Organizations, People and Strategies in Astronomy I (OPSA I), 285-294
Ed. A. Heck,

BIG SCIENCE AND ITS PROBLEMS: THE DEVELOPMENT OF THE RUTHERFORD APPLETON LABORATORY

JACK MEADOWS
Information Science Department
Loughborough University
Loughborough LE11 3TU, U.K.
jack.meadows@btinternet.com

Abstract. Research establishments have to cope with a continually changing environment. Available funding and research imperatives change with time. The question is how an establishment can remain viable throughout these changes. The Rutherford Appleton Laboratory provides an interesting case study of one establishment that has managed to survive and flourish for over fifty years despite the problems. The Rutherford Laboratory was set up in the 1950s to provide facilities for high-energy physics in the UK. By the 1970s, the need for a British accelerator had declined because of the facilities offered by CERN. The Rutherford Laboratory therefore branched out into other areas of particle physics. A major development at the end of the 1970s saw the Appleton Laboratory merged with the Rutherford Laboratory. The Appleton Laboratory had started life as an ionospheric research station. With the dawn of the space age, it became involved in satellite tracking. The growing demands of space research strained its resources and the merger with the Rutherford Laboratory was intended to strengthen its capabilities, especially in dealing with NASA. The combined Rutherford Appleton Laboratory is now the main government research establishment in physics-related areas in the UK. The joint Laboratory has proved very adaptable: the research emphasis now differs greatly from the original motivations for either component part.

1. Introduction

'Big science' had become a well-established phrase by the 1960s. It reflected a trend in science which had been greatly encouraged by developments during the Second World War. The characteristic features of big science are a large central facility – a particle accelerator, for example – which acts as a research focus both for the staff of the institution where the facility is situated and for visitors. Running the facility requires the participation of support staff who can call on a range of skills. Similarly, external users typically consist of groups of researchers, the members of which can also call on a variety of skills. All this entails the expenditure of large sums of money. So 'big science' has come to be defined as something requiring big facilities plus big staff complements plus big budgets. Such costly facilities typically involve either direct or indirect funding from the government.

Exactly how this is provided varies from country to country. In the United States, for example, some large facilities have been established at universities; in Germany, many have come under the Max Planck research institutes; in the UK, the preferred placement has been in government research establishments. In the immediate aftermath of the Second World War, such facilities mainly encompassed research centres devoted to some aspect of nuclear physics. The growth of space research since the 1950s has added another area of big science.

In a sense, astronomy predates both of these as a big science. Large telescopes used by visiting observers go back a century. The difference was that the visiting observers were often individual researchers, rather than groups. This has changed in recent decades, and observational astronomy can now be reckoned a part of big science. The interesting question is what happens to such facilities if the needs of researchers change and the facility loses its previous importance. The history of the Rutherford Appleton Laboratory in the UK provides useful insights into possible answers to this question[1].

2. Creating a National Facility

Discussion of the need for a national particle accelerator in the UK began in the 1950s. The idea was not universally welcomed. A number of universities already possessed accelerators, and they foresaw that a central facility would reduce the likelihood of further such university-based accelerators being developed in the future. Moreover, some feared that the ultimate result would be an increased central control of research activities in the field. But it was the question of future costs that clinched the argument. A document that went to the British government in 1956 contained the following key statement:

> *"Given the cost and complexity of the necessary machines and the limited resources available, the needs of universities for the larger machines can hardly be met in the future on the basis of separate provision for each university or even each major university. The setting up of a new*

[1]For a detailed history of the Laboratory, see Meadows (2009).

research institute for the use of universities and other organisations working in the field would appear to be the best alternative." (Litt 1979, p. 14)

This alternative had been pushed hard by John Cockroft. He was not only one of the most respected nuclear physicists of the time, he had also pioneered the creation of an Atomic Energy Research Establishment [AERE] at Harwell, near Oxford, immediately after the war. He believed that it would be advantageous to build the proposed new establishment also at Harwell, with the difference that, whereas activities at AERE were classified as confidential, the new establishment would encourage open publication. His advice was accepted. This made at least some university physicists suspicious that the new establishment would have its policy controlled by AERE: a suspicion that was enhanced when the new establishment recruited staff from AERE. The problem was made worse by the fact that many nuclear physicists resided in the north of the UK and were unhappy at having their major facility situated in the south. The latter objection was solved in the 1960s by setting up a separate establishment at Daresbury in the north of England. The suspicions of AERE gradually died down as the new facility – named the Rutherford High Energy Establishment in memory of Ernest Rutherford – developed its programme.

