

View of the experiment in the East Hall which is measuring parameters in neutral kaon decay. The beam is coming from the top right. The three multiwire proportional chambers are arranged two on the downstream and one on the upstream side of the large (2.4×0.6 m) aperture analyzing magnet which is near the top right-hand corner of the picture.

cynicism about the ultimate success. A certain faith was necessary. Happily CERN was one of the best examples of international collaboration but several others, such as Trieste, Ispra, Grenoble and the various space centres were all contributing.

The questions of the location of these centres was, however, also important. There were certain basic requirements which had to be filled in any given circumstance, but the final decision was essentially political and a reasonable distribution across Europe was indispensable. This is far from the case at present and must be corrected in the future.

It had been hoped that the German site of Drensteinfurt would be selected for the 300 GeV but the cost reductions associated with the latest proposition for CERN Lab. II shifted the balance in favour of this second choice. The stability afforded to the present laboratory was also a valuable element and it insured against a future over-provision of facilities in this domain and consequently an excessive production of physicists. Taking into consideration all these aspects then the compromise solution of CERN Lab. II was a good one.

In concluding, Professor Heisenberg recalled the remarks of the U.S. Ambassador in Bonn who (like many others) had compared the construction of giant machines for science nowadays with the erection of the pyramids in ancient Egypt and the cathedrals during the Middle Ages. People in the present era are willing to offer something to the goddess of enlightenment. The power of this enlightenment was, however, limited and we must remain critical of it. A better understanding between peoples had to come from it. The work at CERN was evidently consistent with this ultimate objective.

Eta Measurements

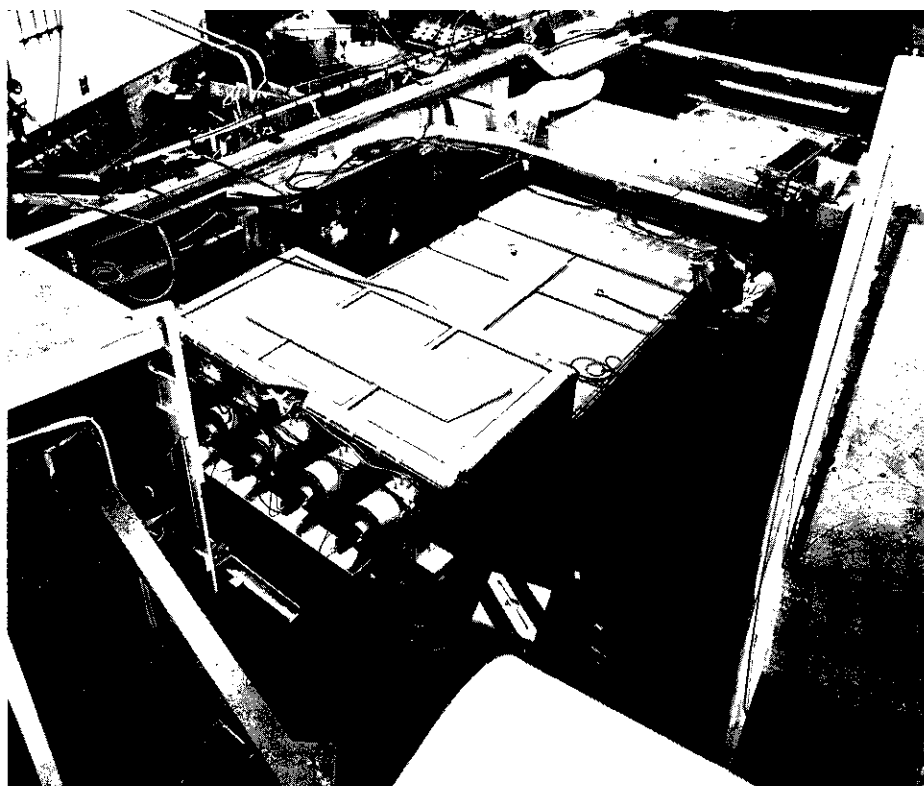
In the article in the last issue on the Amsterdam Conference, mention was made of the experiment now being carried out at CERN on various measurements on the $\eta^\pm$ parameter, which represents the ratio between the amplitude of the charged two-pion decays of the long-lived neutral kaon (K_L) and that of the short-lived kaon (K_S), i. e. $K_L \rightarrow \pi^+ \pi^-$ and $K_S \rightarrow \pi^+ \pi^-$. Because the K_L decay into two pions violates the charge conjugation $\times$ parity symmetry law (CP), it should be possible by these measurements to obtain more accurate information on the validity of a proposed theory to explain the phenomenon of CP violation, the so-called superweak theory.

