# Search Sources of Cosmic Rays Ultrahigh Energy

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The arrival directions of ultrahigh energy extensive air showers (EAS) by Yakutsk, AGASA and P. Auger data are considered. It is found that the arrival directions of EAS by Yakutsk, AGASA data are correlated with pulsars from side Input, by P.Auger data are correlated with pulsars from Output of Local arm Orion. It is shown that the majority of these pulsars have a short period rotate around of their axes, then it is expected by catalogue of pulsars.

## 1. INTRODUCTION

At first we have analyzed extensive air showers (EAS) by data of Yakutsk EAS array. Showers with energy $E > 5 \times 10^{18}$ eV, with zenith angles $< 60^\circ$ and the axes lying inside of perimeter of array are considered. Accuracy definition a solid angles of arrival directions is $5 - 7^\circ$, energy - $\sim$ 30%.

Early we have been found showers with a deficit content muons [1]. Theoretical calculations show [2], that the content muons of showers reflect a mass composition of the particles which have formed them. Probably, EAS with the usual content muons are formed by the charged particles, EAS with the deficit content muons - neutral particles.

## 2. EXPERIMENTAL DATA

Among EAS with the deficit content muons we found 21 EAS without muon component (a threshold of registration muons by detectors is $> 1$ GeV). If a probability of registration this EAS was $> 10^{-3}$ the given EAS was excluded from consideration. Each case of registration of showers without muons components was carefully checked - whether measured parameters of EAS is certain correctly. Also we have found 5 EAS with pour muons - a density muons at distance $> 100$ m from axis was less, than it is expected ones more $3\sigma$ .

In Fig.1 on equal - exposition map of celestial sphere distribution of these 26 EAS is shown. Distribution of EAS with deficit muons is not isotropic, from a galactic plane some excess a observed number of EAS is observed: $n(|b| < 30^\circ)/n(|b| > 30^\circ) = 1.9 \pm 0.7$. In case of isotropy this ratio will be equal 1.2 according to [3].

We have found among these EAS 5 doublets and from them 4 doublets are located at one region of a celestial sphere: $\delta = 20^\circ - 75^\circ$ and $60^\circ < RA < 80^\circ$. The fifth doublet which consists of two EAS: one without muons and the other - with poor muons, is located near Input of the Local arm of the Galaxy Orion.

We are interested in this maximum of doublets and consider a distribution of EAS with usual muons on a right ascension RA. We divided a observed region of energy $E > 10^{18}$ eV into 4 intervals: 1) $10^{18} - 5 \times 10^{18}$ eV, 2) $5 \times 10^{18} - 10^{19}$ eV, 3) $10^{19} - 4 \times 10^{19}$ eV, 4) $> 4 \times 10^{19}$ eV and the distribution of EAS on the right ascension was analyzed by harmonic functions of Fourier (Fig.2).

Note, that phase of 1-st harmonic $RA \sim 300^\circ$ at $E \sim 10^{18}$ eV from the Local Arm of Galaxy varies gradually with energy to $RA \sim 90^\circ$ at $E \sim 4 \times 10^{19}$ eV where 4 doublets are located.

Further we consider distribution EAS on the right ascension also. We have divided a region of energy into 3 intervals: 1) $5 \times 10^{18} - 10^{19}$ eV, 2) $10^{19} - 4 \times 10^{19}$ eV, 3) $> 4 \times 10^{19}$ eV.

In Fig.3 distribution of particles is shown. We

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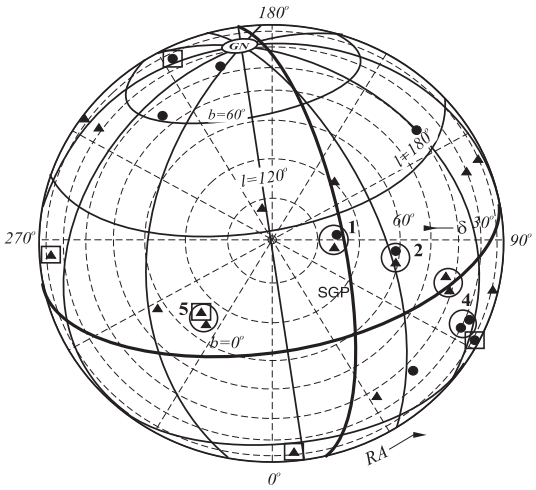


Figure 1. Distribution EAS with deficit muons: ▲ - EAS which correlated with pulsars, •- EAS which uncorrelated with pulsars. ◯ - doublets, □ - EAS which consist from poor muons. $\delta$ - declination, RA - a right ascension, b,l - galactic latitude, longitude.