The proton synchrotron at the Rutherford Establishment – called 'Nimrod' – came into operation in the 1960s. Meanwhile, during the 1950s, planning had been going ahead for a new European nuclear facility, labelled CERN, near the Swiss frontier. The intention was to build there a much more powerful accelerator than that planned for the Rutherford Establishment. The result was that, from the start, British particle physicists divided their time between the Rutherford Laboratory (as it soon became) and CERN. Fortunately, the characteristics of the British accelerator made it more useful for certain types of experiment than the CERN accelerator. Internationally, there was some idea that, as new accelerators were required, they should be distributed to different countries. So there was the possibility that the UK might gain an additional accelerator that way. A panel was set up to assess the various sites that were put forward.[2] In the end the sensible option was taken, and it was decided to concentrate all the international machines at CERN.

By the 1970s, the Rutherford accelerator was coming to the end of its useful life. In the years since its creation, it had become increasingly clear that British particle physicists would be focussing their main research interests on CERN in the future. Tentative plans for a new British accelerator that had been drawn up were therefore scrapped. The question now was

[2]Its comment on the suggested British site was: "It can be very depressing to live in a place where the sun seldom shines." (Goldsmith & Shaw 1977, p. 51)

what would happen to the Rutherford Laboratory. It was making a valuable research contribution as the UK centre for developing detection equipment for accelerators at CERN and elsewhere. It also acted as the UK centre organising British research at CERN. Yet, without an accelerator of its own, it seemed to have lost its raison d'être.

3. Change of Focus

Particle research after the Second World War had gone off in a number of different directions. One was the use of neutrons as a tool to explore the structure of all types of material. In Britain, research on this topic initially depended on using a neutron beam from one of the Harwell reactors. However, this approach proved increasingly outdated, and British researchers had to make use of a new neutron beam facility at Grenoble. In view of its successful cooperation with CERN, the Rutherford Laboratory took over the job of developing equipment and coordinating UK/European activities in this new area. Senior staff at the Laboratory now pointed out that by cannibalising parts from other machines – some at the Rutherford Laboratory and some elsewhere – and using existing buildings, a new type of neutron beam source could be created in the UK on the cheap. The core component would be another proton synchrotron, but this one would be used to provide neutrons via collisions between the protons and a target. The proposal was given official backing, and the facility was opened by the then Prime Minister, Margaret Thatcher, in 1985, at which point it received its current title ISIS. ('Isis' is not an acronym : it is the name given to a local stretch of the river Thames.) In this ingenious way, the Laboratory replaced an aging machine by a new one with a bright future. Moreover, while Nimrod had been essentially a national facility, ISIS rapidly became an international centre for neutron diffraction research. With various updates, ISIS continues as a major international facility today.

Meanwhile, the 1970s saw other developments. Interest in the applications of lasers was growing in the research community. Low-power lasers were relatively cheap, but high-power lasers were another matter. The British government therefore decided to set up a national centre to develop high-power lasers and to provide university access to them. The Rutherford Laboratory had the necessary infrastructure and management in place to handle both complex technology and visiting researchers, so it was decided to site the new laser facility there. Similarly, the field of microelectronics was developing rapidly in the 1970s, but the equipment needed for microcircuit technology was expensive. Again, it was decided to fund a central facility at the Rutherford Laboratory. Both of these new developments fall under the heading of 'big science'. The work of the Laboratory particularly emphasized the design and construction of instrumentation. From the viewpoint of both staff and management, expansion into these new fields made good sense.

