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Abstract. Transmission measurements have been performed at the time-of-flight facility GELINA to provide data for a new evaluation of neutron resonance parameters for ^{89}Y. The measurements were carried out at a 50 m transmission station using a Li-glass scintillator with the accelerator operating at 800 Hz. This report provides the experimental details required to deliver the data to the EXFOR data library, maintained by the International Network of Nuclear Reaction Data Centres (NRDC). The experimental conditions and data reduction procedures are described. In addition, the full covariance information based on the AGS concept is given such that resonance parameters together with their covariances can be derived in a least-squares adjustment to the data.

1 Introduction

To study the resonance structure of neutron induced reaction cross sections, neutron spectroscopic measurements are required, which determine with a high accuracy the energy of the neutron that interacts with the material under investigation. To cover a broad energy range such measurements are best carried out with a pulsed white neutron source, which is optimized for time-of-flight (TOF) measurements [1].

The TOF-facility GELINA [2][3] has been designed and built for high-resolution cross section measurements in the resonance region. It is a multi-user facility, providing a white neutron source covering a neutron energy region from 10 meV to 20 MeV. The GELINA facility can host up to 10 experiments at measurement stations located between 10 m and 400 m from the neutron production target. The electron linear accelerator provides a pulsed electron beam with a maximum energy of 150 MeV, a maximum peak current of 10 A and a repetition rate ranging from 50 Hz to 800 Hz. A compression magnet reduces the width of the electron pulses to about 2 ns [4]. The electron beam hits a mercury-cooled uranium target producing Bremsstrahlung and subsequently neutrons via photonuclear reactions [5]. Two water-filled beryllium containers mounted above and below the neutron production target are used to moderate the neutrons. By applying different neutron beam collimation conditions, experiments can use either a fast or a moderated neutron spectrum. The neutron production rate is monitored by BF_3 proportional counters, which are mounted in the ceiling of the target hall. The output of the monitors is used to normalize the time-of-flight spectra to the same neutron intensity. The measurement stations are equipped with air conditioning systems to reduce electronic drifts in the detection chains due to temperature changes. The temperature in the measurement stations is continuously monitored.

This report describes the transmission measurements carried out at GELINA with ^{89}Y metallic samples. To reduce bias effects due to e.g. dead time and background, the measurement and data reduction procedures recommended in Ref. [1] have been followed. In the description of the data, the recommendations resulting from a consultant's meeting organized by the Nuclear Data Section of the IAEA (NDS/IAEA) have been followed [6].

2 Experimental conditions

The transmission experiments were performed at the 50 m measurement station of flight path 4 with the accelerator operating at 800 Hz. The moderated neutron spectrum was used. A shadow bar made of Cu and Pb was placed close to the uranium target to reduce the intensity of the γ-ray flash and the fast neutron component. The flight path forms an angle of 9° with the direction normal to the face of the moderator viewing the flight path. The samples and detector were placed in an acclimatized room to keep them at a temperature of 20°C.

The neutrons scattered from the moderators were collimated into the flight path through an evacuated aluminum pipe of 50 cm diameter with annular collimators, consisting of borated wax, copper and lead. A set of Pb, Ni and Cu annular collimators was used to reduce the neutron beam to a diameter of 45 mm at the sample position. Additional lithium and B_4C collimators were installed to absorb neutrons that are scattered by the collimators. A ^{10}B overlap filter with an areal density of about 0.08 at/b was placed close to the neutron target to minimize the contribution of slow neutrons coming from previous accelerator bursts. The impact of the γ-ray flash in the neutron detector was reduced by a 16 mm thick Pb filter placed in the beam.

The samples were placed in an automatic sample changer at a distance of approximately 24 m from the neutron source. Close to the sample position Co, and in one case Na, black resonance filters were mounted in automatic filter changers to determine the background contribution at 2850 eV and 132 eV respectively, and to obtain its time dependence. The Co filter was permanently in the beam to continuously monitor the background level and to account for the impact of the sample or other filters placed in the beam [1]. The neutron beam passing through the sample and filters was further collimated and detected by a 6.35 mm x 151.6 mm diameter NE912 Li-glass scintillator. The scintillator was connected through a boron-free quartz window to a 127 mm EMI 9823 KQB photomultiplier (PMT), which was placed outside the neutron beam perpendicular to its axis. The detector was placed at about 48 m from the neutron target and the diameter of the neutron beam at the detector position was about 90 mm.

The TOF of the detected neutron was derived from the time difference between the stop signal T_s, obtained from the anode pulse of the PMT, and the start signal T_0, given at each electron burst. This time difference was processed with a multi-hit fast time coder with a 1 ns time resolution. The TOF and the pulse height of each detected event were recorded in list mode using a multi-parameter data acquisition system developed at the EC-JRC [7]. Each measurement was subdivided in different cycles. Only cycles for which the ratio between the total counts in the transmission detector and in the neutron monitor deviated by less than 1 % were selected. The dead time of the detection chain t_d = 3510 (10) ns was derived from a spectrum of the time-interval between successive events. The uncertainties due to dead time corrections in the region of interest are very small and can be neglected.

