Rutherford Laboratory
Technical leaflet

B14

K1 BEAM AND SACLAY BUBBLE CHAMBER

This project is a co-operative effort between the Rutherford Laboratory and D.P.Ph.E. of Saclay, near Paris. The film taken is being analysed by collaborations of British and French bubble chamber analysis groups in the Universities, the Rutherford Laboratory and Saclay.

The bubble chamber is operated with a filling of either liquid hydrogen or liquid deuterium. Any charged particles passing through the liquid leave a trail of small bubbles, which can be photographed. The liquid must be maintained at a certain critical temperature and pressure (about 7 atmospheres and 33° Kelvin for deuterium) and expanded by moving a piston at the moment that a particle beam arrives from Nimrod. The bubbles form in the wake of the particles, and are then photographed in 3 separate stereo cameras using flash lights. The liquid is then compressed again to await another burst of particles. This chamber can take two photographs per Nimrod cycle, that is it can take about 60 pictures per minute. The sensitive volume of liquid is 80 cm x 50 cm x 50 cm. A magnet surrounds the chamber, so the particles move in spiral orbits in a field of up to 18 K gauss. The curvature of the spiral corresponds to the momentum of the particle, and the darkness or bubble density of the track corresponds to the velocity of the particle, slower particles producing a denser track.

Events of interest are selected by scanning the photographs taken, and selected photos are measured on accurate machines constructed for the purpose. The measurements are analysed by computer, when the events are reconstructed in space and identified, and all the physical quantities of interest calculated. The high accuracy of measurements, down to 0.02 mm in the chamber, and the information on curvature and bubble density on all tracks mean that very complex reactions involving several different fundamental particles, can be successfully analysed.

The Kl beam is designed primarily to provide pure beams of K^-, π^+, π^-, K^+ mesons of momenta up to 2.2 GeV/c, so that their interactions with the hydrogen or deuterium of the chamber can be studied free of any background from other particles in the beam.

The beam selects either a positively charged or negatively charged beam of particles from one of two separate targets inside the Nimrod vacuum vessel. The range of momentum selected is about 1%. Such a beam contains a mixture of particles, for example the positive beam contains ε^+, μ^+, π^+, K^+ and protons. However, all will have different velocities, the heavier particles being slower than the lighter particles of the same momentum. These differences of velocity are small, but by using "separators" in which the beam is deflected by a very strong electric field, the particles may be physically separated into spots or images several millimetres apart. Collimating slits of brass may then be adjusted to allow only the wanted particles to pass on to the bubble chamber. To obtain a high purity K beam, this process is carried out twice in K1, there being two separators and two mass separation slits. The separators consist of a vacuum tank with two parallel plates normally 10 cm apart with about 500 Kilovolt between them.

Experiments in progress on K1 are:

a) A study of N* production in proton-neutron (using proton beam and deuterium) collisions around 2 GeV/c.

b) K^-+p interaction at 1.5-2.0 GeV/c K^- momentum

and

c) K^-+d interaction at 1.5-2.0 GeV/c K^- momentum.

The principal aim of these experiments is to find and elucidate the properties of any states resonant between the K mesons and the nucleons. The momentum range corresponds to resonance masses of 2.0-2.2 GeV/c^2.

All of the K^-p and K^-n interactions seen will be measured, in particular some in which there are only two particles in the final state:

$K^-+p \longrightarrow K^-+p$ $\quad$ $K^-+p \longrightarrow Y^*+\pi$

$\longrightarrow \bar{K}^0+n$ $\quad$ $\longrightarrow K^{*-}+p$

$\longrightarrow \Sigma^++\pi^-$

$\longrightarrow \Sigma^-+\pi^+$

$\longrightarrow \Lambda^0+\pi^0$

$K^-+n \longrightarrow K^-+n$ $\quad$ $K^-+n \longrightarrow Y^*+\pi$

$\longrightarrow \Lambda^0+\pi^-$ $\quad$ $\longrightarrow K^{*-}+n$

$\longrightarrow \Sigma^-+\pi^0$

If the K - nucleon system resonates at a particular K momentum, enhanced production and characteristic angular distributions will be seen in the channels important in its decay. For example, a particular resonance might be seen as a peak in the cross section for $(\Lambda^0+\pi^0)$ and $(\Lambda^0+\pi^-)$ and might cause the angular distribution of the Λ^0 and π to vary rapidly as the K momentum is varied. From this data, the decay properties and the spin and parity of the new resonance might be deduced. The successful classification of new particles in this way is essential to our understanding of the wealth of particles which have been found to exist. Resonances of higher and higher mass must be found and classified in order to test current theories of classification of the fundamental particles.

d) π^++p interaction at 0.8 - 1.1 GeV/c momentum.

This experiment is intended to study the decay properties of any nucleon-pion resonances in this momentum range.

e) The decay of the η particle.

The eta meson is unusual in that it decays by an electromagnetic interaction, rather than by the "strong" or "weak" interaction common to most particles and resonances. Several modes of decay will be measured in this experiment, but in particular we study

$$\eta^0 \longrightarrow \pi^+ + \pi^- + \pi^0$$

$$\eta^0 \longrightarrow \pi^+ + \pi^- + \gamma$$

both of which can be seen and readily identified in a deuterium bubble chamber using the reaction

$$\pi^+ + d \longrightarrow p + p + \eta^0$$

for its production.

A question of great interest at the present time is whether charge conjugation C is violated or not in the electromagnetic interaction. The violation we are seeking would appear as a difference in the spectra of π^+ and π^- in the above two eta decays. The spectra might also show any anomaly in the interaction of pairs of π mesons.