PROPOSED

Lucas Heights TANDEM ACCELERATOR

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Proposal

It is proposed that an 8 million volt tandem accelerator (LHTA — Lucas Heights Tandem Accelerator) be installed at the Australian Atomic Energy Commission's Lucas Heights Research Laboratories, Lucas Heights, Sydney. This new facility, expected to cost $6 million, will not only extend many established applications of science in Australia but will also introduce a number of new technologies. These new technologies would benefit many sections of the Australian community — from resources to research, from health to heritage and from erosion to corrosion. All have high relevance to national objectives such as

Ultra Sensitive Trace Element Analysis for

- Management of Groundwater Resources
- Salinity in Soil
- Soil Erosion
- Antarctic Research

Applied Physics for

- Nuclear Safeguards
- Energy Sources — Fission, Fusion, Solar
- Study of Material Surfaces
- National Heritage - Archaeology and Archaeometry
- Occupational Health

Prepared By

Australian Atomic Energy Commission

In consultation with

Australian Institute of Nuclear Science and Engineering

Bureau of Mineral Resources

Australian National University

Commonwealth Scientific and Industrial Research Organization

Ultra Sensitive Trace Element Analysis

Management of Groundwater Resources

The future of much of the interior of Australia depends critically on the assured supply of good quality groundwater. Nearly three billion tonnes of water was pumped from 348 000 wells in 1974. In regions such as the Gulf Division of South Australia, groundwater usage is as much as 44 per cent of the water available for recharge. Increasingly, Australia will require sophisticated water management models if this precious resource is to be conserved.

Environmental isotopes such as carbon-14 and chlorine-36 can be used to develop and validate hydraulic models on which management strategies are based. These isotopes may also be used to obtain an understanding of the reasons for variations in water quality and thereby contribute to the good husbandry of the resource and the development of strategies for future exploration. Accelerators such as LHTA are currently the only means for measurement of chlorine-36 at environmental levels.

Typical flowing bore in the Great Artesian Basin

Salinity in Soil

Salination and waterlogging are serious man-made problems which are affecting significant areas of prime agricultural land. The problem is particularly severe in parts of the Murray Basin, NSW, and in the south-west of Western Australia. The chlorine-36 technique can be adapted to study salinity problems that have appeared in the past few decades, since a large well-defined pulse of the isotope was generated by atmospheric nuclear testing in the 1950s and 1960s. The isotope is an environmental tracer which can be used to investigate the impact of agricultural practice, deforestation and urban and industrial development on salinity.

Waterlogging and salination of agricultural land
Photo courtesy Dr R.J. Loughran, University of Newcastle, NSW

