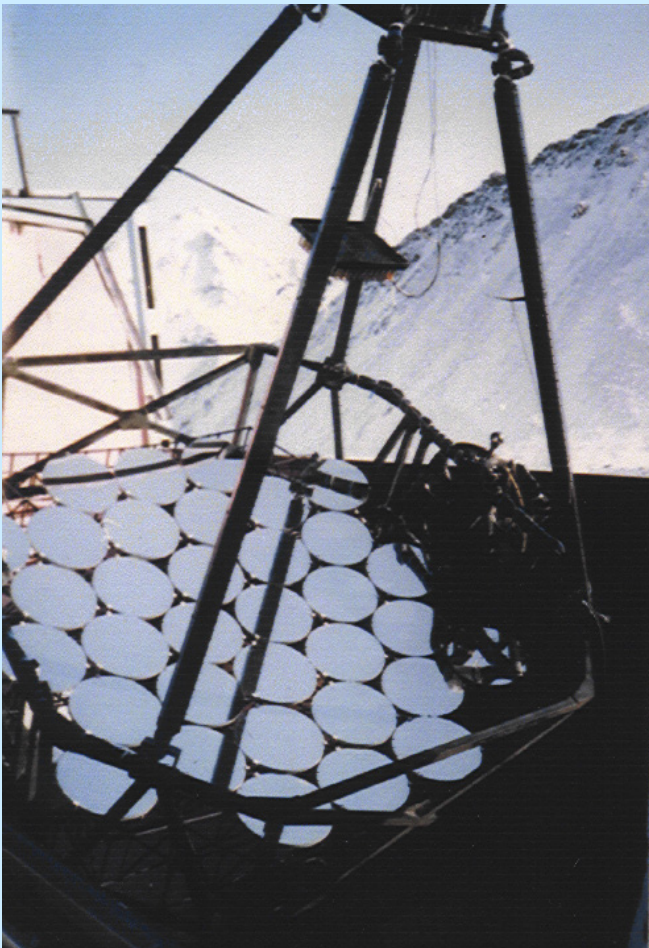


**A search for astrophysical point sources of
neutrino with high mountain SHALON
atmospheric Cherenkov telescopic system.**

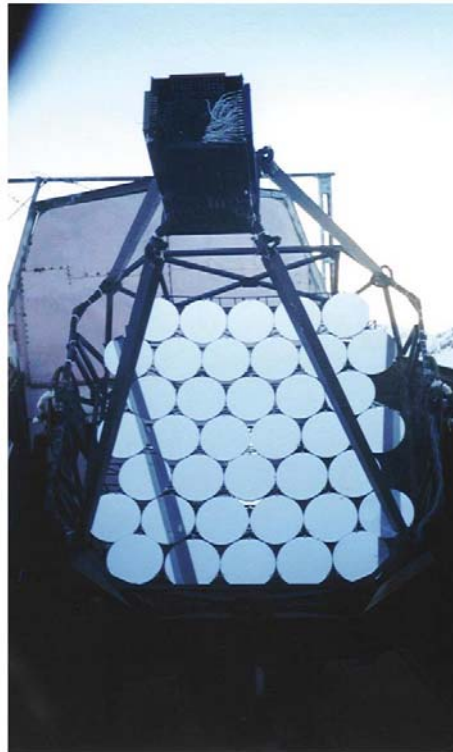
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S. I. NIKOLSKY, V. Y. SINITSYNA,

*P. N. Lebedev Physical Institute,
Leninsky prospect 53, Moscow, 119991 Russia*



A search for astrophysical point sources of neutrino with SHALON Atmospheric Cherenkov Telescopic System.



