The Australian Institute of Nuclear Science and Engineering (AINSE Ltd.)

AINSE Supported Facilities (ASF) Guide

2019-2020

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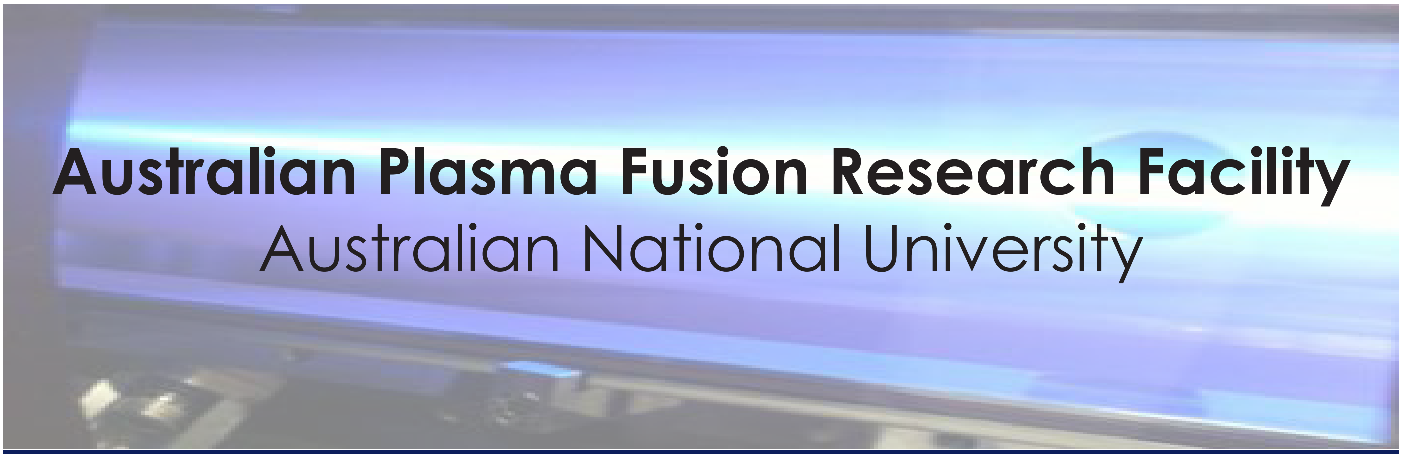
THE AUSTRALIAN INSTITUTE OF NUCLEAR SCIENCE AND ENGINEERING



Australian Plasma Fusion Research Facility

Australian National University

The Australian Plasma Fusion Research Facility (APFRF) is a uniquely versatile plasma research facility, located in the Research School of Physics and Engineering within the Australian National University (ANU) in Canberra. Research within the facility aims to build upon Australia's internationally recognised position of excellence in basic plasma physics and its applications. Plasma – an ionised gas – plays a critical role in advanced technologies such as fusion energy, mobile phones, solar-cells, nano-chip fabrication, aerospace applications, high-efficiency lighting, biotechnology, and cancer treatment.

Our aim is to enable Australian scientists, engineers and industry to tackle the "grand challenge" problems such as that presented by fusion energy research and plasma-processing. The facility environment provides excellent postgraduate and undergraduate training, and generates spin-offs with commercial potential.

Research Opportunities

Furthering knowledge of basic plasma physics and technologies for applications such as plasma processing of semiconductors and plasma-material interaction, especially fusion reactor relevant materials.

Significant contributions to the global fusion research effort and an increased Australian presence in the field of plasma fusion power.

Fundamental studies of confinement, turbulence and transport of particles and energy in confined plasmas.

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.

Improvements in skills of Australian industry in the areas of materials, instrumentation, modern power engineering, and communications and control.

Availability

The Facility is available to all Australian physicists and engineers and is affiliated with AINSE. 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 and plasma equipment for studying wave, turbulence or confinement physics, or materials interaction, possibly leading to further experimentation on international devices. One such device is the Magnetised Plasma Interaction Experiment (MAGPIE).

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MAGPIE

The construction of the linear plasma device, the MAGnetised Plasma Interaction Experiment (MAGPIE) delivers access to conditions comparable to those found in the boundary regions of reactor-scale devices. As well as being a test-bed for advanced diagnostics development and for basic plasma physics studies, MAGPIE serves those in the Australian materials science community wishing to explore the properties of advanced materials under high plasma power fluxes. The linear plasma device employs a unique combination a high-power laboratory radio-frequency plasma, a target chamber and a set of advanced diagnostics for plasma and material analysis to correlate the plasma parameters with surface processes.

