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STUDY OF INTERACTIONS IN WHICH γ RAYS AND ELECTRONS WITH LARGE TRANSVERSE MOMENTUM ARE EMITTED

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- I - INTRODUCTION -

One of the simplest and useful preliminary ISR experiment is to obtain quantitative information on particle production rates, angular distributions and momentum spectra.

A calculation of these production rates has been obtained using the thermodynamical model of HAGEDORN and RANFT [1] as a starting point [2]. The predicted spectra of mesons (π, K) and baryons (P, Λ, Σ) for large production angles at ISR in the region near 90° are illustrated on figures 1 and 2. These spectra have a sharp fall-off with momentum of secondary particle and the rates vary slowly with production angles in the region near 90° ± 30°.

A preliminary measurement of these spectra is necessary in order to judge the possibilities of using the high centre of mass energy of ISR in attempts to investigate the existence of conjectured new particles too heavy to be produced by present accelerators.

For instance any conspicuous deviation from the exponential decrease with momentum - in the high energy range from 2 to 20 GeV/c - of the meson or baryon spectra would certainly yield interesting and very useful information for the planning of later more sophisticated experiments.

In this experiment we propose to measure the γ ray and electron spectra at large production angles and in a wide range of momentum. Preceding experiments have shown that very specific detectors for electrons and γ rays could be successfully used with a momentum resolution $\frac{\Delta P}{P} \sim 20\%$ in precisely the whole range from 2 to 20 GeV/c [4]

In the next paragraphs we will review : a) the spectra we intend to measure and the information which can be derived from these measurements - b) the experimental set-up and background limitations.

- II - AIMS OF THE EXPERIMENT -

This proposed experiment has the following objectives :

1) Measurement of the γ ray spectra.

The measurement of the γ ray spectrum above $P\gamma = 1.5$ GeV/c will provide information on the π° spectrum - it will give an interesting comparison with the charged particle production experiment data [5] and will help to get a better understanding of large angle multiple pion production processes.

It is also necessary in order to calculate accurately the electron background spectrum expected from γ ray materialisation - within the same detector assembly and geometry.

Observation of large transverse momentum π°'s would also have considerable direct experimental interest. It would give a strong motivation to look for possible evidence of massive particle ($M \geq 2$ GeV) decaying into pion pairs - for instance strong decays such as $W^{\pm} \to \pi^{\circ}\,\pi^{\pm}$ with the same large solid angle detector.

2) Measurement of the electron spectrum.

As mentioned previously the electron spectrum will be produced mainly by : (a) π° and K° decays and subsequent γ ray materialisation in the 0.2 mm stainless steel vacuum chamber wall [6] and detector walls - (b) Dalitz-pair decays and (c) other less frequent meson and baryon leptonic decays.

For the predicted meson and baryon spectra this electron background - illustrated on figure 4 - should decrease exponentially with momentum, so that the production of high energy electrons with momentum larger than 2 GeV/c could be explored down to low production cross sections $\sigma \neq 10^{-34}$ cm^2. These rates could be obtained in a reasonable running time with ISR luminosity $\simeq 4.10^{30}$ cm^{-2} sec^{-1}.

The measurement of the electron spectrum will thus provide an upper limit for observing massive vector meson $M_W > 2$ GeV leptonic decays :

$$W^{\pm} \to e^{\pm} + \nu_e$$

As a by product of these measurements, one could look for electron pairs ($e^+ e^-$). Observation of electron pairs is of considerable interest by itself and will provide the production cross section of virtual γ rays of large energy [7] The mass spectrum of $e^+ e^-$ pairs could be explored to search for possibly existing massive particles such as heavy vector mesons if they have an appreciable decay rate in lepton pairs [8].

This spectrum is also required in order to correct the single electron spectrum for contributions in which one electron escapes detection. [7]

- III - EXPERIMENTAL ARRANGEMENT -

The experimental set-up is shown on figure 5. It consists of a Cerenkov electron detector and a large solid angle electron shower detector subtending 25% of 4π solid angle.

a) Electron Cerenkov counter :

This threshold electron Cerenkov counter will have a length of 50 cm, it will operate with ethylene at a pressure of 1 atmosphere - The expected rejection ratio against $\pi^{\pm}$ and $K^{\pm}$ will be equal to $\approx 10^{-4}$. Further discrimination against charged particles, other than electrons, will be obtained by observing the electron shower development in the following thick plate spark chamber.

b) Electron shower spark chamber :

The thick plate spark chamber will have approximately 2m x 2m area and a total thickness of about 20 radiation lengths of lead plates. A sufficient number of gaps, approximately 30, will provide enough information on the shower development to get a momentum resolution of the order of ± 20% [4] by counting the number of sparks in each shower.

