Determination of the Parameters of Multisectional Liquid Scintillation Spectrometer and of Prototype of “Gamma” Installation at the IREN Facility

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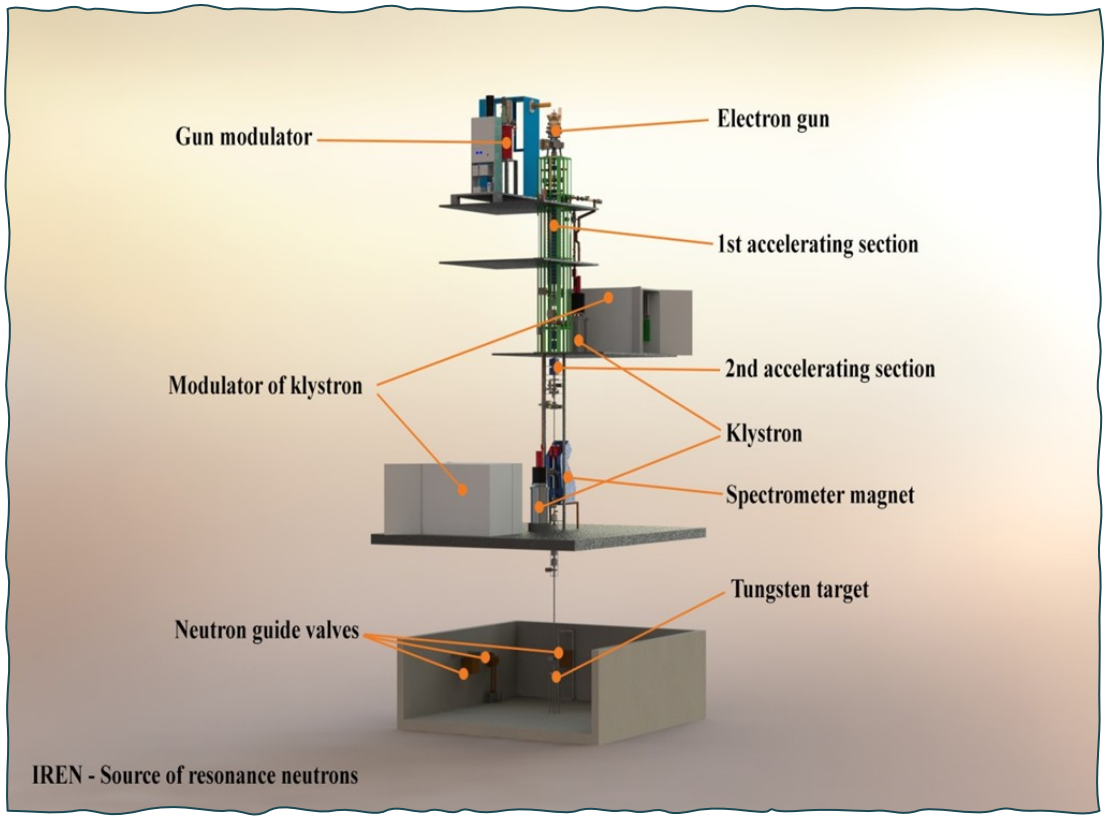
Facility

Parameters of the IREN:
Peak current - 3A
Repetition rate - 50 Hz
Electron pulse duration - 100ns
Electron energy - 120MeV
Neutron intensity ~ $2 \cdot 10^{11}$ n/s



