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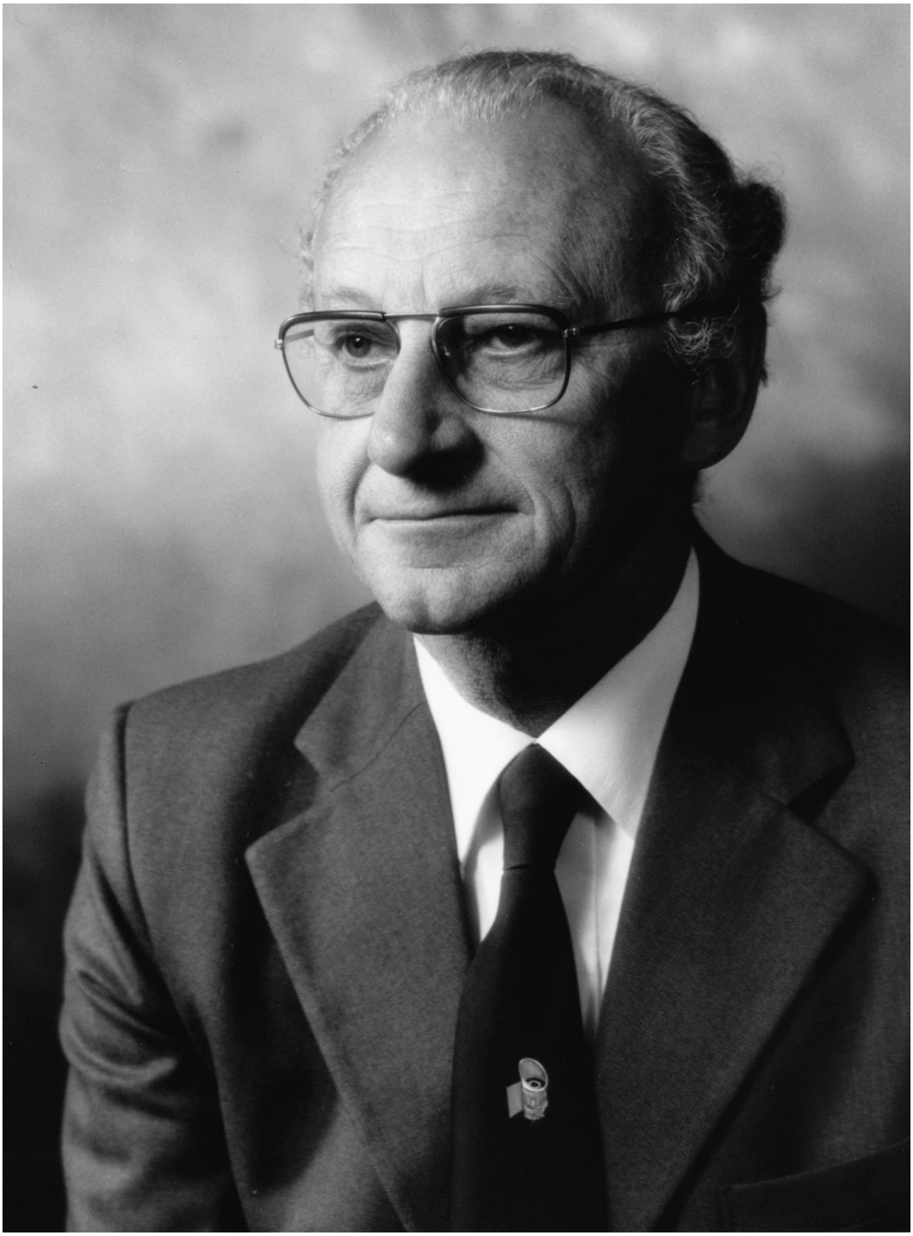

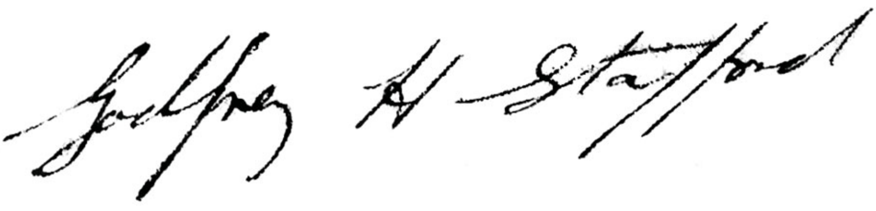

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15 April 1920 — 29 July 2013

Elected FRS 1979

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Godfrey Harry Stafford's career as a physicist began with research in cosmic rays in the 1940s and he lived to see the discovery in 2012 of the Higgs boson at the CERN Large Hadron Collider. He made major contributions to the construction and exploitation of accelerators at the Rutherford Laboratory in the UK and was its director from 1969 to 1981. During this period he oversaw the diversification of the laboratory into the multi-disciplinary centre it is today. He was master of St Cross College, Oxford, from 1979 to 1987 and president of the Institute of Physics from 1986 to 1988. He was a major supporter of physics as an international activity: he was a founder member of the European Physical Society in 1968 and its president 1984–86, and he had significant links with CERN that spanned 25 years.

EARLY LIFE

Godfrey Stafford was born on 15 April 1920 in Sheffield, England, the second child of Henry and Sarah Stafford. Sarah (née Fletcher) came from Ilkeston in Derbyshire, and Godfrey was baptized there on 23 May 1920. He attended primary school in Sheffield, but in 1928 the family emigrated to South Africa, where a sister of Godfrey's father lived. The main reason for leaving England was the shortage of suitable jobs at a time of economic depression. Godfrey's father was an engineer, but also a keen musician, and he applied to be principal bassoonist in the Cape Town City Orchestra. The application was unsuccessful, so Godfrey's father went

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to South Africa without any definite prospect of employment, and the family followed a few months later. There were certainly times of concern when his father was unemployed, but Godfrey remembered his childhood in the Cape Town area as a happy one, with plenty of outdoor activity.

After primary school, he completed his secondary schooling in 1936 at Rondebosch Boys' High School in Cape Town. He admired the headmaster, W. Mears, a historian who may well have inspired his initial inclination in that direction; but science became his main interest, despite it being taught by a strict disciplinarian who instilled fear but no great enthusiasm for the subject. Throughout his school days Godfrey's mother, who had been headmistress of a primary school in Ilkeston before her marriage, provided much support and encouragement. University entrance required passing the Senior Certificate, which was taken in a broad range of subjects, including history, physics and chemistry, and in 1937 Godfrey entered the University of Cape Town (UCT), supported by a Council Entrance Scholarship, to study for a BSc.

At university his academic career flourished. Initially he had planned to specialize in chemistry with a view to becoming a teacher, but by the end of his second year he realized that physics suited him much better, noting that he won the class medal for best student in physics, but not in chemistry. For the third year he was one of only five physics students, so tuition was on an almost personal basis. He also found the atmosphere in the physics department both relaxed and inspiring, particularly the teaching of the Australian C. B. O. Mohr, who had worked at the Cavendish with H. S. W. Massey (FRS 1940).

