Scientific & Educational Centre NEVOD

Study of EAS registered by the PRISMA-32 array, in the Cherenkov water calorimeter NEVOD

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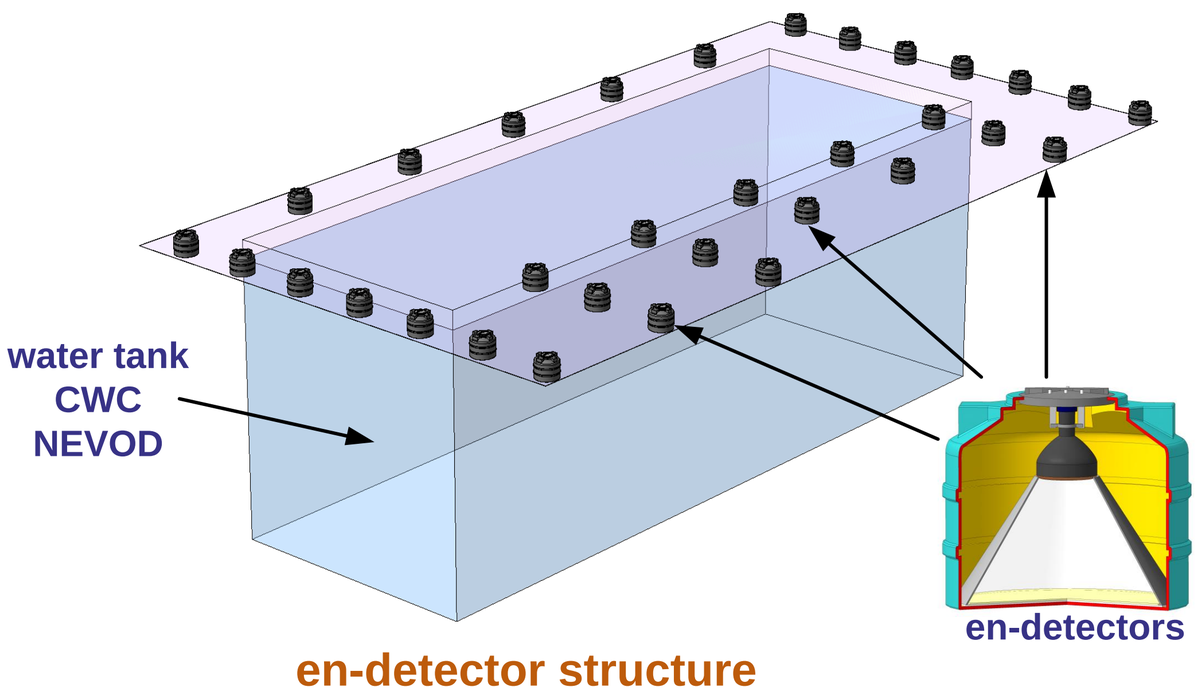
In MEPhI on the basis of the Experimental complex NEVOD, there are two installations that allow to detect the EAS hadron component in a continuous mode: the Cherenkov water calorimeter (CWC) NEVOD and PRISMA-32. The CWC NEVOD has a volume of 2000 m^3 in which the registration system of 91 quasi-spherical modules with FEU-200 PMTs registering Cherenkov radiation from any direction with almost the same efficiency is deployed. The PRISMA-32 array is a new type facility for studying EAS hadron component that consists of two clusters of 16 electron-neutron scintillation detectors in each. The PRISMA-32 array allows to register simultaneously two main EAS components: electron-photon and hadron ones. In PRISMA-32 the hadron component is detected by means of registration of neutrons produced as a result of interactions of hadrons with nuclei of atoms of the air or with matter near the detectors. The data on the comparison of the characteristics of EAS simultaneously registered by CWC NEVOD and PRISMA-32 are presented. Groups of events with different positions of the shower axis (inside or outside the facility) are considered.

PRISMA-32

The array of 32 en-detectors combined of two 16-detector clusters. If is located inside the experimental hall situated on the 4th floor of the NEVOD building around the water tank. The neutrons are registered as delayed pulses within a time gate of 20 ms. It is more than sufficient to collect a main part of thermal neutrons produced by EAS hadrons. A 2-fold coincidence trigger condition is applied for each cluster of 16 en-detectors to store the data. The total area of the facility is ~ 500 m^2.