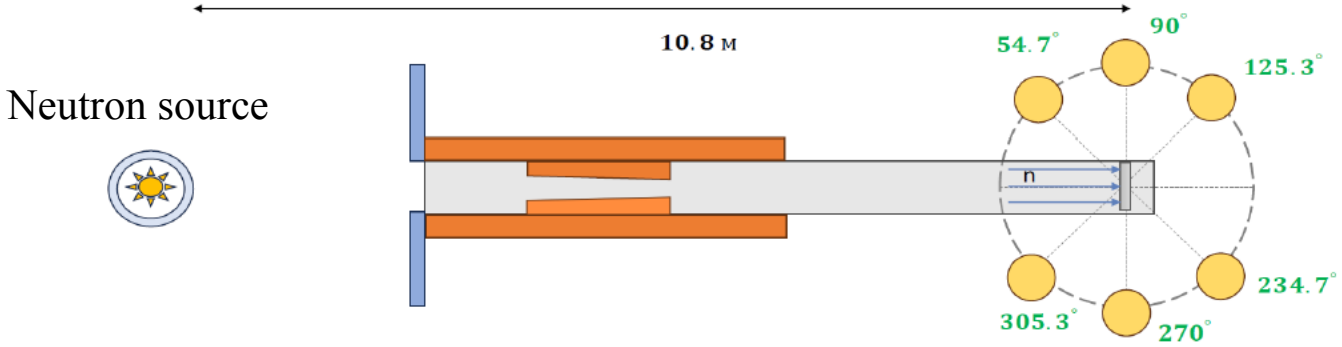
General scheme of the IREN facility. Accelerator and target hall.
https://flnp.jinr.int/en-us/main/facilities/iren

Facility

Used neutron beams:

№3, 60m from the target. Setup consisting of 6 sections of liquid scintillation detectors.
№4, 11m from the target. Setup consisting of 6 BGO scintillation detectors and one HPGe 35% detector.

Both setups are used for Neutron Resonance Capture Analysis (NRCA – determining the neutron energy, resonance width (Γ), and partial neutron resonance widths $\Gamma_{n1/2}$ and $\Gamma_{n3/2}$).



2D scheme of the experimental setup at the 4th channel.

Neutron Flux Determination

To determine the absolute value of the neutron flux was used the activation method using gold monitors where one of the monitor is covered by cadmium layer for absorption of thermal neutrons (and neutrons with energy lower than thermal) from the neutron beam.

$$F = \frac{N \cdot M \cdot \lambda \cdot e^{\lambda t_{dec}}}{m_{Au} \cdot N_A \cdot \gamma \cdot \varepsilon \cdot \theta \cdot \sigma_{th} \cdot [1 - \exp(-\lambda t_{irr})] \cdot [1 - \exp(-\lambda t_{meas})]}$$

Monitors were irradiated during at least 12 hours. The induced activity of Eγ=411.8 was measured using HPGe detector with 35% efficiency of γ-ray capture and FWHM=2.1 keV for 60Co 1332.5 keV. For the channel №3 measurement was performed only once, for channel №4 – several times, results:

Neutron Flux Determination

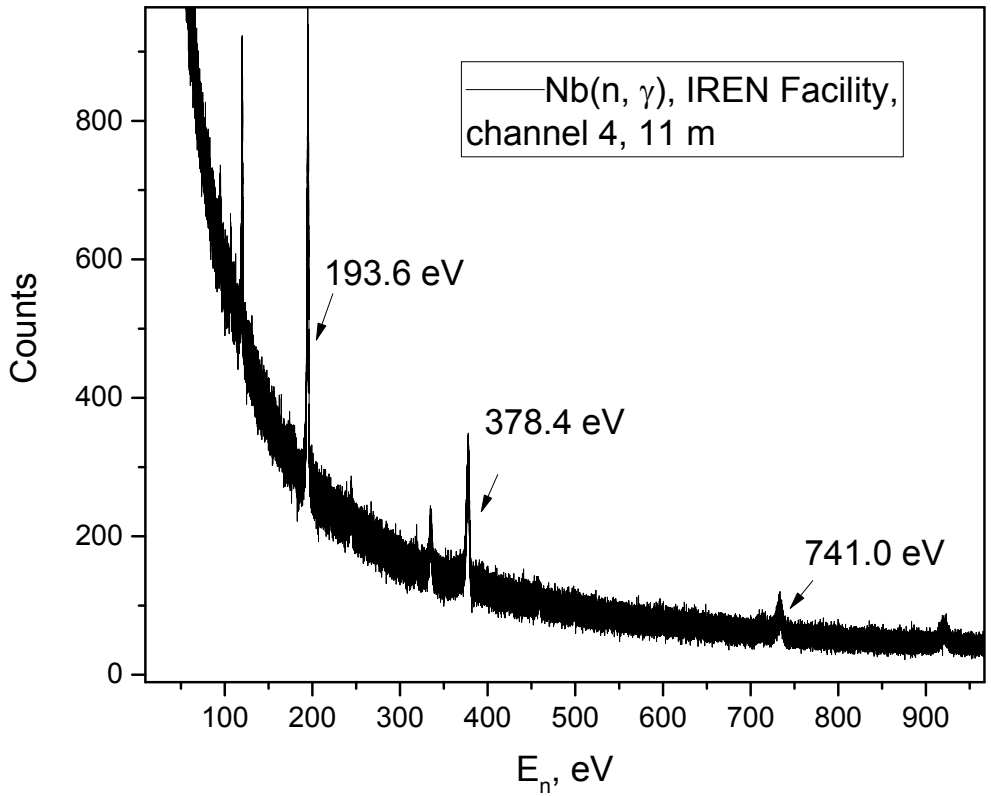
Date	Chn. №3			Chn. №4		
	Fth	Fres	Fth/Fres	Fth	Fres	Fth/Fres
15.03.2024	-	-	-	$4.76*10^4$	$5.4*10^3$	8.8
16.02.2024	-	-	-	$2.65*10^4$	$4.07*10^3$	6.51
14.02.2024	217	133	1.63	-	-	-
17.10.2023	-	-	-	$1.30*10^4$	$8.31*10^3$	1.56