For his MSc project in 1941 Godfrey worked with Mohr on cosmic rays and a study of the 'second maximum' in the Rossi curve. The Rossi curve concerns the interaction of high-energy particles with matter, which might be a solid target or, for cosmic rays (mainly protons), the atmosphere itself. The energy of the incident particle is converted into a shower of secondary particles that cascade down through the atmosphere. At ground level these shower particles are mainly muons (from pion decay) and electrons and positrons (from muon decay). Muons generally penetrate substantial depths of lead. In contrast, electrons and positrons (of sufficient energy) interact with matter to generate showers through bremsstrahlung of photons that then convert into pairs of electrons and positrons, which then continue the showering process. Such showers can be observed behind a few centimetres of lead, but are contained completely by *ca* 10 centimetres. However, some observers, including Mohr and Godfrey, reported the observation of an increase in shower activity after significantly greater depths of lead or iron, and this was referred to as the 'second maximum' of the Rossi curve. With the benefit of hindsight, such observations were almost certainly due to showers initiated by the rare, but not impossible, process of radiation of a photon by a muon, thus initiating a 'soft' shower from the photon.

Godfrey's academic career continued to prosper; he was awarded first-class honours in the exams at the end of 1941 and also the prestigious Ebden Scholarship, tenable at the University of Cambridge. Luck played a part at this point: the scholarship was available only once every few years, and 1941 was such a year. Furthermore, the scholarship was first offered to a chemist, who turned it down in favour of a Rhodes Scholarship at Oxford. So, in normal times Godfrey would have soon travelled to Cambridge to continue his academic career, but times were far from normal.

The Second World War

The outbreak of the Second World War resulted in a huge upheaval in South African politics: the prime minister, J. B. Hertzog, wanted South Africa to remain neutral, but that motion was defeated in parliament and he resigned. He was replaced by J. C. Smuts FRS, and South Africa declared war on Germany on 6 September 1939. In 1941 Stafford volunteered for the South African Navy as an Electrical Lieutenant.

In June 1940 the British Admiralty had sent a message to several of the then-Empire's major ports, including Cape Town, ordering the establishment and operation of 'degaussing' to protect shipping against magnetic mines. The South African effort was led by Brian Goodlet, who had been the professor of electrical engineering at UCT (1937–39 and again from 1941) and had earlier designed high-voltage transformers used by T. E. Allibone (FRS 1948) and by J. D. Cockcroft (FRS 1936) and E. T. S. Walton in the development of particle acceleration at the Cavendish. Stafford joined Goodlet's team, and spent six months on Robben Island, which later became notorious as the penal settlement for political prisoners such as Nelson Mandela. He was then sent to Durban as the Degaussing Technical Officer, and found himself, at the age of 21, in charge of a dozen engineers and physicists who were older and more experienced (except in degaussing) than him. He later described this period as being of considerable formative significance. As an Electrical Officer, he was also responsible for the disposal of any mines that were washed up on the coast. Happily, there were only a few.

Stafford was greatly inspired by Goodlet, and Goodlet must have been impressed by his young lieutenant, for he arranged for Stafford and a former student to be seconded to the Royal Navy when Goodlet himself was called back to the UK to become chief scientist at Rosyth, near Edinburgh. Goodlet had wanted his two young assistants to work with him, but this fell through, and they were assigned instead to radar work at the Admiralty Signal Establishment at Witley, near Haslemere. Among the Witley scientists were H. Bondi (FRS 1959), T. Gold (FRS 1964) and F. Hoyle (FRS 1957), who spent some of their evenings discussing astrophysics (Roxburgh 2007). Stafford was involved in sea trials on aircraft-warning radar. This had the consequence that, soon after D-Day, he was sent to Normandy to check the warning radar on all the cruisers involved in the landings, as the ships were having difficulty detecting the German bombers laying mines at night. In common with many of that generation, he spoke little of this afterwards, but in his late eighties, talking to his son-in-law Mark Piney in 2008, he recalled his trip to the Normandy beaches (this can be heard at https://indi.to/FKqR2). The dangers were real: he was on board HMS *Scylla* when it was so badly damaged by a mine that it had to be withdrawn for repairs.

Soon afterwards, Stafford volunteered for a sea-going appointment and was assigned to HMS *Palomares* as its senior radar officer. His experience at Witley enabled him to incorporate some recent developments into the ship's radar equipment before they became standard issue. The *Palomares* was *en route* to the Pacific to take part in the landings at Malaya when it broke down in the Mediterranean, and its war, and Stafford's, came to an end.

After the war Stafford returned to South Africa, but first he visited Sir Lawrence Bragg FRS at Cambridge and arranged to use his Ebden Scholarship to study for a PhD at the Cavendish Laboratory starting in 1946.

1946–54: Cambridge, Cape Town, Harwell, Pretoria and back to Harwell

Back in Cape Town, Stafford was offered a temporary lectureship at the university, and he lectured on electromagnetism to the physics MSc students. In 1946 he returned to the UK and began his PhD research at the Cavendish under Denys (later Sir Denys) Wilkinson (FRS 1956). Stafford later felt that the Cavendish years were not entirely satisfactory, partly because of the time taken for the laboratory to recover from the effects of the war and partly because Wilkinson was recovering from serious exposure to radiation suffered in Canada in 1945 and was barred from the Cavendish for much of Stafford's time there. However, he was able to guide Stafford's PhD work, which began with the construction of an ionization chamber that operated at up to 90 atmospheres and 4000 volts (1),* and which was then used in the study of the photo-disintegration of the deuteron and neutron cross-section measurements (2, 3, 4). Stafford was awarded his PhD in 1950, and he and Wilkinson became friends and colleagues for the rest of their lives.

Meanwhile, in South Africa the Smuts government lost the 1948 election to the Nationalist Party, ushering in the start of the apartheid era. Before this defeat, Smuts had asked Basil (later Sir Basil) Schonland FRS to lead the new South African Council for Scientific and Industrial Research (CSIR). Schonland, who had studied at the Cavendish in the 1920s with Sir Ernest Rutherford FRS (PRS 1925–30), recruited Stafford but arranged for him to work first at the Atomic Energy Research Establishment (AERE) at Harwell to study what was known about civilian defence against atomic weapons. Stafford described this work as 'very dull', but in his second year at Harwell he met up again with Jim Cassels (FRS 1959), whom he had known at Cambridge, and Gerry Pickavance (FRS 1976), who was the group leader for the experimental programme at the Harwell synchrocyclotron, which had been completed in 1949. With the agreement of Schonland, Stafford joined the Pickavance and Cassels group, and they carried out several experiments on nucleon–nucleon scattering. Stafford remembered this time as a very happy and stimulating period. More significantly, the association with Pickavance shaped his long-term career. It was also a time of big changes in his personal life: he married Helen Goldthorp Clark (known as Goldy) in 1950 (see figure 1), and their son Toby was born in 1951.

Cockcroft, then director at Harwell, wanted Stafford to extend his stay there to continue working with Pickavance and Cassels, but South African politics intervened. One of the senior CSIR scientists had to leave South Africa because of her opposition to apartheid, and Stafford was required to return there in 1952 to replace her as head of the CSIR Biophysics Subdivision. But the stay in South Africa did not last long: in 1954 Pickavance offered him a job at Harwell in the cyclotron group. The family had now increased with the birth of twin daughters, and there was a desire not to bring up a young family under the apartheid regime. Professionally, the offer was certainly attractive, with the prospect of getting back to high-energy physics research. The family moved back to the UK, and Godfrey and Goldy lived in the Oxford area for the rest of their lives.

* Numbers in this form refer to the bibliography at the end of the text.

