

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

The most exciting news during June was that after years of preparation and the last few months of intense activity to instal the equipment for the most complex experiment ever to be attempted at CERN, the 'neutrino pre-run' was a complete success. The

proton synchrotron, the fast ejected-beam system, the CERN heavy-liquid bubble chamber and the massive spark-chamber array all worked smoothly, and everything pointed to the fact that CERN now possesses a new and outstanding tool for scientific research.

Beginning on Thursday, 13 June, at 8 a.m., initially with alignment of the beam and measurements of the ejection efficiency, the run continued more or less without pause until 6 a.m. on the morning of Sunday, 16 June. The first 'neutrino events' were observed around 7 p.m. on the first day. Most of the time the protons in the ejected beam had a momentum of 23.8 GeV/c, but for 10 1/2 hours on the Saturday this was changed to 21.1 GeV/c. The pulse repetition rate was one every three seconds.

After removing the restrictions on the intensity of the proton beam, previously imposed to limit induced radioactivity near the ejection magnets, new high values were obtained; the average for the whole run was nearly 7×10^{11} protons per pulse. The operating voltage of the kicker magnet was chosen so as to eject 18 of the 20 bunches in each pulse, giving an average intensity at the target of about 6×10^{11} protons per pulse, focused into a spot 2 mm in diameter (as shown in the photograph in last month's CERN COURIER). The magnetic horn was operated at its maximum current of 300 000 A, and arranged to focus positive pions, resulting in an intense beam of muon neutrinos directed towards the detection apparatus.

This apparatus was in two complementary parts. Immediately behind the steel wall, 23 metres thick, designed to absorb all particles except neutrinos, was the heavy-liquid bubble chamber, operated by the Nuclear Physics Apparatus Division. Beyond this was the spark-chamber assembly, operated by members of the Nuclear Physics Division, consisting of three consecutive sections: a 20-ton array, 2 m wide and 1.6 m high, known as the production region, designed to show interactions of the neutrinos; a large magnet for

momentum measurements on the particles produced; and a 55-ton 'range-chamber', essentially for observing whether the particles emerging from the production region interacted or just stopped. This latter was not yet in operation for the pre-run.

Since neutrino reactions are so rare, the bubble-chamber cameras were adjusted to take two exposures on each frame of film, and the 27 000 photographs obtained thus represent 54 000 expansions of the chamber. Considerably fewer photographs were taken by the spark chamber, since various scintillation counters were arranged to ensure that the chamber was only triggered by events that might possibly have been from neutrinos. Even so, most of these triggers were due to muons or neutrons which had managed to get around the shielding.

Nothing much can be said about the results yet, since this was only a preliminary experiment. The main runs will be spread over several weeks or more, and careful measurements and analysis will be necessary on all the photographs thought to be of neutrino reactions before definite conclusions can be drawn. This may take some months. However, the kind of particle tracks so far obtained, both in the bubble chamber and in the spark chamber, are quite consistent with last year's Brookhaven result that muon neutrinos and electron neutrinos are two different kinds of particle.

The CERN experiments are designed to investigate in more detail the nature of the interactions both of neutrinos and antineutrinos (the latter coming from the decay of negative pions), and to search for the existence of a boson 'particle', thought by many to be involved in weak interactions in the same way as pions and kaons are involved in strong interactions.

The collaboration of many people in many Divisions of CERN, not to mention the good-natured indulgence of others whose activities had sometimes to be interfered with, has produced a neutrino beam and detection apparatus with many unique features particularly suited for

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The cover photograph shows one of the lighter aspects of the neutrino experiment. This notice, in many colours which we unfortunately cannot show, marks the entrance to the zig-zag passage, through concrete shielding in the South hall of the proton synchrotron, leading to the enclosure which contains the CERN heavy-liquid bubble chamber. Together with the massive spark-chamber assembly, situated in a similar heavily shielded enclosure, the bubble chamber is now being used to give, for the first time ever, detailed information on the extremely rare interactions caused by neutrinos. At this stage the programme is exploratory and also includes an experimental study of the postulate of the 'intermediate boson', a very short-lived particle, which many theoreticians believe may have a role in weak interactions.

