THE 29TH INTERNATIONAL SCIENTIFIC CONFERENCE OF YOUNG SCIENTISTS AND SPECIALISTS (AYSS-2025)

CALCULATION OF NEUTRON SELF-SHIELDING FACTOR FOR ^{186}W TARGET USING THE PHITS CODE

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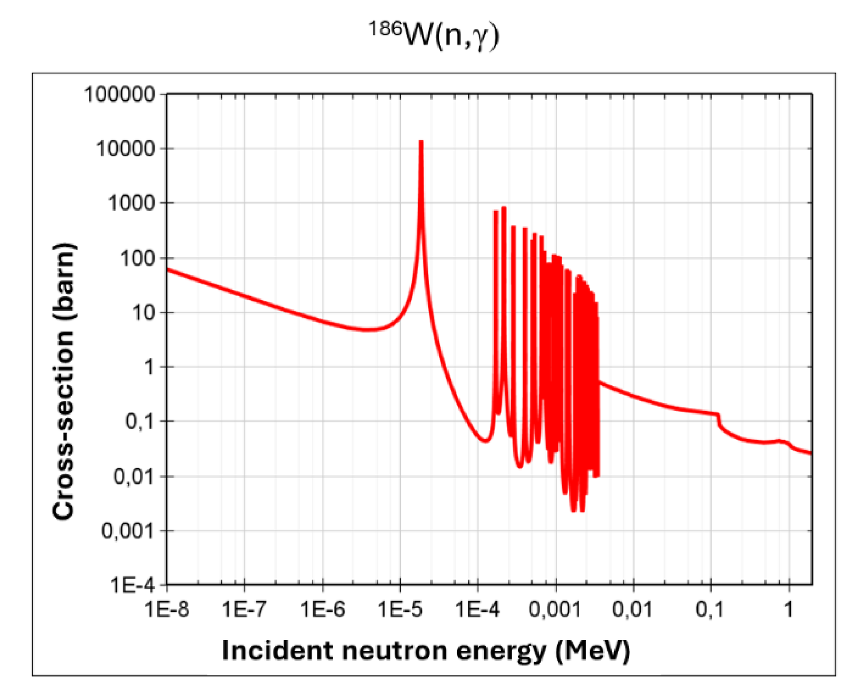
ABTRACT

Thermal and epithermal neutron self-shielding correction factors for the (n,γ) reaction in the ^{186}W target were determined by simulation using the PHITS code. The ^{186}W cylindrical target was in the form of metal powder diluted in an aluminum (Al) matrix at various concentrations. A Maxwellian neutron source with an average peak energy at 0.0253 eV was applied to the thermal neutron group and a $1/E^{1+\alpha}$ distribution was applied to the epithermal neutron group. Neutron correction factors were investigated for different dilution concentrations of ^{186}W in the ^{186}W(Al) sample under two irradiation conditions: an isotropic neutron field and a collimated neutron beam. Additionally, neutron correction factors were calculated for various wire diameters under irradiation with a collimated neutron beam.

INTRODUCTION

The isotope ^{186}W has a relatively high thermal neutron capture cross-section and resonance integral, which significantly influence the neutron self-shielding effect in samples irradiated for (n,γ) reaction studies.



The aim of this study is to investigate the thermal and epithermal neutron self-shielding correction factors of ^{186}W targets currently used in experiments at the Dalat nuclear research institue, using PHITS code.

METHODS

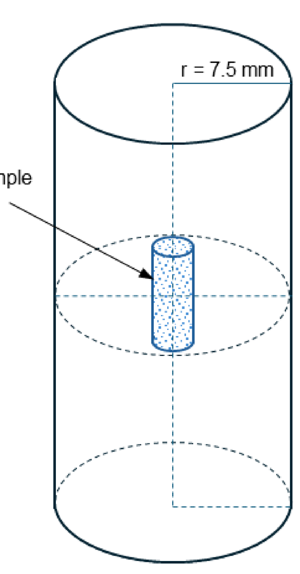
The thermal (G_{th}) and epithermal (G_{epi}) neutron self-shielding factors are calculated using the following equations:

$$G_{th} = \frac{\int_{E_1}^{E_2} \phi(E)\sigma(E)dE}{\int_{E_1}^{E_2} \phi_0(E)\sigma(E)dE}, \qquad G_{epi} = \frac{\int_{E_2}^{E_3} \phi(E)\sigma(E)\mathrm{d}E}{\int_{E_2}^{E_3} \phi_0(E)\sigma(E)\mathrm{d}E}$$