CP violation

The K^0 has been at the origin of many puzzling discoveries and new ideas.

Already at its first observation it was called strange because it decayed slowly (10^{-10} s), but was produced at an observable rate by cosmic radiation. Therefore this particle did not decay by strong interaction, by which it was produced. The problem was solved by the postulate (made by Prof. Gell-Mann and Prof. Nishijima) that there is a new quantum number S (strangeness) which is conserved in strong interactions but not in weak interactions. Since such a quantum number is an additive one like the charge number, the antiparticle $\bar{K}^0$ of the K^0 is different from the K^0 . But, it is still possible by weak interaction to make transitions $K^0 \leftrightarrow \pi^+ \pi^- \leftrightarrow \bar{K}^0$. So, K^0 and $\bar{K}^0$ can mix with each other.

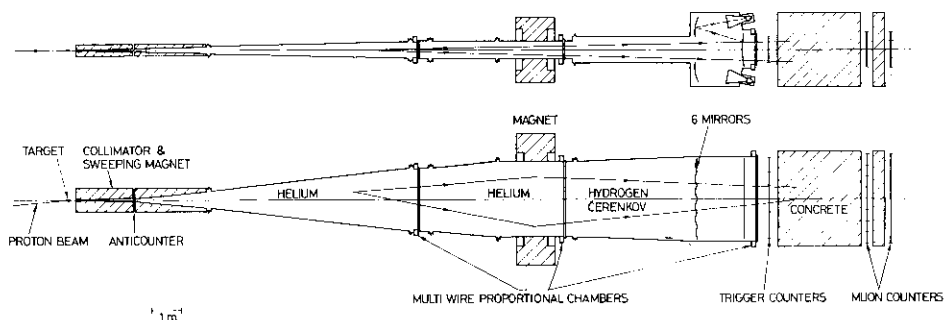
In fact, the observed particles which have a definite mass and mean lifetime are not the K^0 and $\bar{K}^0$ but linear combinations thereof, which are called the K_S (short-lived) and K_L (long-lived). Before 1964 it was assumed



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Diagram of the experimental layout:
side view on top, plan view below.

Below: The back of the double-plane mirror of the threshold Cherenkov counter used in the experiment on the measurement of η^{+-} . Its design required two apparently contradictory properties: strict planeness and very high transparency with regard to the beam. This did not worry the West workshop, which used a 25 μm gauge aluminised Mylar film, stretched as a reflective surface. The photograph was taken before the aluminium coating was applied on a light frame braced with piano wire.



(and in agreement with experiment) that the weak interaction is invariant under the combined CP operation where C is the particle-antiparticle conjugation and P the spatial reflection (parity) operator. This would imply that the particles K_S and K_L have a definite CP quantum number. For K_S : $CP = +1$, for K_L $CP = -1$.

The discovery that the decay $K_L \rightarrow \pi^+ \pi^-$ exists as well as $K_S \rightarrow \pi^+ \pi^-$ destroyed the picture of CP invariance of the weak interaction: since the $\pi^+ \pi^-$ state has $CP = +1$, there is a change of CP quantum number in the decay $K_L \rightarrow \pi^+ \pi^-$.

Since then experimenters have measured with increasing precision the probability of this decay $K_L \rightarrow \pi^+ \pi^-$ and the phase angle difference φ^{+-} between the decay amplitudes for $K_L \rightarrow \pi^+ \pi^-$ and $K_S \rightarrow \pi^+ \pi^-$. (Elementary processes are represented by a complex number having an absolute value and a phase angle, as it is necessary to describe the wave character of particles).

The knowledge of this angle φ^{+-} is required to distinguish between different models of CP violation. One of those postulates the existence of a new force in nature, the 'superweak' interaction; it predicts $\varphi^{+-} = 43.2^\circ$. Other models which implement CP violation into the weak interaction, give values of φ^{+-} in the range $35^\circ - 50^\circ$.

In experiments done up to now, the η^{+-} phase has been measured with an accuracy of only 4° , due partially to the number of observed events being too small.

It has become possible, through the progress made with MPC's (multiwire proportional chambers), to set up an experiment which, by the accumulation of a large number of events within a short time, will allow this phase to be measured to within 1° .

This experiment, carried out by a CERN-Heidelberg group, began at

CERN in the East Hall after a great deal of preparation occupying two years. It has run for 6 weeks machine time and several more data taking weeks are still needed. There are also other results to be extracted from the data.

