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ABSOLUTE FAST NEUTRON FISSION CROSS-SECTION MEASUREMENTS OF 235-U AND 259-PU USING THE TIME-CORRELATED ASSOCIATED PARTICLE METHOD

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Abstract: Absolute fission cross-section measurements of U-235 at 4.45 and 18.8 MeV and of Pu-239 at 4.8, 8.65 and 18.8 MeV neutron energies have been performed using the Time-Correlated Associated Particle Method (TCAPM). Accuracies of ~ 2% were reached.

Absolute fission cross-section measurements have been performed (Tab.1 and Tab.2) in accordance with recommendations of the IAEA /1,2/, applying the Time-Correlated Associated Particle Method (TCAPM) /3,4/ at new neutron energy spot points. Neutrons were produced in the  $D(d,n)^3$ He and  $T(d,n)^4$ He reactions at the 5 MV tandem accelerator of the CINR Rossendorf (GDR), using ~ 1 mg/cm<sup>2</sup> thick target foils of deuterated polyethylene or 2-4 mg/cm<sup>2</sup> thick selfsupporting Ti-T targets, respectively.

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





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To determine the amount of not separated background within the AF window, background spectra were recorded from target foils without D or T. An example of the spectra for the correction procedure is shown in Fig.2; the shape of the <sup>3</sup>He peak in the region of the <sup>4</sup>He background peak used for the <sup>4</sup>He spectrum normalization was obtained from AP spectra measured in coincidence with associated neutrons which were detected by a large scintillator.



Thin fission foils (6 plates  $<300 \,\mu\text{g/cm}^2$  Pu-239; 5 plates <500  $\,\mu\text{g/cm}^2$  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 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 (~9 MBq for 4 mg Pu-239).

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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 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 labelled 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: Fission chamber spectrum of a Pu-239 measurement at 3.65 MeV (measuring time: 82 hours)

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Mean neutron energy (MeV) FWHM of energy distr. (MeV)	4.45±0.20 0.23		18.8 ± 0.20 0.60		
	Corr.	Error contr.	Corr.	Error contr.	
	(%)	(%)	(\$)	(%)	
Counting of coincidences					
- Statistics of effect	-	1.26	-	1.01	
- Random coincidences	1.40	0.17	2.82	0.21	
Fission chamber efficiency					
- Correlated background	-		1.72	0.04	
- Extrapolation to zero	1.18	0.26	1.67	0.16	
- Fragment absorption	2.00	0.85	1.73	0.78	
AP counting					
- Background	2.92	0.67	5.62	1.35	
Neutron cone					
- Neutron scattering	0.25	0.40	0.44	0.40	
- Effective fission foil thickness due to the cone aperate	0.05	0.05	0.12	0.08	
Fissile layers					
- Areal density	-	0.93	-	0.93	
- Inhomogenity	-	0.72	-	0.72	
Result $G_f$ (10 <sup>-24</sup> cm <sup>2</sup> )	1.057±0.022		1.999±0.045		
Standard deviation (%)	2.10		2.25		

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

Mean neutron energy (MeV) 4.8±C.20		8.65±0.20		18.8±0.20			
FWHM of energy distr. (MeV	) 0.25		0.45		0.60		
	Corr. (%)	Error contr. (%)	Corr. (%)	Error contr. (%)	Corr. (%)	Error contr. (%)	
Counting of coincidences							
- Statistics of effect	*	1.27	-	1.08	-	2.52	
- Random coincidences	0.64	0.11	1.86	0.17	4.55	0.63	
Fission chamber efficiency				,			
- Correlated background	-	-		-	0.34	0.13	
- Extrapolation to zero	1.50	0.31	1.04	0.24	2.57	0.85	
- Fragment absorption	1,21	0.46	1.20	0.43	1.30	0,39	
AP counting							
- Background	2.30	0.36	1.62	0.32	5.92	1.74	
Neutron cone							
- Neutron scattering	0.25	0.40	0.36	0.40	0.34	0.40	
- Effective fission foil thickness due to the cone aperture	0.08	0.05	0.07	0.05	0.12	0.08	
Fissile layers							
- Areal density	•	1.00	-	1.00	-	1.00	
- Inhomogenity	-	0.88	•	0.85	-	0.88	
Result G <sub>f</sub> (10 <sup>-24</sup> cm <sup>2</sup> )	1.74	1.740±0.035		2.350±0.044		2.487±0.088	
Standard deviation (%)		2.00		1.85		3.55	

Tab.2: Results, corrections and error contributions of the presented TCAPM fission cross-section measurements on 239-Pu Further efforts will be made to carry out more precise areal density measurements of fission foils.

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