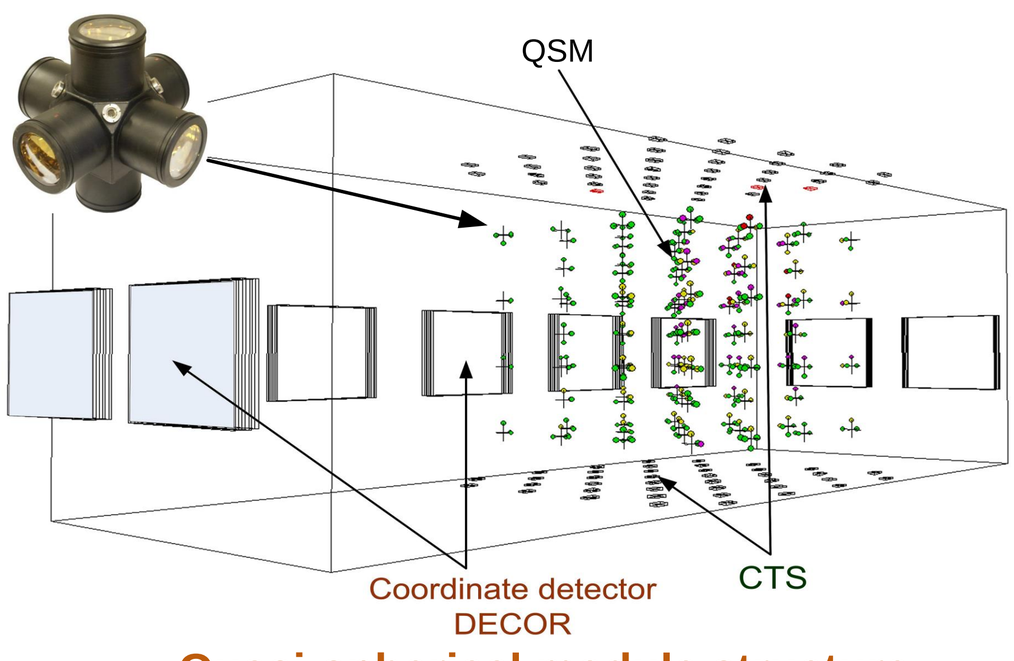


en-detector structure

Thin layer (~ 30 mg/cm^2) of a special inorganic scintillator ZnS(Ag) + ^{6}LiF with area of 0.36 m^2 is placed at the bottom of cylindrical polyethylene (PE) 200-liter tank which is used as the detector housing. The efficiency of thermal neutron detection of the en-detector for is 20%. Registration of scintillation flashes is provided by FEU-200 placed on the lid of the tank. FADC (ADLINK 10-bit PCI slot PCI-9810) is used for pulse shape digitizing (20000 samples with a 1-μs step).

Cherenkov water calorimeter NEVOD

Cherenkov water calorimeter (CWC) NEVOD with a volume of 2000 m^3 (9 m depth) is located on the surface of the ground in the MEPhI campus and is intended for the registration of all major cosmic ray components. The detecting lattice consists of alternating planes: four planes with 16 quasispherical modules (QSMs) and three planes with 9 QSMs. In its turn, each plane is formed with vertical clusters consisting of 4 or 3 QSMs. The distance between the modules is 2.5 m along the water tank axis, 2.0 m across it and 2.0 m in the vertical direction.



Quasi-spherical module structure

Quasispherical module consists of a waterproof aluminum housing, intra-module electronics and six FEU-200 photomultipliers with plastic protective illuminators. QSM dimensions are 0.56×0.56×0.56 m^3. It includes six flat photocathode photomultipliers oriented along the axes of the orthogonal coordinate system. Such detecting system registers Cherenkov radiation from any direction with almost equal efficiency.

Results

The data of facilities collected during 2016-2018 are used for the analysis.

