Comparison of experimental events with an galo with calculations on model "Tien-Shan"

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Abstract

Events with an halo were registered on the complex installation "Hadron-44", containing X-ray emulsion chamber and ionization calorimeter. The installation is situated at the altitude 3340 meters above the sea level. The characteristics of these events are compared with results of calculations on the model "Tien-Shan".

1. Introduction

In the model "Tien-Shan" [1] we accept the following characteristics of the elementary act:

1. At increase of energy the section of interaction increases by logarithmic law.
2. The average coefficient of inelasticity is taken as 0.65
3. The average multiplicity of particles, born in the act, depends on energy by the law a logarithm in square.
4. The average cross impulse is taken as 0.355 GeV/sec, and it is supposed that projections of the cross impulse on axes X and Y have normal distribution.

EAS born by primary protons of energies from $1 * 10^{17} eV$ to $3 * 10^{17} eV$ were simulated by this model and values of energies of protons were taken with a step $5 * 10^{16} eV$. Interaction of the primary proton took place at height Z1 above the installation (values of Z1 were taken from 0 to $2.5 km$ with a step $0.5 km$). For each value of energy and height ten showers were simulated. One of these ten showers, with the biggest number of electrons with energy higher than $1 MeV$ under a $4 cm$ thick layer of lead, was selected. Distributions of electron flux density under the $4 cm$ thick layer of lead at distances up to $20 mm$ from the shower axis were determined in the selected showers.

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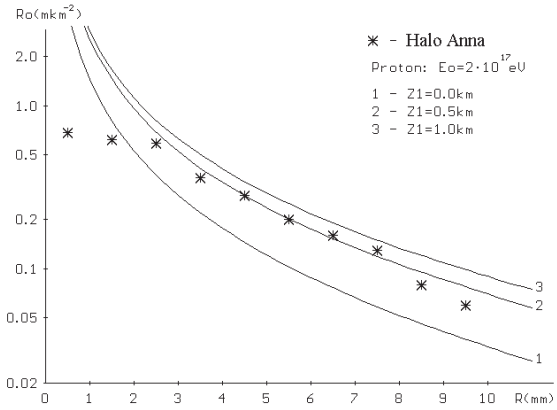

Fig. 1.

2. Results

We compared the results of carried calculations with characteristics of two halos. These halos were registered at the installation Hadron-44 and they were called "Anna" and "Sholpan". Calculations show that in all the showers that we simulated the big densities of electron fluxes appear near the axis of the shower.

The flux of such density is not observed near the axis of the shower in halo "Anna". In figure 1 we see that in halo "Anna" at distance up to $3mm$ from the shower axis the density of charged particles flux has gently sloping distribution. It is obvious thata halo of such type appears in showers with development not described by standart ideas.

From figure 2 we see that in halo "Sholpan" at distances less than $1mm$ from the shower axis the flux of particles is not described by the model calculations made by us. But in the central region of the halo (at distances less than $1mm$ from the shower axis) we could not make measurements because of big densities of tracks.

Comparison of distribution of a charged particle flux in halo "Sholpan" with results of calculations allow us to conclude: this halo might form in the shower that is described by standard ideas about the elementary act. The first act of the shower had to take place near the installation or even in the target of the installation. The carried out calculations showed that halo can appear only in the showers which get the installation in the early stage of development.

In order to clear up properties of processes in the development of EAS where halos, such as "Anna" or "Sholpan" appear, We considered different sets of gamma- quanta falling on the lead layer situated above the film. It was supposed that these gamma- quanta are products of decay of the neutral pions generated in the target situated at distance $Zg = 10m$ above the lead layer. That's why

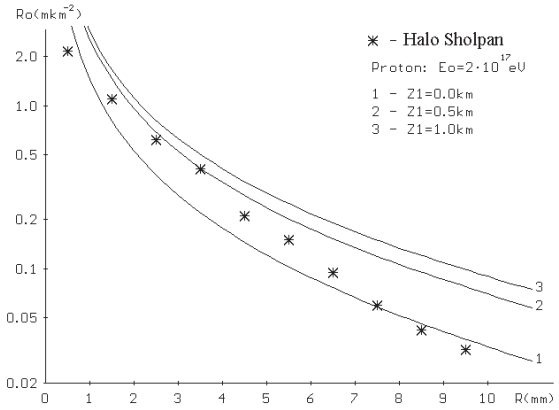

Fig. 2.

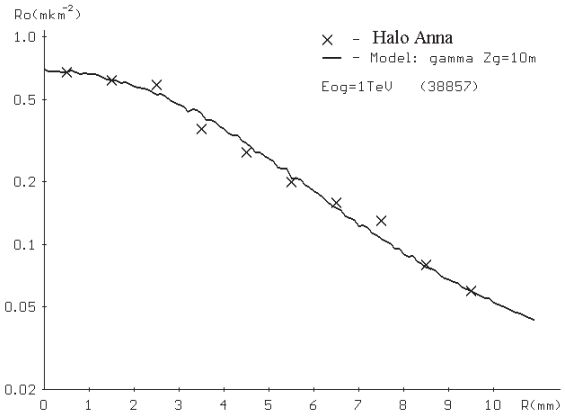

Fig. 3.

gamma- quanta, that came on the lead layer, had space distribution formed by cross pulses of pions. These cross pulses are described above in characteristics of the model "Tien- Shan".

Figure 3 demonstrates the calculation distribution of density of the flux of electrons generated in a $4cm$ thick lead approximately by forty thousand gamma-quanta with energy $1TeV$ each. We see the amazing accordance of calculation results with distribution of density of the electron flux in halo "Anna". Obviously, such good accordance points that the shower, where halo "Anna" appeared, is characterized by strong dissipation of energy in the very beginning of its development.

From figure 4 we see that a set of gamma- quanta in the range of energies from $2TeV$ to $3TeV$ allows to describe distribution of electron flux density in halo "Sholpan". Unlike halo "Anna" this halo is not described by the flux of gamma

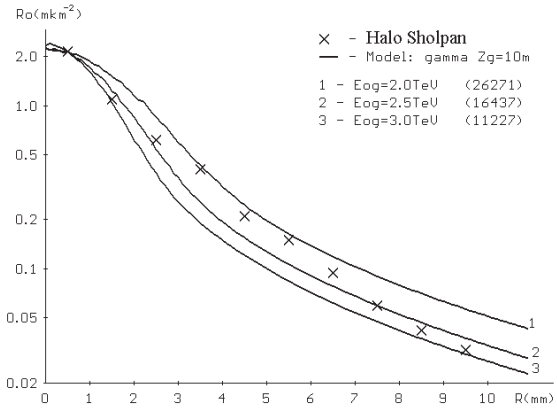

Fig. 4.

- quanta that is monochromatic in energy. That's why we can admit that it was formed in the usual shower, that started to develop near the installation.

3. Conclusions

The obtained results allow us to conclude the following:

1. Standard ideas about EAS development in the core region gives the flux of electrons that is much bigger than in halo "Anna".

2. Distribution of density of electron flux in the central part of halo "Anna" (at distances less than $3mm$ from the shower axis) is explained by too big dissipation of energy at early stages of EAS development.

3. A good accordance of calculations, where big fluxes of gamma- quanta falling on the lead layer situated above the nuclear emulsion, with experimental data points that the huge number of gamma- quanta with close energies appear in the shower, where halo is formed.

4. References

1. Beismbaev R.U., Drin E.A., Sadykov T.K. et al. Electron- photon cascades in the model "Tien- Shan". Preprint of IPT 2002-01.