Contents

Introduction

The Australian Institute of Nuclear Science and Engineering (AINSE) was established by the Commonwealth Government in 1958 to provide a mechanism for access to the special facilities at Lucas Heights by universities and other tertiary institutions and to provide a focus for cooperation in the nuclear scientific and engineering fields. Today nuclear science at the Lucas Heights Science and Technology Centre is devoted to supporting activities and research in a wide range of disciplines. These have applications in advanced technology, manufacturing, mining, agriculture, medicine and environmental protection. All are of vital importance to Australia's future.

Many of the techniques and much of the expertise at Lucas Heights cannot be found elsewhere in Australia. AINSE plays an indispensable role in providing university researchers with access to major scientific facilities and encouraging a national cooperative research effort. This has worked efficiently and cost effectively. Universities are saved from duplicating expensive items of equipment and Commonwealth funding can be directed towards one national facility instead of having several with sub-critical funding.

Mission

AINSE will advance research, education and training in nuclear science and engineering and their applications within Australia by being, in particular, the key link between universities, ANSTO and major nuclear science and engineering and associated facilities.

Objectives

AINSE's objectives are

1. to provide a mechanism for users in member organisations of AINSE to have access to major nuclear science and engineering and associated facilities at ANSTO and other agreed sites for research purposes

2. to facilitate graduate and undergraduate education and training experience utilising major nuclear science and technology facilities at ANSTO and other agreed sites

3. to encourage collaboration and cooperation between member organisations of AINSE in areas primarily related to nuclear science and engineering and their applications

4. to sustain and support the development of major nuclear science and technology facilities at ANSTO and other agreed sites for shared use by member organisations of AINSE.

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Dr Dennis Mather
Scientific Secretary

President's Report

Professor Ron MacDonald, President

AINSE is entering the year 2000 and the new millennium (whenever it starts) as a strong organisation. Almost all the universities of Australia are members and we have the University of Auckland, New Zealand, to give an international flavour.

AINSE has successfully completed forty years and is set to easily reach its 50th. If we look back, though, the AINSE of today is a different organisation to the AINSE that was created forty years ago. At that time, almost all existing universities were members; there were nine of them. The rapid expansion of the fifties and sixties saw an increase in membership, but still almost all the universities in Australia were members. Again, the expansion of the 80s with amalgamations and new universities saw further increases in university membership numbers to thirty six.

Throughout all the changes ANSTO has maintained its $2 for $1 subscription rate. Over the 40 years, there have been times of tension within AINSE and significant changes in policy and implementation have been introduced to smooth these tensions. As a result, AINSE is still alive and well.

During 1999 AINSE was involved in discussions which created a new way of working for the future. AINSE has recognised its strength as a cooperative involving all the universities and ANSTO and has used that strength to gain Government (in dollar terms predominantly from the Australian Research Council (ARC)) support for collaborative projects that provide infrastructure to support researchers in Australia. This is a major benefit provided by AINSE for researchers and one can expect AINSE proposals to continue for at least the next few years.

The ARC, however, changed the rules for support of AINSE projects. With earlier ventures, the projects were submitted through a host university and AINSE managed the outcomes and provided a cash contribution on behalf of AINSE member organisations. ANSTO also made additional cash contributions where appropriate.

Whilst AINSE made a contribution to the proposed infrastructure funding in line with the usual requirements of ARC for Research Infrastructure and Equipment Fund applicants, the actual contribution from each university (as measured by their share of the AINSE-funded input) was small.

The ARC has apparently realised this and now requires member institutions who will benefit from the infrastructure to contribute individually as well as through AINSE. This may seem a little tough, but is not totally unreasonable.

What is important is that AINSE continues to seek infrastructure funding on behalf of collaborating institutions, though the funding input may have to be better managed to maximise the use of funds available. It is a certainty, however, that AINSE will continue its efforts to provide such research infrastructure. The advent of a neutron beam from the new reactor will ensure this.

In other ways, however, AINSE will have to carefully evaluate its support. There is a shift in research emphasis towards the biological and environmental sciences. This is reasonable, and AINSE must ensure that it provides support in these newer areas, consistent with its mission to develop nuclear techniques and apply them in all appropriate areas, while it continues its support in existing areas.

I close with a note of thanks to our very able secretariat team. They all provide high quality support to AINSE and without their dedication, AINSE would not be the strong organisation that it is today.

Scientific Secretary's Report

Dr Dennis Mather, Scientific Secretary, AINSE

Nineteen ninetynine has been an eventful year for the secretariat. We reduced our reliance on external consultants, with the result that staff took on new challenges and developed new skills. We also took on a trainee.

AINSE was unsuccessful in its application to the Australian Research Council (ARC), for continued access to the UK neutron spallation source, ISIS, through the Research Infrastructure and Equipment Fund (RIEF). Fortunately the Department of Industry Science and Resources came to our assistance and we are very grateful for their financial support of this important aspect of our activities during 1999.

AINSE organised five conferences during the year. We also sponsored the Australian Nuclear Association conference in Canberra and attended the International Congress of Radiation Research in Dublin.

The AINSE Winter School, which is held in July, was extended from four to five days, to allow an experiment in radiation biology.

We introduced a system of carrying over research grants into February, which effectively extends the grant year to fourteen months. This proved to be quite successful and will be continued.

I continued my program of campus visits, travelling to sixteen universities in Western Australia, the Northern Territory, Victoria, New South Wales and the Australian Capital Territory.

Council and Committees

I am grateful to the councillors and the many committe members, listed in Section 2, who have generously given their time and expertise.

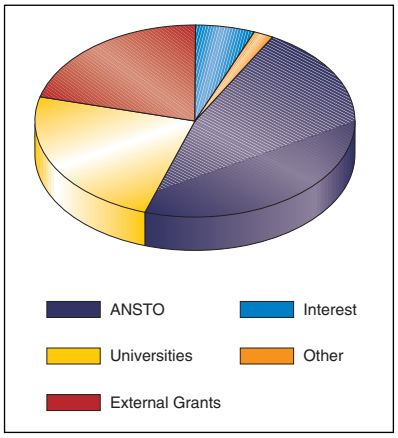
The vacancy on the Executive Committee created by the retirement of Professor Trevor Ophel was filled by Professor Hans Coster from the University of New South Wales.

Other Council changes included

- Ballarat University - Dr Dennis Arne moved to School of Mines, Curtin University, based at Kalgoorlie. He was replaced by Mr Stafford McNight
- Charles Sturt University - Professor Alistair Robertson replaced by Dr Ken Page
- La Trobe University - Professor Andrew Gleadow took up an appointment at Melbourne University and was replaced by Dr Paul Pigram
- Monash University - Dr Trevor Hicks was on sabbatical leave for most of the year and was replaced by Professor Peter Kershaw
- Murdoch University - Professor Katerinya Longley was replaced by Associate Professor Stephen Thurgate
- Victoria University - Professor Paul Clark was replaced by Professor Vaughan Beck
- Chairmanship of the neutron scattering specialist committee passed from Dr Trevor Hicks to Associate Professor Evan Gray of Griffith University.

Finances

AINSE is a non-profit-making institute incorporated under the *NSW Associations Incorporation Act 1984*. In 1999, income of $2,519,090 was made up of $1,181,700 from ANSTO, $614,000 from universities, $521,666 from external grants, $153,886 from interest on investments, and $47,838 from other sources, mainly conference registrations.



Operating revenue

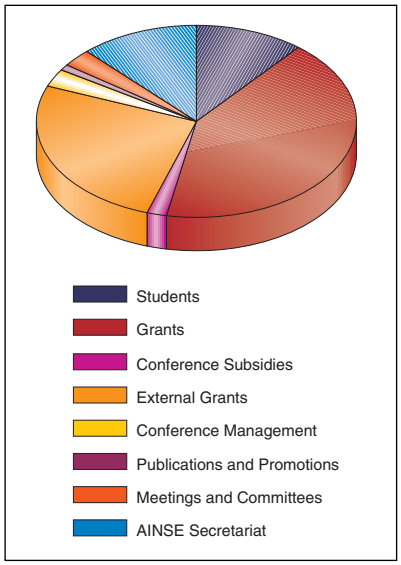
Membership subscriptions are reviewed annually to reflect the use made of Lucas Heights facilities, averaged over the preceding five years. On average, for the period 1995 to 1999 inclusive, universities received research and training benefits amounting to 3.58 times their subscriptions. Since the costs of facilities are subsidised by ANSTO, the actual benefit multiplier is more like five.

The majority of AINSE funds are used to support university research. University projects are mainly supported through grants to cover costs associated with operating and developing ANSTO's facilities.

AINSE's operating expenses in 1999 were $2,225,434, leaving a surplus for the year of $293,656. This surplus is due largely to an apparent shortfall in the take-up of AINSE Grants. The carry over to February of grants for the previous calendar year was once again encouraged, and just under $100,000 in 1999 grants has been approved for carry over until the end of February 2000.

AINSE acts as a peak body on behalf of its member organisations in applying for and administering major research infrastructure grants. In 1999 an ARC grant under the RIEF Program of $243,729 was awarded to provide infrastructure support for small angle, polarised neutron and reflectometry instruments at ANSTO's neutron scattering facilities.

