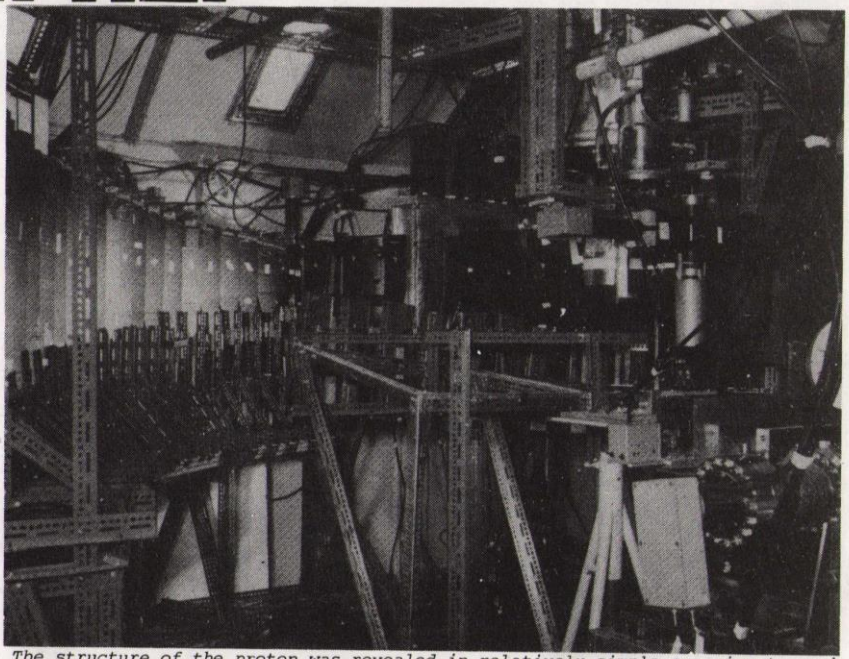
Bulletin
of the Rutherford Appleton Laboratory
11 Mar 1985 No.3

20 Years in HEP

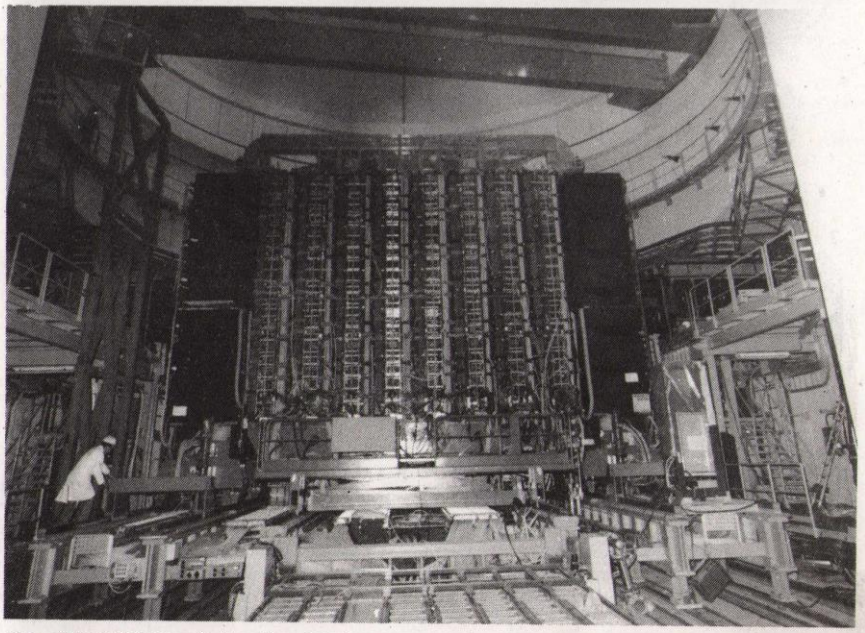
In this the 20th Anniversary year of SERC, it is natural that we should take stock of our achievements in that time. At the Council's inception the Laboratory was predominantly involved in the field of high energy physics, it therefore seems logical to begin a review of the Laboratory's now diverse and notable contributions to world science with a synopsis of the advances made in this "elder statesman" of our research disciplines.

