Chilbolton Observatory

Chilbolton

Stockbridge

Hampshire

SO20 6BJ

Tel: (01264) 860391

Fax: (01264) 860142

Daresbury Laboratory

Keckwick Lane

Daresbury

Warrington

WA4 4AD

Tel: (01925) 603000

Fax: (01925) 603100

Rutherford Appleton Laboratory

Chilton

Didcot

Oxfordshire

OX11 0QX

Tel: (01235) 821900

Fax: (01235) 445808

CLRC

COUNCIL FOR THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS

Annual Report 1998-99

CLRC

COUNCIL FOR THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS

Cover photo:
Over 100 6th form physicists, with their teachers, spent a day experiencing the excitement of Particle Physics at a special Institute of Physics Masterclass held at CLRC Rutherford Appleton Laboratory in March. With the emphasis on practical sessions and seeing science in action, the students were kept busy all day and, according to post-event feedback, carried on their discussions about particle physics well into their journeys home. Complementing formal education by relating school science to front-line research takes advantage of the Council's unique role.

ISSN 1366-235X

Report of the Council for the Central Laboratory of the Research Councils
1 April 1998 – 31 March 1999

In accordance with Schedule 1 to the Science and Technology Act, 1965, the Council for the Central Laboratory of the Research Councils submits the following report on its activities from 1 April 1998 to 31 March 1999

Dr ARC Westwood FREng NAE

Chairman and Chief Executive

Laid before Parliament on 23 February 2000

CCLRC

Glossary

Expansion of the acronyms used in the 1999 Annual Report

AATSR	The Advanced Along-Track Scanning Radiometer
BBSRC	Biotechnology and Biological Sciences Research Council
BNSC	British National Space Centre
CCLRC	Council for the Central Laboratory of the Research Councils
CDS	Coronal Diagnostic Spectrometer
CERN	Conseil Europeen pour la Recherche Nucleaire *(the European laboratory for particle physics)*
CLF	Central Laser Facility
CLRC	Central Laboratory of the Research Councils
CNR	Consiglio Nazionale delle Richerche
CMOS	Complementary Metal-Oxide Silicon
CMF	Central Microstructure Facility
CMS	Compact Muon Solenoid
CRABS	Cellular Radio Access for Broadband Service
CSR	Comprehensive Spending Review
DARTS	Daresbury Analytical Research and Technology Service
DL	Daresbury Laboratory
DTI	Department of Trade and Industry
EES	Engineering Education Scheme
EPSRC	Engineering and Physical Sciences Research Council
EU	European Union
FAMIS	Financial Accounting and Management Information System
FREng	Fellow of the Royal Academy of Engineering
FRS	Fellow of the Royal Society
GBq	Gigabecquerel
GEM	General Materials Diffractometer
HEFCE	Higher Education Funding Council for England
HET	High Energy Transfer chopper spectrometer
IiP	Investors in People
ILL	Institut Laue Langevin
INRIA	Institut National de Recherche en Informatique et en Automatique
ISO	Infrared Space Observatory
JIF	Joint Infrastructure Fund
JREI	Joint Research Equipment Initiative
LHC	Large Hadron Collider *(at CERN)*
LMB	Laboratory of Molecular Biology *(part of the Medical Research Council)*
MeV	Mega electron volts
MoD	Ministry of Defence
MRC	Medical Research Council
NAE	National Academy of Engineering
NAO	National Audit Office
NERC	National Environment Research Council
OFSTED	Office for Standards in Education
OST	Office of Science and Technology
PPARC	Particle Physics and Astronomy Research Council
PUS	Public Understanding of Science
RAL	Rutherford Appleton Laboratory
RIKEN	Institute of Physical and Chemical Research in Japan *(RIKEN is an abbreviation of its Japanese name, Rikagaku Kenkyusho)*
SLAC	Stanford Linear Accelerator Centre
SOHO	Solar and Heliospheric Observatory
SRS	Synchrotron Radiation Source
TBq	Terabecquerel
TOSCA	a new neutron spectrometer on ISIS
UK	United Kingdom
UKAEA	United Kingdom Atomic Energy Authority
USA	United States of America
VHF	Very High Frequency
VR	Virtual Reality
W3C	World Wide Web Consortium

CCLRC

Mission and Council membership

The mission of the CCLRC

As set out in the Royal Charter

The objects for which the Council is established and incorporated are:

a) *to promote high quality scientific and engineering research by providing facilities and technical expertise in support of basic, strategic and applied research programmes funded by persons established in this Our United Kingdom and elsewhere;*

b) *to support the advancement of knowledge and technology, meeting the needs of research councils, other customers and their user communities, thereby contributing to the economic competitiveness of Our United Kingdom and the quality of life;*

c) *to provide advice, disseminate knowledge, and promote public understanding in the fields of science, engineering and technology as engaged in by the Council under a) and b) above.*

Chairman and Chief Executive

Dr Albert R C Westwood FREng NAE served as Chairman and Chief Executive throughout the year.

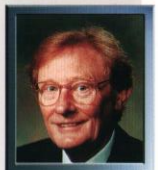
Members

Professor Brian Eyre CBE FREng	*University of Oxford*
Professor Richard Henderson FRS	*MRC Laboratory of Molecular Biology, Cambridge*
Professor Julia Higgins CBE FRS FREng	*Imperial College, London*
Professor Louise Johnson FRS	*University of Oxford*
Professor Sir John Krebs FRS	*Natural Environment Research Council*
Mr Richard Lawrence-Wilson	*Director, Administration and Finance, CCLRC*
Dr Allyson Reed	*Commercial Director, CCLRC*
Mr Philip Ruffles FRS FREng	*Rolls Royce plc*
Dr Gordon Walker	*Director, Research and Development, CCLRC*
Professor Robin Williams FRS	*University of Wales, Swansea*

Professor Eyre, Professor Higgins and Professor Krebs were also Council members respectively of PPARC, EPSRC and NERC.

CCLRC

Foreword



Dr A R C Westwood FREng NAE
Chairman and Chief Executive

The past year has been extremely productive. One of the primary responsibilities of the Council is to develop and operate world class facilities for the benefit of our colleagues in academia. Several actions are worthy of note in this regard, for example, upgrading the capabilities of the synchrotron X-ray source at Daresbury so that it can unravel the structure of complex biological molecules at least twice as fast as before; commissioning MAPS, the world's most advanced neutron spectrometer which will provide new insight into the origins of magnetism, superconductivity and other phenomena; arranging for components from Lawrence Livermore Laboratories' now decommissioned NOVA laser to be donated to our Central Laser Facility, and integrated into the Vulcan laser system to provide one of the most powerful and versatile lasers in the world for scientific studies; and presenting a successful case to DTI-OST for the design and construction of a next generation synchrotron X-ray source, DIAMOND. Funds have now been set aside for the new source, the Wellcome Trust has promised to make a major financial contribution, and it should come on line in 2005.

Of course, equipment is merely a means to an end, the end being significant advances in mechanistic understanding. Again, we are happy to note that research programmes at the CLRC, usually carried out jointly with university associates, have produced a number of exciting developments. To note just a few… new understanding of the nature of interactions between nerve cells and an optically active silicon surface open up the eventual prospects of artificial eyesight; results from work at the Soudan mine in Minnesota support a recent finding by Japanese workers which implies that neutrinos have mass; combining quantum mechanics with advanced parallel computing techniques is permitting new insights into the mechanisms of the industrially important phenomenon of catalysis, possibly leading to the predictable development of more efficient catalysts… and hence 'cleaner' chemical processes; and from Space Science has come the widely publicised discovery of the first conclusive, quantitative link between solar activity and global warming. The latter finding followed closely on the award of the Chapman Medal of the Royal Astronomical Society to team leader Mike Lockwood for his extensive work on Sun-Earth interactions. Finally, from ISIS has come new insights into the structure and behaviour of the polymer electrolytes used in rechargeable batteries, the molecular structure of antibodies such as immunoglobulin, and the origins of superconductivity in certain organic materials.

The management team was strengthened by the arrival of new Finance Director, Stuart Hopley, and Head of Human Resources, Paul Hartley. Richard Holdaway was promoted to replace the retiring Director of Space Science Division, Eric Dunford, and Keith Jeffrey has served as Acting Director Information Technology (IT) and Chief Information Officer on Brian Davies' retirement. During the year, Keith's IT staff and members of the Finance Department worked closely with technical staff from Oracle and Pricewaterhouse Coopers and we now have a financial management system that permits control of our numerous projects.

During the year we welcomed HRH The Duke of Edinburgh to CLRC Daresbury Laboratory and HRH The Duke of Kent to CLRC Rutherford Appleton Laboratory. Both showed great interest and enthusiasm for the work presented to them… as did the more than 5000 visitors, including over 1000 school children, who attended our Open Days in June 1998.

Regarding the future of the CCLRC, our Charter calls for us to support the advancement of science and technology not only in meeting the needs of the (funding) research councils, but also of "other customers… thereby contributing to the economic competitiveness of the United Kingdom". I believe that there is more we could do in regard to the latter responsibilities and we have begun to do so. We have become active members of the Association of Independent Research and Technology Organisations, are discussing with MoD the possibility of becoming a more significant element of their science base, have spun out another startup company, Interactive Media Corporation, and were proud to note that one of the products of an earlier collaboration, Bookham Technology, was featured as a commercial success story in the Government's White Paper on Competitiveness.

Looking ahead, advances in information technology and more proficient use of the Web provide opportunities for novel, distributed and more efficient ways of conducting research that will, in time, enhance the return on the taxpayer's investment in CCLRC.