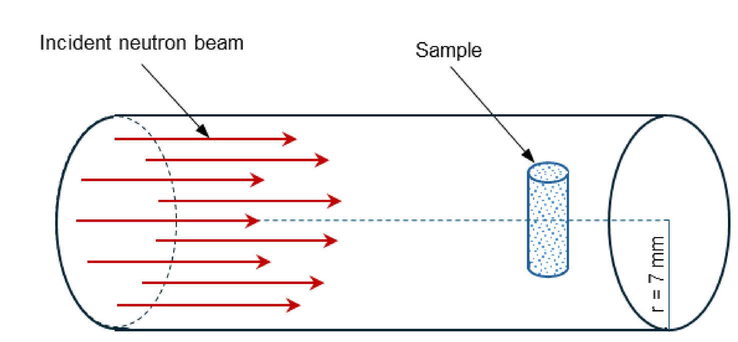
where: + $\phi(E)$: the neutron flux in the real sample within the energy region of interest;

+ $\phi_0(E)$: the neutron flux in the infinitely diluted sample;
+ $\sigma(E)$: the (n,γ) reaction cross-section;
+ E_1, E_2 and E_3: the energy boundaries of the neutron regions of interest. with thermal neutrons ranging from 10^{-5} to 0.55 eV, and epithermal neutrons from 0.55 eV to 0.2 MeV

The simulation configurations:



The isotopic neutron source

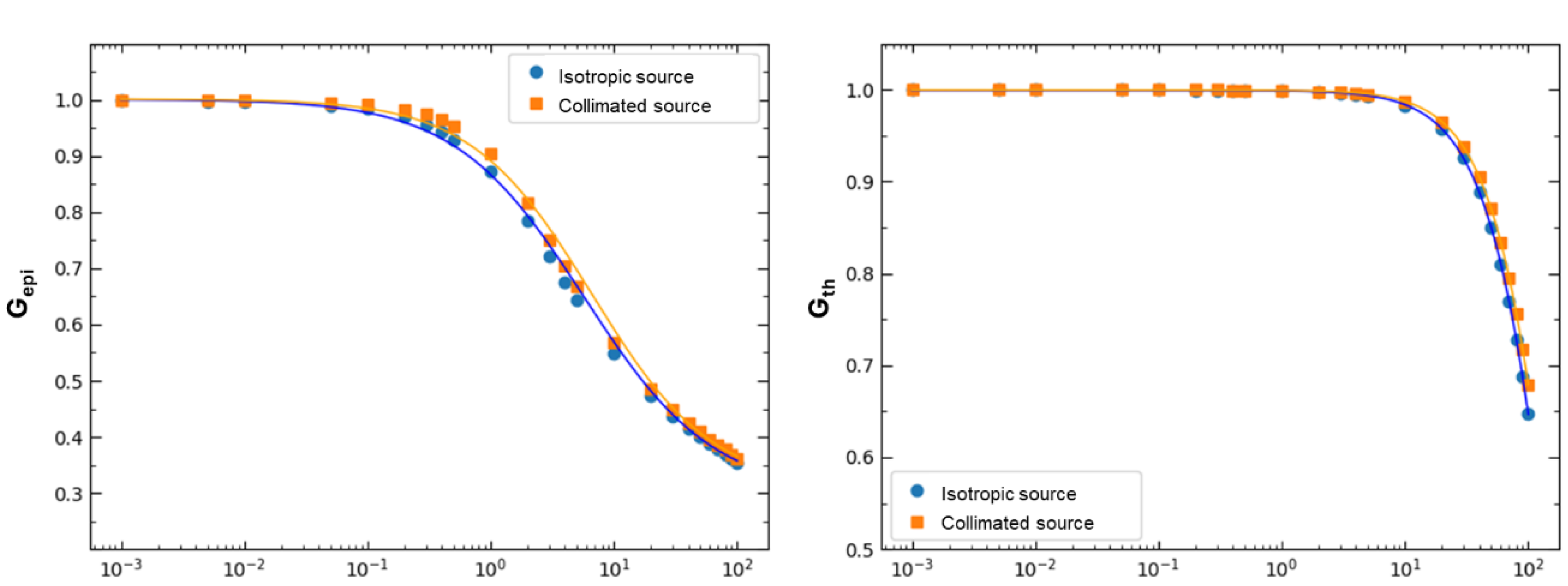


The collimated neutron source

RESULTS

The simulation results of G_{epi} and G_{th} factors with different ^{186}W content of target