The measurements were performed with yttrium metallic samples. Specifically, the samples consisted of seven square foils, each with a thickness of 0.64 mm, and one disk-shaped sample with a thickness of 2.00 mm. Different combinations of these components were used to assemble the measured samples, described in Table 1. The disk sample has a 99.9% purity, while all others present a contamination of 0.5% of Ta and Ho. The area was determined by an optical surface inspection with a microscope system from Mitutoyo [7].

Table 1 Characteristic of the ^{89}Y samples used for the transmission measurements. The areal density n_d was derived from the mass and area provided by the manufacturer.

Sample	Thickness /mm	Mass/g	Area/mm2	Areal Density (at/b)
^{89}Y	1.28	14.354 (10)	2526 (2)	3.8140 (8) x 10^{-3}
^{89}Y	2.00	43.320 (10)	5041 (5)	5.8360 (5) x 10^{-3}
^{89}Y	3.28	57.674 (10)	-	9.650 (1) x 10^{-3}
^{89}Y	4.55	42.636 (10)	2532 (2)	13.352 (2) x 10^{-3}

3 Data reduction

The AGS code [9][10], developed at the JRC Geel, was used to derive the experimental transmission from the TOF-spectra. The code is based on a compact formalism to propagate all uncertainties starting from uncorrelated uncertainties due to counting statistics.

3.1 Experimental transmission

The experimental transmission T_{exp} as a function of TOF was obtained from the ratio of a sample-in measurement C_{in} and a sample-out measurement C_{out}, both corrected for their background contributions B_{in} and B_{out}, respectively:

$$T_{exp} = N\frac{C_{in} - KB_{in}}{C_{out} - KB_{out}}. \tag{3.1}$$

The TOF spectra, C_{in} and C_{out}, were corrected for losses due to the dead time in the detector and electronics chain. All spectra were normalized to the same TOF-bin width structure and neutron beam intensity. The latter was derived from the response of the BF_3 flux monitors. To avoid systematic effects due to slow variations of both the beam intensity and detector efficiency as a function of time, data were taken by alternating sample-in and sample-out measurements in cycles of about 600 seconds. Such a procedure reduces the uncertainty on the normalization to the beam intensity to less than 0.25 %. This uncertainty was evaluated from the ratios of counts in the ^{6}Li transmission detector and in the flux monitors. To account for this uncertainty the factor N= 1.0000 (25) was introduced in Eq. (3.1). The background as a function of TOF was approximated by an analytic expression applying the black resonance technique [1]. The factor K = 1.00 (3) in Eq. (3.1) was introduced to account for systematic effects due to the background model. Its uncertainty was derived from a statistical analysis of the difference between the observed black resonance dips and the estimated background [11].

The time-of-flight t of a neutron creating a signal in the neutron detector was determined by the time difference between the stop signal T_s and the start signal T_0:

$$t = (T_s - T_0) + t_0, \tag{3.2}$$

with t_0 being a time-offset which was determined by a measurement of the γ-ray flash. The flight path distance L = 47.669 (4) m, i.e. the distance between the centre of the moderator viewing the flight path and the front face of the detector, was derived previously from results of transmission measurements using uranium standard references [11].

3.2 Background correction

The background as a function of TOF was parameterized by an analytical function:

$$\mathrm{B}\,(\mathrm{t}) = \mathrm{b}_0 + \mathrm{b}_1 \mathrm{e}^{-\lambda_1 \mathrm{t}} + \mathrm{b}_2 \mathrm{e}^{-\lambda_2 \mathrm{t}} + \mathrm{b}_3 \mathrm{e}^{-\lambda_3 (\mathrm{t}+\tau_0)}. \tag{3.3}$$

It consists of a time independent and three time-dependent exponential terms. The time independent component b_0 is related to the ambient radiation and background contributions that lost any time correlation. The first time-dependent component is due to 2.2 MeV γ-rays resulting from neutron capture in hydrogen present in the moderator, the second exponential term is due to neutrons scattered inside the detector station and neutrons scattered at other flight paths, and the last one originates from slow neutrons coming from previous accelerator pulses. The decay constants λ_1 and λ_2 were derived from transmission data measured with additional black resonance filters, while λ_3 was obtained by extrapolating the TOF spectra behavior at large times, i.e. for t > 1 × 10^6 ns. The parameter τ_0 is related to the operating frequency of accelerator (τ_0 =1.25 ms for 800 Hz). This extrapolation applied to each measurement also provides the amplitudes b_0 and b_3. The weights of the first and the second time-dependent background components was studied by including short cycles with Na and Co filters in the beam. The b_1/b_2 ratio obtained in these short cycles was used for adjusting the amplitudes b_1 and b_2 together with the information of the black resonance dip of the Co filter, which was permanently in the beam during the transmission measurement. Example of a dead-time corrected and normalized sample-in spectrum with the background contributions from Eq. (3.3) are shown in Figure 1.

Table 2. Parameters for the analytical expressions of the background correction for the sample-in and sample-out measurements for the sample of 1.28 mm thickness.