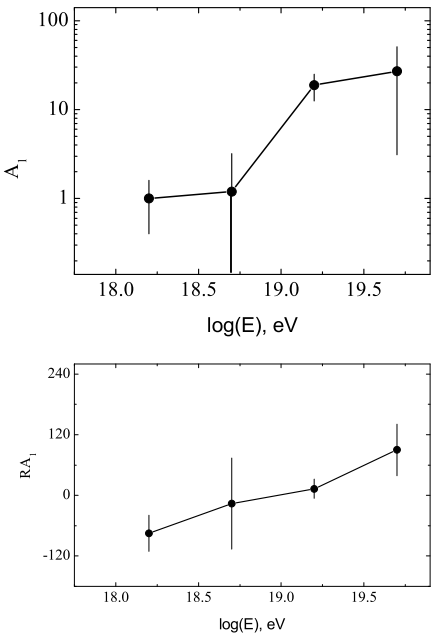


Figure 2. Amplitudes $A_1$ and phase's $RA_1$ 1-st harmonic Fourier are shown in energy intervals.

observe a maxima of the distribution particles at 2 first intervals of energy at coordinates $60° < RA < 90°$. Most likely from this region of celestial sphere we observe neutral and charged particles.

From 26 EAS with deficit muons only 17 EAS correlate of angular distance 6° with pulsars [5] (we choose 6° because at $E \sim 10^{19}$ eV and this angular distance from pulsars a correlation between arrival direction of EAS with usual muons and pulsars at was maximum [6]). Arrival directions of 17 EAS are marked by triangles. Distribution of these EAS which correlate with pulsars is isotropic in the mainly, but the majority of them it is observed near a galactic plane.

Further we have considered the arrival directions EAS with energy $E > 4 \times 10^{19}$ eV - do they correlate with pulsars?. Thus, we have selected pulsars which are situated at angular distances $< 6°$ from arrival directions of EAS. According by Yakutsk data we have found such 19 EAS from 34 (these EAS are noted by triangles, Fig.4), according to array AGASA [7] - 21 EAS from 57 (Fig.5), according to array P. Auger [8] - 10 EAS from 27 (Fig.6). Arrival directions of these EAS, which are correlated with pulsars, are situated near a galactic plane and at Input (Yakutsk and AGASA) and at Output (P. Auger) of the Local arm of the Galaxy Orion. Note, earlier we found anisotropy of arrival directions particles with energy $E > 4 \times 10^{19}$ eV from side Input and Output of the Local arm by data of these arrays [9]. Correlation with pulsars and anisotropy arrival directions of EAS is not possible to explain by extragalactic origin of particles.

We consider the rotation periods of pulsars which correlated with EAS. Ratio number of pulsars with periods $P_0 < P$ to the number of pulsars which have the periods $P_0 > P$ is shown in Fig.7 (in case of Yakutsk array we have considered EAS

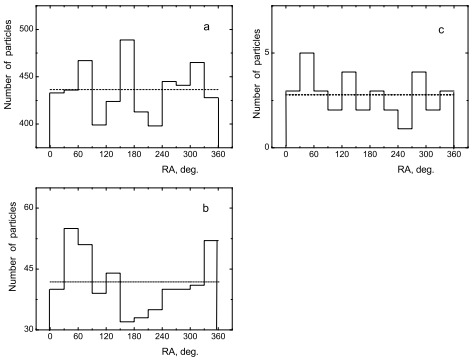


Figure 3. Distribution particles in energy intervals: a) $E = 5 \times 10^{18} - 10^{19}$ eV; b)$10^{19} - 4 \times 10^{19}$ eV; c) $E > 4 \times 10^{19}$ eV.

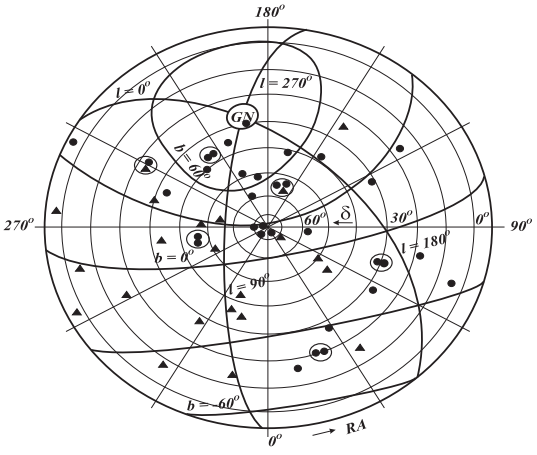


Figure 5. AGASA: distribution particles with $E > 4 \times 10^{19}$ eV. ▲, •- EAS which correlate and uncorrelare with pulsars according to.

