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CZELTA - detector of the secondary cosmic rays shower

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Abstract. We present basic facts about the CZELTA detector of secondary cosmic rays showers. This detector is located on the roof of the building of the Faculty of Natural Sciences of the Šafárik University in Košice. It consists of three scintillation detectors which simultaneously detect secondary cosmic rays showers. The system has fully operated since October 2010 and provides data to the central server. The detector is a great improvement of the technical infrastructure of cosmic research at the Šafárik University. It allows us to study high energy particles as well as to involve students into cosmic physics research and give them opportunity to work with original data.

Key words: cosmic particles – detection

1. Introduction

Cosmic rays consist of high-energy particles coming to the Earth from outer space (primary cosmic rays) and a shower of particles created in the Earth's atmosphere as a consequence of interaction of primary particle with the atmosphere (secondary cosmic rays). Secondary cosmic rays originate about 30 km above the Earth's surface and consist of many different particles (e.g. pions, mesons, electrons, positrons, neutrons). This shower can reach the surface of the Earth and the stricken area as well as the amount of the produced secondary particles depends on the energy of the primary particle.

The composition of charged primary particles varies with energy, however, about 90% of primary particles are protons, 7% are α-particles (helium nuclei), 2% are electrons and positrons and 1% are heavier nuclei (Perkins, 2009). Neutral primary particles are composed of photons, neutrinos and anti-neutrinos.

The sources of cosmic rays are: (i) - solar wind with energy of particles $E < 10^{10}$eV, (ii) - interstellar ionized gas with $E \sim 10^{10-11}$eV, (iii) - supernovae with $E < 10^{15}$eV, (iv) - processes in supermassive black holes in active galactic nuclei and quasars with $E < 10^{19}$eV, (v) - gamma ray bursts $E \sim 10^{19}$eV, and (vi) - exotic sources and topological defects in space-time $E > 10^{19}$eV.

The maximum detected energy of primary cosmic rays reaches values between 10^{20-21}eV. For comparison, the most powerful accelerators on the Earth can accelerate particles up to $\sim 10^{12}$eV. A big mystery remains the existence of particles with energy above 10^{20}eV. Those particles should not exist in such big amounts as it is observed by cosmic ray experiments.

2. CZELTA detector

CZELTA (CZEch Large-area Time coincidence Array) is a project of the Institute of Experimental and Applied Physics (IEAP) of the Czech Technical University (CTU) in Prague (Nyklíček & Smolek, 2005). It is based on the ALTA project. The aim of this project is to made a relatively sparse net of detection stations, which will be placed mainly on the roofs of selected high schools or universities in Europe. These stations can detect secondary cosmic rays showers with minimal energy of primary particles $\sim 10^{14}$eV. According to construction of the detection station, one can determine also an approximate location of the source in the sky.

The working station is composed of three square scintillation detectors with the dimensions 60x60 cm located in a plastic box with stabilized temperature (Fig. 1, left panel). A BC-408 scintillator is used. Each scintillation detector is connected to a photo-multiplier, which detects photons originated from the passage of particle of the secondary cosmic ray shower through the scintillator. The photo-multiplier is calibrated by a LED calibration diode.

All three detectors are pairwise connected, so particles of a cosmic shower have to hit all three scintillators to be stored. The detectors are arranged into a triangle with a side length of 10 m. The area of the triangle defines a minimal size of the shower and, therefore, a minimal energy of an original primary particle has to be $> 10^{14}$eV. A GPS signal is used for the time-labeling of the events in each detector. The accuracy of time determination is $\sim$10 ns. Time difference among the signals from the detectors is used for the calculation of the point in the sky (up to a certain resolution) from which the original primary particle came from (Fig. 3). Using precise time calibration we can study long distance correlations of cosmic showers.

The signal from scintillation detectors is recorded by an electronic block connected to the control computer (Fig. 1, right panel). The electronics evaluate each signal from all photo-multipliers together with the GPS time signal and determine counts of detected particles as well as the location where the particle came from. Data are sent to the central server, where measurements from all stations are collected. All these data are freely accessible from the web page: *http://czelta.utef.cvut.cz/index.php*. This server provides also information about the status of individual stations, histograms of events counts (Fig. 2), as well as directions of events (Fig. 3).

3. CZELTA in Slovakia - SKALTA

The CZELTA detector for the Faculty of Natural Sciences of the Šafárik University in Košice was provided in the frame of Centre of space research: space weather influences. Because of tradition, we renamed it to SKALTA (SlovaKiAn Large-area Time coincidence Array). The system is installed on the roof of the building of the Faculty of Natural Sciences (Fig. 1, left panel).

SKALTA started to collect data at the end of June 2010. Till the end of the September 2010, the detector operated in a testing mode, where all components and functions were extensively tested. Since October 2010 SKALTA has operated in a normal mode with full connection to the central server.

4. Conclusion

The SKALTA detector is a great improvement of the technical infrastructure of cosmic research at the Šafárik University. This instrument allows us to study cosmic particles with energy exceeding that obtained in the most powerful accelerators on the Earth (e.g. LHC). The great benefit of SKALTA is a possibility to involve university as well as high school students into research and give them opportunity to work with original data.

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URL: ALTA, `http://csr.phys.ualberta.ca/alta/`

Figure 1. Left panel: the scintillation detectors on the roof of the building of the Faculty of Natural Sciences of the Šafárik University in protecting plastic boxes, right panel: the electronic block for data acquisition with the control computer for a data analysis.

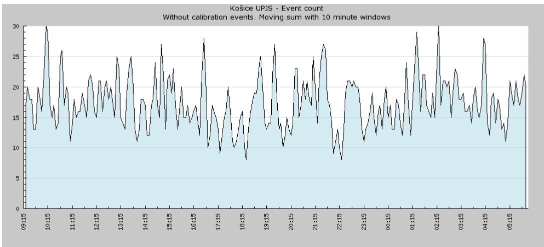

Figure 2. A histogram of events counts.

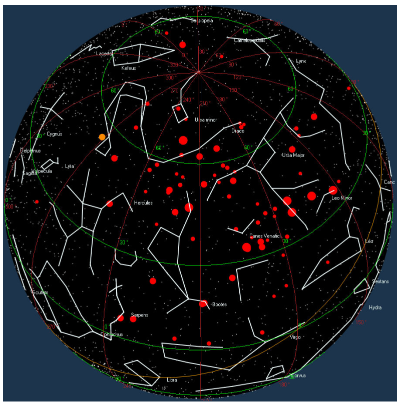

Figure 3. The positions of detected cosmic rays showers in the sky.