ID	$b_0/10^{-8}$	$b_1/10^{-6}$	$\lambda_1/10^{-5}$ ns^{-1}	$b_2/10^{-8}$	$\lambda_2/10^{-6}$ ns^{-1}	$b_3/10^{-6}$	$\lambda_3/10^{-6}$ ns^{-1}
B_{in}	2.67	1.22	2.94	6.09	1.35	1.94	3.00
B_{out}	2.72	1.22	2.94	6.40	1.35	2.00	3.00

Table 3. Parameters for the analytical expressions of the background correction for the sample-in and sample-out measurements for the sample of 2.00 mm thickness with both a Co and a Na black resonance filters.

ID	$b_0/10^{-8}$	$b_1/10^{-7}$	$\lambda_1/10^{-5}$ ns^{-1}	$b_2/10^{-8}$	$\lambda_2/10^{-6}$ ns^{-1}	$b_1/10^{-6}$	$\lambda_3/10^{-6}$ ns^{-1}
B_{in}	1.94	6.75	2.94	4.23	1.35	1.36	3.00
B_{out}	1.97	6.98	2.94	4.38	1.35	1.43	3.00

Table 4. Parameters for the analytical expressions of the background correction for the sample-in and sample-out measurements for the sample of 2.00 mm thickness with only the Co black resonance filter.

ID	$b_0/10^{-8}$	$b_1/10^{-7}$	$\lambda_1/10^{-5}$ ns^{-1}	$b_2/10^{-8}$	$\lambda_2/10^{-6}$ ns^{-1}	$b_3/10^{-6}$	$\lambda_3/10^{-6}$ ns^{-1}

B_{in}	2.13	8.35	2.94	4.23	1.35	1.36	3.00
B_{out}	2.25	8.32	2.94	4.38	1.35	1.43	3.00

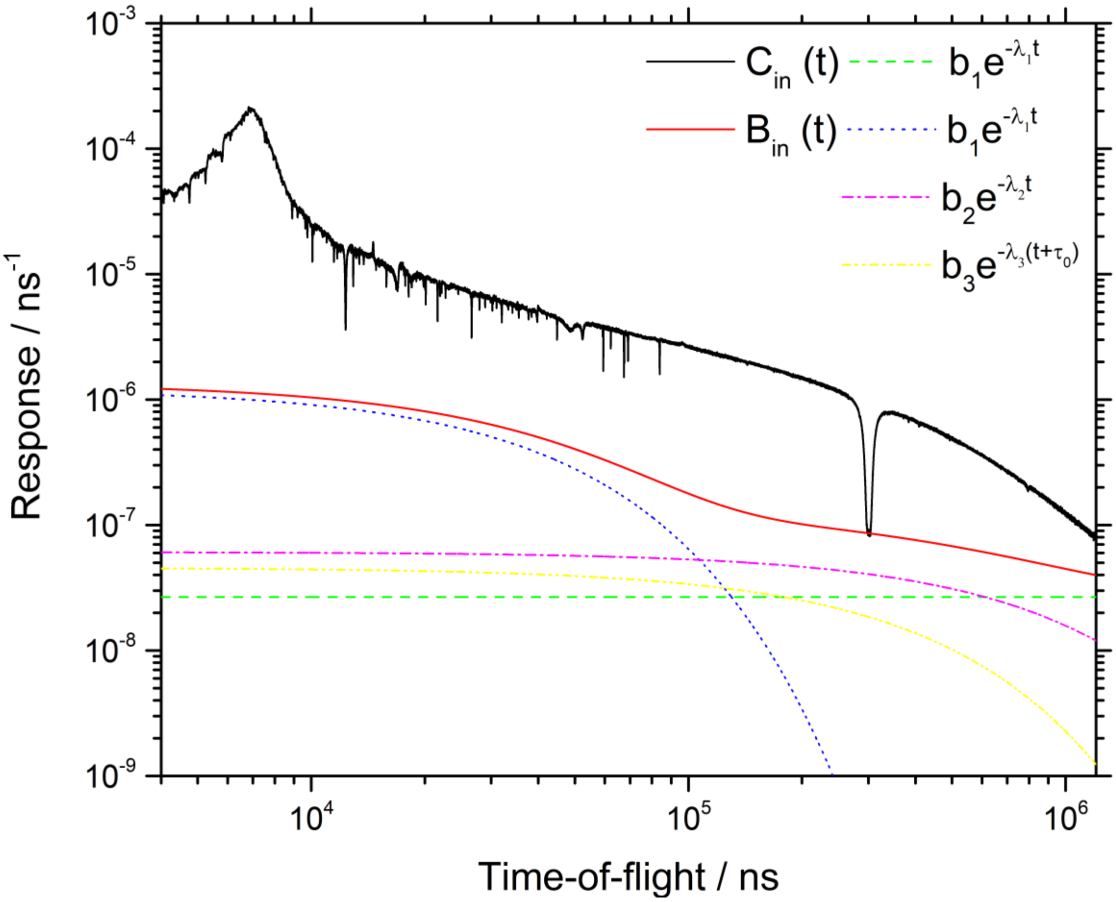
Table 5. Parameters for the analytical expressions of the background correction for the sample-in and sample-out measurements for the sample of 3.28 mm thickness.

