A BRIEF HISTORY OF SOUTH AFRICA'S CYCLOTRONS

(Banquet speech)

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Ladies and gentlemen,

It is indeed a pleasure to be with so many old friends from all parts of the world tonight – and my use of the word "old" refers not to their age but to the duration of our acquaintance! It is also an honour to have been called back from oblivion to address you.

Well aware of the brilliantly witty after-dinner speeches at recent cyclotron conferences, and also of my own limitations, I was at first reluctant to accept this invitation. However, I was persuaded by the fact that several of these speeches in the past have dealt with history rather than humour, together with the realisation that a brief account of this country's involvement with cyclotrons might be most appropriate at this first conference of its kind in South Africa. After all, it took so long to get the cyclotron community to come here that we cannot risk waiting for another opportunity. So please bear with me for a while!

In 1947, the year after the birth of the South African CSIR (Council for Scientific and Industrial Research), a Radioactivity Division was established as part of its National Physical Laboratory. The first head of this division, Dr S J du Toit, after an extended study tour abroad, proposed the construction of South Africa's first cyclotron. This proposal was approved early in 1950, thus heralding the beginning of local involvement in cyclotrons and their applications more than forty-five years ago. The cyclotron was a classical solid-pole machine intended to accelerate hydrogen ions up to 16 MeV and alpha particles to 32 MeV. It was locally designed and constructed, accelerated its first deuteron beam in 1956 and started routine operation in 1958. Efficient beam extraction and energy variability were among the improvements that were added in due course.

Initially the cyclotron was used primarily for research and training in nuclear physics. Joining the laboratory in 1956, I was probably the first user of the new accelerator, utilising the internal deuteron beam to produce radioactive mercury-197 for my postgraduate work in beta spectroscopy. For this I required targets of 1 mm thick pure gold which I had to procure in person from the South African Mint. This was no simple matter at the time and I had to fill in all sorts of special forms to justify the purchase of gold in unworked form. I remember vividly how hard it was to make the officials believe that my ultimate purpose really was to convert the precious gold into mercury and, once I had assured them that it could be done, how utterly disgusted they were with such irresponsibility! I also remember how the cyclotron crew then battled for several days to produce the deuteron beam until they discovered that someone had by accident reversed the connections to the electrolysis cell in which deuterium was produced from heavy water. Oxygen had therefore been fed into the ion source. This event in the late fifties surely deserves being recorded as one of the very early attempts to accelerate heavy ions in a cyclotron, unsuccessful and unintentional though it may have been!

Let me return to serious history. Apart from the physics research, which over the years led to hundreds of publications in international journals and the training of many of the older South African nuclear physicists, the cyclotron gradually came to be used more and more for the production of radioisotopes for commercial purposes. This program, which started in 1965, initially supplied sodium-22 for export. Gradually other industrial radioisotopes were added to the list which even included cadmium-109 and iron-55 for use on the Viking space craft during its mission to Mars. For local industrial use special sealed cadmium-109 sources were produced to serve in portable gold-reef analysers. Routine production of medical radioisotopes started with the first delivery of iodine-123 in 1970, soon to be followed by fluorine-18, iron-52 and gallium-67. Towards the end of its life the cyclotron still ran for 24 hours per day, six days per week, mostly for the production of short-lived medical radioisotopes like gallium-67, rubidium-krypton-81, indium-111 and iodine-123. These were regularly supplied to all large South African hospitals for diagnostic studies in many thousands of patients each year.

The Pretoria cyclotron was finally closed down in November 1988. Despite its relatively modest capabilities it had served the country well for more than 30 years. Not only did many nuclear physicists, many patients and the nuclear medicine fraternity as a whole benefit from the operation of this machine, but it deserves credit for having created in this country a certain awareness with respect to modern science and technology, for establishing specific technical skills and expertise and for leaving behind a pool of scientists, engineers and technicians well versed in matters ranging from accelerator technology to radiation protection. Many of these people have since gone abroad or found employment in other local enterprises but some have remained and constituted an important core without whose contributions the present National Accelerator Centre, this conference and the rest of my story might not have existed.

