
Physics monitor

hadrons, and new ultra heavy particles up to 10^{15} GeV in mass. Their apparent absence in the form of hydrogen-like atoms at the low concentration levels achieved in this experiment seems to provide strong evidence against the existence of stable charged particles with masses greater than the proton.

The experiment has an interesting historical parallel. In August 1937, Rutherford's last paper appeared in 'Nature'. It described a search for natural tritium in an electrolytically enriched sample of heavy water using Aston's mass spectrometer. The search was unsuccessful only because tritium is unstable, reducing its concentration to less than 10^{-17} rather than 10^{-9} if it had been stable. Natural HTO was later detected (in the same sample) by counter techniques.

A comparison between the 1937 experiment and the latest measurements is a nice reflection on the evolution of our experimental abilities. Lord Rutherford began with 13 000 tons of water and experimented on 11 ml of heavy water (an enrichment factor of 10^7). The Rutherford Laboratory began with 120 000 tons of water and experimented on 0.02 ml of heavy water (an enrichment factor of over 10^{11}). Lord Rutherford had a detection sensitivity of 10^{-5} and an overall sensitivity of 10^{-12} . The corresponding figures for Rutherford Lab are better than 10^{-17} and 10^{-28} .

The continuing hunt for neutrino oscillations

Last year, evidence from a number of very different experiments sparked off a flurry of interest in the possibility of neutrino 'oscillations'. After the discovery in 1962 that neutrinos come in different kinds, all the evidence had been that these different neutrinos were immutable and could not mix. Then suddenly last year, experiments using low energy neutrinos from fission reactors, together with studies on the beta-decay of tritium, gave preliminary results which pointed to a possible mixing between electron and muon-type neutrinos (see July/August 1980 issue, page 189). Some initial high energy neutrino results from CERN also provided preliminary evidence for such an effect, although a subsequent study using the narrow-band neutrino beam showed nothing out of the ordinary.

In classical neutrino theory, the particle, no matter what species — electron, muon or tau — is massless and travels at the speed of light. This assumption makes the theory neat, but has yet to be proved. The new evidence, as yet still slim, points to the possibility that the different types of neutrino have different masses and therefore travel at different speeds. If so, the composition of a neutrino beam would appear to change as it travels along.

Some of last year's indications for such neutrino oscillations came from a reactor experiment comparing the rates of deuteron dissociation through the charged and neutral weak current. Fred Reines' group obtained a result which was not in agreement with the theoretical predictions using zero mass neutrinos.

In the meantime, other explana-

tions have been proposed which could account for this result. Nuclear binding effects in the deuteron, together with uncertainties in detection efficiencies and in the reactor neutrino spectrum, could mean that the effects seen in the reactor studies are not 'clean'. In addition, results from another reactor neutrino experiment, this time at Grenoble, have given results in agreement with the simple non-oscillating theory.

In the search for neutrino oscillations, experiments which make their measurements at a fixed distance from the source of neutrinos are difficult to analyse as they require a precise knowledge of the neutrino flux — notoriously difficult to quantify with confidence. More reliable indications are expected from experiments which compare readings at different distances from the neutrino source, which should be able to detect any changes in the composition of a neutrino beam.

