New Results of the EAS-1000 Prototype Operation

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Abstract

The EAS-1000 prototype was constructed in the central part of the EAS MSU array for the new instrumentation testing and for checking its reliability and stability at a long EAS array operation. A brief description of the prototype structure and the first scientific results of the prototype operation are presented.

1 Introduction

Since 1996 the prototype of the EAS-1000 array is being operated in the central part of the EAS MSU array on the site of Moscow University. The main aim of the prototype operation is testing of new instrumentation and checking of reliability and long duration stability of apparatus in natural conditions. The prototype comprises 8 scintillation detectors (Detector Unit—DU) with 1 sq.m area each, placed in orthogonal net with step 22 m (Fig. 1). Scintillator is viewed with one photomultiplier (FEU-173). The PM signal amplitude (charge is integrated over 5 microsec) and the signal arrival time are digitized and sent via optical fiber cable to the Central Registration Unit.

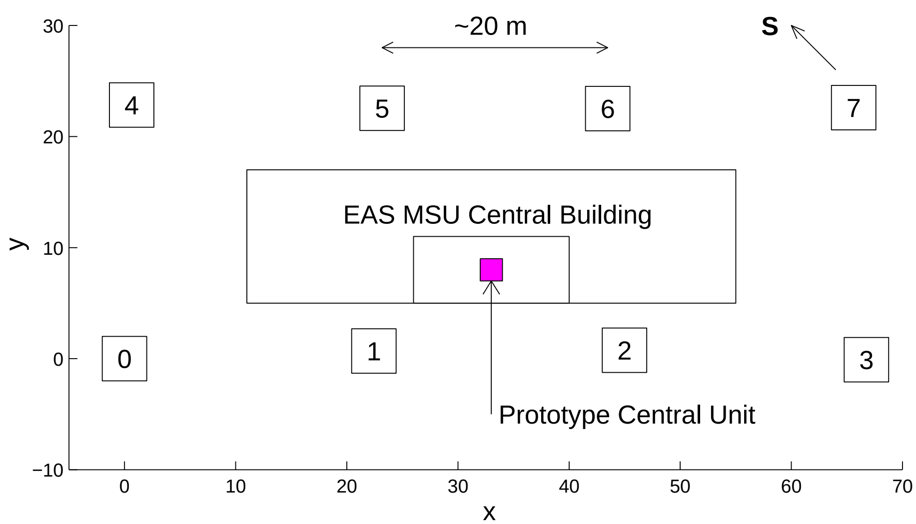

Figure 1: The layout of the detector units of the EAS-1000 prototype.

The electronics of the prototype can measure time intervals in range 5 nsec–50 microsec with accuracy of 5 nsec and amplitude in range 1–10^4 relativistic particles (r.p.) with accuracy of 10% (Fomin et al., 1998). The digital part of electronics implemented on Field Programmable Gate Array (FPGA) XC-4008 with 3000–13000 gates/package from Xilinx Inc.

The EAS events are selected by coincidence in time of the DU signals with the amplitude threshold 0.3 r.p. in 4 neighboring DU making a square in the orthogonal network. The coincidence resolving time (3.8 microsec) is quite sufficient for shower registration at detector spacing 500 m for any zenith angles.

2 Scientific Results

The experimental data were collected during the prototype operation time in the period from August, 1997 till February, 1999. For analyses 184 days were selected when all 8 detectors worked on round the clock (total time 4416 hours). The number of detected showers is 1.51×10^6 (mean rate 5.7 shower per minute).

The distribution of arrival temporal intervals between neighboring showers is presented in Fig. 2. It can be approximated well by exponential distribution of the arrival time intervals assuming that the moments of the event occurrence are completely random. The mean value of a temporal interval is about 10.6 sec.

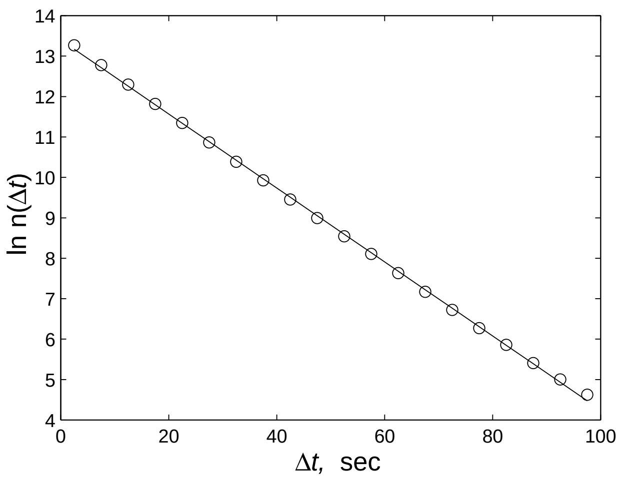

Figure 2: Distribution of arrival temporal intervals.

