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Investigation of the EAS Neutron Component with the URAN Array

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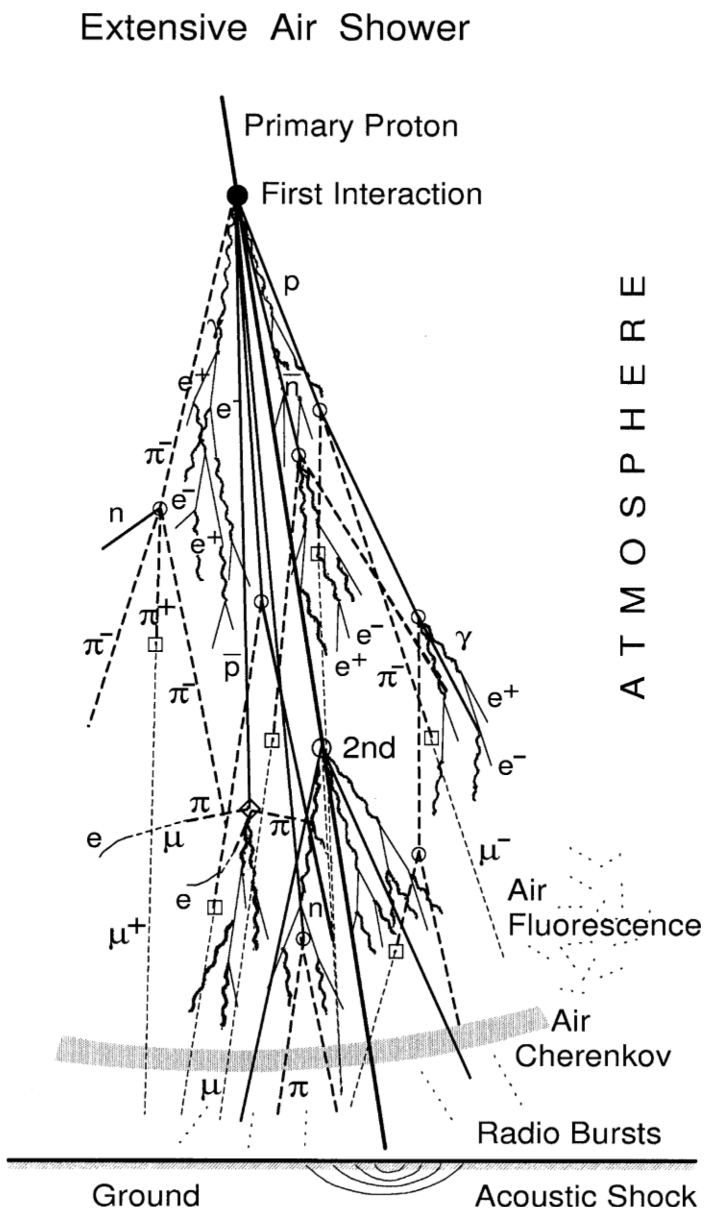


Introduction

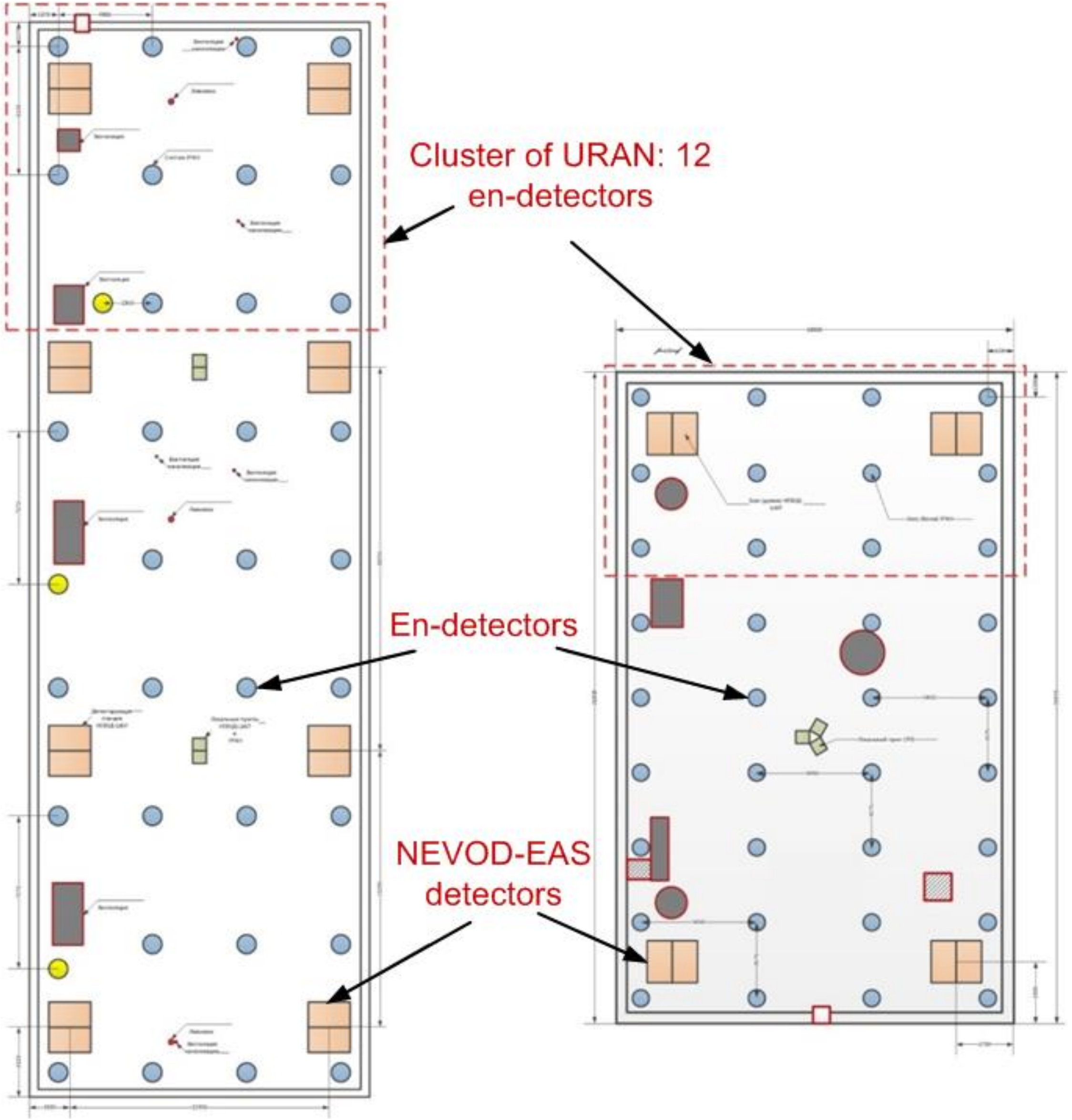
In 2001 a new method for studying the hadrons of EAS by means of registering secondary thermal neutrons (created by hadrons) was proposed by Y. Stenkin and J. Valdes-Galicia.

