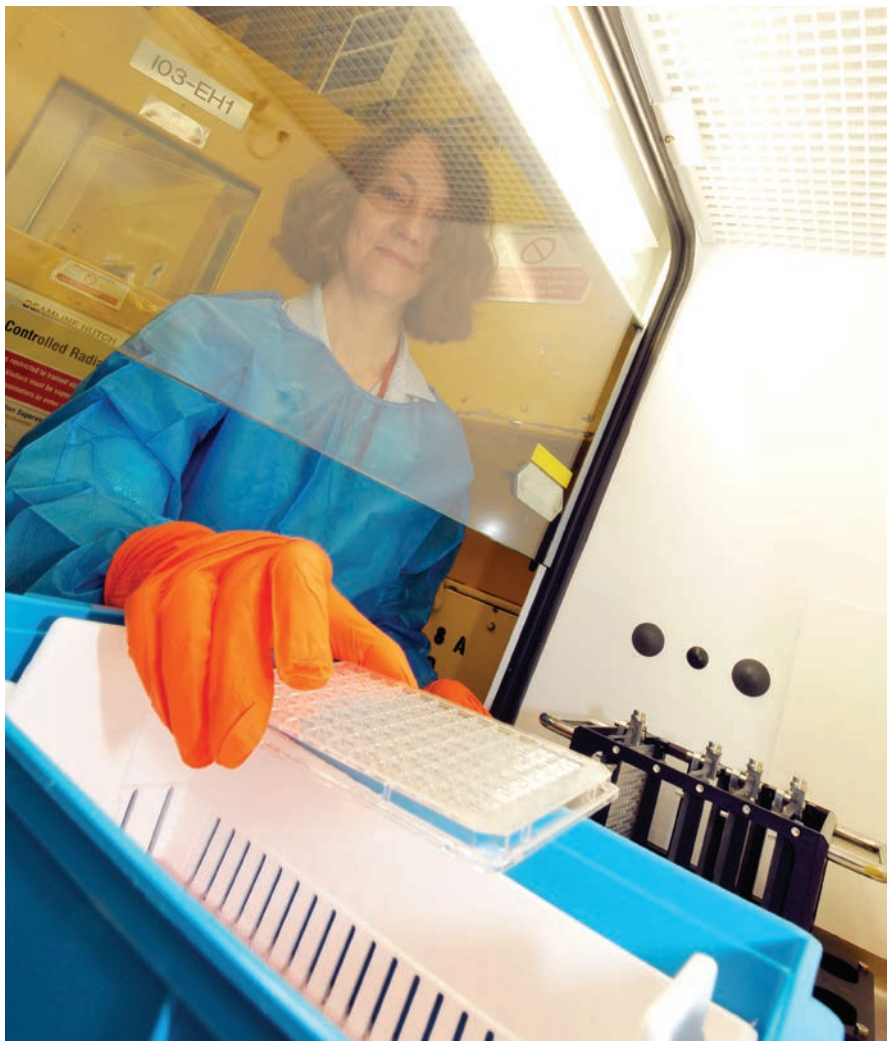
JOEL TEM at Diamond's Electron Physical Sciences Imaging Centre (ePSIC)

Steve Pritchard, Senior Press Officer, Diamond Light Source

Diamond is the UK's synchrotron facility, accelerating electrons to near light speed causing them to emit light 10 billion times brighter than the sun. The light is directed into laboratories known as 'beamlines' where researchers study a vast range of subjects, from new medicines and treatments for disease to innovative engineering and cutting-edge technology. Sited at the Harwell Science and Innovation Campus in Oxfordshire, UK, Diamond is approximately the same size as Wembley Stadium, employs over 600 staff and has welcomed 10,000 users.

2017 marks an exciting double anniversary for Diamond Light Source, the UK's national synchrotron science facility. Fifteen years since the joint venture agreement between the Science and Technology Facilities Council and the Wellcome Trust was signed bringing the company into being, it's also ten years since we welcomed our first users to the facility. Pic 1 or pic 5 depending on info box

However, time (and science) stands still for no one, and over the next decade Diamond will implement a strategy to sustain the facility as a world-leading centre for synchrotron science supporting UK research and industry, and users from around the world. But first, and as we recently celebrated the publication of the 5,000th paper using data from the facility, it seems only right to look back at some of the key highlights and milestones from the last ten years.



