CCLRC

ISIS 2004 Review of the Year

ISIS

ISIS*2004* Review of the Year

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ISIS 2004 Review of the Year

Review of the Year

ISIS provides world-class facilities for neutron and muon investigations of materials across a diverse range of science disciplines. This part of ISIS 2004 details the work of the facility over the past year, including accounts of science highlights and descriptions of major instrument and accelerator developments, together with progress on the Second Target Station.

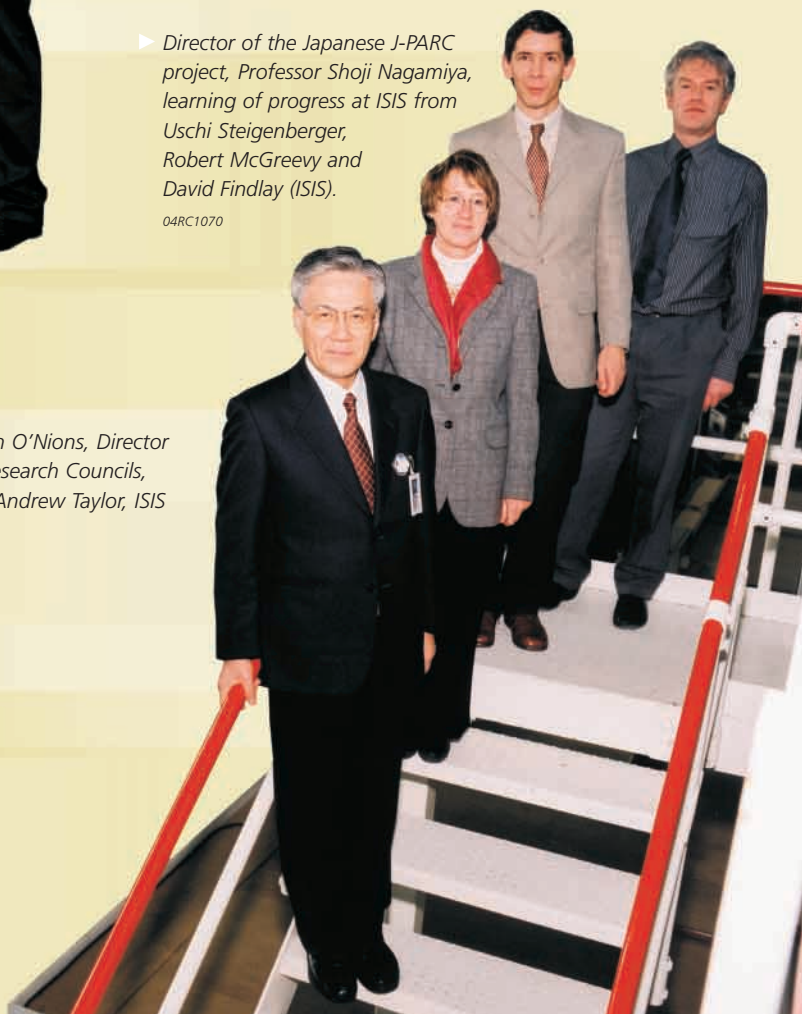
Contents

▲ *Professor A De Maio, former President of the Italian CNR (right), and Professor M Fontanesi, Rector of the Università di Milano Bicocca (left) with Professor John Wood, Chief Executive of CCLRC, during the signing of a Memorandum of Understanding for collaboration on the development of new technologies and instrumentation. Italian scientists have made major contributions to several ISIS instruments, including PRISMA, MuSR, EMU, TOSCA, VESUVIO, and looking to the future, NIMROD on ISIS's Second Target Station which should be available in 2008.* 04RC2241

▲ *Mr Dipesh Shah, Chief Executive Officer of UKAEA, touring ISIS with Andrew Taylor, John Wood and Mike Johnson (Director, Instrumentation Department).* 04RC2570

▲ *Professor Gonzalo Leon (Madrid, Spain), Professor Jose-Luis Martinez (ICMM, Madrid) and Professor Jose Gomez-Sal (University of Santander, Spain) visiting ISIS with John Wood, Andrew Taylor and Roger Eccleston.* 03RC3481

▶ *Director of the Japanese J-PARC project, Professor Shoji Nagamiya, learning of progress at ISIS from Uschi Steigenberger, Robert McGreevy and David Findlay (ISIS).* 04RC1070



◀ *Professor Sir Keith O'Nions, Director General of the Research Councils, visiting ISIS with Andrew Taylor, ISIS Director.* 04RC2396

Foreword

Celebrating Twenty Years of Excellence!

On 16th December 2004 at 19:16 we will celebrate the 20th Anniversary of first neutrons at ISIS.

Such milestones provide an opportunity to look back and reflect on the considerable achievements of both the ISIS facility and its user community, and to look forward to the future. ISIS has been a remarkable success. Scientifically, it has enabled researchers world-wide to make advances in an ever-widening range of scientific disciplines. Technologically, it has set the direction that future neutron sources are now following.

Our long shutdown of summer 2004 has seen much activity. The ageing Cockroft-Walton pre-injector which for 20 years has been our source of 665 keV H^- ions has now been replaced by a 21st century device – the radiofrequency quadrupole. The risks of this bold upgrade were mitigated by an 18 month campaign on a test stand – but congratulations are nevertheless in order to the entire linac team for a job well done. Likewise ISIS now boasts 4 additional rf cavities in the synchrotron itself, operating at twice the fundamental frequency. These 'dual harmonic' devices are designed to increase proton trapping efficiency, minimising losses and activation in the ring and leading to increases in both intensity and reliability in due course. Again congratulations are in order for the entire synchrotron team. In the target area, the beryllium reflector system has been rebuilt both to take the higher intensity expected from the dual harmonic upgrade, and to provide an optimum moderator for our newest chopper spectrometer MERLIN, which is fast taking shape on the south side of the ISIS experimental hall.

The shutdown also provided an opportunity to maintain and upgrade the neutron instruments, and the muon beams have emerged with a new intermediate target and a new enhanced detector array for MuSR. A major focus of activity has been the specification and design of the initial instrument suite for the Second Target Station. Attracting funding from the UK, Europe and the EU, these state-of-the art instruments will keep ISIS competitive especially in the growth area of nanoscale science. Facility development grants are also being channelled to keep our existing neutron and muon instrument suite at the cutting edge.

Lord Sainsbury (left) with ISIS facility Director Andrew Taylor. Announcing funding for additional ISIS Second Target Station and DIAMOND instruments, Lord Sainsbury said, 'The ability to look deeper into matter is fundamental to achieving new breakthroughs in many areas from medical treatment and drugs to understanding the origins of our planet'.

Diamond is fast taking shape at the east end of the RAL site and is now recognisable as a synchrotron light source. Soon work will begin on the instrument hall for the ISIS Second Target Station at the site's west end, with both projects aiming for science in 2007. It was particularly gratifying that Lord Sainsbury, the Minister for Science and Innovation, was able to announce additional funding for instrumentation on both facilities when he inaugurated the Diamond booster tunnel in early October. We look forward in hope to a future announcement funding the Research Complex at RAL for the benefit of both communities.

A year around ISIS

▲ *An old friend of ISIS, Dr B A Dasannacharaya (formerly of BARC, India), delighted to hear of recent progress at the facility from Director Andrew Taylor.* 03RC3420

▲ *Michelle Tam, Fay Smallwood, Edwina Glennie, Alison Ho and Catie Gladstone from Downe House School visited ISIS in March as part of the Oxford Particle Physics Masterclass.* 04EC1563

▲ *ISIS is now officially recognised by the Guinness Book of World Records as the world's most powerful pulsed spallation neutron source. Ian Gardner, former Head of the ISIS Accelerator Division, receives the certificate from David Hawksett, Science and Technology Editor, Guinness World Records.* 04EC1836

◄ *Dr Yoshimi Matsuzaki (JAERI, Japan) visiting the ISIS Second Target Station site with Andrew Taylor.* 03RC3225

► *CCLRC Council members visited ISIS in October. From left to right: Ms Anne Kensall (business advisor), Professor Peter Gregson (Deputy Vice-Chancellor, University of Southampton), Professor Mike Cruise (Pro-Vice-Chancellor, University of Birmingham), Professor Graham Davies (Head of the School of Engineering, University of Birmingham).* 03RC3394

▲ *Alex James, bass-player from supergroup Blur, visited ISIS with his father during a tour of RAL. Blur composed a piece of music for the Beagle 2 mars lander, part of the Mars Express mission which involved the RAL Space Science Department. Roger Eccleston (ISIS) is describing how the facility works.* 04EC2158

ISIS Facility Access Panels

The ISIS Facility Access Panels (FAPs) are comprised of some 70 international experts, and twice per year meet over two days to review all beamtime proposals submitted to the facility.

▲ *Roger Cowley (Oxford University) chairing the Excitations Panel.* 04RC2455

◀ *Javier Santisteban (Open University), Gerry Swallowe (Loughborough University) and Ru Lin Peng (Uppsala University), members of the Engineering Panel.* 04RC2426

▲ *Pam Thomas (Warwick University) discussing Crystallography proposals.* 04RC2469

▶ *Clive Washington (AstraZeneca) with John Tomkinson (ISIS).* 04RC2416

▲ *The Disordered Materials Panel hard at work.* 04RC2473

▶ *Clemens Ritter (ILL) examining proposals.* 04RC2466

Highlights of ISIS science

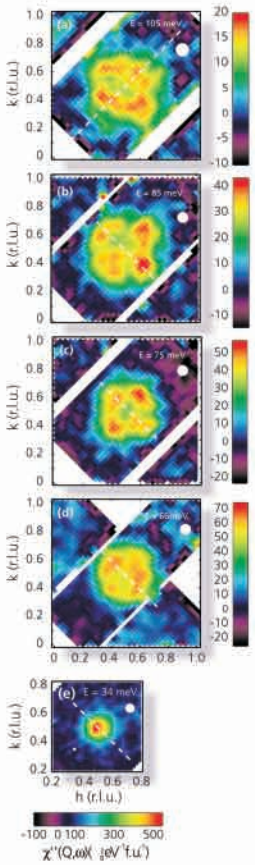
The advanced facilities provided by ISIS enable world-class research to be performed by scientists from around the world, together with facility staff. Academic and industrial applications of the intense neutron and muon beams encompass a very broad range of science areas. Presented in the following pages are brief summaries of recent scientific highlights; more detailed accounts can be found in the highlight article sheets accompanying ISIS 2004.

Superconductivity and magnetism

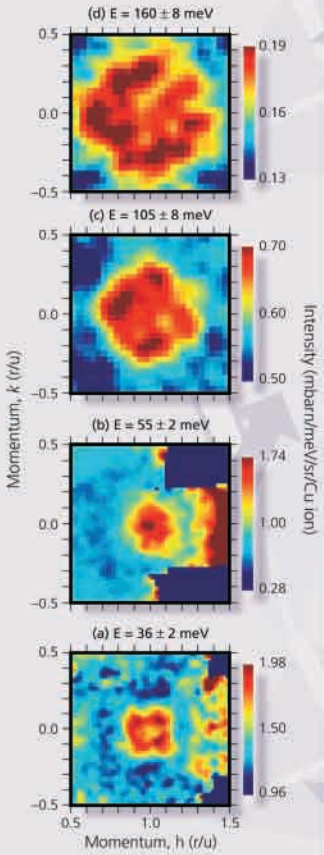
The mechanism of superconductivity in high-T_c materials

Despite almost 20 years since the discovery of superconductivity in layered copper oxide compounds – the so-called high-T_c materials – the precise mechanism responsible for their superconducting behaviour is still to be revealed. In conventional superconductors, attractions between electrons mediated by lattice vibrations have been known to be responsible for the superconducting properties for a long time. But this mechanism cannot explain high-T_c behaviour. The parent compounds of the copper oxide superconductors are all insulators which show antiferromagnetism. As these compounds are doped to produce superconducting material, this antiferromagnetism is lost. Some magnetic fluctuations continue to exist, however, and it is possible that these play an important role in the mechanism of high temperature superconductivity. One key to demonstrating whether this is the case is the identification of features in the magnetic excitations that are common to the different families of high-T_c materials.

Inelastic neutron scattering can be used to study the magnetic fluctuations in these materials, something that the MAPS spectrometer at ISIS is specifically designed to do. Recently, two separate groups have used the instrument to study the magnetic behaviour in two different high-T_c materials. Hayden et al have explored $YBa_2Cu_3O_{6.6}$, looking in detail at the pattern of magnetic excitations as a function of excitation energy and temperature. They found a particular form of high-energy excitations characterised by a square structure in reciprocal space. Tranquada et al investigated $La_{2-x}Ba_xCuO_4$ with x=1/8. In high energy excitations they found a structure remarkably similar to that seen by Hayden et at in the $YBa_2Cu_3O_{6.6}$ material, perhaps pointing to universal features in the magnetic excitation spectrum of these copper oxide materials. The interpretation of these results, in terms of the underlying superconductivity mechanism, remains a topic of discussion, but it is hoped that these discoveries will lead to a new level of understanding of how these superconductors work.