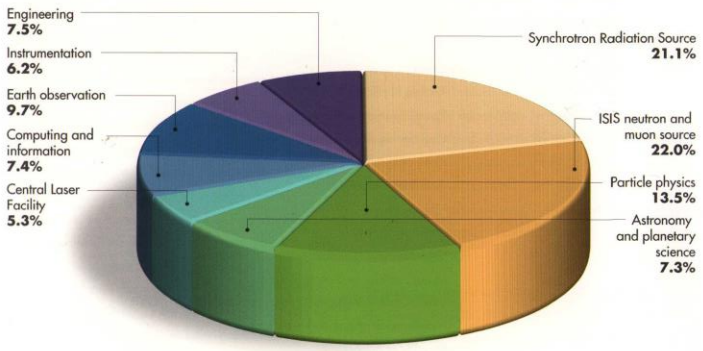
CCLRC

Contents

CCLRC

Performance

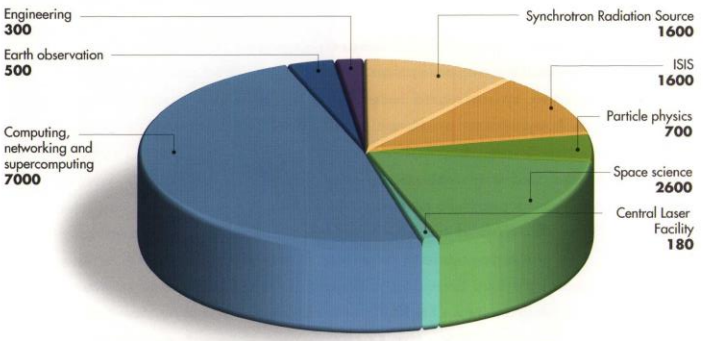
Facilities and programmes in 1998-99



Customers

The ten largest customers in 1998-99	*£ millions*
Engineering and Physical Sciences Research Council	40.1
Particle Physics and Astronomy Research Council	18.1
Natural Environment Research Council	5.9
Commission of the European Communities	3.6
Biotechnology and Biological Sciences Research Council	2.8
DTI Radiocommunications Agency	2.0
Medical Research Council	1.5
The Royal Institution	0.9
Matra Marconi Space	0.8
RIKEN	0.7

Principal user communities in 1998-99



** The computing community is 7500 but the user lists contain users also registered on other facilities. The numbers shown do not include engineers supported in 515 institutions across the UK and Europe through the Council's microelectronics support centre.*

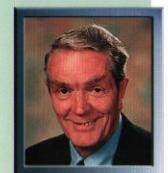
PERFORMANCE AGAINST TARGETS

Target definition	1997-98 Result	1998-99 Target	1998-99 Result
1. ISIS PULSED NEUTRON, MUON AND NEUTRINO SOURCE			
Weighted user satisfaction level on a scale of 0 to 100.	83	80	84
2. ISIS PULSED NEUTRON, MUON AND NEUTRINO SOURCE			
Level of integrated current.	672mA-hr	630mA-hr	656mA-hr
3. SYNCHROTRON RADIATION SOURCE			
A 'high' level of user satisfaction with the service provided.	83%	80%	78%
4. SYNCHROTRON RADIATION SOURCE			
Operating efficiency.	94%	90%	92%
5. CENTRAL LASER FACILITY			
Vulcan user satisfaction levels of 'good' or above.	88%	80%	80.1%
6. CENTRAL LASER FACILITY			
Vulcan shot success rate.	96%	90%	94%
7. OVERALL EFFICIENCY			
Running costs as a percentage of total budget.	11.5%	11.5%	11.8%

Footnotes:

1. All users of ISIS are given an exit questionnaire after completing their experiments. The target applies to the weighted score on a 5 point scale from 'excellent' to 'poor' of responses to 15 questions about aspects of the services provided.
2. The integrated current delivered during the year by the ISIS synchrotron is a global measure of the neutron, muon and neutrino production. It is a strong indicator of the capability to undertake experiments at the facility.
3. All users of the SRS are given an exit questionnaire after completing their experiment, inviting them to rate as 'high', 'medium' or 'low' their satisfaction level with a variety of detailed parts of the service. This target is for the overall service provided to SRS users.
4. The figure refers to the total amount of time the synchrotron operated divided by the time scheduled during the whole year.
5. All users of Vulcan are given an experimental report form after completing their experiment. The target applies to the average score on a 6 point scale from 'outstanding' to 'wholly unsatisfactory' in response to 7 questions about aspects of the services provided.
6. The target refers to the success rate of full Vulcan disc amplifier shots delivered to the target areas during experiments.
7. Running costs are defined by Government to cover specific central administrative functions and are subject to special controls.

CCLRC Programme review



Dr Gordon Walker
Director, Research and Development

The Central Laboratory of the Research Councils (CLRC) is the UK's primary user facility organisation, providing world class sources of X-rays, neutrons, muons and laser light to scientists from both the UK and abroad. It operates on three main sites, the Rutherford Appleton Laboratory, the Daresbury Laboratory and the Chilbolton Observatory, and is the home of internationally renowned researchers in fields from microelectronics to particle physics. As a result, a critical mass of expertise has developed to which researchers have access, either directly or via the appropriate funding research council. Over the past year the emphasis has been on building partnerships both with universities and industry. Eighty per cent of the funding for the programmes carried out by the CCLRC comes through partnership with other UK research councils, whilst the remaining twenty per cent comes through direct partnership with universities, industry and overseas organisations.

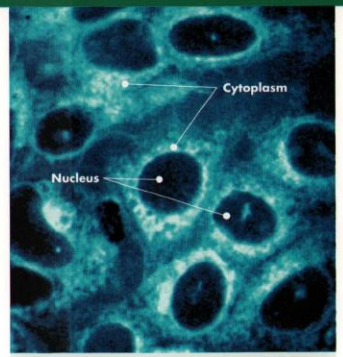
More than 10,000 people have used CLRC's facilities and services over the past year – usually working in close collaboration with CLRC's support scientists and engineers. This year has seen several major developments. These include an upgrade of the Synchrotron Radiation Source, a new neutron spectrometer, TOSCA, on the ISIS neutron and muon facility, and the first phase of a new femtosecond laser – ASTRA. Such developments are an essential part of maintaining CLRC's position at the forefront of scientific and technological research and helping the UK's academic and industrial communities to reach levels of performance they could not achieve on their own.

Synchrotron Radiation

The Synchrotron Radiation Source (SRS) at CLRC Daresbury Laboratory produces very bright light in a broad energy band that covers the electromagnetic spectrum from far infrared to hard X-rays. This source was the first of its type anywhere in the world. The light is fed to 40 experimental stations where researchers select the range of wavelengths they need for a particular experiment. For example, X-rays may be chosen to determine the complex structure of proteins, whilst ultraviolet light is used to study how these huge molecules fold. Running 24 hours a day, the SRS delivered over 5000 hours of beam time to about 2000 users. Synchrotron radiation has applications in many areas of physical, chemical, biological, materials, environmental and medical science research.

Researchers from King's College London have been using ultraviolet light from the SRS to investigate how potentially harmful phyto-oestrogens, such as coumestrol, are absorbed into living cells. These plant-derived oestrogens, found in plants such as soy, linseed and hops, can cause significant biological effects in both animals and man. Using a technique called ultraviolet confocal fluorescence microscopy, it is possible to tell exactly where and how much of the chemical has been absorbed. Early results show that coumestrol interacts with the cells' cytoplasm.

Another chemical known to affect human health is sulphur dioxide – the main source being fossil-fuelled power stations. A team of scientists from Reading University have used soft X-rays to find the mechanism by which sulphur dioxide molecules break up in the Earth's upper



An ultraviolet confocal fluorescence micrograph showing that coumestrol interacts with the cytoplasm of living cells. As well as its more traditional importance to materials and chemical research, the SRS is used more and more each year for biological and medical studies.

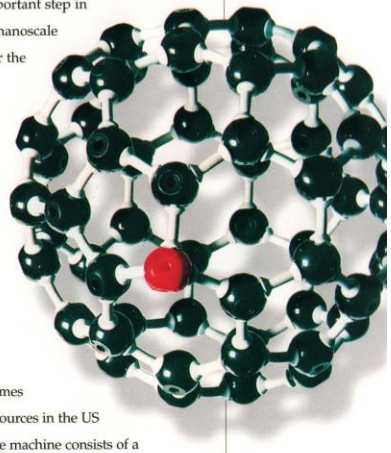
atmosphere. Their results show that the main reaction involves a core electron being removed from the sulphur atom, leaving behind a hole into which an electron from a bonding orbital falls with the simultaneous ejection of another bonding electron. This results in the breaking of the chemical bond between the sulphur and one of the oxygen atoms. High speed particle detectors and fast timing electronics were used to collect and correlate the fragments produced from an ionisation event. From these data, the kinetic energy released and the time-scale of the break-up could be determined. Such information is also of interest to planetary scientists: sulphur dioxide has been found to be present in the atmospheres of Venus and Io, one of Jupiter's moons.

In some cases it is not enough simply to understand processes at the atomic level, it is also necessary to control them. An example that has real potential for the fabrication of molecular nanostructures for the 21st century is the chemical modification of individual fullerene molecules – buckyballs. A team of scientists from Nottingham University, using a combination of scanning tunnelling microscopy, photoelectron spectroscopy and X-ray absorption, have shown that one such species – azafullerene, $C_{59}N$ – will sublime and adsorb onto a clean silicon surface in monomeric form. This result was unexpected since azafullerene usually exists as a dimer. Analysis of valence band photoemission data, collected at the SRS, reveals that a strong interaction occurs with a clean silicon surface, stabilising the monomer. This type of experiment is an important step in the development of nanoscale electronic devices for the next millennium.

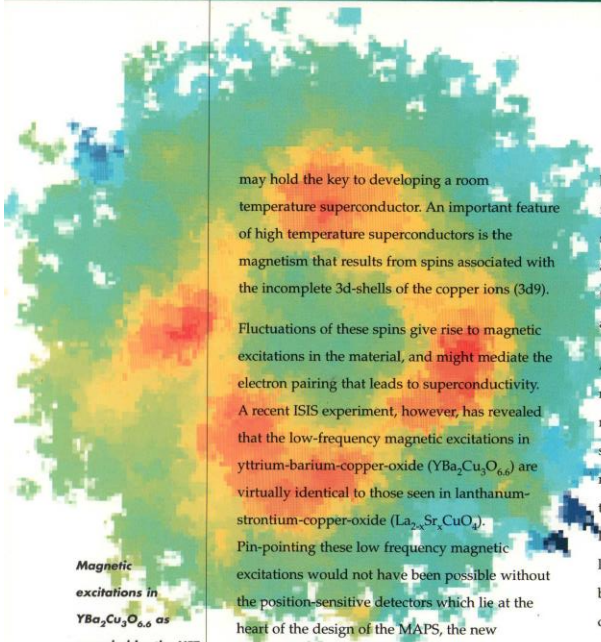
ISIS

The ISIS facility at CLRC Rutherford Appleton Laboratory is the world's most powerful pulsed neutron and muon source. Its overall performance is ten times greater than that of sources in the US and Japan. This huge machine consists of a synchrotron similar to that of the SRS but, in this case, protons rather than electrons are being accelerated. Bunches of these high energy protons are released from the accelerator 50 times per second and directed onto a heavy metal target where they shatter its atomic nuclei into fragments, including copious numbers of neutrons. These neutrons are then directed down beam tubes that radiate from the target, feeding sixteen different experimental stations. The proton beam also feeds the important RIKEN and EU-funded Muon facilities. The ISIS user community of over 1600 researchers is drawn from physics, chemistry, biology, earth and materials sciences.