Type	Number of events
PRISMA Cl. 1	1207971
PRISMA Cl. 2	605595
PRISMA Cl. 1 + Cl. 2	102442
CWC NEVOD, PRISMA trigger	694712
Joint events	62863

In during the data analysis, various selection criteria were used:

K1 - in each cluster of PRISMA-32 ≥ 2 detectors, A ≥ 10 ADC code;

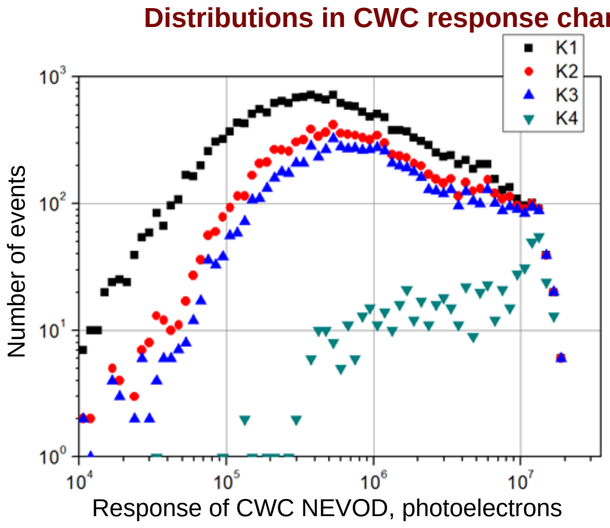
K2 - in each cluster of PRISMA-32 ≥ 4 detectors, A ≥ 10 ADC code;

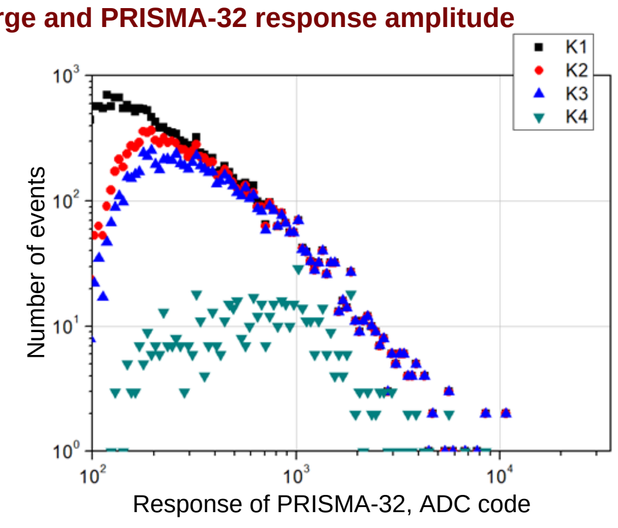
K3 - in each cluster of PRISMA-32 ≥ 4 detectors, A ≥ 10 ADC code and N_n ≥ 4 neutrons in one of the clusters;

K4 - in each cluster of PRISMA-32 ≥ 4 detectors, A ≥ 10 ADC code, N_n ≥ 4 neutronsin one of the clusters and EAS axis inside the water tank.

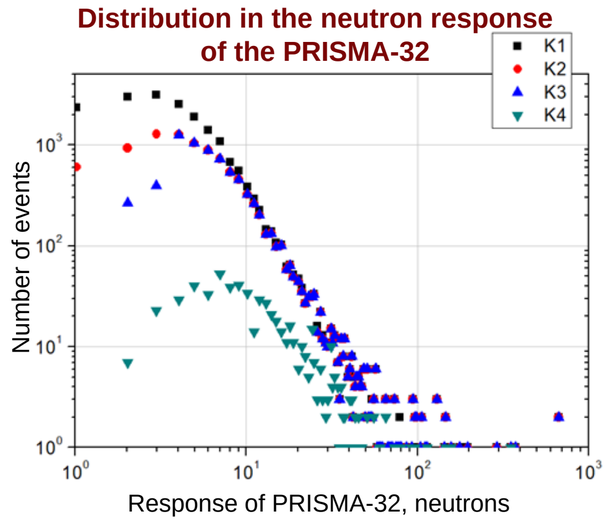
For approximating the spatial distribution of particlesThe coordinate reconstruction algorithm uses the empirical Nishimura-Kamata-Greisen function.

