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FISSION NEUTRON SPECTRUM OF ^{252}Cf FROM 0.002 TO 1 MeV

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ABSTRACT

Measurement of fission neutron spectrum from 0.002 to 1 MeV for spontaneous fission of ^{252}Cf by time-of-flight technique are reported. The low energy part of the spectrum shows some deviation from the expected Maxwellian shape.

РЕЗЮМЕ

Методом времени пролета измерены спектры мгновенных нейтронов спонтанного деления ^{252}Cf с 2 кэв до I Мэв. В области ниже 500 кэв отмечено превышение спектра нейтронов по сравнению с ожидаемым Максвелловским распределением.

KIVONAT

A 0.002 - 1 MeV energiatartományban repülési idő módszerrel megmértük a ^{252}Cf spontán hasadásánál keletkező neutronok energiaeloszlását. A spektrum kis energiáju tartományában /E_n < 0.5 MeV/ jelentős többlet mutatkozik a várt Maxwell-eloszláshoz képest.

The spontaneous fission neutron spectrum of ^{252}Cf from 0.003 MeV to 15 MeV has been measured by Meadows [1] by time-of-flight technique using a hydrogenous liquid scintillator detector at the higher and a ^{6}Li-loaded glass scintillator at the lower neutron energies. Meadows pointed out that the low energy part of the experimental spectrum shows some deviation from the Maxwellian shape, while the agreement is excellent for the spectra above 0.5 MeV.

To study the low energy behaviour of the spectrum we have measured the energy spectrum of neutrons emitted in the spontaneous fission of ^{252}Cf in the range 2 keV - 1 MeV.

A schematic drawing of the experimental apparatus is shown in Fig. 1. The energy of the fission neutrons was evaluated from the flight time measured over a given distance. The neutrons were detected with 7.6 cm diam. by 0.3 cm thick Nuclear Enterprises glass scintillator containing 7.3 % lithium enriched to 96 % in ^{6}Li. The efficiency curve was taken from [1].

A ^{252}Cf fission source rating 1.7×10^{5} fissions per minute on thin stainless steel foil, and later a ^{252}Cf source rating 1.1×10^{6} fissions per minute on thin platinum foil, was mounted in the centre of a gas scintillation cell 10 cm in diam. and 6 cm long. The gas scintillation counter contained a mixture of 80 % argon and 20 % nitrogen gas at a pressure of 1 atm. The gas scintillation counter was chosen to prevent the counting of other than fission events in view of the large background contribution from α , neutron and gamma radiation.

For measurements at 15.5, 30 and 57.5 cm flight paths the flight times up to 400 nsec were measured by a time-to-pulse height converter. Because of the high count rate of the fission detector, the neutron detector was used for triggering the time converter. The stop signal was provided by the fission detector. The limited signals from the fission detector were sent through a delay line of 400 nsec. The zero time was determined from the position of the prompt gamma ray peak, with a correction for the gamma ray flight time. The time scale was calibrated by recording the position of this peak at different values of the delay varied by the use of calibrated delay lines. The channel time was 0.39 nsec. The time calibration, the detector pulse heights and bias levels were checked daily and if necessary, adjusted.