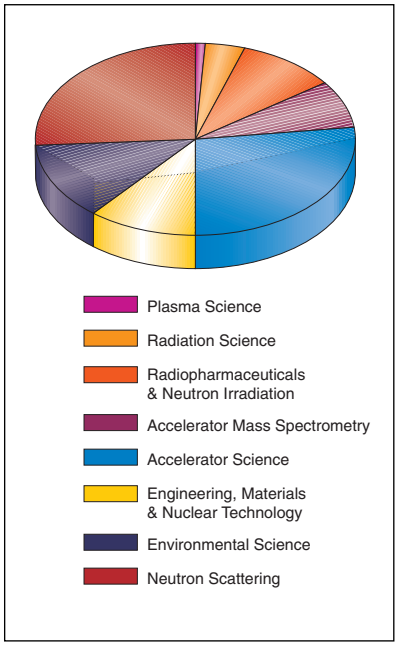
Membership of ISIS was this year funded through a grant from the Department of Industry Science and Resources for $350,000, supplemented with $25,000 each from ANSTO and AINSE. ISIS is the most powerful pulsed neutron source in the world and is located at the Appleton Rutherford Laboratories in the United Kingdom. Membership enables Australian scientists to use these specialised small angle neutron scattering techniques for a wide range of research activities that would not be possible within Australia. Twenty-one projects were granted access for a total of fifty-eight days (see full list in section 2, page 34).



Operating Expenses

The Financial Statements for the calendar year 1999 were prepared by ANSTO and audited by Gardner Escott & Co and are presented in this Annual Report.

Grants and Postgraduate Research Awards



Grants by specialist areas

Funding for 159 university projects was awarded in 1999 under the AINSE grant scheme and forty one 1998 projects were carried over. Highlights of the research in these areas are given in pages 8 to 23 and full research reports for each of the projects can be found on our home page.

In 1999, twenty postgraduate students received AINSE postgraduate awards for access to ANSTO's facilities. ANSTO subsidises these awards by providing additional time on its facilities at no cost to AINSE. The students also provide valuable support for ANSTO's research. In addition, seventy three students gained access to the facilities via grants held by their supervisors.

The AINSE Winter School at ANSTO was held early in July over five days, one day more than in 1998. A scholarship was provided to every university to enable a nominated third year student to participate. Feedback from all quarters judged this program to be an outstanding success. A more comprehensive report is given on pages 26 and 27 of Section 1 of this Report

and details of the feedback can be found on our home page. Despite many requests to extend the winter school to allow more students to participate, we have decided this will not be possible because of the increased burden it would place on both AINSE and ANSTO in terms of personnel and cost.

Neutron scattering review by ARC Committee for International and National Cooperation

In March the ARC Committee for National and International Cooperation spent a day at AINSE reviewing the improvements in neutron scattering facilities and the benefit to research afforded by the investment of $1,296,000 from ARC grants in the period 1992 to 1999.

The committee met with representatives of ANSTO and with a broad cross section of university researchers and students who have used the facilities.

Success in Research Infrastructure and Equipment Fund (RIEF) Program

During the year we prepared two successful applications for RIEF funding for 2000. The first, for membership of ISIS, attracted $255,000 from ARC and is supported by $83,333 from universities and by $25,000 from each of ANSTO and AINSE.

The second, a grant application for a new accelerator, attracted $1 million from ARC, $264,000 from universities, $600,000 from ANSTO and $300,000 from AINSE. The University of Wollongong is the lead institution for this project, contributing $100,000, and the University's Professor Allan Chivas will chair the Stakeholders Committee.

Conferences

The conferences Oncology: Therapy, Diagnosis and Palliation at the University of Sydney and Plasma 99 at the Australian National University were held in February. The conferences were well attended and feedback was extremely positive.

The Quaternary Dating Workshop held at Lucas Heights in June was the first event run by AINSE without an external conference organiser. Congratulations are due to AINSE staff members Irene Parker and Nerissa Dawson for this seamless transition.

The largest conference during the year was the Nuclear Techniques of Analysis Conference, which was held in November. It was attended by a broad cross section of the community and was financially supported by twelve enterprises.

I am indebted to all members of planning committees for their invaluable contribution to the conferences.

AINSE supported the 3rd Australian Nuclear Association Conference in Canberra, 27-29 October 1999, by providing travel subsidies to contributors from member universities.

A small contingent visited Dublin for the Eleventh International Congress for Radiation Research in July. It was led by Dr Roger Martin and Associate Professor Ron Cooper, Australia's delegates to the International Association for Radiation Research Council. AINSE will be responsible for organising the Twelfth International Congress for Radiation Research, to be held in Brisbane in 2003. ICMS Pty Ltd has been appointed to facilitate organisation of the Congress.

Awards

The AINSE Gold Medal was awarded to Professor Ian McDougall and presented at the Council meeting in Canberra in December. He will deliver his medal address at the Council meeting in May 2000. The Student Gold Medal was awarded to Ismunander who worked under Dr Erich Kisi at the University of Sydney.

Professor Trevor Ophel was awarded the AINSE Honorary Fellowship at the December Council meeting. Trevor has invested a great deal of time and effort in the affairs of AINSE over very many years. He will continue to sit on the Specifications Committee for the accelerator which is to be purchased with the 2000 RIEF Grant.

AINSE Staff

As previously mentioned, we decided at the beginning of the year that we would no longer use an external conference manager and publications consultant, and that these duties would instead be carried out by AINSE staff with the assistance of a trainee. We spent most of the year searching for a suitable person for this trainee position. Melissa Farlow commenced in September and has filled the position to our expectations.

Acknowledgments

I would like to thank Irene Parker, Nerissa Dawson and Melissa Farlow for their support throughout the year and the good will with which they have accepted new challenges. I would also like to thank all those from the universities and ANSTO, there must be hundreds, for their help and advice throughout the year. Finally, I owe special thanks to Tim Tapsell for his photos of the Winter School, Jeff Evans, Jeane Balcombe and Cheryl Jones, whose contributions to the preparation of this report have been enormous.

AINSE Postgraduate Scholar Dr Tracey Hanley presenting her doctoral thesis to AINSE Scientific Secretary Dr Dennis Mather

Accelerator Science

Research Areas

The Accelerator Science Specialist group uses accelerator-based ion beam analysis techniques to analyse and characterise surfaces and near-surface structures. The techniques, which are non destructive and highly sensitive, are used in geological studies, characterisation of ancient ceramics and antique metal artefacts, zoological research into lizard physiology, tracing and provenance of obsidian to establish former trade and migration routes in the South Pacific, and investigations into the detailed structure of opto-electronic materials to assist fabrication methods.

The group uses ANSTO's 3MV Van de Graaff and 10MV FN-tandem accelerators. The former provides beams of protons and alpha particles, while the tandem beams span a wider range of ions and energies. Most applications involve a combination of nuclear techniques. These may include Proton-induced X-ray Emission (PIXE), Proton-induced Gamma-ray Emission (PIGME), Rutherford Back Scattering (RBS), Forward Recoil Analysis and Recoil Time-of-flight spectroscopy.

Selected Research Activities

Selwyn Ranges rock art

A distinctive style of rock paintings and engravings that have been found in the Selwyn Ranges near Mt Isa in Northwest Queensland include a stylised human form, which the local Kalkadoon Aboriginal community has associated with figures from the Molonga ceremony, that was last held in 1897.

Professor Iain Davidson and Dr Peter Grave and their team from the University of New England established radiocarbon dates for the paintings and a nearby ochre quarry that range from 200 to 1000 years. A heat treatment pit used for roasting ochre and stone tools was dated to 4300 years.

The researchers found that heat can cause the yellow paints to turn red, which means that some of the many red paintings may originally have been yellow. The analysis also revealed that various organic materials had been mixed into the paints. Red paints were often mixed with fats, while yellow and brown paints were made with blood, egg yolk or saliva.

The research is aimed at understanding how ochre was traded between different Aboriginal groups, and why Aboriginal people decided to paint certain pictures with different ochres.

The PIXE/PIGME facility at ANSTO was used to characterise ochres from ten different locations in North West Queensland. Samples as small as 1mg allow researchers to study the composition of the paint, minimising damage to the paintings.

Rock art from the Selwyn Ranges

Ochres used to paint the figures came from within the tribal region, even though ochre was widely traded with tribes outside the area. This suggests the paintings may have signified land that was managed by the Kalkadoon people.

Towards better, cheaper solar cells

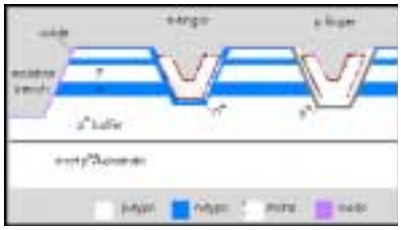
A new solar cell design invented at the University of NSW and being commercialised by Pacific Solar could help to significantly reduce the cost of photovoltaic electricity.

The new, parallel multijunction (PMJ) thin film silicon solar cell is designed to work with low cost, poor quality silicon. By contrast, the single-junction cells currently used to produce photovoltaic electricity have to be manufac-

tured from relatively expensive, high quality silicon.

In 1999 Dr Mark Keevers at the University of NSW fabricated PMJ test cells on high quality silicon and irradiated them with 10MeV protons at ANSTO's tandem accelerator to controllably degrade the silicon quality. These experiments enabled him to compare the tolerance of PMJ and single-junction cells to poor quality silicon. The results clearly demonstrate the superior tolerance of the PMJ cell, and represent the first experimental evidence of this theoretically predicted advantage.

Ongoing work focuses on determining the role of various loss mechanisms in limiting the performance of the PMJ solar cell. The importance of one of these losses, called junction recombination, is somewhat controversially debated in the photovoltaics community.



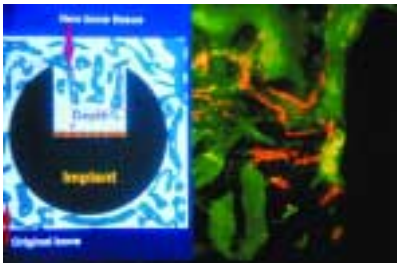
Schematic cross section of the fabricated parallel multijunction solar cells

Ioning out implant problems

Last year 38,500 artificial hips and knees were put into Australian patients. Approximately 15% of these were replacement prosthesis.