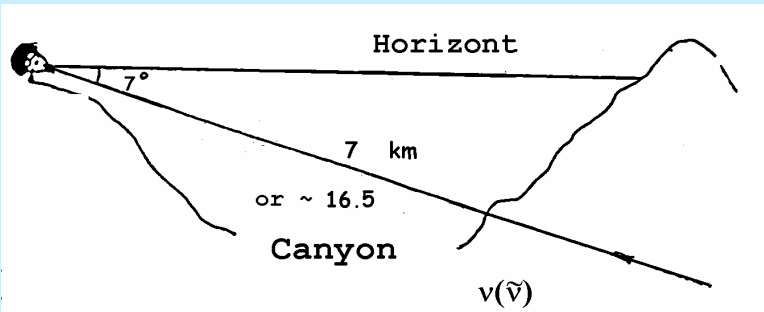
The detection of Extraterrestrial Very High Energy Neutrinos by atmospheric Cherenkov Telescopic System SHALON is discussed. The analysis of results of observation of extensive air showers at height of 3338 m above the sea level by means of gamma-telescope SHALON at the zenith angles 72° , 76° , 84° , 97° are presented. The observation results are compared with the data of detection of showers according to the direction into the zenith. The observation has been carried out at Tien -Shan station with SHALON gamma-telescope. The SHALON telescopic system has mirror with area of 11.2 m^2 and 144 PMT matrix with 0.1° angular resolution, that has the most in the world field of view $>8^\circ$. It allows to control the background of cosmic ray particle emission and the atmospheric transparency continuously with observation that means the increasing of observation efficiency. So it is the telescope characteristics that permit to start the search of local neutrino sources with energy $10^{13} - 10^{16} \text{ eV}$ on EAS generating in mountain-range located at some 6 and more kilometers from gamma-telescope (in Russian the SHALON abbreviation means - the Extensive Air Showers from Neutrino).

A search for astrophysical point sources of neutrino with SHALON Atmospheric Cherenkov Telescopic System.

A neutrino telescope detects the Cherenkov radiation generated in water or ice by passage of relativistic charged particles produced by neutrino collisions with nucleons in the detector volume. Because of weakness of neutrino interaction the very large detector volume is required. Some alternative approaches have been proposed. One of them is using a earth matter or mountain as a target volume for conversion neutrinos to leptons which then initiate extensive air shower (EAS) in the atmosphere, then showers can be detected by Cherenkov telescope. Observations of neutrino initiated EAS at the mountain shadow seems attractive because of mountain valley screened from background showers of cosmic rays and the only particles that can survive are neutrinos with energies $> 10^{13}$ eV came under the horizon. The cascades with energy $> 10^{13}$ eV are generated by neutrino in the ground of mountain on the thickness < 300 g/cm². The Cherenkov radiation of the hadron cascades will be observed along the direction of neutrino by gamma-telescope placed on the distance about 7 kms from a mountain slope in area of more than 7×10^5 m². So, UHE neutrinos may be searched in observations at large zenith angle.

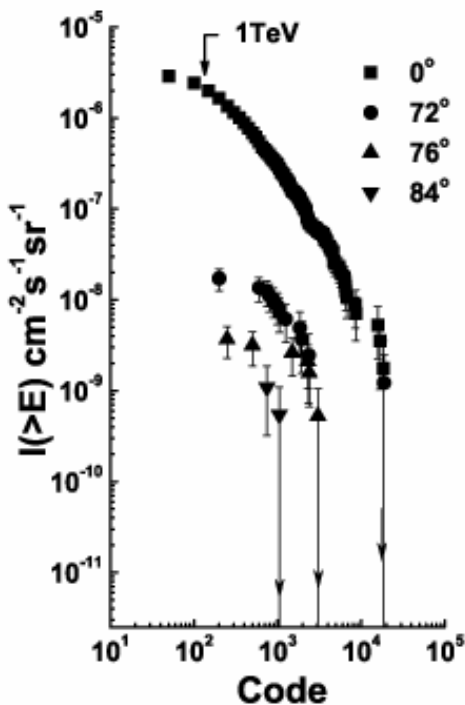


Extensive Air Showers under a Large Zenith Angle

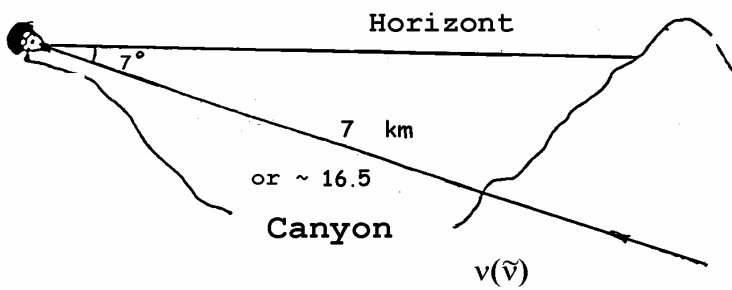


The telescope is calibrated according to the observations of EAS of cosmic ray at 0° - zenith angle. The cosmic ray shower image detected in the SHALON telescope, generally is elliptic spot in the light receiver matrix, written in the ADC counts (CODE).

