THE MEASUREMENT OF Cf-252 SPONTANEOUS
FISSION PROMPT NEUTRON SPECTRUM IN THE LOWER ENERGY

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Abstract: The prompt neutron spectrum from Cf-252 spontaneous fission in the low energy has been measured with TOF method. The neutron detectors were the lithium glasses(with different products and thickness). The fragment detector was a mini-ionization chamber. The intensities of the Cf-252 source were different in different run. The flight paths varied from 30 to 50 cm. The prompt neutron detectors' efficiencies were calculated with Monte Carlo method. The absolute efficiencies of the detectors will be determined by experiment, which will be done in CBNM, Geel, Belgium. The experiment was carried out in a 1960 m^3 hall, and the corrections were considered. The preliminary result was given. And the last result will be given after the determination of the neutron detector efficiencies.

(neutron spectrum,Cf-252,lithium glass,ionization chamer,preliminary result)

Introduction

The prompt neutron spectrum from the spontaneous fission of Cf-252 has been defined as a standard neutron spectrum/1,2/. The detailed shape of the neutron energy spectrum is required with high precision. Californium source are widely used for neutron detector calibration and for other applications. In recent years a number of the spectra have been measured /3,4,5,6,7,8/. The measured data were evaluated by W. Mannhart/9/ at higher precision. The evaluated data was recommended by Data Section, IAEA/10/. Even though, a rather large discrepancies at lower and higher energy are still exist. Therefore, the further work is still needed both in experimental and theoretical direction.

Description of the Experiment

The prompt neutron spectrum of Cf-252 in the low energy of 0.05 - 1.2 MeV was measured using TOF method. In the first run, the neutron detector is NE912 lithium glass (45 mm in diameter, 9.55 mm in thickness). A RCA 8850 PM is coupled with the detector. The fragment detector is a mini-ionization chamber/11/. The structure and the size of the chamber are shown in Fig. 1. The weight of the chamber is about 1.65g. The experiment was carried out in a 1960 m^3 neutron hall. The flight path is 30 cm. The intensity of the Cf-252 fission source is 3757 f/s. The backing of the Cf-252 source is a stainless steel chip, which was highly polished. The thickness of the backing is 0.1 mm. The source was made by means of transfusion in vacuum. The data acquisition time was 403 hours in this run. The TOF spectrum is shown in Fig. 2. The time resolution of the prompt gamma-ray peak was 1.8 ns for the system. A NE913 Li-7 enriched glass was used to estimate the gamma-ray disturbance for the neutron spectrum measurement in the interested neutron energy region. The size of the NE913 detector was same as the NE912 detector. The background of scattering scale was estimated using a copper cone.

In the second run, the neutron detectors were two China made ST602 lithium glasses, which were positioned at 0° and 45° respected to the normal
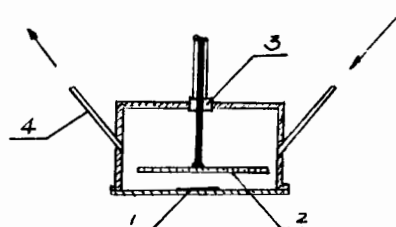

Fig. 1. Mini-ionization chamber
1. Cf-252 Source
2. Collective electron pole
3. Fluoroplastic insulator
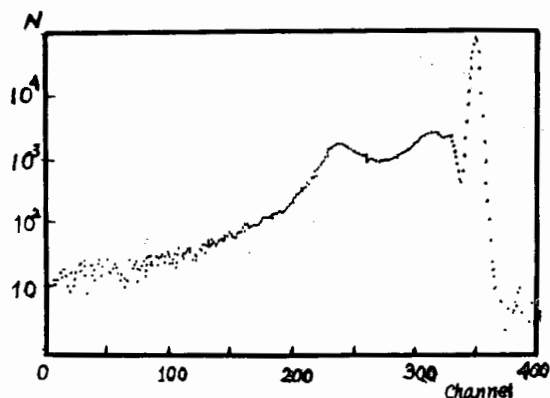4. Capillary inlets for flowing gas(pure methane)

Fig. 2 TOF Spectrum of Cf-252(L=30cm)

line of Cf-252 source plane and the flight paths were 30 cm and 50 cm. The diameter of the detectors is 40 mm, the thickness of the detectors are 3 mm and 10 mm(at 0° and 45°, respectively). The data were acquired for 720 hours. The Cf-252 source used in the run was a electroplated one. The intensity of the source was 2×10^4 f/s.

