Scientific & Educational Centre NEVOD

Reconstruction of the characteristics of air showers according to the URAN array data

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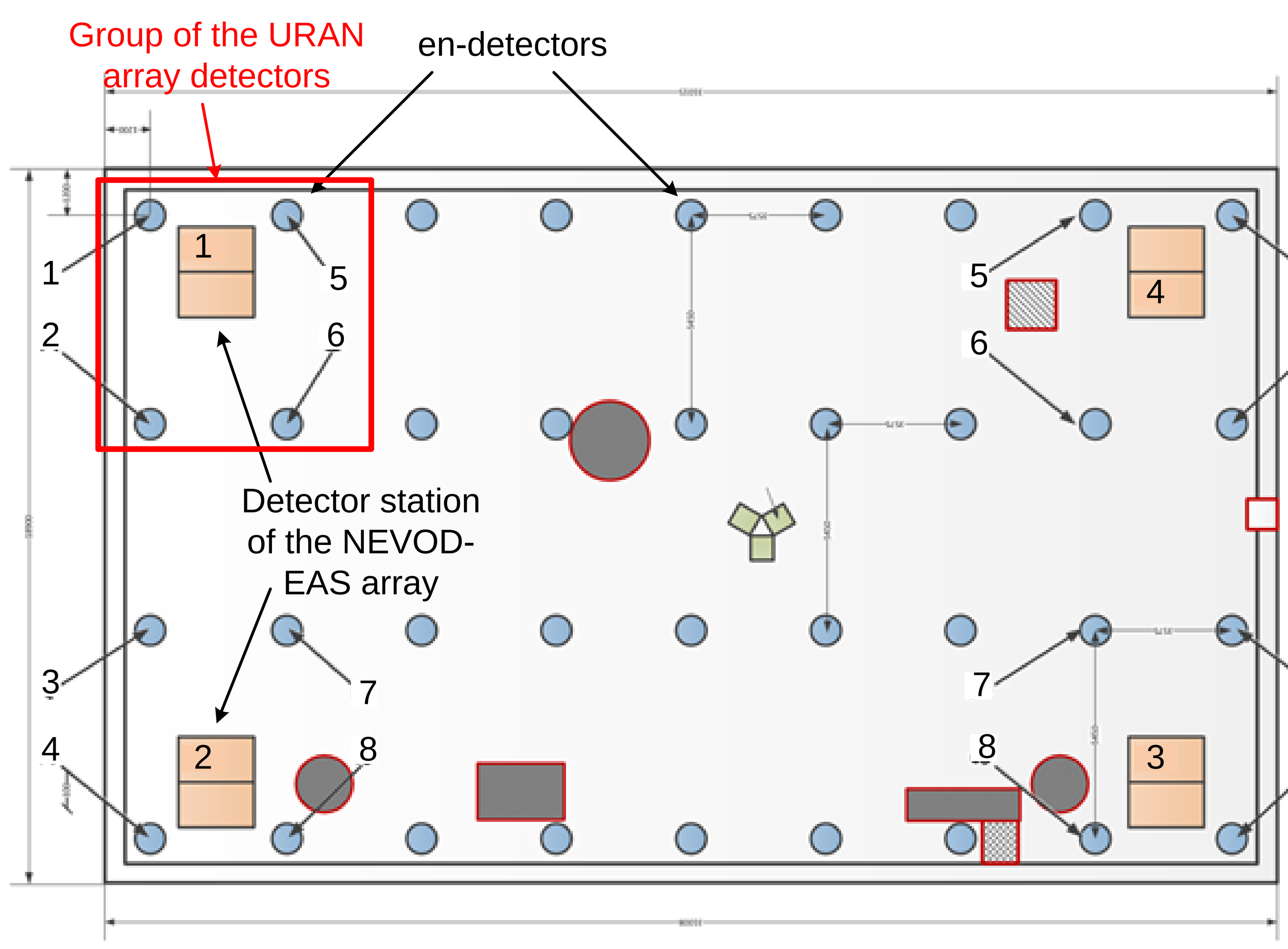
One of the important directions of investigations of extensive air showers (EAS) is the study of EAS hadrons, which are the primary component of air-showers and form all it's basic characteristics. One of the methods for studying EAS hadrons is the registration of neutrons that are produced as a result of nuclear fission in medium during the passage of EAS hadron component on the surface of the Earth. In the Scientific and Educational Center NEVOD, together with RAS, the URAN array was designed to register neutron component of the EAS recorded to the Earth's surface. The URAN array consists of 72 electron-neutron detectors (en-detector) based on the inorganic scintillator and is deployed on the roofs of MEPhI laboratory buildings. The total array area is ~ 10^3 m^2. According to the URAN array data, the following EAS characteristics are reconstructed: core position, age, arrival direction and size. These parameters are reconstructed by fitting the measured particle density with a lateral distribution function. The first results on the determination of EAS characteristics using the URAN array data, are presented.