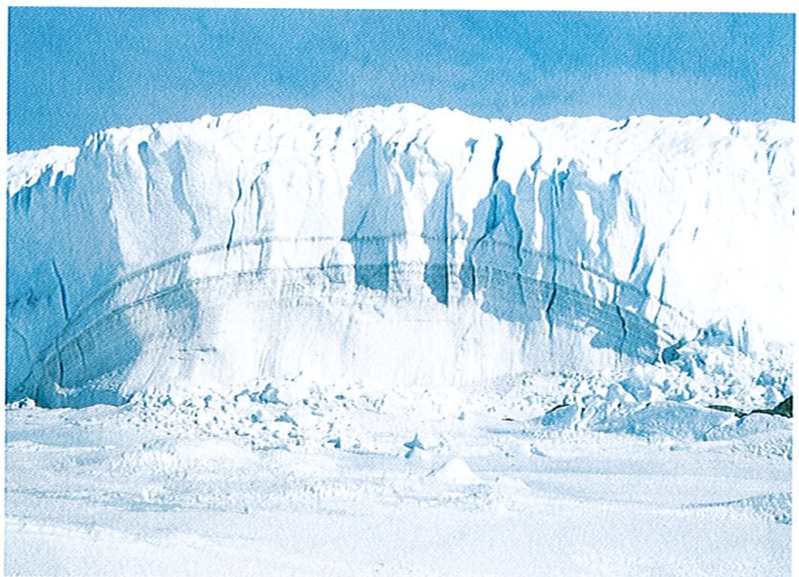
Soil Erosion

Australia already has costly problems of land degradation, and land conservation is a national priority. Soil erosion can be rapid or subtle, but soil that is lost is only re-formed by very slow chemical and physical processes. In order that land remain usable we must understand erosion, sedimentation and the slow re-formation of soils. In the environment there are ultra-low levels of certain radioisotopes such as beryllium-10, carbon-14, aluminium-26 and calcium-41 that may be used as tracers for these processes. Measurements are only possible by accelerator mass spectrometry.

Rural Australia blowing away — Melbourne 1983. Photo courtesy Australian Bureau of Meteorology

Antarctic Research

Deep ice cores provide a record over several hundred thousand years of the deposition of volcanic dust and micrometeorites, and indicators of climatic change such as the level of carbon dioxide. They also provide a unique record of man's impact on the environment since industrialisation. Critical to an understanding of these processes is an ability to date ice cores. Carbon-14, chlorine-36, beryllium-10 and other techniques may be used. Severe problems arise because of the very small amount of material available. Accelerator spectrometry is essential because measurements are then possible on a few milligrams of material. Accurate dating will contribute to an understanding of the relationship between past climatic change and the extent of the Antarctic ice sheet. Insights into the causes of past changes will assist long-term prediction of the effect on climate of industrialisation, land-use change and other human activities.



Environmental layering in section of Antarctic glacial wall. Photo courtesy Antarctic Division, Department of Science and Technology

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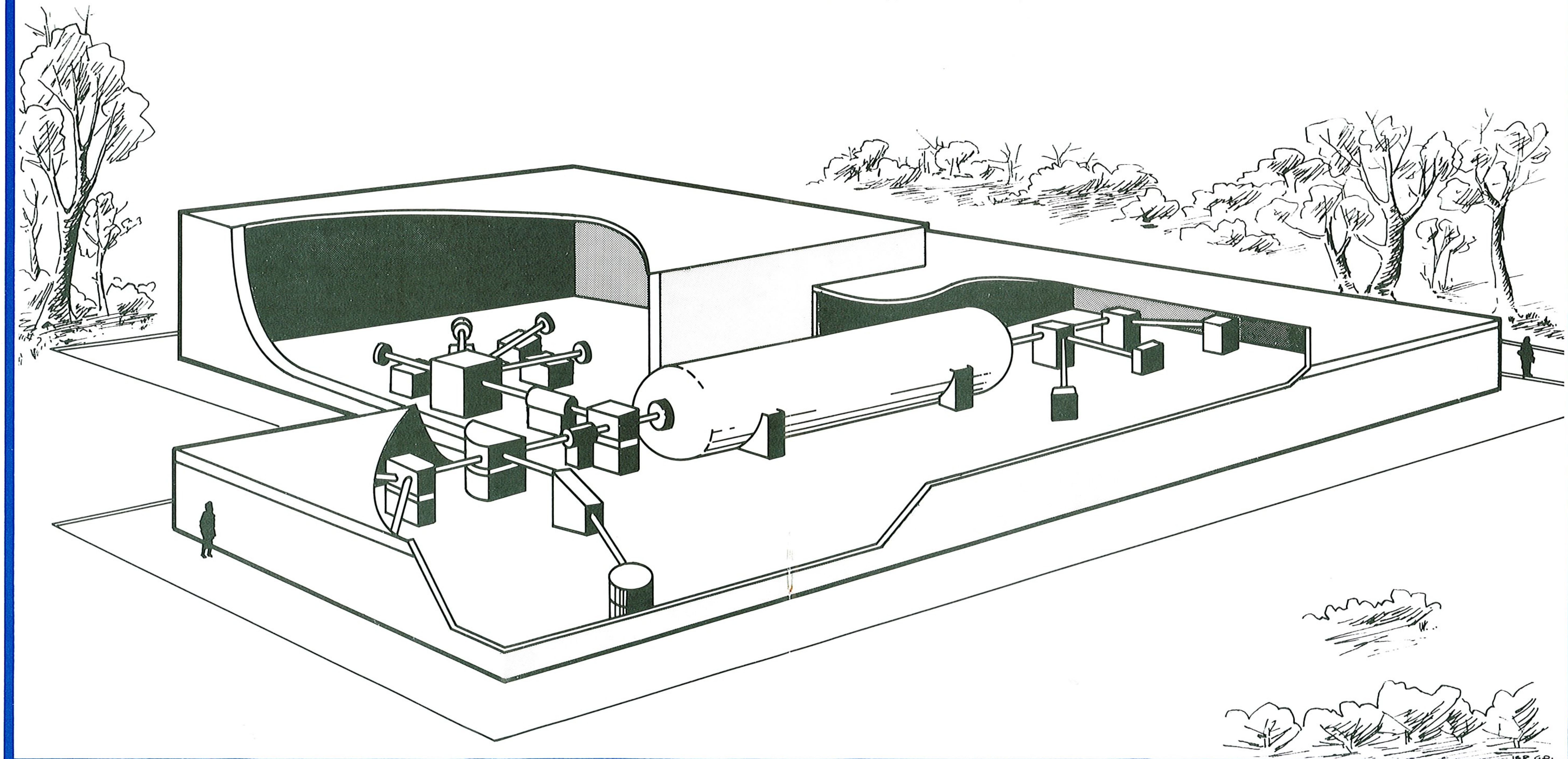
.Specifications