As a result of the interactions of hadrons with the environment matter, evaporative neutrons with an energy ~ MeV are born. These neutrons are subsequently slowed down and then may be detected by the installation.

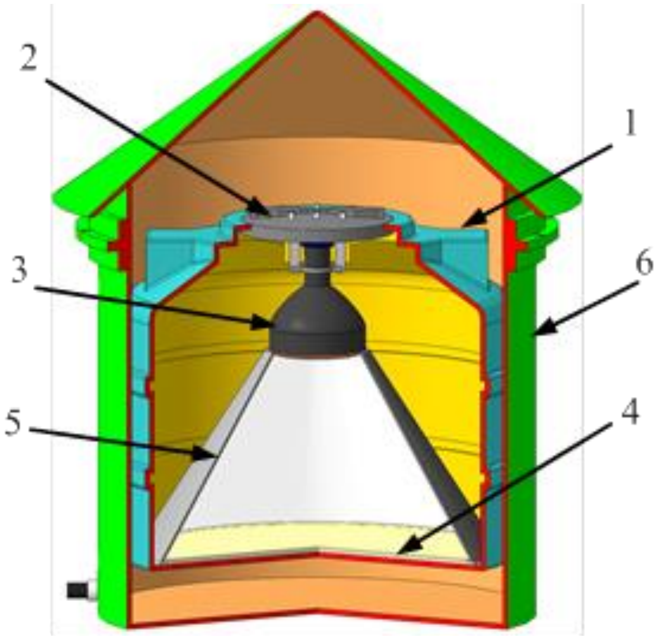
In order to register such neutrons it was proposed to utilize a scintillation detector based on an inorganic scintillator ZnS(Ag) with additions ^{6}Li and ^{10}B.

The URAN array

The array of clusters: 6 clusters, 72 detectors, square ~ 10^3 m^2



The design of electron-neutron detector (en-detector):



1 – light isolation case;

2 – cap with detecting elements;

3 – PMT-200;

4 – scintillator ZnS(Ag)+ B_2O_3;

5 – reflecting cone,

6 – protective case.

The scintillator

$^{10}B + n \rightarrow {}^{7}Li + \alpha + 2{,}792$ MeV (7%)