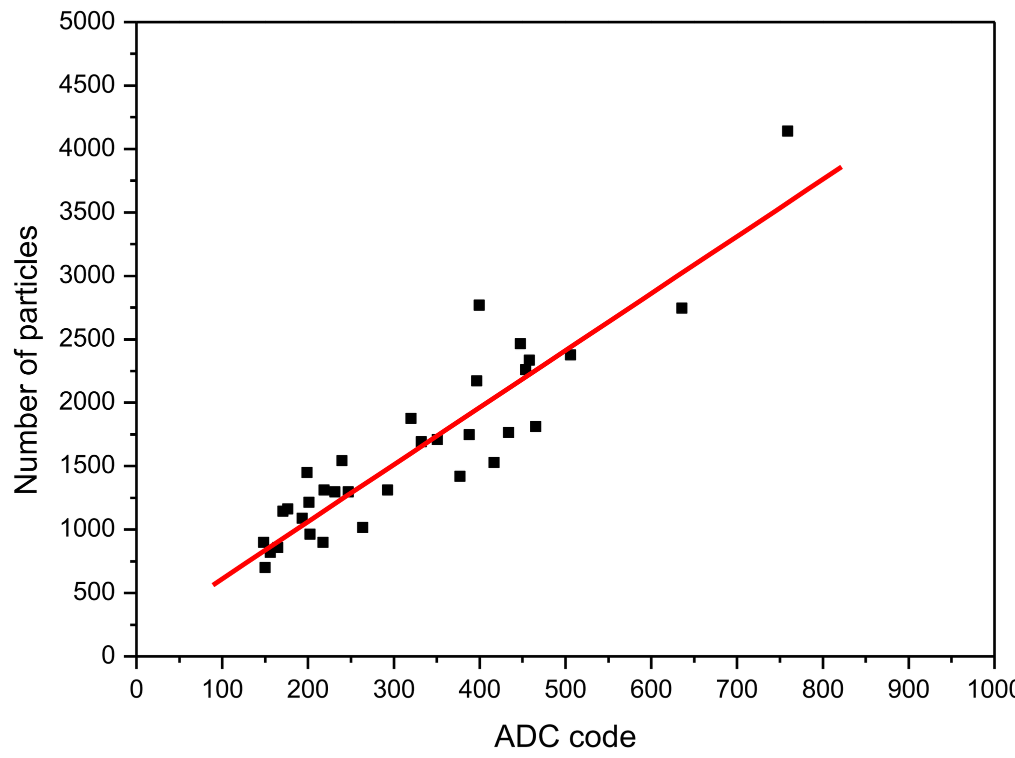
Calibration of the en-detectors to the particle counts

The scintillator used in the URAN array detectors is sensitive to the multiple passage of charged particles. This allows to use data on the EAS charged component obtained with the URAN array to determine the main parameters of showers: core position, age and size. Calibration of en-detectors of the URAN array (obtaining of a coefficient for conversion of signal amplitude (in ADC codes) to the number of charged particle) is an important task.

