Neutron Flux Density Spectral Parameters of IREN

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Introduction

• The Aim of the Research

Determining 2 main parameters of the neutron spectra of IREN

-The Maxellian-temperature T_M for thermal neutron

-The α-shape factor for epi-neutron spectra

• The Method for Research

Both ways of the simulation Monte-Carlo using MCNP code, and experimental measurement

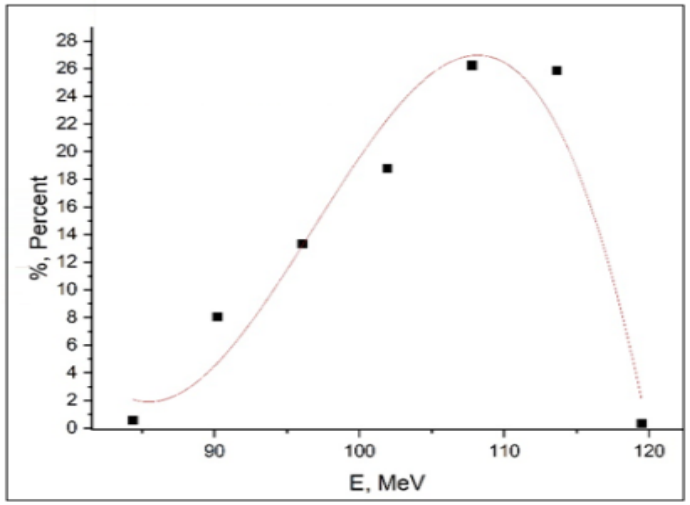
Simulation MCNP

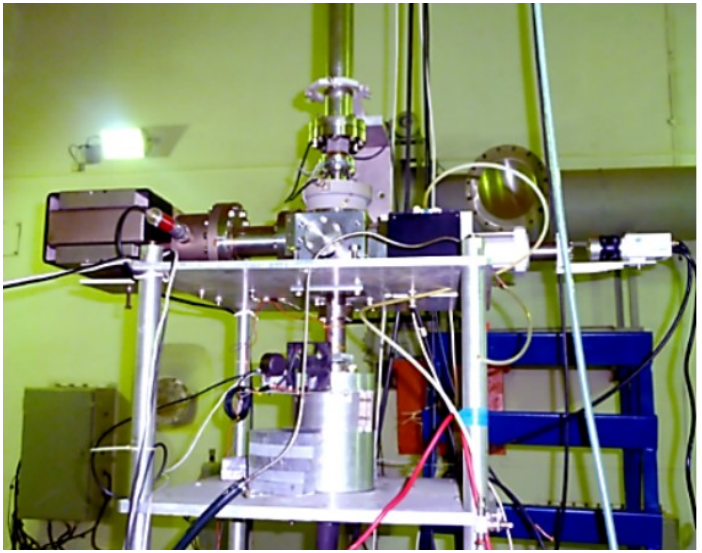
Input Data:

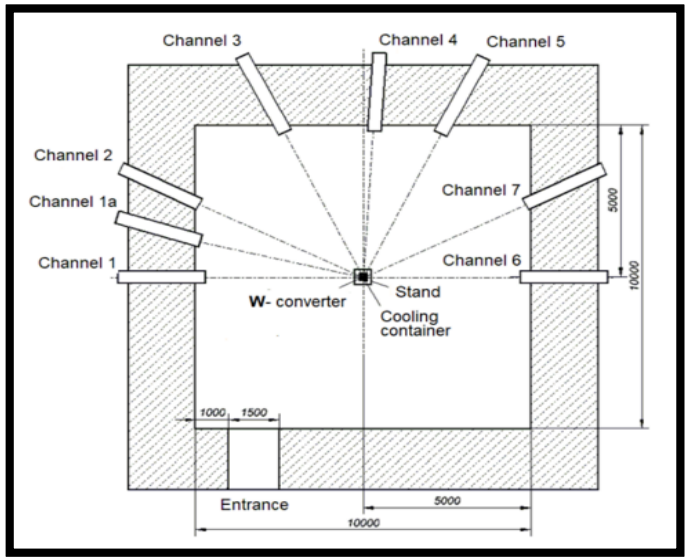
The energy spectra of the accelerated electron beam in 2023