The aim of high energy physics is to identify the fundamental varieties of matter - the "elementary particles" - and to understand the nature of the forces that act on them, clustering them together to form the atoms, molecules and macroscopic structure of our universe. The last 20 years have seen an astonishing advance in our vision of Nature's scheme. British physicists have contributed greatly to these discoveries and experiments in which they have played a major part have helped confirm a radical new theory of radioactivity by Imperial College's Abdus Salam, for which he shared the 1979 physics Nobel Prize. The experiment at CERN for which the 1984 prize has just been awarded owed much of its success to a major effort by British physicists. The success of Salam's theory stimulated theorists to construct a unified theory of all matter and forces. This grand design will (if successful) describe the universe's behaviour immediately following the big bang and show how the present diversity developed as the universe expanded and cooled from that primaeval cauldron. Experiments to test these ideas are already under way. Even if they are disproven, the fact that we are in a position to seriously consider them is an astonishing achievement of the human intellect.

British science has a historical tradition in the discovery of new structures when Nature is studied at microscopic distances - atoms, nuclei, protons and neutrons were all first resolved here. Thomson discovered the electron in his 1899 Cambridge experiments which were performed purely for curiosity into how Nature works. We tend to take



The structure of the proton was revealed in relatively simple experiments such as this, which was running on Nimrod in 1965.



The observations of the W and Z bosons required a massive 2000 ton detector, shown in its pit at the $\bar{p}p$ collider, CERN.

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20 Years in HEP

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his esoteric discovery for granted in modern television and electronic applications. In 1968 at Stanford in California electrons were fired at hydrogen targets with such great energy that they penetrated within the protons in the hydrogen nunclei. The electrons were violently deflected in the collision, suggesting that protons are not diffuse but have a compact inner structure. British physicists had much experience with neutrino beams at CERN, Geneva, and used them to probe the proton, complementing the Stanford electron scattering experiments. As a result it became clear that the proton is a cluster of more basic particles known as "quarks".

This direct detection of quarks within protons was in many ways analogous to Rutherford's historic discovery of the nucleus within the atom. Just as practical exploitation only followed after the detailed dynamics of atomic and nuclear structure were unravelled, so is it crucial to pinpoint the way that the proton and other nuclear materials are constructed from quarks. One can only speculate as to the practical applications which will result in future decades, but past experience suggests that they will be important in some new form of high technology.

Establishing the existence of quarks inside nuclear particles and studying their properties owes a great deal to experiments at the Rutherford Laboratory "Nimrod" proton accelerator. Such experiments revealed that protons and neutrons are not really fundamental particles, but merely the lowest energy states of dynamical systems of quarks having a multitude of higher energy states. Just as the proliferation of atomic elements had led Mendeleev to his periodic table and Thomson's proof of atomic substructure, so did the proliferation of nuclear particles originally generate the suspicion that quark clusters comprise these states. R H Dalitz and his Oxford group in particular showed how the quark hypotheses efficiently explained the accumulating data and paved the way for the Stanford and CERN experiments that directly "saw" the quarks within the proton.

That nuclear material is ultimately built from quarks is now well accepted as a result of these pioneering experiments; some nuclear physicists are now attempting to understand nuclei in terms of quarks rather than simply neutrons and protons. During the last twelve years the advent of more powerful machines at CERN has enables British and European physicists to lead the world in detailed studies of the quarks within the nucleus. These experiments have led to radical new insights into the properties of the forces at work in and around the nucleus. The result has been a dramatic shift in our perception of Nature. In particular the "EMC" effect was discovered at CERN which shows that quarks behave differently in heavy nuclei than in free protons. Theorists at Oxford and RAL have shown how this implies that the quarks are effectively freer in nuclear matter and that they frequently group themselves in the nucleus in the form of pions and other exotic particles, rather than exclusively as protons and neutrons.

The Natural Forces

Gravity mutually attracts all particles and although it is the dominant force between bulk matter, its effect on individual atoms is exceedingly feeble and it plays no observable role in present day atomic experiments. The familiar electromagnetic force is important in atomic structure. Electrons are held in place remote from the nucleus by the electromagnetic attraction between opposite charges; electrons being negatively and the atomic nucleus being positively charged.

Gravity and electromagnetic effects are observed macroscopically and have long been familiar. The discovery of the atomic nucleus revealed two more forces at work in and around nuclei; a strong force that holds the nucleus together and a weak force responsible for radioactive phenomena. The strong force that clusters protons and neutrons together and builds the nucleus is so strong that vast energies can be released when its grip is broken. During the last decade European collaborations at Hamburg and CERN have shown that this strong force is but a remnant of an even more powerful and more fundamental force that clusters quarks together to build the proton and neutron themselves. The source of this force is rather similar to electromagnetism. Quarks and electrons carry electric charge and so feel electromagnetic forces but in addition the quarks (but not electrons) carry a further charge, whimsically known as the "colour" charge, which generates chromodynamic forces analogous to electromagnetic forces.