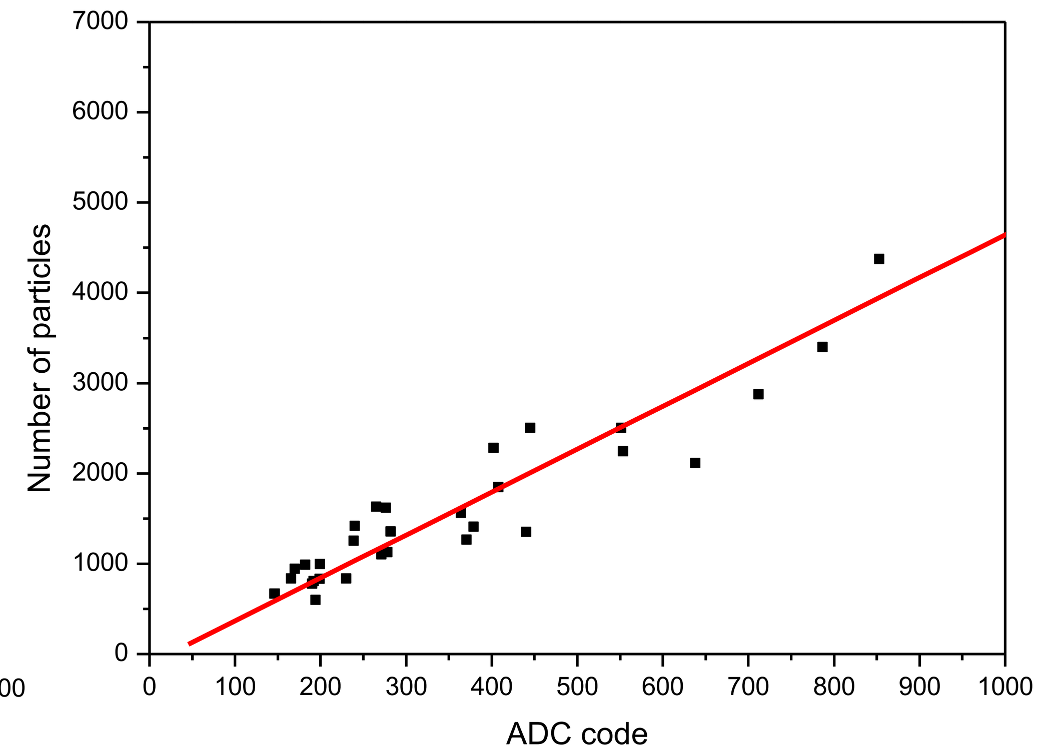


Layout of the detectors of URAN array and the detection stations of NEVOD-EAS array

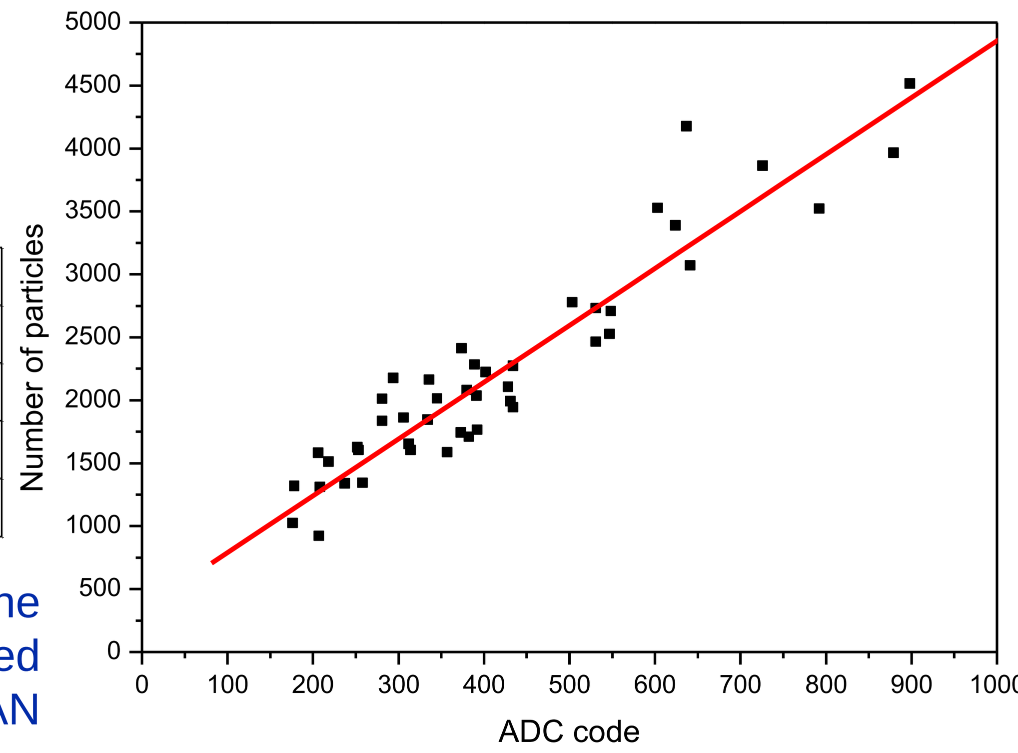
Signal amplitude as a function of the number of registered particles for Gr 1