In an attempt to improve the longevity of joint prostheses, Professor Rolfe Howlett from the University of NSW, Dr Peter Revell from the University of London, and Dr Peter Evans, ANSTO, have been working on a project to improve the biocompatibility of the devices to make them last longer and be more quickly accepted by the body. To achieve this, ANSTO's metal vapour vacuum arc was used to implant divalent ions into bioceramics used for the outer coating of the prosthesis.

It was found that bone ingrowth and volume of bone were significantly stimulated when alumina and hydroxyapatite surfaces (the substrata) were implanted with magnesium ions.



The composite image above shows an increased rate of bone formation in a rabbit around a mock prosthesis made of hydroxyapatite implanted with magnesium ions

The Australian Research Council also supported this research.

Tooth PIXE

Dr Denise Donlon and her PhD student Anne-Marie Williams, of the University of Sydney, are looking at the deposition of trace elements in teeth from children who died in the mid to late 1800s whilst living at the Randwick Destitute Children's Home. It is hoped that information about the trace element deposition will help determine the diet and health of these children.

Sixty-five skeletons were exhumed from the Randwick Destitute Children's Cemetery in 1996 and 1997 during redevelopment at the Prince of Wales Hospital.

The cemetery was unmarked but records from that time indicate that 175 children died at the institute between 1858 and 1916. The largest number of deaths occurred in 1867 when seventy eight children died from whooping cough and measles.

Children were placed in the institution because their parents were unable to look after them; many probably suffered periods of malnutrition before entering or while in the institution.

The research uses PIXE analysis to determine which elements were deposited in the teeth while the child was alive and what changes in elemental composition have occurred since death. Results have found several elements in the enamel, including strontium, zinc, lead, iron and nickel. The next stage will involve comparing these teeth to teeth from modern children and looking at the deposition of the elements throughout the tooth.

Upper jaw bone of skeleton exhumed from the Randwick Destitute Children's Cemetery

Accelerator Mass Spectrometry

Research Areas

Accelerator Mass Spectrometry (AMS) is an ultrasensitive analytical technique used to identify and count selected isotopes. Isotopic concentrations at the level of 1 part in 10^{15} can be measured in long-lived radioisotopes such as carbon-14, beryllium-10, aluminium-26, calcium-41, chlorine-36 and iodine-129.

Carbon-14 analysis is probably the best known AMS technique. It is used in a wide range of disciplines including archaeology, Quaternary science, global climate change and nuclear safeguards.

Selected Research Activities

The enigma of an ancient desert lake

The Flinders Ranges in South Australia are now devoid of rivers. During rare downpours the streams draining this rugged desert mountain range carry large boulders and coarse sand and gravel. Throughout the ranges deep gullies have cut down into fine-grained alluvial clays. No such clays are accumulating today. Even more curious is the presence of finely laminated lake clays in the central ranges within and upstream of Brachina Gorge. There are no lakes present today within these arid ranges.

How and when did the Brachina lake form? Could a lake form there today if there was a suitable dam? In an attempt to answer these questions, Professor Martin Williams and his team from the University of Adelaide took shells and charcoal from the lake sediments and dated them, using both AMS radiocarbon and Optical Stimulation Luminescence techniques.

To their surprise, they found that the lake was in existence from 35,000 until 13,500 years ago. It was even there during the last glacial maximum, which was a time of extreme cold and aridity throughout southern Australia. The researchers discovered that the reasons for the lake's survival are complex and include a change in runoff associated with widespread dust mantles on the hill-slopes; higher groundwater tables linked to the demise of the river red gums; and the presence of a calcareous tufa dam initiated by a combination of reed growth and a fine sediment plug from a tributary valley.

Brachina Gorge, central Flinders Ranges, showing the sharp contact between the late Pleistocene lake clays overlying the Cambrian bedrock

How sandy reef islands form

Low-lying reef islands associated with coral atolls appear particularly susceptible to erosion if the sea level rises, which is an anticipated effect of greenhouse warming. In order to understand this risk, it is necessary to learn when and how the sands that compose the islands have been deposited.

The sands are made up of fragments of skeletons of organisms, predominantly coral and foraminifera (microscopic, shelled sea organisms) living on the reefs, with smaller contributions from coralline algae and molluscs. Because the sands are organic in make up, individual grains can be dated through AMS radiocarbon dating techniques.

The radiocarbon date indicates the time of death of the organism; it does not indicate when the sand grain was deposited. To estimate this it is necessary to assess the time taken for sand grains to be reworked before they are deposited. To this effect Associate Professor Colin Woodroffe and his coworkers at the University of Wollongong have compared ages determined on bulk samples and coral gravel with the ages of individual constituent grains. Initially this work was undertaken on sand samples from a series of pits across an elongated reef island on the Cocos (Keeling) Islands, an Australian atoll in the Indian Ocean. This work has more recently been extended to mid-Pacific atolls such as Makin, the northernmost island in the Republic of Kiribati.

The results from the Cocos (Keeling) Islands indicate close agreement between ages for different constituent grains, implying there was only a short period of time between the death of the organism and deposition on the island shore. Radiocarbon dating shows that all these islands were formed in this way, accreting sand over the past 3500 years. This particular island group has built up predominantly through the addition of new sediment to the oceanward shore, though with minor accretion along the lagoon shore, and extension at either end as a result of longshore movement of sand.

In contrast, Makin Island in the mid-Pacific has been built primarily from the shells of dead foraminifera, and it began to form only about 2600 years ago. It appears to have built oceanward through the continued supply of dead foraminifera.

Sustained growth of such islands in future will depend upon maintaining viable populations on the reef of the organisms that contribute to the sand.

Exposure age dating of moraines in New Zealand.

The sequences of glacial moraines in the New Zealand Southern Alps cannot be dated by the radiocarbon method. Consequently, Dr Paul Augustinus, from the University of Auckland, and Dr James Shulmeister, Victoria University of Wellington, have initiated a program of exposure-age dating moraines from the Cobb River and other valleys in the northern part of New Zealand's South Island, using the cosmogenic nuclides beryllium-10 and aluminium-26. These nuclides are produced on the surface of exposed rocks by cosmic ray bombardment following the removal of ice. The scientists believe they will be able to obtain, for the first time, reliable ages for a complete late Pleistocene glacial sequence. The ages of the moraines and any evidence of a glacial advance around 10,000 to 11,000 years ago (during the Younger Dryas), would be of considerable significance given the current debate regarding the existence of a Younger Dryas cooling event in the Southern Hemisphere.

Environmental Science

Research Areas

AINSE's environmental science projects utilize four main areas of ANSTO facilities and expertise

- the Cameca SIMS 5f Secondary Ion Mass Spectrometer
- environmental radioactivity, chiefly through lead-210 and caesium-137 dating procedures
- uranium/thorium measurements for Quaternary dating
- neutron activation analysis (NAA).

The SIMS instrument is used to solve a broad range of surface analysis and biological problems. AINSE-supported researchers use it to analyse mineral surfaces and their reactions during beneficiation, to assess the suitability of silicon and other semi-conductor materials for their use in electronic and solar energy applications, and to treat the surface of metals and alloys. Biological applications are being developed.

Selected Research Activities

Chronology of contaminated sediments in Sydney Harbour

A study by AINSE postgraduate scholar Stuart Taylor of the University of Sydney of sediments laid down in Sydney Harbour has enabled him to identify areas contaminated by stormwater and specific industrial sources. Measurements of lead-210, radium-226, and caesium-137 at the Environmental Radiochemistry Laboratory, ANSTO, were used to date sediment layers containing trace metals and pesticide residues and establish the history of pollution in the Harbour.

Sydney Harbour

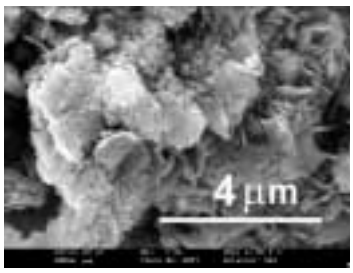
Contamination of the sediments began in the early 1900s, peaked around 1970, and has since generally declined. Trace metal concentrations are lower in the surface layers of the sediments than they were twenty years ago due to a reduction in the flux of contaminants into the upper reaches of the Harbour.

It is apparent that contaminants settling to the estuary floor are continually remobilised into the water column and this may account for a general increase in trace metal concentrations in the lower reaches of the Harbour. Re-suspension of highly contaminated localised sediment may lead to contaminant dispersion throughout the entire harbour and have significant adverse implications for benthic and pelagic biota.

Sulfur cycling in acid sulfate soils

The use of SIMS to accurately determine sulfur isotopes at a micron scale is allowing Dr Leigh Sullivan and Richard Bush at Southern Cross University to study the transformation of sulfur in coastal sediments. The iron sulfides they are examining include aggregates of microscopic pyrite (FeS_2) and greigite (Fe_3S_4).

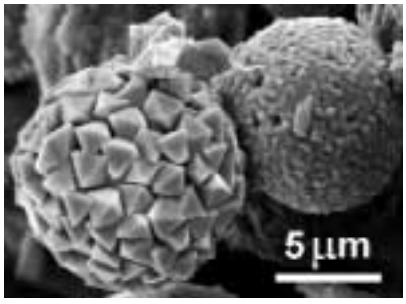
Acid production by sulfide oxidation has dramatically increased as a result of



greigite

the widespread drainage of coastal floodplains. Many Australian estuaries are severely affected by this process and it has led to massive fish kills, fish and oyster disease, corrosion of engineering structures and the release of toxic concentrations of iron, aluminium and heavy metals.