Images of the magnetic scattering in $YBa_2Cu_3O_{6.6}$ for various energy transfers at 10K.



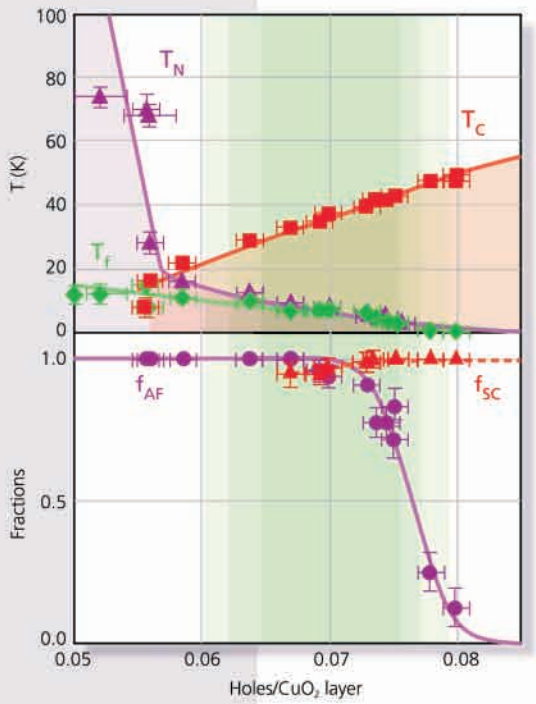
Magnetic scattering from $La_{2-x}Ba_xCuO_4$ with x=1/8 at 12K.

***'The structure of the high-energy spin excitations in a high transition temperature superconductor'**, SM Hayden et al., ISIS 2004 Highlights*

***'Quantum magnetic excitations from stripes in a copper oxide superconductors'**, JM Tranquada et al., ISIS 2004 Highlights*

Muons as probes of magnetism and superconductivity in high-T_c materials

Muons also provide a very useful probe of magnetic and superconducting materials, and have been used to explore the coexistence of magnetism and superconductivity in high-T_c superconductors. The frequency of the muon spin precession is proportional to the local magnetic field intensity experienced by the implanted muons. Where antiferromagnetic order exists, a net magnetic field is produced at the muon site which can be seen through the muon response in zero applied magnetic field. For a superconducting state, application of a magnetic field produces a particular distribution of internal fields which again can be detected by implanted muons. Through observation of these different responses, muons have been used to map out the phase diagram of $YBa_2Cu_3O_{6+x}$ samples as a function of x, allowing the disappearance of magnetism and the onset of superconductivity to be seen. In combination with susceptibility measurements, the coexistence of these two behaviours over a range of x values has been observed, and explained by a model involving the existence of magnetically-ordered regions within superconducting material.

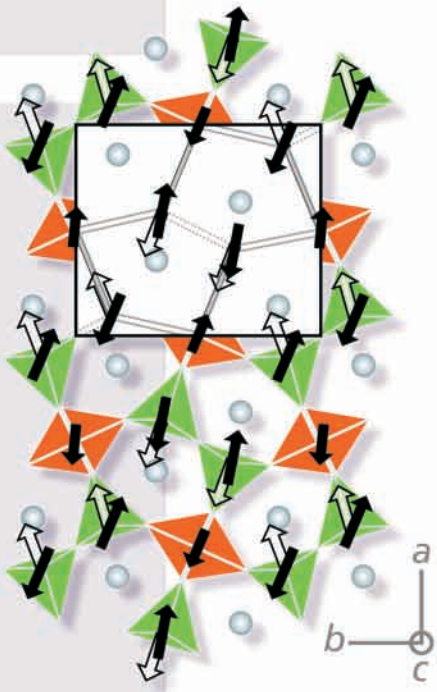


Phase diagram of $YBa_2Cu_3O_{6+x}$ produced using implanted muons, together with the fraction of muons experiencing a magnetic or a superconducting environment.

***'Coexistence of magnetism and superconductivity in $YBa_2Cu_3O_{6+x}$ studied by muons'**, S Sanna et al., ISIS 2004 Highlights.*

Diffraction studies of magnetic and electrical ordering

Ferroelectricity is the effect whereby an ionic crystal may show a spontaneous dipole moment, in a similar fashion to a ferromagnetic material exhibiting a magnetic moment. Whilst the coexistence of ferroelectricity with ferromagnetism is rare, systems where magnetic and electric ordering effects are coupled – so-called magnetoelectric multiferroic materials – are more common. However, understanding the atomic-level mechanisms behind multiferroic behaviour is challenging. Recent work on $TbMn_2O_5$ is helping provide insight into the correlation between ferroelectricity and magnetism. $TbMn_2O_5$ is a structurally complex material that has a rich magnetic phase diagram. The GEM and SXD diffractometers have been used to explore changes in the magnetic structure and in the atomic displacements as a function of temperature, and these effects can be correlated with anomalies in the dielectric constant and electric polarisation. It has been shown that magnetic frustration due to competing interactions between Mn ions is key to understanding the links between magnetism and ferroelectricity in this material, and that independent ordering of both Mn and Tb ions plays a part in its ferroelectric behaviour.



Crystal structure of $TbMn_2O_5$, with atomic moments and displacements indicated.

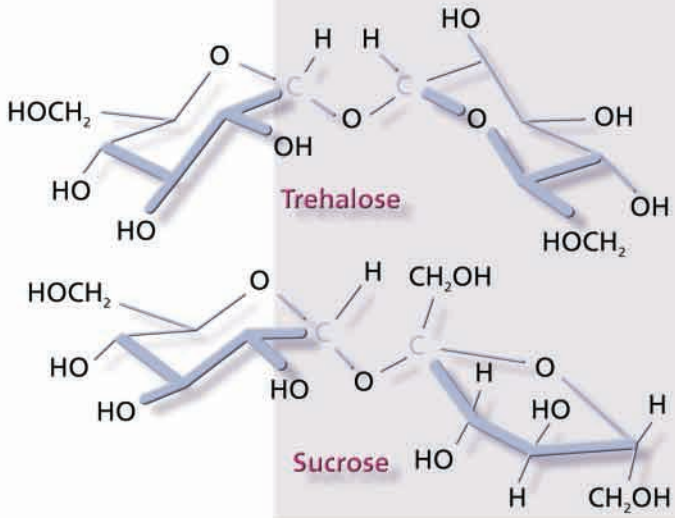
***'Competing magnetic interactions and ferroelectricity in $TbMn_2O_5$'**, LC Chapon et al., ISIS 2004 Highlights.*

Molecular and bio-molecular systems

Protection mechanisms for biomembranes

The disaccharide sugar trehalose seems to be unique in enabling living organisms to survive under conditions of dehydration or freezing without suffering loss of function. Despite its effectiveness, and the potential uses that this brings in the pharmaceutical industry and in the cryogenic protection of vaccines and transplant organs, the mechanisms for this behaviour are not understood. Characterisation at a microscopic level is necessary, particularly of how the molecules are moving and vibrating in the glassy state that trehalose forms below below 350 K. Neutron measurements on the OSIRIS spectrometer have enabled detailed studies of the dynamics of the disaccharides trehalose and sucrose above and below their glassy transitions, with results being compared with those from other sugars. It is found that those sugars which are effective bioprotectors have a characteristic molecular vibrational signal that can tell them apart from less effective molecules and which can help us to understand their bioprotective behaviour.

The disaccharide sugar bioprotectors trehalose and sucrose.

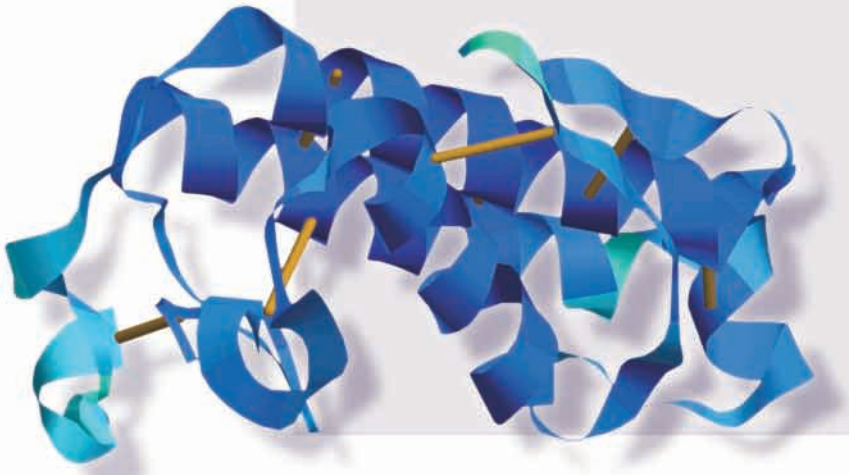


***'Sugar coating for protection of biomembranes'**, C Branca et al, ISIS 2004 highlights.*

Understanding the behaviour of cell membrane catalysts

Phospholipase A_2 (PLA_2) enzymes catalyse the hydrolysis of phospholipids, the main component of biological cell membranes. They occur in a wide range of biological environments, but, whilst their chemical action is well characterised, what controls their specificity and activity is not understood. To explore this further, neutron reflectivity has been used to study the interaction of PLA_2 with a supported phospholipid bilayer. The reflectivity technique is sensitive to the surface coverage of the phospholipid, and, with deuteration of the phospholipids, the amount of PLA_2 and its location at the interface with the membrane can be studied. By fitting the reflectivity results to calculations based on a model of the membrane-enzyme interaction, the behaviour of the PLA_2 as a function of time after addition was deduced. It was observed that the PLA_2 associates itself with the membrane during an initial penetration phase, followed by the start of hydrolysis leading to the membrane's destruction.

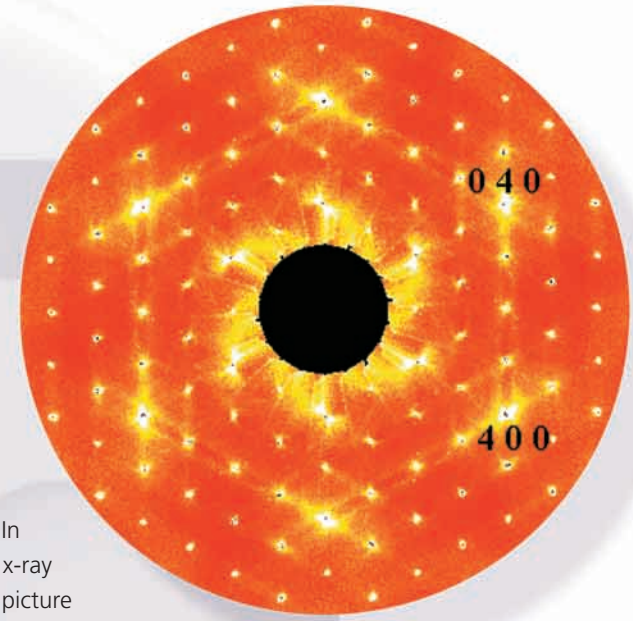
Structure of the bovine pancreatic phospholipase A_2.



***'Phospholipase A_2 hydrolysis of supported model membranes'**, HP Vacklin et al., ISIS 2004 highlights.*

Order from disorder: studies of benzil, $C_{14}D_{10}O_2$

Crystallographic studies using Bragg diffraction provide detailed information on the average structure of a substance at the atomic level. But the properties of many materials are controlled not just by their average structure, but by local deviations from this structure – disorder. In a neutron experiment, this disorder gives rise to diffuse scattering, observation of which gives insights into the ways atoms and molecules interact with each other. Described here are results of neutron diffuse scattering studies of the molecular material Benzil. These form part of a programme of neutron and x-ray investigations aimed at studying how molecular flexibility influences crystal packing and the formation of different crystal structures by the same molecule (polymorphism), of relevance to the pharmaceutical industry. The ISIS SXD instrument is ideally suited to diffuse scattering studies, and results from benzil single crystals have enabled observation of a previously-unseen molecular vibrational mode. In combination with x-ray results, a detailed picture of the atomic level behaviour of benzil is being built up.



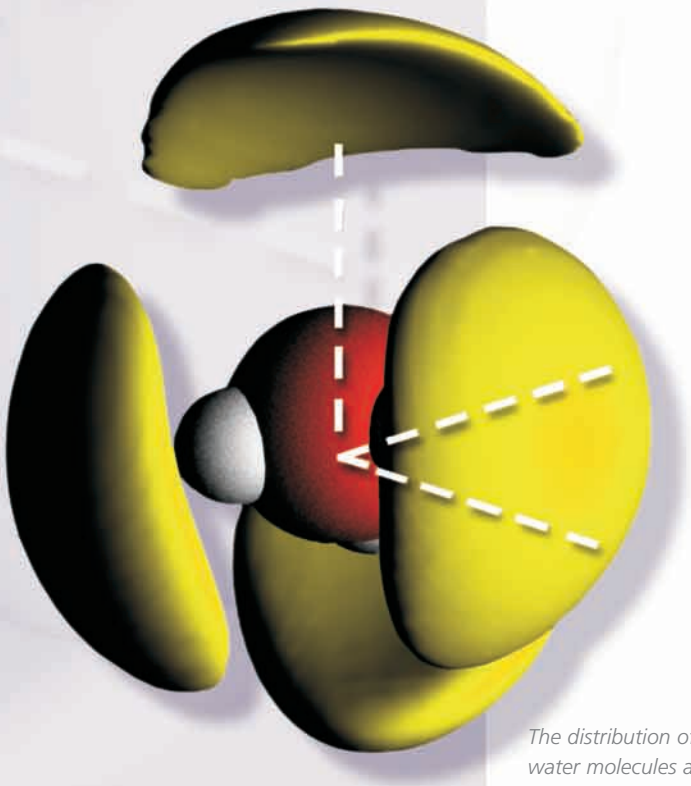
Diffuse scattering data from benzil taken on SXD.