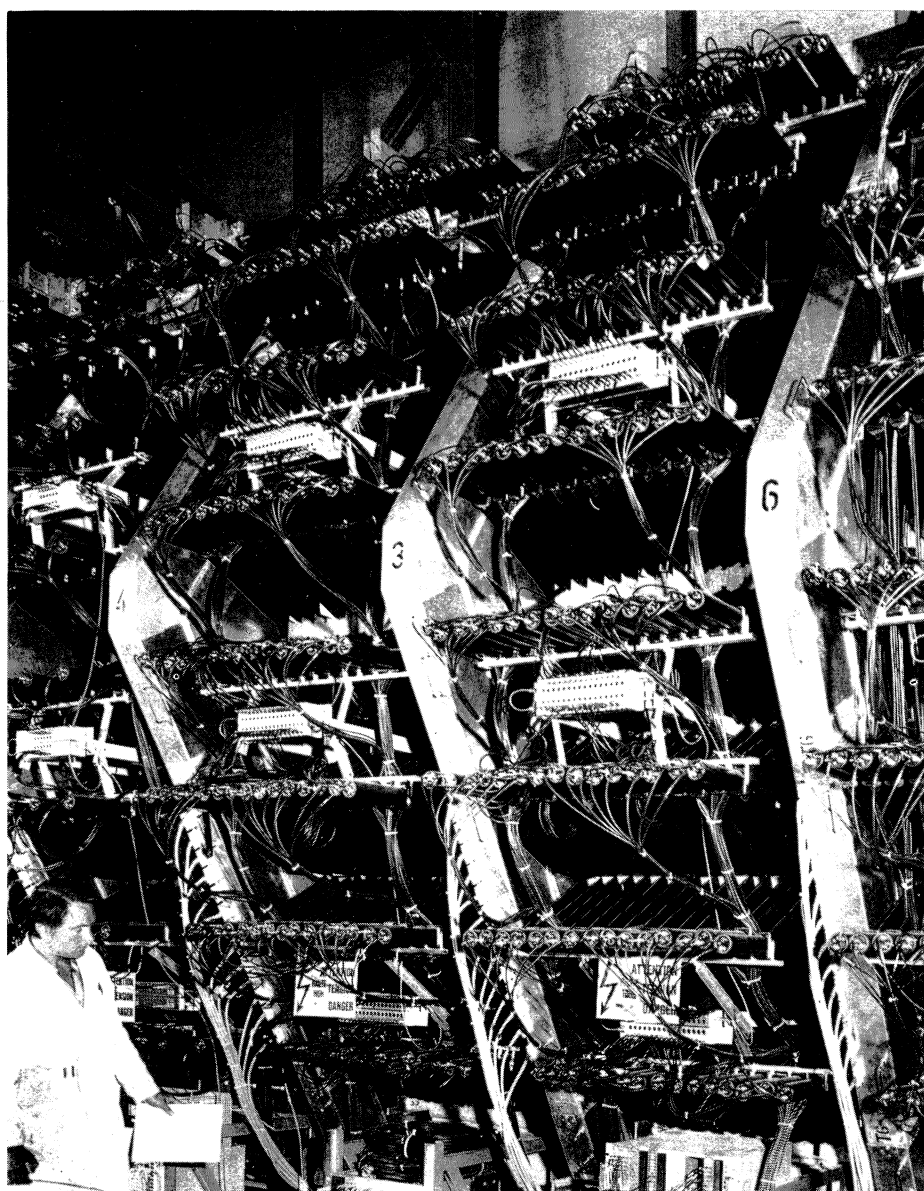
To try and provide a conclusive answer to the neutrino oscillation question, new experiments are being considered. Ideally, oscillation effects should show up best at long distances from the neutrino source, and at low neutrino energies, but because of the difficulties of working with neutrinos, some optimum solution has to be reached. At CERN the possibility of using a lower energy neutrino beam, derived from the 28 GeV proton synchrotron, is being looked at. This would be the first experiment specifically designed to look for neutrino oscillations in an energy range which favours their detection. The idea is that near the new neutrino source, the CERN / Dortmund / Heidelberg / Saclay collaboration would have detector modules identical to those used in their large WA1 experiment using neutrino beams from the SPS

400 GeV proton synchrotron. The new lower energy neutrinos would also pass through the main WA1 detector some 1000 m downstream, enabling the flux of muon-type neutrinos to be measured in two places. The natural divergence of the neutrino beam over this distance is known, and any oscillations changing the level of muon neutrinos would show up as an additional small effect. Another possibility with

the same neutrino beam is to look for transformations of muon-type neutrinos to electron-type neutrinos using a bubble chamber.

A new low energy neutrino experiment is being assembled at Brookhaven (see page 12) which could help shed more light on the question, while further evidence could come from continuing experiments both at reactors and using high energy beams.

Whether successful or not, the search for neutrino oscillations looks as though it will add another interesting chapter to neutrino history, which already includes some of the most important discoveries in particle physics.



Modules of the CERN / Dortmund / Heidelberg / Saclay high energy neutrino experiment (WA1) at the SPS. Similar modules could be used in a new experiment using a low energy neutrino beam to look for signs of neutrino oscillations.

(Photo CERN 77.6.76)