Output information:

Neutron spectra at position **h=5cm** from the top of moderator

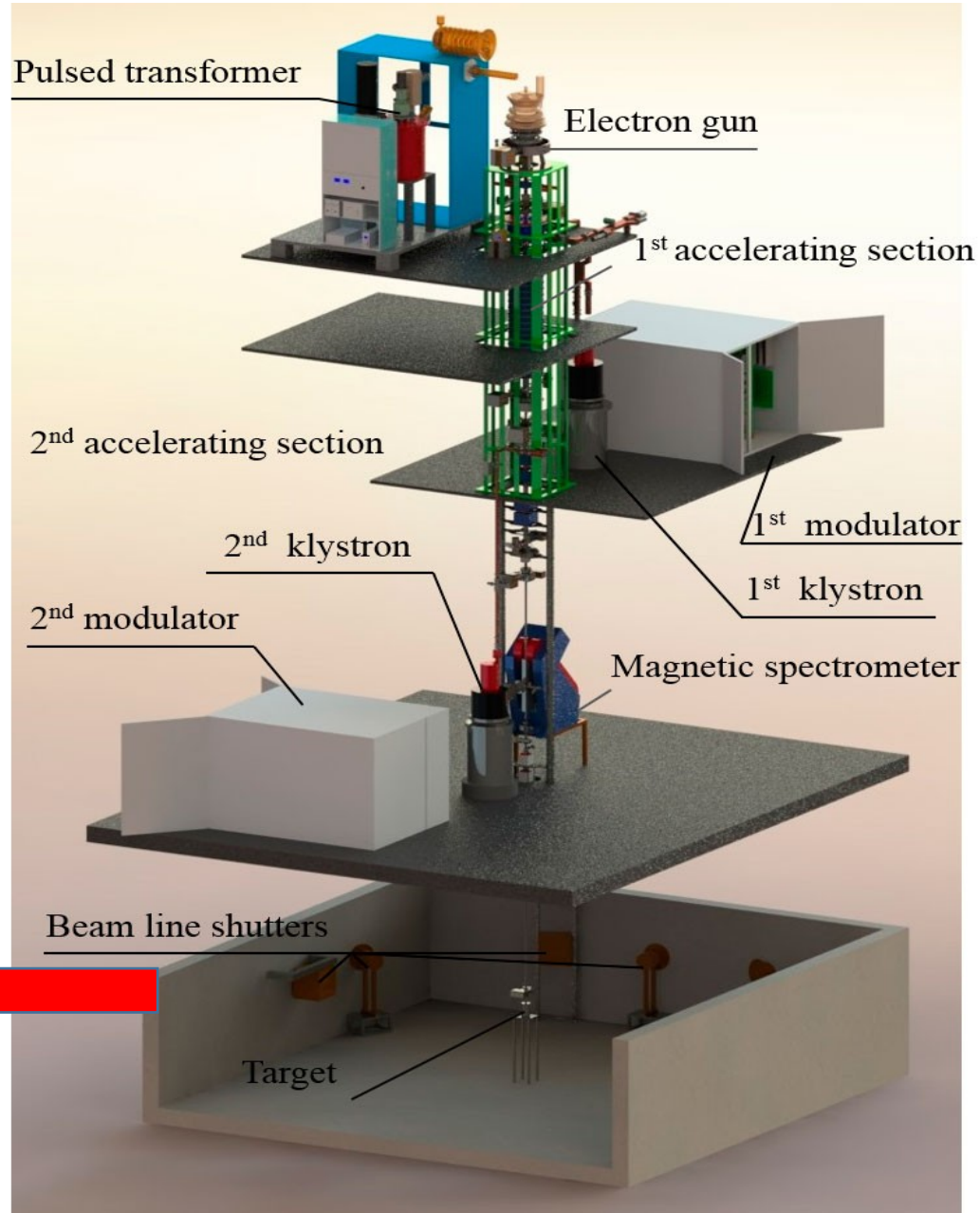






- W-converter system and Out-channels in IREN