The reformation of iron sulfides during wet periods is a potentially important acid-consuming mechanism in acid sulfate soil. The SIMS results indicate pyrite is forming in the upper part of acid sulfate soil profiles which experience seasonal watertable fluctuations. Recently formed pyrite can be identified by the greater abundance of ^{34}S. Pyrite containing less ^{34}S was accumulated during the Holocene when the sediments were deposited. The recently formed pyrite could only be detected by analysing the individual microscopic aggregates using the spatial resolution provided by SIMS. The similarity in the isotopic composition of greigite and recently formed pyrite and the role of greigite in pyrite formation are being further examined by SIMS analysis.



pyrite

Impact of urban pollution

Buffalo Creek is located on the edge of Darwin's northern suburbs and has extreme (8m) seasonal and tidal variations. This estuary has been affected by significant nutrient inputs over the past twenty eight years. The major source of nutrients is the Leanyer/Sanderson sewage treatment plant (STP), which releases secondary treated effluent directly into Buffalo Creek. Minor nutrient inputs come from storm water drains and leachate from a disused refuse dumping site. When excess nutrients enter waterways they can lead to excessive growth of unwanted algae and blooms of free floating plankton, which may be toxic to other organisms.


Buffalo Creek

The impacts of past and present activities on Buffalo Creek are being studied through a combination of nutrient and metal analyses using lead-210 dating. Preliminary comparisons of nutrient concentrations before and after 1972 indicate that the STP has a significant impact on the nutrient levels in Buffalo Creek.

SCUBA under Nullarbor

Dr Julia James and her research associates of the School of Chemistry at the University of Sydney are carrying out paleo-environmental studies in the caves that lie beneath the Nullarbor Plain, a 200 000 square kilometre limestone area bordering the Great Australian Bight. The caves contain numerous deposits that encapsulate an immense diversity of information concerning the plain's past, including landscape change, climate and vegetation regimes and the associated sea levels in the Great Australian Bight. The cave deposits have remained undisturbed through time and are laid down in chronological sequences. Their deposition may have taken hundreds of thousands of years. One group of deposits providing paleo-environmental data consist of unique submerged calcite speleothems formed by a mixing precipitation mechanism 20 m below the watertable.

AINSE postgraduate scholar Annalisa Contos is working on bio-mineralisation in the Nullarbor Caves. In the brackish cave waters there is a bacterial community that causes calcite precipitation. One of the aims of Annalisa's research is to to study the relationship between the calcite precipitating bacteria and the submerged calcite speleothems and so gain a better understanding of the paleo-microbiological-environment beneath the Nullarbor.


Diver coring submerged calcites.
Photo: Peter Rogers

Engineering, Materials and Nuclear Technology

Research Areas

The Materials Assessment group offers an integrated service that concentrates on structural integrity and remaining life assessment. This is complemented by a blend of excellent facilities and broad experience in collaborative research and development and in the assessment of plant integrity, safety and the behaviour of plant with changed operating conditions. Expertise that is related to Synroc fabrication, such as sol and powder processing, and advanced sintering methods such as hot isostatic pressing, is often utilised in collaborative projects with universities and industry.

X-ray diffraction, scanning electron microscopy, and transmission electron microscopy facilities are well suited for phase identification, determination of unit cell parameters, studies of phase transformations, imaging of microstructures, and quantitative microanalysis of a variety of solid materials. A field emission transmission electron microscope and imaging filter provides a combination of diffraction techniques, high resolution imaging with a resolution approaching one Angstrom, digital image capture, nanometre scale microanalysis and electron energy loss mapping and spectroscopy. Sample preparation facilities are also available for most applications.

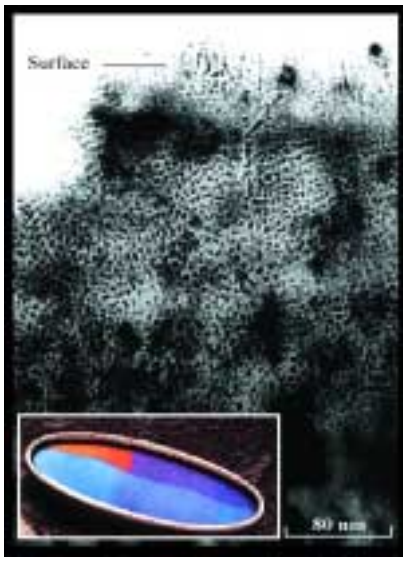
Research into the sol-gel route for bonding silica and alumina at temperatures below 600°C is being undertaken together with work on bio-compatible sol-gel matrices for the controlled release of drugs and radiopharmaceuticals. Plasma processing techniques are being developed that modify material surfaces to enhance the value of industrial products.

Selected Research Activities

Nanometre sized gas bubbles in metals

Helium can be implanted into metals using ion beams. Helium is insoluble and forms gas bubbles in the metal which, at high helium doses, coarsen to form random cavities a few nanometres across, a few millionths of a millimetre. Plasma-Immersion Ion Implantation (PI^3) is an alternative means of forming and oxidising nanoporous surfaces. PI^3 is of particular interest for two reasons: it is suited to industrial applications that need to implant large surface areas with complicated shapes; and the lower energies involved in PI^3 produce cavities closer to the surface.

The potential of titanium dioxide for use in a diverse range of applications including sophisticated catalysts, biocompatible implants and selective optical absorbers, has led Dr Andreas Markwitz and his team at the Institute of Geological and Nuclear Science to concentrate on implantation of helium into titanium and two of its alloys. Helium implantation considerably enhances the penetration of oxygen into these metals, even without subsequent oxygen implantation. The figure is a transmission



Nanometre size bubbles in metals

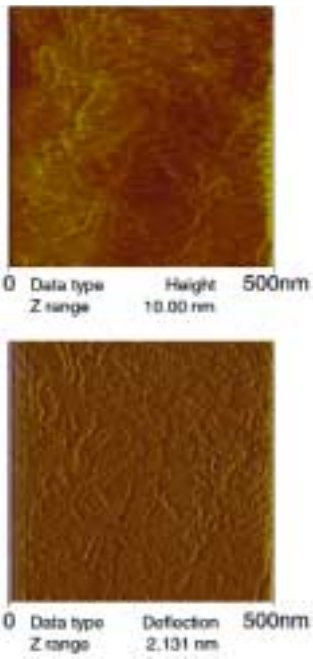
electron micrograph taken from a section prepared transverse to the surface of titanium metal following PI^3 implantation of helium. A high degree of cavitation is evident in the surface.

The inset in the figure (QUOIL Jewellery Wellington New Zealand) shows an interesting application in the creation of art objects. The different colours are caused by differential optical interference at the surface caused by differences in the thickness of the oxide layers.

DNA sequencing

Current methods of sequencing DNA are very slow and laborious. Dr Joe Shapter and his team at Flinders University are investigating the possibility of sequencing DNA using scanning tunneling microscopy (STM). The key element is to resolve each base in the DNA chain at a level that allows the identification of the base.

The team has been testing the viability of depositing DNA onto metal substrates and subsequently imaging them with STM. Atomic Force Microscopy (AFM) experiments allow testing of adsorbate stability and the level of adsorbate concentration, both of which are critical elements in successful STM imaging. AFM images show isolated or small clusters of DNA molecules on the gold substrate.



500nm AFM image showing strand structures representative of DNA

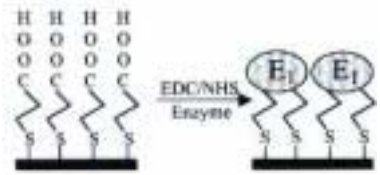
Upon close examination, the 'isolated' DNA molecules or clusters were very stable and not 'dragged' by the AFM tip. It is hoped that with a lower solution concentration, most if not all of the adsorbed DNA will not be in clusters but isolated in a stable form.

Biosensors from monolayer on gold

Biosensors are increasingly becoming practical and useful tools in medicine, food quality control, environmental monitoring and research. Coupling of biorecognition molecules such as enzymes, antibodies, or whole cells with signal transducers, is the basis of a biosensor. Self-assembled monolayers (SAMs) can potentially provide a reproducible and robust method of fabricating immobilised enzyme layers where some control over the orientation and distribution of the enzyme is afforded.

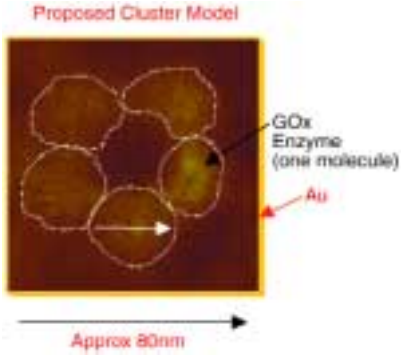
The well-ordered monolayers formed by alkanthiols on metal surfaces can be used to immobilise single layers of enzymes close to an electrode surface with a high degree of control over the molecular architecture of the recognition interface.

This study by Dr Justin Gooding, begun at Flinders University and continuing at the University of New South Wales, is concerned with the immobilisation of glucose oxidase (GOx), an enzyme much used in electrochemical biosensors for determination of glucose in medical and industrial situations.



Schematic representation of the immobilisation of GOx to a SAM on a gold surface

The enzyme electrodes were fabricated using the self-assembly of 3-mercaptopropionic acid (MPA) onto gold.



AFM of GOx immobilised on the SAMs shows clusters of 5 or 6 GOx molecules evenly distributed over the surface to make a uniform enzyme monolayer

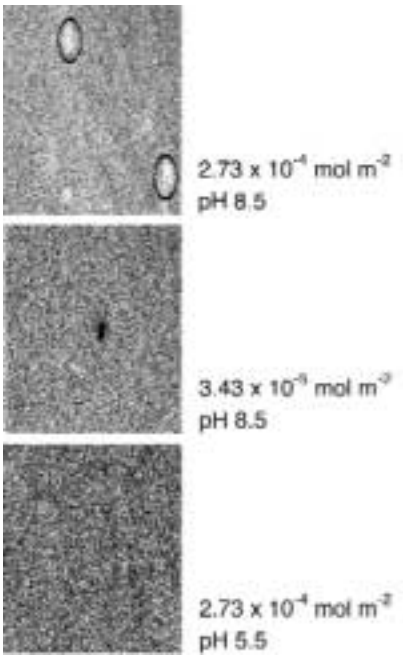
Testing of the biosensor imaged in the AFM experiments for sensitivity to glucose concentration is very promising, as is the fact that the sensors can be made reproducibly.

