Above: *Dr Nick Terrill, Principal Beamline Scientist, overseeing the installation of the first girder, carrying vacuum equipment and magnets, into the storage ring*

Right: *Diamond storage ring being prepared for installation of girders*

voltage is used to accelerate the electrons; this happens in a linear accelerator (**linac**). They are then accelerated further along a circular path. Electric fields speed the electrons up and magnetic fields cause them to move around in a circle.

The aim is for the electrons in the Diamond beam to travel close to the speed of light. Once this has been achieved, they are deflected off to a doughnut-shaped vacuum chamber called the **storage ring** where they circle through specially designed magnets arrayed around the ring (see Box 2). Electrons can move at a steady speed in a straight line without losing energy; however, when the magnetic field causes them to move in a curved path, they lose energy, which emerges as beams of very bright, highly-focused light of different wavelengths. It is this light that scientists use to drive their experiments.

As the electrons curve around the storage ring, the light they emit travels off along a tangent to the ring (Figure 1). Scientific experiments will be set up in laboratories around the perimeter of the ring, at the points where these beams emerge (see Box 3). The laboratories are known as stations or ‘hutches’.

The electrons in the storage ring beam have an energy of 3 giga-electronvolts (GeV); that is, the energy they would have if they were accelerated by a 3-billion volt battery.

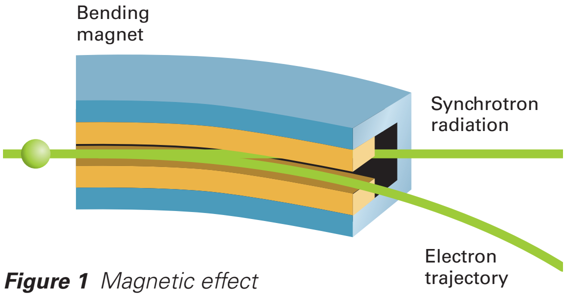


Figure 1 *Magnetic effect*

Box 2 Controlling the beam

The beam, as fine as a human hair, travels down the centre of an array of electromagnets. The powerful magnets are made from a super-conducting metal; it is cooled to a temperature close to absolute zero, where it loses all electrical resistance. Similar magnets are used in hospitals, in MRI (magnetic resonance imaging) body scanners.

Box 3 First experiments

When Diamond opens in 2007, seven experimental stations will come online, each with its own beamline coming off the storage beam:

- an extreme conditions beamline, for studying materials under intense temperatures and pressures
- a materials and magnetism beamline, set up to probe electronic and magnetic materials at the atomic level
- three macromolecular crystallography beamlines, for decoding the structure of complex biological samples, such as proteins
- a microfocus spectroscopy beamline, able to map the chemical make-up of complex materials, such as moon rocks and geological samples
- a nanoscience beamline, capable of imaging structures and devices at a few millionths of a millimetre

Plans and funding are in place for a further 15 beamlines to be added over the next few years, for all sorts of other experiments.

Because the electrons in the storage ring are losing energy, they slow down. Their speed is maintained by passing them through radio frequency cavities, which boost their energy each time they come around.

What benefits will Diamond bring?

Diamond will produce ultraviolet and X-ray beams of exceptional quality and brightness, a thousand billion times brighter than those from a hospital X-ray tube. These beams will enable scientists and engineers to delve deep into the basic structure of matter and materials, leading to scientific breakthroughs in the fields of biotechnology, medicine, environmental and materials science.

Biology and medicine

The fight against illnesses such as Parkinson’s, Alzheimer’s, osteoporosis and many cancers will benefit from the new research techniques available at Diamond. Investigating the structures of the proteins involved in such diseases will help scientists to understand them better, opening new avenues for treatment. For example, the ‘anti-flu’ drug Relenza,