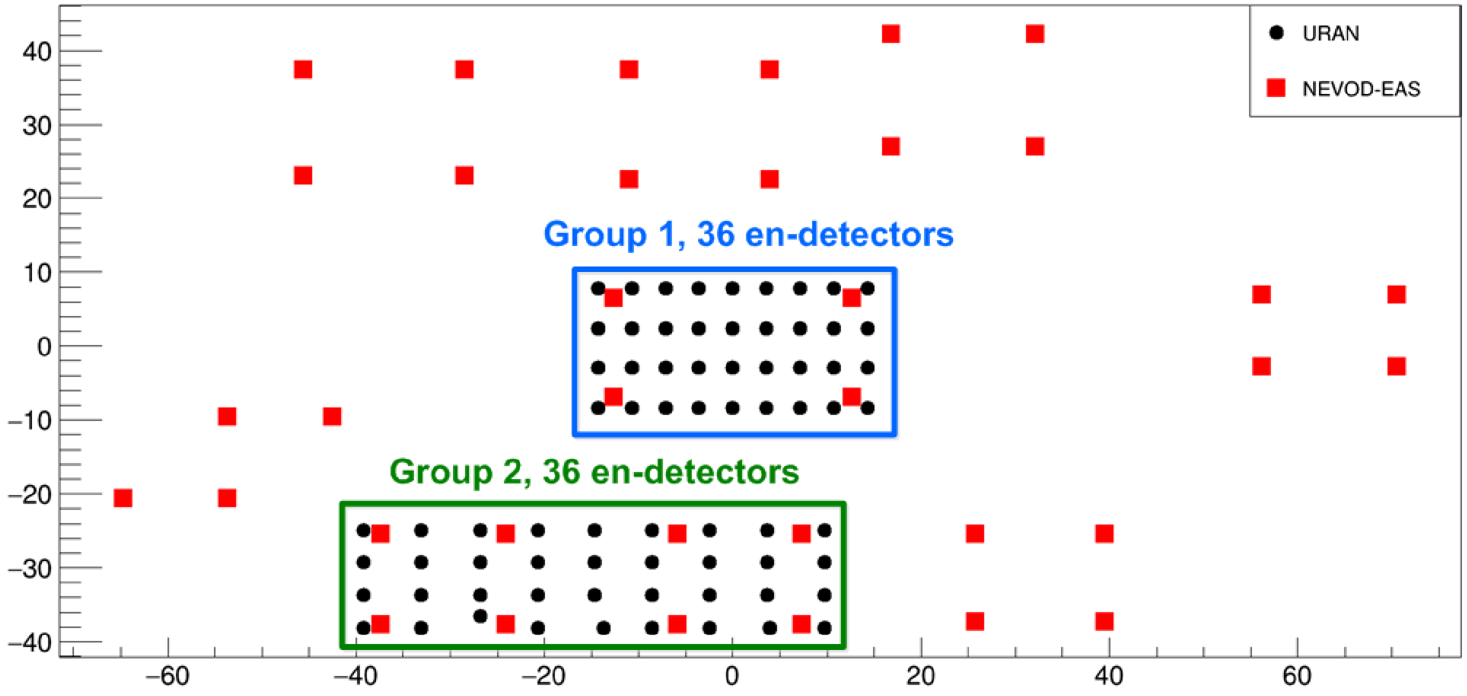
$^{10}B + n \rightarrow {}^{7}Li^{*} + \alpha + 2{,}31$ MeV (93%)

$^{7}Li^{*} \rightarrow {}^{7}Li + \gamma + 482$ KeV,

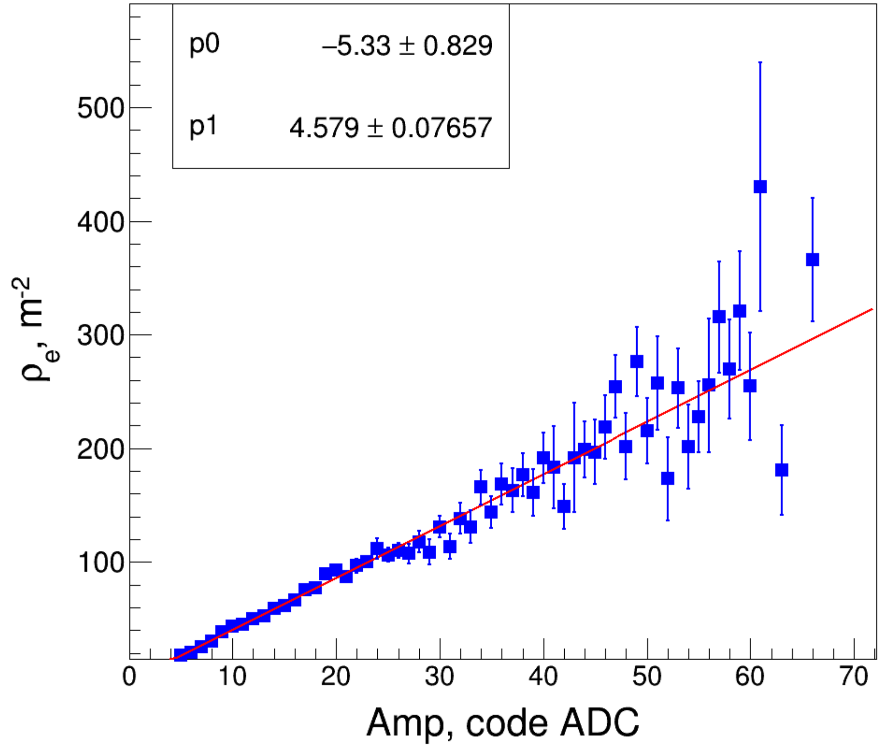
The calibration of neutron detectors by the charged components of EAS

The reconstruction of EAS parameters is based on the value of charged particles density. That is why it is very important for us to know how many charged particles are contained in detector response (ADC code). NEVOD-EAS, which works together with URAN as a unified synchronized system, helps to measure this value (the amount of charged particles for ADC code).