Figure 1. Goldy and Godfrey in London (near Piccadilly Circus) around the time of their marriage in 1950. Photograph: the Stafford family.

1954–57: Harwell, the synchrocyclotron and the birth of the Rutherford Laboratory

For the next 27 years Stafford was based first at Harwell and then at the next-door Rutherford Laboratory, which was founded in 1957. Before describing his career in this period, it is appropriate to summarize briefly the situation of high-energy (or ‘particle’) physics in the UK in 1954, almost 10 years after the end of the Second World War.

Particle physics has two main ancestral threads: the use of naturally occurring radioactivity to probe matter and the atom, and the study of cosmic rays. It was soon appreciated that energy was the key to probing matter more deeply, and both electrostatic and combined electric and magnetic methods to accelerate particles were invented in the 1930s. The former is limited, by breakdown in air, to energies of a few mega electron volts (MeV). (A proton with kinetic energy of 100 MeV is moving at 43% of the speed of light.) In the case of combined fields, the magnetic field guides the particles round through the same relatively small electric field (a ‘cyclotron’), enabling far higher energies than the purely electrostatic method. The original ‘cyclotron’ design was developed to cope with relativistic effects (‘synchrocyclotron’). Further developments led to the ‘synchrotron’, in which a variable magnetic field confines the particles to a relatively small volume throughout the acceleration cycle. The basic idea of the synchrotron is still in use today, notably in the Large Hadron Collider at CERN.

In the wake of the scientific contribution to the UK war effort, funding for particle physics was relatively generous, even in a period of post-war austerity. Much of this funding went into building accelerators. By 1954, Harwell had the 175 MeV synchrocyclotron mentioned above and plans for a 600 MeV proton linear accelerator. In addition, the universities had a 1000 MeV proton synchrotron at Birmingham, a 350 MeV electron synchrotron at Glasgow, a 380 MeV proton synchrocyclotron at Liverpool and a 125 MeV electron synchrotron at Oxford. And then there was CERN.

The UK was one of the 12 signatories to the convention establishing CERN in June 1953, and formal UK ratification followed at the end of the year. The UK had not signed the provisional CERN convention in 1952 as it had the major programme of domestic accelerators outlined above. Both the UK government and its scientists wished the fledgling CERN well, but good wishes tinged perhaps with a certain paternalistic air, and this continued into the 1960s. But Cockcroft was a strong supporter of CERN; in 1952 CERN set up a group to study a possible synchrotron design, and this group had its headquarters at Harwell. Soon afterwards three key Harwell accelerator experts, John (later Sir John) Adams (FRS 1963), Frank Goward and Mervyn Hine, moved to CERN in Geneva. Adams later led the construction of the CERN 28 GeV synchrotron and in the 1970s its successor, the Super Proton Synchrotron (SPS).

Stafford also had an opportunity to go to CERN at this time, but he preferred to take the post in the cyclotron group at Harwell as this offered the prospect of getting on with experiments straight away. The study of nucleon–nucleon scattering at relatively low energies provides essential input into the understanding of the nucleon–nucleon force and thus of how the nucleus is held together. Phase shifts are a way of characterizing scattering in a model-independent way, and both constrain and test proposed theories. It is very helpful in extracting phase shifts from the experimental data to have scattering information using polarized beam and/or target particles.

Stafford and co-workers set about studying neutron–proton scattering using a (partially) polarized neutron beam. Their first paper (5) reported on polarization effects in neutron–proton scattering at 98 MeV. Exploiting the beam polarization required the direct but mechanically delicate process of rotating the 'counter telescope' by 180 degrees around the line of the neutron beam. However, this method is beset with systematic errors (5), and Richard (Dick) Wilson, who worked at the Harwell cyclotron in the 1950s before moving to Harvard, suggested instead rotating the neutron polarization vector by precession in a magnetic field. Improved results using this new method soon followed (6, 7, 9). It worked well, was simpler to implement (once the magnet was built) and led to smaller errors. The technique was copied quite widely (for example, Barschall 1964; Walker *et al.* 1965).

As well as the polarization measurements, Stafford and his team devised and built a neutron time-of-flight spectrometer. This required modification of the timing structure of protons extracted from the Harwell cyclotron to kick all the protons onto a target at the 'same' time, to within a few nanoseconds. This dynamic kicker required a deflecting voltage of *ca* 60 kV to be applied with a rise time of less than *ca* 20 nanoseconds, and precisely phased with respect to the radio-frequency (RF) cycle of the cyclotron (8). Using it, Stafford and his colleagues made precise measurements of the total cross-section for neutron scattering on several materials (from hydrogen to uranium) at energies from 15 to 120 MeV. The spectrometer was used by other teams over a period of several years (for example, Bowen *et al.* 1961; Riddle *et al.* 1965; Marshak *et al.* 1968).

By 1957 CERN had completed its first accelerator: a synchrocyclotron (CERN SC) capable of accelerating protons to a kinetic energy of 600 MeV. This was significantly above the Harwell top energy (175 MeV), and, importantly, above the threshold for pion production. Together with Franz Heymann, a lecturer at University College London, Stafford proposed two experiments. One was to repeat the neutron polarization experiment using the same magnetic technique to rotate the polarization detector as developed at Harwell. The second was to exploit the higher energy of the CERN SC to study pion production. But major developments at Harwell and in the UK organization of particle physics intervened.

First, the responsibility for all atomic energy work (civil and military) was moved to a stand-alone, publicly funded organization at arm's length from government: the UK Atomic Energy Authority (UKAEA), established in 1954.

Second, it was becoming clear that providing every interested university physics department with its own accelerator was completely impractical, both financially and operationally. Despite having (eventually) joined CERN, there was much discussion of the need for a national laboratory, equipped with a state-of-the-art, national-scale accelerator and facilities. This discussion was not without some agonizing on the part of the university community, concerned that such a development would subvert university research in particle physics. The flavour of the deliberations can be found in the recollections of Wilkinson at the Nimrod Commemoration Evening held in 1978 (Wilkinson 1978). Wilkinson's recollections were interestingly frank, with the result that the published proceedings of the Nimrod event were held up for some 18 months while clearance was obtained from the Cabinet Office (J. Litt, personal communication, 2014).

It was also recognized that such a national laboratory, with its focus on fundamental research and primary aim of providing facilities for the university community, would not sit easily within the framework of the UKAEA, which often required, for example, some level of security and vetting of personnel.

Finally, there had been a major advance in accelerator science. As mentioned above, by 1954 Harwell had plans for the construction of a 600 MeV proton linear accelerator (PLA). The 'official' reason for building such an accelerator, as presented by Cockcroft to the Atomic Energy Board in 1953, was that it would be an excellent source of neutrons to make fissile material, although the neutron measurement on which this was based subsequently proved to be too high. However, Cockcroft certainly also had in mind its use by the university community: the energy was above the threshold for pion production, and, as a linear accelerator, one could extract a high-intensity beam.

