

The European Organization for Nuclear Research (CERN) came into being in 1954 as a co-operative enterprise among European governments in order to regain a first-rank position in nuclear science. At present it is supported by 13 Member States, with contributions according to their national revenues: Austria (1.92 %), Belgium (3.78), Denmark (2.05), Federal Republic of Germany (22.47), France (18.34), Greece (0.60), Italy (10.65), Netherlands (3.87), Norway (1.46), Spain (3.36), Sweden (4.18), Switzerland (3.15), United Kingdom (24.17). Contributions for 1963 total 92.5 million Swiss francs.

The character and aims of the Organization are defined in its Convention as follows

'The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character, and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available.'

Last month at CERN

As already recorded in the previous issue of *CERN COURIER*, May 1963 will be remembered in the history of CERN as the month in which, for the first time ever, protons with energies as high as 25 GeV were extracted as a focused beam from an accelerator. This, generally recognized to be a remarkable technical achievement, highlights the fact that scientists and engineers in Europe are once again among the leaders in the field of high-energy physics and its associated technology.

The foresight of those who planned CERN rather over ten years ago is now being confirmed.

During the first three weeks of the month, the proton synchrotron operated on a similar timetable to that of April, each night being given to physics experiments and most of each day to the final installation and testing of the fast ejection system. The beam was ejected for the first time on Sunday 12 May. Towards the end of the month, failure of one of the hydraulic components for the kicker magnet interrupted tests for about a week, allowing more time for nuclear physics.

Experiments were mostly those using particle counters, although a final run was made with the *École Polytechnique* heavy-liquid bubble chamber in the kaon beam (k_3) in the North hall. For much of the time, the intensity of the accelerated proton beam was deliberately kept below its maximum, to limit the induced radioactivity in the target area, but towards the end of the month values of around 6×10^{11} protons per pulse were being obtained. Unusually low energies were also demanded by the continuation of the experiment on proton-proton scattering, one run being with protons of momentum 4.9 GeV/c.

In its heavily shielded blockhouse in the path of the neutrino beam, the 20-ton brass and aluminium spark chamber was completed and tested with cosmic-ray particles.

During tests for some experiments on inelastic interactions of pions, using the m_3 beam in the South hall, the *Saclay/École Polytechnique* 81-cm bubble chamber was successfully operated for the first time with liquid deuterium instead of liquid hydrogen.

On 21 May a one-day informal meeting was held at CERN to discuss 'geometry programmes' for the reconstruction of events in heavy-liquid bubble chambers. These programmes are the 'instructions' which are fed into a computer, together with measurements of

the track positions on two or more stereoscopic photographs, in order to obtain the curvature and direction in space of each track and the positions of any interactions. At the meeting, which was organized by the Track Chambers Division, various programmes already in use at CERN and in other laboratories were described and discussed, and some suggestions were put forward for further improvements.

The last major part of the 1.5-m British national hydrogen bubble chamber arrived at CERN on 11 May. Weighing 30 tons, and with a width of 4 metres, it consisted of the vacuum tank, with the chamber inside complete with its glass windows.

The journey was made by road from the Rutherford Laboratory, Chilton, which was left on 20 April. In order to prevent the windows, which have a thickness of 16 cm, from moving during transport it was essential that the inflatable window gaskets should be kept pressurized throughout the journey. A vessel filled with compressed nitrogen was used to supply the gaskets, and in the event of leakage this could be topped up by means of a bicycle pump. Because of the fragility of the chamber and especially of the windows, the speed of the transporter was limited to 15 km/hour.

The sea-crossing from Tilbury to Antwerp was made on 22 April, and there was then a delay of about two weeks at Antwerp, which was finally left on 6 May. Members of the British team travelled with the tank during all stages of its journey.

As soon as CERN was reached, the tank was mounted on its supporting bridge and placed in its final position in the East bubble-chamber building.

The results of an important experiment carried out at CERN on the properties of the so-called strange particles were published in *Physical Review*

Continued on p. 82

Contents

Last month at CERN . . .	78
Fast ejection of protons from the CERN proton synchrotron	79

The cover photograph shows the pulsed beam-transport units which guide the external proton beam of the CERN proton synchrotron from the point where it leaves the accelerator until it interacts with a target. The proton beam, which is now the basis of the most intense neutrino beam in the world, travels inside the evacuated tube seen near Roger Gerst, who is making some adjustments to a position monitor. A description of the fast-ejection system begins on p. 79.

CERN COURIER

is published monthly in English and in French. It is distributed free of charge to CERN employees, and others interested in the construction and use of particle accelerators or in the progress of nuclear physics in general.

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Published by the
European Organization for
Nuclear Research (CERN)

PUBLIC INFORMATION

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Editor:
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Tel. 34 20 50

Printed in Switzerland

5. After their journey of hundreds of thousands of kilometres inside the synchrotron ring, the protons extracted from the accelerator are guided to their target at the magnetic horn by the beam-transport system, which focuses them into a fine beam whose cross-section is exactly the size of the spot shown here.

