Aeroplanes, shampoo and super-microscopes

Where do protons travel at almost the speed of light, and neutrons see things 10 000 times thinner than a human hair? Take a trip to ISIS – one of the UK's world-leading research centres.

ISIS uses neutrons to study materials at an atomic level. It acts like a "super-microscope", and can be used for physics, chemistry, materials science, geology, engineering and biology. The Rutherford Appleton Laboratory in Oxfordshire is its home.

Neutrons are tiny particles found in the nucleus of nearly every atom. Neutrons can be released from their nuclei when hit by a very fast moving proton beam.

At ISIS, a proton beam travelling at 84 per cent of the speed of light is fired at a small tungsten target (no bigger than a packet of biscuits) to release neutrons (see numbers **1-3** on diagram). The protons are accelerated to high speed using a circular synchrotron accelerator. Every proton goes 10 000 times around the accelerator before being fired at the target. The whole process takes 10 milliseconds from start to finish. During this time, the protons have travelled 1655 kilometres. That's the same as a journey from London to Aberdeen and back! This happens 50 times a second.

Once the neutrons have been released from the target, they fly down beam pipes (see **4**) leading to instruments (see **5**) that are used for experiments.

Because neutrons have no electric charge and are so small, they can penetrate deep into materials. By looking at how they scatter off the atoms inside materials, they reveal the atomic structure of the material under study.

At ISIS, it is possible to see detail at scales 10 000 times thinner than a human hair. This makes it much easier to see the exact make up of things and understand how they behave.