The prospect of this machine was one of the reasons that had attracted Stafford back from South Africa to Harwell. Pickavance was appointed to lead the PLA project, which meant that, almost as soon as he arrived back at Harwell, Stafford was acting group leader of the cyclotron group. Then, in 1955, the intensity argument in favour of a linear accelerator vanished: the extraction of a high-intensity beam from a synchrotron was successfully demonstrated at the Liverpool synchrocyclotron (Crewe & Gregory 1955), and higher energy could be produced more economically at a synchrotron. So, with the argument based on neutron production also no longer valid, Cockcroft convened a series of meetings in 1955 and 1956. Eventually the decision was made to build a 7 GeV proton synchrotron, but, as was much discussed thereafter, using 'weak focusing' and not the recently proposed 'strong focusing'. Weak focusing was considered the more certain route to a high-intensity machine than the then recently proposed, but technically less sure, strong focusing. With the great benefit of hindsight, the decision in favour of weak focusing was overly cautious.

The result of all this organizational and technical upheaval was that, by mid-1957, the National Institute for Research in Nuclear Science (NIRNS) was set up to provide the universities with facilities and equipment that were beyond the scope of an individual university. The Rutherford Laboratory was established next door to the Harwell site as the first NIRNS laboratory. Schonland, then Cockcroft's deputy at Harwell, suggested that the new laboratory should have Rutherford in its name. Initially it was the Rutherford High Energy Laboratory, but the name has changed many times since 1957. In this memoir the name 'Rutherford Laboratory' or simply 'Rutherford' is used, unless the context requires use of the contemporary name.

Pickavance was appointed as the Rutherford's first director, with the primary responsibility for the construction of the 7 GeV accelerator, later named Nimrod. The PLA was no longer the next accelerator of choice, but the first stage of a 50 MeV accelerator was already under construction before further stages were cancelled in 1955. Ownership was transferred to the new laboratory and Stafford followed Pickavance onto the NIRNS staff, with responsibility for the PLA. The PLA building was, conveniently, situated on the periphery of the Harwell site, and could therefore easily be transferred to the Rutherford Laboratory. There was also the possibility of transferring the Harwell synchrocyclotron to NIRNS, but this was viewed by the universities as a (further) sign of an attempt to take over the universities' role in particle physics research, and, in the end, the UKAEA largesse in terms of accelerators was limited to the PLA.

Stafford's new role and responsibilities limited the time he could devote to experiments, and he was not able to follow up on his proposal for an experiment on pion production at the CERN SC, but he did manage to participate in the polarization experiment, the results of which were published in 1962 (11). Stafford's participation made him one of the first UK ‘commuters to CERN’, which he felt provided him with valuable insight into what university-based researchers would need when using the Rutherford Laboratory facilities later.

1957–69: Exploiting the PLA and Nimrod at the Rutherford Laboratory

Stafford’s task as head of the PLA group was to oversee the completion of the PLA, commission it and develop and oversee a programme of experiments. The PLA would be the only working accelerator at the laboratory until Nimrod came into operation at the end of 1963. The main components of the PLA were the three ‘tanks’ that sustained RF electric fields, precisely phased to the passage of the accelerating protons. Such tanks are technically challenging, and initially required opening up weekly for manual, finger-aching polishing to restore their performance. But the polishing cannot have harmed the basic soundness of their construction: two of the three tanks (tanks 2 and 3) are still in use in the injector into the ISIS synchrotron at the Rutherford (J. S. Thomason, personal communication, 2020). The tanks are still opened up for servicing, but now only every five years.

Paul Williams, who worked at the Rutherford for many years and was its director from 1986 to 1998, recalls visiting in the late 1950s as a young graduate student (Williams 2014):

> I have memories of meeting this energetic physicist (Stafford) who showed us round the PLA buildings; his energy, his piercing eyes and his South African accent have stayed with me ever since.

Inspired perhaps by the success of the polarized-neutron work with the Harwell synchrocyclotron, Stafford and his team constructed a polarized-proton source for the PLA (12). Despite his growing organizational responsibilities, Stafford took part in experiments using this polarized beam (13, 15). Also, as at the Harwell cyclotron, it was possible to modify the intrinsic 5 ns bunch-spacing of the accelerated beam from the PLA so that 1 ns-long bunches of protons hit the target spaced by around 180 ns, thus enabling a measurement of the energy of produced neutrons by time-of-flight. This time-of-flight system was then used to study neutron production. In a series of papers, Stafford and co-workers studied reactions in which a proton from the PLA struck a target nucleus, causing ejection of a neutron, thus creating an isobar of the original nucleus (see, for example, (16)). The results were valuable in furthering understanding of the nucleon–nucleon force in the nucleus.

In 1963 Stafford presented a conference report on the potential of proton linear accelerators for pion production. Commenting on the PLA at Rutherford, he noted that it had taken some time and effort to get the accelerator operational (14):

> This machine has a 1% duty factor and has been in use for research now for about three years ... A permanent engineering staff of 60 are required to service and operate the accelerator and to design and build the equipment for the 50 nuclear physicists who use the machine and the team of 30 who are concerned with accelerator research and RF valve development.

As Stafford also noted in his report, the duty factor of only 1% resulted from the huge power dissipation in the RF tanks due to ohmic losses. This had led Stafford and his colleague A. P. Banford to propose, in an earlier publication (10), the use of superconducting material in the RF tanks to reduce the ohmic losses by a factor of *ca* 10^4 in an accelerator like the

Rutherford PLA, allowing a much higher duty factor. This is probably the most influential of Stafford's scientific publications. Superconducting RF is now the subject of a biennial international conference and is an essential component of many linear accelerators around the world, notably the free-electron laser (XFEL) at the Deutsches Elektronen-Synchrotron (DESY) in Hamburg and the planned International Linear Collider.

The 50 nuclear physicists mentioned by Stafford in his report (14) would have included his own team from the Rutherford and some physicists from Harwell, but comprised mainly physicists from the UK universities. As already noted, there were concerns in the university community about a national centre. It was, therefore, essential that the interaction between the new Rutherford Laboratory and the university community should get off to as good a start as possible, and this was surely uppermost in the minds of both Pickavance and Stafford. Once operational, the PLA hosted many university groups (see, for example, Ashmore *et al.* 1965), and Stafford felt that working with a large university community on the PLA was very rewarding. This approach set the tone and ethos of the Rutherford Laboratory.

Toward the end of August 1963 Nimrod accelerated protons up to 8 GeV, and beams were first extracted for experiments in December. With the construction phase over, Stafford was appointed head of the High Energy Physics Division, with responsibility for the Nimrod research programme. Interest in using Nimrod was high, and interested physicists, usually from more than one university, sometimes also working with Rutherford physicists, had to submit proposals, which were then assessed. In keeping with the emphasis on university participation, a selection panel was established with most of its membership drawn from the universities.

Despite becoming operational several years after the higher-energy (strong-focusing) synchrotrons at CERN (28 GeV, 1959) and Brookhaven (33 GeV, 1960), Nimrod was able to make a major contribution to the development of particle physics, particularly in the area of the baryon resonances (excited states). In 1967 Stafford presented a summary of the first few years of Nimrod operation (18), and reported on more than 30 experiments. The experience of operating Nimrod had been very positive, although a failure in the power-supply system in February 1965 meant it operated at reduced energy and intensity for much of that year.