Layout of detectors of the URAN and NEVOD-EAS installations



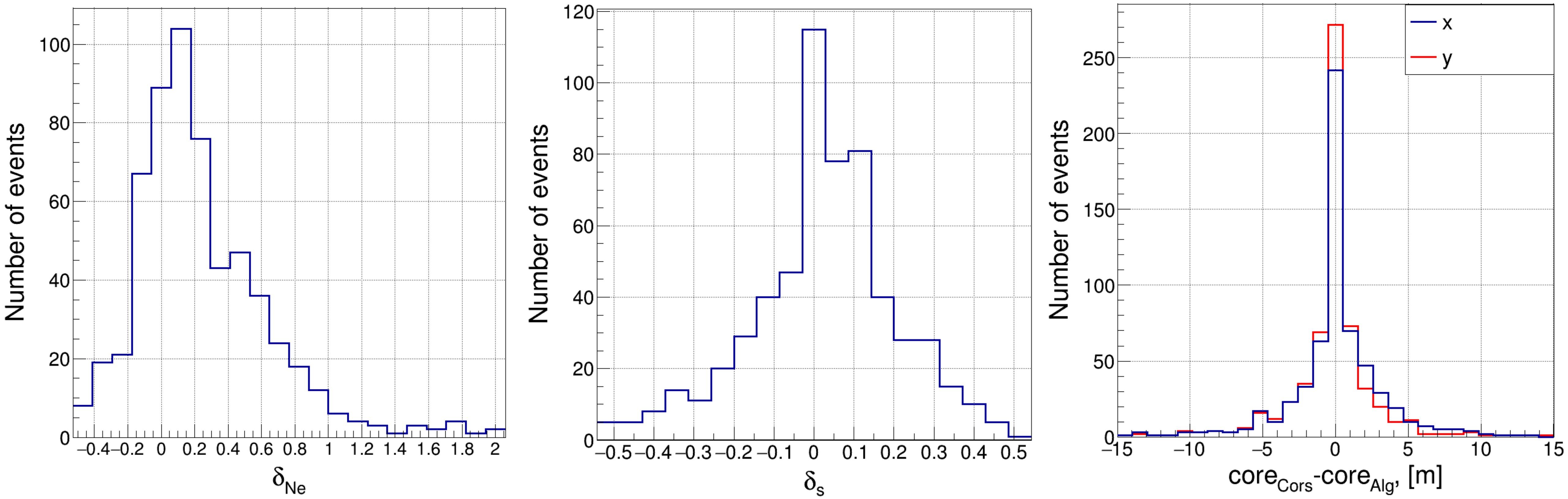
The dependence of the average particle density from the average amplitude in the en-detector (Group 1)



Checking the accuracy of EAS parameters recovery

The accuracy of the reconstruction of the EAS parameters was checked using the results of modeling the response (Geant4) of the setup to the passage of the EAS (CORSIKA). The primary CR particles were protons whose energies were played out in the range of 10^{15} - 10^{17} eV according to the power-law CR spectrum with an exponent of 2.7, and the zenith angles θ varied in the range from 0° to 50°.

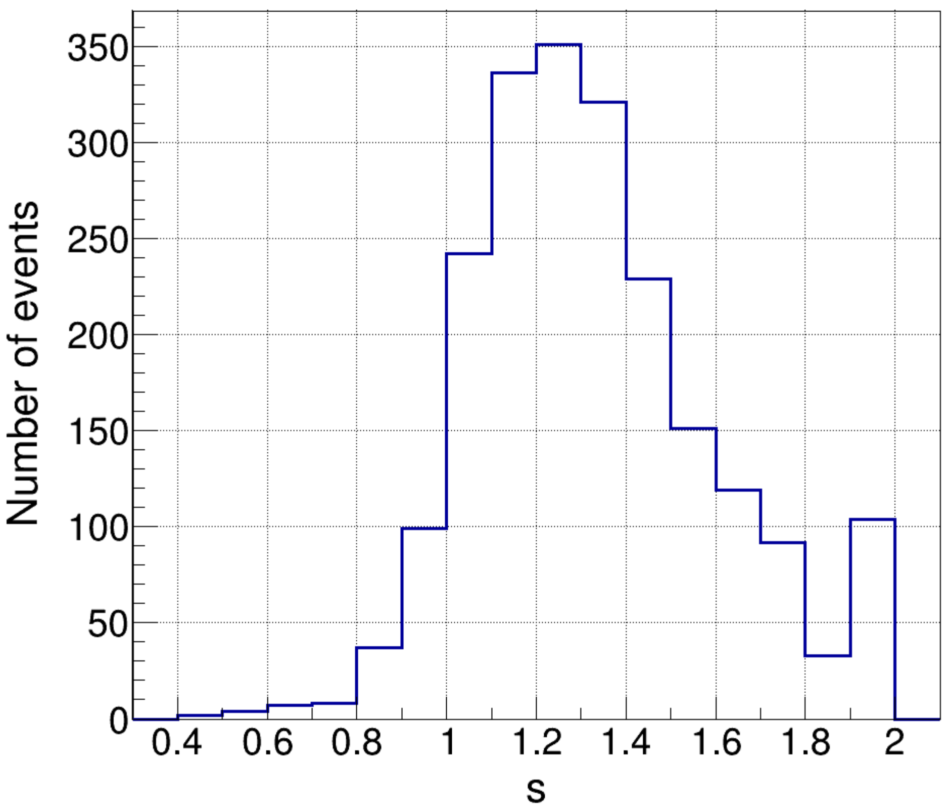
Relative errors in the definition of N_e, s, X and Y