Linear plasma devices such as the MAGnetised Plasma Interaction Experiment (MAGPIE) provide a cost-effective solution for studying plasma-material interactions relevant to fusion as they provide (1) sufficient access to the plasma-material interaction region to deploy a comprehensive set of diagnostics and (2) controlled access to a wide range of fusion-relevant plasma conditions.

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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 1-100 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 200 nm – 1000 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 oC), 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:
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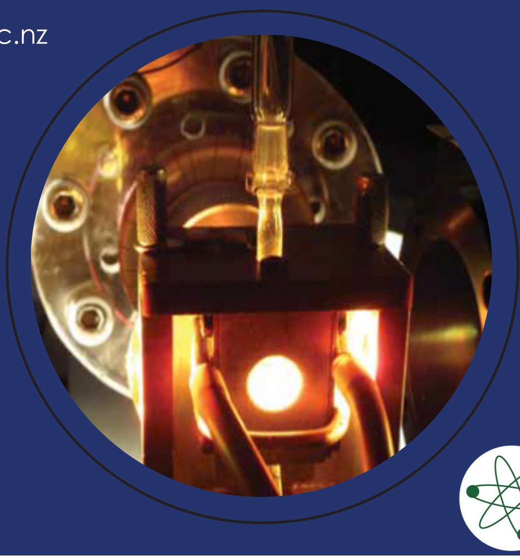

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Positron facilities

School of Physics, University of Western Australia

Our scientific facilities encourage a national cooperative research effort and provide access to 'beam and bulk' positron techniques with expertise, unique in Australia. The UWA beam delivers about 1000 positrons/sec at energies from near zero to about 5 keV into significant surface science facilities including channelplate position-sensitive detectors for positron and electron spectroscopies, Auger and LEED analysis in 10^{-11} Torr UHV system; and positron spectroscopies using NaI, BaF2 and HPGe detectors with automated computer operating systems. The bulk materials characterization systems have Positron Annihilation Lifetime Spectroscopies (PALS), Coincidence Doppler Broadening (CDB) and Age-Momentum Correlation (AMOC) facilities with 40 uCi Na22 sources, associated with high performance and multiparameter materials analysis, for example a timing resolution of 160 ps and Doppler energy resolutions of 1.2 keV.

The aims of the UWA research are consistent with those of AINSE for cooperation in the nuclear scientific and engineering fields. We seek novel fundamental and applied projects. The UWA Facility was initially supported by the ARC through LIEF and Centre of Excellence grants with participants including the ANU, Flinders, Griffith, Murdoch, Curtin, Adelaide, UWA, James Cook and Charles Darwin Universities, ANSTO, and the CSIRO. Our research trains scientific researchers at all levels and in a wide range of disciplines with applications in technology, manufacturing, mining, agriculture, medicine and environmental protection, all of vital importance to Australia's future. There are strong links with international researchers and laboratories notably throughout Europe and India, China and Japan which are mutually supportive. Data analysis programs are available for most materials.

The positron beam surface studies have included Reflected positron angles and energies and Angular distribution of reemitted positrons from W(100) with over layers of oxygen, LiF, and Ni.

Above: Setup for low energy positron beam interaction with surfaces.

The bulk materials studies use thermalized positrons and positronium which effectively probe electron density distributions and annihilate to produces gamma rays that are detected in space and time coincidences. The resulting information includes positronium lifetimes, the 'free space' of voids and defects in materials, at the nano-scale and at depths of the order of microns. Studies have ranged from polymer-modified mortar, wood and fibres, interface widths in binary polymer blends, ultrafine-grained aluminum severely deformed at room and cryogenic temperatures, Nb-doped TiO_2, SnO_2, and ZrO_2; brown type-I diamonds, radiation-damaged natural zircons; metakaolin-based geopolymers; Structural and antibacterial properties of gamma radiation-assisted in situ prepared Ag-Polycarbonate matrix; Synthesis and characterization of molecular imprinted polymers and reduced graphene oxide (rGO)/$NiCoFe_2O_4$.

The UWA Facility has flexibility and diversity to meet various needs and to enable methodology of positron annihilation techniques; construction for positron beam and positron annihilation measurements; application research in material science and technology support on gamma-ray detection for nuclear imaging.