As division head, Stafford visited the 'control room' of each experiment every evening when the experiments were taking data. He was also able to take an active part in some of the early experiments, making detailed and precise measurements of the total cross-section at several energies using proton, pion and kaon beams (see, for example, (17)). He was now a person of considerable standing, and he could exercise authority when necessary—he was on the overnight shift on a Nimrod experiment when a key piece of electronic equipment, a Laben pulse-height analyser, failed. The expert was at home and did not have a domestic telephone, so a telegram was composed, 'Laben up spout. Come in. Godfrey', and was delivered by a General Post Office dispatch rider to the expert's home at half-past three in the morning, causing some local disturbance and excitement (a fuller account of this incident can be heard at https://indi.to/FkkDS, starting after 3 min 30 s).

In 1966 Pickavance and Stafford reported on the relationship between the Rutherford Laboratory and the universities at the meeting European Collaboration in Physics. Hostel accommodation and furnished and unfurnished houses were available for university users, and the cost of travel and incidental expenses were met by the laboratory; in summary, they felt they had done their best for university users to facilitate working at a national laboratory. The university users came overwhelmingly from the southern part of the UK. This was one factor in the decision of NIRNS to establish a second laboratory at Daresbury, which is about midway between Liverpool and Manchester. Approval for a 4 GeV electron synchrotron was given in 1962, and the machine, named NINA, became operational in 1966. The model and style of university usage were essentially the same as at the Rutherford.

In 1966 Stafford was appointed deputy director of the Rutherford but continued to head the High Energy Physics Division. It was again a time of significant change in the arrangements for the administration and funding of UK particle physics. In 1965, the role of NIRNS had been taken over by the new Science Research Council (SRC), with a remit covering a much broader area of science. The responsibility for particle physics, including the Rutherford and Daresbury laboratories and matters related to CERN, now came under the Nuclear Physics Board (NPB), which reported upward to the SRC. The first chairman of the NPB was Cecil Powell FRS. One of its first problems was CERN.

By the early 1960s both CERN and Brookhaven were contemplating the construction of accelerators of a few hundred GeV. The CERN Council was initially in favour of establishing a second laboratory at a new site to host this new accelerator, with a design energy of 300 GeV. This proposal struggled to attract sufficient support from the CERN member states, and in June 1968 the UK government decided it would not be able to participate for financial reasons. Brian (later Lord) Flowers FRS, then chairman of the SRC and chief UK delegate to the CERN Council, had to inform the council of the UK decision, followed immediately by a statement in a personal capacity expressing his deep regret at the official decision he had just announced.

Neither the UK particle physics community nor its leaders were ready to give up on participation in the 300 GeV project, but it was clear that significant financial savings in the domestic expenditure would be required. In March 1969 Flowers addressed the Rutherford staff and informed them that the SRC proposal was to reduce Nimrod operation, starting in 1970, and close it in 1975. The Rutherford Laboratory would become a ‘staging post’ for the preparation of experiments to be mounted at CERN and elsewhere, and the laboratory would also start up other SRC-sponsored research. In parallel, the UK particle physics community would have to be reduced in number. At Daresbury, the development of a synchrotron radiation facility was being considered, as well as the possible upgrade of the electron synchrotron to 15–20 GeV.

In September 1969 Pickavance was appointed to be SRC’s full-time Director of Nuclear Physics, thus becoming responsible for both the Rutherford and Daresbury laboratories as well as for matters related to CERN. A primary task was to get the UK decision on the 300 GeV project reversed. Stafford was the obvious successor as the Rutherford director and he was duly appointed.

1969–81: Rutherford director

Stafford’s first task was to deal with the SRC proposals for the future of Nimrod and the laboratory. Not surprisingly, he considered these proposals logistically and logically flawed because Nimrod still had good physics to offer and the Rutherford was the natural site for a future national accelerator. Furthermore, he felt it would not be sensible or practical to have the staging post for the preparation of experiments at one laboratory, the Rutherford, and the national accelerator at another, Daresbury.

An important component of these future prospects of Nimrod and the laboratory came from the possible application of superconductivity to accelerators. Accelerator designers were fully aware of the potential of superconducting magnets, but no-one had a practical solution to the problem of ‘flux jumps’ and the associated transition of the superconductor back to the normal, resistive state. Then, in 1968, a group of Rutherford scientists, Peter Smith, Martin Wilson and colleagues, succeeded in developing a cable made up of many superconducting filaments that eliminated these problems (Smith *et al.* 1968). This is crucial for the use of superconductivity in accelerator magnets, which are cycled regularly between low and high magnetic fields. The work of the group had been strongly supported by Stafford. Many years later he confided to Wilson that getting the necessary funding from the NPB had not been easy, not least because some of the money would be paid to outside industry (Imperial Metal Industries, UK) to develop the super-thin filament (Wilson 2014).

In one of his first acts as director, Stafford launched a major programme to develop the cable further and build prototype superconducting magnets suitable for a synchrotron. Since its development, this superconducting cable, later named Rutherford Cable, has been used in all successful superconducting accelerator magnets, including those at the CERN Large Hadron Collider.

Discussion of the SRC’s drastic proposals for the Rutherford Laboratory must have continued at the NPB through 1970, and Stafford certainly interacted with the board. Pickavance was also refining the financial plan underpinning the SRC proposals, but perhaps the most significant development was political. Somewhat against expectation, the Conservatives won the UK general election in June 1970, and Margaret Thatcher, the new Secretary of State for Education and Science, visited CERN on 24 September 1970. By this time CERN had developed a ‘Project B’ version of the 300 GeV project, which involved siting the accelerator on Swiss and French territory adjacent to the existing laboratory and making significant use of existing CERN infrastructure. Mrs Thatcher’s visit included discussion with the CERN senior management, which surely covered the savings possible from the Project B proposal and the importance of UK involvement.

On 4 December 1970, Mrs Thatcher informed the House of Commons in a written answer that the UK would join the 300 GeV project and that a ‘careful appraisal of priorities’ had shown that the cost could be found without additional public expenditure. It is probable that her visit to CERN was significant in the UK decision, and it may even have been pivotal.

Mrs Thatcher’s ‘careful appraisal of priorities’ had, of course, to be implemented. The earlier SRC proposal to run down Nimrod and focus on Daresbury for the national accelerator was re-visited, and by the end of 1972 there was a significant change: Nimrod would run to the end of the decade and be equipped with a new injector (to increase its intensity), and NINA would close in 1977. Furthermore, planning for a new national accelerator for the 1980s was also undertaken. By the end of 1973 a very ambitious project had been conceived for the Rutherford site: a first phase would consist of an electron–positron collider of energy $14 + 14$ GeV, to be followed later by a proton ring, of up to 200 GeV if superconducting magnets were available, for electron–proton collisions. The plan had a suitably ambitious name: Electron–Positron/Proton Intersecting Complex, EPIC. (A collider, in which two beams travelling in opposite directions collide, has a huge advantage over a beam striking a stationary target. In the latter case, conservation of momentum ‘uses up’ much of the initial energy.)

A costed proposal for the electron–positron ($e^+ e^-$) phase, making maximum re-use of Nimrod and NINA components, was submitted to the SRC in November 1974. This was the same month as the ‘November revolution’ in particle physics: the simultaneous discovery of the J/ψ particle in $e^+ e^-$ collisions at the Stanford Linear Accelerator Center (SLAC) in California and in the $e^+ e^-$ final state in p-Be collisions at Brookhaven. Almost overnight, this discovery vaulted the $e^+ e^-$ collider into the machine of choice for particle physics, so the physics case for the $e^+ e^-$ collider was readily accepted by the SRC and further work to develop the proposal was approved. However, the SRC also stated that full approval (at a cost of over £20 million) would require a significant contribution from European partners.