Even though it has been over a decade since the discovery of high temperature superconductors, scientists have yet to come up with a widely accepted theoretical mechanism for high temperature superconductivity, knowledge that



A ball and stick model of nitrogen doped fullerene – azafullerene, $C_{59}N$ – which can be stablised in monomeric form when adsorbed onto a clean silicon surface. By bringing a variety of analytical techniques to bear on new materials, the SRS contributes to the identification of new applications and process development.



Magnetic excitations in $YBa_2Cu_3O_{6.6}$ as revealed by the HET spectrometer on ISIS. HET uses position-sensitive detectors which also lie at the heart of the new MAPS instrument.

may hold the key to developing a room temperature superconductor. An important feature of high temperature superconductors is the magnetism that results from spins associated with the incomplete 3d-shells of the copper ions (3d9).

Fluctuations of these spins give rise to magnetic excitations in the material, and might mediate the electron pairing that leads to superconductivity. A recent ISIS experiment, however, has revealed that the low-frequency magnetic excitations in yttrium-barium-copper-oxide ($YBa_2Cu_3O_{6.6}$) are virtually identical to those seen in lanthanum-strontium-copper-oxide ($La_{2-x}Sr_xCuO_4$). Pin-pointing these low frequency magnetic excitations would not have been possible without the position-sensitive detectors which lie at the heart of the design of the MAPS, the new spectrometer at ISIS. A single measurement on MAPS produces half a gigabyte of data – 100,000 times the capability of conventional spectrometers.

A new type of technology involving supercritical fluids offers a way of dispensing with toxic solvents used in the chemical industry. Naphthalene (C_6H_{10}) in carbon dioxide (CO_2) has become a model system for studying supercritical fluid extraction processes by both computer simulation and experimentation. Preliminary analysis of neutron diffraction data suggests that the CO_2 molecules form a well-defined ring around each naphthalene molecule.

As well as systems comprising small molecules, neutrons can also provide information about macromolecules, such as proteins. A team of scientists from Surrey University have been using neutron reflectivity measurements to determine the structure of the protein films at air/liquid and liquid/solid interfaces. The adsorption of lysozyme – a globular protein present in many biological fluids – was found to depend on concentration, the pH of the protein solution and also the nature of the solid surface.

Work on the next generation of instruments is underway. Next year will see the addition of a new diffractometer, GEM (the most sensitive diffractometer of its type) to the instrument suite, further consolidating the position of ISIS as the world's premier pulsed neutron and muon facility.

MAPS is the latest spectrometer at ISIS, producing much more data from a single measurement than ever before.

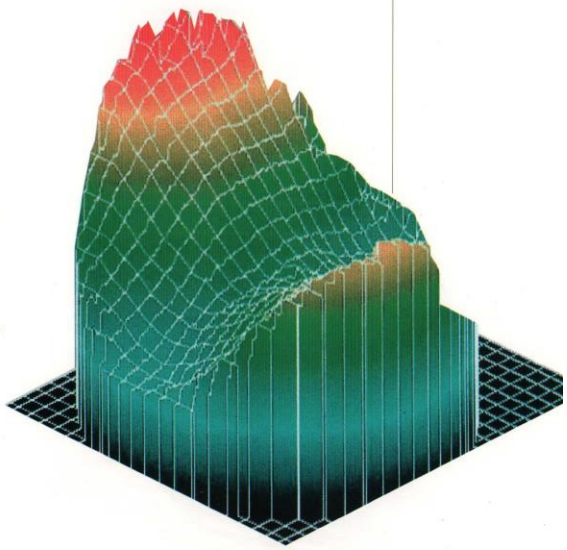
Lasers

The Central Laser Facility provides researchers from around the world with access to high power glass and titanium sapphire lasers as well as a number of smaller scale, tuneable lasers. The largest of CLRC's lasers is Vulcan which is capable of generating very short (10^{-12} seconds), ultra bright (50×10^{19} Watts/cm^2), coherent pulses of light. These are capable of producing extreme temperature and pressures when they strike a target – enough to create a plasma out of solid aluminium.

A group of scientists from Imperial College, University of California, Ecole Polytechnique, Lawrence Livermore National Laboratory and CLRC Rutherford Appleton Laboratory have been studying how electrons can become trapped and accelerated to high energies in a large amplitude plasma wave created in an ionised gas. A short, sub-picosecond ($<10^{-12}$ seconds) pulse of laser radiation originating from the Vulcan laser with a power of approximately 50 terawatts (50×10^{12} Watts) is focused into a jet of helium gas. Measurements of the energies of electrons trapped in the plasma wave created have shown energies of up to 100 MeV which correspond to the production of electric fields within the plasma of 100 GV.m^{-1}. This is the highest collective electric field ever produced in a laboratory and represents an increase by a factor of 10,000 over conventional techniques.

The ASTRA laser, one of CLRC's latest developments, can produce pulses of even shorter duration – only 50 femtoseconds (10^{-15} seconds) long. This capability has been used in research carried out by a team of scientists from Edinburgh University and CLRC to advance significantly the understanding of the way in which light interacts with molecules of atmospheric pollutant gases. This work may also lead to a technique for the accurate measurement of very small concentrations of such molecules.

The first objective is, by using the short pulse duration, to produce ions of the original molecule before it has time to dissociate, enabling signals from the parent ion to be detected. The second objective is to eliminate the need to calibrate the spectrum of ions observed for each individual contaminant. It was discovered that, above a certain power level, the probability of ionisation of all the molecules present is the same and that the intensity of the ionisation signal does not increase with a further increase in irradiation power. Advances in laser technology indicate that a portable laser and detection system based on femtosecond laser photo-ionisation spectroscopy could enable state-of-the-art air quality monitoring to be carried out almost anywhere.



A measurement of the beam quality of the ultra-short (sub-picosecond) pulse on the VULCAN laser. Maintaining beam quality and integrity whilst working at ultra-high intensities is a continuous challenge. The phase profile indicates a beam distortion of ~2.5 microns.

Particle Physics

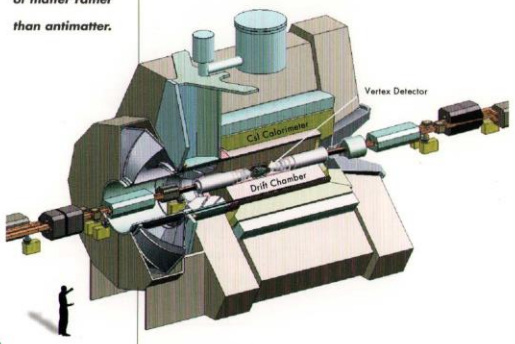
The Standard Model is the theoretical framework particle physicists use to describe the fundamental building blocks of matter and their properties. It describes the universe very precisely in terms of two sets of fundamental particles – the quarks and the leptons – and the force-carrying particles – gauge bosons – through which they interact. This model is based upon symmetry principles applying most naturally to massless particles. Although it suggests how particles acquire mass through symmetry breaking, the mechanism has still to be established and the pattern of observed masses remains a mystery.

CLRC's physicists and engineers have played key roles in a number of developments through the year. In the following examples, their contribution has been particularly significant in ensuring the success of the collaborations which are the norm in particle physics.

One of the most important measurements from the Large Electron Positron collider at CERN in Geneva was the mass of the W particle at 80.35 GeV/c^2 (± 0.07%), obtained from studies of pair production in electron-positron annihilations. The W particles are the carriers of the 'weak force' responsible for both radioactivity and nuclear reactions in the Sun. The measurement is important because its value constrains the mass of the remaining undiscovered particle in the Standard Model – the Higgs particle. Particles acquire their mass in the Standard Model in a manner devised by Peter Higgs of Edinburgh University. According to this mechanism, particles interact with a new particle, the Higgs boson, with a strength that determines their masses. Although there is no direct experimental evidence yet for the Higgs boson, subtle quantum mechanical effects mean that a precise determination of the W and top quark masses allows the mass of the Higgs to be predicted. The indications are that the Higgs particle may be lighter than previously thought.

Within the Standard Model, the neutron is expected to have a very small electric dipole moment corresponding to a unit positive and negative charge separated by about 10^{-32} cm. Most ideas of physics beyond the Standard Model, for example those proposing the existence of new particles at higher masses, give much larger values. By studying the behaviour of very low energy neutrons in electric and magnetic fields at ILL in Grenoble, a new upper limit of 6.3×10^{-26} cm has been determined, severely constraining possible extensions to the Standard Model. Work is underway to reduce this limit still further.

The BaBar experiment, designed to observe differences in the decay of matter and antimatter particles – B and Bbar mesons – is due to begin at the PEP II accelerator at SLAC in California in 1999. The aim is to try to understand why the universe is made mostly of matter. To observe any asymmetry, every particle in the decay cascade has to be identified and the energy of every photon emitted has to be measured. The main focus of the UK effort this year was the design, construction, installation and operation of the endcap part of the calorimeter together with the readout electronics for the whole of the calorimeter, used for detecting electromagnetic radiation from particle decays.



The BaBar detector for the PEP II accelerator at SLAC in California. The BaBar experiment is designed to detect asymmetries in B-meson decays, which could explain why the universe is made of matter rather than antimatter.

Space Science and Technology

Much of our knowledge of the Universe and its origins is gathered from space. CLRC has worked with universities to build and test some of the most advanced satellite systems: some looking outwards into space, others scrutinising the Earth itself. Meanwhile, the academic Starlink data service and software library at CLRC Rutherford Appleton Laboratory provides researchers with the support they need to explore the ever-growing volume of astronomical information.

A new subject in astronomy – the study of circumstellar shells – was opened up by ISO, the Infrared Space Observatory. Spectrometers on board this satellite detect these 'clouds of dust' and analyse the type and amount of any associated gas. Data from these instruments has revealed that these clouds contain magnesium-rich silicates in the form of minerals known as olivines and pyroxenes – common constituents of igneous rock found here on Earth. Similarly, large amounts of ice have been detected as well as solid carbon dioxide. This information will help astronomers understand more about how stars evolve and what material is left over to seed comets and planets around new stars.