Observations at large zenith angles have been aimed on study of spectra of the air showers induced by cosmic rays crossing through different atmosphere thickness and events accompanying the passing of EAS and cosmic ray particles near horizon. The observation at large zenith angles 72° , 76° , 84° showed that the efficiency of Cherenkov light detection drops essentially as a zenith angle increases, perhaps because of dissipation and absorption in the atmosphere. So, the comparison of observation results shown that at the zenith angle 84° the number of observed showers is ~ 25 times less than expected by estimation with neglecting by absorption and dissipation of Cherenkov photons in the atmosphere.

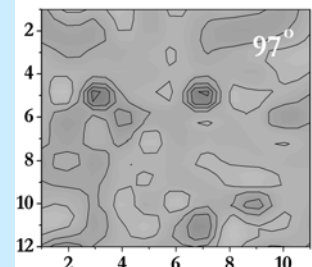
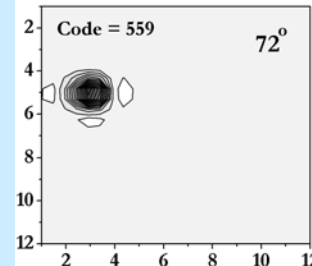
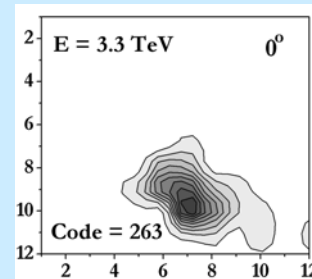
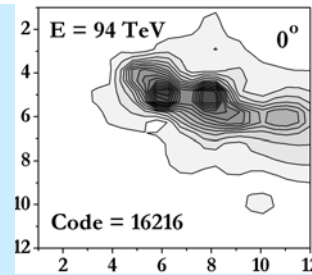
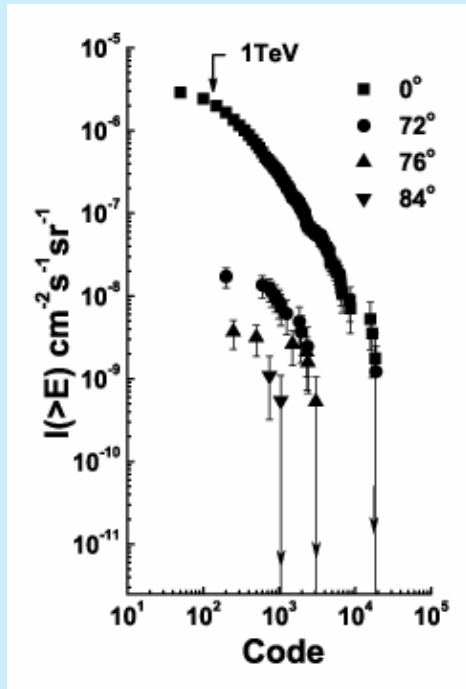


