news and views

Too many electron neutrinos?

from D. J. Miller

A CURIOUS and completely unexpected effect has been found in the 'beam dump' experiment at CERN. An experiment with a modified version of the CERN neutrino beam has shown that the ratio of the number of neutrino-induced events producing an electron to those producing a muon was seven times greater than expected from contemporary theories.

The normal neutrino beam at CERN is derived from a mixed beam of π and K mesons which is produced when protons from the super proton synchrotron (the SPS) collide with a small metal target. The pions and kaons have lifetimes of around 10^{-7} s. In a tunnel some hundreds of metres long a large fraction of them decays, giving a mixture of neutrinos and charged particles, mostly muons. A thick shield of steel, concrete and earth stops the charged particles, but the neutrinos pass through the shield and into the detectors. For the beam dump experiment a thick metal plug was placed immediately after the small target in the proton beam. The bulk of the pions and kaons would interact in the plug and never enter the decay tunnel, so it was expected that the number of neutrino interactions seen in the detectors would be substantially reduced.

But why do a neutrino experiment with such a spoiled beam? This special short run had been asked for by a CERN-Dortmund-Heidelberg-Saclay (CDHS) collaboration who were puzzled by the properties of neutrino-induced events with three final-state muons which had been observed both in their massive steel detector and at Fermilab in the USA (see *News and Views*, **269**, 286; 1977). Perhaps these trimuon events were caused by a new kind of neutrino which might be produced by the decay of a short-lived particle. If this particle had a lifetime of 10^{-11} or less then it would be expected to decay rather than to interact, even if it were passing through a dense metal target or plug. So the beam-dump experiment should see just as many events due to the new kind of neutrino (if it existed), but far fewer events caused by the neutrinos from pion or kaon decay.

Oddly enough, the excitement so far about the beam-dump results does not concern trimuon events at all. As usual, the neutrino beam was used simultaneously by CDHS and by two big bubble chambers, Gargamelle and BEBC. About 70,000 pictures were taken in each chamber, and scanned within about 6 weeks to find all the neutrino events. No one expected to see useful numbers of trimuon events in these scans—the bubble chambers are not massive enough. Events were simply classified as having an associated muon, an associated electron, or no associated lepton (electron or muon). An event with a muon was assumed to be due to a charged current (CC) interaction of a muon neutrino, an event with an electron was assumed to be due to a CC interaction of an electron neutrino, and events without a lepton were taken to be neutral current (NC) neutrino interactions.

The ratio of electron events to muon events in BEBC was 15 to 34 and in Gargamelle it was 9 to 18. But the predicted number of electron events, given this total of 52 muon events, was only 3.5. This prediction is based on the known production and interaction rates of pions and kaons, together with various other neutrino-producing processes such as hyperon decay. The CDHS detector has difficulty in separating electron CC events from NC events, but this collaboration also reports an excess of events without a final-state muon.

The obvious kind of explanation for a greater number of electron events than expected is to assume that there is indeed a short-lived neutrino parent which becomes proportionately more important when the pions and kaons have been absorbed in the plug of the beam-dump. This parent must decay almost as frequently to give an electron neutrino as it does to give a muon neutrino. But results at e^+e^- machines and in other neutrino experiments have established the existence of just such a particle—the D meson, a charmed particle with a mass of 1.85 GeV/c^2 (see *News and Views* **262**, 537; 1976). D mesons are known to decay about 10% of the time to give an electron and an electron neutrino in the final state, and about 10% of the time with a muon and a muon neutrino. The lifetime is around 10^{-13} s so there is very little chance that a D will interact before it decays. Unfortunately, to account for the observed rate of electron events in the beam dump experiment, the rate of production of D mesons must be about 1 in 200 proton interactions. A number of different experiments over the past few years have placed upper limits on the possible rate of D production at less than 1 in 20,000 proton interactions. So the obvious explanation seems to be ruled out, and new theoretical ideas may be needed to explain the results. Perhaps the τ lepton, which has been observed in e^+e^- collisions, has a neutrino related to it which causes these events and the trimuons too. Maybe the neutrinos from D meson decays interact more strongly than the neutrinos from pion and kaon decays.

Further results from the beam-dump experiment are eagerly awaited. Already it seems that the overall event rate is a little higher than expected and there may be more NC events than in normal neutrino experiments. It is possible that a second beam-dump run will be done during 1978, with the target at the end of the decay tunnel rather than at the beginnig of it. This would give a considerable increase of neutrino flux through the detectors, but high radiation levels in the tunnel make it hard to see how the equipment can be installed for such a move. Meanwhile, normal neutrino experiments are continuing and there are tantalising rumours of new results from these which could be as significant as the beam dump data.

Results are being submitted to *Physics Letters* by the CERN-Universities collaborations who analysed the bubble-chamber film. □

D. J. Miller is in the Department of Physics and Astronomy at University College, London.