Central to electromagnetic forces is the presence of radiation - photons. Analogously, associated with colour forces should be radiation - known as "gluons". In 1978 a team of British scientists, part of a major international collaboration, working in Hamburg, found the first direct evidence for gluons, an essential observation supporting the colour charge theory of quark forces. Just as the marriage of the electromagnetic force field with relativity yields the well established theory of quantum electrodynamics (QED) so is colour described by quantum chromodynamics (QCD).

It would be premature to claim that QCD is fully established but there is no evidence against it so far. Devising more exacting tests of it is one of the current aims of high energy physics in the UK and elsewhere. Excitement in the possibility that it is correct is heightened by the similarities it shares with Salam's new and successful theory of the weak force of radioactivity.

Although radioactivity has been known since Becquerel's work in 1896, it resisted attempts to construct a satisfactory theory for over 70 years. Then, following some advances in mathematical physics due in particular to Goldstone at Cambridge, Kibble in London and Higgs at Edinburgh, the way was clear for a viable theory of the weak force. Glashow at Caltech had proposed a model of the force as early as 1964 but a full theory only emerged when Salam and, independently, Weinberg utilised the above advances. This enabled them to predict the existence of W and Z particles (the weak force's analogues of electromagnetism's photon) and specify their masses. The theory successfully predicted a host of other phenomena, in particular the existence of a new weak force acting on neutrinos. This was discovered by a British-European collaboration at CERN in 1973. The theory was brilliantly confirmed in 1983 when the W and Z were produced at the super collider of protons and antiprotons at CERN. Dr A Astbury (Rutherford Appleton Laboratory), Professor J Dowell (Birmingham University), Professor P Kalmus (QMC, London), led the British groups collaborating in this major experiment for which the overall co-ordinator, Professor C Rubbia, won the 1984 Nobel Prize.

Unification: Astrophysics & Particle Physics Meet

Theory, now confirmed by experiment, thus portrays weak and electromagnetic forces not as independent but as intimately related. As the QCD theory of quark forces is so similar to those describing weak and electromagentic forces, speculation is now rife that all three are profoundly related. Indeed there are even hints of this in experients at CERN. In violent collisions involving protons and neutrons at the highest energies their inner structures are fleetingly heated to temperatures hotter than in any star. Under these very hot conditions the nuclear processes take on a different aspect to that exhibited at lower temperatures. The strong force acting on quarks and electromagnetic forces acting on electrons appear less dissimilar than hitherto.

The new theories unifying the forces accommodate this behaviour. They imply that the asymmetry and disparity in our cold everyday world is but a frozen remnant of a symmetry and unity prevalent at ultra high energies - conditions prevalent in the Big Bang. As a result the recent discoveries in high energy physics have provided a new window on the nature of the Big Bang and given fresh impetus to astrophysics. Not only do the forces merge but the quarks and electrons appear to be siblings, themselves composed of yet more basic elements sometimes called preons.

This is the feature that distinguishes the discovery of the quark structure in matter from the earlier elucidation of atoms, nuclei, protons and neutrons. Quarks, the building blocks of nuclei, and electrons, at the periphery of atoms, are siblings and may be interconvertible. If so, protons built of quarks, may decay into particles like electrons. If confirmed then we may have uncovered the reason for the dominance of matter over antimatter in the present universe. British and world physicists are presently searching for evidence of proton decay - originally proposed by Pati and Salam - with exciting implications for the unified theories.

This is the physics of the next decade - testing notions on Genesis by temporarily recreating ultra hot conditions in particle collisions. As insight into stellar processes is in consequence improved, so might the ability to control them here on Earth be achieved. Just as Becquerel in discovering radioactivity and Thomson in discovering the electron, both at the turn of the century, could not foresee the present atomic age emerging from their esoteric discoveries, we cannot foresee what our insights on unity in nature will lead to. Surely it will be no less startling than hitherto.

Award for JD Lawson

We are pleased to announce the award to Dr John D Lawson, FRS, of the Institute of Physics 'Thomas Young Medal and Prize' for 1985, for his many contributions in the field of Charged Particle Beams".