Dr Katherine McAuley using the category 3 facility on the I03 beamline.

Dedicated Facility

Synchrotrons such as Diamond have been long associated with particle physics, with the Large Hadron Collider (LHC) at CERN still prominent in the news today. Harnessing the light produced by electrons as they race round a synchrotron – initially seen as a by-product of particle-collider machines – is a relatively new idea, with the UK leading the way building the first user-dedicated facility in 1980. These bright beams open up new areas for investigation across a wide range of sciences, with applications in engineering, health and medicine, cultural heritage, and many more.

Diamond works across virtually all fields of research; our first users were studying topics as diverse as magnetism, proteins found in our cells, and the composition of a meteorite! One of those first users, Professor David Stuart, is now our Director of Life Sciences and has harnessed the power of Diamond to research the structure of viruses and proteins that interact with viruses – opening new avenues for research in the fight against diseases like foot-and-mouth disease virus (and its human variant) and influenza.

Biosciences Research

Much of our work in the last ten years has been in the biosciences, with the light produced at Diamond particularly suited to imaging proteins and viruses and previously unprecedented resolution. Many of our users are interested in the processes and symptoms of diseases such as Alzheimer's and cancer that will affect the majority of us or our family in our lifetimes. Researchers from the University of Keele used data gathered in part at Diamond to show that brain lesions caused by Alzheimer's disease could be the source of a neurotoxic form of iron. They hope that their research will help further studies into better diagnosis tools and treatments.

Many of our users work using the broad range of beamlines that form our macromolecular crystallography (MX) 'village'. These beamlines offer a range of specialities and are capable of determining the three dimensional structures of large biological beamlines. In 2013, scientists from the Universities of Oxford and Reading, The Pirbright Institute, and Diamond created a prototype vaccine for the foot-and-mouth disease virus using beamlines from across the MX village. Using facilities including our I03 beamline, which can be configured for biocontainment level 3, the new synthetic vaccine, currently undergoing clinical trials, contains no live virus, making it safer, and it is engineered to stay stable outside a refrigerated environment – enabling prevention the world over.

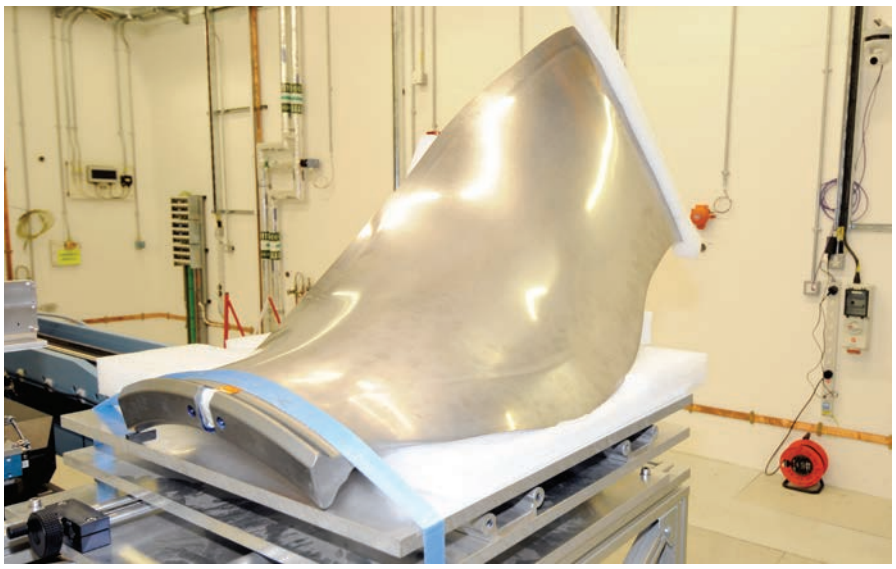
One of the strengths of the beamlines at Diamond is the flexibility of the beamlines scientists, who are able to tailor their instruments to probe a variety of subjects. One such example is one of spectroscopy beamlines, I18, where researchers have worked on topics as varied as the structure of wheat grains to new catalysts and historical artefacts. Using complementary X-ray fluorescence (XRF) and X-ray absorption spectroscopy techniques, researchers from Rothamsted Research were able to gain new insights into the distribution of different mineral components in wheat grains. Their research will help efforts to develop new grains which retain key minerals such as iron and zinc, helping to prevent a variety of chronic health problems including cardiovascular disease and Type 2 diabetes.