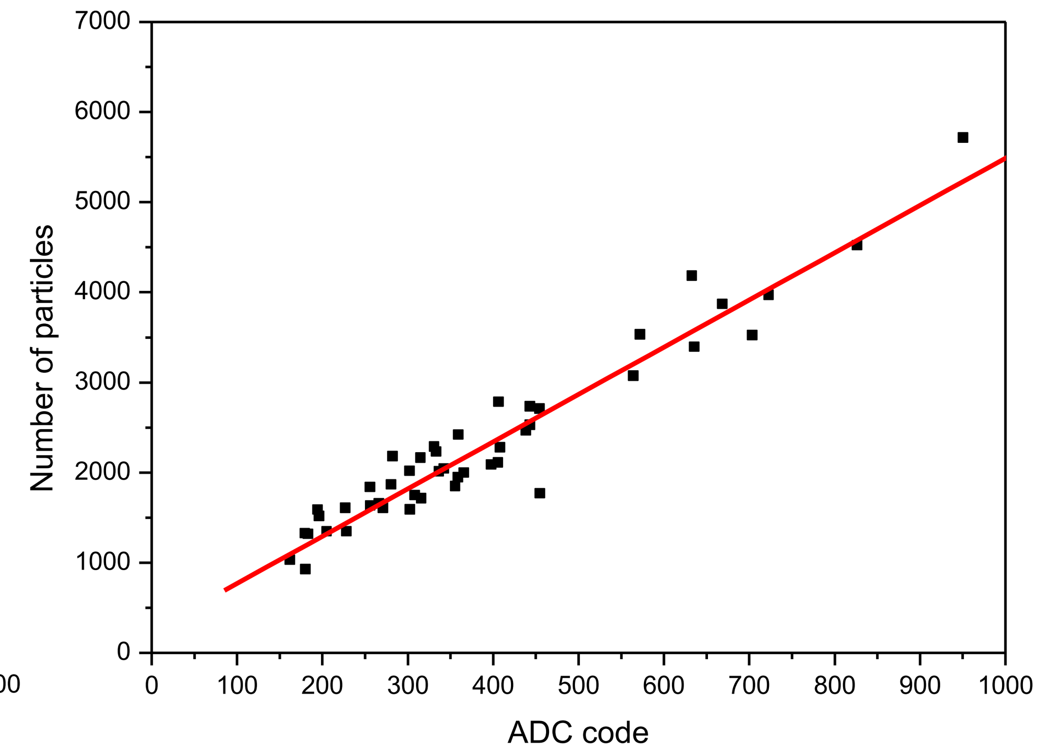
Signal amplitude as a function of the number of registered particles for Gr 2



Signal amplitude as a function of the number of registered particles for Gr 3



Signal amplitude as a function of the number of registered particles for Gr 4



Such calibration is possible due to the close location of the NEVOD-EAS array detector station to the URAN array detectors. To determine the response of the URAN array to the passage of charged multiple particles, we used the value averaged over four detectors (Group of the URAN array detectors - Gr) located around the detector station of the NEVOD-EAS array. The data of the URAN and NEVOD-EAS arrays collected during 2018 were used. The figures on the right show the response of four URAN array detector groups as a function of the number of particles detected in the NEVOD-EAS array. The correlation coefficients is presented in Table 1.

Table 1.

