Variation of fluence for ^{241}Am-Be neutron spectrum with different thicknesses of high-density polyethylene

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Introduction

Neutron fluence is an important aspect of radiation. The protection from neutron source, mainly in environment where neutrons are present for examples-Nuclear Reactor, Medical facilities, and research laboratories, can be determined from its fluence. The material used for shielding against neutron should have high hydrogen content like polyethylene, Paraffin and water, etc [1].

The presence of an unshielded ^{241}Am-Be source in premises poses concerns. The unwanted radiation can interfere with accuracy of other experiments. This will also cause hazards for the person who is involved in experimental measurements. In view of the above, the present study focusses on reduction of background radiation, up to 1μSv/h at 1 meter from the source. Setting up proper shielding for ^{241}Am-Be neutron source is essential for above mentioned reasons.

The geometry availing high density polyethylene (HDPE)for decreasing neutron dose rate to a permissible level was simulated using *FLUKA* software. For accumulation of events liquid scintillator (BC-501A) detector was used. The events were studied and analysed using Compass Software. The experimental arrangement is being carried out in radiation detection and measurement laboratory at Amity Institute of Nuclear Science and technology.

Simulation and Experimental Details

We are using 5"x3" Liquid scintillator (Xylene as Detecting material) for neutron spectroscopy utilising ^{241}Am-Be source of 40mCi Strength. Calibration with a ^{22}Na gamma source helps establish the relationship between the channel numbers recorded by the detector and the actual gamma-ray energies. As this is an organic scintillator so the visibility of Compton edge has been taken for calibration purpose as shown in Fig.1. We are in the process of generating the neutron energy spectrum of ^{241}Am-Be source, with and without shielding.

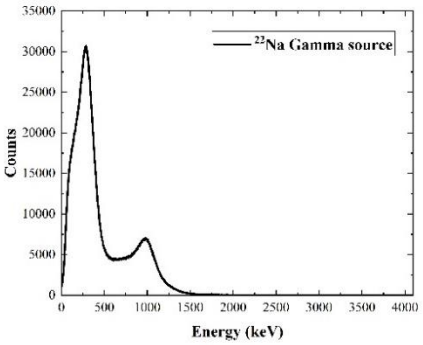

Fig. 1. Calibrated Spectrum using ^{22}Na source

The shielding geometry was done using FLUKA Software (Version3.3) [2] taking HDPE into consideration.

In the FLUKA Geometry, concerned high-density polyethylene (HDPE) is of 0.94g/cm^3 density with 30cm x 30cm, length and breadth. The HDPE which has a high hydrogen content is used for moderation of fast neutrons. For optimization of the thickness, we used 8 cm, 10cm and 16 cm thick HDPE material. As FLUKA can simulate the interaction between the materials with neutron, photon, elementary particles and heavy ions this Monte Carlo tool was used. Also, FLUKA can handle very complex geometries.

The Neutron Source Spectra was taken from ISO [3,4]. Source is considered as isotropic. For best results rectangular parallelopiped (RPP) geometry as shown in Fig. 2. was considered, approximately 10^6 neutron events were simulated which was followed for 5 cycles.

Result, Discussion and Future scope

To determine the ambient dose equivalent rate H*(10) from a radiation source using FLUKA, the following steps are typically followed:

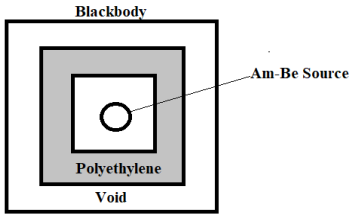

Fig. 2. Basic RPP Geometry used in FLUKA

1. Spectrum of Fluence vs Energy is obtained using the USRTRACK card in FLUKA. This card allows scoring the particle fluence as a function of energy in a given region of the geometry (for 8cm thickness of HDPE) shown in Fig. 3.
2. The particle fluence is then calculated using the USRBIN card, which scores the fluence in a 3D mesh superimposed on the geometry
3. We are estimating H*(10) for neutron, calculated by multiplying the particle fluence (which is normalized with respect to real data) and then the appropriate conversion factor from fluence to dose equivalent [5]. These conversion factors are based on the recommendations of the International Commission on Radiological Protection (ICRP) Publication 74 [5].

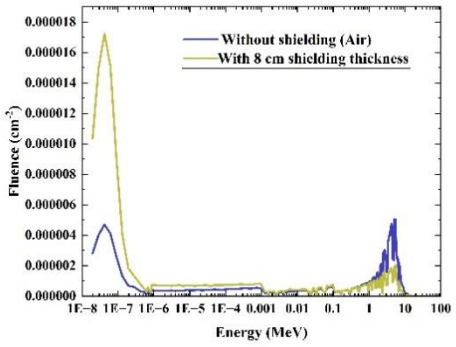

Fig. 3: Neutron Spectrum of With and without Shielding of Polyethylene

According to FLUKA calculation, the dose at 1 cm from the source is 22.7μSv for 40mCi ^{241}Am-Be Source and After shielding of 8 cm thick Polyethylene the dose coming out to be 0.0138μSv and which matches with the background radiation level.

Presently, we are in the process of conducting the experimental work. The experimental work aims to further validate the simulation.

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