ID	$b_0/10^{-8}$	$b_1/10^{-6}$	$\lambda_1/10^{-5}$ ns^{-1}	$b_2/10^{-8}$	$\lambda_2/10^{-6}$ ns^{-1}	$b_3/10^{-6}$	$\lambda_3/10^{-6}$ ns^{-1}
B_{in}	2.58	1.19	2.94	5.95	1.35	1.85	3.00
B_{out}	2.72	1.22	2.94	6.40	1.35	2.00	3.00

Table 6. Parameters for the analytical expressions of the background correction for the sample-in and sample-out measurements for the sample of 4.55 mm thickness.

ID	$b_0/10^{-8}$	$b_1/10^{-7}$	$\lambda_1/10^{-5}$ ns^{-1}	$b_2/10^{-8}$	$\lambda_2/10^{-6}$ ns^{-1}	$b_3/10^{-6}$	$\lambda_3/10^{-6}$ ns^{-1}
B_{in}	1.65	4.63	2.65	3.12	1.35	41.4	2.70
B_{out}	1.50	6.61	2.65	5.32	1.35	1.20	2.70

Figure 1. TOF spectrum with the 1.28 mm thick ^{89}Y sample and the Co filter in the beam at 800 Hz together with the total background (B_{in}) and its different components as given in Eq. (3.3).



4 Results

The AGS code [9][10] was used to derive the experimental transmission and propagate both the correlated and uncorrelated uncertainties. The code is based on a compact formalism to propagate all uncertainties starting from uncorrelated uncertainties due to counting statistics. It stores the full covariance information after each operation in a concise, vectorized way. The AGS formalism results in a substantial reduction of data storage volume and provides a convenient structure to verify the various sources of uncertainties through each step of the data reduction process. The concept is recommended by the NDS/IAEA [6] to prepare the experimental observables, including their full covariance information, for storage into the EXFOR data library [13][14]. The experimental transmission resulting from the measurement of the 3.2 8mm thick ^{89}Y sample is shown in Figure in the energy region from 1 to 150 keV. Figure 3 provides a more detailed view of the transmission in the energy region around 2.6 keV, comparing results from the 1.28 mm and 4.55 mm thick ^{89}Y samples.

Figure 2. Transmission as a function of neutron energy from the measurement of the 3.28 mm thick ^{89}Y sample and the accelerator operating at 800 Hz.

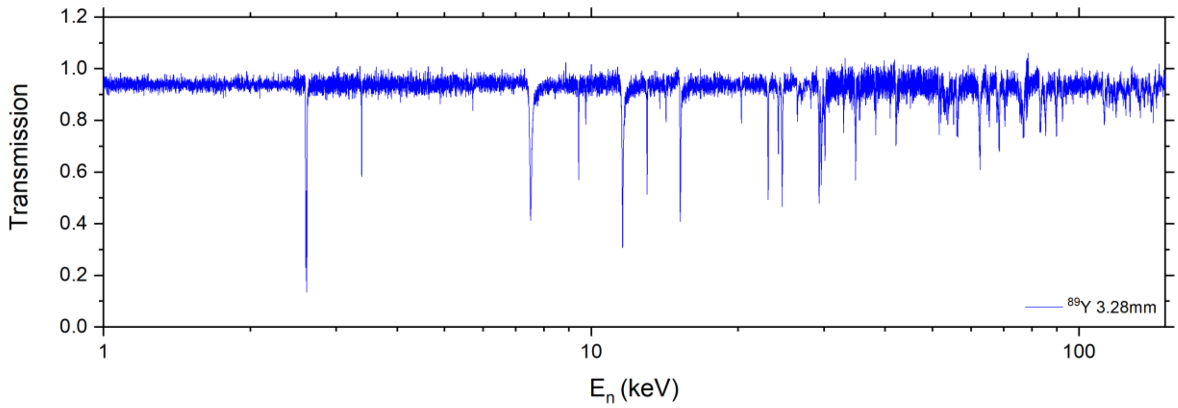
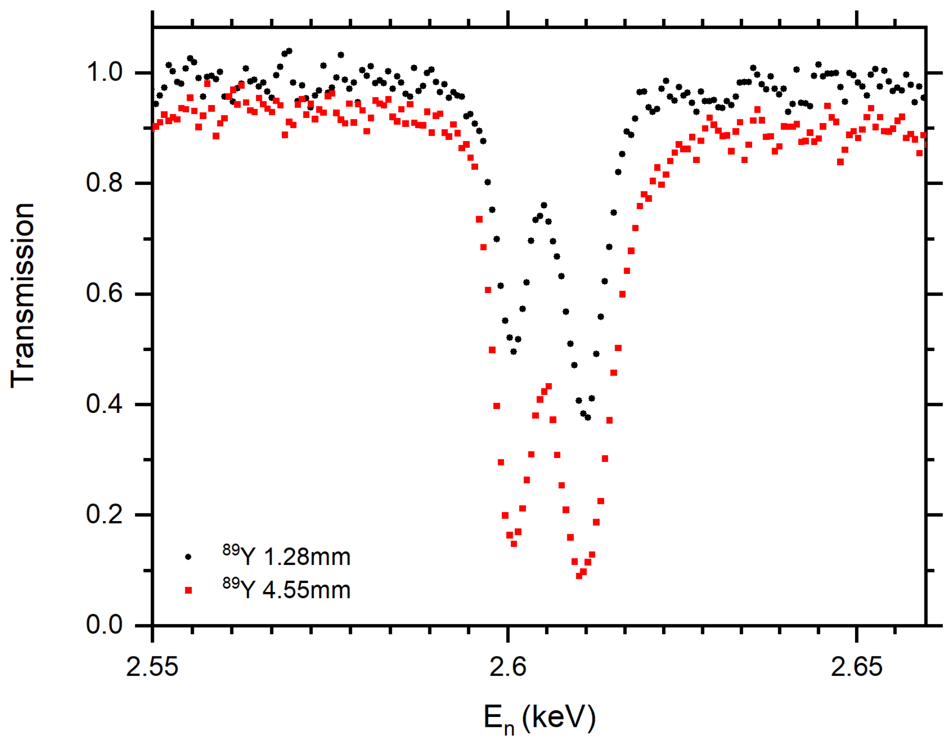