Gr	correlation coefficients
1	4.5±0.4
2	4.7±0.3
3	4.5±0.2
4	5.2±0.2

Reconstruction of the extensive air showers

To determine the EAS parameters, the NKG lateral distribution function was used:

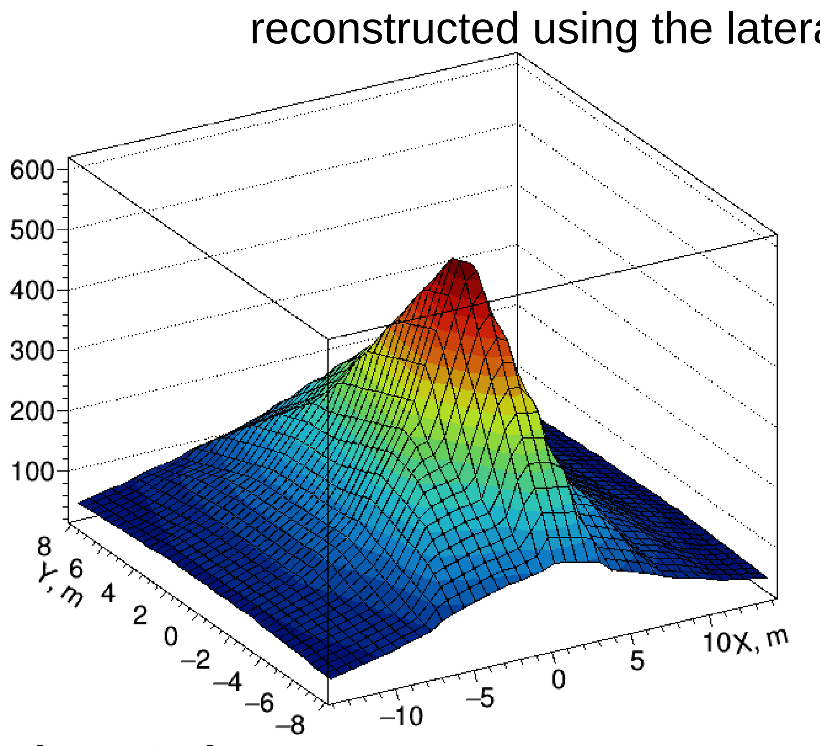
$$\rho(r) = N_e C_1(s) (\frac{r}{r_m})^{s-2} (1 + \frac{r}{r_m})^{s-4.5}$$

ρ (r) - particle density, N_e - shower size, s – shower age, $C_1(s) = \frac{1}{2\pi r^2} (\frac{\Gamma(4.5-s)}{\Gamma(s)\Gamma(4.5-2s)})$

Figures 1, 2 show the distributions in EAS size (Fig. 1) and in EAS age (Fig. 2) obtained with the URAN array according to the data collected in 2018. The direction of arrival of EAS was taken into account according to the data obtained at the NEVOD-EAS array.

Figure 1 show that the experimental distribution is fitted by a first-degree polynomial with a slope factor of -2.7.

An example of a registered event by URAN array (on the right) and the same event reconstructed using the lateral distribution function (on the left)