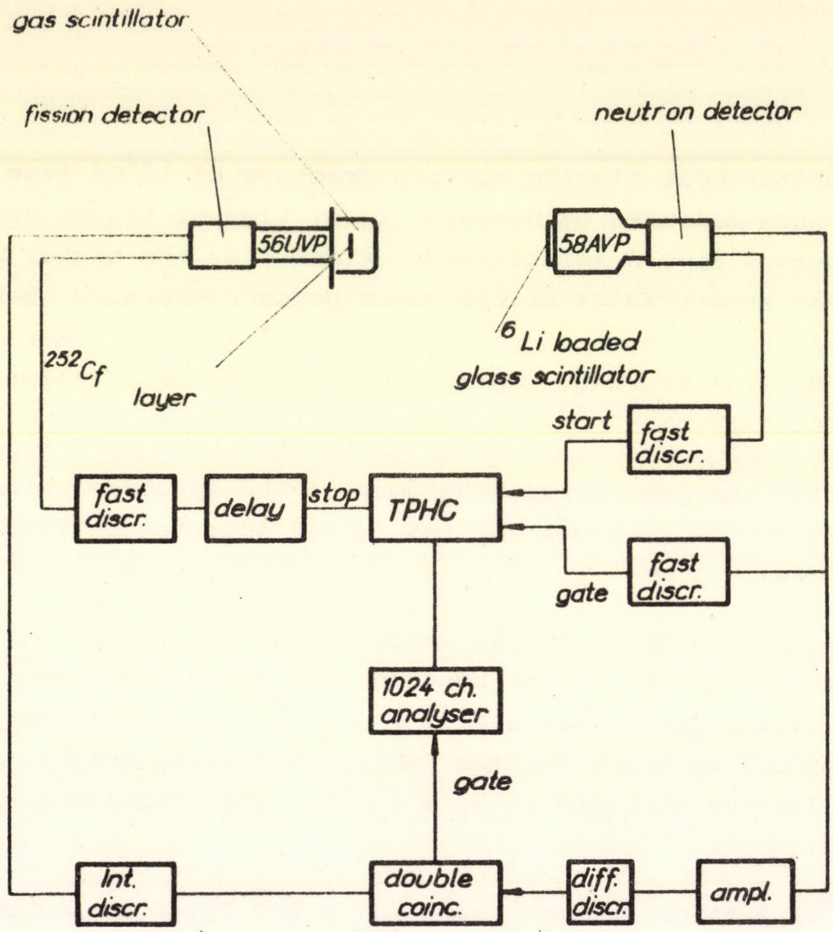

Fig. 1 Block diagram of the apparatus

The background sources arising when time-of-flight technique is used for measuring fission neutron energies were studied in detail elsewhere[2].

The random coincidence background was measured simultaneously in a given range of the spectrum by suppressing systematic events in this region with appropriate delays.

The spectrum distortion due to the systematic-random coincidences was calculated from the measured spectra.

In order to reduce the scattered background, the detector was prepared from light material, using 0.1 cm aluminium and the window of the fission chamber from 0.03 cm aluminium. To measure the scattered background, a 13 cm long brass cone was placed between the detectors for runs at 57.5 cm flight path and a cone 7 cm in length for other runs.

The background caused by the detection of delayed gamma rays was measured at 3.5 cm flight path and was normalized to the measured spectra taking into account the different solid angles and the number of fissions detected.

The results of the measurements carried out at different flight paths are given in Table 1 and Fig. 2. It can be seen from Fig. 2 that below 0.5 MeV each measurement gives a certain amount of surplus neutrons as compared to a Maxwellian with T = 1.57 MeV, which fits quite closely the experimental data between 0.5 - 6 MeV [2]. The data measured at different flight path were summarized taking into account the error of each point, the results are given in Table 2 and Fig. 3.

Our measured data are in good agreement with the data of [1, 3]. The interpretation of the results will be done elsewhere [4].

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Table 1

The results of the measurement on the fission neutron spectrum of ^{252}Cf. Flight paths: A - 15,5 cm, B - 30 cm, C - 57.5 cm

E_n MeV	$N(E)$ arb. units	$\frac{\Delta N(E)}{N(E)}$ %	
0.0024	0.768	5.9	A
0.0027	1.019	6.4	A
0.0032	0.632	5.7	A
0.0036	0.742	6.0	A
0.0042	0.814	6.3	A
0.0046	0.752	7.7	A
0.0051	0.984	5.4	A
0.0059	1.271	5.7	A
0.0070	1.114	4.7	A
0.0080	1.621	6.7	A
0.0090	1.268	15.1	B
0.0092	1.034	5.6	A
0.0106	1.221	5.2	A
0.0106	1.021	14.8	B
0.0120	1.202	15.0	B
0.0122	1.321	4.9	A
0.0140	1.362	13.8	B
0.0160	1.460	12.1	B
0.0160	1.543	5.6	A
0.0175	1.477	12.4	B
0.0180	1.654	7.1	A

E_n MeV	$N(E)$ arb. units	$\frac{N(E)}{N(E)}$ %	
0.0195	1.435	13.2	B
0.0210	1.821	5.8	A
0.0230	1.635	6.0	A
0.0230	2.059	11.6	B
0.0270	1.854	8.7	B
0.0270	1.942	4.9	A
0.0320	2.275	9.1	B
0.0340	2.271	11.2	C
0.035	2.129	4.3	A
0.037	2.153	7.2	B
0.040	2.432	10.1	C
0.044	2.655	5.8	B
0.045	2.412	5.1	A
0.055	2.915	8.3	C
0.055	2.749	5.4	B
0.060	3.123	4.2	A
0.065	3.049	6.1	B
0.065	3.108	8.4	C
0.075	3.219	8.5	C
0.075	3.177	7.1	B
0.075	2.935	3.8	A
0.085	3.495	6.3	B
0.086	3.489	8.2	C
0.095	3.529	5.8	B
0.095	3.754	3.1	A
0.101	3.621	7.3	C
0.110	3.999	4.2	B
0.121	4.198	6.1	C
0.135	4.205	3.6	B
0.146	4.488	5.8	C
0.165	4.334	2.9	B
0.175	4.712	4.2	C
0.180	4.703	3.0	B
0.200	4.851	3.5	C
0.220	4.477	1.7	B
0.270	4.850	1.9	B
0.276	4.879	1.6	C
0.315	4.989	1.5	B
0.346	5.012	1.6	C
0.370	5.090	2.0	B
0.445	5.094	2.2	B
0.463	5.175	1.9	C
0.520	5.428	3.5	B
0.544	5.379	3.1	C
0.628	5.385	4.5	C
0.661	5.597	4.4	C
0.729	5.602	4.0	C
0.792	5.611	4.4	C
0.852	5.449	4.3	C
0.938	5.214	4.3	C
1.073	5.132	4.8	C

