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NEUTRON ENERGY SPECTRUM MEASUREMENTS OF NEUTRON SOURCES WITH AN NE-213 SPECTROMETER

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The neutron energy spectra of the following sources were measured using a fast-neutron spectrometer with NE-213 liquid scintillator: ^{252}Cf, Am–Be and T(d,n)^{4}He from a Van de Graaff accelerator (400 keV). The measured proton recoil pulse-height data were unfolded using the FANTI code to obtain the neutron energy spectrum. The spectrometer gives neutron spectra in the range of 2–16 MeV, with 6% intrinsic efficiency and a resolution between 4% and 11%. The ^{252}Cf neutron energy spectrum was measured and the results obtained showed good agreement with the spectrum usually published in the literature, which can be fitted by the expression $N(E) = \sqrt{E}\ \exp(-E/T)$ with the constant $T = 1.42$ MeV.

1. Introduction

For many experimental investigations in the field of dosimetry, metrological instrumentation, nuclear reactor research and high-power accelerators it is necesssary to measure the energy spectra of neutrons. At IPEN/CNEN-SP we have developed a fast-neutron spectrometric technique using NE-213 liquid scintillator for measuring the spectra of available neutron sources [1,2]. In particular, we paid attention to the ^{252}Cf neutron spectrum because it can be fitted by the well-known Maxwellian distribution which can be compared with the measured spectrum.

This article will describe the method employed to measure the spectra of fast-neutron sources, the unfolding technique and finally a comparison between the fitted and measured ^{252}Cf neutron source spectrum.

2. Description of the experiment

The neutron spectra of Am–Be, T(d, n)^{4}He and ^{252}Cf sources were obtained by using the fast-neutron spectrometer which uses an NE-213 liquid scintillator (2 in. × 1.5 in.) encapsulated in a standard type VH-1 aluminium can, connected to an RCA-8850 photomultiplier through a light guide. The pulse-shape discrimination technique has been used to resolve neutron- and gamma-ray pulse-height data. The electronic system, which is shown in fig. 1, was calibrated using some IAEA standard gamma-ray sources and the 4.43 MeV gamma-rays from an Am–Be source. With this calibration the spectrometer gives a neutron spectrum in the range of 2–16 MeV, with 6% intrinsic efficiency and a resolution between 4% and 11%.

3. Results and discussion

The measured pulse-height spectra of recoil protons from neutron interactions with the scintillator material were unfolded using the FANTI code [3],which applies the matrix inversion method to obtain the neutron energy spectrum.

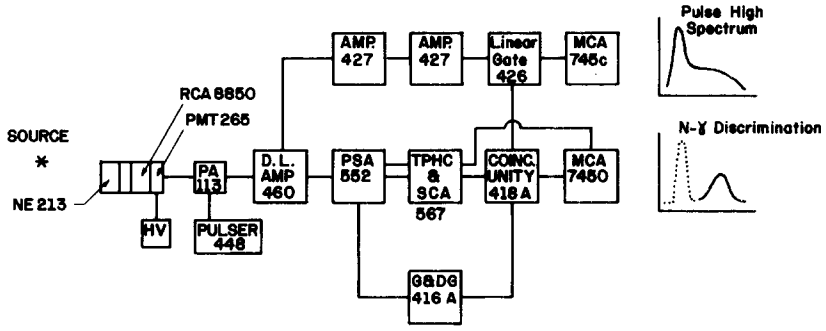

Fig. 1. Fast-neutron spectrometer with associated electronics.

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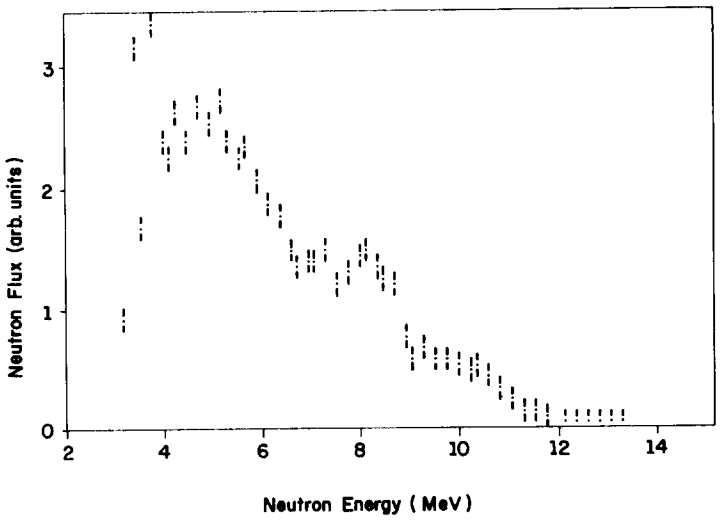

Fig. 2. Am–Be neutron energy spectrum.