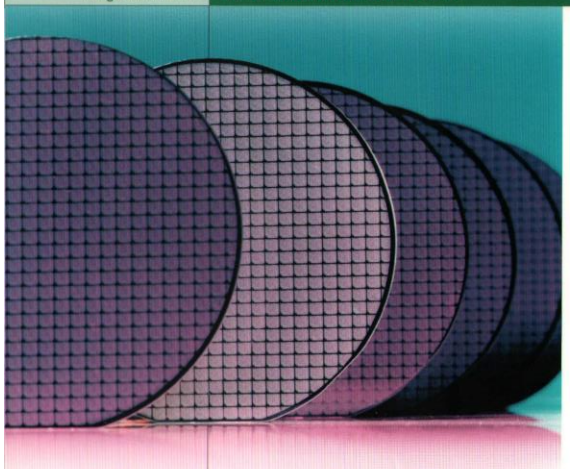
Every eleven years, the 'north and south' poles of the Sun change places – known as the solar cycle. This can have a profound effect on the Earth's magnetic field giving rise to magnetic storms that can, in turn, disrupt power supplies or affect navigational equipment. In November 1997, the Sun produced its first active region of the new solar cycle. On the 4th of November, and again on the 6th, this active region produced two very large X-ray flares and each was followed by fast eruptions called coronal mass ejections. In particular, the later ejection was one of the fastest ever seen, passing out into the surrounding solar wind to generate a strong shock wave producing a stream of very energetic (about 100 MeV) protons which flooded the Earth's inner heliosphere. These caused havoc as they hit communication and meteorological satellites, disrupting many of the signals being sent to Earth. By continuously monitoring data from SOHO and other satellites, CLRC scientists are now able to give some advance warning of solar flares and mass ejections several hours before they reach the Earth. This allows satellite shut-down to minimise damage and allows power station operators to be prepared for effects on supply and transmission.

The solar magnetic field influences the Sun's total power output – the solar irradiance. Although the rise in the solar irradiance during this century is only very small (0.1% of the total output) it can still have a marked effect on the Earth's climate. By comparing solar irradiance figures to the surface temperatures on Earth since the turn of the century, CLRC's Professor Mike Lockwood estimates that all of the global warming that occurred up to 1920 can be attributed to an increase in solar output. Between 1930 and 1970, only half the amount of global warming can be attributed to the Sun and this figure reduces to one third from 1970 onwards – man's contribution to global warming seems to be escalating.

An image of the solar corona, taken by SOHO, showing the development of a coronal mass ejection and the tracks produced by the energetic protons. SOHO results are providing new insights into the mechanisms that cause the corona to be much hotter than the surface of the Sun itself.

Engineering and Instrumentation

CLRC's engineers work in partnership with both industry and universities to transform ideas into reality, on projects ranging from the design of huge superconducting magnets for the ATLAS



Microelectronics is at the heart of CLRC's operations. Advanced microcircuits are custom designed for specific purposes, for example in systems control, data acquisition and data processing.

experiment at CERN to the design of radar for radiocommunication studies and meteorological research. This year saw the completion of the technical description and layout of SIRIUS, a next generation radioactive ion beam accelerator. The broad science areas which could benefit from such a facility were also identified. The study of nuclear physics demands beams of energetic particles to induce nuclear reactions on target atoms. It is now widely accepted that the best way to carry out such experiments is to use two accelerators: the first to produce the broadest possible range of exotic nuclei with maximal intensities and the second to accelerate these unstable nuclei up to the required energy. The preferred method of producing radioactive nuclei for post acceleration is via the spallation of medium and heavy mass targets with high energy protons. The UK has the ideal source of such protons in the ISIS synchrotron accelerator.

Current research pushes instrumentation to its limit as experiments require larger amounts of data to be collected over shorter periods. Such equipment does not come off the shelf: detectors have to be designed specifically for a particular type of experiment.

Advanced microelectronics is the key technology that underpins most of the developments in 'state-of-the-art' instrumentation. The optimisation of the design of analogue microelectronics to maximise the signal to noise ratio for a system of sensors requires access to the most advanced microelectronics technology. Likewise the data acquisition systems designed to process the massive quantities of data encountered in modern scientific experiments also require the latest electronics system design tools and techniques.

A recent example of advanced analogue electronics is the APV25 chip designed by CLRC for the readout of the silicon tracking detector in the Compact Muon Spectrometer (CMS) at the CERN Large Hadron Collider. The technology used is 0.25 micron complementary metal-oxide silicon – CMOS – which provides the research community with improved performance, at reduced cost, when compared, for instance, to a previous design based on 1.2 micron technology. The APV25 chip will be used to read out the ten million separate detectors that make up the CMS tracking detector. The analogue output from the 100,000 chips involved will be transmitted by optical fibres to an off-detector readout system involving 1000 large format circuit boards. This system will read and process data at more than 1.6 terabytes per second – equivalent to reading 3000 complete Encyclopaedias Britannica every second.

Computing

Many of the activities at CLRC's laboratories generate large amounts of data, all of which has to be stored and analysed using the latest computing techniques. In many cases, especially where data are used to model systems, conventional computers are unable to deliver the necessary performance and parallel processing is the only realistic option. CLRC's computational scientists and engineers have worked with university colleagues to develop powerful software suites and programming methodologies to exploit the most advanced computer architectures now and in the future. These have the ability to perform billions of calculations a second, allowing researchers to model some aspect of the physical world, such as climate change, the action of and industrial catalyst, or the structure of a molecule that could be useful in cancer therapy.

One modern approach is based on a number of parallel networks of commodity PCs, known as *Beowulf* machines. With help from collaborators in the US National Institute of Health, a Beowulf pilot system was assembled at CLRC Daresbury Laboratory, based on Pentium II processors with ethernet connections between them. This is now being used extensively for scientific calculations which are truly parallel – just the kinds of calculation that have previously been performed using conventional massively parallel systems.

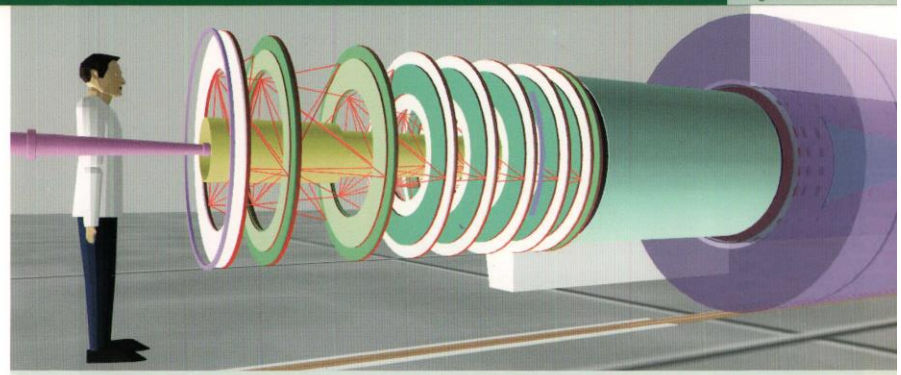
Investigations are now underway on how to scale performance up to larger numbers of processors, the merits of different types of processors and networks (or switches), and the effect of different operating systems (NT versus Unix or Linux). Such systems are expected to have a major impact in many areas of science and engineering in future years.

The Virtual Reality (VR) Centre at CLRC Rutherford Appleton Laboratory provides facilities for groups of scientists and engineers to interact with 3D virtual environments in real time using a large stereo projection screen. Individuals can also experience them using a head-worn personal viewing system. The latter enables the user to feel totally immersed within the virtual environment and to move around it and interact with it as though it was a real location.

CLRC scientists are using VR techniques to develop new experimental facilities for the Large Hadron Collider (LHC) project at CERN. VR enables them to optimise the design of one of the most challenging components of the ATLAS experiment – the inner vertex detector – that has to measure the exact positions of particles emerging from the LHC interaction region. In order to do this, its own position must be very accurately measured. A novel optical survey system using light sources and detectors is being incorporated in the design. This will enable the positions of the components of the detector to be constantly monitored during operation of the experiment to take account of the small displacements that will inevitably occur deep inside this huge magnetic detector system.

And there's more...

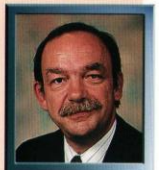
This concludes a brief 'dip' into the work of CCLRC. More details can be found in the Council's newsletter *Science & Technology*, its website *http://www.clrc.ac.uk/* and from the contacts listed towards the end of this report.



A virtual reality model showing the internal components of the ATLAS inner vertex detector at the Large Hadron Collider at CERN. The sight lines of the built-in optical surveying system for monitoring the alignment of the detector components are indicated in red. VR techniques have now developed into an essential design tool for complex constructions.

CCLRC

Achieving our objectives



Richard Lawrence-Wilson
Director Administration

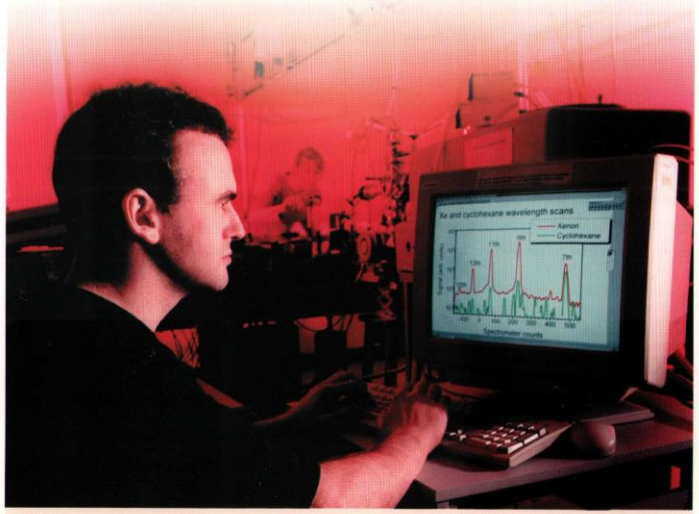
Operations

The Council for the Central Laboratory of the Research Councils (CCLRC) was established on 1 April 1995 as a Research Council under the Science and Technology Act 1965. As the name indicates, CCLRC provides facilities and services supporting the grantholders of the funding research councils – specifically, BBSRC, EPSRC, MRC, NERC, PPARC – and others. These councils are the principal stakeholders in CCLRC, providing some eighty per cent of the funding. In addition there is a significant, and increasing, percentage from other sources.

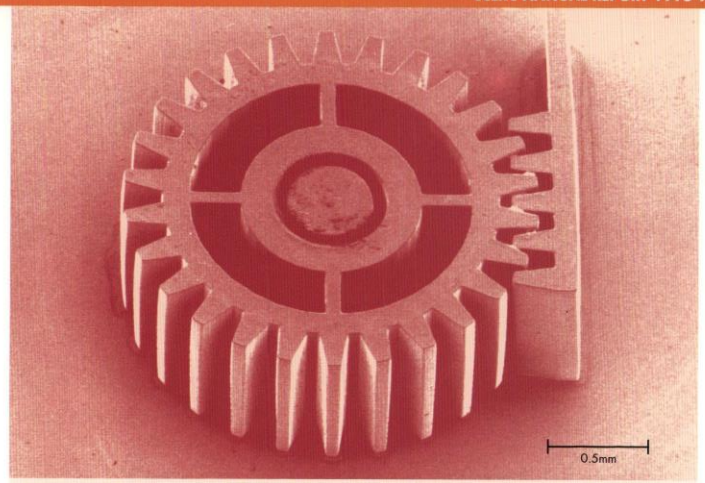
CCLRC has a strategic role in providing the national facilities and technical expertise for very large instruments such as neutron and synchrotron X-ray sources and lasers. A key objective is to develop the services provided to the users and to increase the utilisation both by the science base through the research councils and directly with industry and Government.