Figure 1. Transmission as a function of neutron energy in the region around 2.6 keV from the measurements of the 1.28 mm and 4.55 mm ^{86}Y samples.



The format in which the numerical data will be stored in the EXFOR data library is illustrated in the Appendix. The data include the full covariance information based on the AGS concept. The total uncertainty and the uncertainty due to uncorrelated components are reported, together with the contributions due to the normalization and background subtraction. Applying the AGS concept the covariance matrix *V* of the experimental transmission can be calculated by:

$$V = U_u + S(\eta)S(\eta)^T, \tag{4.2}$$

where U_u is a diagonal matrix containing the contribution of all uncorrelated uncertainty components. The matrix *S* contains the contribution of the components η = {*N*, *K*} creating correlated components. The uncertainty due to the dead time correction can be neglected. The experimental details, which are required to perform a resonance analysis on the data, are summarized in the Appendix.

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Appendix

A. SUMMARY OF EXPERIMENTAL DETAILS

A. 1 Experiment description (ID 1)

1. Main Reference		[a]
2. Facility	GELINA	[b]
3. Neutron production		
Neutron production beam	Electron	
Nominal average beam energy	100 MeV	
Nominal average current	50 μA	
Repetition rate (pulses per second)	800 Hz	
Pulse width	2 ns	
Primary neutron production target	Mercury cooled depleted uranium	
Target nominal neutron production intensity	3.4×10^{13} s^{-1}	
4. Moderator		
Primary neutron source position in moderator	Above and below uranium target	
Moderator material	2 water filled Be-containers around U-target	
Moderator dimensions (internal)	2 x (14.6 cm x 21 cm x 3.9 cm)	
Density (moderator material)	1 g/cm^3	
Temperature (K)	Room temperature	
Moderator-room decoupler (Cd, B, …)	None	
5. Other experimental details		
Measurement type	Transmission	
Method (total energy, total absorption, …)	Good transmission geometry	[c][c]
Flight Path length (m) (moderator centre-detector front face)	L = 47.670 (8) m	
Flight path direction	9° with respect to normal of the moderator face viewing the flight path	
Neutron beam dimensions at sample position	45 mm in diameter	
Neutron beam profile	-	
Overlap suppression	^{10}B overlap filter	
Other fixed beam filters	Co, Pb	
6. Detector		
Type	Scintillator	
Material	Li-glass	
Surface Dimensions	152.4 mm diameter	
Thickness (cm)	6.35 mm	
Detector(s) position relative to neutron beam	In the beam	
Detector(s) solid angle	-	
Sample		
7. Type (metal, powder, liquid, crystal)	Metal	
Chemical composition	^{89}Y (>99.5 at %)	
Sample composition (at/b)	$3.8140(8) \times 10^{-3}$ at/b	
Temperature	20 ℃	
Sample mass (g)	14.354(10) g	
Geometrical shape (cylinder, sphere, …)	Squared	

Surface dimension Nominal thickness (mm) Containment description	2526(2) mm^2 1.28 mm None	
Data Reduction Procedure **8.** Dead time correction Back ground subtraction Flux determination (reference reaction, …) Normalization Detector efficiency Self-shielding Time-of-flight binning	 Done (< factor 1.05) Black resonance technique - 1.0000 (25) - - Zone length bin width 12288 1 ns 12288 2 ns 8192 8 ns 6144 16 ns 4096 32 ns 4096 64 ns 4096 128 ns 4096 512 ns 2048 1024 ns	[c]**Error! Reference source not found.**
Response function **9.** Initial pulse Target / moderator assembly Detector	 Normal distribution, FWHM = 2 ns Numerical distribution from MC simulations Analytical function defined in REFIT manual	 [e][f] [g]

A. 2 Experiment description (ID 2)

1. Main Reference		[a]
2. Facility	GELINA	[b]
3. Neutron production Neutron production beam Nominal average beam energy Nominal average current Repetition rate (pulses per second) Pulse width Primary neutron production target Target nominal neutron production intensity	 Electron 100 MeV 50 μA 800 Hz 2 ns Mercury cooled depleted uranium 3.4 x10^{13} s^{-1}	
4. Moderator Primary neutron source position in moderator Moderator material Moderator dimensions (internal)	 Above and below uranium target 2 water filled Be-containers around U-target 2 x (14.6 cm x 21 cm x 3.9 cm)	