***'Diffuse neutron scattering from benzil, $C_{14}D_{10}O_2$'**, Welberry et al., ISIS 2004 highlights.*

Neutron diffraction studies of local structure around water ions

Whilst there is no long-range structure within a liquid, short-range correlations between the liquid's molecules or atoms do exist and play an important part in determining the liquid's properties. Neutron diffraction can be used to explore these correlations and to build up models of average structures within liquids. In this example, a combination of neutron diffraction, isotope substitution and numerical modelling has been used to explore the local structure around OH^- and H^+ ions in water. This local structure is important owing to its role in proton transfer mechanisms which in turn affect many biochemical processes. A traditional view would have both ions surrounded by three water molecules. However, computer simulations and now neutron diffraction data, have shown that, whilst this is true for the H^+ ion, the OH^- ion is four-fold co-ordinated.

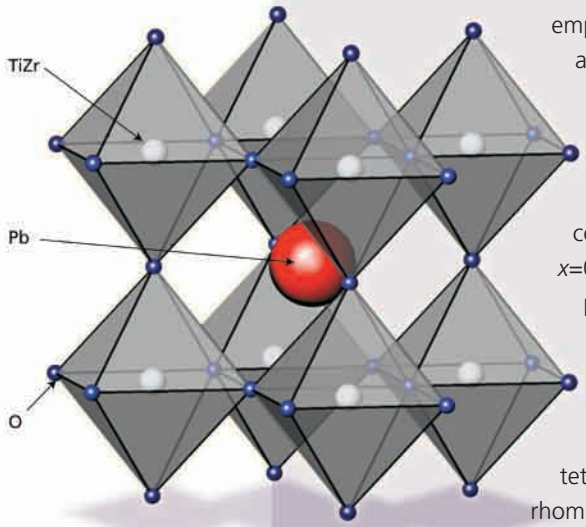
***'Solvation shell of OH^- and H^+ ions in water'**, A Botti et al., ISIS 2004 Highlights.*



The distribution of water molecules around a central H_3O^+ ion.

Advanced materials

High-pressure tuning of material properties for technological applications

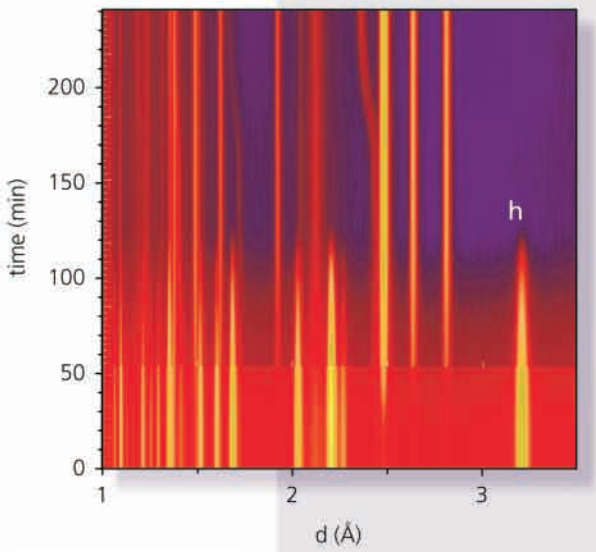


The ideal cubic structure for perovskite-type $PbZr_{1-x}Ti_xO_3$ materials.

Piezoelectric materials, which allow the interconversion of mechanical and electrical energy, have a wide variety of technological uses. Lead zirconate titanate (PZT, $PbZr_{1-x}Ti_xO_3$) is the most heavily employed, for example as an ultrasonic transducer in medical diagnostic applications. For compositions near x=0.48, its exceptional piezoelectric properties were originally attributed to a mixture of tetragonal and rhombohedral phases but, more recently, additional monoclinic phases have been identified. The present study has involved a neutron diffraction investigation of the structure PZT with x=0.60. It has been found that the application of pressure to this PZT composition results in the same monoclinic phases seen at low temperatures in material with x=0.48. Studies with varying pressure have allowed the mechanisms behind the exceptional piezoelectric response to be explored. The ability to control the phase diagram of this material using external pressure suggests that the control of the stress state of thin films of PZT may be used in a similar manner, to produce high-performance material for new applications.

***'Pressure-tuning of piezoelectric properties for technological applications'**, J Rouquette et al., ISIS 2004 Highlights.*

Hydrogen storage mechanisms explored



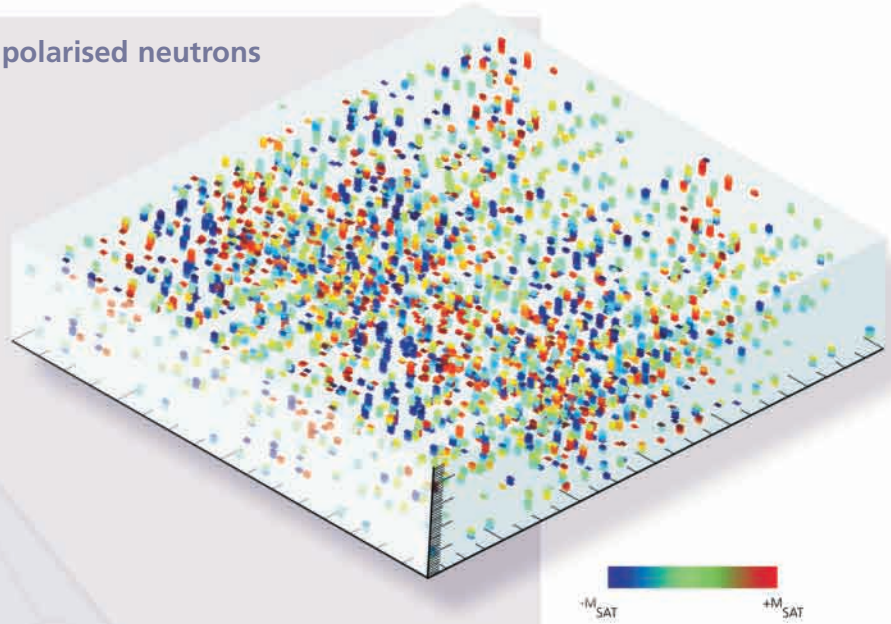
Diffraction patterns taken on the GEM instrument during desorption of deuterium from $MgNb_{0.04}D_2$.

There is much technological interest in developing methods for storage of hydrogen, particularly for use in power sources for a wide variety of applications. Mg is a promising candidate as a hydrogen storage material as it can absorb up to 7 wt%, but the bulk material has a slow hydrogen sorption rate. However, use of nanostructured Mg, as well as addition of catalysts such as V or Nb, can significantly increase the rate of hydrogen absorption. Neutron scattering has been used to explore in detail the mechanisms involved in hydrogen loading and unloading in this material. Time resolved, in-situ measurements have followed the roles of the various crystalline phases present and allowed their contributions to the hydrogen sorption process to be determined, shedding new light on hydrogen uptake processes.

***'Hydrogen sorption of Nb-catalysed, nanostructured Mg'**, FM Mulder et al., ISIS 2004 highlights.*

Nanomagnet behaviour studied using polarised neutrons

Data storage devices and other technologies are now employing magnetic materials with very different geometries from the standard, bulk magnets we commonly use. Magnetic thin films and nanostructured materials are finding uses in a wide range of applications. Understanding their magnetic behaviour, which can be very different from that of conventional magnets, is important for developing new applications. Neutron reflectivity has been used to characterise the properties of iron nanocubes, tens of nm in size, embedded in an insulating material. The reflectivity measurements were made using spin polarised neutrons, a technique well-suited to investigating the magnetic and structural depth profile in thin-film systems. Combined with numerical calculations, the technique has produced a more precise 3D picture of the magnetisation throughout the nanocrystal collection, allowing the interactions between the individual iron nanocubes to be studied.

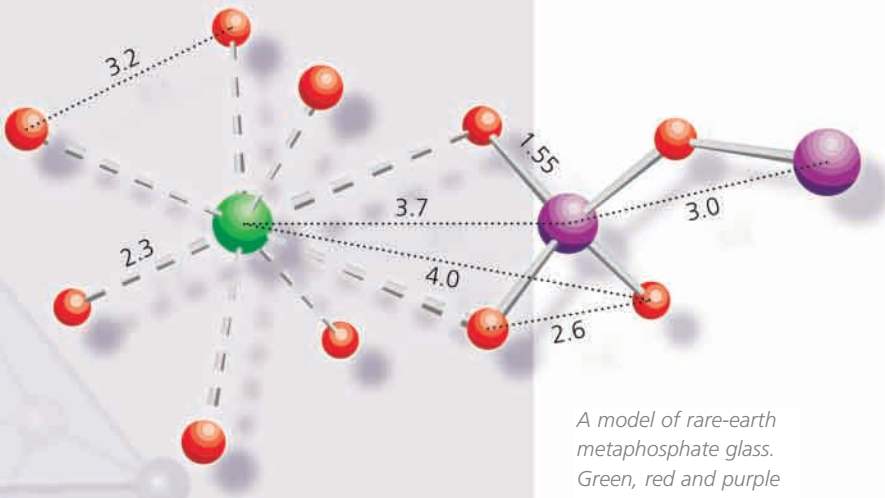


3D simulation of the magnetization for a collection of nanomagnets.

***'Magnetisation of a collection of nanomagnets'**, T Charlton et al., ISIS 2004 Highlights.*

Atomic structure of rare-earth phosphate glasses revealed on GEM

Rare-earth phosphate glasses have shown great promise in the laser and optoelectronics industries. Their optical and magnetic characteristics are affected by their atomic-level structure, and in particular the closest approach distance of the rare-earth ions. However, direct measurement of this distance has proved impossible by conventional techniques. Recently, the high count rates of the GEM diffractometer, together with application of fields of several Tesla, have enabled a unique magnetic difference method to be used to provide information on rare-earth separation distances in these materials. Measurements with and without an applied field enabled the contributions to the neutron diffraction pattern from the rare-earth ions to be isolated, revealing the shortest average rare-earth to rare-earth distance. The results indicate a homogeneous ion distribution with no clustering, also important information for optoelectronic applications.



A model of rare-earth metaphosphate glass. Green, red and purple circles represent the rare-earth, oxygen and phosphorous atoms respectively (distances in Å).

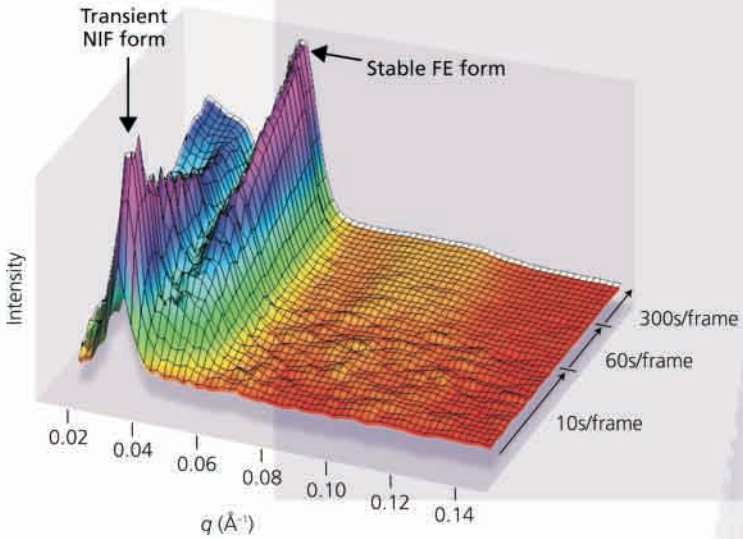
***'Magnetic differences on GEM – direct observation of closest R...R approach in rare-earth phosphate glasses'**, J Cole et al., ISIS 2004 Highlights.*

Bigger, faster and under pressure

Real-time studies of polymer crystallisation

Recent advances in neutron techniques have created opportunities for investigation of dynamic processes in real-time and in-situ. For example, Small Angle Neutron Scattering (SANS) measurements usually take minutes to hours to make, but recently it has been shown that useful SANS spectra can be recorded in seconds for some systems. This opens the way to using the technique for real-time studies, and the method has been demonstrated for the case of the crystallisation of long-chain linear alkanes. The complex nature of these molecules means that crystallisation can take place via metastable, transient states, an understanding of which is of potentially significant importance in industrial polymer processing. Two different theories had been proposed to explain the crystallisation mechanism via intermediate structures. SANS measurements, performed with frames as short as 10s, have been able to determine which theory is correct, paving the way for future dynamical studies of materials under plant processing conditions.

