.au/
Braoudakis, Dr George	02 9717 3473		gbx@ansto.gov.au	
Sullivan, Dr James	02 6125 0040		james.sullivan@anu.edu.au	
Callaghan, Dr Paul	02 9717 9762		paul.callaghan@ansto.gov.au	
Charil, Arnaud	02 9717 9501		Arnaud.charil@ansto.gov.au	
Chavara, Dorji	02 9717 7351		Dorji.chavara@ansto.gov.au	
Chisari, Mr Robert	02 9717 3283	02 9717 9286	rcx@ansto.gov.au	
Cohen, Dr David	02 9717 3042	02 9717 3257	dcz@ansto.gov.au	
Comarmond, Dr Josick	02 9717 9453		mjc@ansto.gov.au	
Cresswell, Dr Tom	02 9717 9412		Tom.cresswell@ansto.gov.au	
Davies, Dr Justin	02 9717 9002		justin.davies@ansto.gov.au	
Fernando, Dr Kapila	02 9717 9488	02 9717 3177	kapila.fernando@ansto.gov.au	
Fink, Dr David	02 9717 3048	02 9717 3257 or 9265	fink@ansto.gov.au	
Fraser, Dr Ben	02 9717 3887		benjamin.fraser@ansto.gov.au	
Gadd, Ms Patricia	02 9717 3140	02 9717 9270	psp@ansto.gov.au	
Grant, Ms Maxine	02 9717 9894		mgt@ansto.gov.au	
Greguric, Dr Ivan	02 9717 3759		ivan.greguric@ansto.gov.au	
Harrison, Dr Bob	02 9717 3150		robert.harrison@ansto.gov.au	
Heijnis, Dr Henk	02 9717 9086	02 9717 9270	hhx@ansto.gov.au	
Hollins, Dr Suzanne	02 9717 3701		suzanne.hollins@ansto.gov.au	
Holt, Dr Stephen	02 9717 3173	02 9717 3606	stephen.holt@ansto.gov.au	
Hotchkis, Dr Mike	02 9717 3148	02 9717 3257 or 9265	mah@ansto.gov.au	
Howell, Mr Nick	02 9717 3071		nrh@ansto.gov.au	

Hua, Dr Quan	02 9717 3671	02 9717 6265	qhx@ansto.gov.au	
Hughes, Dr Cath	02 9717 9366		ceh@ansto.gov.au	
Ionescu, Dr Mihail	02 9717 3301	02 9717 3257	mio@ansto.gov.au	
Jacobsen, Dr Geraldine	02 9717 9060	02 9717 9265	gej@ansto.gov.au	
Knott, Dr Robert	02 9717 9125	02 9717 3606	rbk@ansto.gov.au	
Lengkeek, Dr Nigel	02 9717 3622		nigel.lengkeek@ansto.gov.au	
Levchenko, Dr Vladimir	02 9717 3046	02 9717 9265	vld@ansto.gov.au	
Liu, Dr Guo Jun	02 9717 7220		gdl@ansto.gov.au	
Lumpkin, Dr Greg	02 9717 3742		gregory.lumpkin@ansto.gov.au	
Mazumder, Dr Debashish	02 9717 9219		dma@ansto.gov.au	
Mendis, Mr Kith	02 9717 7089	02 9717 7139	klm@ansto.gov.au	
Meriaty, Mr Haider	02 9717 9257	02 9717 3899	ham@ansto.gov.au	
Middleton, Mr Ryan	02 9717 7243		ryan.middleton@ansto.gov.au	
Nelson, Dr Andrew	02 9717 9477	02 9717 3606	andrew.nelson@ansto.gov.au	
Nguyen, Dr Vu	02 9717 9081		vhn@ansto.gov.au	
Nuclear Safeguards Officer	02 9717 3872 or #3658	02 9717 9288	safeguards@ansto.gov.au	
Parmar, Dr Arvind	02 9717 9602		arvind@ansto.gov.au	
Pascali, Dr Giancarlo	02 9717 7611		giancarlo.pascali@ansto.gov.au	
Pellegrini, Dr Paul	02 9717 9708		paul.pellegrini@ansto.gov.au	
Pham, Dr Tien	02 9717 9515		tien.pham@ansto.gov.au	
Reilhac-Laborde, Dr Anthonin	02 9717 3246		Anthonin@ansto.gov.au	
Reinhard, Dr Mark	02 9717 3396		mark.reinhard@ansto.gov.au	
Siegele, Dr Rainer	02 9717 3967	02 9717 3257	rns@ansto.gov.au	
Smith, Dr Andrew	02 9717 9054	02 9717 3257	andrew.smith@ansto.gov.au	
Triani, Dr Gerry	02 9717 9070		gerry.triani@ansto.gov.au	
Wassink, Mr David	02 9717 3818	02 9717 3710	dfw@ansto.gov.au	
Williams, Dr Alastair	02 9717 3694		agw@ansto.gov.au	
Wong, Mr Henri	02 9717 9211	02 9717 9286	henri.wong@ansto.gov.au	
Zahra, Mr David	02 9717 9893		david.zahra@ansto.gov.au	
Zawadzki, Ms Atun	02 9717 3480		aab@ansto.gov.au	