SIMULATION OF GAMMA-INITIATED SHOWERS

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Abstract

The main average characteristics of muon, electron and hadron components of exstensive air showers were calculate using a standart model of nuclear interaction. The obtained results are in good agreement with Tien Shan experimental data.

1. Introduction. The method of analysis of the anomaly in the development and structure of exstensive air showers /EAS/ gives the real possibility [1] for experimental investigation of gamma-quanta with high energy in the primary cosmic radiation. On the basis of Tien Shan experimental data was shown [2], that EAS poor in muons and high energy hadrons are initiated by gamma-quanta with energy - 10^{15} eV.

2. Method. The development of electron-photon component with a threshold energy of 500 MeV in homogenous atmosphere was simulated with help of Monte-Carlo method. The primary energy of the initiated photon was $E_{o\gamma}=10^{15}$ eV.

The probability for realization of the cross-section:

$$\sigma_{\gamma p}(E) = 114.3 + 1.647\, \ell n^2 (0{,}0213\, E)$$, where $\sigma_{\gamma p}$ is in μb and E in GeV.

It was supposed, that the nuclear cascade, initiated by a proton with the same energy as the correspondent photon energy, starts in the point of the photonuclear interaction. Further there were used the differential energy spectra of pions for different deepnesses in the atmosphere[4] in attempt to evolute the analogous spectrum for the observation level 700 g. cm^{-2}. By this way were calculated the total number of muons with energy $E_\mu > 5$GeV too.

The energy flux carried by the electron-photon component of the same type of EAS was estimated with help of the lateral distribution function $\mathcal{E}_{e\gamma}[r,s]$[5] of the average energy per electron. In this case the correspondent energy flux density is:

$$\rho_E(r,s) = \rho_e(r,s)\, \mathcal{E}_{e\gamma}(r,s) = \left[N_e/(m R_M)^2\right] f_{NK}(r/m R_M, s)$$, were $\rho_e(r,s) =$ is the modifed[6] NK funktion of the lateral distribution of electrons in a shower.

3. Results. The average energy of the hadron component E_h in EAS, initiated by a primary gamma-quanta with energy 10^{15} ev was estimated for the threshold energy of the Tien Shan experimental data - $E_{htr} \geq 3.8$ GeV:

$$E_{htr}\,(> 3.8\,\text{GeV}) = 1.62 \cdot 10^{12}\,\text{eV}$$

Only ~3% of the primary energy were transfered as energy of the electron-photon component and there are ~11.5 GeV in each photonuclear interaction.

The number of muons with $E_\mu > 5$ GeV in the same showers was estimated as $N_{\mu\gamma}(E_\mu > 5\ \text{GeV}) = 555$.

4. Discusion. The total number of muons N_γ in gamma-initiated shower with energy $\sim 6.10^{14}$ eV was estimated with help of a semiemperical method[2] as 255 for the Tien Shan experimental data. Taken into account the $N_\mu(E)$ dependance[4] we obtain $N_{\mu\gamma}(6.10^{14}\text{eV}) = 361$. The average relation between total numbers of muons in gamma-initiated N_γ and normal $N_{\mu A}$ showers was estimated as $\left(\overline{N_{\mu\gamma}/N_{\mu A}}\right) = 0.047$. Taken into account the total muon fluctuations for the Tien Shan experiment[2] we can obtain the threshold value for the selection of muon poor showers:

$\left(N_{\mu\gamma}/N_{\mu A}\right) = 0.15$, what is in good agreement with the semiemperical value 0.11 [2].

The energy of the electron-photon component transfered in the Tien Shan calorimeter[7] is:

$$E_{ec} = 2\pi \int_{0.2m}^{3m} dr\, r\, \rho_E(r,s) = 6.94.10^{13}\text{eV}$$

The correspondent part of the energy of hadron component was estimated as $E_h = 3.7\ 10^{11}$ eV, taken into account the results[7, 8] about the lateral distributin of hadrons with different energies. So is the average value of the relation[2] $(E_h / E_e) = 5.3\ 10^{-3}$ and including the total fluctuation of (E_n / E_e) for Tien Shan experiment[2] we obtain for the threshold value for hadron poor shower selection $(E_h / E_e) = 1.5\ 10^{-2}$, which confirms the semiemperical value $1.42\ 10^{-2}$ too.

5. Conclusions. The results of the present calculation confirms the criteria, adopted by the analysis[2] of the Tien Shan experimental data, for selection of muon and hadron poor showers as gamma-initiated showers with energy $\sim 10^{15}$ eV

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