

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

September saw the final machine runs for the first part of the **neutrino experiment** and the presentation of some of the early data derived from a study of the photographs obtained.

As reported in our July issue (p. 86), the experiment used the fast extracted

beam of the proton synchrotron directed towards a target to produce large numbers of pions, which were then concentrated in the forward direction by the so-called 'magnetic horn'. The pions disintegrated into muons and muon neutrinos during their flight and the neutrinos alone penetrated some 23 metres of steel shielding to traverse first the CERN 1150 mm heavy-liquid bubble chamber and then the special spark-chamber array.

From 27 June the experiment ran, for five or six days at a time, every other week until 17 September. Out of many hundred thousands of photographs, about 260 have been found showing neutrino interactions in the bubble chamber, and some 2500 showing events occurring in the spark chamber. It is in these photographs that the answers will have to be found to the various questions that the experiment was designed to elucidate.

Although it is easy to think of an 'experiment' as the exposure of some more or less complex equipment to a particle beam from an accelerator, there is much more involved in reality. There is first the preparation of the equipment, then the machine run itself, then the analysis of the results. An important subsidiary to the latter is the calibration of the equipment, which can become of vital importance when rare events are being sought against a more numerous 'background' of processes which might look very similar. The results of the neutrino experiment presented in September at the Brookhaven 'Conference on fundamental aspects of weak interactions', as well as the later ones given during the Sienna 'International Conference on elementary particles', were all of a preliminary nature and therefore subject to revision.

Even so, the results were impressive. First of all (as was apparent even from the first run in June) the discovery last year at Brookhaven of the existence of two types of neutrino (one associated with a muon and one with an electron)

has been completely confirmed. In addition, the CERN experiment shows that similar neutrinos are produced in the decay of kaons — a muon neutrino when the kaon decays to a muon and an electron neutrino when (more rarely) it decays to an electron.

Another conclusion is that the results confirm the general theoretical belief that the number of particles classified as 'leptons' in the universe is constant, that is, either they are produced or destroyed as pairs of particle and anti-particle, or when one disappears another takes its place. Thus, when positive pions were focused by the neutrino horn, their decay produced each time a positive muon (antiparticle) and a neutrino (particle). Disappearance of the latter then produced a negative muon (particle), recognized by its curvature in the magnetic field and lack of interaction. Previously the law had only been verified for electrons and electron neutrinos.

In the CERN experiment, too, it has been possible for the first time to use the neutrino as a probe to investigate the structure of nucleons (neutrons and protons). Although lacking considerably the refinement of other measurements using electrons, the results are similar. (This is not as trivial as it might at first seem — for example, even in everyday experience, objects can look different when viewed in different coloured lights.)

The neutrino reactions observed have been separated for convenience into two classes: 'elastic', when only a muon and a recoil nucleon are produced from the neutrino, and 'inelastic', when other particles (pions, etc.) are produced. It has been found that the cross-section (chance of happening) of the elastic events at different neutrino energies is in excellent agreement with theory, but at the higher neutrino energies the number of inelastic events seems to be much greater than expected. This has not only led the theorists to look again at their equations but it has also given the experimentalists many more photo-

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The cover photograph was taken at the heart of one of the electronic-counter experiments in progress at the proton synchrotron during September. In this experiment, to study the beta decay of the lambda particle, lambdas are first produced in association with kaons, and here one of the physicists of the team, Ian Blair, is seen making adjustments to the controls of the large cylindrical water Cherenkov counter that forms part of the counter system for detecting the kaons.

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Roger Anthoine

Editor:
Alec G. Hester

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graphs of complicated events than they had planned for. It is an interesting discovery, which has also made the final analysis of all the results more difficult and time consuming.