Processing metal sulfide ores

An understanding of the specific surface reaction mechanisms and kinetics of copper activation of pyrite is enabling scientists to develop a better method of separating sulfide minerals from gangue.

Dr Andrea Gerson and Mr Chris Wiesener from the Ian Wark Research Institute, at the University of South Australia have been working on a SIMS investigation of the mechanism of copper adsorption on the metal sulfide mineral pyrite (FeS_2).

The surface of a polished flat of pyrite was analysed using dynamic SIMS prior to and after copper(II) adsorption under different conditions. SIMS provides an image of the copper distribution as a function of depth from the surface and across the surface of the pyrite.



The lighter areas in the images given above indicate a higher Cu concentration

The spatial copper distribution at pH 5.5 and 8.5 with low copper concentrations shows a uniform coverage. However, this is not the case at pH 8.5 and with high copper concentration, which shows both the adsorbed copper over the surface of the pyrite and localised colloidal patches of copper in the form of copper(II) hydroxide.

Neutron Scattering

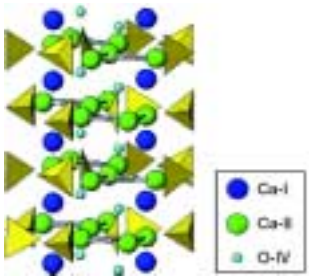
Research Areas

AINSE-supported facilities at ANSTO include

- high and medium resolution powder diffractometers
- high and medium resolution single crystal diffractometers
- small angle neutron scattering
- long wavelength polarisation analysis spectrometer.

AINSE continued to manage Australia's partnership with the world's most intense pulsed neutron source, ISIS at the Appleton Rutherford Laboratories in the United Kingdom. This facility gives Australian researchers access to a wide range of techniques which are unavailable in Australia. These include neutron reflectometry, neutron vibration spectroscopy, and muon spin resonance techniques, to name only a few. Australian researchers were awarded fifty-eight days of beam time for twenty-one projects during 1999.

AINSE is grateful for the assistance of the Department of Industry, Science and Resources, which provided most of the money needed for the 1999 subscription to ISIS.



The structure of calcium hydroxyapatite. The O-IV atom is positioned at z = 0.202(2)Å above and below the Ca-II triangle. The phosphate groups are shown as tetrahedra

Selected Research Activities

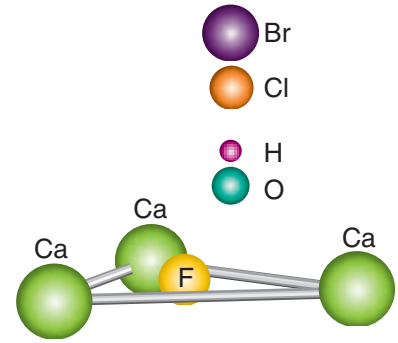
Pollution, teeth and apatites

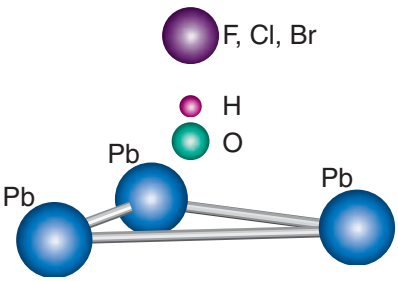
Research into the mineral hydroxyapatite (HAP), which is the main component of bones and teeth, could lead to the discovery of a means of cleaning up lead-contaminated soils and to a better understanding of the movement of this toxic metal in the body.

A team of scientists led by the University of Sydney's Dr Ron Fenton has used neutron diffraction to study the structure of synthetic HAP with some of the calcium ions substituted with lead and with various anions, including fluoride, chloride and bromide.

The lead compounds generally had bigger crystal units than the analogous ones substituted with calcium. The study also revealed subtle changes in the position of the anions that relate to the amount of lead in the structure.

The team also aims to design materials that mimic the way teeth and bones encapsulate lead. These materials could then be used to treat lead-contaminated soils.



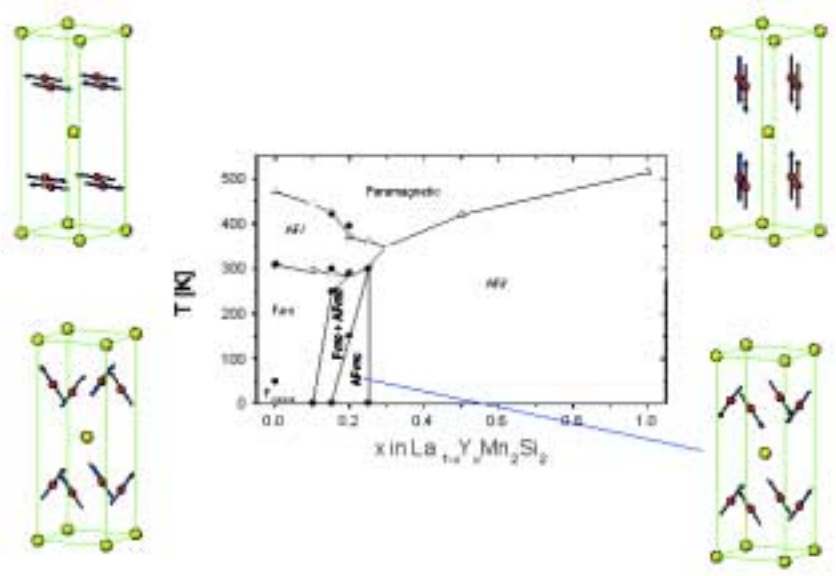


Relationship between the anion positions and the calcium and lead triangle

Rare-earth transition metal intermetallic compounds

Interest in these rare-earth compounds has been stimulated by the success of $Nd_2Fe_{14}B$ - the world's strongest magnet, which has found extensive application since its discovery fifteen years ago.

Compounds based on the rare-earth transition-metal system with the tetragonal $ThCr_2Si_2$-type structure are an important class of RT_2X_2 compounds which exhibit a wide range of phenomena including heavy superconducting and fermionic behaviour.



The magnetic phase diagram of $La_{1-x}Y_xMn_2Si_2$ as derived from a combination of neutron diffraction data and Mössbauer effect results

Professor Stewart Campbell's group at the Australia Defence Force Academy, the University of NSW, aims is to explore the complex magnetic behaviour of $La_{1-x}Y_xMn_2Si_2$ compounds as the predominant ferromagnetism of $LaMn_2Si_2$ gives way to the antiferromagnetism of YMn_2Si_2 with increasing Y concentration. The competition between these magnetic interactions has led to the set of magnetic structures shown in the diagram.

Interest in this fascinating series now centres on gaining an improved understanding of the intricate balance between interplanar and intraplanar interactions, which accounts for the wide range of magnetic order observed for these compounds.

Structural studies of metal oxides

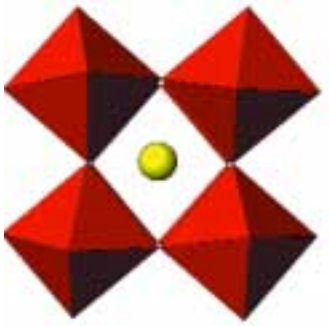
A team led by Dr Brendan Kennedy at the University of Sydney is studying the crystal structure of a class of mineral oxides called perovskites which includes the most abundant mineral on Earth, perovskite ($CaTiO_3$). Perovskite is ideal for studying the phase transitions that occur in $MgSiO_3$ under the high temperature and pressure conditions that occur in the Earth's core. It is also a major component in the synroc ceramic wasteform, designed to immobilise high level radioactive waste.

The work centres on a perovskite in which strontium is substituted for calcium in $CaTiO_3$ (calcium titanium oxide). This compound, $SrTiO_3$, is the unit of synroc that immobilises strontium and has cubic crystals.

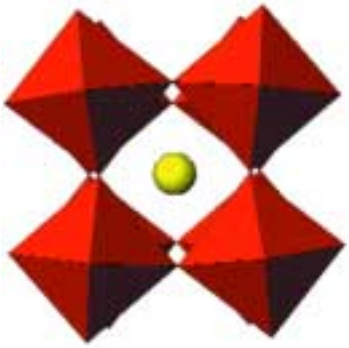
Kennedy's group wanted to find out how the crystal structure changed when zirconium was partially substituted for titanium at various points in the crystal lattice.

They characterised the structure using powder neutron diffraction methods and found a continuous transition from cubic through tetragonal to orthorhombic symmetry as the amount of zirconium was increased. Increasing temperature triggered a similar sequence of phase transitions.

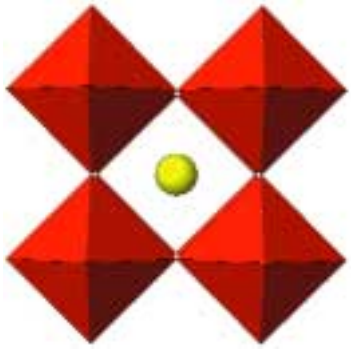
This work will also help in the development of synroc.



orthorhombic



tetragonal



cubic

The yellow ball represents strontium and the red octahedra are the TiO_6

Plasma Fusion

Research Areas

The AINSE grants allocated by the Plasma Fusion Specialist Committee for 1998 provided travel and accommodation assistance to the collaborative activities of the Australian Fusion Research Group (AFRG) on projects related to the National Plasma Fusion Research Facility at the Australian National University. AFRG collaborators are the Australian National University, Central Queensland University, Flinders University, the University of Canberra, the University of New England, the University of Sydney and the University of Western Sydney. All these projects involve the development of sophisticated measurement systems for the highly asymmetric Heliac plasma to help gain better understanding of plasma confinement and transport in this novel magnetic configuration.