LUE-200 linear accelerators includes



Simulated Neutron Spectra and Fitting

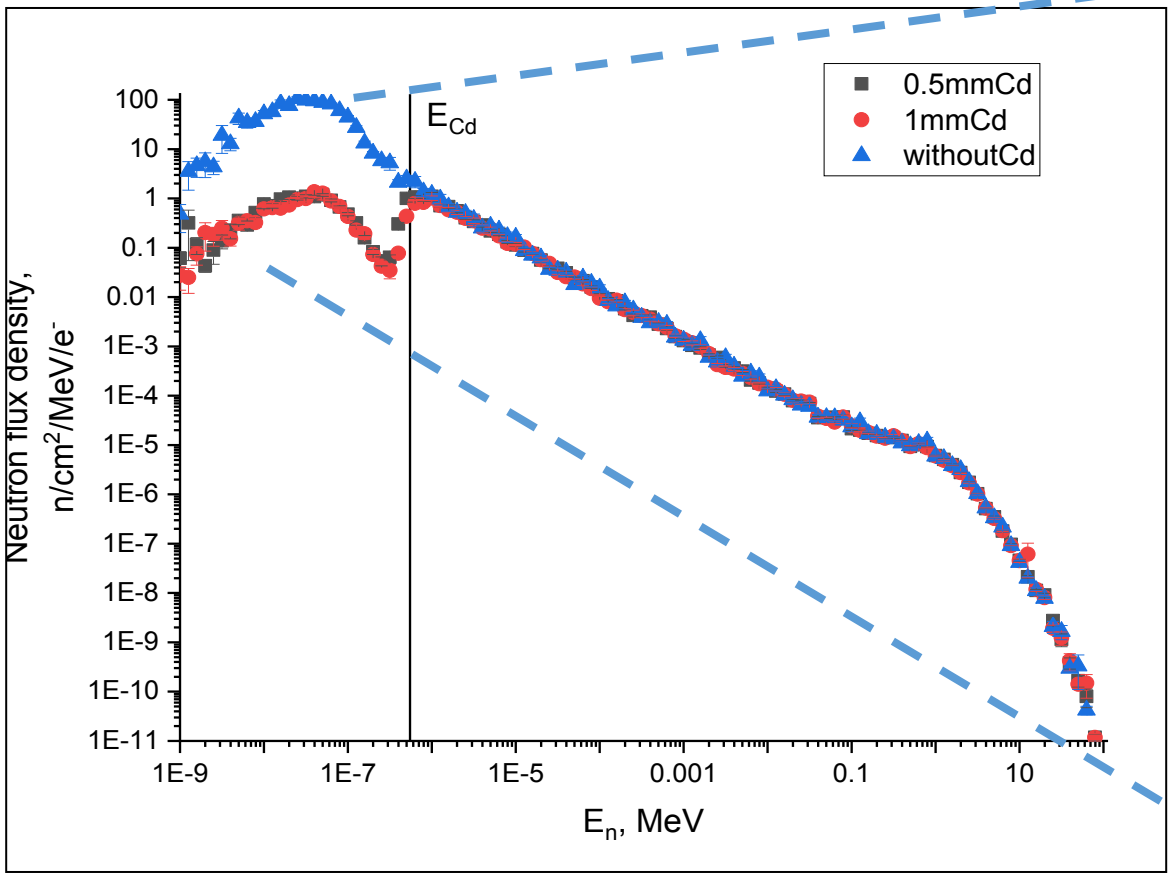
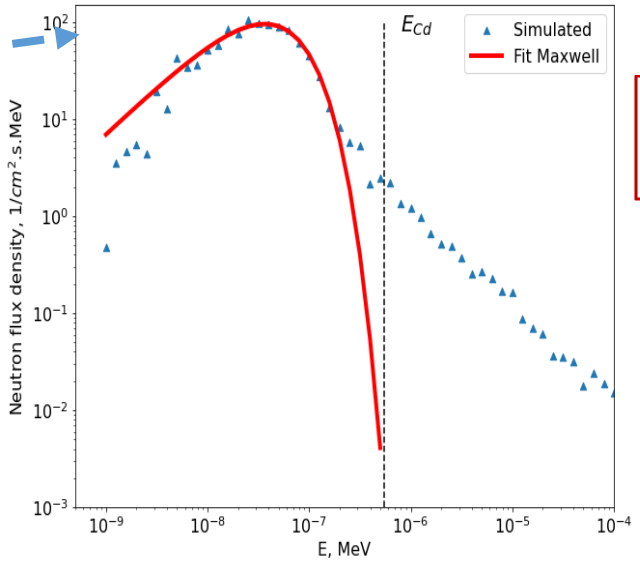
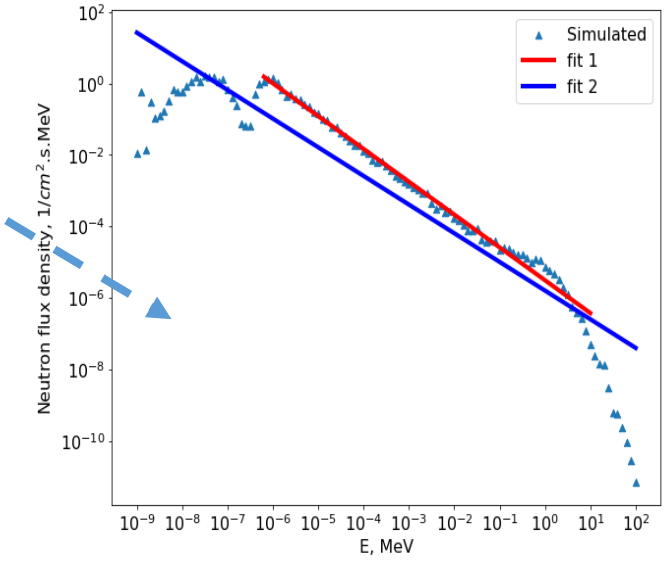