During the late fifties and early sixties several other accelerators were installed in South Africa, mostly by universities, and by 1966 six machines (the cyclotron, two ageing Cockcroft-Waltons and three of the present five Van de Graaffs) were being used, largely for basic research and training. At the annual physics conference held in July of that year, the local nuclear physicists arranged a special meeting to discuss the state and future of research facilities for nuclear physics in South Africa. Their view was that the accelerators then available within the country were too small and old to enable their users to continue doing research which would be internationally competitive in the long run. They agreed that the country would fairly soon need to acquire a large, modern centralised accelerator facility (or, at most, two) which would have to be shared among all users. A study group was elected to explore all relevant matters in more detail and report back at each annual physics conference.

In due course these efforts gained the support of the South African Institute of Physics and, in the early seventies, aroused the interest of local radiotherapists who wished to use an accelerator for cancer therapy with high energy neutrons and protons. With financial support from the Cape Provincial Administration a detailed feasibility study was initiated in 1973. Task groups, consisting of experts from all parts of the country, were appointed to investigate modern accelerator developments and the use of accelerators in the physical and medical sciences. The final report, which was published in 1975, recommended the local design and construction of a 200 MeV separated-sector cyclotron, to be operated as a national facility and used for research, cancer therapy and the production of radioisotopes.

At the end of 1975 the government approved the proposed project and its siting in the Western Cape. Design studies and the search for a suitable site were initiated and, in April 1977, the CSIR was charged with the responsibility for administering the project, which would be funded separately by the government. The task of designing and building the new accelerator was entrusted to a team led ever since by Dr Adriaan Botha.

The combination of requirements posed by the applications in medical and physical sciences dictated an accelerator capable of handling a variety of particles, a broad range of beam intensities and easily variable energies. In the early design phase the decision was taken to have two solid-pole injector cyclotrons, one to supply light ions (also at high beam currents) to the 200 MeV cyclotron and the other for injecting heavy ions. Each component of these three cyclotrons and all their associated equipment had to be planned, designed and specified in detail by NAC staff, and was then purchased or manufactured on site, or elsewhere in this country or, in some instances, imported from abroad. All assembly, integration and the supply of services and control instrumentation as well as commissioning were handled in-house.

Construction of the first building on the present site started in 1979 and by 1984 the buildings and services were mostly completed. The light ion injector delivered its first beam of protons in May 1985, first injection into the separated-sector cyclotron followed in September and protons were first accelerated to 66 MeV in October 1985, the month in which the centre was inaugurated. Less than a year later, in September 1986, protons at the full design energy of 200 MeV were extracted for the first time. The first radioisotopes were produced in October 1986, the first physics experiment followed a month later and routine operation, seven days per week and 24 hours per day, started in February 1987.

Cancer patients were first treated with neutrons at NAC in September 1988 and, exactly five years later, patient treatment with 200 MeV protons also got underway. The medical radioisotope production program, which used to depend on the Pretoria cyclotron, was transferred to the new centre at the end of 1988 without interrupting the service. Resource limitations and the priority assigned to proton therapy slowed down the completion of the second injector cyclotron which finally started operation during 1994, delivering heavy ions or polarised light ions for further acceleration in the large cyclotron. This finally completed the project as envisioned twenty years ago.

The performance and operating statistics of South Africa's new generation of its own cyclotrons have been reported at this and previous conferences. After more than eight years of remarkably reliable operation of the separated-sector cyclotron and its first injector, these machines have earned their place among the best-running cyclotrons ever built. Over each of the past six years, more than 6 000 hours of useful beam were delivered. As planned from the outset, these beams have been used for research and training by dozens of scientists and students from all parts of the country, for treating close to a thousand patients with high-energy neutrons or protons and for producing the radioisotopes that have been used in diagnostic procedures in tens of thousands of patients.

What I have summarised in a few minutes tonight, reflects some of the results of nearly five decades of hard work by many people. I refer to those who have been responsible for designing, constructing, operating and utilising the cyclotrons of this country. I have had the pleasure of knowing almost all of them and I wish to salute them all tonight and to pay tribute to their ingenuity, perseverance and dedication. I am convinced that, over the past forty-five years, cyclotrons have made a significant contribution to science, technology and medicine in this country. It is my sincere hope that cyclotrons and their applications will, for many more years, contribute to the quality of life of the people of South Africa and that this country will, in turn, contribute to further developments in this field.