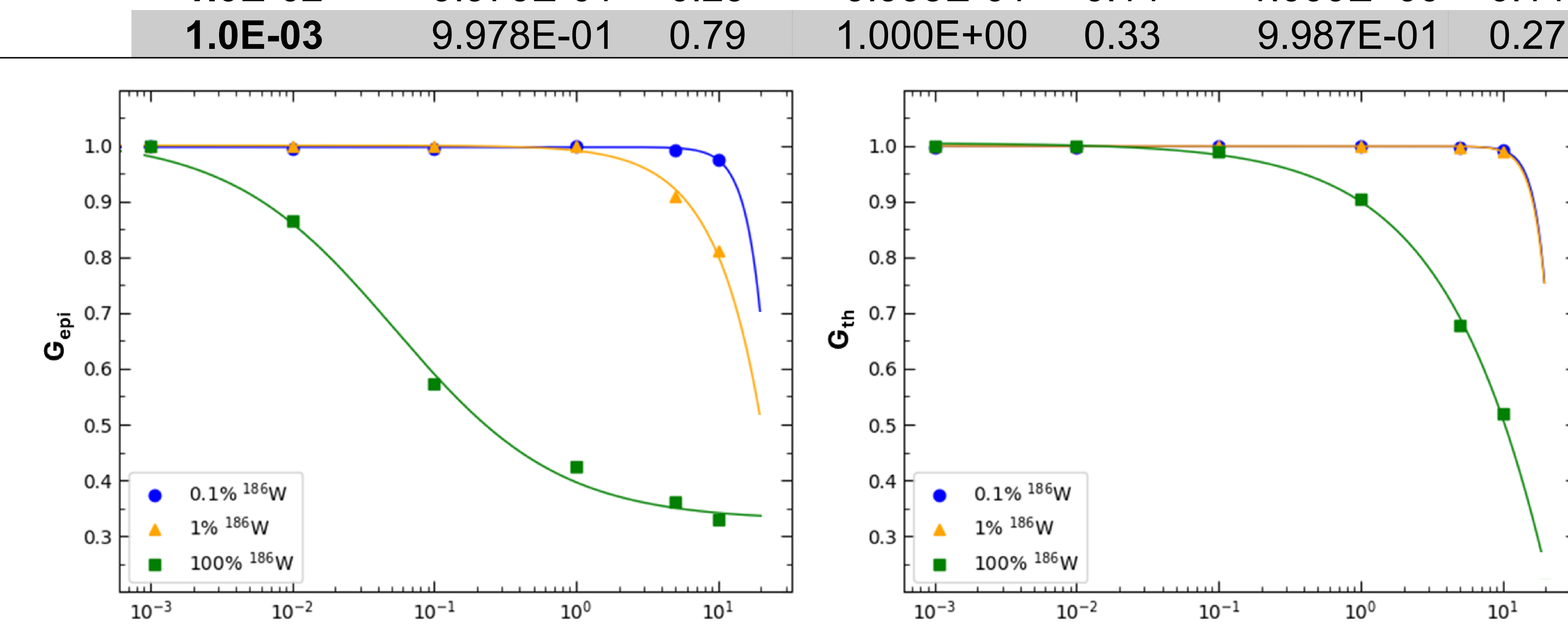
^{186}W content (%)	The isotopic neutron source				The collimated neutron source			
	G_{epi}	Error (%)	G_{th}	Error (%)	G_{epi}	Error (%)	G_{th}	Error (%)
100	3.541E-01	0.30	6.475E-01	0.09	3.621E-01	0.09	6.796E-01	0.06
90	3.613E-01	0.30	6.872E-01	0.09	3.695E-01	0.09	7.180E-01	0.06
80	3.690E-01	0.30	7.278E-01	0.09	3.774E-01	0.09	7.568E-01	0.06
70	3.777E-01	0.30	7.690E-01	0.09	3.862E-01	0.09	7.956E-01	0.06
60	3.875E-01	0.31	8.101E-01	0.09	3.964E-01	0.09	8.337E-01	0.06
50	3.994E-01	0.31	8.507E-01	0.09	4.089E-01	0.09	8.706E-01	0.06
40	4.146E-01	0.30	8.894E-01	0.09	4.252E-01	0.09	9.055E-01	0.06
30	4.364E-01	0.31	9.254E-01	0.09	4.485E-01	0.11	9.374E-01	0.07
20	4.720E-01	0.32	9.572E-01	0.09	4.866E-01	0.13	9.650E-01	0.07
10	5.488E-01	0.37	9.828E-01	0.10	5.682E-01	0.18	9.867E-01	0.07
5	6.431E-01	0.38	9.922E-01	0.06	6.692E-01	0.23	9.943E-01	0.04
4	6.765E-01	0.39	9.939E-01	0.06	7.049E-01	0.26	9.956E-01	0.04
3	7.214E-01	0.42	9.955E-01	0.06	7.515E-01	0.29	9.968E-01	0.04
2	7.840E-01	0.45	9.969E-01	0.06	8.167E-01	0.33	9.980E-01	0.04
1	8.716E-01	0.49	9.983E-01	0.06	9.043E-01	0.37	9.990E-01	0.04
0.5	9.295E-01	0.47	9.991E-01	0.05	9.540E-01	0.30	9.994E-01	0.04
0.4	9.421E-01	0.48	9.992E-01	0.05	9.644E-01	0.30	9.995E-01	0.04
0.3	9.552E-01	0.48	9.994E-01	0.05	9.741E-01	0.31	9.996E-01	0.04
0.2	9.690E-01	0.49	9.995E-01	0.05	9.825E-01	0.31	9.997E-01	0.04
0.1	9.846E-01	0.49	9.996E-01	0.05	9.913E-01	0.31	9.998E-01	0.04
0.05	9.900E-01	0.43	9.996E-01	0.05	9.952E-01	0.15	9.999E-01	0.04
0.01	9.963E-01	0.44	9.997E-01	0.05	9.981E-01	0.15	9.999E-01	0.04
0.005	9.969E-01	0.44	1.000E+00	0.04	9.984E-01	0.15	1.000E+00	0.03
0.001	1.000E+00	0.41	1.000E+00	0.04	1.000E+00	0.11	1.000E+00	0.03



