

# Project of the URAN array for registration of atmospheric neutrons

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**Abstract.** The project of a new setup is directed at the registration of atmospheric neutrons (URAN) generated by hadronic component of extensive air showers (EAS). The setup includes 72 en-detector which simultaneously register two major EAS components: electromagnetic by the group passage of charged particles and hadron component by the thermal neutrons. The neutrons and charged particles are detected using a specialized scintillation composition made of granulated alloy of crystals based on the ZnS(Ag) powder with an admixture of B<sub>2</sub>O<sub>3</sub>.

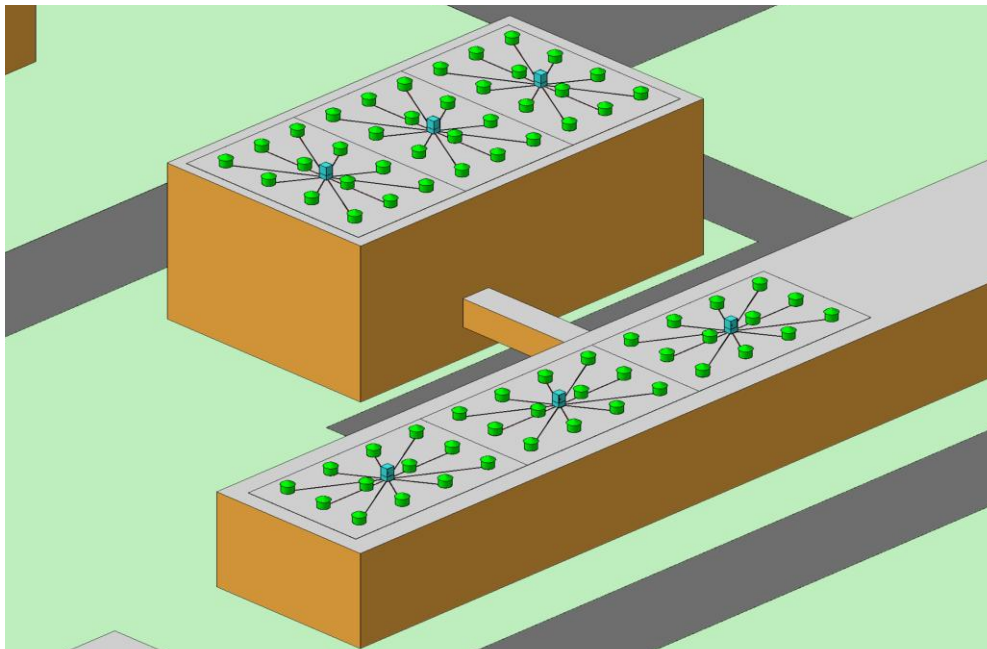
## 1. Introduction

The main purpose of the proposed project is the creation of the setup for the detection of the extensive air shower (EAS) neutron component in the range of PeV-energies of cosmic rays (CR), where the ‘knee’ (the steepening) of the size spectrum of EAS registered on the Earth’s surface is observed. Neutrons are the only EAS component unexplored by now. At the same time, the neutron component which is formed by the interaction of the shower hadron core with the atom nuclei of the atmosphere carries important information about the EAS development [1]. Creating of a detector for its investigation will enable to obtain novel data for understanding the processes of the EAS development and for correct interpretation of the EAS study results from the viewpoint of estimation of the primary cosmic ray energy spectrum and composition. An important feature of the setup should be the possibility of simultaneous registration of the EAS electron-photon and hadron components using the same detector. This would remove many of systematic uncertainties in comparing the results of measurements of these components [1].