Dr Lawson is highly distinguished in this field, where his insight and analytical ability have resulted in several important advances. It was he who enunciated the, now universally adopted, 'Lawson Criterion' governing energy 'break-even' in thermo-nuclear power generation and is author of the standard text 'The Physics of Charge Particle Beams'.

He is at present engaged in the study of various new concepts, particularly the free electron laser, new particle accelerator ideas using lasers and inertial confinement fusion driven by heavy ion beams.

The award commemorates Thomas Young (1773-1829), a British physicist and physician who discovered the principle of interference of light, showing it to be caused by light waves. He also made important discoveries in the physiology of vision and is also remembered for Young's modulus, the ratio of stress to strain in elasticity. Young was also an Egyptologist of some note and was instrumental in deciphering the hieroglyphics on the Rosetta Stone.

RAL Lectures

The next lecture in this series will take place on Thursday 14 March at 3.15pm in the R22 Lecture Theatre.

ALVEY'S IKBS IMAGE INTERPRETATION RESEARCH THEME

by

Professor John P Frisby
Image Interpretation Theme Coordinator
Artificial Intelligence Vision Research Unit, Sheffield University

A large multi-site Alvey IKBS Image Interpretation research programme started on 1 October 1984. It integrates work in four universities (Edinburgh, QMC London, Sheffield and Sussex) and four companies (BAe, GEC/Hirst, IBM UK and Plessey). The goals of the Theme are to develop methods for computer interpretation of stereo and moving images. Target applications include automatic assembly work stations and guidance systems for underwater remotely operated vehicles. The lecture will describe the scientific background to the Theme's work, which centres around the objective of producing a rich description of the three dimensional structure of scene surfaces. An algorithm capable of recovering range data from stereoscopic images will be described and problems to be overcome in the use of these data for surface descriptions will be reviewed. Finally, a brief outline will be given of research being conducted on a surface-based shceme for representing three dimensional object models.

The lecture will not presume any prior knowledge of the field, nor will it try to present much in the way of algorithmic details. Rather, its goal will be to communicate the rationale underlying the general strategy of the Theme, whose roots lie in the fields of artificial intelligence and psychophysics.

Trade Exhibition

Balzers High Vacuum Ltd will be demonstrating helium leak detectors and mass spectrometers, together with an exhibition of vacuum components, coating plant accessories, electronic thin films and laboratory accessories on Wednesday 17 April in R12 Conference Room from 10.00 to 16.00 hrs.

Mobilex are staging a mobile exhibition of Varian and Oriel products including cryopumps, portable lead detectors, UHV/HV components, monochromators, remote optical analysis equipment, argon-ion lasers and IR optics, etc. The date - Wednesday, 3 April, the place - ouside R20 and the time - 1000-1600 hrs.

SERC's 20th Anniversary

The twentieth anniversary of the Science and Engineering Research Council falls on 1 April, and it is proposed that a number of special activities will be arranged to celebrate the occasion.

At RAL, major events will naturally include the official opening of the Spallation Neutron Source and the launching of the Giotto spacecraft, but in addition will include a Schools' Visit Programme, when young people from local schools will be invited to see for themselves the variety of research that is pursued at the Laboratory.

Detailed plans are still in preparation and will be reported in the Bulletin when finalised. Watch this Space!

Art & Craft Exhibition

The fifth Art and Crafts Exhibition is to be held, under the auspices of Rec. Soc., in the R68 Conference Room on Tuesday 22 October, Wednesday 23 October and Thursday 24 October. It is hoped that staff of the Laboratory will be willing to display their work on these days.

Application forms will be available later in the year. If you are interested or require further information, please contact Fran Childs Ext. 6478 or Cathy Doidge Ext. 6580.

Acknowledgement

Mrs Marie Radcliffe would like to thank all David's friends and colleagues for their help and support over the last few months.

Film Badge Notice

It is Period 3 Film Strip RED. Please be sure you are wearing the correct dosimeter and return all old ones.

NEXT FILM ISSUE Monday 25 March.

Yours ?

A handbook entitled "The Solution to Your Ultraminature Coaxial and Multi-contact Connector Problems" has been received by Stores, from Microtech Inc of Boothwyn USA.

Anyone ordering this book should contact A C Peters, Stores R9 Ext 5223.