- Terminal Voltage 2-8 million volts
- Terminal Stability ± 1 kilovolts
- Flat-topped Transmission
- Beam Tube UHV System

- Ion Beam Strippers
  - Carbon Foils
  - Gas Stripper
  - Terminal Pumping

- Beam Pulse Width
  - Low Energy Buncher 1 microsecond
  - High Energy Buncher 100 picoseconds

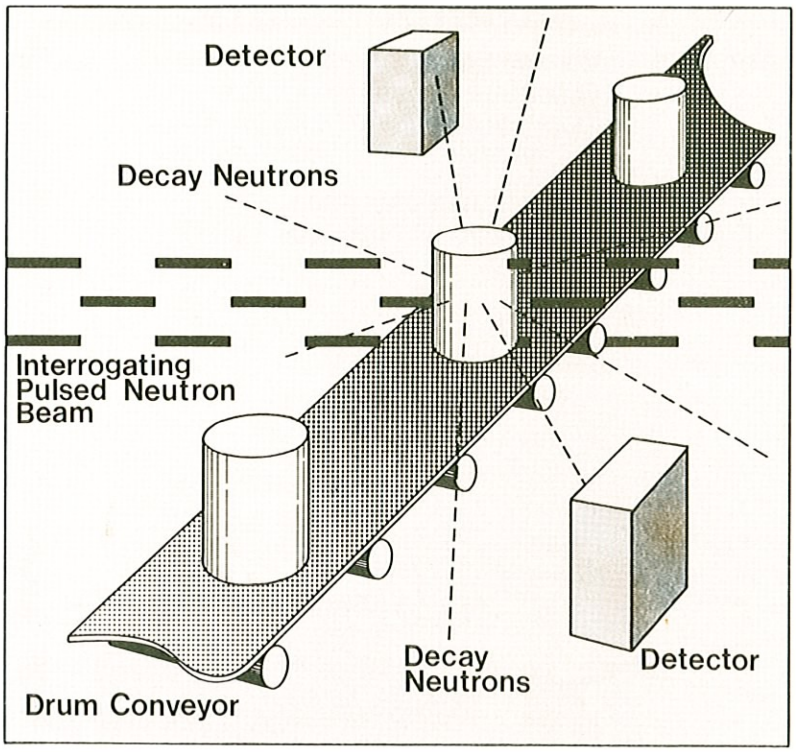
- Beam Currents
  - 20 microamps Proton
  - 20 microamps Deuteron
  - 2 microamps He
  - 15 microamps C
  - 1 microamp Li