## 2. The URAN detector

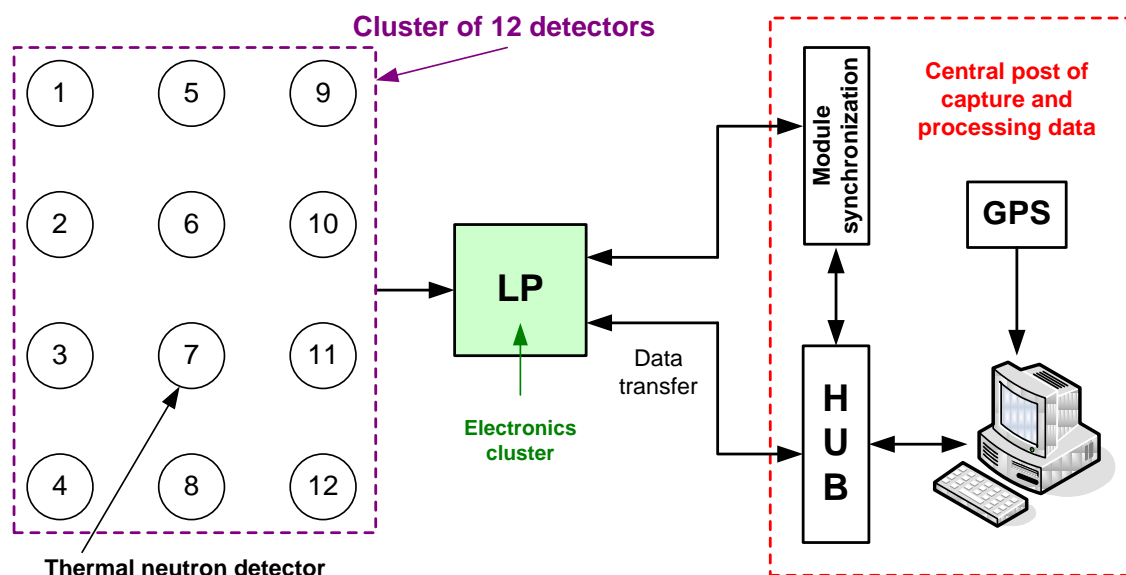
The URAN setup includes 72 en-detectors for simultaneous registration of electron-photon (e) and the neutron (n) EAS components. The en-detectors are combined into independent cluster structures of 12 detectors. Clusters are located on two roofs of the laboratory buildings (3 clusters on each roof). The layout of the URAN setup is shown in figure 1. The characteristic distance between the detectors is 4–5 meters. The total area of the setup is  $\sim 10^3$  m<sup>2</sup>.





**Figure 1.** The layout of the URAN detector counters.

To ensure the operation of the detectors and primary cluster data processing, the Local Posts (LP) are used. The structure of the URAN cluster is shown in figure 2. The cluster LP contains: the 12-channel high-voltage power supply which allows remote variation of the supply voltage of any detector; the low-voltage ( $\pm 12$  V) power supply which ensures operation of the preamplifiers and integrator-amplifiers; two 12-channel boards of amplitude analysis; the crate for the boards of amplitude analysis; the mediaconverter and the LP thermostabilization system. One LP can support operation of two clusters.



**Figure 2.** The cluster structure of the URAN detector.

Transferring of analog signals from the detector to the LP is performed via coaxial cables housed inside the metal hoses intended to protect them against environmental influences and mechanical

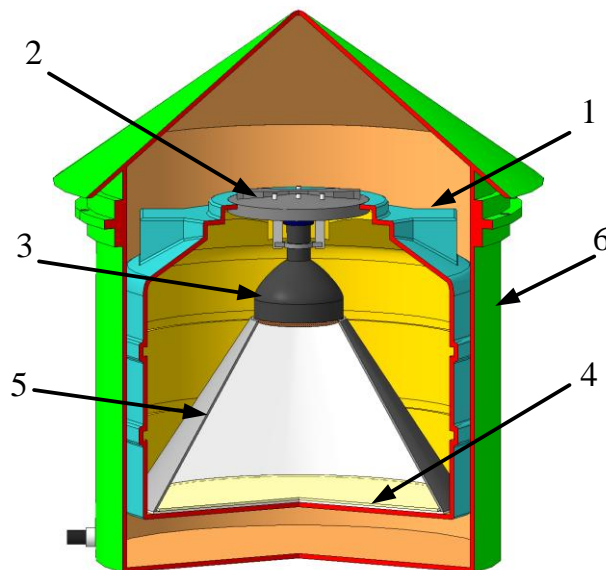
damages. Apart from the coaxial cables, the hoses contain the cables for the PMT high-voltage and amplifier low-voltage power supply. Data transmission from the LP to the Central DAQ Post located in one of the laboratory buildings is performed via fiber-optic communication lines.

