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The fission probability of heavy elements with μ^- - mesons has been especially studied by means of nuclear emulsions exposed to meson beams /1-4/. The results (table 1) strongly depend on the distribution of fissile isotope inside the emulsion, and on the validity of assumption that the atomic capture probability is proportional to Z. For instance, in the two extremes, when uranium is homogeneously distributed into emulsion and only in gelatine, the fission probability differs by a factor of two /2/. At the same time, the assumption that the atomic capture probability depends of Z or does not, leads for the fission probability to values which differ by a factor of 10 or more (see ref. /3/).

Table 1 The available data on the fission yield per μ-capture

	^{232}Th	^{238}U
Galbraith and Whitehouse [a]		<0.025
John and Fry [b]		0.15±0.06 0.07±0.03
Petrascu and Mihul	0.018±0.012	
Belovitskii et al [d]		0.070±0.008
Chultem et al [e]	0.0043±0.0010	0.031±0.007

[a] Ref[1] [b] Ref[2] [c] Ref[3] [d] Ref[4] [e] Ref[5]

Assumptions

1 Emulsion is a homogeneous mixture

2 Atomic capture probability is proportional to Z

3 Fissile isotope is dispersed only in a gelatin

Only recently the systematics of the absolute fission probabilities for six isotopes measured by another method than that of nuclear emulsions have been published /5, 6/. It has been obtained measuring the yield of fission per μ -capture in ^{238}U and relative yields of fission in other elements with ^{238}U as the reference. The evident disagreement with the predictions based on the known up-to date Γ_n/Γ_f values made it important to repeat the measurement of the fission yield per μ-capture. In the present case the μ-stop number has been found in a fissile element and not in an aluminium as in our previous work /5/.

In this work we measured the fission probability of ^{232}Th with μ-mesons, detecting simultaneously the fission events and the mesic X-ray spectrum of thorium inside the chamber. Then, the fission probability is

$$W_f^{\mu^-} = \frac{N_f}{N_{\mu^- - stops}} = \frac{n_f}{\epsilon_f} \cdot \frac{\epsilon_\gamma I_{m-n}}{A_\gamma^{m-n}},$$

where $N_{\mu^- - stops}$ is the number of muons stopped in thorium, N_f is the number of the fission events in thorium, ϵ_f is the efficiency of the fission chamber, ϵ_γ is the photopeak efficiency of Ge(Li) detector, I_{m-n} is the intensity of m-n mesic transition and A_γ^{m-n} is the area of the photopeak of the m-n transition in thorium.

The measurements have been performed at the μ^--beam of JINR Dubna synchrocyclotron. The geometry of the experiment is shown in *Fig. 1*. The ionization chamber, filled with methane at 2.5 *atm* contains a number of 14 parallel targets 7×10^{-3} *cm* thick, 4.6 *cm* diameter of metallic thorium. Between each two targets there is an aluminium electrode 2×10^{-3} *cm* thick. The 3rd and the 4th detectors of the telescope are inside the chamber. The 3rd detector is a plastic scintillator 0.03 *mm* thick and 4.6 *cm* diameter and the 4th detector is a glasslike form plastic scintillator 8 *cm* in diameter and 0.4 *cm* thickness of the wall. The thorium targets and aluminium electrodes are fixed directly on the 4th detector by means of a 0.008 *cm* diameter fishing-line, at a distance of 0.2 *cm* each other. In this way the main materials between

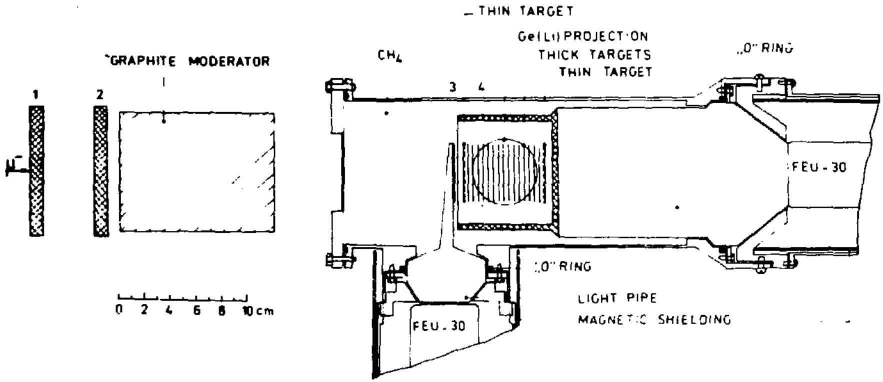

Fig. 1. Geometry of the experiment.