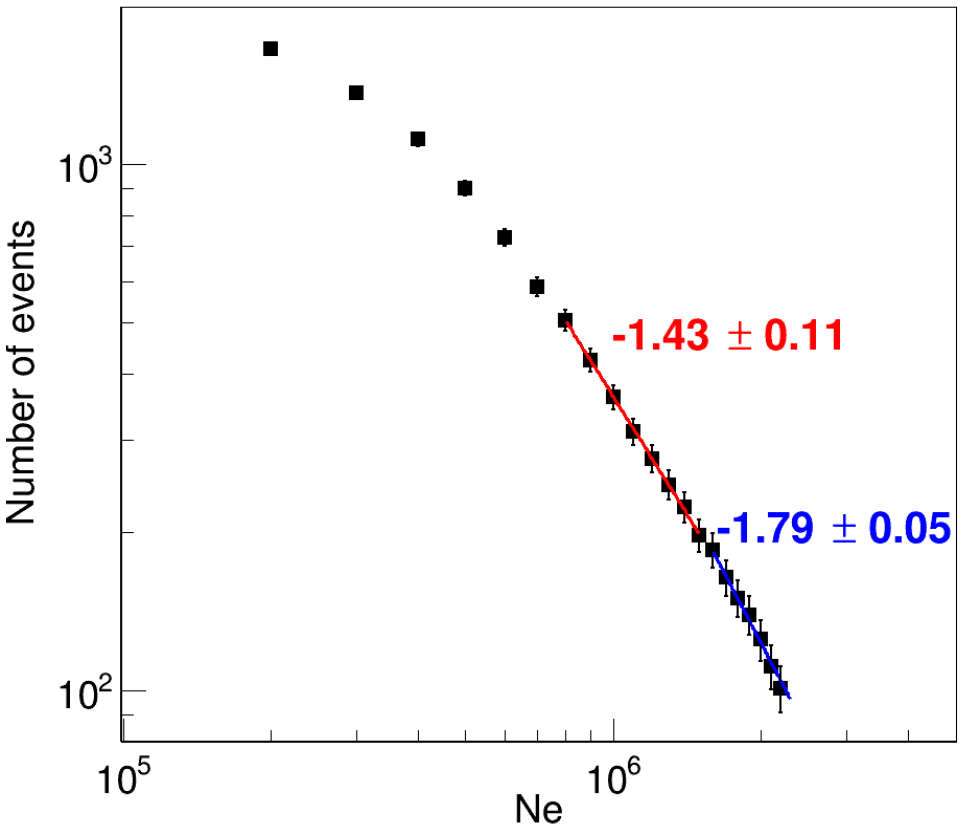
Recovery of EAS parameters

Trigger conditions for each cluster: Response **at least two detectors** in each cluster with an amplitude for the charged component at least 10 ADC codes ~ **17 charged particles.** To reconstruct the parameters (Ne, s, X, and Y) and analyze showers, a sample consisting of **2948 events** was used with the **value of triggering clusters = 6**, measurement period 01.01.2019 - 31.12.2019. To determine the angels of direction of arriving showers, we used the data of the NEVOD-EAS array.