Real-time SANS spectra of a long-chain linear alkane during isothermal crystallisation at 110 °C.

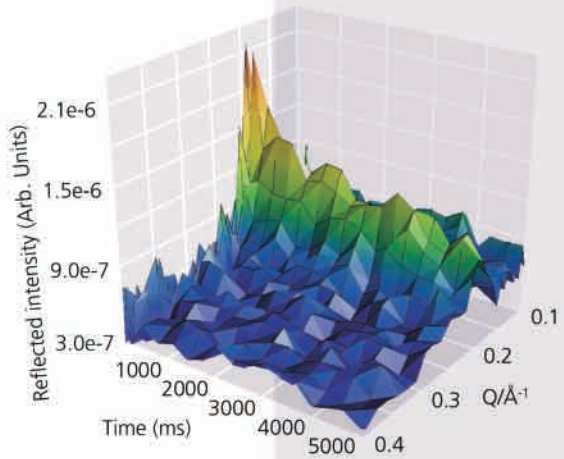


***'Real-time SANS study of transient phases in polymer crystallisation'**, XB Zeng et al., ISIS 2004 Highlights.*

Stroboscopic measurements of liquid crystal reorientation

Sub-second timescale neutron reflectivity measurements are now possible using stroboscopic techniques to probe non-equilibrium systems. In this case, an external stimulus can be applied to a sample which is synchronised to the ISIS 20 ms pulse structure. The technique has recently been demonstrated using a thin film of a liquid crystal. Many liquid crystals exhibit a nematic phase in which their rod-like molecules tend to order with their long axes parallel, together with layer formation over a short-range. This results in a diffuse scattering peak which can be used as an indication of molecular orientation. The direction of molecular alignment can be affected by application of either an electric or a magnetic field, and in the present experiment an AC field was applied to the liquid crystal layer either continuously or in pulses. The stroboscopic technique enabled reflectivity measurements to follow the time evolution of the molecular orientation after a 320 ms AC pulse. Demonstration of this method paves the way for future real-time reflectivity measurements on a variety of molecular and ionic systems.

The neutron reflectivity intensity from the nematic phase of a liquid crystal following application of a 320 ms AC pulse.



***'Time resolved neutron reflection from a liquid crystal'**, RM Dalgliesh et al., ISIS 2004 Highlights.*

Stress measurements on welded aircraft components

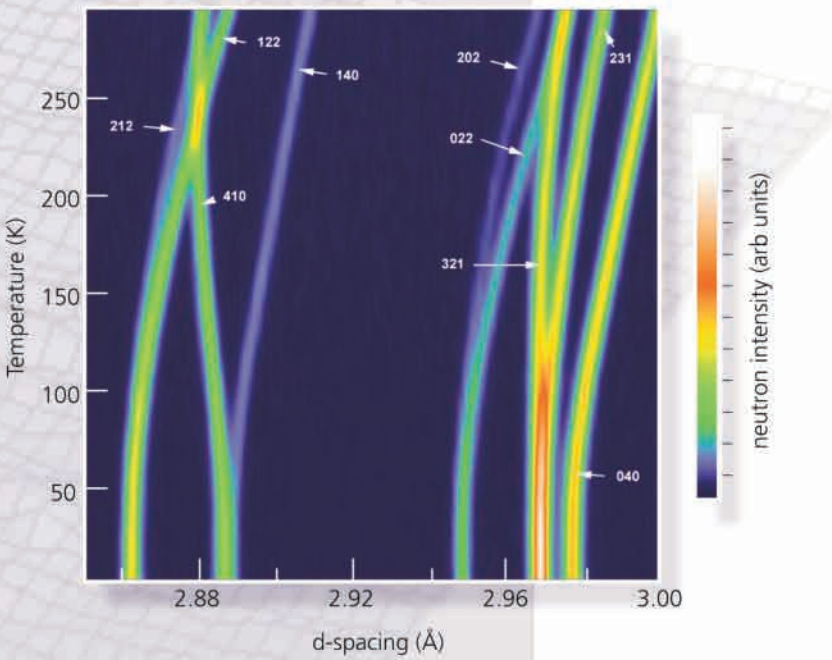
ENGIN-X, the neutron instrument designed for studies of stress in engineering components, is able to accommodate the largest samples studied at ISIS. It allows investigation of complex, fabricated components to provide detailed information on internal stresses that is difficult to obtain using small, laboratory-sized representative samples. An EPSRC programme involving AirbusUK, the Open University, Cranfield University and ISIS is using the technique to study residual stresses in structural-scale aircraft test panels. In this case, it is vital to understand how the stresses that exist following component welding affect fatigue crack growth. ENGIN-X is proving particularly valuable as the residual stresses measured in small, laboratory weld specimens do not necessarily represent those seen in larger welded structures. The instrument now has facilities to produce a 3D computer representation of a sample for the planning and execution of measurements, including calculation of measurement positions and exposure times.

A structural-scale aircraft test panel in place on the ENGIN-X instrument.

***'The determination and consequences of residual stress on the fatigue performance of welded aircraft structures'**, L Edwards et al., ISIS 2004 Highlights.*

Modelling planetary interiors

The ability to perform neutron investigations of materials under a variety of pressures and temperatures enables their properties in unusual environments to be explored. For example, if we wish to understand the internal structure and dynamics of planets and moons in our solar system, it is important we know how their components behave under the relevant conditions. The large, icy, Galilean moons of Jupiter are believed to have mantles containing $MgSO_4$ salts, including Epsom salt ($MgSO_4 \cdot 7H_20$), yet almost nothing is known of the physical properties of these salts under conditions other than ambient temperature and pressure. Gas pressure cells on the HRPD diffractometer have been used to study these materials under high pressures and low temperatures, enabling crystallographic behaviour and thermoelastic properties to be determined. These results, together with future work exploring other aspects of the behaviour of these salts, provide valuable information for the modelling of planetary interiors and have applicability to other scientifically and economically important mineral species.



Temperature dependence of the diffraction pattern of deuterated Epsom salt recorded on HRPD at ambient pressure.

***'Epson salts on the moons of Jupiter'**, AD Fortes et al., ISIS 2004 Highlights.*

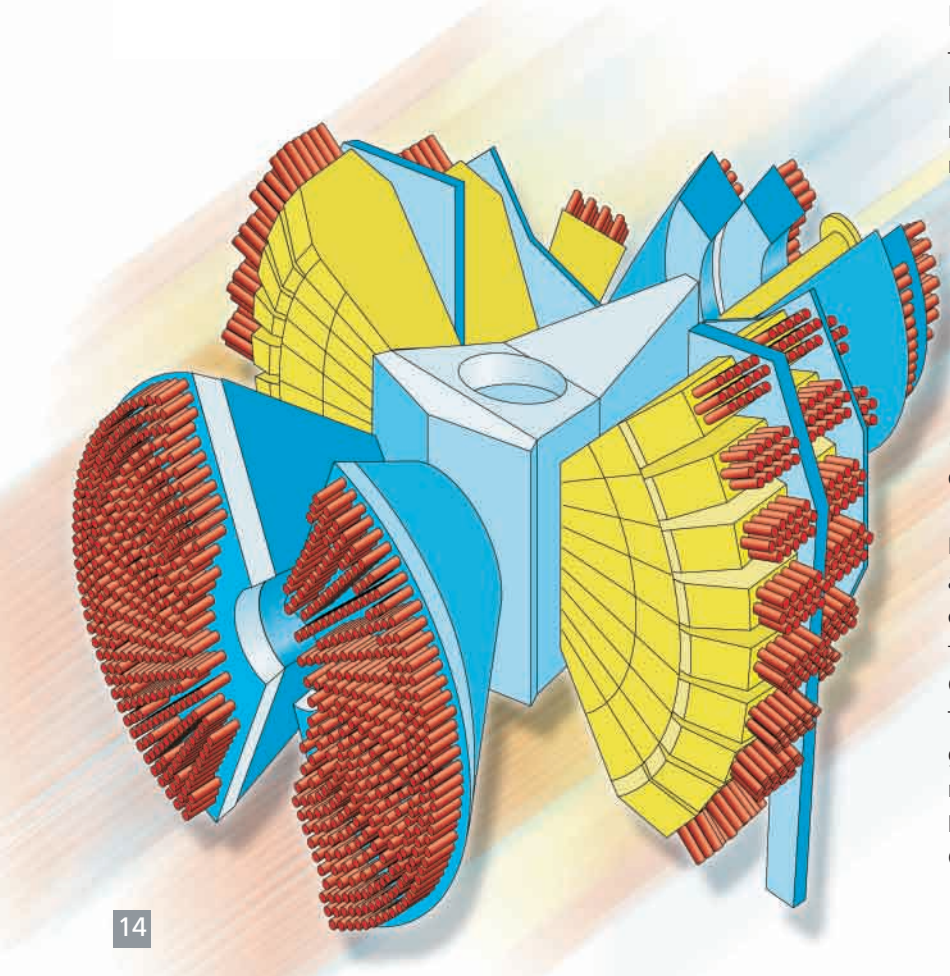
Instrument developments

Development at ISIS is a continuous process, driven both in response to the changing needs of the user community and to maintain ISIS as a world-class neutron and muon source. Evolution of the existing instruments, and design and construction of new ones, open up fresh opportunities for materials investigations. Some of the major improvements over the past year on First Target Station Instruments are described here.

GEM

The period of detector installation, testing and commissioning on GEM is now over. The most recent addition, an extra 30% detector solid angle at 90° scattering angle, is now complete and operational, with all the remaining banks running reliably. The grant to complete the GEM detector array is finished, and the remaining work, namely to install a lifting mechanism on the oscillating radial collimator, is being carried out at the time of writing. GEM is now heavily in demand by the user community, with beamtime heavily contested at the Facility Access Panels. It is clear that the present instrument cannot cope adequately with the user demand and the starting of the Second Target Station will open up opportunities for revamping the diffraction suite at ISIS as a whole.

The GEM instrument.



MERLIN

MERLIN will be a high count rate, medium resolution, chopper spectrometer, with a very large solid angle of detectors covering nearly 180° in the horizontal plane and ±30° in the vertical plane. This large solid angle and the incorporation of supermirror guides will mean that MERLIN will have a count rate some thirty times that of HET. Installation of the instrument is taking place at present, with the beamstop now in place and the front end shielding and glass guides currently being installed. The 3 m long position sensitive detectors have been ordered and MERLIN will begin operation with a detector coverage of 70%. The project is scheduled to finish around July 2005 with a period of commissioning to follow.

LOQ, CRISP and SURF

Though the multiwire area detector installed on LOQ in Spring 2001 continues to work well, a realtime data logging system was installed to monitor performance. Some temperature-induced efficiency variations have been noted and, though it is not clear that much can be done to alleviate the problem in the current Experimental Hall, the information gleaned is informing the design of the Second Target Station SANS instrument.

Devinder Sivia from ISIS has made a long-overdue enhancement of COLETTE (the SANS data reduction program), including colour data display and an increased number of output formats.

On the Sample Environment front, the Plate-Plate Rheometer funded by an EPSRC grant awarded to Nigel Clarke at Durham has completed its first experiment. Crevice corrosion is forcing the early retirement of the SANS Pressure Cell but a replacement is in design. A SANS Temperature-Jump Apparatus from Julia Higgins' group at Imperial College has also been given a new lease of life following upgrades to the LOQ Data Acquisition Electronics and Instrument Control Program.

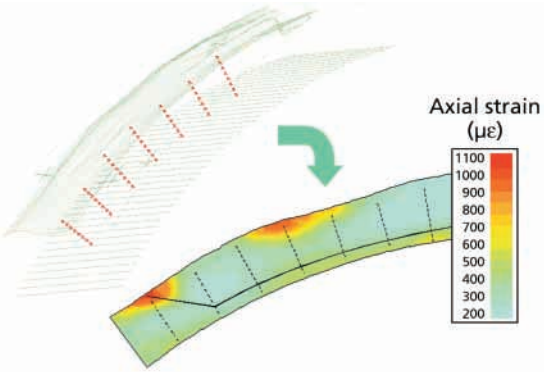
Tim Charlton (ANL, ISIS) and Phil Taylor (ISIS) with the CRISP MOKE.
04EC2971

The polarisation analysis capability of CRISP continues to be developed with the commissioning of a new analyser mirror assembly. This device will allow polarisation analysis of off-specular neutrons, enabling the in-plane magnetic structure of thin films to be probed in greater detail than is currently possible. In addition, a new Magneto Optical Kerr Effect (MOKE) device is about to be commissioned in order to enable the magnetic hysteresis loops of samples to be measured in-situ. The SURF motor drive electronics have been replaced with a more modern and flexible system, and this is likely to be duplicated on CRISP in due course.

