

Physics monitor

Protontherapy pioneer and Fermilab founder Robert Wilson was guest of honour at the recent International Symposium on Hadrontherapy at CERN. It was in 1946 - exactly half a century ago, that Wilson wrote his landmark paper pointing out the possibilities of using protons for therapy.

Hadrons for health

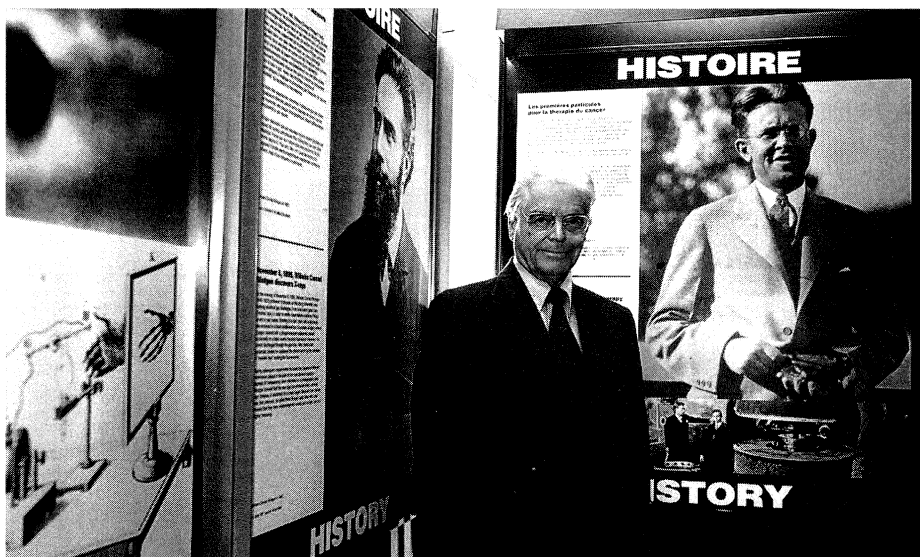
A recent conference at CERN refocused attention on the use of particle beams for therapy.

With money hard to come by in the economic depression of the 1930s, Ernest Lawrence at Berkeley had to cast his net wide to obtain backing for his new invention - the cyclotron. It was medical applications which provided a driving force for the development of these early particle accelerators.

The use of naturally radioactivity substances such as radium for cancer therapy had long been realized. In 1934, following the discovery of artificial radioactivity by Irène and Frédéric Joliot, Lawrence saw how these unstable nuclei could be used as synthetic radiation sources in medicine or as tracers in biological research, a technique invented by the Hungarian physicist George de Hevesy at Rutherford's laboratory in Cambridge. Lawrence's proposal brought in welcome money from the Rockefeller and Macy Foundations.

The following year, with the help of his brother John, a physician, Lawrence looked at the possibility of using high energy radiation - particle beams from the cyclotrons - rather than the artificial isotopes. While this brought more powerful beams and better therapy, the radiation source could no longer come to the patient - instead the patient had to go to the source.

With Harvard offering Lawrence a job, the University of California was able to obtain fresh funds for a new medical accelerator, and induce Lawrence to stay on the West Coast. In 1938 Lawrence's mother was the first cancer patient to be successfully



treated with neutrons, derived from a cyclotron beam.

In Europe, Enrico Fermi in Rome, after discovering the high yield of radioactive substances produced by slow neutrons, had also seen the potential of particle beams for therapy, and a new Istituto Superiore di Sanità, set up to provide the necessary support, built the first MeV Cockcroft-Walton accelerator and has remained a traditional centre of particle and nuclear physics expertise in Italy.

The discovery of nuclear fission and the Second World War diverted physicists' attention. As researchers picked up the threads of their peacetime activities, at Harvard in 1946 Robert Wilson wrote a landmark paper pointing out the possibilities of using protons for therapy. Rather than 'wandering' around, like neutrons, protons penetrate tissue and eventually deposit a high energy density in a small region, the famous 'Bragg peak'. If this peak can be made to

coincide with the tumour, then the beams provide a precision scalpel.

Before leaving for a new career at Cornell, Wilson began a programme of protontherapy at Harvard in collaboration with Massachusetts General hospital. In Europe, proton beams of 185 MeV from the synchrocyclotron at Uppsala's Gustaf Werner Institute were used to combat cancer in the 1960s.