4. New Acquisitions

The diversification of activities at the Rutherford Laboratory described above came from the establishment of new centres and facilities at the site. The 1970s also saw major changes in the Laboratory's work via the absorption of other, already existing bodies. In 1961, the Atlas Computer Laboratory was established: it shared the Rutherford Laboratory site, but was an independent entity. Its creation reflected official recognition of the fact that the most powerful computers were too expensive for each individual university to buy, so that a central facility was needed. (The word 'Atlas' in the title was the name of the first powerful computer bought by the new Laboratory.) The problem was that the cost of computing power was dropping rapidly. Universities were acquiring increasingly powerful computers, while the central facility found it difficult to update its computer provision in a comparable way. As the national focus for computing in the UK, the Computer Laboratory was under pressure to buy a British computer. By the 1970s, however, IBM were producing considerably more powerful computers than anything available in the UK.

While the Computer Laboratory was trying to find a way out of this impasse, the Rutherford Laboratory was allowed to purchase its own computer from IBM. The result was that, the Computer Laboratory had to obtain time on the Rutherford computer, rather than vice versa, as had originally been planned. The Atlas computer was switched off in 1973, at a time when government funding of science was being squeezed. Various options were floated, but the final decision was to merge the Atlas Computer Laboratory with the Rutherford Laboratory and to upgrade their computing facilities together. Not all the staff of the Computer Laboratory were happy with this conclusion. They believed that a separate 'National Computer Centre' should have been established: after all, the Rutherford Laboratory's focus was on the development of instrumentation, which was not seen as a significant interest for the Computer Laboratory. There was also some opposition from user groups, who feared the takeover might be geared to the interests of the Rutherford Laboratory. As the review panel that investigated the future of the Computer Laboratory reported:

> *"We were all impressed by the need for any proposed arrangement to maintain the confidence of the non high energy users of these facilities and of the need to make it clear to them that they would not take second place to the physicists currently being catered for by the Rutherford*

Laboratory."[3]

The Rutherford Laboratory management tried hard to allay these fears. They were helped by the growing diversification of activities away from high-energy physics at the Laboratory itself. In subsequent decades, and especially after the growth of networking, the Laboratory's role in computing became generally accepted. By the time of the take-over, it had become evident that the next major advance in computing would be networking. In assuming the Computer Laboratory's role to assist universities, the Rutherford Laboratory found that it now became the focus for university networking. In recent years, this has proved advantageous for two of the Laboratory's particular interests – space science and high-energy physics. The volume of data flow in these two fields has become so large that it has been necessary to set up dedicated computer 'grids' to handle it. Because of its background in networking, the Laboratory has proved to an important focus for the development of such grids.

Another merger, of even greater significance, occurred at the end of the 1970s. The Appleton Laboratory was a government institution which had been set up after the First World War with the prime aim of using radio waves to investigate the Earth's upper atmosphere. With the advent of the space age at the end of the 1950s, it became involved in the use of balloons, rockets and satellites for exploring the upper atmosphere. NASA was keen on having access to a satellite tracking ground station in the UK, and the Appleton Laboratory was seen as the appropriate body to run such a station. The Laboratory now became designated as the central UK body for managing space projects and operating the related facilities. Its involvement in space science expanded rapidly, putting an increasing strain on its resources, and raising the fear that it might not be able to fulfil all of its commitments.

In particular, there were fears that its role as NASA's partner in the UK might be affected. One of the main problems was the relatively small size of the Appleton Laboratory. At the end of the 1970s, it had some 300 staff, only a quarter of the number employed at the Rutherford Laboratory. The government therefore took the decision to merge the Appleton Laboratory with the Rutherford Laboratory, encouraging the latter to expand its activities in space research. (The Rutherford Laboratory had already devoted some effort to building and running space-related equipment.) Several Appleton Laboratory staff were unhappy with this decision. Indeed, a number refused to move, either leaving, or taking early retirement. The Rutherford management made a considerable effort to be accommodating – including a change in the management structure – and most of those who transferred

[3]SRC-Atlas Computer Laboratory Report of Council Working Party [ALP 6-73], 1973, p. 7.

