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Selection of showers with given energies at the GAMMA experiment (Armenia)

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Abstract

Some years ago, we defined the possibility to select showers generated by primaries with different masses but with the same primary energy at mountain altitude. The new GAMMA experiment (Armenia, 3200 m. a.s.l.) gives us the possibility to check our method using a EAS selection parameter specially adapted for this experiment.
We show that experimental data are in particularly good agreement with the corresponding values obtained by simulation using the CORSIKA code. This possibility to pick up showers fixed energies will be used to determine the primary mass composition around the knee and to select gamma-showers with energies in the range of 10^6 GeV.

1 Introduction:

One of the main purposes of EAS experiments is the determination of the energy and the mass composition of the cosmic projectiles generating extensive air showers (EAS). Though the goal is clear, an approach for a correct answer is rather complicated. Important reasons are the current standard procedures in use to extract physical information from the experimental data, e.g. a shower selection by fixed values of the shower size. It is known that fixed sizes of showers generated by primaries of different masses correspond to different primary energies. Therefore the determination of the primary mass composition from fixed size bins is not a very promising way.

2 Selection of showers with fixed energies :

A new parameter allowing a selection by fixed energies has been proposed some years ago for high-mountain altitude experiments, (J. Procureur and J.N. Stamenov, 1995). The general shape of this parameter has been proposed to be $\alpha_e(r_1)=r_1^2\rho_e(r_1)/f_{NKG}(r_2,S_{r_3-r_4})$ where $\rho_e(r_1)$ is the lateral density of the electromagnetic component measured at distance r_1 from the shower center, f_{NKG} is the well known Nishimura-Kamata-Greisen function and $S_{r_3-r_4}$ is the local age determined from densities measured at r_3 and $r_4\,m$ from the core. It has been shown that this parameter, inside the uncertainties of the nuclear interaction at very-high energies, is model independent, (Brankova *et al*., 1998), and using the CORSIKA code, (Capdevielle *et al*., 1990), the α parameter has been defined as $\alpha_e(135)=135^2\rho_e(135)/f_{NKG}(3,S_{25-135})$. It means that showers picked up with constant value of $\alpha_e(135)$ are generated by primaries with different masses but with the same energy. In fact, such a shower selection needs to measure and simulate very carefully the densities of charges particles far from the shower axis. If experimentaly this problem can be solved using detectors with large effective areas, it is more difficult, using simulation codes with pure Monte Carlo procedures, to generate muons with very low energies, (some MeV). To avoid this technical difficulty, we define a new definition of the α parameter such as $\alpha_e(40)=40^2\rho_e(40)/f_{NKG}(1,S_{15-70})$. Then, the lateral distribution of charged particles has to be carefully measured at distances not too close or not too far from the showers axis to be polluted respectively by hadrons and low energy muons.

3 Results :

Figure 1 shows the energy of primary protons and iron nuclei generating showers with given values of $\alpha_e(40)$. Results are obtained by simulation using the CORSIKA code, for the observation level $t_0 = 700\,g.cm^{-2}$ and for showers with zenith angle smaller than 30°.

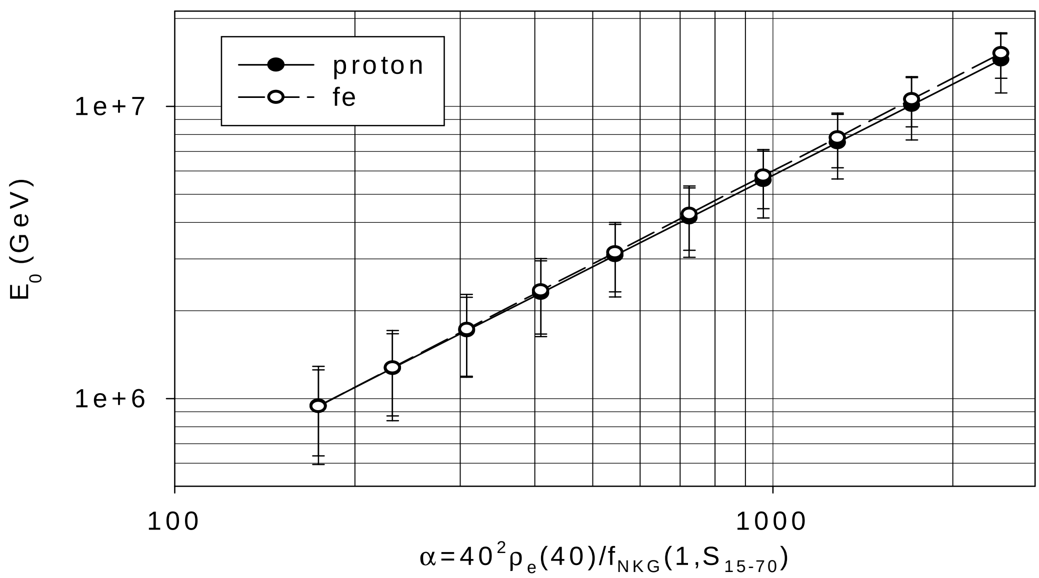

Figure 1

This figure confirms that showers selected with given values of $\alpha_e(40)$ are generated by primaries with the same energy, independently of the mass.