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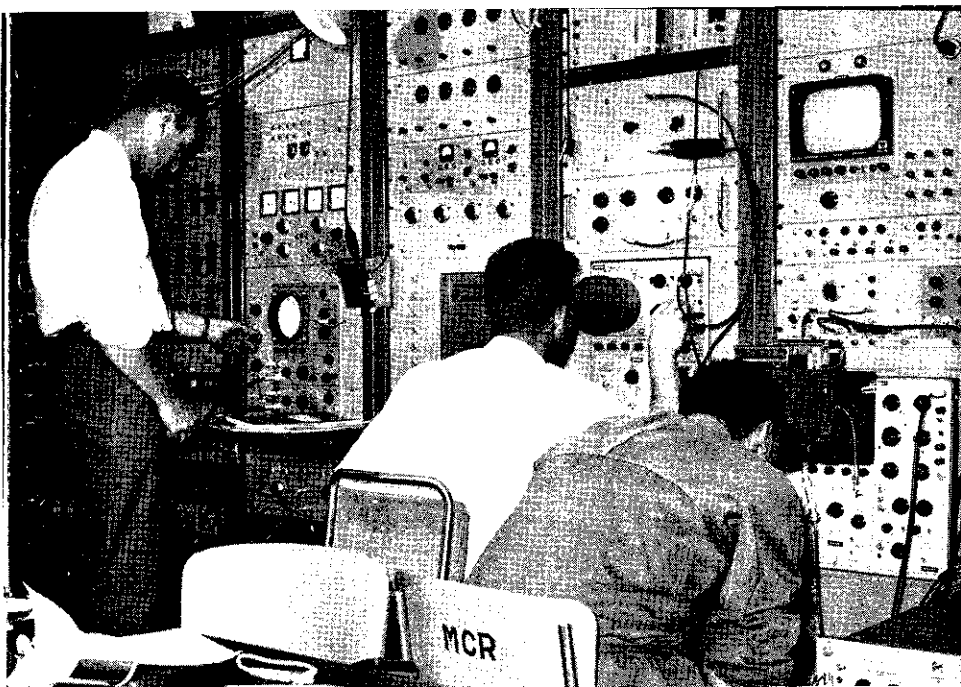
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Activity at the control panels for the beam-ejection system, in the main control room of the proton synchrotron, during the setting up of the beam for one of the neutrino runs. On the left, Berend Kuiper adjusts the oscilloscope that shows the operation of the hydraulic system for the kicker and ejection magnets. In the centre, Hendrick Dijkhuizen checks the kicker-magnet pulse on an oscilloscope measuring time in thousandths of a millionth of a second (as mentioned in last month's article on the ejection system). Next to him, Georges Paillard views a similar oscilloscope, equipped with a camera, showing the number of proton bunches in the ejected beam. The television screen for viewing the ejected beam at various points of its trajectory is higher up on the same panel.

such investigations. The very high intensity of the synchrotron, the large fraction of the accelerated beam that is ejected and its short pulse length, and the focusing action of the horn, combine to give a neutrino flux which is about a hundred times higher than anything achieved previously. Neutrinos or anti-neutrinos can be selected at will. For the first time, it appears that neutrino reactions have been observed in a bubble chamber. The diversification of the spark-chamber array makes it well suited for the analysis of rare events, and the magnetic field incorporated is especially useful in this respect as it will provide a distinction between positive and negative particles which pass through it.

Apart from the run with the neutrino beam, the main experiments at the **proton synchrotron** during the month continued to be those using counters for particle detection. In addition, the **Saclay/École Polytechnique 81-cm bubble chamber**, filled with liquid deuterium (heavy hydrogen), carried out a long run in the m_3 beam, lasting most of the month, during which 204 000 photographs were taken. This was primarily to study the reactions of medium-energy positive pions with neutrons. A target consisting only of neutrons is impossible to obtain, but liquid deuterium is very near to it, since each deuterium nucleus consists of one neutron and one proton, comparatively loosely bound together. Reactions between the pions and the protons can be allowed for on the

basis of previous work with liquid hydrogen as the filling for the bubble chamber, when only protons were present.

Although early in the run one of the **10-m electrostatic separators** in the m_3 beam gave some trouble with its vacuum system, both operated particularly well from the point of view of stability of the high-voltage field between the plates inside each tank. For one separator, situated in the entry part of the beam, inside the ring tunnel, the rate of sparking across the gap was only one spark per day, at a field of 50 kV/cm (700 kV across a gap of 14 cm); for the other, in the South hall, the rate was about six per hour, but this is still considered low for this field strength.

As mentioned in the report of the neutrino pre-run, the synchrotron **beam intensity** was increased considerably during the month. Visitors to the main control room or the experimental areas could see values of over 8×10^{11} protons per pulse often appearing on the digital display panels that announce the intensity pulse by pulse, and for one shift of 8 hours the average reached 7.82×10^{11} protons per pulse.

A report on the preliminary results from the neutrino experiments, by H. Faissner (NP Division) and R. Voss (NPA Division), formed an unexpected ending to the **Track Chamber Jamboree**, held at CERN on 27 June.