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|--------------|----|----|-----|-----|------|-----|------|-----|-----|-----------|-----|----|----|----|-----|-----|------|-----|------|-----|-----|-----|-----|
| EVENT No 224 | | | | | | | | | | 0° | | | | | | | | | | | | | |
| 23:52:39.71 | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | 18 | 17 | 11 | 39 | 46 | 29 | 67 | 35 | 40 | 40 | 20 | 13 | 18 | 17 | 11 | 39 | 46 | 29 | 67 | 35 | 40 | 40 | 20 |
| 8 | 0 | 21 | 25 | 0 | 42 | 58 | 86 | 60 | 67 | 44 | 21 | 8 | 0 | 21 | 25 | 0 | 42 | 58 | 86 | 60 | 67 | 44 | 21 |
| 0 | 22 | 27 | 70 | 0 | 109 | 108 | 75 | 87 | 53 | 41 | 22 | 0 | 22 | 27 | 70 | 0 | 109 | 108 | 75 | 87 | 53 | 41 | 22 |
| 0 | 0 | 17 | 72 | 686 | 624 | 164 | 147 | 180 | 100 | 83 | 79 | 0 | 0 | 17 | 72 | 686 | 624 | 164 | 147 | 180 | 100 | 83 | 79 |
| 15 | 0 | 66 | 112 | 391 | 1379 | 797 | 1300 | 244 | 131 | 214 | 166 | 15 | 0 | 66 | 112 | 391 | 1379 | 797 | 1300 | 244 | 131 | 214 | 166 |
| 7 | 23 | 27 | 98 | 143 | 144 | 493 | 767 | 799 | 497 | 599 | 297 | 7 | 23 | 27 | 98 | 143 | 144 | 493 | 767 | 799 | 497 | 599 | 297 |
| 11 | 15 | 13 | 30 | 50 | 79 | 122 | 257 | 184 | 246 | 284 | 260 | 11 | 15 | 13 | 30 | 50 | 79 | 122 | 257 | 184 | 246 | 284 | 260 |
| 11 | 14 | 24 | 23 | 34 | 58 | 133 | 88 | 124 | 126 | 167 | 175 | 11 | 14 | 24 | 23 | 34 | 58 | 133 | 88 | 124 | 126 | 167 | 175 |
| 9 | 13 | 27 | 24 | 23 | 33 | 41 | 53 | 52 | 31 | 58 | 69 | 9 | 13 | 27 | 24 | 23 | 33 | 41 | 53 | 52 | 31 | 58 | 69 |
| 7 | 13 | 24 | 12 | 22 | 12 | 65 | 58 | 48 | 110 | 47 | 57 | 7 | 13 | 24 | 12 | 22 | 12 | 65 | 58 | 48 | 110 | 47 | 57 |
| 10 | 14 | 19 | 22 | 14 | 18 | 45 | 28 | 0 | 21 | 31 | 53 | 10 | 14 | 19 | 22 | 14 | 18 | 45 | 28 | 0 | 21 | 31 | 53 |
| 11 | 17 | 8 | 9 | 21 | 19 | 24 | 17 | 14 | 26 | 34 | 23 | 11 | 17 | 8 | 9 | 21 | 19 | 24 | 17 | 14 | 26 | 34 | 23 |
| EVENT No 46 | | | | | | | | | | 0° | | | | | | | | | | | | | |
| 23:35:50.56 | | | | | | | | | | | | | | | | | | | | | | | |
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| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
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| 0 | 0 | 0 | 0 | 0</ | | | | | | | | | | | | | | | | | | | |



Extensive Air Showers under a Large Zenith Angle

The analysis of the observations allows one to make the following conclusion. At first, a night star sky doesn't produce any background events, preventing the observations of electron-photon cascades coming from under the earth surface. Secondary, the observation of Cherenkov bursts from extensive air showers under the large zenith angles, for example using of horizontal extensive air showers for investigation of an energy spectrum of ultra-high energy cosmic rays is complicated by absorption of Cherenkov photons by a large atmosphere thickness.



The spectra of showers observed under 0° , 72° , 76° and 84° zenith angles

| Zenith angle, Θ° | Atmosphere depth, g/cm^2 | Number of Cherenkov bursts per hour |
|------------------------------|-----------------------------------|-------------------------------------|
| 72° | 2250 | 7 ± 1.14 |
| 76° | 3000 | 1.8 ± 0.5 |
| 84° | 5950 | 0.5 ± 0.01 |