Given the physics potential, both SLAC in the USA and, more significantly, the DESY laboratory in Germany had plans for a new $e^+ e^-$ collider. The scale of such projects meant that it was impossible, even undesirable, for both European proposals to proceed. In October 1975 the German government authorized the construction of the DESY machine, PETRA. In practice, this killed EPIC, and it was cancelled officially soon afterwards. Remarkably, just a few months later, in 1976, Stafford and his team were able to submit a proposal for an entirely different facility to exploit neutrons.

Neutrons

Beginning in the 1950s the potential of neutron scattering was becoming apparent, using neutrons that exited a reactor through small channels or ‘ports’, and demand for neutrons for academic research grew. In the early 1960s Harwell designed a high-flux beam reactor (HFBR) optimized to meet this demand. (For today’s neutron community, the HFBR means the reactor constructed at Brookhaven that ran from 1965 to 1996.) Discussions of a possible European project took place, but the UK decided in 1964 in favour of a national facility.

Harwell (UKAEA) submitted a proposal for an HFBR in 1966, and a revised proposal jointly with the SRC in 1968. In 1970 it was further decided that the UKAEA should not contribute to the cost, as the proposed reactor was primarily for academic research, and the responsibility for the HFBR proposal fell to the SRC alone. By this time, the Institut Laue–Langevin (ILL) at Grenoble, a joint nuclear reactor project by France and Germany, was close to operating, and in 1971 the SRC had to decide between applying to join ILL and pursuing an HFBR in the UK. It decided, narrowly, for the latter, and proposed this to the UK government; but the government, stimulated perhaps by the recent vote in parliament to join the European Common Market, chose to pursue UK membership of the ILL instead. These discussions proceeded rapidly, and the UK became an equal member (with France and Germany) of the ILL in January 1973.

However, a reactor is not the only way to produce neutrons. A heavy nucleus, for example tungsten or uranium, is neutron-rich and neutrons can be shaken loose when the nucleus is struck by a sufficiently energetic particle. Starting in the 1950s, Harwell built a series of electron linear accelerators that produced neutrons in this way by photoproduction. By the early 1970s, based on the pioneering work of Jack Carpenter in the USA, the case for a spallation neutron source using a proton accelerator, with the prospect of a much higher yield of neutrons, was being developed.

Some work was done at the Rutherford on a possible accelerator-based neutron source. However, this was considered ‘unofficial’ while EPIC was the official Rutherford proposal for a major new facility, but once EPIC was cancelled in 1975, Stafford was able to act with great speed and effectiveness. He convened a working group, which concluded very quickly that a neutron source (referred to as the SNS—the spallation neutron source) using a proton accelerator and based on existing Nimrod infrastructure was feasible and would also complement and extend the excellent results already coming out from ILL. Andrew Taylor (FRS 2019), who was to play a major role in the development and exploitation of neutrons at the Rutherford, joined the burgeoning project in October 1975 and recalls (A. D. Taylor, personal communication, 2020):

> Importantly we built MUSTA (Mock Up Spallation Target Assembly) using a de-tuned 800 MeV proton beam from NIMROD to generate spallation neutrons and quantify the thermal neutron performance. This later proved to be a key measurement in confirming the viability of the project. Geoff Manning was inspirational. Godfrey (Stafford) summoned me to his office to report these results, to counter arguments made against building SNS. Although as Lab Director he terrified me at the time, his support was critical to the project succeeding.

A complete proposal for the SNS, including scientific case, technical specification, costings and timescale, was submitted to the SRC in December 1976. The SNS would be based on a (strong-focusing) 800 MeV proton synchrotron with the extracted proton beam striking a uranium target to produce the neutrons. By making extensive use of existing Nimrod and NINA components and infrastructure, the cost (*ca* £10 million) was estimated to be only a third of a completely new facility. As mentioned by Taylor, there were counter arguments and some physicists believed a UK reactor was the better, surer approach, but official government approval followed in June 1977.

The construction of the SNS required the closure of both NINA (in 1977) and Nimrod (in 1978) to enable re-use of components and infrastructure (see figure 2). The construction took place during a period of severe pressure on public expenditure in the UK, which stretched the schedule, but the experimental programme of neutron scattering began in 1985. At around the same time as the SNS construction, spallation sources in the USA and Japan were also being developed, and Stafford was keen to foster international collaboration. Initially this was called LARJ (Los Alamos, Argonne, Rutherford, Japan), but soon became ICANS (International Collaboration—not conference!—on Advanced Neutron Sources). The twenty-third ICANS meeting took place in 2019.

The SNS was opened officially by Prime Minister Thatcher in October 1985, at which point it was renamed ISIS. Its performance and facilities have been improved and enhanced significantly since then, and it is a widely used world-class facility that is expected to continue to operate for many years.

With the closure of NINA and Nimrod, all accelerator-based experiments carried out by UK particle physicists moved to CERN and other overseas centres, completing a trend that had been increasing for several years. At the Rutherford Laboratory close collaboration with the university particle physics community continued and continues through the design, construction and operation of particle detectors, for which the resources of the laboratory have been essential.

Further diversification: lasers, computing, space

Lasers

By the early 1970s the potential of lasers for plasma research was becoming apparent, and with it the need for facilities on a scale that could not realistically be provided to each interested university. So, as happened for particle physics accelerators, planning began for a national

Figure 2. Stafford and Pickavance switching off Nimrod, July 1978. Photograph: Rutherford Appleton Laboratory/UK Science and Technology Facilities Council.

facility. Following a report on the science case to its Science Board in 1973, the SRC set up the Laser Steering Committee, chaired by Dan Bradley (FRS 1976), to develop the proposal.

Paul Williams recalls that ‘Godfrey [Stafford] led an initiative in the SRC and convinced the interested parties that the best solution would be for one super-laser to be built at the Lab’ (Williams 2014), but a complication arose. It had been realized that lasers might in principle be able to confine and compress a plasma to such a degree that controlled nuclear fusion occurred: inertial confinement fusion. Some experimental results in the early 1970s stimulated considerable interest, so the UKAEA, with its laboratory at Culham (established in 1960 to explore fusion energy), was interested in high-power lasers. It was eventually agreed to propose a facility sited between Rutherford and Harwell and operated jointly by the SRC and UKAEA, and a detailed proposal to this effect was submitted to the SRC in December 1974. However, results on laser-induced compression were considered ‘sensitive’ and touched on national security. As a result, the proposal had to be treated as strictly confidential because it contained sensitive technical data and, more consequentially, the facility would have to be operated in a bi-polar fashion: open access for academic research, but with security restrictions for the fusion-related studies. Stafford was extremely uncomfortable at this prospect. Fortunately, it never materialized. The UKAEA withdrew from the joint proposal in September 1975, and the SRC approved the Central Laser Facility (CLF) as an SRC-only facility in October 1975.

The CLF was established very quickly, and experiments began at the end of 1976. Like ISIS, it has been developed and upgraded extensively and is recognized as a world-leading centre through its work with its university partners, industry and the international community.