A second key objective is to develop the core competences and other capabilities that can contribute significantly to the nation's science and technology knowledge base, and that can be sustained by virtue of an evident competitive edge derived from scale, capability and flexibility.

A strategic aim of CCLRC is to secure a broadening and growth of CCLRC's collaborator base to ensure that the public sector investment is being exploited and to ensure that CCLRC contributes fully to the UK science, engineering and technology base as a whole. The Government's Comprehensive Spending Review (CSR) target is for CCLRC to derive 30% of its income from non-Research Council sources within 5 years. CCLRC's approach is based on partnerships: strategic partnerships with major organisations, including joint ventures, and with start up companies, including the licensing of intellectual property as appropriate.



Researchers Dr Nick Hay and Emma Springate from Imperial College, London working in the ASTRA laser facility. The newly commissioned ASTRA ultra-high intensity laser facility complements the existing Vulcan interaction facility. The CLF also operates the Lasers for Science Facility where a diverse range of laser equipment is available for use to the research community.



A scanning electron micrograph of a tiny rack and pinion, less than 1mm high, fabricated in a single step process from a commercial resist material by scientists at the Central Microstructure Facility. CLRC's advanced technological capabilities are available to both the industrial and university research communities and are used increasingly by small, start-up companies who need access to the latest techniques but lack the capital to make the necessary investment.

In order to maximise the efficiency and effectiveness of CCLRC in supporting its major stakeholders, every opportunity is taken to access complementary funding sources. In the UK, this has included successful collaborations with university partners under JIF and JREI mechanisms, direct contracts with other Government Departments and private sector funding. Looking further afield, contracts with the EU and countries across the globe complement the domestic activity, bringing a welcome broadening of CCLRC's horizons and providing direct recognition of the world-class status of CCLRC's facilities and activities.

To further these connections, a small Direct Vote has been established, arising from the CSR, which allows CCLRC to invest in activities which represent the future for facility and technology developments or exploitation.

Major facilities and programmes

The operation of the Synchrotron Radiation Source (SRS) at the Daresbury Laboratory is funded principally by EPSRC (65%) with BBSRC and MRC contributing 17% of the total operating costs. The current balance of users is 85% from physical sciences and 15% life sciences. Over the coming years this balance is expected to shift more towards life science studies.

Following consultations with users, CCLRC has carried out a feasibility study on a new synchrotron. The DIAMOND proposal is for a medium energy X-ray electron storage ring based on the use of insertion devices, at a cost of approximately £173M. Following the CSR, provision for funding a new facility has been made by the Wellcome Trust (up to £110M) and the Government (£35M in this CSR period with more to follow in the next). BBSRC, EPSRC, MRC and NERC have all indicated their need for such a facility and detailed consultations with the

A virtual reality image of the new MAPS detector on ISIS. CLRC's skills in VR are brought to bear on a wide range of design projects. Advanced visualisation techniques allow designers to be sure that interacting components will fit before committing them to production.

potential user communities are taking place to firm up on the specification.

The Council's ISIS Review Panel, chaired by Professor Sir Michael Thompson, confirmed that ISIS provides the scientific communities in the UK, elsewhere in Europe and beyond with neutron facilities that are unmatched anywhere in the world. It urged that attention be paid to refurbishing critical components of the ISIS facility and recommended that demand for the facility justified an upgrade to the accelerator and the timely addition of a Second Target Station. The UK research councils and international partners have now agreed a seven-year £17M refurbishment programme for the ISIS accelerator, target station and key beamline components.

The Vulcan laser accounts for approximately 75% of the Central Laser Facility programme. An upgrade of the Vulcan laser, which has been funded by EPSRC, will become operational in 2002. The ASTRA and Lasers for Science facilities have been the subject of research council awards during the year, taking them into the next millennium.

Primary funding for Space Science and Technology comes from Service Level Agreements with PPARC and NERC. CCLRC has recently been integrated as a full partner in the British National Space Centre (BNSC). This will give further scope for participation in new international space programmes, the first of which is a role on behalf of BNSC to support the UK community in the use of the International Space Station.

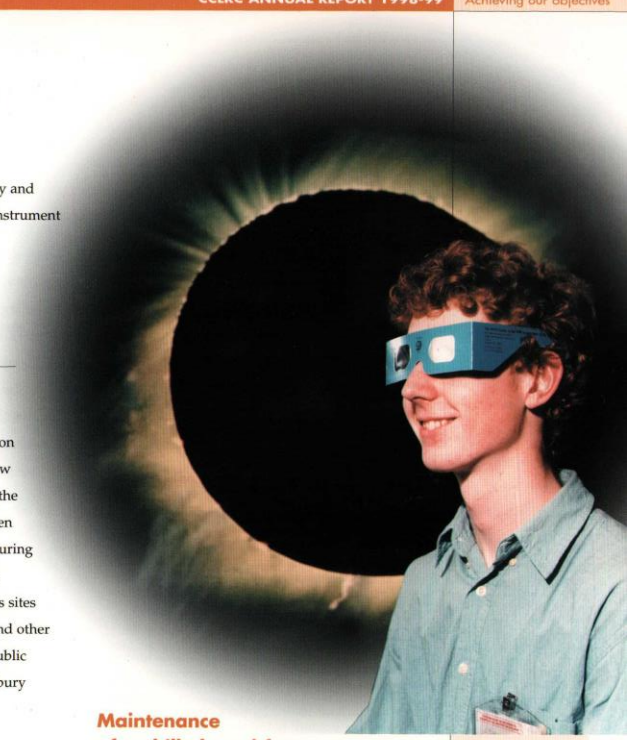
PPARC funds, via a service level agreement with CCLRC, a strong particle physics support activity for its community. This includes the provision of local user support for UK researchers working at distant sites as well as computing, theory and administrative support for the community and technical support and co-ordination for instrument development.

Public Understanding of Science and Technology (PUST)

Following the successful Open Days at CLRC Daresbury Laboratory in 1997, a similar event at CLRC Rutherford Appleton Laboratory took place in July 1998 and saw over 3000 members of the public touring the facilities, with a further 1100 schoolchildren and 650 professional visitors welcomed during the preceding week. The two laboratories welcomed some 3000 further visitors to its sites during the year for a variety of lectures and other events, including 900 who attended six public lectures – a new initiative at CLRC Daresbury Laboratory.

CCLRC also played a leading role, in collaboration with PPARC, in a DTI SET event on 'The Eclipse, the Sun and the Stars' held in London and hosted by the Science Minister, Lord Sainsbury. This event attracted a capacity audience of several hundred, including Lords, MPs and senior Whitehall staff.

CCLRC played an important role in the establishment of a new science news service, AlphaGalileo, providing the media with 24-hour access to breaking science stories. As well as providing support for the pilot service, along with other research councils, OST, the Wellcome Trust, the French Government and others, CLRC Rutherford Appleton Laboratory provides the technical development, management and support for the site. This is funded through an award from the British Association for the Advancement of Science, the overall project co-ordinator for AlphaGalileo.

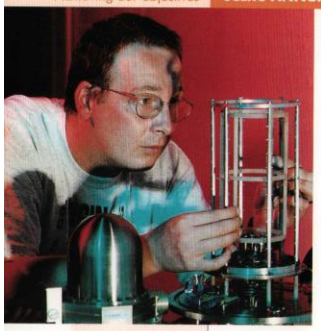


The 1999 Eclipse provides a real chance to get a scientific message across to a large number of people who might otherwise be difficult to reach. CLRC played a significant role in the Eclipse Group, set up to promote a series of public events, a Website and appropriate media coverage to take full advantage of the opportunity.

Maintenance of a skilled workforce

CCLRC is committed to ongoing training and development to ensure that it takes full advantage of modern practices in scientific, technical and administrative activities. This is already embedded in the annual review of staff performance and is now being addressed more globally in the context of Investors in People (IiP). In October 1998, the Heart of England Training and Enterprise Council acknowledged the commitment made by CCLRC to work towards achieving the IiP standard. Departments have worked throughout the year to develop the processes necessary to attain the standard, and a staff survey conducted in early 1999 confirmed that significant progress had been made. Process implementation is now under way and the Laboratory expects to be ready for assessment in April 2000.

Management and Trade Union sides enjoyed good relationships during 1998-99. The Council's



Care and attention to detail is the key to success. In this case, a Space Cooler is being assembled ready for testing prior to its deployment for an ESA satellite mission. CLRC staff bring a wide range of skills and expertise to bear on advanced science and engineering projects.

management recognises and appreciates the time and effort which was given by the Trades Union representatives to the consultative processes that aim to ensure a framework of partnership in achieving the objectives of the Council.

Equality of opportunity

The Council is committed to equality of opportunity in the workplace and has policies and procedures in place to ensure that employment and advancement are judged solely on the basis of ability, qualifications and suitability for the work available. Regular monitoring verifies that these procedures are operating effectively. Recruitment by the Council is undertaken on the basis of fair and open competition. The Council has adopted the policy statements on equal opportunities and on race relations issued by the Cabinet Office.

The Council pays particular attention to supporting those with family or other caring responsibilities by means of flexible working arrangements and other forms of support including part-time working, job sharing and career breaks. The workplace nursery provided by the Council at CLRC Rutherford Appleton Laboratory continues to operate at full capacity and received a glowing report from the OFSTED inspectors.

The Council's policy is that disablement is no bar to recruitment or to advancement within its workforce. Applicants with disabilities are given full and fair consideration for any vacancy. The Council has carried out detailed reviews on both its sites in order to ensure that, wherever possible, physical barriers to mobility are removed. The Council has established links with groups and organisations that promote the employment of people with disabilities.

Health & Safety

The Council has published a Safety Policy Statement together with subsidiary statements for each of its main sites. Safety Committees, including representatives of the workforce, are maintained at each site, meeting regularly and operating in accordance with the recommendations of the Health and Safety Executive. The Council monitors safety performance by means of regular reports and has set targets for the maintenance and improvement of health and safety.

The number of reportable lost time accidents of duration greater than three days was just 3.5 per 1000 employees (for example, comparing favourably to the 1998 national average for the electrical/electronic (research) category of 5.7). The total number of days lost was 202 - 126 days of which were attributable to a single occurrence – compared to 102 days the previous year.