Fig.3 : Neutron flux distribution with Cd of different thicknesses By MCNP simulation





❖ Thermal neutron

$$\varphi_{th}(E) = \Phi_1 \cdot \frac{E}{(kT)^2} \cdot exp^{-E/kT}$$

$E_{cut\text{-}off}$ (eV)	$T_{thermal}$ [Kelvin]
0.1	426 ± 19
0.55	425 ± 15
1	425 ± 15
Average	425.3 ± 16

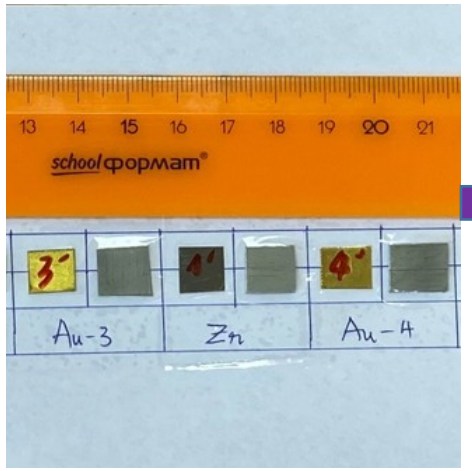
❖ Epi-thermal neutron

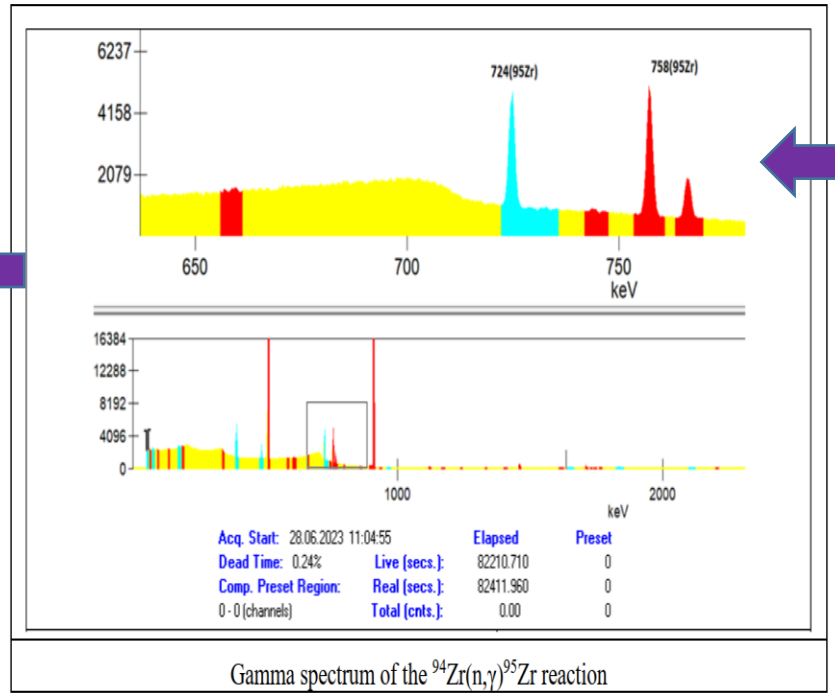
$$\varphi_{epi-th}(E) = \Phi_2 \cdot \frac{1}{(E)^{1+alpha}}$$

	α-factor
Fit 1	-0.08 ± 0.011
Fit 2	-0.198 ± 0.033

Experimental Layout

- Based on the reactions of $^{197}Au(n,\gamma)^{198}Au$ and $^{94}Zr(n,\gamma)^{95}Zr$ through the neutron activating of Au and Zr monitoring foils to determine the ***α*-factor** experimentally.





Gamma spectrum of the $^{94}Zr(n,\gamma)^{95}Zr$ reaction

Cadmium ratios

Table. 1: The obtained cadmium ratios

Reaction	CR	dCR
$^{197}Au(n,\gamma)^{198}Au$	2.579	0.005
$^{94}Zr(n,\gamma)^{95}Zr$	1.341	0.035

Experimental Value of α-factor

- **The equation to determine α-factor** [2]:

$$\frac{(CR - F_{Cd})_{Au}}{(CR - F_{Cd})_{Zr}} = \frac{G_{Zr}}{G_{Au}} \frac{\{(Q_0 - 0.426) * (\bar{E}_r)^{-\alpha}\}_{Zr} + C_\alpha}{\{(Q_0 - 0.426) * (\bar{E}_r)^{-\alpha}\}_{Au} + C_\alpha}$$

Where: F_{Cd} is the Cd-filter epi-thermal neutron transmission factor,