In order to check the reality of this fixed energy shower selection, we have drawn on a common graph, the size dependence versus the primary energy on one hand and versus $\alpha_e(40)$, on the second hand, (figure 2). It can be seen on this figure that, for primary protons or iron nuclei, the

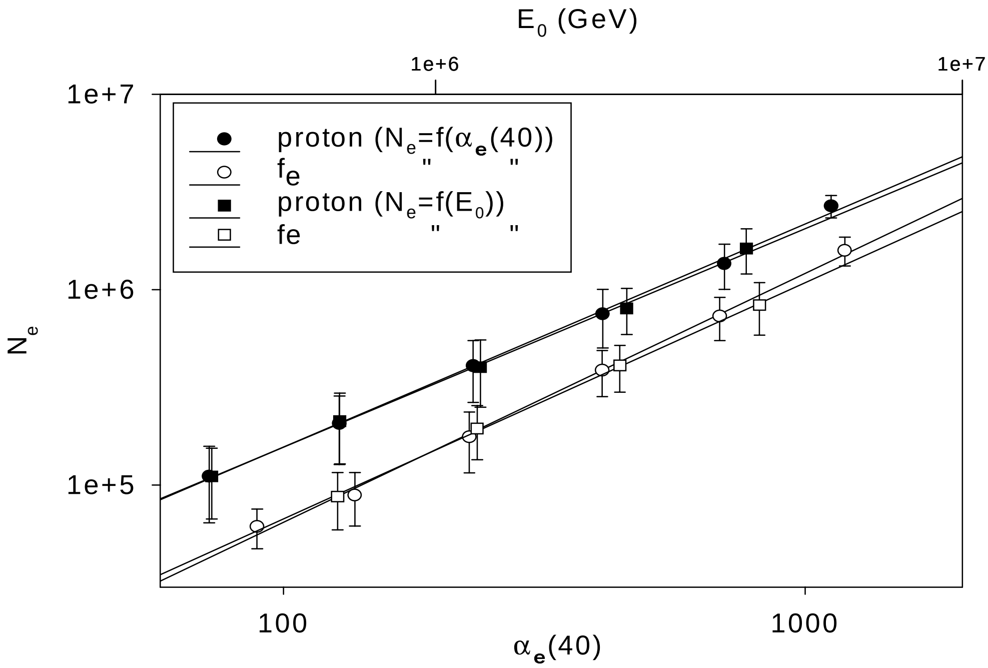

Figure 2

correspondent curves are superposed. This proof that the selections of showers with fixed values of $\alpha_e(40)$ or fixed values of the primary energy E_0 are equivalent, independently of the primary mass.

4 Comparison with the GAMMA data:

The present definition of $\alpha_e(40)$ is proposed to be apply to the GAMMA experiment, (Armenia, 3200m *a.s.l.*), (Chilingarian *et al*, 1999). On figure 3, are drawn the experimental and simulated size dependences versus the parameter $\alpha_e(40)$. Results from simulation have been obtained for the normal mixed composition : proton : 40%, α-nuclei : 21%, light-nuclei (*<A>=14*): 14%, medium-nuclei (*<A>=26*):13% and heavy-nuclei (<A>=56):12%. Simulated values of $\alpha_e(40)$ are limited to $\alpha_e(40) \approx 1000$ for the only reason that the energy upper limit of the CORSIKA code is restricted to $10^7\, GeV$

A good agreement is obtained between experimental measurements and simulated results.

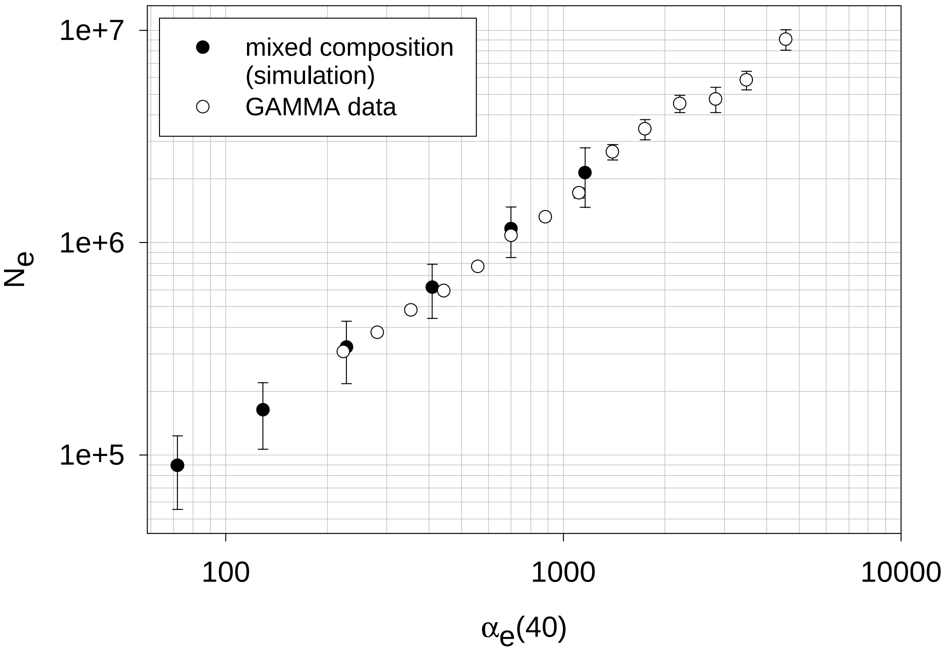

Figure 3

Conclusion:

In the present work, we define a realistic parameter $\alpha_e(40) = 40^2 \rho_e(40) / f_{NKG}(1, S_{15-70})$, depending only on the shower electromagnetic component and easily measurable to select, among showers registrated by the GAMMA experiment, those generated by primaries with the same energy independently of their mass.

This possibility to pick up showers fixed energies will be used to determine the primary mass composition around the knee and to select gamma-showers with energies in the range of 10^6 GeV

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