

## TECHNISCHE UNIVERSITAT DRESDEN

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ABSOLUTE FAST NEUTRON FISSION CROSS-SmETIOR HBASUREMENTS OF 235-U AND 239-PU USING THE FIIE-CORRETLATED ASSOCIATED PARTICLE METHOD
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> Abstracts Absolute fiesion cross-3ection weesurements of $0-235$ at 4.45 and 18.8 HeV and of Pu-239 at $4.8,8.65$ and 18.8 HeV neutrom exergies heve been performed using the TimeCorrelated Associated Particle Method (TCAPM). Accuracies of $\sim 2 \%$ wers reached.

Absolute fission cross-section measurements have been performed. (Tab. 1 and Tab.2) in accordance with recommendations of the IAEiA /1,2/, applying the mime-Correlated Asbociated Particle Hethod (fCAPM) 13,4 / at nem neutron energy spot points. Neutrons were produced in the $D(d, n)^{3}$ Re and $T(d, n)^{4}$ Ee reactions at the 5 MV tandem accelerator of the CINR Rosseadorf ( $G D R$ ), using $\sim 1 \mathrm{mg} / \mathrm{cm}^{2}$ thick target foils of deuterated polyethylene or $2-4 \mathrm{mg} / \mathrm{cm}^{2}$ thick selfsupporting Ti-T targets, respectively.

To identify the associated charged particles (AP) in the presence of a high background of scatitered deuterons (rates $\gtrsim 10^{5} s^{-1}$ ) and alpha particles from ( $d, \infty$ )-reactions, a fast particle identification system / $5 /$ was developed based on a telescope comprising two thin completely depleted Si(SB) detectors (Fig.1).

Fig.1: Simplified block diagram of the AP identification system


To detemine the amount of not separated background within the AF Window, background spectra were recorded from target foils Without $D$ or T. An axample of the spectra for the correction procedure is shown in Fig.2; the shape of the ${ }^{3}$ Be peak in the region of the ${ }^{4}$ beckground peak used for the ${ }^{4}$ ge spectrum normalization was obtained from AP spectra measured in coincidence With associated neutrons which were detected by a large scintillator.

## 편.2:

Typical AP spectrum and normalized spectra used for background correction of the 239-Fu measurement at 8.65 MeV


Thin fission foils ( 6 plates $<300 \mu \mathrm{~g} / \mathrm{cm}^{2}$ Pu-239; 5 plates $<500 \mu \mathrm{~g} / \mathrm{cm}^{2} \mathrm{U}-235$ ) were placed inside a parallel plate ionization chamber (FC) filled with methane. The chamber was adjusted to the maximum of the measured associated neutron cone profile, which was completely intercepted by the active area of all fission foils. The short current pulses ( $30-40 \mathrm{~ns}$ ) were analysed by means of a nanosecond stretcher /5/. This method allowed a high fission fragment detection efficiency ( $>96 \%$ ) also at high alpha activities of the fissile material ( $\sim 9 \mathrm{MBq}$ for 4 mg Pu-239).

The fission foils of high purity ( $>99.99 \%$ ) were calibrated by means of low-geometry alpha counting.

Fissions were counted in coincidence with the registered AP; the FWHM of the coincidence peak was $2-6 \mathrm{~ns}$. A CAMAC system registered pulse-height spectra of the fission chamber and the AP channel as well as the time distribution of AP-FC coincidences to perform the corrections needed. The FC spectrum (Fig. 3 ) was labelied with the FC timing signal to determine the timing threshold (CFT), and with the AP-FC coincidence signal to obtain the plateau extrapolation.


Fig.3: Fissicn chamber spectrum of a Pu-239 measurement at 3.65 MeV (measuring time: 82 hours)