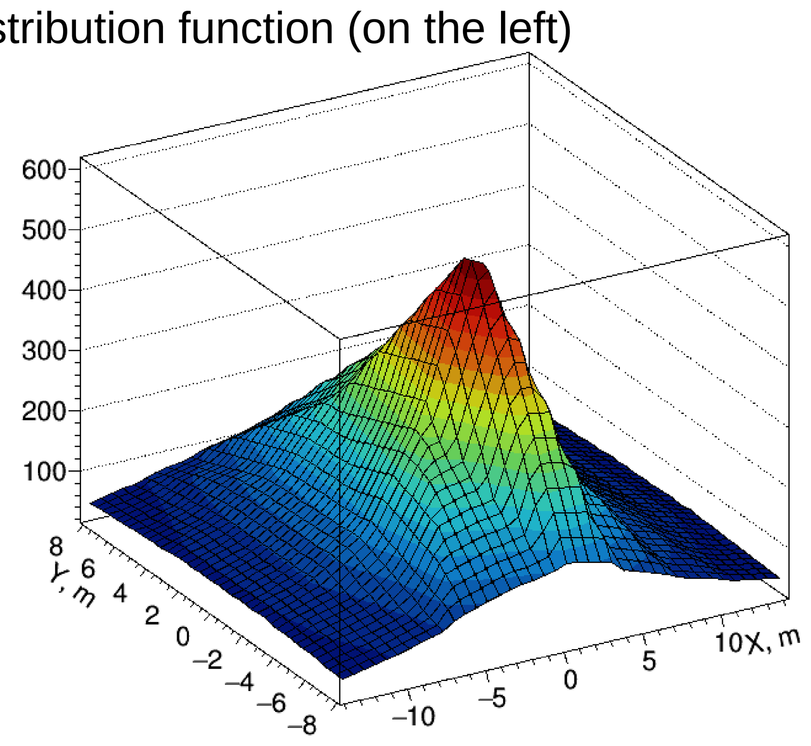


Fig.1 Particle number distribution in showers

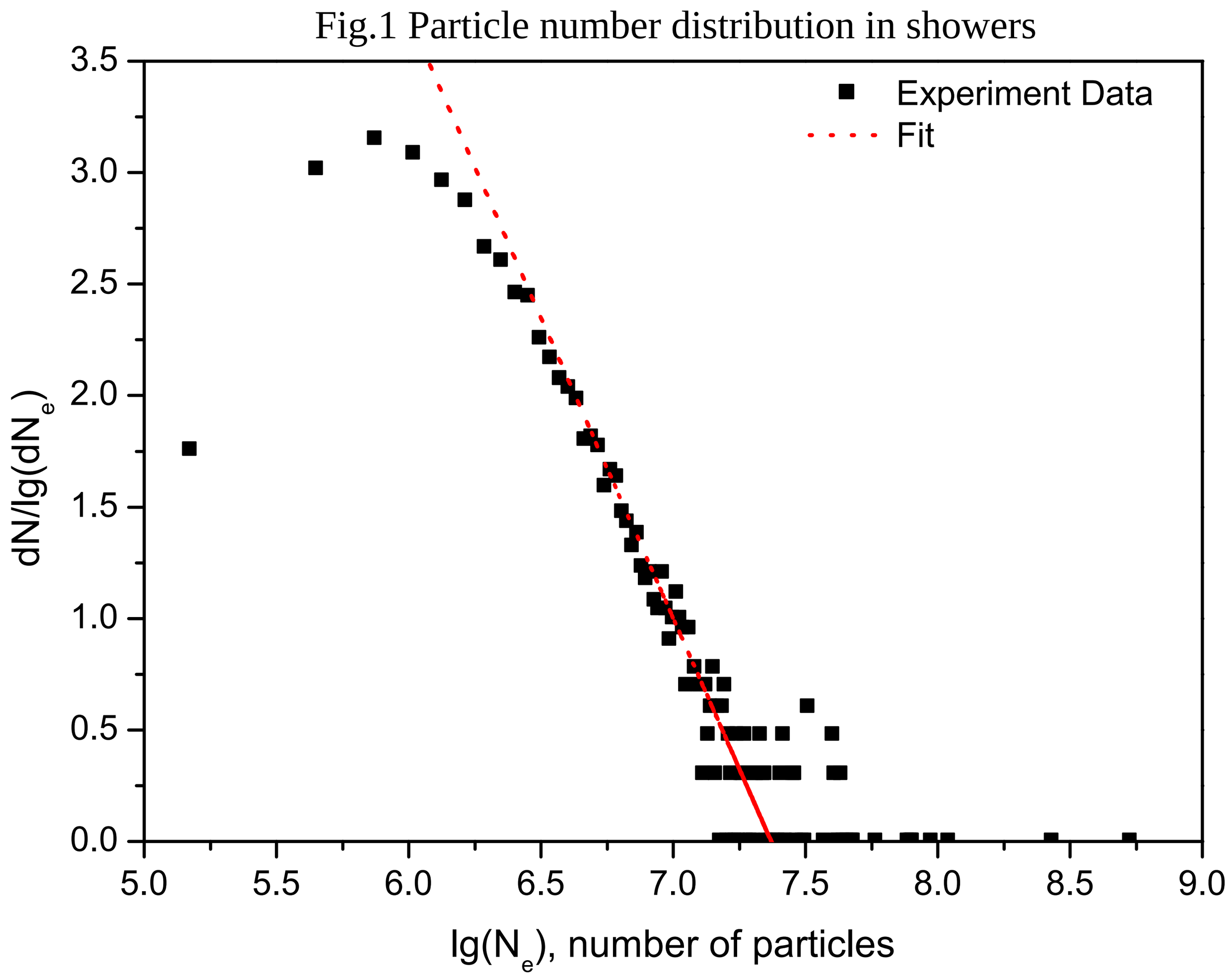
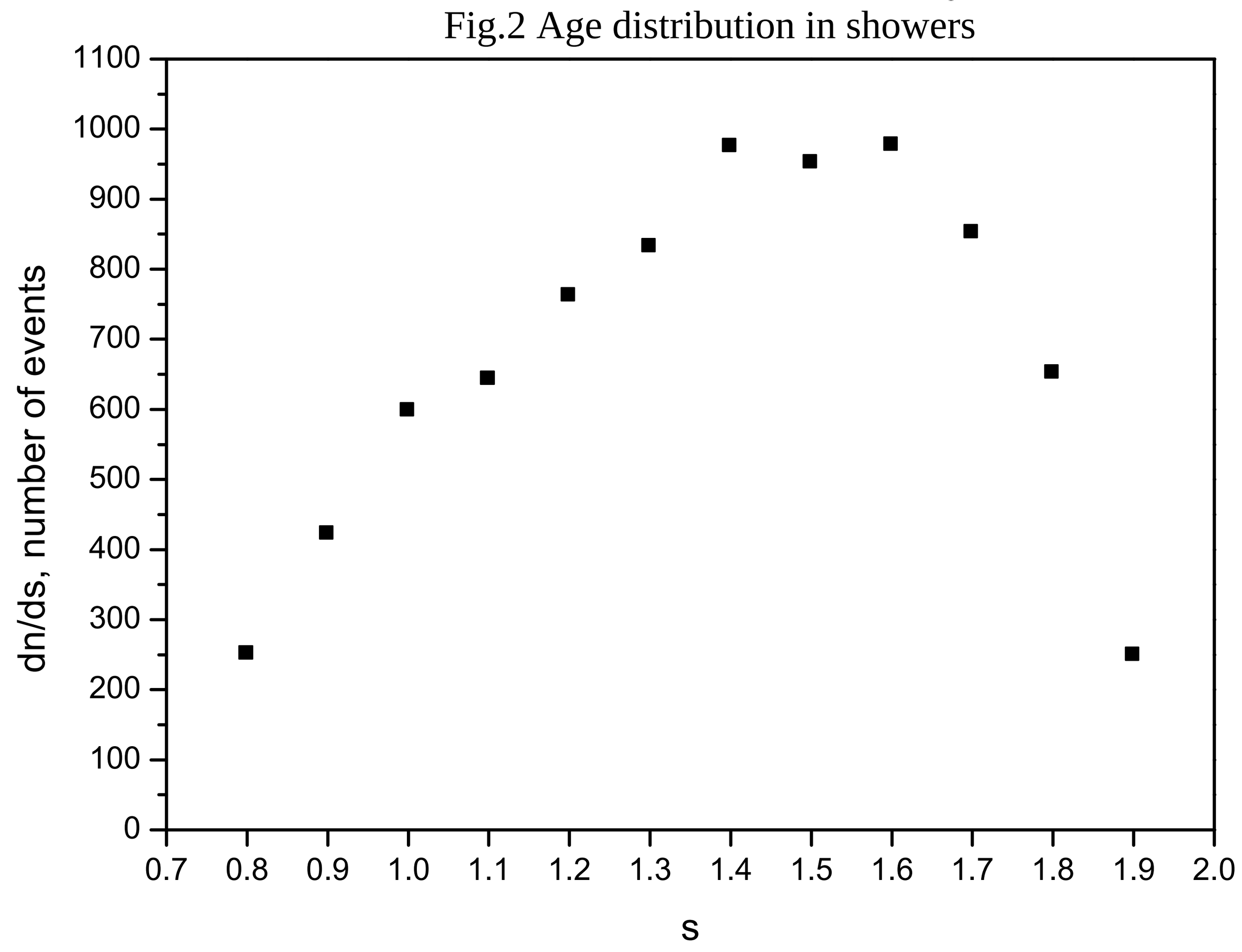


Fig.2 Age distribution in showers



Conclusion:

The paper presents drawings of the dependence of ADC codes on the number of registered particles, obtained from the URAN and NEVOD-EAS arrays. The dependencies obtained have a similar appearance. Using the data from Table 1, one can obtain the coefficient of conversion amplitude response of detector of the URAN array into the number of particles, the value of which is ~ 4.7.

According to the URAN array data for 2018, the distributions were obtained for: the number of particles in EAS and the age of EAS.