The Central Post of control and data acquisition ensures operation of the URAN setup in the exposition and monitoring modes, controls all Local Posts of the setup and stores experimental data. Main elements of the Central DAQ Post are: the central computer, the network equipment, the mediaconverters (Ethernet→Op. Link) and the module of external synchronization. Time synchronization of clusters with an accuracy of 10 ns is performed using global positioning systems (GPS/GLONASS).

At the central computer, information about registered events is processed by a special software and is stored in files that contain event timestamps and parameters of the signals from the detectors of triggered clusters. The software also allows automatic control of all elements of the cluster Local Post of primary data acquisition.

### 3. En-detector

For the registration of the EAS neutron component, a new type of detector well-proven in the PRISMA-32 setup (MEPhI, Moscow) [2] is used. The scheme of the detector with the outer enclosure is shown in figure 3. The detector housing represents a light-tight black plastic tank with a volume of 200 liters (570×740 mm). To improve the light collection, the diffusely reflecting cone is used. The ZnS(Ag)+B<sub>2</sub>O<sub>3</sub> scintillator is located on the base of the cone. The FEU-200 photomultiplier is placed at the top of the cone. The PMT with a high voltage divider mounted on the tank cover using a special holder forms the detecting block. The effective area of the scintillator is ~ 0.36 m<sup>2</sup>.



**Figure 3.** En-detector design; 1 - light protecting housing, 2 – lid, 3 – FEU-200 PMT, 4 – scintillator layer, 5 - light reflecting cone, 6 – outer metal enclosure.

As the detectors will be used in outdoor conditions, the external galvanized steel cylindrical enclosure (diameter of 800 mm, height of 1100 mm and wall thickness of 0.9 mm) with a conical roof has been developed for their protection.

### 4. Registering electronics of the URAN detector

The cluster registering electronics will ensure the operation of detectors and signal digitizing and will be located in the Local Posts. Electronics of one cluster includes two 12-channel boards of amplitude

analysis developed according to Euromechanics 6U standard. One board is designed for digitizing analog signals from the 12<sup>th</sup> dynode output (with an integration time of 1  $\mu$ s) and allows selection of events according to various triggering conditions (triggering of 1 or several counters within a specified time gate), registration of delayed neutrons during 20 ms and data transmission from a cluster to a Central DAQ Post. The second board is intended for digitizing analog signal from the 7<sup>th</sup> dynode output. Using of two dynodes provides wide dynamic range of measured energy releases produced mainly by the EAS electron component.

For the 12<sup>th</sup> dynode measurements, the board of amplitude analysis with an integrated controller, sampling frequency of 200 MHz and 5  $\mu$ s time gate is used. The sampling frequency can be switched to 1 MHz. The time gate can be increased up to 20 ms in steps of 1  $\mu$ s. For the 7<sup>th</sup> dynode, the board of amplitude analysis with an integrated controller and sampling frequency of 1 MHz is used.

## 5. Conclusion

The URAN setup will allow to obtain novel data about extensive air showers and their hadron component. The spectrum of EAS in the number of thermal neutrons, the function of the lateral distribution of hadrons in the EAS and other parameters of hadron component will be obtained. Additionally, the URAN setup will become an integral part of existing and being created detectors of the Unique Scientific Facility ‘Experimental complex NEVOD’ which already includes the detectors NEVOD, DECOR, CTS, as well as the NEVOD-EAS and TREK detectors that are now under development and construction.

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## References

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