Australian Government | ansto Nuclear-based science benefiting all Australians

Nuclear science

Nuclear science is the study of the atomic world

Everything is made of atoms. We are entirely composed of them, as is everything that surrounds us.

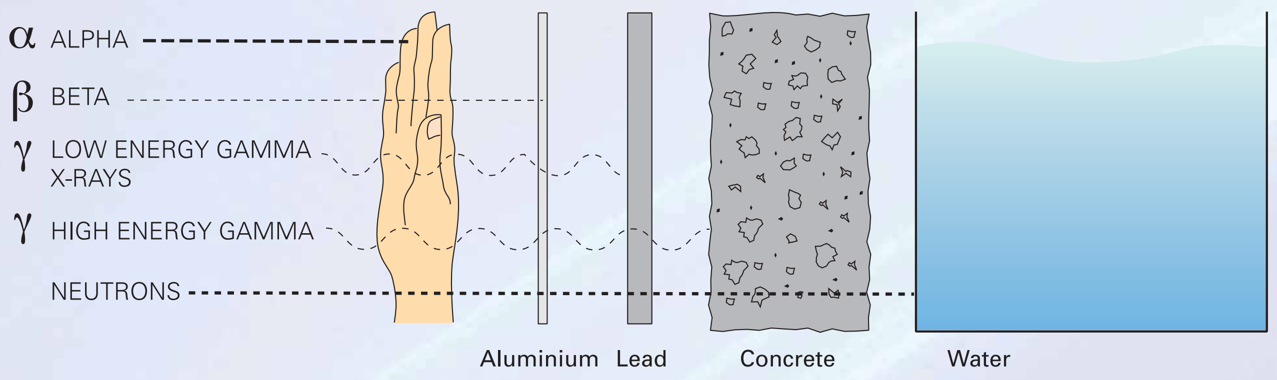
Learning what atoms do and what happens when they combine is of critical importance. It has a constant effect on our lives. If we know how atoms get together, or can be best combined with others, new, more efficient materials and drugs can be developed through 'molecular engineering' and ‘rational drug design’. Investigation of matter at the atomic level is one of the most important fields of scientific research. ANSTO is the home of Australia’s nuclear science expertise.

Radioactive decay

Radioactive decay is the spontaneous radioactive disintegration of an atomic nucleus resulting in the release of energy in the form of particles (for example, alpha or beta), or gamma radiation, or a combination of these.

Radioactive decay is one process through which unstable atoms can become more stable.

Penetration of radiation



Alpha decay (α)

In alpha decay, a positively-charged particle is emitted from the nucleus of an atom. An alpha particle consists of two protons and two neutrons (a helium-4 nucleus). Although alpha particles are normally highly energetic, they travel only a few centimetres in air and are stopped by a sheet of paper or the outer layer of dead skin.

Beta decay (β)

In beta decay, a particle is emitted from the nucleus of an atom. A beta particle is an electron with either negative or positive electric charge. Beta particles may travel metres in air and several millimetres into the human body. Most beta particles may be stopped by a small thickness of a light material such as aluminium or plastic.

Gamma decay (γ)

Gamma decay occurs when the nucleus of an atom is in too high an energy ‘state’. The nucleus will drop to a lower energy state and release gamma rays, which are a high energy form of electromagnetic radiation (light). Like all electromagnetic radiation, gamma rays travel in a wave like pattern and at the speed of light. They can only be stopped by dense materials such as lead, steel, concrete or several metres of water.

Fission vs fusion

When atoms split apart or join together, energy is released. This is nuclear fission and nuclear fusion.

Nuclear fission

The nucleus of some atoms can be split apart. When this is done, both particles and energy (in the form of heat and light) can be released.

The word fission means to split apart. Inside a nuclear reactor, such as OPAL, uranium atoms are split apart in a controlled chain reaction.

In a chain reaction, neutrons released by the splitting of the atom go off and strike other uranium atoms, splitting those and releasing another lot of neutrons to continue striking more uranium atoms. In nuclear reactors, design features and control rods are used to regulate the splitting so it does not go too fast.

Nuclear fusion

Fusion is when smaller nuclei join together to make a larger nucleus. The sun is powered by nuclear fusion of hydrogen atoms into helium atoms. This releases tremendous amounts of energy in the form of heat, light and other radiation.

Scientists have been working on controlling nuclear fusion for a long time, trying to make a fusion reactor to produce electricity. To date, prototype fusion reactors have consumed more energy than they have produced, but scientists believe that the future of fusion research is promising.