Experimental Determination of Energy Resolution Function of Installation at 4th Channel

We estimated the energy resolution function $R(E, E')$ of the setup at the 4th channel of the IREN facility using experimental data from $^{93}_{41}Nb(n,\gamma)\,^{94}_{41}Nb$ reaction. Experimental data – convolution of the installation resolution function with a function describing the physical process: $Y_{\gamma\,exp} = \int R(E,E')Y_{\gamma}(E')dE'$. The resolution function is defined by the shape of the neutron pulse of the facility. The form of resolution function:

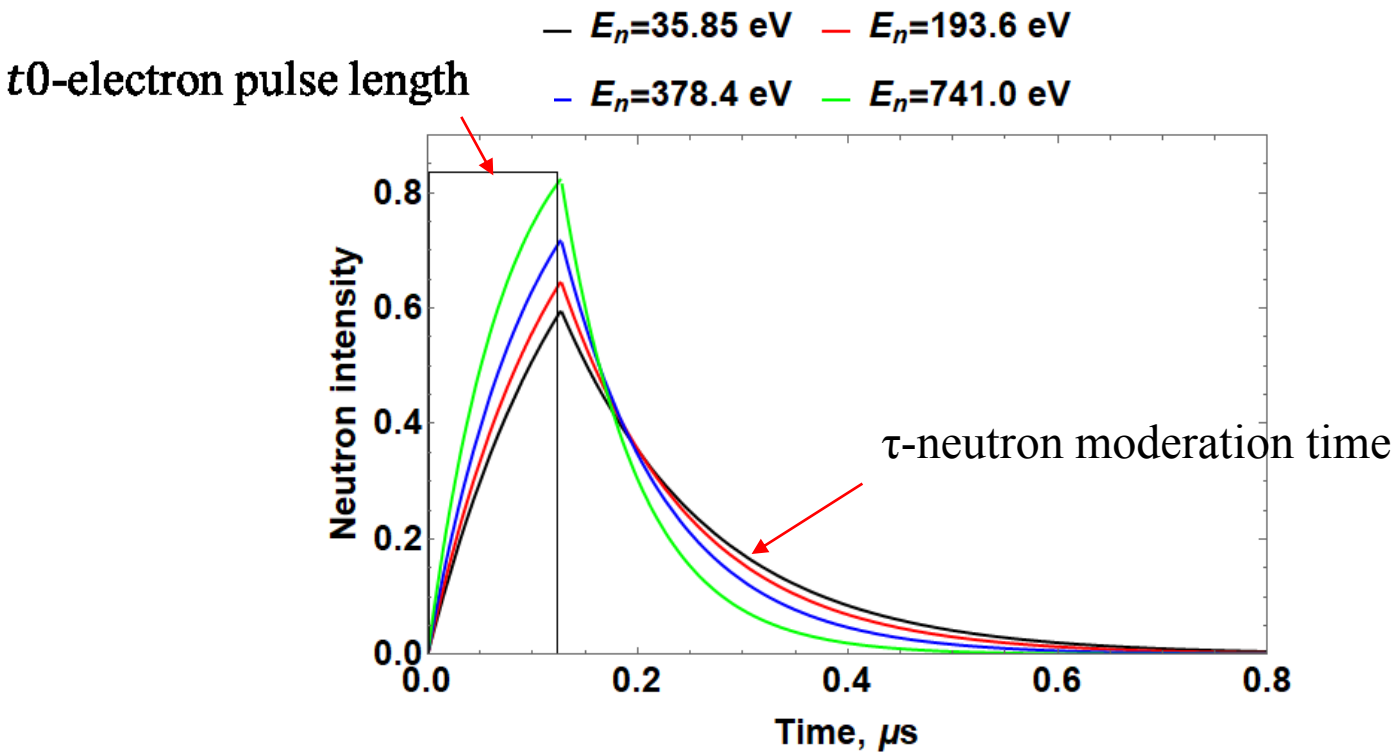
$$R(E,E') = \begin{cases} 0, & E' < E - \varepsilon_0; \\ \frac{1}{\varepsilon_0}\left(1 - e^{t_0/\tau} \cdot e^{-\frac{E'-E}{\tau \cdot W}}\right), & E - \varepsilon_0 \le E' \le E; \\ \frac{1}{\varepsilon_0}\left(1 - e^{t_0/\tau}\right) \cdot e^{-\frac{E'-E}{\tau \cdot W}}, & E' > E, \end{cases} \quad where\ \varepsilon_0 = \frac{2 \cdot t_0 \cdot E^{3/2}}{72.3 \cdot L}, W = \frac{2 \cdot E^{3/2}}{72.3 \cdot L}$$