Trigger counters will be placed in the spark chamber assembly such that the system will be triggered by electrons with a range that ensures them a momentum greater than 2 GeV/c.

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The expected trigger rate - figure 4 - will vary from several per minute to a few per hours according to the momentum range above 2 GeV/c, so that optical spark chambers could be used.

c) Background from beam-gas interactions :

The calculated production rates of π° and K° from beam gas interactions in the whole 90° ± 30° region having a momentum greater than 1.6 GeV/c is practically negligible - as the kinematical momentum limit in the same region is less than 1.8 GeV/c. Consequently this source of electron background should be rather small.

As these detectors could be placed vertically with regard to the intersecting beams, the charged particle background should also be reduced.

d) γ-ray detection :

Thin plate spark-chamber will be placed around the intersecting region in order to measure the direction of electron and other charged particles produced - Lead converter of variable thickness placed after these thin plate spark chambers will permit to measure accurately the total flux of γ rays going through the whole detector assembly with the same triggering logic.

Measurement of γ-rays in the thick plate spark chambers only and in a smaller solid angle region will be carried out in the initial test runs of the equipment.

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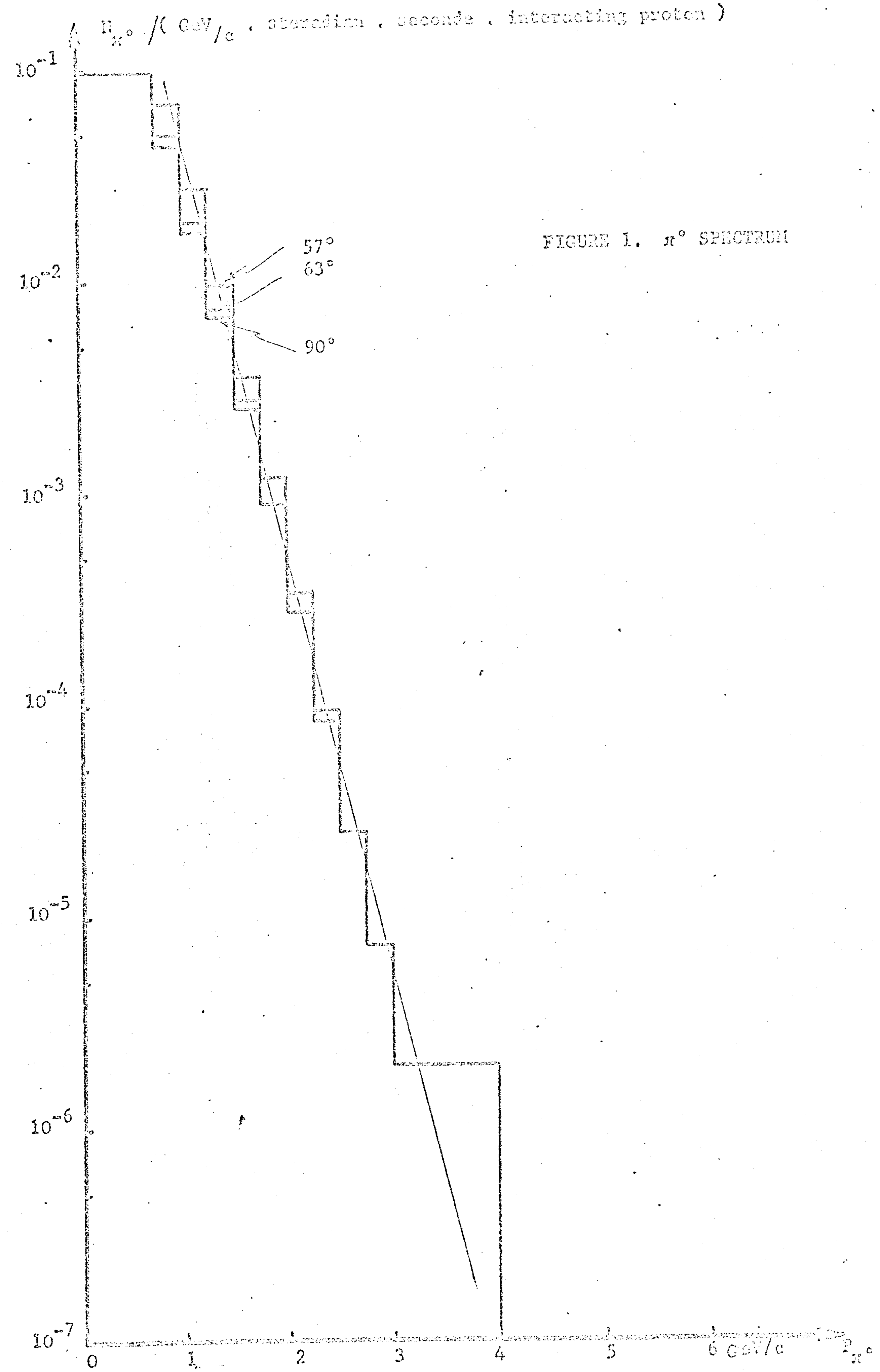