The very same beamline was used in conjunction with two other beamlines at the facility to help conservationists involved with the preservation of the Tudor warship Mary Rose. Working closely with the Mary Rose Trust and our close neighbour pulsed neutron and muon source, ISIS, we've helped to identify the efficacy of a treatment to prevent the decay of the wooden ship, caused by interactions between sulfur picked up from the sea bed and iron elements of the ship.

Studies in Materials Science

In our Engineering and Environment Village researchers are also increasingly looking to use the physical sciences tools across a range of problems. On the I11 Powder Diffraction beamline, users are able to investigate a range of materials in situ and recently the beamline has supported work into new lithium-ion battery materials. The beamline also is being used for our first ever citizen science project, Project M, where secondary school students from 100 schools from across the UK will grow calcium carbonate samples that will be analysed in a 24-hour period.

Another beamline in this area is our Joint Engineering and Environmental Processing (JEEP) beamline, I12. Offering environments that allow users to study scientific problems in very close to real-world settings, it is our highest energy beamline. With a unique ability to penetrate samples of significant thickness, it enables researchers can perform investigations into a process without having to scale it down.



Fan blade from Rolls-Royce engine on the JEEP beamline, I12.

Engineers from Rolls-Royce were the first to use this beamline, a prime example of where Diamond partners with industry to help advance technological capabilities. Rolls-Royce were interested in testing coating on the fan blades of their Trent 1000 engine used to power the Boeing 787 Dreamliner, and gifted Diamond one of the blades which now takes pride of place outside our control room. More recently, the beamline was used to image bone samples at high resolution – an idea that originated from a researcher touring the facility whilst working on another beamline and seeing a potential application for their research.

HRH The Princess Royal with Professor Andrew Harrison,CEO, Diamond Light Source at the launch of the VMXi beamline

Whilst Diamond is free at the point of access to any researcher who will published their work in a peer-review journal, the facility has also welcomed almost 100 different companies to carry out proprietary projects.

These users often enjoy the complementary nature of the beamlines at Diamond, with the global speciality chemicals company, Johnson-Matthey, long-standing users on I18, also being the first users on our hard X-ray nanoprobe beamline, I14. They've also sited an high-tech electron microscope same building alongside Diamond's electron Bio-Imaging Centre (eBIC) and electron Physical Sciences Imaging Centre (ePSIC), as Diamond becomes a world centre for excellence in nanoscale imaging.

In February this year, HRH The Princess Royal unveiled a new Versatile Macromolecular Crystallography in situ (VMXi) beamline, which is currently the only one of its kind worldwide. The beamline is solely dedicated to in situ X-ray measurements and has the capacity to store and carry out thousands of user crystallisation experiments under one roof. As a result, scientists will also be able to examine crystals at a much earlier state than previously possible and Diamond will be able to deliver increased capacity to researchers.

Overhead view of Diamond and the Harwell Science and Innovation Campus, Oxfordshire, UK

User Flexibility

Whilst users at Diamond are able to stay on the campus and can be provided with laboratory space adjacent to the beamline they are working on, automation and remote access is driving many of our developments in the next few years. Users are increasingly able to use the facility via 'remote access', ensuring they can select samples of interest remotely and investigate the data whilst still continuing their daily roles in their home institutions.

Our staff are all extremely proactive and know the importance of continuously developing over the next ten years to maintain our place as a world-class facility. Our Phase III plans will see the number of operational beamlines rise from 28 at present to 33 by 2020. We also want to maintain links with the facilities across the Harwell Science and Innovation Campus and our aim is to make Diamond a cornerstone the campus as it continues to be a site for scientific discovery and innovation.

Phase III will involve a range of upgrades to our facilities, from the storage ring through sample preparation and handling, to detectors for upgraded beamlines and dauntingly large volumes of data. The balance of roles and organisation of the staff at Diamond will also evolve as we embrace a wider range of skills required to support science that is even more diverse as well as technical developments.

We firmly believe that synchrotron science can continue to support excellent research and innovation from science and industry, and believe that our can have societal benefits to us all, addressing the environment and more efficient energy devices, to the healthcare issues affecting billions of people.

All pictures Credit: Diamond Light Source