Experimental Determination of Energy Resolution Function of Installation at 4th Channel



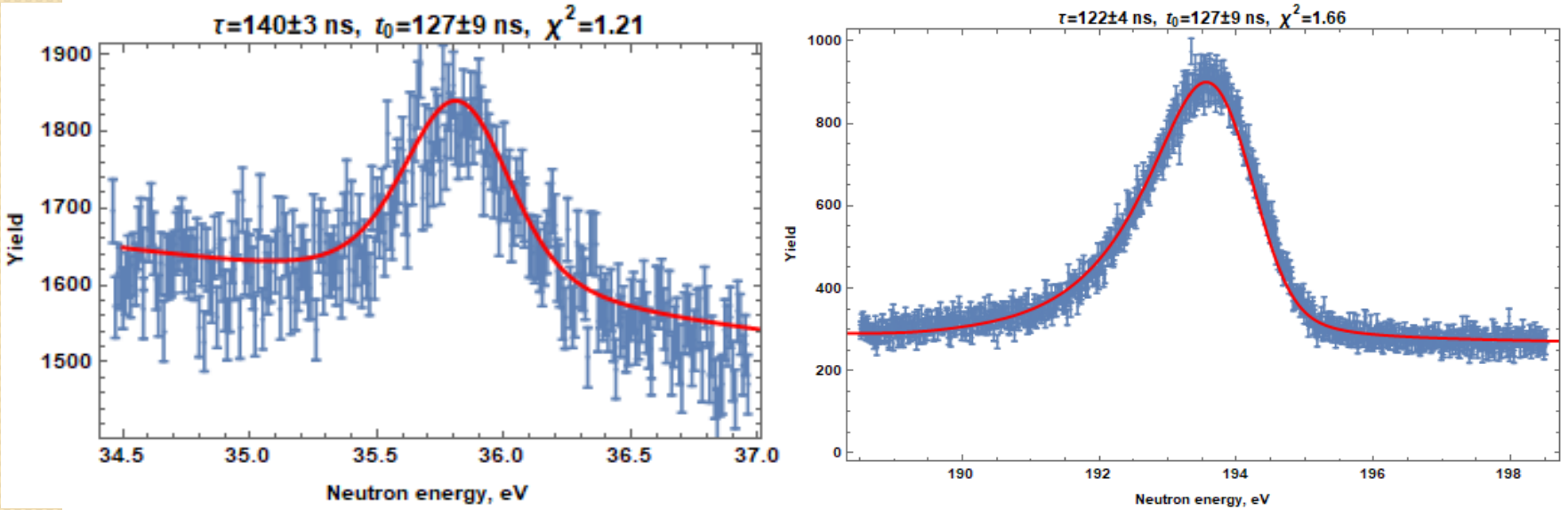
The experimental spectrum of γ-quanta from the capture measurement with the sample of natural niobium, thickness of the sample 200 μm.