This was the yearly meeting held under the auspices of the CERN **Track**

PROF. V. F. WEISSKOPF TO STAY ANOTHER YEAR

At the Council meeting held at CERN on 20 June it was announced that Prof. V.F. Weisskopf had agreed to continue as Director-general of the Organization for a further year, until August 1964.

Other staff changes

It was also announced that **S.A. ff. Dakin**, Directorate Member for Administration, is returning to the United Kingdom at the end of September and will be replaced by **G.H. Hampton**, who is at present Assistant Director for Personnel and Administration at the headquarters of the U.K. Atomic Energy Authority's Production Group, Risley.

L. Kowarski, Leader of CERN's Data Handling Division, is going to Purdue University for a year, beginning in September, as visiting professor of nuclear engineering. **G. Macleod** has been appointed Deputy Division Leader and will be in charge of the Division during Dr. Kowarski's absence. He will also be a member of the Data Handling Policy Group, which has been set up by the Director-general to co-ordinate policy and actions in this field. **Y. Goldschmidt-Clermont**, previously Deputy Leader of this Division has transferred temporarily to the Track Chambers Division, as from 1 June, together with a number of his former group, including the operating staff of the IEPs (instruments for the evaluation of photographs).

Chambers Committee to report on progress over the past year and to review future plans. This Committee, of which Prof. B. P. Gregory (École Polytechnique, Paris) is chairman, and R. Budde (CERN) secretary, is one of the three Experiments Committees that guide CERN's experimental programme. Any proposal for an experiment involving a bubble chamber at CERN, by a group in CERN, from one of the Member states or sometimes from outside the Organization, has first to be submitted to the Committee, which circulates it among the members. Once a month, there is a meeting to consider each new proposal from the points of view of its usefulness to physics and the possibility of fitting it into the general experimental programme. More detailed discussions

on carrying out the experiment (which chamber to use, scheduling, etc.) also take place in the Committee. The recommended programme is then submitted to the Nuclear Physics Research Committee for incorporation into the overall programme, which of course includes experiments using other techniques.

The Committee contains representatives from CERN and outside laboratories responsible for operating the various bubble chambers, representatives from CERN concerned with particle beams and accelerator operation, and representatives of the different experimental groups, chosen on a regional basis.

The **Jamboree** is held once a year and as many people as possible are invited from all laboratories that participate in the track-chamber work. Anyone else who is interested may also attend. This year, the Jamboree was organized by M. Derrick, of Oxford University, and some 150 people attended from about 30 laboratories. The morning session was devoted to reports on the various experiments that had been done in the past year, beginning with an introductory talk by Prof. Gregory in which he gave a résumé of the various beams that had been used. He also gave figures for the number of photographs taken during the previous twelve months — 500 000 with the École

Polytechnique heavy-liquid chamber and 1 100 000 with the Saclay/École Polytechnique 81-cm liquid-hydrogen chamber. In the afternoon, reports were given on the British national chamber, expected to come into use this autumn, the separated beam, ϕ , planned for the East area, and possible experiments for the coming year.

Two new technical novelties were also discussed, both designed to observe gamma rays produced as a result of nuclear interactions with protons. In a liquid-hydrogen bubble chamber, the gamma rays which come mostly from the decay of neutral pions, can only rarely be detected, so the group under Prof. A. Lagarrigue, of the École Polytechnique, Paris, is now converting its heavy-liquid chamber to incorporate a liquid-hydrogen target in the beam-entry side. Reactions will thus take place in the hydrogen and the products, including electron showers formed by any gamma rays, will form tracks in the heavy liquid, which will be photographed and examined in the normal way. Another approach has been put forward by a combination of groups in Warsaw, Cracow, and Prague. Their proposal is to bring a spark chamber to CERN and place it behind the British national bubble chamber, where it would detect gamma rays arising from interactions inside the latter. The spark-chamber photographs would then have to be correlated with those from the

bubble chamber in order to get full information on each event.

Among a number of fundamental research experiments at the **synchrocyclotron** carried out recently, there was one last May which provides a good indication of how even the 'purest' research can lead to more practical developments. This experiment, carried out by P. Fowler of Bristol University, was designed to investigate in more detail the behaviour of negative pions stopped in water, with a view to the possible use of this kind of elementary particle in the radiological treatment of deep cancer tumours. Such a use depends on the fact that charged particles, unlike x-rays or gamma rays, lose most of their energy towards the end of their range, and negative pions in particular are captured by nuclei after they have been slowed down. Moreover, one of the chief reactions is with oxygen nuclei contained in water, and this produces heavily ionizing alpha particles. It thus appears possible to direct a narrow, intense beam of pions at a tumour with the assurance that the major destructive effect will be in the tumour itself, the surrounding healthy tissue being little affected.