Consideration of the efficiency determination for the neutron detectors

Efficiency determination of the neutron detector is very important for determining the shape of the spectrum. For lack of suitable neutron source the efficiencies of the neutron detectors were calculated using Monte Carlo method/12/. In the calculation the delayed time of $^6Li(n,alpha)T$ events caused by multiple scattering was considered(prompt efficiency). Using this method the efficiency of the NE912 detector was got in the neutron energy range of 10 KeV to 2.0 MeV. The calculated integrated efficiency of the detector is shown in Fig. 3 and compared with A. Lajtai's relative measured data. Except a few points the consistent is good. The efficiencies of the other two ST602 lithium glasses were also calculated. The absolute efficiency determination of the neutron detectors will be done with a white light neutron source in CBNM Geel, Belgium as a cooperation program with Geel Establishment.

Data analysis and preliminary result

Using the calculated prompt efficiency of the NE912 detector the prompt neutron energy spectrum of Cf-252 was got for the first run. The corrections considered here are following:
(1). The environment background;
(2). The accidental coincidence;
(3). The scattering on the backing;
(4). The time resolution;
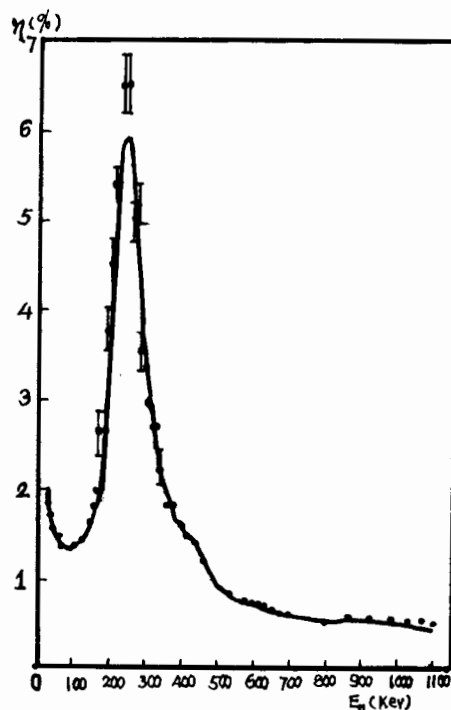(5). The random background.

Fig. 3 The calculated efficiency of the neutron detector
(I-data measured by A.Lajtai)

After these corrections the neutron spectrum was fitted with Maxwell distribution (Fig. 4) and compared with Maxwell distribution at T=1.42 MeV (Fig. 5). The uncertainties contained in the fitting were following:
(1). The statistical uncertainty;
(2). The uncertainty from the efficiency calculation;
(3). The uncertainties caused by conversation between the time scale and the energy scale. e.g. the uncertainty of the flight path, the uncertainty from the determination of the gamma-ray peak position and the uncertainty from the determination of the channel width in the TOF spectrum et al.. Without absolute efficiency of the neutron detectors the present result is preliminary. And the data got in the second run have not been treated yet.
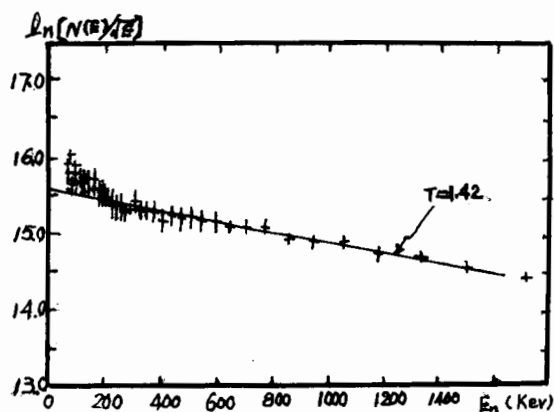

