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DEVICE FOR INVESTIGATION OF HIGH ENERGY PRIMARY COSMIC RAYS

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Abstract. The paper describes a device intended for investigation of energy spectra and chemical composition of primary cosmic rays in the ranges of energy ($5 \cdot 10^{11} - 10^{14}$) eV and charges $1 \leq Z \leq 26$ and for obtaining characteristics of nucleus-nucleus interactions. A device comprises an ionization calorimeter, an iron layer of $\sim 5\lambda_{int}$, and plastic scintillators providing special resolution 6 x 6 cm, and two sectioned Cerenkov detectors for measurement of nuclei charges in the ranges $1 \leq Z \leq 6$ and $Z \geq 5$.

1. General Description.

The scheme of a device is shown in fig. 1. An ionization calorimeter consists of eight iron layers (I) each 10 cm thick and two lead layers 2 and 3 cm thick.

Under each absorber, eight scintillators (2) are positioned. Plastic scintillators have the form of rectangular planes 52 cm long, 6.4 cm wide, and 2 cm thick, with polish surfaces. At one face of each scintillator a plexiglass lightquid (3) is attached at which face a photoelectric multiplier (4) is resided. Longitudinal axes of scintillators in neighfouring rows are mutuallt perpendicular. This arrangement yields the information on a place and direction of a particle shower in ionization calorimeter.

There are 80 scintillators and 80 measuring channels in the ionization calorimeter. Each channel has tow measuring ranges of amplitudes of impulses from a photoelectric multiplier. In a sensitive range amplitudes are measured in the interval 2mV--100 mV, and in a rough one impulses are measured in the interval $\sim$60 mV to $\sim$ 3 V.

2. Characteristics of Main Elements of Ionization Calorimeter.

The above described calorimeter was constructed on the basis of a principle of standardness of all characteristics of measuring units including power supply of photoelectric multipliers . This principle is realized as follows. The standard voltage of 1300 volt with the same potentials distribution over dynodes is impressed on all photoelectric multipliers. An output signal produced by a relativistic particle (muon) is made standard by means of opaque blind (5) which covers a part of the photocathode area. After tuning 0ith blinds have been made a standard for all multipliers light-filter (6) decreasing light flux by a factor of $\sim$ 800 is located between scintillators and photoelectric multipliers. Characteristics of measuring channels being made standard reguired electric units of amplitude-into-duration transformation to be standard.

Fig. 2 shows the mean characteristic of an output impulse as a function of amplitude A. For the characteristics standardness it is important that the dependence of a light fraction leaving a scintillator on a point where scintillation arouses is identical.

The mean dependence $\mathcal{I}(\ell)$ obtained after measuring with 40 scintillators is shown in fig. 3. Errors show the rms deviation of individual characteristics from the mean one. Individual characteristics were normalized at the point $\ell = 26$ cm.

3. DZ-1 and DZ-2 Charge Detectors

DZ-1 charge detector comprises 11 identic Cerenkov counters with independent registration of impulse amplitudes. Each counter consists of plexiglass radiator (7) $\sim$3.5 cm thick with optical contact with photoelectric multiplier (8). The area of each radiator is $\sim$ 200 cm^2, end the upper surface of it is pointed black. Therefore, a particle travelling from upward down produces a singhal at the multiplier output which amplitude is $\sim$ 20 - 30 times that from a particle travelling from downward. These counters are intended D measure charges of particles from $Z = 1$ to $Z = 6$.

DZ-2 charge detector is located above DZ-1 detector. It is intended for measuring charges of nuclei with $Z \geq 5$. This detector comprises four identic Cerenkov counters. Each counter is a plexiglass plate (9) 1 cm thick which is resided in a box (10). The internal surface of a box is pointed white and has gr great reflection coefficient. A photoelectric multiplier (11) with photokotod area $\sim$ 180 cm^2 is located into the side surface of the box. Impulses from multiplies of each counter are measured in a wide range of amplitudes.

4. System of Particle Registration

The device register only the particles which produce master signal. Master signal is produced under the following conditions. In any counter of DZ-1, a signal is $\geq 1/3$ of a probable amplitude of a single-charge particle; in n row of ionization calorimeter, energy release is $\geq \mathcal{E}_K$; total energy release in ionization calorimeter is $\geq E_j$. Values of n_1, $\mathcal{E}_k$, and E_j can be set from a distance. $n = 3,5,7,9$, for $\mathcal{E}_k$ and E_j three values are provided which overlap a mutual interval in one order . A master signal opens keys in all measuring channels for $\sim 1\ \mu s$ and switch on a blocking for several seconds. During this blocking the information is read from all measuring channels and stored in the device. New particles are not registered during the blocking. The device can measure amplitudes of signals of each of 95 detectors, amplitudes of summery signal in each row of ionization calorimeter scintillators, and an amplitude of summary signal over all detectors of ionization calorimeter. To realize these measurements in the device use is made of 1528 triggers inquired. The overall energy consumption of the device is about 10 watt.