The main features of the MPC's used are their size (5400 wires on six planes, the largest measuring $2.7 \times 0.9 \text{ m}^2$) and also the fact that this is the first instance of their use in a large scale experiment for both measurement and the selection of interesting events. The resolution time of these chambers is 40 ns, and their efficiency is greater than 99 %. The readout time which is about 400 ns (compared with $\sim 5 \text{ ms}$ in wire spark chamber experiments) makes it possible to deal with almost 100 000 event candidates per PS burst (5×10^{10} protons in 400 ms). After all undesired candidates have been rejected, 700 two prong events are being recorded at present per PS burst.

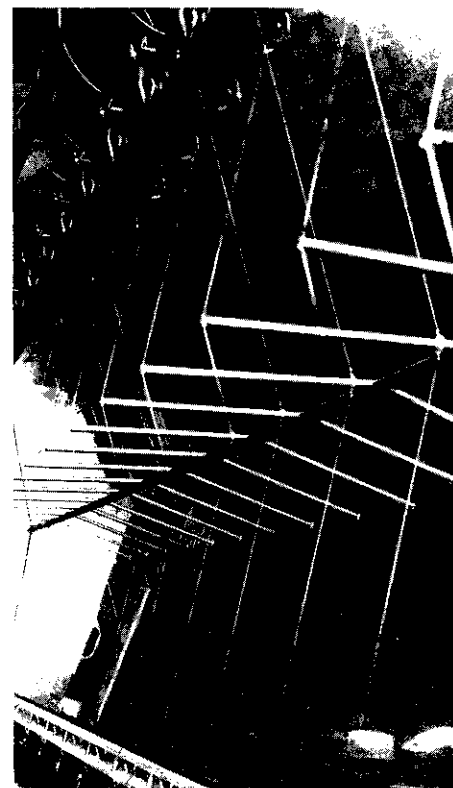
The phase φ^{+-} is measured by determining the life time distribution of $K^0 \rightarrow \pi^+ \pi^-$ decays and this means measuring the decay points and the momenta of the K^0 .

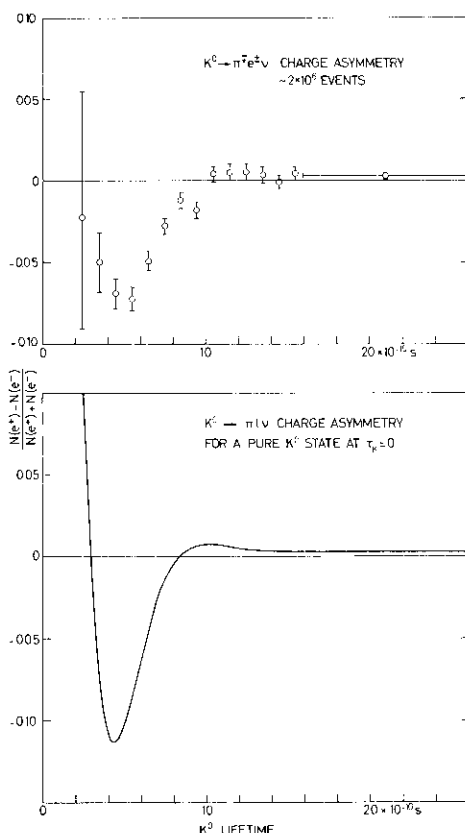
As the figure shows, the equipment includes, from left to right, a platinum target which is hit by the protons, a collimator with a slit placed in the field of a magnet and arranged at an angle of 4° with respect to the proton beam axis; a volume of helium reducing multiple scattering; a spectrometer consisting of a wide-aperture analysing magnet ($2.4 \text{ m} \times 0.6 \text{ m}$) associated with three multiwire proportional chambers, each with two wire planes; scintillation counters opening the gates of the MPC's whenever there are two particles, one on each side of the counter array, and triggering the readout and decision logic of the MPC's; a large Cherenkov threshold counter (with a novel mirror system) filled with hydrogen at atmospheric

pressure to identify electrons, a concrete shield for stopping pions; and 16 scintillation counters to detect muons and locate them.

The flow line of the experiment is as follows:

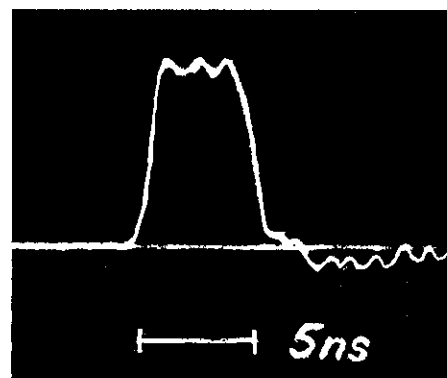
- the production of various particles by the interaction of the protons in the target;
- the elimination of most of the charged particles deflected by the magnetic field, by means of the collimator;
- the reduction of the background by orienting the collimator slit at 4° from the proton beam axis. This angle is the result of a compromise between maximizing the number of high-energy K^0 produced and minimizing the background caused by the protons;
- the decay of the K^0 in the volume of helium; the two charged decay products traverse the 6 chamber planes and the trigger counter array;
- the start of the recording and deci-





Charge asymmetry in the decay $K^0 \rightarrow \pi^\pm e^\pm \nu$ as a function of K^0 lifetime; 2×10^6 events.