Engineering

ENGIN-X has been dedicated to the engineering user programme for a full year. The capacity for mapping stresses in large components has been fully exploited, with experiments being completed on samples of up to 300 kg mass and 2 m in length. Complex sample environments have featured, such as investigation of stress generation in-situ during TIG welding. In-situ testing facilities are also in high demand, and the 50 kN stress rig is now requested for more than one third of all experiments. Several experiments have been completed on single crystals, including demonstration of a new method using the transmission technique.

Development has continued apace on the automation of strain scanning procedures. January saw the delivery of the new coordinate measurement machine (CMM), equipped with laser scanning head, which enables the exact shapes of samples to be scanned prior to allocated beamtime. This generates a computer model of the sample which can be incorporated in a virtual representation of the beamline for automation of all stages of the experiment. Also recently delivered is a new rotary positioning device (cyclamen manipulator) which will greatly extend the flexibility in sample positioning.



SSCANSS (Strain SCANning Simulation Software) is improving the quality and efficiency of strain scanning on ENGIN-X. The figure shows the planning of measurement points around the complex surface of a repair weld, and results plotted on a true representation of the surface profile.

e-VERDI

The EC-funded e-VERDI project, in collaboration with the universities of Rome, Milan and Kent, aims to develop a very low angle scattering capability for VESUVIO, so that low momentum transfers ($1 < q < 10$ Å^{-1}) and high energy transfers ($1 < \omega < 5$ eV) can be accessed. This should enable the first neutron measurements of very high energy magnetic excitations. Eventually the Very Large Area Detector (VLAD) bank will cover the angular range 1°-5° at a distance of about 2 m from the scattering sample. The VLAD detectors, together with high angle detectors used for the study of momentum distributions, will access a unique range of (q,ω) space. The University of Milan are developing new detectors for the VLAD bank, based on the resonance detector technique, and early results are very encouraging.

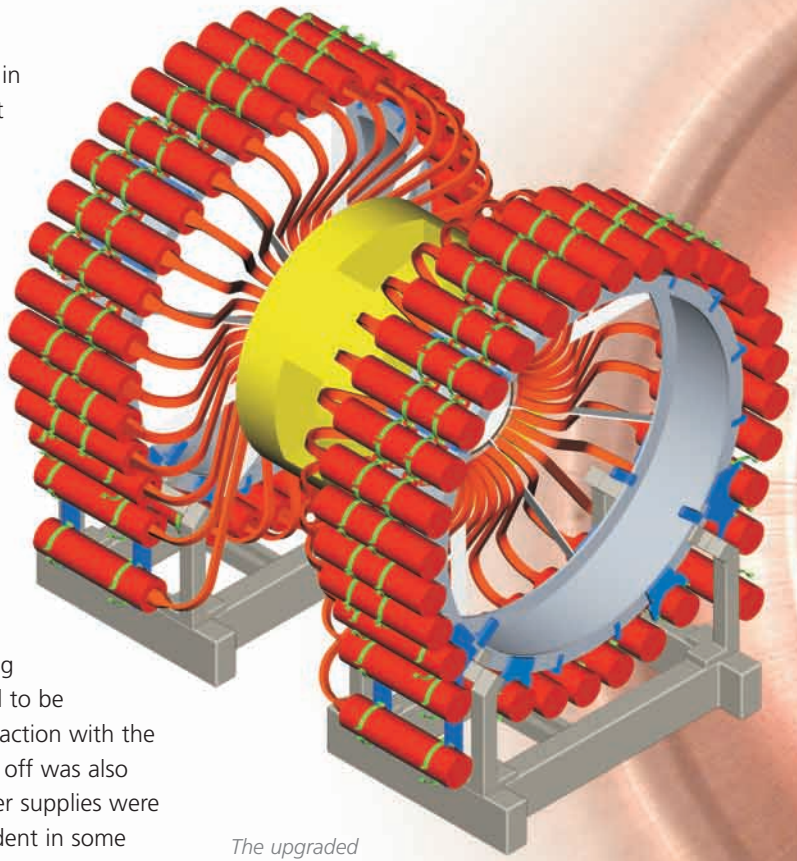
Muons

The MuSR spectrometer is presently seeing its first development since its installation 17 years ago. A very cost-efficient upgrade is seeing its 32 detectors being replaced by an array with 64 elements, leading to a doubling of the instrument data rate; larger developments are still hoped for, however, as an increase to 256 detector elements is needed to fully exploit the available muon flux. At the same time, the data acquisition electronics are being replaced by a modified neutron DAE-II, improving compatibility with neutron instruments and adding additional flexibility for experiments requiring pulsed environments. MuSR in its new form will be fully up and running by the end of the first cycle after the long 2004 shut-down.

SANDALS

SANDALS suffered a serious loss in detector performance in the past year which has necessitated it being shut down to allow the source of the detector instabilities to be investigated. After many tests it was found that the incident monitor detectors were sensitive to operation of the cryomagnet on the neighbouring beam lines. Elsewhere in the detector suite the effects of residual magnetic fields were identified and were found to be causing unstable photomultiplier performance. The air conditioning inside the blockhouse was found to be ineffective and a significant interaction with the air conditioner switching on and off was also noted. Detector electronics power supplies were found to be temperature dependent in some cases, and a notable detector electronics deadtime was discovered over a range of Q values.

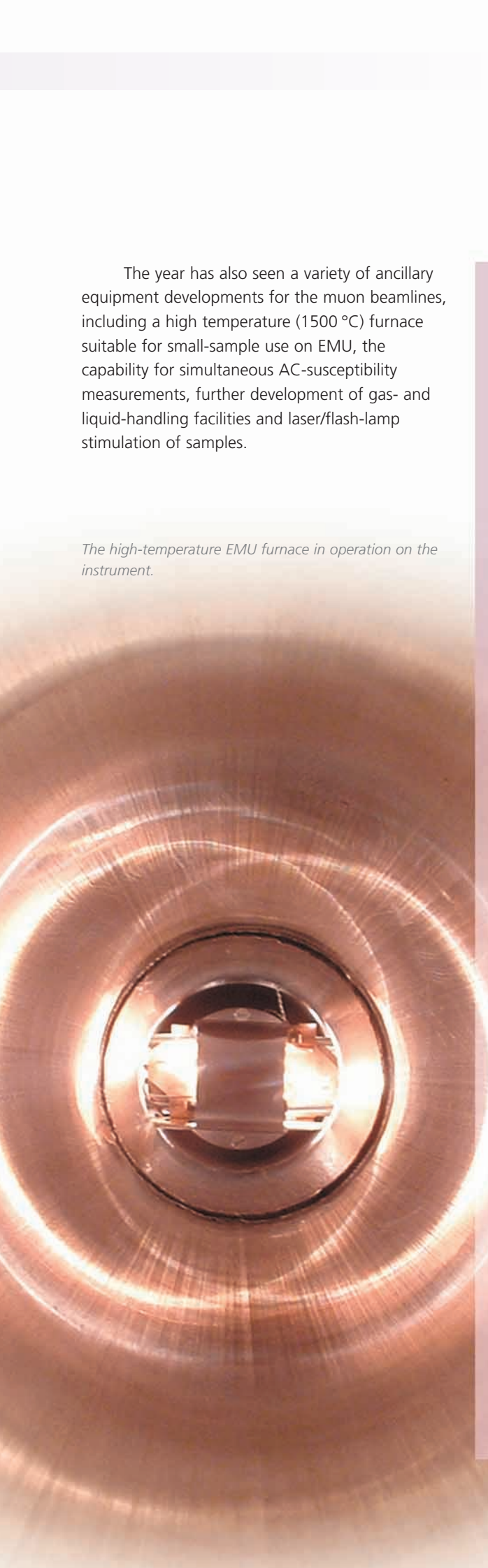
Following all these findings a detector refurbishment programme was established and work is on course to enable SANDALS to start operation again late in 2004.



The upgraded MuSR instrument will provide a factor of at least two in data rate.

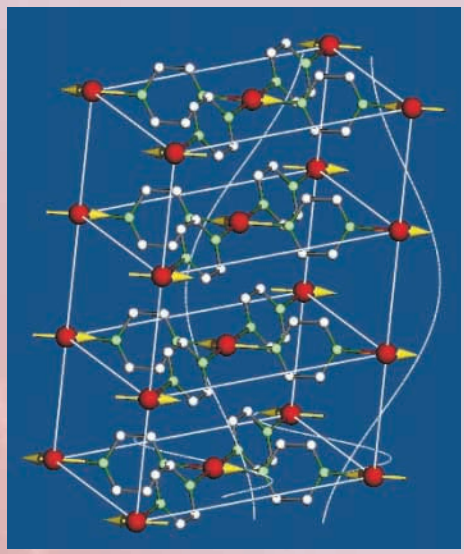
The year has also seen a variety of ancillary equipment developments for the muon beamlines, including a high temperature (1500 °C) furnace suitable for small-sample use on EMU, the capability for simultaneous AC-susceptibility measurements, further development of gas- and liquid-handling facilities and laser/flash-lamp stimulation of samples.

The high-temperature EMU furnace in operation on the instrument.



Crystallographic Software

In the field of neutron crystallography, software provision for data reduction and analysis is as important as instrumentation hardware for delivering a high-impact science programme. For this reason, a collaboration was set up in 2003 between Laurent Chapon and Paolo Radaelli (ISIS) and Juan Rodriguez-Carvajal (LLB, France) with the aim of providing the user community with powerful public-domain tools for structural research in crystallography and magnetism. The first milestone of this collaboration was the release of a new version of 'Fullprof', which reads template files for all ISIS powder diffractometers. More recently, the first version of 'FSTUDIO', written by Laurent Chapon, a package for visualising crystal and magnetic structures, has also been released. A further collaboration has been initiated between Bill David (ISIS) and Alan Coelho (currently consultant for Bruker) with the aim of developing a next-generation data analysis programme, based on the computer algebra paradigm, which will be freely available to academic users.



Magnetic structure of $Fe(NCS)_2pyz$ showing a sinusoidal modulation (PRB 69 (2004) 224405) created by FSTUDIO.

In addition to these collaborative projects, a series of other tools for data reduction, visualisation and analysis have been developed. The IDL-based program 'SEQUENTZ' has been written by Graeme Blake (ISIS) for sequential refinements using the GSAS Rietveld package. The 'ARIEL' package is now employed for most experiments on GEM and HRPD, and it will soon be made available on all other diffractometers; its features enable texture analysis for archaeometry experiments. To meet the requirements for time-of-flight single-crystal diffraction the IDL based data reduction/visualisation software 'SXD2001' is being developed by Matthias Gutmann (ISIS). This package allows for data visualisation and treatment of multiple crystals with unknown orientation.

Second Target Station Project

Work has continued apace on the new ISIS Second Target Station. Instrument design, target and moderator calculations, beam transport work and actual building construction have all seen substantial progress over the past year. First neutrons are expected in late 2007, with the experimental programme due to start in autumn 2008.

Buildings

New buildings to house ISIS experimental support staff have risen rapidly behind the existing experimental hall during the year and will be ready for occupation from October. Many laboratories and staff offices must be relocated for construction of the main Second Target Station building. Pressure, furnace and sample environment electronics laboratories will be relocated to the south side extension of the existing experimental hall, whilst mechanical and electrical workshops will be amalgamated in the new building.

The new support services building during construction.

Architect's impression of the new experimental hall building.

Meanwhile, significant progress has been made with the main Second Target Station building concept. In addition to experimental areas, it will include a reception area, a public viewing gallery, rest facilities, a coffee bar, meeting rooms and data analysis facilities. Construction will start at the beginning of 2005.

Instruments

Baseline specifications for the seven instruments to be built for the project were completed at the end of June. Following consolidation of the specifications and development of initial designs, there will be a technical review by external and internal experts. External sponsors nominated by the neutron scattering community will participate as members of Instrument Advisory Committees that will meet regularly to review the development of each instrument.

offSPEC is an advanced reflectometer giving access to nanometre length scales parallel and perpendicular to interfaces, using the technique of spin-echo to decode the path neutrons have taken through the instrument. By enabling the explicit separation of specular and off-specular reflectivity, new surface structures such as patterned data storage media, mesoporous films and biological membranes can be investigated.

INTER is a high-resolution, high-flux neutron reflectometer designed for the study of chemical interfaces. Three ^{3}He gas detectors will allow routine measurement of both transmitted and reflected beams. In combination with a two-dimensional multi-detector, contributions to the signal from small-angle scattering or in-plane correlations can be separated.

