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A THIN DETECTOR WITH IONIZATION TUBES FOR HIGH ENERGY ELECTRONS AND PHOTONS

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A THIN DETECTOR WITH IONIZATION TUBES FOR HIGH ENERGY ELECTRONS AND PHOTONS

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Abstract

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A thin Detector with Ionization Tubes for High Energy Electrons and Photons.

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p. 12. (IHEP 81-108).

Refs. 2.

A possibility to measure the energy of electrons and photons with a simple detector, consisting of a lead convertor and ionization tubes filled with pure argon, has been studied. The measurements have been performed in a 26.6 GeV electron beam. The best energy resolution $\sigma/E \sim 16\%$ was achieved for the convertor thickness 40 mm and argon pressure >20 atm.

The performance of the detector in magnetic field up to 16 kGauss has been also studied. It turned out that the mean pulse height rises approximately linearly with increasing magnetic field and becomes flat at $H \sim 10$ kGauss. This behaviour is the same for magnetic field perpendicular and parallel with respect to the ionization tubes. The energy resolution depends weakly on the magnetic field.

Ionization tubes filled with argon or xenon under high pressure may be used for minimum ionizing particle detection.

Аннотация

Аматуни Ц.А., Денисов С.П., Краснокутский Р.Н., Лебеденко В.Н., Шувалов Р.С.

"Тонкий" детектор с ионизационными трубками для регистрации электронов и γ-квантов высокой энергии. Серпухов, 1981.

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Библиогр. 2.

Изучена возможность измерения энергии электронов и γ-квантов высокой энергии при помощи простого детектора, состоящего из свинцового конвертора и ионизационных трубок заполненных чистым аргоном до высокого давления. Исследования проводились на пучке электронов с импульсом 26,6 ГэВ/с. Наилучшее энергетическое разрешение $\sigma/E = 16\%$ достигнуто при толщине конвертора 4 см и давлении аргона > 20 атм.

Исследованы характеристики детектора при работе в магнитном поле. Оказалось, что амплитуда сигнала не зависит от направления поля и растет почти линейно с увеличением напряженности до 1 тл, а затем выходит на плато. Энергетическое разрешение слабо зависит от напряженности поля вплоть до 1,6 тл.

Показано, что при помощи ионизационных трубок, наполненных аргоном или ксеноном до высокого давления можно регистрировать одиночные частицы с минимальной ионизацией.

1. INTRODUCTION

The performance of a simple high energy electron and photon spectrometer, consisting of a lead convertor and a scintillation counter, has been studied in ref./1/. It was shown that the best energy resolution $\sigma/E = 0.69\ E^{-0.45}$ (E is the electron energy in GeV units) is achieved when the convertor thickness is close to the shower maximum depth. The detector can be used for electron/hadron discrimination: the probability to identify a 40 GeV hadron as an electron with the same energy is ~0.4%, for a 35-40 mm lead convertor and 95% electron detection efficiency.

In the present experiment ionization tubes were used for shower particle detection. Ionization tubes have certain advantages. The tubes are simple in construction and reliable in operation. They can work in strong magnetic fields and can be easily made of practically any size, still with high uniformity of characteristics. The calibration is simple. The main disadvantage is the low signal level, and hence, the necessity of using low noise amplifiers. The resolution time of the tubes is worse than that of scintillation counters.

2. THE EXPERIMENTAL SETUP

The experiment has been performed in the 26.6 GeV/c electron beam of the IHEP accelerator. The beam was defined by scintillation counters S_1-S_4 and A (see fig. 1). The ring anticoincidence counter A was used to suppress the effects due to the halo of particles surrounding the main beam. The S_4 counter located 50 cm upstream from the electron detector was 1x1 cm^2 in size. The beam momentum spread was 0.3%. Hadron contamination did not exceed 0.1%. The typical flux was $\sim 10^3$ pps.

The ionization detector consisted of two layers of stainless steel tubes (fig. 1). There were 10 tubes in the first layer and 11 tubes in the second. The length of each tube was 36 cm, the outer diameter was 10 mm and the wall thickness was 1 mm. The anode wires (ϕ 100μ) were made of berillium bronze. The tubes were designed to operate under pressure up to 150 atm. They were filled with high purity argon or xenon. All the anode wires were connected to a charge sensitive preamplifier/2/ with a 2N4861A type transistor at the input. The signals from the amplifier were digitized by a 1024 channel ADC and then transferred into a HP-2100 computer for on-line processing.