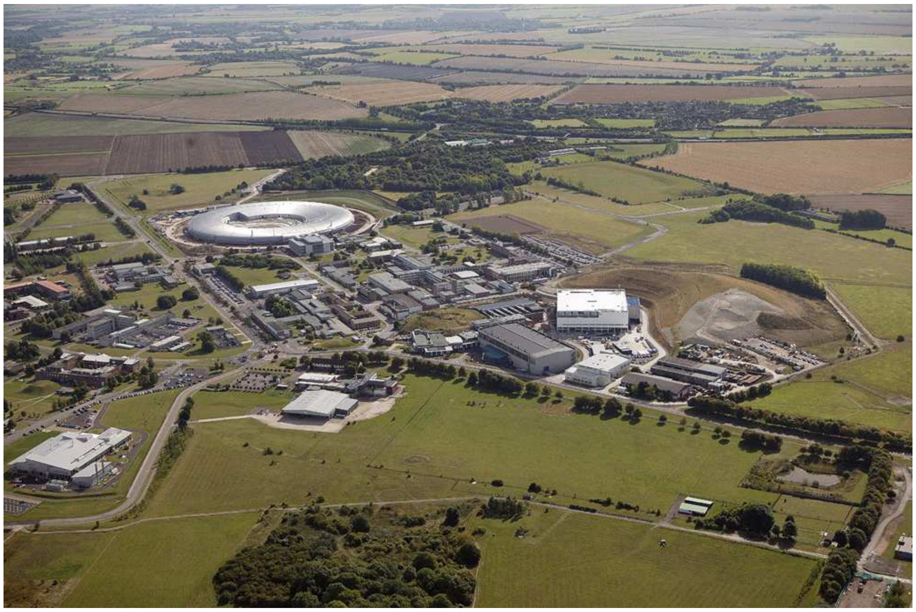

Figure 1. Aerial view of Rutherford Appleton Laboratory. The large silver-coloured building hosts the DIAMOND light source that started operations in 2007. It represents the single largest UK scientific investment over the past 40 years. (Courtesy RAL)

thought a reasonable attempt had been made to welcome them. The problem was that every research establishment has its own culture and needs, and these can take longer to merge. One of particular importance in the Rutherford-Appleton merger related to instrumentation. This was a prime focus of interest at both establishments, but there were differences in approach. The staff at the Rutherford Laboratory produced instrumentation to very high levels of accuracy, but not usually with stringent limits on weight and size, as was essential for space experiments. Again, this was a problem that disappeared with time and experience.

These mergers raised the staffing complement at the renamed Rutherford Appleton Laboratory to over 1,600, only a tenth of whom were involved in high-energy physics, the original purpose of the Laboratory. It was now the major focus for big science activity involving physics in the UK across a range of fields. The so-called 'Matthew principle' was coming into operation[4]. This pulling power is well reflected by the DIAMOND story. When its synchrotron reached the end of its life, the Daresbury Laboratory, like the Rutherford Laboratory, was faced with the question of what

[4]'Unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath.' (The Gospel according to St. Matthew Chapter 25, verse 29. See Merton, 1968)

to do next. Like the Rutherford Laboratory, it decided to branch out in a new direction. The Daresbury synchrotron produced considerable amounts of radiation from the electrons that it accelerated.

By the early 1970s, this radiation was being used for an increasing range of experiments. The staff at Daresbury therefore proposed the creation of a new machine designed specifically to produce synchrotron radiation. This was approved, and the new synchrotron came into service in 1980. By the 1990s, it was clear that this machine, in turn, would soon need to be replaced by an updated model. Staff at Daresbury therefore began work on designing the proposed new machine. The problem proved to be finding the funding. The financial logjam was eventually broken when a major UK charity – the Wellcome Trust – agreed to contribute part of the cost of construction. However, this led to an immediate complication. The Trust, and soon the government, felt that the Rutherford Appleton Laboratory would provide a better home for the new facility, not least because of the range of activities that was already supported there. Proponents of Daresbury were naturally dismayed, and mounted a vigorous campaign to overturn this decision, but, in the end, they were unsuccessful. DIAMOND was built at the Rutherford Appleton Laboratory site – it opened in 2007 – and the staff at Daresbury were left to seek what they might do next.