For the calendar year 1998, both CLRC Daresbury Laboratory and CLRC Rutherford Appleton Laboratory were awarded Gold Awards for Occupational Safety by the Royal Society for the Prevention of Accidents. The two main prerequisites for the Award are a high quality safety management system and a low accident record.

Environmental policy

The Central Laboratory is subject to all statutes and regulations applying to private sector bodies. All statutory requirements were fully complied with during the year. The Council has published an environmental policy statement setting standards and targets relating to its scientific and technical operations and to waste, emission and other environmental aspects of its work.

Amanda Frank from Occupational Health checks a member of CLRC staff. Both main sites have resident Occupational Health teams – provided under contract by RGIT Ltd.

An inevitable consequence of the operation of the ISIS facility is the production of small quantities of radioactive gas, mainly tritium, which are discharged to atmosphere via monitored ventilation stacks. The Environment Agency authorises these discharges and sets the allowable limits. The authorised limits for 1998-99 were 2,860 GBq of tritium and 200 TBq of nuclides. The measured discharges of 698 GBq for tritium and 29 TBq of nuclides during the year were well within these limits. Some 2.4 tonnes of low-level solid radioactive waste was sent to AEA Technology, Harwell for disposal and 214 litres of low-level aqueous radioactive waste was sent to the UKAEA for disposal.

The recycling of materials has been extended and now includes toner and printer cartridges, fluorescent tubes, drinks cans, scrap metal and office and workshop waste. The quantity of paper recycled as a percentage of the amount purchased has increased year on year over the last four years:

	1995-96	1996-97	1997-98	1998-99
Percentage recycled	**23**	**29**	**62**	**68**

Year 2000 compliance

The Council set up a Year 2000 project team early in 1997. The team continued its work during 1998-99 and, by the end of the year, all systems were either compliant or plans were in place to achieve compliance before the end of 1999.

Financial and management systems

1998-99 was the third year in which the Council produced accounts on an accruals basis and the second in which they were produced from the system termed FAMIS (Financial Accounting and Management Information System).

The report of the Comptroller and Auditor General on the Council's accounts for 1997-98 led to a hearing of the Public Accounts Committee in March 1999 at which the Chief Executive was examined on the procurement, installation and implementation of FAMIS. The Committee concluded that the complexity of the FAMIS project had been underestimated, that the decision not to parallel run the new and old systems was based on an inadequate analysis, and that there was an unacceptable lack of communication between the Council and the Department of Trade and Industry. They concluded that it was essential that the Council and the Department take steps to resolve the outstanding issues as soon as possible and learn lessons from the project.

The operation of FAMIS was reviewed in the Autumn of 1998 and a project plan has since been followed to complete the implementation of the system's key elements. This has enabled the production and audit of the Council's 1998-99 accounts to the agreed timetable. The software has been upgraded to a later release which is Year 2000 compliant. A joint project team composed of Council staff and consultants from the suppliers continued to work to put in place the final elements of the system. Full acceptance is expected in Autumn 1999.

CCLRC Commercial partnerships

Dr Allyson Reed
Director
Marketing
& Business
Development

One of the key aims of CLRC is to facilitate the innovation process by helping industry to introduce new and emerging technologies – an essential element of success in today's competitive world. CLRC is already engaged in successful collaborations with over 120 companies, from routine sample analysis to truly integrated partnerships covering areas from aerospace engineering to environmental science. The number and total value of commercial sales continues to rise year on year with especially strong growth in the industrial sector.

Resident companies

New and developing companies are encouraged to use the facilities of CLRC and several have established operations on CLRC sites. One such company, PFE Ltd has set up comprehensive fabrication and testing facilities for the production of a new type of field emitting display in the ATLAS centre at CLRC Rutherford Appleton Laboratory. The company holds the patents on a generic broad area field emitter that is not only far cheaper to manufacture but can be scaled up to large sizes and realistic production volumes with comparative ease.

PFE Ltd is a young company developing field emitter displays using facilities at the CLRC Rutherford Appleton Laboratory. PFE is one of several companies on the Chilton site, another being Ceravision which is developing flat panel displays using microtechnology equipment and expertise at RAL. In this latter case, CCLRC has taken a small stakeholding in the company – an arrangement that attracted the company back from Silicon Valley in the USA.

Bookham Technology, Qudos Technology and Exitech continued to make good use of the clean room and silicon processing facilities at CLRC Rutherford Appleton Laboratory's Central Microstructure Facility, as does Ceravision. These companies utilise the facilities in the fields of optical switching, silicon microcircuits, laser technology and flat panel displays.

Over the past few years there have been several spin-out companies exploiting intellectual property developed at CLRC. The most recent example, and the first in which CCLRC holds significant equity, is a company called the Interactive Media Corporation (IMC) whose aim is to get an interactive service named IRIS to market as quickly as possible.

IRIS aims to combine the best features of a television service with those available on a PC. The result is a PC which looks like a TV but can also allow users to surf the Internet, log into their home computer, send e-mail messages and a whole lot more.

The concept was first proposed by researchers from CLRC and Trinity College, Dublin. Eighteen months later, Jury's Hotels was hosting a live trial for its paying guests. One year later, IMC installed an IRIS system in a 'designer' hotel for plastic surgery patients in Harley Street in London. Now several multimedia companies are seeking licensing deals with IMC to apply this technology to corporate, educational and domestic use.

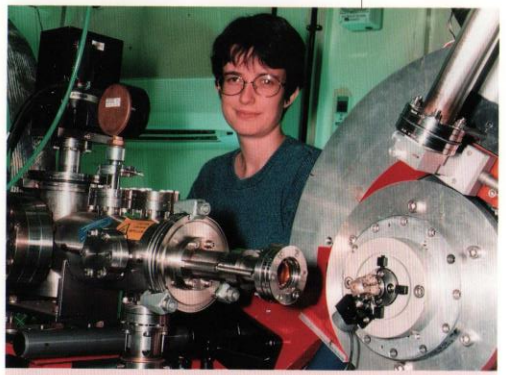
Sample analysis service

DARTS provides a turnkey sample analysis based on X-ray techniques at the Synchrotron Radiation Source. This value-added service provides for rapid turnaround and access to a wide variety of complementary techniques and analysis from infrared microscopy to X-ray diffraction. This year DARTS has almost doubled its income with its main customers coming from the pharmaceutical and healthcare industries.

Detector systems

A new type of photon detector system, RAPID, has been developed, and installed, at the Daresbury Synchrotron. This system has a count rate capability at least two orders of magnitude higher than conventional solid state detectors, enabling scientists to collect high quality X-ray diffraction data over very short timescales (milliseconds). CLRC has now joined forces with Oxford Instruments to supply one of these detectors to Japan's SPring-8 – the World's brightest high energy synchrotron.

C-TRAIN is the name of another new and highly compact detector system designed at CLRC Daresbury Laboratory. This reveals chemical 'fingerprints' by measuring the intensity of fluorescence X-rays emitted from a sample when stimulated with a single energy X-ray beam generated from a synchrotron light source. This new detector system is the combination of a novel detector design from EG&G Ortec with XSPRESS (X-ray Signal Processing Electronics for Solid State Detectors) digital electronics developed at the Laboratory. This detector is now being marketed by EG&G Ortec and will soon be appearing at synchrotron laboratories around the world.

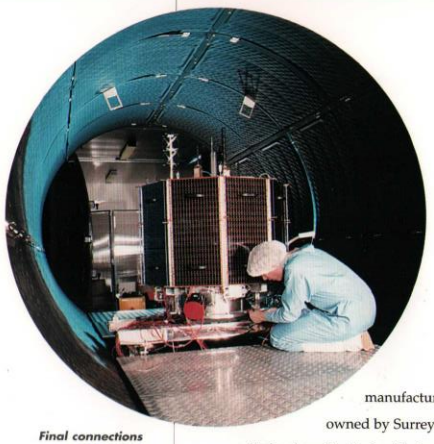


DARTS' Elizabeth MacLean, at work on SRS Station 2.3. The powder diffraction techniques it supports are used by the materials industry.

Satellite testing

Europe's most advanced space-based thermometer for use in climate research has completed its calibration campaign at CLRC Rutherford Appleton Laboratory. The heat-sensing instrument, known as the Advanced Along Track Scanning Radiometer (AATSR) spent many months in a purpose-built space simulation chamber at RAL during its sophisticated test sequence. Its seven detectors, which operate at infrared and visible wavelengths, were radiometrically calibrated and its optical, thermal and electrical performances were checked. It has now been delivered to Matra Marconi Space in Bristol for integration into Europe's largest environmental satellite, ENVISAT.

Closely following the testing of AATSR, an experimental and educational minisatellite completed thermal vacuum testing in the same chamber. UoSAT-12, which has been designed,



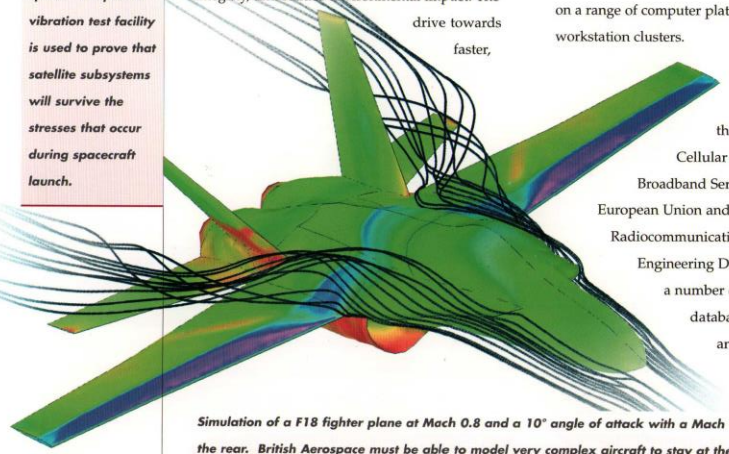
Final connections being made to the UoSAT-12 spacecraft within the space test chamber prior to thermal vacuum testing at CLRC Rutherford Appleton Laboratory. The facility can carefully mimic the conditions to be encountered in space. A separate vibration test facility is used to prove that satellite subsystems will survive the stresses that occur during spacecraft launch.

manufactured and is owned by Surrey Satellite Technology Limited, will demonstrate advanced low Earth orbit communications and Earth observation payloads. Weighing 350 kg, the minisatellite carries novel propulsion, attitude control and navigation experiments, and has a five year design life.

Modelling

Computer simulation is a major element in many design processes. It can reduce development times, improve product efficiency, reliability and integrity, and reduce environmental impact. The drive towards faster, more accurate simulations inevitably means that conventional computers are unable to deliver the necessary performance: parallel processing is the only realistic option. The Computational Science and Engineering Department at CLRC Daresbury Laboratory, in collaboration with industry, is now tackling 'real world' simulation problems using these advanced computing techniques.