FIGURE 1. π° SPECTRUM

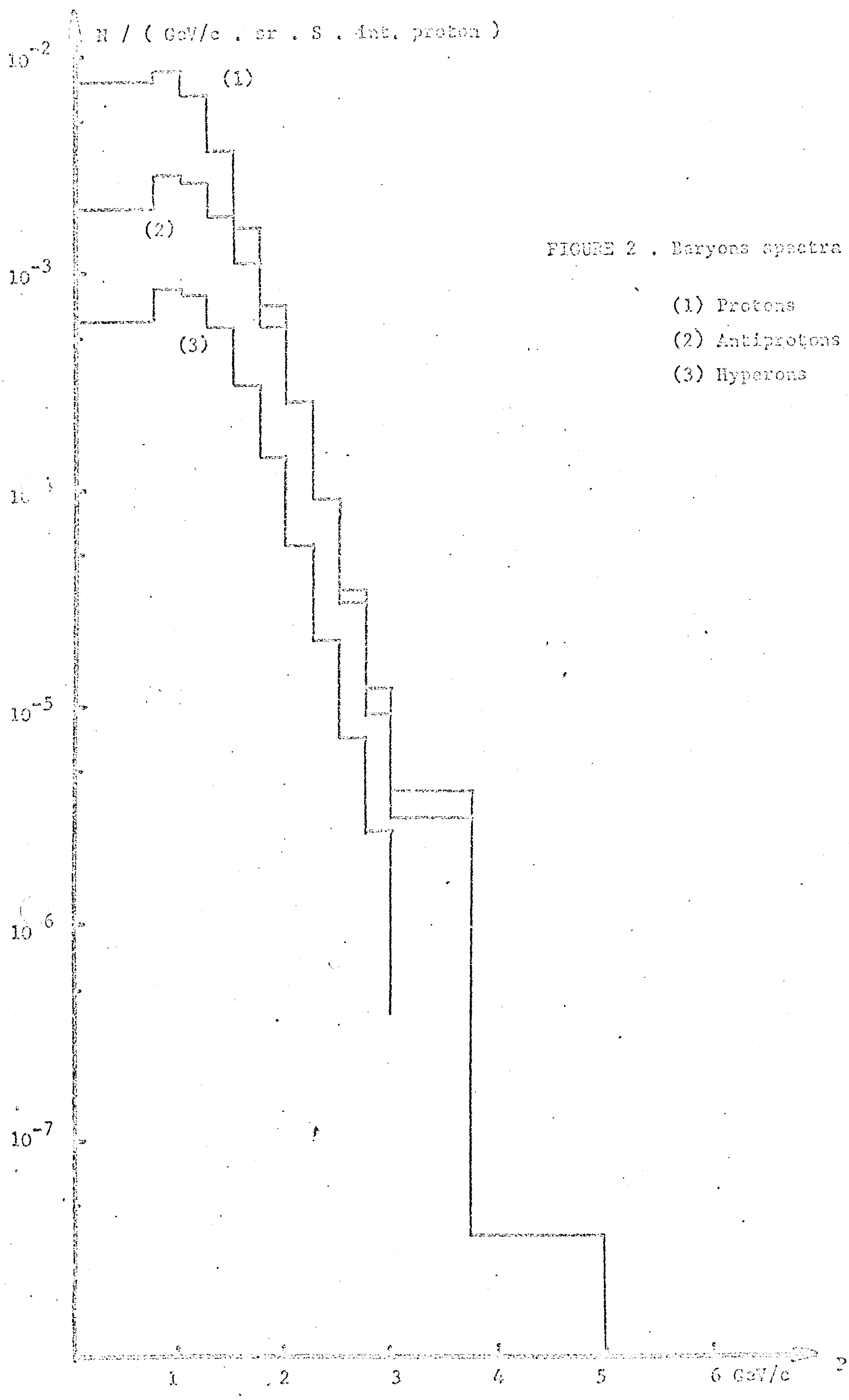

FIGURE 2 . Baryons spectra

(1) Protons

