Study of the Fission Barrier Parameters of ^{233}Th ◇

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The (n,f) cross section of ^{232}Th exhibits considerable structure in the vicinity of the fission threshold. Early measurements indicated well-defined peaks at 1.40, 1.60 and 1.73 MeV neutron energies [1]. The fine structure in the neutron-induced cross section $\sigma_{nf}(E_n)$ of ^{232}Th was observed for the first time by using neutron time-of flight technique [2]. The energy resolution of 1.6 MeV neutrons was 3 keV. This fine structure was interpreted in terms of rotational bands located in a putative third well in the fission barrier. In order to support the existence of the third well in the potential energy surface of Th isotopes, Blons and coworkers used the (d,pf) reaction measuring the fission probability and the fission fragment angular distribution. From the analysis of the ^{232}Th(n,f) cross section and ^{232}Th(d,pf) data, the resonance structure at E_n=1.6 MeV, which corresponds to 6.4 MeV excitation energy, was identified as a hyperdeformed resonance, claiming the existence of a (shallow) third minimum.

As the average energy difference of the rotational bands was comparable to the one we observed recently for ^{234}U [3] and ^{236}U [4], the expected depth of the third minimum should be much bigger than the one considered in Ref. [2].

In order to derive more accurate values for the barrier heights and to deduce the depth of the third minimum for ^{233}Th, in our latest experiment we measured the fission probability of ^{233}Th and the angular distribution of the fission fragments following the ^{232}Th(d,pf) reaction using the deuteron beam of the Munich Tandem accelerator at an energy of 14 MeV. A 70 μg/cm^2 thick $^{232}ThO_2$ target deposited on a 22 μg/cm^2 thin carbon backing was used. The kinetic energy of the proton ejectiles was analysed with the Q3D magnetic spectrometer set at $\Theta_L = 139.2°$ relative to the beam axis, covering a solid angle of 10 msr. The position of the analyzed particles in the focal plane was measured with a position-sensitive light-ion focal plane detector with individual cathode strip readout of 890 mm active length. Fission fragments were detected by two-position sensitive avalanche detectors (PSAD) constructed at ATOMKI, covering a total solid angle of 2.5 sr. The energy resolution was determined by measuring the low-lying states of ^{233}Th. Taking into account the long-term stability of the Tandem accelerator, the overall energy resolution in the high excitation energy region was 7 keV. The angular distribution of the fission fragment was calculated. The measured fission probability between 40^o and 80^o and between 70^o and 110^o is shown in Fig 1.

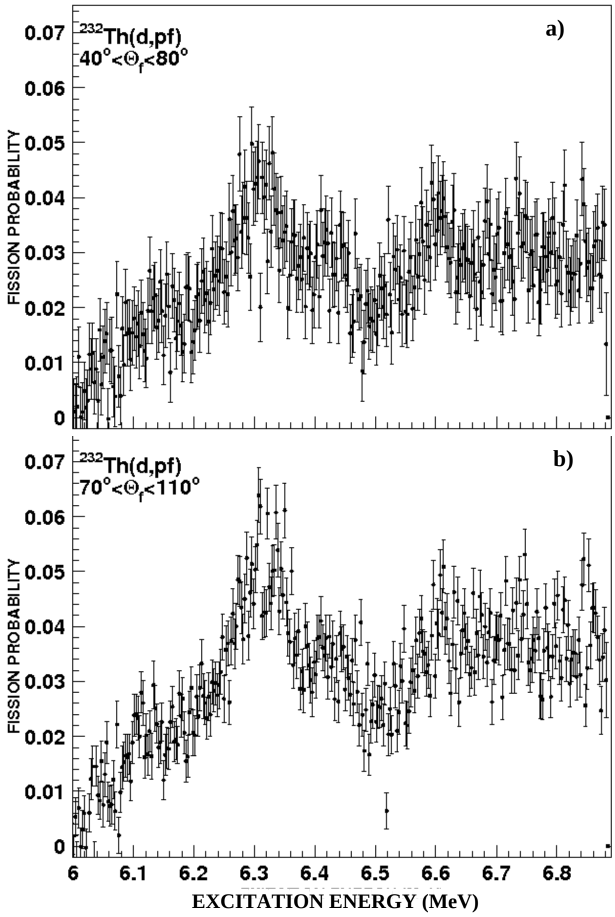

Fig. 1: Fission probability of ^{233}Th measured at E_d =14 MeV. a) $40^o \leq \Theta_f \leq 80^o$, b) $70^o \leq \Theta_f \leq 110^o$.

The low fission probability resulted in a limited statistics, nevertheless when comparing our results with the previous ones obvious differences can be noticed. We observe a structure below 6.2 MeV, which is more pronounced in the angular region between 70^o and 110^o. In the angular region between 40^o and 80^o we observe a resonance at 6.6 MeV, which was not seen by Blons and coworkers. In order to understand these differences the presently ongoing analysis of the angular distribution of fragments will be refined.

References

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