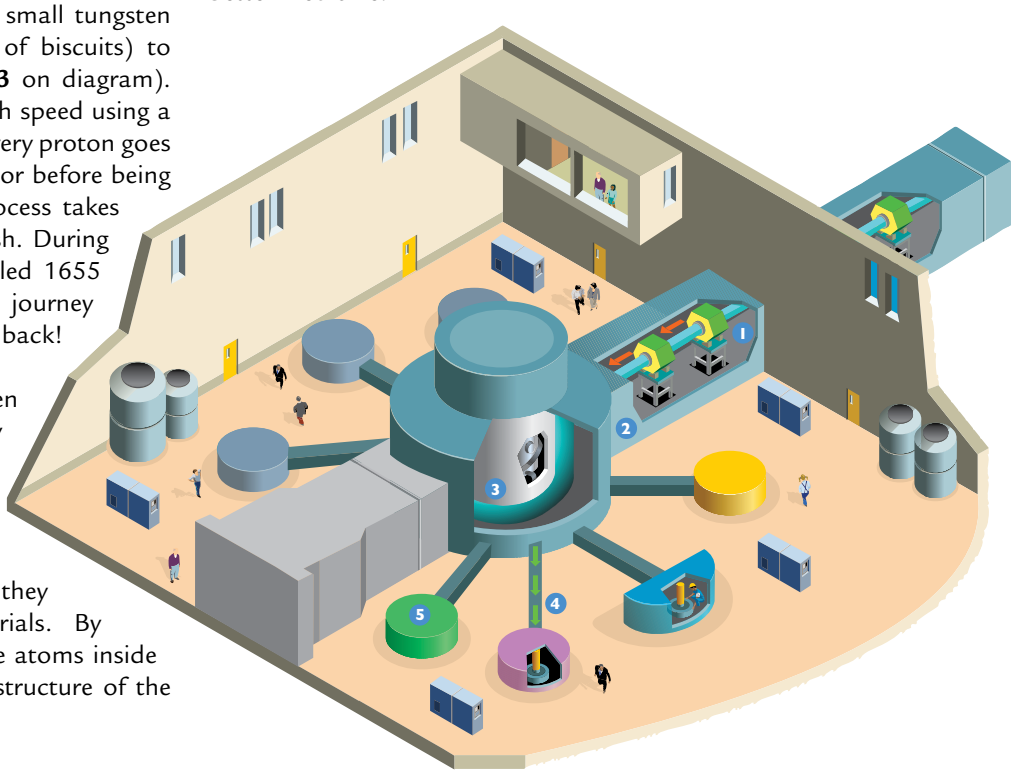
The big picture

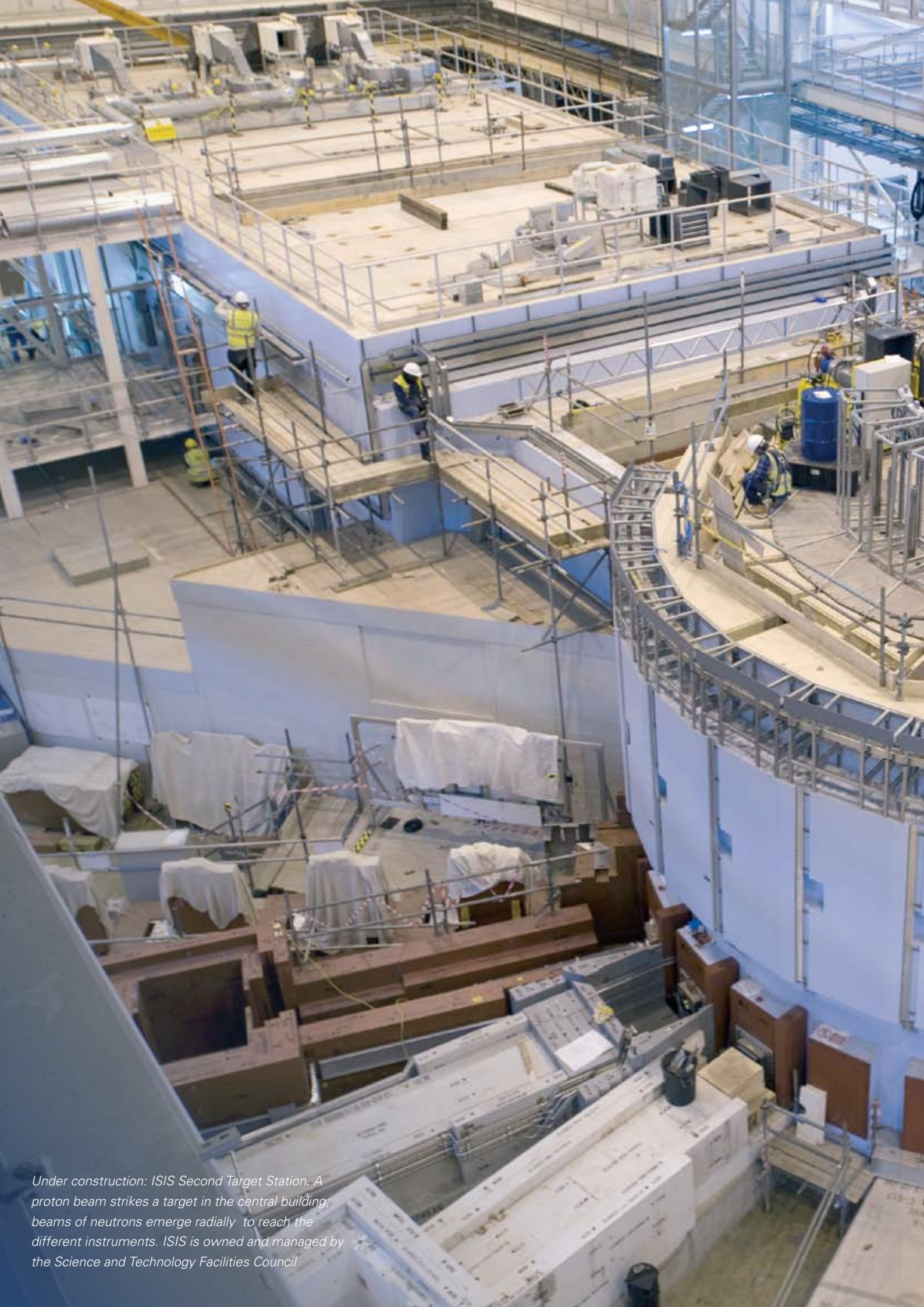
Different instruments are used to do different types of experiments. There are currently 20 instruments already in use, and ISIS has just doubled in size, adding seven new instruments with more to follow in the new 'Second Target Station' building. The photograph on pages 10-11 shows the Second Target Station under construction.

Scientists use the instruments to look at samples ranging from aeroplane wings to shampoo.

Understanding materials at an atomic level can lead to exciting discoveries that impact our lives. ISIS can help to create super-fast computers, make transport safer and more efficient, and provide better medicine.

The ISIS buildings in Oxfordshire; the new building at the front is the Second Target Station.





Under construction: ISIS Second Target Station. A proton beam strikes a target in the central building; beams of neutrons emerge radially to reach the different instruments. ISIS is owned and managed by the Science and Technology Facilities Council

Catalyst

www.sep.org.uk/catalyst

ISIS sees through muddy water

One of the really useful things about using neutrons is that they allow scientists to see clearly both organic and inorganic (non-living) material.

Recently, ISIS scientist Steve King experimented on a sample of river water to try to understand how tiny particles of pollutants bind together and how they are transported through the river.

Working alongside Helen Jarvie at the NERC Centre for Ecology and Hydrology, Steve was able to see the exact shape of certain tiny inorganic particles present in the water and how the organic matter either keeps them suspended or causes them to settle. Steve found the tiny particles had a ragged and porous fractal shape, resulting in much higher surface area than previously assumed. The larger the surface area the greater the potential for pollutant uptake and transport.

This makes it easier to understand how pollutants like pesticides or excess fertiliser attach themselves to these particles and get carried downstream. With experiments like this, we can better understand how humans affect the ecology of rivers and can then take steps to make our water systems cleaner.

Helen Jarvie of the Natural Environmental Research Council works alongside Steve King.

Steve King collects water samples from a polluted watercourse.

Making aircraft safer

Neutron science can also be valuable in testing the strength of engineering parts, such as aircraft wings. Airplane company Airbus used ISIS to see how best to manufacture a new airplane wing.

The strength of an aircraft wing depends partly on how strongly the different components are joined together with welding. It is important to understand any areas of weakness that may be present in the structure before it goes into production.

Using neutrons, scientists at ISIS are able to see deep within engineering components and structures and determine if there are any areas of stress and strain that might lead to cracks appearing in the future.

Once manufacturers understand any potential flaws in their components, they can adjust their processes to make sure that aircraft parts are as safe as possible.

This makes air travel safer for all of us.

A section of an Airbus wing being positioned for examination in one of ISIS's test stations.