Contact Scientists: Professors Jim Williams and Sergey Samarin.
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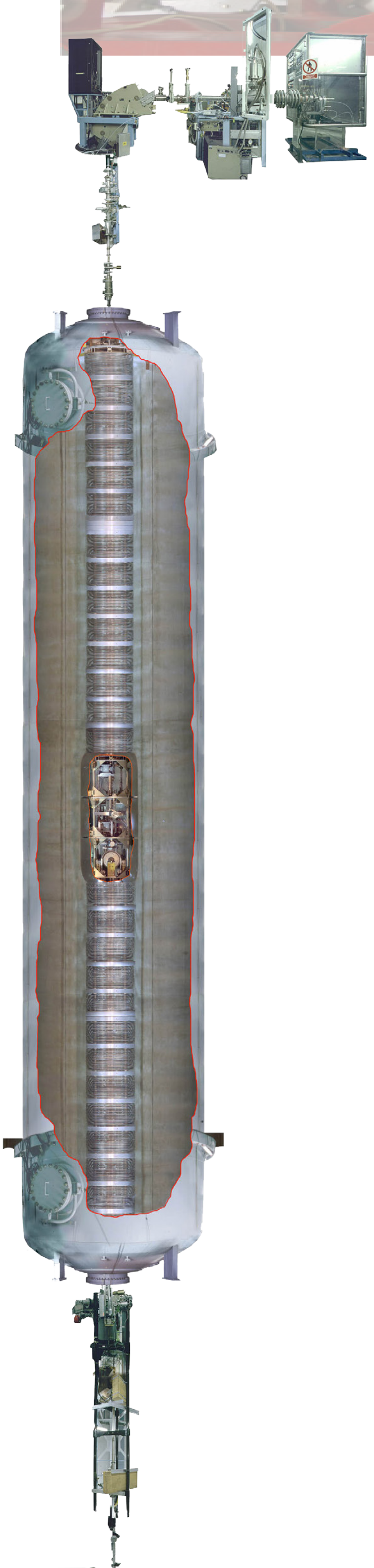
Heavy-Ion Accelerator Facility (HIAF)

Department of Nuclear Physics
Australian National University

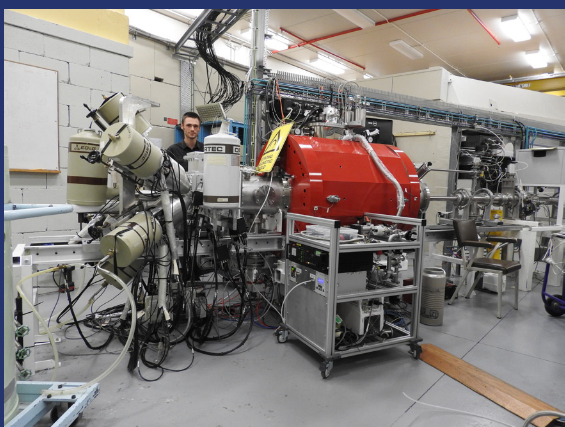


Introduction
The powerful 15 million volt 14UD accelerator at the ANU can accelerate beams of most elements in the Periodic Table, from hydrogen to uranium. Maximum available energies depend on Z, and range from 30 MeV for protons, to 5 MeV/nucleon for nickel (i.e. ~300 MeV), to 1 MeV/nucleon for uranium. Energies are precisely defined, stable and may be changed easily and rapidly. Beam intensities up to 10^{12} ions/s are available, and can be varied readily. It supports a wide range of research that includes fundamental nuclear physics, ultra-sensitive atom counting by accelerator mass spectrometry, materials science, and medical applications.

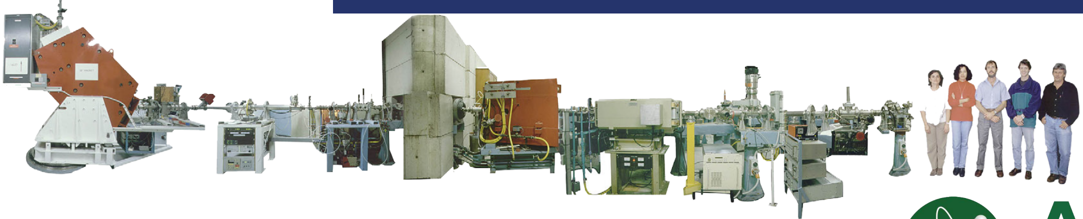
Equipment: Instrumentation includes two large superconducting solenoids with highly-sophisticated detection systems for separating the products of heavy-ion fusion reactions; a high-efficiency detection system for the fission products from heavy-ion-induced reactions; a multi-detector gamma-ray array; a superconducting solenoid for studies of conversion electrons and electron-positron pairs; and a cryo-cooled target (4K) for hyperfine interaction studies. In addition, pulsed beams with flexible spacing and with time resolution below 1 ns are available from the accelerator. Extensive electronics and multi-parameter data acquisition systems read out the data.

Research interests of the Department and outside users include the following.