CERN/SIS 18219

The practical side, very briefly

The fast kicker magnet inside its vacuum tank is shown in fig. 4. It is about 1 metre long and U-shaped in section, and is seen in position out of the beam, which passes through the tank in the oval aperture in the end wall. At injection into the PS, the protons actually need the whole of the vacuum chamber for their betatron oscillations. It is only towards the end of the accelerating cycle that the circulating beam contracts sufficiently to pass easily through the kicker-magnet gap. Thus both the kicker magnet and the ejection magnet have to be clear of the normal limits of the vacuum chamber early in the accelerating cycle. Then, near the end of the cycle, each magnet is moved rapidly into place by means of a hydraulic mechanism. For the kicker magnet, this is partly visible to the right of the photograph. It is only when the magnets are in their correct places that the spark-gap and 'ignitron' switches can be fired to energize them. Thus in detail the whole system is quite complex, involving hydro-mechanical servo-mechanisms which position each magnet quickly and accurately, high-energy storage networks, pressurized spark gaps, delay lines and many other exciting developments of modern technology. Those of us who can remember that ten years ago an oscillograph with a sweep of a few nanoseconds per centimetre was a technical marvel, occupying about the space of a normal office, cannot help but pause in wonder occasionally at the development of technology. Such oscillographs have developed to be commonplace devices, to be installed unobtrusively in many places in the fast ejection system to monitor the timing cycles and wave forms. It has only been by using such available apparatus, and then hand-making the rest of the equipment in the CERN and other specialized workshops, that it has been possible to acquire all the components which are essential for the fast ejection system.

The enhanced neutrino beam

The ejection system was originally designed as a general facility for the PS because its constructors believed it would have many important uses. In fact, not very long after the project was first defined by B. Kuiper and G. Plass, it became clear that the equipment would be of fundamental importance for neutrino experiments. Theoretical physicists had previously pointed out that the large accelerators then about to come into operation at CERN and at Brookhaven should make it possible to observe interactions of neutrinos coming from the decay of beams of pions and kaons. The first successful neutrino experiment, at Brookhaven in 1962, used a target inside their synchrotron and depended on the decay of those relatively few pions which sent neutrinos towards the spark-chamber detectors. A greatly increased neutrino flux could have been obtained had it been possible to use pions travelling much nearer to the direction of the protons incident on the target. This is the theme of the enhanced neutrino beam at CERN.

The ejected beam is led by a transport system (cover photograph), which is physically small but of great focusing strength (fig. 5), on to a target in a device called the magnetic horn, which is designed to focus as many pions and kaons as possible towards the neutrino detectors. There is a region of free flight from the magnetic horn, and then a thick shielding impenetrable to all particles but the neutrinos which come from those pions and kaons, still relatively few, which decayed. Actually there are other neutrino-producing decays also, but so far the sensitivity of the detectors is too small for them to be of practical importance.

Thanks to the extracted beam, there will be an overall improvement in the rate of 'events', produced by interactions in the detectors, which will be between one and two orders of magnitude greater, according to the particular neutrino energy, than in the first experiments at CERN in 1961. It is unnecessary to stress the practical importance of such an increase in intensity in a long-term programme of experiments; information which previously would have taken one year of machine time becomes obtainable in a matter of weeks ●

A.G.H.

Last month at CERN (cont.)

Letters on 1 May. They concern the relative 'parity' of two of the particles, the sigma and the lambda. Parity is a concept of the wave nature of all 'elementary particles'; it is said to be 'even' (plus) if the 'wave function' calculated for the mirror image of a particle is identical to that of the particle itself, and 'odd' (minus) if one wave function has a positive value and the other an equal negative one. Parity is one of the characteristics used to specify a particular particle or particle state.

Naturally parity is involved in any theory of sub-nuclear particles, and in

some cases different theories predict different values. Thus in this case, according to the 'global symmetry' model, the sigma and the lambda should have the same parity, whilst some other models predicted that one should be opposite to the other. By combining the results of several different experiments carried out at the Lawrence Radiation Laboratory, Berkeley, it seemed more likely that the former prediction was correct, but the CERN experiment is the first to prove this by direct comparison of the two particles.

The experiment was carried out as a co-operative venture between European and American physicists. About a million negative K mesons in the k_3 beam of

the CERN proton synchrotron were brought to rest in the interior of the Saclay/École Polytechnique 81-cm liquid-hydrogen bubble chamber, where they reacted with protons to produce neutral sigma hyperons. Many of these decayed into a lambda hyperon and a pair of electrons (one positive, one negative), and from measurements on the tracks of the electrons it was possible to deduce that the lambda had the same parity as the sigma rather than the opposite one. The measurements and calculations on the bubble-chamber pictures were carried out at CERN, the University of Maryland and the U.S. Naval Research Laboratory, Washington, D.C. ●