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Letters to the Editor

EFFICIENCY OF A COSMIC RAY NEUTRON DETECTOR DETERMINED BY THE MONTE-CARLO METHOD

ОПРЕДЕЛЕНИЕ КОЭФФИЦИЕНТА ПОЛЕЗНОГО ДЕЙСТВИЯ ДЕТЕКТОРА МОНТЕ-КАРЛО

KUDELA K.,* PAVLISKO J.,** Košice

For the measurement of the cosmic ray neutron leakage flux and for the estimation of energy spectra of such neutrons the apparatus BANAN was developed [1]. This apparatus was launched on three flights of stratospheric balloons. for the evaluation of the data obtained in these experiments it is necessary to know the dependence of the efficiency of the registration of neutrons on energy. The estimation of the spectra of the neutron flux was provided in the energy range 1—10 MeV.

The efficiency of the neutron detector is mainly determined by the efficiency of the organic scintillator, where the neutrons are moderated and the energy deposition of recoil protons (and other charged products of interactions produced by neutrons) is detected by a photomultiplier. For efficiency evaluation the Monte-Carlo method was used, as in similar cases [2, 3]. The difference of our case is that in cosmic ray applications we must assume a nearly isotropic flux of particles incident on the detector. Besides, our geometry (see Fig. 1) does not make it possible to apply algorithms used in the quoted papers.

The simulation of processes connected with the neutron passing through a detector and leading to the detection of the neutron was provided by the method of statistical experiments in the following steps:

1. Generation of the neutron incident point onto the surface of the detector and of the direction cosines of the impacting neutron (isotropic angular distribution).
2. Simulation of the point of interaction according to the formula for the free path $l = -\ln \gamma/\Sigma_T$, Σ_T — total macroscopic cross section, γ — random number from the interval (0,1).
3. Simulation of the type of interaction (from known cross sections for the elastic scattering on C, H, for inelastic scattering on C, and for reactions $^{12}C(n, n')3\alpha$ and $^{12}C(n, \alpha)^9Be$).
4. Simulation of the value of energy of the recoil proton (of the nucleus) or of the charged products of reactions. In this we assume the isotropic angular distribution of these particles in the CMS system.

In step 4 the scattering angle of the neutron after interaction and its new energy were obtained. Then, there followed step 2 to 4 with this neutron. The energy of the charged particles (products of neutron interactions) was according to the formulas in [4] changed into light output S. The neutron was registered if $S > S_{min}$, was the minimal light output, determined by characteristics of the photomultiplier circuit and by conditions of the light collection.

* Ústav experimentálnej fyziky SAV, Moyzesova ul., CS-040 01 KOŠICE.

The process of simulation was interrupted if the neutron left the active region of the scintillator, if it was registered, or if it was not registered after 6 collisions in the scintillator.

For the computation of efficiency by the described method there was developed a program in FORTRAN and applied on an IBM/370 computer. The results for the real geometry of the detector (legend in Fig. 1) R1 = 1.6 cm, R2 = 4.5 cm, D1 = 14.6 cm and for the composition of the scintillator of type NE-102 (numbers of C and H nuclei $N_C = 4.78 \times 10^{22}$ cm^{-3}, $N_H = 4.82 \times 10^{22}$ cm^{-3}) and of type NE-213 ($N_C = 4.05 \times 10^{22}$ cm^{-3}, $N_H = 5.28 \times 10^{22}$ cm^{-3}) are given in Figs. 2a and 2b for two discrimination levels ($E_{min} = 0.092$ and 0.81 MeV, respectively). At every energy 5×10^3 events were generated. The step in energy was 0.1—0.5 MeV.

The described method and the developed program may be used for the evaluation of the neutron efficiency registration in the scintillator of a hollow cylinder form under the conditions of a cosmic ray

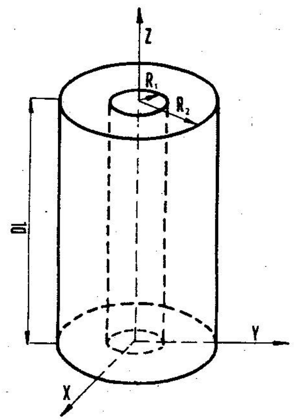

Fig. 1. Geometry of the detector

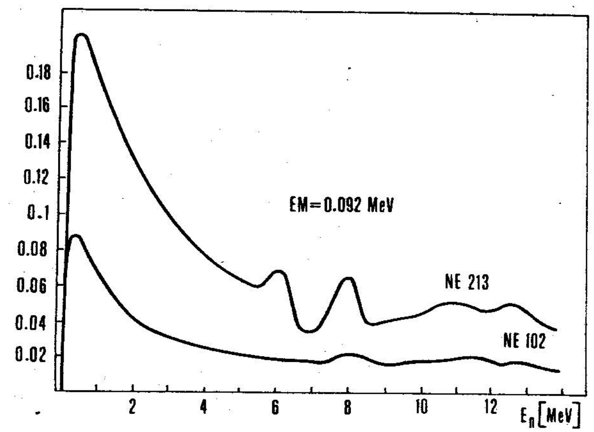

Fig. 2a

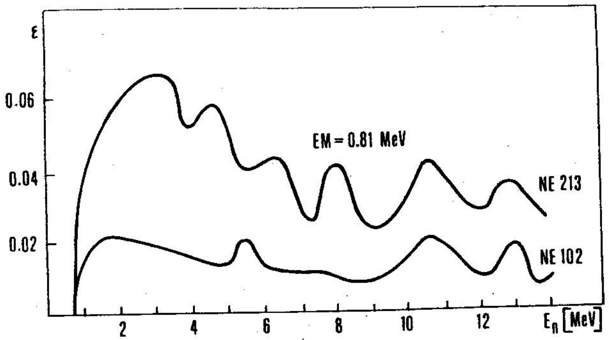

Fig. 2b

experiment, i. e. a nearly isotropic flux of particles if the *n*-gamma discrimination is secured (in our case by means of the pulse shape discrimination). The form of the scintillator enables to locate in the inner part the proportional counter (in our case ^{3}He, which in coincidence with the scintillator secures the registration of only neutron events.

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