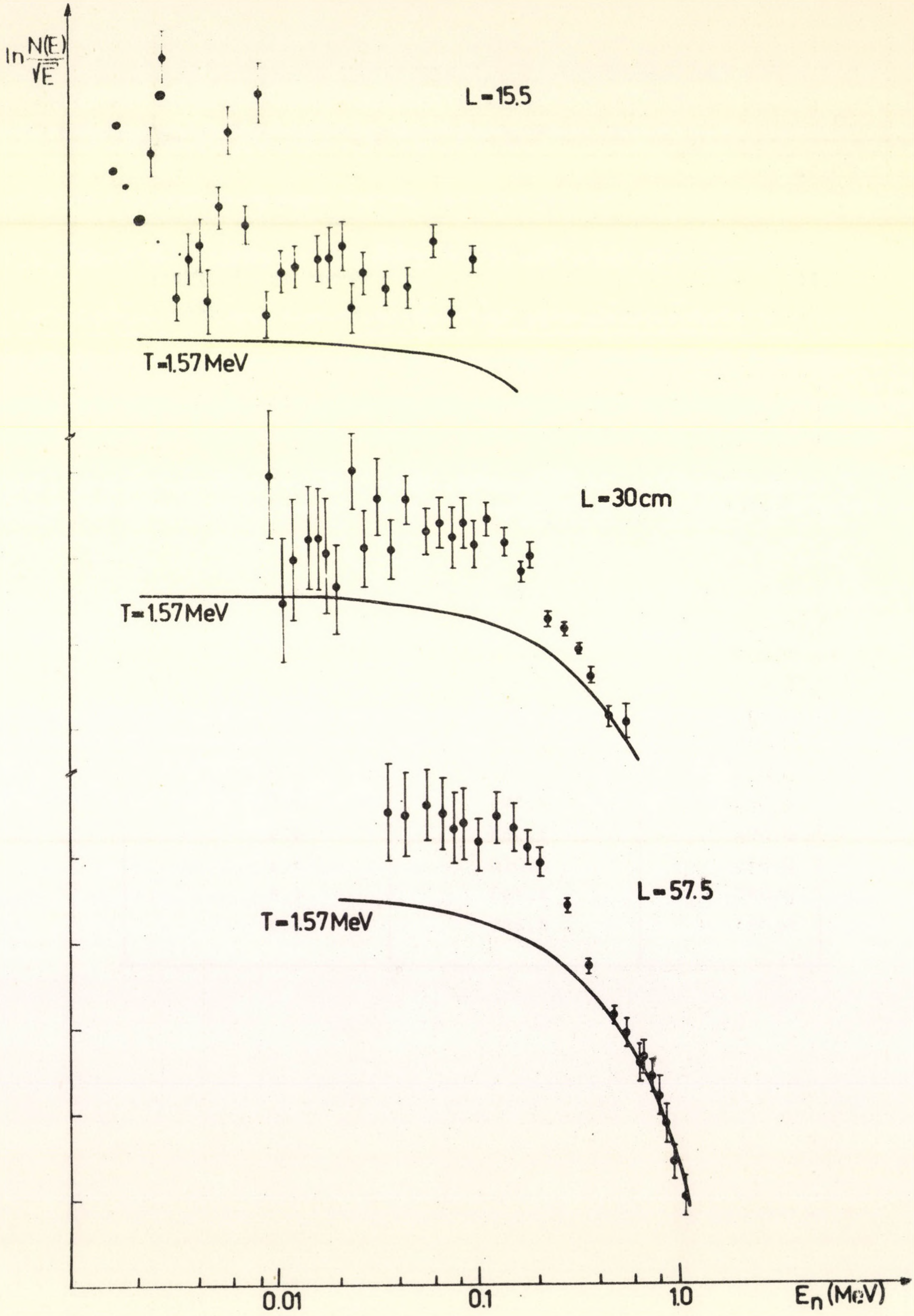

Fig. 2

Fission neutron spectra of ^{252}Cf measured at different flight paths

Table 2

The summarised results of the measurement on the fission neutron spectrum of ^{252}Cf in the range 0.009 - 0.095 MeV