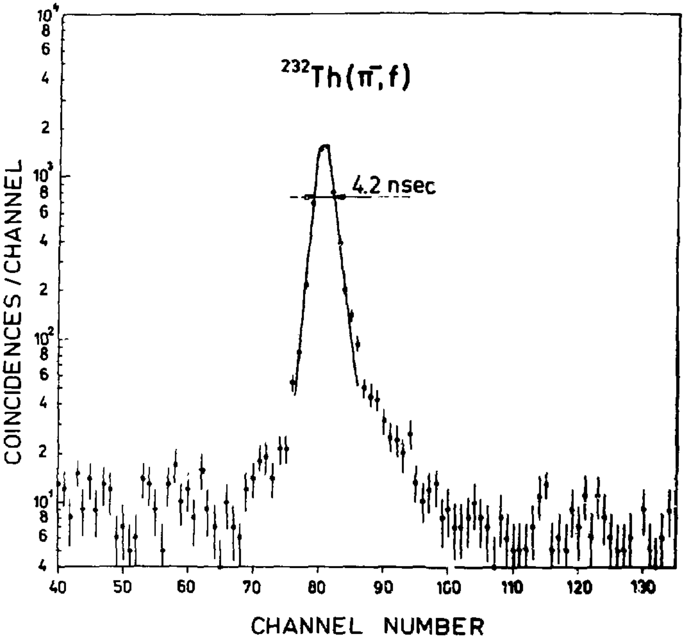

Fig. 2. The time spectrum of Th(π^-, f) *coincidences.*

the 3rd and 4th detectors are: 18.639 *g* Th , 1.55 *g* Al and 0.5 *g* CH_4 .

The muon beam is monitored as usually by an (1,2) coincidences; a muon stopped between the 3rd and 4th counters is registered as an $(1,2,3,\bar{4})$ event, the bar indicating an anticoincidence. The time resolution of telescope - fission coincidences is about 4 *ns (Fig. 2).*

The registration efficiency of the fission fragments was measured by means of Th(n, f) reaction, using a 14 *MeV* neutron beam of a (d, t) neutron-generator. At both the sides of the target system there is a thin ThO_2 target (0.5 mg/cm^2) deposited on an aluminium foil having a diameter of 4.6 *cm*. The number of the fission events from the thick target system was measured at the various thresholds of an integral discriminator as a function of α-activity, measuring $n_f + n_\alpha$ with beam-in and n_α without neutron beam. At the same time, the fission integral spectra of the thin targets were got and the "plateau", extrapolated to the zero amplitude, was considered as 100% efficiency. Then, using the masses of the targets and the geometrical factors, the fission efficiency of the thick target system was founs as a function of α-activity (*Fig. 3*).

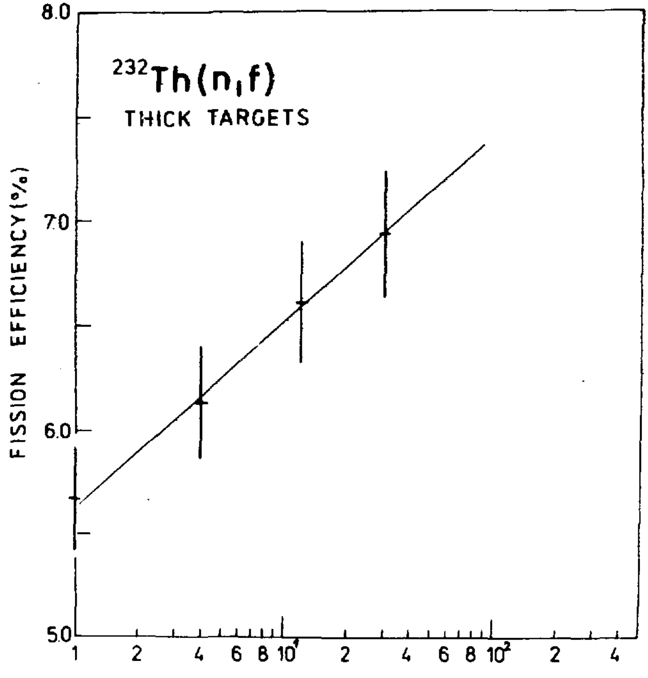

Fig. 3. The fission efficiency of the thick-target system.

