First Results Obtained With Wide-Angle Cerenkov Light Telescope - BEO - p. Mussala

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Abstract

The first results from experiment using Cerenkov light of EAS, reflected from the snow surface of Ice Lake - p. Mussala, Bulgaria are described.

The construction of the telescope was started in autumn 2000.The first measurements with 1-meter diameter reflectors and FEU110 were carried out in winter 2000-2001.

During 2002-2003 the detector was improved. The first results obtained in winter 2002-2003 are presented in this paper.

Introduction

Our experiment is based on the Prof. A.E. Chudakov (1972)[1] idea to detect the Cerenkov light from EAS reflected by snow surface.The special feature of that method is the possibility to use a sensitive area over some hundred square kilometers with comparatively small detectors.

The intensity of Cerenkov light from EAS is proportional to the energy of the primary cosmic ray particle so this method is a calorimetric one. It gives the possibility for experimental investigation of the primary spectrum of the cosmic rays with very and ultra high energies.

The Basic Environmental Observatory on peak Mussala (2925-m a.s.l) provides a real opportunity for realization of that method. The Ice Lake is located in the Mussala circus region, at 200 m below the peak (2925-m a.s.l). The lake's area is approximately 20.10^3 m^2. Its surface retains an ice-cover approximately 7 to 8 months annually.

Detector is situated on the 212m high mountain ledge nearby Ice Lake and registers the Cerenkov light of the air showers reflected from the snow surface of the lake.The limits of the zenith angle for the photons descended by the reflecting surface, are determined by the terrain's specifics: d=0.73 rad

The detector setting up consists of two parabolic reflectors with 1.40-meter diameter each. The light spots are detected by two photomultipliers (FEU-49B),

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which are placed on the focal plane of the each reflector.In order to reduce the noise from the starlight background blue filters are attached on the cathodes of the photomultipliers.

Simulations

Monte Carlo simulations were done in order to estimate the expected characteristics of the telescope. Except the simulation for registering Cerenkov light pulses reflected from the lake surface, we carried out also simulations of events when the detectors are pointed to the zenith and register direct Cerenkov light pulses from the night sky. (Although it's not the aim for which the detectors are constructed, zenith measurements are a good way to check the simulations and the correct work and adjustment of the detectors.)

In both simulations we used our approximation of lateral distributions of Cerenkov photons on the basis of simulation data (CORSIKA) given by Arqueros at all [4].For the zenith simulations we take randomly distributed axes of the showers in a circle with radius 1000 m around the detectors.In the simulation of reflected from the lake Cerenkov light we take the axes of the showers in a circle with radius 200 m. (As the lake is ~80m diameter and the mountain slopes around it limit the zenith angle of the shower axes falling to the lake to 0.73 rad).The distribution of the simulated events according the number of Cerenkov photons reaching the cathode of the photo multiplier – spectra by number of photons - is shown on fig. 1a (detectors pointed to zenith) and fig. 1b (detectors pointed at the lake).In both cases are done simulations in two energy regions 3.10^{14} eV to 10^{16}eV with $\gamma = 2.6$ and above 3.10^{15}eV with $\gamma = 3$. Integral spectra are shown on the figures 1a, 1b.

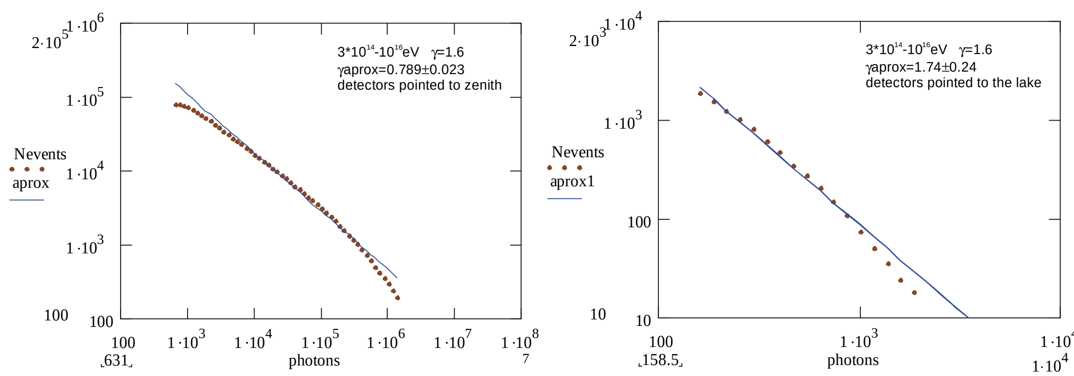

Fig. 1. Simulated amplitude spectra of cherenkov pulses

Experimental results

After first registration of Cerenkov light pulses reflected from the lake surface with oscilloscope, the two photomultipliers were connected to a coincidence circuit and the dependence of the of the number of coincidences per minute (counting rate) on the threshold of the discriminators was explored. The result is shown on fig. 2.