Up and Away

Bob Evans

85RB 1679

Bob Evans of SNS Division was given what could politely be described as a rousing send-off by his many friends and colleagues at his retirement presentation on Friday, 15 February.

Dr Trevor Hyman gave the traditional 'This is Your Life' run-down on Bob's career, aided and abetted by most of the audience. From his early days as a bell-boy on the Cunard White Star Line, through tales of his years (37 of them) in the RAF, to his joining RAL - all was graphically detailed.

Bob, it was said, is one of those people who never seem to remain still for any length of time and it was for this reason as well as for his RAF connections that he was affectionately christened 'Wings'.

Bob's life in the RAF seems to have been a very busy one. He travelled extensively, won many campaign medals and even worked on Concorde in hot weather trials in South Africa. At RAL he also appears to have covered the ground. He worked on Nimrod Power Supplies and on a range of SNS equipment, particularly the extraction supplies in R4 and the Extracted Proton Beam supplies.

"We wish you a long and happy retirement" said Trevor presenting Bob with an antler-headed walking stick, a small bell on a presentation plinth (to remind him of his early days), a cheque and a Ray Roberts card.

"I am really sorry to leave", Bob replied. "I have made a great many friends and had a very happy time. Thank you all, very much".

John Simkin

85RB 1672

Also leaving for pastures new last month (8 February) was John Simkin of Computing Application Group. After 15 years at RAL in the business of developing computer algorithms for electromagnetic field calculations, superconducting magnets, and the use of interactive graphics to facilitate this work, he is going into business for himself.

In his speech of thanks to John for his years of dedicated service, Bill Trowbridge (Group Leader) bandied about words like harmonic analysis, TRIM, GFUN, TOSCA SCARPIA and COMPUMAG; obviously full of meaning and much appreciated by the large gathering of colleagues who had come to wish John well. The author, however, wishes to 'pass' on explanations!

So, with much sadness, they applauded John's remarkable and brilliant career at RAL and wished him every success with his new venture, presenting him with a token of esteem and affection, a book entitled "The Gengis Khan Guide to Business".

John thanked everyone for the gift and said that he was sad to be going. He had enjoyed life at RAL tremendously, gained much from the people with whom he had worked and the project on which he had been engaged. Programmes which they had pioneered, were now in use world-wide and he was proud to have been involved. He hoped his new role would be as satisfying.

Christian Fellowship

The Fellowship holds its meetings on Thursdays at 12.30pm in the R2 Conference Room and all are welcome.

14 Mar Prayer Meeting - Meyrick Ward
21 Mar Visiting speaker
28 Mar Easter Meditation - Chris Biddlecombe

Horticultural Society

The AERE Horticultural Society are organising a slide lecture by Mr K Burras of the Oxford Botanical Gardens on Thursday 28 March at 7.30pm in the RAL Lecture Theatre, R22. He will talk about the Botanical Gardens. Coffee and Biscuits will be served.
Tickets, Members 50p Non-member 60p, are available from John Hogston, R2 Ext. 5183.

Thanks

John Thomson wishes to thank all his friends for their good wishes and gifts on his retirement. He also says "Cheerio" to all he was unable to see and best wishes for the future.

Alf Brown also sends his grateful thanks for the excellent way in which his retirement "farewell" was conducted. He is also appreciative of the extreme generosity of the farewell gifts. "I suppose it is a day to which one looks forward with some trepidation, but as it turned out I think it was quite a happy occasion", he writes.

H.A. (Bert Aldred) wishes to thank all his friends and colleagues for the very generous presents and warm reception on the occasion of his retirement and expressed appreciation for all the cooperation and assistance he has had over the years. He apologises to all those he was unable to see personally.

Coffee at Cosener's

Our St, Valentine's Buffet Supper on Friday, 15 February was a great success, and we extend our thanks to Mrs Flynn, the manageress of The Cosener's House, and all her staff, for providing a most extensive and delicious display of dishes, all beautifully presented.

Don't forget our next coffee morning is on

Tuesday, 19 March

from 10.30 until noon. We look forward to seeing you there. Please bring your pre-school children, and if you know of any new-comers to the area, bring them too!

For information about our get-togethers, please contact:

Suzanne Litchfield (Abingdon 21310)
Zoe Patrick (Wantage 68809)

Bulletin

Editor: Jean Banford
Building R1
Rutherford Appleton Laboratory
Chilton, Didcot, Oxon OX11 0QX
Abingdon (0235) 21900 ext 5484

INTERNAL Events

HEP SEMINARS
R61 CONF. ROOM - 1100 HRS.

