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Investigation of muon component of EAS at Mt. Aragats

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Abstract. The paper presents analyses of muon component of EAS measured with "GAMMA" installation at Mt. Aragats. It shows a strong dependence of muon lateral distribution shape and of total muon number from the age parameter of EAS electron-photon component. Obtained N_μ/N_e dependence demonstrates abrupt change in the knee region.

1 Introduction

The EAS muon component studies done with the "GAMMA" installation of ANI Cosmic Ray Observatory are presented. The installation is placed at Mt. Aragats, 3250 m.a.s.l. It consists of 25 registration stations measuring electron-photon component of EAS and is located in concentric circles with radii of 17, 28, 50 and 70 m respectively. Each station consists of 3 scintillation detectors with the area of $1m^2$ and 5 cm thick. 150 similar detectors are arranged in the underground laboratory for measuring EAS muon component. The registration threshold of muon detectors E_μ is $\approx 5GeV$ for 60 detectors and $\approx 2,5GeV$ for 90 detectors. The reported results were obtained during 5875 hours run of "GAMMA". The EAS parameters determination accuracies are:

- total number of particles $_\triangle N_e \leq 10\%$
- place of shower axis $(_\triangle x, _\triangle y) \leq 2m$
- age parameter $_\triangle S \leq 0.05$

Detailed description of the installation is given in Ref. (V.S. Eganov et al., (2000)). The data presented below refer to showers with $E_\mu > 5GeV$ in the zenith angle interval $\theta \leq 30°$.

2 Experimental results

From the Fig. 1 it is obvious that the shape of muon lateral distributions (MLD) significantly depend on shower size N_e. Moreover, experimental points are described well by the same curve only in limited shower size range, if $lg(N_e) < 6.47$. At greater N_e measured densities are significantly higher than approximations obtained by experimental data at low N_e and the difference increases with increasing N_e. Experimental muon lateral distributions for different age parameters and for $N_e = (3.16 - 5.62) * 10^5$ are given at Fig. 2.

A noticeable dependence of MLD function form on S parameter is observed. That has to be taken into account in procedure of integration of MLD function for correct reconstruction of the number of muons in the each shower.

For the description of MLD by a functional form the Greisen function

$$\rho_m(r) = C \times r^{-0.75}(1 + r/r_0)^{-2.5}$$

has been adopted, including experimentally obtained C and $r_\circ$ dependence from N_e and S parameters:

$$r_0 = 180 \times S^{1.5}(N_e/10^5)^{-0.15},$$

$$C = 0.42 \times (1 + 0.7 \cdot S) \times (N_e/10^5)^{0.97}$$

Muon lateral distributions for different N_e are given in Fig. 3. Distributions are approximated by adopted Greisen function. Approximations rather well describe experimental data for distances from shower axis greater than 4 m and for shower sizes up to $N_e \approx 3 \cdot 10^6$. Experimental MLD functions are flatter and higher than approximation (dashed curves) at greater N_e and difference increases with increasing N_e. The deviation of muon densities at shower sizes greater $3 \cdot 10^6$ compared with the curves at Fig. 1 reflects the change of MLD form. The approximation function parameters have to be altered for the satisfactory description of MLD for shower sizes $N_e > 3 \cdot 10^6$ in the following way:

$$r_0 = 180 \times S^{1.5}(N_e/10^5)^{-0.11},$$

$$C = 0.42 \times (1 + 0.7 \cdot S) \times (N_e/10^5).$$

This new approximation is shown in Fig.3 as solid curves.