Nuclear Physics: Studies of
- nuclear fusion reactions for the synthesis of new superheavy elements;
- collectivity and shapes of nuclei as many-body systems;
- quantum interactions of weakly-bound exotic nuclei using beams of short-lived radioactive isotopes;
- nuclear structure through nuclear magnetism;
- atomic and condensed matter applications of hyperfine interactions;
- energy dissipation mechanisms in nuclear reactions.



Left: The 8 Tesla superconducting solenoid magnet configured as SOLENOGAM. Nuclear isomers produced by nuclear reactions before the solenoid are selected and transported to the focus of the magnet where their gamma-ray decays can be studied with an array of germanium detectors.



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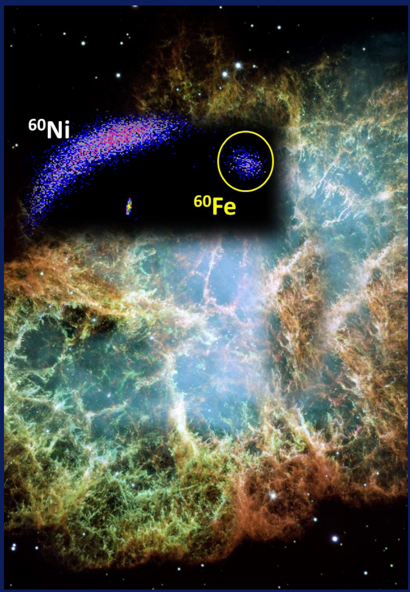
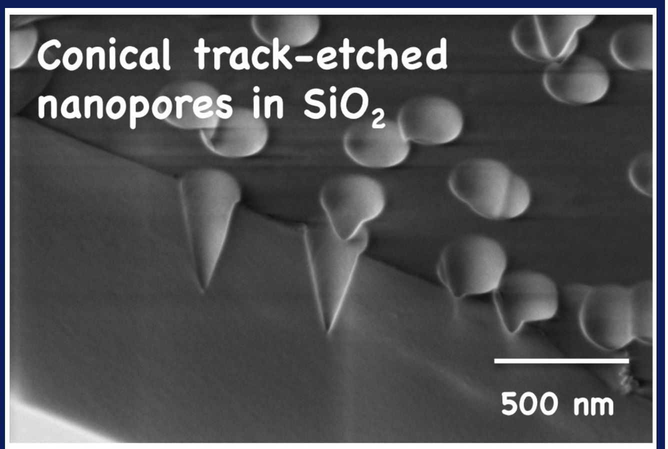
Accelerator mass spectrometry: Long-lived radionuclides in the environment, either naturally-produced by cosmic rays or man-made, can be quantified with exquisite sensitivity. The Facility supports a wide range of research, including exposure dating and erosion measurements for studies of landscape evolution and sustainability (^{10}Be, ^{26}Al, ^{36}Cl, ^{53}Mn, plutonium), nuclear astrophysics (^{60}Fe), hydrology (^{36}Cl), and tracing the dispersal of the products of nuclear accidents and discharges (plutonium, ^{236}U, ^{129}I).



Characteristic fingerprints of recent nucleosynthesis may be detected by AMS. ANU's world-leading separation power of the supernova-product ^{60}Fe from abundant stable ^{60}Ni is shown. The crab nebula is a famous example of a recent Supernova explosion.

Materials science: Swift heavy ions can be exploited in a number of ways in materials research and nanotechnology. They can generate long narrow defects (ion tracks) in many materials that can be used for generating high aspect ratio nanopores by chemical etching. These have commercial applications as filters or can be used as templates for nanowire growth. Ion tracks are important for geo- and thermochronology as a proxy for fission tracks in minerals. Irradiation with heavy ions can also be used to investigate the performance of electronic materials under cosmic radiation or in other high radiation environments. Energetic heavy ions can also produce fast radioactive ions via nuclear reactions, which can be implanted into materials to study dopant-defect interactions via perturbed angular correlations, or for wear studies of medical prostheses.

SEM micrograph of conical nanopores in silicon. These were produced by selective etching of tracks created by fast heavy ions.



Medical science: Energetic heavy ions can produce new radioisotopes for medical research.

Accessibility: the Department strongly encourages outside users. It provides both practical support and training in the operation of the accelerator and associated instrumentation. Prospective users should contact in the first instance the AINSE Councillor, Dr. Toni Wallner (Anton.Wallner@anu.edu.au, 0435 061 917) or the Head of Department, Prof. Andrew Stuchbery (Andrew.Stuchbery@anu.edu.au, 0401 079 721 or 02 6125 2083). AINSE provides travel and accommodation assistance.

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