E_n MeV	$N(E)$ arb. units	$\frac{\Delta N(E)}{N(E)}$ %
0.0090	1.054	5.2
0.0106	1.191	4.9
0.0120	1.307	4.6
0.0160	1.527	5.0
0.0177	1.602	6.1
0.020	1.729	5.3
0.023	1.713	5.3
0.027	1.919	4.2
0.033	2.164	3.6
0.038	2.232	5.8
0.045	2.507	3.8
0.055	2.794	4.5
0.065	3.069	4.9
0.075	3.010	3.1
0.085	3.493	4.9
0.095	3.699	2.7

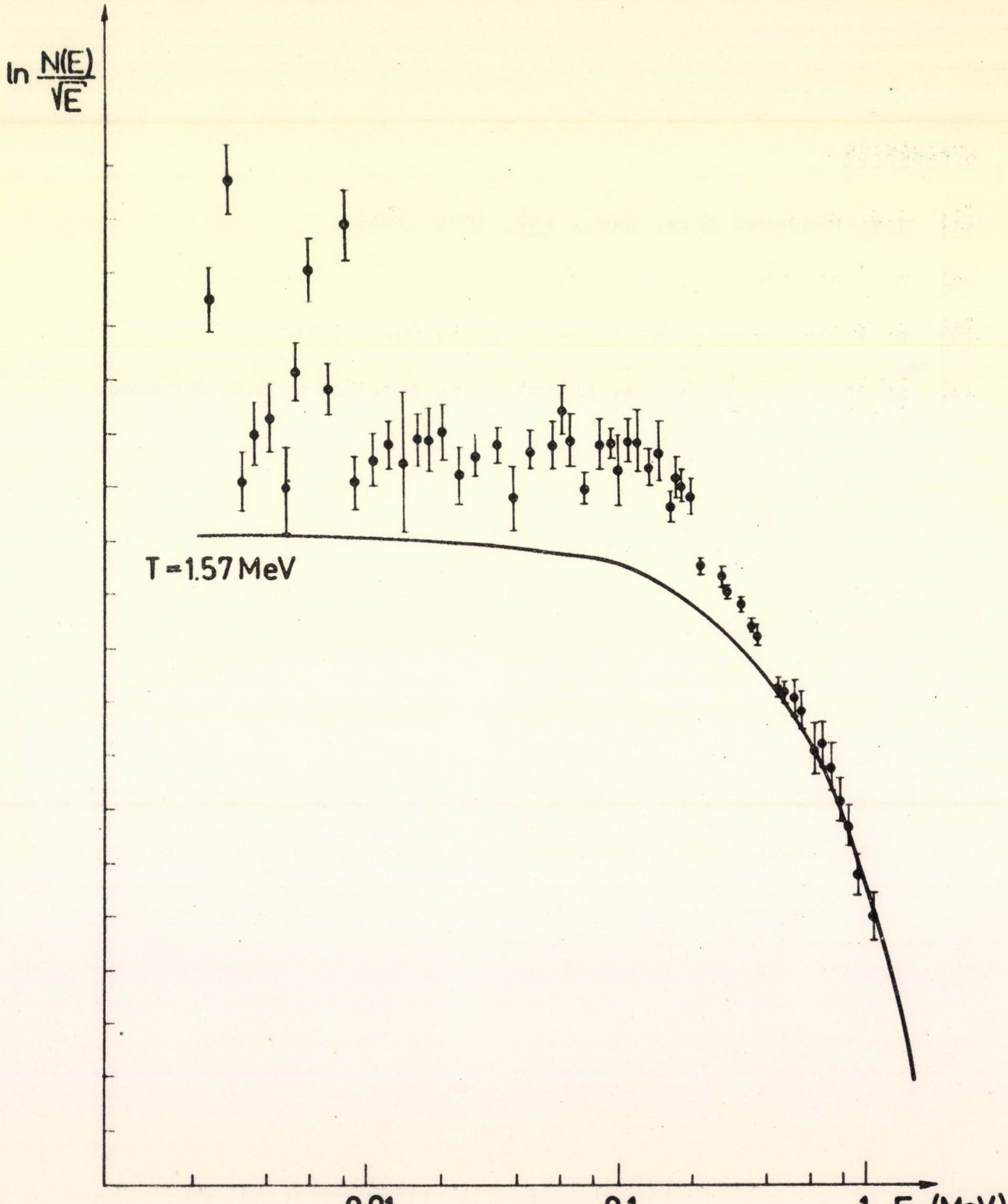

Fig. 3

The measured energy spectrum of neutrons from the spontaneous fission of ^{252}Cf

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