Distribution of recorded showers by age



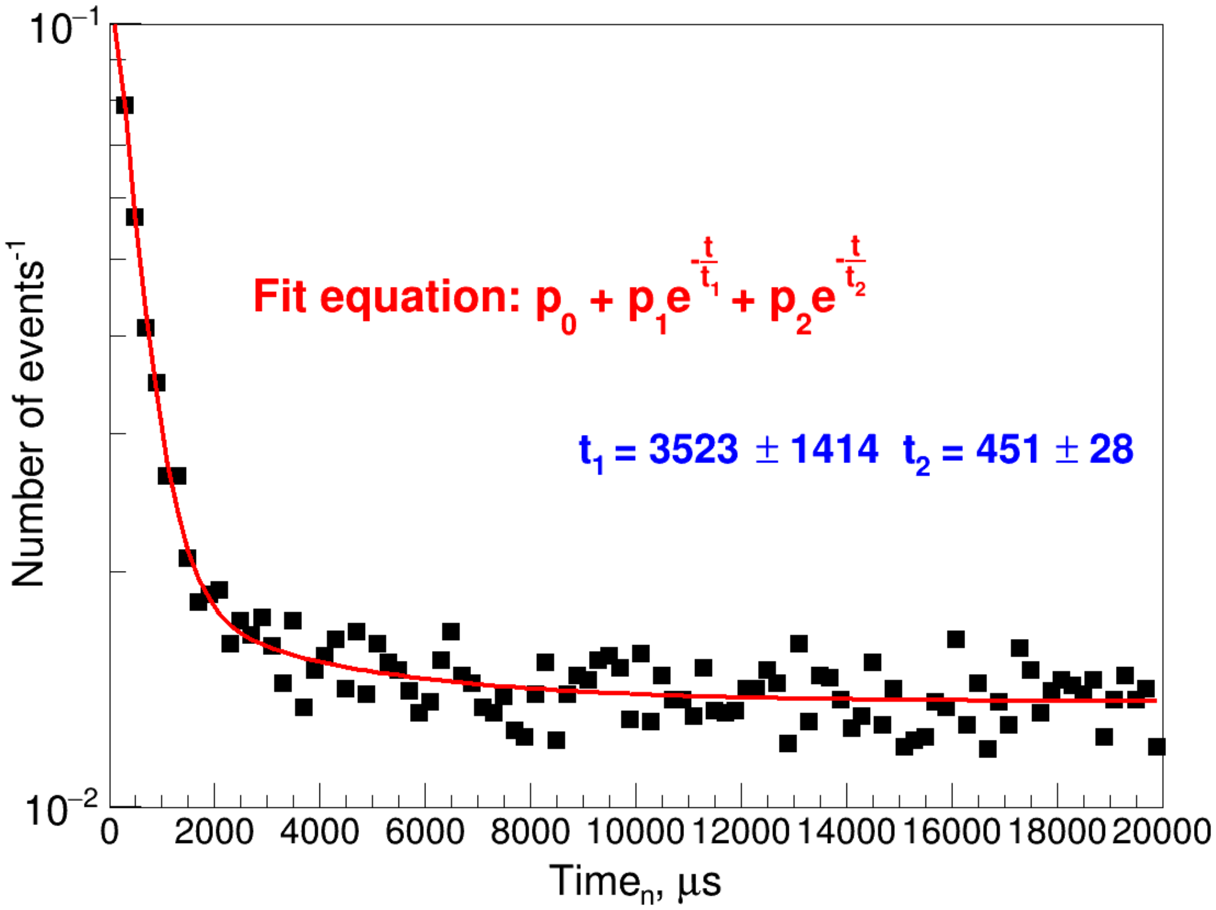
Distribution of recorded showers by N_e



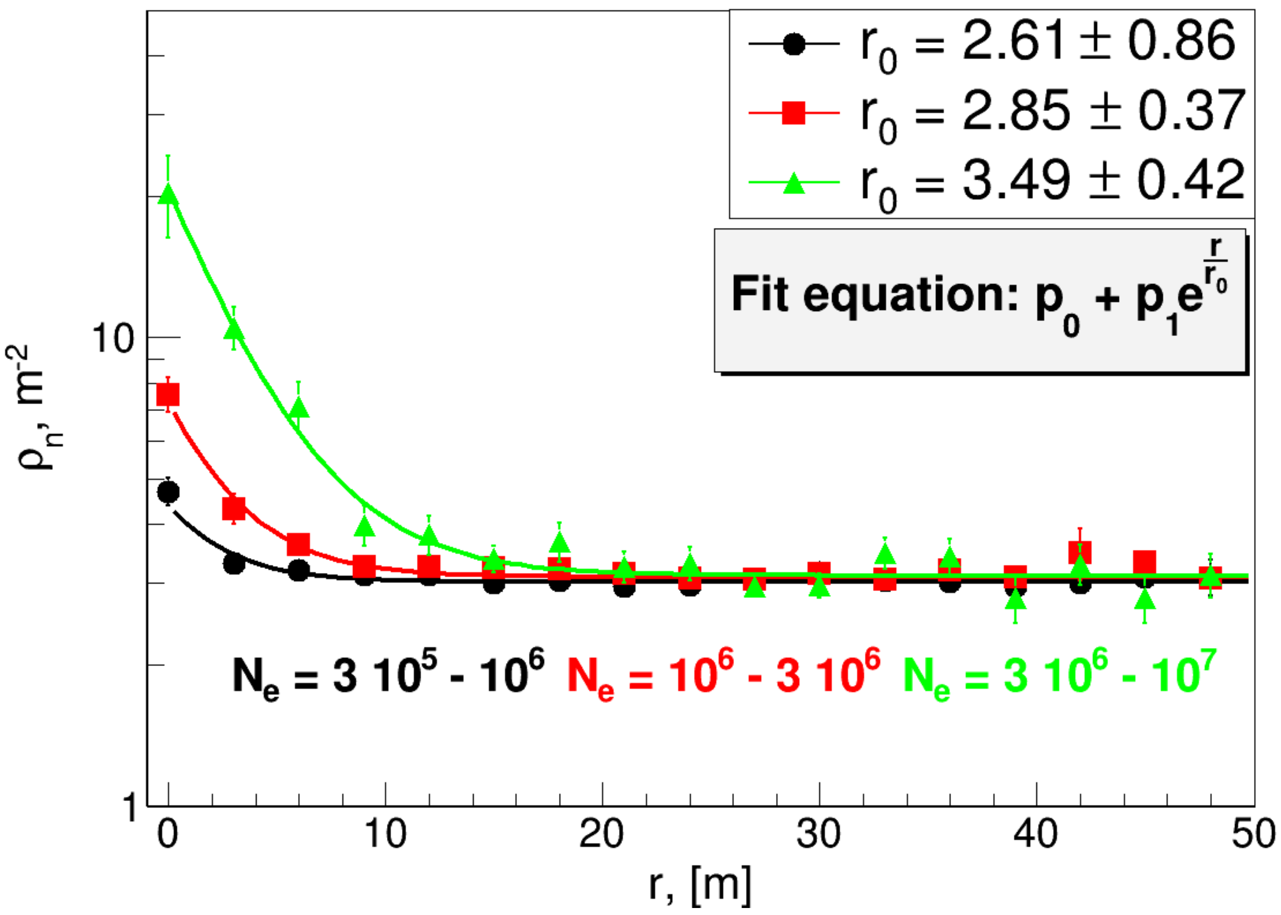
The neutron component of EAS

LDF are plotted for different intervals of N_e: $3 \cdot 10^5$ - 10^6; 10^6 - $3 \cdot 10^6$; $3 \cdot 10^6$ - 10^7.