Oscilloscope photograph showing a pulse 100 kV high and 4 ns long produced by the experimental generator developed at CERN.



2) on the selection rule $\Delta Q = \Delta S$ (charge change equal strangeness change).

Up to now a total of 3×10^8 events, including several million $K^0 \rightarrow \pi^+ \pi^-$, have been recorded.

The analysis of the data collected so far is not finished, but the experiment has demonstrated that it is possible to operate such a large set up of proportional multiwire chambers and to take data at a rate 100 times higher than similar experiments before.

electrodes. Beyond a certain field gradient, discharge is induced by the presence of free electrons in the gap. If the free electrons can be eliminated, the equipment can be operated in the supercritical range, where the charging voltage can be increased by up to forty times, thus providing in the subsequent discharge extremely short pulse rise and duration times. The presence of free electrons results however in an immediate transition from the supercritical to the critical range.

The principal sources of free electrons are those escaping naturally from the surface of a body from thermal and chemical field emission effects and those produced by ionization of the gas in the gap.

Gygi and Schneider's equipment seeks to eliminate these sources in a variety of ways:

- 1) The electrodes are of platinum or rhodium at the cathode and stainless steel at the anode. The atmosphere is argon at normal pressure and, above all, the charging time is very brief (40 ns). All of these reduce to a negligible value the probability of formation of free electrons by the electrodes;
- 2) The distance between the electrodes is very small which reduces the likelihood of the passage of cosmic rays;
- 3) The electrodes are of a special form and great care has been taken in their manufacture; the sides, for example, are coated with silicone rubber.

The electrode system is relatively wide which means that the number of discharge points is increased. To take advantage of this the present design of feed line comprises four 80 ohm lines in parallel, reducing the impedance to 20 ohms. Strict simultaneity in the discharge of the electrodes is ensured by a special

sion logic by a 2-fold coincidence between 2 trigger counters;

— the selection, by means of the chamber logic circuits, of those events giving twelve tracks one in each of the right and left-hand halves of the six wire planes in the MPC's (one track in the right and one in the left-hand of each plane). It should be noted that, in the case of the horizontal wires, the planes are divided into two distinct halves which are symmetrical on the left and on the right;

— the simultaneous recording of the signals of the electron and muon counters in time with the 2-fold trigger coincidence.

These events are then buffered in an on-line computer and recorded on magnetic tape.

The recording sequence is then finished. The data now have to be processed off-line to allow all the K^0 decay reactions to be identified, i. e. $K^0 \rightarrow \pi^+ \pi^-$, $K^0 \rightarrow \pi^\pm e^\pm \nu$, $K^0 \rightarrow \pi^\pm \mu^\pm \nu$, $K^0 \rightarrow \pi^+ \pi^- \pi^0$.

The identification procedure used is based on the information provided by the muon and electron counters and on spatial and kinematic reconstruction programs using the coordinates of the tracks in the three chambers. The K^0 decays into muons and electrons are not eliminated but retained to provide information:

1) on the mass difference between K_S and K_L and

100 kV — 4 ns

High voltage, very short pulse generators with rise and decay times shorter than a nanosecond can find many applications in high energy physics for both experimental and accelerator equipment. E. Gygi and F. Schneider at CERN have just completed an experimental generator capable of providing 100 kV pulses 4 ns long, with rise and decay times of 0.6 ns and a repetition frequency of 1 Hz. It also has a low impedance — 20 ohms — and could thus be used in conjunction with step-up transformers.

The generator is of conventional layout, in that it comprises a charging circuit (a Marx generator plus a charging line) discharging into a line with the same characteristic impedance via a spark-gap. It differs radically from its predecessors in two respects: the very short charging time of the line (40 ns) and the special design of the spark-gap. This makes possible a charging voltage of 200 kV across 8 mm, at a pressure of one atmosphere or less, whereas in an ordinary spark-gap it would not exceed 5 kV in similar conditions.

Normally, the maximum voltage which may be applied to the electrodes of a spark-gap depends on the distance, the nature of the gas and its pressure, and the form of the