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A LOOK BACK TO CERN COURIER VOL. 8, MAY 1969, COMPILED BY PEGGIE RIMMER

VILLIGEN

Original SIN

A “meson factory” of novel design is being built by SIN (Schweizerisches Institut für Nuklearforschung – Swiss Institute for Nuclear Research) at Villigen near Zurich. It involves a two-stage machine capable of accelerating intense beams of protons. The first stage is a 70 MeV isochronous cyclotron injecting into an isochronous ring cyclotron which completes acceleration to over 500 MeV, well above the 450 MeV threshold for pi-meson production. The machine will be operating fully from the middle of the 1970s.

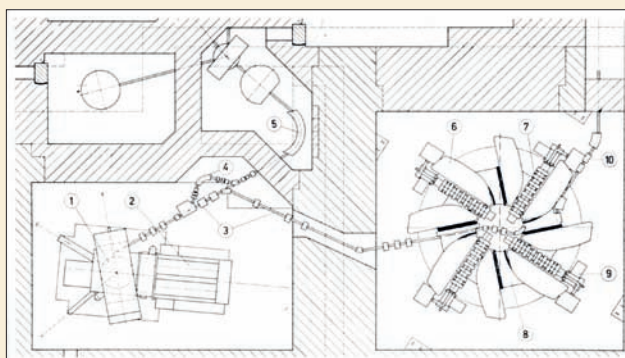
Evolution of the cyclotron

A cyclotron depends on the fact that, in a uniform magnet field, charged particles take the same time to travel round their orbit regardless of their velocity. A voltage of fixed frequency applied across a gap accelerates protons each time they come round the cyclotron and spiral outwards with increasing energy. This remains efficient up to energies around 20 MeV, when the speed of the protons becomes a significant fraction of that of light, their mass begins to increase noticeably (2%) and they take longer to orbit (2%).

In a synchrocyclotron (such as the CERN 600 MeV machine), particles are accelerated to higher energies with a constant magnetic field by continuously adjusting the frequency of the field in the accelerating gap to keep in step with the changing rotation frequency. However, this means that particles must be injected and accelerated in pulses, many times per second.

To regain a continuous beam, sectors can be placed on the poles of fixed-frequency cyclotrons such that the circular orbits become scalloped. The magnetic field seen by a particle can then increase with radius and the distances travelled can be arranged to compensate for the increase in mass.

High-voltage accelerating cavities can be positioned between magnet sectors at the outer part of the machine but there is no room at the centre. This led SIN to lift the centre portion out of the machine, leaving an (eight-sector) isochronous ring with the removed portion, a conventional isochronous



A simplified layout of the 500 MeV Villigen accelerator:
 1) injector cyclotron; 2) r.f. system; 3) beam-transport system;
 4) beam-switch for simultaneous use of the 70 MeV beam;
 5) low-energy beam-analysing system; 6) sector magnets of the ring cyclotron; 7) r.f. cavities; 8) free section of the vacuum chamber; 9) vacuum pumping system and r.f. power stages; 10) beam-transport system for the ejected protons.

cyclotron, sitting alongside as an injector.

The Swiss goals were for an energy of over 500 MeV with a proton beam intensity of the order of $100 \mu\text{A}$. Such intense beams must be ejected with very high efficiency which means that the outermost particle orbits must be well separated radially so that fields applied to the full energy orbit can bend particles out of the machine without affecting neighbouring orbits.

RF cavities in four of the eight gaps between the magnets in the ring will each give up to 500 keV to the protons. The energy gain per turn can be as large as 2 MeV to give an orbit separation at 500 MeV of

8 mm (separation on the CERN synchrocyclotron is currently 0.04 mm). With such a separation a septum extraction system can yield calculated efficiencies of 95%.

Experimental programme

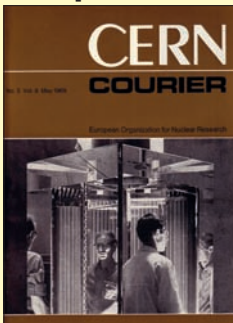
The machine will be used for intermediate energy physics with pion and muon beams and the experimental programme will be determined by the high beam intensity and the 100% duty-cycle. This opens up new fields of research which until now have barely been touched or have been without prospects. Some of these fields connect different branches of science, such as muonium chemistry and pion-radiation

biology. The first acceleration stage will, however, be capable of accelerating many types of particle to different low energies for nuclear-physics research.

There are a number of fundamental problems in classical elementary-particle physics which have not been solved with present accelerators but which can finally be attacked with the beams of a “meson factory”, for example, the study of rare decay modes. The abundance of particles will make it possible to use instruments with unprecedented resolution, such as crystal spectrometers.

● Compiled from texts on pp139–141.

Compiler's Note



The SIN machine started operation in 1974. Three years later, candidates for neutrinoless decays of muons into electrons were reported, violating lepton-flavour conservation and causing great excitement. Although later disproved, they launched an ongoing search for such decays, which are forbidden in the Standard Model.

In 1988, SIN merged with the Federal Institute for Reactor Research across the Aare river to form the Paul Scherrer Institute (PSI). In collaboration with several universities, hospitals and industry, future-oriented projects in solid-state physics, biomedicine, renewable energy and environmental sciences were established.

Notably, PSI has become a world-class centre for cancer therapy, pioneering the high-precision spot-scanning technique for proton irradiation of deep-seated tumours. It has recently developed a facility for the irradiation – under anaesthetic – of infants. On a lighter note, thanks to its competence in materials research, PSI made a precise determination of the age of Ötzi, the Ice Mummy found in 1991.

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