A good example of this is a recent project, funded by British Aerospace, to parallelise an industrial code for obtaining Euler predictions of flows over complex aerodynamic configurations. The package, FLITE3D, is used extensively by British Aerospace in aircraft design and simulation. It contains complex algorithms designed for standard sequential computers and is not inherently well-suited to multi-processor computers. So the parallelisation of the code required careful design and analysis. The target platform for British Aerospace was a 128 node Silicon Graphics Origin machine. The final version, however, is fully portable and has been tested by British Aerospace on a range of computer platforms, including workstation clusters.



Simulation of a F18 fighter plane at Mach 0.8 and a 10° angle of attack with a Mach 1.0 jet issuing from the rear. British Aerospace must be able to model very complex aircraft to stay at the forefront of technology. By use of parallel processing, a more complete investigation of key parameters can be undertaken, vital where the flow behaviour can be unpredictable (courtesy of British Aerospace).

Another major project completed this year was CRABS, Cellular Radio Access for Broadband Service, funded by the European Union and the DTI Radiocommunications Agency. CLRC's Engineering Department developed a number of tools based on databases of building, terrain and vegetation which can be used to accurately predict and optimise signal coverage. The completion of the CRABS project, in which CLRC played a pivotal role, will open up the worldwide delivery of high quality digital television and internet services to homes by using high frequency radio signals as a more cost-effective option than optical fibres.

Information Technology

CLRC's Information Technology Department is a member of the World Wide Web consortium, W3C, which, in November 1997, launched a joint project between INRIA (Institut National de Recherche en Informatique et an Automatique) and CLRC to increase European industry's awareness of W3C and the Web. In a series of high profile seminars, industry champions were encouraged to demonstrate the positive impact of the Web to their future business. By the end of the project, European membership of W3C had increased 38% faster than in the US, with 330 organisations now on board.

Another example of the continuing, wider impact of CLRC's IT activities takes us to Bordeaux – not for wine but for water! CLRC software engineers, in close collaboration with a team from Suez Lyonnaise des Eaux, one of the world's largest water companies, have developed and installed a computer system to handle potential flood waters.

Since devastating floods in 1982, the Bordeaux urban community has invested in a huge network of underground storage tanks, high capacity pipes and water retention basins which are monitored continuously. As soon as the water levels reach a certain limit in one of these basins, an alarm is triggered. In a potential flood situation the number of alarms triggered escalates rapidly and the task becomes extremely difficult. The new system not only filters and groups the alarms from the network but also interprets them and gives immediate advice on how best to tackle the situation.

The RAMSES control centre where the levels of water in Bordeaux's huge underground drainage network are monitored. As well as their application in industries based on the very latest technologies, modern IT solutions are applied to the most traditional of industries (courtesy of Suez Lyonnaise des Eaux).

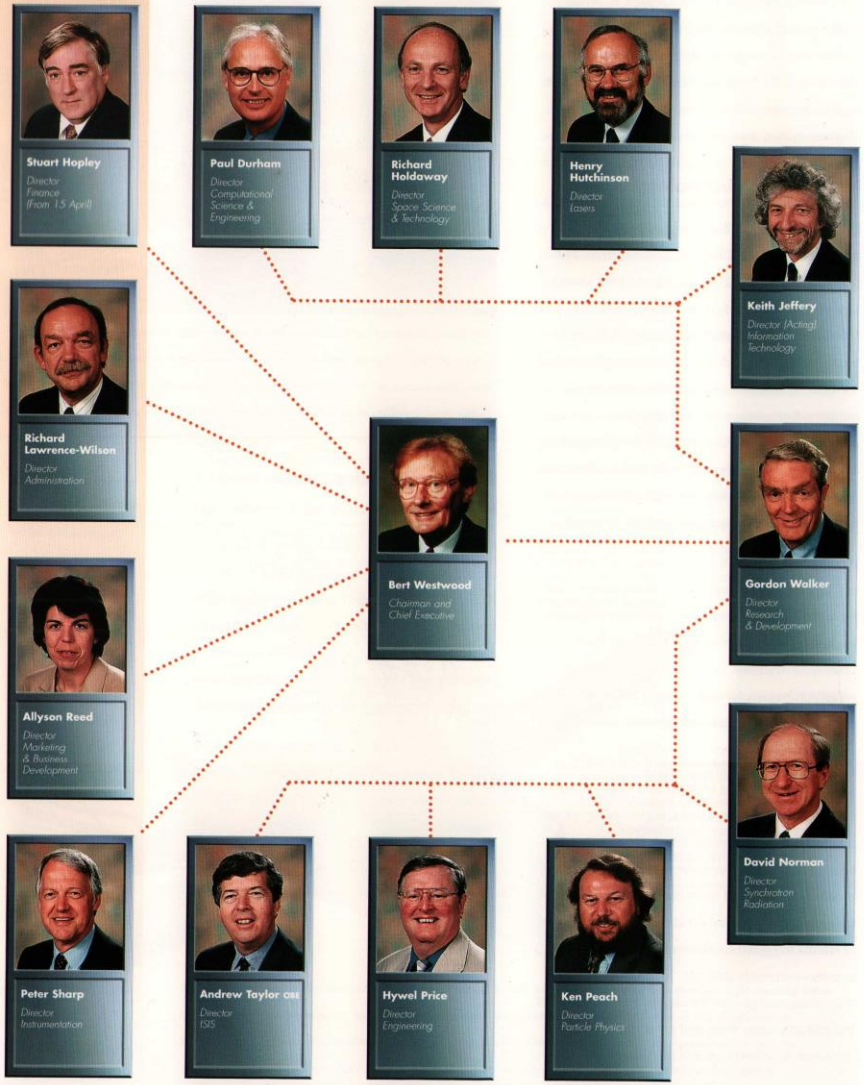
Business Development – new partnerships

More than 200 senior industrialists visited CLRC on an 'industry day' chaired by DTI DG (Industry) Alastair MacDonald and many individual visits were also arranged during the year. New partners are always welcome and a specialist Business Development Manager for your industrial sector can link you with the technology that you need.

The resources of CLRC are there to be exploited to solve industrial and university problems alike and a commercial interface is there to make this happen.

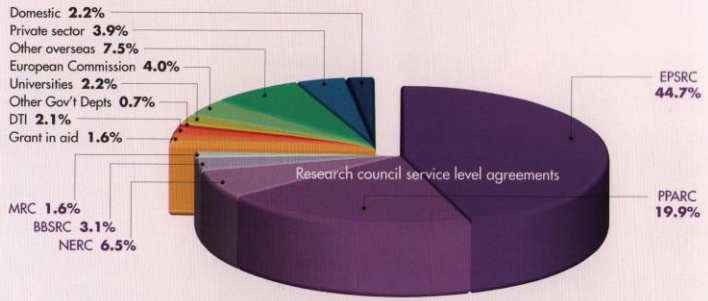
Contact the Business Development Office for further details (see contacts at the end of this Report).

CCLRC Senior management
(At 1 April 1999)

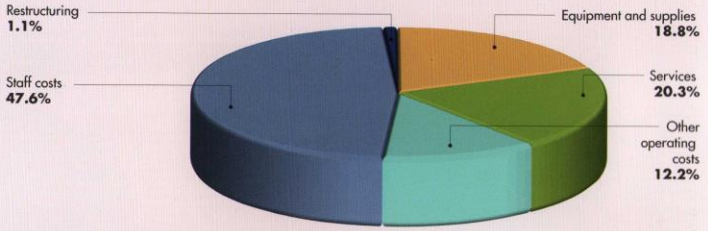


CCLRC Financial summary 1998-99

Operating turnover



Total recurrent operating income 1998-99 £91.2M (1997-98 £96.5M)



Total recurrent operating expenditure 1998-99 £96.6M (1997-98 Restated* £96.6M)

The accounts for 1998-99 record a deficit of £5.4M. Income from operating activities was significantly less than the previous year with growth in income from external bodies overshadowed by a significant reduction in income from the UK Research Councils. In contrast, operating expenditure, reflecting the fixed-cost, long-term nature of much of the Council's operations, fell slightly. The deficit is underwritten by the Government's Science Budget. The Council has agreed an Operating Plan for the next two years which is targeted to return the operating position to break-even by 31 March 2001. Management information arrangements are being developed after earlier implementation problems with the new financial system. Full details of 1998-99 financial performance are available in the Council's accounts, which are published separately.

Resources

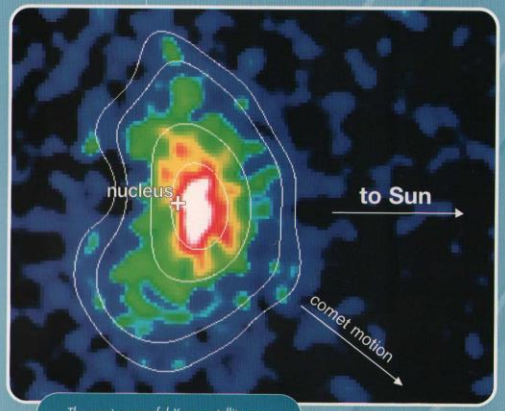
	1998-99	1997-98
Staff (average whole-time equivalent employed)	1691	1722

CAPITAL ASSETS

Values at the year end	£M	£M Restated*
Land and buildings, at cost or valuation	113.1	107.8
Plant and equipment, net book value after depreciation	137.1	145.4
Assets under construction, at cost or valuation	11.3	6.2
Total fixed assets employed	261.5	259.4

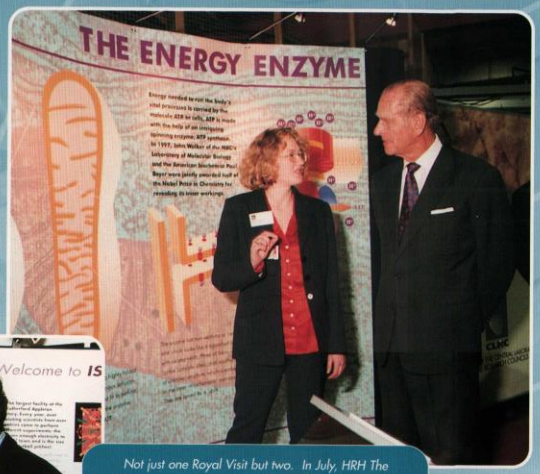
** Restated due to changes required by Financial Reporting Standard 12, Provisions, Contingent Liabilities and Contingent Assets.*

Events 1998-99



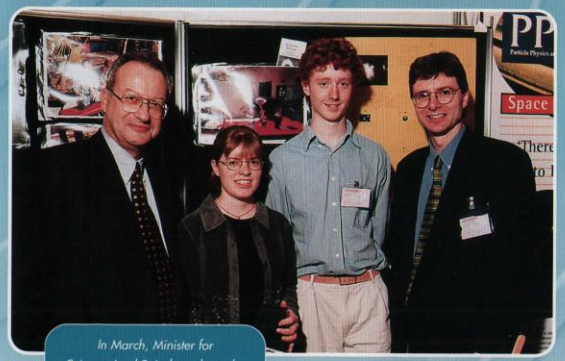
The most successful X-ray satellite ever, ROSAT, completed its mission in February 1999, having provided astronomers with images and data on unquantified X-ray sources for almost ten years. ROSAT made the first ever extreme ultra-violet (EUV) image (shown here) and, in parallel, made X-ray measurements, of a comet when it observed Comet Hyakutake in 1996. The combination of simultaneous X-ray and EUV measurements proved a powerful means of investigating the physical mechanism responsible for the observed emission. The results showed that there must be previously unsuspected 'high-energy' processes taking place in the comet, probably due to the influence of the Sun's radiation and/or the solar wind.