Applied Physics

Nuclear Safeguards

A facility which provides a neutron source of accurately known intensity will be developed on one of the beam lines of the accelerator. This will be used for a number of applications including neutron detector calibration for nuclear safeguards purposes, the interactions of neutrons with living cells and accurate neutron dosimetry. It is also planned to use the pulsed neutron capability of the accelerator to study the application of neutron decay techniques to safeguard quantities of fissile materials which may not be measurable by other means; for example, waste drums from fuel element reprocessing plants, which could contain significant quantities of plutonium.



Schematic arrangement for non-invasive assay of nuclear wastes

Energy Sources — Fission, Fusion, Solar

Current trends in energy production point to a future in which there will be a combination of fission, fusion and solar systems. The accelerator would provide new measurement capabilities for research on all these systems.

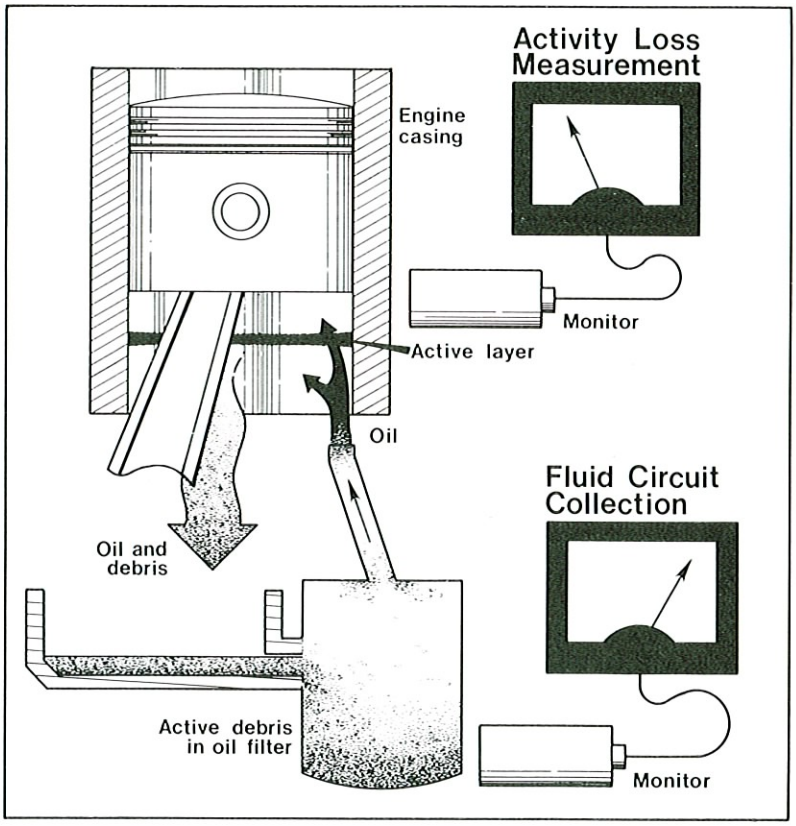
The operation of reactors, based on either fission or fusion, relies on a knowledge of how neutrons interact with the components of the reactor, especially at high energy. LHTA would produce neutrons at all energies relevant to such studies, a capability that does not exist at present in Australia.

Heavy ion implantation, important in the development of the semiconductors for solar energy systems, is limited by present low energy ion implantation systems. LHTA would enable heavy ions to be implanted into a target material to greater depths than currently possible. It could also be used as a diagnostic tool to study such materials.

Study of Material Surfaces

Non-destructive examination in industry is becoming increasingly important. Wear on material surfaces is a prime example. LHTA would be able to provide an activation service that irradiates only the surface layer of machine parts with very low total activity levels, in contrast to present methods which activate the whole sample. This would enable wear rates of machinery to be measured many times more accurately than hitherto, with no radiation hazard.