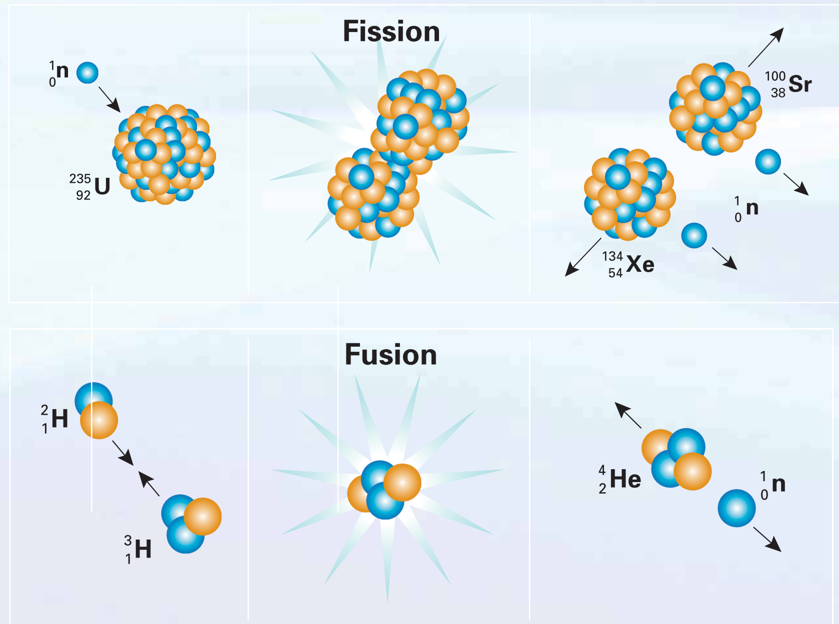
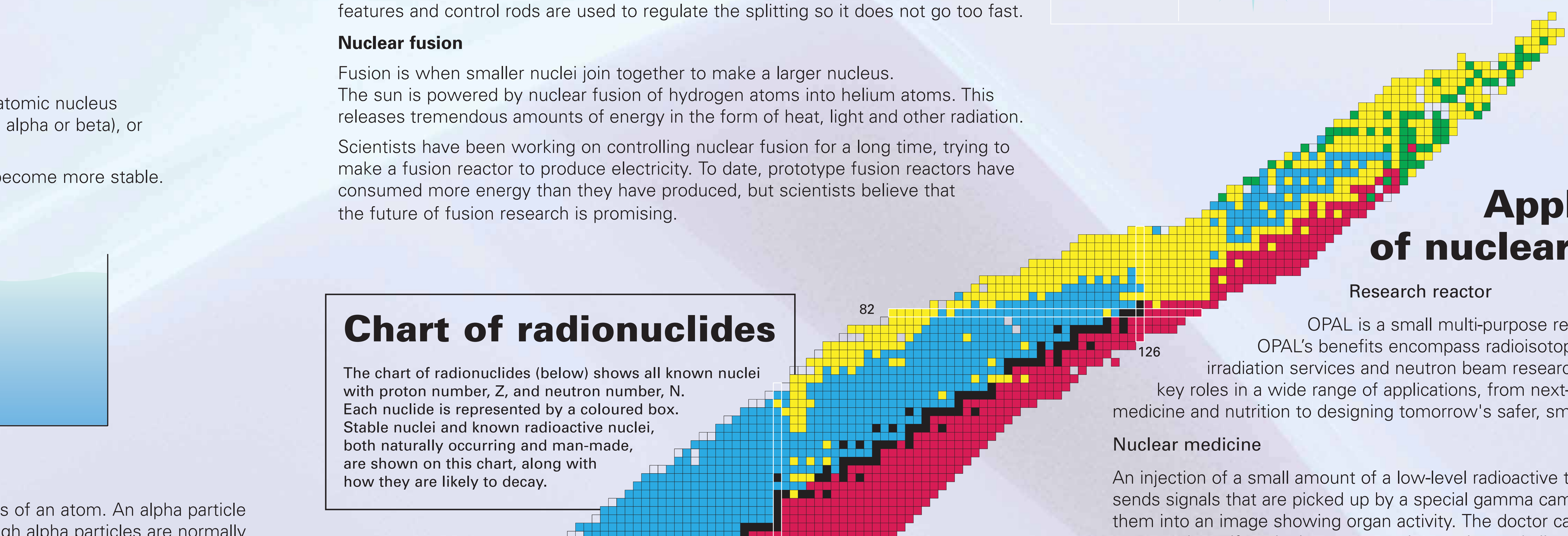
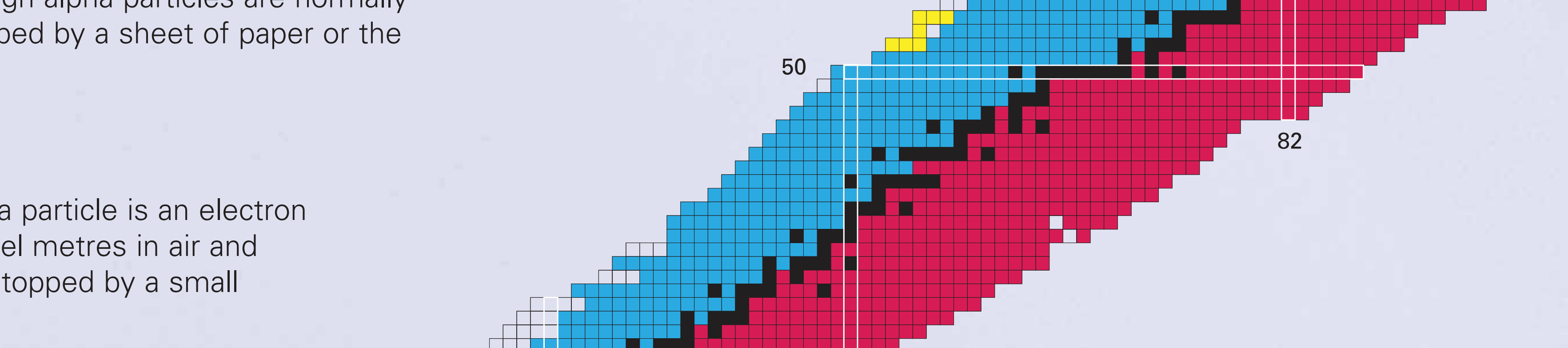
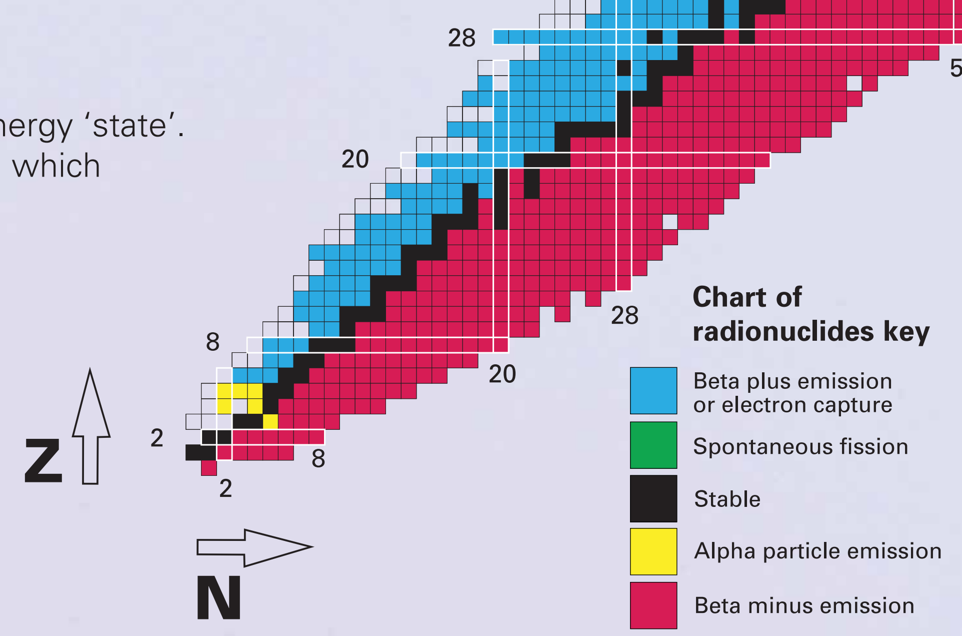