| 開ean neutron energy (維V) <br> FWins of enexgy distr. (MoV) | $\begin{gathered} 4.45 \pm 0.20 \\ 0.23 \end{gathered}$ |  | $\begin{gathered} 18.8 \pm 0.20 \\ 0.60 \end{gathered}$ |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Corr. <br> (\%) | Error contr. (\$) | Cosy. <br> (8) | Ryrex contr. <br> (\%) |
| Counting of coinoidexoes <br> - Statistics of effect <br> - Random coinoidences | $1.40$ | $\begin{aligned} & 1.26 \\ & 0.17 \end{aligned}$ | $2.82$ | $\begin{aligned} & 1.08 \\ & 0.21 \end{aligned}$ |
| Fission chamber efficiency <br> - Correlated background <br> - Extrapolation to zero <br> - Fragment absorption | $\begin{aligned} & 1.18 \\ & 2.00 \end{aligned}$ | $\begin{aligned} & 0.26 \\ & 0.85 \end{aligned}$ | $\begin{aligned} & 1.72 \\ & 1.67 \\ & 1.73 \end{aligned}$ | $\begin{aligned} & 0.04 \\ & 0.16 \\ & 0.78 \end{aligned}$ |
| AP counting <br> - Background | 2.72 | 0.67 | 5.62 | 1.35 |
| Neutron cone <br> - Neutron scattering <br> - Effective fission foil thickness due to the cone aperi ure | $\begin{aligned} & 0.25 \\ & 0.05 \end{aligned}$ | $\begin{aligned} & 0.40 \\ & 0.05 \end{aligned}$ | 0.44 <br> 0.12 | $\begin{aligned} & 0.40 \\ & 0.08 \end{aligned}$ |
| Fissile layers <br> - Areal density <br> - Inhomogenity |  | $\begin{aligned} & 0.93 \\ & 0.72 \end{aligned}$ |  | $\begin{aligned} & 0.93 \\ & 0.72 \end{aligned}$ |
| Result $G_{f}\left(10^{-24} \mathrm{~cm}^{2}\right)$ <br> Standard deviation (\%) | $1.057 \pm$ $2 .$ | $0.022$ | $1.999 \pm$ $2$ | $\begin{aligned} & 0.045 \\ & 25 \end{aligned}$ |

Tab.1: Results, corrections and error contributions of the presented TCAPM fission cross-section measurements on 235-U

| Mean neutron energy ( ( <br> FuHM of energy distr. (MgV) | $\begin{gathered} 4.8 \pm 0.20 \\ 0.25 \end{gathered}$ |  | $\begin{gathered} 8.65 \pm 0.20 \\ 0.45 \end{gathered}$ |  | $\begin{gathered} 18.8 \pm 0.20 \\ 0.60 \end{gathered}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Corr. <br> ( | Error contr. (\%) | Corz. <br> (\%) | Eryor oontr. (\%) | Corx. <br> (\%) | $\begin{gathered} \text { Erwor } \\ \text { contz } \\ (f, y) \end{gathered}$ |
| Counting of coincidencea <br> - Statistics of effect <br> - Random ooinoidences | $0.64$ | $\begin{aligned} & 1.27 \\ & 0.11 \end{aligned}$ | $1.86$ | $\begin{aligned} & 1.08 \\ & 0.17 \end{aligned}$ | $4.55$ | $\begin{aligned} & 2.52 \\ & 0.63 \end{aligned}$ |
| Fission chanbex efficioncy <br> - Correlated background <br> - Extrapolation to zero <br> - Fragment absorption | $\begin{aligned} & 1.50 \\ & 1.21 \end{aligned}$ | $\begin{aligned} & 0.31 \\ & 0.46 \end{aligned}$ | $\begin{aligned} & 1.04 \\ & 1.20 \end{aligned}$ | $\begin{aligned} & 0.24 \\ & 0.43 \end{aligned}$ | $\begin{aligned} & 0.34 \\ & 2.57 \\ & 1.30 \end{aligned}$ | $\begin{aligned} & 0.13 \\ & 0.85 \\ & 0.39 \end{aligned}$ |
| AP counting <br> - Bacirground | $2.30$ | 0.36 | 1.62 | 0.32 | 5.92 | 1.74 |
| Seutron cone <br> - Neutron scattering <br> - Effective fission foil thickness due to the cone aperture | $\begin{aligned} & 0.25 \\ & 0.08 \end{aligned}$ | $\begin{aligned} & 0.40 \\ & 0.05 \end{aligned}$ | $\begin{aligned} & 0.36 \\ & 0.07 \end{aligned}$ | $\begin{aligned} & 0.40 \\ & 0.05 \end{aligned}$ | $\begin{aligned} & 0.34 \\ & 0.12 \end{aligned}$ | $\begin{aligned} & 0.40 \\ & 0.08 \end{aligned}$ |
| Fissile layexs <br> - Areal density <br> - Inhomogenity |  | $\begin{aligned} & 1.00 \\ & 0.88 \end{aligned}$ |  | $\begin{aligned} & 1.00 \\ & 0.85 \end{aligned}$ |  | $\begin{aligned} & 1.00 \\ & 0.88 \end{aligned}$ |
| Result $\sigma_{p}\left(10^{-24} \mathrm{~cm}^{2}\right)$ <br> Standard deviation (\%) | $1.7$ | ¹0.035 2.00 | $\begin{array}{r} 2.350 \\ 1 \end{array}$ | $0 \pm 0.044$ 1.85 | $2.4$ | $7 \pm 0.088$ 3.55 |

Tab.2: Results, corrections and error contributions of the presented TCAPM fission cross-section measurements on 239-Pu

Further gforts will be made so aarry out mare yresise axral density neacuremeats of inssion rotis.

## REFEREHOSS

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