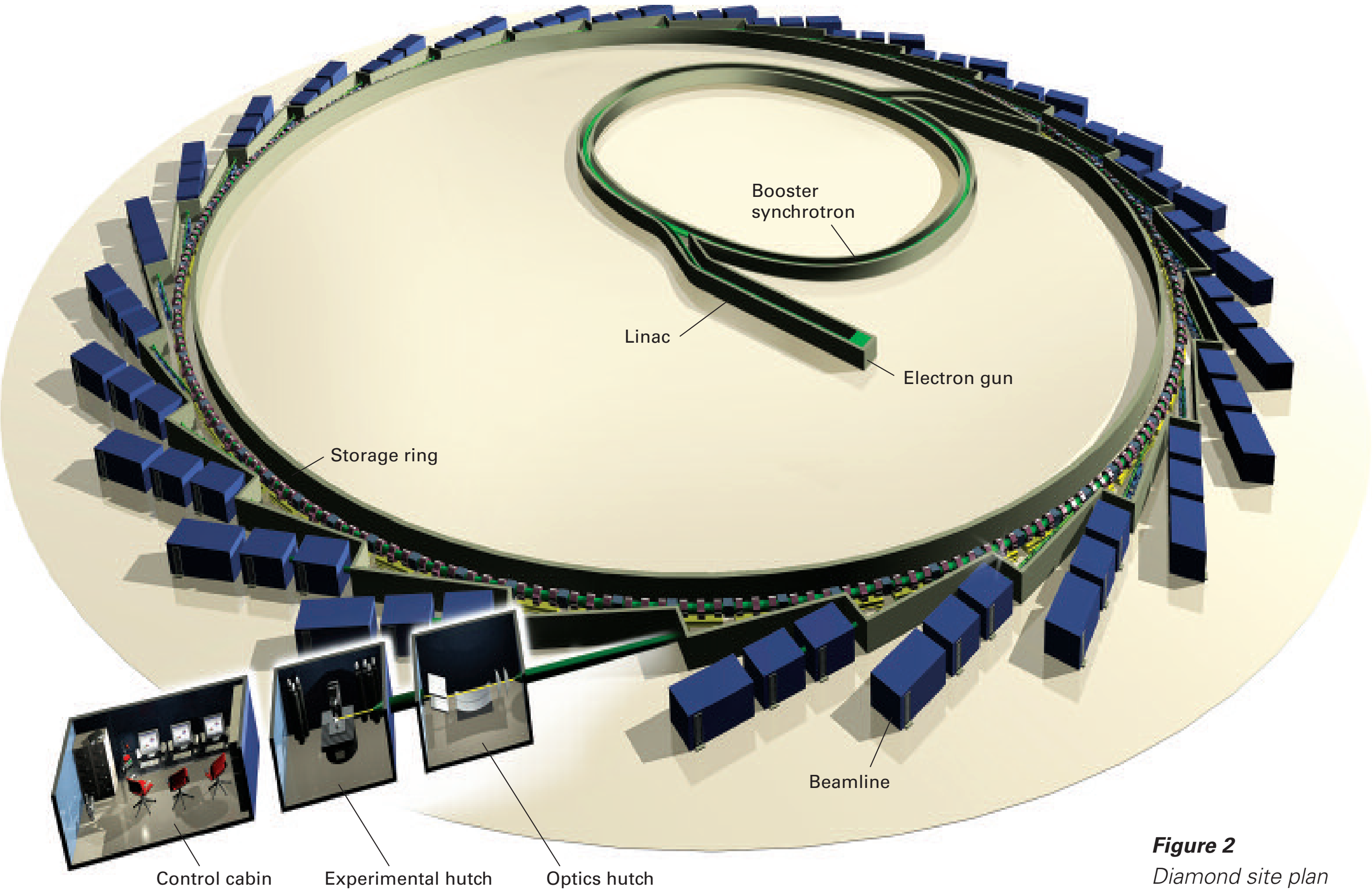


Figure 2
Diamond site plan

The electron beam travels in an evacuated tunnel; the electrons would be stopped by collisions with air molecules if any were present.

which was developed using structural information provided by synchrotron light, was a huge milestone in biomedical science.

Physical and chemical sciences

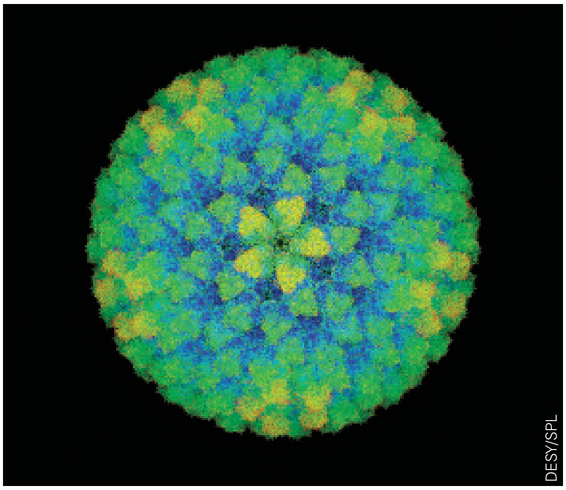
Without innovative, pioneering materials to choose from, UK industry would struggle to compete in the fast-moving world of product design. Often, understanding the structure of a new material is the key to perfecting the performance of the final product.

For electronic devices such as transistors, purity is crucial. The tiniest defect can ruin the quality of the entire component, leading to expensive waste during manufacture. A transistor is built up from layers of semi-conductor materials only a few atoms thick, so it is very difficult to see its structure. Using a synchrotron source, engineers can image structures down to an atomic scale, helping them to understand the way impurities and defects behave and how they can be controlled.

Environment and earth sciences

Pollution is one of the major problems facing us today. Understanding how contaminants make their way into the environment and how to counteract them can be a real challenge.

Some plants and microorganisms have a natural ability to absorb toxic metals from contaminated land and then deactivate them. Diamond will help researchers to understand how this happens and to identify organisms that target specific types of contaminant, opening up cheap and effective ways of cleaning up polluted land.


DESY/SPL

Synchroton radiation was used to determine the structure of this virus particle — a pathogen which causes bluetongue, a serious disease in cattle and sheep

Synchrotron light has already helped scientists to understand the mechanisms and chemistry behind high levels of arsenic in Asian wetlands and pollutants in Pacific Ocean corals.

***David Sang** writes textbooks and is an editor of* CATALYST.

- **Find out more about the Diamond Project and watch its progress on a webcam on its website (www.diamond.ac.uk).**