$\bar{E}_r$ is effective resonance energy (eV) as defined by Ryves.
$G = G_{epi}/G_{th}$ factor is the ratio of the
G_{epi} epi-thermal neutron self-shielding factor
G_{th} the thermal neutron self-shielding factor and $C_\alpha = \frac{0.426}{(2\alpha+1)E_{Cd}^{\alpha}}$, and $Q_0 = \frac{I_0}{g*\sigma_0}$.

Calculated by *MATSSF code*

Table. 2: Nuclear data used for **α** determination

Isotope	G_{th} [3]	G_{epi} [3]	G	Q_0 [4]	$\bar{E}$ eV [4]	F_{Cd} [5]	g [6]
^{197}Au	0.8837	0.2142	0.2424	15.7	5.65	1.009	1.0054
^{94}Zr	0.9997	0.9812	0.9815	5.31	6260	1.0	1.0004

Experimental value of α-factor: -0.181 ± 0.012

Comparision and Conclusion

❖ **2 main characteristic factors of spectral neutron : $T_{thermal}$ = 425.3±16 Kelvin**

	α-shape factor	Dif. to Ex. value %	
Experimental result	**-0.181 ± 0.012**		
Fit 2: neutron spectra after 0.5mm Cd cover	**-0.198 ± 0.033**	**9.4**	
Fit 1: corresponding to ideal epithermal neutron	**-0.080 ± 0.011**	**55.8**	

➢ **Conclusion:** The values of the factors T and α have been reliably determined and can be used for other subsequent studies. However, this study also shows the disadvantages of the Cadmium transmission method.

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