Density (moderator material)	1 g/cm^3	
Temperature (K)	Room temperature	
Moderator-room decoupler (Cd, B, …)	None	
5. Other experimental details		
Measurement type	Transmission	
Method (total energy, total absorption, …)	Good transmission geometry	[c][c]
Flight Path length (m) (moderator centre-detector front face)	L = 47.670 (8) m	
Flight path direction	9° with respect to normal of the moderator face viewing the flight path	
Neutron beam dimensions at sample position	45 mm in diameter	
Neutron beam profile	-	
Overlap suppression	^{10}B overlap filter	
Other fixed beam filters	Co, Pb, Na	
6. Detector		
Type	Scintillator	
Material	Li-glass	
Surface Dimensions	152.4 mm diameter	
Thickness (cm)	6.35 mm	
Detector(s) position relative to neutron beam	In the beam	
Detector(s) solid angle	-	
Sample		
7. Type (metal, powder, liquid, crystal)	Metal	
Chemical composition	^{89}Y (>99.9 at %)	
Sample composition (at/b)	5.8360(5) x 10^{-3} at/b	
Temperature	20 ℃	
Sample mass (g)	43.320(10) g	
Geometrical shape (cylinder, sphere, …)	Cylinder	
Surface dimension	5041(5) mm^2	
Nominal thickness (mm)	2.00 mm	
Containment description	None	
Data Reduction Procedure		[c]**Error! Reference source not found.**
8. Dead time correction	Done (< factor 1.05)	
Back ground subtraction	Black resonance technique	
Flux determination (reference reaction, …)	-	
Normalization	1.0000 (25)	
Detector efficiency	-	
Self-shielding	-	
Time-of-flight binning	Zone length bin width 12288 1 ns 12288 2 ns 8192 8 ns 6144 16 ns 4096 32 ns 4096 64 ns	

	4096 128 ns 4096 512 ns 2048 1024 ns	
Response function		
9. Initial pulse	Normal distribution, FWHM = 2 ns	
Target / moderator assembly	Numerical distribution from MC simulations	[e][f]
Detector	Analytical function defined in REFIT manual	[g]

A. 3 Experiment description (ID 3)

10. Main Reference		[a]
11. Facility	GELINA	[b]
12. Neutron production		
Neutron production beam	Electron	
Nominal average beam energy	100 MeV	
Nominal average current	50 μA	
Repetition rate (pulses per second)	800 Hz	
Pulse width	2 ns	
Primary neutron production target	Mercury cooled depleted uranium	
Target nominal neutron production intensity	3.4 x10^{13} s^{-1}	
13. Moderator		
Primary neutron source position in moderator	Above and below uranium target	
Moderator material	2 water filled Be-containers around U-target	
Moderator dimensions (internal)	2 x (14.6 cm x 21 cm x 3.9 cm)	
Density (moderator material)	1 g/cm^3	
Temperature (K)	Room temperature	
Moderator-room decoupler (Cd, B, …)	None	
14. Other experimental details		
Measurement type	Transmission	
Method (total energy, total absorption, …)	Good transmission geometry	[c][c]
Flight Path length (m) (moderator centre-detector front face)	L = 47.670 (8) m	
Flight path direction	9° with respect to normal of the moderator face viewing the flight path	
Neutron beam dimensions at sample position	45 mm in diameter	
Neutron beam profile	-	
Overlap suppression	^{10}B overlap filter	
Other fixed beam filters	Co, Pb	
15. Detector		
Type	Scintillator	
Material	Li-glass	
Surface Dimensions	152.4 mm diameter	
Thickness (cm)	6.35 mm	
Detector(s) position relative to neutron beam	In the beam	
Detector(s) solid angle	-	
Sample		

16. Type (metal, powder, liquid, crystal) Chemical composition Sample composition (at/b) Temperature Sample mass (g) Geometrical shape (cylinder, sphere, …) Surface dimension Nominal thickness (mm) Containment description	Metal ^{89}Y (>99.9 at %) 5.8360(5) x 10^{-3} at/b 20 ℃ 43.320(10) g Cylinder 5041(5) mm^2 2.00 mm None	
Data Reduction Procedure		[c]**Error! Reference source not found.**
17. Dead time correction Back ground subtraction Flux determination (reference reaction, …) Normalization Detector efficiency Self-shielding Time-of-flight binning	Done (< factor 1.05) Black resonance technique - 1.0000 (25) - - Zone length bin width 12288 1 ns 12288 2 ns 8192 8 ns 6144 16 ns 4096 32 ns 4096 64 ns 4096 128 ns 4096 512 ns 2048 1024 ns	
Response function **18.** Initial pulse Target / moderator assembly Detector	 Normal distribution, FWHM = 2 ns Numerical distribution from MC simulations Analytical function defined in REFIT manual	 [e][f] [g]