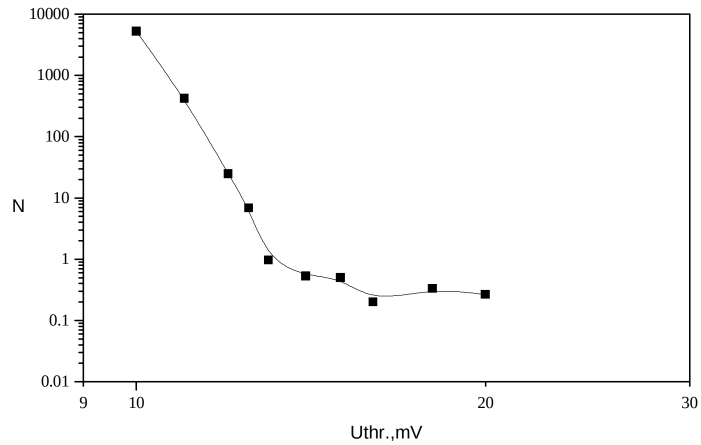

Fig. 2. Counting rate of the two detectors (pointed at the lake) at different thresholds of the discriminators.

Below 12-13 mV the counting rate sharply increases because of random coincidences due to the fluctuations of the night sky light background. Over 12-13 mV the number of coincidences per minute decreases with a smaller extent – this part of the counting characteristic are the Cerenkov pulses.

According to this first results and the slopes of the pulses (registered by storage oscilloscope) a 2 channel 8 bits logarithmic ADC was constructed. Its block scheme is shown on fig 3." Master " condition is coincidence of the anode pulses over the threshold for the two photomultipliers. The dynamic range of the input pulses is 10^3.

The first measurements of the amplitude distribution of the anode pulses of the photo multipliers are made in the winter of 2003."Master" condition was the coincidence of the pulses that were over the threshold of discriminators. (The threshold was set to 12.5 mV according to fig .3 During the exposition time of 974 min 1960 events registered.

On fig. 4a is shown the amplitude spectra (integral) of the anode pulses of the photo multipliers for Cerenkov light reflected by the lake surface and on fig.4b that for direct zenith measurements (detectors pointed to zenith).

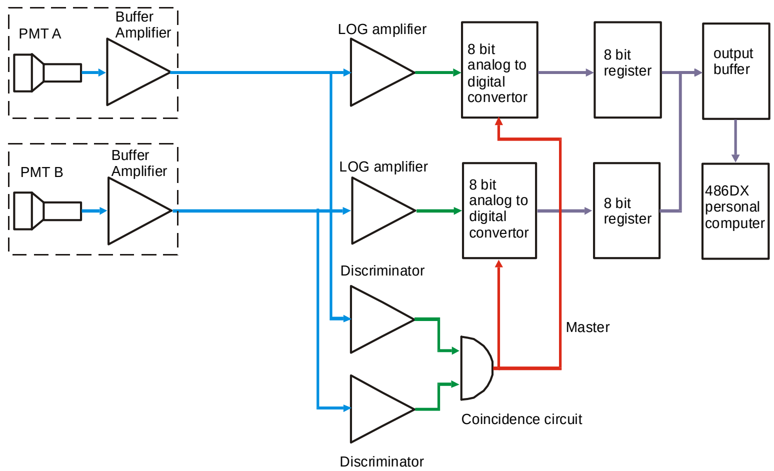

Fig. 3. Block - Schematic of the ADC

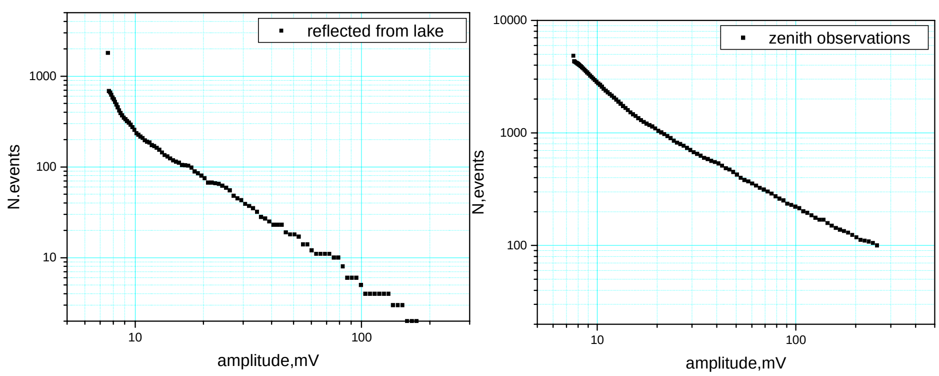

Fig. 4. Amplitude distribution (integral spectra) of registered cerenkov pulses a) reflected from lake b) zenith observations

Conclusions

With improved detector the first results were obtained in winter 2002-2003.The obtained amplitude spectra of the registered events from the Ice Lake are shown.Calibration of the photomultipliers and ADC channels is in progress. Further experimental investigations will be carried on the next autumn.

References

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