(2) Antiprotons

(3) Hyperons

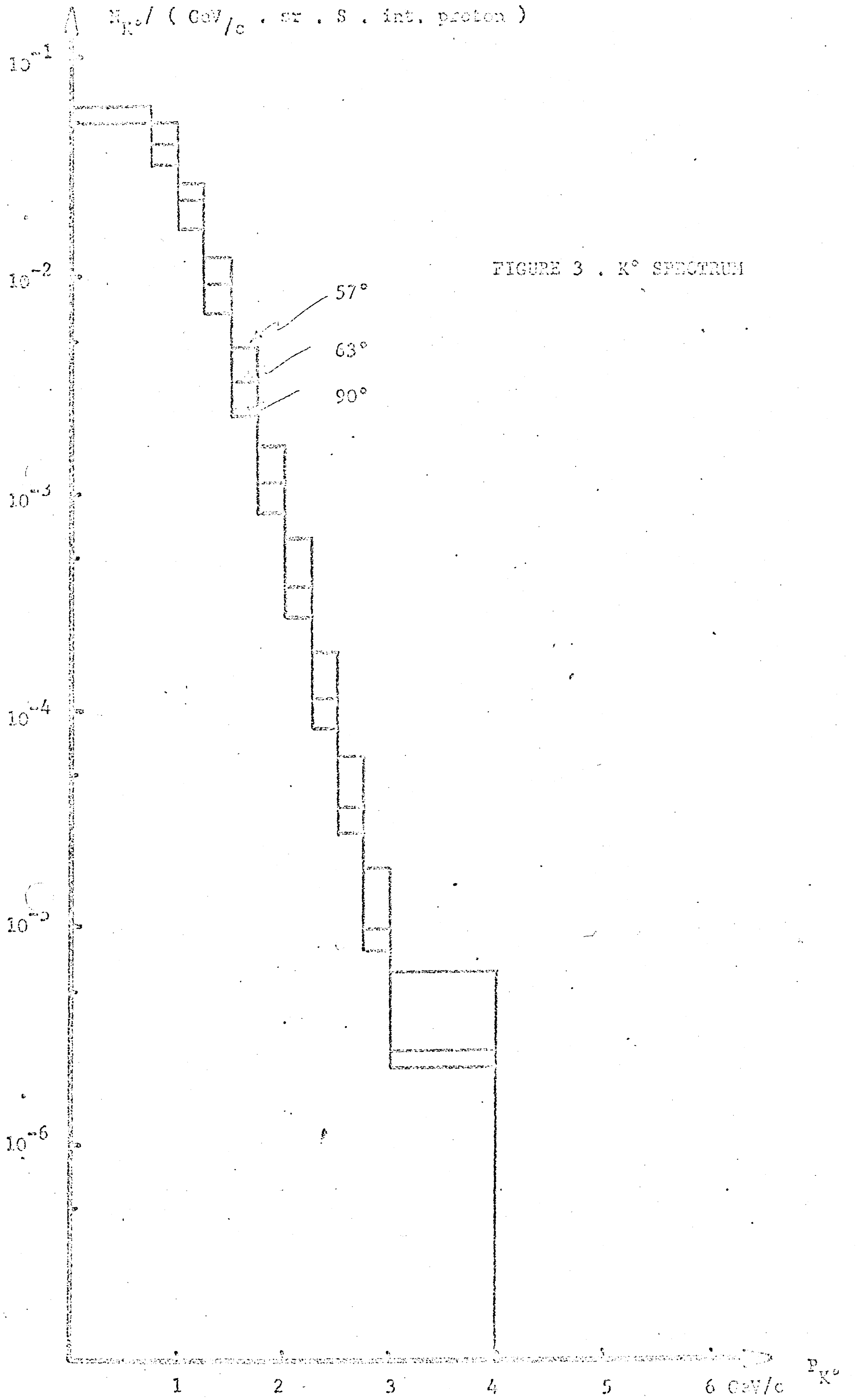

FIGURE 3 . K° SPECTRUM

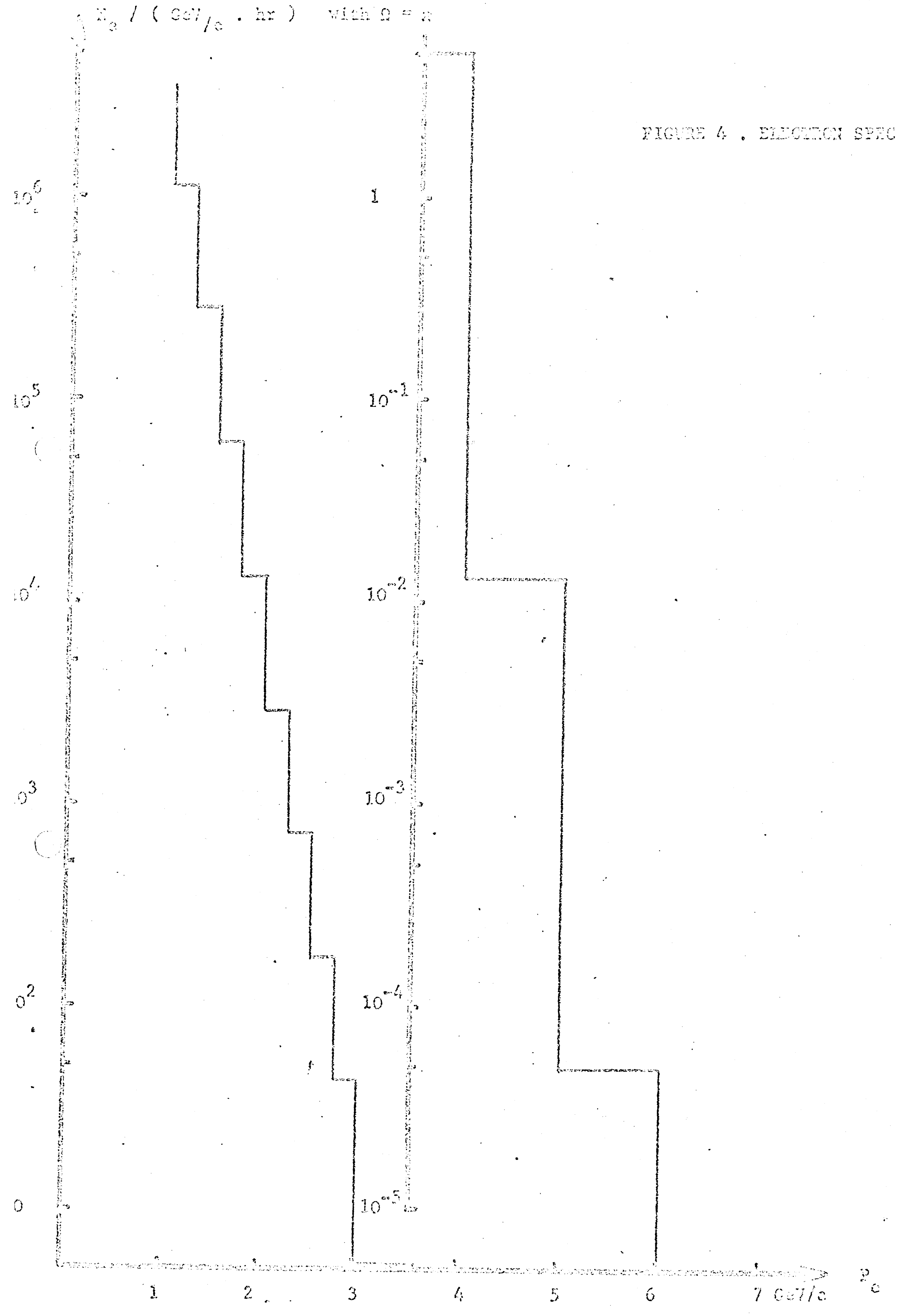

FIGURE 4 . ELECTRON SPECTRUM

FIGURE 5 . HORIZONTAL SECTION THROUGH ONE HALF OF THE DETECTOR .