Dependencies of muon number from total number of shower particles N_e are presented in Fig. 4. Upper dependence

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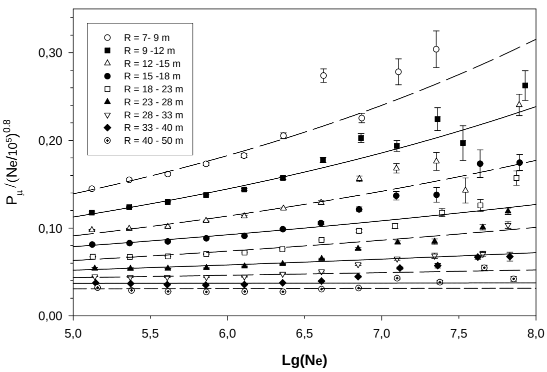

Fig. 1. Muon density at different distances from shower axis vs N_e

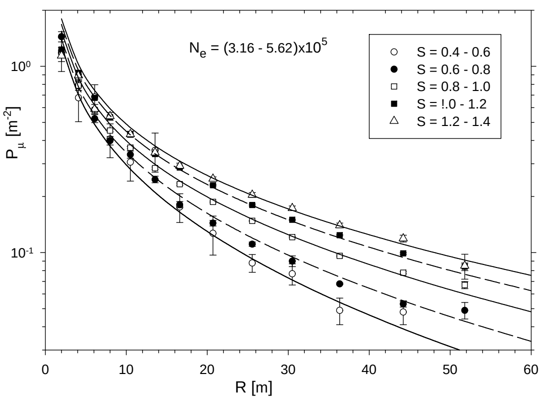

Fig. 2. Muon lateral distribution for different age parameters and $N_e = (3.16 - 5.6) \cdot 10^5)$

is obtained by determination N_μ for each registered shower by our experimental approximations. The lower curve is obtained by integrating experimental lateral distributions over observed range of distances 6-60 m (so called truncated muons). Both dependencies change slope at $N_e \approx 3 \cdot 10^6$. Similar change was observed earlier in Ref. (A.A. Chilingarian et al., (1999)), (Yu.A. Fomin et al., (1987)), (J. Weber et al., (1997)).

3 Conclusions

There is an indication in Fig. 3 and 4, that there are some changes in cosmic rays fluxes at energies of primary particles about $4.5 \cdot 10^{15} eV$. That change leads to flattening of MLD functions and growth of relative number of muons in shower. Possible explanation of the changes (including the change of mass composition, strong interaction, or methodical effects) are under consideration now.

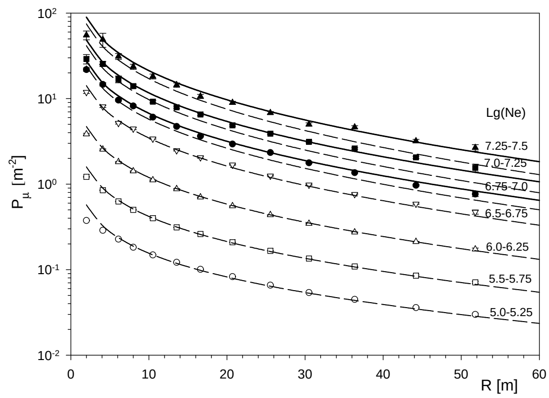

Fig. 3. Muon lateral distributions for different N_e

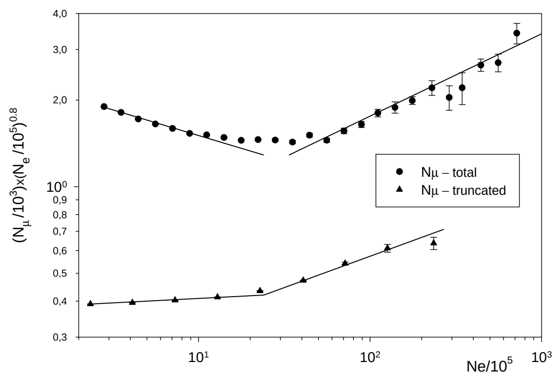

Fig. 4. Dependencies of muon number N_μ from the shower size N_e

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References

V.S. Eganov et al., 2000, J.Phis.G.; Nucl.Part.Phys., 26, 1355.

A.A. Chilingarian et al., 1999, Proc.26-th ICRC, Salt Lake City, Utah,1, 260.

Yu.A. Fomin et al., 1987, Proc.20-th ICRC, Moskow, 1, 397.

J. Weber et al.,1997, Proc. 25-th ICRC, Durban, 6, 153