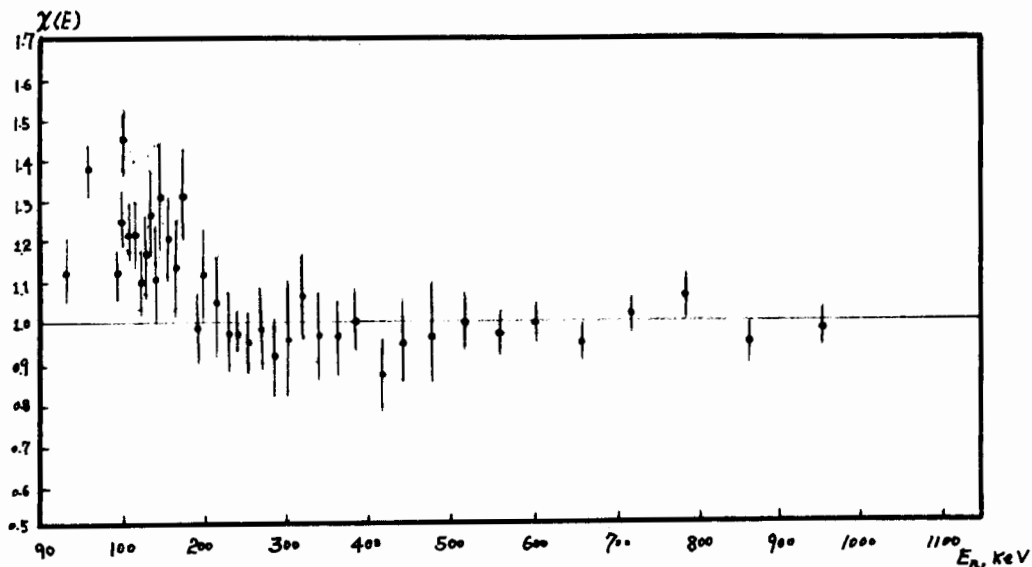Fig. 4 The neutron spectrum fitted with Maxwell distribution

Fig. 5 The ratio of the experimental data and Maxwell distribution
at t=1.42MeV (the flight path is 30cm)

REFERENCE

1. Proc. IAEA Panel on Neutron
Standard Reference Data, 20-40 Nov.
1972, CONF 721127, p.362, IAEA, Vienna
(1974).
2. Proc. IAEA consultants' Meeting on
Prompt Fission Neutron Spectra, Aug.
1971, p.169, IAEA, Vienna (1972).
3. A. Lajtai et al., Smolenice
Meeting, p.177 (1983).
4. R. Bottger et al., IAEA-TECDOC-
410, p. 186 (1987).
5. W. P. Poenitz et al., Smolenice
Meeting, p. 175 (1983).
6. B. V. Blinov et al., Report
INDC(CCP)-238/L (June 1985).
7. J. W. Boldeman et al., Nucl. Sci.
Eng., 93(1986)733.
8. H. Marten et al., Report
INDC(GDR)-28/L (Sept. 1984).
9. W. Mannhart, IAEA-TECDOC-410,
P.158 (1987).
10. Proc., 16th INDC Meeting, 19-23
Oct. 1987, Beijing, China.
11. J. Men et al., Report on 1th
Conference on Nuclear Data
Measurement, 10-15 April, 1988,
Chengdu, P. R. China.
12. Guoyou Tang et al., Internal
Report IHIPN8801, Institute of Heavy
Ion Physics, Peking University,
Beijing, China.