A. 4 Experiment description (ID 4)

19. Main Reference		[a]
20. Facility	GELINA	[b]
21. Neutron production Neutron production beam Nominal average beam energy Nominal average current Repetition rate (pulses per second) Pulse width Primary neutron production target Target nominal neutron production intensity	 Electron 100 MeV 50 μA 800 Hz 2 ns Mercury cooled depleted uranium 3.4 x10^{13} s^{-1}	

22. Moderator		
Primary neutron source position in moderator	Above and below uranium target	
Moderator material	2 water filled Be-containers around U-target	
Moderator dimensions (internal)	2 x (14.6 cm x 21 cm x 3.9 cm)	
Density (moderator material)	1 g/cm^3	
Temperature (K)	Room temperature	
Moderator-room decoupler (Cd, B, …)	None	
23. Other experimental details		
Measurement type	Transmission	
Method (total energy, total absorption, …)	Good transmission geometry	[c][c]
Flight Path length (m) (moderator centre-detector front face)	L = 47.670 (8) m	
Flight path direction	9° with respect to normal of the moderator face viewing the flight path	
Neutron beam dimensions at sample position	45 mm in diameter	
Neutron beam profile	-	
Overlap suppression	^{10}B overlap filter	
Other fixed beam filters	Co, Pb	
24. Detector		
Type	Scintillator	
Material	Li-glass	
Surface Dimensions	152.4 mm diameter	
Thickness (cm)	6.35 mm	
Detector(s) position relative to neutron beam	In the beam	
Detector(s) solid angle	-	
Sample		
25. Type (metal, powder, liquid, crystal)	Metal	
Chemical composition	^{89}Y (>99.5 at %)	
Sample composition (at/b)	9.650(1) x 10^{-3} at/b	
Temperature	20 ℃	
Sample mass (g)	57.674(10) g	
Geometrical shape (cylinder, sphere, …)	Cylinder + Squared	
Surface dimension	-	
Nominal thickness (mm)	3.28 mm	
Containment description	None	
Data Reduction Procedure		[c]**Error! Reference source not found.**
26. Dead time correction	Done (< factor 1.05)	
Back ground subtraction	Black resonance technique	
Flux determination (reference reaction, …)	-	
Normalization	1.0000 (25)	
Detector efficiency	-	
Self-shielding	-	

Time-of-flight binning	Zone length bin width 12288 1 ns 12288 2 ns 8192 8 ns 6144 16 ns 4096 32 ns 4096 64 ns 4096 128 ns 4096 512 ns 2048 1024 ns	
Response function		
27. Initial pulse	Normal distribution, FWHM = 2 ns	
Target / moderator assembly	Numerical distribution from MC simulations	[e][f]
Detector	Analytical function defined in REFIT manual	[g]

A. 5 Experiment description (ID 5)

1. Main Reference		[a]
2. Facility	GELINA	[b]
3. Neutron production		
Neutron production beam	Electron	
Nominal average beam energy	100 MeV	
Nominal average current	50 μA	
Repetition rate (pulses per second)	800 Hz	
Pulse width	2 ns	
Primary neutron production target	Mercury cooled depleted uranium	
Target nominal neutron production intensity	3.4 x10^{13} s^{-1}	
4. Moderator		
Primary neutron source position in moderator	Above and below uranium target	
Moderator material	2 water filled Be-containers around U-target	
Moderator dimensions (internal)	2 x (14.6 cm x 21 cm x 3.9 cm)	
Density (moderator material)	1 g/cm^3	
Temperature (K)	Room temperature	
Moderator-room decoupler (Cd, B, …)	None	
5. Other experimental details		
Measurement type	Transmission	
Method (total energy, total absorption, …)	Good transmission geometry	[c][c]
Flight Path length (m) (moderator centre-detector front face)	L = 47.670 (8) m	
Flight path direction	9° with respect to normal of the moderator face viewing the flight path	
Neutron beam dimensions at sample position	45 mm in diameter	
Neutron beam profile	-	
Overlap suppression	^{10}B overlap filter	
Other fixed beam filters	Co, Pb	

6. Detector		
Type	Scintillator	
Material	Li-glass	
Surface Dimensions	152.4 mm diameter	
Thickness (cm)	6.35 mm	
Detector(s) position relative to neutron beam	In the beam	
Detector(s) solid angle	-	
Sample		
7. Type (metal, powder, liquid, crystal)	Metal	
Chemical composition	^{89}Y (>99.5 at %)	
Sample composition (at/b)	13.352(2) x 10^{-3} at/b	
Temperature	20 ℃	
Sample mass (g)	42.636(10) g	
Geometrical shape (cylinder, sphere, …)	Squared	
Surface dimension	-	
Nominal thickness (mm)	4.55 mm	
Containment description	None	
Data Reduction Procedure		[c]**Error! Reference source not found.**
8. Dead time correction	Done (< factor 1.05)	
Back ground subtraction	Black resonance technique	
Flux determination (reference reaction, …)	-	
Normalization	1.0000 (25)	
Detector efficiency	-	
Self-shielding	-	
Time-of-flight binning	Zone length bin width 12288 1 ns 12288 2 ns 8192 8 ns 6144 16 ns 4096 32 ns 4096 64 ns 4096 128 ns 4096 512 ns 2048 1024 ns	
Response function		
9. Initial pulse	Normal distribution, FWHM = 2 ns	
Target / moderator assembly	Numerical distribution from MC simulations	[e][f]
Detector	Analytical function defined in REFIT manual	[g]