H-1NF National Plasma Fusion Research Facility

The main facility activities in 1999 were the second round of upgrades to the facility, and test runs associated with this. This stage marked the completion of the main project and included installation and commissioning of a new magnetic field power supply; vacuum upgrades, including twenty six additional or upgraded access ports and a cryopump; and commissioning of the electron cyclotron heating system as part of the collaboration with Kyoto University and the Japanese National Institute for Fusion Science (NIFS).

Comprehensive tests showed very stable programmable constant current into H-1NF up to 8,500A (14,000A into a dummy load), with variations of a small fraction of one ampere. This ensures highly accurate magnetic geometry, avoids interference with measurement systems, and avoids induction of current into this inherently current-free plasma configuration.

A secondary supply powers the control windings and allows the plasma shape to be varied under computer control over a much wider range than other plasma configurations, with the option of varying the current during a plasma pulse. The connections between these supplies and the five windings of the Heliac are made in a very flexible and convenient manner through a 'patch panel' capable of carrying 14,000A for two seconds, and this panel reports configuration information to the power supply. This enables full exploitation of the wide range of magnetic characteristics accessible to the H-1NF.

Credit for the success of this ambitious and unique project, which combines a power plant similar to that powering a 'very fast train' with the precision and flexibility of a laboratory instrument, is due to a number of Australian and International companies in a wide range of industry areas. The companies include Walsh & Associates, Consulting Engineers in Sydney; ABB, in Melbourne; Technocon AG, Switzerland; TMC Ltd (manufacturers of transformers), Melbourne; CEGELEC (AC-DC converter manufacturers), Sydney; A-Force Switchboards (14kA patch panel), Sydney and HOLEC Engineering (switchgear), Sydney.

The vacuum upgrade, which provided extra ports for users to connect experiments to the H-NF, was very professionally carried out by Cowan Engineering of Gosford.

The facility now has a degree of redundancy in power, heating and vacuum systems. As a result the remaining upgrades to heating and launching systems and bringing the machine up to full magnetic field (1 Tesla) will produce much smaller interruptions to operation over the next two years.

Many diagnostic systems were installed or upgraded when H-1NF was shut down. These new systems include

- a fifty-five channel fibre-optic rotating wheel for vector tomography developed at the ANU
- a 2mm microwave scattering system to be used for turbulence studies (ANU)
- a modulated solid-state spectrometer (MOSS) camera for ultra-high resolution spectroscopic imaging (ANU and the University of Canberra)
- a soft X-ray emission camera (University of Canberra).

Additional diagnostic and analysis systems in development include

- a laser-induced fluorescence system for the measurement of electric fields, which is being developed by Associate Professor Brian James and his colleagues at the University of Sydney under an ARC Large Grant
- a fibre optic bolometer, which is being developed by Professor Gerry Woolsey and his colleagues at the University of New England under an ARC Small Grant
- a wavelet signal processing system for turbulence data, which is being developed by Dr Xuehua Shi and her colleagues at Central Queensland University
- a new three-dimensional plasma stability simulation program, which is being developed by Professor Robin Storer of Flinders University.

Work on H-1NF has also resulted in the development of spin-off technologies of commercial interest. These include

- the MOSS spectrometer, which is being commercialised in collaboration with Australian Scientific Instruments Pty Ltd
- the plasma antenna, a novel antenna system for use in communications in radar, which is being developed with support from DSTO and ARC SPIRT funding to the ANU, CEA Technologies, and Neolite Neon.

Although much of the effort in 1999 was developmental, the scientific results of work on H-1NF have continued to attract attention from the international community. Highlights included two invited talks at the International Stellarator Workshop in Madison, Wisconsin in October 1999; an invited talk on the plasma antenna at the American Physical Society Division of Plasma Physics Conference in November 1999; and a number of journal papers.

Radiation Science

Research Areas

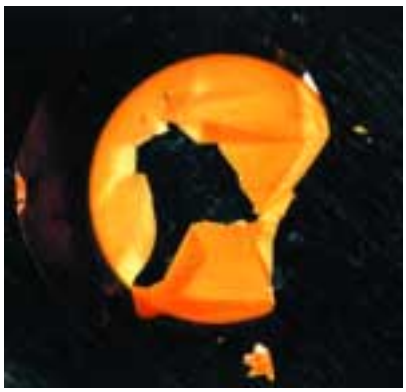
Projects supported cover a wide range of areas in chemistry, molecular biology, pharmacology, materials science, polymer science, radiotherapy and environmental science.

Selected Research Activities

Advanced polymers

The University of Queensland's Polymer Group has focussed its studies on the radiation chemistries of two classes of polymers: fluoropolymers and polysiloxanes. The studies, led by Associate Professor David Hill, have identified free radicals and new polymer structures that are formed following irradiation. Solid state Electron Spin Resonance and Nuclear Magnetic Resonance techniques have been used to measure the yields of these radiolytic products.

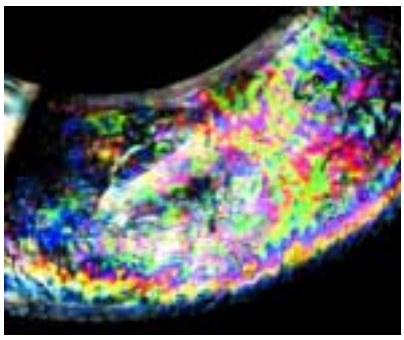
Fluorinated alkanes and fluorinated aromatic polyimides have been studied. Fluorinated polyimides have been developed as surface coatings and construction materials, again, principally for space applications. Because of their extremely high radiation and chemical resistance they also have potential uses as insulators in fusion factors.



The photograph to the left, obtained from NASA-Langley, shows a polyimide film that has been exposed in low earth orbit to a high radiation dose. The large opaque part of the image is the exposed portion of the polymer, which has become brittle, the transparent brown part of the polymer, on the left hand side, which was covered up in space, is unexposed polymer. (The copolymers of tetrafluoroethylene and hexafluoropropylene, FEP, are also utilized in a wide range of applications, including the production of thermal blankets for space vehicles in which they form the matrix polymer.)

Dr Senake Perera, previously at Griffith University and now at the University of New South Wales, has investigated the radiation chemistry and radiation grafting of vinyl monomers onto a range of rubbers. The studies aim to improve the properties of the rubbers for use in a range of new applications. Some of these studies involve collaborative work with the Rubber Institutes in Malaysia and Sri Lanka.

Dr Clive Baldock from the Queensland University of Technology has been developing radiation dosimeters for use in radiation therapy using electron accelerators. The dosimeters are based upon protein-containing hydrogels that mimic the structure of human organs. The principle behind the action of the dosimeter involves radiation-induced polymerisation of an acrylamide monomer, which is incorporated into the gel.



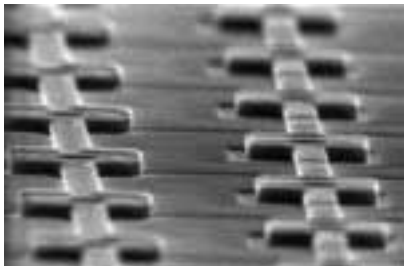
The photograph above of a thin sample of an extruded fluoropolymer was taken through a microscope. The colour in the photograph shows the non-uniform morphology of the sample across the extrusion. This has relevance in studies of the radiation grafting on these materials.

Cellular level microdosimetry

The radiation Physics Group at Wollongong University, headed by Associate Professor Anatoly Rozenfeld, is using semiconductor sensors as the basis for new methods and instrumentation for dosimetry in radiation oncology. Dosimetry is important because it enables nuclear medicine workers to predict the radiobiological quality of a therapeutic beam at different depths in a phantom. The microdosimeter is based on a silicon-on-insulator (SOI) 10-micron-size p-n junction array, with each unit in the array modeling a biological cell, and is able to measure linear energy transfer (LET) spectra of a charged particle field.

A prototype of the microdosimeter has been successfully tested in the United States, Japan and at ANSTO, in water and perspex phantoms in different radiation therapies including fast neutron therapy, boron neutron capture therapy, and heavy ions and proton therapy.

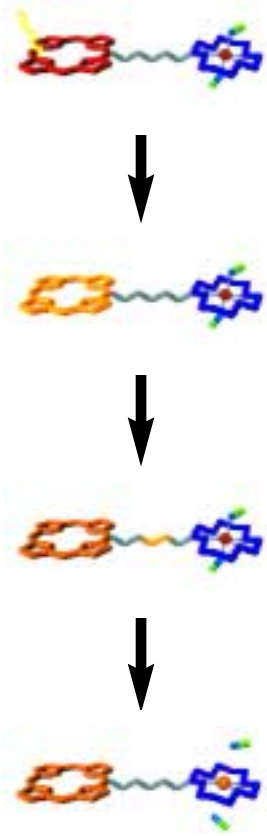
This microdosimetric instrumentation is at the stage of commercialistion.



SOI p-n junctions sensor for microdosimetry fabricated in collaboration with Fujitsu Research Laboratory. Each of the small structures is about 5 microns long

Complexes go for cancer

The development of 'prodrugs', those that are selectively activated by radiation to produce toxic species, may provide a route to the development of tumour-specific drugs. Photo-induced electron transfer occurs from the donor (at left in the diagram below), an organic molecule, to the acceptor, an inorganic complex (purple), resulting in the release of a molecule, which could be a cytotoxic drug (green), from the metal complex.



Associate Professor Peter Tregloan and his research team at the University of Melbourne have been investigating the mechanism of reduction of the cobalt complexes using pulse radiolysis and spectrophotometry, with a view to designing prodrugs that will optimise the delivery of cytotoxic molecules to cancer cells.