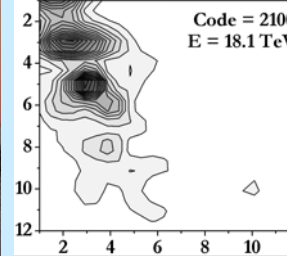
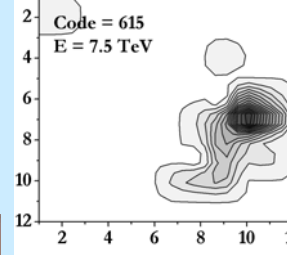
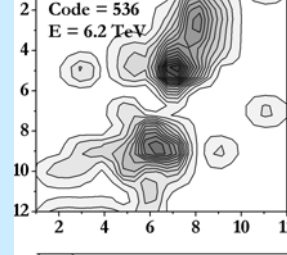
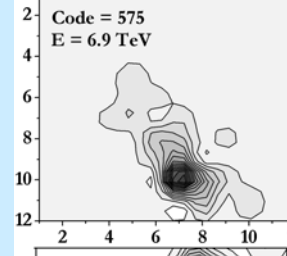
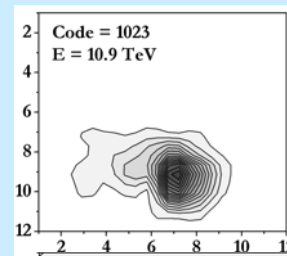
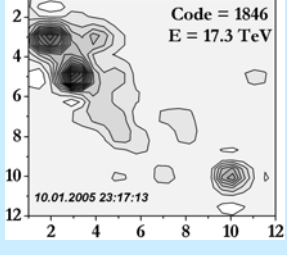
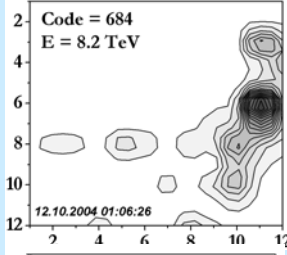
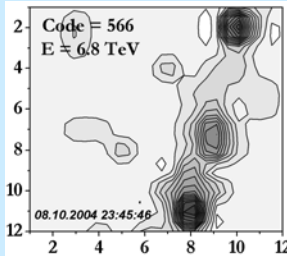
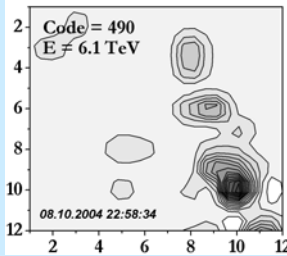
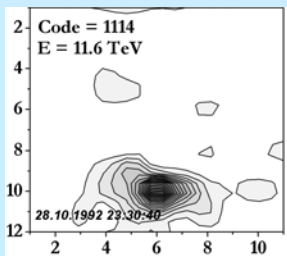
The amplitude of gray - scale shower image is proportional to the ADC count. The number, named CODE, shows the range of detected signals in the ADC counts, which are proportional to shower energy.

A search for upward UHE neutrinos with SHALON atmospheric Cherenkov telescope

0°

97°

Observations at 97° zenith angle have been done in cloudless nights in absence of artificial lights and dry air. During 324 hours of observation 323 short-range bursts were recorded. The picture of 318 of these is flash that chaotically or smoothly spread along whole the matrix or its part. These events may be interpreted as a reflection of EAS Cherenkov burst from a snow mountain slope or as a ionisation luminescence of the atmosphere if vertical EAS transits within field of view. But 5 events have form characteristics similar to those observed at 0° zenith angle. These cascades look like the usual extensive air showers generated in atmosphere with narrow light shape. The shower energies are in the range of 6 - 17.5 TeV. The background for this events can be some reflections of cosmic ray EAS in the mountain slope. First of all it could be a reflection of showers initiated by particles born in interaction of very high energy cosmic rays and rock matter nucleons. The energy of detected showers is more than 6 TeV. There is no albedo particles of such high energies. One more source of particles with high transverse energy is jet production. The probability of hadronic jet production with energy of observed showers is ten orders of magnitude less than one for detection of shower generated by secondary particles of UHE neutrino interaction. The estimated neutrino event rate is one shower per 100 hours for neutrino of all flavours and fluxes expected by models. It corresponds to rate of $\sim 10^{-15} \text{ cm}^{-2} \text{ s}^{-1}$ that is comparable to fluxes of weak gamma-quantum sources presently observed by SHALON.



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