3. RESULTS

The experimental procedure consisted in measuring the pulse height distributions with convertors of different thickness. One of the measured distributions is shown in fig. 2. The distributions were fitted to a Gaussian. The mean and the variance of the Gaussian distributions obtained from the fit were in a good agreement with the mean A and variance σ^2, calculated directly from the spectra.

The detector characteristics measured without the magnetic field are presented in Figs. 3 and 4 and Table 1. From these data one can conclude that:

1) the best resolution $\sigma/A \sim 15.5\%$ is achieved for a 41 mm thick convertor, in agreement with results obtained in ref./1/;

2) the resolution is independent of high voltage in the 200-2000 V interval (the argon pressure was 72 atm);

3) the resolution worsens when the pressure becomes lower than ~10 atm. This is probably due to electronic noise.

One of the reasons that makes the ionization tubes attractive is their ability to operate in strong magnetic fields. This feature may be important, for example, in designing external electron identifiers for bubble chambers. One has to take into consideration, however, that the mean pulse height depends on magnetic field (see fig. 5): it increases approximately linearly and then reaches a plateau at H ~10 kGauss. This behaviour is the *same for magnetic* field direction perpendicular and parallel to the tubes and can be explained by the twisting of soft shower electrons in the magnetic field, resulting in total track length increase. The energy resolution of the detector worsens only slightly with increasing magnetic field. The dependence of the mean pulse height and the resolution on argon pressure and high volatge in a 16 kGauss field is given in Tables 2 and 3.

The possibility of minimum ionizing particle detection by the ionization tubes was studied in a 40 GeV/c hadron beam. The tubes were filled with xenon under 59.5 atm, or argon under 140 atm. In the latter case three 2N4861A type transistors, working in parallel, were used in the preamplifier to improve the signal/noise ratio. The main amplifier was of a conventional spectrometric RC-CR type, with integration and differentiation constants $\tau_i = \tau_d = 2\,\mu$sec. The equivalent noise charge in this case was 3.2 10^3 electrons.

The results presented in fig. 6 show that high pressure ionization tubes have $\sim$100% efficiency of minimum ionizing particle detection. The total length of the tubes (detector capacity and hence the signal to noise ratio depends on the total length of the tubes) can be as long as 10 meters.

4. CONCLUSIONS

The energy resolution of a simple detector consisting of a lead convertor and ionization tubes, filled with pure argon under high pressure has been studied in a 26.6 GeV electron beam. The best resolution $\sigma/E \sim 16\%$, is achieved for a 40 mm lead convertor and argon pressure $\gtrsim$20 atm. The energy resolution turned out to be independent of high voltage applied to the tubes in the 200-2000 V range.

The performance of the detector in magnetic field has been studied. Detector response appears to be independent of magnetic field direction and increases approximately linearly, reaching a plateau at $H \sim 10$ kGauss. The energy resolution depends weakly on magnetic field strength up to $H \sim 16$ kGauss.

It is shown that minimum ionizing particles can be detected with $\sim$100% efficiency when the ionization tubes are filled with argon or xenon under high pressure.

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Table 1

Dependence of the mean pulse height and resolution on high voltage for a 36.8 mm convertor and 72 atm argon pressure. Errors quoted are statistical.

U, (V)	200	500	1000	1500	2000
A	349.2±1.5	426.5±2.2	448.1±2.7	448.9±2.0	450.3±2.2
$\frac{\sigma}{A}$,%	16.2±0.5	16.3±0.4	14.9±0.7	17.2±0.5	15.7±0.4

Table 2

Dependence of the mean pulse height and resolution on high voltage for 75 atm argon pressure, 50 mm convertor and a 16 kGauss magnetic field (the field is parallel to the tubes). Errors quoted are statistical.