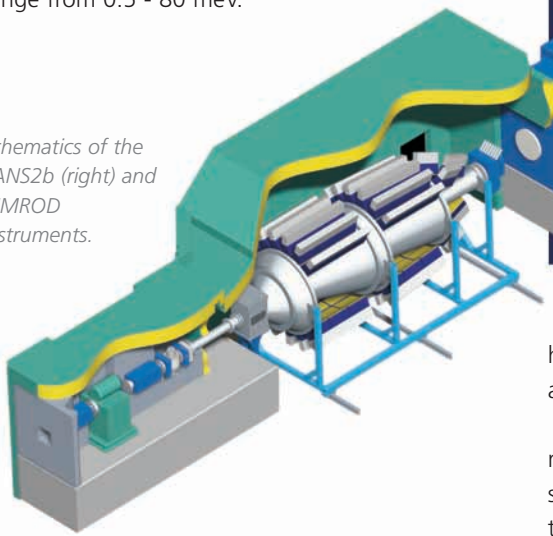
polREF is a polarised neutron reflectometer designed for the study of the magnetic ordering in and between the layers and surfaces of thin film materials. Through precise control of the neutron spin, unique information on the size and direction of the magnetism as a function of depth can be obtained allowing thin film structures to be studied layer by layer.

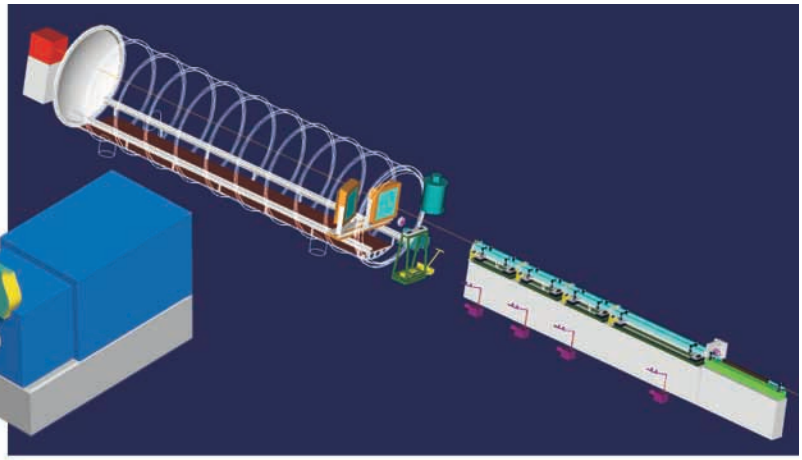
SANS2b uses multiple position-sensitive detectors for Small Angle Neutron Scattering across length scales in the nanometre to micrometre range, and is well-placed to exploit the trend towards studying non-equilibrium or complex, multicomponent systems.

NIMROD will provide continuous access to length scales ranging from the interatomic through to the mesoscopic, bridging the gap between SANS and wide-angle neutron scattering.

WISH is a long-wavelength diffractometer primarily designed for powder diffraction at long d-spacing in magnetic and large unit cell systems with the option of enabling single-crystal and polarised beam experiments.

LET will have a considerable impact in many disciplines including bio-materials, polymers, magnetism, geo-science and quantum fluids through its unique ability to make quasi-elastic and inelastic measurements over a wide dynamic range from 0.5 - 80 meV.





Schematics of the SANS2b (right) and NIMROD instruments.

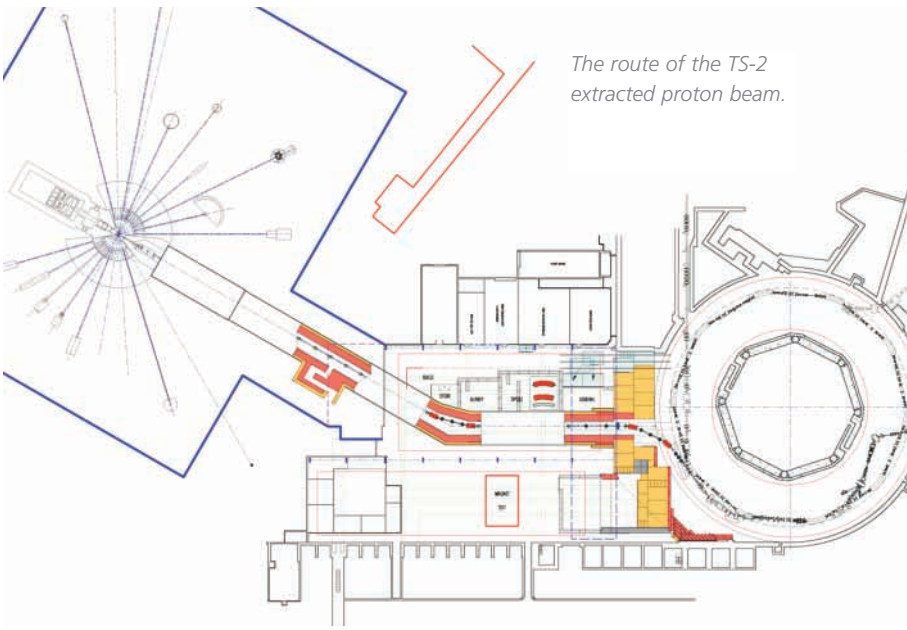
Target and moderators

The Second Target Station is a low-power neutron source operating at 10 Hz optimised for the production of long wavelength neutrons. The low power of the target enables the use of solid methane as a moderator material, and this choice dominates much of the target design. One of the most important design factors is the geometric coupling between the target and the moderators. The angle covered by the moderators has been maximised whilst keeping the distance each neutron travels through the target to a minimum to reduce absorption.

The coupled moderator is a composite hydrogen/solid-methane system without a decoupler or poisoning layer, that generates an intense, long-wavelength flux with broad pulse shapes from two distinct faces.

A solid methane face with a deep, narrow groove giving high brightness and a cold spectrum, has been designed for small angle scattering and reflectometer instruments that only view a small area of the moderator surface. A flat hydrogen face has a slightly warmer spectrum and a much larger flux integrated over the whole face.

The decoupled solid-methane moderator has multi-vane gadolinium poisoning and will give a similar flux, but with a much colder spectrum, to the existing ISIS water or liquid-methane moderators. One face has a narrow pulse shape similar to the existing liquid methane moderator although with a much cooler spectrum, whilst the other has a broader pulse shape similar to the existing hydrogen moderator.



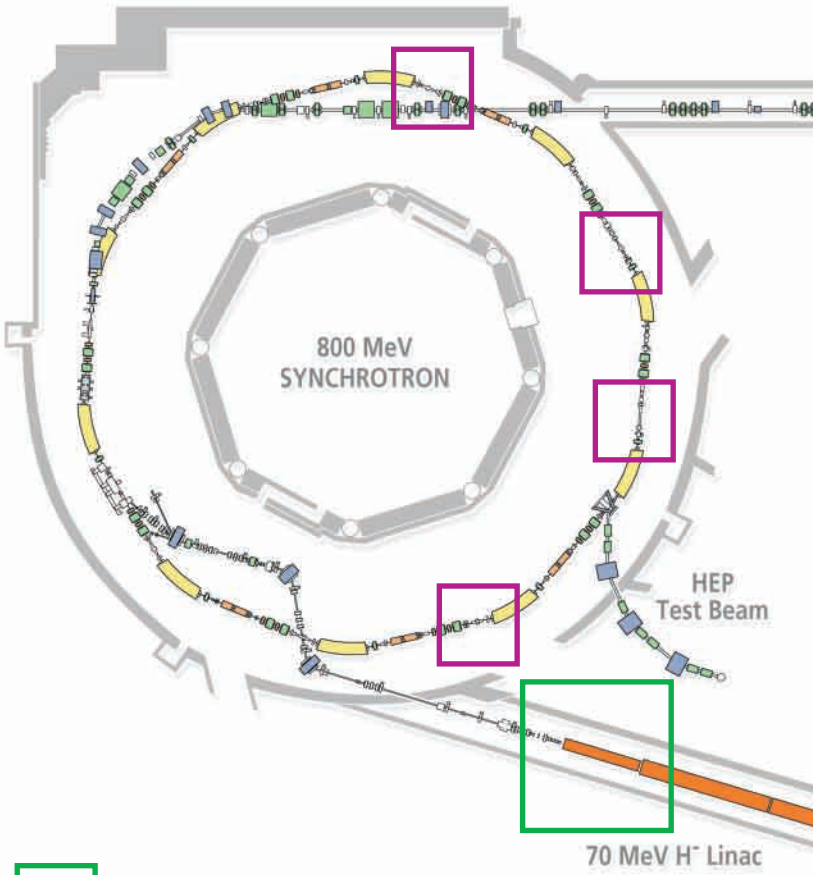
The route of the TS-2 extracted proton beam.

Regular updates on the progress of the project can be found on the Second Target Station website, ts-2.isis.rl.ac.uk

Accelerator and target developments

Increasing the ISIS proton current

Much preparation has been made over the past year to enable major work on the ISIS accelerator and targets to take place during the 2004 long shutdown. The work is aimed at equipping the facility to run with a 50% higher proton current, providing additional neutrons and muons and enabling operation of the Second Target Station. But how will the proton current increase work?



The Synchrotron

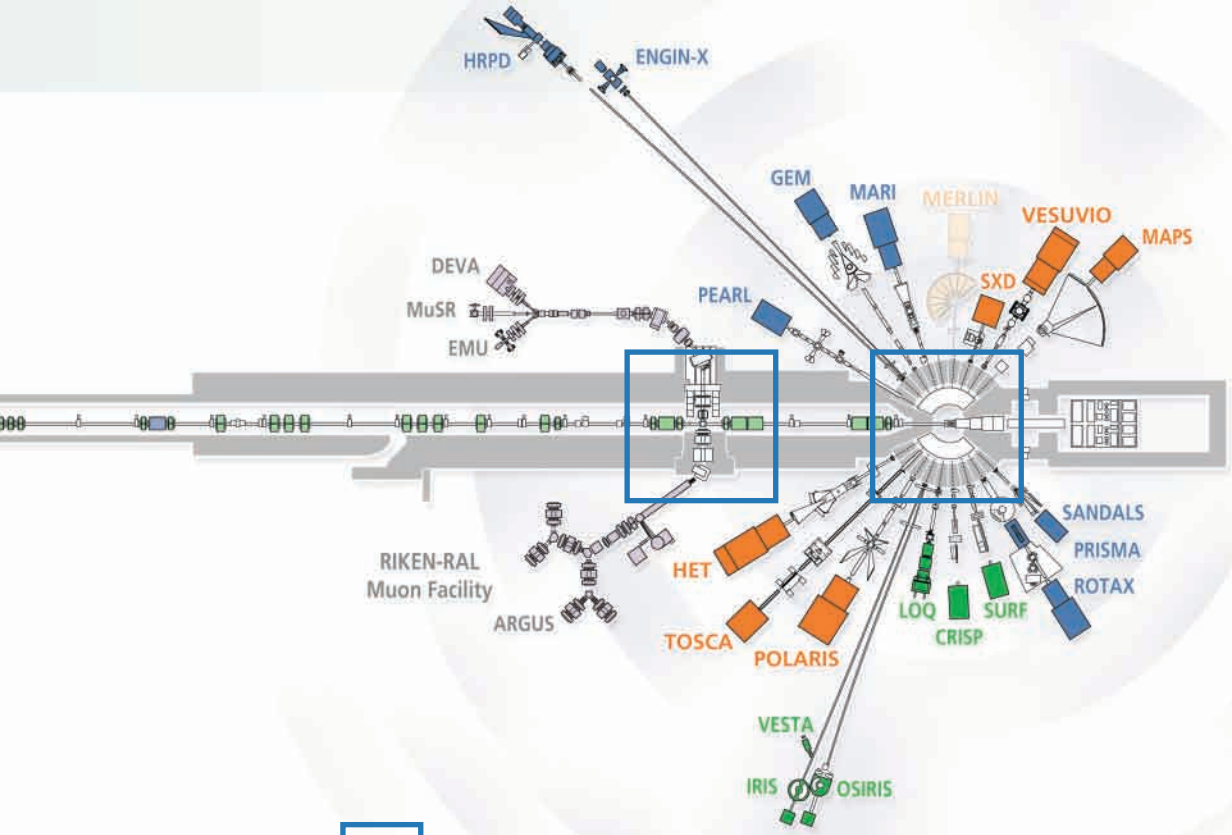
The four new RF accelerating cavities required for the ISIS second harmonic upgrade have now all been installed in the synchrotron ring, along with their high power drives and electrical and mechanical services. Together with the six fundamental RF accelerating cavities the second harmonic system will allow the 50% extra current produced by the linac to be trapped and accelerated whilst keeping the absolute proton losses at the same level as before. Commissioning of the systems is now underway. Over the year or so after the end of the long shutdown the proton beam current will slowly be raised to the higher level with beam loss levels and patterns being closely monitored at all times.

Jim Loughrey and Rod Rose of the Operations and Installations Group aligning the beamline next to the second harmonic cavity in super-period 8 of the ISIS synchrotron. 04EC2364

Installations

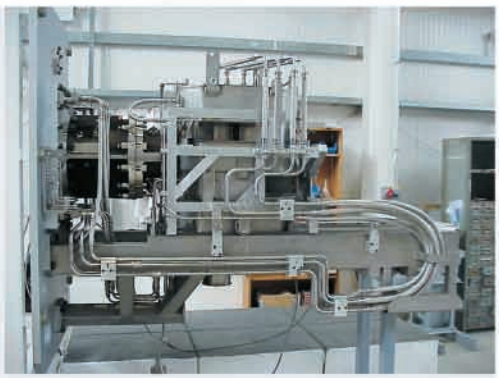
Much effort has been focused on the preparation of components for installation on ISIS. As well as the RFQ and the two remaining second harmonic RF cavities and associated systems, work is well advanced to install a new stand-alone 1 MW cooling system for the linac and to replace the obsolete high purity water system heat exchanger circuit. Electrical installation and commissioning of a revised beam permit chain to allow operation with the RFQ is also underway.