13 March K Narain/RAL
'Kac-Moody Algebras and Mandelstan Operators'

27 March M Berry/Bristol
'The Quantal Adiabatic Phase'

NEUTRON DIVISION SEMINARS
R3 CONF. ROOM - 1330 HRS.

12 March A Howie/Cambridge
'Study of Localised Inelastic Scattering Events by Electron Microscope'

COMPUTING SEMINAR
COLLOQUIUM - ATLAS CENTRE - 1515 HRS.

12 March Dr John Baldwin/UC Cardiff
'Running a University Computing Centre'

NIMROD LECTURES
R61 CONF. ROOM - 1400 HRS.

11 March C Batty/RAL
'Physics at LEAR'

18 March X Tata/CERN
'Seeing Susy at the $p\bar{p}$ Collider'

25 March K Winter/CERN
'Measurements of the Electroweak Mixing Angle'

ASTROPHYSICS SEMINARS
R68 CONF. ROOM 12 - 1400 HRS.

20 March Dr Colin Coleman/Oxford
'Active Galactic Nuclei'

3 April Dr Gordon Bromage/RAL
'Ultraviolet Obervations of the Seyfert Galaxy NGC 4151'

EXTERNAL Events

SEMINARS in PLASMA PHYSICS
DEPT. ENG. SCI. - OXFORD - 1615 HRS.

12 March Prof. P Cutler/Oxford
'Conductive Fluids in Strong Electric Fields'

ELEM PART THEO SEMINARS
NPD - OXFORD - 1430 HRS.

15 March I Moss/Newcastle
'The Origin of the Universe'

ELEM PART PHYS SEMINARS
NPD - OXFORD - 1430 HRS.

14 March D G Lafferty/Manchester
'Diffractive Production of the Multi-meson Final States'

THEO. PHYS SEMINARS
QMC - LONDON - 1430 HRS.

14 March Prof. N W Ashcroft/Cornell & Cambs
Very Dense Phases of H and He: Possible New States of Matter.

THEORETICAL & HEP SEMINARS
SOUTHAMPTON - 1430 HRS.

15 March B Buxton/GEC
'Recent Ideas on the Use of Stochastic Optimisation Techniques in Computer Vision'

22 March T Jones/Liverpool
'A Finite(?) Reatistic(?) Supersymmetric SU(5) Theory: Low Energy Predictions

Trade Exhibition

Auriema Ltd will be holding a one day exhibition of their products on Thursday, 14 March in R12 Conference Room from 10.00 - 16.00hrs.

RAL TECHNOLOGY LECTURES

The next lecture in this series will be held on Thursday 28 March 1985 at 3.00 pm in the R22 Lecture Theatre.

THE SCIENCE REVOLUTION IN MEDICAL IMAGING

by

DR R J OTT
ROYAL MARSDEN HOSPITAL

Since the development of X-ray computed tomography (CT) in the mid-1970 s the techniques used in medical imaging have undergone a considerable revolution due to the application of new methods particularly in physics and computing. X-ray CT is now capable of rapid imaging to produce dynamic information with high spatial resolution of the order of 1 mm throughout the body. Digital subtraction techniques enable particular organs in the body, such as the vessels and the skeleton to be highlighted with considerable precision providing remarkable improvements in image quality compared with the conventional X-ray. In Ultrasound the development of new transducers and, in particular, the production of real-time scanners, has enabled this technology to be applied across the board in medicine, particularly due to the low cost of the equipment involved. Future development will include the production of ultrasound microscopes to look at the molecular structure of tissues in vivo. Radionuclide imaging has also undergone a technological advance and in particular the development of gamma cameras can now provide excellent images of the distribution of a radiolabelled tracer within the body. The applications of multiwire proportional chamber techniques, particularly to positron emission tomography, may provide in the near future an order of magnitude improvement in radionuclide imaging so that the functional information obtained from these images can be coupled with high precision anatomical features. In particular measurement of the function of the brain, the heart and the central nervous system, may be revolutionised using modern positron tomographic scanners.

FOR YOUR DIARY: The next lecture in the series will be held on Thursday 18 April 1985 by Professor Peter M Bainum, Howard University, Washington, and will be entitled "On the Dynamics of Tethered-Subsatellite Systems".