# Research Activities with Am-Be Neutron Source at Manipal

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## Introduction

In 2012, Manipal Centre for Natural Sciences (MCNS) came into its own as Centre for Excellence under Manipal Academy of Higher Education (MAHE). From its inception, this “all-research” center has been striving to promote fundamental research in forefront areas of natural sciences. In context to nuclear physics, MCNS in houses 16 Ci Am-Be neutron source [1], 50 keV tabletop accelerator [2] and radiation detection laboratory to explore fundamental research. The objective of this paper is to present an overview of the research activities carried out with Am-Be neutron source at MCNS. In this context, we present some results of neutron spectrum and cross-section measurements with Am-Be neutrons source at MIT, MAHE.

## Am- Be Neutron Source Facility

The Americium Beryllium (Am-Be) neutron source facility is located at Manipal Institute of Technology (MIT), Manipal Academy of Higher Education, Manipal. It has an activity of 16 Ci. It has 433 years of half-life and $2.2\times10^6$ neutrons/sec yield per Curie of the activity. It is securely stored in an underground facility and is raised to the operational position using a pulley system, as shown in Fig. 1.

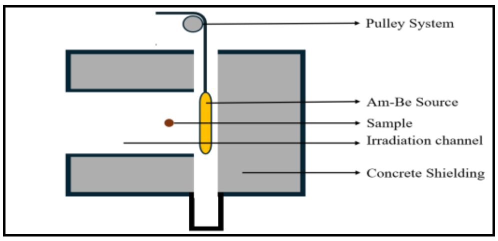


***Fig.1** Schematic of Am- Be Source at MAHE.*

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The neutrons from the source have energy up to approximately 11 MeV, with an average energy of around 4 MeV from the bare source. The ISO standard spectrum of the bare source is shown in Fig 2 [3]. Several studies have reported that the neutron energy distribution from the source varies according to the structural materials around it due to the neutron interactions.

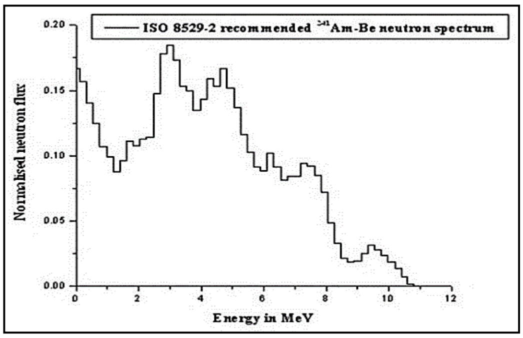


**Fig. 2** ISO standard Am-Be neutron spectrum

## Neutron spectrum from Am- Be Source at Manipal

At MIT Manipal, Am-Be source is doubly encapsulated with stainless steel and enclosed within a concrete bunker that has an opening on one side to facilitate sample irradiation. Therefore, determining the exact nature of the neutron spectrum at the irradiation location is crucial for conducting precise experiments for the cross-section measurements. In this context, a combination of experimental and Monte Carlo techniques has been employed to measure the nature of neutron spectrum at irradiation location.

The multi-foil activation technique was utilized to collect experimental data, where foils with known neutron capture cross-sections were irradiated under identical conditions. In the present study, we selected six different foils: $^{55}$Mn, $^{63}$Cu, $^{197}$Au, $^{58}$Ni, $^{115}$In, and $^{45}$Sc. Detailed cross-section data for these foils are available, enabling precise calculation of neutron flux and energy spectrum.

Monte Carlo simulations were conducted to complement the experimental measurements. These simulations modelled the geometry of the irradiation facility and the interaction of neutrons with them. The simulations provided an initial estimate of the neutron spectrum, which served as the basis for iterative adjustments during the unfolding process. The simulated neutron spectrum from Am-Be neutron source is shown in Figure 3.

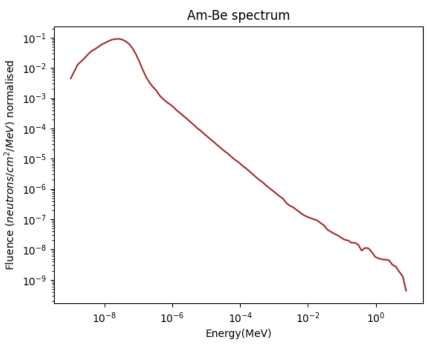


**Fig. 3** Monte Carlo simulated spectra (with shielding) at the irradiation location.

It can be seen from the Fig.3 that resultant neutron spectrum at the irradiation location significantly changed due to multiple scattering with shielding materials. The spectrum unfolding procedure was carried out using an iterative method that adjusts the initial guess of the neutron spectrum to match the measured data. The unfolding was performed with the SAND-II code [4]. The final unfolded spectrum revealed significant moderation of the neutron energies within the concrete shielding, with a pronounced peak in the thermal region. The unfolded spectrum was subsequently used for the cross-section calculations, leading to improved precision and a reduction in uncertainties.

## Thermal neutron capture cross-section measurement of Ce-140

Several irradiations were carried out to measure the thermal neutron capture cross-section of cerium isotopes with and without cadmium cover using Am- Be source at MAHE. We have employed neutron activation and off-line gamma-ray spectrometric method for the cross-section determination. A typical gamma-ray spectrum irradiated $CeO_2$ sample is shown in Fig. 4.

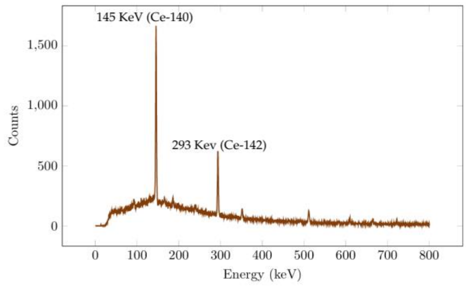


**Fig. 4** Gamma-ray spectrum of irradiated $CeO_2$

Standard flux monitors (Gold & Indium) were used to measure the neutron flux at the irradiation location. we obtain the thermal neutron flux of $4.655 \times 10^3$ n/cm$^2$ at the irradiation location using standard gold foil, which was irradiated along with the cerium samples. We have determined thermal neutron capture cross-section of $^{140}$Ce(n, $\gamma$)$^{141}$Ce and it is $0.54 \pm 0.04$ barns which align well with previously measured data.

## References

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