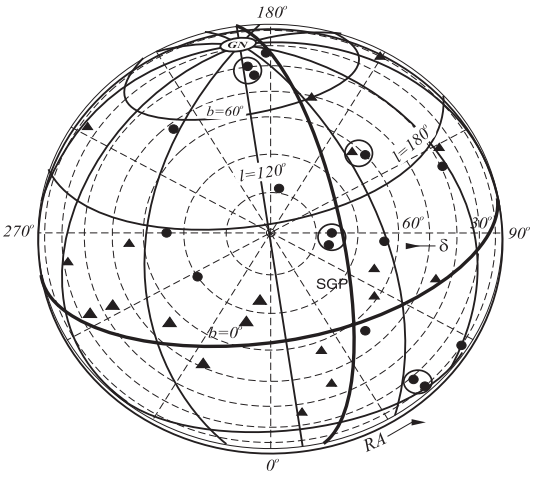


Figure 4. Yakutsk: a distribution particles with $E > 4 \times 10^{19}$ eV: ▲, •- EAS which correlate and uncorrelare with pulsars according to.

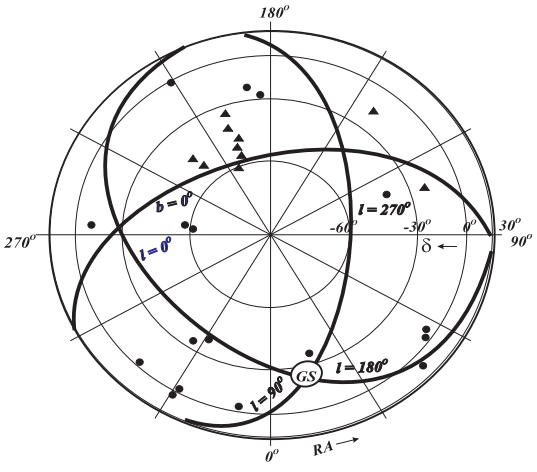


Figure 6. P.Auger: distribution particles with $E > 4 \times 10^{19}$ eV. ▲, •- EAS which correlate and uncorrelare with pulsars according to.

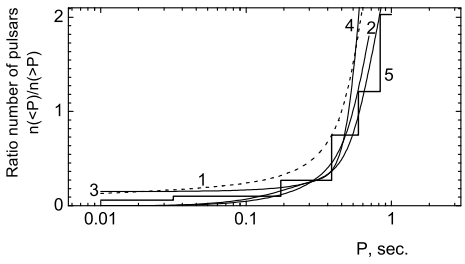


Figure 7. Ratio number of pulsars with period $P_0$ - $n(P_0 < P)/(n(P_0 > P)$: 1 - pulsars, which correlated with deficit muons EAS of Yakutsk; 2 - pulsars, which correlated with EAS of Yakutsk; 3 - pulsars, which correlated with EAS of AGASA; 4 - pulsars, which correlated with EAS of P. Auger; 5 - pulsars according catalogue [5].

with a deficit and usual muons). As seen from Fig.7 majority of pulsars have short periods $P_0$ than it is expected according to the catalogue of pulsars. Some authors showed that short period pulsars can accelerate heavy nuclei up to $10^{20}$ eV [10,11].

## 3. CONCLUSION

The analysis of EAS with a deficit content muons by Yakutsk data show that third part of them form doublets which are located in mainly on right ascension $60^\circ < RA < 90^\circ$ . At this coordinates maximum distribution of usual EAS at energy $E \sim 10^{19}$ eV by Yakutsk data is observed.

It is found that particles with energy $E > 4 \times 10^{19}$ eV by data of Yakutsk, AGASA and P.Auger correlate with pulsars which are situated near Input and Output of Local arm of Galaxy Orion. Majority of these pulsars have a short period rotation around their axes. Facts that anisotropy and corelation EAS with pulsars from side Local arm Galaxy of Orion it is difficult to explain by an extragalactic origin of cosmic rays. Most likely cosmic rays have a galactic origin and their sources are pulsars.

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