In material surfaces there are many elements present in trace quantities. Current multielement techniques to measure them are limited to about one part in a million. LHTA would extend this to one part in a billion by using the new technique of charged particle activation analysis. While it is now possible to measure the concentration of hydrogen in a surface at depths up to a micrometre, the new accelerator would allow surface concentrations of other elements (such as carbon, nitrogen and oxygen) to be measured at much greater depths in materials such as titanium and iron.

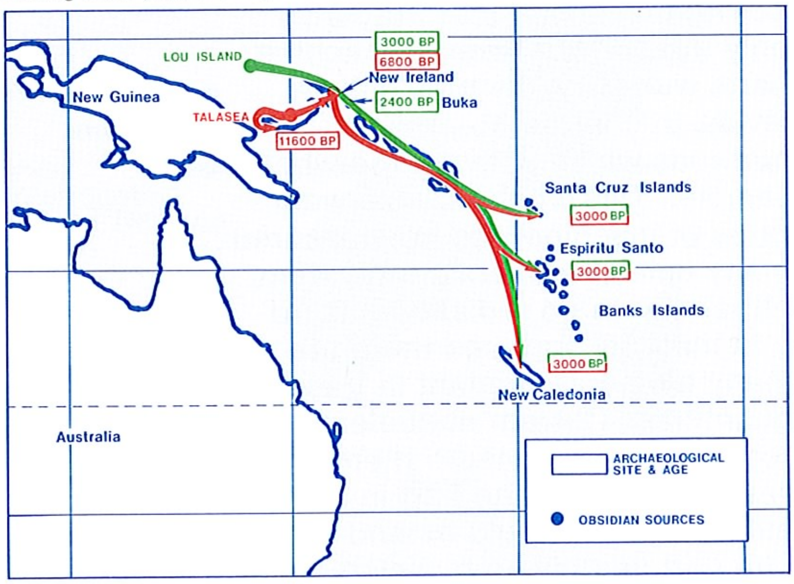


In situ wear analysis by thin layer activation

National Heritage — Archaeology and Archaeometry

Accelerator based techniques are widely used to analyse items of the national heritage. Archaeological samples such as volcanic glass and pottery from Melanesia and New Zealand may be traced to their origin and museum objects such as coins, bronzes and paintings can be authenticated. With a high energy accelerator, relative ages of bones, volcanic glass and perhaps even stones could be found by measurement of elements such as hydrogen and sodium on their surfaces. The ultra-trace element analysis system would also extend radiocarbon dating measurements to much smaller samples than now possible.