Experimental Determination of Energy Resolution Function of Installation at 4th Channel



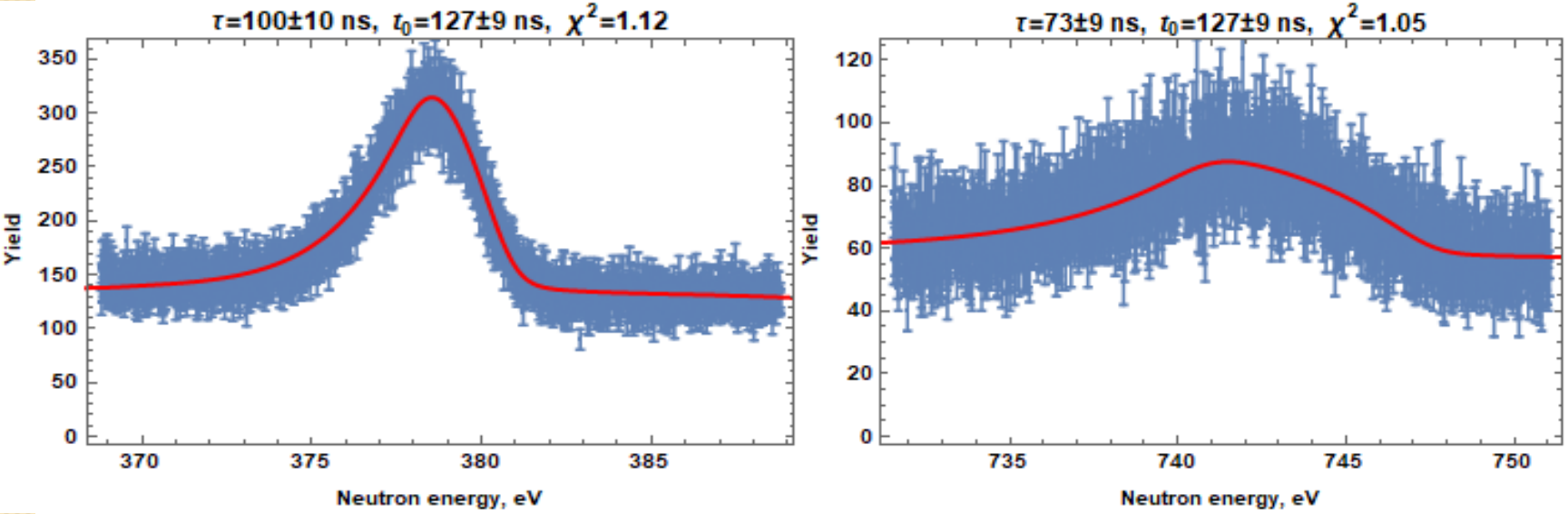
The neutron pulse of the IREN facility for different neutron energies obtained from experimental data.

Experimental Determination of Energy Resolution Function of Installation at 4th Channel



The fitting curves for different neutron resonances.

Experimental Determination of Energy Resolution Function of Installation at 4th Channel



The fitting curves for different neutron resonances.

Experimental Determination of Energy Resolution Function of Installation at 4th Channel

Resonance energy, eV	T *Neutron moderation time*	t_0 *Electron pulse length*
	$140 \pm 3\ ns$	$127 \pm 9\ ns$
193.6	$122 \pm 4\ ns$	
	$100 \pm 10\ ns$	
741.0	$73 \pm 9\ ns$	

The authors kindly thanks the stuff of IREN facility for their help.

Looking forward to meet You at FLNP, JINR, Dubna!