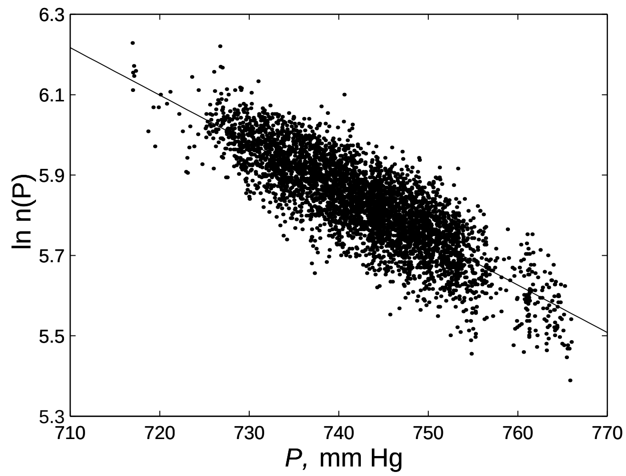

Figure 3: Dependence of the showers rate on pressure.

For each detected shower the main parameters are determined: the arrival direction of shower axis, its position on the observation level, the total number of charged particles. The values of atmospheric pressure and temperature are also registered.

The dependence of showers rate on pressure is presented in Fig. 3, where $n(P)$ is a number of shower per hour and P is the mean pressure during an hour. This dependence is well described by exponential law with the barometric coefficient

$$\beta = (1.18 \pm 0.02) \times 10^{-2} \quad \text{mm Hg}^{-1}.$$

The straight line in Fig. 3 is the result of linear regression.

As to the temperature coefficient, the correlation of shower rate with temperature is practically absent in temperature interval studied.

The sidereal time variation of cosmic rays was also studied. Using the method of harmonic analysis we obtained the amplitudes and phases of the first and the second harmonics. They are

$$A_1 = 1.8 \times 10^{-3}, \quad \psi_1 = 76^\circ, \quad \text{and} \quad A_2 = 4.4 \times 10^{-4}, \quad \psi_2 = 35^\circ$$

respectively. The errors for amplitudes and phases were calculated according to (Linsley, 1975) and proved to be as follows:

$$\sigma(A_{1,2}) = 1.15 \times 10^{-3}, \quad \sigma(\psi_1) = 36^\circ, \quad \sigma(\psi_2) = 74^\circ.$$

Thus, the presented values of the amplitudes are only the upper limits for the anisotropy. The obtained result corresponds to the median primary energy about 3×10^{14} eV.

The current data on the anisotropy for the northern hemisphere are shown in Fig. 4, taken from (Smith & Clay, 1997). Increasing of statistics for further study of the cosmic ray anisotropy will be continued.