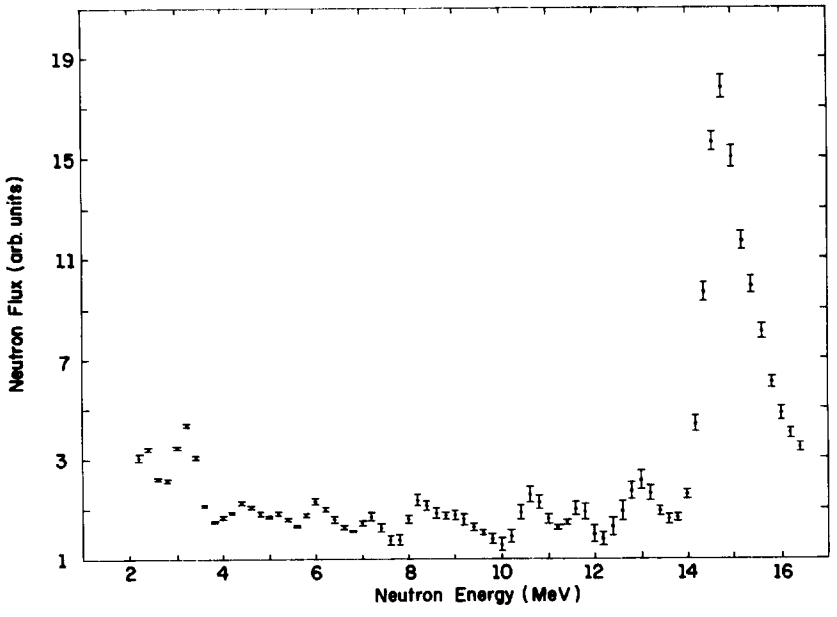

Fig. 3. T(d, n)^{4}He neutron energy spectrum.

The measured neutron spectra from Am–Be, T(d, n)^{4}He and ^{252}Cf sources are shown in figs. 2–4. The measured ^{252}Cf neutron spectrum shows a good agreement with the spectrum published in the literature [4], which can be fitted by the expression $N(E) = \sqrt{E}\exp(-E/T)$ with the constant $T = 1.42$ MeV. The neutron spectra of Am–Be and T(d, n)^{4}He agree with the literature results [5].

4. Conclusions

The results presented in this article show that a fast-neutron spectrometer can be useful for application in radiation dosimetry [6] since biological damage is a function of neutron energy. It can be used in a mixed field of gamma and neutron radiations. This spectrometer has been used in shielding benchmark experiments

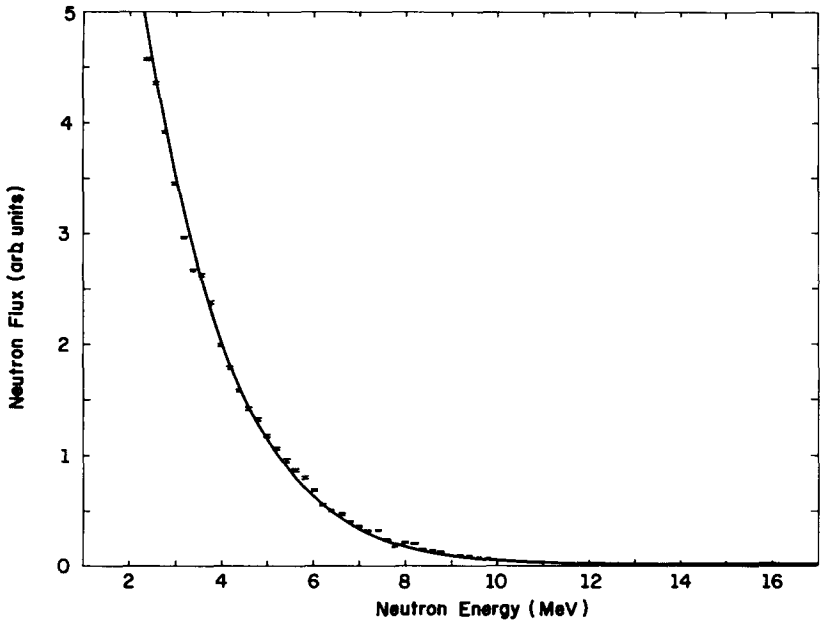

Fig. 4. ^{252}Cf neutron energy spectrum.

as well as in the characterization of reactor sources [2].

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