Neutron transmission measurements of ^{nat}Fe at nELBE

A. EXPERIMENT DESCRIPTION

1. Main Reference	A.R. Junghans et al., Annals of Nuclear Energy (2025) 111363	[A]
2. Facility	nELBE time of flight facility	
3. Neutron production		
Neutron production beam	Electron (ELBE with SRF injector)	
Nominal average beam energy	40 MeV	
Nominal average current	≈2 μA (13 - 20 pC bunch charge)	
Repetition rate (pulses per second)	100.0 kHz	
Pulse width	5 ps	
Primary neutron production target	Liquid Pb-target	
Target nominal neutron production intensity	10^{11} n/s at 1 mA	
4. Moderator		
Primary neutron source position in moderator	No moderation of neutrons	
Moderator material Moderator dimensions (internal) (thickness, height×width×depth,…)	No moderator. The source volume is a 11 mm * 11 mm Mo tube with liquid Pb flowing through	
Density (moderator material)	No moderator	
Temperature (K)	Liquid Lead temperature 420 C	
Moderator-room decoupler (Cd, B, …)	Not available	
5. Other experimental details		
Measurement type	Neutron transmission	
Method (total energy, total absorption, …)	Time-of-flight	
Flight path length (m) (moderator –detector)	Target-detector 868.34(30) cm	
Flight path direction	Single flight path only	
Neutron beam dimensions at sample position (mm × mm, diameter in mm, …)	Sample in open field in front of 2.5 m long collimator	
Neutron beam profile	uniform beam profile,see R. Beyer et al., NIM A723(2013)151–162	[B]
Overlap suppression (Filter material and thickness, chopper, …)	No beam overlap, detection threshold is ca. 10 keV, Stripline-Kicker used to suppress dark current from injector	
Other fixed beam filters	5 cm Pb filter between neutron production target and transmission sample	
6. Detector		
Type	plastic scintillator	
Material	EJ 228	

Surface Dimensions (mm × mm. diameter in mm, …)	200 * 20 mm^2	
Thickness (mm)	5 mm	
Distance from sample (m)	Sample-detector 768 cm	
Detector(s) position relative to neutron beam	detector in beam 0 deg	
Detector(s) solid angle	Neutron beam larger than detector cross section	
7. Sample		
Type (metal, powder, liquid, crystal)	pure iron (ALLIEDPUREIRON, exceeds ARMCO grade 4)	
Chemical composition	iron, natural isotopic comp.	
Sample composition (at/b)	0.16948(54); 0.4250(14); 0.7645(25)	
Temperature	22-25 °C	
Sample mass (g)	77.1563(10); 193.4559(10); 348.01(1)	
Geometrical shape (cylinder, sphere, …)	Right cylinder	
Surface dimension (mm × mm, diameter in mm, …)	diameter 25.00(2) mm	
Nominal thickness (mm)	20, 50, 90 mm	
Containment description	No containment	
Additional comment	Transmission was measured for three different thicknesses. ALLIEDPUREIRON has a purity of 99.9 % Contaminants (Mn,Cr, Ni,Cu,P,Si,S,C,N,V,Ti,Al) on the level of 0.03%(Mn) or less than 0.01% all others. Molar mass value used: 55.85 g/mol Experiment took place 16.11.-24.11.2020 and 10.02-22.02.2021	
8. Data Reduction Procedure		
Dead time correction	Dead time measured per event, time of flight dependent correction, see R. Beyer et al., NIM A723(2013)151–162 Live time factor 0.86 – 0.99	[B]
Back ground subtraction	Constant background subtracted ca. 80% of which is beam off background	
Flux determination (reference reaction, …)	Relative measurement no flux determination	
Normalization	See Main ref. [A]	
Detector efficiency	Cancels in relative measurement	
Self-shielding	URR self shielding correction not applied	

Time-of-flight binning	20/40.96 = 0.488 ns bin size from TDC	
9. Response function	Gaussian response function, described in ref.[A]	
Initial pulse	Initial pulse length negligible (5ps)	
Target / moderator assembly	ΔL = 0.55 cm (1 sigma) from detector thickness and beam spot size on neutron production target	
Detector	Δt = 0.205 ns (1 sigma) time resolution measured from width of bremsstrahlung peak in ToF spectra	

B. DATA FORMAT

Column	Content	Unit	Comment
1	Index Number		Count of data points
2	t	ns	absolute time-of-flight
3	E_u	MeV	Upper limit of kinetic energy of tof bin
4	E_l	MeV	Lower limit of kinetic energy of tof bin
5	E	MeV	Kinetic energy of tof bin (arithmetic mean of E_u,E_l)
6	Transmission		Transmission per time of flight bin
7	Uncorrelated uncertainty		Uncertainty from counting statistics and background subtraction
8	Total cross section	b	Effective total cross section per time of flight bin
9	Uncorrelated uncertainty	b	Uncertainty from counting statistics and background subtraction
10	Time of flight spectrum (Target IN)		Target IN summed over full experiment, rebinned to 20 TDC channels (0.488 ns) dead time corrected before background subtraction (arb. units)
11	Time of flight spectrum (Target OUT)		Target OUT summed over full experiment, rebinned to 20 TDC channels (0.488 ns) dead time before background subtraction (arb. units)
12	Relative background level		Target IN ratio of constant background to ToF spectrum
13	Relative background level		Target OUT ratio of constant background to ToF spectrum

REFERENCES

[A] A.R. Junghans, R. Beyer, R. Capote, D. Bemmerer, T. Hensel, T. Kögler, S.E. Müller, K. Römer, K. Schmidt, R. Schwengner, S. Turkat, J. Turko, S. Urlaß, Annals of Nuclear Energy 218, (2025) 111363
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[B] R. Beyer, E. Birgersson, Z. Elekes, A. Ferrari, E. Grosse, R. Hannaske, A.R. Junghans, T. Kögler, R. Massarczyk, A. Matić, R. Nolte, R. Schwengner, A. Wagner, NIM A723 (2013) 151–162
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