Tracing trade patterns in prehistoric communities



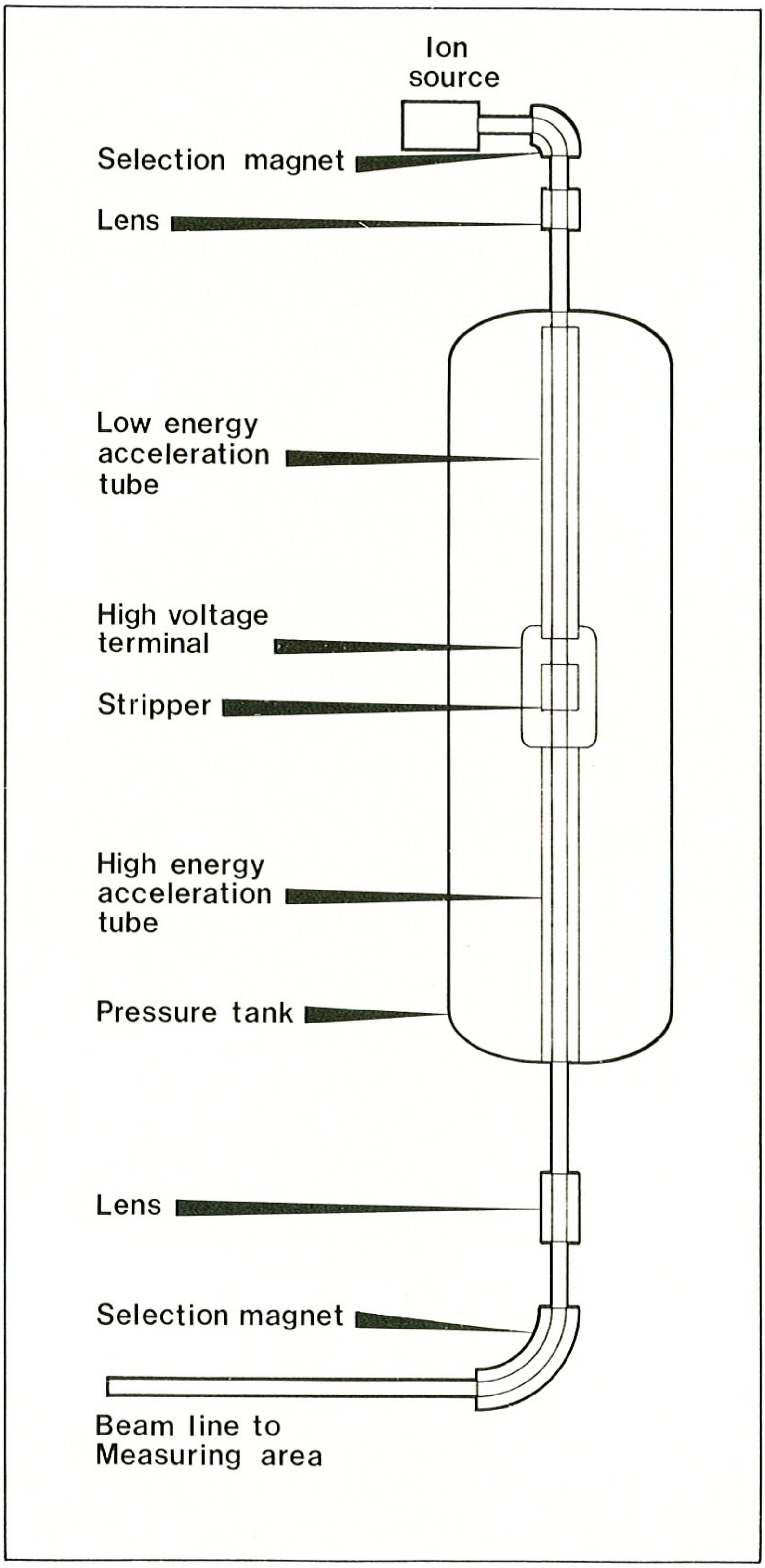
Occupational Health

The increasing recognition of the hazardous nature of some chemicals in industry has focused attention on the work environment. Accelerator – based methods of monitoring can provide sensitive and accurate analyses of factory air, soil and water, and can include tissue samples from exposed personnel. Both the range of elements and the detection sensitivities would be improved by analysis methods possible with the new accelerator. It is anticipated that all the currently known toxic materials could be monitored.

Typical factory environment

Operating Principles

The initial stage of an electrostatic accelerator is an ion source where negatively charged atoms are generated by 'sputtering' atoms from a sample of interest or by ionising a gas, and are accelerated by a small electrostatic field (200 kilovolts). This ion beam is then deflected through 90 degrees by a magnet, into the main accelerating tube where the ions are attracted by the positively charged terminal of the tandem accelerator. Within the terminal, they are travelling at high speed and pass through either a carbon foil or a gas stripper. In the collisions that take place between the negatively charged ions and the electrons of the stripper atoms, a number of electrons are stripped from the outer orbits of the ions and the ion charge changes from one unit of negative charge to a number of units of positive charge. The positive ions are then repulsed by the positive voltage of the centre terminal. By the time the ions reach the end of the accelerating tube they have reached a high energy, equal to (x+1) E MeV, where E is the voltage of the terminal and x is the positive charge of the ion after passing through the stripper. On leaving the accelerator, the ions pass through an analysis magnet before entering a target area. Such beams can be measured directly to determine the amount of a rare, stable isotope or radioisotope present in the original sample or they can be used for the other studies described here.



Major features of a tandem accelerator

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