Stuart Edmonds, Duncan Couchman and Sean Keen of the Operations and Installations Group in front of the new linac water plant. 04EC2365

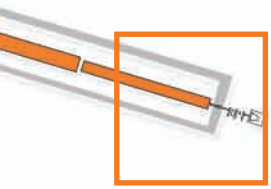


Neutron and Muon Targets

The neutron and muon targets have also had to be prepared for the 50% current increase. The equipment required for higher intensity running has been designed, manufactured and assembled for installation in the 2004 shutdown. This includes the replacement of the neutron target reflector assembly and a complete rebuild of the muon target ladder to allow better cooling of the thin graphite target plates which the proton beam passes through. Assessment of shielding upgrades for the target station has also been completed.



The new neutron target assembly during construction.



The Injector

H^- ions fron the ion source are accelerated to 665 keV in the preinjector before entering the linear accelerator (linac). The past year has seen intense preparation for the installation of the 665 keV 202.5 MHz 4-rod Radio Frequency Quadrupole (RFQ) accelerator. The RFQ replaces the present ISIS Cockcroft-Walton DC preinjector, and will allow 50% more beam to be captured in the linac. A dedicated test facility has allowed the RFQ to be operated in excess of 2000 hours prior to installation. Extensive measurement of beam parameters shows them to be in good agreement with theoretical predictions, paving the way for future, more challenging RFQ development work.

The RFQ installation on ISIS and some of the members of the team who made it possible.

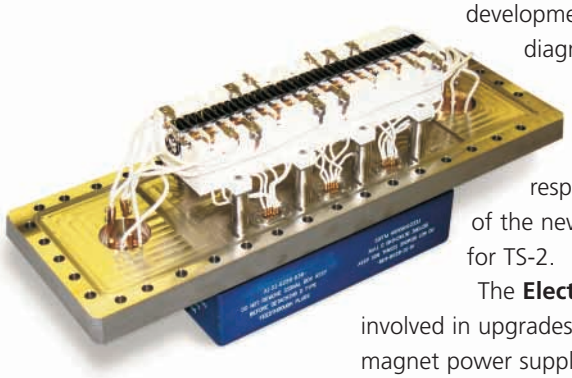
04EC2361

Other Accelerator and Target Developments

As well as work on increasing the ISIS proton current, the Accelerator and Target Divisions have been involved in a wide variety of other development programmes.

Following its commissioning by the **Injector Group** last year, the ion source development rig is opening up exciting new possibilities. Extensive finite-element modelling of thermal and electromagnetic conditions inside the source, coupled with experimental investigation of new extraction geometries and magnetic field arrangements, point the way to high-current beams with low emittance.

The **Synchrotron Group** has started major development work on the beam diagnostics in the ring, beginning with the installation of new gas ionization beam profile monitors, and has been responsible for the detailed design of the new extracted proton beam line for TS-2.



A new gas ionisation beam profile monitor for the synchrotron ring. The 40 individual channeltron detectors in the monitor will allow instantaneous measurement of the horizontal beam profile.

The **Electrical Engineering Group** are involved in upgrades to the synchrotron main magnet power supply and 60 kV pulsed extraction kicker systems, together with development work for neutron beam line chopper power supply and control systems.

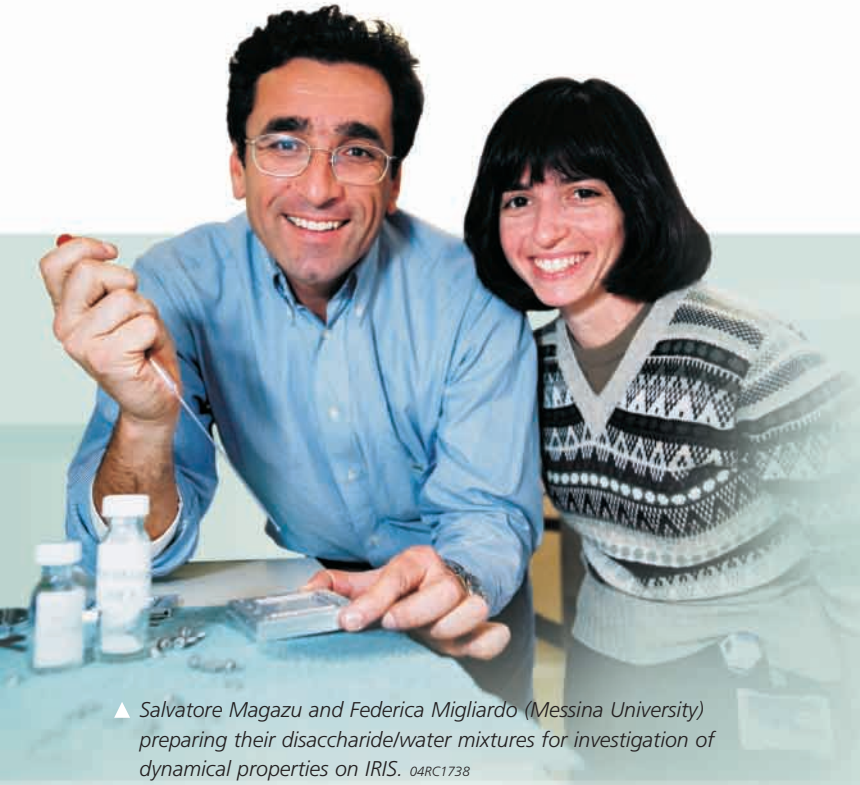
Within the **Neutron and Muon Targets Group** work on the TS-2 project has increased rapidly since TS-2 approval was granted. Reviews of the design of the existing target station have been held to identify improvements which can be incorporated into the TS-2 design.

Much of the **Control Group's** work over the past year has focused on installation of new synchrotron and ion source equipment. However, the Group is also responsible for converting controls applications running under old GEC computers to new systems. GEC 4000 series computers were installed at the Rutherford Appleton Laboratory during the 1970's to control particle accelerator beam lines, physics experiments and telecommunication systems. GEC 4000 serial no. 1 was moved from the laboratory to the Science Museum some time ago, but others of these old machines are still in use in the ISIS controls system - their removal is being finalised as the applications they run are converted.

Bob Mannix, Controls Group leader, with one of the old GEC 4000 computers (in use continually since 1978). The computers are maintained 24/7 by Marconi PLC.

Operations and Installations Group work has included the upgrade of the 1.3 MW chilled water system, the build of a spare extract septum magnet assembly and preparatory work on replacing the machine equipment and personnel interlock systems. Preliminary design work has also been carried out on the vacuum system and personnel and beam permit interlock systems required for TS-2 and the associated extracted proton beam line now under construction.

Plans for the implementation of the Muon Ionization Cooling Experiment (MICE) on ISIS are progressing in the **Future Projects Group**. A hole has been cut into the synchrotron room for the superconducting solenoid that will form the decay channel for the muon beam. In the past year a matching section has been designed for the beam line, the safety case for the design of the liquid hydrogen absorber has passed an external review and the bulk of the RF system equipment has been sourced. The MICE project is an international collaboration and calls on resources in the Building Projects Group, Engineering Department, ASTeC and ISIS.



▲ *Salvatore Magazu and Federica Migliardo (Messina University) preparing their disaccharide/water mixtures for investigation of dynamical properties on IRIS.* 04RC1738

▶ *Sarah Thornley (Reading University) at LOQ during her studies of the effect of nucleating agents in polymer melts under shear flow.* 04RC1797

▲ *Alan Snedden (Birmingham University) with his Aurivillus ferroelectric sample during studies of cation ordering on GEM.* 04RC1748

▶ *Matt Tucker (Cambridge University) and David Parfitt (Oxford University) preparing the Paris-Edinburgh cell for studies of cation ordering in superionic copper halides at high pressure.* 04RC1515

▶ *Helena Vieira Alberto (Coimbra University) mounting her sample on an EMU 'fly-past' holder for muon studies of shallow-donor hydrogen states in wide band gap semiconductors.* 04RC1508

A year around the Facility

Review of ISIS Muons

Following an application to the CCLRC's Facility Development Fund to enable significant upgrades to the ISIS muon instruments and beamlines, a review was commissioned of the ISIS Muon Facility to examine its current effectiveness and the requirements for future developments. The review was chaired by Prof. Marshall Stoneham FRS (UCL), with Prof. Mike Charlton (Swansea), Prof. John Davies (Bath) and Dr. Alex Amato (PSI Muon Facility) also taking part. The review panel were strongly supportive of the proposed development plans, recognising both the historic contribution that muons have made across a broad range of systems and the likely future potential that an upgraded facility would have. Their full report will be available shortly.

The muon facility review panel. Clockwise from front left: Prof. Marshall Stoneham FRS, Dr. Alex Amato, Prof. Mike Charlton and Prof. John Davies. 04RC2194

Radiography meeting

Radiography at pulsed neutron sources has yet to take advantage of the pulsed nature of the neutron beam, relying simply on the integrated flux. A meeting of the European radiography community was held at The Cosenor's House at the end of March. The meeting recommended that one of the priorities for the European research community should be realising the potential of pulsed sources, through focused development work. The UK community was well represented, and details of bio-material, archaeological and geological interests were presented in addition to the more traditional engineering studies. Assessment of the most appropriate detector technologies by the ISIS Detector group is ongoing, as well as studies as to the optimum beamline and Target Station for this development.

In March 2004 Ministerial advisers from countries across the enlarged European Union gathered in the UK, at the invitation of the CCLRC, to discuss strategy and plans for access by their research communities to future neutron sources. The discussions built on the work of the European Strategy Forum for Research Infrastructures undertaken during 2003. Such meetings play an important part in building a common understanding within Europe on future requirements and how these are to be delivered in a timely way so as to sustain the competitiveness of science that depends on access to leading edge facilities. Pictured here, during a visit to ISIS are (left to right) Lars Borjesson (Chalmers University of Technology, Sweden), Andrew Taylor (ISIS), Ferenc Mezei (HMI, Germany), Helmut Rauch (Vienna, Austria), Yves Petroff (Ministrie de la Recherche, France), Rainer Kopke (Bundesministerium für Bildung und Forschung, Germany), Robert Feidenhans'l (Risø, Denmark), Jose-Luis Martinez (ICMM, Spain), Luis Ruiz (Spanish Ministry of Science and Technology, Spain), Mats Johnsson (Ministry of Education and Science, Sweden), Robert McGreevy (ISIS). 04RC2013

Hydrogen in Oxides Meeting

This symposium and workshop was held at the Royal Institution in April and was co-organised by Steve Cox from the ISIS Muon Group, together with colleagues from Dundee, UCL and the RI. It brought together 47 materials scientists, solid state and computational chemists, crystallographers and geologists, with a common interest in the title subject. The presentations included ten invited talks on subjects such as hydrogen in minerals, technological aspects of hydrogen in electronic oxides, neutron diffraction studies of hydrogen in proton-conducting oxides and theoretical studies of hydrogen behaviour. Discussions covered optical, electronic, and chemical applications, as well as mineralogical aspects.

Workshop on Sample Environment at Neutron Scattering Facilities

The forth in a series of workshops on sample environment for neutron facilities was held earlier in the year at The Cosener's House, Abingdon, and brought together 32 technical specialists, scientists and industrial suppliers serving neutron institutes around the world. Discussions on possible options for high field magnets, led by Michael Meissner (HMI), were particularly animated, with possibilities for fields beyond the cryogenic system limit of 15 T being explored. The continued rise of dry cryogenic equipment and the drive to produce integrated sub-4 K systems were also of great interest, and a proposal from Lou Santodonato (Oak Ridge) for an effective benchmarking method for different systems, wet and dry, was favourably received.

Attendees at the Sample Environment Workshop. 04EC2510

Requirements for a single, simple system providing a wide temperature range (4 K to 1000 K for example) were discussed, and Heinrich Kolb described developments at the FRM-II reactor of a range of equipment including a piezoelectric goniometer system which can work in both very low temperatures and high magnetic fields. The meeting was also an opportunity for the community to show its appreciation to the father of cryogenic applications in neutron scattering, Serge Pujol, designer of the ubiquitous 'orange' cryostat, who will be retiring from the ILL shortly. Most of the talks from the meeting are available at http://www.isis.rl.ac.uk/UserSupport.

