Rutherford Laboratory

Technical leaflet

B.15

K4 Experiment: A study of the leptonic decay modes of positive K-mesons

(OXFORD UNIVERSITY)

This experiment has been designed to make simultaneous studies of the three-body decay modes of the K^+ meson:

$$K^+ \rightarrow \pi^0 + \mu^+ + \nu\mu$$

and

$$K^+ \rightarrow \pi^0 + e^+ + \nu_e$$

For these particular decay modes the energy distributions of the π^0, μ^+ and e^+ are being measured, and also in the former reaction, the spin polarisation of the μ^+ by observing its further decay

$$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}\mu$$

These measurements allow the investigation of the form of the couplings in the weak interaction which is responsible for the decay, of the form factors, or spacial distributions involved in the decay, and that the same weak interaction is responsible for both the electron and the μ-meson modes of decay. The polarisation of the μ-meson will also give a test of CP non-invariance which has been observed in K^0 decays. The branching ratio for the rare decay mode $K^+ \rightarrow e^+ + \nu$ will be measured.

The K^+ beam is produced from a target in the external proton beam which is shared with the K6 experiment. There is one 13ft. stage of electrostatic separation to select the K^+ mesons from the π^+ and protons which are all produced in the target. This separation is achieved by virtue of the different deflections produced on particles of the same momentum but different masses, when they pass between parallel plates having an electric potential difference of 700,000 volts. The K^+ mesons pass through scintillation counters (numbers 1,2,3 on the diagram) and stop in a small beryllium plate spark chamber. With an average lifetime of 10^{-8} seconds, they decay, and the spark chambers are triggered when a charged decay product passes through the scintillation counters 5 and 6.

If a zero-charged pion (π^0) is produced in the decay, it will decay almost immediately to a pair of gamma-rays which will produce showers of electrons in the brass plate spark chambers. The charged decay product has its momentum measured by its deflection in the analysing magnet, and its velocity measured by a Cerenkov counter filled with propane gas, which signals that the particle was a high velocity electron rather than a slower μ-meson, or π-meson. The particles are tracked through the analysing magnet by four thin-plate spark chambers, S1, S2, S3 and S4, whose spark positions are detected accoustically by microphones around the periphery, and recorded on magnetic tape for feeding directly into the ATLAS computer. Finally, the particles are stopped in a thick aluminium plate spark chamber (the range-chamber) where the decay of a μ-meson into an electron is observed by delaying the firing of this spark chamber for 3 microseconds giving time for their decay.

The direction of the electron in this final decay is a measure of the polarisation (or orientation of the spin) of the μ -meson.

There is a final counter (9) to veto the recording of decays by more copious decay modes $K^+ \rightarrow \mu + \nu$ and $K^+ \rightarrow \pi^+ + \pi^o$, which have sufficiently energetic decay products to pass right through the range chamber.