U,(V)	200	1000	2000
A	517±4	566±6	545±5
$\frac{\sigma}{A}$,%	18.2±0.6	19.0±0.8	19.5±0.8

Table 3

Dependence of the mean pulse height and resolution on argon pressure for a 50 mm convertor, 1000 V high voltage and a 16 kGauss magnetic field (the field is parallel to the tubes). Errors quoted are statistical.

P,atm	10	30	76
A	74.5±1.0	227±7	567±5
$\frac{\sigma}{A}$,%	22.3±0.9	15.2±1.4	17.8±0.6

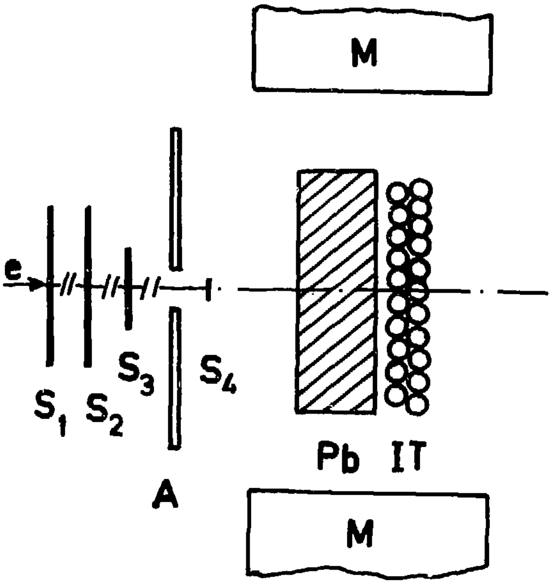

Fig. 1. The layout of the experimental set-up: S_1-S_4 - scintillation counters, Pb - lead convertor, IT - ionization tubes, M - magnet.

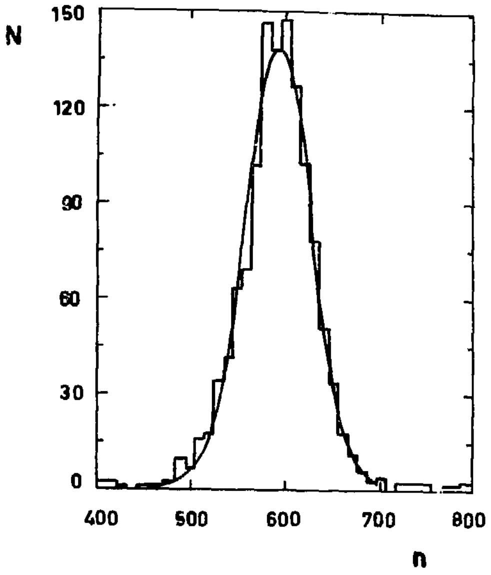

Fig. 2. Pulse height distribution for 26.6 GeV electrons, 36.8 mm lead convertor and 72 atm argon (n - ADC channel number).

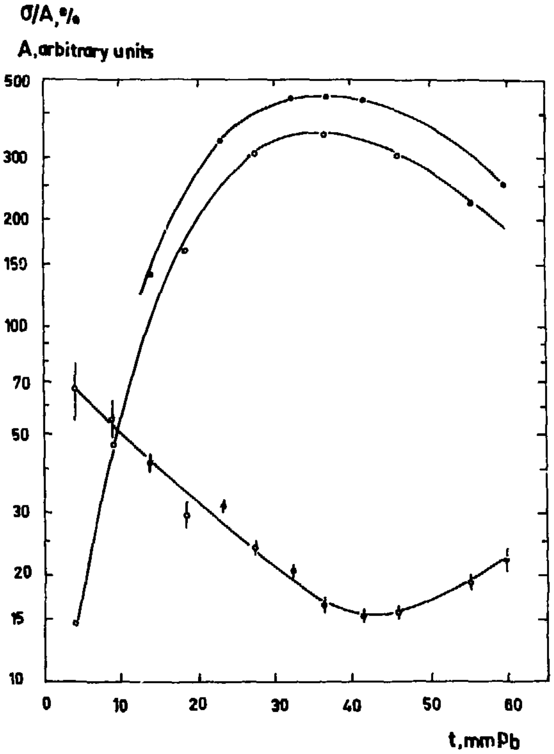

Fig. 3. Dependence of the mean pulse height and the resolution on convertor thickness for argon pressure 72 atm. High voltage 200 V (o) and 1500 V (●). The curves are drawn by hand.