6. Acknowledgements

We are grateful to a large group of engineers and technicians of our Institute whose selfless efforts made feasible carrying out this work.

Figure Captions

Fig. 1. The scheme of a device.
1- ionization calorimeter absorber, 2 - scintillators, 3 - lightquids; 4 - photoelectric multipliers (FEU-84); 5 - diaphragms; 6 - lightfilters; 7 - Cerenkov counters (DZ-1); 8 - photoelectric multipliers (FEU-49); 9 - Cerenkov counters (DZ-2); 10- crate of DZ-2 charge detectors; 11- photoelectric multipliers (FEU-49).

Fig. 2. The averaged characteristics of an amplitude-time transformator. A is the amplitude of an input signal; m stands for duration of an output signal.

Fig. 3. The mean dependence of light fraction leaving the end of a scintillator on distance between a scintillation source (Co^{60}) and the scintillator end. Errors - the rms deviation of individual characteristics $J(\ell)$ from the mean one.

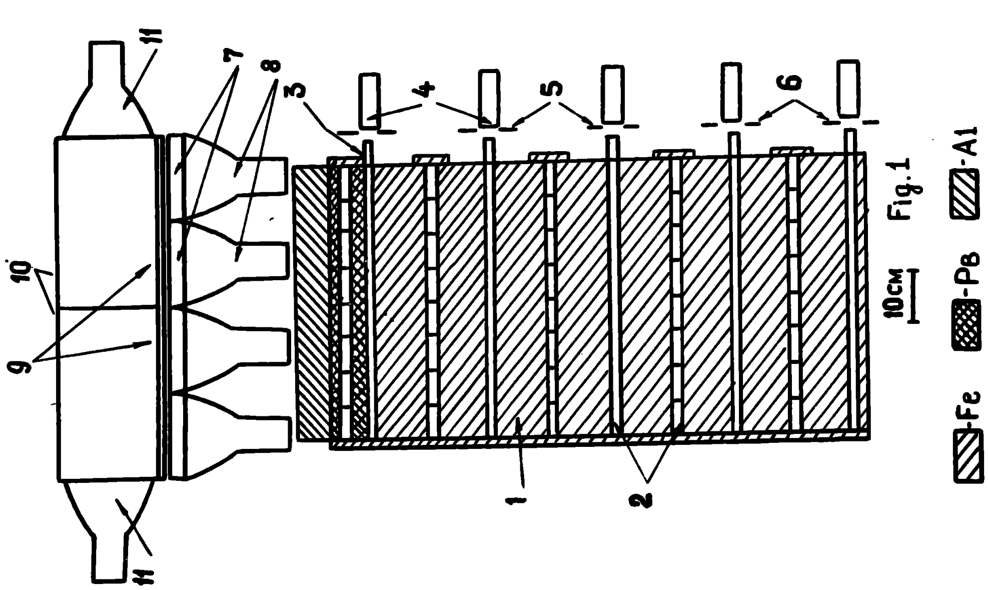

Fig.1

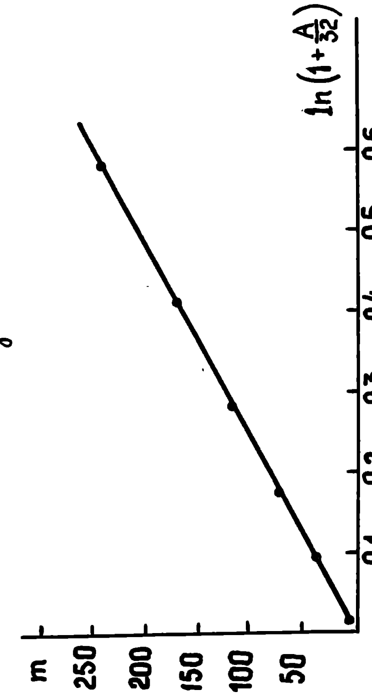

Fig.2

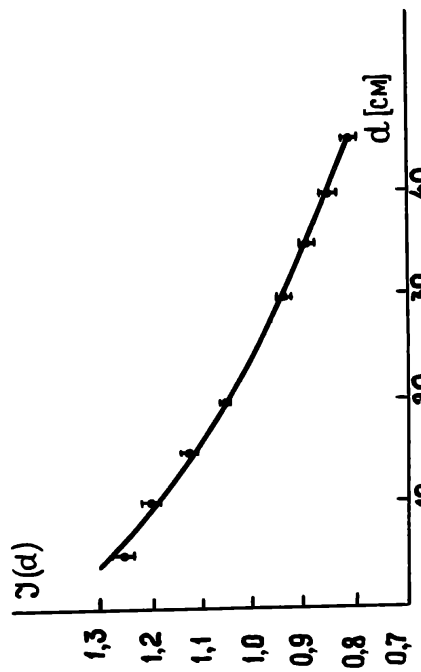

Fig.3