The experiment at the synchrocyclotron was made with nuclear emulsions, some in their normal state and some soaked in water, so that, by comparison, the reactions of the negative pions captured in water could be determined. The results will give a good approximation to the behaviour of pions in cancer tissue, since this is very largely water.

At the moment, it is not possible to produce beams of pions of sufficient intensity to make their use in radiology practicable, but the growing development of 'meson factories' for fundamental research makes it likely that suitable accelerators could also be produced for medical work if the usefulness of pions was proved. Pions, it will be recalled, are 'particles' with a mass of 140 MeV predicted on theoretical grounds nearly thirty years ago (in 1935), discovered in cosmic rays in 1947 and first produced artificially in 1948.

The **vacuum tank for the CERN 2-metre liquid-hydrogen bubble chamber** arrived on the site on 3 June. Manufactured in Lille (France) according to CERN specifications, from special stainless steel supplied by a company in Firminy (France), the vessel is made up of 5 main elements, of welded construction, bolted together. The central



The East experimental hall is now partly in use, as can be seen in this photograph, taken during May, looking towards the East bubble-chamber building. To the left is part of the equipment for the proton-proton interaction experiment using the proton beam c_7 ; to the right is the proton beam c_6 , used for precise investigations on the secondary particles produced by proton interactions in various targets.

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24th session of Council

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** Alternate

Last month at CERN (cont.)

frame measures approximately 4 m x 4 m x 70 cm, to this are bolted the side covers with their snouts (each about 4 m x 4 m x 2 m), and the snouts are closed by covers fitted with windows to allow flash illumination on one side and photography on the other.

When the bubble-chamber assembly is completed, this tank will contain the chamber proper, and the space between them will be pumped down to a vacuum of better than 10^{-5} torr (like a gigantic vacuum flask) to prevent heat transfer from the outside atmosphere to the liquid hydrogen in the chamber at a temperature of -250° C. The tank in turn will be enclosed by the electro-magnet, which provides a uniform magnetic field of 17 000 gauss.

In the main, 60-mm plate was used for construction of the tank, to eliminate the need for webbing, which would have increased the overall dimensions and thus demanded a larger overall size for the magnet. The completed tank occupies a volume of some 4 m x 4 m x 5 m and weighs 50 tons.

During the last stages of its manufacture, a team of CERN technicians was present at the works, to check on the quality of the finished parts and the assembly, and to perform the acceptance tests. The assembled tank was then brought by road to CERN, a journey taking 5 days, with a police escort all the way because of its large dimensions.

The tank is now suspended from its bridge in the East bubble-chamber building, and is undergoing a series of tests to ensure its fitness for final operation.

In the early evening of 19 June, a short ceremony to the memory of Niels

Bohr was held in the upper foyer of the CERN Administration building. The occasion was the unveiling by the President of the CERN Council, Mr. J. Willems, of a bust of Prof Bohr, the work of the sculptor H. Isenstein. Present at the ceremony were the Danish physicist's widow, Mrs. Margrethe Bohr, and his son, Prof. Aage Bohr, as well as many members of CERN. The address given by the Director-general on this occasion is published on p. 89.

On 27 June, CERN was visited by Mr. Louis Armand, accompanied by members of the 'Conseil d'administration' of the 'Houillères de Lorraine', of which he is chairman, and by Mr. Brasillac, Director-general of 'Charbonnages de France'. Mr. Armand, who has recently been elected to the 'Académie française', is a member of the French Atomic Energy Commission, and a member of the Supreme Council for Scientific Research and Technological Progress. From 1957 to 1959, he was President of the Euratom Commission. The visitors had lunch with CERN's Director-general, Prof V. F. Weisskopf, when they were joined by Profs. L. Leprince-Ringuet and B. P. Gregory, of the Ecole Polytechnique, and some of the CERN staff.

The Staff Association Committee for the year 1963/64 met for the first time on 25 June, under the new chairman, Guy Vanderhaeghe. At the meeting thanks were expressed to the 12 retiring members (out of 24) of last year's committee, and particularly to the former chairman, Mike Pentz, for the enormous amount of work he accomplished during his two years in office. Guy Vanderhaeghe is a physicist who was until recently in the Emulsion Group of the Nuclear Physics Division. He is now head of CERN's Training and Education Section.

The construction of the vacuum tank for the CERN 2-m bubble chamber can be seen from this photograph, taken during its unloading into the East bubble-chamber building. The three ports in the snout cover on the left will eventually house high-intensity flash light sources for illuminating the bubble chamber inside the tank.

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