Participants at the canSAS meeting held at RAL and co-organised by the Large Scale Structures Group at ISIS. canSAS provides a forum for X-ray and neutron instrument scientists, other facility staff, and their users, to exchange ideas on all aspects of software for SAXS and SANS experiments. 04RC2195

Left to right: Chris Goodway (ISIS), Manolis Pantos (SRS, Daresbury Laboratory), John Dreyer, Winfried Kockelman, Andy Church, Laurent Chapon (ISIS) and Roy Garner (The Manchester Museum) prepare for neutron examination of the Greek Helmet. 04EC1786

Archaeology at ISIS – getting a head in the headlines

As highlighted in last year's ISIS annual report, neutron diffraction at ISIS is being employed to explore archaeological objects for reconstructing ancient manufacturing techniques and for authenticity investigations. One such study has involved a 2700 year-old Greek Helmet from The Manchester Museum. ISIS has been used to look at the helmet's metallurgy, and has established that the helmet's nose guard is not original – it was probably repaired by a Victorian owner. The neutron data contain clear indications of the working processes involved in the production of the helmet which was more than likely cast as a 'skull-cap', then beaten and heated in an interactive cycle and dressed down to its final thickness. Infrared spectroscopy, X-ray diffraction and X-ray fluorescence at the SRS have also been used to examine the corrosion products on the surface of the helmet, and the results will help the museum conserve the helmet for future generations. Earlier in the year this work was featured in a story in the Guardian newspaper's Life section, with a photo of the helmet taking the full front page of the supplement.

Neutrons and Muons in EU Framework Programme 6

ISIS is playing host to a new project which brings together the European facilities and user communities involved in neutron scattering and muon spectroscopy. In EU Framework Programme 6 (FP6) all of the different activities related to a common type of Research Infrastructure are combined into a single project. NMI3 - the Integrated Infrastructure Initiative for Neutron Scattering and Muon Spectroscopy – is a 21 M€ project running from 2004 to 2008. NMI3 will fund access to 5000 beam days at facilities across Europe. It also includes eight joint research activities, involving 50 European research groups, to develop new instrumentation and advanced techniques. Four networking activities will disseminate the results and build on the natural degree of integration and collaboration that already exists between neutron and muon users, facilities and related laboratories. Funds can be provided for training activities and workshops, together with support for the European Neutron and Muon Web Portals (http://www.neutron-eu.net/, http://www.muon-eu.net/) and work to increase public understanding of the applications of neutron and muon techniques in different research areas.

Through NMI3 ISIS has funding to support European scientists wishing to use neutrons or muons. Researchers wishing to apply should tick the relevant box on the ISIS experiment proposal form. ISIS, together with 11 other European partner laboratories, will also be receiving 11 M€ for a 'Construction of New Infrastructures' project to support the construction of the first 7 instruments for Target Station 2. This project will be coordinated by Universita Roma Tre.

Gordon Squires (Cambridge), one of the first neutron scatterers in the UK, giving the after-dinner lecture on Enrico Fermi at the ISIS-IOP Theoretical Magnetism meeting held at The Cosener's House earlier this year. The meeting covered theory and experiment in topics as diverse as quantum phase transitions, orbital ordering, low-dimensional and frustrated magnetism, and stripes in transition metal oxides. There were nearly 60 participants from the UK, Europe and the US.

Neutron and Muon Training Courses

The next annual Neutron Training Course will be held at ISIS in the second week of February 2005. It will be more streamlined than in previous courses, lasting only one week, and is still aimed primarily at providing a practical introduction to the technique for U.K. research students. As usual, demand is expected to be high for the limited number of places available. Further details can be found at www.isis.rl.ac.uk/trainingcourse.

A training course on pulsed muon techniques will also be held at ISIS from 31st January to 4th February 2005. The course will be aimed at young researchers who are new to the technique and who will be using it for their research. It will consist of lectures in the technique's fundamentals, together with practical, on-beam sessions. Support will be available for U.K. and European researchers. Further details can be found on the ISIS muon web page (www.isis.rl.ac.uk/muons/).

ISIS People

Each year sees the comings and goings of ISIS staff. John Dreyer retired after many years service in the User Support Group - he will be sadly missed by ISIS staff and users alike. Andy Church has taken over responsibility for pressure and furnaces. The User Support Group has welcomed Beth Evans, Mick Dudman and Sarah Langham who are supporting cryogenic facilities.

John Dreyer, who retired earlier in the year, looking forward to a relaxing time with help from new garden furniture. 04RC2480

Chick Wilson left as Leader of the Crystallography Group to become Regis Professor of Crystallography at the University of Glasgow. Mark Daymond and Jude Dann both left as instrument scientists on the Engineering programme; Ed Oliver and Javier Santisteban will now be looking after ENGIN-X. Simon Levett joined as an instrument scientist on MARI, and Felix Fernandez-Alonso is now working on IRIS. Julie Bellingham became the project manager for the NMI3 project which is being co-ordinated through ISIS; and Edith Knight retired after long service in the ISIS Admin Office.

ISIS staff regularly take part in the annual Harwell-Rutherford rounders competition. Here we see some of the 'Neutron Stars', glorying in another victory.

Chris Frost (ISIS) demonstrating diffraction using microwaves to students attending the 'Living in a Materials World' open day at ISIS. 03EC3566

Richard Welberry and Darren Goossens (Australian National University) showing SXD data during explorations of the temperature dependence of diffuse scattering from Benzil. 04RC1513

Bella Lake (Oxford University) and Alan Tennant (St. Andrews University) modelling their high resolution spectroscopy studies of $Mo_{72}Fe_{30}$ on OSIRIS. 04RC1803

ISIS in facts and figures

FAP 1 Diffraction	FAP 2 Liquids	FAP 3 Large Scale Structures	FAP 4 Excitations	FAP 5 Molecular Spectroscopy	FAP 6 Muons	FAP 7 Engineering
W Clegg	*P Smith*	*A Rennie*	*R Cowley*	*H-P Trommsdorff*	*S Blundell*	*G Swallowe*
R Angel	J Bermejo	D Bucknall	J Annett	C Andreani	K Chow	J Bouchard
M Catti	F Bruni	O Byron	C Broholm	F Cavatorta	J Davies	L Edwards
J Hriljac	M Dove	P Doyle	A Krimmel	R Coldea	A Fisher	S Hainsworth
P Lightfoot	T Fukunaga	J Eastoe	D McKenzie Paul	E Karlsson	M Iwasaki	R Lin Peng
A Powell	K Refson	R Felici	K Prassides	S Kilcoyne	P Mendels	E Patterson
P Radaellli	P Salmon	I Gentle	A Schofield	D O'Hare	E Morenzoni	
S Redfern	J Swenson	B Hickey	A Tennant	G Reiter	B Rainford	
C Ritter	J Yarwood	J Lawrence	K Yamada	G Sankar	J Stride	
J Steed		F Mulder		C Washington		
P Stephens		P Olmstead				
P Thomas		S Roser				
R Ibberson	*D Bowron*	*J Webster*	*T Perring*	*J Mayers*	*S Cottrell*	*E Oliver*
S Hull	*A Soper*	*S Langridge*	*S Bennington*	*J Tomkinson*	*P King*	*M Daymond*

Table 1: *ISIS Facility Access Panel Membership. The FAPs meet twice per year to review all proposals submitted to the facility based on scientific merit and timeliness.*

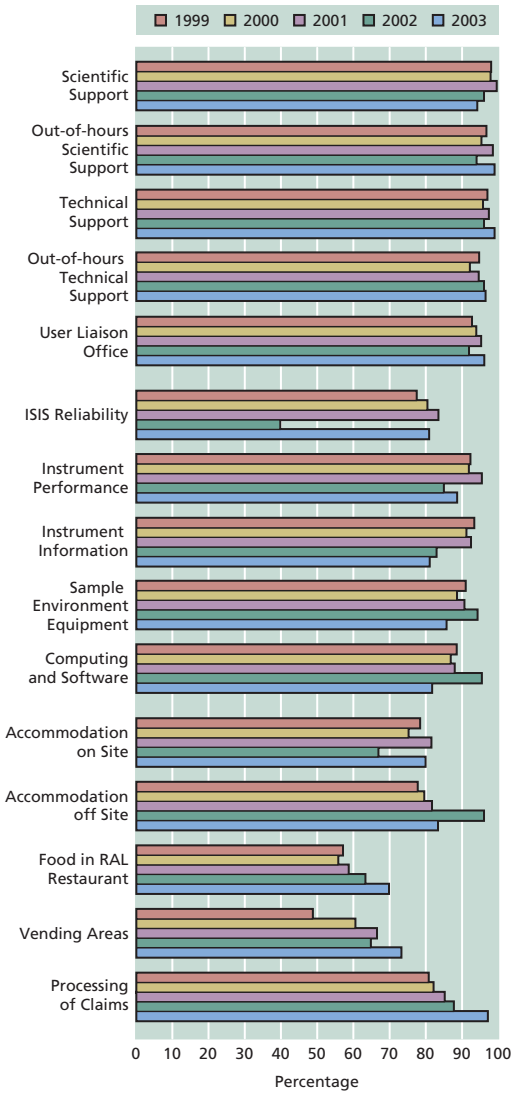
Chairman	R J Stewart	University of Reading
IUG1 Crystallography	P Battle R J Nelmes	University of Oxford University of Edinburgh
IUG2 Liquids & Amorphous	A Barnes N Skipper	University of Bristol University College London
IUG3 Large Scale Structures	R J Stewart A Zarbaksh	University of Reading Queen Mary College London
IUG4 Excitations	D Mckenzie Paul A Boothroyd	Univesity of Warwick University of Oxford
IUG5 Molecular Spectroscopy	K Ross D Timms	University of Salford University of Portsmouth
IUG6 Muons	J Jayasooriya S Kilcoyne	University of East Anglia University of Leads
IUG7 Engineering	G Swallowe M Fitzpatrick	Open University Open University

Table 2: *ISIS User Committee Membership. The IUC exists to represent the user community on all aspects of facility operation.*

A D Taylor	Director ISIS
U Steigenberger	ISIS Division Head
R Browning	ISIS User Office Manager
R S Eccleston	ISI Division Head
R L MCGreevy	IDM Division Head
Z A Bowden	ISIS User Support Group Leader

User Satisfaction

All users visiting the facility are invited to complete a satisfaction survey which addresses the quality of the scientific, technical and User Office support, the ISIS, Instrument and Support equipment performance and reliability, and the quality of the accommodation and restaurant facilities. The feedback obtained in this way helps to ensure a high quality service is maintained and improved where necessary.



ISIS user survey results 1998 - 2003.

Beam statistics 2003 - 2004

ISIS continues to be the world's most successful pulsed spallation neutron source. For the period of this report and during scheduled operating cycles, ISIS delivered a total of 656 mA.hrs of user proton beam to the muon and neutron targets at an average current on target of 177μA.

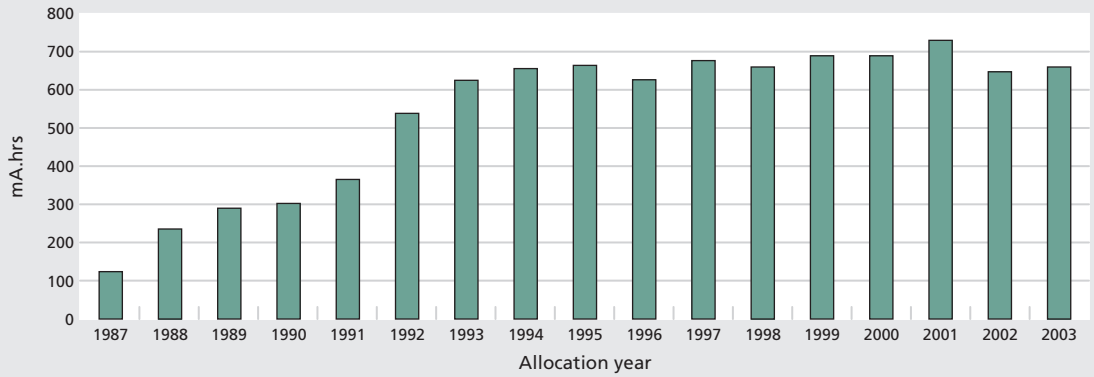
The tables below give beam statistics for the individual cycles in the year 2003 - 2004, together with year-on-year statistics for ISIS performance.

Cycle	03/1	03/2	03/3	03/4	03/5
Beam on target (hrs)	624	890	964	316	998
Total beam current (mA.hr)	106	155	176	56	163
Average beam current on target (μA)	170	175	183	177	179
Best day beam current (μA, average over 24 hrs)	176	176	184	176	181
Average beam trips per day	25	15	14	16	12

Table 3: *ISIS operational statistics for year 2003-2004.*

Year	1997	1998	1999	2000	2001	2002	2003
Total scheduled user time (days)	168	175	168	168	168	160	172
Total time on target (days)	153	160	153	154	158	148	154
Total integrated current (mA.hrs)	672	656	687	687	725	630	656
Average current on target (μA)	183	171	187	186	192	178	177
Peak current averaged over 24 hours	197	193	198	194	200	187	184
μA.hrs per trip	81	72	106	120	141	178	237
Total power consumption (GWh)	47	42	52	46	46	53	57

Table 4: *Year-on-year ISIS performance summary.*



Total integrated ISIS current.

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