Professor Lucio Bianco, President of the Consiglio Nazionale delle Ricerche (CNR) the council that promotes and co-ordinates scientific research in Italy, stands proudly by the plaque that he unveiled to inaugurate Tosca, the latest addition to the ISIS family of instruments. Tosca was funded by the CNR with a major contribution coming from the HEFCE through the Joint Research Equipment Initiative in collaboration with the University of Kent at Canterbury.



Not just one Royal Visit but two. In July, HRH The Duke of Edinburgh toured the Synchrotron Radiation Source at CLRC Daresbury Laboratory, learning about its work on enzymes (pictured here with SRS scientist Bridget Murphy) chocolate and other materials, then going on to open the Visitor Centre. In December, HRH The Duke of Kent visited CLRC Rutherford Appleton Laboratory, touring ISIS (shown here with ISIS Director, Andrew Taylor OBE), Lasers and the Space Science Department.

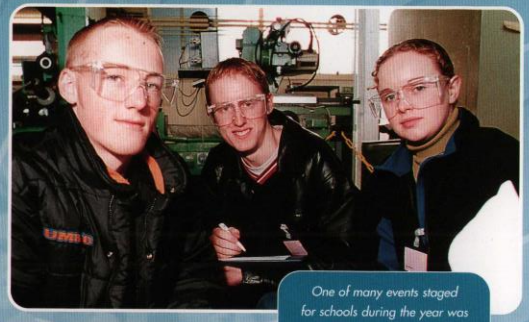
Director-General of the Research Councils, Dr John Taylor OBE FRS FREng, visited CLRC Rutherford Appleton Laboratory in January 1999. As well as touring the Central Laser Facility, where he is pictured with Director, Henry Hutchinson, he took the opportunity to see the other major facilities on the Chilton site.



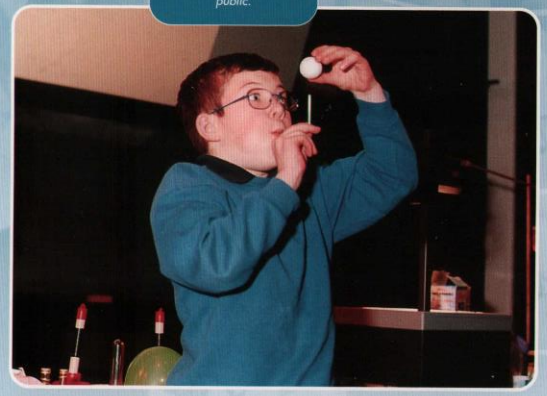
In March, Minister for Science, Lord Sainsbury, hosted a special event at DTI in London to celebrate SET99 - the National Week of Science and Technology. PPARC and CCLRC mounted a special exhibition and lecture programme on 'The Eclipse, The Sun and The Stars' which attracted a capacity audience of several hundred from Parliament and Whitehall. Pictured here with the Minister are teacher, Neil Tunstall, and pupils from Helston School in Cornwall who came to the event to show some of the Eclipse-related work they are doing in conjunction with the two Research Councils. Lord Sainsbury also visited CLRC Daresbury Laboratory in December.

Public lectures at CLRC Daresbury Laboratory have proved very popular. Six lectures have been held with many being over-subscribed by three or four times.

The successful CLRC Rutherford Appleton Laboratory/Didcot 6th Forms project team pictured at the Engineering Education Scheme (EES) Annual Presentation and Assessment Day. As Engineering is crucial to the work of CLRC, it is pleased to support the EES both by hosting the Day and by supporting a local team throughout the year in their project work. The scheme forms part of the Royal Academy of Engineering's Engineering Continuum, designed to ensure that good engineers are taken through their careers in a rigorous fashion.



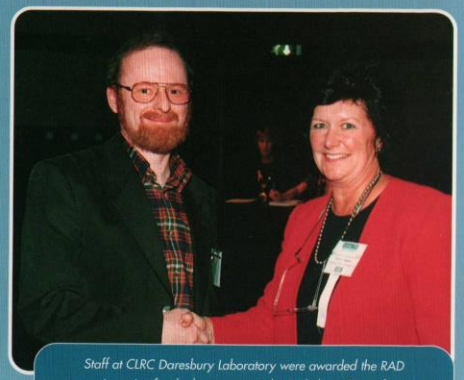
CLRC laboratories are promoting the public understanding of science by working with their local communities. Basic science concepts are explained in an interactive way to schools and the general public.



One of many events staged for schools during the year was a safety seminar, jointly organised by the Institution of Occupational Safety, the Esso Research Centre and CLRC Rutherford Appleton Laboratory. The seminar set out to give 'A' level students an understanding of the underlying principles of health and safety in the workplace before they start full-time employment, presented in a practical (and fun) way. Both main CLRC Laboratories received 1998 Gold Awards from the Royal Society for the Prevention of Accidents as recognition of the quality of safety management systems and the low level of accident rates.

Seven CLRC scientists participated in the first National Showcase of Science, Engineering and Technology held at the House of Commons. Over 300 young researchers from University, Industry and Government Laboratories competed for the 'Westminster Awards and Prizes' at the showcase which aimed to highlight young researchers' contributions to British science.

CLRC's Ruth Bamford was presented with a special PPARC prize by Dr Geoffrey Findlay of PPARC, for her work on radio experiments to be performed during the UK 1999 Total Solar Eclipse. The judges liked her project because it successfully combined a timely event - the eclipse - with original research on radio propagation. Ruth's poster was chosen because the judges were impressed by her ability to explain the project clearly to the MPs and other guests. Photo courtesy Frank Dumbleton.

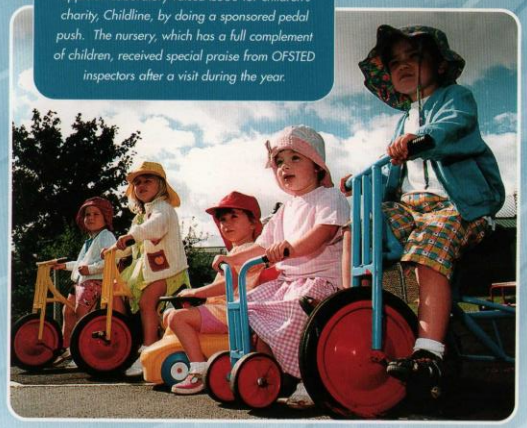


Staff at CLRC Daresbury Laboratory were awarded the RAD magazine prize for the best poster at the Radiology 98 conference, organised by the British Institute of Radiology, covering all kinds of medical imaging, and attracting more than 2000 delegates. The poster entitled 'The advantages of Synchrotron Radiation for Breast Imaging' focused on some work carried out at Daresbury by Rob Lewis, Bill Helsby and Chris Hall in association with the Christie Hospital. Rob Lewis is pictured with Professor Judith Adams, Chairman of the congress committee. Photo courtesy Rob Lewis.

Mike Lockwood received the Royal Astronomical Society's Chapman Medal in October. Mike, head of solar terrestrial physics at RAL, has been working on projects investigating the magnetic interactions between the Sun and Earth and it was for this work that the RAS chose him for this award.

Both the Sun and the Earth have vast magnetic fields around them which interact, and these interactions are of great interest to scientists. The magnetic fields around the Earth help deflect the Solar Wind - the stream of energetic particles which radiates continuously from the Sun. The effects of the Solar Wind include the spectacular Aurora Borealis as well as the occasional breakdown in navigation, power or communication systems on Earth. Understanding how the magnetic fields of the Sun and the Earth interact will help scientists of the future produce solar weather forecasts.

Ready, steady, GO! Around thirty children from the Little Stars nursery at CLRC Rutherford Appleton Laboratory raised £330 for children's charity, Childline, by doing a sponsored pedal push. The nursery, which has a full complement of children, received special praise from OFSTED inspectors after a visit during the year.



CLRC Rutherford Appleton Laboratory welcomed some 5000 people to its Open Days in June. Themed days attracted schools, the public and professional visitors – university, governmental and industrial – with hands-on experiments and displays backed by topical lectures, industrial updates and the opportunity to meet and discuss projects with CCLRC staff.

CCLRC

Further information

Contact points

Further details of CCLRC's programme are available in departmental publications. These and specific information on the programme are available from the following contacts:

Information Technology	01235 445634
Engineering	01235 445612
Instrumentation	01235 445566
ISIS	01235 445610
Lasers	01235 445655
Particle Physics	01235 445448
Space Science & Technology	01235 445111
Synchrotron Radiation	01925 603324
Administration	01235 445644
Finance	01235 445181

Other, more general enquiries should be directed to the following:

- **Press and Public Relations**

Daresbury Laboratory	01925 603272
Rutherford Appleton Laboratory	01235 445789

- **Marketing and Business Development**

Daresbury Laboratory	01925 603432
Rutherford Appleton Laboratory	01235 445700

- **Libraries**

Daresbury Laboratory	01925 603397
Rutherford Appleton Laboratory	01235 445384

More details are available from CCLRC's World Wide Web pages

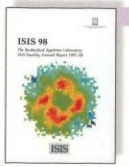
The URL of its home page is **http://www.cclrc.ac.uk/**

Publications

A range of publications is available from the Press and Public Relations section including:

- **Science & Technology – the newsletter of the Central Laboratory**
- **More specialised reports including those from the ISIS, SRS, Central Laser and Central Microstructure Facilities.**

Science & Technology
Three issues yearly



ISIS
Annual Report

SRS
Annual Report

Lasers
Annual Report

Central Microstructure Facility
Annual Report