Radiopharmaceuticals and Neutron Irradiation

Research Areas

Radiopharmaceutical research focuses on the development of radionuclides and radiopharmaceuticals for diagnostic and therapeutic applications in the areas of neurology, cardiology and oncology. The researchers use *in vivo* and *in vitro* evaluations of labelled compounds and carry out clinical trials with promising radiopharmaceuticals.

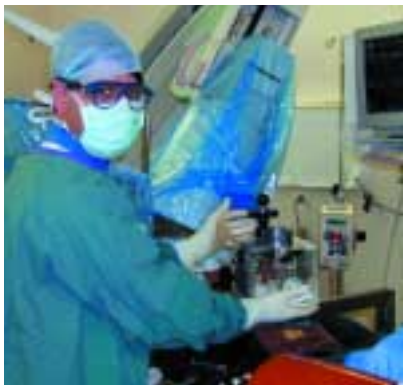
Radiopharmaceutical sciences consist of

- radiopharmaceutical chemistry
- short-lived positron emission tomography (PET) and single photon emission computed tomography (SPECT) radiopharmaceuticals
- molecular radiopharmaceuticals
- bio-radiopharmaceuticals
- radionuclide development
- radiopharmaceutical dosimetry
- radiopharmacology
- molecular design and structure
- process control for synthesis and quality control
- hot atom chemistry
- GMP "boutique" synthesis

Selected Research Activities

Radiation keeps arteries clear

Treatment for narrowed arteries includes bypass surgery or the less invasive balloon dilatation (angioplasty) with stent placement. Unfortunately, re-narrowing (restenosis) of a coronary artery in the six-month period following balloon dilation and stenting occurs in 20 to 30% of patients. This is called instent restenosis.



Dr Mark Pitney with rhenium-188 balloon in its acrylic box shield during a procedure

Conventional therapy with further balloon dilation or stenting for instent restenosis is somewhat unrewarding as further narrowing occurs in up to 80% of patients.

Radiation treatment is intended to discourage the overgrowth of normal tissue during the healing process that occurs following angioplasty. After conventional treatment of the re-stenotic segment, a balloon catheter is carefully placed in the treated coronary artery. A liquid isotope (rhenium-188) is injected into the balloon. The inflated balloon catheter allows delivery of beta radiation to the lining of the coronary artery. The size of the artery and the activity of the isotope determine the treatment time, usually three to six minutes. When the treatment time is over the radiation source (rhenium-188) is removed from the catheter and the catheter is then removed.

The advantages of using rhenium (Re-188, the liquid radioisotope) with a dilation balloon catheter delivery method are ease of accurate positioning and delivery of a uniform dose to the vessel walls.

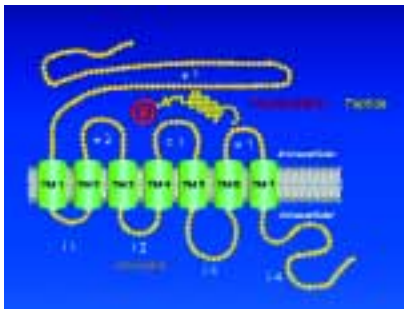
Currently a pilot study is being conducted by Dr Mark Pitney at the Department of Cardiovascular Medicine, Prince of Wales Hospital. To date, approximately twenty five patients have been treated, with only one patient having a recurrence of symptoms due to further renarrowing. If these preliminary results are confirmed in future work, this therapy may well have an enormous impact on all patients receiving angioplasty and stenting.

Human peptides find cancers

Regulatory peptides are small proteins, sometimes just a few amino acid residues in size, which are involved in the function of virtually all body systems. They generally pass on their message by connecting to a specific receptor on the target cell. The peptide and receptor can be thought of as a key and lock: only when

the correct key is used will the receptor work.

Peptides are small and potent, and diffuse rapidly through the body. These qualities ideally suit them to being used as tracers in nuclear medicine. Much research is focussed on altering the peptides so that they bind better to receptors while decreasing their ability to activate the receptor, so that greater amounts of peptides can be used. Cancer cells often have too many, or the wrong type, of receptors compared to normal tissues.

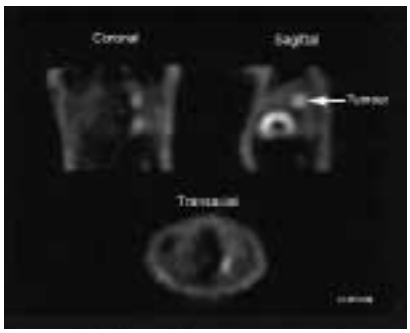


Peptides found in the gastrointestinal tract have been synthesised and radiolabelled. Dr David Macfarlane and his team at the University of Queensland, have been working on improving the performance of radiolabelled peptides to detect the receptors on cancers that form in the gastrointestinal tract.

Fluorine for diagnosing lung cancer

The best chance of curing patients with lung cancer is surgical resection of the tumour. Fluorine-18 FDG PET imaging is established as a useful tool for accurate pre-operative assessment of these patients. However, there is only one dedicated PET camera in New South Wales and not all patients requiring assessment can obtain such a study because of this limited access.

Dr Monica Rossleigh at the the Prince of Wales Hospital's Department of Nuclear Medicine has used a Picker Axis gamma camera which is able to image fluorine-18 FDG using co-incidence detection. The technique is being assessed by applying it to lung cancer patients.



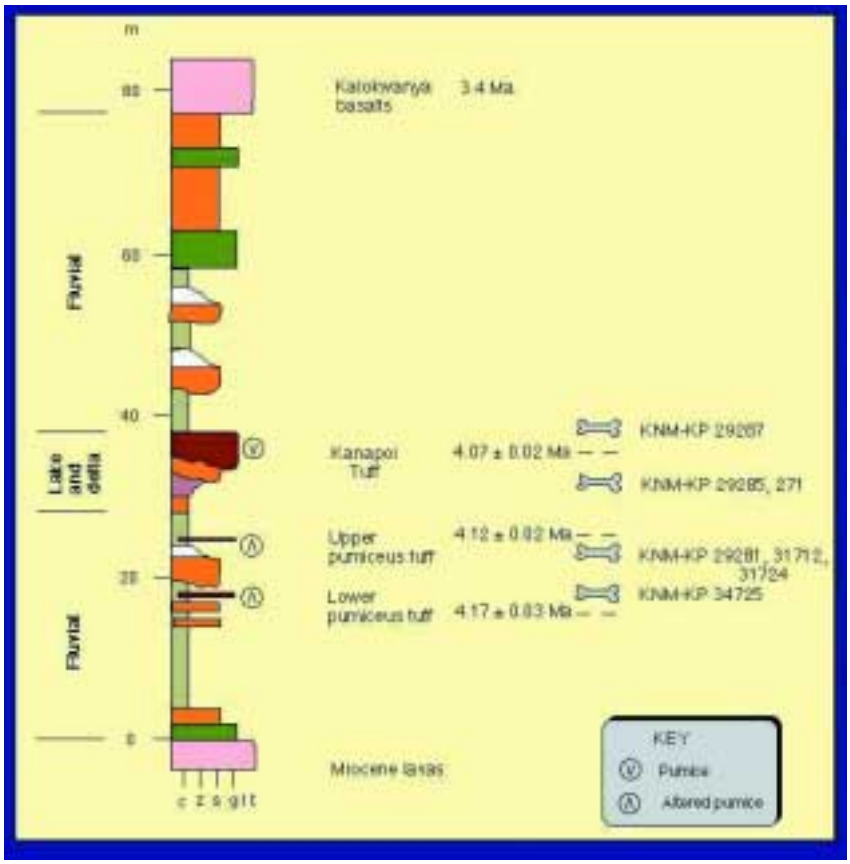
Fluorine 18-FDG image of the chest using coincidence detection. The patient's lung cancer avidly accumulates the tracer (tumour arrowed). There is no evidence of distant spread, confirming that the patient is a suitable candidate for surgical resection. Physiological heart uptake is seen below the tumour.

Approximately forty patients were enrolled in this study. The following parameters were assessed - identification of the primary tumour, status of draining lymph nodes and presence of distant spread. Pathological confirmation of scan findings was obtained where possible. In other patients, the scan findings were correlated with the results of other imaging investigations and with follow up assessments. The influence of the FDG PET studies on staging of the disease as well as the effect on patient management was also assessed.

Hominids more than four million years old

Sediments exposed at Kanapoi in the Turkana Basin, northern Kenya, have yielded a suite of hominid fossils that has led to the definition of the new species, *Australopithecus anamensis*. The nature of one of the fossils, a leg bone (tibia), indicates that this species walked upright.

Three horizons within the sequence at Kanapoi have been isotopically dated by Professor Ian McDougall at the Australian National University using the ^{40}Ar-^{39}Ar method on single crystals of feldspar from contemporaneous volcanic pumice clasts. These results are consistent with the stratigraphic order and demonstrate that the hominid fossils are between 4.17 and 4.07 million years old, currently the oldest known examples of well-authenticated hominid fossils exhibiting bipedality.



AINSE Awards

Honorary Fellow

AINSE Honorary Fellowships are awarded by Council to individuals for distinguished and dedicated services to the Institute. By maintaining links with AINSE, the scientific community will continue to benefit from the wisdom and experience of some outstanding scientists.

Professor Trevor Ophel receiving his award from AINSE President Professor Ron McDonald

Trevor Ophel's formal connection with AINSE began in 1961 when he received a travel grant to attend the Gordon Conference on photonuclear reactions, a research area in which Australia was very active. Nothing comes for free, and in the last decade he has contributed to AINSE through service on the Executive (1994 to 1996), and as President (1997 and 1998). In the previous two decades he had attended numerous Council meetings as proxy for the Australian National University representative.

At the ANU he has fostered the role of AINSE as an avenue for supporting a broad range of research at ANSTO and has argued successfully (often unofficially) the merit of supporting AINSE through the ANU Institutional subscription.

