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Influence of a Registration Threshold on an Increase Boundary of the Number of Inclined EAS

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Abstract: Influence of a registration threshold on an increase of the number of inclined extensive air showers with zenith angles ϑ greater than ~50° by data of Yakutsk EAS array is considered. An increase beginning at the energy above 10^{18} eV, that has been established earlier is caused by the limited energy range of EAS array. Such an increase can be for lesser energies also. Shower with big errors in arrival direction have been considered. Distortion of the number of showers dependence on zenith angle by such showers was not found.

Research of increase of inclined showers number on a data of Yakutsk EAS array, which was started in [1,2], is continued at this article. As it was shown earlier such increase correspond to transition from prevalence of electron-photon component of shower with short absorb length to muon component mainly with weak absorbtion with zenith angle growth. Abundance of inclined showers is caused by their weak absorbtion, by big absorbtion length. At giant array Pierre Auger it was noted a considerable number of very inclined showers, offering a novel view on EAS [3]. Moreover charm can be cause of an abundance of the inclined showers number at ultrahigh energies too [4].

Figure 1 shows the number of registered showers as a function of charged particles densities at a distance of 600 m from the axe ρ_{600} for different zenith angles ϑ. Influence of a registration threshold of a EAS array at ρ_{600} <0.2 particles/m^2 is seen. Figure 2 present the number of showers as a function of primary particle energy E_0 for the same zenith angle intervals as in Figure 1. It is seen that the number of showers with angles

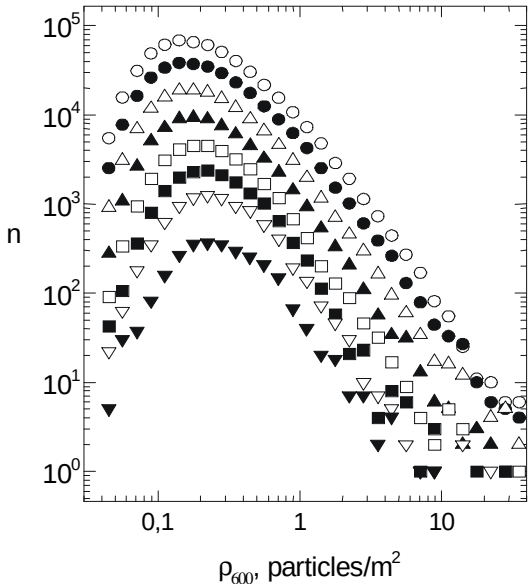

Figure 1. Dependence of n - a number of showers on charged particles density at a distance of 600 m from the axe ρ_{600} for different zenith angles: ○ - $\cos\vartheta > 0.9$, ● - $0.9 \geq \cos\vartheta > 0.8$, Δ - $0.8 \geq \cos\vartheta > 0.7$, ▲ - $0.7 \geq \cos\vartheta > 0.6$, □ - $0.6 \geq \cos\vartheta > 0.5$, ■ - $0.5 \geq \cos\vartheta > 0.4$, ∇ - $0.4 \geq \cos\vartheta > 0.3$

cosϑ<0.5 is greater than that with the other angles. In [1,2] it was shown by using the Yakutsk EAS array data that a bent point in dependence of the number of showers on the zenith angle begins from energies $E_0 > 10^{18}$ eV. It is seen from Figure 2 that the number of showers is less considerably because of influence of an array registration threshold with an energy $E_0 < 10^{18}$ eV at the angles from cosϑ =0.3 to cosϑ =0.5. So abundance of the inclined showers number may exist for energies $E_0 < 10^{18}$ eV also.

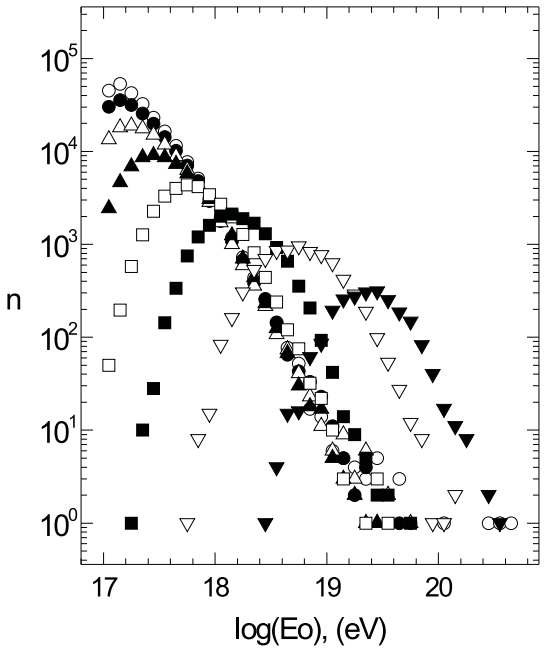

Figure 2. Dependence of n - a number of showers on primary particle energy E_0 for different zenith angle ϑ. Angles correspond to the given ones in Figure 1