From Cornell, protontherapy pioneer Wilson went on to found the new Fermi National Accelerator Laboratory, which has its own therapy unit. Fermilab collaborated with Loma Linda Hospital in California for the construction of a successful dedicated protontherapy unit.

As well as protons, other heavy particle beams too can be useful, and programmes using beams of pion have been carried out at Los Alamos in the US, at the Canadian TRIUMF Laboratory in Vancouver and at the Swiss Paul Scherrer Institute in Villigen.

However beams of heavier nuclei pack a stronger punch and are more effective than protons in sheer cell-destroying power. With the availability of such beams at Berkeley from the late 1950s, California scientists began a new therapy programme, work which came to an end when Berkeley's accelerator was decommissioned in 1993.

In 1995, the purpose-built Heavy Ion Medical ACcelerator (HIMAC) began providing beams for therapy at Japan's National Institute of Radiological Sciences (NIRS), in Chiba, near Tokyo. More recently this has been joined by a new venture based at Darmstadt's GSI Laboratory (January, page 16).

In Italy and for Europe, a Hadron-therapy Collaboration masterminded by Ugo Amaldi of CERN, initiated in 1991, aims to refoster interest in these schemes and revive the illustrious tradition of Enrico Fermi. The TERA Foundation provides the administrative infrastructure and pushes for funds.

Design work began in 1992 and a first study published in 1994 for a new therapy centre to be built in Milan using a synchrotron to take protons to at least 250 MeV and carbon ions to 375 MeV per nucleon.

Another design study caters for the needs of TOP (Terapia Oncologica con Protoni) for Rome's Istituto Superiore di Sanità, which now has funds to build a novel high frequency (3 GHz) proton linac as a prototype for future hospital-based centres.

The design of such machines demands accelerator expertise under project leader Philip Bryant, and specialists from CERN, from GSI, from the Austrian AUSTRON project and from TERA collaborate in ongoing design work, paralleling Fermilab's 'godfather' role for the Loma Linda centre.

These projects and the specialized design work for them, as well as medical research in general, are highlighted at a new series of International Symposia on Hadrontherapy, the first of which was organized by the TERA Foundation and held in Como, Italy, in October 1993. The second, held at CERN from 12-13 September, coincided with the 50th anniversary of Wilson's milestone paper which first proposed the idea of using protons to treat cancer. Because high energy proton beams were a dream in those days, guest of honour Wilson said the idea went down initially 'like a lead balloon'.

As well as particle beams, many other aspects of modern physics benefit medical and biological research. The genealogy of detectors opened by Georges Charpak's development of the multiwire chamber provide the imaging complement to new methods of scanning. Thanks to the World Wide Web, pioneered at CERN, the internet is now the medium of choice to disseminate research findings, assisted by powerful computers, as new genomes are mapped in detail.

But with 50 years separating the Wilson paper and developments which are still blazing an initial trail, delegates at the CERN meeting rued the slow rate of progress and spoke of half a century as a 'Wilson unit'. For his part, the hadrontherapy pioneer urged his successors to 'make the idea work'.

A European travelling 'Hadrons for Health' exhibition produced by CERN in collaboration with GSI Darmstadt and the TERA Foundation and organized by Werner Kienzle and Alessandro Pascolini is also passing the message.

LEAP LEAR

In physics, LEAP (conference on Low Energy Antiproton Physics) is a biennial event, so that a LEAP year is not necessarily a leap year.

The 1996 LEAP was made this summer in Dinkelsbühl, a small medieval town in the heart of Germany, and was attended by scientists whose research focuses mainly on CERN's LEAR low energy antiproton ring. The meeting was especially significant in that it was the last such meeting to be held while LEAR was still in operation. With the decision to close the facility, the research community looks forward to the proposed AD antiproton project (November 1995, page 6) and subsequent developments.

One highlight was high precision spectroscopy using high power lasers on antiprotonic atoms (December 1994, page 16). This experiment at LEAR investigated highly excited atomic levels of antiprotons bound to helium-4 nuclei. These live as long as several microseconds and can be regarded as short-term storage for antimatter. Hyperfine splitting provides a test of quantum electrodynamics at the part per million level (if any further assurance is still required) and exhibits the sophistication of three-body calculations. Further experiments at the AD would provide a precision measurement of the magnetic moment, and possibly the quadrupole moment, of the antiproton.

Light meson spectroscopy has benefited considerably from the Crystal Barrel, Obelix and Jetset studies at LEAR. This is particularly evident in the mass range 1400 - 2200 MeV and for zero spin, positive