Self-shielding correction factor curves for ^{186}W(Al) targets with varying ^{186}W content

The simulation results of G_{th} and G_{epi} for ^{186}W wire targets with different diameters in a collimated neutron beam

STT	Diameter (mm)	0.1% ^{186}W		1% ^{186}W		100% ^{186}W	
		Factor	Error (%)	Factor	Error (%)	Factor	Error (%)
G_{epi}	**1.0E+01**	9.749E-01	2.32	8.060E-01	2.31	3.337E-01	2.42
	5.0E+00	9.913E-01	2.33	9.043E-01	2.34	3.644E-01	2.42
	1.0E+00	9.997E-01	2.32	9.928E-01	2.31	4.277E-01	2.42
	1.0E-01	9.932E-01	2.33	9.942E-01	2.34	5.789E-01	2.42
	1.0E-02	9.951E-01	2.49	9.932E-01	2.46	8.729E-01	2.54
	1.0E-03	1.000E+00	3.27	1.000E+00	3.27	1.000E+00	3.42
G_{th}	**1.0E+01**	9.913E-01	0.06	9.894E-01	0.04	5.190E-01	0.10
	5.0E+00	9.970E-01	0.04	9.962E-01	0.06	6.789E-01	0.12
	1.0E+00	1.000E+00	0.04	1.000E+00	0.06	9.032E-01	0.10
	1.0E-01	9.995E-01	0.09	9.992E-01	0.07	9.891E-01	0.12
	1.0E-02	9.976E-01	0.29	9.995E-01	0.14	1.000E+00	0.14
	1.0E-03	9.978E-01	0.79	1.000E+00	0.33	9.987E-01	0.27



Dependence of the neutron self-shielding correction factors on the wire diameters

CONCLUSION

The self-shielding factors G_{th} and G_{epi} decrease markedly from ~1.0 to ~0.3 as the ^{186}W content increases from 0.001% to 100%. In addition, both factors vary strongly with wire diameter, with more pronounced effects in the epithermal region.

REFFERENCES

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