Temporal readings of three detectors of Yakutsk EAS array were ~400 nsec greater than proper for a long time. Measuring accuracy is 100 nsec. Distributions of difference between temporal readings of these detectors and neighbouring ones arranged at distance of 500 m are presented in Figure 3. Such difference results in azimuth asymmetry. Figure 4 shows azimuth dependences of the shower number for all zenith angles for master triangles in which temporal reading of one detector is late by ~400 nsec.

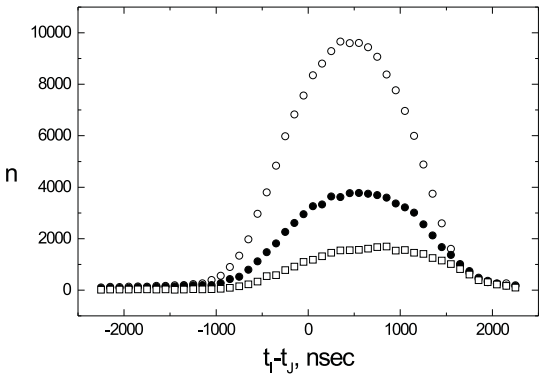

Figure 3. Distributions of difference between temporal readings of detectors with big errors and neibouring ones arranged at distance of 500 m

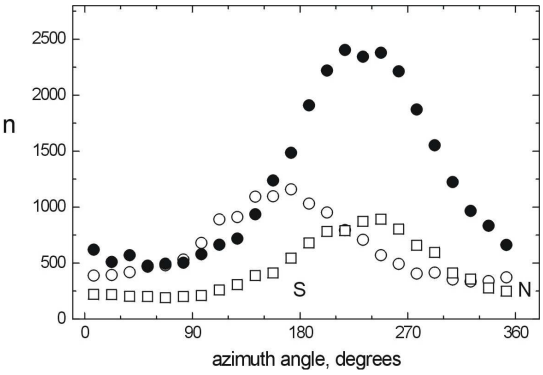

Figure 4. Azimuth dependences of the shower number for all zenith angles for master triangles in which temporal reading of one detector is late by ~400 nsec

It can be proposed that temporal reading error leads to error in arrival direction of shower and accordingly to distortion of dependence of the number of showers on zenith angle. But it is not take place as it is seen in Figure 5 for energies $E_0 > 10^{19}$ eV. Increasing boundary for showers with big errors begins with greater zenith angles for energies log E_0 > 19.6. Share of abundance of inclined showers for showers with big errors is much greater. Possible explanation may be assumption that appearance of an abundance of the inclined showers number is caused by occasinal coincidences of temporal readings. It becomes incomprehensible in that case that increase boundaries of the number of showers registered by small and large masters of Yakutsk array are

close although differ somewhat. We would remind that at the Yakutsk array the ground-based stations are located in the form of grid consisting of equilateral triangles with sides of 500 m - a small master and 1000 m - a large master.

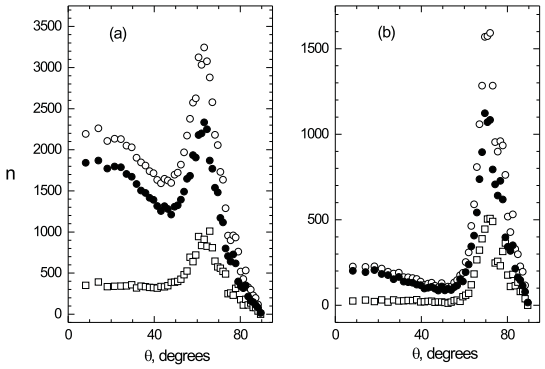

Figure 5. Dependence of n – a number of showers on a zenith angle ϑ for all showers - ○, for showers with big errors in arrival direction - □ and ordinary showers - ●. (a) - $\log E_0 > 19.0$ eV, (b) - $\log E_0 > 19.6$ eV

This question need further investigation. Influence of occasinal events on a shift of increase boundary of the number of showers depending on energy E_0 should be considered. Relative share decrease of abundance of the number of inclined showers registered by large master as compared with small master was shown in [2]. Influence of occasinal events on this decrease should be considered too.

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References

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