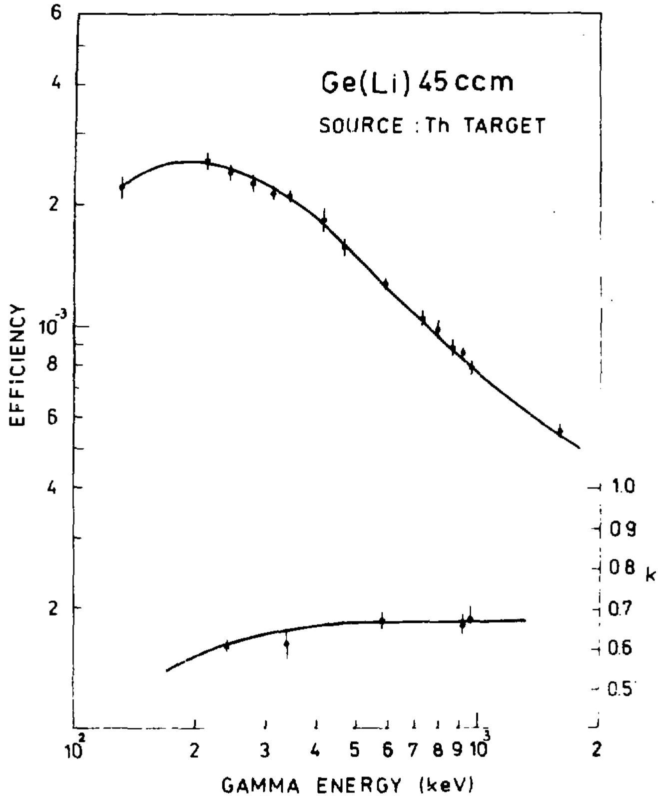

Fig. 4. The gamma efficiency of Ge(Li) detector in the geometry shown in fig. 1. The efficiency measured in-beam is smaller by a factor k (the right-hand scale).

The emerging mesic X-rays in the target system traverse the 4th counter and the wall of the chamber and enter a 45 *cm* true-coaxial Ge(Li) detector. The time resolution for coincidences between the telescope and Ge(Li) was $2\tau = 11$ *ns*.

The absolute gamma intensity (γ /*g sec*) of γ-rays from the thorium material, used by us in the chamber, was determined with a thin Th target and gamma standard sources. Then the ratio between the photopeak area measured with the chamber in the used geometry and the absolute intensity gives the efficiency for that energy. The efficiency obtained in this way (*Fig. 4*) includes the geometrical factor, the selfabsorption and the absorption of the γ-rays in the materials between target and Ge(Li) detector.

In the time of the experiment, the efficiency of the Ge(Li) detector was measured again simultaneously with the mesic X-ray spectrum, detecting the spectrum of thorium activity into a time-window between 0.7 and 10.0 μs from the moment when a μ-stop is counted. The product of the number of (1,2,3,4) coincidences and the width of the time-window determines the time in which the γ-spectrum of Th was measured. One of these spectra is shown in *Fig. 5*. The width of the time-window was measured by means of a frequency generator. This efficiency measured in-beam is smaller than that anterior by a factor k (*Fig. 4*, the right-hand scale). The diminution of the efficiency is due to the different geometry in the time of the experiment, to the nonefficiency of the timing channel and to the dead-time and pile-up of the electronics both in the start and stop channels.

A mesic X-ray spectrum is shown in *Fig. 6*. We chose for our aim the transition 5g - 4f because here the background is smaller and the gamma efficiency is quite high. The measurement of the absolute intensities of muonic transitions in lead, thorium and uranium has been performed recently in the Laboratory of Nuclear Problems, JINR, Dubna. The preliminary result for 5g - 4f transition in ^{232}Th is $I_{5-4} = 0.290 \pm 0.017$, which has been used in the present work.

One of the time distribution spectra of fission is given in *Fig. 7*. The background due to the chance coincidences has been measured at the left-hand of the prompt peak and it is shown in this figure.