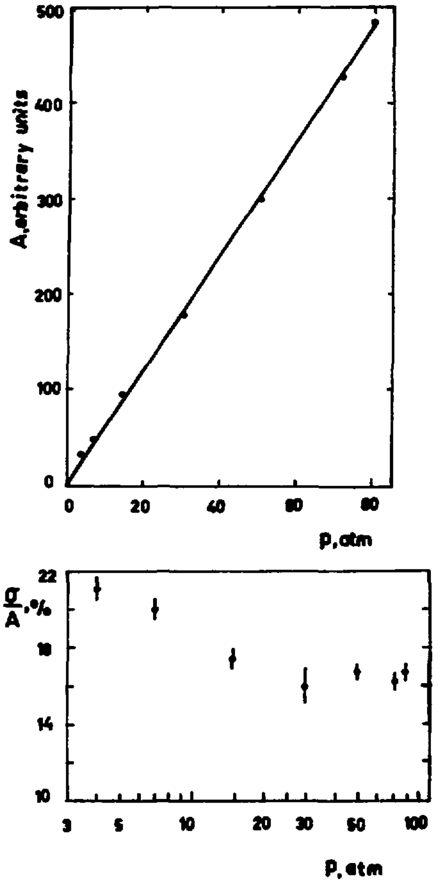

Fig. 4. Dependence of the mean pulse height and the resolution on argon pressure for a 36.8 mm convertor and 500 V high voltage.

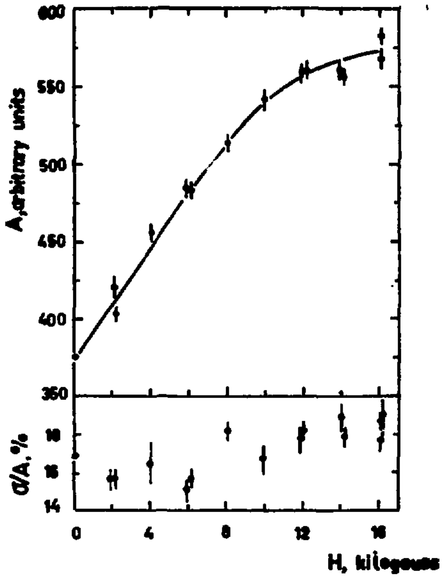

Fig. 5. Dependence of the mean pulse height and the resolution on the magnetic field strength for a 50 mm thick convertor, 1000 V high voltage and 75 atm argon pressure. Black circles: the field is parallel to the tubes; open circles: the field is perpendicular to the tubes. The curve is drawn by hand.

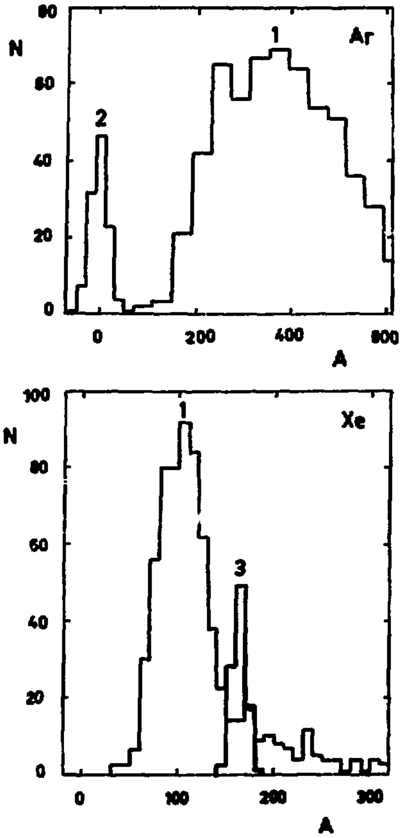

Fig. 6. Pulse height distributions: 1) - from 40 GeV/c pions. Argon pressure is 140 atm, xenon pressure is 59.5 atm (the density is 0.73g cm^{-3}); 2) - ampli-fier noise; 3) test signals of $5 \cdot 10^4$ e. The equivalent noise charge (FWHM) is $6 \cdot 10^3$ e.

Цена 6 коп.

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