Distributions in CWC response charge and PRISMA-32 response amplitude

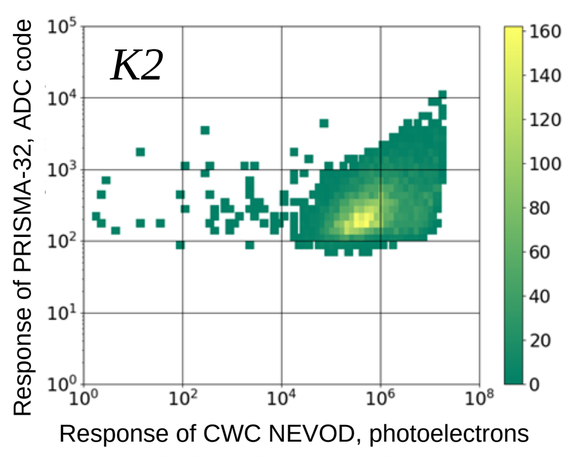


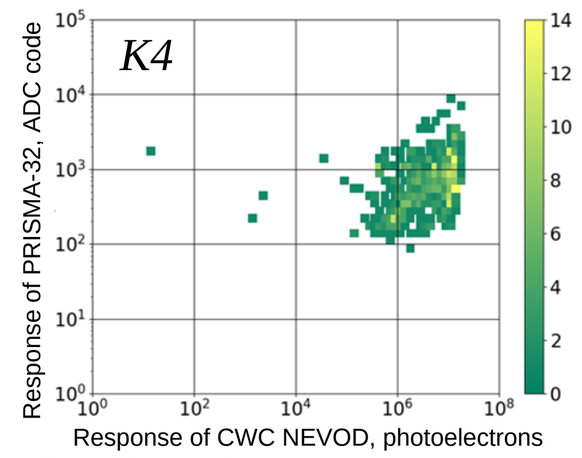


Distribution in the neutron response of the PRISMA-32

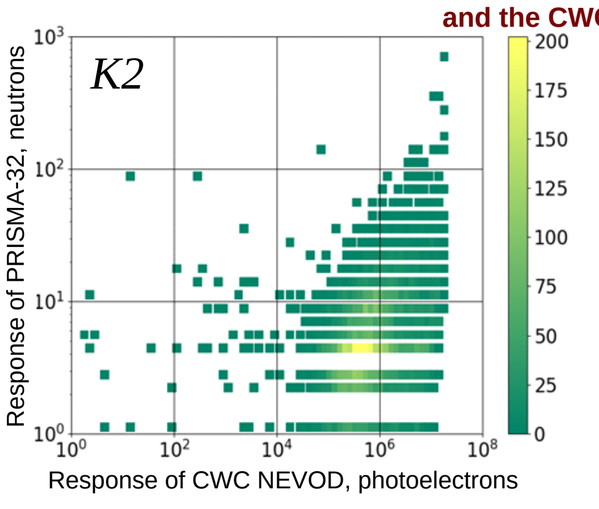


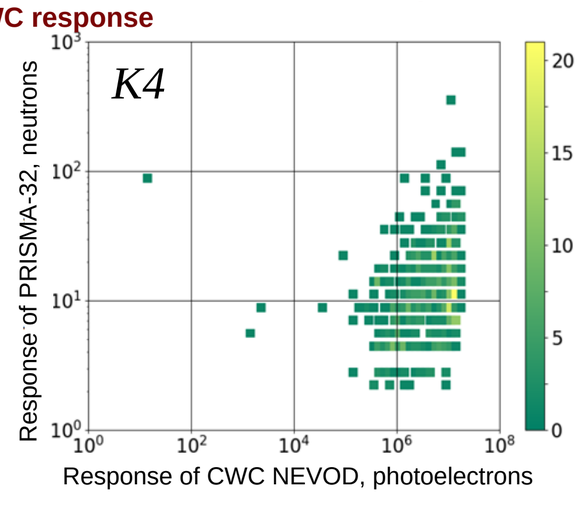
Correlations between responses PRISMA-32 and CWC to EAS changed component





Correlations between the response of PRISMA-32 to EAS neutron component and the CWC response





Conclusion

The phenomenological characteristics of the join events in the CWC and PRISMA-32 registered during three years of Data taking were obtained.

Correlation parameters of the response amplitudes of the CWC NEVOD and PRISMA-32 for K1-K3 are (0.21 ± 0.02)□10^{-3} ADC code / photoelectron, for K4 is 0.40 ± 0.02.

The correlation parameters of the response amplitudes of the CWC NEVOD and the number of neutrons registered by PRISMA-32 are (2.9 ± 0.5)□10^{-7} neutrons / photoelectron.

The spectra of the CWC NEVOD and PRISMA responses were analyzed. The feature of the amplitude spectrum of joint events for the CWC NEVOD was found: a significant deviation of the slope from the slop of the spectrum of non-joint events (0.5 vs. 1.5). The amplitude spectra of joint events and PRISMA-32 events differ less (1.5 vs. 1.7).

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