Computing

In the 1950s it gradually became clear that computers had potential far beyond lengthy numerical calculations. In particular, computers could handle the 'book-keeping', storage and routine analysis of scientific data. In 1961 a national laboratory for computing was established, under NIRNS. The laboratory, sited between Harwell and Rutherford, was to be equipped with a state-of-the-art Atlas computer developed and manufactured by the University of Manchester and the UK company Ferranti. Atlas would provide powerful computing facilities for the entire academic community and government departments, notably the Met Office. Jack Howlett had been involved with numerical analysis and computers since the 1940s and moved over from AERE Harwell to be director of the Atlas Laboratory, as it was named. The Atlas computer was delivered in 1964 and ran until 1973, by which time the next-door Rutherford Laboratory, Daresbury Laboratory and many of the universities had substantial computing installations of their own.

So, alongside the discussion in the early 1970s of the futures of the Rutherford and Daresbury laboratories and their facilities, the SRC also considered how to organize better its provision of computing. Prompted in part by Howlett's impending retirement in August 1975, it was finally decided that the Atlas Laboratory, which now came under the SRC, should merge with the Rutherford Laboratory, and this took place in 1975. In parallel, some of the Atlas Laboratory's computing support of the academic community, for example in atomic and molecular physics, was transferred to Daresbury. Computing has evolved hugely since then, and computing support for the academic community has flourished at both laboratories.

Space

By the mid-1970s the Appleton Laboratory—situated at Ditton Park, Slough, and named after the Nobel-prize winner Sir Edward Appleton FRS—supported atmospheric, Solar System and astrophysics research in the universities, including the building of the instruments sent into space. As with other disciplines, the need for international co-operation had become apparent in the 1950s, leading eventually to the formation of the European Space Agency. The Appleton Laboratory's role for the UK 'space science' community therefore had many similarities to the emerging role of the Rutherford Laboratory for the particle physics community, and a merger of the (smaller) Appleton Laboratory with the Rutherford looked attractive.

This merger started in 1979 and went through with relatively little friction. Stafford welcomed this further, major diversification of the laboratory's activities. In 1979 Richard Holdaway was a young Appleton scientist joining the Rutherford Laboratory. Speaking at the 2014 event to celebrate Stafford's life, and by then head of RAL Space, Holdaway recalled Stafford's kindness to the arriving Appleton staff. At Ditton Park he had been accustomed to being addressed as Holdaway by senior staff; at Rutherford he was pleasantly surprised at Stafford's greeting: 'It's Richard, isn't it? How is your programme going?' (Holdaway 2014).

Like ISIS and the CLF, space science is now one of the major components of the Rutherford Laboratory's activities, and it supports academe and industry in research that spans Earth's climate to the fundamental physics of the Universe.

With the merger of the Appleton Laboratory in 1979, the site was renamed the Rutherford Appleton Laboratory (RAL), a name that is still in use today. John Houghton FRS moved from Oxford to be director of the Appleton, and Geoff Manning became director of the Rutherford, with Stafford as director general of the combined laboratory.

In April 1980 Stafford turned 60. The general direction for the future laboratory was clear, and, although the new activities were by no means fully established, he could perhaps feel more certain of the laboratory's long-term future than when he started as director in 1969. He would keep a watchful eye on 'his' laboratory for the rest of his life—he was appointed its first honorary scientist—but in 1981 he was ready to relinquish the reins, as there were by then other, different calls on his time.

1979–87: Master of St Cross

St Cross was founded as an Oxford college in 1965, to provide a college 'home' for graduate students and academic staff, particularly scientists. The first master, 'Kits' van Heynigen, keen for the college to embrace modern technology, wondered if a computer could be accommodated on the site. He soon learned that this would require substantial and unaffordable infrastructure, but he was put in touch with Jack Howlett, then the director of the SRC's Atlas Laboratory. Howlett suggested that a terminal linked to the Atlas computer at Harwell by a telephone line could be very useful and would require only a small, ordinary room. Thus St Cross became the first Oxford college to have a network connection to a mainframe computer. Howlett was elected a fellow of St Cross by special election in 1966 and became an active member of the college.

Probably through the Howlett connection, Pickavance was elected as a visiting fellow in 1968 and Stafford in 1971. When van Heynigen was due to retire as master, in the summer of 1979, a selection committee was set up to consider his successor. Stafford was on the point of writing to the committee with some suggestions when he received a letter inviting him to become the second master of St Cross. He took over, initially on a part-time basis, in September 1979. The college faced some interesting challenges, but the circumstances were much more propitious than those he faced when he became the Rutherford director in 1969.

The need for larger college premises and the finances to pay for them dominated the first years of St Cross. After some 10 years, a remarkable opportunity arose: Pusey House consisted of a beautiful set of buildings in the centre of Oxford, which were occupied by the university's Faculty of Theology and Religion and the Pusey chapter. In 1976 the faculty was about to move to new quarters, and it was suggested that St Cross could move in. It was eventually agreed that St Cross would purchase some of the buildings on a 999-year lease as well as the right to develop the garden area behind the main buildings, but substantial funds were needed. Happily, a large benefaction from the Blackwell family, owners of Blackwell's, the famous Oxford bookshop, enabled the deal to go through, so, when Stafford took over as master, the main components for the move to Pusey House were in place.

Stafford made an early, lasting impact: a new dining hall was needed, and he proposed a steel-reinforced ceiling that created a large ground-floor space that became the dining hall. Following further building in the 1990s, this dining hall became a spacious common room that continues to benefit from Stafford's idea. The college was finally able to take up occupancy of Pusey House in September 1981, just as Stafford retired from the Rutherford Laboratory and devoted himself full-time to St Cross.

His principal aims as master were to increase the number of graduate students, broaden the scope of their research and provide more college accommodation for them. During Stafford's mastership the number of graduate students rose first to 36, the university-imposed limit as of 1982, and by 1987 was close to the revised upper limit of 75; and a significant fraction used college accommodation. (By 2021 the number of graduate students exceeded 500.)

Stafford also wanted to raise further endowments. Speaking at the Founders' Feast in 1980, he noted that a large single benefaction, on a scale that can lead to a change of college name, still evaded St Cross—and it continued to do so, although there was a steady flow of relatively small legacies, and then, in 1987, a very generous benefaction. The first call on these funds was to build in the garden area behind the existing buildings. Plans had to pass Oxford City Council's planning committee, which proved tortuous, and work on the first building in the garden began only in 1991.

Stafford's nine years as master spanned the move into the new home and the clear evolution of the college towards its present-day state. Many viewed his mastership as transformational. Speaking at the dinner to mark the end of his tenure, Derek Roe, then the vice-master, noted the rate of increase of student numbers and financial capital during Stafford's term and observed that 'Were your immediate successors to continue progress at that rate, we should in a short while become the richest college in Oxford and one of the largest' (Roe 2014).

As an honorary fellow, Stafford enjoyed continued links with St Cross for the rest of his life and had several close, long-term friends among the fellowship.

Community leader

Stafford believed profoundly in co-operation and the use of shared facilities, and he was a natural supporter of international collaboration. He was enthusiastic about the idea of the European Physical Society (EPS) and was a member of the steering committee that led to its formation in 1968. He was also the scientific secretary of the organizing committee for the first EPS conference in Florence in 1969. In 1984–86 he was the EPS president.

As already mentioned, Stafford was an early user of CERN. Once Nimrod began operating in 1964, the CERN Director-General invited Stafford to attend CERN's nuclear physics research committee, which then oversaw all of CERN's research programmes, in order to facilitate co-ordination between the experimental programmes at CERN and at the Rutherford.