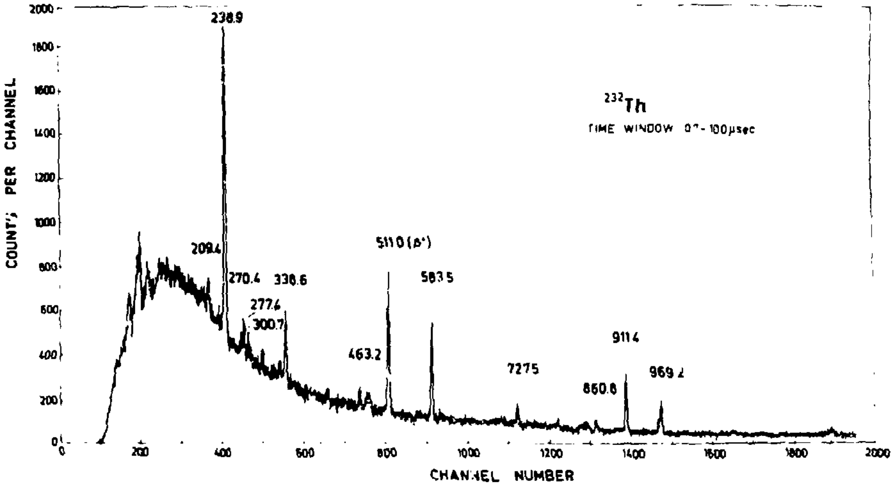

Fig. 5. The spectrum of γ-rays emitted by Th measured simultaneously with the muonic X-ray spectrum.

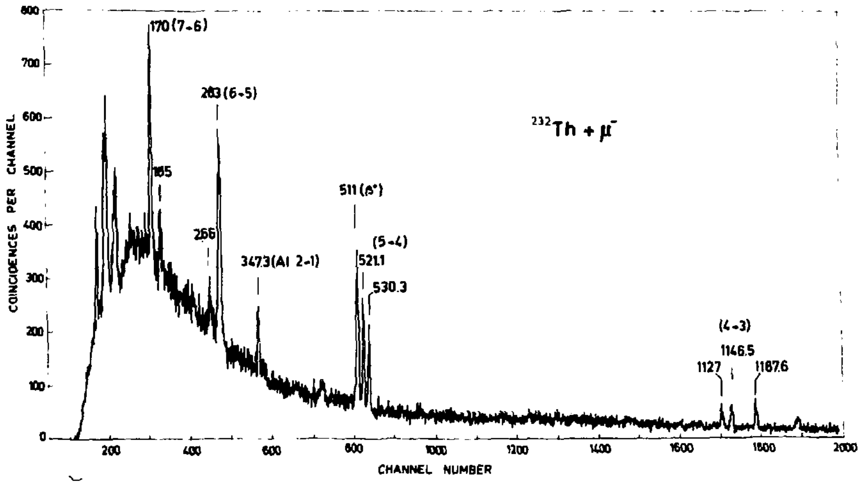

Fig. 6. Muonic X-ray spectrum of thorium.

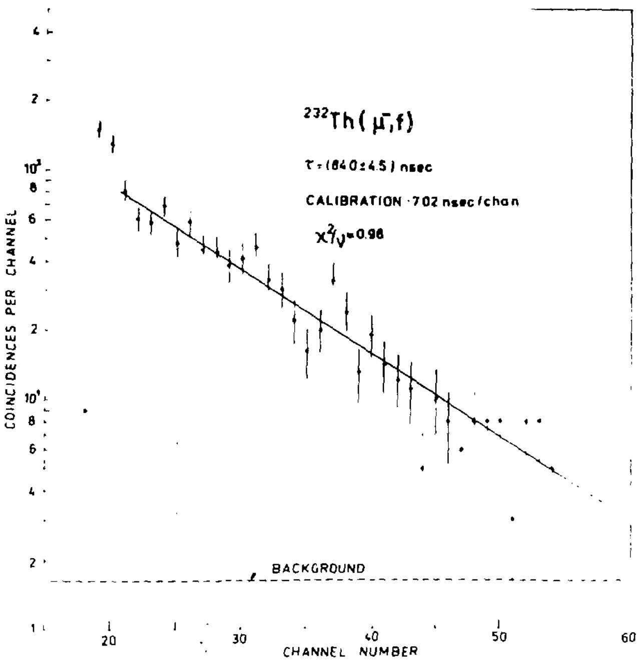

Fig. 7. The time distribution spectrum of fissions events in thorium.

By this method we get for the fission probability of ^{232}Th per μ-stop the result

$$W_f(\mathrm{Th}) = 0.0049 \pm 0.0007$$

which is in a good agreement with our previous result /5/. If one uses the ratio of the fission probabilities with μ^- and π^- found by Diaz et al. /7/ for ^{232}Th and the relative fission probabilities with π^- for thorium and uranium isotopes /5/ then one gets the results shown in table 2 for the fission probabilities per π^--capture. These

Table 2. Fission probabilities per π^-capture.

^{232}Th	^{235}U	^{238}U
0.058 ± 0.008	0.162 ± 0.023	0.135 ± 0.018

values are a factor of 2 to 3 smaller than those known in literature /4,8,9/ got by means of nuclear emulsions.

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