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A Telescope to Identify Electrons in the Presence of Pion Background

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G E N E V A

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I. Introduction

Two instruments have recently been developed which can be used to distinguish electrons and pions of the same momenta in the GeV region : the lead glass total absorption Čerenkov counter ¹⁾ and the total absorption scintillation detector ²⁾. For both instruments the probability of mistaking a pion for an electron of the same momentum is of a few per cent. In this article we describe a simple method by which such a probability is decreased by nearly a factor of 10. The improvement is achieved by also looking at the first stage of the shower development, as it occurs in a lead slice of about two radiation lengths. This first stage of the shower development is observed in a scintillation counter following the Pb slice. The further development of the cascade showers occurs in a lead glass Čerenkov counter ¹⁾ which is an essential part of the telescope described here.

The telescope has been used in an actual experiment ³⁾. Electrons of momenta in the range 1 to 2.5 GeV/c were detected with an average efficiency of $\sim 80\%$. The corresponding pion contamination (i.e. the probability for a π^- in the same momentum range to appear as an electron) was 0.3%.

II. Description and Principle of Operation

The telescope is shown to scale in Fig. 1. It consists of a 1 cm thick slice of lead, followed by a 28 cm diameter, 1 cm thick scintillation

counter (N), and finally by the 35 cm diameter, 30 cm long lead glass Čerenkov counter (Č) of Gatti et al.¹⁾.

If the pions lost energy only by ionization in the Čerenkov counter, then using the Čerenkov pulse height alone there would be a negligible chance of mistaking a pion for an electron of the same momentum. However, the pions can undergo nuclear interactions and convert into electromagnetic energy via charge exchange. Consequently the pion spectrum has a tail, in which about 2% of the pions extend under the electron peak.

The purpose of the lead sheet and counter N is to make a preliminary rejection of the pions. A high-energy electron will, in general, start a cascade shower in the ~ 2 radiation lengths of the Pb sheet. The electron pulse-height distribution in counter N will therefore have a much higher peak than the pulse-height distribution of a pion of the same momentum. The higher pulse heights produced by pions in counter N are caused by :

- i) statistical fluctuations;
- ii) nuclear stars;
- iii) charge exchange followed by shower production.

In the Čerenkov counter

- i) will give the normal pion spectrum and tail;
- ii) will give small pulse heights;
- iii) will give only the tail of the pion spectrum. This tail will appear with reduced intensity because the lead presents less material in which the pion may charge exchange than does the first part of the Čerenkov counter.

The thickness of lead is chosen so that there is a high probability of greater than unit multiplication of electrons. With this system, by discriminating to accept only large pulse height in N and in the Čerenkov counter, we may expect to obtain high electron efficiency and low pion contamination.

III. Calibration of the Telescope

The properties of the telescope were examined using the simple set-up shown in Fig. 1. The beam telescope DAB was used to separate pions or electrons from a 1.15 GeV/c pion beam containing ~5% electrons, of the CERN Proton Synchrotron. Counter D was a gas Čerenkov counter filled with hydrogen at three atmospheres and sensitive only to electrons. A and B were two small beam-defining counters.

The following measurements were made :

- i) The beam was defined as described above and the pulse-height spectra of pions and electrons in counter N were measured using a TMC pulse-height analyser. The results are shown in Fig. 2. The true width of the pion curve was 37%, but there was some broadening caused by amplified noise before the pulse-height analyser input. The dotted curve shows the electron spectrum after a correction for the pion contamination of the selected electrons.
- ii) Counter N was included in the beam telescope coincidence to gate the Čerenkov spectrum (Fig. 3). The discriminator level of N was set at minimum to accept all particles crossing N. Note that the electron curve shows quite clearly a pion contribution. This was estimated to be $(10.5 \pm 1.5)\%$ of the electron

spectrum by comparing the integral spectra of pions and electrons. This contamination, we believe, was caused by low-energy knock-on electrons produced in 3 cm of scintillator placed upstream in the beam by another group. These electrons were coincident with the pions; they produced a count in the hydrogen Čerenkov counter, but were not energetic enough to produce large pulses in N or in the Čerenkov counter.

- iii) The discrimination level of N was increased so as to accept only 10% of the pions, and the pion and electron spectra in the Čerenkov counter were remeasured. These results are also shown in Fig. 3. It may be seen that a large fraction of the pions which give large pulse heights in N give very small pulse height in the Čerenkov counters.

These results are summarized in Fig. 4 which shows the normalized integral spectra in the Čerenkov counter for measurements ii) and iii).

To use the telescope, in practice one would impose a discrimination level in the Čerenkov counter. It may be seen that for useful discrimination levels (channels 30 to 80), the normalized spectra are effectively the same for high or low pulse heights in counter N.

Use may be made of this independence to optimize the trigger levels to obtain minimum pion contamination for a fixed electron efficiency. Figure 5 shows the expected results of this optimization. As we see, we can get 80% electron efficiency with 0,3% π -contamination.

References :

- 1) G. Gatti, G. Giacomelli, W.A. Love, W.C. Middelkoop and T. Yamagata.
Rev. Sc. Instr. 32, 949 (1961)
- 2) G. Backenstoss, B.D. Hyams, G. Knop and U. Stierlin.
Nuclear instruments and methods, 20, p. 294-296 (1963)
- 3) M. Conversi, T. Massam, Th. Muller and A. Zichichi.
Physics Letters 5, 195 (1963)

Figure Captions :

Fig. 1. Counter arrangement and electronics

A,B,N = plastic scintillator counters

D = hydrogne Cerenkov counter

C = lead glass Cerenkov counter

Pb = lead foil

d = delay

a = amplifier

t = trigger

ds = discriminator

c = coincidence input

v = anti-coincidence input

c.u. = coincidence unit

sc = scaler

Fig. 2. Pulse height spectra in counter N

Fig. 3. π and e spectra in the Cerenkov counter

Fig. 4. Integral spectra in the Cerenkov counter

Fig. 5. Showing the minimum π efficiency as a function of electron efficiency

FIG. 1

FIG.3 π and e spectra in the Čerenkov counter

FIG. 4 Integral spectra in the Čerenkov counter

FIG. 5 Showing the minimum π efficiency as a function of electron efficiency.