B. Data format

Column	Content	Unit	Comment
1	Energy	eV	Relativistic relation using a fixed flight path length (L = 47.670 m)
2	t_l	ns	Low bound
3	t_h	ns	High bound
4	T_{exp}		Transmission
5	Total Uncertainty		
6	Uncorrelated uncertainty		Uncorrelated uncertainty due to counting statistics
7	AGS-vector (K_{in})		Sample-in background model uncertainty
8	AGS-vector (K_{out})		Sample-out background model uncertainty
9	AGS-vector (N)		Normalization (u_N/N = 0.25 %)

Comments from the authors:

– The AGS concept was used to derive the experimental transmission

$$T_{exp} = N \frac{C_{in} - K_{in} B_{in}}{C_{out} - K_{out} B_{out}},$$

and to propagate the uncertainties, both the uncorrelated due to counting statistics and the uncertainty due to the normalization and the background contributions.

– The quoted uncertainties are standard uncertainties at 1 standard deviation

B.1 DATA (ID 1)

E/ keV	t_l / ns	t_h / ns	T_{exp}	u_t	u_u	AGS $K_{in} = K_{out}$	N
150.026	8898	8900	0.960010	0.023781	0.023660	-0.000047	0.002400
149.959	8900	8902	0.993662	0.024461	0.024335	-0.000008	0.002484
…	…	…	…	…	…	…	…
75.0052	12584	12586	0.990098	0.025827	0.025708	-0.000020	0.002475
74.9814	12586	12588	0.974543	0.025429	0.025312	-0.000049	0.002436
…	…	…		…	…	…	…
1.00034	108960	108976	0.979083	0.022177	0.022042	-0.000048	0.002448
1.00005	108976	108992	0.947468	0.021494	0.021362	-0.000113	0.002369

B.2 DATA (ID 2)

E/ keV	t_l / ns	t_h / ns	T_{exp}	u_t	u_u	AGS $K_{in} = K_{out}$	N
150.026	8898	8900	0.930056	0.025757	0.025652	-0.000067	0.002325
149.959	8900	8902	0.995279	0.027319	0.027206	-0.000006	0.002488
…	…	…	…	…	…	…	…
75.0052	12584	12586	0.904416	0.027317	0.027223	-0.000148	0.002261
74.9814	12586	12588	0.917529	0.027451	0.027355	-0.000127	0.002294

…	…	…		…	…	…	…
4.00139	54480	54488	1.008835	0.040103	0.040023	0.000017	0.002522
4.00021	54488	54496	0.994282	0.040117	0.040039	-0.000048	0.002486

B.3 DATA (ID 3)

E/ keV	t_l / ns	t_h / ns	T_{exp}	u_t	u_u	AGS $K_{in} = K_{out}$	N
150.026	8898	8900	0.946141	0.026798	0.026693	-0.000049	0.002365
149.959	8900	8902	0.961965	0.027020	0.026912	-0.000034	0.002405
…	…	…	…	…	…	…	…
75.0052	12584	12586	0.975834	0.030452	0.030354	-0.000039	0.002440
74.9814	12586	12588	0.968051	0.030525	0.030429	-0.000053	0.002420
…	…	…		…	…	…	…
1.00034	108960	108976	1.015683	0.028711	0.028599	0.000032	0.002539
1.00005	108976	108992	0.986039	0.027867	0.027758	-0.000032	0.002465

B.4 DATA (ID 4)

E/ keV	t_l / ns	t_h / ns	T_{exp}	u_t	u_u	AGS $K_{in} = K_{out}$	N
150.026	8898	8900	0.935247	0.023111	0.022993	-0.000077	0.002338
149.959	8900	8902	0.976257	0.023925	0.023800	-0.000029	0.002441
…	…	…	…	…	…	…	…
75.0052	12584	12586	0.923502	0.024429	0.024320	-0.000151	0.002309
74.9814	12586	12588	0.911000	0.024095	0.023987	-0.000174	0.002277
…	…	…		…	…	…	…
1.00034	108960	108976	0.936015	0.021381	0.021253	-0.000143	0.002340
1.00005	108976	108992	0.931257	0.021149	0.021020	-0.000151	0.002328

B.5 DATA (ID 5)

E/ keV	t_l / ns	t_h / ns	T_{exp}	u_t	u_u	AGS $K_{in} = K_{out}$	N
150.026	8898	8900	0.895390	0.023142	0.023033	-0.000105	0.002238
149.959	8900	8902	0.896866	0.022860	0.022749	-0.000100	0.002242
…	…	…	…	…	…	…	…
75.0052	12584	12586	0.885977	0.025211	0.025113	-0.000200	0.002215
74.9814	12586	12588	0.861767	0.024266	0.024169	-0.000234	0.002154

...	...	...		...	...	...	...
1.00034	108960	108976	0.907138	0.022609	0.022494	-0.000205	0.002268
1.00005	108976	108992	0.893567	0.022355	0.022242	-0.000233	0.002234

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