Time distribution of EAS neutrons



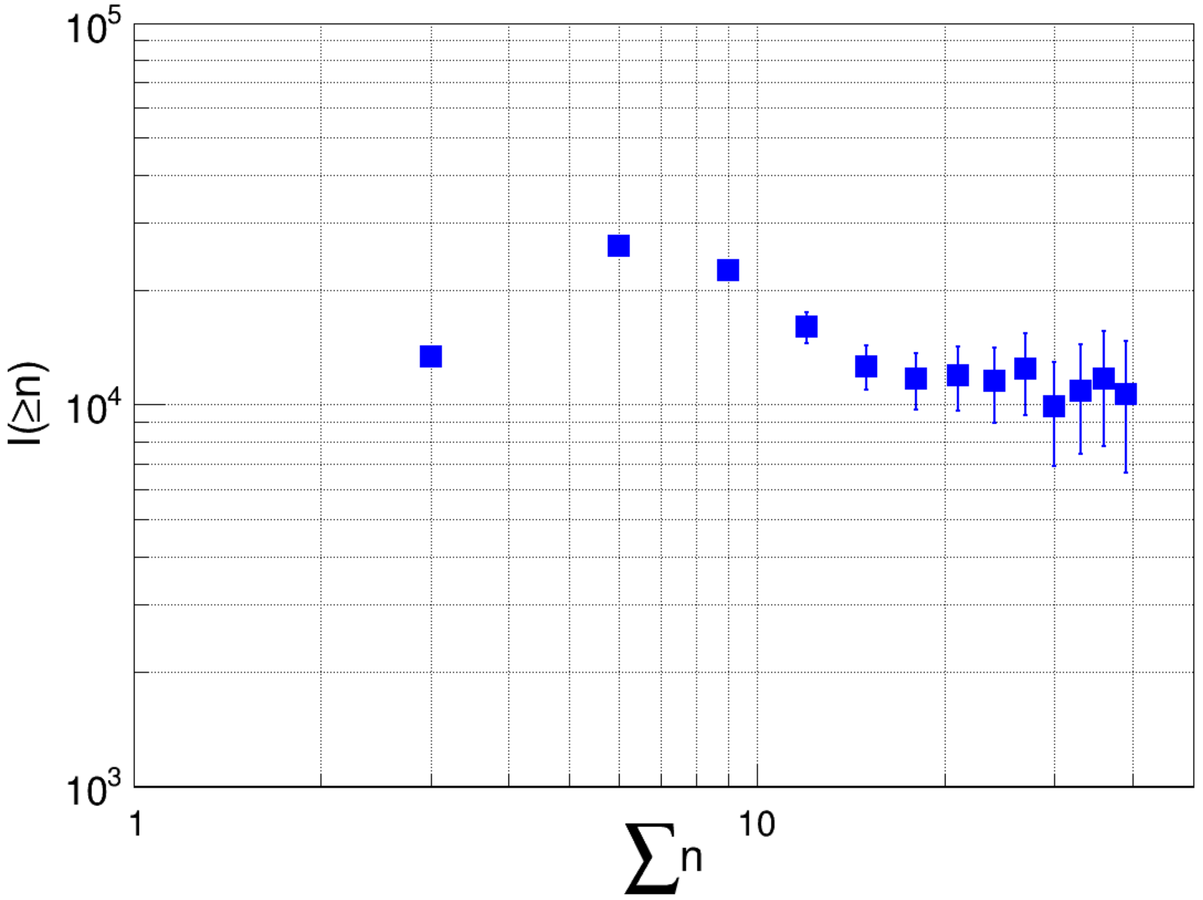
LDF of neutron component



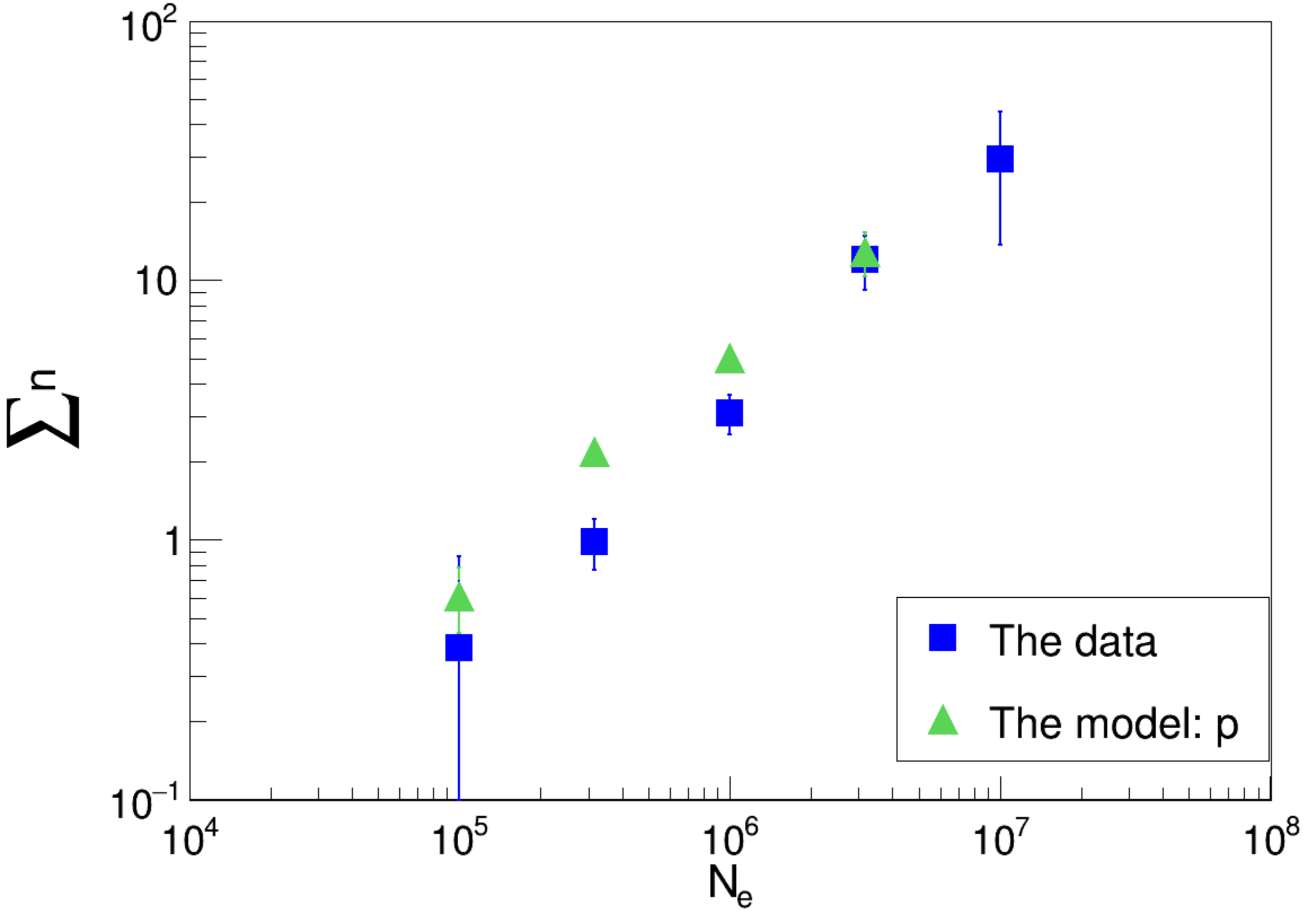
The neutron component of EAS

The integral distribution of EAS neutrons is described by a power function with an index of 2.0 ± 0.1

Distribution of registered showers by the number of neutrons



Dependence of the registered neutrons from the shower power



Conclusion

The processing of data was obtained from experimental series unit URAN for 2019 year.

The analysis of EAS (detected by experimental series URAN array) was conducted, which resulted in:

- **LDF of neutron component** for different intervals of N_e;
- The **distribution of registered showers** by the number of neutrons;
- Dependence of the registered neutrons from the shower power;
- The time distribution of EAS neutrons.

It has been demonstrated that it is possible to detect the charged EAS component by means of en-detectors, though it is better to evaluate EAS parameters by means of the classical installation NEVOD-EAS.

THANK YOU FOR YOUR TIME!