2.9 INSTRUMENTS AND METHODS

Fission Rate Determination in Delayed Neutron Emission Measurements with T(p,n) and D(d,n) Neutrons

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The purpose of the present work is to create a method of determination of fission event rate in a sample irradiated with quasimonoenergetic neutrons from the $T(p,n)^3He$ and $D(d,n)^3He$ reactions. The consideration is given for the case of the measurements of DN yields from neutron induced fission of ^{237}Np.

Fission rate in samples

In general the calculation of fission rate in the sample is a quite complicated problem [6] connected with solving the neutron transport kinetic equation taking into account neutron multiple scattering in a sample and construction materials of the experimental setup. It is necessary to account for a composite nonmonoenergetic spectrum of accelerator-based neutron source as well. In the general form the value of $R(E_n)$ can be presented as the functional of the following type:

$$R(E_n) = \langle \Sigma(E) \cdot \Lambda(r) \cdot \varphi(E, E_n, r) \rangle_{E,r} \tag{1}$$

where $\Sigma(E)$ is the effective macroscopic fission cross-section for neutrons with energy E, $\Lambda(r)$ is the neutron path length in the sample in the direction of radius-vector r of the interaction point, $\varphi(E,E_n,r)$ is the neutron flux on the sample with average neutron energy E_n , the sign $\langle\rangle_{E,r}$ denotes the averaging over all coordinates r and neutron energies E. The value of $\varphi(E,E_n,r)$ is associated with a spectrum of accelerator-based neutron source φ_0 by the relation

$$\varphi(E,E_n,r) = \Phi_0(E_n) \cdot \langle \varphi_0(E',E_n\Omega) \cdot G(E' \to E, \Omega \to r) \rangle_{E',\Omega}, \tag{2}$$

where Ω is the unit vector of an outgoing neutron direction, $\Phi_0(E_n)$ is the total neutron yield from an accelerator target

$$\Phi 0(En) = \langle \varphi 0(E', En\Omega) \rangle E', \Omega, \tag{3}$$

$G(E' \to E, \Omega \to r)$ is the Green function (scattering indicatrix) of the system which is taking into account the features of neutrons transport for the given geometry of experiment. The normalization constant $\Phi_0(E_n)$ can be determined by the comparison of the calculated value with the count rates $R_i(E_n)$ of two monitor fission chambers (with fissile layers made of the same material ^{237}Np, i is the chamber's number) located directly in front of and behind the researched sample in the same neutron flux.

Results

The test of the method (to estimate the $R_s(E_n)$ value properly) was carried out by measuring the count rate $R_i(E_n)$ in the fission chambers placed at different distances from the neutron target and by comparing the results with calculated values W_i (Fig.1).

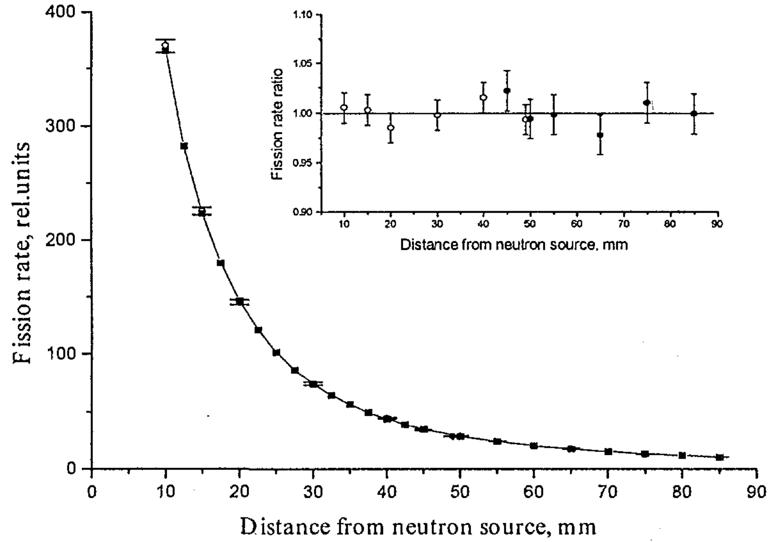

Fig. 1. Comparison of fission rates in the fission chambers at different distances from a neutron source T(p,n) obtained by measuring $R_i (E_n)$ and on the basis of W_i calculations. The energy of primary protons is 1.974 MeV.

In Fig.2 the results of calculations of the values ($W_i{\cdot}W_s^{-1}$) for the ^{237}Np sample obtained for two cases of neutron flux monitoring (by one and two fission chambers) are presented.

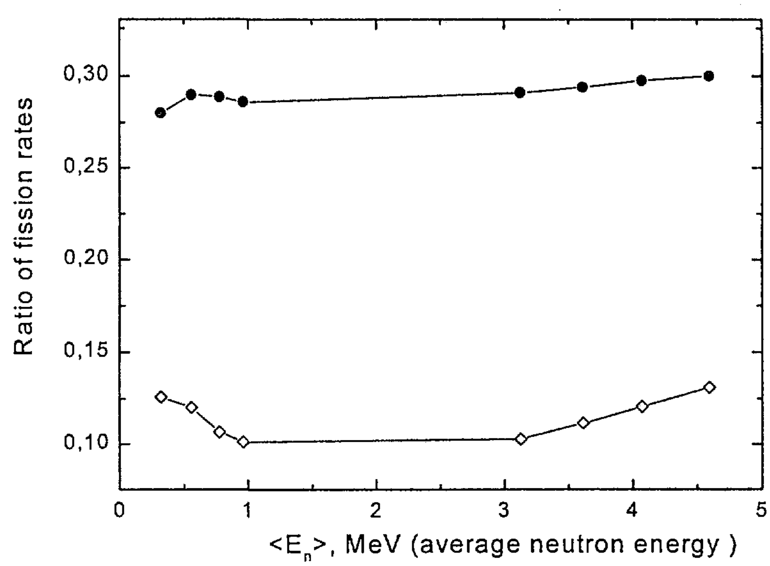

Fig. 2. The ratio of fission rates in a layer of fission chamber and ^{237}Np sample $W_i{\cdot}W_s^{-1}$. Open circles are related to "one fission chamber" geometry. Black circles are related to "two fission chambers" geometry. The points are connected by straight lines for visualization.