Since their inception, he has been a stalwart supporter of what were the biennial AINSE Conferences on Nuclear and Particle Physics, as a regular contributor, as a member of the organising and program committees on various occasions and as chairman of the 1986 Conferences. In recent years he has taken an increasing role in the equivalent conferences focussed on the Applications of Nuclear Techniques.

He is recognised worldwide as an expert in hybrid detector systems, developed as part of leading research work on the study of the measurement of masses of exotic nuclei. Such detectors, and his understanding of the physical processes in the transport and measurement of heavy ions, were important parts of the knowledge brought to the collaborations between the Australian National University and ANSTO (then AAEC) which led to the first Australian forays into Accelerator Mass Spectrometry. While initially developed on the Australian National University facility, which maintains an independent program, it is now a fully-fledged operation at ANSTO in the guise of ANTARES, a major and integral part of the research and facilities supported by AINSE.

By virtue of his experience and expertise in accelerators and in a broad range of detection techniques, Professor Ophel has been Convenor of the Specialist Group on Accelerator Applications since about 1988, part of his continuing involvement with AINSE.

Gold Medals

1998 Gold Medal

The 1998 Gold Medal was awarded to Professor Ian McDougall of the Australian National University, at the meeting of AINSE Council, on Thursday 2 December 1999.

Professor Ian McDougall receiving his award from AINSE President Ron MacDonald

Citation

Professor Ian McDougall is one of Australia's most distinguished earth scientists. His pioneering work in the fields of potassium-argon and $^{40}Ar/^{39}Ar$ dating have made fundamental contributions spanning a broad spectrum of applications over four decades. It would be difficult to over-estimate the importance of these methods on the modern earth sciences as they provide much of the foundation upon which the numerical geological time scale is based. Professor McDougall's work in $^{40}Ar/^{39}Ar$ dating, in particular, represents an important application of nuclear science in Australia and has been supported by AINSE over many years.

In addition to his role in developing these dating techniques, his contributions have been particularly significant in establishing the geomagnetic polarity time scale as one of the foundations of the theory of plate tectonics; characterising the evolution of oceanic island chains and demonstrating their relationship to underlying plate motions; development of a highly-precise time framework for hominid evolution in East Africa; development of $^{40}Ar/^{39}Ar$ step heating methods as a powerful tool for understanding time-temperature relationships in the evolution of geological terranes; and application of noble gas geochemistry to study mantle-derived materials, including the identification of a primordial solar noble gas component within the earth.

1998 Student Gold Medal

The 1998 Student Gold Medal was awarded to Ismunandar from the University of Sydney, for excellence in research carried out by a postgraduate student. Ismunandar was awarded the medal on 27 May 1999 and made a presentation to the Council on the structures and properties of bismuth(III)-containing metal oxides.

Citation

Ismunandar made extensive use of the neutron scattering facilities at HIFAR to study the structure of a number of metal oxides. His work at ANSTO was supported by a number of AINSE grants. His work during PhD studies was always first class and productive. He has recently produced an excellent thesis that reports a great deal of new, high quality work on mixed-metal oxides and this underlies his considerable strengths in crystallography and materials chemistry.

One of the most significant achievements of his work has been his combining of neutron scattering with anomalous dispersion diffraction and his studies will set the standard for subsequent workers in the field. This aspect of his studies has resulted in the first insight into the thermal effects on cation disorder in lead-bismuth oxides. This has important implications for the fabrication of ferroelectric devices.

Through his hard work and understanding Ismunandar demonstrated himself to be an outstanding research student.

Ismunandar, left, receiving his award from AINSE President Professor Ron McDonald

The AINSE Winter School

Nuclear Techniques Applied to Natural Processes

The third AINSE Winter School on nuclear techniques applied to natural processes was held at the Lucas Heights Science and Technology Centre from 3 to 7 July 1999.

Introduction

The Winter School was held over a five-day period, from Saturday to Wednesday, instead of four days; the extra day providing time for an extra experiment, further data analysis and discussion of experiments. Thirty six students participated in the Winter School; sixteen physics majors, eleven chemistry majors, three engineering majors, two medical physics majors, two biology majors, one geology major and one student majoring in medicine. The students were divided into four groups of seven and one group of eight, with each group containing approximately the same number majoring in physics, chemistry and other areas.

A background lecture and experimental session was provided for each of the following topics

- Neutron Scattering
- Ion Beam Experiments
- Natural Radioactivity
- Radioactivity and the Living World
- Radiation Chemistry.

Radioactivity and the Living World was included for the first time this year.

Keynote lectures

David Malin from the Anglo-Australian Observatory delivered a fascinating after-dinner lecture on Saturday 3rd July entitled A Universe of Colour. This is the third time David has given a talk at the Winter School and he once again showed an excellent range of photographs of astronomical and terrestrial objects, including satellite photographs of the Earth at night.

Julia James from Sydney University delivered an after dinner lecture on Monday 5th July entitled Chemistry, Caves and Tourism. Julia provided a very appropriate and extremely interesting summary of her research and consulting work on cave chemistry, which has utilised dating techniques at ANSTO. Slides were shown from field trips to caves in New South Wales, Victoria, Maralinga and the Ok Tedi mine in New Guinea.

Emily Tan, from Monash University, dissecting mussels in the radioactivity and the living world experiment.

Rosie Dawkins at the single crystal diffractometer instrument

General comments

Having the Winter School over a five-day period with an extra experimental session and workshop provided students with more time to reflect on and analyse data and report their results and conclusions.

Two AINSE postgraduate scholars, Alison Funston and Karen Gunton, helped supervise experiments. This was so successful that AINSE has decided to utilise postgraduate scholars in future Winter Schools.

Julia Lock, from the University of Adelaide, pipetting reagent in the radiation chemistry experiment.

Thanks

AINSE is indebted to Professor Helen Garnett, ANSTO's Executive Director, for supporting the Winter School, to the many ANSTO staff members who contributed their time and talent, to Ken Doolan, Julia James, Ron Cooper, David Sangster and Gerald Laurence from the universities involved, and to the two after-dinner speakers, David Malin and Julia James.

More details of the Winter School can be found on our home page.

Nathan Langford, from the University of Queensland, taking measurements in the neutron scattering experiment.

From the Winter School Committee, Mr David Sangster, Dr Julia James and Dr Ken Doolan

1999 Conferences and Workshops

There were 172 participants at the conferences and 187 at the workshop/symposiums. AINSE conferences play a major part in the information exchange process for scientific and technological information, providing a forum for debate and an opportunity for young researchers to present their work. Participants from member organisations are assisted with travel and accommodation expenses and receive a discount on registration fees.

5th Symposium on Advances in Radiopharmaceuticals Symposium Oncology: Therapy, Diagnosis and Palliation

The 5th Symposium on Advances in Radiopharmaceuticals Symposium - Oncology: Therapy, Diagnosis and Palliation was held at the Veterinary Science Conference Centre, Sydney University, on 19 February 1999. There were eighty-two participants including twenty eight from ANSTO, five from overseas and nine students.

The invited speakers, including Professor Peter Volk, Northern California PET Imaging Centre, and Professor James Bishop, Sydney Cancer Centre, were supported by contributions from local researchers.

Dr Stuart Carr, left, Director of ANSTO's Radiopharmaceuticals Division, with Dr Geoff Bower, President, Australian and New Zealand Physicians in Nuclear Medicine

2nd Quaternary Dating Workshop

The 2nd Quaternary Dating Workshop was held on Thursday 8 and Friday 9 April 1999 at AINSE, Lucas Heights. There were sixty four participants including sixteen from ANSTO and twenty nine students. Twelve papers and four posters were presented.

11th AINSE Conference on Nuclear Techniques of Analysis

The 11th AINSE Conference on Nuclear Techniques of Analysis was held on 24 – 26 November 1999 at AINSE, Lucas Heights. There were 108 participants including twenty seven from ANSTO, three from overseas and fourty one students. Forty-two papers and thirty-seven posters were presented. The medal for best student oral presentation was awarded to Tessica Weijers from the Australian National University, and best poster presentation was awarded to Dusan Losic from Flinders University. This conference

Dr David Cohen of ANSTO awarding the medal for best student oral presentation to Tessica Weijers from the Australian National University (above) and best poster presentation to Dusan Losic from Flinders University (below)

was sponsored by John Morris Scientific Pty Ltd, Coherent Scientific Pty Ltd, the University of Surrey, Scientific Technology Pty Ltd, Javac Pty Ltd, Balzers Aust Pty Ltd, Andrew Young & Co, AVT Services Pty Ltd, Alphatech International Pty Ltd, National Electrostatics Corp USA, Stanton Scientific, and Thermo Optec (Aust) Pty Ltd.

1st AINSE Symposium on Neutron Scattering - Small Angle Scattering and Reflectometry

The 1st AINSE Symposium on Neutron Scattering - Small Angle Scattering and Reflectometry was held on 30 September – 1 October 1999 at AINSE, Lucas Heights. There were fourty-one participants including thirteen from ANSTO and eight students. Twelve papers and eleven posters were presented.

22nd AINSE Conference on Plasma Science and Technology

The 22nd AINSE Conference on Plasma Science and Technology was held on 7 – 9 February 1999 at the Australian National University. There were sixty four participants including one from ANSTO, two from overseas and seventeen students. Twenty three papers and posters were presented. The medal for best student oral presentation was awarded to Wayne Solomon from the Australian National University, and best poster presentation was awarded to Horst Punzmann from the Australian National University.

Left to right Professor David McKenzie from the University of Sydney, George Collins from ANSTO and Dr George Ward from the Australian National University at the 22nd AINSE Conference on Plasma Science and Technology

Professor Heinrich Hora from the University of NSW and Professor Nakai from Osaka University