5. The Factors Involved in Success

Government-supported research establishments in the UK became the subject of a sweeping review in the 1990s. The question was whether any of them might be either privatised or closed. It was soon clear that history and prestige were not enough to rescue an establishment from adverse judgement. Thus it was decided in 1998 that the Royal Greenwich Observatory should be closed. This was a shock to the astronomical community, for the Observatory had existed for over 300 years, and had traditionally been seen as the premier astronomical establishment in the UK. However, its activities overlapped appreciably with those of the Royal Observatory Edinburgh. It was thought more efficient to have a single agency to manage use of astronomical facilities worldwide, and the ultimate assessment was that this could be done better by the Observatory at Edinburgh. The Rutherford Appleton Laboratory came out of the review much more successfully. In terms of selling the Laboratory, no potential buyer could be identified for such a large and diverse establishment, and other options – such as the universities running the facilities – were likely to prove more expensive for the Treasury than the existing provision. At the same time the facilities at the Laboratory were so widely used that closure was not an option. In consequence, the Rutherford Appleton Laboratory continued (and continues today) as the leading 'big science' centre in the UK.

Analysing the history of the Rutherford Appleton Laboratory reveals a range of problems from which 'big science' establishments can suffer, along with some indication of ways in which these problems can be alleviated. A basic one relates to the establishment's 'niche' position – the particular research field for which the establishment provides services. Two problems can arise from this. The first is that the niche field declines in importance; the second is that other bodies appear which overlap the research niche of the establishment. In the case of the Nimrod accelerator, both problems appeared. The type of experiments that the accelerator could encompass declined in importance, and CERN provided better facilities. Two responses to this problem seem possible – to find a new niche, or to expand to cover several niches. With ISIS, the Laboratory pursued the first option. At the same time, smaller niches – lasers and microelectronics – were occupied. These were too small to deserve an establishment of their own, but they complemented the interests already existing in the Laboratory. (It obviously helps the creation and retention of new niches if there is some degree of synergy between them.) The Laboratory now began to evolve into a general big physics establishment, rather than remaining a niche one. The addition of the Atlas Computer Laboratory and the Appleton Laboratory extended very significantly the niches covered. Indeed, the attraction of the Rutherford Laboratory as a centre for supporting university research led it into areas which were not big science at all. For example, it became the home of the Energy Research Support Unit, which was particularly concerned with the use of wind power.

General establishments have the advantage that decline of one of the niches they cover does not necessarily mean decline of the whole establishment. The disadvantage is that, unless the establishment is a major player, expanding niches may be diverted to competing establishments. The Rutherford Appleton Laboratory is now large enough to dominate the national scene, and to be the natural focus for international cooperation. Consequently, the latter problem is not currently pressing. But flexibility is still important. The Laboratory is no longer acquiring other niches at the rate it did in the 1970s and 1980s. What it has done is to respond to government pressures on research to concentrate on topics that may have future applications. By the end of the 1990s, the Laboratory was collaborating with over 120 commercial companies, and in the past decade it has been involved in the creation of a number of new companies. The drawback to this changed emphasis is that the Laboratory has two functions – to assist university researchers and to carry out its own research activities. There has, of course, always been the potential for conflict here, especially over the division of research funding between the universities and the Laboratory. Currently, university researchers in the UK are under the same pressure as the Laboratory to produce applicable research, and see the Laboratory as a possible competitor. With government funding now tight, getting the correct balance between its two functions is possibly the most sensitive problem facing the Laboratory. However, most of its users agree, whether reluctantly or not, that had the Appleton Laboratory not come into existence, it would have certainly been necessary to invent it.

References

1. Goldsmith, M. & Shaw, E. 1977, Europe's Giant Accelerator, Taylor & Francis, London, 262 pp. (ISBN 0850661218)
2. Litt, J. (Ed.) 1979, Nimrod: The 7Gev Proton Synchrotron, Science Research Council, London, 68 pp.
3. Meadows, J. 2009, Big Science: Fifty Years of the Rutherford Appleton Laboratory (1957-2007) Lulu Press, Rayleigh, North Carolina, 126 pp. (ISBN 9781409255628)
4. Merton, R.K. 1968, The Matthew Effect in Science, *Science*, **159**, 56-63.