This applies particularly to the question of the existence of a new, really fundamental 'particle', known as the intermediate boson, or W particle. Such a particle has been postulated on theoretical grounds as being associated with the weak interaction in the same kind of way as the pion is associated with strong interactions and the photon with electromagnetic interactions. Because an elastic neutrino interaction is purely weak, investigation of such reactions was thought to give the best chance of finding the W particle. According to the theory, this weak interaction between a neutrino and a nucleon is made up of two successive 'not-so-weak' interactions: between the neutrino and the intermediate boson and between the boson and the nucleon. Since only one such 'semi-weak' interaction is required to produce the boson, it should be formed abundantly from neutrinos of energy sufficiently high to create its rest mass (the higher the mass, the higher the neutrino energy required). The particle would then disintegrate very quickly after formation, two of its important modes of decay being into a muon and a neutrino or into an electron and a neutrino. Bubble-chamber or spark-chamber photographs showing two muons, or an electron and a muon, proceeding from the same spot, with no other tracks, would thus indicate the existence of the particle.

About 80 'candidates' for such an event were found among the spark-chamber photographs and one rather dubious one among the bubble-chamber photographs. Such a low number shows that if the W particle does exist it has a relatively high mass, more than 1.4 times the mass of the proton. A major difficulty, however, exists in proving beyond doubt that the two tracks seen are really those of leptons and not of other particles — no easy task in a spark-chamber, which gives no direct identification of tracks. Many of the eighty photographs undoubtedly show pions behaving by chance like muons. It remains to decide the most probable interpretation of these photographs, by such means as further calibration, investigation of the different sorts of behaviour of particles of a given kind, and calculations of a statistical nature. At the moment there is no proof that the W particle exists; only indications, which have to be investigated further.

On Friday 6 September, members of the Administration Division gathered in the coffee lounge to say goodbye to their Division leader and Directorate Member for Administration, S. A. ff. Dakin, who was returning to the United Kingdom. The photograph shows him (right) receiving some farewell gifts, presented on behalf of the Division by B.W. Gamble, head of the General Services section. Mr. Dakin's services to the Organization during the preceding five years (as well as a previous year as interim Director) were acknowledged in speeches by Prof. V. F. Weisskopf, Director-general, and G. Vanderhaeghe, President of the Staff Association.



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Early in September the a_4 beam in the PS North hall was used to obtain new sets of spark-chamber photographs of muons and of pions, as part of the calibration check to help in the vital distinction between these two particles. Shortly afterwards, work began on dismantling parts of the main experimental set-up, which will be modified before further runs are carried out in a few months time.

Apart from the neutrino experiment, a number of electronic-counter and spark-chamber experiments by various groups of the **Nuclear Physics Division** were in progress at the synchrotron during the month. One of these, in the beam m_3 , was the so-called 'Papep' experiment, designed to detect and investigate the production of **electron-positron pairs from the annihilation of antiprotons** (as mentioned in last month's *CERN COURIER*, p. 117). At the Sienna conference it was revealed that, out of fourteen hundred million antiprotons annihilated in the target, seven had been seen to produce the required lepton pair. If the proton were 'point-like' with no structure, 40 such events would have been seen. In another experiment the **beta decay of the lambda bda particle** was being studied, in order to establish a number of important relations in the theory of weak interactions. For this experiment, still in progress, pola-

rized lambda particles (with their spins aligned in a known direction) are produced by pions in the beam g_1 and the directions of the electrons produced in the beta decays are found from observations on spark-chamber photographs. Scintillation and Cherenkov counters give a basic rejection of events (600 times more common) in which the lambda particle decays to a proton and a pion. In the d_{15} pion beam (10 GeV/c), a group was carrying out preliminary runs with equipment to study the **production of gamma rays in the 'peripheral' interaction of a pion with a proton**, while further along this beam, at the far end of the South hall, spark-chambers were being tested in the former magnet of the Wilson cloud chamber, for a proposed check on negative **kaon interactions** with protons.

After the neutrino tests, the North hall was occupied with preparations for later experiments, involving the change of the a_4 beam into one known as a_5 . In the East hall, the o_2 beam was fully tested ready for the British bubble chamber. The length of this beam, nearly 150 metres, has posed some novel problems, because over such a distance even the curvature of the earth and the earth's magnetic field have to be taken into account during the alignment of the various magnets along the beam path ☉