INVESTIGATION OF APPLICABILITY OF THE ASKARIAN METHOD FOR HIGH-ENERGY NEUTRINO DETECTION IN THE AVAN SALT MINE

V. S. Pogosov, O. F. Pogosova, L. A. Poghosyan, E. E. Reimers

A.I. Alikhanian Natianal Science Laboratory, Yerevan, Armenia

Received 27 December, 2010

Abstract-The results of the first stage measurements of the attenuation lengths of radio waves in the Avan salt mine are presented. The goal of these measurements was to determine the availability of the Avan salt dome to utilize it for ultrahigh energy cosmic neutrino detection by means of Askaryan method application. The necessity for additional measurements is concluded.

Ultra-high energy (UHE) cosmic neutrino detection is interesting for many reasons. Apparently only it can give the information about far sources of high-energy particles. Thus, gamma-quanta with energies about 1 TeV can pass without a significant interaction with relic microwave cosmic background radiation about 100 Mpc, and 1 PeV gamma-quanta about 10 Kpc only. The charged component of cosmic rays (though exceeds hundreds times of photons one) does not give an information about a place of sources because of an influence of intergalactic magnetic fields on their trajectories. The UHE charged particles, which aren't deviated by magnetic fields noticeably, interact intensively with above mentioned relic background. This process, which is named GZK-process, was first described by Greisen, Zatsepin and Kuzmin [1,2]. The above constrains the possibilities to use charged and photon components of cosmic rays in high-energy astrophysics. Outer Galactic astrophysics in the region out of 100 Mpc at the energies above 10¹⁶ eV requires to use other particles. Among the known particles only high-energy neutrinos can be used for this purpose. High-energy neutrinos could be produced through the interaction of extremely accelerated particles with the remnant gas or through GZK-processes, and the secondary neutrino spectrum has a strong dependence on the primary cosmic rays spectrum. So, the investigation of this neutrinos spectrum gives the unique opportunity to retrace the evolution of the cosmic rays acceleration and propagation processes. In addition, the detection of high energy neutrino allows to study their interaction with nucleons at energies of hundreds TeV in the center of mass system. Such neutrinos could be detected through secondary high-energy charged particles, which are produced as the result of neutrinos - target interactions. An enormous huge volume of target and effective detection system are needed for this kind of experiment.

A promising approach toward satisfaction to conditions mentioned above is to utilize the method, based on the detection of radio component of the coherent Čerenkov radiation of the electron-photon cascade in condensed matter produced by high-energy charged particles. The

radiation arises as the result of an excess of electrons in a cascade because of annihilation of positrons in matter, and processes of involvement of Compton electrons and δ -electrons into the shower. This effect was first described by G. Askarian [3]. He obtained that the intensity of radio component of the coherent radiation quadratically increases with the energy of showers, and exceeds the intensities of optical Čerenkov radiation and all the others radiation processes at the energies of several PeV. Askarian also proposed a few materials as detection media, including salt. An experimental confirmation of the Askarian effect in salt was proved at SLAC [4]. Applicability of this method depends on two basic conditions – an attenuation length of radio waves in the chosen media, and the volume of this media, because these two conditions determine the effective volume of a target. The possibility to place the wide spread system of receiving antennas is needed also.

The capability to utilize the Avan salt dome, which has a volume of several cubic kilometers, for UHE neutrino detection is considered. There is an empty area about square kilometer in this salt mine at the depth of 660 m of water equivalent, where our underground laboratory is placed. Such an area allows putting a large array of receiving antennas. The main question is the attenuation lengths for radio waves in this salt. This subject was the goal of our investigation. On one of the walls in underground laboratory five parallel 1.5 m boreholes for antennas allocation were drilled. Each borehole has 1.5 m depth. Maximal distance between holes is 12.5 m, which is determined by technical conditions, taking into account the minimal expenses and the fact that we wanted to test our measurements method on this stage. Each pair of boreholes was used to place there transmitting and receiving dipole antennas. A pulse generator which provides a set of sine pulses in the 50-500MHz region was made. To avoid problems connected with reflections as well as with a possible radiation of outer cable of transmitting system, the pulse generator was embedded into the transmitting antenna. Control measurements showed the absence of signal in the receiving system when transmitting antenna is placed into borehole and receiving one is out of holes. It proves an ability of chosen method. A receiving antenna was connected to high sensitive device SMU-8.5. The intensity of radio waves should decrease with a distance from the transmitting antenna as 1/Rbecause of axial symmetry of the dipole antenna radiation. So the ratio of intensities I_1 and I_2 of signals that detected by antennas placed at distances R_1 and R_2 consequently from the transmitting antenna should be the following:

$$\frac{I_1}{I_2} = \frac{R_2}{R_1} \exp\left[\alpha \left(R_2 - R_1\right)\right],$$

where $\alpha = 1/L$, *L* is the attenuation length in salt.

There are values of the attenuation lengths obtained for four different radio frequencies – 140 MHz, 200 MHz, 330 MHz and 400 MHz in one set of our measurements presented in the table below.

Frequency, MHz	140	200	330	400
L, meters	2.56 ± 0.30	2.29 ± 0.24	1.11 ± 0.06	0.90 ± 0.04

Table

It should be made a conclusion that our salt mine is not applicable for above mentioned neutrino experiments if obtained properties are the same for all the salt dome. But as it was emerged later, there is a volume which is filled with water abuts on the wall where the measurements were carried out. This circumstance could dramatically change the real properties of the salt in the investigated region. It is necessary to investigate the other regions to make the final conclusions. So we are going to continue our measurements.

Acknowledgements

We are grateful to head of COMETA enterprise K.Mosoyan for technical aid, and to V.Sahakyan, who was one of the initiators of presented work. We much obliged to Avan Salt Mine management and miners for the gratuitous constant assistance.

REFERENCES

- 1. G.T.Zatsepin, V.A.Kuzmin, Sov. Phys. JETP Lett., 4, 78 (1966).
- 2. K.Greisen, Phys. Rev. Lett., 16, 748 (1966).
- 3. G.A.Askar'yan, Sov. Phys. JETP, 14, 441 (1962)
- 4. P.Gorham et al., Phys. Rev. D, 72, 023002 (2005).