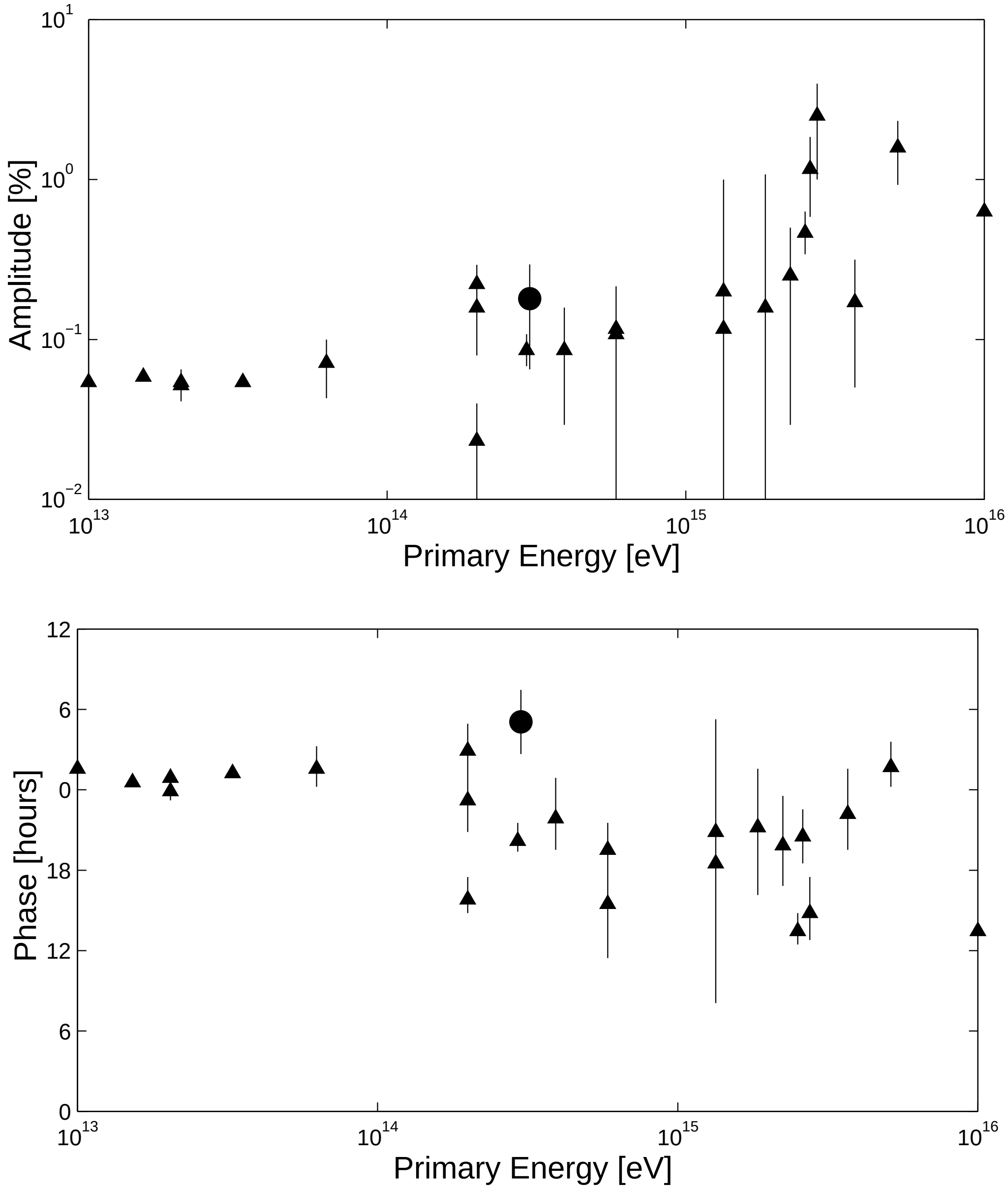

Figure 4: Amplitude and phase of the first harmonic. Circles represent our results.

In addition we can point out that the prototype allows to obtain some EAS parameters. The results of the EAS electron lateral distribution were published in (Fomin et al., 1998). Here we present experimental data on the EAS density spectrum (Fig. 5). Increasing of the density spectrum slope at densities $\gtrsim 10^3$ m^{-2} is explained by existence of the knee in the EAS size spectrum as it follows from the analysis made in our earlier paper (Kulikov et al., 1982).

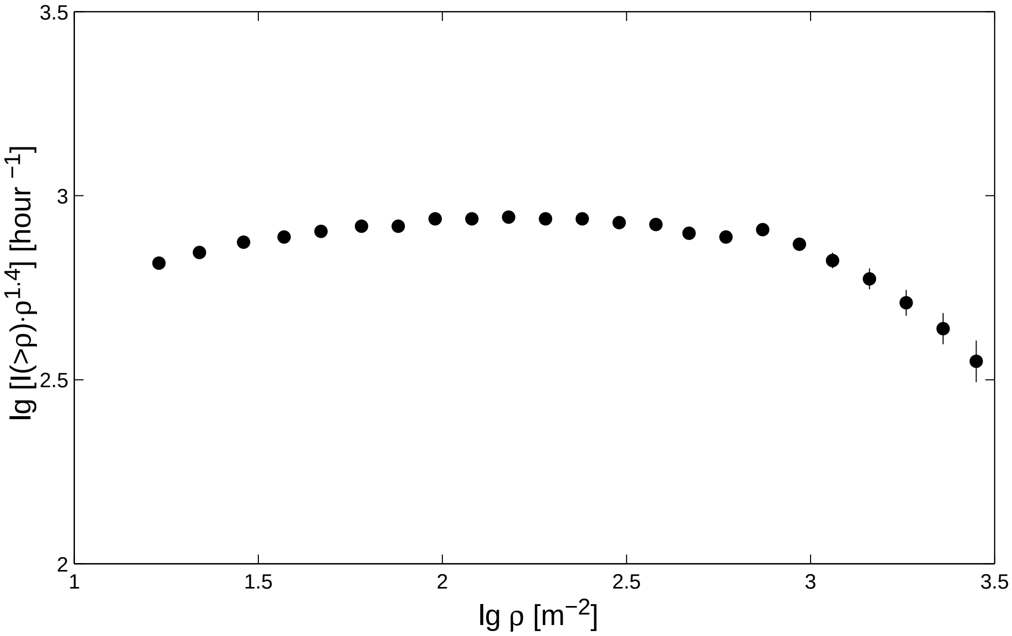

Figure 5: The EAS density spectrum.

Acknowledgments

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