In 1973 he was invited to become a member of CERN's scientific policy committee (SPC), which advises CERN's governing body, CERN Council, on major scientific policy. Election to the SPC was on the basis of a person's scientific standing; Stafford was vice-chair of the SPC for 1976–77 and then its chair for 1978–80. During his time as chair, the SPC had to advise CERN Council on the proposal to build a large electron–positron (LEP) collider as CERN's major new accelerator after the SPS. The physics case for such a facility was strong by the late 1970s, but it was nevertheless a major decision, taken at a time of (not uncommon) budgetary concerns and with far-reaching consequences for CERN: the 27 km tunnel excavated for LEP was made deliberately large enough to accommodate a post-LEP proton machine, today's Large Hadron Collider. As SPC chair, Stafford attended CERN Council and served as one of the UK delegates to Council during that period.

In the UK, Stafford was president of the physics section of the British Association for the Advancement of Science (now the British Science Association) in 1986, and president of the Institute of Physics 1986–88.

Family life and retirement

Helen Goldthorp (Goldy) Clark was born in Adelaide, Australia, in 1920. She came to London in 1948 to study for a PhD. Visiting Cambridge with a close friend, she met the research student Godfrey Stafford, and romance soon blossomed. As mentioned earlier, they were married in 1950. Family life started at Harwell, switched to South Africa in 1952 and then back to Harwell in 1954. By then the family had increased with the arrival of a son, Toby, in 1951 and twin daughters, Elizabeth (Liz) and Anne, in 1953. The family settled happily in Abingdon, a few miles from the Rutherford Laboratory. Godfrey and Goldy both missed the sun and warmth of their childhoods, so, as soon as the children were old enough, summer holidays were spent camping in the south of France and later in Italy.

Standards in the Stafford household were high: the children were expected always to try their hardest and do their very best. All three went to university and on to high-level professional careers. In 1971 the family moved to the Oxford village of North Hinksey, and Godfrey and Goldy lived there, in Ferry Cottage, for the rest of their lives. As the daily demands of her growing family reduced, Goldy began to have time for her wider interests. Always a believer in ‘doing’, she taught biology part-time and took adult classes in literature. The Soviet invasion of Czechoslovakia in 1968 prompted her, together with two friends, to establish the Abingdon branch of Amnesty International. During Godfrey’s time as director of the Rutherford, Goldy was able to accompany him on some of his official trips, and she often went to social occasions and events at St Cross during Godfrey’s mastership and afterwards.

Rachael, the first of five grandchildren, arrived in 1984, and Godfrey and Goldy both revelled in their roles as grandparents. There were many family gatherings, outings and trips involving the three generations (see figure 3). This period of happy, carefree retirement was broken when Goldy’s memory started to fail in the late 1990s and she required increasing amounts of care, which Godfrey gave with unstinting love and devotion. Goldy died in 2003—they had been married for 53 years.

In the last decade of his life, Godfrey enjoyed relatively good health; he would regularly cycle between St Cross and North Hinksey, although eventually succumbing to some battery power to assist pedalling. He enjoyed the company and conversation of friends, regular visits to the Rutherford Laboratory and St Cross, playing bridge, often with long-time friends and colleagues Norman Lipman and Geoff Manning, and, above all, his family, who provided support and brought him much pride and joy. His intellectual vigour remained undiminished. Margaret Yee, a colleague from St Cross, became a close friend during this time and remembers many delightful meals and discussions with Godfrey and visiting academics. As a researcher into the ‘principles of knowing’ and inter-disciplinary exchange, she found herself challenged regularly on the relative roles of science and theology.

His visits to the Rutherford often included listening to a seminar, but also checking what his successors were up to. It was his wont after such visits to provide feedback on how aspects of the laboratory could be managed better. His last visit was in 2013 (see figure 4), and Andrew Taylor, then director, duly received five hand-written pages full of very sensible but hard-to-implement advice. In the early summer of 2013 he became unwell and was diagnosed with aortic stenosis. He was booked in to have an artificial valve fitted, and e-mailed Margaret Yee that he expected to skip around like a newborn lamb afterwards, but there were complications after the operation and he died in July at the age of 93. Celebrations of his life and legacy

Figure 3. Almost all the family *ca* 1999. From the left: Anne Stafford (front), Godfrey (back), Max Wallis (front), Liz Stafford (back), Goldy (front), Toby Stafford (back), Alice Stafford (front), Simon Wallis (back), Rachael Wallis (front), Gabriel Wallis (back), Sam Stafford (front) and Mark Piney (front). Photograph: the Stafford family. (Online version in colour.)

were held at St Cross and a little later at the Rutherford, with many expressions of gratitude and admiration.

Conclusion

Godfrey Stafford lived a long and eventful life. He was of the generation that served in the Second World War and then enjoyed the ensuing prosperous peace. His family life brought him great happiness. His career spanned a remarkable era of discovery and development in particle physics. He contributed significantly to experiments using early accelerators and with ideas and support for their development, notably the applications of superconductivity. He was a strong supporter of international co-operation. He was master of St Cross as the college grew towards its present state. But his principal legacy is the Rutherford Laboratory, which he joined at its inception, where he oversaw the exploitation of the PLA and Nimrod accelerators and went on to be its director, guiding its transformation in the 1970s. As director he was quiet-spoken, approachable but not too approachable, demanding but supportive, and he had the complete respect of his staff. He understood from the start that the nature of the laboratory's interaction with the wider academic community was fundamental. There is no Stafford Building or Stafford Road at the laboratory, but the man himself would, I think, be quietly content that in many key respects he laid the foundations for the Rutherford Laboratory that flourishes today.

Figure 4. Visiting the ISIS facility at Rutherford Appleton Laboratory with Paul Williams (left), 2013. Photograph: Rutherford Appleton Laboratory/UK Science and Technology Facilities Council. (Online version in colour.)

Awards and recognition

1976	Commander of the Order of the British Empire
1979	Fellow of the Royal Society
1980	Honorary DSc, University of Birmingham
1981	Glazebrook Medal and Prize, Institute of Physics

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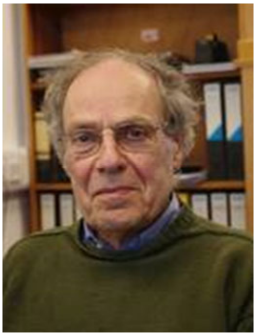
The frontispiece photograph was taken in 1979 and is © Godfrey Argent Studio. The photographs in figures 2 and 4 are shown with the permission of the Science and Technology Facilities Council. The photographs shown in figures 1 and 3 are with permission of the Stafford family, as is the recording of Stafford's 2008 recollection of D-Day. All are gratefully acknowledged.

It is also a pleasure to acknowledge those organizations that provide rather complete and online-accessible digital archives. They are of enormous assistance to anyone writing a memoir of this type, particularly during a time of pandemic.

Author profile

Norman McCubbin



Professor Norman McCubbin has worked on experiments at the CERN (Geneva) and DESY (Hamburg) laboratories. He joined the Rutherford Laboratory in 1975 and knew Stafford first as director and then as a highly respected 'elder statesman'. McCubbin retired in 2011, but he is still active in the ATLAS experiment at CERN and teaching undergraduates at St Anne's College, Oxford.

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