Chart of radionuclides

The chart of radionuclides (below) shows all known nuclei with proton number, Z, and neutron number, N. Each nuclide is represented by a coloured box. Stable nuclei and known radioactive nuclei, both naturally occurring and man-made, are shown on this chart, along with how they are likely to decay.







Applications of nuclear science

Research reactor

OPAL is a small multi-purpose research reactor. OPAL’s benefits encompass radioisotope production, irradiation services and neutron beam research. All three play key roles in a wide range of applications, from next-generation medicine and nutrition to designing tomorrow's safer, smarter materials.

Nuclear medicine

An injection of a small amount of a low-level radioactive tracer into the body sends signals that are picked up by a special gamma camera, which turns them into an image showing organ activity. The doctor can then determine if an organ is malfunctioning or cancer is growing and allocate the appropriate treatment. ANSTO provides 80 per cent of the nuclear medicines to Australian hospitals to help doctors diagnose disease.

Environmental research including carbon dating

Many different forms of environmetal research are conducted at ANSTO including research into climate change, carbon dating of various objects, air pollution analysis and isotopic analysis of natural water systems to help understand water movements and what must be done to ensure future water supply.

To undertake this work, ANSTO has some of the most sensitive instruments for this kind of research in the world. Two of these instruments are powerful particle accelerators which are used to conduct accelerator mass spectrometry (AMS) - used in climate change analysis and carbon dating - and ion beam analysis (IBA) which is used for tracking air pollutants and conducting radiation research.

Silicon doping

ANSTO is a leading provider of irradiated silicon for use in advanced electronic devices, integrated circuits and other industrial applications.

The doping process involves treating large silicon crystals with neutrons from OPAL in a process that transforms a small number of silicon atoms inside the crystals into phosphorus atoms. This transforms the material into a semiconductor.